

A41D-07 Numerical Modeling of Topography-related Heterogeneity in the Atmospheric Boundary Layer: Implications for Area-averaged Estimates of Surface Fluxes

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Introduction

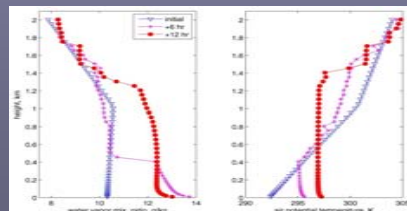
Land surface heterogeneity at a subgrid scale affects surface fluxes in different ways. Previous studies were mainly focused on evaluating an integral thermo- and aero-dynamical impact of small-scale surface variability modulated by changes in a vegetation fraction cover on surface fluxes. Less attention were paid on examination the direct effects of topography-related heterogeneity on surface fluxes (Huntingford et al. 1998, Blyth 1999). The objective of this study is to investigate the effects of different slopes, roughness lengths, and boundary/initial conditions on domain-averaged surface fluxes. Idealized 2-D numerical simulations with an atmospheric mesoscale model were performed to understand better these effects.

Model and initial/boundary conditions

The state-of-the-art Regional Atmospheric Modeling System (RAMS/Cotton et al. 2003/) developed at Colorado State University and MRC/ASTER Inc. was used for numerical Large-eddy Simulations (LES) of the surface ABL over a hilly terrain. The RAMS model can be easily configured for 1-D and 2-D runs. A series of 2-D (in x-z plane) simulations were performed to study the effects of a terrain represented by a sequence of low hills on domain-averaged surface fluxes. The computational domain was 2 km height (with the grid spacing increasing from 10 m at the surface to 50 m around height of 400 m) and 2.5 km width having 50 m spacing. The terrain was represented by a series of sine-shape hills and each hill had a typical half-width L_x and a constant height of 40 m. Following values of L_x corresponding to different number of hills within the domain were used: $2L_x = 1250$ (two hills), 500 m (five), and 250 m (ten). Simulations with a flat terrain are considered as control runs.

Periodic lateral boundary conditions were used.
Speed of initial background flow (U): 3 m/s and 7 m/s.
Surface roughness length (z_0): 1 cm and 10 cm.

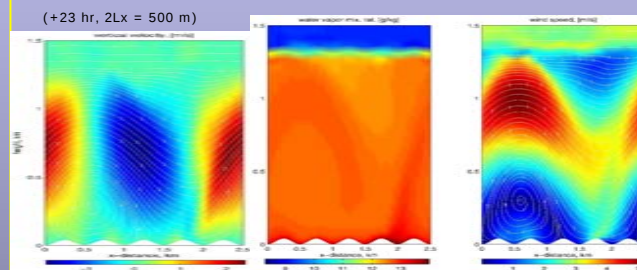
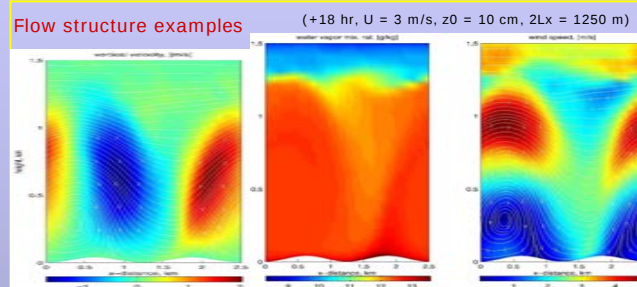
Profiles of water vapor mix. rat. and potential temperature



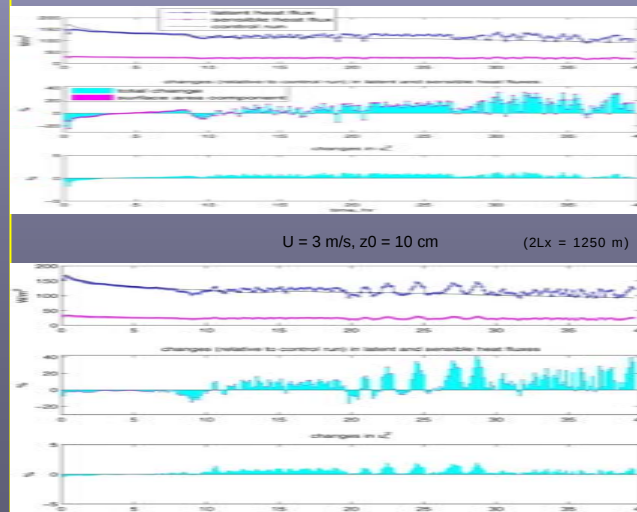
Constant values (for the water vapor mixing ratio and the air temperature) of the difference between the surface and the first model layer were used.

Results

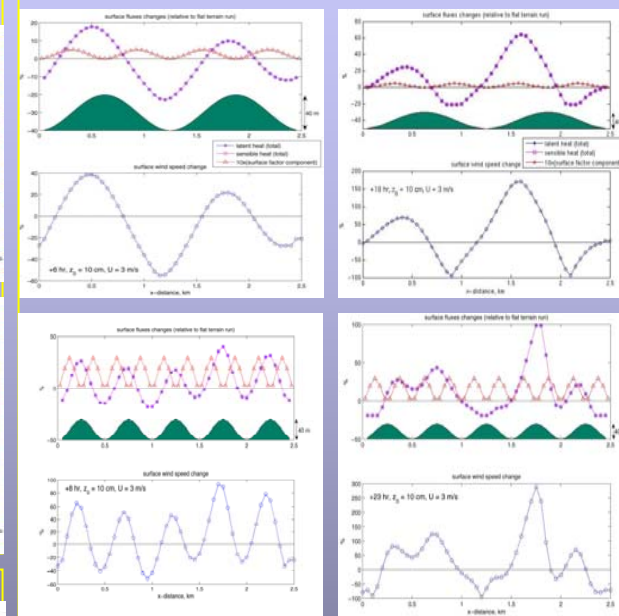
Flow structure examples



Difference between domain-averaged surface fluxes (2Lx = 500 m)



Surface fluxes variability within computational domain



Summary

A systematic increase by 20-30% of domain-averaged surface fluxes simulated at 3 m/s speed of the atmospheric background flow over a series of sine-shape low hills is observed in comparison to those over the flat terrain. Several components, such as surface wind speed, drag, and terrain area increase contribute to this change of fluxes. The major component responsible for surface fluxes augmentation is associated with the increase of the surface wind, modulated by organized vertical circulation cells developing within the ABL. Because the depth and intensity of these circulations depend on the vertical structure of the ABL it is difficult to suggest a reliable parameterization accounting for the above increase of surface fluxes.

Acknowledgments

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References

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- Cotton, W.R., and Coauthors, 2003: RAMS 2001: Current status and future directions. *Meteorol. Atmos. Phys.*, **82**, 5-29.
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