Anholt offshore wind farm wake investigated from satellite data and wake models

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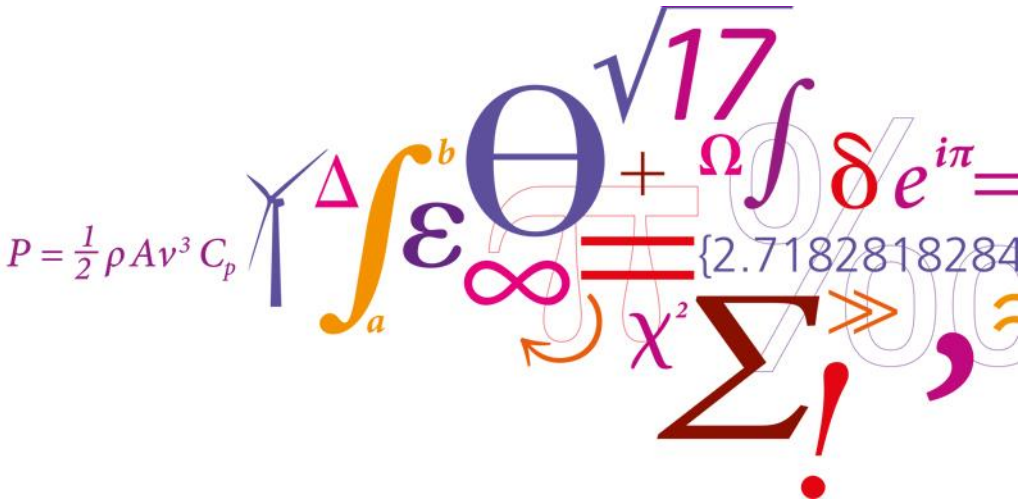


DTU Wind Energy
Department of Wind Energy

Offshore Wind Energy Conference, 6-8 June 2017, London, UK

Anholt offshore wind farm

Research question

How well can we quantify the wake effect from modelling and satellite?

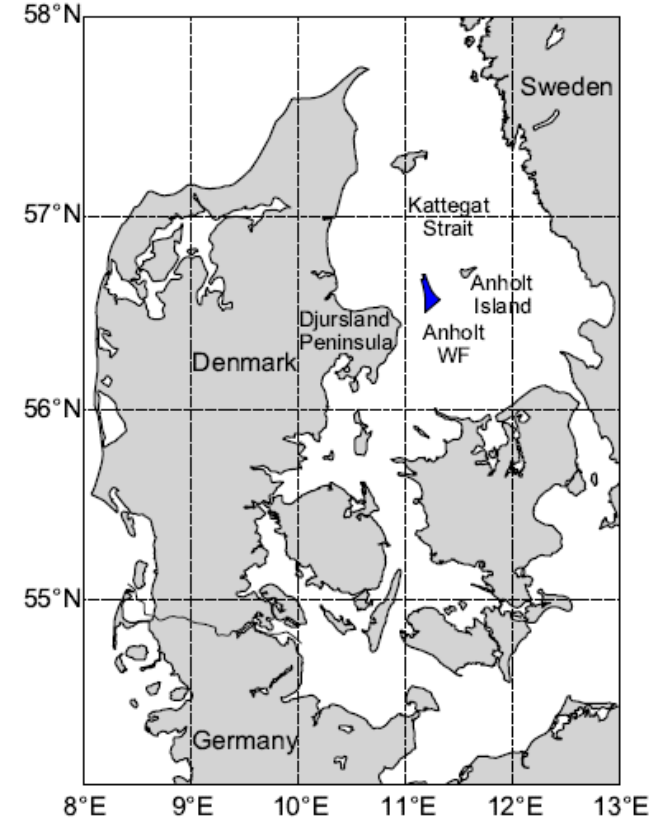
Sub-task:

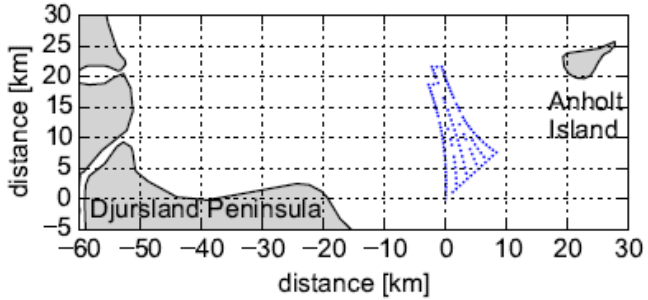
How large is the coastal wind speed gradient?

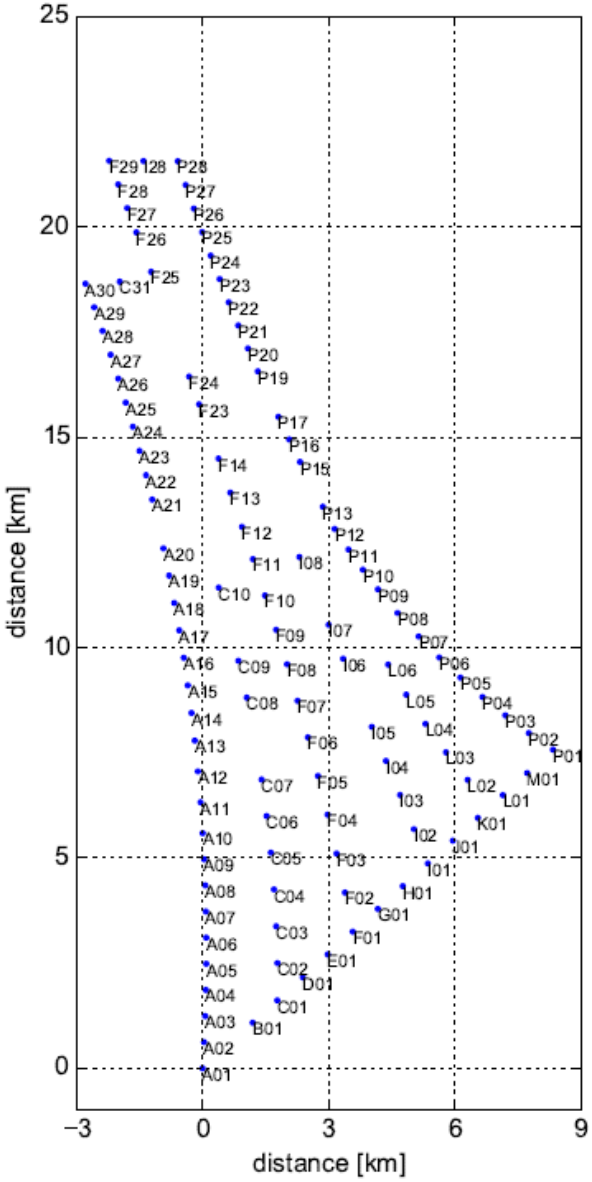
Data

- Supervisory control and data acquisition (SCADA)
- Satellite Synthetic Aperture Radar (SAR)
- Weather Research and Forecasting model (WRF)
- Reynolds-averaged Navier-Stoke model (RANS)

