

The importance of internal variability in simulated 21st century sea ice loss

CESM Workshop: PCWG session
Breckenridge June 21, 2011

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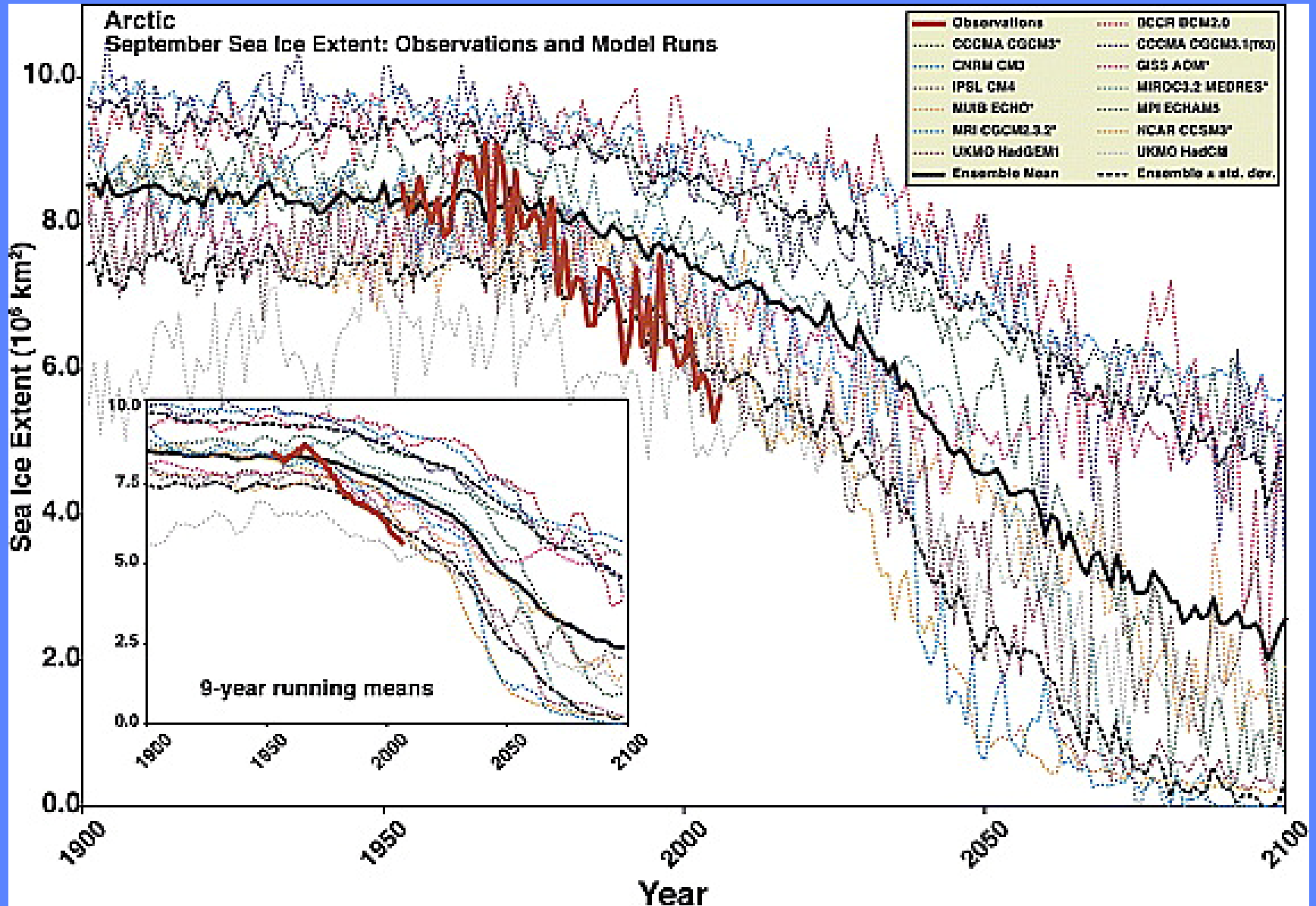
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acknowledgments:

Marika Holland, Adam Phillips, Dennis Shea, Alex Jahn, Jen Kay, Matt Long, Dave Bailey, Gary Strand,

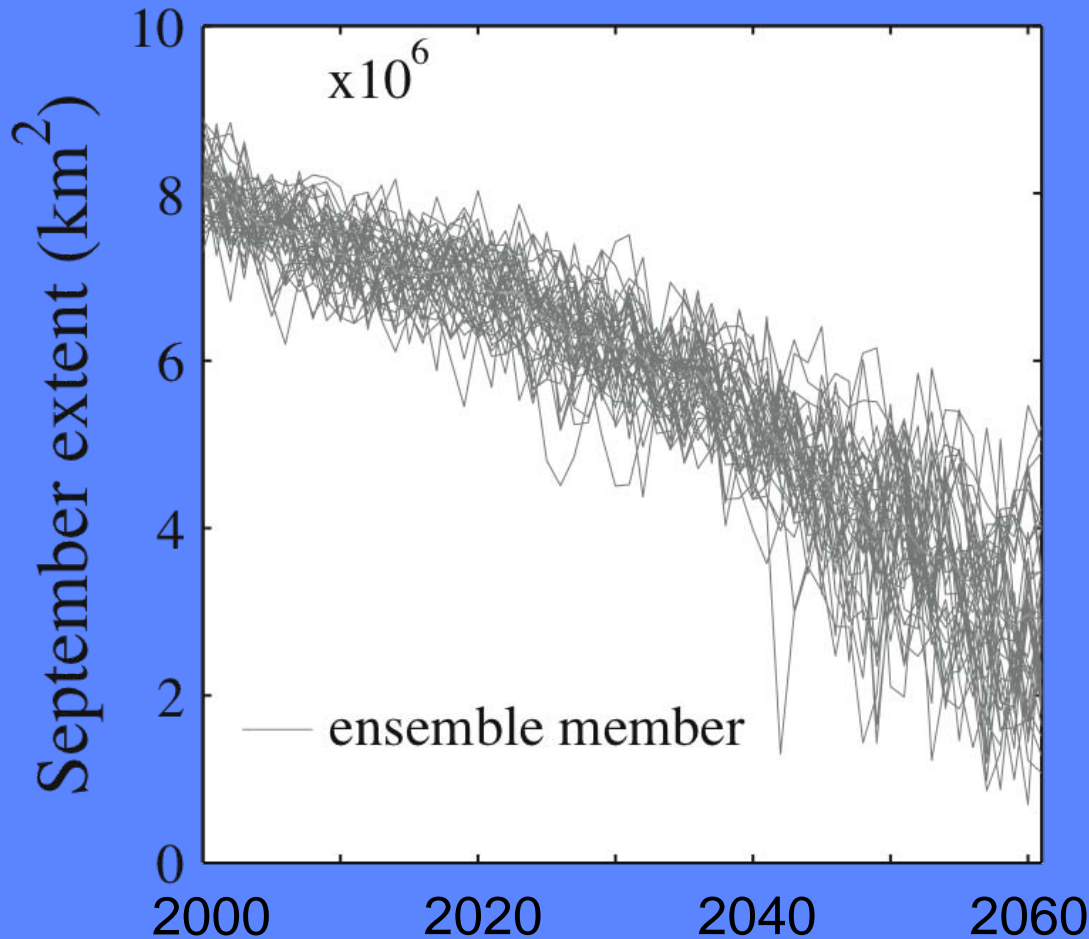


Different sources of variability



Stroeve et al., 2007 GRL (A1B scenarios: 21st century)

