Internal Variability in Simulated 21st Century Arctic Sea Ice Loss:

Climate Forcing and Response

Polar Climate Working Group Meeting

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acknowledgements:

Marika Holland, Adam Phillips, Dennis Shea, Matt Long, Dave Bailey, Gary Strand

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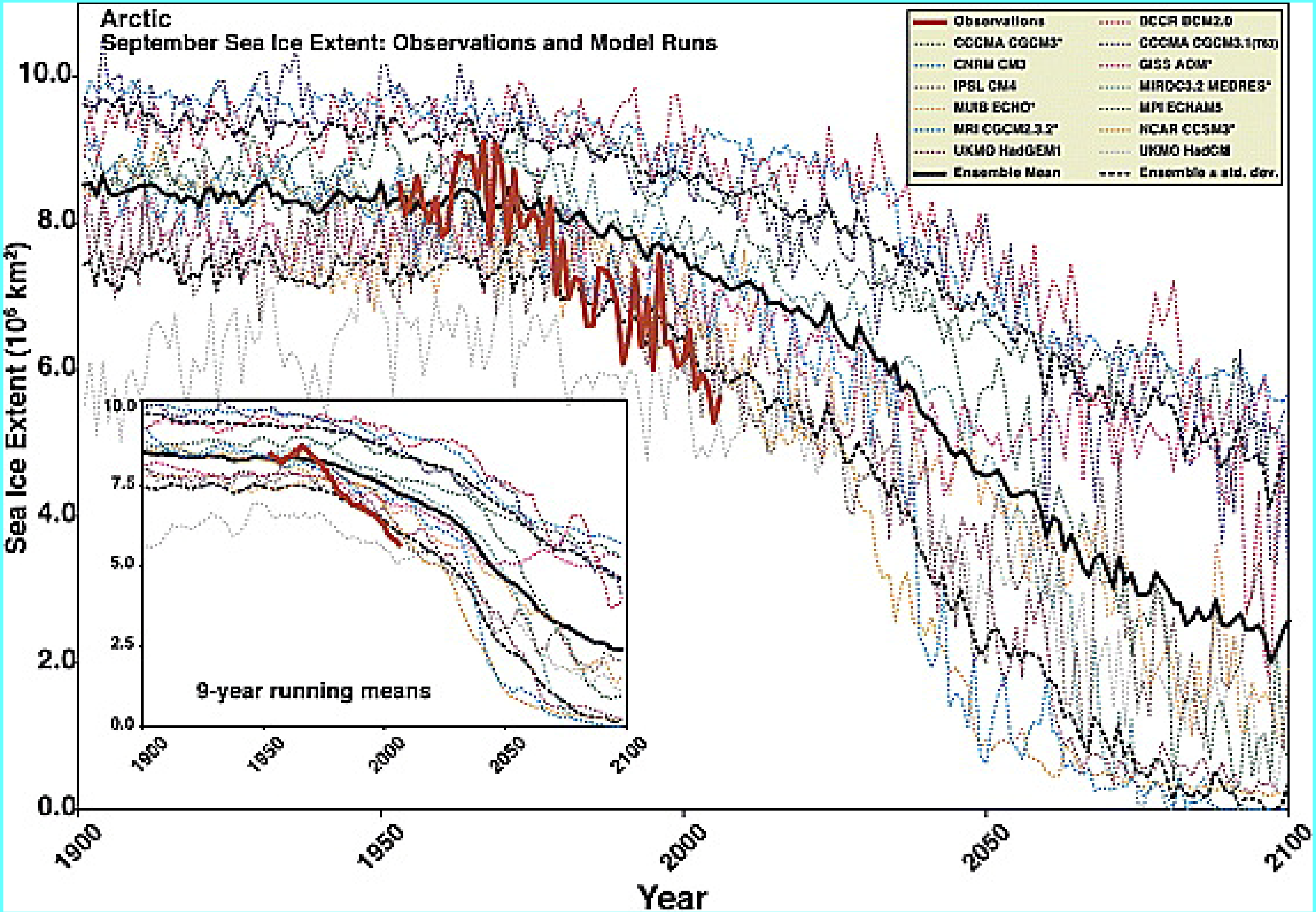
Quick outline

- 1) Observed and simulated ice loss
- 2) Comparing the simulated evolution of sea ice extent and volume
- 3) Some preliminary assessments of climate forcing and response

Observed and simulated ice extent



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

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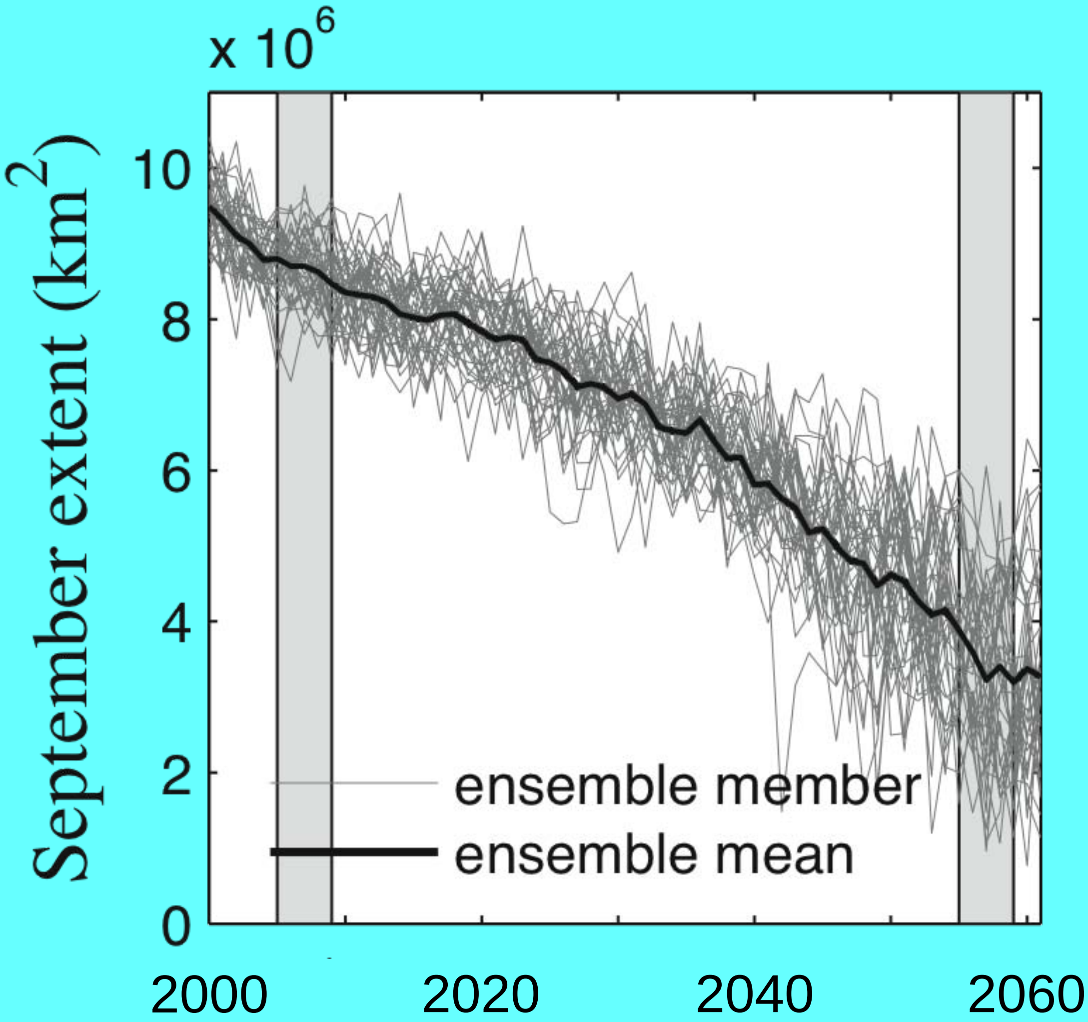
simulated ice extent



