

Atmospheric and oceanic drivers of regional Arctic winter sea-ice variability in present and future climates

vEGU 2021

Jakob Dörr, Marius Årthun, Tor Eldevik, Erica Madonna

Geophysical Institute, University of Bergen, Norway

Bjerknes Centre for Climate Research, Bergen, Norway

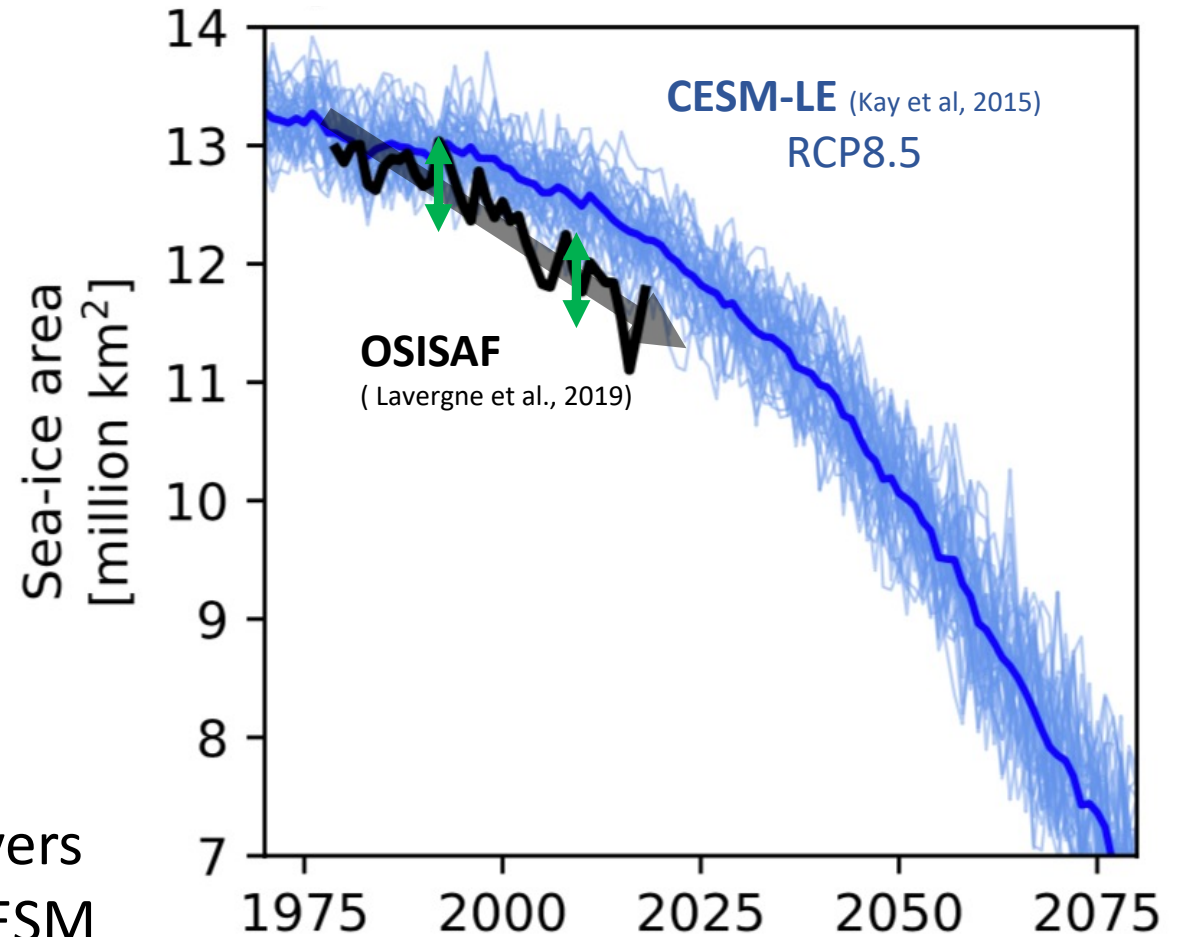


Winter Arctic sea ice and internal variability

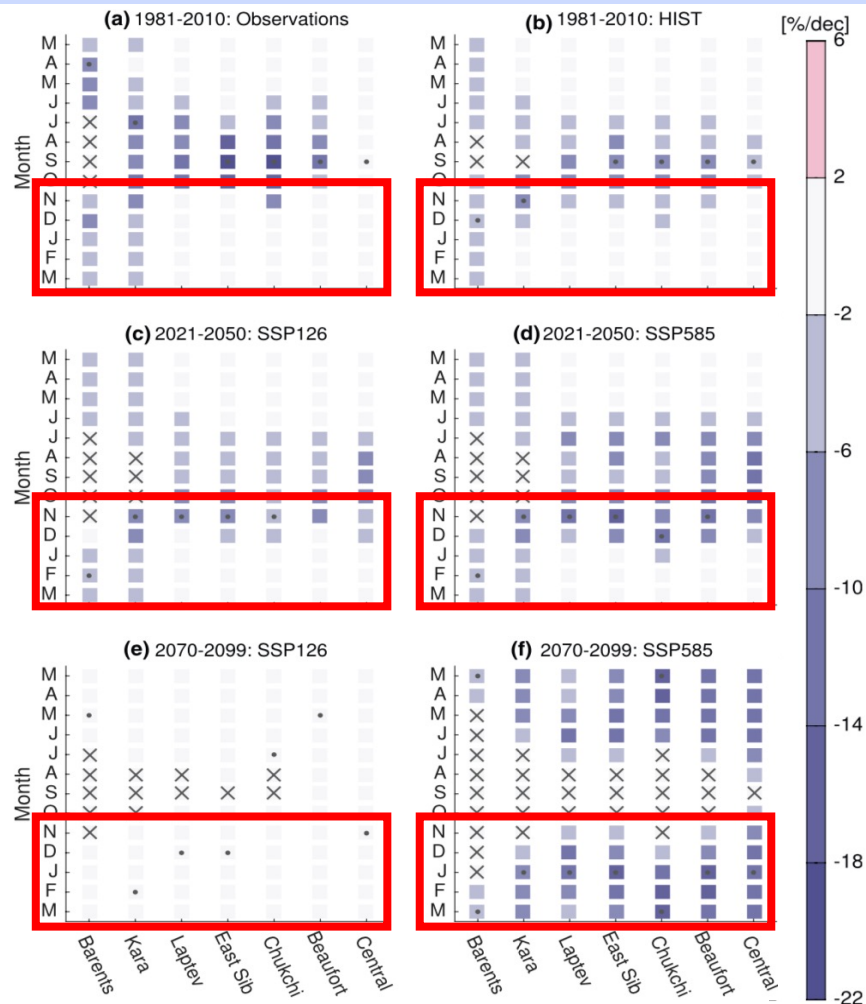
- define winter as November - March
- Externally forced sea-ice loss
- Overlaid internal variability
 - Leads to uncertainty in projections

What influences **internal variability** of winter sea ice, now and in the future?

