Atmospheric rivers contribute to Greenland Ice Sheet mass loss

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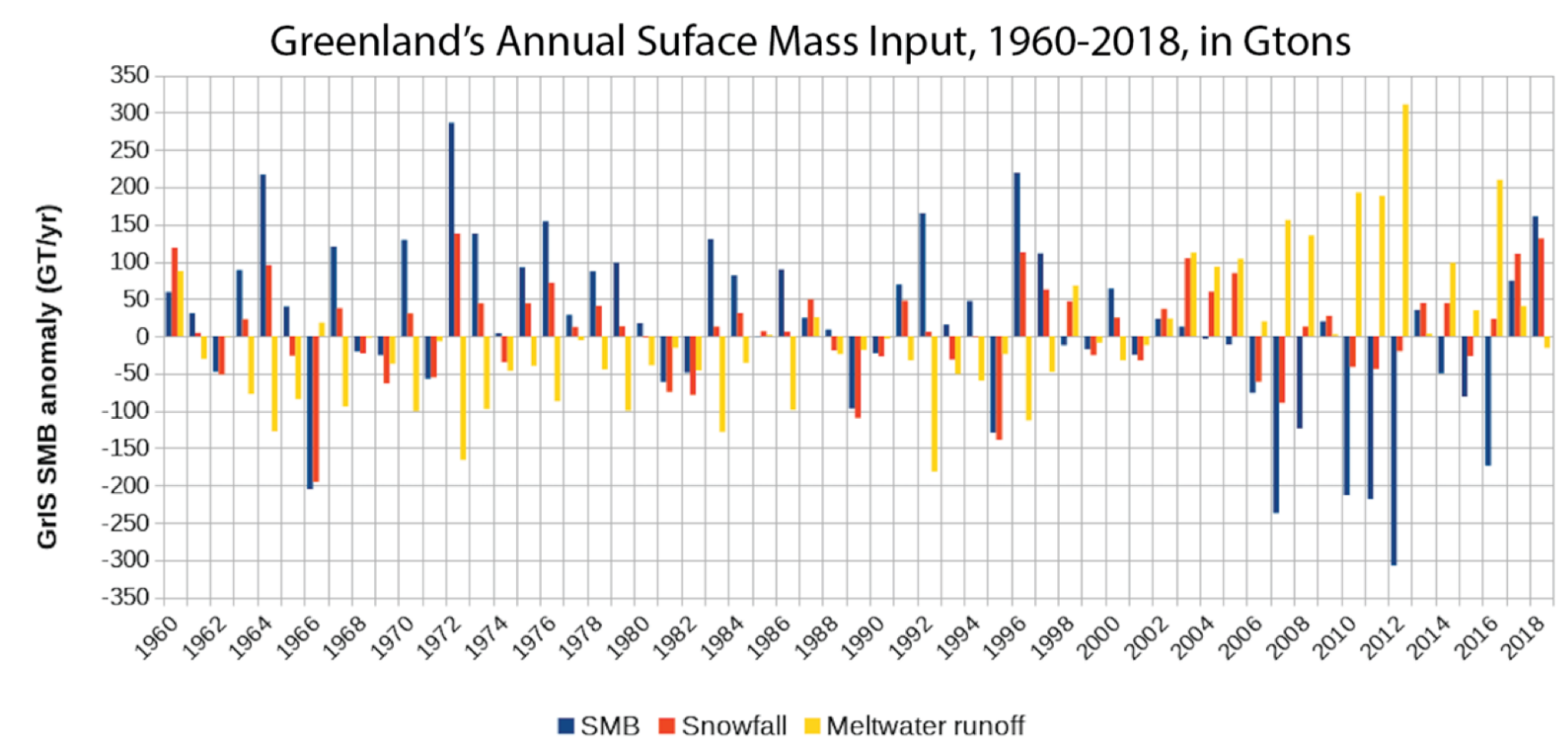
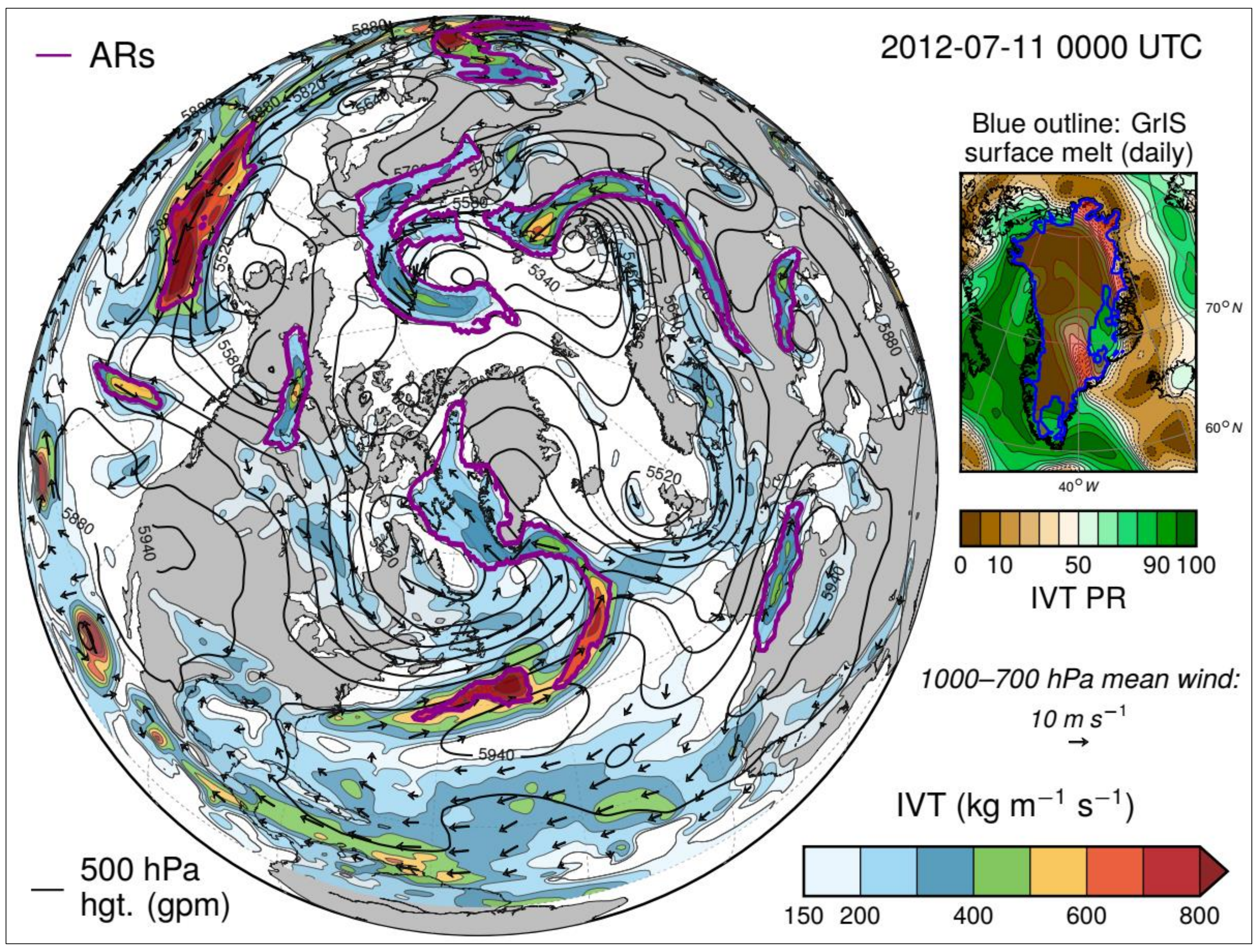
1. Greenland Ice Sheet (GrIS) **mass loss is accelerating**

