Present and future influence of ocean heat transport on Arctic winter sea ice variability

Jakob Dörr, Marius Årthun, Tor Eldevik, Erica Madonna

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the Nansen LEGACY

BJERKNES CENTRE for Climate Research

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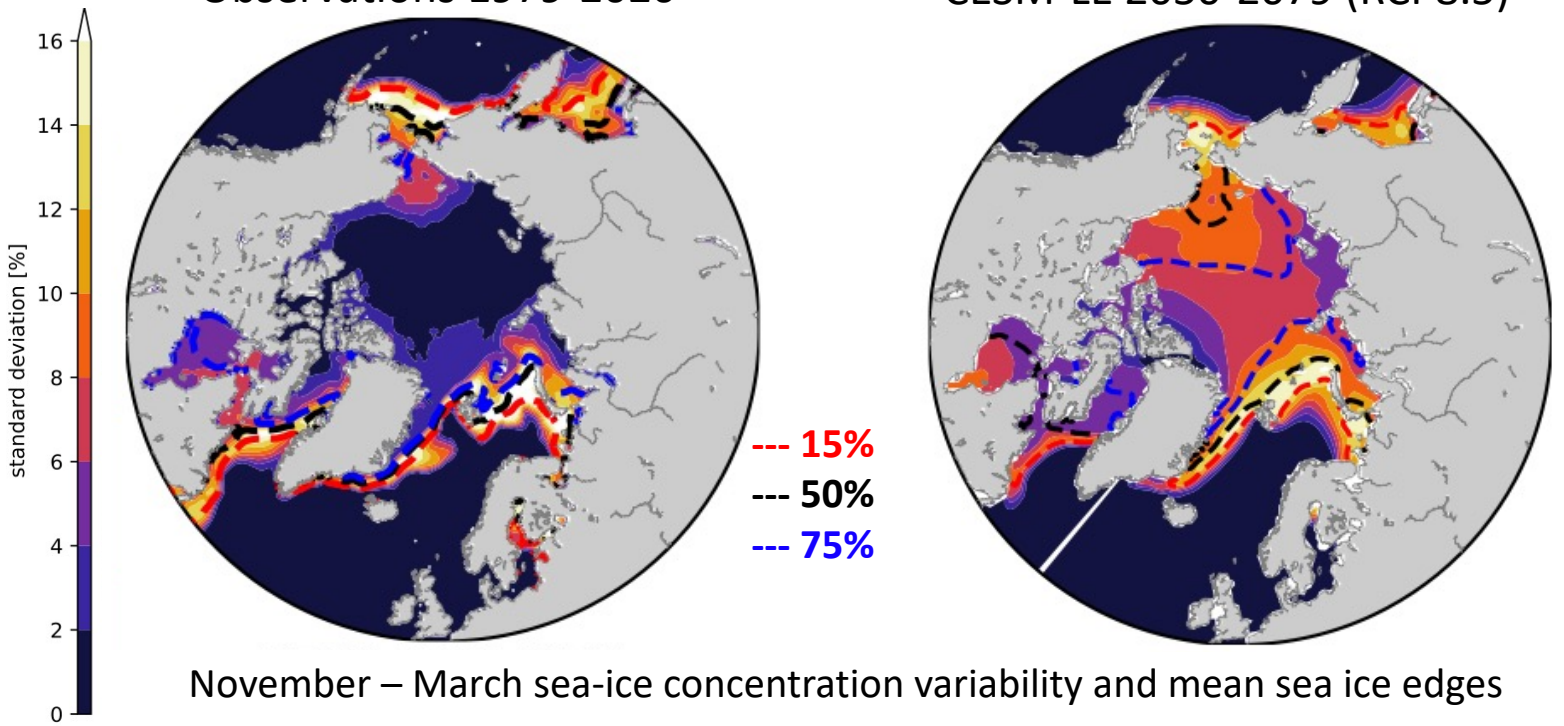
Present and future winter sea-ice loss and variability

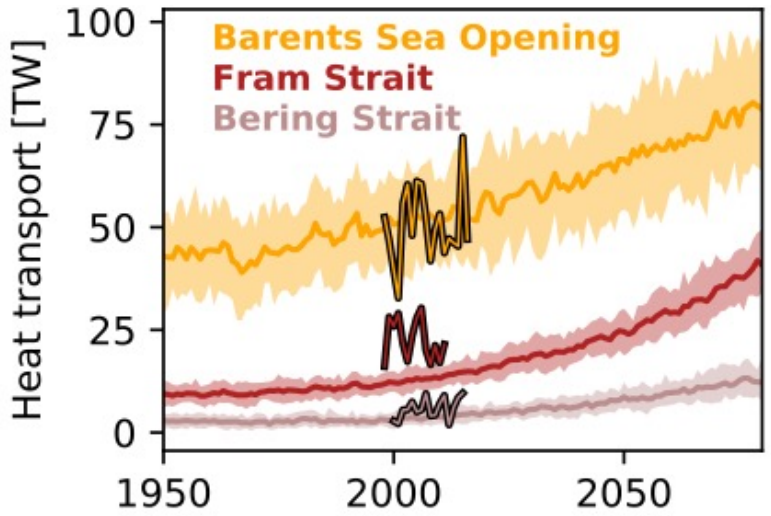
- Winter sea ice loss is overlaid by internal variability
- Most winter concentration variability currently located in the Barents and Bering Seas
- future ice loss and variability expand towards more central regions
- Winter sea ice is influenced by Fram Strait, Barents Sea Opening and Bering Strait heat transport

How will the influence of ocean heat transport on winter sea ice variability change in the future?



