EMS Annual Meeting Abstracts
Vol. 10, EMS2013-140, 2013
13th EMS / 11th ECAM

At what scale can models ignore mesoscale circulations over heterogeneous landscape

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This study deals with the scale issues relating to land-atmosphere interactions over inhomogeneous landscapes. There are three main tasks. The first is to provide a modelling verification of Raupach's (1991) scale classification of surface heterogeneity. The second is to assess the importance of landscape-induced mesoscale circulations on convective boundary layer (CBL) development and to identify a critical length scale that separates significant mesoscale circulations from the weaker ones. The third investigates the validity of a scale separation that leads to the mesoscale flux definition, and the problems associated with representing mesoscale effects in large-scale models. Extensive mesoscale modelling experiments with the Regional Atmospheric Modelling System (RAMS) with relatively simple surface and atmospheric conditions form the basis of the study.

The study found that the non-dimensional heterogeneous length scale lambda = X over (U_m t_*) (where X is the characteristic heterogeneous length scale, U_m the mean wind speed in the CBL and t_*, the convective time scale) is able to distinguish microscale and mesoscale surface heterogeneity with the critical scale at 10. This scale corresponds roughly to X of 50km for typical convective daytime conditions.

Strong landscape-induced mesoscale circulations can significantly modify the CBL development across a heterogeneous landscape but they only occur when lambda is greater than 10 or X is larger than 50km. The mesoscale kinetic energy and mesoscale available potential energy are capable of identifying these significant mesoscale circulations.

The sensitivity study on grid spacing suggests that the scale separation between mesoscale and turbulence scales, as well as the mesoscale flux definition, is questionable.

This study advocates using the simple aggregated schemes for surface turbulent fluxes over most real-world heterogeneous landscapes in large-scale models. It warns against developing a generalized mesoscale flux parameterization without clear understanding of the scale separation issue.