Wind Speed Gradients and Wakes Mapped Using SAR for A Study Area in South-East China

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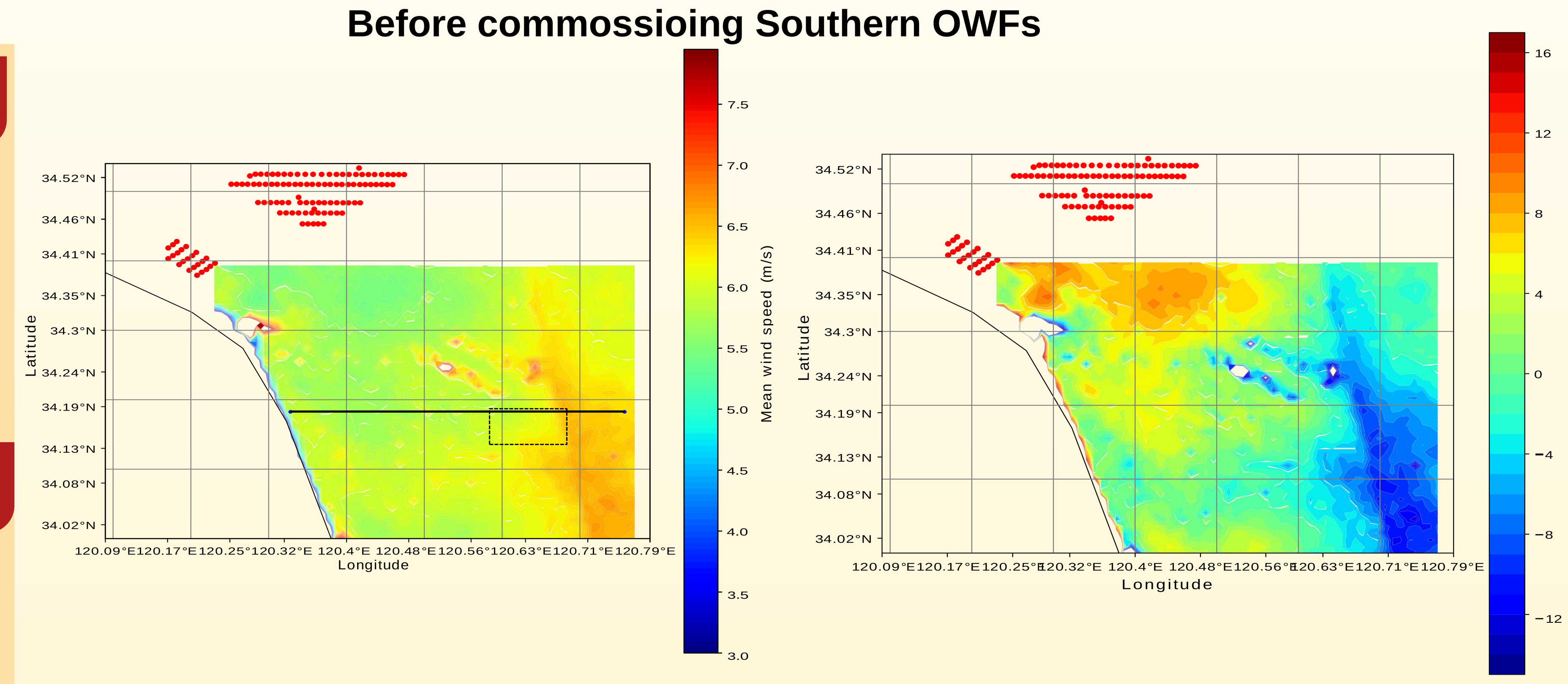
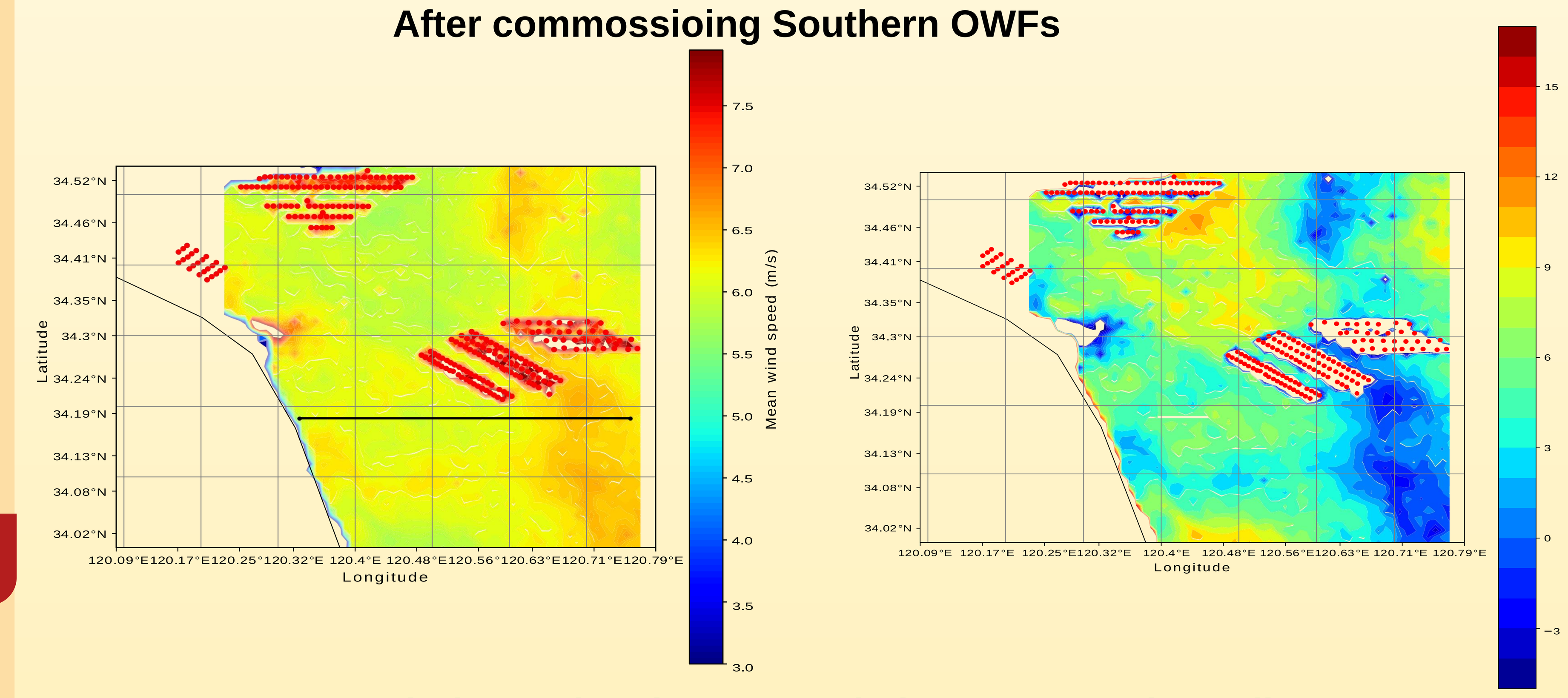
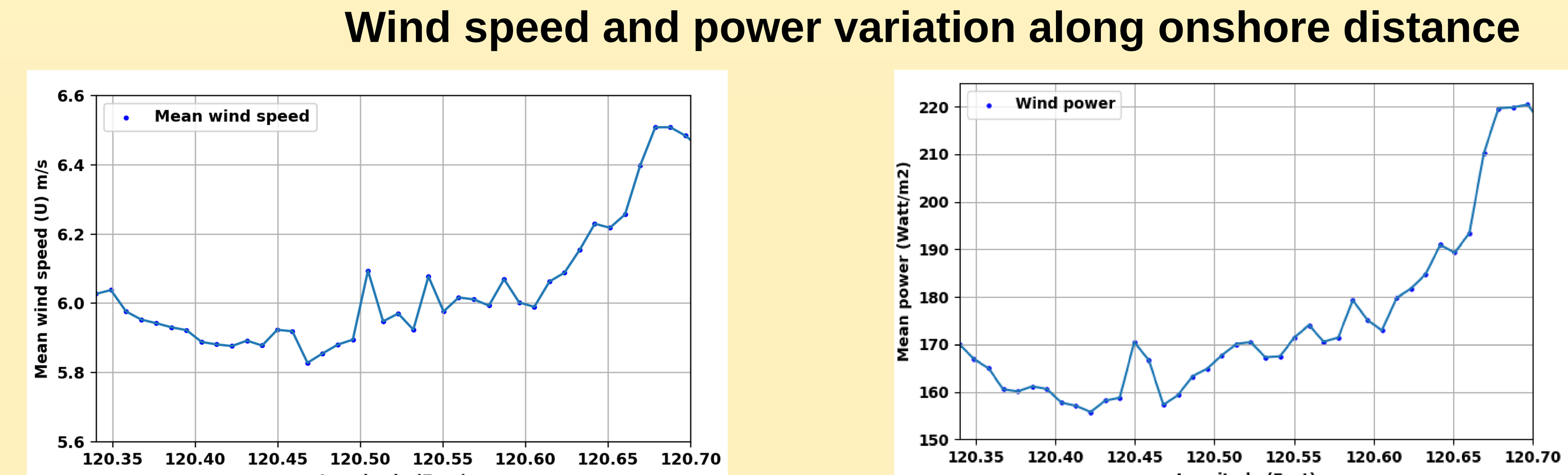
Before commossioing Southern OWFs



