Successes and discrepancies in predicting regional trends in atmospheric circulation

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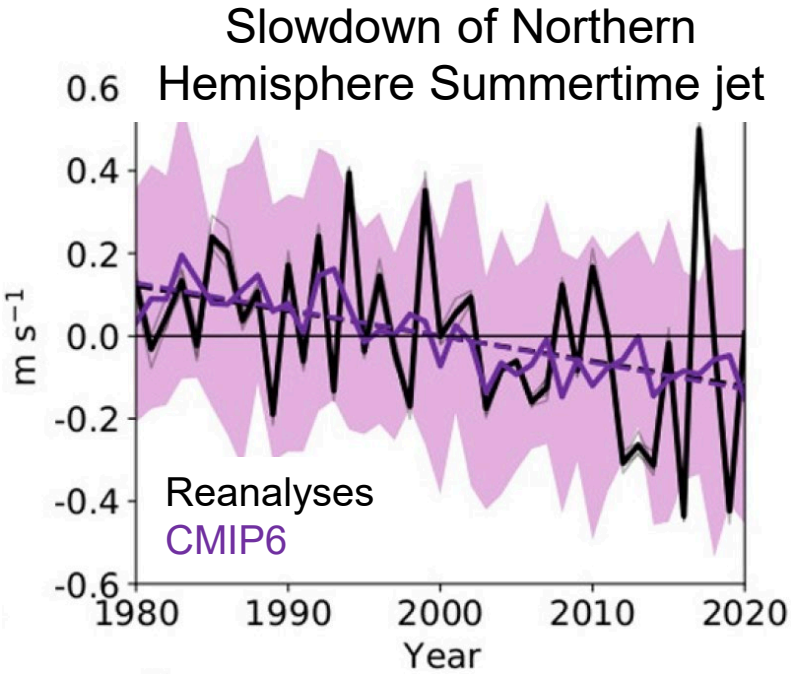
Alexander von HUMBOLDT STIFTUNG

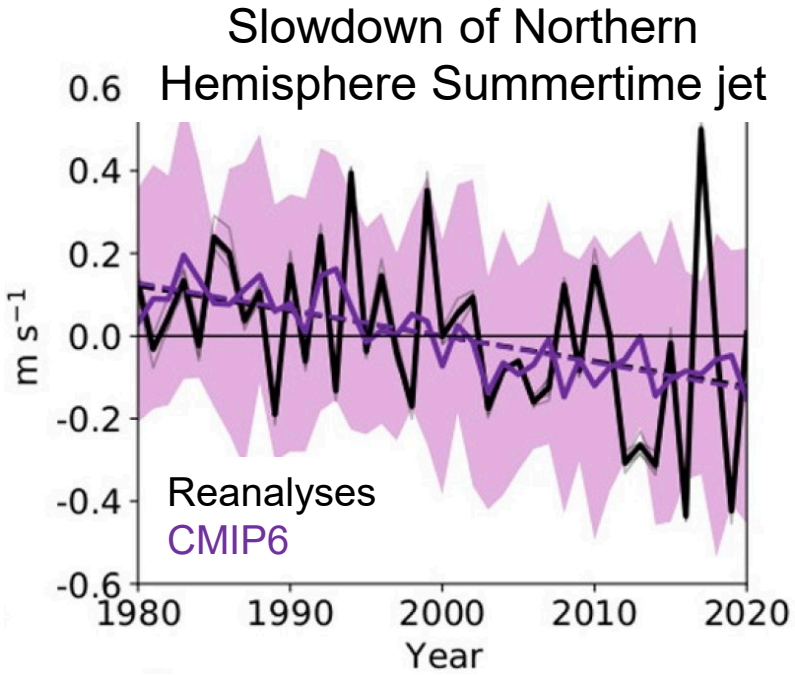
USA TODAY/NASA

Global climate models show skill in summertime jet stream slowdown

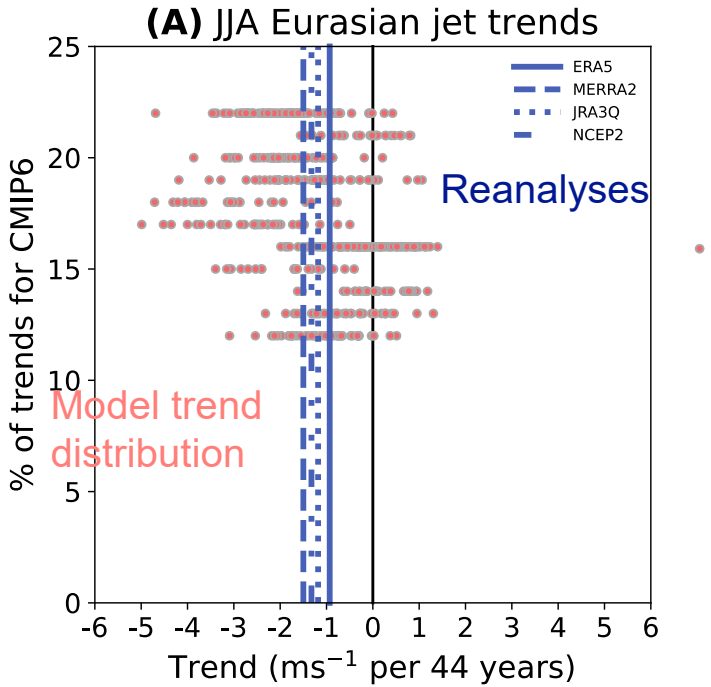


Kang, Shaw et al. (2024, AGU Adv.)

