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CFD Study of the Performance of an Operational Wind Farm and its Impact on the Local Climate: CFD sensitivity to forestry modelling

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Any past, current or projected future wind farm developments are highly dependent on localised climatic conditions. For example the mean wind speed, one of the main factors in assessing the economic feasibility of a wind farm, can vary significantly over length scales no greater than the size of a typical wind farm. Any additional heterogeneity at a potential site, such as forestry, can affect the wind resource further not accounting for the additional difficulty of installation. If a wind farm is sited in an environmentally sensitive area then the ability to predict the wind farm performance and possible impacts on the important localised climatic conditions are of increased importance.

Siting of wind farms in environmentally sensitive areas is not uncommon, such as areas of peat-land as in this example. Areas of peat-land are important sinks for carbon in the atmosphere but their ability to sequester carbon is highly dependent on the local climatic conditions. An operational wind farm's impact on such an area was investigated using CFD. Validation of the model outputs were carried out using field measurements from three automatic weather stations (AWS) located throughout the site. The study focuses on validation of both wind speed and turbulence measurement, whilst also assessing the models ability to predict wind farm performance.

The use of CFD to model the variation in wind speed over heterogeneous terrain, including wind turbines effects, is increasing in popularity. Encouraging results have increased confidence in the ability of CFD performance in complex terrain with features such as steep slopes and forests, which are not well modelled by the widely used linear models such as WAsP and MS-Micro. Using concurrent measurements from three stationary AWS across the wind farm will allow detailed validation of the model predicted flow characteristics, whilst aggregated power output information will allow an assessment of how accurate the model setup can predict wind farm performance. Given the dependence of the local climatic conditions influence on the peat-land's ability to sequester carbon, accurate predictions of the local wind and turbulence features will allow us to quantify any possible wind farm influences.

This work was carried out using the commercially available Reynolds Averaged Navier-Stokes (RANS) CFD package ANSYS CFX. Utilising the Windmodeller add-on in CFX, a series of simulations were carried out to assess wind flow interactions through and around the wind farm, incorporating features such as terrain, forestry and rotor wake interactions. Particular attention was paid to forestry effects, as the AWS are located close to the vicinity of forestry. Different Leaf Area Densities (LAD) were tested to assess how sensitive the models output was to this change.