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Global Climate modelling of Saturn to determine the nature of its equatorial oscillation

Deborah Bardet, Aymeric Spiga, and Sandrine Guerlet
CNRS - LMD, Paris, France (deborah.bardet@lmd.jussieu.fr)

Introduction: The Saturn's Semi-Annual Oscillation (SSAO) observed by Cassini is a source of debate within the community, because of its similarities (sometimes conflicting) with both the terrestrial Quasi-Biennial Oscillation (QBO) and the terrestrial Semi-Annual Oscillation (SAO). As the QBO, the downward propagation of the SSAO occurs almost to the tropopause (Schinder et al. 2011). In contrast, the half a Saturn year period of the SSAO is advocated for a seasonal forcing and hints the SAO mechanism driving. Moreover, observation of anomalies in warm temperature and high hydrocarbon concentration at winter tropics is interpreted as the downwelling branch of a meridional stratospheric circulation.
Using DYNAMICO-Saturn Global Climate Model (GCM) -- with an higher vertical discretization (96 vertical levels from $3x10^{5}$ to 10^{-1} Pa) than previous works (Spiga et al. 2020, Bardet et al. 2021) -- we performed simulations lasting at 13 simulated Saturn years, to study Saturn's stratospheric equatorial oscillation, its inter-hemispheric circulation and the driving mechanism connecting them.

Results: Firstly, DYNAMICO-Saturn depicts a stratospheric equatorial oscillation of temperature and zonal wind. The new vertical resolution permits to stabilize more the oscillation periodicity and its eastward phase compared to previous study. The period varies between 0.5 and 1 simulated Saturn years. Indeed, because of irregularity in the waves and eddy-to-mean forcings, the downward propagation is carried out by episodes of descent followed by episodes of stagnation at a given level of pressure. The amplitude of the associated temperature oscillation is under-estimated by 10 K compared to the Cassini observations.

Secondly, DYNAMICO-Saturn also models an inter-hemispheric circulation taking place from the summer tropical latitudes to the winter ones, with a strong subsidence between 20 and 40° in the winter hemisphere. The main subsidence branch is located in the same latitude region as temperature and hydrocarbons anomalies observed by Cassini (Guerlet et al. 2009, 2010, Sinclair et al. 2013, Fletcher et al. 2015 and Sylvestre et al. 2015). Furthermore, eddy-to-mean interaction diagnostics show that the phases of Saturn's equatorial oscillation are controlled by the inter-hemispheric circulation. During the solstices, the cross-equatorial drift of the inter-hemispheric circulation, associated to the forcing of the mid-latitude planetary-scale Rossby waves, drive the equatorial zonal wind to westward direction. In contrast, during the equinoctial overturning of the inter-hemispheric circulation, the residual mean circulation is reduced to an unique ascendance at

the equator to permit the transport and eastward moment deposition of Kelvin waves from the troposphere.

Perspectives: This present modelling study of the dynamics of Saturn's stratosphere confirms the SAO-like character of the Saturn's equatorial oscillation. However, we will also explore the putative part of the QBO-like character of it. We plan to use this new vertical resolution combine to the subgrid-scale gravity wave parameterization.