Tipping points in the climate system and their impact over water availability in the tropics

Cristiano M. Chiessi et al.

Take away messages

- The strength of the Atlantic meridional overturning circulation (AMOC) partially controls long-term tropical South American precipitation
- AMOC is a tipping element of the climate system that may collapse within the 21st century
- Paleoclimate archives allow the investigation of the causes and consequences of an AMOC collapse
- A concerted international and multidisciplinary effort is necessary to address the effects of an AMOC collapse over tropical precipitation and ecosystems

Water availability

Precipitation

Evaporation + transpiration + runoff + infiltration

Demand + pollution

Water availability

Precipitation

Evaporation + transpiration + runoff + infiltration

Demand + pollution

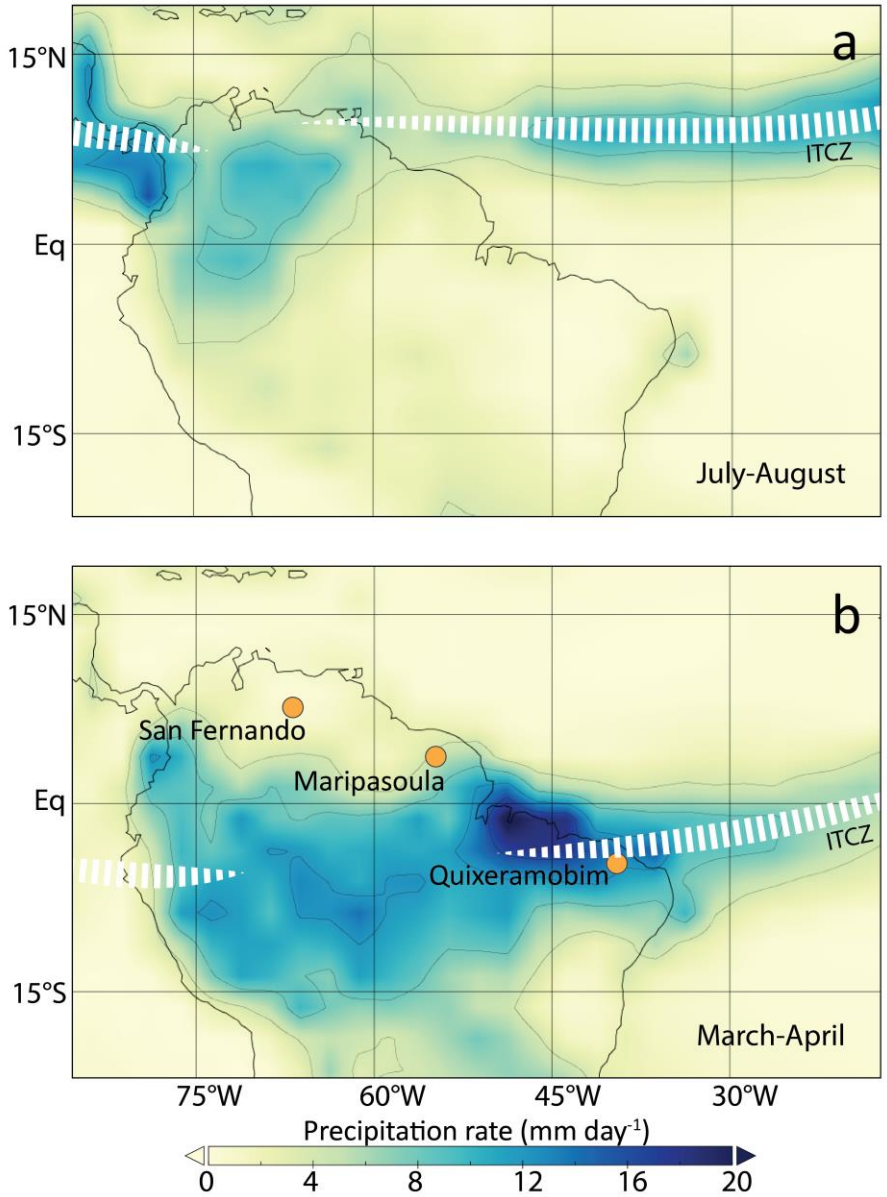
Water availability

Tropical precipitation

Evaporation + transpiration + runoff + infiltration

Demand + pollution

Tropical precipitation and the Atlantic meridional overturning circulation



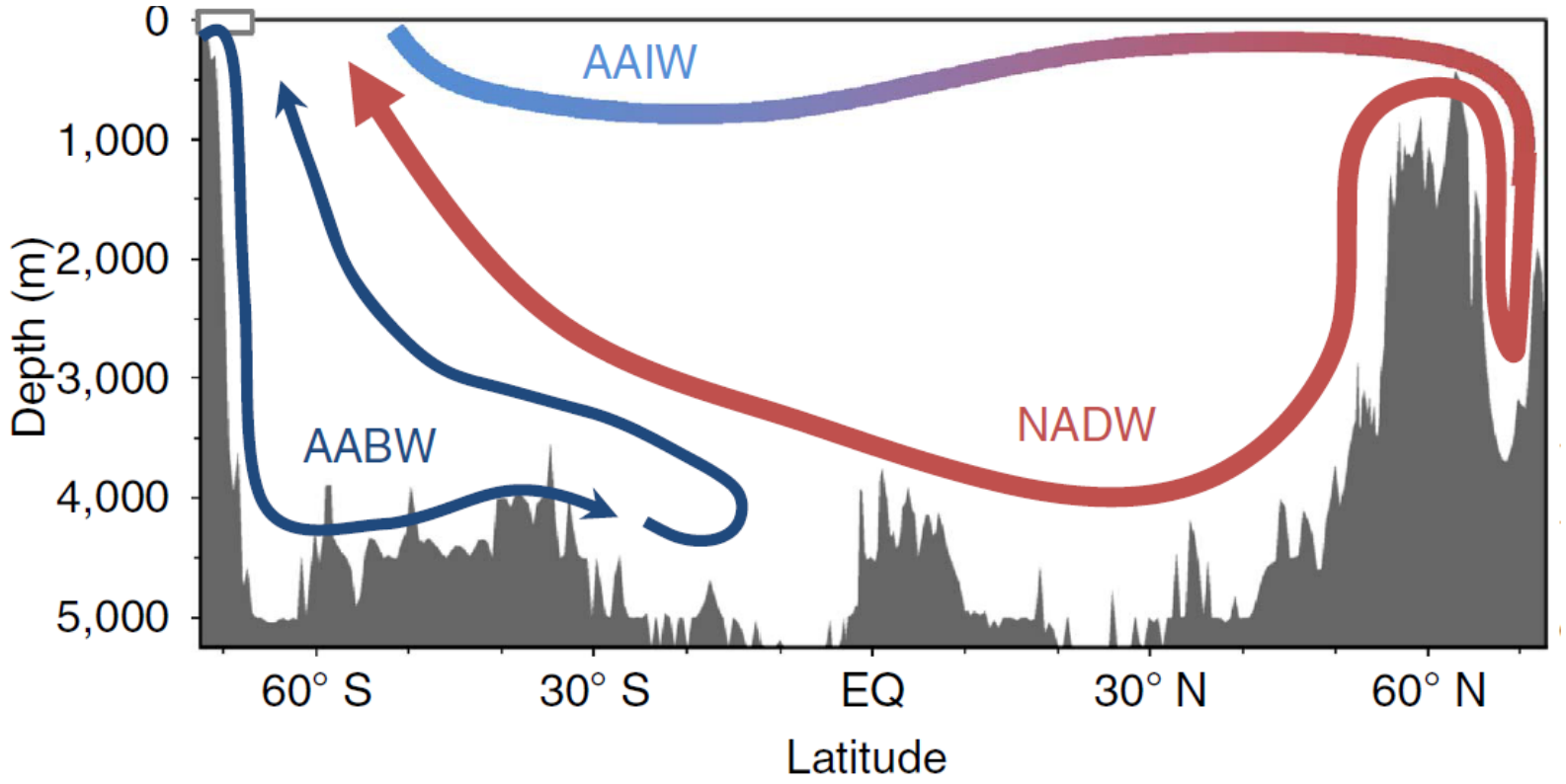
- Tropical rainbelt or Intertropical Convergence Zone (ITCZ)
- Migrates latitudinally according to the N-S gradient in sea surface temperatures

