ECCOv4r4-Based Analysis of Cooling Trends in the Upper Tropical Eastern Pacific (CROCODILE)

Feng Jiang, Andrea Mosso, Antonio Robles, Suman Shekhar, Zhangzhe Zhao

1 Who are we?

2 What are we working on?

3 Behind the project

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1

Who are we?

An international team!

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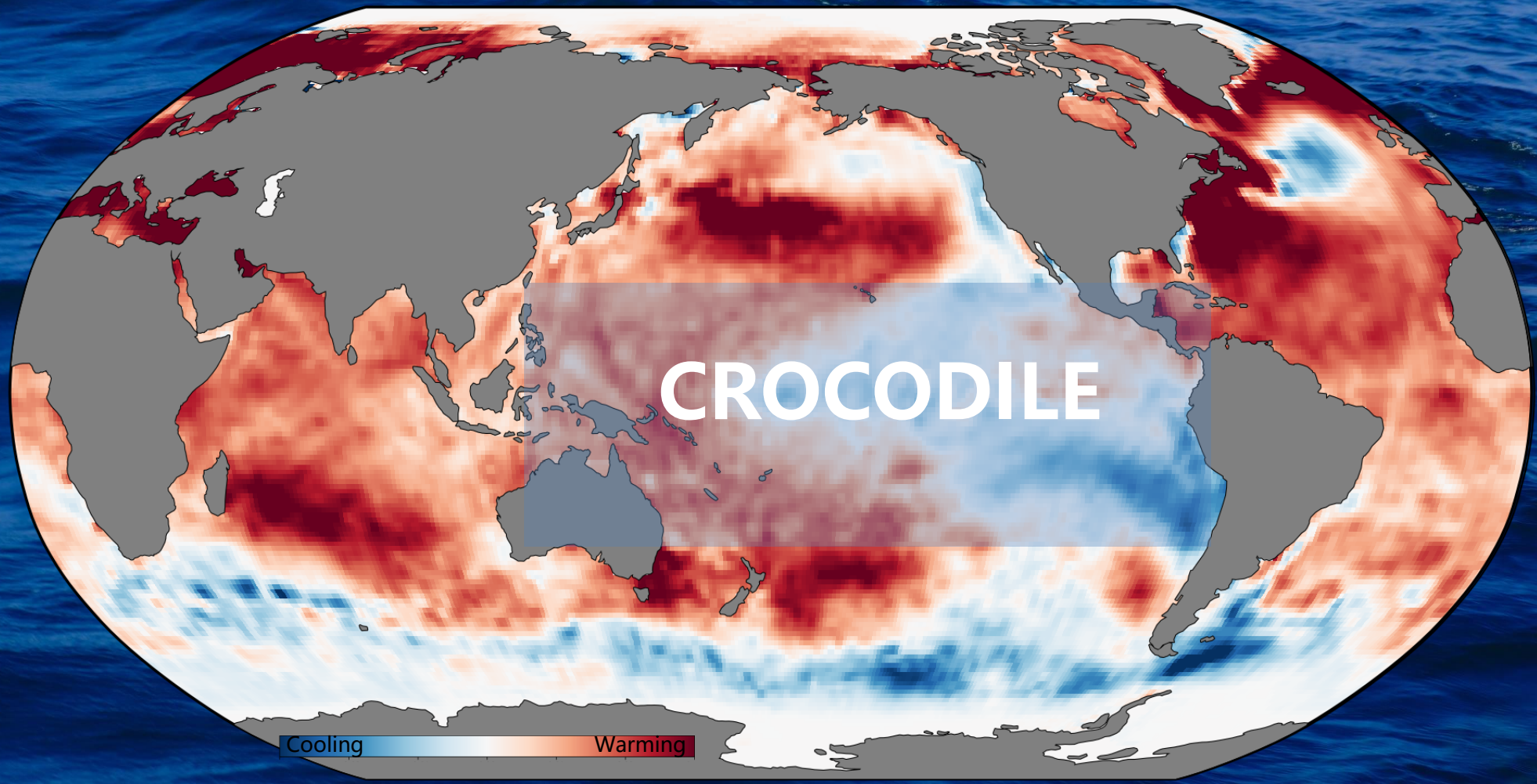
2

What are we working on?

