Gravity waves parameterized by a transient gravity-wave model coupled with convective sources: Wave intermittency

*Young-Ha Kim[1], Gergely Bölöni[1], Sebastian Borchert[2], Hye-Yeong Chun[3], Ulrich Achatz[1]

1. Goethe-Univ. Frankfurt, Germany, 2. DWD, Germany, 3. Yonsei Univ., Korea

Gravity waves (GWs) transport a large amount of momentum throughout the deep atmosphere, which is crucial for large-scale circulations in the middle atmosphere. Due to the scales of GWs and their sources, down to about 1-10 km, they are not fully resolved in large-scale models, so that their effects are parameterized in a simplified framework. Such simplications include, among others, the steady-state assumption by which the vertical profiles of GW properties are diagnosed instantaneously throughout the model-grid column at each time step. Thus, in the steady-state representation, GWs are modeled as if they propagate to the model top within one time step, and the interaction between GWs and the mean flow is ignored unless waves dissipate. In the real atmosphere, it can take a long time for GWs to propagate to, e.g., the mesosphere (˜10 hours or more, depending on the wave characteristics), and the mean flow may evolve substantially during the time, which can induce both non-dissipative and dissipative GW-mean-flow interactions. In this regard, a prognostic GW model, Multi-Scale Gravity-Wave Model (MS-GWaM), has been developed, fully representing the transient GW dynamics.

In this presentation, we show the application of MS-GWaM to a global model as a subgrid-scale parameterization and investigate the effects of transient GW dynamics. A particular interest is in the representation of GW intermittency, which can affect the vertical distribution of GW forcing (by determining wave-breaking altitudes). In order to include the wave sources' intermittency and variability, MS-GWaM is coupled to convective sources, diagnosed by cumulus parameterization, based on an analytic formulation of GW response to a heat source. In addition to this, a spatio-temporally uniform, persistent source is prescribed in the extratropics to take into account other non-orographic sources. Orographic sources are currently not coupled to MS-GWaM, so that the intermittency is assessed only for the non-orographic GWs. The GW intermittency is investigated by probability distributions of GW pseudomomentum flux as well as by the Gini index of the flux. The modeled intermittency is found to be quite high in the tropics, compared to that in the extratropics. In both regions, the Gini index has faily similar values to those observed by superpressure balloons reported in previous studies. A control simulation is performed using GW parameterization based on the steady-state assumption, but coupled to the same wave sources, in order to assess the effects of transient GW modeling on the simulated intermittency. In comparison with the control simulation, it is found that the transient GW modeling leads to increase in the intermittency of GWs from the persistent source but mitigates the intermittency from convective sources.

Keywords: gravity wave, transient parameterization, wave intermittency