Geophysical Research Abstracts
Vol. 14, EGU2012-3152-1, 2012
EGU General Assembly 2012

Stochastic eddy-diffusivity/mass-flux parameterization for moist convective boundary layers

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A new eddy-diffusivity/mass-flux (EDMF) based parameterization for moist convective boundary layers is introduced. In this EDMF framework, turbulent fluxes are a sum of a deterministic turbulent-kinetic-energy based eddy diffusivity component and a stochastic mass-flux component. The mass-flux component is represented by a fixed number of steady state plumes and plays a dominant role in the convective-dominated regions. One of the key, yet poorly understood, components of mass-flux parameterizations is the interaction of the plumes with their environment. In current parameterizations this interaction is represented as a lateral entrainment of the environmental air into the plumes. Thus, the entrainment rate is one of the key parameters determining the fate of the plumes. In our new EDMF approach the entrainment rate is modeled as a simple stochastic process following a Poison distribution. This stochastic parameterization of entrainment attempts at representing the possible intermittency of the entire entrainment process as well as the uncertainties related to entrainment.

The EDMF parameterization is integrated into a single-column-model with a probability-density-function based description of cloudiness and simple long-wave radiation. We show that the model is able to capture essential features of moist boundary layers, ranging from the stratocumulus to shallow-cumulus regimes. Detailed comparisons of a few important cases with LES results are shown to confirm the value of the present approach.