Satellite-Based Monitoring of Wind Park Turbulent Wakes

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BACKGROUND

Figure 1. Location and layout of the offshore wind farm alpha ventus. Crosses and cirles indicat different turbine types with diameters of 126 m and 116 m (two southerly rows). One LiDAR was operated on the substation (◊) and two on the research platform Fino1 (□).

Spaceborne active microwave devices, such as Scatterometer and Synthetic Aperture Radar (SAR), apply Geophysical Model Functions (GMFs) to relate the observed Radar backscatter to sea surface roughness and associated wind speeds. However, GMFs are tuned with large footprints of SAR [1] or scatterometer data and were initially not designed to resolve small-scale structures such as wind turbine wakes or wind gusts. SAR images contain radar backscatter values at a high spatial resolution while retaining the large coverage area. Recent direct comparison of observations obtained by high resolution TerraSAR-X (TS-X) X-band SAR data and platform-based Doppler LiDAR installed in the German offshore Wind park Alpha Ventus reveled a remarkable agreement in the investigation of small scale wind field structures [2,3].

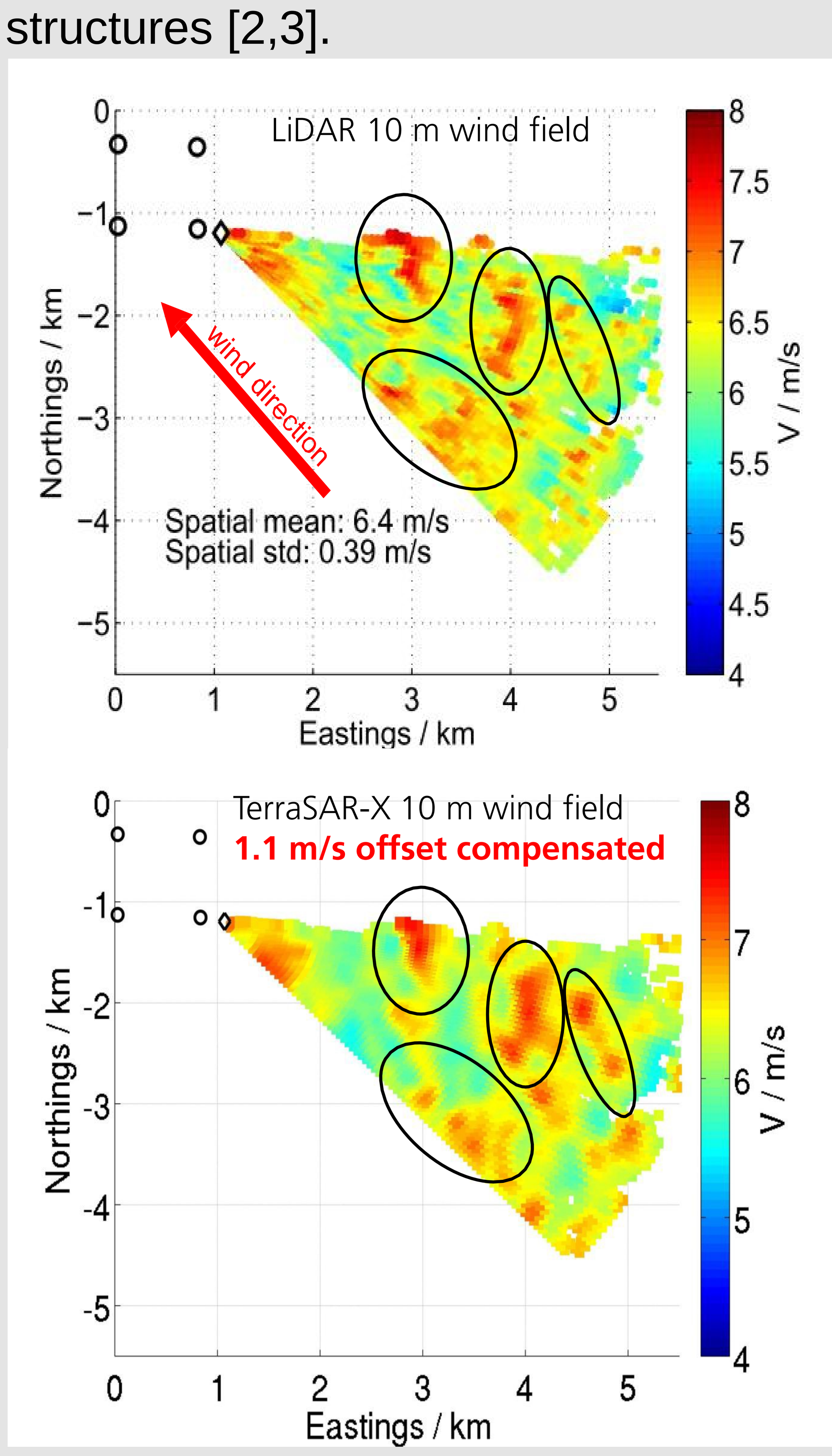

Figure 2: Comparison of LiDAR Wind Observations (top) and SAR-based Wind fields (bottom) [2].

