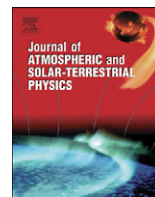




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Review Article

Middle atmosphere dynamics with gravity wave interactions in the numerical spectral model: Tides and planetary waves

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ABSTRACT

As Lindzen (1981) had shown, small-scale gravity waves (GW) produce the observed reversals of the zonal-mean circulation and temperature variations in the upper mesosphere. The waves also play a major role in modulating and amplifying the diurnal tides (DT) (e.g., Walterscheid, 1981; Fritts and Vincent, 1987; Fritts, 1995a). We summarize here the modeling studies with the mechanistic numerical spectral model (NSM) with Doppler spread parameterization for GW (Hines, 1997a, b), which describes in the middle atmosphere: (a) migrating and non-migrating DT, (b) planetary waves (PW), and (c) 10-h global-scale inertio gravity waves. Numerical experiments are discussed, which illuminate the influence of GW filtering and nonlinear interactions between DT, PW, and zonal mean variations.

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1. Introduction

The fundamental properties of diurnal tides (DT) and planetary waves (PW) are well understood (Chapman and Lindzen, 1970; Holton, 1979; Kato, 1980; Volland, 1988). Measurements from the ground and with spacecraft have shown that the DT in the mesosphere and lower thermosphere exhibit large seasonal and inter-annual variations, and that they are modulated by PW

(e.g., Avery et al., 1989; Manson et al., 1989; Vincent et al., 1998; Gille et al., 1991; Hays et al., 1994; Burrage et al., 1995a, b; McLandress et al., 1996; Wu et al., 1998; Leblanc et al., 1999a, b; Manson et al., 2002; Huang and Reber, 2003, 2004; Wu and Jiang, 2005; Zhang et al., 2006; Mukhtarov et al., 2009; Huang et al., 2006, 2010).

In the mesosphere, the DT, PW, and small-scale gravity waves (GW) attain large amplitudes, and their interactions have been the subject of theoretical studies (e.g., Walterscheid, 1981; Fritts, 1984, 1995a, b; Fritts and Vincent, 1987; Vial and Forbes, 1989; Forbes et al., 1991; Forbes, 1995). Numerical models have been employed to study the DT under the influence of the zonal-mean circulation, eddy viscosity, and GW interactions (e.g., Lindzen and

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