- + GrIS is the single **largest land ice contributor to global mean sea level rise** during the 21st century

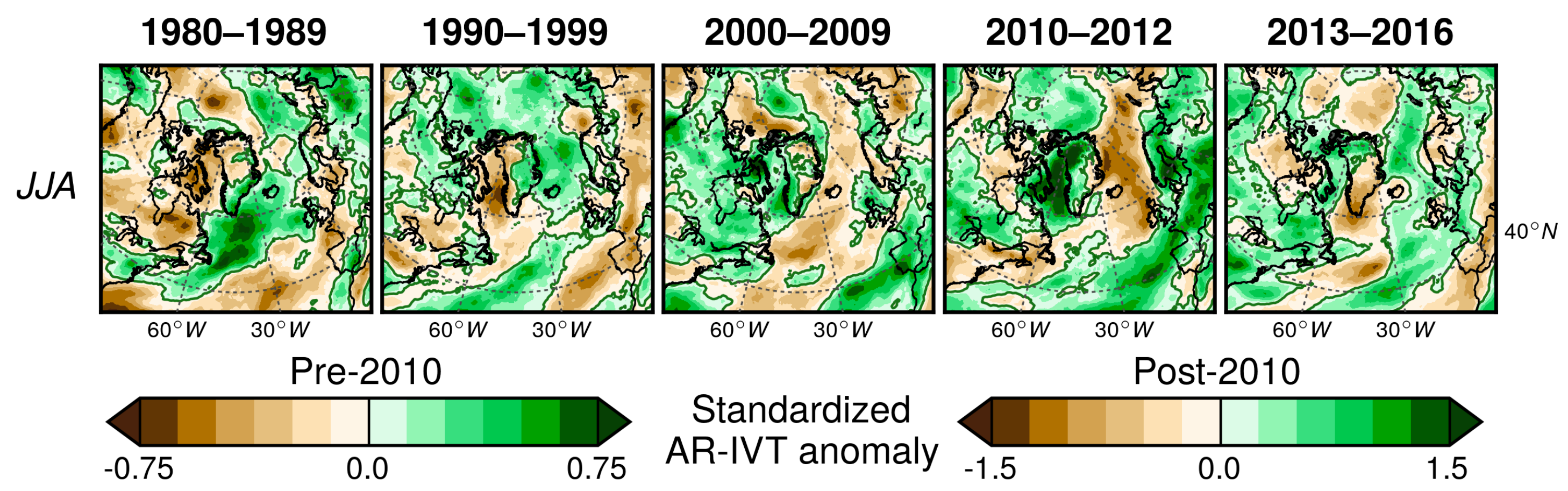


- + Has moisture transport by **atmospheric rivers (ARs)** contributed?



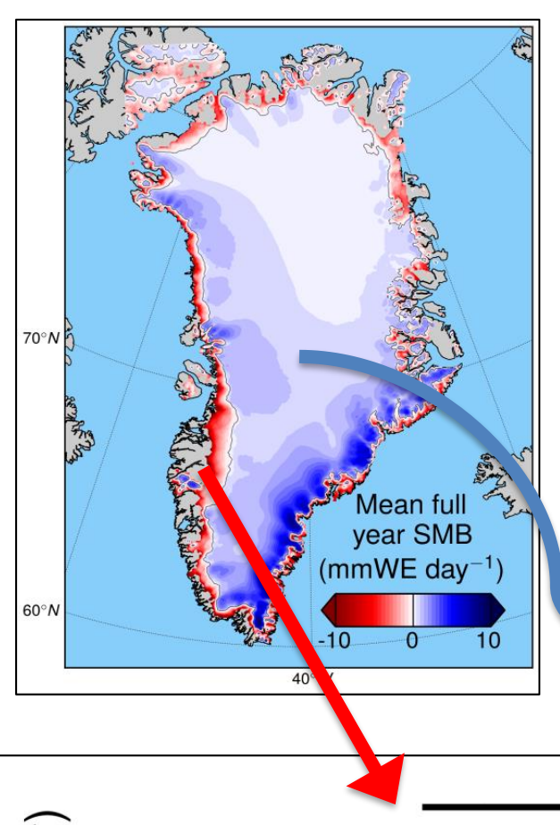
IVT = vertically integrated water vapor transport; IVT PR = IVT climo percentile rank

