[1]Rapid Sea Ice Changes in the Future Barents Sea

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Abstract. Winter Arctic sea ice loss is strongest in the Barents Sea. The anthropogenic ice decline is superimposed by pronounced internal variability that represents a large source of uncertainty in future climate projections. A notable manifestation of internal variability are periods of rapid ice loss or growth that greatly exceed the anthropogenic trend. These rapid ice change events are associated with large displacements of the sea ice edge which could potentially have both local and remote impacts on the climate system. In this study we accordingly present the first investigation of the frequency and drivers of these rapid ice change events in the future Barents Sea, using multi-member ensemble simulations from CMIP5 and CMIP6. A majority of rapid sea ice changes are triggered by trends in ocean heat transport or surface heat fluxes. Rapid ice change events are a common feature of the future Barents Sea until the region becomes close to ice free. As their evolution over time is closely tied to the average sea ice conditions, rapid ice changes in the Barents Sea serve as a precursor for future changes in adjacent seas.

1 Introduction

The Arctic is the region of most intense warming on the planet, with temperatures increasing twice as fast as the global average, i.e., an Arctic amplification of climate change (Cohen et al., 2020). The strong temperature increase is accompanied by a decline in sea ice thickness (Kwok, 2018) and extent ([2]Onarheim et al., 2018) in all regions and all seasons. Future climate simulations project the strong sea ice decline to continue, leading to seasonally ice-free conditions in the Arctic as early as the middle of the 21st century (Notz and SIMIP Community, 2020; Årthun et al., 2021). However, future Arctic sea ice loss and the projected timing of ice-free conditions display a substantial spread across different models (Jahn et al., 2016). This large uncertainty results from model structure and emission scenario[3] but also internal climate variability (Swart et al., 2015; Bonan et al., 2021). Understanding internal variability is therefore important to predict future sea ice change under anthropogenic warming.

Whereas Arctic summer ice loss has largely occured in the central Arctic, winter ice loss has so far been confined to the outer shelf seas. The Barents Sea (Fig. 1) is the area of most intense winter sea ice area (SIA) loss, being on track towards year-round ice-free conditions in the second half of the 21st century (Onarheim and Årthun, 2017). A large part of the recent winter sea ice loss in the Barents Sea can be related to internal variability that is particularly strong in this region (England et al., 2019; Årthun et al., 2019; Bonan et al., 2021). On the sub-decadal timescale this variability is manifested in multi-year episodes of pronounced ice growth or ice loss that greatly exceed the long-term trend. These events of rapid ice changes are important to understand as they are characterized by substantial movements of the sea ice edge that have potential implications

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I have been asked to review the manuscript "Rapid Sea ICe CHanges in the Future Barents Sea" by Rieke et al. The topic of the work is important for current climate resarch, as the Arctic is constantly changing alongside global warming. In particular, the Barents Sea is a part of the region representing an important connection between the Arctic basins and the remainder of the Eurasian shelves, and lower latitudes.

Whereas the data basis for analysis appears state-of-the-art and the analytical approach overall sound there are several details that I suggest be clarified before publication.

The method of relating different derived quantities to changes in sea-ice cover is not clearly explained. The calculation of heat transport has, in the past, been challenged, and at least a few sentences of explanation why the approach used here is valid would be in order.

Thus, I suggest to publish this manuscript, subject to the modest corrections outlined in my comments. Note that I submit the comments as PDF comments in the form of a comment summary.

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could also cite the current IPCC report: Meredith, M., M. Sommerkorn, S. Cassotta, C. Derksen, A. Ekaykin, A. Hollowed, G. Kofinas, A. Mackintosh, J. Melbourne-Thomas, M.M.C. Muelbert, G. Ottersen, H. Pritchard, and E.A.G. Schuur, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In press.)

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scenarios

for e.g., marine ecosystems (Fossheim et al., 2015; Sandø et al., 2021), shipping routes (Melia et al., 2016), and terrestrial climate (Lawrence et al., 2008; Zhang et al., 2018). Rapid ice loss events have been investigated for pan-Arctic summer sea ice (Holland et al., 2006; Auclair and Tremblay, 2018). And although there have been several studies conducted on interannual
30 winter sea ice variability in the Barents Sea (Kwok, 2009; Schlichtholz, 2011; Årthun et al., 2012; Nakanowatari et al., 2014; Skagseth et al., 2020), a detailed investigation of rapid ice change events is lacking.

In this study we accordingly present the first investigation of rapid ice change events (RICEs) in the Barents Sea using large ensemble climate model simulations. We first quantify the probability of rapid ice change events in present and future climates, demonstrating that strong – more than 7 times the observed ice decline – multi-year sea ice trends are a common
35 feature of the Barents Sea until it becomes close to ice-free, leading to substantial displacements of the sea ice edge on rather short timescales. The drivers of these rapid sea ice changes are thereafter investigated. Our analysis is largely based on a large ensemble simulation from the Community Earth System Model version 1, but the sensitivity of our results to model differences and future emission scenarios is also assessed using CMIP6 models.

