P4.7 THE INFLUENCE OF NOCTURNAL BOUNDARY LAYERS REGIMES ON THE SURFACE ENERGY BUDGET.

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1. INTRODUCTION

Stratified nocturnal boundary layers include different singularities, which makes study and modelling them difficult (Mahrt, 1999; Derbyshire, 1999). We will organize our study of the nocturnal boundary layer by considering two idealized classes, weakly and very stable boundary layers. We recognized that actual boundary layers are more complex.

Weakly stable boundary layers are characterized by moderate or strong winds or cloudy conditions, such that the surface cooling is relatively slow and turbulence more o less continuous. Characteristics of this type of boundary layer are expressed as a function of surface fluxes, the boundary layer depth, the surface friction velocity and the Obukhov length. Therefore it can be assumed that present boundary layer models will be able to reproduce its mains features.

Very stable boundary layers are characterized by weak winds, clear skies corresponding to strong net radiative cooling at the surface, elevated shear associated with low-level jets, which can generate intermittent turbulence, which often is transported downward (Mahrt et al. 2002) as a downward bursts from turbulence. These turbulent events generate downward heat flux and temporary warming of the near surface air. The cooling of the soil ceases and temporary warms, which in turn increases the outward long wave radiation and decreases the soil heat flux (Soler et al., 2002). As some of these mechanisms are not considered in numerical models, in this work we try to analize the capability of coupled soil–atmosphere models, to simulate these phenomena. In particular, we have used the Noilhan-Planton model to simulate the temporal evolution of soil temperature as well as the sensible heat flux.

2. DATA

We analize data from two experimental campaigns, SABLES98 and CASES99. SABLES98 took place over the northern Spanish plateau in September 1998, over a region of relatively flat grassland, described in Cuxart et al., (2000). The primary data set is three levels of sonic anemometer data, three levels of slower response measurements of wind sped, wind direction and temperature, an infrared surface temperature sensor, a net radiometer, three levels of subsoil temperature, two levels of soil moisture and one ground heat flux sensor. CASES99 took place in Southeast Kansas, USA in October 1999 over relatively flat grassland largely described in Poulos et al., (2001). The primary data set comes from two levels of sonic anemometer data, and essentially the same instrumentation as in SABLES98, which has been deployed in a 10-m tower placed on a shallow gully. Quality control data were described in Cuxart et al., (2000) and Soler et al., (2002).

3. LAND SURFACE MODEL

The Noilhan an Planton model has been described in detail by Noilhan and Planton (1989), and extensively validated (Jacquemin and Noilhan 1990). The model is a simplified version of Deardorff's parameterization, including representation of the different components of the surface heat flux and moisture budget over various types of soils and canopies. It includes two layers in the soil and a single canopy layer. From a thermal point of view, the model computes the evolution of the surface temperature of the ground-vegetation medium T_s, and the mean deep ground temperature T_2. The soil hydrology parameterization scheme involves the use of two time dependent variables: The volumetric ground surface moisture content, W_g, associated with a thin upper layer, 1 cm thick, the bulk soil moisture, W_2, which corresponds to the total soil depth. The evolution of soil temperature and moisture includes thermo-hydraulic coefficients, calibrated as functions of both soil texture and moisture, (Noilhan and Planton, 1989). Turbulent surface

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fluxes are computed in terms of bulk aerodynamic formula, using the mean wind speed and temperature at the first observational height and the drag coefficient for heat. Its computation requires integration of Monin-Obukhov similarity theory between a reference level within the surface layer and the roughness length for momentum and heat. Commonly, the air temperature at the roughness height (aerodynamic temperature) is often replaced by the surface radiative temperature. Since the latter is quite different from the inferred aerodynamic temperature, the thermal instability may be substantially overpredicted or underpredicted for the unstable and stable cases, respectively. One solution is to define a thermal roughness for heat, Z_{0t} different from that for momentum Z_{0m}. Based on comparisons of simulations with observations, different authors have found different relations between Z_{0m} and Z_{0t}, which improve model simulated surface fluxes. However, this ratio would have prescribed as a function of vegetation and soil type. Presumably, the more physical approach is to relate the ratio to the property of the flow. In this study, we test different surface-layer schemes and different values of ratios Z_{0m}/Z_{0t}, using the Paulson scheme and the relation proposed by Zilitinkevich (1995). This relation is written as a function of von Kármán constant (K= 0.4), the kinematic molecular viscosity ν, the roughness Reynolds number Re*, the surface friction velocity u_* and an empirical constant C, which for this study has been taken equal to 0.1.

We focus our attention on the prognostic equation for the surface temperature T_s, for the deep ground temperature T_2 and for the turbulent heat flux, as these variables could be compared with the measurements.

4. RESULTS AND DISCUSSION

The model is executed during seven nights, three for SABLES98 and four for CASES99, where the boundary layer can be considered as a prototype of very stable boundary layers with intermittent turbulence and downward turbulence bursts. As an example, in figures 1, 2, 3 and 4 we present the measurements corresponding to the night 26-27 October 1999 during CASES99 experiment.

