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Interactive comment on "Future interannual variability of Arctic sea ice in coupled climate models" *by* John R. Mioduszewski et al.

Anonymous Referee #2

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This study by Mioduszewski and co-authors is concerned with the future (and to some degree past and present) variability of the Arctic sea ice cover in GCMs. The article focuses on seasonal aspects of the variability in sea ice area, and on potential drivers of such variability. The authors find a strong correlation between ice area variability and ice thickness, and argue that thermodynamic processes have a stronger impact on variability than dynamic processes.

The study is concerned with an important topic that fits well within the scope of The Cryosphere. I agree by-and-large with the comments of the other reviewer, and would hope to see some substantial revisions of the manuscript. Furthermore, several parts of the manuscript are marked by a somewhat disappointing standard of language and presentation, in particular given the experience and seniority of the co-authors. Below

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I will detail concerns that I have in addition to those voiced by the other reviewer.

General comments:

1. The abstract and introduction should be thoroughly revised (see specific comments below). The writing improves from Section 2 onward.

2. Please consider the geographic muting effect of Eisenman (2010) in more detail. i.e. what do analogues to Fig S1 and Fig 1 look like when using Eisenman's "equivalent ice extent"? This would help quantify the role that the distribution of land around the Arctic basin plays in this context.

3. I share the concerns of the other reviewer in that the discussion of the CMIP5 analysis is somewhat vague and incomplete. It also should be put more clearly in context with other recent work on the subject.

4. In Sec 3.3 it seems odd to choose Sept and Dec as months to study the roles of ice retreat and expansion, respectively. First, the sea ice minimum occurs typically in mid-Sept, which means that there's substantial ice expansion in the 2nd half of the month (as remarked in L.314). Thus, if the authors want a fully retreating month, why not choose August? December, on the other hand, is fairly early in the ice expansion phase, so if the aim is to capture as much as possible of the preceding expansion, why not choose February? Or January? To that point, in the conclusions (L.413-414) the authors relate Fig 6c,d to "Nov-Jan" variability (rather than to Oct-Dec, as used in the analysis).

5. As pointed out by the other reviewer, this work needs to be put carefully in context with the very recent paper by Massonnet et al ("Arctic sea-ice change tied to its mean state through thermodynamic processes", Nature Climate Change, 2018). I appreciate that the latter study was published after this one was submitted.

Specific comments:

I would suggest moving Fig S1 to the main text as Fig 1. I'd also suggest color-coding

the different months sequentially in this figure so that the seasonal cycle becomes more visible.

L.49: I would suggest deleting "independent".

L.52-54: This sentence is somewhat confusing. Some months see an essentially monotonic increase and it's not immediately clear what part of the sentence refers to CESM-LE and what to CMIP5. I suggest rephrasing and/or splitting into 2 sentences.

L.55: "inversely" correlated. This is used at several points in the ms. Unless I'm mistaken, isn't the rate of retreat "directly" correlated with the variability? In other words, the larger the rate of retreat, the larger the variability (?). At L.428 the authors talk about the rate of change. Here I can see the inverse relation: the more negative the rate of change, the larger the variability.

L.58: "...indicating that [for most of the years (?)] substantial future thinning ..."

L.59-60 "... depends on the season, primarily due to whether ..." This could be written more clearly.

L.98 "... reduces the [mean] thickness of the basin ice back ..."

L.100 " ... the [estimated] negative trend ..."

L.103 "[Output from] many climate models suggest[s] ..."

L.113-114 rephrase

L.117 I agree with the other reviewer that the implied causality between reduced extent and loss of multi-year ice is misleading.

L.118 "Increased thin ice ...". Replace with "Overall thinner ice ..."

L.121 "... ice growth and retreat rates ..." I'd argue this should either be "expansion and retreat" or "growth and melt"

L.129 "relationship between ice area and its variability". Do the authors mean the

"mean ice area" and the "variability in ice area"?

L.130 "... it is only beginning to become visible ..." The relationship is becoming visible? Does this mean that we are starting to observe a correlation between the mean ice area and the variability of ice area? Please clarify.

L.143 "... monthly differences are [societally/economically?] important ..."

L.148 "... characterize internal variability [of CESM]" (see other reviewer's comment)

L.198 "... follows [an analogous] three-phase progression ..."

L.222 "inverse" see comment at L.55

Fig.3 I find it hard to decipher the individual curves here. What about splitting the figure into 2 panels, with panel (a) showing spring/summer months and (b) showing fall/winter months. The missing curves in each panel could shown as faint gray in the background for reference. Again, I would use a sequential color map.

L.240 "... between ice thickness and [ice area] variability ... " Otherwise it might be read as "ice thickness and ice thickness variability"

L.267-272 Would it be worth showing another thickness curve (<0.2 m) in Fig 4 to illustrate the phase dependence (and different area coverage) for different ice thicknesses?

Fig 5: The left hand side of the bounding boxes was cut off. Also, the resolution of the figure was low (jpg? Better to use png with resolution > 150 dpi). It'd be nice to add the respective decade in the top left corner of each panel.

L.275: Please mention CESM-LE in the caption.

L.287: "... thin ice and [the variability of] inter-annual ice coverage ... "

L.280-282: How much of this difference is simply due to the limited run length of the simulations? In other words, once the ice retreats further in winter and spring after 2100, would one then also see the horse-shoe pattern in those seasons? Conversely,

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in the summer, are the regions of high variability restricted to the Arctic boundaries during earlier decades in the simulations?

L.293 "expanding" rather than growing

L.304 Why is a different method used here to calculate the standard deviation?

L.337-340 delete "rather than melt". Split into two sentences?

L.342 "[mid] 21st century"

L.345 "frazil [ice]"

Fig 6: The (a)-(d) labels are too big and bold, and the rest of the text in the figure is too small.

L.376 Isn't the smaller magnitude of spring variability just a result of the time series ending in 2100 (before the ice edge retreats into the Arctic basin in spring)?

L.415 "... ice area variability [in winter] also coincides ..."

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