Global climate models show skill in Eurasian jet stream slowdown

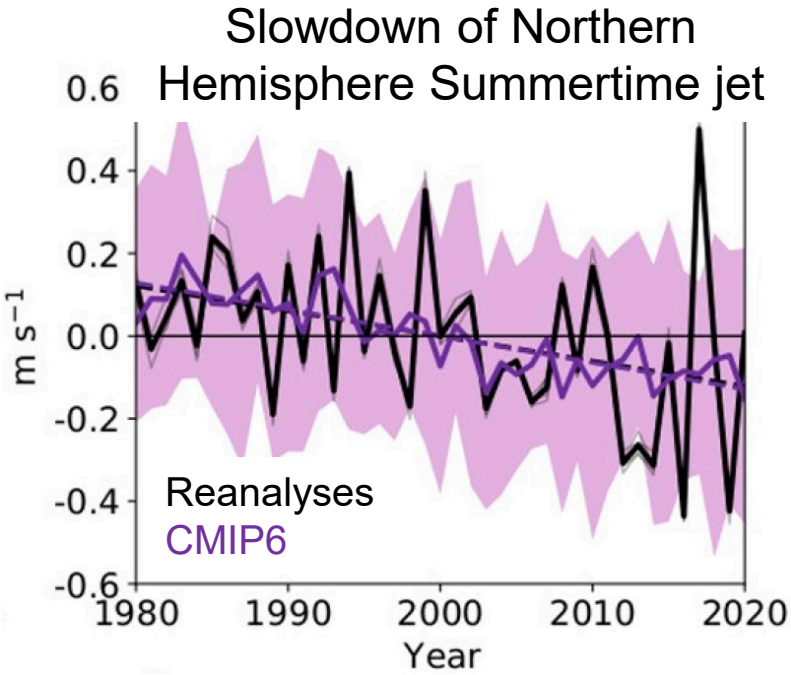


Kang, Shaw et al. (2024, AGU Adv.)



Dong et al. (2022, Nature Comm.),
Simpson, Shaw et al. (2025, Sci. Adv.)

Anthropogenic aerosol forcing dominates the slowdown



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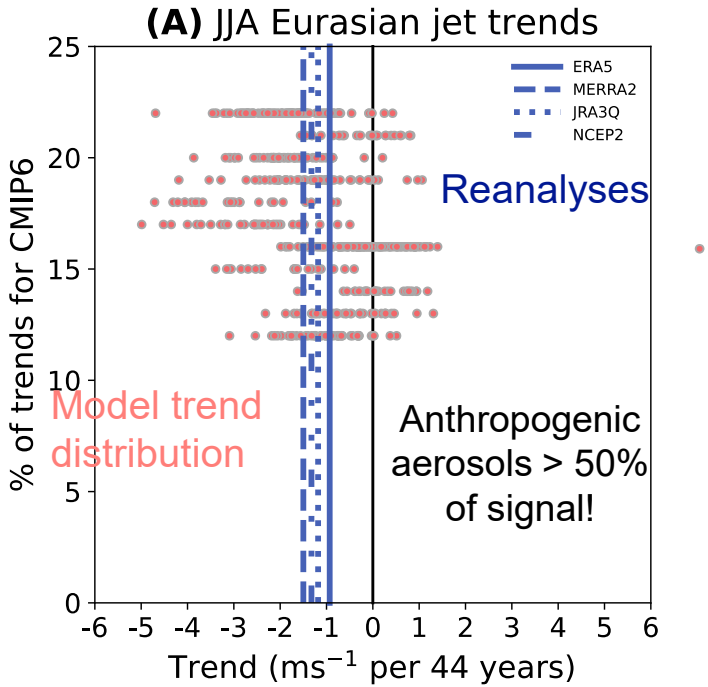
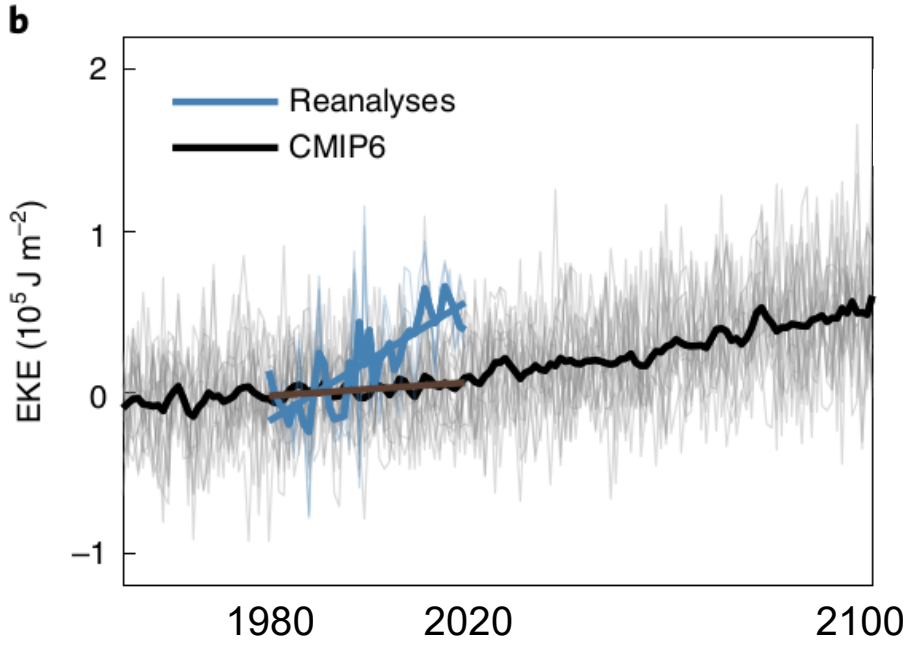