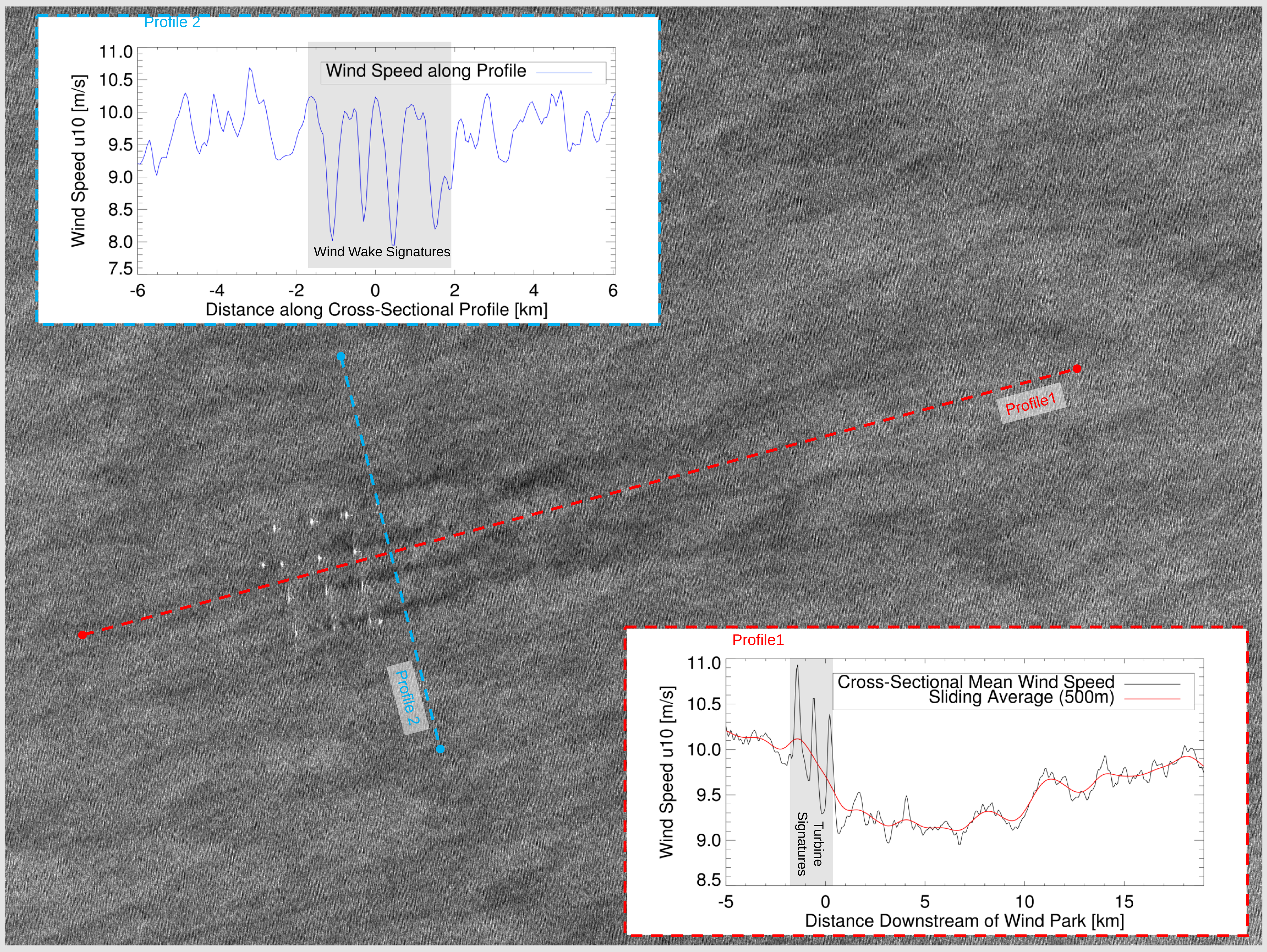

Figure 3: Radar backscatter image from Alpha Ventus Wind Park (Aug 23, 2012). Turbulent wakes of single turbines are visible. Inlet plots depict wind speed profiles. Full relaxation to background value occurs ~20 km downstream of this relatively small turbine array.

