ASCAT winds used for offshore wind energy applications

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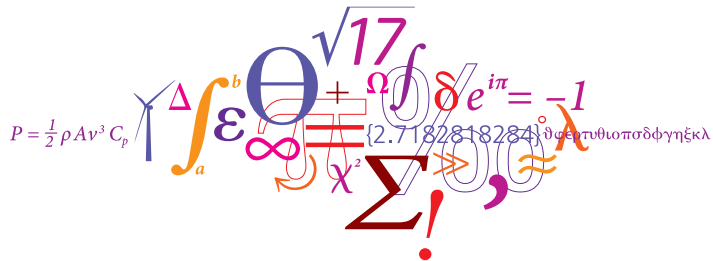

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Motivation

- Resource assessment and spatial planning
- Efficient use of financial resources & research capabilities
- Cover all EU Member States and some Associated Countries (including EEZ)
- Reduce overall uncertainties in determining wind conditions
- Offshore wind atlas extending 100 km
  - Mesoscale modelling atlas
  - Satellite winds atlas
  - Experimental measurement campaigns

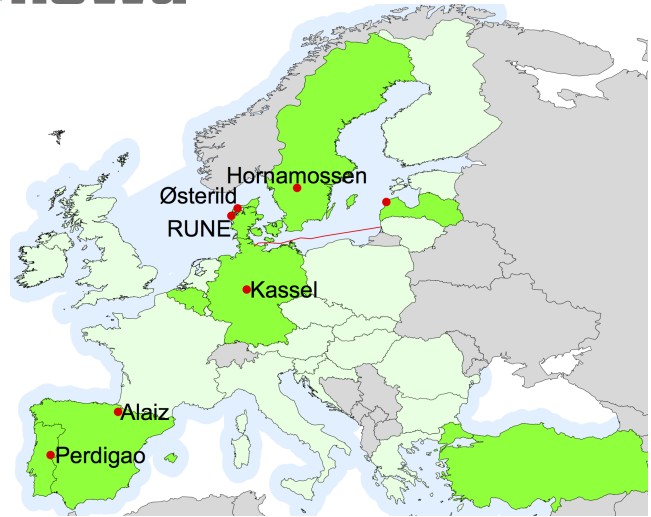


Figure: NEWA partners (green), offshore (blue) and onshore (light green) coverage, experimental sites (red dots), ferry route (red line).

ASCAT Winds

- Stress Equivalent Wind from CMEMS (`http://marine.copernicus.eu/`)
- Resolution 12.5 km
- 2013-now: WIND_GLO_WIND_L3_NRT_OBSERVATIONS_012_002
- 2007-2012: WIND_GLO_WIND_L3_REP_OBSERVATIONS_012_005
- 10-year mean wind speed extrapolated using the method of Badger et al. (2016)[1].
  - SDW: Stability Dependent Wind
    - u_* assuming neutral conditions
    - u_z using long-term stability correction
  - ENW: Equivalent Neutral Wind
    - u_* assuming neutral conditions
    - u_z assuming neutral conditions

[1] Badger et al., 2016.Extrapolating Satellite Winds to Turbine Operating Heights. *J. Appl. Meteorol. Clim.* 55 975-991

Measurements

- Meteorological masts
- Wind speed and direction measurements at various heights from 21-m to 100-m
- Temporal availability: 2007-2016
- EZ, M2/M7, GG as 10 m winds (ENW and SDW)[2]
- Filtering for winds 3-24 m s ^{1}and wake-free directions

