Arctic amplification and its seasonal migration from $1/8\times$ to $8\times CO_2$ forcing

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CESM Polar Climate WG

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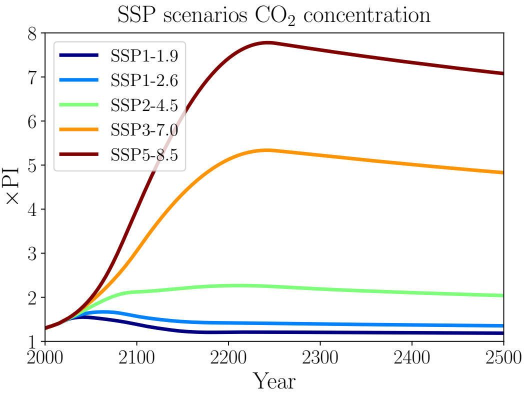
Outline

1. Liang et al., NPJ, 2022: Arctic amplification, and its seasonal migration, over a wide range of abrupt CO_2 forcing
2. Zhou et al., submitted: Stronger Arctic Amplification Produced by Decreasing, not increasing, CO_2 Concentrations

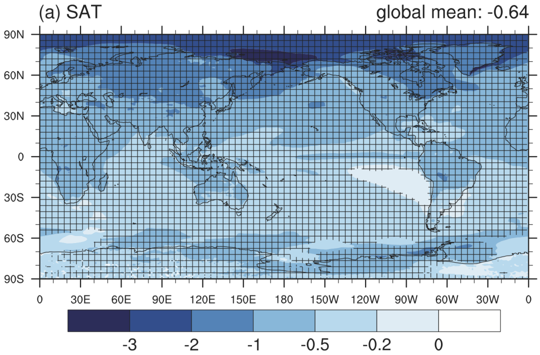
Arctic amplification (AA) at high CO_2

- SSP5-8.5 scenario projects around $4\times CO_2$ by 2100 and $8\times CO_2$ by 2200
- Most previous AA studies are focused on $2\times CO_2$ and $4\times CO_2$



Meinshausen et al., 2019

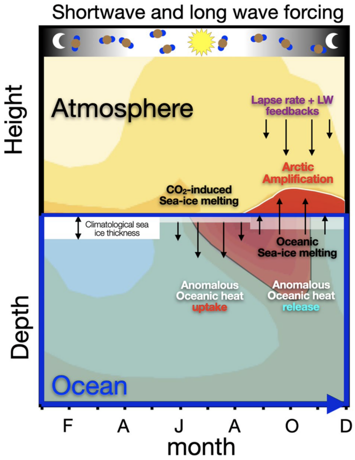
Comparing Scenarios of CO_2 reduction and increase



Jiang et al., 2020

- In the analysis of the atmospheric impact of aerosols, the cooling is the largest in the Arctic regions.

Anomalous Seasonal Ocean Heat Uptake/Release



Chung et al., 2020

- The seasonality of sea ice directly influences the thermal storage of the oceans, leading to pronounced seasonality in the energy transfer mechanisms within the Arctic region.

Model Runs

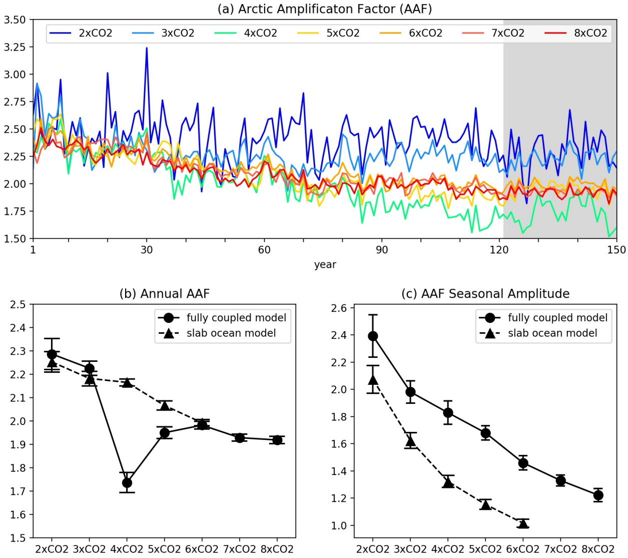
Model:

- **CESM1-LE**: 30-level CAM5 (1°) and 60-level POP2 (1°)