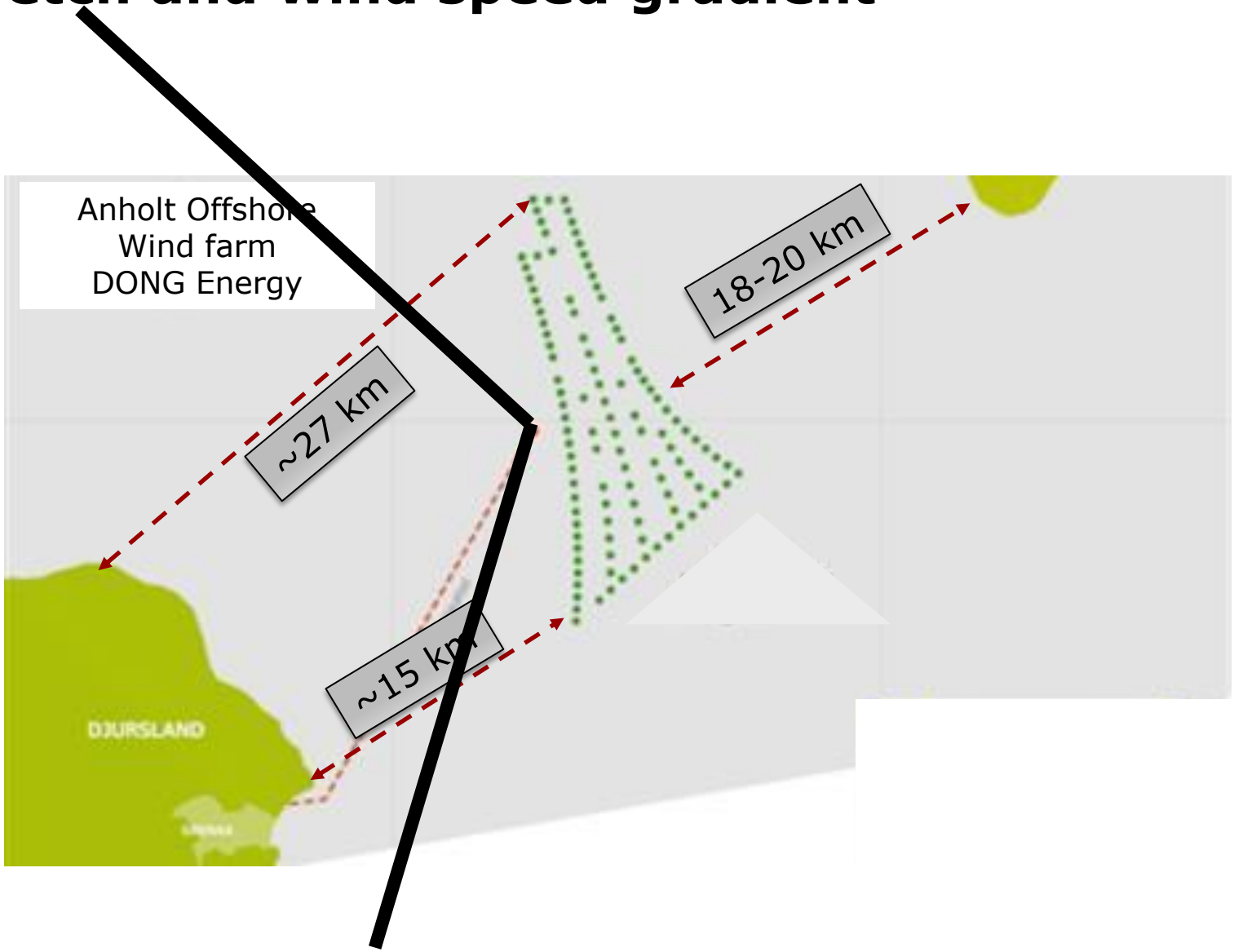
Location


58°N
57°N
56°N
55°N
8°E
9°E
10°E
11°E
12°E
13°E
Sweden
Kattegat
Strait
Anholt
Island
Anholt
WF
Djursland
Peninsula
Denmark
Germany


