STEADY BUT MODEL-DEPENDENT POLAR AMPLIFICATION IN 21ST CENTURY FORCED RESPONSE IN CMIP6

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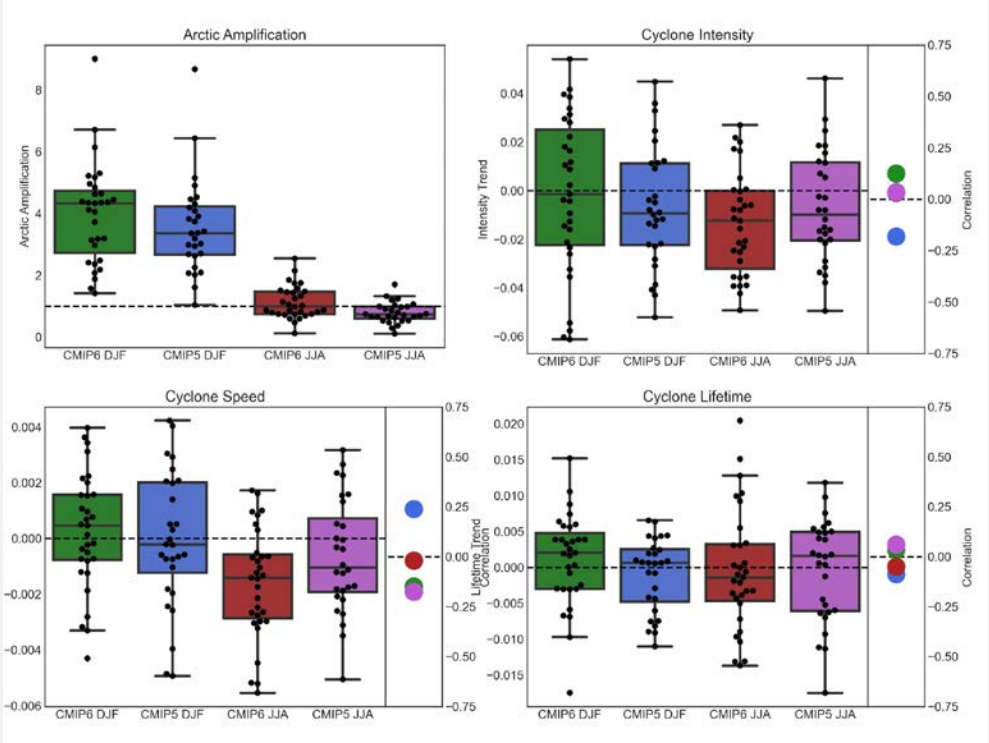
Polar Amplification of Climate Change Across Hemispheres and Seasons: Causes and Constraints

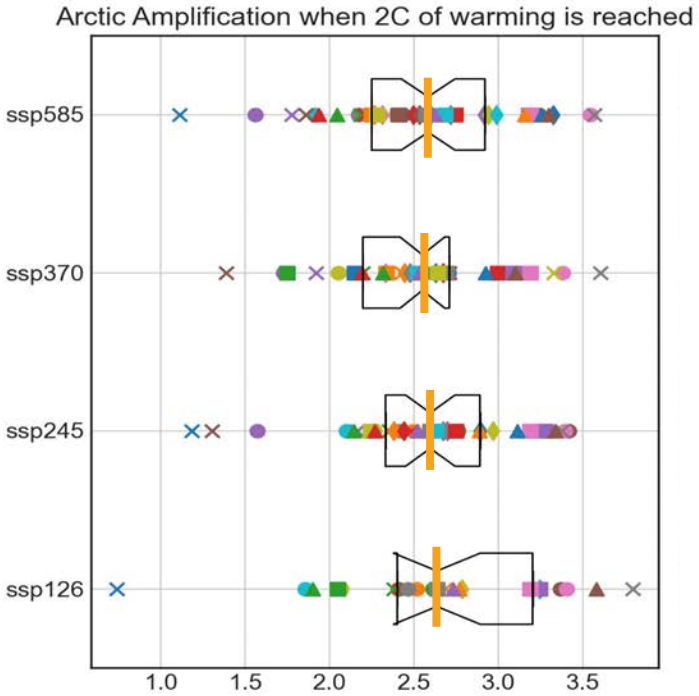
OUTLINE

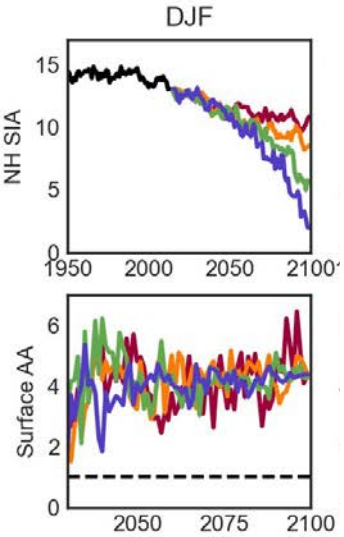
- Motivation : Can we use CMIP6 to find a understand sources of uncertainty in Arctic Amplification? What about the Antarctic?
- Use Hawkins & Sutton 2009 framework:
  - Scenario Uncertainty
  - Model Uncertainty
    - Seasonal variation
  - Internal Variability

- Can model spread in some metric of Arctic warming help explain model spread in metrics related to the storm tracks in historical climate simulations? (No)

