[Reviewer 1]

The paper describes the performance of the fully-coupled Regional Arctic System Model (RASM) with respect to the simulation of polynya events north of Greenland. A 42-year long simulation (1979-2020) is analysed in combination with satellite products and weather station data. Additionally, two ensembles are generated by forcing RASM with output from the Community Earth System Model (CESM) Decadal Prediction Large Ensemble (DPLE) simulations. The two ensembles, initialized in December 1985 and December 2015, are investigated with respect to precondition of winter polynya events. The paper describes a nice application of dynamical downscaling. However, the paper needs major revision mainly because of two main points of criticism:

[R1-A] It is not immediately clear what the added value of this paper in comparison to the papers of Moore et al. (2018) and Ludwig et al. (2019) is. In both of the latter papers sea ice-ocean models (PIOMAS in case of Moore et al. and NAOSIM in case of Ludwig et al.) are used to analyse the polynya event in more detail as possible with observations alone with almost identical findings (e.g. that preconditioning has no effect on the polynya event in 2018). I suggest to revise the manuscript carefully to make clearer the scientific added value of this study.
→ Moore et al. (2018) focused on how the polynya in February 2018 occurred and Ludwig et al. (2019) addressed what processes were involved in it. They both used an ice-ocean model to study it, which means that the models are prescribed with reanalysis or gridded products on every grid cell. On the other hand, RASM is a fully-coupled high resolution regional model, which allows us to further study interactions between ice, ocean, and atmosphere. In addition, we have investigated every winter polynya event since 1979, which additionally includes polynyas in February 2011 and 2017 and December 1986 in this revised manuscript. Moreover, since RASM is a fully-coupled model (where ocean, atmosphere, and sea ice fields are predicted every time step), it allows us to estimate the number of polynyas that would occur under the observed level of climate warming in each simulation in both ensembles, 30 years apart. It is found that simulated polynyas would occur as long as certain atmospheric conditions are met. This implies that an initial condition of SIT (or decline of SIT due to forced climate warming in the study region) is not a critical factor in occurrence of such polynyas north of Greenland.

[R1-B] Unfortunately, winter is defined in this study from January to March excluding December. If December would have been included the authors would have not missed the polynya north of Greenland in December 1986– Moore et al. (2018) missed it as well because they concentrated on February only (see plot below based on own unpublished analyses). Inspection of the wind field in December 1986 north of Greenland in reveals a northward wind anomaly of almost the same strength and duration as in February 2018. However, there is a dramatic difference. While the occurrence of the 2018 polynya coincides with a sudden stratospheric warming (SSW) event a few days earlier (and associated with a strong decrease in the NAO) the 1986 event does not show any SSW nor any strong NAO change.

→ We thank the reviewer for this suggestion and accordingly have expanded our analysis of winter polynyas to include December, which was missed in Moore et al. (2018). Hence, in the revised manuscript, the winter is defined from December to March and thus the December 1986 polynya is added and thoroughly examined in the subsection 4.2.2 and Fig. 9. In addition, we found that satellite SIC was below 90% in some other years: December 1984 and 2002, but they are excluded because dynamic sea ice transport as defined in this study is too small to count them as polynyas (Fig. S5). Moreover, we further investigated RASM-DPLE ensemble simulations including December, which in turn shows that more polynyas were produced when sea ice was thicker in 1985-1995.

RASM hindcast simulations reproduced the polynya in December 1986 as it is observed in satellite measurements (Figs. 9a and 9b) and confirmed it is a latent heat polynya (Fig. 9c). Although the wind in December 1986 was as strong as in February 2018, its duration was shorter (Fig. S6). If the wind in December 1986 was similar to the wind in February 2018, it is expected that the polynya would be comparable to the observed. As the reviewer reported, all the polynyas except one in February 2018 occurred in non-SSW winters, but we found that there was a link with an AO reversal (Figs. 3a and 9e).

Beside two major points of criticism I listed below a number of points the authors are ask to take into account in the revision. The importance of my suggestions is indicated by minor/major in front of each item but follows the order in the manuscript.

[R1-1]. Minor - line 49 'Introduction': Some of the citations given are pretty old and should be replaced by newer publications. One could be https://journals.ametsoc.org/view/journals/clim/34/13/JCLI-D-20-0848.1.xml
→ We added a newer publication, i.e., Ricker et al. (2021), as well.

[R1-2]. Major – line 60: Figure 1 needs some heavy revision. Panel a) is too dark. Panel b) and c) should be shown in a similar projection as a) to make the comparison easier. The rectangle in b) and c) does not compare well will panel a). Obviously RASM is not able to reproduce the large area of open water north of Fram Strait that can be seen in the observations. This should be discussed in the text and reasons for the deficit should be given (certainly shortcomings in the vertical mixing of the ocean model). The SIT from CFRv2 in panel c) is very unrealistic. A brief discussion on the reliability of SIT from CFSv2 is necessary if the plot should be shown.
→ Fig. 1a is replaced with the VIIRS nighttime image on February 25th, 2018, after brightened, so that we can compare overall open water areas on the same day in the northern Greenland as well as north of Svalbard. Due to the nature of satellite images, we cannot show the whole Arctic. But Fig 1 rather emphasizes how unrealistic sea ice condition is in CFSv2. Even though the RASM simulation relies on the downscaling of CFSv2 atmospheric boundary conditions, RASM sea ice is very well represented, indicating the potential capability of regional climate models used for dynamical downscaling. We also discussed overestimation of sea ice coverage north of Svalbard where basal melting is dominant. This could be due to that ocean heat transport underestimation along the pathway of the West Spitsbergen Current. Please see the first paragraph of the Discussion.