distance [km]
distance [km]
Djursland Peninsula
Anholt
Island

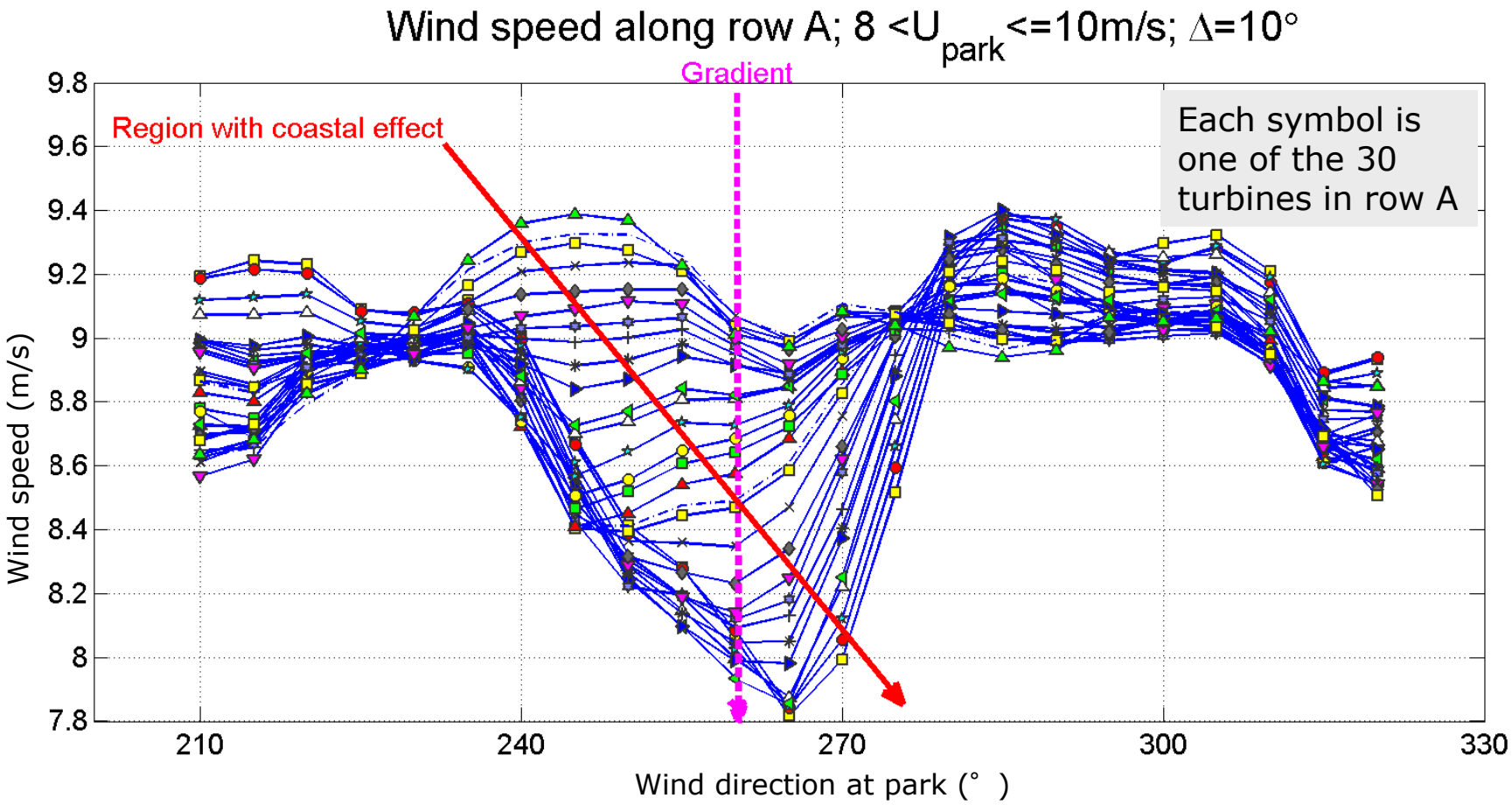

distance [km]
distance [km]

Fetch and wind speed gradient



Coastal wind gradient investigation

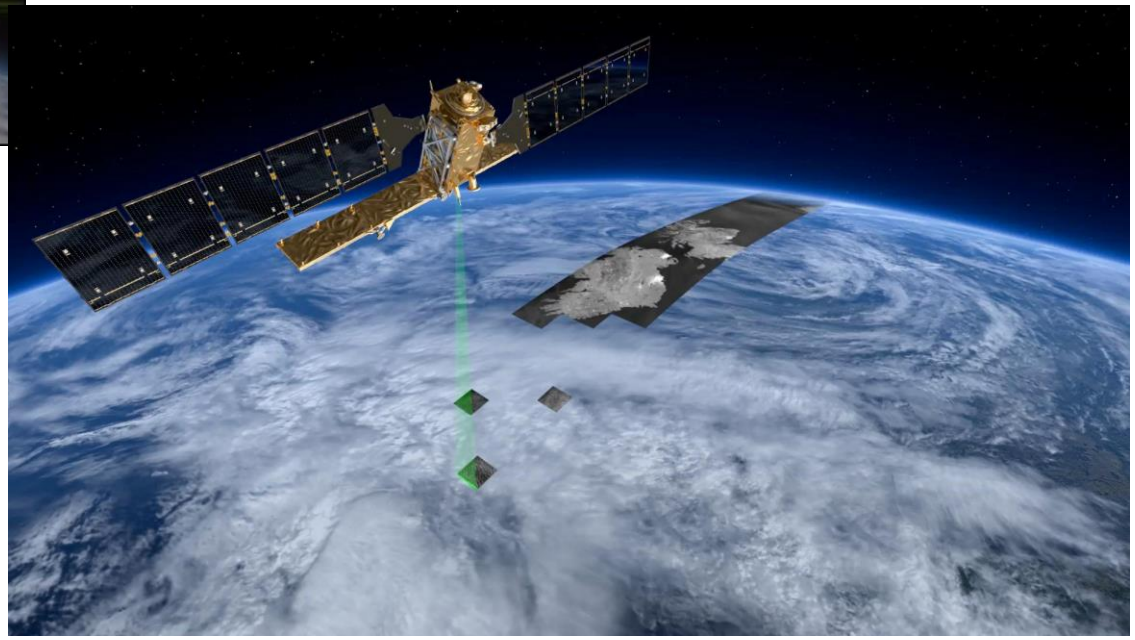
SCADA
Wind speed interval 8 to 10 m/s
Westerly flow from 210 ° to 320°



