



The Role of Regolith in the Water Cycle on Mars

Renyu Hu

Jet Propulsion Laboratory

California Institute of Technology

February 25, 2021

Surface Water Reservoirs on Mars

Polar layered deposits

21±3 m Global Equivalent Layer (GEL)
Zuber et al. 1998; Plaut et al. 2007

Ice-rich regolith (Lat>50°-60°)

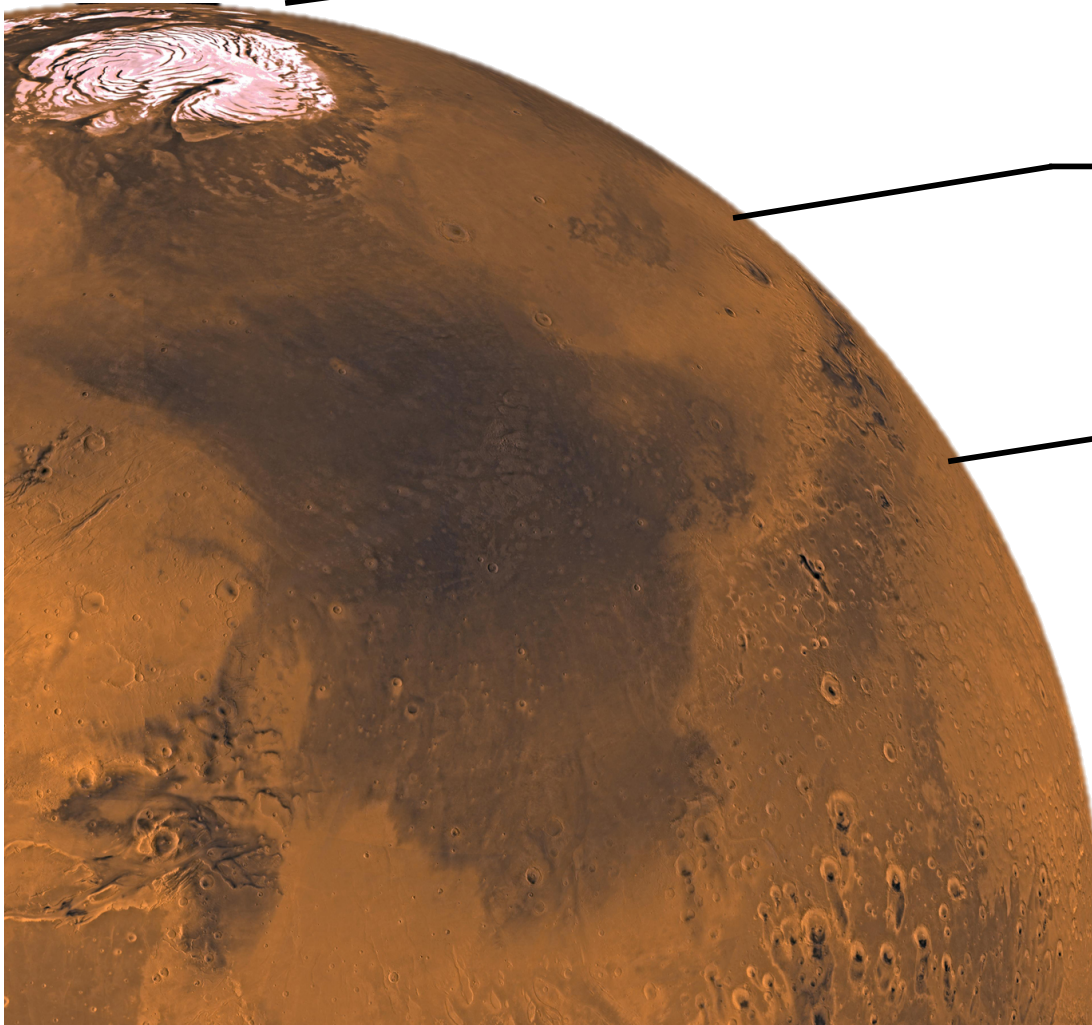
7 m GEL
Mouginot et al. 2007

Localized shallow buried ice (Lat~30°-60°)

