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RESEARCH FOR GRAND CHALLENGES

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Tropical Atlantic climate change

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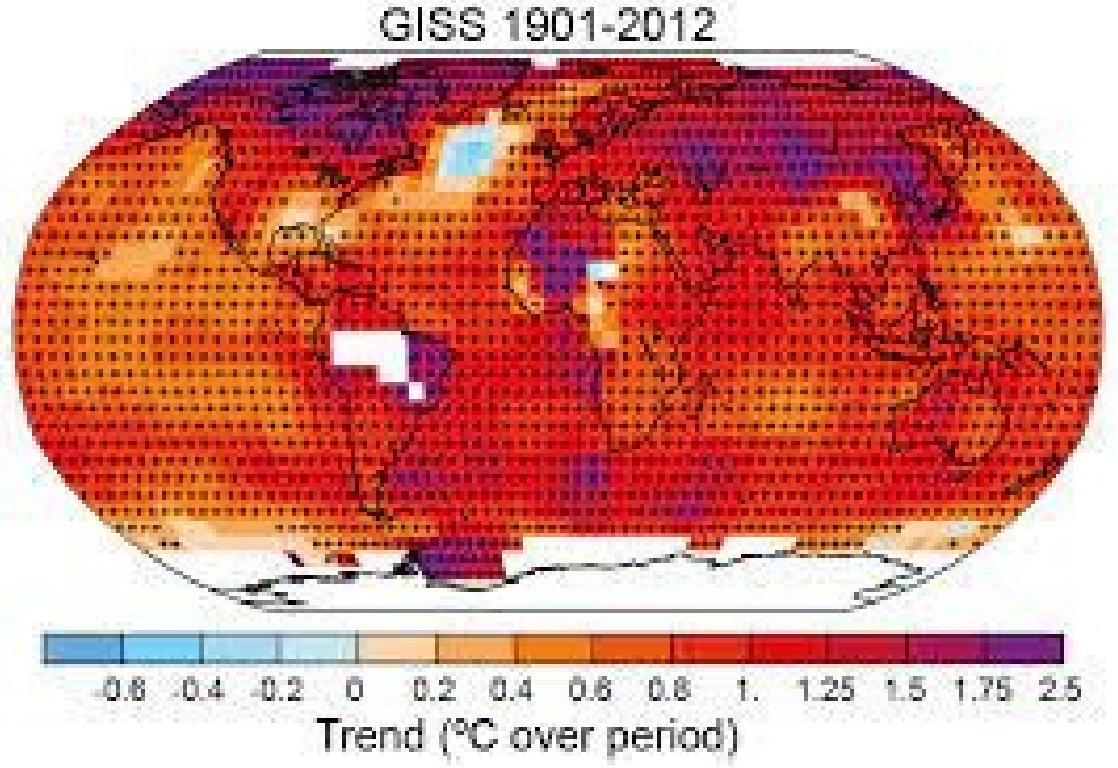
Background

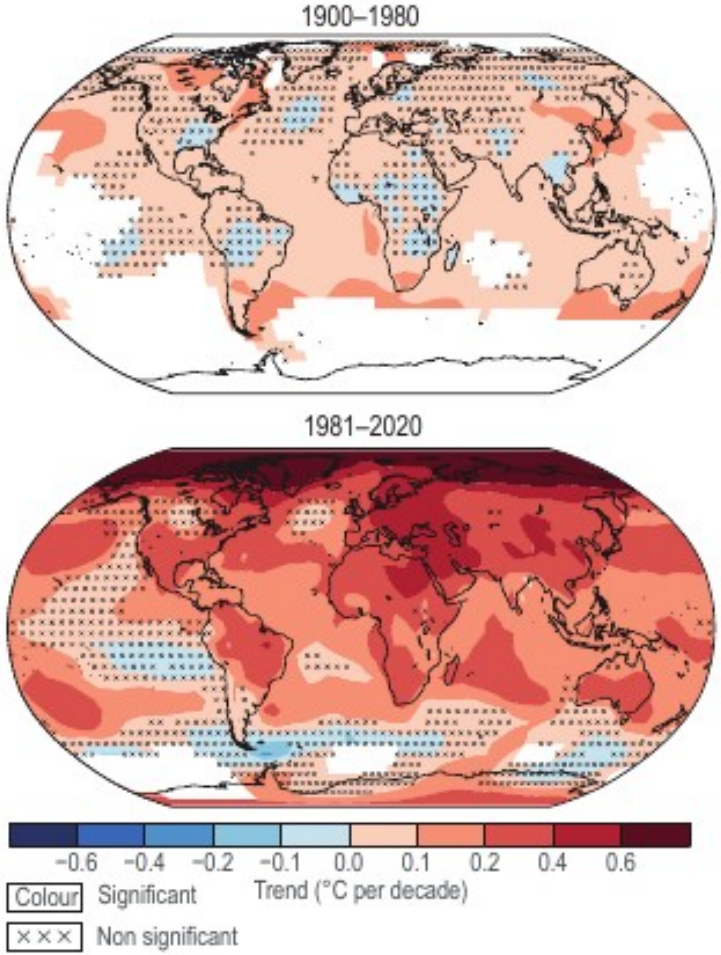


- **Widespread warming trends over land and oceans**

Background

- Accelerated warming during the satellite era since 1981.
- Not everywhere is warming; in facts, some places may as well well be cooling!

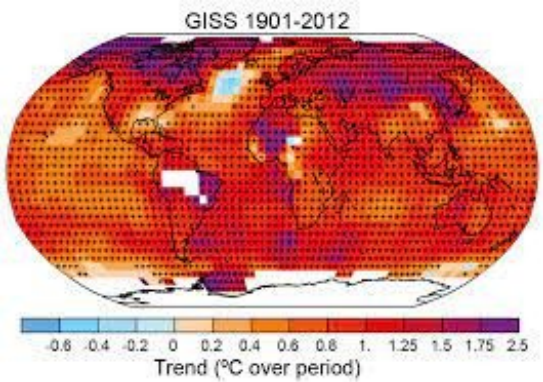
Gulev et al 2021, *IPCC AR6*



Outline

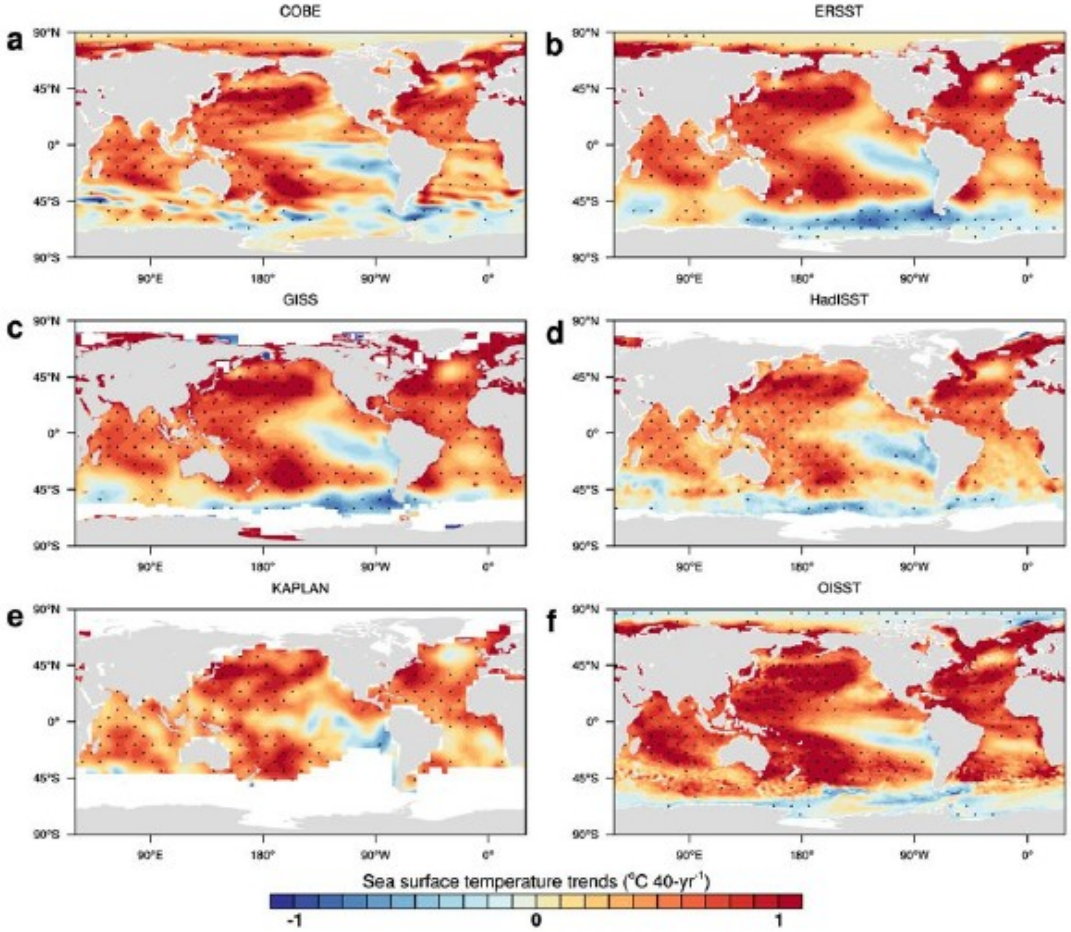
- **“Warming holes” in tropical oceans during the satellite era**
- Tropical Atlantic variability and impacts under climate change
- Atlantic interactions with the Pacific under climate change

