Emergent constraint on Arctic amplification and Arctic lapse-rate feedback

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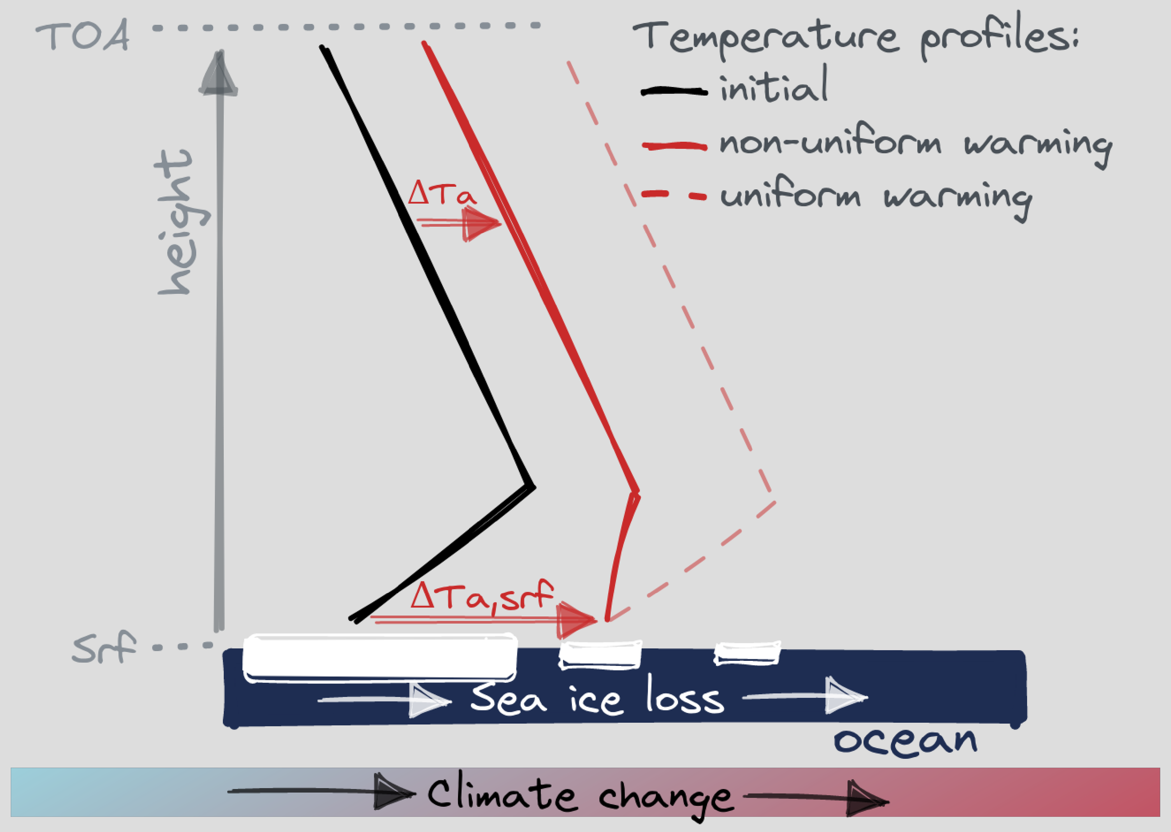
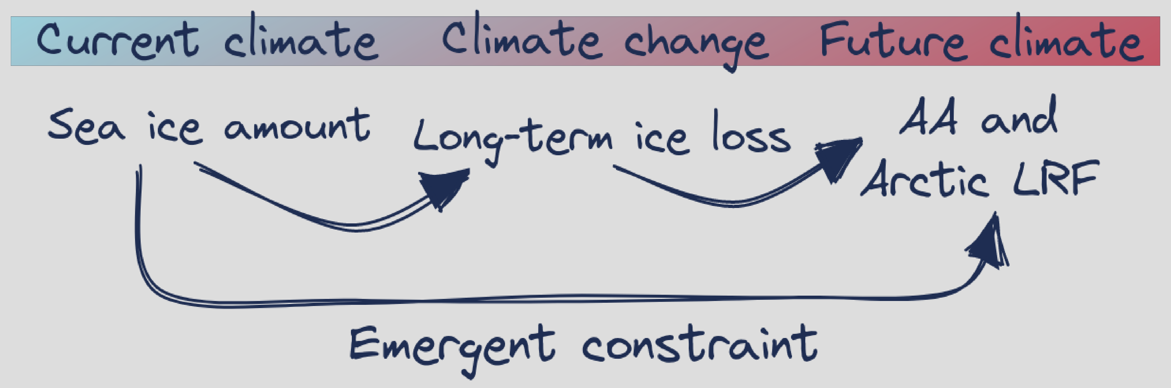
Introduction

