Gravity waves from thunderstorms: impact on atmospheric and climate models.

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Small scale atmospheric waves, usually referred as internal 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 acceleration to the mean flow, which can significantly alter the thermal and dynamical structure of the atmosphere.

GW may have spatial scales that range from few to hundreds of kilometres 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 parameterization 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) parameterization 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 parameterization 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, the mesoscale meteorological model WRF (Weather Research and Forecasting) has been used to generate and propagate GW forced by convection and orography, without any GW parameterization. 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" (OHP) in Southern France.

Such comparisons allow, to a certain extent, to validate 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).