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SMALL-SCALE WIND VARIATIONS AROUND OFFSHORE WIND FARMS: A USE CASE FOR SAR-BASED WIND FIELDS AND A COMPARISON WITH ON-SITE LIDAR MEASUREMENTS

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Over the past years, the increasing exploitation of renewable energy resources has boosted the construction of offshore wind farm, in particular in the German Bight. As a wind farm is an arrangement of wind turbines, the interaction of downstream turbulent wind wakes with adjacent turbines in the array is of substantial importance with special respect to the power output efficiency. Moreover, the shadowing effects of whole wind farms on neighboring turbine clusters are a major subject of interest. The downstream continuation of turbulent wakes is very complex and is influenced by a variety of meteorological parameters such as wind speed, wind direction and the ambient atmospheric stability conditions. While numerical models are routinely applied to simulate these effects, these data has to be complemented with observations with a high spatial resolution. Spaceborne remote sensing of sea surface winds with microwave sensors has developed into a mature technology over the past decades. Due to the capability to measure with high spatial coverage and being almost unaffected by weather conditions, it is now playing an important role in Earth Observation (EO). Hence, the observations are commonly used for the improvement of numerical weather prediction (NWP). While scatterometers yield only coarse-resolution data, synthetic aperture radar (SAR) has proven to measure local wind related sea surface roughness with both, high resolution and wide coverage. On the other hand, earth-bound remote sensing techniques have evolved significantly. Especially Doppler LiDAR has become an important tool for offshore wind energy related research in the last years. Ground-based LiDAR windscanners enable to measure vertical wind profiles or horizontal planar scans of the radial wind speed within a range of several kilometres. While both methods have been successfully validated against meteorological models and in-situ point measurements, our contribution presents a direct comparison of platform based LiDAR measurements and high resolution 2D sea surface wind fields derived from spaceborne SAR. The observations consist of a series of coincident wind field observations around the offshore wind farms “alpha ventus” and “Riffgat” in the North Sea taken with TerraSAR-X, Sentinel-1 and multiple scanning long range LiDAR systems. The comparison of both techniques is carried out with a special focus on the question how small scale wind variations derived by SAR from sea surface roughness translate to variations observed at greater heights as captured by the LiDAR instruments. Within this context, we present and discuss methods that have been developed to account for different measuring heights and scan duration of the two independent datasets. Our initial results indicate that high resolution SAR-based wind fields are well-suited to identify and quantify small scale wind variations and therefore represent a valuable complementary data source e.g. for numerical models of offshore wind farms and NWP in general. The wind processor is part of the operational processing chain at the DLR ground station Neustrelitz and wind field data can be provided within near-real-time to users. The wind processor is compatible with TS-X, TD-X and Sentinel-1 products.