A NEW MARS IONOSPHERE/AIRGLOW MODEL BETWEEN 60 AND 500 KM ALTITUDE.

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In the framework of the exploration of Mars and of its atmosphere, we present a new model of the ionosphere and of the airglow (optical emission emitted by the atmosphere excited by the solar radiation), in the 60-500 km altitude range. This model is specially used to prepare the scientific return of the Mars-Express, Nozomi, and NetLander missions. We present here the main inputs and outputs of these models, and the various possibilities of inferring information on the neutral atmosphere of Mars.

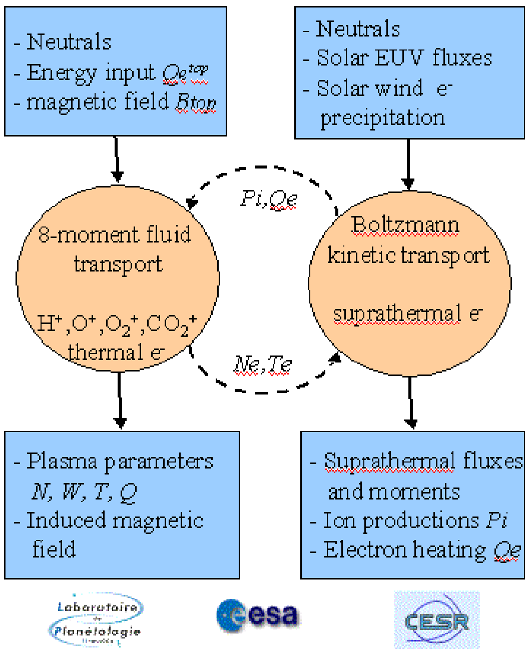

Figure 1: Synopsis of the model. The main inputs of the fluid part are the neutral atmosphere, a downward electron heat flow at the top of the ionosphere Q_e^{top}, and the induced magnetic field at the top B_{top}. The inputs of the kinetic part are the neutral atmosphere, the solar fluxes and the solar wind electrons. The outputs of the fluid part are the plasma densities (N), velocities (W), temperatures (T) and heat flows (Q), and the induced and horizontal magnetic field. The main outputs of the kinetic part are the ion production and the thermal electron heating rate Q_e. The kinetic part gives the ion production and Q_e to the fluid part. The fluid part provides the electron densities and temperatures to the kinetic part.

The kinetic/fluid/MHD model

Between 500 and 100 km, the ionosphere is modelled by a coupled kinetic/fluid/MHD model (Witasse, 2000; Blelly *et al.*, 2002; Lilensten *et al.*, 2002; Witasse *et al.*, 2002), allowing us to describe both the photochemical controlled and the transport controlled regions. This code is a one dimensional model, based on an ionospheric model developed for the Earth, and is divided into two parts, as shown on Figure 1. The first one solves a stationary Boltzmann kinetic equation for the photoelectrons, and provides the photoelectron fluxes, the ion productions, and the thermal electron heating rate. The second part solves the fluid equations (continuity, momentum, energy and heat flow) for the thermal plasma component. A convection-diffusion equation for the induced horizontal magnetic field is also solved, enables us to investigate the interaction between the upper atmosphere and the solar wind.

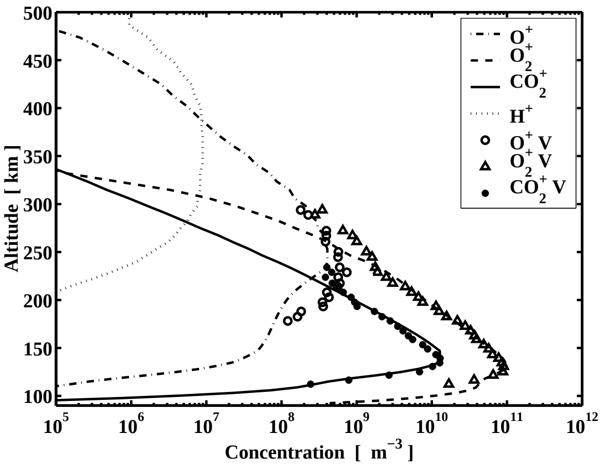

Figure 2: Densities of the 4 main ions included in the model: H^+, O^+, O_2^+, CO_2^+. The Viking 1 lander measurements are also plotted for comparison.

