Comment on wcd-2021-61

Anonymous Referee #3

Referee comment on "Improved teleconnection between Arctic sea ice and the North Atlantic Oscillation through stochastic process representation" by Kristian Strommen et al., Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2021-61-RC3, 2021

This is an interesting paper on Arctic-midlatitude teleconnections. While focusing on the role of stochastic parameterizations, the paper also provides useful and novel physical insight into the possible factors affecting the representation of this teleconnection in climate models. The paper was clearly and logically written, and the results interesting, so I enjoyed reading it. I do however have several comments regarding the physical interpretation of the findings.

Main comments:

1) Interpretation of Fig. 6

I'm not sure I fully agree with the interpretation of the lagged relationships between Z500 and sea ice – or I may have misunderstood the authors. The text L360–368 seems to imply that the Z500 anomalies are a "response" to the sea ice at all lag times. This makes sense at positive lags (December onwards, when Z500 lags the sea ice), but for the November anomalies (1st row of Fig. 6) we also need to consider the possibility that it is the circulation driving the sea ice, rather than the other way around. I think this is indeed what is happening: the Z500 anomalies are consistent with northerly flow into the Barents sea area, which would drive enhanced sea ice concentration. I believe this also explains why the November Z500 anomalies are so consistent among ERA5, CTRL and OCE. In any case, the possible two-way interaction between Z500 and the sea ice needs to be discussed in the context of Fig. 6.

2) AMIP results

I am still unclear as to why the AMIP simulations show no midlatitude response to the sea ice anomalies. I understand the result in Fig. 7 that there is two-way coupling, and the NAO □ ice effect is absent from AMIP. But the ice □ NAO effect should be in AMIP, so why don't we see that? Also, is this result consistent with any prior work looking at AMIP runs with other climate models?

3) Coupling timescales

I feel some clarification is needed on the timescales at play in the sea ice–NAO coupling. Figure 7 suggests the coupling happens on daily timescales; but it's not obvious how to reconcile this with the finding that the NAO responds to November sea ice anomalies on the timescale of a *season* (DJF). My interpretation would be that the sea ice anomalies are relatively persistent (Fig. B5), so the November anomalies are a skillful predictor of those occurring later in the winter season – and these anomalies continue forcing the NAO through the winter. Is this consistent with the authors' thinking? Please clarify in the paper.

4) Coupling in CTRL

Figure 8b suggests the BG sea ice in CTRL does have a measurable impact on the NAO, which appears at odds with the lack of an ice □ NAO relationship in Fig. 7. Is this because the BG sea ice varies so little in CTRL – so that even though the effect is there, the impact is minimal because there's almost no forcing?

5) NAO definition

I was unclear as to the NAO metric as defined L166, and since this is key to the result, the definition seems important. I don't understand the subtraction of the daily climatology after the calculation of the PC. Why not deseasonalize the data beforehand? If using non-deseasonalized data, there is a risk that the EOFs are capturing the seasonal cycle (an externally forced signal), rather than the true internal atmospheric variability. It was also unclear to me whether the EOFs were calculated for each CTRL and OCN realization separately, or whether these realizations were concatenated prior to computing the EOFs. While it probably makes little difference, I'd favor the latter, which should give more robust EOFs – and ensures any differences among the realizations aren't due to differences in the EOF basis.

Minor comments:

1) Please fix the citation format – the parentheses are often in the wrong places. I suspect

this may be due to mixing the Natbib commands \citet and \citep in LaTeX. One example is L25, where it should be "(Hoskins and Karoly 1981)", "(Garcia-Serrano et al. 2015)".

2) Consider clarifying the definition of the word "deterministic" – not being a stochastic parameterization expert, I initially thought this might mean "prescribed SST" as opposed to coupled, when actually this means "not stochastic".

Typos etc:

L52: "are a manifestation"

L169: "are computed"

L208: "to reduce"

L218: "sea surface"

L229: "Examination… supports"

L297–300: This text is a repetition of L179–183, so I suggest deleting.

L405: Strictly speaking, Table 1 shows the correlations between the LIM NAO and LIM sea ice – not LIM NAO with true NAO. The latter is shown in Fig. B6.

L423: "may have changed" □ I think you mean "between CTRL and OCN", but it's not entirely obvious from the phrasing.

Caption of Table 1, L3: broken link to section 5.2

Figures 4 and 6: Suggest highlighting the BK and BG regions with boxes in the maps