Is ECMWF Resolved Gravity Wave Correct?

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Gravity wave (GW) is one of the most important dynamic components to generate atmospheric circulations in the stratosphere and above. It is also a key factor of the coupling between the troposphere and stratosphere. Because GWs are small-scale perturbations, they are traditionally parameterized in the GCMs, which rely poorly on observations.

The latest ECMWF reanalysis has a very fine horizontal and vertical resolution to resolve more GWs. In this study, we compare GWs observed by Atmospheric Infrared Sounder (AIRS) with ECMWF resolved GWs. AIRS observational filter is first applied to the reanalysis both horizontally and vertically. We then calculate the temperature (brightness temperature) variances from the filtered ECMWF results (AIRS observations) by assuming that they are induced by GWs. The comparison is conducted in the stratosphere for the entire globe with careful selection of AIRS channels.

ECMWF resolved GWs screened by AIRS filter show overall agreement with AIRS observations throughout the stratosphere. The geographical peaks of both orographic and convective GWs agree especially well with AIRS measurements, despite that some of the orographic GWs generated above Northern Hemisphere (NH) plateaus are too weak or not in the correct location in the reanalysis. Moreover, ECMWF reanalysis in general produces smaller ratio between orographic and convective GWs than AIRS, indicating either the orographic GWs are too weak or convective GWs are too strong. Interestingly, in the Southern Hemisphere (SH) winter, ECMWF produces a poleward curved belt of GW enhancement in the vicinity of SH jet stream in the middle to upper stratosphere, while this belt closely follows the latitude circle in the observation. In general, the reanalysis result has better agreement in SH (NH) winter in terms of orographic (convective) GW strengths and locations.

Although AIRS radiance is assimilated in ECMWF reanalysis, the high-frequency portion, i.e., GWs and other small-scale features, is ignored due to their small signal-to-noise ratio. Hence, the disagreement between AIRS measurements and the reanalysis is particularly important for us to understand the deficiency of assimilation processes as well as the model physics. This validation work is the first step we moves toward the goal.

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