U.S. DEPARTMENT OF ENERGY

Georgia Tech College of Sciences
School of Earth and Atmospheric Sciences

Modulation of Regional Carbon Uptake by AMOC and Alkalinity Changes in the Subpolar North Atlantic under a Warming Climate

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Georgia Tech Ocean Science & Engineering

08/06/2024

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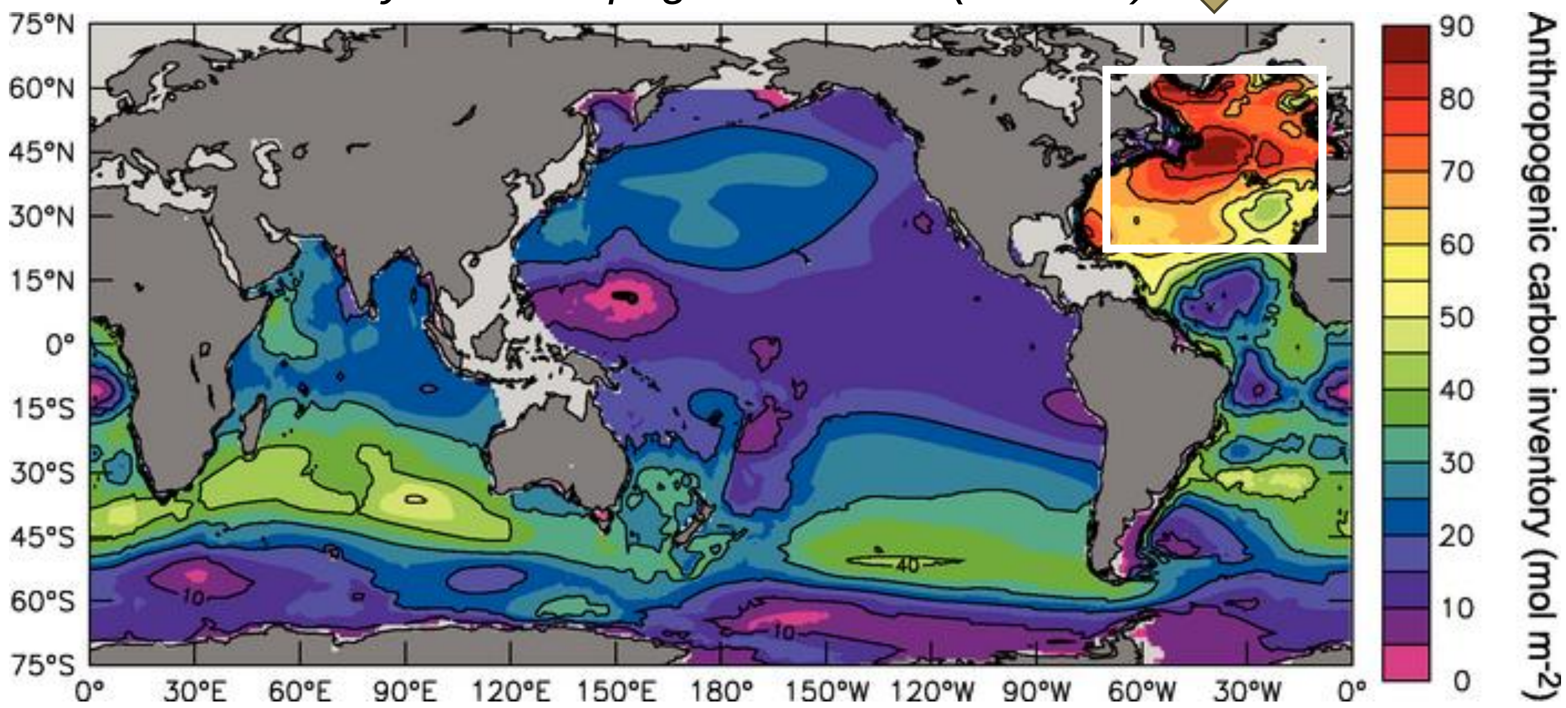
Motivations

Impact of AMOC Slowdown

The AMOC is a crucial component of Earth's climate system and its alteration has significant implications for temperature, salinity, and the **carbon cycle**.

Column inventory of anthropogenic carbon (mol m^{-2})



(credit: IPCC AR4 WGI, 2007)

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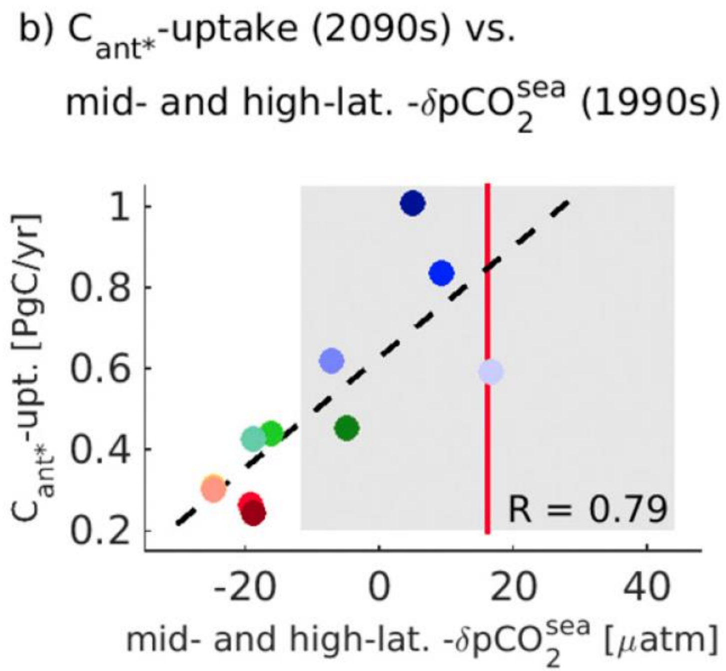
Investigating Mechanisms Behind Reduced CO_2 Uptake

AMOC contributes to the vertical transport of DIC from the surface to interior ocean, which modulates the air-sea difference in partial pressure of CO_2 (pCO_2).

(Goris et al., 2018)



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Role of Alkalinity and Other Factors

The trends of pCO_2 are driven by SST, SSS, alkalinity, and DIC. The amount of CO_2 uptake reduction contributed by surface alkalinity and diminished subduction remains uncertain.

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The trends of pCO_2 are driven by SST, SSS, alkalinity, and DIC. The amount of CO_2 uptake reduction contributed by these variables remains uncertain.

Two plausible mechanisms linking the AMOC slowdown to the decline of regional CO_2 uptake:
diminished subduction and reduction in surface alkalinity

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Methods

lat: 40°N to 65°N
lon: 55°W to 15°W

Data - CMIP6

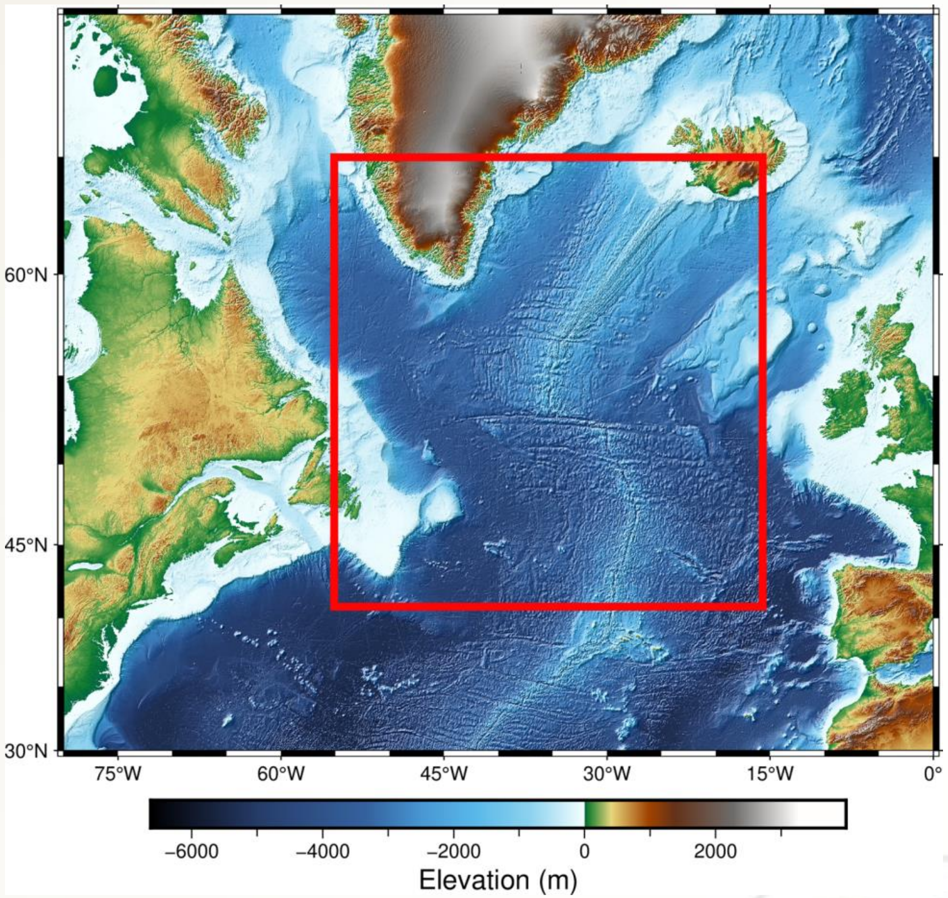
1. CESM2
2. NorESM2-LM
3. ACCESS-ESM1-5
4. MPI-ESM1-2-LR
5. CMCC-ESM2
6. CNRM-ESM2-1
7. UKESM1-0-LL
8. MIROC-ES2L
9. CanESM5
10. IPSL-CM6A-LR

