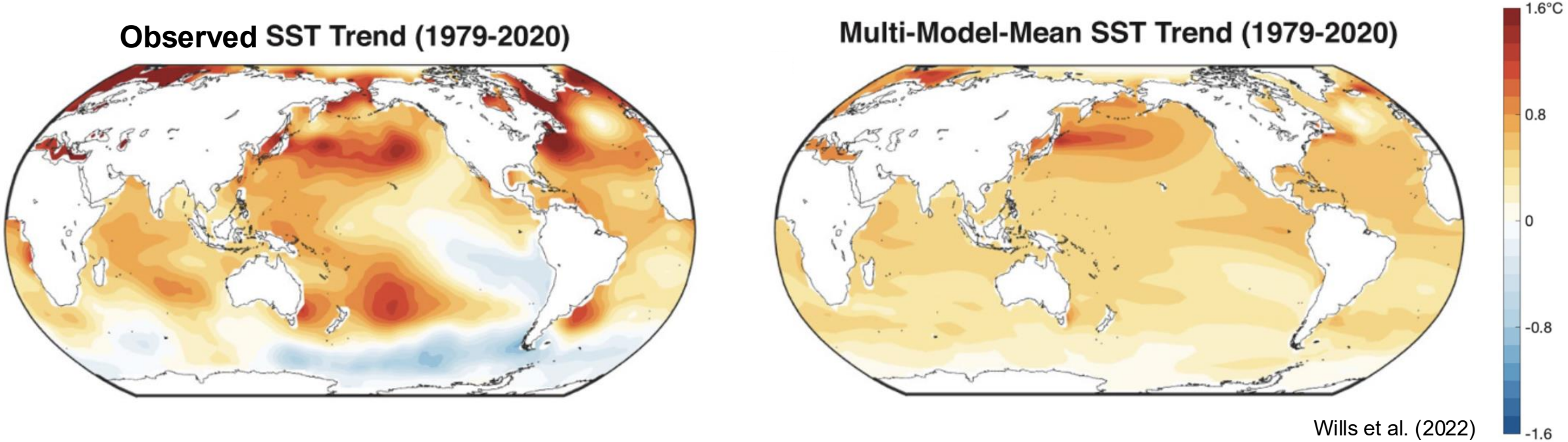
# Using a model hierarchy to clarify ocean dynamics relevant to tropical Pacific climate change

Matt Luongo
CICOES & School of Oceanography
2025 CICOES Spring All Hands Meeting
Jun 24th 2025

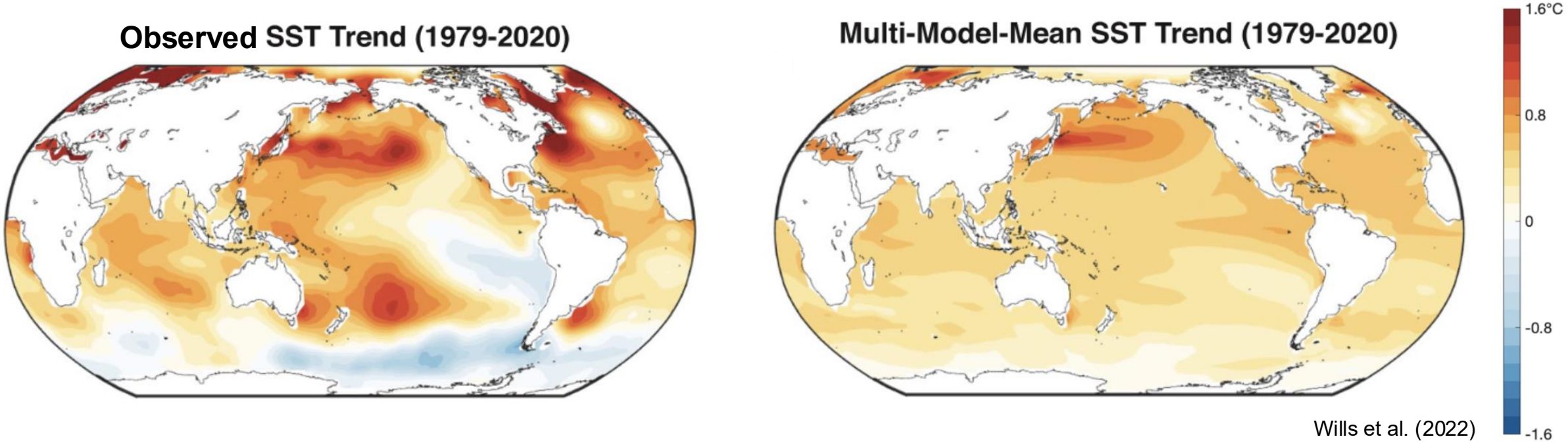
# The **mismatch between observed and modeled historical tropical SST trends** is a current research focus in climate dynamics.




Wills et al. (2022)

This mismatch has major implications for global meteorological & ecological impacts!

# The **mismatch between observed and modeled historical tropical SST trends** is a current research focus in climate dynamics.

