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Global Climate Modeling of Saturn's stratosphere

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Introduction: The Cassini spacecraft allowed a detailed characterization of Saturn's stratosphere and its seasonal variability. In particular, infrared sounding on board Cassini revealed an equatorial, periodic oscillation of stratospheric temperature, associated with a putative vertical structure of winds similar to the Earth's Quasi-Biennial Oscillation (in contrast, Saturn's oscillation is semi-annual), as well as a possible inter-hemispheric transport of stratospheric hydrocarbons reminiscent of the transport of trace species by the wave-driven Brewer-Dobson circulation on Earth and a warm stratospheric disturbance in the aftermath of the Great White Storm of 2010-2011. To address these questions and better understand Saturn's atmospheric circulation, we have developed a General Circulation Model for Saturn. It employs the new DYNAMICO icosahedral hydrodynamical core which allows us to perform simulations at an horizontal resolution of 1/2° in longitude/latitude. Such a high resolution is necessary to start resolving eddies arising from hydrodynamical instabilities and their forcing on planetary-scale dynamics. This Saturn GCM was recently used to study the tropospheric dynamics, addressing topics such as tropospheric jet formation, evolution and stability, or planetary wave activity. In the present study, we performed new simulations with the model top extended to 1 μbar in order to investigate Saturn's stratospheric circulations.
Results: Our new GCM simulations for Saturn exhibit several remarkable features in the stratosphere.
Firstly, equatorial winds are asymmetric: eastward jets are stronger than westward ones. The equatorial zonal jet displays a strong vertical shear with alternatively positive and negative jets stacked on the vertical. It also undergoes episodes of very fast downward propagation of the zonal wind shear extrema. This pattern is similar to a QBO-like oscillation, but the amplitude and period do not match the observed ones. However, stratospheric temperature changes are very different. Temperature fluctuates on rapid timescales and can not be associated with winds oscillation. Secondly, between the bottom of the stratosphere (40 mbar) to the model top, our simulations exhibit two tropical (at 20°N and 20°S) strong oscillations in opposition of eastward and westward winds with annual period.
Perspectives: To improve the physical forcing of the QBO-like oscillation in Saturn's equatorial stratosphere, we have two possibilities inspired by Earth's atmospheric modelling. We plan to add either a stochastic gravity wave drag parametrization or a thermal plume parametrization to our GCM. Both are expected to produce a more realistic wave spectrum, which strongly impacts the simulation of the equatorial oscillation and the downward propagation of winds. We will consider the residual meridional circulation in the stratosphere and analysis of planetary-scale waves activity.