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Mass-Flux Subgrid-Scale Parameterization in Analogy with Multi-Component Flows: A Formulation Towards Scale Independence

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The mass-flux parameterization formulation is generalized by taking an analogy of the large-scale atmospheric flow with multi-component flows. This generalization permits to include any subgrid-scale variability into the mass-flux parameterization. Those include stratiform clouds as well as cold pools in the boundary layer.

An important finding under the present formulation is that the subgrid-scale quantities are advected by the velocities characteristic of given subgrid-scale components (subcomponent flows), rather than by the large-scale flows as simply defined by grid-box average. This formulation, as a result, ensures the lateral interaction of subgrid-scale variability crossing the grid boxes, which are missing in the current parameterizations, and leading to a reduction of the grid-size dependence in its performance. It is shown that the subcomponent flows are driven by subcomponent pressure gradients. The formulation, as a result, furthermore includes a self-contained description of subgrid-scale momentum transport.

The formulation is applicable to a situation in which the scale separation is still satisfied, but fractional areas occupied by individual subgrid-scale components are no longer small. A complete formulation is presented and various implementation issues are discussed. The present formulation is also expected to alleviate problems arising from increasing resolutions of operational forecast models without invoking more extensive overhaul of parameterizations. The proposed formulation, furthermore, provides a general framework for developing subgrid-scale parameterizations in a manner that they do not depend on the model resolution.

The full manuscript is currently available at GMDD