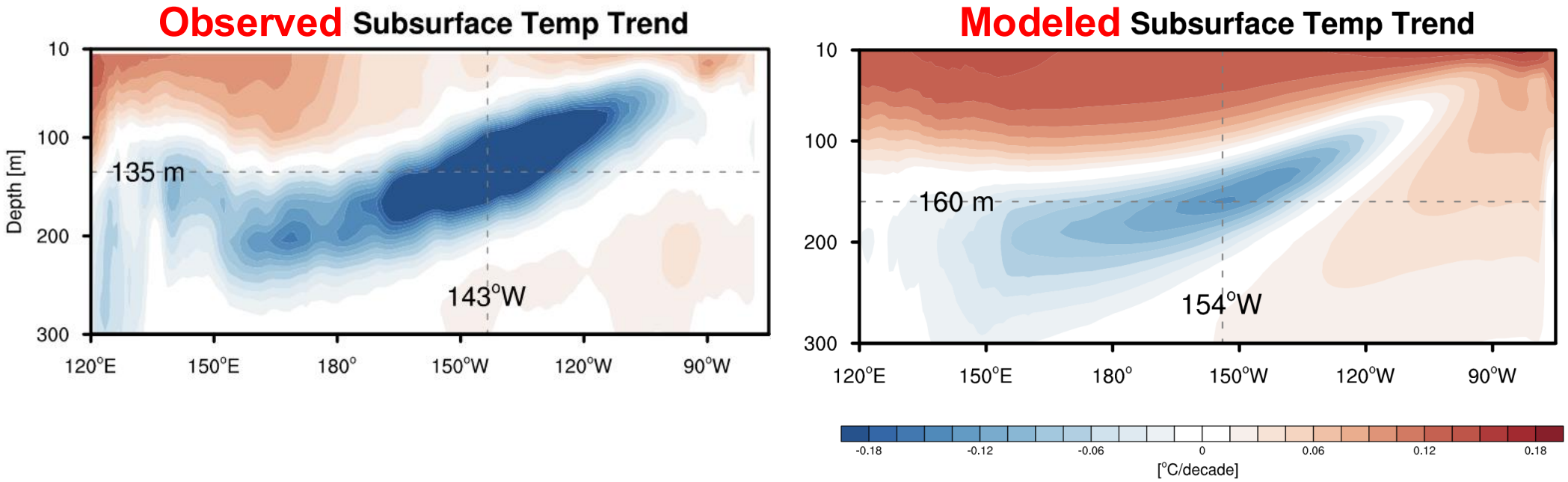



Wills et al. (2022)

Many studies have taken an atmospheric perspective on the observed La Niña-like trend. **However, different subsurface dynamics can lead to similar surface patterns.**

# Before we investigate the observation-model similarities and discrepancies, **do we understand what the coupled models are doing to begin with?**

