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Interannual variability of dust and ice in the Mars atmosphere: Comparison of MRO Mars Climate Sounder retrievals with MGS-TES limb sounding retrievals

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Abstract

Dust and ice play important roles in Martian atmospheric dynamics on all time scales. Dust loading in particular exerts an important control on atmospheric temperatures and thereby on the strength of the atmospheric circulation in any given year. We present the first comparisons of MGS-TES aerosol opacity profiles with MRO-MCS aerosol opacity profiles. While the differences in vertical resolution are significant (a factor of 2), we find good agreement at particular seasons between nightside zonal average dust opacity profiles from the two instruments. Derived water ice opacities are likewise similar but show greater variability.

1. MGS-TES aerosol profiles

The Thermal Emission Spectrometer (TES) instrument on board the Mars Global Surveyor spacecraft was routinely operated as a limb-sounding instrument for a portion of each observation sequence, obtaining a set of such observations once in every 10° of travel in latitude during the MGS mission. The latitudes of observation were shifted by 5° on each succeeding orbit. The resulting aerosol opacity profiles represent a unique and important dataset for Mars years 25, 26, and 27.

2. MRO-MCS aerosol profiles

The Mars Climate Sounder instrument on board the Mars Reconnaissance Orbiter spacecraft is a limb sounder that has obtained simultaneous vertical profiles of temperature, dust, and water ice opacity since September 2006 (Ls 110 of Mars year 28). MCS obtains soundings with a spacing of 1.5° of latitude. For the present investigation we focus on a Martian season (northern spring, Ls 70-80) and latitude range (50° N - 60° N) that are known to be characterized by relatively low aerosol opacities. Around 1000 MCS nightside opacity profiles for MY 29 and MY 30 were averaged for the comparisons detailed here. The MGS-TES limb opacity profiles for the corresponding local time and season are binned in 5° steps of latitude and L_s. Six such bins were found to contain valid data and the corresponding profiles are plotted in Figs. 1 and 2. Each TES profile represents an average of 74-107 individual soundings. Because the TES data are referenced to the aeroid, it was necessary to add an offset of 4 km to the reported TES altitudes in order to bring the altitude scales into agreement. (The MCS altitudes reference the MOLA altimetry, and the mean surface altitude for the MCS profiles averaged was – 4 km).

3. Dust comparison

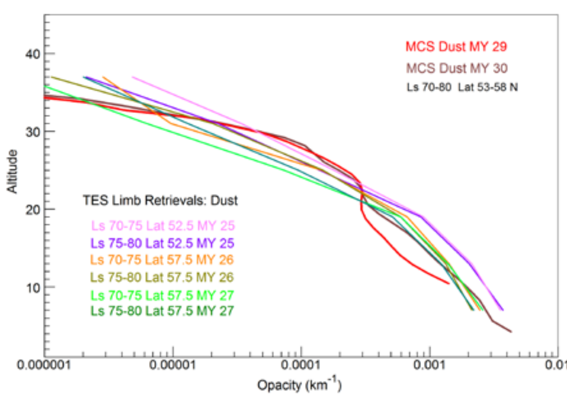

Figure 1: Northern spring season dust opacities. The frequency employed in the MCS dust retrieval is 463 cm^{-1} (wavelength 21.6 µm).

Figure 1 illustrates the zonally-averaged dust opacity profiles obtained from the MCS dataset (heavy brown and red lines) and the corresponding zonal average MGS-TES limb dust opacity profiles. Although the MCS opacity values tend to be lower than the TES values below 20 km, this difference may be attributable either to interannual variability or possibly to the factor of two difference in vertical resolution of the two instruments. In general the agreement is quite satisfactory. The TES profiles from year 25 show higher dust opacity than those from years 26 or 27 below 20 km, while the MCS year 29 profile is significantly clearer than that for year 30 below 20 km. True interannual variability is a likely explanation in each case.

4. Water ice comparison

Figure 2 illustrates water ice opacity profiles from the same sets of MCS and TES selections. Nightside water ice opacities in northern spring between 50º N and 60º N are remarkably consistent over the 5 Mars years represented. Once again the overall agreement is good. The differences between MCS and TES generally lie within the year-to-year variability seen by TES.

Lower opacities are reported by TES in year 27, and a somewhat lower altitude of the maximum opacity is suggested in MY 26. Interannual variability is the most likely cause. As before, the higher vertical resolution of MCS could account for some of the differences between the structures seen.

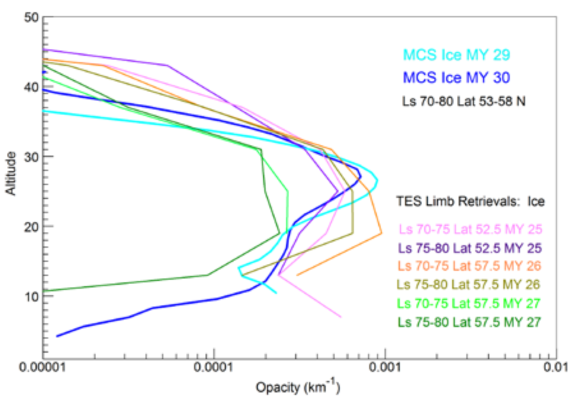

Figure 2: Water ice opacity comparison (northern spring). The frequency employed for the MCS ice retrieval is 842.7 cm-1 (wavelength 11.86 µm).

5. Summary and conclusions

The combined record of TES and MCS atmospheric dust and water ice opacities spans nearly 6 Mars years. The instrumental records unfortunately do not overlap. Comparisons of atmospheric opacities obtained using different instruments in different Mars years are therefore important for elucidating the performance characteristics of the instruments and the strengths and weaknesses of the respective retrieval methods. Of even greater interest is the question of the inter-annual variability of aerosol loading, which may be addressed both by comparisons within the separate datasets, and by comparisons between them. Work to develop a unified multi-instrument aerosols climatology has barely begun. Future work with these datasets may provide important constraints for general circulation models of the Mars atmosphere.

Acknowledgements

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