DUST PARTICLE SIZES FROM MARS CLIMATE SOUNDER OBSERVATIONS. J. L. Benson[1], M. D. Smith[2], and M. J. Wolff[3], [1]University of Maryland Department of Astronomy, College Park, MD, USA *(jennifer.benson@jpl.nasa.gov)*, [2]NASA Goddard Space Flight Center, Greenbelt, MD, USA, [3]Space Science Institute, Brookfield, WI, USA.

Introduction: Vertical variations in aerosol particle sizes can have a dramatic effect in their net impact on the state and evolution of the Martian atmosphere. Through absorption of solar radiation, aerosols heat the atmosphere by tens of Kelvins, significantly alter the general circulation, and are a key component of the water cycle via cloud nucleation. Changes in the size of aerosol particles will significantly affect their radiative properties and change their ability to heat or cool both the atmosphere and the surface [1,2]. Due to the diversity of atmospheric processes dependent on aerosol particle size, the limited nature of current constraints on vertical size profiles represents a large problem.

Dynamical modeling of the Martian atmosphere has reached a level of sophistication such that the vertical variations in aerosol microphysical properties are recognized as fundamentally important in reproducing observed behavior [3,4]. Although there have been a few promising initial results from Mars Express and Mars Global Surveyor [5,6], a systematic study of the vertical distribution of aerosol particle sizes is critically needed in order to constrain and validate modern dynamical simulations.

The ~5 km vertical resolution, dedicated atmospheric sounding data collected by the Mars Climate Sounder (MCS) [7], provides the crucial systematic temporal and spatial sampling to investigate the vertical variation of aerosol particle size. The simultaneous acquisition of IR and visible wavelength data by MCS provides the necessary spectral range to constrain aerosol composition (i.e., dust vs. ice) and particle size at altitudes between 10-60 km above the surface.

Data and Methods: MCS is a nine channel visible and infrared radiometer with limb-staring arrays optimized for atmospheric sounding. The MRO orbit [8] allows MCS to make radiance observations from pole to pole, in the morning (3:00) and afternoon (15:00).

The MCS IR A1, A2, and A3 channels are primarily sensitive to emission by CO_2 in the 15 µm absorption band, and thus to temperature. Two of the MCS IR channels, A4 (12 µm) and B2 (42 µm), are sensitive to water ice aerosols in the atmosphere as they are near peaks in the water ice absorption profile for cloud particles. In both channels, the ice is primarily absorbing, although there is a significant scattering contribution as well. Another two IR channels, A5 (22 µm) and B1 (32 µm) are sensitive to dust, with A5 near the peak and B1 on the shoulder of the long wavelength dust spectral feature. The solarband channel (A6) is sensitive to scattered sunlight from aerosol hazes, especially dust and water ice. The combination of A6 with A5 and B1 provides significant dust particle size sensitivity in the daytime. A6 also provides water ice particle size sensitivity to small particles when combined with A4 and B2. The solarband channel has been calibrated by [9] using a combination of CRISM and MARCI contemporaneous observations.

We have developed our own independent temperature and aerosol retrieval algorithm. Aerosol scattering is important for the MCS IR channels used for temperature retrieval and we include full multiple scattering in our radiative transfer (RT) model. In addition, the limb-viewing geometry requires that the spherical geometry inherent in the observations also be explicitly treated. We have developed and validated a highly accurate forward RT code that treats multiple scattering and accounts for spherical geometry in an approximate way that allows for relatively rapid retrievals.

The forward RT model uses the discrete ordinates method to treat scattering [10]. This is the same approach used by the popular DISORT radiative transfer package. In our code the atmosphere is divided into vertical layers, and the number of radiation "streams" can be set as high as necessary to accurately model the angular dependence of scattering. We use 100 layers, each 0.1 scale heights (~ 1 km) thick, and 4 streams (2 pairs) to describe the radiation field. Atmospheric state variables (temperature, gas abundance, aerosol abundance, aerosol scattering properties, etc.) can be specified separately for each vertical layer.

Our temperature retrieval algorithm uses MCS IR radiance observations from the A1, A2, and A3 channels to determine the temperature between the surface and ~60 km. TES climatology values are used for surface temperature, which are retrieved from TES nadir spectra at the same season and location in an earlier Mars year. We use a TES climatology atmospheric temperature profile as a first guess. The retrieval finds the model parameters (atmospheric temperature profile, aerosol extinction profiles, and surface pressure) that provide a "best fit" in a chi-squared sense between the observed data (radiance as a function of height above the limb) and the radiance computed from the forward RT model.

We employ a three-stage retrieval process in order to determine the aerosol particle sizes. First we iterate between dust, water ice, and temperature using the MCS IR channel radiances to retrieve a self-consistent temperature profile and dust and ice extinction profiles. We then use those retrieved quantities to calculate the "best-fit" to the MCS solarband channel. Finally we use the ratio of the solarband-IR optical depths to derive the particle size.

