Increasing importance of North American sourced moisture for the Arctic summertime water vapor feedback

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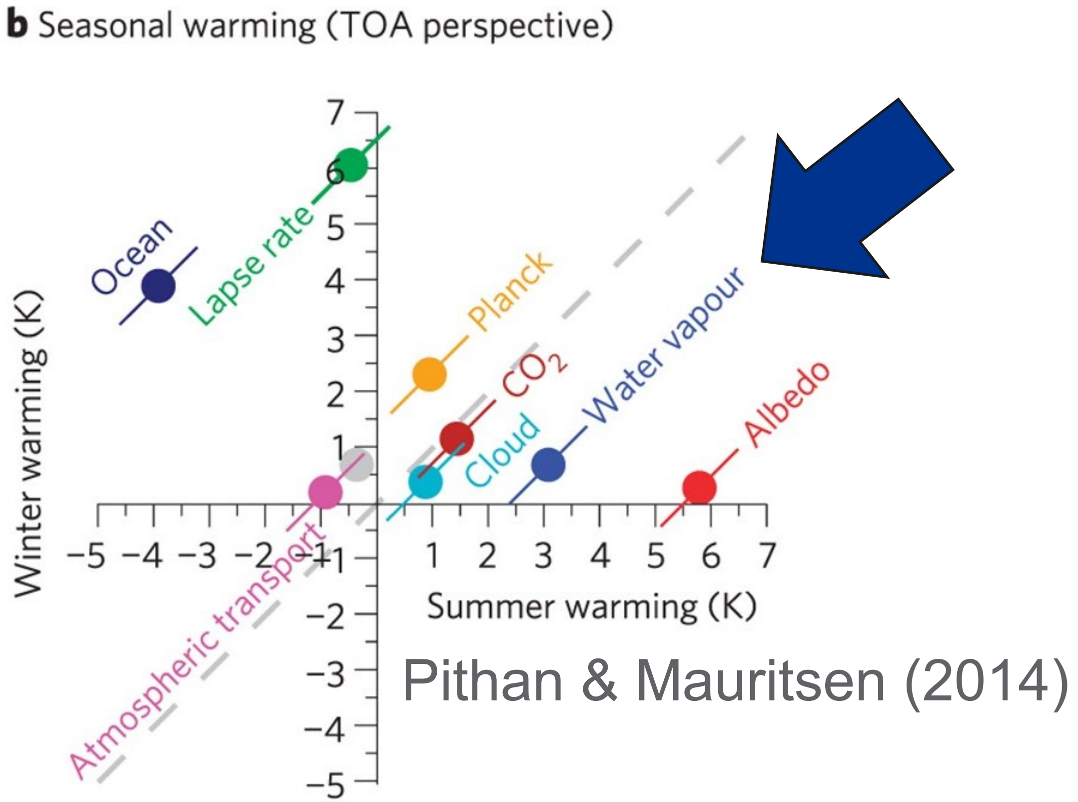
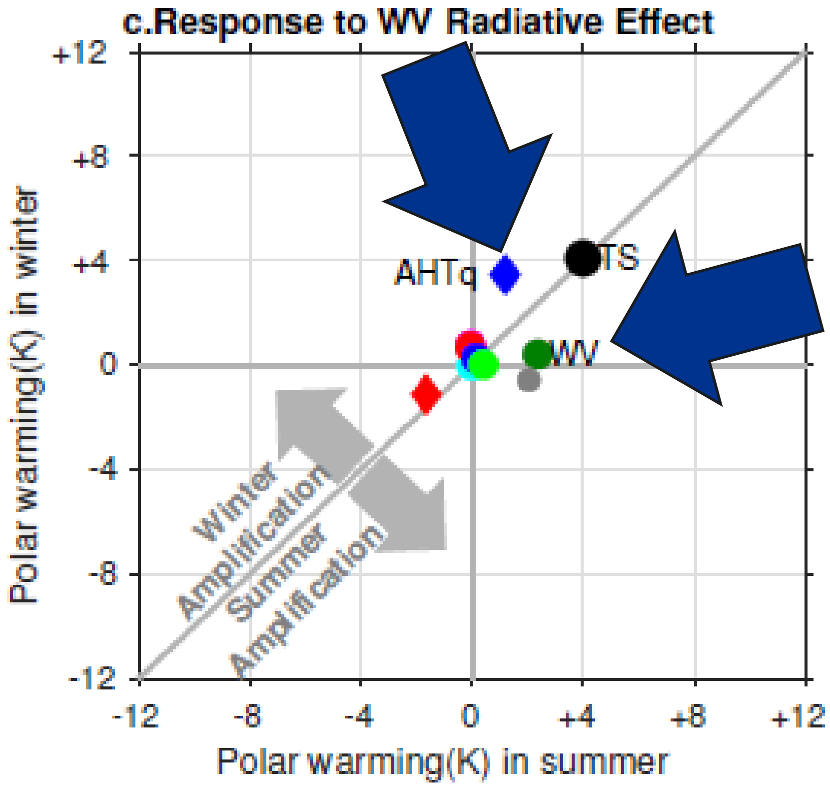
CESM Polar Climate Modeling Working Group