November – March sea-ice concentration variability and mean sea ice edges

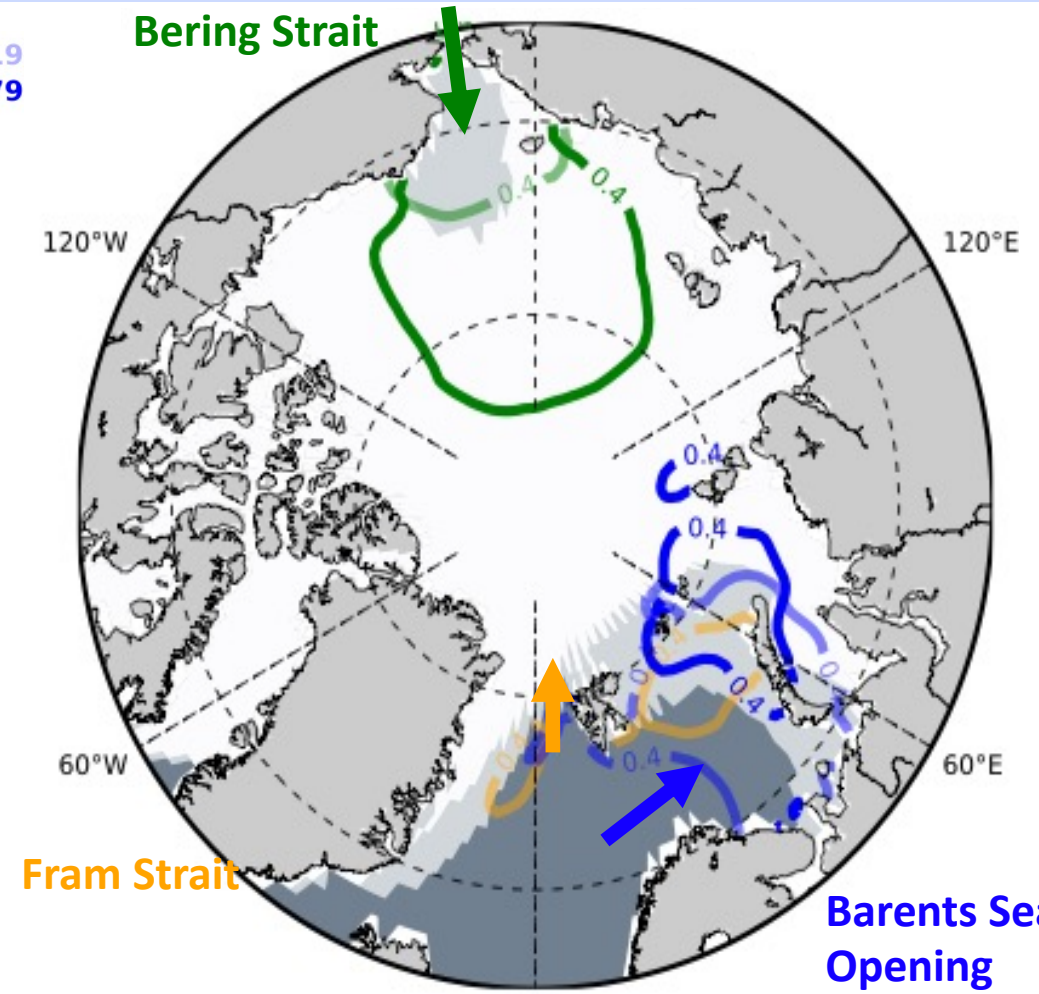
Ocean heat transport and winter sea ice in CESM-LE



Barents Sea Opening 1990-2019
Barents Sea Opening 2050-2079
Bering Strait 1990-2019
Bering Strait 2050-2079
Fram Strait 1990-2019
Fram Strait 2050-2079

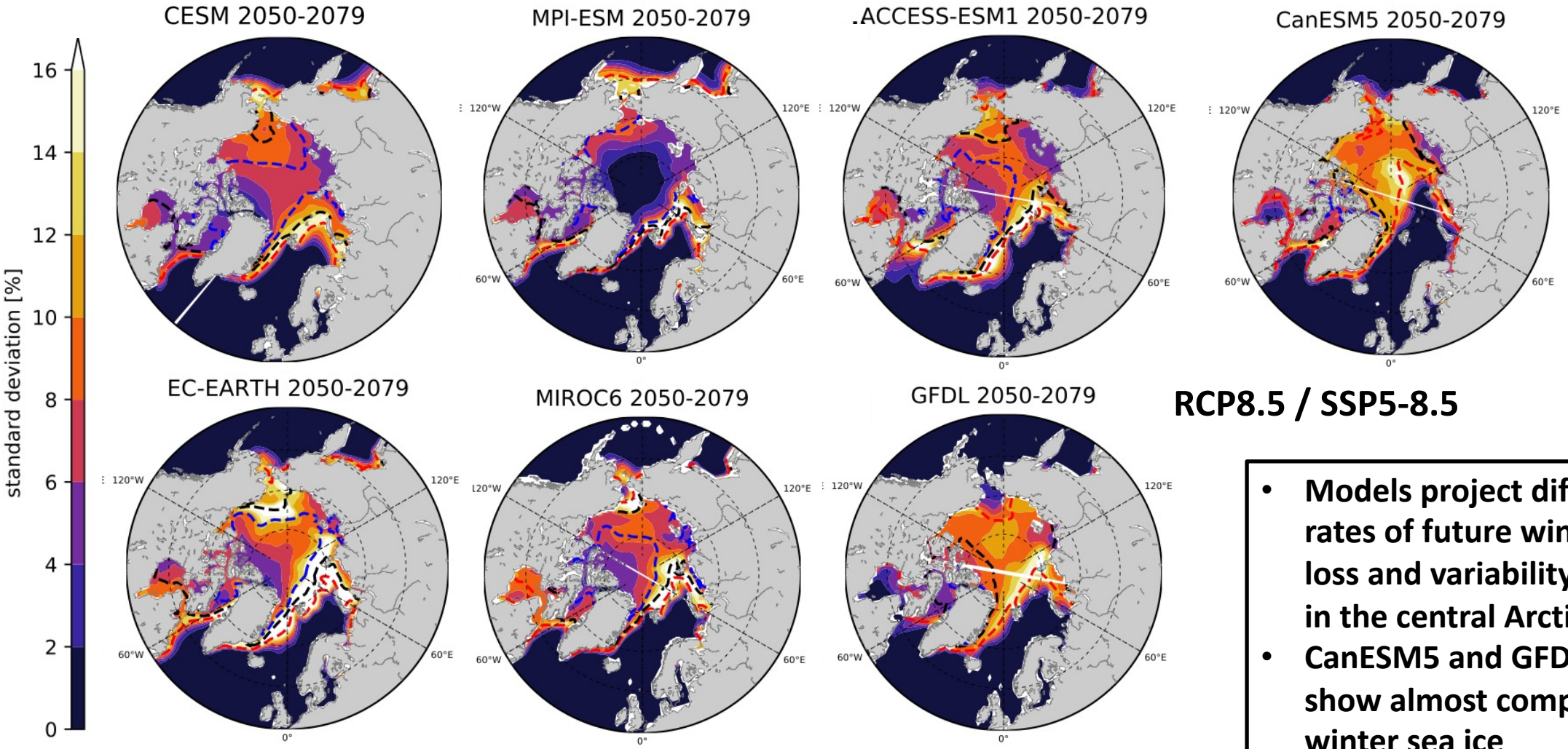
Time series of annual mean heat transport (0˚C ref temp.) in CESM-LE and observations

