

Evaluating and comparing ASCAT and Sentinel-1 SAR winds against NDBC buoys

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Abstract

This study assesses and compares the accuracy of the widely used ocean wind vector products from two European C-band spaceborne radars: MetOp-A/B Advanced Scatterometer (ASCAT) and Sentinel-1A/B synthetic aperture radar (SAR) in Interferometric Wide (IW) mode. Two years (2019 ~ 2020) SAR/ASCAT winds are validated against the ground truth from the offshore/coastal meteorological buoys of National Data Buoy Center. Winds from radars and buoys are considered spatially matched if the buoy is located within the satellite wind cell, with a time difference limited to 30 min. To evaluate SAR/ASCAT winds against buoys in the same framework, we use 43 offshore buoy stations as common reference, and then validate them at comparable spatial resolution (25 km). Intercomparison results show that ASCAT winds exhibit higher accuracy level with root mean square error (RMSE) of 0.92 m/s (21.71°) in terms of the wind speed (direction). Regarding the Sentinel-1 SAR, offshore wind speed (direction) data downsampled to 25 km present an RMSE of 1.03 m/s (27.48°), showing very little change compared to 1 km products originally provided by ESA. Furthermore, wind accuracy degrades for Sentinel-1 SAR at both 1 km and 25 km resolutions when validated against coastal buoys, where ASCAT winds are usually unavailable. In general, our results demonstrate that the Sentinel-1 winds are as accurate as ASCAT in open ocean, while the performance of coastal SAR winds could be further improved. This finding could be helpful for better exploiting synergies in the ocean wind datasets from these two spaceborne radars.

Introduction

Ocean surface winds monitoring relies on remote sensing technology for global coverage, where ASCAT and SAR complement each other in offshore and coastal wind measurements, making them ideal for data fusion. However, the consistency of accuracy between ASCAT and Sentinel-1 has not been systematically compared.

This study addresses this critical gap through a unified validation framework using NDBC buoy networks. Our findings establish fundamental understanding for synergistic use of these datasets in both offshore and coastal regimes.

Objective & Study areas

The objective of this study is to compare the accuracy of ASCAT and Sentinel-1 SAR wind measurements, using buoy data as a benchmark:

- SAR collocated buoys (n=106)
- ASCAT collocated buoys (n=43)

