Jet Propulsion Laboratory
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Widespread Shallow Water Ice on Mars at High and Mid Latitudes

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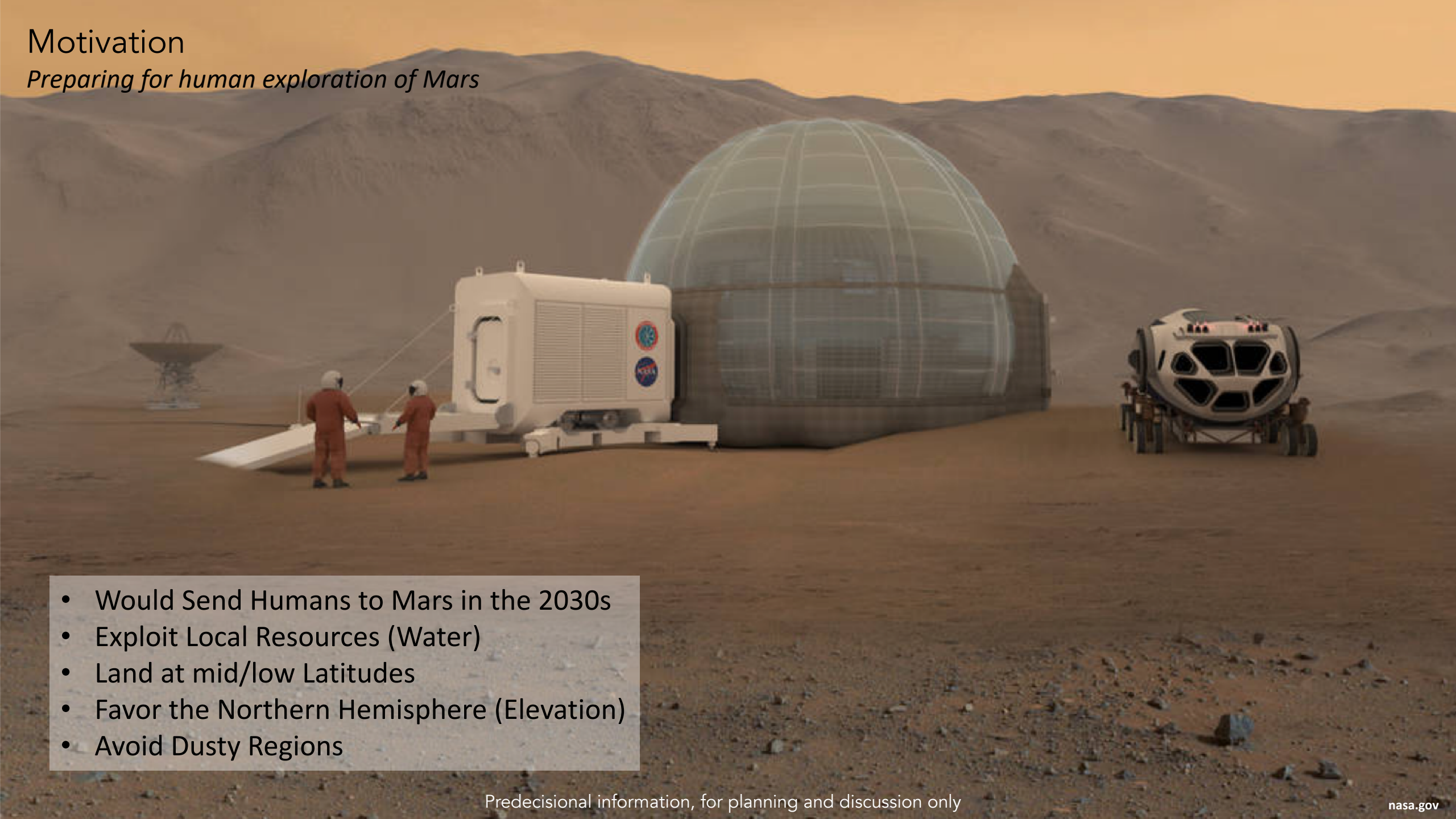
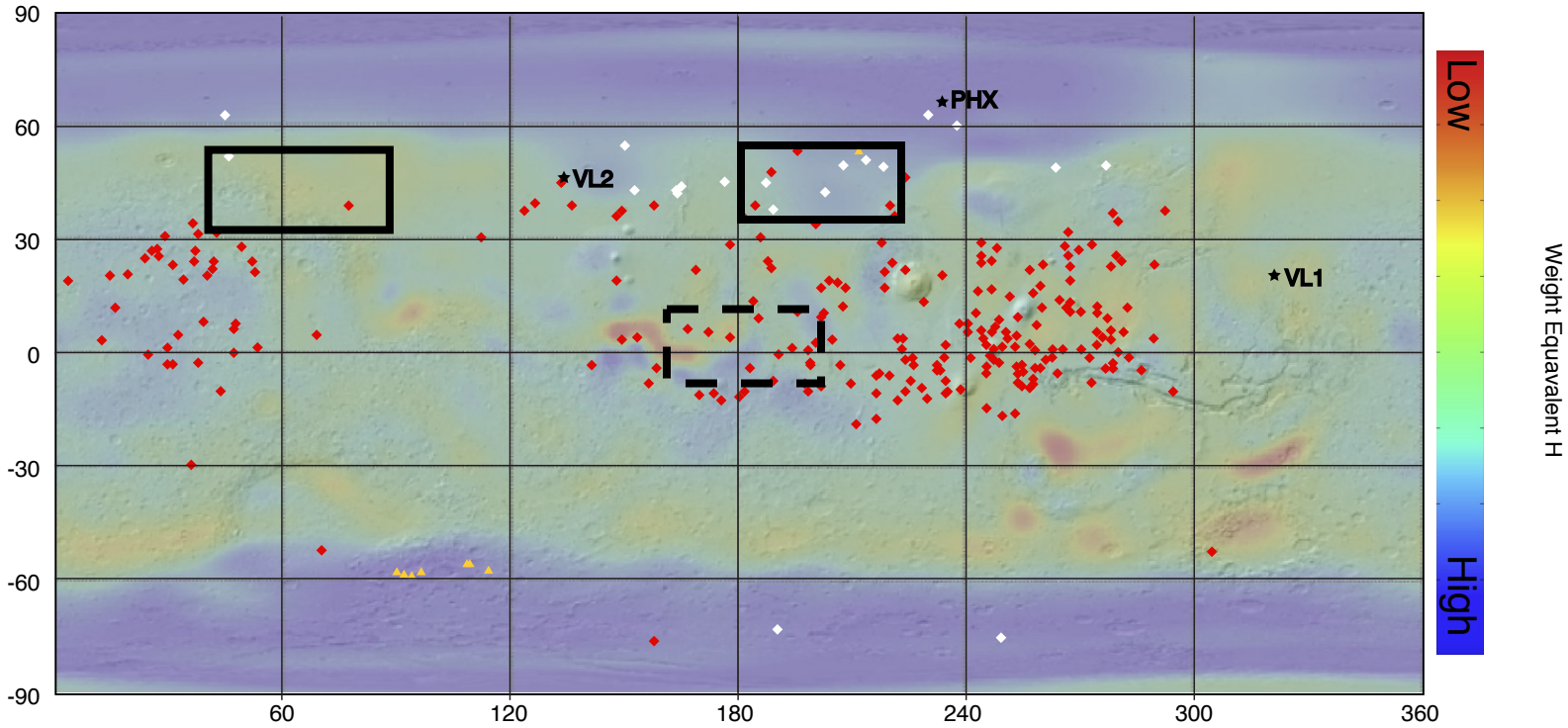
Motivation

