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Using SST and land cover data from EO Missions for improved mesoscale modelling of the coastal zone

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Introduction

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 [1]. The accuracy of modelled wind resource predictions can be improved by using local wind measurements to calibrate the models. RUNE investigated cost-effective measurement solutions for improving the wind resource modelling of coastal areas. The wind over a coastal area was measured by land-based LIDAR systems [6], an offshore LIDAR buoy and satellite radar remote sensing (SAR and scatterometers). Simulations using the Weather Research & Forecasting (WRF) meso-scale model were performed. The aim was to evaluate the uncertainty of the modelled wind in the coastal zone and further improve it. Moreover LIDAR measurements were used to evaluate the wind speed retrieval from high resolution SAR systems (Sentinel-1 and TerraSAR-X). The WRF model used a high-resolution satellite SST reanalysis product from the Danish Meteorological Institute (DMI), specifically developed for the North Sea and Baltic Sea region. To improve the physical description of the domain, the elevation, topography and land use, the CORINE land cover database and the SRTM elevation database are used as boundary conditions; with a spatial resolution of 100 m to 250 m, the CORINE land cover information represent a more accurate classification of land uses for the entire domain. SST, land cover, and elevation information from Earth Observation platforms are unique due to their extended spatial coverage and resolution, such that they can be implemented in the meso-scale model to better represent the actual conditions in the study area. Such improvements are expected to strengthen the model's ability to represent land- sea and air-sea interactions, the atmospheric stability and the local topographic features that partly affect the coastal zone.

Data & Methods

- 2 different SST products
  - DMI L4 SST [2]
  - OI SST [4]
- 2 different land use classifications
  - USGS
  - CORINE (250 m)
- 2 different PBL schemes
  - MYJ
  - YSU

