CHARACTERISTIC SPECTRAL ASPECTS OF A MARTIAN DUSTSTORM.

Christian Muller and Didier Moreau

Belgian Institute for Space Aeronomy, Brussels, Belgium.

Christian.Muller@bira-iasb.oma.be

ABSTRACT

Computed spectra of the Martian atmosphere transmission as observed by the ISO SWS show the possibility of detecting the dust level altitude during a global dust storm. Dust composition can also be derived from the analysis of the spectral response. A Target of Opportunity proposal is accepted in order to realise these scientific objectives. Unfortunately, the ISO solar elongation requirement limits extremely the Mars observation possibilities and the chances of observing before the end of ISO lifetime are now very low. The historical Martian storm season begins only at the middle of October 1997 and the atmosphere observed until the end of September 1997 shows an exceptional clarity.

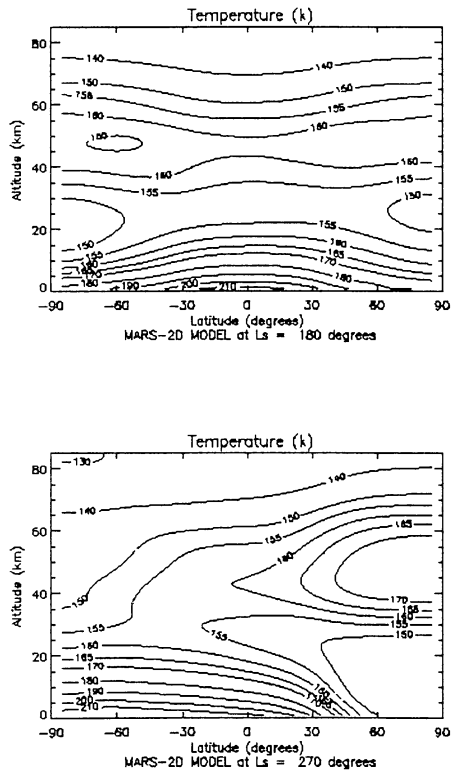

Fig. 1: calculated thermal profiles for the solar longitudes of 180° and 270°.

INTRODUCTION

One of the most surprising meteorological event on Mars is the development of sand storms which can encircle the entire planet (Zurek, ,1982). These storms primary originate from three regions (Hellespontus, Noachis and Solis Planum). Previous observations also shown a multitude of local sand storm occurring everywhere on the planet and that these storm begin when Mars approach of perihelion conditions (Fig. 3). Perhaps the least understood aspect of this Martian eolian process is the mechanism for dust uplifting in the current atmosphere. Local storm on Mars appear every years and probably every seasons. Several theories have been proposed to explain initiation of these storms, dust devils (Zurek, 1982) or volatiles desorption from the regolith in response to a heating of the surface. The last theory on initiation of dust storms on Mars has been recently proposed by Rybakov et al. (1997). From theoretical estimates and laboratory modelling experiments, these authors argue that impact of small cosmic bodies on the surface may be the cause of local storm on Mars.

Numerous studies (Zurek, 1982; Haberle et al., 1982) shown that airborne dust can induce an increase of the daily net heating rate of the atmosphere. This increase of atmospheric temperature has, obviously, a direct impact on the chemical and dynamical structure of the atmosphere. Feedback on chemistry do not depends solely of the temperature increase but also modify the efficiency of photolysis and induce heterogeneous reactions at the surface of airborne dust. In order to theoretically predict distribution of trace gases and dust in the current Martian atmosphere for synthetic spectra calculation purpose, we updated our two-dimensional model of the Martian atmosphere (Moreau et al., 1991) to introduce the feedback of dust on the physico-chemical structure of the atmosphere. This model is the first two-dimensional numerical model accounting for an interactive treatment of dynamical, radiative and chemical processes in the Martian atmosphere. In the MARS-2D model, latitude and altitude are used as co-ordinates, with an horizontal resolution of 5 degrees and a vertical resolution of 1 km. The dynamical transport occurs through the zonal-mean diabatic circulation driven by the net atmospheric heating/cooling rate. Forcing by gravity waves and Rossby waves is also incorporated in the dynamical scheme.

