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## USING SST FOR IMPROVED MESOSCALE MODELLING OF THE COASTAL ZONE

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### 1. Introduction

Many offshore wind farms are located and planned in the near-coastal areas, where the winds are higher and connection to the grid is easier. Existing wind measurements in near-shore and offshore areas are sparse and scarce, therefore simulations from state-of-the-art meso-scale models are used for wind resource predictions. In coastal and near-shore areas, models are inaccurate and uncertain, mainly because of numerical approximations, which do not resolve the large changes in local topographic features and atmospheric stability well (Floors 2013). In coastal and near-shore areas, such models are rather inaccurate and uncertain, primarily due to their numerical approximations, which do not resolve the large changes in local topographic features and atmospheric stability well. The accuracy of modelled wind resource predictions can be improved by using local wind measurements to calibrate the models.

The RUNE project aimed at Reducing Uncertainty of Near-shore wind resource Estimates and investigated cost-effective measurement solutions for improving the wind resource modelling of coastal areas. During the RUNE project, the wind over a coastal area was measured by land-based lidar systems, an offshore lidar buoy and satellite radar remote sensing (SAR and scatterometers) while simulations from the Weather Research & Forecasting (WRF) mesoscale model were performed. The purpose of the analysis is to evaluate the uncertainty of the modelled wind in the coastal zone and further improve it. The high-resolution daily SST analysis product from the Danish Meteorological Institute (DMI) (Høyer and Karagali, 2016), specifically developed for the North Sea and Baltic Sea region was introduced as a boundary condition to WRF. In addition, to improve the physical description of the domain, the elevation, topography and land use, the CORINE land cover with a spatial resolution of 100~m to 250~m and the SRTM elevation database were used as boundary conditions.

This study provides an overview of the measurement campaign and the lidar systems in Section 2 and the description of the model set-up in section 3. Some preliminary results regarding the sensitivity of the model to different options for the SST, land use, resolution and PBL scheme are presented in Section 4.1 while comparisons with the lidar measurements are presented in Section 4.2. Finally, the conclusions are available in Section 5.

### 2. Measurement Campaign

Measurements during the RUNE campaign were obtained in the west coast of Denmark (Figure 1) during the period November 2015 to February 2016.

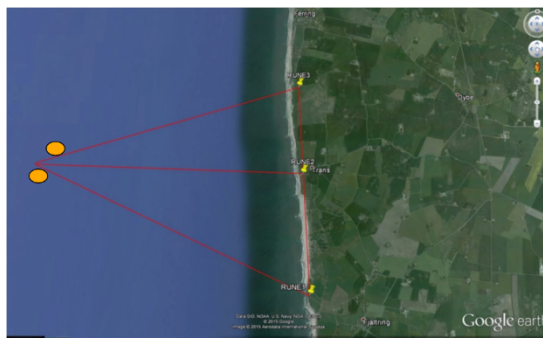


Figure 1: Location of the measurement campaign with markers for the onshore lidars and yellow dots for the lidar and wave buoy (16 m depth).

Three scanning lidars were installed on the coast, the north and south instruments were programmed to operate in dual scanning mode (DD), with a separation distance of 50 meters and a 1 sec scanning time. The middle lidar was operating in sector scanning mode, obtaining wind speed every 200 m and each plane was scanned for 45 sec at 60 degrees. Four vertical profilers were installed on land scanning with a resolution of 20 meters. The scanning pattern for all the instruments is depicted in Figure 2.

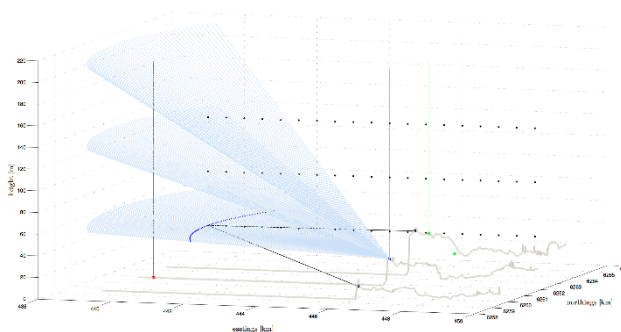


Figure 2: 3D overview of the scanning pattern for the lidar instruments on land (right side, vertical lines), the DD system (two black lines), the sector scans (light blue) and the lidar buoy (red vertical line, left side).