2 Data and Methods

40 The main part of this analysis is based on future simulations from the Community Earth System Model Version 1 (CESM1; Hurrell et al., 2013), a fully coupled climate model that has a horizontal resolution of approximately 1° in all model components. We make use of two sets of experiments from the model. The large ensemble simulation (CESM-LE; Kay et al., 2015) consists of 40 members and covers the period from 1920-2100 based on historical greenhouse gas emissions until 2005 (Lamarque et al., 2010) and the RCP8.5 (Moss et al., 2010) thereafter. The other experiment applies an external greenhouse gas forcing
45 that limits global warming to 2°C (CESM-2C; Sanderson et al., 2017). This experiment consists of 11 members over the period 2006-2100. The model setup is identical to the CESM-LE with the external forcing as the only difference. The setups of the individual simulations differ only in slightly perturbed initial atmospheric conditions. All differences between the members are thus solely a result of internal variability (Deser et al., 2020). This allows us to split the variables into a common part (the ensemble mean) representing external forcing, and an individual part representing internal variability. In our analysis we
50 subtract the ensemble mean from each ensemble member to focus on internal variability.

As the Barents Sea is practically ice-free in summer, our analysis is based on winter means (November-April). To assess rapid ice changes we first calculate linear trends of Barents Sea ice area (15-60° E, 70-81° N; Fig. 1). We note that our results do not qualitatively change if we consider sea ice volume or sea ice extent instead. RICEs were then defined as linear trends that exceed a threshold of $7.7 * 10^4$ km^{2}yr^{-1} over at least five years. This corresponds to two standard deviations of the distribution
55 of 5-year trends in CESM-LE between 2007 and 2025 (Fig. 2a), and is equivalent to 7 times the observational ice decline over the satellite era ($11.0*10^3$ km^{2}yr^{-1} for 1979-2017, based on Walsh et al., 2017). Our results are not sensitive to the exact choice of this threshold. We apply the same threshold to CESM-2C and the CMIP6-models to enable direct comparison. Trends in ocean heat transport via the Barents Sea Opening (BSO), sea ice area transport between Franz Josef Land and Novaya Zemlya (eastern gateway) and between Svalbard and Franz Josef Land (northern gateway), net surface heat fluxes, sea level pressure
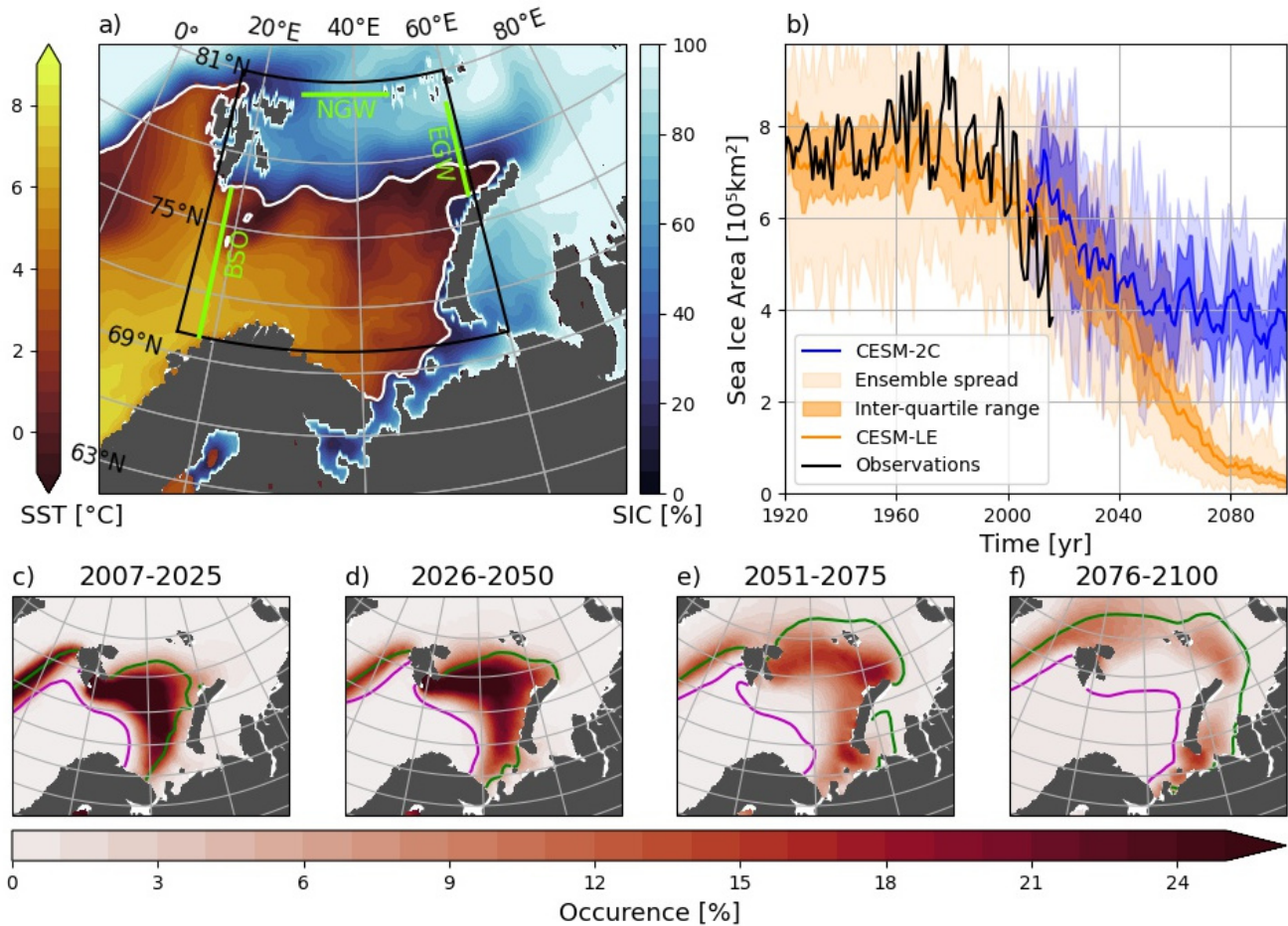
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Figure 1. a) Observed winter (November-April) mean sea ice concentration (SIC; Walsh et al., 2017) and sea surface temperature (SST; Hersbach et al., 2019) in the Barents Sea (black box) between 2013 and 2017. Note the two different colorbars. The white line indicates the mean location of the winter ice edge (15%-SIC). b) Winter sea ice area in the Barents Sea from observations, the CESM-LE and CESM-2C. c) - f) Occurence of strong 5-year trends in SIC ($\geq$8%/yr) during different time periods of the CESM-LE simulations. The coloured lines indicate the southernmost (magenta) and northernmost (green) location of the ice edge during the respective time periods.