Chiessi et al. (2021)

Tropical precipitation and the Atlantic meridional overturning circulation

Transports to the North Atlantic

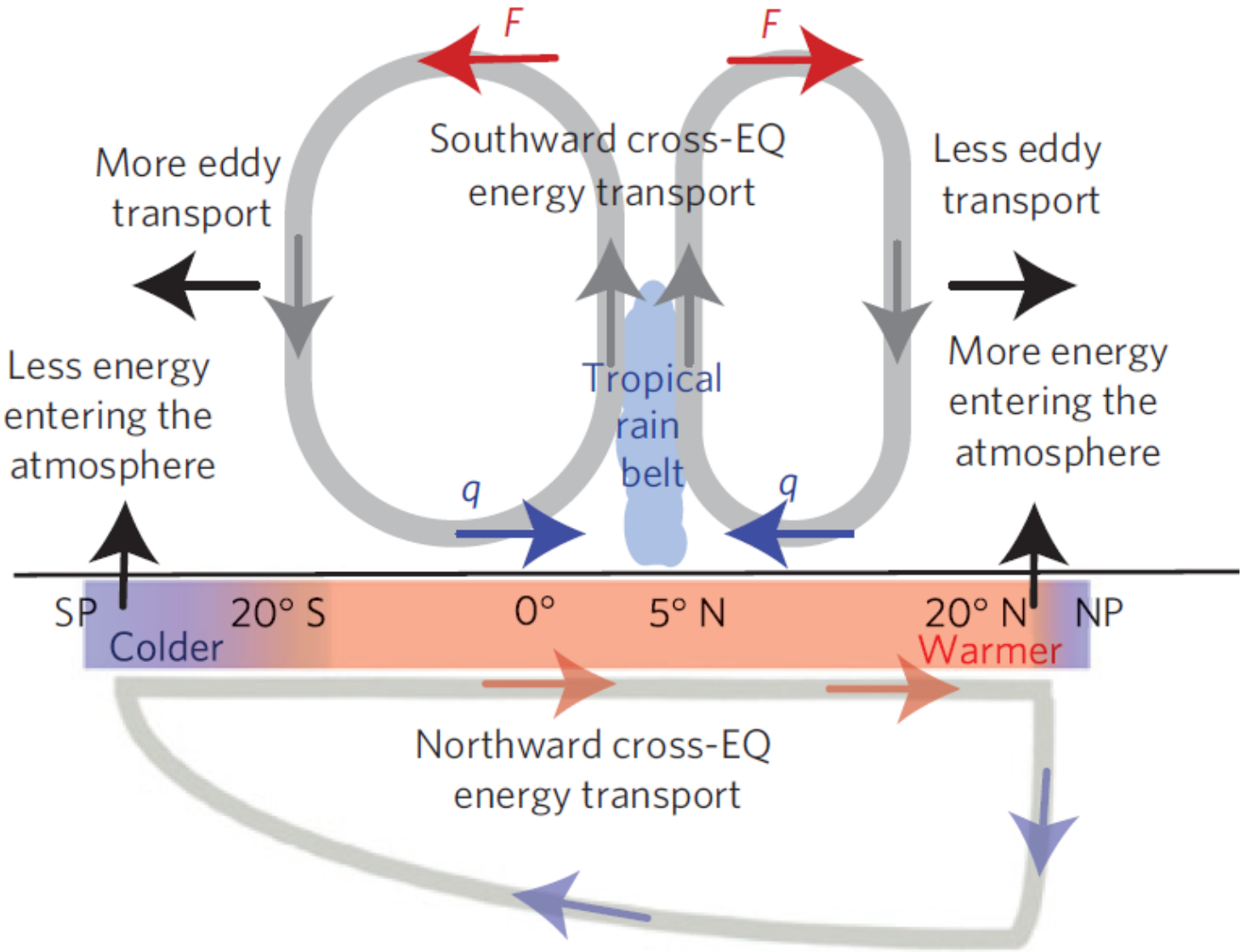
- 16 Sv of surface waters
- 0.4 PW of energy (28.000 Itaipu hydroelectric power plants)



