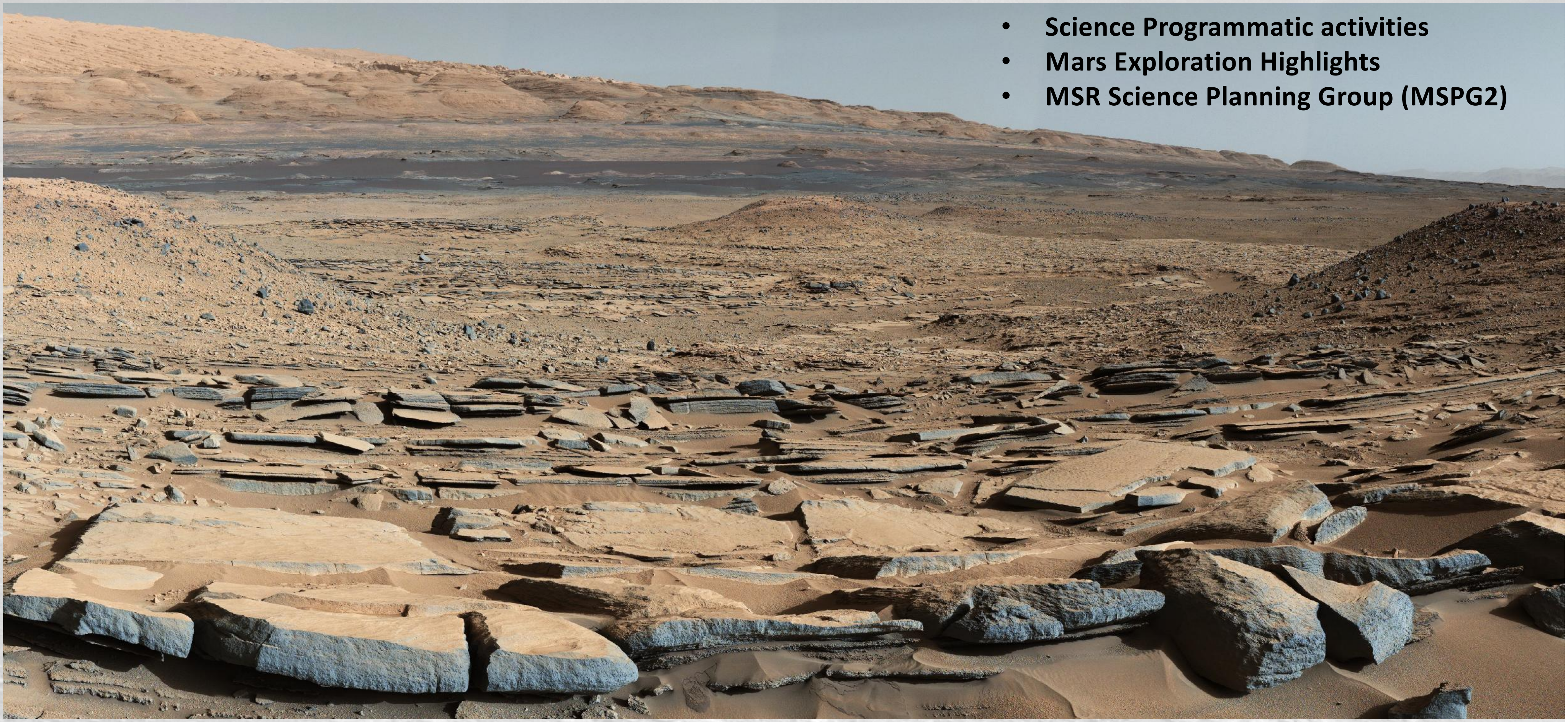
Mars Science



- **Science Programmatic activities**
- **Mars Exploration Highlights**
- **MSR Science Planning Group (MSPG2)**

Michael Meyer
Chief Scientist

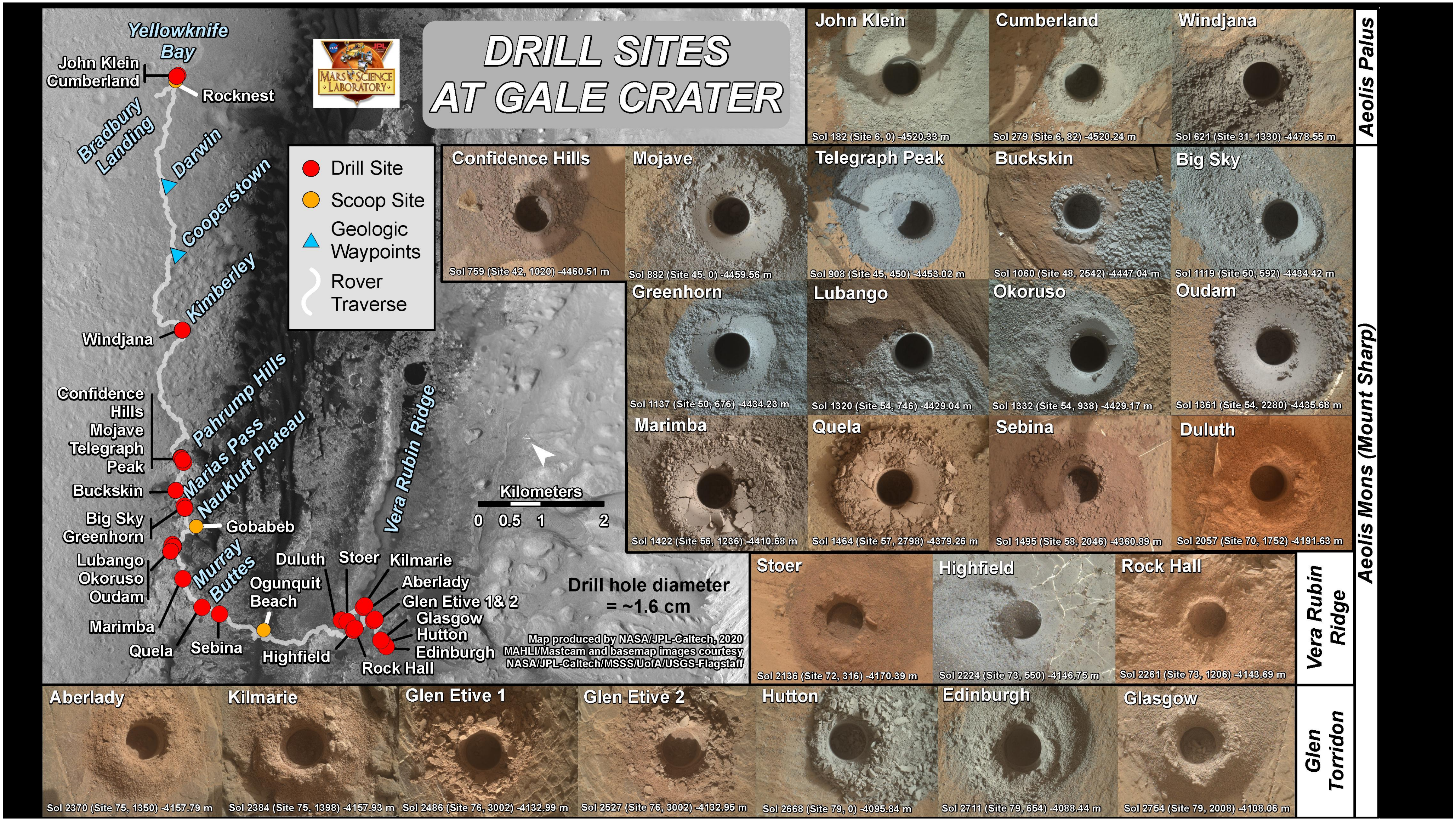
PAC Aug. 17, 2020

Mars Science Programmatic Activities

- Mars Architecture Strategy Working Group – what could and should be done in addition to or after Mars Sample Return
  - Preliminary report in ppt form presented at HQ, MEPAG virtual meeting, and draft formally reviewed by senior members of the Mars community
  - Written draft in preparation, expect to be submitted possibly as early as end of August or early September
  - White paper containing key findings/recommendations submitted to decadal process *Mars, The Nearest Habitable World – A Comprehensive Program For Future Mars Exploration*
- Over 70 Mars White Papers submitted to the *Planetary Science and Astrobiology Decadal Survey 2023-2032*
- NASA/ESA Mars Sample Return Sample Planning Group – Phase 2
  - To address science and curation planning questions for analyzing samples brought from Mars
  - Established in June 2020