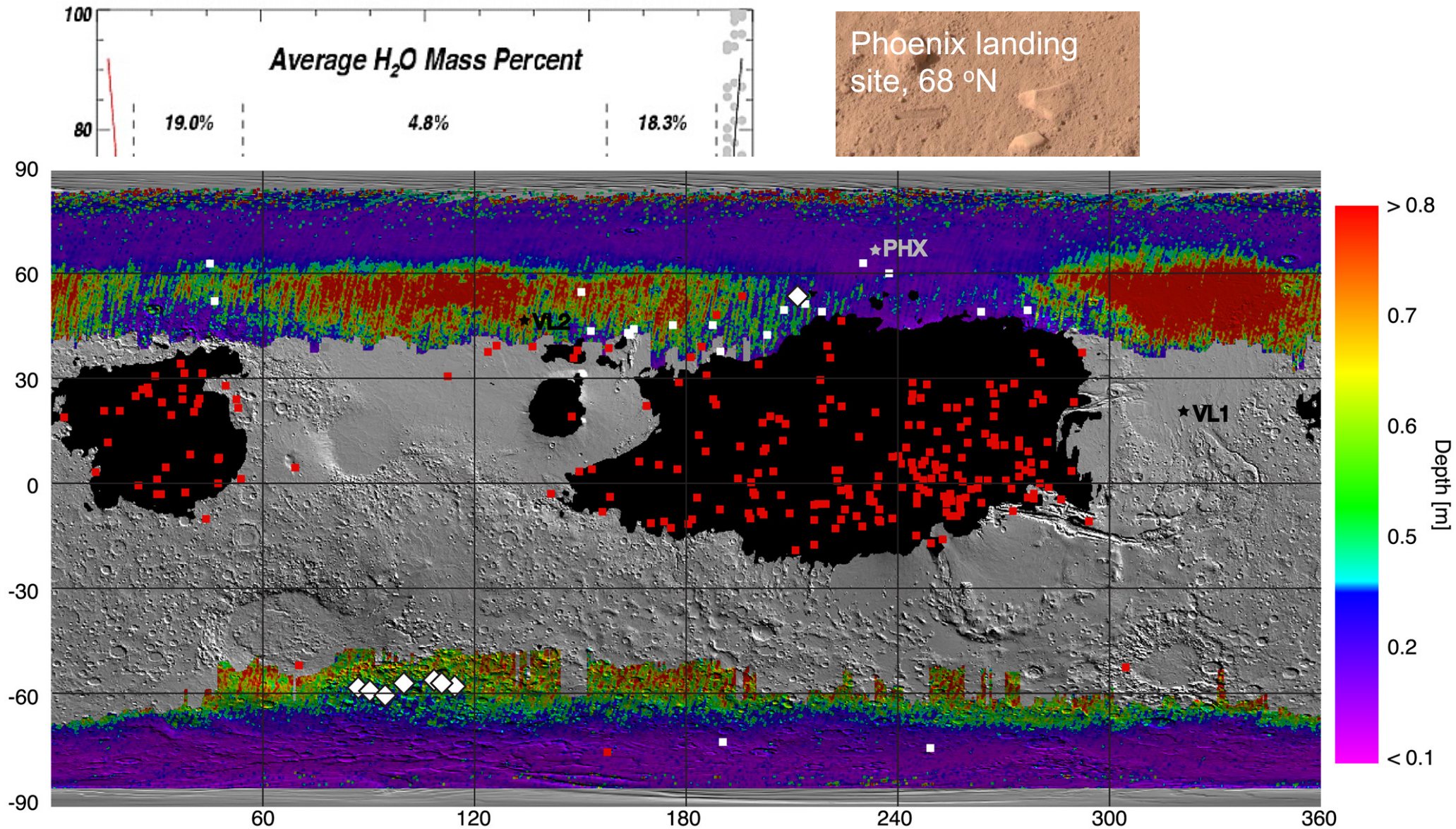
<5 m GEL
Carr & Head 2015

Atmosphere

~2 × 10⁻⁵ m GEL
Smith et al. 2009

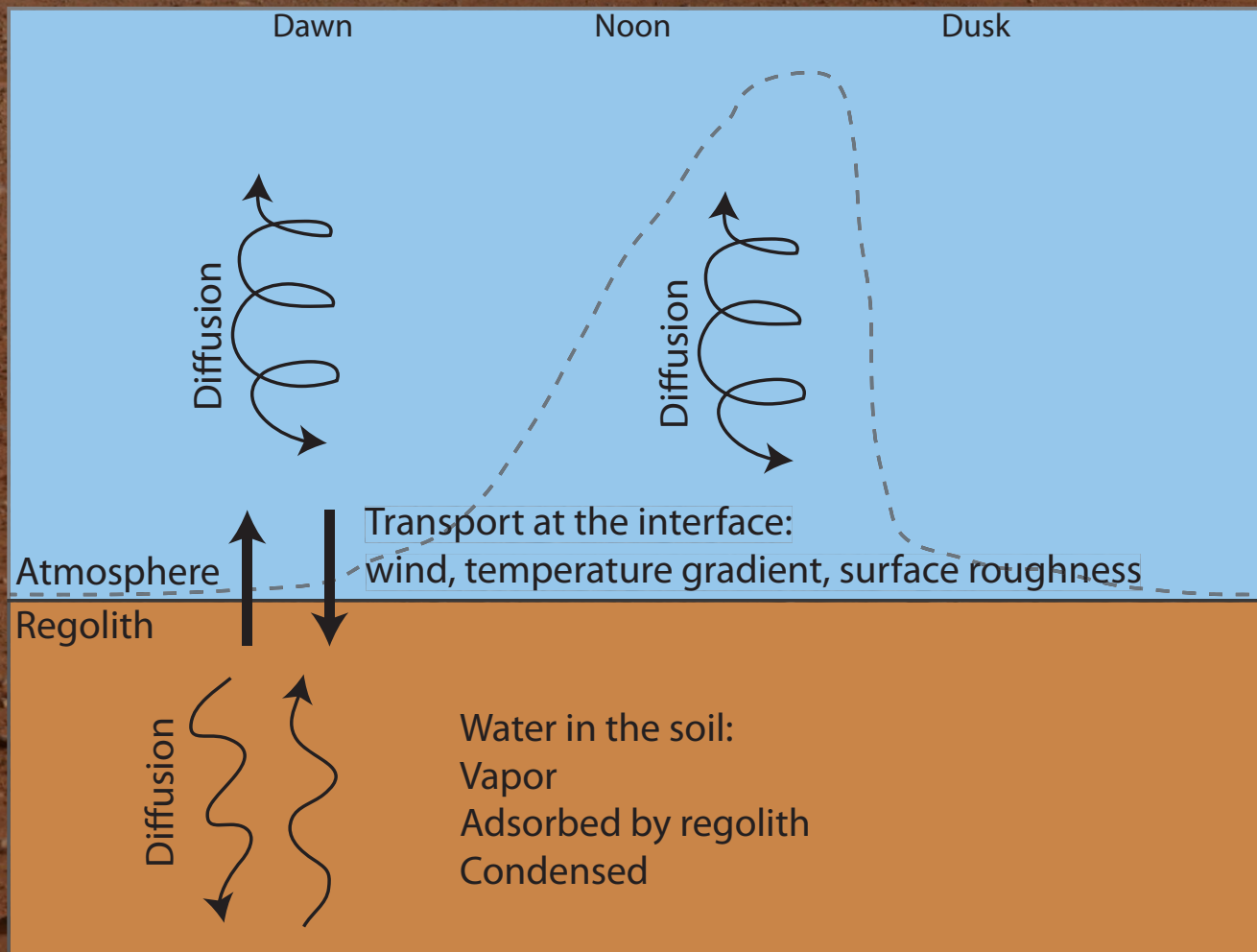


Icy Regolith and “Bulk Ices”



