MARS 2020 MEDA MEASUREMENTS OF NEAR SURFACE ATMOSPHERIC TEMPERATURES AT JEZERO

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1. Introduction: MEDA

Since February 18, 2021, Perseverance has been exploring Jezero Crater (18ºN, 77ºE). The meteorology of this location is being investigated with the Mars Environmental Dynamics Analyzer (MEDA) [1], which among many other sensors has 5 Air Temperature Sensors (ATS) to measure near surface temperatures. These sensors are located at two altitudes: two are at 0.85 m, in the front of the rover, and three are at 1.45 m around the Remote Sensing Mast (RSM), distributed azimuthally so that at least one sensor is located upwind. Local air temperatures are measured with a frequency that can be as high as 2 Hz. In addition, the temperature of the surface and at an approximate altitude of about 40 m are measured with the Thermal Infrared Sensor (TIRS), which operates with a sampling frequency of 1 Hz. MEDA records atmospheric variables typically over 50% of a full sol and its data allow to study temporal scales ranging from micro-turbulence to seasonal effects. Here we show data from the first 400 sols of the mission covering the period from northern Spring (Ls=5º) to early Autumn (beyond Ls=180º).

2. Methodology

Analysis of the ATS data requires understanding the effects of the rover and its Radioisotope Thermoelectric Generator (RTG) on the local air temperatures being measured. Since the rover is embedded in the rover's thermal boundary layer, different effects are observed along the sols due to varying winds and rover orientations. The two sensors at 0.85m are partially sheltered from environment winds in the front of the rover and are fully shielded from RTG effects. At nighttime, when winds are weaker, residual contributions from the rover may appear in the temperature data. Measurements obtained by the combination of ATS in the RSM at 1.45m are less affected by these problems, since their azimuthal orientation guarantees that at least one sensor is located upwind.

A comparison of ATS data and winds measured by MEDA concludes that, in most cases, the minimum temperature of the three ATS at the RSM is obtained by the sensor that is located upwind, and can be considered a good measurement of the environment temperature. Similarly, at 0.85m the sensor that is less exposed to environmental wind generally records a warmer temperature than the other.

We use an algorithm that analyzes the signals from the 5 ATS and produces temperatures at z=0.85m and z=1.45m preserving the thermal fluctuations of the ATS that has lower temperatures. This is done using a sliding time window of 1 minute. A comparison with simultaneous wind data validates the selection done by the algorithm.

Temperature measurements with the TIRS instrument are not subject to these complications, and the only relevant effect that needs to be taken into account is the time when direct solar light enters the Field of View of the upward looking IR channel that measures air temperatures. These measurements correspond to a range of altitudes with a weighting contribution function that peaks at z~40m. TIRS measurements of surface temperatures rely on the thermal infrared emission from a patch of terrain that is significantly smaller than the one used in the Mars Science Laboratory (MSL). Thus, surface temperatures measured by MEDA/TIRS in Jezero are more dependent on the specific location than those measured by MSL in Gale crater.

3. Results

3.1. Diurnal Cycle

Figure 1 shows combined results of several sols of air temperatures at z=1.45m (colors) and z=0.85m (gray). The amplitude of the diurnal thermal cycle driven by solar insolation is about 60 K. Daytime hours show temperatures with an unstable vertical thermal gradient that leads to strong convection accompanied by thermal fluctuations of +/-6 K. As the sun goes down in the sky, the afternoon hours transits towards a null thermal gradient and null thermal fluctuations when the Planetary Boundary Layer collapses. In the evening and early night, stable conditions are found. As the night advances, a weak thermal inversion is broken, resulting in apparently unstable thermal conditions. The weak night-time winds, partially causing some residual effects on the ATS at z=0.85m, complicate the interpretation of the night-time thermal gradient. A comparison with simultaneous TIRS temperatures will be shown to unveil the complex nature of nighttime thermal gradients at Jezero.