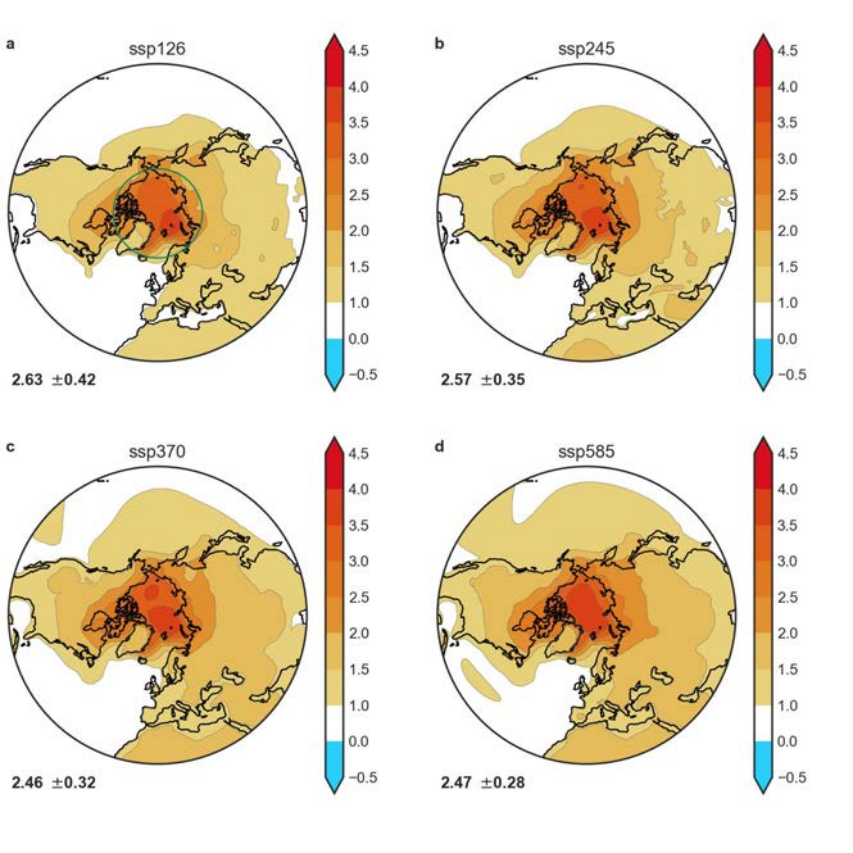


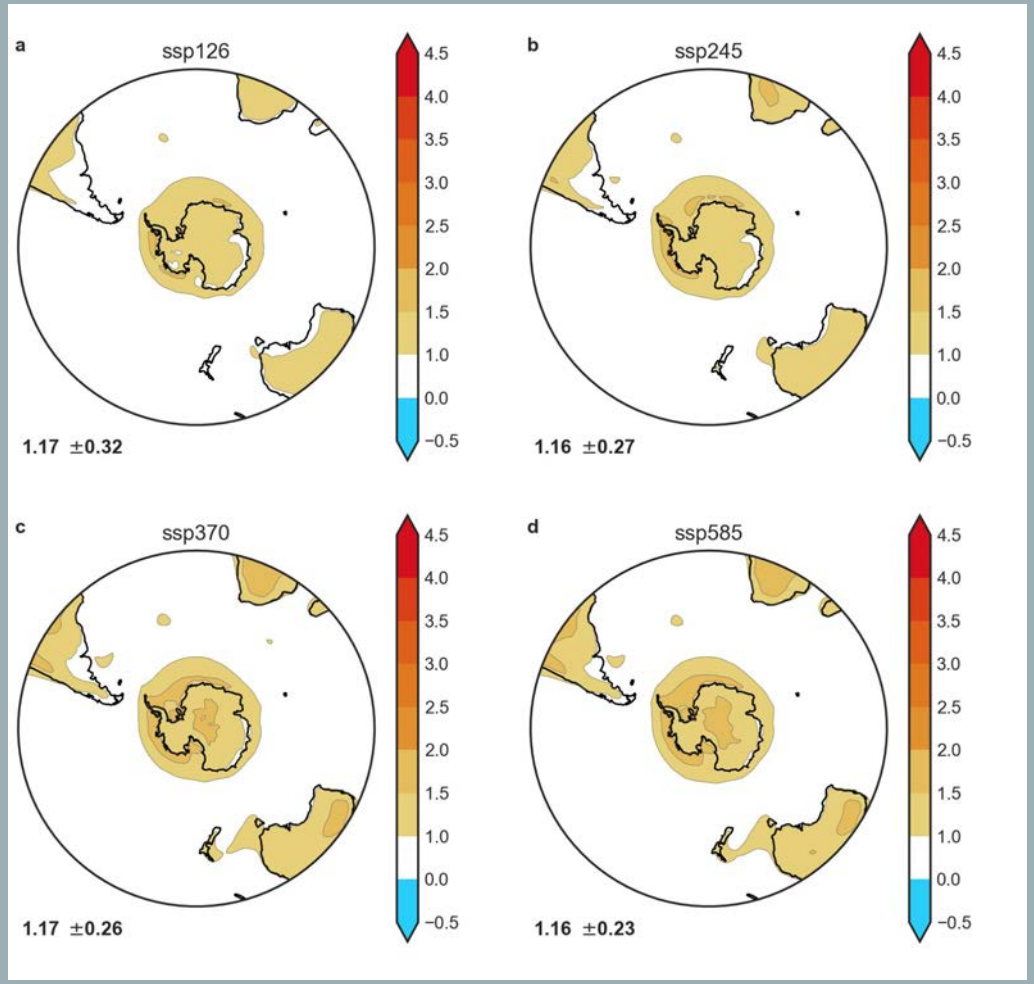
- "Note, interestingly enough, that the long-term values of Arctic amplification are quite similar to the near-term values" (Barnes & Polvani 2015)
- Is Arctic amplification a constant? Can we take advantage of this quality when assessing AA uncertainty in CMIP6?
- For this workshop: What about the Antarctic?





