

→ ATLANTIC FROM SPACE WORKSHOP

23–25 January 2019
National Oceanography Centre
Southampton, UK

Satellite SAR Winds for
Offshore Wind Farm
Planning and Wind
Farm Wake Interaction

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DTU Wind Energy

DTU Wind Energy is an internationally leading research center for wind energy.

DTU Wind Energy is the largest university department for wind energy in the world.

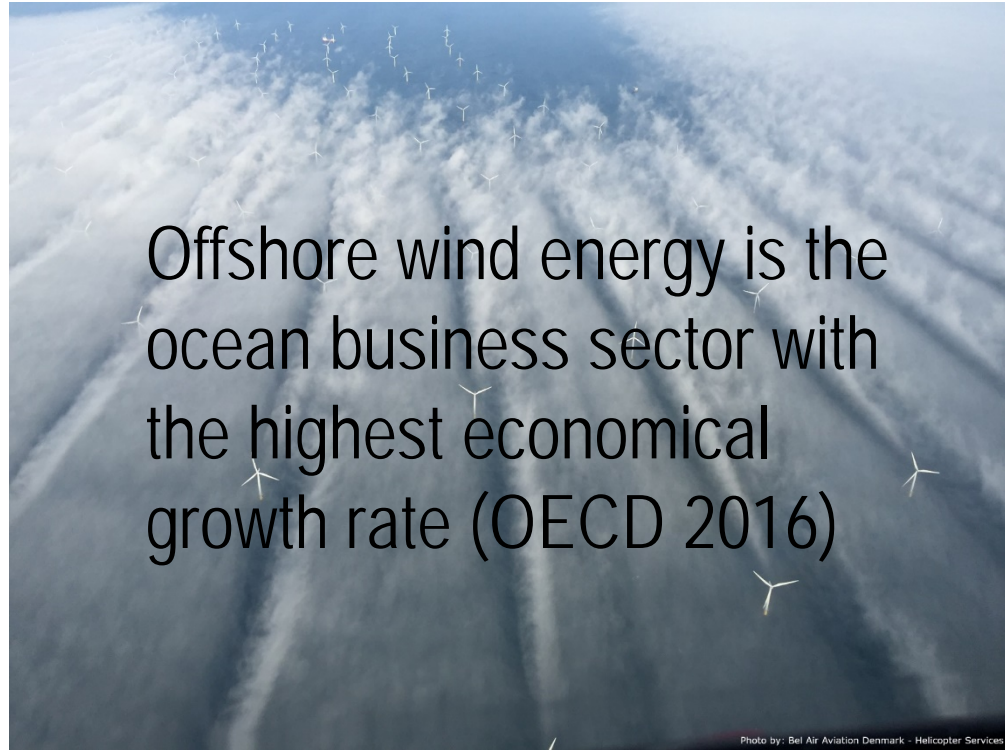
230+ employees
hereof 150+ academics and 40 PhD students.



European wind industry contributed EUR 36 billion to the EU's GDP in 2016, supports 263,000 jobs and generated EUR 8 billion of exports.

Much of the industry and supply chain is located in economically less-advantaged areas, bringing quality jobs to those areas: 82% of the 263,000 jobs are high-skilled.

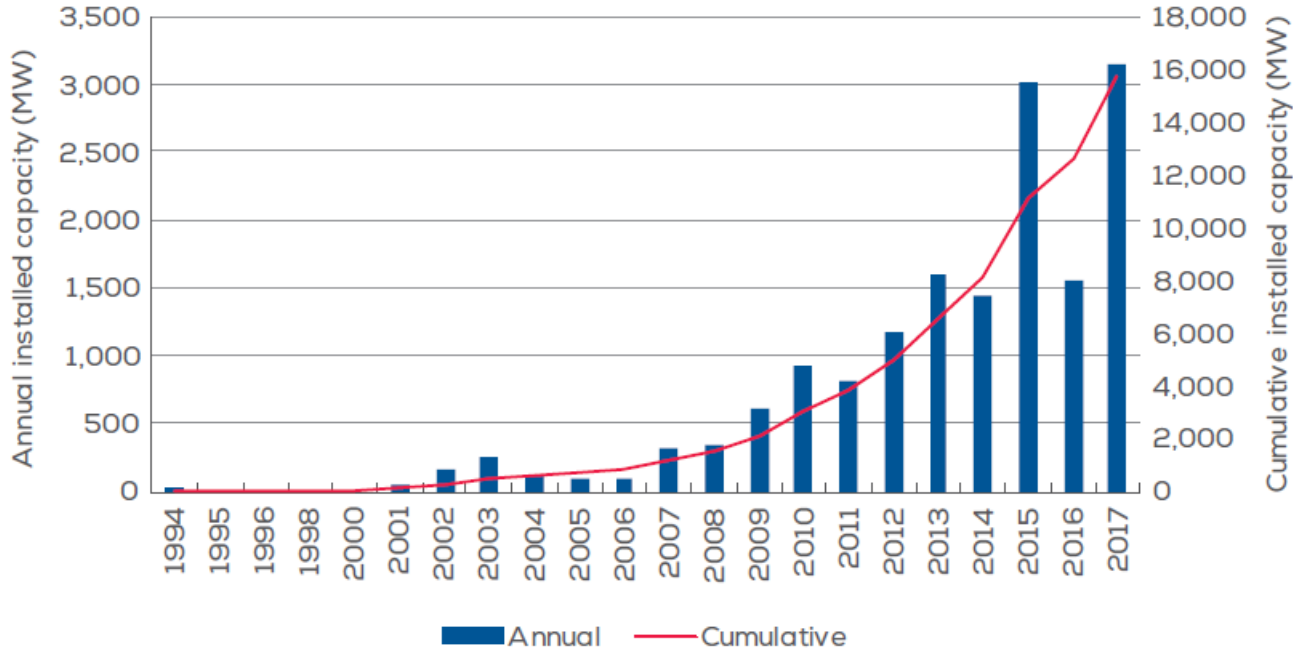
Source: WindEurope.