- The LRF is positive in the Arctic due to **amplified near-surface warming**, and muted warming in the free troposphere
- Long-term **sea ice loss** relates to the strength of Arctic amplification [1,2], and Arctic LRF [3,4].



Hypothesis

The current-climate sea ice amount sets the stage for long-term sea ice loss, which mediates future AA and Arctic LRF.



Methods and Data

- **CMIP6 simulations** [5,6]:
  - Current climate: 2005-2034 (historical + SSP5 scenario)
  - Future climate: 2070-2099 (SSP5 scenario)
- Arctic amplification $= \dfrac{\Delta T_{a,\,srf,\,ARCTIC} / dt}{\Delta T_{a,\,srf,\,GLOBE} / dt}$

  = Ratio of linear trends of Arctic and global warming [7]
- Sea ice amount:
  - SIC (Arctic-average)
  - SIE (Northern Hemisphere)
- **Satellite data**: EUMETSAT OSI SAF [8]

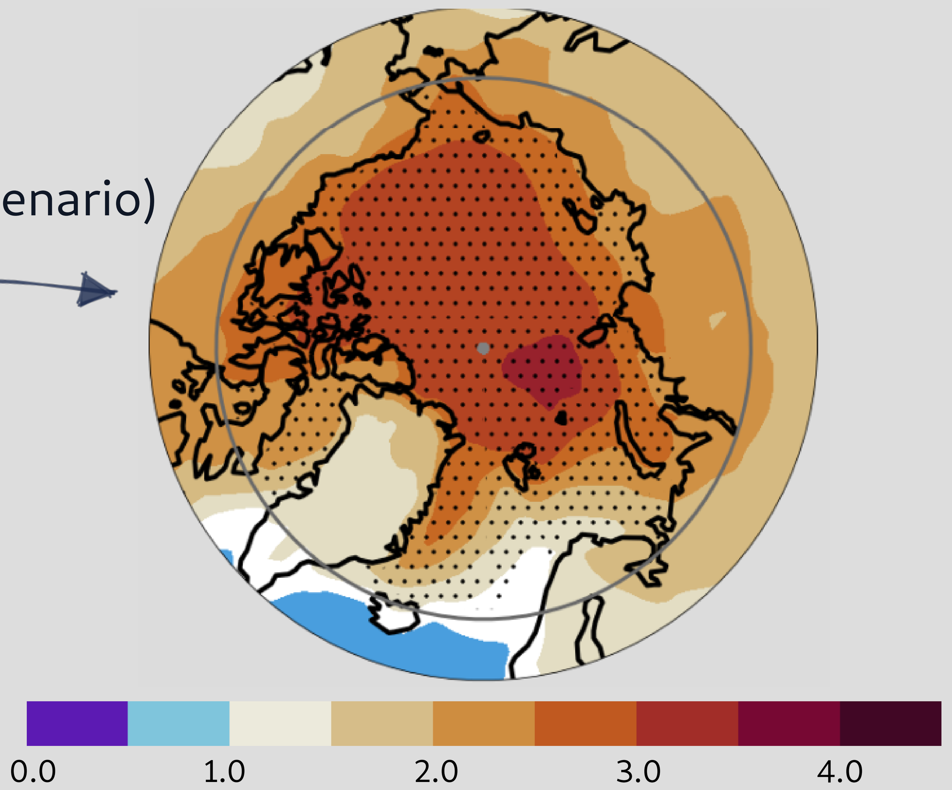


Figure 1. End-of-century Arctic warming, as local amplification factor: Ratio of local and global-mean warming trend 2005–2099, as model average. Dotted areas: Ice covered ocean in the current climate. Figure adapted from [9].

