Offshore wind farm wake study using Envisat ASAR and Radarsat in the North Sea

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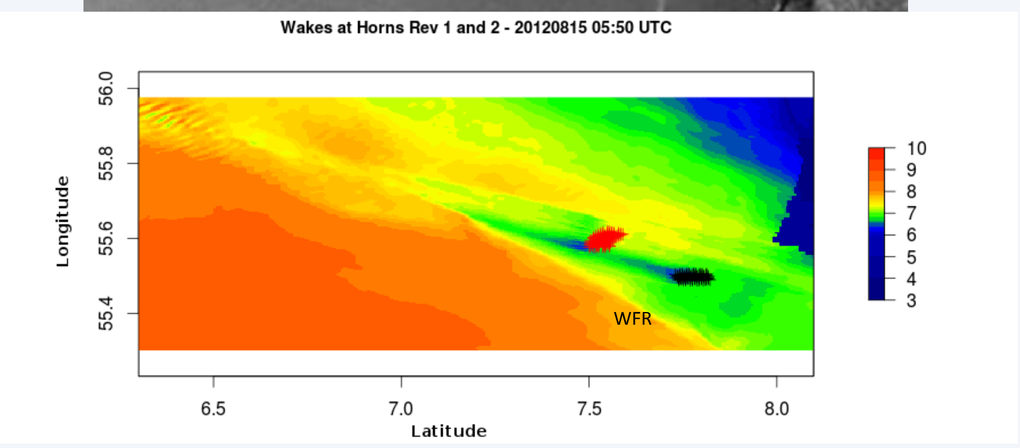
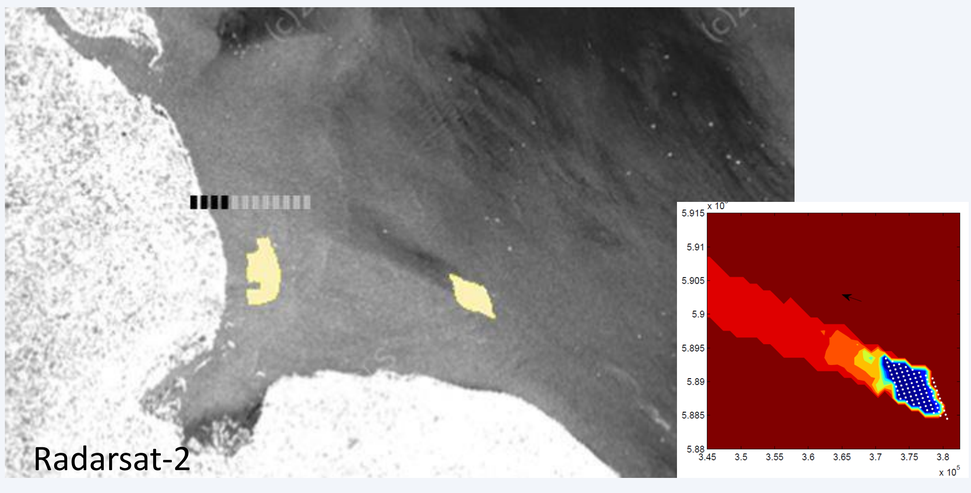
Introduction

Offshore wind farm projects in the Northern European Seas are expanding fast. According to EU plans a major share of renewable energy will be from offshore wind farms. The strategic planning in each country depends upon knowledge on the offshore wind resource and a list of environmental conditions among other topics. Once offshore areas have been designated for possible wind farm construction the development plans initiate. It is of importance to ensure a reliable estimate of physical conditions as well as of the economic terms. The FP7 project Design Tools for Offshore wind farm Clusters (DTOC) with partners from the European Energy Research Alliance (EERA) and valuable industrial participants addresses some of the challenges of planning offshore wind farm clusters. A major effort is on integration of software needed for calculation of annual energy production, estimation of the wind farm losses such as wake deficit, electrical losses among others and also the cost of inter-array and long-distance electrical cables.



The wind farm wakes (notice dark area downstream) at Horns Rev-1/-2 near Denmark from Radarsat-2 and the WRF wake model results.



The wind farm wake (notice dark area downstream) at Sheringham Shoals near the UK from Radarsat-2 and the PARK wake model results.

