Response to Reviewer 1's Comments

We appreciate the reviewer's positive assessment of this study. Below are our responses to the comments.

The authors addressed the comments from the reviewers in the last round of revisions adequately. I only have a few comments included below.

General Comments: Section 4 Conclusions and Future Work: The authors discuss which terms in the surface energy budget change the most under the influence of atmospheric rivers along the ice edge and over the summer sea ice. While these statements fit the results shown in the manuscript, I suggest that the authors are clear that these are likely most important in summer. Both case studies shown in the manuscript are from summer, when shortwave fluxes are higher and conditions near the ice edge are different than in winter.

The case studies shown in the first half of this manuscript are in summer. We also examine the winter season and find that the relationship between ARs and sea ice change is similar and even stronger in winter (not shown in this manuscript but presented in 2021 AGU fall meeting). In the second half of this manuscript, we investigate the full daily time series for 1981-2020 everywhere in the Arctic Ocean focusing on weather timescales and find that similar relationship holds for the whole Arctic Ocean through the entire seasonal cycle (Figure 10).

Specific Comments: Figure 4a. It is difficult to see the box where the values in Figure 6 are taken from. Is the box along the sea ice edge?

Yes, the box is near the summer sea ice edge. It was partially covered by sea ice before the cyclone and became ice free after the cyclone.

Response to Reviewer 2's Comments

We thank the reviewer for detailed comments and insightful suggestions. This study has been greatly strengthened and improved by this review. We revise the manuscript carefully to address these comments. Below are our responses to each comment.

Comments to "Impact of Atmospheric Rivers on Arctic Sea Ice Variations" by Li et al

General comments:

This study shows that atmospheric rivers impact the variability of partial sea ice concentration, both in specific case studies and generalized for the Arctic domain. The manuscript is structured *well, and explain the physical links and processes that lead from northward moisture transport to reductions in sea ice concentration. To do so, the authors use ERA5 reanalysis data.*

Although I appreciate the author' improvements based on the previous round of revisions, I still find that the manuscript lacks scientific depth, in particular with respect to how rigorously the authors present their results and the low degree of discussing their findings in the context of previous literature. Not all of there findings are new and they certainly need to be contextualized to what is known about moisture transport to the Arctic and related extreme events. This should appear in the introduction and discussion sections in much more depth. Further, because the authors look at short time scales (days) and primarily on small regions only, the impact of internal climate variability (which atmospheric rivers are part of) is large and hence should be discussed is a broader sense as well. I strongly encourage the authors to properly account for these aspects before I can recommend publication. Relevant literature to start with is e.g.: 1) https://doi.org/10.5194/wcd-3-1-2022, 2) https://doi.org/10.1038/s41561-017-0041-0, 3) https://doi.org/10.1038/s41561-019-0363-1
To make that clear, I do not expect just occasional changes, but a substantial rewrite/expansion of at least introduction and discussion.

We appreciate reviewer's comments on fitting this study in the context of previous studies on moisture transport into the Arctic. We add more references including 3 references suggested by the reviewer. We improve introduction and discussion by summarizing previous relevant studies and emphasizing the novelties of this study.

This study focuses on ARs, which are extreme and episodic moisture transport events on weather timescales. In the general study for the whole Arctic during 1981-2020, we examine the full daily time series for 40 years for each grid box in the Arctic Ocean. Our method of extracting the weather signal from full time series involves removing climatology, interannual variability and trends. Moisture transport on larger timescales, such as interannual variability related to internal climate variability, and trends related to climate change, have very different physical mechanisms and is out of scope of this study.

Specific comments:

1) 119: references for "most former studies" are missing

References are added.

2) It becomes not clear to the reader how Supplementary Fig. 1 differs from Fig. 1 and Fig. 2 are for ERA5 and S1 is for satellite observations. Is the point the authors want to make that both look similar?

Fig 1 uses original fields from ERA5 on Aug 5, 2012 when ARs happened; Fig2 calculates anomalies (original fields minus climatologies) based on ERA5 on Aug 5, 2012; S1 calculates integration of original fields from ERA5 for Aug 5-12, 2012 through the life cycle of the cyclone.

Fig 1 and Fig 2 are similar in showing ARs impacts on surface energy balance, but Fig 2 strengthens the conclusion by removing the climatology. S1 examines the total effect of the cyclone on sea ice. Note that the AR lasts for less than one day, while the cyclone lasts for one week.

3) l. 171: It is not clear what AR2 means, this needs to be mentioned here.

This is AR scale determined based on AR duration and maximum IVT during AR (Ralph et al., 2019). AR2 means AR Cat 2 (Moderate): Mostly beneficial, but also somewhat hazardous.

4) The x-axis labeling in Fig. 3 and Fig. 6 should have the same style.

The first cyclone happened during August 5-12, 2012 in one month in Fig. 3. The second cyclone happened during July 25 - Aug 2, 2020 in two months in Fig. 6.

5) The panel titles should be shortened, esp. in Figs. 7, 8, 10, 11.