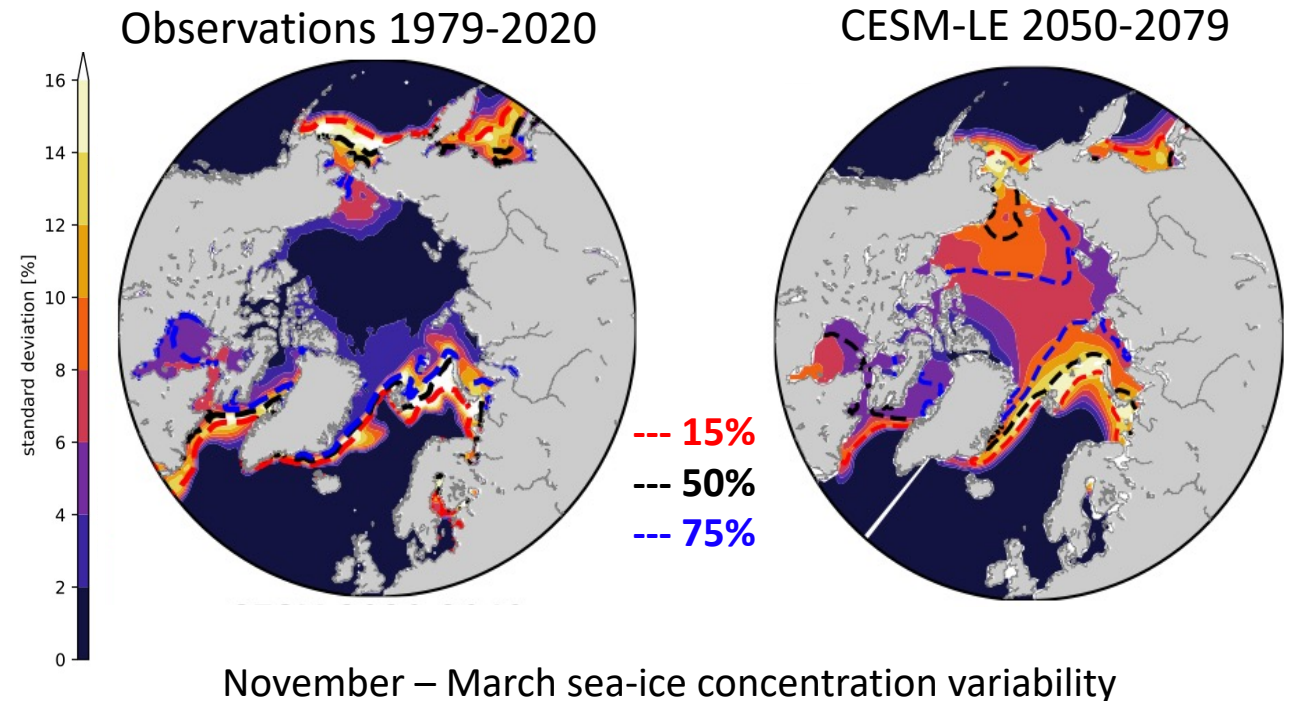
- Analyze main atmospheric and oceanic drivers using a combination of observations and CESM Large Ensemble (CESM-LE)



Present and future winter sea-ice loss and variability



CMIP6 and observed regional sea-ice concentration trends from Årthun et al. (2021)



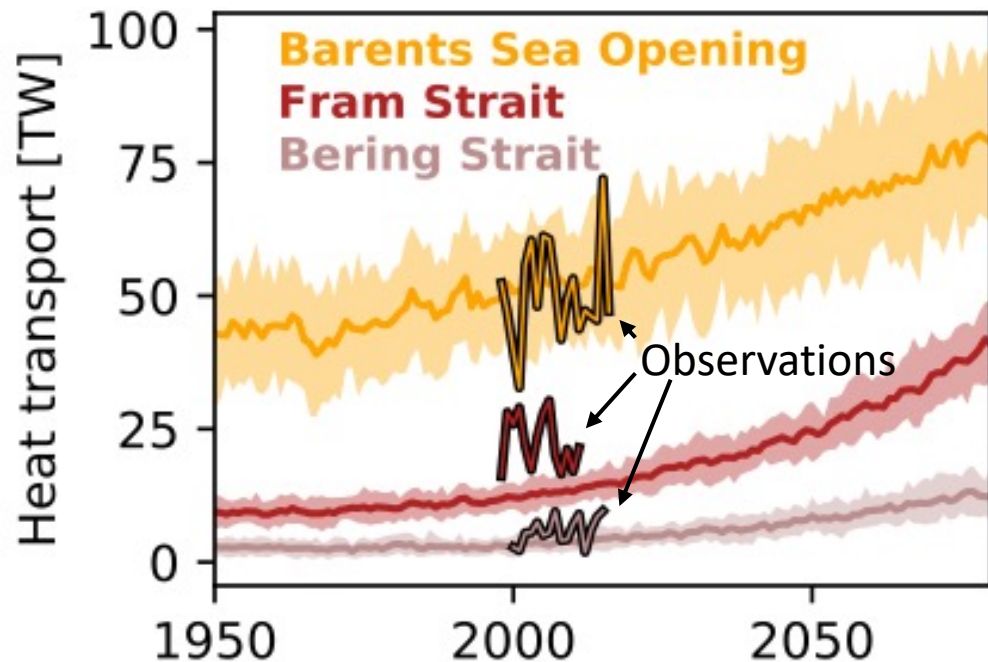
- Most winter concentration variability currently located in the Barents and Bering Seas
- future ice loss and variability expand towards more central regions