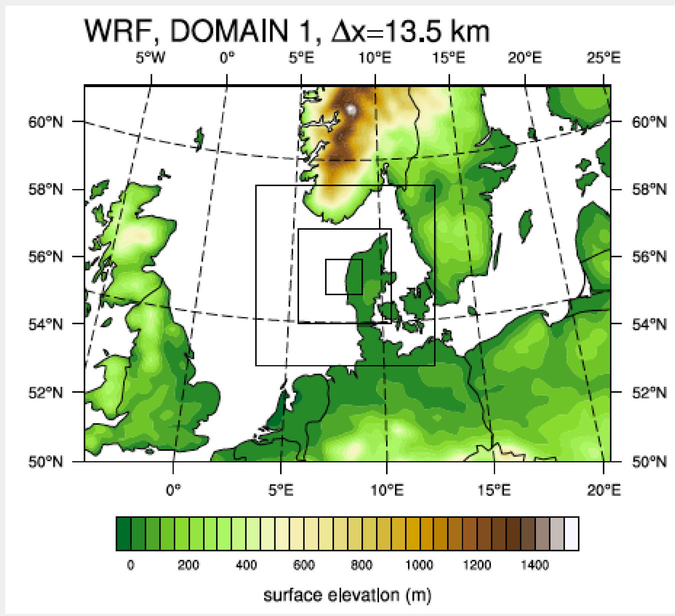


Figure : Domain configuration for the RUNE sensitivity simulations

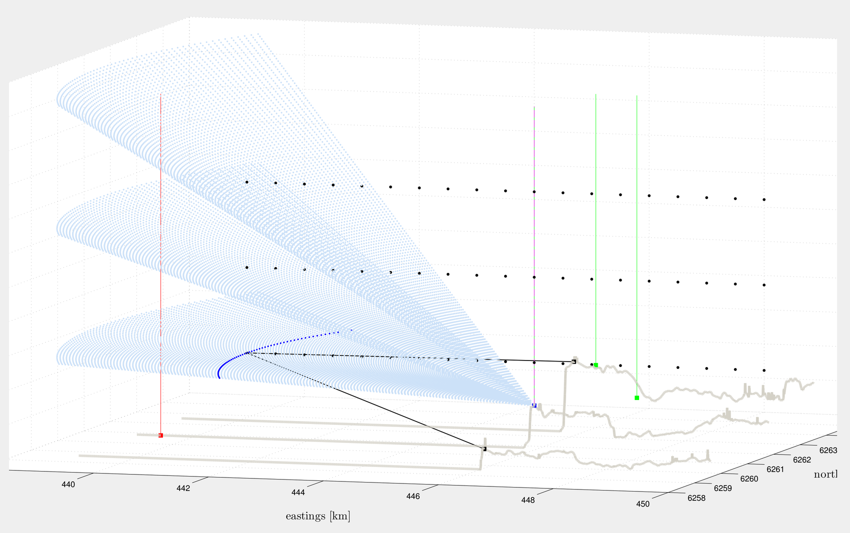


Figure : Three dimensional overview of the measurements at the experimental site. The blue points denote the range gates from the scanning LIDAR and the black points denote the points from the dual Doppler set-up. The scanning LIDAR obtained wind speed every 50 m, each plane was scanned for ∼45 s at 60°. Separation distance for dual Doppler system ∼200 m, scanning for ∼1 s. The vertical lines denote profiling LIDARs.

- 4 different spatial resolution set-ups
  - 18, 6, 2 km
  - 12, 4, 1.3 km
  - 9, 3, 1 km
  - 13.5, 4.5, 1.5, 0.5 km
- Grid points along measurements
- Fixed height
- Measurements from
  - 3 scanning LIDARS
    - 1 dual Doppler system
    - 1 sector scanning system
  - 4 profiling LIDARS

WRF Sensitivity Tests

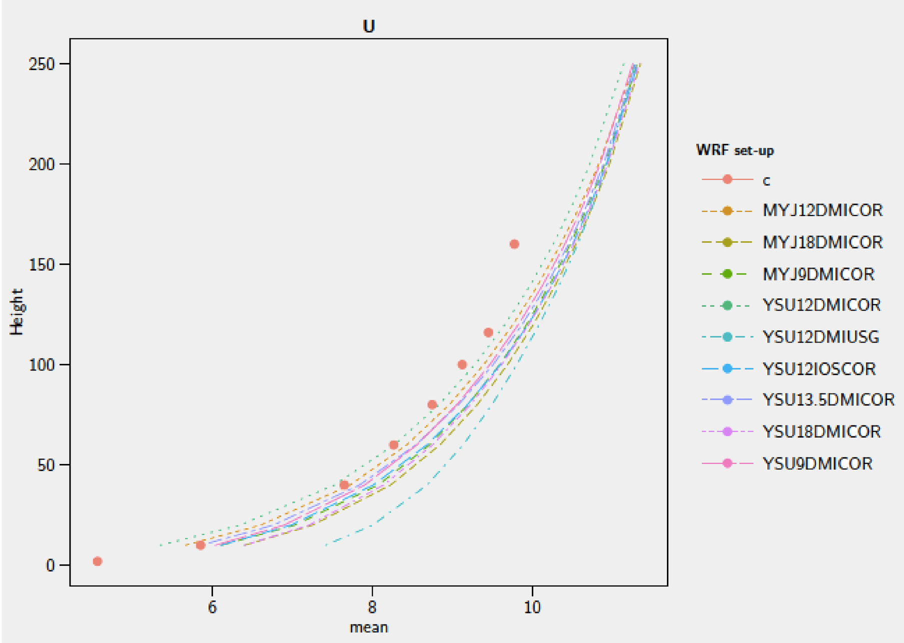


Figure : Mean wind speed profile from Høvsøre from the cup anemometers (c) and different WRF set-ups.