- **CESM-LE projects expansion of influence of ocean heat transport through the Bering Strait and the Barents Sea Opening**
- **Fram Strait ocean heat transport has limited (direct) future influence on winter sea ice**
- **Do other models project similar expansions?**



Correlation of annual mean heat transport and winter sea ice concentration. Grey and white filled contours show present and future sea ice edge

Sea ice loss and variability for different models

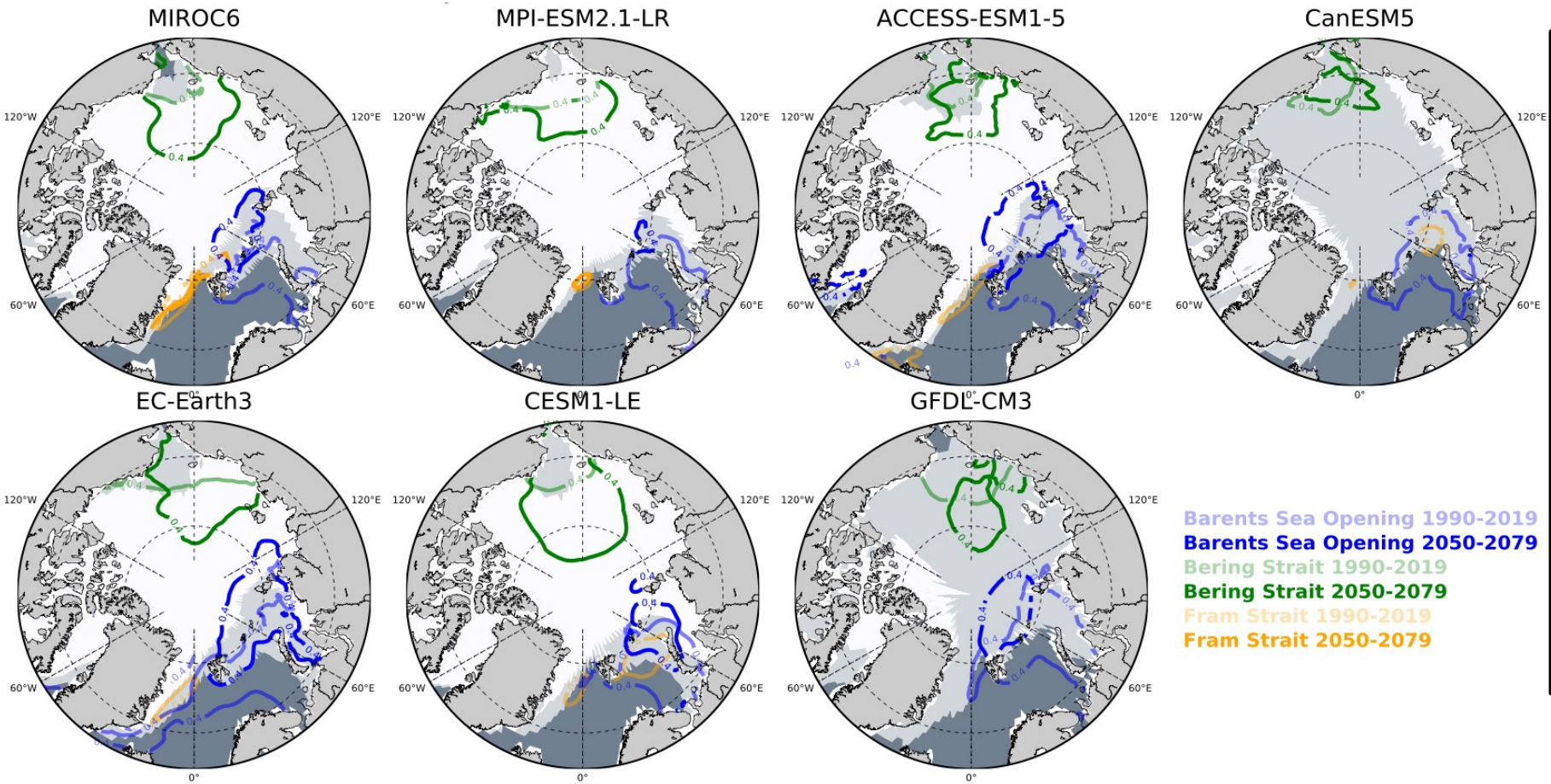


RCP8.5 / SSP5-8.5

November – March sea-ice concentration variability and mean sea ice edges

- **Models project different rates of future winter sea ice loss and variability increase in the central Arctic**
- **CanESM5 and GFDL-CM3 show almost complete loss of winter sea ice**