NCAR CCSM3:

39-member T42 ensemble

Slightly different atmospheric initial conditions in each ensemble member

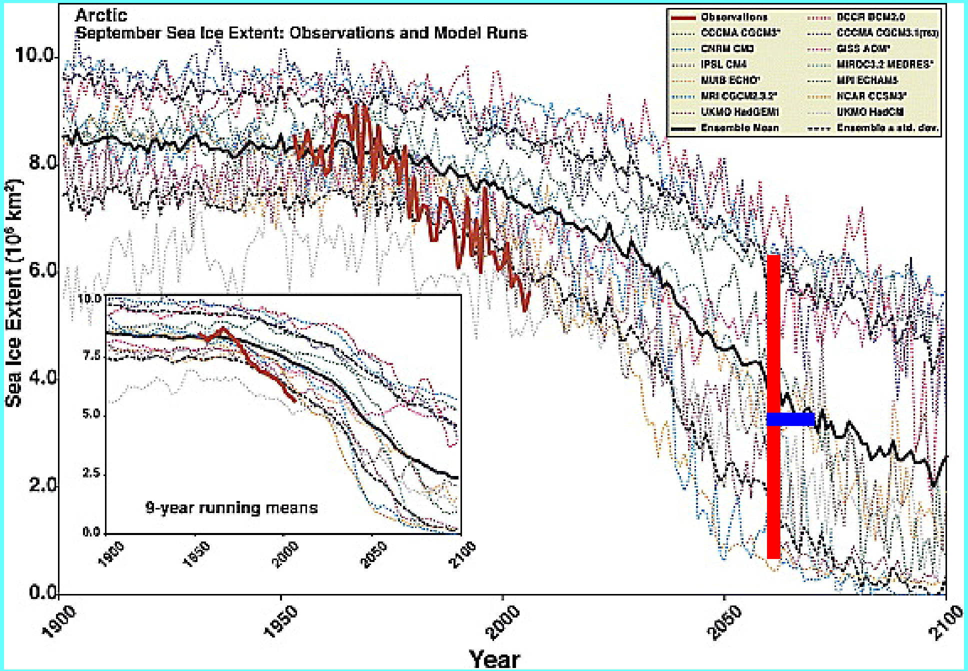
A1B 21st century forcing

Initial ice is too extensive & too thick (but it is not alone in this regard…)

Initial ice is distributed incorrectly

2005-2009 vs. 2055-2059 average defines a "50-year epoch difference"

Observed and simulated ice extent



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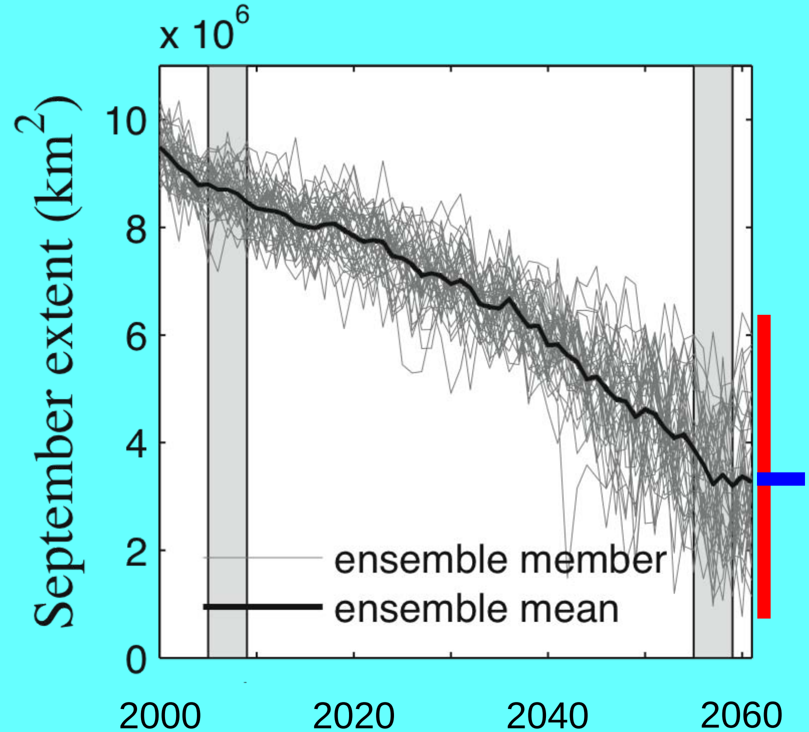

NCAR CCSM3:

Between 42% and 74% reduction in epoch September sea ice extent

Key result:

Internal variability is comparable to intra-model variability.