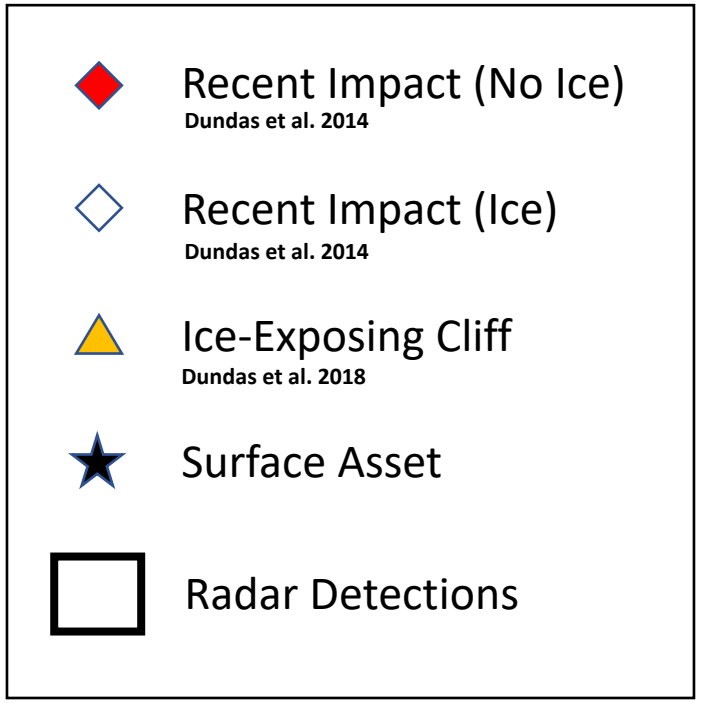
Preparing for human exploration of Mars

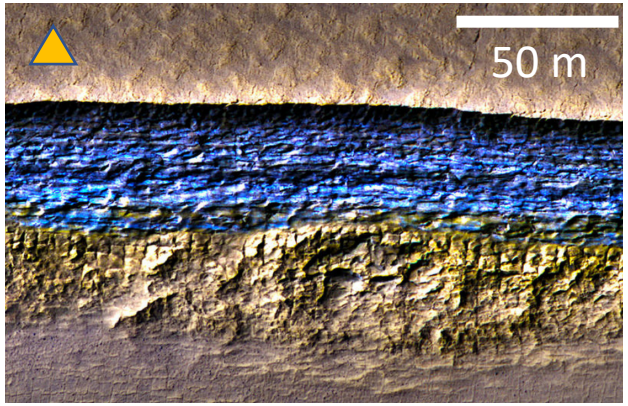


- Would Send Humans to Mars in the 2030s
- Exploit Local Resources (Water)
- Land at mid/low Latitudes
- Favor the Northern Hemisphere (Elevation)
- Avoid Dusty Regions