Piqueux et al. 2019; also see Byrne et al. 2009; Dundas et al. 2014, 2018

Regolith-atmosphere exchange on Mars



Regolith is an exchangeable reservoir for CO_2 , N_2 , and H_2O , and trace gases

Recent suggestion of a regolith reservoir of CH_4 (Hu et al. 2016; Moores et al. 2019)

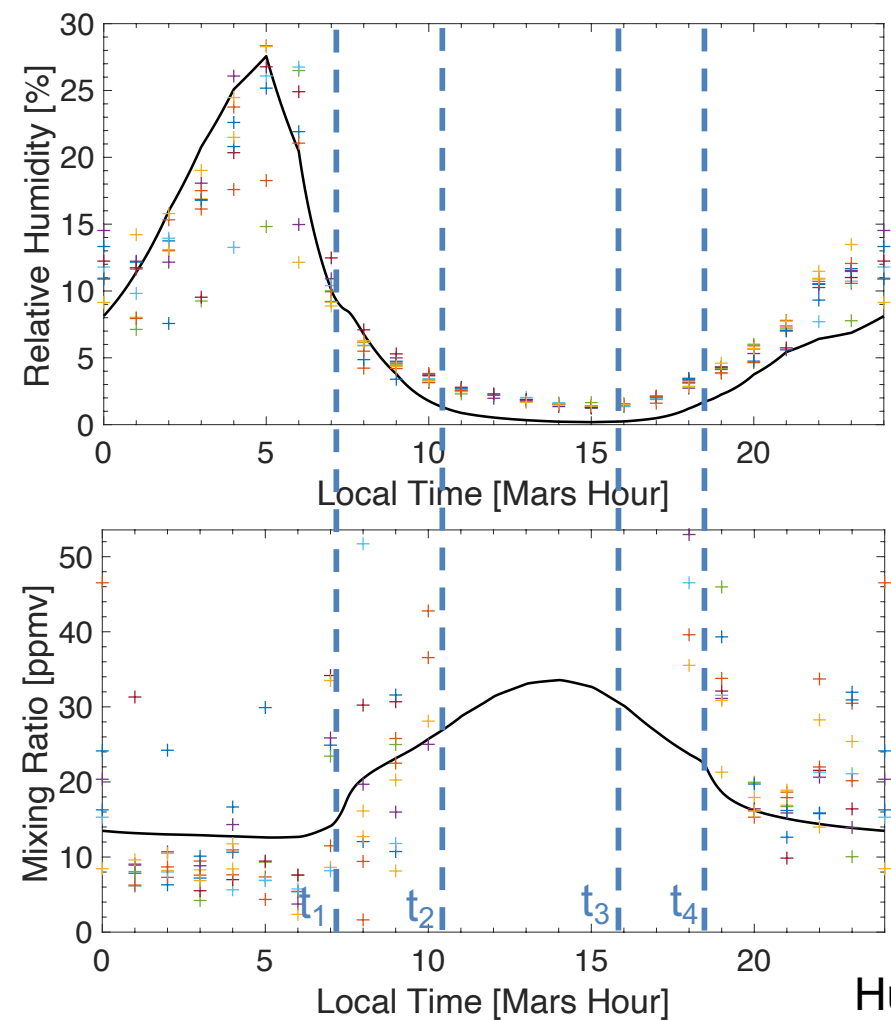
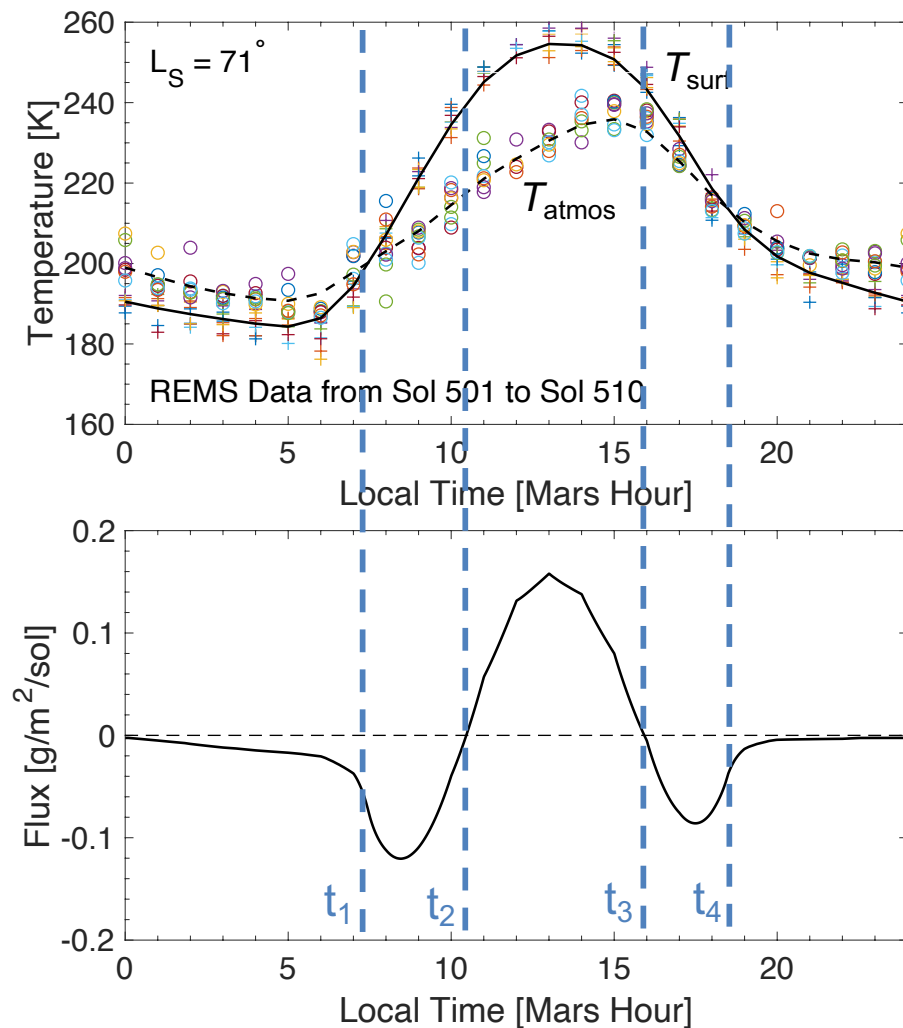
The regolith exchange also impacts the atmospheric D/H (Hu 2019)