Large amount of energy controls sea surface temperature gradient

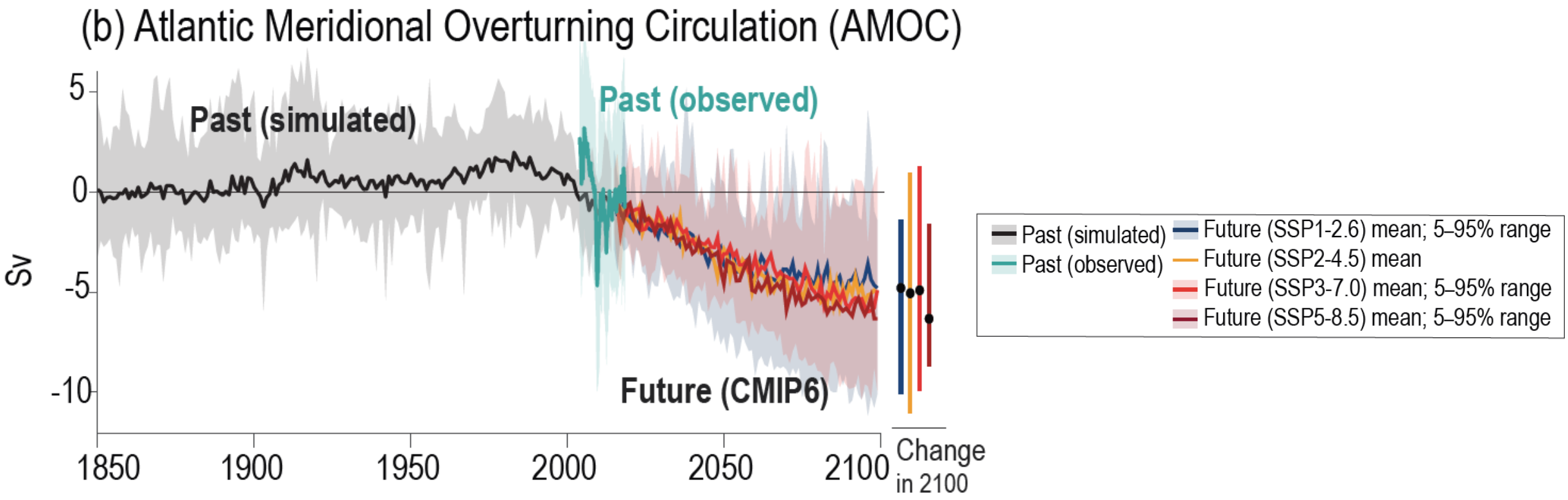
Howe et al. (2016)

Tropical precipitation and the Atlantic meridional overturning circulation



Frierson et al. (2013)

The future of the Atlantic meridional overturning circulation



- IPCC numerical models suggest a decrease in AMOC strength
- High confidence in the decline, but low confidence in the magnitude of the trend
- Most IPCC models show a salinity bias

Liu et al. (2017), Arias et al. (2021)

The future of the Atlantic meridional overturning circulation

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Warning of a forthcoming collapse of the Atlantic meridional overturning circulation

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AMOC is a tipping element and can collapse within the 21st century, strongly affecting sea surface temperatures and tropical precipitation

Dietlevsen and Dietlevsen (2023)

