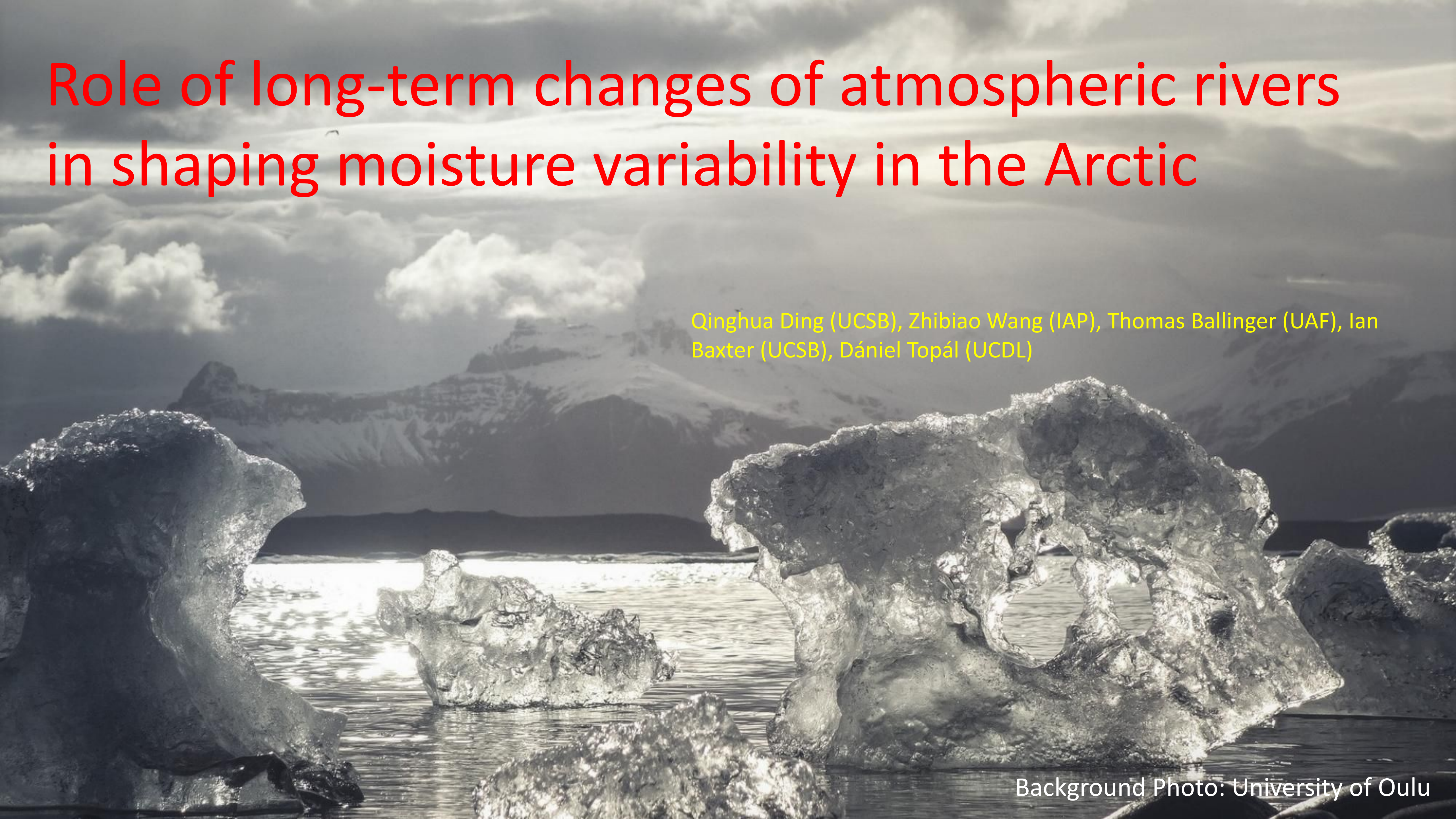
Role of long-term changes of atmospheric rivers in shaping moisture variability in the Arctic

Qinghua Ding (UCSB), Zhibiao Wang (IAP), Thomas Ballinger (UAF), Ian Baxter (UCSB), Dániel Topál (UCDL)