Results: Figure 1 shows a comparison of retrieved temperature profiles using the retrieval method described here (BSW-Benson, Smith, Wolff - retrieval) to those of the MCS team retrieval. The overall agreement between the BSW retrieval and the MCS Team is quite good.

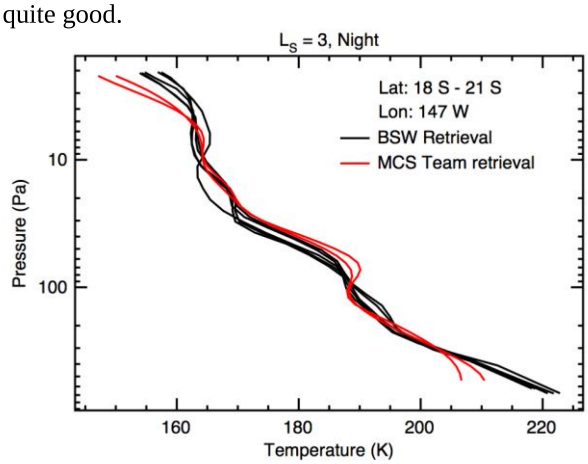

***Figure 1**: Retrieved temperature profiles at L_S=3° at night. **Black**: Temperature profiles retrieved using the described methodology (BSW Retrieval). **Red**: MCS Team retrieved temperature profiles in the same location.*

Figure 2 shows the model fit to the MCS radiances from A5, B1, and A6 using the retrieval methodology described above for an observation at L_s=3°. Our retrieval is able to provide excellent fits to the observed MCS data. The data from Figure 2 are converted to optical depth per unit length (extinction). Figure 3 shows the retrieved dust extinction as a function of height for the A5 and A6 channels. Using the ratio A6/A5 enables particle size to be retrieved. Here we find a gradient in dust particle size from 0.8 µm at 30 km to 2 µm at 10 km.

We will present additional results of the application of our particle size retrieval scheme for dust.

References:

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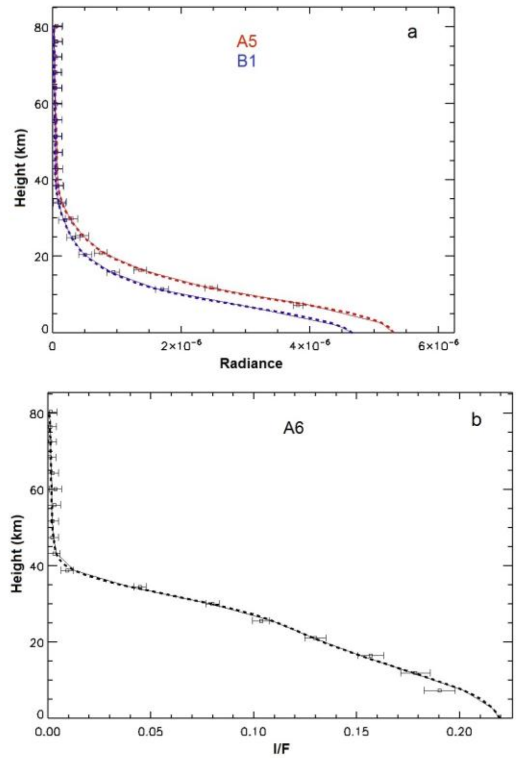

***Figure 2**: Fit to the MCS radiances. The points are the MCS observations and the dotted lines are the model fits sampled at observation heights. Observation at L_S=3° (day), 29° N, 45° E. (a) A5 (red) and B1 (blue) radiance and best fit as a function of height. (b) A6 solarband I/F and best fit as a function of height.*

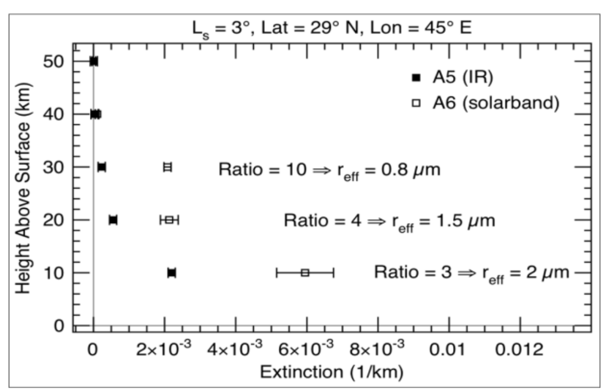

***Figure 3**: Retrieved dust extinction as a function of height (km) at L_S=3° (day), 29° N, 45° E. **Filled box**: retrievals with A5 (22 µm) using the BSW method. **Open box**: retrievals with A6 (solarband) using the BSW method. The ratio A6/A5, with the calculations shown in Fig.1, enables particle size to be retrieved.*