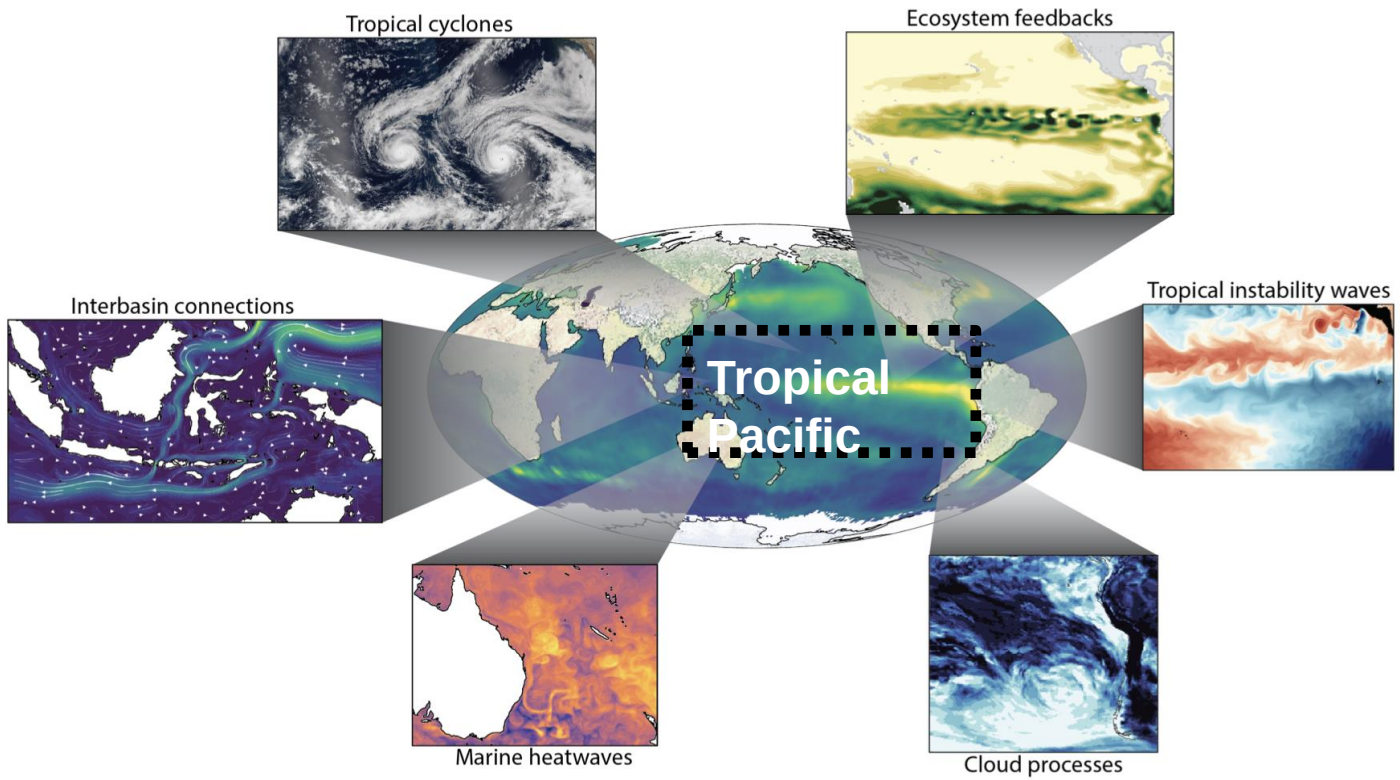
A cooling trend in a warming planet!



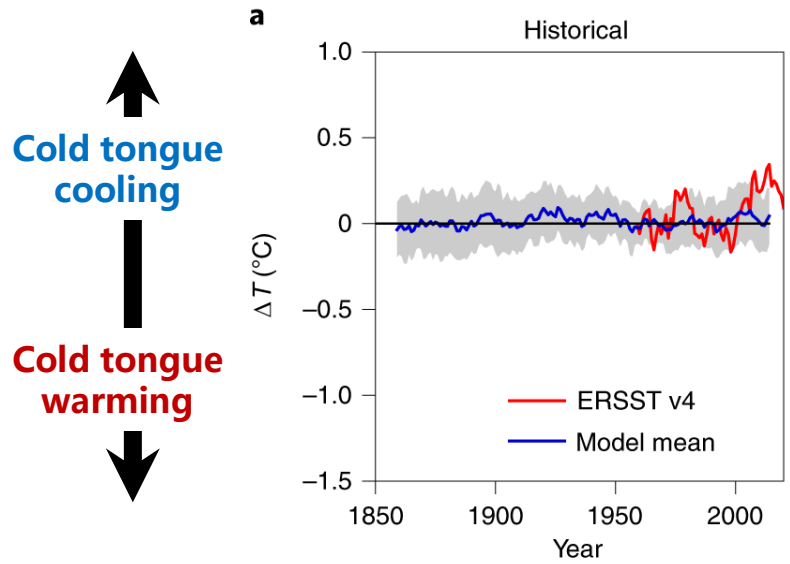
Why Does Tropical Pacific Cooling Matter