Motivation: Contribution of water vapor to summer Arctic warming



Pithan & Mauritsen (2014)

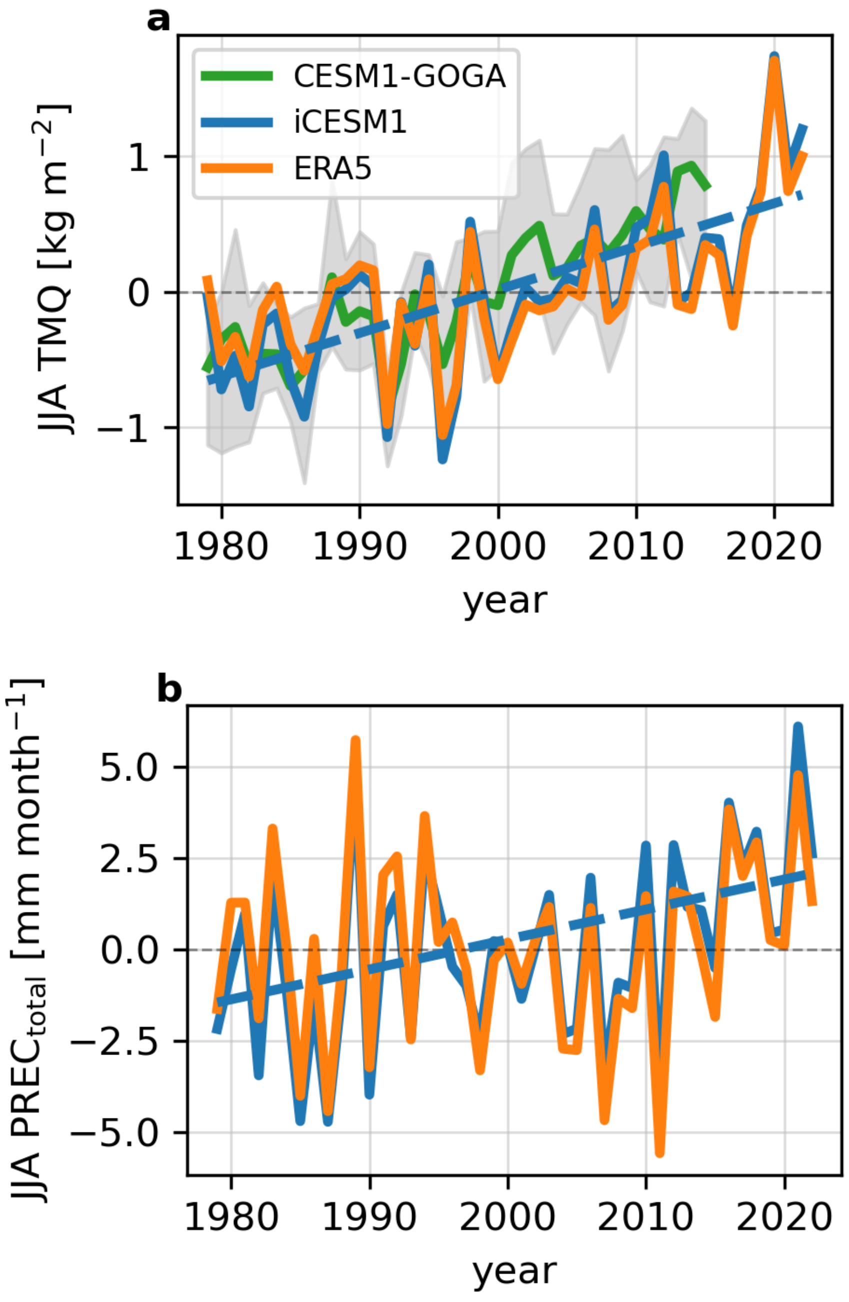


Chung & Feldl (2023)

