Tropical Hydroclimate Change during Heinrich Stadial 1: An Integrative Proxy-Model Synthesis

PaleoWG

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and

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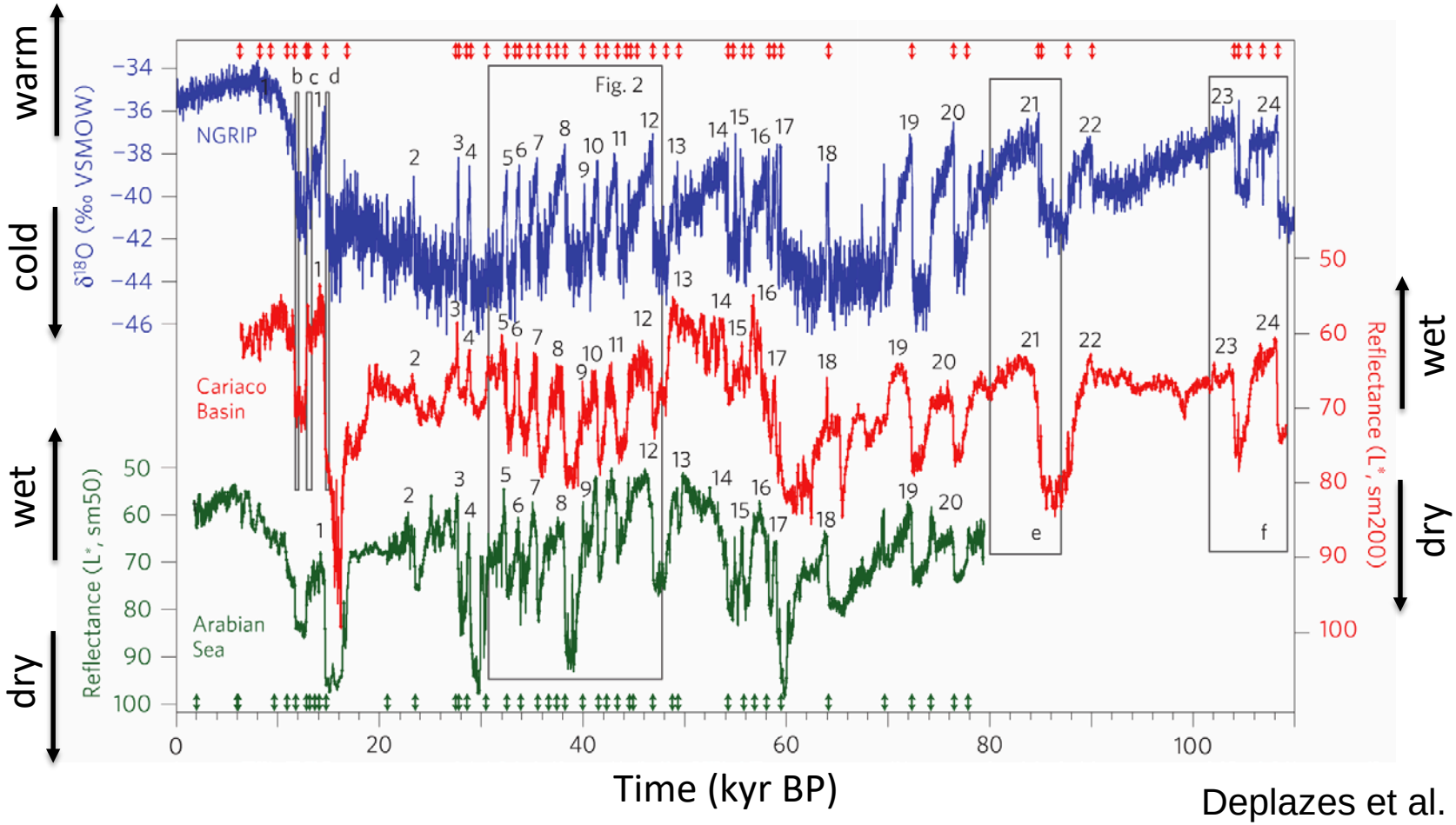
UTIG

