Design of a Direct-Detection Wind and Aerosol Lidar for Mars Orbit

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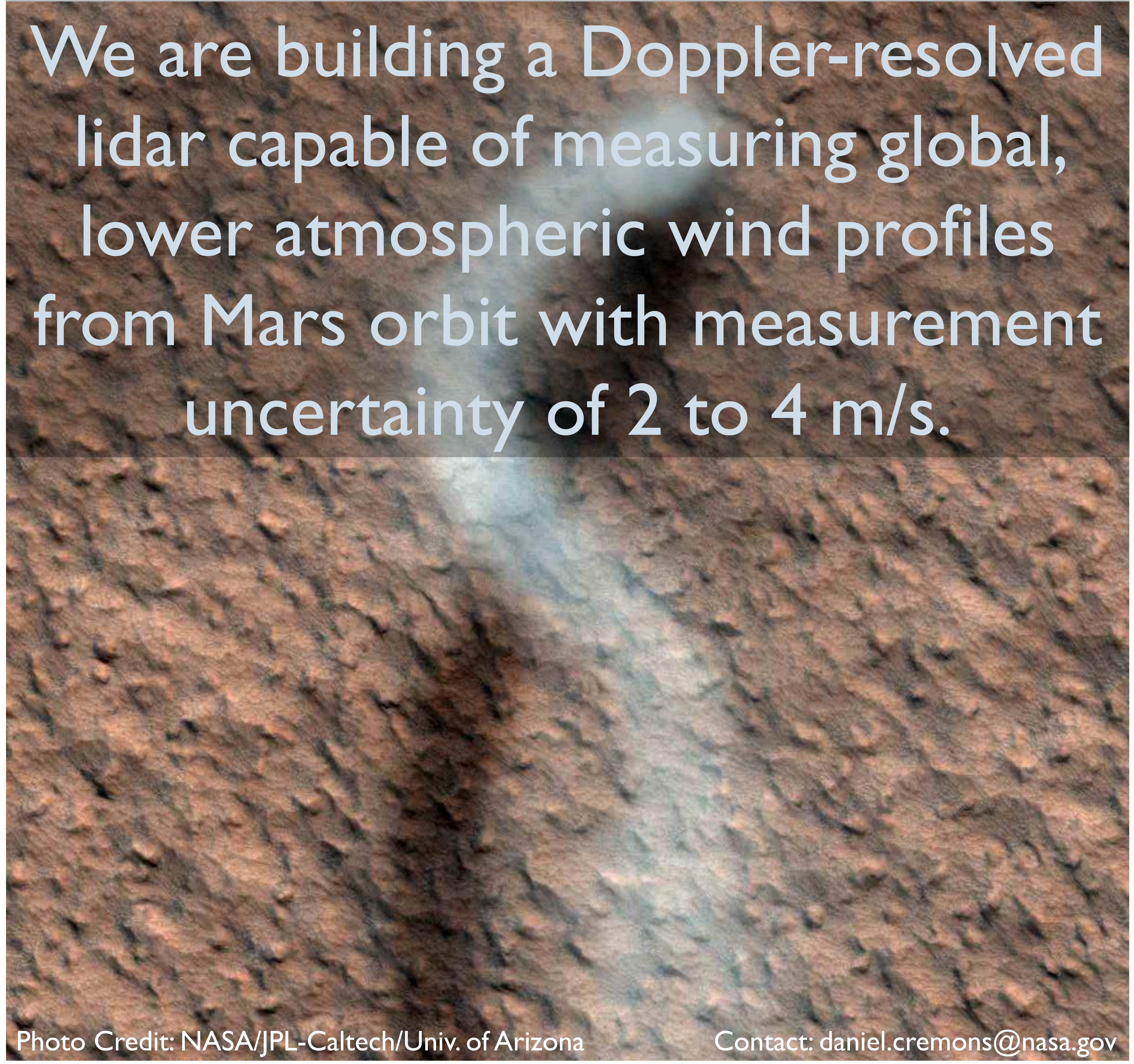
Motivation

- Observations show that the main variability in the present Mars climate is related to variations in **the spatial and temporal distribution of dust and water ice aerosols**.
- Despite their importance, there are **very few direct observations of Mars winds**. Current knowledge relies on a few cloud and wind streak observations, isolated observations from the Viking and Mars Science Laboratory landers, and indirect inferences of wind speeds that are often imprecise and contain many assumptions.
- Wind velocities provide sensitive input and validation for **Global Circulation Models (GCMs)**, and are important for the safety and precision of spacecraft **entry, descent and landing (EDL)**. Mars weather and wind predictions are important since dust storms and high winds affect **mission operations on the surface** that require visibility and consistent solar irradiation

