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Influence of stratospheric gravity waves on TID activity at middle latitudes

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This study investigates the role of hotspots in stratospheric gravity waves (GWs) in the generation of traveling ionospheric disturbances (TIDs) at middle latitudes. We utilize observations of GWs at 35 km altitude by the Atmospheric InfraRed Sounder (AIRS) on NASA's Aqua satellite to characterize stratospheric gravity wave activity. The evolution of GWs with altitudes extending from the stratosphere to mesosphere-lower-thermosphere (MLT) region is examined using temperature observations from the Sounding of the Atmosphere using Broadband Emission Radiometry instrument. Ground-based total electron content observations from GNSS receivers are used to characterize TID activity in the ionosphere. Simulations by the High Altitude Mechanistic general Circulation Model (HIAMCM) that is nudged to the Modern-Era Retrospective analysis for Research and Applications version 2 (MERRA-2) reanalysis in the troposphere and stratosphere are used to study multi-step vertical coupling between the stratosphere and the thermosphere. We investigate two case studies, the Arctic winter of 2016/2017 when a sudden stratospheric warming developed in January-February 2017, and the winter of 2019/2020 that was characterized by mostly strong polar vortex conditions. The hotspot in stratospheric GWs peaks at 55-75N at the edge of polar vortex and in a limited range of longitudes. Our results indicate that GW activity evolves with altitude and expands to 35-40N in the MLT region. Amplifications of TIDs during times of high stratospheric GW activity are seen from ~25-30N to 60N. HIAMCM simulations indicate a very good agreement with observations in the timing of GW activity and latitudinal coverage. We conclude that TIDs are generally amplified during high stratospheric GW activity and weakened during the periods of low stratospheric GW activity (during and after SSW).