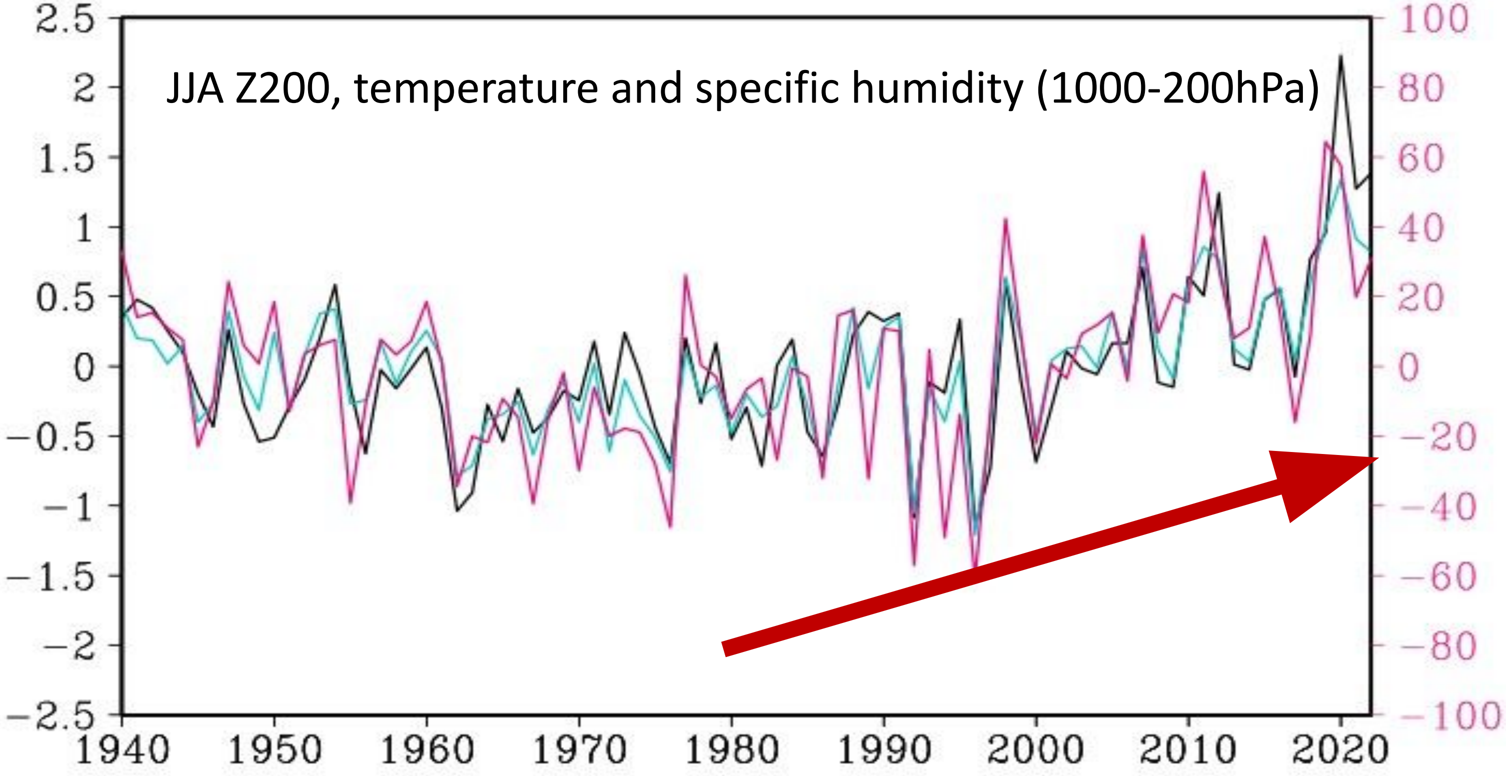


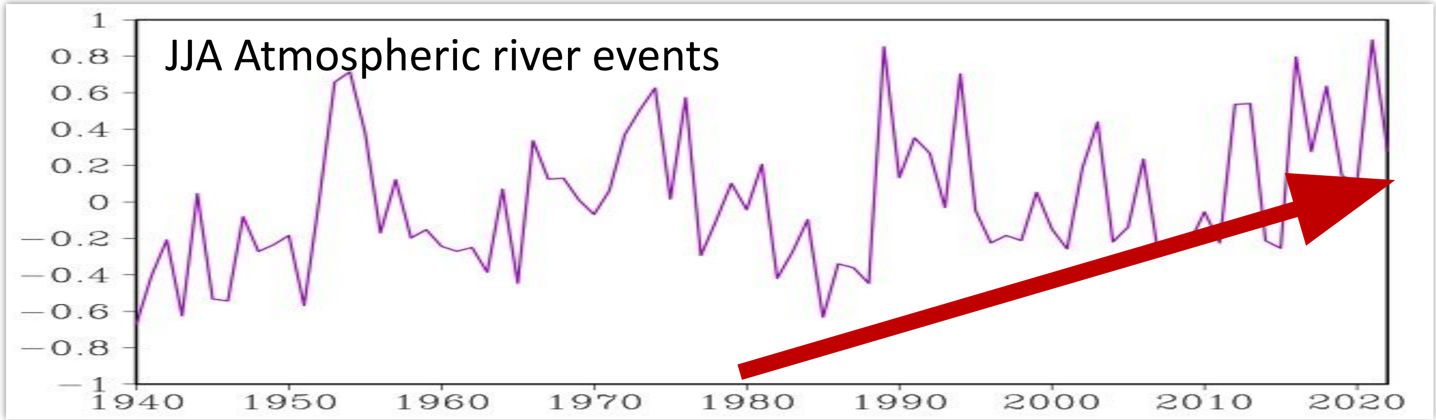
Background Photo: University of Oulu

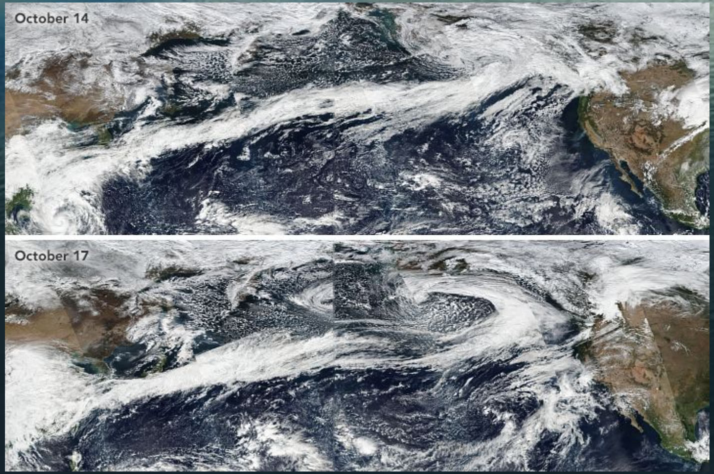
The Arctic is becoming wetter and stormier

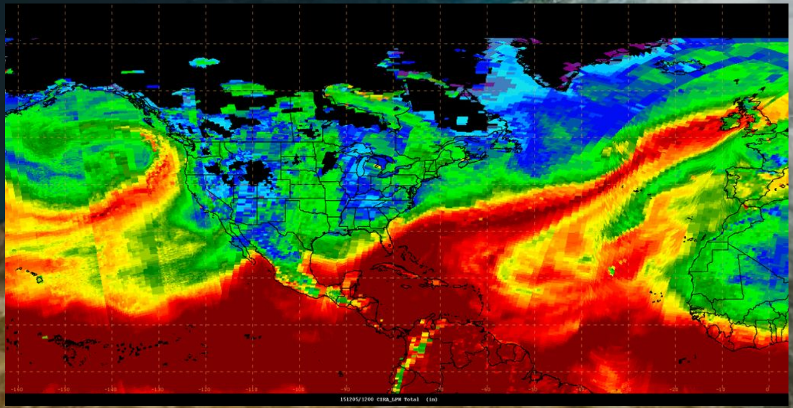
Kerem Yucel/Agence France-Presse

Large scale atmospheric variables in the Arctic (70-90N) from 1940 to 2022 in ERA5