2. **Moisture transport** by ARs **increased** alongside mass loss

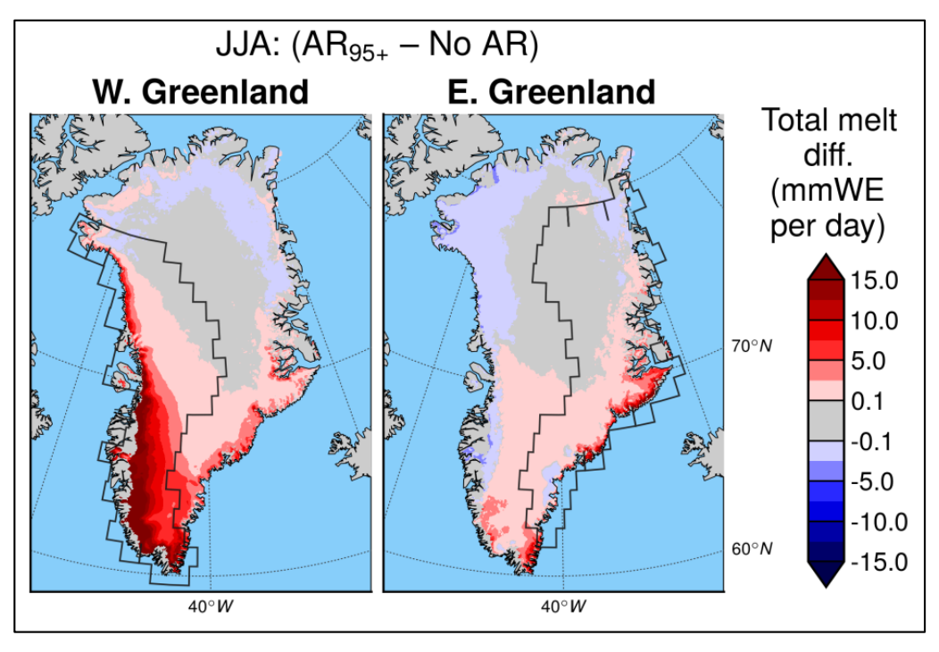


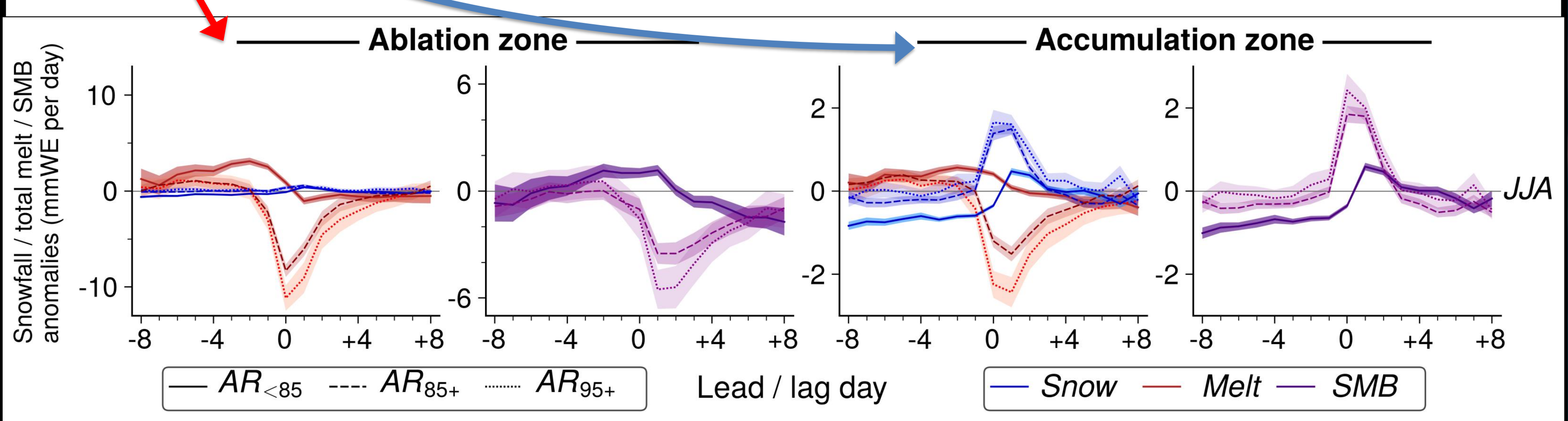
AR-IVT = Integrated water vapor transport within AR outlines

3. Strong summer ARs cause **intense melt events**



- + Plots below show melt, snow, and SMB averaged over the **West Greenland** ablation and accumulation zones during ARs
- + $AR_{<85}$, AR_{85+}, and AR_{95+} refer to IVT PR (AR_{95+} are strongest)





