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The Mars Climate Sounder Investigation: An overview of scientific contributions and current efforts

J. H. Shirley (1), D. J. McCleese (1), A. Kleinböhl (1), N. G. Heavens (2), J. Benson (1), J. T. Schofield (1), and D. Kass (1)

(1) California Institute of Technology – Jet Propulsion Laboratory, Pasadena, California, 91109 USA, (2) Department of Earth and Atmospheric Sciences, Cornell University, Ithaca N. Y. 14853 USA (James.H.Shirley@jpl.nasa.gov).

Abstract

The Mars Climate Sounder instrument (MCS) on board the Mars Reconnaissance Orbiter spacecraft has obtained simultaneous vertical profiles of temperature, dust, and water ice opacity in the Mars atmosphere since September 2006 (L_s 110 of Mars year 28). MCS resolves atmospheric structures to altitudes of ~80 km with resolution of ~5 km. The unprecedented coverage of the middle atmosphere (40-80 km) has yielded new insights into the nature and variability of the fundamental Mars atmospheric circulation [1] and the diurnal tide [2]. The MCS global record of temperature versus pressure extends the period of nearly continuous observations of the Mars atmosphere (begun by MGS-TES) to nearly 6 Mars years. The availability of simultaneous retrievals of temperature and dust and water ice opacity has greatly improved our scientific understanding of the distribution of aerosols with altitude in the Mars atmosphere during different seasons [3, 4]. A relationship linking diurnal cycles of water ice cloud formation with tidally-driven diurnal temperature changes has come into sharp focus with the aid of the MCS data. MCS data has also led to the recognition of previously unknown features in the vertical distribution of dust throughout the Mars year [3].

MCS has recently begun an observational program that alternates conventional in-track scanning at 3 pm and 3 am local time with side-looking scans that provide atmospheric profiles of temperature, pressure, and aerosol opacity for a range of local times. The additional scans allow much improved temporal coverage for resolving coherent structures within the temperature and opacity fields.

1. Dust investigations

MCS data reveals new features and previously unsuspected complexity of the Mars dust cycle. The high altitude tropical dust maximum [3] (Fig. 1) observed in late northern spring and early northern summer in Mars years 28, 29, and 30 is one example.

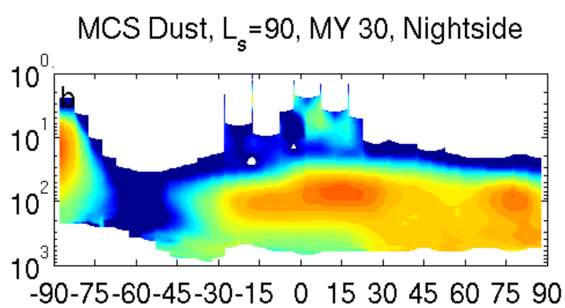

Figure 1. $\log_{10}$ of zonal average dust density-scaled opacity ($m^2\ kg^{-1}$), latitude (º) versus pressure (Pa). Contours are every 0.1 log units. White space at top (and the darkest blue) indicates density-scaled opacity below $10^{-6}\ m^2\ kg^{-1}$.

An analogous structure was observed during southern summer of Mars year 29. The resolved structures have limited longitudinal variability. Longitudinally narrower structures of higher concentration and at higher altitudes also have been observed. In some cases, these structures appear to be associated with dust storm activity.

2. Water ice and clouds

MCS observations document a remarkable relationship linking the formation of water ice clouds at particular altitude levels in the atmosphere to contemporaneous temperature variability due to tides. High altitude cloud layers form where tidally-controlled atmospheric temperatures fall below the water ice condensation temperature, and dissipate when temperatures rise. MCS provides unprecedented coverage of cloud opacity, vertical structure, and spatial extent on the nightside (Fig. 2).

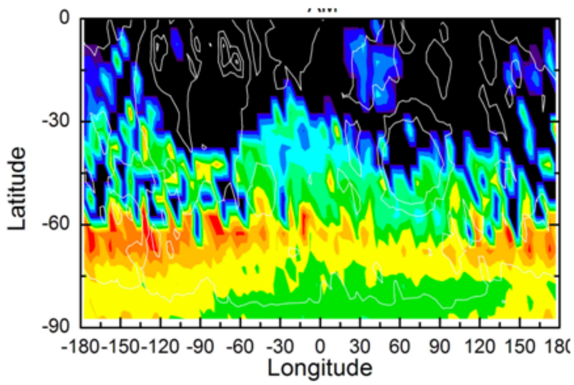

Figure 2: Nighttime water ice opacity map (843 cm^{-1} or ~12 µm) [4] showing the extent of Mars' south polar hood between L_s 178-193, MY 29. Opacity ranges from 0 to 0.855.

3. Cross-track scanning

Since September 2010 MCS has employed an observation strategy that includes side-looking ("cross-track") limb soundings. Fig. 3 illustrates atmospheric temperature structure for a period from L_s 148º-162º.

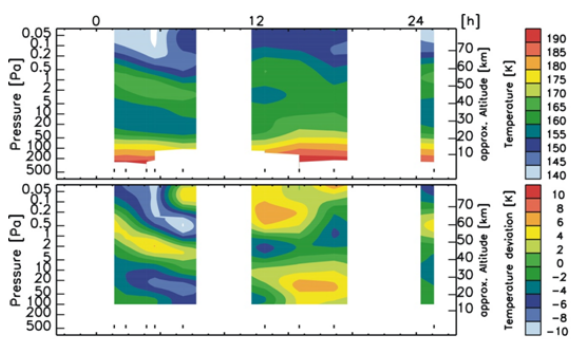

Figure 3: Northern mid-latitude (50º-55º N) temperature structure with local time (scale at top).

Figure 3 illustrates tidally-controlled warm and cold structures that propagate vertically downward with local time. The upper plot shows temperature versus pressure, while the lower shows temperature difference from the zonal mean. A semidiurnal pattern is evident. This approach is capable of resolving both migrating and non-migrating tides, as well as other features such as Kelvin waves, in the Mars atmosphere.

6. Summary and Conclusions

MCS continues to provide simultaneous measurements of Mars atmospheric temperature and dust and ice opacity of unprecedented vertical resolution. MCS will support Mars Science Laboratory landing operations in 2012. The multi-year climatology now available may offer new insights on interannual variability and atmospheric oscillations.

Acknowledgements

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