Drivers of sea-ice variability analyzed in this work

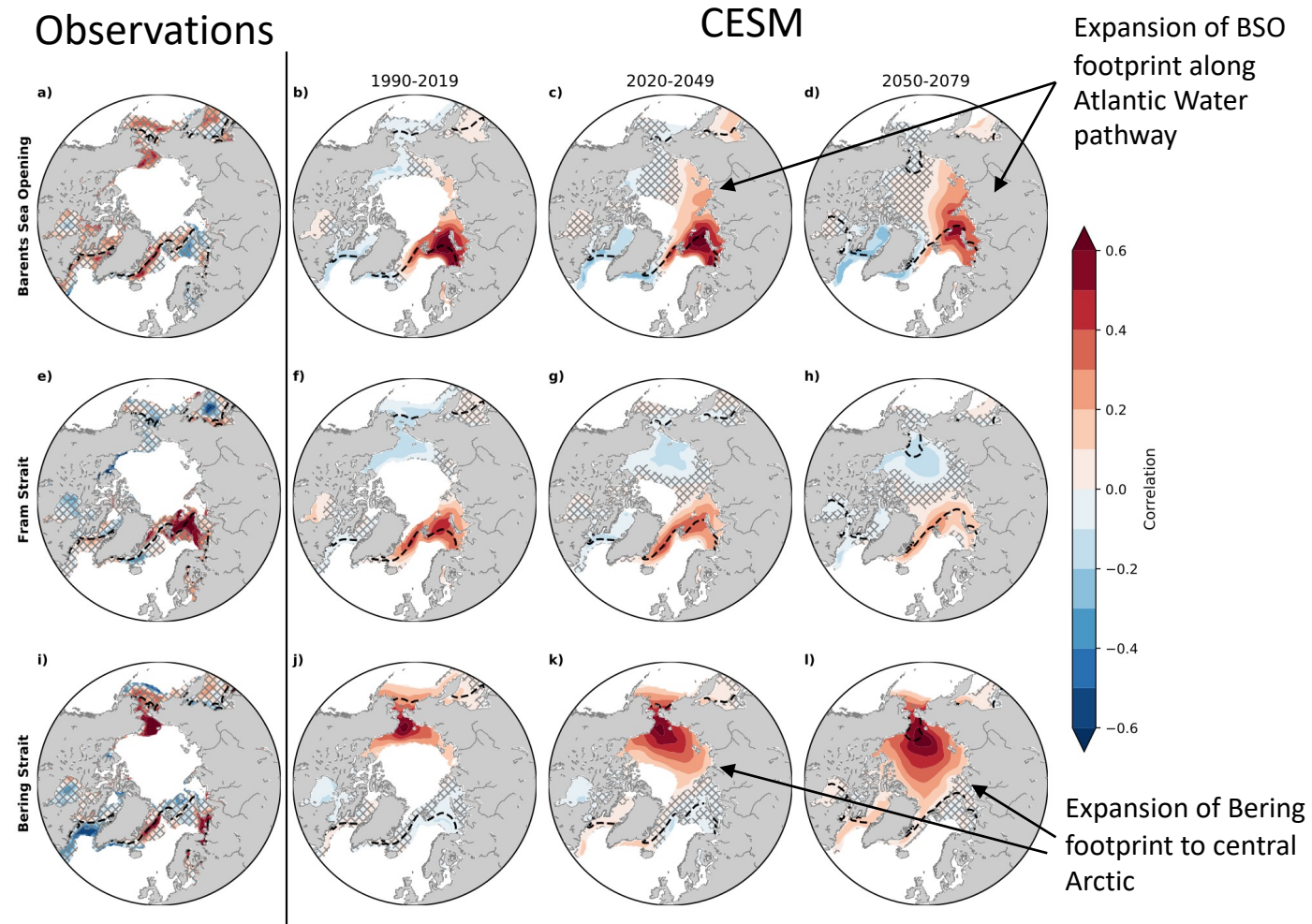
- **Ocean heat transport** (annual mean)
 1. Barents Sea Opening (BSO)
 2. Fram Strait inflow
 3. Bering Strait
- **Atmospheric circulation** (Nov - Mar)
 - Sea-level pressure, surface winds
 - Hemispheric circulation modes
- **River runoff** (annual mean)
 - No significant influence on winter sea ice in CESM



Influence of ocean heat transport on winter sea ice



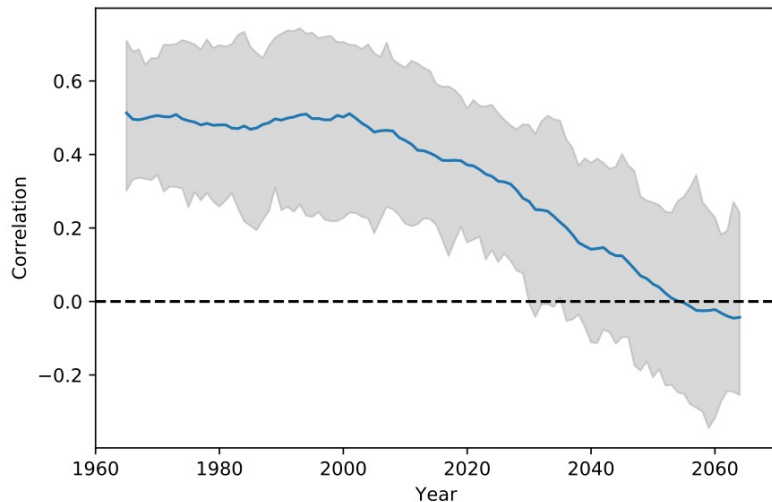
- CESM consistent with observations, except for Fram Strait
- Weak BSO influence in observations, likely due to short record
- Bering Strait and BSO heat transport have largest influence, and future expansion of influence



