MARS CORRECT:
CRITIQUE OF ALL NASA MARS WEATHER DATA

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This Report is dedicated to the memory of our uncle, Eugene Roffman, the first great scientist in our family. When he was 92 years old, on the last day that we saw him alive, he gave us the key to the door hiding one of the great mysteries of the universe. He then asked us to unlock it and reveal to the world what would be found. This father and son work is the fruit of our twelve-year journey to fulfill his request. May it forever distract humanity from the petty squabbles that threaten to destroy our species.

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BASIC REPORT FOR MARS CORRECT: CRITIQUE OF ALL NASA MARS WEATHER DATA

ABSTRACT: We present evidence that NASA is seriously understating Martian air pressure. Our 12-year study critiques 3,025 Sols up through 8 February 2021 (8.51 terrestrial years, 4.52 Martian years) of highly problematic MSL Rover Environmental Monitoring Station (REMS) weather data, and offers an in depth audit of over 8,311 hourly Viking 1 and 2 weather reports. We discuss analysis of technical papers, NASA documents, and personal interviews of transducer designers. We troubleshoot pressures based on radio occultation/spectroscopy, and the previously accepted small pressure ranges that could be measured by Viking 1 and 2 (18 mbar), Pathfinder and Phoenix (12 mbar), and MSL (11.5 mbar – altered to 14 mbar in 2017). For MSL there were several pressures published from August 30 to September 5, 2012 that were from 737 mbar to 747 mbar – two orders of magnitude high – only to be retracted. We challenged many pressures and NASA revised them down. However **there are two pressure sensors ranges listed on a CAD for Mars Pathfinder**. We long thought the CAD listed two different sensors, but based on specifications of a new Tavis sensor for InSight that is like that on PathFinder, it appears that the transducer could toggle between two pressures ranges: 0-0.174 PSIA/12 mbar (Tavis Dash 2) and 0-15 PSIA/1,034 mbar (Tavis Dash 1). Further, an **Abstract to the American Geophysical Union for the Fall 2012 meeting,** shows the Finnish Meteorological Institute (FMI) states of their MSL (and Phoenix) Vaisala transducers, "The pressure device measurement range is 0 – 1025 hPa in temperature range of -45°C - +55°C (-45°C is warmer than MSL night temperatures), but its calibration is optimized for the Martian pressure range of 4 – 12 hPa." So in fact of the first five landers with meteorological suites, three were actually equipped to measure Earth-like pressure.

All original 19 low µV values were removed when we asked about them, although eventually 12 were restored. REMS always-sunny opacity reports were contradicted by Mars Reconnaissance Orbiter photos. We demonstrate that REMS weather data was regularly revised after they studied online critiques in working versions of this report. REMS even labelled all dust 2018 Global Dust Storm weather as sunny, although they did list the µV values then as all low. Vikings and MSL showed consistent timing of daily pressure spikes which we link to how gas pressure in a sealed container would vary with Absolute temperature, to heating by radioisotope thermoelectric generators (RTGs), and to dust clots at air access tubes and dust filters. Pathfinder, Phoenix and MSL wind measurements failed. Phoenix and MSL pressure transducer design problems included confusion about dust filter location, and lack of information about nearby heat sources due to International Traffic and Arms Regulations (ITAR). NASA Ames could not replicate dust devils at 10 mbar. Rapidly filled MER Spirit tracks required wind speeds of 80 mph at the assumed low pressures. These winds were never recorded on Mars. Nor could NASA explain drifting Barchan sand dunes. Based on the above and dust devils on Arsia Mons to altitudes of 17 km above areoid (Martian equivalent of sea level), spiral storms with 10 km eye-walls above Arsia Mons and similar storms above Olympus Mons (over 21 km high), dust storm opacity at MER Opportunity blacking out the sun, snow that descends 1 to 2 km in only 5 or 10 minutes, excessive aero braking, liquid water running at or near the surface in numerous locations at Recurring Slope Lineae (RSL) and stratus clouds 13 km above areoid, we argue for an average pressure at areoid of ~511 mbar rather than the accepted 6.1 mbar. This pressure grows to 1,050 mbar in the Hellas Basin.

1. INTRODUCTION

Mars has long fascinated humanity and often been seen as a possible safe harbor for life. In July, 1964 that hope was dealt a crushing blow by Mariner 4. Images and data obtained from no closer than 9,846 km showed a heavily cratered, cold, and dead world. Air pressures posted on a NASA site were estimated at 4.1 to 7 mbar, (http://nssdc.gsfc.nasa.gov/planetary/mars/mariner.html)[1] although A. J. Kliore (1974) of JPL listed the Mariner 4-derived pressure range as 4.5 to 9 mbar[2]. Mariner 4 saw daytime temperatures of -100° C (not seen on landers), with no magnetic field. Mariners 6, 7 and 9 got closer but still did not give us a picture that was much friendlier. Mariner estimates for pressure, based on radio occultation, spanned a range of 1 or 2.8 to 10.3 mbar.[3] All pressure estimates were close to a vacuum when compared to average pressure on Earth (1,013.25 mbar). However from a distance of 1,650 km, after a dust storm that obscured everything upon its arrival in orbit, Mariner 9 could see evidence of wind and water erosion, fog, and weather fronts.[4] When Vikings 1 and 2 landed, we learned of a high frequency of dust devils on Mars too. Phoenix witnessed snow falling.[5] The HIRISE and MER Spirit showed unexpected bedform (sand dune and ripple) movement.[6]

All landers agreed that pressure at their respective locations was somewhere between 6.5 and **12.94 mbar (MSL Sol 1784 at solar longitude [Ls] 46) on August 13, 2017**, pressures over 9.25 mbar were consistently revised down. See Table 1. The low pressures make it very hard to explain the weather plainly seen. This is particularly true of dust devils and blowing sand. NASA/JPL credibility suffered a major blow when, after 9 months of publishing constant winds of 2 m/s from the east, one of their partners, Ashima research, met our demands to change all wind reports to Not Available (N/A) and to alter all daily published sunrise/sunset times from 6 am and 5 pm between August 2012 and May 2013 (except for October 2, 2012) to match our calculated times at http://davidaroffman.com/photo4_26.html (within one minute)[7] that reflected seasonal variations to be expected at 4.59° South on a planet with a 25.19° axial tilt. These alterations were two minor battles won in our dispute with NASA/JPL. They were accompanied by an e-mailed thank you from JPL's public relations director, Guy Webster, but they do not constitute victory for our side. That comes only when NASA also reverses course on ridiculously low pressure claims that we believe our report can refute.

There is an issue of how to best conduct this challenge to the Establishment and it is important that we clarify our concerns up front. Before Guy Webster, Ashima Research, and the MSL REMS Team also began to change their reports to match the corrections that we detailed on our web site and in this report, Webster insisted that I submit this full report (which is in fact updated approximately every month now for ten years), to Icarus. I prefer to submit and annual update to the International Mars Society while posting running updates on my web sites.

The full report is over 1,220 pages in length. As alluded to above, it is a living document that is constantly updated and expanded. However this was not the problem with formal publication at the Icarus venue he suggests. The problem is that our report goes beyond mere data analysis to delve into the nature of the specific people who have published what we feel is clearly erroneous data. We have gotten to know many of them quite well.

Table 1– Pressures revised by JPL/REMS after we highlighted them or published them in earlier versions of our Report

Date	MSL Sol	Ls	Initial Pressure Reported	Pressure for the previous sol	Final Pressure Reported after JPL Revisions
Aug 25, 2012	19	160.4	785 Pa		719 Pa– then changed to N/A
Aug 27, 2012	21	161.4	790 Pa	N/A	741 Pa
Sept 1 to Sept 5, 2012	26	164	742 to 747 **h**Pa 74200 to 74700 (Pa)	743 Pa	745, 743, 745, 747 and 747 Pa
Sep 12, 2012 (This date later changed to 9/11/2012)	36	169.5	799 Pa	749 Pa	750 Pa
Sep 16, 2012 (date later altered)	39	172.3	804 Pa	750 Pa	753 Pa – then changed to 751 Pa
Sep 16, 2012 (date later altered)	39	172.3	804 Pa	750 Pa	753 Pa – then changed to 751 Pa
Oct 3, 2012 **Series alteration starts here and goes to 10/12/2012**	57	181	779 Pa	770 Pa	769 – Pa. Note the steady progression without reversals that were seen between 10/3/2012 and 10/12/2012 in initial results. This series looks very fudged.
Oct 4, 2012	58	182	779 Pa		769 Pa
Oct 5, 2012	59	183	781 Pa		771 Pa
Oct 6, 2012	60	183	785 Pa		772 Pa
Oct 7, 2012	61	184	779 Pa		772 Pa
Oct 8, 2012	62	184	782 Pa		774 Pa
Oct 9, 2012	63	185	786 Pa		775 Pa
Oct 10, 2012	64	186	785 Pa		776 Pa
Oct 11, 2012	65	186	785 Pa		777 Pa
Oct 12, 2012	66	187	781 Pa		778 Pa
Nov 11, 2012	95	204	815.53 Pa	822.43 Pa	822 Pa
Dec 8, 2012	121	221	865.4 Pa	867.5 Pa	869

Date	MSL Sol	Ls	Initial Pressure Reported	Pressure for the previous sol	Final Pressure Reported after JPL Revisions
Feb 19, 2013	192	267	940 Pa – a high until now. Pressures were declining since 925 Pa in late January 2013.	921	N/A
Feb 22, 2013	195	269	886 Pa – quite a large drop	Last 2 reports were 940 Pa on Feb 19 and 921 Pa on Feb 18, 2012	N/A
Feb 27, 2013	200	272	937 Pa	917 Pa	N/A
May 2, 2013	262	311	900 Pa	868.05 Pa	N/A
Aug 21, 2013	370	9	**1,149 Pa**	865 Pa	865 Pa
Aug 27, 2014	731	185	754 Pa	771 Pa	771 Pa
Oct 11, 2014	775	211	823 Pa	838 Pa	838 Pa
April 16, 2015	957	326	823 Pa	N/A – next sol 848 Pa	N/A
Nov 10, 2015	1160	66	**1177 Pa**	898 Pa	899 Pa
Nov 12, 2015	1161	66	**1200 Pa**	899 Pa (revised)	898 Pa
April 2, 2016	1300	131	945 Pa	753 Pa	752 Pa
April 3, 2016	1301	131	**1154 Pa**	753 Pa (2 sols earlier, 751 Pa on Sol 1302	752 Pa
Oct 17, 2016	1492	242	921 Pa	906 Pa	910 Pa
Oct 23, 2016	1498	242	897 Pa	909 Pa	907 Pa
Oct 27, 2016	1502	249	928 Pa	903 Pa	907 Pa
Jan 10, 2017	1575	296	860 Pa	868 Pa	871 Pa
Feb 10, 2017	1606	314	815 Pa	850 Pa	846 Pa
Feb 15, 2017	1610	317	864 Pa	847 Pa	N/A
Aug 13, 2017	1784	46	**1294 Pa**	879 Pa	883 Pa
Mar 24, 2018	2001	148	913 Pa	717 Pa	716 Pa
Mar 25, 2018	2002	148	**1167 Pa**	913 revised to 716	715 Pa
Nov 7, 2018	2223	283	850 Pa	865 Pa	863 Pa
Nov 12, 2018	2228	286	884 Pa	863 Pa	860 Pa
Aug 8, 2019	2490	63	887 Pa	872 Pa	873 Pa
Nov 9, 2019	2580	104	**1153 Pa**	790 Pa	788 Pa
Dec 17, 2019	2619	121	757 Pa	747 Pa	746 Pa
Apr 28, 2020	2747	191	754 Pa	759 Pa	761 Pa

Table 1 shows some (not all) of how JPL/REMS altered off the curve data for August and September 2012 and August 2013 and on through at least April 28, 2020 after we either brought the deviations up to JPL Public Relations Director Guy Webster, or published them on our davidaroffman.com and marscorrect.com websites.

The staff of Icarus is, in large part, composed of JPL personnel, with agendas and personal reputations at stake. In the past we wrote that to submit this report to them alone is to fight our war on their turf. However, after an attempt to hand deliver a copy of the report to Ames, we received a request from the Journal of Astrobiology to review a 2019 paper entitled *Evidence of Life on Mars?* by R. Gabriel Joseph et. al. After the Journal published our own paper entitled *Meteorological Implications: Evidence of Life on Mars?* (Roffman 2019) with links to this Report, we have entered a new era. However some of our words were altered to conform to NASA policy and there is an obvious split within NASA as to how much to tell the public. An editor at the Journal told me that for information revealed about Martian life, “NASA wants to proceed with baby steps.”

Having set the stage for our continuing struggle with NASA, we fire the opening salvoes with an in depth look at the issue of Martian dust devils.

1.1 Comparison of Martian and Terrestrial Dust Devils

Dust devils on Earth and Mars are similar with respect to geographic formation regions, seasonal occurrences, electrical properties, size, shape, diurnal formation rate, lifetime and frequency of occurrence, wind speed, core temperature excursions, and dust particle size.[9] The only significant differences lie in measured absolute and relative pressure excursions in the cores of Martian and terrestrial dust devils. Clogged dust filters and pressure equalization ports on landers may have diminished accuracy of dust devil pressure change measurements (see sections 2.1 through 2.6 below).

*1.1.1 Geographic occurrences and the Greenhouse and Thermophoresis Effect_*

Thousands of dust devils per week occur in the Peruvian Andes near the Subancaya volcano (Metzger, 2001) which is 5,900 meters high.[10] Dust devils are also seen in abundance on a Martian volcano, Arsia Mons. But the base altitude of some dust devils there has been about 17,000 meters.[11] Such an altitude on Mars supposedly would have about 1.2 mbar pressure, compared to about 478 mbar at Subancaya on Earth. Reis et al. state that 28 active dust devils were reported in their study region for Arsia Mons, with 11 of them at altitudes greater than 16 km, and most inside the caldera (see Figure 1). They don’t fully understand how particles that are a few microns in size can be lifted there, and state that 1 mbar “requires wind speeds 2-3 times higher than at the Mars mean elevation for particle entanglement.”

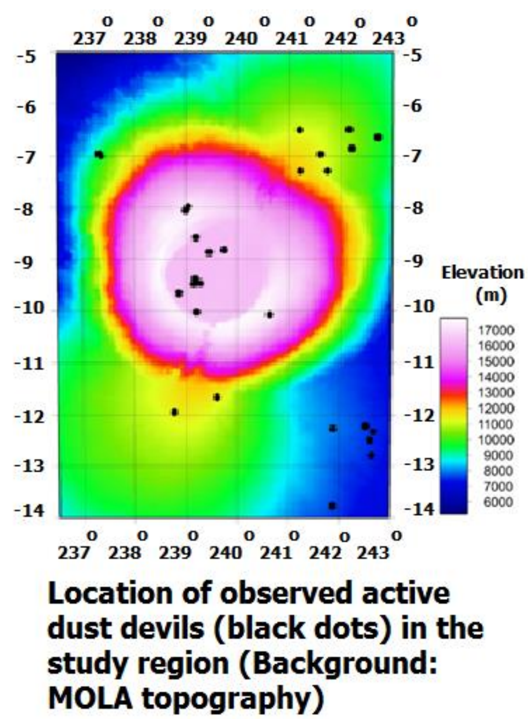


Figure 1 – Arsia Mons Dust Devils (reproduced from Reis et al., 2009)

Reis et al. (2009) suggest a greenhouse-thermophoretic (GT) effect that they believe explains ~1 mbar dust lifting at Arsia Mons.[11] Their article states that "Laboratory and microgravity experiments show that the light flux needed for lift to occur is in the same range as that of solar insolation available on Mars." They concede that high altitude dust devils do not follow the season of maximum insolation, but indicate that the GT-effect would be strongest around pressures of 1 mbar. However, if anything we would expect such dust lifted at high altitude to just drift away. The GT effect does not explain the structure of these events at high altitude, or why the dust rotates in columns that match dust devils produced at lower altitudes. Further, Figure 1 shows that dust devils form at successively lower levels (i.e., higher pressures) as altitudes decline from 17 km to about 7 km, so there is nothing unique about reaching the theorized ~1 mbar-level at the top of Arsia Mons.

1.1.2 Seasonal Occurrences and Electrical Properties.

Dust devils usually occur in the regional summer on Earth. On Mars their tracks are most often seen during regional spring and summer. [12] There are indications that there may be high voltage electric fields associated with Martian dust devils. Such fields would mirror terrestrial dust devils, where estimates are as large as 0.8 MV for one such event.[13]

1.1.3. Size and Shape

About 8% of terrestrial dust devils exceed 300 m in height. Bell (1967) reports some seen from the air that are 2,500 m high.[14] Mars orbiters have shown dust devils there often are a few kilometers high and hundreds of meters in diameter, outdoing the larger terrestrial events. Martian dust devils can be 50 times as wide and 10 times as high as terrestrial ones.[15] Still, a NASA Spirit press release (8/19/2,004) stated, "Martian and terrestrial dust devils are similar in morphology and can be extremely common."

1.1.4. Diurnal Formation Times

About 80 convective vortices were recorded by Pathfinder. Most occurred between 1200 and 1300 Local True Solar Time.[16] On Earth noon is about the peak time.

1.1.5 Wind Speeds

Stanzel et al. assert that dust devil velocities were directly measured by Mars Express Orbiter between January 2004 and July 2006.[17] They had a range of speeds from 1 m/s (2.2 mph) to 59 m/s (132 mph). Even on the high end, we do not see the 70 m/s required to lift dust by a NASA Ames apparatus discussed below in section 1.2.

1.1.6 Core Temperature Excursions.

Balme and Greeley[18] state, "Positive temperature excursions in vortices measured by Viking and MPF landers had maximum values of 5-6 K. These values are similar to terrestrial measurements." However they note low sampling rates on Mars, "measurements with an order of magnitude higher sampling rate show temperature excursions as great as 20ºC." Ellehoj et al.[19] indicate that core excursions for Martian dust devils can be up to 10 K (ºC).

1.1.7 Dust Particle Size – The Problem of Martian Dust <2 Microns and Wind Speeds

Balme and Greeley[18] also state, *"The Martian atmosphere is thinner than Earth's… so much higher wind speeds are required to pick up sand or dust on Mars. Wind tunnel studies have shown* *that, like Earth, particles with diameter 80-100 µm (fine sand) are the easiest to move, having the lowest static threshold friction velocity, and that larger* ***and*** *smaller particles require stronger winds to entrain them into the flow. However, much of Mars' atmospheric dust load is very small, and the boundary layer wind speeds required to entrain such fine material are in excess of those measured at the surface (Magalhaes et al., 1999).[20] Nevertheless, fine dust is somehow being injected into the atmosphere to support… haze and … local… and global… dust storms."*

The problem of dust particle size is more serious than indicated above. Optimum particle size for direct lifting by the wind (with the lowest threshold velocity) is around 90 µm. This requires a wind at 5 meters altitude to be around 30-40 m/s. For smaller particles like the 1 µm size dust typically suspended in the air over Mars, the threshold velocity is extremely high, requiring enormous wind speeds (>500 m/s) at 5 m altitude which would never occur. It is thus argued that saltation must be crucial to the lifting of very small particles into the air (Read and Lewis, 2004, 190).[9]

Saltation occurs when large particles are briefly lifted into air by surface winds, and then soon fall out by sedimentation.[21] On impact with the surface, they may dislodge smaller particles and lift them into the air. Read and Lewis indicate that the velocity that fine sand (~ 100 µm) would have on impact is only about 50 to 80 cm per second (1.8 to 2.88 kph).[9]

1.1.8. Core Pressure Excursions

Roy E. Wyatt (1954) of the Weather Bureau Regional Office in Salt Lake City, Utah reported that a small ~15 m high, 15 to 18 m wide dust devil had its center pass within 2.4 to 3 m of a microbarograph on August 12, 1953 in St. George, Utah (Figure 2) at an altitude of ~899 m above sea level.[22] A drop from 913.644 to 912.289 mbar was recorded. This 1.355 mbar drop in pressure equals 0.148%.

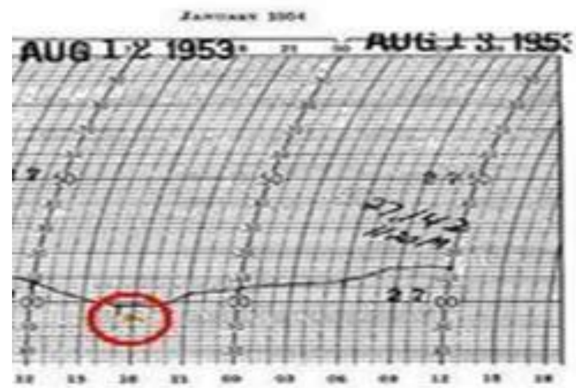


Figure 2 – Dust devil pressure drop in Salt Lake City, Utah where a small, ~50-foot high, ~60 foot wide dust devil had its center pass 8-10 feet from a microbarograph on August 12, 1953 in St. George, Utah.

Balme and Greeley (2006) report that Pathfinder "identified 79 possible convective vortices from pressure data."[12] Recorded pressure drops were from ~0.075% to ~0.75%. Figure 3 shows dust devil events for Pathfinder and Phoenix. If we examine the pressure drop seen by Phoenix from 8.425 to 8.422 mbar, that 0.003 mbar pressure drop is only about 0.036%. The Pathfinder event shows a drop in pressure from about 6.735 to 6.705 mbar (0.03 mbar). That is about a 0.445% drop. While the percent pressure drop is larger on the Pathfinder event than the Utah event, it was smaller for the Phoenix event. So absolute *and* percent pressure drops on Mars are producing almost the exact same storms, indeed often bigger storms, than we see on Earth. It might be argued that pressure is smaller on Mars; but so too is kinetic energy. Clearly, as we approach a vacuum, *if we are going to see* ***weather events*** based on pressure differences, there should be at least the same size percent pressure drops to drive them, not smaller ones. However, most telling is that while the percent drops on Martian dust devils appear to overlap their terrestrial cousins; for hundreds of days Viking 1 and 2 almost always saw much larger pressure increases each sol about 7:30 AM local time with increases up to 0.62 mbar from the previous hour at that time.

As will be discussed later in this report, after Mars Science Laboratory data was scrubbed by JPL, there was not during one full Martian year of weather data (669 Martian sols) even one sol where the average pressure from one sol's average pressure differed from the next by more than 0.09 mbar (MSL Sol 543 saw this drop from MSL Sol 542), although before they scrubbed the data there was an increase of pressure from MSL Sol 369 to MSL Sol 370 of 2.84 mbar (from 8.65 mbar to 11.49 mbar), and a drop on MSL 371 of the same 2.84 mbar back to 8.65 mbar. This report discusses MSL 370 in more detail later, but note that after we raised the issue of this pressure to Guy Webster at JPL, JPL altered the pressure reported for Sol 370 to 8.65 mbar, thus indicating no pressure change at all from MSL Sol 369 through Sol 371.

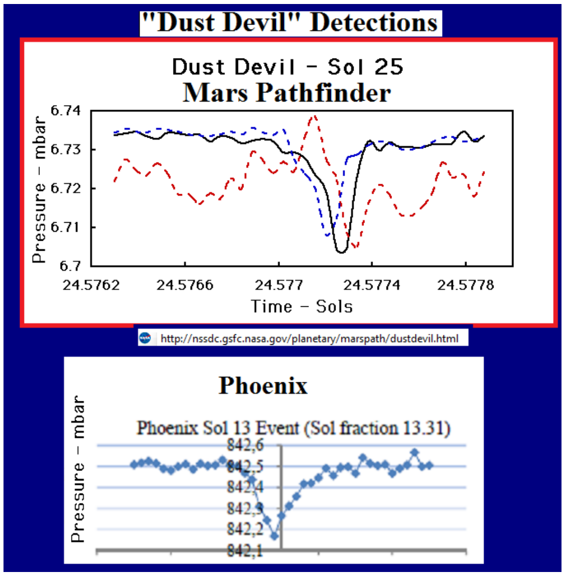


Figure 3 – Pressure drops at Phoenix and Pathfinder during dust devils (adapted from Elohoj et al. 2009 & http://nssdc.gsfc.nasa.gov.planetary/marspath/dustdevil.html).

Figure 4 offers evidence that internal events on the Vikings were having a much greater impact on pressure readings than dramatic events like dust devils. Pressure increases at the 0.26 to 0.3 time-bins were comparable to pressure drops associated with global dust storms. An increase of 0.62 mbar in about 59 minutes that makes up one time-bin equates to a pressure rise 13 times greater than the largest (0.477 mbar) pressure fall shown for all 79 Pathfinder dust devil events, and about 21 times greater than the largest (.0289 mbar) pressure drop seen for a Phoenix dust devil.

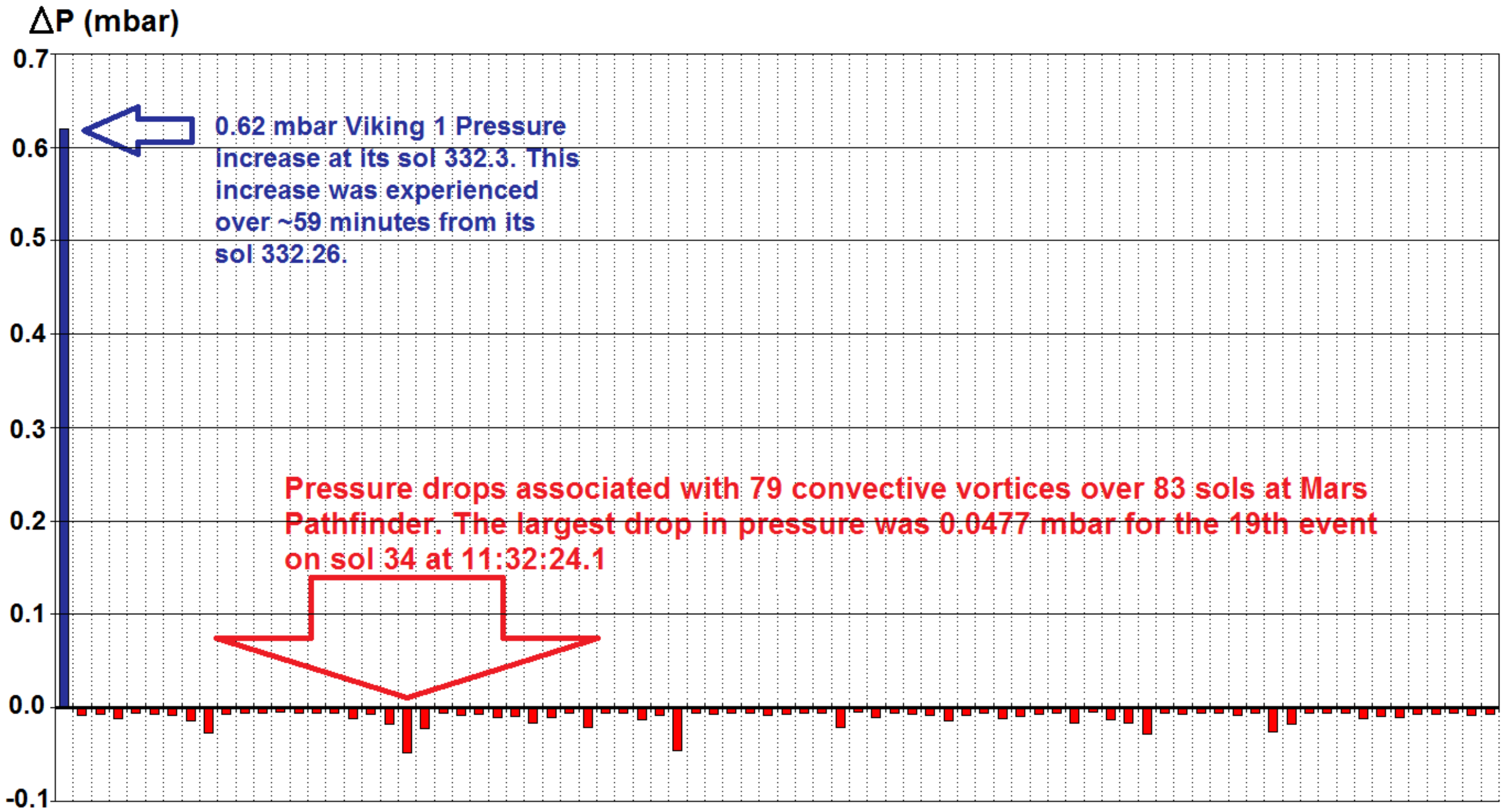


Figure 4 – Relative magnitude of 0.62 mbar increase in pressure for Viking 1 at its sol 332.3 and pressure drops for 79 convective vortices/dust devils at Mars pathfinder over its 83 sols. Source: Murphy, J. and Nelli, S., Mars Pathfinder Convective Vortices: Frequency of Occurrence (2002) http://tide.gsfc.nasa.gov/studies/Chen/proposals/IES/2002GL015214.pdf

2. NASA Ames Test of Martian Pressures and Dust Devils

An effort was made at the Ames facility to simulate Martian dust devils at a pressure of 10 mbar. A NASA (2005 article) states that, "The high-pressure air draws thin air through the tunnel like a vacuum cleaner sucks air.[23] Scientists also compare this process to a person sucking water through a straw. The resulting simulated Mars wind moves at about 230 feet per second (70 m/s)." Actual recorded dust devil wind speeds seen on Mars by Pathfinder and Phoenix were about 6 m/s.[24] Seventy m/s is 252 kilometers per hour, nearly the strength of a category 5 hurricane. NASA Ames was unable to replicate a dust devil with a fan spinning at the 10 mbar pressure level. They state that "the simulated (10 mbar) Martian atmosphere in the wind tunnel is so tenuous that a fan would have to spin at too high a speed to blow thin wind through the test section." As such, it becomes harder to accept that dust devils can occur in such low pressures. The problem becomes more severe when we see Martian dust devils operating at even lower speeds, or on Arsia Mons where pressure is ~1 mbar (see Table 2).

Findings (Bridges, et al., 2012)[25] based on HiRISE and MER Spirit photos of Martian bedforms (moving dunes and sand ripples) are also at odds with surface meteorological measurements and climate models which indicate that 129 kph winds (termed threshold winds) capable of moving sand are infrequent in the ~6 mbar atmosphere (Arvidson et al., 1983[26]; Almeida et al., 2008[27]). In fact, the required winds were never seen in 8,311 hourly pressures checked for Vikings 1 and 2. This will be discussed in greater detail later in Section 7.2.

	A	B	C	D	E	F	G	H	I
1	MARS SITE	ENTERING ARGUMENTS SCALE HEIGHT 10.8 KM AND AVERAGE MARTIAN PRESSURE 6.1 MBAR							
2		KILOMETERS	10.8km Scale	RATIO B/C	=-EXP(D VALUE)	1/E value	-F VALUE = PRESSURE	PERCENT OF	PRESSURE IN
3			Height (MARS)				MULTIPLE OF	PRESSURE AT	MILLIBARS
4							6.1 MBAR MEAN	MEAN AREOID	
5	MEAN AREOID	0	10.8	0	-1	-1	1	100	6.1
6	MOUNTAINS:								
7	OLYMPUS MONS	21.2874	10.8	1.97105556	-7.178249532	-0.139309729	0.139309729	13.93097294	0.849789349
8	ASCRAEUS MONS	18.219	10.8	1.68694444	-5.402946454	-0.185084196	0.185084196	18.50841959	1.129013595
9	ARSIA MONS	17.7807	10.8	1.64636111	-5.188066639	-0.19275003	0.19275003	19.275003	1.175775183
10	PAVONIS MONS	14.0574	10.8	1.30161111	-3.675213077	-0.272093068	0.272093068	27.20930675	1.659767712
11	ELYSIUM MONS	14.1226	10.8	1.30764815	-3.697467582	-0.27045538	0.27045538	27.045538	1.649777818
12	HECATES THOLUS	4.85326	10.8	0.44937593	-1.567333748	-0.638026203	0.638026203	63.8026203	3.891959838
13	VALLEYS:								
14	VALLES MARINERIS	-5.67947	10.8	-0.52587685	-0.591036885	-1.69194178	1.69194178	169.194178	10.32084486
15	LYOT (DEEPEST IN N. HEM)	-7.036	10.8	-0.65148148	-0.521272948	-1.91838077	1.91838077	191.838077	11.7021227
16	HELLAS BASIN	-8.18	10.8	-0.75740741	-0.468880469	-2.132739721	2.132739721	213.2739721	13.0097123
17	LANDERS:								
18	VIKING 1	-3.627	10.8	-0.33583333	-0.71474222	-1.399105821	1.399105821	139.9105821	8.534545509
19	VIKING 2	-4.505	10.8	-0.41712963	-0.658935497	-1.517599226	1.517599226	151.7599226	9.257355279
20	PATHFINDER	-3.682	10.8	-0.34092593	-0.711111581	-1.40624907	1.40624907	140.624907	8.578119329
21	PHOENIX	-4.126	10.8	-0.38203704	-0.682469776	-1.465266353	1.465266353	146.5266353	8.938124755
22	MSL at GALE CRATOR	-4.4	10.8	-0.4074074	-0.665373057	-1.5029163	1.50291628	150.291628	9.167789309

SOURCE FOR ALL HEIGHTS EXCEPT PHOENIX & MSL:
DAVID E. SMITH ET AL. (2001), MARS ORBITER LASER ALTIMETER: EXPERIMENT SUMMARY AFTER FIRST YEAR OF GLOBAL MAPPNG OF MARS

TABLE 2 – Pressure at various elevations on Mars based on a scale height of 10.8 and a pressure at Mars Areoid of 6.1 mbar. Atmospheric pressure decreases exponentially with altitude. In determining pressure for Earth, the formula for scale height is $p = p_0 e^{-(h/h0)}$ where p = atmospheric pressure (measured in bars on Earth), h = height (altitude), P_0 = pressure at height $h = 0$ (surface pressure), and H_0 = scale height.

2. OVERVIEW OF INSTRUMENTATION PROBLEMS.

Differences between terrestrial and Martian dust devil pressure excursion measurements hinge largely on the accuracy of the 354-gram Tavis magnetic reluctance diaphragm used for Vikings in 1976, and Pathfinder in 1996; and a 26-gram Vaisala Barocap ® sensor developed in 2008 by the Finnish Meteorological Institute (FMI) for the Phoenix and MSL Curiosity. Did any probes sent to Mars ever have the ability to measure pressures near those associated with terrestrial dust devils? The initial answer appeared to be "no." However, as will be discussed later in conjunction with Figure 10B, Tavis CAD 10484 indicates that Pathfinder had a second pressure range of 0 to 15 PSIA. This means it could measure up to 1,034 mbar. There is a real need for clarification here.

Tavis sensor pressure ranges for Viking had limits of about 18 mbar. There was a question of whether or not the limit was closer to 25 mbar due to Tavis CAD no. 10014 (see Figure 10A) that indicates a limit of 24.82 mbar (0.36 PSIA). However, Professor James E. Tillman, director of the Viking Computer Facility, in a personal communication dated 27 May 2010, insisted that the limit was 18 mbar. This figure is understood to be what NASA espouses now. The 18 mbar Viking figure is backed by NASA report TM X-74020 by Michael Mitchell dated March 1977.[29] It states:

> *Two variable reluctance type pressure sensors with a full range of 1.79 x 10^3 N/M^2 (18 mb) were evaluated to determine their performance characteristics related to Viking Mission environment levels. Twelve static calibrations were performed throughout the evaluation over the full range of the sensors using two point contact manometer standards. From the beginning of the evaluation to the end of the evaluation, the zero shift in the two sensors was within 0.5 percent and the sensitivity shift was 0.05 percent. The maximum thermal zero coefficient exhibited by the sensors was 0.032% over the temperature range of -28.89°C to 71.11°C.*

It gets a lot colder than *-28.89°C* on Mars, but Professor Tillman insisted that "The pressure sensors were located inside the lander body and heated by RTG (*radioisotope thermoelectric generator*) units. They were not exposed to ambient Martian temperatures." This report will question whether rapid ingestion of dust during the landing process also prevented transducers from ever correctly measuring ambient Martian pressures.

Figure 5A is the very first picture ever transmitted from the surface of Mars to Earth. It was taken between 25 seconds and 4 minutes after the landing and it makes clear that dust was an immediate issue when the landing occurred. Figure 5A also shows that rocks were also kicked up and landed on at least one footpad.

Figure 5B shows that again with the MSL landing rocks kicked up on landing fell on the lander deck. As is shown later in this paper on Figure 50E, dust covered a camera lens cover on the MSL too. So it's a safe bet that dust could have quickly made its way into the MSL's Vaisala pressure transducer's dust filter.

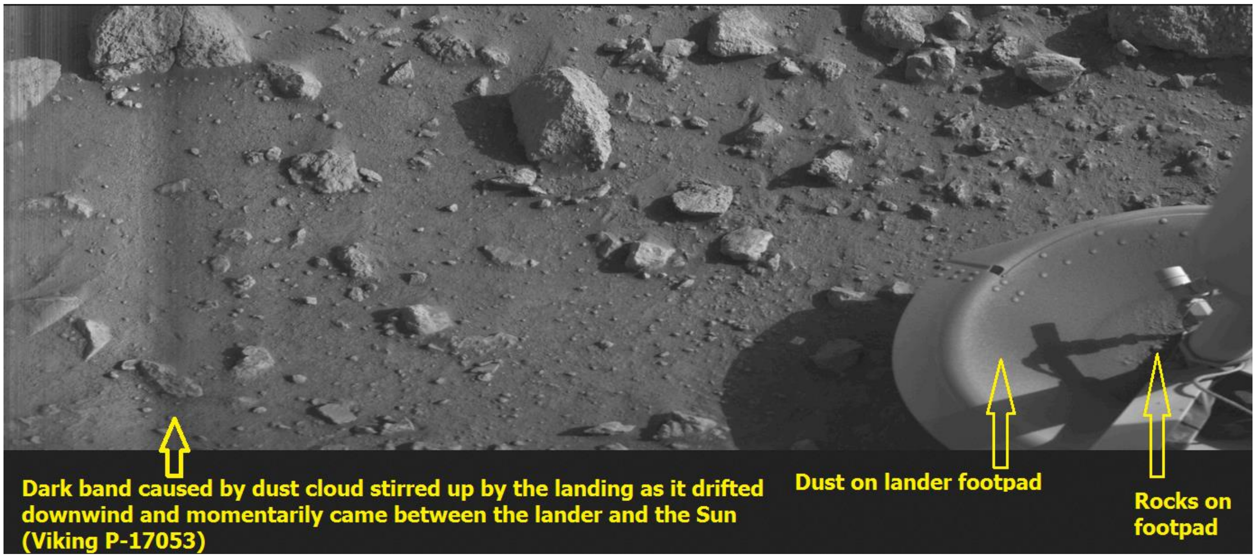


Figure 5A: Viking 1 footpad with dust, sand and rocks on it right after landing. Effects of dust cloud stirred up are to the left. For a better view, see the NASA image at http://upload.wikimedia.org/wikipedia/commons/a/ae/Mars_Viking_12a001.png

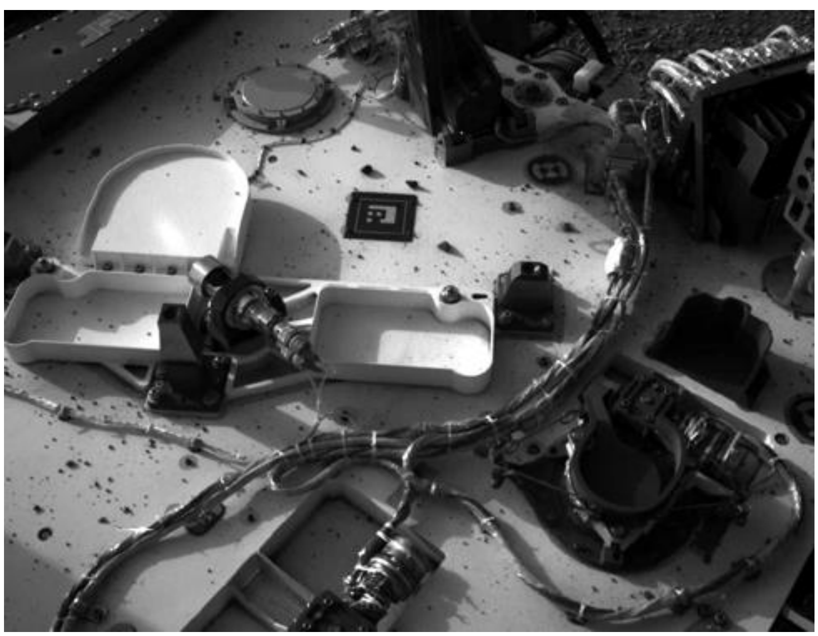


Figure 5B: During the landing, many rocks were again kicked up and landed on the deck of the MSL Curiosity. The issue, however, is whether any dust was ingested by the pressure transducer. Source: http://astroengine.com/2012/08/08/sol-2-rocky-debris-on-curiositys-deck-hints-of-thunderous-landing/

2.1 Vikings, MSL, and Gay-Lussac's Law.

RTGs may be at the root of problems with Viking and MSL pressure readings which appear to vary inversely with outside temperatures. That is, when it gets colder outside and RTGs need to warm the inside of the landers, the pressure recorded inside goes up. Temperature and pressure variations seen for Viking 1 Year 1 almost exactly match what would be expected in accordance with Gay-Lussac's Pressure Law (see Figures 6 through 9C). To counteract a minimum Year 1 temperature of 177.19K seen, and to raise internal temperatures to the maximum Year 1 external temperature seen (255.77 K), air caught behind a dust clog would experience a pressure rise. If Viking 1 sucked in enough dust and sand on landing to clog, but not enough to equalize the internal pressure with the air pressure outside, then whatever Year 1 minimum pressure seen inside the lander at the Tavis pressure transducer (6.51 mbar) would increase in pressure in accordance with Gay-Lussac's Law. As is shown on Figure 6, when the above two temperatures and 6.51 mbar are entered into the calculator, the expected pressure is shown to be 9.397 mbar. The actual maximum pressure recorded by Viking 1 was 9.57 mbar. That is a 98.19% agreement with the idea that the air access tube for the sensor was clogged. For Viking 2, the minimum and maximum temperatures were 152.14 K and 245.74 K. The minimum pressure found was 7.29 mbar. The maximum predicted pressure was 11.775 mbar. The maximum pressure recorded by VL-2 was 10.72 mbar, which is 91.04% of the predicted value. See Figure 6.

The data points on Figure 6 are meant to get some sense of whether the pressure limits seen were roughly in line with expectations based on heat applied to a sealed space (behind the dust clots). They were, but obviously more so in Viking 1's first year. By Year 2 overall predictions were off by 9 or 10 percent, but the calculations are less certain because of many incidents involving stuck pressure readings, sometimes for days on end. Annex C of this report supports this allegation, but Annex D also highlights stuck pressure readings for Viking 1. The old cliché "Garbage in Garbage out" sums up the problem. Temperature data seemed credible for the Vikings (except when reported as Absolute Zero). However temperatures (in particular, ground temperatures) were problematic for MSL as is detailed in Section 14.1 of this report. We assert that pressure data was not credible for any lander.

When comparing maximum air temperatures seen at MSL and Viking 1, we show in Annex M to this report that the highest air temperature seen after JPL revised it year 1 data was 4º C (274.15K). MSL sits at 4.59 º South on Mars at an altitude of 4,400 meters below areoid. Viking 1 was also in the tropics at 22 º North. However VL-1 was at an altitude of 3,627 meters below altitude. R.M. Haberle[111] at NASA Ames claims that the adiabatic lapse rate for Mars is about 2.5K km^{-1}. Using that rate we would expect the maximum temperature at VL-1 to be about 1.9325 K lower than at MSL however the maximum temperature at VL-1 was only 255.77K, while the maximum (revised) temperature for MSL Year 1 (on MSL Sol 227/March 2, 2013) was 274.15K, a full 18.38 K warmer than at VL-1. Further, before JPL revised its MSL temperatures it indicated a maximum air temperature at MSL of 8º C (281.15 K) on MSL Sol 102 (November 18, 2012) but they later altered this temperature to -3º C (270.15 K). The high for MSL Year 2 was 11º C (284.15K) on Sol 760. So, it would appear that there is room to question the accuracy and consistency of air temperature sensors on these two missions.

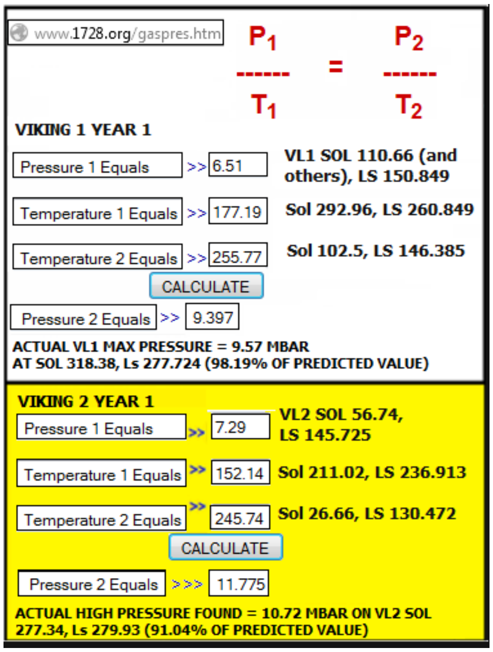


Figure 6: Pressure calculator with entering arguments based on VL- 1 and 2 Year 1 results. Prediction is 98.19% in agreement with measured results for Viking 1, 91.04 % in agreement for VL-2.

Annex D displays our attempt to predict pressure on what is basically an hourly frequency (actually once per time-bin, with each time-bin equal to about 59 minutes) for Viking 1 sols 1 to 116 and 134 to 350. While previous researchers focused on diurnal pressure cycles, Annex D focuses on the percent differences between pressures measured and pressures predicted based on heat being applied by RTGs when temperatures fell. There was a distinct pattern seen, often as clear as what one would see when looking at a healthy electrocardiogram. Pressures would vary – sometimes by up to 26% from the predicted value, and then settle back to almost 0 percent difference, always at the same time of day for long periods of time.

Annex D is voluminous, providing all temperature and pressure data available for Viking 1. Each page has the 25 time bins for one sol on the left side and for another sol on the right. Appendix 1 to Annex D has data for VL-1 sols 1 to 91 on the left; and sols 92 to 116 plus 134 to 199 on the right. Appendix 2 to Annex D has data for VL-1 sols1 to 200 to 274 on the left, then for sols 275 to 350 on the right. When the percent difference is less than 2%, the data is shown in red bold fonts.

Annex E just singles out the percent differences seen for the .3 and .34 time bins over VL-1 sols 200 to 350. This (generally around sunrise time) is one of the times when it would be reasonable to expect heat from the RTGs to access equipment (like cameras) that need to begin their daily operations. The average percent difference was 2.67%. Of the 302 pressure predictions made, 72 had a percent difference of less than 2%. See Table 3 and Figure 8 for further details.

7 MOST ACCURATE TIME-BIN PRESSURE PREDICTION TIMES			7 LEAST ACCURATE TIME-BIN PRESSURE PREDICTION TIMES		
TIME-BIN	LOCAL TIME	PREDICTIONS MORE ACCURATE THAN 2% DIFFERENCE	TIME-BIN	LOCAL TIME	PREDICTIONS MORE ACCURATE THAN 2% DIFFERENCE
.10	2:30 AM	27.6%			
			.14	3:30 AM	11.6%
			.18	4:30 AM	1.5%
			.22	5:30 AM	1.8%
.30	7:30 AM	27.7%			
			.34	8:30 AM	16.7%
.42	10:30 AM	33.6%			
.46	11:30 AM	28.6%			
			.54	1:30 PM	10.4%
			.58	2:30 PM	9.8%
.66	4:30 PM	37.5%			
.70	5:30 PM	30.6%			
			.74	6:30 PM	15.8%
.94	11:30 PM	28.6%			

Table 3: Viking 1 cyclic accuracies for pressure predictions. See Figure 8 and Annex F for further details. The data source was the Viking Project site at http://www-k12.atmos.washington.edu/k12/resources/mars_data-information/data.html.

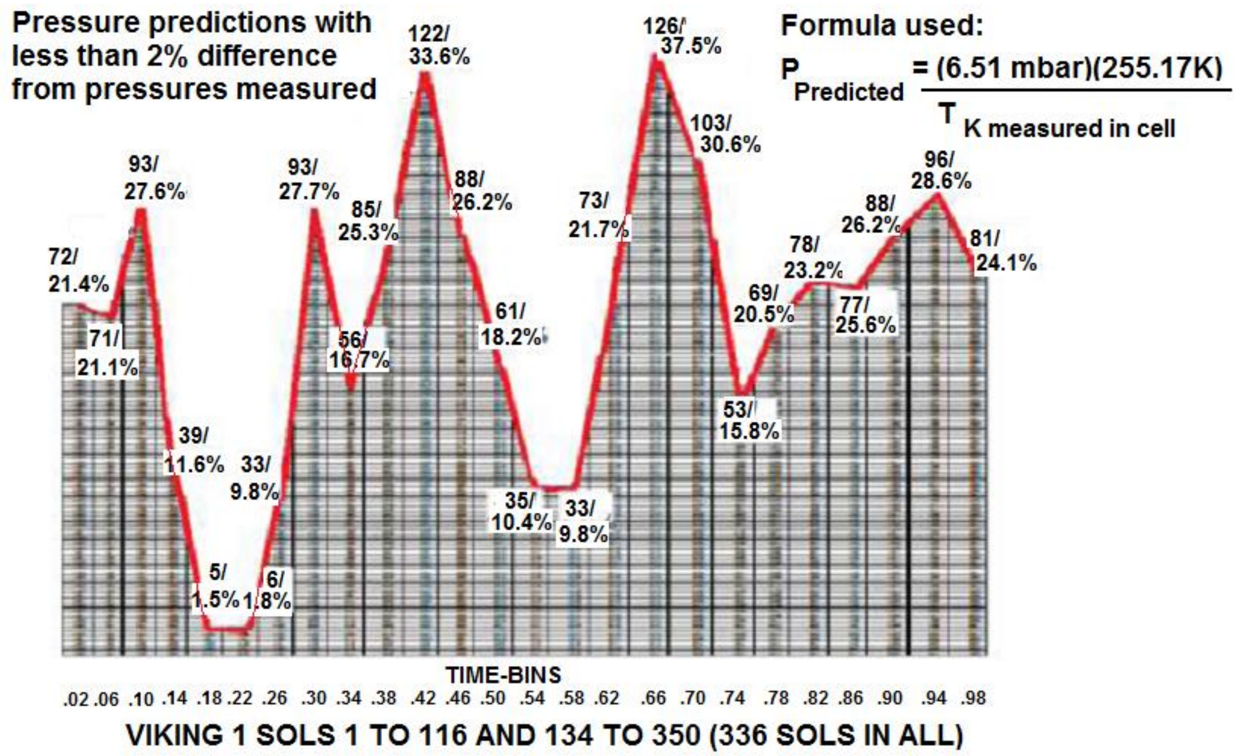


Figure 7: Viking 1 cyclic accuracies for pressure predictions. See Annex F for further details. The data source was the Viking Project site at http://www-k12.atmos.washington.edu/k12/resources/mars_data-information/data.html.

Annex F focuses just on time-bins that have a percent difference between measured and predicted pressures that is under 2%. It makes clear that gradually the time of the greatest percent difference agreement would shift by a time-bin. For example, there is a better than 2% difference agreement at the 0.3 time-bins starting at VL-1 Sol 211 continuing until VL-1 sol 288, a 78-day run. The agreement was at the next later time-bin (0.34) for sols 205 to 210 just before the long run, and the agreement switches back and forth between these two time bins until sol 299. Then the agreement moves the 0.38 time bin as Viking 1 experiences the first day of winter at its Sol 306.

There is a similar run of small percent differences in the middle of the night. For example, in the 0.1 time-bin between Sols 255 and 350, there were only nine times that the percent difference was 2% or more. Likewise, the percent difference was (except for once) always under 2% in at least one of the two time-bins labeled as 0.66 and 0.7 (early evening) between sols 200 and 240. Where pressures drift away from the 2% standard, it is believed that the RTGs were not permitted to transfer heat to the transducers and heat was slowly lost to the frigid outside. Figure 8 is a sample of Annex F (sols 228 to 250).

VL1 SOL	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3	0.34	0.38	0.42	0.46	0.5	0.54	0.58	0.62	0.66	0.7	0.74	0.78	0.82	0.86	0.9	0.94	0.98	Vl1 SOL
228	198							194									215			204						228
229								196	199									215	210	204			200	199	202	229
230								192	197									209	204	201	198	196	198	199	198	230
231	196							192	196									210	206	202	200					231
232								193	199									209		203	200			197	199	232
233								193	199									211		203	200	198	198	200	198	233
234	197							193	199									211		304	201	200				234
235								195	201									211	205	203	201	198	196	197	198	235
236	195							191	197									213	207	203	200	197	197	195	198	236
237	198	197						192										212	207	204	201	198	198	200		237
238	195	193					193	192	192										206	203	200	197	197	196	194	238
239	195	196						192										213	205	203	200	197	195	196	196	239
240	197	193						190										209	205	202	198	195	194	194	193	240
241	195	195						189												203	200	197	195	195	197	241
242	196	194						191											206			197	196			242
243	194	191						190											206			197	195	197		243
244	197	197						191											206	203	200	197	197	196	195	244
245	196	196	195					192													199	197	194	192	191	245
246	190	189					186	189														195	193			246
247		193	189				187	189													198	196	194	192	190	247
248	192	194	192					189										208			199	196	195	194	192	248
249	193	194	191					189															193	192	191	249
250	190	189	187				185	187													197	194			194	250

BLOCKS IN RED ARE WITHIN 2% OF PREDICTIONS BASED ON GAY-LUSSAC/AMONTON'S GAS LAWS.

FORMULA USED IS $P = \frac{6.51 \text{ mbar} \cdot 255.17K}{T_K}$ Measured in cell

28K Temperature range for accurate pressure predictions this page (185 to 213K)

Figure 8 – Sample of Annex F showing the times of day (for sols 228 through 250) when pressure predictions had less than a 2% difference from measured pressures at Viking 1. **The formula used assumes that the pressure transducer is no longer in contact with the ambient atmosphere on Mars.**

Most striking is what happens in a close examination of graphs that sum up Viking-2 sol averaged temperatures and pressures. Figure 9A and 9C show that as temperatures fell, often pressures rose. To counter falling temperatures, RTG heat is allowed to access the lander interior to maintain temperature stability there. As this occurs, air trapped behind any dust clot would experience a pressure increase. When the Figure 9C graph is inverted and displayed as Figure 9B, the temperature and pressure graphs are nearly an exact match. The biggest discrepancy is after a hiatus with no data between Viking 2 sols 560 to 633 (Ls 68 to 100 in Martian spring to summer). VL-2 pressure readings were often stuck for 10 hours to six days (see Annex C for VL-2 sols 639-799). When pressures were stuck, temperatures were not.

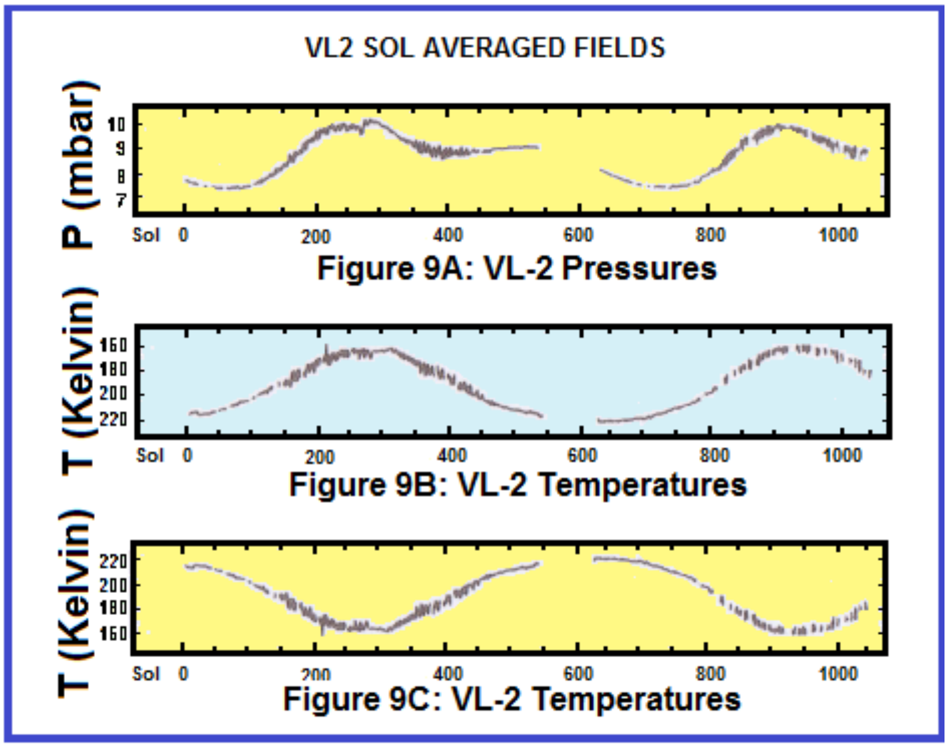


Figure 9A to 9C: Graphs shown as Figure 9A and 9C are redrawn from Tillman and Johnson. Figure 9B inverts the direction of temperatures on the Y axis to show how heating by RTGs to counter increasing cold outside produces a curve very similar to the pressure curve.

2.2 Mars Pathfinder (MPF) and Phoenix Pressure Issues.

The MPF Tavis sensor had a limit of 0.174 PSIA (see Figure 10B). But, "The pressure sensor obtains data in two ranges simultaneously; 0 – 12 mbar for descent and **only 6 – 10 mbar for surface observation**" (http://atmos.nmsu.edu/PDS/data/mpam_0001/document/asmtinst.htm).

The above link indicates that the tube entry port lies in the plane of the aperture between the lander instrument shelf and 2 petals. [30] It is oriented perpendicular to the anticipated airflow during descent. As no objects were allowed to extend beyond the lander profile during descent the **entry port location is not ideal** As was shown on Table 2 earlier, based on an average pressure of 6.1 mbar at Mars areoid, the average pressure to be expected for Pathfinder at an elevation of 3.682 km below areoid would be about 8.58 mbar. If we accept the variations in pressure shown on Figure 9A and later on Figure 18, and then allow for pressure increases due to dust storms, a limit of 10 mbar for the sensor seems ill-advised.

The range of sensitivity and accuracy of the Vaisala Barocap® and Tavis sensors are crucial. With Mars Phoenix, three Barocap sensors [LL(B1), and RSP1 (B2, B3)] were used. They had problems associated with a nearby heat source. Problems were particularly noted when temperatures rose above 0ºC. According to Taylor et al. (2009) calibration coefficients were also withheld from the Finnish Meteorological Institute (FMI) due to International Traffic in Arms Regulations (ITAR). The 5-12 mbar range of Barocaps was probably due to the data from the Tavis sensors before, but Tavis sensors were limited due to radio occultation pressure experiments (not as accurate as in situ measurements) by the Mariners. Radio occultation results are discussed further in Section 5.

An issue with respect to how fast the dust filters for transducers on landers could have clogged relates to when the air tube was initially exposed to ambient conditions. If open to space all the way down, then air might not rush in so fast; while if the tube were suddenly opened on the surface, more dust might be expected to rush in, even at supersonic speeds. Alvin Seiff, et al. (1997) indicates that for Pathfinder the plan was for atmospheric pressure (and temperature) to be measured during parachute descent from ~8 km to the surface[31] The air inlet was connected to the flared tube fitting shown in Figure 10B by one meter of 2 mm inside diameter tubing. Dr. Robert Sulliavan (Cornell University) told us (on July 27, 2011) that while 1μ particles on the surface of Mars clump together quickly, larger particles that were easier to move would be lifted on landing. He was not sure about whether they would clog a dust filter as fast. But if MPF suddenly ingested 1μ particles suspended in the air below 8 km right after parachute deployment, the hot air associated with the entry-related heat might cause a problem for the tiny filter.

Mars Pathfinder pressures are discussed in greater detail in section 11.

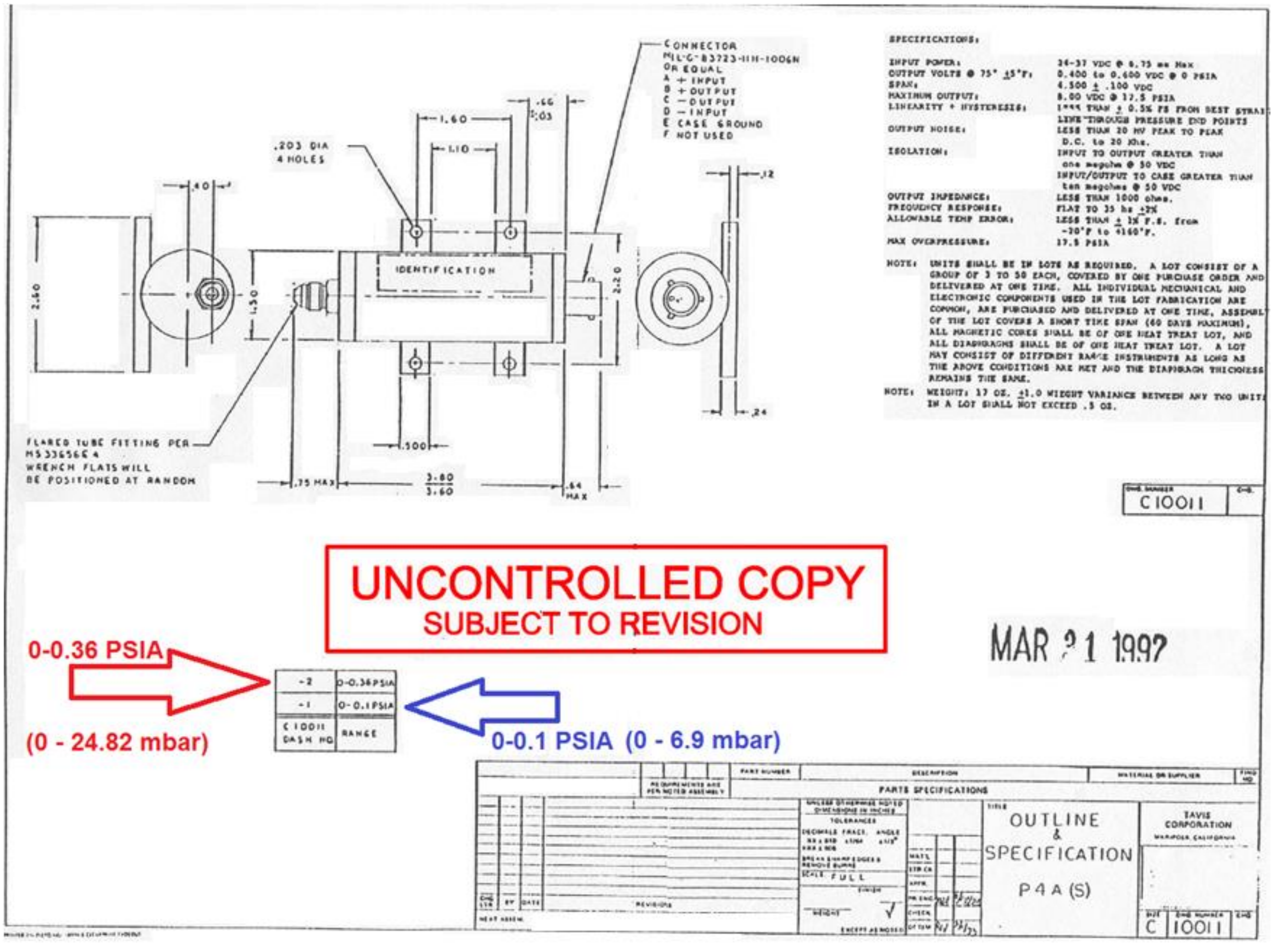


Figure 10A – Reproduced from Tavis CAD Diagram 10011. For Vikings Tavis Dash No -2 had a 0.36 PSIA limit (24.82 mbar). However, Tavis Dash No -1 had a 0.1 PSIA limit (6.9 mbar). Source: Personal communication, Tavis Corporation 10/29/2009

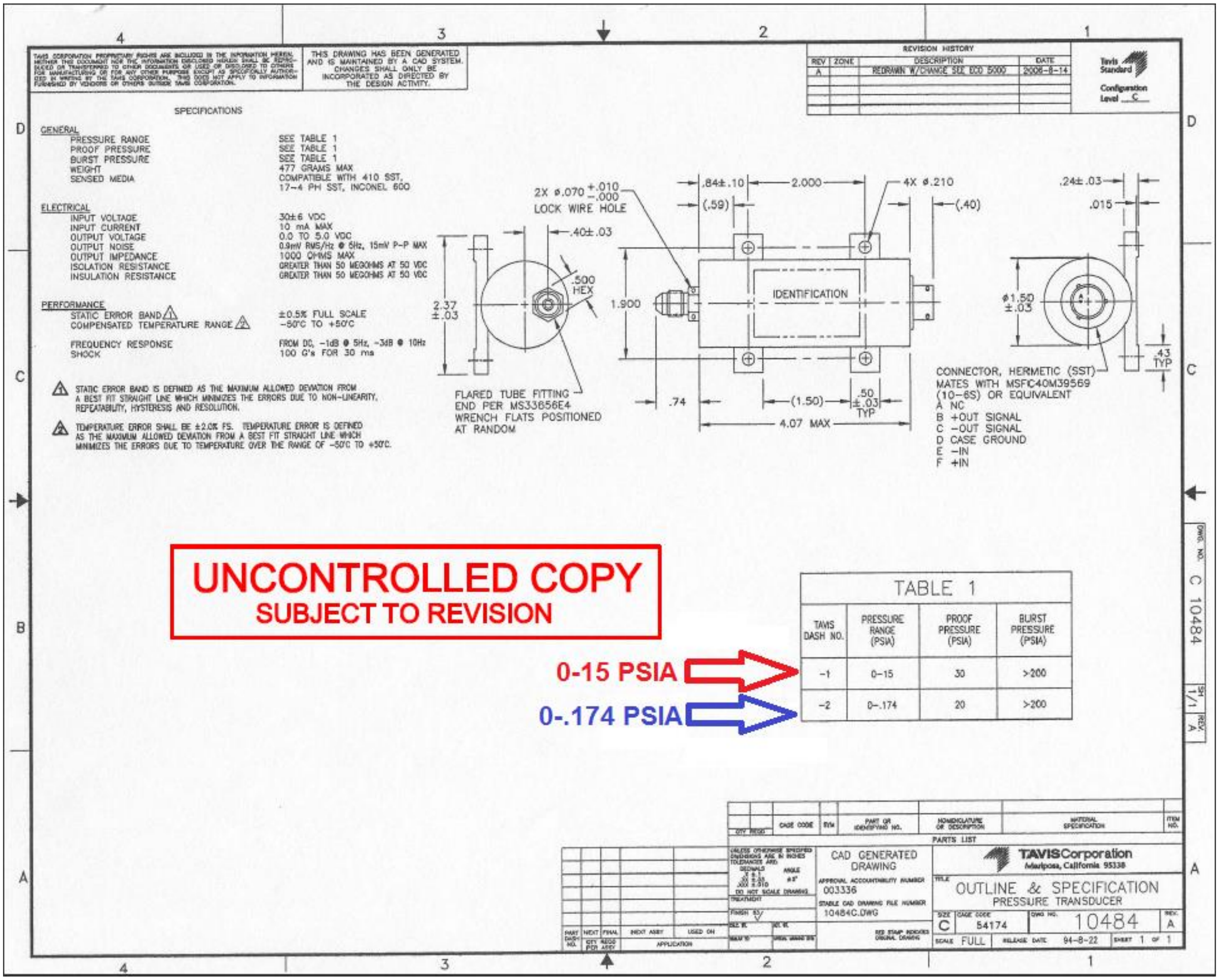


Figure 10B – Reproduced from Tavis CAD Diagram 10484. For Mars **Pathfinder Tavis Dash No -2** had a 0.174 PSIA limit (**12 mbar**), **but Pathfinder Tavis Dash No -1 had a 15 PSIA limit (1,034 mbar – best suited for Earth-like pressures)**. Source: Personal communication, Tavis Corporation 10/29.2009

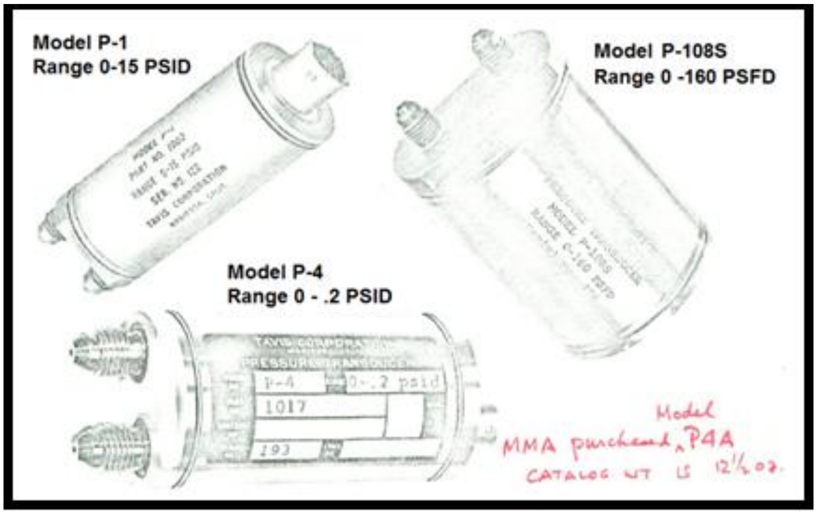


Figure 10C – Three different Tavis transducers.
Source: Tavis specifications obtained from NASA Ames.

2.3 Which Transducers were used?

A Tavis spokesman (Marty Kudella) thought Pathfinder used Part 10484 (Tavis Dash No. 2). The red words **uncontrolled copy subject to revision** on both CADS shown allow for a possible need in the future to alter transducer pressure range.

Figure 10B lists it as having a 0.174 psia limit (12 mbar), the same limit later imposed by Vaisala on Phoenix. It first appeared that NASA also ordered a Tavis transducer that could measure from 0 to 15 psia (1,034 mbar): Part 10484, Tavis Dash No. 1 – see Figure 10B again. For 9 years we believed that it supposedly remained on Earth and wrote that if for classified reasons, a decision was made to send it in place of the 12 mbar transducer, none of the pressure data published by NASA for Pathfinder would be reliable. If there was a separate transducer that could measure Earth-like pressure its final disposition still isn't clear at this time, but based on information from the InSight Mission that landed on Mars on November 26, 2018 it seems possible that the same Tavis transducer could operate in either the low or high pressure range. Our Italian partner, Marco de Marco, called Tavis Corp. for clarification. They knew who he is, but wouldn't answer his questions. We will look at the evidence for one physical transducer rather than two in conjunction with Figure 10D below, but first let's discuss Tavis transducers in general.

Apparently similar looking and sized Tavis transducers could measure up to 0.1 psia (6.9 mbar), 0.174 psia limit (12 mbar), 0.2 psia (13.79 mbar), 0.26 psia (17.9 mbar), 0.36 psia (24.82 mbar), or 15 psia (1,034 mbar). Given their outward similarity and the enigma of Martian weather, the possible installation of the wrong Tavis sensor cannot be overlooked. Perhaps somebody wanted a 15 mbar sensor, and mistakenly chose the 15 psia transducer. People made mistakes back then, and they still do today as will be abundantly apparent later when we examine REMS (Rover Environmental Monitoring Station) data for MSL. For five days straight from September 1 to September 5, 2012 they published Martian pressures of over 740 hPa (Earth-like), when they supposedly meant 740 Pa. A pressure of 740 hPA = 740 mbar, while 740 Pa = 7.4 mbar. They published numerous other similar questionable items or obvious errors (see Section 2.7 and Figures 17A and 17B).

As for the Pathfinder, three different Tavis transducers are shown on Figure 10C. See Annex G for further information about various Tavis transducers, but now let's look at what we learned one night before InSight reached Mars. Until that time we were only told about the geological missions of the probe. Then, at a press conference, we learned that there are also meteorological sensors aboard, including the same Tavis sensor. Figure 10D clarifies a lot. With respect to the dual pressure range, Tavis states "Tavis specializes in custom configurations and capabilities for your specific application. Discuss your application requirements with our engineers for your exploration science needs" (http://pressure-transducers.taviscorp.com/item/all-categories/ressure-transducers-for-interplanetary-exploration/10484). Could a radio signal cause the sensor to toggle from the low range to the high? Again, Tavis wouldn't tell us, but it's quite possible.

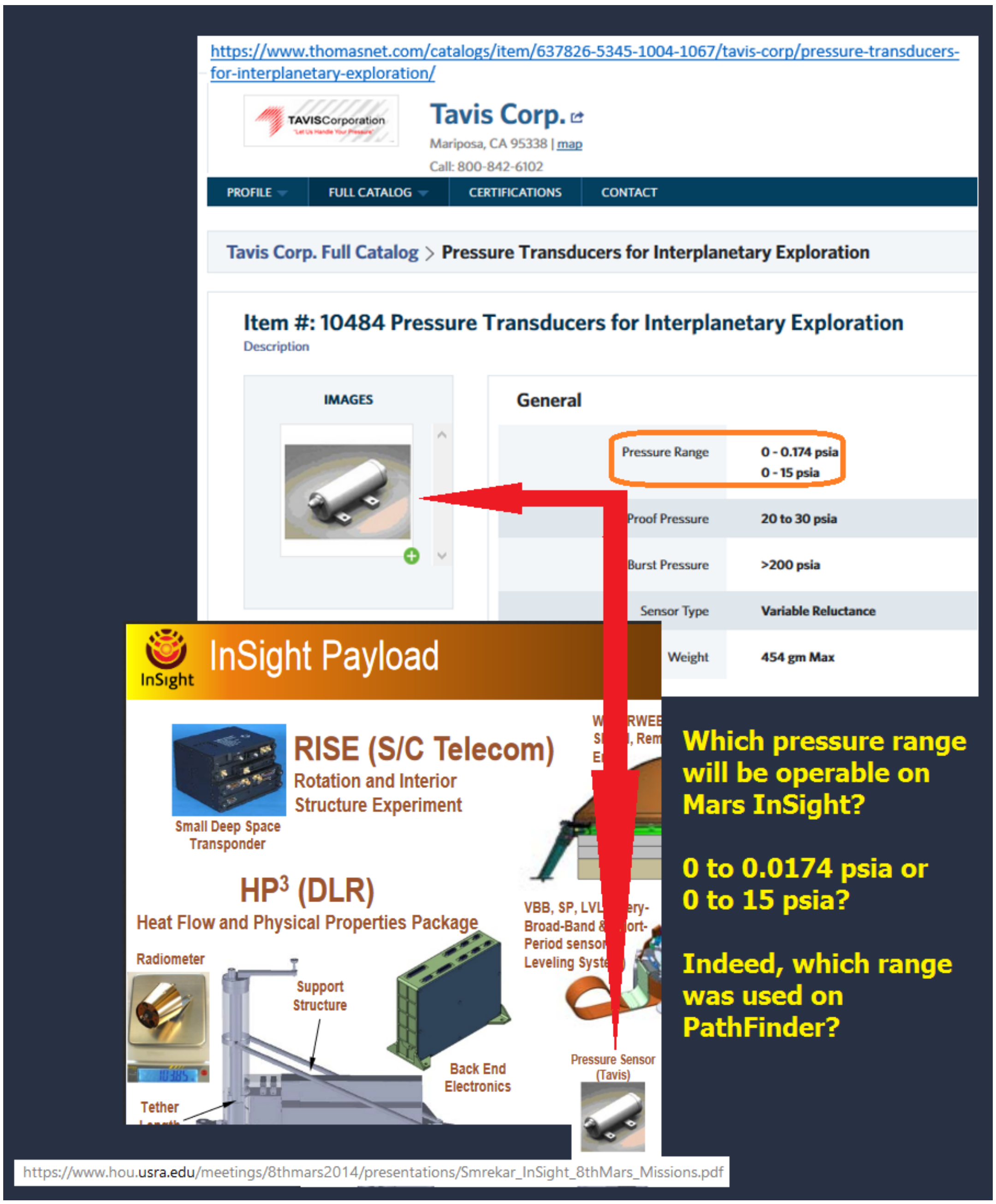


Figure 10D – Tavis Transducer 10484 was used on both Pathfinder and Insight.

The issue of pressure sensors is clouded by restrictions on information related to ITAR that handicapped the FMI (and Vaisala) with respect to the calibration coefficients needed for analysis of raw pressure data on Phoenix (Taylor et al., 2009).[32] They indicate problems associated with pressure analysis for Phoenix because pressure sensors used depended on Vaisala Thermocap® temperature sensors. But, "After Phoenix landed it appeared that the actual thermal environment was worse than the expected worse case. The temperature was not only changing rapidly, but there were also fast changes in the temperature gradient due to a nearby heat source. Information on a re-location of the heat source had not been provided initially due to ITAR restrictions."

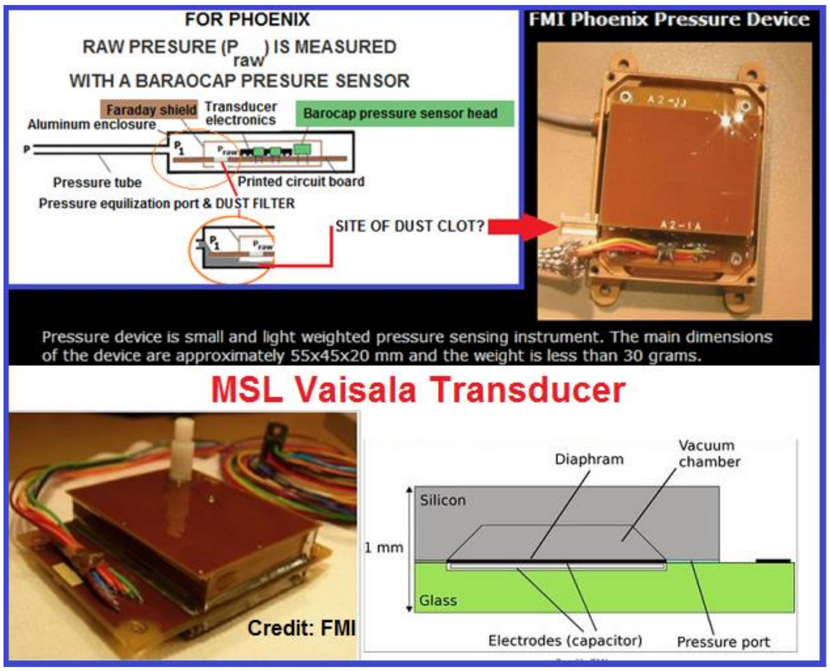


Figure 11A – The top transducer is for Phoenix. Note the tiny dust filter shown under P_{raw} (adapted from Doc. No: FMI_S-PHX-BAR-TN-00 FM-00 Revision 1.0 dated 2009-02-26). The report is entitled The Time Response of the PHOENIX Pressure Sensor). An area of concern for clogging by dust is highlighted. The photo on the right is adapted from http://www.space.fmi.fi/phoenix/?sivu=instrument. The bottom pictures are for MSL.

2.4 Issues Raised by the FMI. The FMI report by Kahanpää and Polkko (2009) discusses the Vaisala pressure sensor that it designed for use on Phoenix.[34] It states, *"We should find out how the pressure tube is mounted in the spacecraft and* ***if there are additional filters*** *etc."* The one and only filter for the Vaisala transducer is shown on the top of Figure 11A (with its near twin for MSL shown on the bottom of Figure 11A). I challenged the above statement on November 14, 2009, and published a criticism of it on my web site on November 17, 2009. Kahanpää's partial response from the FMI to my assertion that, "something stinks" about his request for information on additional filters was as follows:

> "Your nose smelled also a real issue. The fact that we at **FMI did not know how our sensor was mounted in the spacecraft and how many filters there were** shows that the exchange of

information between NASA and the foreign subcontractors did not work optimally in this mission!" (Kahanpää, personal communication, December 15, 2009).

In his e-mail of December 15, 2009, Kahanpää made clear that there was no extra filter. However, the confusion in his report highlights another possibility. As is shown in Figure 11B, the filter is very small (~10 mm^2).

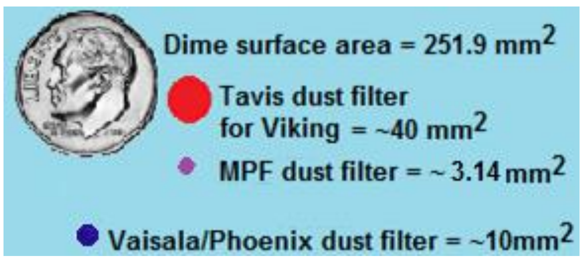


Figure 11B – Relative size of dust filter for landers on Mars. 2 mm diameter of MPF tubing from Seiff et al. (1997).

Kahanpää is a critical man to understand. He was the scientist on the REMS Team responsible for publishing pressure data for MSL. As is shown later on Figure 17A, in Section 2.7 and elsewhere in this report, the REMS Team published pressures that varied from 747 hPa to 747 Pa in early September 2012. Annexes M to R of this report detail other radical alterations in pressure data published for MSL Years 1 and 2. There is cause to ask whether Kahanpää was forced to alter data or whether he published Earth-like pressures to protest what he knew to be deliberate disinformation.

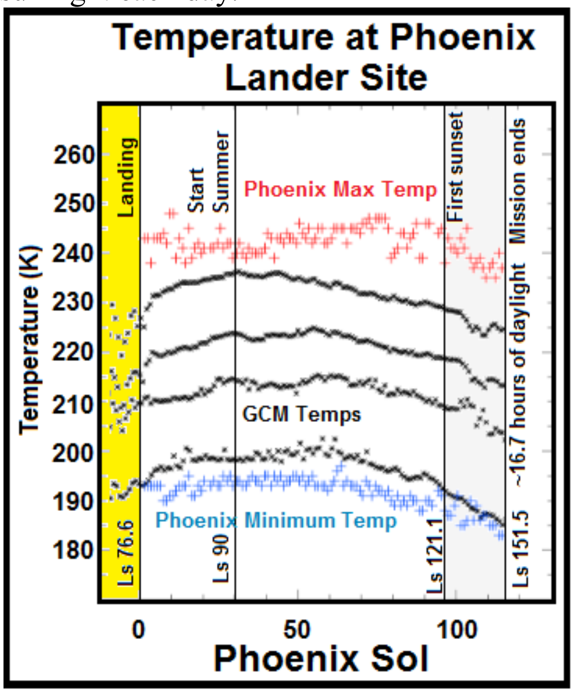
Like the Tavis transducers that were used for Vikings and Pathfinder, the Vaisala transducer was exposed to a vacuum on the way from Earth to Mars. Again, when Phoenix landed, a lot of dust was raised by the retrorocket. The air pressure outside was supposed to be low, almost as low as outer space. The flow of air into the transducer therefore should not have been too fast. However, if the pressure outside was higher than expected, the rate of flow of air and dust into the Phoenix would be faster than planned for, with the result that dust would be rapidly sucked in just like a vacuum cleaner would inhale it. A tiny filter might well quickly clog with dust so fast (at supersonic speeds) that it would prevent more air from reaching the pressure transducer.

