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Conditional sampling of wind farm flow fields

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In large wind farms the turbines are heavily loaded by the turbulent wakes of the upstream rotors. These loads can lead to severe damage of the wind turbine components. In order to improve turbine control, further insight into flow patterns that cause these structural loads is of interest.

In the current work conditional averaging is used to examine the effect of turbulent flows on the turbine loads. Conditional sampling has been used with success for the identification of large-scale turbulent structures in various experimental studies, e.g. Refs [1, 2]. Here, we apply this method to numerical simulations of wind farms using structural dynamics variables as conditions for the average. In this way the flow field is averaged for every realization of a trigger condition, shedding light onto the interdependence between flow patterns and structural response.

The simulations are performed using our in-house large-eddy simulations code SP-Wind [3], which utilizes a highly-parallelized pseudo-spectral spatial discretization scheme and a fourth-order time-marching scheme. To account for the tower and blades dynamics, a flexible multibody dynamics code has been implemented and integrated into the SP-Wind code. The multibody dynamics module employs the floating frame of reference formulation [4], and the model order is further reduced using modal transformation.

Results are shown for aligned wind farm layouts operating at rated or above-rated flow regimes in neutral atmospheric boundary layer conditions. These include mean flow field variables and turbulence properties correlated with different trigger conditions for blades displacement and power output.

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