Mesopause airglow modulation by Doppler-ducted gravity waves

J. B. Snively (1), V. P. Pasko (1), M. J. Taylor (2), W. K. Hocking (3)

(1) The Pennsylvania State University, Pennsylvania, USA, (2) Utah State University, Utah, USA, (3) University of Western Ontario, Ontario, Canada

(jbs231@psu.edu / Phone: +1-814-863-1780)

Ducted atmospheric gravity waves are frequently observed in airglow imaging experiments. Such waves are known to propagate in ducts formed by thermal variations [e.g., Walterscheid et al., JASTP, 61, 461, 1999; Hecht et al., JGR, 106, 5181, 2001] or wind structure [e.g., Isler et al., JGR, 102(D22), 26301, 1997]. Doppler ducts typically arise from the wind flow associated with large-scale atmospheric wave and tidal motions. Additionally, large-scale wind structures are accompanied by thermal perturbations, which affect any superimposed short-period gravity wave motions.

We explore a short-period gravity wave event, captured by airglow imager along with synoptic meteor radar wind data at Bear Lake Observatory (42 deg. N latitude, 112 deg. W longitude). The small-scale gravity wave is observed to propagate to the south-east, with $\sim$22 km horizontal wave length and fast $\sim$75-80 m/s horizontal phase velocity. A large-scale wind flow is simultaneously apparent in radar data, and is likely associated with the semidiurnal tide. The large-scale wind flow along the direction of wave propagation has a peak of nearly 60 m/s, with an approximate vertical wavelength of 40 km. Using measured wind data and wave properties, in conjunction with model wind and temperature data [Hedin et al., JGR, 96, 7647,1991; JGR, 96, 1159, 1991], it is revealed that the wave is ducted primarily by Doppler-shift. The observed wave also shares some features with a wave reported by Taylor et al. [GRL, 22, 2849, 1995], including a phase reversal between OH and OI emissions intensities.

Using a fully-nonlinear fluid dynamics and photochemistry model, short-period wave excitation and airglow modulation is simulated. Excitation by idealized, in-situ, sources is demonstrated. Model airglow perturbations are found to exhibit a distinct phase-shift between OH and OI emission layers arising from time and temperature dependence of associated reactions [e.g., Snively and Pasko, GRL, 32(8), L08808, 2005, and references cited therein], in agreement with the observation. Modeled and observed events are compared, and differences between wave properties of modeled and observed waves are examined. In particular, differences between phase velocity of modeled and observed waves may indicate significant thermal variations associated with the large-scale tidal wind flow.