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Observation and modeling of mesospheric Na density and OH airglow perturbations by a gravity wave approaching a critical level

Jonathan Snively (1), Pierre-Dominique Pautet (1), Michael Taylor (1), Gary Swenson (2), and Alan Liu (2)
(1) Utah State University, Center for Atmospheric and Space Sciences, Logan, UT, United States., (2) University of Illinois, Department of Electrical and Computer Engineering, Urbana, IL, United States.

Atmospheric gravity waves at a broad range of temporal and spatial scales are frequently observed in MLT airglow imaging experiments. Airglow data provide significant insight into gravity wave propagation, directionality, and seasonality, and allow estimations of wave fluxes [e.g., *Swenson et al.*, JGR, 104(D6), 1999]. The USU CEDAR Mesospheric Temperature Mapper (MTM) is a specialized CCD airglow imaging system, which was operated at Maui MALT from November 2001 to December 2006. The MTM captures OH(6,2) and O_2(0,1) emissions intensities and associated rotational temperatures. The MTM is able to reveal two-dimensional structure of intensity and temperature perturbations associated with small-scale gravity waves, and has been used to assess zenith temperatures, showing close agreement with simultaneous lidar temperature data [*Zhao et al.*, J. Geophys. Res., 110, D09S07, 2005].

Here we investigate the vertical and horizontal structure of a small-scale gravity wave ($\sim$18 minute period and $\sim$37 km horizontal wavelength) captured by the Maui MTM on April 11, 2002. The event was strongly visible in the OH(6,2) image data, showing intensity perturbations $\sim$ 5-10 %, however relatively weak in the O_2 data. Lidar temperatures and winds suggest the presence of a critical level shortly above $\sim$90 km, which would have contributed to increased dissipation, and reduced detectability, due to small vertical scale.

With imaged intensity and rotational temperature data, along with evolving Na lidar profile data, we reconstruct and simulate the wave event under realistic ambient conditions using a suite of numerical models. Hydroxyl photochemistry and dynamics of O_3, H, O, and Na densities are obtained with a two-dimensional nonlinear numerical model for gravity wave dynamics [*Snively and Pasko*, JGR, 113, A06303, 2008], allowing direct comparison of OH(6,2) intensity and brightness-weighted temperature perturbations [e.g., *Makhlouf et al.*, JGR, 100(D6), 11289, 1995]. The strong sheared wind flow leads to dramatic variations of wave characteristics throughout the observable region, explaining the strong OH emission and relatively weak O_2 emission. Krassovsky ratios and integrated cancellation effects of the modeled and observed airglow signatures are investigated, finding significant agreement, and inferred wave amplitude measurements are compared with modeled wave characteristics. Implications for wave momentum flux calculations from lidar and airglow data are discussed.