# Combining Satellite Wind Maps and Mesoscale Modelling for a Wind Atlas of the South Baltic Sea

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# Combining satellite wind maps and mesoscale modelling for a wind atlas of the South Baltic Sea

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## Abstract

Satellite Synthetic Aperture Radar (SAR) data from Envisat are used. The wind resource statistics based on SAR wind maps are calculated. The SAR-based results are valid at 10 m above sea level. WRF mesoscale model results are calculated at several heights. Finally, the results are compared to independent data sets such as QuikSCAT and selected meteorological data. The wind atlas may be used by wind farm developers in the South Baltic Sea.

The work is supported by the EU South Baltic Program in South Baltic OFFER project.

## Objective

To provide a wind atlas for the South Baltic Sea

## Method: SAR

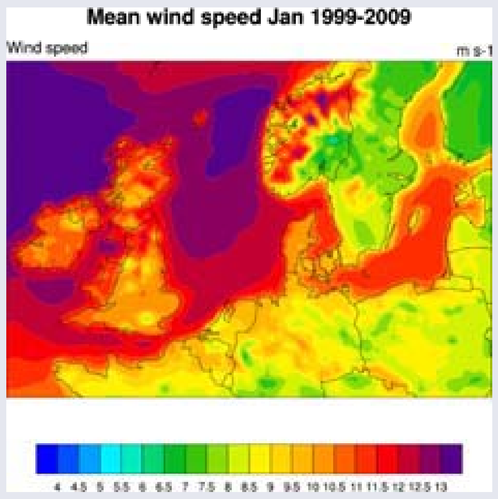
Satellite remote sensing images from Synthetic Aperture Radar (SAR) from the European Space Agency satellite Envisat are used. The SAR images are calibrated and thereafter the geophysical model function CMOD-5 is used to retrieve wind speed. As a priori information to solve the CMOD-5 equation is used wind direction from a global atmospheric model. Wind directions are available every 6 hours at 1 degree latitude and longitude grid and the values near 10 m are extrapolated in space and time to provide optimal input. Comparing wind direction and wind speed to meteorological observations in the South Baltic Sea shows high correlations and small bias. The number of SAR wind maps used for any location in the region of interest varies from 350 to more than 500 using Envisat ASAR wide swath mode images. The wind resource statistics based on SAR wind maps are calculated for 10 m above sea level.

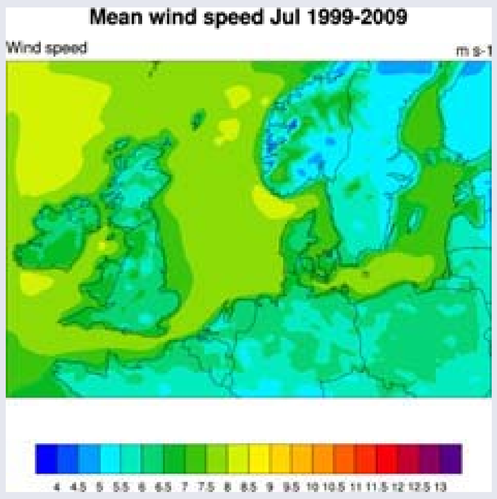
## Method: QuikSCAT

Ocean wind maps from the satellite QuikSCAT from 1999 to 2009 are used in the analysis. The data cover the South Baltic Sea twice per day for 10 years. However due to sea ice flagging of the data, only the central part of the Baltic Sea has a data series during all seasons. Winter conditions are not represented in the coastal areas.