60 and surface air temperature have then been calculated over the duration of the events to assess their relationship to the RICEs. Ocean heat transport across Barents Sea Opening is calculated as

$$OHT_{BSO} = \int_S \rho c_p F dS \tag{1}$$

with ρ and c_p the density and specific heat capacity of water, and F the advective heat flux per unit volume (model variable UET). UET is calculated in the model using a reference temperature of 0°C. Sea ice area transport is calculated as the product of
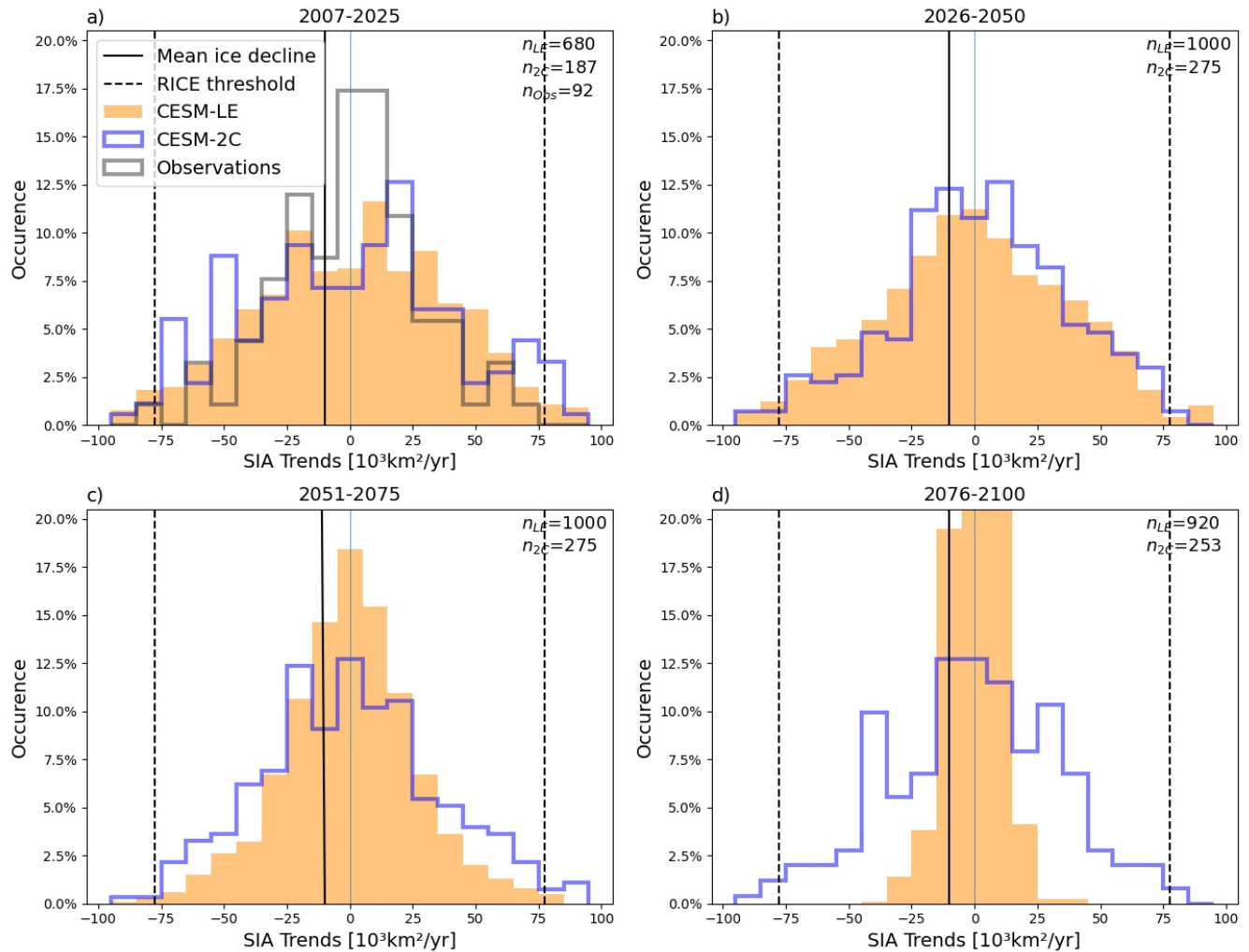
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(SIA)

