Effects of vegetation on thermal stratification in atmospheric surface layer

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The objective of this study was to quantify the influence of the underlying surface created by vegetation on vertical profiles of air temperature near the ground. For this purpose, an extended steady-state soil-vegetation-atmosphere transfer model for homogeneous plant canopies was developed and tested. The model verification was carried out for various plant canopies growing in different geographic, soil and climatic conditions with satisfactory results. Consequently, the model appeared to be a suitable tool for a quantitative analysis of air temperature dynamics above homogeneous plant canopies.

The values of air temperature simulated according to the model depend on various soil, canopy and atmospheric characteristics. During the model simulations, the surface and atmospheric effects on air temperature were separated that enabled to express the partial dependences of air temperature above vegetation on individual plant characteristics. Obtained results indicated that the stomatal resistance and physiological control of transpiration has a great importance for time variability of air temperature above dense vegetation. Besides other plant characteristics, also the degree of the root system development turned out to be an important factor affecting primarily the evapotranspiration and finally air temperature above plant canopies. It was shown that soil moisture in the root zone had a potential to make a critical impact on the energy balance structure of vegetated surfaces and subsequently on the air temperature near the evaporative surface.

An interesting consequence of vegetation effects on the air temperature is the thermal inversion occurring sometimes at midday of clear summer days near the ground above dense plant canopies. A case study was carried out with aim to explain this phenomenon. Results of model simulations led to conclusion that the thermal inversion can occur during clear summer days only above dense canopies sufficiently supplied with soil water and simultaneously, under high evaporative demands of the atmosphere.

Finally, importance of obtained results for better understanding of relations between vegetation and surface layer of the atmosphere is evaluated and possible application of developed model as a surface block in a GCM is discussed.