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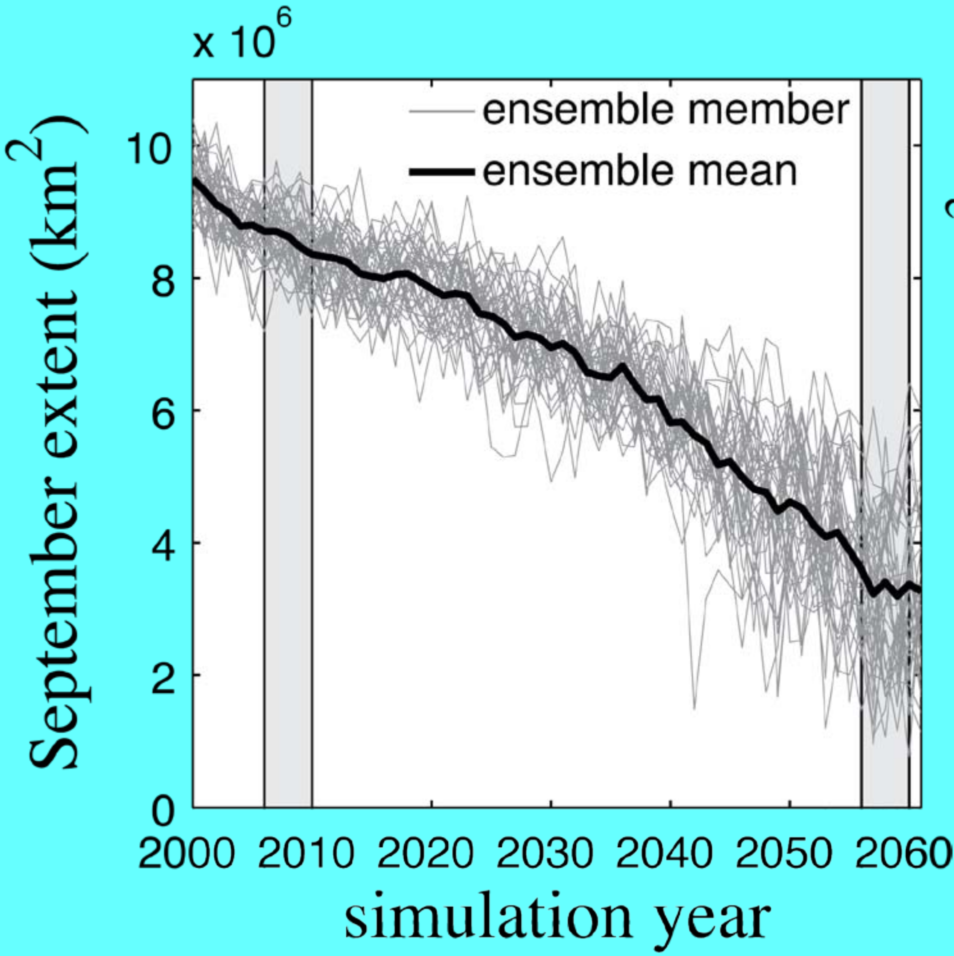
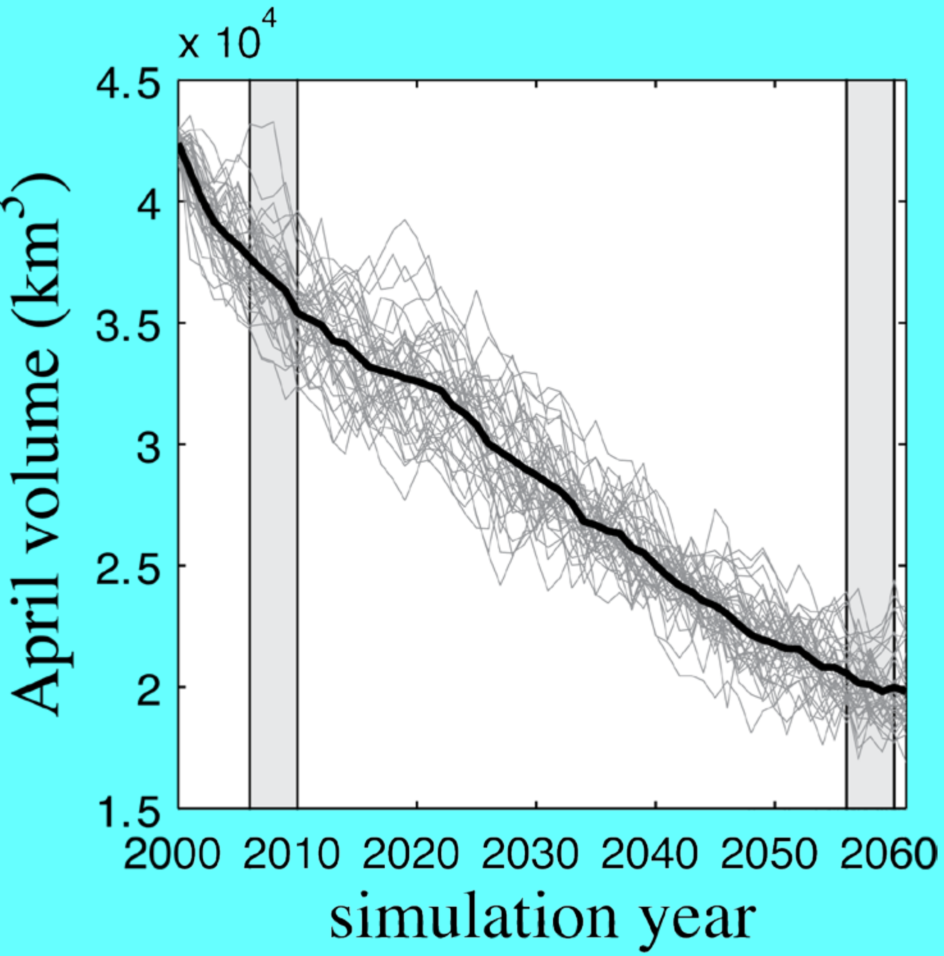
Simulated ice volume and extent: CCSM3





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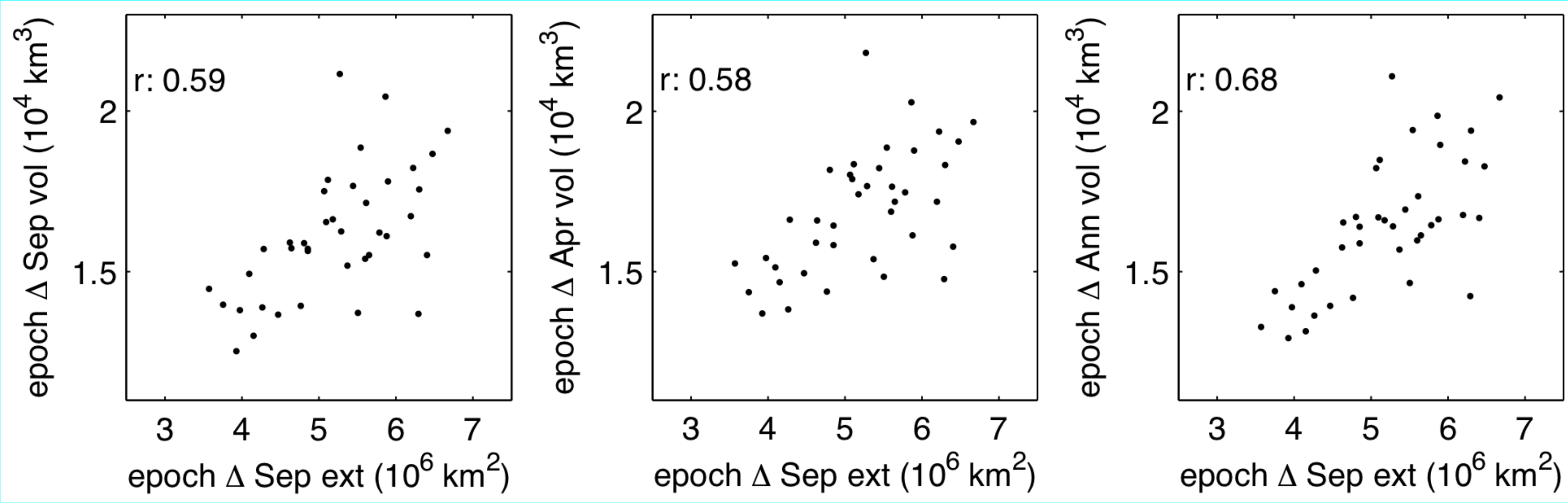
Epoch diff in extent (x) & volume (y)