Time Periods

Historical
1950-2014

SSP5-8.5
2015-2100

Geographic Area



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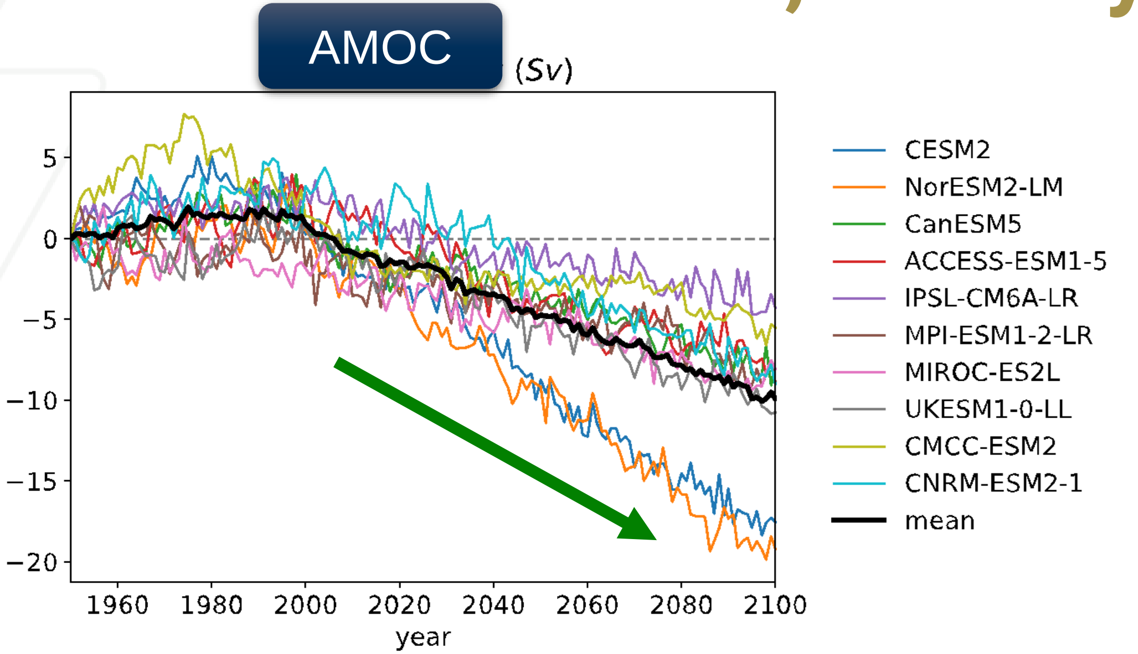
Anomalies of AMOC, Salinity and Alkalinity



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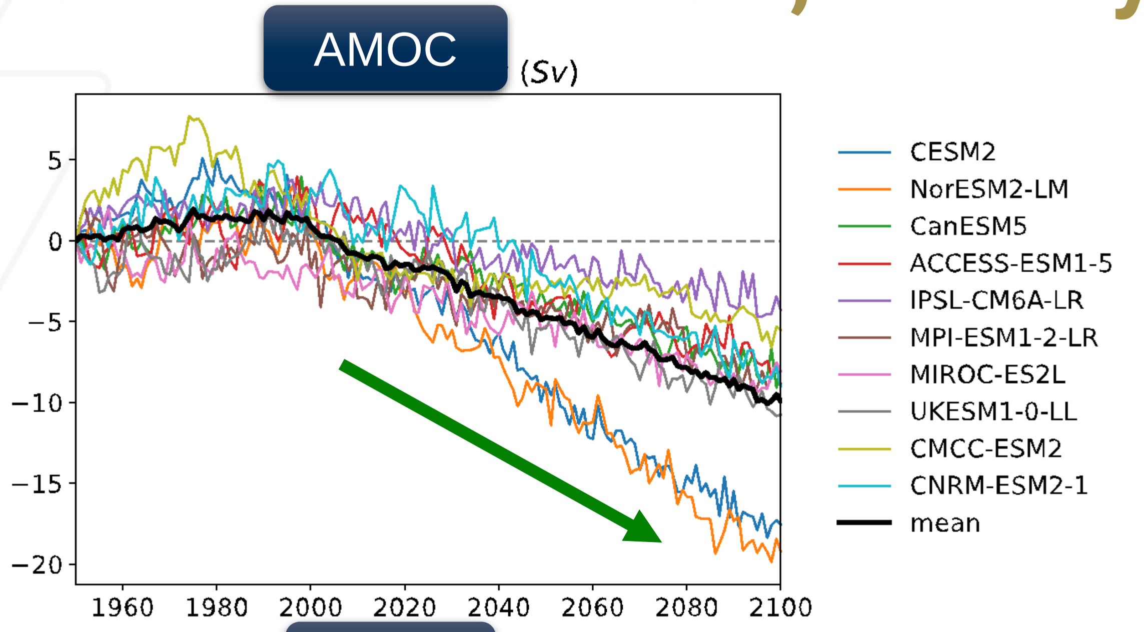