One of 8 Postcards from Curiosity's 8th Anniversary of landing on Mars – 5:32am UTC, August 6, 2012

View from base of Mt Sharp, March 24, 2014

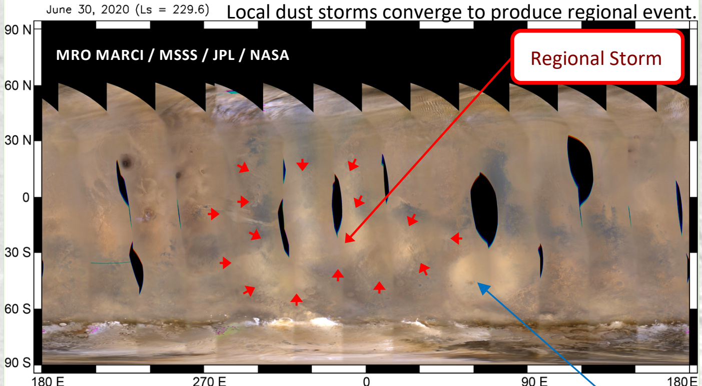

DRILL SITES AT GALE CRATER
MARS SCIENCE LABORATORY
Drill Site
Scoop Site
Geologic Waypoints
Rover Traverse
Yellowknife Bay
John Klein
Cumberland
Rocknest
Bradbury Landing
Darwin
Cooperstown
Kimberley
Windjana
Pahrump Hills
Confidence Hills
Mojave
Telegraph Peak
Marias Pass
Naukluft Plateau
Buckskin
Big Sky
Greenhorn
Gobabeb
Lubango
Okoruso
Oudam
Murray Buttes
Marimba
Quela
Sebina
Ogunquit Beach
Highfield
Duluth
Stoer
Kilmarie
Aberlady
Glen Etive 1& 2
Glasgow
Hutton
Edinburgh
Rock Hall
Vera Rubin Ridge
Kilometers
0 0.5 1 2
Drill hole diameter = ~1.6 cm
Map produced by NASA/JPL-Caltech, 2020
MAHLI/Mastcam and basemap images courtesy
NASA/JPL-Caltech/MSSS/UofA/USGS-Flagstaff
Aeolis Palus
Aeolis Mons (Mount Sharp)
Vera Rubin Ridge
Glen Torridon
John Klein
Sol 182 (Site 6, 0) -4520.33 m
Cumberland
Sol 279 (Site 6, 82) -4520.24 m
Windjana
Sol 621 (Site 31, 1330) -4478.55 m
Confidence Hills
Sol 759 (Site 42, 1020) -4460.51 m
Mojave
Sol 882 (Site 45, 0) -4459.56 m
Telegraph Peak
Sol 908 (Site 45, 450) -4453.02 m
Buckskin
Sol 1060 (Site 48, 2542) -4447.04 m
Big Sky
Sol 1119 (Site 50, 592) -4434.42 m
Greenhorn
Sol 1137 (Site 50, 676) -4434.23 m
Lubango
Sol 1320 (Site 54, 746) -4429.04 m
Okoruso
Sol 1332 (Site 54, 938) -4429.17 m
Oudam
Sol 1361 (Site 54, 2280) -4435.68 m
Marimba
Sol 1422 (Site 56, 1236) -4410.68 m
Quela
Sol 1464 (Site 57, 2798) -4379.26 m
Sebina
Sol 1495 (Site 58, 2046) -4360.89 m
Duluth
Sol 2057 (Site 70, 1752) -4191.63 m
Stoer
Sol 2136 (Site 72, 316) -4170.39 m
Highfield
Sol 2224 (Site 73, 550) -4146.75 m
Rock Hall
Sol 2261 (Site 73, 1206) -4143.69 m
Aberlady
Sol 2370 (Site 75, 1350) -4157.79 m
Kilmarie
Sol 2384 (Site 75, 1398) -4157.93 m
Glen Etive 1
Sol 2486 (Site 76, 3002) -4132.99 m
Glen Etive 2
Sol 2527 (Site 76, 3002) -4132.95 m
Hutton
Sol 2668 (Site 79, 0) -4095.84 m
Edinburgh
Sol 2711 (Site 79, 654) -4088.44 m
Glasgow
Sol 2754 (Site 79, 2008) -4108.06 m

https://mslreports.jpl.nasa.gov/surface/data/surface/strategic/8/MSL_Drill_targets_sol2754_8x14_v2.jpg

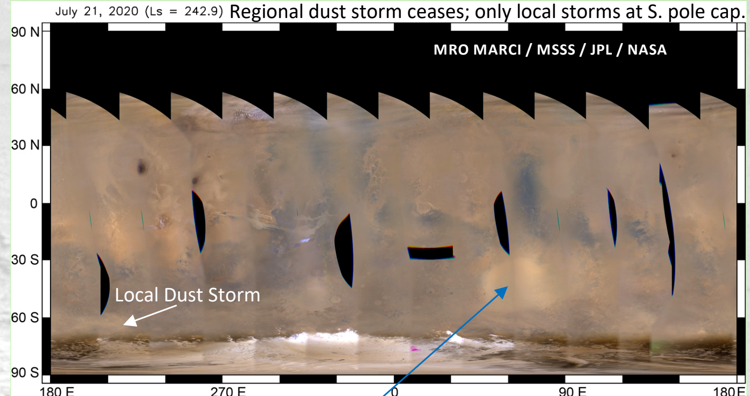
Mars Reconnaissance Orbiter

Mars Year 35 Regional “A” Dust Storm

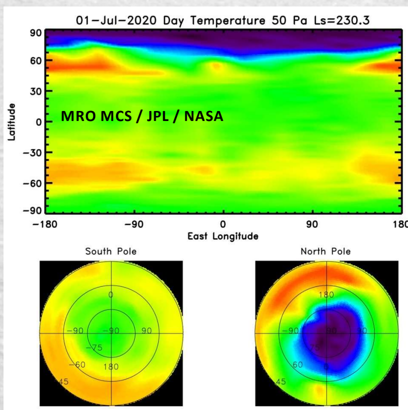
June 30, 2020 (Ls = 229.6) Local dust storms converge to produce regional event.



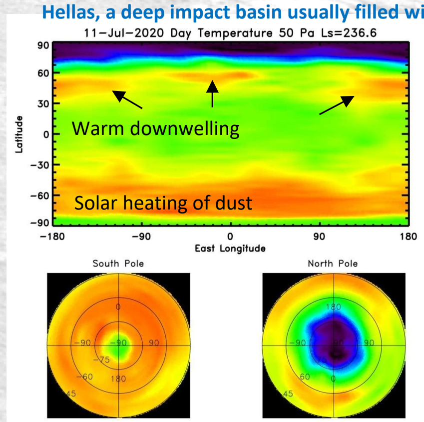
July 21, 2020 (Ls = 242.9) Regional dust storm ceases; only local storms at S. pole cap.



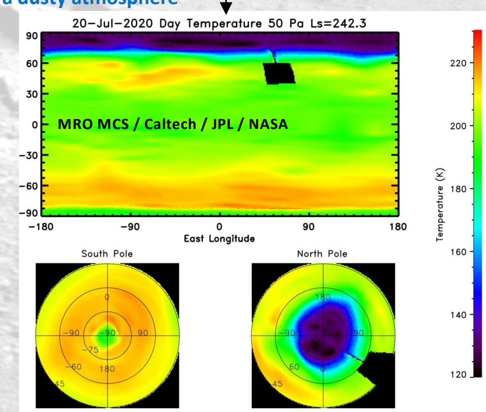
Hellas, a deep impact basin usually filled with a dusty atmosphere



Middle atmosphere (~30 km) temperatures near their seasonal values for middle southern spring; dust not yet lifted to these altitudes.