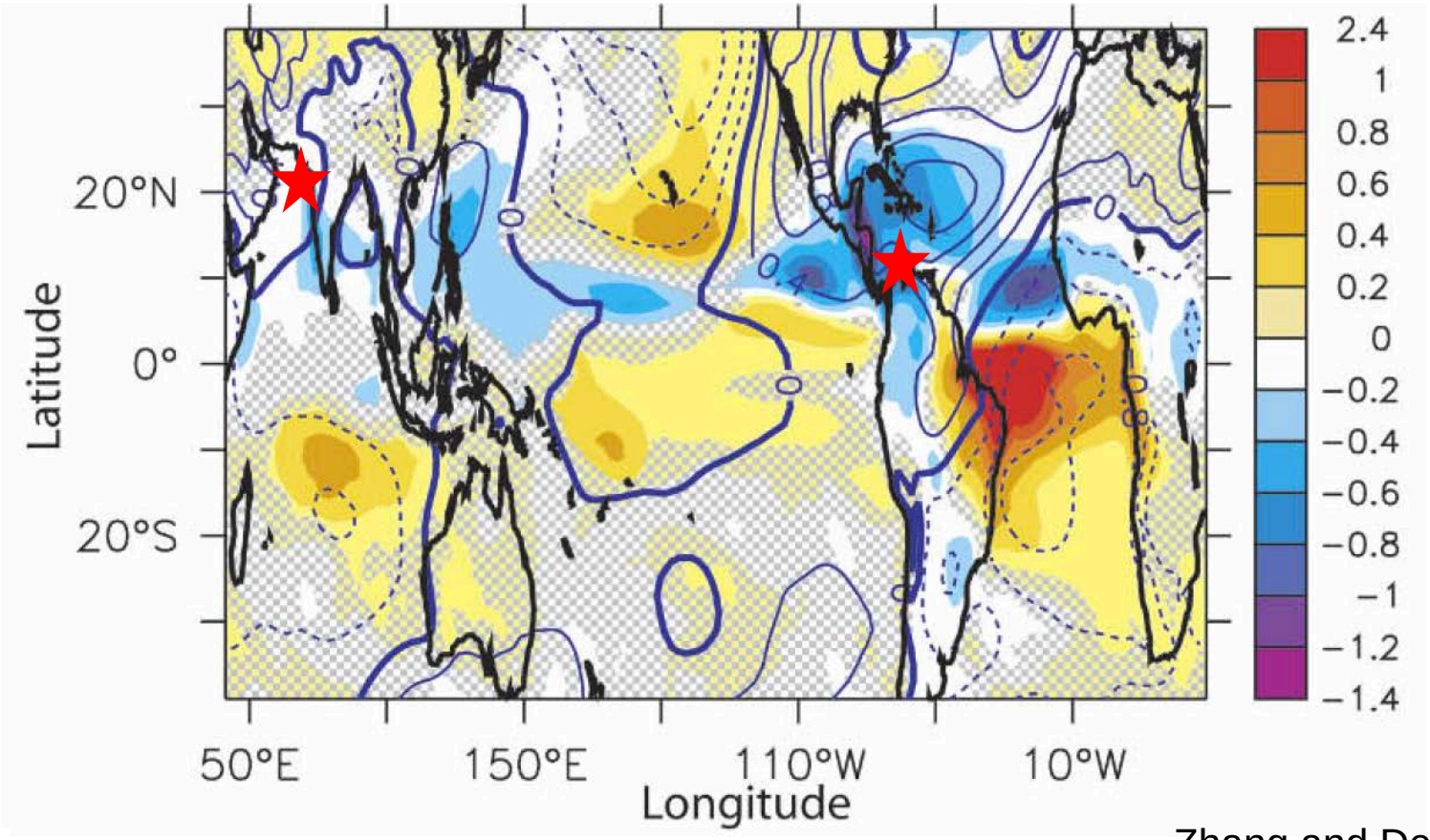
Large changes in tropical hydroclimate associated with abrupt cooling events in the North Atlantic



Deplazes et al. 2013

The mechanisms whereby the response is communicated to the tropics remain uncertain

Models simulate large tropical hydroclimate changes when the AMOC collapses

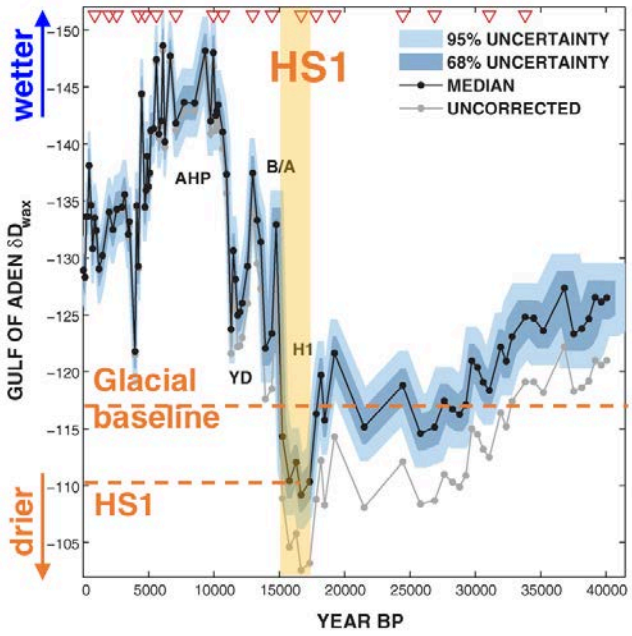


Zhang and Delworth 2005

Do these responses explain all the available paleo data?

We revisited this question by comparing hosing experiments with paleo data

- **Proxy record synthesis**
  - **Rainfall-sensitive proxies, mostly terrestrial,**
  - **We re-interpret departures during Heinrich Stadial 1 relative to glacial/deglacial background,**
  - **Put the changes in categories: tter.**

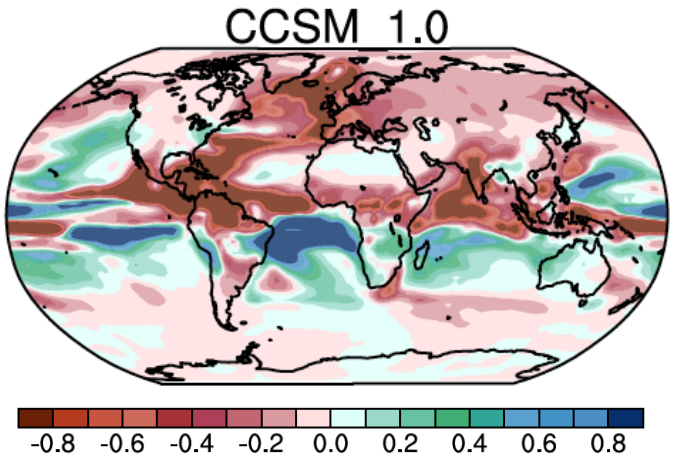


Example for δD_{wax} record from Gulf of Aden (Tierney et al. 2013)

We revisited this question by comparing hosing experiments with paleo data

- **Multi-model ensemble**
  - **Expanded from Kageyama et al. 2013.**
  - **Freshwater hosing experiments under LGM boundary conditions.**
  - **Inter-model differences:**
    - **Models physics and resolution,**
    - **Freshwater hosing magnitude and location.**

climates.