With a clogged filter, pressure at the Barocap pressure sensor head would stay pegged at a low pressure reading. If there was a higher pressure on the outer side of the dust clog, it could not be felt on the inner side where the Barocap resided. This could explain the confusion by Kahanpää & Polkko and why they asked in their report about more filters being present. Even if the FMI team eventually received the needed information about relocation of heat sources, corrections to the pressure indicated at the Barocap pressure sensor head would not reflect what the true pressure was on the other side of the dust clog.

One difference between the Vikings and both Pathfinder and Phoenix is that the latter two landers did not include Radioisotope Thermoelectric Generator (RTG) heaters. Therefore, it would be expected that as the sun grew lower on the horizon and temperatures dropped, pressure would go down steadily. In looking at data for Phoenix derived from Nelli et al., 2009, this is exactly what happened (see Figure 12A). The pressure fell in a nearly linear fashion.

Figure 12A is extracted from graphs produced by Nelli et al. (2009).[33] Their graphs included projections made from a General Circulation Model (GCM) with values hypothesized for 3 am, 9 am, 3 pm and

9 pm local time at Phoenix. We added Ls and data about day length for clarity. Phoenix landed in the Martian arctic in late spring. There was no sunset until Ls 121.1 on its 96th sol on September 1, 2008. By the time the mission ended there were about 16.7 hours of sun light each day.



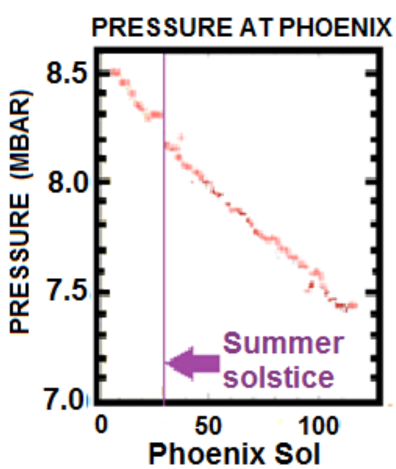


Figure 12A – Pressure and Temperatures Recorded by Phoenix (adapted from Nelli et al, 2009). Ls and day length data have been added to the top graph.

The pressure data appears to be sol averaged, while the temperatures are not. But what kind of pressure drop would be expected if the average temperature dropped from 195K to 180 K, with a starting pressure of 8.5 mbar? The answer is about 7.85 mbar. The actual pressure at the end of the series shown on the graph is about 7.4 mbar, which is better than a 94% match with the prediction based on Gay-Lussac's Law and a clogged pressure tube. However, when Phoenix landed on Mars on May 25, 2008, it was not yet summer. The summer solstice occurred on June 24, 2008. By that time there was no change in the temperatures evident on Figure 12A, but pressure was running about 8.2 mbar. Using the same temperatures as above with an entering argument of 8.2 mbar the projected pressure would be 7.57 mbar. That is an agreement of 97.78%.

Unlike pressure calculations based on an inverse of normal temperature and pressure relationships that factor in RTG heat becoming available to Viking transducers, on Phoenix there was no RTG. If there was no heater, pressures would be expected to fall directly with the fall in ambient pressures. This happened, but there were indeed four heaters that were turned off just before the lander died.[109] The third one operated the Surface Stereo Imager and the meteorological suite of instruments. **It was thought that electronics that operate the meteorological instruments should generate enough heat on their own to keep most of those instruments and the camera functioning.** This sounds like there was no need to pump heat into the pressure transducer. If so, there may indeed have been slow cooling of the air trapped behind the clogged dust filter, with no timed heat pumps to cause pressure spikes seen with the Vikings and MSL.

There was nothing to keep Phoenix alive once it got too cold. Its death supposedly came when ice built up on and broke the solar arrays.[110]

With respect to Phoenix design, Kahanpää & Polkko repeatedly mentioned funding problems, although the meteorology package for Phoenix cost $37,000,000. Not only was an anemometer unfunded, but a way to change the dust filter was also left off the shopping list. Indeed until Insight in 2018 it was unclear if anyone conducted tests to see to how much dust was required to clog the filters, or if such tests were conducted, what size dust particles, and what density of dust particles were involved.

Kahanpää & Polkko (2009) stated that the Mars Science Laboratory launched in 2011, is a $2 billion cornerstone mission and is therefore handled in a different way than the $454 million dollar *scout mission* Phoenix.[34] The actual cost of MSL was $2.5 billion. However, MSL's FMI-built sensors (delivered in 2008, see http://space.fmi.fi/solar.htm)[35] are in the 0.01 to 11.5 mbar range (see http:/ http://space.fmi.fi/solar.htm/www.spaceflight101.com/msl-rems-instrument-information.html),[36] still too low (the REMS Team initially reported a mean pressure of 12 mbar for Sol 1161**).** I discussed this problem with Dr. Ashwin Vasavada, JPL's Deputy Director of the MSL, but the inadequate transducer was apparently sent anyway.

On December 9, 2012 at http://davidaroffman.com/custom3_45.html we published a prediction that maximum pressure published for MSL would occur around January 31, 2013. Initially our estimate of the date was only off by 2 days, but our 9.45 to 9.5 mbar estimate was higher than the 9.25 mbar published by the REMS Team. However on July 3, 2013 REMS changed all its data. Our estimate was then listed as off by 19 days, but the new pressure was 9.4 mbar, quite close to our 9.45 to 9.5 figure. They later changed it to N/A. Our slightly off eye-balled prediction was only based on our beliefs that the REMS Team would extrapolate (politically expedient) results from pressure curves seen by Viking I and 2 (see Figure 12B), making sure to keep all their invented data points between those of Viking 1 and Viking 2 because MSL's altitude was between those two probes. Sure enough when we called attention to four MSL pressures that were above the curve in August and September 2012 (see the red hexagon on Figure 12B and also see Table X); JPL dropped them back to match the curve when they revised their data on July 3, 2013 Likewise, after a pressure of 11.49 mbar was reported for MSL sol 370 and we called JPL about it, the next sol (371) pressure was back down to 8.65 mbar. They reported 11.77 mbar for Sol 1,160 and 12 mbar for Sol 1,161 but at http://marscorrect.com/photo2_28.html we show they revised them down to 8.99 and 8.98 mbar. Up through the end of 2018 JPL tends to alter data more than 7 Pa (0.07 hPa/mbar) off the expected or politically desired pressure curve.

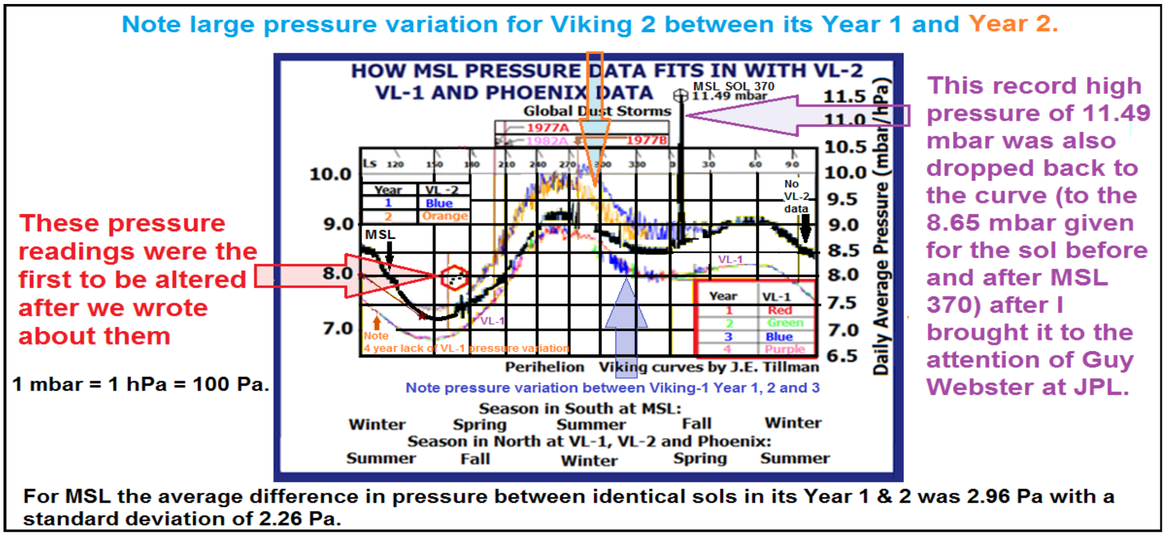


Figure 12B: Except for Sol 370 the black MSL pressure curve is suspiciously too close to the Viking 2 curve above it and the Viking 1 curve below it.

2.5. DID ANY TAVIS OR VAISALA TRANSDUCERS PEG OUT AT THEIR MAXIMUM PRESSURES?

One defense for Tavis and Vaisala transducers would be that if they were short of the ability to measure the actual ambient pressures around them, they should have pegged out at the maximum values possible. Under this scenario, the Vikings would have recorded a continuous pressure of 18 mbar, Pathfinder 10 mbar, Phoenix should have stayed pegged on 12 mbar, and MSL should be stuck at 11.5 mbar. But it did essentially did happen for MSL on its Sol 370 (August 20-21, 2013) when for Ls 9, the pressure shot up suddenly to 1149 Pa which is 11.49 mbar (essentially 11.5 mbar). See Figures 14A to 14D. Pressures for the previous 5 days in Pa were 839 (Sol 365), 861 (Sol 366), 862 (Sol 367), 863 (Sol 368) and 865 (Sol 369).

For Sols 1160 to 1161 at Ls 66 they initially posted pressures higher than the 1150 Pa limit – 1177 Pa on Sol 1160 and 1200) for Sol 1161. Then after we highlighted them, they reduced them to 898 and 898 Pa. Again on Sol 1301 the initial pressure posted was 1154, but when we highlighted it they dropped it back to 752 Pa. See Figures 14E to 14F. Note: Later with Figure 88 we show that the REMS Team revised the pressure range from up to 1150 Pa to up to 1400 Pa, and in fact on Figure 86 we show that the FMI Abstract originally published in December, 2012 had a pressure range of up to 1,025 **h**Pa/mbar (earth-like). On Sol 1794 they published a pressure of 1293 Pa, then they knocked it way back to 883 Pa after we highlighted the issue.

2.5.1. How extraordinary was the (temporary) 1,149 Pa pressure spike of MSL Sol 370?

Before we found FMI altering maximum pressure ranges, we focused on the last 45 sols of data and did a Quality Control Individuals Test assuming that each sol was an independent sample of atmospheric pressure (see Figure 13). The upper and lower control limits (UCL and LCL) encompass all data points except for the 44th point which occurred on Aug 21. The standard deviation of this process is 13.7 so that UCL here represents a 3-sigma distance above the 859.1 mean value. Data points within 3-sigma of their mean are considered to be under control and exhibiting normal variation. Any data point exceeding 3-sigma is cause for concern. On a production line, quality control inspectors would be required to explain what went wrong with either the process settings or production line tools. In practice, 3-sigma exceptions are anticipated no more than 6.7 times per hundred measurements while 6-sigma exceptions should occur no more than 3.4 times per million observations. Really large sigma values, should be very, very rare. The Sol 370 measured value of 1149 Pascal is huge, just over 21-sigma from the mean value.

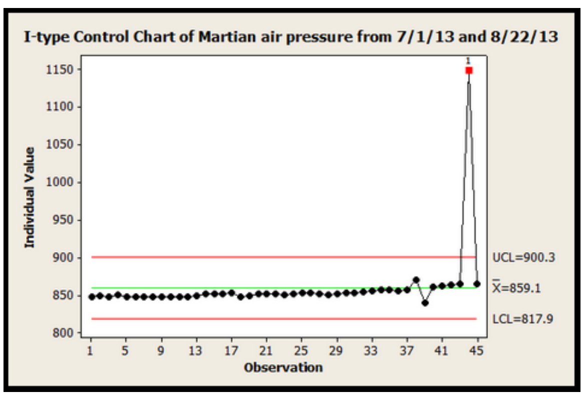


Figure 13. Quality control Individuals test.

JPL's REMS Team, seven months after I highlighted the significance of 1149 Pa, went back to their report and changed its 1149 figure to 865 Pa – right what it was the sols before and after Sol 370. This is shown on Figure 14C. However, at least as of November 18, 2015 (before they took down all MSL weather), Ashima Research did not revise their data. As is shown on Figure 14D, until they gave up and took their data down they still showed 1149 Pa for Sol 370.

Why didn't Ashima revise its report? They were criticized by me on line for less than ethical behavior with respect to MSL data early on, and I published a negative evaluation of their General Circulation Model (GCM). So perhaps they didn't want to add fuel to the fire. For months I thought that perhaps they simply hadn't caught up with the changes made by the REMS Team. However when I updated this section of our report on May 22, 2016, over 18 months since Ashima made any update or revisions to its Mars data at http://marsweather.com/data I found that link no longer worked and Ashima has apparently gone out of the business of keeping up with constant REMS Team changes in their Martian weather data.

2.5.2 The importance of gleaning data from identification of our web site readers.

On January 20, 2016 we caught a Spanish IP address at 161.111.124.7 from the *Consejo Superior de Investigacions* reviewing the bulk of our Mars weather spreadsheets. On checking we found that they oversee the *Centro de Astrobiologia* (CAB) in Madrid. The reverse IP address of 161.111.124.7 is 7.124.111.161 which is at the Department of Dense.

The CAB is home of the REMS Team that issues all weather reports for MSL. On the day after this review was caught, very much as we predicted, the REMS Team dropped the pressure for Sol 1160 from 1177 Pa to 899 Pa and for Sol 1161 from 1200 Pa to 898 Pa (See Annex P of this report and our web site at http://marscorrect.com/photo2_28.html).

Our research challenges Establishment positions about Martian atmospheric conditions. As such, for purposes of feedback about the quality of our work, it was our standard operating procedure for three years to track and record our web site readers from NASA, the Kremlin, the CAB/REMS Team, and the Finnish Meteorological Institute (FMI), the European Space Agency, Russian aerospace institutions outside of the Kremlin, the Chinese National Space Administration, the Japan Aerospace eXploration Agency (JAXA) and the Indian Space Research Organization. After a while we found that what looked like NASA Ames or the Kremlin was in fact often the U.S. Department of Defense.

There was no cooperation between our Government and us until word got out via a 3.5 hour TV interview translated into Italian that we were involved with in identifying what appears to be primitive life on Mars. The interview is on line at https://www.youtube.com/watch?v=PqCxAErabuU. Some of it is discussed in Section 15.3 of this report and shown on Figures 71 to 73. In February, 2019 we were asked to review new findings and publish our comments about them. By June, 2019 the results were public along with caveats like, "evidence of life is not proof of life," but (while we still need DNA-type evidence) we doubt that people will be fooled for long. The evidence is overwhelming. Our findings about Martian wind, given in Section 7 of this Report earned us one of 14 chances to review and vote on publishing what's up there. As for who is monitoring us now it's almost all by our Government and intelligence agencies, but not a concern so long as no effort is made to disrupt my publications.

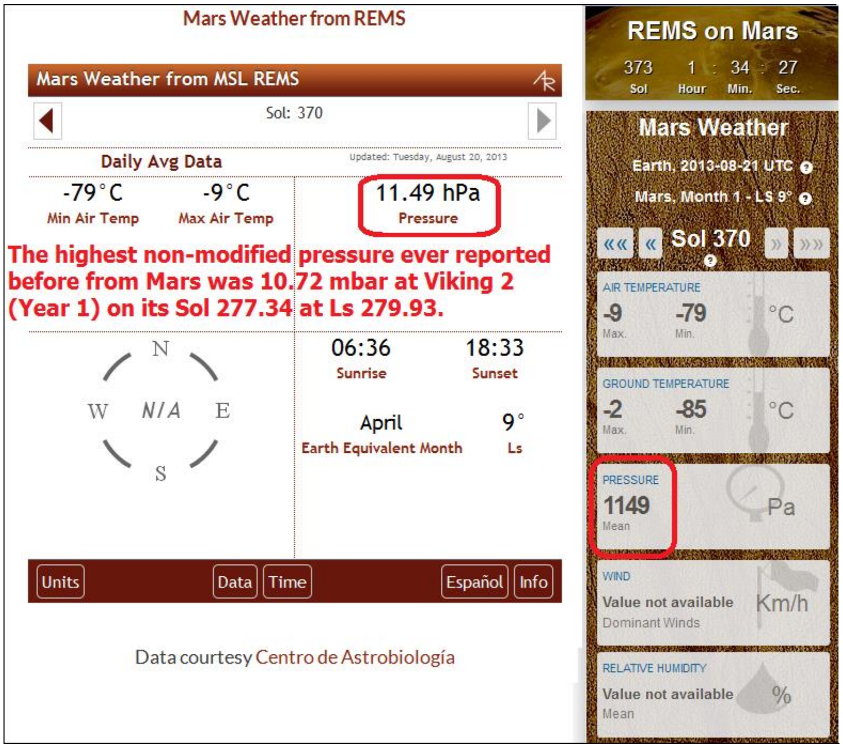


Figure 14A – MSL's pressure sensor suddenly pegs out at essentially 11.5 mbar. 1,149 Pa = 11.49hPa/11.49 mbar which is as much as REMS originally claimed the instrument is capable of measuring. This suggests an even higher pressure during Sol 370 because this figure is always an average pressure for the day (meaning that some of the day had to have pressure that exceeded the transducer's capabilities).

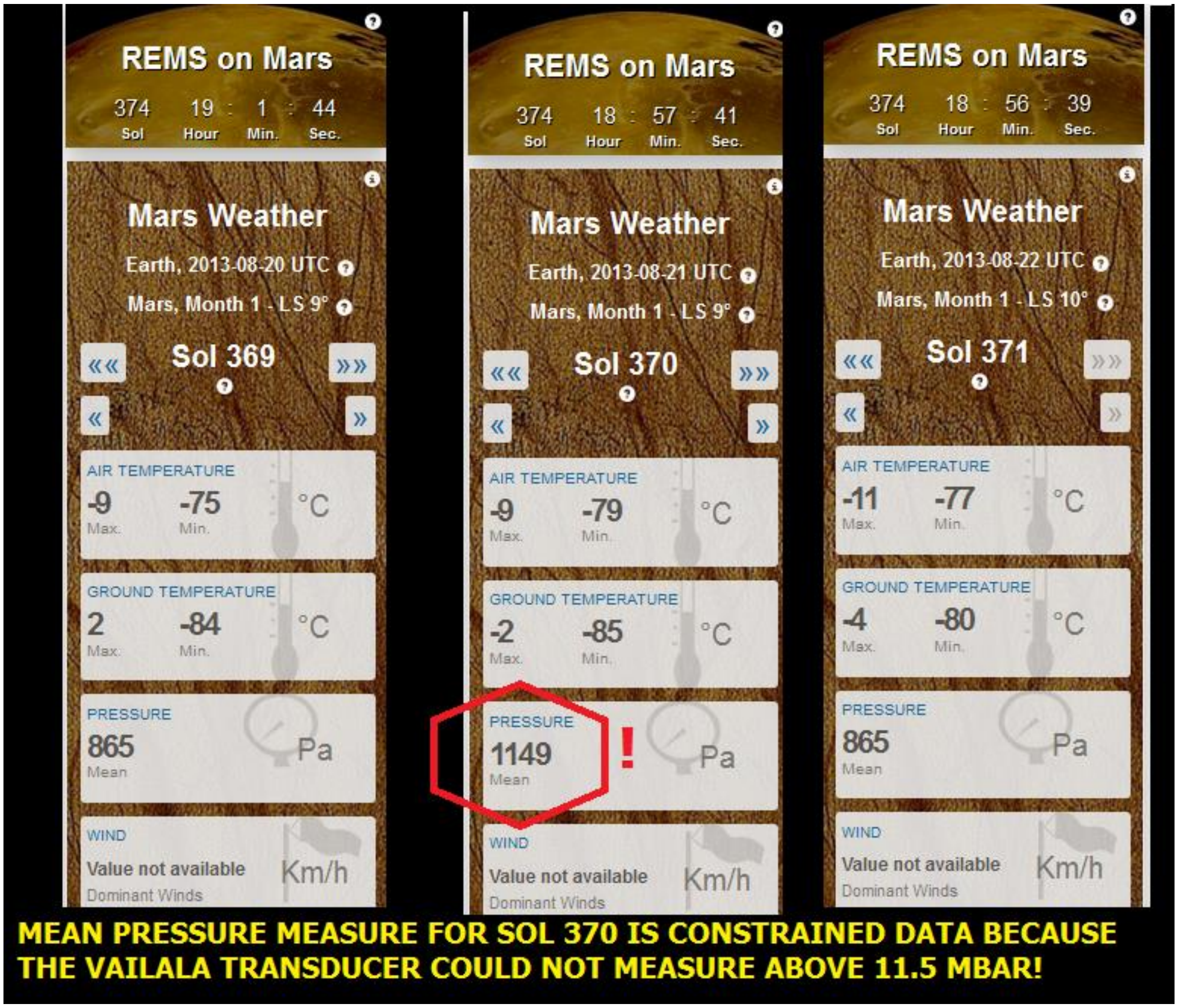


Figure 14B – The pressure the day before the 1149 Pa (11.49 mbar) spike was 865 Pa (8.65 mbar on Sol 369). After I called JPL about it, the pressure for the next day (Sol 371) returned to a more politically correct 865 Pa again.

Figure 14C – Sol 370 shows that the REMS Team and JPL approach to problem solving – they simply rewrite history and hope that nobody will notice it.

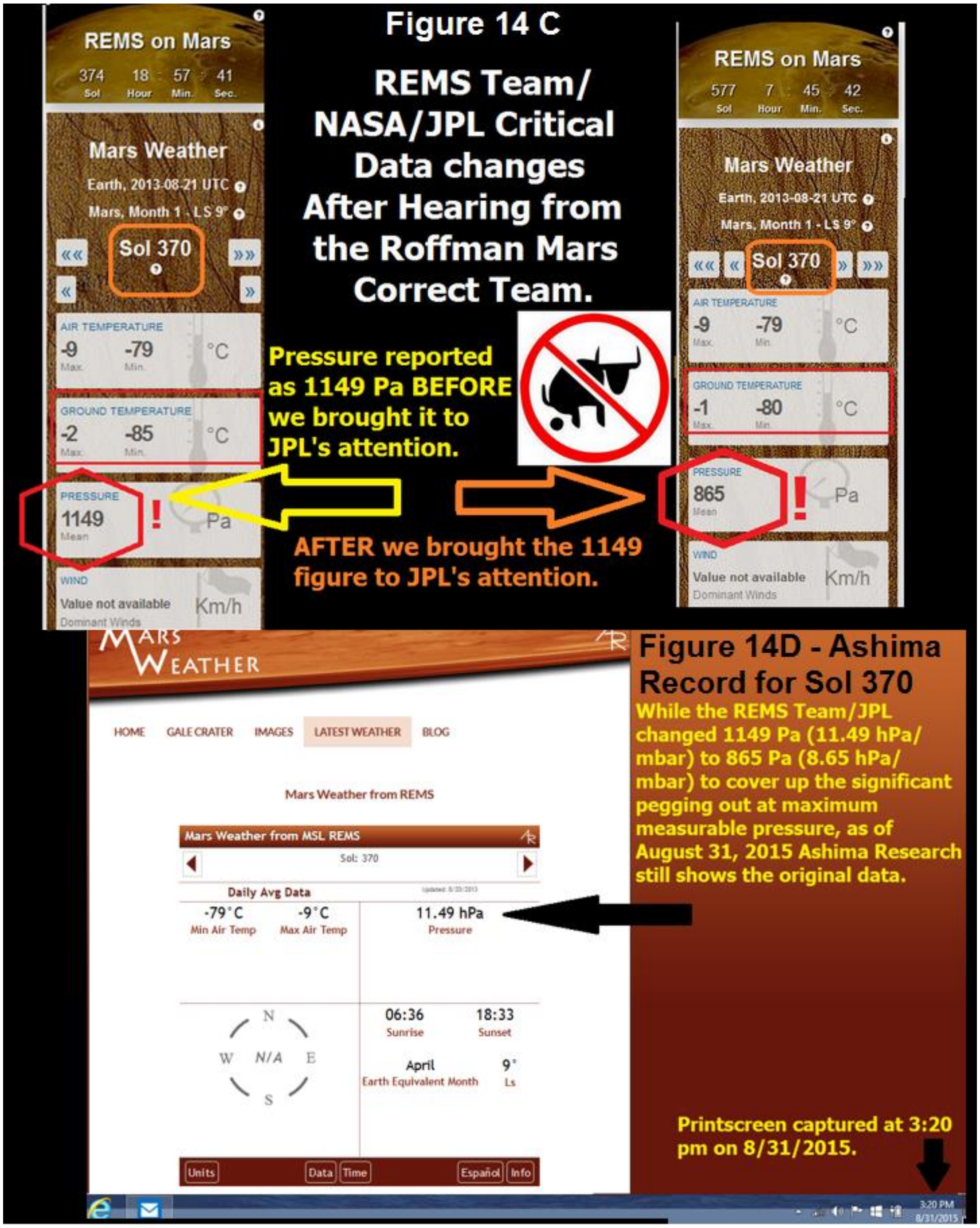


Figure 14 D above – The REMS Team never succeeded in getting Ashima Research to revise Sol 370 history as of August 31, 2015 (and on through at least July 14, 2017). They still show the original pressure figure of 1149 Pa (11.49 hPa/mbar).

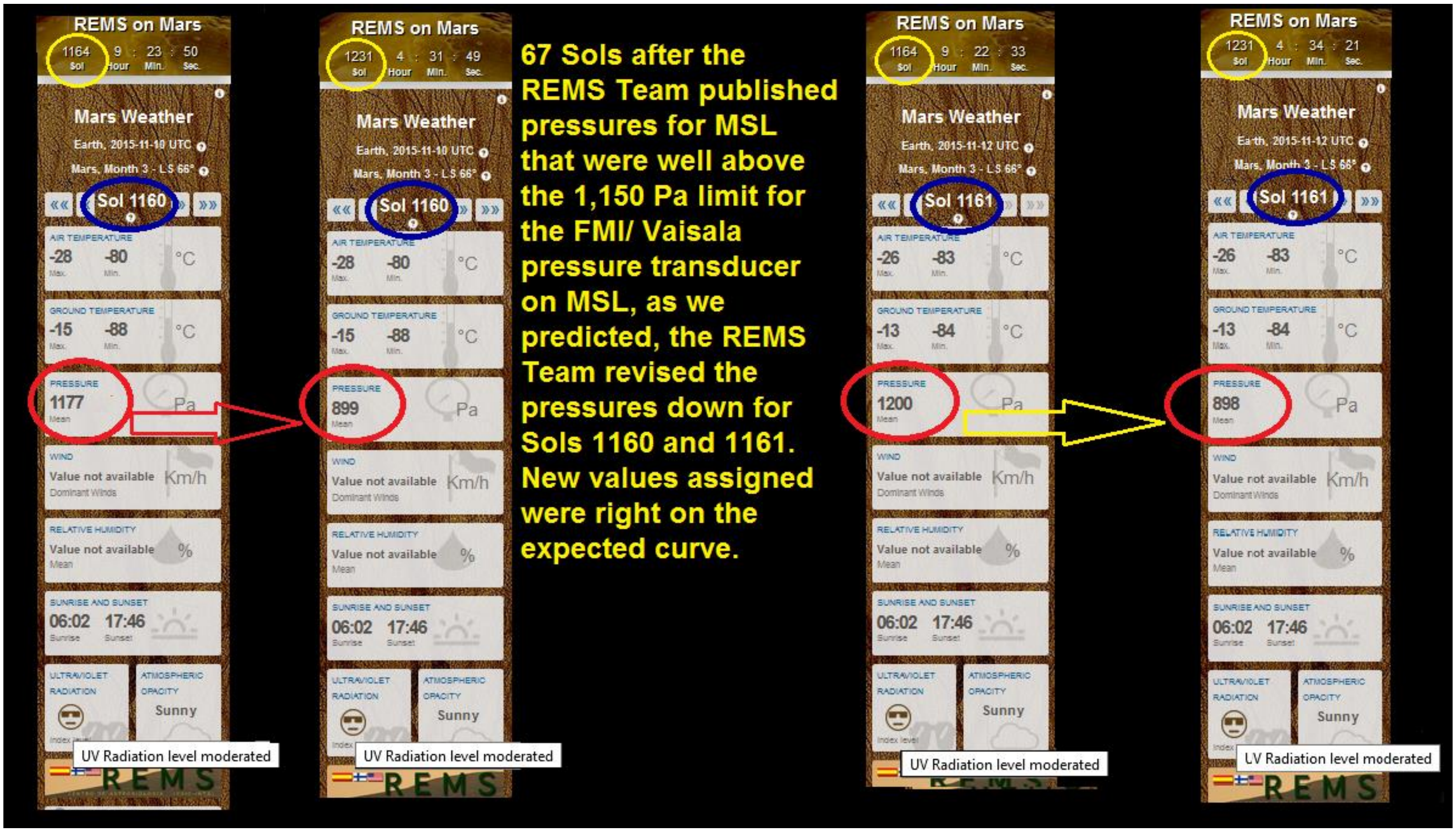


Figure 14E – Again on sols 1160 and 1161 The REMS Team/JPL posted inconsistent pressures that were higher still. The final result? Same as before. They threw out their first reports and gave us pressures on the curve that they wanted us to use.

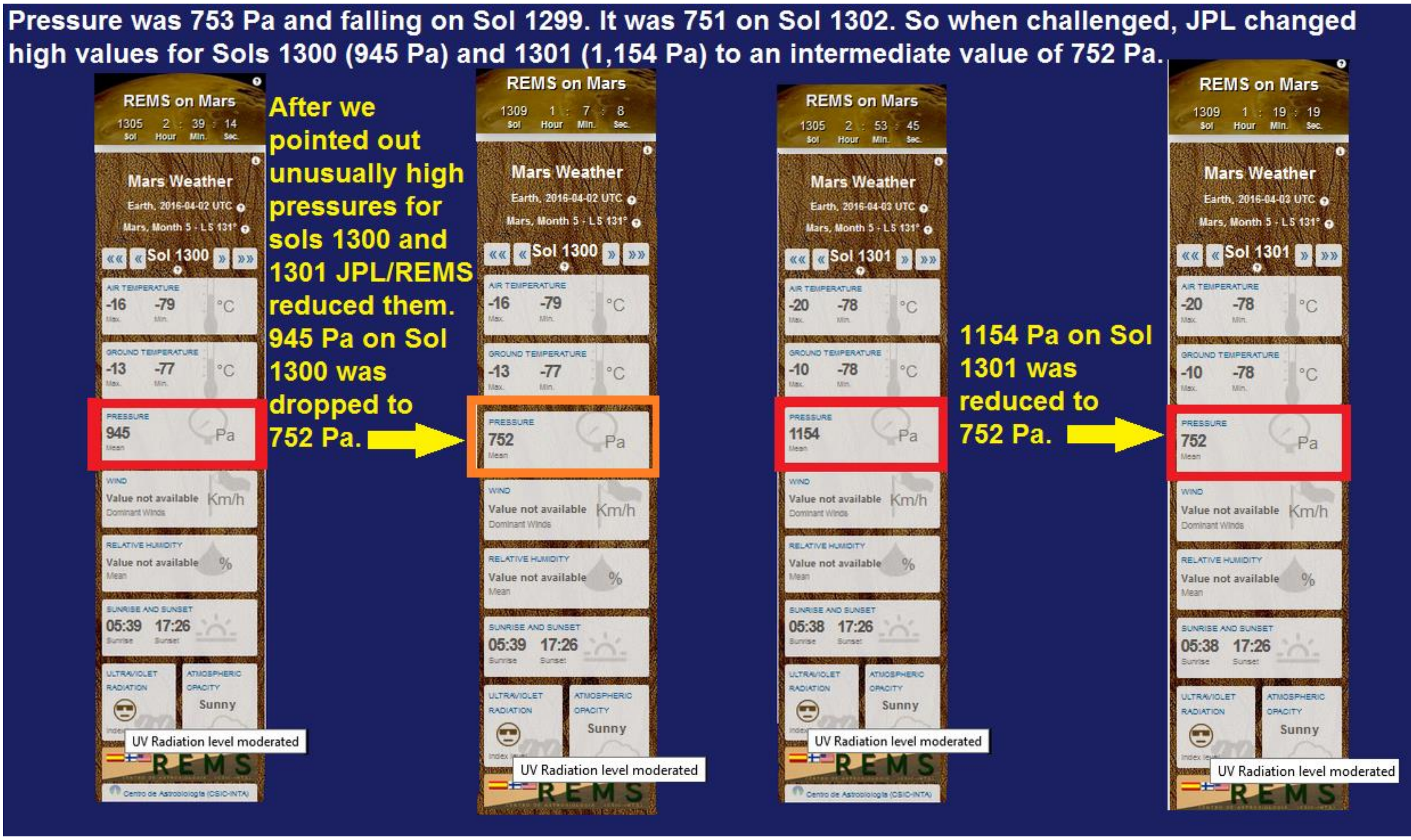


Figure 14F – Once again, when record pressures were published for sols 1300 and 1301 and we predicted at http://marscorrect.com/photo2_29.html that they would revise them, they did. The REMS pressure for Sol 1299 was 753 Pa, and for Sol 1302 was 751 Pa. So they revised pressure for Sol 1300 from 945 Pa to 752 Pa and for Sol 1301 from 1154 Pa to 752 Pa.

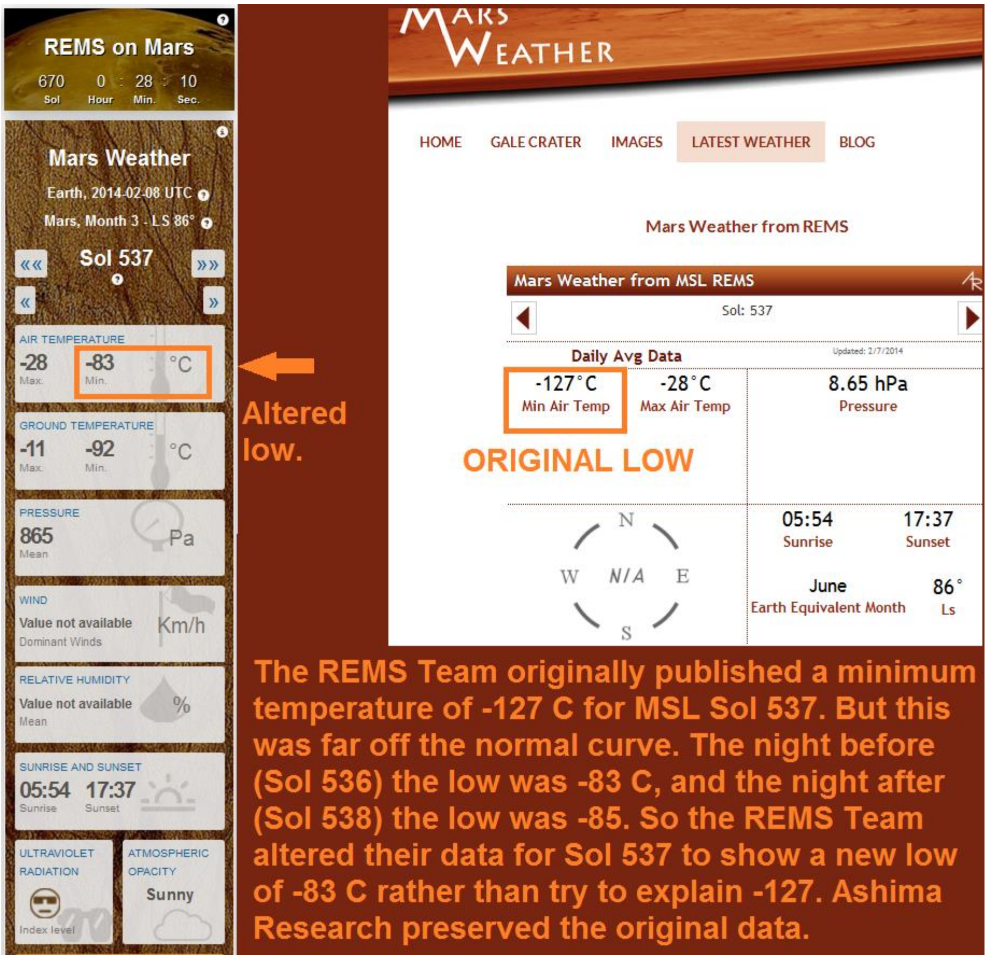


Figure 14G – REMS also altered temperature data that is off the expected curve.

As Figure 14G shows, it's not just pressures that are revised when they are off the expected curve. The REMS Team originally showed a minimum air temperature of -128° C for Sol 537. The night before this (Sol 536) the low was -83° C, and the night after it (Sol 538) was -85° C. So to make the data fit the curve they revised Sol 537 to show a low of -83° C. Ashima Research took its data directly from REMS, but it didn't always replicate the changes to data made by the REMS Team. This is demonstrated on Figure 14F. A temperature of -128° C is cold enough for carbon dioxide to freeze,[37] but these temperatures are not associated with near equatorial latitudes like that at MSL (4.59° South). See Section 14 for more about MSL temperature measurement problems.

2.5.3. Why is it so wrong to alter data to fit an expected curve?

On August 24, 1992 I owned a house in Homestead, Florida. The weather was beautiful the day before and the day after. But on August 24th Hurricane Andrew struck my town, destroying it, my house, and much of Miami. Leveling off the data for that week would have missed what was vital. Likewise, we cannot understand Martian weather (global dust storms, dust devils, moving sand, snow, flowing water, storms over Arsia Mons and Olympus Mons etc.) when data there is treated in a way shown by Figures 14A to 14 E.

As for earlier transducers sent, Tavis transducers used on the Vikings both had an upper range of about 18 mbar (actually 17.9 mbar in accordance with NASA report TM X-74020 by Michael Mitchell dated March 1977).[29] The issue here too is how fast they might clog *while* in the initial process of landing. When Apollo 11 landed on the moon, about 22 seconds before the contact light came on Apollo 11 radioed the words "Picking up some dust." How much dust was kicked up before the Viking landers? Professor Chris Mihos (Case Western Reserve University) indicates that for Viking 2 "due to a radar misidentification of a rock or highly reflective surface, the thrusters fired an extra time 0.4 seconds before landing, which cracked the surface and raised dust." All descriptions of the Viking 1 site indicate that it was also dusty. Figure 5A showed exactly how dusty it was within 25 seconds to 5 minutes after landing.

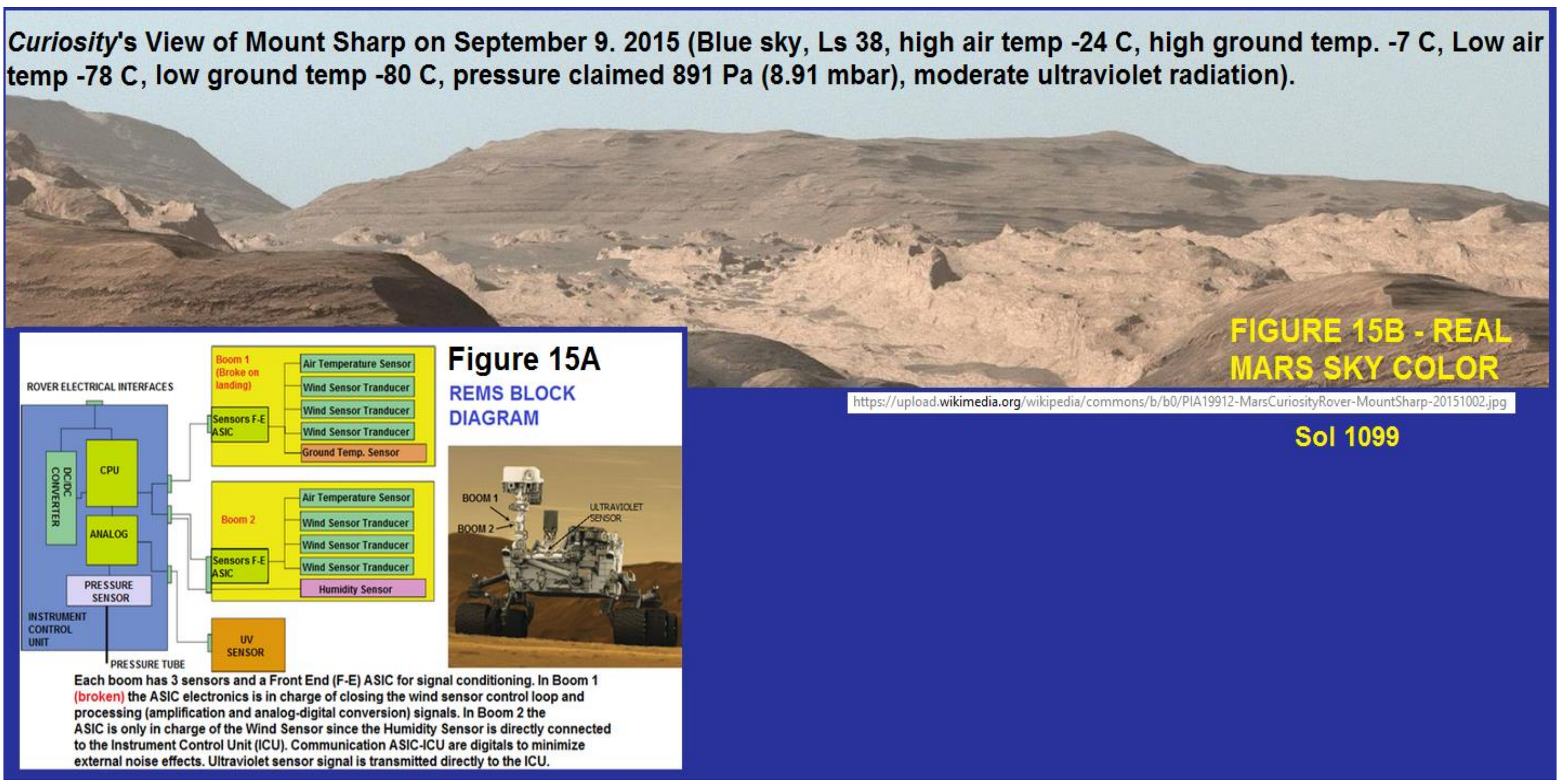


Figure 15A MSL REMS Block Diagram. Boom 1 broke on landing. Adapted from http://rd.springer.com/article/10.1007/s11214-012-9921-1/fulltext.html
Figure 15B – Color of the sky as seen from MSL on its Sol 1099. This photo, according to some sources, was white balanced which affects the exact shade of the sky which may vary with dust load.

It is also argued that rocks kicked up on MSL's landing broke one of the two REMS meteorology booms (Boom 1). They were shown on Figure 5B. The first color picture sent from MSL with a lens cover on also showed much dust between the lens and the atmosphere. The color of the atmosphere (See Figure 15B and later Figure 44I) became bluer when the cover was removed; again raising questions about how effective the dust filter would be for the pressure transducer. Although it was initially reported that MSL's relative humidity sensor was working properly on landing, it too had a dust filter and there was no relative humidity data reported on daily REMS Team or Ashima Research reports for Sols 19 (August 25, 2012) through at least Sol 1,344 (May 18, 2016). See Section 13. In fact, in checking for Sol 3039 on February 22, 2021, there is still no relative humidity on the daily weather report.

Why didn't MSL's pressure sensor peg out faster? Why did it take until Sol 370? My initial answer was that air intake tubes clogged on landing for all landers, MSL included, but after a year of roaming around Mars, the dust clot was either knocked loose when the lander moved over a rock, or was degraded enough to let air rush in to max out the transducer.

What about the next day? There was likely to be a panic at the REMS Team/JPL. If the published figure for Sol pressure had only risen to 11 mbar, they might look for an answer in some weather system. But by maxing out they really can't say what the actual maximum pressure was for the day. It's like what would happen when a 120 kg man tries to determine his mass on a scale that can only measure up to 50 kilograms. The needle may indicate 50 kg, but that in no way indicates his real 120 kg mass.

As for the 11.54, 11.77 and 12 mbar pressures initially published I'm not sure why they were put out. They don't appear to be typographic errors. The 11.77 mbar (1177 Pa) pressure for Sol 1160 was actually a revision of an 897 Pa pressure that was right on the expected curve, and consistent with the 897 Pa pressure published for sol 1162.

It's likely that the answer here lies not with science or error, but with a human personality. One name stands out above all others – the designer of the pressure sensor – Henriq Kahanpää at the Finnish Meteorological Institute (FMI). If not Kahanpää then one of his colleagues in the REMS Team in Spain might be taking deliberate action not in line with NASA wishes. We record IP addresses of all NASA, REMS Team, FMI and Kremlin visitors to our marscorrect.com and davidaroffman.com websites each day. There was a visit from the FMI IP address 193.166.223.5 on 12/21/2015. Kahanpää and his cohorts know well what I'm writing about their data. I also think I understand the pressure that they're under to back the (NASA) party line. He demonstrated some courage in questioning NASA, admitting that something stinks there in conjunction with not being given all info needed to build proper transducers, but I don't know how far he's willing to go in challenging his bosses. At first I thought REMS Team's numerous mistakes were due to human error. But it's possible that weather data published by them that's far off the expected curve is a signal to scientists that they are being forced to invent or corrupt their data. A sample from our Annex P of how we track REMS data and color-highlight problems follows:

TABLE 4A – SAMPLE OF HOW THE MARS CORRECT TEAM TRACKS WEATHER DATA PUBLISHED BY THE REMS TEAM/JPL

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Sol	**Ls**	**Pressure (Pa)**	**Earth Date**	**Hi Air Temp** °C	**Low Air Temp** °C	Δ Air Temp °C	Δ Air Temp C/40	Hi Ground Temp °C	Low Ground Temp °C	Daylight change in Temp °C Air to Ground	Nighttime change in Temp °C Air to Ground	Pressure Year 1 same Ls	Δ Pressure Yr 1 to 2 (yellow = > 7 Pa)	~Ls Year 1	Pressure Yr 1 before revision	UV Yr 1	UV Yr 2	**Comments**
						Yellow = -59°C or warmer)	**Green = <1.5**	**Red = > 0°C**	**PURPLE = >=90°C or colder**	**Blue = >10°C**	**PURPLE = >10°C**							
1159	**66**	**898**	**11/9/ 2015**	**-28**	**-82**	**-54**	**1.35**	**-14**	**-84**	**14**	**-2**	**903**	**5**	**66**	**N/A**	**M**	**M**	
1160	**66**	**1177**	**11/10/ 2015**	**-28**	**-80**	**-52**	**1.3**	**-15**	**-88**	**13**	**-8**	**903**	**274**	**66**	**N/A**	**M**	**M**	**Pressures here & Sol 1161 are above the ability of the MSL Pressure sensor to measure.**
1160 Revised	**66**	**899**	**11/12/ 2015**									**903**	**4 revised from 274**					**Bingo! Revision for this sol predicted above.**
1161	**66**	**1200**	**11/12/ 2015**	**-26**	**-83**	**-57**	**1.425**	**-13**	**-84**	**13**	**-1**	**902**	**298**	**67**	**N/A**	**M**	**M**	**Watch for JPL to alter pressures for sol 1160 and 1161.**
1161 Revised	**66**	**898**	**11/13/ 2015**									**902**	**4 revised from 298**					**Revision for this sol predicted above.**
1162	**67**	**897**	**11/13/ 2015**	**-27**	**-84**	**-57**	**1.425**	**-12**	**-84**	**15**	**0**	**902**	**5**	**67**	**N/A**	**M**	**M**	
1163	**67**	**896**	**11/14 2015**	**-29**	**-86**	**-57**	**1.425**	**-12**	**-87**	**17**	**-1**	**900**	**4**	**68**	**N/A**	**M**	**M**	
1164	**68**	**896**	**11/15/ 2015**	**-35**	**-86**	**-51**	**1.275**	**-14**	**-88**	**21**	**-2**	**901**	**5**	**68**	**N/A**	**M**	**M**	**Record cold high temperature.**

MSL Weather data for two Martian years is found in the following Annexes to this Report (the Table of Contents (Annex CC) shows weather links to Sol 2871 of MSL Year 5).

TABLE 4B – LINKS TO 5 MARTIAN YEARS OF WEATHER DATA		
ANNEX M	**One Year of MSL Weather Reports** http://davidaroffman.com/ANNEX%20M%20of%20All%20NASA%20Mars%20Weather%20Data%20Revised%20Aug%2027%202015%20to%20Critiqu.pdf	M-1 to M-38
ANNEX N	**Weather Reports for MSL Year 2 Ls 151 to Ls 270 (late winter to end of spring), Sols 670 to 864** http://davidaroffman.com/ANNEX%20N.pdf	N-1 to N-13
ANNEX O	**Weather Reports for MSL Year 2 Ls 270 to Ls 0 (summer), Sols 865 to 1,020** http://davidaroffman.com/ANNEX%20O.pdf	O-1 to O-11
ANNEX P	**Weather Reports for MSL Year 2 Ls 0 to Ls 90 (autumn), Sols 1019 to 1,213** http://davidaroffman.com/ANNEX%20P.pdf	P-1 to P-15
ANNEX Q	**Weather Reports for MSL Year 2 to 3 Winter, Ls 90 to Ls 180 (Sols 1,213 to 1,392)** http://davidaroffman.com/ANNEX%20Q.pdf	Q-1 to Q-18
ANNEX R	**Weather Reports for MSL Year 3 Spring, Ls 180 to Ls 270 (Sols 1,392 to 1,534** http://davidaroffman.com/ANNEX%20R%20REVISED.pdf	R-1 to R-37
ANNEX S	**Source: Document: Two Martian Years of MSL High Air and Ground Temperatures.** http://davidaroffman.com/ANNEX%20S.pdf	S-1 to S41
ANNEX T	**Source Document: Two Martian Years of MSL Low Air and Ground Temperatures.** http://davidaroffman.com/ANNEX%20T%20TO.pdf	T-1 to T-64
ANNEX U	**Comparison of Ultraviolet Radiation and Pressures at Gale Crater, Mars for MSL Years 1 and 2** http://davidaroffman.com/ANNEX%20U.pdf	U-1 to U-28
ANNEX V	**Weather Reports for MSL Year 3 Summer, Ls 270 to Ls 0 (Sols 1,534 to 1,686.** http://davidaroffman.com/ANNEX%20V.pdf	V-1 to V-28
ANNEX W	**Weather Reports for MSL Year 3 Fall, Ls 0 to 90 (Sols 1,687 to 1,881** http://davidaroffman.com/ANNEX%20W.pdf	W -1 to W-24
ANNEX X	**Weather Reports for MSL Year 3-4 Winter, Ls 90 to 180 (Sols 1,881to 2060** http://davidaroffman.com/ANNEX%20X.pdf	X-1 to X-31
ANNEX Y	**Weather Reports for MSL Year 4 Spring, 180 to 270 (Sols to 2060 to 2204)** http://davidaroffman.com/ANNEX%20Y.pdf	Y-1 to Y-19
ANNEX Z	**Weather Reports for MSL Year 4 Summer, 270 to 0 (Sols to 2203 to 2357)** http://davidaroffman.com/ANNEX%20Z.pdf	Z-1 to Z-19
ANNEX AA	**Weather Reports for MSL Year 4 Fall, Ls 0 to 90 (Sols 2357 to 2550) http://davidaroffman.com/ANNEX%20AA.pdf**	AA-1 to AA-21

ANNEX BB	**Weather Reports for MSL Year 4-5 Winter, Ls 90 to 180 (Sols 2,550 to 2728 http://davidaroffman.com/Annex%20%20BB.pdf**	BB-1 to BB-26
ANNEX CC	**Weather Reports for MSL Year 5 Spring, Ls 180 to 270 (Sols 2729 to 2871) http://davidaroffman.com/ANNEX%20CC.pdf**	CC-1 to CC-16
ANNEX DD	**Weather Reports for MSL Year 5 Summer, 270 to 0 (Sols to 2871 to 3025 http://davidaroffman.com/ANNEX%20DD.pdf**	DD-1 to DD-19

2.6 The Dust filter on Viking.

We asked Professor Tillman about the filter used for the Viking. On 27 May 2010, he wrote, “The sensors were connected to the ambient atmosphere through a ¼ inch (0.635 cm) tube fitted with a dust filter. Blockage of this system by dust would have been readily detectable in a rapid change in sensitivity to diurnal and synoptic pressure variations and a change in the annual cycle of pressure. No such changes were observed.”

The final statement above is not true. Diurnal patterns vanished almost completely between sols 639 to 799 on Viking 2 as is fully documented in the data audit in Annex C of this report. However, the main issue is how fast the pressure tubes and filters would clog. If immediately upon landing as the retrorockets kicked up the dust, then the patterns alluded to by Professor Tillman would still be there because they were established up front. Those patterns, however, would not reflect ambient pressures on Mars.

2.6.1. The issue of Viking pressure reports and digitization.

Professor Tillman sent us a slide that showed that Viking surface pressure measurement and resolution were limited by digitization to 0.088 mbar (0.088 mbar = 1 DN (A-D Converter, 8 bits). An audit showed 0.09 mbar was the most common change for VL-2 on its sols 1 to 199. Between its landing in the summer on its sol 1 at Ls 118 and the end of the summer at Ls 180, there were 4,476 pressures recorded between a low of 7.38 mbar and a high of 8.96 mbar. About 78.57% were either no pressure at all or one of 19 specific pressures, usually 0.09 mbar apart (see Table 4B). The remaining 27.26% were apparently the result of interpolation and/or the cubic-spline technique. 21.64% were exactly 7.47 mbar.

Balme and Greeley report diurnal pressure variations observed by Tavis transducers showed the maximum pressures were at midnight and 1000 for Viking and Pathfinder.[12] Minimums were at 0400. Phoenix (with no RTG heater) showed no midnight or night pressure maximum. Its maximum pressures were at 0830 and 1530 local time (Taylor et al.).[32] For MSL the initial max pressure was about 0730 and minimum pressure was around 1600. So once the transducer type was altered there was no agreement about diurnal pressure cycles.

2.6.2. The issue of daily pressure spikes at consistent time-bins.

A large pressure increase rate at the same time every day would be consistent with a limited amount of Martian air trapped behind a clogged dust filter or pressure equalization port. As was shown on Table 3 and Figure 8, there were multiple such hikes found in the Viking Project Group data.

Data was divided into 25 bins per sol, each about 59 minutes. The 0.26 to 0.30 time-bin should be an appropriate time to make RTG heat available and to turn on equipment. If air were trapped between the dust filter and the transducer, it would be expected that pressure would increase rapidly at this time. Figures 16A to 16L and Annex A show that this happened for VL-1 starting around its Sol 108 Ls 149 (late summer) until the last data posted at Sol 350 in winter (Ls 297). Likewise for VL-2, there was almost always a pressure increase in the .26 to .3 time-bin after the summer.

For VL-1 in the 333 days examined, pressure only decreased 5 times in this time bin (4 of these in the early summer before Sol 108, with none then more than 0.02 mbar, and the 5th case was just 0.03 mbar on sol 240, Ls 227.084). All of these 5 exceptions were for amounts less than the 0.08 to 0.09 accuracies allowed by digitization of pressure data described above.

Specific reported VL2 pressure between landing at LS118 and LS 180	Number of times Reported out of 4,476 pressures Recorded
0	246
7.38	305
7.47	969
7.56	542
7.64	378
7.73	263
7.82	101
7.91	59
7.99	39
8.08	74
8.17	79
8.26	84
8.35	48
8.43	59
8.52	38
8.61	37
8.7	133
8.79	0
8.88	38
8.96	25
Total times reported	3,517
% of 4,476 pressures	78.57%
Interpolated values	959
% Interpolated	27.26%

Table 4C – Digitization limitations and the specific pressures reported by VL-2 for its first summer on Mars.

For VL-2 over 206 sols specified, pressure only decreased twice, each time just .01 mbar. The next time-bin (0.3-0.34) showed a much more varied pattern. Red lines show the first time-bin and blue show the second time-bins on Figures 16A-16L.

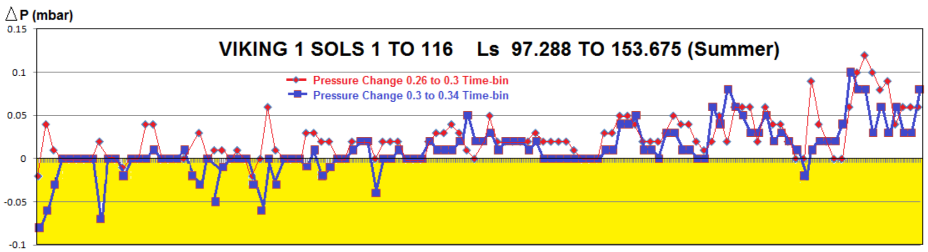


Figure 16A – Viking 1 Sols 1 to 116.

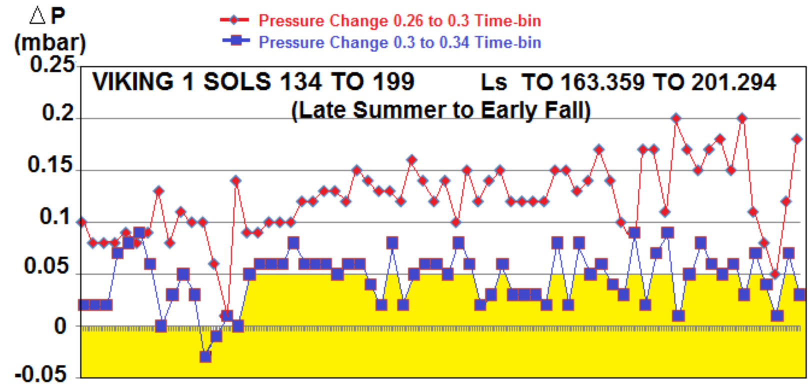


Figure 16B – Viking 1 Sols 134 to 199 (no data available for Sols 117 to 133)

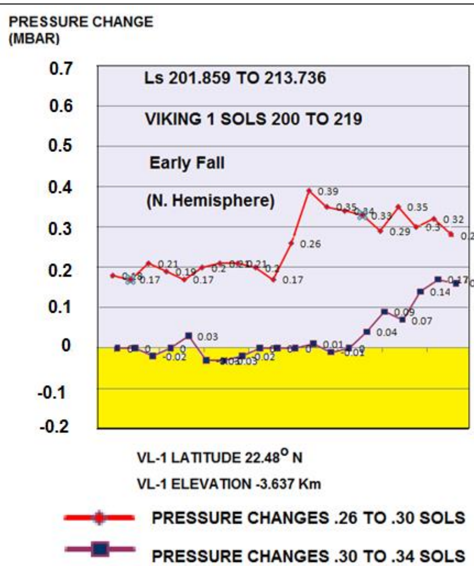


Figure 16C – Viking 1 Sols 200 to 219

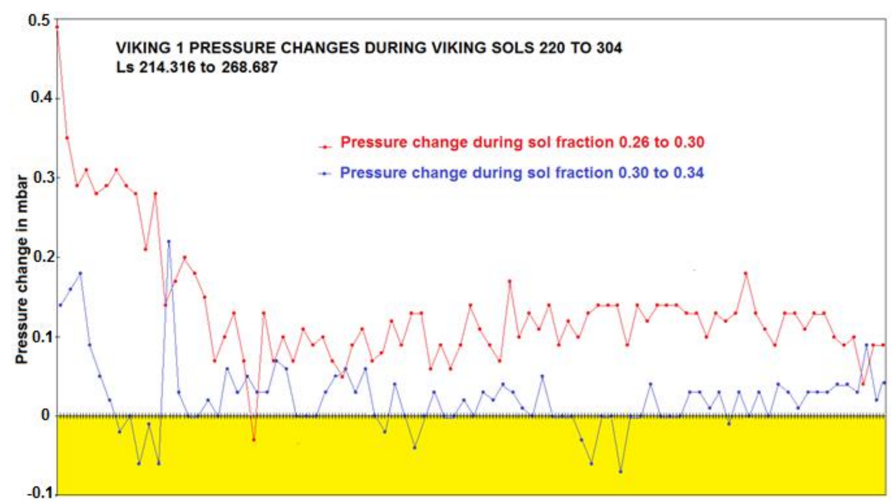


Figure 16D – Viking 1 Sols 220 to 304

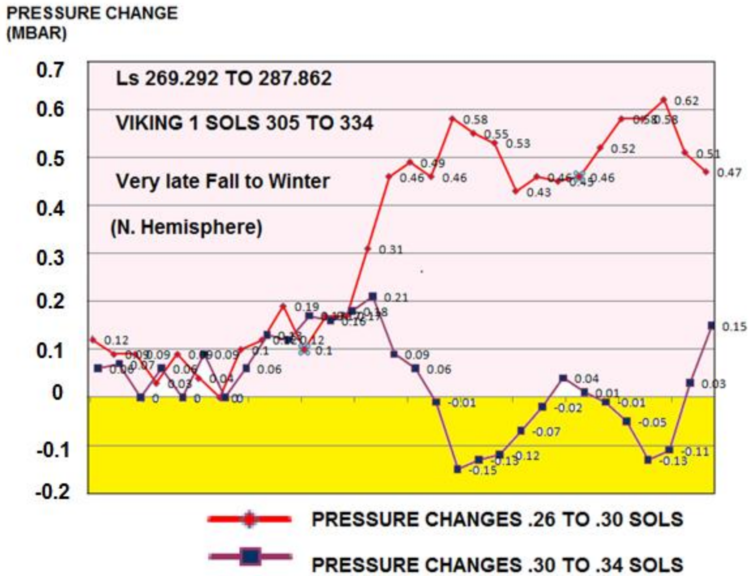


Figure 16E – Viking 1 Sols 305 to 334

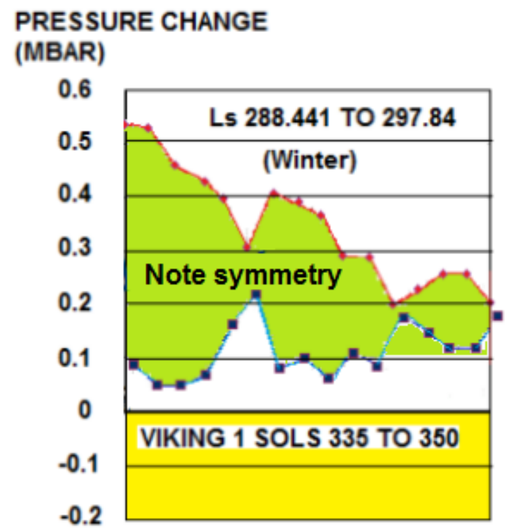


Figure 16F – Viking 1 Sols 335 to 350

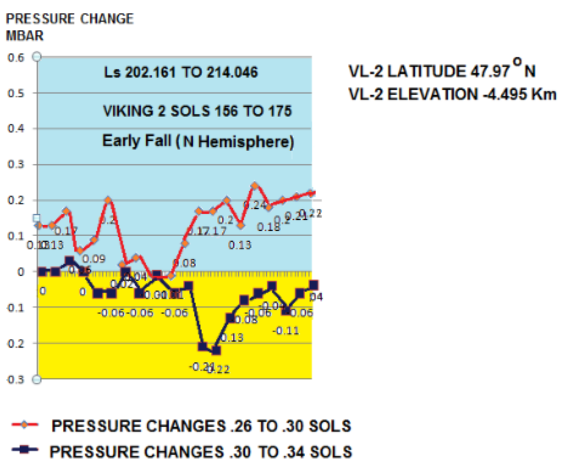


Figure 16G – Viking 2 Sols 156 to 175

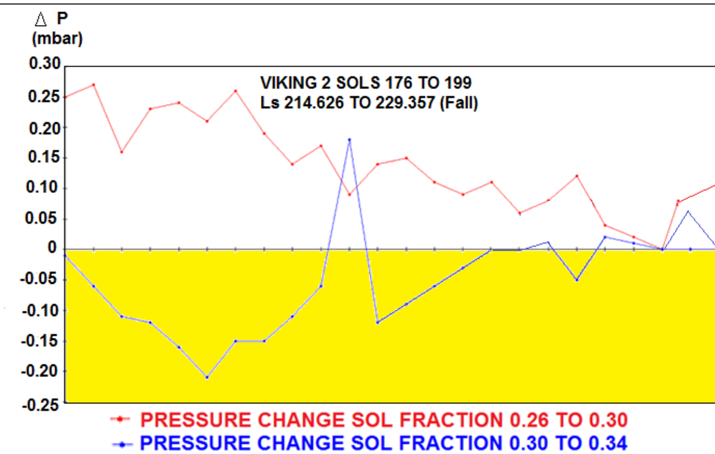


Figure 16H – Viking 2 Sols 176 to 199

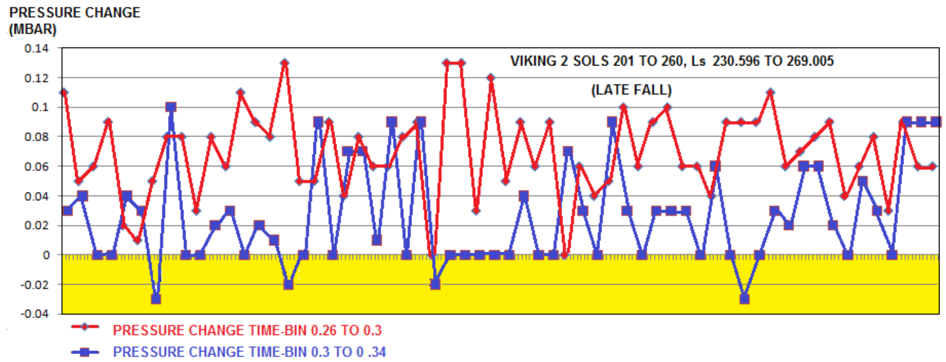


Figure 16I – Viking 2 Sols 201 to 260 (no pressure for Sol 200 available)

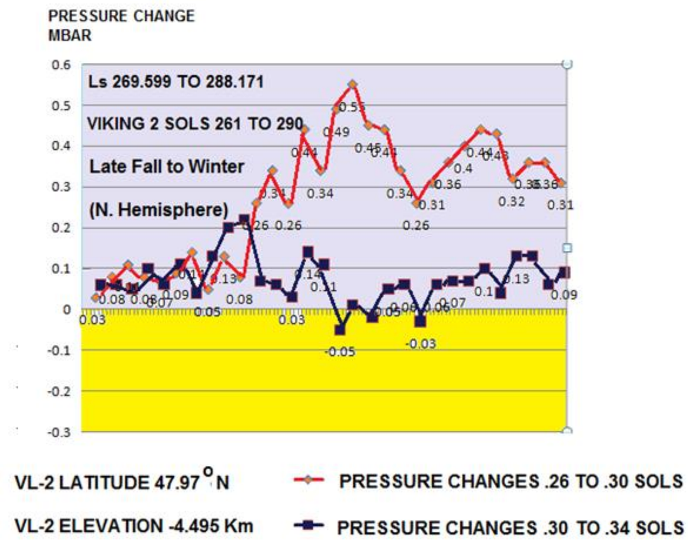


Figure 16J – Viking 2 Sols 261 to 290

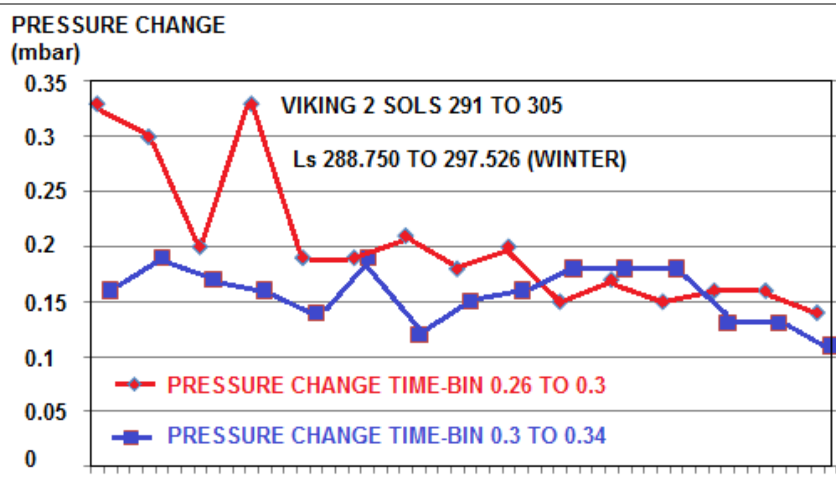


Figure 16K – Viking 2 Sols 291 to 305

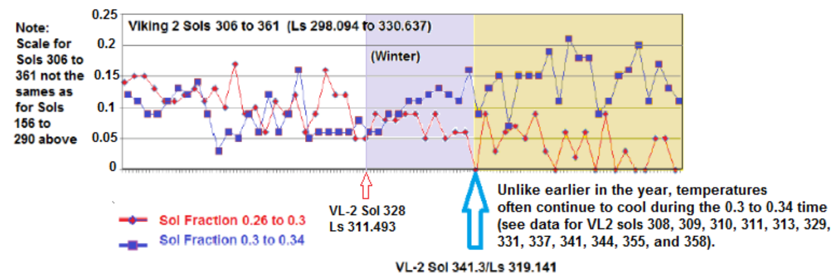


Figure 16L – Viking 2 Sols 306 to 361

TABLE 5 – VIKING 1 (Latitude 22.8º North) PRESSURE AND TEMPERATURE CHANGES TIME-BINS 0.26 TO .3 AND .3 TO .34 SOLS 1 TO 116 AND 134 TO 350							
SEASON	**SOLS**	**Ls 0 to 89.99 = Spring; 90 to 179.99 = Summer; 180 to 269.99 =Fall; 270 to 360 (0) = Winter**	**Average ΔP Time-bin 0.26 to 0.3 (mbar)**	**Average ΔP Time-bin 0.3 to 0.34(mbar)**	**Average Temperature °C for both 0.26 to 0.3 and 0.3 to 0.34 time-bins**	**Average ΔT Time-bin 0.26 to 0.3 (mbar)**	**Average ΔT Time-bin 0.3 to 0.34(mbar)**
Summer	**1-116**	**97.288-153.675**	**+0.0232**	**+0.0104**	**-70.3115**	**+13.7217**	**+12.7851**
Summer	**117-133**	**153.676-163.58**	Data Missing from Viking Project				
Summer-Fall	**134-199**	**163.359-201.294**	**+0.1224**	**+0.0459**	**-71.3448**	**+11.4991**	**+11.454**
Fall	**200-219**	**201.859-213.736**	**+0.2560**	**+0.0300**	**-75.64**	**+6.897**	**+8.16**
Fall	**220-304**	**214.316-268.687**	**+0.1362**	**+0.0231**	**-85.57**	**+2.1648**	**+5.8447**
Later Fall to Winter	**305-334**	**269.292-287.862**	**+0.3257**	**+0.0297**	**-86.56**	**+0.5386**	**+1.731**
Winter	**335-350**	**288.441-297.84**	**+0.3486**	**+0.1144**	**-88.225**	**+0.4119**	**+0.4569**

Table 5 – For Viking 1 Year 1, there was a larger pressure increase in the 0.26 to 0.3 time-bin than in the 0.3 to 0.34 time bins. From Sols 134 on, the magnitude of pressure increases in the first time bin was much greater than pressure drops associated with Martian dust devils. Both time-bins showed temperature increases. The amount of the temperature increases grew smaller from summer to winter, with slightly larger increases in the early time-bin in the summer and early fall, and slightly greater increases in the second time-bin from Viking 1 sol 200 onward.

TABLE 6: VIKING 2 (latitude 47.97º North) PRESSURE AND TEMERATURE CHANGES TIME-BINS 0.26 TO .3 AND .3 TO .34, SOLS 156 TO 361							
SEASON	**SOLS**	**Ls 0 to 89.99 = Spring; 90 to 179.99 = Summer; 180 to 269.99 =Fall; 270 to 360 (0) = Winter**	**Average ΔP Time-bin 0.26 to 0.3 (mbar)**	**Average ΔP Time-bin 0.3 to 0.34 (mbar)**	**Average Temperature °C for both 0.26 to 0.3 and 0.3 to 0.34 time-bins**	**Average ΔT °C Time-bin 0.26 to 0.3 (mbar)**	**Average ΔT °C Time-bin 0.3 to 0.34 (mbar)**
Early Fall	**156-175**	**202.161-214.046**	**+0.1260**	**-0.0605**	**-94.9583**	**+1.705**	**+4.689**
Fall	**176-199**	**214.626-229.357**	**+0.1382**	**-0.0504**	**-101.112**	**+1.0942**	**+3.05**
Later Fall (No Pressure data on sol 200)	**201-260**	**230.596-269.005**	**+0.0698**	**+0.0265**	**-108.66**	**+0.3897**	**+1.3195**
Late Fall to Winter	**261-290**	**269.599-288.171**	**+0.2773**	**+0.0737**	**-109.153**	**+0.931**	**+0.6193**
Winter	**291-305**	**288.750-297.526**	**+0.2040**	**+0.1567**	**-111.0824**	**+0.1667**	**+0.2573**
Winter	**306-328**	**298.094-311.493**	**+0.1161**	**+0.0874**			
Winter	**329-361**	**312.041-330.637**	**+0.0491**	**+0.1282 (First larger pressure increase in this time-bin)**			
Winter (last 2 rows combined).	**306-361**	**298.094-330.637**	**+0.0766**	**+0.1114**	**-110.275**	**-0.0884**	**+0.9902**

Table 6 – With the exception of Sols 329 to 361, for all time-bins examined for Viking 2 Year 1, there was a larger pressure increase in the 0.26 to 0.3 time-bin than in the 0.3 to 0.34 time bins. Note: This study includes increased cooling rather than warming in the 0.3 to 0.34 time-bins on 12 sols. As the heater is needed more, pressures increase more during sols 329 to 361 in the later time-bin than in the earlier 0.26 to 0.3 time bin.

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2.7. *MSL Weather Reporting Fiasco*.

The MSL REMS Team initially put out continually flawed data at http://cab.inta-csic.es/rems/marsweather.html. The REMS Team went from listing the pressure on August 28, 2012 as 7.4 hPA (mbar) and the month as **3** when it was really month **6**; to a September 1, 2012 pressure of 742 hPa (Earth-like, seen in much of the U.S. West every day) in month **3** to 743 hPa pressure for September 2, 2012 which was correctly listed as month **6**. Between September 5 and 6, 2012 reported pressures dropped from 7.47 **hPa** to 1% of that – 7.47 **Pa**. See Figure 17A.

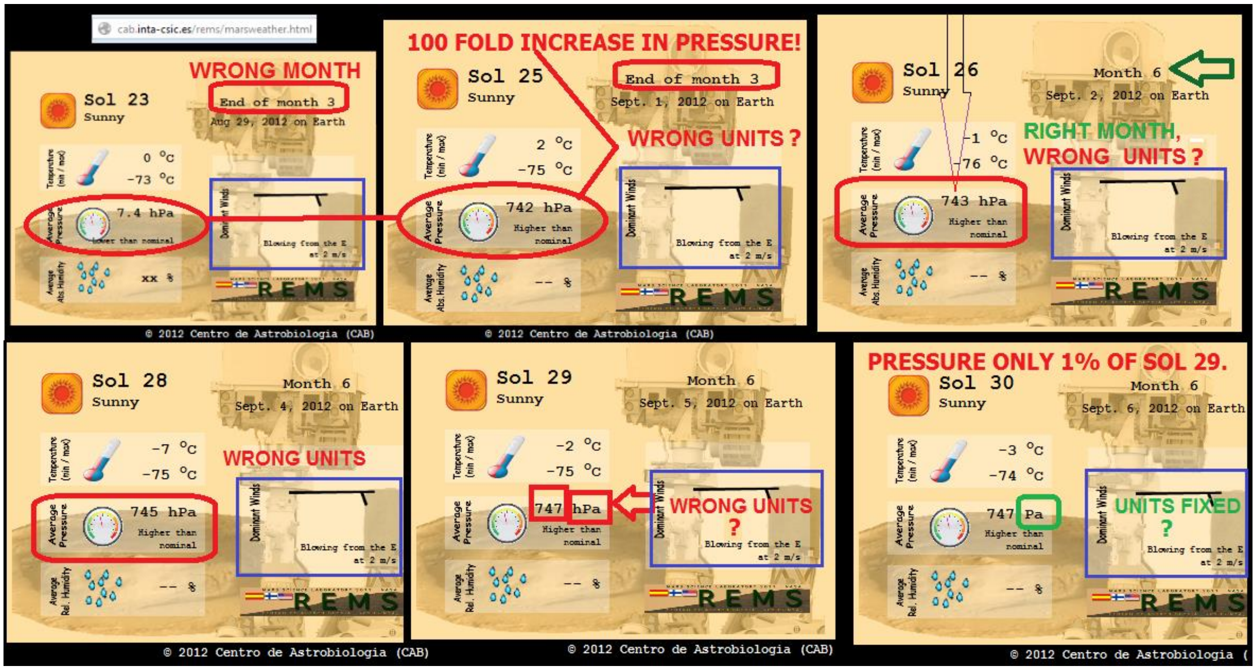


Figure 17A: REMS data confusion: For the first 2 months the Rover Environmental Monitoring Station (REMS) Team at the Centro de Astrobiologia in Spain was confused about Martian month and pressure units. From September 1 to 5, 2012, they reported terrestrial-like pressures of over 740 hPa (mbar); then dropped back to similar numbers but with Pa. All winds were erroneously reported as 2 m/s (7.2 km/h).

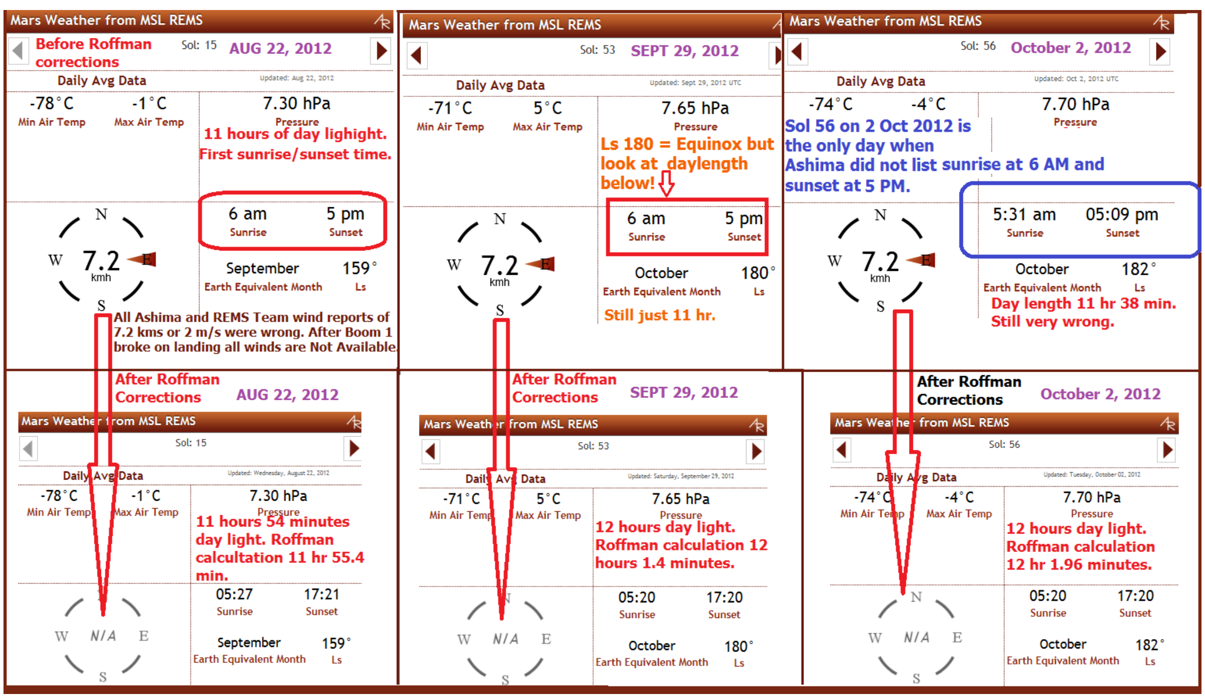
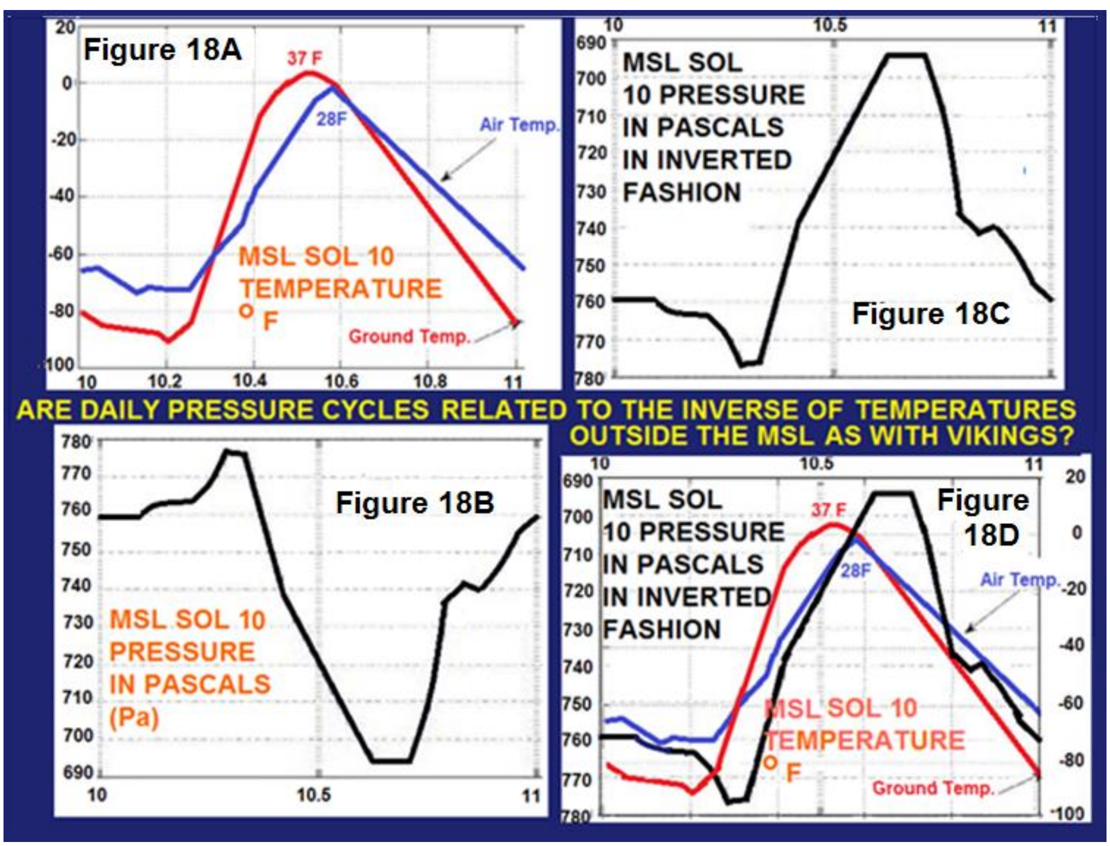


Figure 17B: At least until April 3, 2013 winds were always stuck at 2 m/s from the east and no relative humidity was reported, however in May, 2013 they and Ashima Research altered all report winds to show wind as not available ever (due to damage suffered to Boom 1 on landing). Sunrise/sunset times were radically altered to line up with calculations done by David Roffman at http://davidaroffman.com/photo4_26.html.

Until July 3, 2013 we knew that over the preceding year the REMS Team and Ashima Research had put out clearly erroneous winds, sunrise and sunset times, pressure units, dates on their reports, months and claims about relative humidity that were not reflected on their reports. We (wrongly) assumed however that at least the temperature reports were reliable. That assumption was demolished on July 3, 2013 when they revised all temperatures back to the landing, wiping out scores of days where they had claimed high air temperatures above freezing. See Table 20 in Section 15.