Atmospheric Models

- For this work we extracted aerosol profiles using extinction profiles (version 5.2.4) from the Mars Climate Sounder (MCS) on the MRO. The MCS extinction retrievals were then scaled to the MARLI wavelength of 1064 nm.
- The first atmospheric case was chosen to represent a relatively dust-free atmosphere, where water ice scattering would make up a significant portion of the backscattered signal. This was drawn from MCS data averaged over Northern Hemisphere spring (Ls = 5°–30°) of Mars year 34 (MY34) northern latitudes (60° N–80° N).
- The second case was an average from Southern Hemisphere spring (Ls = 150°–230°) of MY33 mid-latitudes (50° S–25° N), representing an intermediate dust scattering case.
- Finally, a model was created from MCS data during the MY34 global dust storm (80° S–80° N) to calculate lidar performance under high dust loading.



We are building a Doppler-resolved lidar capable of measuring global, lower atmospheric wind profiles from Mars orbit with measurement uncertainty of 2 to 4 m/s.

Photo Credit: NASA/JPL-Caltech/Univ. of Arizona

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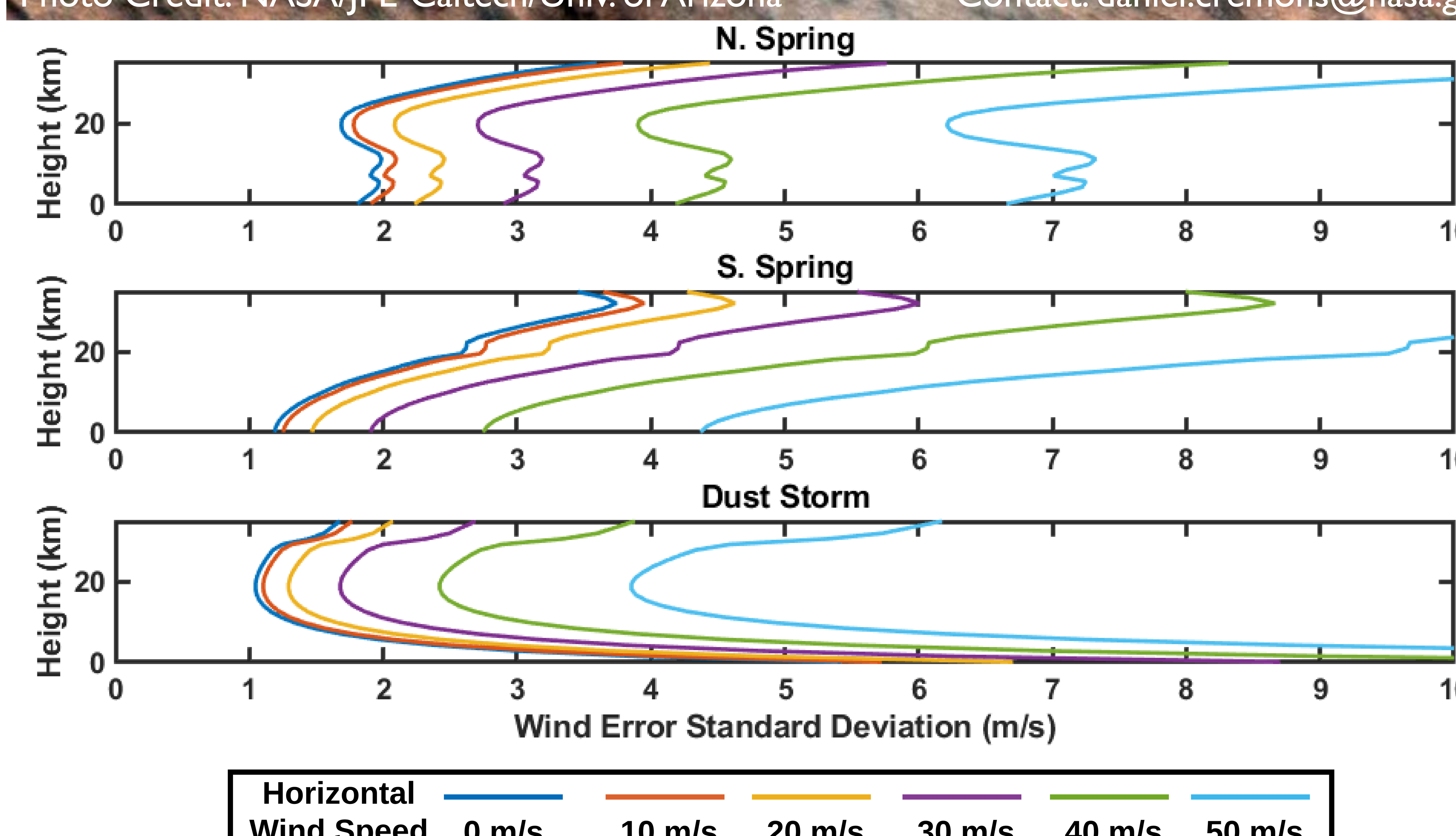
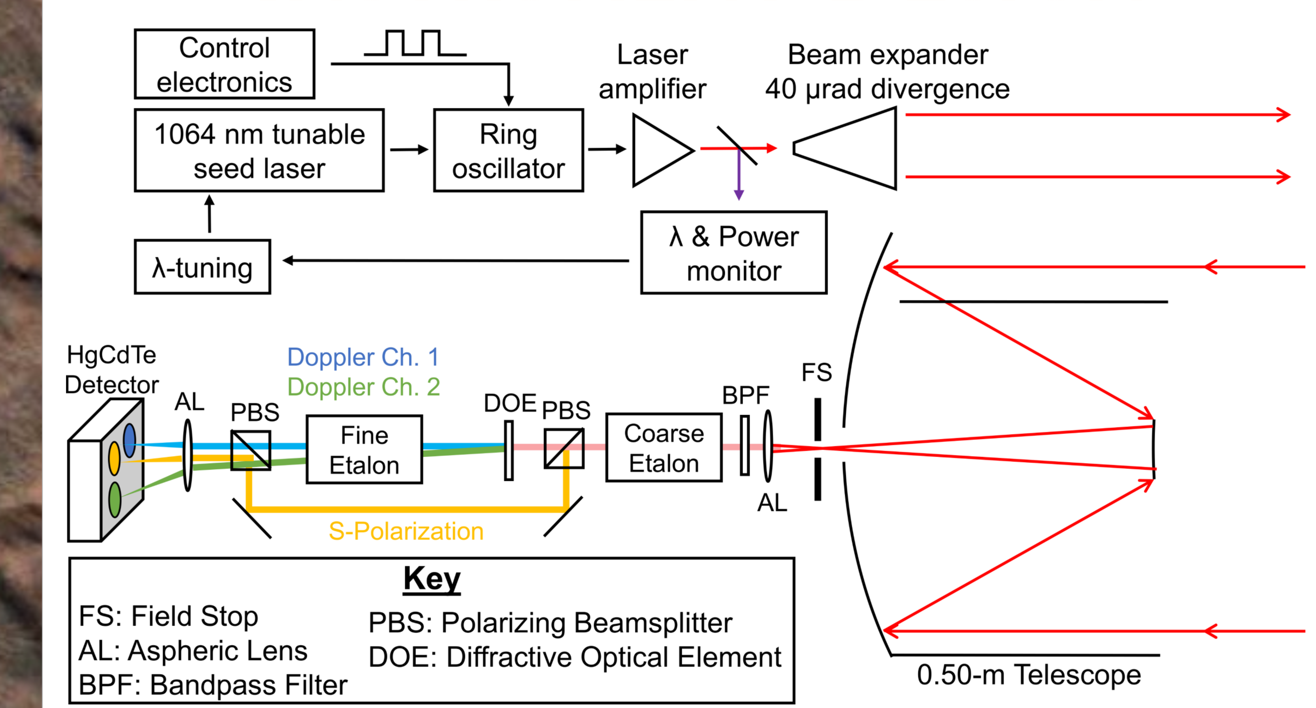
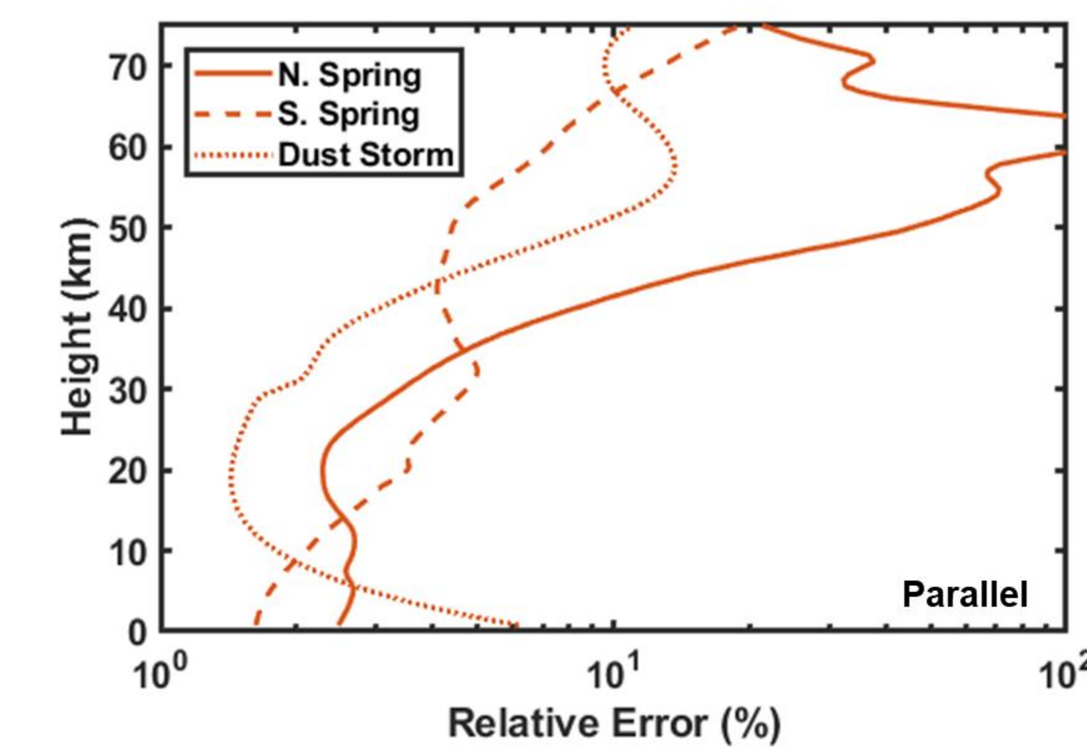