A cooling signal despite global warming is cool!

But why should we care?



(Karamperidou et al., 2020)



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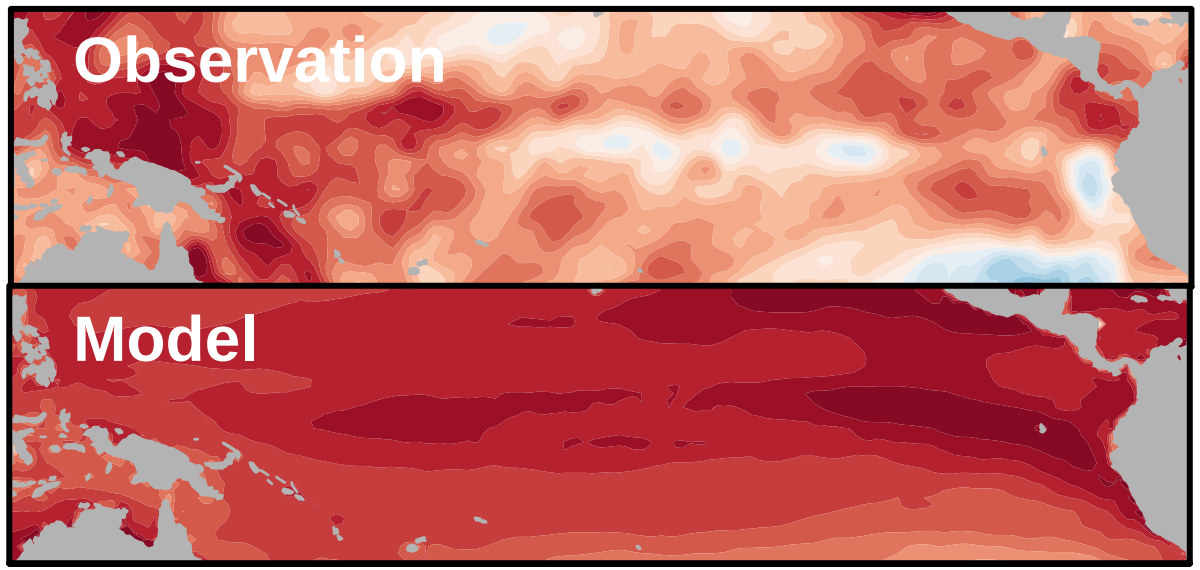