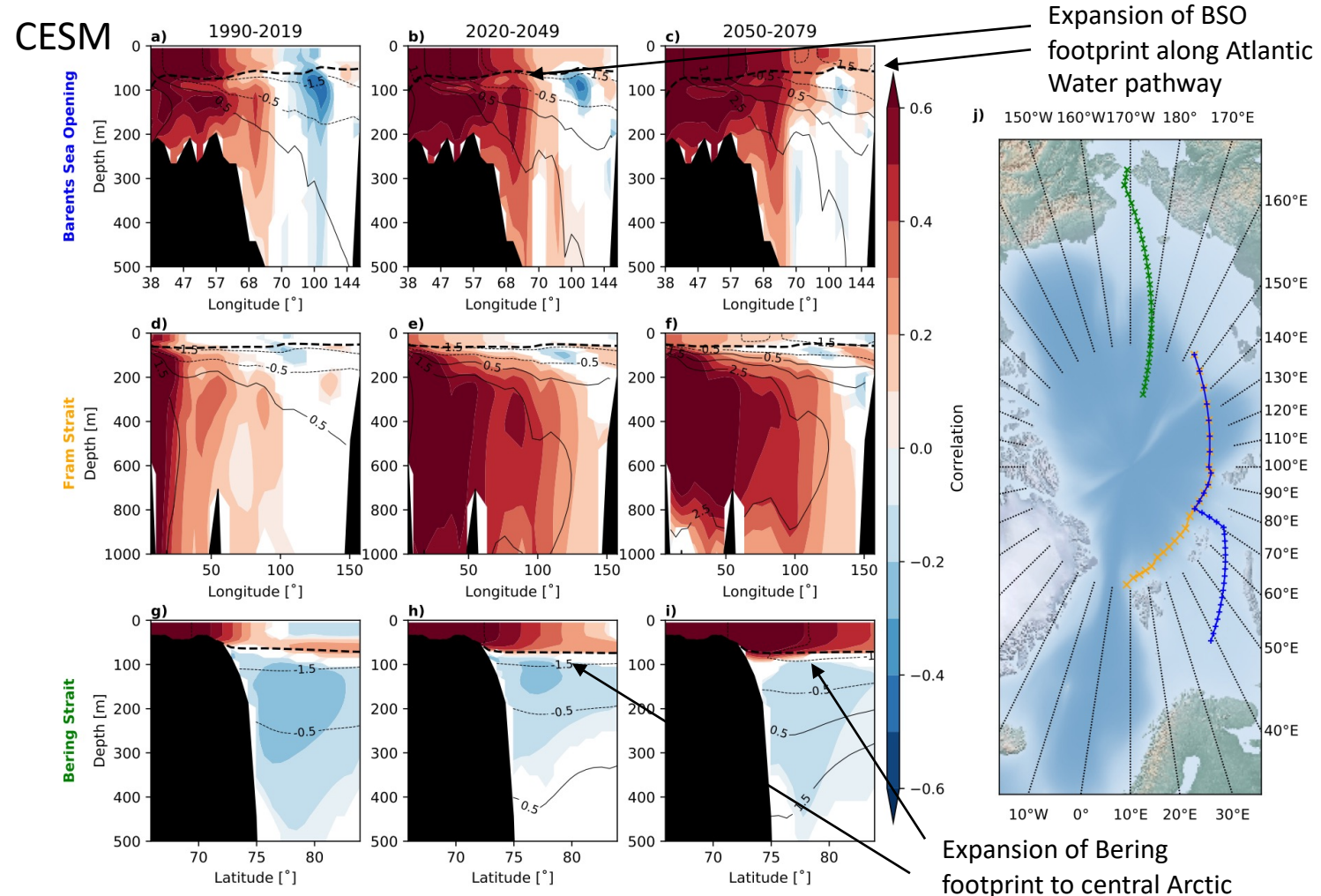
Correlation of heat transport with following winter sea-ice concentration (values are inverted to represent sea-ice loss)

Influence of ocean heat transport on winter water temperature

- Consistent with influence on sea ice, influence of BSO and Bering heat transports on surface layer temperatures
- Fram Strait heat transport influence mostly confined to lower depths
- Fram Strait heat transport influence on Barents Sea sea ice likely only through connection with BSO heat transport; weakening influence on sea ice due to decreased future correlation

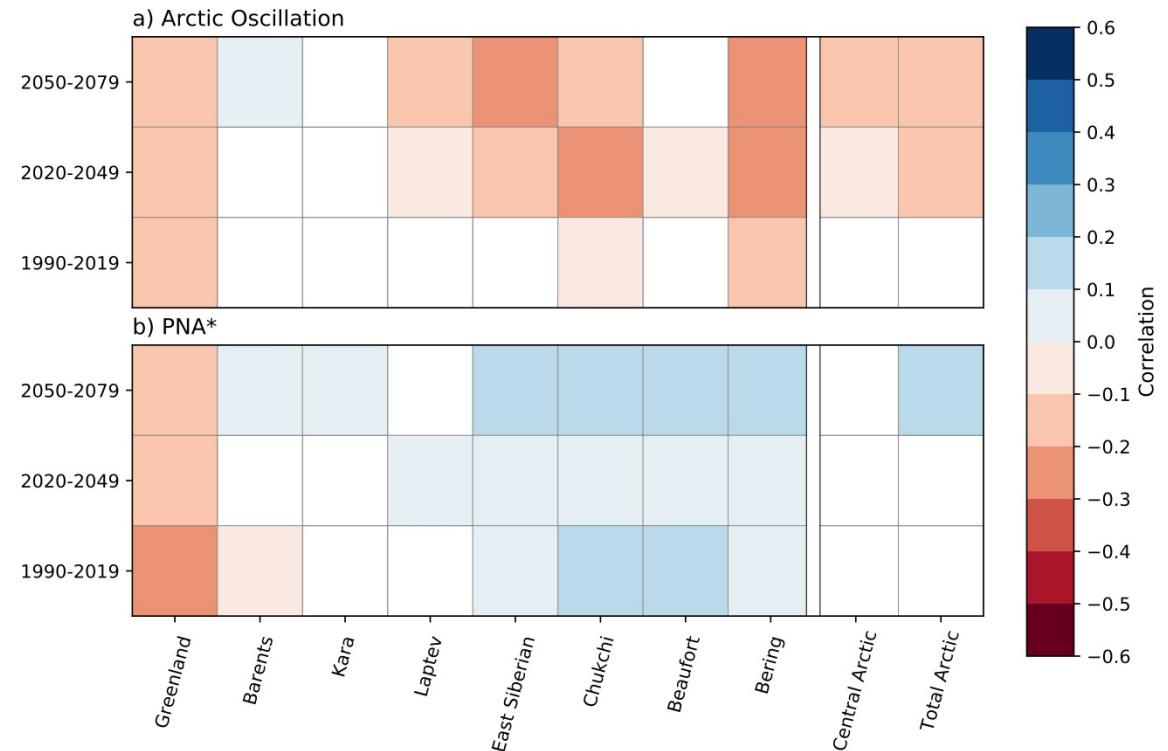
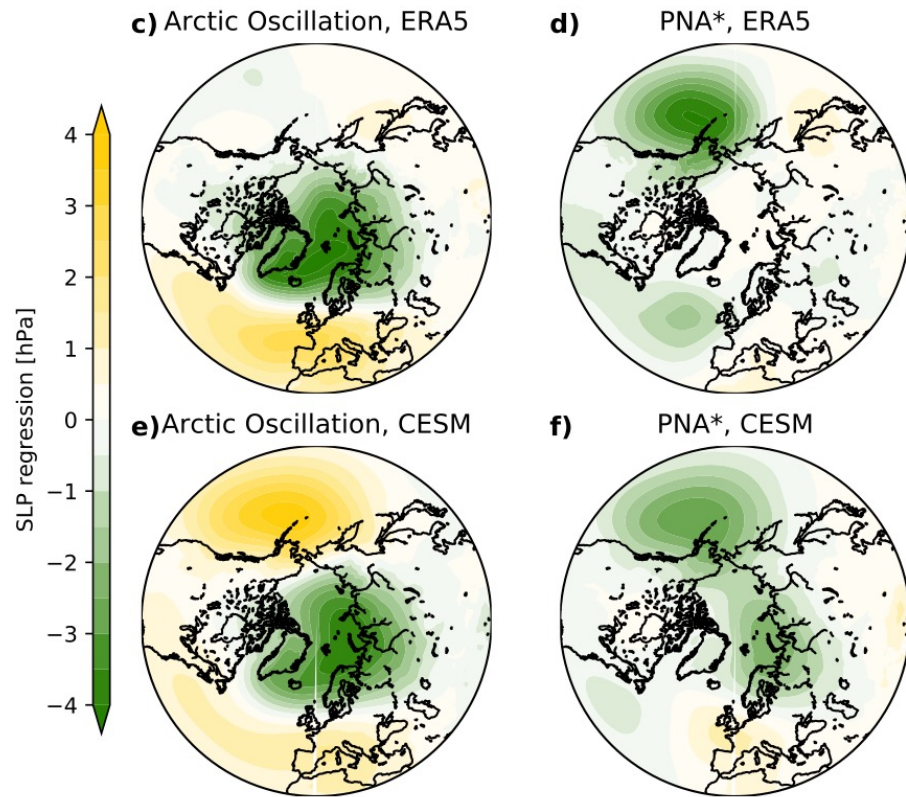