CONCLUSIONS

- SAR-based wind fields accurately describe small scale wind field variations and can be used to monitor turbine wake signatures
- On larger scales, SAR wind fields reveal shadowing effects of wind parks
- Statistical analysis of wind park shadows can be used to identify areas of possible influence of turbine arrays and quantify harvesting deficits due to adjacent parks

REFERENCES

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[3] J. Schneemann, J. Hieronimus, S. Jacobsen, S. Lehner, and M. Kühn, "Offshore wind farm flow measured by complementary remote sensing techniques: radar satellite TerraSAR-X and lidar windscanners," in Journal of Physics: Conference Series, 2015, vol. 625, p. 012015.

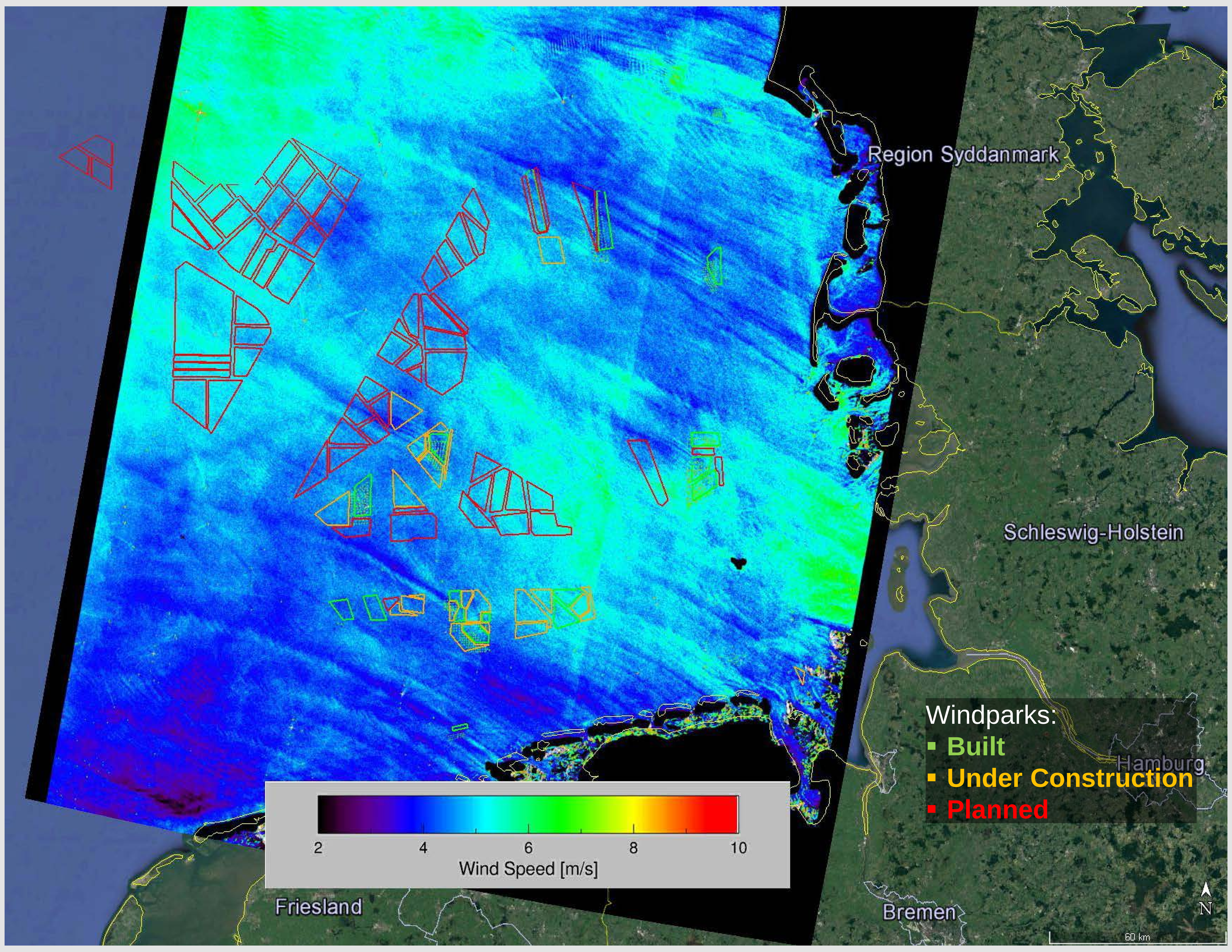

Figure 4: Windfield over the German Bight based on Sentinel-1 SAR data from Aug 20, 2015. Shadowing effects and turbulent wind wakes from larger offshore wind parks extend as far as 80 km.

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