“Warming holes” in tropical oceans during the satellite era



„Warming holes”

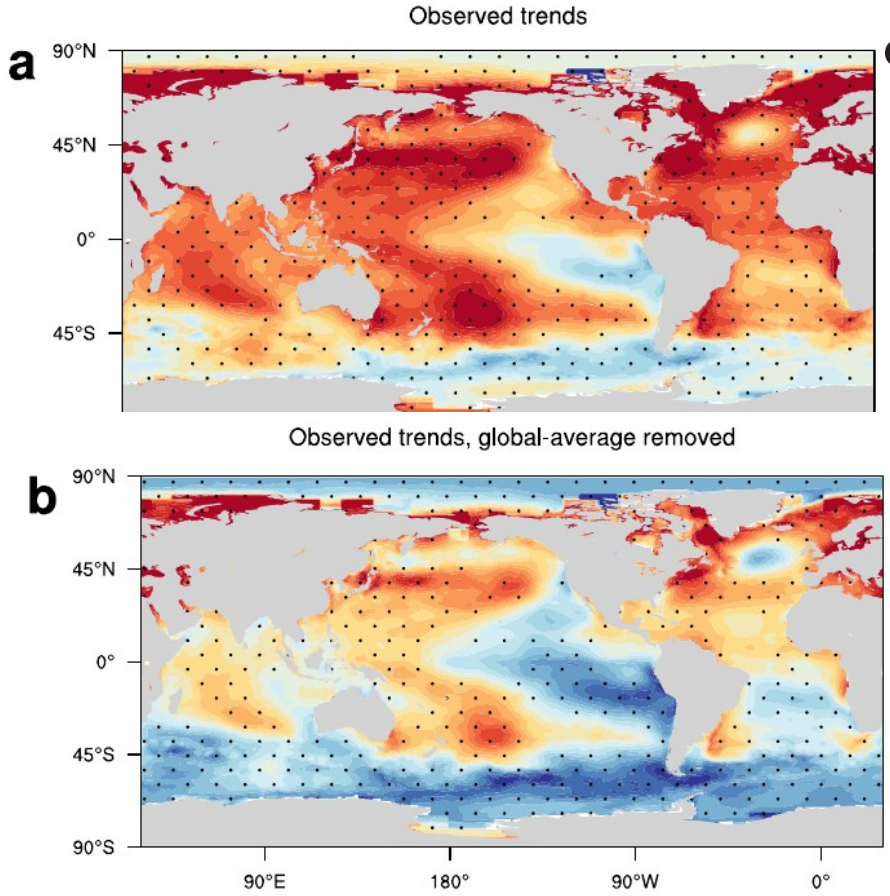
- No warming in the eastern boundaries, most prominent in the Pacific.



Latif et al 2023, *Comm. Earth & Environ.*

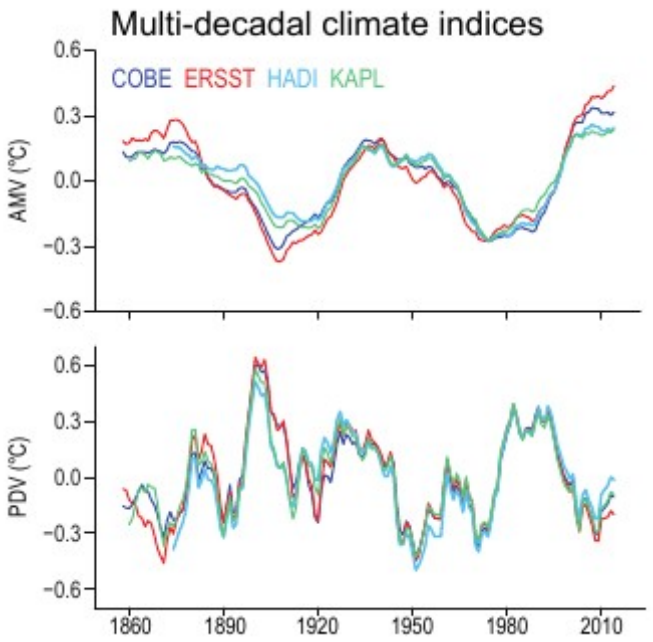
„Warming holes”

- No warming in the eastern boundaries, most prominent in the Pacific.
- “Warming holes” become more prominent after accounting for global warming.

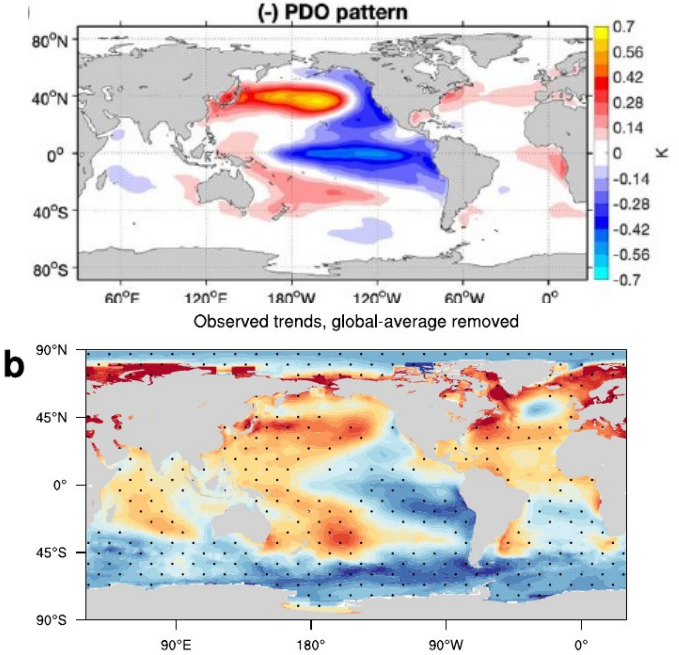


Latif et al 2023, *Comm. Earth & Environ.*

Warming holes explained by Pacific decadal oscillation

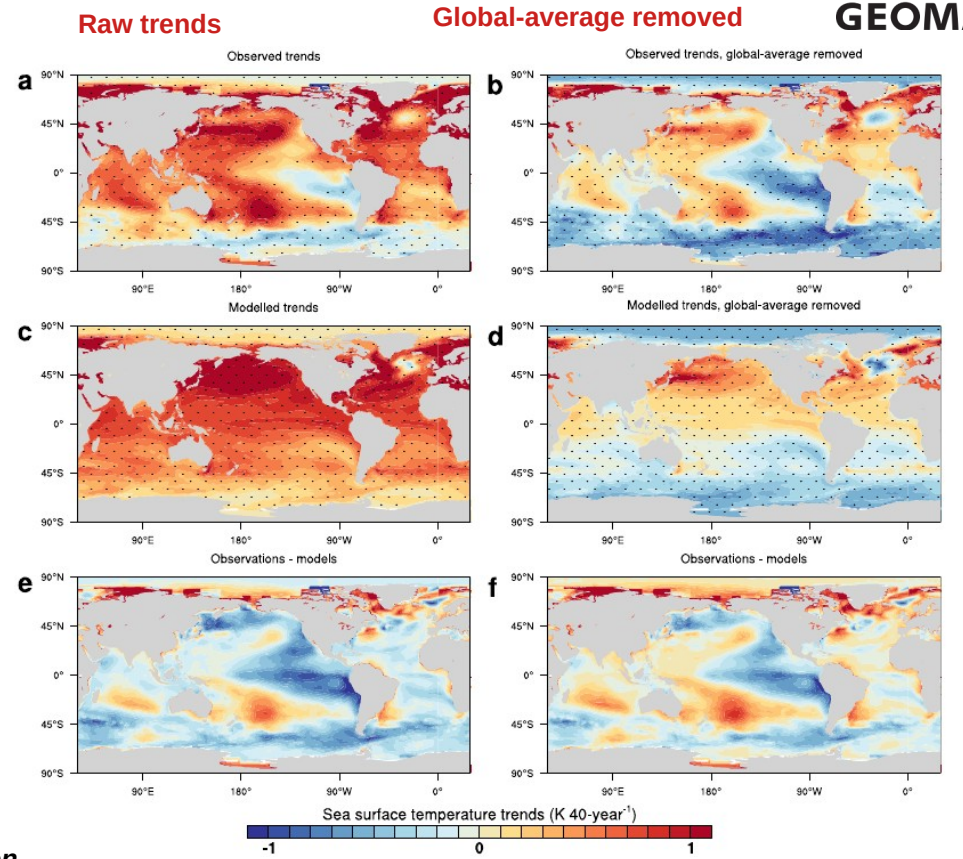


Gulev et al 2021, *IPCC AR6*



Latif et al 2023, *Comm. Earth & Environ.*

CMIP6 ensemble fail to reproduce „warming hole”