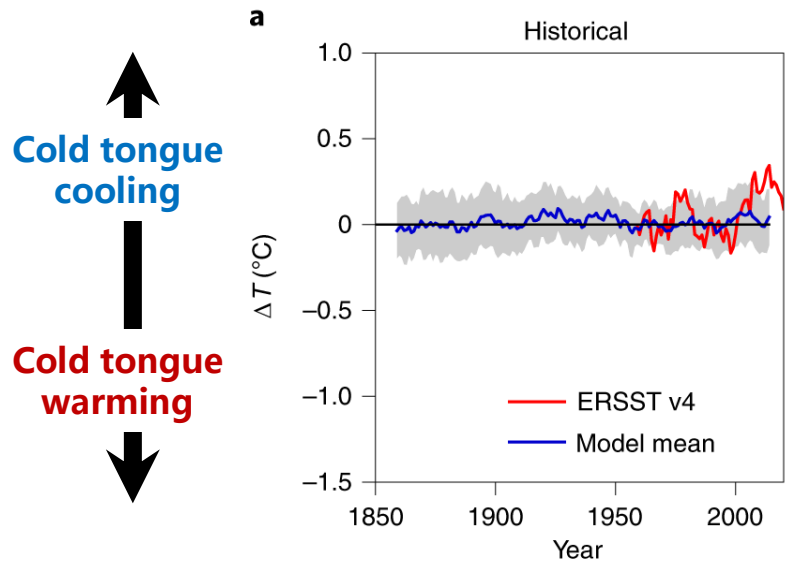

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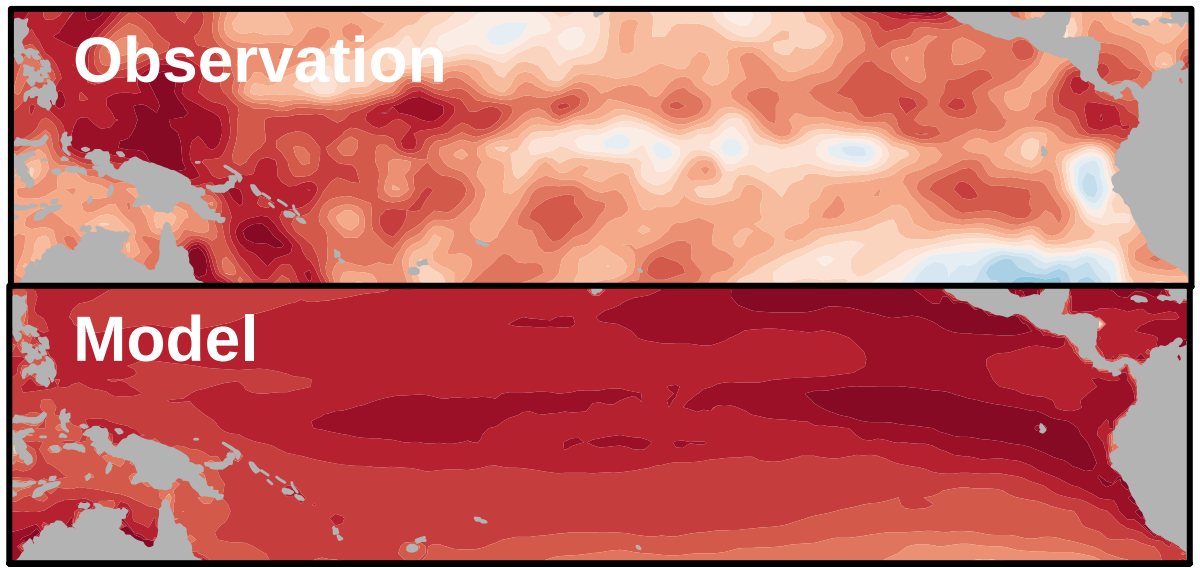
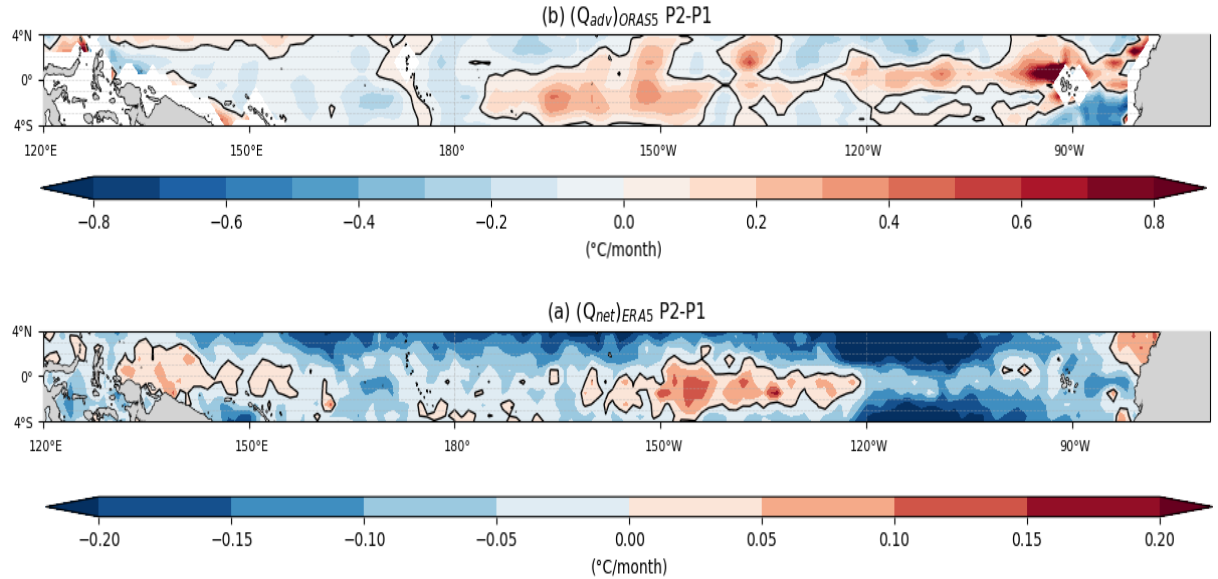