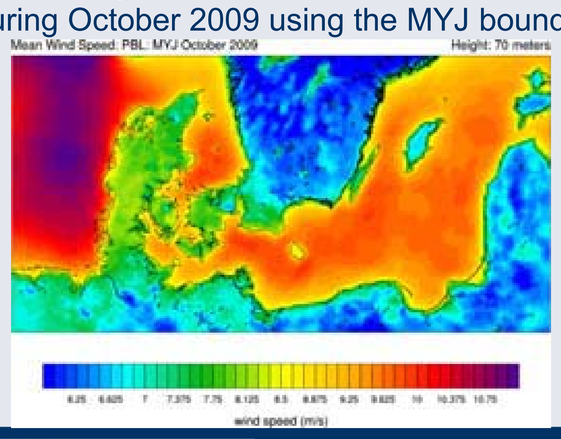
## Method: WRF mesoscale model

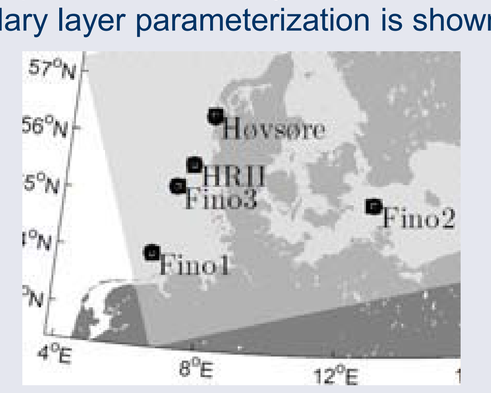
The Weather Research and Forecasting model (WRF) is used to calculate wind resources at several heights. The maps below are from an 11-year downscaling for 1999 to 2009, with two domains, 45 km and a nest at 15 km. The boundary conditions are from NCAR/NCEP reanalysis II, and the increased resolution SSTs 1/4 degree. Mean wind speeds are shown for January and July at 80 m.




For WRF a statistical-dynamical downscaling by quantifying representative weighting functions from the long-term statistics to apply to around two years of daily WRF results, is in progress. Furthermore, WRF is being tested with six difference parameterizations for the boundary layer and compared to available meteorological observations. Mean wind speed simulated by WRF at 70 meters during October 2009 using the MYJ boundary layer parameterization is shown.