Latif et al 2023, *Comm. Earth & Environ.*

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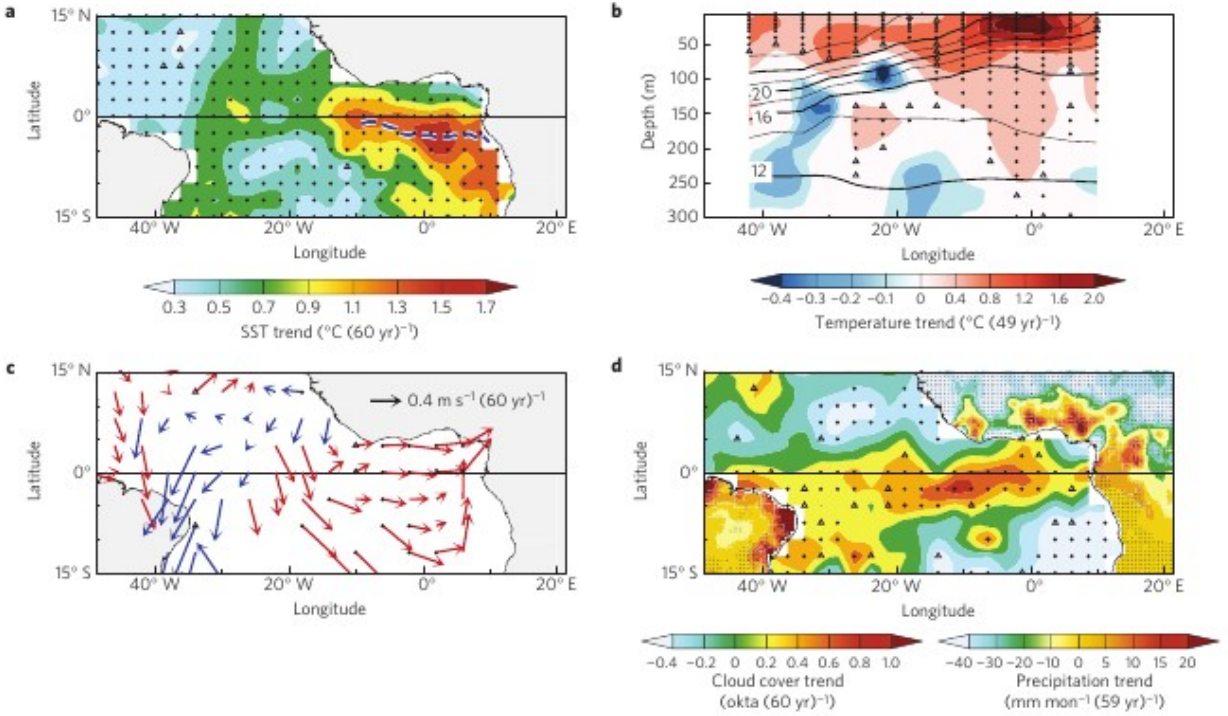
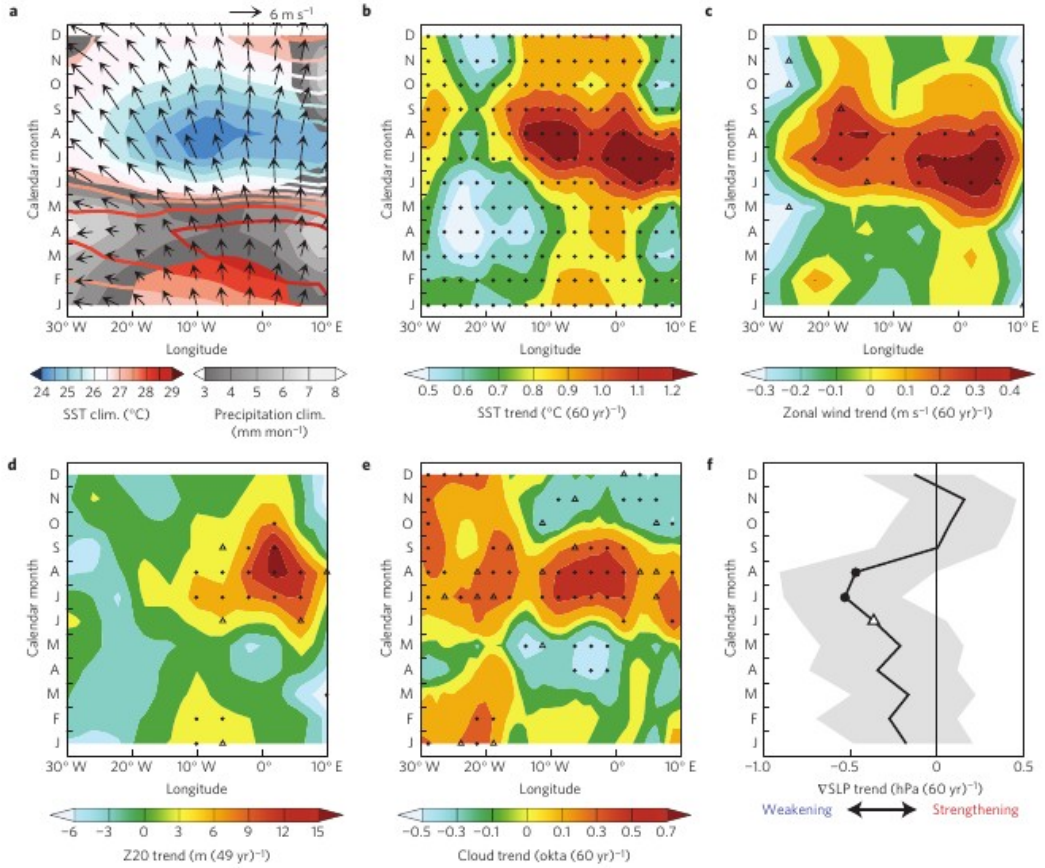
A switch in trends in the Atlantic cold tongue region: 1950-2009 vs 1981-present

Atlantic Nino-like warming of the Atlantic in observations, 1950-2009



Tokinaga & Xie, 2011; *Nature Geoscience*

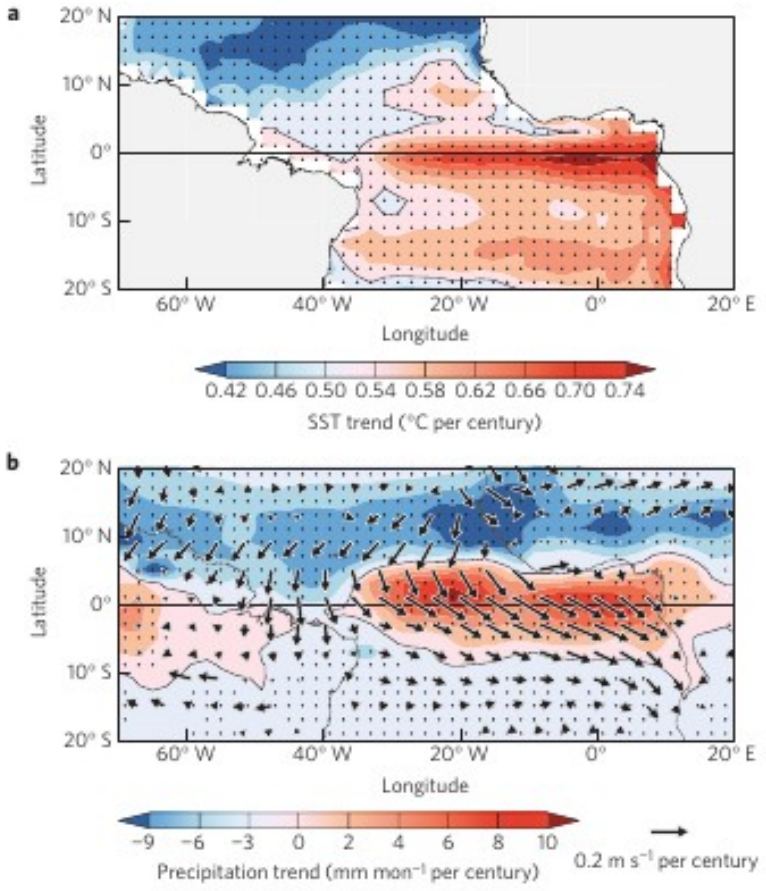
Trends phase-locked to the upwelling season along the equator, 1950-2009.