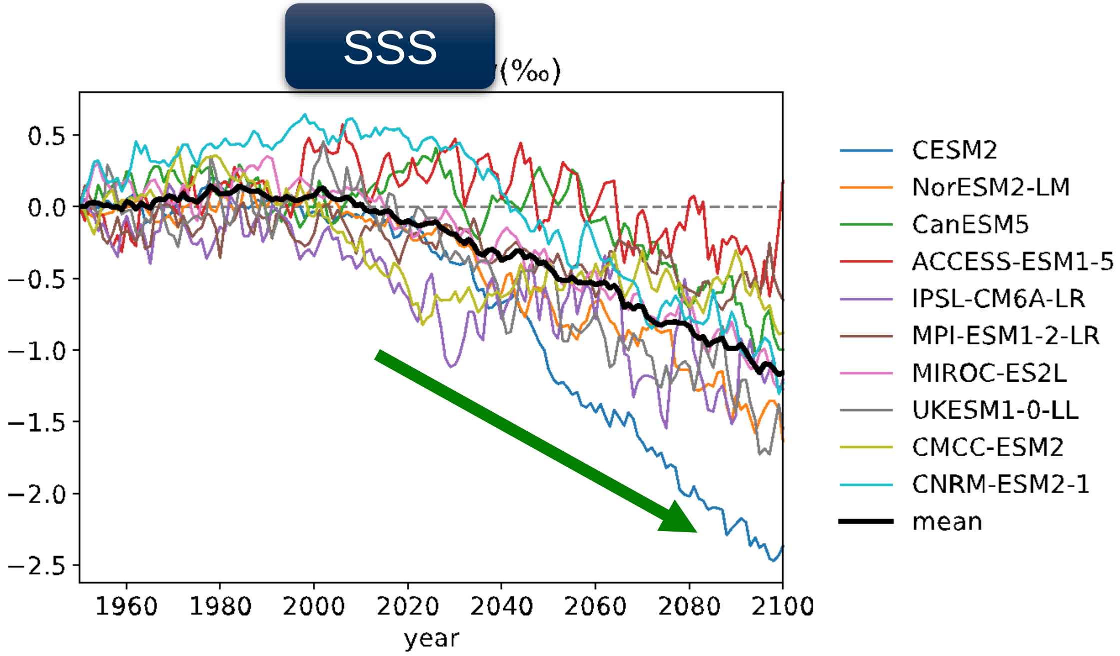

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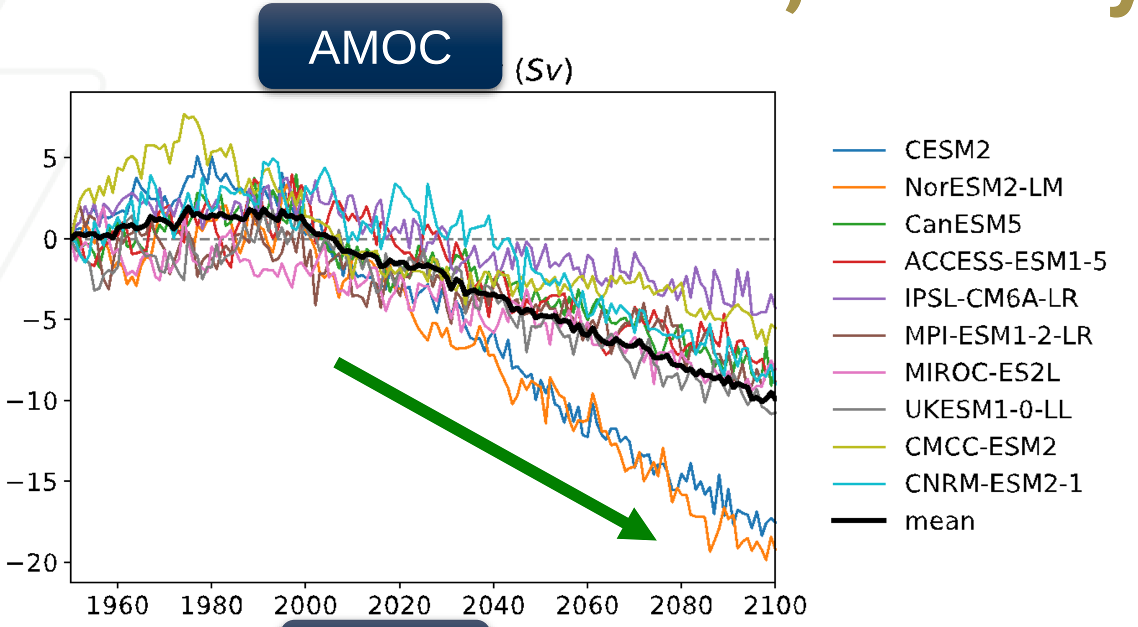