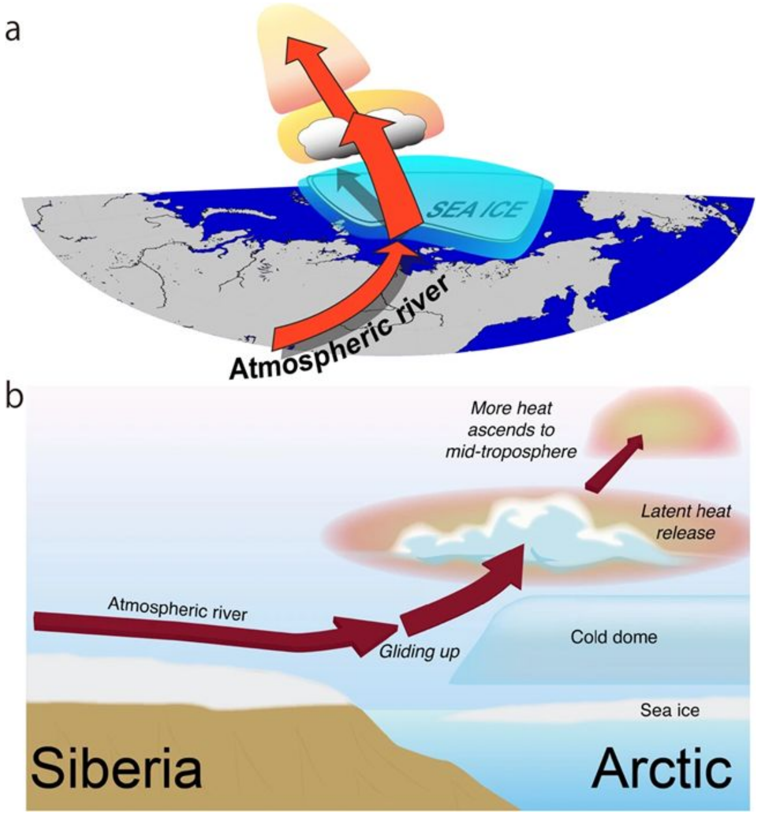






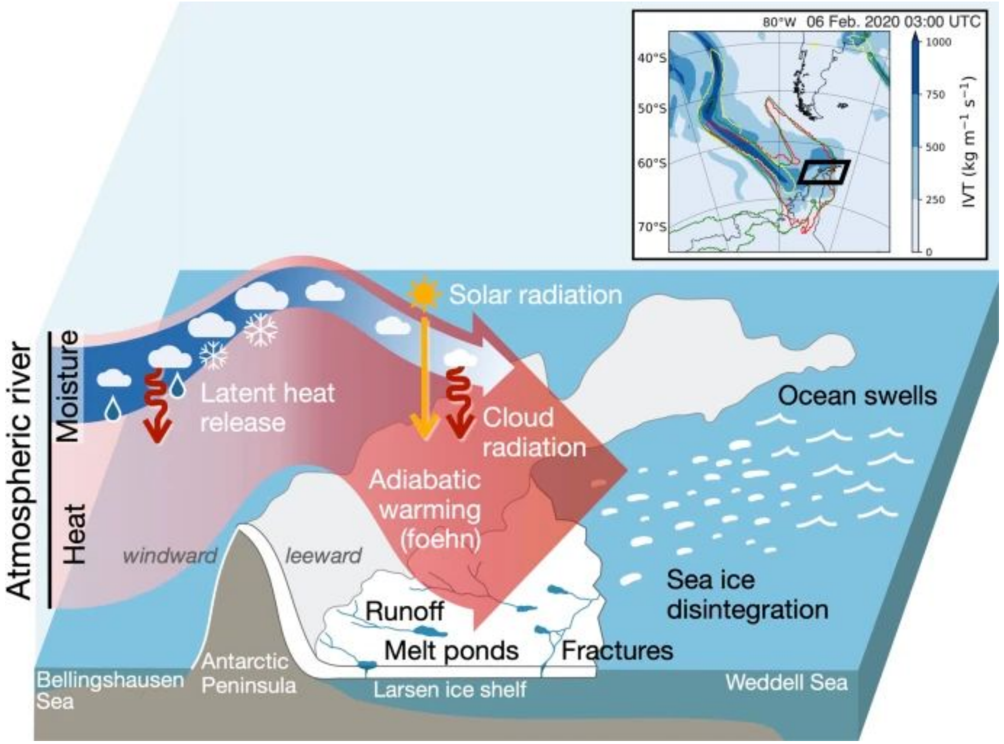
scientificamerican.com

Climate-weather interactions in the polar regions



Schematics of tropospheric Arctic heating through the upward glide of Siberian atmospheric river.

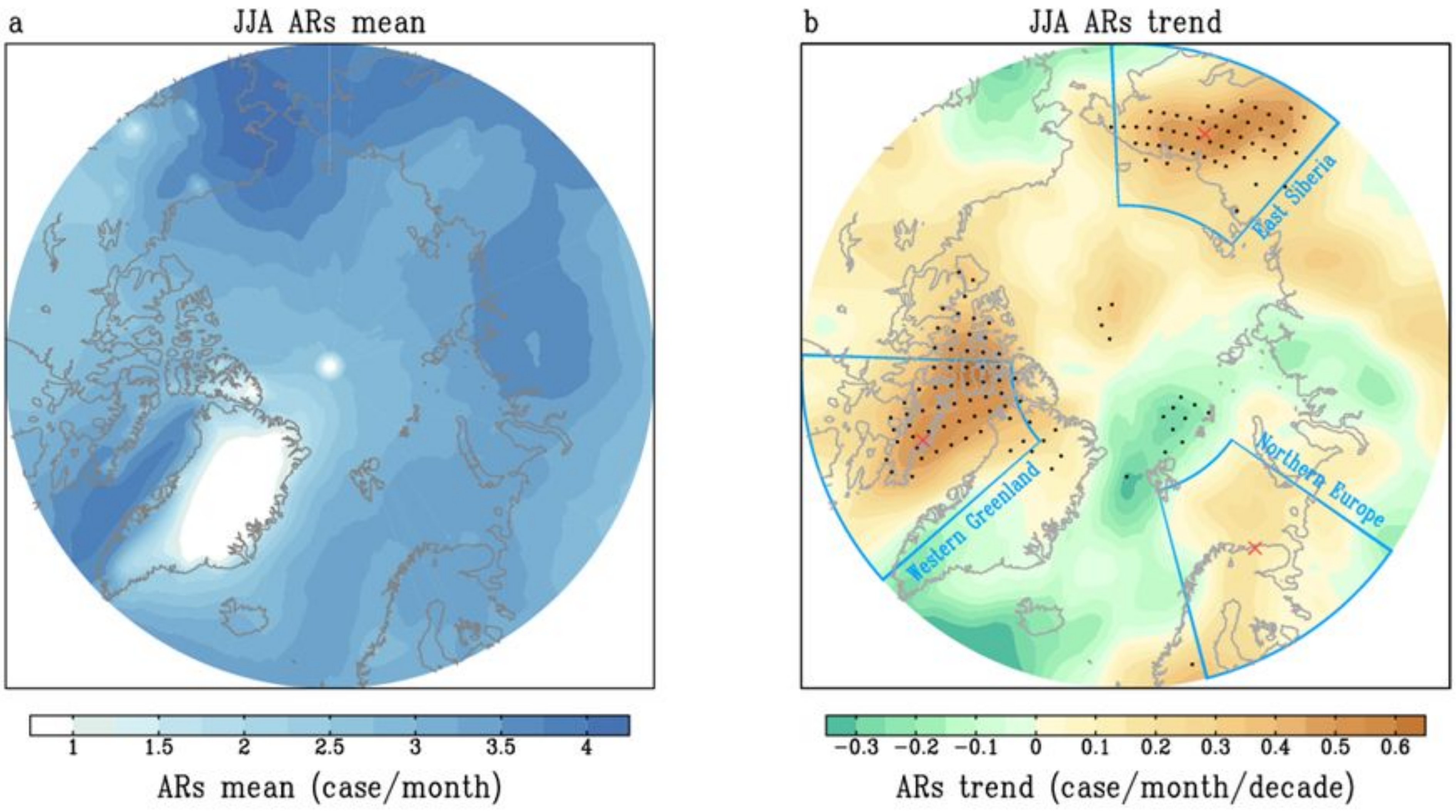
Komatsu et al. 2018



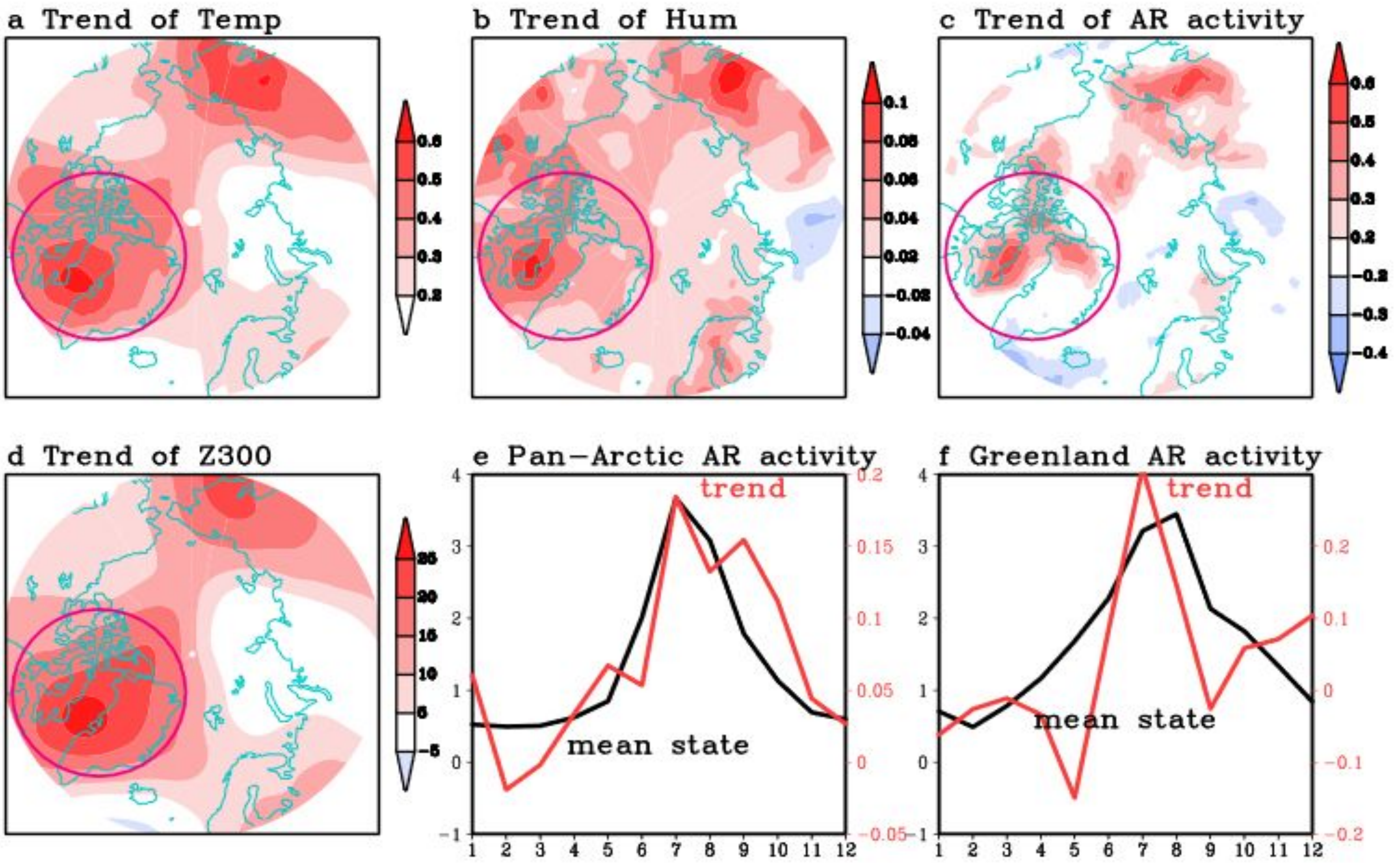
Intense atmospheric rivers can weaken ice shelf stability at the Antarctic Peninsula