Tokinaga & Xie, 2011; ***Nature Geoscience***

CMIP3 historical ensemble, 1900-1999.

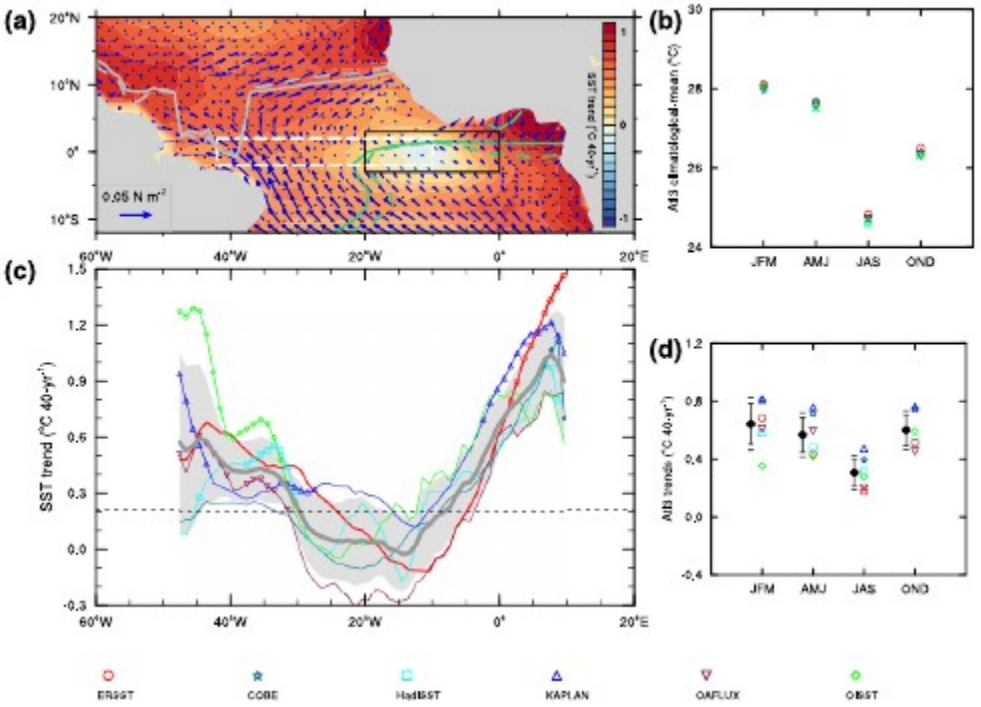
- CMIP3 shows Atlantic meridional mode-like trends.
- Precipitation increased over the warm SSTs, decreased precipitation over West Africa.



Tokinaga & Xie, 2011; *Nature Geoscience*

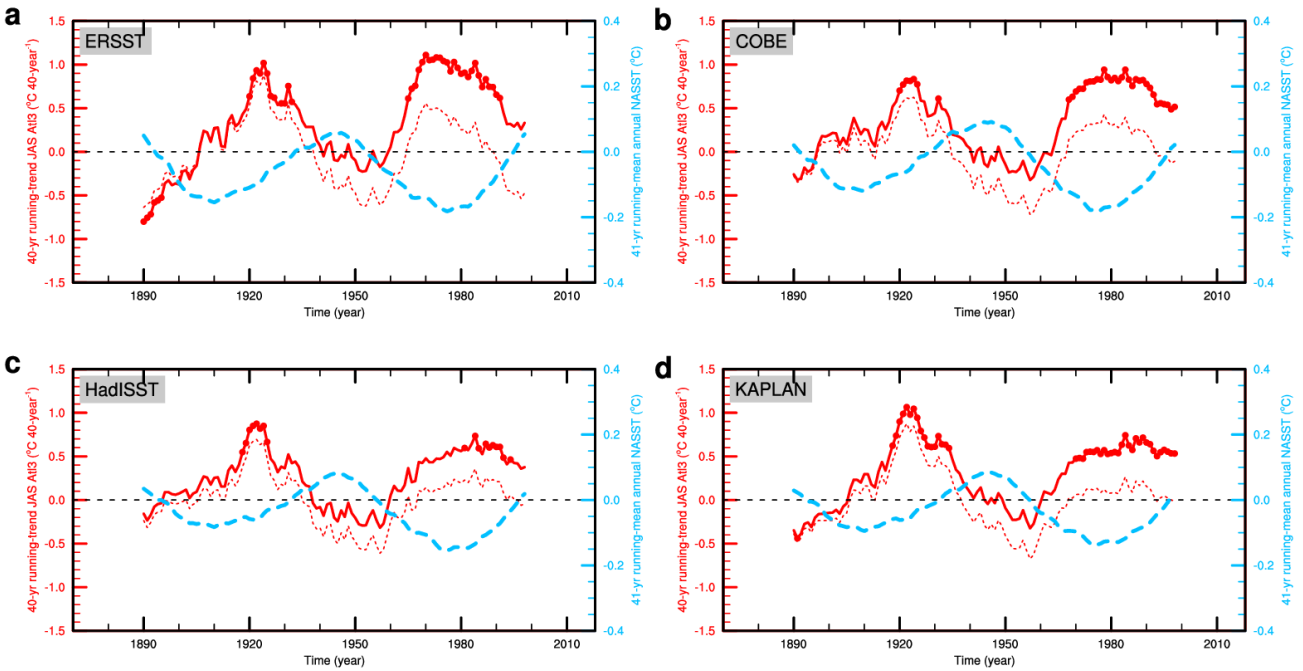
„Warming hole” 1981-present

- Also phase-locked to the boreal summer upwelling season.



Nnamchi et al., 2020, *JGR Oceans*

40-year trends show multidecadal variations

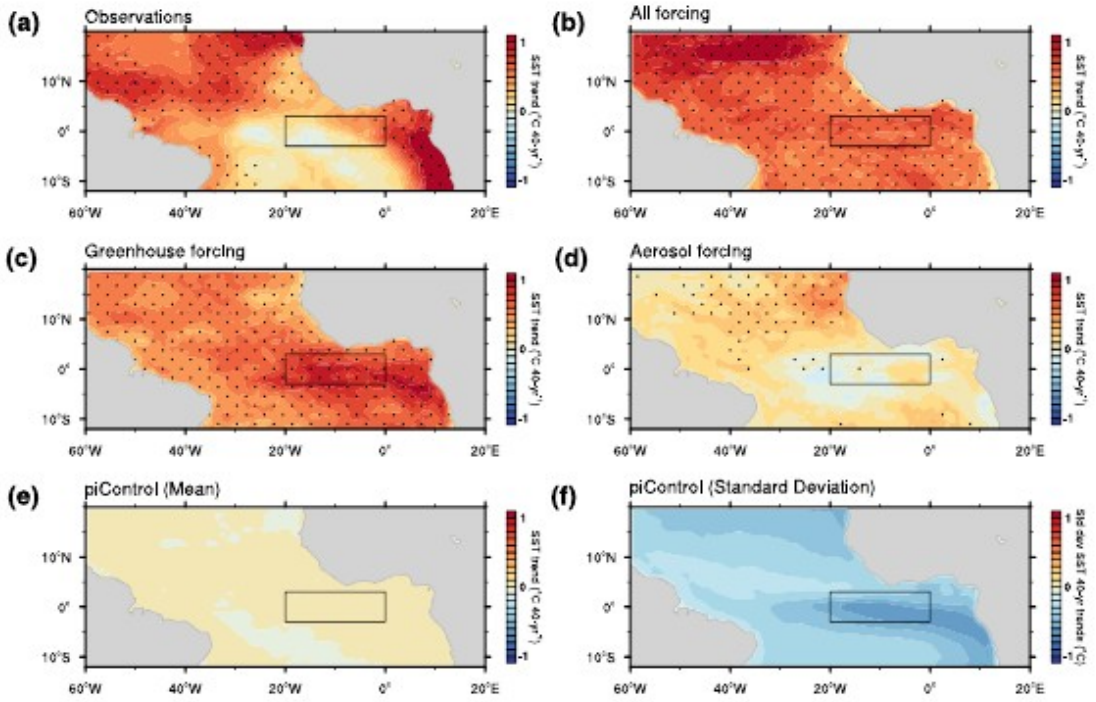


Dotted, **red** curve is detrended

Nnamchi et al., 2020, *JGR Oceans*

CMIP6 historical ensemble 1979-2005.

- Warming hole not seen.
- Northward gradient could be linked to aerosol forcing.

