

Aeolus: A Mars Network Mission Addressing Climate and Surface Processes, D. Banfield¹, A. Colaprete¹, A. Cook¹, D. Mauro¹, J. Bookbinder¹, B. Maryatt¹, J. Wilson¹, M. Kahre¹, A. Cassell¹, ¹NASA Ames Research Center, Moffett Field, CA.

Introduction: Aeolus is an integrated satellite/probe mission to observe surface and atmospheric forcing and general circulation of Mars. The mission includes observations of surface energy balance, atmospheric temperatures, aerosols and clouds, and horizontal winds from orbit and a network of micro-surface probes that measure surface pressure, temperature, key trace gasses, total sky brightness and possibly some indication of winds, saltation and local dust lifting. Critically, Aeolus will make the measurements at all local times of day, providing information on both seasonal and diurnal variability. To date, direct measurements of Martian wind speeds have only been possible at the surface and over small areas limited by rover traverse capabilities. From orbit, thermal measurements (e.g., estimates from assumed geostrophic balance) as well as images of dust storms and dune migration have provided inputs to derive current data sets on Martian winds. However, Mars General Circulation models suggest that wind speeds derived from these indirect measurements may be in error by 50 to 100%. For this reason, direct wind velocity measurements have been deemed “High Priority” by MEPAG (Mars Exploration Program Analysis Group); measuring wind speeds and corresponding thermal data that is providing the drivers of the winds is vital to more fully understanding the climate of Mars.

Science: Aeolus science objectives are tied directly to gaps in our current understanding the Martian climate, as outlined in the NRC Decadal Survey. The overarching goal of the mission is to provide critical empirical data for refining climate models and to investigate poorly understood atmospheric phenomena. The first objective is to (1) produce a vertically resolved global wind velocity (zonal and meridional) map of Mars. Winds on Mars have never been directly measured, except during some surface missions, including Viking, Pathfinder, Phoenix, Curiosity, Insight, and Perseverance. All other wind speeds (aside from some poorly resolved, higher altitude ground-based measurements) have been derived from indirect thermal measurements, compositional variations in the atmosphere, or orbital imagery. Based on comparison with GCM results, wind speeds derived from these indirect measurements may be in error by as much as 50 to 100%. Creating a global horizontal wind speed map would provide essential ground truth and corrections to the current Mars climate models. The

last two objectives are to (2) determine the global energy balance at Mars, and to (3) correlate wind speeds and surface temperatures with H₂O, CO₂, and dust (aerosol) column densities. Feeding into each of these objectives are surface observations that will resolve diurnal and semi-diurnal wave propagation, changes in column opacity and the transport of key trace gasses. The surface observations may also provide wind speed estimates along with detecting saltation and local dust lifting. The simultaneous measurements from the surface and from orbit will allow us to characterize the planet's general circulation and its interaction with the dust, water, and CO₂ cycles.

Payload: The Aeolus orbiter will carry three instruments: (1) Mars Doppler Wind and Temperature Souder (MDWTS), (2) Thermal Limb Sounder (TLS) and (3) the Surface Radiometric Sensor Package (SuRSeP). MDWTS utilizes gas cell radiometers to measure winds with an accuracy of better than 5 m/s day and night from the near surface (<5 km, depending on atmospheric opacity) to altitudes as high as 120 km with < 5 km vertical resolution. The TLS will measure atmospheric temperatures, water ice clouds, and dust abundances across all altitudes where winds are measured. SuRSeP is a nadir viewing radiometer, will measure the total reflected solar and emitted thermal radiance, surface temperature, and water cloud and dust total column abundances. The combined spectral and thermal measurements will provide a new understanding of the global energy balance, dust transport processes, and climate in Mars' atmosphere.

The micro-surface probes include sensors to measure surface pressure, temperature, trace gasses, including H₂O, CO, O₃ and CH₄, and total sky brightness, from which sky opacity can be derived. Simple measurements for wind, saltation and local dusting are also being considered. A minimum of 18 probes will be deployed, distributed across all longitudes and latitudes between +/- 60 deg. Sensors will be sampled once per hour with periodic higher sampling campaigns, making a synoptic network.

Conops: Aeolus will consist of a single satellite in a near-polar orbit with the baseline mission observing all seasons of an entire Martian year (two Earth years). The orbit inclination is selected to provide observations over all local times within 60-90 days, allowing both diurnal and seasonal changes to be observed.