The 7.4 hPa pressure seen on Figure 17A for Sol 23 was totally consistent with Viking 1 and 2 pressures shown on Figure 12B. This does not mean we accept the 7.4 to 7.47 hPa pressure range on Figure 17A as being correct. We do not. We expected that the same type sensor, delivered to JPL at the same time as Phoenix, would produce similar results on MSL. One reason that we are suspicious (other than JPL changing some of its pressure data to meet our concerns as was highlighted on Table X in Section 2.4) is that as was the case with the Vikings, there was an inverse relationship between daily pressure and temperature. This is shown on Figures 18A to 18D below.



Figures 18A to 18D show that with MSL there was an inverse relationship between claimed ambient temperatures and pressures again.

3. CAVES ON AND SPIRAL CLOUDS ABOVE ARSIA MONS AND OLYMPUS MONS ON MARS.

Cushing and Wynne (2007) proposed that photos from the Mars Odyssey mission reveal football-field size holes (see top of Figure 19) that could be entrances to caves on Arsia Mons.[38A] The seven suspect caves ranged from 100 to 251 meters wide and 130 meters deep. The claim that they are caves is based on an analysis of photographs from the Thermal Emission Imaging System aboard NASA's Mars Odyssey orbiter. The dark spots don't look like impact craters since they lack raised rims or blast patterns. In 2012 JPL released a photo of a hole on Pavonis Mons, with the floor of a cavern visible about 20 meters below (see right side of Figure 19).

The dust devil issue here is whether drafts rising from inside these caves on Arsia Mons could serve as the cause of the dust devils that are seen even at 17 km there. Temperatures in these features are warmer than the outside air at night and cooler during the day. Dust devils are not the only feature spiraling up from Arsia Mons. As seen on Figure 20, the Jet Propulsion Laboratory states that:

> Just before southern winter begins **(NOTE: This is in error, JPL should have indicated just before southern spring begins),** sunlight warms the air on the slopes of the volcano. This air rises, bringing small amounts of dust with it. Eventually, the rising air converges over the volcano's caldera, the large, circular depression at its summit. The fine sediment blown up from the volcano's slopes coalesces into a spiraling cloud of dust that is thick enough to actually observe from orbit. The spiral dust cloud over Arsia Mons repeats each year, but observations and computer calculations indicate it can only form during a short period of time each year. Similar spiral clouds have **not** been seen over the other large Tharsis volcanoes, but other types of clouds have been seen... The spiral dust cloud over Arsia Mons can tower 15 to 30 kilometers (9 to 19 miles) above the volcano.[38B] However, while I was producing an updated version of this report, I checked my link to Figure 20 and found that JPL had added an image of a similar storm on Olympus Mons at an altitude of over 21 km above areoid.

Arsia Mons is at 9° South. With respect to the season, southern spring begins at Ls 180. It extends to Ls 270. Ls 90 to 179.9 is southern winter. Figure 20 shows these storms between Ls 150.4 and 180. They are therefore between the late winter and the first day of spring, but the storm over Olympus Mons in the northern hemisphere at Ls 152.6 is in late summer. Figure 20 shows structures analogous to the eye walls of small hurricanes associated with the spiral clouds. They are about 10 km across and appear quite vigorous on Arsia Mons and about 7 km across at Olympus Mons. These pictures were taken just before when planetary pressures should be near minimums. At such high altitude, there shouldn't be enough pressure differentials to drive these storms if NASA is right, but they are plainly wrong.

Figure 19– Left: Seven black spots like the one above on Arsia Mons may be caves or just pits. Images were taken from the Thermal Emission Imaging System aboard NASA's Mars Odyssey orbiter reproduced from **http://www.planetary.org/blogs/emily-lakdawalla/2007/1114.html**. Right: Opening to Pavonis Mons discovered in 2012. The floor of the cavern is ~20 meters deep. Source: **http://hirise.lpl.arizona.edu/ESP_023531_1840**

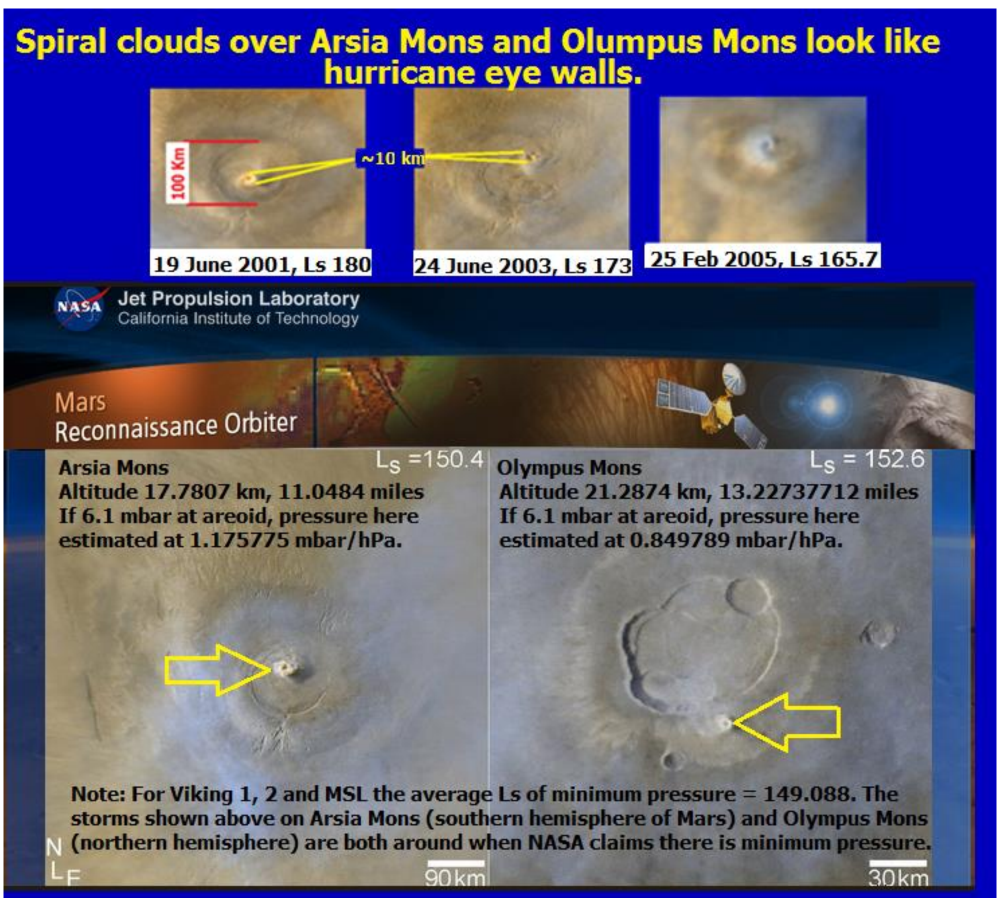


Figure 20: Spiral clouds over Arsia Mons and Olympus Mons adapted from http://photojournal.jpl.nasa.gov/catalog/PIA04294 and http://mars.jpl.nasa.gov/mro/multimedia/images/?ImageID=894&NewsInfo=59C884BFF2B8E0EDCEDF15F64B98BC57A54F95914A0576D9DF4145F3BFA98ECDCED7889AA9

4. THE ISSUES OF SNOW, WATER ICE, AND CARBON DIOXIDE ON MARS.

Phoenix captured snow on Mars. This was not unexpected. Richardson et al. (2002)[39] discussed snow on Mars before it was seen by Phoenix, but they declared that in order to get a good fit to all other data, cloud ice particle sizes must be used that are about an order of magnitude too large (that is, 20 µm rather than the 2 µm observed).

They state that "significant work remains to be done assessing the quality of GCM predictions of Martian circulation vigor and resultant tracer transport." They concede the need to bump up ice particle size to levels that are "unrealistically large." While they were not specific about why the ice particles need to be so much bigger than those seen, it would make sense that if pressure were as low as advertised by NASA, the 2 µm ice particles would sublimate back into the atmosphere before the snow could fall, but that at 20 µm it could survive to hit the surface at such low pressures. If so, it follows that 2 µm ice particles survive because in fact the pressure is much higher than NASA has been telling us. Wherever we look at the weather plainly seen on Mars; it fails to match pressures under 10 mbar.

On August 21, 2017 a new study (with lead author Aymeric Spiga, of the University of Pierre and Marie Curie in Paris – see http://www.nature.com/ngeo/journal/vaop/ncurrent/full/ngeo3008.html?foxtrotcallback=true) noted that previous research suggested that if snow did fall from Martian clouds, it would waft down very slowly.[118] "We thought that snow on Mars fell very gently, taking hours or days to fall 1 or 2 kilometers [0.6 to 1.2 miles]." Now, Spiga et.al found that, "Snow could take something like just 5 or 10 minutes to fall 1 to 2 km [0.6 to 1.2 miles]." The researchers were analyzing data from Mars Global Surveyor and Mars Reconnaissance Orbiter when they noticed a strong mixing of heat in the Martian atmosphere at night "about 5 km from the surface," Spiga said. "This was never seen before.

"You expect heat to get mixed in the Martian atmosphere close to the surface during the daytime, since the surface gets heated by the sun," Spiga explained. "But my colleague David Hinson at Stanford University and the SETI Institute saw it higher up in the atmosphere and at night. This was very surprising." The scientists discovered that the cooling of water-ice cloud particles during the cold Martian night could generate unstable turbulence within the clouds.

"This can lead to strong winds, vertical plumes going upward and downward within and below the clouds at about 10 meters [33 feet] per second," or about 22 mph (36 km/h), Spiga said. "Those are the kinds of winds that are in moderate thunderstorms on Earth." Here again, the more we study Mars, the more it looks like Earth.

4.1. Annual Pressure Fluctuations Recorded by Viking 1, Viking 2, and Phoenix - Maximum Pressure in the Northern Winter?

Leighton and Murray postulated that the Martian polar caps, largely carbon dioxide, control the average atmospheric pressure on Mars.[40] They wrote this a decade before Viking 1 touched down on Mars. Supposedly CO_2 freezes out of the atmosphere at the poles in winter. This drops air pressure. However, it appears from Figure 21B that air pressure actually increased in the Northern hemisphere's winter.

The usual response is that the increase in pressure is caused by what was frozen carbon dioxide at the South Pole subliming due to the arrival of summer there. Viking 1's latitude was 22.8º North (still *tropics* on Mars), but Viking 2 landed at about 48º North, much closer to the North Pole, yet pressures there were still higher in winter although CO_2 should freeze out at the North Pole in its winter.

4.1.1. Ls of minimum pressure.

In conducting the research for this report, and most especially in seeing how our questioning of pressures reported by JPL seemed to cause JPL to alter those pressures (see Table X earlier) to match the Viking pressure curves shown on Figure 21B, it became apparent that to question the Viking pressure curves was tantamount to heresy in JPL eyes. These curves were primarily due to the efforts of Professor James Tillman at the University of Washington's Viking Computer Facility. In explaining the pressure curves Tillman wrote:

> "The first minimum of pressure, about sol 100 (aerocentric longitude (Ls) 145) corresponds to the maximum amount of carbon dioxide sublimation in the South Polar Region, while the second, about sol 434 (Ls 346), corresponds to northern winter. Because of the elipticity of the Martian orbit, the difference in the semiannual heating and cooling produces this semiannual difference in the amount of carbon dioxide in the polar regions."[41]

For absolute minimum pressure seen by landers on Mars, we now have 5 Martian years of data for the time around Ls 145 – one for Viking 1, two for Viking 2, and three for MSL. The (suspect) data is summed up on Table 7. Average Ls =148.44767. It appears that the latest minimum pressure (707 Pa) occurred at Ls 145 on MSL Sol 2665 on February 4, 2020.

4.1.2. Ls of maximum pressure.

For Vikings 1 and 2 there was only a variation of about two solar degrees (Ls 277.724 to Ls 279.93) between maximum pressures seen. But for MSL from its Year 1 to Year 2 the Ls of the maximum (non-revised) pressure of 925 Pa for Year 1 and 2 shifted from 252 to 257. The statement above was valid until Sol 1,160 when JPL temporarily altered an 897 Pa pressure at Ls 66 to 1,177 Pa (more than the pressure sensor on MSL was then rated to measure). They reported an even higher pressure (1200 Pa/12 mbar) for Sol 1,784 and higher still pressure for Sol 1,294 (1294 Pa). As we predicted they revised all three pressures down to 899, 898 and 883 Pa respectively. The pressure for Ls 66 in MSL Year 1 was 903 Pa. The three high pressures here can't be explained by having a decimal misplaced as was the case in September 1 to 5, 2012 when 742 to 747 hPa was altered to 742 to 747 Pa. Clearly the sol 1,160 and 1,161 high pressures are related to serious "personnel issues" within the NASA organization. The problem is captured on Figure 21A. For MSL Year 3, after four revisions, the surviving max pressure was 911 Pa on Sol 1517 @ Ls 259. Previous revisions were from 945 to 752 Pa and 1154 to 752 Pa (sols 1300 to 1301 at Ls 131), 921 to 910 Pa (sol 1492, Ls 242), and 928 to 907 Pa (Ls 249).

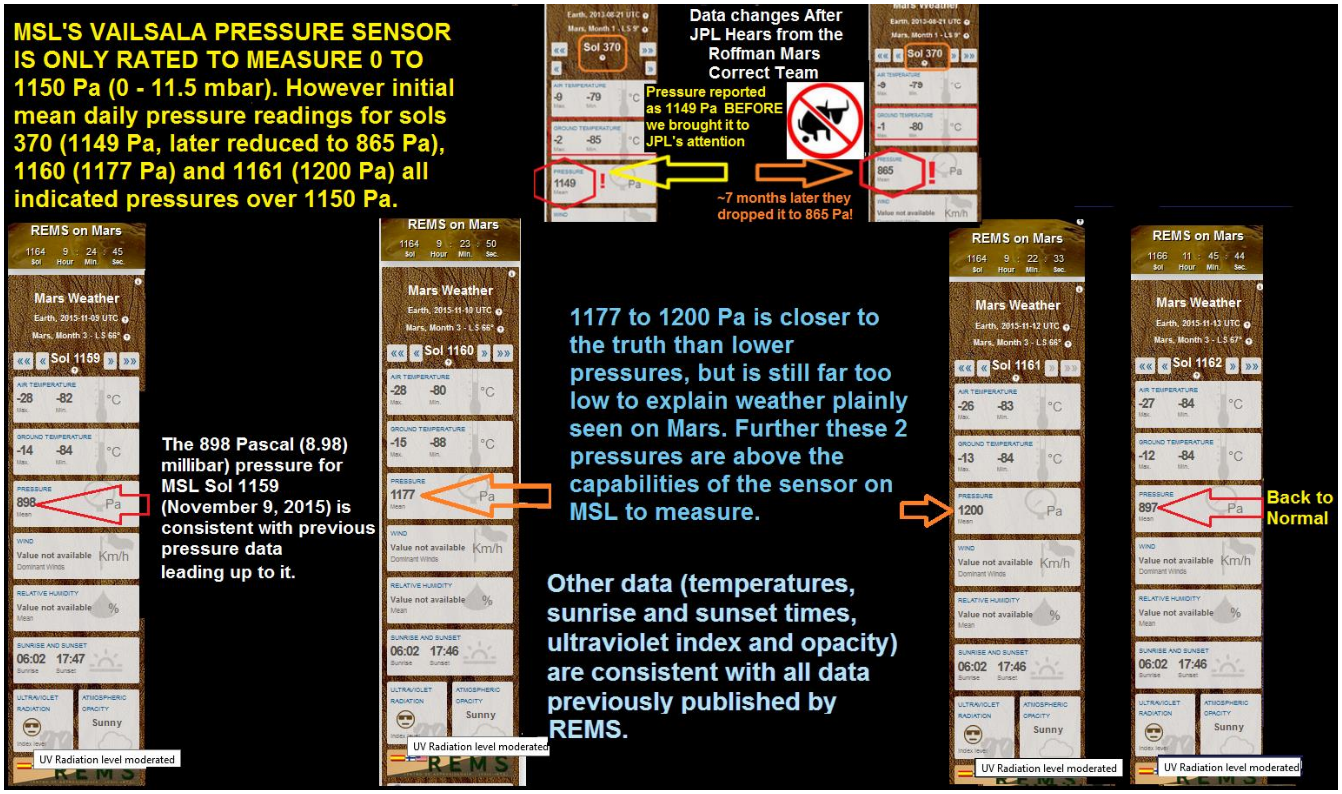


Figure 21A – 1,177 and 1,200 maximum pressures published exceeded the 1,150 Pa limit of the Vaisala pressure sensor on MSL. Later the REMS Team put out a pressure of 1,154 Pa for Sol 1301, but revised it to 752 Pa after we published a prediction at http://marscorrect.com/photo2_29.html that they would do so. High pressures are likely errors but they certainly point to personnel problems within the NASA/JPL/REMS Team organization.

Overlooking the pressures shown on Figure 21B, the total variation for Ls of maximum pressure is from Ls 257 (MSL Year 2) to Ls 279.93 (Viking 2). This is a difference of 22.93 solar degrees. See Table 8. Given the small variation in daily pressures from MSL Year 1 and 2 (about 2.5 Pa per sol with a standard deviation of about 2.115 Pa for the first 118 sols of MSL Year 2), the large variation for the sol of maximum pressure is somewhat surprising and may be another hint that the pressure measurements are flawed. There was **no variation in maximum pressure between MSL Year 1 and 2. Both were given as 925 Pa.**

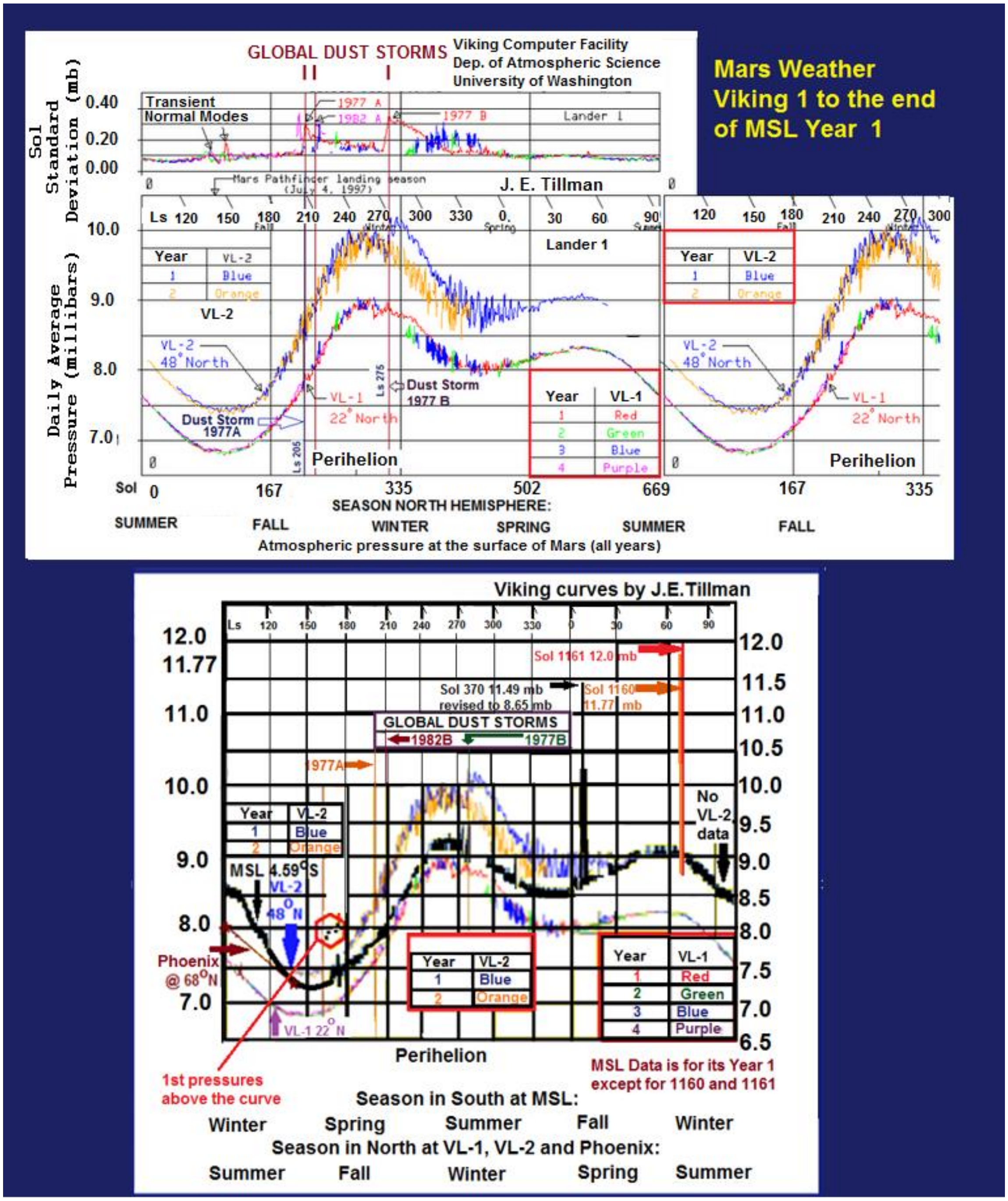


Figure 21B – The top and bottom curves show pressure fluctuations over 4 Martian years at Viking 1 and 2 sites. An approximation of the MSL data for its first year is in black between them (see Figure 23 for an accurate MSL pressure plot). On the left is a reproduction of the Figure 12A Phoenix data. The Phoenix and MSL data most closely matches Viking 2. Adapted from the Tillman, Viking Computer Facility, from Nelli et al., 2009, and from the REMS Team and Ashima Research. MSL and Phoenix carried similar Vaisala pressure transducers. We suspect that MSL pressures published were fudged approximations founded on the accepted Viking pressure curves shown above rather than legitimate pressure readings. The 11.49 mbar pressure for Sol 370 was removed by JPL after we made an issue about it. The 11.77 mbar , 12 mbar and 12.94 mbar pressures for Sols 1160, 1161 (November 10-12, 2015) and 1784 (August 13, 2017) all exceed the 11.5 mbar capability of the transducer on MSL, but they were reduced later.

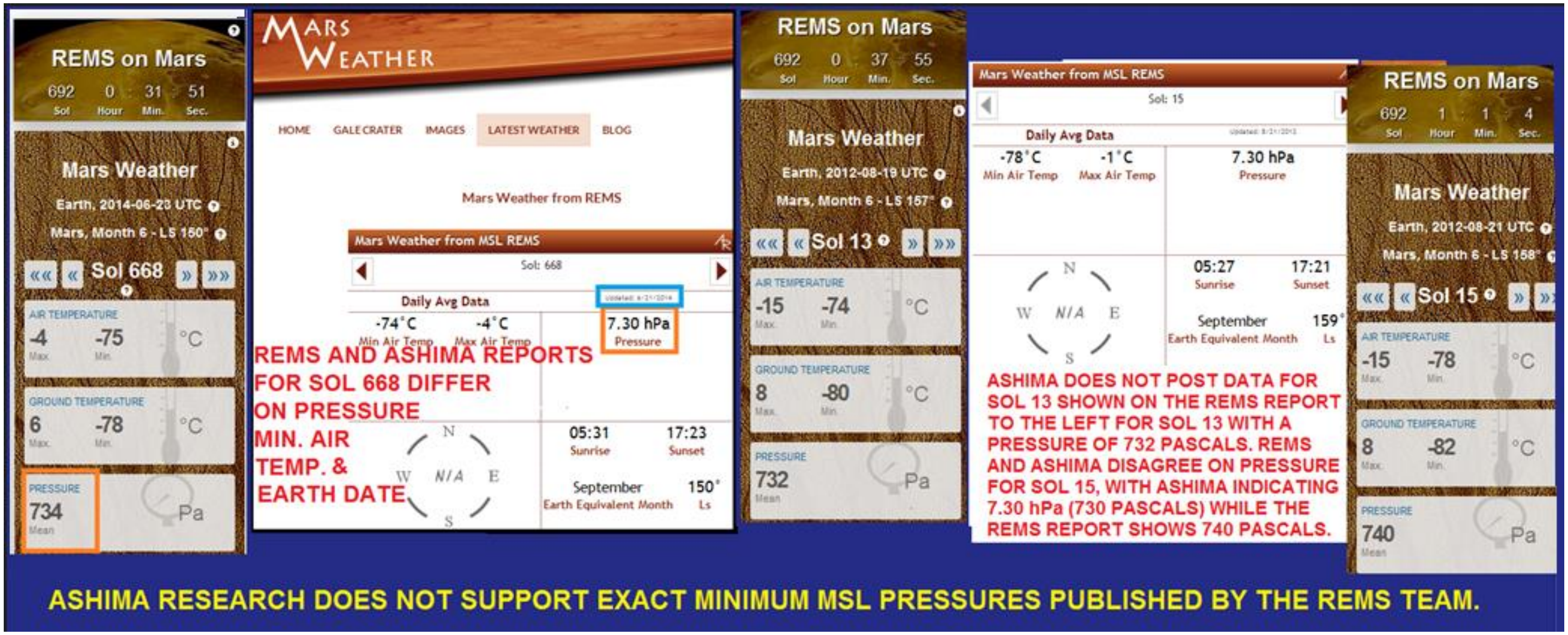


Figure 22A: There are many differences in the reports posted by the JPL REMS Team and Ashima Research before they ceased publication. Ashima claimed it took its data directly from MSL REMS. For Sol 668 REMS lists the pressure at 734 Pa with the Ls 150. Ashima showed 7.30 hPa (730 Pa) but gave the Earth date as June 21, 2014 rather than June 23, 2014.

At the start of the MSL mission the REMS made several changes to its data, but now shows a pressure of 732 Pa on Sol 13. (August 19, 2016) Ashima Research did not replicate that data on its site.

For Sol 15 (Ls 158) as of February 26, 2021 shows a pressure of 740 Pa while Ashima last listed the pressure for Sol 15 at 730 Pa. The Sol 15 reports agree about date (August 21, 2012), however REMS shows the Ls at 158 and Ashima showed it as a 159. An on-line calendar at http://www-mars.lmd.jussieu.fr/mars/time/martian_time.html shows that the sol started at Ls 158.3 While both REMS and Ashima listed the minimum air temperature as -78° C, they disagreed about maximum air temperature with REMS listing it as -15° C and Ashima posting -1° C.

TABLE 7 – Pressures at Ls 90 and minimum pressures seen by VL-1, VL-2 and MSL				
Lander	Year	Mbar pressure at Ls 90	Mbar Minimum Pressure	Ls of Min.
VL-1	Year 1	N/A (7.51 at Ls 97)	6.51	150.156
VL-2	Year 1	N/A (7.72 at Ls 118)	7.29	145
VL-2	Year 2	N/A (8.06 at Ls 100)	7.27	148.48 and 155.393
MSL	Year 1 (June 13, 2014)	8.56	*7.30 on Sol 1 changed to N/A. Then 7.32 on Sol 664	150 changed to N/A. Then Ls 147.
MSL	Year 2 (May 7 to 9, 2016)	8.50	7.32 on Sols 1334, 1335 and 1336.	Ls 148 to 149
MSL	Year 3 (March 25, 2018)	8.32	7.15 on Sol 2002	148
MSL	Year 4 (February 4, 2020)	8.29	7.07 on Sol 2665 on 4 Feb 2020	145
Average Ls of minimum				148.44767

Table 7: *Originally JPL published a pressure of 7.05 mbar for Sol 1 at Ls 150, and 7.18 mbar for Sol 9 at Ls 155, however they later changed these pressures to N/A. VL- 1 and VL-2 data from http://www-k12.atmos.washington.edu/k12/resources/mars_data-information/data.html.

Since there is no ocean on Mars to slow the time of maximum cooling it would seem like the coldest time in the southern hemisphere would be at Ls 90, yet we see that minimum pressures can occur over 65 degrees later as Mars moves through its 360 degree orbit of the sun. If the average minimum pressure seen at Ls 149 is correct, that's just 31 degrees short of spring in the southern hemisphere at Ls 180.

As is indicated on Table 7, the data available to the public from the Viking Computer Facility (and Professor Tillman) lacks information about Ls 90 for both Vikings. However for Viking 1 there was a 1 mbar decrease in pressure from Ls 97 to Ls 150.156 (7.51 mbar down to 6.51 mbar). For Viking 2 Year 1 pressure decreased 0.43 mbar from Ls 118 to Ls 145 and for Viking 2 Year pressure decreased 0.769 mbar from Ls 100 to Ls 148.48 and 155.393. These Figures are based on essentially hourly temperature readings (25 per sol). For MSL we only have questionably revised daily average pressures, but from Ls 90 to Ls 147 there was a decrease of 1.25 mbar in Year 1 and 1.17 mbar in Year 2. What kind of pressure difference should we expect just due to the difference in elevation of Vikings 1, Viking 2 and MSL?

TABLE 8 – Landers and Expected Pressures Based on Landing Altitude								
Lander	Km below areoid	Elevation below VL – 1	Expected Average pressure based on 6.1 mbar at areoid/scale height of 10.8	Expected pressure increase from VL-1 (mbar)	Minimum pressure stated.	Max. pressure stated (after MSL revisions removing 12.94, 12, 11.77, 11.49, 9.54, 9.4, 9.37 and 11.67 mbar).	Average of high and low pressures	Pressure increase from VL – 1
VL -1	-3.627	N/A	8.535 mbar	N/A	6.51 @ Ls 150.156	9.57 @ Ls 277.724	8.04	N/A
MSL Year 1	-4.4	0.773	9.168 mbar	0.633	7.32 @ Ls147-148	9.25 @ Ls 252	8.285	0.245
MSL Year 2	-4.4	0.773	9.168 mbar	0.633	7.32 @ Ls 1334-1336	9.25 again @ Ls 257	8.285	0.245
MSL Year 3	-4.159	0.532	8.926 mbar	0.633	7.15 @ Ls 148	9.11 @ Ls 259	8.13	0.09
MSL Year 4	-4.109	0.482	8.924	0.633	7.07 @ Ls 145	Not available	N/A	N/A
VL – 2	-4.502	0.875	9.257 mbar	0.722	7.27 @148.48 and 155.393	10.72 @ Ls 279.93	8.995	0.955
MSL Year 5	-4.128	0.501	8.9397mbar	0.4047	7.07@ Ls 145	8.96 @ Ls 256	8.015	-0.025

Table 8 – Landers and Expected Pressures Based on Landing Altitude. *Originally JPL published a pressure of 7.05 mbar for Sol 1 at Ls 150, and 7.18 mbar for Sol 9 at Ls 155. See Table 7 notes.

Using a scale height of 10.8, and an average pressure of 6.1 mbar at areoid, the average annual pressure at Viking 1 should be about 8.535 mbar, while for Viking 2 we would expect about 9.257 mbar. The difference is 0.722 mbar (see Table 2 earlier in this report). Viking 2 is estimated to have landed at 48.269° North (there are slight differences published for this figure), whereas (see Table 9), it got much colder (down to -117.34° C/155.81K in Year 2) on the winter solstice (Ls 270°) than what was experienced at Viking 1 (-95.14° C/ 178.01K in year 1), which landed in the tropics at 22.697° North. These temperatures are still too warm for snow to fall as frozen carbon dioxide. The temperatures required for that is supposedly -128° C (145.15K) or colder, which is associated with a latitude of 70º N or higher.[42] How long would there be no daylight at all at 70º N or S?

Annex L shows how day length varies with Ls and latitude on Mars. For the southern hemisphere at 70º S there is no sunrise from Ls 54.2 until Ls 125.9. For MSL Year 1 this was from November 24, 2013 to May 5, 2014 (157 Martian sols); and for Year 2 it was from October 15, 2015 to March 22, 2016. Further south time in darkness lengthens. Due to the eccentricity of the Martian orbit, the spans of darkness are not the same at both poles. Martian months, each 30º of Ls position apart, vary from 46 sols at perihelion to 66 sols to aphelion. The South Pole is in cold darkness for 371 sols while the North Pole is dark for 297 sols, a difference of 74 sols. After May 5, 2014 (Ls 125.9) at 70º S sunlight shines at that latitude and daylight lengthens between there and the Antarctic circle at 64.81º S, and yet MSL data backs Viking 1 and 2 data showing a decrease in worldwide pressure on Mars until at least Ls 145 – all supposedly due to carbon dioxide freezing at the South Pole.

Figure 22B - REMS plays games with the minimum pressure so far for MSL Year 3 on Sol 2002.

On May 5, 2014 pressure at MSL was listed as 7.65 mbar. At Ls 145 pressure was down to 7.35 mbar. It actually went down after that to 7.30 mbar on Sol 668 at Ls 150. But weather data at the beginning of the MSL mission was later revised a lot. While later altered to N/A, originally the REMS Team published a pressure of 7.05 mbar for Sol 1 at Ls 150, and 7.18 mbar for Sol 9 at Ls 155.

For MSL Year 3, on April 2, 2018, it looked like minimum pressure occurred at Ls 148 on March 25, 2018. The pressure was down to 7.15 mbar according to the REMS Team, however before posting this figure they had first published a pressure of 11.67 mbar (1,167 Pa) which we had mocked on our site. In fact, back on February 28, 2018 we predicted that on March 25, 2018 the REMS Team would publish a fake pressure of about 711 to 713 Pa on March 25, 2018. When they posted 1167 Pa, a pressure higher than an unaltered pressure that they allowed for the 2,001 sols before it, it looked like they were just playing with us directly. In short, we are saying that the REMS Team *knows* its data is fictitious, and they figure that nobody else who is important to them had the brains, nerve, or political inclination to call them on it. After NASA read our Figure 22B top cartoon, they altered their data. We document their **Sol 2002 folly** game on this issue at http://davidaroffman.com/photo5_19.html.

For Viking 1 (22.697° North) looking at hourly pressures for the days around Ls 125.9 pressures were between 6.84 and 7.05 mbar. By Ls 145 the pressures for the day around then were down to between 6.68 and 6.96 mbar.[43] For Viking 1 the minimum pressure (6.51 mbar) actually did not occur until Ls 150.156. **That's over 60 degrees of solar longitude past the winter solstice.**

For Viking 2 the hourly pressures for the sol around Ls 125.9 pressures were between 7.56 and 7.64 mbar, however as is addressed in great detail in Annex C to this Report (see **http://marscorrect.com/ANNEX%20C%209%20September%202013.pdf**), pressures do not appear to be reliable because they were generally stuck at 7.64 mbar. Annex C (pages C-18 to C-19) shows that in Viking 2 pressures were also stuck at Ls 125, but the pressure it was stuck at was 7.56 mbar, however due to data digitization (discussed in Section 2.6.1 and Table 4B of this report), pressures between 7.56 and 7.64 were generally not published (and if they were they were based on interpolation rather than actual transmitted data).

For Viking 2, (at about 48º North) Ls 145 on Year 1 pressures were down to between 7.29 and 7.47 mbar. The 7.29 mbar pressure was reported for Ls 145.745 and it was the lowest pressure observed for Viking 2 in Year 1. For Viking 2 at Ls 145 pressures were stuck at 7.38 mbar (see page C-40 in Annex C to this report) for part of the Ls, but were often stuck at 7.47 mbar, the same pressure given for Viking 2 Year 1 at this Ls.[44] **For Viking 2 Year 2 the minimum pressure of 7.27 mbar was observed at Ls 148.48 and again as late as Ls 155.393, over 65 degrees past winter solstice**. Read and Lewis note that, "the thermal inertia of the surface… takes some time to change its temperature and tends to lag behind the seasonal movement of the subsolar point," but this much of a lag, given no ocean (at least on the surface), is enough to suggest that carbon dioxide at the poles is not the root cause of pressure fluctuations, assuming that pressure readings are not distorted by inadequately designed pressure transducers. At this Ls 155.393 at a latitude of 70º South where it is supposed to get cold enough for carbon dioxide to solidify in the winter there are already more than 8.4 hours of daylight each day.

However at 80º South there is no sunrise until about Ls 155.5 (see Table 10). The actual permanent polar ice cap is much further south, not centered on the South Pole and only about 350 to 400 km in diameter, although the seasonal (mostly water ice) south polar cap is closely centered on the South Pole and covers the surface up to a latitude of 70º South.[45]

VIKING 1 YEAR 1 WEATHER Ls 270.005 TO 270.957

Year	Solar Longitude L s (deg.)	Sol	Wind Speed m/sec	Wind Dir deg.	Pressure mb (Average 8.793 mb)	Temperature F.	Temperature C.
1	270.005	306.38	7.9	62	8.94	-111.75	-79.86
1	270.031	306.42	8.1	70	8.94	-93.01	-69.45
1	270.057	306.46	6.8	78	8.94	-78.99	-61.66
1	270.083	306.50	5.9	86	8.91	-69.98	-56.66
1	270.109	306.54	6.1	28	8.85	-65.37	-54.10
1	270.135	306.58	5.2	35	8.76	-61.91	-52.17
1	270.160	306.62	5.2	27	8.70	-64.69	-53.72
1	270.186	306.66	6.5	15	8.60	-71.43	-57.46
1	270.212	306.70	6.2	23	8.58	-80.11	-62.28
1	270.238	306.74	3.6	35	8.58	-95.43	-70.79
1	270.264	306.78	2.9	41	8.67	-107.87	-77.70
1	270.290	306.82	3.1	52	8.76	-112.77	-80.43
1	270.315	306.86	1.4	56	8.85	-118.33	-83.52
1	270.341	306.90	0.4	35	8.91	-119.52	-84.18
1	270.367	306.94	0.4	40	8.94	-123.09	-86.16
1	270.393	306.98	0.4	44	8.94	-124.84	-87.13
1	270.419	307.02	0.4	48	8.94	-127.24	-88.46
1	270.445	307.06	1.0	52	8.94	-130.29	-90.16
1	270.470	307.10	0.6	30	8.91	-131.03	-90.57
1	270.496	307.14	0.8	24	8.78	-135.68	-93.15
1	270.522	307.18	0.5	32	8.70	-136.71	-93.73
1	270.548	307.22	0.4	28	8.67	-135.86	-93.26
1	270.574	307.26	0.9	20	8.76	-139.25	-95.14
1	270.600	307.30	2.3	38	8.85	-138.68	-94.82
1	270.625	307.34	3.1	36	8.85	-129.42	-89.68
1	270.651	307.38	4.3	41	8.85	-108.31	-77.95
1	270.677	307.42	4.4	24	8.85	-89.56	-67.53
1	270.703	307.46	4.6	23	8.94	-77.34	-60.75
1	270.729	307.50	4.5	20	8.91	-69.42	-56.35
1	270.755	307.54	3.6	34	8.83	-60.63	-51.46
1	270.780	307.58	3.9	356	8.76	-56.85	-49.36
1	270.806	307.62	4.3	8	8.67	-59.90	-51.05
1	270.832	307.66	6.7	355	8.58	-66.38	-54.66
1	270.858	307.70	6.3	9	8.58	-78.08	-61.16
1	270.884	307.74	3.1	21	8.58	-94.38	-70.21
1	270.909	307.78	2.1	36	8.67	-108.63	-78.13
1	270.935	307.82	5.1	46	8.76	-111.03	-79.46
1	270.961	307.86	4.4	67	8.81	-115.54	-81.97
1	270.987	307.90	3.0	75	8.88	-120.24	-84.58

VIKING 2 YEAR 1 WEATHER Ls 270.013 TO 270.994

Year	Solar Longitude L_s (deg.)	Sol	Wind Speed m/sec	Wind Dir deg.	Pressure mb (Average 9.771 mb)	Temperature F.	Temperature C.
1	270.013	261.90	5.2	196	9.67	-151.87	-102.15
1	270.039	261.94	5.8	205	9.67	-153.74	-103.19
1	270.065	261.98	9.5	211	9.67	-156.15	-104.53
1	270.090	262.02	11.7	208	9.58	-158.62	-105.90
1	270.116	262.06	11.4	211	9.58	-161.81	-107.67
1	270.142	262.10	8.8	207	9.58	-164.16	-108.98
1	270.168	262.14	6.0	201	9.63	-165.50	-109.72
1	270.194	262.18	5.0	213	9.67	-163.77	-108.76
1	270.220	262.22	7.1	208	9.67	-167.15	-110.64
1	270.245	262.26	6.6	197	9.71	-167.30	-110.72
1	270.271	262.30	6.4	198	9.79	-169.19	-111.77
1	270.297	262.34	6.3	205	9.85	-169.31	-111.84
1	270.323	262.38	5.2	221	9.85	-169.20	-111.78
1	270.349	262.42	6.5	234	9.76	-162.99	-108.33
1	270.375	262.46	7.0	233	9.82	-157.45	-105.25
1	270.400	262.50	8.1	236	9.82	-152.84	-102.69
1	270.426	262.54	8.5	231	9.76	-149.06	-100.59
1	270.452	262.58	10.0	226	9.76	-146.06	-98.92
1	270.478	262.62	9.6	232	9.76	-147.71	-99.84
1	270.504	262.66	9.9	234	9.69	-152.70	-102.61
1	270.530	262.70	9.4	241	9.67	-158.04	-105.58
1	270.555	262.74	8.1	234	9.65	-162.45	-108.03
1	270.581	262.78	6.2	225	9.70	-166.00	-110.00
1	270.607	262.82	3.1	225	9.82	-167.22	-110.68
1	270.633	262.86	1.6	212	9.85	-166.81	-110.45
1	270.659	262.90	2.2	225	9.85	-172.50	-113.61
1	270.684	262.94	3.0	238	9.85	-171.15	-112.86
1	270.710	262.98	3.8	222	9.76	-170.86	-112.70
1	270.736	263.02	2.1	237	9.76	-171.45	-113.03
1	270.762	263.06	2.4	228	9.76	-172.21	-113.45
1	270.788	263.10	2.6	231	9.70	-172.71	-113.73
1	270.814	263.14	1.7	219	9.71	-170.81	-112.67
1	270.839	263.18	1.1	225	9.85	-163.44	-108.58
1	270.865	263.22	1.2	231	9.85	-163.07	-108.37
1	270.891	263.26	1.1	221	9.89	-167.78	-110.99
1	270.917	263.30	1.1	216	10.00	-165.37	-109.65
1	270.943	263.34	1.7	214	10.05	-163.71	-108.73
1	270.968	263.38	3.1	219	10.05	-163.64	-108.69
1	270.994	263.42	4.2	225	10.02	-163.39	-108.55

VIKING 2 YEAR 2 WEATHER Ls 270.014 TO 270.995

Year	Solar Longitude L_s (deg.)	Sol	Wind Speed m/sec	Wind Dir deg.	Pressure mb (Average 9.937 mb)	Temperature F.	Temperature C.
2	270.014	930.50	5.9	267	10.02	-168.30	-111.28
2	270.039	930.54	6.4	275	10.02	-162.13	-107.85
2	270.065	930.58	7.0	296	10.02	-157.58	-105.32
2	270.091	930.62	6.5	300	10.02	-156.50	-104.72
2	270.117	930.66	6.0	306	9.99	-163.07	-108.37
2	270.143	930.70	5.6	322	9.94	-169.08	-111.71
2	270.169	930.74	3.8	335	9.92	-174.59	-114.77
2	270.194	930.78	3.2	351	9.94	-174.41	-114.67
2	270.220	930.82	1.7	335	10.00	-175.05	-115.03
2	270.246	930.86	1.1	292	10.02	-175.04	-115.02
2	270.272	930.90	3.2	222	9.94	-178.08	-116.71
2	270.298	930.94	3.4	223	9.92	-176.12	-115.62
2	270.324	930.98	2.5	232	9.94	-175.72	-115.40
2	270.349	931.02	2.6	241	9.95	-177.97	-116.65
2	270.375	931.06	1.9	245	9.95	-179.21	-117.34
2	270.401	931.10	1.1	157	9.94	-169.37	-111.87
2	270.427	931.14	0.9	96	9.94	-172.05	-113.36
2	270.453	931.18	1.1	135	9.96	-168.47	-111.37
2	270.479	931.22	1.2	135	10.02	-169.10	-111.72
2	270.504	931.26	1.4	141	10.11	-168.90	-111.61
2	270.530	931.30	2.3	157	10.18	-167.03	-110.57
2	270.556	931.34	2.5	173	10.20	-167.82	-111.01
2	270.582	931.38	2.6	191	10.17	-163.88	-108.82
2	270.608	931.42	4.5	205	10.11	-161.57	-107.54
2	270.633	931.46	3.3	185	10.05	-150.48	-101.38
2	270.659	931.50	6.4	207	10.02	-156.39	-104.66
2	270.685	931.54	6.9	217	10.03	-157.95	-105.53
2	270.711	931.58	5.0	218	10.02	-149.78	-100.99
2	270.737	931.62	4.3	208	9.94	-146.67	-99.26
2	270.763	931.66	2.3	191	9.88	-148.83	-100.46
2	270.788	931.70	1.0	151	9.85	-153.62	-103.12
2	270.814	931.74	2.2	196	9.84	-159.02	-106.12
2	270.840	931.78	1.6	-180	9.85	-157.95	-105.53
2	270.866	931.82	2.4	152	9.87	-161.39	-107.44
2	270.892	931.86	3.3	160	9.85	-163.30	-108.50
2	270.918	931.90	4.0	162	9.76	-164.33	-109.07
2	270.943	931.94	5.8	193	9.74	-165.86	-109.92
2	270.969	931.98	4.0	181	9.76	-167.94	-111.08
2	270.995	932.02	7.6	198	9.78	-168.92	-111.62

Table 9 – Comparison of Viking 2 and Viking 2 Pressures for Ls 270. **Note: For MSL** at Ls 270 the maximum air temperature was -3°C, maximum ground temperature was 5°C; minimum air temperature was -68°C and minimum ground temperature was -72°C. Only one pressure was offered: 915 Pa (9.15 mbar).

TABLE 10 – DAY LENGTH VARIATIONS AT 70° AND 80° SOUTH					
Λsun (0 for spring in northern hemisphere)	Latitude (phi)	δdegrees = arcsin((sin(25.19)*sin(Λsun))	H = arccos((SIN(-.17) - SIN(lw)* SIN(δ))/(COS(lw)*COS(δ)))	Day Length = 2*1.027491*H/360	Daylight In Earth Hours Via David Roffman Calculation (=E value * 24)
0	-70	0	90.49705225	0.516582815	12.39798756
30	-70	12.28711642	53.87695079	0.3075449	7.381077605
54.1	-70	20.16781904	0.882302365	0.005036432	0.120874365
54.2	-70	20.19437665	NO SUNRISE	NO SUNRISE	NO SUNRISE
90	-70	25.19	NO SUNRISE	NO SUNRISE	NO SUNRISE
125.8	-70	20.19437665	NO SUNRISE	NO SUNRISE	NO SUNRISE
125.9	-70	20.16781904	0.882302365	0.005036432	0.120874365
150	-70	12.28711642	53.87695079	0.3075449	7.381077605
180	-70	2.98768E-15	90.49705225	0.516582815	12.39798756
232.8	-70	-19.81718752	177.8637735	1.015296814	24.36712353
232.9	-70	-19.8445113	NO SUNSET	NO SUNSET	NO SUNSET
270	-70	-25.19	NO SUNSET	NO SUNSET	NO SUNSET
307.1	-70	-19.8445113	NO SUNSET	NO SUNSET	NO SUNSET
307.2	-70		90.49705225	0.516582815	12.39798756
330	-70	-12.28711642	127.3929641	0.727195133	17.4526832
24.5	-80	10.16609473	1.618141094	0.009236808	0.221683388
24.6	-80	10.20542913	NO SUNRISE	NO SUNRISE	NO SUNRISE
90	-80	25.19	NO SUNRISE	NO SUNRISE	NO SUNRISE
155.4	-80	10.20542913	NO SUNRISE	NO SUNRISE	NO SUNRISE
155.5	-80	10.16609473	1.618141094	0.009236808	0.221683388
0	-80	0	90.97903719	0.519334122	12.46401892
203.6	-80	-9.810908137	176.4237002	1.007076468	24.16983522
270	-80	-25.19	NO SUNRISE	NO SUNRISE	NO SUNRISE
336.4	-80	-9.810908137	176.4237002	1.007076468	24.16983522

Malen et al. (2001) calculated between 100 and 150 g/cm^2 is deposited at 80º South each winter and is removed by sublimation each spring and summer.[46] At that latitude darkness extends from Ls 24.6 to Ls 155.4 (about 278 sols, from September 21, 2013 to July 3, 2014).

As indicated earlier, the driving idea behind Martian air pressure cycles seems to be the work of Leighton and Murray (1966), published ten years before any lander would be on Mars transmitting in situ pressures back to Earth. They postulated that the Martian polar caps, largely carbon dioxide, control the average atmospheric pressure on Mars. If they were right we might understand the almost even double hump curve (see Figure 23) of Martian pressure shown below (for each Martian year) based on how pressures at MSL were reported, but they were wrong about a number of things including their belief that that the permanent deposit of CO_2 would be found in the north.[40] **One pole that is largely carbon dioxide ice and the opposite pole that is water ice should not produce such symmetrical pressure spikes twice each year. Having seen JPL alter data (often after prompting from us), we believe that the pressure curves seen on Figure 23 are due to unwarranted data manipulation and loyalty to Leighton and Murray's 1966 discredited ideas.**

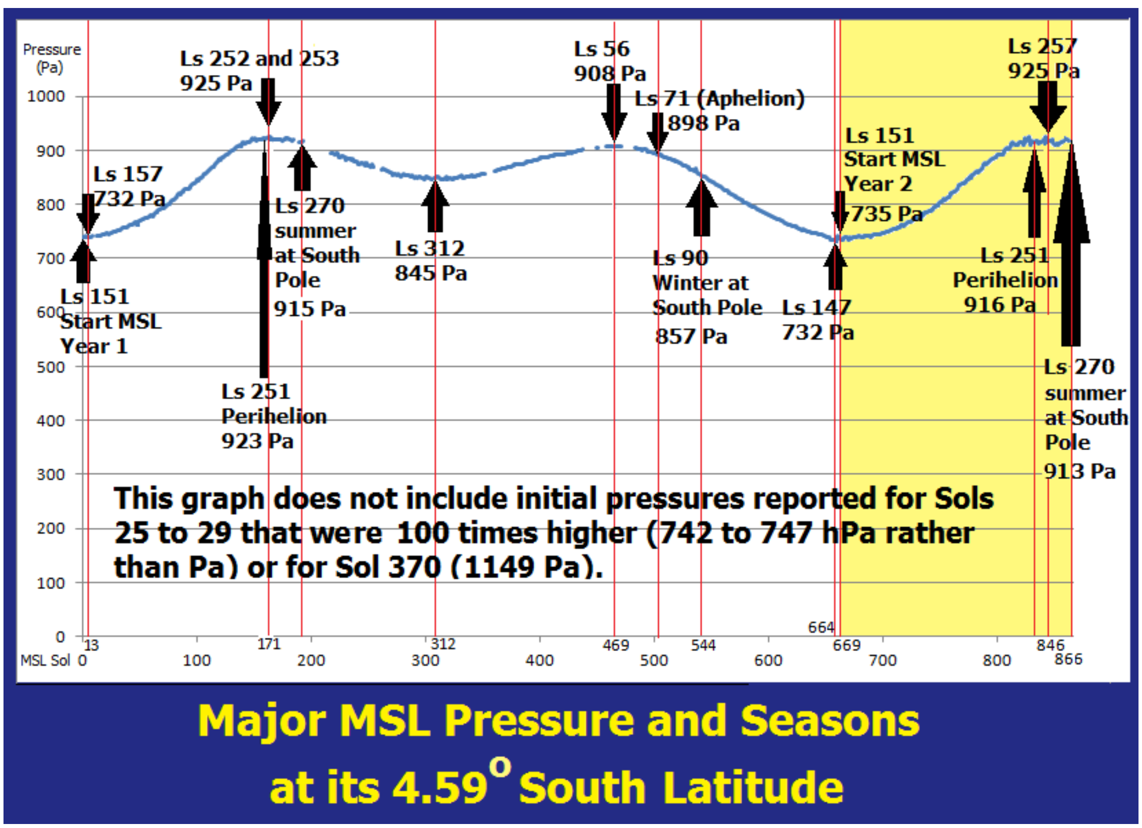


Figure 23 – Pressure curve for MSL Year One.

Malin et al. supported a large surface reservoir of solid carbon dioxide, but point to high resolution of south polar regions acquired in 1999 and 2001 that suggest retreating solid carbon dioxide and global climate change. However, the picture painted by similar pressure curves in Figure 23 above may be challenged by the following synopsis found in the References and Notes section of the Malin et al. paper:

> Although there is broad consensus that the southern residual cap is CO_2, the general impression from the literature is that the material is thin and may occasionally completely sublime. **The only evidence put forth for this variability is the ground-based detection of abundant water vapor during the 1969 southern summer[47], an observation that would be at odds with the presence of CO_2 ice upon which the atmospheric water vapor would tend to deposit. The Viking orbiters observed only trace amounts of water vapor in 1977[48], as would be expected in the presence of year-round CO_2 ice, and an analysis of Mariner 9 infrared measurements indicated that the southern residual cap in 1971 and 1972 also retained CO_2 frost throughout the summer[49]. These inconsistent observations[50] have been taken as evidence of an inter-annual instability [(42)] and have been used to argue that Leighton and Murray's prediction of a large surface reservoir is wrong,[51] or that as yet unknown feedback processes between the other CO_2 reservoirs (atmosphere, polar cap, carbonate rocks, and gas adsorbed onto fine-grained regolith materials) maintain the near-zero mass of the surface frost.[49]**

The Malin et al. article was published in 2001. Since then on September 26, 2013 NASA announced an MSL finding that,

> "A key finding is that water molecules are bound to fine-grained soil particles, accounting for about 2 percent of the particles' weight at Gale Crater where Curiosity landed. This result has global implications, because these materials are likely distributed around the Red Planet." As lead author Laurie Leshin, of Rensselaer Polytechnic Institute…put it, "that means astronaut pioneers could extract roughly 2 pints (0.946353 liters) of water out of every cubic foot ($0.028317m^3$) of Martian dirt…" [52]

Water vapor in the atmosphere will be discussed later in conjunction with Figures 61 to 63 in Section 14 of this report. Relative humidity at Gale Crater varied from less than 10% to about 60%. Further, in 2011, we learned that, "It seems that previous models have greatly underestimated the quantities of water vapor at heights of 20–50 km, with as much as 10 to 100 times more water than expected at this altitude." See http://sci.esa.int/mars-express/49342-esa-orbiter-discovers-water-supersaturation-in-the-martian-atmosphere/

What we may be looking at might be due to lack of information or confusion or inadequately designed equipment in earlier years. However, at times, as with the improper color of the Martian atmosphere portrayed by NASA (allegedly at the order of NASA Administrator Dr. James Fletcher at the landing of VL-1,) it is hard to believe that more of the data is not being colored by an agenda not in line with scientific integrity.[53] Sky color problems are illustrated later in conjunction with 50A through 50I.

At the North Pole there is no more than a meter of frozen carbon dioxide in its winter, and there are about 8 meters of frozen carbon dioxide at the South Pole in its winter. There is no large perennial CO_2 cap at either pole.[54] Thus it's hard to understand why the Figure 23 pressure curve derived from MSL data is almost symmetrical. Indeed, there seems to be a growing realization that there is not enough CO_2 at the poles to control Martian air pressure in the fashion thought before.

Any attempt to calculate the temperature required for CO_2 to freeze on Mars requires a correct understanding of pressure (and in particular partial pressure of CO_2 there as well as temperature). On Earth the lowest temperature ever recorded -89.2º C/-128.56 º F (183.95K) was at the Vostok Station in Antarctica.[55] The temperature required to freeze pure CO_2 at 1 atmosphere of pressure (1,013.25 mbar) is -78.5º C (194.54 K), but carbon dioxide constitutes only .0004 atmospheric of partial pressure. At that low partial pressure a temperature of -140º C is required to produce solid carbon dioxide which is why the gas does not freeze anywhere on Earth. At the (NASA) expected pressure for the Martian South Polar area the temperature of all CO_2 ice would be ~142K/ -131.15º C/ -204.07º F (Byrne, S. and Ingersol, A.P.).[56]

All efforts to explain what is being seen in terms of rapid springtime CO_2 ice retreat at the South Pole and weather in general are based on a need to fit what is seen with expected pressure based on published lander data. We argue that there are too many problems with weather seen for the pressures asserted by NASA to be true. Weather mysteries can best be resolved by exposing why the data is flawed.

Given the fact that about a meter CO_2 is condensing out of the atmosphere over the Martian North Pole in its winter, we might expect the pressure to not be as high there as it is in the tropics, where at least on Earth, the atmosphere is thicker anyway. But the average pressure between Ls 270° and 271° was 9.771 mbar for Viking 2's Year 1 and 9.937 mbar for the same period for its Year 2. During this same period for Viking 1 the average pressure was given as only 8.793 mbar. So for Year 1, the average pressure was 0.978 mbar higher than expected at Viking 2; and for Year 2 it was 1.114 mbar higher than projected. Whatever carbon dioxide was supposed to be sublimating at the South Pole where it was summer solstice did not seem to affect the much closer Viking 1 as much as it allegedly did the much further North Viking 2.

The same problem was present again with MSL which sat at 4.59 º South (closest to the South Pole). There the average annual pressure should be around 9.168 mbar, and pressures should be higher or highest around Ls 270. The actual average reported pressure for Ls 270 was 9.1325 mbar. However, the REMS Team revised their data on July 3, 2013 to have average daily pressures vary at MSL between Ls 267 and Ls 272 to between 8.86 mbar at Ls 269 (MSL Sol 195 on February 22, 2013) and a high for the year of 9.40 mbar on Ls 268 for Sol 192 on February 19, 2013. This variation in pressure, 0.54 mbar over three days, seems quite high, but we discussed earlier an increase of 0.62 mbar in a single hour at Viking 1 at its sol 332.3 at Ls 286 (see Figures 4 and 16e and http://www-k12.atmos.washington.edu/k12/mars/data/vl1/segment3.html). When we started to write about the 9.40 mbar pressure, which was off the predicted pressure curve, JPL revised it again. By June 17, 2014 JPL eliminated all data for MSL Sol 192 except sunrise and sunset times. Again, when pressure measured is not what was predicted they simply refuse to stand by what their sensors tell them. Ashima Research also revised its report to show no data for MSL Sol 192.

5. RADIO OCCULTATION.

In trying to understand what was seen by radio occultation experiments conducted by the Mariner spacecraft, a problem was encountered when (for too long) we put our faith in a NASA website about the Mariner Mars Missions.[57] Later we found important discrepancies between its Figures and those published in 1974 by A. J. Kliore of the Jet Propulsion Laboratory.[58] These differences are highlighted on Table 11.

Initially we thought that a distant flyby might miss pressures at the top of the huge mountains on Mars, but an orbiter should not. In fact, when Mariner 9 arrived at Mars, a global dust storm obscured everything except the top of Olympus Mons. However, seeing Olympus Mons does not equate with measuring pressure there by radio occultation.

Table 11 – Comparison of Martian pressures via radio occultation

Spacecraft/ type/ Arrival	CPA in km	Max P mbar	Min P mbar	Pressure range in mbar
Mariner 4 (flyby) 7/14/65 **Source:** http://nssdc.gsfc.nasa.gov/planetary/mars/mariner.html	9,846	**7.0**	**4.1**	**2.9**
Mariner 4 (flyby) 7/14/65 **Source: (Kliore. A.J., 1974)**	9,846	**8 to 9**	**4.5 to 5**	**4.5**
Mariners 6 & 7 (both flyby) 7/31/69 and 8/5/69 **Source:** http://nssdc.gsfc.nasa.gov/planetary/mars/mariner.html	3,430	**7.0**	**3.8**	**3.2**
Mariner 6 7/30/69 **Source: (Kliore. A.J., 1974)**	3,430	**6.9**	**5**	**1.9**
Mariner 7 **Source: (Kliore. A.J., 1974)**	3,430	**7.3**	**4.2**	**3.1**
Mariner 9/Orbiter/11/13/71 **Source:** http://nssdc.gsfc.nasa.gov/planetary/mars/mariner.html	1,650	**10.3**	**2.8**	**7.5**
Mariner 9 **Source: (Kliore. A.J., 1974)**	1,650	**10.3**	**1**	**9.3**

Collectively, Mariners 4, 6 and 7 only attempted to make six pressure measurements on Mars. Each of these three spacecraft could only offer a pressure for the point on Mars tangent to the line that ran from the spacecraft to Earth as the craft first passed behind Mars (an occultation entry point) and again when they reestablished line of sight with Earth after emerging from the occultation status (the exit pressure). The dynamic range in geo-potential topography on Mars is huge, from 21,287.4 m on Olympus Mons down to -8,180 m at the bottom of the Hellas Basin. The total change in elevation is 29,467.4 m. At 29,467.4 m above sea level on Earth pressure would fall from 1,013.25 mbar to about 12.75 mbar (about the previously presumed pressure in the Hellas Basin on Mars). Mariners 4, 6 and 7 missed these extremes.

Did any of the above Mariners ever measure pressure on Olympus Mons? No. Olympus Mons is nowhere near the points on Table 12, which sums up entry and exit points provided by Kliore et al. (1974).[58]

The 260 Mariner 9 occultation experiments also failed to see either the highest or the lowest places on Mars (see Figure 24 which includes the Tharsis area). Most of the entry and exit occultation points for Mariner 9 are shown on Figure 24.

With respect to Olympus Mons, a literature search shows a remarkable variation of elevations cited with 27 km often at the upper range (Zubrin, 2008).[59]

We asked Dr. Shane Byrne at LPL about it. He stated, "The older (higher) elevation number is based on much less reliable stereo topography data and should be discarded" (personal communication, September 2, 2010). He later referred me to an article by David E. Smith et al. (2001).[60] Those Figures are now adapted as standard for this report. For Olympus Mons, this means that its height above areoid is 21.2874 km, although in rising from a basal point 378 m below areoid, its total relief is 21.6654 km.

Flyby and Date/Ls/ Season (N. Hemisphere)	Entry Position and Pressure	Exit Position and Pressure
Mariner 4 7/15/1965 Ls 142.6 (summer)	50.5° South latitude in the Mare Chronium region. 4.5 to 5 mbar	60° North latitude in Mare Acidalium. 8 to 9 mbar
Mariner 6 7/30/1969 Ls 199.5 (Fall)	4° North Meridani Sinus. 5 mbar	80° N Boreosyrtis. 6.9 mbar
Mariner 7 8/4/1969 Ls 202.5 (Fall)	68.2° South near Hellaspontus. 4.2 mbar.	38.1° N in the Arcadia- Amazonis area. 7.3 mbar

Table 12 – The only six attempts conducted by Mariners 4, 6 and 7 to measure pressure on Mars by radio occultation.

Kliore et al. claimed to have measured pressure on Pavonis Mons.[58] Table 2 in this report shows its altitude at 14.057 km above areoid, with a pressure of about 1.66 mbar if the pressure at areoid is 6.1 mbar. The Kliore assertion about Pavonis Mons led to a much better understanding of radio occultation deficiencies. Kliore wrote:

> "By coincidence, the location of measurement 434 entry fell very close to the top of the volcanic feature known as Middle Spot (Pavonis Mons), which was one of the four prominent features first discovered in Mariner IX television pictures during the Martian dust storm (Masursky et al., 1972).[61]
>
> "Although the location of the occultation tangency point did not fall within the caldera of the (Pavonis Mons) volcano, the geometry was such that the line of sight practically bisected the entire shield volcanic structure, thus making it virtually certain that the beam was actually intercepted by the highest feature along the track, which is likely to have been the summit area. ***The radius that was measured here was 3417.4 km which is about 13.6 to 13.8 km above adjacent occultation measurements. On the basis of pressure altitudes***, the height of Middle Spot was 12.5 km, and the pressure at the top was about 1 mb."

The last sentence sounds like what was actually measured was only the height of the mountain, but the 12.5 km height specified then does not match the 14.057 km MOLA specified height that is accepted now. Further, the phrase "***On the basis of pressure altitudes***" seems to imply that once an altitude was determined, a simple scale height calculation was employed to derive pressure. This is quite different from an occultation experiment that directly derives air pressure. If the altitudes asserted as a result of Mariner 9 radio occultation are not being upheld today, it follows that extreme caution should be exercised before accepting pressures based on legitimate attempts to derive pressure by radio-occultation.

5.1 Shifting Standards – The Relationship of the MOLA Topography of Mars to the Mean Atmospheric Pressure.

Smith et al. (2001)[60] point out that, "The average atmospheric pressure on Mars is ~6.1 mbars, which is close to the triple point of water. Early topographic models of

Mars [e.g., Wu, 1991] were referenced to this atmospheric pressure surface. The **use of a pressure surface as a reference introduced considerable error into estimates of elevation because of temporal variability in the height of the pressure surface due to seasonal variations in CO_2 content** and dynamical motions of the atmosphere…

> To relate surface topography to atmospheric pressure, it is necessary to first compare planetary radii obtained from spacecraft occultations to those derived from MOLA. The occultations yield a measure of both planetary radius and atmospheric pressure and thereby provide a unique linkage between these quantities… **MOLA radii**, which **are considerably more accurate than radii obtained by occultations**, can then be related to occultation-derived surface pressures. By comparing MOLA radii to Viking and Mariner 9 occultations, Smith and Zuber [1998] showed that the zero point of MOLA topography corresponds to an atmospheric pressure of ~5.2 mbars at Ls=0°. (Ls=0° corresponds to the vernal equinox in the northern hemisphere.) The 6.1-mbar pressure level occurs at approximately -1600 m relative to the zero reference of MOLA topography for Ls=0°. However, the height of the 6.1-mbar surface needs to be adjusted, depending on the date. **Seasonal variations in atmospheric pressure associated with the exchange of CO_2 between the atmosphere and polar caps are expected to produce vertical variations in the height of the 6.1 mbar surface of 1.5 to 2.5 km over the course of the Martian year [Zuber and Smith, 1998]**."

The Achilles Heel of the above Smith and Zuber argument is the pervasive need by almost all traditional researchers to relate their findings to the pressure chart represented earlier by Figure 9A. But those Figures match what would be expected in accordance with Gay-Lussac's Law for a gas trapped behind a dust clot in the air access tubes for the pressure transducers.

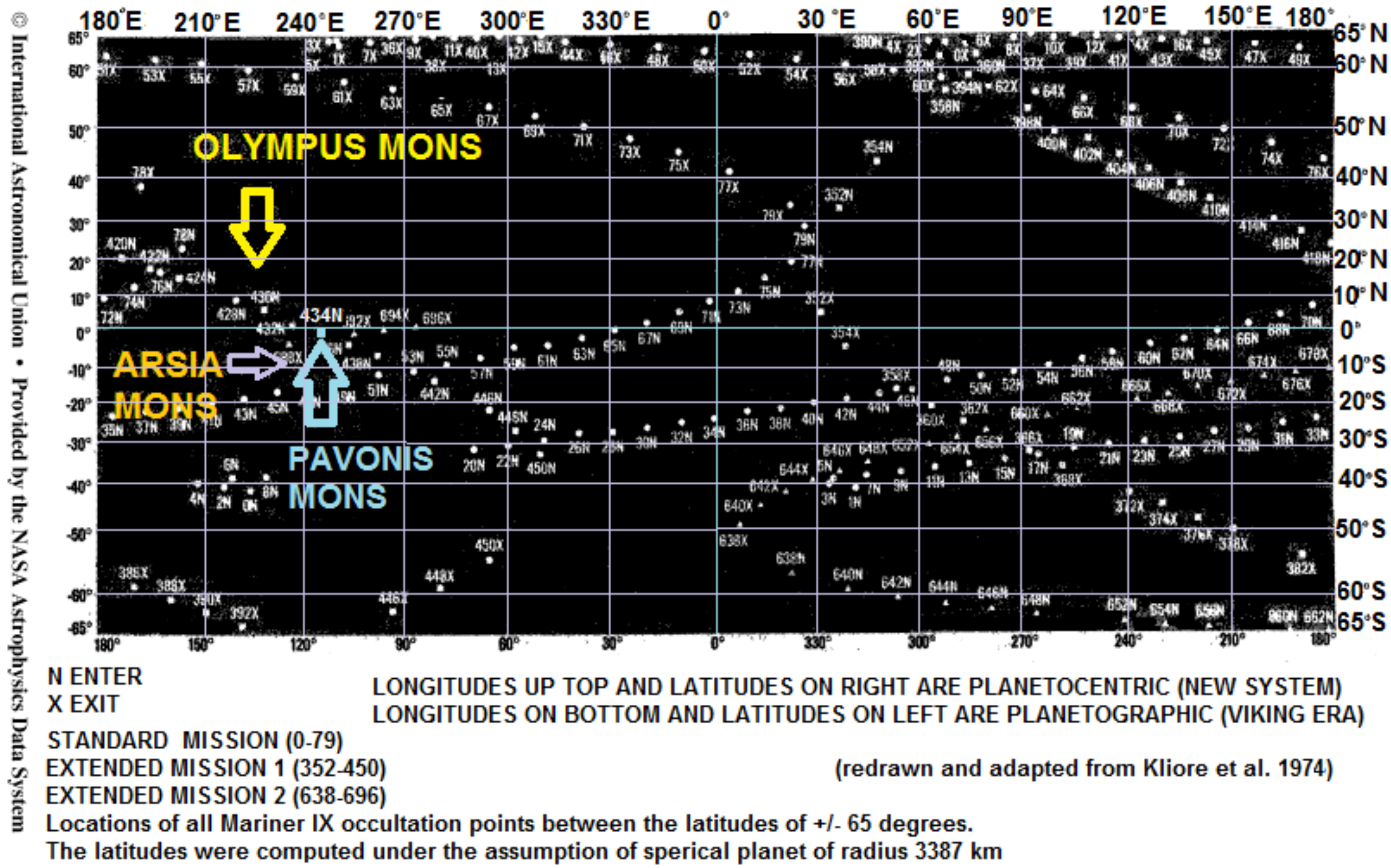


Figure 24 – Radio Occultation experiments on Mariner 9 missed Olympus Mons and Arsia Mons, but not Pavonis Mons (434N). Mountain locations are: Olympus Mons 17.3495N, 226.31E; Pavonis Mons 0.0626096S, 246.674E; Arsia Mons 9.12736S, 238.261E.

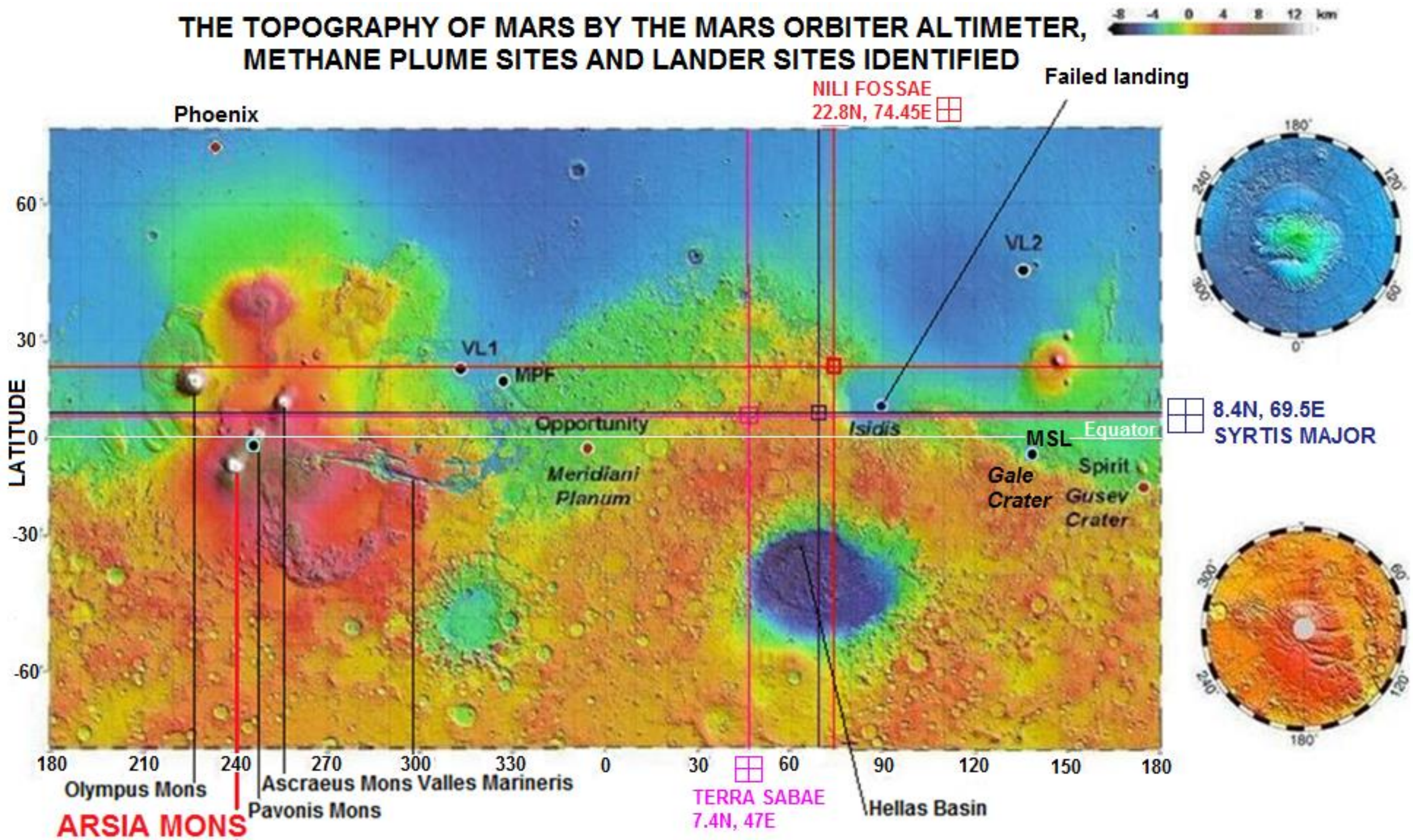


Figure 25: MOLA map of Mars with major topographic features, landing sites, and locations of methane plumes identified by Krasnopolsky et al. (2004).

One of the most memorable demands ever heard on film was made by the Wizard of Oz for Dorothy to pay no attention to the man behind the curtain (exposed by her dog, Toto). She didn't believe him. Likewise, it makes no sense to ignore plainly visible Martian weather, be it dust devils, spiral clouds with 10-km wide eye walls over Arsia Mons or 7-km wide eye walls over Olympus Mons (shown earlier as Figure 20), sand blowing around without sufficient threshold winds to explain the movement (see Section 7.2 and Figures 28 to 30 below), or global dust storms that reduced visibility at Opportunity – blocking out over 99 percent of direct sunlight received there (see Figure 37 later).

6. SPECTROSCOPY PRESSURE READINGS BY MARS EXPRESS ORBITER.

An attempt to measure surface pressures was made by Mars Express Orbiter. Results for the nine pressures obtained over a Martian year are shown on Figure 26A. This section compares the data so derived with that of the Viking 1 lander shown on Figure 26B.

Is it reasonable to base projected pressures for Figure 26A on Martian year 24 (from July 15, 1998 to May 31, 2000)? There were two regional dust storms that year – but no global dust storms. The first regional storm began at Ls 224 in Chryse and lasted until Ls 232 in month 8. The second storm began in Amazonis at Ls 228 and lasted until Ls 243 in month 9. The curve of pressure changes shown on Figure 26A greatly resembles the annual pressure curves shown back on Figure 21B. Indeed, it is almost an exact match for VL-1 pressures shown on Figure 21B almost two decades earlier despite the fact that the Vikings encountered three global dust storms.

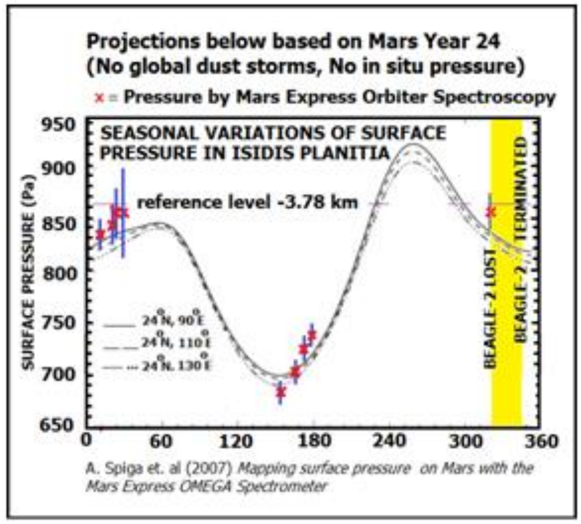


Figure 26A – Mars Express OMEGA spectroscopy-derive surface pressures (redrawn from Spiga et al. 2007).

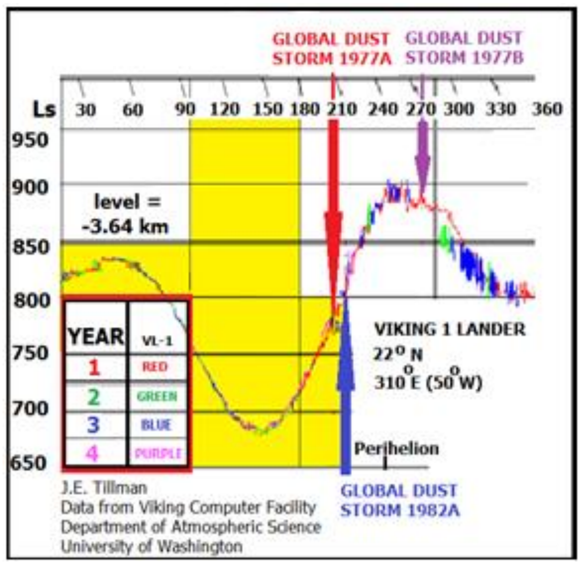


Figure 26B – 4 years of in situ pressures at Viking 1 lander site (redrawn from Tillman, 1985, 1988 and 1997).

Figure 26A is a bit deceptive. There was no lander on Mars capable of measuring in situ pressure for Martian year 24 (Pathfinder terminated its 2.5 months of operations on September 27, 1997; and Phoenix operations ran from May 25, 2008 to November 10, 2008 (http://www-mars.lmd.jussieu.fr/mars/time/martian_time.html).

There are other concerns about spectroscopy. Pressure may vary radically at times across the planet, and (as will be discussed further below in section 10.2) there are serious questions about why Mars Reconnaissance Orbiter (MRO) encountered atmospheric density that was 350% higher than predicted by the Mars-GRAM (Global Reference Atmospheric Model) during aerobraking operations over the south pole (Atkinson, 2006).[62] And yet, in discussing the limitations of the Mars Express spectroscopy operations, the Spiga *et al*. (2007) make clear that water ice clouds and frosts can distort the critical CO_2 absorption band at 2 μm and may falsify the pressure retrieval. [63] They conclude by stating "the spectral signature of water ice is thus not included in our model, thus we simply avoid the regions with clouds and frosts." This, of course, rules out the South Pole where the aerobraking problem was encountered. That water distorts pressure readings by spectroscopy for Mars is enormously important because on September 26, 2013 NASA announced that,

> "A key finding is that water molecules are bound to fine-grained soil particles, accounting for about 2 percent of the particles' weight at Gale Crater where Curiosity landed. This result has global implications, because these materials are likely distributed around the Red Planet."[64]

As lead author Laurie Leshin, of Rensselaer Polytechnic Institute in Troy, N.Y. put it, "that means astronaut pioneers could extract roughly 2 pints (0.946353 liters) of water out of every cubic foot (0.028317m³) of Martian dirt they dig up."

As will be discussed later in conjunction with Figures 61 - 63 in Section 14 of this report, relative humidity at Gale Crater varied from less than 10% to about 60%. Further, in 2011, we learned that, "It seems that previous models have greatly underestimated the quantities of water vapor at heights of 20–50 km, with as much as 10 to 100 times more water than expected at this altitude."[65]

With an apparent timely reading of pressure by OMEGA in hand from Mars Express, the Beagle-2 which detached from it to land then on December 25, 2003, was immediately lost, however the lander was found largely intact on January 17, 2015. At http://marscorrect.com/photo2_21.html, we discuss discrepancies between original and revised landing coordinates and target ellipse size with ellipse size varying from 50km*8 km to 500 km*100km. In the end the claim was that Beagle 2 was only 5 km off target, but if that is true it should not have taken 11 years to find it. Between January 17 and 18, 2015 we saw major revisions in Wikipedia about the actual target. Further, where the question of air pressure is greatest around the South Pole of Mars, the attempt by Mars Polar Lander to set down there in 1999 was also a failure – although supposedly due to improper hardware testing.

7. MARTIAN WIND PROBLEMS

Until Phoenix landed in 2008, the only landers carrying dedicated meteorology instruments were Vikings 1, 2 and Pathfinder. There was little wind speed data for Mars after the Vikings due to calibration problems with the wind sensors for Pathfinder (Schofield et al., 1997).[67] Winds were too light (largely <5 m/s), but wrong assumptions about air pressure on Mars might have also *caused* calibration problems as wind speed **u** is related to pressure through Equation 1 from a NASA article about the Mars Pathfinder Windsock:

EQUATION 1: u = sqrt{[2 R(1) M g tan (theta)]/ [R(2) A(d) rho]}

In Equation1 R(1) = distance between pivot and center of mass, M = non-counter-balanced mass, g = acceleration of gravity, R(2) = distance between pivot and center of aerodynamic pressure, A(d) = effective aerodynamic cross-section, and rho = atmospheric density (a function of pressure, temperature, and molecular weight).

An MPF hot-wire anemometer also had calibration problems. Such technology is sensitive to pressure, gas composition, air temperature, and their own overheating which may induce systematic errors (Pedrero, Jaime, 2010)[68], and, in fact, in May, 2013 Ashima Research and apparently the REMS Team both caved in to our demands to Guy Webster that they replace all winds published with Not Available since they were clearly erroneous at a never changing speed and direction of 2 m/s (7.2 km/h) from the east for 9 months – especially given that Boom 1 broke on landing (see Figure 15A).

Schofield et al. (1997)[67] indicate that while **Pathfinder** was operational from July 4 to September 27, 1997, it **had no pressure data for the most crucial sol – its first operational day on Mars.** The reason given by the above reference is there were "various spacecraft software reset and downlink problems." If the problems only occurred *after* the first day; and if the first day's pressure data was consistent with the Vikings, then Pathfinder's data could be used to refute the claims made herein. However, that is not the case. We are still dealing with a Tavis transducer with no way to keep the dust out of its pressure air access tube on or in the seconds before landing, and no way to change a clogged dust filter. The critical time is in the final landing process. So when the spacecraft has to reset the software and correct downlink problems then, the issue of exactly what is entailed in these *corrections* becomes one of extreme importance. It should be noted that for MSL all data originally listed for sols 1 to 9 was also deleted by JPL.