14 hosing experiments with the following models:

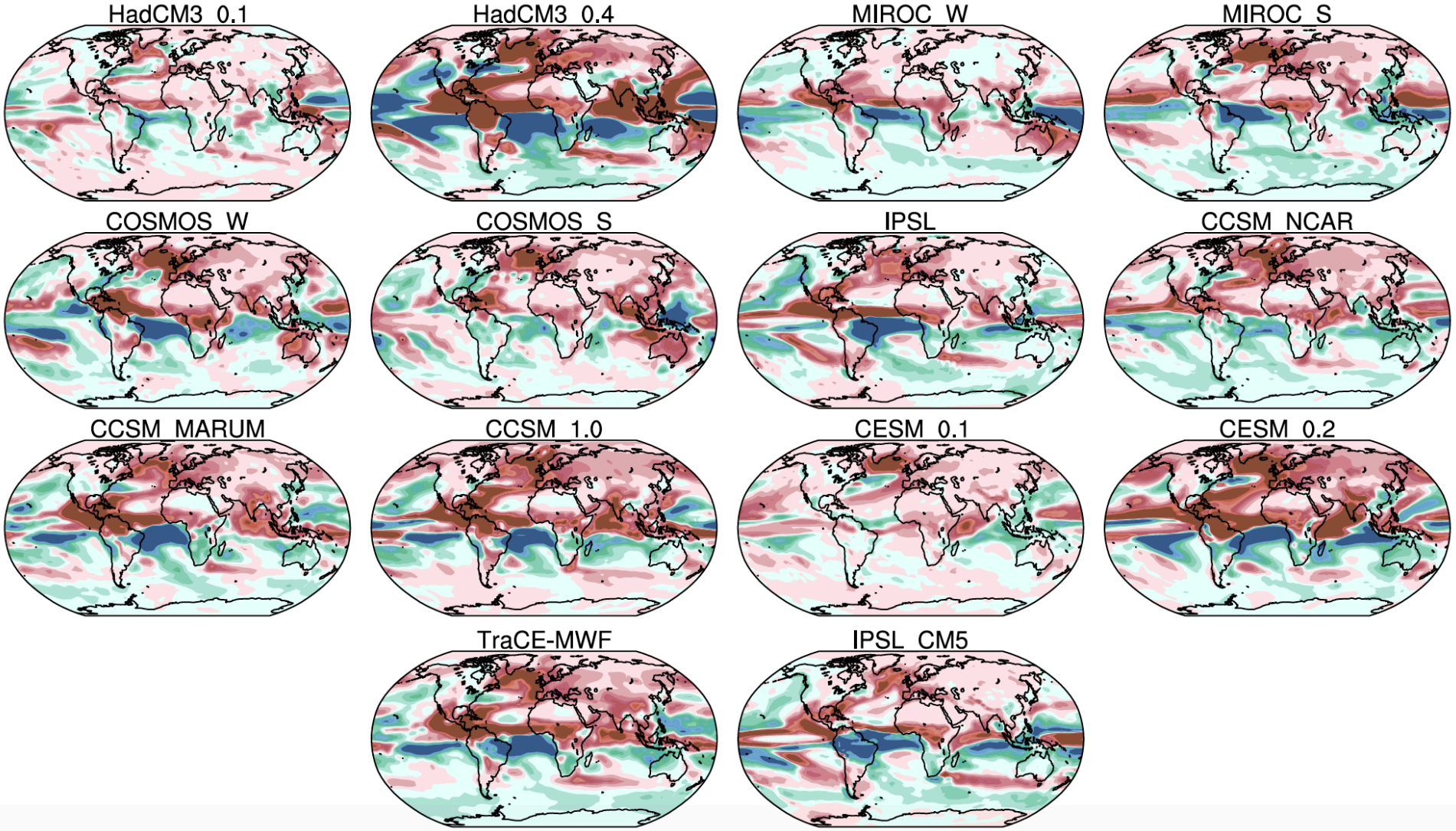
HadCM3
MIROC
COSMOS
IPSL-CM4
CCSM3

Kageyama et. al. 2013

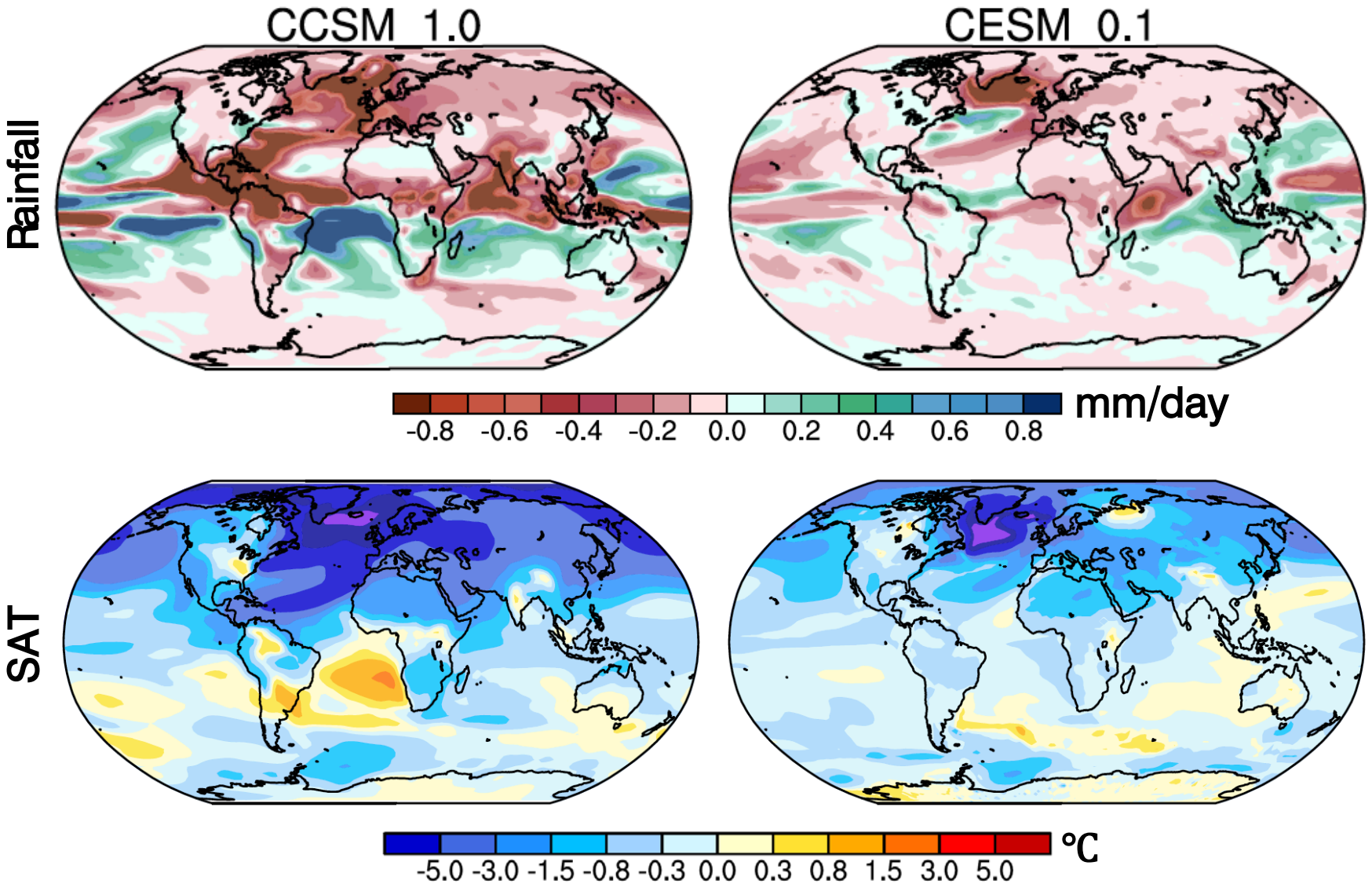
Some models ran experiments with different amounts of fresh water forcings and location