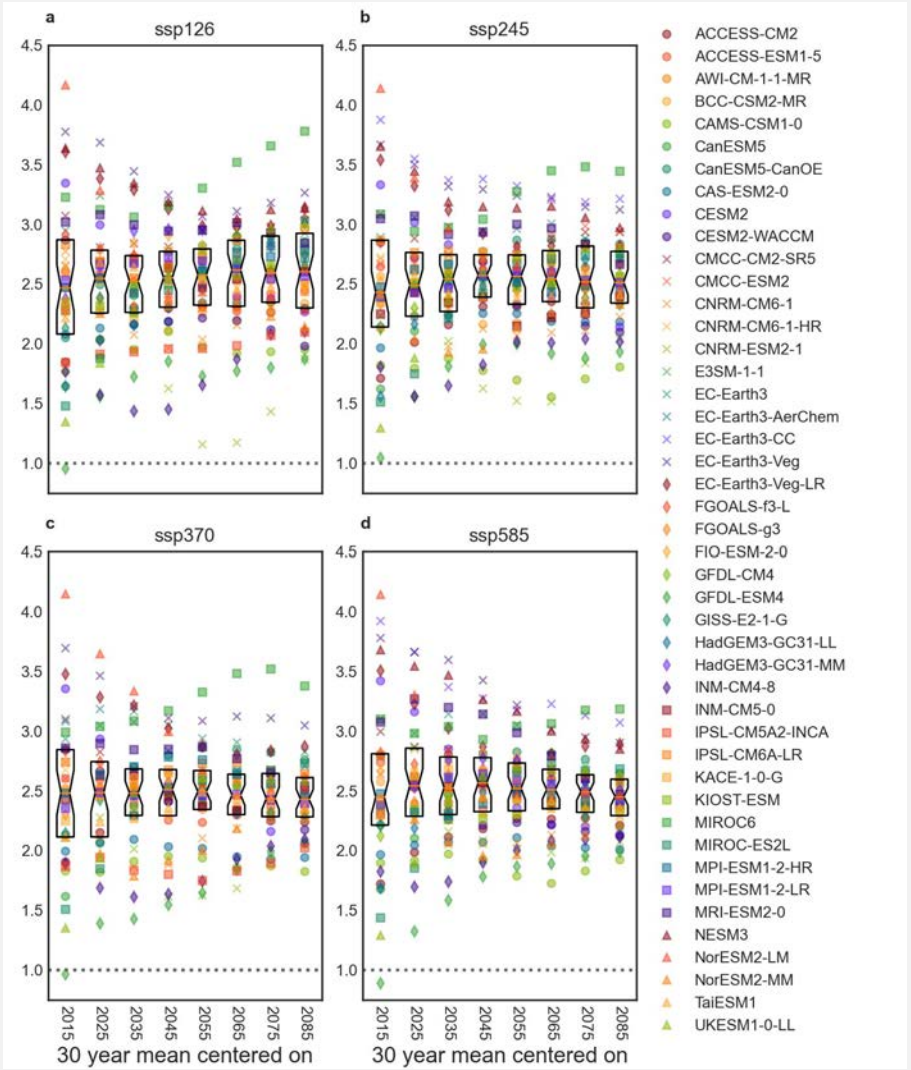
- Arctic warming at end of 21st century is approx. 2.5 times as large as global warming
- Pattern of local amplification is similar across scenarios (instance of ‘pattern scaling’)
- Reduction in model spread in ssp585





SCENARIO UNCERTAINTY: ANTARCTIC

- Antarctic warming is ~1.2 times larger than global warming at end of 21st century, similar to any landmass (Land-sea contrast?)
- Like Arctic, little difference with scenario in local amplification, reduced spread with strength of forcing.



MODEL UNCERTAINTY

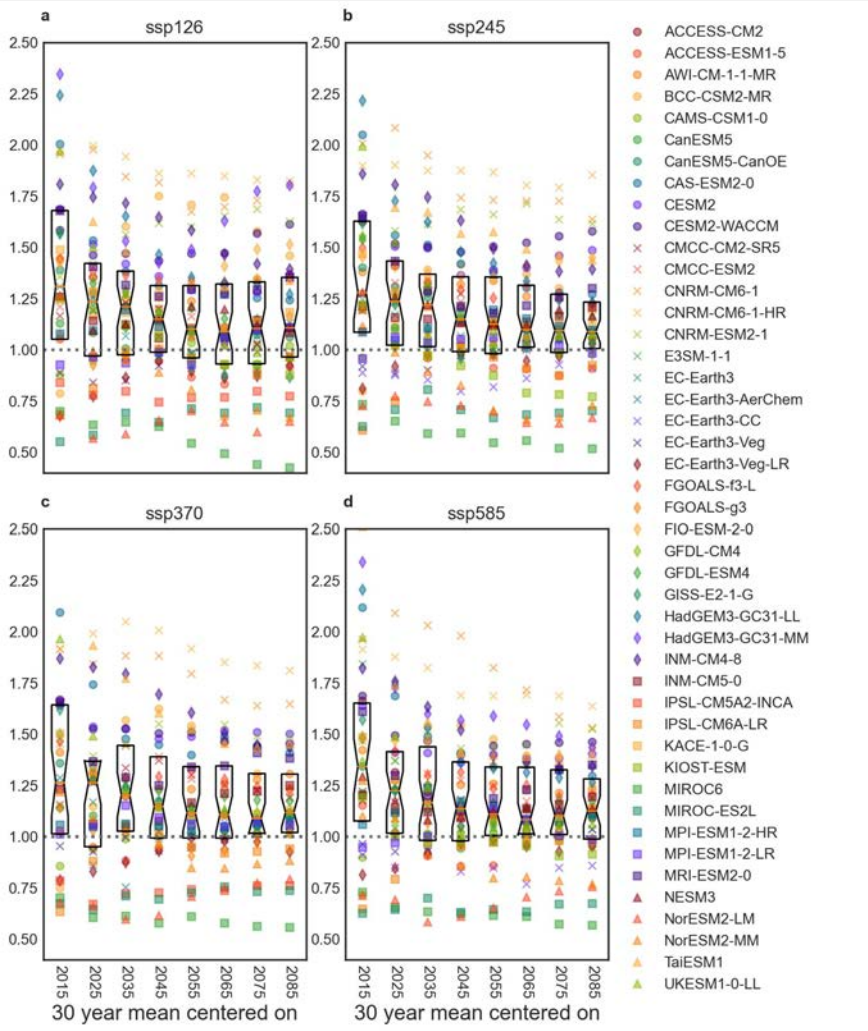
- Relatively ‘flat’ time series in the multi-model mean
- Looking at any individual model there is more variability in time
- Spread: 1-4.2 currently, 1.8-3.2 in ssp585 at end of century (best estimate of model uncertainty given strongest forcing)