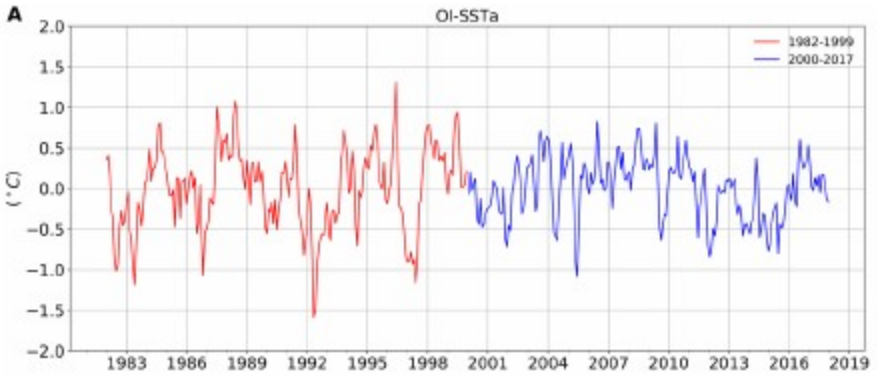


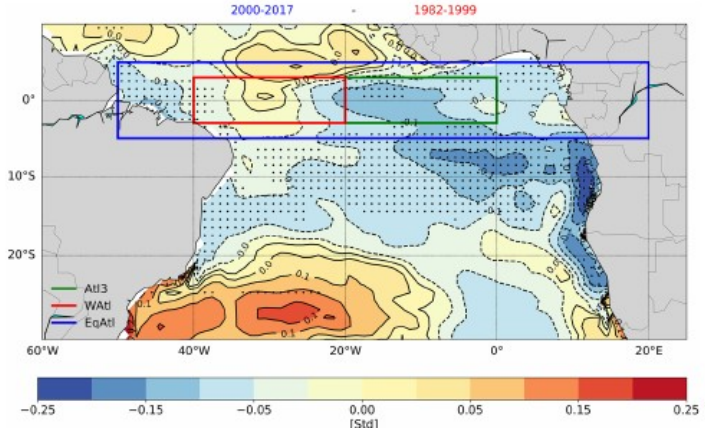
Nnamchi et al., 2020; *JGR Oceans*

Outline

- “Warming holes” in tropical oceans during the satellite era
- **Tropical Atlantic variability and impacts under climate change**
- Atlantic interactions with the Pacific under climate change

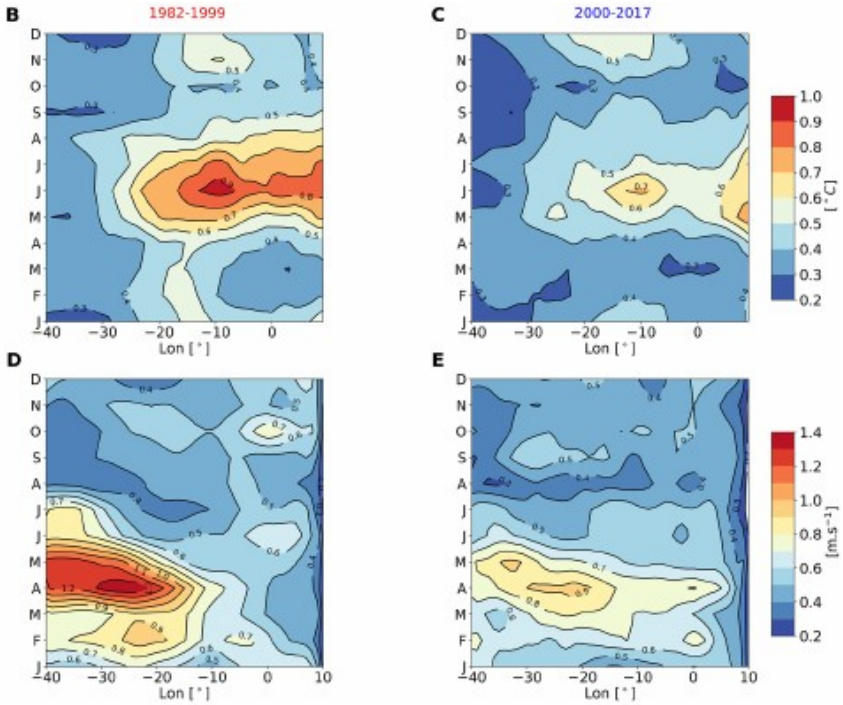
Weakened Atlantic Nino variability during the satellite era