After commossioing Southern OWFs



Wind speed and power variation along onshore distance



Abstract

The rapid increase of offshore wind installations in the south-China sea near the coast triggers a new demand for studying the effects of horizontal wind speed gradients and wind power variation within the coastal zone. The abundance of SAR data offers an opportunity to investigate the complexity of wind fields in costal zones. The wind speed and power declined up t 8% and 22 %, respectively. Costal upwelling effects can manipulate the wind deficit values at downstream side in this area.

Introduction

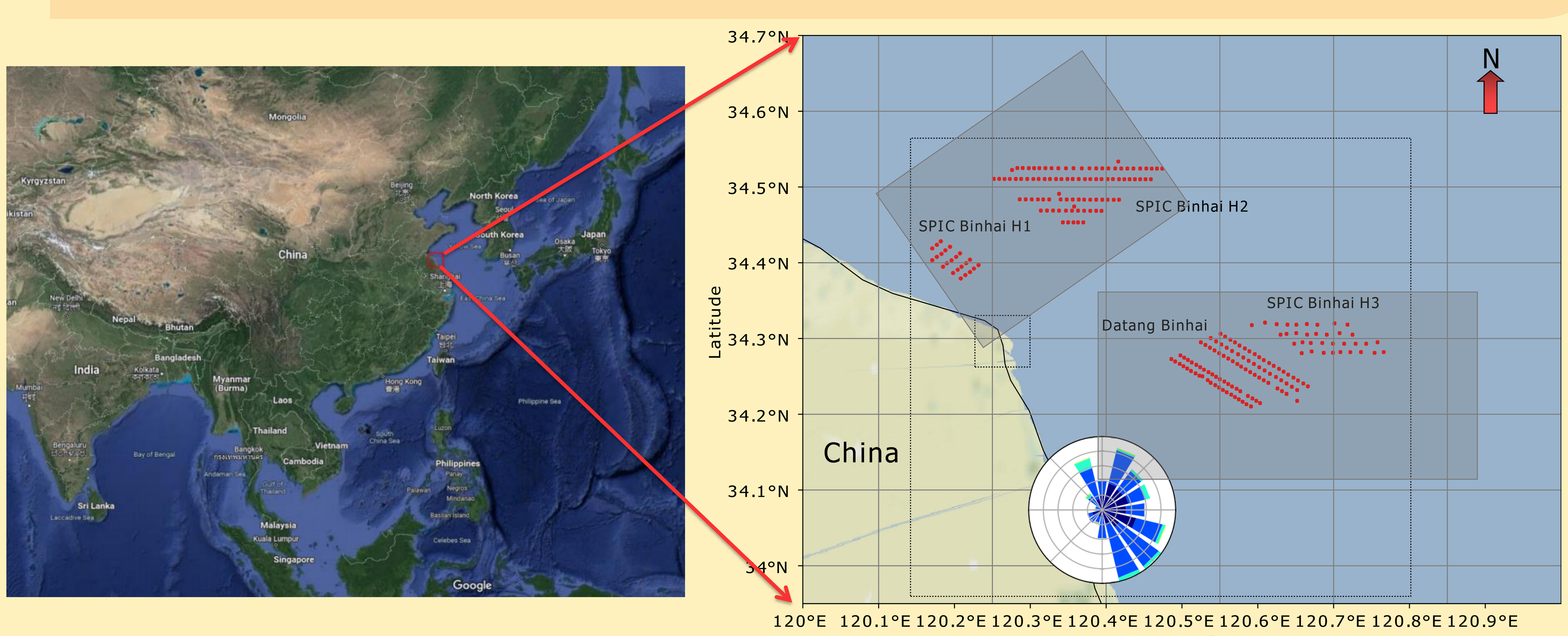
The SAR radar observables (NRCSs) relate to local near-surface wind speed using Geophysical Model Functions (GMFs). Several functions used to retrieve Sea Surface Wind (SSW) speed such as the C-band Model (CMOD) family. CMOD5.n is the updated version of CMOD5 function that relates the roughness components of the ocean surface or frictional velocity, radar incident angle and wind direction relative antenna look direction with SSW at 10 m mean sea level (m.s.l) for the neutral stable conditions from the vertical polarized images (VV). The following is the empirical function relation in which the dependency of NRCS for the CMOD family.