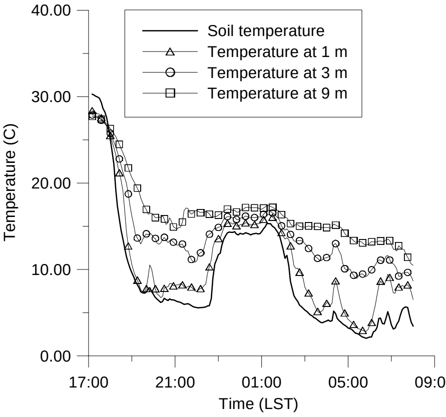

Figure 1. Time evolution of measured air and surface temperature.

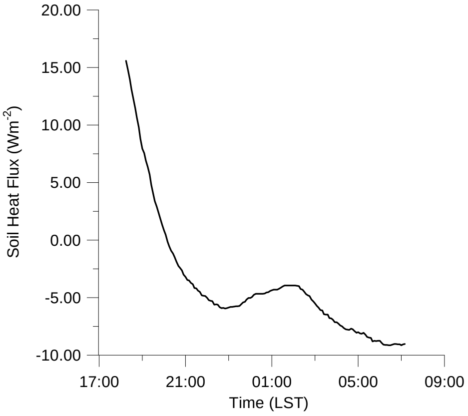

Figure 2. Time evolution of measured soil heat flux at 0.08 m depth.

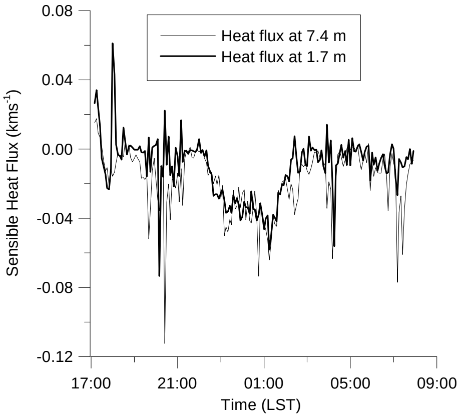

Figure 3. Time evolution of measured sensible heat flux.

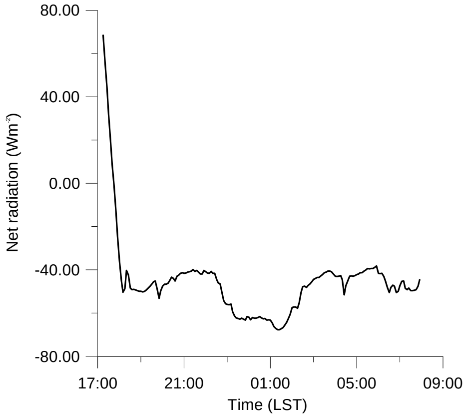

Figure 4. Time evolution of measured net radiation.

These figures show the disturbances induced by turbulent events, and associated downward heat flux, modify both the air and soil temperatures, the soil heat flux and consequently the net radiation. Figures 5 and 6 show the time evolution of simulated surface temperature and sensible heat flux corresponding to the night 26-27 October.

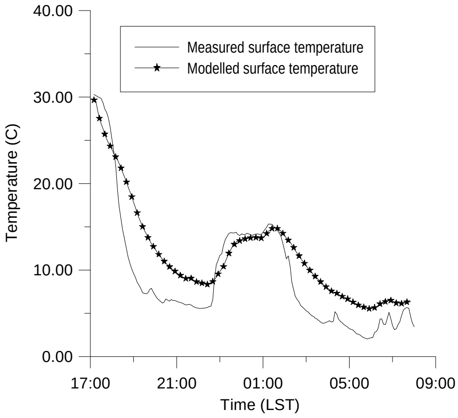

Figure 5. Time evolution of measured and modelled surface temperature.

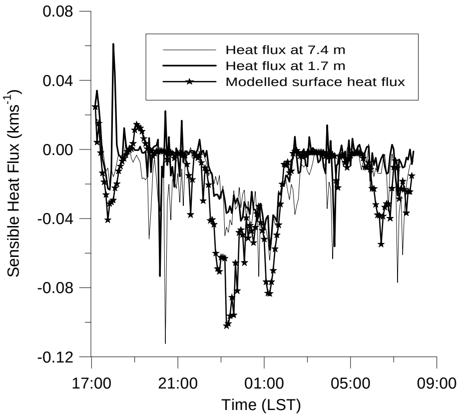

Figure 6. Time evolution of measured and modelled sensible heat flux.

In both figures we can see good agreement between measurements and the simulation; although the model temporarily overestimates the downward sensible heat flux. Good agreement could be due to the fact that in all simulations, the air temperature imposed to the model is the one measured at the second level, at 3 m height, which during the turbulent event increases considerably, and forces increases downward sensible heat flux. We think that if the model has been forced with data coming from numerical models of the atmosphere, the comparison would be less favourable.

Although the model presents good results, it shows some discrepancies with measurements, especially for the downward latent heat flux values, which in some cases are too high, even forcing positive values of the sensible heat flux.

5. CONCLUSIONS

A first attempt to model the surface temperature and the surface sensible heat flux is carried out during nights with very stable stratification and only weak intermittent turbulence. The surface model generally compares favourably with the observations when forced by the observed surface air temperature. Discrepancies between the model and measurements, we think, are related to the overestimated downward latent heat flux calculated by the surface model. This inadequacy is currently under investigation.

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