### 3. Meso-scale del

The Weather Research and Forecasting (WRF) model is used to simulate the wind speed evolution near the coast. Sensitivity tests related to the model set-up were conducted to evaluate the appropriate configuration in order to predict accurately the wind speed at a certain location. The inputs of land cover and sea surface temperature descriptions were investigated. In addition, different horizontal resolution and planetary boundary layer (PBL) schemes were tested, because these parameters were shown to have great influence on the description of wind speed with height (Floors 2013). The set of experiments aimed at exploring the sensitivity to land and sea-surface data was run between the 1st of October and the 9th of December 2014.

Two different SST products were tested, the daily OI SST (Reynolds et al., 2007) with a horizontal resolution of 0.25 degrees and the DMI North Sea-Baltic Sea daily analysis (Høyer and Karagali, 2016), with a resolution of 0.02 degrees. Two different land use products were implemented in WRF for the land characterization. The standard USGS product and the CORINE land use product, with a higher spatial resolution (250 m). All experiments used the ERA Interim data as boundary conditions and are summarized in table Table 1.

Abbreviation	PBL	SST	Land Cover	Resolution (m)
YSU18DMICOR	YSU	DMI	Corine	2000
YSU12DMICOR	YSU	DMI	Corine	1333
YSU13.5DMICOR	YSU	DMI	Corine	1000
YSU9DMICOR	YSU	DMI	Corine	500
MYJ18DMICOR	MYJ	DMI	Corine	2000
MYJ12DMICOR	MYJ	DMI	Corine	1333
MYJ13.5DMICOR	MYJ	DMI	Corine	1000
MYJ9DMICOR	MYJ	DMI	Corine	500
YSU12IOSCOR	YSU	OI (Reynolds et al., 2007)	Corine	500
YSU12DMIUSG	YSU	DMI	USGS	500

Table 1: Explanation of the different experimental set-ups.

An example of the WRF domain and the grid configuration, for a certain spatial resolution, is shown in Figure 3.

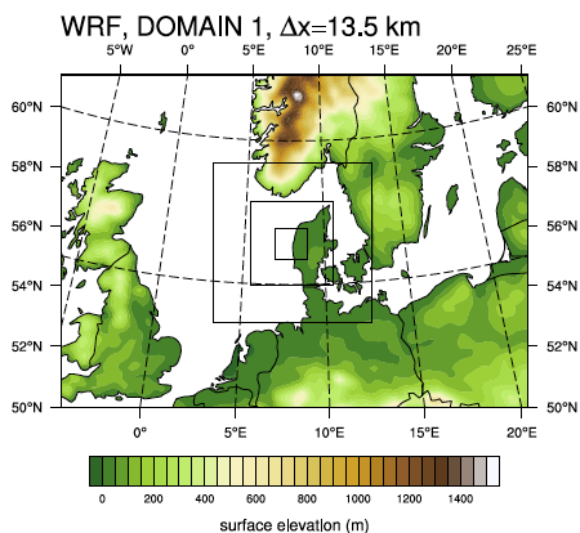


Figure 3: WRF domain configuration.

## 4. Results

### 4.1. WRF Sensitivity tests

The sensitivity of the coastal wind gradient, depending on the WRF set-up was evaluated and is presented for different heights in Figure 4. It is evident that the gradients are larger for the lower heights. The color lines

represent the different set-ups, which show some minor deviation in wind speed for the offshore areas; the MYJ PBL scheme (warmer colours) produces wind gradients that are lower offshore compared to the YSU scheme. An average 0.3 m/s offshore wind speed difference is attributed to the resolution of the model grid. A noticeable kink on the wind gradient at the point of the coastline, especially for the higher levels, could be attributed to a speed up effect due to the change of roughness from water to land.

