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Jovian Stratospheric Circulation: Insights from Cassini Observations and Coupled Dynamical-Chemical Modeling

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Abstract

Simultaneous observations of stratospheric temperature and hydrocarbon species acquired by the Cassini Composite Infrared Spectrometer (CIRS) (Nixon, et al., 2010) and the vertical and latitudinal distributions of aerosol retrieved from the Cassini Imaging Science Subsystem (ISS) provide the necessary data for an accurate simulation of the state of the stratosphere of Jupiter. The hydrocarbon distributions, the spatial variation of whose abundances is controlled by the stratospheric circulation, themselves can confirm the model formulation of global mass transport processes. In this study, a two-dimensional chemical transport model will be forced by output from a physics-based three-dimensional global circulation model, providing a model-measurement inter-comparison with stratospheric tracer species that can be tied back to specific dynamical processes.

1. Introduction

New data products for the stratospheric distribution of acetylene, ethane, and aerosols, derived from relevant Cassini instrument measurements will support both the provision of accurate inputs for the global circulation model and the inter-comparison with the chemical model results. From the retrieved hydrocarbon, aerosol (see 'Aerosol and Cloud in the atmosphere of Jupiter' by Zhang et al. in the same meeting) and temperature distributions, a net radiative forcing is derived to drive the general circulation model. Furthermore, a two-dimensional chemical transport model (Liang, et al., 2005) is then forced by the GCM output and produces a global map of hydrocarbon distribution in the stratosphere of Jupiter.

2. Model and Results

We used the Explicit Planetary Isentropic Coordinate (EPIC 3.8) general circulation model (Dowling et al. 1998) in order to investigate the dynamical response of Jupiter's upper troposphere and lower stratosphere to the heating derived by the Cassini observations. To this end we assimilated the heating into a two dimensional pressure-latitude model that extends from 0.01 mbar at the top to 1 bar at the bottom. The model has 48 layers equally spaced in log theta with a 10-layer sponge above 0.2 mbar to dampen upwardly propagating gravity waves. In the latitudinal direction the model covers 120 degrees with a latitudinal resolution of 0.9 degrees. For altitudes above the 500 mbar level, the nominal temperature profile used to initialize the model is the one derived by Lindal et al. (1981) from the Voyager radio-occultation experiment. Below this level, we use a wet adiabatic expansion (Stoker, 1986) corresponding to the values for the mixing ratios of the condensable compounds of one-times-solar for the H_2O and three- times-solar value for the NH_3 and NH_4SH (Atreya et al., 1999). The zonal winds are initialized with the average winds derived from Cassini observations at ~ 500 mb (Porco et al., 2003). Below this level the zonal winds are set to be initially constant with altitude and above that level the zonal winds set to initially decay to zero in 2.4 scale heights (Gierasch et al., 1986). Figure 1 shows the model input: a 2-D map of the net heating rate derived from Cassini measurements. In Figures 2 and 3, we show the contour of temperatures and zonal winds after 2000 days (1 day =24 hr).

3. Figures

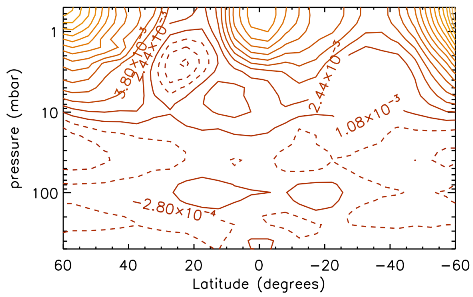

Figure 1: Net heating rate map.

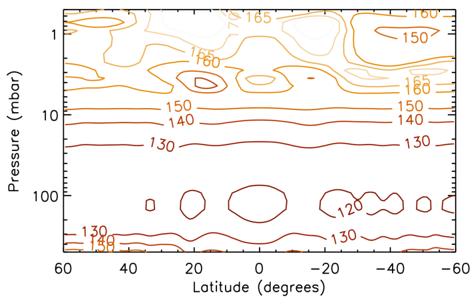

Figure 2: Temperature map from EPIC.

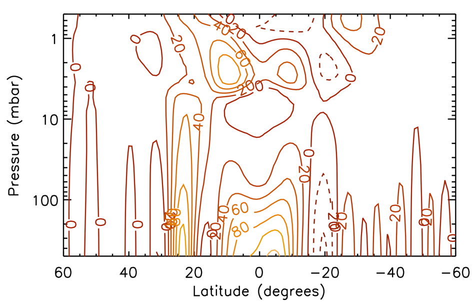

Figure 3: Zonal wind map from EPIC.

Acknowledgements

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