Simulated internal variability



NCAR CCSM3:

39-member T42 ensemble

Slightly different atmospheric initial conditions in each ensemble member

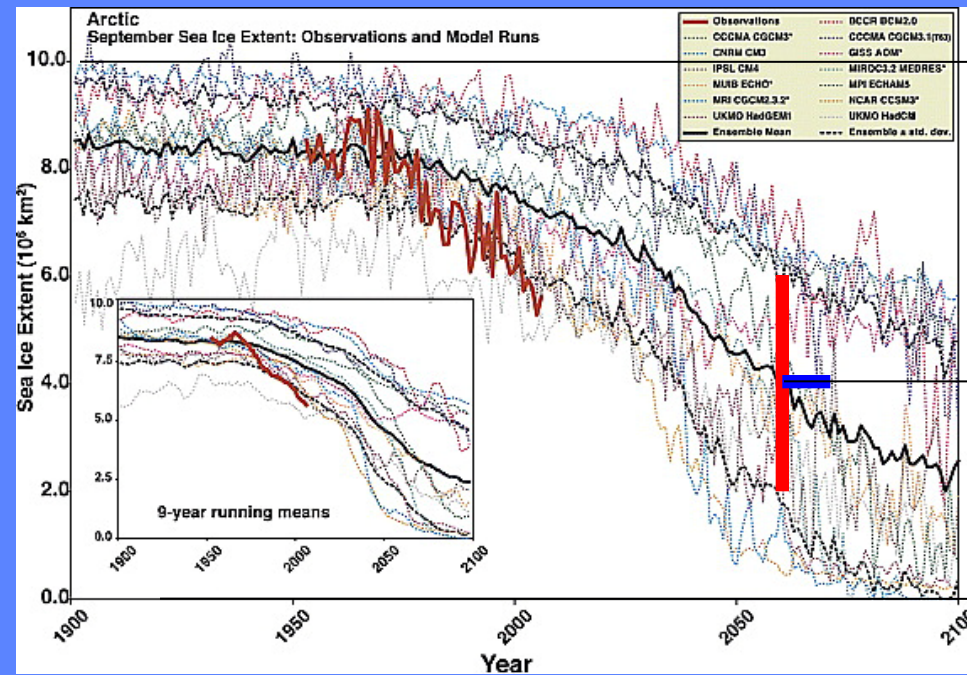
A1B 21st century forcing

Initial ice is a bit too extensive & too thick (but it is not alone...)

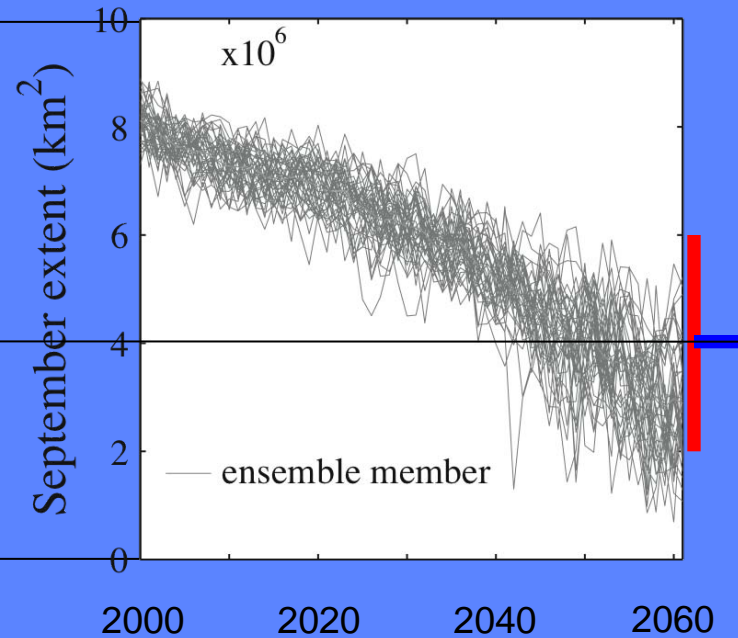
Initial ice is distributed incorrectly

BUT...unique large fully-coupled ensemble

Observed and simulated ice extent



Stroeve et al., 2007 GRL



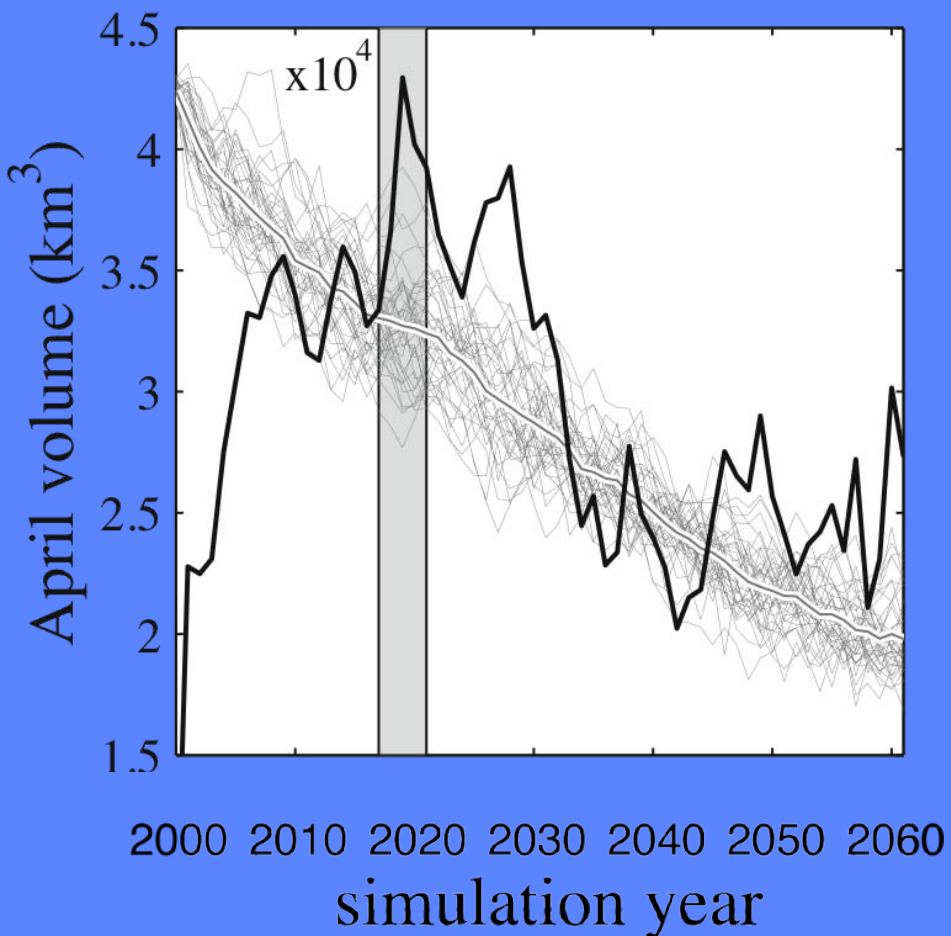
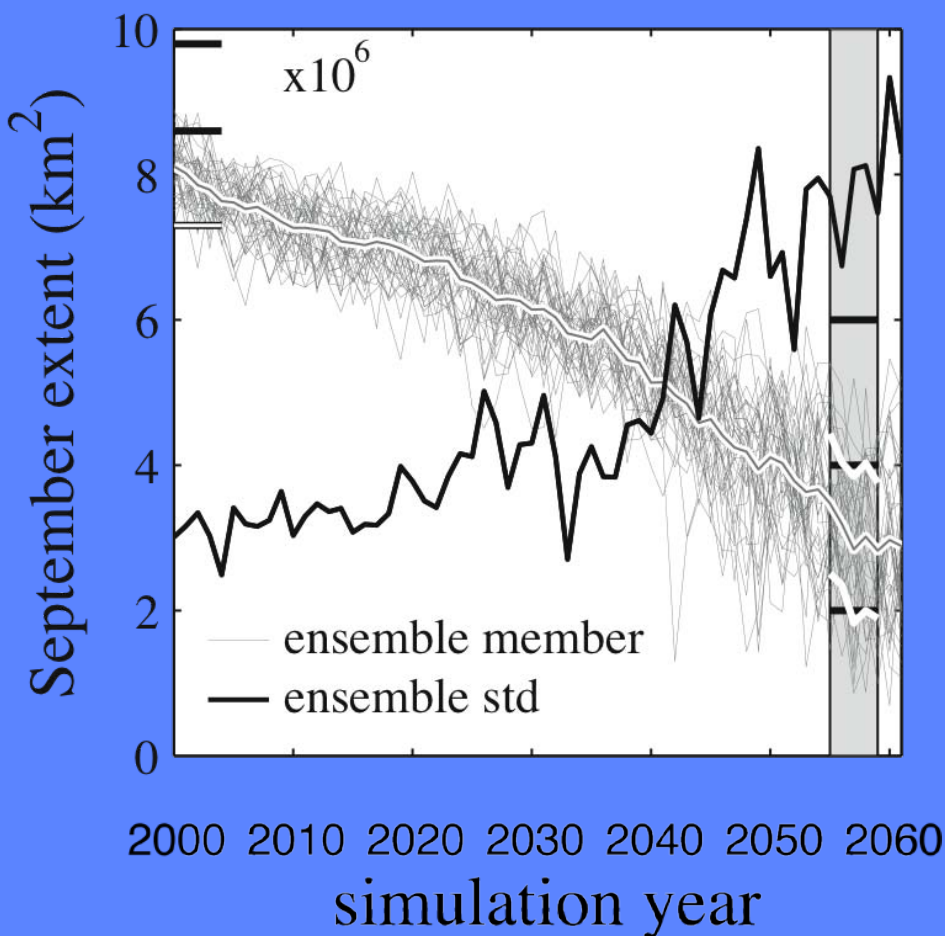
NCAR CCSM3