IPSL-CM5
CESM1

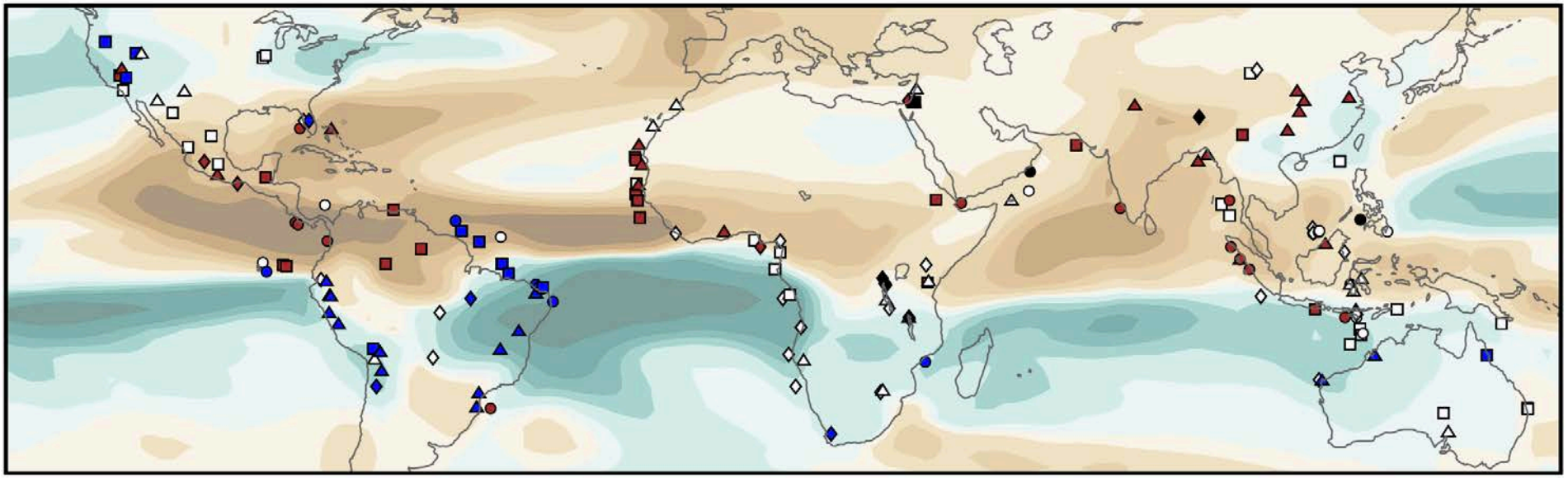
Models show common patterns, and differences

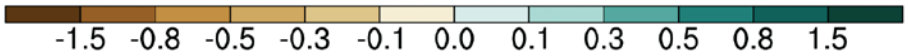


Models show common patterns potentially related to the magnitude of tropical Atlantic cooling

