The Emergence and Transient Nature of Arctic Amplification in Coupled Climate Model Large Ensembles

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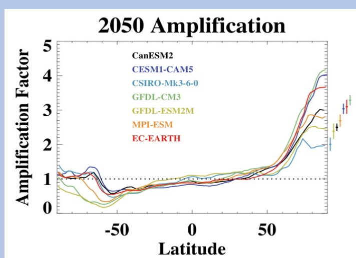
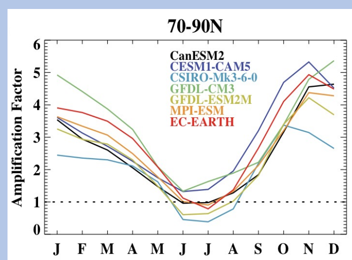
We analyze simulations from seven model large ensembles that are part of the CLIVAR multi-model large ensemble (Deser et al., 2020). We examine the properties of simulated Arctic Amplification (AA), when an AA signal emerges from the noise of internal variability, and factors that result in a changing AA over time.

Simulated properties of Arctic Amplification

By 2050, all models simulate amplified Arctic warming that is maximum in late fall

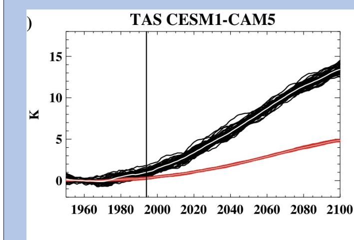


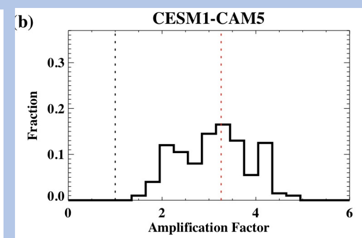


*Amplification factor is defined as the average surface air temperature change relative to the global change. The change is computed relative to the 1950-1969 period for each model.

Emergence of Arctic Amplification

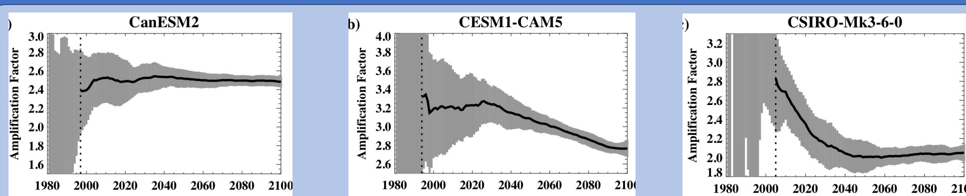
When does Arctic warming exceed global warming across all members?





Amplified Arctic warming emerges from **1994** (CESM1) to **2005** (CSIRO).
At ToE, there is considerable uncertainty in AA magnitude across members
(Example shown for CESM1-CAM5)

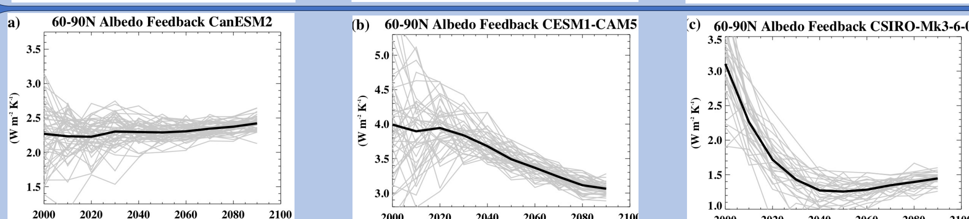
21st Century Transient Changes in Arctic Amplification



Results from 3 Representative Models

70-90N Amplification Factor Timeseries

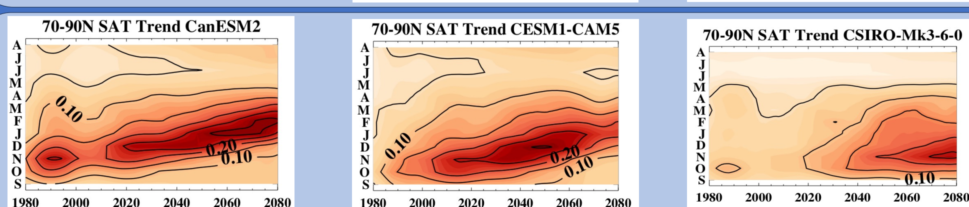
In the 21st century, AA shows little change or declines, depending on the model



Arctic Albedo Feedback Timeseries*

- Changes in AA are associated with changes in the strength of the albedo feedback
- These are related to the rate, location, and seasonality of sea ice and snow loss

*Albedo feedback computed using the radiative kernel method



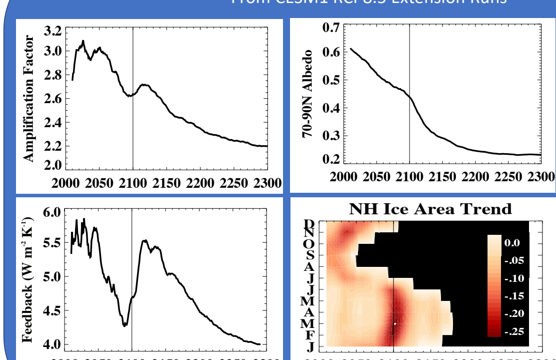
Timeseries of Arctic Monthly Warming*

- Over the 21st century, the seasonal timing of maximum AA transitions from fall to winter.
- This is consistent with changes in the seasonal timing of maximum ice loss.

*20-year running trend in monthly surface air temperature
Contour interval of 0.05 °C/year

Transient change beyond 2100

From CESM1 RCP8.5 Extension Runs



Transient AA changes are strongly associated with the rate of albedo change resulting from seasonal sea ice loss

An early 22nd century AA increase results from rapid May-June ice loss and albedo change.

Afterwards, albedo changes decline as the Arctic goes ice-free. This weakens the albedo feedback and AA saturates at a reduced value.

Conclusions and Implications

- AA emerges in the late 20th-early 21st century, depending on the model
- Both Internal variability and model structure cause uncertainty in the near-term magnitude of Arctic amplification
- Characteristics of Arctic amplification, including magnitude and seasonal timing, change over the 21st century and beyond
- These changes are associated with variations in the strength of the albedo feedback, which are associated with the rate, location and seasonality of ice and snow loss and the simulated albedos of these surfaces
- Present-day observational constraints on AA are affected by internal variability
- Paleo constraints also have limitations given the dependence of AA on albedo changes which are affected by the extent and location of ice and snow cover

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