- Rate of Polar Amplification set by summertime warming (albedo + WV)
- Source of this water vapor (WV)?

Experiment Design

- Moisture tagging (isotope-enabled CESM1, iCESM1)
  - 8 regions (based on land/ocean)
  - 54 regions (based on lat,lon)
  - Singh et al. (2016, 2017)
  - Harrington et al. (2021)
- Nudging (ERA5)
  - u, v, T
  - Fixed GHG concentrations
- **Goals:**
  - Replicate ERA5 Arctic hydrological cycle
  - Characterize regional contributions to "observed" summer WV feedback

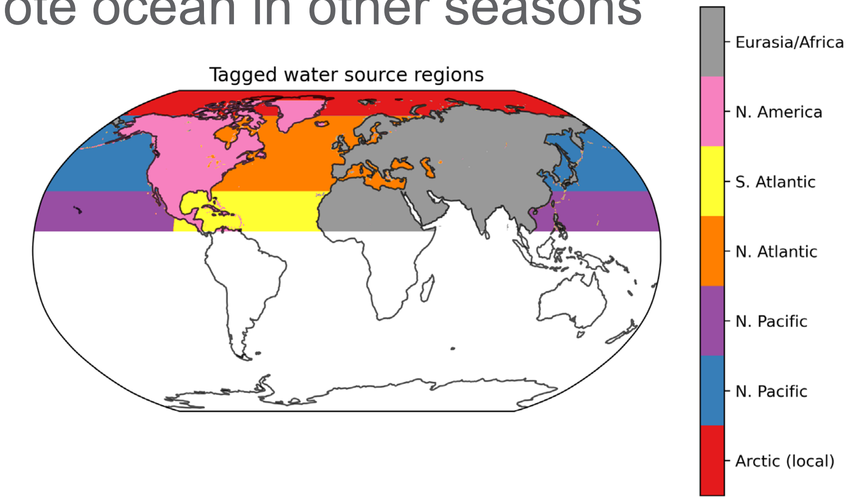


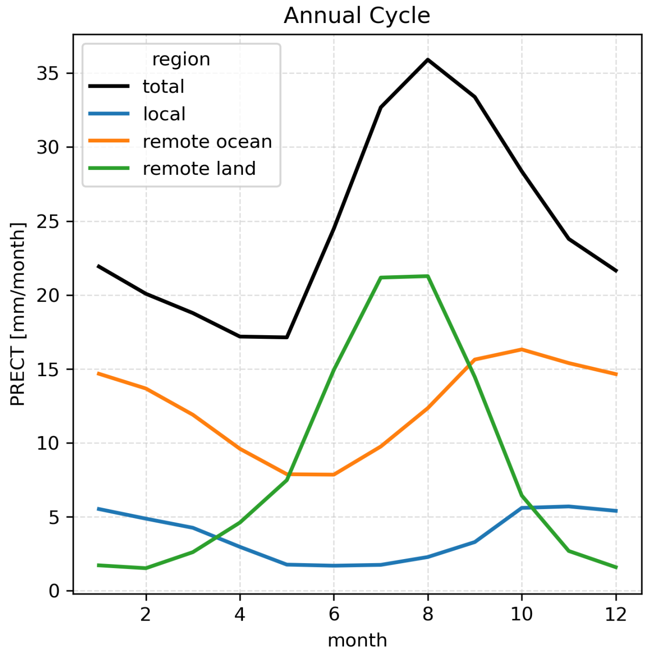
Annual Cycle vs. Trends

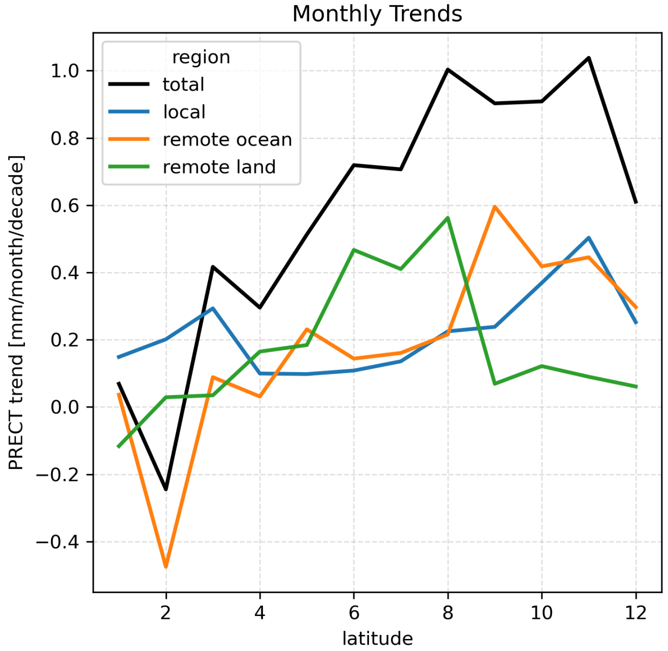
- Land sources dominate in summer (~62%)
  - Singh et al (2016, 2017) – 80% remote
  - Harrington et al. (2021) – 56% land
  - Fearon et al. (2021) – 32% land

- Local and remote ocean sources (North Atlantic) dominate in other seasons

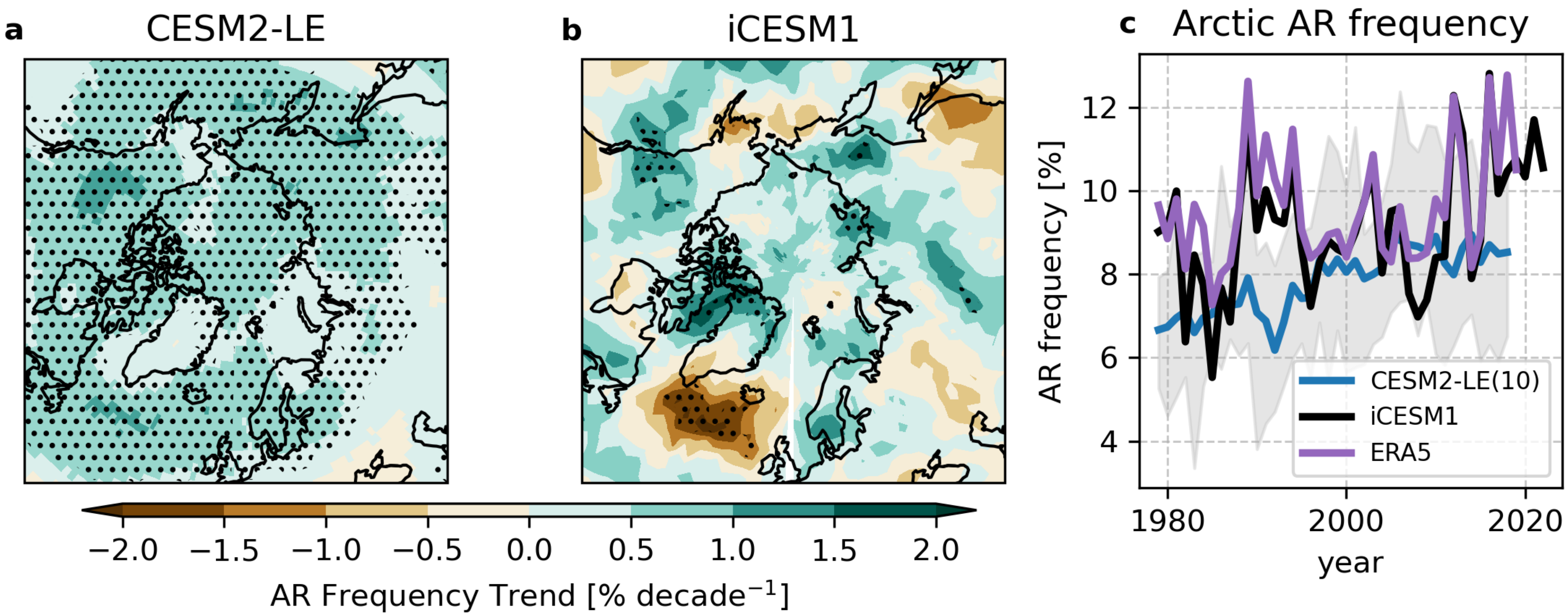
- Relative changes favor local sources in summer and remote ocean in other seasons