4. ARs enhance melt through both **"cloudy"** and **"clear" atmospheric regimes**

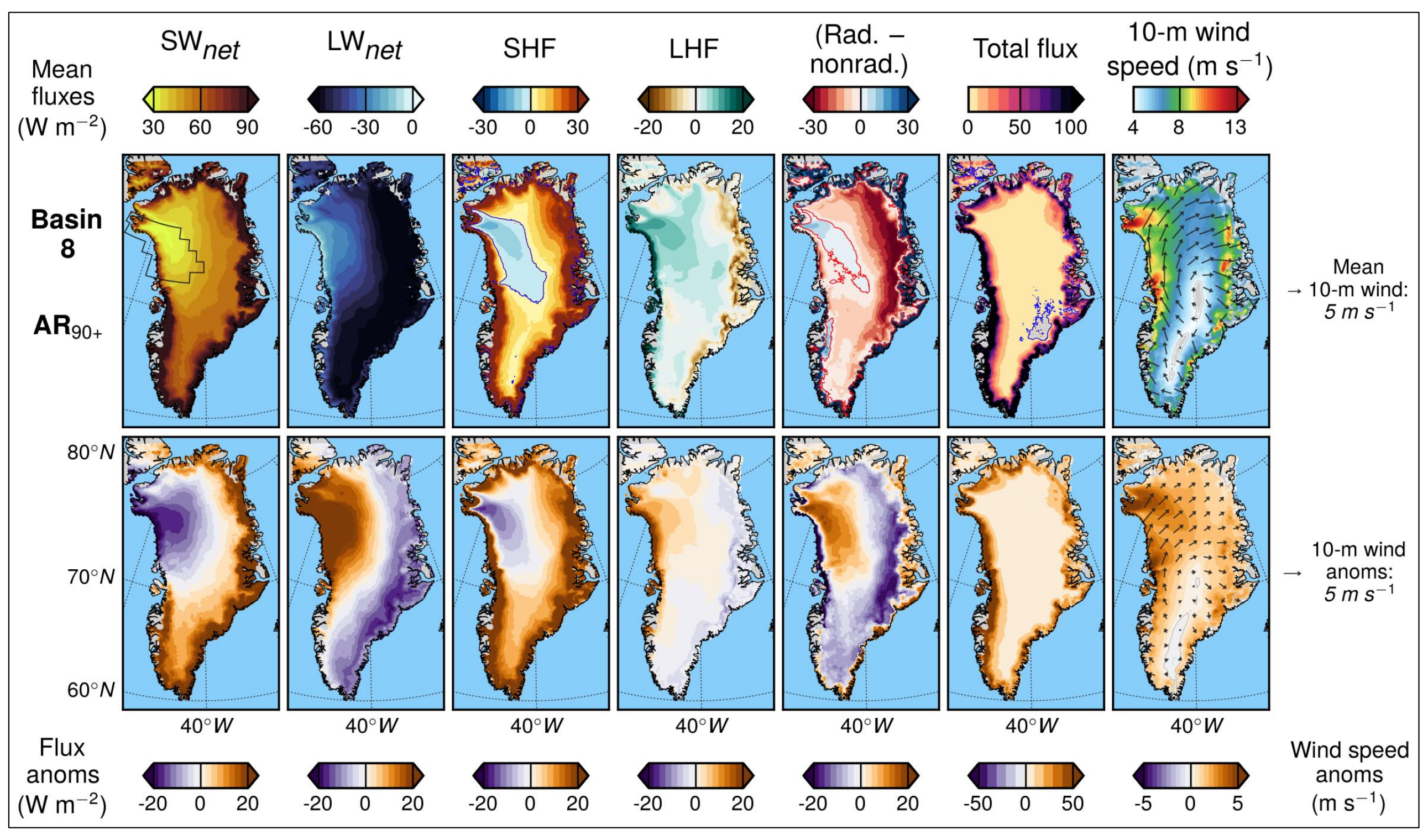
Surface energy balance = SW_{net} + LW_{net} + **SHF** + **LHF**