Correlation of Fram Strait and BSO heat transport in CESM



Correlation of heat transport with following winter water temperature

Influence of winter atmospheric circulation: hemispheric modes



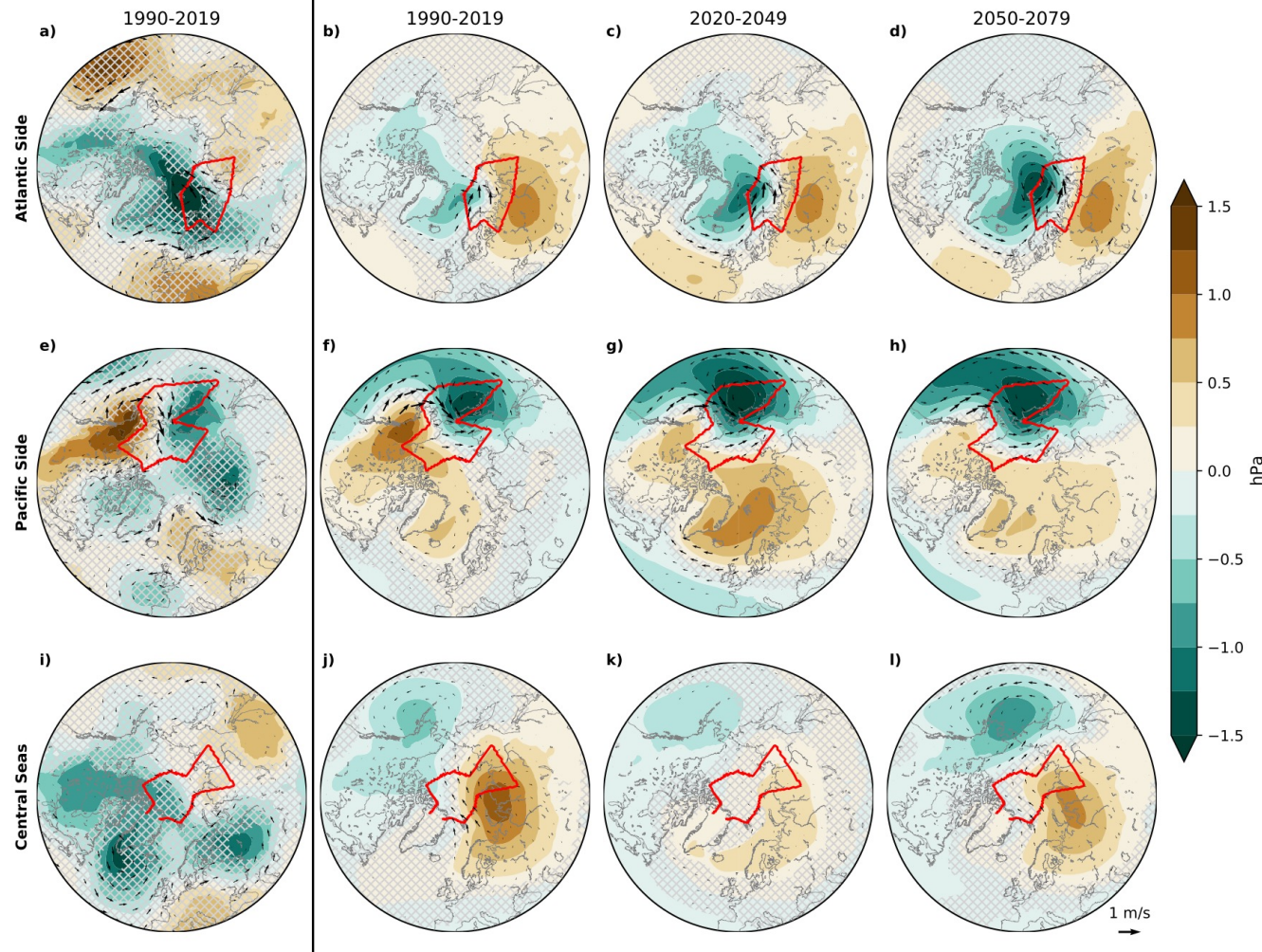
Correlation between principal components and regional sea-ice areas in CESM (values are inverted to represent sea-ice loss)

- Main modes: **Arctic Oscillation (AO)** and **Pacific-North America Like (PNA*)**
- Weak connection between regional sea-ice area and modes, no significant correlation in observations (not shown)