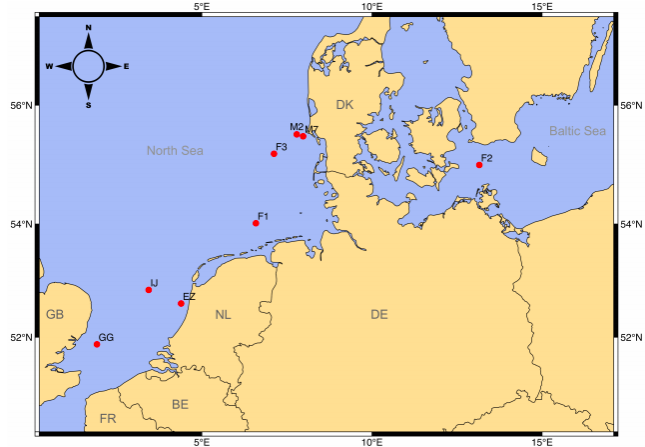


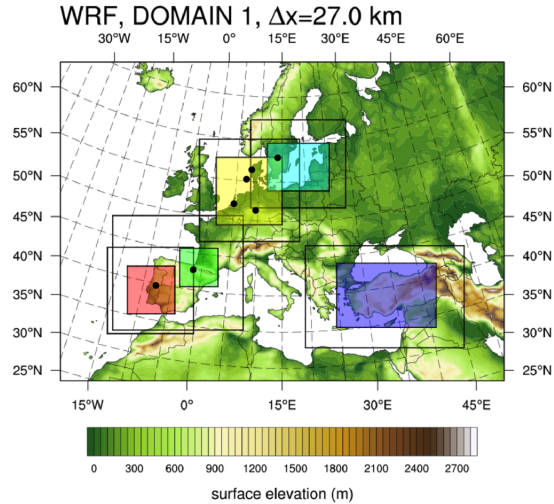
Figure: Locations of in situ measurements[3].

[2]Karagali I. et al. “Wind Characteristics in the North and Baltic Seas from the QuikSCAT Satellite.” Wind Energy 17.1 (2014): 123–140.

[3]Madsen Visbech, Jens, "Validation of Satellite Surface Winds from ASCAT against Meteorological Mast Observations", BSc thesis, June 2018

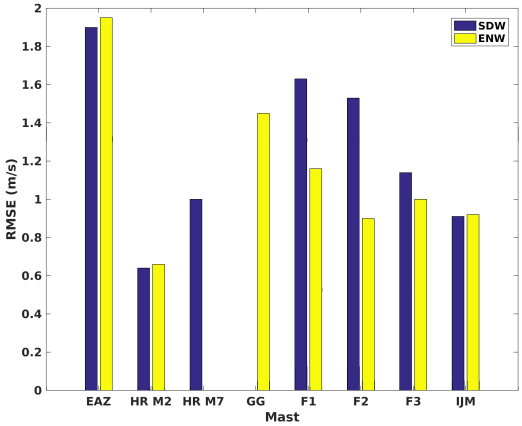
Weather Research & Forecasting (WRF) Model

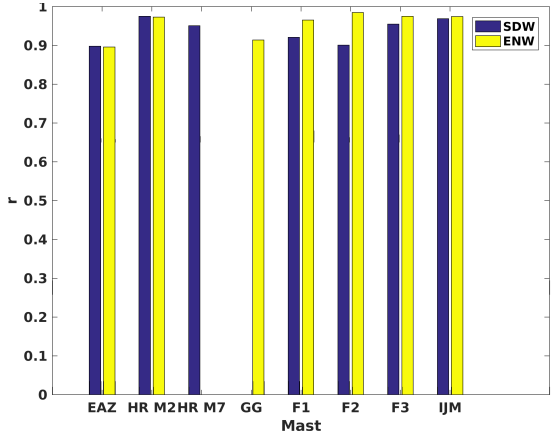
1. NEWA Sensitivity experiments (2015)
   - ERA Interim (.75°× .75°)
   - OISST (.25°×.25° + Lake)
   - Fixed roughness
   - New parameters for land surface classification
   - Inner grid, 3×3 km
2. 10 years of WRF outputs from Nuño Martinez et al. (2018)[4], to derive long-term stability correction



[4] Nuño Martinez E, Maule P, Hahmann A N, Cutululis N A, Sørensen P E and Karagali I 2018 *Renew Energ* 118 425–36