The effect of an AMOC collapse over tropical precipitation

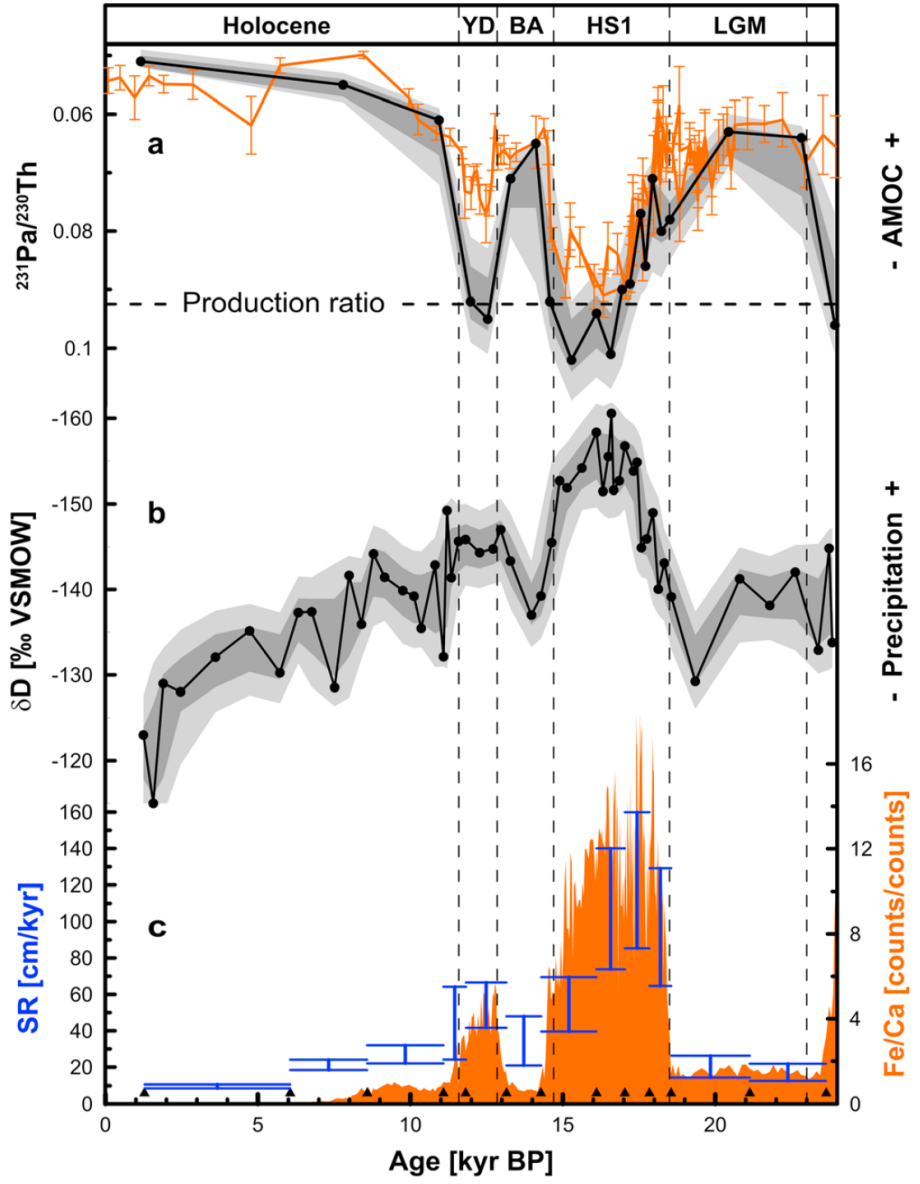
Where to look for the effects of an AMOC collapse over tropical precipitation?

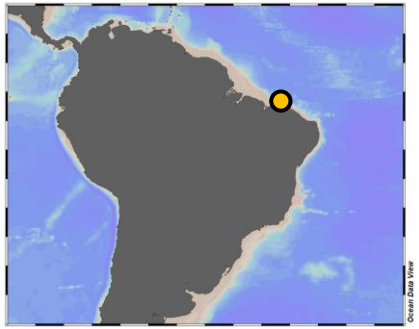
- No AMOC collapse in the instrumental record
- Numerical climate models do not appropriately simulate tipping elements

AMOC collapsed in the geological past and paleoclimate archives allow the investigation of the causes and consequences of such events

The effect of an AMOC collapse over tropical precipitation

- Marked increases in precipitation over northeaster Brazil during AMOC slowdown
- Decrease in precipitation over northernmost South America
- Increased sea surface temperatures in the South Atlantic

