EMS Annual Meeting Abstracts
Vol. 8, EMS2011-349, 2011
11th EMS / 10th ECAM

Forecasting the weather
- ensemble techniques
in probabilistic weather prediction

Towards a general formulatoin for parameterization of small-scale process in atmospheric modelling

J.-I. Yano
CNRM, Météo-France, Toulouse Cedex, France (jun-ichi.yano@zmaw.de)

Small-scale atmospheric physical processes on a broad range of time and spatial scales (from local turbulence to mesoscale processes) have a strong influence on weather and climate. Parameterization must be properly constructed in such way that the nature and interactions of these processes should be well represented in order to enable accurate and skilled weather forecasting, as well as reliable climate simulation and scenario studies. Additionally, the increased resolution of NWP and climate models is setting new requirements to parameterization. Especially for this reason, parameterization must also be carefully formulated in such way that it can be adopted to any scales.

The present talk aims to cover these wide range of issues of representation of small-scale processes, interactions and implementation in models. The general problem of parameterizing small-scale physical processes will be discussed from this perspective.

In order to properly responding to these challenges, the parameterization problem must be formulated in general manner as much as possible. More specifically, a parameterization must be constructed in stepwise manner from the accepted physical laws. At each step of the formulation reduction, it must be made clear what approximations or hypotheses are introduced. These approximations and hypotheses must be stated in such manner that they can be verified either by observation or more direct numerical simulations.

The author has proposed mode decomposition as a main guiding principle for achieving such stepwise logical construction of parameterization (QJ, 2005). This general strategy is based on the fact that subgrid-scale processes more than often consist of coherent structures, such as boundary-layer plumes, convective towers, mesoscale organization.

Though the choice of modes for decomposition remains open in general, it must be chosen in such way that they can represent the subgrid-scale coherent structures efficiently. Since these subgrid-scale structures are typically isolated in space, wavelet is identified as a natural choice for subgrid-scale decomposition. Diagnostic studies show that wavelet can compress the subgrid-scale data even up to 1% level relatively easily. In principle, parameterization simply consists of running a system under such a highly compressed mode prognostically. However, a major obstacle found with the wavelet-based approach is in calculating physical processes (such as water condensation) in wavelet space. This is rather difficult, because these processes are more than often conditioned by a state at a given physical point.

For this reason, a more traditional mass-flux formulation is closely re-examined from a similar perspective. Its basic premise is in subdividing the grid box domain into various sub-segments with constant values (at each vertical level). In classical example of Arakawa and Schubert (1974), the whole grid box is subdivided into a homogeneous background environment and ensemble of convective plumes. The author proposes to call this principle the segmentally-constant approximation (SCA) in more general sense.

A self-contained prognostic (predictable) model can be constructed by introducing only this purely geometrical constraint (SCA) for the mass-flux parameterization into a full physical model. Application of this procedure to the nonhydrostatic anelastic model is named NAM-SCA (MWR 2010). Basic working of NAM-SCA will be presented.