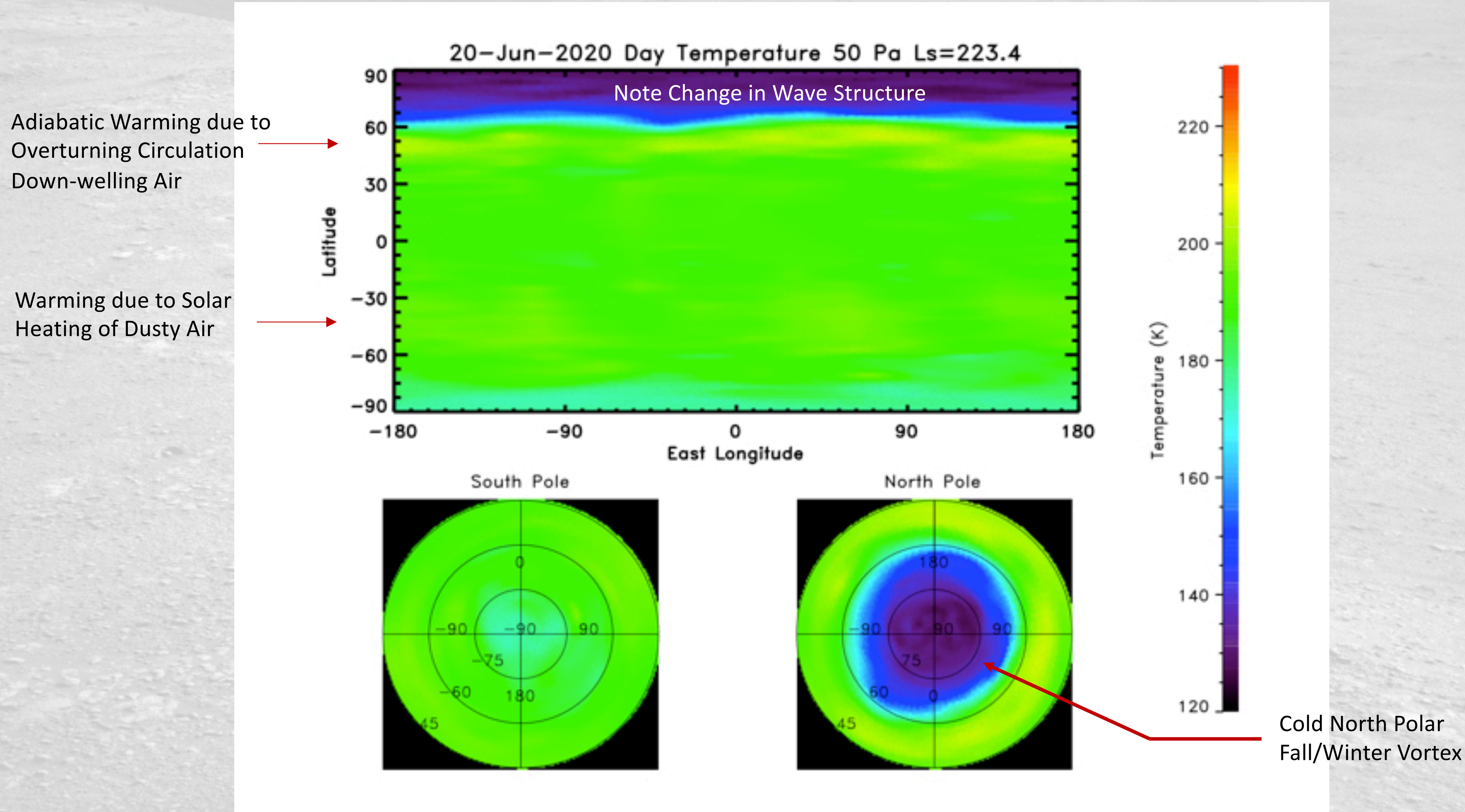
Middle atmosphere temperatures at their peak as dust is lifted higher into the atmosphere. Solar heating of the dust warms southern mid-latitudes. Enhanced downwelling warms edge of N. polar vortex.



Middle atmosphere warming wanes as dust haze thins in the absence of new dust injection.

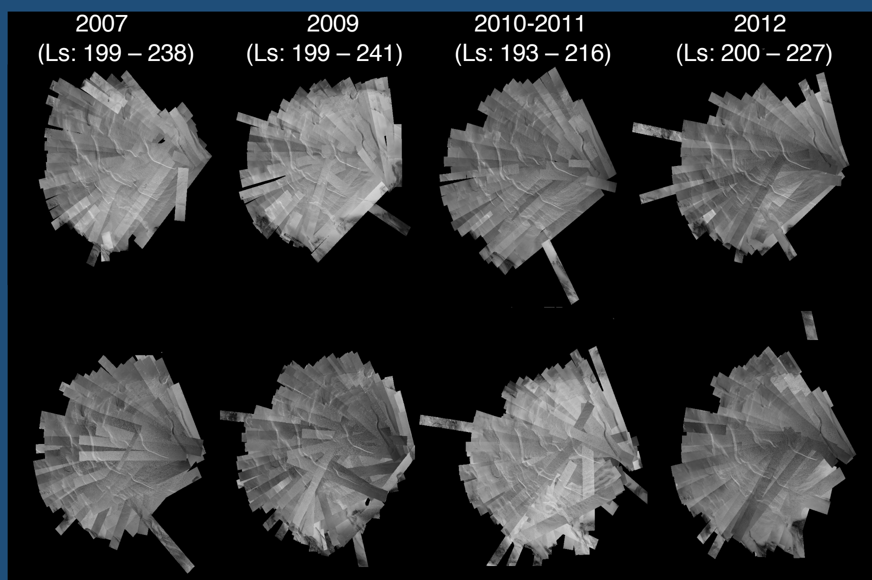
Daily Daytime 50 Pa Temperatures During A *Mars Regional Dust Storm*

