P2.1

THE SURFACE LAYER IN THE NCEP ETA MODEL

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The surface layer of the Eta Model is parameterized following the similarity theory. This theory requires that boundary conditions be prescribed at two levels in the air. As usual, the values of the relevant variables at the lowest model level are used as the upper boundary conditions. Over open water surfaces, the values at the interface of the explicitly parameterized viscous sublayer (Janjic 1994) and the turbulent layer on top of it are used as the lower boundary conditions. The height of the marine viscous sublayer is different for different variables, and depends on the flow regime. When a threshold value for friction velocity (or roughness Reynolds number) is exceeded, the viscous sublayer for momentum collapses. At a still higher threshold value, the viscous sublayer collapses completely, and the similarity theory is applied in the usual way, i.e., using the values at the roughness height as the lower boundary condition. The integral similarity functions used over water (Lobocki 1993) were derived from the Mellor-Yamada Level 2 scheme (Mellor and Yamada 1982).

As an illustration of the performance of the combination of the marine viscous sublayer and the Lobocki's functions, equivalent bulk aerodynamic coefficients for momentum and heat were evaluated at the 10 m height as functions of the wind speed. The results are shown in Fig. 1 for neutral (thick lines) and unstable (thin lines) stratifications. In the unstable case the virtual potential temperature difference was 5° across the 10 m layer. The discontinuities visible particularly in the case of the equivalent bulk aerodynamic coefficients for heat are caused by the changes of the viscous sublayer regime, and are supported by the laboratory measurements of Mangarella et al. (1973).

A new land surface scheme has been recently coupled to the Eta Model (e.g., Chen et al. 1996). With this scheme, the radiative skin temperature is obtained from the surface energy balance equation. In order to adapt the surface layer formulation in such a way as to use the radiative skin temperature as the lower boundary condition, a viscous sublayer parameterization has been introduced over land following Zilitinkevich (1995). With this parameterization,

$$z_{0T} = z_{0M}\, e^{-A_0 \sqrt{\frac{u_* z_{0M}}{\nu}}} \qquad (1)$$

where, z_{0M} and z_{0T} are the roughness heights for momentum and heat, respectively, ν is the molecular viscosity of the air, and A_0 is an empirical constant. Also, the Beljaars (1994) correction is applied in order to avoid the singularity in the case of free convection. With this correction, a fraction of the surface buoyancy flux is converted into the kinetic energy of unorganized flow near the surface so that the friction velocity, and therefore the Monin-Obukhov length remains nonzero. Finally, for a technical reason, the Lobocki's (1993) functions were replaced over land by those derived by Paulson (1970).

The impact of the viscous sublayer parameterization over land is illustrated by the