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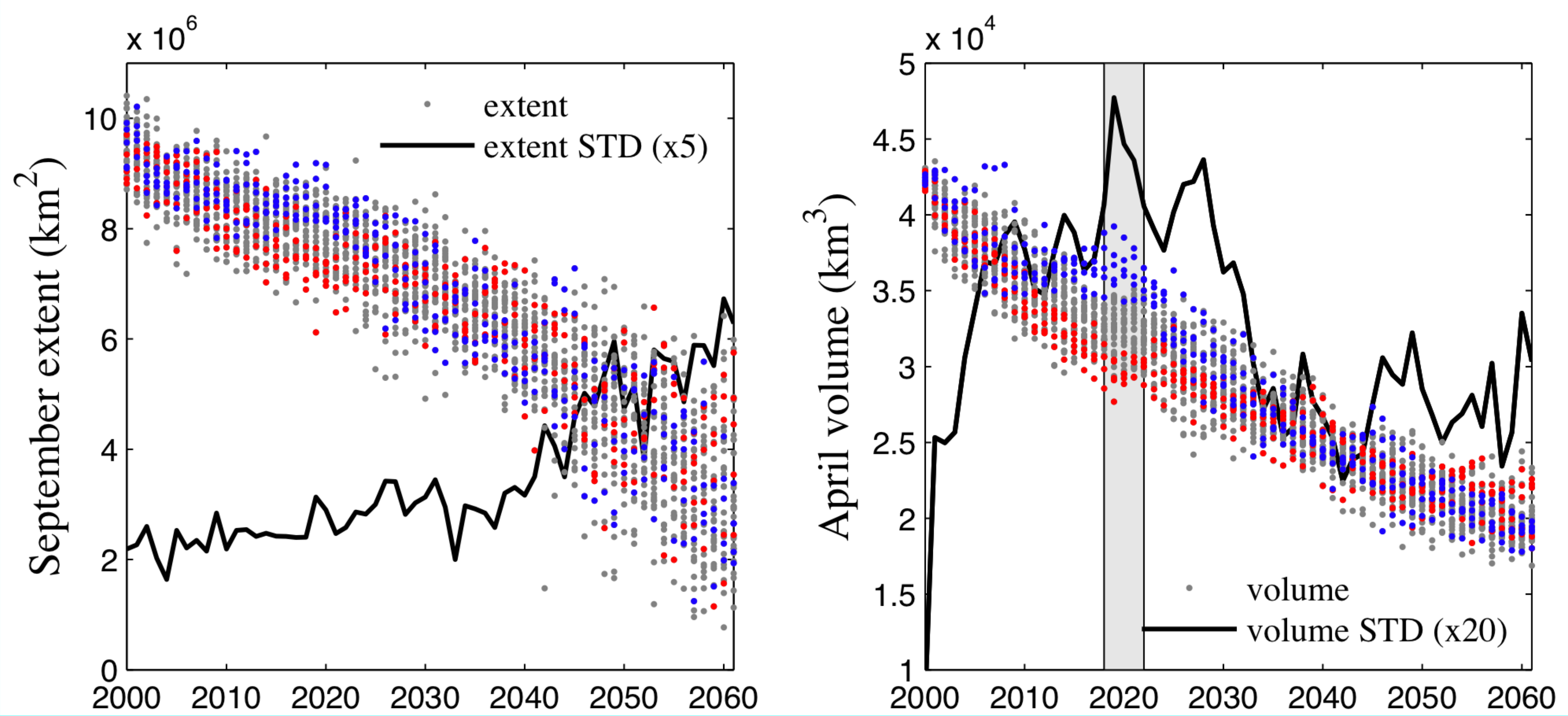

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