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This appears to be an arbitrary choice. Seawater at typical Barents Sea salinities in winter freezes around -2 deg C. Please elaborate a bit more how sensitive your results are to this choice of reference temperature. Refer to / cite the following publication:

Schauer, U. and Beszczynska-Möller, A.: Problems with estimation and interpretation of oceanic heat transport – conceptual remarks for the case of Fram Strait in the Arctic Ocean, Ocean Sci., 5, 487–494, https://doi.org/10.5194/os-5-487-2009, 2009.

Figure 2. Histograms of internally-driven 5-year trends of SIA (deviations from the ensemble mean) during different time periods in the 21st century for the CESM-LE and CESM-2C. The black solid line indicates the maximum 30-year ensemble mean ice decline in CESM-LE ($10.0*10^4 \text{km}^2 \text{yr}^{-1}$ for 2031-2060), the dashed lines indicate the threshold for RICEs. [1] The sample size (number of trends) of the histograms is indicated in the top-right corner. A 4th-order polynom has been removed from observations (Walsh et al., 2017) prior to calculating trends to represent the externally-forced signal (following Bonan et al., 2021).

4 Rapid Sea Ice Changes in CESM1

To quantify the occurrence of rapid ice change events in the Barents Sea, distributions of 5-year SIA-trends are presented in Fig. 2 for the CESM-LE and CESM-2C for different periods. The distribution of observed trends after 1920 is shown for
90 comparison, and is similar to both, the historical simulations of CESM-LE (not shown) and the future simulations between 2007 and 2025 (Fig. 2a). Until 2050 CESM-LE and CESM-2C show similar distributions with many trends being much stronger

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I know this may seem picky, but if you used the same colours for the nLE, n2C and nObs as in the legend it would be intuitively easier to associate the "n" to the correct set of data.

In the following, we will focus on the tails of the distributions, i.e., RICEs as these trends lead to the strongest changes in Barents Sea ice conditions. In CESM-LE we find 31 ice growth and 44 ice loss events between 2006 and 2100 and in CESM-2C we find 13 ice growth and 19 ice loss events that exceed our definition of a rapid ice change event (Section 2; vertical dashed lines in Fig. 2). This corresponds to an average of 2 RICEs per ensemble member in CESM-LE and 3 in CESM-2C.

105 The RICEs are associated with a large displacement of the ice edge, with ice loss (growth) events leading to a northward (southward) movement of the ice edge of up to 900 kilometres (Fig. 3). Ice loss events are on average related to a somewhat larger displacement than ice growth events, and the [1] displacement also increases over time as sea ice retreats into the northeastern part of the Barents Sea (see the numbers given in Fig. 4). Two example cases from CESM-LE are depicted in Fig. 3. During an ice growth event in the second half of the 21st century, the ice edge is pushed 678 km southwards from close-to-average

110 sea ice conditions into the south-western part of the Barents Sea resulting in a present-day location (Fig. 3b). The example ice loss event in the early 21st century results in a rapid northward retreat of the ice edge (Fig. 3c). These examples emphasize the severity of RICEs as they can initiate a shift from average ice conditions to an unusually northward or southward location of the ice edge in only a few years. All ice growth events in CESM-LE, even those after 2050, result in an ice edge location very close to or even south of the present-day average (represented by the ensemble mean 2007-2025).

