EPSC Abstracts
Vol. 12, EPSC2018-235-2, 2018
European Planetary Science Congress 2018

Atmospheric model support for NOMAD on ExoMars/TGO

Frank Daerden (1), Lori Neary (1), Sébastien Viscardy (1), Justin Erwin (1), Séverine Robert (1), Shohei Aoki (1,13,14), Yannick Willame (1), Ann Carine Vandaele (1), Stephen Lewis (2), James Holmes (2), Paul Streeter (2), Manish Patel (2), Francisco González-Galindo (3), Miguel Angel Lopez-Valverde (3), José Juan Lopez-Moreno (3), Marco Giuranna (4), Giuseppe Sindoni (4), Francesca Altieri (4), Giancarlo Bellucci (4), Franck Lefèvre (5), Geronimo Villanueva (6), Michael J. Mumma (6), Michael D. Smith (6), Giuseppe Etiope (7, 4), James Whiteway (8), R. Todd Clancy (9), Michael J. Wolff (9), Robert E. Novak (10), Sophie Bauduin (11), Jacek W. Kaminski (12), Ian R. Thomas (1), Bojan Ristic (1), Cédric Depiesse (1), Jon Mason (2), and the NOMAD team.
(1) Royal Belgian Institute for Space Aeronomy BIRA-IASB, Brussels, Belgium, (2) Open University, Milton Keynes, UK, (3) Instituto de Astrofisica de Andalucia (IAA/CSIC), Granada, Spain, (4) Istituto di Astrofisica e Planetologia Spaziali (IAPS), Istituto Nazionale di AstroFisica (INAF), Rome, Italy, (5) LATMOS, Paris, France, (6) NASA Goddard Space Flight Center, Greenbelt, MD, USA, (7) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy, (8) York University, Toronto, ON, Canada, (9) Space Science Institute, Boulder, CO, USA, (10) Iona College, New Rochelle NY, USA, (11) Université libre de Bruxelles, Belgium, (12) Institute of Geophysics, PAS, Atmospheric Physics, Warsaw, Poland, (13) Fonds National de la Recherche Scientifique, Belgium, (14) Tohoku University, Japan. (Frank.Daerden@aeronomie.be)

Abstract

Mars atmospheric models have become increasingly important for the support of space missions to Mars and for the interpretation of the obtained observations. The NOMAD ("Nadir and Occultation for MArs Discovery") spectrometer suite on board the ExoMars Trace Gas Orbiter (TGO) has been designed to investigate the composition of Mars' atmosphere, with a particular focus on trace gases, clouds and dust, and started its science operations in April 2018. Within the NOMAD science team, a wealth of state-of-the-art models and related expertise has been incorporated to support and validate NOMAD in terms of (1) observation planning, (2) providing a priori for retrievals, (3) interpretation of observations and derivation of new science results, and (4) data assimilation. This abstract provides an overview of the modeling capability on the NOMAD science team and addresses how models can contribute to fulfill the main science objectives of the mission.

1. Introduction

The NOMAD team includes 3 of the most advanced Mars General Circulation Models (GCMs) to date: (1) the GEM-Mars model [1, 2], (2) the UK version of the LMD model [3, 4], and (3) the LMD model [3, 5]. Besides the parameterizations for atmospheric dynamics and physics, necessary to represent the atmospheric circulation and thermodynamic state, the applied GCMs uniquely contain modules for atmospheric chemistry, which is crucial to understand and interpret the observations by NOMAD.

2. Planning of observations

The complexity of TGO's operations, the observational constraints, and the specific capabilities of the various instruments and channels, impose a dedicated planning of observations for optimal science return. Atmospheric models can help in this planning by indicating which times, seasons and geolocations are of special interest, e.g. where current knowledge of atmospheric processes is known to be poor and requires specific observations. This may relate to the water cycle, photochemical cycles, dust storms etc. In the case of detection of special events, e.g. for methane, atmospheric models can provide new forecasts to support the mid-term observation planning.

3. A priori information for retrieval

At BIRA-IASB the GEM-Mars model has been applied to prepare atmospheric profiles to be used as a priori information in the retrieval algorithms. This work is presented in detail in an accompanying abstract at this conference by Erwin et al.

4. Interpretation of observations and new science results

TGO was designed to provide a refined search for atmospheric trace gases. Besides advancing the detection limit for many species and creating inventories of them, the other main science objectives of TGO are (1) to understand the atmospheric processes that involve the detected trace gases, and (2) search for sources and sinks of the detected trace gases. This is where model support is vital, as it directly relates theoretical processes (reactions, sources, sinks, …) to a 3D+time atmospheric state, that can be compared to the (sparse) set of observations. The differences between model and data provide direct insight in the plausibility of the imposed processes, and provide suggestions in how to modify them if necessary. In the case of detection of methane releases, the models can provide information on the source location by either doing an ensemble of forward simulations [Viscardy et al., this conference] or by calculating back trajectories [6].