Wille et al. 2022

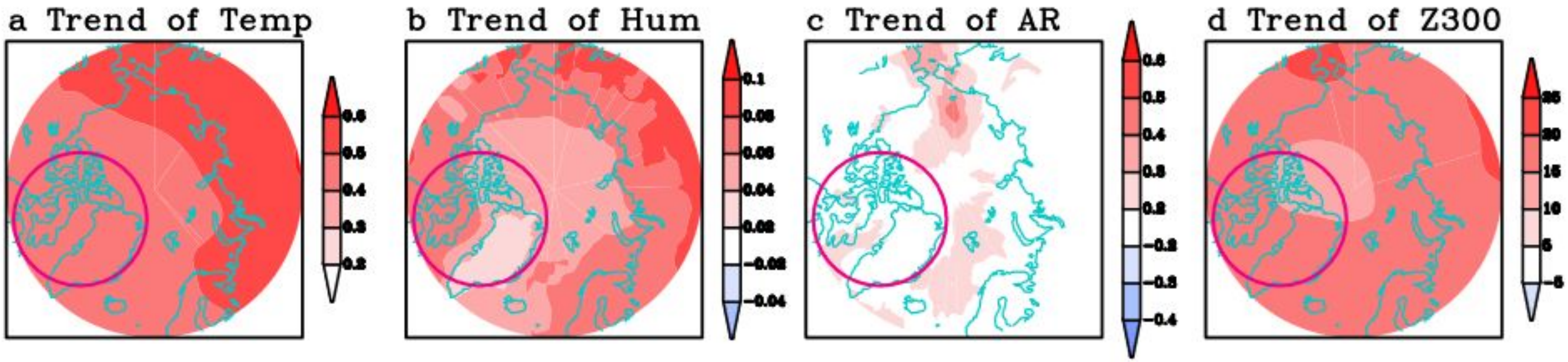
Long-term changes of JJA atmospheric rivers from 1979 to 2022 in ERA5



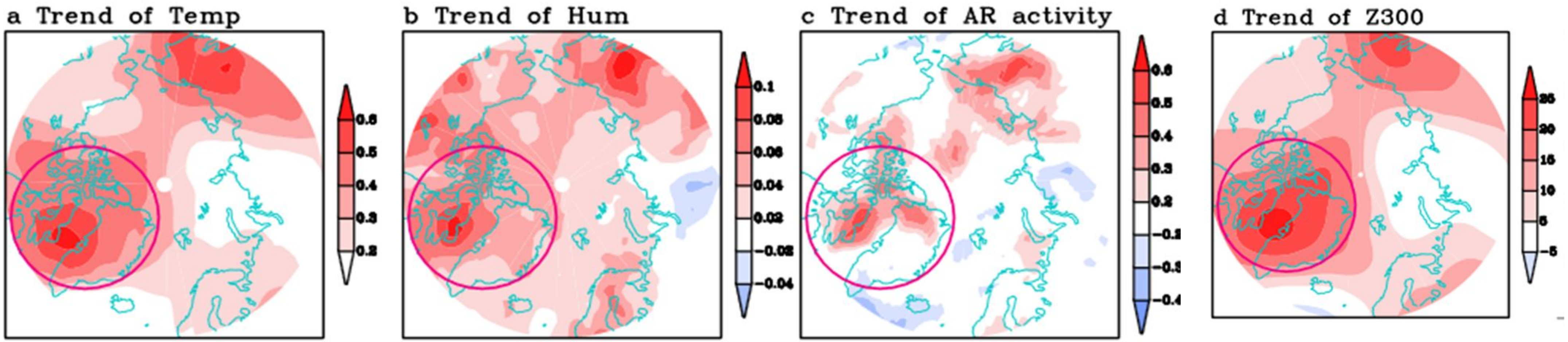
Role of long-term changes of atmospheric rivers in shaping moisture variability in the Arctic (1979 to 2020)



CMIP6 Historical runs(10members, 1979-2020)

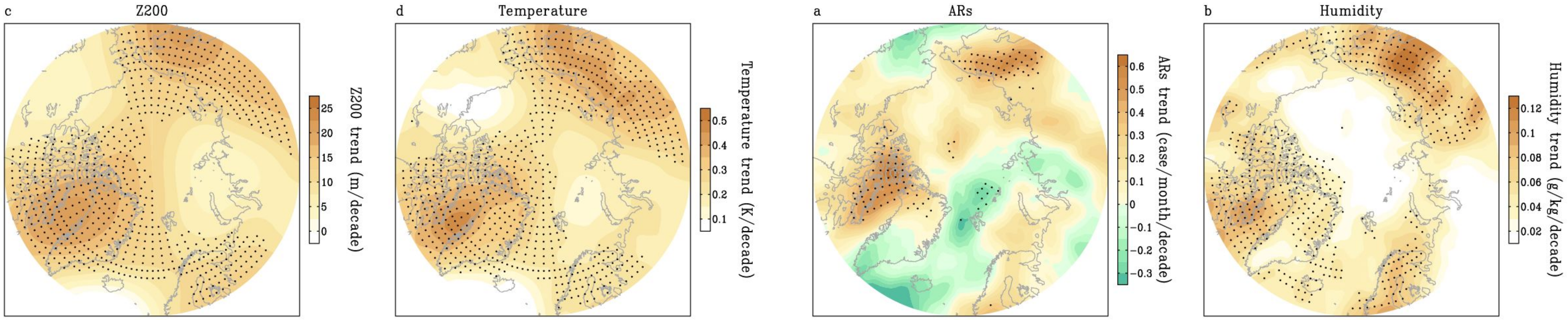


ERA5 (1979-2020)

