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A NOVEL SAMPLING METHOD FOR SATELLITE-BASED OFFSHORE WIND RESOURCE ESTIMATION

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Abstract

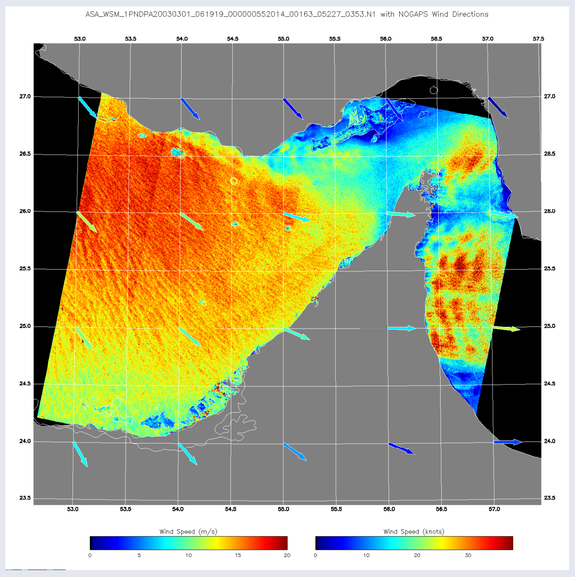
Synthetic aperture radar (SAR) measurements from satellites can be used to estimate the spatial wind speed variation offshore in great detail. The radar senses cm-scale roughness at the sea surface which can be translated to wind speed at the height 10 m using an empirical geophysical model function. A system has been setup at Risø DTU, the National Laboratory for Sustainable Energy in Denmark, for offshore wind retrievals from Envisat radar data.

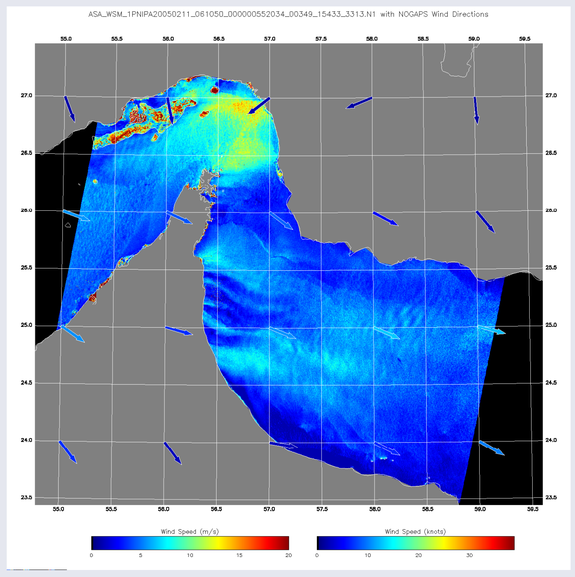
If 70 or more overlapping satellite SAR scenes are available for a given area of interest it is possible to estimate the wind resource from the satellite samples. A major advantage of satellite-based offshore wind resource assessment is the spatial information gained at high resolution from the satellite imagery. Limitations include the low sampling rate and the fixed acquisition times of satellite data. A new satellite scene is typically available every 3-4 days over a given site of interest and the acquisition takes place in the morning and evening only.

At Risø DTU we have utilized our ever-growing collection of wind maps from Envisat to compute wind statistics for the North Sea and the Baltic Sea. The reliability and the spatial coverage of the satellite-based wind climatology have improved gradually as more data were collected. The satellite scenes have been treated as random samples and weighted equally in our previous analyses. Here we introduce a novel sampling strategy based on the wind class methodology that is normally applied in numerical modeling of wind resources. The method is applied within a wind and solar resource assessment study for the United Arab Emirates funded by Masdar and coordinated by the United Nations Environment Programme (UNEP).

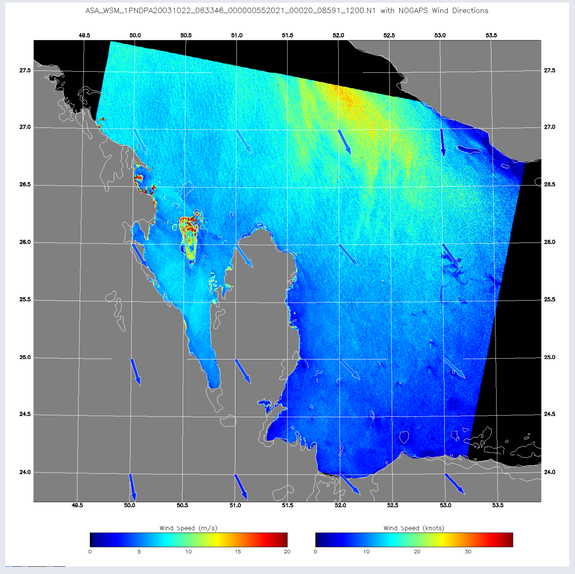
Thirty years of NCEP/NCAR re-analysis data are used to define approximately 100 geostrophic wind classes. These wind classes show climatologically representative large-scale meteorological conditions for the region of interest. The wind classes are used to make the most representative selection of satellite images from the Envisat image catalogue. The frequency of occurrence of each wind class is used to weight the satellite-derived winds for the calculation of wind climatology. The applied selection and analysis method improves the reliability of wind climate estimates compared to random selection of images each given equal weighting.

