

Don't Forget About...: Dealing with the Unexpected

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Mars



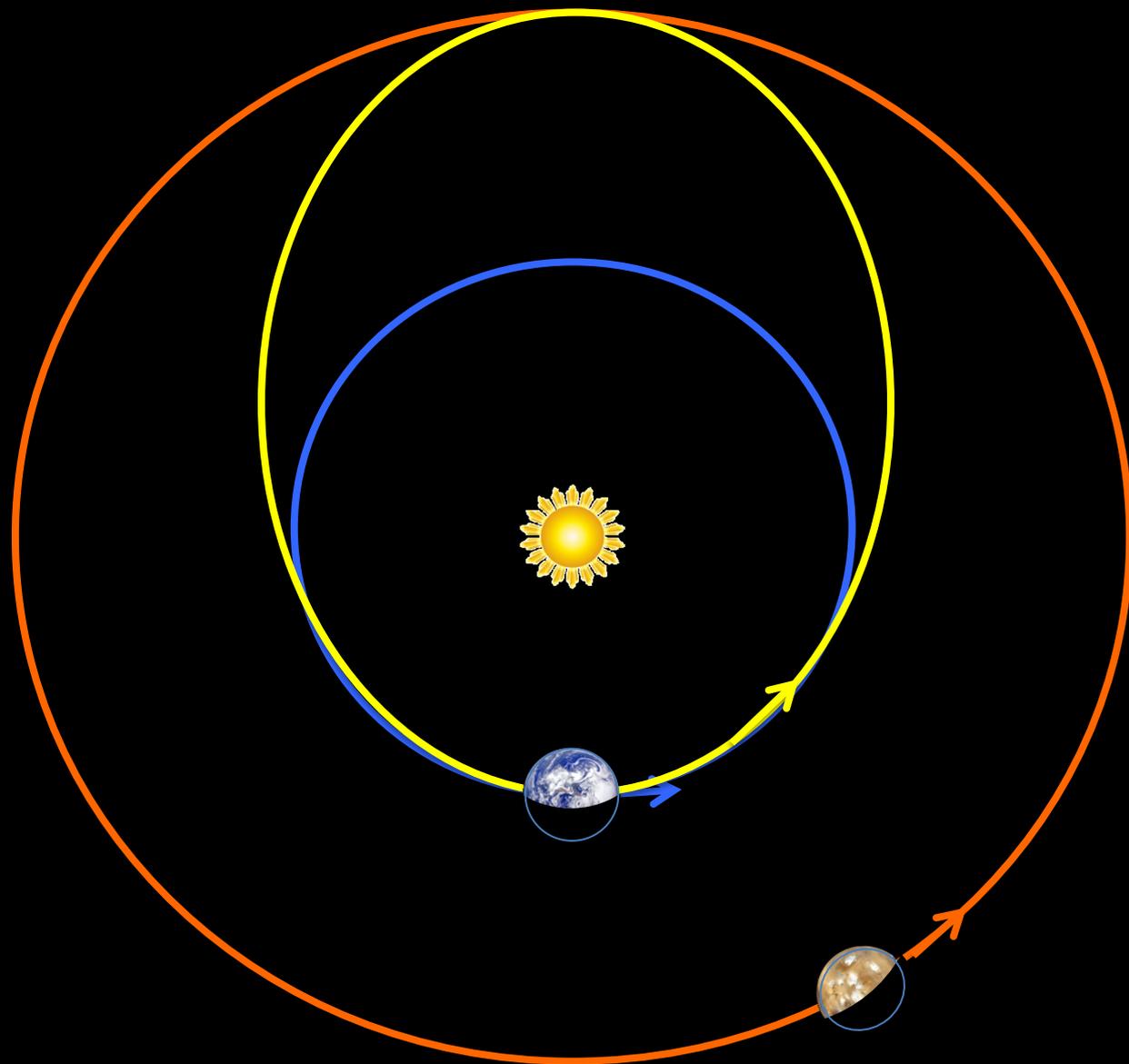
Home



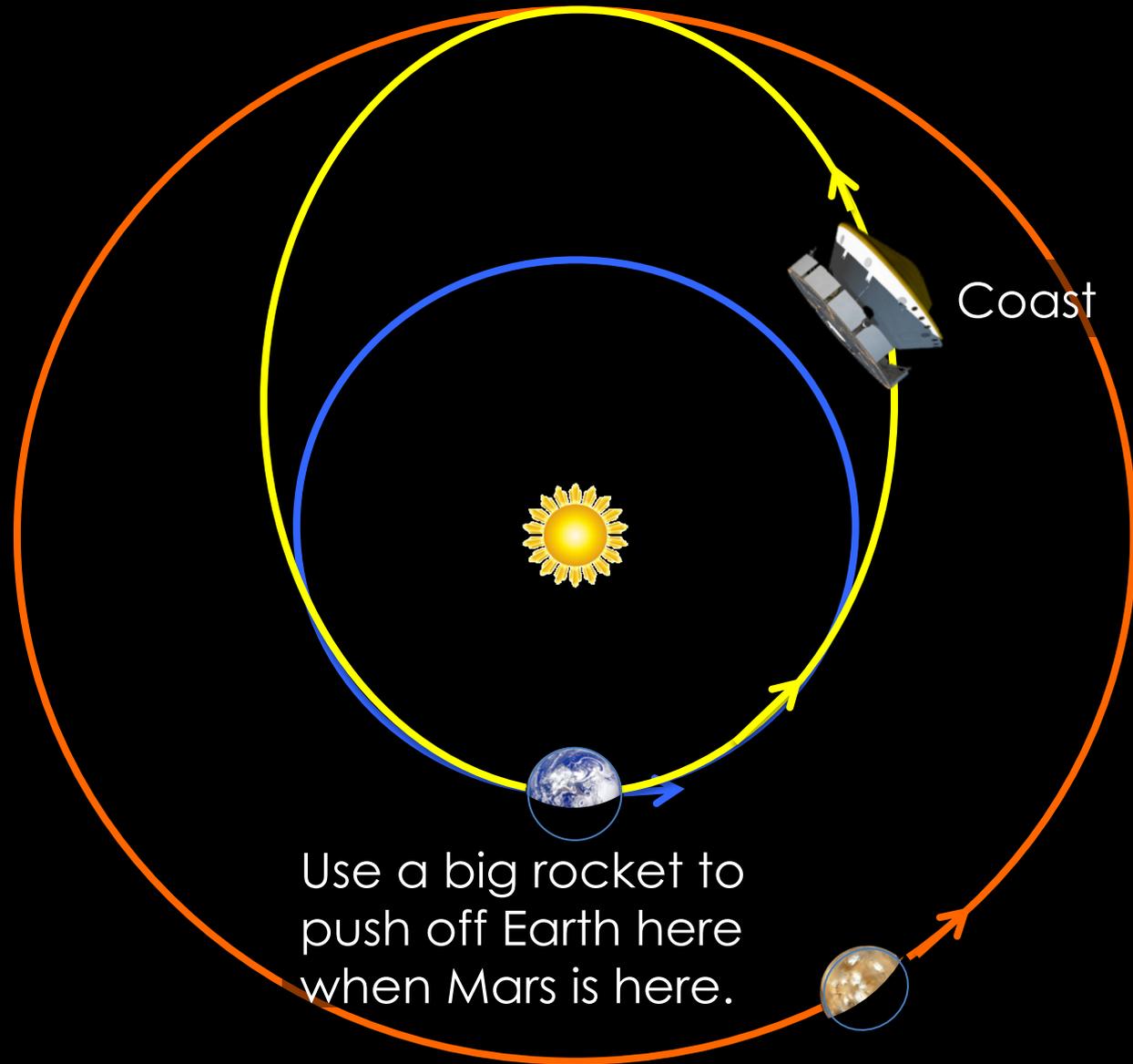
Gravity:	3/8 gee	1 gee
Distance to sun:	1.52 AU	1 AU
Solar irradiance:	590 w/m ²	590 w/m ²

Earth-Mars synodic period = 780 days (26 months)