Offshore wind energy capacity in Europe



Cumulative and annual offshore wind installations (MW)



4,149 offshore turbines.

Two 350 MW wind farms, to be built by 2022 offshore in the Netherlands, will be the world's first to be built without public subsidy.

Source: WindEurope

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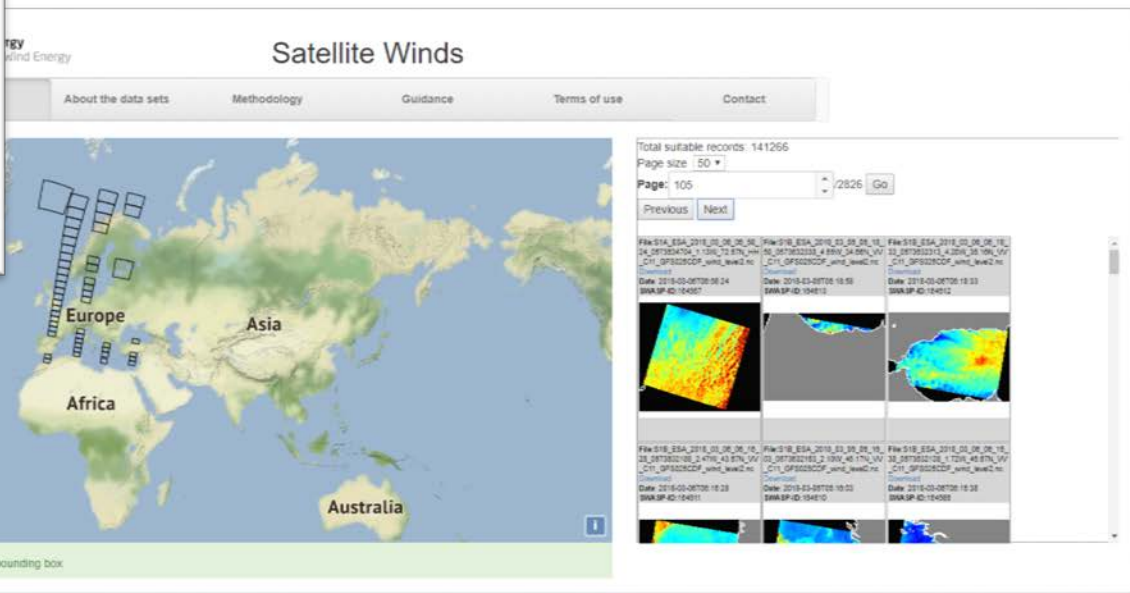
Plus Envisat and S-1 wind maps along the US East coast

View, search and download wind maps:

<https://satwinds.windenergy.dtu.dk/>

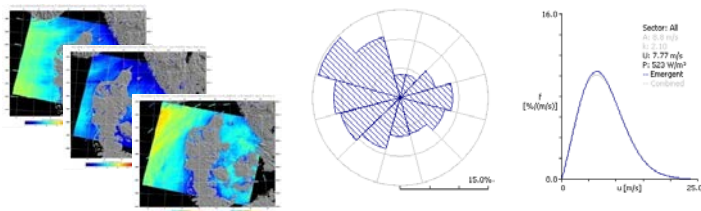


Image courtesy: Google Earth

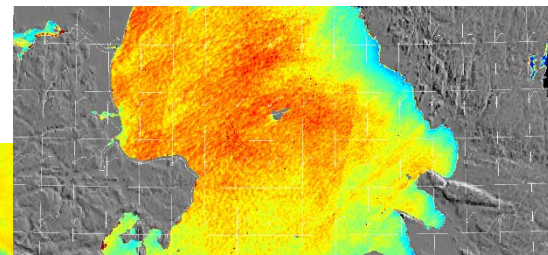


The screenshot shows the 'Satellite Winds' website interface. At the top, there is a navigation bar with links for 'About the data sets', 'Methodology', 'Guidance', 'Terms of use', and 'Contact'. Below this is a world map with a bounding box drawn over Europe. To the right of the map, there is a search and filter section with 'Total suitable records: 141266', 'Page size: 50', and 'Page: 105' of 2826. Below the search section, there is a grid of wind maps. Each map has a small thumbnail and a list of metadata including file names, dates, and IDs.