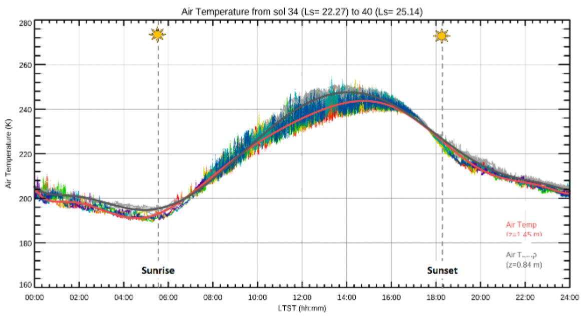

Fig. 1: ATS retrieved air temperatures between sols 34 and 40. Temperatures at z = 0.85m are shown in gray. A fit to these data is shown with a black line. Colored data show ATS measurements at z = 1.45m. Each color corresponds to data from a different sol. The red line is a fit to those data.

We will also show a characterization of the thermal oscillations at different levels and a comparison with the vertical thermal gradient.

3.2. Seasonal evolution

We find a progressive increase of temperatures as the summer advances that is well matched at z=1.45m by what the Mars Climate Database (MCD) [2] predicts at Jezero for the standard dust climatology. A Fourier analysis of ATS data allows to study the contributions of different thermal tides to the daily cycle of temperatures. These thermal tides show a nearly constant behavior from Ls=6 to Ls=135 with thermal amplitudes that smoothly increase afterwards in a period of time where regular clouds started to be observable in MEDA data from other sensors. Figure 2 shows the coverage of the data acquired and some of these effects.

3.3. Thermal oscillations and turbulence

The fast cadence of MEDA data allows us to study the thermal oscillations at elevations from the surface of z=0.85m to z~40m. Different regimes of oscillations and turbulence are observed at different times of the sol. Clear differences between the fully convective regime near noon and the evening and nighttime will be shown and compared with previous studies at other Martian locations [3-4].

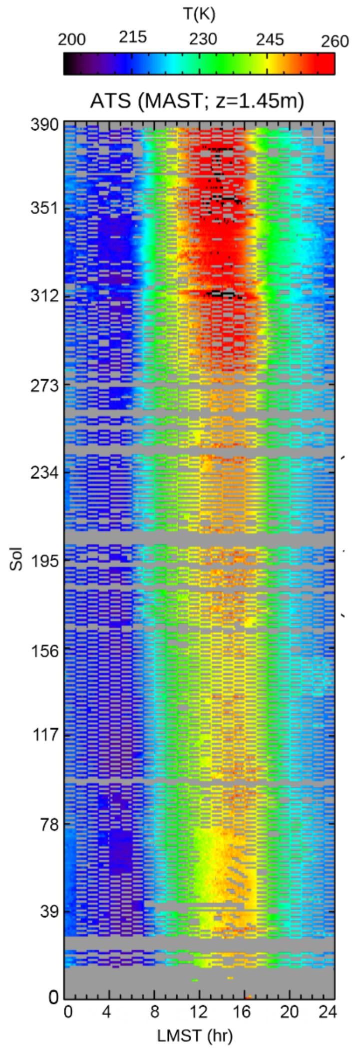

Figure 2: ATS temperatures at z=1.45m showing MEDA coverage. The full map at high-resolution, especially when combined with equivalent data at other altitudes, shows the effects of different influences on temperatures that will be discussed.

4. Dust Storm

A regional dust storm crossed Jezero at Ls=315. The effects of the storm were strong and clear in the temperature data. We will show results concerning the specific response of temperatures to the storm at different altitudes from the surface to z=40m, the effects on thermal tides, the modification of the vertical thermal gradient and the changes in the amplitudes of thermal oscillations.

5. Discussion

A comparison of MEDA diurnal cycles of temperature with model simulations obtained with MRAMS, MarsWRF [5-6] (Figure 3) and seasonal values from MCD [2] shows a general good agreement between those models and MEDA temperatures.

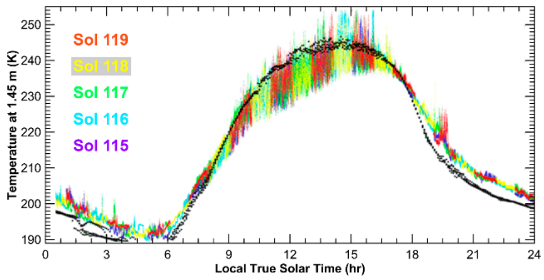

Figure 3: Simple example of comparison between MarsWRF temperatures (black dots) and MEDA ATS temperatures (colors) at Ls~60º.

A comparison of temperatures measured at Jezero with other landing sites offers a new opportunity to understand the different factors that affect the Martian climate.

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