Impact of atmospheric stability on offshore windpark wakes in the German Bight as observed by X-band and C-band Synthetic Aperture Radar

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C-band and X-band Synthetic Aperture Radar (SAR) data acquired by the Sentinel-1 and TerraSAR-X satellites are used to study atmospheric wakes behind offshore wind parks in the German Bight. A particular focus is on the impact of atmospheric stability on wake parameters like the wake length. Stability parameters are estimated from measurements taken at the FINO-1 observation platform. Based on a data set covering different seasons and concentrating on the first German offshore wind park Alpha Ventus (AV), it is shown that in this area stable atmospheric conditions favour longer wakes. This is first demonstrated for situations, where the wake behind AV was unperturbed by other neighbor wind parks. In this case wakes of more than 30 km length are observed. In a second step the more complicated situation with wake superposition from different neighboring wind parks is analysed. It is shown that in this case the merged wakes can extend to more than 70 km downstream. The analysis is challenged by two factors. First of all, the FINO-1 platform is within the wind farm wakes for a certain range of wind directions. This means stability estimates for the upstream conditions are not straightforward to obtain in these conditions. The second complication is associated with an apparent increase of radar cross section downstream of wind parks observed on many SAR scenes, typically within the first 10 km downstream the wind park. A semi-empirical model is proposed to explain this effect by an increased downward momentum flux associated with increased turbulence generated by the wind park. Applying numerical inversion methods, a couple of typical downstream wind speed profiles are reproduced with this model based on SAR derived estimates of the friction velocity.