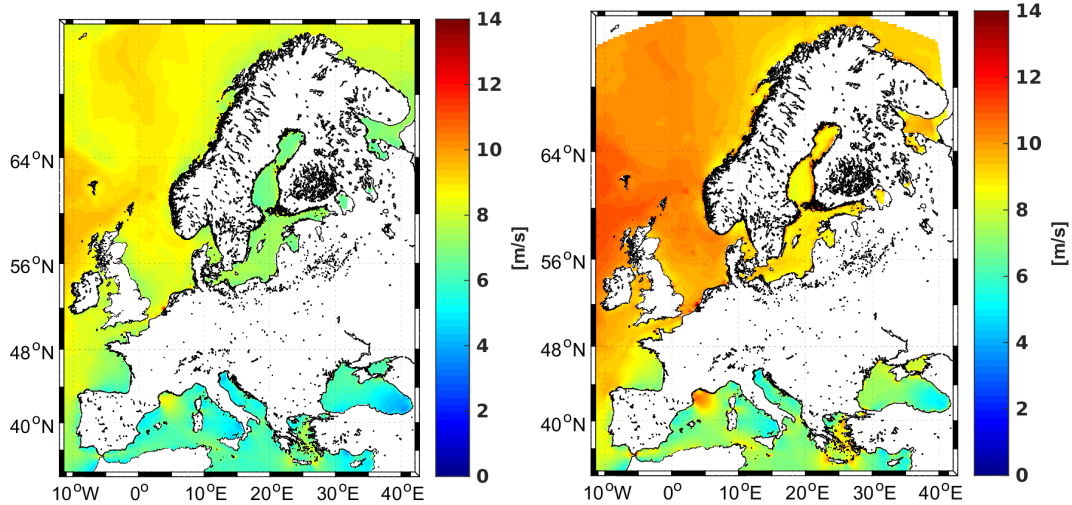
ASCAT vs In Situ at 10-m





N. of match-ups (SDW/ENW): EAZ 280/285, HR-M2 45, M7 421, GG 59, F1 1038/56, F2 960/27, F3 966/86, IJM 2119/171. [3]

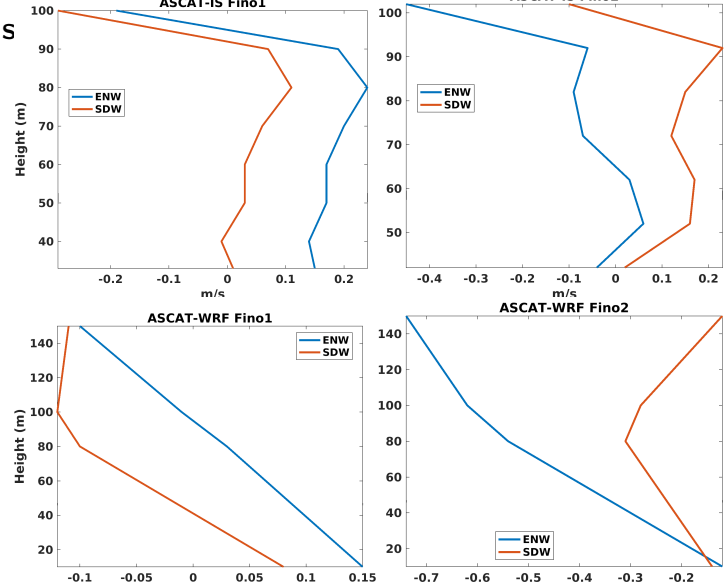
ASCAT Wind Atlas



Wind atlas at 10-m (left) and 100-m (right) from ASCAT A/B, 2007-2016.

