Response to Referee #3

RC : *This paper is a careful reanalysis of the eddy covariance measurements of momentum and carbon dioxide fluxes from the Southern Ocean Surface Ocean Aerosol Production study (SOAP). Every aspect of motion correction and flow distortion on the means and fluxes is considered and appropriate corrections applied. The smooth dependence on wind speed, of the friction and mass transfer velocities, suggests that the corrections are accurate and complete. The slightly higher friction velocities than those from COARE 3.5 may be a fetch effect: COARE was open ocean while SOAP was shorter fetch corresponding to higher drag coefficients. The divergence from quadratic of the CO2 mass transfer velocity above wind speed of 16 m/s has important repercussions for the global carbon budget and is the main scientific (rather than technical) product of this fine work.*

AC : We would like to thank the reviewer for this very positive review. The fetch was variable during SOAP, but the predominant wave direction was from the south-south-west (Law et al., 2017, Fig. 6) which has a long fetch. The full set of wind back-trajectories is available if needed. But a few examples using a particle tracking model can be found in (Law et al., 2017, Fig. 5). These show that for southerly wind direction, the fetch was actually considerable. For the SOAP experiment which was conducted east of New Zealand wind direction can be used as a proxy for fetch, with northerly and westerly wind directions being related to limited fetch, while southerly and easterly wind directions feature open ocean fetch conditions. A map of the cruise track can be found in (Law et al., 2017, Fig. 1).
In Fig. 1 the observed neutral drag coefficient C_{D10N} is shown as function of $u_{10\mathrm{N}}$, which was computed from the air flow distortion corrected wind speed measurements from the bow mast. The data are also shown as $1\,\mathrm{m\,s^{-1}}$ wind speed bin-averages, which were computed for the total data set and for the four quadrants of the true wind direction northerly, easterly, southerly, and westerly, which here denote true wind directions between 315° and 45°, 45° and 135°, 135° and 225°, and 225° and 315°, respectively. No dependence of the drag coefficient is visible for wind speeds above $7\,\mathrm{m\,s^{-1}}$. For lower wind speeds the drag coefficient appears to have some dependence on the true wind direction.
The exercise is repeated in Fig. 2, using the relative wind direction to the bow instead of the true wind direction. Fig. 2 reveals a much stronger dependence of the measured C_{D10N} on the relative wind direction, which is visible for the full range of observed wind speeds and is likely caused by residual flow distortion bias either in the u_* or in the $u_{10\mathrm{N}}$ estimates. For lower wind speeds the contribution of the ship's speed over ground to the relative wind speed becomes relatively more important. This can lead to relatively higher errors in $u_{10\mathrm{N}}$ and may explain the higher variability in the observed C_{D10N}. Notably the relative wind direction sector $-22.5°$ to $+22.5°$ shows the least variability of C_{D10N} at low wind speeds. This sector is dominated by station measurements, since the ships bow was pointed into the prevailing wind direction during the stations, whenever possible. Based on these observations we suggest that during SOAP C_{D10N} was biased higher than COARE 3.5 due to residual air flow distortion effects in $u_{10\mathrm{N}}$ to a greater degree than any fetch effects. We have added the following sentence to Sec. 3.3 *Effect of the air flow distortion corrections on friction velocity*: "The neutral drag coefficient $C_{\mathrm{D10N}} = u_*^2\, u_{10\mathrm{N}}^{-2}$ computed from the measurements showed no dependence on the true wind direction, which could have indicated an effect of the varying fetch. The measured C_{D10N} varied, however, on average by about ±7% with the relative wind direction for relative wind directions within ±90° to the bow."

