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Modelling wave—boundary layer interaction for wind power applications

A. D. Jenkins (1), I. Barstad (2), A. Gupta (2), and M. Adakudlu (3)

(1) Uni Research, Bergen, Norway (alastair.jenkins@uni.no), (2) Uni Research, Bergen, Norway , (3) Geophysical Institute, University of Bergen, Bergen, Norway

Marine wind power production facilities are subjected to direct and indirect effects of ocean waves. Direct effects include forces due to wave orbital motions and slamming of the water surface under breaking wave conditions, corrosion and icing due to sea spray, and the effects of wave-generated air bubbles. Indirect effects include include the influence of waves on the aerodynamic sea-surface roughness, air turbulence, the wind velocity profile, and air velocity oscillations, wave-induced currents and sediment transport. Field observations within the boundary layers from floating measurement may have to be corrected to account for biases induced as a result of wave-induced platform motions.

To estimate the effect of waves on the atmospheric boundary layer we employ the WRF non-hydrostatic mesoscale atmosphere model, using the default YSU planetary boundary layer (PBL) scheme and the WAM spectral wave model, running simultaneously and coupled using the open-source coupler MCEL which can interpolate between different model grids and timesteps. The model is driven by the WRF wind velocity at 10 m above the surface. The WRF model receives from WAM updated air–sea stress fields computed from the wind input source term, and computes new fields for the Charnock parameter and marine surface aerodynamic roughness.

Results from a North Atlantic and Nordic Seas simulation indicate that the two-way coupling scheme alters the 10 metre wind predicted by WRF by up to 10 per cent in comparison with a simulation using a constant Charnock parameter. The changes are greatest in developing situations with passages of fronts, moving depressions and squalls. This may be directly due to roughness length changes, or may be due to changes in the timing of front/depression/squall passages.

Ongoing work includes investigating the effect of grid refinement/nesting, employing different PBL schemes, and allowing the wave field to change the direction of the total air–sea stress.