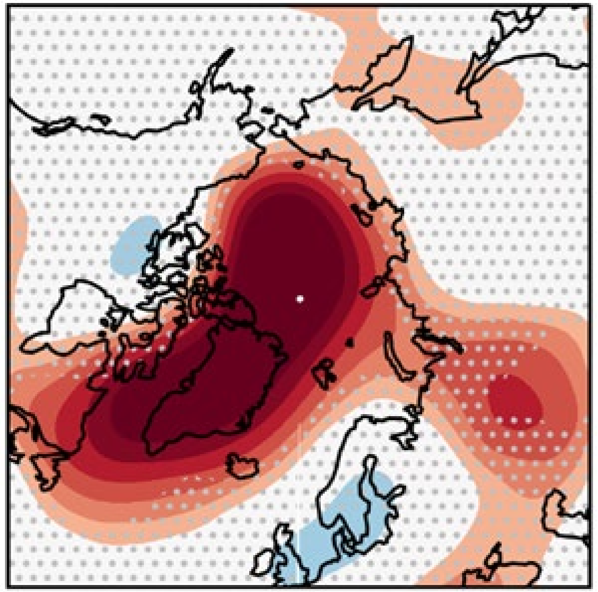
Increasing atmospheric rivers (AR) frequency from major pathways



- 4 Major pathways
  - 80-92% of transport trends due to changes in ARs

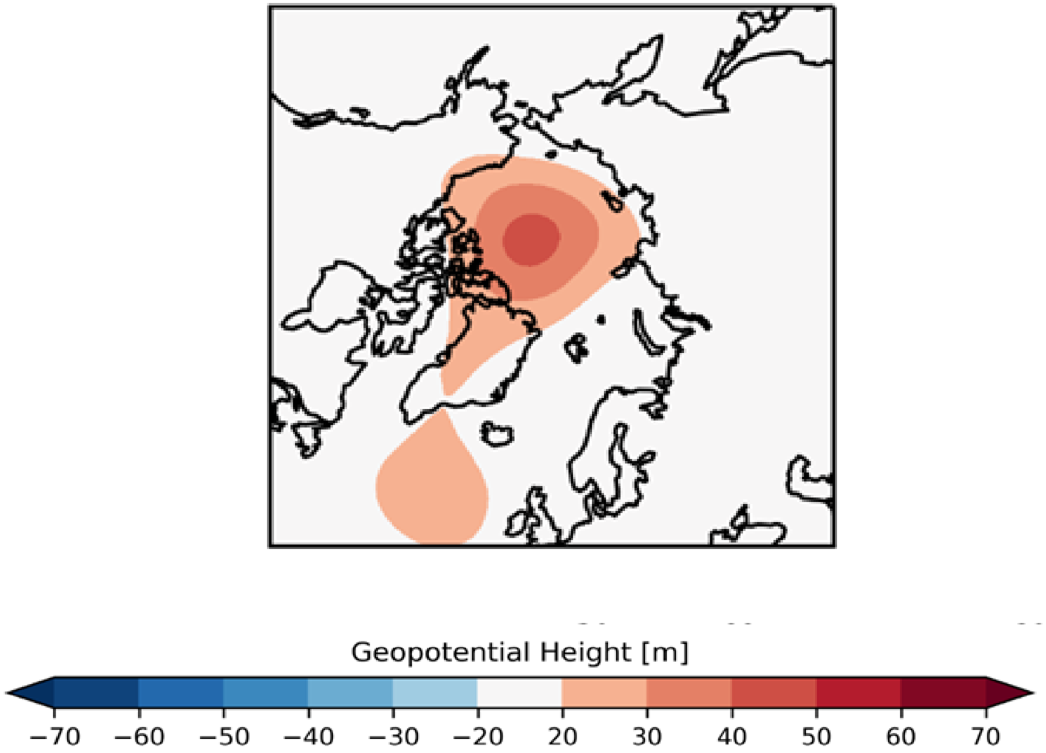
The CESM struggles to capture anticyclonic circulation over Greenland