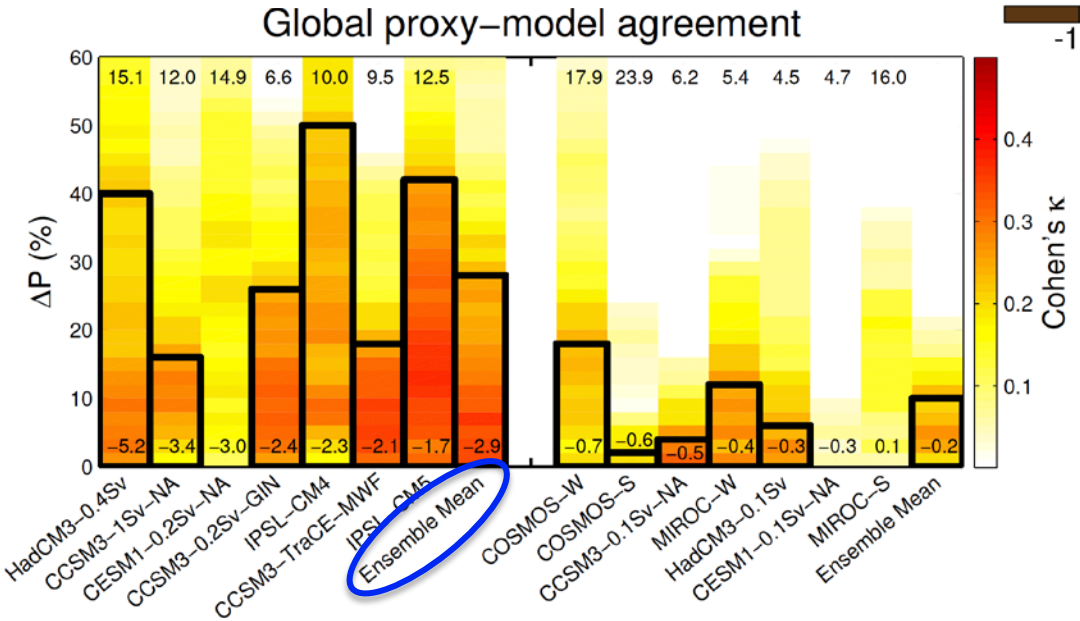


Compare simulated rainfall response to a paleoclimate proxy network





rainfall anomaly (mm/day)



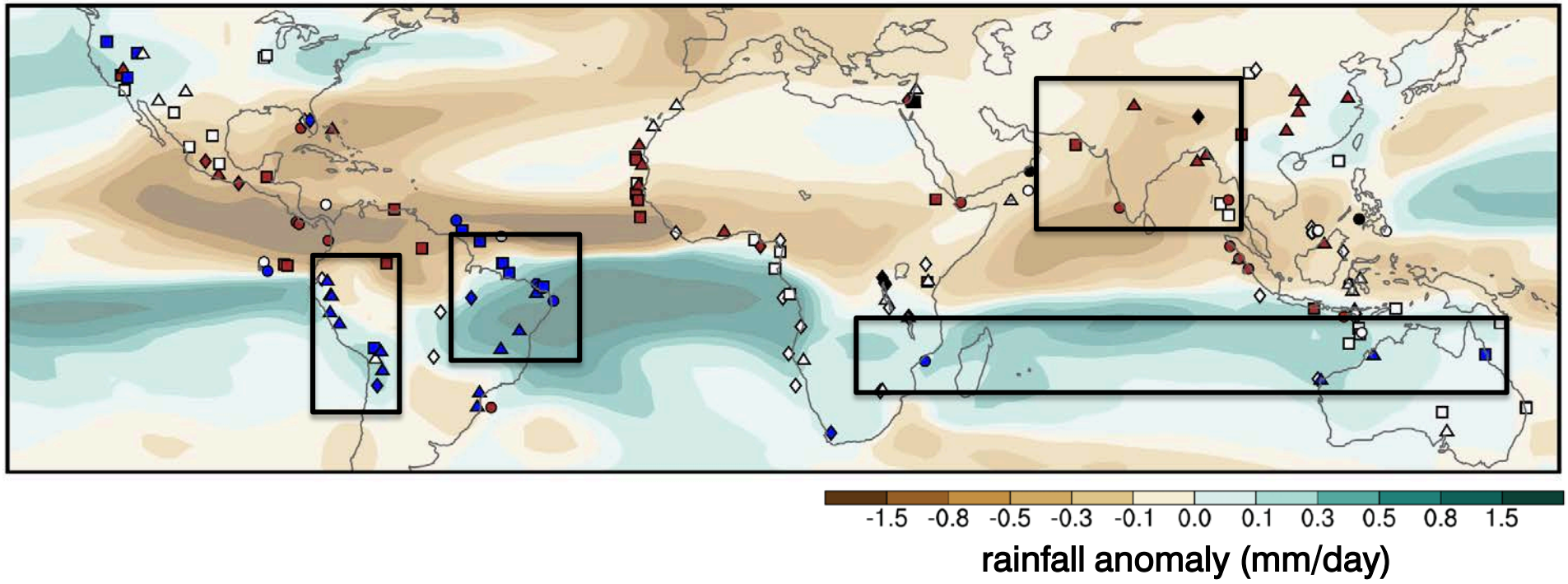
Paleoclimate Rainfall Proxy Interpretation

- Drier
- Wetter
- Unchanged
- Unclear

Paleoclimate Proxy Categories

- Marine Isotope
- Terrestrial Isotope
- Aridity
- Vegetation

Why does tropical Atlantic cooling matter?



