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Comparing offshore wind farm wake observed from satellite SAR and wake model results

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Offshore winds can be observed from satellite synthetic aperture radar (SAR). In the FP7 EERA DTOC project, the European Energy Research Alliance project on Design Tools for Offshore Wind Farm Clusters, there is focus on mid- to far-field wind farm wakes. The more wind farms are constructed nearby other wind farms, the more is the potential loss in annual energy production in all neighboring wind farms due to wind farm cluster effects. It is of course dependent upon the prevailing wind directions and wind speed levels, the distance between the wind farms, the wind turbine sizes and spacing. Some knowledge is available within wind farm arrays and in the near-field from various investigations.

There are 58 offshore wind farms in the Northern European seas grid connected and in operation. Several of those are spaced near each other. There are several twin wind farms in operation including Nysted-1 and Rødsand-2 in the Baltic Sea, and Horns Rev 1 and Horns Rev 2, Egmond aan Zee and Prinses Amalia, and Thompton 1 and Thompton 2 all in the North Sea. There are ambitious plans of constructing numerous wind farms – great clusters of offshore wind farms.

Current investigation of offshore wind farms includes mapping from high-resolution satellite SAR of several of the offshore wind farms in operation in the North Sea. Around 20 images with wind farm wake cases have been retrieved and processed. The data are from the Canadian RADARSAT-1/-2 satellites. These observe in microwave C-band and have been used for ocean surface wind retrieval during several years. The satellite wind maps are valid at 10 m above sea level. The wakes are identified in the raw images as darker areas downwind of the wind farms. In the SAR-based wind maps the wake deficit is found as areas of lower winds downwind of the wind farms compared to parallel undisturbed flow in the flow direction. The wind direction is clearly visible from lee effects and wind streaks in the images.

The wind farm wake cases are modeled by various types of wake models. In the EERA DTOC project the model suite consists of engineering models (Ainslie, DWM, GLC, PARK, WASP/NOJ), simplified CFD models (FUGA, FarmFlow), full CFD models (CRES-flowNS, RANS), mesoscale model (SKIRON, WRF) and coupled meso-scale and microscale models.

The comparison analysis between the satellite wind wake and model results will be presented and discussed. It is first time a comprehensive analysis is performed on this subject. The topic gains increasing importance because there is a growing need to precisely model also mid- and far-field wind farms wakes for development and planning of offshore wind farm clusters.