Reanalysis data Do Not Have A Clue



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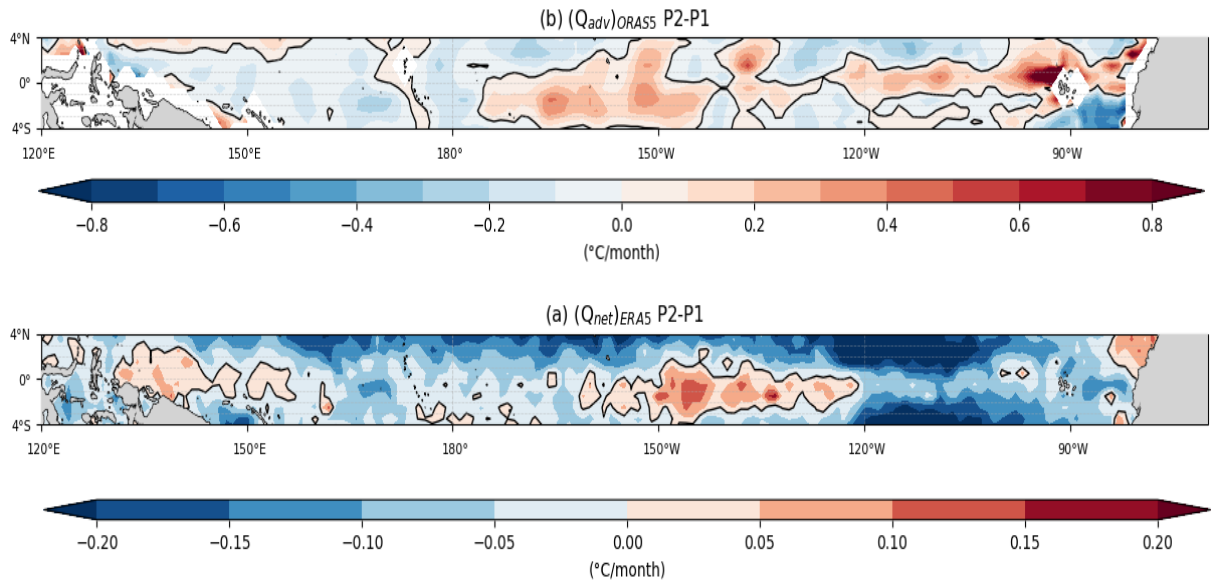
Why?

Our Guess

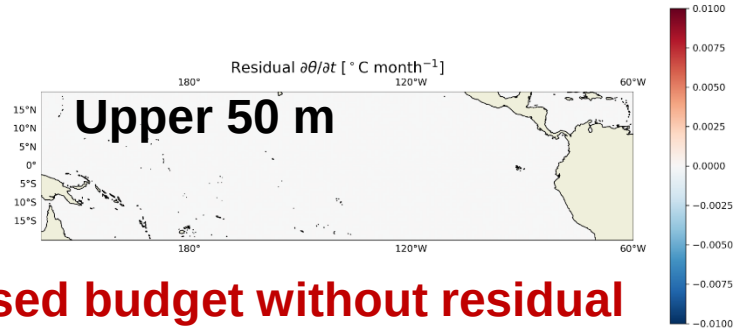
"The budget is not closed, and the possibly important mixing is in the residual."

Reanalysis data Do Not Have A Clue



Go ECCO!