From Earth to Mars & back



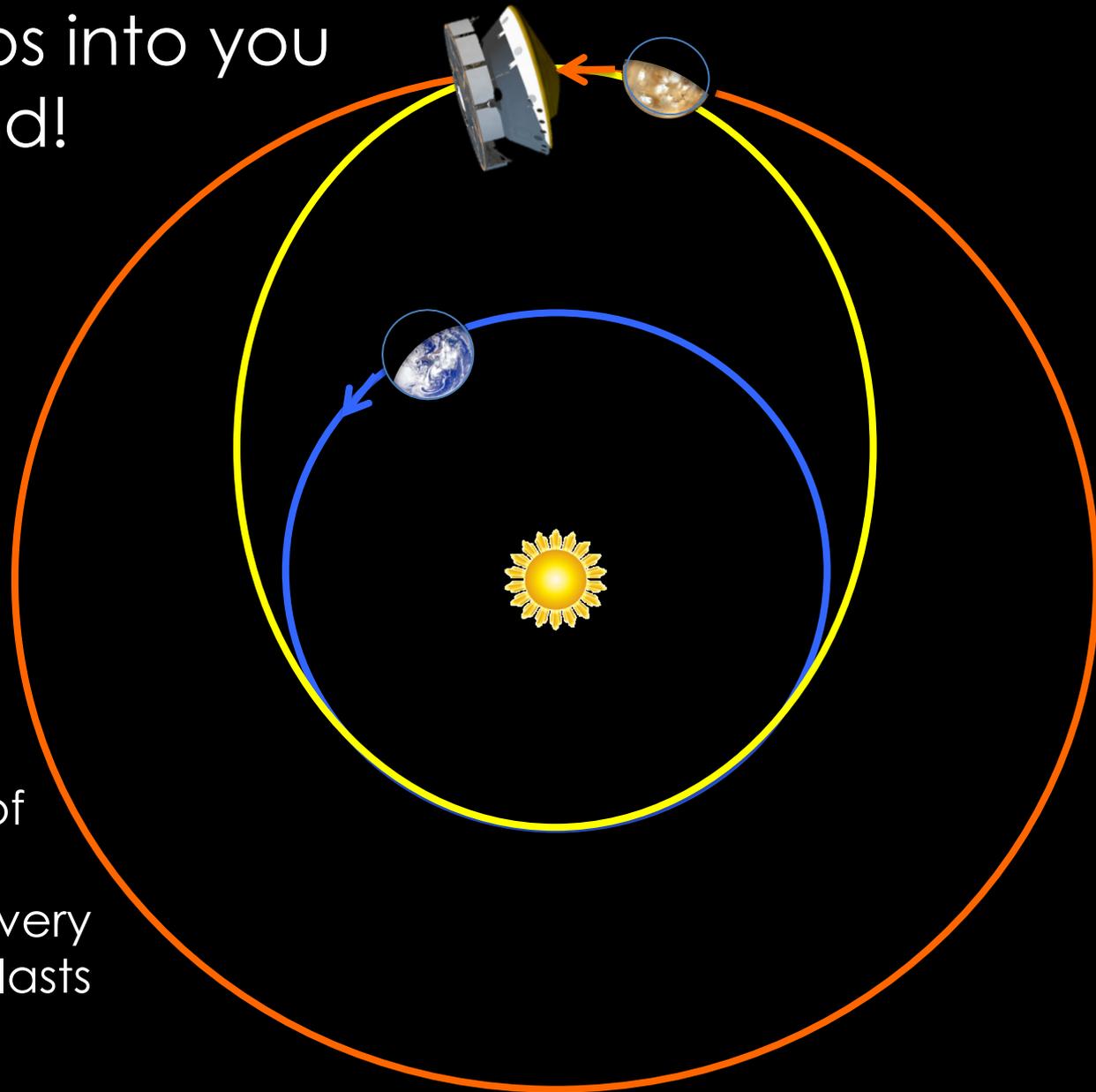
From Earth to Mars



Use a big rocket to push off Earth here when Mars is here.



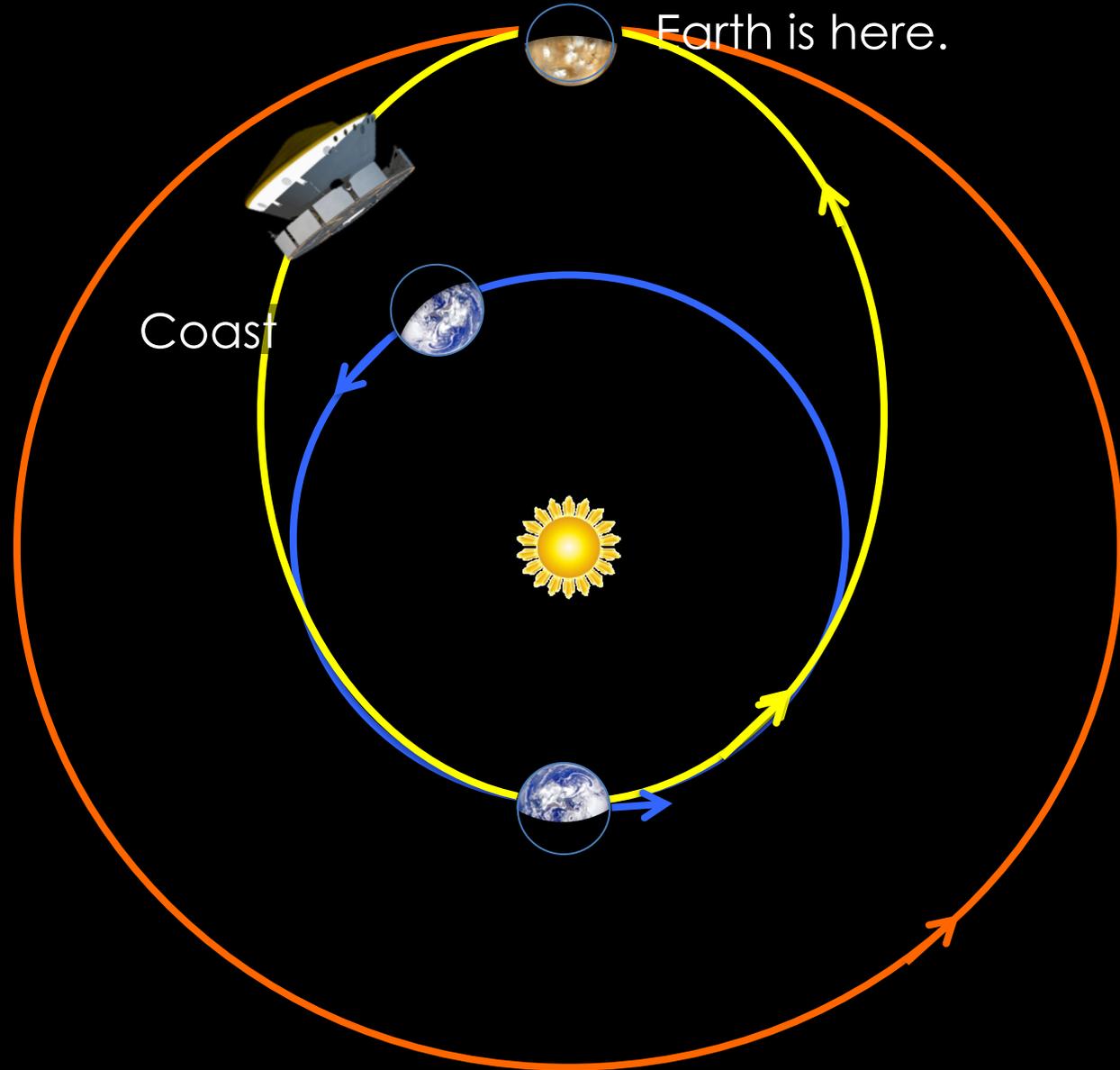
7 months later,
Mars bumps into you
from behind!



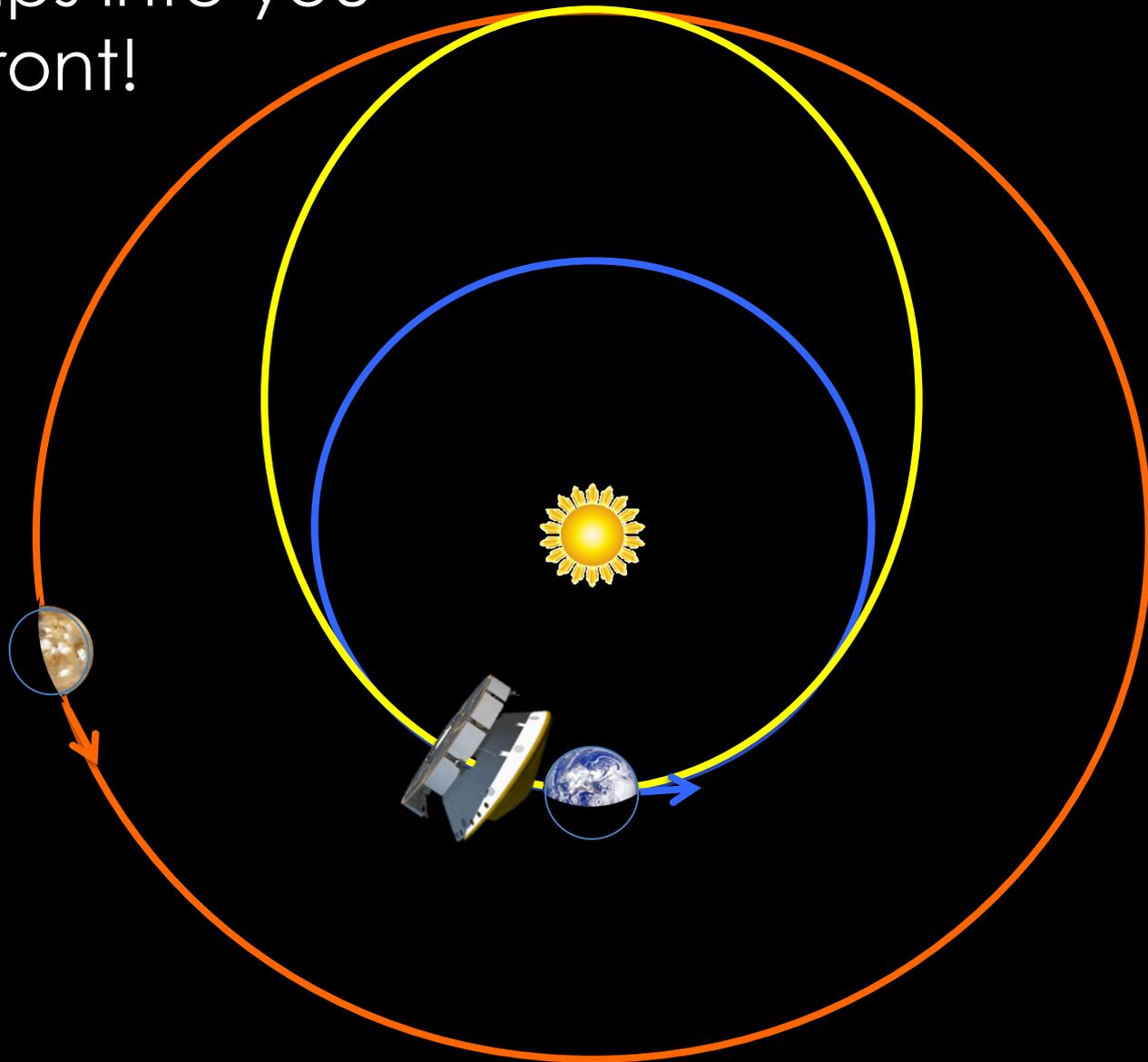
This alignment of
Earth and Mars
occurs about every
26 months and lasts
only about 3-4
weeks.

