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Atmospheric Responses to Arctic Sea Ice Loss in a High-top Atmospheric General Circulation Model

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1. Introduction and model description

Rapid Arctic warming and sea-ice decline in recent decades might have profound impacts on midlatitude weather and climate. This study uses Whole Atmosphere Community Climate Model version 6 (WACCM6) to investigate the atmospheric responses to the Arctic sea-ice reduction. The high-top configuration and finer vertical resolution of WACCM6 allow more realistic representation of stratosphere-troposphere interactions.

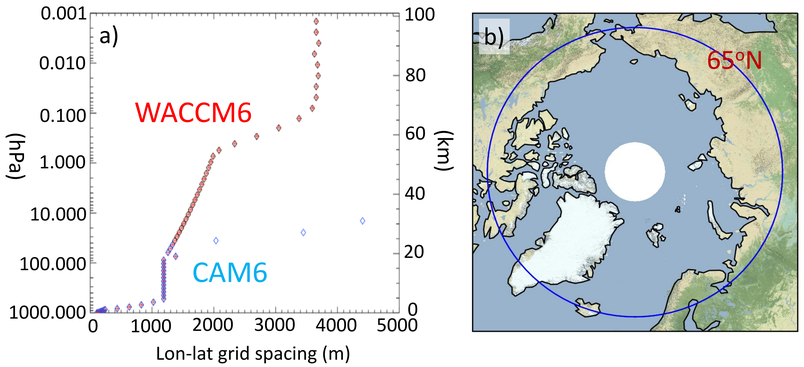

Fig 1. (a) Vertical and horizontal grids of WACCM6 (CAM6) adopted from J. Richter's presentation at NCAR. (b) The Arctic geographic domain.

2. Experiment design

EXP1	EXP2
Time-varying Arctic SIC	*Climatology Arctic SIC*
Time-varying Global SST	*Time-varying Global SST*

- 1979-2014 AMIP-type simulations forced with daily sea-ice concentration (SIC) and sea surface temperature (SST) from Met Office Hadley Centre, with GHG concentration and aerosol given by CMIP6.
- 12 members for EXP1 and 7 members for EXP2.
- **Response to Arctic Sea-ice decline = EXP1 minus EXP2**

3. ~60% of the annual-mean Arctic warming trend can be attributed to the sea-ice decline.

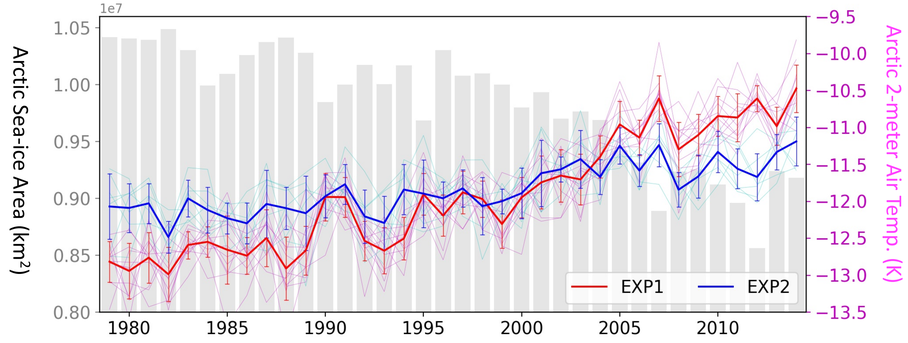

Fig 2. Annual-mean Arctic sea-ice and 2-meter air temperature time series.