115 To understand and possibly predict these RICEs and their impacts, it is essential to identify the underlying mechanisms. [2] We thus calculate the corresponding trend for potential drivers during each event, and assume those whose trend exceeds the threshold of one standard deviation to be related to that event. The relative importance of the investigated drivers is not sensitive to the exact choice of this threshold. [3] Also note that as RICEs can be related to anomalous trends in more than one driver, ratios can add up to more than 100%. There are no significant differences between ice growth and ice loss events, and the forcing is

120 therefore evaluated for ice growth and ice loss events combined. Based on previous literature we consider three main drivers: [4] *Ocean heat transport:* Previous studies found a strong influence of BSO ocean heat transport on sea ice variability, with stronger (weaker) heat import leading to less (more) sea ice (Schlichtholz, 2011; Årthun et al., 2012; Docquier et al., 2021). We find ocean heat transport to be the most dominant driver of rapid ice changes. 79% (84%) of all RICEs in CESM-LE (CESM-2C) exhibit a simultaneous trend in [5] OHT that exceeds one standard deviation (Fig. 4). For 5-year-trends the standard

125 deviation in OHT is 5.8 (5.2) $\mathrm{TW\,yr^{-1}}$. In comparison, the OHT increase needed to induce the observed sea ice loss in the Barents Sea since 1979 is approximately 1 $\mathrm{TW\,yr^{-1}}$ (Li et al., 2017).

Sea ice transport: An increase (decrease) in ice import can be associated with a growing (decreasing) sea ice cover, both via direct import and influences on local ice formation via stratification changes (Kwok, 2009; Lind et al., 2018). This is the case in 33% and 32% (22% and 25%) of the events for the northern and eastern gateway in CESM-LE (CESM-2C) (Fig. 4).

130 The threshold of one standard deviation is 7.4*10^4 (8.8*10^4) $\mathrm{km^2yr^{-2}}$ for the northern and 4.3*10^4 (5.2*10^4) $\mathrm{km^2yr^{-2}}$ for the eastern gateway. This would mean that even the strong increase in ice import between Svalbard and Franz-Josef-Land that observations show between 1999 and 2003 (6.5*10^4 $\mathrm{km^2yr^{-2}}$; Kwok, 2009) would be slightly too small to be considered relevant for triggering a RICE.

Surface heat fluxes: Changes in atmospheric circulation and associated heat and moisture transport can also influence the

135 sea ice cover (Woods and Caballero, 2016; Boisvert et al., 2016). In support of this, our results show a negative trend in sea

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Looking at Figure 4, I see that the distances increase from (a) to (b) but in (c) only CESM-LE increases further. Perhaps rephrase and state "during the first half of the 21st century" ?

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Again, please specifiy briefly what choice of thresholds you tried.

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I don't understand how you obtained those % numbers -- did you calculate some sort of explained variance? How did you "related" the trends quantitatively? Deserves a couple of extra sentences.

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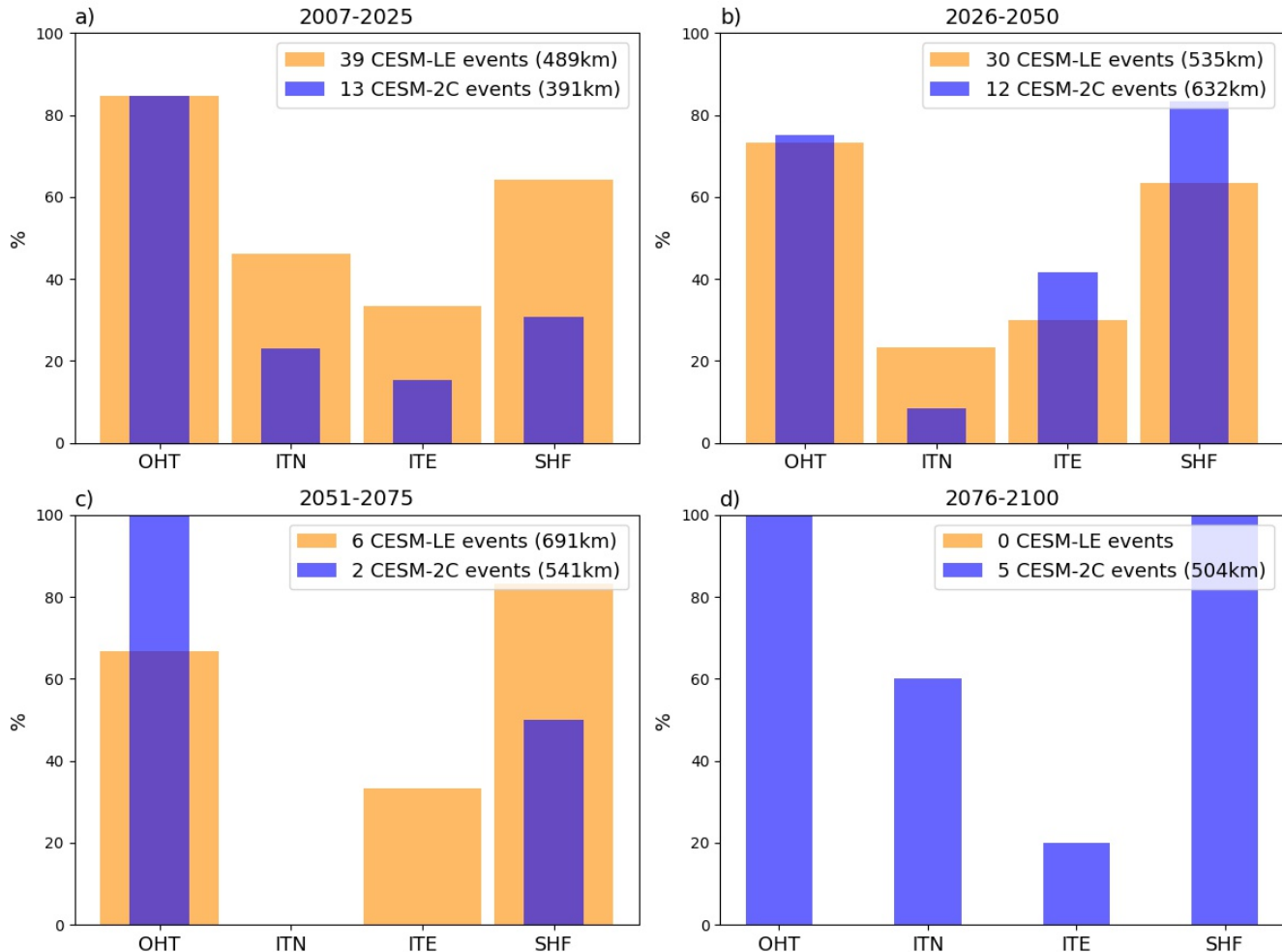
See my comment above -- explain a bit more why the approach of calculating OHT is physically meaningful or why the result is not sensitive to the choice of reference temperature.

