

Interactive comment on “Trends and spatial variation in rain-on-snow events over the Arctic Ocean during the early melt season” by Tingfeng Dou et al.

Anonymous Referee #2

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Summary

This study evaluates the performance of four reanalysis datasets (ERA-I, JRA-55, MERRA2, and ERA5) in representing the timing of ROS events and the phase change of precipitation during the spring melt season over the Arctic Ocean. Comparing with observations at 15 Arctic coastal weather stations, the authors find that the date of the first ROS events in ERA-I is closer to the observations than that in the other three products, while ERA5 better represents the phase change of precipitation associated with ROS events in spring. The study then investigates trends and spatial variations of ROS events and rain-precipitation-ratio (RPR) over the Arctic Ocean during the melt

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season. The results show trends towards earlier spring ROS events over most of the Arctic Ocean in recent decades, with the most negative trends in the marginal seas. There has been a clear transition from solid to liquid precipitation over the Arctic Ocean from March to June, consistent with more ROS events in spring.

General Comments

This is an interesting study and fits well to The Cryosphere. Overall the paper reads well, however, I have one major concern, which is the weak justification of the use of ERA-I and ERA5 for trend analyses. In addition, the structure of the paper is not always clear. Outlined in the comments below are some suggestions that will hopefully improve the final version of the paper.

Why the four reanalysis products (ERA-I, JRA-55, MERRA2, and ERA5) are chosen for the study? Especially MERRA2 instead of MERRA? Boisvert et al. (2018) suggested that precipitation in MERRA was realistic but there were large biases in MERRA2. In their abstract: “When compared with drifting ice mass balance buoys, three reanalyses (ERA-Interim, MERRA, and NCEP R2) produce realistic magnitudes and temporal agreement with observed precipitation events, while two products [MERRA, version 2 (MERRA-2), and CFSR] show large, implausible magnitudes in precipitation events.”

Observations from 15 coastal station are used to assess the performance of the reanalysis in this study. In my opinion, the observations at the coastal stations may be representative of nearby marginal seas, but unlikely to be representative of the central Arctic Ocean. Therefore the justification of using ERA-I for ROS events and ERA5 for RPR analyses is rather weak in the paper. The authors should at least provide a summary of evaluation results from previous studies, i.e. Boisvert et al. (2018). In addition, it is critical for the reanalysis products to be consistent over time (1980-2017) for trend analyses. Please verify this in the paper.

Specific comments

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Section 2.1, Please provide a bit more detail about the reanalysis products, such as the resolutions. Map in Fig. 2(b) is somewhat blurry, is that due to the coarser resolution of JRA-55 relative to the other three products?

L83-84, are the results sensitive to the 0.5 mm threshold used to determine the occurrence of rainfall? I suggest the authors do some tests on this if haven't already. Ideally, the results shouldn't be too sensitive to the threshold.

L97-98, "The sea ice extent is calculated from SIC using a threshold of 15%", please provide a reference.

Section 2.3, Please explain why observations at other weather stations are not included, such as those along the coast of European Arctic.

Fig.2, it would be helpful to provide some comments about the positive/late trends occurring in (a)-(c), but not in (d).

Section 3.2, I'd suggest to move the first paragraph to the Introduction. I think this would make the paper tighter and make it easier for readers to have a better understanding of the linkages between different components of the paper.

Fig.3, I wonder if the significant correlations between EMO and ROS are due to the fact that they are both correlated with surface air temperature (SAT)? SAT was used to indicate melt onset on sea ice in previous studies. Dou et al. (2019) suggested that the year-to-year variability of the timing of first spring ROS was closely tied to the timing of persistent warming events.

L195, FRD is not defined.

Section 3.3, I'd suggest move the first paragraph to the Introduction, see above.

L317, ESAO is not defined.

L321-330, "ERA5 more reasonably reproduces the observed RPR and its trends than ERA-I compared with station observations. Several new techniques have been incor-

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porated into ERA5...”, this seems to be in contrast with the large negative bias for first EOS events in ERA5 relative to ERA-I and observations shown earlier (L150), can you explain why?

Fig.5, I'd prefer to have maps in May on the upper panel and June on the bottom panel. Please include the name of the reanalysis product used for the results in Fig.3 and 7 in the captions.

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