MODEL UNCERTAINTY

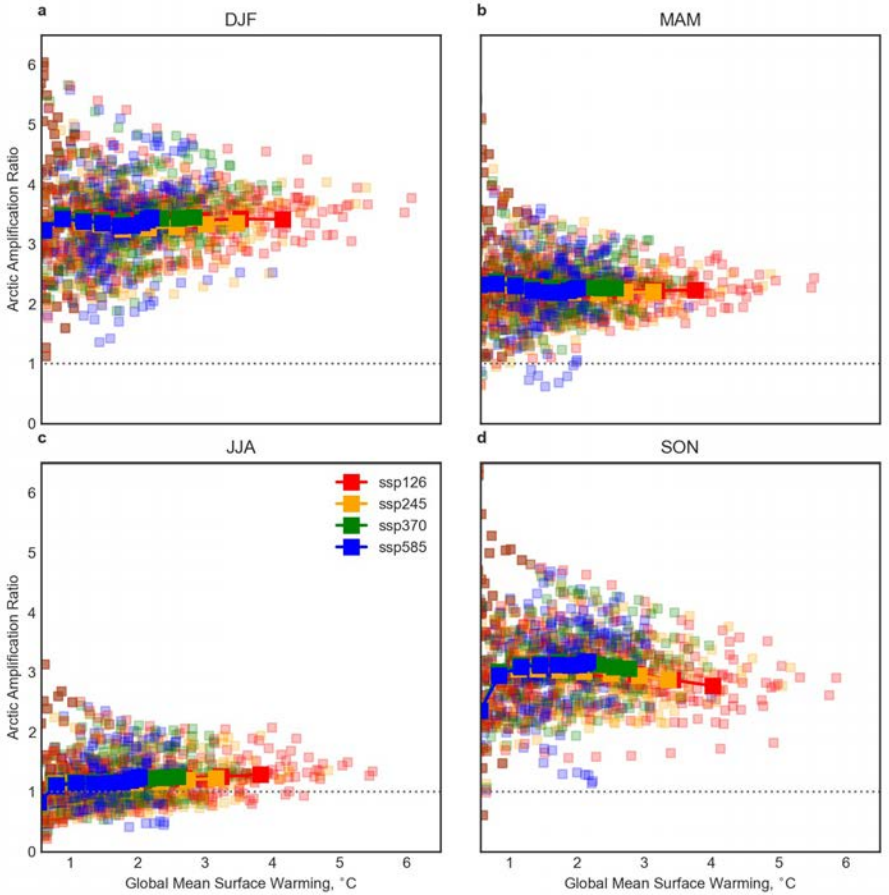
Not as steady in time – possible downward trend?

Spread of 0.5 – 2.3 in present is only reduced to 0.6-1.75 in future. (still smaller than AA!)

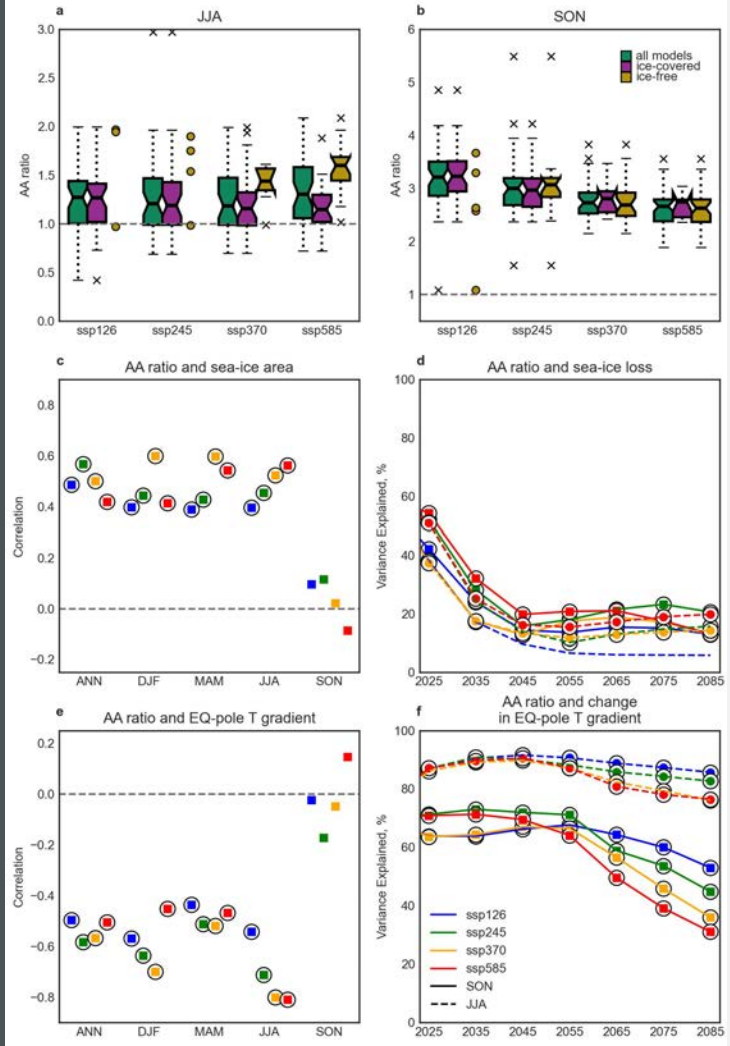
Many models do not support amplification of Antarctic warming