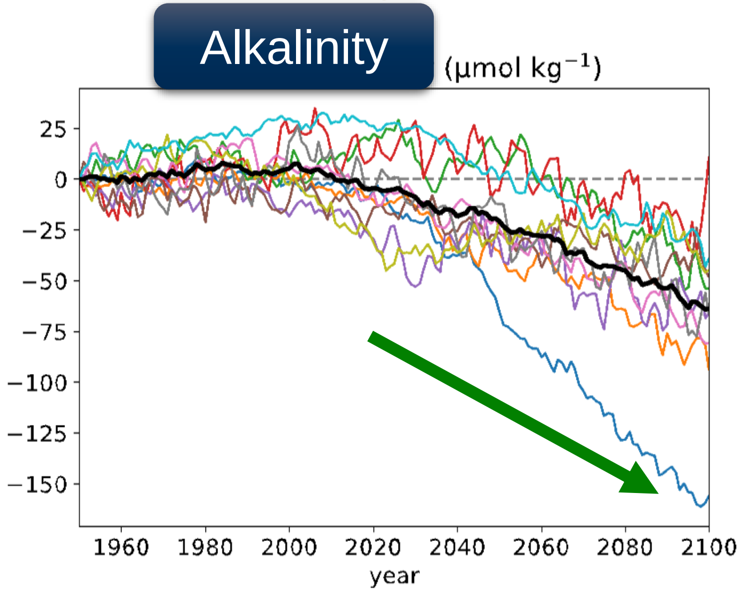

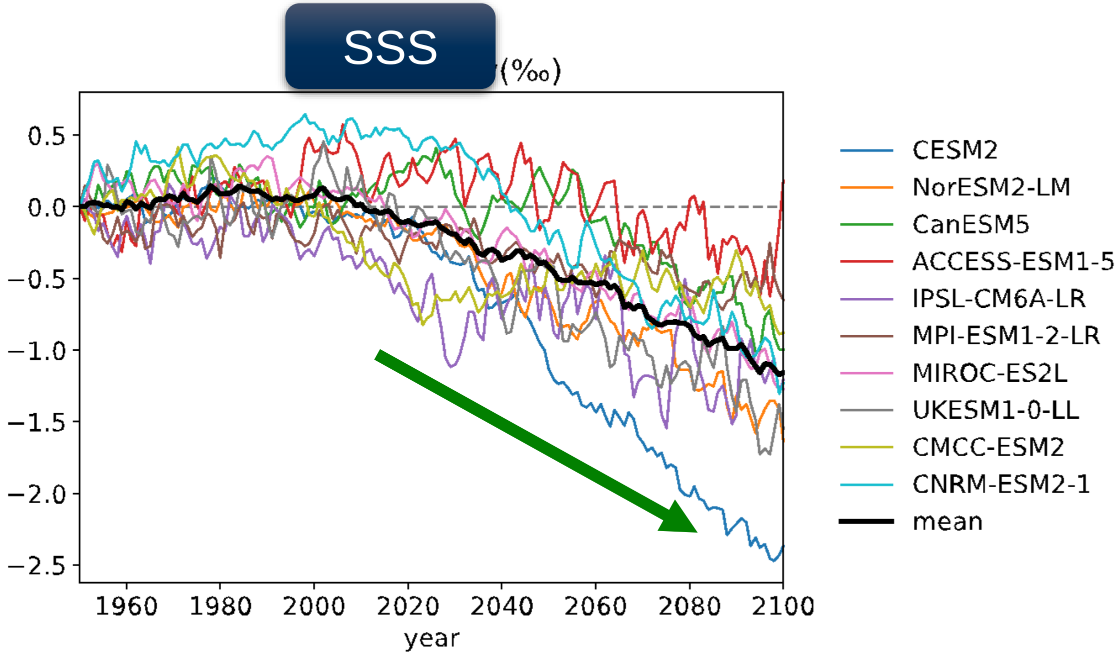

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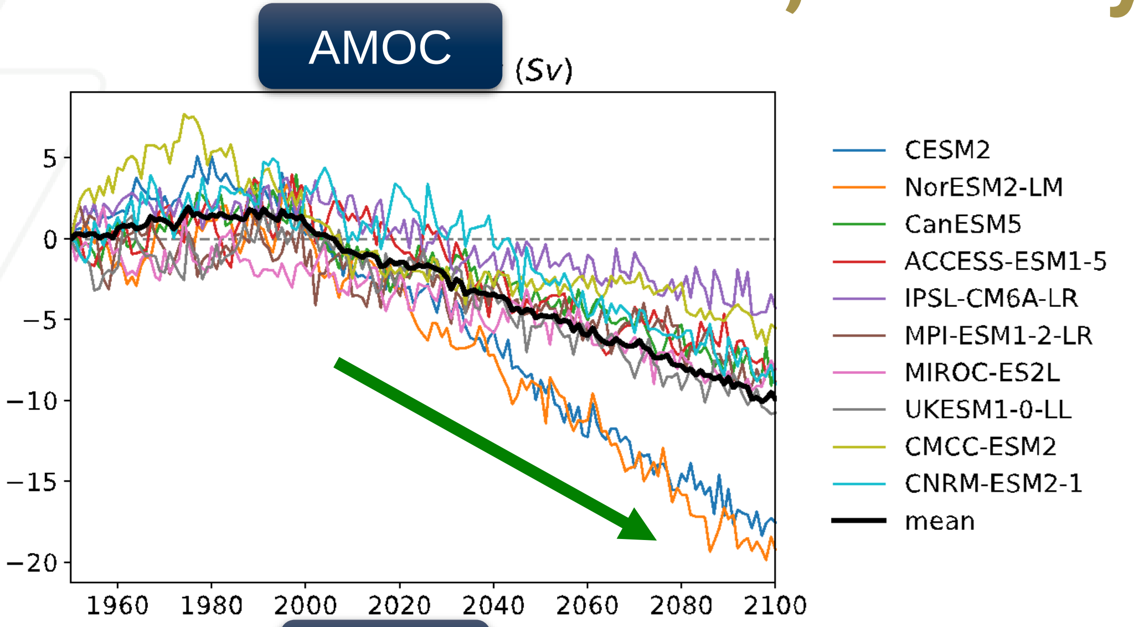
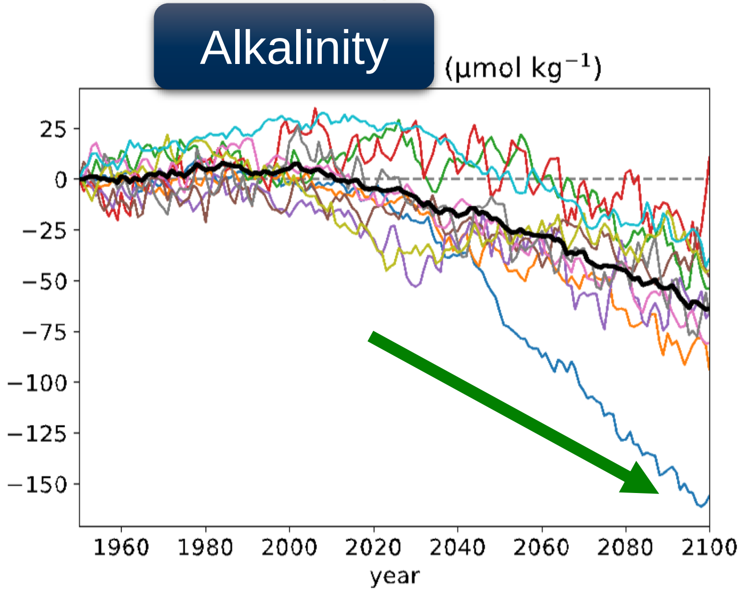
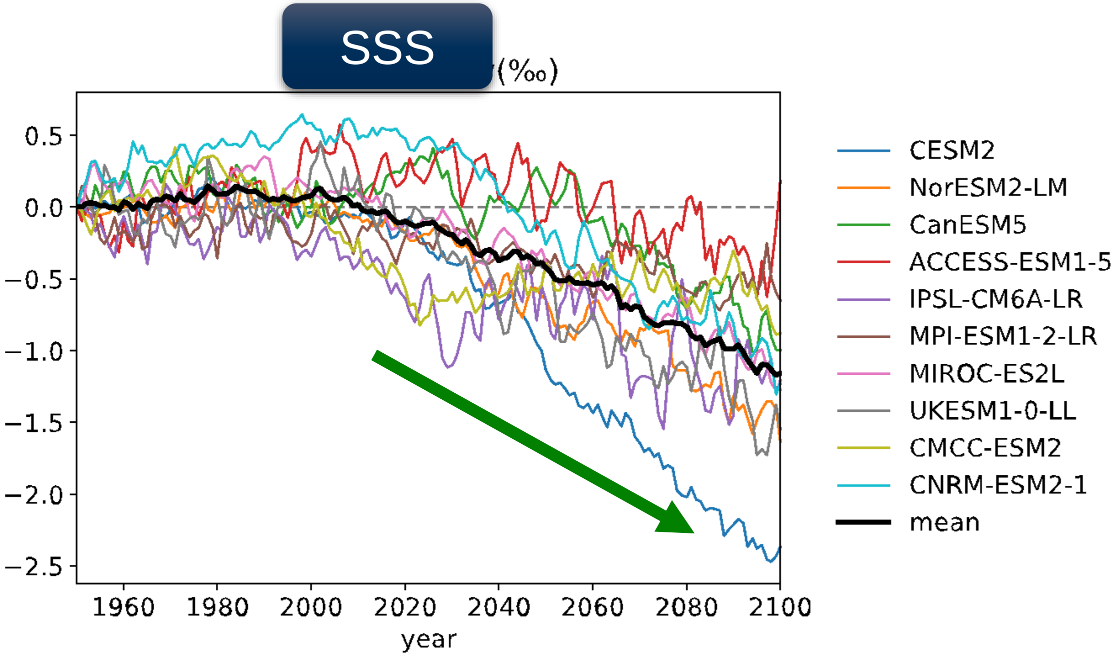
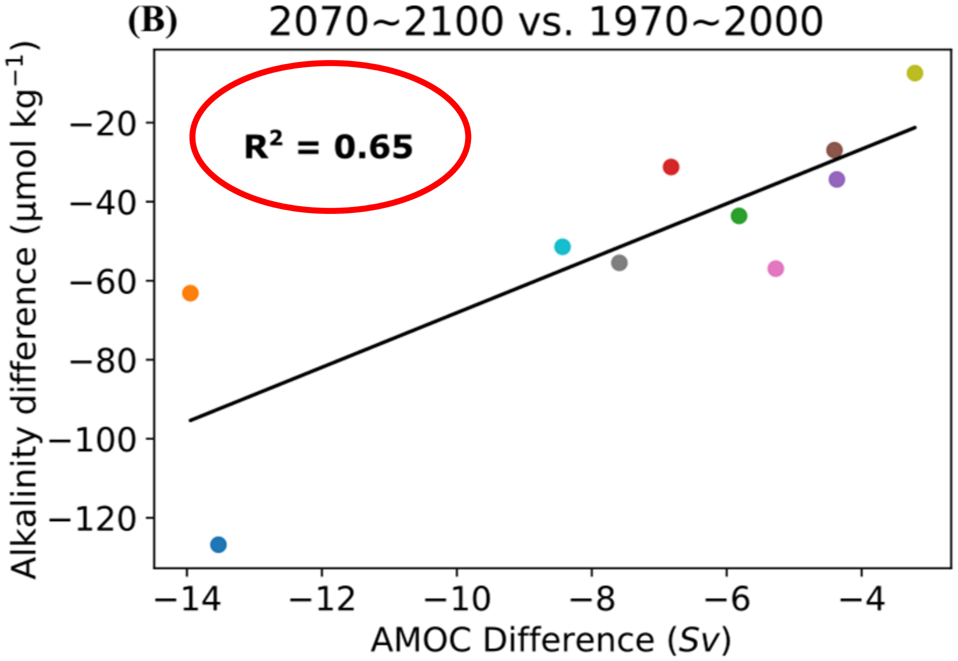


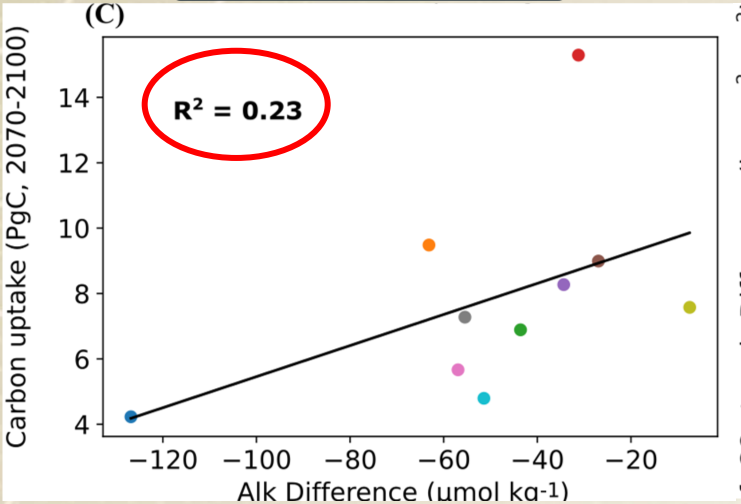






CO_2 uptake and $p$$CO_2$

$fgCO_2$ vs ALK



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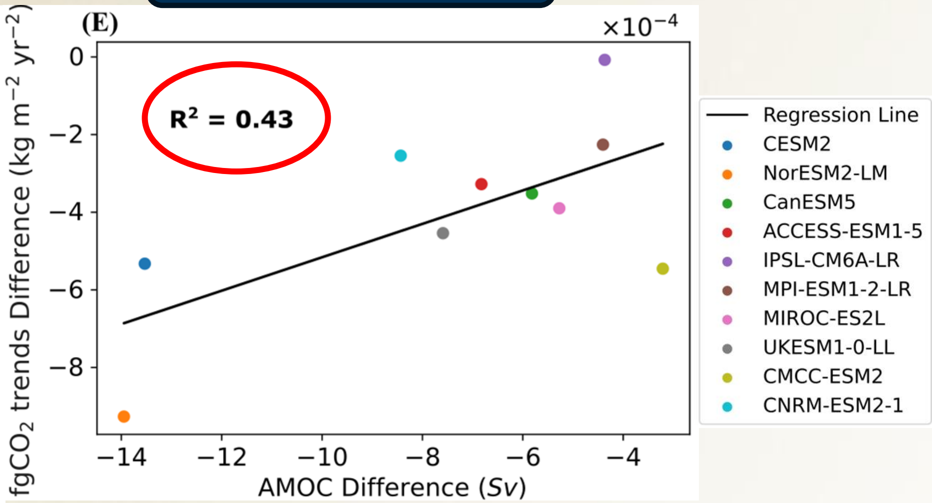

