WIND DIRECTION RECORD OF AEROSOLS OBSERVED BY THE MARS SCIENCE LABORATORY

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Introduction:

Since the beginning of the mission, the Mars Science Laboratory (MSL, Curiosity) has observed the behavior of overhead aerosols through movies taken by the Navigation Camera (Navcam). These movies are useful to capture a variety of parameters such as optical depth [1,2] and aerosol motion [3]. With an average cadence of 3-4 sols, a seasonal record of observed wind directions can be created and analyzed for five Mars Years (MYs).

Wind studies have been completed at Gale Crater using the Rover Environmental Monitoring Station (REMS) [4,5,6]. However, this only provides near surface winds and the loss of Boom 1 restricts REMS from properly measuring wind direction if the incoming winds relative to the rover is between 90 and 270 degrees [6]. To fill in the gaps, Mars Global Climate Models (GCMs) have been used in comparison with REMS observations [7].

Mars GCMs have shown that wind direction does change with altitude [3] and this must be taken into consideration. Data from the Cloud Altitude Observation (CAO) will be included that correlates wind speed from two observations to calculate altitudes of overhead water-ice clouds. Altitudes from the CAO have already predicted clouds between 20-40 km which seemed to agree with modelled results [3]. By noting the wind direction associated with these altitudes, the CAO can help pinpoint any patterns associated with altitude and wind direction.

Methods:

Zenith Movies. The atmospheric movie that is analyzed for meteorological wind direction is the Zenith Movie (ZM). It consists of eight frames pointed vertically (~85°) to observe aerosol movement directly above the rover. Due to this pointing, the ZM has a time constraint of ± 2.5 hours from local noon to avoid sun saturation in the frames.

Due to the thin nature of Martian aerosols, an imaging technique is needed. Known as the Mean Frame Subtraction (MFS), it subtracts the mean frame by each individual frame to reveal any changes, hence aerosol movement. An example of a raw and MFS movie is shown in Figure 1.

All ZMs within the data set are given a quality number to determine what aerosols are within the frames. If they have more uniform motion, they are classified as water-ice clouds. Any chaotic movement is considered dust. Any movie with noticeable movement is analyzed further by overlaying a compass rose to find meteorological wind direction.

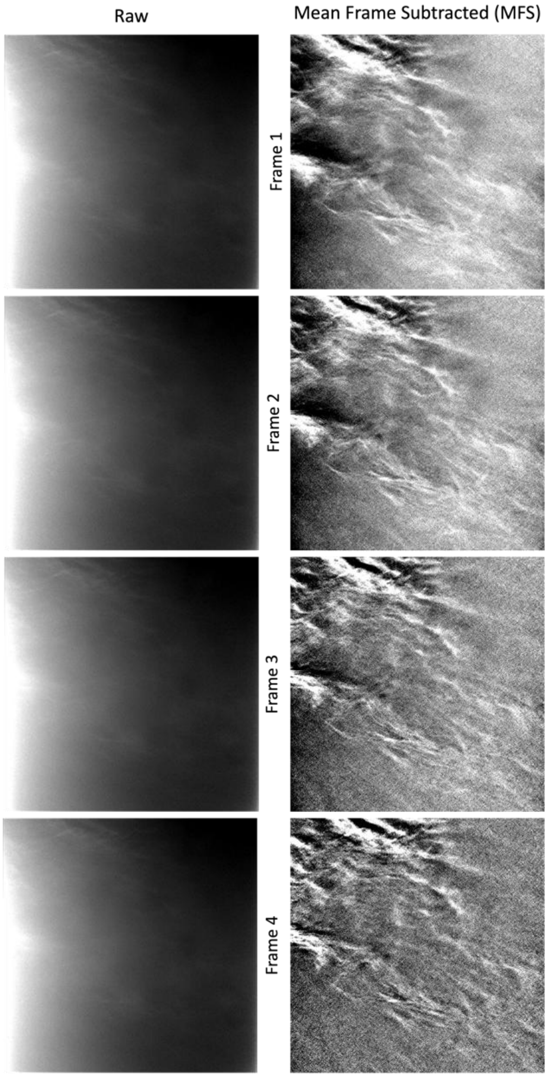

Figure 1: A ZM taken on sol 1758 (06:47 LTST, L_s 34°, MY 34). The top represents the raw frames where only faint clouds can be seen. When applying the MFS, more clouds are visible within the frame, as seen in the bottom.

Cloud Altitude Observation. To determine the altitude of the observed wind directions, the CAO will be used. This observation consists of two eight-framed movies, a ZM and Cloud Shadow Movie (CSM), shown in Figure 2. The vertical pointing of the ZM allows an angular distance to be calculated by considering the field of view (FOV) of the Navcam and pixel size of the image. Dividing the duration of the movie translates the angular distance into an angular wind velocity. The CSM on the other hand is pointed directly at Aeolis Mons (Mount Sharp) to capture shadow movement across the mountain. By using a Digital Terrain Model (DTM) a distance can be calculated and translated into an absolute velocity by noting the time duration of the shadows. Comparing the angular and absolute velocity from each movie allows the calculation of altitude of the observed aerosols.