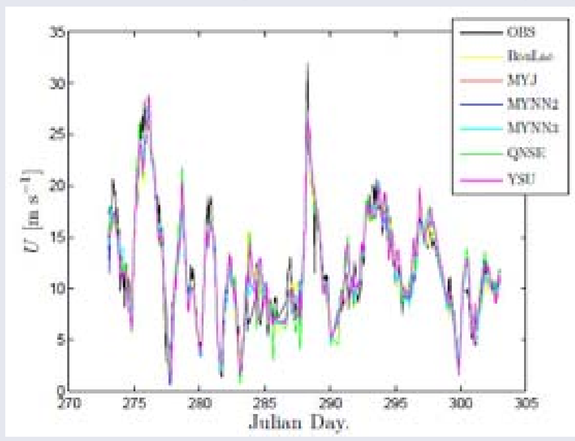


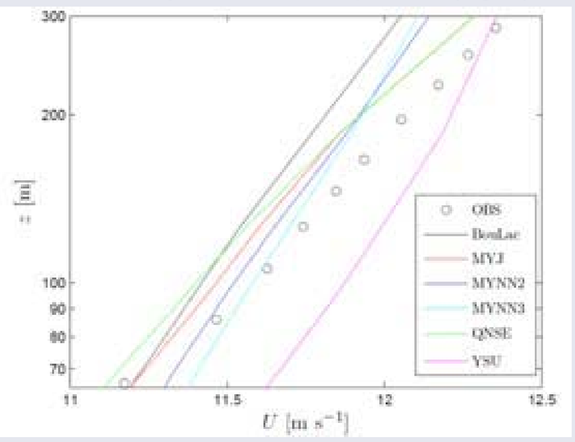




Map indicating comparison sites

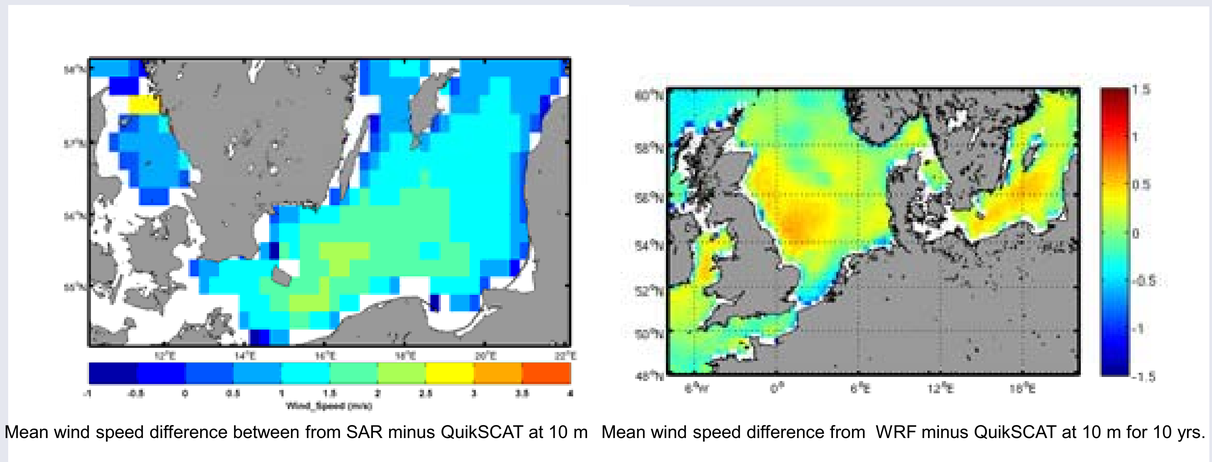
## Results

Comparing HRII (Horns Rev) lidar data and WRF results from six PBL schemes each hour during 11/2009 at 300 m (left) and monthly mean wind profile (right).



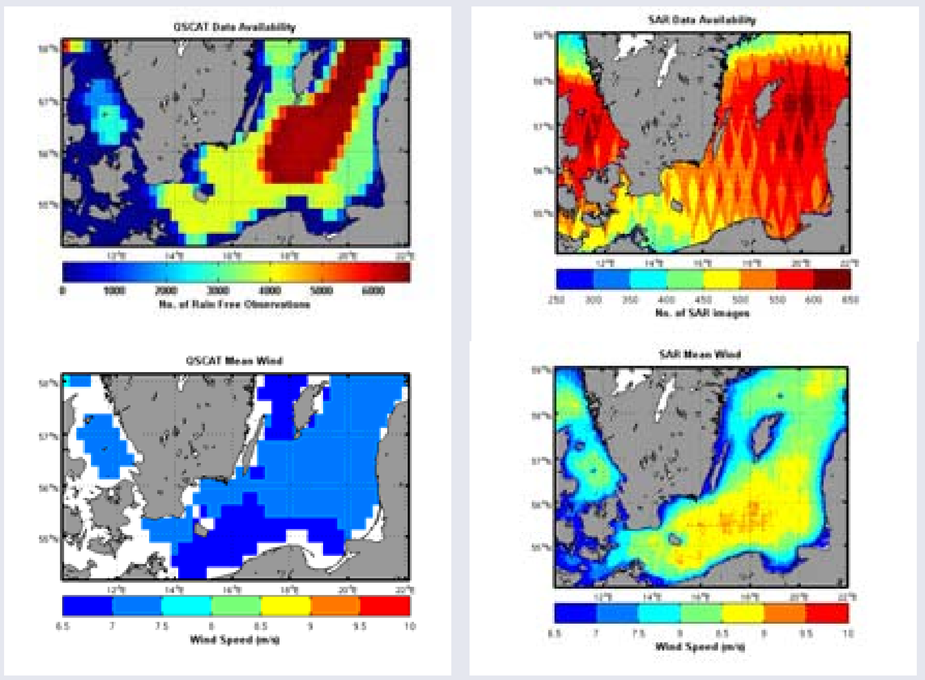

More than 1000 wind speed maps based on SAR have been compared to meteorological data in or near the South Baltic Sea. The results show r.m.s.error of 1.17 $ms^{-1}$, bias -0.25 $ms^{-1}$ and correlation coefficient $R^2$ 0.783 according to Hasager *et al.* 2011. The analysis was based on 900 collocated wind speeds from SAR and wind speeds from meteorological masts. In a study by Badger *et al.* 2010 using meteorological data from two offshore and one coastal mast in the North Sea Weibull scale and shape and energy density where compared to SAR-based results. The conclusion was that the SAR-based results appeared to have similar or lower error than is typically expected in mesoscale modelling.




Mean wind speed difference between from SAR minus QuikSCAT at 10 m  Mean wind speed difference from  WRF minus QuikSCAT at 10 m for 10 yrs.

Comparing SAR-based mean wind speed with QuikSCAT (top figure) and differences between WRF and QuikSCAT mean wind speed (bottom figure) shows major differences between results.

Differences in data availability of QuikSCAT and SAR and the full resolution of QuikSCAT and SAR mean wind speed maps are shown below for 10 m height..




## Conclusions

The challenge is to find suitable meteorological data to evaluated the various results with. The work is in progress and will be completed in Spring 2011.

## References

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2. M.Badger; J.Badger;M.Nielsen;C.B.Hasager;A.PeñaWind class sampling of satellite SAR imagery for offshore wind resource mapping. *J. Applied Meteorology and Climatology* **2010,** 49,12,2474-2491.

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