- **Wetter NE Brazil**
- **Indian monsoon changes**
- **Wetter Andes**

Paleoclimate Rainfall Proxy Interpretation
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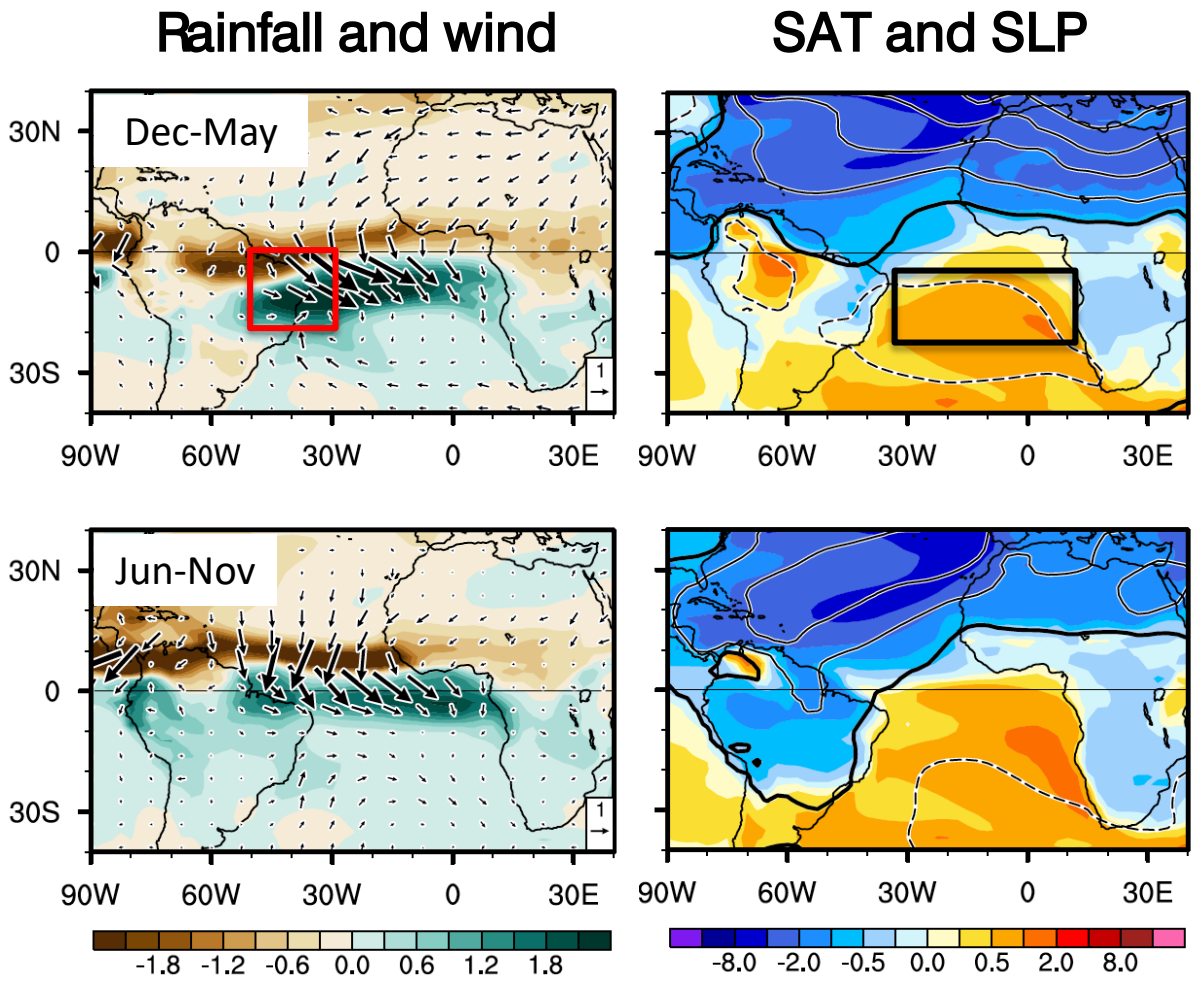
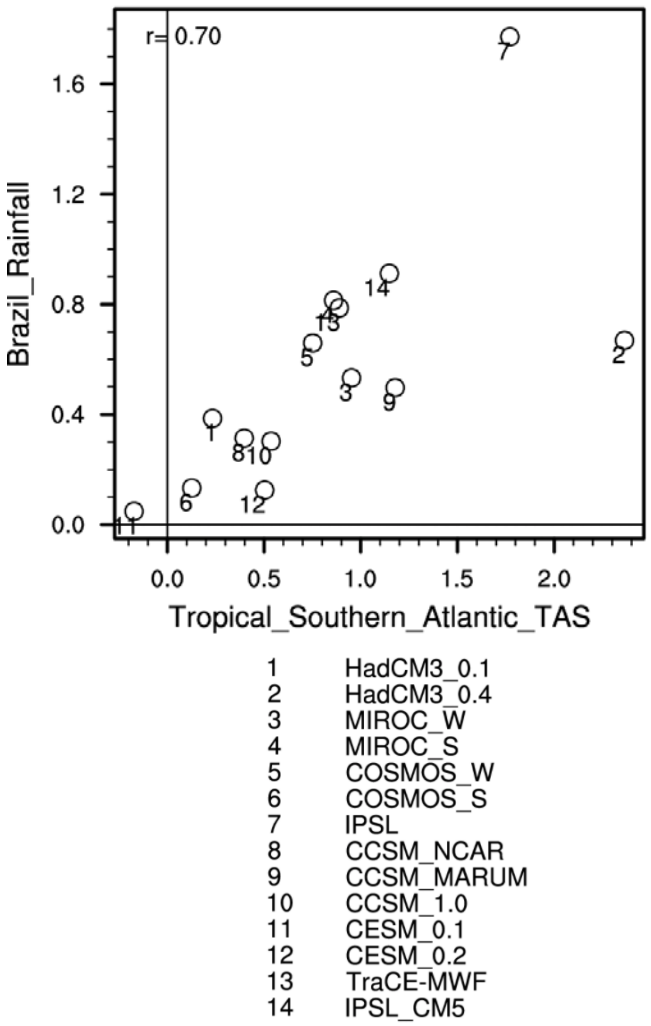
Wetter NE Brazil – warmer tropical S Atlantic