	Sea-Ice Area (km^2)	2-meter Air Temp. (K)	Surface Heat Fluxes (W/m^2, "+" upward)	
Linear Trend (units per year)	-43177	0.068 ± 0.0041	0.020 ± 0.034	← **EXP1**
	0	0.026 ± 0.0046	-0.076 ± 0.018	← **EXP2**
Standard Deviation (without trend)	231425	0.40 ± 0.039	2.722 ± 0.280	← **EXP1**
	0	0.36 ± 0.037	2.742 ± 0.294	← **EXP2**

4. Zonal-mean temperature responses to Arctic sea-ice decline are primarily confined in lower troposphere.

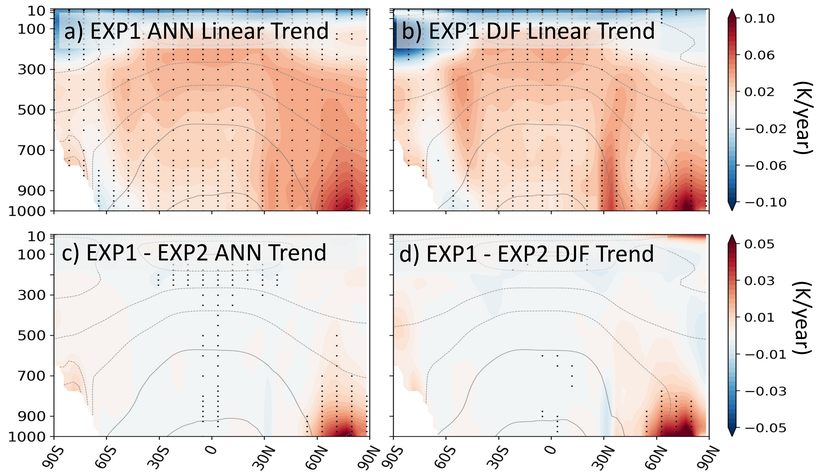

Fig 3. (a), (b) ANN and DJF zonal-mean temperature linear trends. (c), (d) Responses to sea-ice decline in ANN and DJF. Dots: significance at 5%

5. The warm Arctic-cold continent pattern in surface air temperature trends is not robust.

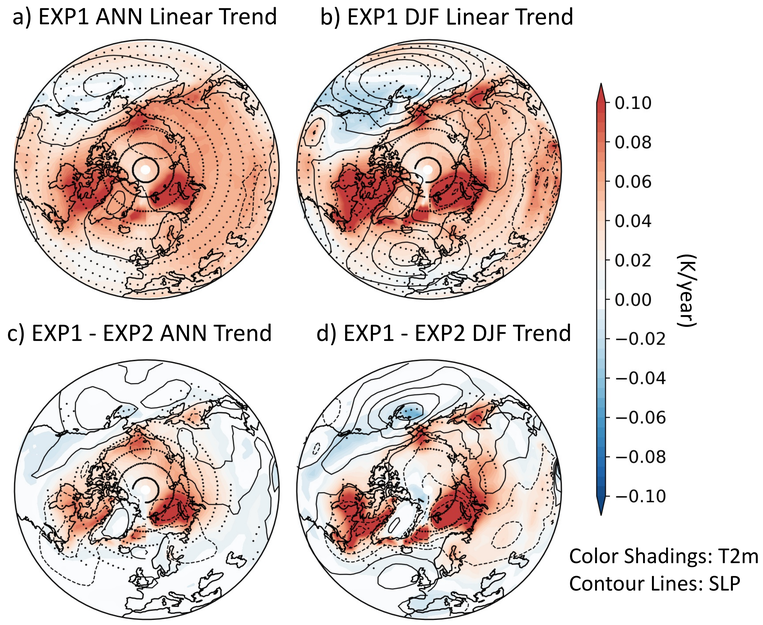

Fig 4. (a), (b) ANN and DJF lon-lat 2-meter temperature trend maps. (c), (d) Responses to sea-ice decline in ANN and DJF. Dots: significance at 5%

6. Summary

- ~60% of the Arctic near-surface warming trend in 1979-2014 can be attributed to sea-ice reduction and associated surface heat flux changes.
- The remote impacts of Arctic sea-ice reduction reach to Eurasia, where warmer air temperatures appear in lower troposphere.
- This pan-Eurasian warming pattern is distinct from the so-called warm Arctic-cold continent pattern.

7. Acknowledgements

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