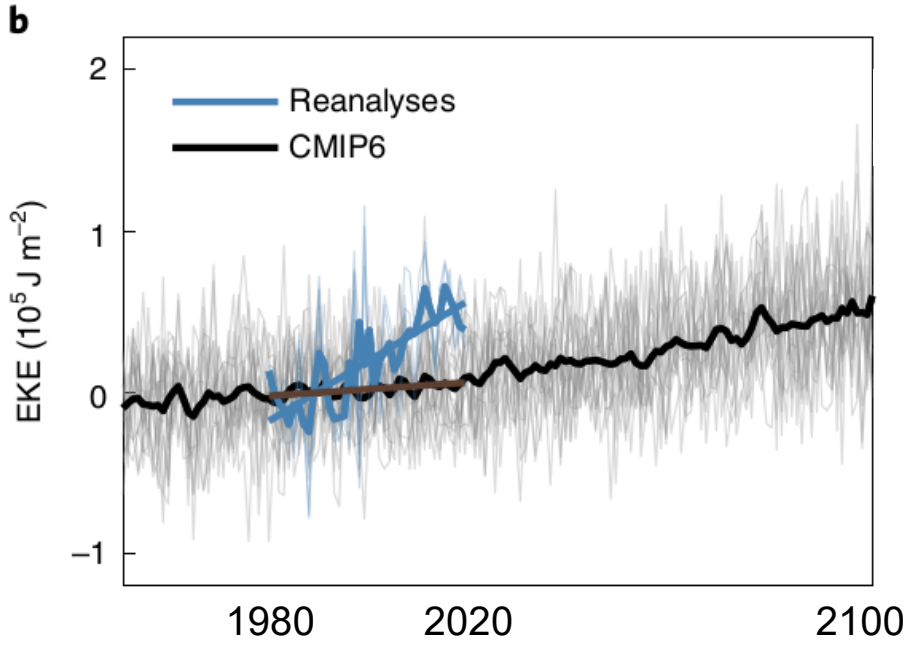
Dong et al. (2022, Nature Comm.),
Simpson, Shaw et al. (2025, Sci. Adv.)

Southern Hemisphere storms seem to be strengthening faster than model predictions

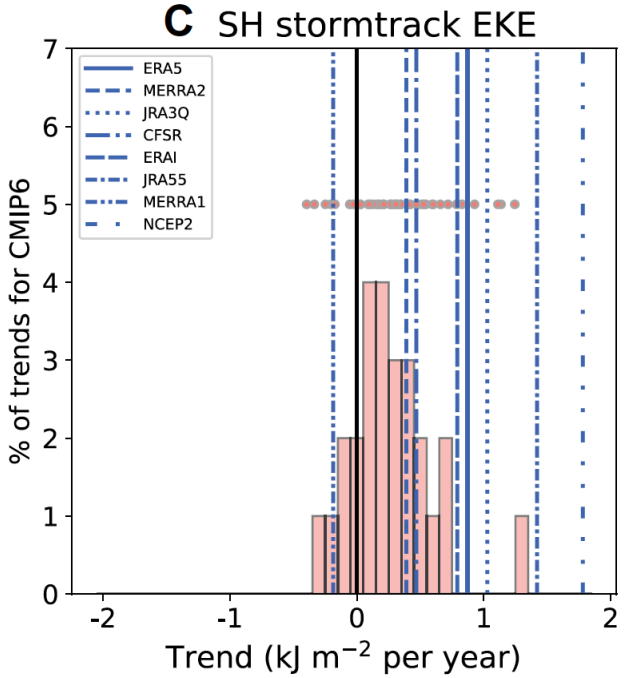


Chemke et al. (2022, Nature CC),
Shaw et al. (2022, PNAS)

Situation is uncertain due lack of observational constraints



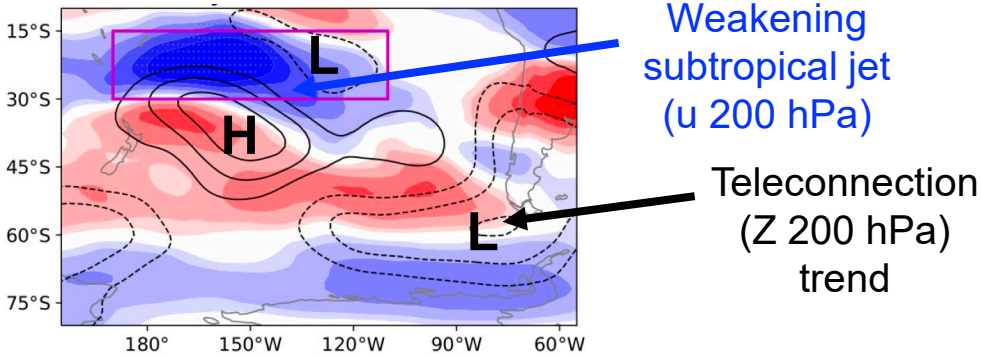
Chemke et al. (2022, Nature CC),
Shaw et al. (2022, PNAS)



Kang, Shaw et al. (2024, npj),
Simpson, Shaw et al. (2025, Sci. Adv.)