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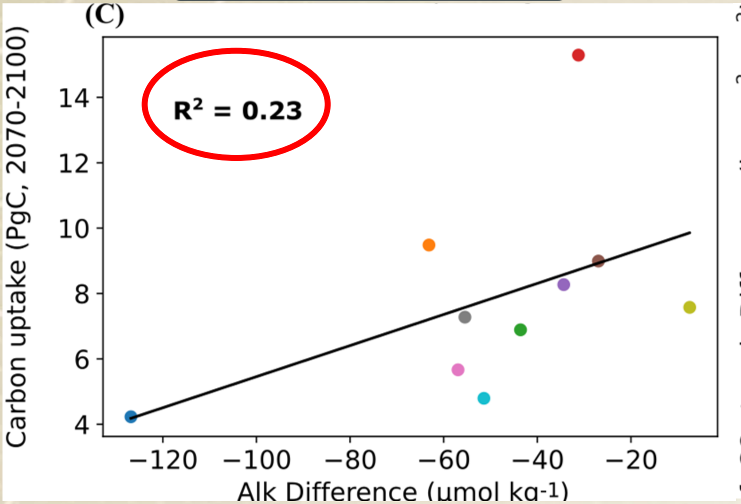

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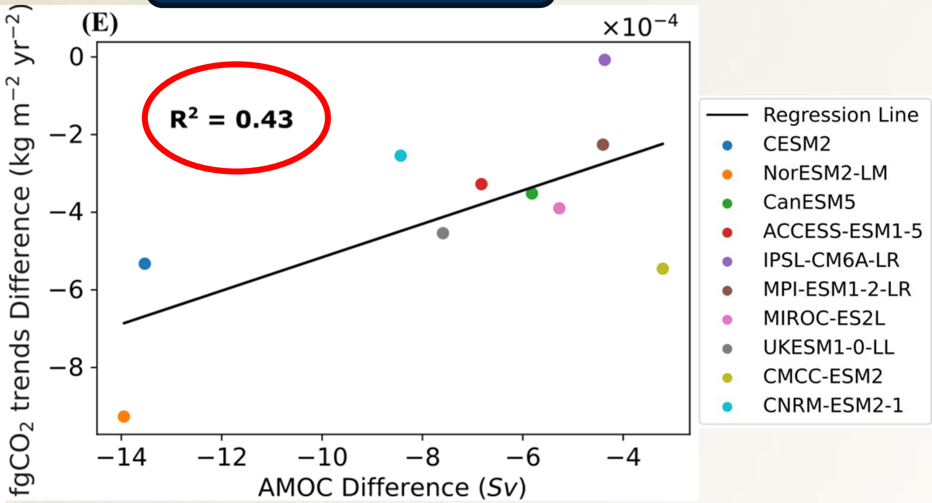

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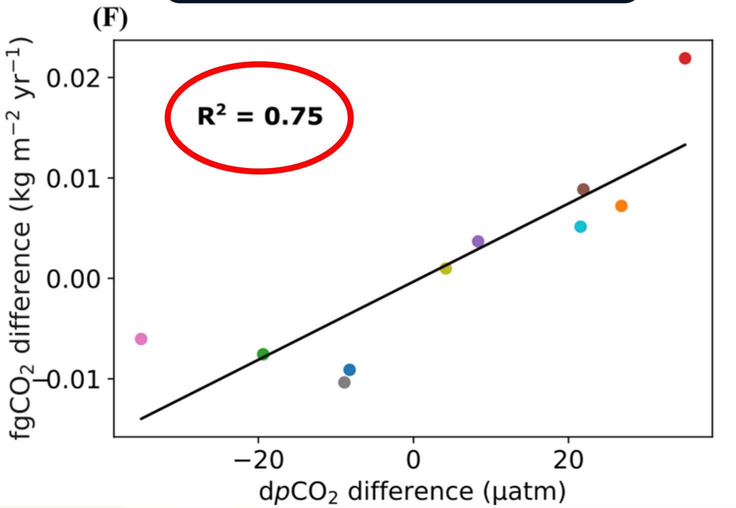

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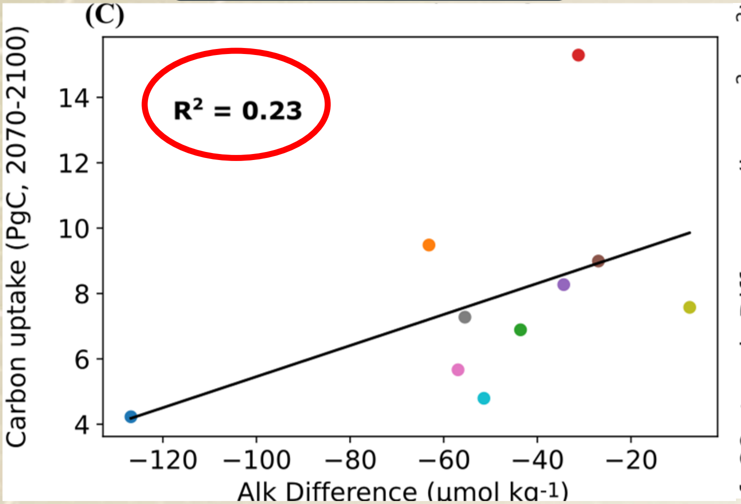

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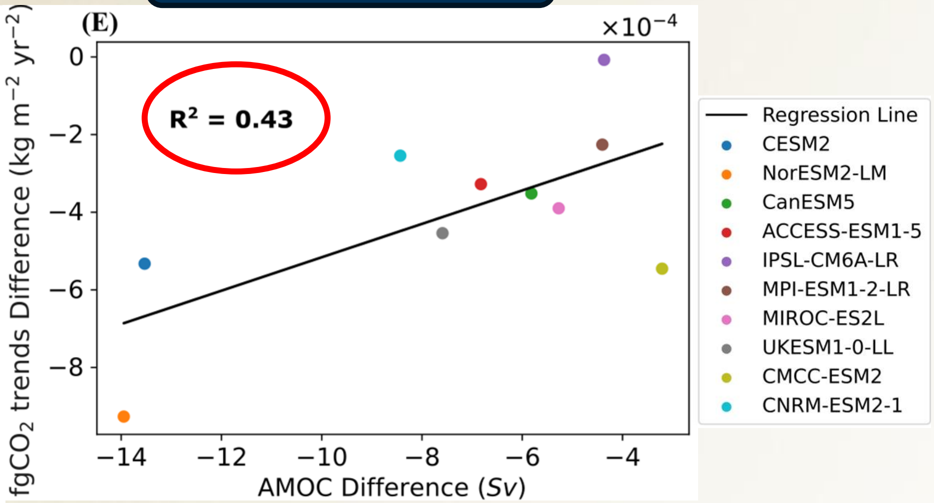