**1958-2022**



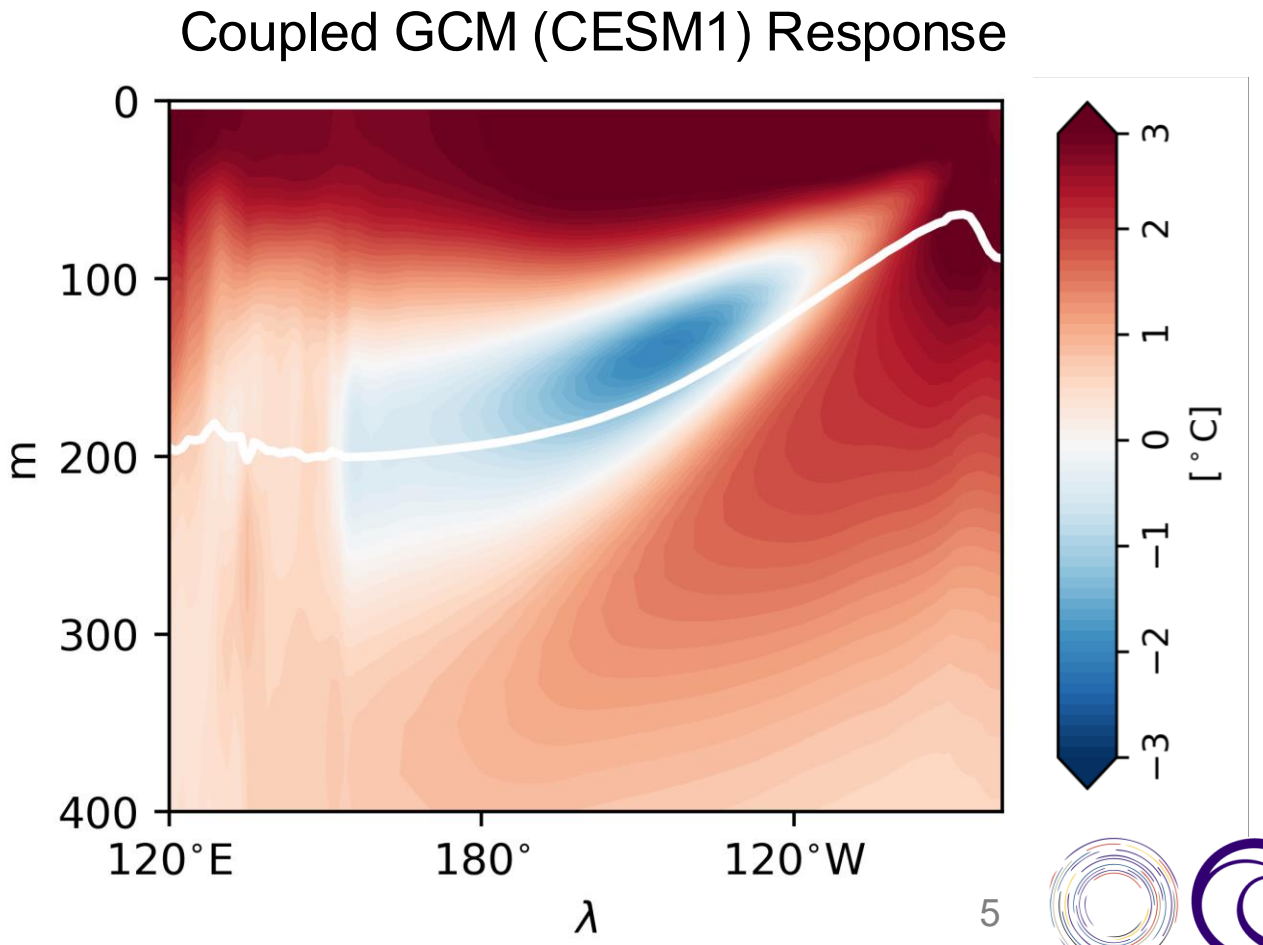

Jiang et al. (2025)

# What dynamics drive the tropical Pacific ocean's modeled temperature response to climate change?

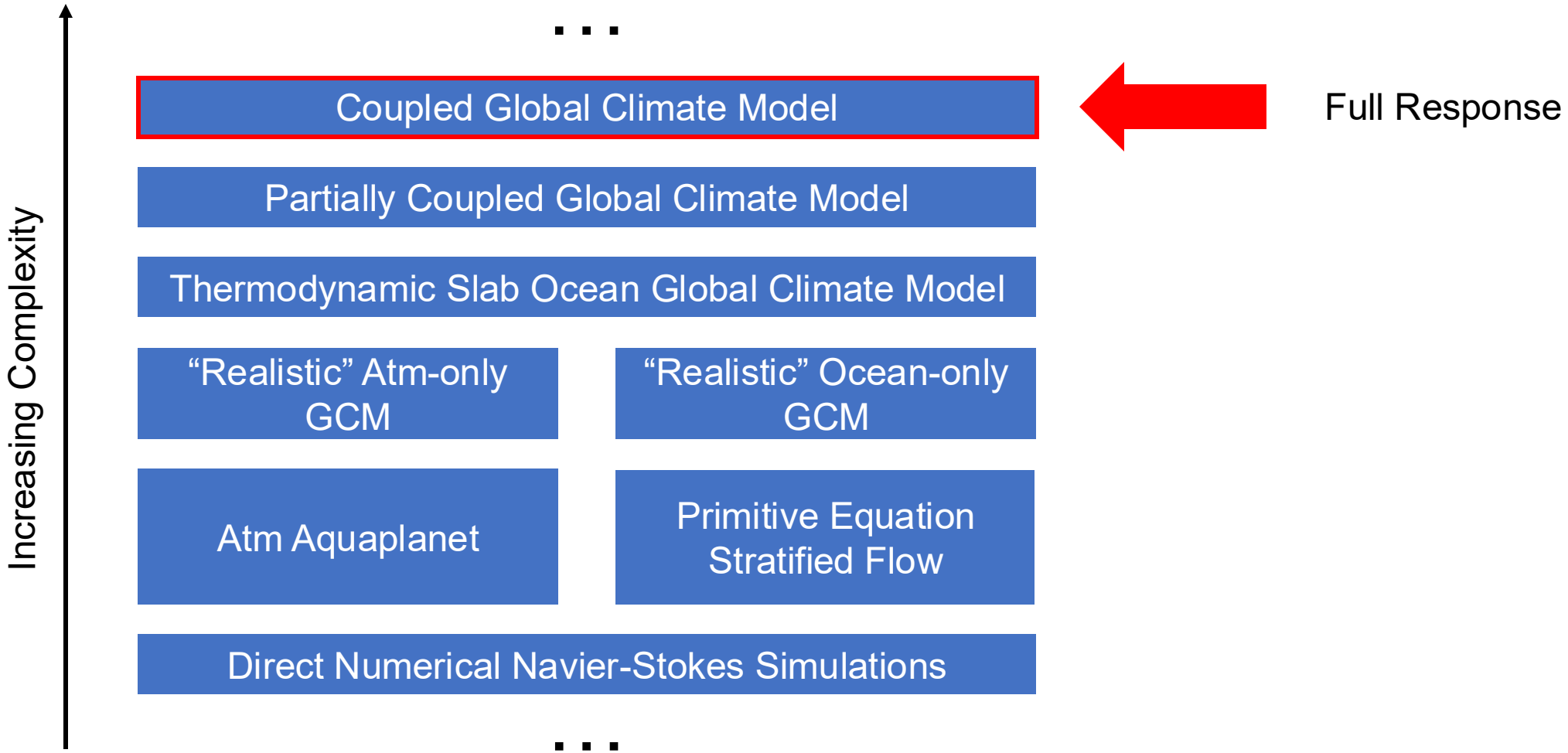
Here, I consider an **idealized, quasi-steady climate change forcing** to understand the complex, transient response.