From Mars to Earth

Use a rocket to push out of Mars orbit here when Earth is here.



7 months later,
Earth bumps into you
from the front!

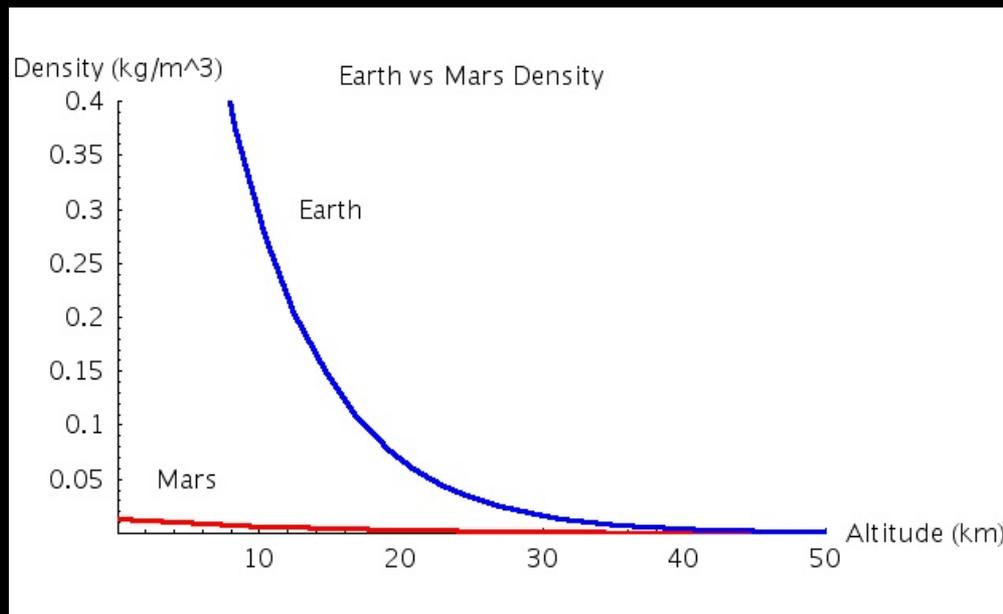




Mars Atmosphere

- About 1% of Earth's density at surface (equivalent to 120 k ft)
- But its FAR from being a vacuum.

CO ₂ :	95.3%
N ₂ :	2.7%
Ar:	1.6%
O ₂ :	0.13%
CO:	0.08%



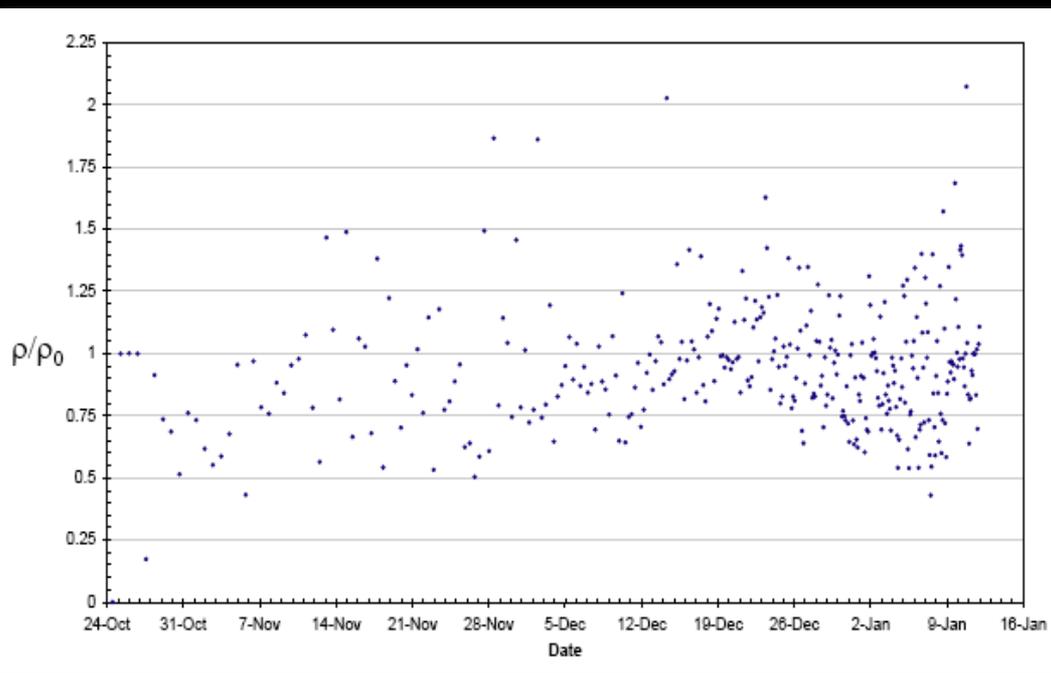
- ± 35% annual density variation
- ± 5% diurnal (daily) density variation



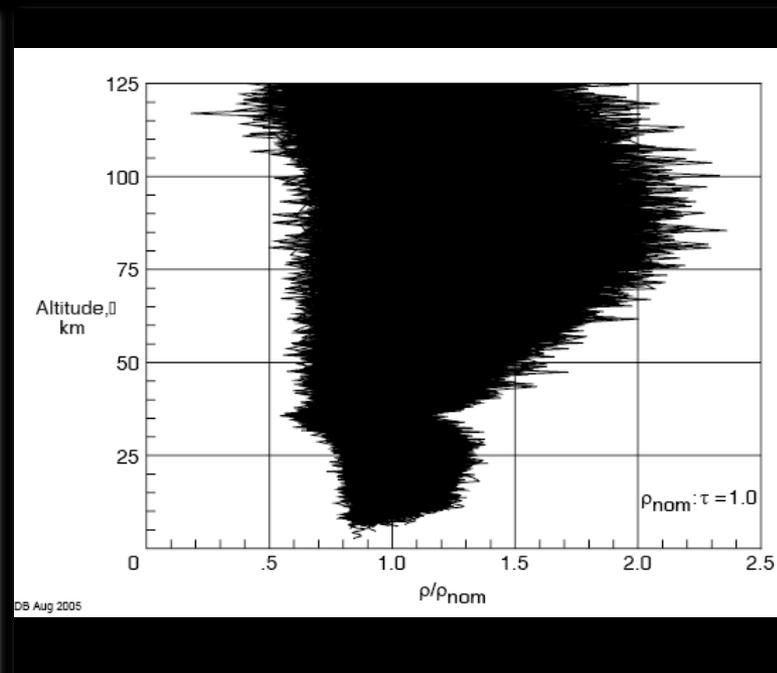
The Unknowns:

Density variations due to dust and temperature can be difficult to model

Atmospheric Density Variations at 70 km

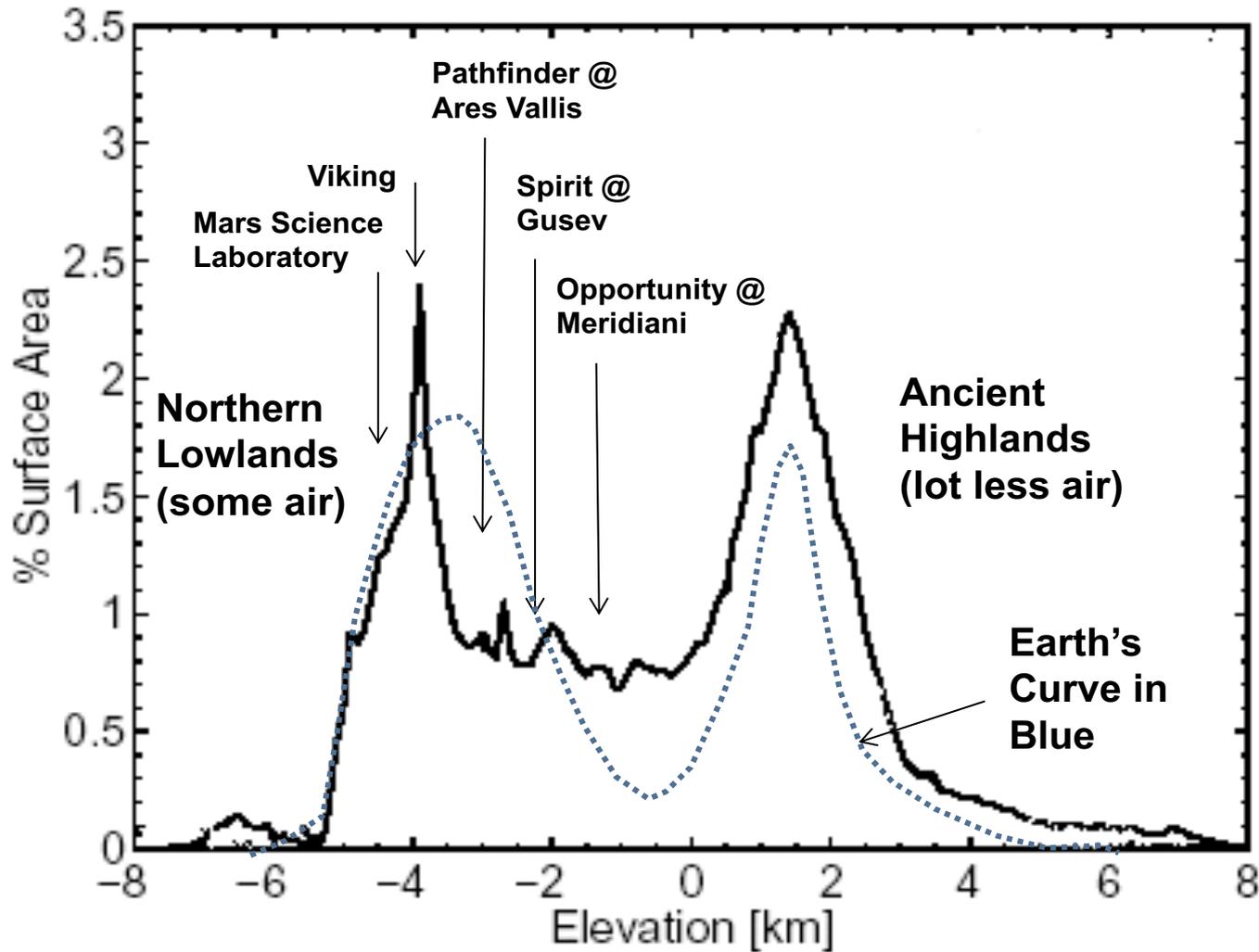


Mars Atmospheric Density Uncertainty

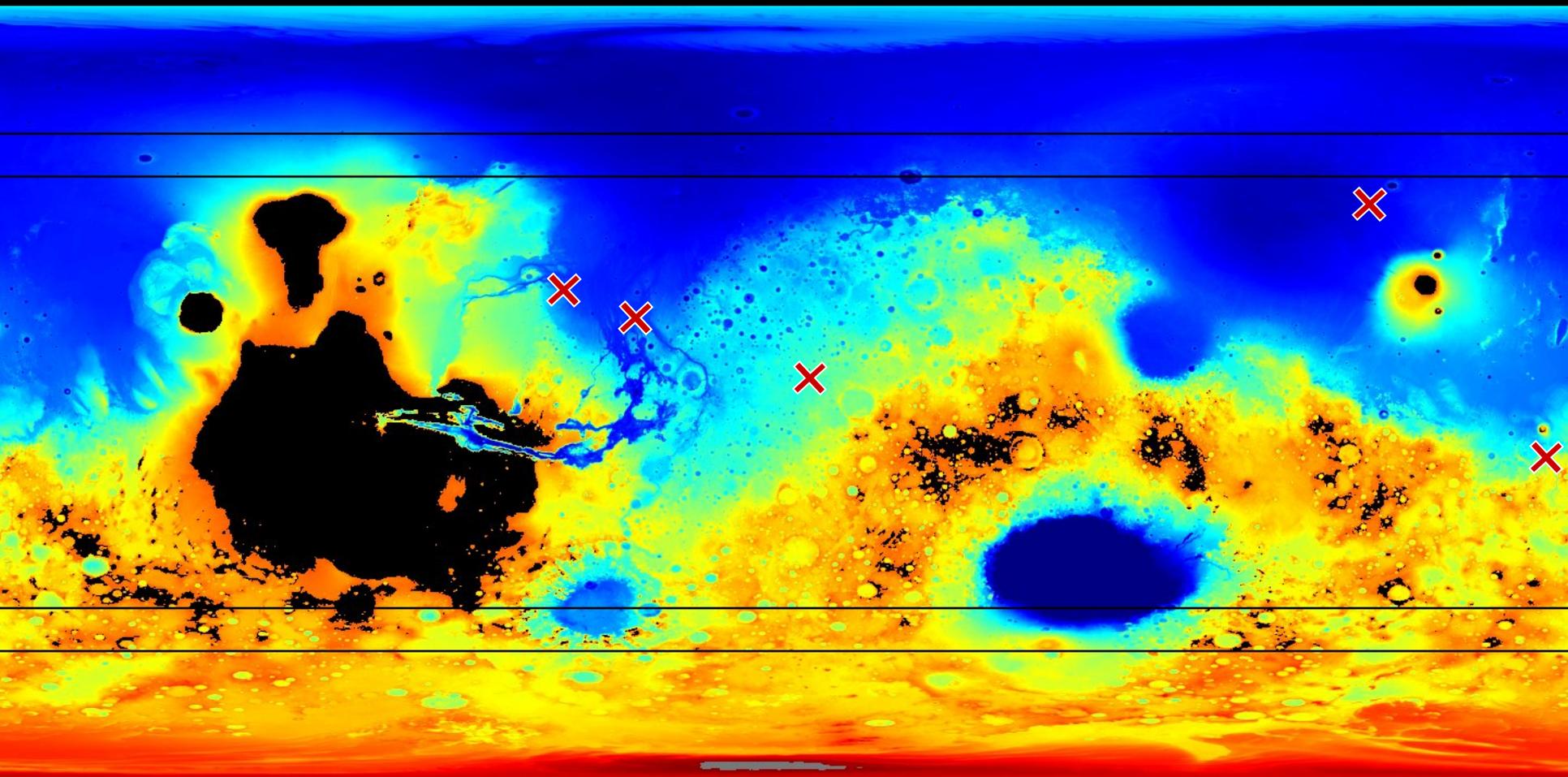




Mars' Bimodal Hypsometric Curve