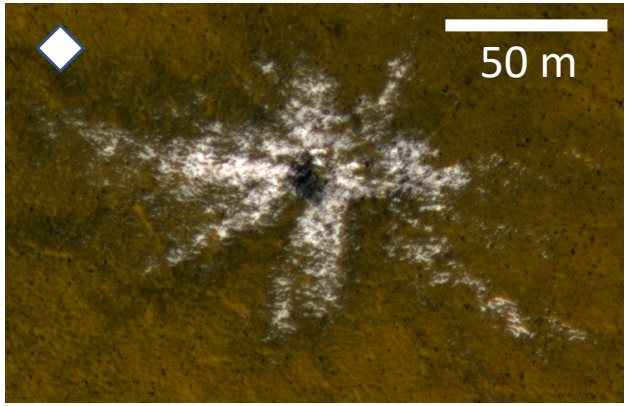
Water Ice at Mid/Low Latitudes



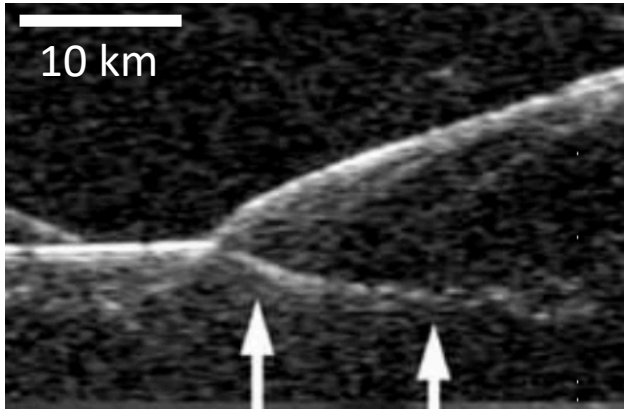




Dundas et al. 2018

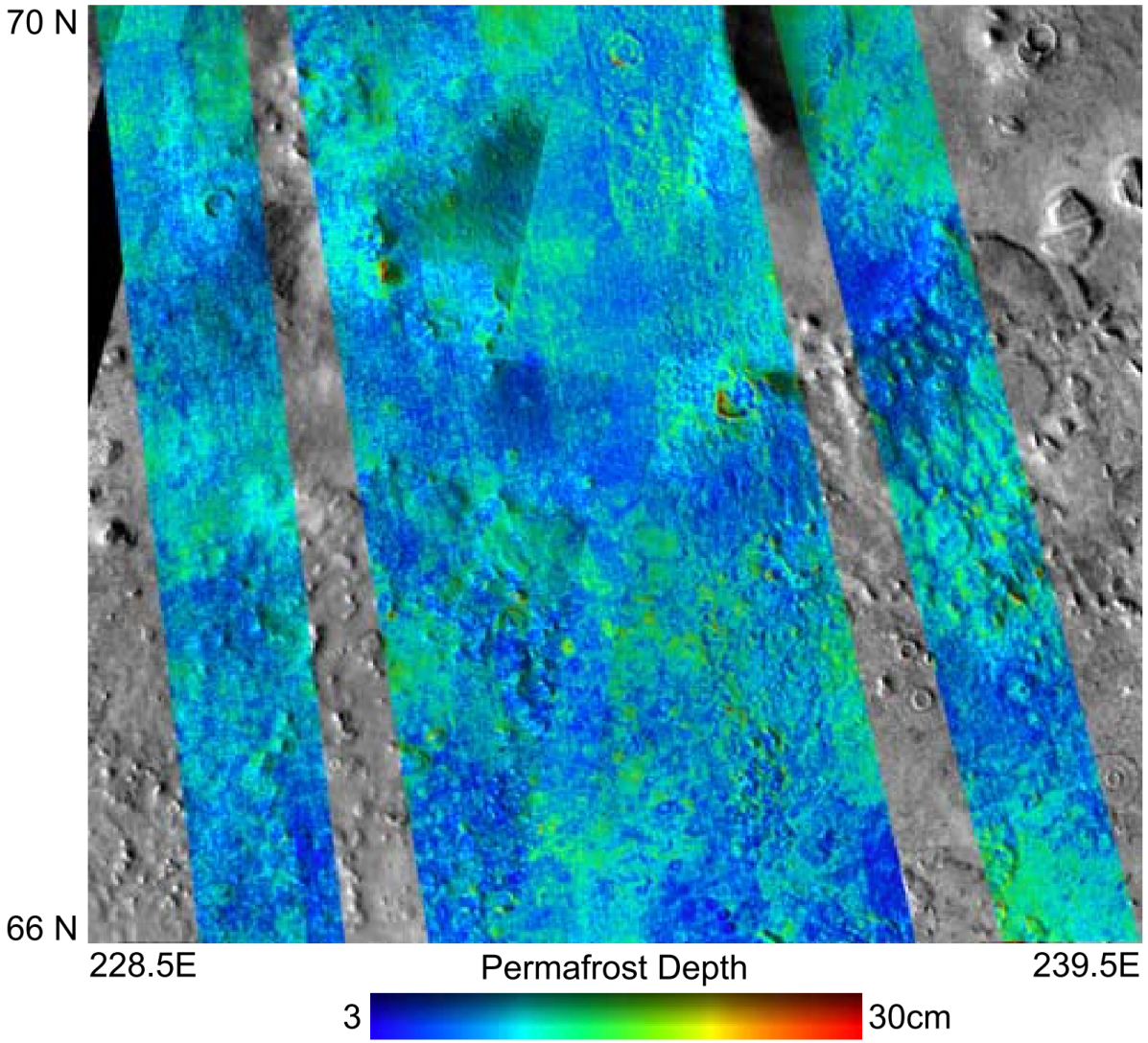


Byrne et al. 2009

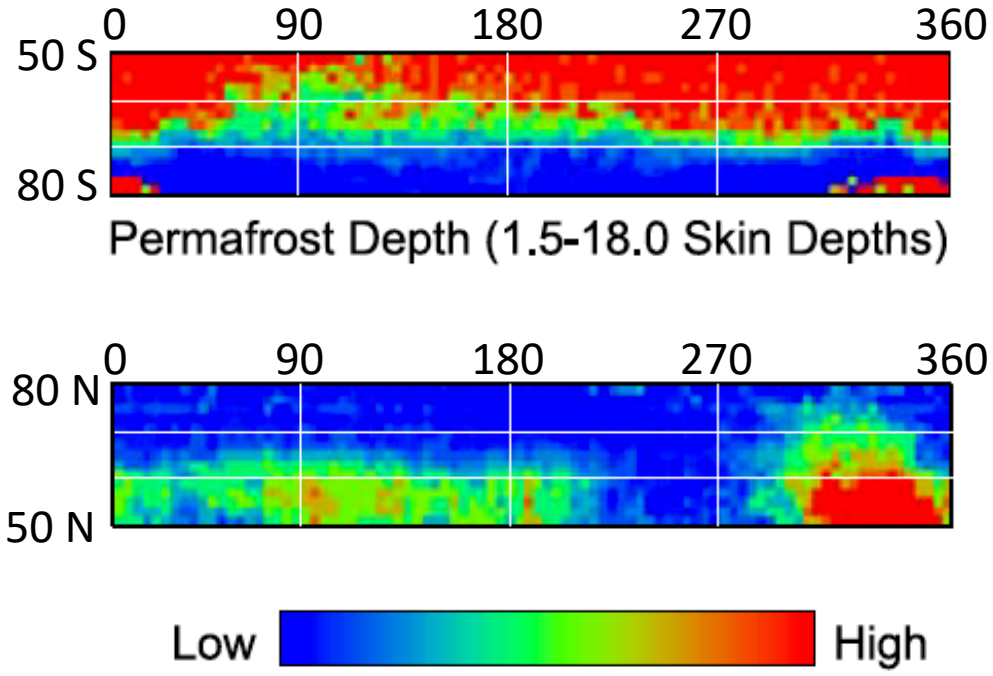


Plaut et al. 2009

Water Ice at Mid/Low Latitudes



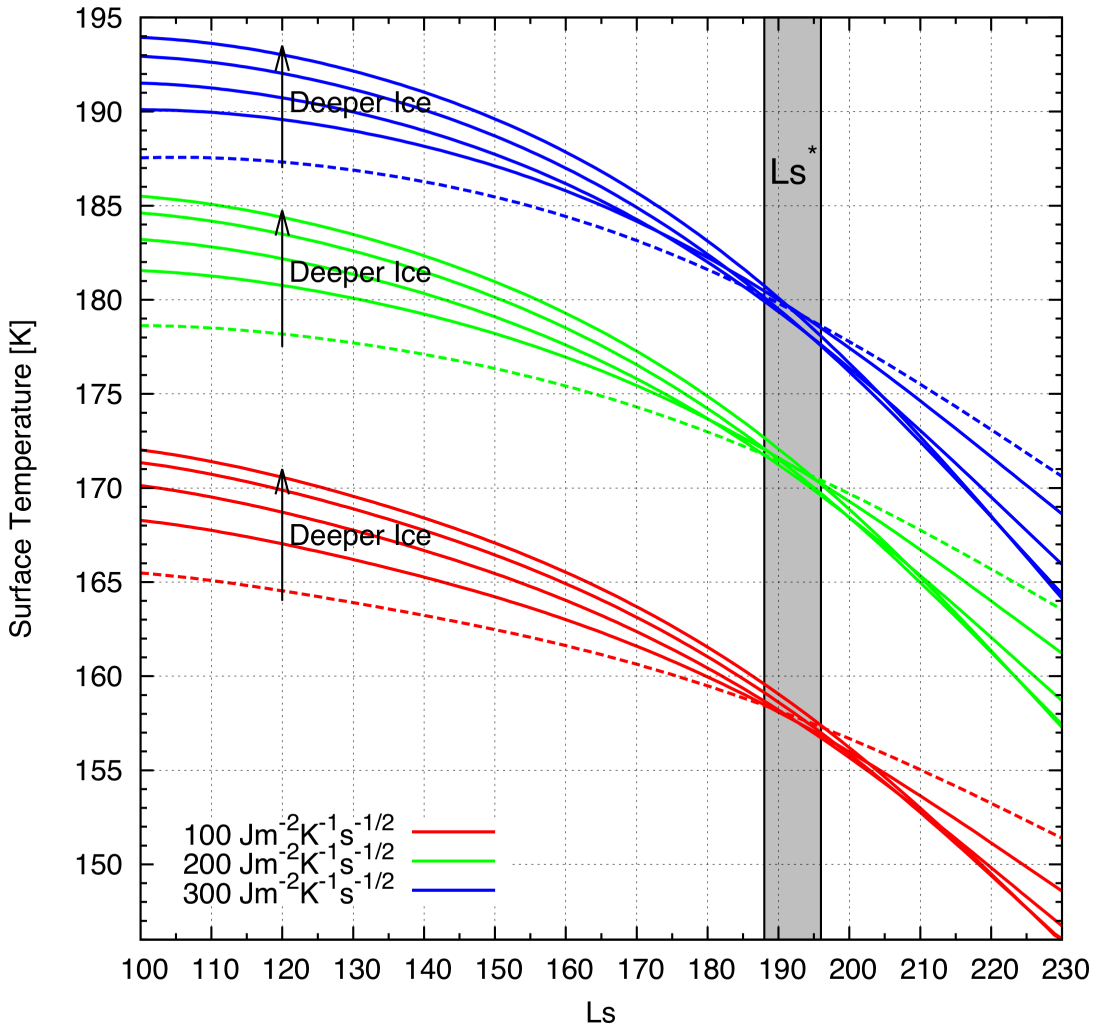
Bandfield 2007



Bandfield and Feldman 2008

