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

Charlotte Bay Hasager¹, Romain Husson², Pauline Vincent², Merete Badger³, Patrick Volker², Alfredo Peña², Jake Badger¹, Elena Cantero³, Ana Palomares⁴, Alexis Mouche⁵, ¹DTU Wind Energy, Denmark, ²CLS, France, ³CENER, Spain, ⁴CIEMAT, Spain, ⁵IFREMER, France

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 the offshore areas. The work is supported by EERA DTOC project funded by FP7 ENERGY-2011-1/ n° 282797.

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.

Acknowledgements
•The work is supported by EERA DTOC project funded by FP7-ENERGY-2011-1/ n° 282797.
•Envisat ASAR data are from ESA. Radarsat data are from MacDonald, Dettwiler and Associates Ltd.