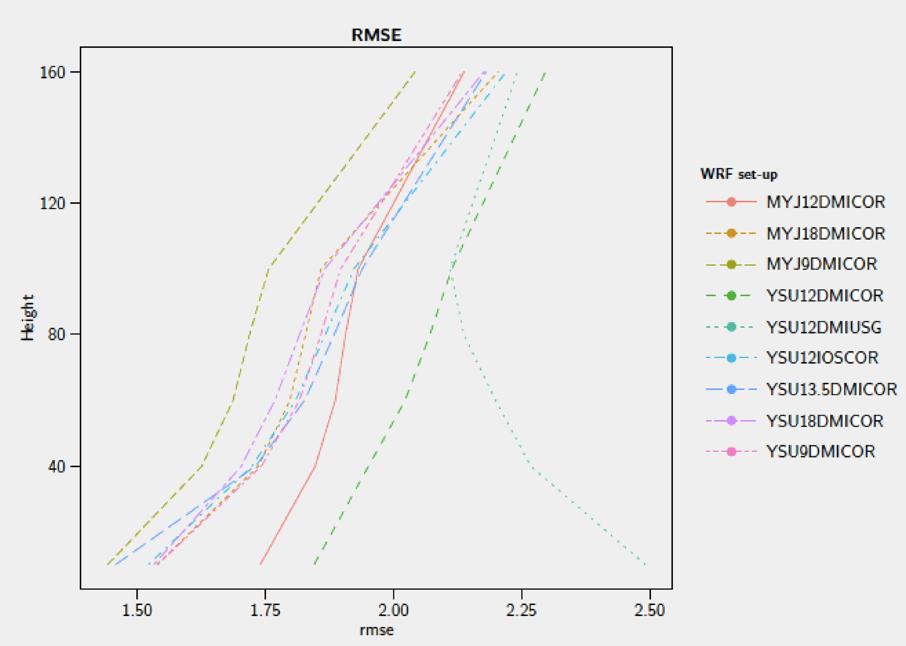


Figure : RMSE of the wind speed profile between measurements and WRF simulations.

