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# Modeling atmospheric dynamics in Jupiter's troposphere

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## 1. Introduction

### 1.1. Observational background

Jupiter's tropospheric dynamics is characterised by the presence of alternately prograde and retrograde jet streams whose speeds are included between 10 and 150 m $s^{-1}$ and which delimit zones and belts, where wind shear is respectively anticyclonic and cyclonic [10]. The equatorial jet is superrotating with a velocity equal to 100 m $s^{-1}$. Some large vorticies like the Great Red Spot (GRS) and the White Ovals can be observed (from $10^3$ km large to $10^4$ by 2 $10^4$ km for the GRS), as well as convective storms and lightnings, particularly studied by Galileo [8] and Cassini [3] missions. These storms are typically few thousands kilometers large and occur almost exclusively in belts but since the Juno mission reached Jupiter, we can see some features that look like small (100 km large) convective clouds in zones. The Juno mission has especially revealed Jupiter turbulent poles and polar clusters of cyclones [1].

### 1.2. Modeling context

To model solar system gas giant atmosphere, there are two kind of models : deep models (for example [5]) and shallow models. Both imply an inverse cascade of energy from small-scale eddies to large-scale jets due to the fast rotation rate of these planets. The difference is the perturbation source: magnetohydrodynamics effects at great depth in the first case, baroclinic instabilities or convection in the second one. We place ourselves in the second case and try to reproduce jovian tropospheric main features.

## 2. Model

For that, we use a gas giant General Circulation Model (GCM) which contains a dynamical core and several physical parametrizations. The dynamical core DYNAMICO solves atmospheric primitive equations under the shallow water and hydrostatic assumptions on an icosahedral grid [2] to ensure good energy and momentum conservation as good scalability properties for massively parallel computing. The main physical parametrization is the radiative model adapted from Saturn to Jupiter [4], which uses the k-distribution method. A Rayleigh friction is added at the base of the model to parametrize a deeper drag due to magnetohydrodynamics effects [9]. Eventually, to model the troposphere, we need to include the stratosphere in our GCM in order to model correctly the tropopause and avoid side effects.

## 3. Results and possibilities

In high resolution simulations (0.5 degree resolution in longitude and latitude), we can see about ten jets which are alternately prograde and retrograde (*cf.* figures 1 and 2). Their speed has the good order of magnitude in absolute value but the equator show a subrotation instead of a superrotation. But above all they are too broad and too few and their migration toward high latitudes, which takes place during the first years of the simulation, reduces this number to height. We investigate these issues and will discuss about the results during the conference.

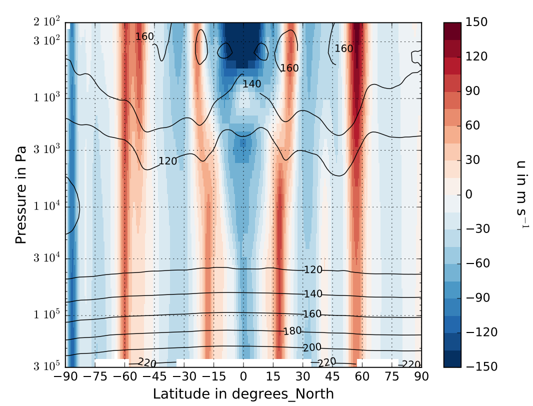


Figure 1: *Zonal mean zonal wind (in m $s^{-1}$) in function of pressure and latitude after 4 simulated jovian years with temperature contours (in K).*

One possibility to explain the differences between simulations and observations is the absence of convection parametrization. Indeed, convective activity is supposed to be one of the large-scale circulation energy sources and able to modify jets width and speed [7]. Therefore we are replacing the simple convective adjustment by a moist convection parametrization. We chose the thermal plume model originally developped in LMD [6] to model Earth boundary-layer convection and adapted to moist convection ([11], [12]). The choice relevance and the effects of the parametrization on the simulated large-scale circulation will be discussed during the conference.

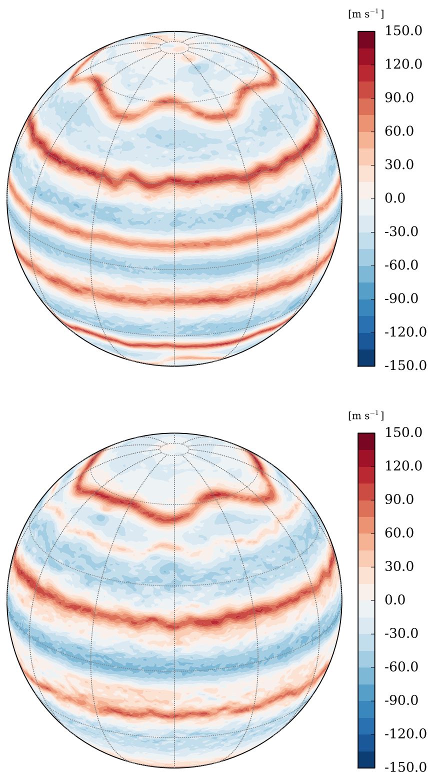


Figure 2: *Zonal wind speed (in m/s) at the 1-bar pressure level after* $1$ *(top) and* $4$ *(bottom) simulated jovian years.*

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