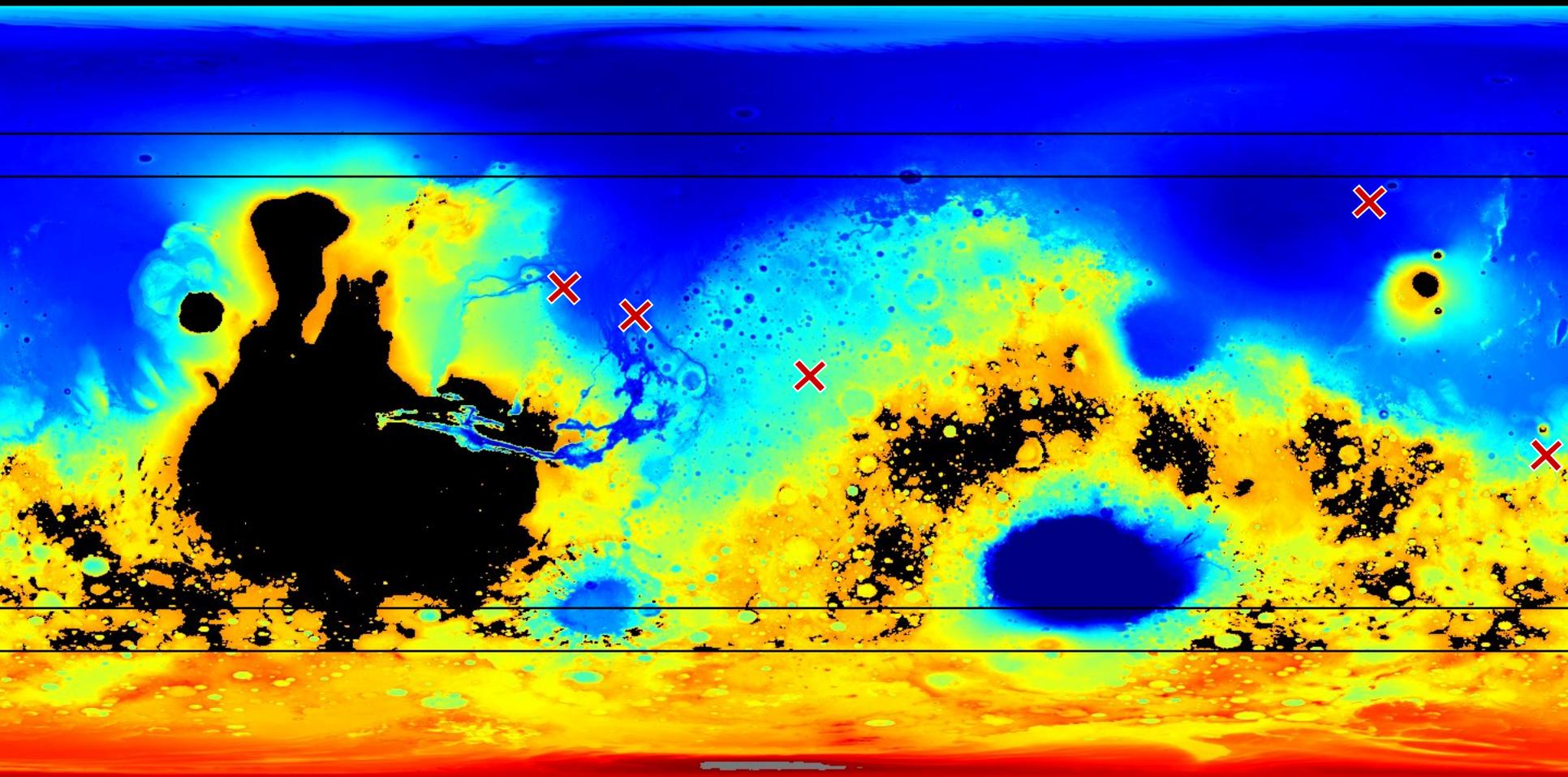


Mars above 2.5 km in Black



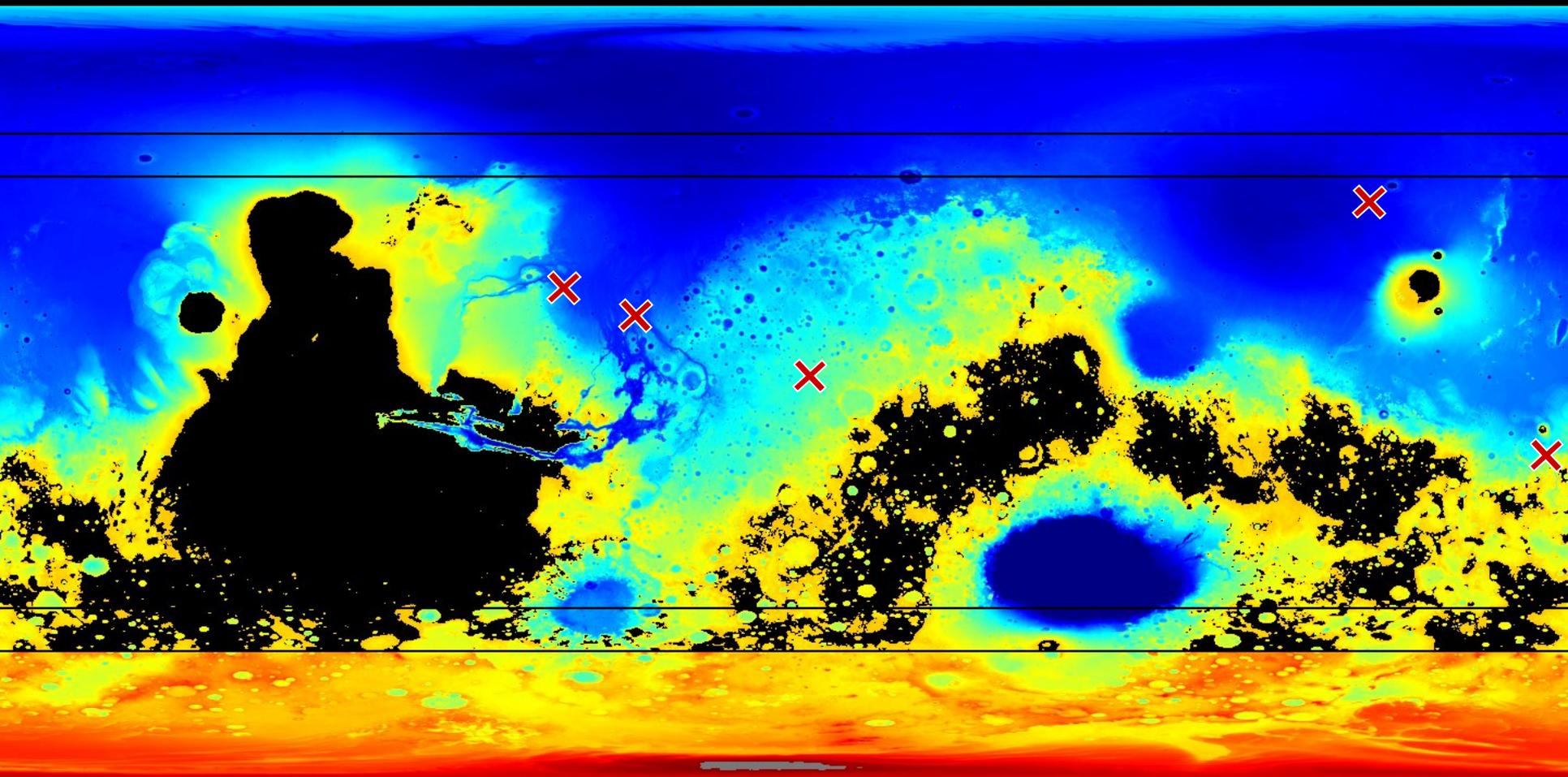
MOLA Topography $\pm 90^\circ$ Lat, 180° to -180° W
Lon

Mars above 2.0 km in Black



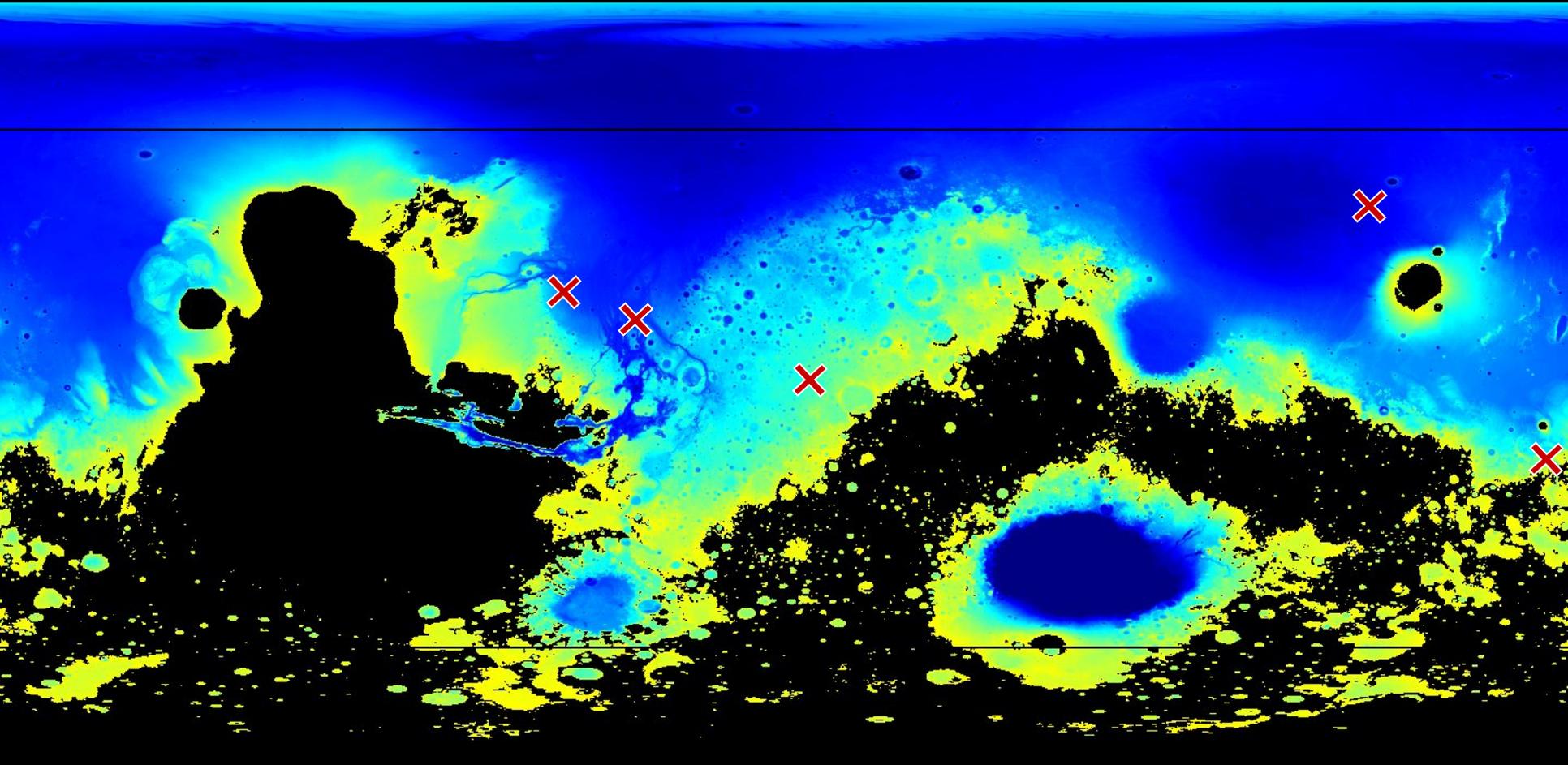
MOLA Topography $\pm 90^\circ$ Lat, 180° to -180° W
Lon