e ERA-I JJA Z200



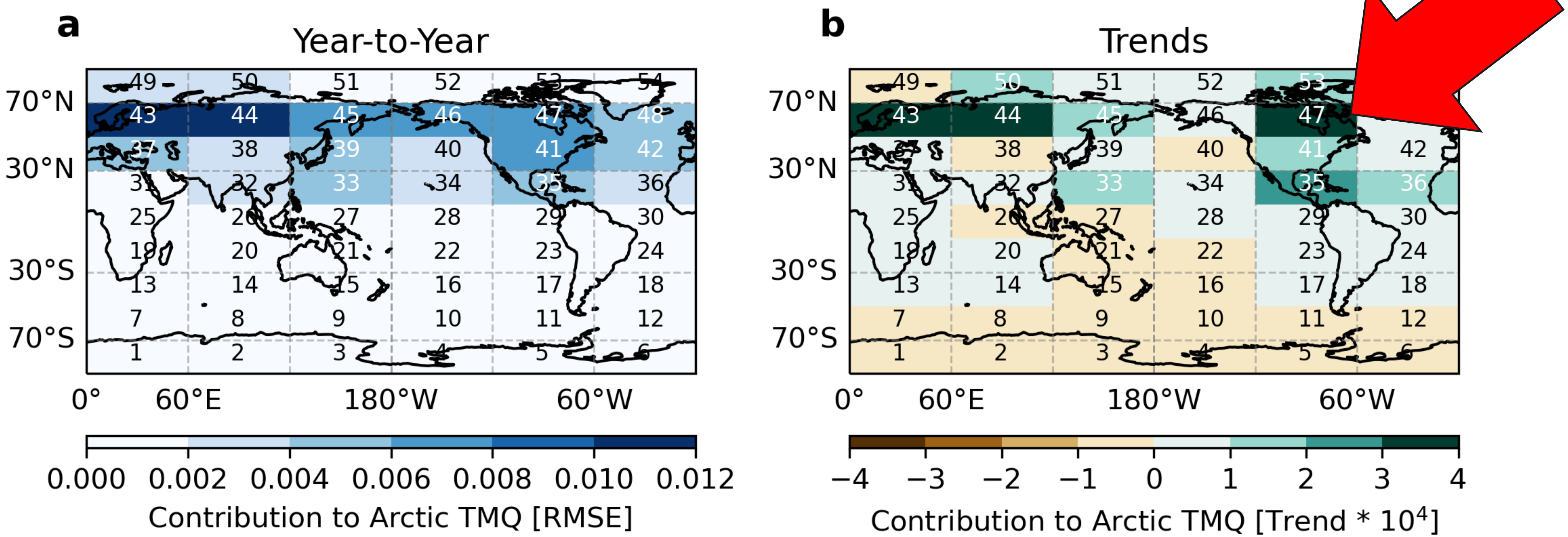
Z200 = 200 hPa geopotential height