7.1. Anemometer/Wind Speed Issues.

Understanding Martian wind is crucial in preparing for future manned missions to Mars. When we originally wrote this we had no idea that we would ever be involved with finding life on Mars. However, after Rhawn G. Joseph et al. had viewed our father & son TV interview on September 3, 2017 in which we discussed possible life seen on MSL Sol 1185, they pursued the subject, obtained better photos than we had, and in the Journal of Astrobiology published *Evidence of Life On Mars?*[152] The Journal asked us to write a commentary on it, which we entitled *Meteorological Implications: Evidence of Life on Mars?*[153] The Journal challenged whether apparent puffballs (fungi that appeared to both grow and reproduce over 3 sols) were really life, or merely hematite uncovered by Martian wind. However, our article uses findings below in Section 7.2 (see Figures 28 & 29) to show that with NASA-accepted low pressures the wind is not strong enough to move the sand. Therefore the apparent life there is either Martian in origin, or as Joseph et al. believes, contamination from Earth in the form of fungi, lichens, algae and bacteria. Whatever the source, Joseph et al. present evidence that rovers Curiosity and Opportunity are both contaminated. Correct wind data is central to understanding this. One of the first instruments chosen for Phoenix should have been an anemometer, yet none was included (Taylor et al. 2008).

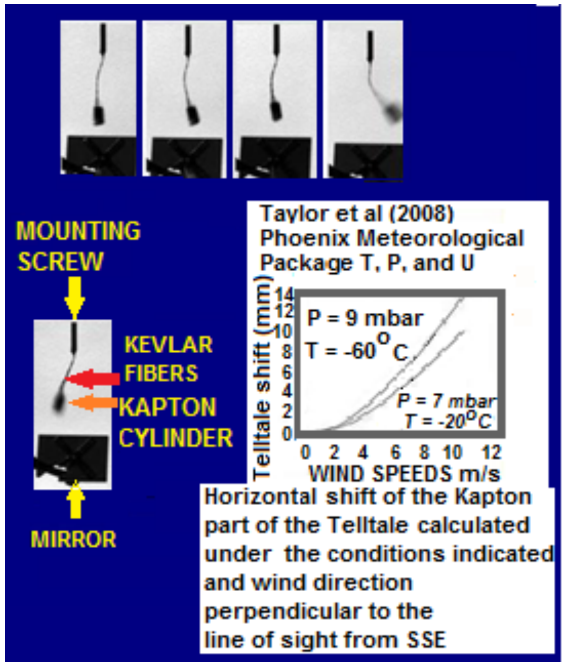


Figure 27 – Phoenix telltale waving in Martian wind. Out-of-phase image may indicate a dust devil occurrence. Images taken before & after the event have west winds estimated at 7 m/s. During the event south winds are estimated at 11 m/s. Adapted from Taylor et al., 2008.

The Taylor paper states, "We had hoped to include an anemometer in the MET package. Faced with a lack of resources to achieve this, and the real desire to have some wind information we decided to make use of the SSI camera and have a novel Telltale to achieve this."[68] See Figure 27.

The above Taylor paper rated the Telltale as capable of measuring wind speed in two orthogonal directions normal to gravity in the range of 2 to 5 m/s with an accuracy of 1 m/s or 20%, whichever is greater; and in the range of 5 to 10 m/s with only 40% accuracy. What happens when wind speed exceeded 10 m/s? The Telltale reaches maximum deflection, goes horizontal, and "loses its wind speed/deflection correlation ability." This means that it is worthless in determining how strong winds are that exceed 22.4 miles per hour. Again, Stanzel et al. (2008)[17] report dust devil velocities as high as 59 m/s (132 mph) seen by Mars Express Orbiter.

The MPF IMP windsock was ineffective because light wind (< 5m/s) dominated the mission. Calibration for this windsock was only at 1,015 mbar and ~15 mbar of terrestrial air – see Annex H. Higher surface pressures for Mars were apparently not considered. The 15 mbar figure factored in molecular weight differences between our air and CO_2.

7.2 Martian Bedforms – Too Much Movement of Sand Dunes and Ripples for 6.1 mbar

In November 2012 an article was published by Dwayne Brown of NASA Headquarters and Priscilla Vega at JPL entitled *NASA Orbiter Catches Mars Sand Dunes in Motion.* The first startling confession was that:

> "Mars either has more gusts of wind than we knew about before, or the winds are capable of transporting more sand, said Nathan Bridges, planetary scientist at the Johns Hopkins University's Applied Physics Laboratory in Laurel, Md., and lead author of a paper on the finding published online in the journal *Geology*. We used to think of the sand on Mars as relatively immobile, so these new observations are changing our whole perspective."

It states that wind-tunnel experiments have shown that a patch of sand would require winds of about 80 miles/hour (128.7 km /hour) to move on Mars compared with only 10 mph (16 km/hour) on Earth. It then makes the understatement that measurements from the Viking landers, in addition to climate models, showed such winds should be *rare* on Mars. The word *rare* was too generous.

How does the above required 128.7 km/hour compare with winds observed on Mars? The set of graphs on Figure 28 below show how wind speed varied at Viking 1 between its sols 1 and 350 (with the exception of sols 116 to 133 because data was missing then). Every sol (Martian day) was divided into 25 time bins, with wind readings provided for each one. During sols 1 to 199 the maximum wind recorded was 59.06 km/hr. Between sols 200 and 350 there was one incident where winds reached 96.08 km/hr, but at no measured point over 8,331 measurements, did the wind ever reach 128.7 km/hr. Average winds for Viking 1 were about 9.85 km/hr during sols 1 to 199, and 19.08 km/hr during its sols 200 to 350. All wind data was obtained from the Viking Project Group headed by Professor James Tillman.[71]

For Viking 2 during sols 1 to 199 the maximum wind recorded was 35.57 km/hour mph. From sols 200 and 399 it was a good bit windier, but the maximum winds at 83.5 km/hr – were still short of the 128.7 km/hour figure required to move the sands. Average wind for Viking 2 was about 12.13 km/hr from sols 1 to 199; and 21.45 km/hr from sols 200 to 399.

*7.2.1 Issues Raised by the paper on **Planet-wide sand motion on Mars** by Nathan T. Bridges (et al., 2012).*[25]

The Bridges et al. paper states that, "prior to Mars Reconnaissance Orbiter data, images of Mars showed no direct evidence for dune and ripple motion. This was consistent with climate models and lander measurements indicating that winds of sufficient intensity to mobilize sand were rare in the low-density atmosphere." It then reveals new findings that show that many sand ripples and dunes across Mars exhibit movement of as much as a few meters per year, demonstrating that Martian sand migrates under current conditions in diverse areas of the planet. However, in an effort to explain it, they speculate that "most motion is probably driven by wind gusts that are not resolved in general circulation models."

A response to the resolution suggestion is that, as is noted before in conjunction with the 8,331 wind velocity measurements recorded at Viking 1 and Viking 2, in no case was a gust ever caught that hit 80 mph. The windiest day seen was with Viking 1 with a 57.9 mph gust during its sol 214.78 when the planet was at Ls 210.872 (Martian fall in the northern hemisphere). Did this gust come out of a sudden event like a dust devil? No, obviously it was a storm of some sort, because the winds began to rise in the morning that day at sol fragment 214.38, then they fell off toward Martian midnight. Based on data from Professor Tillman's Viking Project Site, the incident is shown growing and subsiding on Table 13.

TABLE 13 – Profile of the windiest Viking day on Mars				
VL-1 SOL	**LS`**	**Wind direction**	**Wind Speed M/S**	**Wind Speed MPH**
214.38	210.621	290	1.2	2.68
214.42	210.646	249	2.6	5.82
214.46	210.671	254	4.6	10.29
214.5	210.696	283	7.6	17.00
214.54	210.721	305	9.4	21.03
214.58	210.746	331	19.9	44.52
214.62	210.771	343	22.5	50.33
214.66	210.796	356	22.6	50.55
214.7	210.821	6	21.2	47.42
214.74	210.847	19	17.8	39.82
214.78	**210.872**	**19**	**25.9**	**57.94**
214.82	210.897	24	25.2	56.37
214.86	210.922	25	18.8	42.05
214.9	210.947	29	13.8	30.87
214.94	210.972	33	9.2	20.58
214.98	210.997	355	4.9	10.96

Table 13 – Profile of the windiest Viking day on Mars with the greatest wind gust recorded at VL-1 sol 214.78.

Bridges et al. note that dunes and ripples (collectively termed bedforms) are abundant and widespread on Mars, with concentrations surrounding the north polar layered deposits, within craters and other depressions that trap sediment, and as isolated patches on the plains. The area surrounding the north polar layered deposits includes some of the lowest elevations on Mars. Low elevation implies higher pressure, which means that it becomes easier for the winds to move sand, but the assumed increase in pressure at the altitudes in question are still insufficient to move the sands on a widespread basis. Even at Lyot (7.036 km below areoid), the lowest point in the northern hemisphere, we would only expect pressure to peak at about 11.7 mbar if there is 6.1 mbar at areoid (See Table 1 earlier in this report).

Bridges et al. notes that comparing the movement map to predictions of the Ames General Circulation Model (GCM) (Haberle *et al.*, 2003)[72,] shows no correlation to the high wind frequency regions. They believe this demonstrates that the models do not resolve small-scale topographic, katabatic winds (as occur in the north polar region; Ewing *et al.*, 2010), and general boundary layer turbulence that may cause gusts above threshold (Fenton and Michaels, 2010). However, the GCMs are based on the assumption that the average pressure at Mars areoid is only 6.1 mbar. If the movement maps do not resemble the GCM predictions, then this again may support our contention that the ultralow pressure is incorrect. The gusts above the 80 mph threshold were not seen in the 8,331 measurements that we checked from Vikings 1 and 2.

Terrestrial katabatic winds carry high density air from a higher elevation down a slope under the force of gravity. They can rush down elevated slopes at hurricane speeds, but most are not that intense and many are on the order of 10 knots (18.52 km/hour) or less. However, looking at the map shown earlier (Figure 25), it appears that the entire circumpolar area is well below areoid with no mountains until about 45° North latitude is reached. It's not certain from looking at the map that enough topographic relief exists in the far north in a wide enough area to use katabatic winds to explain the sand movement there, though they might come into play further south where the Mars Exploration Rovers (MERs) were deployed.

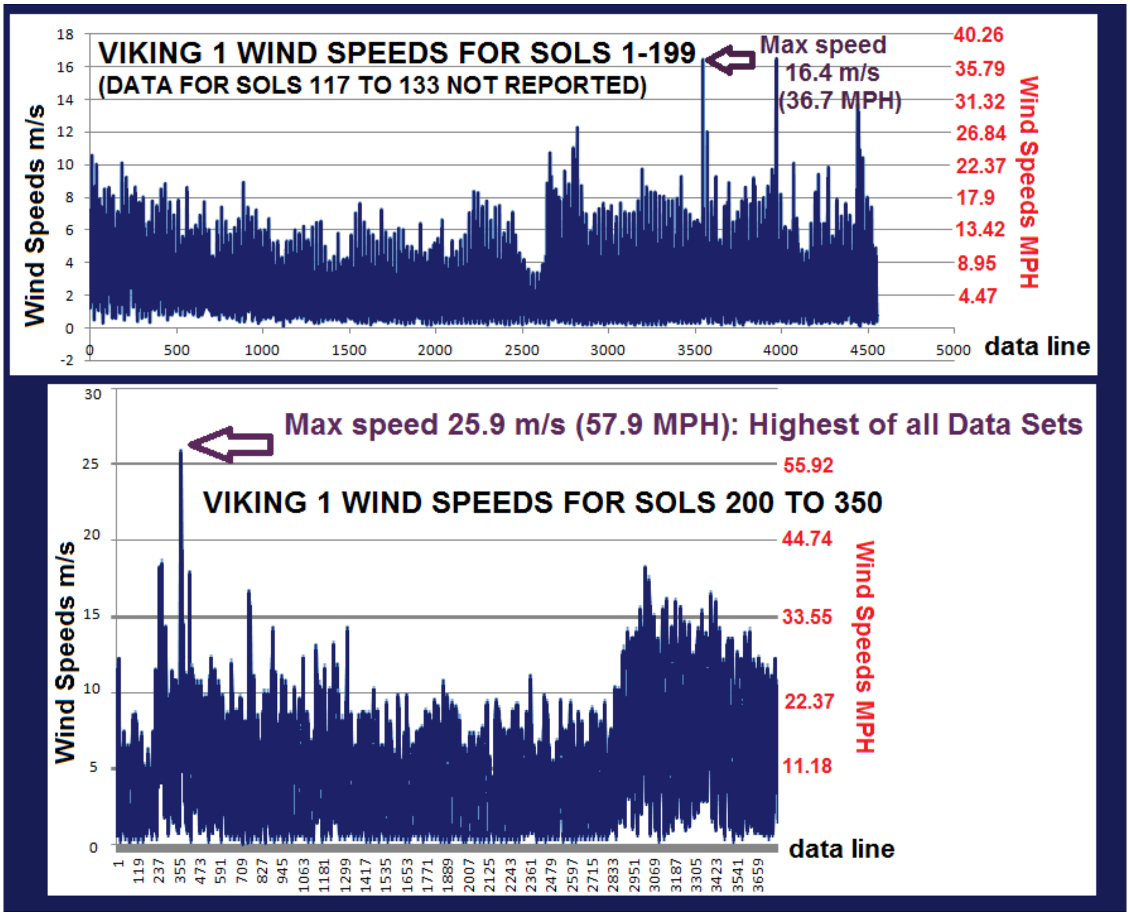
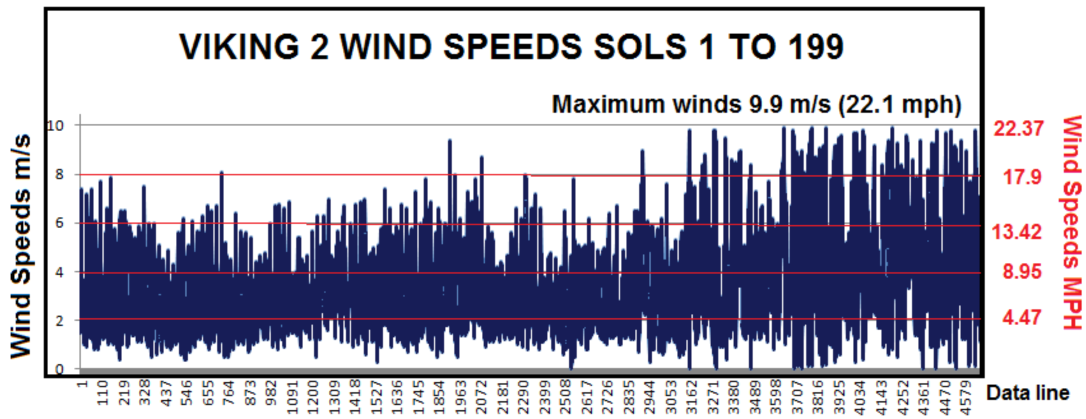


Figure 28 – Wind speeds recorded at Viking 1 for its sols 1 to 116 and 134 to 350



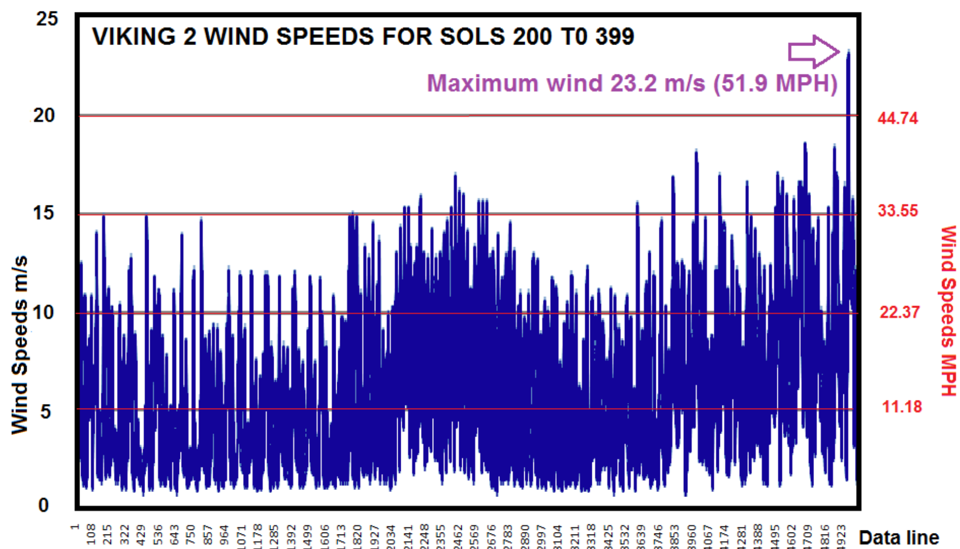


Figure 29 – Wind speeds recorded at Viking 2 for its sols 1 to 399

Bridges et al. state, “Below the resolution of HiRISE as seen by the MER rovers, the evidence for motion of fine sand is compelling, with indications of sand blowing out of Victoria Crater that erases rover tracks (Geissler et al., 2010), craters superposed on the ripples being filled with sand (Golombek et al., 2010),[75] ripples from winds funneled along the troughs, and one observation of small sand ripple migration (Sullivan et al., 2008).”[76]

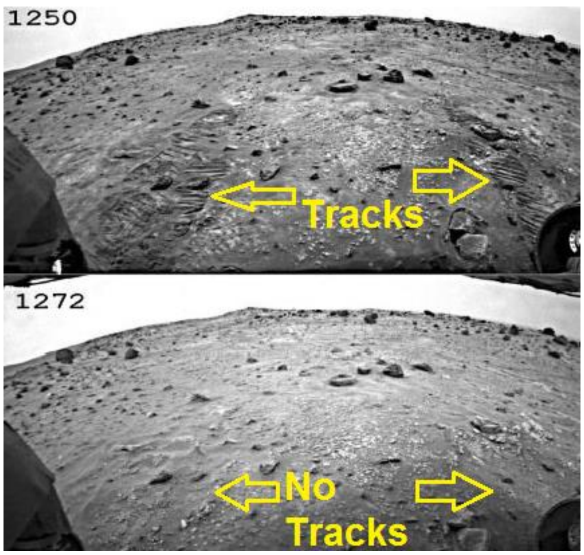


FIGURE 30: Erasure of Spirit’s tracks during the 2007 global dust storm between its sol 1250 and sol 1272. Credit: NASA/JPL, courtesy of Geissler, et al/JGU.

An example of tracks being erased is shown in Figure 30 where Spirit’s tracks vanished during the 2007 global dust storm. Spirit landed ~1.9 km below areoid. If the average pressure at areoid is about 6.1 mbar, with a scale height of 10.8 km, the average pressure at -1.9 km should only be about 7.27 mbar – quite low if wind is expected to move the sand. Unfortunately the rover carried no meteorological instruments. This means that it could not measure pressure or wind. However we can compare the time that it felt the dust storm to the time that Viking 1 experienced its two global dust storms in 1977 (see Figure 31).

We could also look at what happened to Viking 2 then, but both MER Spirit and Viking 1 were in the Martian tropics while Viking 2 was at almost 48° North. As such, it is appropriate to examine the winds experienced by Viking 1 during dust storm 1977a, which began at Ls ~205, and dust storm 1977b which started at ~Ls 275 (see Figure 31). Note – both Vikings landed at an altitude about 3.6 to 4.5 km below the areoid. Identical winds at the much higher Spirit would be less able to move sand.

We reviewed the hourly winds for 20 sols after each of these Ls (Solar Longitude) positions in the Martian orbit, where Ls 0 = the start of spring (in the northern hemisphere where Viking 1 landed), Ls 90 = the start of summer, Ls 180 = the start of fall, and Ls 270 = the start of winter. In skimming through the data it appears that in the 20 sols that began at Ls 205, the maximum wind at Viking 1 was 25.9 m/s (57.93 mph – see Figure 28 above), but this velocity did not occur until Ls 210.872. For the second dust storm the maximum wind was 18.3 m/s (40.9 mph). Note: For Global Dust Storm 1977a the first hourly wind for Viking 1, Ls 205 was reached by coincidence at its Sol 205. The initial hourly wind examined was at Ls 205.017 at Sol 205.38. Hourly winds were then tracked through its Sol 224.98. This occurred at Ls 217.301. For Global Dust Storm 1977b the first hourly wind examined for Viking 1 was at Ls 275.005 at its Sol 314.14. Hourly winds were then tracked through its Sol 333.98. This occurred at Ls 287.385.

So even during Global Dust Storms 1977a and 1977b, there was not enough wind to move sand at the accepted pressure. From January 23 to 24, 2017 sand was observing to be moving under Curiosity. See the video at **https://photojournal.jpl.nasa.gov/archive/PIA21143.gif**.

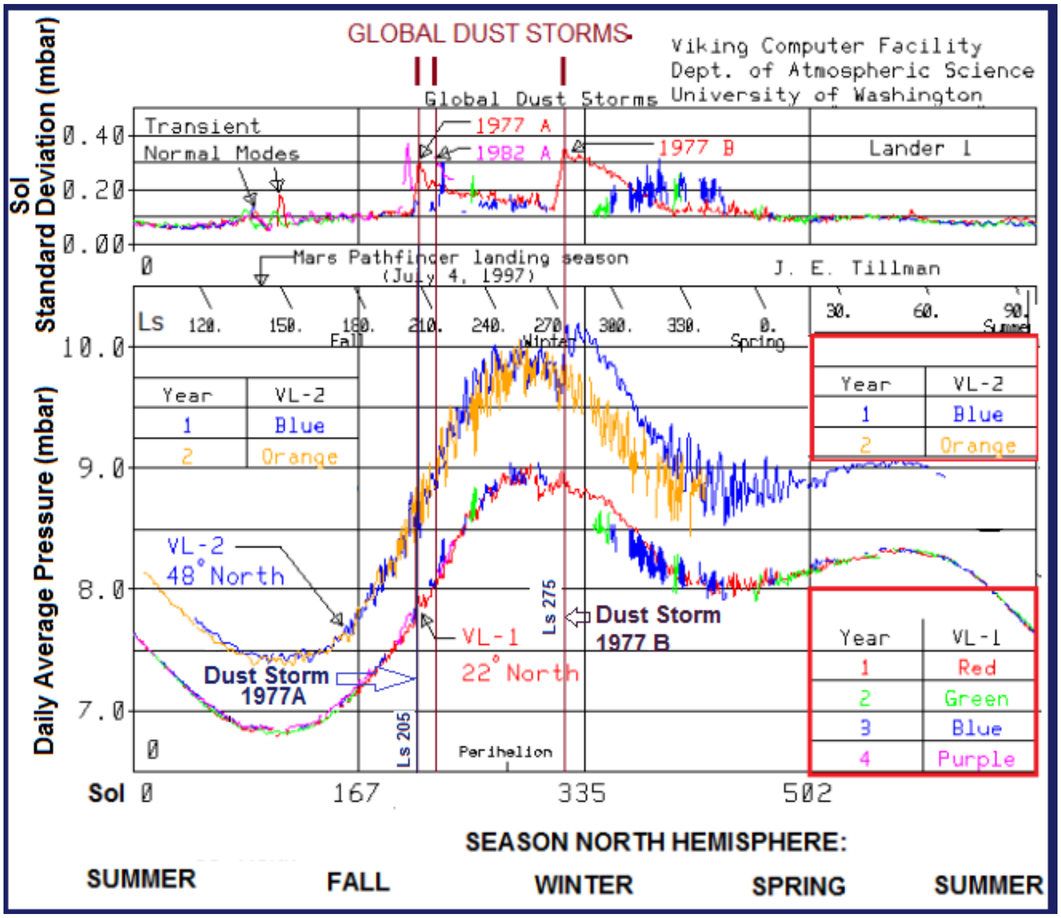


Figure 31 – Dust Storms and pressures recorded at Vikings 1 and 2. This figure is adapted from the Viking Computer Facility, University of Washington.

Bridges *et al*. offer guidance about the relationship between pressure and threshold speeds. In a discussion about obliquities (planetary axis tilt) greater than the present 25° to 50°, they mention that at **pressures of 10–15 mbar** compared to the current ~6 mbar the threshold friction speed is approximately inversely proportional to the square root of atmospheric density, such pressure increases **will reduce threshold friction speeds by 30%-60%.**

During Viking 1's sols 1 to 350 the maximum wind velocity recorded was 57.9 mph. For Viking 2 between its sols 1 to 399 its maximum wind was 51.9 mph. If the surface pressure is actually 10 to 15 mbar, and threshold speeds are reduced from 80 mph to 30% or 60% less, then these speeds become something between 56 mph (with a 30% reduction) and 24 mph (with a 60% reduction. The 24 mph speed is entirely consistent with velocities plotted on Figures 28 and 29 above. The highest wind recorded for Viking 1 also exceeds the 56 mph requirement. Therefore, **the winds seen at Vikings 1 and 2 are consistent with moving sand at pressures of at least 10 and 15 mbar.** The frequently shifting sands could, of course, also be consistent with higher pressures. **The 8,331 wind measurements are not at all consistent with a pressure of 6.1 mbar.**

Bridges et al. conclude that "...these results show that winds in the present low-density atmosphere of Mars are sufficient to move dunes and ripples in many areas of the planet. A major climatic change with a thicker atmosphere is not required.**"** We think that the last sentence needs to be lengthened a bit. The full sentence should read, *"A major climatic change with a thicker atmosphere is not required* ***because the thicker atmosphere already exists now."***

8. DO DOWNRANGE LANDINGS MEAN THINNER OR THICKER AIR?

A NASA paper challenges its own assumptions about air pressure, although it goes in the opposite direction of what we think is true (however, only at mid altitudes between 20 and 50 km). The 2009 article by Prasun N. Desai is entitled *All Recent Mars Landers Have Landed Downrange – Are Mars Atmosphere Models Mis-Predicting Density?*[77] It notes downrange landings of 27 km (Pathfinder), 13.4 km (Spirit) 14.9 km (Opportunity) and 21 km (Phoenix). Desai et al. (2008) thought Phoenix encountered a lower density profile ranging from a few percent to a maximum of 8%, but he wrote that "the primary cause of the Phoenix downrange landing was a higher trim angle of attack during the hypersonic phase of entry, which resulted in Phoenix flying a slightly lifting trajectory." The cause was unknown. It resulted in parachute deployment occurring 6.4 seconds late. His work, and reports about Pathfinder, suggest up to 40% less density than expected at 50 km, but about 5% higher density than expected at h = 0.

We asked Dr. Desai if Phoenix might have experienced a limited skip effect. If a spacecraft comes in a bit too shallow, the increased buoyancy felt from below might make it take a small skip, not causing it to return to space, but resulting in it landing long. This seemed to line up with what he called a slight lifting trajectory in his article. However, Desai's overall position was that if the air is denser than expected, the friction will cause the probe to slow faster than expected, and land *short* of its target (not long, as with Pathfinder, Spirit, Opportunity, and Phoenix).

Desai was not always consistent about the altitude that was most important with respect to deceleration. He wrote that,

> "Another important aspect to the atmospheric density is in what altitude region is the density lower**. The most important altitude band for entry and descent is between 20-50 km**, prior to the parachute being deployed. That is where almost all of the deceleration occurs (~90% of the velocity is reduced), and therefore the downrange distance traveled. Above and <u>below this altitude band</u>, the downrange distance traveled is minimally affected by mis-prediction of density... Also, the density just doesn't disappear in the entire column of air (actually CO_2)**. If the density is lower in this mid-altitude band, then the density is higher at lower altitudes 0-20 km**. **Basically, more of the column of CO_2 moves lower** (the CO_2 just doesn't disappear). As such**, a little of the effect of the lower density at higher altitude is made up by the higher density at lower altitudes, although far from all."** (Desai, personal communication, March 22, 2010)

The pressure graphs in the Desai (2008) article are reproduced on Figures 32-34. They show data beginning at 100 km for Spirit, 80 km for Opportunity, and 70 km for Phoenix. Missing in the Desai article was a graph for Pathfinder (which was furthest downrange at 27 km). Desai concludes:

> "Does the fact that every one of these entries encountered a lower atmospheric density profile than predicted indicate a random occurrence or is there a systemic bias in current Mars atmospheric models? As such, a question is posed to the atmospheric community to consider if the Mars modeling assumptions are appropriate or are there underlying modeling issues that need to be reexamined or reevaluated. Additionally, although the entire density profile is necessary for entry, descent, and landing design; **nearly all deceleration during entry occurs between 10-50 km**. As such, prediction of density within this altitude band is most critical for entry flight dynamics and design."

Note the second (published) statement by Dr. Desai refers to a minimum deceleration altitude of concern of 10 km rather than his more recent e-mail of 22 March 2010 that used 20 km.

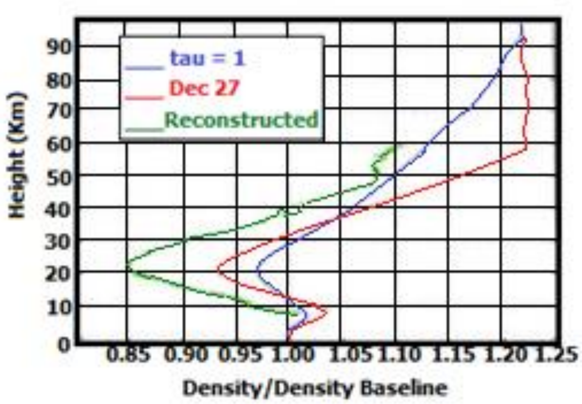


Figure 32– Reconstructed density for Spirit Landing (redrawn from Desai, 2008)

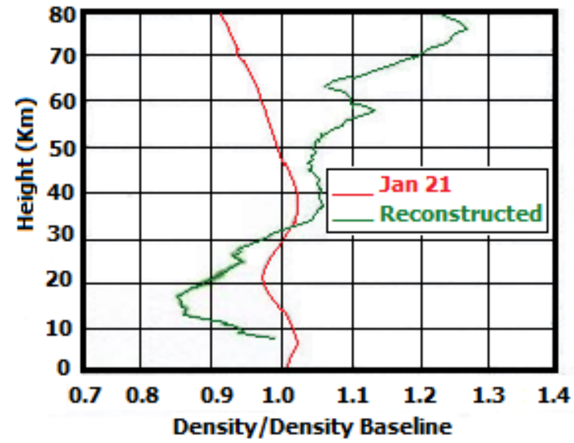


Figure 33 – Reconstructed Density for Opportunity Entry (redrawn from Desai, 2008)

For Spirit it looks like all reconstructed densities were lower than what was expected or encountered (see Figure 32). However, as noted earlier, Spirit is the rover that photographed sand filling in its tracks during the 2007 dust storm (see Figure 30). This is not consistent with low air densities at the surface.

For Opportunity (Figure 33) the densities encountered were lower than expected only below ~32 km (especially so between 10-20 km), but higher than expected above 32 km. For Phoenix all reconstructed pressures were below what was assumed for landing day (Figure 34). Desai informs us that for successful landers, navigation errors upon Mars arrival were very small and that, as such, entry interface conditions (initial targeting on entry) was not responsible for downrange landings. What about MSL Curiosity? It landed about 2 miles northeast of its target but the accuracy was not due to better understanding of air pressure. Rather, the lander had thruster rockets that allowed it to make a more controlled landing, with corrections applied as necessary.

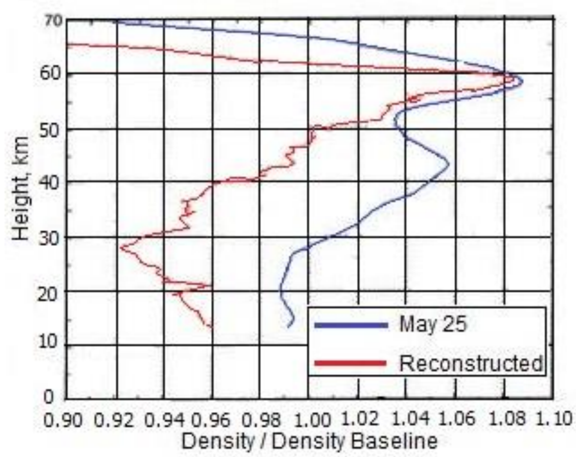


Figure 34 – Reconstructed Density for Phoenix Entry (redrawn from Desai, 2008)

The moment aerodynamic issues are introduced for entry into an alien atmosphere there are many places for errors to occur. Density is one such area, but not the only issue. Buoyancy determines overall structure of the atmosphere and what causes air to move around (Read & Lewis, 2004).[79] Buoyant forces combine with aerodynamic issues when it comes to getting a landing right. Increasing density of the fluid increases buoyancy forces, even before we consider parachute issues, although, strangely enough, the parachute used for the Phoenix was actually reduced to 39 feet from the 42 feet used for Pathfinder.

I asked Dr. Desai about the buoyancy issue. He replied, "As for buoyancy forces, if you make calculations of its magnitude, it is quite small not only due to the density on Mars being low, but also because the volume of these landers are quite small as well. Hence, for these reasons, it is just a very small effect." (Desai, Personal Communication, March 22, 2010)

The answer above is based on assumption that the density of the Martian atmosphere is always low at all altitudes. Yet dust storms can radically alter the density equations in short order. A dust storm at Luke Air Force Base on July 5, 2011 turned day to night in surrounding areas (see Figure 35). While the measured pressure increased by at least 6.6 mbar (more than average pressure at Mars areoid), pressure was only taken once per hour; all the increase was due to dust in a cloud that only rose to somewhere between 5,000 and 8,000 feet. Dust storms also turn day to night on Mars (see Figure 38). The essential question is, "*What ambient Martian air density is required to support such a mass of dust?"* Finally, Desai only requested help in explaining four spacecraft landing long. It is possible that two other craft listed as *lost* (Mars Polar Lander and Deep Space 2 on December 3, 1999) actually landed *short* and crashed as a result of it.

The Vaisala pressure transducer used for MSL was rated for a maximum pressure of 11.5 mbar. Without considering the 11.49, 11.54, 11.77 and 12 mbar pressures that were off the curve, with no dust storm, the highest *revised* average daily pressure for MSL Year 1 was 9.25 mbar, and as a *daily* average, there must have been higher pressure than that sometime during the Sol 172 (at Ls 254) in question. The highest pressure for MSL Year 2 was also 9.25 mbar (Sol 846 at Ls 257). If we add the 6.6 mbar increase in pressure caused by a dust storm at Luke Air Force Base just to the 9.25 mbar pressure, the total reaches 15.85 mbar, far above the maximum 11.5 mbar maximum pressure allowed for the Vaisala transducer. So the pressure range (publically) chosen makes no sense at all, and may be indicative of a less than honest Martian image being put out by NASA. The 11.49, 11.54, 11.77 and 12 mbar pressures reinforces this conclusion. For Sol 370, even if we accept the 8.65 mbar replacement pressure that is likely manufactured, 8.65 + 6.6 mbar still equals 15.25 mbar, which is above the transducer's capacity. We warned

Dr. Vasavada (MSL Project Scientist) about this twice before MSL launched in November 2011, once in August at the Mars Society Convention in Dallas, and again by phone in October.

Figure 35 – Arizona Dust Storm of July 5, 2011. Pressure at Luke Air Force Base increased during the dust storm by 6.6 mbar – more than average pressure (6.1 mbar) at areoid on Mars.

Earlier we reported the remark made by one of the Vaisala transducer's designers, "The fact that we at **FMI did not know how our sensor was mounted in the spacecraft and how many filters there were** shows that the exchange of information between NASA and the foreign subcontractors did not work optimally in this mission!" (Kahanpää, personal communication, December 15, 2009). Kahanpää is part of the current REMS Team for the MSL. We see no evidence that the exchange of information between NASA/JPL and the REMS Team or FMI has in any way improved since he wrote that above in 2009. Earlier on Figure 17a we showed the REMS Team weather reports from August 29, 2012 through September 6, 2012. They reported that the pressure suddenly went up from 7.4 hPa (mbar) on August 29 to 742 hPa on September 1. We were not alone in immediately notifying JPL and Ashima Research about this. In fact, for five days we wrote and received e-mails back from JPL's public relations man, Guy Webster. He in turn indicated that Dr. Vasavada at JPL was notified. But JPL is in California, and the REMS Team is in Spain. The REMS Team continued to publish Earth-like pressures of 742 to 747 hPa until reverting back to 7.47 hPa on September 6. Unless they deliberately chose to reveal a secret that pressure was two orders of magnitude higher than advertised, they proved that communication (perhaps due to language barriers) was again not working optimally. As for the 1,200 Pa pressure they reported for Sol 1,161 (Ls 66 – see Figure 21A) we doubt that they meant 1,200 hPa/mbar unless they were taking a wild guess. If the real pressure for September 5, 2012 (Sol 30, Ls 166) was 747 mbar, it's not likely to increase to 1,200 mbar suddenly in 2015 unless some explosive event occurred nearby. It seemed unlikely that a dust or sand storm could be the cause because the REMS Team listed opacity for every day of concern is listed as "sunny." However we learned that the never changing "sunny" over at least the first 3,025 sols is also disinformation. We know this because there were many weeks where a separate report put out by Malin Space Science Systems show the true sky conditions at Gale Crater, Mars. The report making clearer cloud and dust conditions for all of Mars may be found at http://www.msss.com/msss_images/subject/weather_reports.html.

Whatever the reason, especially because these high pressures are beyond the initial 11.5 mbar limit of the pressure transducer to measure, we need to hear from Kahanpää himself on the issue. The top figure was 11.5 mbar (see Figure 71 later) for close to 5 years, was altered by the REMS Team from 11.5 mbar to 14 mbar (1400 Pa) – see Figure 72. But this is disinformation too. The real figure is 1,025 hPa/mbar (1,102,500 Pa). See Figure 70. This limit is in the Abstract given by the FMI to the American Geophysical Union in 2012.

9. DUST OPACITY AND PRESSURE. Dust storms can greatly alter the opacity (τ) on Mars. While (up through MSL Sol 3,025) the REMS Team lists all sols at MSL with opacity as "sunny," this claim is directly contracted by the Malin Space Science Systems (MSSS) in their weekly Martian weather reports at http://www.msss.com/msss_images/subject/weather_reports.html. Figure 36 shows REMS daily reports labelled SUNNY although the Malin reports raise doubts. Table 14 shows 38 weeks of weather reports by MSSS that seem to contradict REMS Team claims of constant sunny skies published for MSL at Gale Crater. Some MSSS reports are not as clear as we would like. Table 14 lists issues that need clarification.

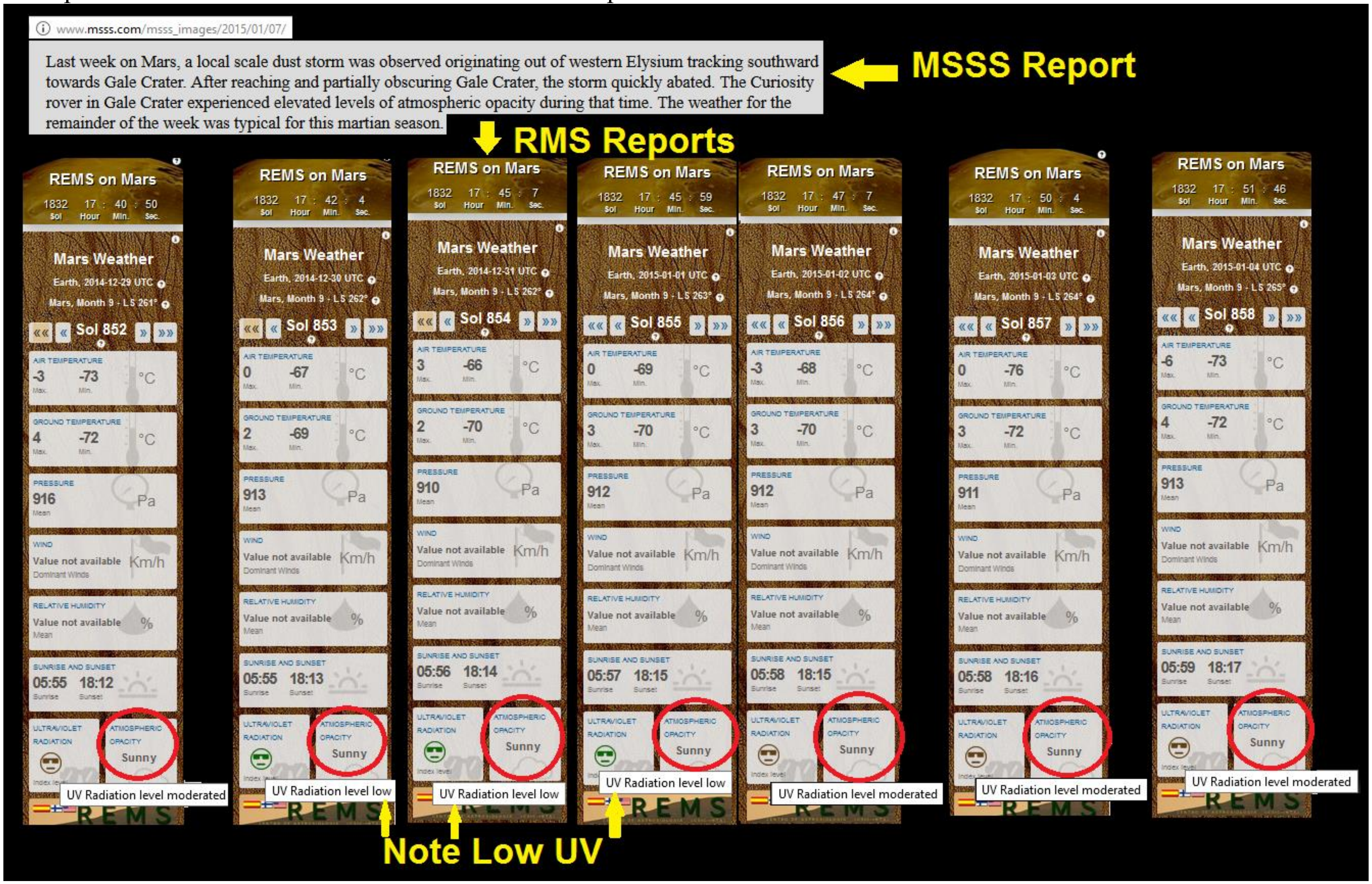


Figure 36 – REMS reports showing only sunny weather for Sols 852 to 858 (December 29, 2014 to January 4, 2015). MSSS commentary is up top.

TABLE 14 – Extracts of the MSSS reports that mention cloudy or dusty weather at the Curiosity Rover in Gale Crater, Mars, and weather in equatorial regions where Curiosity is found.		
Terrestrial Week (Full Martian weather at the link)	**Conditions at Curiosity**	**Issues**
30 August 2012 – 2 September 2012	Water ice clouds continued to dominate the afternoon skies at equatorial latitudes, including at Curiosity.	Do these clouds only form in the afternoon? Are there enough clouds to negate the REMS opacity rating for these sols as "sunny?"
3 September 2012 – 9 September 2012	Water ice clouds were observed over the Curiosity rover site in Gale Crater.	Are there enough clouds to negate the REMS opacity rating for these sols as "sunny?"
10 September 2012 – 16 September 2012	Afternoon water ice clouds were observed over equatorial latitudes, including the Curiosity rover site in Gale Crater.	Do these clouds only form in the afternoon? Are there enough clouds to negate the REMS opacity rating for these sols as "sunny?"
17 September 2012 – 23 September 2012	Aside from a few tenuous water ice clouds, skies over the Curiosity rover site in Gale Crater remained relatively clear.	Sunny or partly cloudy?
24 September 2012 – 30 September 2012	Scattered water ice cloud cover was observed around the Curiosity rover site in Gale Crater	Sunny or partly cloudy?
8 October 2012 – 14 October 2012	Aside from scattered, diffuse water ice cloud cover, skies around the Curiosity rover site in Gale Crater remained relatively clear.	Sunny or partly cloudy?
22 October 2012 – 28 October 2012	Afternoon water ice clouds were observed over equatorial latitudes, including near the Curiosity rover site.	Do these clouds only form in the afternoon? Are there enough to negate the REMS opacity rating for these sols as "sunny?"
29 October 2012 – 4 November 2012 **(Sols 82 to 88 – See Figure 36)**	Water ice clouds persisted over the equatorial latitudes, including near the Curiosity rover site in Gale Crater.	If the clouds persisted, were they present in the morning, or did they only reform in the afternoon?
5 November 2012 – 11 November 2012	Water ice clouds persisted over the equatorial latitudes, including near the Curiosity rover site in Gale Crater.	Are there enough clouds to negate the REMS opacity rating for these sols as "sunny?"
12 November 2012 – 18 November 2012	But both rover sites experienced elevated atmospheric dust levels as a result of the storm, similar to atmospheric opacity levels experienced on typical hazy summer day in Los Angeles. With higher atmospheric dust concentrations came a warming of the thin Martian atmosphere,	Was the sun obscured?

	resulting in a diminishing of water ice cloud cover across the tropics.	
Terrestrial Week	**Conditions at Curiosity**	**Issues**
6 May 2013 – 12 May 2013	Hazy conditions persisted across the southern tropics including the Curiosity site due to continuous storm activity.	Is the hazy condition enough to negate the REMS opacity rating for these sols as "sunny?"
13 May 2013 – 19 May 2013	In the southern tropics, skies above the Curiosity rover site in Gale Crater were still murky, but they were beginning to slowly clear.	Is the murky condition enough to negate the REMS opacity rating for these sols as "sunny?"
20 May 2013 – 26 May 2013	Clearing afternoon skies observed over the Curiosity rover site in Gale Crater.	Is the morning condition enough to negate the REMS opacity rating of "sunny?"
27 January 2014 – 2 February 2014	Water ice clouds were present in the afternoon across the tropics of both hemispheres and over all the major shield volcanoes. Afternoon skies remained storm-free over the Curiosity rover site in Gale.	Since the landers are in the tropics we assume this means there were water ice clouds present. Does the statement that afternoon skies were storm free mean that there was no dust storms, but the skies were not sunny due to ice clouds?
17 March 2014 – 23 March 2014	Diffuse water ice clouds dominated the afternoon skies over all the major shield volcanoes, as well as, most tropical latitudes of both hemispheres. Skies were storm-free over Curiosity.	Since the landers are in the tropics we assume this means there were diffuse water ice clouds present. Does the statement that afternoon skies were storm free mean that there was no dust storms, but the skies were not sunny due to ice clouds?
24 March 2014 – 30 March 2014	Diffuse water ice clouds, associated with the developing aphelion cloud-belt, were present at equatorial latitudes and over the large shield volcanoes. Afternoon skies continued to remain storm-free over the Curiosity rover site in Gale Crater.	Since the landers are in the tropics we assume this means there were diffuse water ice clouds present. Does the statement that afternoon skies were storm free mean that there was no dust storms, but the skies were not sunny due to ice clouds?
14 April 2014 – 20 April 2014	The aphelion water ice cloud belt was present at equatorial latitudes. Skies were relatively clear and storm free over the Curiosity rover site in Gale Crater.	Since the landers are in equatorial latitudes we assume this means there were water ice clouds present. Does the statement that afternoon skies were relatively clear and storm free mean that there was no dust storms, but the skies were partly sunny rather than sunny?

Terrestrial Week	**Conditions at Curiosity**	**Issues**
23 June 2014 – 29 June 2014	Water ice clouds reaching altitudes of up to 30 kilometers, continued to be a prominent afternoon feature at tropical latitudes in both hemispheres. One of the first large dust storms of the Martian "regional dust storm season", covering an area greater than four times that of the state of California, began in Hellas Basin. During the next two sols the storm moved to the east, at an average speed of 25 m/s (about 56 mph). The western trailing edge of the storm was observed coming within 1440 kilometers of the Curiosity rover site. Though skies had become dustier over the last couple of months, both rover sites remained storm-free, at Endeavor and Gale crater.	Define the cut off between tropical latitudes (about 25 degrees North or South) and equatorial latitudes. If skies had become dustier over the last couple of months, but both rover sites remained storm-free, at Endeavor and Gale crater at what point does dust lower opacity from sunny to not sunny?
30 June 2014 – 6 July 2014	The regional storm in Promethei, noted in last week's report, had abated. A second storm developed early in week in Hesperia and moved north across the equator into Isidis in the northern hemisphere. However enough of that dust lofted into the atmosphere by the storm was transported eastward over the Curiosity rover site by the westerly (west-to-east) winds that dominate the tropical circulation. Both rover sites continued to remain storm-free, at Endeavor and Gale crater. The amount of dust transported was relatively small and had a negligible impact on rover operations and science.	If the storm persisted long enough that dust lofted into the atmosphere by the storm was transported eastward over the Curiosity rover site by the westerly (west-to-east) winds that dominate the tropical circulation, does this imply that it was not sunny? Define "negligible" impact on rover operations and science. How does it differ from zero?
20 October 2014 – 26 October 2014	The widespread dust-lifting activity raised global atmospheric opacities to annual highs, as recorded by the Curiosity. While Curiosity experienced increased atmospheric opacities, it was largely spared from direct contact with storms. However Opportunity, just off to the east of the Acidalia storm-track, was less fortunate and experienced extremely hazy skies due to its proximity to areas of dust-	Was opacity great enough to imply that this was not a sunny day?

	lifting along the cross-equatorial storm track.	
Terrestrial Week	**Conditions at Curiosity**	**Issues**
24 November 2014 – 30 November 2014	The Curiosity continued to experience seasonally elevated dust levels in the atmosphere compared to previous Martian years, despite that skies continued to remain storm-free.	Was opacity great enough to imply that this was not a sunny day?
1 December 2014 – 7 December 2014	Both the Opportunity rover on Meridiani Planum and the Curiosity rover in Gale Crater experienced dusty but storm-free skies.	Was opacity great enough to imply that this was not a sunny day?
29 December 2014 – 4 January 2015 **(Sols 852 to 858 – see Figure 37)**	Last week on Mars, a local scale dust storm was observed originating out of western Elysium tracking southward towards Gale Crater. After reaching and partially obscuring Gale Crater, the storm quickly abated. Curiosity experienced elevated levels of atmospheric opacity during that time.	Was opacity great enough to imply that this was not a sunny day?
30 March 2015 – 5 April 2015	As a result of all the storm activity during the past couple of weeks, the Curiosity experienced dustier skies.	Was opacity great enough to imply that this was not a sunny day?
23 November 2015 – 29 November 2015	Condensate water-ice clouds, associated with the developing aphelion cloud-belt, dominated the afternoon equatorial skies. Curiosity experienced storm-free skies each afternoon.	Were the afternoon clouds enough to imply that this was not a sunny day?
30 November 2015 – 6 December 2015	Condensate water-ice clouds, associated with the aphelion cloud-belt, dominated the skies at equatorial latitudes. Curiosity in Gale Crater and Opportunity were storm-free.	Were the clouds enough to imply that this was not a sunny day?
7 December 2015 – 13 December 2015	The aphelion cloud-belt continued to develop at equatorial latitudes. Gale Crater experienced storm-free skies each sol.	Were the clouds enough to imply that this was not a sunny day?
14 December 2015 – 20 December 2015	The Martian aphelion cloud-belt continued to dominate the afternoon skies over low latitudes. Curiosity encountered storm-free skies.	Were the afternoon clouds enough to imply that this was not a sunny day?

21 December 2015 – 27 December 2015	The aphelion cloud-belt continued to expand its presence of water-ice clouds over equatorial regions. Curiosity experienced storm-free skies each sol.	Were the clouds enough to imply that this was not a sunny day?
Terrestrial Week	**Conditions at Curiosity**	**Issues**
25 January 2016 – 31 January 2016	Curiosity experienced storm-free afternoon skies.	Were the mornings not storm free?
1 February 2016 – 7 February 2016	The aphelion cloud-belt, composed of diffuse water-ice aerosols, prevailed over the mid-to-low latitudes. Afternoon skies were storm-free each sol over the Curiosity.	Were the afternoon clouds enough to imply that this was not a sunny day?
8 February 2016 – 14 February 2016	The condensate water-ice clouds strewn across the equatorial regions (the aphelion cloud-belt), continued to be the most prominent weather feature on Mars this past week. Storm-free skies persisted over Curiosity.	Were the condensate water-ice clouds strewn across the equatorial regions enough to keep the days from being sunny?
15 February 2016 – 21 February 2016	Apart from condensate clouds over Gale, skies were relatively clear Curiosity.	Were the condensate clouds enough to keep the sols from being sunny?
26 September 2016 – 2 October 2016	The Curiosity rover site did experience some elevated atmospheric dust levels due to the dust activity over Elysium Planitia.	Were the dust levels at Curiosity enough to keep the days from being sunny?
27 February 2017 – 5 March 2017	Equatorial water-ice clouds were at a minimum due to the warmer and dustier conditions. The Curiosity rover in Gale Crater encountered seasonal dust levels on par with previous Martian years.	Were the dust levels enough to keep the days from being sunny?
6 March 2017 – 12 March 2017	Curiosity rover in Gale Crater experienced storm-free but dusty skies while Opportunity felt the impact of the nearby regional storm throughout the week.	Were the dust levels enough to keep the days from being sunny? What was the nature of the regional storm? Was it a dust storm, a windy storm, or a storm with clouds?
13 March 2017 – 19 March 2017	The Curiosity rover in Gale Crater encountered dust levels typical for this time of Mars year.	Gale Crater encountered dust levels typical for this time of Mars year. We need a definition of typical in terms of opacity.
4 September 2017 – 10 September 2017	Curiosity in Gale Crater experienced scattered water ice cloud cover throughout the week, but remained free of any afternoon dust storm activity.	Curiosity experienced scattered water ice cloud cover throughout the week, but remained free of any afternoon dust storm activity. Ice clouds are different from dust. Was it sunny in the morning?

On Figure 37 the REMS Team, as always, labels Sol 82 as "SUNNY." But Malin's commentary for this week states, "A local scale dust storm was observed originating out of western Elysium tracking southward towards Gale Crater. After reaching and partially obscuring Gale Crater, the storm quickly abated. Curiosity experienced elevated levels of atmospheric opacity during that time." If REMS used the terms PARTY SUNNY, or PARTLY CLOUDY or HAZY its reports would have value. They never do, and thus on examining the Malin record on Table 14 all that can be said for this segment of the REMS reports is that like the rest of REMS data (with the possible exception of the high air and ground temperatures), it's worthless.

Figure 37 shows visibility for different values of opacity on Mars due to a dust storm at Opportunity between sols 1205 and 1235. All photos were taken between 10:53 and 11:30 local time. The dust in the Martian air over Opportunity blocked 99 percent of direct sunlight. This fact alone makes it very hard to accept that pressures would be unaffected.

No higher resolution available.
Mars_dust_opacities_MER-B_Sol_1205_to_1236.jpg (800 × 533 pixels, file size: 39 KB, MIME type: image/jpeg)

Figure 37 – Opacity changes at Opportunity from sols 1205 to 1235. Redrawn from http://www.jpl.nasa.gov/news/news.cfm?release=2007-080.

J. D. Parsons (2000)[80] addresses the compressibility of dust storms and positive feedback for their formation. Pre-dust storm density values are around 9.4 g/m^3. A sample dust storm given in the Parsons paper would have additional densities of 17g/m^3 in order to even be created. This is an order of magnitude greater than terrestrial storms. It also constitutes an increase of at least several hundred percent over previously accepted values. In the Sahara, pressures have been observed to increase during dust storms. Likewise when a huge dust storm hit Luke Air Force on July 5, 2011, pressure rose by 6.6 mbar (more than accepted average pressure at Mars areoid) between the storm's arrival at 0255Z 6 July 2011 (pressure 1,004.7 mbar) and 0555Z when the pressure was up to 1,011.3 mbar. Pressure dropped as visibility cleared at 0655Z (personal call to Luke AFB meteorology, July 6, 2011).

The Parsons (2000)[80] paper proposes a gravity current analog for dust storms and mentions that such currents should be constrained to the height of the inversion layer (but dust storms on Mars can still have effects at 160 km). Perhaps most important, increased pressure makes it easier to entrain particles (hence higher pressure may explain dust storms and dust devils).

Figure 38 is adapted from page 181 in *The Martian Climate Revisited* by Read and Lewis,[79] which states that τ is derived from pressure data. During a Martian year opacity varies greatly. The clear season is in the northern summer with optical depth τ values of ~0.3 to 0.5. During northern winter τ values of ~2 to 5 or higher were seen during dust storms (see Figure 38). Black dots are the Year One data, black pluses are the Year Two data, and the red X's are extrapolations from the pressure data. This is for Viking 1.

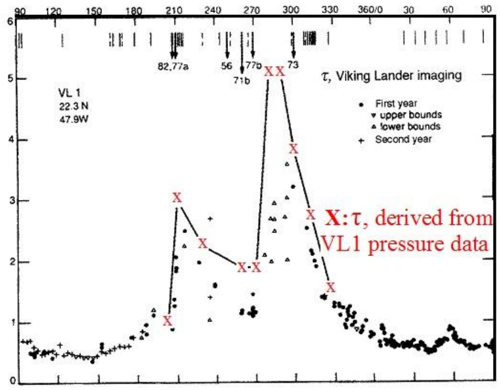


Figure 38: VL1 Pressure and Opacity, redrawn from Figure 7.2 in The Martian Climate Revisited, Read and Lewis (2004).

10. EXCESSIVE DECELERATION DURING AEROBRAKING OPERATIONS.

It is cost efficient to slow a spacecraft approaching a planet like Mars by aerobraking – dipping the probe into the atmosphere to use free drag rather than expensive fuel. This was done with Mars Global Surveyor (MGS) and Mars Reconnaissance Orbiter (MRO). In both cases, more air was encountered than expected.

10.1 Mars Global Surveyor (MGS).

When MGS was launched in 1996, the intent was to achieve a circular pole-to-pole, Sun-synchronous orbit around Mars with an altitude of approximately 300 km above the surface and an orbital period of just under 2 hours. In an attempt to accomplish this orbit using minimal fuel, MGS used aerobraking. It was deliberately flown through the upper atmosphere of Mars during periapse to use the aerodynamic drag forces to modify its orbital parameters. The effort did *not* go as planned and the early maneuvers led to excessive decelerations (Read & Lewis 2004, 11).[78]

If Mars has a higher than expected atmospheric density, it would explain unexpected excessive decelerations. As shown in Figure 40 and discussion below, it is believed that a dust storm produced the unexpected drag, but the effects at a normalized altitude of 121 km (75 miles) seem quite high for a planet that is supposed to have an average surface pressure of only about 6.1 mbar.

Johnston et al. (1998)[81] reported that (1) "On the onset of a dust storm, the atmospheric density could more than double in a 48 hour time period," and (2) "If during aerobraking, the spacecraft experiences dynamic pressure values greater than this limit line, the periapsis altitude of the orbit must be raised immediately in order to re-establish the 90% atmospheric density capability." Both happened.

Note the tremendous increase in dynamic pressure shown on Figure 39. At an altitude normalized to 121 km, the dust storm caused dynamic pressure to rise from about 0.15 N/m^2 on November 9^{th}, 1997 to 0.84 N/m^2 on December 7, 1997. While the Johnson et al. (1998) article referred to atmospheric density more than doubling during a dust storm, the increase in dynamic pressure felt at 121 km over four weeks was 5.6 times the pre-storm values.

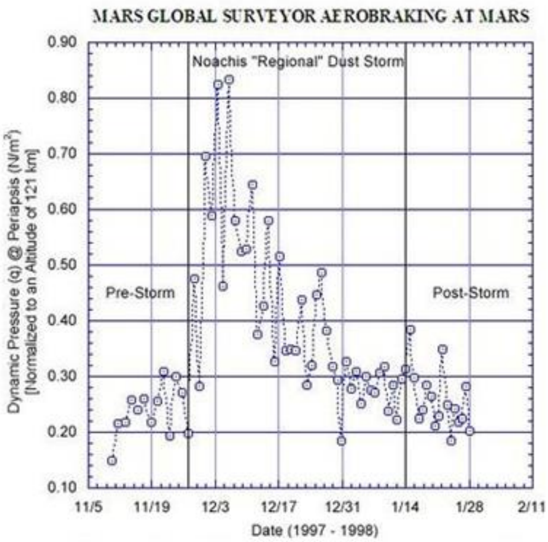


Figure 39 – Actual Dynamic Pressure – Normalized to an Altitude of 121 km (reproduced from Johnson, et al, 1998)

10.2 Mars Reconnaissance Orbiter (MRO).

MRO also employed an aerobraking process. Its navigation team relied on an atmospheric model called the Mars-GRAM (Global Reference Atmospheric Model). Mars-GRAM is a computer database of information from what previous missions have encountered. It provided a prediction of the atmospheric density, giving the navigators an estimate of how far down into the atmosphere the spacecraft should go.

The atmospheric density that MRO actually experienced was much different than what was predicted by the Mars GRAM (Atkinson, 2006).[82] Two quotes are most notable in the Atkinson article:

(907) "At some points in the atmosphere, we saw a difference in the atmospheric density by a factor of 1.3, which means it was 30% higher than the model," said Han You, Navigation Team Chief for MRO. "That's quite a bit, but around the South Pole we saw an even larger scale factor of up to 4.5, so that means it was 350% off of the Mars GRAM model."

(2) "When we first started out at a somewhat higher altitude, the Mars GRAM model was doing pretty well," said Richard Zurek, Project Scientist for MRO. "When we got to the lower altitude the scale factor to which it was off was larger and it became even larger as periapsis moved toward the South Pole."

11. THE GLOBAL DUST STORM OF 2018.

When we look at all the weather reports from the REMS Team up until MSL Sol 2082 there are plenty of reasons for great concern about the validity of the data. They are reinforced by the fact that the Jet Propulsion Laboratory pulled down or altered the REMS Team/NASA data on many occasions after Guy Webster, their public relations agent, either heard directly from us by phone or read our reviews of the data – something that we document with before and after print screens of the REMS Team published weather data plus IP address reports for readers. Most notable was the removal by NASA of all wind data in May 2013 after we called Mr. Webster about the fact that over 9 months their data never changed from 7.2 kph from the East even though the Viking 1 and 2 landers showed changes in wind speed and direction every hour for 8,311 hourly reports. Further, Ashima research, in conjunction with JPL showed impossible (and also never changing) sunrise and sunset times for the same period, but they eventually retracted them all based on our day length calculations. Some the changes to their data based on our suggestions was documented back on Table X of this Report.

Although NASA/JPL is well aware of fundamental flaws to the weather data reported by MSL Curiosity (and earlier landers) amazingly they still offer up ludicrous information. As such, we in turn offer below all MSL data for the Global Dust Storm of 2018. We will then show that the data is likely to be manufactured in particular with respect to pressure measurements which seem to be based on readings in previous years at the same Ls (solar longitude), increases in altitude due to Curiosity climbing Mt. Sharp, but which failed to account for the weight of the dust and how that is likely to contribute to an increase in pressure even though the lander is a little over 200 meters higher than it was in the previous Martian year.

Figure 40 shows that when the 2018 Global Dust Storm hit MSL that UV levels dropped to low. The figure shows MSL Sols 2082 to 2090. Low UV continued until at least Sol 2139, then appeared intermittently through 2,147. After that the effects of the storm were no longer apparent. Although this storm totally blocked out the sun at MER Opportunity as is shown below on Figure 41, enough sunlight had been blocked at MSL to prevent shadows from being formed, and to obscure many geographic features (see Figure 42). When we saw a similar dust storm on Earth darken Luke Air Force Base pressure rose by at least 6.6 mbar in an hour. Even if we say that gravity on Mars is only 38% of Earth's, an overhead mass of dust with a similar weight should produce an increase in pressure of a least 38% of 6.6 mbar. That's about 2.598 mbar which is 259.8 Pa.

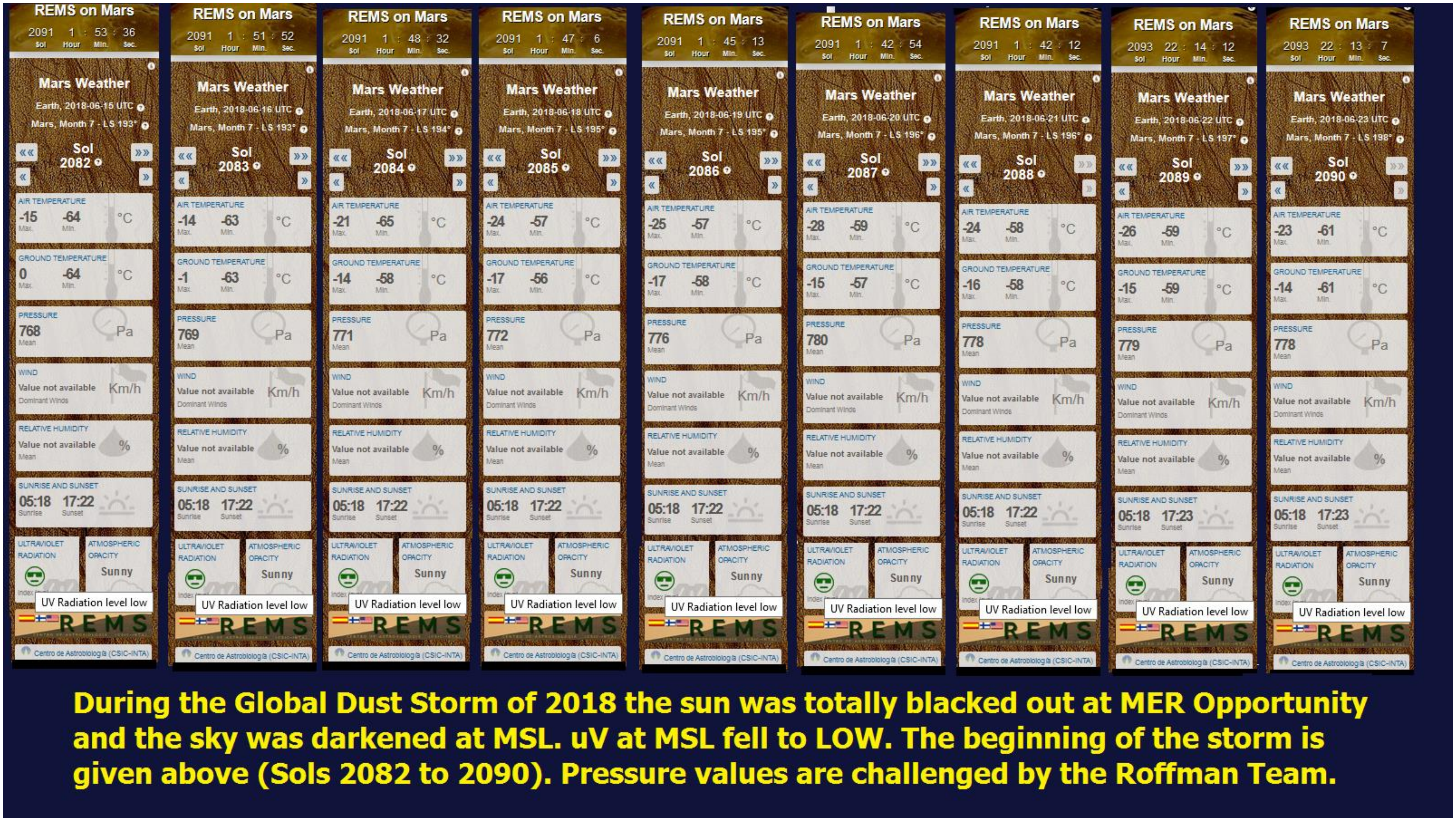


Figure 40 - NASA is likely to leave these Low uV values intact. They were reported for MSL during the Global Dust Storm of 2018.

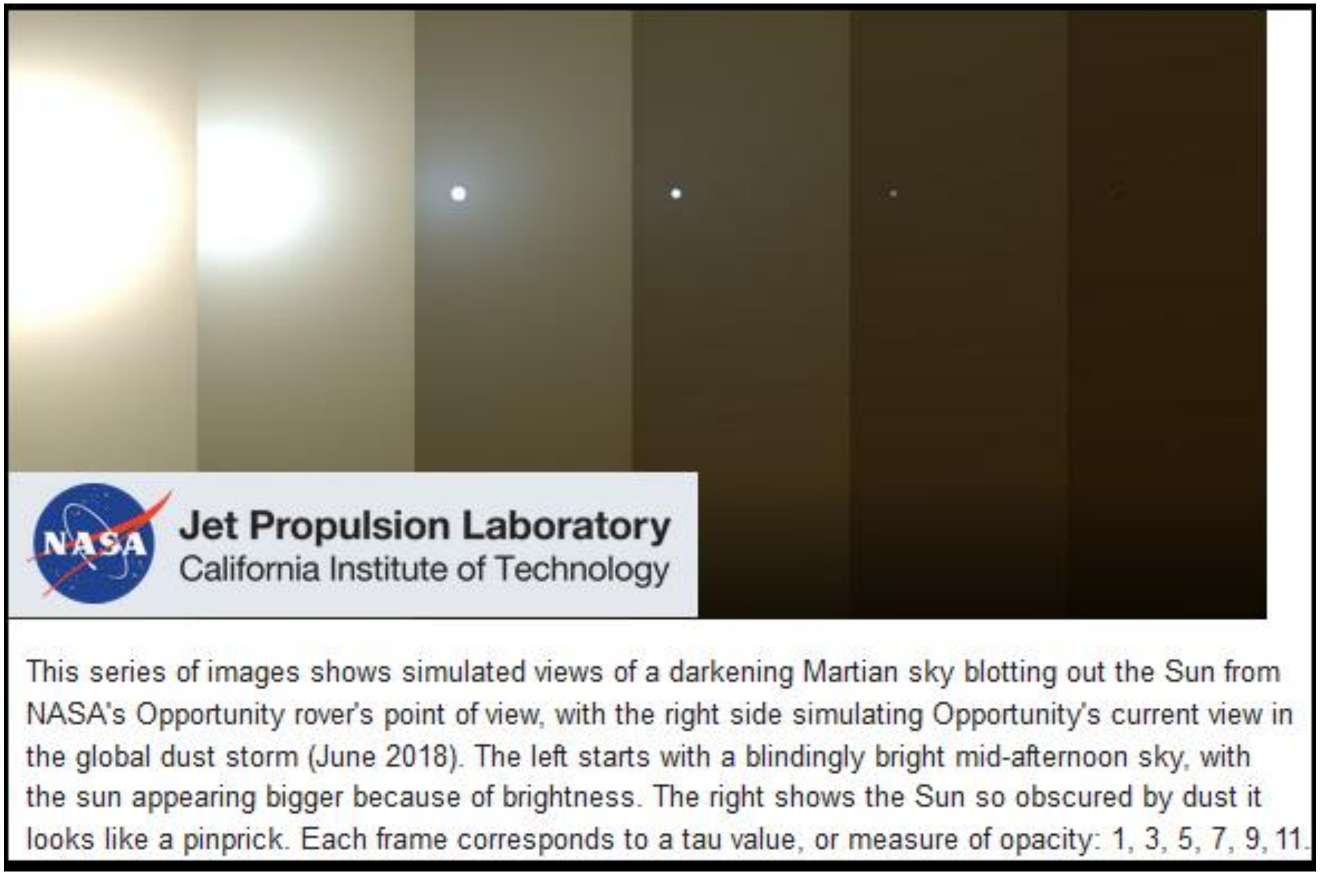


Figure 41 – The 2018 Global Dust Storm at MER Opportunity blacks out the sun. It should take more than saltation for a near vacuum atmosphere to support this much dust.

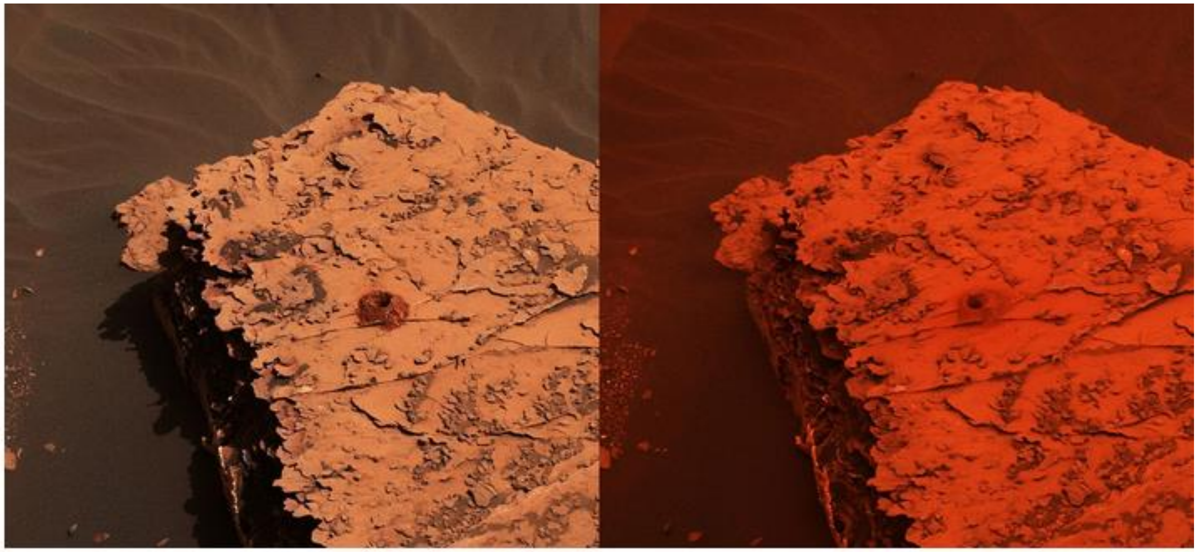


Figure 42 - Two images from the Mast Camera (Mastcam) on NASA's Curiosity rover depict the change in the color of light illuminating the Martian surface since a dust storm engulfed Gale Crater. The left image shows the "Duluth" drill site on Sol 2058 (May 21); the right image is from Sol 2084 (June 17). The cherry red color in the post-storm image is due to a few factors. One difference between the two images is exposure time: the dust over Curiosity creates a low-lighting condition that requires a longer exposure time for the camera. The pre-storm image had an exposure time of 7.3 milliseconds, which is normal for the rover; the later image had an exposure time that was 66 milliseconds -- or nine times longer. Credit NASA/JPL-Caltech/MSSS

11.1 Pressures Claimed for the 2018 Global Dust Storm.

In comparing pressure for the 2018 storm with pressures at MSL in 2016 (the previous Martian year) at the same solar longitude (Ls) we must first consider how the altitude changed as Curiosity climbed Mount Sharp. The (publically available) altitude record in 2018 was adequate, but the record during 2016 for the period of time between Ls 192 and Ls 241 is not available online although NASA has one diagram that is somewhat helpful. In Figure 43 it is modified by us to draw in the information that is available.

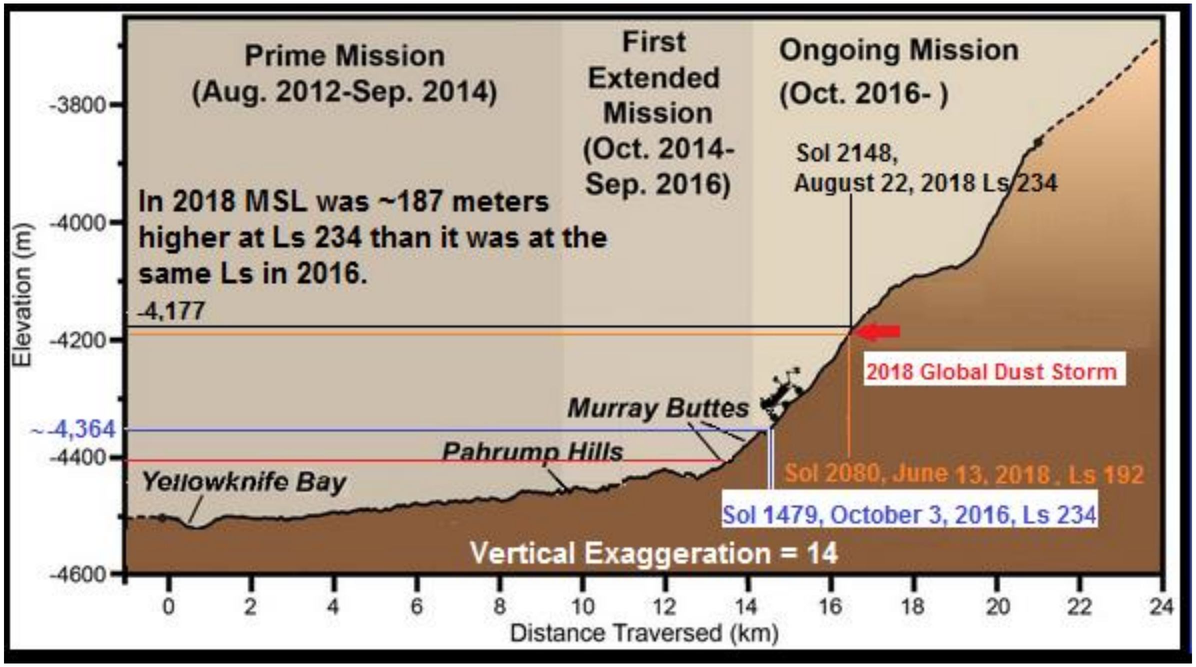


Figure 43: The altitude from – July 26, 2016 to October 15, 2016 was somewhere between 4,400 meters in July to 4,360 meters below areoid.

Altitude data, when available, is presented on Table 15A. It is taken from the NASA/JPL web site at https://mars.nasa.gov/msl/mission/whereistherovernow/. For the previous Martian **year we are interested in** Ls 192 to 241, **sols 1412 to 1476**. Unfortunately JPL offers a Site 54, Drive 2202, **Sol 1353** map (https://marsprogram.jpl.nasa.gov/resources/7848/curiositys-traverse-map-through-sol-1353/) and **then no such map until** Site 58, Drive 2760 at **Sol 1501** (https://mars.nasa.gov/imgs/2016/10/MSL_TraverseMap_Sol1501-full.jpg**)**. Not that during the dust storm the lander climbed 29 meters from 4,192 meters below areoid to 4,163 meters below areoid, then descended 18 meters to 4,181 meters below areoid.

TABLE 15 A – MSL Sols, Ls and Altitude in Meters Below Areoid						
YR 3			YR 4 (Dust Storm)			
Sol	Ls	Height	Sol	Ls	Height	Δ Height
1412	192	N/A	2080	192	-4,192 m	N/A
1413	193	N/A	2081	192	-4,192 m	0
1414	193	N/A	2082	193	-4,192 m	0
1415	194	N/A	2083	194	-4,192	0
1416	194	N/A	2084	194	-4,192	0
1417	195	N/A	2085	195	-4,192	0
1418	196	N/A	2086	195	-4,191	+1 m
1419	196	N/A	2087	196	-4,192	-1 m
1420	197	N/A	2088	196	-4,193	-1 m
1421	197	N/A	2089	197	-4,192	+1 m
1422	198	N/A	2090	198	-4,193	-1 m
1424	199	N/A	2092	199	-4,186	+7 m
1426	200	N/A	2094	200	-4,177	+9 m
1427	201	N/A	2095	201	-4,171	+6 m
1430	203	N/A	2098	203	-4,165	+6 m
1434	205	N/A	2102	205	-4,163	+2 m
1436	206	N/A	2104	206	-4,165	-2 m
1439	208	N/A	2106	208	-4,164	+1 m
1440	209	N/A	2108	209	-4,164	0
1448	214	N/A	2116	214	-4,159	+5 m
1451	216	N/A	2119	216	-4,159	0
1458	220	N/A	2126	220	-4,163	-4 m
1460	222	N/A	2128	221	-4,169	-6 m
1464	224	N/A	2132	224	-4,170	-1 m
1476	232	N/A	2144	232	-4,181	-11 m
1490	241	~4,360	2158	241	-4,156	+25 m

Let's look at how our Table 15B below covers the 2018 dust storm at MSL. It shows the weather from MSL Sol 2080 (about a day before the storm arrived) up through Sol 2148. The UV dropped from high in Sol 2080 to low by Sol 2082 See Column R). Looking at Column C for the pressure during the storm, and Column N for the pressure at the same Ls in the previous Martian year, pressures in Year 4 dropped by 13 to 27 Pa from the previous year (see Column O). **The average drop in pressure was about 20.87 Pa. In the 13 sols before arrival of the dust storm (Sols 2066 through Sol 2079) the average drop in pressures was 16.69 Pa.** So the average pressure drop during the storm was 4.18 Pa more during the storm than before it. **After the storm** as I update this report on September 5, 2018 REMS has published data for 10 more sols (Sols 2150 through 2,159). The pressure drops in Pa for these 10 sols (compared to the previous year) were as follows: -19, 19, -19, -21, -19, -23, -23, -26, -24 and -23. **The average drop was 21.6 Pa. Again, this compares to an average drop of 20.87 Pa during the storm and 16.69 16.69 Pa before the storm.**

At Sol 2090 MSL Curiosity was at an altitude of about 4193 meters below areoid. The Sol from the previous Martian year where the Ls was the same was Sol 1422 which was 8/6/2016 on Earth. At that time Curiosity was about [4,400 meters below areoid](). So it climbed about 207 meters since then. **Based on a scale height calculation with 610 Pa (6.1 mbar) at areoid, climbing 207 meters from 4,400 meters to 4,193 below meters pressure should drop 17.4 Pa IF there is no dust storm.** The scale height calculation is given below.

KILOMETERS	10.8 km Scale Height (MARS)	RATIO A/B	=-EXP(C value)	1/D scale height	PRESSURE MARS BARS	PRESSURE IN MBAR	PRESSURE IN PASCALS	DROP IN PRESSURE FROM YEAR 3 TO 4 ONLY DUE TO CLIMB
-4.4	10.8	-0.407407407	-0.665373057	-1.50291628	1.50291628	9.167789309	916.7789309	
-4.193	10.8	-0.388240741	-0.678249041	-1.474384686	1.474384686	8.993746585	899.3746585	17.40427243
0	10.8	0	-1	-1	1	6.1	610	AREOID

What does it mean that the scale height calculation for drop in pressure due to increase in altitude (17.4 Pa) almost exactly matches the drop in pressure supposedly measured by MSL (17.8 Pa - a 97.75% agreement? It means that the NASA data is likely to be fraudulent. While someone took the time to do the scale height calculation before giving us false data, he (or she) forgot that dust adds weight to the atmosphere. The pressure should have increased - probably by at least 100 Pa - rather than decreased. If it got as dark at MSL as it was at Opportunity due to this storm then the pressure should have gone up by about 233 Pa (the 250.8 Pa calculated above considering Mars gravity minus the 17.8 Pa lost due to altitude increase. We must therefore conclude that again we see the REMS Team manufacturing data.

On Table 15B column subjects and color codings are as follows (Note: JPL calls the first year of MSL on Mars "Year 0," the second year Year 1, the third year Year 2 and the 4th year Year 3):

Column A (Sol). The Martian day is about 39 minutes longer than the terrestrial day.

Column B is solar longitude (Ls). MSL is in the Southern Hemisphere on Mars. The landing was at Ls 150 in winter. Ls 180 begins the spring there. Ls 270 starts summer, Ls 0 starts the fall. Ls 90 starts the winter.

Column C shows the pressure reported by the REMS Team.

Column D shows the date on Earth.

Column E shows the maximum air temperature. With respect to the freezing point, from 0° C at 1 atm pressure it will increase up to 0.01° C at 0.006 atm (which is about the average pressure on Mars as given by NASA). This is the triple point of water. At pressures below this, water will never be liquid. It will change directly between solid and gas phase (sublimation). The temperature for this phase change, the sublimation point, will decrease as the pressure is further decreased

Column F shows minimum air temperature.

Column G shows the air temperature range for each sol. On Earth temperatures can vary by 40 °C in deserts. In column G where the range is 59 °C or less yellow background coloring points that out. The National Park Service claims **the world record in a diurnal temperature variation is 102 °F (57 °C)** (from 46 °F (8 °C) to −56 °F (−49 °C)) in Browning, Montana (elevation 4,377 feet/1,334 meters) on January 23 to 24, 1916. **There were 2 days in Montana where the temperature changed by 57 °C.**

Column H shows temperature range divided by 40. This allows us to compare terrestrial deserts with Gale Crater, Mars. How much cooling occurs at night is related to the density of the atmosphere. Here we see the ratio of cooling on a Mars sol to the typical 40 °C cooling figure for Earth's deserts shown with a green background when that ratio is under 1.5. For MSL Year 1 when we altered the devisor from 40 °C to 57 °C then 88 of the ratios were altered to 1 or less than 1, meaning that Martian air pressure is indeed likely much higher than NASA claims.