Mars above 1.5 km in Black



MOLA Topography $\pm 90^\circ$ Lat, 180° to -180° W Lon

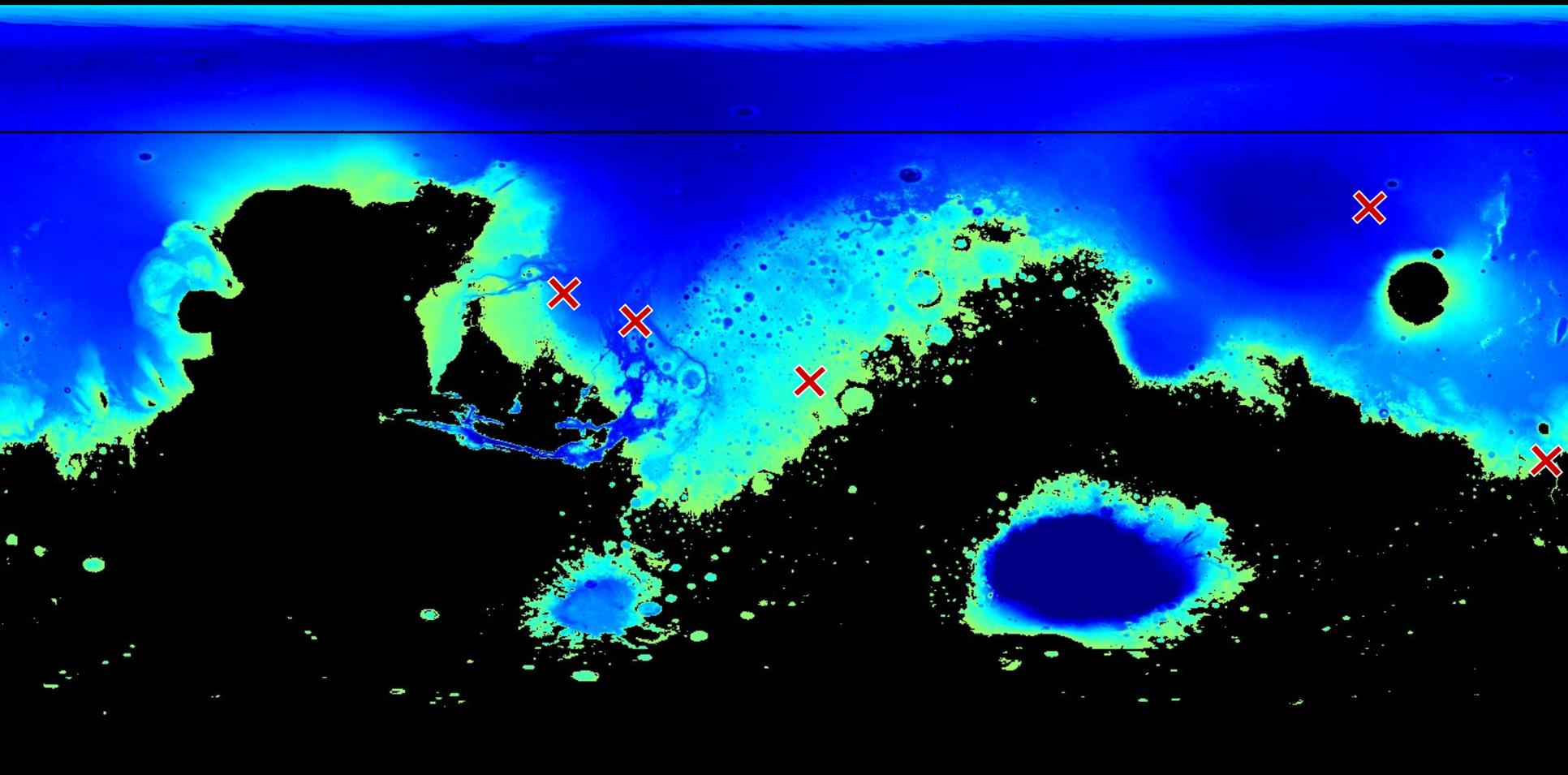
Mars above 1.0 km in Black



-4000 -2000 0 2000 4000

Altitude Above MOLA Areoid (m)

Mars above 0 km in Black



-4000

-2000

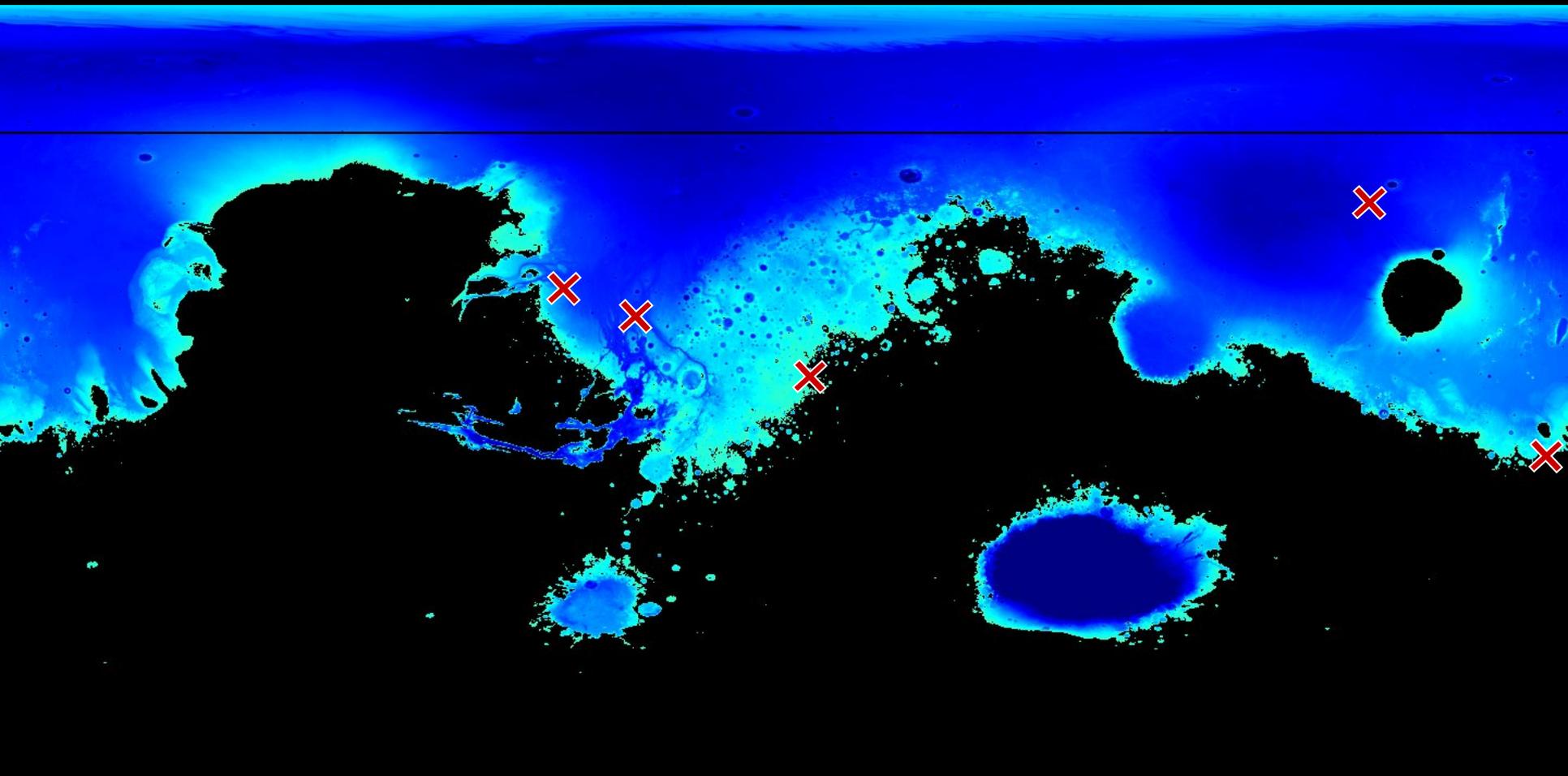
0

2000

4000

Altitude Above MOLA Areoid (m)