We can decompose this response into:

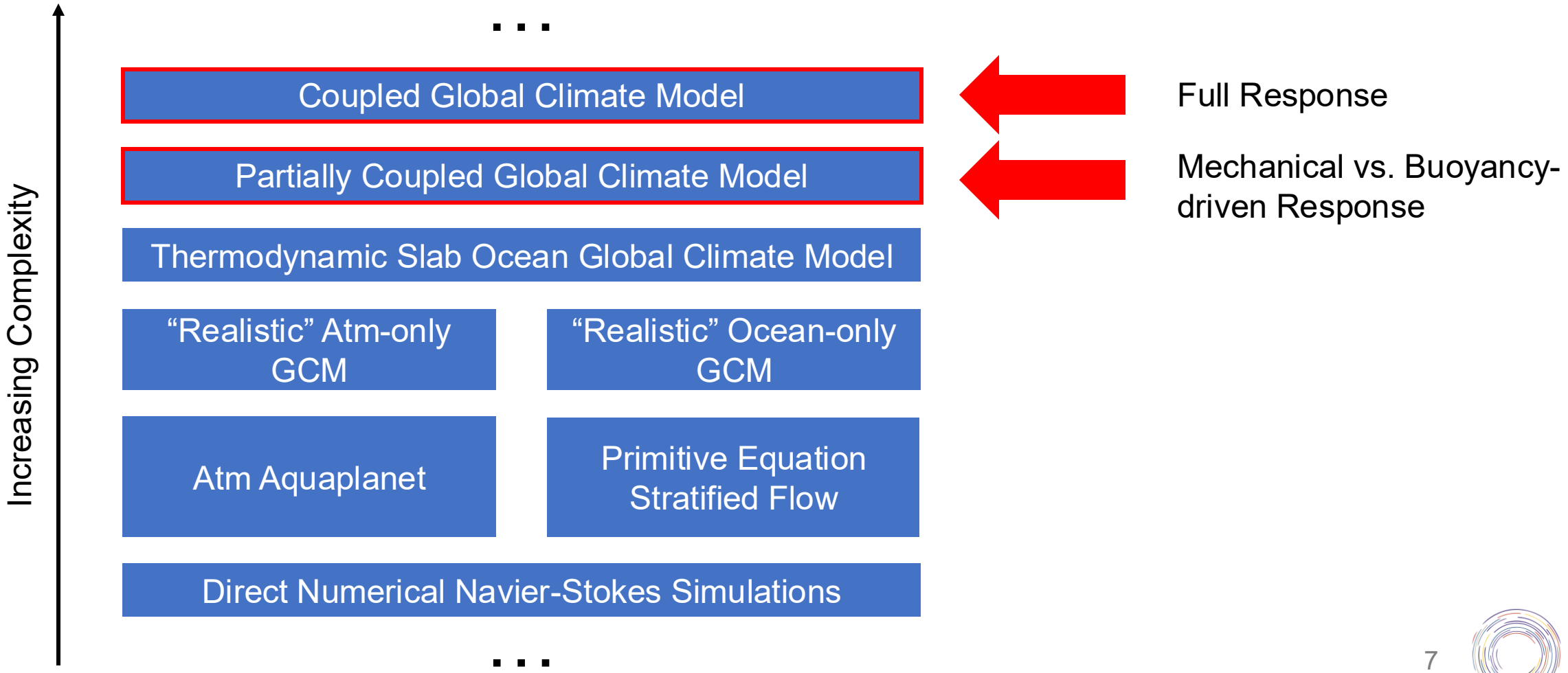
i. Wind stress (Bjerknes)
ii. Ocean circulation
iii. Radiative warming



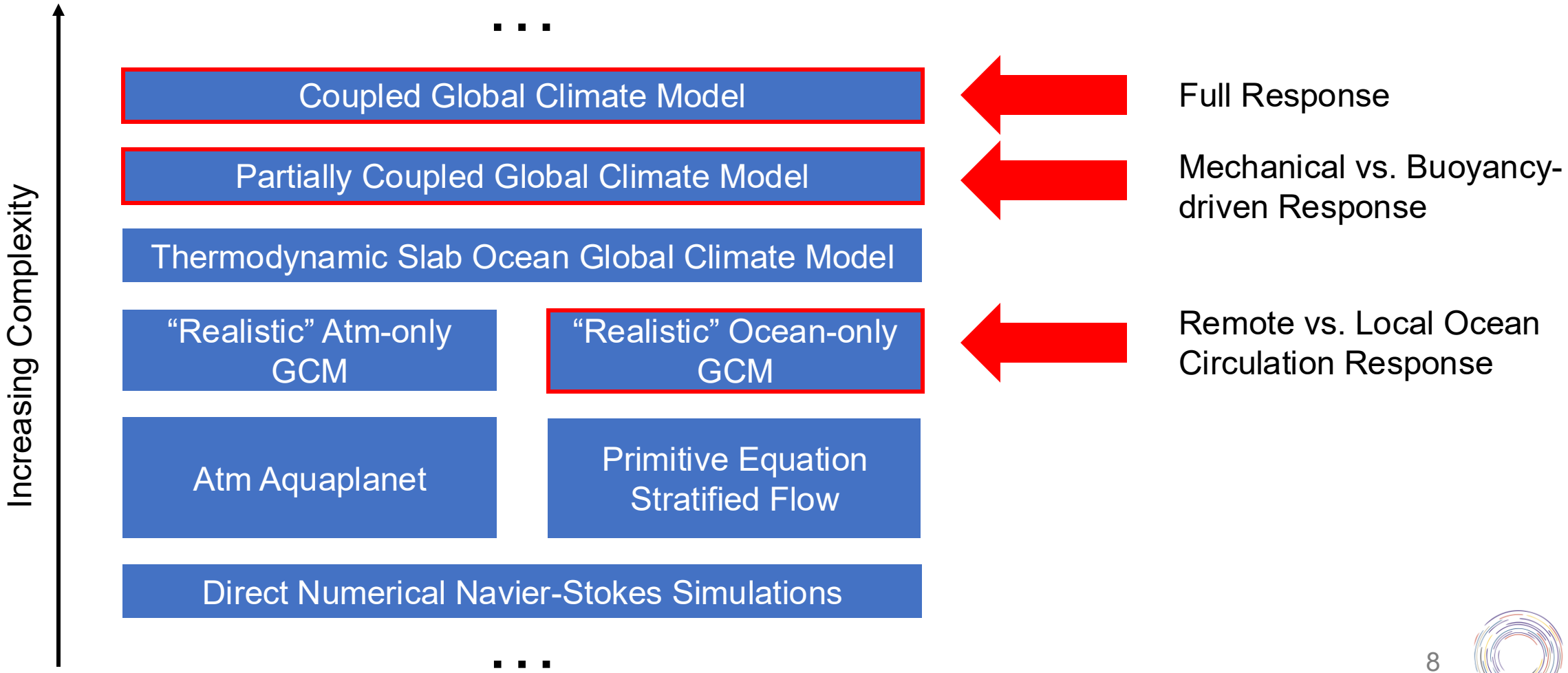
# A model hierarchy sheds light onto the complex coupled dynamics present.