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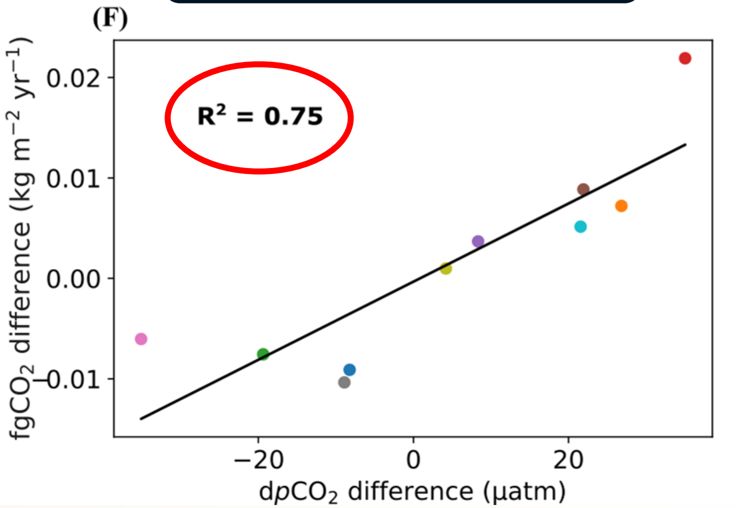
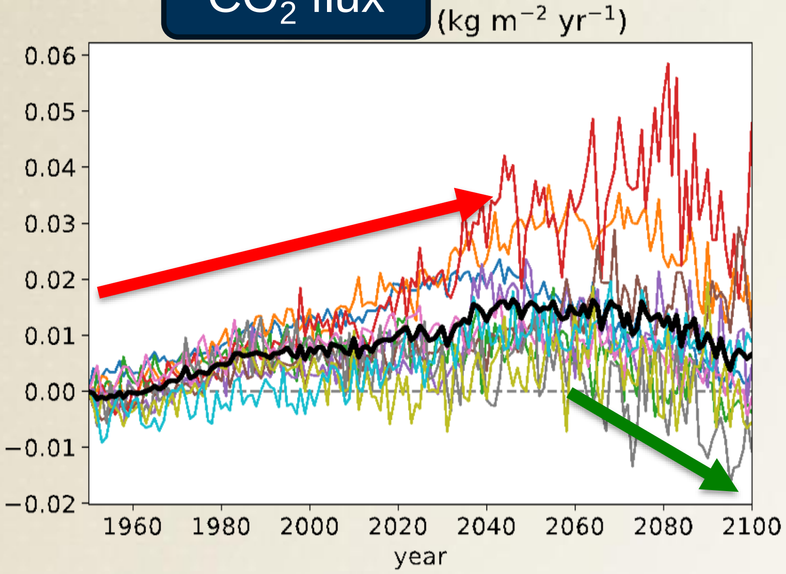
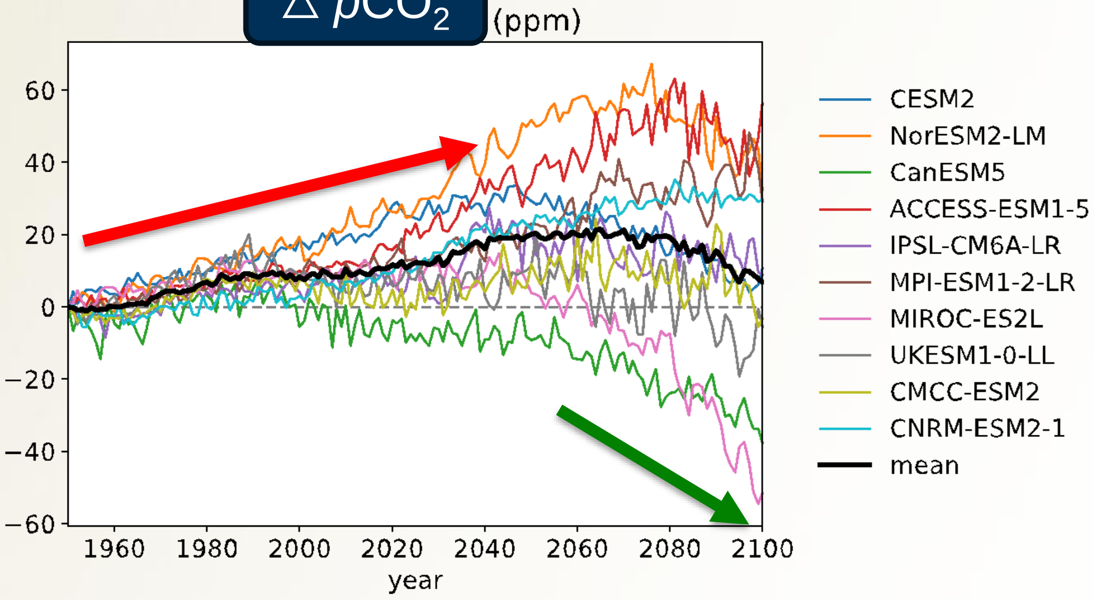


CO_2 flux



△ pCO_2



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pCO$_2$ decomposition

(Sarmiento and Gruber, 2006)

$$\delta pCO_2 = \frac{\partial pCO_2}{\partial SST}\delta SST + \frac{\partial pCO_2}{\partial SSS}\delta SSS + \frac{\partial pCO_2}{\partial DIC}\delta DIC + \frac{\partial pCO_2}{\partial ALK}\delta ALK$$

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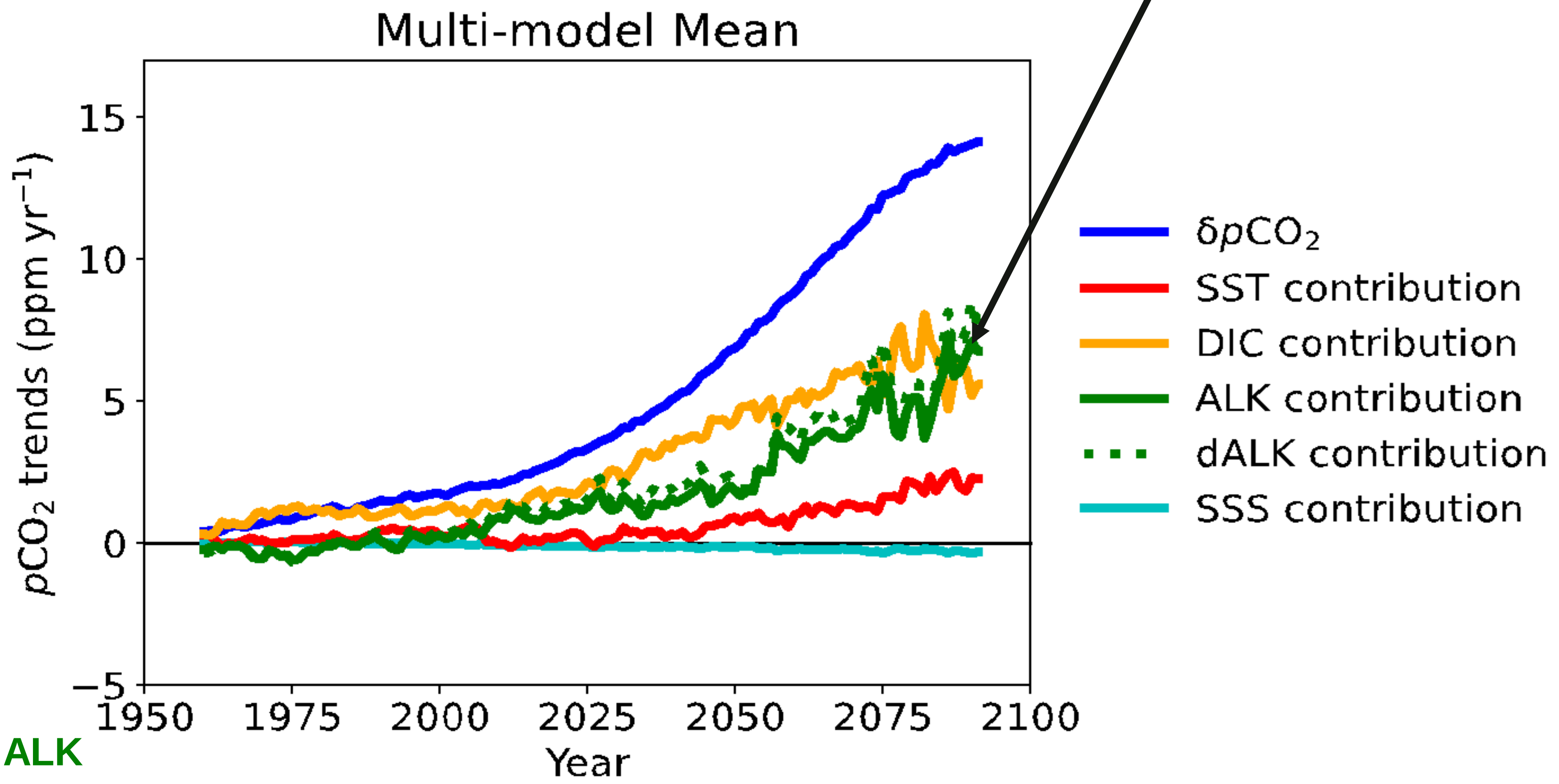

dALK: diluted ALK
Diluted effect (freshwater)