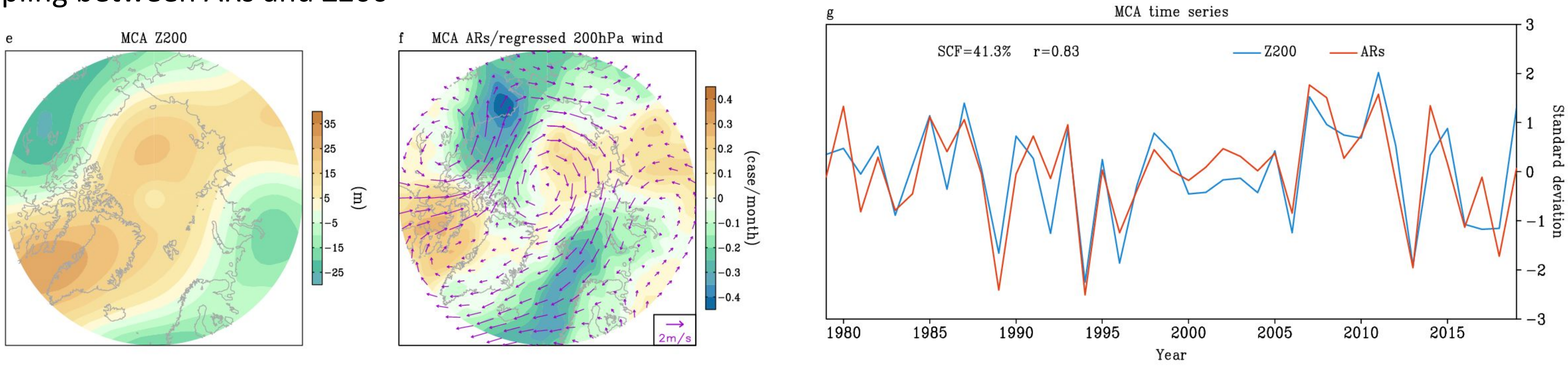


All these fields are closely statistically connected in ERA5

JJA trends from 1979 to 2020

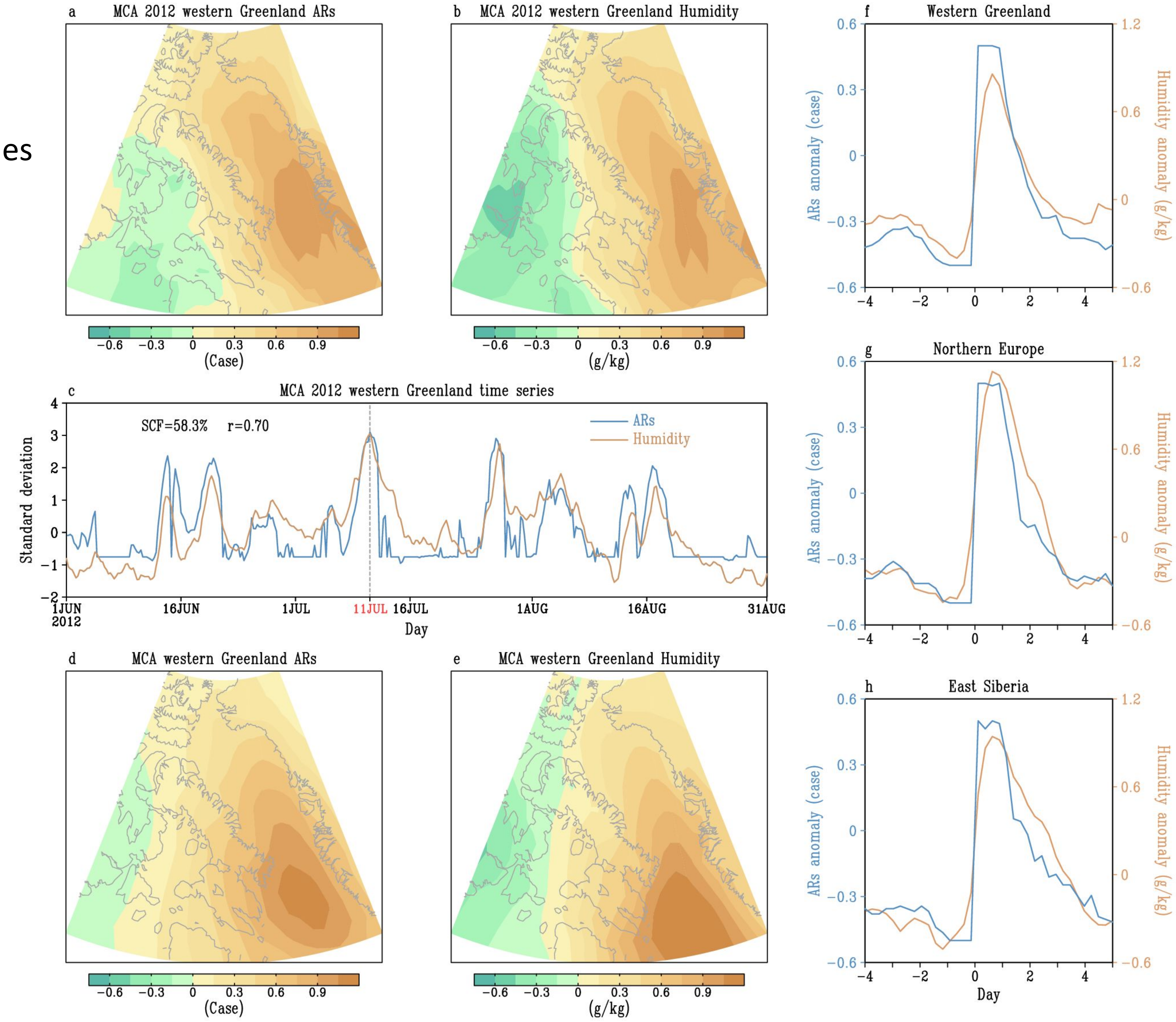


Coupling between ARs and Z200



Statistical connections on shorter time scales

ARs strongly control humidity changes on both high and low frequency time scales



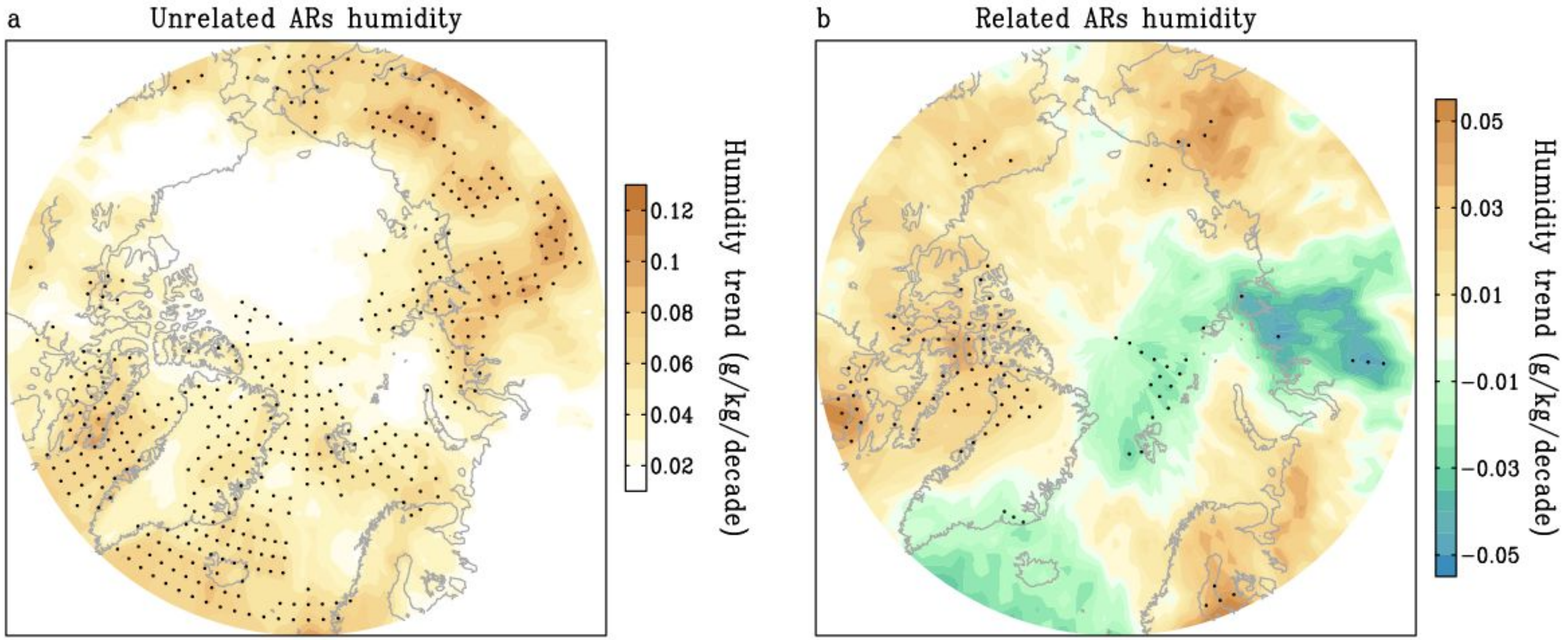
Estimate the contribution of ARs to the long term humidity trend in the Arctic:

The Arctic: 12.7%

Western Greenland: 30.6%

Northern Europe: 34.4%

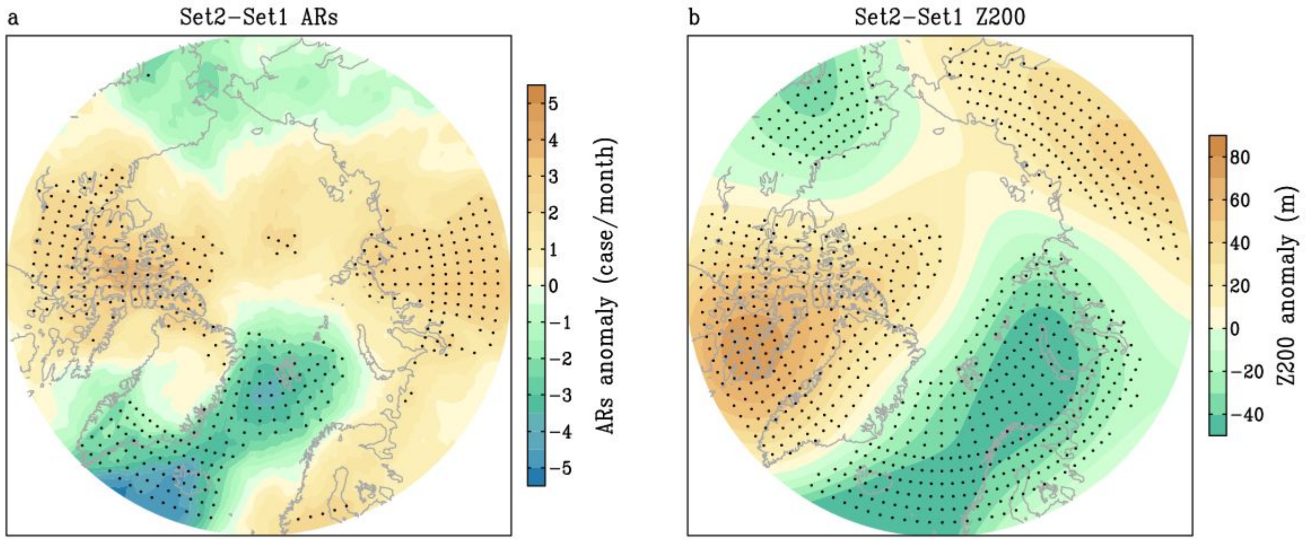
East Siberia: 30.4%



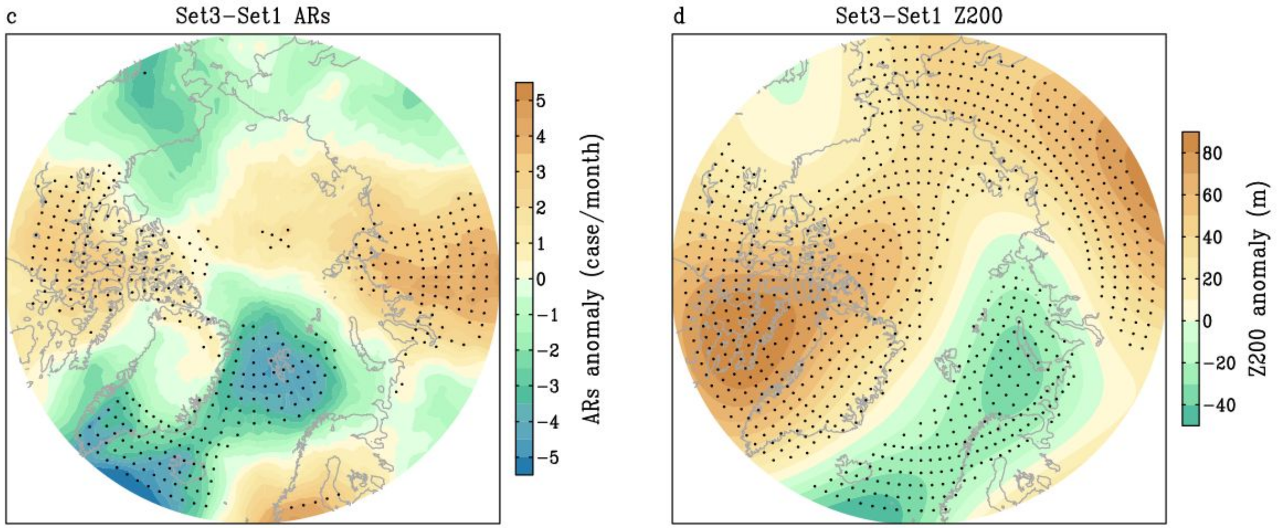
CESM1 nudging experiments: understand how an imposed JJA Arctic circulation trend impacts ARs