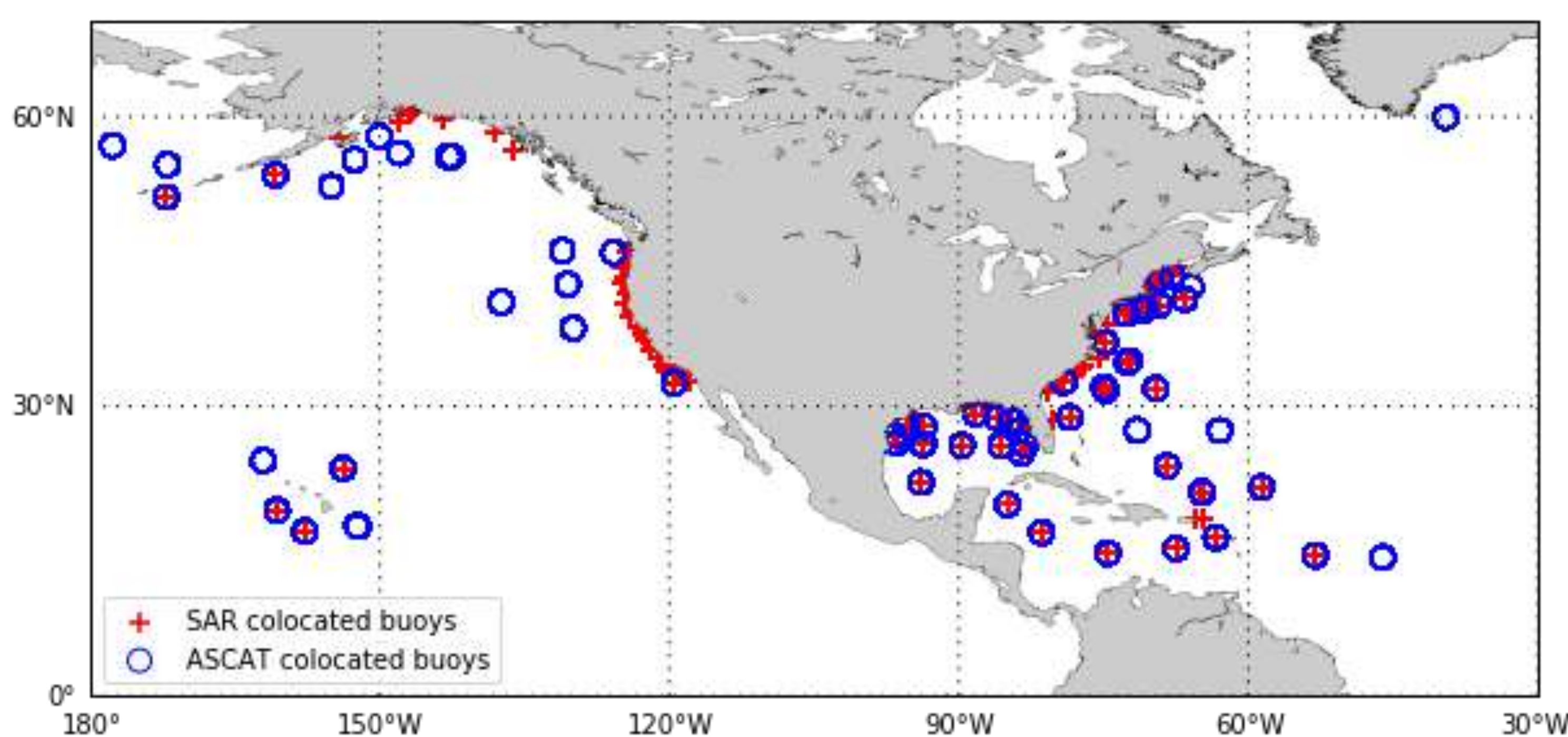


Fig. 1: Locations of the moored buoys from NDBC.

Methodology

(1) 10 m equivalent neutral winds conversion

To facilitate comparison with ASCAT and Sentinel-1 SAR wind data, buoy wind speeds are converted to equivalent neutral winds at a height of 10 meters, accounting for variations in the anemometer heights across different buoys. In this work, the conversion were performed using the Coupled Ocean-Atmosphere Response Experiment (COARE) bulk algorithm (version 3.0) developed by Fairall et al. (2003).

(2) Evaluation index

In the intercomparison of ASCAT and SAR with buoy wind field data, we calculate bias and Root Mean Square Error (RMSE) as follows:

$$Bias = \frac{\sum_{i=1}^N (y_i - x_i)}{N}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^N (y_i - x_i)^2}{N}}$$

where y_i represents the satellite-derived wind estimates and x_i represents the in situ wind records.