- Regional Mapping @ 200+km resolution
- Location-specific @ ~9km [Mellon et al. 2008]
- Local Mapping @ 100 m resolution

Methods



Water Ice / Icy Soil:

- I_{H2O} > 2000 $Jm^{-2}K^{-1}s^{-1/2}$
- Heat Capacitor
- Slower Spring Warming
- Delayed Fall Cooling

Dry Regolith:

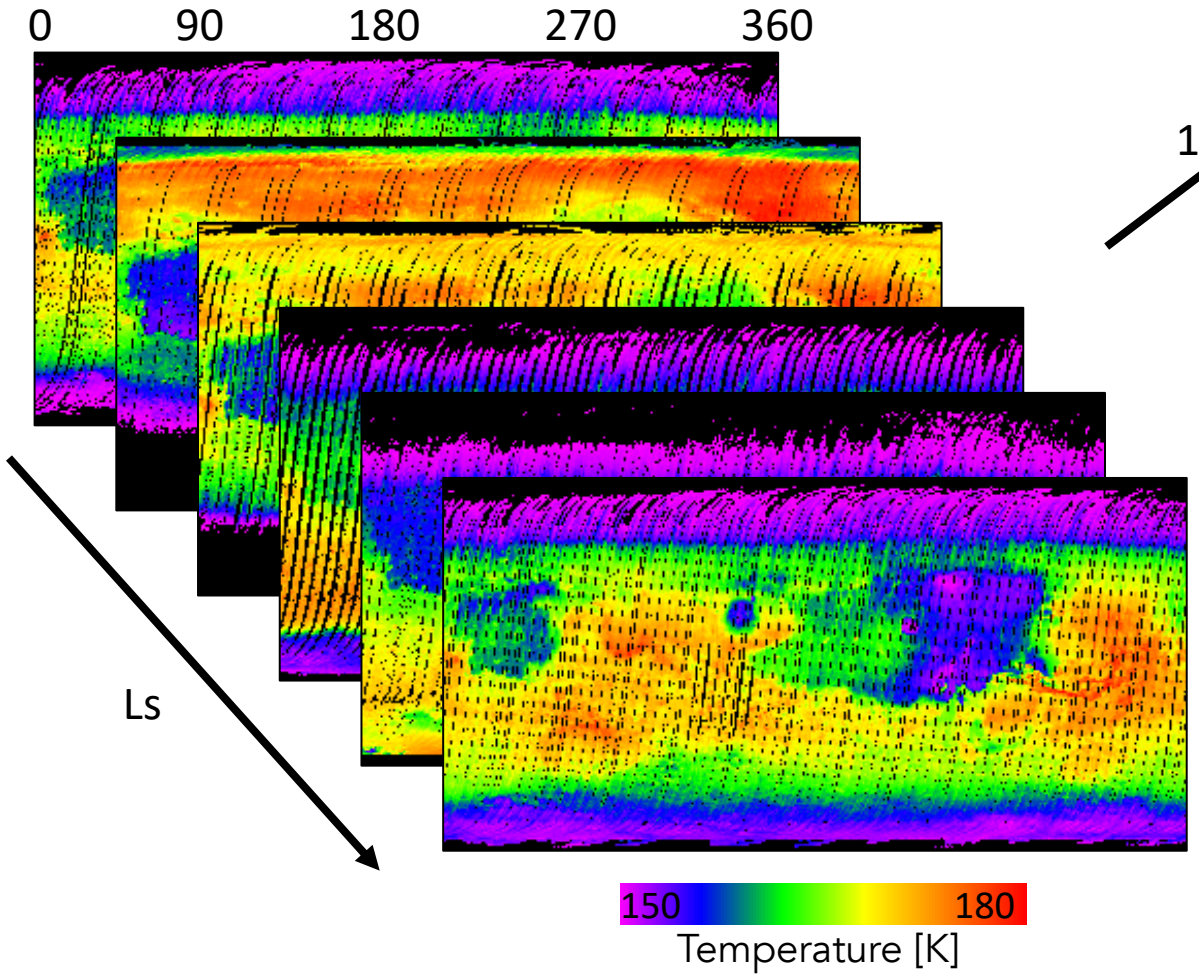
- I_{DRY} 100 – 350 $Jm^{-2}K^{-1}s^{-1/2}$
- Faster Spring Warming
- Faster Fall Cooling