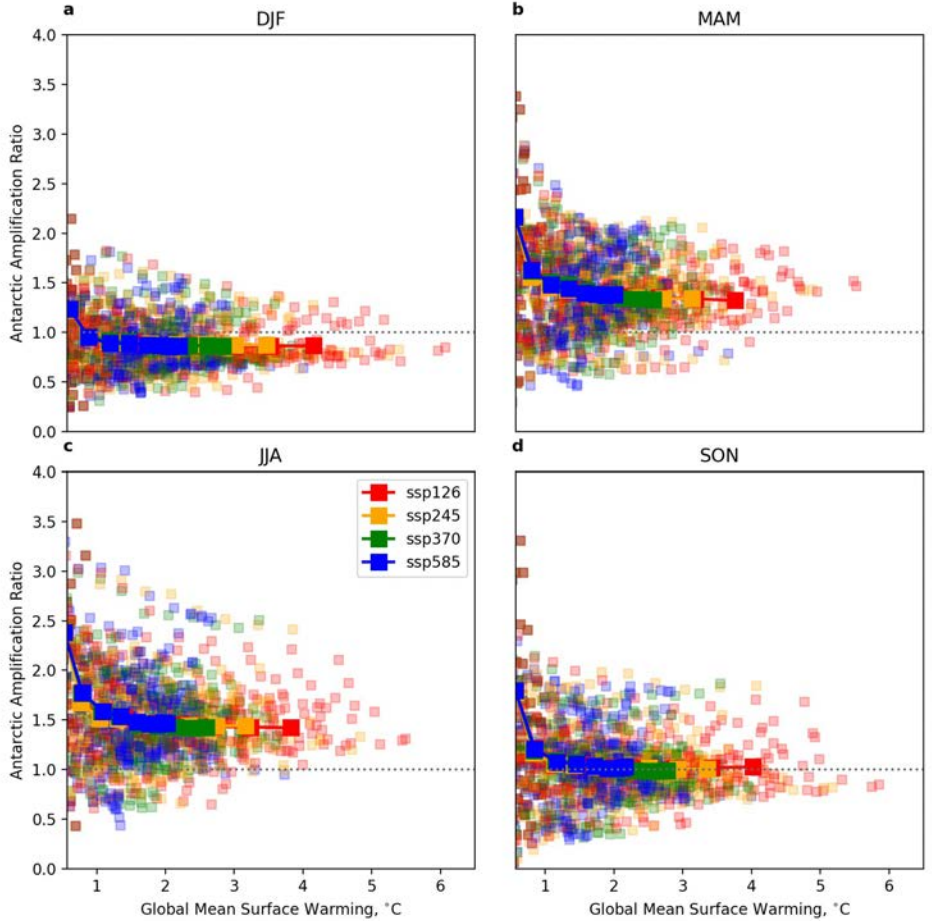
- Steady AA with global mean surface warming in DJF & MAM
  - Convergence toward a value similar to CMIP6 mean
- Slight increase in JJA at high warming/larger forcing
- Decreasing AA in SON
  - Hypothesis: Sea ice feedbacks maintain AA, and some models go ice-free at high warming



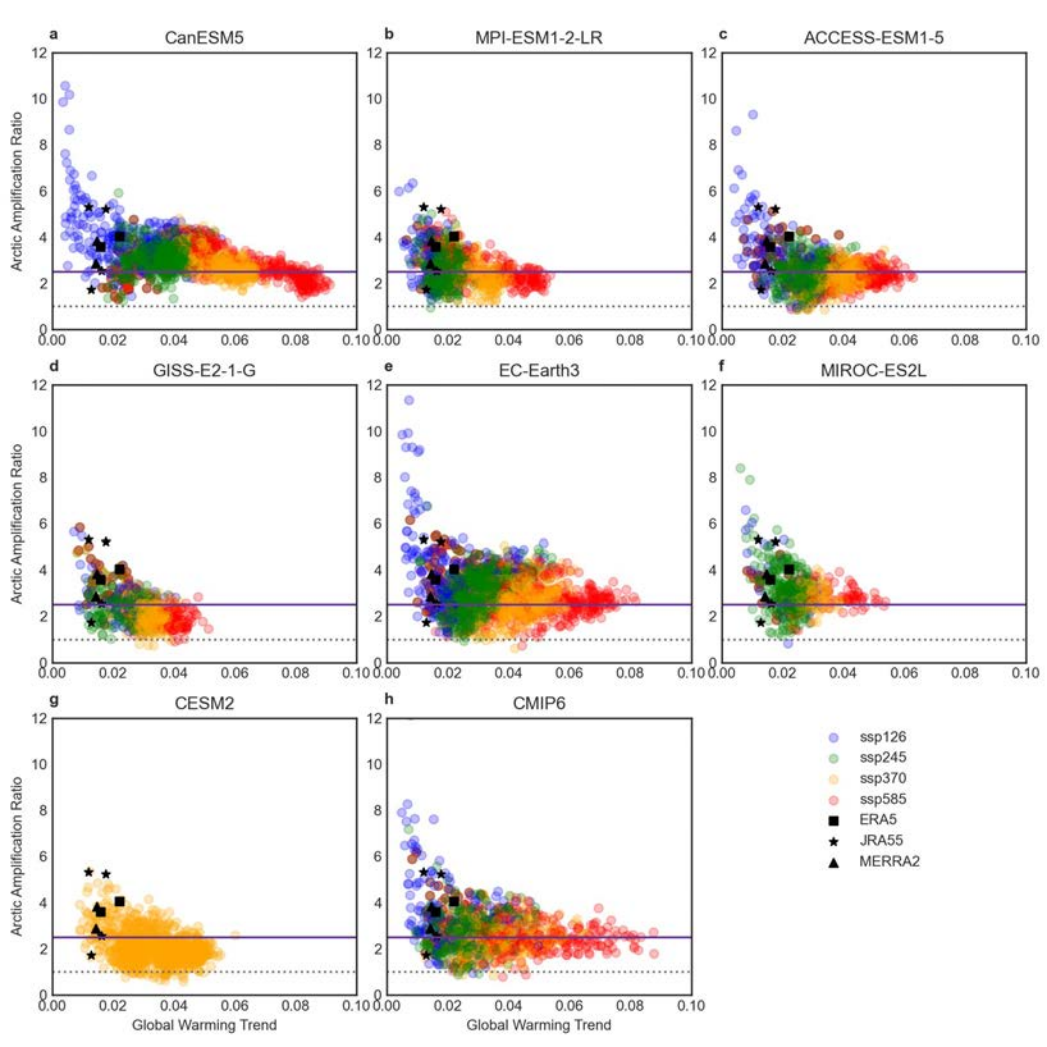
- Separating models by whether they remain ice-covered or not helps explain JJA variation, not SON
- Sea-ice area is uncorrelated with with AA in SON (at end of century)
- Less of the variance is explained by sea-ice loss in time - decorrelation
- AA is also uncorrelated with different between tropical and Arctic temp in SON only (Planck feedback)
  - It remains correlated with change in gradient though!
  - Drop off in time



