Mars PolarDROP: Distributed Micro-landers to Investigate the Polar Ice Caps and Climate of Mars. P.O. Hayne[1], S. Byrne[2], I.B. Smith[3], D. Banfield[4], and R. L. Staehle[5], [1]University of Colorado (Paul.Hayne@Colorado.edu) [2]Lunar and Planetary Laboratory, University of Arizona [3]Planetary Science Institute [4]Cornell University [5]NASA – Jet Propulsion Laboratory, California Institute of Technology.

Motivation: Understanding the recent climate history of Mars requires models that can accurately reproduce observations of the present-day atmosphere. To extrapolate backward in time, these models must also account for volatile exchange between the atmosphere and the polar deposits [1,2]. The polar layered deposits (PLD) record climate variations spanning the last several million years, due to obliquity-driven insolation cycles [3]. However, to interpret this climate record, observational data are lacking in several key areas: 1) surface winds are largely unknown, especially in the polar regions [4,5], 2) quantities of water and CO_2 exchanged with the polar caps are poorly constrained [6], and 3) the spatial scales of fine layers in the PLD may be unresolved from orbit [7]. Therefore, new measurements are needed in order to validate models and confidently extend them to past climate regimes.

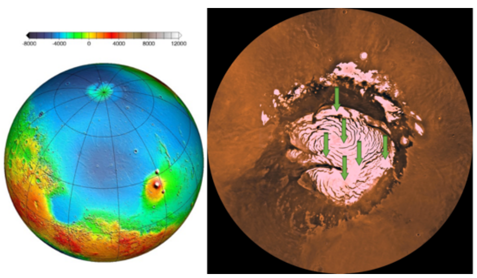

Figure 1. (Left) MOLA topography showing the Vastitas Borealis region, which presents low elevation ideal for entry, descent and landing (Right) Possible distributed landing sites on the northern polar ice cap, indicated by arrows.

A 2017 Keck Institute for Space Studies (KISS) study on Mars polar exploration brought together >30 experts to determine required measurements to investigate the climate record contained in the PLD [8]. This study also developed mission concepts to accomplish these measurements. Here, we report on a mission concept (Mars PolarDROP) using micro-landers to accomplish a critical subset of these measurements.

Science Objectives: As part of the larger KISS study, we developed a set of major science questions to be addressed in order to extract and interpret the climate record stored in Mars' PLD:

a) What are the present and past fluxes of volatiles, dust, and energy into and out of the polar regions?
b) How do orbital forcings and exchange with other reservoirs affect those fluxes?
c) What chemical and physical processes form and modify layers?
d) What is the timespan, completeness, and temporal resolution of the PLD climate record?

The Mars PolarDROP concept addresses Questions (a), (c), and (d), through the following science Objectives:

1) Constrain and validate mesoscale models of polar atmospheric circulation, boundary layer turbulence, and volatile exchange
2) Resolve the thinnest layers in the PLD to constrain rates of accumulation/ablation and link to orbital observations
3) Determine isotopic fractionation recording volatile exchange in the PLD

Implementation: The micro-landers are based on the MarsDROP concept [9], using small probes with parawings to deliver ~1 kg science payload to the surface. Every Mars PolarDROP probe carries meteorological instruments to measure wind velocity, temperature, pressure, and humidity. Possible additional measurements include: 1) ground-penetrating radar to resolve thin layers in the PLD, and 2) tunable laser spectoscopy to determine isotopic abundances in the icy layers. The probes can be dispersed across the NPLD, which is a low-hazard landing site. Any number of probes could be utilized to address the science objectives with varying degrees of completeness.

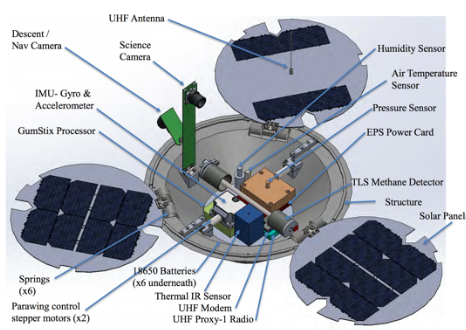

Figure 2: Schematic of a MarsDROP [9] micro-lander with one possible payload configuration. Mars PolarDROP would enable *in situ* measurements of ice composition and layering, as well as local meteorology. The central structure is ~0.3 m in diameter.

References: [1] Jakosky, B. M. and R. M. Haberle, in *Mars*, U. Arizona Press, 1992. [2] Hayne, P. O. et al., *Icarus*, *231*, 2014. [3] Phillips, R. et al., *Science*, 2008. [4] Leovy, C., *Nature*, *412*, 2001. [5] Smith, I. B., and A. Spiga, *Icarus*, 2017. [6] Jakosky, B. and R. Phillips, *Nature*, *412*, 2001. [7] Putzig, N., et al., *Icarus*, 2017. [8] http://kiss.caltech.edu/workshops/polar/polar.html [9] Staehle, R. et al., *Small Satellite Conf.*, 2015.