MAGICS

Mars Atmosphere Global Interactive Chemistry Simulator

DURATION
1/10/2013 - 31/12/2015

BUDGET
150.000 €

PROJECT DESCRIPTION

Context

The atmosphere of Mars consists principally of CO2 (96%) and the inert gas argon (2%), followed by N2 (1.9%), O2 (0.14%) and CO (0.06%). The rest are minority species of which H2O and O3 are the more dominant ones. “Standard” Mars photochemistry involves CO2, H2O and their photolysis products (OH, H2O2, O2(1Δ), …). In the past decade the detection of CH4 (methane) was reported, which meant an important landslide because of its implications for geochemical or even biological activity. Nevertheless these observations remain controversial and have not been repeated since 2006.

In any case these observations triggered a renewed interest in Mars as a possibly much more dynamical planet than thought before. The Belgian spectrometer NOMAD (IASB-BIRA) has been selected for the ESA-Roscosmos ExoMars Trace Gas Orbiter mission, which has been developed to unravel open problems of Mars, including the case of methane. Its launch is foreseen in 2016.

General objectives and underlying research questions

To better understand the chemical processes in the atmosphere of Mars and in order to prepare and plan the NOMAD mission, theoretical tools beyond the state-of-the-art need to be developed. Frontline research in this domain of science makes use of three-dimensional global atmospheric circulation models with interactive atmospheric chemistry, like in the advanced weather prediction systems on Earth. To this perspective, MAGICS plans to further develop a state-of-the-art global interactive simulation tool for Mars atmospheric chemistry. This 3D General Circulation Model (GCM) with online chemistry developed at BIRA-IASB is currently operational for scientific case studies, e.g. in the framework of the NASA Phoenix Mars mission.

The specific objectives for the MAGICS project are then:

1. Evaluate the standard photochemistry in the GCM using existing datasets;
2. Extend the chemistry code in the GCM with new species that can be detected by NOMAD, such as hydrocarbons (CH4 and related species) but also nitrogen-species;
3. If time and opportunity allows, set up numerical experiments that describe possible source and sink processes for such species (notably methane) and help to predict where and when such species could be detectable.

Methodology

The core instrument in the project is the 3D global circulation model (GCM) with online chemistry for Mars, called GEM-Mars (Global Environmental Multiscale model for Mars). GEM-Mars is a complete Mars GCM with full 3D resolved dynamics and circulation from the surface up to ~150 km. The dynamical core with semi-lagrangian, semi-implicit advection scheme is based on the Canadian operational weather forecast model GEM. The GCM has 102 vertical levels and the horizontal resolution can be chosen (it can even be non-uniform), but most simulations are done at 4°x4°. The model currently includes online standard atmospheric chemistry.

Also 1D models will be applied to test chemical schemes and to do specific case studies in support of the 3D simulations.

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Nature of the interdisciplinarity

The model combines numerical simulation of atmospheric dynamics, radiative transfer, lifting and transport of particles, meteorology, atmospheric chemistry, formation of polar cap, ice clouds etc. and is confronted with groundbased, Earth-based and orbital measurements of Mars. In understanding source and sink processes for e.g. hydrocarbons, geophysical, geochemical and biological aspects will have to be considered (within the limits of our competences).

Contacts will be developed in the course of this project with scientists who are deriving fundamental chemistry parameters (reaction kinetics).

The results derived in the project will be useful for the science team of an instrument being prepared for a Mars mission.

Potential impact of the research on science, society and/or on decision-making

The project will contribute to the research community that investigates the atmosphere of Mars. It will also directly support the first Belgian-lead experiment on a planetary space mission, meaning a return on investment made by the country. It will help to consolidate Belgium as an important partner for planetary space research and exploration.

Description of finished products of research (model, scenario, report, workshop, publication, etc…) at short and medium term.

The GCM model for Mars with atmospheric chemistry will be operational at BIRA-IASB. Scientific results will be communicated at international workshops and conferences, and will be published in peer-reviewed journals. Simulation results will be made available in an online database for the NOMAD science team and researchers worldwide. On this website information will be provided for the general public.

CONTACT INFORMATION

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LINKS

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