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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Motion-correlated flow distortion and wave-induced biases in air–sea flux measurements from ships" *by* J. Prytherch et al.

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Reviewers: Sebastian Landwehr and Brian Ward

General comments: This paper addresses the motion-correlated signal which has been observed in momentum flux spectra measured on ships, even after standard motion-correction procedures have been applied to the measured wind speeds. The authors present a dataset, where the motion-correlated signal is relatively large, and accounts on average for $20\% - 30\%$ of the measured momentum flux signal. The authors provide evidence that the peak in the motion-corrected momentum flux spectrum is not caused by wind-wave interaction, but by recirculation of the air flow at the anemometer location which is caused by the push and pull of the bulky structures

nearby. Further they present a simple and efficient way of removing the bias.

We do not agree with the authors suggestion that the overestimation of momentum flux measurements from ships that was reported by (*Edson et al.*, 1998) and *Pedreros et al.* (2003) should be caused by the here addressed motion-correlated flow distortion. This is more likely due to the inaccurate mean wind vector tilt estimation. We see the here presented decorrelation method, however, as a practical approach to reduce bias in direct air-sea flux measurements. We recommend to publish this results with minor revisions.

Specific comments:

We provide specific comments below, but there are also several comments embedded in the article file, which we also provide.

1. (Title) This paper deals with ship motion-induced flow distortion effects in the momentum flux spectra, however, what is the motivation for "wave-induced" in the title?

2. (Page 15545, line 1): Add the following references: *O'Sullivan et al.* (2013) and *O'Sullivan et al.* (2015)

3. (Page 15545, line 14-16): This is really not surprising considering the location of your mast shown in figure 1. It would appear that the flux instruments are several metres back from the bow. A considerable reduction in flow distortion could be achieved by placing the sensors as far forward as possible. Suggest you include a comment to this effect in the conclusions.

4. (Page 15545, lines 21–24): Both *Edson et al.* (1998) and *Pedreros et al.* (2003) show a complete removal of the motion-correlated peak in the momentum flux spectra. It appears therefore more likely to us, that the overestimation of the

shipborne fluxes in (*Edson et al.*, 1998; *Pedreros et al.*, 2003) is due to the inaccurate tilt correction, as described in (*Landwehr et al.*, 2015).

It is however possible that for the here presented measurements the "time-varying flow distortion" is of greater importance, due to the less favourable anemometer position, i.e., surrounded by bulky structures, while *Edson et al.* (1998) and *Pedreros et al.* (2003) mounted their instrumentation in more pristine locations on slim masts and close to the bow.

We had originally applied a similar technique in (*Landwehr et al.*, 2015), but abandoned it for the final version, because one of the reviewers was not willing to discuss this. For this study the reduction in the momentum flux was $\approx 6\%$. (We did not publish this result in the final version)

5. (Page 15546, lines 8–10): The variation of the residual motion peaks in (*Miller et al.*, 2008) might have another cause: *Miller et al.* (2008) estimated the relative orientation of their anemometer and the inertial motion unit with the planar fit approach from (*Wilczak et al.*, 2001). Small errors in this tilt estimation can lead to a less efficient removal of the ship motion signal. Note that the magnitude of the tilt correction applied in (*Miller et al.*, 2008) was higher for the low level anemometers. We had observed this effect during the preparation of (*Landwehr et al.*, 2015) when we applied the tilt corrections to the wind vector prior to the motion-correction.

6. (Page 15548, equation 1): Note that the identification of the natural coordinate system based on a single 30 minute averaging interval can be biased by possible offsets in the vertical wind speed measurement, as elaborated in (*Wilczak et al.*, 2001; *Landwehr et al.*, 2015) this can lead to significant errors in the tilt estimation at low wind speeds.

7. (Page 15550, equation 2): Did the coefficients α_1 and α_2 show any correlation with relative wind direction or the ship speed? If such a correlation exists it could

be used as an argument for your hypothesis.

8. (Page 15550, lines 14–18): The observation of *Edson et al.* (1998) and *Dupuis et al.* (2003) might be more related to the wind vector tilt-estimation, see comment to (Page 15545, lines 21–24).

9. (Page 15551, lines 9–11): The agreement with the COARE 3.5 parametrisation is no argument for the in-significance of the surface currents. Do you have measurements or estimations of the magnitude and direction of the surface currents?

10. (Page 15551, lines 12–14): You could mention (*Landwehr et al.*, 2015) in this context.

11. (Page 15553, lines 19-21): Sharp thought!

12. (Page 15554, lines 23-26): This is a very strong argument.

13. (Page 15567, Figure 5): This is a nice illustration. You might zoom in further on the frequency range of interest. It might be worthwhile to increase the frequency resolution of the spectra, as it appears to be very close to the frequency shift that you want to show. I assume (c) and (d) show $f \cdot |C_{uw}|/u_*^2$?

14. (Page 15568, Figure 6): Figure 6a shows that the average effect of the decorrelation is a reduction in CD, however in Fig. 6b it the effect is the increase the relative CD for $abs(\text{ship} - \text{relative wind direction}) > 20^\circ$ in comparison to the measurements where the wind was blowing bow on. What I want to say is: maybe the label in Fig. 6b should be "linear fit - CD".

References

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