DEVELOPMENT OF THE ATMOSPHERIC BOUNDARY LAYER (ABL) PARAMETRIZATIONS FOR WEATHER AND AIR-QUALITY PREDICTIONS ON FINE SCALES

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Although the advent of high-performance parallel computing technology has made it easy for operational environmental prediction models to be run with finer and finer resolutions to meet the increased demand on detailed predictions, the parameterizations of the atmospheric boundary layer (ABL) in these models are still those designed and tuned up when the models were run within coarser resolutions. It will remain expensive in the next decade to explicitly simulate turbulent mixing and transport of momentum and enthalpy in operational models. In other words, turbulent processes with the ABL will have to be implicitly modeled in operational models through parameterization schemes. Due to the nature of parameterizing the complex, intertwined energy cascading and transfer occurring within the ABL, assumptions are needed to make the parameterization schemes mathematically close. Different assumptions lead to different parameterization schemes. Each assumption has an intrinsic limitation on its applicability for fine vertical and horizontal resolutions.

In this project, we intend to develop an ABL parameterization suitable for fine resolution modeling by starting with a case study comparing four parameterization schemes for the ABL used in the NCAR/Penn State mesoscale model (MM5): the Blackadar, the MRF, the ETA, and the Gayno-Seaman schemes. These four schemes were developed at different times, perhaps with different targeted applications in the developer's mind. Nowadays, they are not only widely used among MM5 users for various applications, from regional climate simulations, realtime weather forecasts, to air-quality predictions, but they also are representative of the ABL parameterization schemes commonly used in current major climate, weather and air-quality models. As a matter of fact, both the MRF and ETA schemes (as indicated by their names) are those developed and used at the National Centers for Environmental Prediction (NCEP), and have been implemented in the WRF model (the designated next-generation operational model).

Figure 1 shows the time-height series of the eddy diffusivity for heat within the lowest 600 m from the four schemes. Although the four schemes were run under the same environmental conditions, there are significant differences in the diurnal change of the eddy diffusivity simulated by different schemes, leading to different ABL structure in the afternoon (see Fig. 2). All of these demonstrate a need for coherent observations of the eddy diffusivity and the ABL structure in our development project.

By implementing the most recent ideas on the ABL parameterization of second-moment closure that are suitable for fine scales, the ABL parameterization under development takes into account the dynamical consistence of the three basic attributes of the ABL parameterization: the prediction of day-time ABL height, the surface flux forcing, and the vertical mixing.

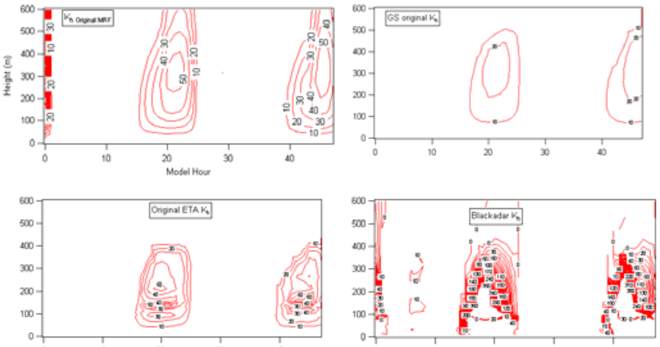

Figure 1. Time-height series of eddy diffusivity for heat K_h (contour intervals are 5 m^2s^{-1}, except 10 m^2s^{-1} in the fouth panel)

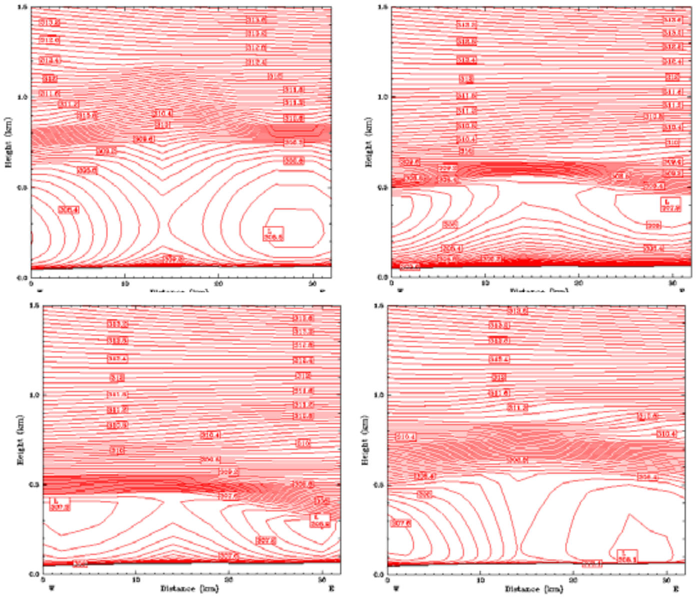

Figure 2. Vertical cross sections of potential virtual temperature (K) for the MRF scheme (upper-left), Gayno-Seaman scheme (upper-right), ETA scheme (lower-left) and Blackadar scheme (lower-right). Contour intervals are 0.1 k.