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A Case for Mars Polar Science in the Solar System

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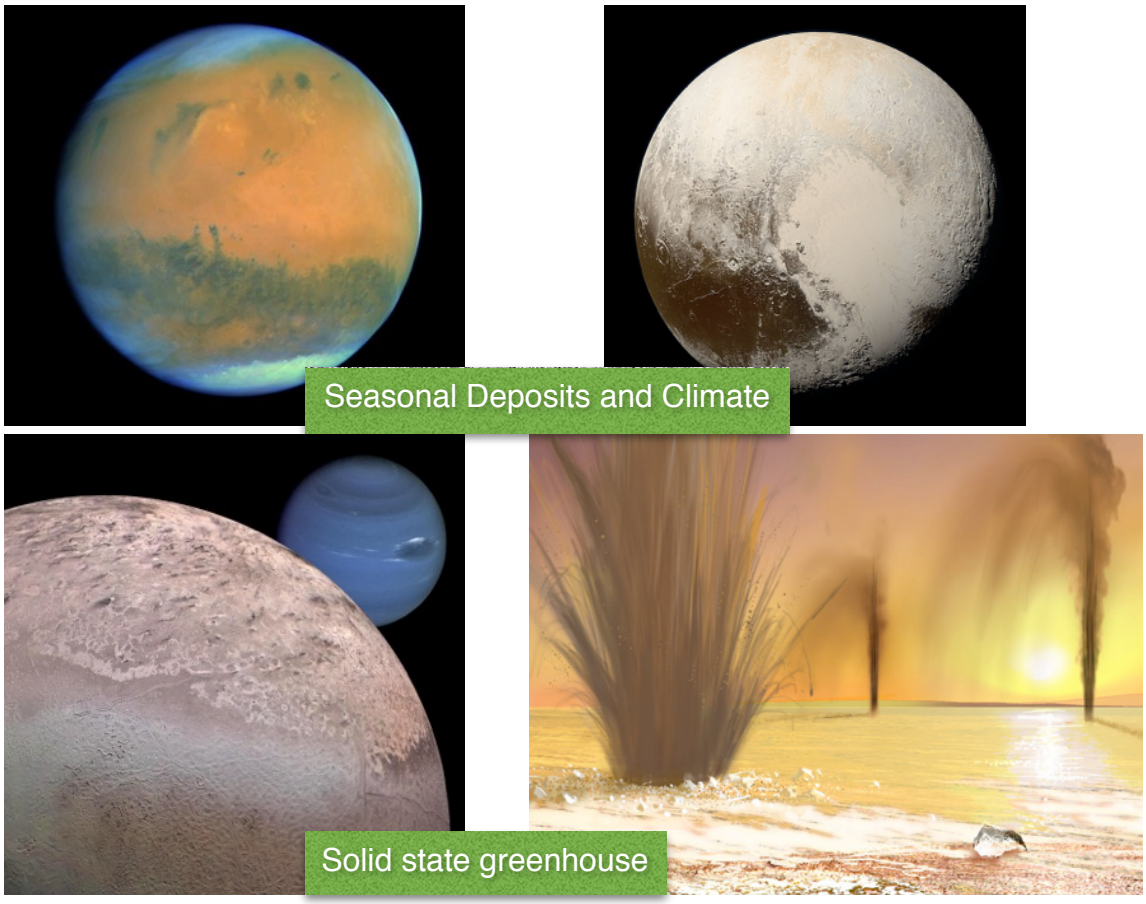
Brief Description: This white paper is intended highlight links between processes and features on numerous bodies in the solar system that have analogous behavior to Mars. Unlike Earth, where one volatile dominates the seasonal cycles, Mars has two, namely water and carbon dioxide. Carbon dioxide only varies between solid and gas, but both phases strongly influence the seasonal behavior of numerous processes, similar to molecular nitrogen (N2) on Pluto and Triton and even H2O on the moon and Mercury.



Ices that volatilize are found on countless bodies in the solar system, from closest in Mercury to farthest visited 486958 Arrokoth. On earth, we experience a temperature and pressure regime that only permits one volatile to readily change phase from gas and liquid to solid and back; however bodies farther out in the solar system exhibit this process for numerous other volatiles such as carbon dioxide, molecular nitrogen, carbon monoxide, methane, and more. Most of these examples are found only in the solid or gaseous phases. On Mars, two volatiles reign, and this provides context for the bodies further out from the sun. In particular, CO2 ice is the primary constituent of the atmosphere and so acts the primary climate driver, controls seasonal activity, drives surface-atmosphere interactions, and acts an agent of geomorphologic change in both the solid and vapor state. Throughout Mars recent history, going back to ~1 GA, the atmospheric pressure on Mars has ranged from a likely 13 mbar to perhaps near-zero. In doing so, CO2 ice forms at the poles and elsewhere, affecting the surface, contributing to layered deposits, and possibly forming glaciers.

Mars, being so different from Earth in this way, is an excellent analogue to other bodies. Pluto and Triton most assuredly have layered ice deposits, perhaps of multiple volatile species, and both have cryospheric processes that exist there and on Mars but not on Earth. One example is jets that form from the solid state greenhouse effect. Another is sublimation driven winds. Because Mars is more readily available than those farther bodies and a reliable analog, future missions to Mars should have a focus on understanding volatile processes that likely play a role in changing the surface and the climate record for outer solar system bodies.

Outstanding questions include but aren't limited to:

- The extent and quantities of solid volatiles on each planetary body
- The processes that act on those solids state volatiles
- Interactions between the gaseous phase and the surface for geomorphology and atmospheric science
- Climate records in layered deposits

Status: Drafting in Progress

Involvement

Co-authors with experience of Mars processes and analogue processes on other bodies who want to contribute to the text, cosigners who support this type of science.

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