SeaSAR 2018

Improving Sentinel-1 Ocean Wind Field Consistency and Accuracy by Minimizing Antenna Beam Signatures

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Abstract:

Wind information retrieval over the sea surface from microwave sensor data has a long and successful history. The accuracy of geophysical model functions (GMFs) applied to relate the microwave backscatter to wind speed and direction in 10m height has been continuously improved from early scatterometer missions to contemporary spaceborne SAR sensors like the current Sentinel-1 (S-1) pair. The statistical accuracy of SAR-based wind speeds is nowadays better than 2m/s (e.g. [1], [2], [3]) and therefore the data is appreciated by met-ocean modellers to validate and improve their models.
State of the art high resolution SAR systems can provide wind fields with a resolution of less than 100 m which have been successfully validated against co-located LiDAR data [4]. SAR-based data is particularly interesting for the offshore wind industry as it combines a resolution near to LiDAR capabilities and a large cross-track coverage of up to 250km for e.g. the two S-1 satellites. The S-1 systems work in TOPS SAR imaging mode, which has been designed to reduce the scalloping effect in burst mode SAR imaging, e.g. ScanSAR. The large spatial coverage of these systems allows wind park operators to get regular snapshots of entire marine regions such as the German Bight and cross-validate model data especially with focus on the impact of wind shadows of adjacent turbine clusters.

A close inspection of the Sentinel-1 Interferometric Wide Swath (IW) mode data over the ocean reveals antenna beam patterns remaining in the calibrated and noise-corrected data, resulting in discontinuous wind speed values across the beam boundaries. While of minor importance when calculating coarse wind fields of several kilometres resolution, high resolution wind fields as desired by offshore wind operators suffer from this uncertainty. A compensation for these errors contained in S-1 IW wind fields is believed to further increase the acceptance of SAR-bases wind data in both, industrial users of the data and the Numerical Weather Prediction (NWP) community for assimilation in met-ocean models.

We present an analysis of the impact of this effect on estimated wind fields based on more than 8000 Sentinel acquisitions with level-2 OCN data available and compare to high resolution ECMWF model data. We propose a correction scheme to minimize the beam pattern impact. The method can be applied to both, level-2 OCN data products and level-1 original IW image data.