User Requirement Document
for the Martian Atmospheric General Circulation Model

1 Introduction

One of the objectives of the ESA/CNRS contract is the improvement and further validation of an already existing General Circulation Model (GCM) of the Martian atmosphere. The improved model will be used first for the production of a climate database to be delivered to ESA. This database will be constructed by computing appropriate statistics on the results of pluriannual integrations of the model. In addition, the GCM itself will be delivered to ESA so that users there will be able to perform additional simulations, for instance on the occasion of the preparation of specific missions to Mars.

The already existing GCM has been developed in common by LMD [2, 4, 3] and AOPP [5, 1]. It model includes two different codes for the representation of large scale atmospheric dynamics, based on different representations of the atmospheric fields : a spectral representation for AOPP and a grid-point representation for LMD. Both codes have been directly taken from Terrestrial atmospheric GCMs. Advantage will be taken of the existence of those two dynamical codes (which essentially cover the range of the numerical methods used in terrestrial GCMs) in order to provide an estimate of the model uncertainties. In addition to this dynamical part, the model includes a set of “physical parametrizations”, originally developed at LMD, which represent the diabatic effects in the atmospheric circulation (as for instance radiative heating and cooling). In terms of model developments to be performed on the occasion of the ESA/CNRS contract, most of the effort will bear on the physical package.

Section 2 below specifies the performances that must be achieved by the model. Section 3 describes the requirements specific to the version of the model which will be used by ESA.

2 Specifications of the model performances

1. The model must reproduce correctly the various atmospheric fields (wind, pressure, density and temperature) at a horizontal resolution of 250 km and on at least 20 horizontal levels extending from the surface to an altitude of about 80 km.

2. The model must be able to reproduce correctly not only the global mean of the different fields but also their spatial and temporal (diurnal, synoptic, seasonal, and interannual) variations. The results will be validated whenever possible by comparison with available data, according to an acceptance test-plan described in an independent document.

3. The model must provide estimates of the fluctuations of the various variables at the time and spatial scales not resolved by the model, especially near the surface in the Planetary Boundary Layer (which is the environment of surface probes) and in the region of gravity wave breaking (the

latter phenomenon may have a significant impact on the entry of a probe in the upper atmosphere).

4. The model must be numerically stable, so that it can be run over long periods of several tens of Martian years.

5. The model must generate history files containing all the variables needed for the compilation of statistics relevant for the climate database.

6. From the numerical point of view, the model must be efficient enough to be run over several tens of Martian years, at the spatial resolution specified above, on the computers available at LMD and AOPP.

The model will not include explicit transport of dust. The atmospheric dust content will be specified a priori, and only the radiative impact of dust will be explicited computed by the model.

3 Requirements for the GCM to be delivered to ESA

The model which will be delivered to ESA is meant to be run over rather short periods (typically a few tens of days) at any chosen season of the year. The model could be used in particular, in case a better representation of the surface conditions becomes available in the future, for performing integrations at an increased spatial resolution. This could be useful for instance for the preparation of the descent of a probe in the Martian atmosphere and for better a priori knowledge of the corresponding surface conditions. In order to fulfill this general requirement, the following conditions must be satisfied:

1. The user must be able to start the model from a set of initial conditions corresponding to any given season, and to run it on periods of a few tens of day with a typical horizontal resolution of 150 km over the region of interest. Such runs will normally not require changes of parameters during the course of the simulation.

2. The user must have the possibility to add parametrizations in the physical package.

3. The user must have the possibility to add variables in the output files of the GCM.

4. The user must have the possibility to produce maps of a field of the model without any additional development.

References

[1] M. Collins, S. R. Lewis, P. L. Read, and F. Hourdin. Baroclinic wave transitions in the martian atmosphere. *Icarus*, accepted for publication, 1995.

[2] F. Hourdin. A new representation of the CO_2 $15\mu m$ band for a Martian general circulation model. *J. Geophys. Res.*, 97(E11):18,319–18,335, 1992.

[3] F. Hourdin, F. Forget, and O. Talagrand. The sensitivity of the Martian surface pressure to various parameters: a comparison between numerical simulations and Viking observations. *J. Geophys. Res.*, 100:5501–5523, 1995.

[4] F. Hourdin, P. Le Van, F. Forget, and O. Talagrand. Meteorological variability and the annual surface pressure cycle on Mars. *J. Atmos. Sci.*, 50:3625–3640, 1993.

[5] M. M. Joshi, S. R. Lewis, P. L. Read, and D. C. Catling. Western boundary currents in the atmosphere of Mars. *Nature*, 367:548–551, February 1994.