Of the total $\sim 4 \times 10^6 \text{ km}^2$ intra-model spread, $\sim 2 \times 10^6 \text{ km}^2$ can be traced back to 20th century.

Key result:

Internal variability in CCSM3 is comparable to intra-model 21st century variability.

Min. ice extent and max. volume: CCSM3

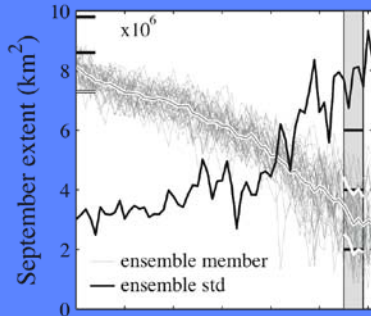


Sept. ice concentration (extent)

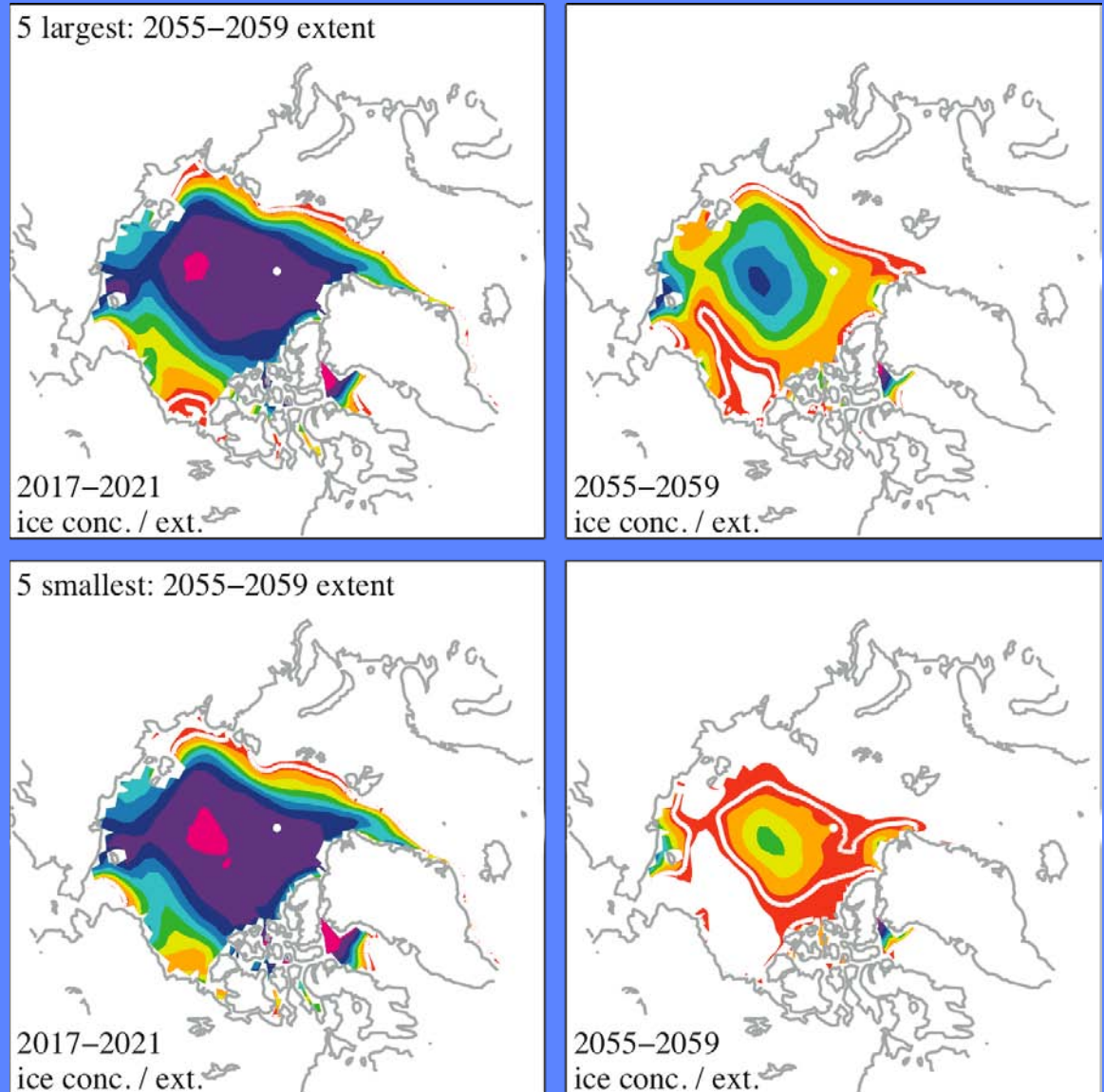
2017-2021

2055-2059

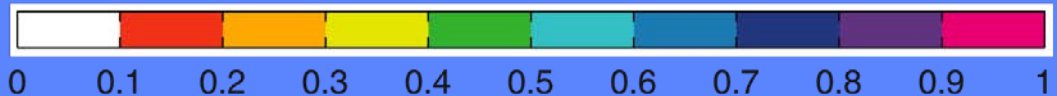
5 ensemble members with the LARGEST 2055-2059 ice extent