WRF, LIDARS and TSX

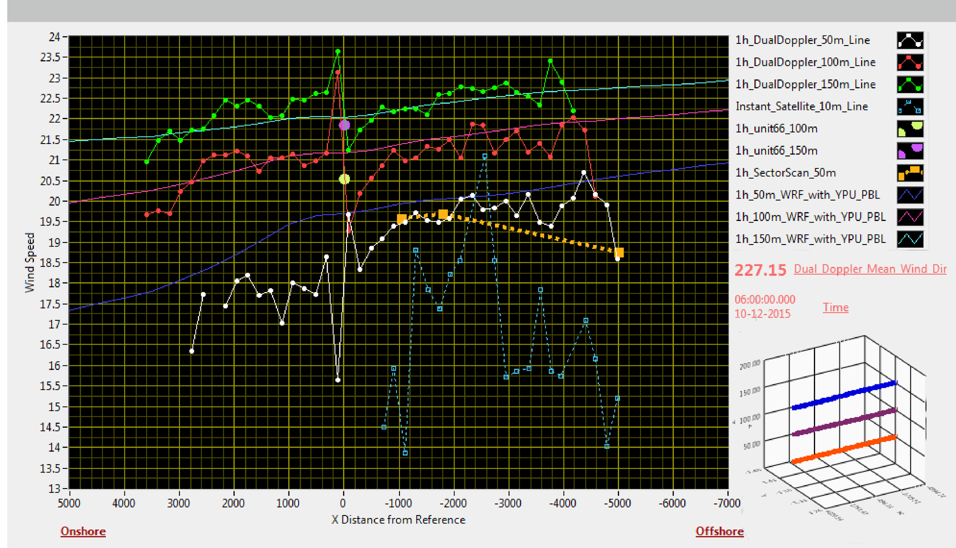
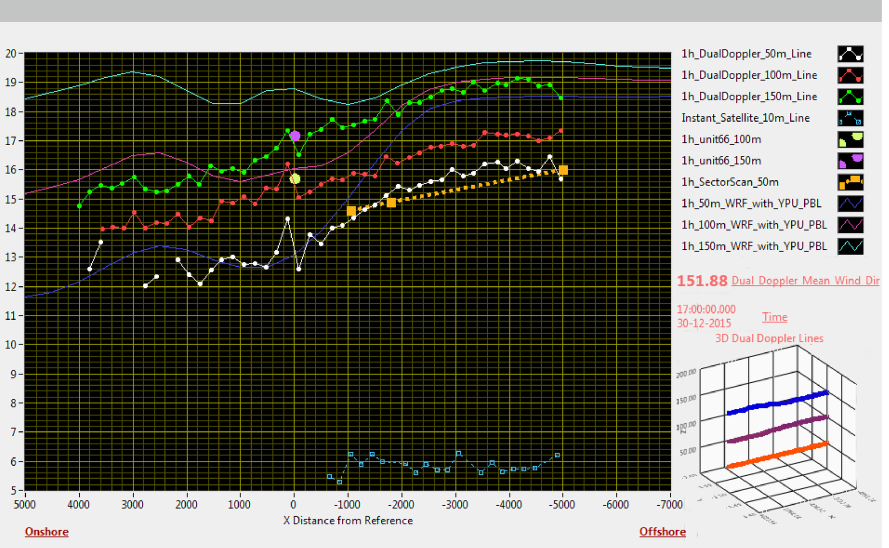
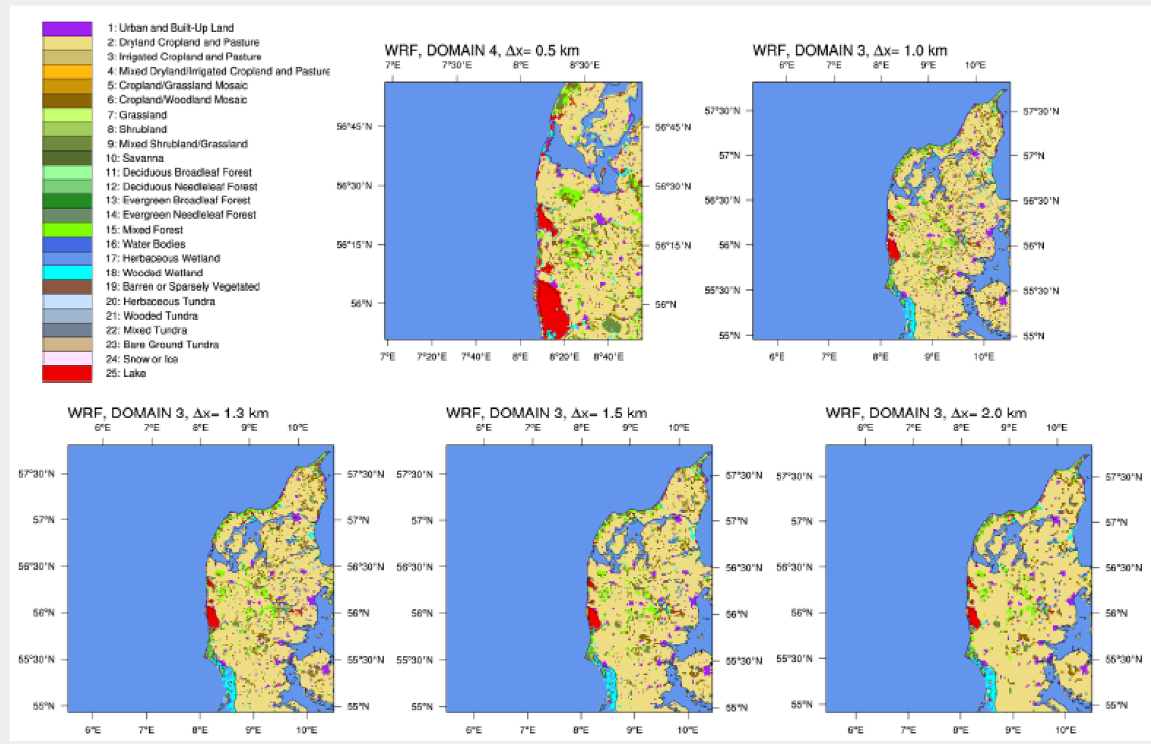