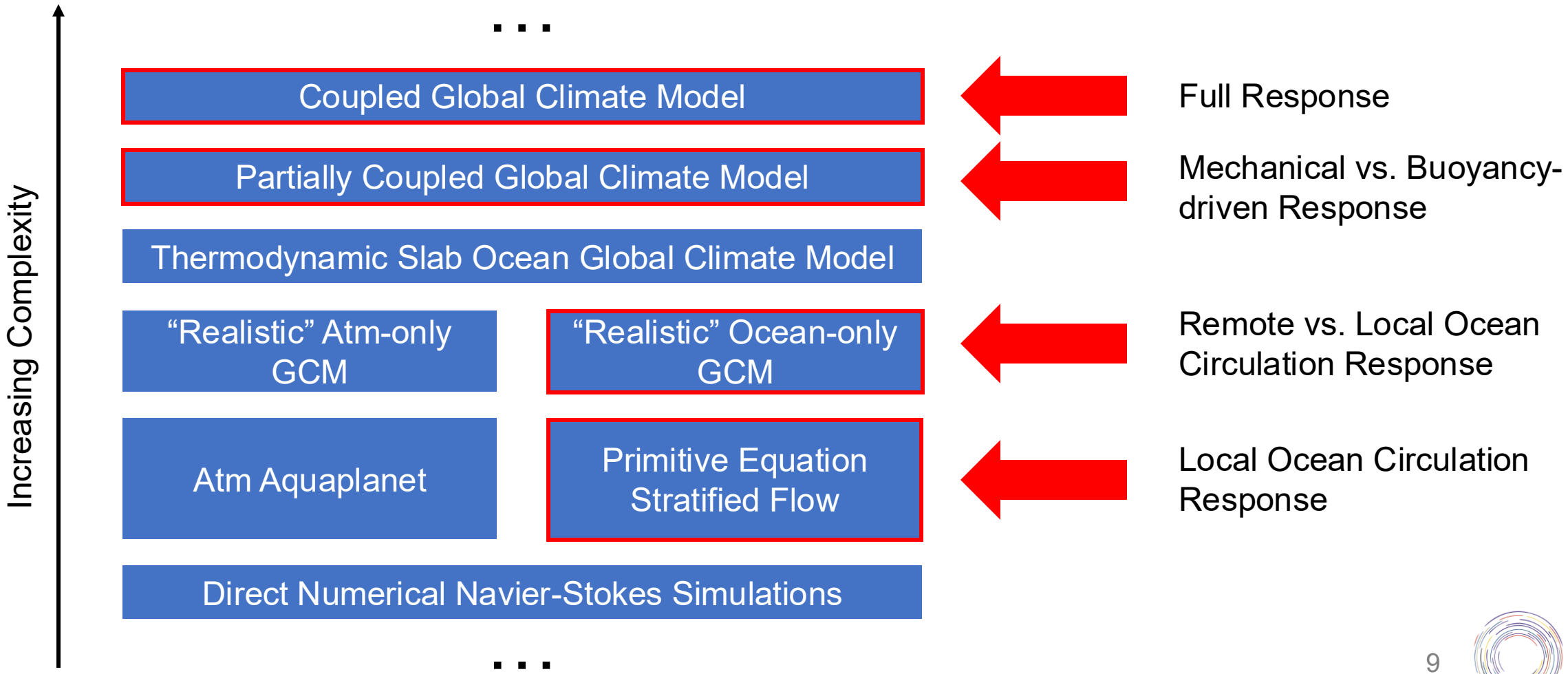
# A model hierarchy sheds light onto the complex coupled dynamics present.