Results

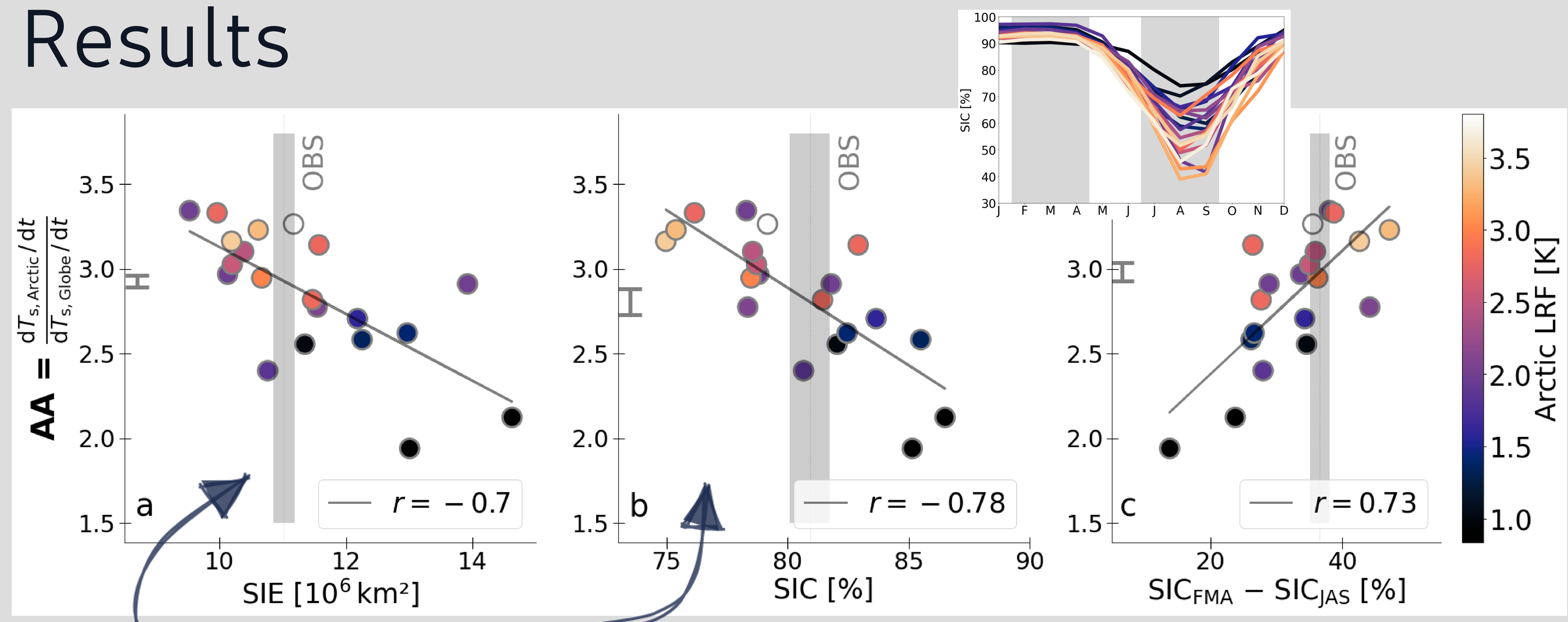
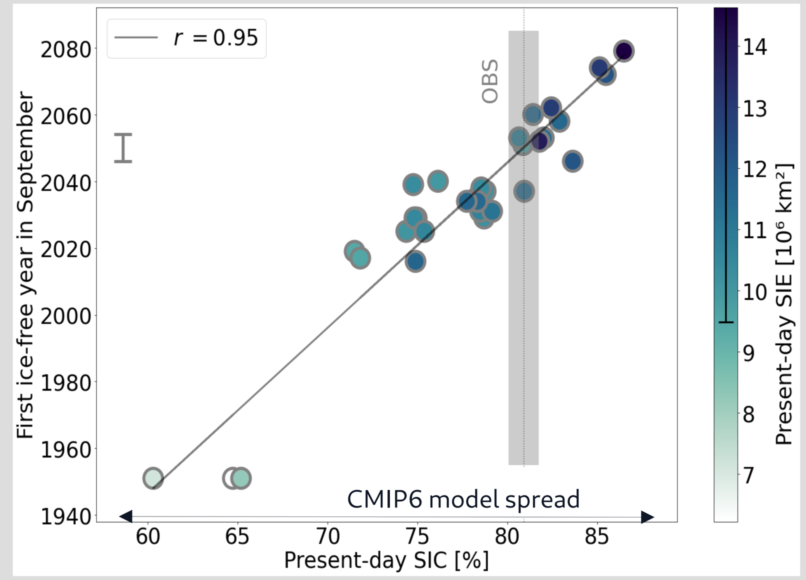