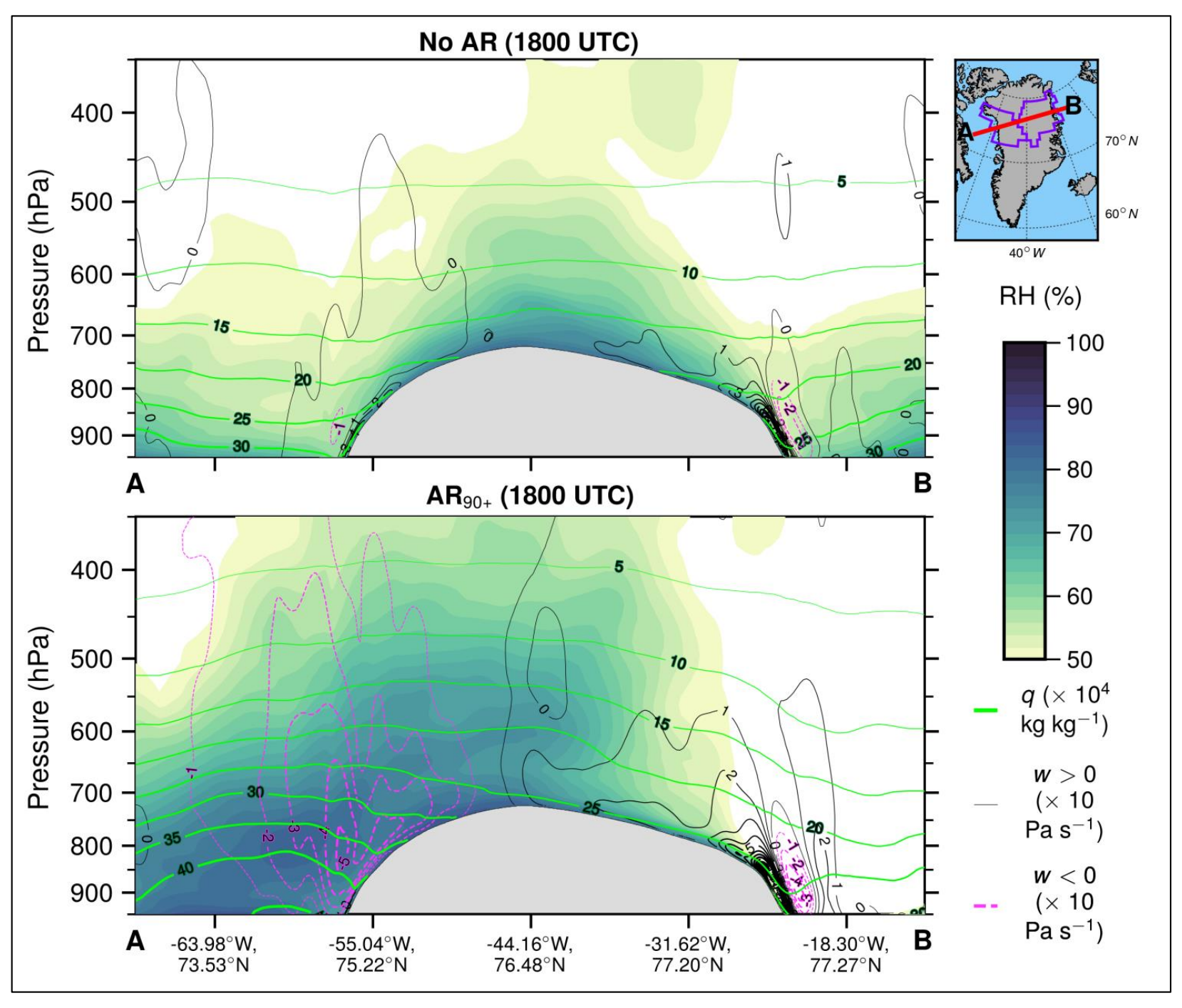
Radiative terms