Column I shows maximum ground temperature. As with terrestrial deserts, the ground on Mars heats more during the day than the air does, and it cools more at night than the air does. In Column K when the maximum ground temperature is given by REMS is above 0°C it is shown with a red background.

Column J shows the minimum ground temperature. When it is -90 °C or colder the background is in purple. **The ground temperatures are not very precise.** The requirement was to measure ground brightness temperature over the range from 150 to 300 K with **a resolution of 2 K and an accuracy of 10 K**.

Column K. Drop in ground temperature from day to night.

Column L shows the increase in temperature from the mast 1.5 meters above the ground down to the ground during the daylight hours. In column N anytime there is an increase in temperature of 11 °C or more this in indicated with a dark blue background.

Column M shows the decrease in temperature from the ground to the air at nights. If the data were valid we would expect similar heating or cooling to occur over the set distance from ground to boom. A quick survey of the data immediately shows that this was not found. In column L we see a variation in heating between 0 °C and at least 15 °C with a 54 °C anomaly on Sol 1,070. For nighttime cooling any variation from 11°C to 19°C is shown with a medium blue background. More than that is shown with a dark blue background.

Column N shows the pressure for the same Ls in MSL Year 1.

Column O shows the absolute value of the change in pressure in Pascals from the same Ls in the previous year (Column [M] - [C]).

Column P shows the original pressure for the same Ls in MSL Year 1 before JPL revised their data.

Column Q shows the Ls during Year 3.

Column R shows the UV for the sol in Year 4.

Column S shows the UV for the sol in Year 3. All sols in MSL Year 1 through 4 have opacity listed as “sunny” which seems dubious.

Column T shows comments, if any, if any and any readings on altitude.

SOL	~LS	PRESSURE Pa	EARTH DATE	MAX AIR TEMP °C	MIN AIR TEMP °C	AIR TEMP RANGE °C	AIR TEMP RANGE °C/40	MAX GROUND TEMP °C	MIN GROUND TEMP °C	Δ GROUND TEMP DAY TO NIGHT	DAYTIME CHANGE IN TEMP °C AIR TO GROUND	NIGHTTIME CHANGE IN TEMP °C AIR TO GROUND	PRESSURE AT SAME LS IN MSL YEAR 3	Δ PRESSURE YEAR 4 TO YEAR 3 SAME LS	~LS year 3	PRESSURE PREVIOUS YEAR BEFORE REVISION	UV YR 4	UV YR 3	MSL YEAR 3 SOL FOR THIS LS/ COMMENTS	MSL Altitude meters below areoid
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
						YELLOW IF <60 °C	GREEN IF<1.5	RED IF > 0 °C	PURPLE = >-90°C OR COLDER	YELLOW NUMBERS = -80 to -89 °C, red background = -90°C or colder drop	BLUE = >10°C	PURPLE = >10°C		YELLOW = > 7 Pa)						
2080	192	768	6/13/2018	2	-67	69	1.725	11	-70	-81	9	-3	782	-14	192	N/A	H	H	(1412)	-4,192
2081	192	770	6/14/2018 Dust storm	-3	-69	66	1.65	6	-71	-77	9	-2	784	-14	193	N/A	M	H	(1413)	-4,192
2082	193	768	6/15/2018 Dust storm	-15	-64	49	1.225	0	-64	-64	15	0	785	-17	193	N/A	L	H	(1414)	-4,192
2083	194	769	6/16/2018 Dust storm	-14	-63	49	1.225	-1	-63	-62	13	0	787	-18	194	N/A	L	H	(1415)	-4,192
2084	194	771	6/17/2018 Dust storm	-21	-65	44	1.1	-14	-58	-44	7	+7	791	-20	194	N/A	L	H	(1416)	-4,192
2085	195	772	6/18/2018 Dust storm	-24	-58	34	0.85	-17	-56	-39	7	+2	791	-19	195	N/A	L	H	(1417)	-4,192
2086	195	776	6/19/2018 Dust storm	-25	-57	32	0.8	-17	-58	-41	8	-1	793	-17	196	N/A	L	H	(1418)	-4,191
2087	196	780	6/20/2018 Dust storm	-28	-59	31	0.775	-15	-57	-42	13	+2	793	-13	196	N/A	L	H	(1419)	-4,192
2088	196	778	6/21/2018 Dust storm	-24	-58	34	0.85	-16	-58	-42	8	0	793	-15	197	N/A	L	H	(1420)	-4,193

SOL	~LS	PRESSURE Pa	EARTH DATE	MAX AIR TEMP °C	MIN AIR TEMP °C	AIR TEMP RANGE °C	AIR TEMP RANGE °C/40	MAX GROUND TEMP °C	MIN GROUND TEMP °C	Δ GROUND TEMP DAY TO NIGHT	DAYTIME CHANGE IN TEMP °C AIR TO GROUND	NIGHTTIME CHANGE IN TEMP °C AIR TO GROUND	PRESSURE AT SAME LS IN MSL YEAR 3	Δ PRESSURE YEAR 4 TO YEAR 3 SAME LS	~LS year 3	PRESSURE PREVIOUS YEAR BEFORE REVISION	UV YR 4	UV YR 3	MSL YEAR 3 SOL FOR THIS LS/ COMMENTS	MSL Altitude meters below areoid
2089	197	779	6/22/2018 Dust storm	-26	-59	33	0.825	-15	-59	-44	11	0	797	-18	197	N/A	L	H	(1421)	-4,192
2090	198	778	6/23/2018 Dust storm	-23	-61	38	0.95	-14	-61	-47	9	0	800	-22	198	N/A	L	H	(1422)	-4,193
2091	198	779	6/24/2018 Dust storm	-22	-63	41	1.025	-13	-60	-47	9	+3	800	-21	199	N/A	L	H	(1423)	
2092	199	781	6/25/2018 Dust storm	-24	-67	43	1.075	-12	-62	-50	12	+5	803	-22	199	N/A	L	H	(1424)	-4,186
2093	199	780	6/26/2018 Dust storm	-24	-63	39	0.975	-14	-60	-46	10	+3	804	-24	200	N/A	L	H	(1425)	
2094	200	783	6/27/2018 Dust storm	-27	-61	34	0.85	-17	-60	-43	10	+1	803	-20	200	N/A	L	H	(1426)	-4,177
2095	201	784	6/28/2018 Dust storm	-25	-61	36	0.9	-17	-60	-43	8	+1	807	-23	201	N/A	L	VH	(1427)	-4,171
2096	201	788	6/29/2018 Dust storm	-22	-63	41	1.025	-15	-59	-44	7	+4	808	-20	202	N/A	L	VH	(1428)	
2097	202	789	6/30/2018 Dust storm	-23	-60	37	0.925	-16	-59	-43	7	+1	810	-21	202	N/A	L	VH	(1429)	
2098	203	791	7/1/2018 Dust storm	-23	-61	38	0.95	-17	-59	-42	6	+2	810	-19	203	N/A	L	H	(1430)	-4,165
2099	203	791	7/2/2018 Dust storm	-25	-61	36	0.9	-16	-58	-42	9	+3	811	-20	204	N/A	L	H	(1431)	
2100	204	797	7/3/2018 Dust storm	-29	-61	32	0.8	-24	-59	-35	5	+2	813	-16	204	N/A	L	H	(1432) 3333	
2101	204	796	7/4/2018 Dust storm	-23	-61	38	0.95	-16	-59	-43	7	+2	821	-25	205	N/A	L	H	(1433)	

SOL	~LS	PRESSURE Pa	EARTH DATE	MAX AIR TEMP °C	MIN AIR TEMP °C	AIR TEMP RANGE °C	AIR TEMP RANGE °C/40	MAX GROUND TEMP °C	MIN GROUND TEMP °C	Δ GROUND TEMP DAY TO NIGHT	DAYTIME CHANGE IN TEMP °C AIR TO GROUND	NIGHTTIME CHANGE IN TEMP °C AIR TO GROUND	PRESSURE AT SAME LS IN MSL YEAR 3	Δ PRESSURE YEAR 4 TO YEAR 3 SAME LS	~LS year 3	PRESSURE PREVIOUS YEAR BEFORE REVISION	UV YR 4	UV YR 3	MSL YEAR 3 SOL FOR THIS LS/ COMMENTS	MSL Altitude meters below areoid
2102	205	797	7/5/2018 Dust storm	-22	-60	38	0.95	-14	-59	-45	8	+1	820	-23	205	N/A	L	H	(1434)	-4,163
2103	205	797	7/6/2018 Dust storm	-26	-58	32	0.8	-16	-58	-42	10	0	824	-27	206	N/A	L	H	(1435)	
2104	206	797	7/7/2018 Dust storm	-23	-59	36	0.9	-15	-58	-43	8	+1	824	-27	206	N/A	L	H	(1436)	-4,165
2105	207	802	7/8/2018 Dust storm	-25	-61	36	0.9	-15	-59	-44	10	+2	821	-19	207	N/A	L	H	(1437)	
2106	208	803	7/9/2018 Dust storm	-27	-63	36	0.9	-16	-59	-43	11	+4	823	-20	208	N/A	L	H	(1438)	
2107	208	807	7/11/2018 Dust storm	-21	-65	44	1.1	-15	-59	-44	6	+6	828	-21	208	N/A	L	H	(1439)	-4,164
2108	209	806	7/12/2018 Dust storm	-24	-65	41	1.025	-15	-58	-43	9	+7	828	-22	209	N/A	L	H	(1440)	-4,164
2109	209	809	7/13/2018 Dust storm	-22	-66	44	1.1	-12	-60	-48	10	+6	828	-19	210	N/A	L	H	(1441)	
2110	210	810	7/14/2018 Dust storm	-20	-59	39	0.975	-12	-59	-47	8	0	829	-19	210	N/A	L	H	(1442)	
2111	211	813	7/15/2018 Dust storm	-20	-67	47	1.175	-12	-60	-48	8	+7	831	-18	211	N/A	L	H	(1443)	
2112	211	813	7/16/2018 Dust storm	-11	-63	52	1.3	-11	-60	-49	0	+3	833	-19	212	N/A	L	H	(1444)	
2113	212	815	7/17/2018 Dust storm	-20	-62	42	1.05	-11	-60	-49	9	+2	836	-21	212	N/A	L	H	(1445)	
2114	213	816	7/18/2018 Dust storm	-19	-61	42	1.05	-10	-60	-50	9	+1	841	-19	213	N/A	L	H	(1446)	

SOL	~LS	PRESSURE Pa	EARTH DATE	MAX AIR TEMP °C	MIN AIR TEMP °C	AIR TEMP RANGE °C	AIR TEMP RANGE °C/40	MAX GROUND TEMP °C	MIN GROUND TEMP °C	Δ GROUND TEMP DAY TO NIGHT	DAYTIME CHANGE IN TEMP °C AIR TO GROUND	NIGHTTIME CHANGE IN TEMP °C AIR TO GROUND	PRESSURE AT SAME LS IN MSL YEAR 3	Δ PRESSURE YEAR 4 TO YEAR 3 SAME LS	~LS year 3	PRESSURE PREVIOUS YEAR BEFORE REVISION	UV YR 4	UV YR 3	MSL YEAR 3 SOL FOR THIS LS/ COMMENTS	MSL Altitude meters below areoid
2115	213	818	7/19/2018 Dust storm	-21	-61	40	1.0	-12	-60	-48	9	+1	841	-25	214	N/A	L	H	(1447)	
2116	214	820	7/20/2018 Dust storm	-21	-62	41	1.025	-10	-60	-50	11	+2	841	-21	214	N/A	L	H	(1448)	-4,159
2117	214	822	7/21/2018 Dust storm	-19	-64	43	1.075	-8	-61	-53	11	+3	841	-19	215	N/A	L	H	(1449)	
2118	215	822	7/22/2018 Dust storm	-19	-68	49	1.225	-10	-62	-52	11	+6	842	-20	215	N/A	L	H	(1450)	
2119	216	824	7/23/2018 Dust storm	-16	-69	53	1.325	-8	-62	-54	8	+7	842	-18	216	N/A	L	H	(1451)	-4,159
2120	216	828	7/24/2018 Dust storm	-16	-67	51	1.275	-8	-61	-53	8	+6	845	-17	217	N/A	L	H	(1452)	
2121	217	829	7/25/2018 Dust storm	-18	-62	44	1.1	-8	-62	-54	10	0	850	-21	217	N/A	L	VH	(1453)	
2122	218	830	7/26/2018 Dust storm	-14	-63	49	1.225	-6	-62	-56	8	+1	854	-24	218	N/A	L	H	(1454)	
2123	218	831	7/27/2018 Dust storm	-18	-68	50	1.25	-6	-63	-57	12	+5	858	-27	219	N/A	L	H	(1455)	
2124	219	832	7/28/2018 Dust storm	-17	-67	50	1.25	-6	-62	-56	11	+5	859	-27	220	N/A	L	H	(1456)	
2125	219	834	7/29/2018 Dust storm	-17	-66	49	1.225	-7	-62	-55	10	+4	860	-26	220	N/A	L	H	(1457)	
2126	220	837	7/30/2018 Dust storm	-18	-63	45	1.125	-8	-63	-55	10	0	859	-22	220	N/A	L	H	(1458)	-4,163
2127	221	838	7/31/2018 Dust storm	-18	-69	51	1.275	-7	-64	-57	11	+5	861	-23	221	N/A	L	H	(1459)	

SOL	~LS	PRESSURE Pa	EARTH DATE	MAX AIR TEMP °C	MIN AIR TEMP °C	AIR TEMP RANGE °C	AIR TEMP RANGE °C/40	MAX GROUND TEMP °C	MIN GROUND TEMP °C	Δ GROUND TEMP DAY TO NIGHT	DAYTIME CHANGE IN TEMP °C AIR TO GROUND	NIGHTTIME CHANGE IN TEMP °C AIR TO GROUND	PRESSURE AT SAME LS IN MSL YEAR 3	Δ PRESSURE YEAR 4 TO YEAR 3 SAME LS	~LS year 3	PRESSURE PREVIOUS YEAR BEFORE REVISION	UV YR 4	UV YR 3	MSL YEAR 3 SOL FOR THIS LS/ COMMENTS	MSL Altitude meters below areoid
2128	221	841	8/1/2018 Dust storm	-20	-65	45	1.125	-7	-62	-55	13	+3	865	-24	222	N/A	L	H	(1460)	-4,169
2129	222	843	8/2/2018 Dust Storm	-21	-66	45	1.125	-7	-63	-56	14	+3	870	-27	222	N/A	L	H	(1461)	
2130	223	844	8/3/2018 Dust storm	-18	-62	44	1.1	-7	-63	-56	11	-1	871	-25	223	N/A	L	H	(1462)	
2131	223	846	8/4/2018 Dust storm	-21	-67	46	1.15	-6	-63	-57	15	+4	871	-24	223	N/A	L	H	(1463)	
2132	224	847	8/5/2018 Dust Storm	-16	-69	53	1.325	-4	-64	-60	12	+5	871	-24	224	N/A	L	H	(1464)	-4,170
2133	225	849	8/6/2018 Dust Storm	-18	-65	47	1.175	-3	-65	-62	15	0	870	-21	225	N/A	L	H	(1465)	
2134	225	851	8/7/2018 Dust Storm	-14	-65	51	1.275	-3	-66	-63	11	-1	873	-22	226	N/A	L	H	(1466)	
2135	226	854	8/8/2018 Dust Storm	-15	-66	51	1.275	-3	-66	-63	12	0	877	-23	226	N/A	L	H	(1467)	
2136	227	856	8/9/2018 Dust Storm	-13	-66	53	1.325	-3	-65	-62	10	+1	879	-23	227	N/A	L	H	(1468)	
2137	227	867	8/10/2018 Dust Storm	-13	-66	53	1.325	-2	-70	-68	11	-4	881	-14	228	N/A	L	H	(1469)	
2138	228	858	8/11/2018 Dust Storm	-16	-68	52	1.3	-2	-65	-63	14	+3	879	-21	228	N/A	L	M	(1470)	
2139	228	857	8/12/2018 Dust Storm	-11	-70	59	1.475	-1	-66	65	10	+4	880	-23	229	N/A	L	M	(1471)	
2140	229	858	8/13/2018 Dust Storm	-10	-70	60	1.5	0	-67	67	10	+3	879	-21	229	N/A	M	M	(1472)	

SOL	~LS	PRESSURE Pa	EARTH DATE	MAX AIR TEMP °C	MIN AIR TEMP °C	AIR TEMP RANGE °C	AIR TEMP RANGE °C/40	MAX GROUND TEMP °C	MIN GROUND TEMP °C	Δ GROUND TEMP DAY TO NIGHT	DAYTIME CHANGE IN TEMP °C AIR TO GROUND	NIGHTTIME CHANGE IN TEMP °C AIR TO GROUND	PRESSURE AT SAME LS IN MSL YEAR 3	Δ PRESSURE YEAR 4 TO YEAR 3 SAME LS	~LS year 3	PRESSURE PREVIOUS YEAR BEFORE REVISION	UV YR 4	UV YR 3	MSL YEAR 3 SOL FOR THIS LS/ COMMENTS	MSL Altitude meters below areoid
			Winding down.																	
2141	230	863	8/14/2018	-17	-66	49	1.225	0	-71	71	17	-5	881	-18	230	N/A	M	M	(1473)	
2142	230	865	8/15/2018	-10	-71	61	1.525	-1	-67	66	9	+4	889	-24	231	N/A	L	M	(1474)	
2143	231	865	8/17/2018	-12	-71	59	1.475	0	-67	67	12	+4	890	-25	231	N/A	M	M	(1475)	
2144	232	867	8/18/2018	-11	-67	56	1.4	1	-69	71	12	-2	888	-21	232	N/A	L	H	(1476)	-4,181
2145	232	868	8/19/2018	-10	-66	56	1.4	0	-66	66	10	0	888	-20	233	N/A	L	H	(1477)	
2146	233	870	8/20/2018	-10	-67	57	1.425	1	-67	68	11	0	887	-17	233	N/A	M	M	(1478)	
2147	233	870	8/21/2018	-15	-68	53	1.325	0	-67	67	15	+1	890	-20	234	N/A	L	M	(1479) LAST LOW UV	
2148	234	872	8/22/2018 DUST STORM OVER	-13	-67	54	1.35	2	-67	69	15	0	893	-21	235	N/A	M	H	(1480)	

11.2. Brief Summary of 2018 Dust Storm Data.

In general the REMS Team-generated dust storm data can be summarized as follows:

(1) Air temperature highs much colder than normal.
(2) Air temperature lows much warmer than normal.
(3) Air temperature range much smaller than normal.
(4) Air temperature ranges often less than what is seen in deserts on Earth.
(5) Air and ground temperature highs below 0° C.
(6) Ground temperature highs much colder than normal.
(7) Ground temperature lows much warmer than normal.
(8) Night ground temperatures usually warmer than air temperatures which is reverse of the normal situation.
(9) Ultraviolet radiation levels are low, something rarely seen before without retraction by NASA.
(10) Change in pressure from the previous Martian year seems to reflect the Ls and altitude change. But no apparent increase in pressure due to the weight of the dust is seen. This strongly suggests that the pressure data can be attributed to a human plugging in the previous year's pressure data, making adjustments for altitude increase based on scale height but failing to consider any effects due to dust load. As such, the data strongly suggests that the data is largely manufactured and as such is not to be trusted.

11.3 Possibility of a Biological Factor In Lifting Dust.

Saltation is a common answer to the question of how dust gets lifted into the Martian atmosphere. The problem is that the wind speeds do not appear to be great enough to lift the dust if it is only 1 µm. However if bacteria cling to the dust, then the combined particle size will grow. Bacterial cells range from about 1 to 10 microns in length and from 0.2 to 1 micron in width.

Life exists on dust on earth. Wikipedia states of dust mites that, "They are generally found on the floor and other surfaces until disturbed (by walking, for example). It could take somewhere between 20 minutes and 2 hours for dust mites to settle back down out of the air." Smithsonian.com states that, "Microbes have been found in the skies since Darwin collected windswept dust aboard the H.M.S. *Beagle* 1,000 miles west of Africa in the 1830s. But technologies for DNA analysis, high-altitude collection and atmospheric modeling are giving scientists a new look at crowded life high above Earth. For instance, recent research suggests that microbes are hidden players in the atmosphere, making clouds, causing rain, spreading diseases between continents and maybe even changing climates."

So the idea that microbes could play a role in Martian dust storms is not as strange as it might appear. However, it's a long way from dust that just carries thoughtless bacteria to something as sinister as the dust storm portrayed in the film Mission to Mars. If there is microscopic life on Mars, there might be a mass spawning that occurs in conjunction with the rising dust. On Earth mass coral spawning is an annual phenomenon that usually occurs over several days to just over a week after a full moon.

Depending on location, it happens at different times of year. For example, coral spawning in Curacao, Netherlands Antilles, normally occurs in September and October. Whereas the same happens at Australia's Great Barrier Reef in spring.

11.3.1. Martian Dust Storm Seasons. For the Martian northern hemisphere Mars seasonal dust storms originate in two seasons, at solar longitude (Ls) 180 to 240° and Ls 305 to 350°. In the southern hemisphere seasonal dust storms usually originate between Ls 135 to 245°. So there is an overlap between Ls 180 to 240°. Length of days in hours at each Ls just mentioned is given in Table 15C below

TABLE 15C - LENGTH OF SOLS ON MARS AT KEY SOLAR LONGITUDES RELATED TO DUST STORMS

Ls	Hemisphere where dust storms start	Northern hemisphere season	Southern hemisphere season	Day length hours at 45° North	Southern hemisphere season	Day length hours at 45° South	Day length at equator
135	southern	Mid summer	Mid winter	14.89	Mid winter	9.85	12.35
180	**both**	**Start fall**	**Start spring**	**12.36**	**Start spring**	**12.36**	**12.35**
240	**both**	**fall**	**spring**	**9.17**	**spring**	**15.57**	**12.35**
245	southern	Late fall	Late spring	8.98	Late spring	15.76	12.35
305	northern	Winter	summer	9.36	summer	15.36	12.35
350	northernnortnorther	Later winter	Late summer	11.78	Late summer	12.95	12.35

11.4 Martian Dust Storms Paths and Radioactive Areas.

H. Wang and R.I. Richardson (2015) discuss three development styles for Martian dust storms.[121] Most common are those travelling along the same route for at least 5 days. These they call "consecutive dust storms." Another development style is through sequential activation of one segment of a route after another as the whole sequence advances forward. They call these "sequential activation dust storms." Finally, a third development style is through the merging of dust from two or more initially separate sequences to create a contiguous dust cover. They will call these ''merging dust storms.'' This appeared to be a very effective way of making larger dust storms including the two global storms in their study of storms occurring between 1999 and 2011. Dust storms originating in the northern hemisphere can cross the equator, but dust storms originating in the southern hemisphere are more likely to go global. Wang and Richardson do not consider any biological origin that may involve merging caused by a desire of life forms to spawn with a diverse genetic population. The idea is mentioned here in case future studies prove the existence of bacteria or other organisms found in Martian dust.

Finally, we will note here that the three most radioactive areas on Mars (Acidalia, Utopia and Arcadia) also generate the most dust storms. See Figure 44.

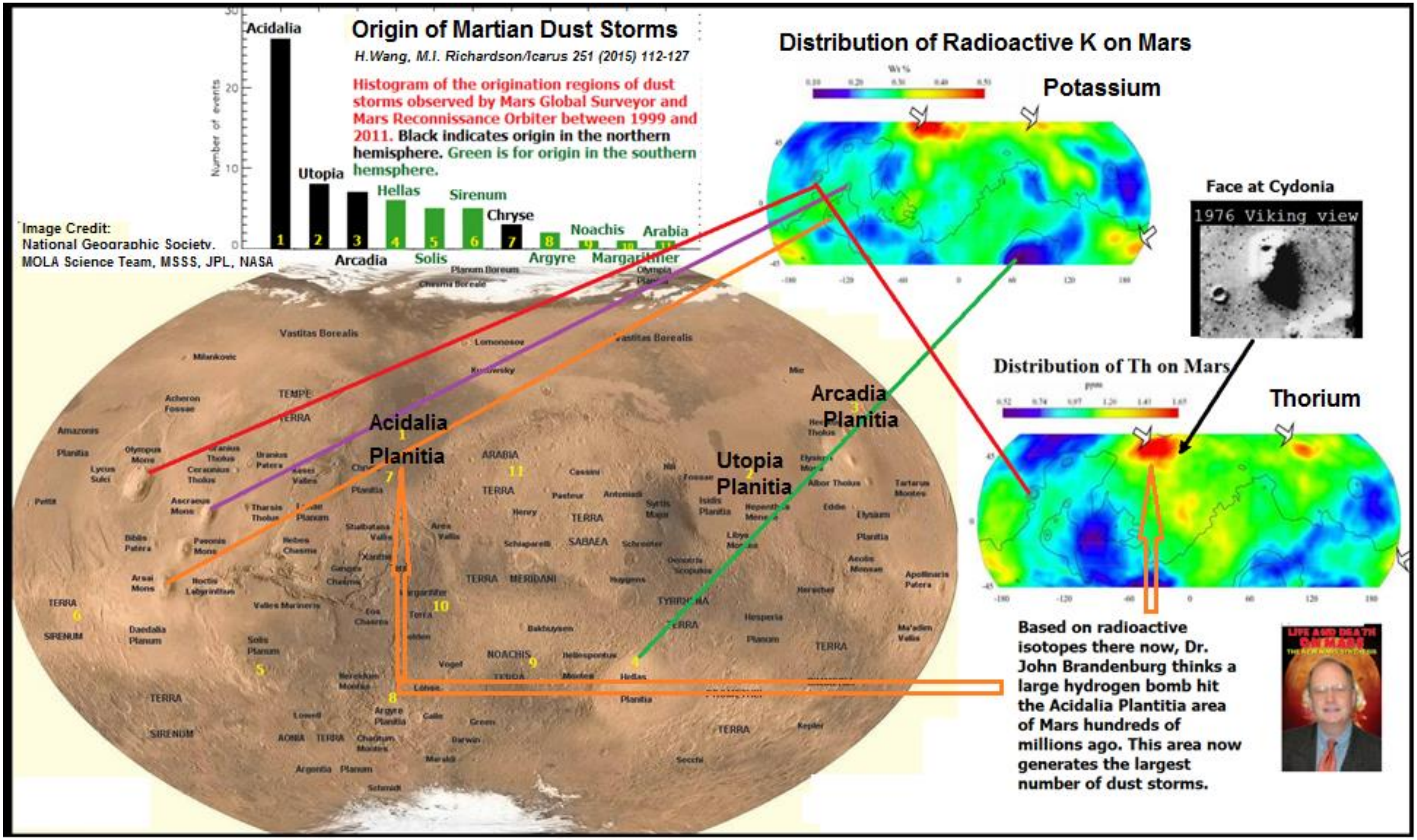


Figure 44 above - Possible correlation between radioactive hot spots and dust storm origination on Mars?

12. MARS PATHFINDER PRESSURES

For Pathfinder (with an air access tube just 2 mm in diameter), the upper range of the transducer was only 12 mbar during descent, but only 10 mbar on the surface.[83]

A 10 mbar limit seems very strange given the Viking-2 10.72 mbar pressure seen. Note that the terrestrial dust storm which hit Luke Air Force Base and Phoenix, Arizona on July 5, 2011 increased air pressure by at least 6.6 mbar, and given that both terrestrial and Martian dust storms can turn day to night, the decision to reduce pressure sensitivities of Pathfinder, Phoenix and MSL landers seems highly ill-advised. Earlier we had written that "There remains the question of what happened to the second Pathfinder sensor ordered that could measure up to 1,034 mbar (15 psia) shown on Figure 10B. Perhaps NASA is not as dumb as they seem to be, and they flew that sensor with a program inserted to cut reported pressures to 1% of what it actually measured. We really need to know the final disposition of this transducer, corresponding to Tavis Dash No. 1 on Tavis CAD Diagram 10484." However, when Insight landed as was shown on Figure 10D, Tavis Corporation published a diagram for the same transducer that listed dual pressure ranges for the same transducer as was used for Pathfinder. The new diagram seemed to support an ability to toggle between low and high pressure ranges with the higher range suitable for Earth's atmosphere. This begs the question of who controlled the switch and did they indeed ever secretly throw it?

What were the Pathfinder pressures made public? Lower than expected. MPF landed on July 4, 1997 at an elevation of -3.682 km, most similar to Viking 1 which sat at -3.627 km. For MPF it was late northern summer at Ls 142.7. As noted earlier in Section 7, Schofield et al. (1997)[67] indicate that **Pathfinder had no pressure data for the most crucial sol – its first operational day on Mars (JPL wiped out all pressure data for the first 9 days of MSL).** The reason given by the above reference is there were "various spacecraft software reset and downlink problems." MPF pressures are shown on Figure 45.

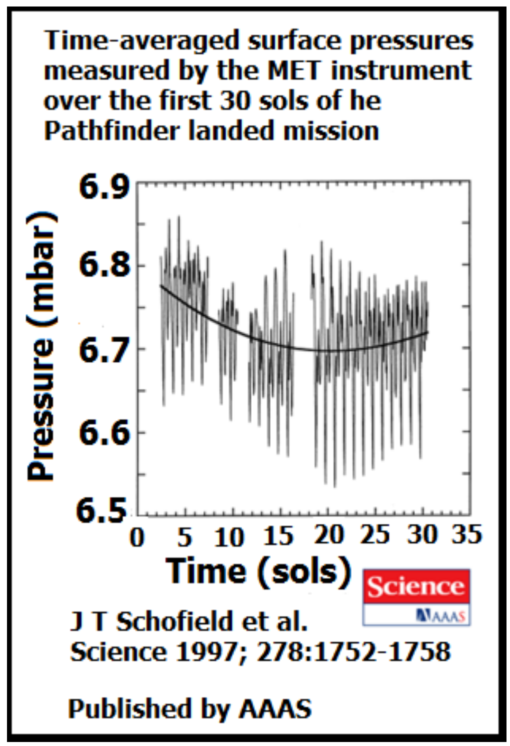


Figure 45: Adapted from Science.
Pressures reported by MPF.
None is given for the critical landing day.

Two sols worth of MPF hourly pressures are shown on Figure 46 where they are compared to the only sol of published hourly pressure data for MSL.

At first it seemed a bit surprising that MSL and Pathfinder displayed a similar diurnal pressure cycle on Figure 46. Pathfinder had no RTG heater on board.

However, the Pathfinder battery *was* used to heat the probe's electronics to slightly above the expected nighttime temperatures on Mars.[95]So again, at local midnight, measured pressures went up because the heater was operating at that time. What was being measured was *not* ambient pressure. It was just the pressure behind the (likely) clogged dust filter.

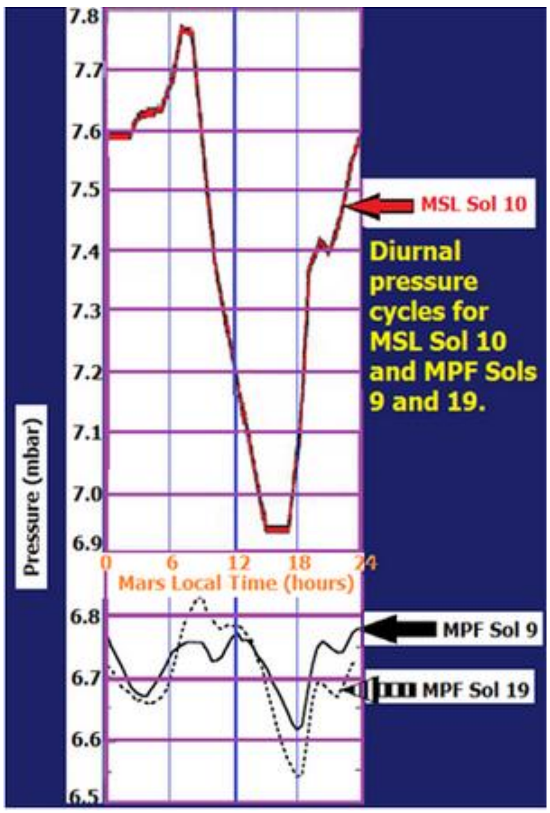


Figure 46 - Adapted from Science. Diurnal ressure cycles for MSL and Mars Pathfinder.

With Phoenix, there was a requirement for the lander to wait 15 minutes after the landing before deploying solar panels. This was to allow dust to settle.[84] But it is unclear as to whether there was any way to prevent dust from being sucked into the pressure transducer and intermediate dust filter before powering up after the solar panels deployment. Since the dust filter was much smaller on the Phoenix than what was found in the ¼ inch diameter Viking air access tubes, the rate of ingestion of dust up front here is particularly important.

13. POTENTIAL PRESSURE ON MARS.

Read and Lewis (2004, pp. 269-270)[79] note potential reserves of CO_2-H_2O clathrate in regolith that could raise surface pressure to 200 hPa (mbar) during periods of high-obliquity when, at some point in the future, Mars would have its axis inclined at a greater angle than it has today. If more clathrate is locked up under deeper polar deposits underground, pressure could go as high as 850 hPa (Jakosky et al., 1995).[85] But if the soil became rich in water ice through precipitation and adsorption into the porous regolith, Read and Lewis state the value might be limited to 15-30 mbar.

If the increase of density seen during aerobraking operations by MRO (30 to 350%) was correct, and could be applied to the Hellas Basin, then pressures there would reach 16.37 to 44 mbar. However, the 350% figure was only for operations over the Martian South Pole. As will be indicated below in conjunction with Figure 57 due to stratus clouds seen 12,318 meters above aeroid, the true pressure at Hellas Basin might actually be higher than what is found at sea level on Earth.

13.1 Did NASA Ever Publically Back 20 Mbar on Mars? In a work entitled SP-4212 On Mars: Exploration of the Red Planet 1958-1978 in Chapter 8, second paragraph (page 243)[86] we read:

> **Mariner 69's occultation experiment indicated that the atmospheric pressure at the surface of Mars ranged from 4 to 20 millibars, rather than 80 millibars as estimated earlier.** This information had a definite impact on the aerodynamic shape of the Mars entry vehicle being designed, since weight and diameter would influence the craft's braking ability. Langley engineers had determined that aerodynamic braking was the only practical method for slowing down a lander as large as Viking for a soft touchdown. The entry vehicle would have a diameter of 3.5 meters, an acceptable ballistic coefficient that would help ensure Viking's safe landing on Mars.

It appears that by Mariner 69's, the article is referring to the Mariner 6 and 7 flyby spacecraft that had their closest approaches to Mars on July 31, 1969 and August 5, 1969. But their NASA-advertised radio occultation pressures for Mars were only 3.8 to 7.0 mbar. The 20 mbar figure is almost 3 times higher. And what are we to make about the 80 mbar figure that is refuted with the 20 mbar estimate? Mariner 4 had flown by Mars on July 14, 1965. Its estimate of pressure on Mars was pegged at 4.1 to 7 mbar on their website located at http://nssdc.gsfc.nasa.gov/planetary/mars/mariner.html, though as mentioned earlier in Section 5, Kliore had it pegged at 4.5 to 9.

If NASA had the 20 mbar figure, and was publishing it too, the question must be asked, *why in the world would it select pressure transducers for the Vikings that could only measure up to 18 mbar and why was a transducer that maxed out at 11.50 mbar chosen for MSL and Perseverance?* Figure 47 shows there were pressure estimates of 20 mbar in 1965 (Evans), but after Mariner 6 and 7 the issue was supposed to be settled with a maximum pressure at 9 mbar (less than the 10.72 mbar measured by Viking 2).

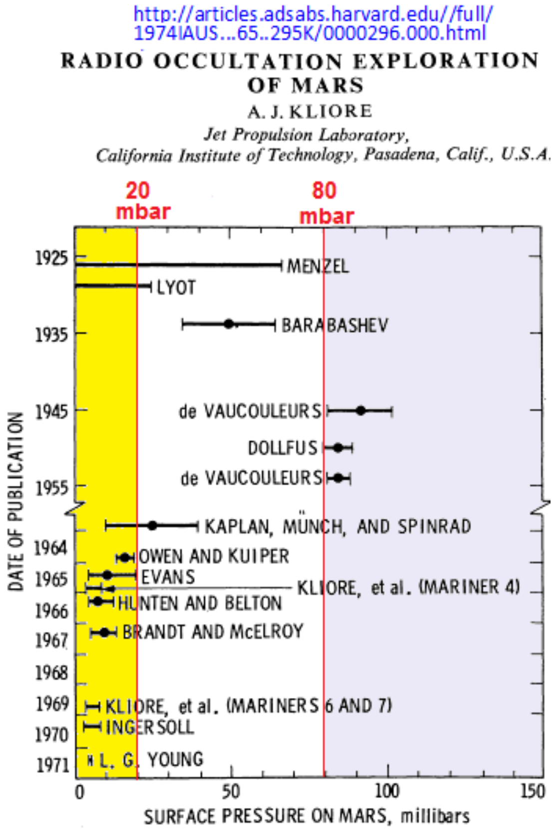


Figure 47 – History of Beliefs about Martian Atmospheric Pressure

Why was a detailed NASA document written in 1978 still putting forward the 20 mbar figure? Perhaps someone realized what is abundantly apparent in this study. The Viking pressure data is fatally flawed. Further, without a fix for dust ingestion by Pathfinder, Phoenix and MSL, they were also fatally flawed. We must at least plan on the pressures seen by studies in 1965 or earlier, but that really should not be the limit. We need a sensor that can measure Earth-like pressures as will be discussed later in conjunction with Figure 57 and the stratus clouds seen 16 km above Mars Pathfinder.

13.2 Biology, Methane, and a Possible Hint of the Real Martian Air Pressure

Given the discovery of methane plumes (identified back on Figure 25) that have a probable biological origin (Krasnopolsky[87] et al., 2004) it was natural that MSL had instruments designed to detect methane. Of particular interest would be methane producing or consuming bacteria that might be attached to dust particles. Bloom of such organisms, with a means of encapsulating or producing methane (lighter than the ambient CO_2) might explain the lifting process seen in dust storms and/or dust devils. When MSL landed there was brief, but temporarily unwarranted excitement when methane was detected by the Sample Analysis at Mars (SAM) shown in Figure 48.

Where did initial the methane seen by SAM during its initial check out come from? SAM had miniature pumps (Wide Range Pumps –see Figure 48). In a JPL press conference held on August 27, 2012 (see http://www.ustream.tv/recorded/25004956) , Mahaffy stated,

> ***The really nice thing about these pumps is they exhaust naturally right at Mars pressure, 10 millibar, 7 millibar.*** *Um, and it turns out there is a very slow leak, uh, into the Tunable Laser Spectrometer and so there was just a little bit of a residual atmosphere"* (that is, from the Earth).

He went on to say,

> *"and so the tens of millibars that we had in there,* ***I think we had 51 millibar*** *and we had assumed that the pump would be fine evacuating that, we routinely evacuate Mars ambient out of the cell but it was just high enough the current sensor on the pump said, nah this is a little bit too high*

I'm gonna turn myself off and it did but SAM continued merrily along its measuring path assuming that we had not turned off and so we measured that gas with both the mass spectrometer and the Tunable Laser Spectrometer. It really led to some excitement. The TLS (Tunable Laser Spectrometer) Team, Chris and Greg, their eyes were wide open. They saw all this methane, and it turns out it's terrestrial methane, but it was kind of a good test….

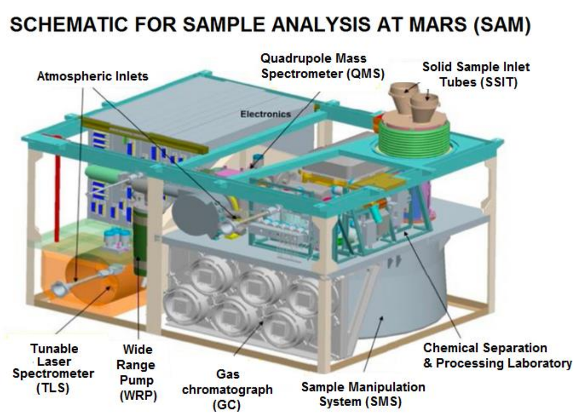


Figure 48 – Sample Analysis at Mars (SAM)

We considered that the 51 mbar mentioned by Dr. Mahaffy might be the first real clue about how high Martian pressure really is. On Earth that pressure would equate to an altitude of about 63,057 feet or 19,220 meters. But based on Figure 57 we think the pressure is higher, closer to 511 at areoid.

On December 16, 2014 JPL announced that it had found methane spikes of 5.5, 7, 7 and 9 ppbv (parts per billion volume), about 10 times higher than the background methane measured earlier (0.7 +/- 0.2 ppbv (see Figure 49). Other organic chemicals found in the Cumberland sample at Gale Crater included chloromethane, dichloromethane, trichloromethane, dichloroethane, 1,2 – dichloropropane, 1,2 – dichlorobutane and chlorobenzene. This is quite a change from NASA's Viking stance of no organic chemistry on detected on Mars. We believe Dr. Levin is owed a Nobel Prize for his work which we discuss further at http://davidaroffman.com/photo2_25.html. There appears to be ample reason to revisit NASA's dismissal of positive results about detection of life by the Labeled Release (LR) life detection experiment on both Vikings (Levin, 1997).[88] The new finding reinforces the position of Dr. Christopher McKay of NASA Ames on January 4, 2011[89] when he found that NASA's 30-year rejection of organic chemicals was wrong.

Previously, the 1997 Levin paper mentions what looked like lichens seen on Mars (at least until a technician under the order of NASA administrator Dr. James Fletcher went through the JPL control room and manually turned the color knobs on the monitors to make everything look red (see Figures 50A and 50B). If Levin were right about lichens living on Mars now, could we extrapolate an air pressure based on maximum altitude where lichens are found on Earth? While one article described lichens (*Cordyceps sinensis*) living at Dolpa in the Himalayan mountains of Nepal at 5,177 m (16,984 feet) where pressure would be about 527 mbar, Sancho et al. (2007)[90] described an ESA astrobiology experiment on the Foton-M2 mission aboard a Soyuz rocket launched on May 31, 2005. They state that,

> *"It returned to Earth after 16 days in space. Most lichenized fungal and algal cells survived in space after full exposure to massive UV and cosmic radiation, conditions proven to be lethal to bacteria and other microorganisms… Moreover, after extreme dehydration induced by high vacuum, the lichens proved to be able to recover, in full, their metabolic activity within 24 hours."*

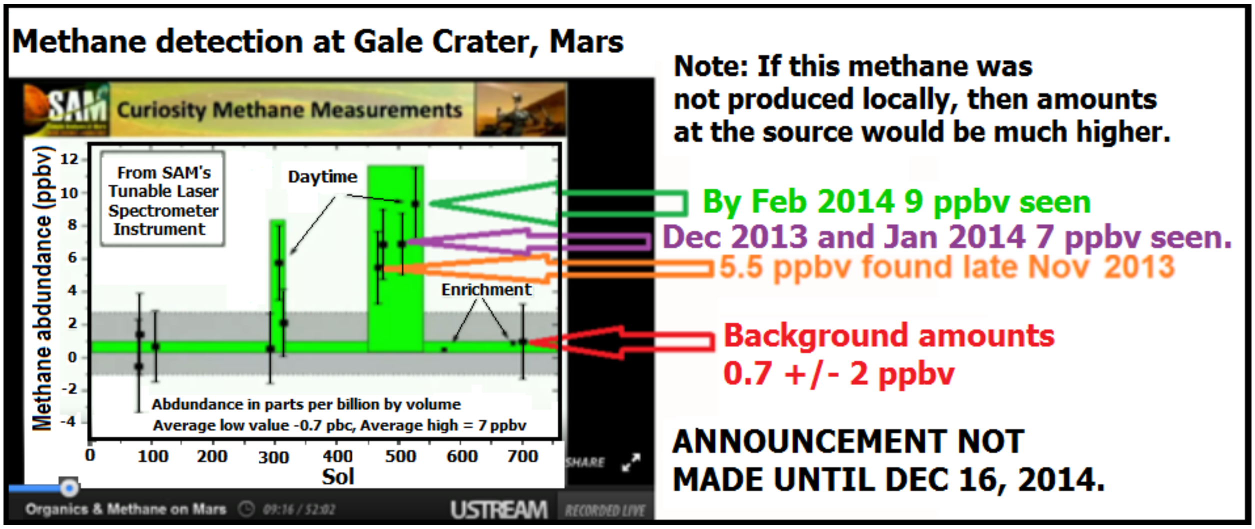


Figure 49 – Methane spikes seen by MSL at Gale Crater.

Thus it must be determined at what altitude (and minimum pressure) the lichens would go into a protective mode. Aware of all this controversy the MSL SAM had, as one of its purposes, an assignment to revisit the question of organic chemistry on Mars. Mahaffy stated at the August 27, 2012 press conference that,

> ***"The SAM is a key tool in Curiosity's search for signs of life****, past or present, and is* ***more sensitive and sophisticated than the sensors on the Viking lander which came up negative for organics.*** *The system is designed, for example, to examine a wider range of organic compounds and* ***can therefore check a recent hypothesis that perchlorate – a reactive chemical discovered by the Phoenix Mars Mission – may have masked organics in soil samples taken by Viking."***

In 2018 we learned that there were more organic chemicals found at Gale Crater. Eigenbrode et. al reported the in situ detection of organic matter preserved in lacustrine mudstones at the base of the ~3.5-billion-year-old Murray formation at Pahrump Hills, Gale crater, by the Sample Analysis at Mars instrument suite onboard the Curiosity rover. Diverse pyrolysis products, including thiophenic, aromatic, and aliphatic compounds released at high temperatures (500° to 820°C), were directly detected by evolved gas analysis. Thiophenes (C_4H_4S) were also observed by gas chromatography–mass spectrometry. Their presence suggests that sulfurization aided organic matter preservation. At least 50 nanomoles of organic carbon persists, probably as macromolecules containing 5% carbon as organic sulfur molecules.[120]

The profiles were consistent with the presence of thiophene (C_4H_4S), 2- and 3-methylthiophenes (C_5H_6S), methanethiol (CH_4S), and dimethylsulfide (C_2H_6S). The presence of benzothiophene (C_8H_6S), a bicyclic thiophene that usually co-occurs with thiophenes, is also suggested by a weak peak in both Mojave release of organic sulfur compounds and related volatiles was observed for Confidence Hills.

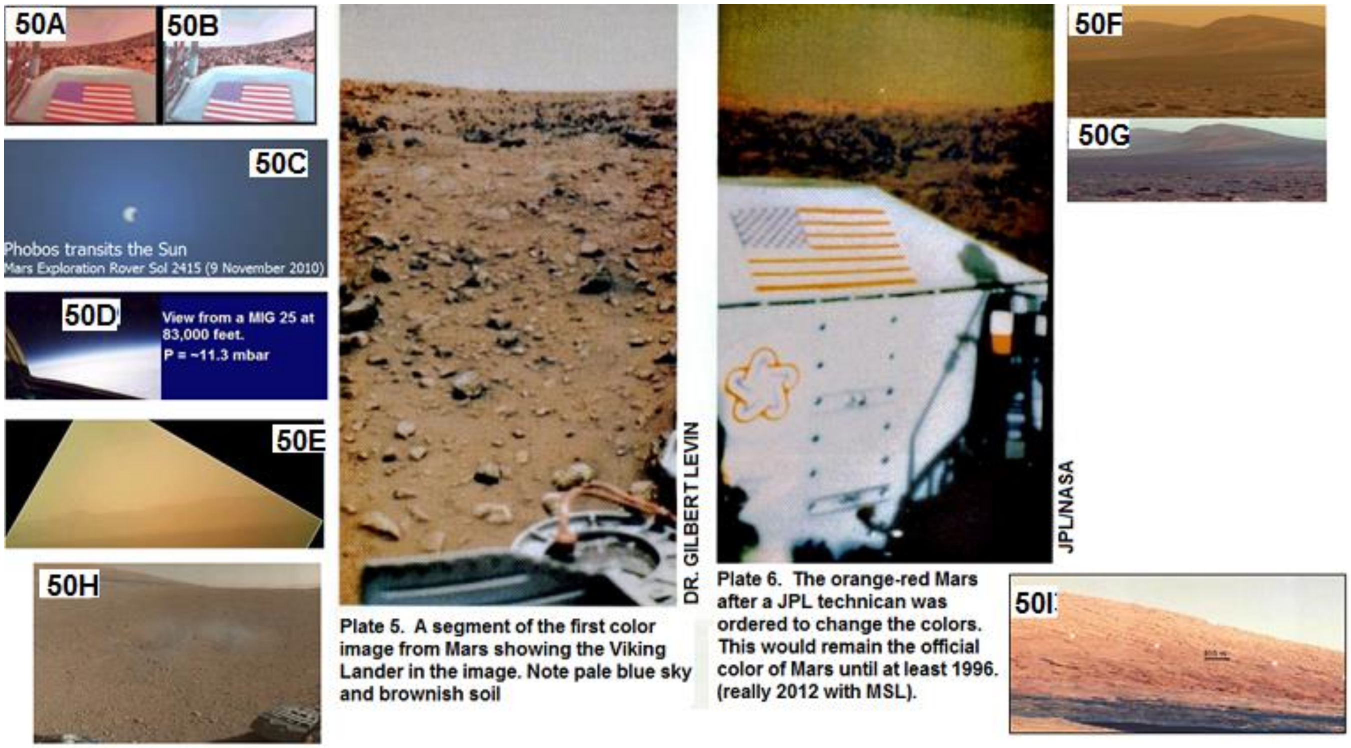


Plate 5. A segment of the first color image from Mars showing the Viking Lander in the image. Note pale blue sky and brownish soil

Plate 6. The orange-red Mars after a JPL technican was ordered to change the colors. This would remain the official color of Mars until at least 1996. (really 2012 with MSL).

Figures 50-A to 50-I plus Plates 5 and 6 (http://www.enterprisemission.com/sir.htm) illustrate the controversy over Martian sky color ever since Viking 1 touched down. 50A shows what NASA released in 1976 after Dr. James Fletcher ordered manual adjustments on monitors that destroyed blue sky color and hid green on rocks. 50B shows true sky color in accordance with colors of the U.S. flag. 50C shows the Martian sky near sunset. 50D shows that for Earth once pressures drop to 11.3 mbar the sky is a dark blue, not bright as seen in day time photos from Mars. 50E shows sky as seen from MSL with a dust cap over the camera lens. 50F shows what has often been portrayed as the Martian sky color as seen from MER Opportunity. Figure 50G shows the same area as 50F, but with "false color applied." 50-H and 50-I show what MSL sees without a cover over its camera lens. Variations on sky color may be due to amount of dust in the air, which varies seasonally. Blue appears to be the correct color when dust loads are low.

13.3 Recurring Slope Lineae (RSL), Perchlorates and Running Water on Mars.

On September 28, 2015 NASA held a press conference at which it was alleged that they had proof of running water at multiple sites on Mars. The press conference is found at http://mars.nasa.gov/news/whatsnew/index.cfm?FuseAction=ShowNews&NewsID=1858.

While the source of the water is not yet pinned down, the very existence of it provides a clue that pressure is higher than NASA has thought. As for how NASA thinks the water can exist at low pressures, they place emphasis on the idea of deliquescence. In reference to it NASA argues that perchlorate salts like those found on Mars have a special capability of being able to absorb moisture until they dissolve in the moisture absorbed and form a solution.

Deliquescence occurs when the vapor pressure of the solution that is formed is less than the partial pressure of water vapor in the air. This is one possible explanation for formation of Recurring Slope Lineae (RSL) – the dark streaks shown growing on Figure 51 below. They are assumed to be due to running water/brine. Soluble salts will deliquesce if Martian air is sufficiently humid. The NASA press conference does refer to snow seen falling at the Phoenix lander site, however it states that rain has never been seen falling on Mars. It also indicates that it's possible that the running water has an underground source, but proof of that will likely have to wait for results from a ground penetrating radar.

As for no rain, earlier we wrote that the REMS Team weather data indicated *that while UV at the Mars Science Laboratory (MSL) varied from low to very high, during the first 3,025 sols there was not a single sol when opacity was not listed as "sunny."* At that time the report indicated 16 sols with low UV but after the number reached 19 sols of low UV the REMS Team deleted them all from their reports. By the end of MSL Year 2 (sol 1,338) there were no sols with low UV and 108 sols with no data. See Section 15 of this Report.

Although we cannot rule out arguments that link water's ability to flow on Mars to widespread amounts of perchlorates dissolved in the Martian water, we submit that the running water is more likely to be linked to atmospheric pressure that is two orders of magnitude higher than what NASA has told us. The authors of the NASA study discussed here are operating under the assumption that the average pressure at areoid is 6.1 mbar (McEwen et al., 2014). As will be explained below in conjunction with Figure 57, we believe that it's closer to 511 mbar at areoid, and higher at lower altitudes.

13.3.1 Length of daylight hours where RSL are found.

We calculated the amount of daylight where RSL are found at Palikir Crater (40.8 South) shown on Figure 51. The sun was above the horizon for 15.3 hours on March 3, 2011 (late spring at Palikir Crater). For April 27, 2011 (early summer) there were about 15.56 hours of sunlight. For May 30, 2011 (the second month of Martian summer) daylight hours then were down to 15.05 hours. A Martian day is 24 hours, 39 minutes. The math to support these calculations is on David Roffman's web site at http://davidaroffman.com/photo2_13.html.

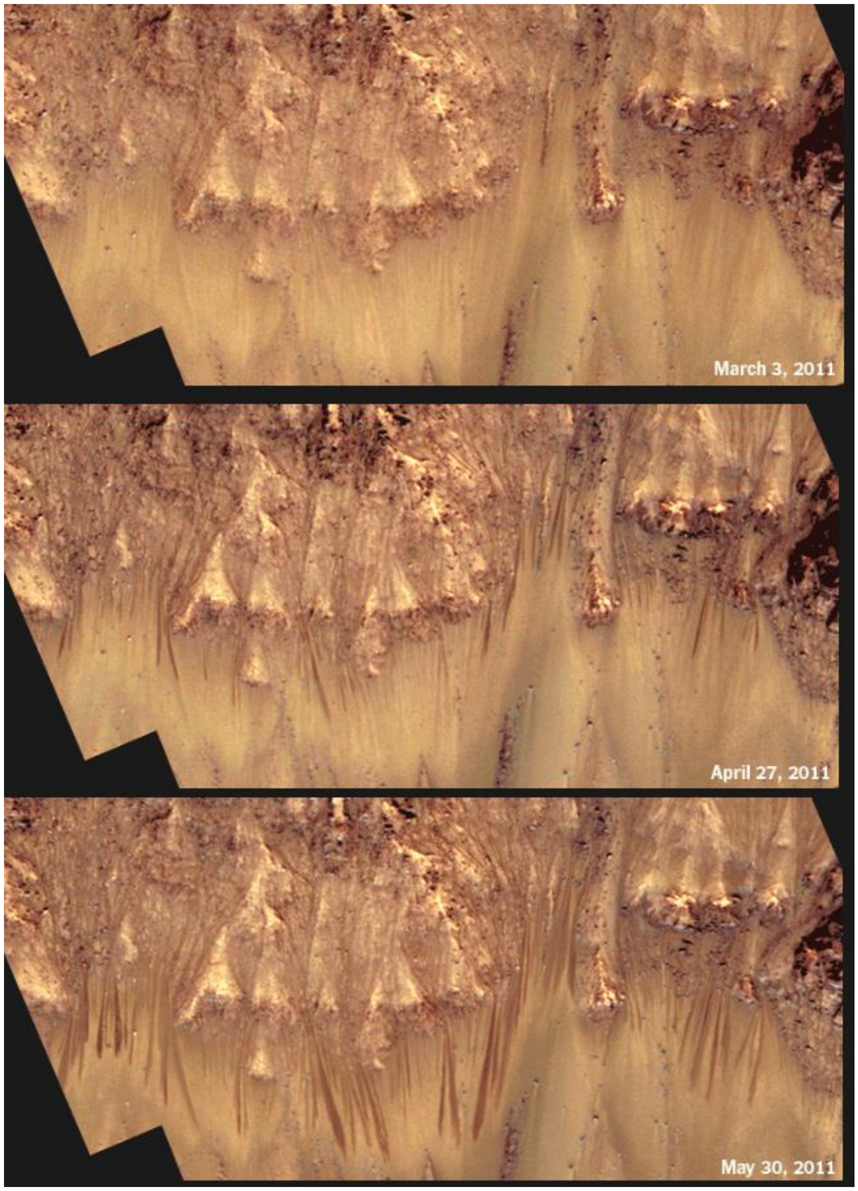


Figure 51: Recurring Slope Lineae (RSL) shown via time-lapse photos of Palikir Crater. The photos show how the streaks extend and darken during warmer months on Mars, then gradually fade as temperatures cool. Palikir Crater is at 40.8° South. The top photo (March 3, 2011) was at Ls 246.9 (spring). April 27, 2011 was Ls 281.5 (early summer). May 30, 2011 was Ls 301.6 (summer). Source: NASA/Jet Propulsion Laboratory/University of Arizona at http://www.uahirise.org/sim/science-2011-aug-4.php

Note: On November 22, 2016 NASA announced that a frozen sea with as much fresh water as is in Lake Superior on Earth was found at on Mars at Utopia Planitia between 39° and 49° North. See https://www.nasa.gov/feature/jpl/mars-ice-deposit-holds-as-much-water-as-lake-superior and Section 12.4 of this Report.

Melas Chasma is in the tropics at 11.5° South (see Figure 52). There daylight varied between 13.1 hours on the first day of summer (Ls 270) to 11.6 hours on the first day of winter (Ls 90). However, McEwen et al., 2014[122] indicate on their Table 1 that at this position there is activity on the north facing slopes between Ls 133° and 161° and on the south facing slope between Ls 192° and 281°. Melas Chasma is south of the equator.[112] The subsolar latitude is to the south only between Ls 208° in the first month of spring there to Ls 331° in the third month of summer.

13.3.2 Latitudes, times and temperatures for evidence of running water.

Figure 52 shows the known locations, but **under 4% of the Martian surface has been imaged well enough to see the features**. In accordance with the 2011 Abstract by Alfred S. McEwen, Lujendra Ojha, et al., RSL appear and lengthen in the late southern spring/summer from 48°S to 32°S latitudes favoring equator-facing slopes–times and places with peak surface temperatures from ~250-300 K. Later it was stated in a paper entitled RECURRING SLOPE LINEAE IN EQUATORIAL REGIONS OF MARS (McEwen et al., 2014) that there is "extensive activity of recurring slope lineae in equatorial regions of Mars, particularly in the deep canyons of Valles Marineris." The McEwen et al., 2014 paper shows the location of RSL at Acidalia Planitia in the northern hemisphere (see Figure 52) and states that there is one confirmed site at 35° North latitude (which is the Acidalia Planitia site).

Figure 53 shows the solar longitude (Ls) and temperatures where RSL form in afternoons on north, east, south and west facing walls of Melas Chasma in Valles Marineris on Mars. Figure 54 shows that while the range of ~250 to 300K was just given for temperatures, in fact where temperatures were below 273 K (the freezing point of water) they were not much below it. This may indicate that the concentration of perchlorates is not high enough to drive the freezing point down by 70 K, something that was shown on a slide by Luju Ojha at NASA at 22:15 into the NASA press conference on September 28, 2015.

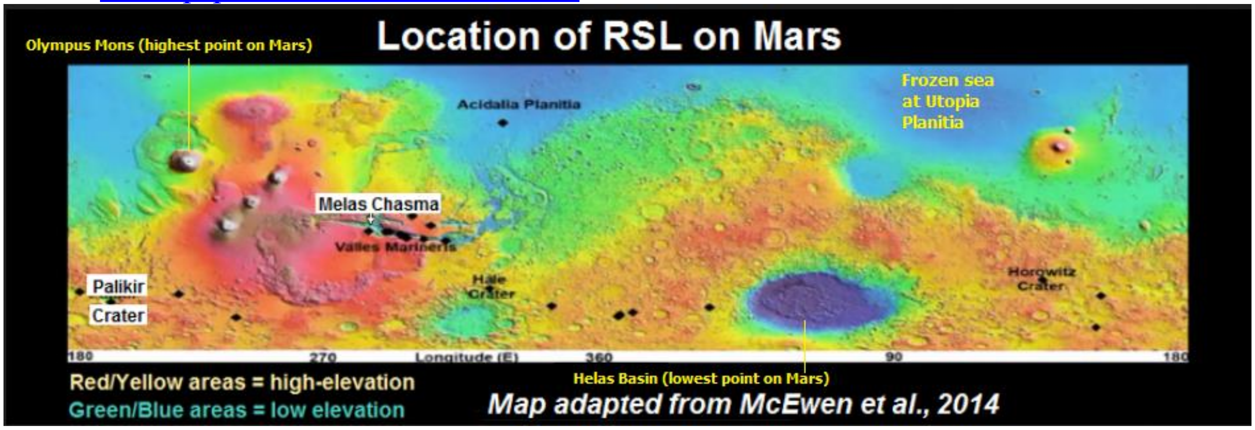


FIGURE 52. Location of Recurring Slope Lineae (RSL) where it is believed that liquid water (brine) flows on Mars. Note the location of Palikir Crater and Melas Chasma.

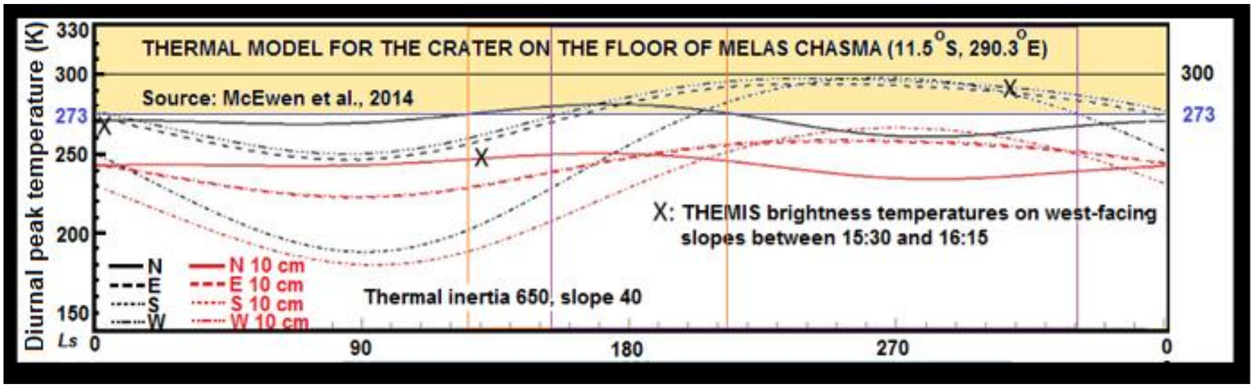


Figure 53 (adapted from McEwen et al., 2014) shows projected surface and subsurface temperatures to a depth of 10 cm at Melas Chasma with directions given.

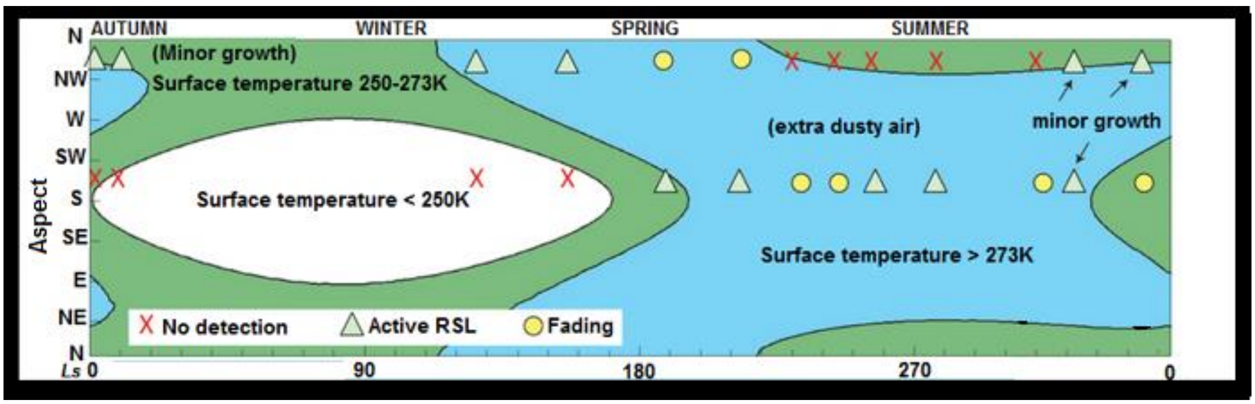


Figure 54 (adapted from McEwen et al., 2014) shows the relationship between temperature, season and direction for RSL at Melas Chasma. The fact is that the temperatures associated with RSL are rarely associated with temperatures much below 273, the freezing point of water in Earth. This may indicate a low concentration of perchlorates.

When water actually runs is affected by the slope. Figures 53 and 54 are based on a slope of 40°. Water runs at Melas Chasma for a little over 41% of the Martian year. The water seen flowing at Palikir Crater (Figure 51), if all inclusive, represents only a little over 15% of the Martian year. Number of hours per sol when RSL were present at Melas Chasma varied from about 11.8 to 13.1 hours.

13.3.3. The role of perchlorates in RSL.

Earlier this report we quoted Dr. Paul Mahaffy's statement that SAM (Sample Analysis on Mars "can therefore check a recent hypothesis that perchlorate – a reactive chemical discovered by the Phoenix Mars Mission – may have masked organics in soil samples taken by Viking." Perchlorates may have cost Gilbert Levin the Nobel Prize for finding life at the Viking 1 and 2 landing sites so far. Both landers got positive results for his labeled release experiments there.

What are perchlorates? They are salts of perchloric acid. An example is potassium perchlorate (formula $KClO_4$). Ironically, the very chemical that may have given Levin so much grief was used by NASA as a reason to explain running water on a planet that they still claim has atmospheric pressure close to that of a vacuum.

Lujendra Ojha (shown on Figure 55) and his colleagues created a computer program that could scrutinize individual pixels in pictures seen from Earth. This was necessary because the areas in concern for RSL are only about 5 meters (16 feet) wide. That data was then correlated with high-resolution images of the streaks. Scientists concentrated on the widest streaks and came up with a 100 percent match between their locations and detections of hydrated salts.

"We're not claiming that we found ... evidence of liquid water. We found hydrated salts," Ojha said. Still, that was enough for NASA, which declared a "Mars mystery solved," in a press advisory.

What Ojha found were spectra for magnesium perchlorate, sodium perchlorate and calcium perchlorate. Light is being absorbed at wavelength of 1.9 and 2.1 microns. These wavelength match what is seen with hydrated salts of perchlorate (ClO_4). This means that there is water in the molecular structure of these salts. Ojhu claims that the Mars Reconnaissance Orbiter (MRO) observes the surface of Mars every day at roughly 3 pm which is the driest time of day. He says that most of the liquid water will have been completely evaporated then. However, he states that the molecular water trapped inside the salts will have been a bit more stable and that is exactly what they observed. This means that the source of molecular water or water in the crystal structure of salts is either due to RSL or some other processes that created these streaks. Regardless, the presence of hydrated salts in the slopes means that the streaks are due to contemporary liquid water. At Palikir Crater they see presence of hydrated salts only when the streaks are present.

Evidence of running water is seen in places with peak surface temperatures from ~250 to 300K. On Earth pure water freezes at 273.15K and boils at 373.15K. At the accepted low pressures on Mars Ojha stated that pure water is very unstable on Mars, being able to exist only between 0° C and 10° C (273.15K and 283.15K). He notes that it would boil above 10° C (50° F). He goes on to state that a perchlorate-brine form of salty water on Mars would stay liquid down to -70° C and not start boiling until the temperature reached 24° C (297.15K). The ~300K figure given above (which was from a 2011 article with Ojha's name on it) for areas with running water thus seems a little high, especially with issues related to latent heat of vaporization. Further, in examining our records for Mars Science Laboratory which is close to the Equator at 4.59° South there never was a temperature claimed (either before JPL revised its temperature data, or after) that was in the range of 300K or 297.15K. Nor was any such temperature recorded by any lander on Mars. Temperatures that high are only linked to what was allegedly seen from orbit. They are apparently also linked to ground temperatures on slopes inclined toward the sun.

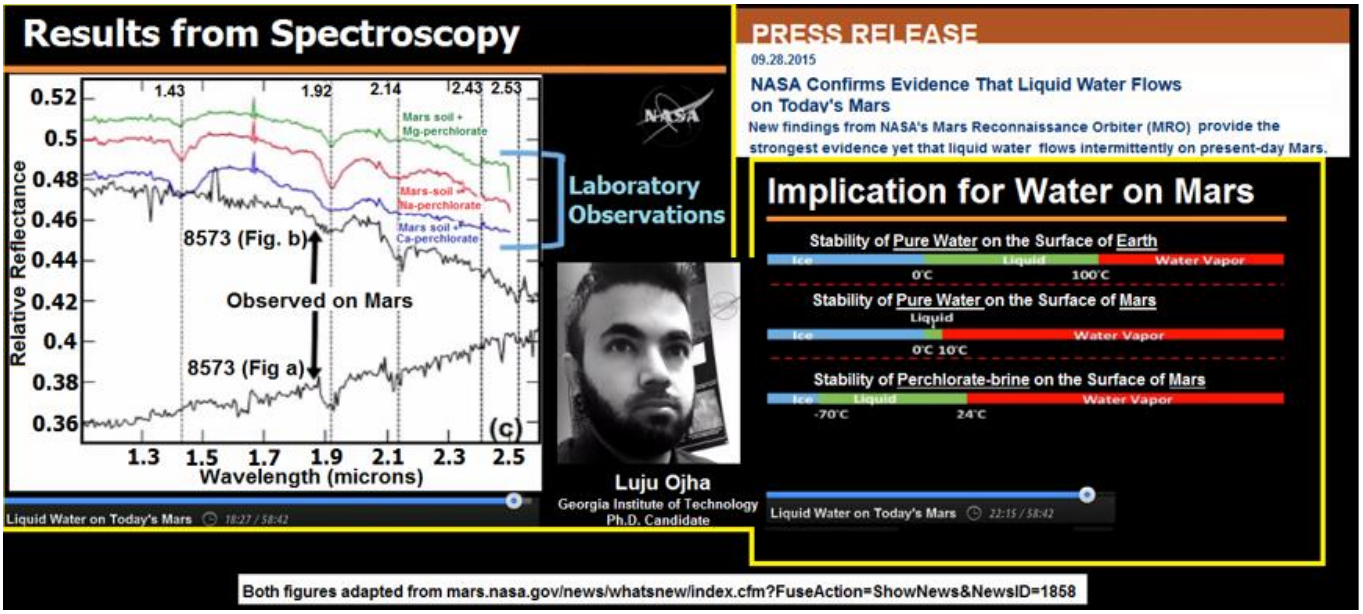


FIGURE 55: The left side shows results from Spectroscopy when matching RSL with perchlorates. The right side shows effects of perchlorates on boiling and freezing points of water at pressures on Mars that are accepted by NASA. We dispute the accepted pressure 6.1 mbar at areoid and instead believe that the real pressure at areoid is about 511 mbar. We argue that the widespread presence of running water strengthens our case.

With respect to everything we heard in the NASA conference of 28 September 2015 we believe that Figure 54 sums it up best. The fact that the temperatures associated with RSL are rarely associated with temperatures much below 273, the freezing point of water in Earth, may indicate a low concentration of perchlorates and/or air pressure that are different from what is found on Earth.

13.3.3.4. *RSL: Could they be sand rather than water?* In November, 2017 a NASA article[155] challenged the water content of recurring slope lineae. Highlights of the article state:

> Dark features on Mars previously considered evidence for subsurface flowing of water are interpreted by new research as granular flows, where grains of sand and dust slip downhill to make dark streaks, rather than the ground being darkened by seeping water.
>
> Continuing examination of these still-perplexing seasonal dark streaks with a powerful camera on NASA's Mars Reconnaissance Orbiter (MRO) shows they exist only on slopes steep enough for dry grains to descend the way they do on faces of active dunes.
>
> The findings published today in Nature Geoscience argue against the presence of enough liquid water for microbial life to thrive at these sites. However, exactly how these numerous flows begin and gradually grow has not yet been explained. Authors of the report propose possibilities that include involvement of small amounts of water, indicated by detection of hydrated salts observed at some of the flow sites.

13.4. Other Water on Mars – the Frozen Sea at Utopia Planitia. On November 22, 2016 NASA announced that researchers using NASA's Mars Reconnaissance Orbiter have determined that, "Frozen beneath a region of cracked and pitted plains on Mars lies about as much water as what's in Lake Superior, largest of the Great Lakes.[115]

Scientists examined part of Mars' Utopia Planitia region (see Figure 56), in the mid-northern latitudes, with the orbiter's ground-penetrating Shallow Radar (SHARAD) instrument. Analyses of data from more than 600 overhead passes with the onboard radar instrument reveal a deposit more extensive in area than the state of New Mexico. The deposit ranges in thickness from about 260 feet (80 meters) to about 560 feet (170 meters), with a composition that's 50 to 85 percent water ice, mixed with dust or larger rocky particles." They further wrote that, "At the latitude of this deposit – about halfway from the equator to the pole – water ice cannot persist on the surface of Mars today. It sublimes into water vapor in the planet's thin, dry atmosphere. The Utopia deposit is shielded from the atmosphere by a soil covering estimated to be about 3 to 33 feet (1 to 10 meters) thick."

Our comment is that a soil covering of only 3 feet seems to be very thin when it comes to stopping sublimation. Clarification is needed with respect to how often the soil is this thin vs. how often it's up to 33 feet. The statement about the planet's thin, dry atmosphere leaves out a specific pressure, and our report disputes the accepted 6.1 mbar pressure at areoid. More, as is seen in Figure 52 Utopia Planitia is about 7 km below areoid meaning that the pressure will be sufficiently above the triple point (the point at which the temperature and pressure at which the three phases (gas, liquid, and solid) of that substance coexist in thermodynamic equilibrium – for water 273.16 K, 6.11657 mbar) thus enabling both ice and liquid water (when warm enough) to exist at the surface (as it does in conjunction with recurring slope lineae at locations noted on Figure 52). Indeed if we accept the absurdly low NASA-backed pressure at areoid, with a MOLA altitude of 7 km below areoid, as our calculation below on Table 16 reveals the pressure would be up to about 11.66 mbar in Utopia Planitia, but we present evidence in conjunction with Figure 57 to back a real pressure of over 700 mbar.

Table 16 – CALCULATION FOR PRESSURE AT UTOPIA PLANITIA (Based on 6.1 mbar at areoid)

A	B	C	D	E	F	G	H
(Entering Arguments Scale Height 10.8 Km And Average Martian Pressure 6.1 Mbar) Kilometers	10.8 Km Scale Height	Ratio A/B	=-Exp(C Value)	1/D Value	Pressure Mars Bars	Pressure In Mbar	Site
0	10.8	0	-1	-1	1	6.1	AREOID
-7	10.8	-0.648148148	-0.523013424	-1.911996814	1.911996814	11.66318056	UTOPIA PLANITIA
-4.495	10.8	-0.404954955	-0.667006856	-1.499234965	1.499234965	9.145333289	VIKING 2 (latitude 47.97 N, longitude 225.74 W)

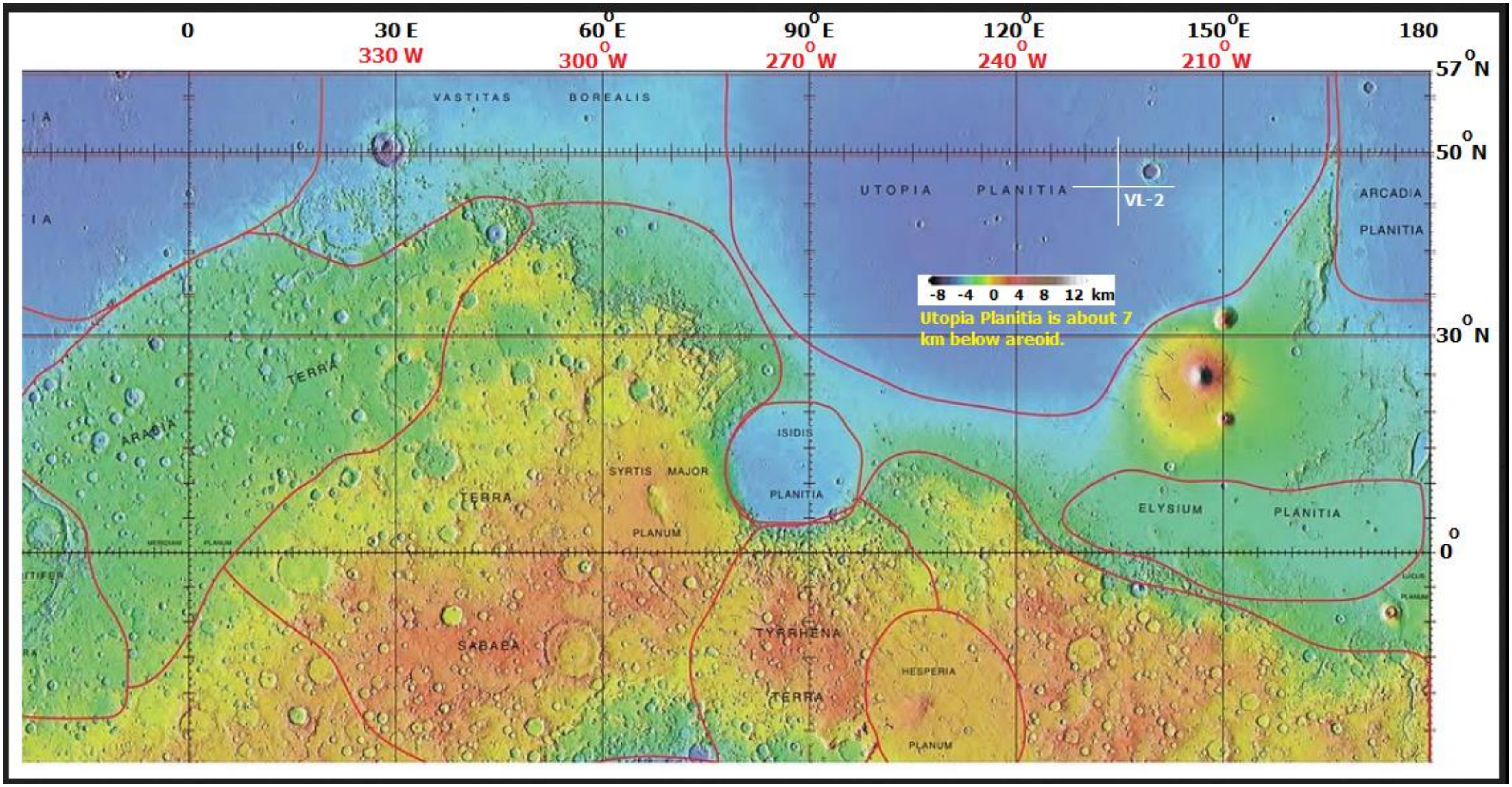


Figure 56 shows a close-up map of Utopia Planitia where the water ice sea was found on Mars

THE NASA ARTICLE CONTINUES:

> "This deposit probably formed as snowfall accumulating into an ice sheet mixed with dust during a period in Mars history when the planet's axis was more tilted than it is today," said Cassie Stuurman of the Institute for Geophysics at the University of Texas, Austin. She is the lead author of a report in the journal Geophysical Research Letters.

Mars today, with an axial tilt of 25 degrees, accumulates large amounts of water ice at the poles. In cycles lasting about 120,000 years, the tilt varies to nearly twice that much, heating the poles and driving ice to middle latitudes. Climate modeling and previous findings of buried, mid-latitude ice indicate that frozen water accumulates away from the poles during high-tilt periods."

ROFFMAN COMMENTS: We discussed axial tilt in conjunction with the potential pressure on Mars earlier in Section 12. There we noted that Read and Lewis (2004, pp. 269-270)[79] postulated potential reserves of CO_2-H_2O clathrate in regolith that could raise surface pressure to 200 hPa (mbar) during periods of high-obliquity when, at some point in the future, They said that if more clathrate is locked up under deeper polar deposits underground, pressure could go as high as 850 hPa (Jakosky et al., 1995).[85] But Read and Lewis state the value might be limited to 15-30 mbar if the soil became rich in water ice through precipitation and adsorption into the porous regolith.

Now we know that the soil is indeed rich in water ice. But we must point out that such a low pressure does not seem conducive to much precipitation. Snow has been seen falling at the Mars Phoenix lander, but supposedly it did not reach the surface. In comparison to the rest of Mars, there are very few craters seen in Utopia Planitia, which seems to suggest a young surface. Since we know that much of the northern hemisphere of Mars was once under water, what we are more likely looking at here is not the result of rain or snow 120,000 years ago. Rather, it is probably an example of the larger sea that once occupied most of the ancient Martian northern hemisphere. **It did not all evaporate and fly off into space.** Rather, the surface froze and was subsequently covered with a relatively thin layer of dust and dirt.

Note that in 2015 NASA Goddard put out an article and video about the ancient Martian ocean. Their article was entitled **NASA Research Suggests Mars Once Had More Water Than Earth's Arctic Ocean**. The accompanying video is at **http://youtu.be/WH8kHncLZwM**. Using ratios in waters of deuterium in water to normal hydrogen they ***determined*** that Mars had lost 87% of its water to space and that all that remained was frozen at the poles of Mars. However the discovery at Utopia Planitia obviously calls into question their conclusion and begs the question as to how much of what is colored blue in the northern hemisphere on Figure 56 is, in fact, not just low areas like Utopia Planitia was thought to be, but are in fact also areas where large amounts of ice will be found.

The newly surveyed ice deposit spans latitudes from 39 to 49 degrees within the plains. NASA says it represents less than one percent of all known water ice on Mars, but it more than doubles the volume of thick, buried ice sheets known in the northern plains. Ice deposits close to the surface are being considered as a resource for astronauts.[115] The only lander to touch down between 39 and 49 degrees North was Viking 2 (at almost 48° North) which recorded a maximum temperature of 245.74 K (-24.71° C/-17.338° F). So it never saw above freezing temperatures (but MSL, near the equator, often did).

13.5 The High End of Pressure Estimates for Mars. There were at least five pressures published by the Remote Environmental Monitoring Station Team with Earth-like pressures of 742 to 747 hPa (mbar) for September 1 to 5, 2012 (Ls 164.1° to 166.3° - shown on Figure 17A) and another found for August 30 that was 735 **h**Pa before revision to 740 Pa.

While the 51 mbar estimate based on the SAM is almost an order of magnitude greater than accepted pressures, it equates to an altitude of 63,057 feet (19,220 meters) above Earth. Walking around at such a low pressure would still require a pressure suit. But there is evidence that suggests pressure far higher than this. While there are caveats, pressures this high make Martian weather far easier to understand. The evidence begins with photos and wording found on a JPL web site.

With regard to the Earth-like high pressure reports from the REMS Team, most of them are shown on Figure 17A. The red and green comments are our comments. Could these pressures be real? Such pressures would explain the weather plainly seen much better than pressures under 10 mbar, but one particular photo of Martian Weather with JPL commentary may have given us a glance at proof that the five really high pressures were actually accurate.

