Geophysical Research Abstracts,
Vol. 10, EGU2008-A-00232, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-00232
EGU General Assembly 2008

Single-column vertical mixing model for the atmospheric convective boundary layer

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The description of the atmospheric boundary layer characteristics and the understanding of vertical turbulent mixing processes in the atmosphere are important for air pollution transport modelling as well as for weather forecasting. Vertical turbulent mixing in the atmosphere is commonly described by different types of local closure, based on the analogy with molecular diffusion. This approach is reasonable during conditions of stable and neutral static stability when the scale of turbulent motion is much smaller than the scale of mean motion. In the convective boundary layer much of the mixing is caused by buoyant plumes originating in the surface layer which rise to the top of the boundary layer and sometimes penetrate into the inversion. We can describe vertical turbulent mixing in the convective boundary layer using a non-local, advection-like concept. The non-local approach means that turbulent fluxes are computed as functions of large-scale gradients rather than local gradients. The non-local concept should represent turbulent mixing and atmospheric transport by eddies of different sizes simultaneously.

Assuming that in the atmospheric convective layer different size large-scale eddies transport the fluid across finite distances and small eddies mix it simultaneously, a simple one-column vertical turbulent mixing model was designed using operator splitting method. Operator splitting is a widely used procedure in the numerical solution of real life complex time-dependent phenomena. The basic idea behind the operator splitting method is decomposing the problem according to the different physical processes in the model (in our case advection-like and diffusion-like processes). The designed model was linked with a model for the mixing height determination and tested for

sequential splitting, weighted sequential splitting as well as Strang-Marchuk splitting methods in bottom-up and top-down numerical tests. The mixing rates were parameterized using turbulence velocity, function of surface turbulent kinetic energy. Our experiments demonstrate that it is possible to improve convective boundary layer model characteristics combining features of local and non-local mixing concepts.