Mars above -1.0 km in Black



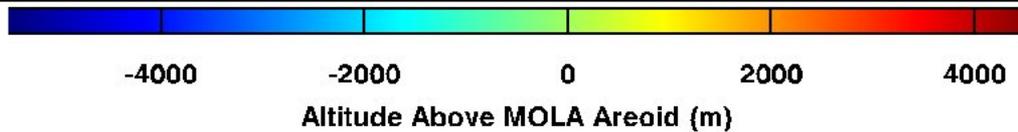
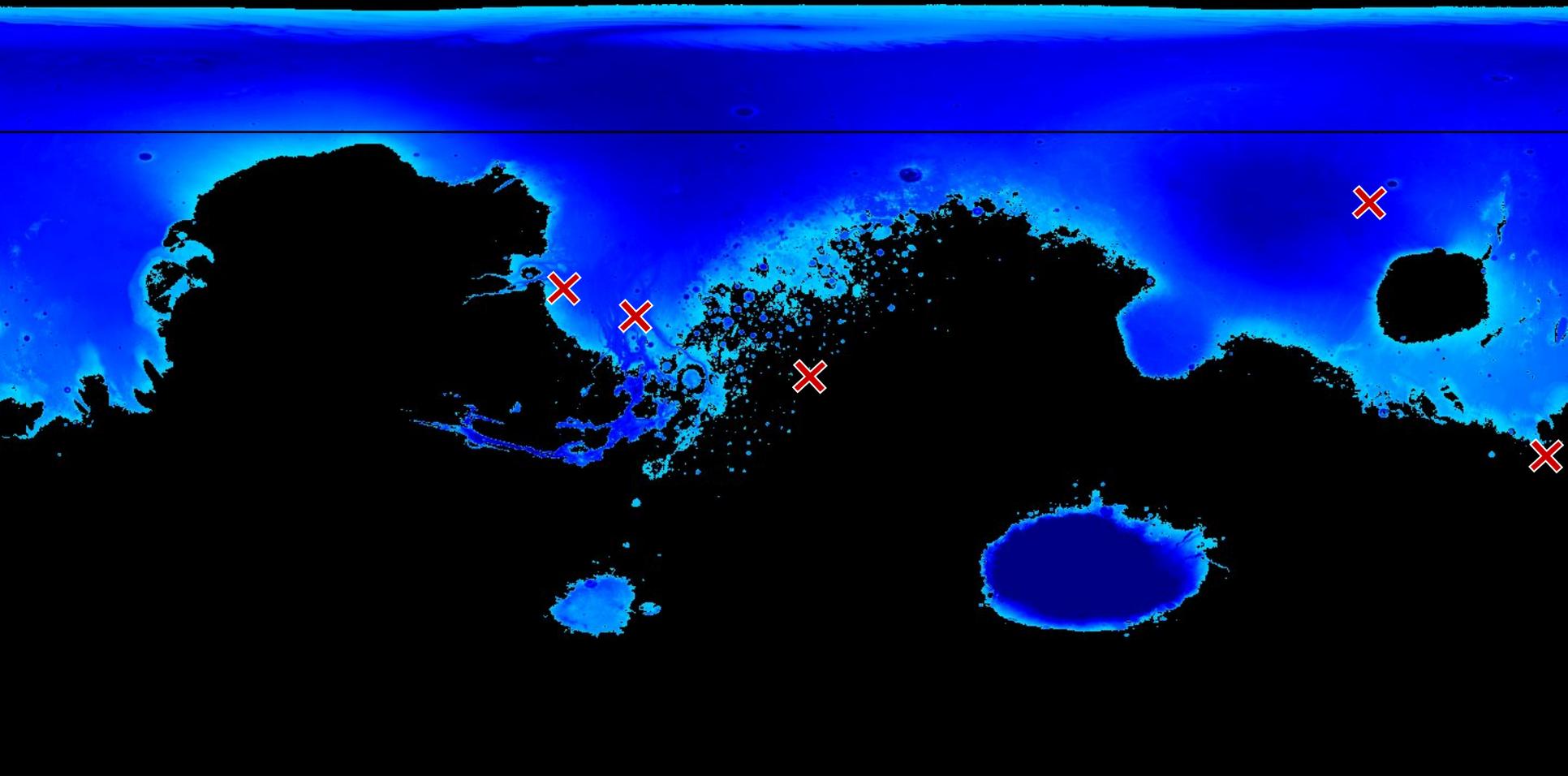
Altitude Above MOLA Areoid (m)

Black area is topography > -1.0 km

Lines at $\pm 60^\circ$ latitude

June 2, 2006

Mars above -2.0 km in Black



Dust Storm 2018



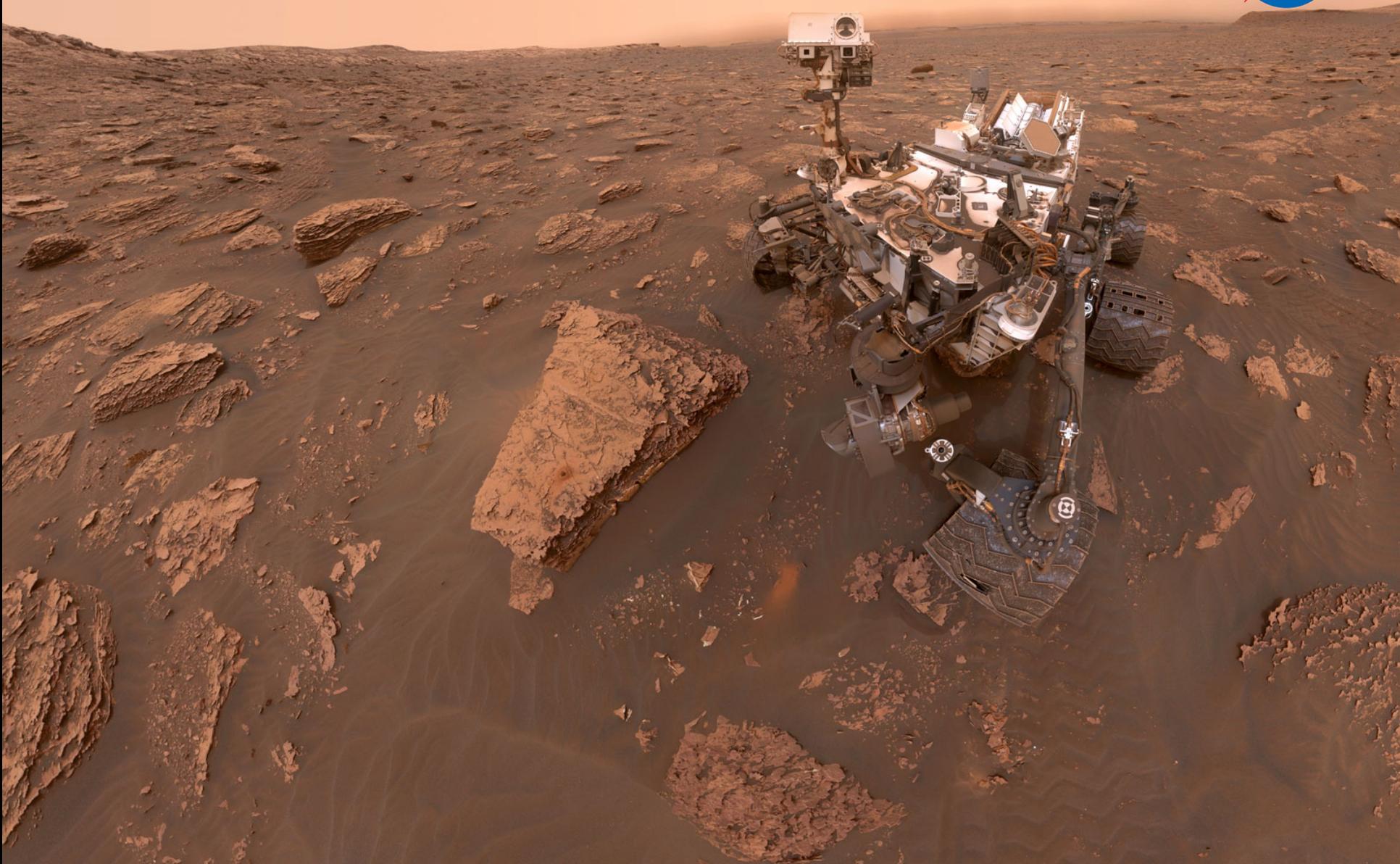
Credit: NASA/JPL-Caltech/MSSS

View of the *daytime* sky from Opportunity on Sol 5111 (early June 2018)



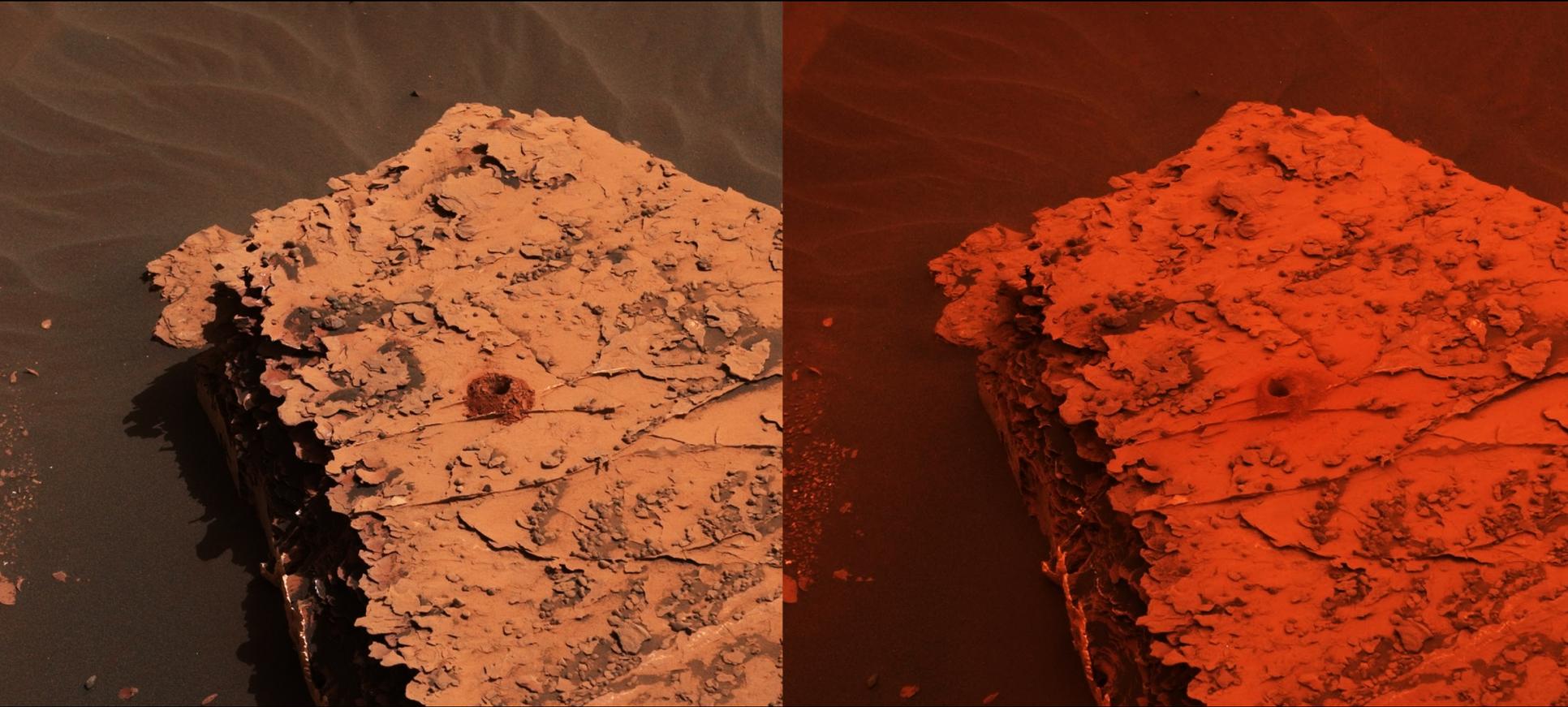
- 0.2 μm : Average iron dust particulate diameter.
- $\text{Tau} > 10$: Approximate optical depth
- 0.005%: Transmittance to the rover from the sun
- 0.02 mm: Thickness of corresponding dust layer that is suspended above rover.