$$\sigma_0 = CMOD(c, v, \emptyset, \theta) = B0\left(c_0, v, \theta\right)\left[1 + B1\left(c_1, v, \theta\right)\cos\cos\emptyset + B2\left(c_2, v, \theta\right)\cos\cos\left(2\emptyset\right)\right]^p$$

where σ is the NRCS and ∅ is the angle between wind direction and scatterometer azimuth look angle (both measured from the North). The other coefficients ci shape the terms Bi, v is the SSW at 10 m.s.l and is the incidence angle.

Objectives and Study Area

The aim of the present study is to map the horizontal speed gradients for a coastal area with several OWFs at the southeastern coast of China. Furthermore, to illustrate the effects of the coastal wind speed gradients on the potential wind power production. Characterizing the spatial wind variability can be used to support different aspects of OWFs planning in this area [1].



Methodology

The collected SAR scenes have been classified according to commissioning date of southern offshore wind farms.

- **SAR wind retrieval**

The SAR radar observables relate to the local near-surface wind speed using an empirical equation called a geophysical model function (GMF)[2].

- **Mean wind speed, deficit and power variation calculation**

A grid of 60×50 km is overlaid over the entire study area and used to retrieve SAR wind measurements with the regular grid spacing 1.5 km between each rectangular bin inside the grid

$$\Delta u = \frac{U_{upstream,x} - U_{downstream,x}}{U_{upstream,x}}$$

$$\%\Delta u = \frac{\vec{U}_{upstream,x} - \vec{U}_{downstream,x}}{\vec{U}_{upstream,x}} \times 100$$