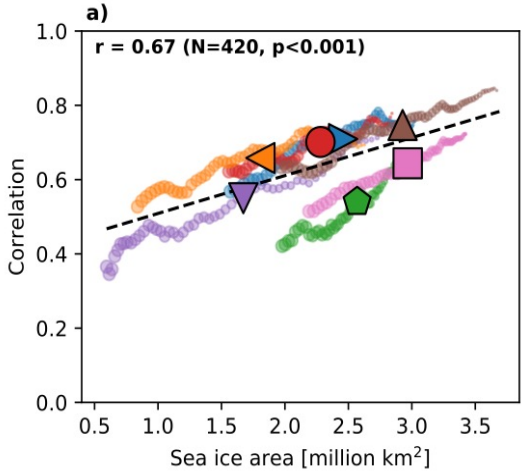
Ocean heat transport and winter sea ice in 7 models

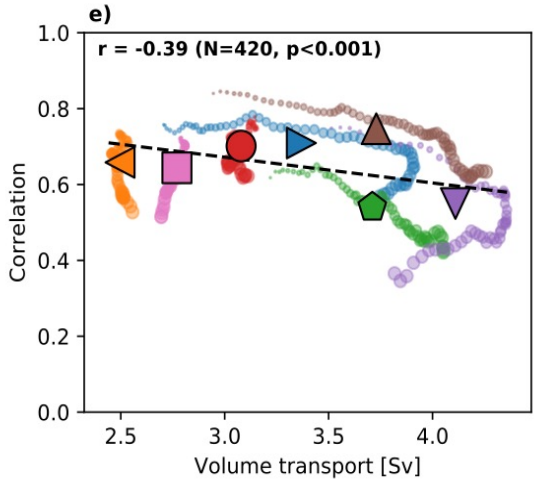


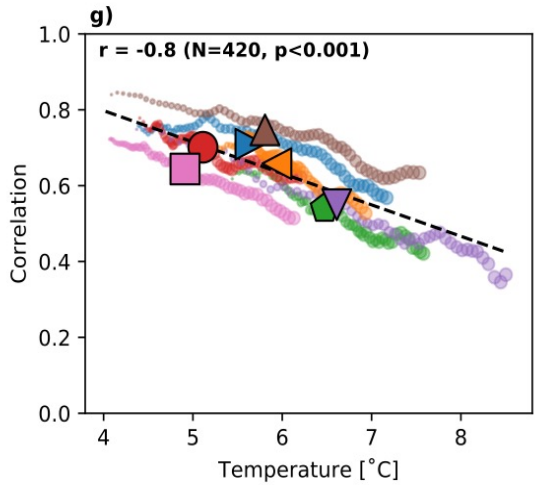
- **Models agree on expanding influence of Bering Strait and Barents Sea Opening heat transport**
- **Fram Strait heat transport has limited influence in all models**
- **Model differences are larger for the Barents Sea Opening**
- **What are model differences dependent on?**

Where do model differences come from?

