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The response of mesoscale models to changes in surface roughness

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Downscaling mesoscale model wind speed fields to microscales for wind energy resource mapping entails knowledge not only of the surface roughness used in the mesoscale terrain description, but also of the ‘effective roughness’ of the mesoscale model. The effective mesoscale roughness is a function of both the input roughness values, as well as the physical and dynamical filtering in the model.

In this work, the responses of two mesoscale models (the WRF and KAM models) to changes in surface roughness are explored in an idealised framework. Both step roughness changes the response to small roughness elements are examined using idealised domains forced by a geostrophic wind perpendicular to the roughness changes in near-neutral conditions. The concept of effective roughness is explored based on the modelled wind profiles, and by considering generalisation of a single roughness change. Furthermore, the effective resolutions of the models are explored using spectra of the wind speeds over the step roughness changes, and by considering the horizontal extent of roughness element required for the models to fully adjust to the altered surface conditions. Thus the precise nature of the surface wind variability induced by roughness elements is described. Results from the two models are contrasted and described in terms of the different dynamical and physical characteristics of the models.

The work is of importance for the fundamental understanding of the spectral response and filtering of mesoscale models. In addition, the analysis is of critical importance for practical downscaling problems in wind energy resource mapping. The effective roughness is the roughness that a mesoscale model actually responds to, and must be taken into account before using the model output in microscale models, where higher resolution roughness information is applied. Incorrect treatment of surface effects can significantly alter assessments of regional wind energy potential, or influence planning decisions relating to global wind energy resources.

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