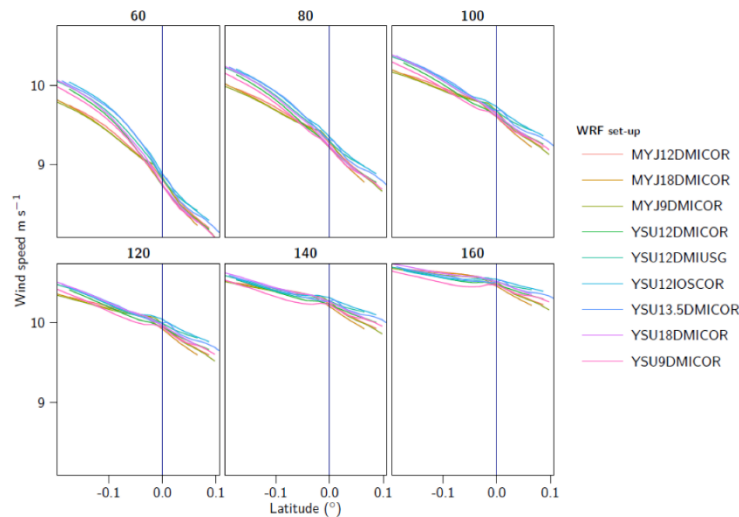


Figure 4: Wind speed (y axis) gradients for different heights, from 60 to 160 meters, from offshore (left side of each panel) to onshore (right side). The coastline is depicted with the blue line.

Figure 5 shows the mean wind speed profiles (left panel) from the WRF model using different set-ups (color lines) and a vertical profiler installed on land (orange dots). There is a large agreement for most model set-ups with the measurements, up to 40 meters above the ground. A deviation of the model from the measurements occurs from 50 m and higher, with the model showing a more pronounced increase of the wind speed with height. The right panel of Figure 5 shows the evolution with height of the root mean square error (RMSE) between the measurements and the model with the lines representing the different set-ups.

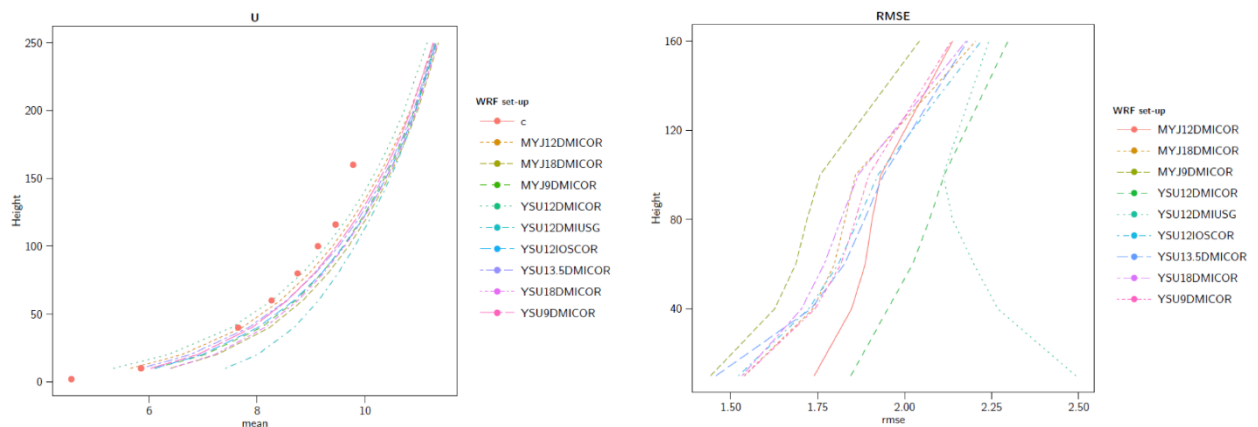


Figure 5: Wind speed profiles with height (left) and root mean square error profiles (right), for the different WRF set-ups compared to cup anemometer measurements (orange dots).

The lowest RMSE is found for the MYJ PBL scheme using the DMI SST and the CORINE land use. The highest RMSE and the only one showing a reduction with height, is found for the set-up using the USGS land cover.

### 5. Modelled vs Measured wind gradients

Some comparisons between the modeled and measured wind gradients from offshore to onshore are shown in Figure 6. Each panel represents a different height, from 50 m (left) to 100 m (middle) and 150 m (right). The profile of the coastal terrain is depicted by the black line and it is not in scale. The color lines represent the different WRF set-ups while the red dots, the Dual Doppler measurements. The purple triangle depicts the reconstructed wind from the sector scan and the blue dot, the wind speed at each height from a vertical profiler.