Discrepancy in tropical SST trends leads to regional discrepancy

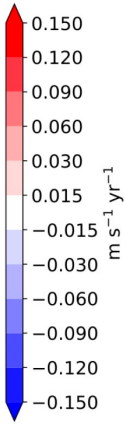
Reanalysis trend



Weakening subtropical jet (u 200 hPa)

Teleconnection (Z 200 hPa) trend

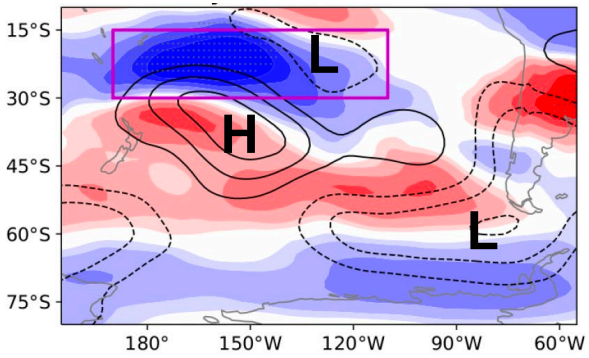
South Pacific



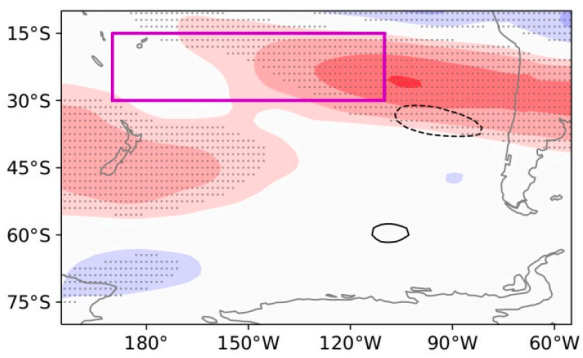
Kang, Shaw et al. (2024, npj)

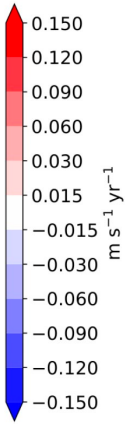
Discrepancy in tropical SST trends leads to teleconnection discrepancy

Reanalysis trend



CESM2-LE





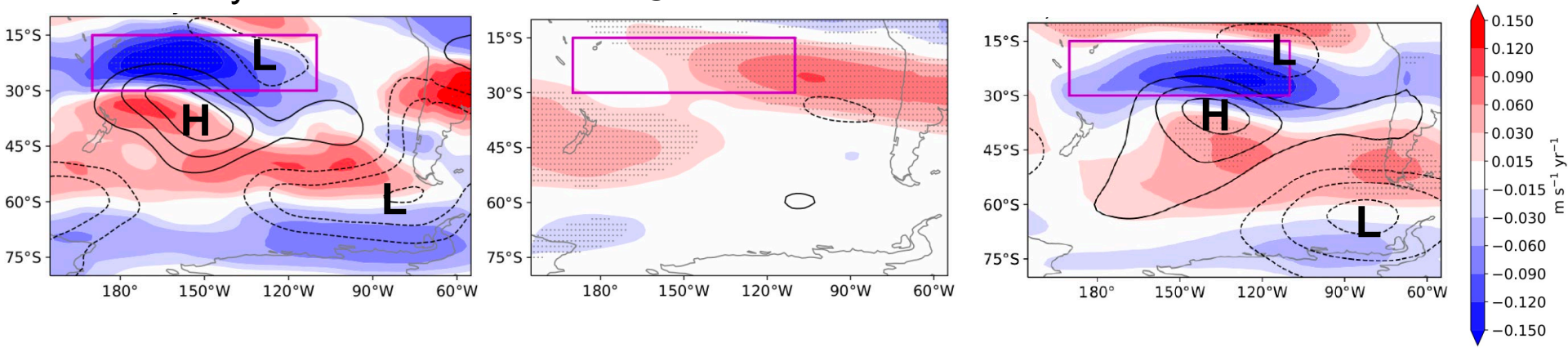
Kang, Shaw et al. (2024, npj)

