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Multi-component interactions of gravity waves in global atmospheric models

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The parameterization of the effects of gravity waves in a global atmospheric model has progressed significantly over the past two decades ever since its need was recognized and its effects were represented in the models. The source of gravity-wave drag considered spans from orography and convective systems to jet streams and frontal systems. The vertical domain of the modeled atmosphere for which drag is applied moved up from the troposphere to include the middle/upper atmosphere. The balance between the drag in the lower and middle atmospheres became important in view of the momentum budget in the models that include the middle atmosphere.

The parameterization problem then advances to treat the interactions with other physical processes. The interactions among the various drag processes, such as gravity-wave drag due to orography and convective processes, form drag, friction drag, low-level drag due to blocking, mountain drag due to resolved orography, started being considered important. The interactions are expanded to other physical processes such as the radiation and atmospheric boundary layer processes. The interactions between gravity-wave drag and radiation / boundary layer mixing indeed play an important role in properly representing the drag processes in atmospheric models. These processes strongly interact with one another and should be evaluated collectively as well as individually in atmospheric models.

The problem extends further to the interaction between the atmospheric forecast model and the data assimilation model. Because an atmospheric forecast model and a data assimilation model are strongly coupled in a forecast system, independent improvements in one model or the other do not automatically improve forecasts. For example, improved middle-atmospheric physics due to improved gravity-wave drag can degrade forecast skill, if the data assimilation cannot take advantage of the improved physics and rejects more observation data that would have been used with the original physics. The forecast skill is often degraded in a forecast system through a disruption of the original balance (realistic or not), which was already calibrated to produce as high forecast skill as possible. Therefore, the forecast and data assimilation models must be considered simultaneously in order to obtain significant forecast improvement.

One of the forthcoming challenges for atmospheric modelers to face in developing the next generation atmospheric forecast systems may well be how to effectively merge or strongly couple various system components, currently represented separately in the systems. At the symposium, selected results from multiple global atmospheric models will be presented to support the discussions.