A Doppler Wind LIDAR for Mars. L.K Tamppari,[1] and G. Spiers[1]. [1]Jet Propulsion Laboratory/California Institute of Technology, M/S 264-530, 4800 Oak Grove Dr., Pasadena, CA 91109, leslie.tamppari@jpl.nasa.gov.

Introduction: The winds on Mars are almost completely unknown, yet are critical for understanding fundamental processes on Mars, such as the dust cycle and the water cycle, and ensuring safe landing of robotic and human spacecraft. Previous wind measurements on the surface of Mars are limited to the Viking, Pathfinder, Phoenix and Curiosity landed missions; single locations with only the Vikings operating simultaneously. A few other indirect wind measurements have been made via techniques such as the thermal wind equation, examining wind generated features on the surface, and cloud motions. A few Earth-based observations of winds have been made, but they are severely limited in space and time. As a result, sophisticated global models are used to understand winds, but these have limited validation. The need for a global, long-term wind measurement set is great.

Science Motivation: Because of the various Mars orbiting spacecraft that have been flown to date, the Martian atmosphere has been characterized farily well in terms of temperature, pressure, and dust and ice aerosols. Upcoming planned missions will determine the trace gases and the upper atmosphere and it's interaction with the space environment. As such, understanding winds on Mars is a missing piece in the basic characterization of the atmosphere and the should be the next major thrust in atmospheric exploration. Winds are a key component in two of the major cycles operating in the Mars atmosphere: dust and water (CO_2 being the third).

Winds and the dust cycle. Dust storms (Fig. 1) are a major part of the Martian climatology, and affect the atmospheric state on local to global scales, but their genesis and evolution are not well understood, particularly with regard to the generation of global dust storms. Why are some storms global while others are regional or local? Intriguingly, a "flushing" storm originating in the northern hemisphere and migrating southwards was seen just prior to the 2007 global dust storm [1], providing a possible mechanism for inciting the global dust storm. Understanding the winds associated with events such as these, how they vary with season and location are important, and perhaps critical, unknowns in dust storm generation and evolution. Dust in turn has feedbacks to the other atmospheric cycles: itmay control of the amount and timing of springtime polar cap CO_2 sublimation [2,3], thus affecting the annual CO2 cycle, and it acts as cloud condensation nuclei for water vapor, affecting transport of water in the system. Further, atmospheric dust lifted and transported by the winds will modify density profiles, affecting spacecraft entry, descent and landing, and, in the future, ascent from the surface of Mars, as well as diminish the power received by landed solar-powered spacecraft during large dust events, and winds can clean off solar panels, providing renewed longevity for landed spacecraft. ***In each of these cases, understanding the winds and their ability to transport dust spatially and temporally will enhance our understanding of these events, their likelihood, and their importance.***

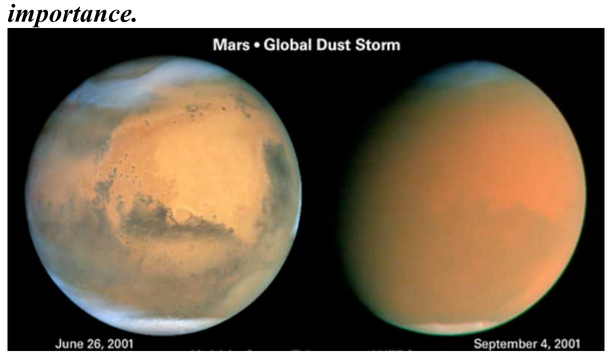

Fig. 1. An example of a global dust storm on Mars (this one in 2001). Image credit: HST.

Winds and the water cycle. One of the biggest mysteries on Mars is under what conditions and when was there sustained water flow. Because water flow is not sustained today, but geomorphic and geologic evidence shows clearly that it was in the past, the question then becomes, how and when has the Martain climate changed? Winds are a key component in the water cycle today, through transport and polar cap evolution and understanding them and their role in today's climate is needed to understand climate change and the rate thereof. Tyler and Barnes [4] show transient eddies that generate winds that blow directly over the north polar cap, particularly at L_s =120°. This could increase sublimation rates due to the effect of strong near surface winds and by bringing in warm air over the polar cap, further allowing for a greater sublimation rate, while carrying moist air away. These eddies no doubt also play a role in southward transport of water out of the polar region but the magnitude of these effects is not quantified. Winds are also thought to play a critical role in the formation and evolution of the north polar cap trough structure [5]. The troughs are thought to be formed through a combination of solar ablation and wind erosion through katabatic jumps [6; Fig. 2). ***Understanding the current wind velocities as a function of season are needed to validate models of these processes, which in turn can be used to validate the trough formation duration and***

sublimation estimates, and gain insight into the climate history of Mars.