# A model hierarchy sheds light onto the complex coupled dynamics present.

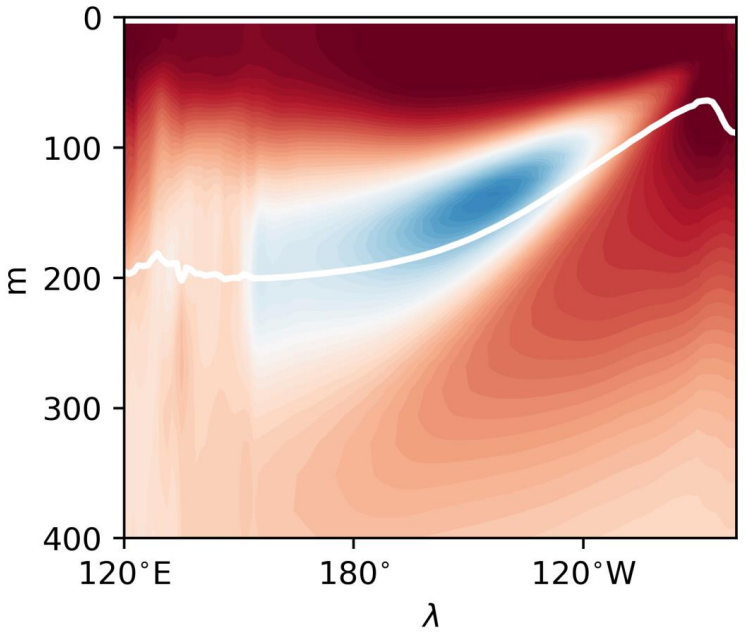


# A model hierarchy sheds light onto the complex coupled dynamics present.



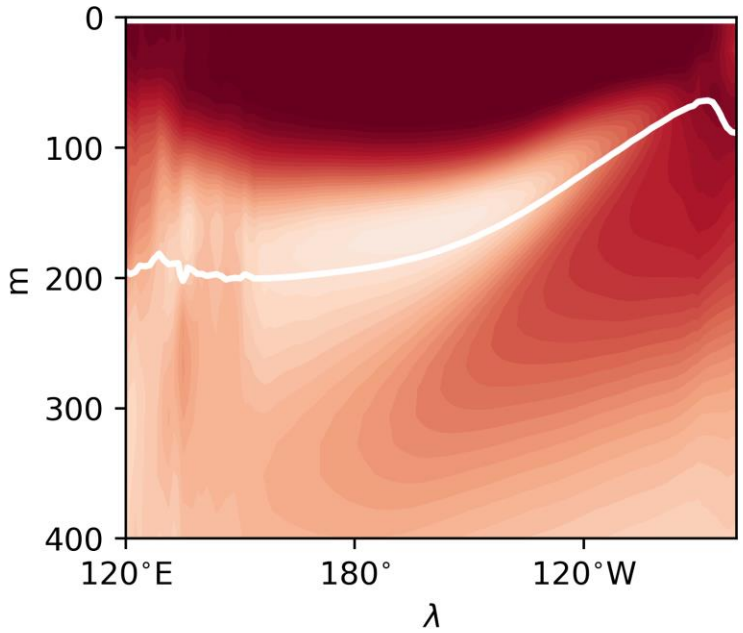
# With this understanding, we can dynamically interpret the **fully-coupled** GCM response.

**Fully-coupled** Eq. T
Response to Abrupt 4xCO2



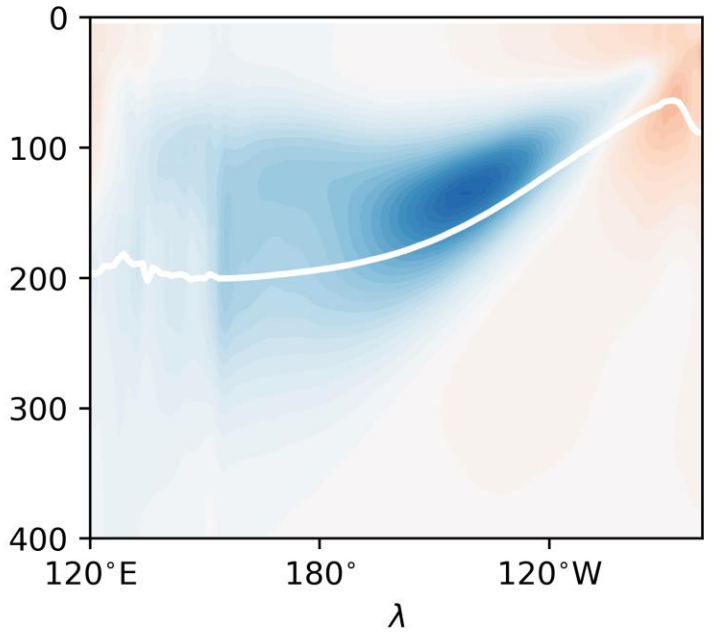

=

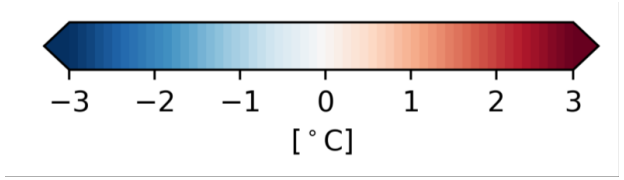
**Buoyancy-driven** Eq. T
Response to Abrupt 4xCO2




