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Detailed Comparison of Observations and Model of Mars Mesospheric Winds around Northern Spring Equinox

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Abstract

During the last decade general circulation models (GCM) for Mars have evolved to a state allowing detailed predictions of atmospheric dynamics. Wind speeds are a key variable in the models and need to be validated by observations. We put a focus on studying the evolution of dynamics in the upper atmosphere of Mars around northern Spring Equinox (L_S = 0). Model calculations predict the global circulation around 50 to 100 km altitude to change from a dominant northern jet configuration during northern winter to a dominant southern jet configuration in early northern summer.

We present a detailed comparison between observations of mesospheric winds on Mars around northern Spring Equinox and predictions of these winds from a general circulation model. Data was gathered using ground based ultra-high spectral resolution observations of non thermal (non-LTE) CO_2 features around 10 µm wavelength (see Fig 1).

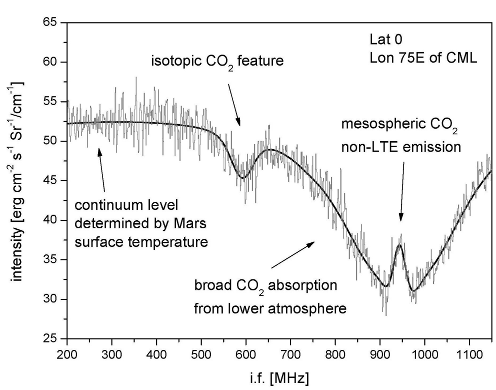

Fig 1: A typical spectrum of absorption and emission features of the P(2) CO_2 transition to retrieve Doppler-shifted wind velocities on Mars.

Observations were carried out during three seasons (L_S=335 (season 1), 357 (season 2), 040 (season 3)) using the Cologne Tuneable Heterodyne Infrared Spectrometer (THIS) at the McMath-Pierce Solar Telescope on Kitt Peak, Arizona and the NASA InfraRed Telescope Facility on Mauna Kea, Hawaii). Results are shown in Fig 2. Heterodyne techniques allow a spectral resolution of more than 10^6 and thus the observation of fully resolved molecular features and the retrieval of Doppler shifts down to ~1 MHz. In the case of our observations this corresponds to an accuracy of 10 m/s. In addition the high spatial resolution on the planetary disk intrinsic to infrared wavelength enables unique groundbased studies of latitudinal variations.

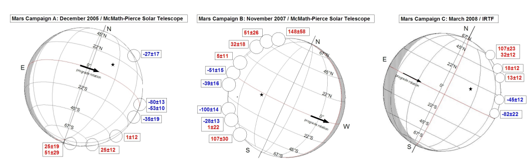

Fig 2: Overview of retrieved results for zonal wind velocities on Mars during the three Mars campaigns. Wind velocities are given in m/s, prograde wind velocities are written in red whereas blue numbers indicate retrograde wind velocities.

The model prediction were composed from the Mars Climate Database (MCD) [Forget2007]. Due to the complex observing geometry the GCM data needs to be extracted from the database in such a way that it reconstructs the field-of-view of the telescope. In addition, since the altitude of the observed winds cannot be determined from the data directly we use the Granada non-LTE radiative transfer code [Valverde2010] to estimate the altitude distribution of emission in our observed spectra as shown in Fig 3.

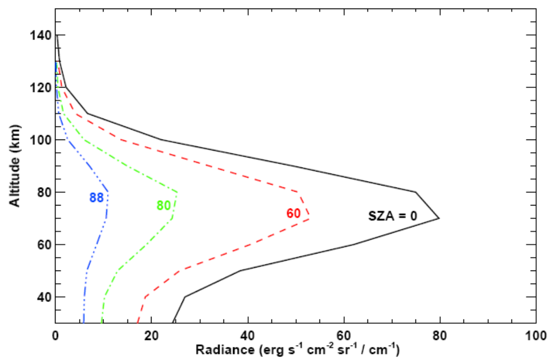

Fig 3: Altitude distribution of non-LTE 10 µm emission from the atmosphere of Mars.

Season 1 was observed in November 2005 and the results from that campaign are in reasonable agreement to an averaged value from the model predictions [Sonnabend2006]. Two additional observing campaigns were conducted in November 2007 and March 2008 to match the seasons 2 and 3. Those data also agree with the averaged model except for some deviations found for higher latitudes (>45 degrees). Additional data was acquired at an LS=60. Data analysis is currently under way.

The presented observations provide the first seasonal study of zonal winds on Mars and the first detailed comparison between GMC and observaed data at high spatial resolution.

References

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