Water Ice has a Measurable Thermal Effect:

- top ~1m (or much less)
- Pronounced Seasons (90°=>30° N and S)
- Except near Ls* (only a function of I_{DRY})

- When Water Ice is Very Shallow (a few cm), Ls* occurs earlier

MRO Mars Climate Sounder Surface Temperature Mapping



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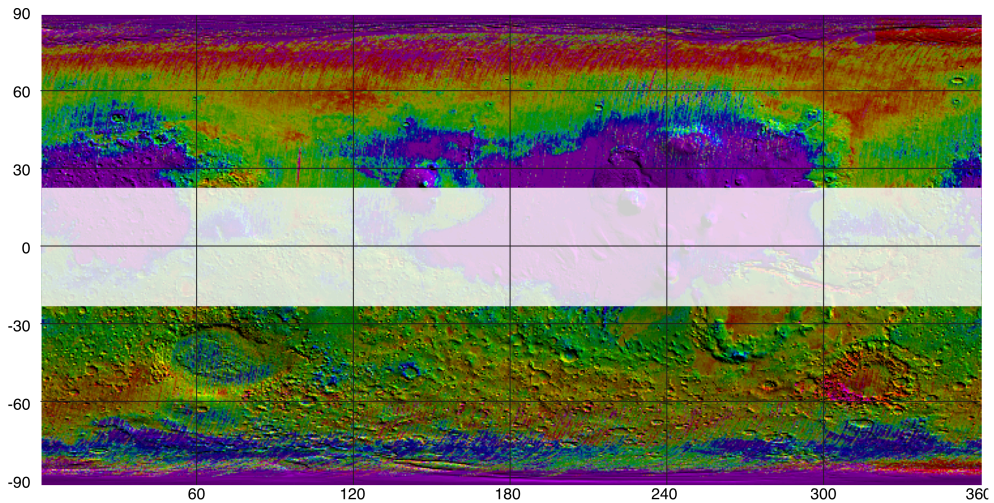

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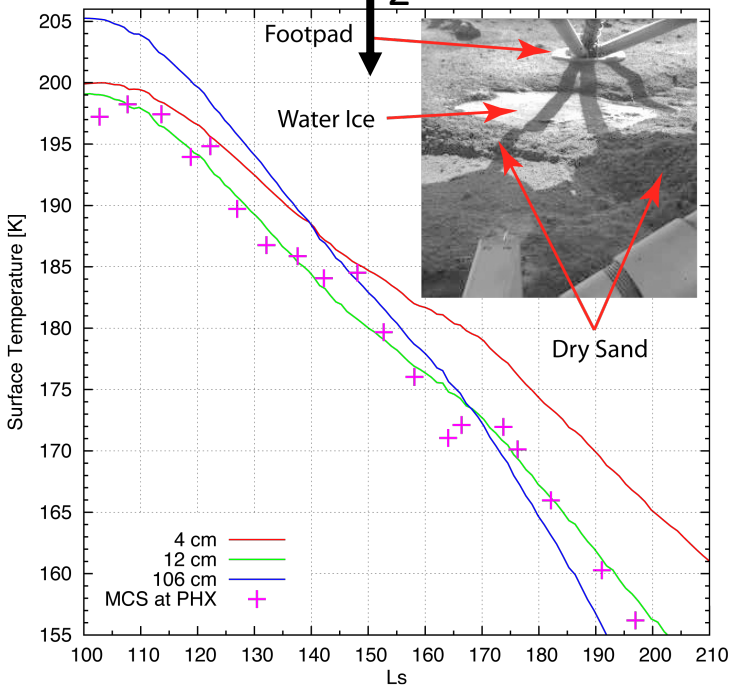
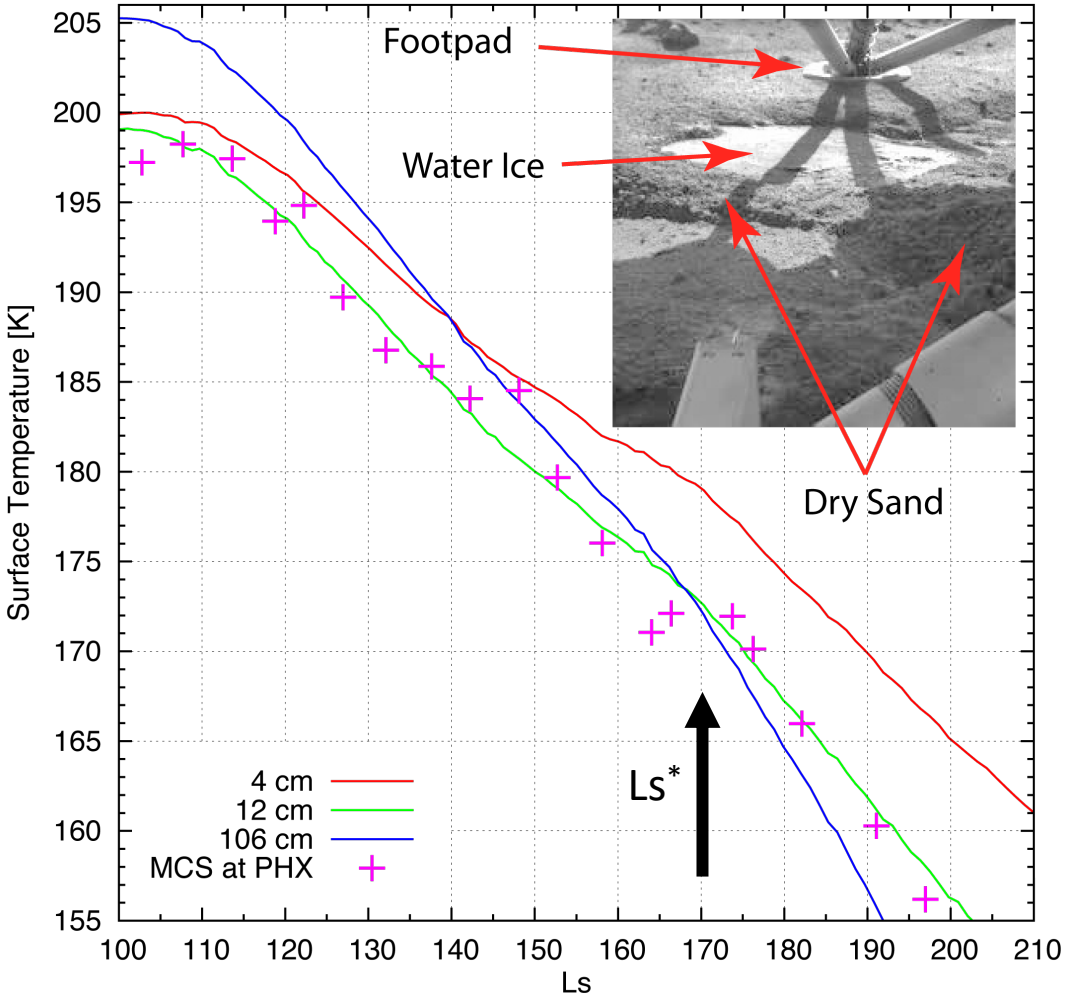