5 ensemble members with the SMALLEST 2055-2059 ice extent

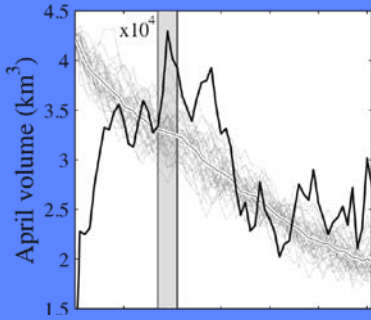


$r_{\text{early,late:39ens}} = -0.19$



April ice thickness, meters (volume)

5 ensemble members with the LARGEST 2017-2021 ice volume

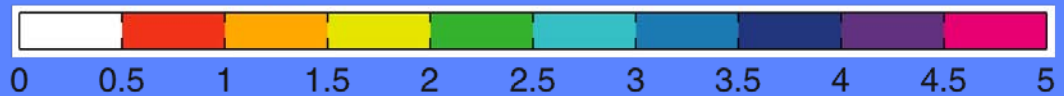
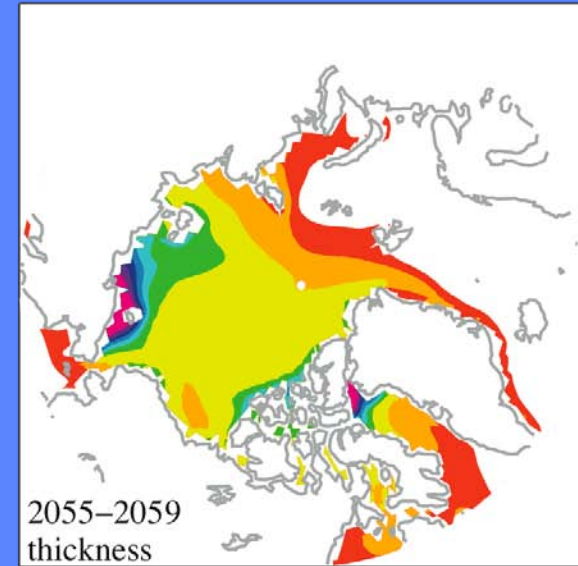
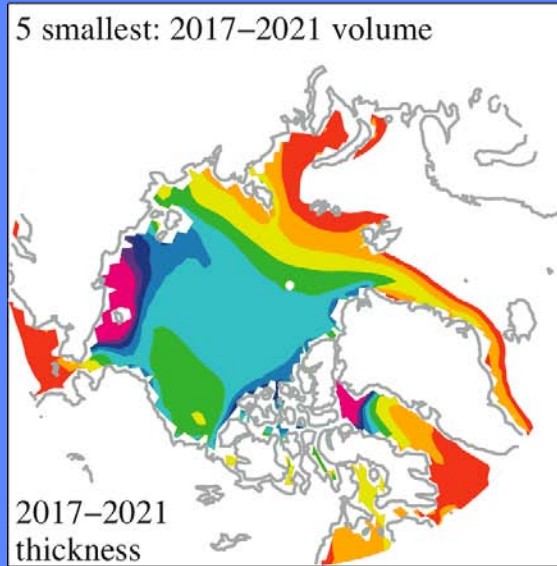
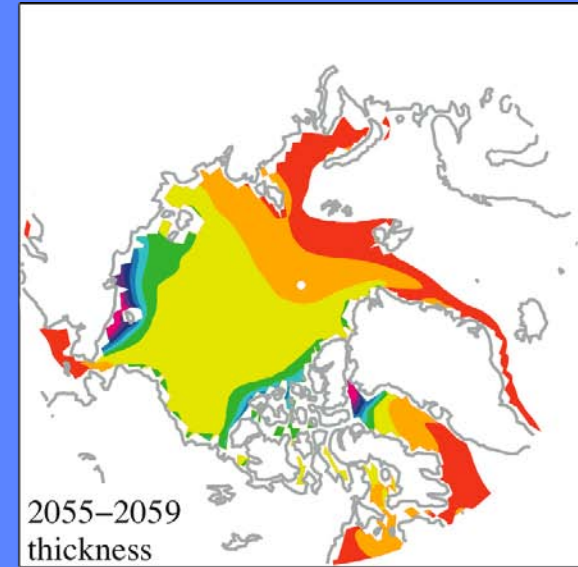
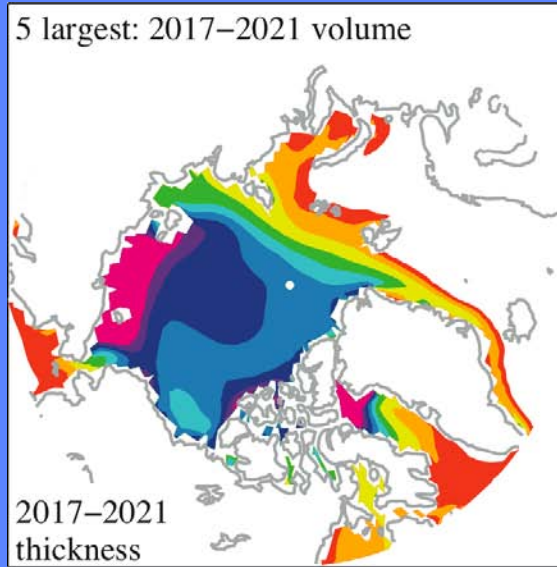