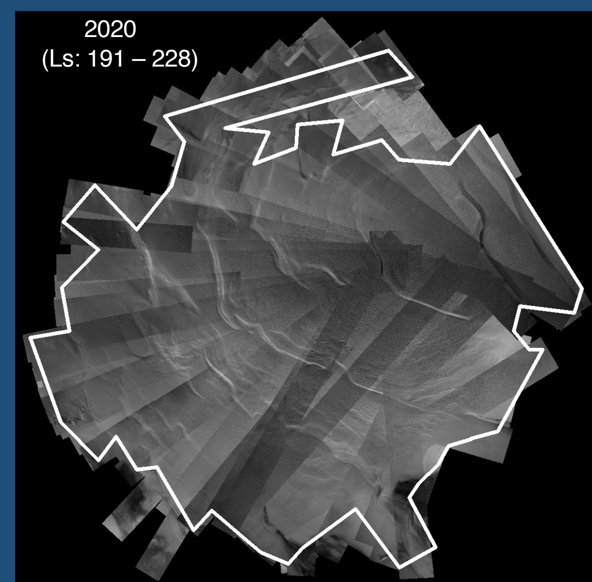
MRO MCS / JPL / NASA



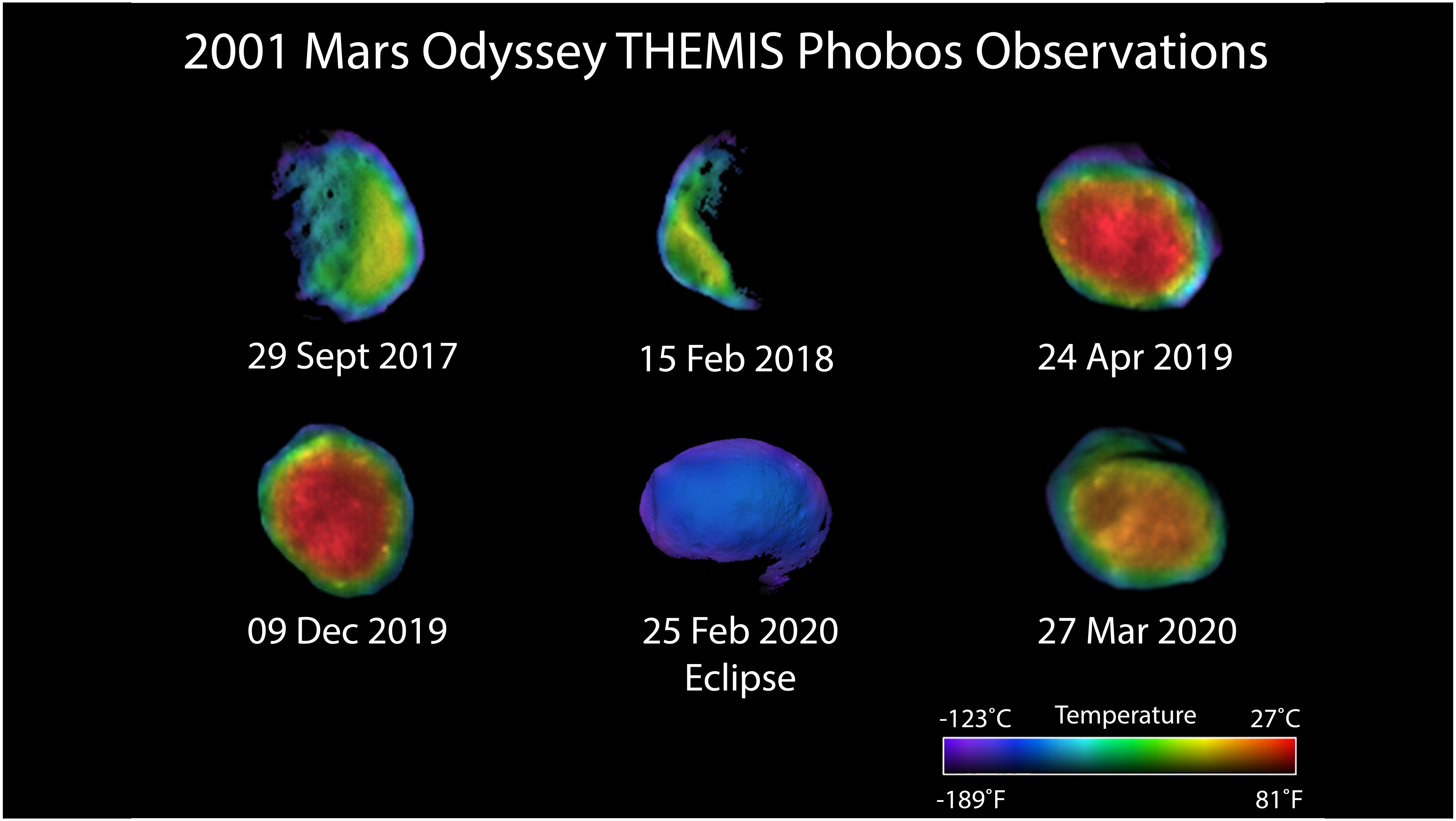
CTX South Polar Residual Cap (SPRC) Spring Campaign

- Goal is to obtain a full CTX mosaic of the south polar residual cap in southern spring
- Began imaging at April 28, 2020 (Ls 191), last image taken at June 28, 2020 (Ls 228)
- 92 images used to complete this mosaic

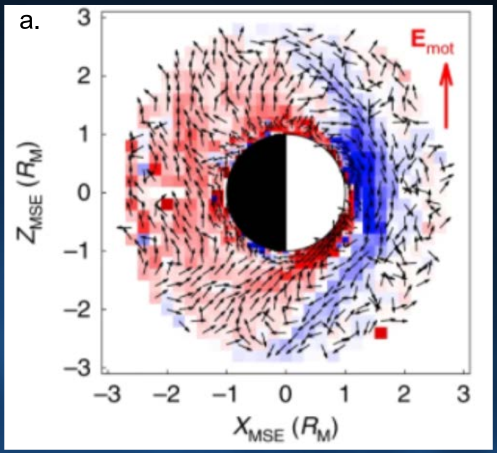


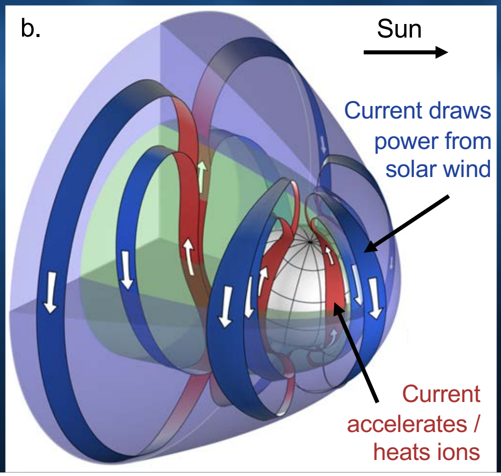


MRO CTX / Malin Space Science Systems / JPL / NASA


2001 Mars Odyssey THEMIS Phobos Observations
29 Sept 2017
15 Feb 2018
24 Apr 2019
09 Dec 2019
25 Feb 2020
Eclipse
27 Mar 2020
-123˚C
Temperature
27˚C
-189˚F
81˚F

MAVEN Uncovers the Structure of Global Electric Currents at Mars





Electric currents determine how and where solar wind energy is transferred throughout the space near a planet.
What drives global currents at Mars?

- Electric currents in space are challenging to measure directly, but can provide a picture of how magnetospheres function. The basic current systems at the *magnetized* planet Earth has been known for decades. MAVEN has provided the first observations of global currents within an *induced* planetary magnetosphere.
- MAVEN does not measure currents directly. Instead, the average magnetic field configuration around Mars was constructed from five years of magnetic field data. Average currents are then inferred from how the magnetic configuration varies spatially.
- The inferred currents are observed to couple the solar wind with the planetary atmosphere while generating hemispherical asymmetries based on the direction of the solar wind's electric field. These results demonstrate the energy transfer between the solar wind and Mars that drives atmospheric escape, with implications for the induced magnetospheres of Venus, Titan, and more.

Figures: (a) Side-view' of electric current directions and strengths computed from spatially averaged MAVEN magnetic field data (red and blue denote currents directed up and down in the figure); (b) 3D illustration of the magnetospheric current systems, based on the MAVEN current maps.

Ramstad et al., *Nature Astronomy*, 2020.

MAVEN Reveals Global Wind Patterns in Mars' Upper Atmosphere

The structure and dynamics of Mars' upper atmosphere is driven by global wind circulation, which redistributes energy input from the Sun. What are the wind patterns on Mars and what is responsible for developing these patterns?

- MAVEN provided the first direct observations of global circulation in the upper atmosphere of a planet other than Earth. Two years of targeted measurements enabled an investigation of the neutral wind speed and direction in Mars' upper atmosphere. These observations show how forces above and below the atmosphere play a role in redistributing energy.
- Wind patterns on Mars are stable over Martian seasons while also having short-term variations. The mapped flow patterns in the upper atmosphere (Figure 1) are notably different from those at Earth due to Mars' lack of a strong dipolar intrinsic magnetic field.
- Mars global circulation observations reveal that winds are forced around surface topography, including mountains and steep slopes. This shift of surface winds generates gravity waves that change the wind pattern and propagate upward to drive dynamics throughout the lower and upper atmosphere. This is the first time that these topography-induced gravity waves have been observed on a global scale in the thermosphere of any planet.

