Detailed investigation of the role of buoy wind errors in buoy-scatterometer disagreement

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Introduction

Direct observations of near-surface winds are crucial for the calibration and validation of estimated winds by satellite-based platforms like scatterometers. For more than 18 years, the Woods Hole Oceanographic Institution (WHOI) operates several moored buoys in the Atlantic (NTAS, SPURS1) and Pacific Ocean (Stratus, WHOTS, SPURS2). These buoys are well equipped with redundant meteorological observation systems that sample all wind-relevant parameters in 1-min resolution. This unique dataset is used to investigate the buoy performance and assess measurement errors, in particular flow distortion. Those errors are then related to satellite-based scatterometer observations of winds, which are different from direct buoy observations.

Buoys

3 WHOI ORS buoys (uop.whoi.edu/ReferenceDataSets/)
2 SPURS (https://spurs.jpl.nasa.gov/) buoys

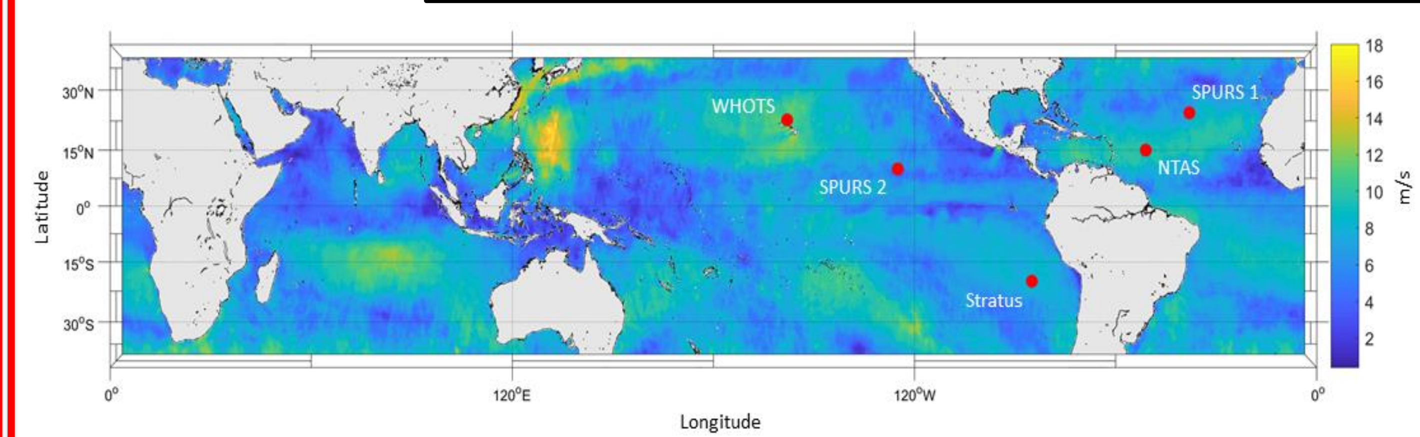


Fig 1. Mean wind speed in the global tropical and subtropical ocean as seen from ASCAT on October 21 2017. The red dots show the sites of the three ORS (Ocean Reference Stations) (WHOTS, NTAS, and Stratus) and the two SPURS sites.

Computational Fluid Dynamics (CFD) study (*Emond et al., 2012*):

- a full numerical mesh of a WHOI MOBS buoy was used
- flow distortion on port and starboard side of the buoy
- accelerated on the far side by up to 3.5% and decelerated on the near side by -1%