5 ensemble members with the SMALLEST 2017-2021 ice volume

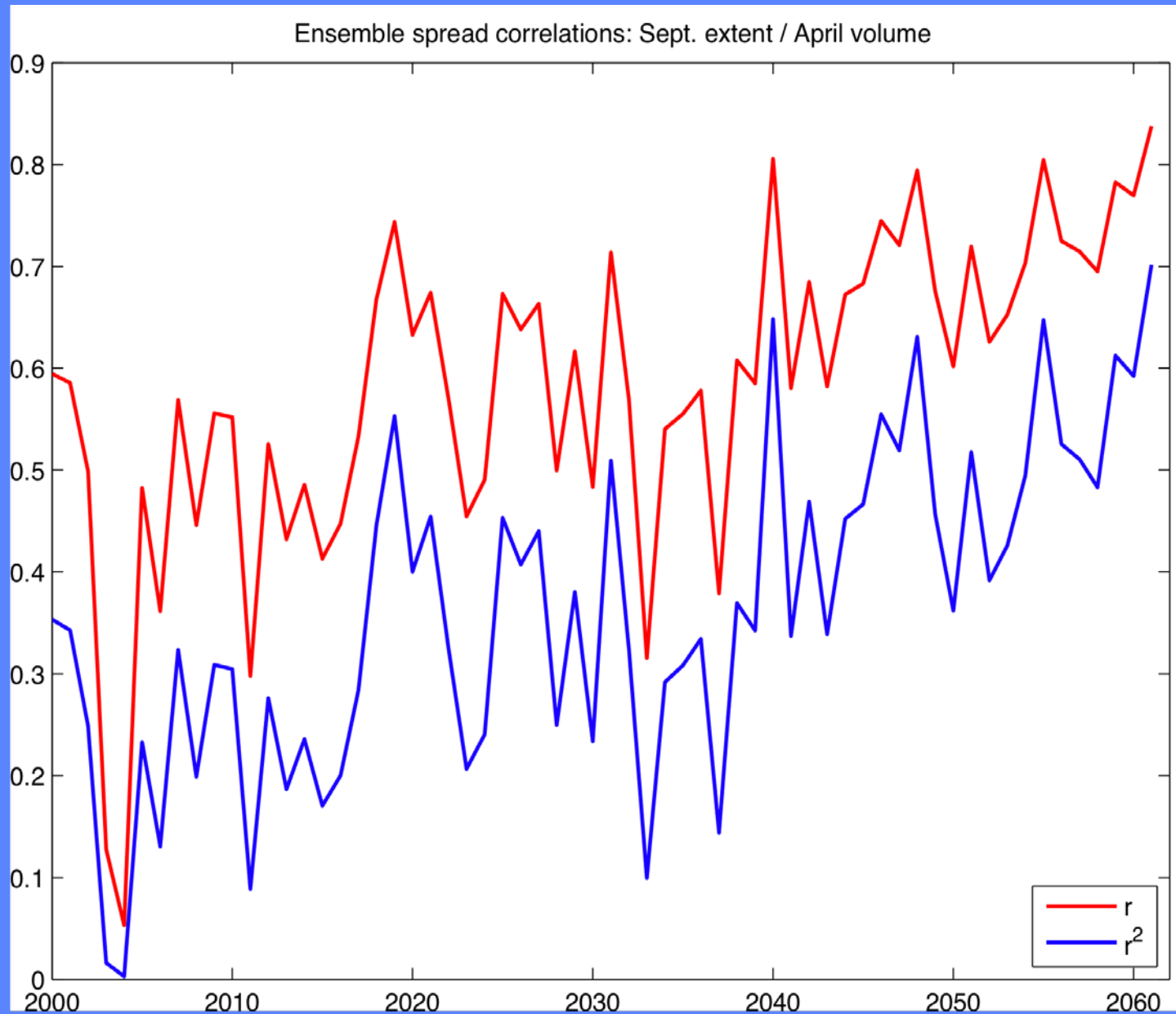
$$r_{\text{early,late:39ens}} = -0.23$$

2017-2021

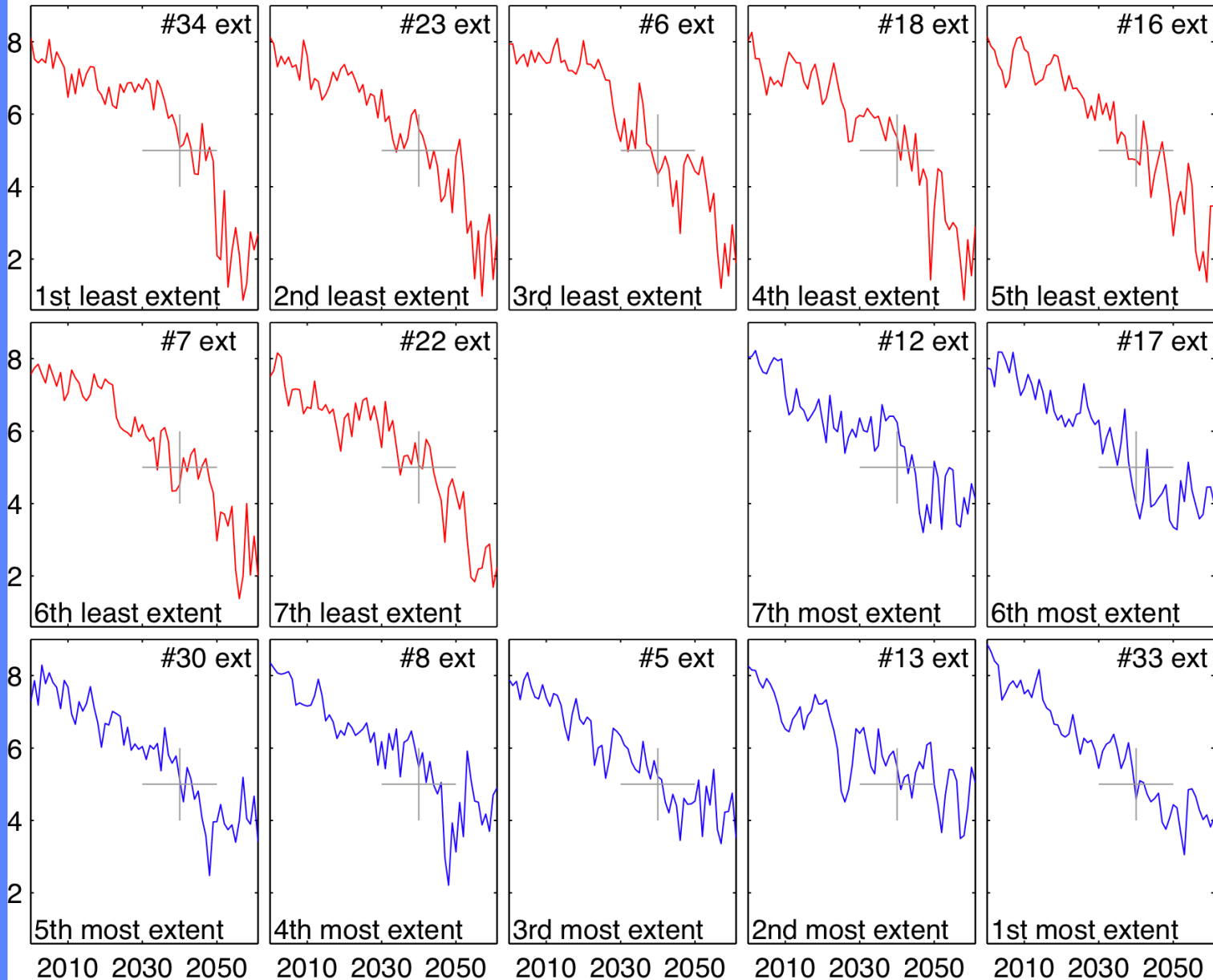
2055-2059



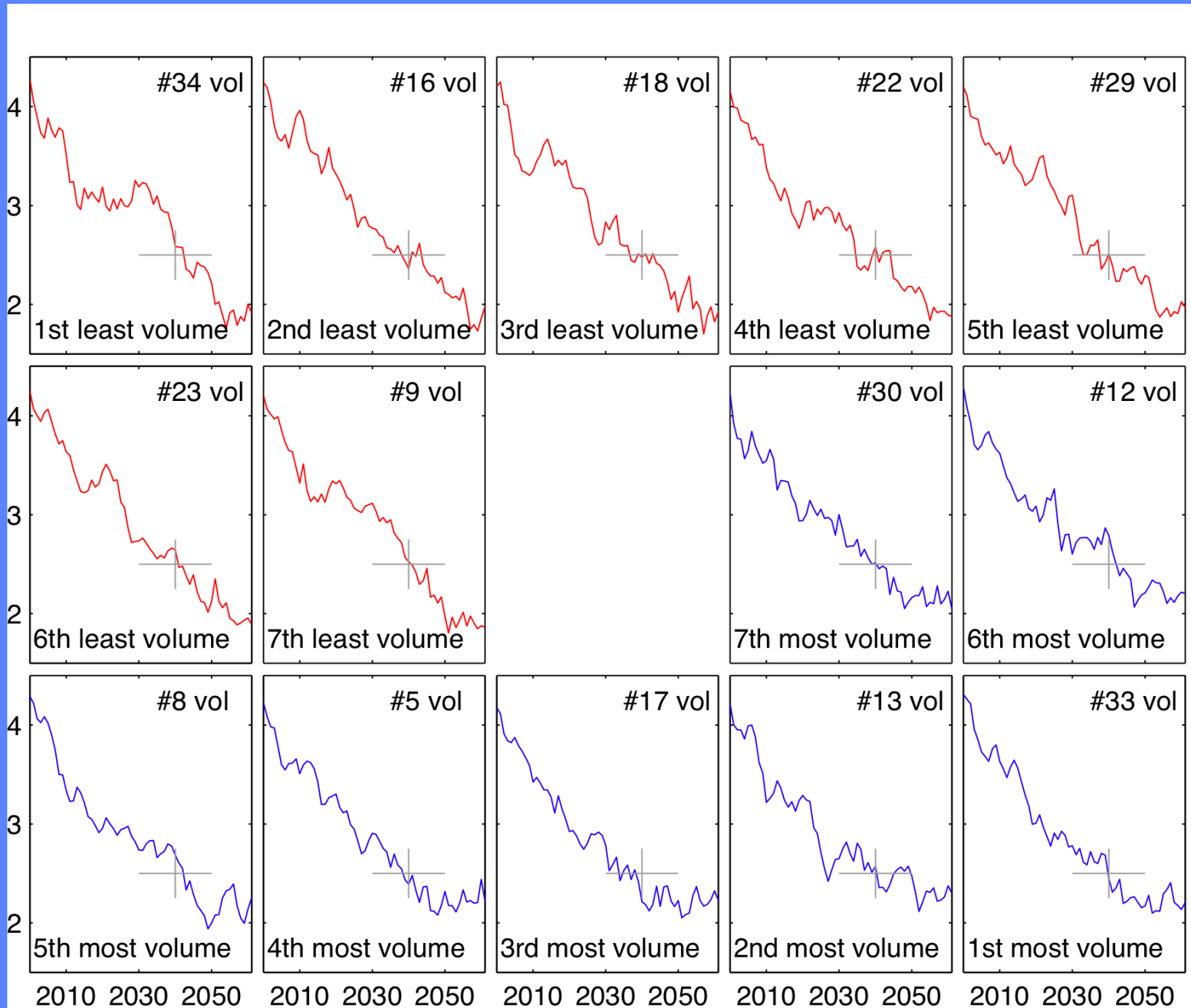
