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Ocean Science Discussions

Interactive comment on "Assessment of responses of North Atlantic winter SST to the NAO in 13 CMIP5 models on the interannual scale" *by* Yujie Jing et al.

Anonymous Referee #2

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General Comments

This manuscript shows that in several CMIP5 historical runs, the wintertime sea-surface temperature (SST) response to the North Atlantic Oscillation (NAO) is not consistent with observations, on interannual timescales. The authors demonstrate that some models that exhibit this discrepancy fail to reproduce the observed relationship between SST and turbulent heat fluxes (TFH), particularly in the subpolar gyre. They attribute this to an over-influential ocean. Most models examined here correctly produce the interannual NAO-SST relationship in the subtropical Atlantic because of the larger influence of Ekman forcing.

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Discussion paper

Overall, this manuscript asks a compelling question and applies a reasonable mechanistic approach to answering it. However, there are several questions I would like to see addressed before I can recommend publication (listed below). In addition to comments below, I think this work would be significantly more impactful with further copyediting.

1. Do the results show model dependence or sensitivity to initial conditions? I think readers will find the results to be more convincing if the authors could rule out dependence on initial conditions in the NAO – SST relationship. One way of doing this might be to look at a single-model large ensemble (e.g. CESM-LENS; Kay et al. 2015). For unfiltered output, it seems like the authors' results should hold (http://webext.cgd.ucar.edu/Multi-Case/CVDP_ex/cesm1.lens_1920-2018/nao.tempreg.djf.png) – but is that still true when bandpass filtered?

2. If the results show model dependence, how do the different models responses to historical forcing influence your results? On line 321, the authors note that the NAO has a negligible response to shortwave radiation – but shortwave radiation does affect SST. Can we be sure that the SHF and LHF are not responding to externally-forced changes in SST over this twentieth century, with the NAO being a bystander? In other words, if the models are responding in different ways to historical forcing, is that alone enough to change the relationship between the NAO and SST/SHF/LHF? One way to address this question may be to look at pre-industrial control runs of the same CMIP5 models the authors already examine.

3. Can the authors make causal claims based on band-pass filtered output? Cane et al. (2017) show that it is difficult to make causal claims about the sign of the relationship between heat fluxes and SST based solely on low-pass filtered data. I think that to show the causal relationship that is described in-text, it would be useful to also present unfiltered/annual average/wintertime average plots so that readers can be sure that the relationships shown are not an artifact of filtering. If the unfiltered results are similar, I think that is worth mentioning in-text.

Specific Comments

Lines 41 – 45: The wording and structure here is a bit too close to Deser et al. 2010 (page 119). Please edit.

Line 46 – 48: I would recommend re-wording to emphasize that the "uniform SST warming" occurs after the NAO+ in observations and pre-industrial control runs of climate models (see Delworth et al. 2017). Further, I would caution that this mechanism is not established as causal in observations (e.g. Buckley and Marshall 2016).

Line 64: Please clarify that Wang et al. (2014) found the NA SST was "underestimated" and "unreasonable" relative to observations (i.e. biased).

Lines 157 – 160: So, the NAO centers of action are stable with time in models, but not observations? I think that's interesting! That figure might be worth including – especially if your later results can explain it. It could be instructive about models.

Line 174: How sensitive are these NAO "spectral peaks" to the authors choice of dataset? How sensitive are they to the time period analyzed? I'll admit, my understanding of the spectral properties of the NAO index is heavily influenced by Wunsch (1999) – so my guess is that the red bands in Fig 3a will move around a bit. If they do move, it is worth asking, how do the authors' results change for different filter cutoffs?

Figures: I found the figures a bit too small to see details. If possible, please increase the size/resolution of the images. Thanks!

Figure 6: Is this a pixel-wise regression or a regression that takes place at each grid point? I assume, but please clarify in-text.

Figure 8a: Same as Figure 6.

Technical Comments:

Line 16: Please clarify the word "obvious"

Lines 21-23: For readers of the abstract, please clarify whether the authors are referring to “meridional advection” by ocean currents (e.g. Ekman) or winds (e.g. southerly component alongside eastern North America).

Line 28: I don’t think I would consider the NAO an “event”.

Line 40: I recommend changing “period” to “phase” since so much analysis of the NAO takes place in frequency-space

Lines 59 – 60: Please clarify the sentence containing “CMIP5-ESMs”

Line 88: You refer to “sea water Y velocity data” as “sea-surface meridional velocity” later in the paper. I think meridional velocity is a bit more clear – I would recommend using throughout.

Lines 101 – 104: Please clarify where the stations are for the station-based NAO index.

Lines 116 – 117: Can the authors please clarify this sentence. From this sentence alone, I can’t understand how “8 year” periods and the “decadal” NAO go together. Interesting paper, though!

Line 154: I think “biased” might be the wrong word here, since the authors are comparing observations to observations.

Lines 254 - 258: This sentence is a bit long an awkward.

Lines 268 – 272: Again, the sentence here is distracting from the useful analysis.

Works Cited

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