

Review of “Changes of the Arctic marginal ice zone” by Rebecca J. Rolph, Daniel L. Feltham, and David Schröder

General comments

The manuscript “Changes of the Arctic marginal ice zone” by R. Rolph, D. Feltham, and D. Schröder provides a clear analysis of evolution in Arctic marginal ice zone (MIZ) extent relative to total sea ice extent (SIE) in a changing climate. In highlighting, based on an operational definition, that the MIZ extent shows no significant trend over the last 40 years despite a decline and well-defined trend in total SIE, this analysis underscores the need for a universal definition for the MIZ, identification of relevant variables in addition to extent for its characterization, and improved understanding of implications in a changing climate for communities influenced by MIZ processes.

This paper addresses relevant scientific questions including characterization of the MIZ, and presents novel analysis that contributes to an understanding of changes in the sea ice cover, and in particular poleward migration in MIZ and total SIE, in the context of a changing climate. Also of interest however is the sensitivity of this analysis to the mathematical and physical definition for the MIZ; investigation of additional techniques used to analyse total SIE (i.e. geographic muting described in Eisenman, 2010) applied to the MIZ that could perhaps explain the absence of statistically significant trends in MIZ extent over the past 40 years and, as noted by other reviewers; further exploration of reasons for the absence of changes in MIZ extent; in addition to alternative MIZ variables/aspects (area, regional variability, zonal mean MIZ edge as in Eisenman, 2010) that do reflect changes in the zone between fully ice-covered and ice-free regions in response to global warming. This is therefore to recommend that the manuscript be published following revisions that address MIZ definitions and analysis. Please find below more specific comments for consideration.

Specific comments

Abstract

p. 1, lines 6 – 8. “It does not logically follow, however, that the extent of the marginal ice zone (MIZ), here defined as the area of the ocean with ice concentrations from 15 to 80%, is also changing”. What are the implications of assumptions associated with a changing MIZ extent?

p.1, lines 14-16. “Given the results of this study, we suggest that future studies need to remain cautious and provide a specific and clear definition when stating the MIZ is ‘rapidly changing’.” Perhaps provide an appropriate definition and context for the statement of a ‘rapidly changing’ MIZ. As is noted below, additional MIZ definitions and changes in additional MIZ characteristics over the past 40 years could be

evaluated and compared with MIZ extent to determine whether these properties and attributes capture a rapidly changing MIZ.

Introduction

p. 2, line 45. Perhaps include 'extent' following 'MIZ'.

p. 2, lines 45 – 46. "It also follows that we need to be aware of the extent to which our observations are able to constrain any model of the MIZ". Does this study also highlight the need for a universal and/or alternative definition for the MIZ?

p. 2, line 57. "Here we also describe how we defined the MIZ and sea ice cover in our calculations". Will the results from this analysis differ for different MIZ definitions?

p. 2, line 58. The timeframe could be indicated following "March, July, August, and September".

Methods

p. 6, lines 167 – 170. Perhaps the MIZ area could be examined in addition to MIZ extent, and results compared to characterize changes relative to total SIE and area over the past 40 years.

p. 6, lines 176 – 177. "...an error of 10%..." Does this uncertainty vary seasonally?

p. 6, lines 177 – 178. Perhaps conduct the same analysis for sea ice area, MIZ area, and relative MIZ area.

Results

p. 7, line 195, and p. 8, line 230. Absence of trend in MIZ sea ice extent and northward migration in MIZ. The absence of statistically significant trends in MIZ extent suggests poleward migration of the southern and northernmost MIZ boundaries at comparable rates. Application of the zonal-mean sea ice edge concept outlined in Eisenman (2010) to the northernmost and southernmost boundaries (in a sense converse to the SIE analysis, since with a deteriorated sea ice cover the northern boundary is less stable and muting less pronounced) would illustrate rates of change for each, as well as regional variability. Also of interest is the transition to lower sea ice concentrations in the MIZ over the past 40 years, documented by MIZ area. Please see also comments pertaining to the Discussion.

Discussion

p. 9, line 256. Perhaps include the phrase 'due to decreasing total SIE' following "slightly decreasing".

p. 9, line 262. Northward migration in the poleward MIZ boundary and area-weighted latitude of the MIZ. Also of interest is the study by Eisenman (2010) describing the role of zonal mean ice edge latitudes in describing asymmetry in winter and summer decline in SIE, in addition to the study by Stroeve et al. (2016) implementing a similar concept to define Antarctic MIZ boundaries according to zonal mean latitudes based also on the approach outlined in Strong and Rigor (2013). It would be interesting to see how evolution in the i) northern and ii) southern latitude MIZ boundaries/edges and iii) area (rather than extent, based on discussions outlined in Notz; 2014) bounded by each, compares with results from the present analysis based on MIZ extent, and whether this approach captures asymmetry in the seasonal cycle as well as rates of poleward migration in the northern and southern MIZ boundaries. Evaluation of MIZ area might also illustrate the nature of transition to a lower sea ice concentration regime in the MIZ over the past 40 years.

Conclusions

p. 10, lines 300-303. “Due to the spread of the observations in MIZ extent...” As previously noted, context for the phrase ‘rapidly changing’ should be provided (i.e. extent and/or other MIZ aspects including northern and southern MIZ boundaries and area).

Technical corrections

p. 8, line 237. Please remove ‘is’.

p. 10, line 295. Perhaps replace ‘big’ with ‘large’.

References

Eisenman, I., 2010: Geographic muting of changes in the Arctic sea ice cover, *Geophys. Res. Lett.*, 37, L16501, doi:10/1029/2010GL043741.

Notz, D., 2014: Sea-ice extent and its trend provide limited metrics of model performance, *The Cryosphere*, 8, 229–243, <https://doi.org/10.5194/tc-8-229-2014>.

Stroeve, J. C., Jenouvrier, S., Campbell, G. G., Barbraud, C., and Delord, K., 2016: Mapping and assessing variability in the Antarctic marginal ice zone, pack ice and coastal polynyas in two sea ice algorithms with implications on breeding success of snow petrels, *The Cryosphere*, 10, 1823–1843, <https://doi.org/10.5194/tc-10-1823-2016>.

Thank you for the opportunity to review this manuscript.