COUPLING A PHOTOCHEMICAL MODEL AND THE LMD-GCM.

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The General Circulation Model of Mars atmosphere developed at the LMD for the last 10 years describes now many aspects of the physics taking place in this atmospheric system. It is a 3-dimensional model, covering altitudes from the surface up to 120 km. It now includes the water cycle, and we are also working on its extension in the thermosphere. But until now, it did not include any description of the detailed composition of the atmosphere. This part of the development of the model will be described in this presentation.

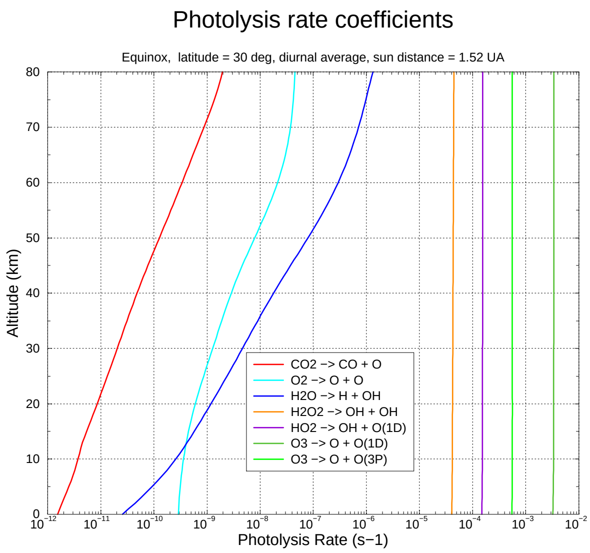

Figure 1: exemple of diurnally-averaged photolysis rate coefficients calculated at equinox for a latitude of 30 degrees. These calculations were performed assuming a temperature profile similar to the one used by Anbar et al. [J. Geophys. Res., 98, 10925, 1993], and for H_2O and O_3 columns equal to 9.8 pr-μm and 1.4 μm-atm, respectively.

We have developed a chemical model of the Mars atmosphere describing at this stage the chemistry of 11 oxygen and hydrogen species: (O, O(^{1}D), O_2, O_3, H, OH, HO_2, H_2O_2, H_2, H_2O, and CO). The first step of this work has consisted in the development of a photochemical module allowing the computation of the photolysis rate coefficients for all conditions of sunlight, atmospheric opacity, or temperature. Based on our experience in the study of the Earth stratospheric chemistry, this module was adapted to Mars by implementing CO_2 as the main UV absorber. However, the model takes also into account the contribution to the UV opacity of H_2O, O_2, and O_3. All the calculations use high resolution temperature-dependant absorption cross-sections. They are performed with a wavelength interval that ranges from 5 nm to 0.1 nm, depending on the variability of the cross-sections or solar flux.

The 10 vertical profiles of photodissociation coefficients are then tabulated for all altitudes between the surface and 120 km, and for all zenith angles between 0 and 95 degrees. In addition to these photolytic processes, 28 chemical reaction rates are also calculated on line using the actual pressure and temperature for each cell of the atmosphere.

The chemical model has then been tested by a series of idealised 1D (vertical) simulations, and has eventually been coupled to the LMD General Circulation Model. Chemical distributions are therefore obtained in three dimensions, under the influence of transport, the solar zenith angle, as well as the amount of water vapor available to produce HO_x radicals.

We will present the main features of the photochemical model and its coupling with the GCM. The impact of current uncertainties of absorption UV cross-sections on the computation of photolysis rates will be discussed. We will then describe the preliminary results of our first GCM-coupled chemical experiments. Emphasis will be put on the three-dimensional seasonal cycle of ozone and related species. In particular, the influence of the water cycle on the chemistry of hydrogen and oxygen species in the lower atmosphere will be studied. First comparisons with observational data will also be presented.

This model will be a unique tool for the interpretation of the chemical data obtained from the instruments onboard the Mars Express mission.