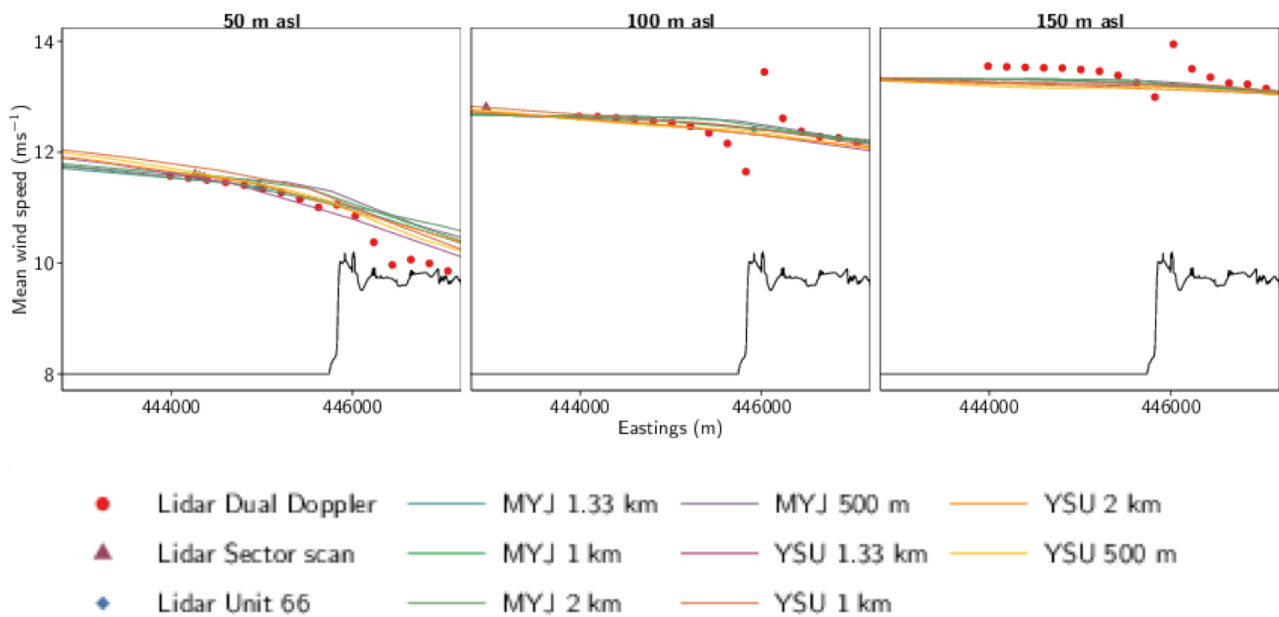


Figure 6: Mean wind speed using 3368 10-min measurements with 100% availability of the Dual Doppler system up to a distance of 2 km offshore and onshore (total 5 km).

The reduction of wind speed over land is represented in the model and measured by the instruments, especially noticeable at the lower height of 50 m. The kink in the measured wind speed occurring exactly at the coastline is speculated to be artificial and due to the limitation of the Dual Doppler scanning pattern, which does not allow for a proper wind reconstruction when the lidar beams oppose each other.

Figure 7 shows a case where the lidar systems had a larger range of up to 5 km offshore and thus more points were available. The MYJ WRF runs consistently matched the DD wind measurements (red dots) for the 50 and 100 m heights, were the differences between model set ups were more pronounced offshore. The sector scans were closer to the YSU WRF runs offshore and for the same heights. At 150 meters, all measurements match with the YSU WRF runs, both offshore and onshore. The kink of the DD system at the coastline appears in this case, while the wind speed gradient flattens for increasing heights from the surface.