Influence of winter atmospheric circulation: Regional patterns

Observations/ERA5

CESM



Regression of sea-level pressure and surface winds onto regional sea-ice area (in red boxes), values are inverted to represent sea-ice loss

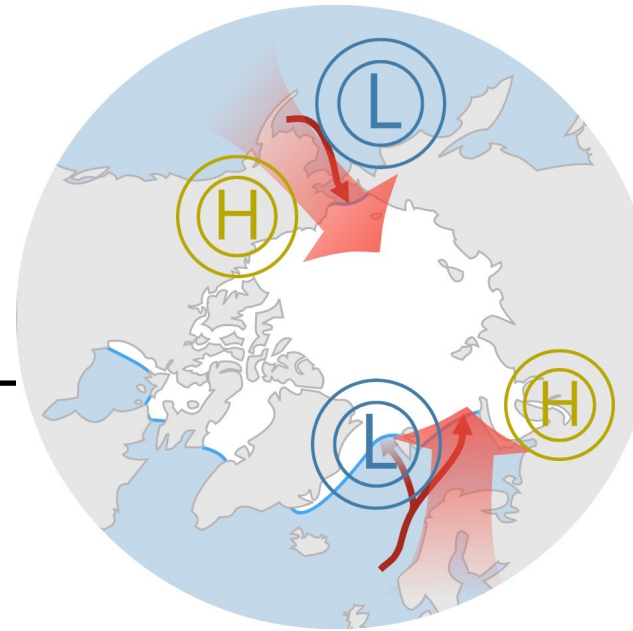
- Nordic seas low connected to sea ice on Atlantic side
- High over Alaska; Low over western north Pacific connected to sea ice on Pacific side
- Similar patterns in Observations and CESM
- Only weak patterns for central regions (not much sea-ice variability there)
- Associated atmospheric heat and moisture advection pathways over eastern north Pacific and via Nordic seas, respectively (see [slide 13](#))

Conclusions

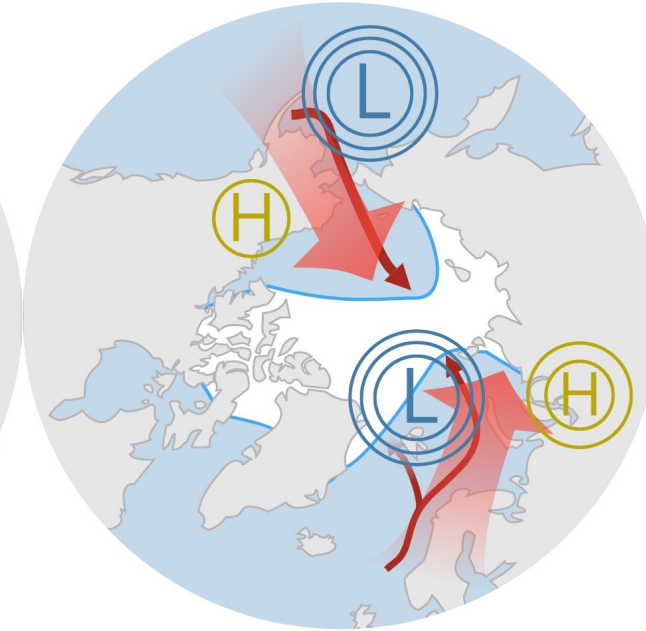
What influences **internal variability** of winter sea ice, now and in the future?

- CESM mostly **consistent** with observations
- **Expanding** influence of Bering Strait, Barents Sea Opening heat transport
- Oceanic and atmospheric advection pathways for Atlantic and Pacific side -> **Atlantification, Pacification**
- **Little** influence of river runoff on variability in CESM

