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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observations of surface momentum exchange over the marginal-ice-zone and recommendations for its parameterization" *by* A. D. Elvidge et al.

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This paper presents atmospheric drag coefficients over fractional sea ice cover derived from measurements with two aircraft over the Fram Strait and Barents Sea. These drag coefficients are compared with results of the most recent parameterizations which calculate drag coefficients as the sum of skin drag coefficients over open water and sea ice and of a form drag coefficient describing the drag caused by ice floe edges. The main findings are that the observations agree well with results obtained from our parameterization (Lüpkes et al., 2012) (L2012) although complex conditions with variable sea ice morphology have been considered. Finally, improvements are proposed for

open constants in the parameterization.

The authors mention that such new observations are urgently needed since the majority of measurements has been carried out 20 years ago and thus before the current larger change of Arctic sea ice.

I fully agree with this point. Furthermore, in my opinion this paper is excellently written, very clearly organized and I think that the data help a lot to understand strengths and weaknesses of the considered parameterizations. As the authors write, it is the largest set of aircraft observed data of this kind. I am impressed also by the degree of agreement with the parameterization by L2012. I have only minor revisions and recommendations which might help to once more improve a little the current version of the manuscript.

Minor Revisions

1. page 26618, lines 3-5: When we called $C_{dn10,i}$ skin drag we were aware of the fact that this 'skin drag' consists again of a sum of 'real' skin drag (drag over a smooth ice surface) and of form drag by ridges. This form drag can be calculated with a similar concept (see Andreas, 2011; Garbrecht et al., 2002). The latter citations could be added here.

2. page 26623 line 25; page 26624 line 1; page 26629 line 10: Similar point as above. Castellani et al. (2014) document the variablility of drag coefficients based on Arctic wide observations of topography (sea ice morphology). This could be mentioned here.

3. page 26621, line 25 and 26622 line 1: Due to our experience the assumption of a constant flux layer leads to an underestimation of neutral 10 m drag coefficients when they are derived from aircraft measurements in 40 m height in neutral or stable conditions. This is the reason why in Garbrecht et al. (2002) (their figure 9) another procedure has been used. It is unclear, however, up to now what

happens under unstable conditions. So, I suggest adding here in addition to your references just that the assumption of a constant flux layer is the best what can be done at present but this could be an issue for future research. (see also next item). Addition of mixed layer heights z_i (if available) would be useful since the accuracy of the constant flux layer assumption depends on z_i.

4. page 26627, line 15: I agree, the value of c_e can be tuned. But with respect to the previous point (constant flux layer assumption) I would not exclude that the 'measured' drag coefficents are slightly underestimated. This point could be mentioned as a possible uncertainty of the new recommended value.

5. page 26628, line 2: L2012 propose to use Charnock for $z_{0,w}$ (equation 14). How does this agree with your measurements?

6. page 26629, line 17-22: One could discuss this mentioning equation 11 and its dependence on the aspect ratio h_f/D_i. Small D_i and large h_f will increase C_d. The sensitivity has been discussed by Lüpkes and Birnbaum (2005) (their Figure 7).

7. page 26630, line 18: One could add that 5 ms$^{-}1$ is a value that is typical for Arctic summer.

8. e.g. page 26634, line 25: Lüpkes and Gryanik (2015) show that the peak value for the surface drag is also a function of stratification. A future challenge is also to validate and quantify this finding.

9. The L2012 scheme is available in different stages of complexity. The most simple one was considered in Lüpkes et al. (2013) and it was called there AWI parameterization with three different parameter sets (AWI, AWI+ and AWI-) giving the range of possible variability. In this scheme C_{df} is just a function of the sea ice concentration. This could be considered in addition here or in another work.

References

Andreas, E.L (2011), A relationship between the aerodynamic and physical roughness of winter sea ice, Q. J. R. Meteorol. Soc., 137, 927-943.

Castellani, G., C. Lüpkes, S. Hendricks, and R. Gerdes (2014), Variability of Arctic sea-ice topography and its impact on the atmospheric surface drag, J. Geophys. Res. Oceans, 119(10), 6743-6762, doi:10.1002/2013JC009712.

Garbrecht, T., C. Lüpkes, J. Hartmann, and M. Wolff (2002), Atmospheric drag coefficients over sea ice-validation of a parametrisation concept, Tellus A, 54(2), 205-219.

Other references are given in the manuscript.