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Analysis of 10 years of wind vector information from QuikSCAT for the North Sea: Preliminary Results from the OREC-CA project

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Abstract

As the land space suitable for wind turbine installations becomes saturated, the direction is turning towards offshore sites. Advantages include increased power production, smaller environmental and social impact as well as extended availability of prospective areas. Offshore wind energy holds the leading role amongst renewable marine energy resources but until recently installation of wind turbines was limited in coastal areas with maximum depth of 20m where sea waves have dissipated most of their energy content. Recent technological advancements allow floating wind turbines to be installed in locations with depths of 200m, promoting the combined use of wind and waves in common conversion platforms. The EU project OREC-CA (Offshore Renewable Energy Coordination Action) aims at gathering information regarding wind and wave resources in Europe, in order to develop a roadmap for research activities on this issue.
Within this context, the search for suitable sites is extended beyond shallow coastal areas, in locations where available measurements of various environmental parameters are limited. Space-borne observations are ideal due to their global spatial coverage, providing information where in-situ measurements are impracticable. The most widely used satellite observations for wind vector information are obtained by scatterometers; active radars that relate radiation backscattered from the sea surface to wind. SeaWinds, the scatterometer on board the QuikSCAT platform, launched by NASA in 1999 provided twice every day wind vector information with global coverage at a spatial resolution of 25km, until 2009. This 10-year long dataset is utilized in the present study for the characterization of wind resources in the North Sea and the Baltic.
Long-term QuikSCAT data have been extensively and positively validated in open ocean and in enclosed seas, and used to map the Mediterranean and Black Sea. Mean wind characteristics along with the Weibull ***A*** and ***k*** parameters are estimated in order to obtain information regarding the variation of wind between various locations of complex morphology including semi-closed basins. Areas with average annual wind speeds of 10 ms^{-1} are located in the Norwegian Sea while in the Baltic, mean wind speeds do not exceed 7 ms^{-1}. Characteristics with seasonal variation include reduced wind speed on the east side of the British Isles as opposed to the west coast of Denmark, likely a signature of the North Atlantic perturbations especially in winter. The amplitude of the annual cycle is estimated at chosen locations showing the variability in different areas.

Data & Methods

QuikSCAT Data

- SeaWinds Scatterometer: Active Microwave Radar
- Measures radiation backscattered from sea surface
- Physical parameter: Equivalent Neutral Wind at 10 m above sea surface
- QuikSCAT: Polar orbiting, sun-synchronous platform
- Known issues: rain and sea ice
- 10 years of observations: 01/08/1999 - 31/10/2009 (3745 days)
- Gridded data obtained from Remote Sensing Systems
- Grid cell dimensions: 25 * 25 km
- For domain of interest: 2 passes per day
- Days with available data: 3733
- Maximum potential passes: 7466
- Maximum available passes: 7085