Experiments

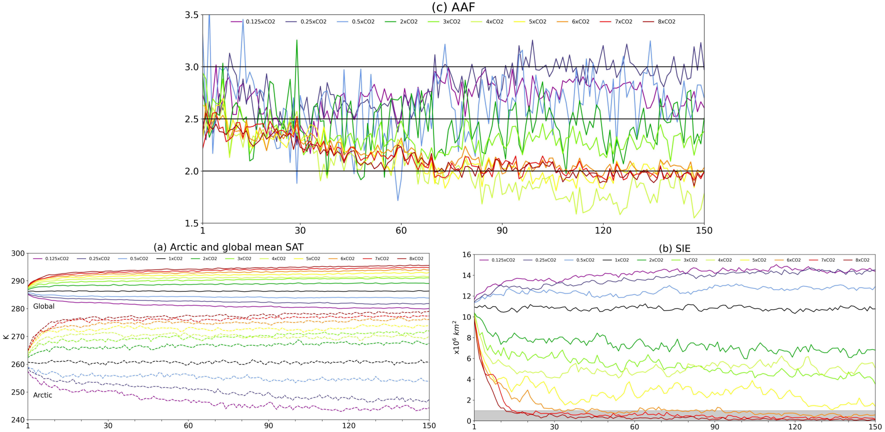
- **Fully coupled abrupt**: $1/8\times$, $1/4\times$, $1/2\times$, $2\times$, $3\times$, $4\times$, $5\times$, $6\times$, $7\times$, $8\times CO_2$ for 150 years
- **Slab ocean**: abrupt $1\times$, $2\times$, $3\times$, $4\times$ $5\times$, and $6\times CO_2$ for 60 years

