**MWX: The Next Generation Met Package for a Mars Network Mission.** Don Banfield[1] , Mark Richardson[2], Ian McEwan[2], Rich Dissly[3], Ashwin R. Vasavada[4] and Chris Webster[4]. [1]420 Space Sciences, Cornell University, Ithaca, NY, 14850, Banfield@astro.cornell.edu, [2]Caltech, [3]Ball Aerospace, [4]JPL.

**Introduction:** Many of the basic questions of Martian synoptic, mesoscale and boundary layer meteorology, as well as the cycling of water have remained unanswered after previous missions. Yet recent modeling efforts and limited observations have revealed their importance for both our understanding of the exchanges of heat, momentum and water occurring between the surface and atmosphere, as well as for practical engineering safety constraints of landed missions.

We have developed a low-cost, low-mass, next-generation meteorology package, known as MWX, that comprehensively addresses the outstanding questions in Martian planetary boundary layer science. MWX's sophisticated and highly-integrated instrument package will, for the first time, enable a closure experiment on the heat, momentum and volatile balances between surface and atmosphere as the forcings change with local time, season and dustiness. MWX will fully characterize convective and turbulent processes in the boundary layer that are known to present problems to lander descent and landing systems.

MWX is also the right choice for a network mission. Correlated pressure and temperature measurements from a more limited sensor suite would yield only the synoptic dynamics. However, the rich set of sensors on MWX would reveal the geographic breadth and diversity of the complex boundary layer processes.

**Science Scope:**

- **Synoptic Meteorology**
- **Mesoscale Meteorology**
- **Boundary Layer Meteorology**
- **Trace Gas Fluxes**
- **Water Transport and Stability**

The high degree of interplay between the surface and atmosphere at Mars drives the level of sophistication required from future meteorological stations. No longer is it sufficient to broadly characterize the synoptic meteorology in the vicinity of a lander. Instead the boundaries between meteorology and other fields of Martian science have blurred. The scope of inquiry dependent on meteorological observations is much broader than was possible with the 1st generation meteorology packages sent to Mars.

- The surface of Mars is a hazardous place for spacecraft, both those already on the surface and those attempting to reach or leave the surface. Mesoscale circulations play a large role in these hazards, and yet we have little appropriate data to constrain and validate mesoscale models. More sophisticated observations are required to improve the models and mitigate these operational hazards.

- Aeolian processes are the current chief agent of change on Mars, and control the shape of many of the landforms we see at Mars. We don't fully understand how mixing differs in the Martian boundary layer from that of Earth. We simply haven't taken the appropriate observations yet at Mars.

- Recent announcements of methane on Mars highlight the possibility that trace gases may act as trails guiding future exploration to interesting sites (e.g., volcanic fumaroles, biological colonies, etc.). Developing the ability to quantify fluxes of trace (or tracer) gases in the Martian boundary layer may prove to be a critically important tool as the exploration of Mars matures.

- Water is critically important on Mars, both for biological and geomorphological reasons. We have some observations of its presence in the regolith and in the atmosphere, but we have only a vague understanding of its exchange between surface and atmosphere. Inventories of reservoirs are not enough. To fully understand the stability and distribution of water on Mars, and to allow extrapolation to ancient scenarios, one must understand its exchange with the atmosphere. Direct measurements of water vapor and its flux through the boundary layer have never been attempted at Mars.

**Integrated Package:**

- **Minimum Payload**
- **Complementary Observations**
- **Simplified Commanding**
- **Autonomous Operations**
- **Closure Experiments**

We have selected a minimum set of instrumentation that can achieve the expanded meteorological science goals outlined above. The individual instruments in the MWX package complement each other to a great degree, compounding each one's scientific potential. Furthermore, by combining the instrument into one package, coordinated experiments can be initiated much more easily, reducing demands on the spacecraft's own commanding system. Finally, we have also designed in autonomous control of power consumption, sequencing and data compression, allowing the MWX package to function largely independent of the spacecraft command system. Because of the diurnal nature of meteorological observations, this will allow relatively painless operation of MWX at all times of day with little impact to the rest of the spacecraft.