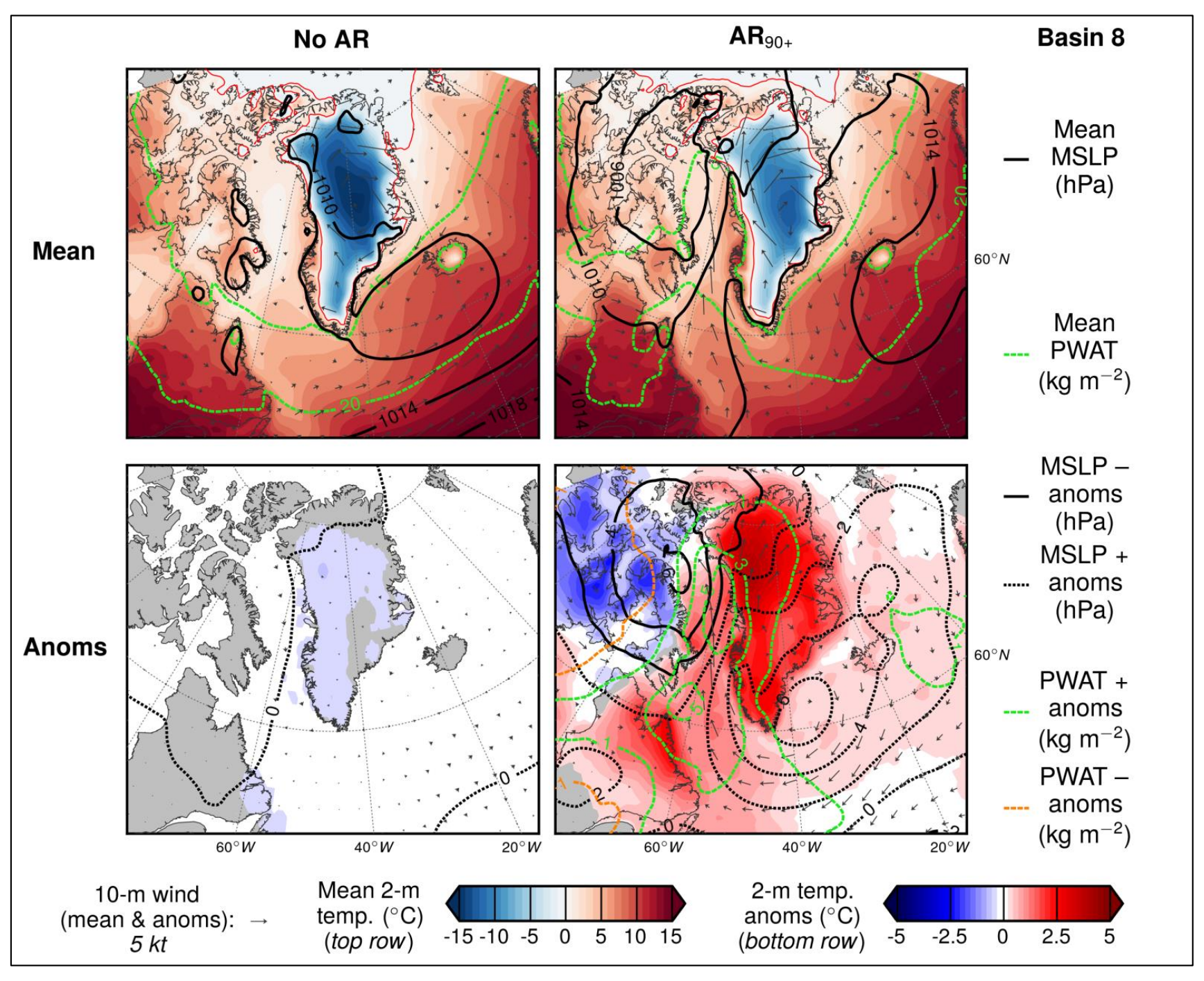
(+ ground energy flux + rain energy flux)