Methods

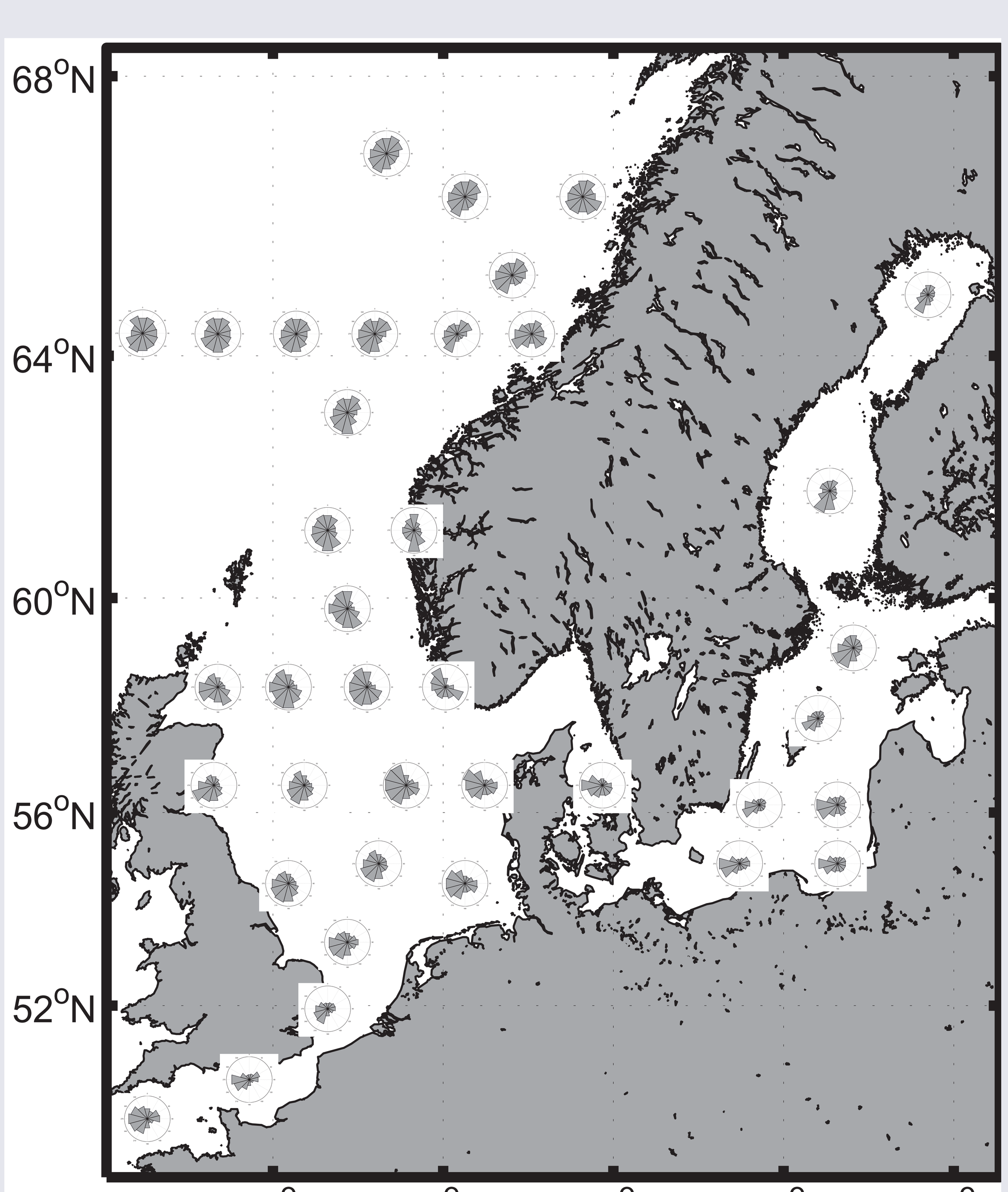
- Frequency distribution of wind speed → Weibull:

$$f(u) = \frac{k}{A}\left(\frac{u}{A}\right)^{k-1} exp\left(-\left(\frac{u}{A}\right)^{k}\right) \qquad (1)$$

- Scale parameter ***A***: spread of the distribution, generally associated with mean wind
- Shape parameter ***k***: symmetry of the distribution, low values associated with asymmetric distributions
- Intra-annual Wind Index from QuikSCAT observations:
  - For every month, estimate Mean Wind Speed over the years
  - Wind Index = $\bar{U}_{month}/\bar{U}$
- Inter-annual Wind Index from QuikSCAT observations:
  - For every year, estimate Mean Wind Speed
  - Wind Index = $\bar{U}_{year}/\bar{U}$