The all-important page is at http://mars.jpl.nasa.gov/MPF/ops/clouds_sunset.html. The photo can be found at http://mars.jpl.nasa.gov/MPF/ops/82453_full.jpg. The quote of interest for the photo is:

The all-important page is at http://mars.jpl.nasa.gov/MPF/ops/clouds_sunset.html. The photo can be found at http://mars.jpl.nasa.gov/MPF/ops/82453_full.jpg. The quote of interest for the photo is:

*"This is the first color image ever taken from the surface of Mars of an overcast sky. Featured are pink **stratus clouds** coming from the northeast at about 15 miles per hour (6.7 meters/second)* ***at an approximate height of ten miles (16 kilometers) above the surface…*** *The clouds consist of water ice condensed on reddish dust particles suspended in the atmosphere. Clouds on Mars are sometimes localized and can sometimes cover entire regions, but have not yet been observed to cover the entire planet.* ***The image was taken about an hour and forty minutes before sunrise by the Imager for Mars Pathfinder (IMP) on Sol 16*** *at about ten degrees up from the eastern Martian horizon."*

The color photo mentioned above is shown on Figure 57. The evidence is based on stratus clouds seen 16 km above Mars Pathfinder.

Pathfinder landed in the Martian tropics at 19.33 North, 33.55 West at 3.682 km below areoid, so 16 km above that would be an altitude of 12.318 km above areoid. Pathfinder is unlikely to have changed its own altitude very much over 16 sols.

We first focus on what minimum pressure is required for stratus clouds to form in Earth's atmosphere. The highest stratus clouds are cirrostratus. They occur at altitudes up to 13,000 meters.[91] As is shown on Figure 57, at 13,000 meters the expected pressure on Earth is 163.33 mbar. With this pressure in mind we can make an estimate of pressure on Mars, but first we state the caveats. The pressures calculated do not factor in higher than terrestrial dust loads in the Martian atmosphere. Nor do they consider the gas composition of the Martian atmosphere (95% CO_2 vs. about 0.04% on Earth). So at best we are shooting here for a ball park estimate.

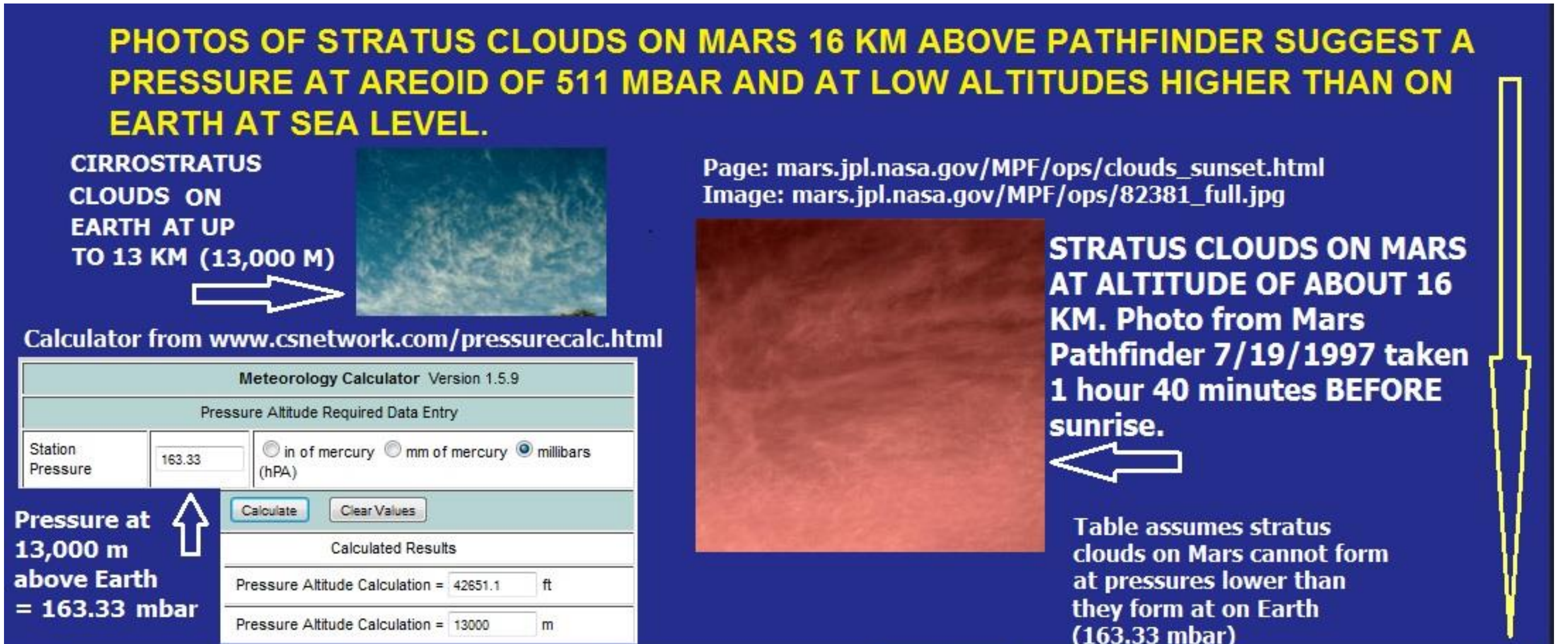
As is also shown on Figure 57, if we assume that (cirro) stratus clouds on Mars cannot form at a lower pressure than similar clouds on Earth, then using a scale height of 10.8 our spreadsheet indicates pressures of around 511 mbar at areoid, and up to 1,054 mbar at the bottom of the Hellas Basin. Using this same logic the indicated pressure for the MSL, 4.4 km below areoid, is about 767 mbar/767 **h**Pa (767 Pa was seen on Sol 1284). While most of the data put out by the MSL Remote Environmental Monitoring Station (REMS) Team is only about 1% of this, for September 1 to September 5, 2012, they published pressures that were 97% in agreement with this calculation. The essential issue thus comes down to whether REMS published results that confused 747 hecto Pascals with 747 Pascals (7.47 hPa/7.47 mbar). Or, did someone in the REMS Team rebel against expected results and in fact give us the truth until silenced? One REMS Team member was Henrik Kahanpää, the designer of the Vaisala pressure sensors used for both Phoenix and MSL. He was discussed earlier in Section 2.4. Again, he wrote, *"We should find out how the pressure tube is mounted in the spacecraft and **if there are additional filters** etc."* We challenged the above statement on November 14, 2009. Kahanpää's partial response to my assertion that "something stinks" about his request for information on additional filters was:

> "Your nose smelled also a real issue. The fact that we at **FMI did not know how our sensor was mounted in the spacecraft and how many filters there were** shows that the exchange of information between NASA and the foreign subcontractors did not work optimally in this mission!" (Kahanpää, personal communication on 12/15/2009).

And so when this particular man allows reports to be issued for five days that back our projected pressures, and later to allow publication of 1,177 Pa and 1,200 Pa pressures for sols 1,160 and 1,161 as well as 1154 Pa on Sol 1301; issues of personnel, agendas, possible disinformation and rebellion should *not* be overlooked. The REMS reports in question were shown earlier on Figure 14D to 14F.

While Kahanpää was clear about his dissatisfaction with NASA is his discussion about how his sensor was employed with Phoenix, I have not seen him write anything about the massive confusion that occurred again with his sensor on MSL. I can only state that the Phoenix and MSL sensors were essentially the same (as was shown back on Figure 11A). Both were delivered to NASA in 2008.[35] However, with Kahanpää as the man on the REMS Team directly responsible for pressure reports from MSL (at least until possible censorship), we see that multiple incidents of highest pressures reported have been eliminated – the first five days in September 2012 (cut a hundred-fold), the 1149 Pa pressure for Sol 370 (reduced to 865 Pa), the 940 Pa pressure (changed to N/A for Sol 192 on February 19, 2013) and 937 Pa for Sol 200 (February 27, 2013) also changed to N/A. On 23 November 2015 we wrote that 1,177 and 1,200 Pa pressures for Sol 1,160 (10 to 12 November 2015) were still standing, but we expected them to be politically revised to 897 Pa +/- 3PA. In fact they were reduced to 898 and 897 Pa. Further, an 1154 Pa pressure for Sol 1301 was also cut to 752 Pa (there was also a 954 Pa pressure on Sol 1300 that was reduced to 752 Pa).

This Section of my report was accessed by someone at IP address 85.76.183.141 in Helsinki, Finland on November 29, 2015. I assume that’s you, my friend Dr. Kahanpää. You are likely walking around with the key to Mars in your pocket. But will you dare to unlock it? Be careful, the list of IP addresses from NASA and other space agencies and governments who read our web sites almost daily is most impressive.



	A	B	C	D	E	F	G	H	I
1	CALCULATIONS BASED ON	ENTERING ARGUMENTS SCALE HEIGHT 10.8 KM AND 163.33 mbar at 12,318 meters							
2	MARS PATHFINDER	KILOMETERS	10.8km Scale	RATIO B/C	=-EXP(D VALUE)	1/E value	-F VALUE = PRESSURE	PERCENT OF	PRESSURE IN
3	VIEW OF STRATUS CLOUDS		Height (MARS)				MULTIPLE OF	PRESSURE AT	MILLIBARS/hPa
4							6.1 MBAR MEAN	MEAN AREOID	
5	CLOUDS 16 KM ABOVE MPF	12.318	10.8	1.1405556	-3.128505941	-0.319641394	0.319641394	31.96413939	163.3303595
6	MARS PATHFINDER (MPF)	-3.682	10.8	-0.3409259	-0.711111581	-1.40624907	1.40624907	140.624907	718.56515
7	MEAN AREOID	0	10.8	0	-1	-1	1	100	510.98
8	MARS SCIENCE LABORATORY	-4.4	10.8	-0.4074074	-0.665373057	-1.50291628	1.50291628	150.291628	767.9601608
9	VALLES MARINERIS	-5.31	10.8	-0.4916667	-0.611606201	-1.635039015	1.635039015	163.5039015	835.4722361
10	HELLAS BASIN	-7.825	10.8	-0.724537	-0.484548845	-2.063775427	2.063775427	206.3775427	1054.547968

Figure 57 – Stratus clouds on Earth are found up to altitudes of 13,000 meters, where pressures are about 163.33 mbar. They are not found over Earth at pressures below this level. The same kind of clouds is found on Mars. If the same minimum pressure is required on Mars, where these clouds were seen 16 km above Mars Pathfinder which was 3.682 km below areoid, it means that the stratus clouds were about 12.318 km above areoid. Based on an accepted scale height of 10.8, this implies a pressure at areoid of about 511 mbar, at Pathfinder of about 718 mbar, with 768 mbar at MSL, 835 mbar at Valles Marineris, and 1,054 mbar in Hellas Basin. The 768 mbar figure for MSL should be compared to REMS Team results for September 1 to 5, 2012 shown earlier on Figure 18.

13.6. *Pressure Drop as MSL Climbs Mt. Sharp vs. Scale Height Predictions.*

This Section correlates Mars Science Laboratory (MSL) pressures claimed with altitude in meters below areoid, the Martian equivalent to sea level. The data was originally published by the REMS Team, who work for JPL and NASA. They often read this report and may in fact be in rebellion to NASA as I write add this section to our report. This is suspected because until March 20, 2017 when the REMS Team published ludicrous data they generally went back and revised it – often after reading the critiques that are found in links provided in our enhanced daily Martian weather reports at http://marscorrect.com/cgi/wp/?page_id=622. But after March 20, 2017 the ground temperature lows became insanely cold and were not matched by very cold air temperature lows. The REMS Team ceased making changes, leaving us to guess as to what was going on. We explain this later in Sections 15.6 through 15.6.2.at http://marscorrect.com/photo5_14.html.

For now let it be known that that until March 20, 2017 the REMS Team and NASA came here many times each week to both check on how their results were being received, and at times to see where they needed to alter those results in an effort to draw less criticism. They even withdrew all their (never changing) wind data after we contacted JPL's public relations man Guy Webster and they altered their Gale Crater Mars sunrise and sunset times to match my son David's calculations. David had applied to work for NASA several times, but

they only choose to read everything we publish, but make no offer – probably in part because our emphasis is always on scientific accuracy rather than political correctness.

Before going any further it should be noted that we have seen the numbering of MSL years is not always the same as what we refer to on our enhanced daily weather at http://marscorrect.com/cgi/wp/?page_id=622. We label the first year of MSL on Mars as Year 1, but in at least one article we have seen it was referred to as Year 0. However we all agree on the Martian sols (days). On our charts Year 1 began at landing on August 5 to 6, 2012. It lasted 669 sols (until June 24, 2014). Year 2 then began, ending on Sol 1,338 on May 11, 2016. We are currently in the fall of Year 5. As I update this article MSL, in the southern hemisphere of Mars, is in the fall season. We have at least 3.025 sols of data minus some critical data for the first 10 sols, and for a few other periods of time. The first look at data comparing some Year 3 and Year 2 is given here as Table 17. Note the small amount of variation in pressure differences. There are 14 sols shown for each year segment. Six of them show pressure differences of 11 pascals (Pa) from one year to the next. The average pressure difference was 11.57 Pa. The smallest difference was 10 Pa and the largest difference was 13.

Table 17 altitudes were derived from JPL at https://mars.nasa.gov/msl/mission/whereistherovernow/. It's not as complete as we would like, but there are often 2 meter altitude curves that can be used for approximation of altitude. During Year 2 for this period between Ls 11 and Ls 18 altitude didn't change by more than a meter – floating between -4,447 and -4,446 meters below areoid. But for Year 3 there was an increase in altitude from about -4,266 to-4,251 meters below areoid. So the Year 3 segment shown started about 181 meters higher than Year 2, and finished about 195 meters higher. Knowing this we can ask, in accordance with scale height calculations, *Is it reasonable to have pressures in Year 3 about 11 Pa lower than they were at a lower altitude in Year 2?*

TABLE 17: Pressure and altitudes for MSL Years 2 and 3 between Ls 11 and 19:

SOL	~LS	PRESSURE Pa	EARTH DATE	PRESSURE AT SAME LS IN MSL YEAR 2	Δ PRESSURE YEAR 2 TO YEAR 3 SAME LS	Yr 2 altitude	Yr 3 altitude	Sol Yr 2
1710	11	848	5/29/2017	859	-11			1041
1711	11	848	5/30/2017	859	-11	-4447	-4266	1042
1712	12	849	5/31/2017	860	-11	-4446		1043
1713	12	850	6/1/2017	860	-10	-4447	-4265	1044
1714	13	849	6/2/2017	861	-12			1045
1715	13	851	6/3/2017	862	-11	-4446		1046
1716	14	850	6/4/2017	863	-13			1047
1717	14	851	6/5/2017	864	-13		-4263	1048
1718	15	852	6/6/2017	864	-12	-4447	-4260	1049
1719	15	853	6/7/2017	863	-10		-4260	1050
1720	16	853	6/8/2017	864	-11		-4257	1051
1721	16	852	6/9/2017	865	-13		-4255	1052
1722	17	854	6/10/2017	865	-11	-4446		1053
1723	17	854	6/11/2017	867	-13			1054
1724	18	856	6/12/2017	868	-12		-4254	1055
1725	18	857	6/13/2017	868	-11	-4446	-4251	1056
1726	19	855	6/14/2017	867	-12			1057

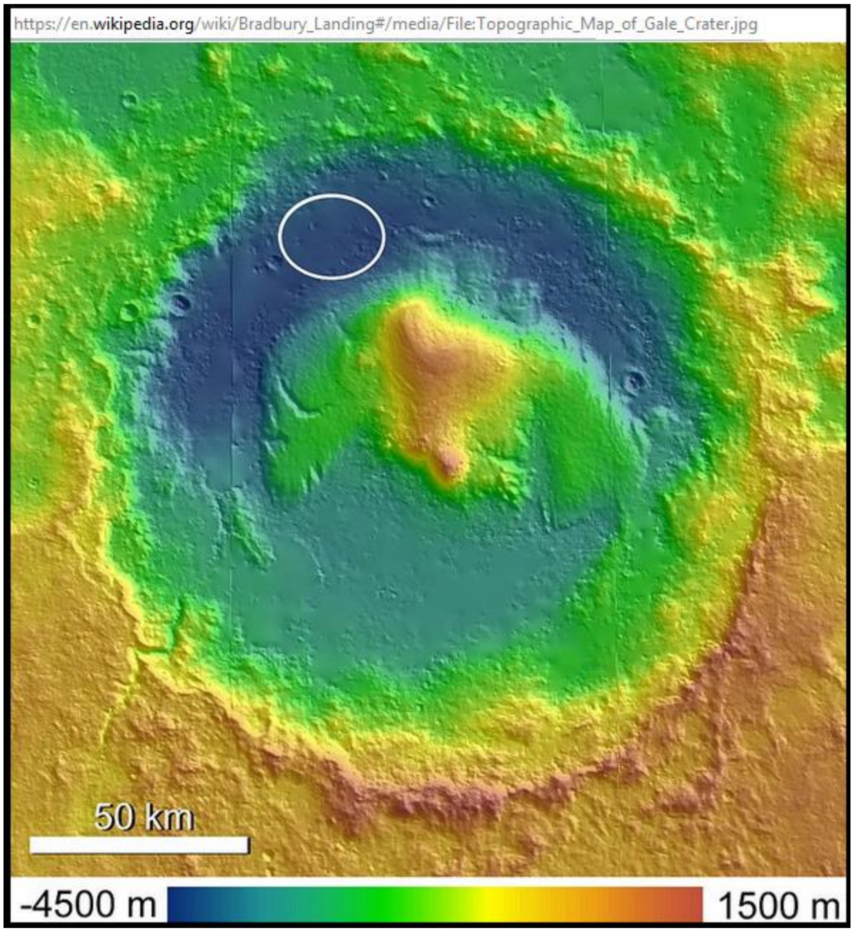


FIGURE 58 – Map of Gale Crater with Aeolis Mons rising from the middle of the crater. The MSL landing ellipse is in the northwest corner, about 4,500 meters below areoid. The landing was under 2.5 km from the target.

In looking at whether the data is reasonable, or apparently fudged as often seemed to be the case with REMS until about March 20, 2017 (when the REMS Team, aware of our critiques, seemed to go into a rebellion mode) we will want to look at variations in pressure using a scale height calculation to see if the approximately 9 Pa pressure differences each year line up with these pressure differences. More important, we will look at the 11 Pa difference between Year 2 Ls 11 and Year 3 Ls 11.

During Year 2 the pressure slowly climbed from 859 Pa to 867 Pa (actually reaching 868 Pa the sol before the end point on Sol 1,057). So the rise during this part of MSL Year 2 was about 8 to 9 Pa. Note that the pressure rose rather than fell but the altitude didn't really change by more than a meter from sols 1,041 to 1,056.

For Year 3 the pressure rose again, this time (sols 1,711 to 1,725) from 848 Pa to 855 Pa (actually reaching 857 Pa the sol before the end point on Sol 1,726). So that's a **rise** of about 7 to 9 Pa for Year 3 – quite similar to what was seen for Year 2 but here the rover is clearly climbing to where average air pressure should be lower if we do not consider seasonal changes.

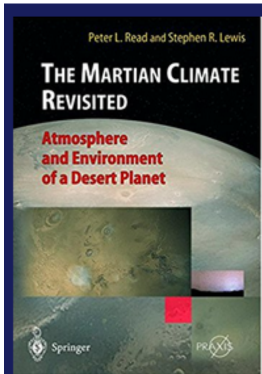
In MSL Year 1 for this period pressures ran from about 866 Pa up to 875 Pa. Again, that's an increase of 9 Pa between sols 374 and 389, but I have not yet been able to find altitude contour maps from that period, so I can't yet definitively comment on how altitude and pressure were, if at all, linked for those sols. However a JPL image shows the rover locations from landing through this period, and it doesn't look like it was more than from about 910 to 1,300 meters from the landing site (about 4,500 meters below areoid). See Figure 58 above to get a feeling for altitudes at Gale Crater.

The expected pressures for altitudes 4,500 meters/4.5 km (Year 1), 4,447 meters/4.447 km (Year 2) and 4,266/4.266 km to 4,251meters/4.251 km below areoid (Year 3) are given on Tables 18A (for a scale height of 10.8 km) and Table 18B (for a scale height of 11.1 km). On Table column K provides a ballpark estimate for how to account for the fact that pressures given are for Ls 11 which is not when maximum pressure occurs. Under Column L highlighted in white numbers with a red background is the amount of pressure drop at Ls 11 from Year 2 to Year 3.

TABLE 18A – PRESSURE CALCULATIONS FOR ALTITUDES DISCUSSED ABOVE USING A SCALE HEIGHT OF 10.8 KM

A	B	C	D	E	F	G	H	I	J	K	L
KILOMETERS	10.8 km	RATIO A/B	=-EXP(C value)	1/D value	PRESSURE	PRESSURE	PREDICTED	INITIAL PREDICTED	TIME & LS	ADJUSTMENT	FINAL PREDICTED
	Scale				MARS BARS	IN	PRESSURE	DROP IN PRESSURE		FOR NOT BEING	DROP IN PRESSURE
	Height					MBAR	IN PA	IN PA FROM		AT MAX PRESSURE LS	IN PA FROM
	(Mars)							YEAR 1 LS 11 & PREVIOUS ROW		859/925.307 = .9283405	YEAR 1 LS 11
MEAN AREOID 0	10.8	0	-1	-1	1	6.1	610			566.287705	
-4.5	10.8	-0.416666667	-0.65924063	-1.516896796	1.516896796	9.253070458	925.3070458	N/A	YEAR 1 LS 11	859.0000055	N/A
-4.447	10.8	-0.411759259	-0.662483744	-1.509471001	1.509471001	9.207773109	920.7773109	4.529734933	YEAR 2 LS 11	854.7948692	4.205136392
-4.266	10.8	-0.395	-0.673680039	-1.484384191	1.484384191	9.054743565	905.4743565	19.83268934 (15. 30295 from Year 2 Ls11)	YEAR 3 LS 11	840.5885168	14.20635234
-4.251	10.8	-0.39361111	-0.674616356	-1.482323977	1.482323977	9.042176261	904.2176261	21.08941968 (1.2567304 from Year 2 Ls 11)	YEAR 3 LS 18	839.4218431	1.166673674

TABLE 18B – PRESSURE CALCULATIONS FOR ALTITUDES DISCUSSED ABOVE USING A SCALE HEIGHT OF 11.1 KM											
KILOMETERS	11.1 km Scale	RATIO A/B	=-EXP(C value)	1/D value	PRESSURE	PRESSURE IN	PREDICTED	INITIAL PREDICTED	TIME & LS	ADJUSTMENT	FINAL PREDICTED
	Height (MARS)				MARS BARS	MBAR	PRESSURE	DROP IN PRESSURE		FOR NOT BEING	DROP IN PRESSURE
							IN PA	IN PA FROM		AT MAX PRESSURE LS	IN PA FROM
								YEAR 1 LS 11 & PREVIOUS ROW		859/925.307 = .9283405	YEAR 1 LS 11
MEAN AREOID 0	11.1	0	-1	-1	1	6.1	610			566.287705	
-4.5	11.1	-0.40540541	-0.66670647	-1.49991045	1.499910449	9.149453737	914.9453737	N/A	YEAR 1 LS 11	849.3808457	N/A
-4.447	11.1	-0.40063063	-0.66989746	-1.49276579	1.492765785	9.105871287	910.5871287	4.358244991	YEAR 2 LS 11	845.3349103	4.045935334
-4.266	11.1	-0.38432432	-0.68091056	-1.46862167	1.468621674	8.958592213	895.8592213	19.08615241 (14.72707419 from Year 2 Ls 11)	YEAR 3 LS 11	831.6623974	13.67251293
-4.251	11.1	-0.38297297	-0.68183133	-1.46663839	1.466638391	8.946494183	894.6494183	20.29595536 (1.20980295 from Year 2 Ls 11)	YEAR 3 LS 18	830.5392883	1.123109076



This book was published in 2004. Note that scale height is given as 10.8 km

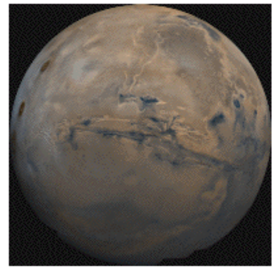
2 **An introduction to Mars** [Ch. 1

Table 1.1. Key planetary and atmospheric parameters for Earth and Mars.

	Earth	Mars
Mean orbital radius (10^{11} m)	1.50	2.28
Distance from Sun (AU)	0.98–1.02	1.38–1.67
Orbital eccentricity	0.017	0.093
L_s of perihelion	281°	251°
Planetary obliquity	23.93°	25.19°
Rotation rate, $\Omega (10^{-5}\,s^{-1})$	7.294	7.088
Solar day, sol (s)	86,400	88,775
Year length (sol)	365.24	668.6
Year length (Earth days)	365.24	686.98
Equatorial radius (10^6 m)	6.378	3.396
Surface gravity, $g\,(m\,s^{-2})$	9.81	3.72
Surface pressure (Pa)	101,300	600 (variable)
Atmospheric constituents (molar ratio)	N_2 (77%)	CO_2 (95%)
	O_2 (21%)	N_2 (2.7%)
	H_2O (1%)	Ar (1.6%)
	Ar (0.9%)	O_2 (0.13%)
Gas constant, $R\,(m^2\,s^{-2}\,K^{-1})$	287	192
c_p/R	3.5	4.4
Mean Solar Constant ($W\,m^{-2}$)	1367	589
Bond Albedo	0.306	0.25
Equilibrium temperature, T_e (K)	256	210
Scale height, $H_p = RT_e/g$ (km)	7.5	10.8
Surface temperature (K)	230–315	140–300
Dry adiabatic lapse rate ($K\,km^{-1}$)	9.8	4.5
Buoyancy frequency, $N\,(10^{-2}\,s^{-1})$	1.1	0.6
Deformation radius, $L = NH_p/\Omega$ (km)	1100	920

https://nssdc.gsfc.nasa.gov/planetary/factsheet/marsfact.html

Mars Fact Sheet



This NASA fact sheet was accessed on 6/25/2017. However, the inaccurate data is old and appears to be from the Viking 1 days.

Mars/Earth Comparison

Martian Atmosphere

Note: In its year 1 Viking 1 recorded 9.57 mbar at Sol 318.38, Ls 277.724; Viking 2 recorded 10.72 mbar in its Year 2 Sol 277.34 at Ls 279.93.

```
Surface pressure:  6.36 mb at mean radius (variable from 4.0 to 8.7 mb depending on season)
                   [6.9 mb to 9 mb (Viking 1 Lander site)]
Surface density: ~0.020 kg/m3
Scale height:  11.1 km
Total mass of atmosphere: ~2.5 x 10^16 kg
Average temperature:  ~210 K (-63 C)
Diurnal temperature range: 184 K to 242 K (-89 to -31 C) (Viking 1 Lander site)
Wind speeds:  2-7 m/s (summer), 5-10 m/s (fall), 17-30 m/s (dust storm) (Viking Lander sites)
Mean molecular weight: 43.34
Atmospheric composition (by volume):
    Major      : Carbon Dioxide (CO2) - 95.32% ; Nitrogen (N2) - 2.7%
                 Argon (Ar) - 1.6%; Oxygen (O2) - 0.13%; Carbon Monoxide (CO) - 0.08%
    Minor (ppm): Water (H2O) - 210; Nitrogen Oxide (NO) - 100; Neon (Ne) - 2.5;
                 Hydrogen-Deuterium-Oxygen (HDO) - 0.85; Krypton (Kr) - 0.3;
                 Xenon (Xe) - 0.08
```

Note 11.1 km scale height.

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Figure 59 – Comparison of scale heights in THE MARTIAN CLIMATE REVISITED and on a NASA web site.

What's immediately noticeable about Tables 18A and 18B is that the pressure calculated for the landing site altitude matches the maximum pressure (925 Pa) that NASA/JPL/The REMS Team permitted the public to see after they altered the data – in large part in response to higher pressures that they first published which were challenged by us. Earlier Table X in Section 2.4 of this report listed most of the changes. For the sake of brevity here, Table 19 only presents pressures that were revised by NASA when they were originally published as being over 925 Pa.

TABLE 19 – Pressures over 925 Pa revised by JPL/REMS after we highlighted them or published them in earlier version of our Report

Date	MSL Sol	Ls	Initial Pressure Reported	Pressure for the previous sol	Final Pressure Reported after JPL Revisions
Sept 1 to Sept 5, 2012	26	164	742 to 747 **h**Pa 74200 to 74700 (Pa)	743 Pa	745, 743, 745, 747 and 747 Pa
Feb 19, 2013	192	267	940 Pa – a high until now. Pressures had been declining since a high of 925 Pa in late January 2013.	921	N/A
Feb 27, 2013	200	272	937 Pa	917 Pa	N/A
Aug 21, 2013	370	9	1,149 Pa	865 Pa	865 Pa
Nov 10, 2015	1160	66	1177 Pa	898 Pa	899 Pa
Nov 12, 2015	1161	66	1200 Pa	899 Pa (revised)	898 Pa
April 2, 2016	1300	131	945 Pa	753 Pa	752 Pa
April 3, 2016	1301	131	1154 Pa	753 Pa (2 sols earlier, 751 Pa on Sol 1302	752 Pa
Oct 27, 2016	1502	249	928 Pa	903 Pa	907 Pa
Mar 25, 2018	2002	148	1167 Pa	913 Pa	715 Pa

Table 19 is evidence that that there is an agenda to keep pressure reported for MSL either at or below the 925 Pa indicated by the scale height calculations on Table 18A and 18B.

As can be seen from Figure 60, a maximum pressure of 925 Pa was seen in MSL Year 1 at Ls 252 and 253 (Sols 170 &171). In MSL Year 2 this same pressure was attained at Ls 257 (Sol 846). If, for the moment, we overlook the 925 pressure maximum allowed by JPL or whoever is behind the data alteration, then it should be noted that Table 17 only deals with pressures produced in MSL Year 3 between Ls 11 and 19. At Ls 11 in Year 1 the pressure given by the REMS Team was 866 Pa. This is about 92.83405% of the maximum pressure of 925 Pa (actually, 925.307 Pa) Now let's use that figure to look at what happened from Ls 11 in Year 2 to Ls 11 in Year 3. There was an increase in altitude of 181 meters and a **decrease in predicted pressure of about 15.30295 Pa (Table XA, cell H8-H9)**, but the **actual NASA-claimed decrease in pressure was only 11 Pa**. However, if the proportional idea is correct and we take 92.83405% of the predicted drop of 15.30395 Pa, then we revise it to a predicted pressure drop of 14.206 Pa. That's quite close to the 11 Pa supposedly measured (5 sols later there was a 13 Pa decrease from Year 2). The predicted and measured differences are clearly in the same ball park, but does this mean that NASA is correct - or does it mean that the data was manufactured by someone who knew how to calculate scale height?

Now, let's dig a little deeper here via modern textbooks (Figure 59). The Martian Climate Revisited use a scale height of 10.8, old sources use 11.1 and this figure is on the NASA webs site visited. The information looks old, mentioning Viking 1 and none of the landers since 1976. What happens if we assume that someone was tasked with predicting, i.e., manufacturing pressures for MSL based on the altitude change from MSL Year 2 to Year 3? Then the predicted pressure decrease (with Ls 11 factored in) becomes only 13.67 Pa! A Pascal is only a hundredth of a millibar. We see that on 4 sols between Ls 11 and Ls 18 the actual pressure drop from Year 2 to Year 3 was 13 Pa.

NASA only sent a pressure transducer that could measure up to 1150 Pa yet, as Table 19 shows, they often reported pressures above 925 Pa, and even above 1150 Pa only to revise them down when we challenged them. Thus there is reason to question the reliability of the data reported. NASA returned to our site to view the CAD for the pressure transducer used on Mars Pathfinder. This CAD (shown as **Figure 10B - See** http://marscorrect.com/images/correct_10b.png), is often visited by other space agencies too. What it shows is that ***two* transducers** were ordered by NASA for Pathfinder**.** Tavis – 2 was for the expected pressure range of 0 to 12 mbar (1200 Pa/0.174 PSIA). But the other transducer (Tavis -1) was designed to measure up to 1,034 mbar (103,400 Pa/15 PSIA). That's higher air pressure than is found at sea level on Earth.

An alternate explanation is that only one transducer was ordered but it could toggle between two different pressure ranges.

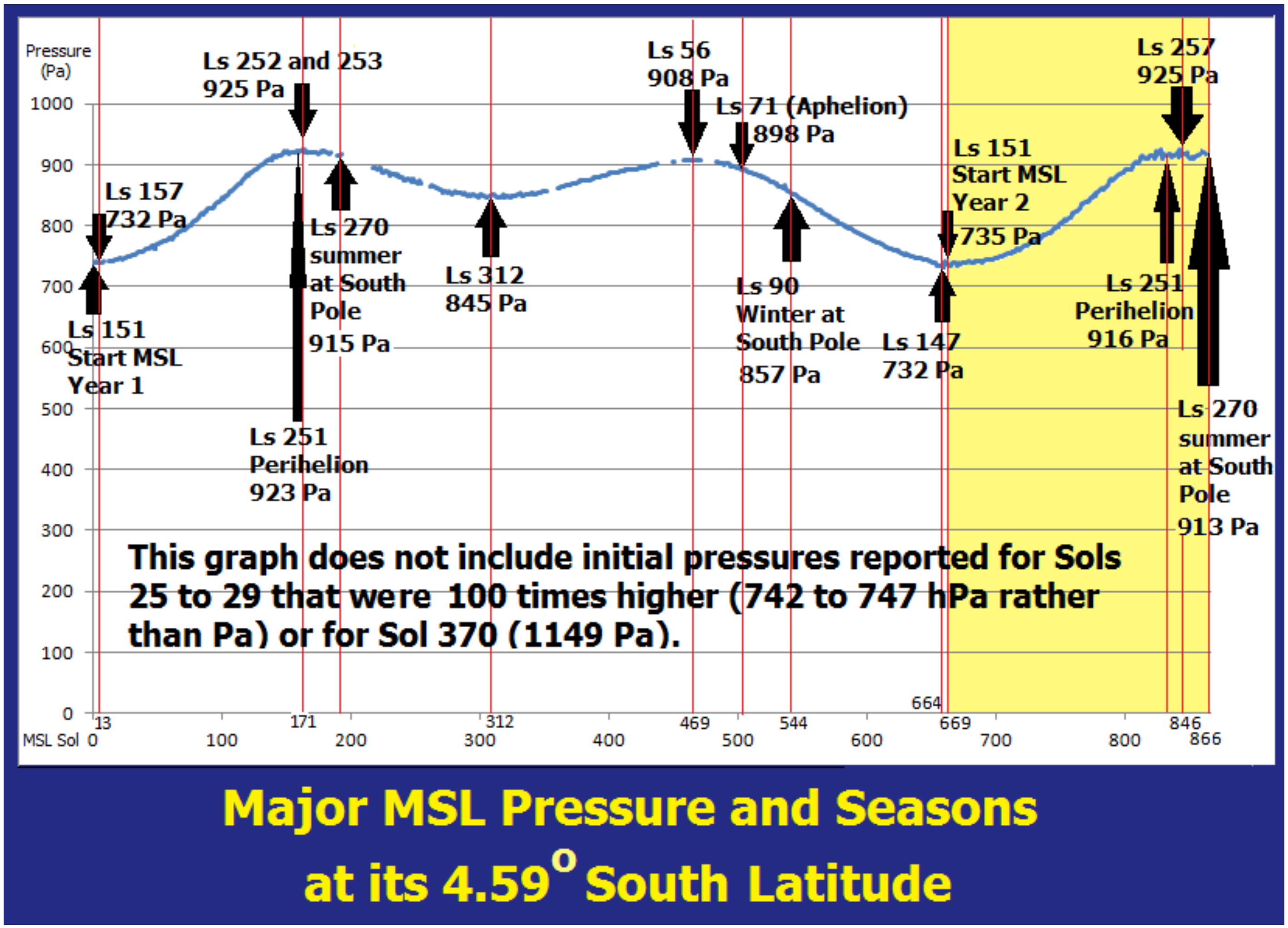


Figure 60 - Comparison of pressure readings by Viking 1, Viking 2, Mars Phoenix, and MSL.

14. RELATIVE HUMIDITY. On 4/9/2013 a statement appeared on FoxNews.Com about relative humidity at MSL. It went as follows:

The Curiosity rover team reported the new results today (April 8) at the 2013 European Geosciences Union General Assembly in Vienna, where scientists also provided other updates about the rover's recent discoveries.

For example, Curiosity's onboard weather station, known as REMS (for Rover Environmental Monitoring Station) has shown that humidity varies from place to place along the robot's route inside Mars' huge Gale Crater. REMS' observations are the first systematic measurements of humidity on the Martian surface, researchers said.

FACT: Not one single daily report for MSL weather issued by the REMS Team between August 22, 2012 and at least Sol 1868 on November 7, 2017 included any figure for relative humidity. As is seen on Figure 61 below all reports simply indicated --% or "Value not available" for relative humidity. Before Ashima Research got out of the business of MSL weather reporting it chose to reproduce none of the relative humidity data (really, lack thereof) on any of its reports taken from the REMS Team.

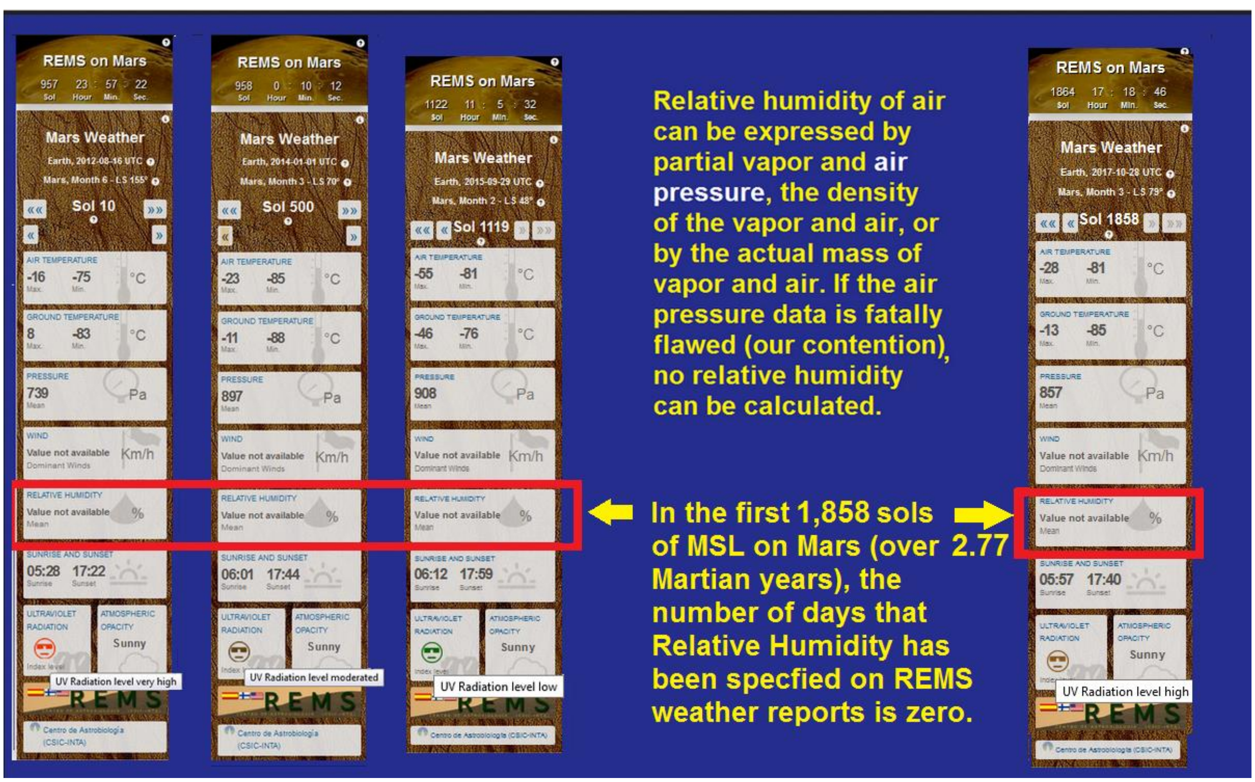


Figure 61 above: Daily weather reports from REMS have not included relative humidity.

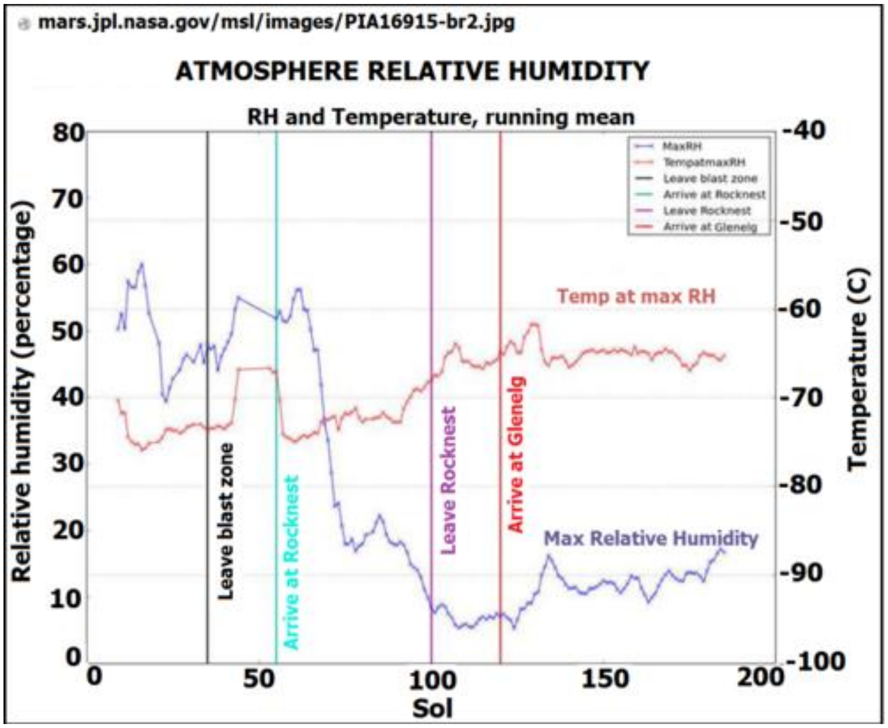


Figure 62 above adapted from the REMS Team: On June 27, 2013 REMS published this chart, but up though at least October 28, 2017 it continues to leave relative humidity reported only as --% on all its daily MSL weather reports.

On June 27, 2013 the information below appeared on the REMS Team website. Figure 62 was also on their site, although we cleaned up the fonts/text for clarification purposes. The relative humidity data offered do not match any of the daily weather reports by the REMS Team, which then continued to list all RH data as --%.

> *4.08.2013 Humidity in Gale Crater: Scant and Variable. This graphic tracks the maximum relative humidity and the temperature at which that maximum occurred each Martian day, or sol, for about one-fourth of a Martian year, as measured by the Remote Environmental Monitoring Station (REMS) on NASA's Curiosity Mars rover. These are the first systematic measurements of humidity on Mars. The data are graphed by sol number (starting with Curiosity's landing day as Sol 0), for a period from mid-August 2012 to mid-February 2013, corresponding to late winter through late spring in Mars' southern hemisphere. Four vertical lines on the graph mark progress points of the rover's traverse. While air temperature is not strongly tied to the rover's location, REMS has measured significantly different relative humidity in the different terrain units where the rover has been. All of the sites along the rover's traverse are extremely dry compared with Earth. Image Credit: NASA/JPL-Caltech/CAB(CSIC INTA)/ FMI/Ashima Research.*

OUR COMMENT: As we illustrate on Figure 63, when the relative humidity data and sol numbers on Figure 62 are matched with actual position, as published by the JPL, it can be seen that all variation in relative humidity, from about 60% down to less than 10% actually only occurs over a distance of about 400 meters. The description above was given by *NASA/JPL-Caltech/CAB(CSIC-INTA* on April 8, 2013. It must be noted again that as of at least February 21, 2021, no relative humidity figure has been incorporated into a REMS weather report. Relative humidity is the ratio of the partial pressure of water vapor in an air-water mixture to the saturated vapor pressure of water at a prescribed temperature. As such, the relative humidity of air depends on temperature and the pressure of the system of interest. If the assumptions about air pressure are wrong, as we believe is the case on Mars, then attempts to measure relative humidity will be worthless. This might be why relative humidity data is left off REMS weather reports.

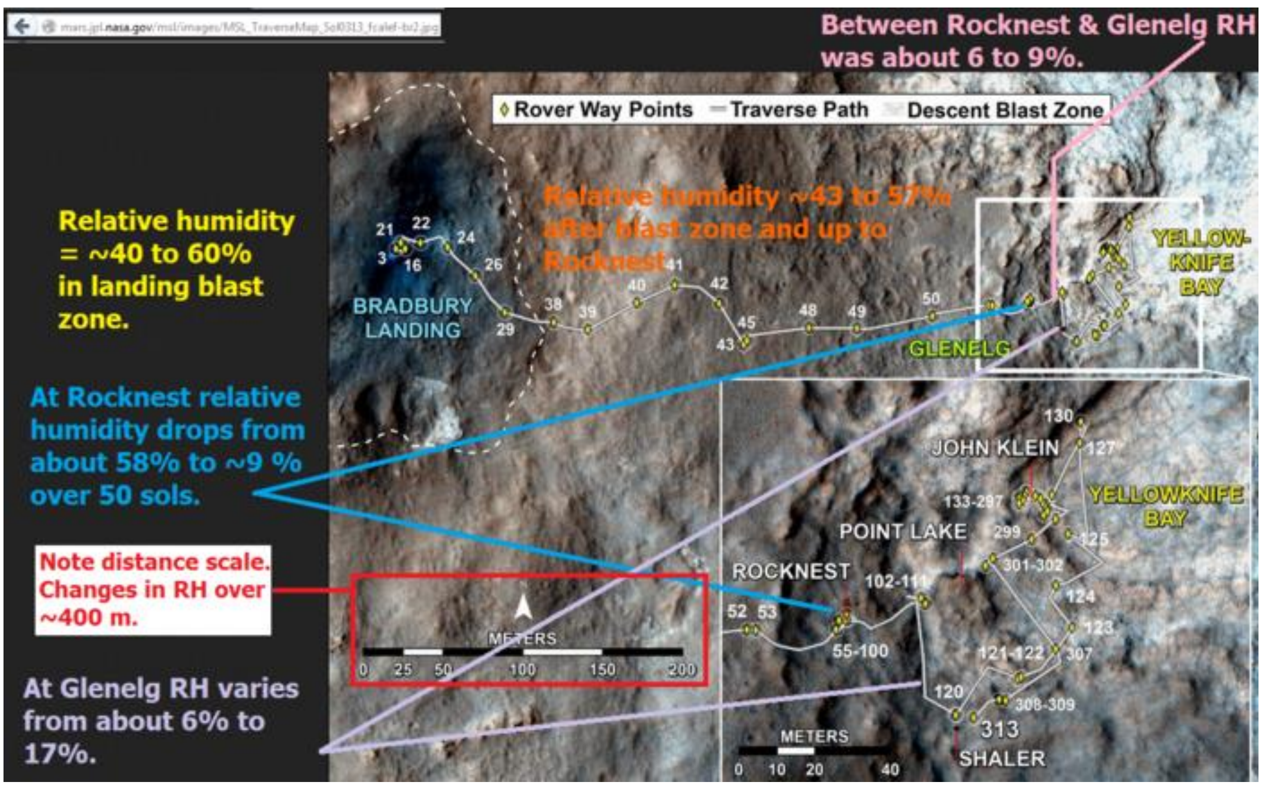


Figure 63: The REMS Team alleges large changes in relative humidity over small distances and with fairly constant temperatures. The relative humidity data shown on Figures 60 and 61 are not matched by daily REMS reports, as we noted in conjunction with Figure 61.

15. TEMPERATURE MEASUREMENT CONCERNS

Until July 3, 2013 we knew that over the first 11 months of operation the REMS Team and Ashima Research had put out clearly erroneous winds, sunrise and sunset times, pressure units, dates on their reports, months and claims about relative humidity that were not reflected on their reports. We (wrongly) assumed however that at least the temperature reports were reliable. That assumption was demolished on July 3, 2013 when they revised all temperatures back to the landing, wiping out scores of days where they had claimed air temperature highs above freezing. Some of these revisions are visible on Table 20 and Figure 64. Ground temperature problems will be discussed in conjunction with Figures 65 through 70.

TABLE 20 – MSL Air Temperatures Altered by JPL in July, 2013

A	B	C	D
SOL	**ORIGINAL MAX AIR TEMP °C**	**NEW MAX AIR TEMP °C**	**CHANGE °C (EQUALS CHANGE K)**
23	**0**	**-16**	**16**
26	**2**	**-14**	**16**
27	**-1**	**-15**	**14**
31	**-3**	**-23**	**20**
38	**-3**	**-13**	**10**
40	**2**	**-12**	**14**
41	**2**	**-12**	**14**
42	**5**	**-7**	**12**
43	**3**	**-12**	**15**
44	**4**	**-10**	**14**
45	**3**	**-9**	**12**
46	**4**	**-12**	**16**
47	**6**	**-9**	**15**
49	**4**	**-10**	**14**
50	**0**	**-10**	**10**
51	**3**	**-7**	**10**
52	**7**	**-7**	**14**
53	**5**	**-5**	**10**
54	**5**	**-9**	**14**
102	**8**	**-3**	**11**
112	**5**	**-8**	**13**
116	**5**	**-6**	**11**
118	**4.53**	**-6**	**10.53**
123	**2.1**	**-10**	**12.1**
124	**5.4**	**-5**	**10.4**
179	**5**	**-7**	**12**

Figure 64: The REMS Team here appears to purposely sabotage all of its remaining credibility by going back and dropping very nearly all of its above freezing air temperatures to below freezing. The question which has not yet been answered by JPL (or by anyone else) – Who ordered these changes and why did they do so?

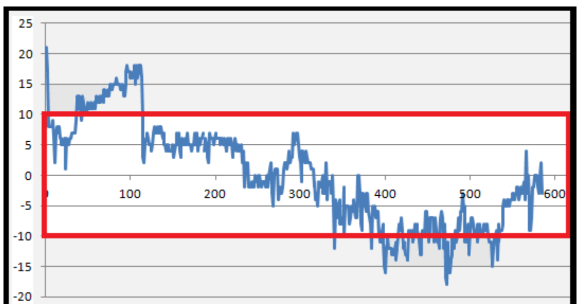
How accurate is the air temperature sensor designed to be? Air temperature was supposed to be recorded at both booms with a PT1000-type sensor placed on a small rod long enough to be outside the mast and boom thermal boundary layers. Its measurement range is 150 to 300 K. It has an accuracy of 5 K and a resolution of 0.1 K [28]. The resolution of 0.1 K sounds fine, but 5 K is 9°F. The average revision in temperature shown on Table 16 is 13.08 K (23.54° F). That's pretty lousy, but the situation is far worse for ground temperatures.

15.1 Ground Temperature Problems.

For most of the first year the MSL REMS Team reports did **not** include ground temperatures. Then they began to include them – right back to MSL Sol 10 at http://mars.jpl.nasa.gov/msl/mission/instruments/environsensors/rems/. However when I tried to make some sense out of the relationship between air and ground temperatures, I found the caveat that,

"Ground temperature will be recorded with a thermopile on Boom 1 that views the Martian surface to the side of the rover through a filter with a passband of 8 to 14 microns. The requirement is to measure ground brightness temperature over the range from 150 to 300 K with a ***resolution of 2 K and an accuracy of 10 K.*** [28]

An accuracy of 10K is almost worthless when looking at so many temperatures hovering around 273K (0° C). In fact, looking at the data from MSL Sols 10 through 652, the REMS Team offered maximum and minimum ground temperature for 584 sols. Fully 413 of the highs (over 70%) were between 283K (10° C) and 263 K (-10° C). See Figure 65. In spring of MSL Year 3 a maximum ground temperature of +24° C was recorded on Sol 1428 at Ls 202.

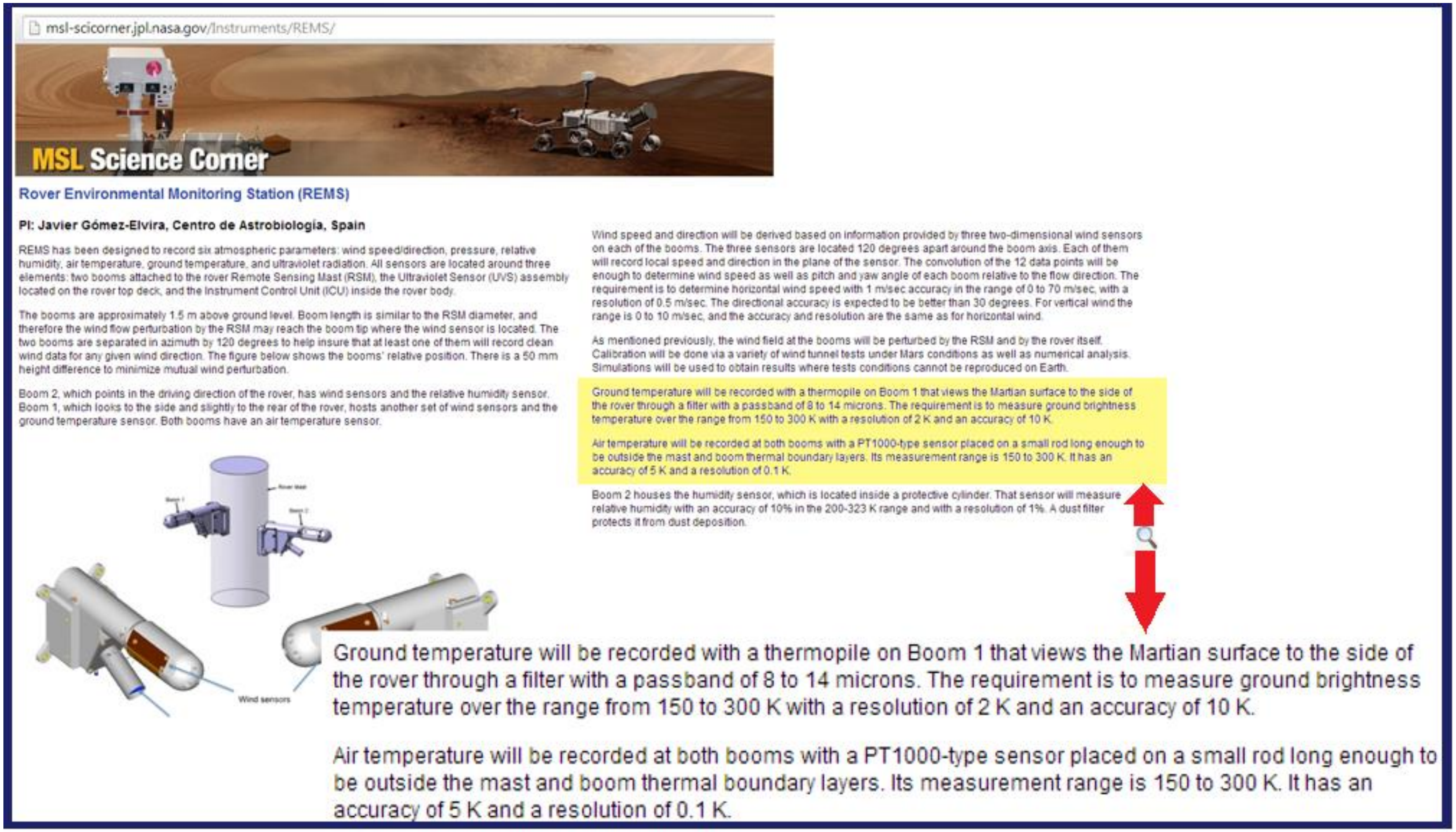


Maximum ground temperatures in degrees Celsius for 584 sols of data by MSL between MSL sols 10 and 652. Resolution is only 2°C and accuracy is only 10°C.

Figure 65. If the accuracy of MSL ground temperatures is only 10K, this creates a huge problem when it comes to understanding heat loss and air density.

If there was an accuracy in the range 1 K or better we could probably deduce something intelligent about air density by looking at the rate of heat loss from the surface up to the boom, but with an accuracy of only 10K on the ground and 5 K in the air, it really isn't worth the effort to do the math. The decision to go with such inaccurate sensors may be due to incompetence, or to design. All that can be said is that for $2.5 billion, we got inaccurate temperature sensors, nonfunctioning wind sensors, a relative humidity sensor that did not merit inclusion of its data on any daily weather reports, and, of course, the same pressure sensor as that on Phoenix that caused its designer so much distress. We also got data that was often suspiciously revised or deleted by JPL after I criticized it to JPL public relations man Guy Webster.

Because JPL often changed published data, all too often after I have published criticism of that data, I often captured what they are saying via print-screen images. This is necessary here too. The 10K accuracy above is captured on Figures 66 and 67. See Figures 68 & 69 for ranges of Martian monthly high and low temperatures.



msl-scicorner.jpl.nasa.gov/Instruments/REMS/

MSL Science Corner

Rover Environmental Monitoring Station (REMS)

PI: Javier Gómez-Elvira, Centro de Astrobiología, Spain

REMS has been designed to record six atmospheric parameters: wind speed/direction, pressure, relative humidity, air temperature, ground temperature, and ultraviolet radiation. All sensors are located around three elements: two booms attached to the rover Remote Sensing Mast (RSM), the Ultraviolet Sensor (UVS) assembly located on the rover top deck, and the Instrument Control Unit (ICU) inside the rover body.

The booms are approximately 1.5 m above ground level. Boom length is similar to the RSM diameter, and therefore the wind flow perturbation by the RSM may reach the boom tip where the wind sensor is located. The two booms are separated in azimuth by 120 degrees to help insure that at least one of them will record clean wind data for any given wind direction. The figure below shows the booms' relative position. There is a 50 mm height difference to minimize mutual wind perturbation.

Boom 2, which points in the driving direction of the rover, has wind sensors and the relative humidity sensor. Boom 1, which looks to the side and slightly to the rear of the rover, hosts another set of wind sensors and the ground temperature sensor. Both booms have an air temperature sensor.

Wind speed and direction will be derived based on information provided by three two-dimensional wind sensors on each of the booms. The three sensors are located 120 degrees apart around the boom axis. Each of them will record local speed and direction in the plane of the sensor. The convolution of the 12 data points will be enough to determine wind speed as well as pitch and yaw angle of each boom relative to the flow direction. The requirement is to determine horizontal wind speed with 1 m/sec accuracy in the range of 0 to 70 m/sec, with a resolution of 0.5 m/sec. The directional accuracy is expected to be better than 30 degrees. For vertical wind the range is 0 to 10 m/sec, and the accuracy and resolution are the same as for horizontal wind.

As mentioned previously, the wind field at the booms will be perturbed by the RSM and by the rover itself. Calibration will be done via a variety of wind tunnel tests under Mars conditions as well as numerical analysis. Simulations will be used to obtain results where tests conditions cannot be reproduced on Earth.

Ground temperature will be recorded with a thermopile on Boom 1 that views the Martian surface to the side of the rover through a filter with a passband of 8 to 14 microns. The requirement is to measure ground brightness temperature over the range from 150 to 300 K with a resolution of 2 K and an accuracy of 10 K.

Air temperature will be recorded at both booms with a PT1000-type sensor placed on a small rod long enough to be outside the mast and boom thermal boundary layers. Its measurement range is 150 to 300 K. It has an accuracy of 5 K and a resolution of 0.1 K.

Boom 2 houses the humidity sensor, which is located inside a protective cylinder. That sensor will measure relative humidity with an accuracy of 10% in the 200-323 K range and with a resolution of 1%. A dust filter protects it from dust deposition.

Ground temperature will be recorded with a thermopile on Boom 1 that views the Martian surface to the side of the rover through a filter with a passband of 8 to 14 microns. The requirement is to measure ground brightness temperature over the range from 150 to 300 K with a resolution of 2 K and an accuracy of 10 K.

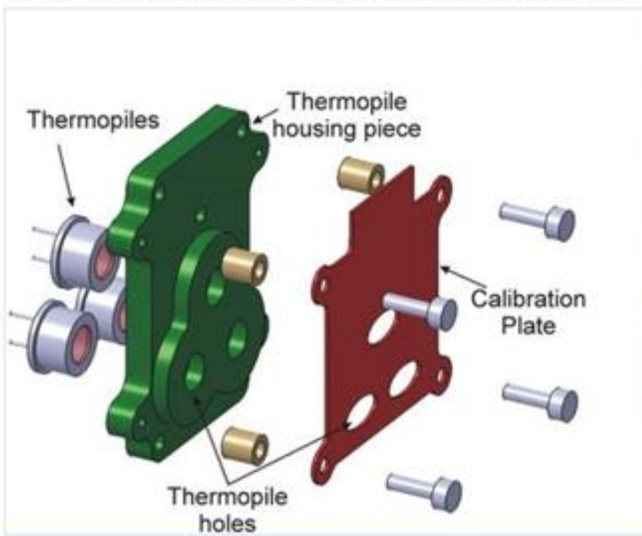
Air temperature will be recorded at both booms with a PT1000-type sensor placed on a small rod long enough to be outside the mast and boom thermal boundary layers. Its measurement range is 150 to 300 K. It has an accuracy of 5 K and a resolution of 0.1 K.

Figure 66 – REMS Team member Javier Gomez-Elvira summarizes REMS weather instrument abilities. The enlarged section is for temperature sensor range, accuracy and resolution.

www.spaceflight101.com/msl-rems-instrument-information.html

Ground Temperature Sensor - GTS

The REMS Ground Temperature Sensor is installed the side-facing Boom #1. Measuring the ground temperature on Mars is important for determination of physical processes involving the surface of the planet such as surface/atmospheric exchange, the energetic drive for turbulence and the water cycle that is active on Mars.
Ground Temperature is recorded with a sensor that views the surface of Mars to the side of the rover through a filter. Temperatures from 150K to 300K can be measured with a resolution of 2K and an accuracy of 10K. This temperature range of the sensor covers the complete spectrum of temperatures occurring on Mars. The GTS (Ground Temperature Sensor) is based on broad-band Infrared Thermopile sensors that uses three filters and electronics to amplify the thermopile sensors. A contact sensor as used on previous missions was not an option for MSL since it would have resulted in fewer operations when the rover performs driving Sols. Also, using thermopiles enables the GTS to operate in the Mars Environment without requiring instrument heaters. The REMS thermopile is the TS-100 manufactured at the Institute for Physical High Technology, Jena, Germany. The thermopile is encapsulated in a TO-5 housing featuring a thermopile filter that was built to specifications and pre-bonded onto the TO-5 as the thermopile window. Inside the encapsulation is an inert Nitrogen Atmosphere as well as a Pt-1000 temperature sensor to provide temperature reference data at the thermopile case base for the thermocouple cold-junction. GTS has a 60-degree horizontal and 40-degree horizontal field of view covering a surface area of about 100 square meters. The sensor is 40 by 28 by 29mm and weighs 20 grams. GTS includes a calibration plate partially in the GTS Field Of View that can be heated up with temperature measurement by a Pt-1000 sensor to provide a calibration source. Since the GTS is facing downward, dust deposition on the sensor is only a minor concern.



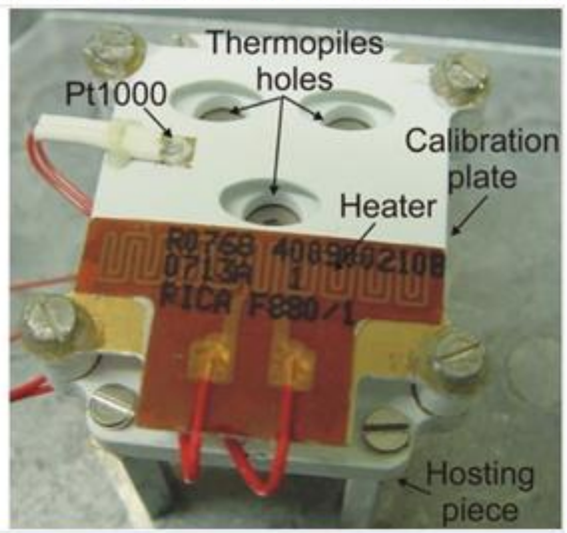


Figure 67 – The MSL Ground Temperature Sensor manufactured by the Institute for Physical High Technology, Jena, Germany.

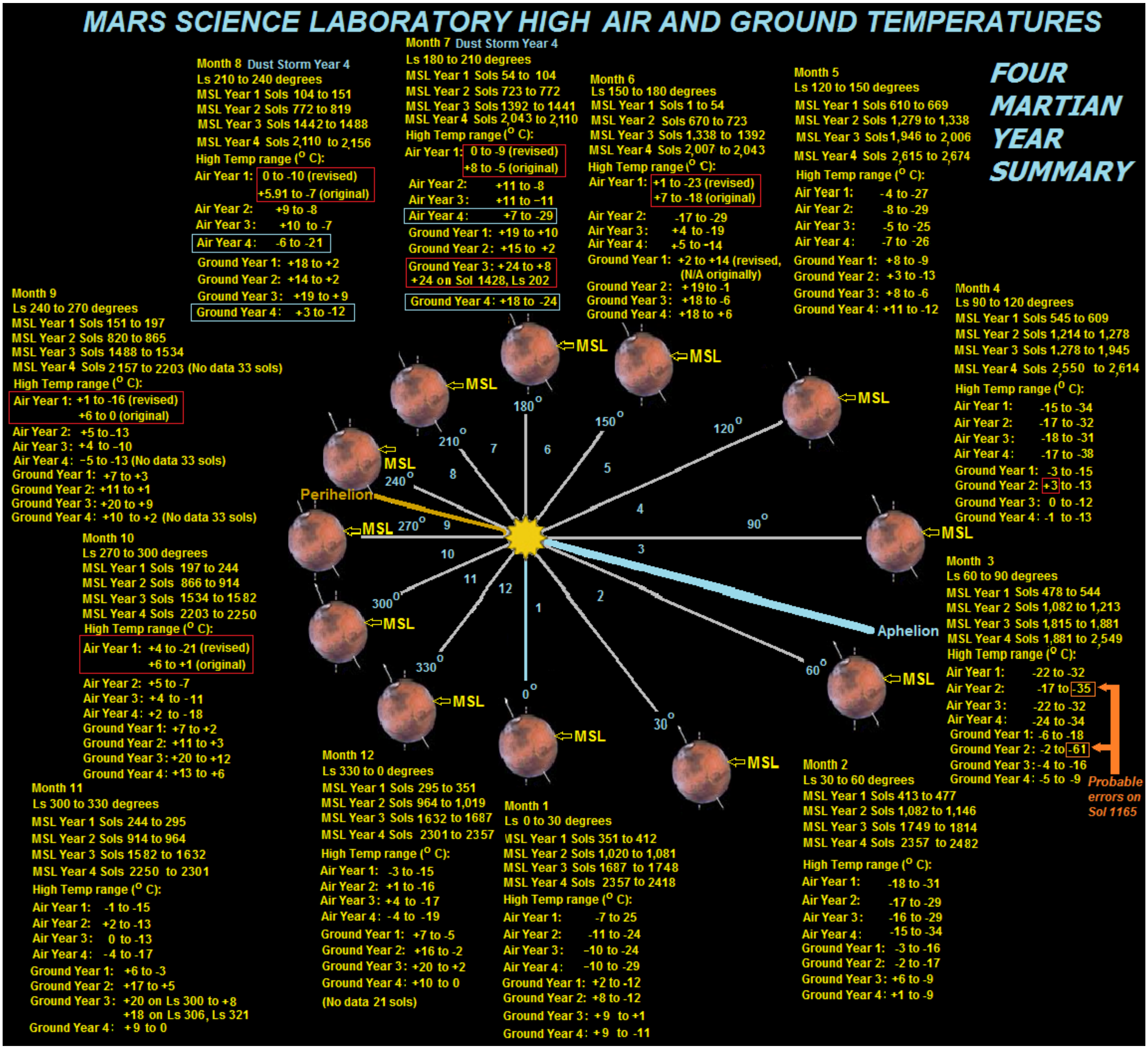


Figure 68 – Mars Science Laboratory high air and ground temperatures for 4 Martian years.

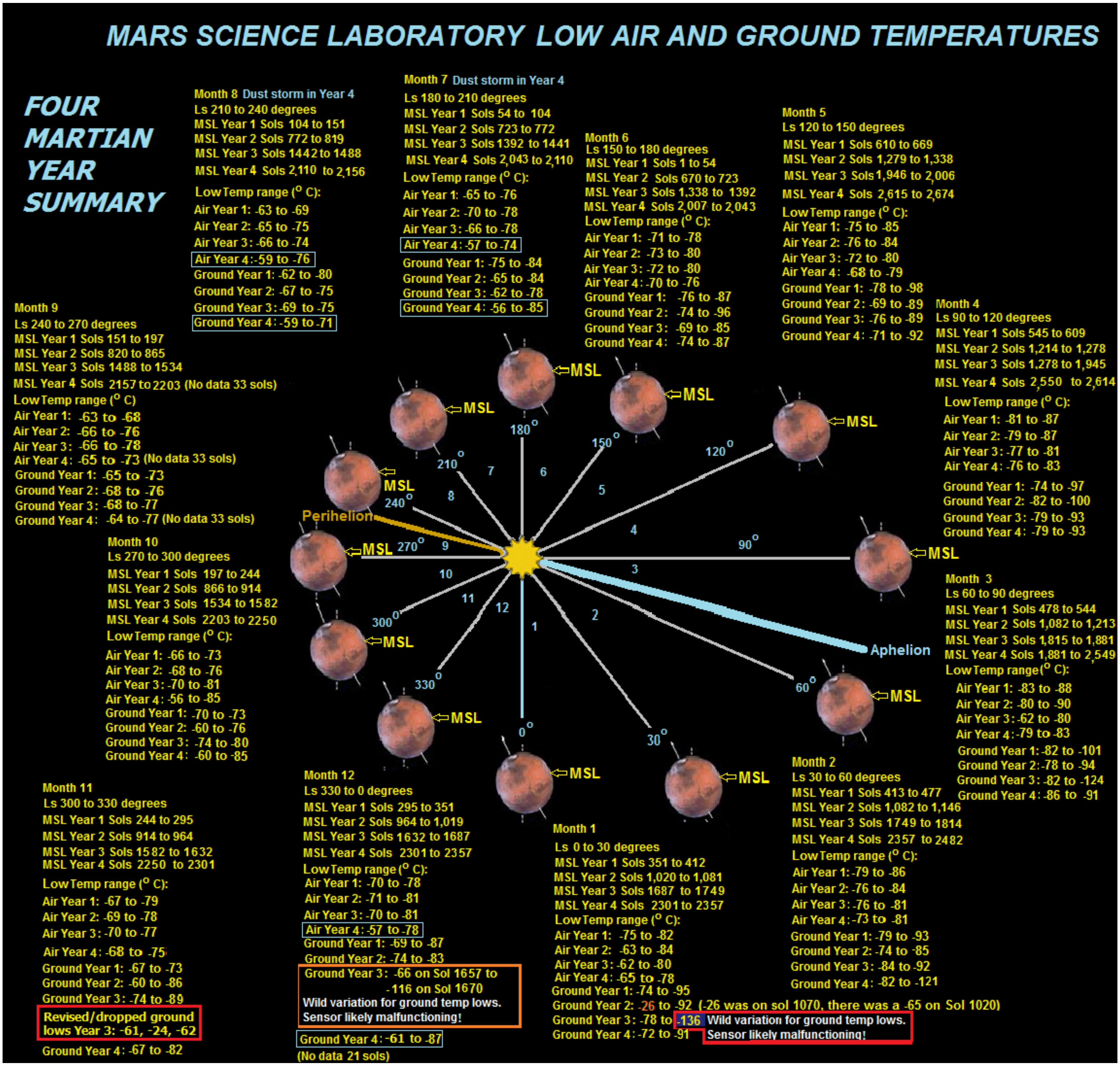


Figure 69 – Mars Science Laboratory low air and ground temperatures for 4 Martian years.

Note that Figure 67 comes with an excuse for the poor accuracy of the ground temperature sensor. It states, “A contact sensor as used on previous missions was not an option for MSL since it would have resulted in fewer operations when the rover performs driving Sols.” Which missions? The only missions on the ground for at least a Martian year were Viking 1 and Viking 2. They only measured air temperature at 1.5 meters above the ground.[92]

Mars Pathfinder (MPF) had three temperature sensors. Their heights were at 0.25 meters, 0.5 meters and 1 meters.[93] Figure 70 shows a plot of temperatures for MPF Sol 78, but again, none of these temperatures are ground temperatures although the lowest sensor was just 0.25 meters above the ground.

It appears that the only lander to actually put a temperature probe into the Martian regolith was Phoenix, which landed in the Martian arctic at about 68° North. There a Thermal and Electrical Conductivity Probe (TECP) measured regolith temperatures from 253K (-20.15° C) down to 181K (-92.15° C) (A. P. Zent *et al.,* 2009).[94] Note that these temperatures are much warmer than the daytime temperatures of -100° C supposedly measured from a distance of 9,846 km by Mariner 4 in 1964.

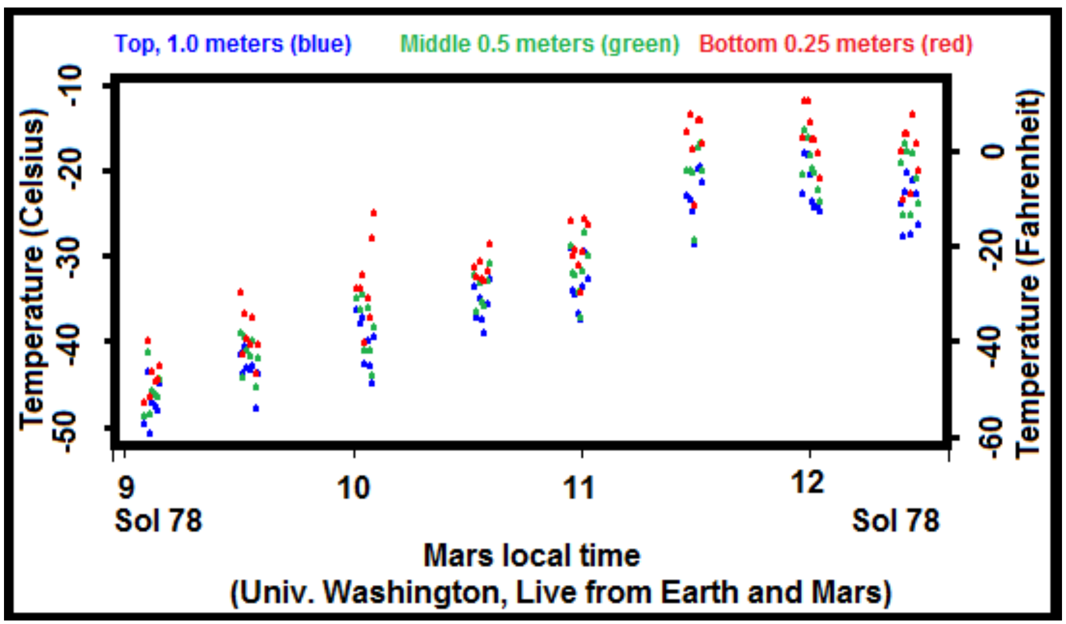


Figure 70 - Adapted from http://www-k12.atmos.washington.edu/k12/mars/LOPS_Pathfinder_temperatures.cgi#plot3.
Unaveraged periodic temperature data from Mars Pathfinder. The data from all 3 sensors on Pathfinder’s 1 meter mast are shown.

15.2 Winter ground temperatures above freezing in MSL Year 2.

Just after the second winter solstice (Ls 90) at MSL on Mars ground temperatures recorded climbed to above freezing. No such temperatures were recorded anywhere near that time in MSL's Year 1. What was even weirder was that while ground temperature highs were record highs for that time of year, nighttime lows were record lows. We looked at whether the MSL was on a slope that might impact angle of incidence of solar rays and therefore temperature, much as was apparent with respect to times that Recurring Slope Lineae (RSL) occurred in association with supposed running water on Mars. However, on the evening of 9 February 2016 we found an MSL position image at http://mars.nasa.gov/msl/mission/whereistherovernow/ which showed elevations and positions for many sols between Sol 1173 (Ls 72 which is late autumn at MSL) and Sol 1248 (Ls 106). We captured it by print screen and adapted it by addition of maximum and minimum ground temperatures. See Figure 73 below**.** Note that all temperatures above freezing occurred when MSL moved little for about 3 weeks in an area where there was a two meter change in elevation over a 10 meter distance. This is a 20% grade (an 11.3° slope).

As of May 14 2016 it appears that the high air or ground temperature is above 0° C at Gale Crater on at least 411 days of the 669 sols in a Martian year. This number is based on at least one above freezing sol in either MSL Year 1 or 2 at the same Ls. Surprisingly the number increased in early winter of **MSL Year 2** on 16 sols between Ls 95 and 104 with above freezing ground temperatures of **+1, +1, +2, +1, +1, +1, +1, +1, +1, +2, +2, +2, +3, +1, +2 and +1 °C** found where in **Year 1** the ground temperatures on those days were **-7, -6, -3, -6, -5, -9, -11, -8, -8, -13, -7, -7, -8, -8, -10 and -9° C.** There were also five sols (1222, 1223, 1230, 1237 and 1244) at Ls 94, 98, 101 and 104 where **the ground temperature in Year 2 was 0° C** while **in Year 1 it was only -10, -7 -5, -9 and -10° C.** A quick summary for this 24-sol period each year is given on Table 21. A more extensive summary can be found below on Figures 71 and 73.

15.3 Why the early winter ground temperatures are so important and possible life seen on Sol 1185.

On Sol 1185, and to a lesser degree on Sol 1189 and later there were items seen on Mars that look like life. See Figure 71. On Sol 1185 they were near what looked like either a geode split open, or possibly a cocoon of some sort. The green color was suggestive of something that might be photosynthetic. The shape would allow Martian winds to move these objects so they could reach nutrients. Moreover, while some cells (if they are there) would benefit from sunlight while facing the sun, those on the bottom would not - unless the sphere shape evolved to allow the bottom cells to reach the top. Is there something analogous in Earth-based botany? Yes. When the cross section of a leaf is examined under a microscope, chloroplasts in the Palisade layer move from top to bottom and back to the top again as the cytoplasm in the cells circulates. This ensures that all chloroplasts get a chance to move up to just under the epidermis so they can absorb more ultraviolet light from the sun and increase the rate at which photosynthesis occurs, Of course, in photosynthesis carbon dioxide and water combine to form sugar (glucose) and oxygen. The Martian atmosphere is supposed to be 95% carbon dioxide, running water is believed to be found in association with RSL in Gale crater, and JPL has announced evidence for brine found by MSL.

TABLE 21 - USUALLY WARM GROUND TEMPERATURES EARLY IN THE WINTER OF MSL YEAR 2								
MSL YEAR	LS RANGE	SOL RANGE (24 sols)	AVERAGE DAY AIR TEMP HI ° C	AVERAGE NIGHT AIR TEMP LO ° C	AVERAGE DROP IN AIR TEMP DAY TO NIGHT	AVERAGE DAY GROUND TEMP HI ° C	AVERAGE NIGHT GROUND TEMP LO ° C	AVERAGE DROP IN GROUND TEMP DAY TO NIGHT
1	93 TO 104	552 TO 575	-26.6667	-84.9583	-58.2916	-8.45833	-90.7917	-82.3233
2	93 TO 104	1,221 TO 1,244	-26.7917	-87.4583	-60.6666	+0.79167	-96.5417	-97.3333

Figure 71 - The green spherical and cocoon-like objects were seen on sols 1185 and 1189. The green spheres might be photosynthetic life. As mentioned with Figure 58 below, MSL returned to the area again on Sol 1248, possibly for a further look or tests to see if this is life. More spheres were seen on Sol 1555, 1571 and 1797.

While the initial look at the possible life was largely between sols 1185 and 1189, on Sol 1248 MSL returned to within 20 meters of the site and it was within less than 10 meters from the site on Sol 1249. See Figure 73.

Kiepe continued to find spheres up through at least MSL 1,797. Altitude variation from Sol 1185 up through 1797 was from about 4,420 meters below areoid up to 4,215 meters below areoid, an increase of 205 meters (672.572 feet).

David Kiepke was apparently not the only one who thought he was looking at life on Mars around Sol 1185. A research paper by Laingtai Lin[119] entitled Putative Martian Microbes Formed Plentiful Ooids on Mars (2016) states in its abstract that:

> *NASA's Mars Rover Curiosity discovered plentiful indigenous spherical ooids at High Dune and Namib Dune in Bagnold dune field, Gale Crater, Mars. The Martian ooids measure about 0.2 mm to 0.5 mm in diameter. Colors of the Martian ooids are various, including white, yellow translucent, green, grey, and yellow. The Martian ooids should have been formed by microbes, because ooids of Earth have recently been found to be formed by microbes and microbial borings are found in ooids of Earth and of Mars. The Martian ooids are unlikely to have been formed by non-biological mechanisms, because there was no highly agitated water at the discovery sites.*

Namib Dune, mentioned in Lin's paper, was shown above on Figure 71. Some of the ooids described by Lin are shown on Figure 72A.

15.3.1. Evidence of Life on Mars. The Journal of Astrobiology published **Evidence of Life on Mars** **by** R. Gabriel Joseph et al. in June, 2019.[152] The Journal has also asked us for a commentary on the above astounding find of likely lichens, alga, bacteria, fungi (including puff balls), cyanobacteria and stromatolites on Mars. Our article, entitled **Meteorological Impact of Evidence of Life on Mars** is published under the name of David Alexander Roffman, Ph. D.[153] There is an acknowledgement for Barry S. Roffman. This was the wish of the publisher, however as the acknowledgment indicates our father and son team have been full partners in *all* Mars research for a period of ten years now.

The Joseph et al. (2019) paper argued that the spheres shown apparently growing and reproducing on Figure 72B below were likely puffballs (fungi), but they conceded that NASA might be right that wind was blowing away sand this revealing more of what was only hematite. Our paper (Roffman, 2019) showed that if NASA is correct about low pressure in the Martian atmosphere, the wind was never strong enough to do that. Therefore Figure 72B almost certainly is proof of life. And what if the atmosphere is two orders of magnitude denser than NASA admits? Then all NASA Mars weather data is worthless. Heads we win, tails they lose. The wind speeds for Mars are documented in Section 7.2.1 of this report. In particular see Table 14 plus Figures 28 and 29.