Method

In the EERA DTOC project images from Envisat ASAR and Radarsat are used to assess the wind conditions near the wind farms. It is observed that the wind farms influence the winds in their neighborhood. Downwind of a wind farm an area with less wind, i.e. reduced wind, as compared to the non-disturbed flow, is observed on several occasions. Clearly this is due to energy extracted from the wind by the wind turbines. The models used for wake deficit calculation mainly have been focused on near-field wake properties for single turbines, as the near-field wake properties with reduced wind speed and increased turbulence levels are important for the decision on how closely to position the turbines, the choice of turbines size and type, etc. In recent years though, the combined effect of a wind farm wake is becoming increasingly interesting to assess for wind farm developers because several wind farms are planned rather closely. That is at distances where the energy extracted from one wind farm will influence neighboring wind farms for certain wind directions and atmospheric conditions.

Results

The focus of the satellite-based study on offshore wind farms hence addresses this topic. Only high-resolution Synthetic Aperture Radar (SAR) images are able to observe the full picture of the wind conditions. Around 50 examples of wind farm wakes are identified in the satellite data. The preliminary results from wake models able to model also the far-field wake are presented and discussed.

Discussion and conclusion

The work is interesting from the scientific perspective of using high-resolution SAR wind retrieval and comparing to atmospheric observations, wind farm information and new state-of-the-art wind farm wake models.

The results show far longer wind farm wakes than previously observed and some wake models are able to model the cases convincingly.

From an applied economical perspective the results may influence decisions among wind farm operators, strategic planners and wind farm developers.

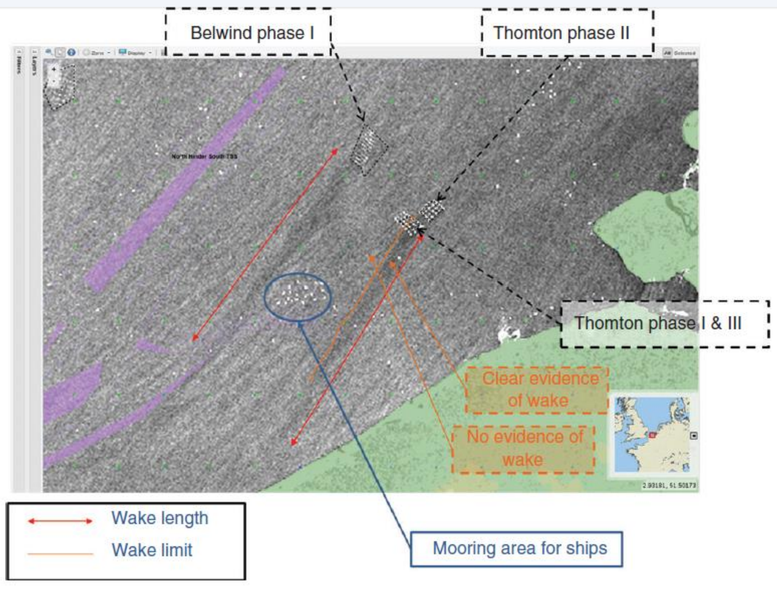
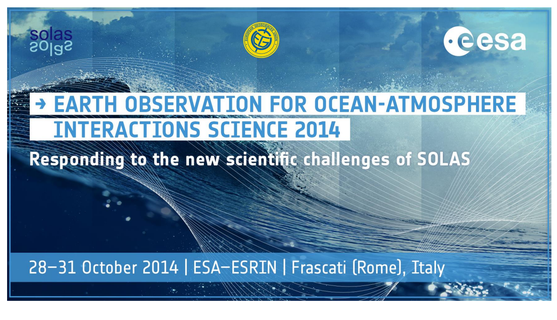


FIGURE 5 | Offshore wind farm wake in the North Sea observed by Radarsat-2. The SAR image is processed by CLS. (Copyright RADARSAT-2 Data and Products © MacDonald, Dettewiler and Associates Ltd.)

From Hasager, CB 2014, 'Offshore winds mapped from satellite remote sensing' *Wiley Interdisciplinary Reviews: Energy and Environment*. 10.1002/wene.123



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