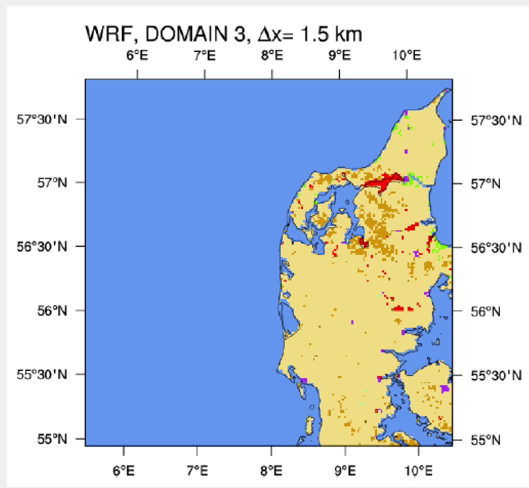
Figure : LIDAR Dual & Sector scans, Profilers, WRF & TerraSAR-X on December 10 2015, 06:00 (left) and December 31 2015, 06:00 (right).

Land Use

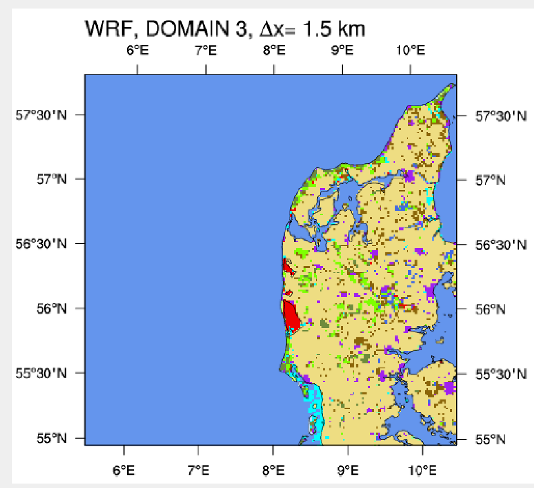
Inner domains at various horizontal resolutions with the CORINE land use ⟶



USGS



CORINE

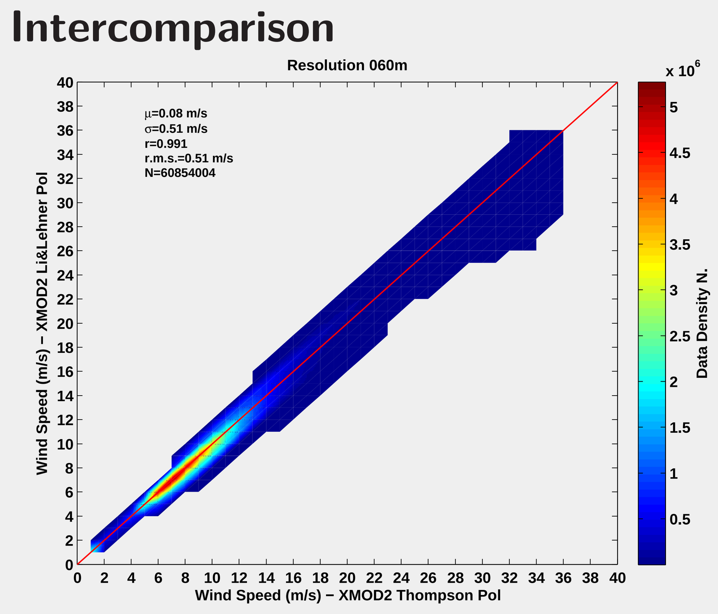


TerraSAR-X

Wind retrieval

- NOAA SAROPS
- GFS 0.25° wind direction
- XMOD2 GMF [3]
- 2 polarisation ratios: [5], [3]
- 3 resolutions: 60, 200 and 500 m

Intercomparison



For In situ comparisons

- Lowest Dual Doppler height ∼ 50 m
- Use of log wind profile
- z_0 = 0.0002 m
- Wind at 10 m

