

Modelling Martian atmospheric chemistry with GEM-Mars

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Abstract

In anticipation of the ExoMars Trace Gas Orbiter (TGO), the GEM-Mars model is used to analyse the photochemistry of the Martian atmosphere. GEM-Mars is a three-dimensional general circulation model (GCM) using the dynamical core of the Global Environmental Multiscale (GEM) model [1] and contains the basic physical parameterisations necessary to simulate the Martian atmosphere. The model is able to reproduce the basic atmosphere, including the CO₂ condensation/sublimation cycle and water cycle, which is an important element in the photochemistry of the Martian atmosphere. The vertical distribution and seasonal and latitudinal behaviour of the chemical constituents will be presented, showing the relationship between ozone, water vapour and the HO_x family.

The GEM-Mars Model

The GEM-Mars GCM has been evaluated using several Mars atmospheric datasets. The dynamical state of the atmosphere is well predicted by the GCM as illustrated in Figure 1 where GEM-Mars results are compared to data from the Thermal Emission Spectrometer [2]. Surface temperatures are usually within a 10K range, and water columns and ice cloud opacities remain within 20% of the measurements.

Chemistry module

The current chemistry package in GEM-Mars has 13 species representing the fundamental photochemistry of Mars: O₃, O₂, O(¹D), O, CO, H, H₂, OH, HO₂, H₂O, H₂O₂, O₂(^a₁Δ_g) and CO₂. There are 15 photolysis and 31 chemical reactions in total. All the species are transported and mixed by the resolved circulation and eddy diffusion. In the upper atmosphere, molecular diffusion is also considered. The set of chemical reactions is solved implicitly using a Gaussian elimination method. The chemical mechanism and rate co-

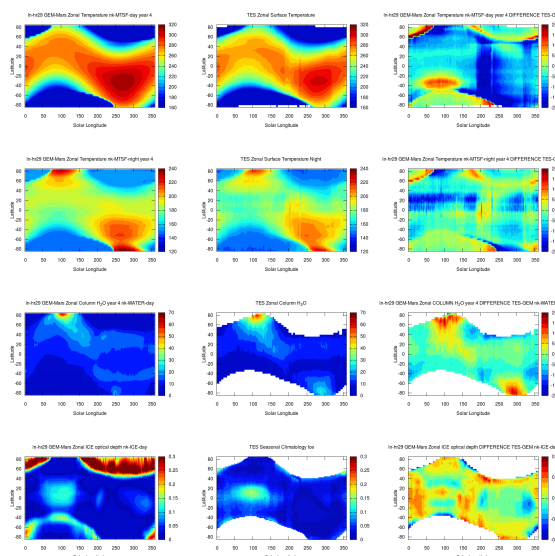


Figure 1: The left are zonal means for GEM-Mars, the centre column shows the seasonal average zonal means for TES, and the right column shows the difference TES-GEM for the following: Row 1: daytime temperature, Row 2: nighttime temperature, Row 3: H₂O column, Row 4: H₂O ice optical opacity.

efficients are based on the work of García-Muñoz et al., 2005 [3]. The preliminary results of a simulation of the chemistry in GEM-Mars are presented in Figure 2 (for HO_x species) and Figure 3 (for O_x species). Although not optimized, these average profiles are consistent with other model studies in the literature.

A more thorough examination of the vertical distribution and seasonal and latitudinal behaviour of the chemical constituents will be presented, showing the relationship between ozone, water vapour and the HO_x family.

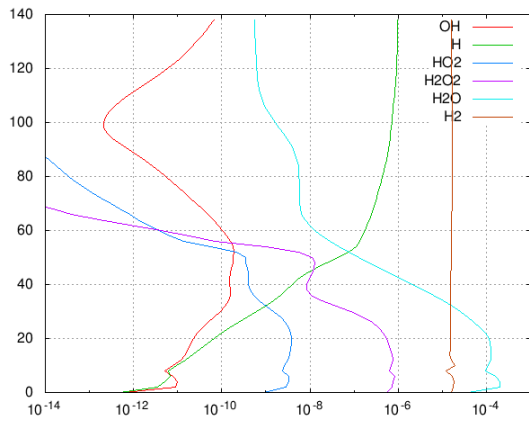


Figure 2: Annual average profiles of HO_x species volume mixing ratios vs. height in km.

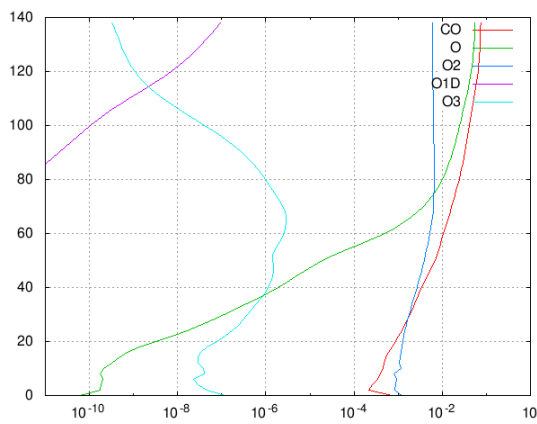


Figure 3: Annual average profiles of O_x species volume mixing ratios vs height in km.

References

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