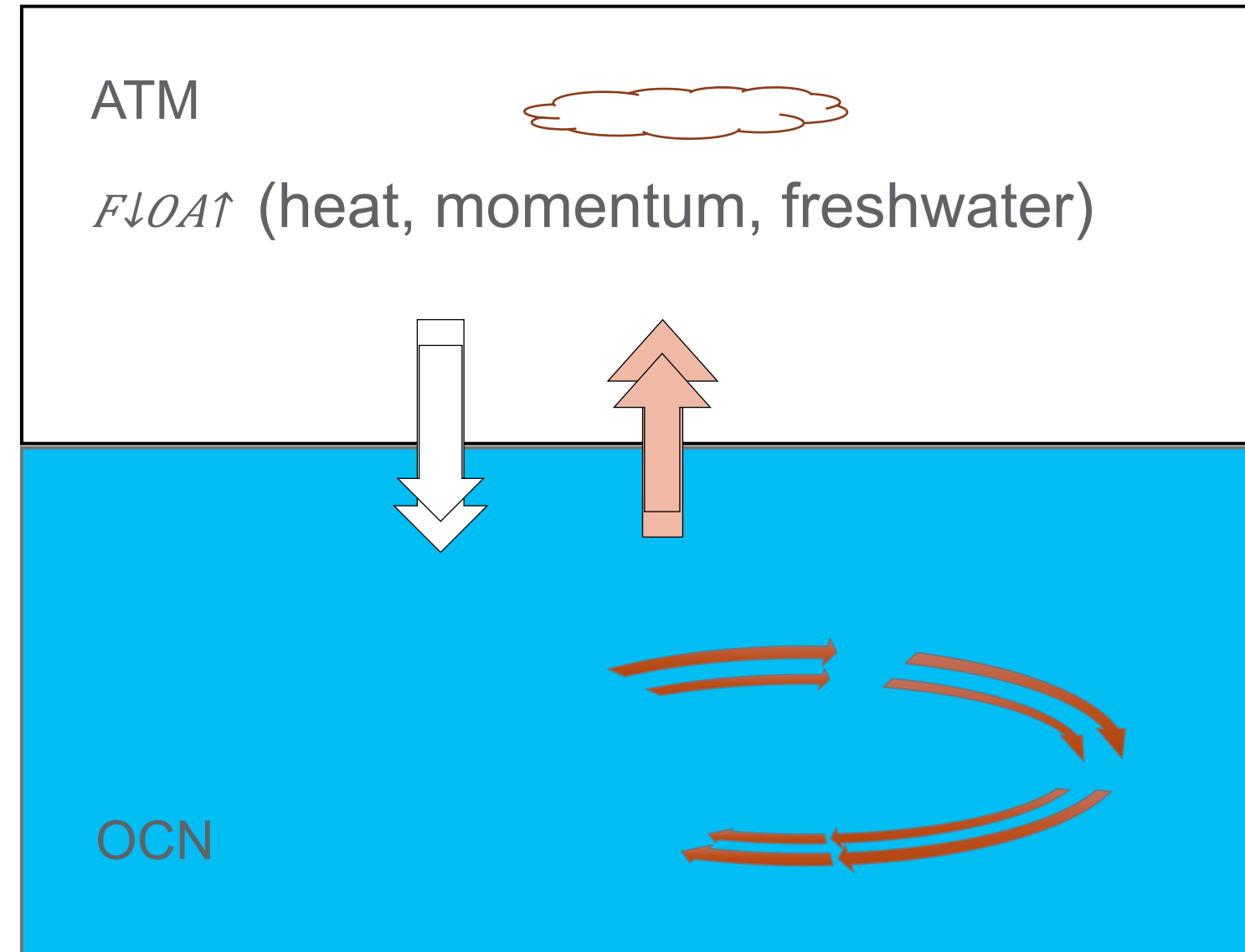


A partial coupling approach to isolate the roles of the ocean and atmosphere in coupled climate interactions

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The coupled air-sea interaction



Full coupling

Traditional methods

- Atmosphere-only (fixed SSTs) simulations
- Ocean-only simulations
- Slab (mixed layer) simulations

Goal: Isolate the roles of the atmosphere and ocean within a coupled model framework?