Atlantic Side

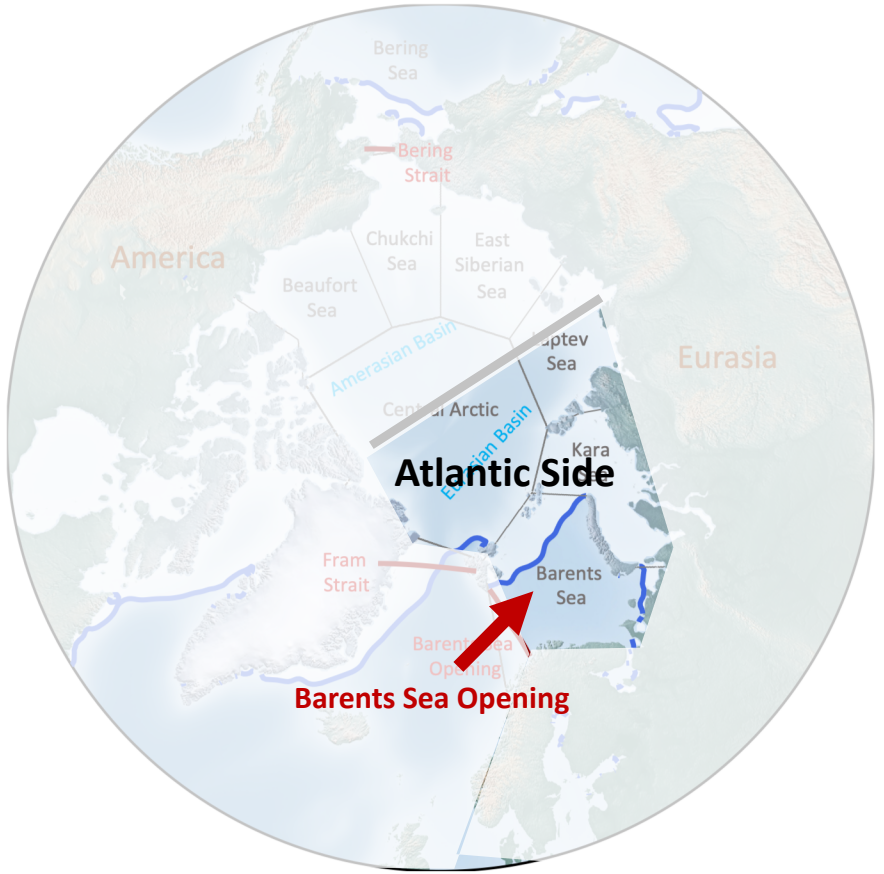






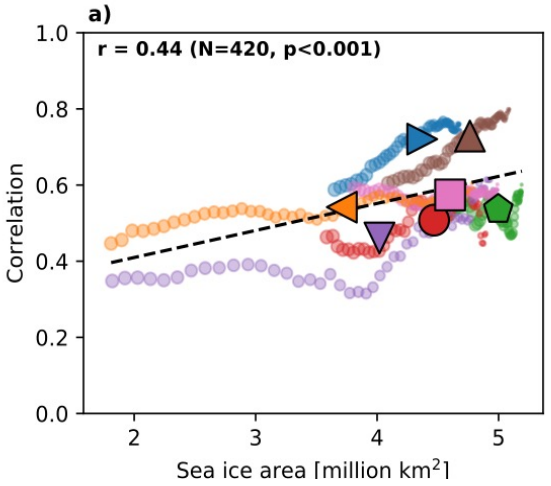
- **Influence of Barents Sea Opening heat transport depends on mean sea ice area and inflow temperature (a, g)**

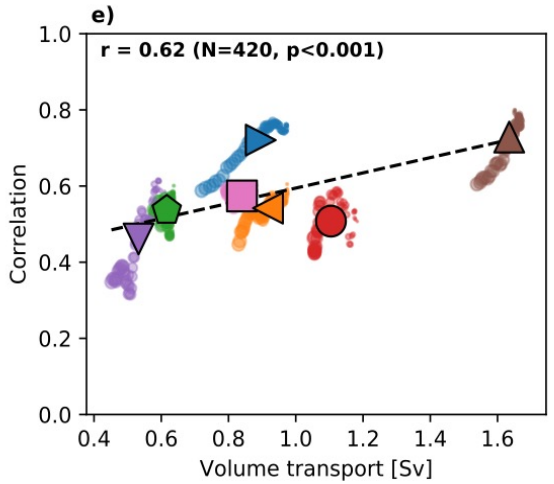
MIROC6
GFDL-CM3
MPI-ESM1-2-LR
ACCESS-ESM1-5
CanESM5
EC-Earth3
CESM-LE

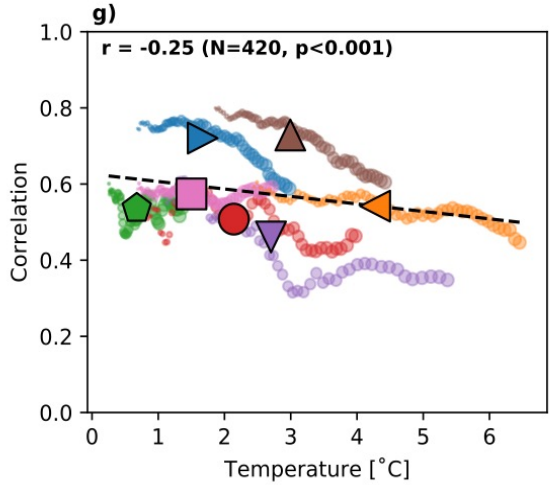


Correlation between Atlantic side winter sea ice area and Barents Sea Opening heat transport as a function of mean sea ice area, mean volume transport and mean inflow temperature. Each small dot represents a 30-yr period (going from 1990-2019 to 2050-2079) for a model, big markers show mean over all periods.