Discrepancy in tropical SST trends leads to teleconnection discrepancy

Reanalysis trend

CESM2-LE

CESM-2 Tropical Pacific Pacemaker

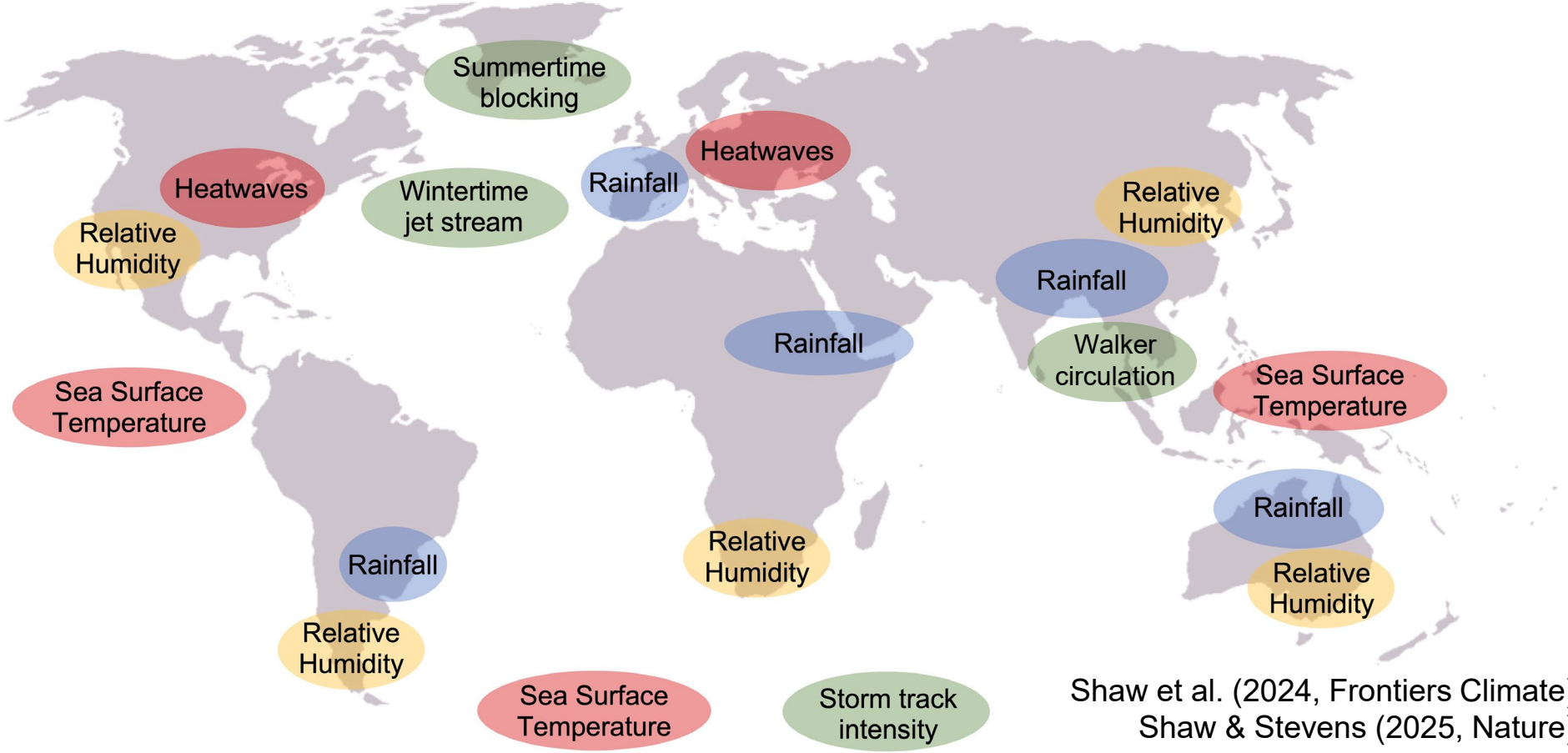


Also impacts in the Northern Hemisphere
Kang, Thomas et al. (2025)

Kang, Shaw et al. (2024, npj)

Exposing knowledge gaps related to coupling between components and scales

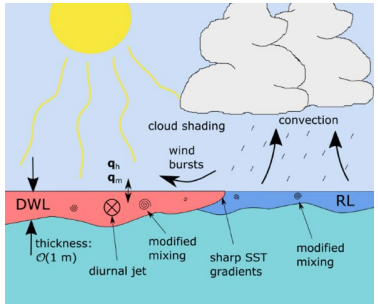
Location of known model-observation discrepancies in historical trends



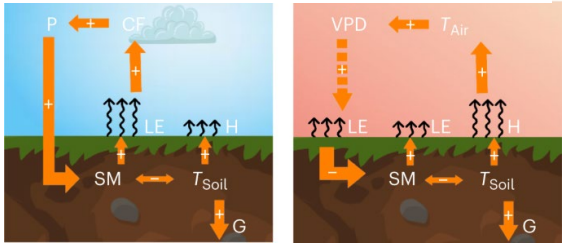
Shaw et al. (2024, Frontiers Climate)
Shaw & Stevens (2025, Nature)

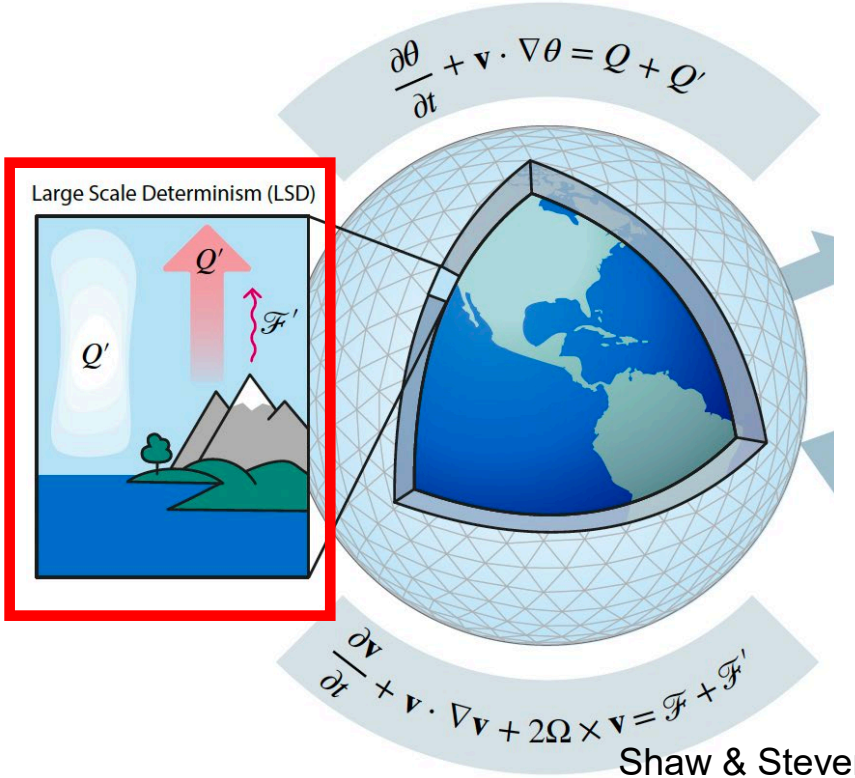
We need to fill knowledge gaps in coupling between components and scales

