

MERIDIONAL AND SEASONAL DISTRIBUTIONS OF TRACE GASES IN THE LOWER AND MIDDLE ATMOSPHERE OF MARS: D. Moreau¹, A. Marten² and Y. Biraud², ¹Belgian Institute for Space Aeronomy, B-1180, Brussels, Belgium, moreau@bira-iasb.oma.be, ²DESPA, Observatoire de Paris-Meudon, 92195, Meudon, France.

INTRODUCTION

In the past, one-dimensional photochemical models have been developed to determine the expected vertical profiles of atmospheric trace compounds in the Martian atmosphere (Hunten and McElroy, 1970; Yung et al., 1977; Lindner, 1988). These models have provided estimates of mean concentrations of these gases as a function of height. They do not however account for the effects of meridional transport nor for the latitudinal and seasonal variations of solar insolation. Two-dimensional models provide a better description of these processes and include a more detailed formulation of mass, momentum and energy transports.

THE MARS-2D MODEL

In this framework, we developed an interactive radiative, dynamical and chemical two-dimensional model of the Martian atmosphere (Moreau *et al.*, 1991) which calculates meridional and vertical distributions of 36 chemical species from 5 chemical families (HO_x , O_x , NO_x , SO_x , Cl_x). The validity of our MARS-2D model extends from south pole to north pole and from the ground to 85 km. Latitude and altitude are used as co-ordinates, with horizontal resolution of 5 degrees and vertical resolution of 1 km. The model is an adaptation to Martian conditions of the two-dimensional model of the Earth's middle atmosphere developed by Brasseur *et al.* (1990).

THERMAL STRUCTURE

In the Martian atmosphere temperature distribution varies mainly with season, latitude, solar activity, and atmospheric dust content. For a clear atmosphere, the radiative heating is mainly produced by radiative processes of carbon dioxide and ozone. The meridional distribution of temperature calculated by the model, when solving the thermodynamic equation in which radiative transfer and transport of heat are explicitly included, is shown in figure 1. Note that for this specific season, the main features of the observed thermal field are well reproduced by the model.

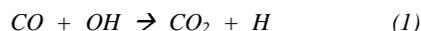
ODD OXYGEN COMPOUNDS

The formation of odd oxygen compounds in the Martian atmosphere results from the photolysis of carbon dioxide in the upper atmosphere and the photolysis of ozone in the lower atmosphere. The odd oxygen destruction results from the recombination of atomic oxygen and ozone which is catalysed by the presence of hydrogen and nitrogen radicals. Figure 2 shows the calculated meridional distribution of ozone for the same season as in figure 1. The model shows

an ozone meridional distribution which is consistent with the very low abundance detected by Mariner 9 (e.g., Barth *et al.*, 1973). Modeling also shows that, in the lower atmosphere, the latitudinal variation of ozone is determined by spatial changes of water distribution which are mainly controlled by condensation processes at winter polar latitudes.

ODD HYDROGEN COMPOUNDS

The current chemical stability of the Martian CO_2 atmosphere against UV photolysis remains intriguing in many aspects. A mechanism was proposed by Parkinson and Hunten (1972) invoking the reaction:



where hydroxyl radicals are mostly produced during the photolysis of H_2O_2 and HO_2 . It appears today that hydrogen peroxide may be the key atmospheric trace constituent for the chemical regulation of H_2 , O_2 and CO in the Martian atmosphere. In the classical photochemical scheme, hydrogen peroxide is almost entirely produced by the HO_2 "self-reaction":



and destroyed during the day through photolysis:



Another significant sink for H_2O_2 is its condensation in the cold regions of the atmosphere. This condensation process is obviously crucial in the lower atmosphere since it restrains the concentration of odd hydrogen compounds and is therefore very significant in the control of the atmospheric chemical stability. Figure 3. shows the calculated meridional distribution of H_2O_2 for a solar longitude of 360 degrees.

