Review of ‘The bulk parameterization of turbulent air-sea fluxes in NEMO4: the origin of sea surface temperature differences in a global model study’, by G. Bonino, D. Iovino, L. Brodeau and S. Masina, submitted to GMD.

Summary

The paper overviews the effect of using alternative air-sea flux parameterization schemes in the NEMO ocean-ice model. The schemes considered are NCAR CORE (large and Yeager 2009), ECMWF (2015) and COARE 3.6 (Fairall, Edson et al.). The focus is on the effect of using a surface skin temperature, rather than a bulk temperature, and on the effect of using different formulations for exchange coefficients (for momentum and heat). Model experiments with the different schemes are compared, as well as sensitivity experiments where aspects of the schemes are mixed. It is found that the schemes cause SST differences of O(0.1deg.C) , surface heat fluxes of O(1W/m2) (i.e. less than 10W/m2), wind stress changes of 10-20%, wind stress curl changes of maybe 10%. Reasons for the differences are explored using the sensitivity experiments. Finally, the results are compared to a previous work that performed similar experiments but using fixed (observed) SST and determined differences in heat flux and momentum flux.

The paper is clear, the experiments well-designed, and the result sections are mostly well-written. The sensitivities are quantified, and the comparison with the fixed SST experiments is interesting. The results are important to know, for climate and/or ocean applications. However I suggest major revisions before publication based on the major comments below and have further minor comments

Major Comments

The paper shows differences of certain fields (SST, heat fluxes, momentum fluxes etc.) between the experiments. Is it possible to say whether any of the cases are more realistic than other , compared to observations, or is it complicated by competing and possibly cancelling effects of other parameterizations or processes? Could you look at other ocean variables (like the surface flow) to help with this?

Can the results be put in context by comparing with known sensitivities to other well-known parameterizations or processes? Do the results have any impact on meridional heat transport?

Minor Comments

Line 5 – “calculate”

Delete (revision 12957), move this to Methods.

Line 16. “weaker than that found by”

Line 20. Isn’t surface radiative flux also highly important???

Line 78. Re “Marsaleix et al.” – based on the title of this paper, it does not obviously mention TKE, but it does mention energetics. Please confirm it is the correct reference. Sorry, I have not read it.

Line 98 “possibly referred to the ocean currents” -> “which may be referred to the ocean currents”

At this point, the reviewer might anticipate experiments to look at the effect of including surface currents in stress. Your paper does not do this, which is fine, but you may want to refer to the extensive literature on the subject (e.g. Renault et al., Sun et al, and many others).

Line 100. “increase”

List starting Line 110. I would add:

3. Effect of including ocean current in stress

4. The form of the exchange coefficients

Then you can mention which of these effects you look at. Am I correct in thinking you do not explicitly look at the effect of convective gustiness? See comment later.

Line 115-116. “is indeed influenced by the” -> “uses the”

Line 119 I suggest “QT increases in response, then the SST will tend…”

Line 128 . NCAR scheme … minimum wind speed of 0.5 m/s … This is interesting, and I just confirmed this is also done in the CESM scheme. Note that the Large and Yeager drag coefficient actually goes to infinity as you approach zero wind speed (your Fig. 1b). So even if the wind speed gets very low, the momentum flux remains significant.

Lines 129-134. I would say that the Large and Yeager scheme also uses MOST. It combines MOST theory with a semi-empirical form of drag coefficient.

Fig. 1b. I understand that you do not focus on high/extreme wind speeds, but I am curious to know what happens above 35m/s. There is some discussion on this topic in Fu et al. (2021), their sections 3.2 and 4.1. (Note that their paper employs the original Large and Yeager (2004) form of drag coefficient, without reduction at high wind speeds.) Note also that ERA5 is a high-resolution dataset and will include extreme wind events. Reference: Fu, Dan et al. 2021: Introducing the new Regional Community Earth System Model, R-CESM. B. Amer. Meteor. Soc., 102, E1821-E1843, https://doi.org/10.1175/BAMS-D-20-0024.1

Lines 134-145. It would be useful to show a zoomed-in plot of Fig .1b for winds 10m/s or less. Also, replace “promote” with another word like enhance or increase.

Line 182. Fig. 2 label shows total surface heat flux, should be turbulent surface heat flux, if I understand the terminology.

Line 221. Fig. 6a shows very small QT (~1 W/m2) over most of the Globe, only small regions reach 10W/m2.

Line 224. Replace with “parameterization, is smaller than the CE of NCAR…” “This leads to an underestimation of evaporation, increased input of heat,…”

Line 236. Fig. 5a->Fig. 5b ?

Line 258-259. I believe you do not explicitly look at the sensitivity to convective gustiness parameterization. So your inferences here are solely based on the fact that CD differences are small in these regions? You can consider running an extra sensitivity experiment with convective gustiness switched off in ECMWF.

Lines 259 onwards. It is not obvious to me from Fig. 8 that the EBUS will be notable regions of enhanced stress and WSC. Perhaps zoom in on an example EBUS and show the causal links more clearly between U, CD, TAU and WSC.

On this topic, the lead author has 2 nice papers on EBUS in JRA55do and ERA-Interim-forced runs. Based on this experience, can you comment on whether the changes to TAU and WSC are realistic and whether they would make a sizeable change to upwelling?

Line 268. Can you see any changes to the North Equatorial Undercurrent, which is mainly an WSC-driven system (e.g. Sun et al. 2021 and references therein, https://doi.org/10.1016/j.ocemod.2021.101876)

Line 286. But the equator to 10deg. N difference is still large with COARE (Fig. 2a, right)

Line 308. “Namely”-> “In particular”

Line 338 “prospective”-> “perspective”

Line 341-3342. Delete sentence starting “Currently”, it can be understood from lines above.