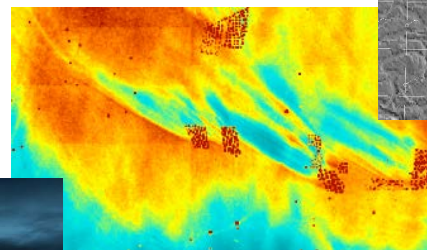
- Mean wind conditions



- Horizontal coastal wind speed gradients



- Wind farm wake effects



Courtesy: Patrick Volker, OffshoreWake project

- Extreme events



Courtesy: Hybrid Wind

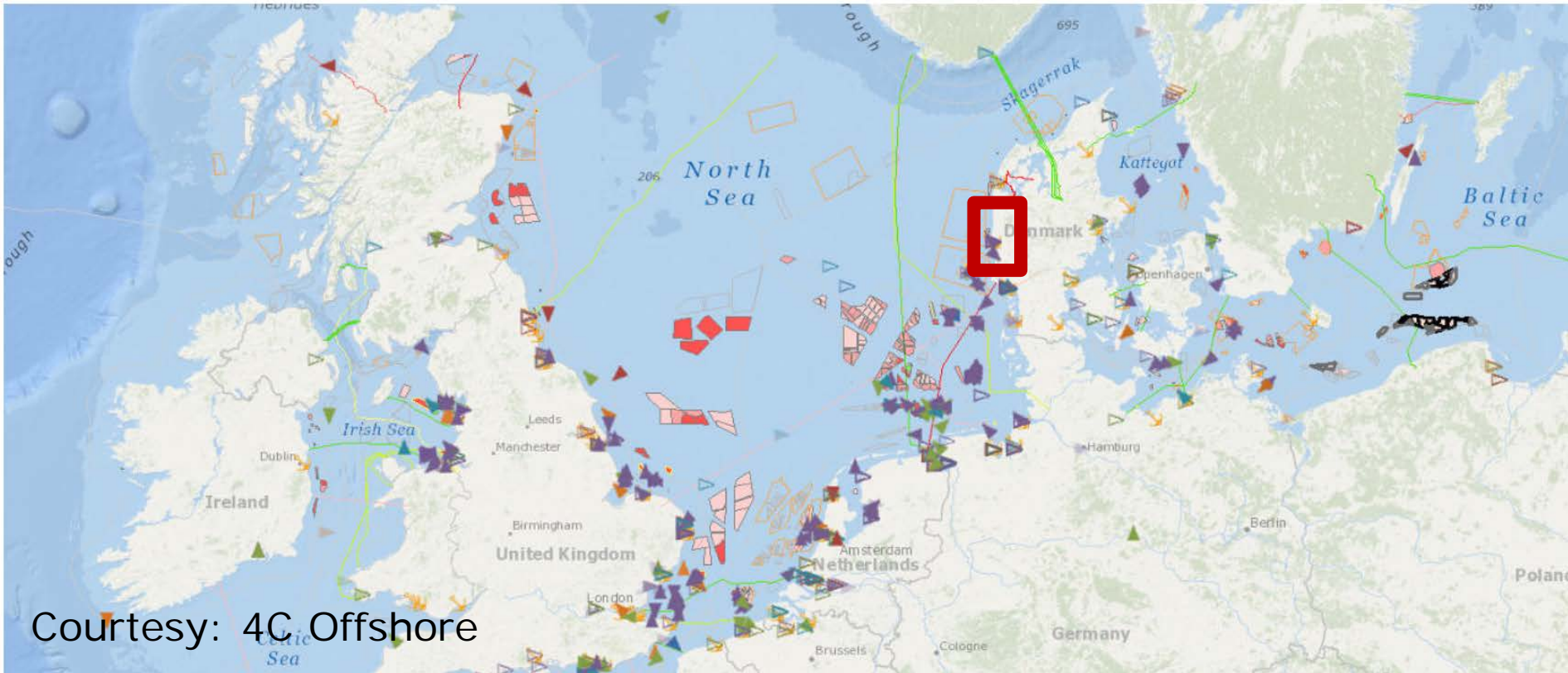
Can we observe wind speed near coastlines with SAR as observed with horizontal scanning lidar?

Can SAR detect coastal wind speed gradients as observed in the wind farm?

Are SAR wind speeds and turbine wind speeds comparable?

Can we see the wake of the wind farm from SAR?