Present



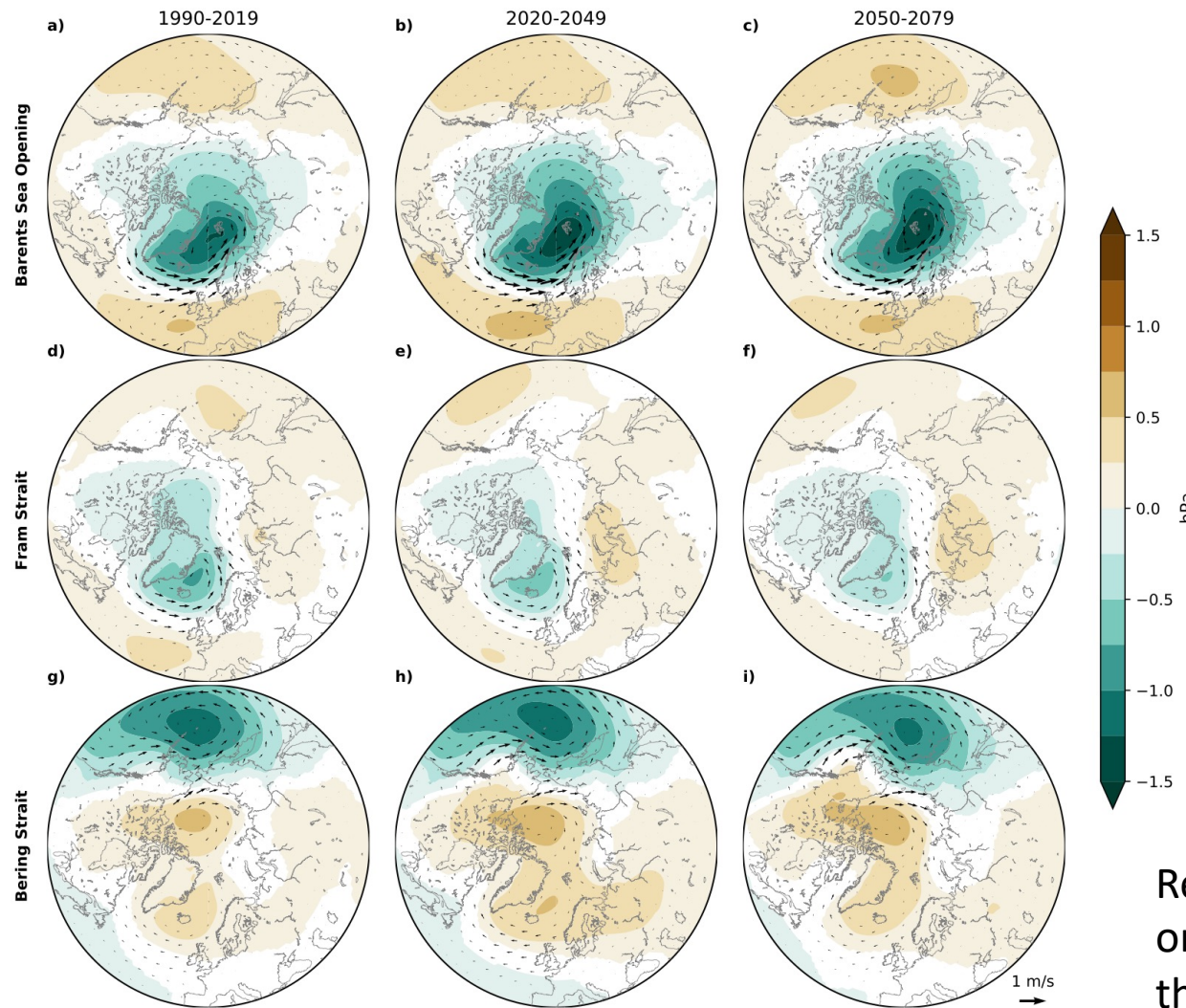
Future



-> Submitted to Journal of Climate

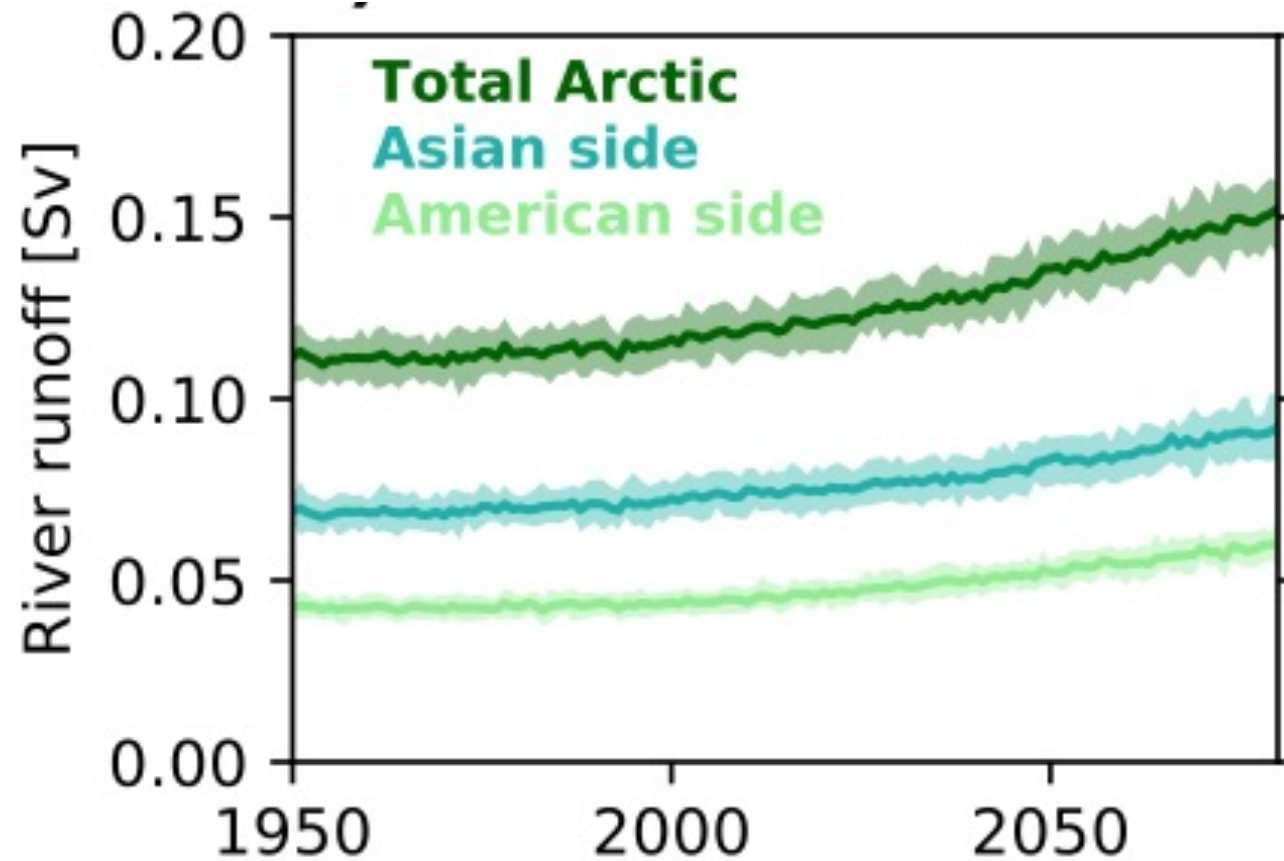
Additional: Atmospheric influence on ocean heat transport

