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Viscosity in the thermosphere: Evidence from gravity wave, neutral wind and direct lab measurements that the standard viscosity coefficients are too large in the thermosphere; and implication for gravity wave propagation in the thermosphere

Sharon Vadas (1) and Geoff Crowley (2)

(1) NorthWest Research Associates, CoRA, Boulder, United States (vasha@cora.nwra.com), (2) Atmospheric & Space Technology Research Associates, Boulder, USA (gcrowley@astraspace.net)

In this paper, we review measurements of 1) gravity waves (GWs) observed as traveling ionospheric disturbances (TIDs) at z∼283 km by the TIDDBIT sounder on 30 October 2007, and 2) simultaneous rockets measurements of in-situ neutral winds at z∼320-385 km. The neutral wind contains a ∼100 m/s peak at z∼325 km in the same direction as the GWs, but oppositely-directed to the diurnal tides. We hypothesize that several of the TIDDBIT GWs propagated upwards and created this neutral wind peak. Using an anelastic GW ray trace model which includes thermospheric dissipation from molecular viscosity and thermal conductivity with mu proportional to the temperature to the power of 0.7, we forward ray trace the GWs from z_i=220 km. Surprisingly, the GWs dissipate below z∼260 km, well below the altitude they were observed. Furthermore, none of the GWs could have propagated high-enough to create the neutral wind peak. In our opinion, this constitutes a significant discrepancy between observations and GW dissipative theory. We perform sensitivity experiments to rule out background temperature and wind effects as being the cause. We propose a modification to the formula for mu, and show that this yields ray trace results that agree reasonably well with the observations. We examine papers and reports for laboratory experiments which measured mu at low pressures, and find similar results. We conclude that the standard formulas for mu routinely used in thermospheric models must be modified in the thermosphere to account for this important effect. We also show preliminary GW ray trace results using this modified formula for mu, and compare with previous theoretical results.