- 0.9-1.5 in CMIP6 mean – less seasonal variation than Arctic
- Models don't converge as clearly toward a single value at higher global warming



- Using 7 large single-model ensembles and the CMIP6 ensemble
- Use (significant) 30-year trends from all available members and scenarios
- High values of AA in ssp126 near end of century when warming slows (issues with defining AA as a ratio)
- ‘Preferred’ AA value of ~2.5 emerges again
- Consistent with reanalysis for similar trends in GMST



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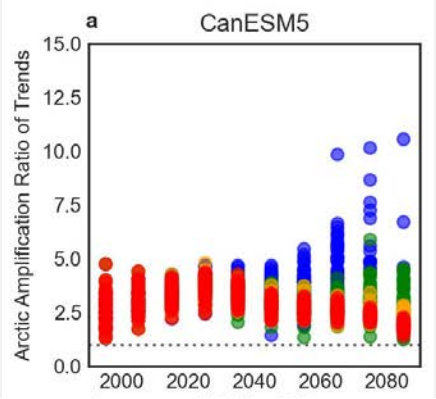
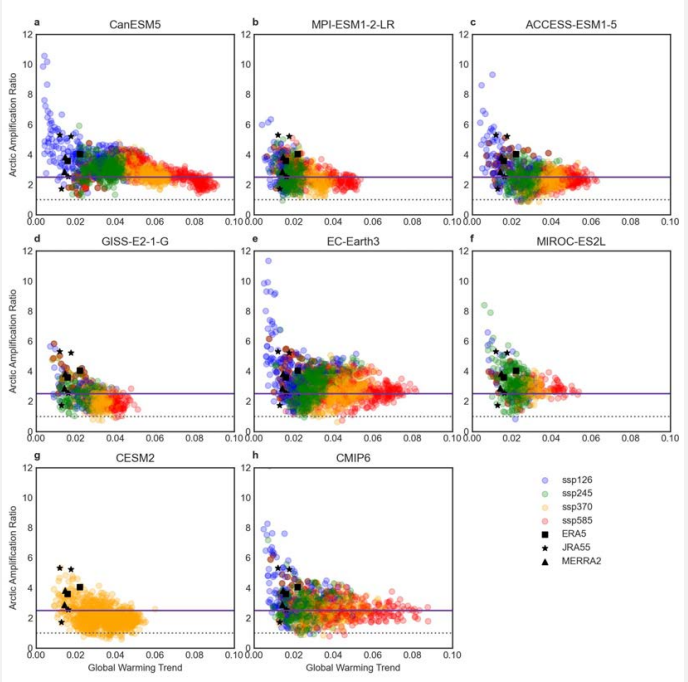
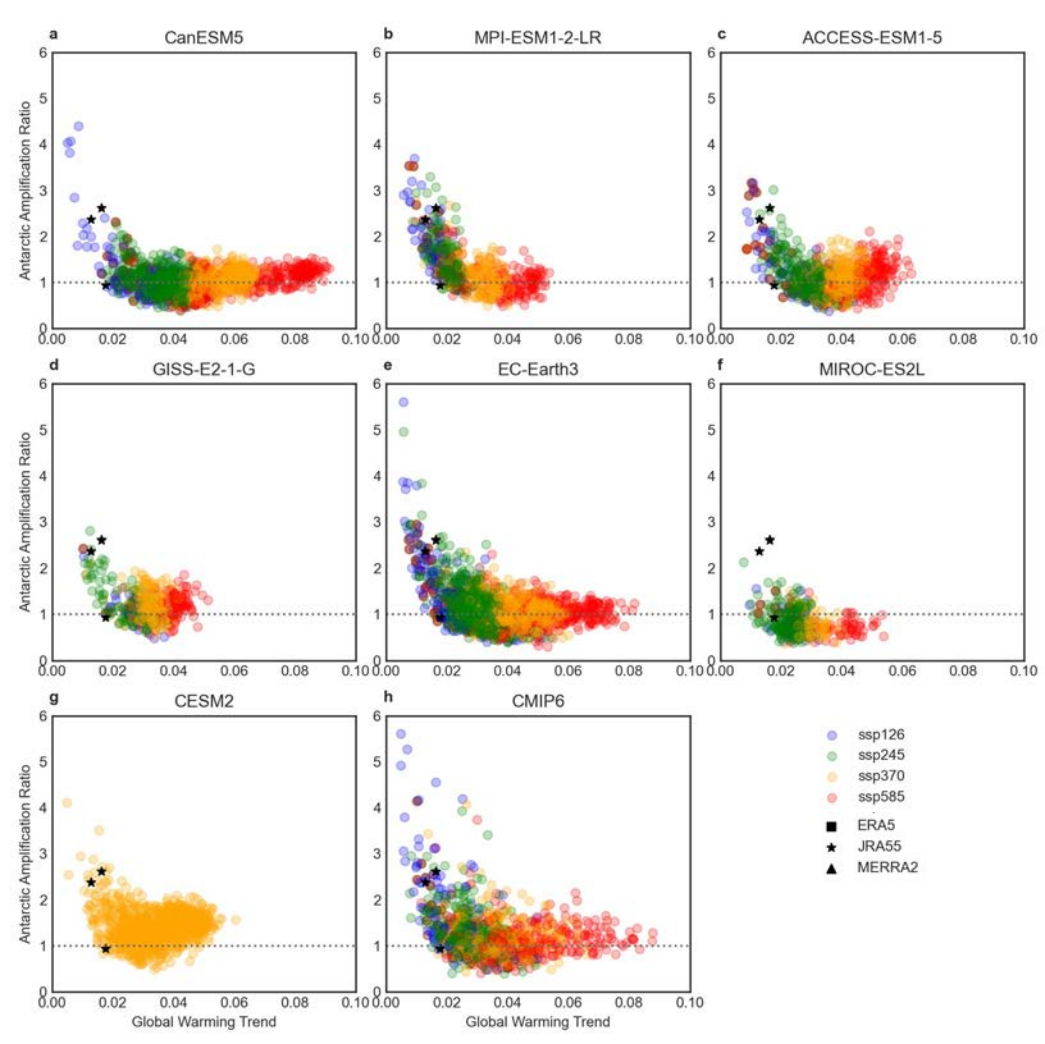
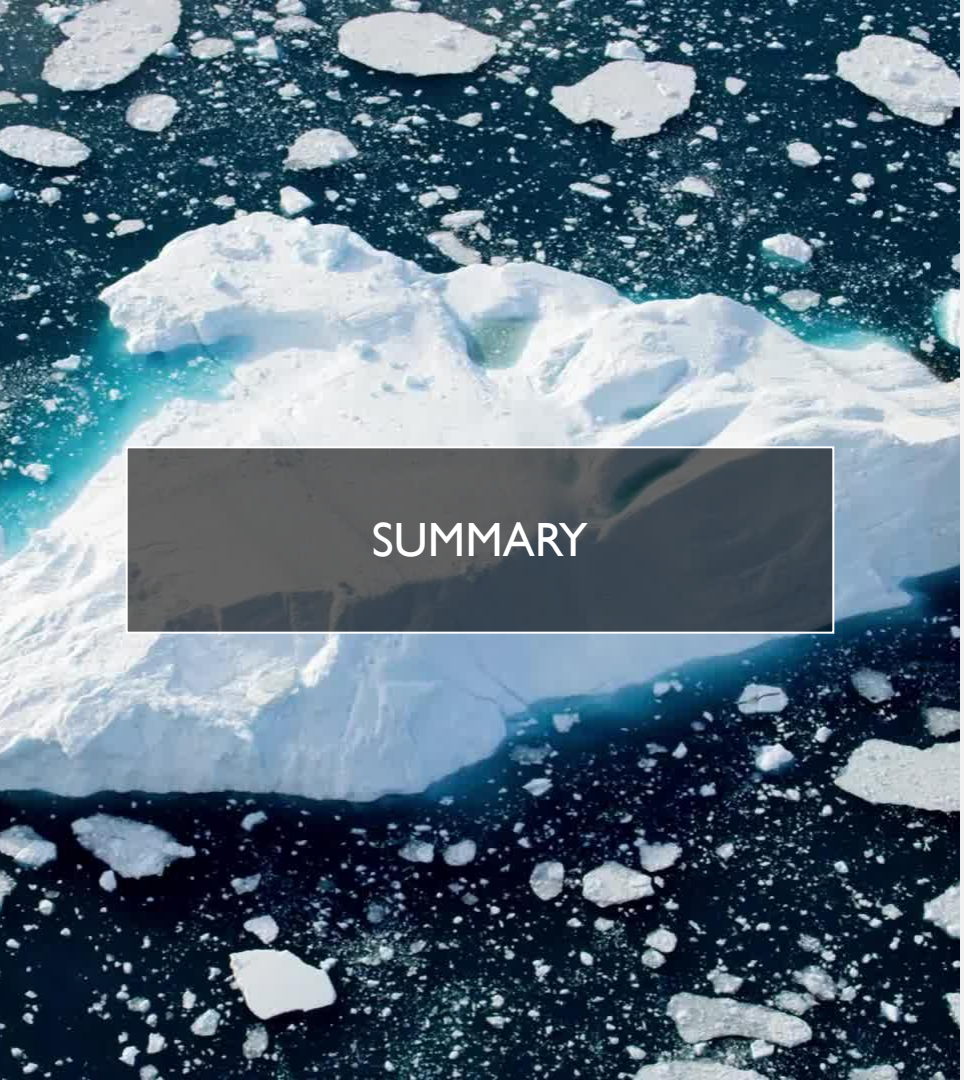