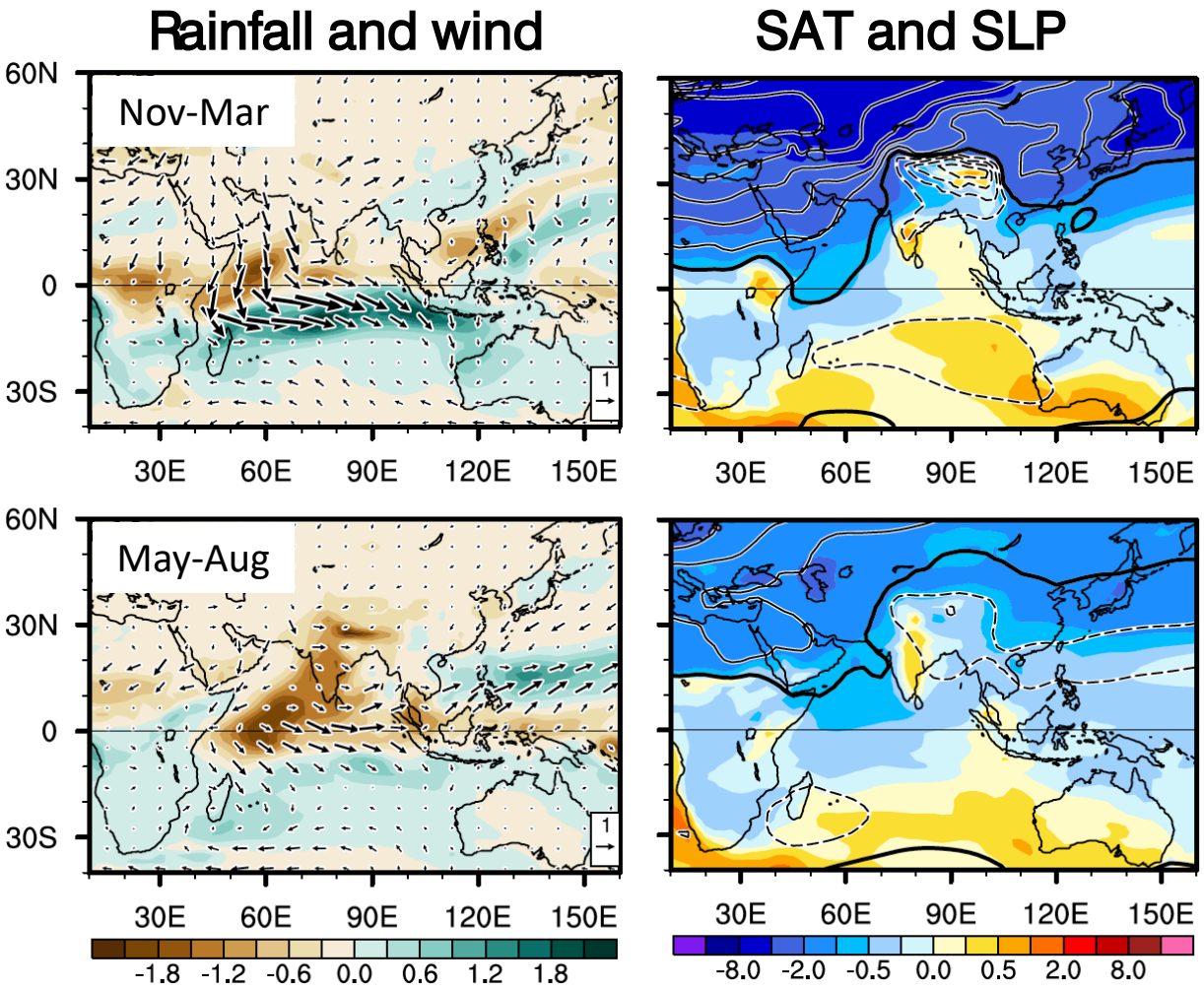




?? Origin of warmer tropical S Atlantic

- **cooling of tropical N Atlantic induces wind-evaporation-SST feedback (r=-0.47)**
- **ocean heat transport**

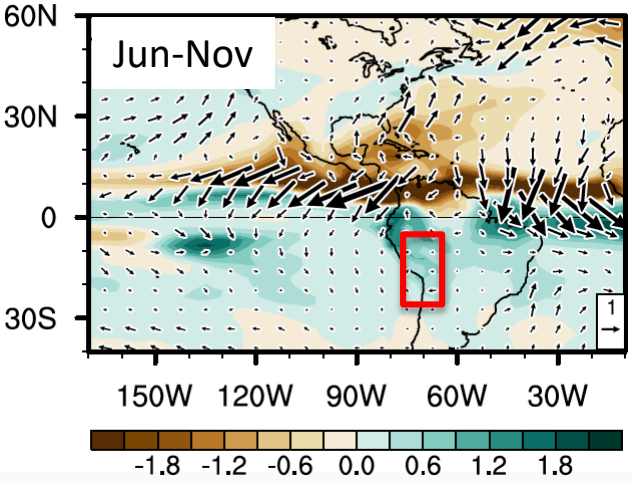
Indian monsoon changes – "ventilation"



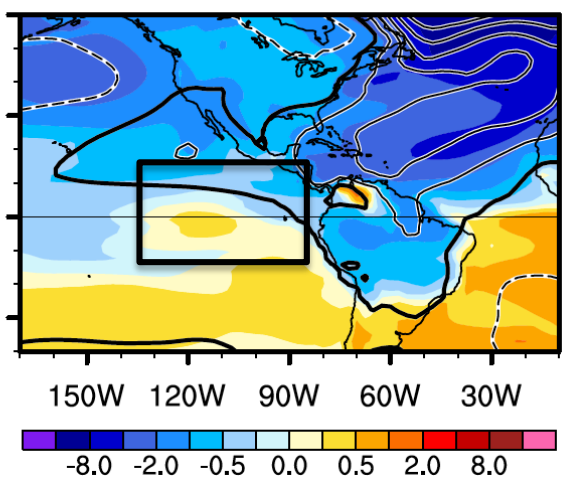
Relative contribution of tropical and high-latitude N Atlantic is highly model dependent explaining disagreement among previous studies Marzin et al. 2013, Y Liu et al. 2014.

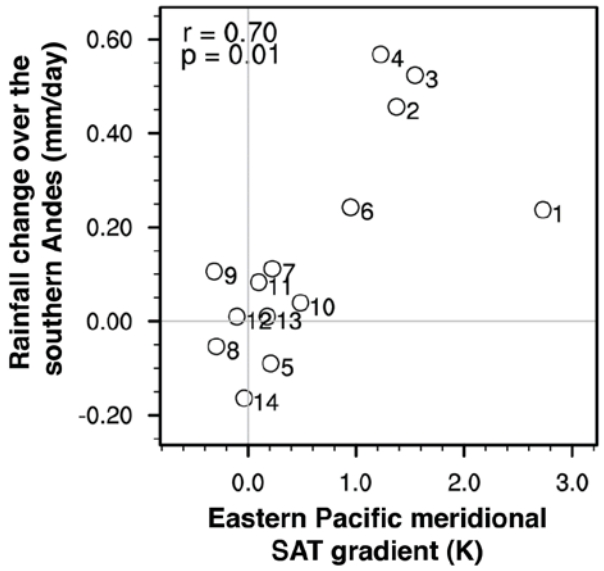
Wetter Andes – eastern Pacific ITCZ shift