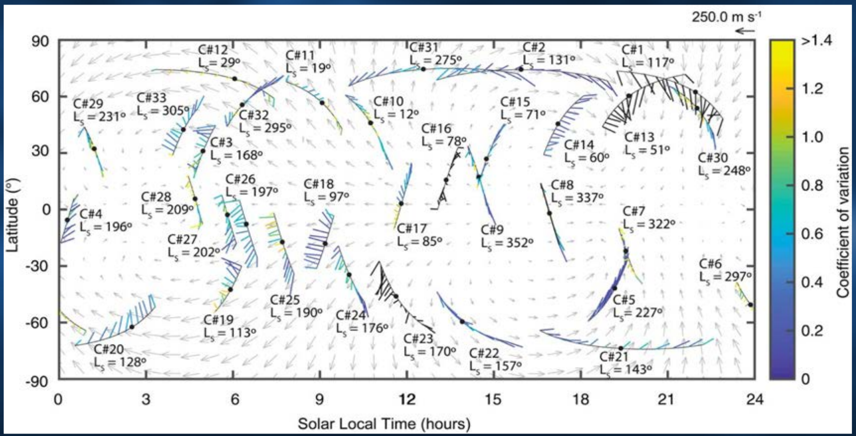
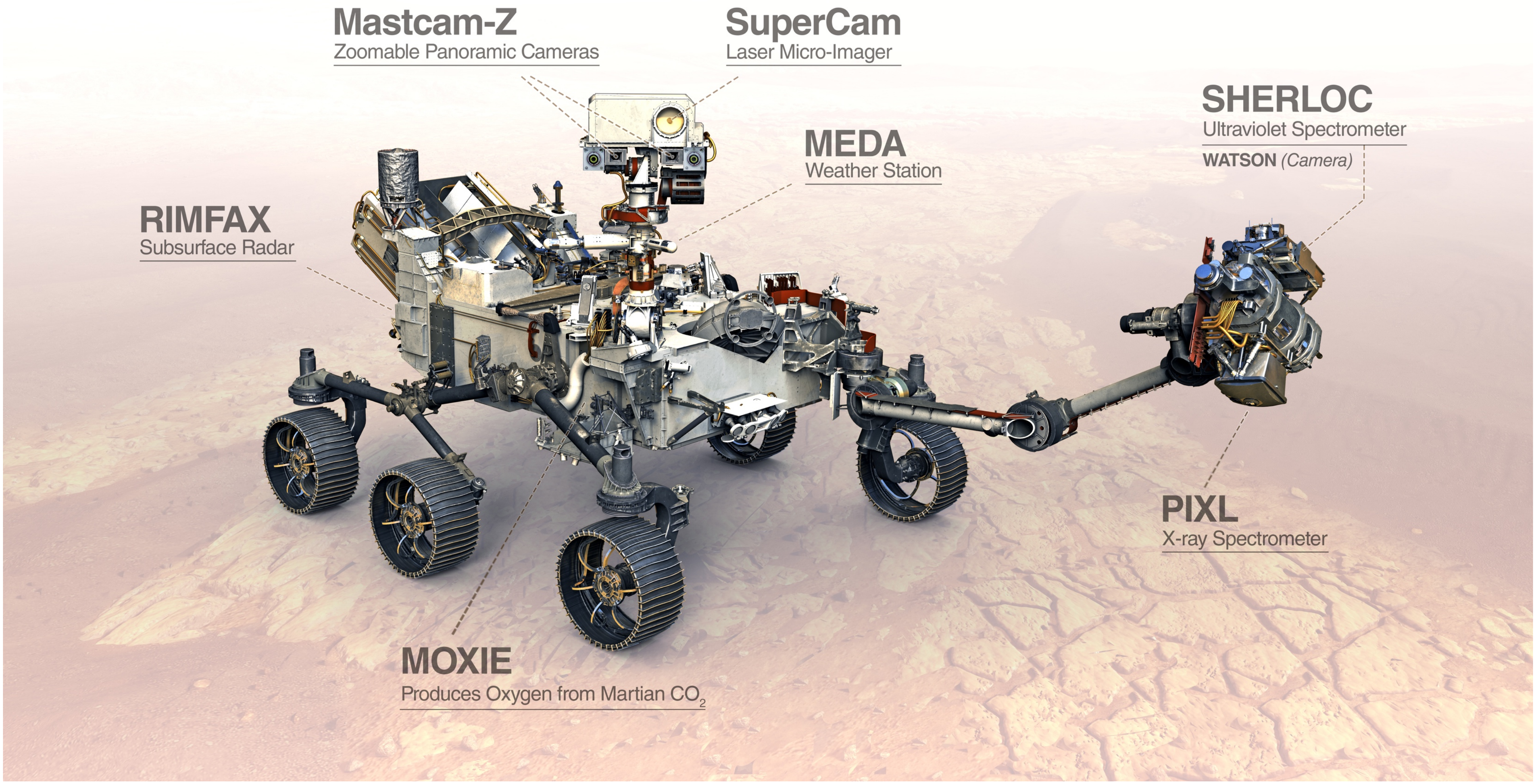


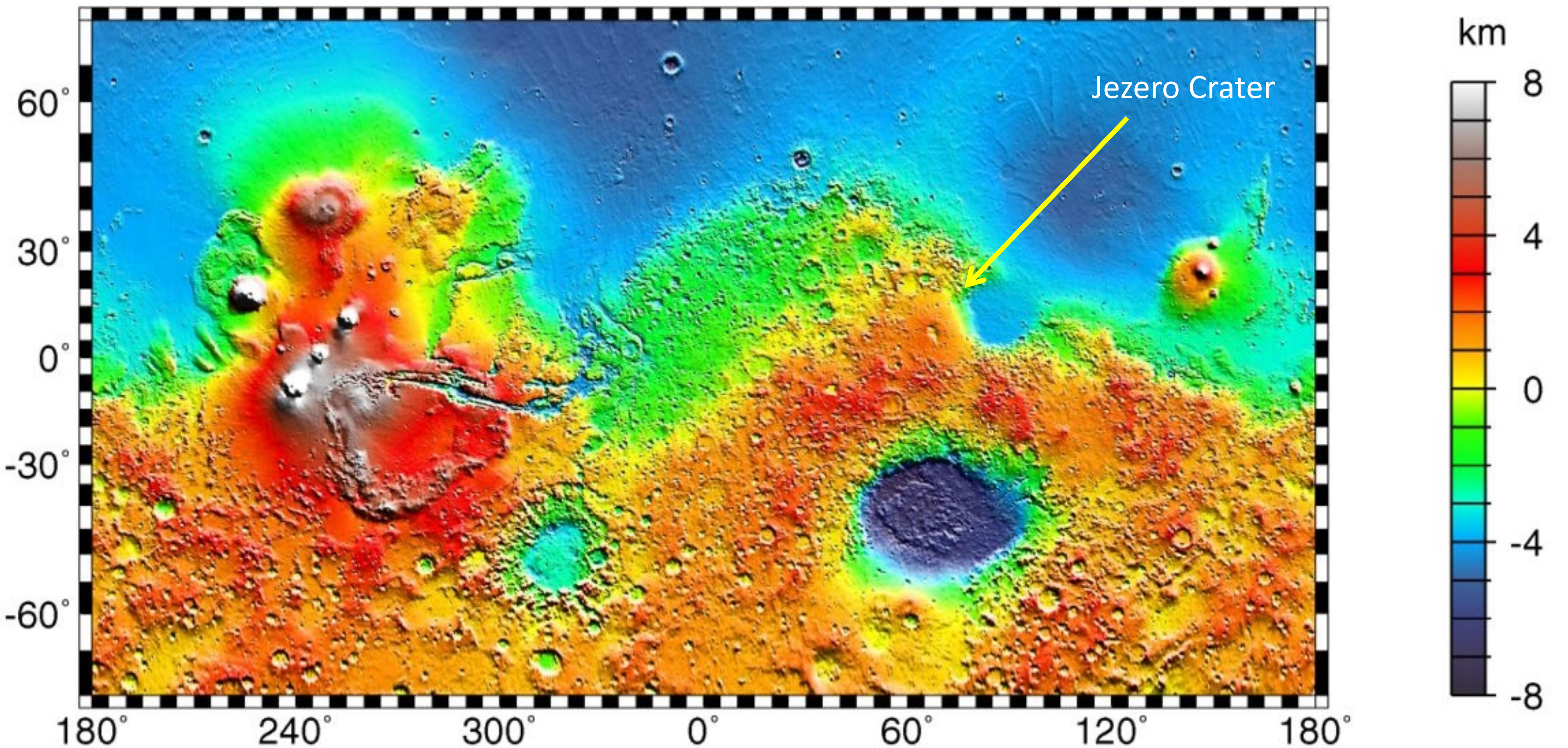
Figure 1. Average neutral wind observations for 33 measurement campaigns demonstrate the speed and direction of winds in Mars' upper atmosphere. Colorful whiskers show average neutral winds measured by MAVEN while light gray arrows indicate model predictions.

