A Discovery-class Mars Climate Mission. L. K. Tamppari[1], N. J. Livesey[1], W. G. Read[1], G. Chattopadhyay[1], A. Kleinboehl[1]. [1]Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA (leslie.tamppari@jpl.nasa.gov).

Science Motivation:

The Mars Exploration Program Analysis Group (MEPAG [1]) and other NASA committees (e.g., the Next Orbiter Science Analysis Group [NEX-SAG; 2]) have cited high-priority science knowledge gaps related to understanding the current Martian climate and weather. Understanding weather and climate drivers, general behavior, stability and history could be improved through a combination of high-TRL existing instruments, flown together on a focused mission or as part of a larger mission architecture. The information gained would provide insight into past climate and be useful for future robotic and human exploration needs as well.

Fortunately, Mars research has benefitted from several orbiting spacecraft that have characterized the Martian atmosphere fairly well in terms of temperature, pressure, dust and ice aerosols, and column water vapor amount. Additionally, the ExoMars Trace Gas Orbiter will measure profiles of the abundance of many key trace gases, and MAVEN is studying the upper atmosphere and its interaction with the space environment.

However, water vapor and wind vertical profiles are very limited, and existing temperature retrievals can be hindered by large amounts of aerosols [3]. Water vapor vertical distributions are important for understanding water cycling between ice and sub-surface reservoirs. Further, water vapor profiles along with simultaneous temperature profiles, even in the presence of dust and ice, are critical to understand cloud formation which has a surprisingly large radiative impact on the atmosphere[4]. Winds are almost completely unmeasured, yet are critical for understanding fundamental Martian processes driving the dust and water cycles. In addition, winds are desired for safe landing of robotic and human spacecraft. In lieu of actual measurements, global circulation model output is often used to aid in spacecraft and mission design, but the models are largely unvalidated against winds. Finally, measurements of T, aerosol and water vapor are needed simultaneously with wind measurements, to fully understand the impact of thermal forcing on wind, and the consequences for transport, as presented in A finding of the NEX-SAG: *"Observation of wind velocity is the single most valuable new measurement that can be made to advance knowledge of atmospheric dynamic processes. Near-simultaneous observations of atmospheric wind velocities, temperatures, aerosols, & water vapor with global coverage are required to properly understand the complex interactions that define the current climate."*

In order to obtain these measurements, we propose a Mars Climate Mission concept, that would include at a minimum three instruments: a sub-mm sounder, a thermal infrared profiler, and a wide-angle camera.

Instrumentation Concept:

A passive sub-mm limb sounding instrument is ideally suited to provide the needed wind, water vapor, and temperature profile measurements. The technique has high heritage in Earth-science, and dramatic advances in associated technology in the past decade (driven in part by the communications industry) enable significant reductions in needed power, mass and complexity. Such an instrument can make measurements both day and night, and in the presence of atmospheric dust loading, measuring between 0–80 km, at ~5 km vertical resolution[5]. To measure the vertical distribution of dust and water-ice aerosols in the atmosphere, a thermal IR profiler similar to the MCS aboard MRO [6] would be ideal and would also provide additional temperature and water vapor measurements to those from the sub-mm instrument, meausured over a similar altitude range with comparable vertical resolution, both day and night. Finally, a wide-angle camera similar to MARCI [7] would facilitate placement of the other measurements into the big picture of weather patterns seen via global maps. Such a payload would likely be in the 40 kg and $55M range and high TRL. An enhancement would be to add a Doppler lidar for higher vertical resolution wind information.

Mission Concept:

This instrument payload could fly on a chemical or solar-electric propulsion system or could be a subset of a larger payload. Ideally it would orbit Mars for at least 1 Mars year. A solar electric propulsion option would allow the orbit to be changed to one that precesses such that multiple local times are sampled over the course of several 10s of sols.

References: [1] MEPAG goals document at http://mepag.nasa.gov/reports.cfm. [2] MEPAG NEX-SAG Report (2015), http://mepag.nasa.gov/reports.cfm [3] D. Kass, pers. comm., 2017; [4] Madeleine et al., 2012. [5] Read et al., (2018), in revis. w/ *Plan. & Sp. Sci.*; [6] McCleese et al. (2007); [7] Bell et al. (2009).