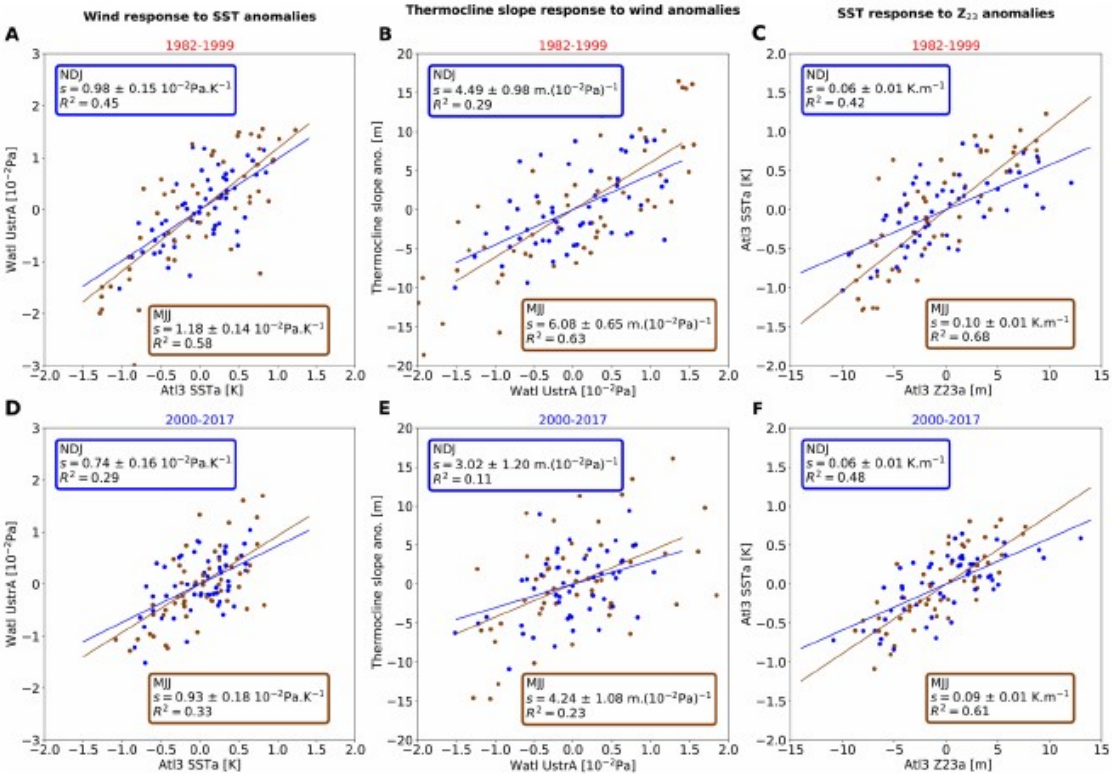
Prigent et al., 2020; *Clim. Dyn.*

Weakened SST and winds



Prigent et al., 2020; *Clim. Dyn.*

Weakened Bjerknes feedback

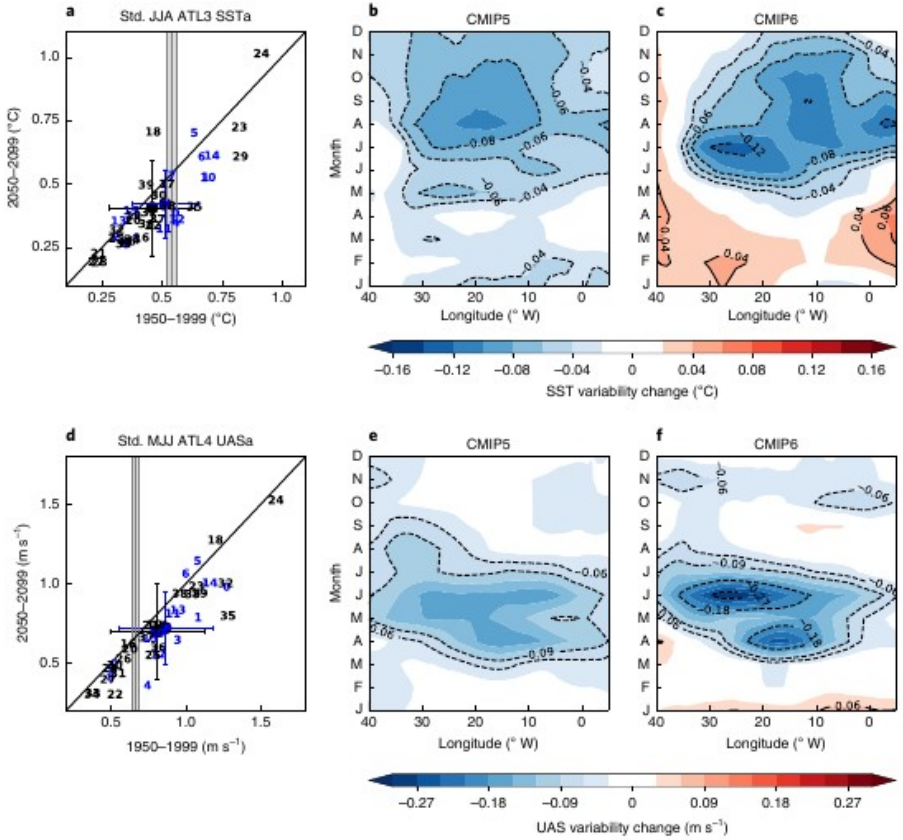


Prigent et al., 2020, ***Nature Geosc.***

Future weakening Atlantic Nino in CMIP6

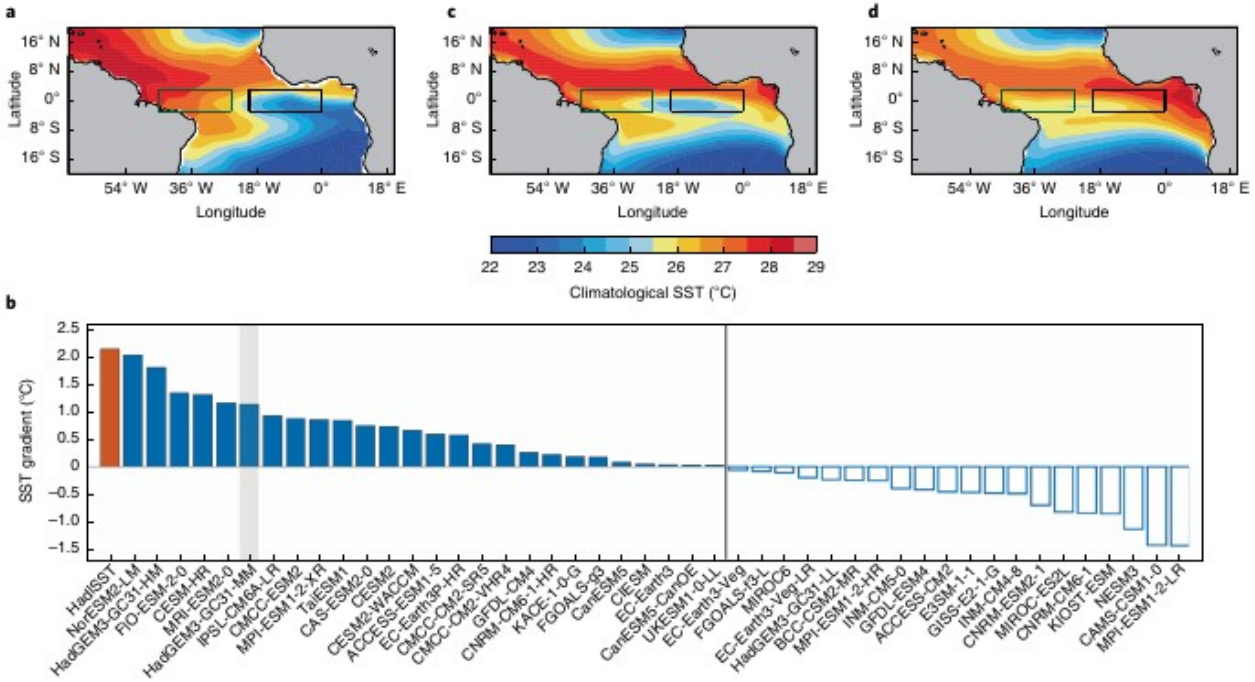
Worou et al., 2022, *ESD*

Weakening Atlantic Nino in CMIP6



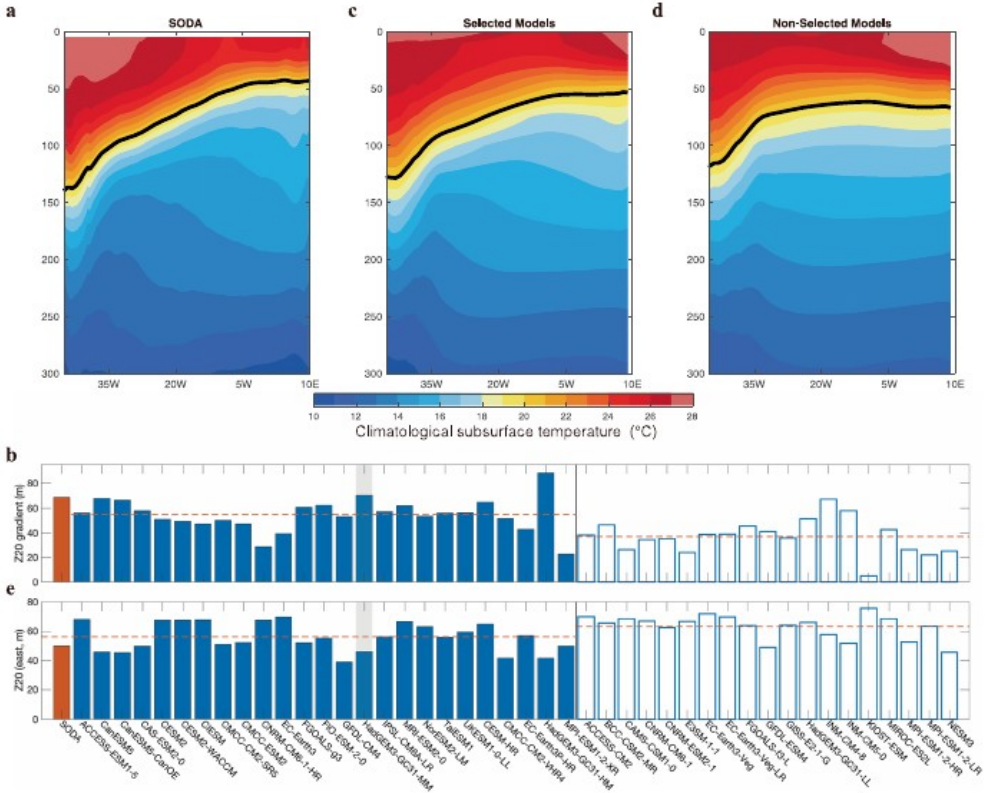
Lander et al., 2022,
Nature Clim. Change.

Accounting for biases in mean state



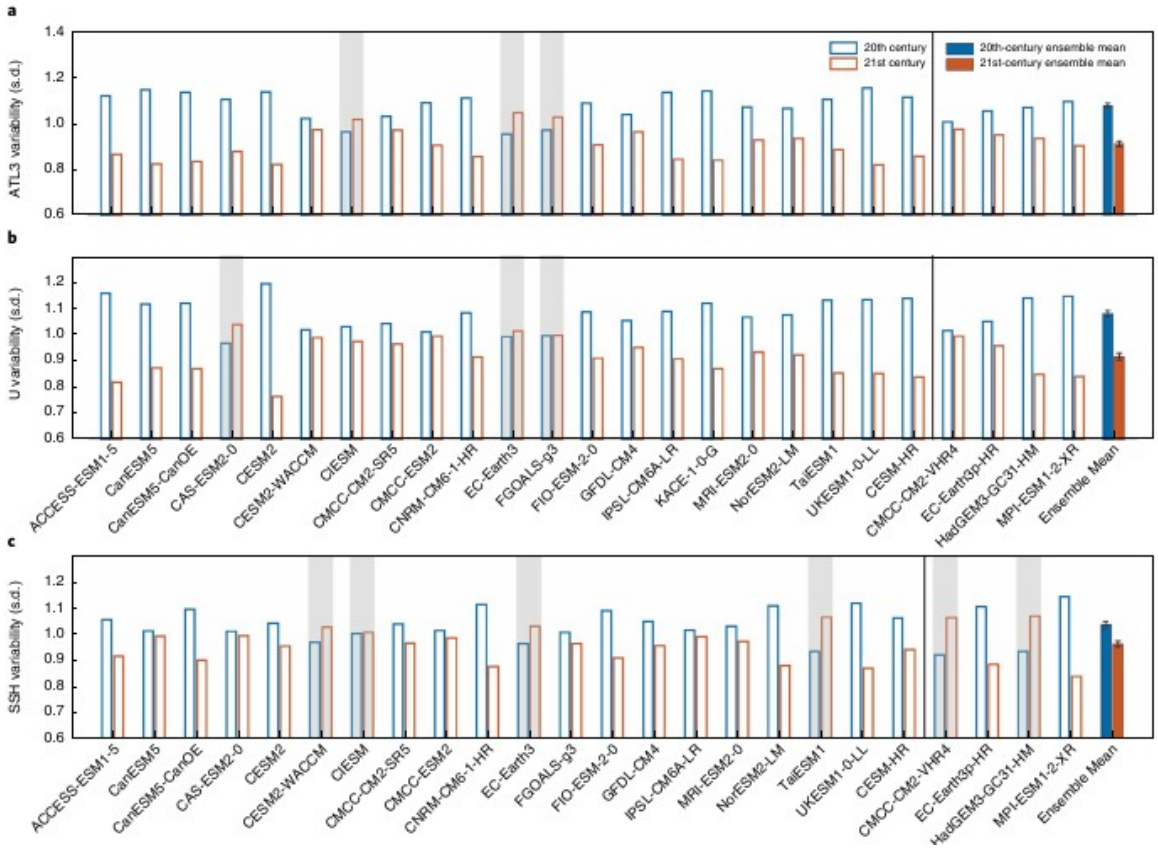
Yang et al., 2022, ***Nature Clim. Change***

