Project Details

ROSES ID: NNH19ZDA001N
Selection Year: 2019
Program Element: Focused Science Topic

Topic: Causes and Consequences of Hemispherical Asymmetries in the M-I-T System

Project Title:
Wave-Driven Asymmetries in the Ionosphere-Thermosphere due to Asymmetries in the Northern and Southern Polar Vortices

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Summary:
The goal of this project is to understand how hemispheric asymmetries in the polar vortices create hemispheric asymmetries in the ionosphere-thermosphere through coupling by gravity waves (GW). The polar vortices have significant hemispheric asymmetry, where there is the stark contrast in the strength, stability, persistence, and breakdown timing of the polar vortices in the two hemispheres. The northern vortex is buffeted by stronger planetary wave activity is weaker than the southern vortex. The higher level of planetary wave activity in the northern hemisphere results in major Sudden Stratospheric Warmings (SSWs) where breaking planetary waves disrupt the vortex and reverse the wintertime circulation of the middle atmosphere. These wind reversals change the propagation paths for different populations of gravity waves through the middle atmosphere. Low wind speeds block the propagation of orographic GWs while the wind reversal also changes the population of non-orographic GWs that pass into the ionosphere-thermosphere thus reversing their forcing of the ionosphere-thermosphere when they finally break. Major SSWs are rare in the Antarctic with only one occurring in the last half-century. Thus through the action of SSWs on the polar vortices there is a systematic hemispheric asymmetry in the propagation of GWs into the wintertime polar ionosphere-thermosphere.

The direct impact of GWs on the ionosphere-thermosphere has only recently been appreciated. Model studies show that GWs breaking in the ionosphere-thermosphere can drive wind perturbations in the E- and F-regions that are comparable to the background winds. Lidar observations and model studies have shown that breaking gravity waves produce secondary waves that propagate further into the thermosphere extending the reach of wave coupling to higher altitudes. These effects are not currently included in circulation models though the magnitude of these effects is similar to the reported discrepancies between current space weather models and observations.

This project will employ both satellite- and ground-based observations to characterize the wintertime GW activity and reanalysis data to characterize the circulation of the polar vortices.. The project will combine new data sets from AIM/CIPS, with established satellite data sets (e.g., TIMED/SABER, Aqua/AIRS, Aura/MLS) to characterize the GW activity in the vicinity of the polar vortices. Lidars at McMurdo, Antarctica and Chatanika, Alaska have accumulated multi-year observations over a wide range of altitudes (stratosphere to thermosphere) and variables (density, temperature and/or wind) that characterize waves and their environment. These lidar measurements will support investigations of the propagation and generation of GWs, and extend the interpretation of the satellite measurements. The different instruments are sensitive to different parts of the wave spectrum and the combination of instruments will provide a more complete view of GW activity. SuperDARN radar measurements characterize GWs in the ionosphere-thermosphere through measurements of medium-scale ionospheric disturbances and provide observations across the polar regions. These SuperDARN measurements have shown that the occurrence of ionospheric disturbances in the Arctic is correlated with the meteorology of the polar vortex consistent with variations in the propagation of GWs. The project will establish the observational basis for a hemispheric asymmetry in GW activity in the middle and upper atmosphere driven by the meteorology of the polar vortices. This project will be integrated into modeling studies of the ionosphere-thermosphere associated with the comprehensive effort of the Focused Science Topic (FST).

Publication References:

no references