

Study on offshore wind farm wakes based on Envisat ASAR, Radarsat-2 and Sentinel-1 - DTU Orbit (08/11/2017)

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Downstream of operating wind farms the mean wind speed is reduced as compared to the upwind conditions. In the offshore environment it is of particular interest to quantify the wind farm wake because turbine arrays are often located in the vicinity of other wind farms. The wakes reduce the annual energy production in clustered wind farms. Envisat ASAR, Radarsat-2 and Sentinel-1 are used in the study covering wind farms in the North Sea and Kattegat Strait. Three types of analysis are performed. The first is a case based on a Radarsat-2 Scan-SAR wide VV scene (30th April 2013 at 17:41 UTC) with winds around 8-9 m/s from the northeast and eight operating wind farms all showing long wind farm wakes. The longest wake is around 55 km. The case has been modelled using an industry-standard engineering microscale wake model (PARK) and using mesoscale model (WRF) including a parametrization for wind farm wake. Both models reproduce the observed very long wind farm wakes convincingly regarding their direction and extent. The second analysis is based on 835 Envisat ASAR wide-swath-mode scenes from 2003 to 2012 (Hasager et al. 2015a) covering the Horns Rev-1 wind farm near the Danish North Sea coast. The wind farm covers an area of around 4 km by 5 km and three concentric circles centered at the wind farm are used for extraction of results. The selected radii are 6, 10 and 13 km. The mean wind speeds in each of the three circles (geo-located) quantify the coastal wind speed gradient. Next step is rotation of the data such that all scenes are aligned with inflow and downstream (wake region) based on the wind direction in the wind field maps. The rotation is done at 1 degree intervals. The data from rotated circles (not geo-located) are normalized with the winds at the side-lobes. Side-lobes are regions expected to be undisturbed by the wind farm wake. The key result of the analysis is the significant wind wake deficit at the inner circle, decreasing at outer circles, as expected. The SAR-based results strongly support the wake model results based on PARK and WRF (Hasager et al. 2015b). The third analysis is based on Sentinel-1 covering the Anholt wind farm located 56.6 °N, 11.25 °E in the Kattegat Strait. The 111 wind turbines, each 3.6 MW, are positioned in irregular lay-out with most turbines at the outer rim. Figure 1 shows Sentinel-1 on 11th September 2015 at 05:32 GMT with winds around 11-12 m/s from the southeast and wind farm wake west of the park with winds around 10 m/s. The wind turbines are visible as hard targets. Cases with winds from 6 to 14 m/s are under investigation. The potential of synergetic use of Sentinel-1a and Radarsat-2 with only few minutes time lag and the forthcoming Sentinel-1b with around 6 hour will increase sampling rate

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