r: September extent / April volume



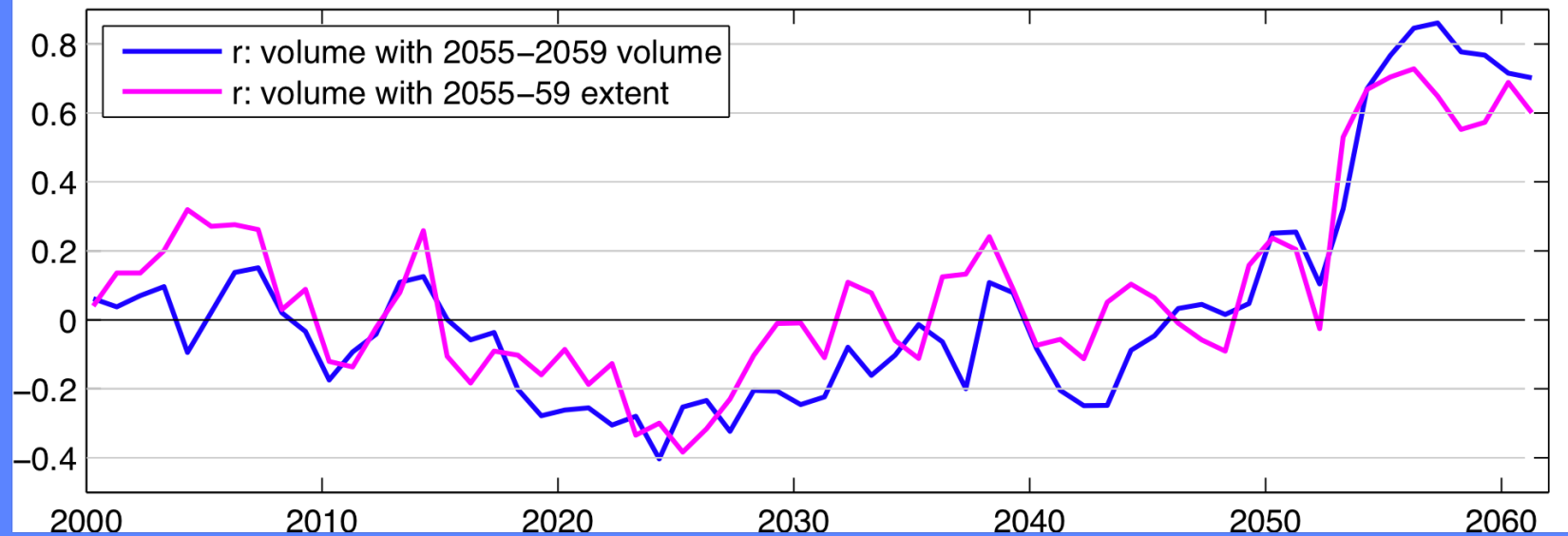
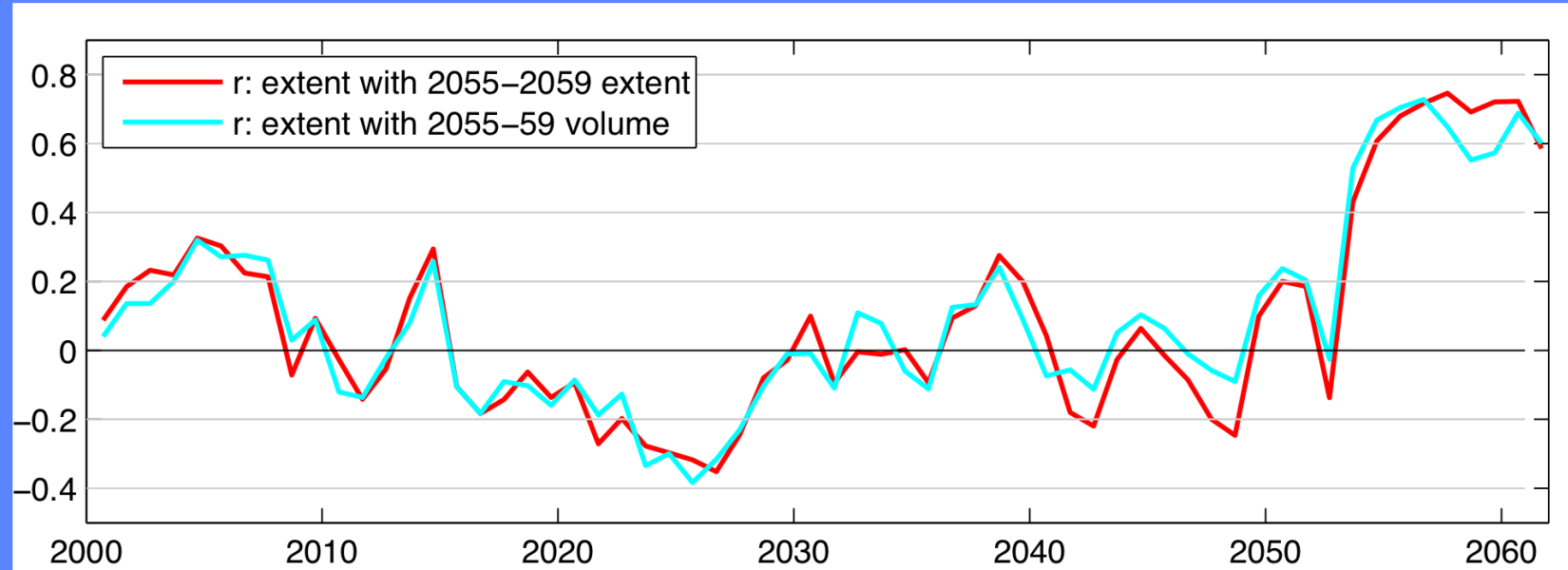
Time evolution: most / least late extent



Time evolution: most / least late volume



Low-frequency ice preconditioning?