ORGANIC COMPOUNDS

In 1988, during the last Phobos 2 mission, 9 sequences of infrared observations of the Martian lower atmosphere revealed two absorption bands (at 2729 cm^{-1} and 2710 cm^{-1}) which were attributed to formaldehyde (Korablev *et al.*, 1993). In order to interpret these observations, we refined the former chemical scheme by adding chemical and photochemical reactions involving simple organic compounds. Simulations have been constrained by recent millimeter observations of minor species that we performed at the IRAM 30-m radiotelescope (Moreau *et al.*, 1998) as well as by the new upper limit of methane abundance published by

Krasnopolski *et al.* (1994). The expected vertical distribution of organic compounds, except for CH_4 , are not uniform with altitude as well as with latitude. The two-dimensional profile of formaldehyde computed using the lower limit of methane concentration (Krasnopolsky *et al.*, 1994) is displayed in figure 4. This distribution results mainly from an equilibrium between fast chemical reactions involving other organic species and trace gases (HO_x , NO_x) and photolysis processes.

CONCLUSION

The main objectives of this paper are to present two-dimensional distributions of trace gases in the current lower and middle atmosphere of Mars under different seasonal conditions. Furthermore, as methane is assuredly not photochemically produced in the today atmosphere, we will discuss the potential sources of organic compounds such as CH_2O .

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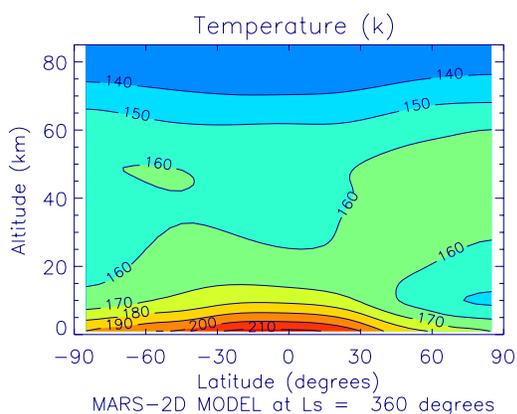


Figure 1. Thermal field calculated for a solar longitude of 360 degrees.

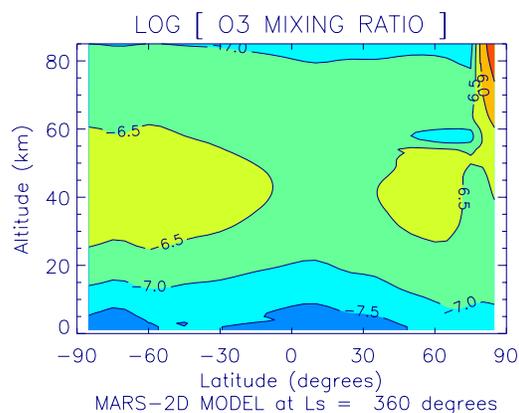


Figure 2. Meridional and vertical distribution of ozone calculated for the same seasonal conditions as in figure 1.

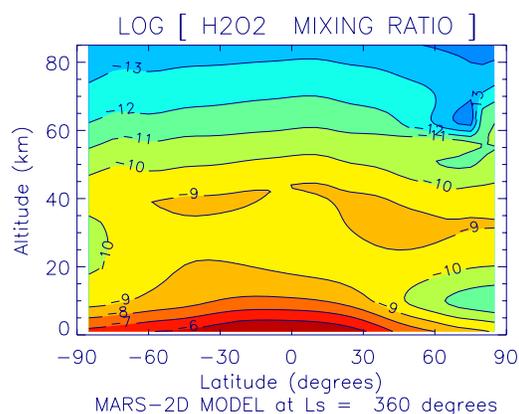


Figure 3. Meridional and vertical distribution of hydrogen peroxide for $L_s = 360$ degrees

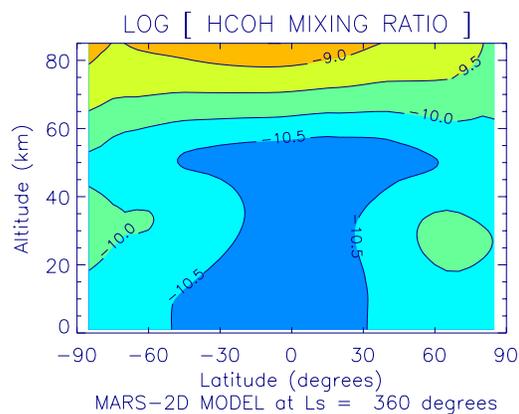


Figure 4. Meridional and vertical distribution of formaldehyde for $L_s = 360$ degrees and using the lower limit for methane proposed by Krasnopolsky *et al.* (1994)