Anomalous ocean temperature decomposition:

$$T \downarrow \uparrow = T + T \downarrow \uparrow$$

$$\partial T \downarrow \uparrow / \partial t = \boxed{F \downarrow O A \uparrow} - \boxed{v \uparrow \cdot \nabla T} - v \cdot \nabla T \downarrow \uparrow$$

$$\partial T \downarrow A \uparrow / \partial t = F \downarrow O A \uparrow - v \cdot \nabla T \downarrow A \uparrow$$

$$\partial T \downarrow R \uparrow / \partial t = v \uparrow \cdot \nabla T - v \cdot \nabla T \downarrow R \uparrow$$

(Passive)

(Redistributive)

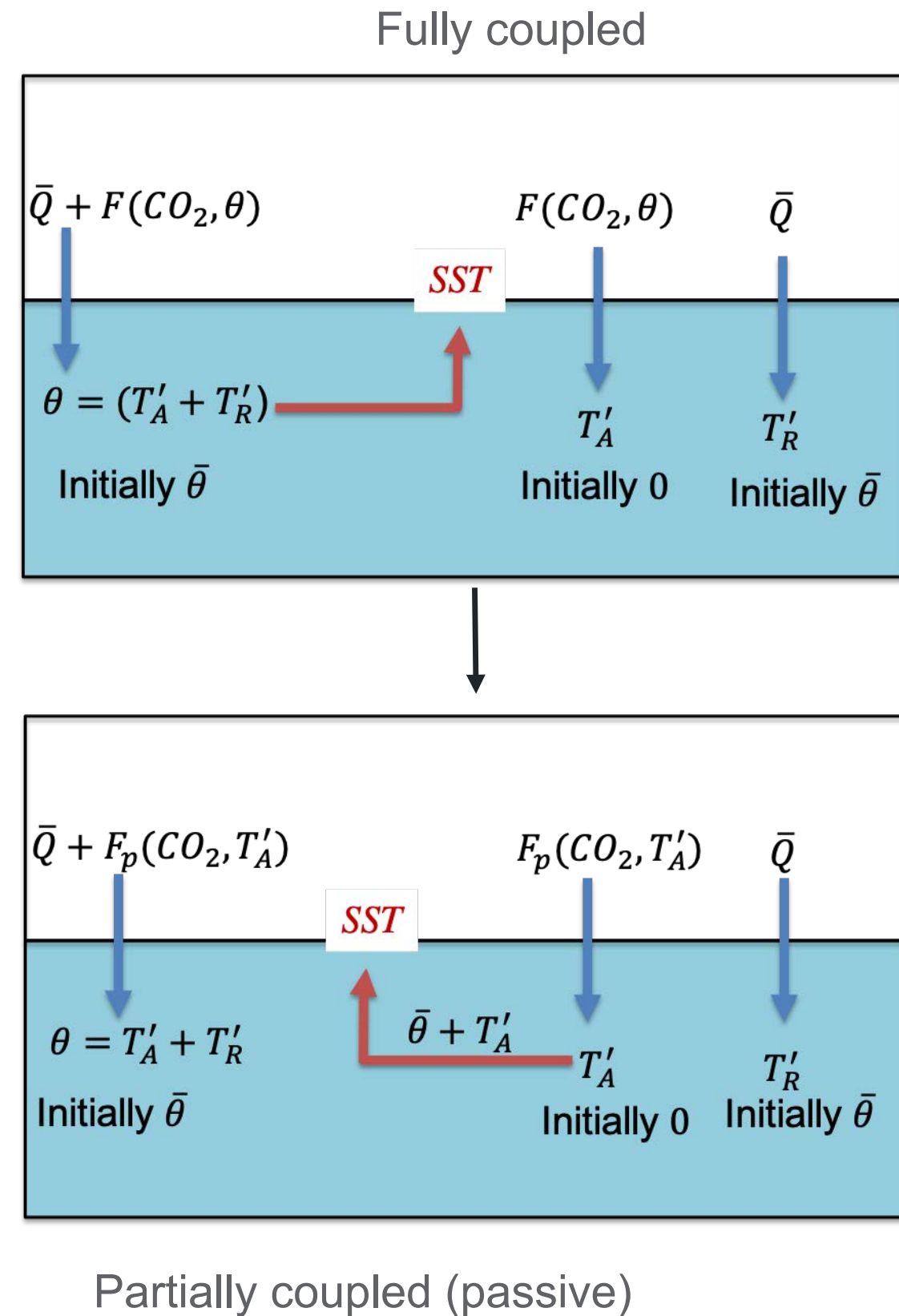
$$T \downarrow \uparrow = T + T \downarrow A \uparrow + T \downarrow R \uparrow$$