Where do model differences come from? Pacific Side

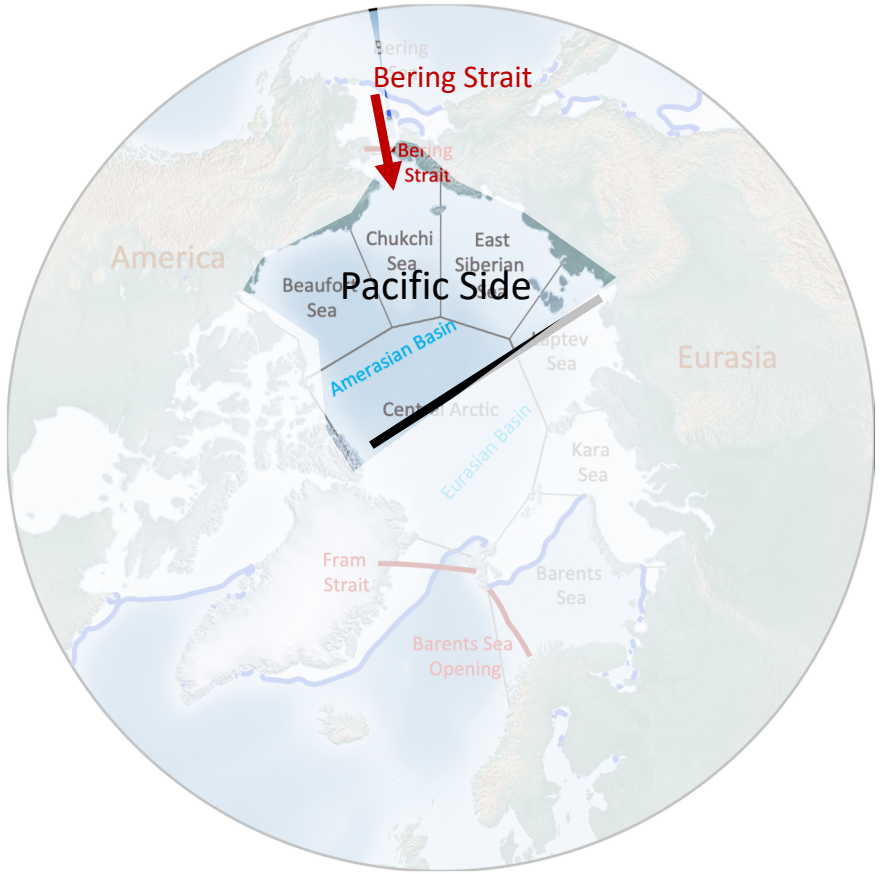






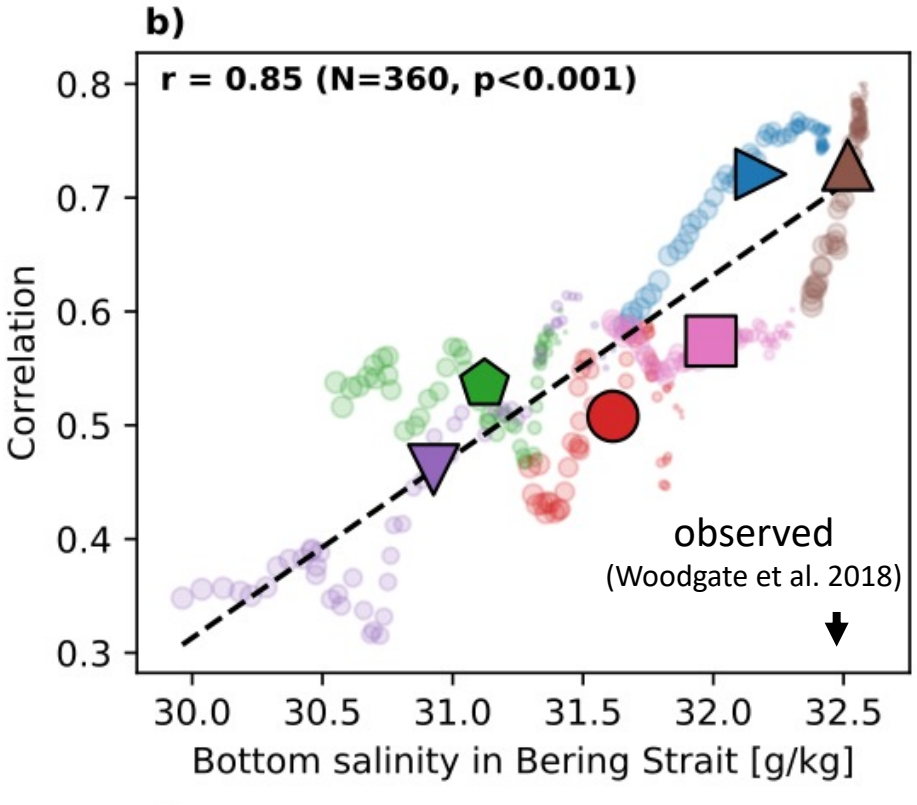
- **Influence of Bering Strait heat transport depends on mean volume transport, and to a limited extent on mean sea ice area**

MIROC6
GFDL-CM3
MPI-ESM1-2-LR
ACCESS-ESM1-5
CanESM5
EC-Earth3
CESM-LE



Correlation between Pacific side winter sea ice area and Bering Strait heat transport as a function of mean sea ice area, mean volume transport and mean inflow temperature. Each small dot represents a 30-yr period (going from 1990-2019 to 2050-2079) for a model, big markers show mean over all periods.

Where do model differences come from? Pacific Side

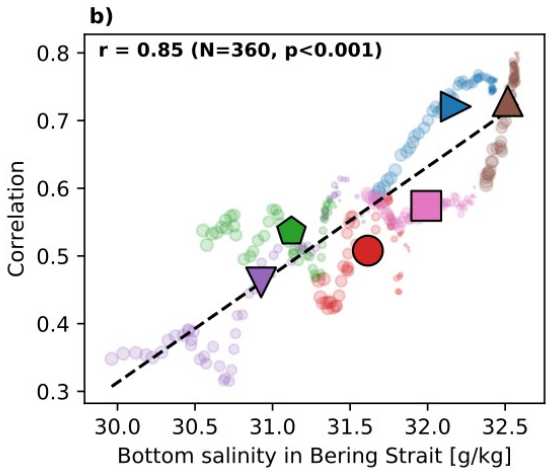


- **Influence of Bering Strait heat transport strongly depends on Bering Strait salinity**
- **This could be related to the vertical stratification on the Chuckhi shelf and the entire Arctic Ocean**