Dust Storm 2018



Credit: NASA/JPL-Caltech/MSSS

Living in Under Salmon Colored Sky



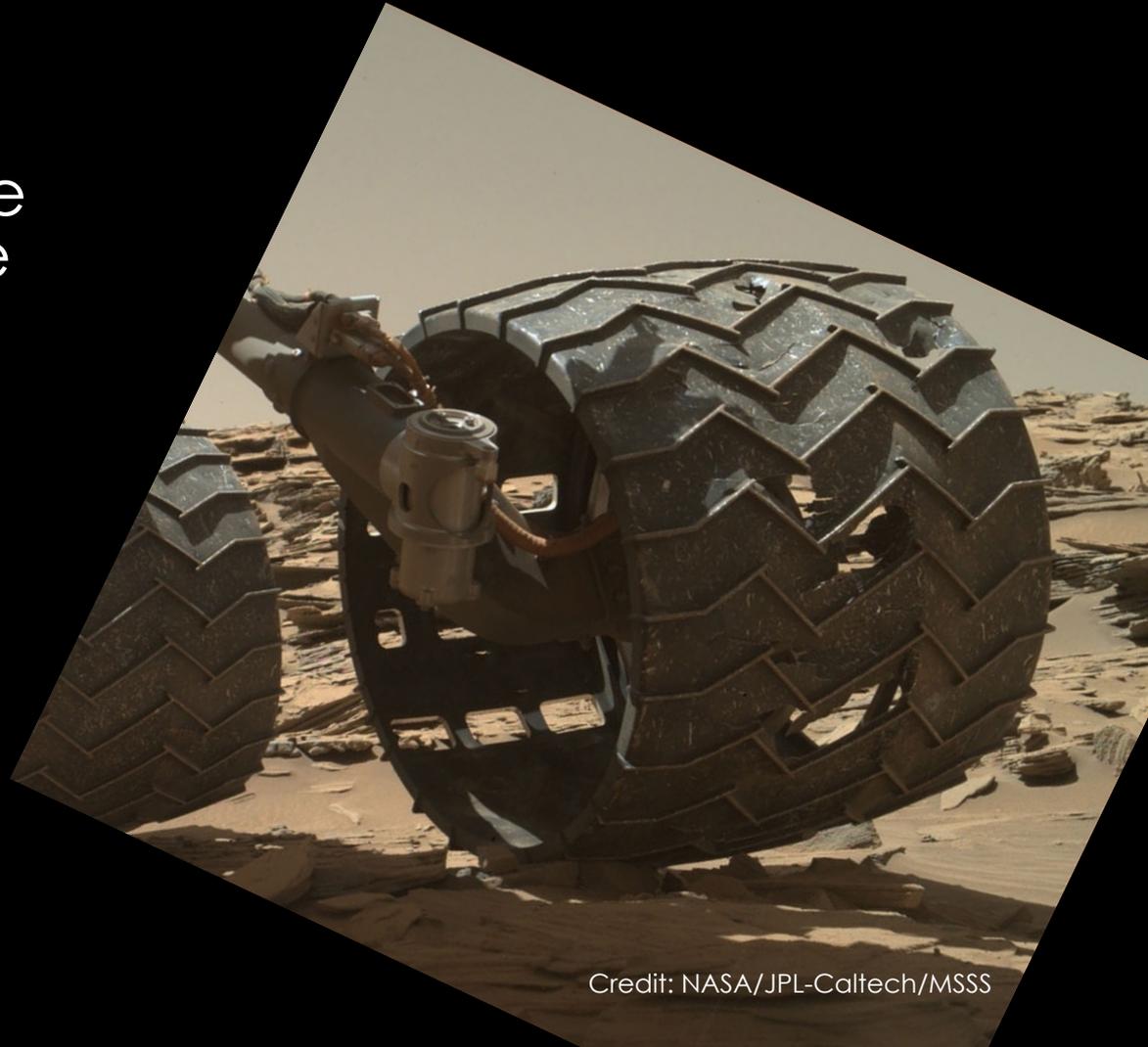
Credit: NASA/JPL-Caltech/MSSS

Watch for sharp rocks (bring thick sole shoes)



Credit: NASA/JPL-Caltech/MSSS

When we designed Curiosity's wheels, we failed to imagine that we would have to drive on firmly embedded wind-sharpened rock.



Credit: NASA/JPL-Caltech/MSSS



Watch for pesky chemicals in the soil

Calcium perchlorate (in the form of ClO_4^-) is probably widespread in Martian soils in concentrations between 0.2% - 1%.

What does this do to equipment over time?

What about impact to the human thyroid?

What ELSE is in the soil? Or just underground?

Nitrates! But in similar small amounts: 0.2% - 1%.

-> use to Nitrogenize plants?

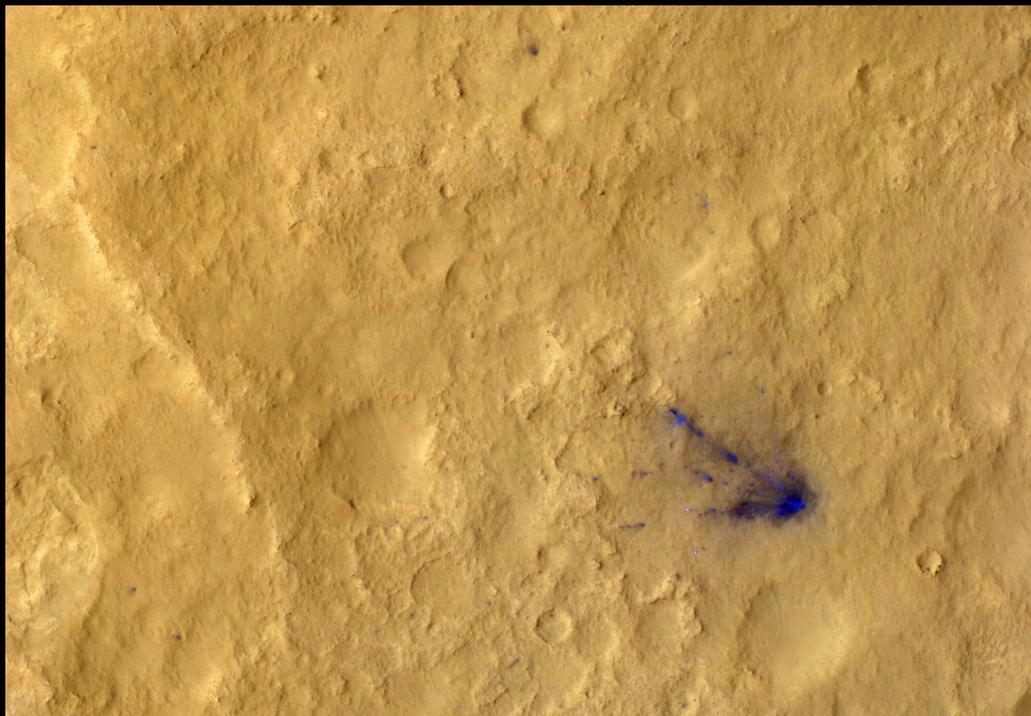


Credit: NASA/JPL-Caltech/LMA/UofA

Watch for things falling out of the sky



When they do, they hit hard (over 300 MPH)



Credit: NASA/JPL-Caltech/LMA/HIRISE UofArizoa



Credit: NASA/JPL-Caltech

Some things are just weirder on Mars



Under pressure or vibration, water trapped in rock can escape (deliquescence) causing rapid liquefaction.

Ice can be sticky

Dust can be clingy (electrostatic charge buildup).

People will tire of salmon colored skies.



Credit: NASA/JPL-Caltech/MSSS



Credit: NASA/JPL-Caltech/MSSS



Credit: NASA/JPL-Caltech/MSSS



Credit: unmannedspaceflight.com User: [wrighteous5280](#)



Final Message

Mars does not read requirements documents nor adhere to interface control documents.

Have a deep respect and humility for what we don't know. Design accordingly.