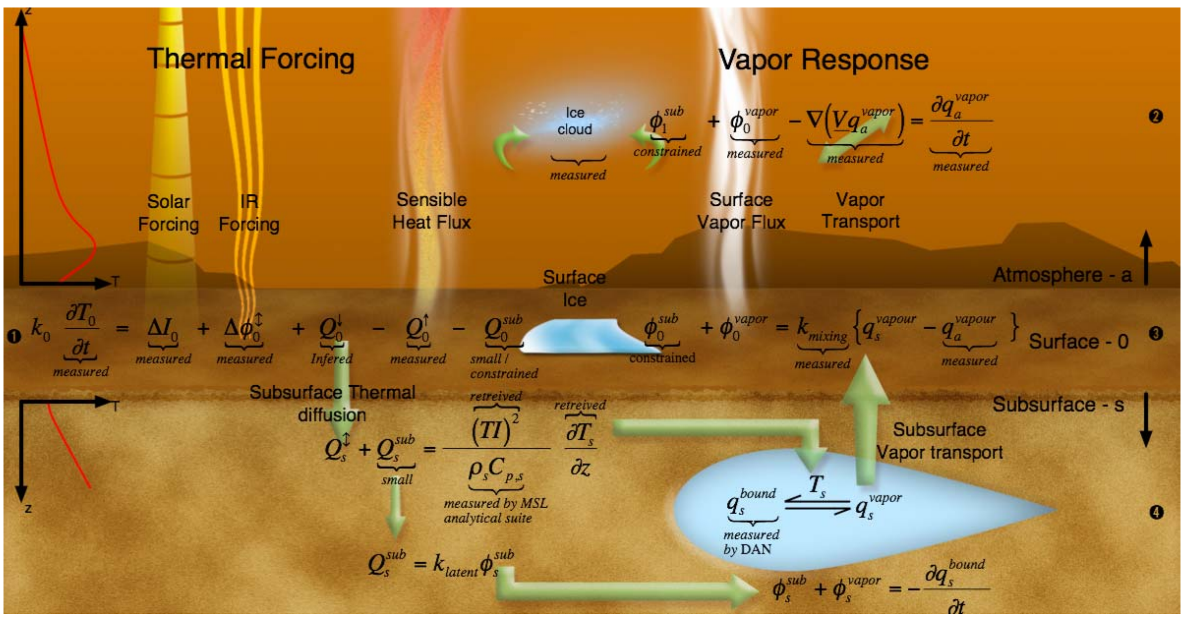
The instrument selection was driven in large part to establish a "Closure Experiment" to understand the complex and inter-related processes controlling the cycling of water between surface and atmosphere. In this way, not only are the responses of the water cycling documented, but also the forcings are observed as well. The relevant processes governing water cycling and those that MWX aims to constrain are diagrammed in the figure below. Water cycling is controlled by the thermal forcing, apportioned among several sources. The resulting thermal state then controls the stability of water in or on the surface, as well as its phase in the atmosphere. These forcings, the response of water vapor and the processes transporting water between surface and atmosphere are all well observed by the MWX instrument complement.

**Technical Implementation:**

- **Sonic Anemometer**
- **Tunable Laser Spectrometer (H2O, CH4)**
- **Multi-Channel Radiometer**
- **Pressure, Temperature**

The Sonic Anemometer delivers winds and temperature with very high sensitivity and sampling rate, an open sensing volume, and 3-D capability. This opens the possibility of fully characterizing the turbulent eddies in the boundary layer, and thus the eddy fluxes of heat, momentum and (with the tunable laser spectrometer) water vapor. This measurement approach is the premier method used terrestrially, with special adaptations for use in the tenuous Martian atmosphere. We have developed miniature acoustic transducers ideal for use on Mars (1cm diameter, 25g), and adopted the radar technique of pulse compression. Using these we have demonstrated tremendous performance under Martian conditions (winds:1cm/s, Temperature: 0.1K @ 10 Hz)

The Tunable Laser Spectrometer, with two separate sensors (one for H2O, one for CH4) has flight heritage from MPL and MSL. With the sonic anemometer, fluxes of water vapor and possibly methane can be measured. Operationally, a diode laser is scanned in wavelength across absorption features of H2O or CH4, yielding a robust, sensitive and fast response quantization of these gases (H2O: 0.1ppm @ 10 Hz; CH4: 0.4ppb @ 1 Hz)



The multi-channel radiometer uses bolometers in heatable housings (for calibration) with interference filters for spectral discrimination. Rather than use a complex spectrometer, this approach yields equivalent information with much less mass, power, cost, risk and complexity. Sensors are placed with various views of sky and ground. Wavelengths are chosen to cover the 15um CO2 band (allowing retrieval of atmospheric temperature up to about 3km), dust emission, ice discrimination as aerosols and ground frosts, incident and reflected solar, and surface temperature. Accuracies of 8W/m^2 in radiative fluxes or 0.5K in temperatures are achieved.

**Resource Footprint:**

- **3kg**
- **<10W operating, 0W quiescent**
- **2500 cm^3 stowed, 4000cm^3 deployed**
- **All components TRL 5 or above**