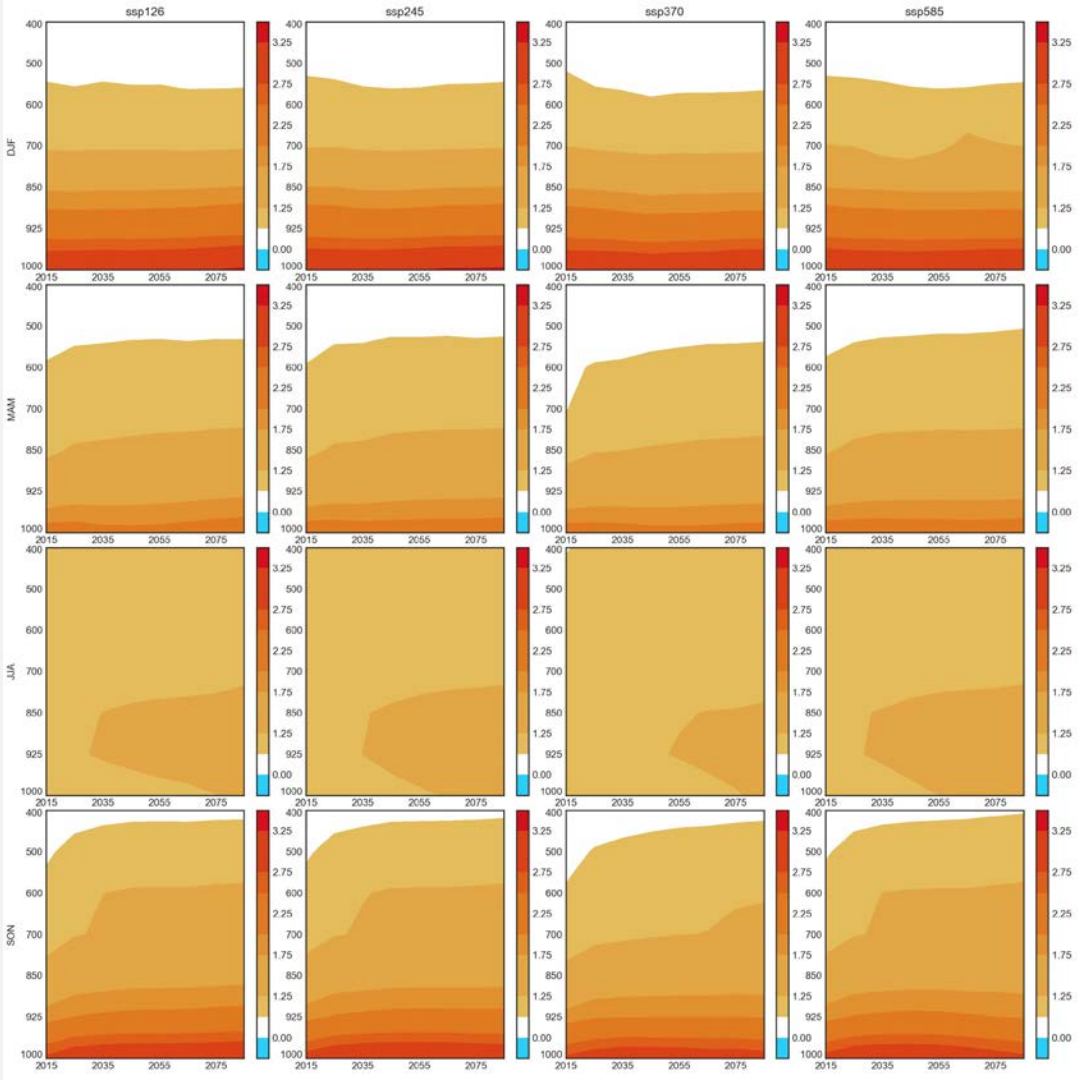
- Upward-curved shape to the distribution:
  - AntA is largest for periods with smaller or larger warming?
- Only JRA55 has AntA for comparison, often falls outside of model internal variability spread, but within CMIP6 ensemble.
- Internal variability in some models is smaller than inter-model spread
  - Opportunity for improvement in modelling Antarctic processes





