COMPASS: CLIMATE ORBITER FOR MARS POLAR ATMOSPHERIC AND SUBSURFACE SCIENCE.

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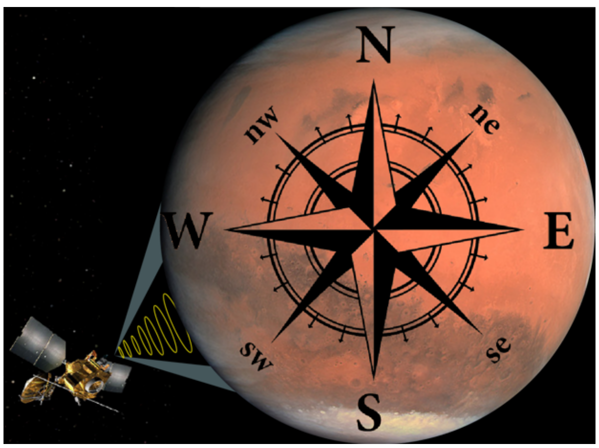
Motivation: Climate change on terrestrial planets is perhaps the most pressing scientific issue of our day, and its study is of broad significance. Mars' continuously varying orbital elements lead to climatic variations that (like on Earth) redistribute ices and affect seasonal volatile cycles. Mars' climate represents a simplified version of Earth's in that it lacks oceans, life, thick cloud cover and human activity. Understanding today's martian climate and the distribution of ice and other volatiles is paramount to determining the history of climate on Mars.

Mars' atmosphere regularly cycles water vapor, water ice, carbon dioxide, dust, and other aerosols around the planet [1,2]. Ice and dust reservoirs that interact with the atmosphere on different timescales are distributed from the poles to more-accessible mid-latitude locations [3-5].



The COMPASS payload quantifies today's climatic processes and provides the required datasets to satisfy long-standing goals in Mars science. Modeling efforts to understand global, regional, and local circulations require input from detailed, global atmospheric observations. Those models are increasingly deployed for past climatic states, making it critically important to have robust observations of the present state for validation. Future investigations may attempt to extract historical climate by sampling the polar layered deposits, but those investigations must understand present day processes to extrapolate backwards in time.

Science Benefits: In a summary of the 6th International Conference on Mars Polar Science and Exploration, a group of attendees listed the high priority science goals for the Mars polar community [6]. The COMPASS mission concept addresses many of these goals directly (highest ranked goals).

- *Determine the energy and mass balance of the polar ice reservoirs, and characterize volatile fluxes*
- *Inventory and characterize the non-polar ices/volatile reservoirs at the surface and near-surface*
- *Quantify the interplay of local, regional, and global circulations in the polar regions, including polar vortex, katabatic winds, transient eddies, among others*
- *Characterize the transport of volatiles and dust aerosols into and out of the polar regions*

Implementation: COMPASS is a Mars orbiting mission that has the dual goals of investigating the current climate and the climatic record of the Polar Layered Deposits and other icy deposits.

The COMPASS mission concept performs orbital observations of atmospheric transport and constituents by tracking water vapor, water-ice, dust, and storms in time and space. A microwave sounder measures 3D global wind speeds and tracks transport of D/H, ozone, and carbon monoxide, all important tracers of atmospheric activity and interaction with major reservoirs. An advanced Mars Climate Sounder quantifies the 3D distribution of aerosols and the P/T structure of the atmosphere. An advanced Mars Color Imager, places these detailed 3D measurements in the context of daily global imagery and tracks changes in surface dust reservoirs.

To quantify past climates through mapping icy deposits in 3D at the poles and buried in the mid-latitudes COMPASS uses a dual-purpose radar with a sounder and a polarized synthetic aperture mode (SAR). Polarization aids in near-surface (<1 m) ice detection. A sounding mode is similar to the Shallow Radar (SHARAD) on Mars Reconnaissance Orbiter (MRO) but with higher gain and bandwidth, giving finer vertical resolution and greater penetration. A high gain antenna (parabolic or phased array) that serves both the SAR and sounder can be articulated or phase shifted depending on the mode required.

Power, mass, and volume meet requirements of Discovery, and cost can be met by a contribution of one instrument by an international partner.

Acknowledgements: A 2017 Keck Institute for Space Studies study on Mars polar exploration, led by these three authors, brought together >30 experts to determine required measurements and mission concepts to accomplish several goals related to understanding Mars' current and past climate. We report on an orbital mission that reflects the study's findings.

References: [1] Jakosky and Farmer, (1982) J. Geophys. Res. 87, 2999–3019. [2] Haberle and Jakosky (1990), J. Geophys. Res. 95, 1423–1437. [3] Bramson et al., *GRL* 42 (2015). [4] Stuurman et al., *GRL* 43 (2016). [5] Dundas et al., Science 359 199-201 (2018) [6] Smith et al., *Icarus* (in press).