THICK

2010s

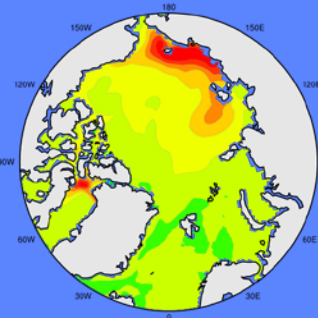
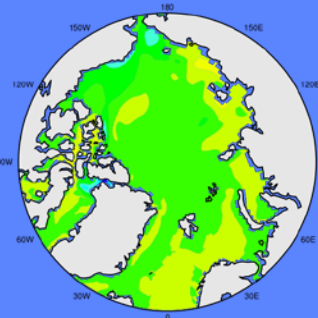
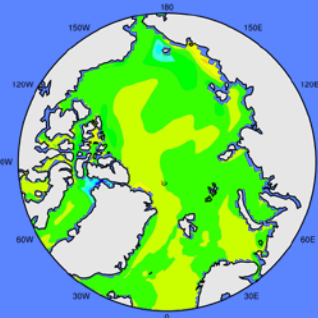
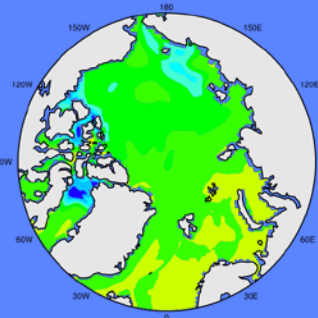
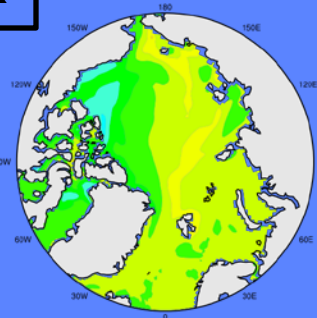
2020s

2030s

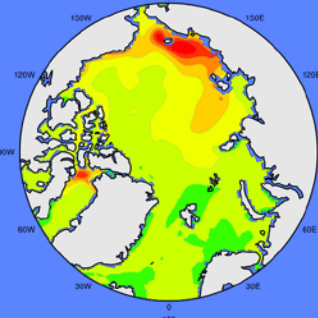
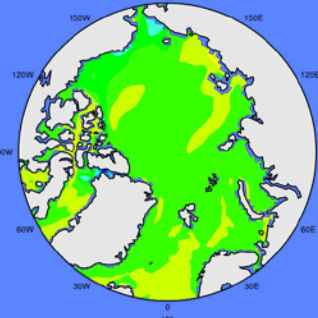
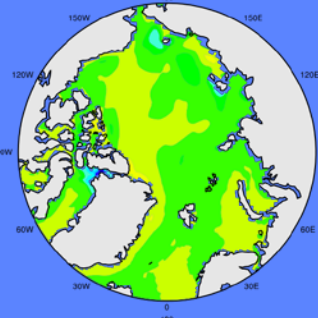
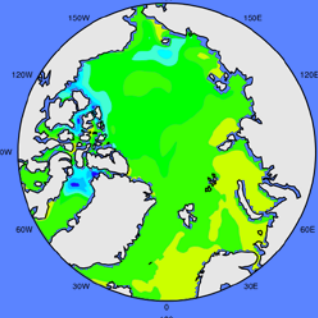
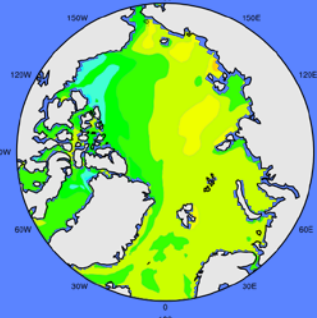
2040s

2050s

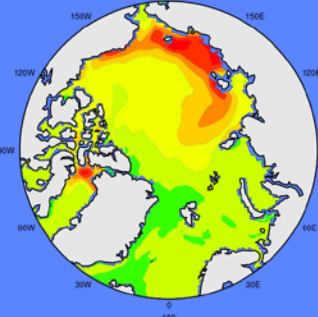
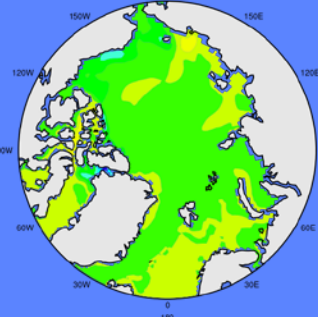
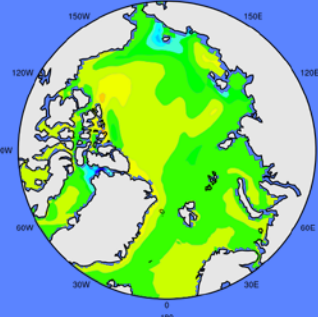
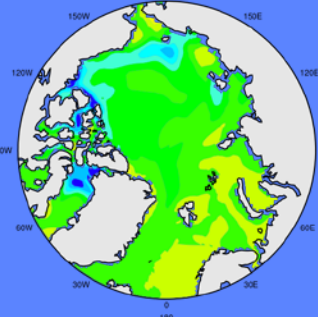
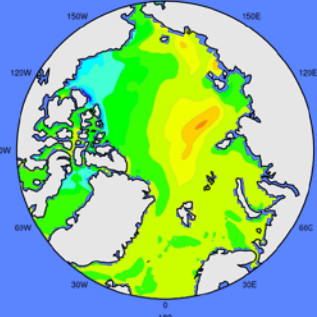
DJF



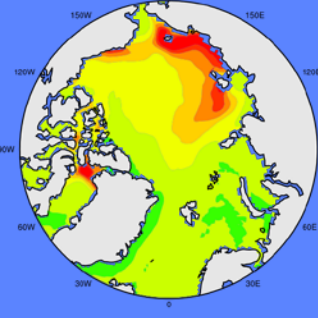
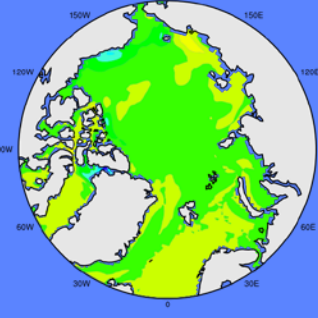
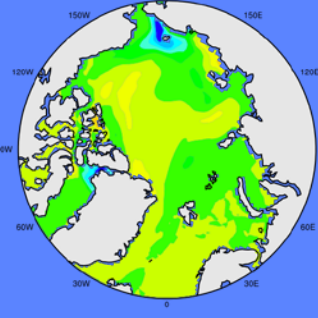
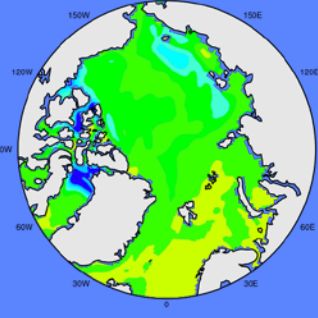
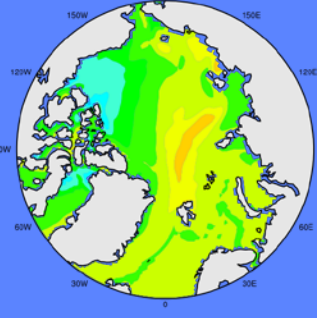
MAM