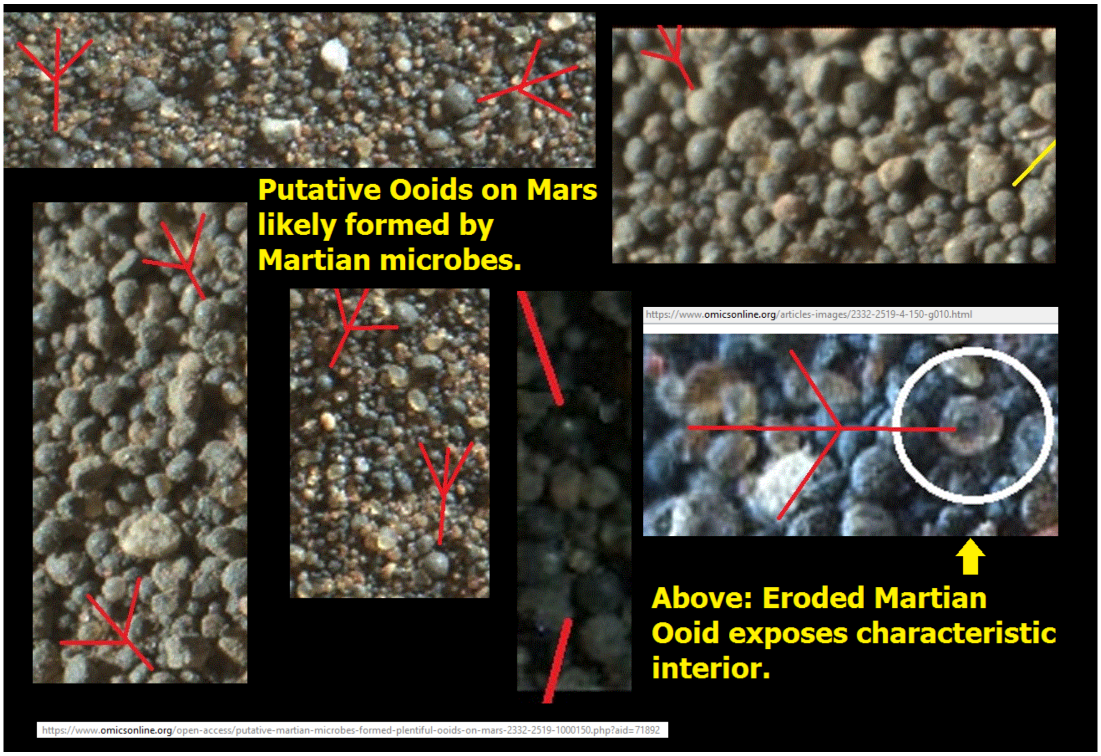
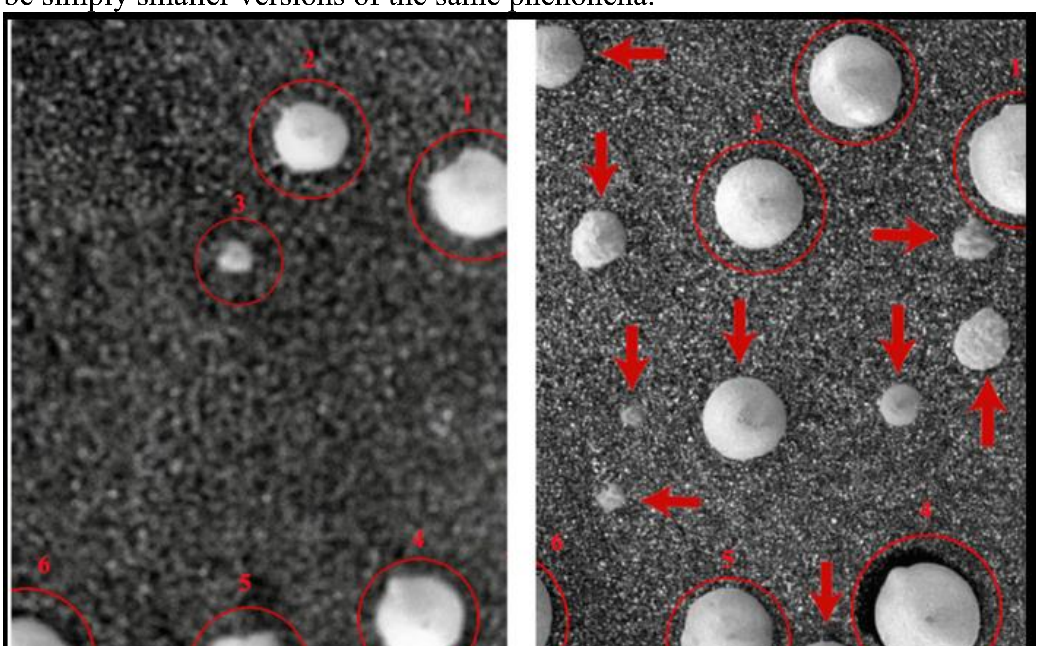
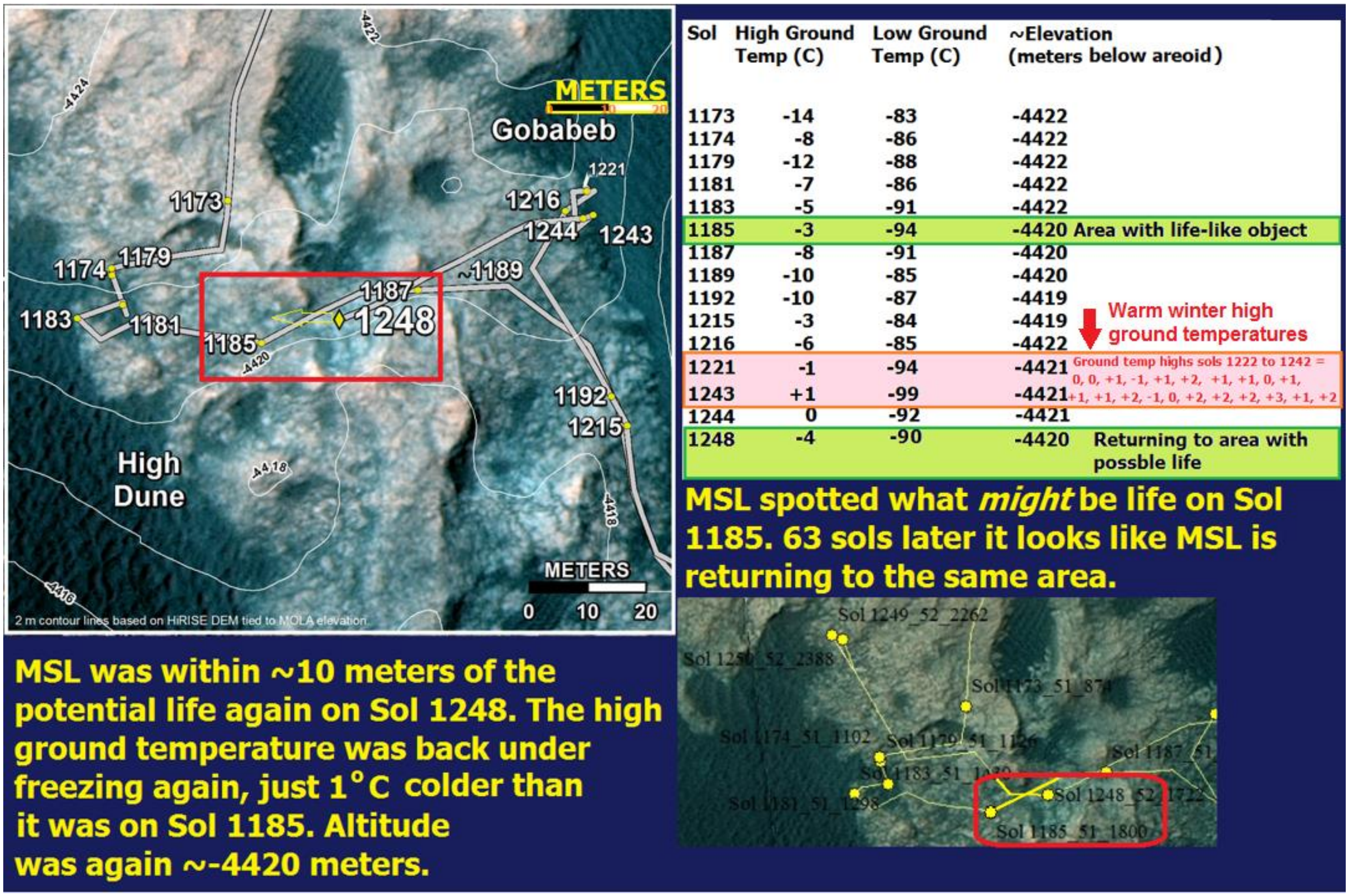


Figure 72A – The putative ooids found in the same area as the spheres shown on Figure 71 might be simply smaller versions of the same phenonena.



Sol 1145-left v Sol 1148-right). Comparing Sol 1145-left vs Sol 1148-right. Growth of fifteen Martian specimens over three days. Specimens labeled 1-5 and marked with red circles have increased in size. Those specified by arrows-Sol 1148-right-demarcate the emergence of ten new specimens which were not visible in Sol 1145-left photographed three days earlier by NASA/JPL. Differences in photo quality are secondary to changes in camera-closeup-focus by NASA. The majority of experts in fungi, lichens, geomorphology, and mineralogy agreed these are likely living specimens, i.e. fungi, puffballs. An alternate explanation is a strong wind uncovered hematite which had been buried beneath sand and dirt.

Figure 72B: Likely growth and reproduction of life on Mars. From R Gabriel Joseph el al. (2019).



Sol	High Ground Temp (C)	Low Ground Temp (C)	~Elevation (meters below areoid)
1173	-14	-83	-4422
1174	-8	-86	-4422
1179	-12	-88	-4422
1181	-7	-86	-4422
1183	-5	-91	-4422
1185	-3	-94	-4420 Area with life-like object
1187	-8	-91	-4420
1189	-10	-85	-4420
1192	-10	-87	-4419
1215	-3	-84	-4419
1216	-6	-85	-4422
1221	-1	-94	-4421
1243	+1	-99	-4421
1244	0	-92	-4421
1248	-4	-90	-4420 Returning to area with possble life

Figure 73 – Elevations and ground temperatures encountered while MSL was at positions noted by JPL. Possible life was seen on Sol 1185, along with a warmer than expected high ground temperature. The position noted for MSL for Sol 1248 is a return to within 20 meters of where the potential life was seen before. Then it moved within about 10 meters of the site. See Figure 71 to view the suspected life.

Figure 74 - Some of the unusually warm ground temperatures including six above freezing seen early in MSL Year 2 Winter.

15.4 MSL Air and Ground Temperature Differences.

The REMS Team states that Mars undergoes very extreme gradients between the ground and the atmosphere at 1.5 m above the surface, with differences of ±40K.[116] However, inconsistent differences in air and ground temperature taken 1.5 meters apart suggest that ground temperatures from MSL are worthless. The ground temperature sensor likely broke on landing.

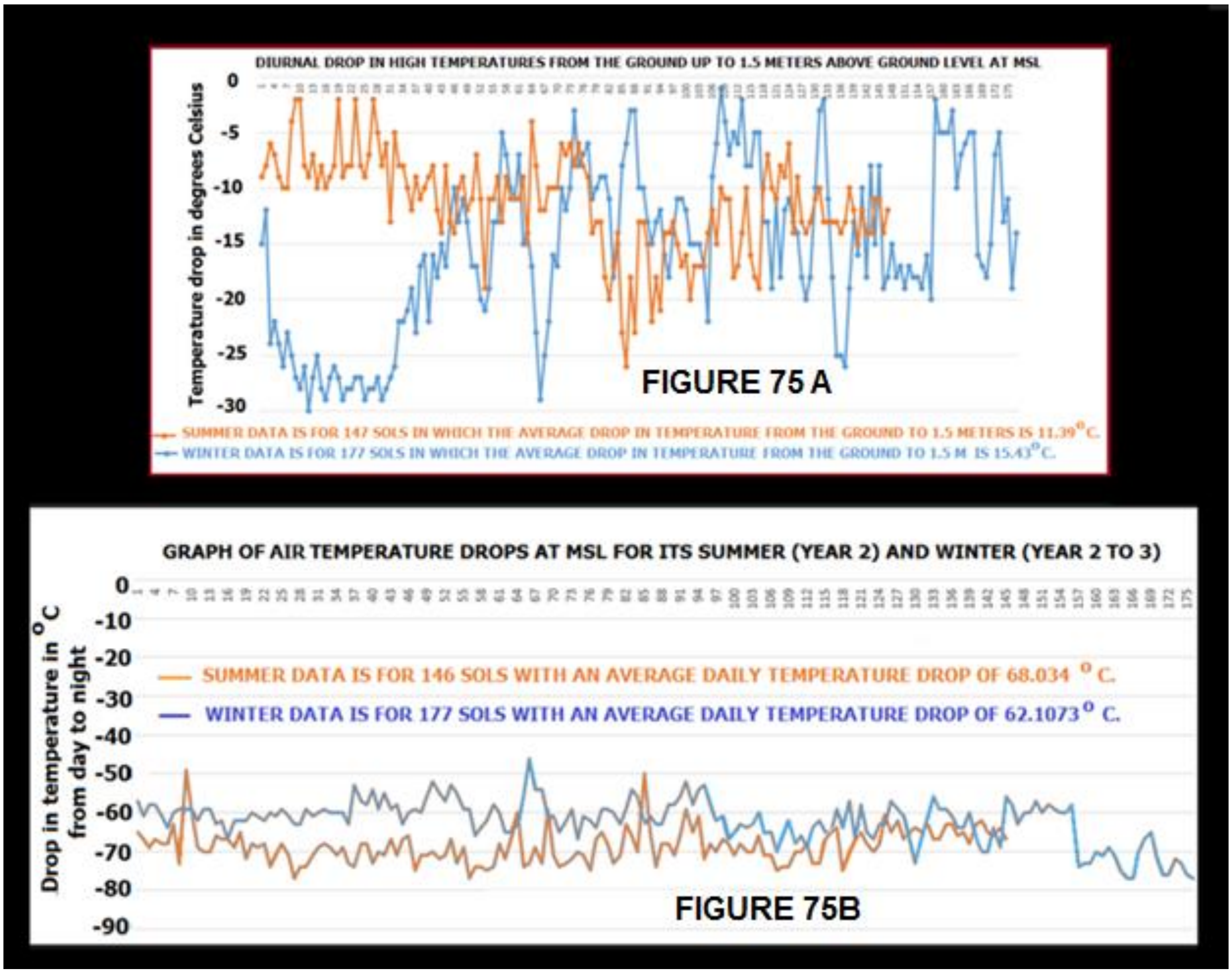


Figure 75A above: According to MSL, daily high temperatures are higher on the ground than they are in the air. Here we look at how much higher. It's an average of 11.39 degrees Celsius in summer and 15.43 degrees in the winter. But, again, the ground temperature sensor is only accurate to 10 degrees Celsius. Figure 75B shows a graph of air diurnal temperature drops in degrees Celsius for MSL Year 2 summer (orange) and MSL Year 2 to 3 winter (blue). It can be seen that although there are exceptions to the rule, in general temperature drops were greater from day to night in the summer (with an average drop of 68.034° C) than in the winter (when the average drop was 62.1073° C).

As was shown in Figure 67, the air and ground temperature sensors on MSL are deeply flawed because of their crude accuracies. For the air temperature sensor the accuracy is to 5° C (9° F) while in the ground temperature sensor its accuracy is just 10° C (18° F). The air temperature sensor has a resolution of 0.1 ° C, but for the ground sensor it's a full 2° C.

On Figure 75A we see enormous variation in the high temperature differences recorded from Booms 1 and 2 (see Figure 76) vs. the ground temperatures for 1.5 meters below the booms. If NASA is correct then the average pressure on Mars at areoid is about 6.1 mbar with pressures at MSL (about 4.4 km below areoid) ranging between about 7.3 mbar and 9.25 mbar (compared to a 1,013.25 mbar average pressure on Earth at sea level). With such low, near-vacuum pressures, we should expect temperature differences between 1.5 meters and the ground to be fairly *consistent* from day to day, but that's not at all what the data shows. Before apparent ground temperature failures or REMS Team rebellion around March 20 2017, in the summer the difference in temperature between the two elevations was as little as 2° C and as much as 26° C. In the winter it was as little as 1° C and as much as 30° C.

JPL notes that in its graph of plots with daily minimum and maximum of ground temperature measured by REMS, a change in the pattern just after Sol 120 corresponds to Curiosity driving onto a type of ground with higher thermal inertia -- thus cooling off more slowly in the evening and warming up more slowly in the morning. They write that, the higher thermal inertia of this area was predicted from orbital infrared measurements and is likely due to greater abundance of exposed bedrock relative to soil or sand." That's fine, but we would still not expect such radical variation in differences of air and ground temperatures to occur as often as they are shown on Figure 75A.

While there are air temperature sensors on Booms 1 and 2 of MSL, a ground temperature sensor is only found on Boom 1 (see Figure 76) which was damaged on landing.

No ground temperatures were published by the REMS Team or JPL until about 9 months after landing. When they suddenly appeared I asked JPL public affairs man Guy Webster about where they suddenly came from. He asserted that "Damage on landing did not include the infrared sensor that provides ground temp information. Ground temps through about Sol 200 were charted in April on the bottom half of http://photojournal.jpl.nasa.gov/catalog/PIA16913." Given that we had already successfully prevailed upon him and JPL to alter all (never-changing) wind data for MSL from 7.2 km/hour from the east to Not Available, and we had likewise succeeded in having him alter all never-changing sunrise/sunset times to line up with calculations that my son (David) and I had done, it was and remains our belief that JPL should likewise dump its ground temperature readings and replace them too with N/A. If they were more reliable we could likely use the differences between air and ground to help calculate air density (and pressure). But the simple fact appears to be that the data is not reliable.

MSL has given us fantastic pictures of Mars, great geological data and new understanding about water just under the surface in many places (as with a frozen fresh-water sea at Utopia Planitia that has an area of the State of New Mexico). In some cases the proximity of liquid water to the surface likely affects ground temperature, but the ground temperature sensor is not sufficient to establish it.

The most important data about Mars remains obscure - weather data. We have no reliable surface wind data after the Viking 1 and 2 landers of the late 1970's. We have no reliable ground temperature data, no reliable pressure data, and no reliable relative humidity data. We had 36 years of wrong sky color that was ordered by former NASA Director James Fletcher, from 1976 until 2012. Further, no lander after Vikings 1 and 2 has included a life-detection experiment, although those two landers (4,000 miles apart) apparently did detect life.

15.4.1 Oxygen Solubility in near-surface Martian environments and aerobic life.

One positive note is that we now know that Mars has enough oxygen in brines near the surface to support primitive life up through the level of sponges. The Abstract for the new finding by **Vlada Stamenković, Lewis M. Ward, Michael Mischna and Woodward W. Fischer in Nature Geoscience** is follows:

Abstract for O_2 solubility in Martian near-surface environments and implications for aerobic life

Due to the scarcity of O2 in the modern Martian atmosphere, Mars has been assumed to be incapable of producing environments with sufficiently large concentrations of O2 to support aerobic respiration. Here, we present a thermodynamic framework for the solubility of O2 in brines under Martian near-surface conditions. We find that modern Mars can support liquid environments with dissolved O2 values ranging from ~2.5 × 10−6 mol m−3 to 2 mol m−3 across the planet, with particularly high concentrations in polar regions because of lower temperatures at higher latitudes promoting O2 entry into brines. General circulation model simulations show that O2 concentrations in near-surface environments vary both spatially and with time—the latter associated with secular changes in obliquity, or axial tilt. Even at the limits of the uncertainties, our findings suggest that there can be near-surface environments on Mars with sufficient O2 available for aerobic microbes to breathe. Our findings may help to explain the formation of highly oxidized phases in Martian rocks observed with Mars rovers, and imply that opportunities for aerobic life may exist on modern Mars and on other planetary bodies with sources of O2 independent of photosynthesis.

The Stamenkovi et el. study is based on 6.1 mbar at areoid. However if we are right and pressure there is really two orders of magnitude higher, there would be even more oxygen dissolved.

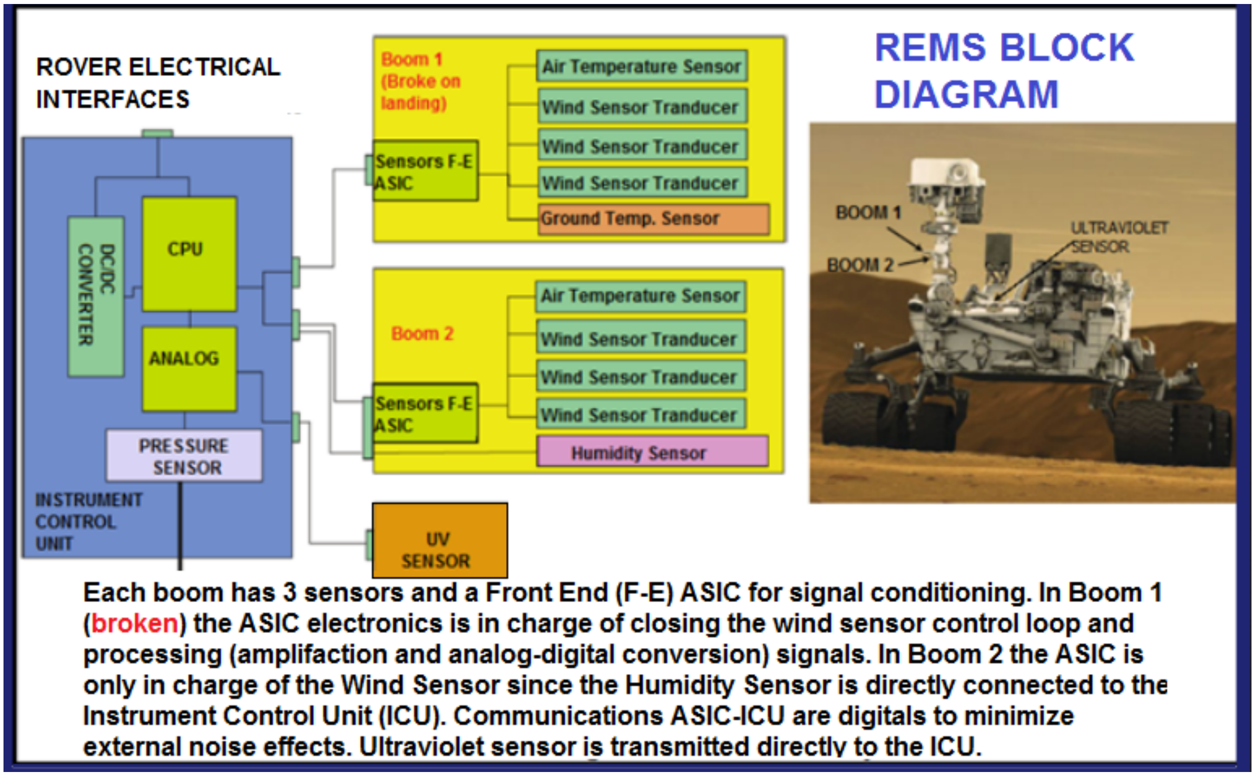


Figure 76: Location of meteorological sensors on Booms 1 and 2 of MSL.

15.5 MSL Diurnal Temperature Variation

Figure 76 shows the temperature data released by NASA for the summer of MSL Year 2 and the winter of MSL Years 2 to 3. Summer in the southern hemisphere occurs in months 10, 11 and 12. There are 154 days in MSL's summer and 179 sols in MSL's winter. Winter in the southern hemisphere occurs in months 4, 5, and 6. Before analyzing the data it must again be noted that the ground temperature sensor at MSL is only accurate to 10K/10°C/18°F. See Figure 67. On Figure 76 we see that air temperatures drop more degrees at night (68.034°C) in summer than in winter (62.1073 °C) although lows are colder in the winter than in the summer. Our record for MSL Year 2 Summer are maintained at our MarsCorrect.com site at http://marscorrect.com/photo4_11.html. There is a PDF version available as Annex O to this Report at http://marscorrect.com/ANNEX%20O.pdf. The record for MSL Year 2 to 3 Winter is maintained at our MarsCorrect.com site at http://marscorrect.com/photo2_29.html. A PDF version is available as Annex Q to this Report at http://marscorrect.com/ANNEX%20Q.pdf.

We wanted to get an idea of how cold it would get in the dark so we could compare it with darkness on the Earth's moon. Daytime on one side of the moon lasts about 13 and a half days, followed by 13 and a half nights of darkness. The sunlit surface can reach 123° C. The "dark side of the moon" can have temperatures dipping to -153° C. The moon only tilts on its axis about 1.54 degrees so there are places at the lunar poles that never see daylight. The Lunar Reconnaissance Orbiter measured temperatures of -238° C in craters at the south pole and -247° C (-412.6° F/26.15K) in a crater at the northern pole. That's the coldest temperature recorded in the solar system.

How do these temperatures compare with Mars? The REMS Team indicates that Mars average surface temperature is -53.15° C and varies widely over the course of a Martian day, from -128.185°C during the polar night to +26.85° C on the equator at midday at the closest point in its orbit around the Sun, with diurnal variations of up to 80°C to 100°C (https://cab.inta-csic.es/rems/intrument-description/ground-temperature-sensor/). As the coldest lunar temperatures are so much colder than the coldest Martian temperatures it's obvious that either the Martian atmosphere or warmth from below the surface is keeping Mars relatively warm at night. The coldest temperatures for the first 31 Martian months of MSL operation on Mars are shown on Table 22.

TABLE 22 – COLDEST AIR AND GROUND TEMPERATURES FOR THE FIRST 29 MARTIAN MONTHS OF MSL OPERATIONS ON MARS

YEAR	SEASON	MONTH	AIR TEMP LOW °C	GROUND TEMP HIGH °C
1	WINTER	6	-78	-87
1	SPRING	7	-76	-84
1	SPRING	8	-69	-80
1	SPRING	9	-68	-73
1	SUMMER	10	-73	-73
1	SUMMER	11	-79	-73
1	SUMMER	12	-78	-87
1	FALL	1	-82	-95
1	FALL	2	-86	-93
1	FALL	3	-88	-101
1	WINTER	4	-87	-97
1	WINTER	5	-75	-98
2	WINTER	6	-80	-96
2	SPRING	7	-78	-84
2	SPRING	8	-75	-75
2	SPRING	9	-76	-76
2	SUMMER	10	-76	-76
2	SUMMER	11	-78	-86
2	SUMMER	12	-81	-83
2	FALL	1	-84	-92
2	FALL	2	-84	-85
2	FALL	3	-90	-94
2	WINTER	4	-89	-100
3	WINTER	5	-84	-89
3	WINTER	6	-80	-85
3	SPRING	7	-78	-78
3	SPRING	8	-74	-75
3	SPRING	9	-78	-77
3	SUMMER	10	-81	-80
3	SUMMER	11	-77	-89
3	SUMMER	12	-81	-116
3	FALL	1	-80	-136
3	FALL	2	-81	-92
3	FALL	3	-124	-129
3	WINTER	4	-81	-93
3	WINTER	5	-80	-89
4	WINTER	6	-76	-87
4	SPRING	7	-74	-85
4	SPRING	8	-76	-71
4	SPRING	9	-73	-77
4	SUMMER	10	-85	-85
4	SUMMER	11	-75	-82
4	SUMMER	12	-78	-87

During the first 29 Martian months of MSL operations measuring air temperature the coldest monthly temperatures ranged from -68°C (-90.4°F) to -90°C (-130°F). **However for Martian month 30 (late summer in Year 3) the REMS Team published a low temperature of -116° C, and for Martian month 31 they published a low of -136° C (-212.8° F). In Martian month 33 they published a low ground temperature of -129° C. These extreme cold temperatures were not seen again in the 3 winter, 3 spring or 3 summer months to follow. We believe that this indicates either instrument failure or personnel problems.** Returning to the first 29 months, for the less certain ground temperatures NASA presents us with a range from -73°C (-99.4°F) to -101°C (-149.8°F). The average of the coldest monthly lows for air temperature is -79.4282°C (-110.97076°F). For ground temperatures it's -85.2414°C (-121.43452°F). With respect to *CO_2* on Earth, it freezes at -78.5°C (-109.3°C), but even at the station at Vostok in Antarctica where the coldest temperature on Earth was recorded at -89.2°C (-128.6°F) dry ice did not form because the station is at 3,288 meters (10,787 feet) above sea level. At Vostok pressure would be down to about 676 Pa. At sea level the partial pressure *at -78.5°C (-109°F), that equilibrium occurs is at a partial pressure of CO_2 of 760 mm Hg (1,013.25 Pa), one atmosphere. Below that pressure, there isn't enough abundance of CO_2 molecules in the vapor phase for collisions with the solid surface to occur at a fast enough rate to make up for the ones that escaped; so the solid CO2; dry ice, will continue to sublimate.*[117]

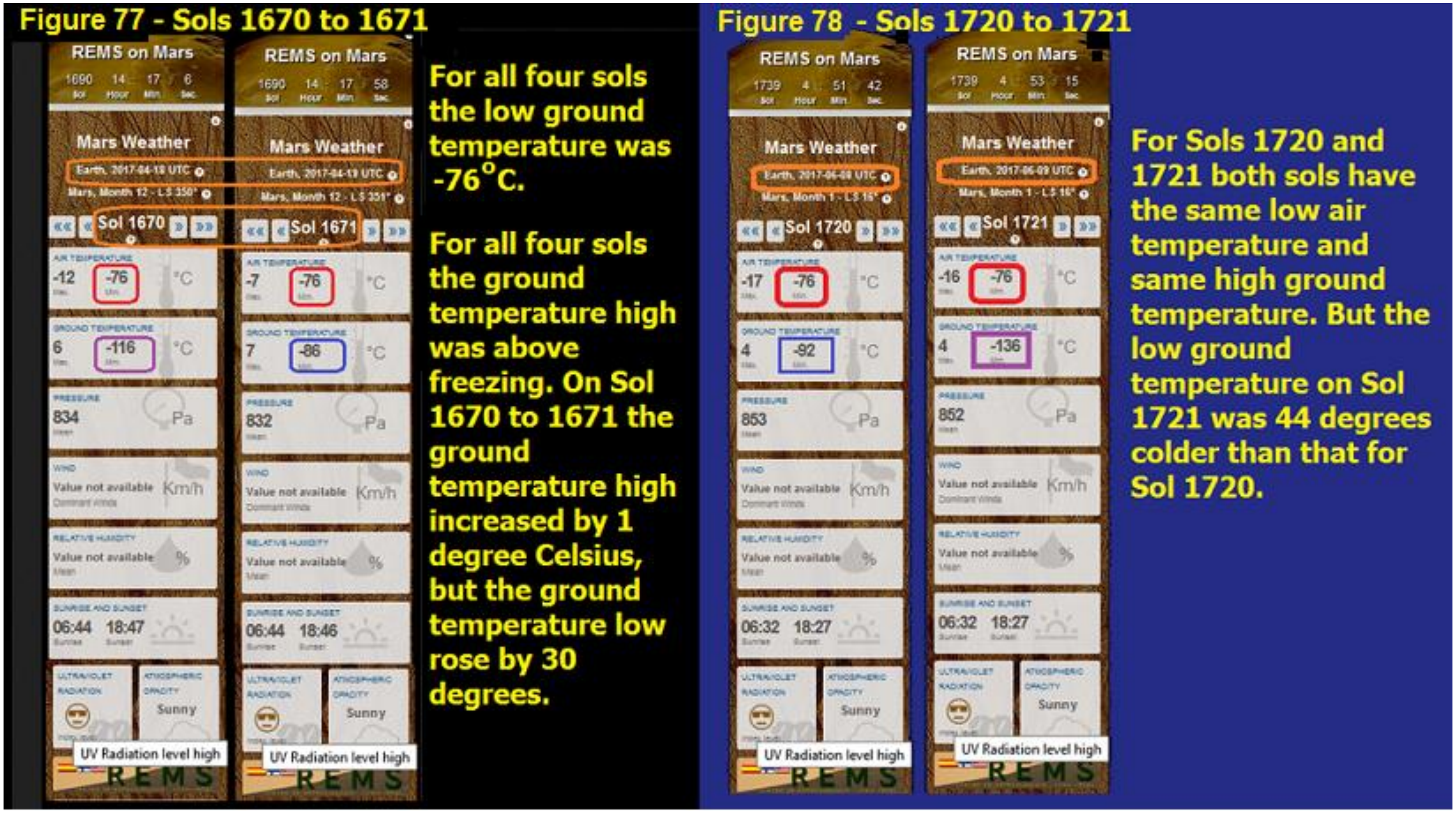


Figure 77– Ground temperature low changes for MSL Sol 1670 to 1671 are not matched by similar air temperature changes. As with Figure 78 the air temperature lows were both -76° C, but here the ground temperature lows differed by 30° C. Figure 78: While low air temperatures for sols 1720 and 1721 were both -76° C, the ground temperature lows differed by 44° C.

15.5.1. Why does the temperature fall more degrees at MSL in summer nights than winter nights? Note, it is of course true that winter nights are colder than summer nights at MSL, but the surprising phenomenon of a larger drop in degrees in summer than in winter is noted above in Figure 76. This seemed strange given the fact that nights are longer by about 32 minutes in MSL's winter than summer, giving more time for the temperature to decline. And yet the rate of air cooling slowed then as the temperature seemed to head toward a limit imposed by the heat retained in the ground or in the atmosphere. Normally the denser the air would be, the harder it would be to cool it.

What do the two seasons look like with respect to the freezing point of water which is similar on Mars and Earth even though the boiling point is believed to be much lower on Mars than the 100° C on Earth (10° C for pure water, 24° C for a perchlorate brine - see Figure 79)?

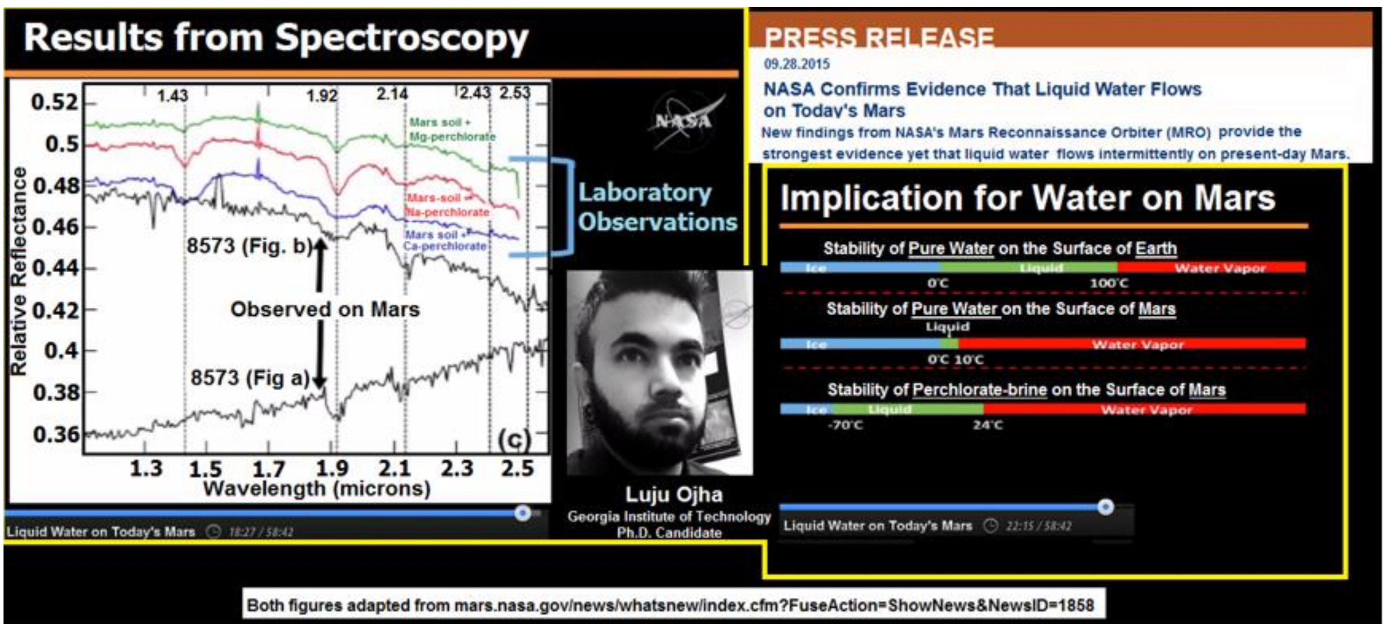


FIGURE 79: The left side shows results from Spectroscopy when matching RSL with perchlorates. The right side shows effects of perchlorates on boiling and freezing points of water at pressures on Mars that are accepted by NASA. We dispute the accepted pressure 6.1 mbar at areoid and instead believe that the real pressure at areoid is about 511 mbar. We argue that the widespread presence of running water strengthens our case.

In the summer all but 11 out of the 146 sols with data had ground temperatures above freezing. Of the 11 remaining sols all ranged between 0° C and -2° C. For air temperatures in the summer there were only 13 sols above freezing and another 12 sols that reached 0° C.

In the winter 70 out of the 177 sols with data had ground temperatures above freezing. Another eleven reached 0° C. For air temperatures in the winter there were only seven sols above freezing and just another one that reached 0° C.

15.6. Probable Failure of the Ground Temperature Sensor or Personnel Issues?

The legitimacy of MSL ground temperature data has been in doubt ever since it first appeared (retroactively) about nine months after landing. However, after we had the first two Martian years of MSL ground temperature data in hand, during the summer of MSL's third year it was clear that there were radical low ground temperature variations taking place on a frequent basis that were unlike anything seen before. Nor did these extremely low temperatures correspond to low air temperature seen 1.5 meters up.

We publish all REMS reports and their revisions on our site at http://marscorrect.com/cgi/wp/?page_id=622. The MSL Year 3 Summer results are also in Annex V of this report. A fragment of them are shown below as Table 23. As was shown on Table 22, during the first 29 months of MSL Curiosity operations -101°C (-149.8°F) was the coldest ground temperature. It was in the late fall. But on Sol 1670 the REMS Team claimed a ground low of -116 °C (-176.8°F), and it was still summer (Ls 340, with about 12 hours 3 minutes of daylight (see Figure 64). Odder still, while ground temperature lows between Sol 1640 and 1687 varied between -66° C and -118° C, a full 50° C range (80° F), the air temperature range only varied from -71 C° to -77° C, a 6° C (10.8 °F) difference. So clearly cold air is not what is producing the super cold ground temperatures. Further, every one of the sols had ground temperature highs above freezing with a range of 2° C (35.2° F) up to 16° C (60.8° F)**. On Sol 1721 (June 9, 2017) at Ls 16 REMS asked us to believe a new record low of -136° C which is -212.8° F.** Again, there was no matching low in air temperature (it was -76° C). The amount of daylight on Sol 1721 was 11 hours 55 minutes.

Could distance moved by the Curiosity Rover account for the erratic temperature variations at night? Not likely. JPL indicates that between Sol 1720 and 1721 Curiosity only moved 12.3 meters, increasing altitude by about one meter from 4,257 meters below areoid to 4,256 meters below areoid (see https://mars.nasa.gov/imgs/2017/06/MSL_TraverseMap_Sol1721_jschroeder-full.jpg). The topography for sol 1717 through 1721 is shown as Figure 80. It does not seem to indicate a major shift in terrain such as rocky to dune formation. The air and ground temperature lows for each sol have been added by us.

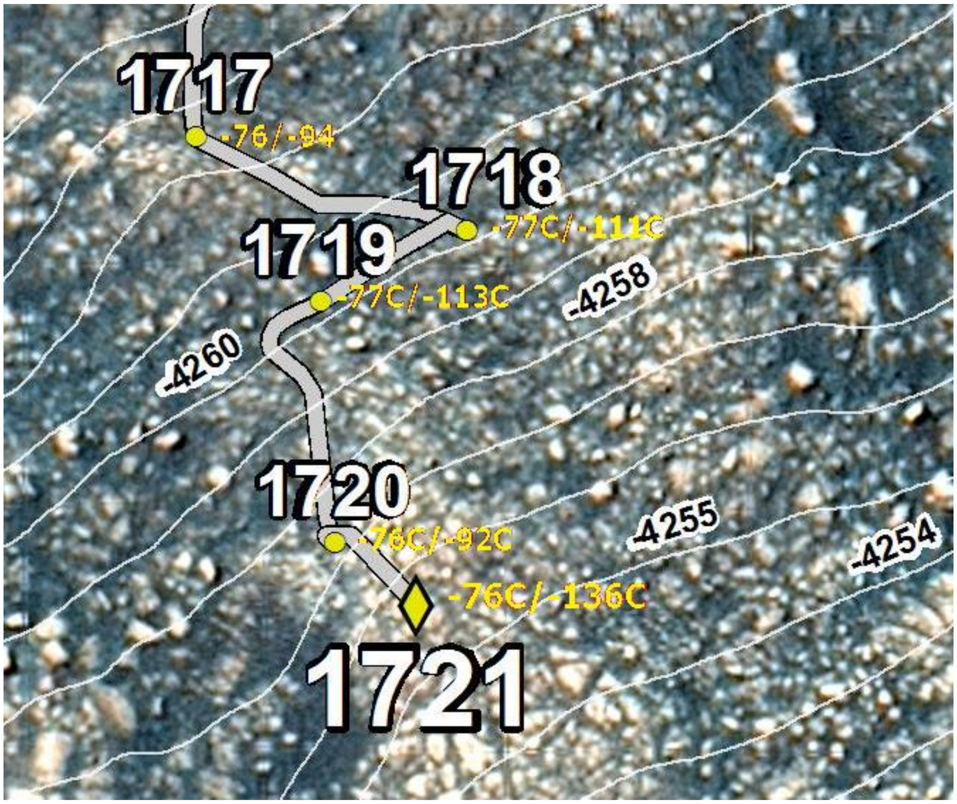


Figure 80 – MSL Sols 1717 to 1721 topography with altitudes below areoid with low air and ground temperatures posted by the REMS Team.

Problems with ground temperature lows began to crop up in March, 2017. This was mentioned by us in conjunction with Sols 1670 and 1671 which are shown on Figure 77. Then, like Figure 78, the air temperature lows were -76° C, but the ground temperature low for Sol 1670 was -116° C, while it was -86° C on the following sol.

The JPL topography map for sols 1639 to 1671 is found at https://mars.nasa.gov/multimedia/images/2017/curiositys-traverse-map-through-sol-1671. On Figure 82 we have tried to pair air and ground temperature lows with sols. For some entries there are best guess estimates where the JPL map lacked a specific point for the sol. On Figures 81 through 82 we looked for a correlation between ground temperature lows and surface type (sand dunes vs. rocks) but there was no consistent pattern that could explain extreme cold seen.

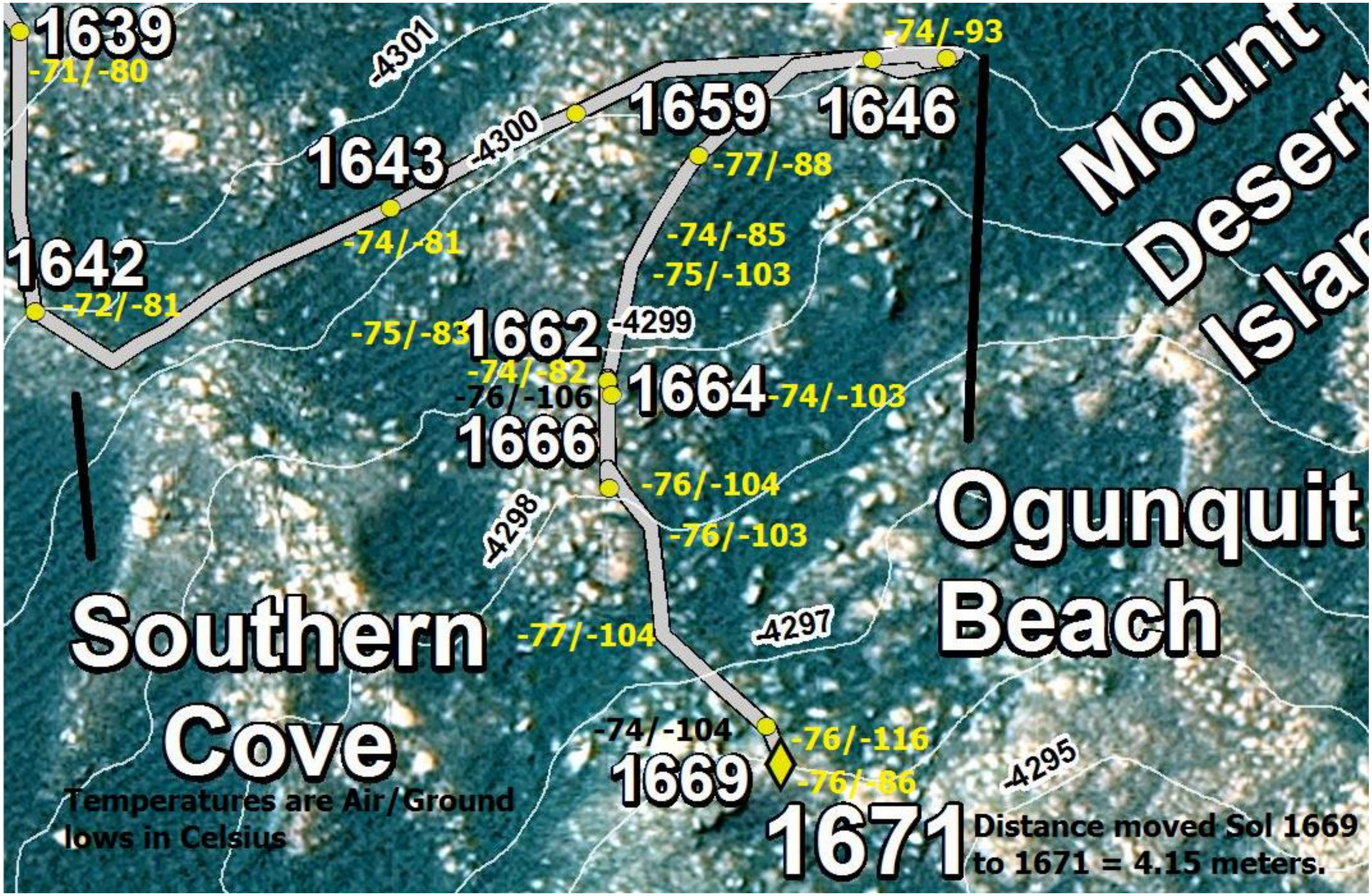


Figure 81 -   JPL identified positions and MOLA altitudes for sols 1639 to 1671. Low air and ground temperatures were added based on REMS Team weather reports. More temperature detail is found on Figure 82.

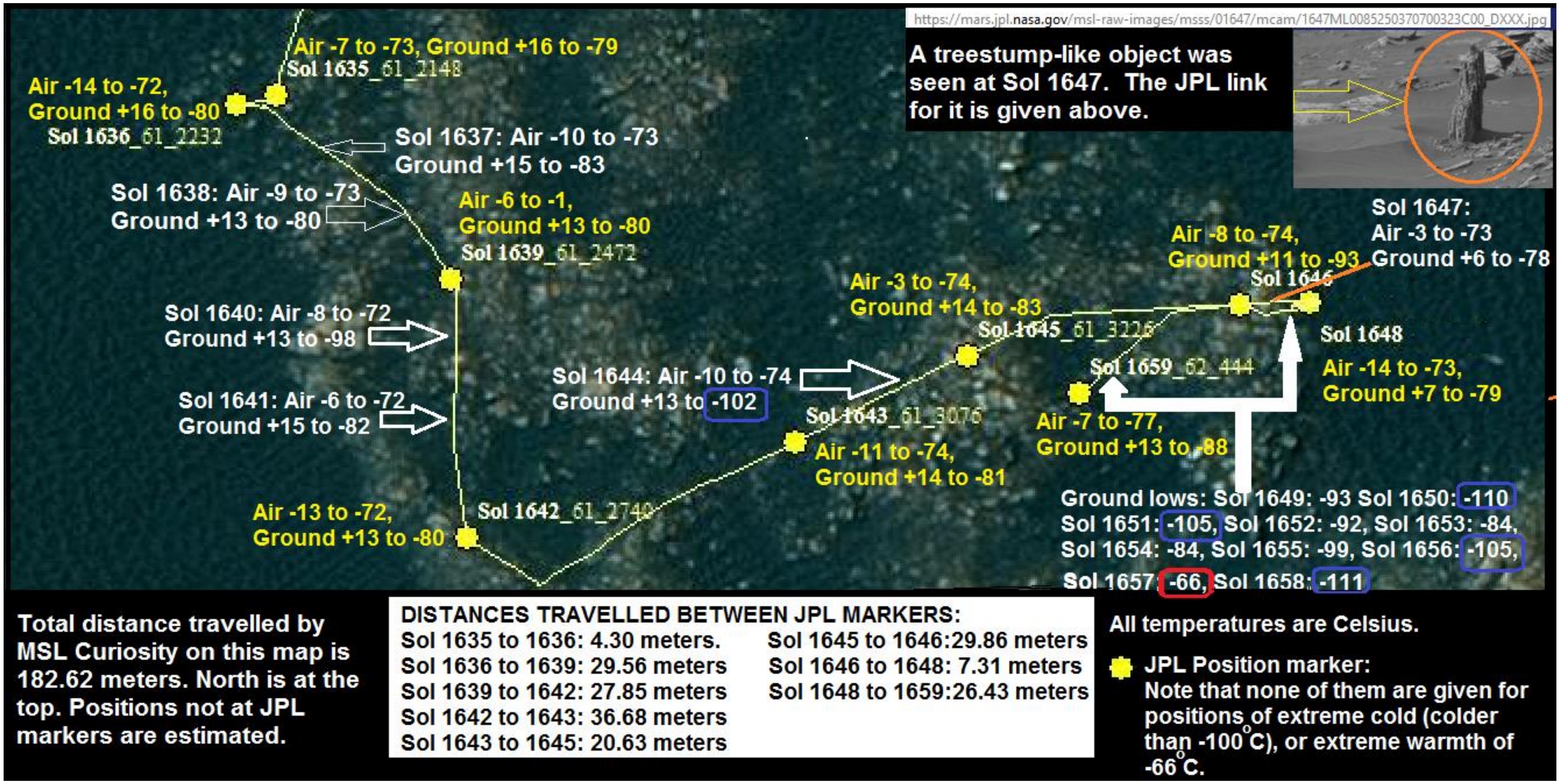


Figure 82 – JPL published the positions for MSL Sols 1635, 1636, 1639, 1642, 1643, 1645, 1646, 1648 and 1649. During these dates low ground temperatures varied between -79° and -93° C. However, the dates that they did not show had ground temperature lows that varied from -80° and -111° C with five temperatures colder than -101° C, the coldest temperature ever observed by MSL. At Sols 1647 to 1648 Curiosity was at an altitude of 4,300 meters below areoid. At Sol 1635 (upper left) Curiosity was at 4,304 meters below areoid.

TABLE 23 –MSL MAXIMUM AND MINIMUM AIR AND GROUND TEMPS SOLS 1634 TO 1684					
A	B	C	D	E	F
SOL	MAXIMUM AIR TEMP °C	MINIMUM AIR TEMP °C	MAXIMUM GROUND TEMP °C	MINIMUM GROUND TEMP °C	∆ GROUND TEMP (DROP DAY TO NIGHT)
			RED IF > 0 °C	PURPLE = -90°C or COLDER	Yellow numbers= -80 to -89 °C, red = -90°C or colder drop
1634	-5	-72	12	-83	-95
1635	-7	-73	16	-79	-95
1636	-14	-72	16	-80	-96
1637	-10	-73	15	-83	-98
1638	-9	-73	15	-81	-96
1639	-6	-71	13	-80	-93
1640	-8	-72	13	-98	-111
1641	-6	-72	15	-82	-97
1642	-13	-72	11	-81	-92
1643	-11	-74	14	-81	-95
1644	-10	-74	13	-102	-115
1645	-3	-74	14	-83	-97
1646	-8	-74	11	-93	-104
1647	-3	-73	6	-78	-84
1648	-14	-73	7	-79	-86
1649	-14	-74	11	-93	-104
1650	-8	-75	12	-110	-122
1651	-8	-77	11	-105	-116
1652	-15	-76	12	-92	-104
1653	-15	-75	12	-84	-96
1654	-17	-75	13	-84	-97
1655	-14	-76	12	-99	-111
1656	-3	-75	12	-105	-117
1657	-9	-75	12	-66	-78

A	B	C	D	E	F	G
	SOL	MAXIMUM AIR TEMP °C	MINIMUM AIR TEMP °C	MAXIMUM GROUND TEMP °C	MINIMUM GROUND TEMP °C	Δ GROUND TEMP (DROP DAY TO NIGHT)
	1658	-8	-77	12	-111	-123
	1659	-7	-77	13	-88	-101
	1660	-5	-74	15	-85	-100
	1661	-5	-75	14	-103	-117
	1662	-3	-75	13	-83	-96
	1663	-6	-74	10	-82	-92
	1664	-8	-74	10	-103	-113
	1665	-7	-76	8	-106	-114
	1666	-8	-76	7	-104	-111
	1667	-9	-76	6	-103	-109
	1669	-12	-74	6	-104	-110
	1670	-12	-76	6	-116	-122
	1671	-7	-76	7	-86	-93
	1672	-5	-74	9	-93	-99
	1673	-6	-75	6	-109	-115
	1674	-6	-75	2	-109	-111
	1675	-6	-75	4	-94	-98
	1676	-11	-76	10	-113	-123
	1677	-8	-74	7	-84	-91
	1678	-11	-74	6	-84	-90
	1679	-12	-75	10	-84	-94
	1680	-11	-74	6	-88	-94
	1681	-12	-74	6	-85	-91
	1682	-13	-76	5	-115	-120
	1683	-15	-75	5	-91	-96
	1684	-14	-75	5	-89	-94

Table 23 - Starting around MSL Sol 1640 (March 18, 2017) extremely low ground temperature lows became totally inconsistent with anything seen before since MSL landed in 2012.

15.6.1 Failure of the Temperature Sensor.

The right question is likely not about why the ground temperature sensor began to fail in March, 2017. Rather, it's why NASA, or the REMS Team working for them, are allowing us now to see that there is something radically wrong with the sensor. The answer is likely very simple. Few people in the world care enough about Martian weather to inspire NASA to care. However, those that do are in many cases middle-level NASA workers who know something's wrong, but are afraid to say something because it might cost them their job. I live in Cape Canaveral, Florida. Most of my neighbors who are not yet retired largely meet this description.

As I wrote earlier, Boom 1 that carried the ground temperature sensor was damaged on landing in 2012. It took about 9 months before the REMS Team began to publish any ground temperatures at all in their daily weather reports. Then 9 months' worth of ground temperature data suddenly appeared, along with a statement by Guy Webster that only the wind sensor on the boom was destroyed (we got him to remove all wind data). In July, 2013 NASA decided to revise a lot of air temperatures way down, dropping many from above freezing to well below it - see Table 20 in Section 15 of this report.

Perhaps the most important thing for our readers to understand is that not all NASA data published by NASA is from NASA alone. In an astonishing twist of fate, much of it in part actually originated here. How is that possible? Look at our records for MSL Sol 1605 (Ls 314, February 10, 2017). See Figure 83 and Annex V of this report. The REMS Team originally published a pressure of 815 Pa, but the preceding day the pressure was 850 Pa. A drop of 35 Pa was not reasonable from one sol to the next. Typically the change in pressure is under 10 Pa. So we predicted that NASA would alter it, and they did indeed back up to 847 Pa. When this happens we don't just put it on our weather spreadsheets. We document the prediction and NASA changes by publishing before and after print-screen showing what NASA did.

For Sol 1605 (February 10, 2017) we also successfully predicted that NASA would alter its temperature data. At first they published a low air temperature of -54° C. We noted that the previous sol (1604) had an air temperature low of -77 ° C. Such large changes from one sol to another have not survived in the past (that is, before about March 20, 2017). Sure enough, NASA altered the air temperature low for Sol 1605 to -73 ° C. Likewise, the initial ground temperatures for Sol 1605 were +10 ° C for a high and -61° C for a low. For Sol 1604 they were +15° C and -77° C. That was too much of a change, so NASA made the predicted change and claimed Sol 1605 ground temperatures were really +14 and -78° C. This cat and mouse game went on for five years, and we have documented it all. NASA seems to have had one agenda only – keep the data on a believable curve, and hope that nobody with access to the purse strings figures out what they have been doing. However, for some reason, this pattern was altered around Sol 1642 (March 20, 2017). The question is, why?

15.6.2 Personnel Issues.

The inventor of the pressure sensor, Henrik Kahanpää of the Finnish Meteorological Institute and of the REMS Team is a frequent visitor of our three websites. So are other REMS Team members. Given the loss of the ExoMars 2016, likely due to bad weather data from NASA, we suspect that major (European) Mars weather personnel have had enough of pressure to confirm suspicions of foul play.

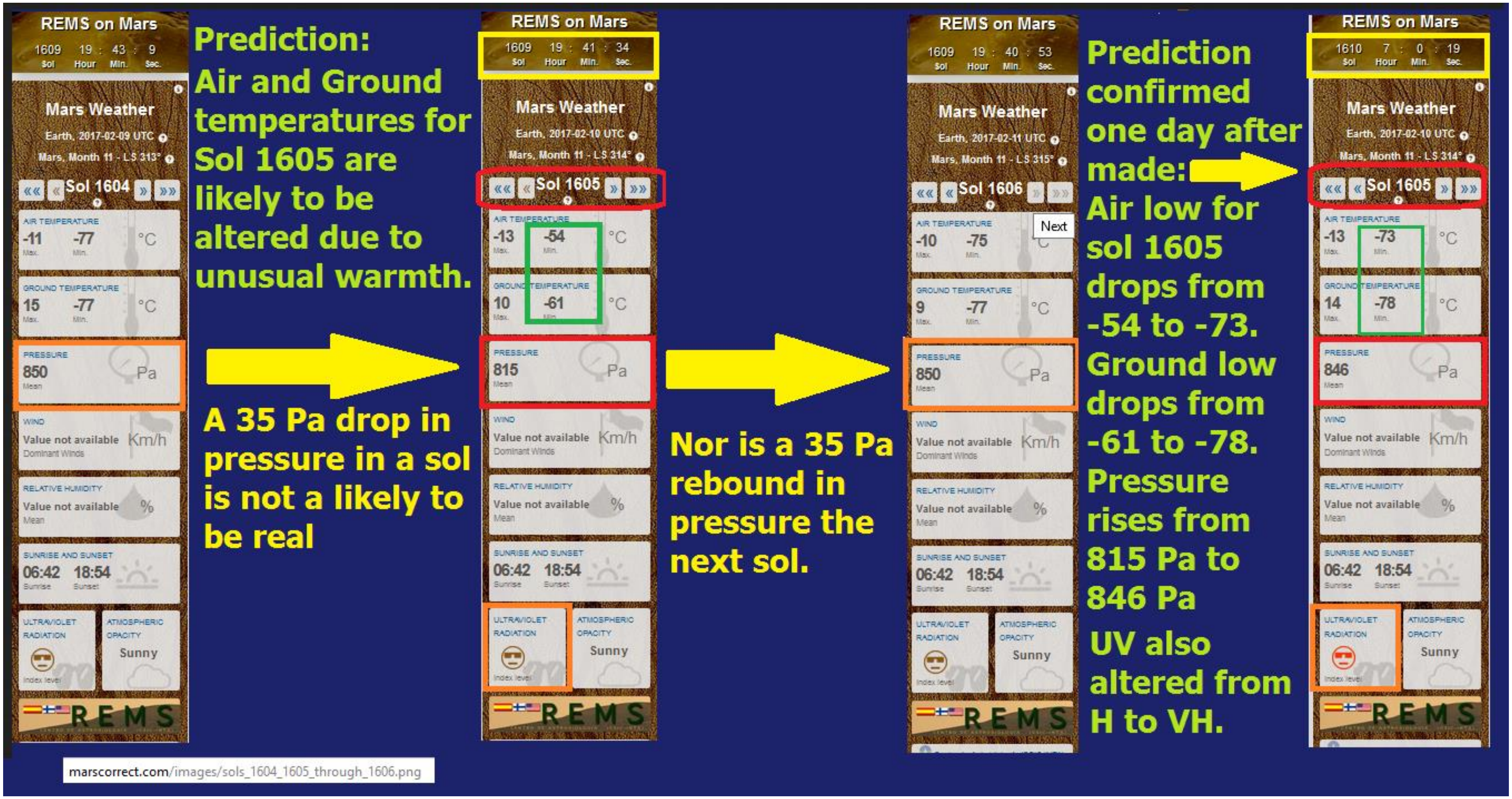


Figure 83 - After we posted the three images on the left someone at the REMS Team or at JPL altered the Sol 1605 report to what is shown on the right. It is quite apparent that before March, 2017 reports that vary too much from the preceding day or previous Martian year at the same Ls do not survive long at the REMS site at http://cab.inta-csic.es/rems/en.

15.6.3 Mixed messages about the range and sensitivity of pressure sensors sent to Mars.

It has on been our position that NASA has understated Martian pressure by two orders of magnitude. On Figure 57 we made a case for a pressure at areoid of about 511 mbar (vs. the accepted pressure of 6.1mbar), at Mars Pathfinder of ~719 mbar, at MSL ~768 mbar, at the Valles Marineris 835 mbar and in the Hellas Basis about 1,054 mbar (more than average pressure of 1,013.25 mbar at sea level on Earth). While mbar are the pressure units that we most prefer, others in the scientific community use pascals (Pa) or hectopascals (hPa). We have often noted mistakes in publication where hPa are confused with Pa and vice versa. The difference between these units is two orders of magnitude (i.e., two decimal places).

The problem first came to our attention when we found that the REMS Team originally published pressures ranging from 737 to 747 hPa between August 30, 2012 and September 5, 2017. On September 2, 2012 we called Guy Webster, the PR man at JPL, and told him that if these pressures were correct, he needed to parade out the President of the United States to announce the greatest discovery in astronomy – that Mars has air pressure like than on Earth. On September 5, 2012 REMS said the pressure was 747 **hPa** (i.e., 747 mbar). The next day they published a pressure of 747 **Pa** (i.e. 7.47 mbar). This was captured by print-screen on Figure 17A. Soon after that they changed all the high pressures, rolling them back from hPa to Pa. Was this a simple accident?

We have worked since 2009 with Viking 1 and 2 data taken from "Mars Meteorology Data; Viking Lander." *Mars Meteorology Data; Viking Lander*. N.p., n.d. Web. 10 Feb. 2015. This is found at http://www-k12.atmos.washington.edu/k12/resources/mars_data-information/data.html. On July 12, 2017 we received an e-mail from an engineer by the name of Nathan Mariels, CEO at Global Electric Technology. In it he wrote:

> Pa is not equal to hPa. **From Viking logs:** "Pressure mb = millibars, 1 mb = 100 hPa, where hPa = hecta Pascals" This is incorrect. 1 mb = 1 hPa = 100 Pa.

The above error was repeated on every data set for Viking 1 and 2. A sample is captured by print-screen on Figure 84.

Nathan found similar errors on MSL data that he examined. He also found different pressure ranges for landers than what we found, although we noted on Figures 10A and 10B that three of four sensors ordered by NASA from Tavis were rated for maximum pressures under 25 mbar, one of them – Tavis Dash Number 1 was rated at 15 PSIA which converts to 1,034 mbar. Pathfinder pressure problems were discussed earlier in Section 12 of this report. The Vikings and Pathfinder all used Tavis pressure transducers which are discussed in great detail in Annex G of this report (**http://marscorrect.com/ANNEX%20G%2010%20September%202013.pdf**). Nathan found similar errors on MSL data that he examined. He also found different pressure ranges for landers than what we found, although we noted on Figures 10A and 10B that three of four sensors ordered by NASA from Tavis were rated for maximum pressures under 25 mbar, one of them – Tavis Dash Number 1 was rated at 15 PSIA which converts to 1,034 mbar. Pathfinder pressure problems were discussed earlier in Section 12 of this report. The Vikings and Pathfinder all used Tavis pressure transducers which are discussed in great detail in Annex G of this report (**http://marscorrect.com/ANNEX%20G%2010%20September%202013.pdf**). After

Vaisala, FMI and NASA read our critiques of the much lighter sensor used on Phoenix and MSL, for Insight NASA chose to go back to the same Tavis transducer that was used on Pathfinder – one with a dual range – likely on each transducer - leaving open the possibility of a cover-up of monkey business/disinformation for pressures.

While it seems hard to believe that a mere copying over of wrong units from one page to another caused serious problems, that's what might have happened with all of the Viking 1 and 2 data at http://www-k12.atmos.washington.edu/k12/resources/mars_data-information/data.html.

The problem with accepting the accident explanation for the Vikings is that it still leaves us with an order in 1976 by Dr. James Fletcher to manually alter the color of the Martian sky on all JPL monitors, and it leaves us with 36 years of altered sky color until we were finally permitted to see blue sky at Gale Crater, Mars in 2012.

```
    Definitions
    ===========

    Year                    Mars year, approximately 687 Earth days
    Solar Longitude,        Angular direction from Mars to the Sun
            L_s;            0 to 360 degrees
            Deg.            90 = summer, 180 = autumn, 270 = winter
                            0 or 360 = spring in northern hemisphere
    Sol                     Martian days after landing; 1 sol is
                                    Viking landed on sol 0
                                    One sol is 24.62 hours
    Wind speed              Meters per second
    Wind direction          Degrees, (direction from which the
                            wind blows)
    Pressure                mb = millibars, 1 mb = 100 hPa, where
                            hPa = hecta Pascals      No, it's 100 Pa!
    Temperature             Degrees; C = Centigrade; F = Fahrenheit

    ================================================================

    These rows of data are formed by checking for bad data,
    removing or reprocessing them, collecting the points into one
    of 25 equal length intervals, "bins", in each sol, and then
    averaging each bin. When no data exist in one to a few bins,
    a value is interpolated, ( using a cubic spline technique,,
    which is not described here.)

    ================================================================

        Solar                   Wind   Wind   Pressure  Temperature
        Longitude               Speed  Dir
Year    L_s (deg.)  Sol         m/sec  deg.     mb        F.       C.


     1  117.993     1.02        0.0        0     0.00  -459.67 -273.15
     1  118.012     1.06        1.5       79     7.82   -97.69  -72.05
     1  118.031     1.10        1.7       65     7.82  -106.44  -76.91
```

Figure 84 – Viking 1 and Viking 2 error in unit conversion.

Now, let's look at another problem brought to my attention by Nathan – an inconsistency with respect to the pressure range and sensitivity on MSL. In particular, let's look at the Abstract put out by the Finnish Meteorological Institute, which created the pressure sensors on Phoenix and MSL.

First let's examine a statement that backs the 1150 Pa figure: In Section 11 of the REMS Calibration Plan (Document No, CAB-REMS-PLN-002, Issue 002, it states:

> **REMS shall measure the Ambient Pressure in the range of 1 to 1150Pa** with a resolution of 0.5 Pa and accuracy of 10 Pa BOL (Beginning of Life) and 20 Pa EOL (End of Life). Requirement 012 (PLD-20), REMS shall measure the Ambient Pressure at a minimum sampling rate of 1 Hz for at least 5 minutes each hour continuously over the mission.

But, in their Abstract to the American Geophysical Union for the Fall 2012 meeting the FMI states:

> **The pressure device measurement range is 0 - 1025 hPa** in temperature range of -45°C - 55°C, but its calibration is optimized for the Martian pressure range of 4 - 12 hPa.

Note: 1025 hPa = 1,025 mbar. So, while it was supposedly optimized for 4 to 12 (not 11.5 mbar – meaning that the problem is not one of a sliding decimal place), it was still capable of measuring up to 1,025 mbar. Again, average pressure on Earth at sea level is 1,013.25 mbar. This is, to borrow a phrase from the Wizard of Oz, a ***horse of a different color***. For the record, we have preserved the FMI abstract showing the 1,025 mbar capacity with the print-screen on Figure 86. As for the temperature range, at MSL there were no reports of low temperatures as warm as -45°C that were not changed to much colder temperatures. For example, there was an air temperature low of -46°C reported by the REMS Team for Sol 880 on January 27, 2014, but they altered it after we highlighted it on our REMS data spreadsheets at http://marscorrect.com/photo4_11.html and in particular the print-screen record seen below as Figure 85. Note: As was shown on Table 15b earlier, during the Global Dust Storm of 2018 the warmest low for air temperature was -58°C on Sol 2103, and the warmest low for ground temperature was -56°C on Sol 2085.

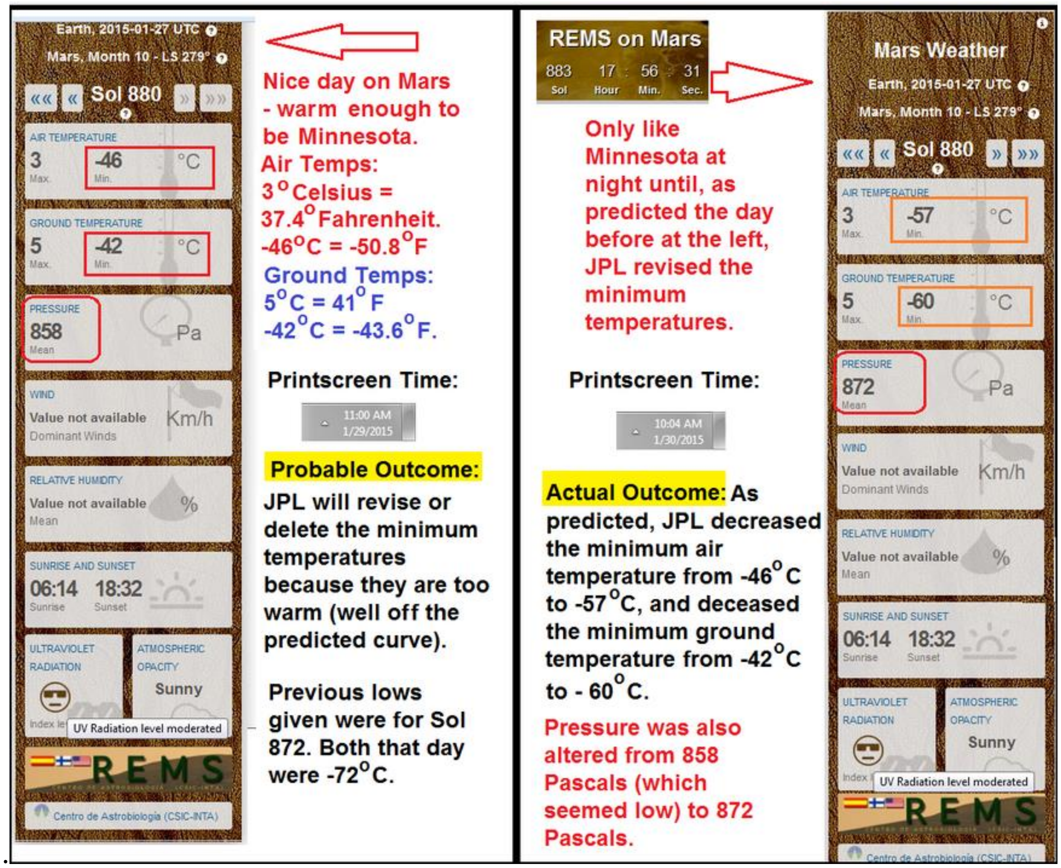


Figure 85 – The REMS Team would not permit low temperatures warmer than -50°C.

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adsabs.harvard.edu/abs/2012AGUFM.P21G..06H

Title: Pressure and Humidity Measurements at the MSL Landing Site Supported by Modeling of the Atmospheric Conditions

Authors: Harri, A. ; Savijarvi, H. I. ; Schmidt, W. ; Genzer, M. ; Paton, M. ; Kauhanen, J. ; Atlaskin, E. ; Polkko, J. ; Kahanpaa, H. ; Kemppinen, O. ; Haukka, H.

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Publication: American Geophysical Union, Fall Meeting 2012, abstract #P21G-06

Publication Date: 12/2012

Origin: AGU

Keywords: 0343 ATMOSPHERIC COMPOSITION AND STRUCTURE / Planetary atmospheres

Bibliographic Code: 2012AGUFM.P21G..06H

Abstract

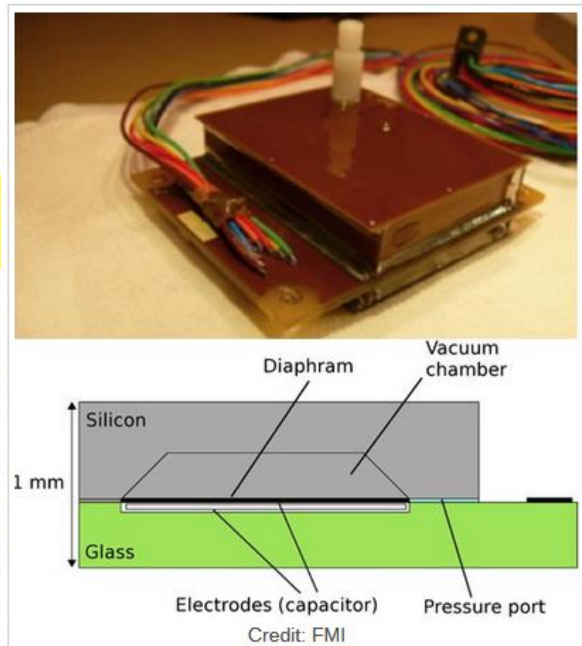
The Mars Science Laboratory (MSL) called Curiosity Rover landed safely on the Martian surface at the Gale crater on 6th August 2012. Among the MSL scientific objectives are investigations of the Martian environment that will be addressed by the Rover Environmental Monitoring Station (REMS) instrument. It will investigate habitability conditions at the Martian surface by performing a versatile set of environmental measurements including accurate observations of pressure and humidity of the Martian atmosphere. This paper describes the instrumental implementation of the MSL pressure and humidity measurement devices and briefly analyzes the atmospheric conditions at the Gale crater by modeling efforts using an atmospheric modeling tools. MSL humidity and pressure devices are based on proprietary technology of Vaisala, Inc. Humidity observations make use of Vaisala Humicap® relative humidity sensor heads and Vaisala Barocap® sensor heads are used for pressure observations. Vaisala Thermocap® temperature sensors heads are mounted in a close proximity of Humicap® and Barocap® sensor heads to enable accurate temperature measurements needed for interpretation of Humicap® and Barocap® readings. The sensor heads are capacitive. The pressure and humidity devices are lightweight and are based on a low-power transducer controlled by a dedicated ASIC. The transducer is designed to measure small capacitances in order of a few pF with resolution in order of 0.1fF (femtoFarad). The transducer design has a good spaceflight heritage, as it has been used in several previous missions, for example Mars mission Phoenix as well as the Cassini Huygens mission. The humidity device has overall dimensions of 40 x 25 x 55 mm. It weighs18 g, and consumes 15 mW of power. It includes 3 Humicap® sensor heads and 1 Thermocap®. The transducer electronics and the sensor heads are placed on a single multi-layer PCB protected by a metallic Faraday cage. The Humidity device has measurement range of 0 - 100%RH in temperature range of -70°C - +25°C. Its survival temperature is as low as -135°C. The pressure device has overall dimensions of 62 x 55 x 17 mm. It weighs 35 g, and consumes 15 mW of power. The sensor makes use of two transducers placed on a single multi-layer PCB and protected by box-like FR4 Faraday cages. The transducers of the pressure device can be used in turn, thus providing redundancy and improved reliability. The pressure device measurement range is 0 - 1025 hPa in temperature range of -45°C - +55°C, but its calibration is optimized for the Martian pressure range of 4 - 12 hPa. In support of the in situ measurements we have analyzed the atmospheric conditions at the MSL landing site at the Gale crater by utilizing mesoscale and limited area models. The compatibility of the results of these modeling tools with the actual environmental conditions will be discussed.

Figure 86 – Print-screen (recorded on July 23, 2017) of the FMI Abstract entitled *Pressure and Humidity Measurements at the MSL Landing Site Supported by Modeling of the Atmospheric Conditions.*

In contrast to what they submitted to the American Geophysical Union in 2012, the standard REMS position on the range of their MSL pressure sensor is shown on Figure 87.

spaceflight101.com/msl/rems-instrument-overview/

Pressure Sensor



The pressure sensor is located in the rover body and is connected to the atmosphere via a tube that exits the rover through a small opening with dust protection. It operates at a range of 1 to 1150 Pa with an end of life accuracy of 20Pa (calibrations show an accuracy of 3Pa). The instrument provides information at a resolution of 0.5Pa. The Pressure Sensor Hardware uses two transducers that are placed on a single unit that is 62 by 50mm in size and protected by Faraday Cages. It is located inside the REMS Instrument Conditioning Unit electronics box. Each pressure transducer has 2 Vaisala Barocap® pressure sensor heads and 2 Thermocap® temperature sensors. The pressure sensor heads are of different types: one is of high stability while the other three are of high-resolution type. The pressure sensor heads are single-crystal silicon micromachined devices detecting capacitance changes that are measured via capacitor plates are are moved by pressure. The REMS pressure transducers have flight history on previous interplanetary missions and are known to provide stable measurements in a range of environments. The pressure heads feature higher inaccuracies just after start-up during instrument activation. That is why pressure sensor data is recorded late in each of the REMS measuring increments.

Figure 87 - The Vaisala Pressure sensor and its range as depicted by Spaceflight101.com.

On July 24, 2017 we found that the REMS Team again altered the maximum pressure to 1400 Pa (14 mbar). See Figure 88. After they raised the maximum pressure from 1150 to 1400 Pa, they published a maximum pressure of 1,294 Pa for Sol 1784 on August 13, 2017. On the previous sol (1783) the presure published was only 879 Pa. Yet even with the newer (likely false) upper pressure range of 1,400 Pa, when we challenged it with our colored spreadsheet and print-screen (http://davidaroffman.com/photo5_15.html), the REMS Team dropped the 1,294 Pa for that sol to 883 Pa.

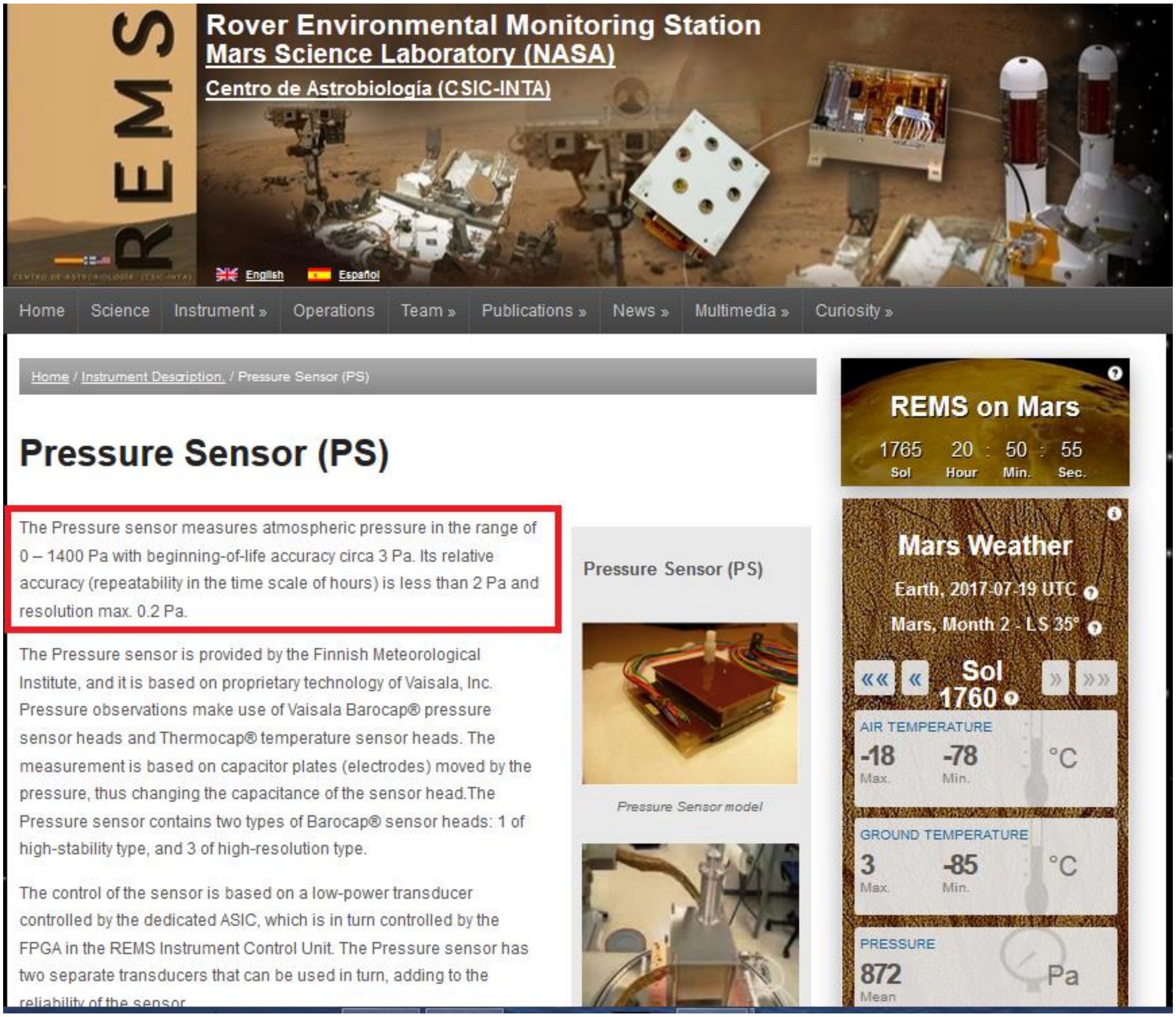


Figure 88 – REMS puts out a new maximum pressure for MSL. This time it's 1400 Pa (14 mbar). Here they also claim a relative accuracy (repeatability in the time scale of hours) of less than 2 PA and a resolution of 0.2 Pa. On Figure 71 the resolution was 0.5 Pa.

15.6.4. A Possible Excuse for REMS Errors.

Nathan Mariels examined the Planetary Data System (PDS) for MSL data. On July 18, 2017 at 8:07 PM, he wrote:

> "There are a lot of data points. Every 5 minutes, unless an event occurs, which causes it to sample 512 points at short intervals. The triggers and timing change depending on the code version. REMS is on version 7. I think that's why you see the pressure from past dates sometimes change. The format of the data changes, so the weather software gets changed, but some older data is then getting converted wrong if the software thinks it's all in the new format."

15.7 Temperature, Pressure and Albedo.

This section merges our findings with an article written in Italian by Marco de Marco (http://www.pianetamarte.net/gale_crater.htm).

De Marco states that, "Gale crater is located south of the Martian equator. According to NASA's albedo maps, the average value recorded is 0.193, with a minimum of 0.111 and a maximum of 0.278; the place for landing has an average albedo of 0.171. With these values it's possible to calculate the maximum daily temperature, taking into account the inclination of the sun rays in relation to the Martian season. From it, distance of Mars from the sun and albedo it's possible to obtain the temperature using Boltzmann's Law which states that the total energy radiated per unit surface area of a black body across all wavelengths per unit time (also known as the black-body *radiant emittance* or *radiant existence*) is directly proportional to the 4th power of the black body's temperature (see Figure 89)

"By applying this principle to the conditions of Gale crater, we already have the first surprises, especially if compared to the data provided by Thermal Emission Spectrometer (TES) from Mars Global Surveyor. In the comparison graph between the calculated data and the values provided by TES for latitude 0 ° and -10 °, there is some discrepancy between the temperatures of those latitudes and theoretical values which could only be explained by accepting values of albedo much higher than the actual ones. From the complete analysis of TES temperature data it can be seen that Mars should have an average albedo of 0.44, where visual albedo is 0.15 and geometric albedo is about 0.3. Always according to TES data the albedo itself varies according to the temperature. This behavior is quite curious! In fact, the albedo map supplied by NASA varies from a minimum of 0.08 to a maximum of 0.32, while according to TES data albedo ranges up to a maximum of 0.84 for polar regions and up to 0.56 in equatorial regions."

