Geophysical Research Abstracts
Vol. 20, EGU2018-19341, 2018
EGU General Assembly 2018

Stratospheric gravity-waves over South Georgia island: testing a high-resolution dynamical model with new 3D satellite observations and techniques

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Gravity waves are key drivers of the atmospheric circulation. However, their accurate representation in General Circulation Models (GCMs) has proved very difficult, as large parts of the gravity wave spectrum are at scales that are near or below the resolution of even modern GCMs. At latitudes near 60S, the inadequate representation of gravity waves in GCMs has been linked to the long-standing "cold-pole problem", where the southern stratospheric polar vortex breaks up too late in spring, with global implications. Progress in solving this problem has been limited due to a historical lack of 3D observations of real gravity waves that can be used to test simulated wave fields produced by the GCMs. This is particularly the case for waves generated by small, sub-grid scale islands in the Southern Ocean, which are strong candidates as sources for the 'missing' waves in models. Here, we present the first use of 3D satellite gravity wave measurements from NASA AIRS/Aqua to test simulated gravity wave fields from a high-resolution (1.5km grid, 118 vertical levels) run of the Met Office Unified Model over the small, isolated and mountainous island of South Georgia (54S, 36W), identified as an intense source of gravity waves. We describe a novel 3D analysis methodology, based upon the application of a 3D Stockwell transform, to provide like-for-like comparison of key gravity wave properties in the observed and simulated wave fields. We compare these observed and simulated wave fields during January (summer) and June-July (winter) 2015. Our results reveal a large number of cases where there are significant differences in the amplitude, persistence and morphology of observed and modelled gravity wave fields. To help constrain the origins of these differences, we make use of tropospheric wind measurements from two radiosonde campaigns that took place on South Georgia during these months. Our results provide insight into the generation of strong gravity wave fluxes by small islands, and our new methodology provides a framework to test and guide improvements in the Unified Model and other GCMs.