Atmosphere-ocean coupling



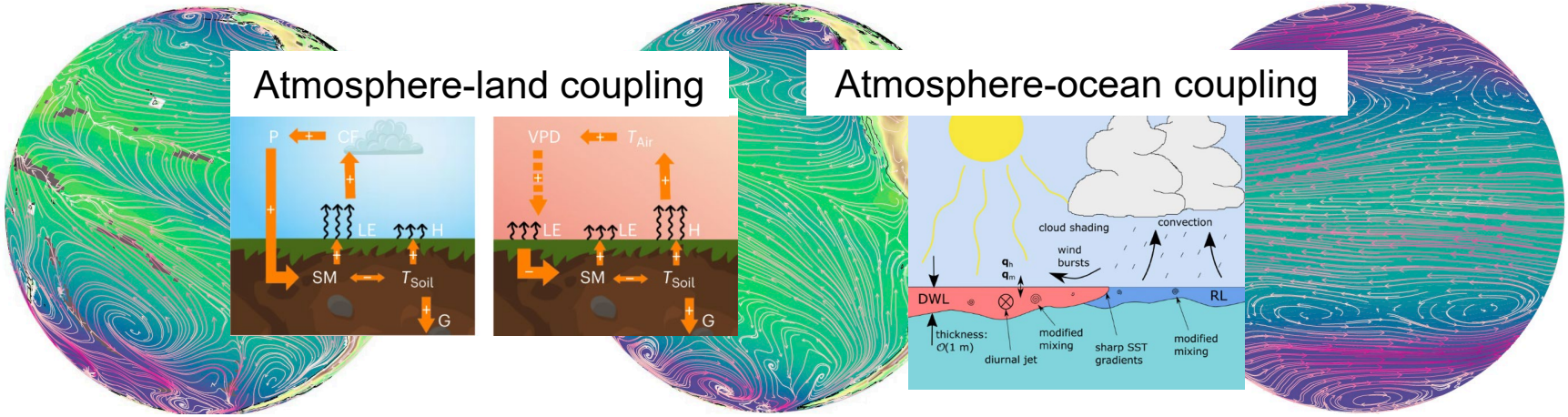
Atmosphere-land coupling





Shaw & Stevens (2025)

We need to fill knowledge gaps related to coupling between climate system components



Atmosphere, ocean, land, ice

Atmosphere, land, ice, prescribed SST

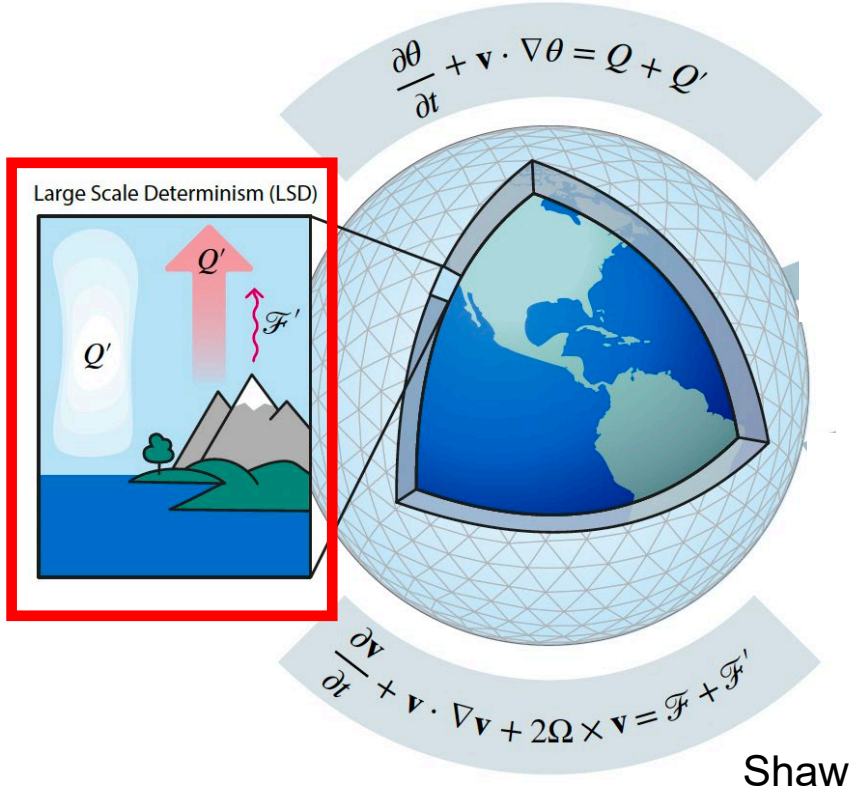
Aquaplanet, prescribed SST

Physical Complexity

Shaw et al. (2016, Nat. Geosc.), Jeevanjee et al. (2017), Maher et al. (2019)

We need to fill knowledge gaps related to the coupling between large and small scales

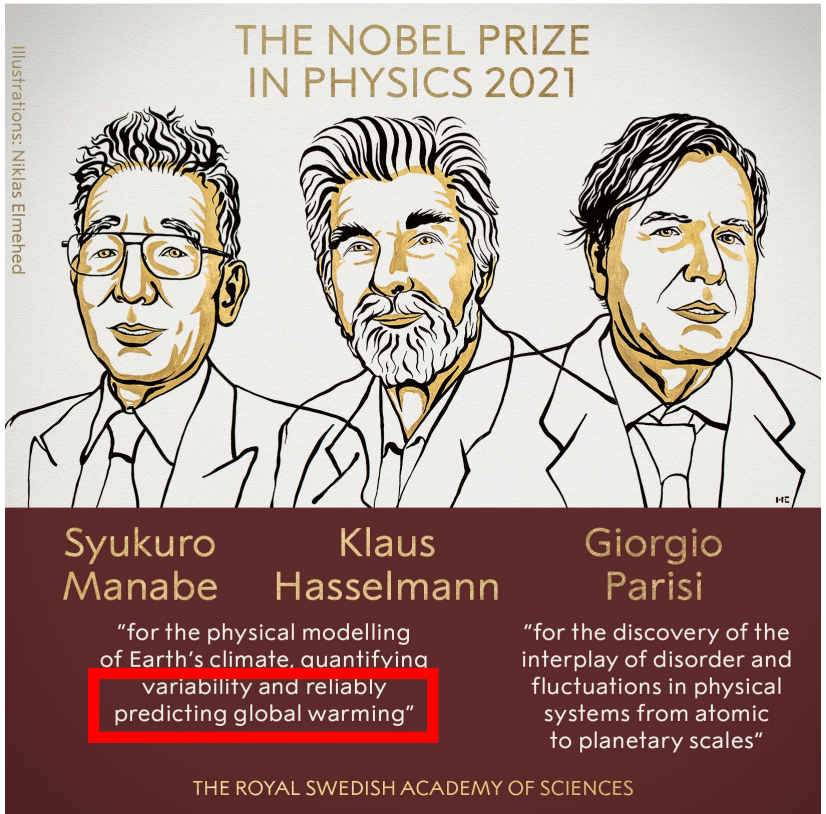
Assume large-scales determine small-scales