Comparison with the Dual Doppler Lidar Scans

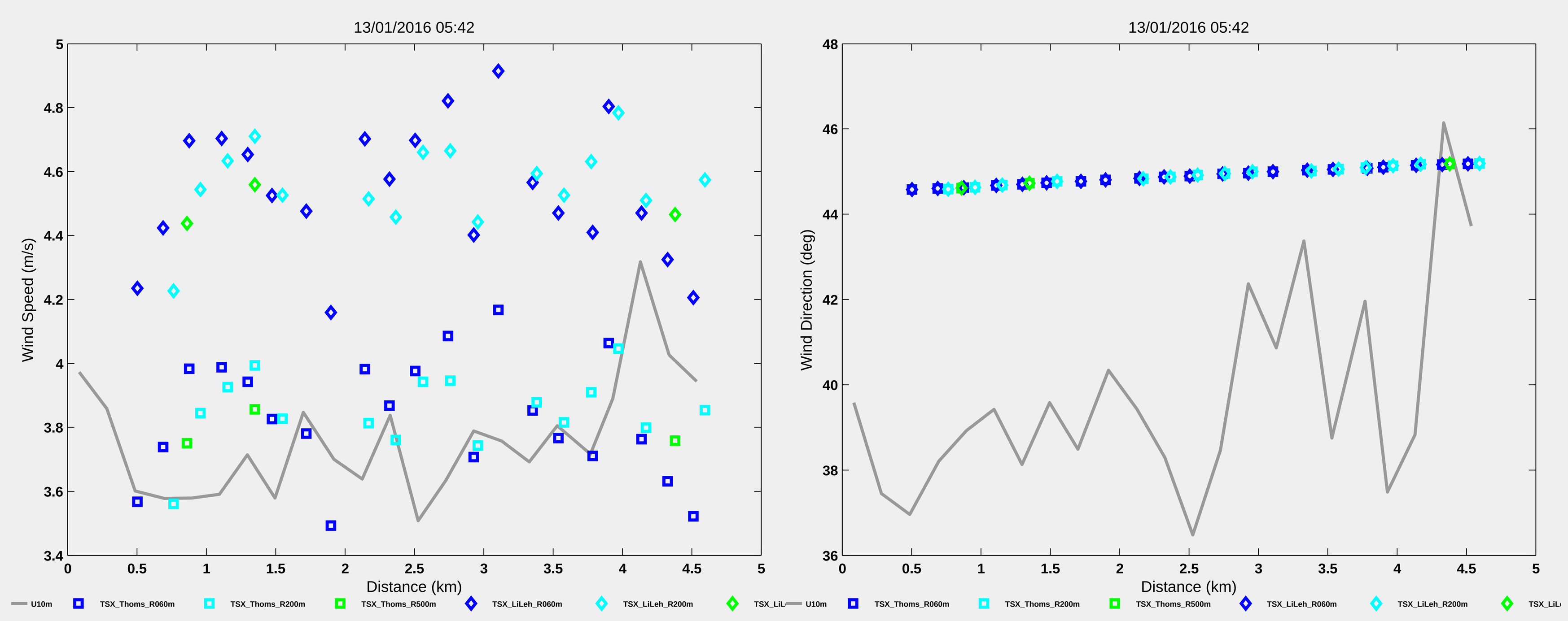


Figure : Wind speed (left) and direction (right) for a transect of a TSX image (SpotLight Mode) matching the Dual Doppler LIDAR scans.

Conclusions

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 CORINE land cover provided a better representation of the land use. The L4 SST Reanalysis for the North and Baltic Sea was selected, as it was found more accurate that global L4 SST products in the region. Example results from comparisons of WRF with the LIDAR scans are available from *Hahmann et al. (2016), Simulating and validating coastal gradients in wind energy resources, EGU2016-14694*. Measurements obtained from LIDARs were used to preliminary investigate the wind retrieval procedure using high resolution SAR images, which showed high sensitivity to the oceanic surface features. Further examination of the wind retrieval process is required.

References

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Acknowledgements

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