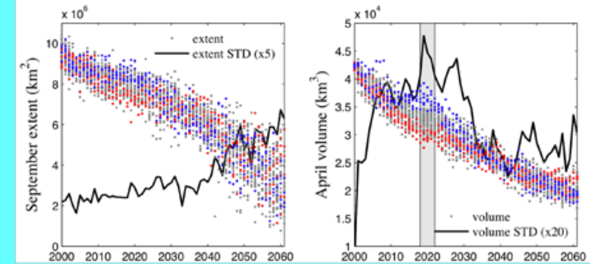
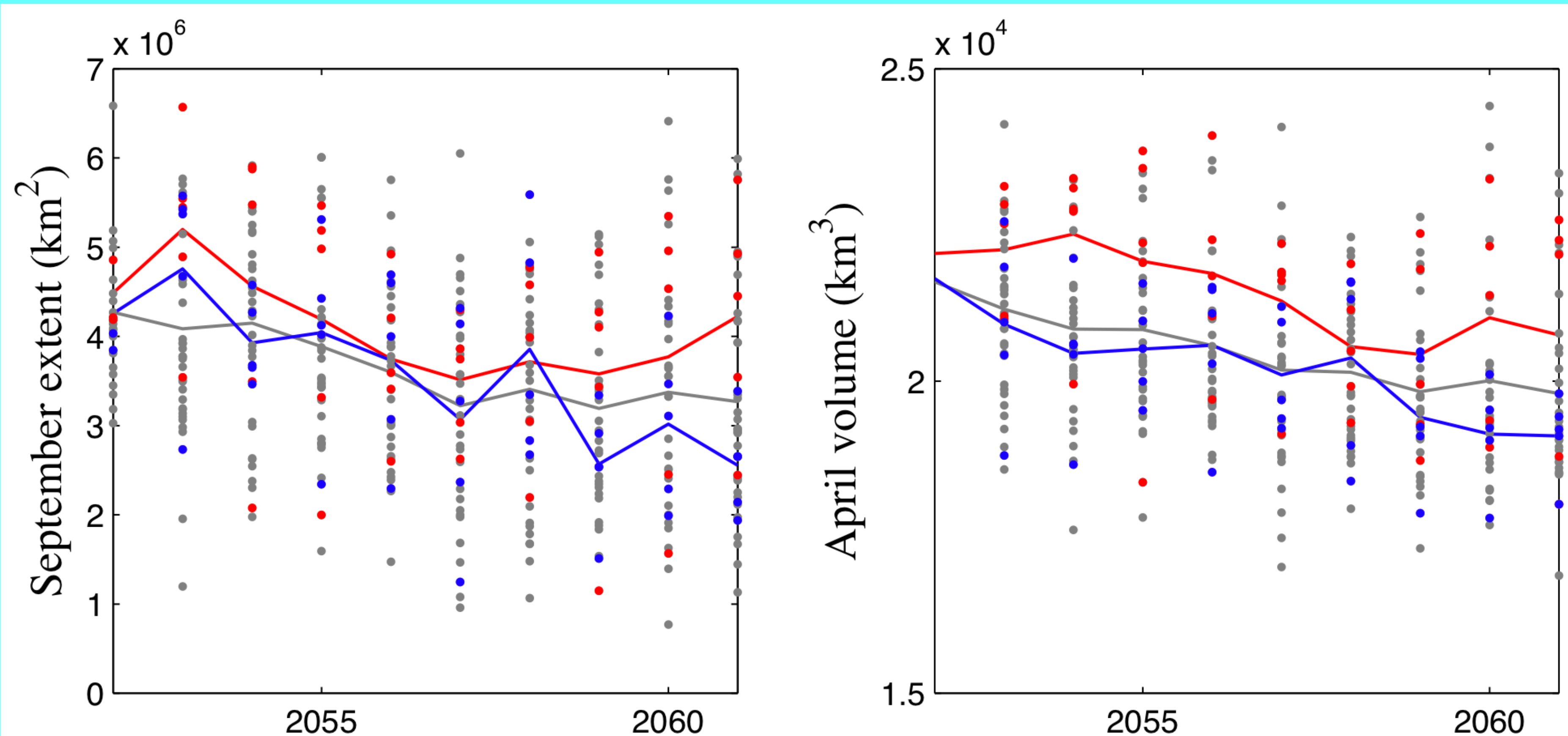
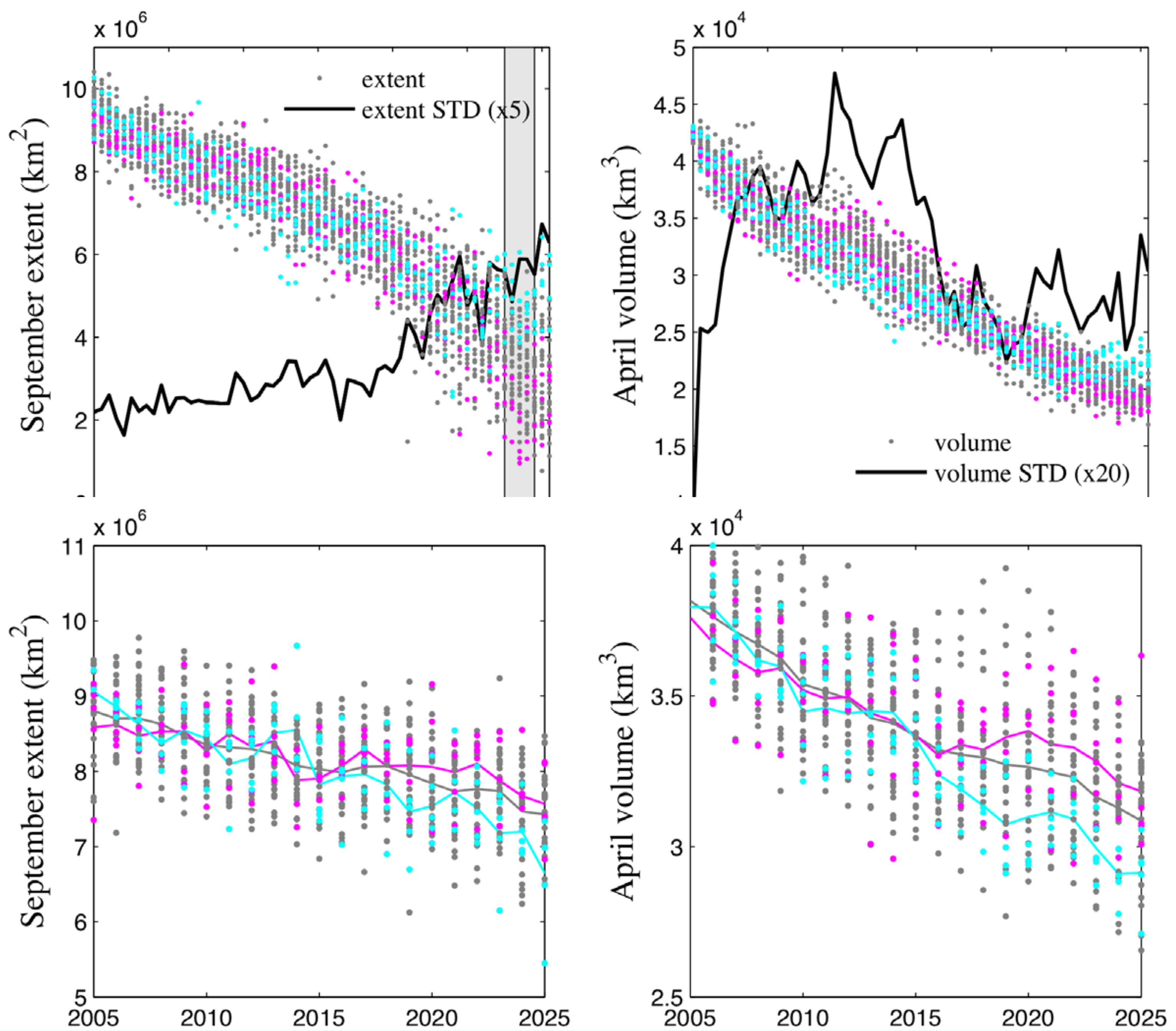
2020 volume to late ice