Map of offshore wind farms



Courtesy: 4C Offshore

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European Space Agency

Wind speed comparisons – horizontal scanning lidar

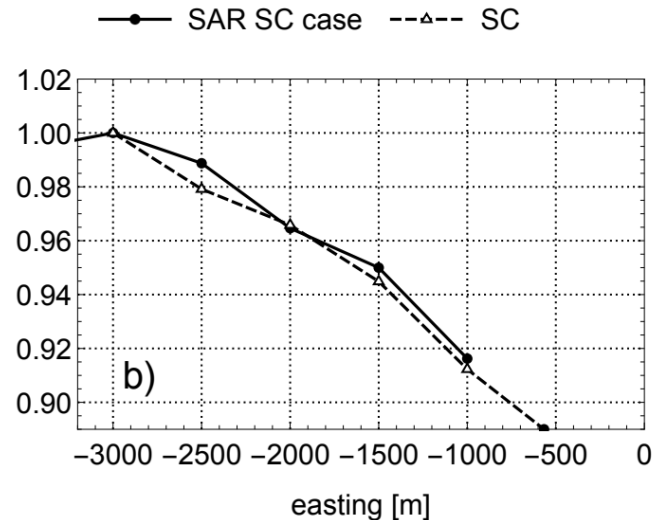
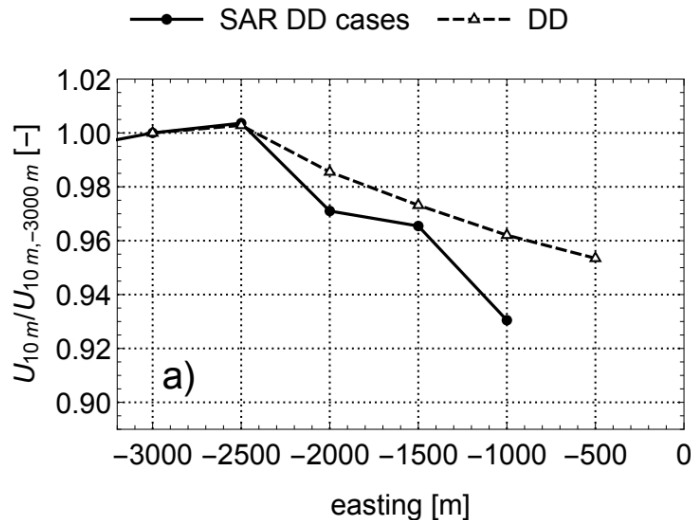
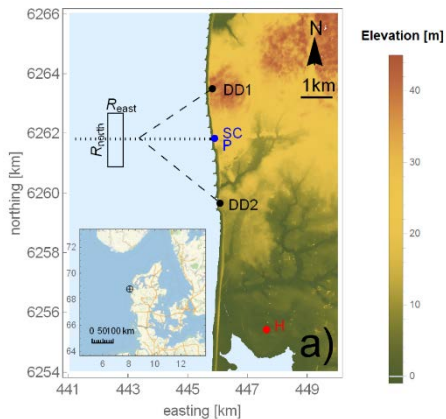
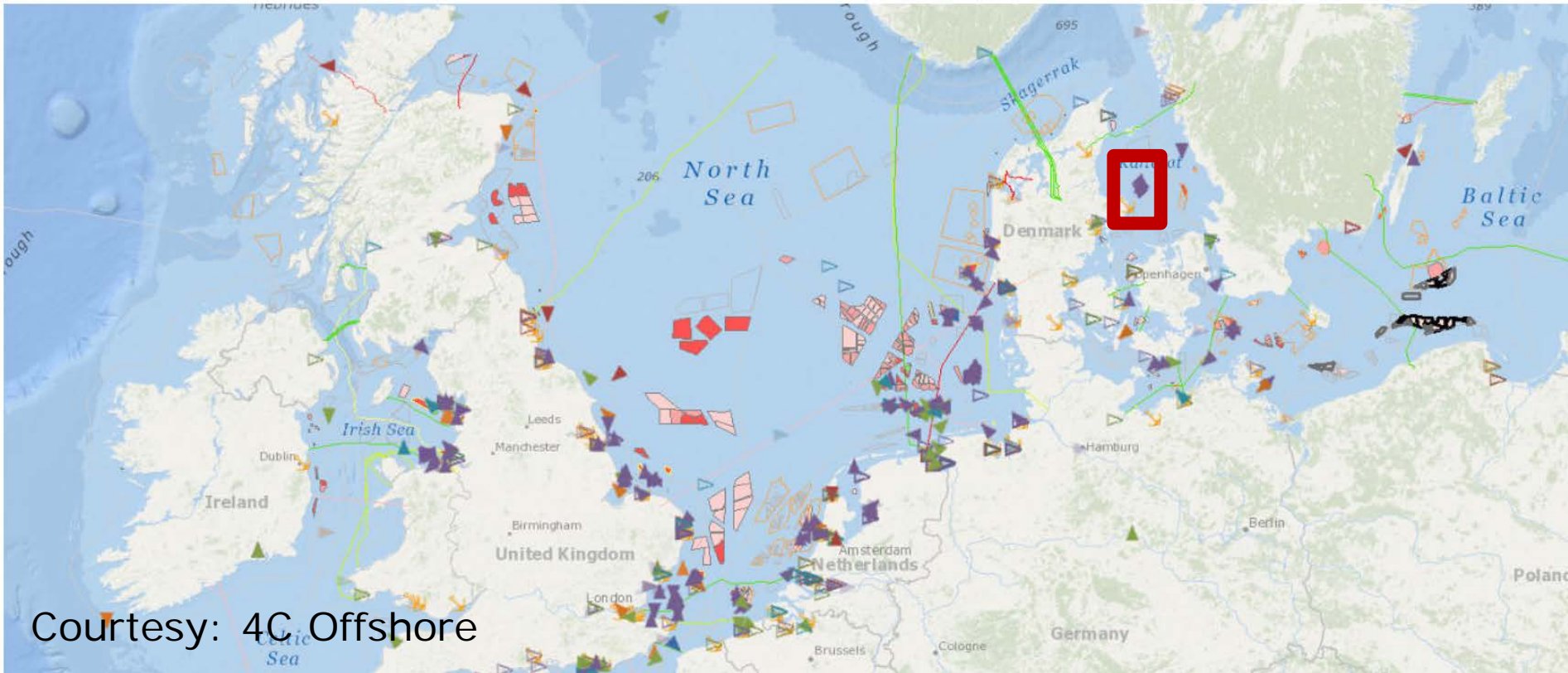