5. Data assimilation

Data assimilation is a technique that allows to combine the dense 3D+time (theoretical) information from models with the sparse set of actual observations, in order to provide the most complete set of information of the atmospheric state and composition. The UK team has considerable expertise on data assimilation for Mars [7] and will extend this work with data assimilation of atmospheric state and chemical composition from the NOMAD observations. Data assimilation is also envisaged using the GEM-Mars model.

Acknowledgements

The NOMAD experiment is led by the Royal Belgian Institute for Space Aeronomy (IASB-BIRA), assisted by Co-PI teams from Spain (IAA-CSIC), Italy (INAF-IAPS), and the United Kingdom (Open University). This project acknowledges funding by the Belgian Science Policy Office (BELSPO), with the financial and contractual coordination by the ESA Prodex Office (PEA 4000103401, 4000121493), by MICIIN through Plan Nacional (AYA2009-08190 and AYA2012-39691), by the Italian Space Agency through grant 2018-2-HH.0, as well as by UK Space Agency through grant ST/P000886/1. US investigators were supported by the National Aeronautics and Space Administration. The research was performed as part of the “Excellence of Science” project “Evolution and Tracers of Habitability on Mars and the Earth” (FNRS 30442502).

The NOMAD Team

Scientific team: Vandaele, Ann Carine; Lopez Moreno, Jose Juan; Bellucci, Giancarlo; Patel, Manish; Allen, Mark; Alonso-Rodrigo, Gustavo; Altieri, Francesca; Aoki, Shohei; Bauduin, Sophie; Bolsée, David; Clancy, Todd; Cloutis, Edward; Daerden, Frank; D'Aversa, Emiliano; Depiesse, Cédric; Erwin, Justin; Fedorova, Anna; Formisano, Vittorio; Funke, Bernd; Fussen, Didier; Garcia-Comas, Maia; Geminale, Anna; Gérard, Jean-Claude; Gillotay, Didier; Giuranna, Marco; Gonzalez-Galindo, Francisco; Hewson, Will; Homes, James; Ignatiev, Nicolai; Kaminski, Jacek; Karatekin, Ozgur; Kasaba, Yasumasa; Lanciano, Orietta; Lefèvre, Franck; Lewis, Stephen; López-Puertas, Manuel; López-Valverde, Miguel; Mahieux, Arnaud; Mason, Jon; Mc Connell, Jack; Mumma, Mike; Nakagawa, Hiromu, Neary, Lori; Neefs, Eddy; Novak, R.; Oliva, Fabrizio; Piccialli, Arianna; Renotte, Etienne; Robert, Severine; Sindoni, Giuseppe; Smith, Mike; Stiepen, Arnaud; Thomas, Ian; Trokhimovskiy, Alexander; Vander Auwera, Jean; Villanueva, Geronimo; Viscardy, Sébastien; Whiteway, Jim; Willame, Yannick; Wilquet, Valérie; Wolff, Michael; Wolkenberg, Paulina – *Tech team:* Alonso-Rodrigo, Gustavo; Aparicio del Moral, Beatriz; Barzin, Pascal; Beeckman, Bram; BenMoussa, Ali; Berkenbosch, Sophie; Biondi, David; Bonnewijn, Sabrina; Candini, Gian Paolo; Clairquin, Roland; Cubas, Javier; Giordanengo, Boris; Gissot, Samuel; Gomez, Alejandro; Hathi, Brijen; Jeronimo Zafra, Jose; Leese, Mark; Maes, Jeroen;Mazy, Emmanuel; Mazzoli, Alexandra; Meseguer, Jose; Morales, Rafael; Orban, Anne; Pastor-Morales, M; Perez-grande, Isabel; Queirolo, Claudio; Ristic, Bojan; Rodriguez Gomez, Julio; Saggin, Bortolino; Samain, Valérie; Sanz Andres, Angel; Sanz, Rosario; Simar, Juan-Felipe; Thibert, Tanguy

References

[1] Neary, L., and F. Daerden (2018), Icarus, 300, 458–476
[2] Daerden, F., et al., in prep.
[3] Forget, F., et al. (1999), J. Geophys. Res. 104 (E10) 24,155–24,175.
[4] Holmes, J. A., et al. (2017), Icarus, 282, 104–117
[5] González-Galindo, F., et al. (2015), J. Geophys. Res. Planets, 120, 2020–2035
[6] Daerden, F., et al. (2015), Geophys. Res. Lett., 42, 7319-7326
[7] Steele, L. J., et al. (2014), Icarus, 237, 97–115