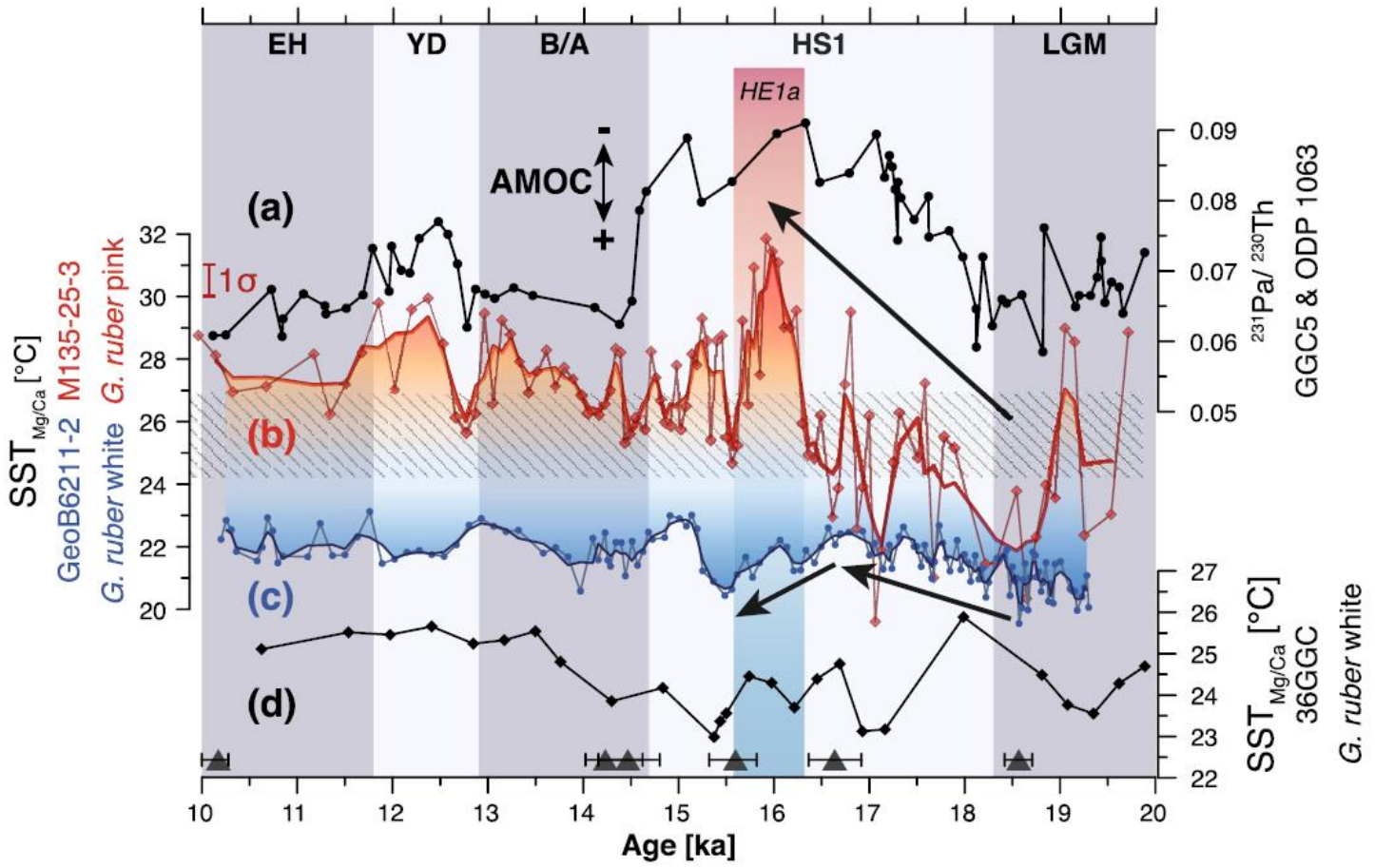


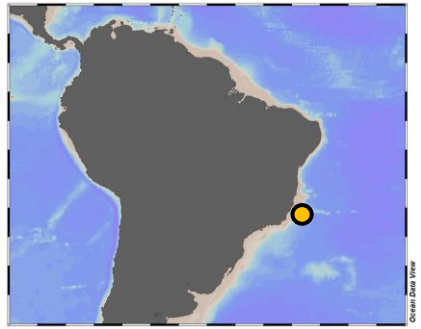


Mulitza et al. (2017)