Validation



This Study

- I_{DRY} ~ 230 $Jm^{-2}K^{-1}s^{-1/2}$
- D_{H2O} ~ 12 cm

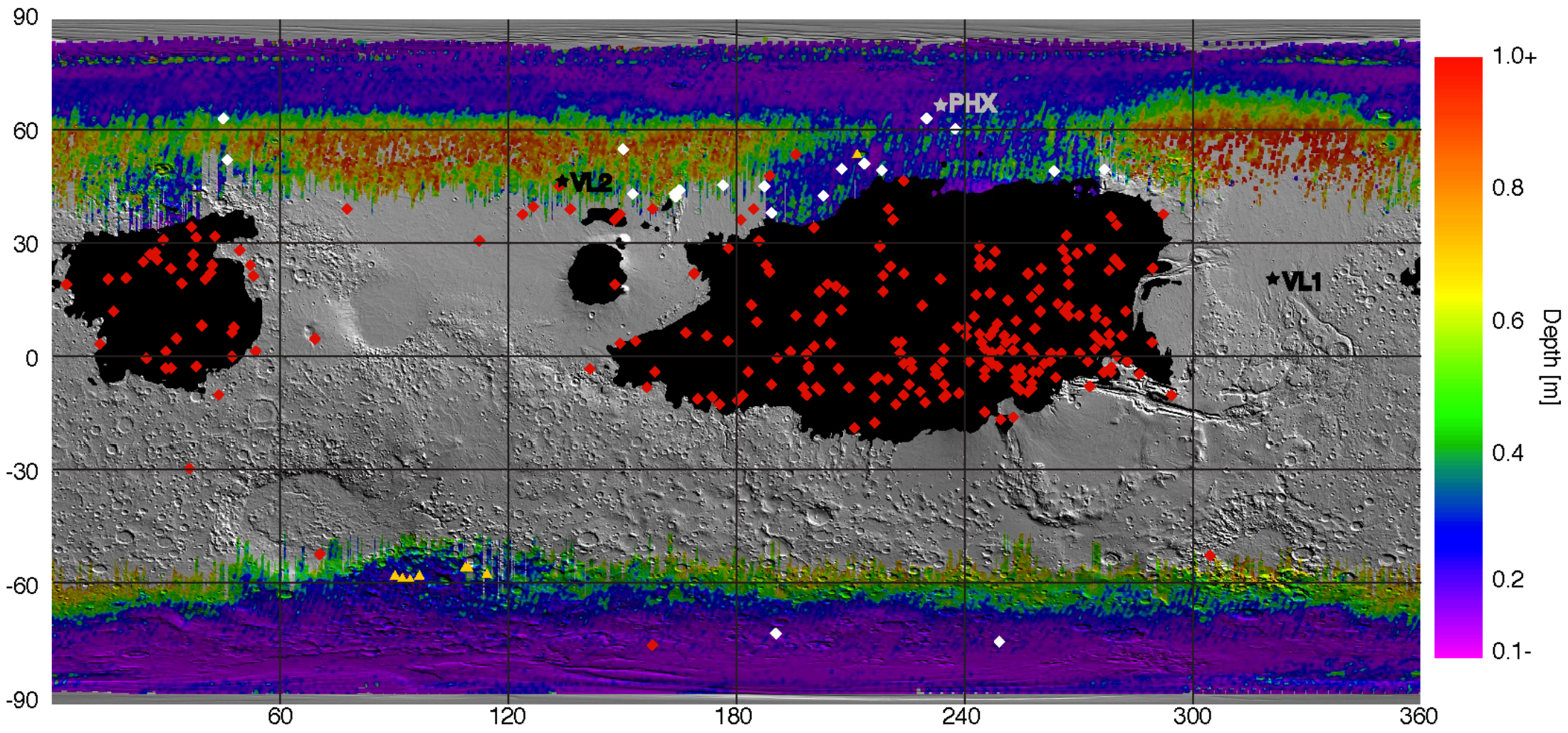
In Situ (Phoenix Lander)

- I_{DRY} 250-300 $Jm^{-2}K^{-1}s^{-1/2}$ Zent et al. 2012
- D_{H2O} 5-18 cm Smith et al. 2009

Other Studies

- I_{DRY} 260-280 $Jm^{-2}K^{-1}s^{-1/2}$ Bandfield and Feldman 2008
- D_{H2O} 4-6 cm Mellon et al. 2008, Bandfield and Feldman 2008