Application of physical laws to large-scales

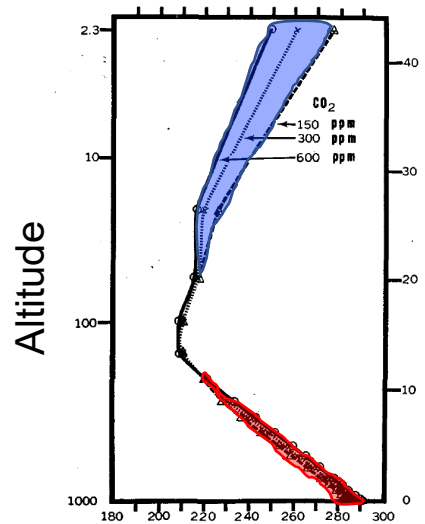
Shaw & Stevens (2025, to appear)

We've made successful predictions that are the basis of the climate change consensus



Manabe's successful predictions define the standard approach of climate science

Radiation + Convection

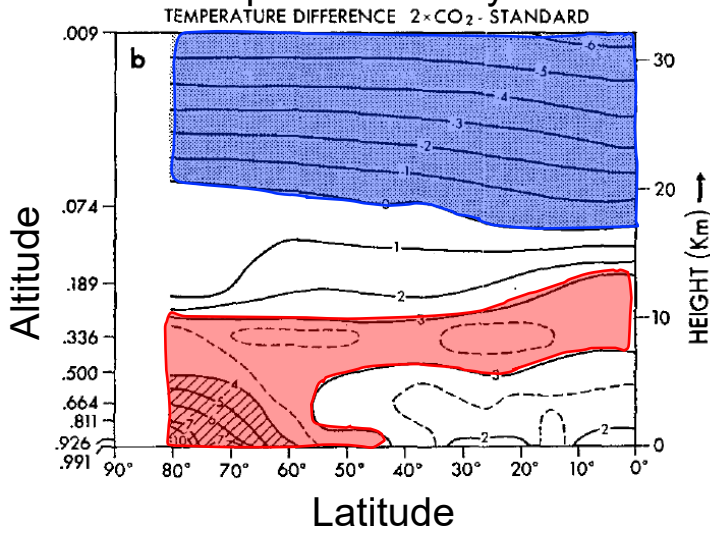


Manabe & Wetherald (1967)

Physical Complexity

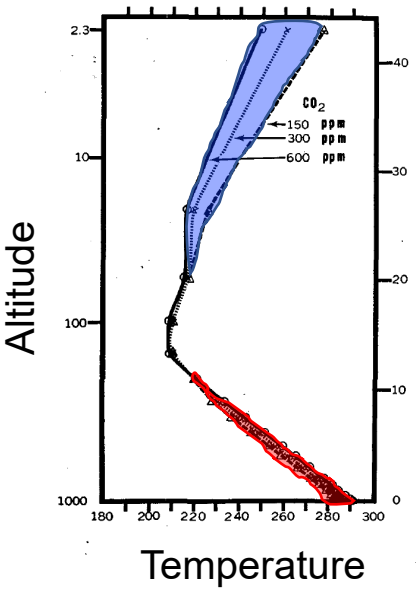
Manabe's successful predictions define the standard approach of climate science

Radiation + Convection + Ice
+ Atmosphere Fluid Dynamics



Manabe & Wetherald (1975)

Radiation + Convection

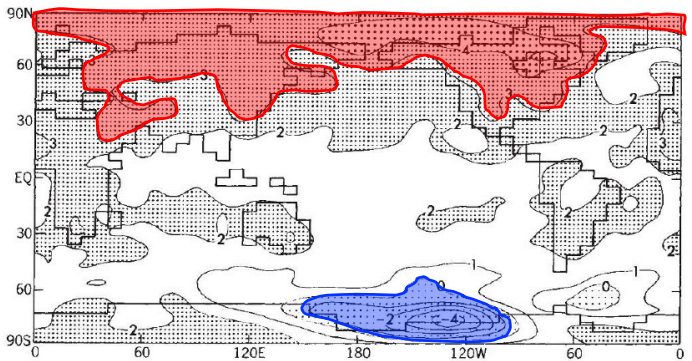


Manabe & Wetherald (1967)