1. Control; 2 wind trend (constant) imposed; 3 Wind trends (constant)+anthropogenic forcing

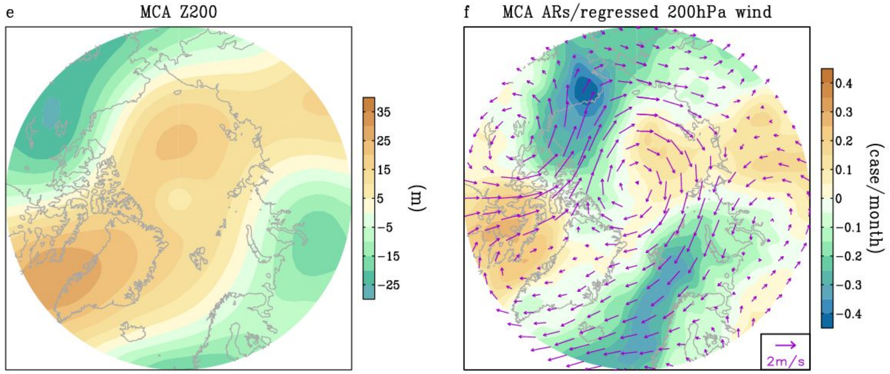
Wind trend minus ctl



Wind trend+anthropogenic minus ctl

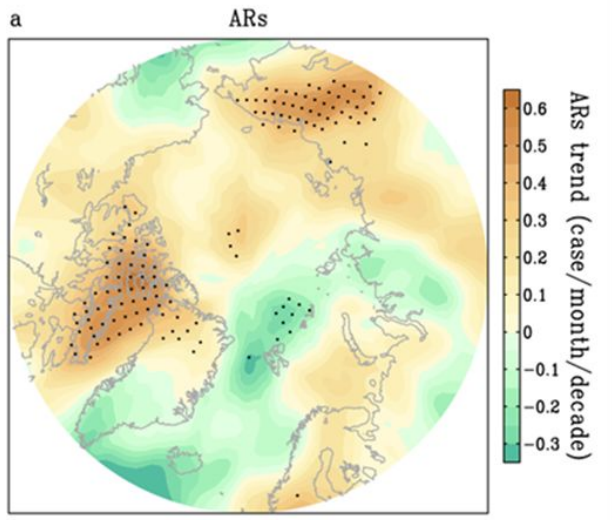


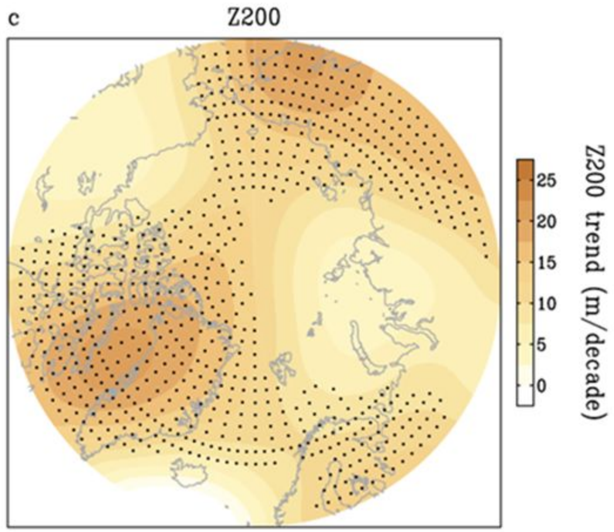
Observed coupling



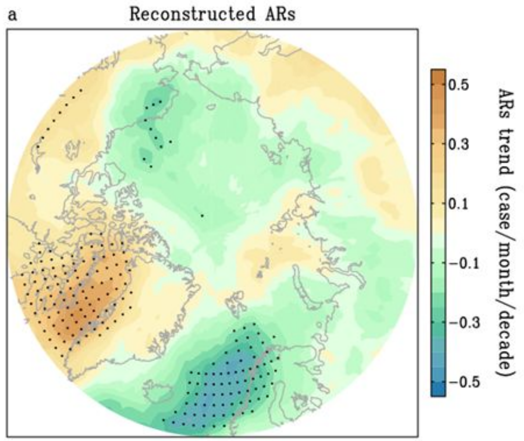
Fingerprint analysis (CESM2-LEN): understand how JJA Arctic circulation trend impacts ARs

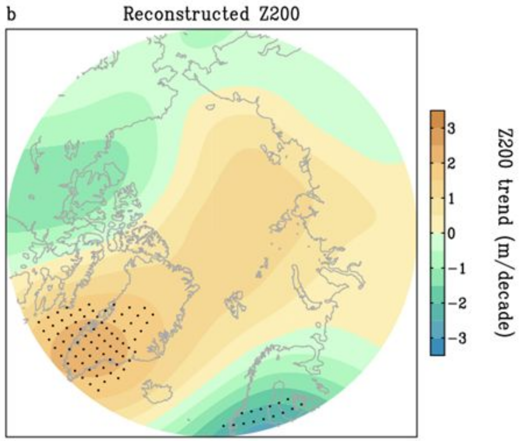
JJA trend in ERA5 (1979 to 2020)





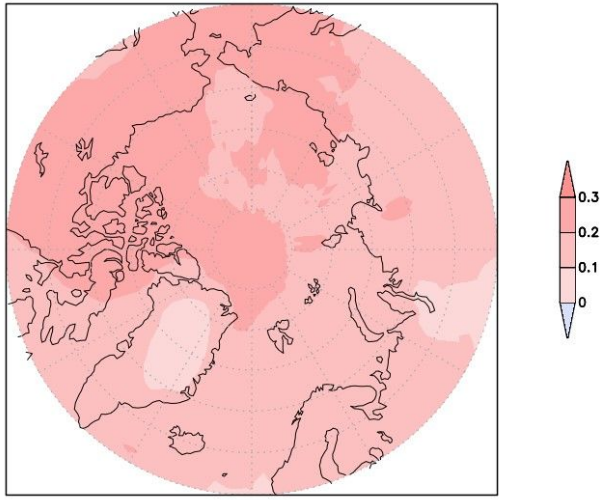
JJA trends in a subgroup of CESM-LEN2 (1979 to 2020)