- Regolith preferentially stores HDO through adsorption (Moores et al. 2011) and condensation

Yung et al. 1988; Haberle et al. 1993; Zent et al. 1993; Savijärvi 1995; Hu et al. 2016; Moores et al. 2019; Hu 2019

Regolith-atmosphere exchange in Gale Crater

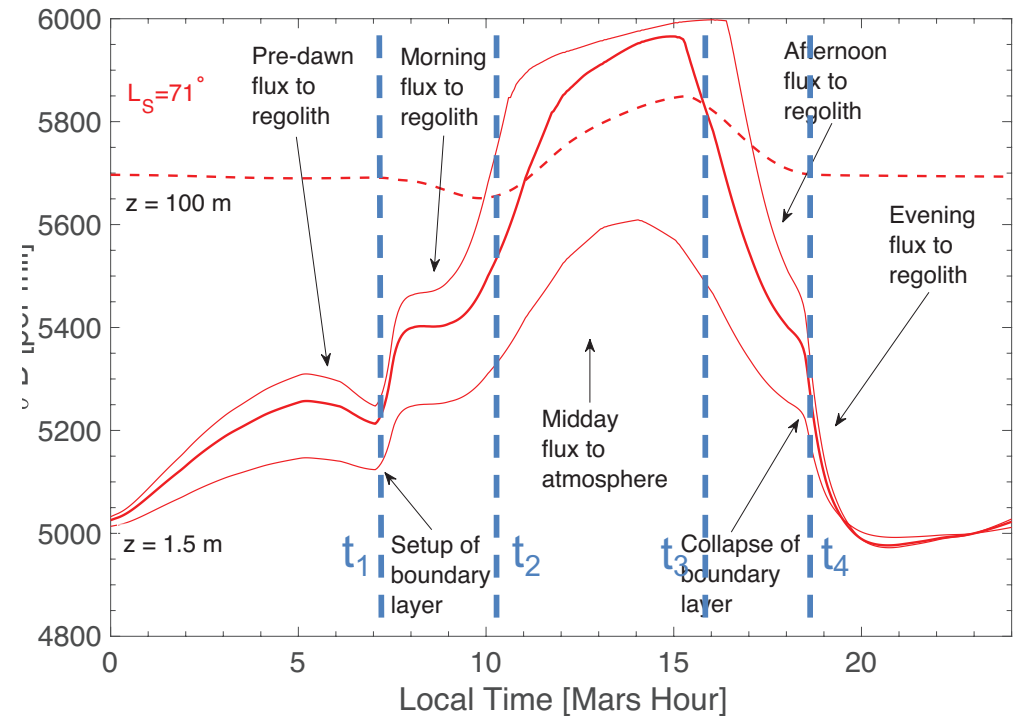
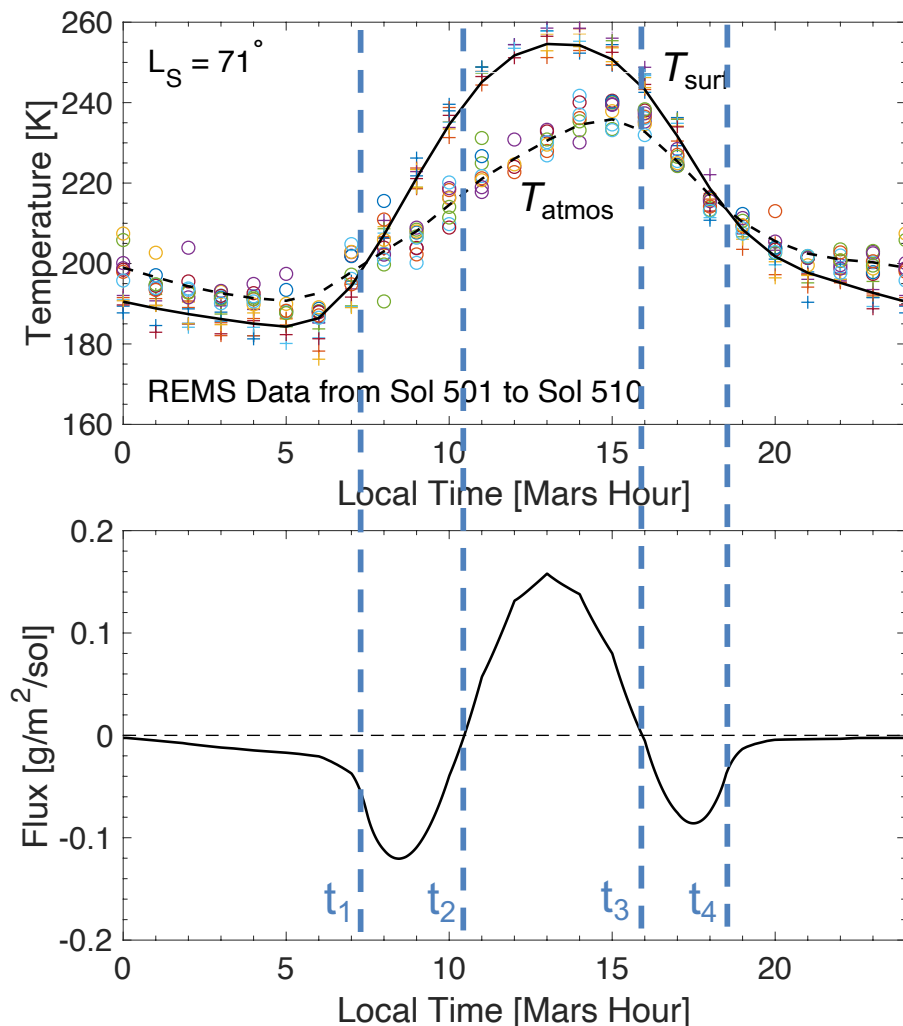
Regolith adsorption and diurnal exchange is required to explain the REMS relative humidity measurements (e.g., Savijärvi et al. 2016, 2019)