ASCAT at In Situ Locations

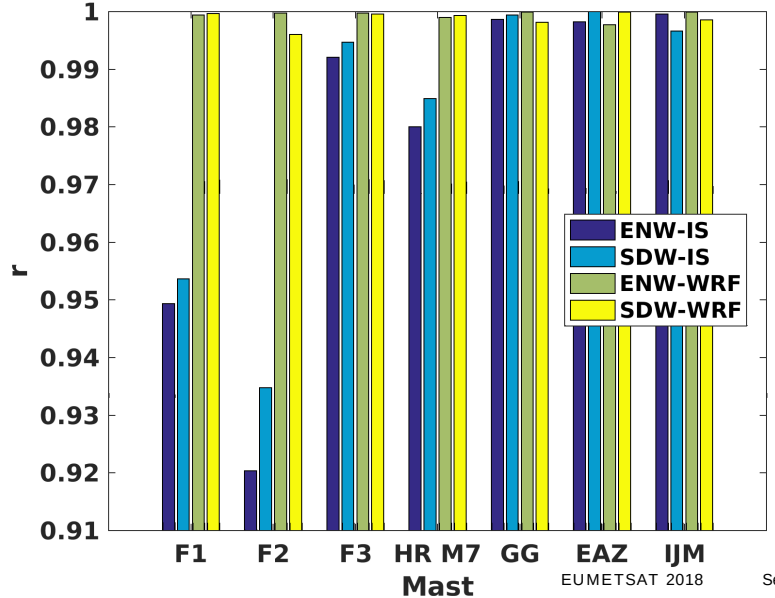
Overall mean wind speed bias at di□erent heights for ASCAT - In Situ (top) and ASCAT - WRF (bottom). Fino 1 & 2 data used for 2015-2016.



[5] Kokaly Kokaly, Usama, "Validation of ASCAT lifted winds", MSc thesis, June 2018

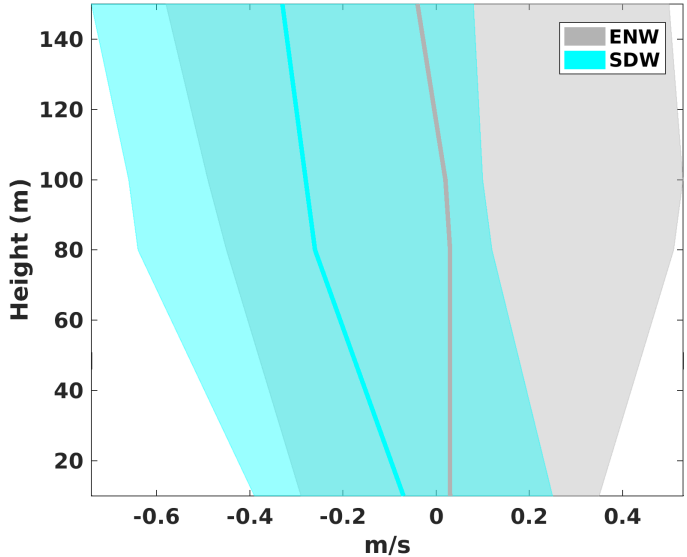
ASCAT - In Situ - WRF correlation

Overall correlation of mean wind speeds at all available heights.[5]