b Z200 Composite



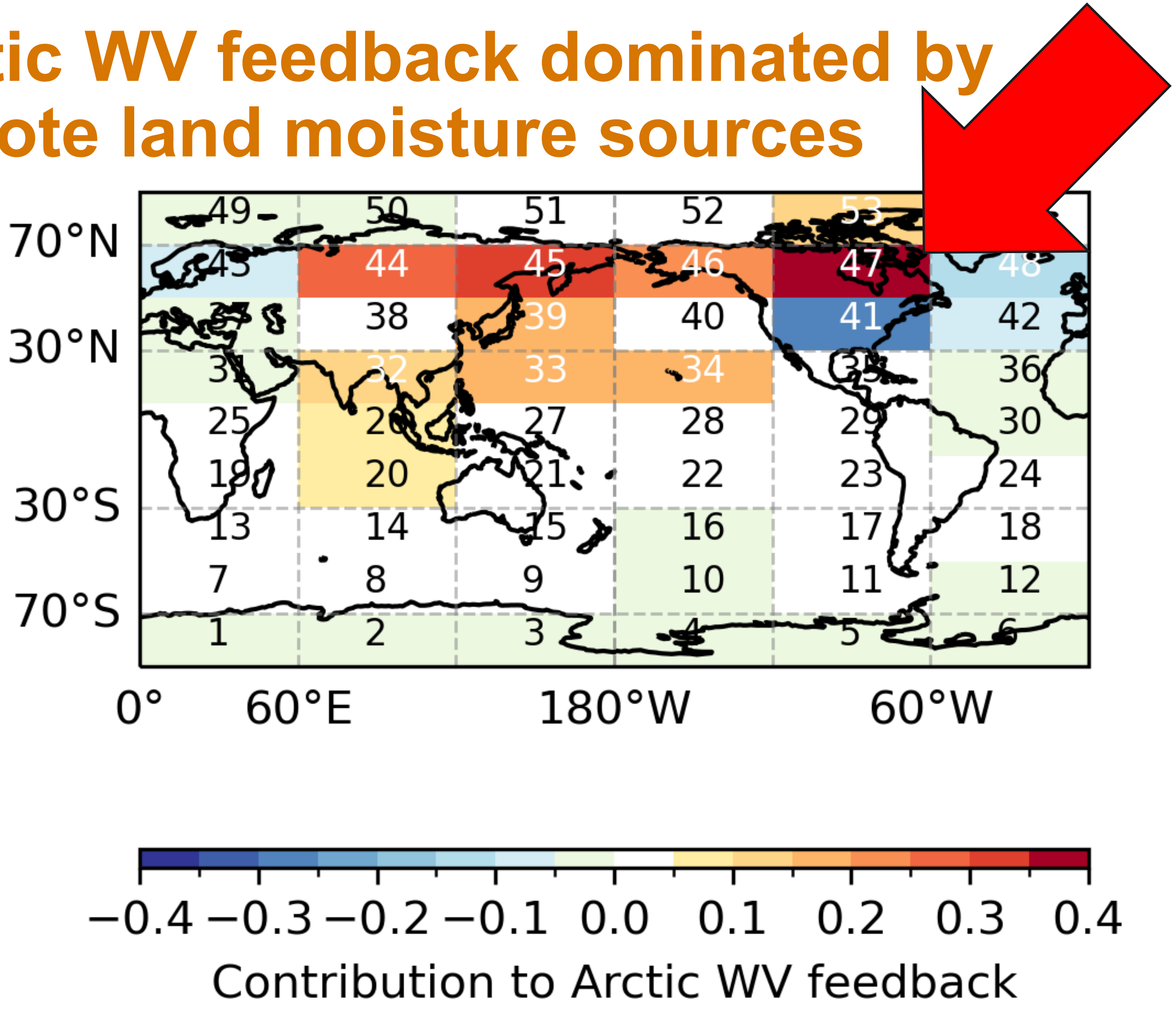
From Baxter & Ding Journal of Climate (2022)