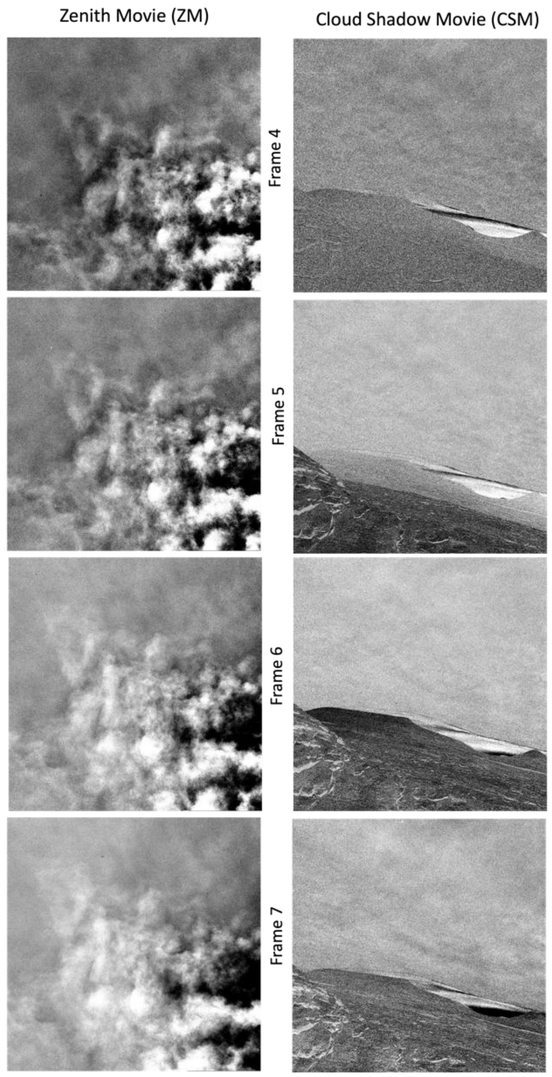

Figure 2: An example of frames 4-7 of a CAO, taken on sol 3324 (15:27 LTST, L_s 141°, MY 36). The top represents the ZM that observes cloud directly above the rover. The bottom figure represents the CSM where shadows are visible moving across Aeolis Mons with aerosol motion above.

Results:

ZM data will include all movies from the beginning of the mission till MY 36. The CAO was not introduced until MY 34 so only 3 MYs of data will be used.

Preliminary results for wind directions measured in MY 34 and 35 are shown in Figure 3. To investigate diurnal effects, data is divided into morning (06:00-10:00 LTST) and afternoon (14:00-18:00 LTST).

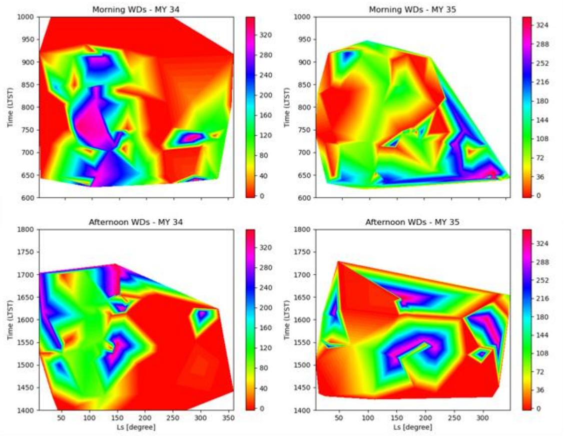

Figure 3: Preliminary results of wind directions of MY 34 and 35. Results are split into morning and afternoon to try to characterize any diurnal effects.

Results from the CAO investigates water-ice altitudes during the Aphelion Cloud Belt (ACB) season. Shown in Figure 4, each MY indicate a consistent altitude between 15-40 km, however, some data points at the start and end of the season have a higher altitude. This could be due to the presence of CO_2 clouds instead of water-ice. A wind direction analysis will be done on each CAO data point and compared to the ZM data set.

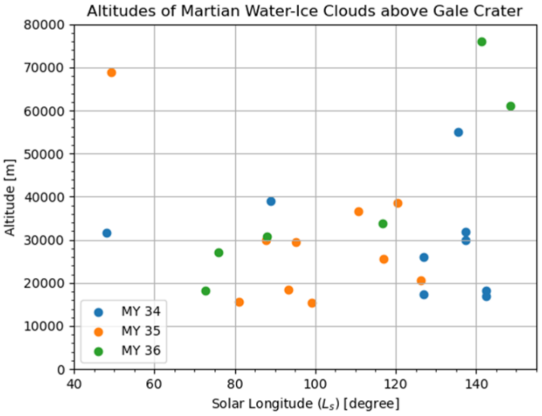

Figure 4: Updated results of the CAO adding on MY 35 and 36. Altitudes agree between each MY but higher altitudes at the beginning and end of the ACB season could be possible CO_2 clouds.

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