Two part Approach:

1. Isolate ocean temperature response component due to anomalous surface fluxes and ocean circulation response using **passive tracers**.
2. Remove the impact of the ocean circulation-driven SST response from air-sea interaction using a **partial coupling method**

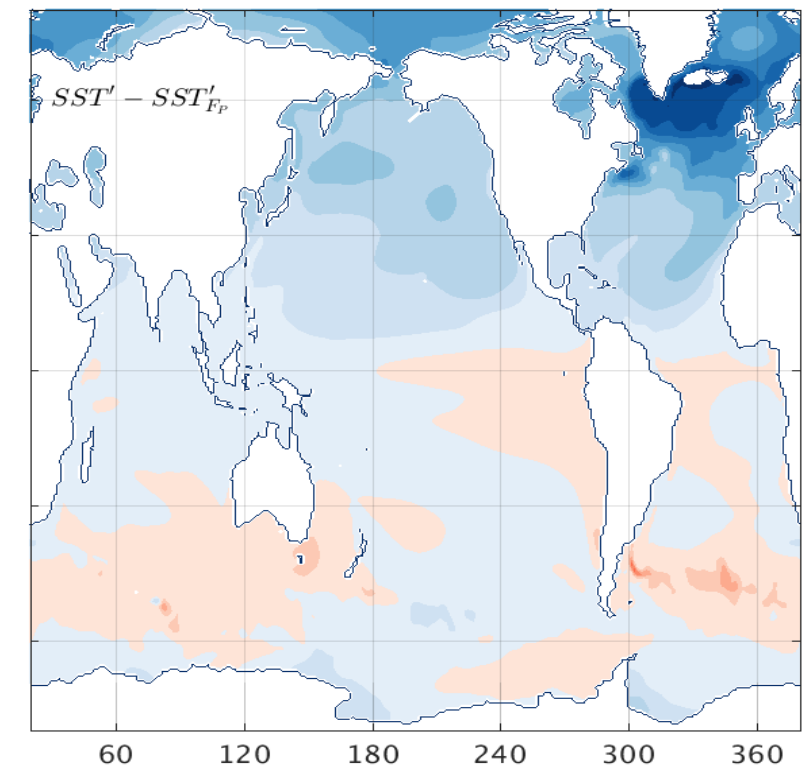
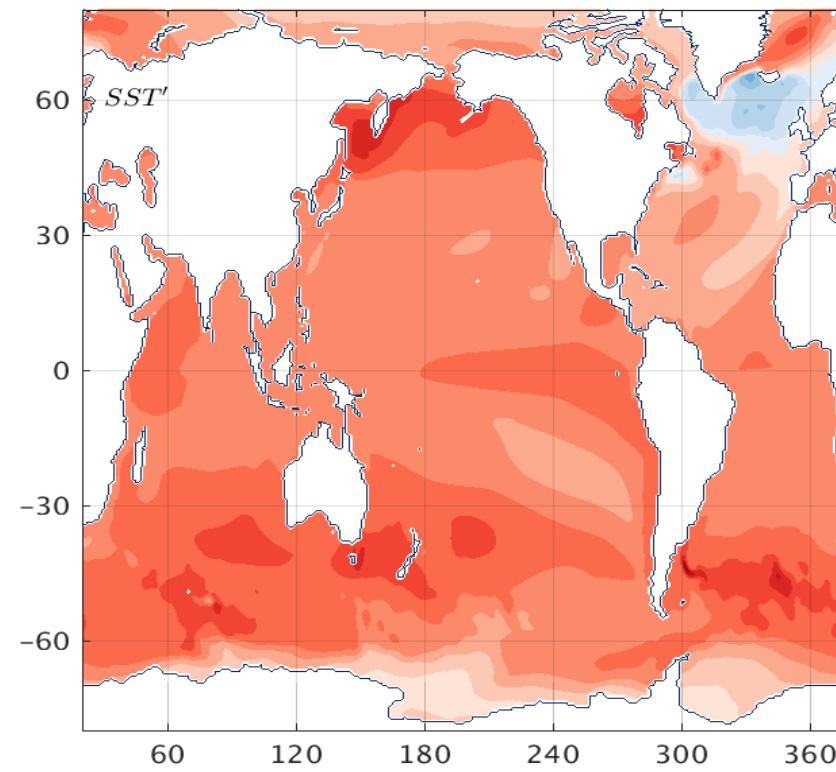
Atmosphere-driven (CO_2 forced) anomalous surface flux isolation