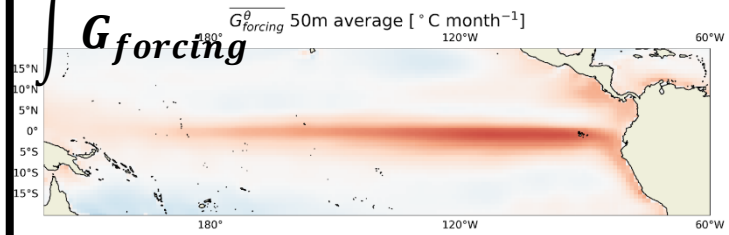
$$\frac{\partial T}{\partial t} = G_{forcing} + G_{advection} + G_{diffusion} + \boxed{Res}$$



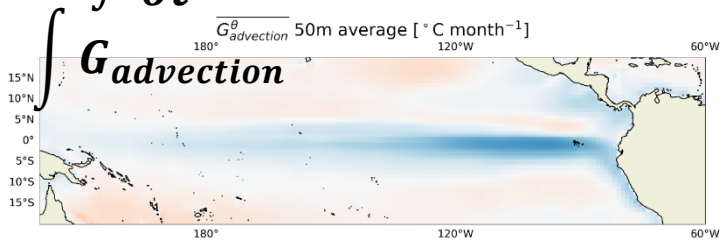
Closed budget without residual

What maintains the climatology $\int \frac{\partial T}{\partial t} \sim 0$

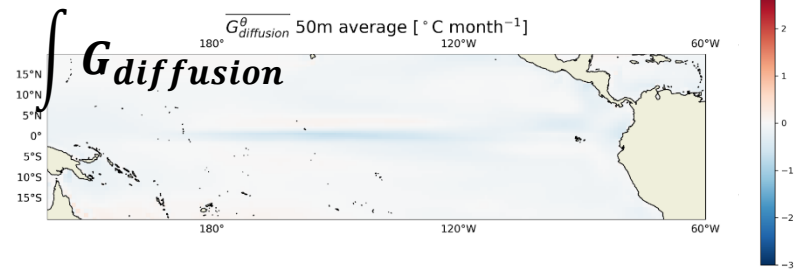
$\int G_{forcing}$



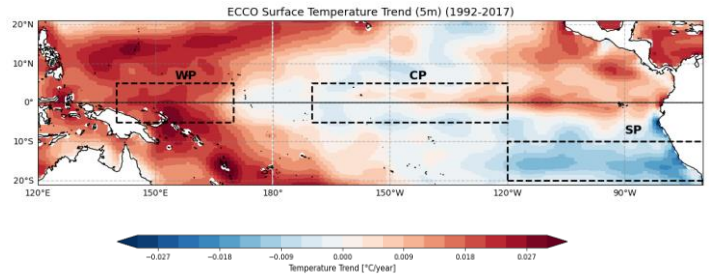
$\int G_{advection}$



$\int G_{diffusion}$

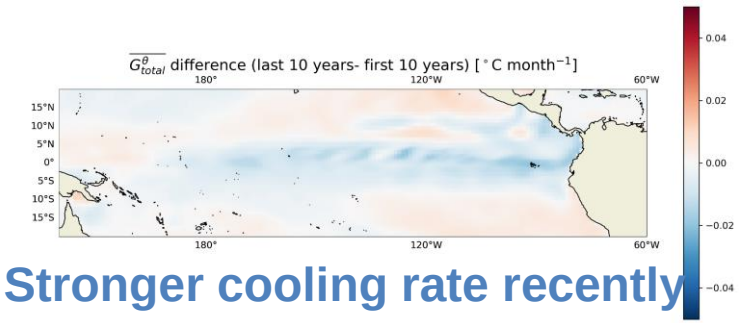


When Climate Changes



$$\int \frac{\partial T}{\partial t} - \int \frac{\partial T}{\partial t}$$

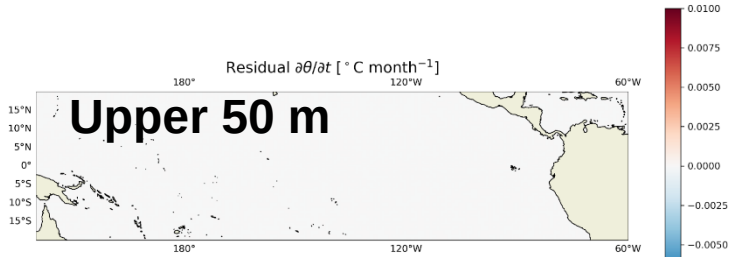
Last 10 years (2008-2017) − **First 10 years (1992-2001)**



Stronger cooling rate recently

Go ECCO!

