Geophysical Research Abstracts
Vol. 17, EGU2015-7686, 2015
EGU General Assembly 2015
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An exploration of Saturn's atmospheric dynamics with Global Climate Modeling

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A decade of Cassini observations has yielded a new vision on the dynamical phenomena in Saturn's troposphere and stratosphere. Several puzzling signatures (equatorial oscillations with a period of about half a Saturn year, interhemispheric circulations affecting the hydrocarbons' distribution, including possible effects of rings shadowing, sudden warming associated with the powerful 2010 Great White Spot) cannot be explained by current photochemical and radiative models, which do not include dynamics. We therefore suspect that 1. the observed anomalies arise from large-scale dynamical circulations and 2. those large-scale dynamical motions are driven by atmospheric waves, eddies, and convection, in other words fundamental mechanisms giving birth to, e.g., the Quasi-Biennal Oscillation and Brewer-Dobson circulation in the Earth's middle atmosphere. We explore the plausibility of this scenario using our new Global Climate Modeling (GCM) for Saturn. To build this model, we firstly formulated dedicated physical parameterizations for Saturn's atmosphere, with a particular emphasis on radiative computations (using a correlated-k radiative transfer model, with radiative species and spectral discretization tailored for Saturn) aimed at both efficiency and accuracy, and validated them against existing Cassini observations. A second step consisted in coupling this radiative model to an hydrodynamical solver to predict the three-dimensional evolution of Saturn's tropospheric and stratospheric flow. We will provide an analysis of the first results of those dynamical simulations, with a focus on the development of baroclinic and barotropic instability, on eddy vs. mean flow interactions, and how this could relate to the enigmatic signatures observed by Cassini. Preliminary high-resolution simulations with a new icosahedral dynamical solver adapted to high-performance computing will also be analyzed. Perspectives are twofold: firstly, broadening our fundamental knowledge of atmospheric waves and instabilities; secondly, provide the community with a "gas giant GCM" capable to interpret past and future observations of gas giants inside and outside our Solar System.