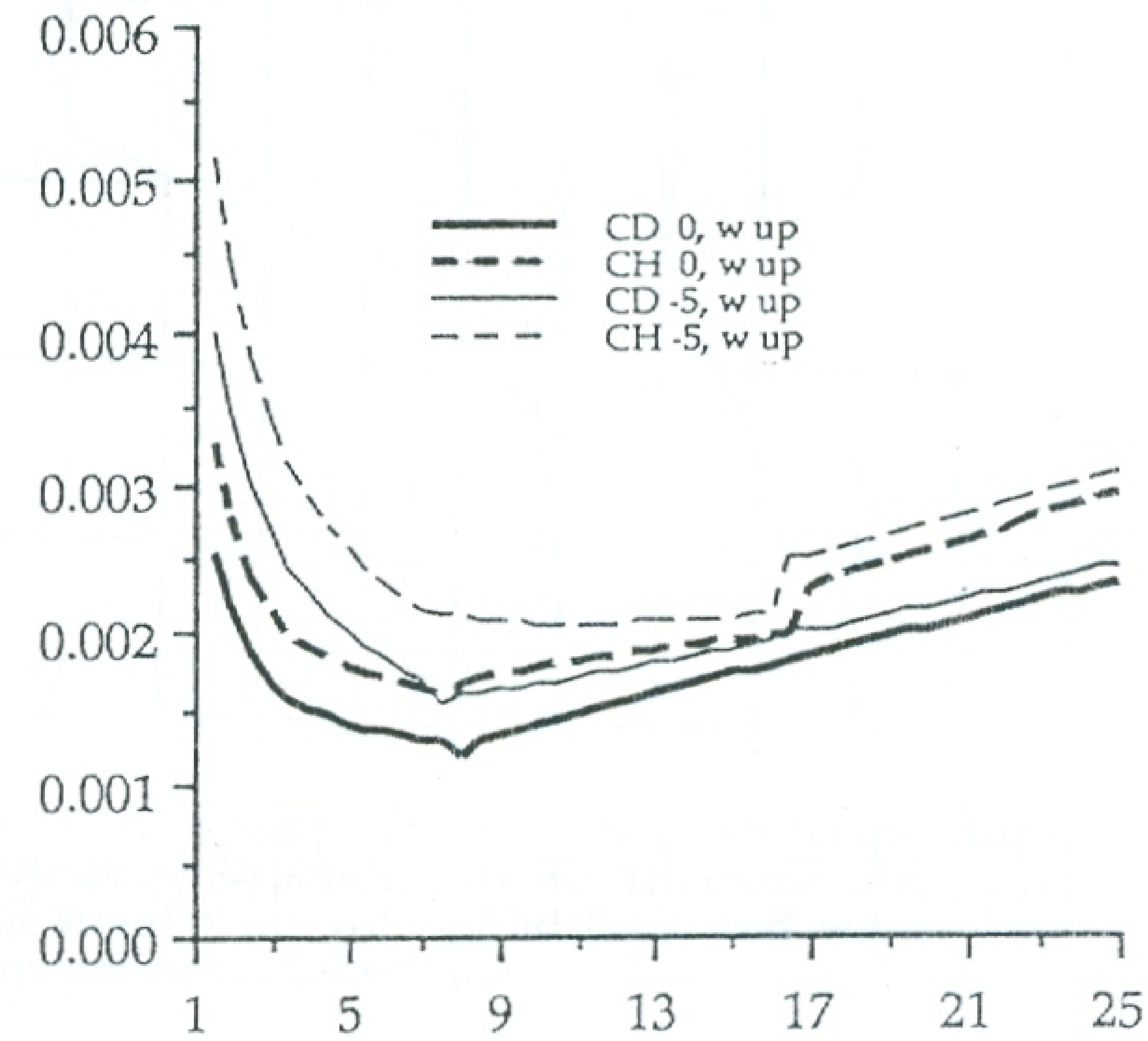

Fig. 1. The equivalent bulk aerodynamic coefficients for momentum (solid lines) and heat (dashed lines) vs. wind speed for neutral (thick lines) and unstable (5° across the 10 m layer) stratifications.

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results shown in Figs. 2-4. Following Zilitinkevich's (1995) estimate, the constant A_0 in (1) was assumed to be 0.3, and in the control run, A_0 was set to zero. The data obtained with the viscous sublayer are plotted using solid lines, while the dashed lines are used for the results from the control run.

The time evolutions of the predicted 2 m temperatures and the surface sensible heat fluxes in 48 hour simulations are shown in Figs. 2-3, respectively. As can be seen from Fig. 2, the

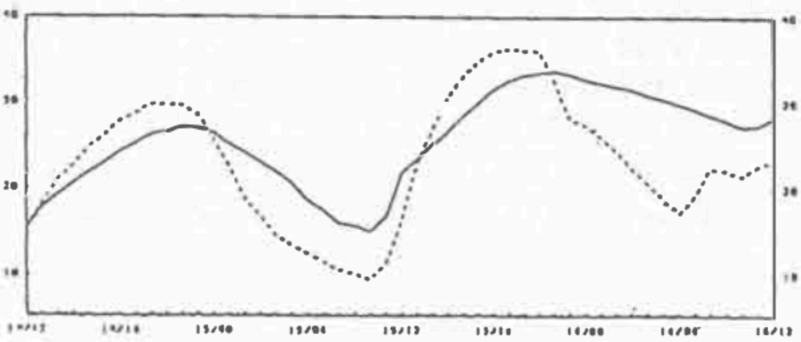

Fig. 2 Time evolution of predicted 2 m temperatures in 48 hour runs with (solid line), and without the viscous sublayer (dashed line).

presence of the viscous sublayer significantly alters the phase and the amplitude of the diurnal cycle of the 2 m temperature. The differences are even more striking in the case of the sensible heat fluxes shown in Fig. 3. In the control run, the flux maxima are more than doubled compared to those in the run with the viscous sublayer.