Rainfall and wind



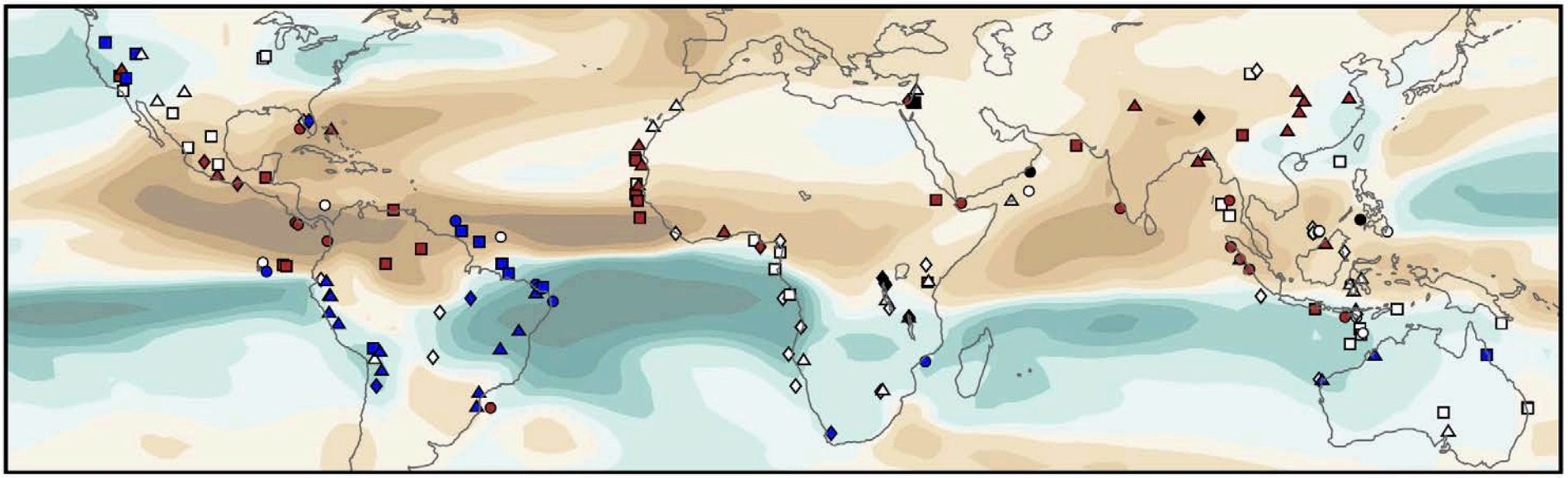
SAT and SLP





Cooling of the tropical N Atlantic is transported to tropical NE Pacific by trade winds through the Panama Isthmus. (e.g. Zhang and Delworth 2005, Xie et al. 2008, Timmerman et al. 2007)

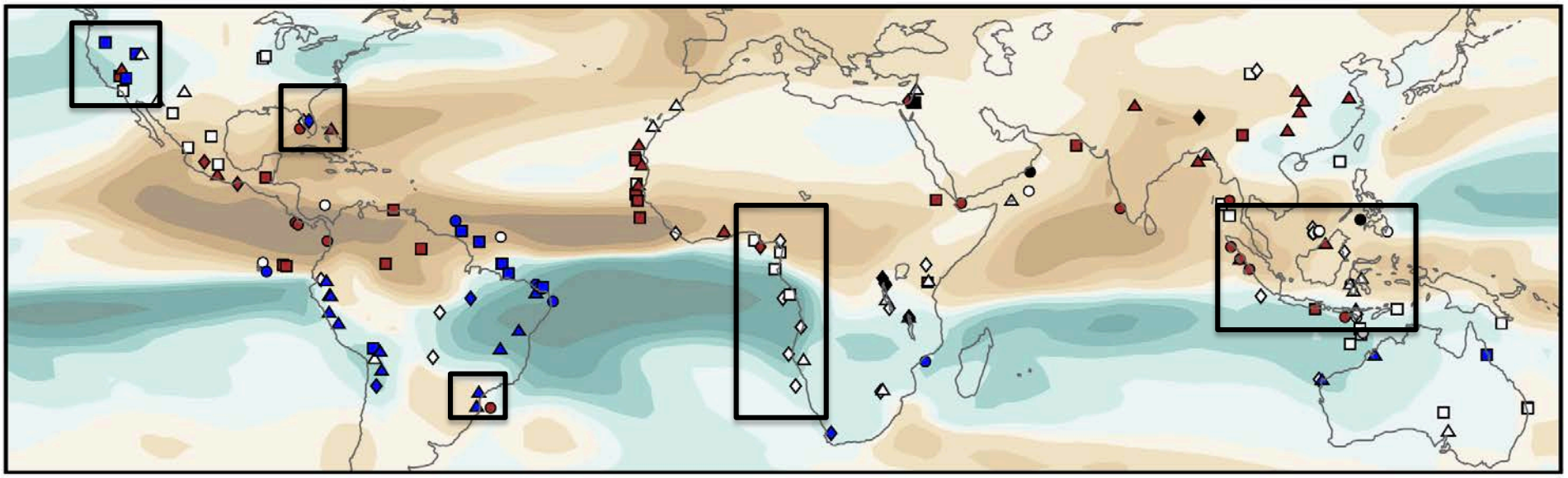
Conclusions



- **Patterns of rainfall changes in the global tropics are related to magnitude of tropical N Atlantic cooling.**

- **Rainfall changes are communicated via multiple mechanisms, more than an ITCZ shift.**

Open questions



Unchanged condition near Congo basin

- **Do proxies record local rainfall?**
- **Are models wrong?**

Unchanged or drier condition over Maritime Continent

- **How robust is the signal among proxy records?**
- **Do models have a good representation of the continental shelf? What about the LGM climatology?**

Conflicting signal in some regions