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

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

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Anholt offshore wind farm

Number of turbines: 111
Wind turbine capacity: 3.6 MW
Rotor diameter: 120 meters

Construction period: 2012-2013

SCADA data for analysis is from January 1st, 2013 to June 30, 2015 (2.5 years)

Courtesy: DONG Energy
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
Anholt Offshore Wind farm
DONG Energy

Fetch and wind speed gradient

~27 km
~15 km
18-20 km
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.


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

Influence of coast line on inflow conditions at hub height of Anholt WF, wd=245.0
RANS, WRF and SCADA
Wind speed at Row A
(turbines from south to north)

wd = 250° ± 5°
wd = 260° ± 5°
wd = 270° ± 5°
wd = 280° ± 5°
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

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