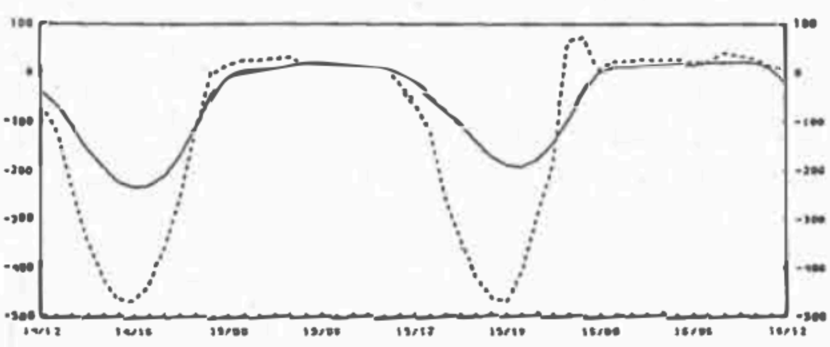

Fig. 3 Time evolution of predicted surface sensible heat fluxes in 48 hour runs with (solid line), and without the viscous sublayer(dashed line).

The data shown in Fig. 4 illustrate the response of the PBL structure to the large differences in surface forcing. The temperatures, dew point temperatures and winds corresponding to late afternoon of the first day of the simulations are shown using height as the vertical coordinate. As can be seen from the figure, the wind is weak, and the boundary layer is predominantly convectively driven. In the control run the mixed layer is about 2.5 degrees warmer, and the dew point temperature is about

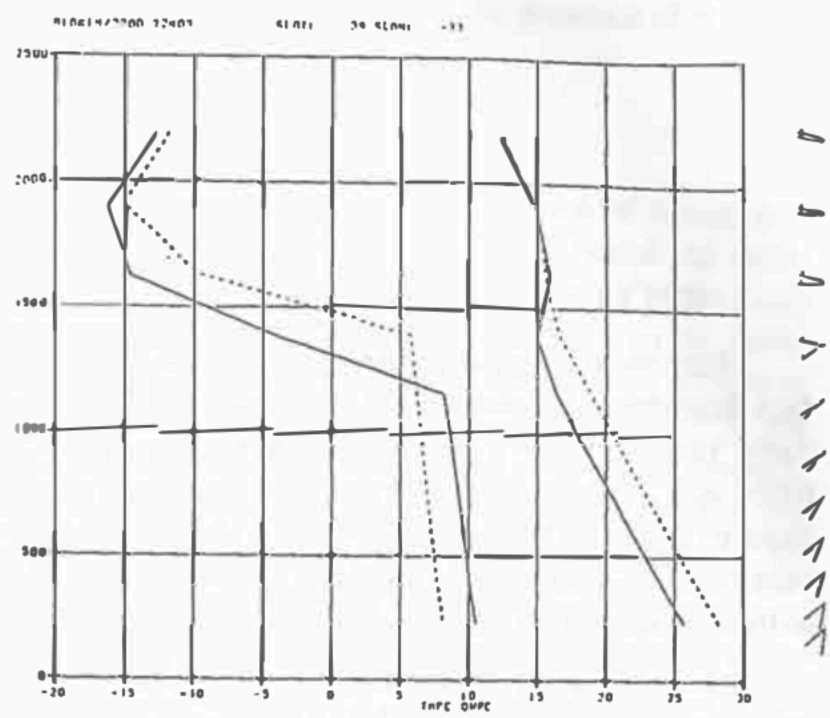

Fig. 4. The temperatures, dew point temperatures and winds corresponding to late afternoon of the first day of simulations with (solid line), and without the viscous sublayer (dashed line).

that much lower. Also, the mixed layer extends further up compared to the run with the viscous sublayer .

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