



## GEM-Mars GCM products and tools available through the VESPA portal.

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### ■ The GEM-Mars General Circulation Model

The GEM-Mars three-dimensional general circulation model [1-3] takes advantage of the operational framework and dynamical core of the Global Environmental Multiscale (GEM) model and is adapted for the simulation of the atmosphere of Mars. The model is operated on a horizontal resolution of  $4^\circ \times 4^\circ$  (45 by 90 grid points) and on 103 hybrid vertical levels ranging from the surface to about 150 km altitude, with a time step of 30.8246 min (1/48th of a Mars solar day or sol). GEM-Mars contains routines for radiative transfer through an atmosphere containing CO<sub>2</sub> gas, dust, and water ice clouds, and also for subsurface heat transfer (including shallow subsurface ice at high latitudes), turbulent convection in the Planetary Boundary Layer, molecular diffusion and gravity wave drag. The model has a CO<sub>2</sub> deposition/sublimation cycle and an interactive surface pressure correction. The vertical distribution of dust can be either self-consistently calculated from dust that is lifted from the surface by shear wind stress and dust devils or prescribed using a predefined vertical profile shape. In both cases, dust total optical depths and their spatiotemporal variation can also be chosen to be constrained by a dust optical depth climatology.

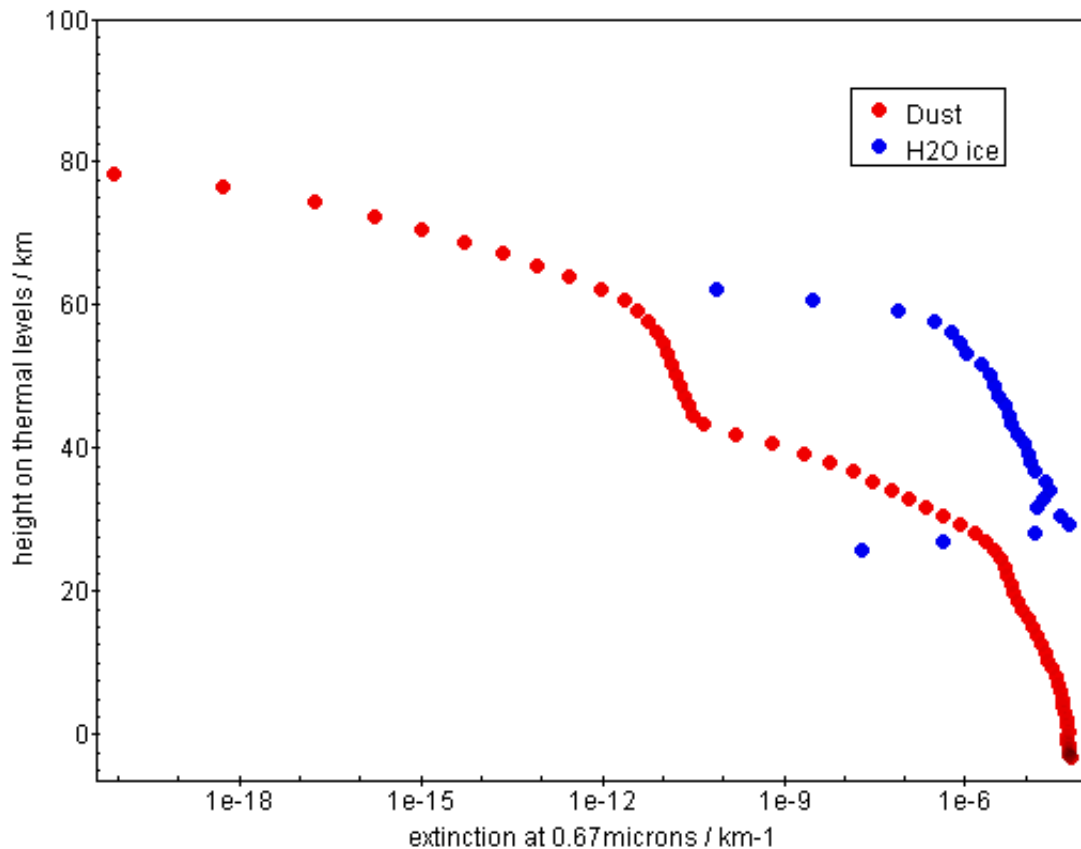
The atmospheric fields from the simulations can be used as a reference, for inputs to retrieval codes and other models, and for comparisons to observations from the surface or orbit. GEM-Mars is the main a priori provider for retrievals from NOMAD. Properties and composition of the simulated atmosphere are given over the whole planet with seasonal and diurnal cycles represented. Two simulated years are provided, one of which includes the global dust storm of 2018 (Mars Year 34) and the next year with lower dust conditions. The data provided are from simulations described in [3]. Global coverage of a single Martian day (sol) is provided every 10 solar longitudes so that seasonal and diurnal cycles are represented.