- Remove redistributive temperature anomaly from coupling and isolate atmosphere-driven (**passive**) surface fluxes
- Ocean-driven (**active**) response is the difference between fully coupled and partially coupled response

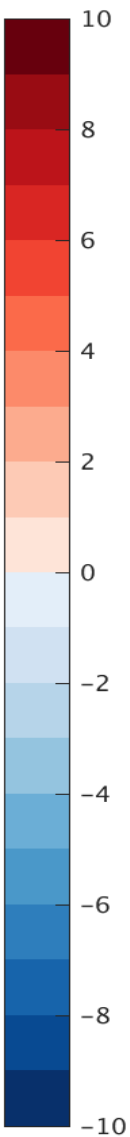
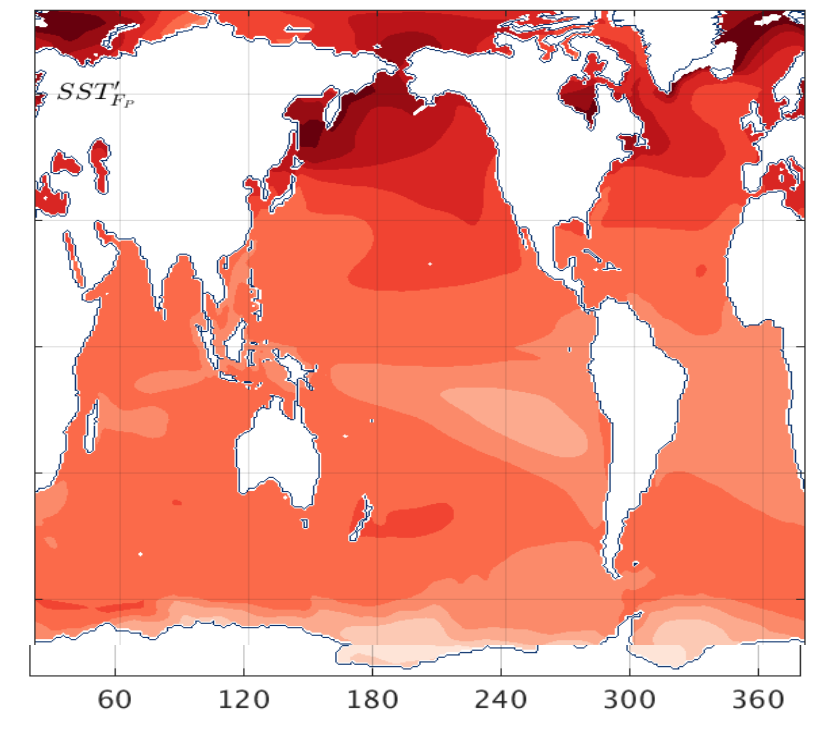
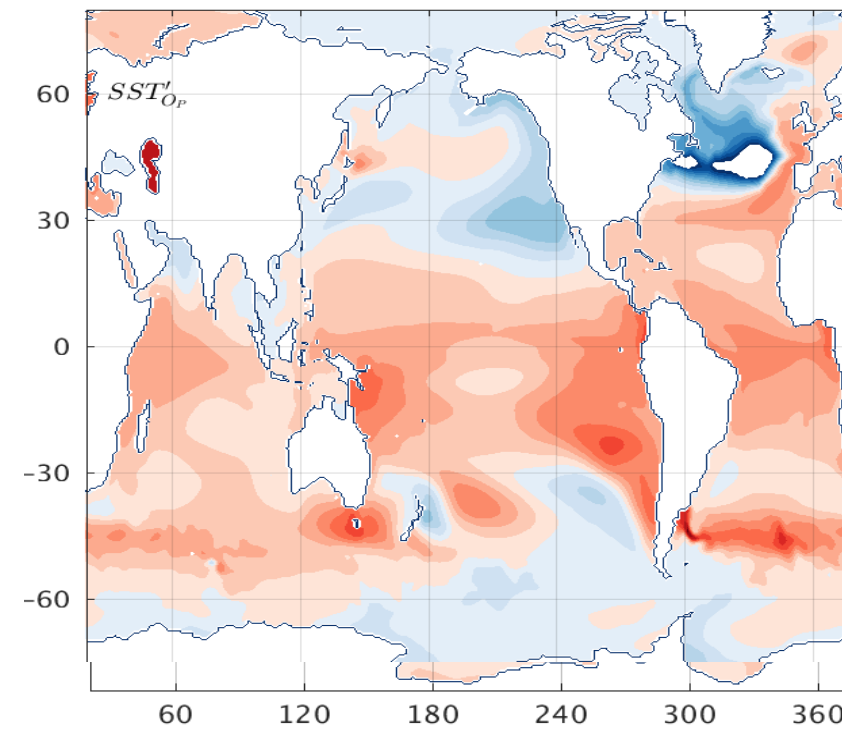


SST anomalies:

Fully coupled

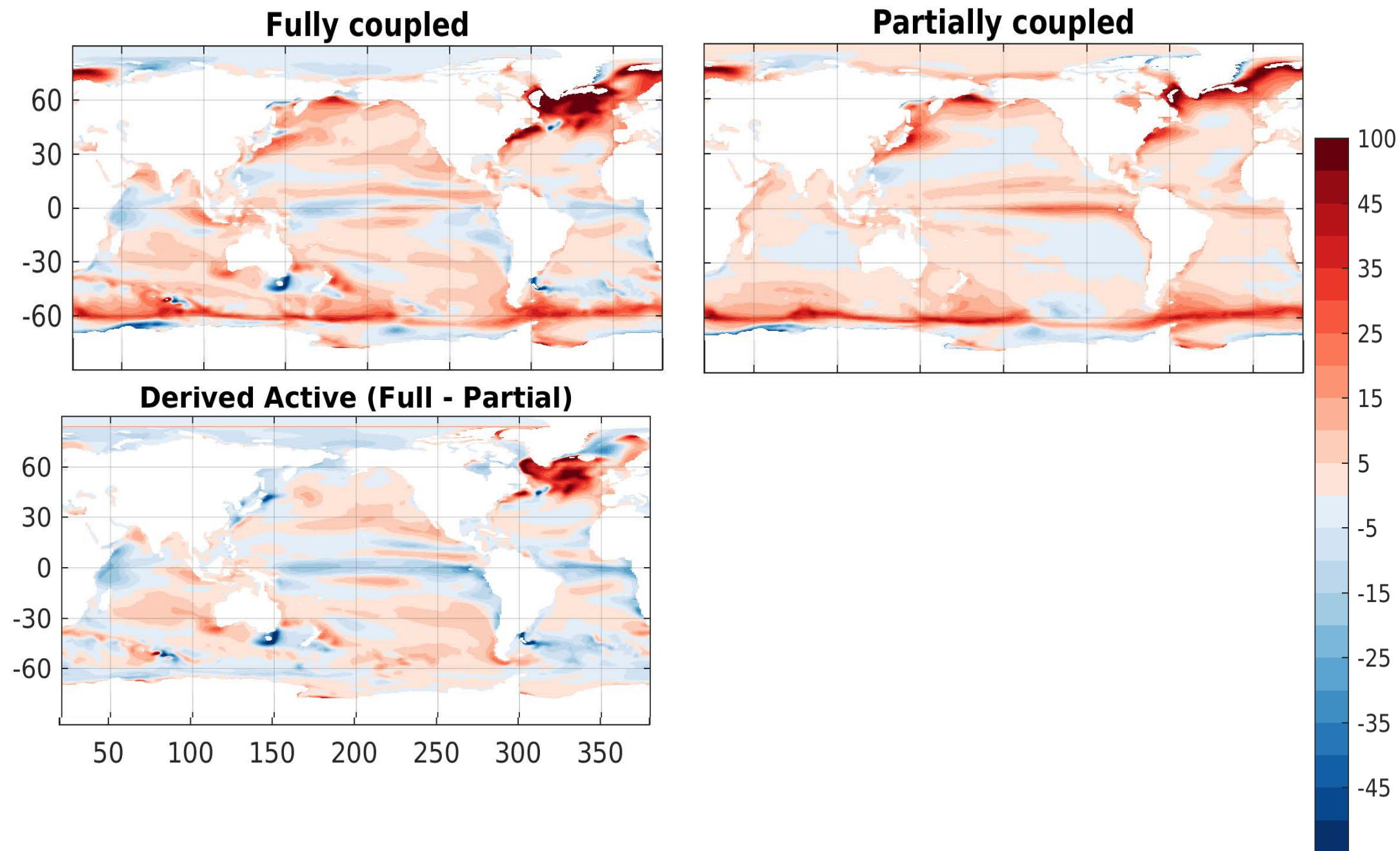


Partially coupled



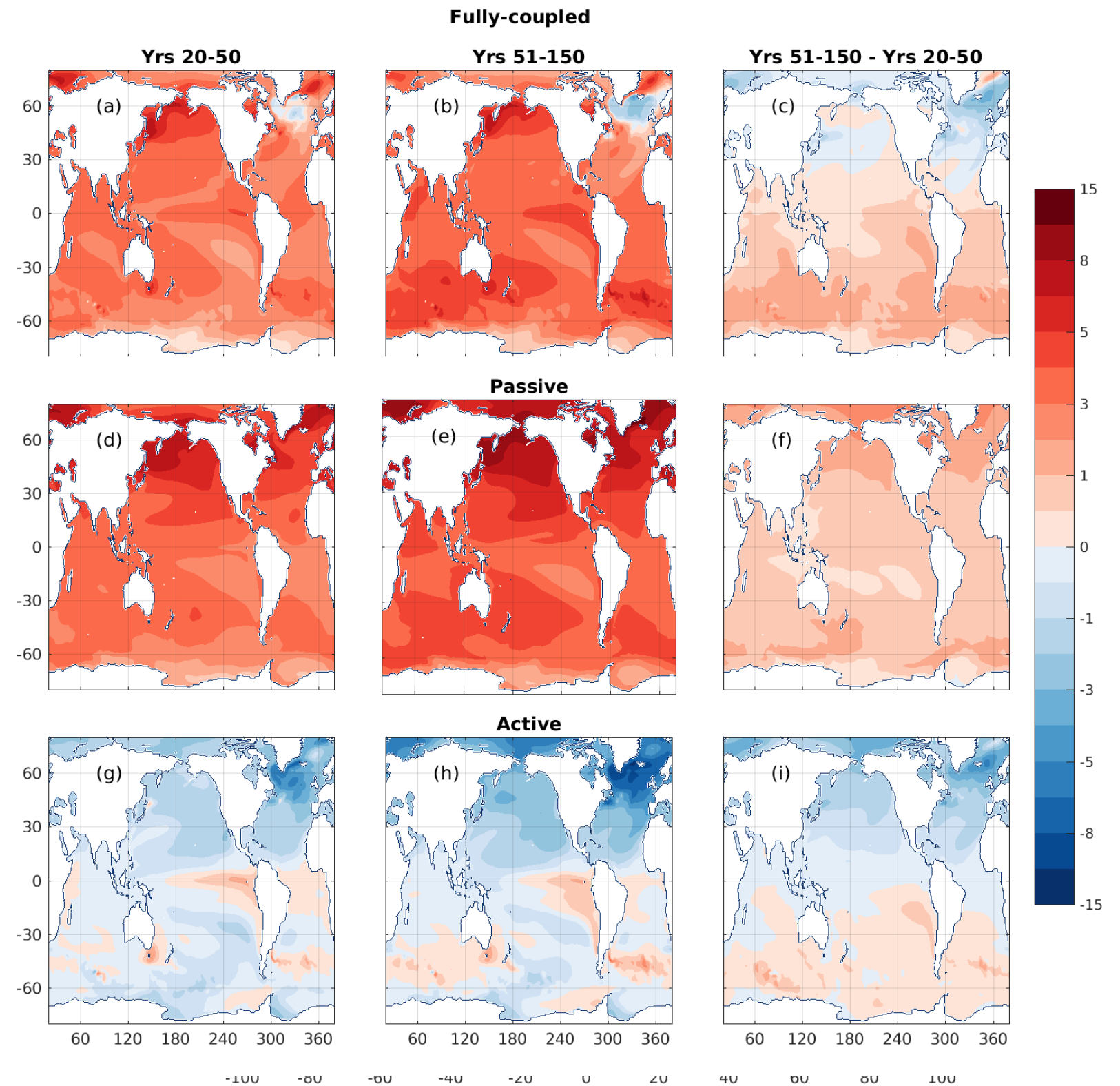
Heat flux components

- Active Atlantic subpolar gyre surface heat input and tropical surface heat loss