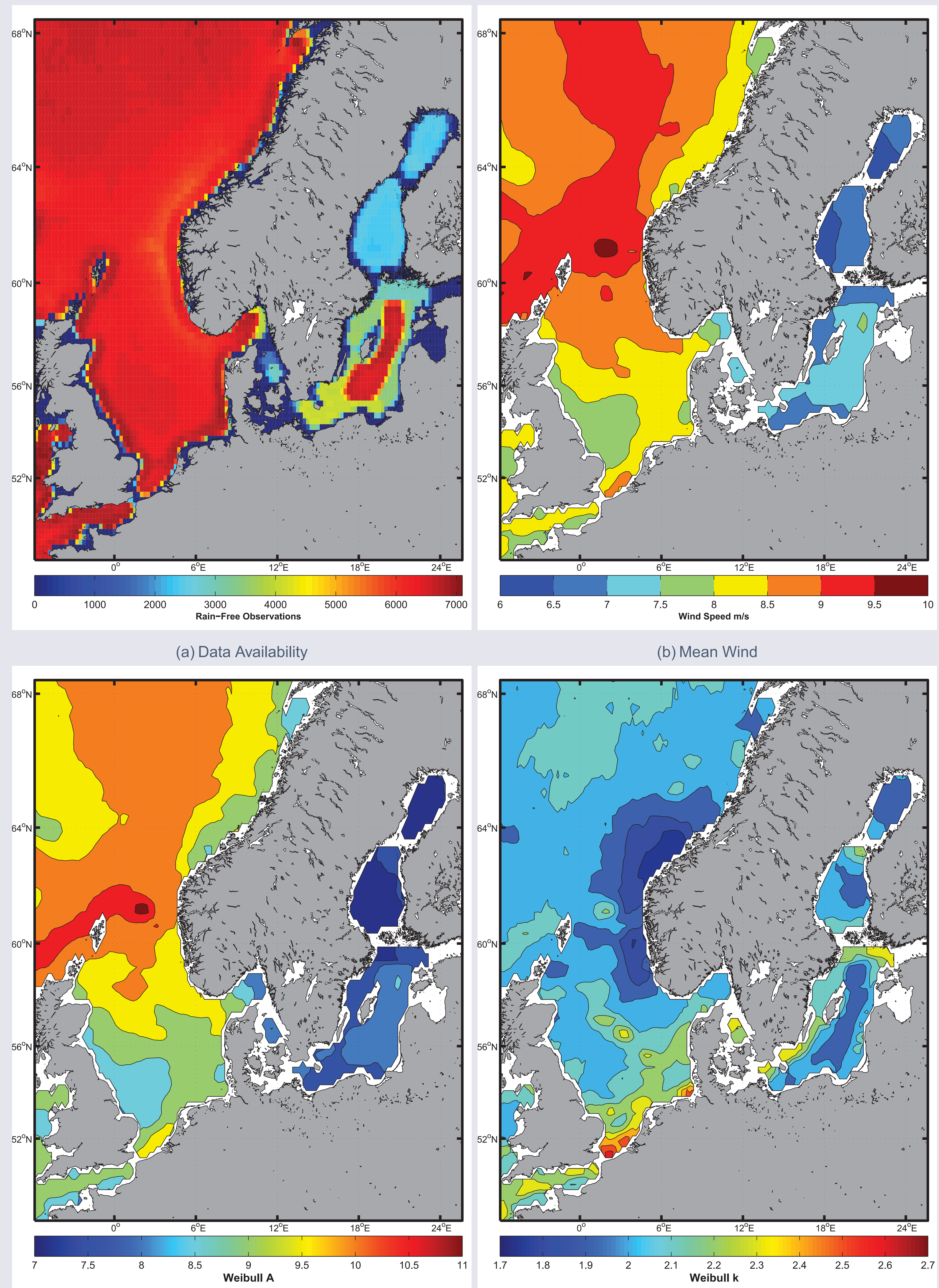
Wind Direction

The figure below shows the spatial variation of wind roses from 10 years of QuikSCAT observations at different locations, with at least 1 year of two observations per day. Wind directions have been separated in 12 sectors where North is centred around 0°, between 345° and 15°. The rest fol low accordingly. We note the following:



- Variation of wind roses from offshore to coastal areas is captured.
- Consistency with expected results: wind rose distributions vary according to orographic features.
- Channelling in the English Channel and in the central Baltic Sea.
- North Atlantic: approaching the Norwegian coast, the wind rose distributions adapt; main wind direction aligning parallel to the coast.
- However, wind roses along the Norwegian North-West coast capture a land component, likely due to a Bora like type of wind.
- This feature does not appear in the South-Western part of the Norwegian coast.