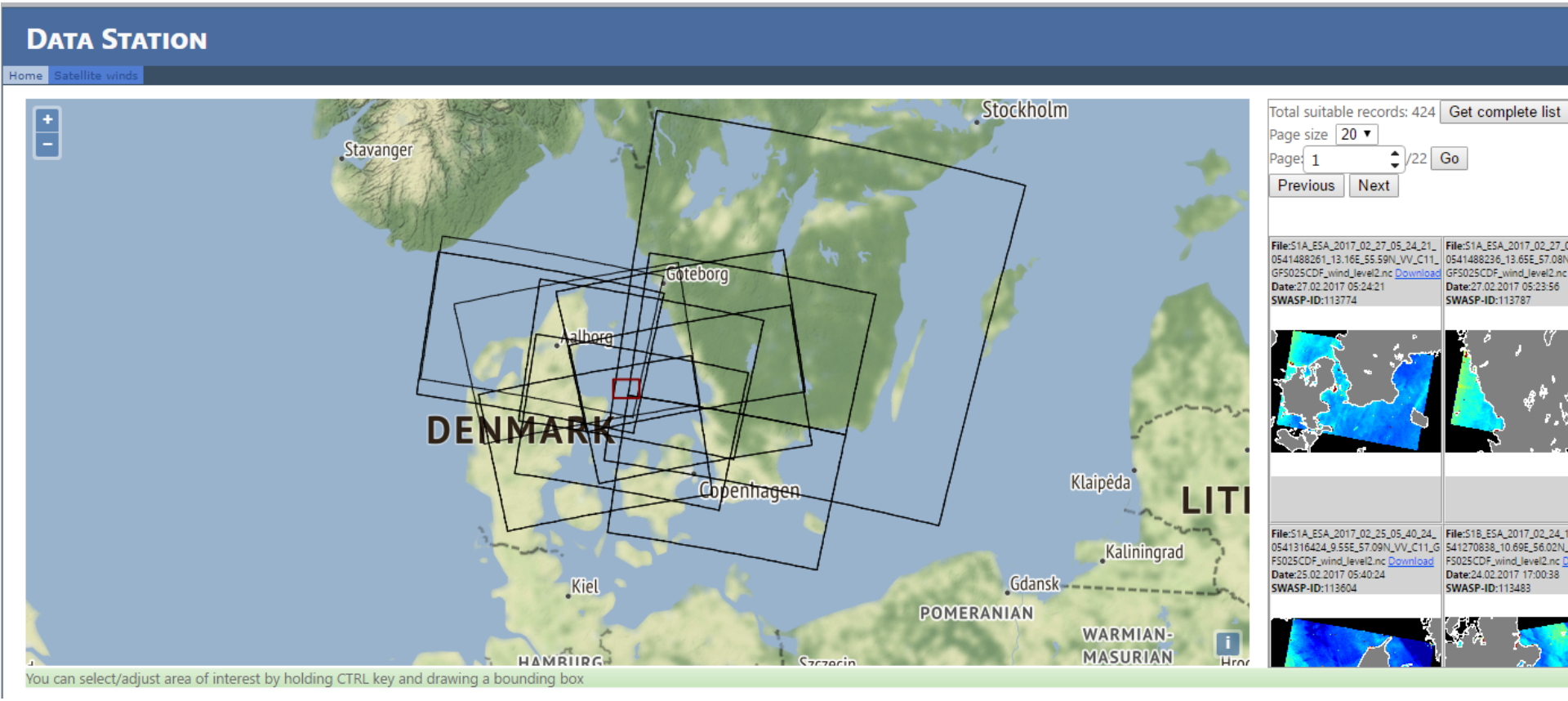
European satellites with SAR

Envisat
2002-2012

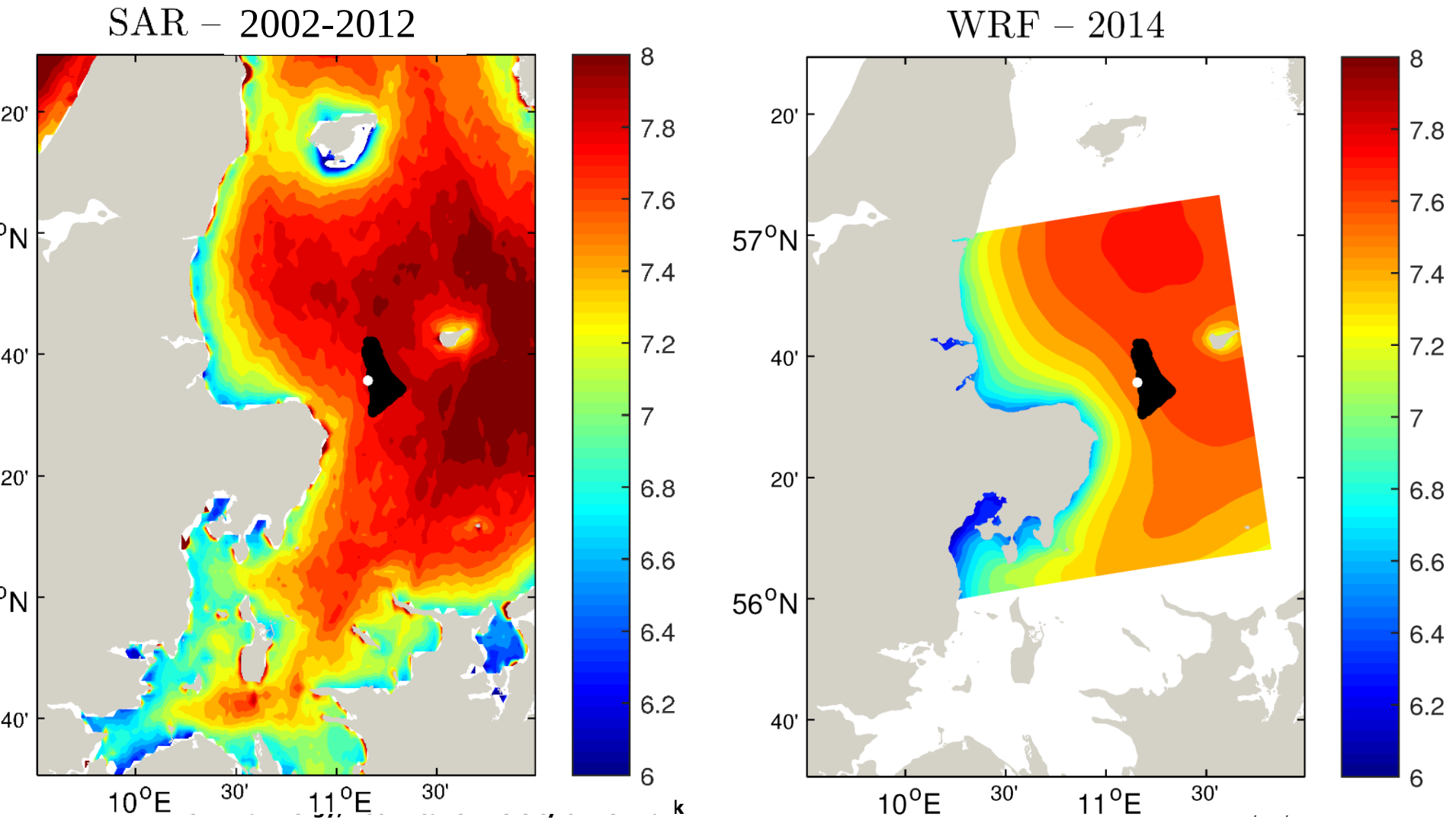
Sentinel-1a/b
2014/2016-present



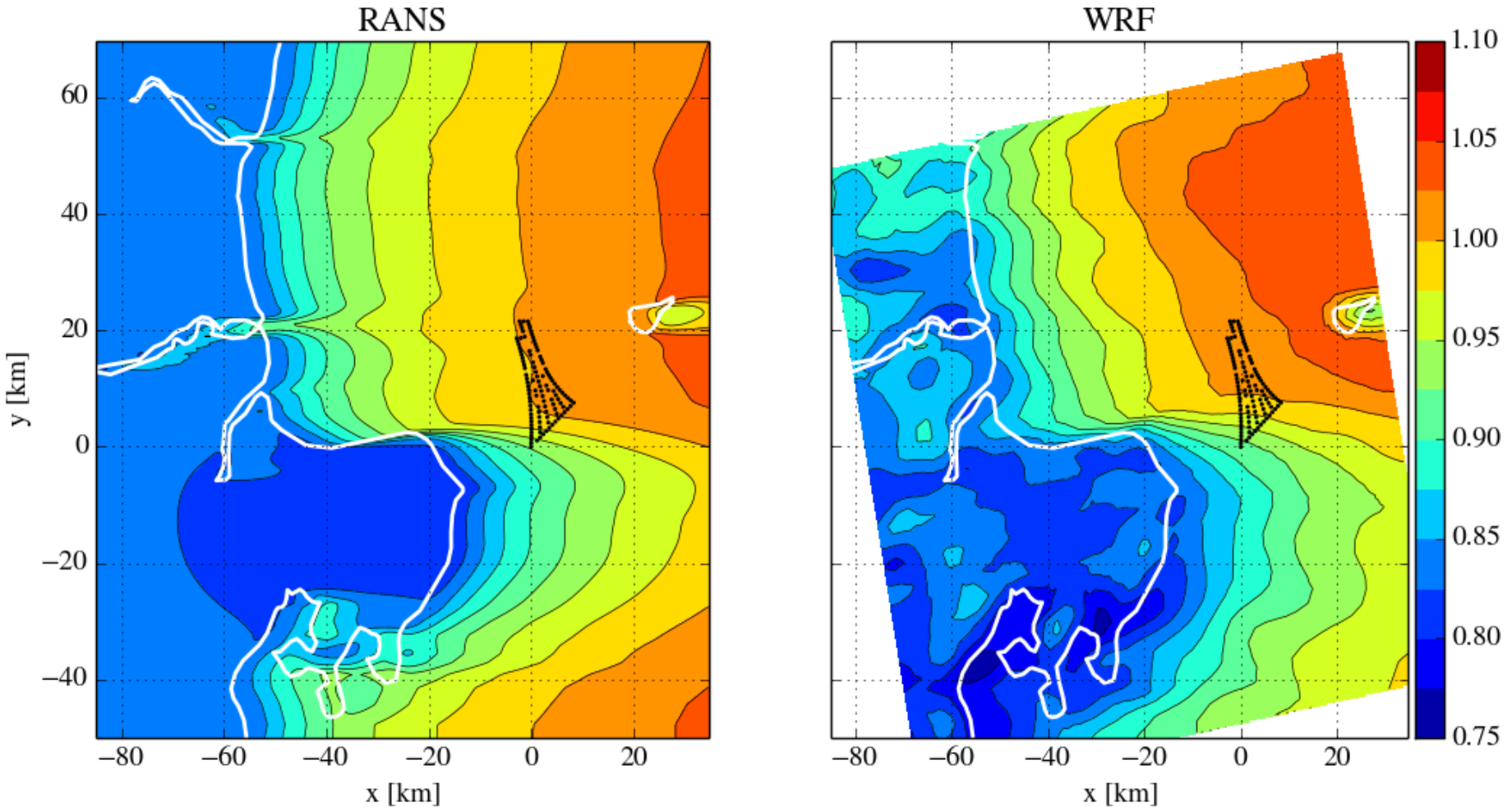
SAR wind data archive



SAR and WRF (without wind farm)
Mean wind speed at 10 m



