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Satellite observations of middle atmosphere-thermosphere vertical coupling by gravity waves

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Atmospheric gravity waves (GWs) are important not only for the dynamics of the middle atmosphere but also for the mean state of the thermosphere/ionosphere (T/I) system. However, observations of GWs in the altitude range of 120-400 km are rare and the penetration of GWs into the T/I system is not fully understood in modeling as well as in observations. In the current study, the correlation between observed GW momentum fluxes in the middle atmosphere (30-90 km) and observed GW perturbations in the T/I is analyzed. In the middle atmosphere, GW momentum fluxes are derived from temperature measurements of the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) satellite instrument. In the T/I, GW induced perturbations are derived from neutral density measured by instruments on the Gravity field and Ocean Circulation Explorer (GOCE) and CHAllenging Minisatellite Payload (CHAMP) satellites. We find generally positive correlations between horizontal distributions in the middle atmosphere and horizontal distributions of GW-induced density fluctuations in the T/I (at 200 km and above). Two coupling mechanisms are likely responsible for these positive correlations: (1) fast GWs generated in the troposphere and lower stratosphere propagate directly to the T/I and (2) primary GWs having their origins in the lower atmosphere dissipate while propagating upwards and generate secondary GWs, which then penetrate up to the T/I and maintain the spatial patterns of GW distributions in the lower atmosphere. The mountain-wave related hot spot over the Andes and Antarctic Peninsula is visible in observations of all instruments. Latitude-longitude variations in the summer midlatitudes seen in observations of all instruments and positive correlations in the same latitude range suggest that GWs with convective origins also propagate up to the T/I. In addition, we present for the first time GW momentum fluxes estimated using GOCE and CHAMP observations. Limitations of the observations as well as of our research approach are discussed.