Results



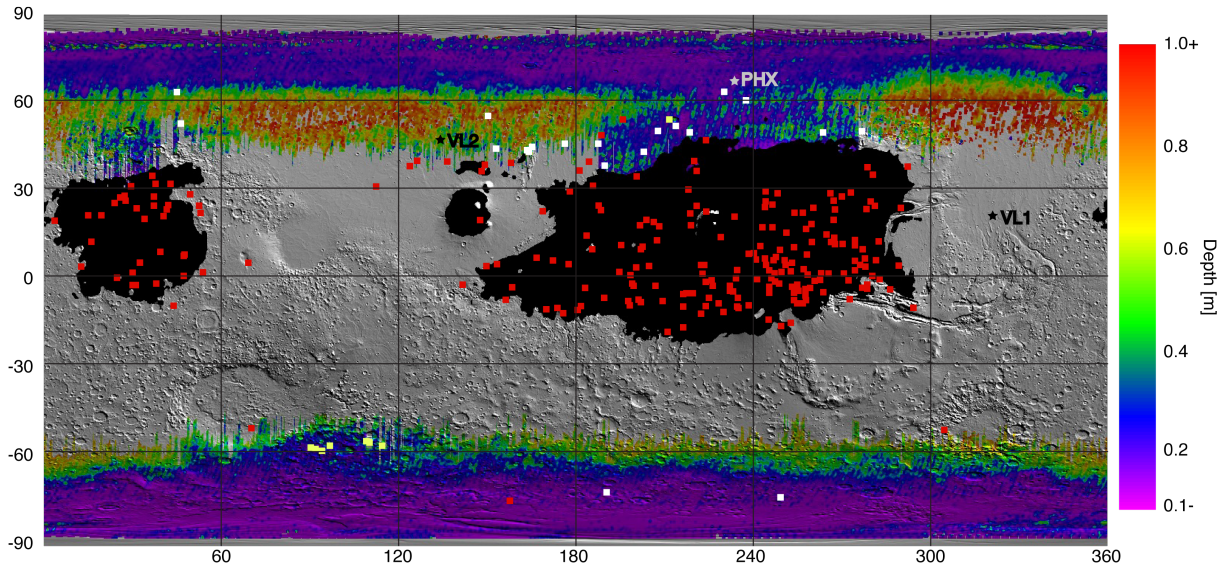
Recent Impact (No Ice)
Dundas et al. 2014