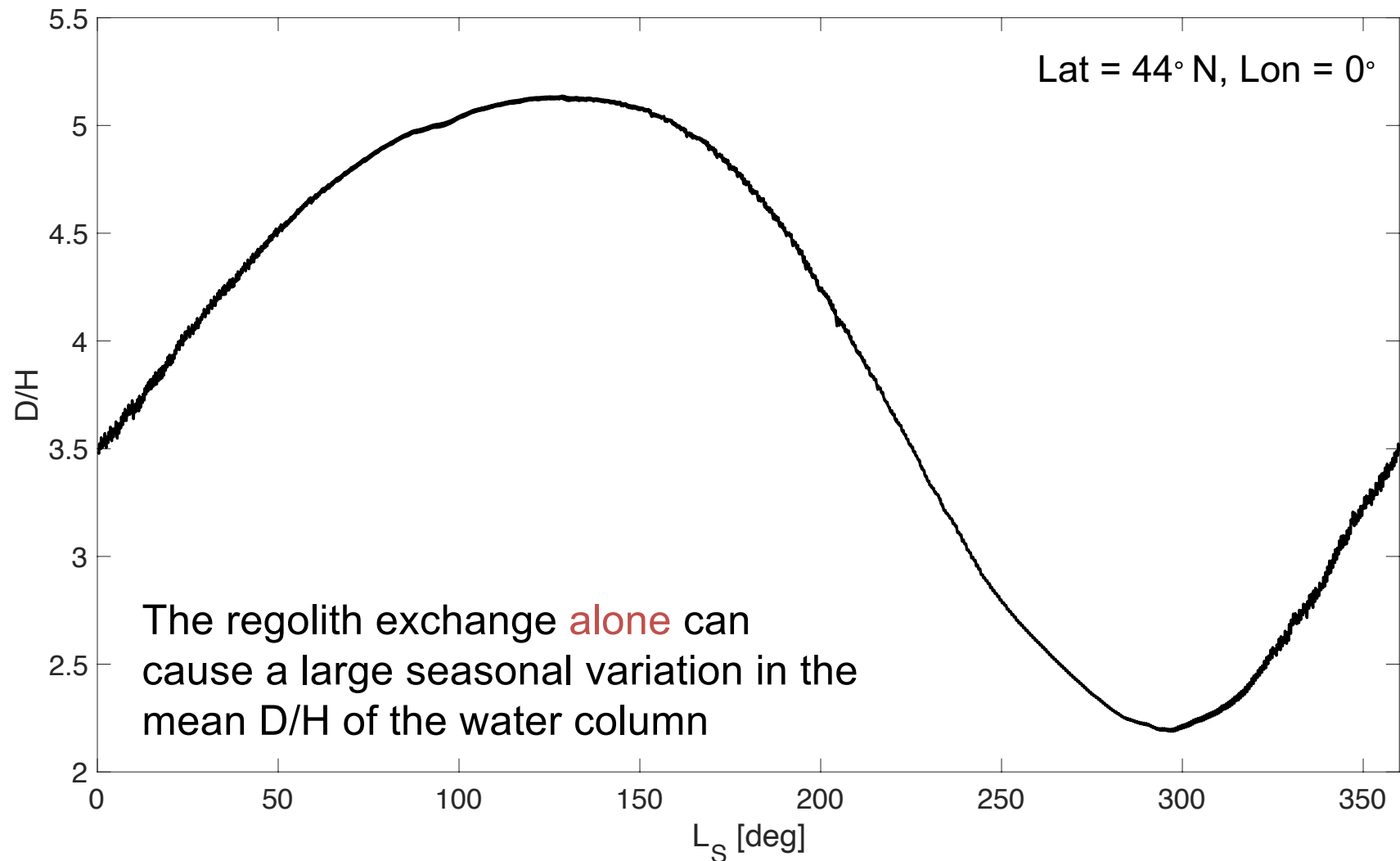
Regolith-atmosphere exchange causes large diurnal variation in D/H