RANS and WRF (without wind farm)
Wind speed at hub-height for 270° ±5°



Results from RANS

Animation 1:

Wind speed at hub-height from RANS without wind farm.

Animation 2:

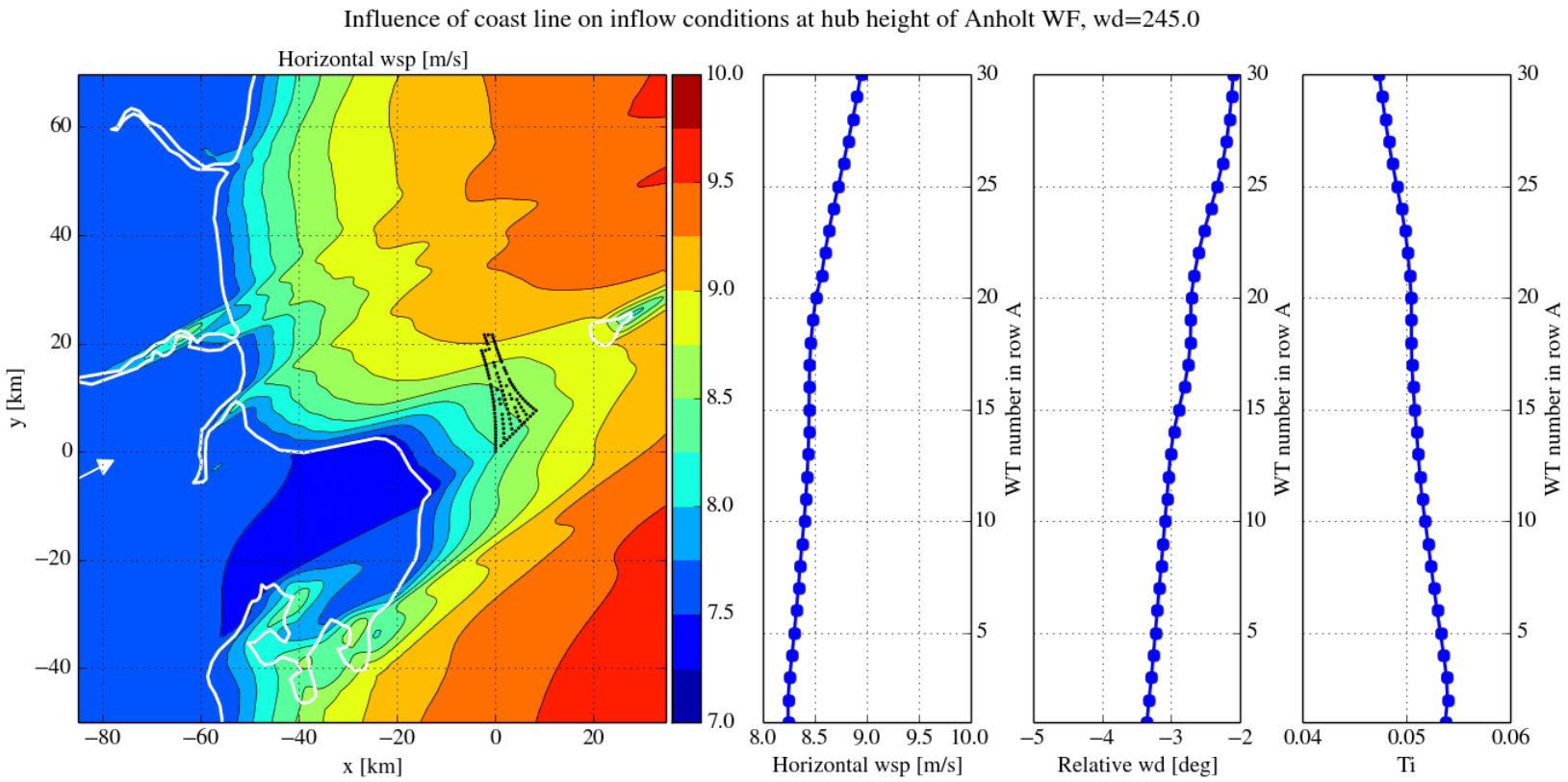
Normalized wind turbine power from RANS and SCADA.