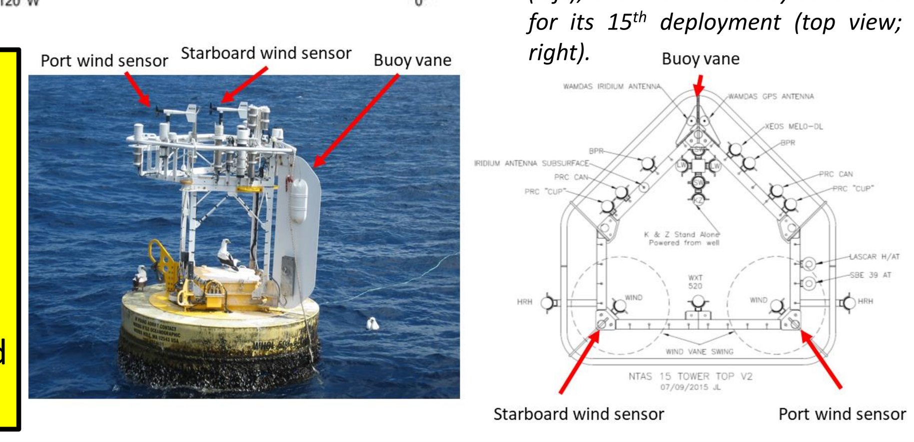


Fig 2. The Stratus buoy before recovery from its 13th deployment (left), and the NTAS buoy schematic for its 15th deployment (top view; right).

Data

Buoy data: time series of wind speed and direction (port and starboard), air temp, humidity, ocean currents, and SST **>>** Equivalent neutral winds (two parameterizations: LKB (*Liu et al., 1979*) and COARE3.0 (*Fairall et al., 2003*)) **>>** averaged 25-km equivalent buoy winds (*Lin et al., 2015*)

Scatterometer: QuikSCAT and ASCAT daily gridded (0.25°) fields with two observ. per day (from Remote Sensing Systems (www.remss.com)

Buoys vs. scatterometer

- Scatterometer grid point closest to buoy site
- Buoy data within 30 seconds to satellite overflight
- 48-pt RMS (roughly a month)

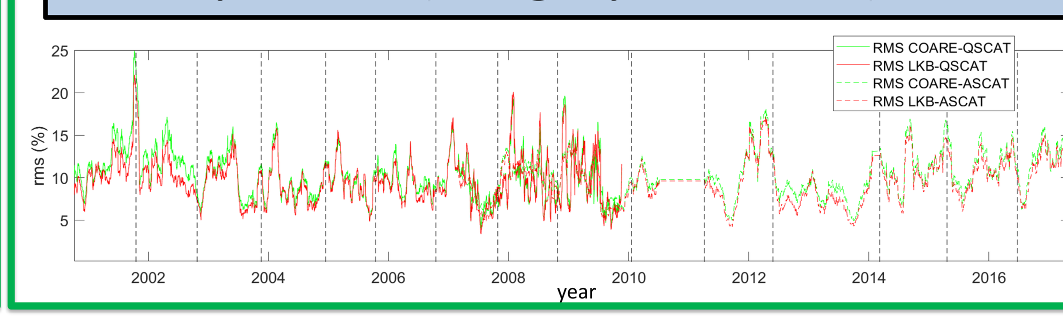
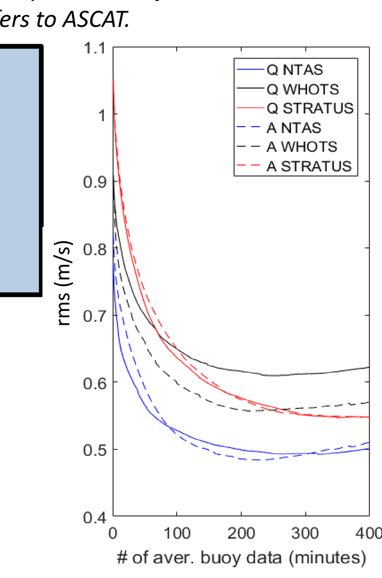


Fig 4. Relative 48-pt-RMS between Stratus and QuikSCAT (solid lines) and ASCAT (dashed lines). The Stratus equivalent neutral winds were estimated with the COARE (green) and LKB (red) parameterization.

Fig 3. Mean RMS between scatterometer and buoy against the averaging time of the buoy data. Q refers to QuikSCAT and A refers to ASCAT.