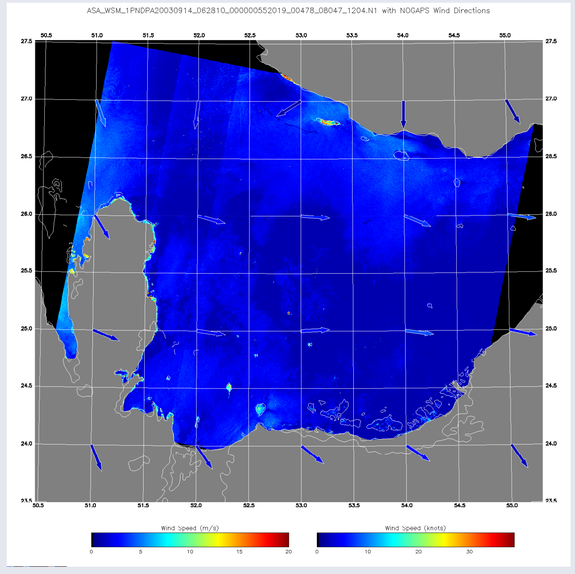
Satellite wind fields





Eastern UAE and Oman: Ocean winds are strongly affected by the mountainous terrain. Sheltering effects are frequently observed; especially at westerly winds.

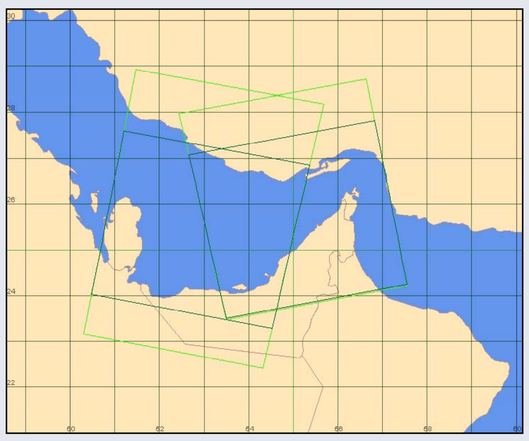




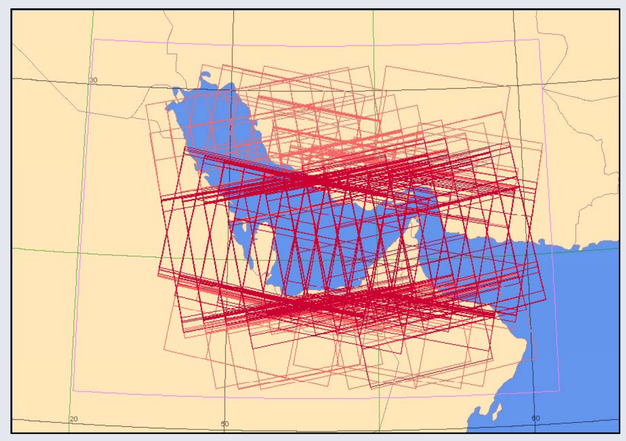
Western UAE and Qatar: Ocean winds are generally weak due to sheltering from the Qatar Peninsula. Prevailing winds are from the north-west.

Sampling method

Sampling of satellite observations is based on 100 wind classes defined using NCEP/NCAR re-analysis data. Satellite images are weighted according to the frequency of occurrence for each wind class.