Figure 6. Relative wind speed nondimensionalized with the wind speed at -3000 m for from the LiDAR and the SAR for (a) the dual Doppler and (b) the sector scans.

From: Ahsbahs, T.; Badger, M.; Karagali, I.; Larsén, X.G. Validation of Sentinel-1A SAR Coastal Wind Speeds Against Scanning LiDAR. *Remote Sens.* **2017**, *9*, 552, doi: [10.3390/rs9060552](https://doi.org/10.3390/rs9060552)

Map of offshore wind farms



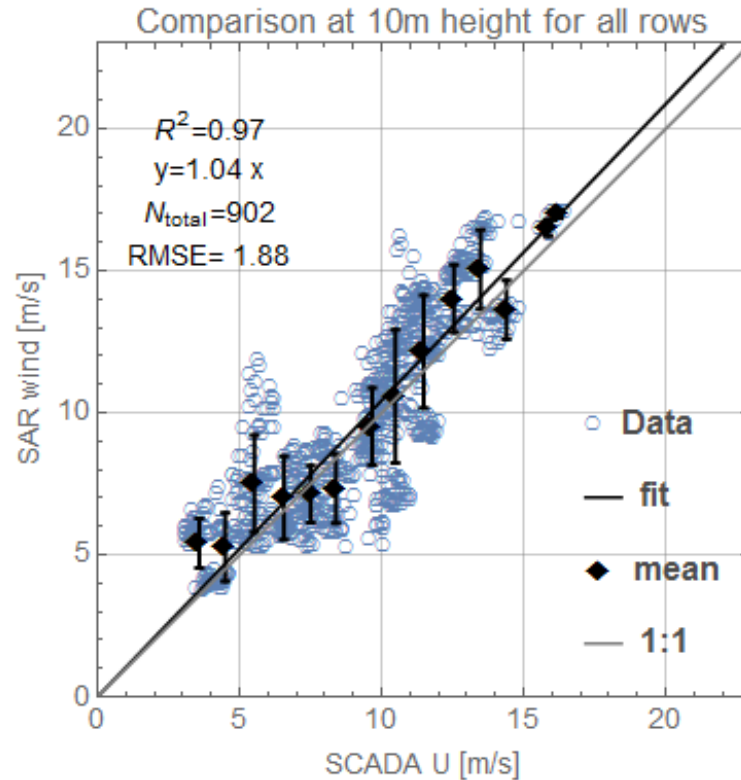
Courtesy: 4C Offshore

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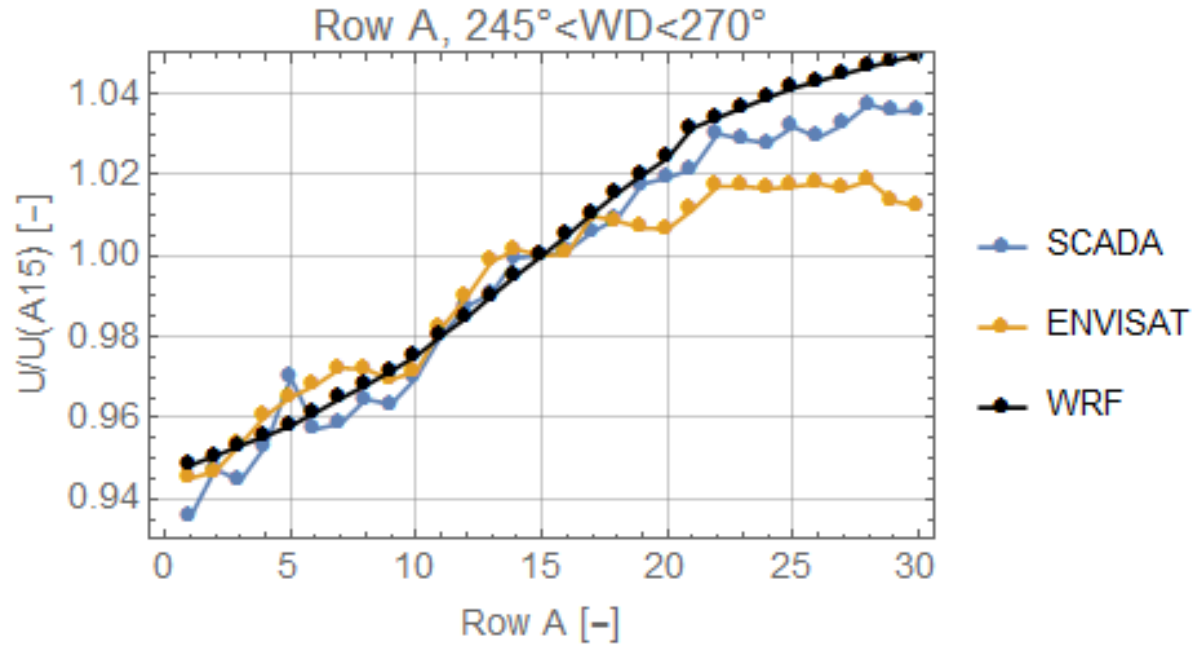
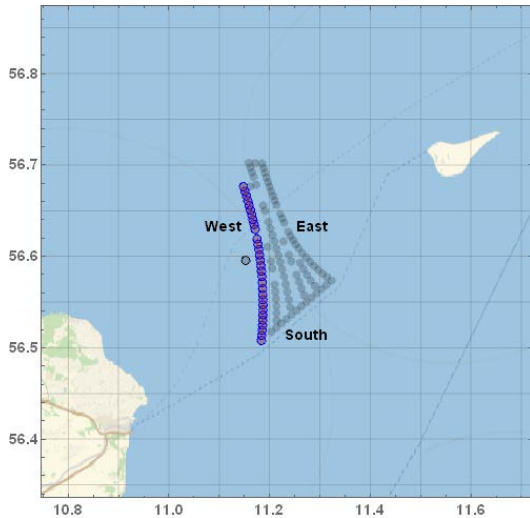
European Space Agency

Comparing SAR and wind turbine wind speed



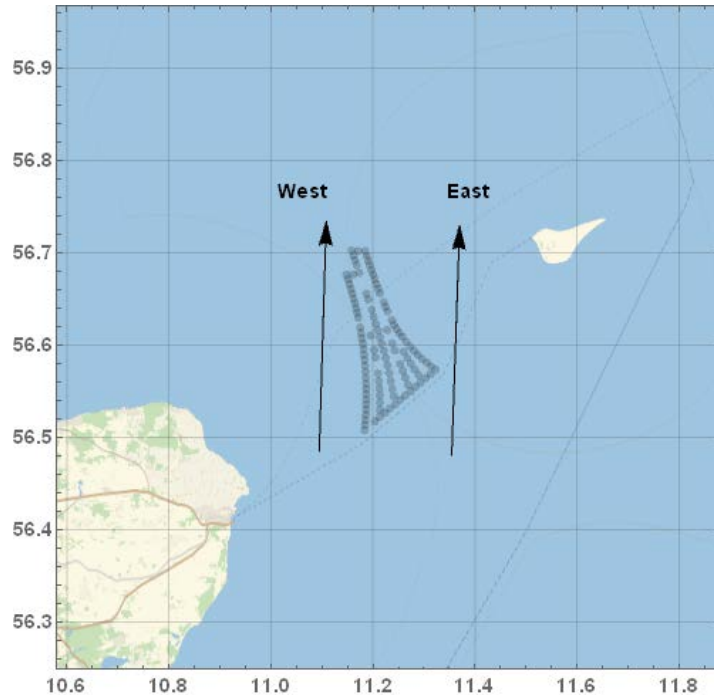
Ahsbaks *et al.* 2018

Comparing wind speed gradient



Ahsbals *et al.* 2018

Comparison study with and without wind farm



Satellite data available:

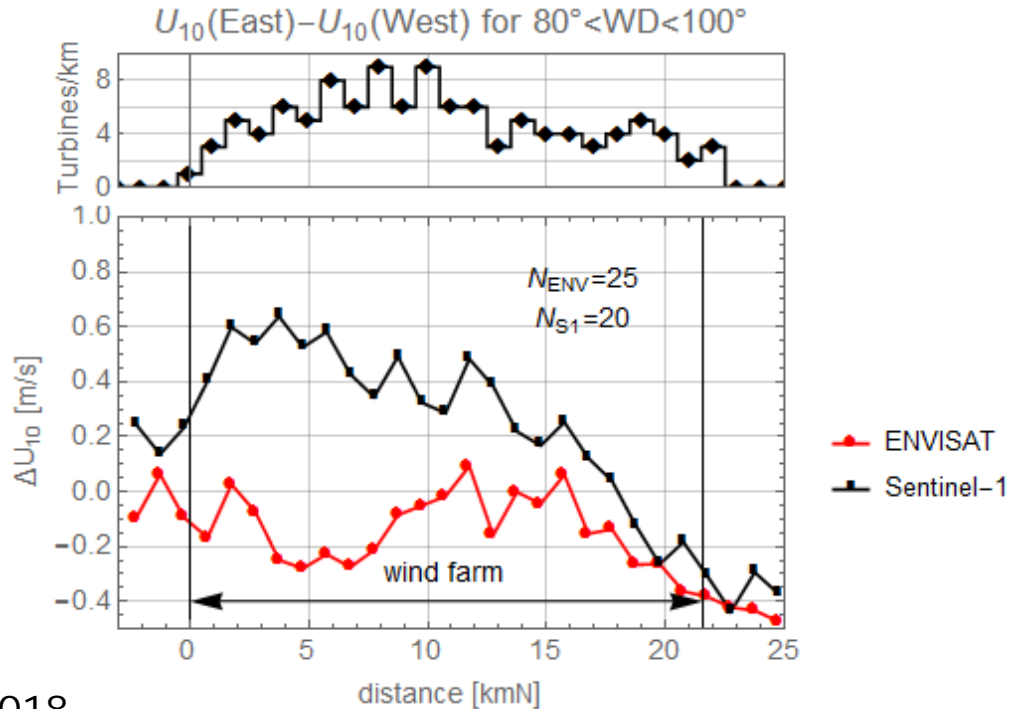
Envisat before wind farm was built

Sentinel-1 after wind farm was built

Two transects

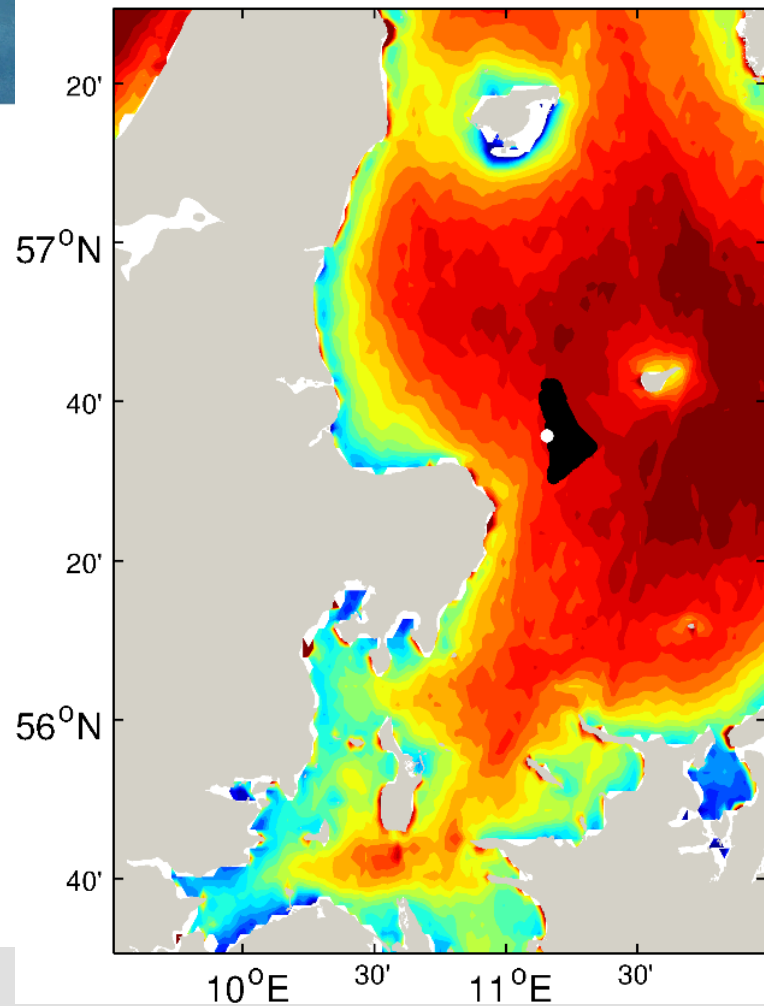
Ahsbahr, T., Badger, M., Volker, P., Hansen, K. S., and Hasager, C. B.: Applications of satellite winds for the offshore wind farm site Anholt, *Wind Energy. Sci.*, 3, 573-588, <https://doi.org/10.5194/wes-3-573-2018>, 2018.