Figure 2 displays the ion densities profiles, for the geophysical conditions corresponding to the descent of the Viking 1 lander in 1976. An excellent agreement has been found between the modelled and the measured profiles, especially for the O_2^+ and the CO_2^+ ions. Regarding the atomic oxygen ion, the discrepancy below 250 km is still unexplained.

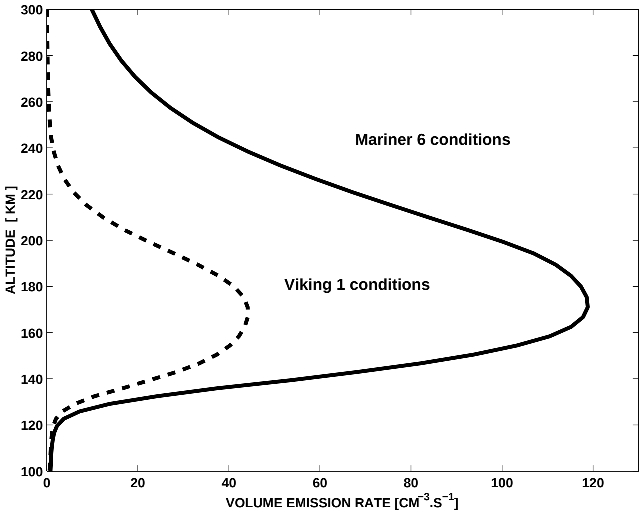

Figure 3: Volume emission rate of the red line of the atomic oxygen. The Mariner 6 (solid line) conditions correspond to a high solar activity, while the Viking 1 conditions (dashed line) correspond to a low solar activity.

This ionospheric code also computes some emission lines of the CO_2^+ ion and of the atomic oxygen. We calculate the volume emission rate (in photons $cm^{-3}.s^{-1}$.) and the intensity (in Rayleigh; the integration is made along the line of sight). As an example, Figure 3 displays the volume emission rate of the 630 nm emission line of the atomic oxygen, for two different geophysical conditions. This line has never been observed at Mars. Its observation in the future may provide useful information on the Martian neutral atmosphere (S.W. Bougher, private communication, 2001).

Modelling of the lower ionosphere

Below 100 km, the ionosphere is described by another model (Molina-Cuberos *et al.*, 2002) including the meteorid ablation, the ultraviolet photoionization and the ion-neutral chemistry. The densities of the electrons and of the Fe^+ and Mg^+ ions are provided, as well as the densities of the neutrals Fe and Mg. These parameters are computed for the daytime as well as for the nightime. Figure 4 shows the density profiles of various components from the Fe family, during the nighttime. This ionospheric layer is not very well known, and may have some consequences on the propagation of radio waves in the 1-10 MHz frequency range (Witasse *et al.*, 2001). We compute also the emission lines of Mg and Mg^+ in the ultraviolet range (285 and 280 nm). That gives an additional possibility of the diagnostic of the atmosphere at these altitudes. These emissions may be observed by the spectrometer SPICAM onboard Mars-Express in 2004.

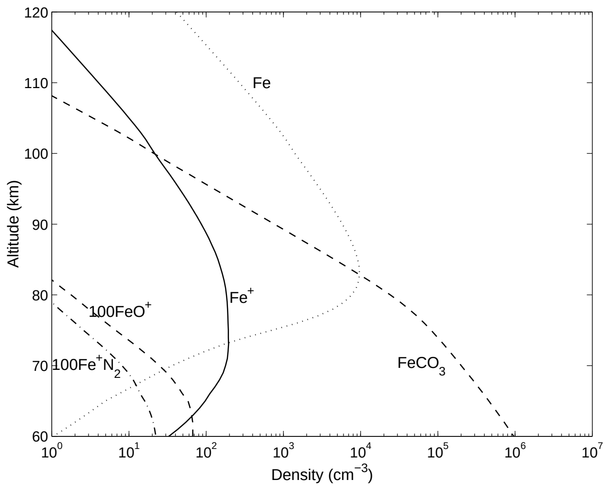

Figure 4: Densities of the atmospheric components which belong to the Fe family, during the nighttime.

Reference

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