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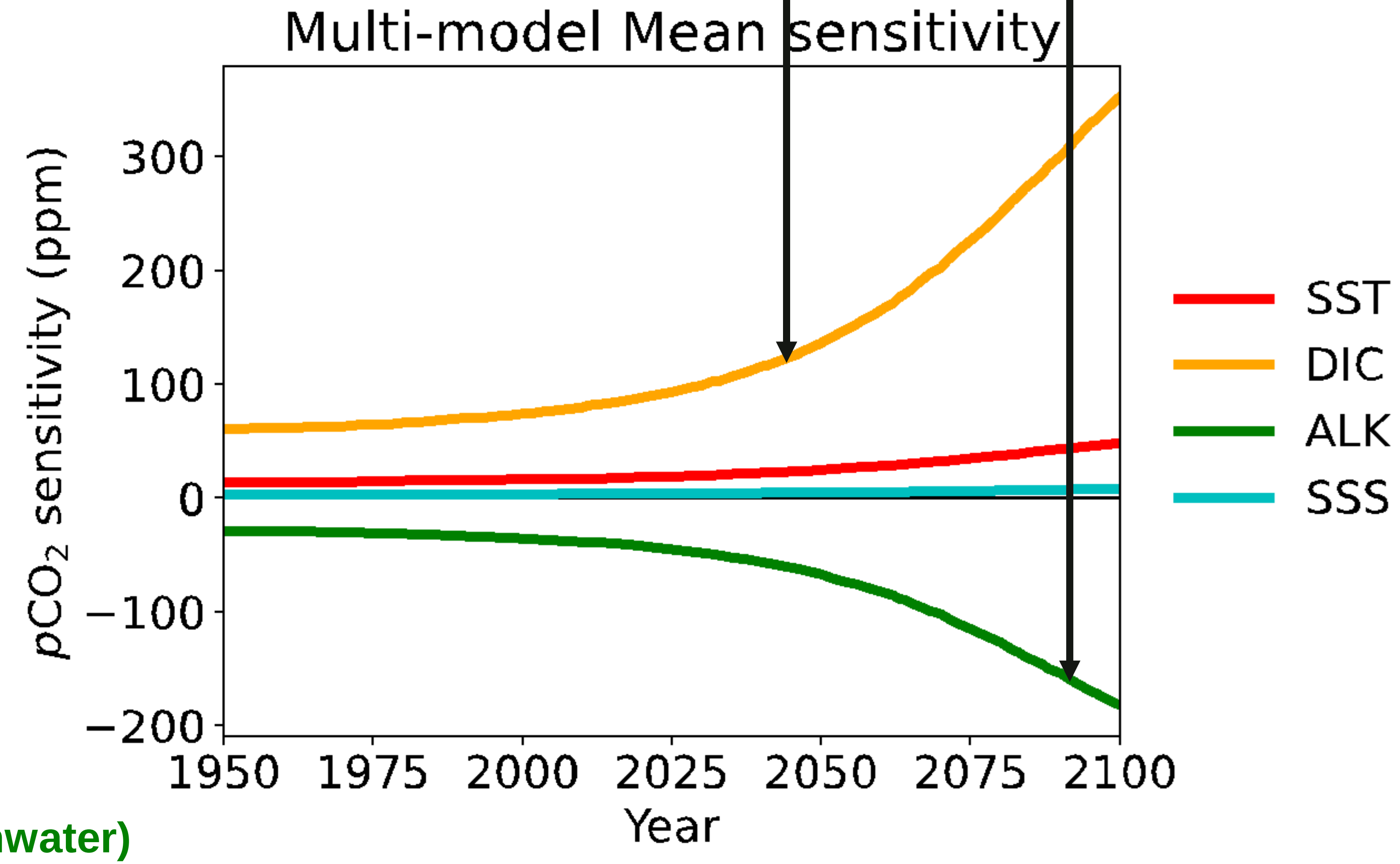

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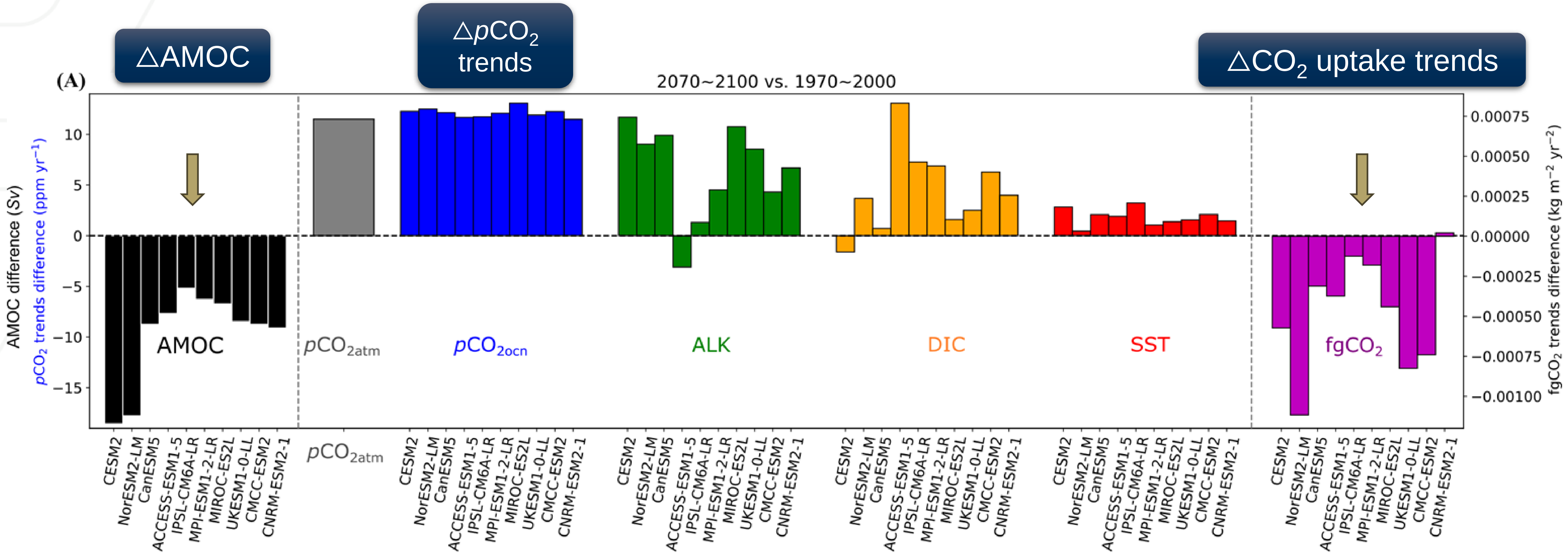
pCO_2 changes between 2070-2100 and 1970-2000



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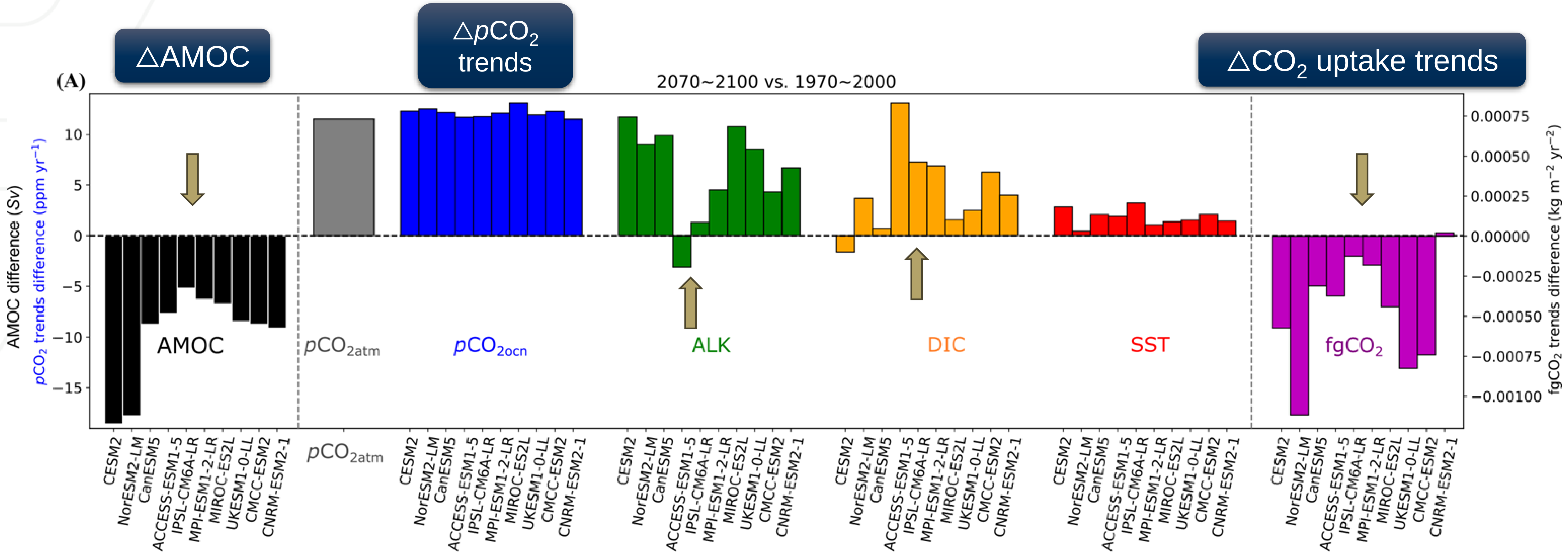