The effect of an AMOC collapse over tropical precipitation

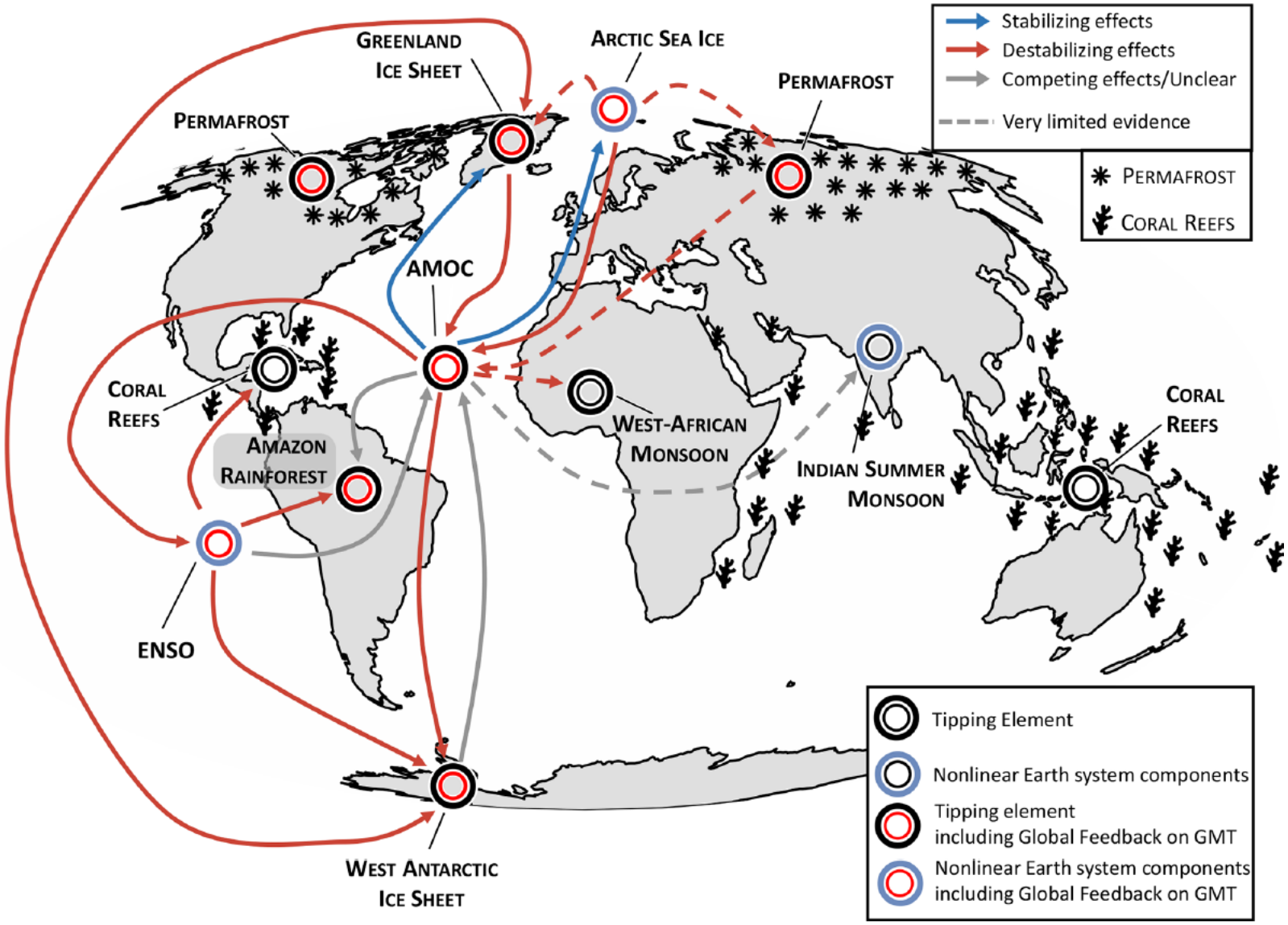
- Warming of at least 4.6°C indicates massive heat accumulation in the tropical South Atlantic
- Effects to tropical precipitation are unclear





Meier et al. (2021)

The effect of an AMOC collapse over tropical precipitation



- Effect of an AMOC collapse over the Amazon rainforest is unclear and there is limited evidence for its effect over the west African and Indian monsoons

Wunderling et al. (2024)

Take away messages

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Many thanks for your attention!

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