Remote sources of summer Arctic water vapor trends



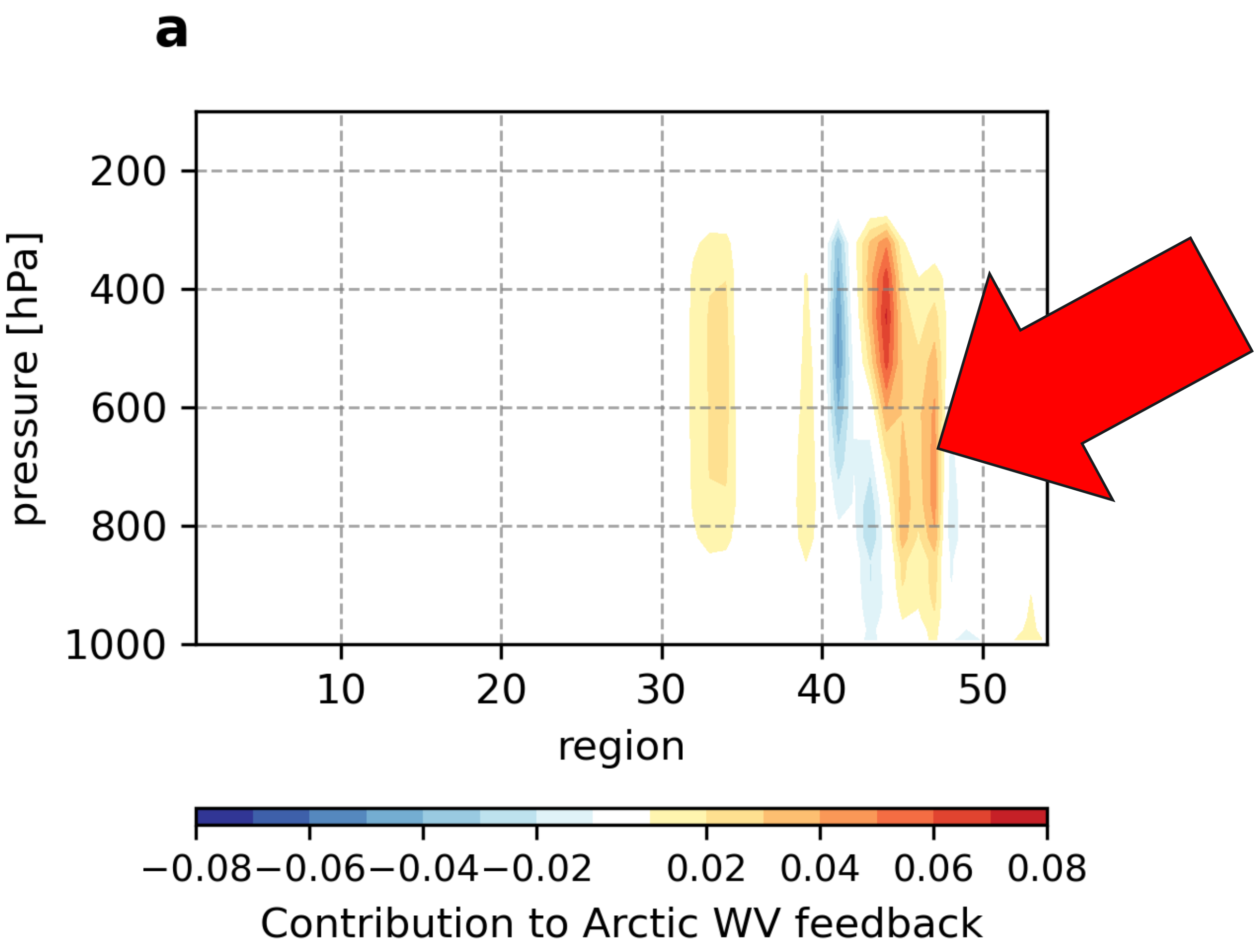
- 50-70N land sources dominate trends (65% from land)

Arctic WV feedback dominated by remote land moisture sources



- 92% contribution from remote sources (~1/4 from northeastern Canada)

Vertical Structure of Transport



- Uniform transport produces most efficient radiative impact
- Weak local impact confined to surface (8%)

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Summary

- By nudging temperature and winds, we can replicate Arctic moisture and precipitation change from ERA5.

- The model struggles to capture anticyclonic circulation over Greenland that diverts moisture transport west of the ice sheet

- The North American pathway (AR-dominated) sourced from over land has the strongest contribution to summertime Arctic WV radiative effects.

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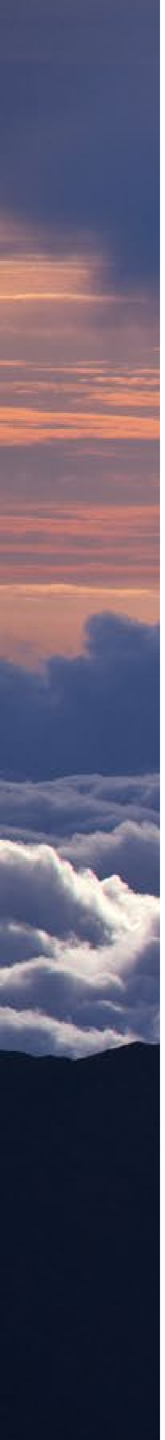

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Thank you