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Use of Satellite Synthetic Aperture Radar (SAR) Images to tune a semi-empirical Model for Wind Speed Deficits downstream of offshore Wind Farms

A two-dimensional advection/diffusion model for the near sea surface wind speed deficit downstream of offshore windparks is fitted to satellite synthetic aperture radar (SAR) images. The Wake2Sea model enables the inclusion of offshore wind farm (OWF) wake effects in existing atmospheric model data at low computational costs and employs the standard Fitch parameterisation to describe the momentum sink associated with wind turbines.Model wind fields from the German weather centre are used as prior information about the unperturbed atmosphere without OWFs. Using 30 Sentinel-1A/B satellites SAR scenes acquired over the German Bight representing different stability and wind speed regimes, a 4DVAR scheme is applied to optimize the agreement between simulated and observed radar cross sections. The method adjusts 8 parameters in the wake model and also applies corrections to the background wind field on a spatial scale of 40 km. An L-curve analysis is applied to choose the weighting of prior knowledge and observations in the cost function. The method improves the match between observations and simulations significantly, if uncorrected model wind fields are used as a baseline. Furthermore, the inclusion of the empirical wake model leads to improvements when the background corrected wind field is used as a reference. Comparisons with data measured at the fixed platform FINO-1 adjacent to the first German offshore wind park Alpha Ventus, showed that the proposed inclusion of wakes in the atmospheric model data leads to a significantly improved match.

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