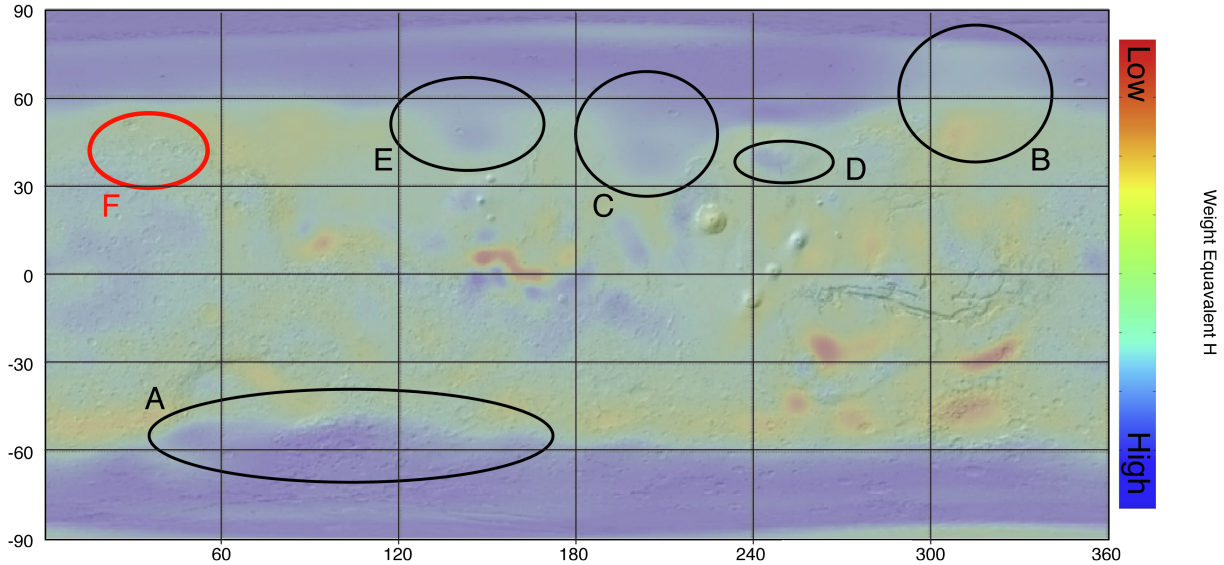
Recent Impact (Ice)
Dundas et al. 2014

Ice-Exposing Cliff
Dundas et al. 2018

Surface Asset

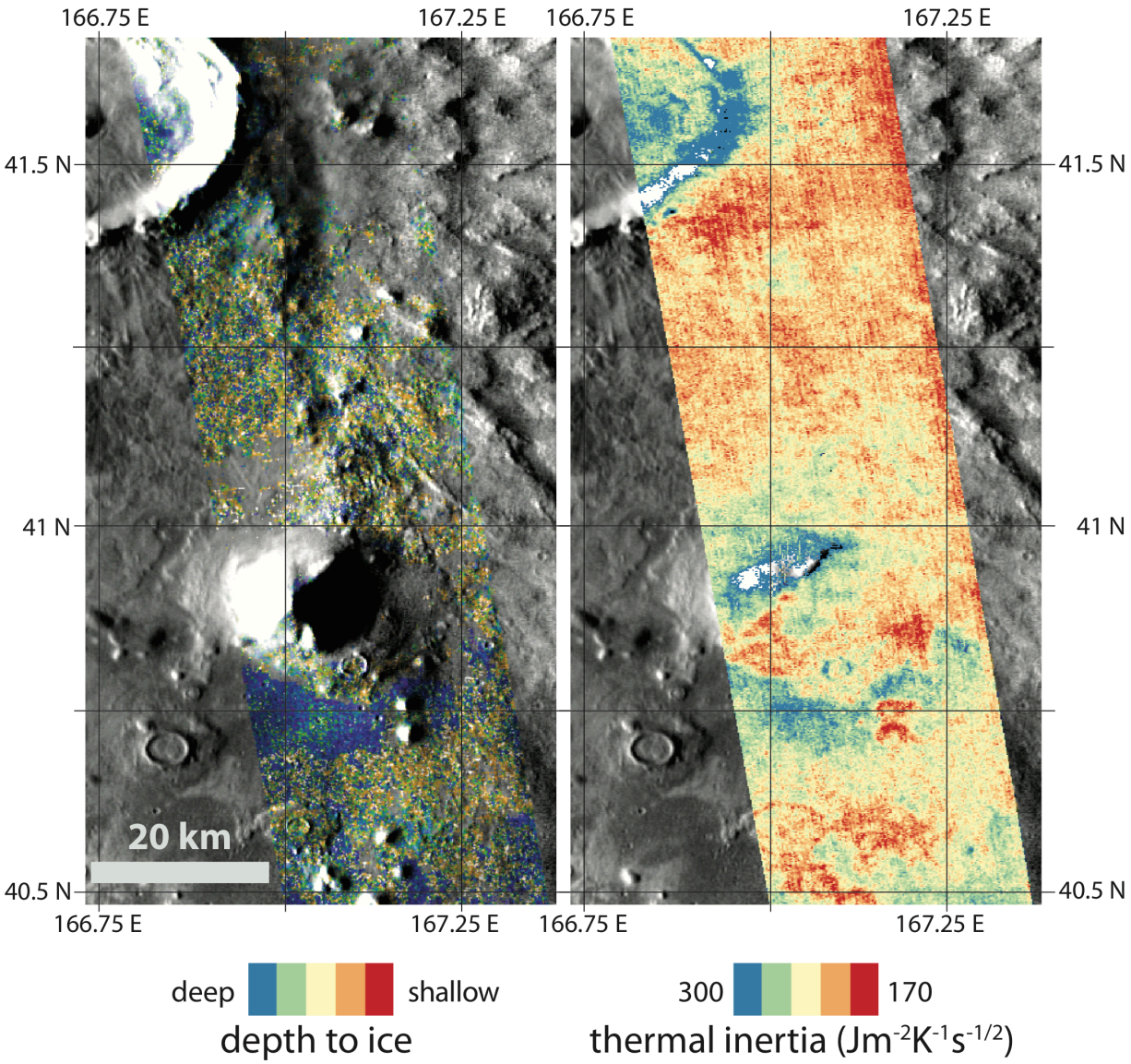
Comparison with MONS





Wilson et al. 2017

Results



1. THEMIS Mapping at 100m
   - Relative Depth
   - Spotty Global Coverage

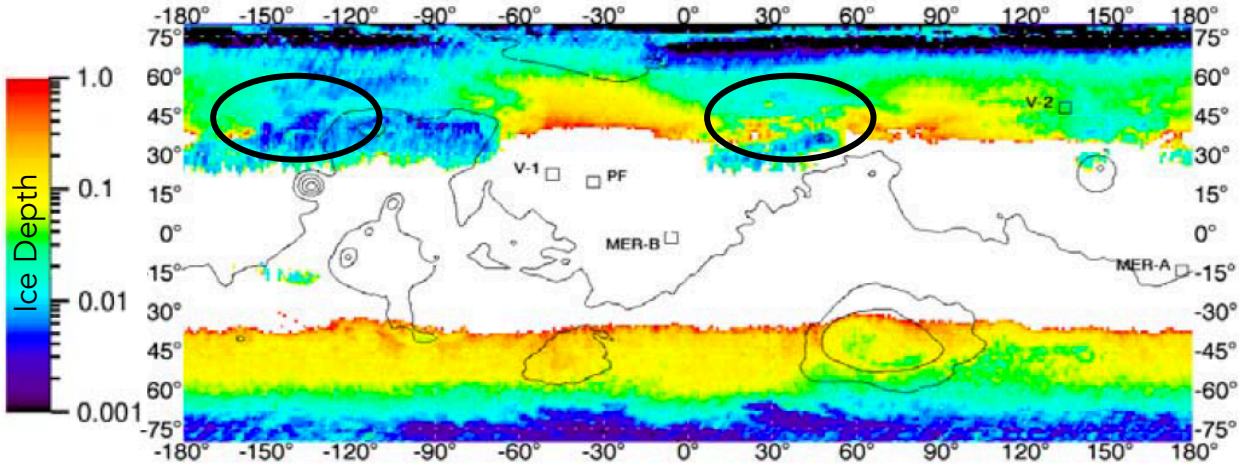
2. Correlation with Surface Features

3. High Lateral Depth Variability

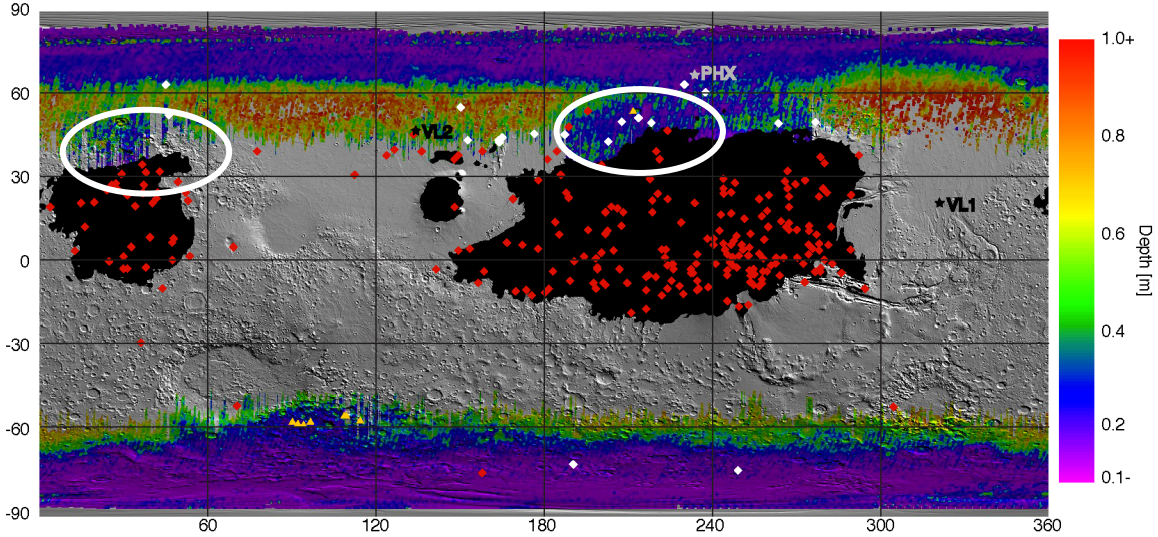
Conclusions

- Richer MCS and THEMIS Datasets
- Improved Numerical Tools
  1. Subsurface Water Ice Mapping in top ~1m Down to ~35°N and 45°S
  2. Numerous Locations with Very Shallow Water Ice
  3. High Lateral Variability at All Scales (Regional, km, m, etc.)
  4. Implication for In Situ Resource Utilization
  5. Implication for Special Regions

- Several Locations Associated with Unstable Ice Under Current Conditions
- … but Potentially Stable with Higher Vapor Pressure
- New MRO MCS Campaign to further improve the mapping resolution



Chamberlain and Boynton 2007



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