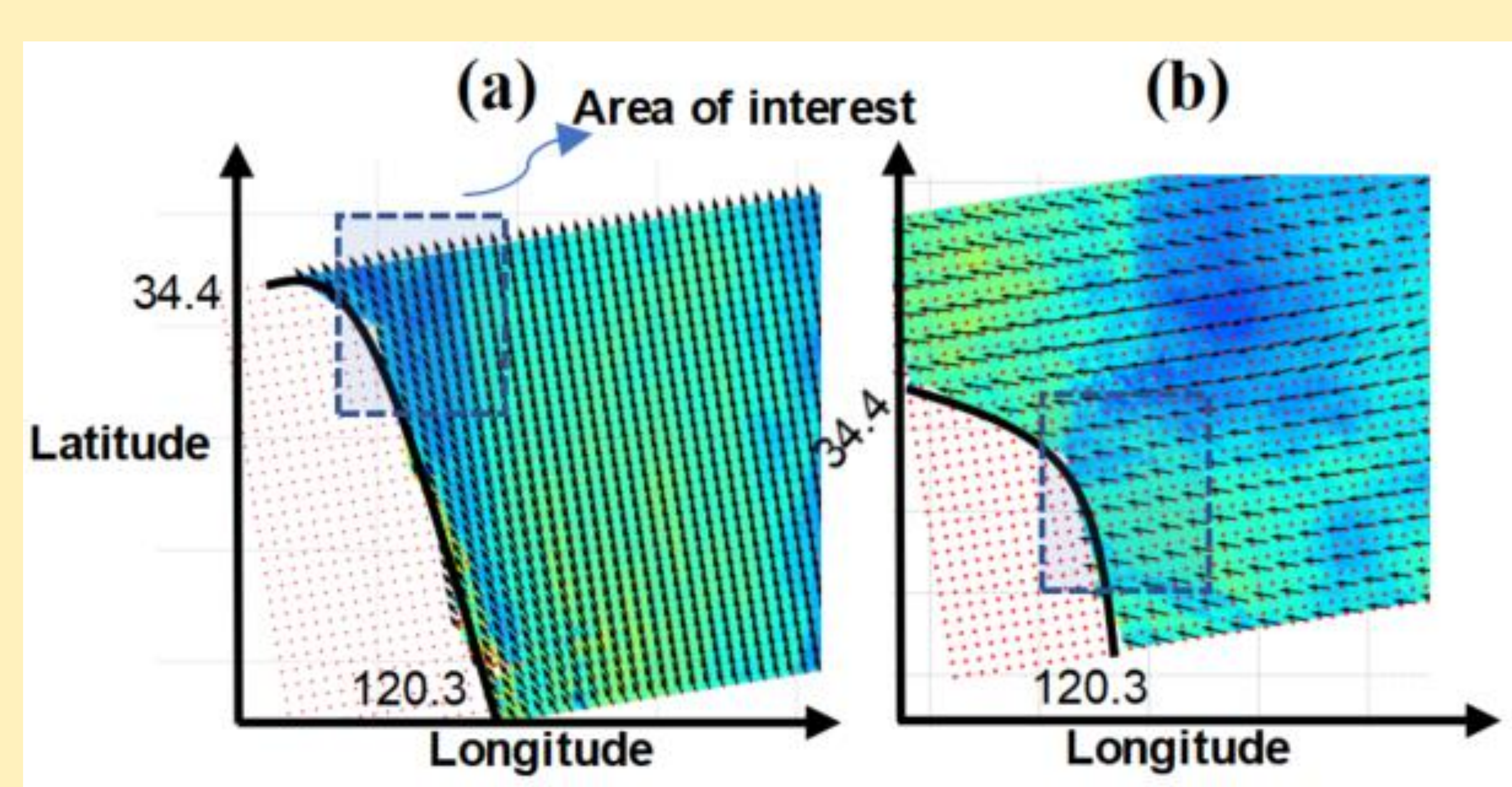
$$\Delta u_{x,final} = \Delta u_{x,after} - \Delta u_{x,before}$$

Results

Before southern OWFs commissioning VS after southern OWFs

Discussion and Conclusion

- The robustness of using SAR data at coastal zone thanks to the high spatial resolution of SAR data
- The study has demonstrated how is the wind speed variation (8% reduction) is proportional with the onshore distance. Subsequently, the variation on wind power (22 %) as well at 10 m level.
- The coastal areas in this region experienced a strong combination of coastal upwelling [3] (two examples are shown below from [1]) and wind speed gradient effects. Recent commissioning dates of the southern OWFs limit the number of samples that we can obtain. Additionally, found that for an area mixed with different features (like sand banks, mud flats) can lead to high standard deviation in mean wind speed, which are not wind induced



Major References

[1] Wind speed gradients and wakes mapped using SAR for a Study area in south-east China, A. Owda & M. Badger, IEEE IGRASS 2022.

[2] H. Hersbach, A. Stoffelen, and S. De Haan, "An improved C-band scatterometer ocean geophysical model function: CMOD5," Journal of Geophysical Research: Oceans, vol. 112, no. 3, pp. 1–18, 2007, doi: 10.1029/2006JC003743.

[3] X. Li, W. Pichel, and X. Yang, "Spaceborne SAR imaging of coastal ocean phenomena," IEEE Geoscience and Remote Sensing Letters, no. 20, pp. 36–38, 1979.

Acknowledgements

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