Proc. First ISO Workshop on Analytical Spectroscopy, 6—8 October 1997 (ESA SP-419, December 1997)

The present version of the model contains 36 chemical species from 5 chemical families (Ox, HOx, NOx, SOx, Clx). The former version of this model (Moreau et al., 1991) has shown its capability to reproduce the main features (e.g., thermal structure, total ozone column) observed by previous spacecraft missions and ground based observations. In order to illustrate model results, figure 1. presents the meridional and vertical distribution of temperature for a solar longitude of 180° and 270°.

OBSERVATION POSSIBILITIES WITH ISO.

Dust storms have been difficult to observe from ground observatories and up to know, few spectral observations specific to a dust storm have been performed.. Mars is indeed difficult to observe spectrally and little dedicated telescope time has been allocated to an attempt of observation during a dust storm. ISO presents the specificity of offering spectral intervals which could never be used from even high altitude observatories on the earth and presents the unique advantage of being a cryogenic system in all its elements. Figure 2 presents a spectrum of the Mars atmospheric transmission in ISO conditions

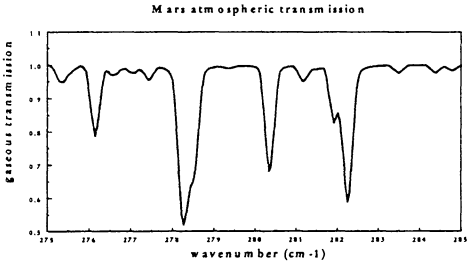

Fig. 2: example of Mars atmospheric gaseous transmission computed in ISO conditions, this spectral interval is inaccessible from an earth based observatory. The variations of this signal can give the height of the dust cloud.

Mars dust storms forecasts.

As the origin of the storms is still controversial the only sure forecasting technique is the observation of dust storms precursors, these can be local storms, loss of contrast on Mars surface features or abnormally small polar hoods. For the present case, the ground observations of Kyoto university observatory (Akabane, private communication) were mainly used while the Marsnet professional and amateur astronomers network was also frequently consulted. However, especially in 1997, the regularity of Hubble Space Telescope observations increased. These sources concurred to show that the Martian atmosphere in the beginning of this year was the cleanest observed since the beginning of the space age. In June of 1997, a local equatorial duststorm was insufficient to perturb the landing of Pathfinder in July, the camera on the Pathfinder lander performs since daily sky and cloud observations while meteorological data are collected, The conclusions are quite surprising, the sky colour exhibits variations from the Viking-like pink to the blue showing a variable dust loading. Clouds have been observed, most of the time very similar to the terrestrial polar stratospheric clouds and thus indicative of stable atmospheric conditions, in one occurrence, a field of stratus cloud has even been observed. These events together with low surface temperatures are incompatible with global dust storms and thus the alert was not declared. In the meanwhile, Mars Global Surveyor was inserted into a distant Martian orbit and the obtained images, already superior to Hubble Space Telescope results show that these clean conditions still extend to the entire planet. The Mars Global Surveyor images will be the best storm monitoring tool for the entire ISO remaining lifetime.

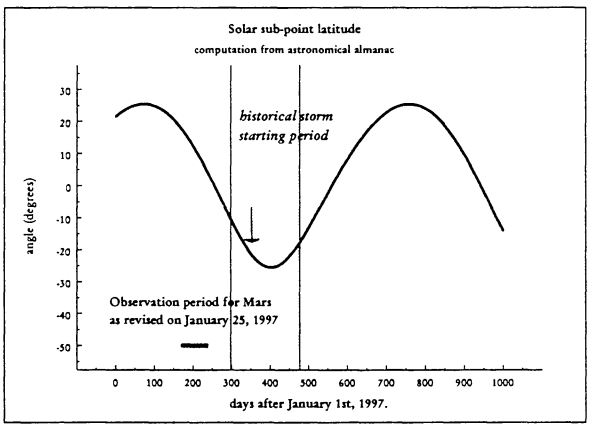

Fig. 3: conditions of Mars observation showing the historical beginning of dust storms, this year at the middle of October 1997 and the ISO Mars observation window, already closed without storm.

Conclusions: The present proposal, if not possible during the ISO lifetime will be resubmitted to future space observatories.

References

Haberle, R.M. et al, Icarus, 50, 322-367, 1982.
Moreau, D. et al, JGR, 96, 7933-7945, 1991.
Rybakov, V.A., JGR, 102, 9211-9220, 1997.
Zurek, R.W., Icarus, 50,288-310, 1982