CESM

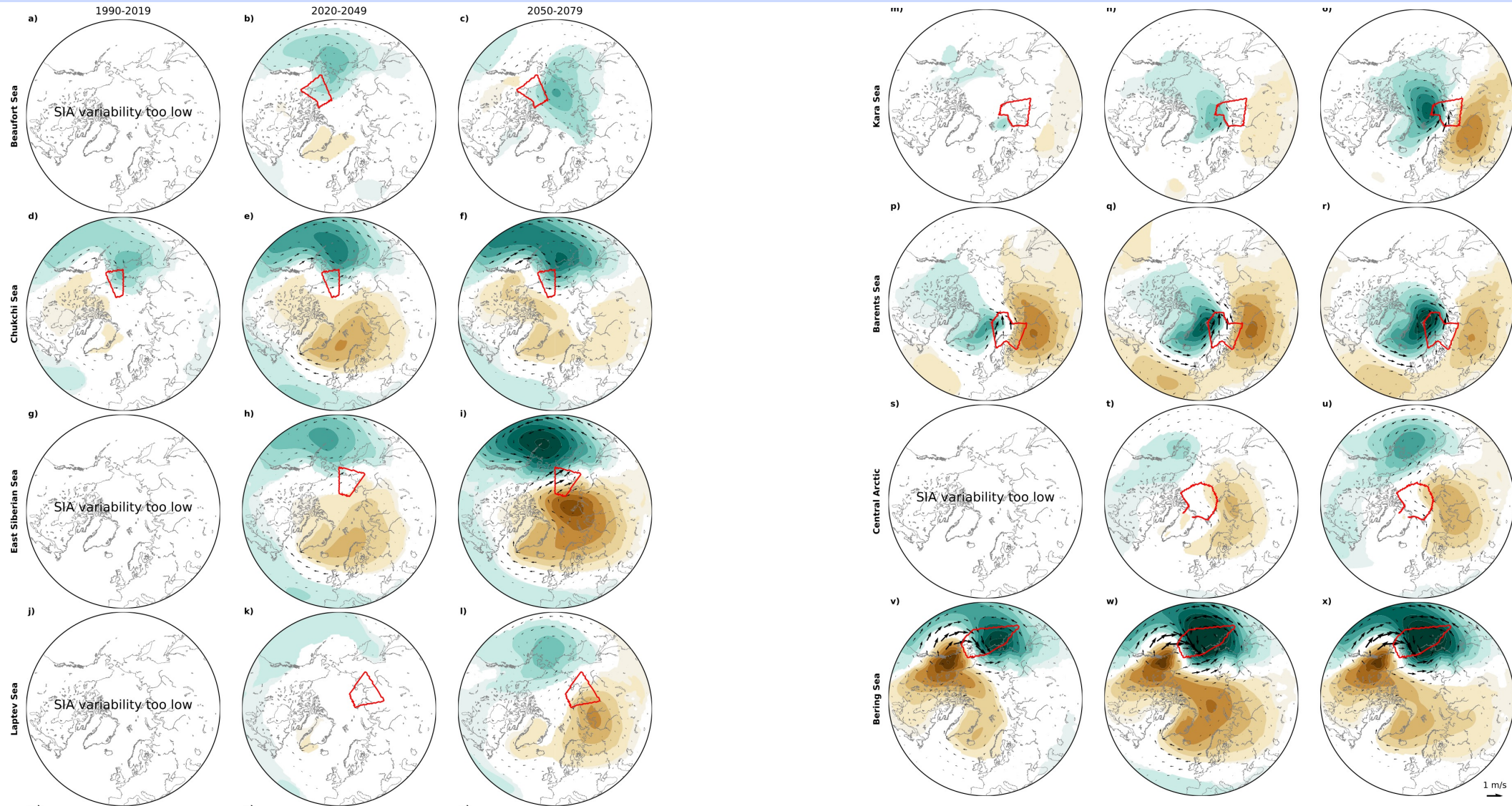


Regression of annual mean sea-level pressure
onto annual mean ocean heat transport through
the three gates

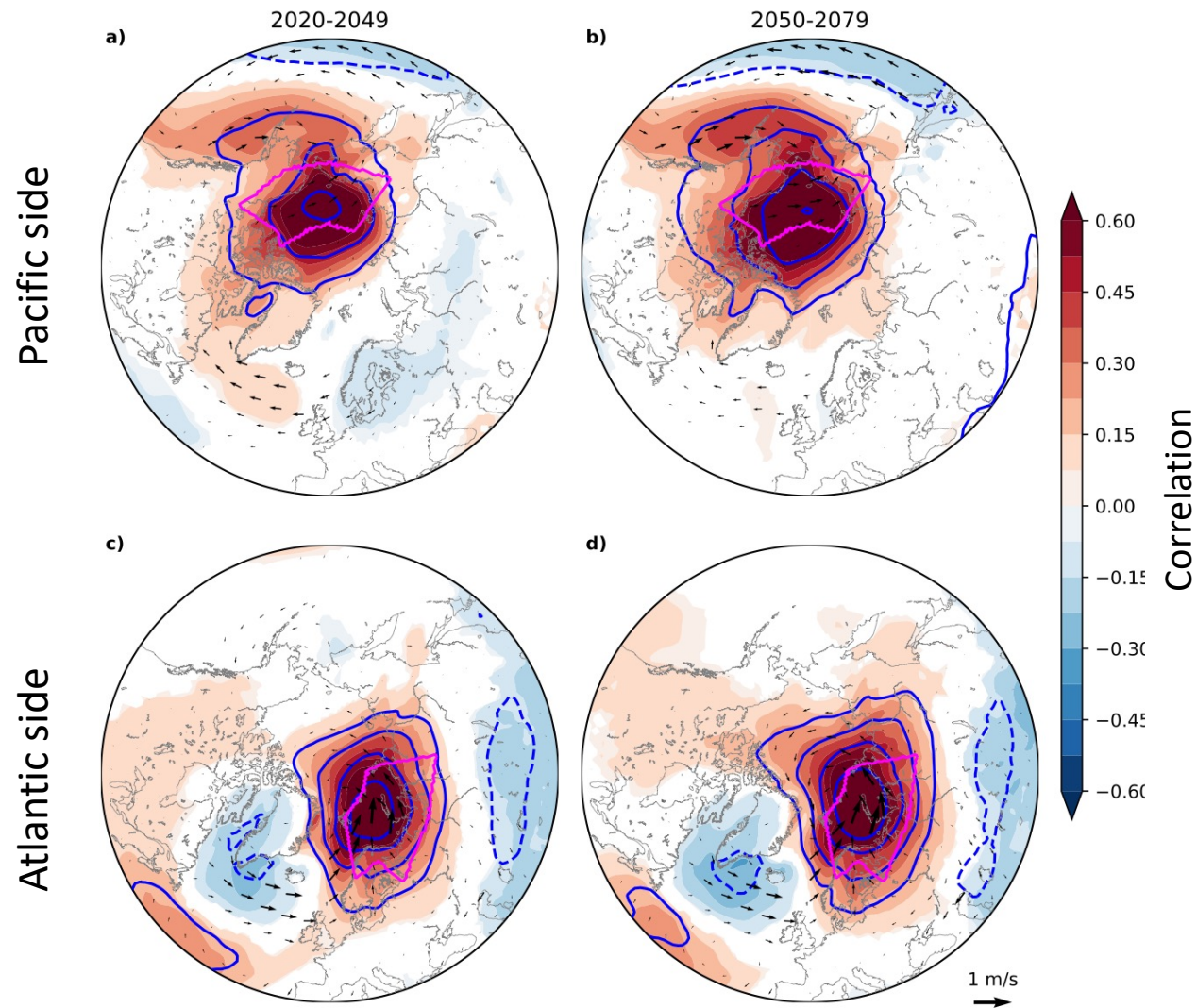
Additional: Annual mean river runoff in CESM



Additional: As slide 8, but for individual seas



Additional: Atmospheric advection pathways



Contours: correlation of sea-ice area with precipitable water (0.15 steps)
Filled contours: correlation of sea-ice area with surface air temperature