Validation results

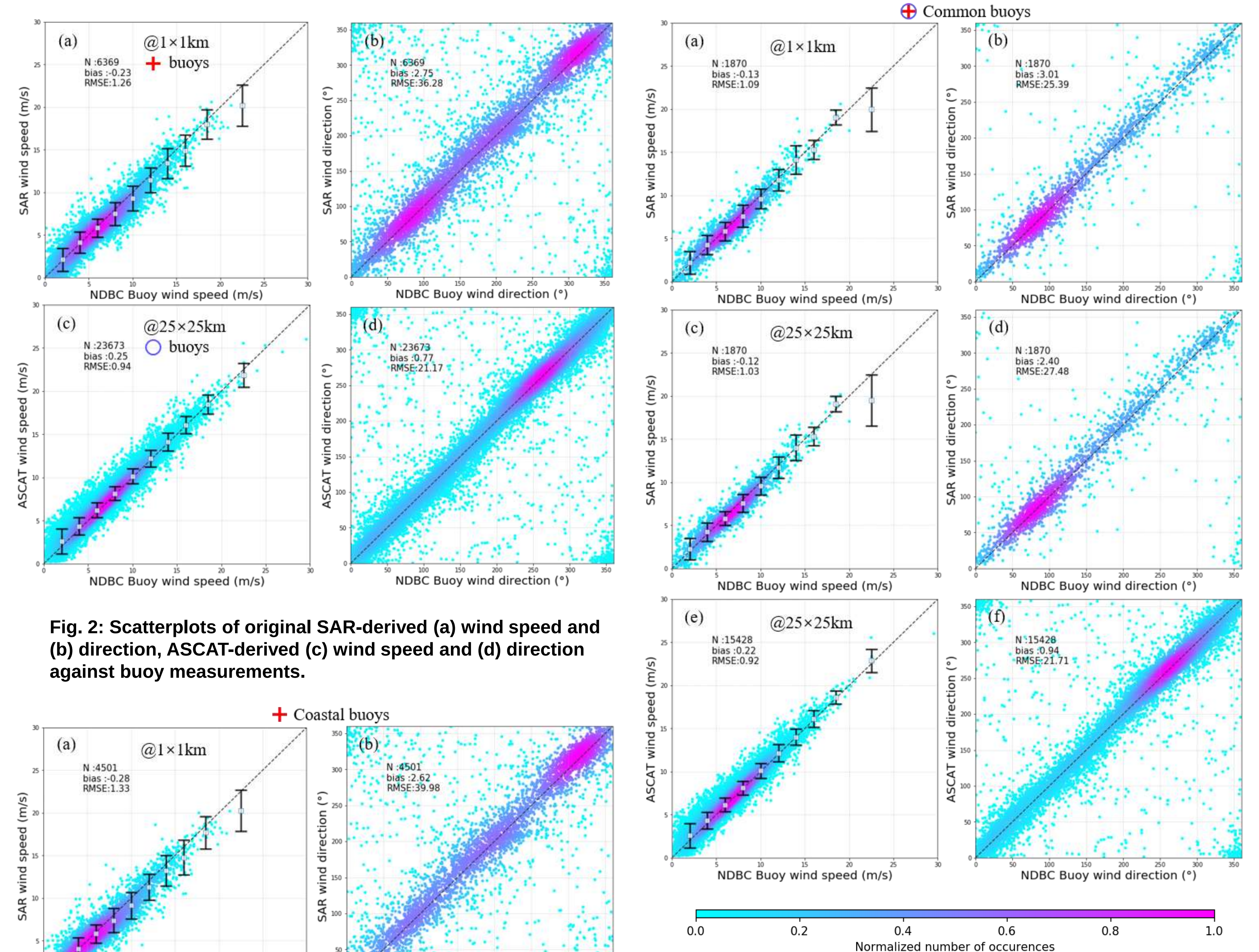


Fig. 2: Scatterplots of original SAR-derived (a) wind speed and (b) direction, ASCAT-derived (c) wind speed and (d) direction against buoy measurements.