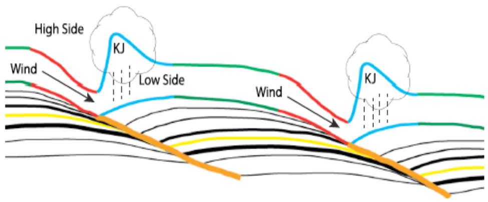

Fig. 2. Cartoon of katabatic winds experiencing "hydraulic jumps" (from [6]). This process, in which water ice is removed from the high side and deposited on the low side, is though to be the mechanism responsible for trough migration and therefore influences the formation and evolution of the polar caps.

LIDAR Concept Design: We have developed a concept LIDAR design, making use of the aerosol scattering provided by dust in the Martian atmosphere. Dust profiles for Gusev crater at the season of the Spirit landing (courtesy Michael Mischna; Fig. 3) and dust profiles provided from model studies (courtesy Melinda Kahre, not shown) have been used to estimate the backscatter as a function of typical Martian particle sizes and laser wavelength (Fig. 4). The backscatter calculations show that using a laser wavelength in the 1-2 micron range, line-of-sight velocities of 1 m/s are feasible below about 35 km. A conceptual drawing of the LIDAR concept is shown in Fig. 5.

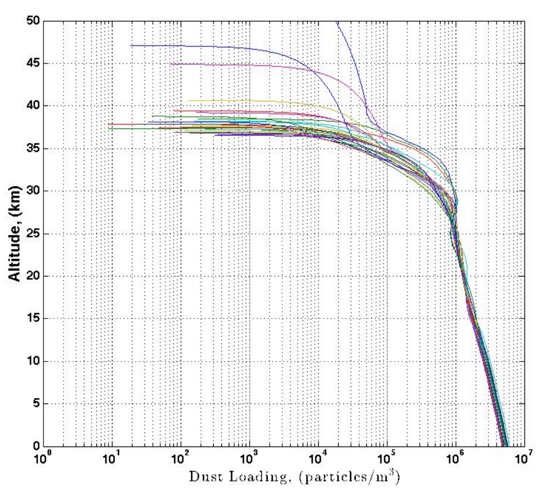

Fig. 3. 23 profiles of the dust loading, collected by MRO, at Gusev Crater for the same season as the Spirit landing. Data provided courtesy Michael Mischna. Model results show that with a 1-2 micron laser wavelength velocity accuracies of 1 m/s are feasible below about 35 km altitude.

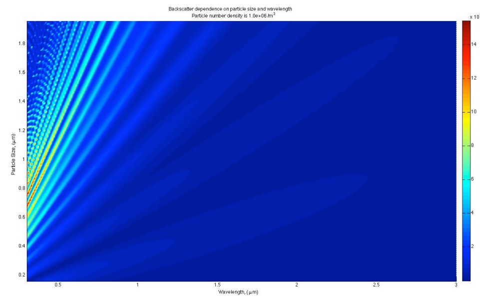

Fig. 4. Mie backscatter based on [7] for 10^6 particles/m^3.

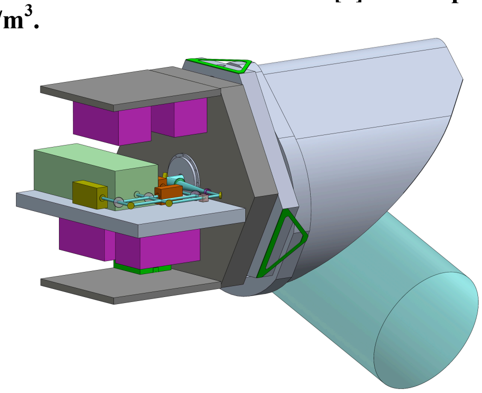

Fig. 5. Conceptual drawing of the LIDAR concept. The resulting volume, 0.84 m^3, would fit within the payload volume available on the MRO bus.

References:

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