M. P. van der Laan, A. Pena, P. Volker, K. S. Hansen, N. N. Sørensen, S. Ott, C. B. Hasager.

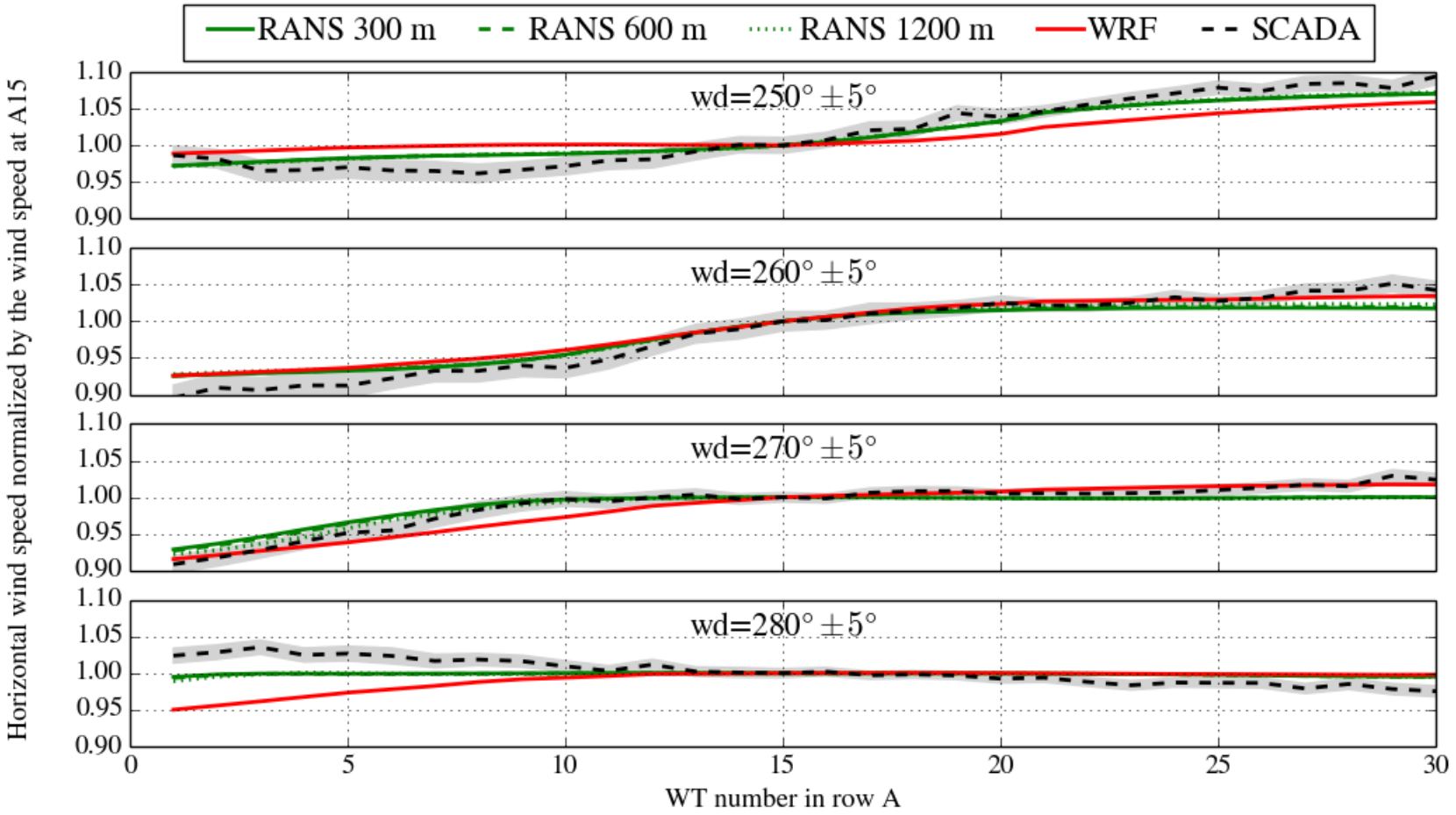
Challenges in simulating coastal effects on an offshore wind farm

IOP Visby wake conference 30 May - 1 June 2017 (in press)

