

## ***Interactive comment on “Air-sea momentum flux climatologies: A review of drag relation for parameterization choice on wind stress in the North Atlantic and the European Arctic” by Iwona Wrobel-Niedzwiecka et al.***

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The authors thank the reviewer for carefully reading our discussion paper and for helpful and constructive comments regarding its content and improvements. We decided to encourage our article with many conclusion both in articles, as in the case of Andreas et al., 2012, Bunker et al., 2003, and during many recent scientific conferences, that further investigation of the differences in the parameterization of the air-sea exchange coefficients are needed.

C1

We would like to start with responding to the major comments. We contain those information also under specific comments.

The aim of the manuscript is to evaluate how much the average monthly and annually momentum transfer values depend on the choice of CD parameterizations, in other words how the selected parameterization affects the total value of momentum fluxes for large reservoirs. This allows constraining the uncertainty caused by the parameterization choice. In order to achieve this, we used observed wind field for the regions of interest, namely the North Atlantic and the European Arctic, areas where European and American oceanographers, including us, operate. This is where most of studies that were basis of the parameterizations we use were performed. We did some comparisons to sub-tropical basins to see the difference in uncertainty caused by the formula choice between the main study regions and less studied subtopics. In our conclusion, we do not indicate which formula should be used in the future (impossible without new data) in the NA and the EU, but the simple fact that none of the parameterizations used now is final. We don't want to suggest end users any conclusions because the differences in the parameterizations used are small, and our goal was to help them make an intelligent and deliberate decision about which parameterizations to use.

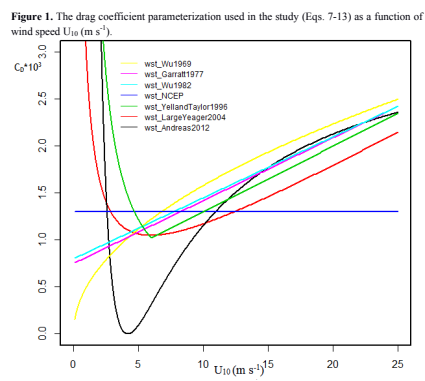
The text of the review is reproduced below in black type; our comments are in blue; and the changes in the original discussion paper are presented in italics. We reorganized the Introduction as the reviewer suggested, also removed equation no 7 and reorganized paragraph with this equation, changed the original title to new one and clearly state the purpose of the study. Please see the supplement material as we included all the answers and the corrected the manuscript there.

Please also note the supplement to this comment:

<https://www.ocean-sci-discuss.net/os-2018-61/os-2018-61-AC2-supplement.pdf>

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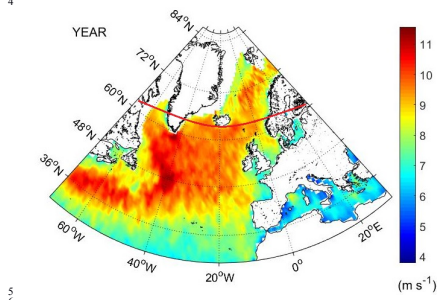
C3



**Fig. 1.** Figure 1

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1 **Figure 2.** Annual mean wind speed  $U_{10}$  ( $\text{m s}^{-1}$ ) in the study area—the North Atlantic and the  
 2 European Arctic (north of the red line).  
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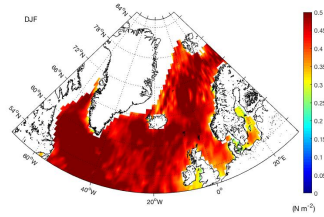
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**Fig. 2.** Figure 2

C5

**Figure 3.** Maps of momentum flux [ $\text{N m}^{-2}$ ] across the sea surface (wind stress) for boreal  
 winters (a) and (c) and summers (b) and (d) for Wu (1969) and A12 drag coefficient  
 parameterizations (the two parameterizations with the highest and lowest average values,  
 respectively).

a) Wu, (1969)



b) Wu (1969)

**Fig. 3.** Figure 3

C6

Figure 4. Monthly average momentum flux values [ $N m^{-2}$ ] for (a) global ocean, (b) North Atlantic, (c) European Arctic, and (d) Tropical ocean. The regions are defined in the text.

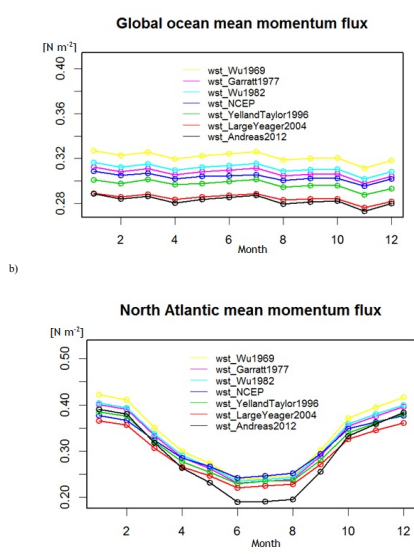


Fig. 4. Figure 4

C7

Figure 5. Area annual average momentum flux values for (a) European Arctic and (b) Tropical ocean. The vertical solid line is the average of all seven parameterizations and the dashed lines are standard deviations for the presented values. Global and the North Atlantic results are not shown because the relative values for different parameterizations are very similar (see Table 1), scaling almost identically between the basins.

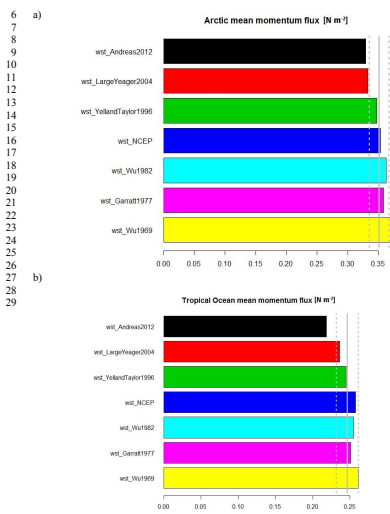


Fig. 5. Figure 5

C8

**Table 1.** Area average annual mean values of momentum flux (wind stress) [ $\text{N m}^{-2}$ ] for all the studied regions and parameterizations. In each column the percentage values are normalized to A12, the parameterization that produced the smallest average flux values.

	Global	North Atlantic	Arctic	W. Spitsbergen	Tropics
Wu (1969)	0.322 (114 %)	0.330 (114 %)	0.375 (114 %)	0.360 (114 %)	0.261 (119 %)
Garratt (1977)	0.307 (109 %)	0.316 (109 %)	0.358 (109 %)	0.344 (110 %)	0.251 (115 %)
Wu (1982)	0.311 (110 %)	0.320 (110 %)	0.363 (110 %)	0.349 (111 %)	0.255 (117 %)
NCEP/NCAR	0.303 (107 %)	0.312 (107 %)	0.353 (107 %)	0.341 (108 %)	0.258 (118 %)
Yelland & Taylor (1996)	0.297 (105 %)	0.306 (105 %)	0.348 (106 %)	0.335 (107 %)	0.245 (112 %)
Large & Yeager (2004)	0.285 (101 %)	0.293 (101 %)	0.333 (101 %)	0.320 (102 %)	0.236 (108 %)
Andreas et al., (2012)	0.283 (100 %)	0.290 (100 %)	0.329 (100 %)	0.314 (100 %)	0.219 (100 %)

**Fig. 6.** Table 1