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There are a lot of acronyms in this manuscrpt, which makes it difficult to understand for the reader who is not an expert on sea ice in CMIP6 models. Consider writing at least some of these acronyms out in full -- for example, "OHT", "ITE", "ITN", "SHF" could be used in figures (defined in corresponding figure caption) but written in full in the text.

Figure 4. The fraction of RICEs that show a simultaneous trend in the respective forcing parameter of more than one standard deviation. The drivers are [1] SO ocean heat transport (OHT), ice transport through the northern (ITN) and eastern gateway (ITE) and surface heat flux (SHF) in the southwestern Barents Sea (Figure 5c).

level pressure over the Fram Strait during ice loss events (Fig. 5a), associated with strengthening westerly winds over BSO and southerly winds over the central and northern Barents Sea. As a result, surface air temperatures increase in the northern Barents Sea (Fig. 5b) during ice loss. Warmer westerly winds also lead to reduced ocean heat loss in the ice-free southern Barents Sea, whereas more heat is lost in the northern Barents Sea as a result of more open ocean area (Fig. 5c; Skagseth et al., 2020). Considering surface heat fluxes in the permanently ice-free southwestern Barents Sea (16-38° E; 71-76° N) as a fingerprint of atmospheric forcing of ocean temperature and, hence, sea ice (Schlichtholz and Houssais, 2011), [2] we find 65% (62%) of the RICEs to be associated with anomalous trends in SHF in CESM-LE (CESM-2C); decreasing (increasing) ocean heat loss corresponding to SIA decline (increase).

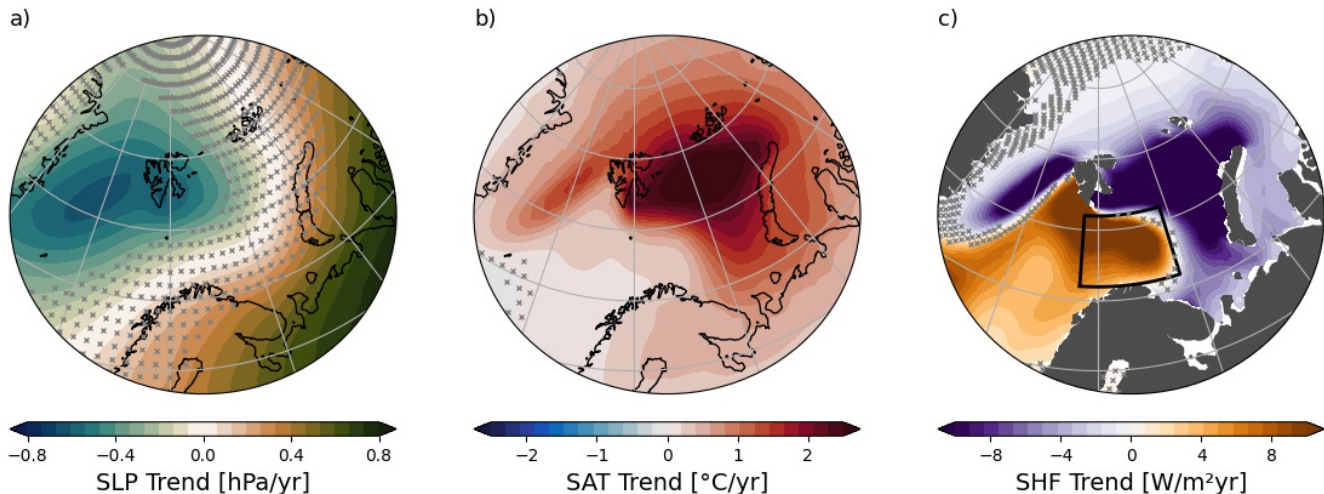Number: 1 Author: anonymous   Subject: Highlight   Date: 11/07/2022, 15:40:53
See comment above.