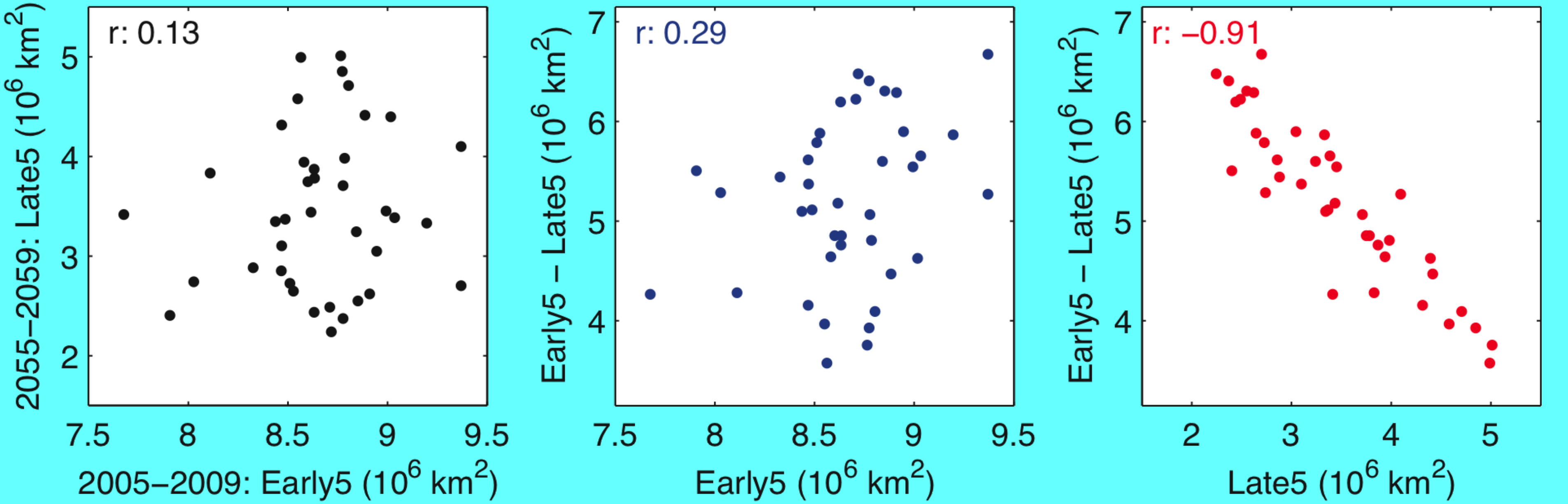


Late extent to early ice



Laboratory

ice extent scatterplots



Early extent has little to do with late extent

Epoch difference only weakly related to early extent

Epoch difference strongly related to late extent

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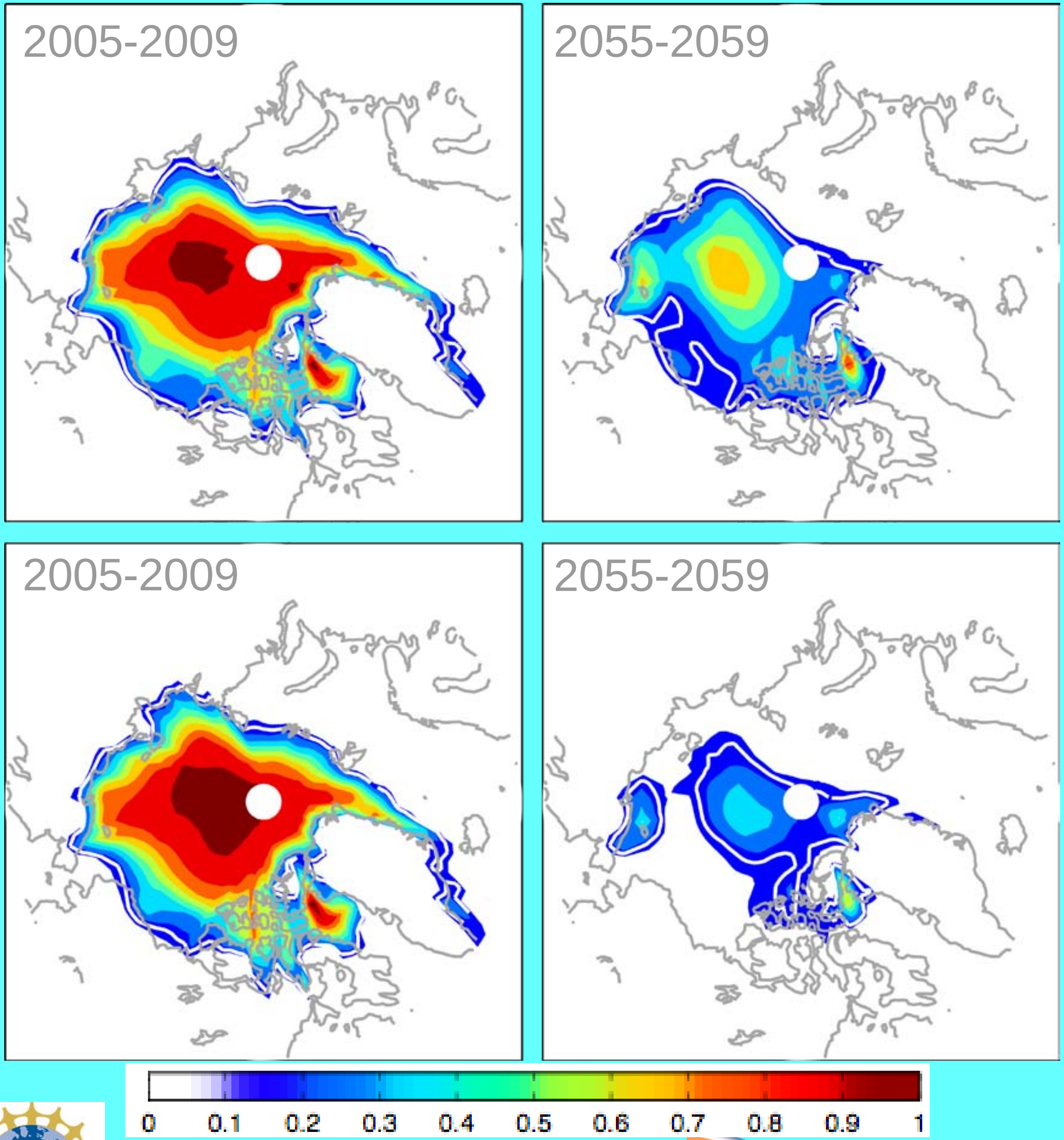
Ice extent & concentration (color shading)



5 ensemble members with the *SMALLEST* epoch (2005-2009) - (2055-2059) difference in ice extent

5 ensemble members with the *LARGEST* epoch (2005-2009) - (2055-2059) difference in ice extent

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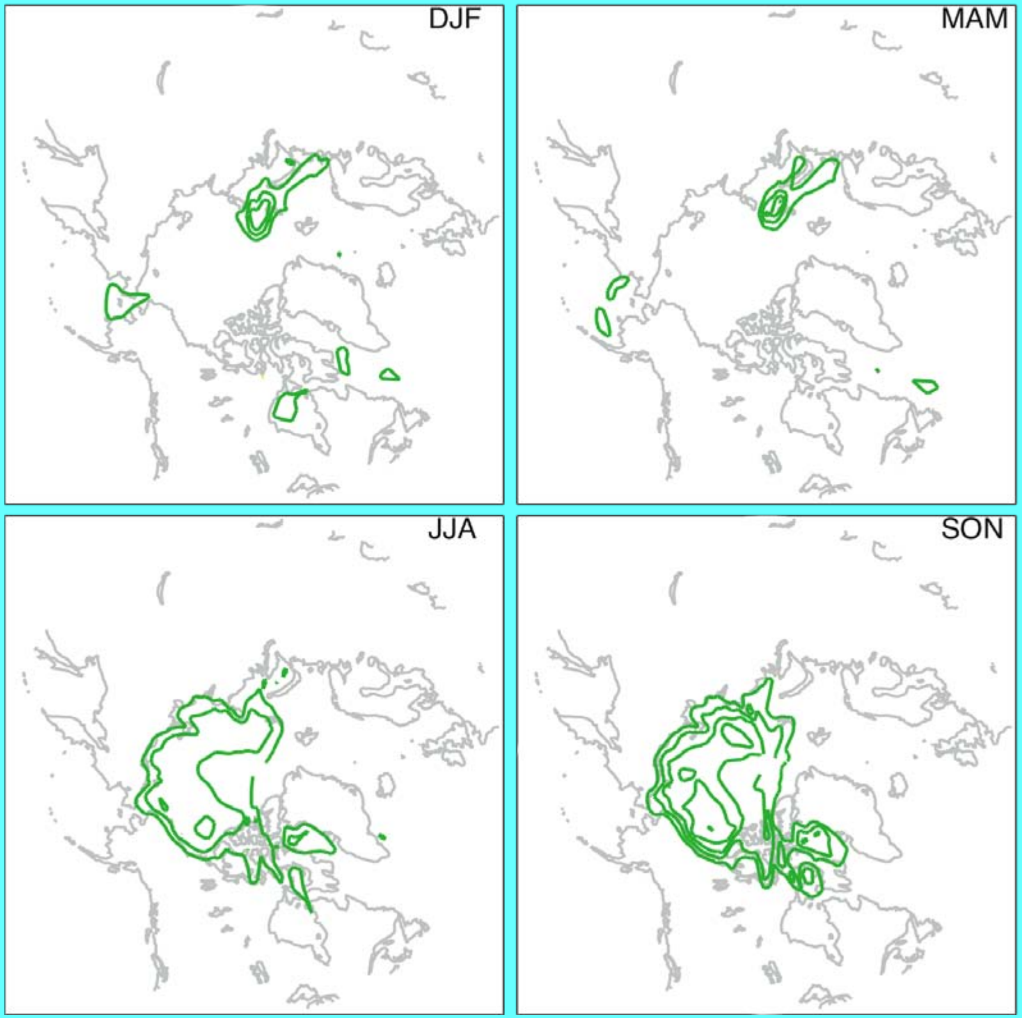
Example climate forcing / response relationships:

regressions onto the ensemble spread in epoch ice extent loss



Ice concentration regression:

c.i. 2% / 1 std Sept. ice extent loss

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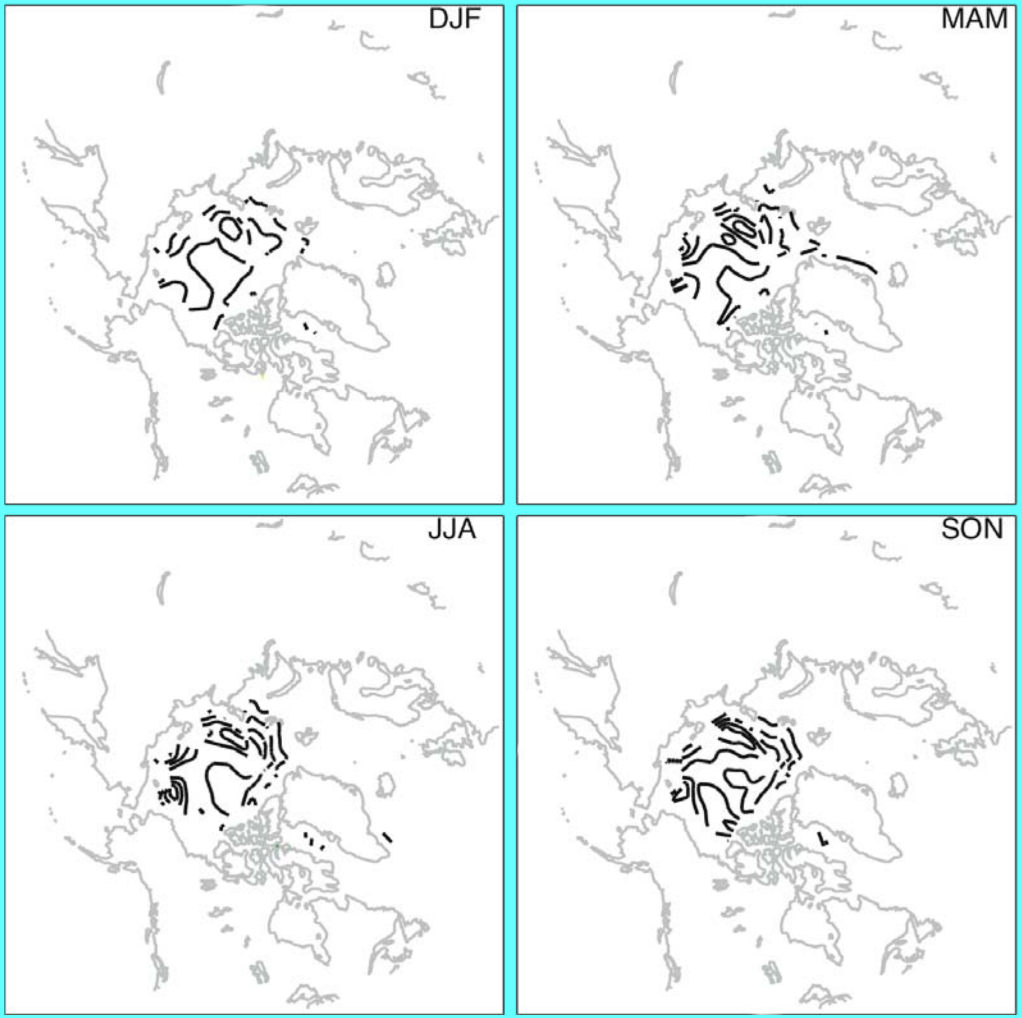

Ice thickness regression:

c.i. 0.05 m / 1 std Sept. ice extent loss

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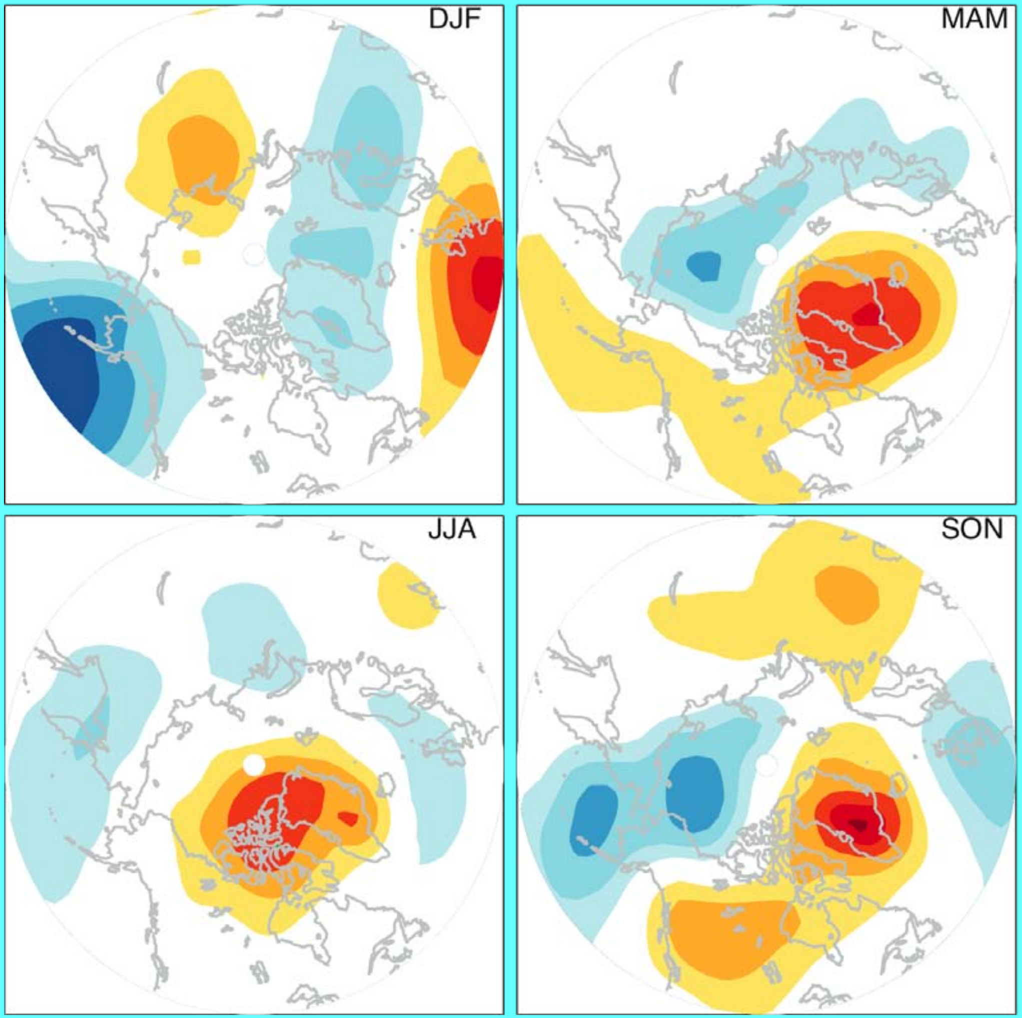

SLP regression (shading):