+

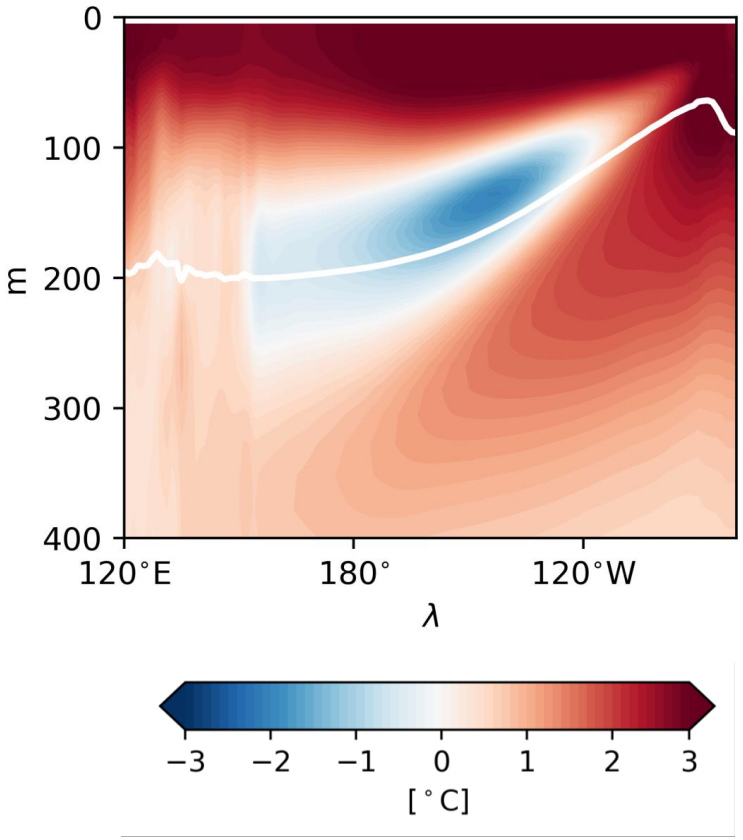
**Momentum-driven** Eq. T
Response to Abrupt 4xCO2



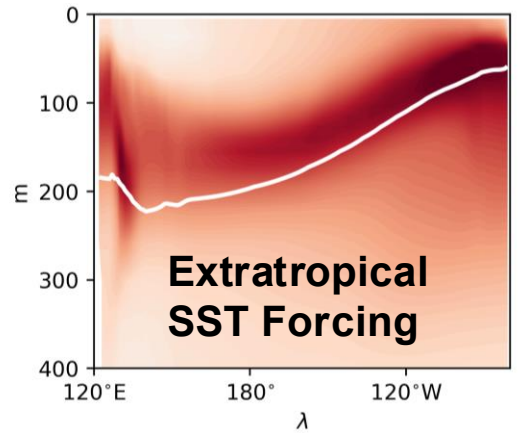
# With this understanding, we can dynamically interpret the **fully-coupled** GCM response.

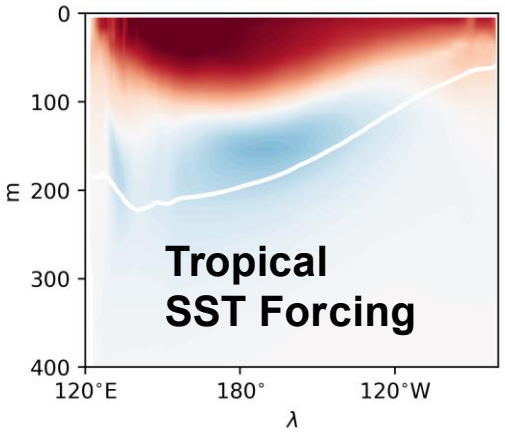
**Fully-coupled** Eq. T
Response to Abrupt 4xCO2




=

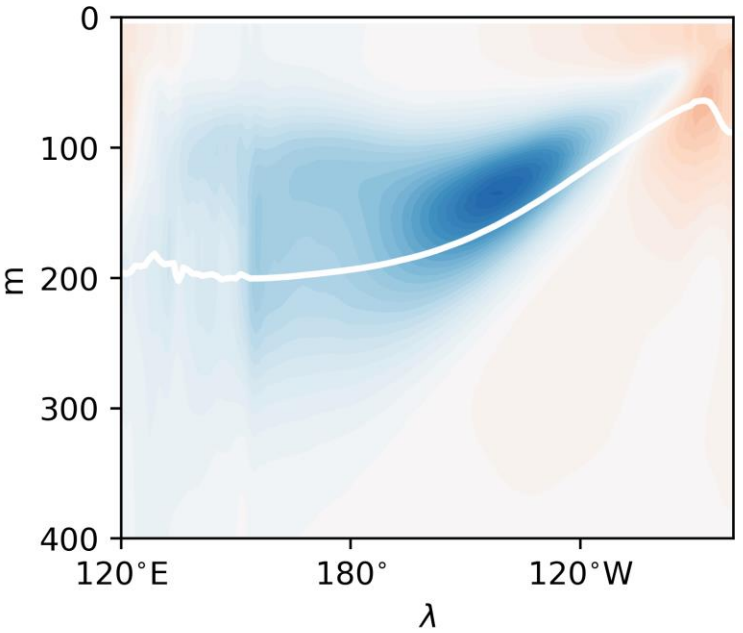
**Buoyancy-driven** Eq. T
Response to Abrupt 4xCO2