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Does that mean you just counted the number of times that RICE were related to anomalous trends in SHF (i.e. where the trens in SHF went outside one standard deviation)? Is that the same way you get the percentages in Figure 4?

Figure 5. Linear trend of a) sea level pressure (SLP), b) surface air temperature (SAT) and c) surface heat flux (SHF) anomalies during ice loss events, averaged over all events. Ocean heat loss is defined as negative, meaning that positive (negative) anomalies refer to less (more) heat loss. The black box indicates the area for averaging SHF to assess its influence on RICEs. Crosses indicate areas where the trend is not statistically significant at the 95% confidence level.

Although the different drivers have been assessed and quantified individually, they are to some extent interconnected. For
145   example, ice loss events are associated with an anomalous atmospheric circulation (Fig. 5a) that will influence both ocean heat transport (Herbaut et al., 2015), surface heat fluxes (Skagseth et al., 2020), and sea ice area transport (Kwok, 2009). 51 (50) % of the RICEs exhibit significant trends in both, OHT and SHF, emphasiszing their interconnection. A detailed analysis of these relationships is not presented here. However, removing (by regression) the linear signal associated with OHT from time series of regional winds over the Barents Sea suggests [1] that atmospheric circulation (wind) anomalies are mainly effecting the sea ice
150   cover through changes in BSO heat transport, consistent with the findings of e.g. Lien et al. (2017).

In general, we find that the relative importance of the different drivers varies somewhat during the simulations, but no systematic change is seen (Fig. 4). Differences between CESM-LE and CESM-2C are also small and show no consistency, suggesting that the forcing of RICEs remains unaffected by the underlying ice conditions.

5   Rapid Sea Ice Changes in CMIP6 models

155   The occurrence of rapid sea ice changes is further studied in a suite of CMIP6 models. Figure 6 shows the distribution of 5-year trends from the CMIP6 models under two emission scenarios. Most models show a distribution of trends that is fairly similar to, yet slightly narrower than the CESM. An exception is CanESM5 that simulates much weaker trends than the other models, likely as a result of the [2] low average SIA in the model after the strong ice loss until 2030 (Fig. 6). During the 21st century SIA decreases in all model simulations and the distributions become more confined to weaker trends. Although the models agree on

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This would suggest that most of the BSO heat transports are volume-transport-driven, rather than driven by changes in temperature of the advected water. That devserves another sentence... Again, I refer to my comment on heat transports above.

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Do you mean that the sea ice loss occured only until 2030? Or does the low average SIA in the model occurs after a strong ice loss that alltogether occur before 2030? Please rephrase to clarify...

a larger SIA. Only the MPI-ESM1-2-LR simulates a stabilisation of the SIA in the Barents Sea under a low-emission scenario (in agreement with CESM-2C), whereas the other CMIP6 models show practically ice-free conditions at the end of the 21st century even under SSP126 (see also Årthun et al., 2021).

165   The different mean states in the models are also reflected in the number of RICEs. The CMIP6 model that simulates the largest average SIC in the Barents Sea, EC-Earth3, also simulates most RICEs per ensemble member (1.6/2.2 in the SSP585/SSP126-simulation) using the same criterion of $7.7 * 10^4 \text{km}^2\text{yr}^{-1}$ (7 times the observational ice loss). However, this model exhibits a very strong anthropogenic ice decline (represented by the maximum 30-year ensemble mean SIA trend of -15.2*10^3km^{2}yr^{-1} in SSP585 between 1993 and 2022; Fig. 6j), which leads to RICEs in EC-Earth3 being weaker relative to the

170   long-term ice loss than in CESM. In contrast, RICEs in ACCESS ESM1 (0.4/1.7 in SSP585/SSP126) are much stronger than the anthropogenic ice loss which is rather small (-7.4*10^3km^{2}yr^{-1} between 1981 and 2010 under SSP585). RICEs can also be found in MPI-ESM (0.4/0.5) and MIROC6 (0.2/0.2), that simulate average ice loss similar to the CESM-LE (-8.3 (1987-2016) and -9.8*10^3km^{2}yr^{-1} (2016-2045) in SSP585). Only CanESM simulates no RICEs whatsoever in either simulation. This model is characterised by a very strong anthropogenic ice loss (-18.8*10^3km^{2}yr^{-1} between 1993 and 2022), resulting in

