Improvement of the land surface processes in JMANHM

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The JMA non-hydrostatic model(JMANHM) is a community model which has been developed for use of both operational prediction and research. JMANHM is known to have several problems in the surface properties such as temperature and humidity:

Problem 1 The cold bias at the surface in case of the unstable conditions.
Problem 2 The wet bias at the surface.

The causes of the problems are the following points:

Cause 1 Too much the surface latent heat flux.
Cause 2 Too small the eddy diffusion coefficients.

The more the surface latent heat flux exists, the more surface cooling occurs. That is why the cold bias at the surface existed. Furthermore, because of the small turbulent mixing with the small eddy diffusion coefficients, the water vapor in the lower model level is accumulated too much. That is why the wet bias at the surface existed.

To remove the Cause 1, the following modifications have been made.

1) Scalar roughness lengths

In JMANHM, the roughness length for scalars (heat and moisture) had been the same as that for momentum. Since this treatment tends to overestimate the surface heat and moisture fluxes, the values of the scalar roughness lengths have been reduced following Garratt and Francey[2].

2) Methods for calculating the bulk coefficients

In JMANHM, a bulk method is used for calculating the surface fluxes. To calculate the bulk coefficients on the land, an iteration scheme by applying Sommeria[6]'s method had been used. To save the iteration time, the value of the dimensionless height ζ had been restricted as follows:

$$-2.5 \leqq \zeta \leqq 1.5 \ . \tag{1}$$

Since this restriction does not give satisfactory results for the strongly stable and strongly unstable cases, the following three methods which do not restrict the dimensionless height ζ have been implemented into JMANHM:

- method by Businger et al.[1]
- method by Kader and Yaglom[3]
- method by Louis et al.[5]

3) Stomatal resistance

The stomatal resistance has been introduced into JMANHM. The stomatal resistance r_s is controlled by using the downward shortwave radiation flux $S_\downarrow$ as

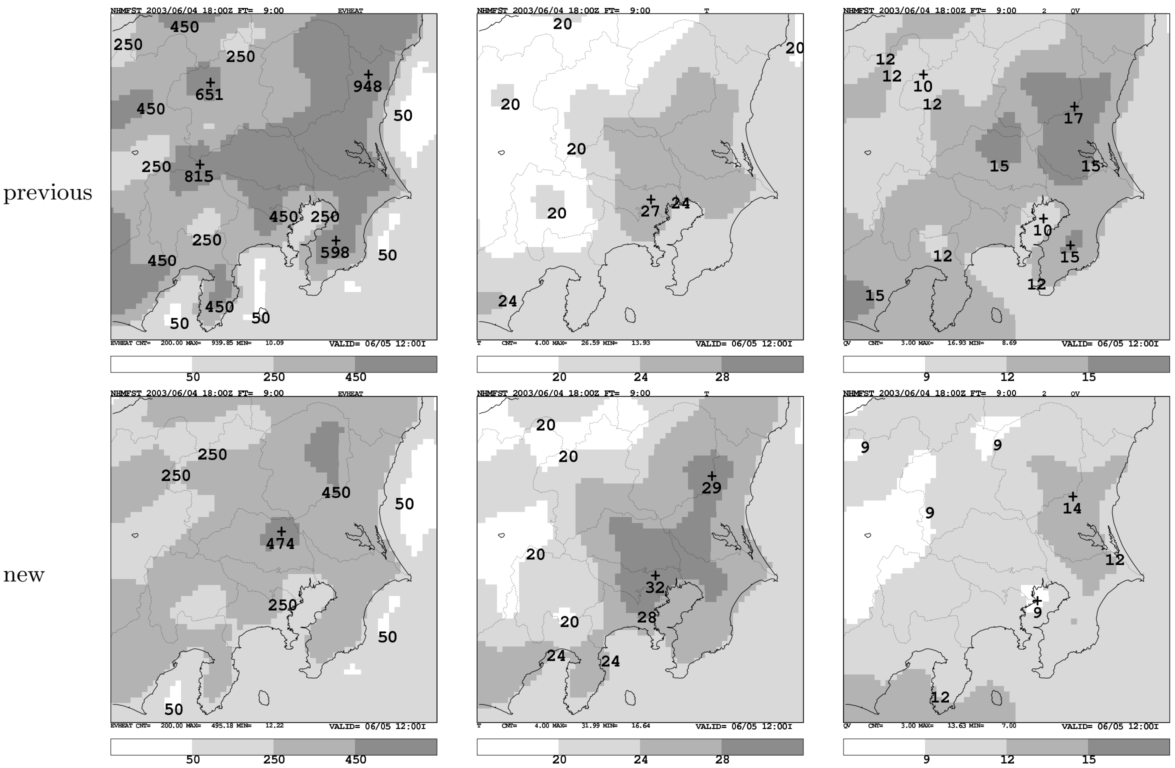
$$r_s = \frac{r_n}{1 + S_\downarrow} + r_d \ . \tag{2}$$