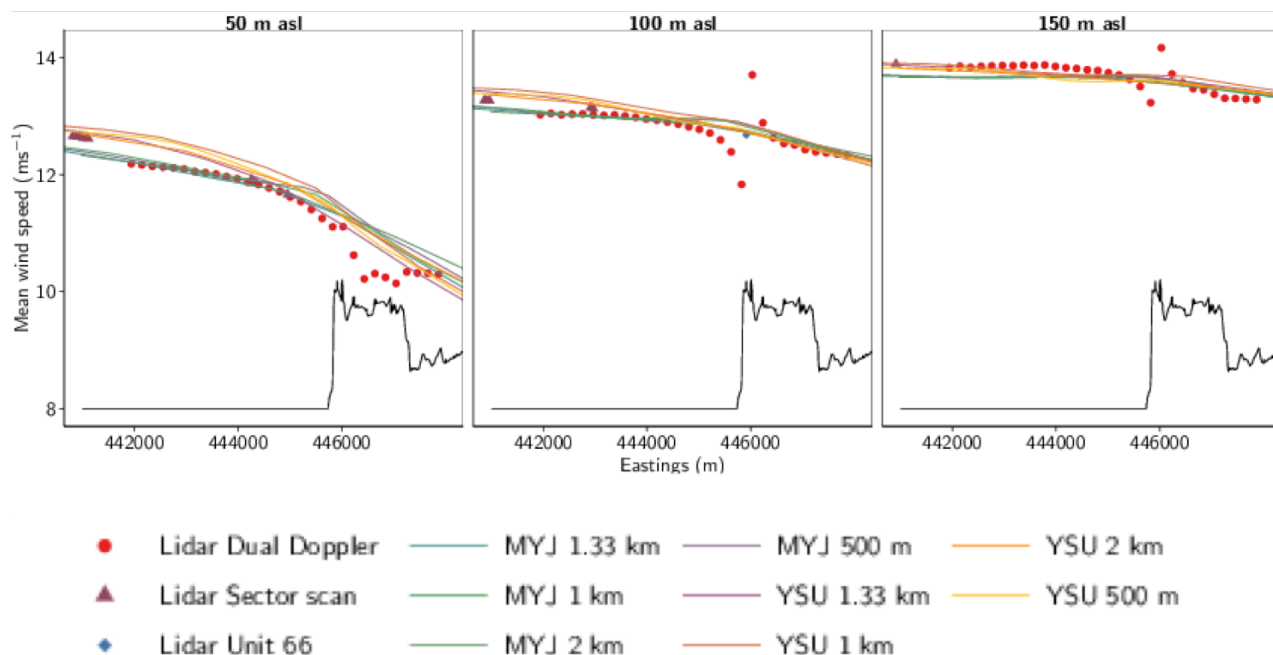


Figure 7: Mean wind speed using 1904 10-min measurements with 100% availability of the Dual Doppler system up to a distance of 5 km offshore and onshore (total 7 km and not filtered for the wind direction).

## 6. Conclusion

This study has summarised the efforts undertaken during the RUNE project to obtain an accurate measured and modelled description of the wind evolution in the coastal zone. Utilising higher resolution SST and land cover data from Earth Observation missions can enhance modelling of the coastal wind gradients. From sensitivity tests it was found that the representation of the coastline, the elevation, topography and land use was improved when implementing the CORINE land cover and the SRTM elevation databases in the WRF model. Moreover, WRF was evaluated using the high-resolution SST reanalysis from the Danish Meteorological Institute (DMI), specifically developed for the North Sea and Baltic Sea region. Sensitivity tests utilising profiling lidars, showed that the modelled wind speed was improved compared to the one produced using the NOAA OI daily SST v2. More example results from comparisons of WRF with the LIDAR scans are available from Hahmann et al. (2016).

## 7. References

- Floors R., Vincent C.L., Gryning S.E., Peña A. and E. Batchvarova, The Wind Profile in the Coastal Boundary Layer: Wind Lidar Measurements and Numerical Modelling. *Boundary-Layer Meteorol.* **147** (3), 469-491, 2013.
- Hahmann A.N., Floors R., Karagali I., Vasiljevic N., Lea G., Simon L., Courtney M., Badger M., Peña A. and C. Hasager, Simulating and validating coastal gradients in wind energy resources, Presentation at EGU2016-14694, 2016.
- Høyer J.L. and I. Karagali, Sea surface temperature climate data record for the North Sea and Baltic Sea, *J. Climate*, 2016.
- Reynolds R.W., Smith T.M., Liu C., Chelton D.B., Casey K.S. and M.G. Schlax, Daily High-Resolution-Blended Analyses for Sea Surface Temperature, *J. Climate* **20**, 5473-5496, 2007.