Comparing SAR winds with and without wind farm to identify wind farm wake behind wind farm

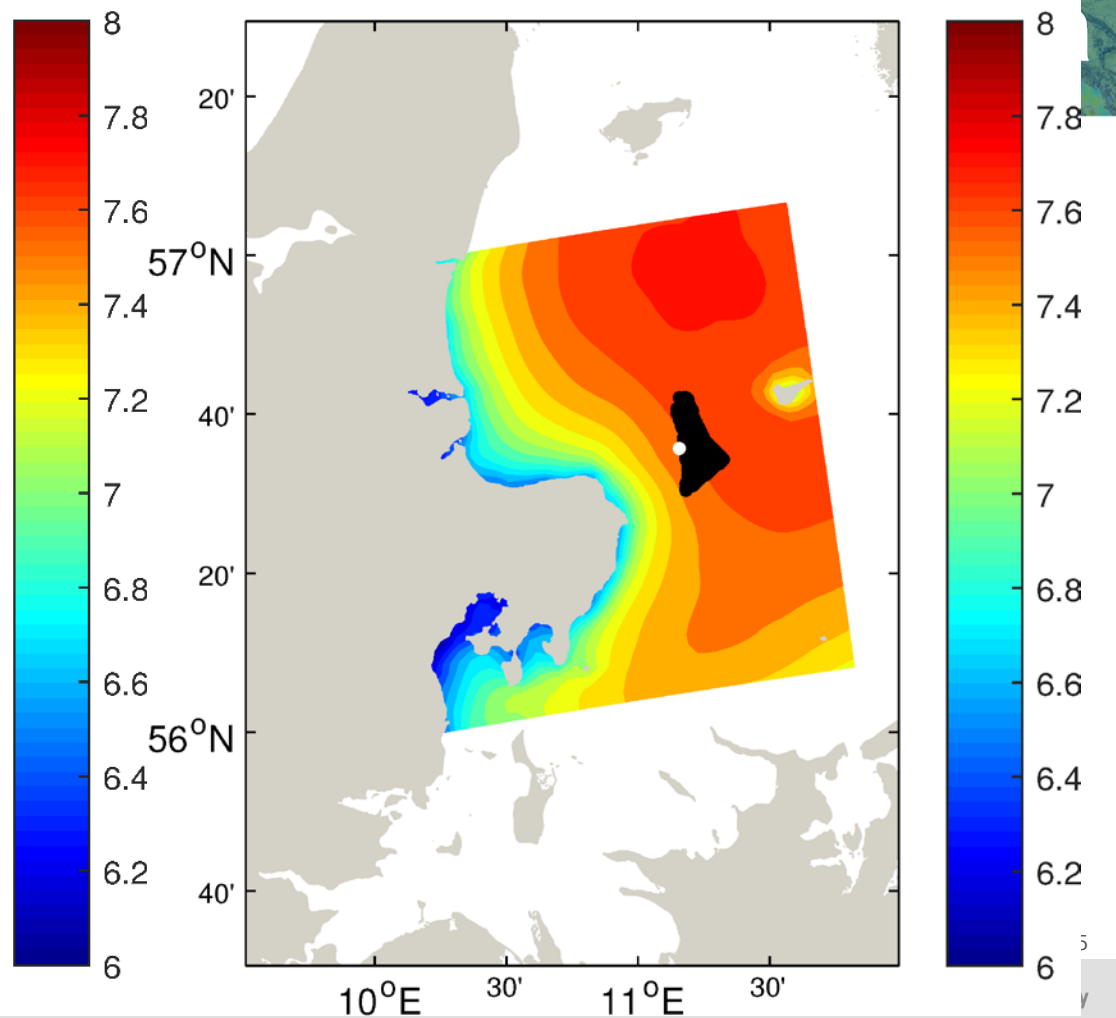


Ahsbabs *et al.* 2018

SAR – no wind farm



WRF – 2014



Can we observe wind speed near coastlines with SAR as observed with horizontal scanning lidar? YES

Can SAR detect coastal wind speed gradients as observed in the wind farm? YES

Are SAR wind speeds and turbine wind speeds comparable? YES

Can we see the wake of the wind farm from SAR? YES

Conclusions



- Open access to SAR observations and derived products has eased application in the wind energy community
- Wind resources offshore can be mapped from SAR
- SAR wind samples have reached numbers that are satisfactory for wind energy resource assessment – and new data is collected daily
- Coastal gradient offshore wind speeds are well captured by satellite SAR
- Wind farm wakes offshore can be quantified from SAR
- (Methods for wind extrapolation from 10 m to the turbine hub height exist)



- Satellite SAR data from the European Space Agency and Copernicus.
- The SAR Ocean Products System (SAROPS) by the Johns Hopkins University, Applied Physics Laboratory and the US National Atmospheric and Oceanographic Administration (NOAA).
- Wind turbine data from Ørsted.
- This work received funding from the EU H2020 program under grant agreement no. 730030 (CEASELESS project), ERANET+ (NEWA project), and the Danish National Funding programme ForskEL (RUNE project).

Policy/business

- Clarify the policy for wind information for planning offshore wind farms. Could it become part of Copernicus?
- Distinguish between wind forecasting every hour and wind resource statistics!

Technical

- SAR-based wind retrieval and scatterometer offer potential in wind energy planning. Consider data delivery/responsibility.

Future need/networking

- Offshore wind energy is key driver in the ocean energy growth and business. It would be relevant to form a cluster/group to contribute more dedicated and relevant to Copernicus.
- Technical, business, energy security, environmental conditions, societal acceptance, etc.