c.i. 0.25 mb / 1 std Sept. ice extent loss

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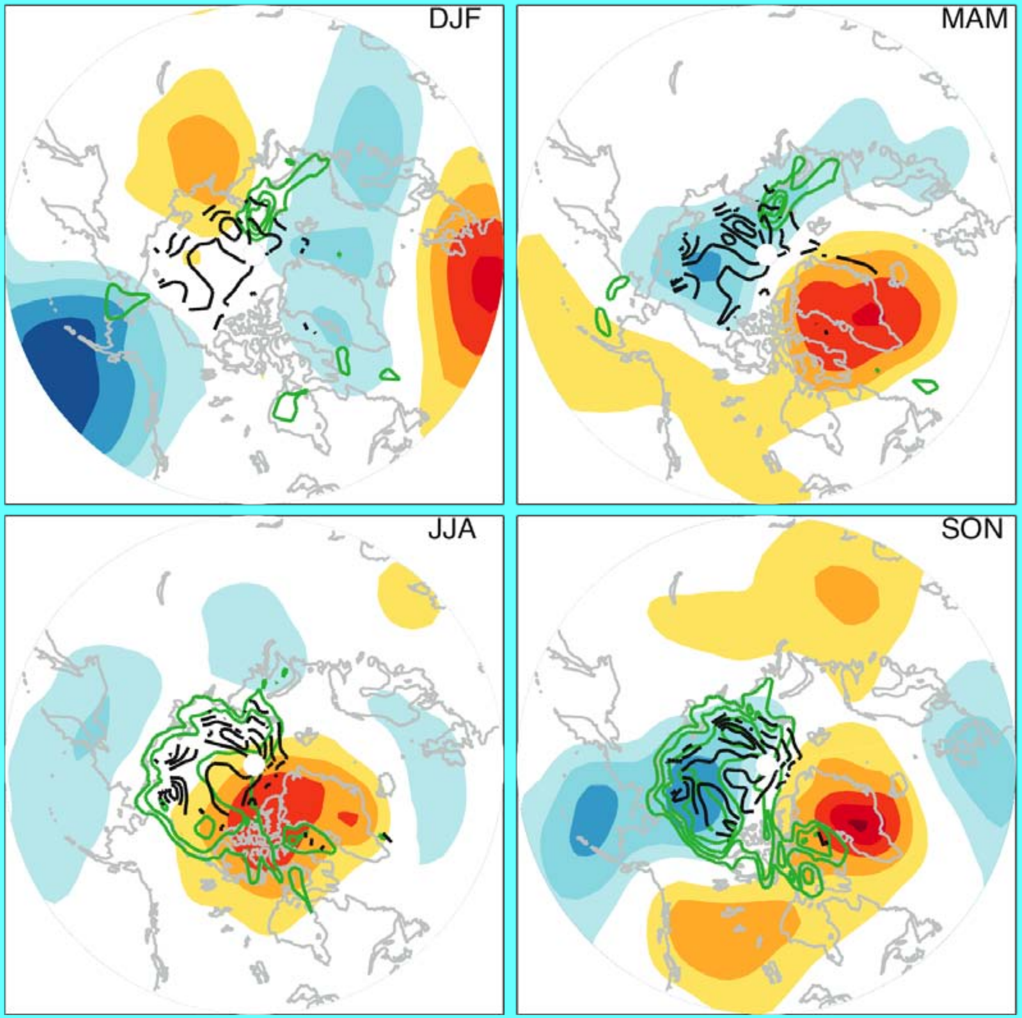

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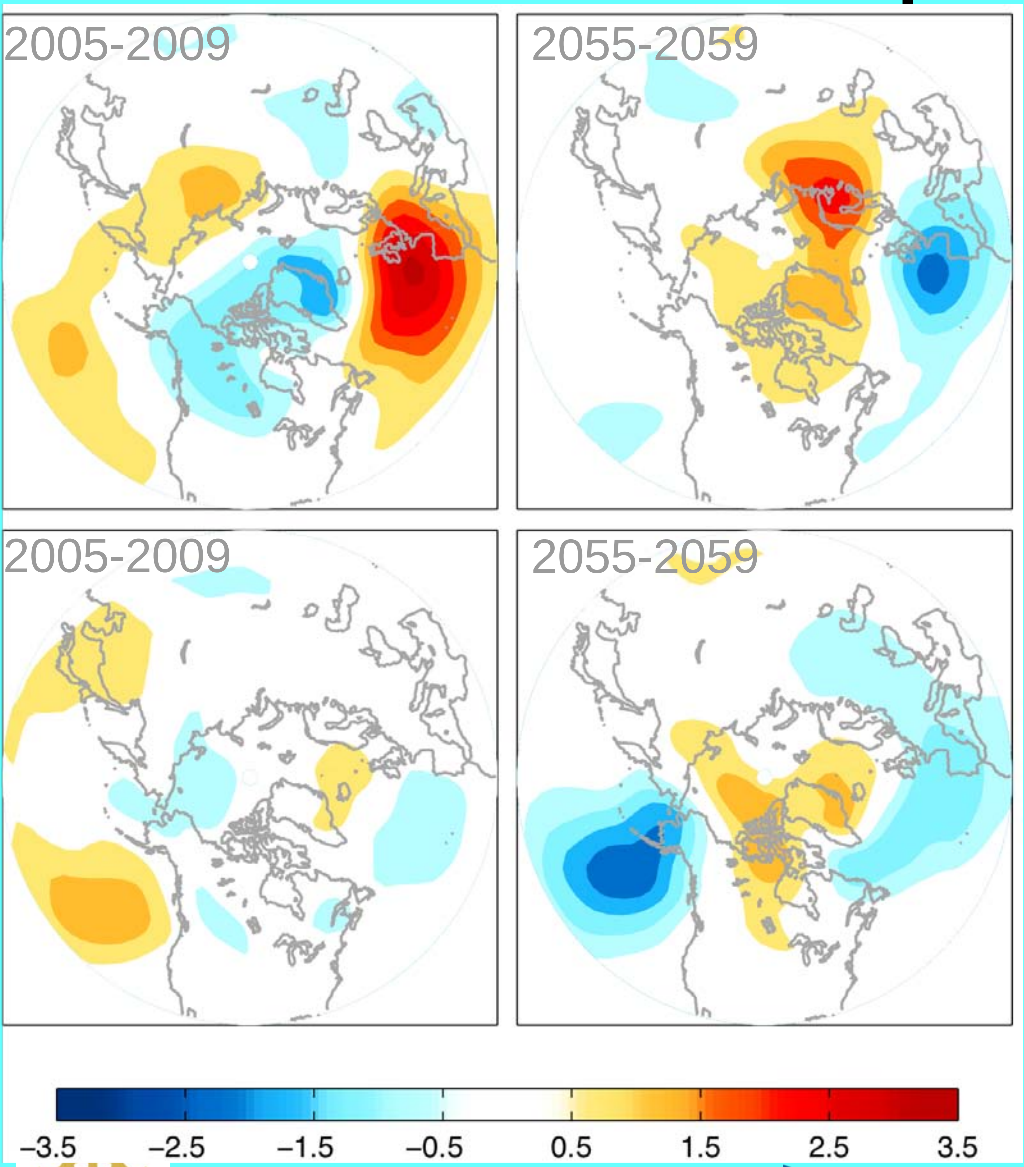
DJF sea level pressure



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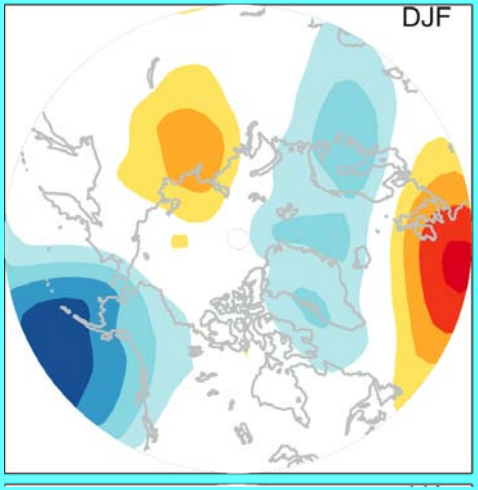

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Work in progress…

- Looking at dynamic (e.g., wind-driven, ocean heat transport) forcing / response to compare with thermodynamic forcing / response

- Compare high-frequency forcing and response to the epoch difference regressions

- Examine robustness in smaller T85 CCSM3 and CCSM4 ensembles; available observations