Overview and status update of the GEM-Mars GCM at BIRA-IASB

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Introduction: The application and development of the GEM-Mars model is ongoing at BIRA-IASB, and we present the latest news and progress on our work.

Update on dynamical core: The GEM-Mars model [1,2] uses the dynamical core of the terrestrial weather forecast model, GEM. To benefit from the frequent improvements and support, we are transitioning to the most recent version, v5.2 (https://github.com/ECCC-ASTD-MRD/gem). Development and testing continue in parallel with v4.2. The new version uses a different horizontal discretization called a Yin-Yang configuration, with two equal latitude-longitude grids perpendicular to each other. The two domains have a static halo region similar to a limited-area piloting region where an interpolation is done to update the variables (see Figure 1).

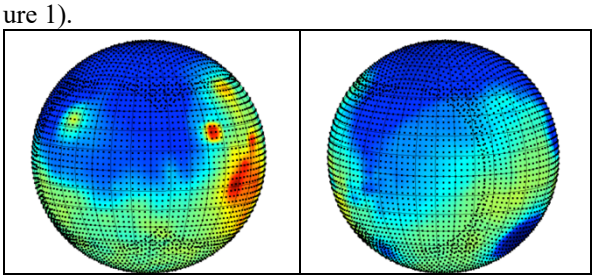

Figure 1 Orthographic projection of topography with grid points indicated by black points.

Physics and chemistry processes: Several updates have been made to the model to better represent the Martian atmosphere. The ice particles radius has been made variable over the planet and with height. All water ice clouds are fully radiatively active. Fractionation of water by vapor deposition was included in the model. Simulations of the D/H ratio in water vapor were published in [7] for conditions inside and out of the 2018 global dust storm, and successfully compared in detail to NOMAD D/H observations. Principle focus of the model lies on photochemistry, which was applied in the conditions of the 2018 global dust storm and compared to NOMAD O_3 observations [9].

Figure 2 shows simulated results from [7]. During the dust storm of MY34, dust is transported to higher altitudes and warms the air. The altitude at which clouds can form is then much higher and this allows the water vapour to be transported to higher altitudes as well. This is important to understand as it has implications for the escape of hydrogen from the atmosphere.

Through the Horizon 2020 RoadMap project (http://roadmap.aeronomie.be), we are testing new parameters for the mechanisms of dust lifting from the surface, derived from lab experiments. This project also led to the implementation of a more sophisticated microphysical representation of the formation of ice clouds. The scheme is based on the work of [10] and includes the nucleation of water ice on dust particles, deposition and sublimation of water vapour on size-resolved ice and the sedimentation of particles. Preliminary results in a one-dimensional model have given guidance on the minimum number of particle size bins to begin testing in the GCM.

Recent publications and collaborations: Several dedicated papers were published recently on GEM-Mars results in relation to the 2018 global dust storm and the NOMAD mission [6, 7, 9]. In addition, results from GEM-Mars simulations have contributed to support data analysis in several other publications. E.g. the climatology of carbon monoxide was examined in [3,4]. GEM-Mars also participated in a joint modeling exercise for the meteorological conditions at the landing site of the Mars 2020 mission [11].

We are also participating in a study to understand the unexplained oxygen variability at Gale crater (McConnochie et al, this workshop).

GEM-Mars is a core model of the ExoMars TGO/NOMAD science team. Model 3D fields as well as output co-located to NOMAD profiles and nadir observations were provided to the retrieval teams as a priori and/or for data analysis and scientific interpretation and contributed to e.g. several studies on H_2O [5, 13], CO [3], O_3 [8, 9], HCl [12], temperature [14] etc.

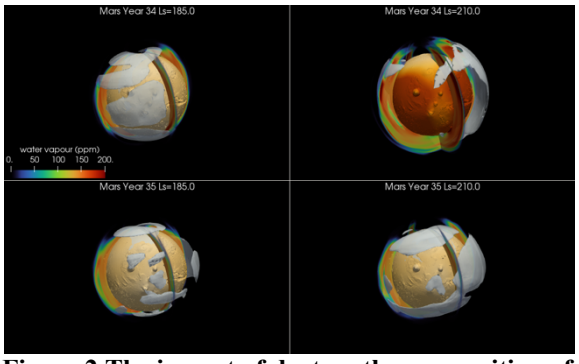

Figure 2 The impact of dust on the composition of the Martian atmosphere. The top two frames show the impact of dust on clouds (white isosurfaces) and water vapour (coloured slices) before and during the dust storm in MY34. The bottom two frames are for the same times during MY35. The surface is coloured by the amount of dust in the atmosphere (total optical depth).

Outreach and data availability: GEM-Mars now has a preliminary website (http://gem-mars.aeronomie.be) to provide news and information about the model and related topics. Model climatologies developed for the RoadMap project will be made available on this site in the future.

Model simulations are now available through the Europlanet VESPA (Virtual European Solar and Planetary Access) portal (http://europlanet-vespa.eu/).

A priori atmospheres are already provided to the NOMAD team directly and through the Planetary Spectrum Generator (https://psg.gsfc.nasa.gov/), and for others, or for specific experiments and scenarios, please contact the authors, we are happy to collaborate.

References:

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