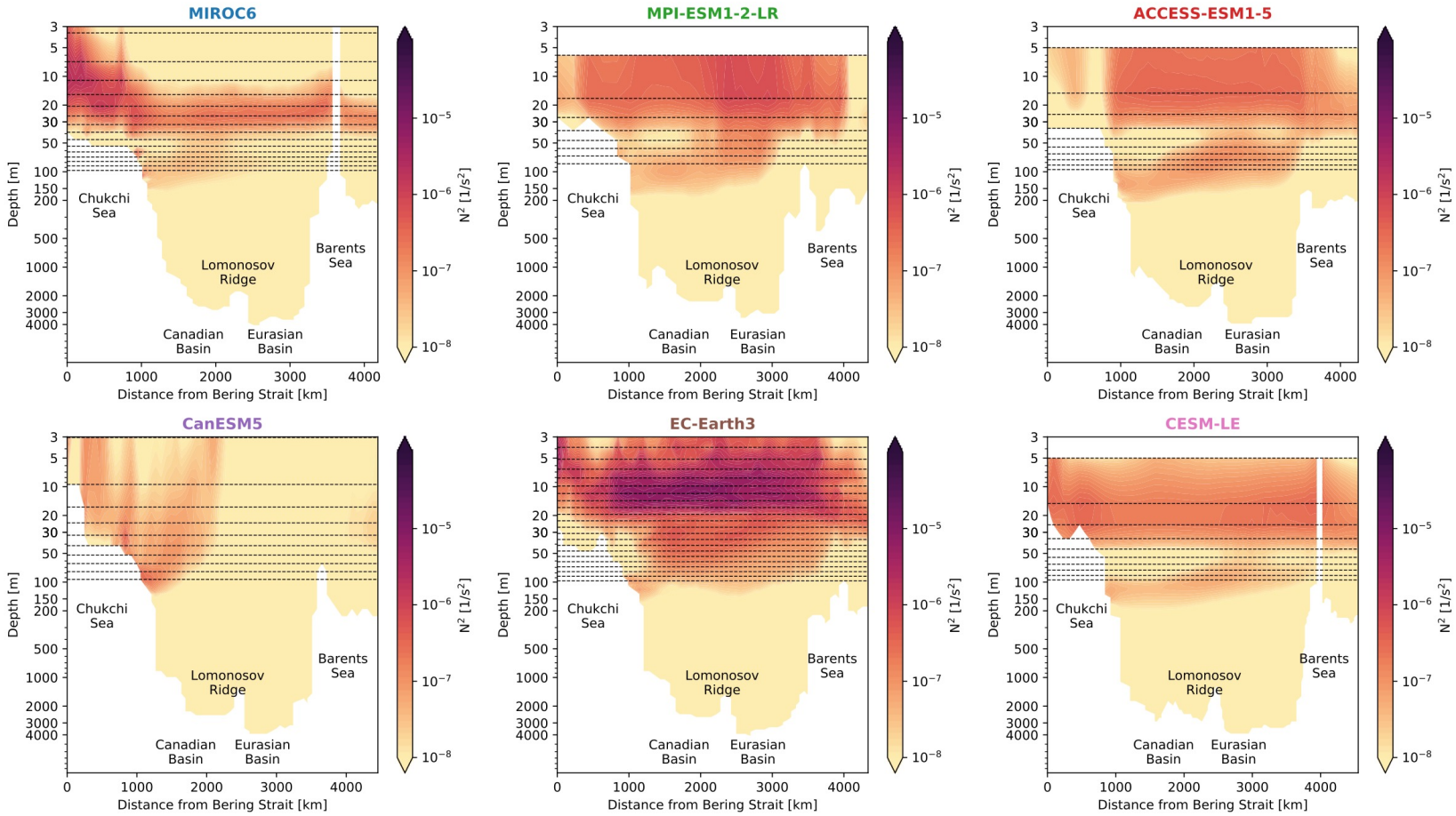
Correlation between Pacific side winter sea ice area and Bering Strait heat transport as a function of mean bottom salinity in the Bering Strait. Each small dot represents a 30-yr period (going from 1990-2019 to 2050-2079) for a model, big markers show mean over all periods.

- MIROC6
- GFDL-CM3
- MPI-ESM1-2-LR
- ACCESS-ESM1-5
- CanESM5
- EC-Earth3
- CESM-LE

Summer (JAS) vertical stability across the Arctic Ocean



- **Models with largest influence of Bering Strait ocean heat transport show more pronounced summer surface mixed layer on the Chukchi shelf**
- **Pacific summer water may be better isolated from the surface processes and have a larger influence in the freezing season**



Mean summer (JAS) vertical stability (Brunt Väisälä-Frequency squared) on a cross section through the Arctic Ocean from the Bering Strait to the Barents Sea for the period 2050-2079. Horizontal dashed lines indicate vertical model levels.

