Sonic Anemometry, Saltation Sensing, and Mars Boundary Layer Peculiarities, D. Banfield[1], [1]NASA Ames Research Center, Moffett Field, CA.

Introduction: We will discuss our two in situ Mars instruments developed to advance our understanding of important science questions that occur at the interface between surface and atmosphere on Mars, namely a highly capable sonic wind sensor, and an advanced saltation sensor. We will also discuss some peculiarities of Mars atmosphere that may lead to there being challenges when porting over terrestrial boundary layer atmospheric science techniques.

Sonic Anemometer: We have developed a next-generation wind sensor for use on Mars that exceeds the capabilities of sensors previously flown to Mars by a factor of ~20 in both sampling cadence (20Hz vs 1 Hz) and precision/sensitivity/accuracy (~5cm/s vs ~1m/s). This instrument is notionally derived from the gold-standard wind sensor used in terrestrial boundary layer studies, sonic anemometry. However, the very low atmospheric density at Mars requires that our instrument brings new techniques to the table, including low acoustic impedance, broadband transducers, and the radar technique of pulse compression to extract these capabilities in a much more difficult acoustic operating environment. The instrument may also yield other capabilities, such as sound speed and attenuation spectra if applied somewhat differently than optimized as a wind sensor.

We are developing this sensor through MATISSE funding and are currently at TRL5 and should arrive at TRL6 in about 1 year. The expected flight mass and power are ~500g, 0.5W (@20Hz sampling, less for slower sampling) for a highly precise, fast, 3-D wind sensor. Note that a single 3-D wind sensor with this performance can resolve the boundary layer's turbulent eddies, opening the possibility of eddy covariance flux techniques, and so could directly yield vertical heat flux and momentum flux (wind stress) through the boundary layer, as well as tracer flux (if combined with a tunable laser spectrometer). We expect that such measurements will open important new avenues of inquiry at the surface of Mars.

Saltation Sensor: We are developing a saltation sensor to help clarify the aspects of this important process as it occurs on Mars, which is expected to differ substantially from that on Earth (due to the lower gravity and lower atmospheric density). This sensor exceeds commercially available instruments (e.g., SENSIT) by not only counting grain impacts, but also yielding each grain's size and speed and a measure of high above the surface the impact occurred. This instrument is designed from the ground up to mate with the sonic anemometer discussed above, and will share electronics making the pair lighter and less power hungry. Saltation is expected to be critical in the lifting of dust at Mars, and yet the critical wind stress threshold for saltation and dust lifting under martian conditions is not yet known. Furthermore, the behavior of saltating grains under martian conditions is believed to differ greatly from that on Earth, but has not been well constrained. We believe that directly measuring an active saltation process at Mars can help unlock some of the fundamental mysteries of the initial stages of dust lifting at Mars, with its attendant critical climate impacts.

We are currently developing this under PICASSO funding and are at TRL4, but will be proposing to MATISSE this year to advance the instrument to TRL6 within 2 years.

Mars Boundary Layer: not constant flux: Terrestrial boundary layer meteorology is generally built on the assumption of a "constant flux layer" close to the surface, where heat and momentum flow through this layer but are not deposited in it at all. Then, empirical relations allow various atmospheric quantities to be inferred in the boundary layer. While this constant flux layer is a good assumption for Earth, it is not for Mars, where CO_2 has strong enough absorption lines that a significant amount of thermal emission from the surface is re-absorbed in the lowest atmospheric layers. Because this "constant flux layer" is not a good assumption for Mars, the usual empirically derived boundary layer relations (Businger-Dyer) may not hold at Mars. It may be a very challenging undertaking to verify these relations utility or lack thereof at Mars, but this should be considered early on as we consider in situ studies at the interface between Mars surface and atmosphere. We need to send high quality instruments carefully designed and chosen to match the specific questions of highest import at Mars.