RANS (without wind farm)
Wind speed at hub-height

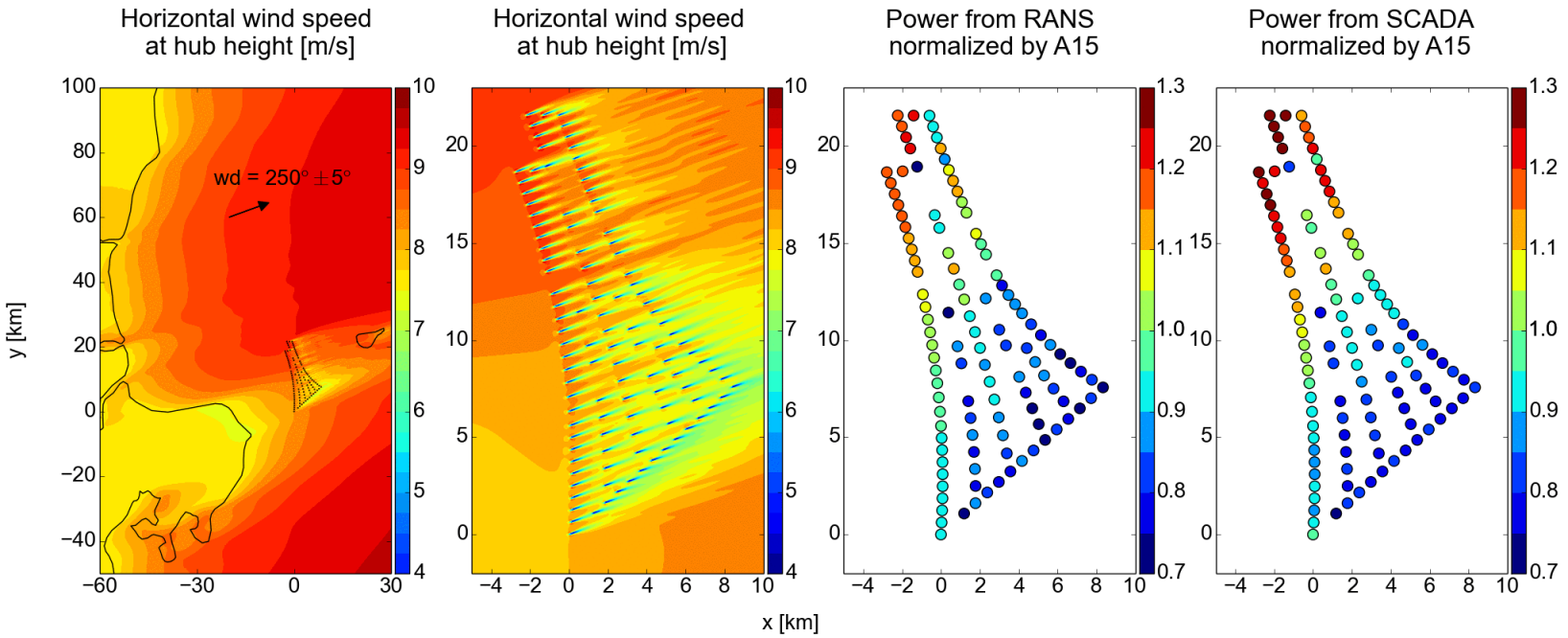


RANS, WRF and SCADA
Wind speed at Row A
(turbines from south to north)