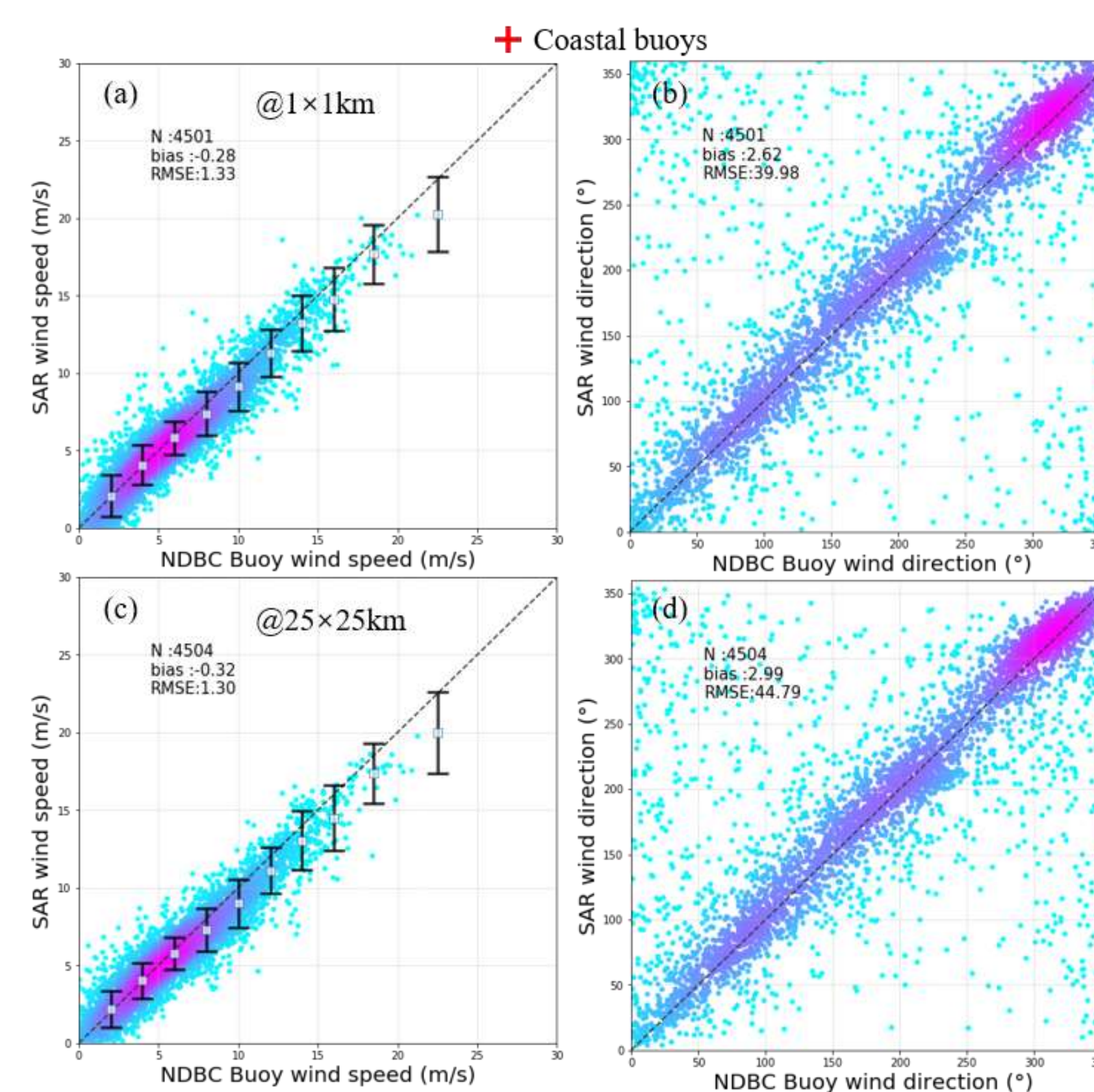


Fig. 4: Scatterplots of 1 km/25km SAR-derived wind speed (a)/(c) and direction (b)/(d) against coastal buoys.

Fig. 3: Scatterplots of (a) 1 km SAR-derived wind speed, (b) 1 km SAR-derived wind direction, (c) 25 km SAR-derived wind speed, (d) 25 km SAR-derived wind direction, (e) 25 km ASCAT-derived wind speed, and (f) 25 km ASCAT-derived wind direction against common buoy measurements.

Conclusions

- Comparison results show ASCAT wind products exhibit higher accuracy than Sentinel-1 SAR, regardless of whether the resolution of SAR is 1 km or 25 km.
- The evaluation results indicate that reducing the resolution of SAR wind data has an insignificant effect on the accuracy.
- These findings indicate that ASCAT wind products generally exhibit higher accuracy. However, comparisons with coastal buoys highlight that SAR has the potential to offer detailed inshore observations, particularly in wind direction, requires refinement.
- Moving forward, future work will focus on developing algorithms for the joint use of ASCAT and Sentinel-1 SAR wind products to further enhance their observational capabilities and precision.

Major reference

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