Geophysical Research Abstracts
Vol. 16, EGU2014-5209-1, 2014
EGU General Assembly 2014

Analysis of gravity wave propagation and properties, comparison between WRF model simulations and LIDAR data in Southern France

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Small scale atmospheric waves, usually referred as internal of Gravity Waves (GW), represent an efficient transport mechanism of energy and momentum through the atmosphere. They propagate upward from their sources in the lower atmosphere (flow over topography, convection and jet adjustment) to the middle and upper atmosphere. Depending on the horizontal wind shear, they can dissipate at different altitudes and force the atmospheric circulation of the stratosphere and mesosphere. The deposition of momentum associated with the dissipation, or wave breaking, exerts an acceleration to the mean flow, that can significantly alter the thermal and dynamical structure of the atmosphere.

GW may have spatial scales that range from few to hundreds of kilometers and range from minutes to hours. For that reason, General Circulation Model (GCM) used in climate studies have generally a coarse resolution, of approximately 2-5° horizontally and 3 km vertically, in the stratosphere. This resolution is fine enough to resolve Rossby-waves but not the small-scale GW activity. Hence, to calculate the momentum-forcing generated by the unresolved waves, they use a drag parametrization which mainly consists in some tuning parameters, constrained by observations of wind circulation and temperature in the upper troposphere and middle atmosphere (Alexander et al., 2010). Traditionally, the GW Drag (GWD) parametrization is used in climate and forecasting models to adjust the structure of winter jets and the horizontal temperature gradient. It was firstly based on the parametrization of orographic waves, which represent zero-phase-speed waves generated by sub-grid topography. Regional models, with horizontal resolutions that can reach few tens or hundreds of meters, are able to directly resolve small-scale GW and may represent a valuable addition to direct observations.

In the framework of the ARISE (Atmospheric dynamics Research InfraStructure in Europe) project, this study tests the capability of the Weather Research and Forecasting (WRF) model to generate and propagate GW forced by convection and orography, without any GW parametrization. Results from model simulations are compared with in-situ observations of potential energy vertical profiles in the stratosphere, measured by a LIDAR located at the Observatoire de Haute Provence (Southern France). This comparison allows, to a certain extent, to validate WRF numerical results and quantify some of those wave parameters (e.g., GW drag force, intrinsic frequency, breaking level altitude, etc..) that are fundamental for a deeper understanding of GW role in atmospheric dynamics, but that are not easily measurable by ground- or space-based systems (limited to specific region or certain latitude band).

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