Non-radiative terms

SW_{net} (LW_{net}) = net shortwave (longwave) radiation; SHF (LHF) = turbulent sensible (latent) heat flux; Rad. – nonrad. = difference between radiative and turbulent fluxes





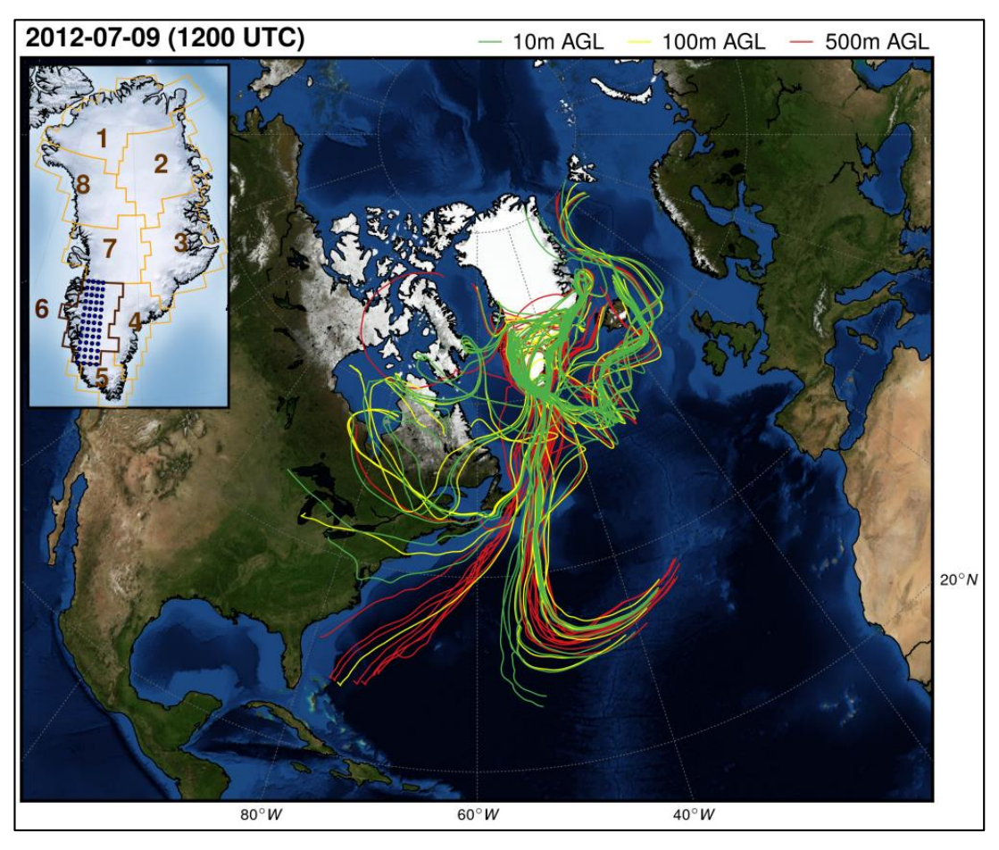


Cross sections of moisture and vertical velocity fields on "no AR" vs. AR_{90+} days in NW Greenland