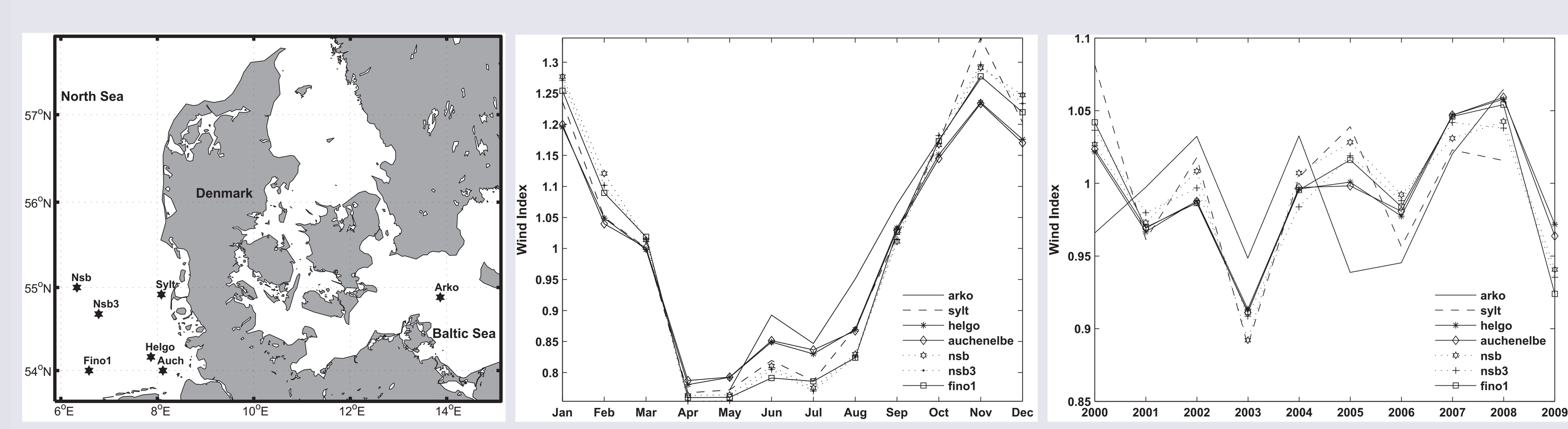
Wind Statistics



(a) Data Availability (b) Mean Wind

(c) Weibull ***A*** (d) Weibull ***k***

Wind Index



(e) Locations (f) Intra-Annual Wind Index (g) Inter-Annual Wind Index

Locations of experimental sites, with platforms and buoys, (left) where Wind Indexes are estimated Intra-annually (middle) and Inter-annually (right) using QuikSCAT data. Wind indexes from in situ measurements will be compared with the QuikSCAT derived ones.

Conclusions

- QuikSCAT data provide a reliable representation of the wind regime in the North Sea and the Baltic Sea
- Wind direction distributions adapt to the coastal morphology but also reflect specific coastal wind regimes. i.e. sea-land breezes or orographic Bora like regimes.
- Wind is channelled through the English Channel in the North Sea
- Baltic basin under observed due to frequent presence of sea ice
- Intense lee effect by the British Isles
- Dominant Western and South-Western directions
- Weibull ***k*** values relatively low in areas with highest mean wind
- Highest ***k*** values in the English Channel and the southern North Sea

References

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