δD can vary by 300 – 1400‰

- The magnitude of variation is greater at a colder location or during a colder season
- Condensation in the regolith or at the surface changes the patterns of the variation



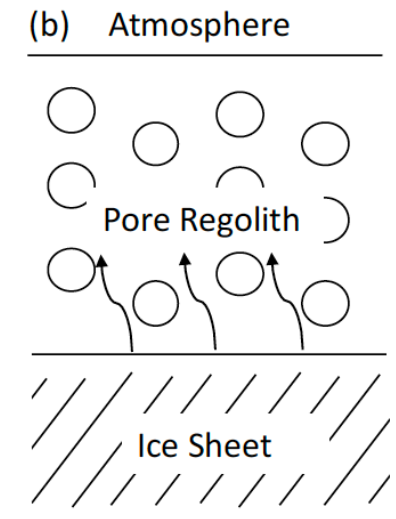
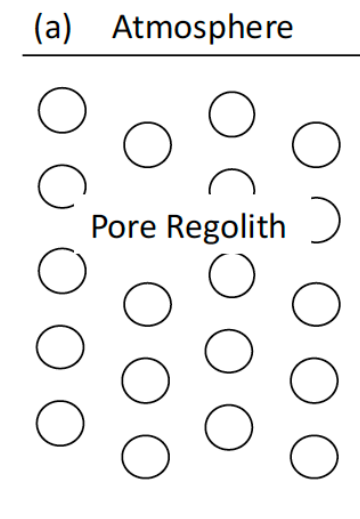
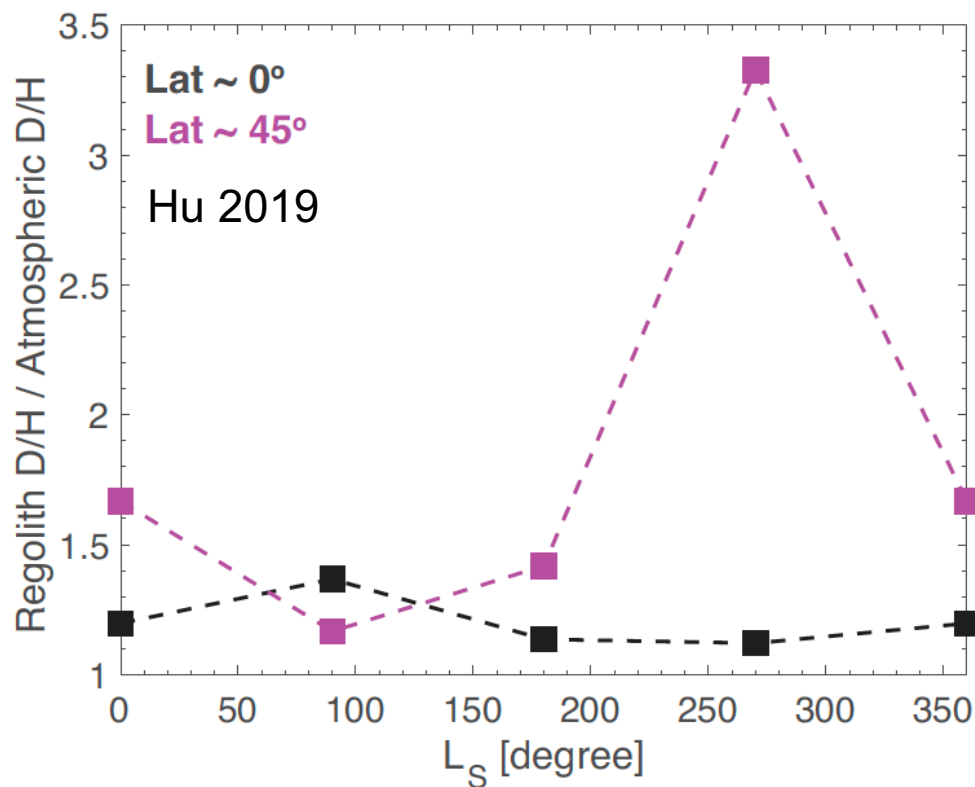
Regolith-atmosphere exchange likely impacts the D/H of water column



Hu et al. in prep. with parameters
from GCM (Neary & Daerden 2018)