[R1-3]. Minor - line 63 'Introduction': I was very surprised to see no hint to the SSW when Moore et al. is cited. The coincidence of the polynia with the SSW is mentioned later under 'Discussion' but I would prefer to have some statements about the possible connection to the SSW when citing Moore et al. for the first time because this is the strongest message in that paper.

→ As suggested, we added the sentence, introducing SSW observed in February 2018 in Moore et al. (2018).

[R1-4]. Minor but important - line 124: CS2SMOS should be referenced correctly.

→ CS2SMOS data are referenced and acknowledged as suggested.

[R1-5]. Minor – line 177: Fig. 3 is referenced before Fig. 2. Check the order of the plots. It makes the manuscript unnecessary complicated to read.

→ Fig. 2 is already introduced in the last paragraph of introduction.

[R1-6]. Major – line 179: "… to early March is captured well …". I disagree with the statement (see comment below – line 216).

→ This sentence is about near-surface air temperature variability in the RASM simulation which captures it well as shown in Fig. 3.

[R1-7]. Major – line 216: "The RASM's realistic representation of the polynya…". What seems to be realistic is the size of the polynya but not the location which is very disappointing for a downscaling system. Fig. 2 shows very convincing that the polynya is located too far to the west – the largest fraction of the polynya is located in areas where CS2SMOS shows thicknesses of more than about 1m! Reasons for the mislocation of the polynya should be discussed. In Ludwig et al. a sound estimate of the size of the polynya is given (about 600.000 km2 in maximum) but the size of the polynya in RASM is not compared to this number. This should be done! Instead modelled volume growth rates are discussed for which no observation analog exists (CS2SMOS based estimates are definitely to uncertain given the very coarse resolution). In Ludwig et al. thermodynamical growth rates based on simple estimates are given which should be discussed together with the estimates from RASM.

→ We acknowledge that RASM has a smaller polynya and a more westward position than published observations. We also have made this difference clearer in the revised manuscript. When RASM is used for dynamically downscaling, atmospheric forcings are prescribed only along the lateral boundaries and nudged at approximately the 500 hPa level and above. Hence, surface atmospheric forcing is predicted every time step. Although RASM near surface wind fields agree well with the reanalysis, slight discrepancies in wind direction or magnitude near the study region may shift the center of the polynya more westward. At the same time, it should be noted that CS2MOS SIT is a 7-day mean SIT, not daily. Hence, the direct comparison between them is not straightforward.

Ludwig et al (2019) estimated the size of the of polynya (a maximum extent of about 60,000 km^2) based on the satellite SIC, although there are large uncertainties between algorithms, which makes the comparison less straightforward. For example, MODIS SIC could produce a polynya size that is half of the current estimate (or about 30,000 km^2). RASM estimated the polynya size based on SIT less than 10 cm, which gave a maximum size of 13,000 km^2, but if the open water area is less than 25 cm of SIT, the maximum size becomes 29,400 km^2 (half the size of Ludwig et al. (2019)'s estimate). Also, the RASM integrated thermodynamic ice growth (53 km^3) is larger than their study (33 km^3).

[R1-8]. Minor – line 232: "… removal due to the polynya …" Not the polynya is removing the sea ice but the winds are removing the sea ice and forming the polynya.
→ It is revised as "ice removal during the polynya formation period"

[R1-9]. Minor – line 237: I do not understand what should be learned from whole subsection.
→ This subsection provides the additional information on how RASM southerly-southeasterly winds contribute to sea ice divergence and thus polynya formation using the SOM analysis. Because the RASM simulation is not forced by reanalysis products, we need to make sure that RASM atmospheric winds are well represented during the polynya period (Fig. 6), and they are confirmed by the ERA-Interim reanalysis wind fields (Fig. S2).

[R1-10]. Major – line 260: The whole subsection 4 might need a revision in the light of the strong wind event in December 1986 mentioned above.
→ We added another subsection for the December 1986 polynya and described how it was developed after thorough analysis (Fig. 9; ice melting, wind pattern, anomalous warming with AO index, dynamic ice volume tendency, and turbulent heat flux over the polynya region). Similar to the recent event in 2018, the strong southerly wind was involved (Table 1), but its duration was shorter (Fig. S6). Hence, this suggests that the size of polynya was smaller than the one in February 2018, as the satellite data indicate in terms of mean SIC in the region (Figs. 7 and S4). Turbulent heat flux was also lower (Table 2).

[R1-11]. Major – line 367 'Discussion': Obviously, the whole subsection needs reformulation after inspection of the December 1986 wind/polynya event.
→ After thorough analysis of satellite SIC in December 1979-2020, as the reviewer pointed out, we included the missing 1986 winter polynya in the revised manuscript. It is described in the new subsection (4.2.2). In addition, we have inspected RASM-DPLE ensemble simulations including December polynyas as well. It turns out that there are more December polynyas in the 1985-initialized runs than in the 2015-initialized ones. Text has been added to the manuscript to address the inclusion of the December polynyas and the additional conclusions that are made with their additions to the study.