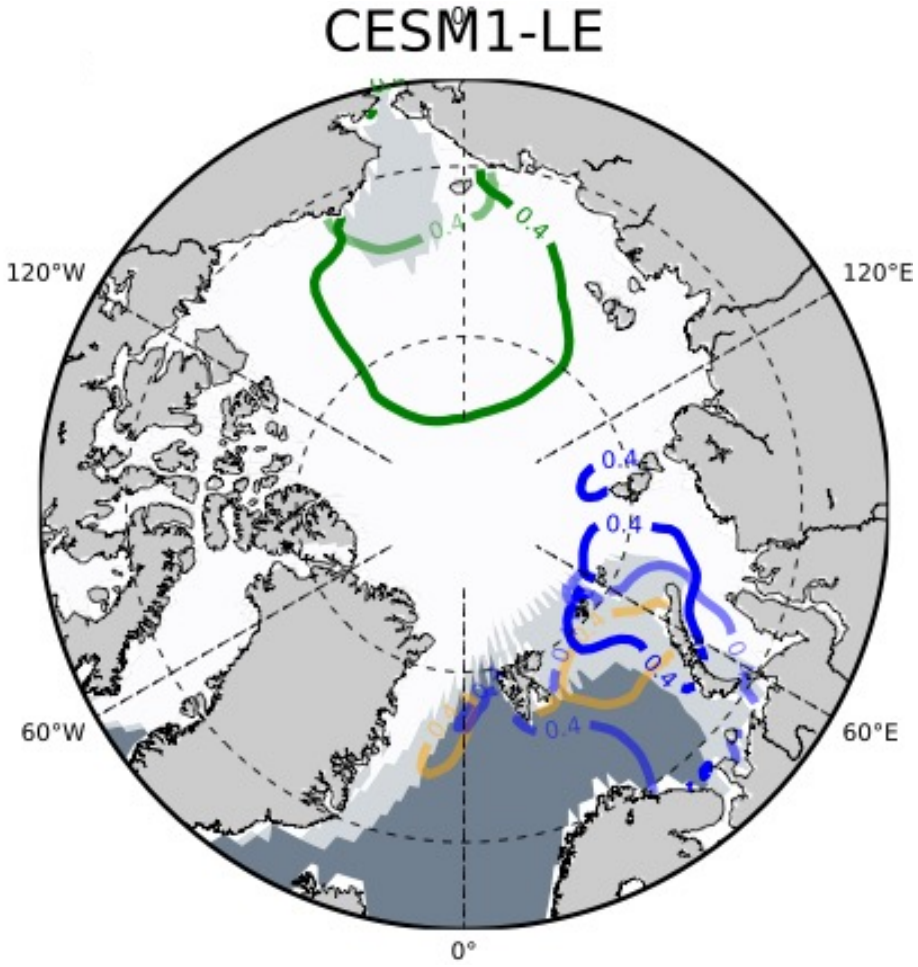
Conclusions

Present and future influence of ocean heat transport on Arctic winter sea ice variability

- **Expanding influence of Atlantic and Pacific inflows** across all models
- Tracer of future **Atlantification, Pacification**

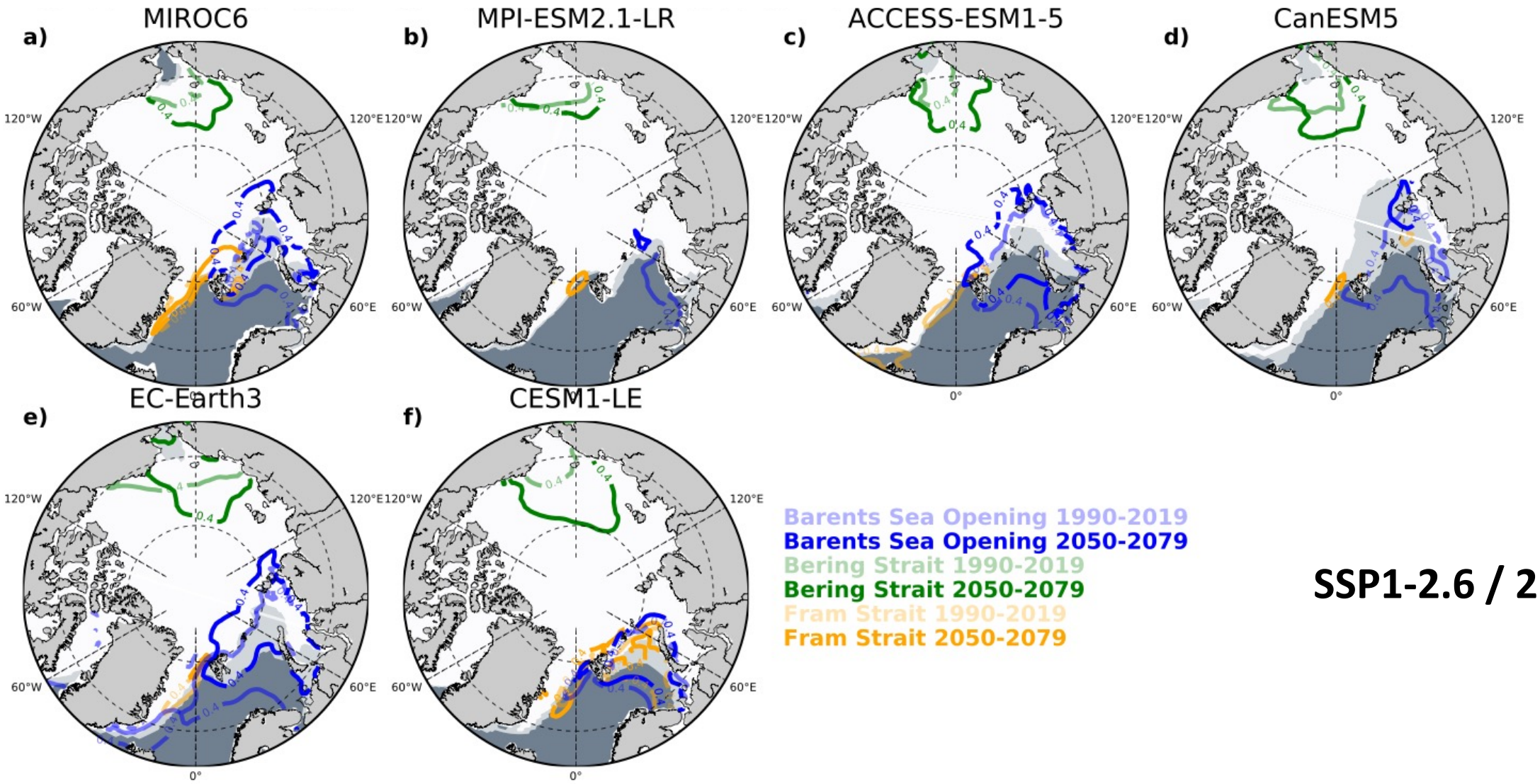
- **Future influence depends on…**
  - Atlantic side: sea ice loss, inflow temperature

  - Pacific Side: volume transport, inflow salinity (and surface stratification)



Additional slide:
Changes in influence under low warming scenarios

Ocean heat transport and winter sea ice for low warming



SSP1-2.6 / 2˚C