### ■ The GEM-Mars data service

The data service is set up with DaCHS software [4] and is accessible through the VESPA portal (<http://vespa.obspm.fr/>) [5] and other TAP interfaces including, e.g., Jupyter notebooks. Coverages are provided by the EPN-TAP parameters which allow searches on specific conditions (Ls, local time, location, etc). The “granule uid” parameter is of the form “GEM-Mars\_myearA\_latB\_lonC\_lsD\_1stE”

where A is the Martian year (34 or 35), B is the latitude (degree), C is the longitude (degree), D is the solar longitude (degree) and E is the local solar time (0-24). The data can be provided for any combination of those coordinates and time. The "access\_url" launches a python WSGI API that reads the user-supplied geometry (Mars Year, solar longitude, latitude, longitude, and local solar time) in the URL, processes the interpolation among the GEM-Mars data and returns a VOTABLE (XML document). Fields included in the VOTABLE are profiles of temperature, pressure, air density, mixing ratios of CO<sub>2</sub>, H<sub>2</sub>O (vapor and ice) and O<sub>3</sub>. Surface values of temperature, CO<sub>2</sub>, and H<sub>2</sub>O ice are also given with the local time and solar zenith angle. An example of "access\_url" is <https://gem-mars.aeronomie.be/vespa-gem?myear=34&lat=-88&lon=328&ls=0&lst=2> and follows the same nomenclature as the "granule\_uid" described previously. The VOTABLE is generated "on the fly" at user request and can be read with VO tools like TOPCAT [6]. Figure 1 shows an example of quick plots that can be produced with TOPCAT and the data from a GEM-Mars VOTABLE.

The interpolation methodology is very similar to the one documented in the MCD user manual. Based on the year, the routine finds the 4 Ls and LST pairs that bound the user-supplied geometry. For each pair, the GCM fields are interpolated to the target latitude and longitude using bi-spherical interpolation. These 4 pairs are then interpolated to the target Ls and LST using bi-linear interpolation. Finally, the surface topography is interpolated from the MOLA database, and the final atmospheric altitude and pressure grid are adapted to the change in surface topography.



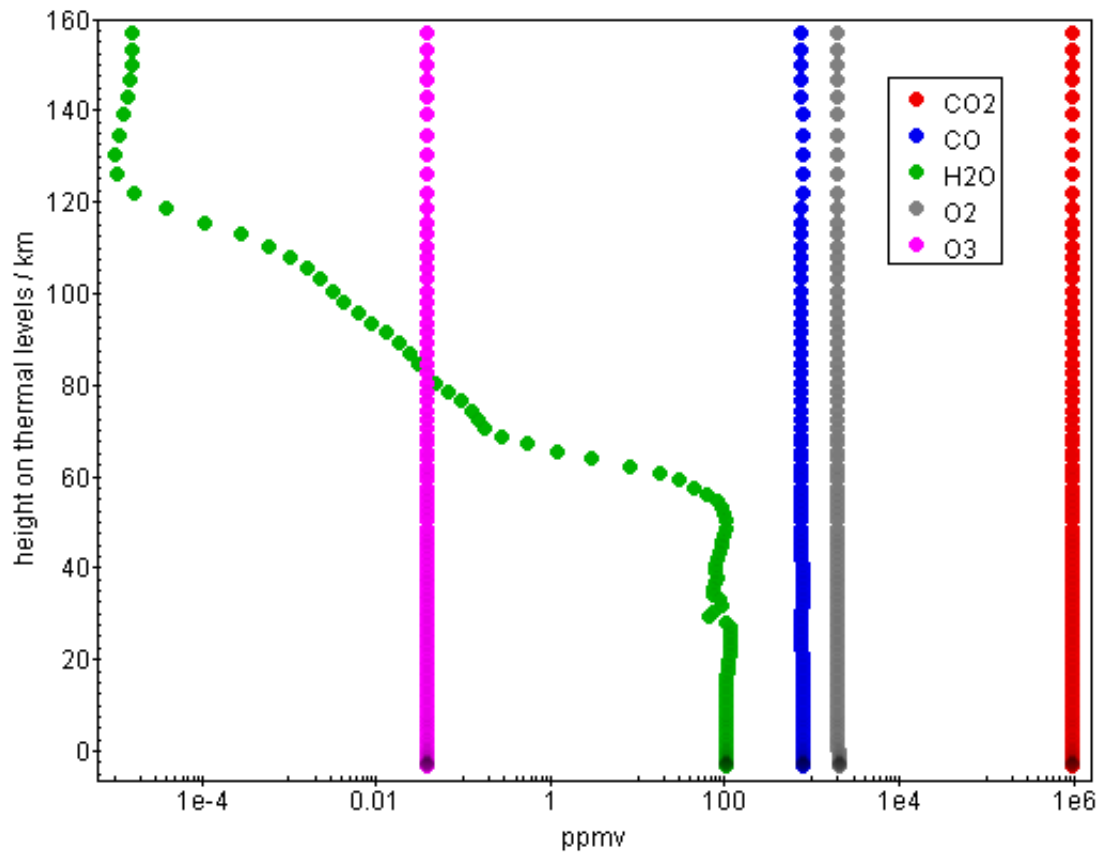


Figure1: Example of plots made with the TOPCAT software and some data from GEM-Mars for Martian year 35, a solar longitude of 350°, a local time of 14 h, a latitude of 4° North and a longitude of 180°.

## References

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