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The LMD general circulation models: tools for a better understanding of atmospheric planetary physics

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THE LMD GENERAL CIRCULATION MODELS : TOOLS FOR A BETTER UNDERSTANDING OF ATMOSPHERIC PLANETARY PHYSICS. *A. Bierjon 1 , A. Delavois 1 , T. Pierron 1 , D. Bardet 1 , J. Naar 1 , A. Boissinot 1 , F. Forget 1 , E. Millour 1 , A. Spiga 1 , F. Hourdin 1 , T.Dubos 1 .
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Introduction

General Circulation Models have proven to be relevant tools to study the atmospheric features of planetary bodies in our universe. Therefore, at the Laboratoire de Météorologie Dynamique, they are developped and used since the 1990s [1] to supply the research with plenty of numerical simulation data to analyze, leading to a lot of results and publications.
Gathering the knowledge we have on the climate processes that occur on the variety of celestial bodies, these models are nowadays the common means to study the atmospheric global trends on bodies like the Earth, Venus, Mars, Jupiter, Saturn, Titan, Pluto, but also exo-planets for recent or paleo-climates.
In this presentation, we introduce the general characteristics of the LMD GCMs that are used byour PhD students and colleagues, in such a way as to share knowledge with the audience about these useful tools.

Theoretical bases and hypotheses

Every GCMs come from the application of the fundamental equations of fluid dynamics, a.k.a. the Navier-Stokes equations, to a rotating sphere. By constraining the problem to this specific case, and via some hypotheses based on the characteristic scales of a planetary flow, one can derive these Navier-Stokes equations into the meteorology primitive equations, which can be used to describe the general atmospheric circulation around a planetary body.

The dynamical grid

On the dynamical grid, GCMs resolve the general or large-scale 3D circulation and ensure the horizontal transport from adjacent cells. This dynamical core can be applied to all GCMs, since it is generic enough to represent any planet's general circulation.
Still, there is a variety of dynamical cores around the world, and two are actually in use at LMD : LMDZ, the historical longitude-latitude grid, and DYNAMICO [2], a more recent icosahedral high-resolution grid, dedicated to massively parallel computation.

Physics representation

Coupled with the dynamical grid, the second part consists in the juxtaposition of independent vertical 1D columns, in which the physical parametrizations and subgrid-scale processes are computed. This physical part is specific to each planet and to the particular interactions that exist on the body we study –non-exhaustively : radiative transfer, chemistry, gravity waves, boundary layer, surface-atmosphere interactions, cloud microphysics, aerosols,…

References

[1] Hourdin, F. (1992). A new representation of the CO2 15 μm band for a Martian general circulation model. J. Geophys. Res., 97(E11) :18,319–18,335.

[2] Dubos, T., Dubey, S., Tort, M., Mittal, R., Meurdesoif, Y., and Hourdin, F. (2015). DYNAMICO-1.0, an icosahedral hydrostatic dynamical core designed for consistency and versatility. Geoscientific Model Development 8, 3131-3150.

Field

Planetology (incuding small bodies and exoplanets)

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