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Ocean wind retrieval from Sentinel-1 SAR and its potential for offshore wind energy

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Retrieval of ocean wind maps from Synthetic Aperture Radar (SAR) is performed routinely at several different research institutions and the European Space Agency (ESA) delivers a Level 1 Ocean Wind (OWI) product based on Sentinel-1 SAR observations. Satellite-based wind maps with an unprecedented coverage and spatial resolution are thus freely available to users in academia as well as for commercial applications. One application of such maps is within offshore wind energy. The planning and development of new wind farms is progressing rapidly; especially in Northern Europe. Since wind measurements at sea are costly and sparse, the use of satellite wind fields as a supplement to ground based measurement techniques holds a promising potential.

In this presentation, the accuracy of Sentinel-1 SAR wind retrievals in the coastal zone is first determined through comparisons with observations from scanning lidars located at the coastline. The horizontal wind speed gradients measured by the scanning lidars are reproduced by the SAR wind speed retrievals. This suggests that SAR wind fields are reliable in nearshore areas up to 1 km from the coastline even though the geophysical model functions applied for the wind retrieval processing are tuned to wind conditions over the open ocean.

The capabilities of SAR wind maps for prediction of wind resources and wake effects of neighboring wind farms is investigated for the Danish wind farm site Anholt. The spatial wind speed variability as predicted from Sentinel-1 observations is in very good agreement with the variability given by wind speed measurements at individual turbines within the wind farm. Satellite-based wind retrievals for the period before (Envisat) and after (Sentinel-1) the year 2013, when the wind farm was erected, show significant differences in the mean wind climate on the lee side of the wind farm. These effects can be associated with the wind power extraction and the formation of a turbulent wake downstream of the wind farm. For certain directional sectors, the interplay between the wind farm wake and coastal wind speed gradients is too complex for resolving the effect of the wind farm on the local wind climate.

Although we have processed SAR scenes to wind maps in a consistent manner since 2002, it is important to analyze the consistency between wind retrievals from different SAR sensors before merging these in connection with climatological analyses of the wind power potential. We have compared the SAR wind maps retrieved from Envisat and Sentinel-1 against other data sources i.e. in situ observations, scatterometer wind speeds, and outputs from Numerical Weather Prediction (NWP) models. Preliminary results suggest that there is currently a minor offset between wind speed retrieved from Sentinel-1 and Envisat. Further analyses at additional sites are required to confirm this finding.