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A Power spectrum analysis of turbulent flows in complex terrain: evaluation of RAMS-LES model against tall mast measurements

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The atmospheric model RAMS is configured to simulate very high resolution turbulent flows to evaluate wind power potential and intra wind farm variability in complex terrain. Two-way nesting techniques and the use of Large Eddy Simulation turbulence closures schemes allows the simultaneous simulation of mesoscale forcing and microscale induced turbulence due to wind flow passing over hills.
The production of a power spectrum, with frequencies ranging from diurnal phenomena to few second turbulent structures is derived from both model output and one second data cup anemometers positioned at heights of 78m, 90m, 102m and 118m above the ground. The analysis of the power spectrum provides a clear evaluation of the model output over the full time scale spectrum.
It is found that both large and small scales structures follow Kolmogorov five third law for decaying turbulence in the Atmospheric Boundary Layer. Further analysis of the spectrum shows a deviation from Kolmogorov trend between mesoscale and microscale spectrum. The deviation can be described as a bump which frequencies are correlated with the terrain orography variability. Further analysis comprises wind direction and stability dependent cases, a detailed influence of the orography and roughness parameterization. The study of transient power ramps is also investigated.
To a larger extent,this study proposes a methodology for the evaluation of the atmospheric model RAMS for wind resource assessment over complex terrain. The use of Spectrum analysis is fundamental to understand the dominant turbulent structures associated with their time scale and the model grid spacing resolution necessary to accurately simulate these structures.