AAF weakens at higher CO_2 levels



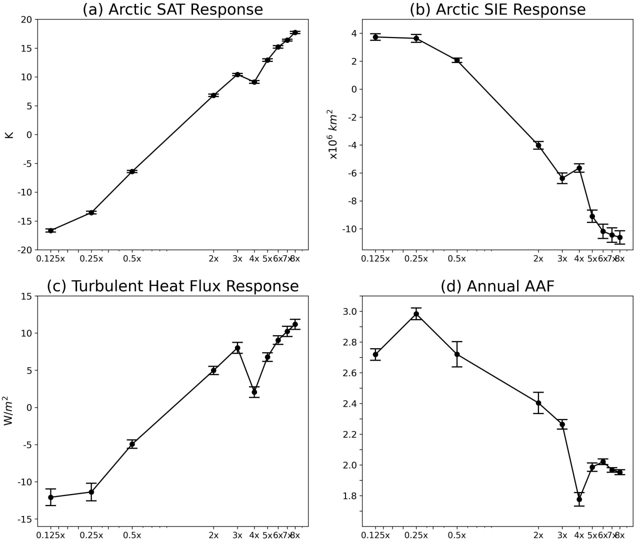
Liang et al., 2022

The cold AAFs are larger than the warm AAFs



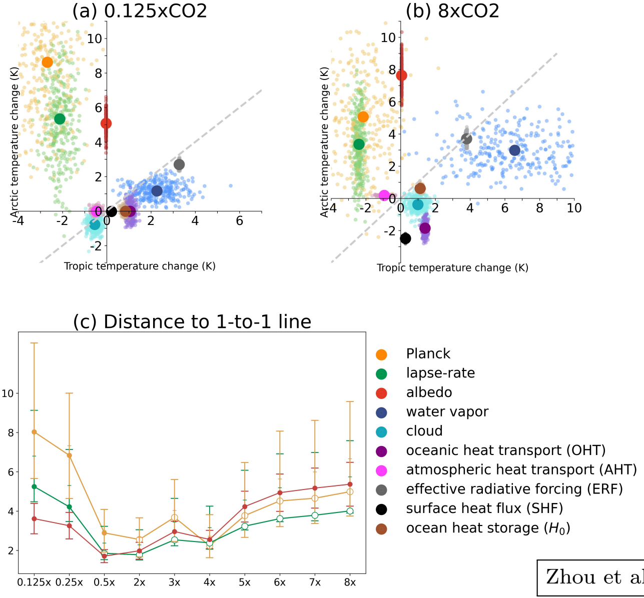
Zhou et al., submitted

Asymmetric Responses in Arctic Amplification



Zhou et al., submitted

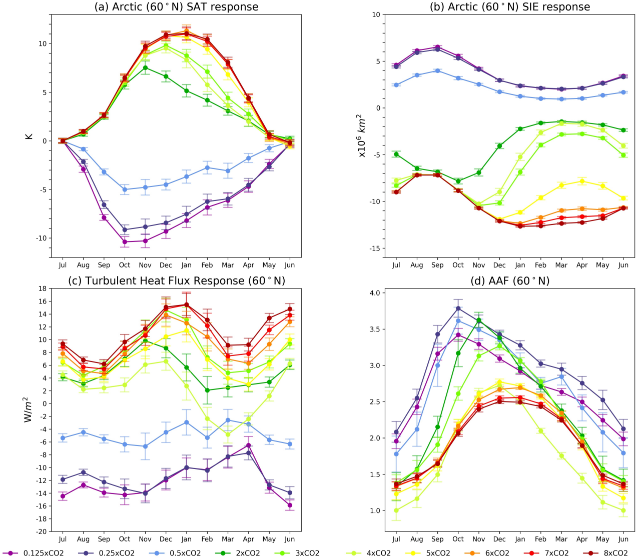
PL, LR and AL feedbacks are main contributors to AAF



Zhou et al., submitted

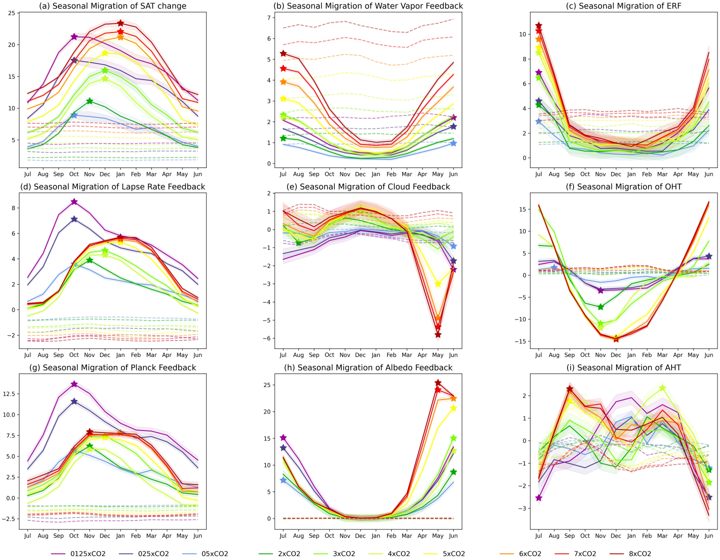
Seasonal migration of AAF peak

- AAF peak in CO_2 increase moves from November to December of January
- CO_2 decrease levels cannot migrate the peak of AAF earlier than October



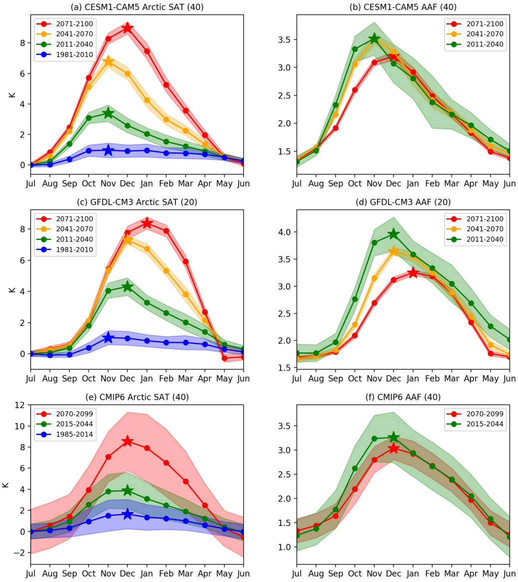
Zhou et al., submitted

Seasonality for feedbacks, ERF, AHT, and OHT



Zhou et al., submitted

Seasonal migration in 21st century



Liang et al., 2022

Summary

- Weaker AA at higher CO_2 levels
- **Decreasing** CO_2 concentrations produce stronger AA than **increasing** CO_2 concentrations
- **Peaks of warm AA** shift gradually from November to December or January as the CO_2 forcing strength enhances
- The seasonal shift in AA emerges in the 21st century in high-CO_2 emission scenario simulations
- **Peaks of cold AA** are locked in October bounded by the maximum sea-ice increase in September.
- Planck, lapse-rate, and albedo feedbacks are the main contributors to producing AAs forced by CO_2 increase and reduction