Title:
Towards the Construction of Statistical Cumulus Dynamics:
Workshop on Concepts for Convective Parameterizations in Large-Scale Models

Text:

An accurate representation (parameterization) of deep convective clouds is essential for the successful simulation of precipitation in climate models. However, the closure of convective parameterizations remains a major unsettled question. Since the parameterization is conceptually a description of an ensemble of convective clouds, the development of "statistical cumulus dynamics" (SCD) would be the ultimate way to provide the closure, just as the statistical mechanics of a microphysical system provides the ultimate basis for its macrophysical thermodynamics.

The concept of SCD was introduced by Arakawa and Schubert (1974, J. Atmos. Sci.) in their seminal work on mass-flux convective parameterization. Although progress since then has been slow, some pioneering work has recently been undertaken across Europe. A workshop was organized at the Max-Planck Institute (MPI) for Meteorology, Hamburg for 12-14 February 2008 for intensive discussions of SCD.

The basic elements of convective parameterizations are traditionally considered to be "plumes". In traditional parameterizations, an entraining plume is considered, although the concept can be generalized in various ways. The workshop began with a review of plumes: their specification, dynamics and interactions.

Also in traditional parameterizations, plumes do not interact with each other directly, but only through modifications of the environment. In this limit, the statistical dynamics for an ensemble of plumes reduces to an analogy of ideal gas dynamics with a Boltzmann distribution for convective mass-fluxes. A key question discussed during the workshop was how to generalize this approach.

A deterministic population dynamics for the ensemble of plumes can be constructed within the Arakawa and Schubert framework. The convective quasi-equilibrium (CQE) introduced by Arakawa and Schubert corresponds to a stationary solution of this system. The stability of the solution, then, defines the validity of the CQE hypothesis. Here, rich resources from dynamic systems theories can be applied.

The question of CQE becomes more challenging when the system is periodically forced, especially for forcing periods which approach the characteristic timescales for convection.
Once the forcing period is below a threshold, the system exhibits hysteresis: how can we generalize CQE in such a situation?

In efforts towards constructing SCD, two more possibilities have been considered. The first is a development from similarity theory, by analogy with the convective boundary layer. A preliminary extension of similarity theory to deep convection presented suggests that the terminal velocity of precipitating water is a key parameter controlling updraft strength.

Another possibility is to use probability density functions (pdf), an approach popular in current descriptions of the non-convective components of clouds. Under this approach, it was pointed out that the hardest part is to provide a proper coupling with convective clouds. How can we construct a fully comprehensive pdf-based description including deep convective clouds as its integrated part?

The meeting was organized by H.-F. Graf (University of Cambridge), J. Quaas (MPI, Hamburg), and J.-I. Yano (Meteo France, Toulouse) with 13 participants from the Czech Republic, France, Germany, Italy, the Netherlands, Switzerland and the UK.

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