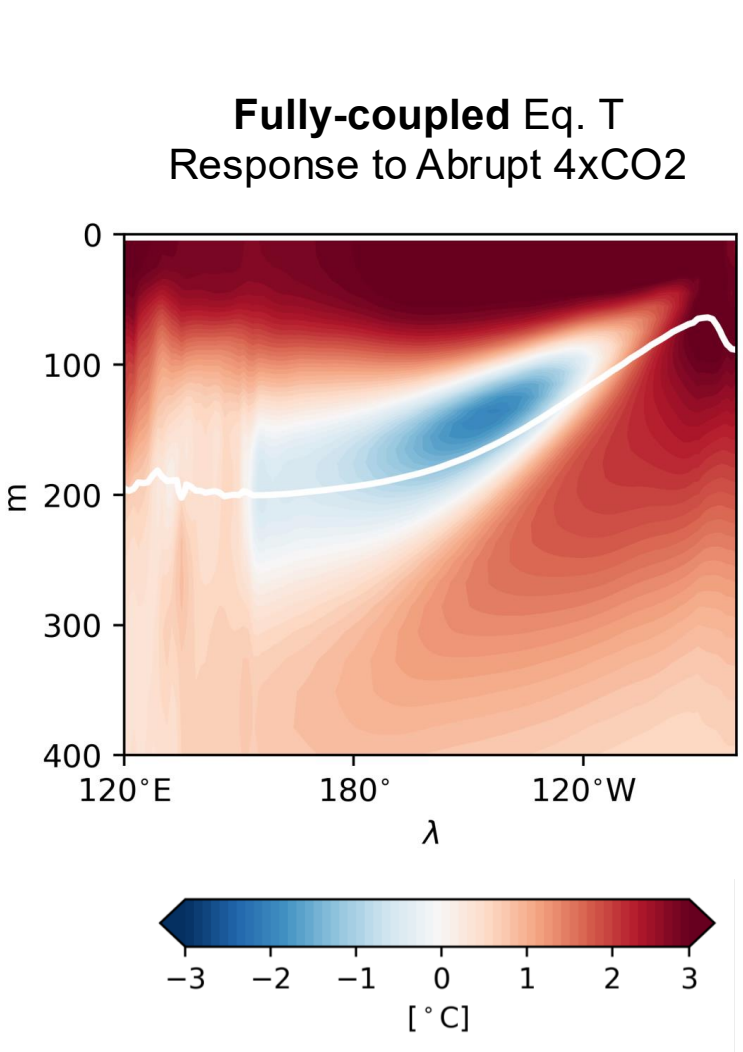



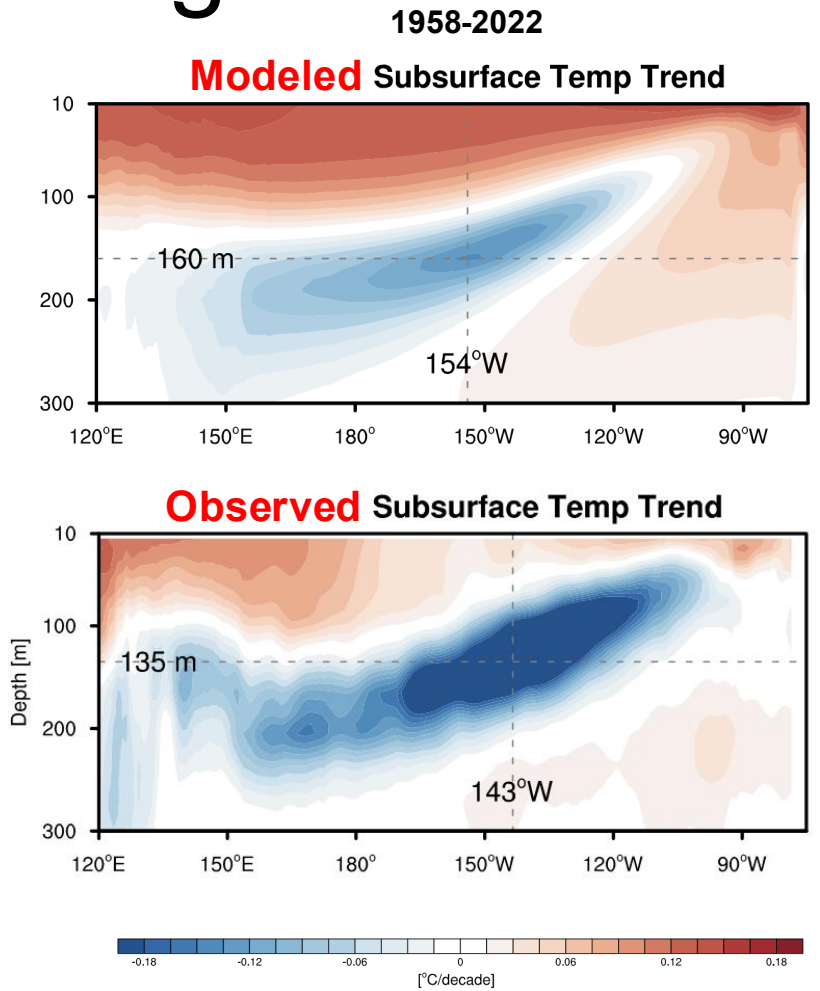

+

**Momentum-driven** Eq. T
Response to Abrupt 4xCO2



# Before we compare our models with observations, we need to understand what our models are doing!




Jiang et al. (2025)

**Thanks!**

mluongo@uw.edu