JJA



SON



SLP

2010s

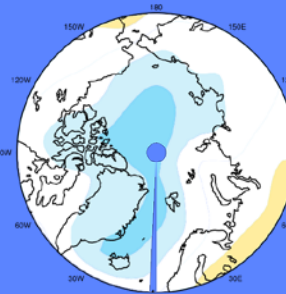
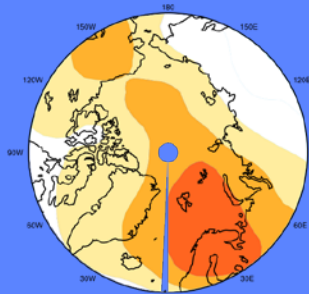
2020s

2030s

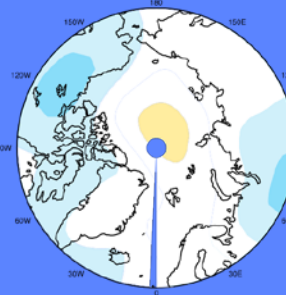
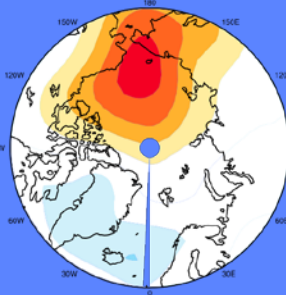
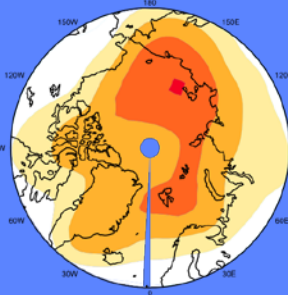
2040s

2050s

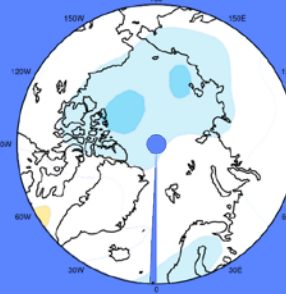
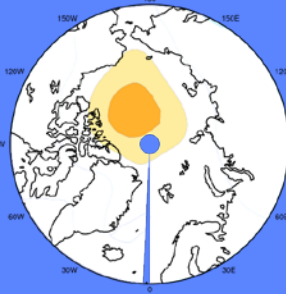
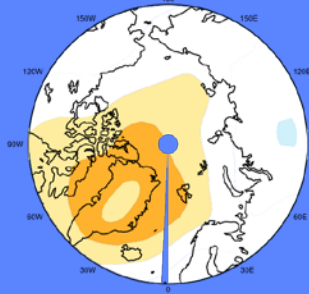
DJF



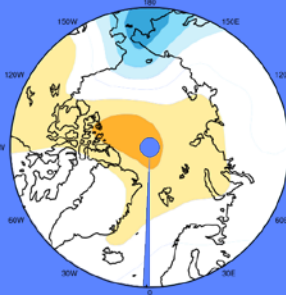
MAM



JJA



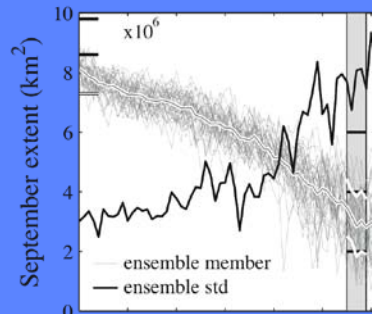
SON



Sea-level pressure anomalies

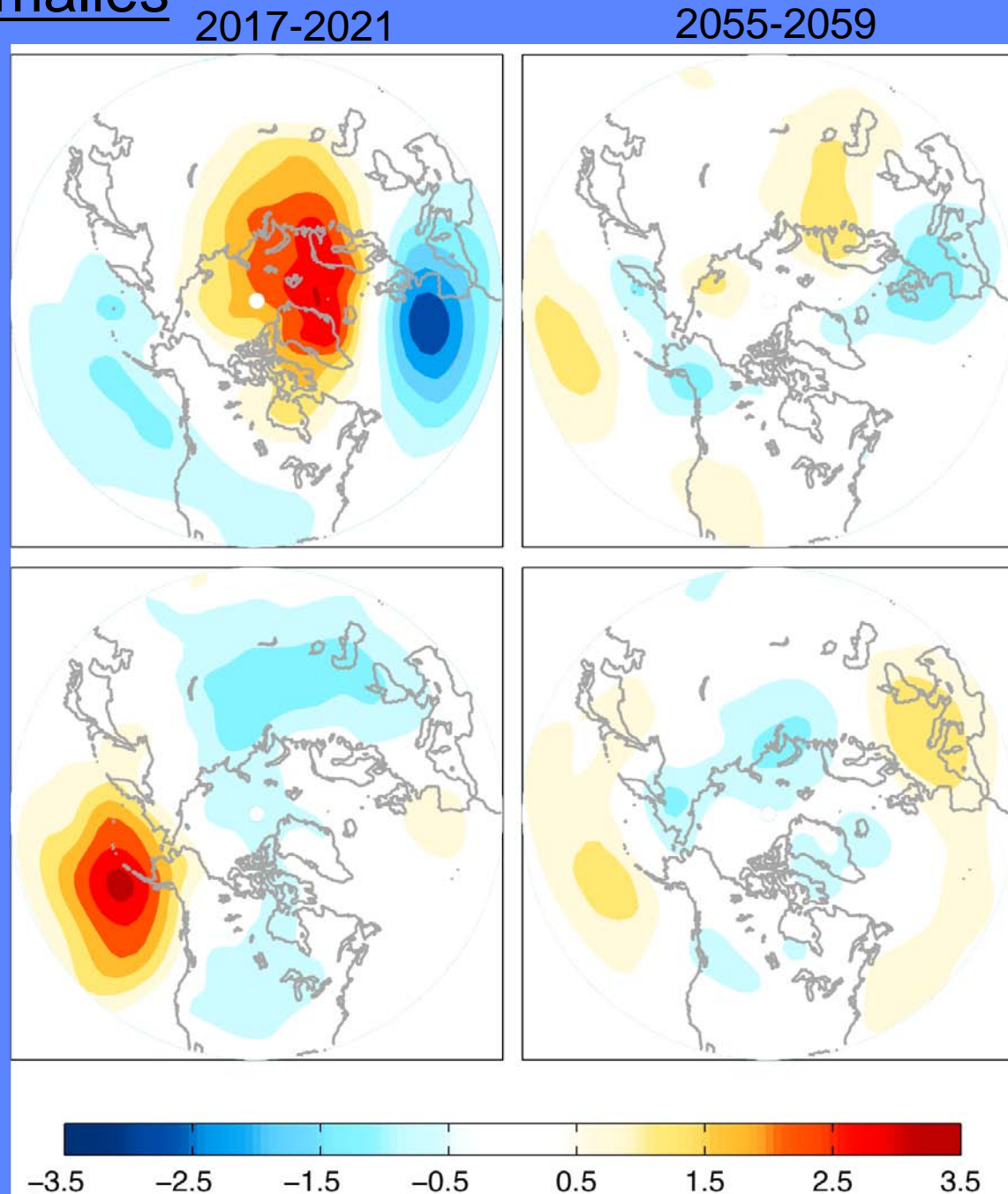
(mb; winter-DJF)

5 ensemble members with the LARGEST 2055-2059 ice extent



5 ensemble members with the SMALLEST 2055-2059 ice extent

Caveat: not all members so selected show these patterns (somewhat noisy...)



Concluding remarks (based on CCSM3)

- Strictly internal (atmospheric) variability is an important source of uncertainty in simulations of future Arctic sea ice
- Early SLP differences are related to the late spread in Arctic ice, but the relationships are weak
- Ensemble spread in sea ice has little long-term memory
- High-frequency SLP “pre-conditioning” (not today...)