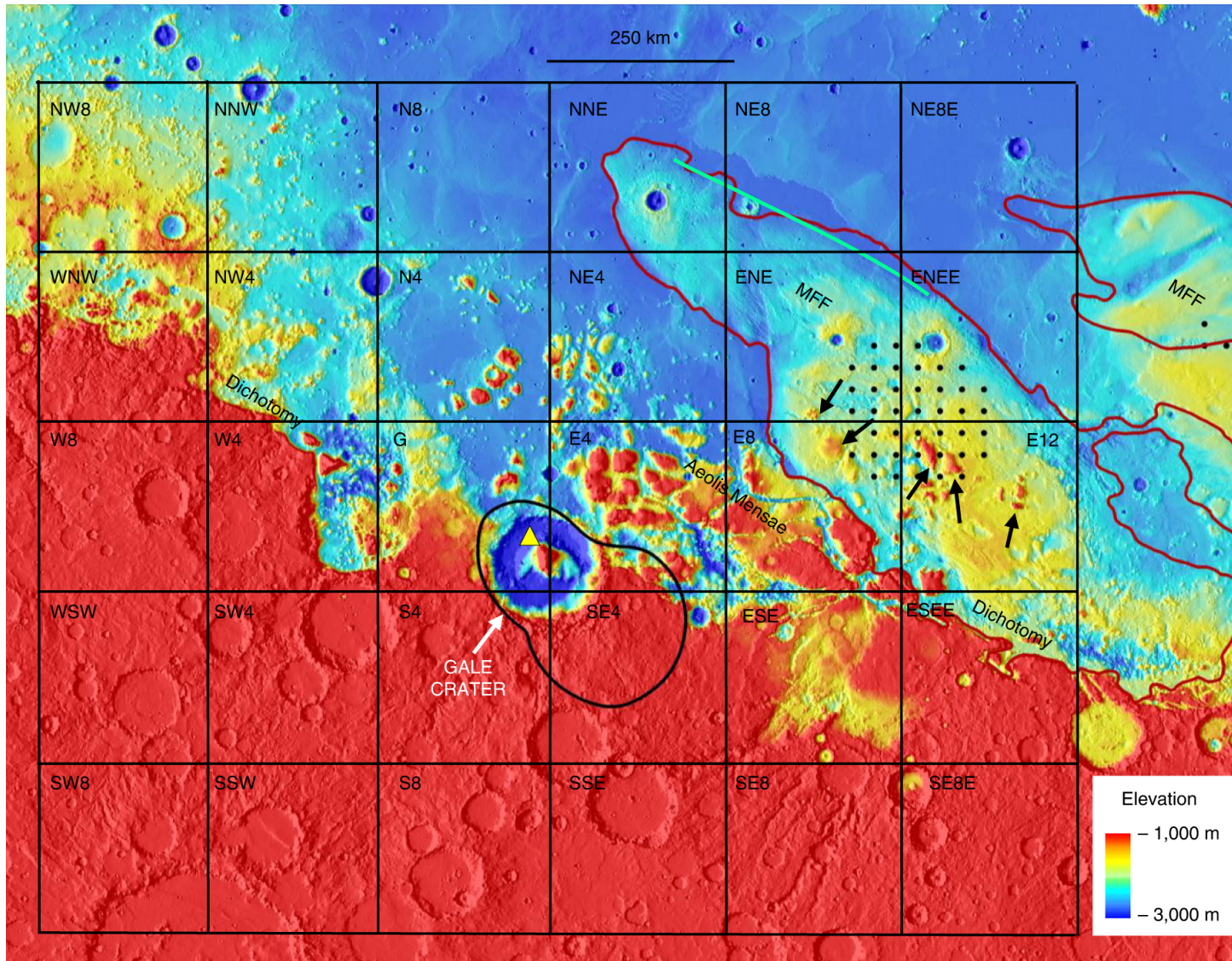
Water in the regolith likely has a distinct isotopic composition than the atmosphere

- Water in the regolith is more enriched in D than water in the atmosphere
- Mid-latitude ice sheets emplaced in the past may be not in isotopic equilibrium with the present-day atmosphere



Mid-latitude ice sheets are likely a remnant record of past climate of higher obliquities, and expected to be losing mass under the current climate (Schorghofer & Forget 2012; Bramson et al. 2017)

Water/ice may be related to methane



Are the sources of methane spikes in or outside of Gale Crater?

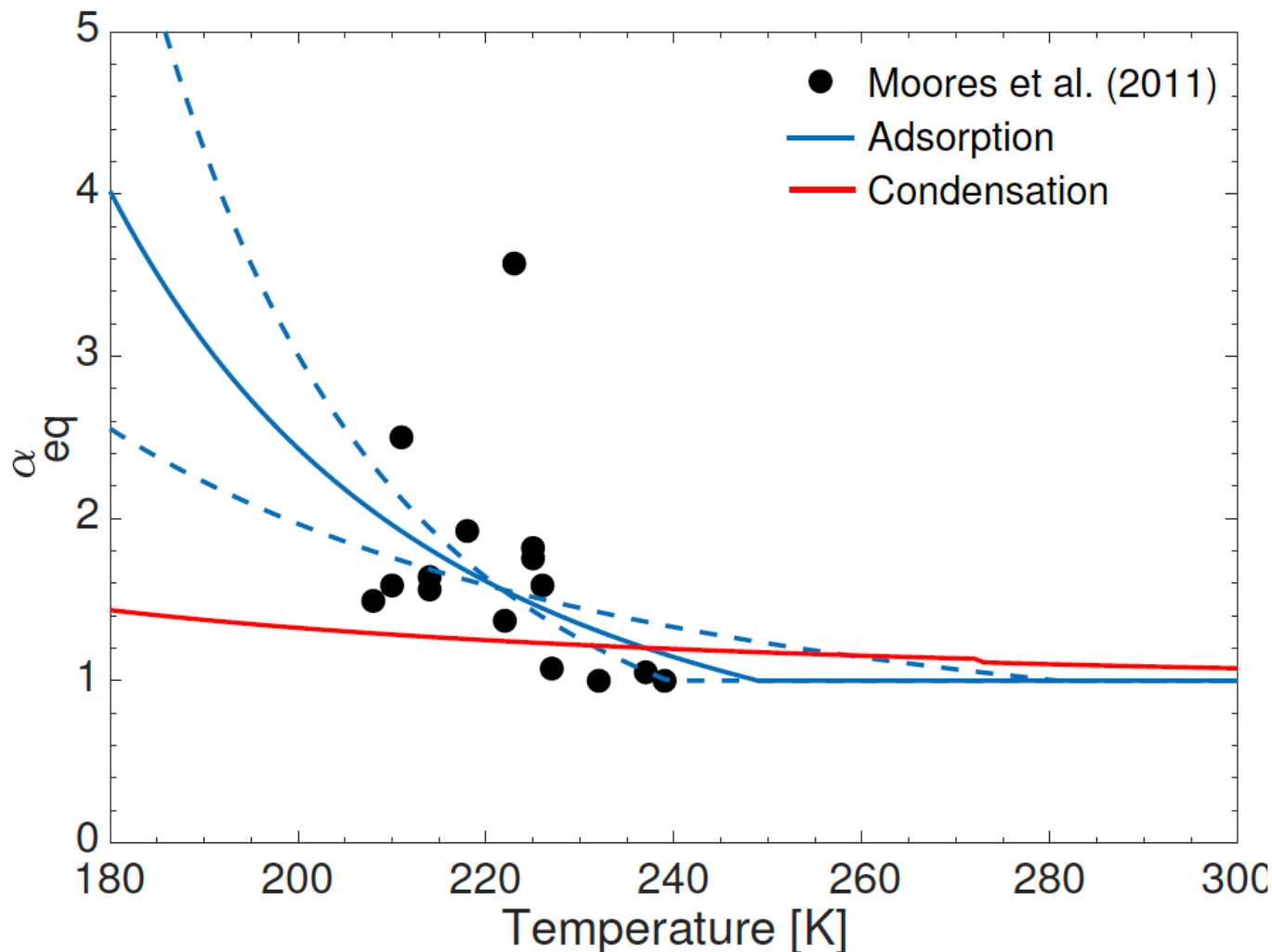
Do the sources have a small footprint?