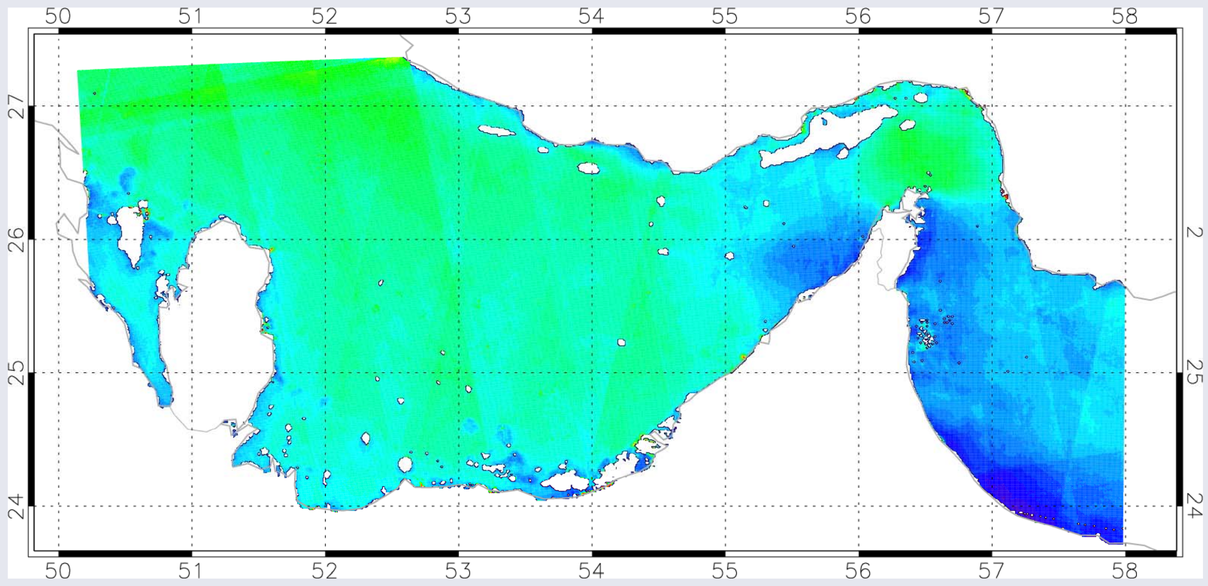
Satellite coverage for one wind class representing a single wind situation.



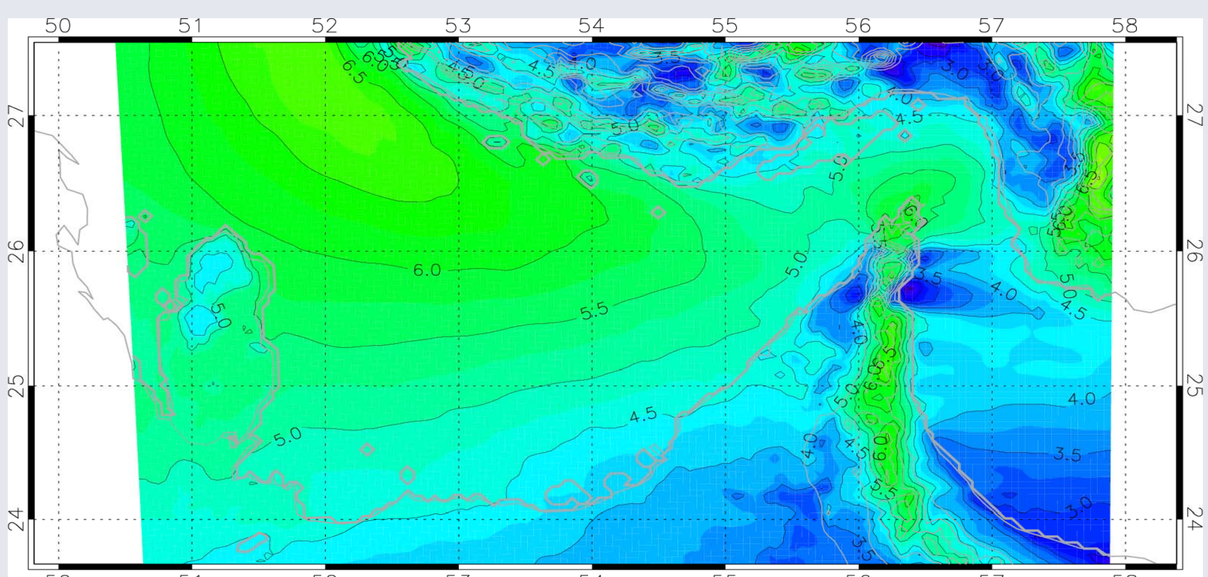
Satellite coverage for all 100 wind classes, amounting to 234 images in total.

Wind resources

Wind fields retrieved from satellite imagery are combined for a statistical analysis.



Map of the mean wind speed at 10 m over UAE based on satellite observations. The spatial resolution is 1 km. The contour plot below uses the same color scale.



Map of the mean wind speed at 10 m over UAE based on KAMM modeling of the same wind classes. A good agreement is found between satellite and model wind speeds offshore.

Conclusions

Detailed wind resource maps can be produced from satellite SAR observations at an accuracy comparable with mesoscale modeling. The use of intelligent sampling, rather than random sampling, of satellite imagery leads to an improved accuracy at a lower cost, as fewer satellite images are needed.

Acknowledgements

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