Geophysical Research Abstracts
Vol. 17, EGU2015-7744, 2015
EGU General Assembly 2015

Gravity Waves Generated by Convection: A New Idealized Model Tool and Direct Validation with Satellite Observations

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In climate models, gravity waves remain too poorly resolved to be directly modelled. Instead, simplified parameterizations are used to include gravity wave effects on model winds. A few climate models link some of the parameterized waves to convective sources, providing a mechanism for feedback between changes in convection and gravity wave-driven changes in circulation in the tropics and above high-latitude storms. These convective wave parameterizations are based on limited case studies with cloud-resolving models, but they are poorly constrained by observational validation, and tuning parameters have large uncertainties.

Our new work distills results from complex, full-physics cloud-resolving model studies to essential variables for gravity wave generation. We use the Weather Research Forecast (WRF) model to study relationships between precipitation, latent heating/cooling and other cloud properties to the spectrum of gravity wave momentum flux above midlatitude storm systems. Results show the gravity wave spectrum is surprisingly insensitive to the representation of microphysics in WRF. This is good news for use of these models for gravity wave parameterization development since microphysical properties are a key uncertainty. We further use the full-physics cloud-resolving model as a tool to directly link observed precipitation variability to gravity wave generation. We show that waves in an idealized model forced with radar-observed precipitation can quantitatively reproduce instantaneous satellite-observed features of the gravity wave field above storms, which is a powerful validation of our understanding of waves generated by convection. The idealized model directly links observations of surface precipitation to observed waves in the stratosphere, and the simplicity of the model permits deep/large-area domains for studies of wave-mean flow interactions. This unique validated model tool permits quantitative studies of gravity wave driving of regional circulation and provides a new method for future development of realistic convective gravity wave parameterizations.