Mesospheric, thermospheric, and ionospheric responses to acoustic and gravity waves at large amplitudes and small scales

*Jonathan B Snively[1], Matthew D. Zettergren[1]

1.Embry-Riddle Aeronautical University

Acoustic and gravity waves (AGWs) are routinely observed in the Earth's mesosphere, lower thermosphere, and ionosphere (MLTI) from ground and space based platforms via remote sensing of mesospheric airglow intensity and ionospheric total electron content (TEC). Recent data from imagers and GPS receivers provide key insight into wave disturbances to the MLTI at high resolution above their respective sources, which include natural hazard events, orographic forcing, and tropospheric convection [e.g., Galvan et al., RS, 47(4), 2012; Nishioka et al., GRL, 40(21), 2013; Fritts et al., BAMS, 2015; Miller et al., PNAS, 112(49), 2015]. Gravity waves with short periods (~minutes) and small scales (~tens to hundreds of kilometers) may carry sufficient momentum to have very strong and localized effects on the state of the MLTI [Fritts et al., JGR, 119(24), 2014]. Evidence also suggests nonlinear impacts of acoustic waves (with periods ~minutes) in the ionosphere and thermosphere, for example as indicated by measured TEC depletions following the Tohoku 2011 earthquake [e.g., Kakinami et al., GRL, 39(13), 2012]; simulations by Zettergren and Snively [AGU FM, NH32C-02, 2015] also support this interpretation.
We investigate the observable features of acoustic and gravity waves at large amplitudes that can strongly perturb multiple layers of the MLTI system. New high-resolution, nonlinear, compressible, atmospheric dynamics models are used to drive airglow photochemical and ionospheric models [e.g., Snively, GRL, 40(20), 2013; Zettergren and Snively, JGR, 120(9), 2015]. Results elucidate the underlying dynamics of nonlinear short-period wave disturbances, in addition to the responses of both the mesospheric airglow and thermosphere-ionosphere systems to enable direct comparisons with data (airglow imagery and TEC). Modeling also reveals that apparently coherent AGWs, at large amplitudes consistent with observations, may have strong localized impacts that may (or may not) be readily observable. Observations and modeling of dynamics spanning multiple layers in the MLTI system may provide new insight into wave coupling processes, the evolutions of broad wave spectra, and wave effects over short time scales.

Keywords: Acoustic and Gravity Waves, Airglow, Ionosphere, Mesosphere and Lower Thermosphere

