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Processes of Neutral Winds in the Jovian Thermospehere

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Abstract

Recent analysis of high-resolution infrared spectroscopy of the Jovian aurora indicates the presence of high-speed neutral winds in Jupiter's thermosphere. While existing 1-D models are useful for understanding global averages of the Jovian thermosphere, 3-D models can provide significant insight into the regional importance of various dynamical processes. We use our fully coupled 3-D Jupiter Thermosphere General Circulation Model (JTGCM) to quantify wind processes that are responsible for generating neutral winds in the auroral thermosphere from 20 μbar to 10^{-4} nbar self-consistently with the thermal structure and compositions (ion and neutral). The heat sources in the JTGCM that drive the global neutral flow are high-latitude joule heating, resulting from frictional motion of ions relative to neutrals, and charge particle heating from auroral particle impact. These sources of high-latitude heating in the JTGCM are strongly related to the current system in the outer magnetosphere that allows plasma to flow in and out of the Jovian ionosphere. Due to Jupiter's rapid rotation, the mapping of this flow at ionospheric heights gives rise to an ion drag process in addition to Coriolis torque that appears to dominate the neutral momentum forcing near the altitude of the ionospheric peak. We find that for a rapidly rotating Jupiter, ion drag and joule heating inputs in the JTGCM significantly intensify the underlying global thermospheric dynamics and develop strong pressure gradients in the auroral oval regions, thereby affecting zonal and meridional winds. The zonal flow of neutral winds in the auroral ovals of both hemispheres is primarily driven by competition between the magnitudes of accelerations resulting from Coriolis forcing and ion drag processes near the ionospheric peak. However, above the ionospheric peak (<0.01 μbar), the acceleration of neutral flow due to pressure gradients in the upper thermosphere is found to be the most effective source of zonal winds, with minor acceleration contributions from curvature and hydrodynamic advection in the south and viscosity and Coriolis forcing in the north. The meridional flow of neutral winds in both ovals in the JTGCM is determined by competition between meridional accelerations due to Coriolis forcing and pressure gradients. The meridional flow, combined with upwelling and downwelling motions of the neutral atmosphere, has been shown to be an important process for transporting significant amounts of auroral heat to non-auroral latitudes. We find that meridional flow in the lower thermosphere, near the peak of the auroral ionosphere, is poleward, with peak wind speeds of ~0.6 km s^{-1} and ~0.1 km s^{-1} in the southern and northern oval, respectively. The corresponding subsiding flow of neutral motion of ~5 m s^{-1} in the southern oval and ~2 m s^{-1} in the northern oval is expected to provide

more dynamical heating in the south than in the north. We also find that the strength of meridional flow in both auroral ovals is gradually weakened and turned equatorward near 0.08 μbar with meridional wind speeds up to ~250 m s^{-1} (southern oval) and ~100 m s^{-1} (northern oval). The corresponding neutral motion in this region is upward, with wind speeds up to 5 m s^{-1} in both ovals. Clearly, the upper thermosphere of auroral regions is expected to cool off due to dynamical cooling provided by the adiabatic expansion and hydrodynamic advection processes, as investigated recently by *Majeed et al.* [2009; see also *Bougher et al*., 2005; *Majeed et al*., 2005].