Accounting for biases in mean state



Yang et al., 2022, *Nature Clim. Change*

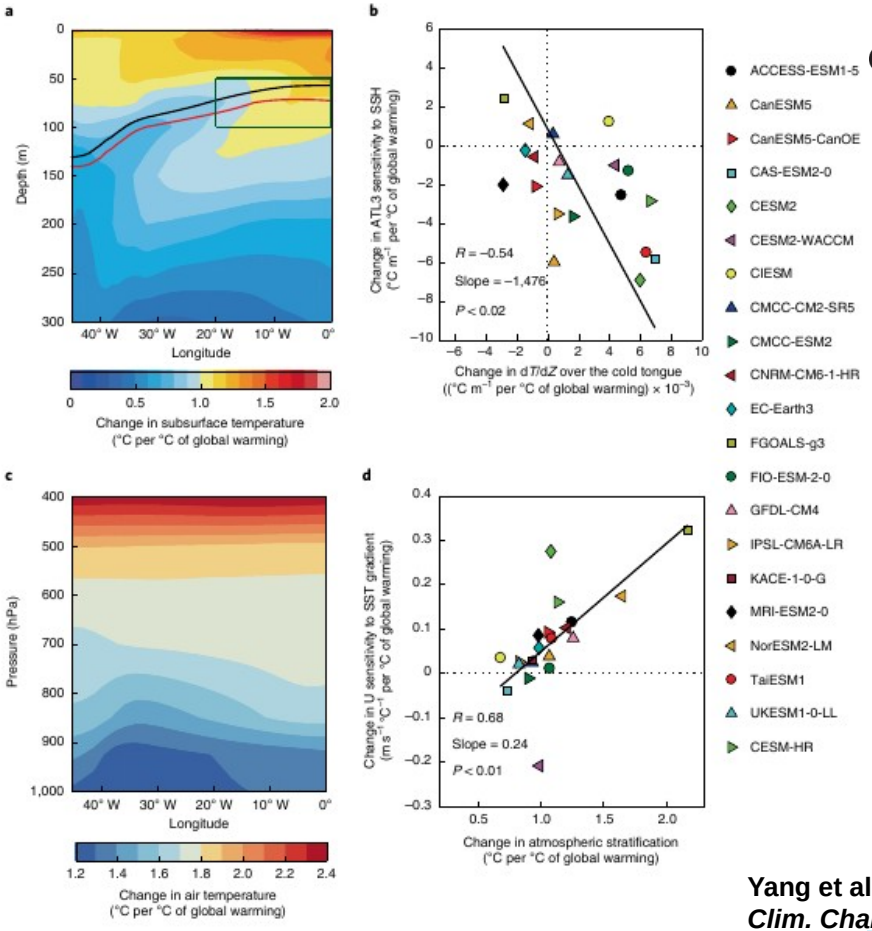
Weakened Atlantic Nino in CMIP6 models with correct east-west SST gradient



Yang et al., 2022, *Nature Clim. Change*

Weakened Bjerknes feedback explained by induced by deeper thermocline and more stable atmopshere

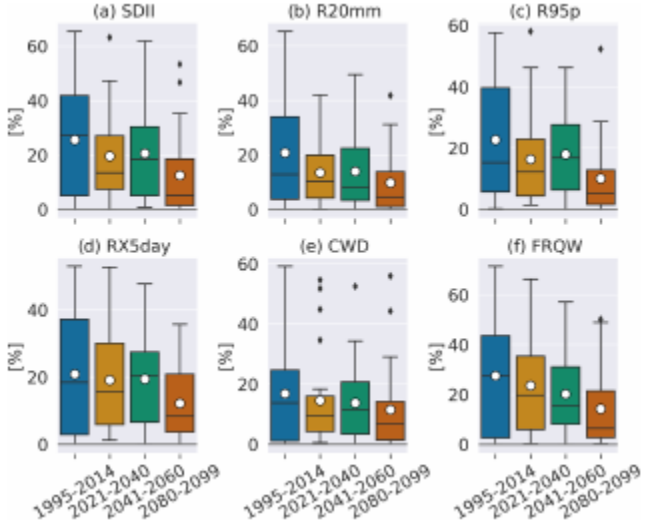
- Faster warming of the **ocean surface** especially in the east.
- **Mid-troposphere** warms faster than the surface, leading to a more stable atmosphere in the future.
- Thus, the Bjerknes feedback is weakened (Lander et al., 2022; Yang et al., 2022).



Yang et al., 2022, *Nature Clim. Change*

Weakening impacts of the Atlantic Nino on Guinea Coast

Tokinaga & Xie, 2011, *Nature Geosc.*



Worou et al., 2023, *WCD*

Outline

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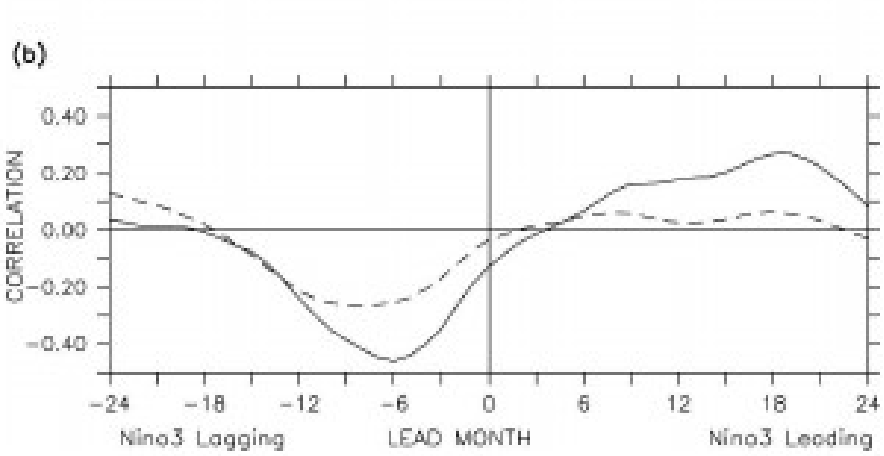
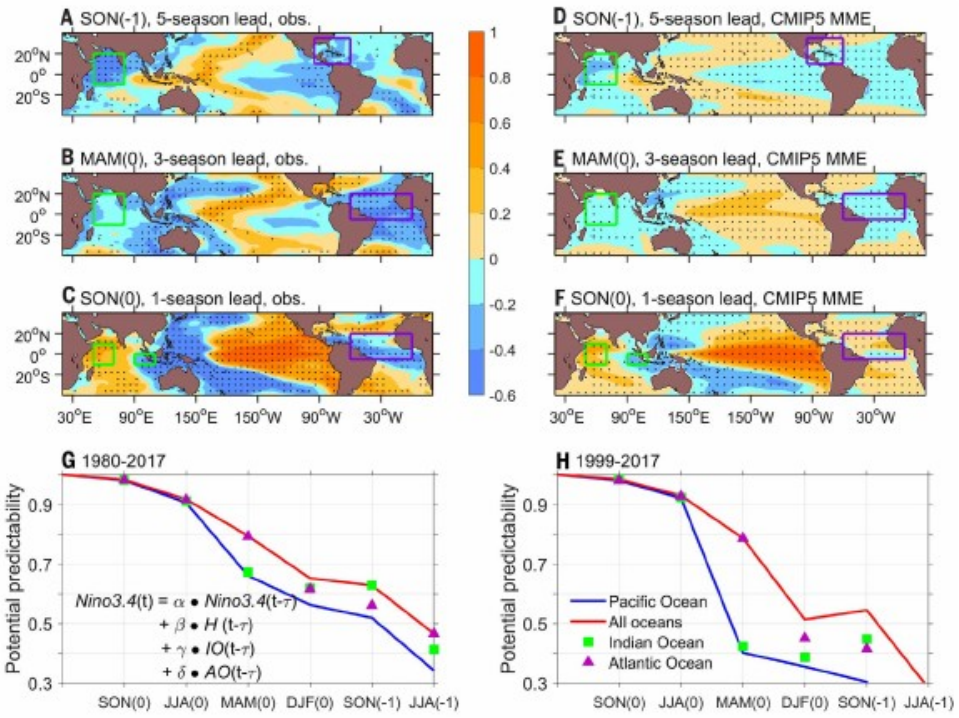
Atlantic variability leads ENSO