Figure 2. Relationship between current-climate sea ice climatology and future AA and LRF: Relationship between **a** SIE and AA, **b** SIC and AA, and **c** seasonal SIC (SIC_{FMA}−SIC_{JAS}) and AA. Color coding by Arctic LRF. OBS: Mean observational estimate (2016–2022). Inset plot in panel **c**: Seasonal cycle of SIC. Figure adapted from [9].

Strength of end-of-century AA and Arctic LRF?

Ice-free Arctic by mid-century?

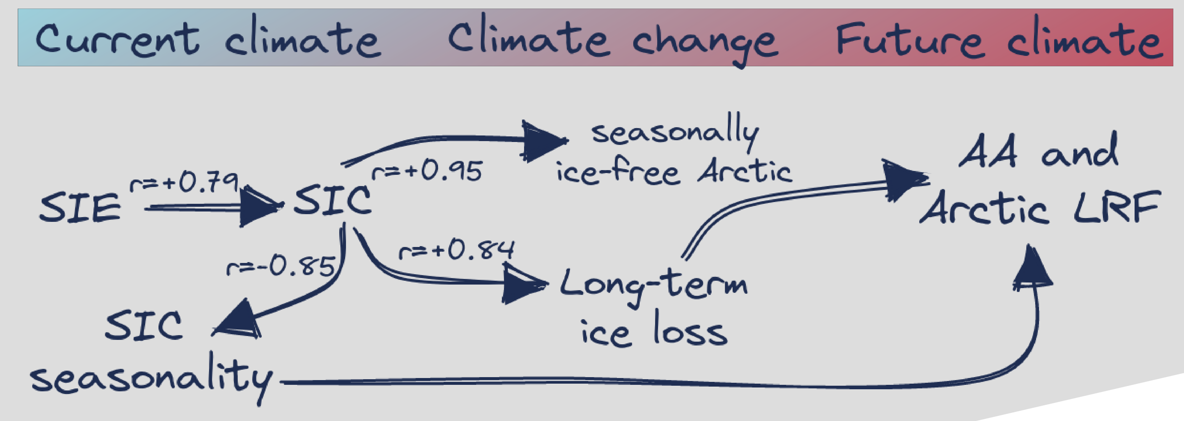
Figure 3. Relationship between current-climate sea ice amount and timing of an ice-free Arctic: Inter-model relationship between SIC and first year with ice-free September across CMIP6. OBS: Mean observational estimate (2016–2022). Figure adapted from [9]



Discussion

We find systematic links across CMIP6 models between:

- Current-climate SIC and the timing of an ice-free Arctic.
- Current-climate sea ice amount and seasonality, and future AA and LRF.



Relationships are shown in [9]

Emergent constraints

- Seasonally ice-free Arctic by 2046–2054
- Future Arctic LRF of 2.7–2.9 K
- Future AA of 2.7–3.0

ABBREVIATIONS

AA – Arctic amplification
LRF – Lapse-rate feedback
srf – Surface, TOA – Top-of-the-atmosphere
$T_{a,\,srf}$ – Near-surface atmospheric temperature
T_a – Atmospheric temperature
SIC – Sea ice concentration
SIE – Sea ice extent

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Presented results are based on: [9] Linke et al. 2023, *ERCL*, under review, „Present-day sea ice amount and seasonality as constraints for future Arctic amplification".

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