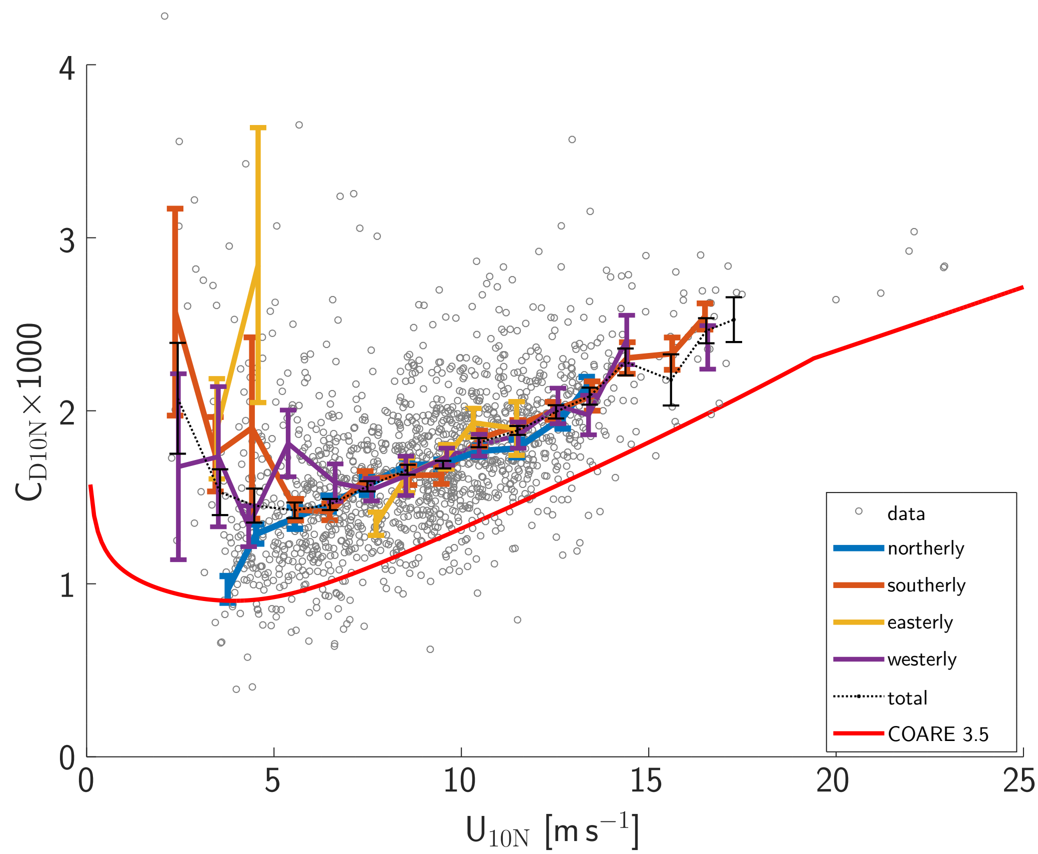

Figure 1: Neutral drag coefficient C_{D10N} as function of u_{10N}. The air flow distortion corrected wind speed measurements from the bow mast were used to calculate u_{10N} and $C_{\mathrm{D10N}} = (u_* u_{\mathrm{10N}}^{-1})^2$. The data are shown as individual measurements and bin averaged over $1\,\mathrm{m\,s^{-1}}$ wind speed bins, which are calculated for the total data set and the four quadrants of true wind directions (e.g. easterly means wind directions between 45° and 135°). The the COARE 3.5 drag coefficient (Edson et al., 2013) is shown for comparison. Bin average values consist of five or more individual measurements. The errorbars indicate the standard error of the mean value of each wind speed and direction bin.

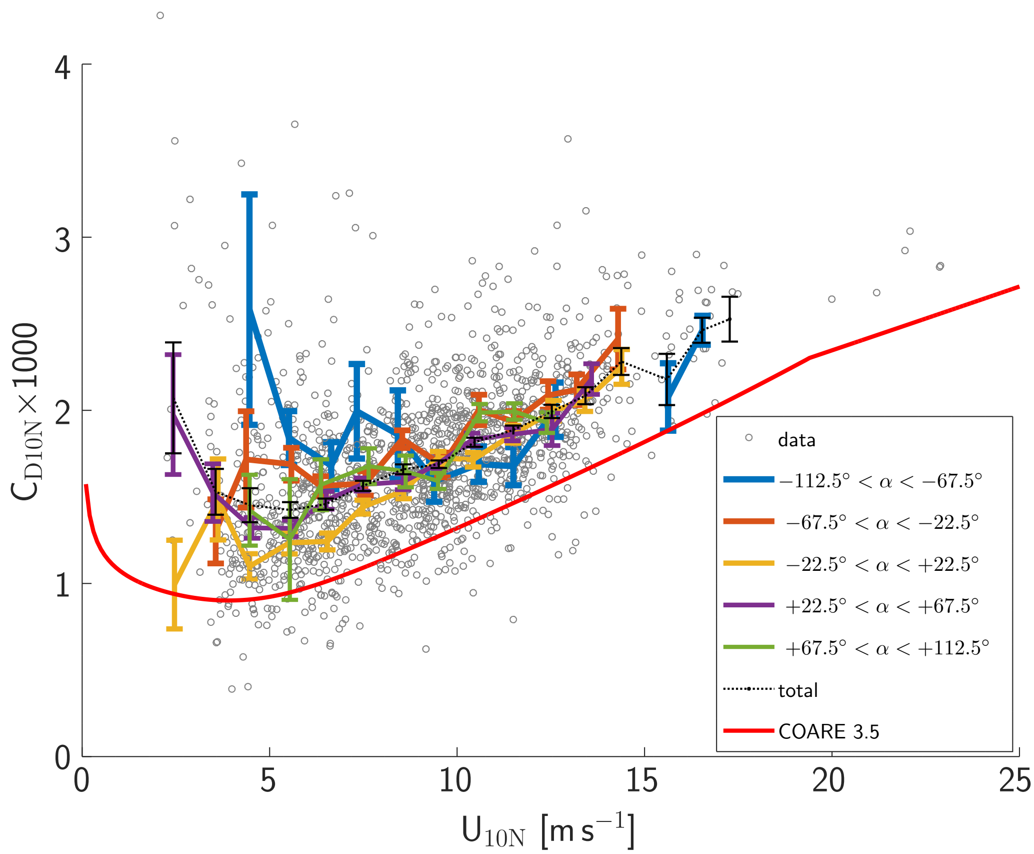

Figure 2: Same as Fig. 1, but the data are grouped by the wind direction relative to the bow of the ship. Here $\alpha = 0$ indicates that the ship was pointed into the prevailing wind direction.

References

Edson, J. B., Jampana, V., Weller, R. A., Bigorre, S. P., Plueddemann, A. J., Fairall, C. W., Miller, S. D., Mahrt, L., Vickers, D., and Hersbach, H.: On the Exchange of Momentum over the Open Ocean, J. Phys. Oceanogr., 43, 1589–1610, doi:10.1175/JPO-D-12-0173.1, 2013.

Law, C. S., Smith, M. J., Harvey, M. J., Bell, T. G., Cravigan, L. T., Elliott, F. C., Lawson, S. J., Lizotte, M., Marriner, A., McGregor, J., Ristovski, Z., Safi, K. A., Saltzman, E. S., Vaattovaara, P., and Walker, C. F.: Overview and preliminary results of the Surface Ocean Aerosol Production (SOAP) campaign, Atmospheric Chemistry and Physics, 17, 13 645–13 667, doi:10.5194/acp-17-13645-2017, URL https://www.atmos-chem-phys.net/17/13645/2017/, 2017.