Benna et al., *Science*, 2019

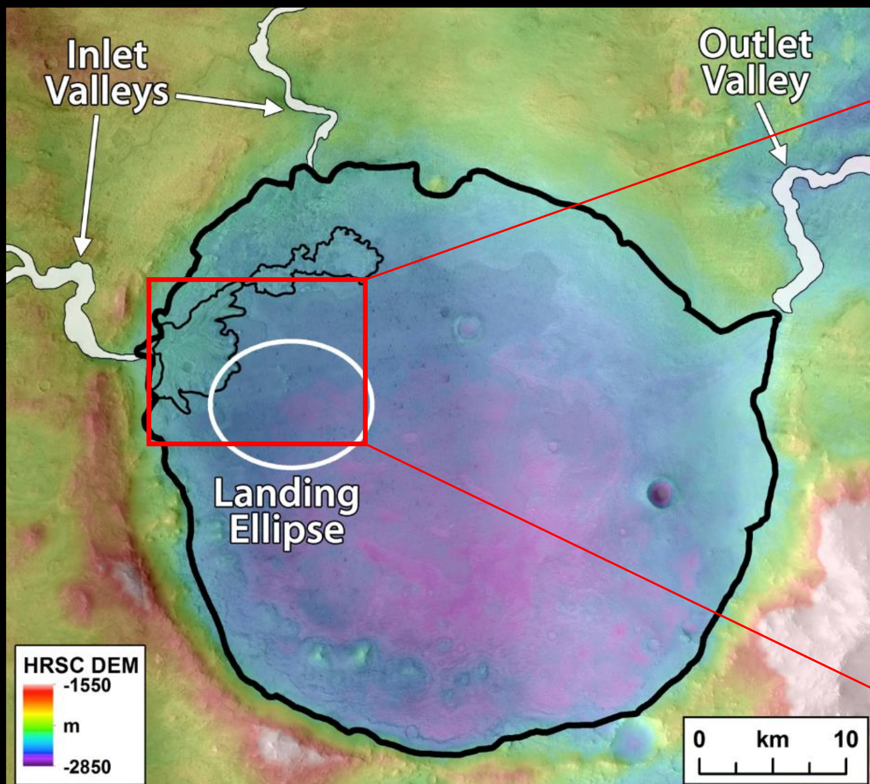


Mastcam-Z
Zoomable Panoramic Cameras
SuperCam
Laser Micro-Imager
SHERLOC
Ultraviolet Spectrometer
WATSON (Camera)
MEDA
Weather Station
RIMFAX
Subsurface Radar
PIXL
X-ray Spectrometer
MOXIE
Produces Oxygen from Martian CO_2

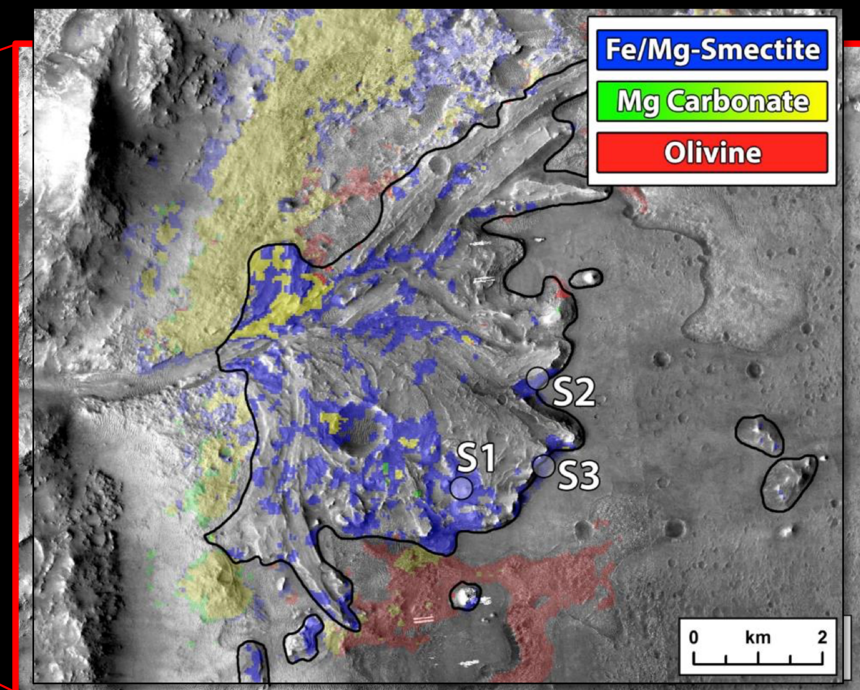
Perseverance Landing Site: Jezero Crater