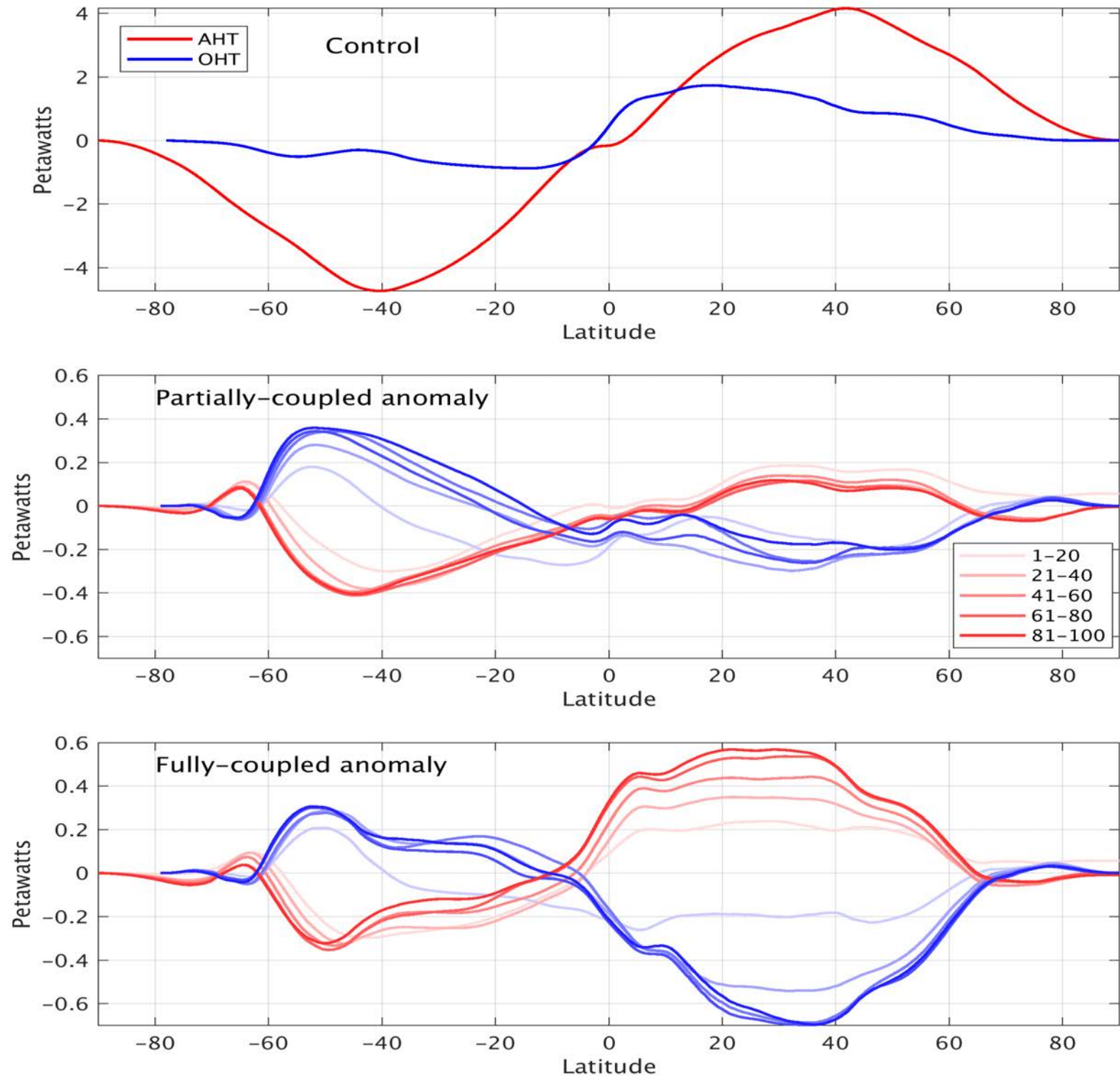
Time evolution of SSTs and surface heat fluxes

- Active SSTs and surface heat flux patterns are the evolving



Heat transports

- ITCZ shift and time evolving atmospheric and ocean heat transports are due to the active response



Lessons learned from the partial coupling approach

- The partial coupling method is useful tool for understanding relative roles of the atmosphere and the ocean fully-coupled response.
- The ocean is responsible for the slower surface warming rate, the temporal evolution of ocean heat uptake pattern and climate sensitivity.
- The ocean-driven active response is strong over the tropical oceans and be could interact even with smaller timescale atmospheric noise forcing.

Thank you

Active (ocean-driven) Surface flux isolation

- Active: Couple redistributive anomaly directly to the atmosphere

(Bouttes et al 2014; Gregory et al 2016)