SUMMARY

- To first order, Arctic (and to a lesser extent, Antarctic) amplification ratio can be considered a constant across time and scenario, in the absence of internal variability
- Internal variability is similar in magnitude to model uncertainty in Arctic, model uncertainty is perhaps larger, though not by a large amount, in Antarctic
- Last point makes it difficult to determine whether modelled AA/AntA is consistent with observations or not.
- Discussion: Is this the right metric to use to try to understand model spread in other aspects of the circulation response?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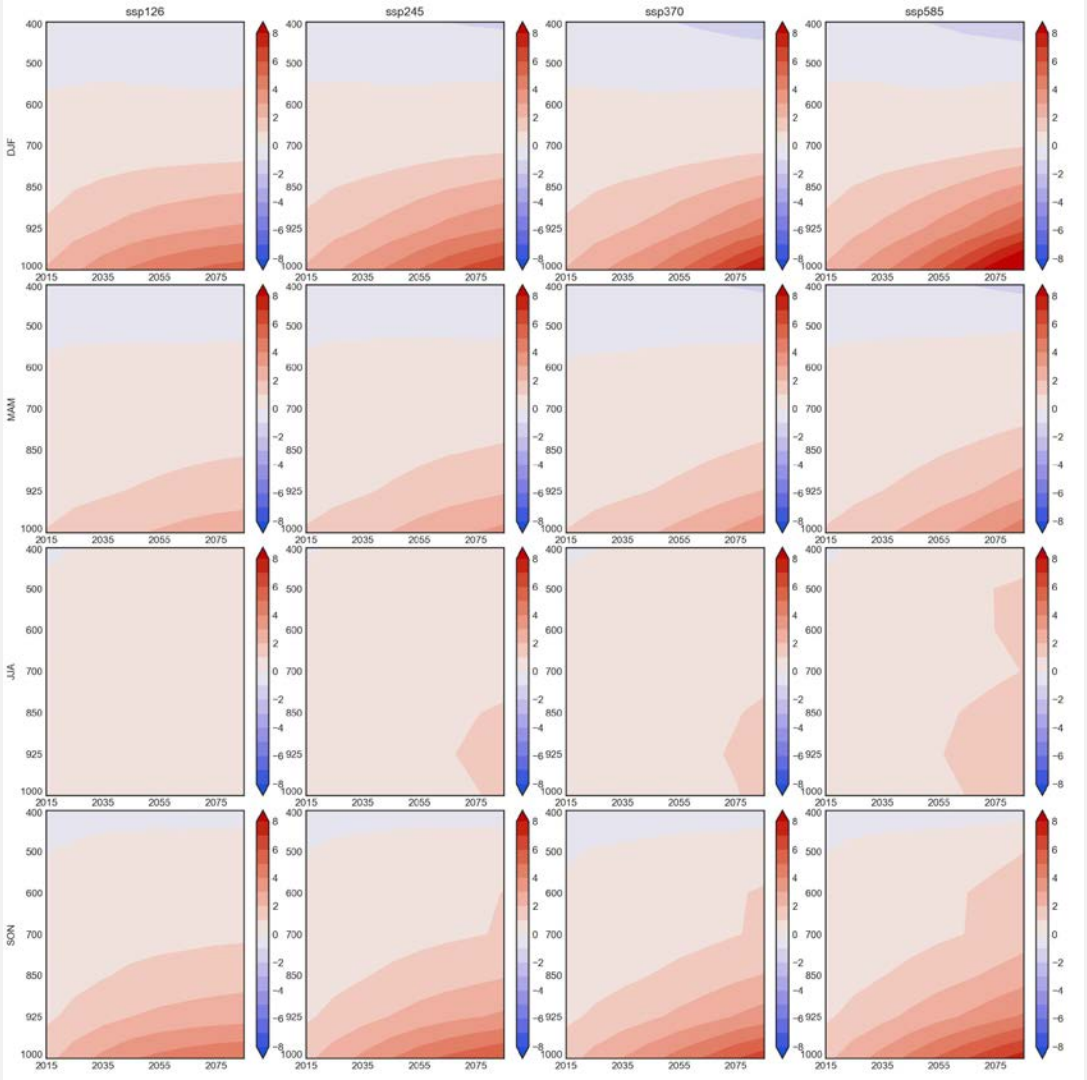
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