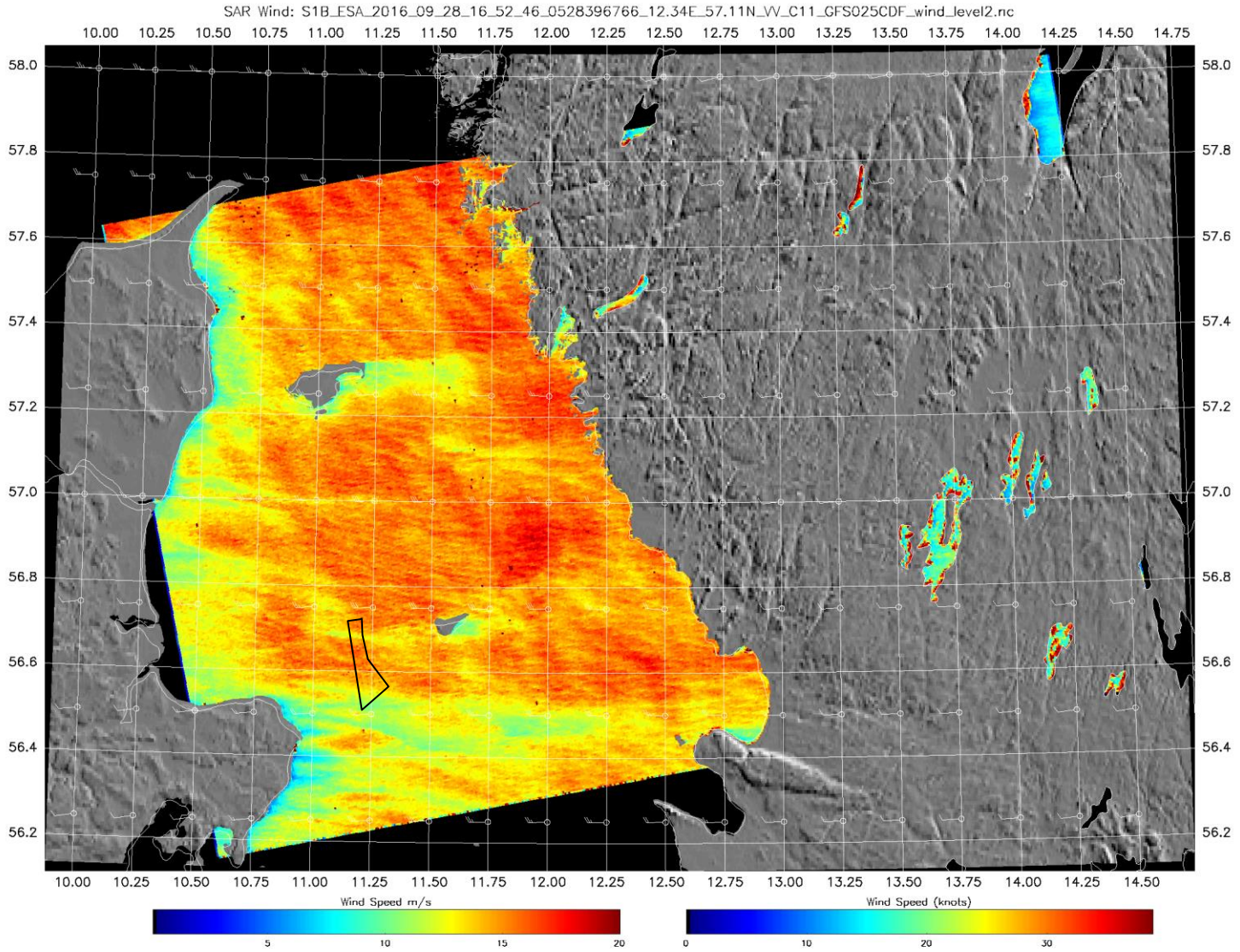


Wake investigation

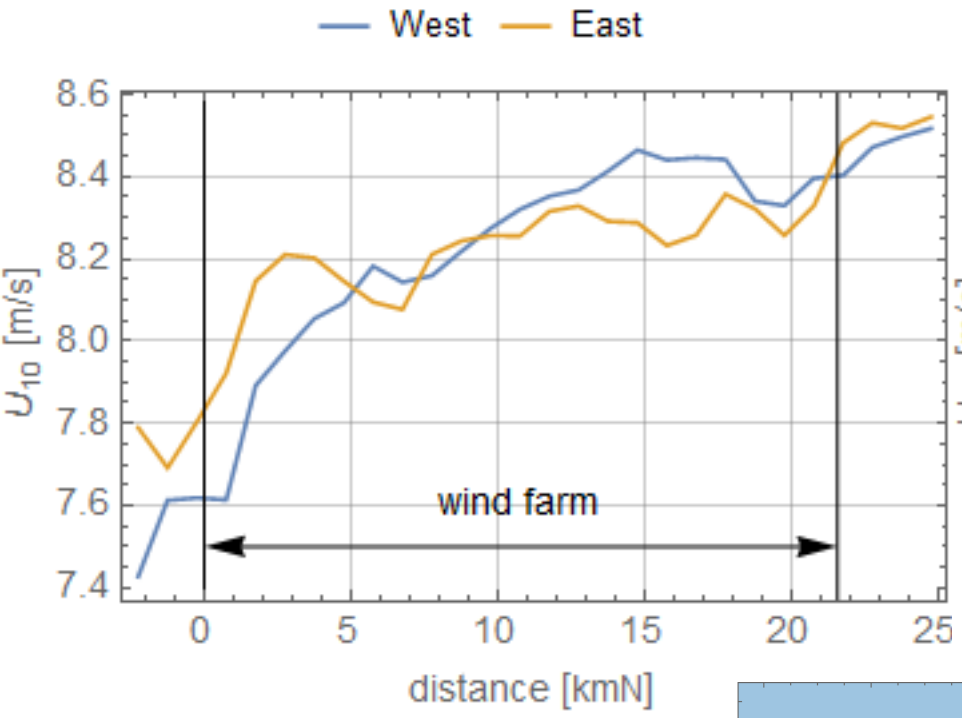
RANS and SCADA wind turbine power (normalized)

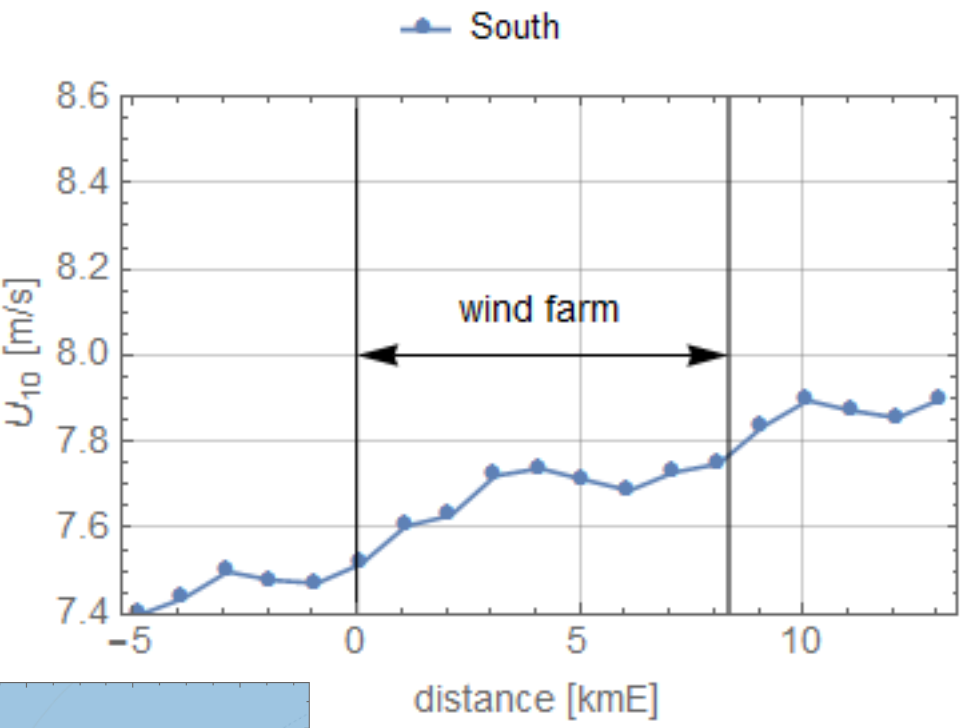


Wakes in SAR wind map



SAR-based mean wind speed at 10 m

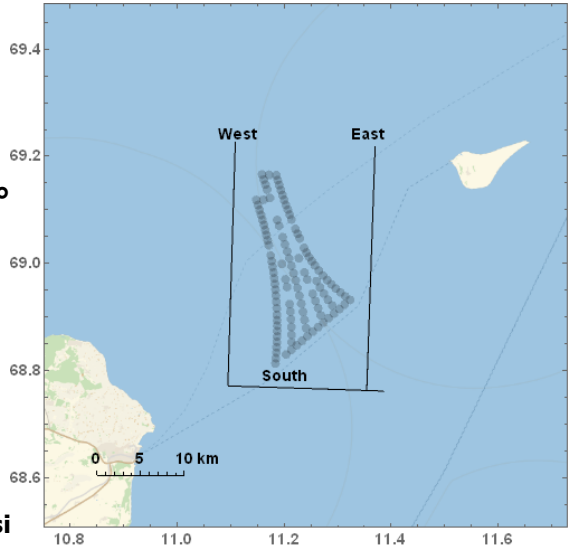




Selection

30 Sentinel-1a/b scenes

Wind direction from 250° to 270° taken from the GFS data



Conclusions

There is significant wind speed gradient at Anholt offshore wind farm in particular for westerly flow.

SCADA, WRF, RANS and SAR confirm the wind speed gradient.

Wind farm wake from RANS and SCADA for specific wind speed and direction compare well.

Satellite SAR analysis indicate far-field wind farm wake.

Acknowledgements

We thank DONG Energy and partners for the SCADA data.

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