

# FINAL RESPONSE

**Manuscript title:** Improved teleconnection between Arctic sea ice and the North Atlantic Oscillation through stochastic process representation

We thank the reviewers and editor once again for their assistance and invaluable suggestions. We record here our response to the various corrections noted by the editor.

**Editor:** *There are inconsistencies in the spelling of heatflux / heat flux throughout the manuscript.*

**Response:** We now use heat flux (or heat fluxes) throughout.

**Editor:** *L35: long climate simulations of just a single model -> long climate model simulations OR long climate simulations of CMIP5 and CMIP6 models OR similar...*

**Response:** We changed it to “long climate model simulations”.

**Editor:** *L39: Suggest to remove "seriously", but keep the footnote, as I believe this will strike a good balance wrt reviewer #1's concerns.*

**Response:** We removed the word ‘seriously’.

**Editor:** *L54-57: The addition of Baker et al. 2018 is useful here - I agree that their study tells us we should not expect all climate models to represent the relevant ice-NAO processes correctly. I believe the last two sentences are not quite accurate, however - they suggest that Blackport and Screen 2021 and Siew et al. 2021 may find that the multi-model mean ice-NAO relationship is too weak because it is heavily influenced by the "bad" models. In fact, both Blackport and Screen 2021 (Fig. 9) and Siew et al. 2021 (figures in supplementary material) also look at individual models, and none produce a long-term ice-NAO*

*relationship as strong as the 35-year relationship which is the focus here. I don't think it's necessary to go into more detail on individual models here, but I would recommend the authors remove/modify the last two sentences, and perhaps just use Baker et al. to make the valuable point that we cannot rule out the possibility that model error causes the signal to be underestimated in climate models.*

**Response:** We removed the mention of B and S here and just wrote instead the following:

“A key point here is that it has been noted in \cite{Baker2018} that not all seasonal forecast models exhibit skillful winter NAO forecasts, implying the existence of model error affecting the forced dynamics of the NAO. It is therefore possible that the weak signal seen in climate model studies is at least in part due to models not representing the relevant processes correctly.”

Which just emphasises the point that there is good reason to expect model error to be influencing the results based on climate models.

**Editor:** L402: *signs* -> *sign* seems to sound better, especially with "has" later in the sentence?

**Response:** We changed from “signs” to “sign”.

**Editor:** L404: *"A positive sea ice anomaly..."* - there's a grammar problem with this sentence.

**Response:** We rewrote this sentence as follows:

“A positive sea ice anomaly in the BKS region (i.e., an extension of the sea ice edge) leads to a reduced local heat flux into the atmosphere. This reduced heat flux then forces the positive phase of the NAO, via some combination of Rossby wave forcing, changes to the meridional temperature gradient and stratospheric pathways.”

**Editor:** L409: *to support* -> *for supporting*

**Response:** We made the change.

**Editor:** *L420: coupled variables -> coupling between variables ... seems better?*

**Response:** We made the suggested change.

**Editor:** *L438: straight forward -> straightforward*

**Response:** Fixed.

**Editor:** *L455: Suggest adding "(see further discussion in section 5.4)" to end of sentence (cf reviewer #2).*

**Response:** We added this sentence.

**Editor:** *L545: Grammatical problem with the "who" clause in this sentence.*

**Response:** We edited the relevant sentence to the following:

“The possible role of inadequate surface coupling in models has more recently been highlighted by \cite{Mori2019a} in the context of surface level teleconnections; \cite{Mori2019b} also emphasised the role of poorly simulated sea ice variability in models.”

**Editor:** *L548-L551: I think it's nice to mention these previous studies in the wrap-up interpretation of the results here, but similar to the comment above, I believe there is some vague/imprecise wording here. The "inconsistency" in models is really the fact that the autumn ice - winter NAO correlations over periods similar in length to the reanalysis exhibit a large spread and can be positive or negative. The CMIP6 results in Fig. 3 are essentially in agreement with CMIP5 historical runs (Fig. 2 Siew et al.), large-ensemble historical runs (Fig. 9 in Blackport & Screen uses several different models, Siew et al. use just one) as well as CMIP5 and CMIP6 pre-industrial runs (Fig. 2 in Siew et al., appropriately bootstrapped). Both Blackport & Screen and Siew et al.*

*show the ensembles as well as individual model results using very similar boxplots as shown in Fig. 3. So one point is that the weak correlations aren't just a function of averaging across many models, but also long simulation periods versus more satellite-length periods. I would suggest modifying the sentence to clarify these points, for example (but of course the authors can rewrite any way they choose): Thus, inadequate coupling could be behind coupled historical runs exhibiting a wide spread in ice-NAO correlations spanning both positive and negative correlations (K&B, Siew), as well as the weak correlations seen when averaging over many ensemble members or longer simulation periods (B&S, Siew)."*

**Response:** We thank the editor for their suggested rewrite, which we followed almost exactly:

“Thus, inadequate coupling may be behind coupled historical runs exhibiting a wide spread in ice-NAO correlations spanning both positive and negative correlations [\citep{Koenigk2017, Siew2021}](#), as well as the weak correlations found when averaging over multiple ensemble members or longer simulation periods [\citep{Blackport2021, Siew2021}](#).”