Bulk ice in the MFF (Wilson et al. 2018) may trap and seal subsurface methane -> how does this ice survive the present-day climate?

Giuranna et al. 2019; confirming Curiosity detections: Webster et al. 2015

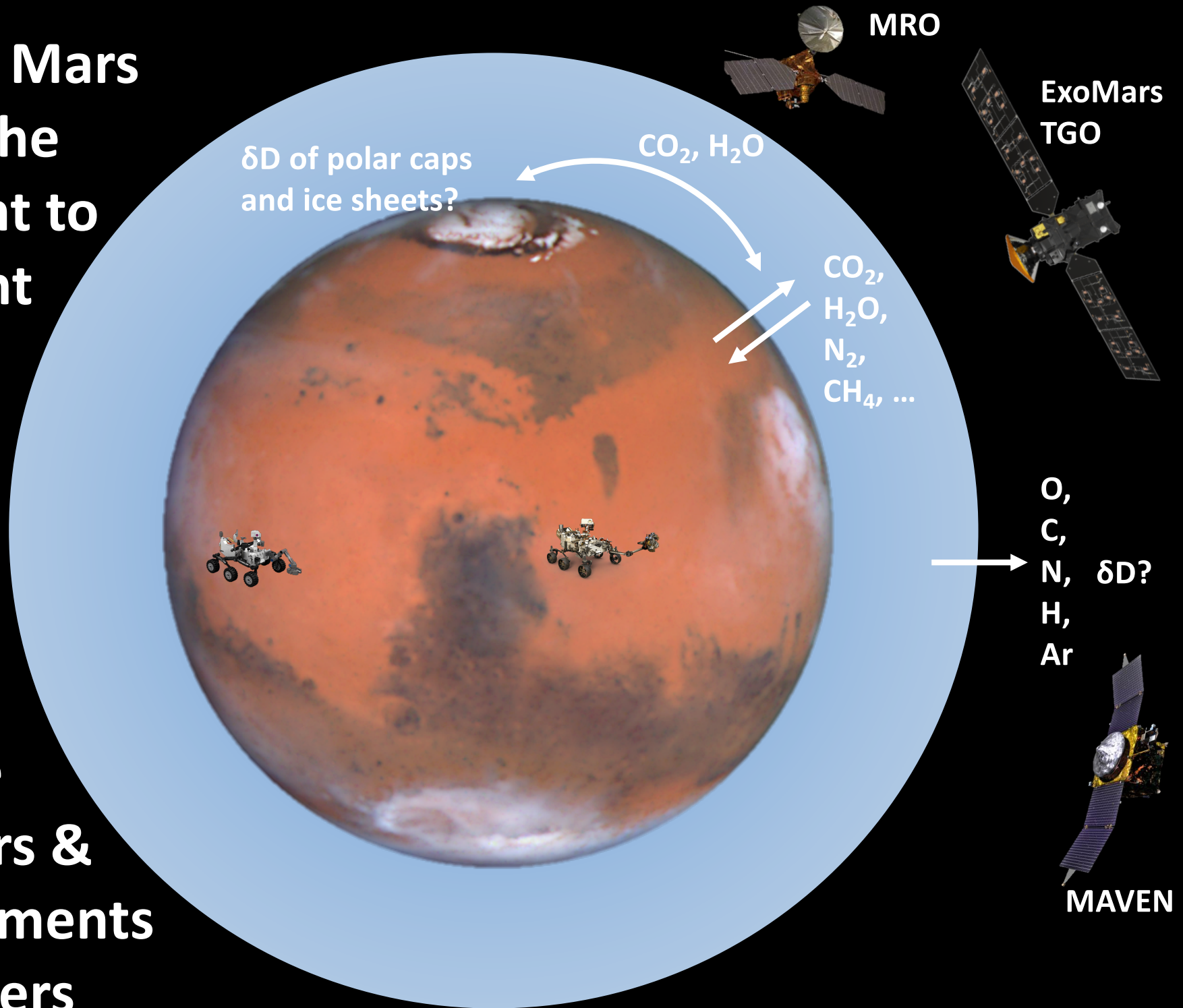
Need for laboratory measurements

- The fractionation factor in water adsorption at $T < 200$ K is needed
- The interaction between deliquescence and water/methane adsorption can be explored experimentally



Active Mars from the Present to Ancient Times

Future
orbiters &
experiments
on rovers





Jet Propulsion Laboratory
California Institute of Technology

© 2021 California Institute of Technology.
Government sponsorship acknowledged.