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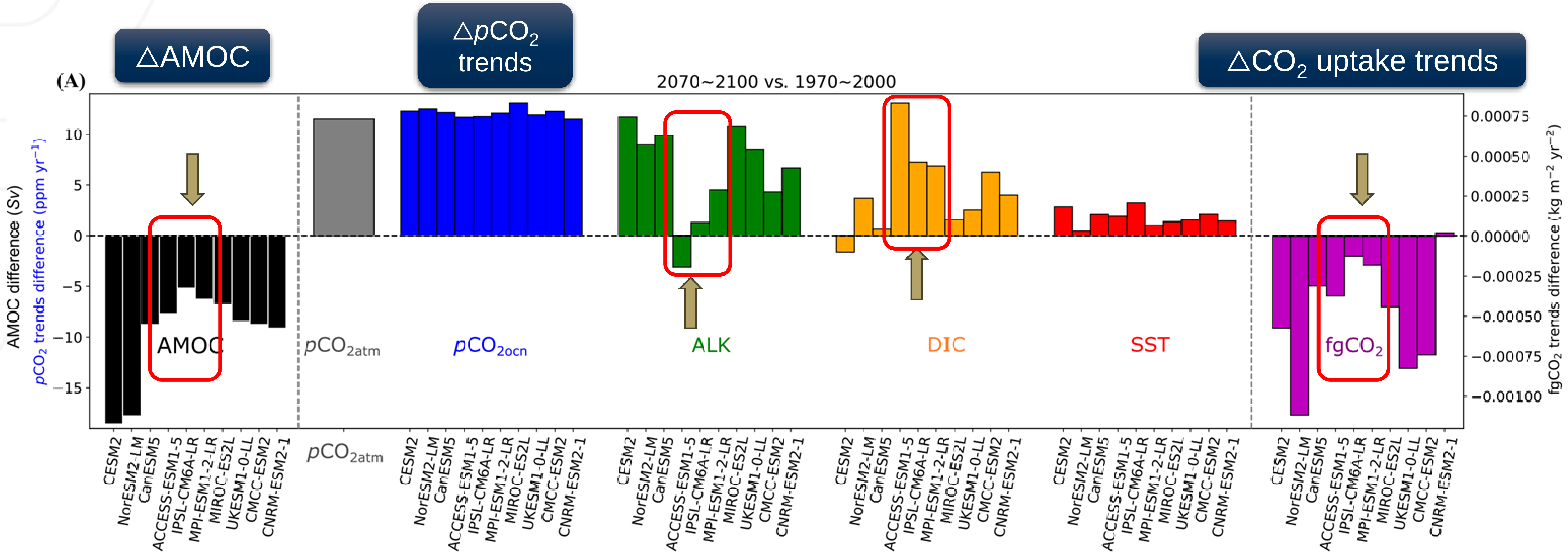

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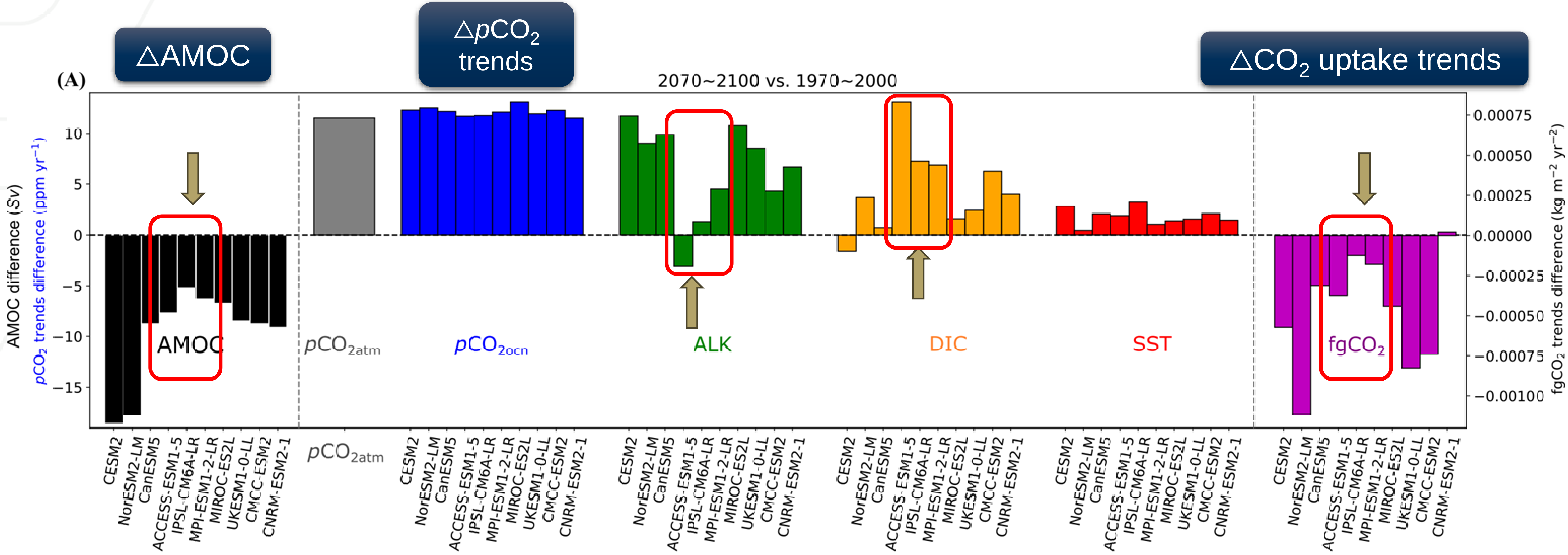

Stronger AMOC slowdown → More salinity reduction → Stronger dilution effect on ALK

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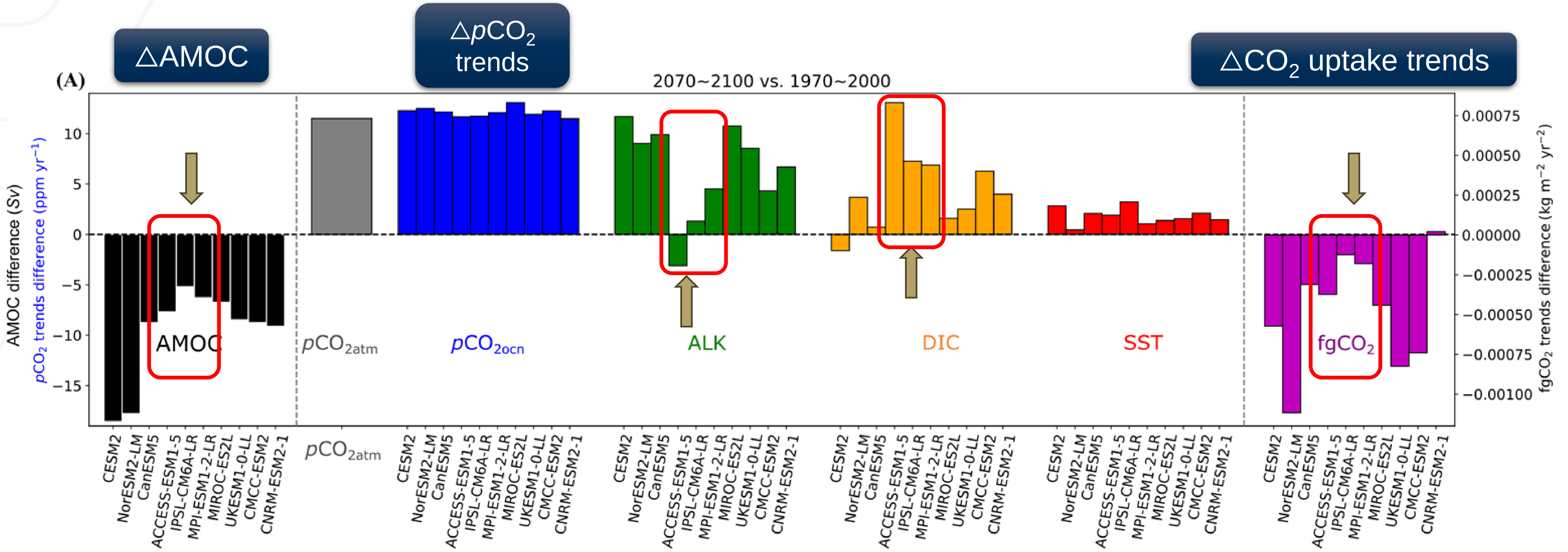

Stronger AMOC slowdown → More salinity reduction → Stronger dilution effect on ALK → Stronger pCO_{2_ocean} increasing → More CO_2 uptake slowdown

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Take home messages

Models with stronger AMOC slowdown generally exhibit weaker surface warming and larger decline of surface salinity and alkalinity.

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AMOC slowdown and surface alkalinity reduction, primarily due to dilution effects, impacts the ocean's capacity to absorb CO_2 and drives the future decrease in regional carbon uptake.

Wednesday Poster Session
Poster #34

Thanks and Welcome Questions!

doi: 10.3389/fmars.2024.1304193

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Acknowledgments

We acknowledge the World Climate Research Programme, which, through its Working Group on Coupled Modelling, coordinated and promoted CMIP6. We thank the climate modeling groups for producing and making available their model output, the Earth System Grid Federation (ESGF) for archiving the data and providing access, and the multiple funding agencies who support CMIP6 and ESGF. We acknowledge the support by the U.S. Department of Energy, through grant DE-SC0021300.

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