Physical Complexity

Manabe's successful predictions define the standard approach of climate science

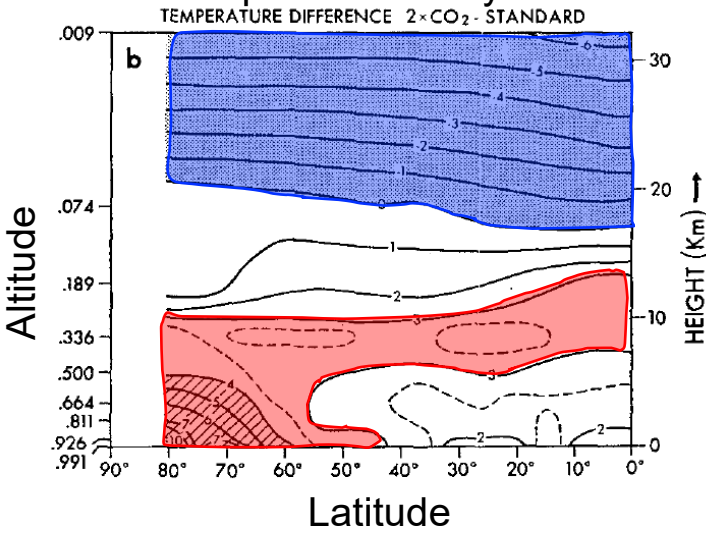
Radiation + Convection + Ice + Atmosphere + Ocean Fluid Dynamics



Longitude

Stouffer, Manabe & Wetherald (1989)

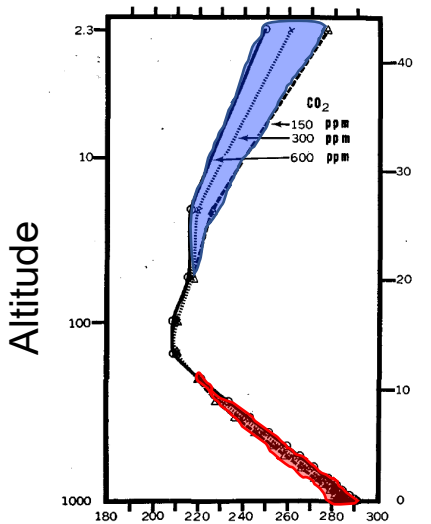
Radiation + Convection + Ice + Atmosphere Fluid Dynamics



Latitude

Manabe & Wetherald (1975)

Radiation + Convection

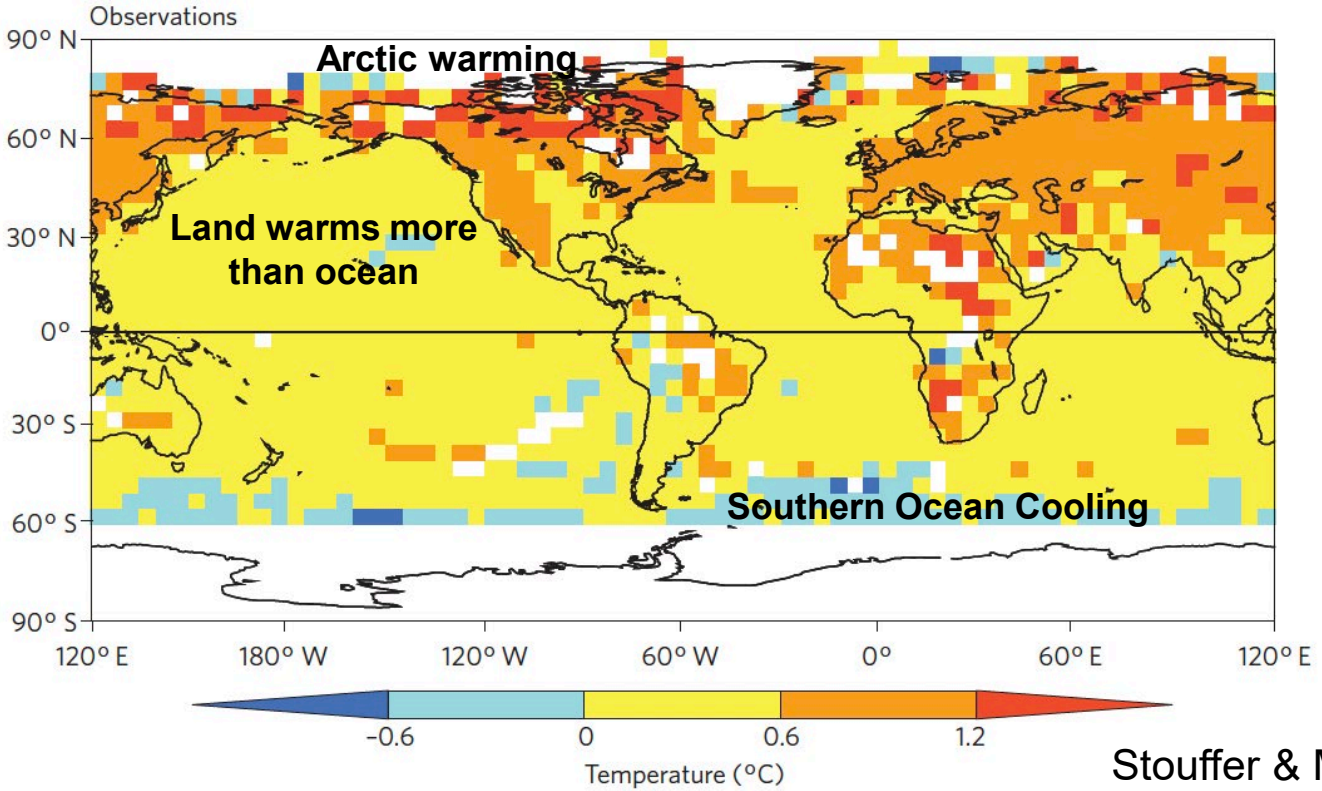


Temperature

Manabe & Wetherald (1967)

Physical Complexity

Predicted temperature signals have emerged across many regions



Stouffer & Manabe (2017)