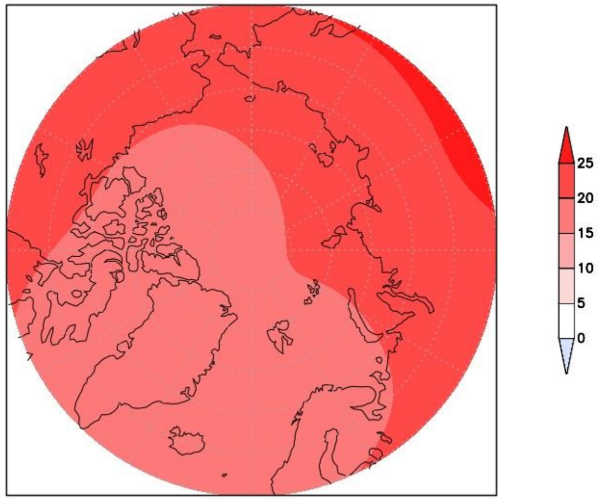


40 member ensemble mean

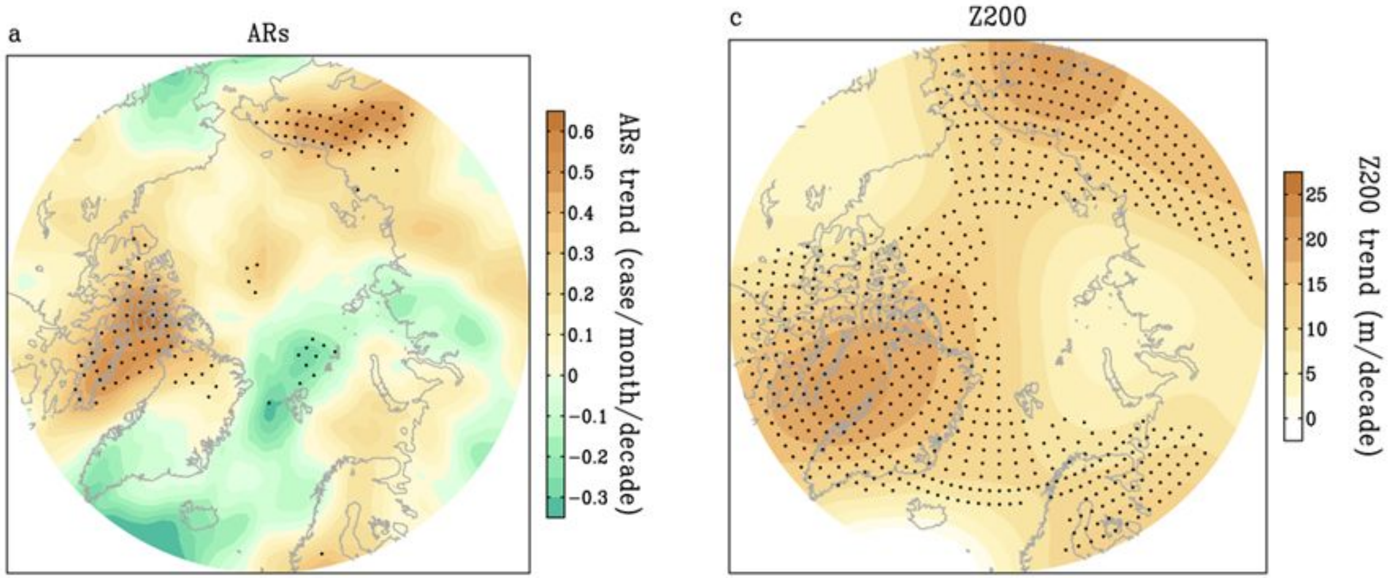
ARs



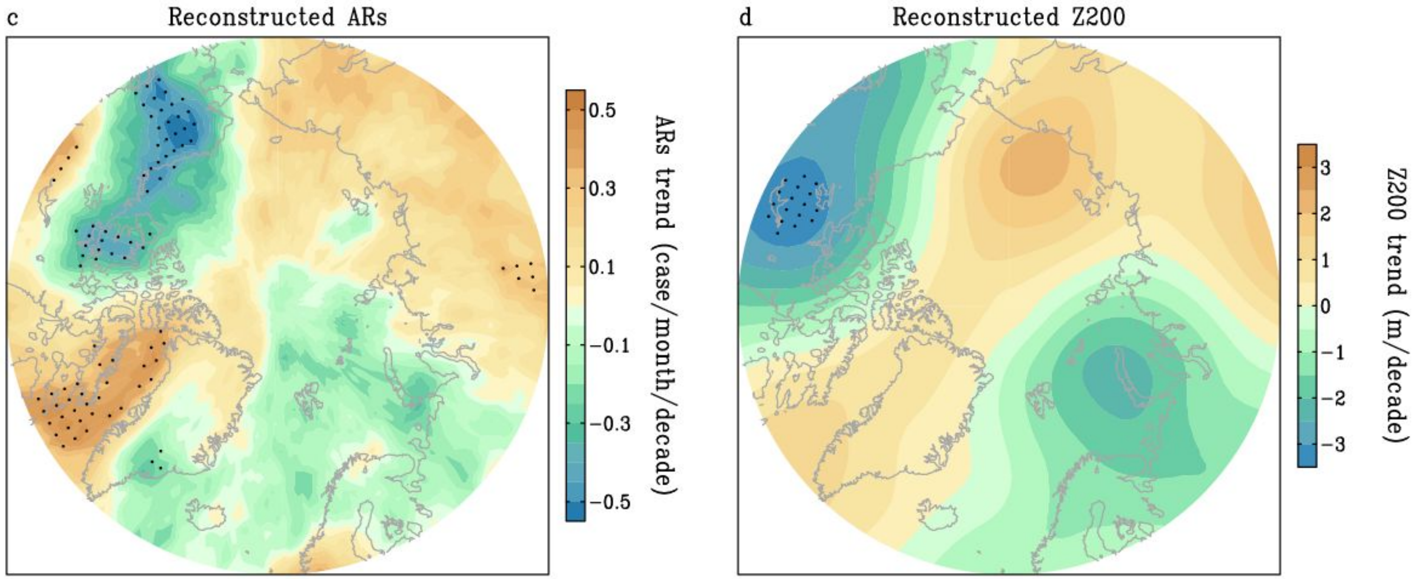
Z200



JJA trend in ERA5 (1979 to 2020)

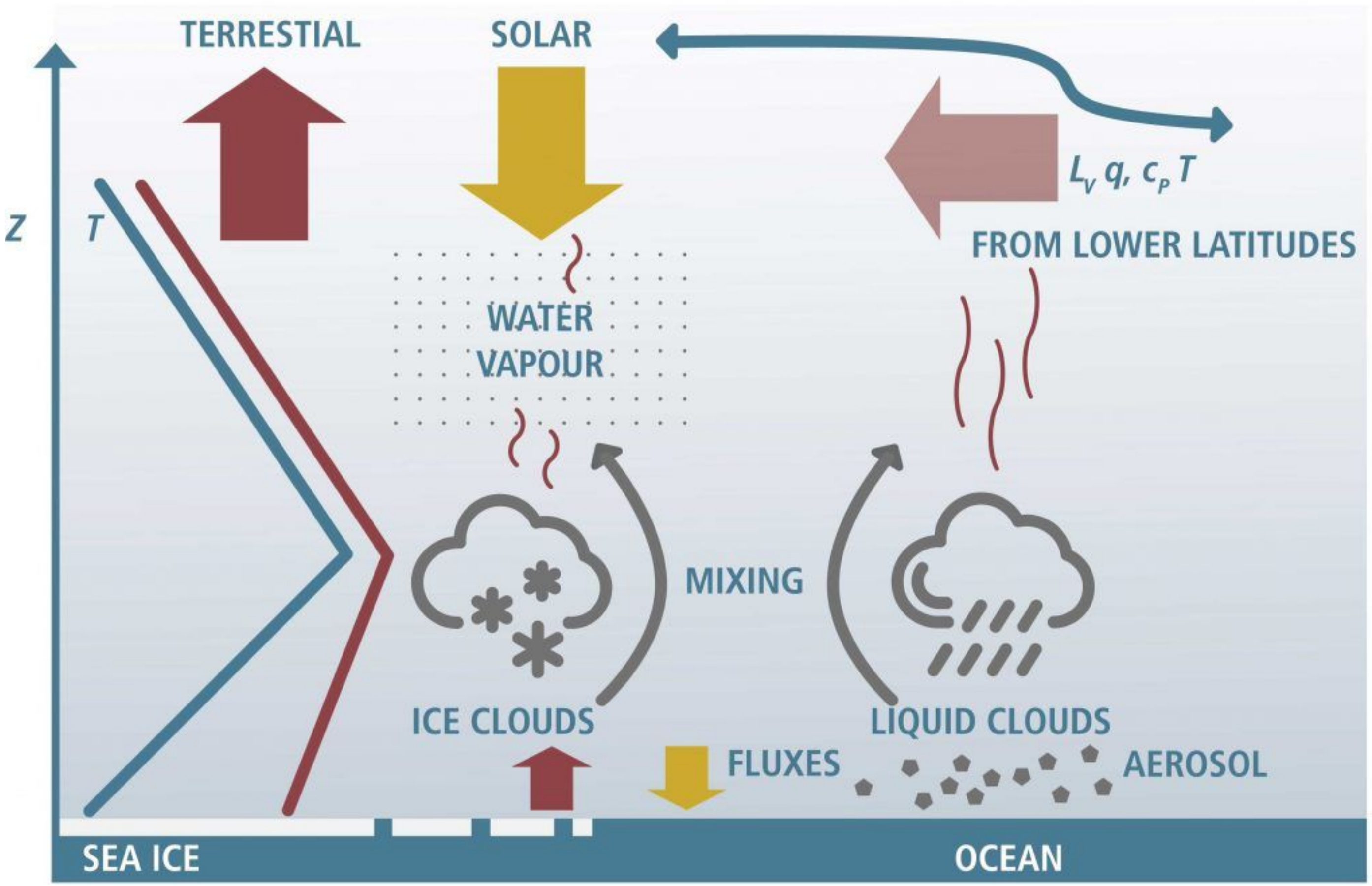


JJA trend in a subgroup of CESM-LEN2 (1979 to 2020)



Take-home messages

1. Low frequency large scale circulation changes in the Arctic play a decisive role to regulate the activity of ARs and thus induce its recent upward trend in the region.
2. This trend of summertime ARs activities may contribute to a 12.7% increase of atmospheric JJA moisture over the entire Arctic since 1979 and above 30% of wetting trends over some key areas, such as western Greenland, northern Europe, and east Siberia.
3. ARs activities, powered by extreme weather systems that are intuitively thought to be unpredictable and chaotic, may serve as a vital mechanism to regulate long term moisture variability in the Arctic.



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