Flow Distortion

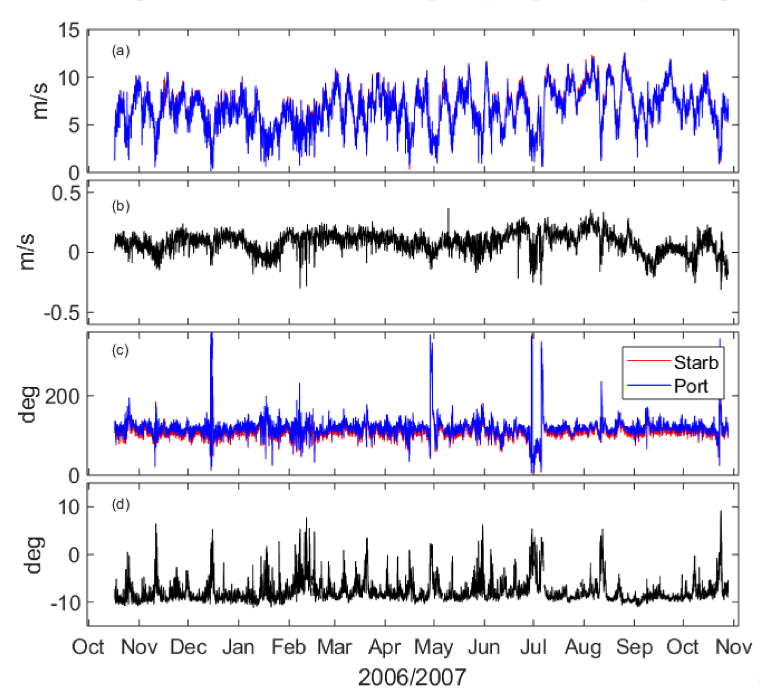


Fig 5. Time series of Stratus' seventh deployment. (a) Wind speed of starboard (red) and port (blue) sensor, (b) the difference between them, (c) the wind direction of starboard (red) and port (blue) sensor, and (d) the difference between them. Shown are one hour averages.

Wind speed difference of up to 5% between starboard and port sensor and linear relation

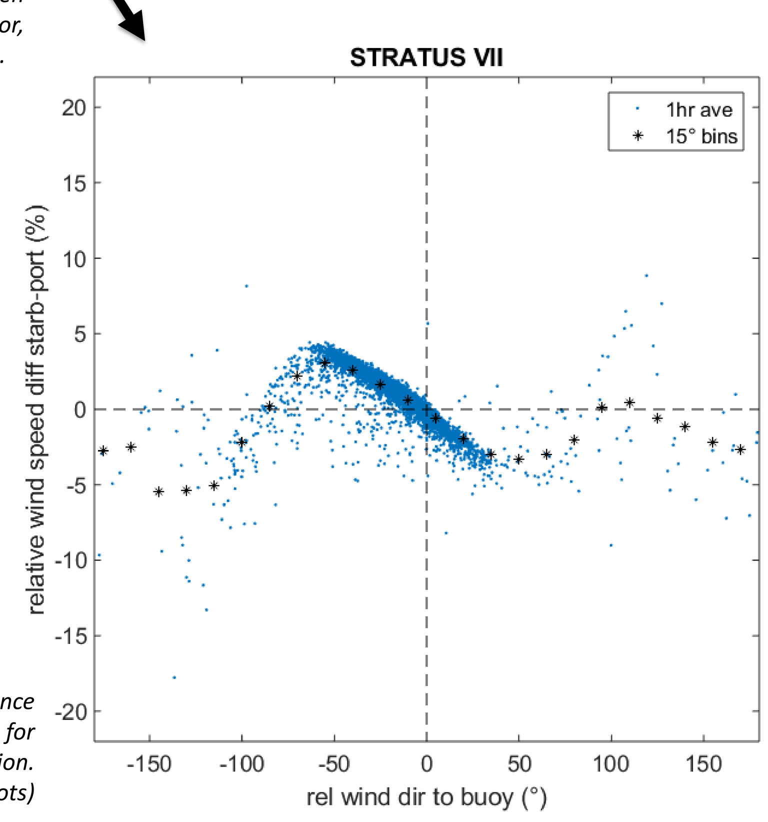
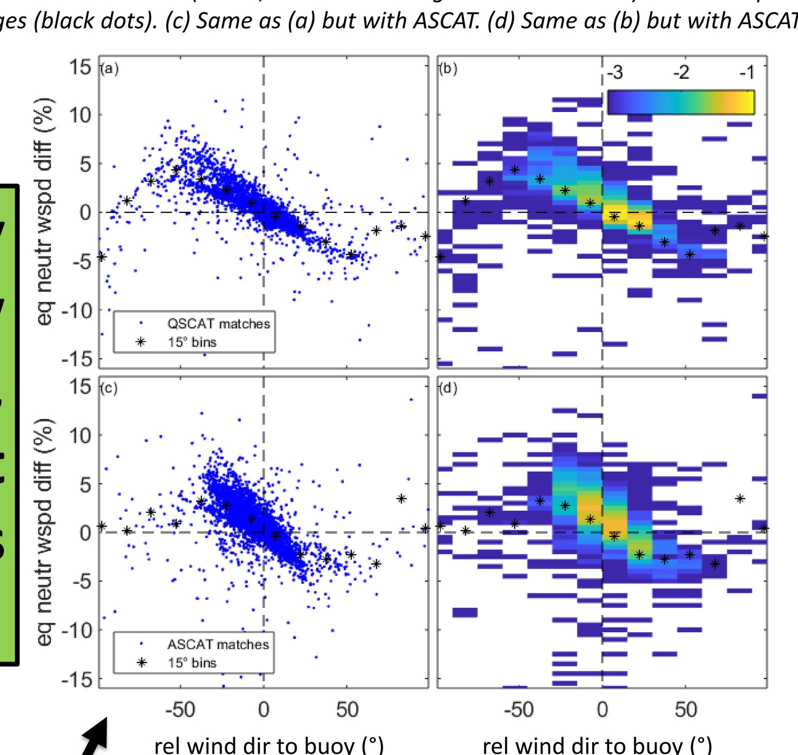