175   ice-free conditions as early as 2025. CanESM5 is also the model with the weakest internal variability, evident from the very narrow distribution of sea ice trends (Fig. 6c; also quantified by the ensemble spread in SIA). The weak internal variability in this model has also been noted in other studies (Bonnet et al., 2021). In general, we find that models with stronger internal variability produce more RICEs. We thus conclude that although the CESM seems to represent an upper bound for RICEs in the Barents Sea, they generally occur also in other CMIP6 models. Model differences in the occurrence of RICEs are closely

180   related to average sea ice conditions and the strength of internal variability.

6 Discussion and Conclusion

The Barents Sea is the area of most intense winter sea ice loss and future projections show a continued decline towards ice-free conditions by the end of this century (Fig. 1 Onarheim and Årthun, 2017). Internal variability in the climate system leads to large interannual to decadal fluctuations superimposed on this long-term trend (England et al., 2019). A visible manifestation

185   of these internally-driven fluctuations is the occurrence of large, abrupt changes in the sea ice cover. These rapid ice change events (RICEs) are several times stronger than the externally-forced ice loss and can hence lead to an acceleration, pausing or reverse of the ice decline. In this study we present the first investigation of RICEs in the Barents Sea. We use outputs from two ensemble simulations from CESM and multi-member CMIP6 simulations to investigate the future evolution of winter sea ice variability in the Barents Sea under different emission scenarios. Although CESM simulates the largest number of RICEs,

190   possibly representing an upper bound for their occurence, RICEs are also found at similar rates in most other models. The occurence of RICEs is directly related to average sea ice conditions and hence to future emissions.

Rapid ice loss events have previously been studied in future climate simulations for the pan-Arctic in summer. Holland et al. (2006) and Auclair and Tremblay (2018) find most of those pan-Arctic events to be associated with anomalies in [1]ocean heat transport which is consistent with our results for the Barents Sea. In addition to OHT we also investigate the influence

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See my comments on OHT above...

195 of other parameters and find a substantial contribution from surface heat fluxes and ice transport. This is largely consistent
with the results from studies focusing on interannual variability in the Barents Sea (Kwok, 2009; Schlichtholz, 2011; Årthun
et al., 2012; Nakanowatari et al., 2014; Skagseth et al., 2020). We emphasize that this is not a priori granted, and note that
distinct mechanisms have been identified for interannual variability and long-term trends in BSO ocean heat transport (Wang
et al., 2019). Venegas and Mysak (2000) also found different dominant mechanisms of sea ice variability in the Barents Sea

200 for different time scales. We find no systematic change of the underlying drivers over time, between the emission scenarios
or between ice growth and loss events. From this we infer that the underlying processes of driving rapid ice changes in the
Barents Sea remain unaffected by global warming and the retreating sea ice.

In this study we have shown the importance of rapid ice changes in the Barents Sea. RICEs are especially important due to
the substantial movements of the ice edge, which, as the border between ice-covered and open ocean, is of large importance

205 for climate (e.g., Zhang et al., 2018) and ecosystem processes (e.g., Fossheim et al., 2015). Identifying the leading drivers of
RICEs is therefore crucial for understanding and predicting such events and their associated broad impacts. When the Barents
Sea approaches ice-free conditions, the area experiencing rapid sea ice changes will retreat past the boundaries of the Barents
Sea into the central Arctic and the Kara Sea, [1] visible footprint of the future Atlantification of the Arctic Ocean (Fig. 1f; Dörr
et al., 2021; Shu et al., 2021). Our results could therefore provide important insight into future sea ice variability in other Arctic

210 seas.

215 *Author contributions.* MÅ conceived the study. OR performed the analysis, produced the figures, and wrote the paper. MÅ and JD con-
tributed to improving the manuscript. All authors contributed to the methods design, results analysis and manuscript reviewing

Competing interests. The authors declare no conflict of interests

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If sea ice change in the northern Barents Sea and the Eurasian basin near the continental slope is a result of Atlantification or, rather, a adriver of it may be an open question (or it's both) -- I'd rephrase this as something like "a visible change associated with future Atlantification".

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I would expect a proper citation of data sources here, i.e. cited here or in the main text and put in the reference list. At least the ERA5 and the SIC observations should be citable (with a doi) and available via a repository. Not sure about the model output. In fact, when following your link for NSIDC, there is a clear indication of "Citing these data": "Walsh, J. E., W. L. Chapman, F. Fetterer, and J. S. Stewart. 2019. *Gridded Monthly Sea Ice Extent and Concentration, 1850 Onward, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. doi: https://doi.org/10.7265/jj4s-tq79. [Date Accessed]. "
Please check for the other data sources, as well.