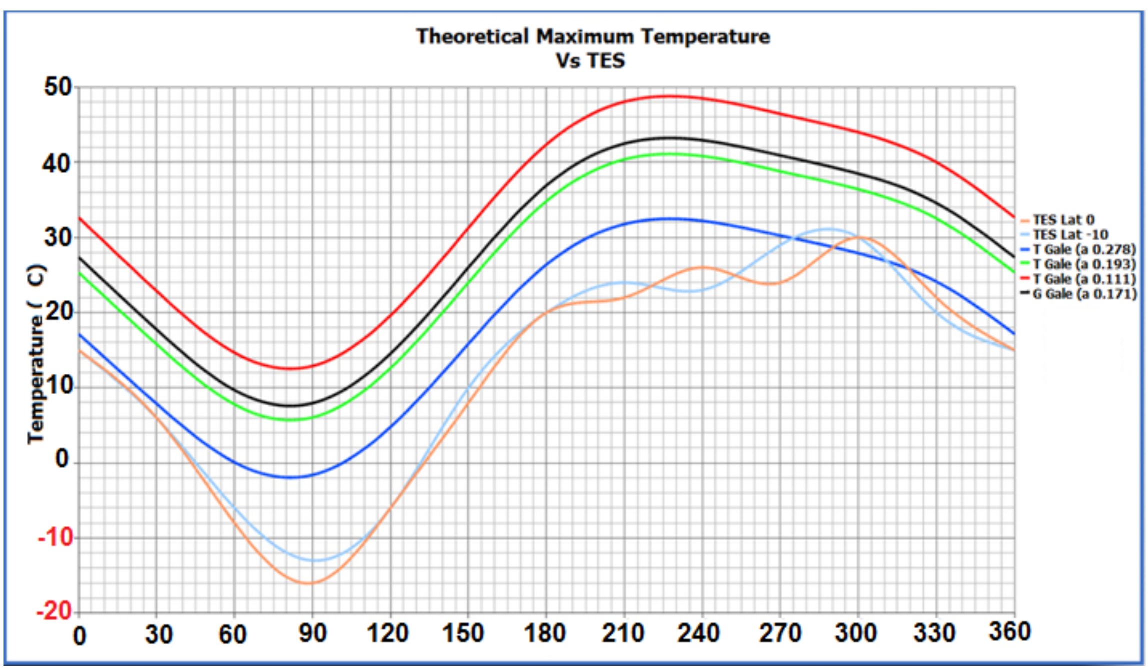


Figure 89 - Maximum temperature calculated according to Boltzman's Law with TES measurements from the equator to -10° latitude (10° South latitude)

"The only explanation for this phenomenon, obviously taking the TES data as correct, would be the massive presence of cloud formations, especially in colder times, as opposed to the activities related to sand storms that usually occur in the warmer moments which in itself would exclude the sand storms from the explanation of this phenomenon. However, since this fact is unconfirmed, it would be more appropriate to deduce the presence of a variable error percentage in the TES data, particularly at the lower temperatures, as shown in Figure 88 above."

De Marco continues, "Returning to the TES data, we will expect temperature variations from a minimum of -16 ° C to a maximum of + 31 ° C. Instead, according to my calculated data, taking into account the different degrees of albedo I would expect variations from a minimum of -2 ° C up to a maximum of almost +49 ° C, as far as the whole crater is concerned. With respect to the specific landing area, the values would vary from a minimum of + 8 ° C to a maximum of + 43 ° C, practically always above the freezing point of the water, at least as far as the maximum daily temperature. As you may also notice the temperature should easily exceed even + 40 ° C.

"Curiosity landed inside Gale crater, on August 6, 2012, when Mars was at the solar longitude (Ls) 150.4 a Martian month before spring equinox the southern hemisphere. According to the graph, at that time the temperature should reach a maximum of + 26 ° C with upward trend. Let's remember then that any phenomena related to the presence of liquid water will provide us with great information on the actual Martian atmospheric density. In fact, Gale crater also has a certain amount of water, with a percentage of between 6 and 8% of the ground mass, also proved by the presence of gullies! It would be extremely interesting to be able to watch live from the Curiosity cameras this water spill from the ground at recurring slope lineae (RSL), as well as the same water behavior once on the surface. If the soil temperature exceeds + 40 ° C, then we will have to shift the lower limit for the Martian atmospheric density to no less than 80 hPa**."** However as is demonstrated throughout the Mars Correct Basic Report there appears to be major flaws in temperature data, one of which is that the REMS Team let us know that ground temperatures are only accurate to +/- 10 °C. In looking through the first 2,281 sols at MSL, the highest ground temperature reported by the REMS Team was +24 C ° on Sol 1,428.

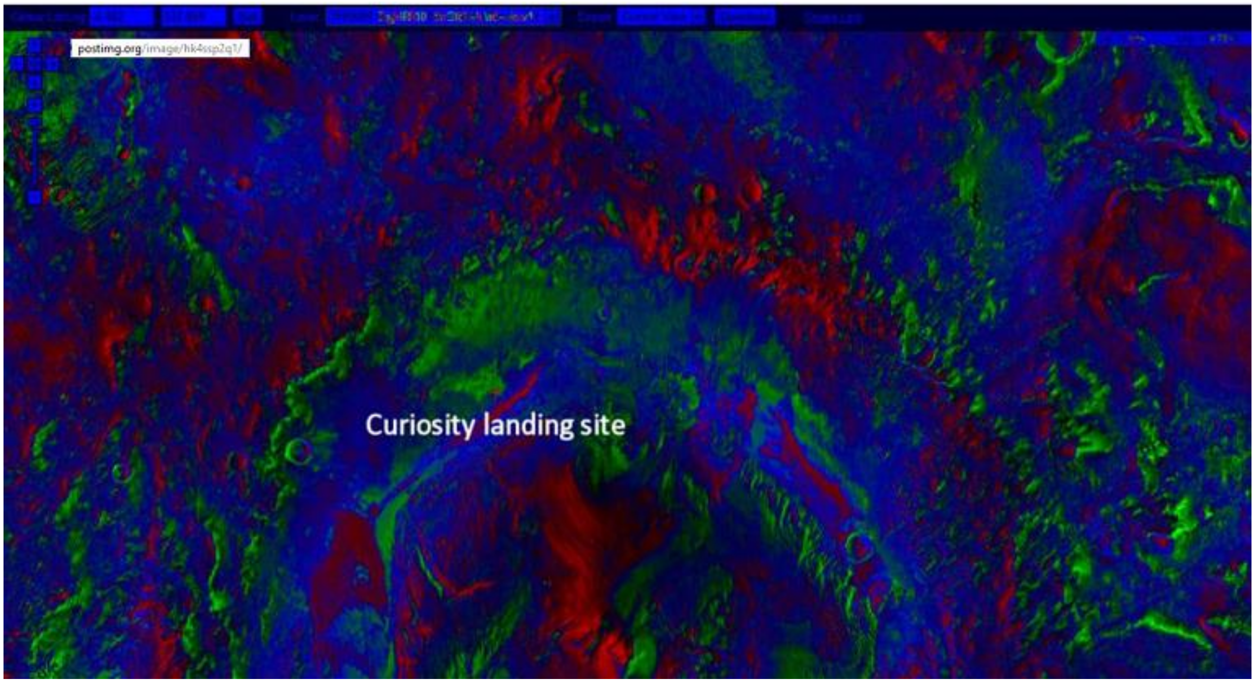


Figure 90 - Combining day and night infrared shooting, Marco de Marco obtained this map in false colors where red spots area areas that tend to warm up more quickly during the day, while green resembles areas that tend to retain more warmth overnight, everything else is shown in blue.

Marco continues, "Another proof of the presence of water inside the Gale crater is provided by the infrared thermal images taken in day and night. Analysis of them provides us with very valuable information on the physical nature of the soil. What appears brighter in a photo, during the day, is given by everything that is able to quickly absorb solar thermal energy by rapidly changing its temperature. Conversely, what remains brighter in a nighttime thermal photo is given by everything that tends to accumulate heat energy, dispersing it and absorbing it much more slowly than anything else. This process, otherwise termed *thermal inertia*, is also an indicator of the density of a body. In fact, a low-density object tends to warm (or cool) much faster than an object with a higher density, which vice versa will react much more slowly to temperature changes.

"Comparing the two infrared, day and night shootings, we can build a map of the distribution of the thermal inertia of the Gale crater. In the map shown, the red corresponds to the hottest areas during the day and therefore to low thermal inertia, the green is the hottest areas at night and therefore high thermal inertia, all the rest is represented in blue. By comparing this type of analysis with other areas of Mars, it is easy to conclude that in many cases green indicates water deposits, as it coincides with the Gullies spillages and the underlying collection areas. It cannot be considered as a certainty of the presence of water, as other materials may mimic the same behavior, but it is also true that all areas where water spills are observed as well as the collection areas are always green in this type of analysis.

“Another indication in favor of the presence of water is the detection of sediment and erosive clay minerals that form only in the presence of water. They are the testimony of the ancient abundance of water on the surface of Mars, but they may also be derived from the transport of water coming out of the inner side of the crater ridge

“We strung together weekly segments of the Malin Mars Weather videos to study cloud patterns between 1 November 2008 and 19 September 2010, both corresponding to the 319th sol of the Martian year (see https://www.youtube.com/watch?v=gmNHToMav3Y). What we found was a prevalent movement from west to east with cloudy bodies sometimes coming from the Elysium plateau near Curiosity, where large cloudy formations are likely to be of orographic (mountainous) origins. Much more often, cloudy bodies come from the basin of Hellas, constantly invaded by clouds that frequently detach and propagate in the direction of the Newton crater. There are also cloud formations associated with sand storms, but in the video they appear darker and turn to orange, as opposed to clouds of water that appear lightly white or slightly turned towards the blue.

“In this regard the precipitation of water on Mars should never exceed a tenth of a millimeter. But such a small quantity of water, mostly discharged into an 11-km air column, should not have any relevance to the optical transparency of the atmosphere, even if brought to saturation. Yet the optical relevance is well visible, and is another point of disagreement with the official data provided. To merit a minimum of optical relevance, concentrations of water vapor or ice crystals in general should amount to a precipitate of at least a couple of millimeters, but this is only possible if we consider the average temperature of Mars to be not less than -40 ° C. In fact, the concentration of water in the atmosphere depends essentially on temperature, regardless of the atmospheric pressure itself, which is only determinant in establishing the possible phases. Normally -63° C is considered as the average temperature. At that temperature, in fact, the water concentration cannot exceed the partial pressure of 0.011 hPa or a 114 micron precipitate. If we wanted to set a partial pressure of at least 0.25 hPa, it would have to have an average temperature of -37 ° C instead of the -63° C currently declared. Strangely, if we apply a minimum greenhouse effect to the thermal model of Mars, since its atmosphere is composed mainly of carbon dioxide, we will easily get an average temperature between -40 ° C and -35 ° C. This obviously would have more effect on the minimum night temperatures, but the data are unclear in this respect. For Marco de Marco and us it’s clear that the official amount of water contained in the atmosphere does not match the observed phenomena.”

16. ULTRAVIOLET RADIATION AND CLOUD COVER AT MSL.

On February 20, 2016 it appeared that for the 1,256 sols accounted for the UV values (recorded or missing) indicated the following:

Table 24 - UV FOR THE FIRST 1,256 MSL SOLS		
UV INDEX	NUMBER OF SOLS	% of SOLS
EXTREMELY HIGH (UV value 5)	0	0%
VERY HIGH (UV value 4)	192 (only 17 in Year 2)	15.3866%
HIGH (UV value 3)	490	39.0127%
MEDIUM (UV value 2)	464	36.9427%
LOW (UV value 1)	19	1.5127%
N/A	91	7.2452%
Average UV value = 2.733906 for 1,167 sols; 91 had no data		

Table 24 – Initial ultraviolet radiation reported through 1,256 sols at MSL.

However we were aware that our exact count of medium and high UV values might have been slightly off because the REMS reports relied primarily on a color code to denote UV level, and the colors they chose for medium and high values were almost identical. As a backup, it was possible to put a cursor on the symbol for each sol. Eventually a printed value would appear that would make the level clear, but this was a very time consuming process that I put off until I found on February 22, 2016 that the Finnish Meteorological Institute (FMI) - was on my web site reading a previous version of this report (which included Table 24). The IP address was 193.166.22.5. The FMI invented the problematic pressure sensor used on Phoenix and MSL. They also form part of the REMS Team that is responsible for all the problematic (Non-Malin) weather reports from Gale Crater on Mars. So I decided to check every medium and high UV report. The May 14, 2016 updated results are shown below in Table 25.

TABLE 25		
FIGURES BELOW ARE FROM THE REMS TEAM AFTER THEY VISITED OUR SITES AND REVISED THEIR DATA AGAIN. Table 24 shows UV for 1,338 MSL sols.		
UV INDEX	NUMBER OF SOLS	% of SOLS
EXTREMELY HIGH (UV value 5)	0	0%
VERY HIGH (UV value 4)	192	14.3498
HIGH (UV value 3)	543	40.583%
MEDIUM (UV value 2)	495	36.9955%
LOW (UV value 1)	0. However, after REMS/NASA read this Table 12 low UV readings were restored in 2017.	0% altered again to 0.9756%
N/A	108	8.0717%
Average UV value = 2.753659 for 1,230 sols (108 had no data).		

Table 25: UV radiation reported up to Sol **1,338** after the REMS Team dropped all 19 original low UV values and then restored 12 of them.

We noted on 2/22/2016 that or sites were visited by FMI which, working for the REMS Team and NASA, bears responsibility for all MSL weather instruments and all 19 low UV values. They then altered these 19 readings to N/A or medium. **Almost all low UV values after 2/22/2016 were also altered.** As we originally wrote there were new low UV values posted by the REMS Team for Sols 1,610 and 1,611. We noted them on 2/15/2017 at http://marscorrect.com/photo4_19.html and have a print-screen of Sol 1,610 at http://marscorrect.com/images/sol_1610_error_fixed.png. Within three days of posting the low values JPL again altered them both (to Not Available).

The UV results shown on Tables 23 to 26 were a bit surprising. If we use a number of 5 to represent a UV index of extremely high, 4 for very high, 3 for high, 2 for medium, and 1 for low, then (ignoring 91 sols where there was no data on Table 24, the average UV index was only about **2.7334** – between medium and high. For Table 25 where there was no data for 108 sols, the average UV index was only about **2.753659.**

For the third year of MSL on Mars there were no surviving low UV findings. The new summary of UV findings for the first three Martian years (2,007 sols) of operations is given on Table 26.

Table 26 - UV FOR 2,007 MSL SOLS		
	NUMBER OF SOLS	% of SOLS
EXTREMELY HIGH (UV value 5)	0	0%
VERY HIGH (UV value 4)	250 (only 17 in Year 2)	13.18565%
HIGH (UV value 3)	1,095	57.753%
MEDIUM (UV value 2)	539	28.428%
LOW (UV value 1)	12 (none of these were in Year 3)	0.6329%
N/A	111	
Average UV value = 2.8349 for 1,886 sols; 111 had no data		

Table 26 - Initial ultraviolet radiation reported through 2,007 sols at MSL.

On Table 26, **the average UV index was only about 2.8349 – between medium and high. Again, this is surprisingly low** because NASA often cites what sounds like extremely high radiation (due to its allegedly thin atmosphere, lack of an atmospheric ozone layer and lack of a magnetic field) as reason why it is so difficult for life to survive on the surface of Mars, however there are other types of radiation - not included on the REMS weather reports - that are supposedly measured by MSL Curiosity. In addition to identifying neutrons, gamma rays, protons, and alpha particles (subatomic fragments consisting of 2 protons and 2 neutrons, identical to helium nuclei. The Radiation Assessment Detector (RAD) RAD identifies heavy ions up to iron on the periodic table. You can view all of the UV data for the first three Martian years of MSL Year 3 in Annex U at **http://marscorrect.com/ANNEX%20U.pdf**.

16.1 Solar Longitude for sols at MSL with very high and low ultraviolet radiation

While Viking 1, Viking 2 and MSL high pressure air measurements were close to perihelion (closest approach to the sun) as shown on Figure 91 the relationship of perihelion to UV was far less certain. The few low UV values that survived NASA editing are spread out around the Martian orbit of the sun (except for the Global Dust Storm of 2018) but the very high UV values were largely limited to the time between the start of spring and the start of fall in southern hemisphere where MSL sits. The average Ls of very high Ls readings was 234.5 whereas the Ls of perihelion when Mars is closest to the sun is 251.

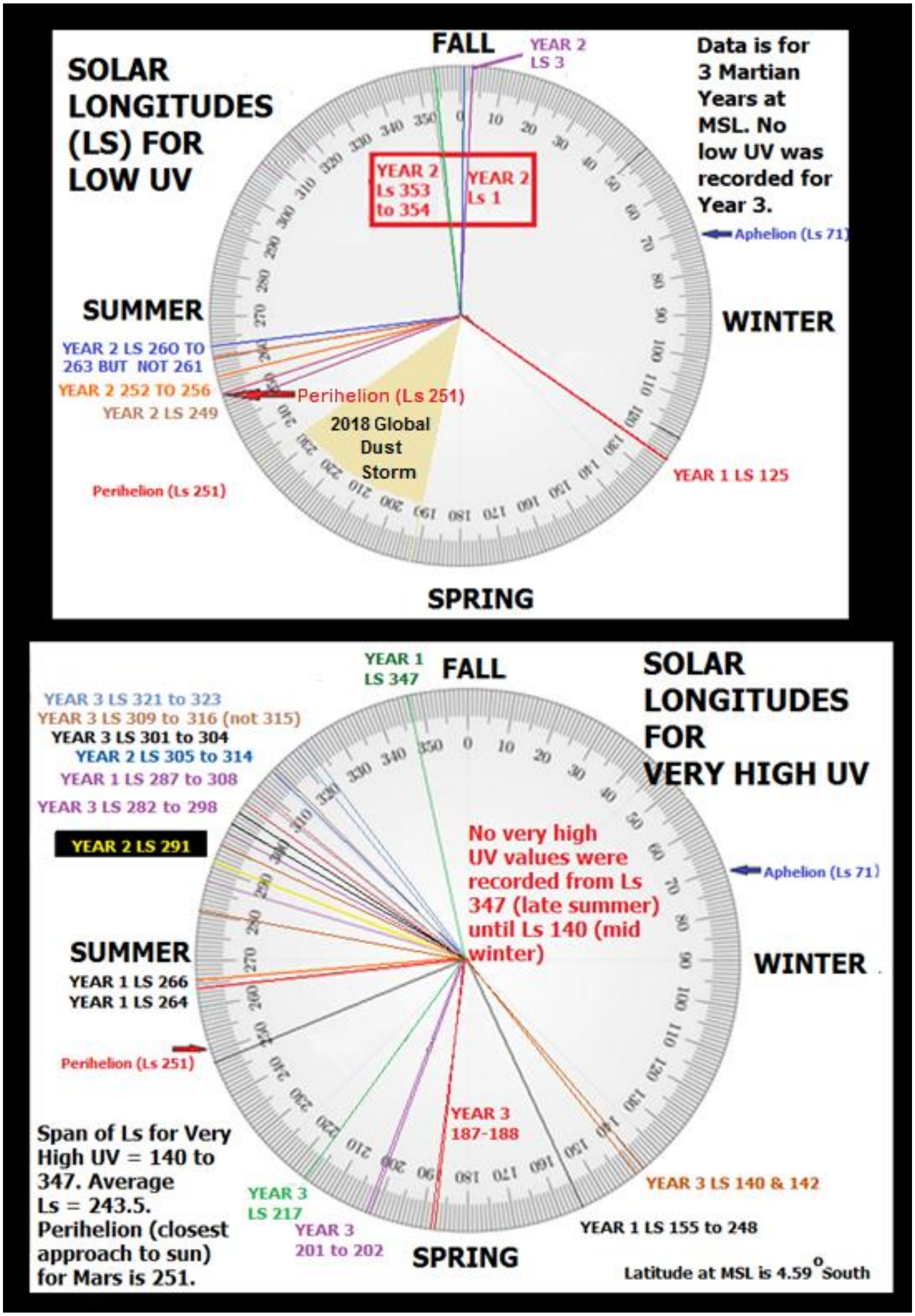


Figure 91 – Ls of Mars when MSL was experiencing low UV (top half) or very high UV (bottom half). All low UV values were removed by the REMS Team or JPL in 2016, but those shown above were reinserted by them in 2017. Low UV was also experienced at MSL during the Global Dust Storm of 2018 from Ls192 to 233.

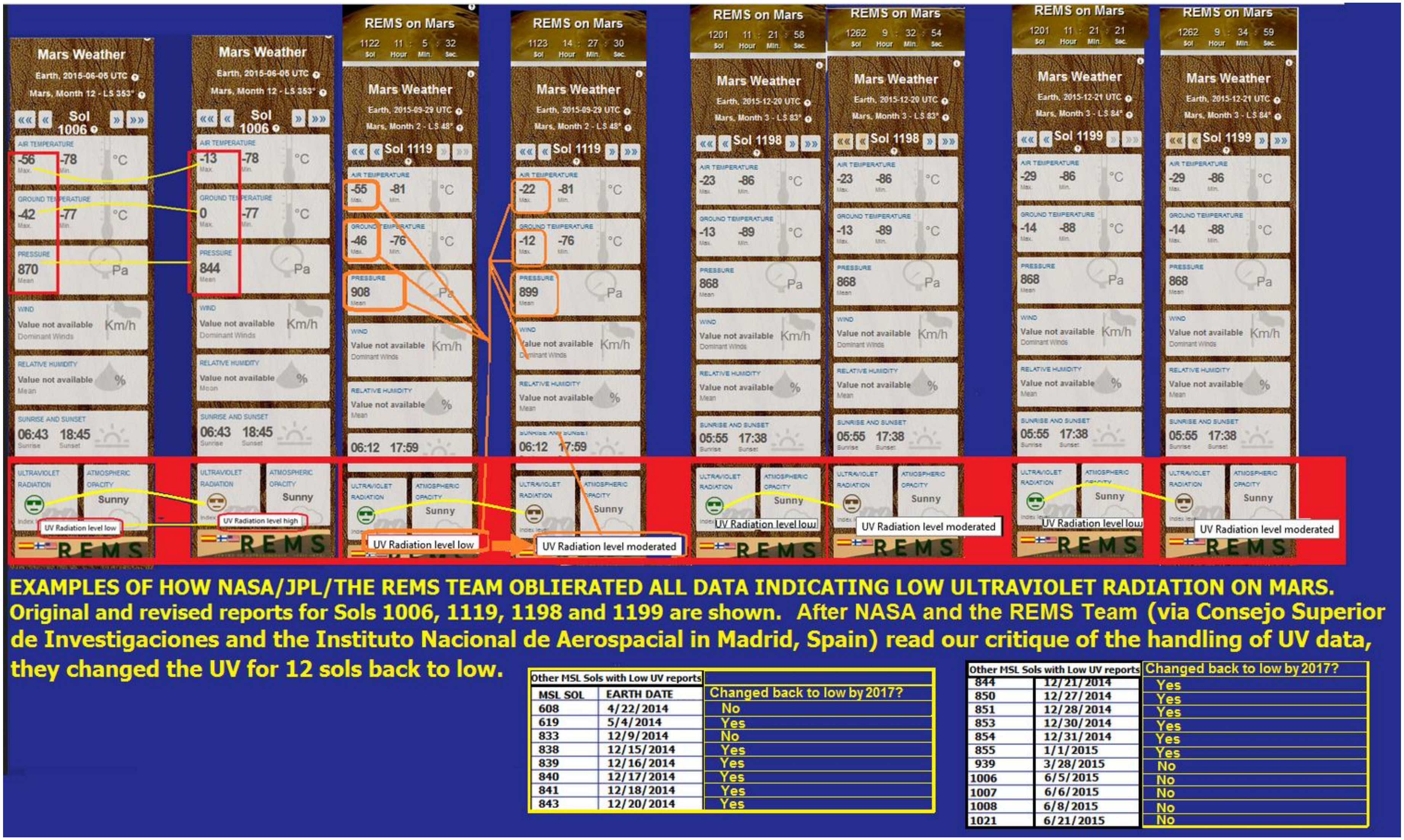
When I did a data check on 2/22/2016 I wasn't surprised to find that I had made the wrong color judgment for about 10 sols, and the corrections were immediately made on my website spreadsheet for UV reports at http://marscorrect.com/photo2_17.html. However, I was shocked to find that after I went to a great deal of trouble to graphically illustrate exactly where Mars was in its orbit around the sun when low UV was reported, all 19 incidents had been removed by the REMS Team and NASA. We believe that this action is another response to critiques seen throughout our websites.

Figure 92 shows print-screen records of several low UV values before they were tossed out of what was presented to the public after all such data was massacred. But while we thought we had summed up in the UV situation with Figure 91, again REMS shocked us reading our Report and restored at least 12 low UV values by October, 2017. The restored data is captured on Figures 93 and 94. This persistent replacing of low UV reports with moderate continued to occur at least through sols 2532 and 2533 (September 21-22, 2019).

Why are low UV values problematic for NASA? One might think that with the ultra-thin atmosphere espoused by them, and no ozone layer, ultraviolet radiation on Mars would be extremely high on at least some days. But at least up September 3, 2019 it never was, even though the REMS Team alleged that every single day at MSL so far has been "sunny." However, this claim by the REMS Team is easily refuted with data provided by the Malin Space Science Systems.

Why is the REMS Team indecisive about the idea of low UV values? Quite simply, 19 sols originally shown with low UV did not fit well with an atmosphere <1 % of Earth's, no ozone layer, and clear sky. That NASA threw out all low UV values after they read our concerns makes their action all the more suspect. They have thrown out all wind reports after our objections, changed their totally wrong sunrise and sunset times to match David Roffman's calculations, and we document many changes made to their temperature and pressure data after we color- highlighted obvious concerns on our weather spreadsheets for MSL Years 1 through 5 (see http://marscorrect.com/cgi/wp/?page_id=622 for links to all our data). Now again, after we recorded our observation of them removing low UV values, we record them read them reading our critique again and restoring most of these values.

Twelve years ago (now) Dr. David Roffman set out to understand Martian weather. At my suggestion, he wrote a simple 10-page paper (*Case for Higher Than Advertised Martian Air Pressure* – see http://davidaroffman.com/rich_text_6.html) for a technical writing course at Embry-Riddle Aeronautical University. That 10-page paper grew into this 1,200+-page full Report (including our Annexes and Appendices). Indeed, with NASA and foreign space agencies constantly at our web sites reading the latest edition of this Report we can state that this Report is becoming a controlling factor in what NASA tells the world about Mars and in what the world believes about NASA's credibility on this topic. As such, we never took down our graphics about the original low UV values posted by the REMS Team. We are right. NASA is wrong. They know it, and thus as Figures 91 to 94 show, even on this they caved in to us and restored most of the low UV values. The low UV values during the 2018 Global Dust Storm which blocked out the sun also speak volumes about much higher than advertised Martian air density and pressure.



Other MSL Sols with Low UV reports		
MSL SOL	EARTH DATE	Changed back to low by 2017?
608	4/22/2014	No
619	5/4/2014	Yes
833	12/9/2014	No
838	12/15/2014	Yes
839	12/16/2014	Yes
840	12/17/2014	Yes
841	12/18/2014	Yes
843	12/20/2014	Yes

Other MSL Sols with Low UV reports		Changed back to low by 2017?
844	12/21/2014	Yes
850	12/27/2014	Yes
851	12/28/2014	Yes
853	12/30/2014	Yes
854	12/31/2014	Yes
855	1/1/2015	Yes
939	3/28/2015	No
1006	6/5/2015	No
1007	6/6/2015	No
1008	6/8/2015	No
1021	6/21/2015	No

Figure 92 – Initial low UV values reported by the REMS Team and how the reports were altered. All low UV values between Sol 608 (April 22, 2014) and Sol 1200 on December 22, 2015 were obliterated by February 22, 2016. We caught this on the day that FMI visited the MarsCorrect.com website. There was some elimination of low UV values before this (after we highlighted them) and FMI, the REMS Team and multiple NASA IP addresses were caught reviewing our UV data before the low UV values were eliminated. By October, 2017 JPL added back 12 low UV values.

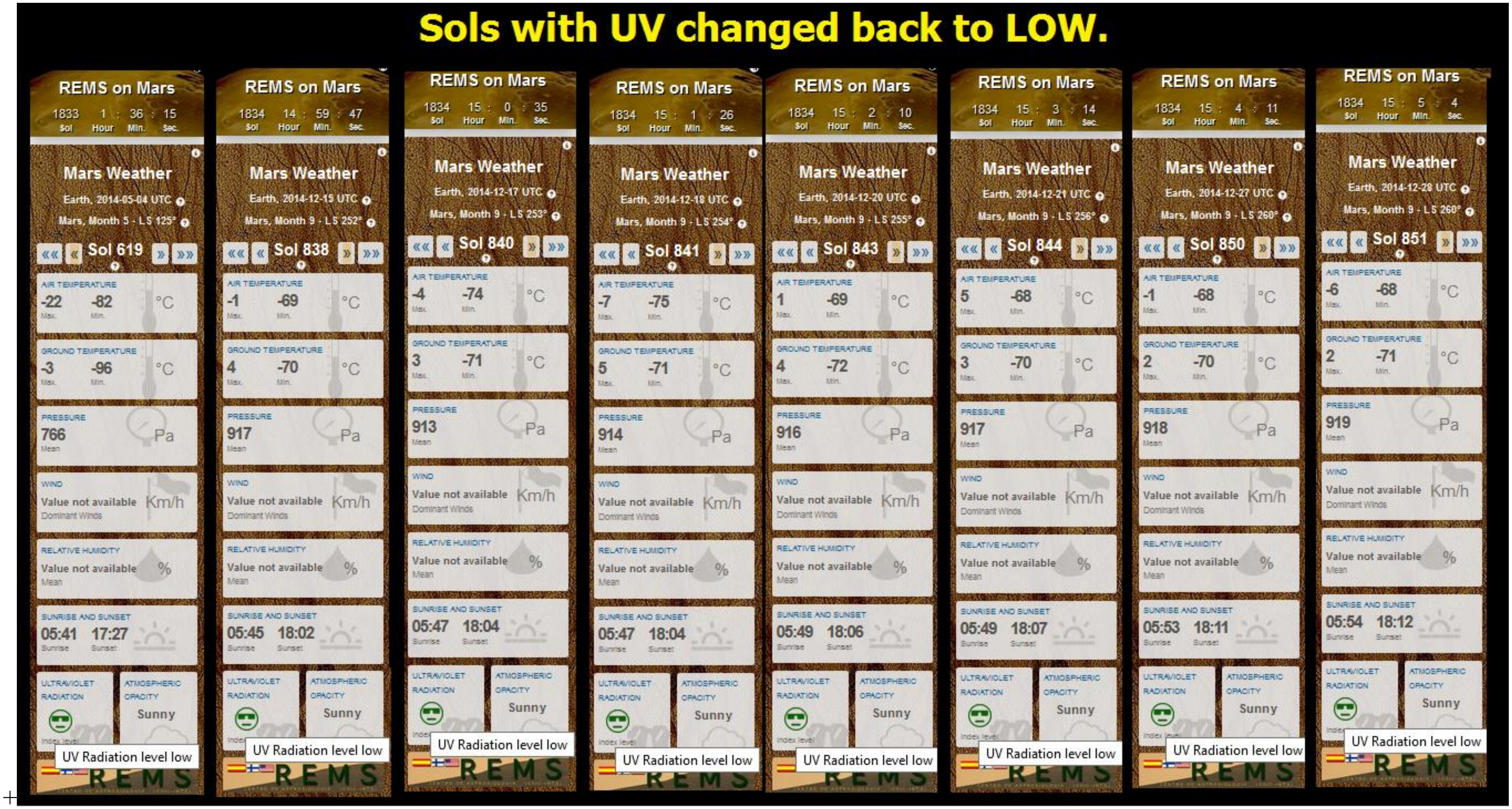


Figure 93 – After the REMS Team (a) dropped all UV values and (b) read our concerns about their behavior they changed at least 12 sols back to low *UV*. See Figure 94 for the rest of such changes

Sols originally reported with low UV		
MSL SOL	EARTH DATE	Changed back to low by 2017?
608	4/22/2014	No
619	5/4/2014	Yes
833	12/9/2014	No
838	12/15/2014	Yes
839	12/16/2014	No
840	12/17/2014	Yes
841	12/18/2014	Yes
843	12/20/2014	Yes
844	12/21/2014	Yes
850	12/27/2014	Yes
851	12/28/2014	Yes
853	12/30/2014	Yes
854	12/31/2014	Yes
855	1/1/2015	Yes
939	3/28/2015	No
1006	6/5/2015	No
1007	6/6/2015	No
1008	6/8/2015	No
1021	6/21/2015	No
1026	6/26/2015	No

Figure 94 – After the REMS Team (a) dropped all UV values and (b) read our concerns about their behavior they changed at least 12 sols back to low *UV*. Figure 93 shows such changes that were not documented on Figure 92.

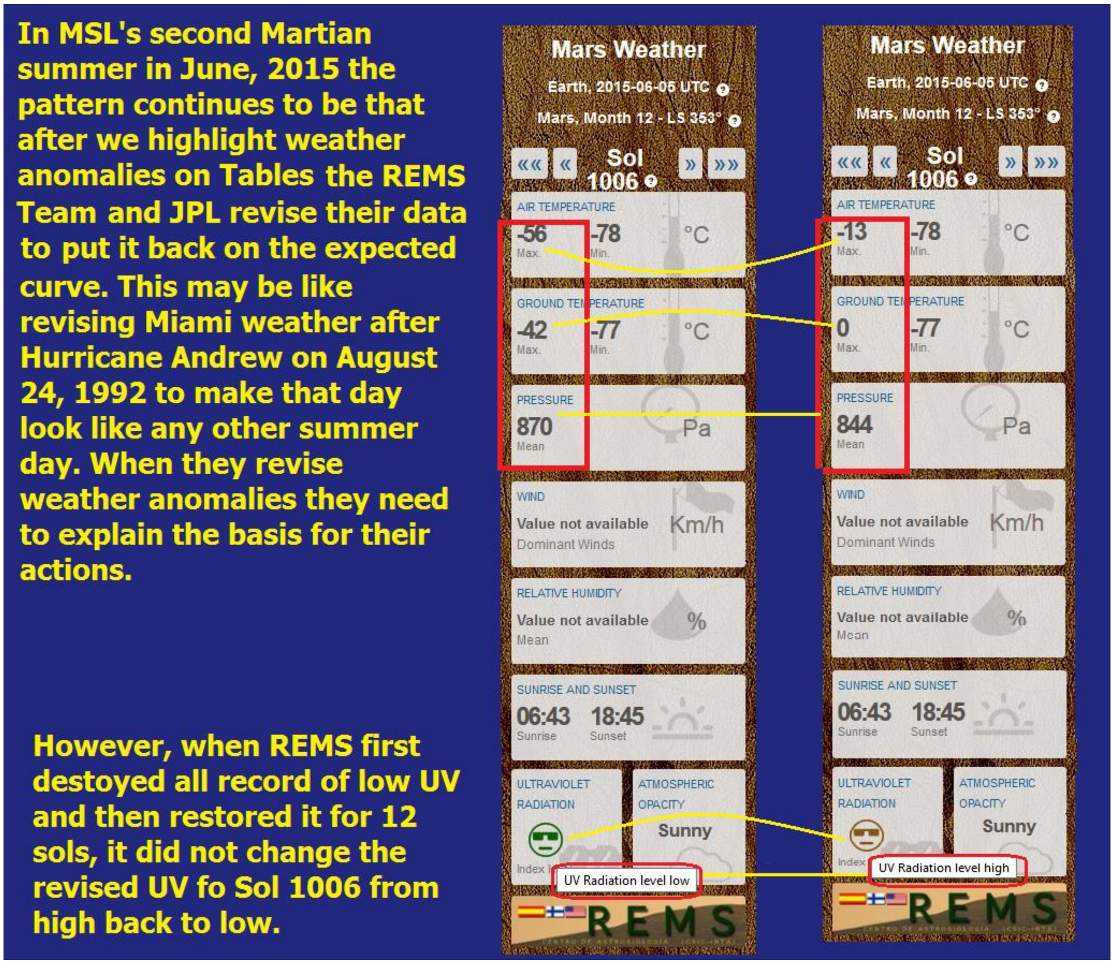


Figure 95 – Not all changes away from low *UV* were restored. As for October 12, 2017 no such restoration has been made yet for Sol 1006.

The data published by the REMS Team/JPL also mention opacity, but as of February 8, 2020 none of the 3,025 reports ever varied from SUNNY. There is reason to question the validity of this data, and in fact it is refuted by photos taken by the Mars Reconnaissance Orbiter and published by Malin Space Science Systems (MSSS).

Relative humidity is higher than expected in some parts of Gale Crater (see Figures 62 and 63 earlier in Section 14). There is brine underground and JPL has indicated that possible RSL have also been seen on the slopes of Mount Sharp in Gale crater (the location of the Curiosity rover), but that has not been confirmed yet. It is also not yet known if the rover would be able to reach them. But given the possibility of so much water, it seems odd that not one day at MSL has been reported to be cloudy by the REMS Team.

Clouds can be seen drifting by behind the Telltale wind device on Phoenix on its Sol 103, but Phoenix landed in the Martian arctic. Stratus clouds were seen 16 km above the Mars Pathfinder - see Figure 57. It landed at 19.1° North which like MSL Curiosity is in the tropics).

Clouds were seen at MER Opportunity (http://mars.nasa.gov/mer/spotlight/20080324_Opportunity.html). It landed at 1.9462°S 354.4734°E.The MSL curiosity landed at a latitude of 4.59° South. The approximate difference in latitude (4.59-1.95) is only 2.64 degrees. As each one degree difference of latitude in Mars is about 59 km, these clouds, though not at the longitude of MSL, were only 155.76 km (96.7847769 miles) north of Curiosity's latitude.

Malin Space Science Systems (MSSS) showed that, as we suspected, the claim up through Mars Science Laboratory (MSL) Curiosity Rover Sol 3,025 that all 3,025 sols reported were “sunny” is a false claim. Rather, it appears, NASA/JPL and in particular Malin have permitted the truth to be published, but not on the primary weather reporting site run by the REMS Team. We think the entire REMS Team should immediately be replaced by Malin, with a possible degree of oversight exercised by the Roffman Mars Correct Team in the U.S. and our partners in Europe including the authors of Evidence of Life on Mars? by Joseph et al. and Marco de Marco if his health is up to the job.

The MSSS images were derived from the Mars Reconnaissance Orbiter Mars Color Imager. A selection of weekly image videos for the period of time from MSL's landing on August 6, 2017 up through September 10, 2017 was shown earlier as Table 14 in Section 9 of this report. The selection was for weeks when MSSS reported weather that seemed to contradict the never-changing sunny reports provided by the REMS Team. All the images were from MARCI (Mars Color Imager) which produces a global weather map of Mars to help characterize daily, seasonal, and year-to-year variations in the red planet's climate. MARCI also observes processes such as dust storms and changes in the polar cap using five visible bands. In addition, MARCI makes ultraviolet observations at two wavelengths to detect variations in ozone, dust, and carbon dioxide in the atmosphere. MARCI observes these processes on scales of tens of kilometers. The Principal Investigator is Mike Malin.

Figure 96 shows sols that were labelled sunny by the REMS Team, but were dubious when we examined the Malin record. From October 29, 2012 to November 4, 2012 rather than describe Gale Crater as being sunny, MSSS indicates that water ice clouds persisted at equatorial latitudes including near the Curiosity Rover site in Gale Crater.

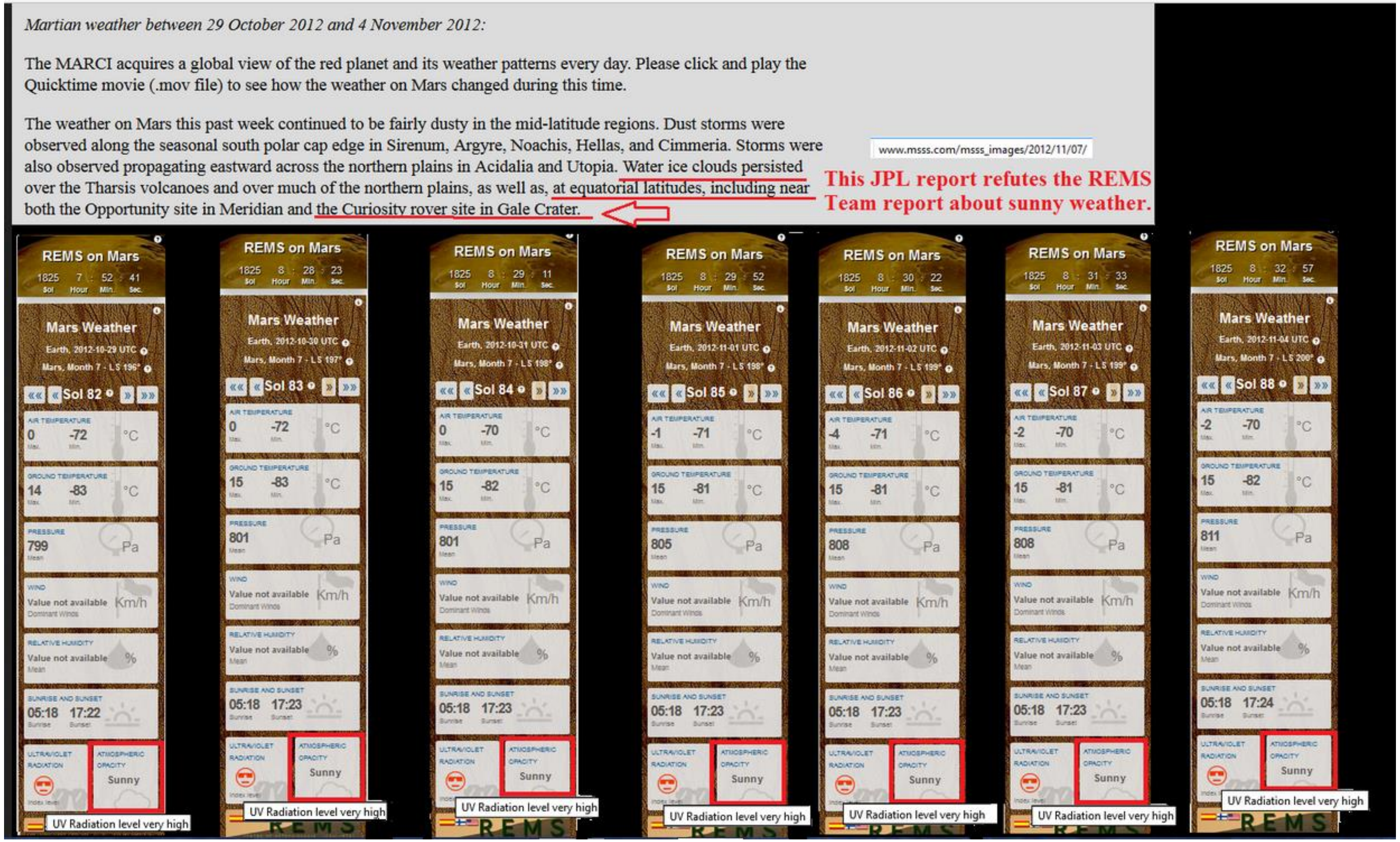


Figure 96 – skies advertised for MSL Sols 82 to 88 were not backed by the MSSS MARCI images.

17. CRASH OF THE EXOMARS 2016 SCHIAPARELLI LANDER.

On May 18, 2017 ESA published its ExoMars 2016 - Schiaparelli Anomaly Inquiry. While our research was not directly cited, we maintain a log of significant IP addresses and readers who access this Report and our Mars-related websites. One of the most frequent readers traces to the Thales Alenia Space Italia S.p.A. in Milan, Italy. They built the Schiaparelli lander. In reading through the Inquiry the following sections were of particular note:

Inquiry paragraph 6.2.2.2 High angular rate due to natural phenomenon.

*With respect to this branch of the failure tree, it has to be noted that hypersonic parachute deployment is a very complex and dynamic phenomenon affected by several uncertainties (**winds**, wake, etc.) and therefore very difficult to predict (and model).*

The following aspects, on which the investigation has focused, have been identified as potentially contributing to the high angular rates at parachute deployment.

1. Mach number different than estimated, potentially due to

*a. **Atmospheric** dispersion **density**/ temperature)*

2. Propagation error from accelerometers into position and velocity

We further note:

Each of the potential contributors to high angular rates have been analyzed. The main contributors appears to be:

2.a. Presence of Wind/Gust

Of course, with respect to atmospheric density we argue for air pressure at areoid that is about 85 times higher than NASA asserts. As for wind/gusts, if NASA was right about a low atmospheric density and pressure, winds aloft would probably be insufficient to cause the loss of the lander. ESA is likely right about correcting the problem with the IMU (Inertial Momentum Unit). Perhaps that will be enough to overcome the density problem, but we challenge the wisdom of their statement that ExoMars 2020 will proceed with models of Atmosphere and Winds as per 2016. However, it is important to understand that a full blown rejection of NASA and JPL without an in situ ESA lander measuring pressures is problematic. ESA still depends upon NASA/JPL experience for advice on a number of space-related matters. If the IMU is fixed it should not, as apparently happened in 2016, go into something akin to a nervous breakdown when the parachute is deployed and runs into much greater atmospheric density than expected. The specific final sequence of events in this "nervous breakdown" are spelled out as follows in ESA's Inquiry:

f) Parachute deployment time (time from mortar firing to peak load factor) was circa 1 sec (in line with the predictions).
- The parachute was deployed, and the parachute inflation triggered some oscillations of Schiaparelli at a frequency of approximately 2.5 Hz.
- About 0.2 sec after the peak load of the parachute inflation, the IMU measured a pitch angular rate (angular rate around Z-EDM axis) larger than expected.
- The IMU raised a saturation flag,
- During the period the IMU saturation flag was set, the GNC Software integrated an angular rate assumed to be equal to the saturation threshold rate. The integration of this constant angular rate, during which the

EDM was in reality oscillating, led to an error in the GNC estimated attitude of the EDM of about 165 degrees. This would correspond to an EDM nearly turned downside up with the front shield side pointing to quasi-zenith.

- After the parachute inflation, the oscillatory motion of Schiaparelli under its parachute was mostly damped and Schiaparelli was descending at a nominal descent rate, with very small oscillations (< 3 deg) around pitch and yaw axis.

- After parachute inflation the angular acceleration around the spin axis changed again

g) The Front Shield was jettisoned as planned 40s after parachute deployment (timer based command) at 14:46:03

h) The RDA (Radar Doppler Altimeter) was switched on at 14:46:19 (15s after Front Shield separation acknowledgment) and provided coherent slant ranges, without any indication of anomalies;

- Once the RDA is on, RIL (Radar in the Loop) mode, "consistency checks" between IMU and RDA measurements are performed. The parameters checked are: delta velocity and delta altitude. The altitude is obtained using the GNC estimated attitude to project the RDA slant ranges on the vertical.

- Because of the error in the estimated attitude that occurred at parachute inflation, the GNC Software projected the RDA range measurements with an erroneous off-vertical angle and deduced a negative altitude (cosines of angles > 90 degrees are negative). There was no check on board of the plausibility of this altitude calculation

i) Consequently the "consistency check" failed for more than 5 sec. after which the RDA was forced anyway into the loop based on the logic that landing was impossible without the RDA. The correctness of the other contributor to the altitude estimation, i.e. the attitude estimate, was not put in question. The RDA was put in the loop (event signaled by RIL time-out flag at 14:46:46).

- The GNC (Guidance Navigation and Control) mode entered was TERMINAL DESCENT where the altitude is scrutinized to release the Back-Shell and parachute if the altitude is below an on board calculated limit.

- Because of the incorrect attitude estimation leading to an estimated negative altitude, the GNC Software validated the conditions for separating the back-shell and parachute

j) Back-shell separation at 14:46:49.

k) Switch-on of the Reaction Control System (RCS).

- First RCS thruster operation was at 14:46:51 (no backshell avoidance maneuver)

l) Switch-off of the RCS 3 seconds later at 14:46:54.

- The criterion for the RCS switch-off was based on the estimation of the EDM (Entry Demonstrator Module) energy (as combination of the altitude and vertical velocity) being lower than a pre-set threshold. Since the estimation of the altitude was negative and very big, the negative potential energy was much higher than the positive kinetic energy (square of the velocity) and this criterion was immediately satisfied the RCS was commanded off as soon as allowed by the thruster modulation logic. This occurred just 3 seconds after the RCS switch on command when the capsule was at an altitude of about 3.7 km, leading to a free fall of Schiaparelli and to the impact on Mars surface about 34 seconds later.

m) The Touch Down occurred at 14:47:28 corresponding to the crash of the surface platform on the surface of Mars at an estimated velocity of ≈150 m/s. The expected landing time was 14:48:05 (some 37s later).

We summarize major events of the Schiaparelli Entry Descent and Land (crash) and times on Table 27 below:

TABLE 27 - PREDICTED AND ACTUAL TIMES OF MAJOR EVENTS IN SCHIAPARELLI EDL

	A	B	C	D	E	F
	ENTRY TIME (2017 report) 14:42:22	Event and time to event based on ESA prediction 2016	Expected Clock time based on 2016 ESA prediction + 14:42:22 entry	Actual time to event in 2017	Clock time of event in 2017	Diversion from planned time
1		Expected parachute deployment +3:21	Expected parachute deployment clock time 14:45:43	Observed time to chute deployment +3:01	Actual clock time of chute deployment 14:45:23	20 seconds early
2				IMU measures pitch rate greater than expected. IMU raises a saturation flag. ~+3:01.2	~14:45:23.2	
3		+4:01	radar on 14:46:23	+3:57	radar on 14:46:19	
4				+4:24	radar in the loop 14:46:46	
5		chute jettison with back-shell +5:22	chute jettison with back-shell 14:47:44	+4:27	back-shell separation 14:46:49	back-shell off 55 seconds early
6		+5:23	14:47:45	+4:29	first thruster fires 14:46:51	54 seconds early
7		+5:52	14:48:14	+4:32	thruster shuts down 3.7 km high 14:46:54	80 seconds early

A	B	C	D	E	F	
ENTRY TIME (2017 report) 14:42:22	Event and time to event based on ESA prediction 2016	Expected Clock time based on 2016 ESA prediction + 14:42:22 entry	Actual time to event in 2017	Clock time of event in 2017	Diversion from planned time	46 seconds early (2016 prediction) 37 seconds Early (2017)
8		Landing +5:52 per 2016 ESA diagram	14:48:14 (2016 prediction) 14:48:05	+5:06 after entry	crash 14:47:28	46 seconds early (2016 prediction) 37 seconds Early (2017)

At some point, hopefully in 2022, ESA will succeed. But here we must caution NASA. There is an old cliché:'

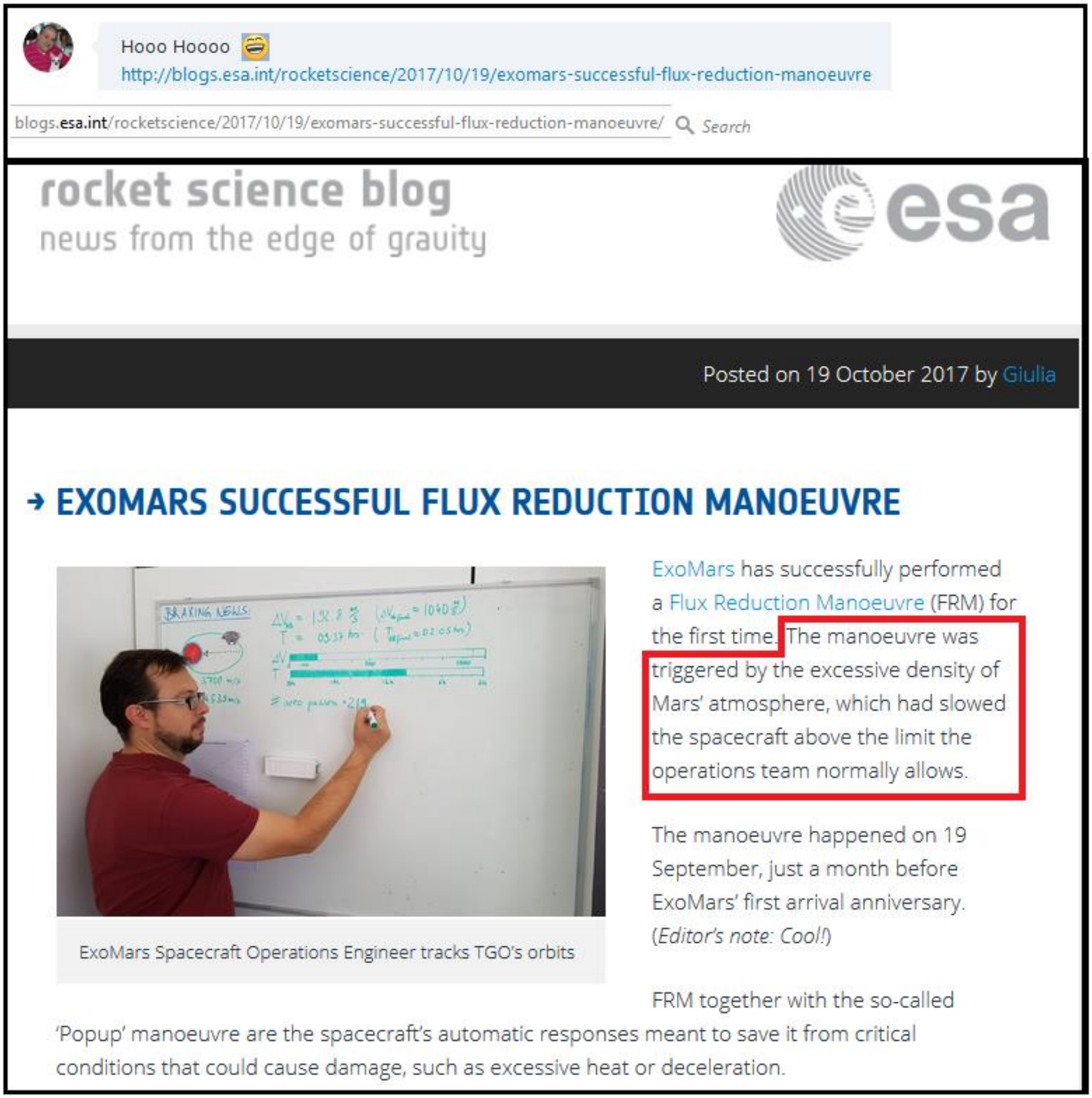
> *Fool me once, shame on you. Fool me twice, shame on me.*

NASA has fooled ESA once. But ESA is on to the problem and should not be fooled again. If NASA announces that they have come to understand that air pressure is much higher than they previously announced, there may be room for plausible deniability with respect to issues related to liability.

Whether NASA blames mistakes on unit conversion, or failure to allow for dust filter replacement on transducers, or inability to provide critical design information with respect to heat sources near the Vaisala pressure sensor due to ITAR, NASA can still preserve its respect if they publically abandon their loyalty to a 6.1 mbar pressure at areoid in time to ensure a successful ExoMars 2022 mission. But if that lander or the Chinese Tianwen-1 lander in 2021 safely arrive on the Martian surface and reveal ongoing fraud on a massive basis, the results for NASA and U.S. Government credibility will be catastrophic.

17.1 ESA gets smarter - Raises ExoMars orbit due to excessive density of Mars's atmosphere.

See Figure 97. This is similar to what was seen with the Mars Global Surveyor and also with the Mars Reconnaissance Orbiter. Both of these incidents were discussed earlier in Section 10 of this report. With the loss of the Schiaparelli lander and now this public ESA statement about excessive density of Martian air, the question remains as to when NASA will reach and publish the same common sense conclusion but we would be surprised to be it occur as a result of observations made by the Perseverance because again it apparently carries a pressure sensor that can only measure up to 11.5 mbar. In the Chinese Tianwen-1 the sensor can measure up to 20 mbar. If NASA is close to being right about air pressure on Mars, the Chinese sensor will be better for measure pressure increases during major global or regional dust storms. But if my son and I are right about average pressure being about 511 mbar, neither the U.S. nor Chinese sensor will be good for anything other than continuing disinformation.



Hooo Hoooo
http://blogs.esa.int/rocketscience/2017/10/19/exomars-successful-flux-reduction-manoeuvre

blogs.esa.int/rocketscience/2017/10/19/exomars-successful-flux-reduction-manoeuvre/ Search

rocket science blog
news from the edge of gravity

esa

Posted on 19 October 2017 by Giulia

→ EXOMARS SUCCESSFUL FLUX REDUCTION MANOEUVRE

ExoMars Spacecraft Operations Engineer tracks TGO's orbits

ExoMars has successfully performed a Flux Reduction Manoeuvre (FRM) for the first time. The manoeuvre was triggered by the excessive density of Mars' atmosphere, which had slowed the spacecraft above the limit the operations team normally allows.

The manoeuvre happened on 19 September, just a month before ExoMars' first arrival anniversary. (*Editor's note: Cool!*)

FRM together with the so-called 'Popup' manoeuvre are the spacecraft's automatic responses meant to save it from critical conditions that could cause damage, such as excessive heat or deceleration.

Figure 97– On October 19, 2017 ESA reported that ExoMars had to raise its orbit. The move was mandated by "excessive density of Mars' atmosphere." We received notice of this from our partner Marco de Marco.

18. CRITICAL OBSERVATIONS. There were problems with just about all aspects of NASA Martian weather data and instruments.

18.1 Dust devils. The enigma of dust devils on a planet with extremely low air pressure first led to this investigation into whether or not the public was being given correct data about Mars. At the beginning of this study in September, 2009 it was found that dust devils matched terrestrial dust devils in every respect except absolute and relative pressure excursions.

18.2 Accuracy of instrument descriptions. In fact, I asked an astronomy professor to obtain weather data for the Phoenix lander from the Planetary Data System (PDS). He did, and sent us an enormous file. A sample of it is posted at http://marscorrect.com/PHOENIX%20TEMPERATURE%20DATA%20SAMPLE.pdf. But, more than 5 years after he obtained it for us, the data remains problematic because there are four temperature columns with data for 0.5, 1, 1.5 and 2 meter elevations. The problem is that there were only three temperature sensors on Phoenix, with locations at 0.25, 0.5 and 1 meter above the lander (Taylor et al 2008).[69] Further, the 2 meter temperatures (on a daily cyclic basis) were found to be a good bit higher than the 1.5 meter readings. For example, at the first sample data line on the link above temperatures are 242.8775K at 0.5 m, 238.7638K at 1 m, 239.8803 at 1.5 m and then up to 257.6K at 2 m, an increase of 17.7197K (about 31.9 degrees Fahrenheit) in a half meter (19.685 inches). The professor was not able to procure clarification from NASA.

Further as noted by Nathan Mariels in Section 15.6.4., when the format of the data is changed some older data gets converted wrong if the software thinks it's all in the new format."

18.3 Data management. At a minimum, poor data management leads to false information being taught in our science classrooms, and it serves as a false basis for public support of tax-funded space programs. Worse, it leads to distrust of our Government and speculation about why our Government appears to be covering up the truth about Mars.

18.4. The crash of the ExoMars 2016. Traditional wisdom is that we could not have had so many successes on Mars if we did not understand the pressure there. But there were many failures right up through and including ExoMars 2016, some unexplained, and only six successful landers that attempted to measure in situ pressure, all with questionable dust filter capabilities and other design problems. Based on two years of almost daily visits for months by Thales-Alena Space Italy (which designed the billion-dollar Schiaparelli lander for ExoMars 2016) to an article found at http://davidaroffman.com/photo4_9.html, it seems likely that they know their failure was at least in part due to trusting in NASA's weather data rather than our analysis of their data, which they had accessed numerous times before the failure.

18.5. During Viking 1 and 2 Year 1, pressures varied closely with Gay-Lussac/ Amonton's Law-based predictions for a gas trapped in a closed container. This may imply that the Tavis transducers employed measured the pressure of air caught behind dust clots rather than ambient air pressure outside the lander. In previous editions of this report we wrote that the same was true for Phoenix and for MSL. Phoenix had no RTG heater, but it did have battery operated heaters. One of them operated the meteorological suite of instruments**.** It was thought that electronics that operate these instruments should generate enough heat on their own to keep most of them running. This sounds like there was no need to pump heat into the pressure transducer. If so, there may indeed have been slow cooling of the air trapped behind the clogged dust filter that, combined with a slowly dying battery and no timed heat pump, led to no pressure spikes seen like those of Vikings and MSL. Thus the pressure recorded simply went down at a steady rate as was shown earlier in Figure 12A (Section 2.4). However, now that we are aware that the Vaisala sensor can measure more pressure than was previously known, the problem may lie elsewhere.

Perhaps conveniently, Phoenix pressure readings (which appear to closely follow the pressure readings of Viking 2 and MSL shown on Figure 21B in Section 4) were cut off at Ls 151.5° of the Martian orbit. This is about when Viking 1, Viking 2 and MSL all recorded minimum pressure. Ls 149.088° was the average Ls of their minimum pressure (see Table 7 for Section 4.1). For Pathfinder the battery was used to heat the probe's electronics to slightly above the expected nighttime temperatures on Mars.[95] Had the battery not been turned off then we might have soon seen the expected rise in pressure if there was reason for Phoenix to continue following the VL-2 curve.

18.6 Data digitization Issues and stuck pressure readings. In Section 2.6.1 we saw that accuracy of the Viking pressure readings was questionable where pressure changes asserted were under .08 mbar because surface pressure measurements were limited by digitization to ≈ 0.088 mbar. Data was especially suspicious where pressures remained stuck for days even though huge hourly temperature changes were being recorded (see Annex C at http://marscorrect.com/ANNEX%20C%209%20September%202013.pdf). The longest such period was between sols 700.5 and 706.46, essentially six full Martian days when the temperature varied from -23.41° C to -83.17° C, a difference of 59.18°C (106.524°F). Pressures that are stuck over such wide variations of temperature almost certainly mean that the pressure sensors were not functioning correctly. Nathan Mariels informed us that normally when a sensor encounters a problem, it will continue to report the last pressure it had. However, when pressures were not stuck, they tended to vary strongly with what would be expected of gas trapped behind a dust clot with the gas being subjected to heating by the RTG.

18.7. Pressure readings affected by heat generating internal events. As noted in Section 2.6.2, highly consistent pressure increases in the mornings at 0730, afternoon at 1630 and nights at 2330 Local True Solar Time at Vikings 1 and 2 suggest that the pressure sensors were reacting to the RTG heaters *or* scheduled internal events that generated heat rather than ambient pressures. A similar pattern was seen for limited MSL data that was released.

18.8 Inconsistent reports about the maximum pressures measurements possible with FMI transducers. Consistent with past actions and as we predicted, the 1,177 Pa, 1,200 Pa and 1154 Pa pressures for sols 1,160 and 1,161 and 1301 were revised down by JPL (to 899, 898 and 752 Pa). They were way above the curve (and above the previously announced 1150 Pa maximum pressure rating of the pressure sensor on MSL) but still too low to explain the weather. However, the 1,200 hPa pressure exactly matches the "optimized" pressure range referred to in the FMI abstract to the American Geophysical Union in 2012. Perhaps the FMI dropped the reported pressure for Sol 1,161 to 898 Pa (8.98 mbar) lest attention be brought on the full range of 1 to 1,025 hPa/mbar on MSL – but this is only speculation.

18.9. Timing of pressure spikes. We made a check in Annex E (http://davidaroffman.com/ANNEX%20E%209%20September%202013.pdf), of what the percent differences were between measured and predicted pressures provided for each time-bin (25 per Martian day/sol between Viking 1 sols 200 and 350). It showed that the percent differences for the period of greatest interest (time-bins 0.3 and 0.34) was only 2.67%.

18.10 Annex F and how the time of day affects the accuracy of pressure predictions.

Annex F (**http://marscorrect.com/ANNEX%20F%20%2010%20September%202013.pdf**) demonstrates that there was great repeatability in the times each Martian day for when the percent difference between measured and predicted pressures was under 2%. The data indicates that when heaters were expected to come on, pressure predictions based on Gay-Lussac/Amonton's Law for a gas being heated in a confined space (behind the dust clots) were quite accurate. But when the heaters were likely to be off, the accuracy of Gay-Lussac/Amonton's Law prediction fell. How much it fell was likely related to how effective insulation was on the Vikings.

18.11. Mariner Pressure Results. Mariner 4, 6, and 7 only provided radio occultation points for six places on Mars. NASA History Office document SP-4212 On Mars: Exploration of the Red Planet 1958-1978 reported occultation pressures for Mariner 6 and 7 (Mariner 69's) at the surface of Mars that ranged from 4 to 20 mbar, and it implied 80 mbar for the Mariner 4 estimate.[96]

18.12. Landing Pressure Capabilities. No Viking ever included instruments that could measure pressures over 18 mbar, Phoenix could supposedly not measure over 12 mbar. However, now that we have seen the 1 to 1,025 maximum pressure for MSL, we must point out that apparently identical Vaisala sensors were delivered to NASA. Earlier we thought that Phoenix and Vaisala sensors were delivered to NASA at the same time, but when we went to check this fact on July 24, 2017 it seemed to vanish. The sensors for both probes look identical. They are shown on Figure 11A. But the weights seem a bit different.

18.13. Deliberate use of flawed sensors. On September 30, 2008 (http://space.fmi.fi/solar.htm) FMI wrote that, "FMI's pressure and humidity sensors for NASA's Mars Science Laboratory mission were delivered in Summer 2008. The launch towards equatorial regions of Mars is planned for 2011, followed by ESA's Exomars mission a few years later, also with atmospheric sensors from FMI aboard." The Phoenix landed on Mars on May 25, 2008. Therefore if the MSL sensor was indeed delivered to NASA in the summer of 2008, the Phoenix version of the sensor was already on Mars. The Schiaparelli lander was likely carrying a flawed Vaisala sensor, but we'll never know what it would have shown in terms of pressure. However ESA should be extremely careful before accepting another FMI-built transducer.

When, in 2013, I called Guy Webster at JPL to tell him that constant winds at Gale Crater, Mars of 7.2 km from the east for nine months were impossible, he immediately told me that he *knew* these REMS reports were wrong and that the wind sensor broke on landing. The next day he deleted the wind data – and NASA also took down impossible sunrise and sunset times, replacing them with times based on David's calculations. Likewise if NASA knows their pressure instruments are faulty they should announce this fact *before* any foreign government can prove them wrong in a way that suggests criminal behavior. They can stay ahead of the problem if they act **now,** but not if, via a successful landing, China or ESA/Roscosmos shows how wrong they are.

In earlier versions of this report we wrote that MPF was restricted to 10 mbar on the surface, and MSL was held to 11.5 mbar. The mean pressure recorded for MSL sol 370 was 11.49 mbar (at least until we challenged it and JPL revised it). The original pressure indicates that for much or most of that day the actual pressure was almost certainly above the maximum pressure that the Vaisala pressure transducer could measure. The REMS Team published 1,177 Pa and 1,200 Pa pressures for sols 1,160 and 1,161, but after over two months of our questioning these pressures on our web sites, JPL backed off and revised the pressures to 899 and 898 Pa. See Figure 14E. They likewise backed off a 1154 Pa pressure for sol 1301 and changed it to 752 Pa. See Figure 14F. However, the REMS Team and the FMI read our findings. So when we found on July, 24, 2017 that REMS was suddenly posting a maximum pressure range of up to 1,400 Pa (see Figure 88) all we could say is, "How Convenient!" But it is totally inconsistent with everything they published before, and then there is that little matter of the transducer actually being capable of measuring up to 1,025 hPa (102,500 Pa – see Figure 86).

18.14. Innocent Mistakes? There were several Tavis sensors with widely different pressure sensitivity ranges. Similar looking and sized Tavis transducers could measure up to 0.1 psia (6.9 mbar), 0.174 psia limit (12 mbar), 0.2 psia (13.79 mbar), 0.26 psia (17.9 mbar), 0.36 psia (24.82 mbar), or 15 psia (1,034 mbar). Given their outward similarity and the enigma of Martian weather, the possible installation of the wrong Tavis sensor cannot be overlooked. For detailed information about Tavis transducers see Annex G to this Report (**http://marscorrect.com/ANNEX%20G%2010%20September%202013.pdf**).

An example of simple mistakes made by Mars "experts" can be seen by examining pressures reported by the REMS Team for MSL. See Figure 17A. In fact, for at least the first eight months after MSL landed, there were many obvious errors in daily reports issued by the REMS Team and the associated Ashima Research Company. These mistakes by the REMS Team included confusion between hPa and Pa pressure units, the wrong Martian month, and as mentioned above, constant wind at 7.2 km/hr (2 m/s) from the east when in fact, with a broken meteorological boom, there was no accurate wind information available.

There was also a failure to include relative humidity in any daily weather reports. Until May, 2013 with Ashima Research there were daily reports with sunrise stuck at 6 AM and sunset stuck at 5 PM local Martian time. The constant 13 hours of night and 11 hours of daylight, whether in late winter or early spring was impossible. In fact, at MSL – just south of the equator - there is never even a single day that has only 11 hours of daylight. Ashima showed that experts are capable of huge mistakes, however in May, 2013 they finally fixed their times, essentially matching day length calculations that we made. In July 2013 these corrected times were included on revised REMS daily reports. We don't know if it was due to our incessant critiques of their work, but by 2016 Ashima removed its web site from the Internet rendering all its weather data (except what we captured by print screens and present in this Report) no longer available to the public.

Due to ITAR, the Finnish Meteorological Institute (FMI, which designed the pressure sensor used on Phoenix and MSL) did not have access to critical information required to both construct the sensor and interpret its results. This caused calibration problems. See Section 2.4.1.

The tiny Vaisala dust filter on Phoenix did not perform in a manner that FMI could understand. The REMS reports provide reason to believe that this remains true for the essentially identical sensor used on MSL (see Figure 11A at http://marscorrect.com/images/corrrect_11a.png).

18.15. Effects of Dust storms. Dust storms on the surface caused dynamic pressures at 121 km to increase by a factor of 5.6. This has not been correlated with pressure increases at the surface, but when opacity values increase to levels high enough to block 99% of light, pressures are likely to increase dramatically. This assertion is backed by a dust storm that turned day to night-like darkness in an Arizona Dust Storm on July 5, 2011. Pressure at Luke Air Force Base increased during the dust storm by 6.6 mbar – more than average pressure (6.1 mbar) at areoid on Mars. See Figures 35, 41 earlier plus Figure 98 below.

Figure 98 – Changes in sky color and opacity due to the dust storm at MSL between May & June 2018.

18.16. **Altitude and pressure changes seen**. After factoring in altitude changes as Curiosity climbed Mount Sharp in Gale Crater during the 2018 Global Dust Storm that hit Curiosity as is shown in Figure 43 (and shut down Opportunity http://davidaroffman.com/images/figure_41at_opportunity.png) there was no increase in pressure that matched what was expected for an atmosphere carrying a new heavy dust load. Our spreadsheet covering this storm at was given earlier as Table 15B (http://davidaroffman.com/custom3_68.html).

18.17. Effects on Aerobraking. Mars Global Surveyor, Mars Reconnaissance Orbiter and ExoMars 2016 all encountered unexpectedly high deceleration during aerobraking operations at Mars. Such high deceleration can only be due to a higher density atmosphere than what was anticipated at altitude. See Sections 10 and 17.1.

18.18. Diurnal pressure fluctuation. Maximum and minimum pressure times seen by Tavis pressure transducers on Vikings and Pathfinder did not match times for these events recorded by the Vaisala (FMI) transducer on Phoenix. However as of the date of this report the REMS Team has only released readily accessible hourly pressures for Sols 9.5 to 13, and hourly temperatures for Sol 10 to 11.5 (although it may exist on the PDS).

18.19. Organic chemicals found on Mars. The original Viking findings rejected life on Mars because NASA claimed the Vikings found no organic chemistry. This absence of organic chemistry has been overturned.[89] Since then, methane has been found to be emitted from at least four sites on Mars (including detection by MSL at Gale Crater). On December 16, 2014 JPL announced that it had found methane spikes of 5.5, 7, 7 and 9 ppbv (parts per billion volume), about 10 times higher than the background methane measured earlier (0.7 +/- 0.2 ppbv (see Figure 47B). Other organic chemicals found in the Cumberland sample at Gale Crater included chloromethane, dichloromethane, trichloromethane, dichloroethane, 1,2 – dichloropropane, 1,2 – dichlorobutane and chlorobenzene.

18/20. Evidence for life on Mars. Levin (1997)[88] believes that the results of the labeled release life detection experiment on both Vikings backed the detection of microorganisms. If correct, this also may point to higher than assumed pressures, and the failure of Viking pressure instruments to correctly record pressure due to clogged dust filters.

We believe that MSL likely photographed life on Mars on its Sol 1185 to 1189 and later returned to it on Sols 1248 to 1249. This was shown on Figures 71 and 73. Our belief was reinforced by the Journal of Astrobiology who contacted us and requested us to produce an article about. See Meteorological Implications: Evidence of Life on Mars? We are less certain that the tree stump-like object seen at MSL on its Sol 1647 (see Figure 82) was what it looked like, but we note that the object seen around Sol 1185 was observed during a period of extraordinarily high winter ground temperatures highs while that seen at in the late summer at Sol 1647 was observed during of period of record cold ground temperature lows.

Prior to MSL which used rockets for a controlled entry, the previous 4 successful landers all were downrange by 13.4 to 27 km, but 3 landers were lost since 1999. All could have landed short. NASA has requested help with its modeling of the Martian atmosphere.[77] True, Beagle 2 was eventually found after 11 years, but the record shows suspect alteration of the landing ellipse size and the full report was classified.

18.21. Problems with transducer design and testing. We believe that (if deliberate disinformation is not a factor) the problem of unbelievable low pressures lies with the design of pressure transducers and the failure of NASA to include a way to replace dust filters that clogged on landing.

During MPF pre-launch calibration of its Tavis transducer, both the flight and pressure sensor was inadvertently exposed to temperatures 30 K below their design limits. See Annex G at **http://marscorrect.com/ANNEX%20G%2010%20September%202013.pdf**. It would also appear that MSL low temperatures reported are far colder than the pressure sensor was designed to handle. At the link just given for Annex G we show NASA Report TM X-74020 which states that the temperature range tested was -28.89° C to +71.11° C.

18.22. Failure to replicate dust devils. NASA Ames could not replicate dust devils without jacking up winds to 11+ times greater than speeds associated with Martian dust devils.

18.23. Sand movement not possible at NASA's claimed Martian air pressure. HiRISE findings about bedforms, and in particular, photos of MER Spirit tracks being filled in by sand demonstrate that air must be denser than assumed. Wind tunnel tests by NASA show that 80 mph (35.76 m/s) are required to move sand at 6 mbar. No such wind velocity was reported in the 8,331 Viking 1 and 2 wind measurements that were reported upon in this report. However, if their pressure sensors were faulty then their wind speeds may have been incorrect too.

18.24. Lower than expected ultraviolet radiation. One might think that with the ultra-thin atmosphere espoused by NASA, and no ozone layer, ultraviolet radiation on Mars would be extremely high on at least some days. But it never was, even though NASA alleged that every single day at MSL so far has been "sunny." If we use a number of 5 to represent a UV index of extremely high, 4 for very high, 3 for high, 2 for medium, and 1 for low, then (ignoring 108 sols where there was no data), for the first 1,338 sols (two Martian years) the average UV index was about 2.75 – between medium and high.

18.25. Stratus clouds at high altitudes. Stratus clouds up to 16 km above Mars Pathfinder (that is, clouds at 12.318 km above areoid) suggest pressures at areoid of around 511 mbar, and at the Hellas Basin above average pressures on Earth.

18.26. The real pressure on Mars? REMS Team reports published between September 1 and September 5, 2012 showed pressures between 742 and 747 mbar. These pressures closely match our prediction of 767 mbar at MSL based on the height of stratus clouds above Pathfinder. Curiously, while we cannot vouch for its validity, we were contacted by a source with an IP address in Estonia. It was about a hoax broadcast in 1977, supposedly made as an April Fool's joke, but it was not released then. The film (at https://www.youtube.com/watch?v=CsVqa2xaBeQ) alleged a joint U.S. - Russian unmanned landing on Mars on May 22, 1962. We can see some kind of probe landing slowly and there are comments (in both English and Russian) about weather conditions on Mars. We hear: Temperature 4 degrees Celsius, Wind speed: 21 km/h, Atmospheric pressure **707.7 millibars.** So the temperature and wind was consistent with NASA weather reports, but they closely matched our pressure findings rather than NASA's. A blurry version of the film just cited is also found on line at https://www.youtube.com/watch?v=Y0keDDnZ8zA, but there it's attributed to a 1945 joint German-Japanese effort.

With respect to the first film link given, the claimed landing at an area on Mars with pressure about what we advocate is not what really caught our attention. Rather, it was that the reverse IP address for my unknown Estonian friend was at the U.S. Department of Defense. Disinformation or leak? I don't know, but the DoD and in fact Fort Huachuca, an Army Intelligence case, is on our sites multiple times daily. They were probably curious to see how I would react to their bait. It's not uncommon for me to see reader IP addresses in Russia or China with a reverse IP that takes me to the DoD Network Information Center or to one specific U.S. military base. We record NASA, ESA, Kremlin, Roscosmos and Chinese Space Agency IPs. It was been our policy to not record military IP addresses but on 6/18/2018 we learned that when a huge number of NASA AMES IP addresses (at least 430) had their first digit removed, what came up was our most frequent DoD reader. We take their interest as an indication that they likely agree with our findings, but are not yet cleared to publically indicate so.

We began documenting all REMS and Ashima Research daily weather data problems on our web site at http://marscorrect.com/photo2_12.html. Annex M to this report combines old and new REMS data claims. See **http://marscorrect.com/ANNEX%20M%20AUG%2027%202015.pdf**. While the REMS Team/JPL and Ashima Research (before Ashima went offline) have altered their reports to match our calculations and assertions, the major disagreement on pressure still remains as of the date of this report. We believe that NASA's pressure figures are at least one, but more likely two orders of magnitude too low.

Successful landings may have been despite NASA's misunderstanding of pressure there, not because of accurate data about it. In fact, the first successful landers (the two Vikings) were designed to land with no prior in situ pressure data. As of February 24, 2021 no probe from another nation ever landed successfully on Mars after the Viking pressure information was published and accepted by the scientific community. We hope that's about to change and that China's Tianwen-1 will not only land successfully in a few months, but also give us an honest read out on the pressure it finds.

Acceptance of low pressure values may actually have *caused* some of the crashes to follow Vikings. It is unwise to ignore weather systems that should not occur in a near vacuum. Indeed, on October 19, 2016 an ESA-Roscosmos Mars lander (Schiaparelli) crashed on Mars after its parachute jettisoned early. The ESA Inquiry is covered in Section 17 of this Report, but note that they did indeed point to problems related to air density.

19. RECOMMENDATIONS

All MSL Weather Reporting should be immediately taken away from the REMS Team and reassigned to Malin Space Science Systems with a degree of independent oversight assigned to someone who understands the implication of all the findings of this Report. Further, NASA should officially justify selecting a pressure sensor for Perseverance that is limited to a maximum pressure of 11.5 mbar (less than some pressures initially published for MSL.

In particular, an independent review of the pressure-related data from Mars should be conducted. As was shown with Figures 14A, B, C and D (all for Sol 370) and elsewhere as with Annexes M through Q to this Report, there is strong evidence to support suspicion that NASA alters data for political, career-enhancing reasons, or national security reasons. At a minimum the original Viking, Pathfinder, Phoenix and MSL pressure transducers should be retested for the effects of dust and cold temperatures that are more consistent with assumed values on Mars.

Originally we wrote that *critical here is the location of the Tavis Dash No. 1 pressure sensor (15 PSIA/1,034 mbar) ordered for Mars Pathfinder. This is the one that could measure Earth-like pressures. If NASA cannot account for it, then there is more reason to suspect that it, rather than the Tavis Dash No. 2 (0.174 PSIA/12 mbar) sensor shown on the same CAD was the actual sensor sent to Mars. The CAD is shown at Figure 10B in this report, and is on our site at http://marscorrect.com/images/correct_10b.png*. However, when we learned that for Mars Insight NASA chose the older Tavis #10484 transducer (see Figure 10D) over the newer Vaisala transducer that we had criticized so much, we also saw that Tavis had both low and high pressure sensitivity ranges on the same component meaning that they could likely toggle between both ranges without the public knowing about it.

As ITAR restricts sharing of sensitive technology with foreign contractors, for U.S. launched Mars missions contracts with these restrictions should only be awarded to U.S. firms. However, because instruments can be flawed, and data can be manipulated, for us to really understand Mars, a manned mission must be funded if it can be shown that such a mission will not bring a dangerous virus (similar to COVID-19) or other pathogen back to Earth.

The father-son Roffman Research Team is divided as to the degree of caution needed. My son, Dr. David Roffman, is willing for the Sample Return portion of the Perseverance lander to be brought back to Earth and he wants to see people on Mars as soon as possible. I don't agree. As was shown in our article Meteorological Implications: Evidence of Life on Mars? and in its parent article Evidence of Life on Mars? by R. Gabriel Joseph et. al (2019) there is outstanding evidence that there are primitive and probably terrestrial-sourced life (algae, bacteria, fungi, basidiomycota (puffballs), cyanobacteria, stromatolites, and lichens on Mars now. I think we should assume that Mars is also home for viruses.

20. ACKNOWLEDGEMENTS

Thanks are due to Professor James E. Tillman for making much of the Viking data available to the public. He answered *some* of our questions; but left unanswered exactly how the rate of heat flow from radioisotope thermoelectric generators to internal components was regulated – by external or internal temperature or by a timer that was set to shift as sunrise occurred later in the Martian calendar?

Further thanks are due to David's Embry-Riddle Aeronautical University's Professors Michael Hickey, Olivero, Jason Aufdenberg, and Yongho Lee.

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We appreciate JPL public relations director Guy Webster for acknowledging via a "thank you" by e-mail on May 17, 2013 that we were right about REMS Team and Ashima Research being wrong on winds, and that we were right about Martian daylight hours as was manifest by Ashima changing their reports to essentially match our figures within a minute or two each day, with the difference being due only to Ashima's rounding off sunrise and sunset times to the nearest minute (see Figure 17B). JPL (the REMS Team) eventually also incorporated

our times into its reports. Concessions made on these two issues reinforce our belief that NASA will eventually be forced to confess that we are right about pressure too.

We also need to acknowledge the tremendous influx of data supporting our findings by Marco de Marco and Matteo Fagone. They are both gifted researchers and talented video production people who have, without our knowing it until late September, 2017, followed our research in detail for six years, and produced quality research and films (in Italian) backing it. Both men interviewed my son and me on September 3, 2017. See the 3 hour, 43 minute show at https://www.youtube.com/watch?v=PqCxAErabuU. After learning about the quality of their work in establishing the true nature of Mars I begun to translate a great deal of their work from Italian into English and to incorporate it into this Report and our web sites. They both have provided excellent links to the European Space Agency which means that together, hopefully, we can do much to ensure that the ExoMars 2022 mission will have a chance to succeed, however they cannot depend on inadequate pressure transducers like those sent to Mars so far.

Finally special thanks are due to Dr. Frank Crossman for the offer to publish our research for the International Mars Society.

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