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Jovian Stratospheric Circulation: driven radiatively or mechanically?

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The existence of large-scale stratospheric circulation has been hypothesized since the 1990s (e.g., Conrath et al. 1990; West et al. 1992). The evidences come from the recent observations of stratospheric tracers such as hydrogen cyanide (HCN), carbon dioxide (CO_2), acetylene (C_2H_2) and ethane (C_2H_6) (Lellouch et al. 2006; Nixon et al. 2010). Previous studies (e.g., Friedson et al. 1999; Liang et al. 2005) also proposed that horizontal eddy mixing affects meridional transport processes. But the relative roles of diffusion (eddy-mixing) and advection in the horizontal transport are highly uncertain (Lellouch et al., 2006). On the other hand, whether the stratospheric circulation on Jupiter is induced by differential heating or mechanical forcing from below is still debated (e.g., Conrath et al., 1990; West et al., 1992), because the lower stratosphere of Jupiter might not be purely radiatively controlled (Simon-Miller et al., 2006; Zhang et al., 2012). In order to investigate the circulation pattern in detail, we introduce a two-dimensional photochemical-diffusive-advective model to simulate the distribution of stratospheric hydrocarbons. Analytical solutions are derived to gain the physical insight of the coupled chemical-transport processes, and validate the numerical methods (Zhang et al., 2013). The meridional transport processes are constrained using the latitudinal distributions of C_2H_2 and C_2H_6 retrieved from Cassini spacecraft measurements during Jupiter flyby in 2000 (Zhang et al., 2012). The derived residual mean circulation pattern shows inconsistency with the instantaneous zonally averaged radiative forcing map during the Cassini flyby (Zhang, 2012), implying that the lower stratospheric circulation might be partly mechanically driven, as is the case for the Brewer-Dobson circulation on Earth. This research was supported in part by NASA NNX09AB72G grant to the California Institute of Technology. XZ was supported by the Bisgrove Fellowship in the University of Arizona.