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Atmospheric Measurement Techniques Discussions

Interactive comment on "Using global reanalysis data to quantify and correct airflow distortion bias in shipborne wind speed measurements" *by* Sebastian Landwehr et al.

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Many thanks to Referee #2 for her/his constructive and supportive comments, which we have kept in *italic* and labelled as referee comment (RC). We provide our author replies (AR) below.

General: *This manuscript presents the correction of shipborne wind observations, which are biased by flow distortion. With the use of reanalysis data these biases can be quantified and the observations can be corrected subsequently. Eventually, the uncertainty of the observations after correction is in the range of the uncertainty of the reanalysis product.*

This work is an important contribution, because in-situ wind speed and direction observations on the open ocean are still rare. Therefore, the existing observations from research vessels, buoys, and other platforms need a critical review since they are used for a variety of purposes like scatterometer calibration, model validation and estimates of air-sea exchange, which are often parameterized with wind speed.
The authors clearly explain their motivation and their method. They use ERA-5 data to fill the gap between observations and to detect and quantify flow distortion, which itself is dependent on the relative wind direction. The ranges of the biases are large for both, relative wind speed and direction. Converting this into true winds, a large error is estimated, which is reduced after applying the bias correction estimated from the flow distortion. As a major result the authors show a final dependence of the corrected bias to the used ERA-5 product. Problems and limits of the approach are discussed and illustrated.
I suggest a minor revision as the manuscript is clearly structured and the scientific workflow is properly described. However, I have some minor specific comments, which are described in detail below.

Authors response: We thank Referee #1 for her/his careful review and the helpful comments.

Specific comments: *There are some inconsistencies in the labels and/or captions of the figures (cf. technical comments to the figures). Please elaborate generally: Whenever data from one sensor are shown, make sure it is stated consistently in the text/labels/caption.*

Authors response: Thank your for this note. We have reviewed the manuscript to improve the consistency.

Technical comments/suggestions:

RC 1: *Page 2/line 26-29: Just a comment. It's true, that buoys are the backbone for validation of other wind products. The impact of flow distortion is smaller compared*

to ships, right. However, flow distortion is an issue for buoys, too. Similar to ships this flow distortion is highly dependent from the structure on the buoy. The problem is that usually it is either not recognized or one is not able to estimate this effect due to the lack of redundant observations. Emond et al., 2012 and Bigorre et al., 2013 extensively studied these effects, which can be on the order of 5-10% of the observed wind speeds.

AR 1: Thank you for this comment. We have modified our statement to specify the range of flow distortion errors in buoy observations found by Emond et al., 2012 and Bigorre et al., 2013: "For buoys, the ratio of the sensor's height above the main structure to the dimension of the structure is much higher, so that airflow distortion is typically lower, in the order of 5% to 10% (e.g. Emond et al., 2012; Bigorre et al., 2013)."

RC 2: *3/21-22: See above comment on buoy flow distortion biases.*

AR 2: The bias in the buoy wind speeds may explain some of the scatter in (Landwehr et al., 2015, Fig. 5), unfortunately I was not aware of the study of Emond et al., (2012) at that time. However 5% are small compared to the errors found in the wind speeds measured at the temporary bow mast of the *Saramiento de Gamboa*.

RC 3: *3/26: Twice per day is rather good from a global point of view. There is even the RapidSCAT program, which deals with the diurnal cycle in wind speed. However, for your purposes it's still small.*

AR 3: Yes indeed.

RC 4: *4/9: Please introduce the abbreviation ACE first (perhaps on page 3/line 31 or whenever it shows up first after the abstract).*

AR 4: Thanks. We have added the introduction of the abbreviation as suggested.

RC 5: *4/16: The mentioned study describes altimeter and radiometer observations. They don't deal with scatterometers, do they?*

AR 5: Yes, Yound and Donelan, (2018) describe biases in observation from altimeter and radiometer sensors but not from scatterometers. We have corrected the mistake.

RC 6: *5/3 (first paragraph): Even though it shows up later in figure 8, a map at this part of the paper might help the reader to follow.*

AR 6: We have added a new figure showing the ship track during the four legs.

RC 7: *5/24: How often does this happen? Can you give an example? Parking of the ship?*

AR 7: The difference between the five-minute average course and the five-minute average heading (vector averages) is larger than 10° for about 21% of the samples. This occurs when the ship is on station, so that the GPS velocity is too small to estimate a reliable course.

RC 8: *6/14: No SSTs from the weather station? What do you mean with 'not yet available'?*

AR 8: The calibration and quality control of the SST measurements from the underway system was ongoing at the time of submission. It has been finalized in the meantime and we are now using the in situ observations combined with SST estimates from remote sensing, instead of the ERA-5 output.

RC 9: *6/23: Replace "form" with "from".*

AR 9: Thanks!

RC 10: *9/3: I'd like to read here a number(or a ratio) of how many data are finally used for the estimation of flow distortion parameters. Just to get an impression. I calculated 40.5(of all 'raw' data). Is that right?*

AR 10: For the port and starboard sensor 13010 and 12863 five-minute samples pass all quality checks (including the IQR de-spiking). These are 38.3% and 37.9% of the available data, respectively. After removal intervals where ERA-5 might have been affected by the assimilation of wind speed and direction data from the Akademik Tryoshinkov, the numbers and ratios

change to 12055 and 11948 samples (35.4% and 35.2%) for port and starboard sensor respectively (see responses to comments 2 and 12 from Referee #1). We have added this information in the text.

RC 11: *9/9: It is five-minute average? Or five (times) minute-averages? I'd suggest to use five-minute, i.e. with a hyphen, and continue this throughout the paper.*

AR 11: Thanks for the suggestion, we have changed all occurrences.

RC 12: *9/22: A function of which relative wind direction? As you've shown before the measurements between the two sensors can differ strikingly. Please clarify. (See also comment to figure 3)*

AR 12: The relative wind direction measured by the starboard sensor. We have now clarified this in the text.

RC 13: *10/31: It looks overcorrected in figure 7, meaning that your peak is now below the ratio 1.0? Any comment on that?*

AR 13: The peak of the histogram of the corrected wind speed ratios is at 0.995. Considering the with of the ratio bins used (0.01), this is very close to 1.

RC 14: *11/4: Unclear formulation "could be caused the uplift". You mean "caused by . . . ". Please clarify.*

AR 14: Yes, the "by" was missing.

RC 15: *11/19: What other sources of uncertainty can play a role for u_{10N}?*

AR 15: Here we considered the accuracy of the measurement height, the influence of the atmospheric stability on the shape of the wind speed profile, and uncertainties in the drag coefficient. Each of these uncertainty sources contributes less than 1% to the relative uncertainty of u_{10N}.

RC 16: *Fig. 1: Caption: Remove one 'the' in the second sentence.*

AR 16: Thanks!

RC 17: *Fig.3: I'm a bit confused. In the text you describe model against starboard, which is also true for the labels. In the caption you describe model/port ratio and difference. Which one is true? What is on the y-axis, port or starboard? Please clarify.*

AR 17: Fig. 3 shows data from the starboard sensor. The caption was wrong and has been corrected.

References

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