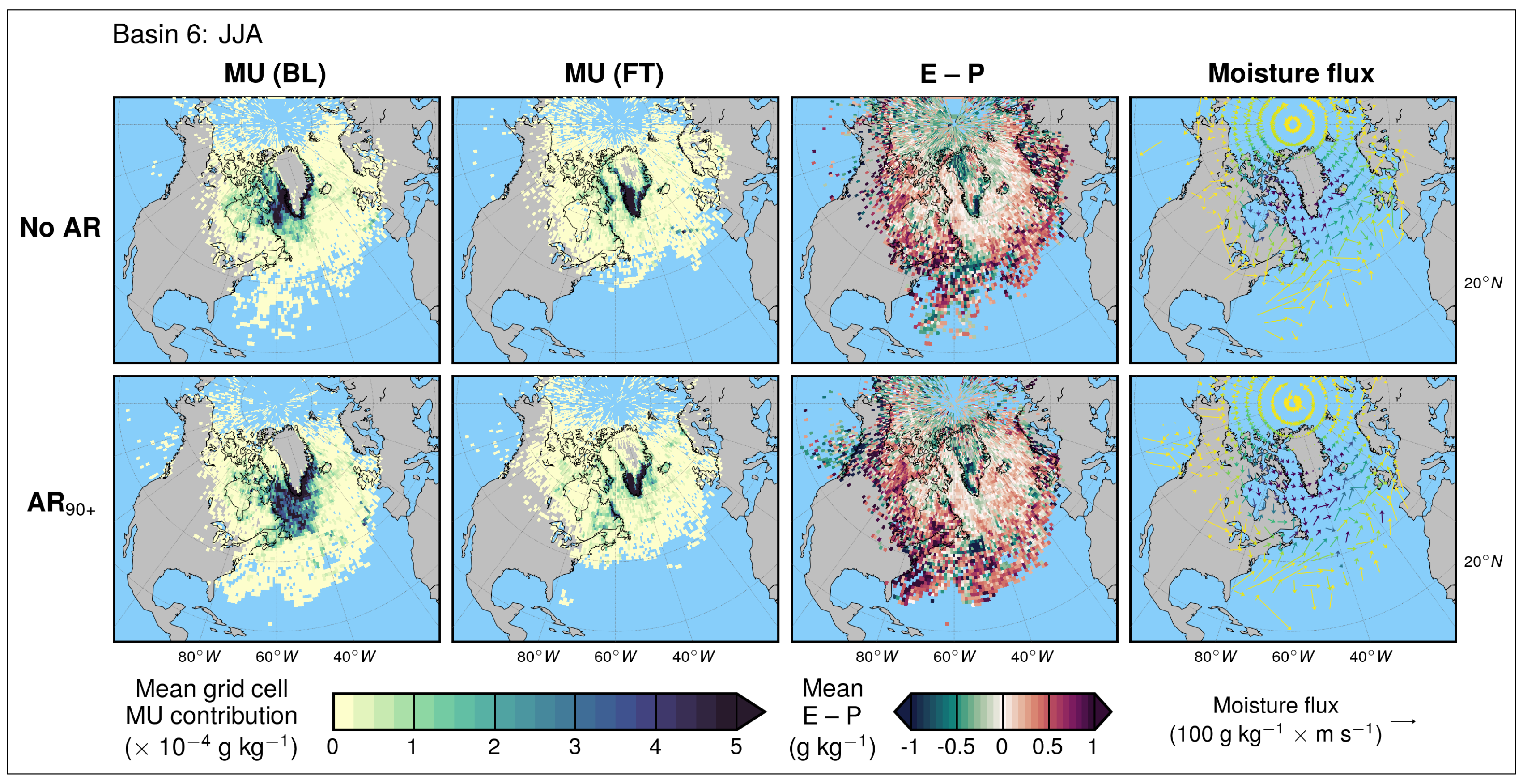
MSLP, 2-meter temperature, 10-meter wind, and precipitable water composites

5. ARs bring moisture from **unusually low latitudes**

- + Example of 10-day **air parcel back trajectories** ending in SW Greenland on 2012-07-09 (*right*)



- + **Moisture uptake** (MU) in the boundary layer (BL) and free troposphere (FT), evaporation minus precipitation (E – P), and moisture flux along air parcel paths during summer "no AR" and AR_{90+} conditions, 1980–2017 (*below*)



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Data and Methods

Data: Modèle Atmosphérique Régionale (MAR) v3.9.6 regional climate model, MERRA-2 and ERA5 reanalyses

Methods

- + Identify ARs using MERRA-2 integrated water vapor transport (IVT) data
- + Classify summer days by AR intensity (e.g. no AR, $AR_{<90}$, AR_{90+}) at the basin scale. Intensity thresholds based on basin-scale climatological percentile rank (PR) of IVT.
- + Analyze surface energy balance (SEB) and mass balance (SMB) [MAR], synoptic atmospheric conditions [MERRA-2], and vertical cross sections [ERA5] across AR categories
- + Model air parcel back trajectories using HYSPLIT model forced with MERRA-2 data

Acknowledgments and References

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Surface mass balance time series image credit: NSIDC / Xavier Fettweis, Université of Liège, Belgium: http://nsidc.org/greenland-today/2018/10/

Mattingly, K. S., T. L. Mote, and X. Fettweis, 2018: Atmospheric river impacts on Greenland Ice Sheet surface mass balance. *Journal of Geophysical Research: Atmospheres*, *123*(16), 8538–8560, doi:10.1029/2018JD028714.