Delta Deposit Inside Jezero Crater

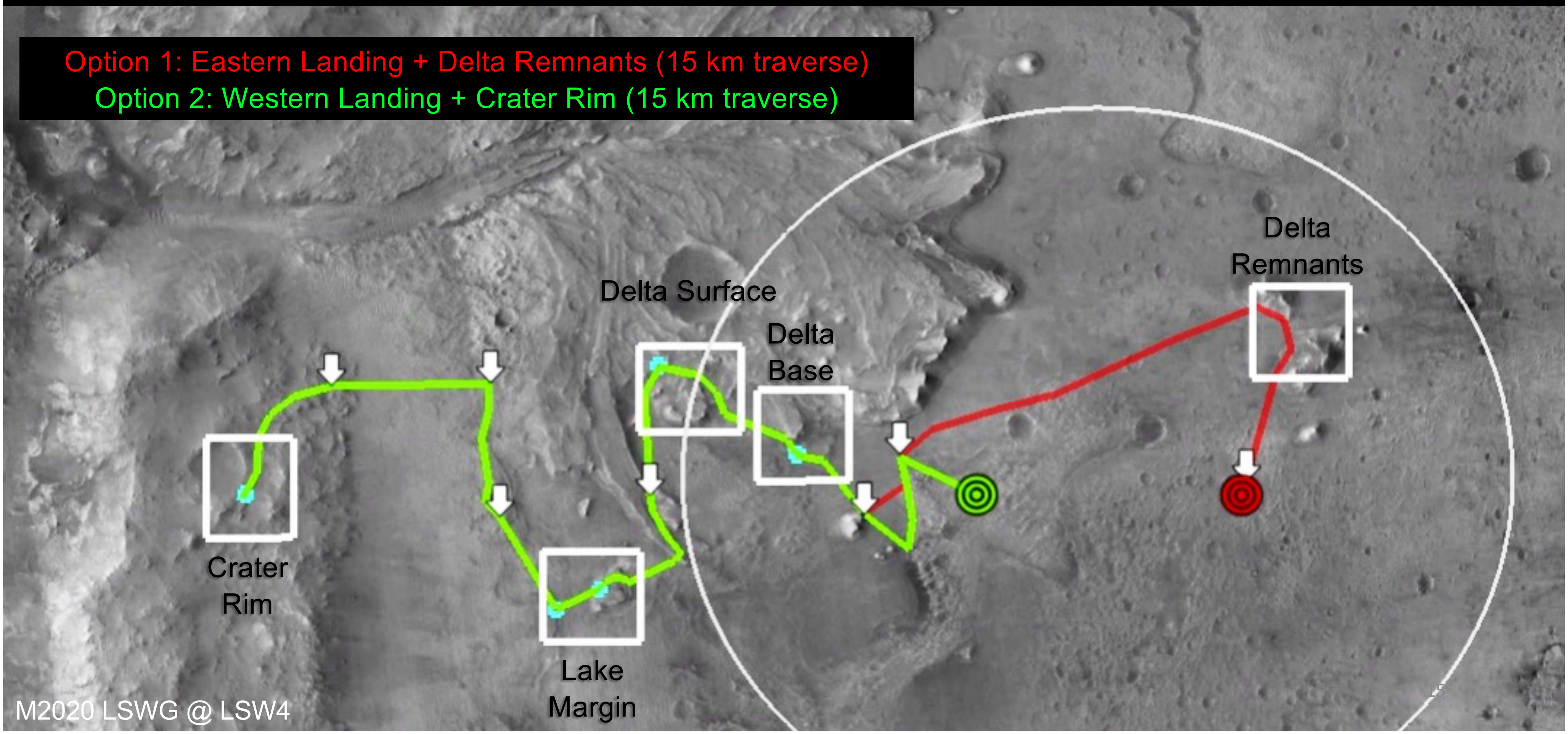


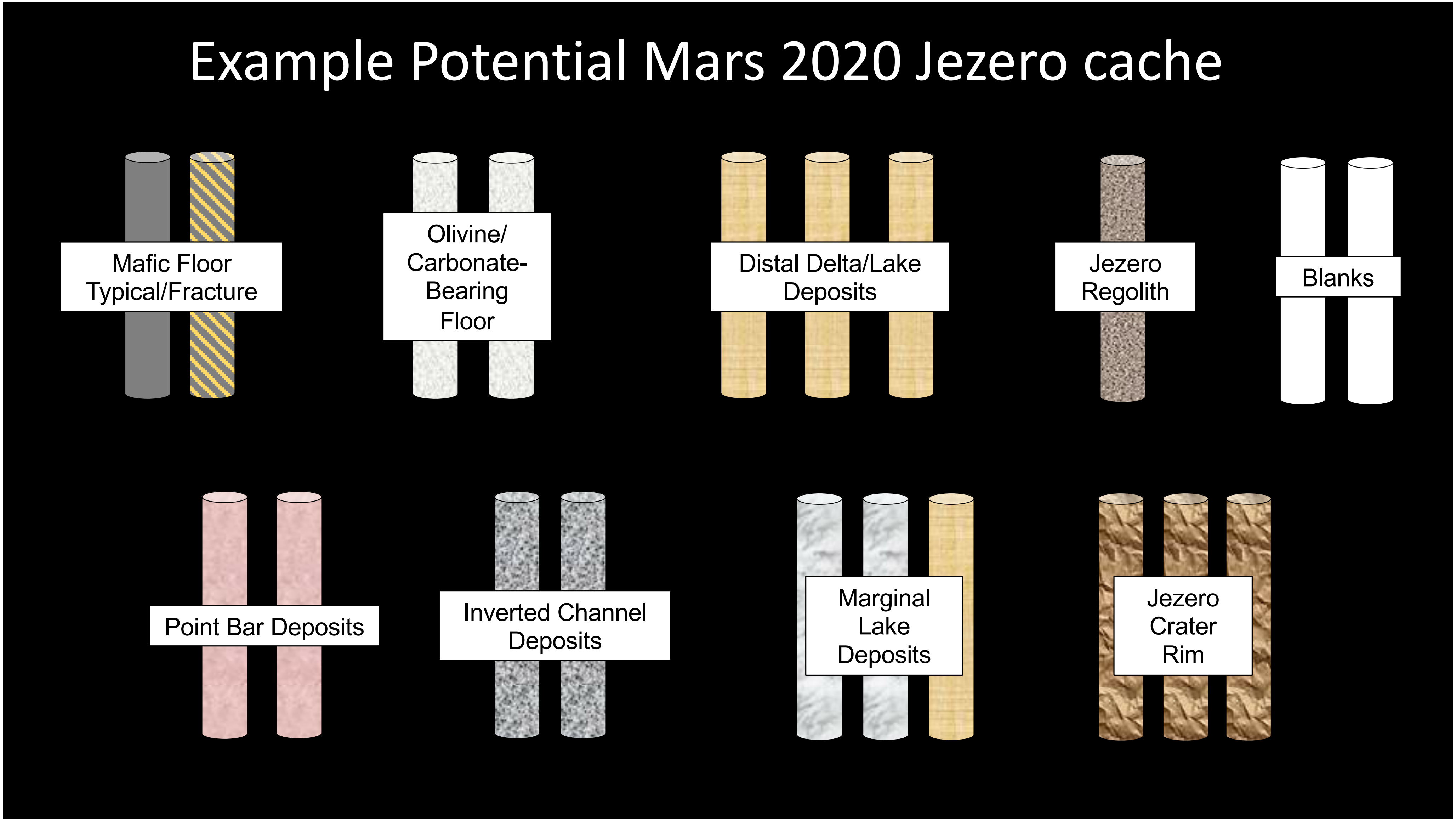
HRSC topography overlain on CTX mosaic



Modified from T. Goudge LSW3

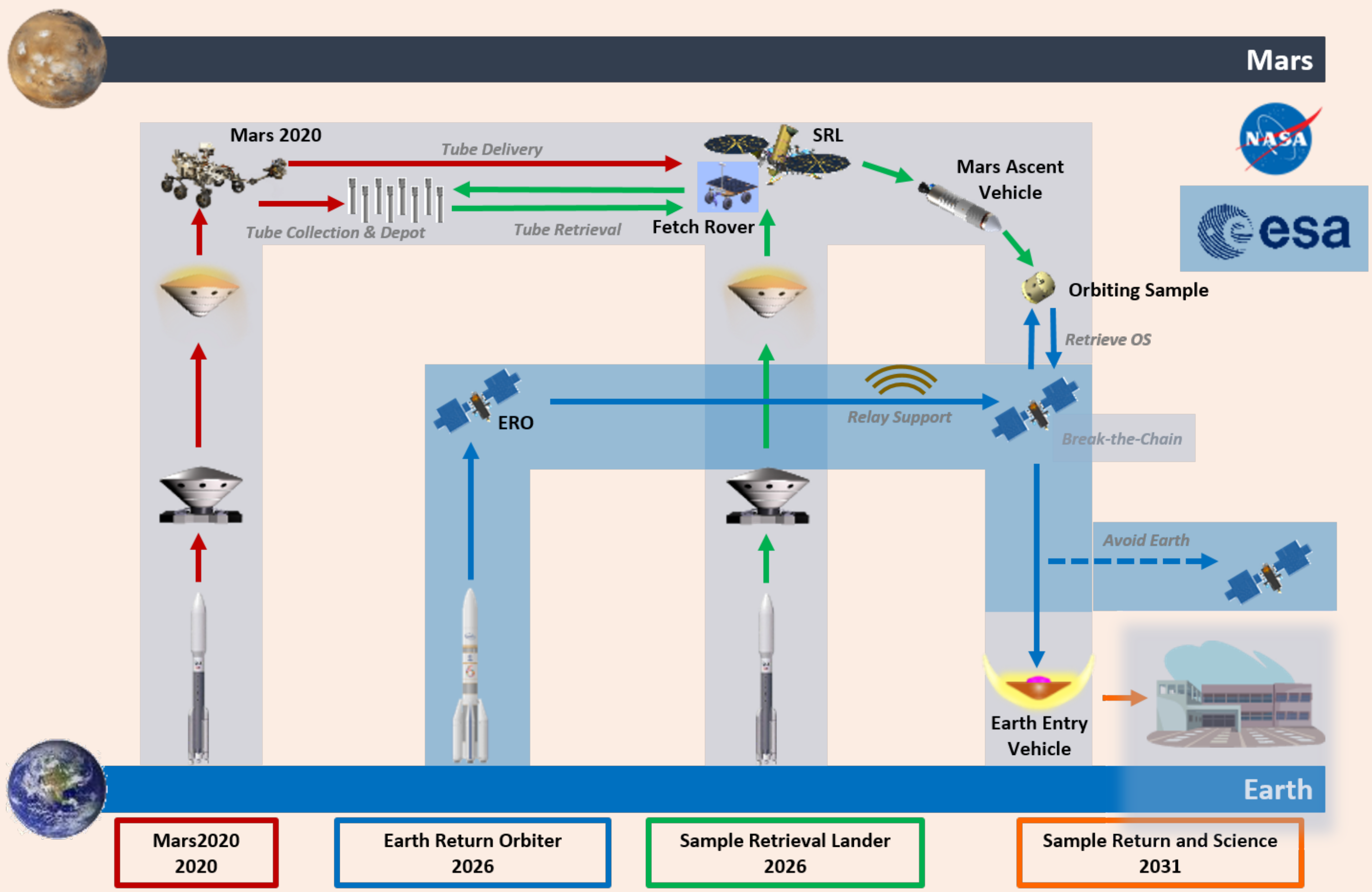
Example Potential Mission Scenario for Jezero crater




Example Potential Mars 2020 Jezero cache
Mafic Floor Typical/Fracture
Olivine/ Carbonate-Bearing Floor
Distal Delta/Lake Deposits
Jezero Regolith
Blanks
Point Bar Deposits
Inverted Channel Deposits
Marginal Lake Deposits
Jezero Crater Rim


Mars Sample Return Challenge
• Protect the Samples from Earth
• Protect the Earth from the Samples
. . . To achieve a quantum jump in our understanding of Mars

Mars Sample Return Campaign Overview



MSR Science Planning Group (MSPG)

MSPG established by NASA and ESA to help develop a stable foundation for international scientific cooperation for the purposes of returning and analyzing samples from Mars.

Report completed Oct 2019

Products*
- Workshop - Science in Containment
- Workshop - Contamination Control
- Science Management Framework

Steps Forward
- Science Management Plan
- Establish a science management structure - an MRSH Council
  - There are analogous major science management organizations (CERN, IODP)
- Expand on technical issues related to MSR

* https://mepag.jpl.nasa.gov/reports.cfm?expand=mspg

The Development of Guiding Principles

Transparency:

- Access to samples must be fair and the processes as transparent as possible.

Science maximization:

- It is imperative that the science management and sample-related processes optimize the scientific productivity of the samples.

Accessibility:

- International scientists must have multiple opportunities to participate in MSR.

Return on investment:

- Agencies funding the MSR campaign should benefit for enabling the samples’ return.