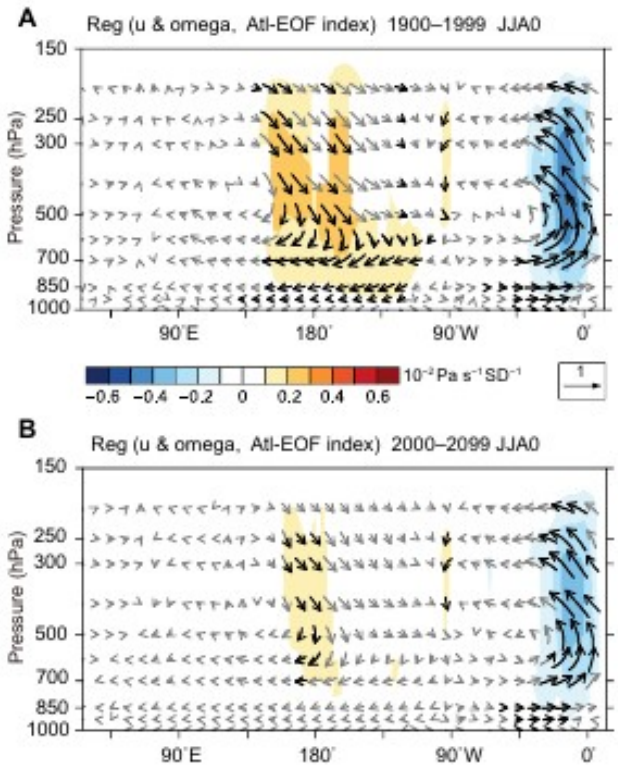
Keenlyside & Latif, 2007, *J. Climate*, Rodriguez-Fonseca, 2009, *GRL*

Atlantic improves ENSO prediction



Cai 2019 et al., 2019, *Science*

Atlantic modifies the Walker cell, enhancing La Nina anomalies



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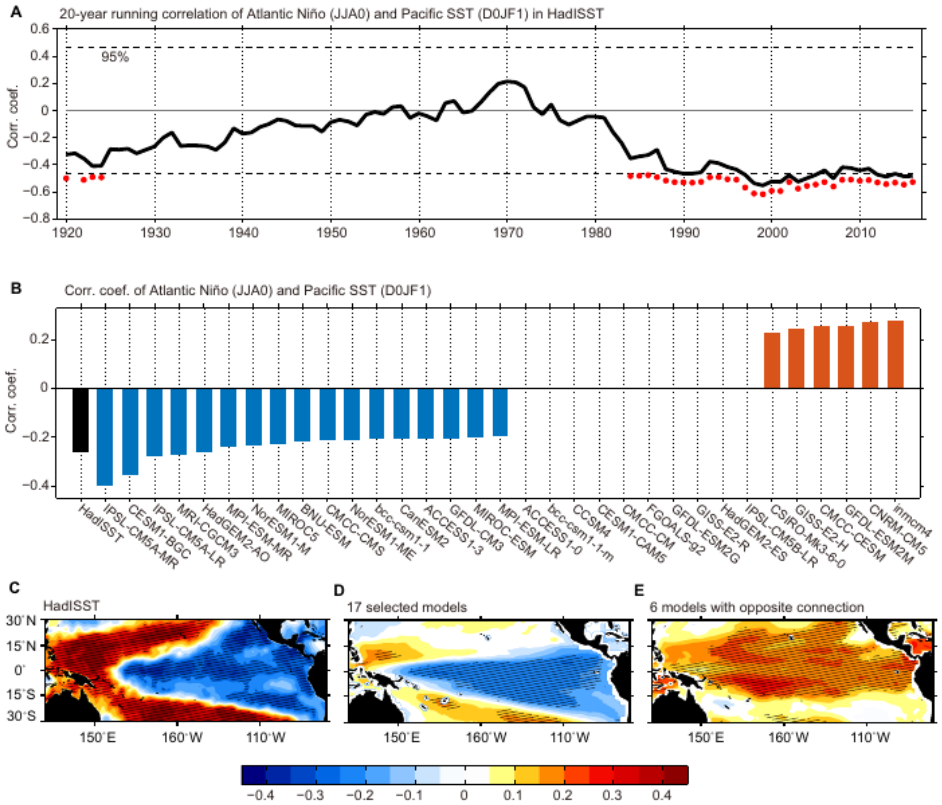
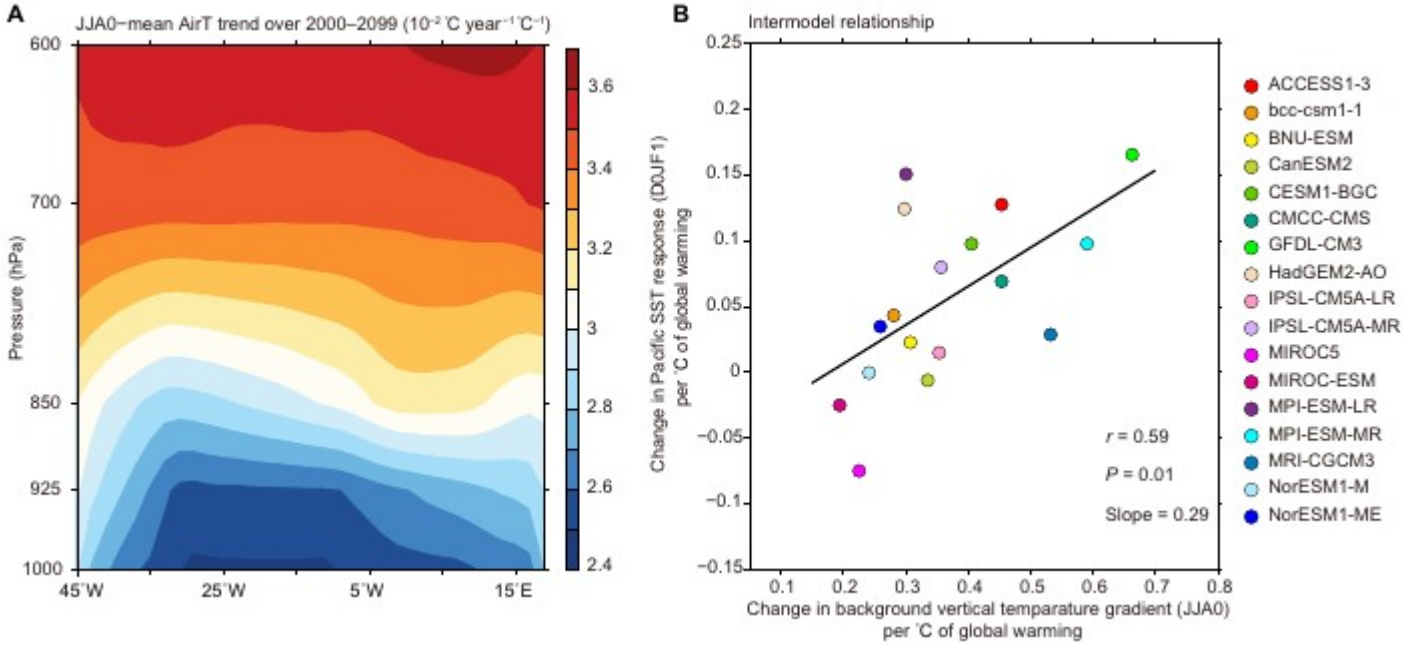


Jia et al., 2019, *Sci. Adv.*

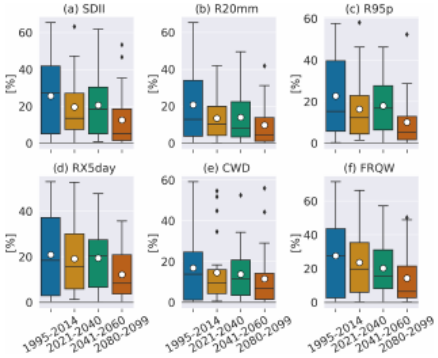
Explained by a stable atmosphere



Jia et al., 2019

Closing perspectives

- Climate change signal over tropical Atlantic is strong mixed with decadal climate variability. Disentangling this connection can be challenging
- The equatorial Atlantic variability is projected to decline under climate change. Variability to the north of the equator gets stronger, giving rise to a north-south SST warming gradient. Aerosol forcing may have played some roles during the historical period.
- The Bjerknes feedback is projected to weaken in the future under increased greenhouse forcing. This is related to stabilisation of the atmosphere and a deeper thermocline under intensified warming.
- Impacts on precipitation over the continent will also weaken.



Worou et al, 2023, *WCD*

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Thank you

04.08.2023