Here r_n and r_d are constants which vary with a season. By using the stomatal resistance, the diurnal variation of stomatal evapotranspiration activity is taken account of and the surface latent heat flux is decreased.

Figure 1 shows the comparison between the previous land surface processes and the new ones at 03 UTC (noon) June 5, 2003. The initial time of this experiment is 18 UTC June 4, 2003. In this experiment, the method by Louis et al.[5] is used for calculating the bulk coefficients of the new land surface processes. By using the new land surface processes, the surface latent heat flux is decreased, and the temperature at 1.5 [m] is increased and the mixing ratio of the water vapor at the lowest level is decreased. Figure 2 shows the time sequence of the temperature and dew-point temperature at 1.5 [m] at Kumagaya. As shown in Figure 2, the Problem 1 is solved, but the Problem 2 remains. Implementation of a new PBL scheme to solve the Problem 2 is another report[4].

References

[1] Businger, J. A., J. C. Wyngaard, Y. Izumi and E. F. Bradley, 1971 : "Flux - profile relationships in the atmospheric surface layer", *J. Atmos. Sci.*, **28**, 181 - 189.



Surface latent heat flux [W/m^2]

Temperature at 1.5 [m] [degree C]

Mixing ratio of the water vapor at the lowest level [g/kg]

Figure 1: The spatial distributions of the surface latent heat flux, the temperature at 1.5 [m] and the mixing ratio of the water vapor at the lowest level over the Kanto region at 03 UTC June 5, 2003.

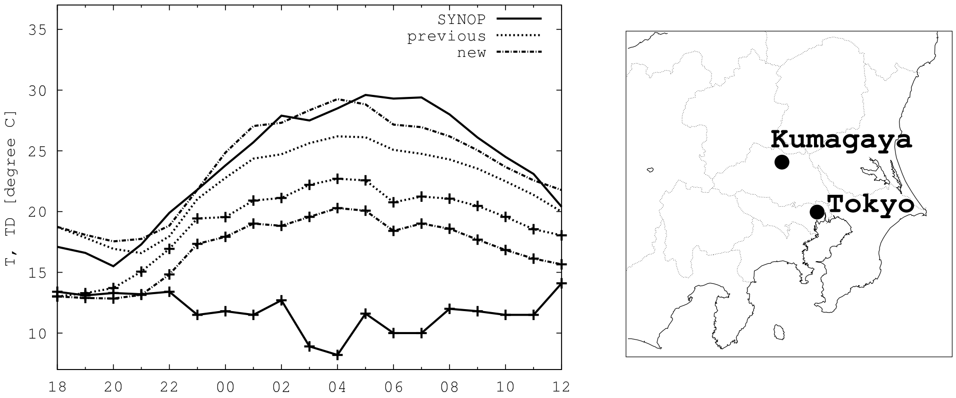


Figure 2: The time sequence of the temperature and dew-point temperature at 1.5 [m] at Kumagaya. The lines and lines with cross dots represent the temperature and dew-point temperature, respectively.

[2] Garratt, J. R. and R. J. Francey, 1978 : "Bulk characteristics of heat transfer in the unstable, baroclinic atmospheric boundary layer", *Boundary-Layer Meteor.*, **15**, 399 - 421.

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[5] Louis, J. F., M. Tiedtke and J. F. Geleyn, 1982 : "A short history of the operational PBL parameterization at ECMWF", Workshop on Planetary Boundary Layer Parameterization, *ECMWF*, England, 59 - 79.

[6] Sommeria, G., 1976 : "Three - dimensional simulation of turbulent processes in an undisturbed trade wind boundary layer", *J. Atmos. Sci.*, **33**, 216 - 241.