

Review of submission entitled “Moisture origin, transport pathways, and driving processes of intense wintertime moisture transport into the Arctic” by Papritz et al.

Overall recommendation: Major revision

This manuscript aims to identify wintertime moisture sources, airstream pathways, and primary large-scale flow features (i.e., cyclones, atmospheric blocking, and cold-air outbreaks) linked to moisture transport into the Arctic at 70°N. To identify these aspects, the authors use trajectory calculations with moisture-uptake tracking and flow-feature detection applied to the ERA5 dataset (1979-present) to compile a set of events which exceed the 90th percentile. Overall, the manuscript is interesting and has the potential to add valuable knowledge on moisture sources, transport pathways (including thermodynamic changes along the path), and large-scale flow configurations driving anomalous moisture transport into the Arctic. However, there are some details that are not described clearly enough for me to fully understand all of the methods amongst other major and minor points outlined below. Therefore, I can not recommend this study be published in *Weather and Climate Dynamics* at this time, but I do think the authors could improve after major revisions.

Major Comments:

1. The abstract is too long. New results on airstreams and their linkage to large-scale flow configurations are not emphasized and are not distinguished well from previous results, such as the North Atlantic is the dominant transport gateway into the Arctic (e.g., Dufour et al. 2016 and others).
2. The description of how poleward moisture transport events are identified and computed is not very clear. For example, in Section 2.2 Line 130: “We then select timesteps for the further analysis based on the exceedance of the so-obtained $\overline{H_L}$ anomalies of the 90th percentile, resulting in 597 intense poleward moisture transport events.” How specifically are anomalies computed? Are these daily anomalies defined as $\overline{H_L}$ minus the long-term daily mean? Is an event detected when the daily anomaly value of $\overline{H_L}$ exceeds the 90th percentile?
3. It is not very clear how trajectory starting points are chosen as described in Section 2.3, beginning on Line 138: “Among all grid points, we then select the smallest subset of grid points as trajectory starting points, which accounts for 50 % of the total poleward moisture transport. With this approach, we select the grid points that contribute most to the poleward moisture transport.” Is the subset of starting grid points selected by rank in terms of \overline{qv} and their contribution to the daily moisture flux at 70°N? Would it be possible to create a schematic/visual for one timestep showing the positions of the starting trajectory grid points for an event?
4. Line 150. Regarding the detection threshold for specific humidity of 0.025 g/kg/3h, have the authors explored the sensitivity of this choice, and if so, does it significantly change the spatial pattern of moisture uptake as shown in Fig. 3? The threshold used in the Sodemann et al. (2008) study was 0.2 g/kg/6h. Is the smaller value choice in this study due to temporal and spatial resolution differences in the data (relative to Sodemann et al. 2008) or because vapor above the

boundary layer is incorporated or other? Does Fig. 3 significantly change if a threshold of 0.1 or 0.2 g/kg/3h is used?

5. Line 153. Are instances of moistening above the planetary boundary layer included in the spatial pattern shown in Fig. 3 and 4? If so, it might also be interesting to see the spatial patterns of surface versus elevated uptake on separate maps, as differences/positioning might be informative in relation to moisture sources?

6. Regarding the clustering of North Atlantic events and their relationship to cyclones, blocks, and cold-air outbreaks, the authors have shown interesting and convincing results in Section 4 for the combined months of NDJFM. Have the results been evaluated in the same framework except for individual month? Can the authors comment on the month-to-month variability?

Minor comments:

1. Line 1 in abstract and again on Line 41. “Poleward moisture transport occurs in episodic, high-amplitude events with strong impacts on the Arctic”. I realize the authors are interested in high-amplitude events, but moisture transport into the Arctic does occur in association with weaker cyclones or flow configurations even though the impact on the Arctic is less. This sentence should be rephrased perhaps with the caveat of “Intense poleward moisture transport occurs in episodic, high-amplitude...”. In addition, since the primary focus in this study is on transport events which exceed the 90th percentile, the authors may want to consider using the nomenclature “moist-air intrusions” introduced by Doyle et al. (2011) and Woods et al. (2013) to describe intense poleward moisture transport into the Arctic.

2. Line 8 in abstract. “This asymmetry between the ocean basins...” The asymmetry in the moisture uptake? Atlantic versus Pacific basins? Please clarify phrasing.

3. Line 84 and throughout the manuscript. “Intense zonal mean transport event”. Should this be revised to “intense poleward moisture transport event”? Please use caution with the phrasing zonal mean transport. The zonal mean has been computed on the meridional flux? Line 81 shows other uses of this phrasing.

4. Line 122. \bar{M} “... is the mass flux into the polar cap”. Should this be “Is the average mass flux into the polar cap”?

5. Line 131. “so-obtained”. Consider rephrasing.

6. Line 223. “are spatial highly unevenly distributed”. Consider rephrasing.

7. Line 318. “which du to” revise to “which due to

8. SST contour labels are needed in Fig. 1, 3, and 4.