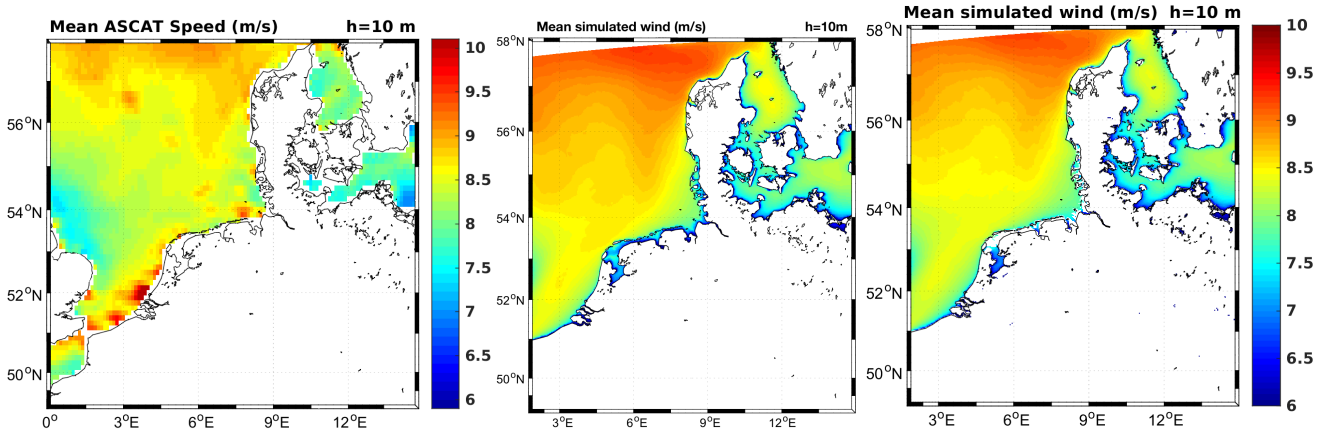


ASCAT vs WRF long-term profiles

10-year mean wind speed (solid) and standard deviation (shaded areas) at various heights from the extrapolated ASCAT product and WRF (all grid points combined)[5]



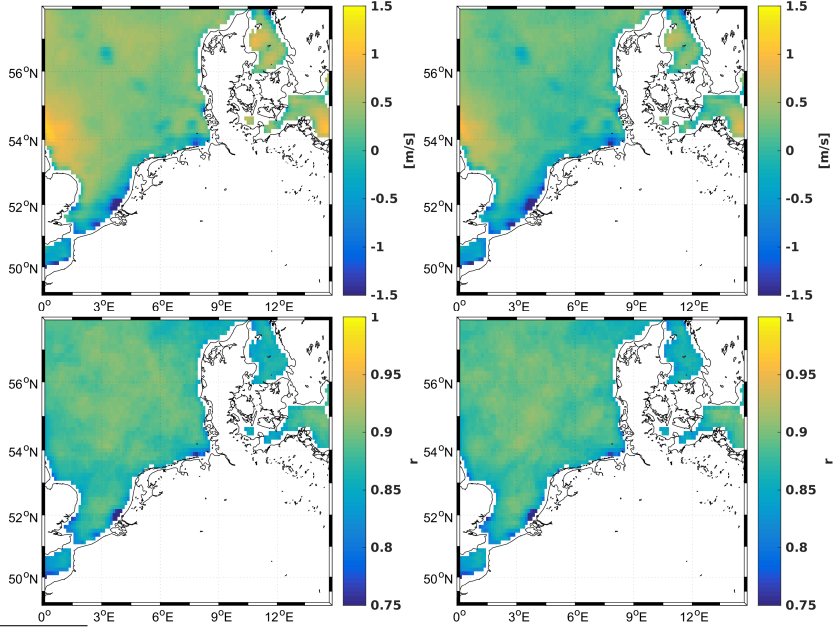
ASCAT vs WRF Mean Wind 2015



10 m mean wind speed for 2015 from ASCAT (left) and WRF using the MYJ (center) and YSU (right) PBL schemes.

WRF-ASCAT

10 m wind speed bias (top) and correlation (bottom) for 2015 between WRF and ASCAT using the MYJ (left) and YSU (right) PBL schemes.[6]



[6] Poulsen, Lina, "Comparison Of ASCAT with In Situ Observations & WRF Model Outputs for the North Sea", Special course, May 2018

Summary

- Comparison of ASCAT 10m winds with in situ data RMSE < 2 m s ^{1}and correlation r>0.9
- Satellite surface winds extrapolated to hub-height relevant levels
- Mean biases in ASCAT-In Situ profiles up to 0.25m s ^{1}in most cases
- Overall ASCAT - WRF profiles, neutral up to 100 m, stable up to 150 m
- Increased spatial variability in the ASCAT 10 m winds compared to WRF
- WRF-ASCAT mean biases up to 0.5m s ^{1}and...
- Correlation higher than 0.85 for most of the domain