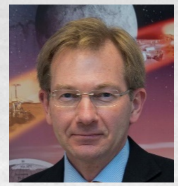
One Return Canister : One Collection

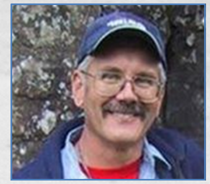
- Samples must be treated as a single collection, regardless of whether or not there is more than one curation facility

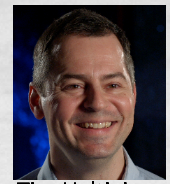
Mars Sample Return Science Planning Group 2

Coordination Team


Michael Meyer


Gerhard Kminek


Dave Beaty


Tim Haltigin


Brandi Carrier

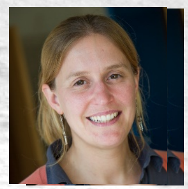
Tactical Team

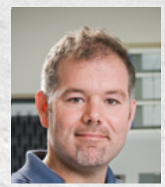

Carl Agee


Henner Busemann


Barbara Calavazzi


Charles Cockell


Vinciane Debaille


Danny Glavin


Ernst Hauber


Bernard Marty


Francis McCubbin


Lisa Pratt


Aaron Regberg


Alvin Smith


Caroline Smith


Kim Tait


Nick Tosca


Arya Udry


Tomo Usui

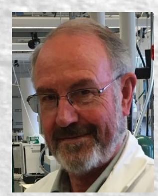

Michael Velbel


Mini Wadhwa


Maria-Paz Zorzano

Strategic Team


Monica Grady


Roger Summons


Tim Swindle


Frances Westall

21

Statement of Task (1 of 3)

MSPG-2 will address MSR science and curation planning questions for which the specifics and the schedule will determined by the NASA and ESA leads. These questions may include, but not be limited to, the following topics:

1. Develop a first draft of the "MSR Science Management Plan." The MSPG-2 is expected either to adopt the MSPG recommendations, or to propose suitable alternatives, regarding science management planning issues. The scope of this task could include, but not necessarily be limited to, the following:
   A. Amplify the planning descriptions of the bodies & processes described in the "Framework" document, Section 4.
   B. Define the interfaces, organizational relationships, and communication pathways between science, curation, Mars 2020, facilities planners, and planetary protection.

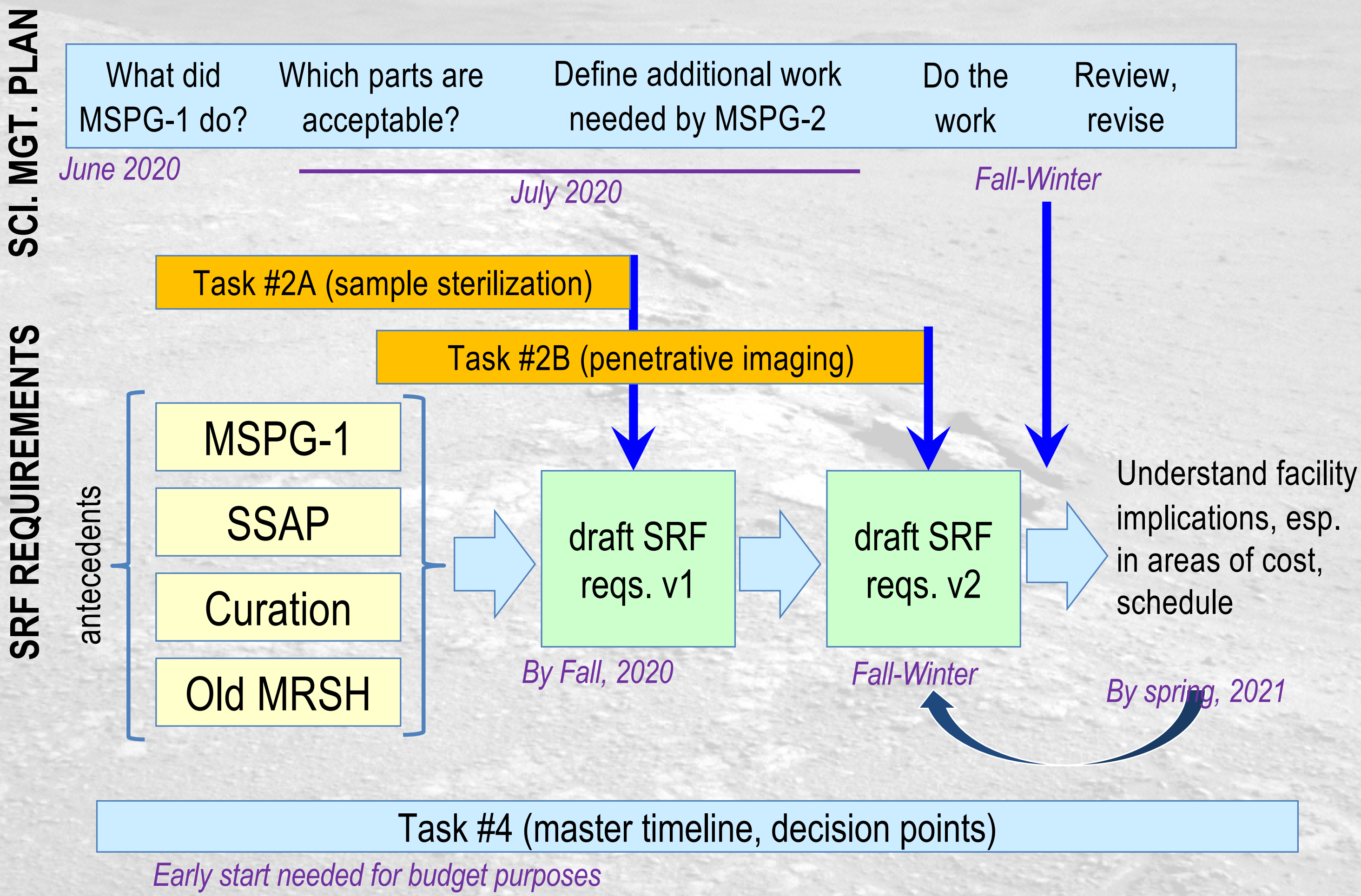
Statement of Task (2 of 3)

2. Technical issues related to the science of MSR and how the implementation of MSR impacts the potential scientific usefulness of the samples. The technical issues considered may include, but are not limited to:
   A. Sample sterilization, including consideration of the effects of sterilization on the science as well as implications for the SRF.
   B. Use of penetrative imaging (synchrotron imaging or CT scanning) on the sample tubes before they are opened.
   C. As needed, propose quantitative sample quality-related requirements for the transport/handling of the samples during the MSR flight campaign. (No issues currently pending)

Statement of Task (3 of 3)

3. Develop approaches and a working list of high-level requirements for the SRF that can be used in cost estimation and budgeting. The requirements specifically need to represent the needs and interests of each of science, curation, and planetary protection. All proposed requirements need a justification statement.
4. A list of key decision points related to the Mars returned samples with inputs from science, curation, and planetary protection, and represent them on a master timeline.

The Logic, Planning the Timeline



Intro: The First Four Telecons

June 18 *(1 hour)*

- General intro
  - Expectations, Organization, Timeline
  - Questions
- Discuss/accept ToR
- Introduce focus groups

Homework for next mtg:

- Read iMOST report (objectives only), “Framework” Focus on 3.1, 3.2.1 and 3.3

June 25 *(1.5 hour)*

- Task #1: Science Management Plan
  - Discuss science objectives for MSR
  - Discuss “Framework” document
  - What is our “to go” plan?

Homework for next mtg:

- Read MSPG workshop reports

July 2 *(1.5 hour)*

- Task #2: Inputs to SRF requirements
- Discuss MSPG Workshop reports
  - Implications for SRF concepts/reqs
  - Curation, Sterilization, Penetrative Imaging, PP

Homework for next mtg:

- Volunteer for Focus Groups

July 9 *(1.5 hour)*

- Task #3: SRF Requirements Definition
  - Requirements/Facilities Focus Group(s)
  - Set up our proposed workshop

READY, SET, ACTION!

- ***First 4 telecons with full MSPG2, which includes the strategic team***
- ***After initial set of telecons, shift to biweekly schedule for MSPG2, begin regular (also biweekly) focus group meetings***


Earth and Moon from Mars imaged by HiRISE 2016