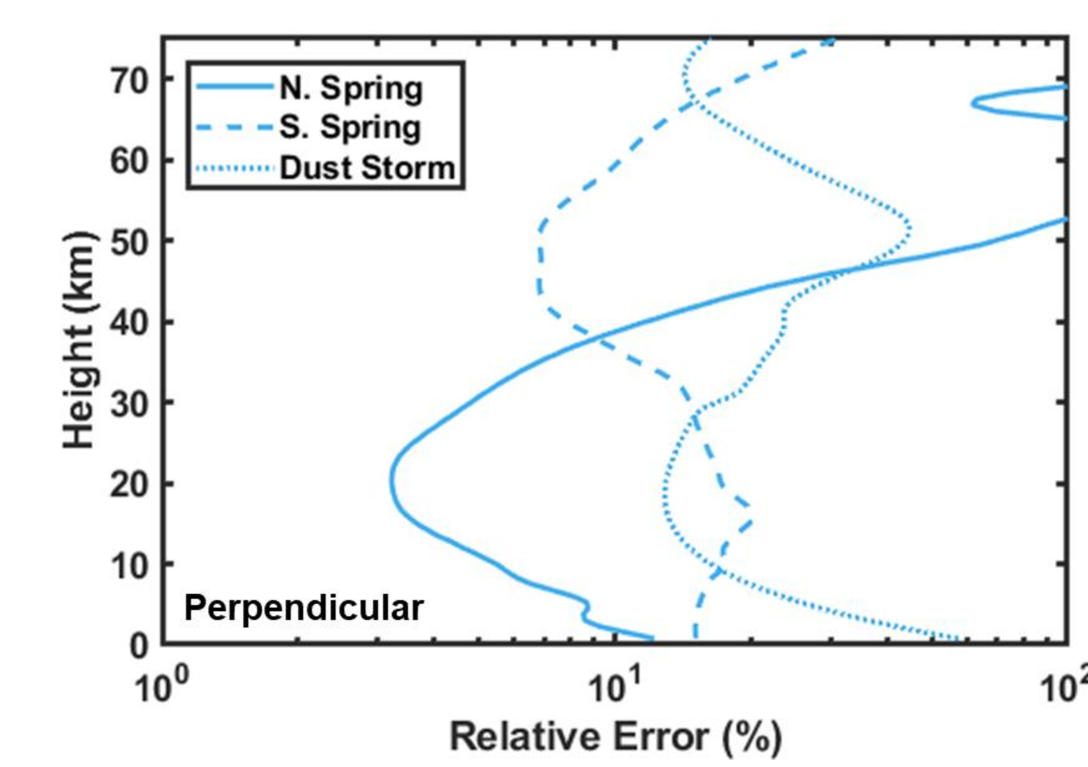
Instrument Design



(above) Instrument block diagram for the MARLI lidar.

Predicted Performance





(above) Expected relative error as a function of height of the MARLI atmospheric backscatter profile measurements in the parallel polarization channel. (bottom) Expected relative error for the perpendicular polarization channel.

(left) The RMS wind-speed uncertainty from the MARLI instrument model computed as a function of altitude from the surface for multiple uniform, cross-track horizontal wind speeds. The three panels correspond to the three atmospheric cases calculated from Mars Climate Sounder data. The horizontal wind speed is denoted by the color.

For more information see our recent open access publication:

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