Fig 6. Relative wind speed difference between starboard and port sensor for Stratus 7 against relative wind direction. Shown are one hour averages (blue dots) and 15° bin averages (black stars).

80% of all buoy deployments show similar structure, eventually **23 out of 45 deployments** are used

Fig 7. Equivalent neutral wind speed difference between the starboard and the port sensor in relative percentage and against the relative wind direction. (a) All data which match with QSCAT (blue) and the bin averages of all data (black dots). (b) Probability of the QSCAT matches within 15° bins (colors; shown is the logarithm to base 10) and corresponding bin averages (black dots). (c) Same as (a) but with ASCAT. (d) Same as (b) but with ASCAT.



A similar structure is even observed, when either the starboard or the port sensor is replaced with a satellite estimate

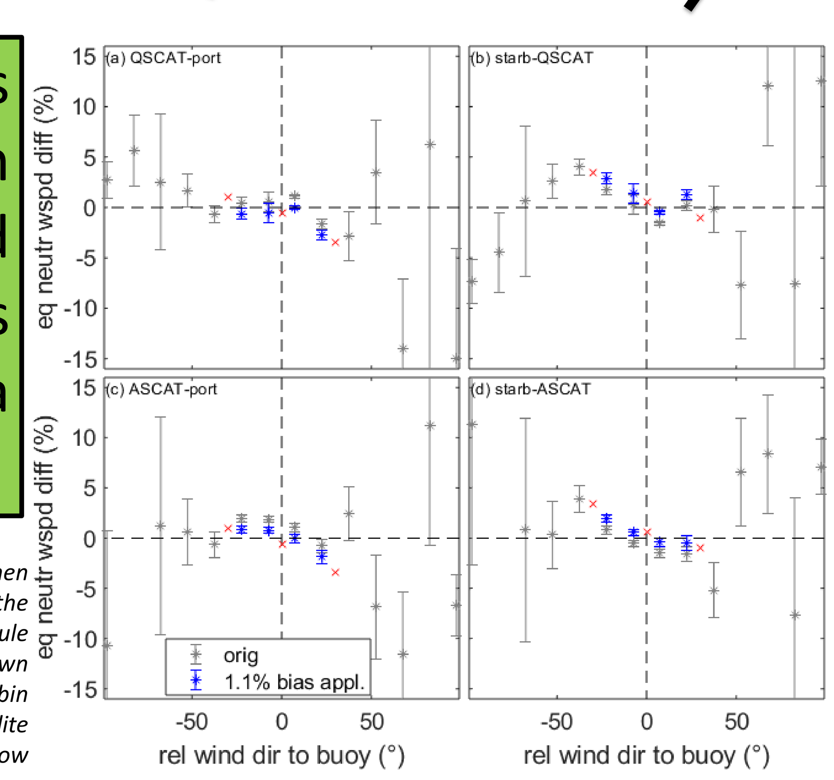
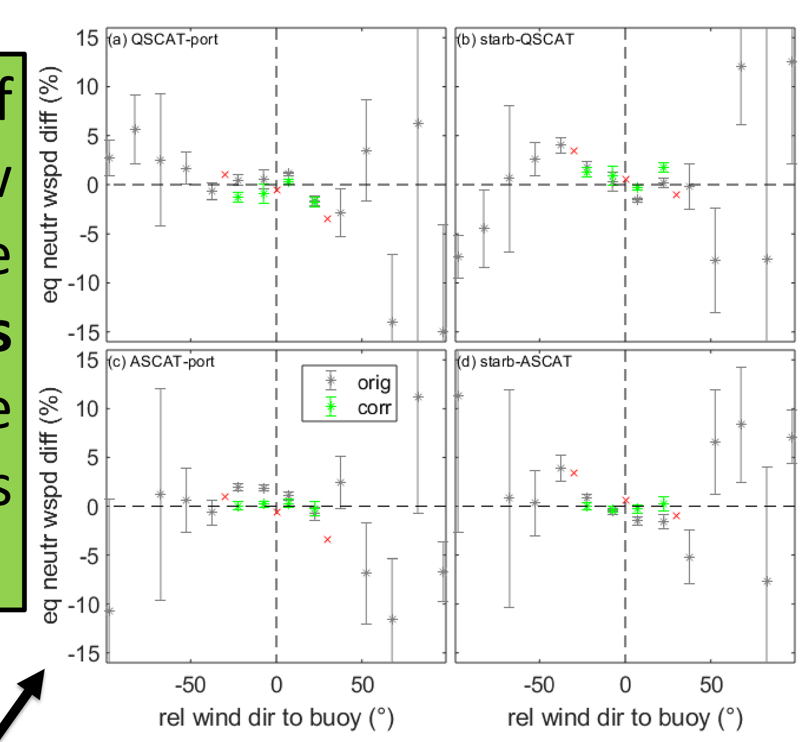


Fig 8. Equivalent neutral wind speed differences, when replacing (a) the starboard module with QSCAT, (b) the port module with QuikSCAT, (c) the starboard module with ASCAT, and (d) the port module with ASCAT. Shown are the original bin averages (grey) and the bin averages within ±30° with 1.1%-bias corrected satellite data (blue). The red crosses indicate the theoretical flow distortion prediction as shown by Emond et al., 2012.

After application of the estimated flow distortion error, the **systematic error is reduced** and the relative difference is below 2%

Fig 9. Same as figure 8, but with bias correction and relative flow distortion correction (green). The red crosses indicate the theoretical flow distortion prediction as shown by Emond et al., 2012.



Error distribution

- ❑ Flow distortion contributes ~30% to the total RMS
- ❑ Other (random) errors remain
- Averaging
- Viscosity correction
- …

Conclusion

A RMS of 0.5-0.7 m/s is observed when comparing wind speeds at WHOI buoys with scatterometers. A detailed investigation of more than 18 years of wind observations at the buoys was performed. Flow distortion errors of ~5% relative wind speed difference are the main result, indicating the importance of the position of the sensor on the buoy. Generally, the flow distortion is responsible for ~30% of the total RMS. Compared to scatterometer observations, the flow distortion still can be observed. This systematic error can be removed from the data. After correction for the flow distortion, random errors remain, e.g. averaging errors from the colocation of scatterometer and buoy or a "wrong" viscosity correction.

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References

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