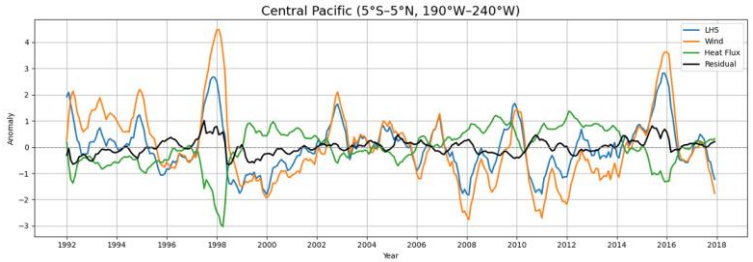
$$\frac{\partial T}{\partial t} = G_{forcing} + G_{advection} + G_{diffusion} + \boxed{Res}$$

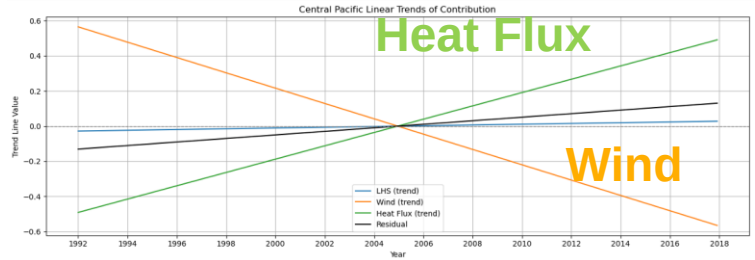


Closed budget without residual

What Does EMU Attribution Tool Say

Tropical surface temperature long-term trends are due to a small balance among large terms





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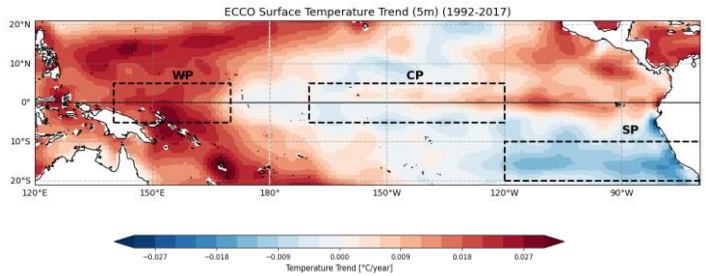

$$\int \frac{\partial T}{\partial t} \quad - \quad \int \frac{\partial T}{\partial t}$$

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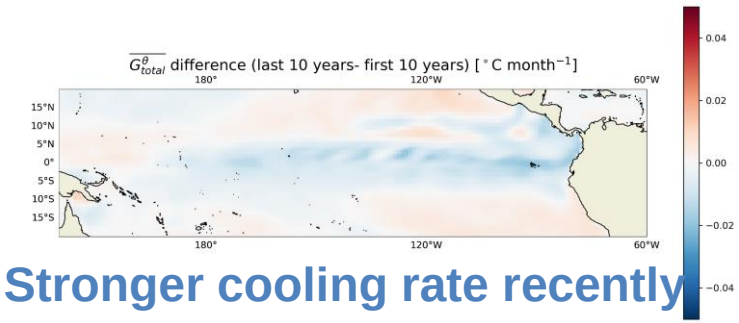


Stronger cooling rate recently

Go ECCO!

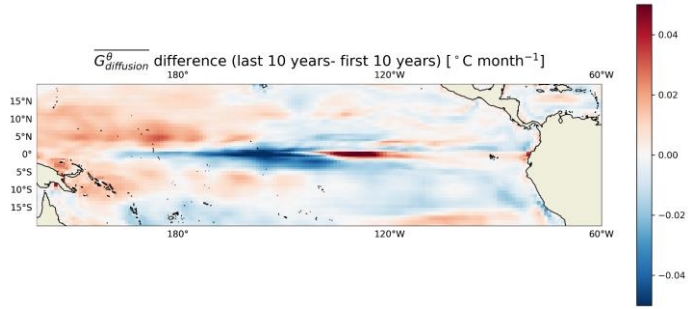
What Does Heat Budget Say

$$\int \frac{\partial T}{\partial t} - \int \frac{\partial T}{\partial t} =$$

$$(G_{forcing} + G_{advection} + G_{diffusion}) -$$
$$(G_{forcing} + G_{advection} + G_{diffusion})$$

A previously-ignored cooling term from mixing

$$G_{diffusion} - G_{diffusion}$$



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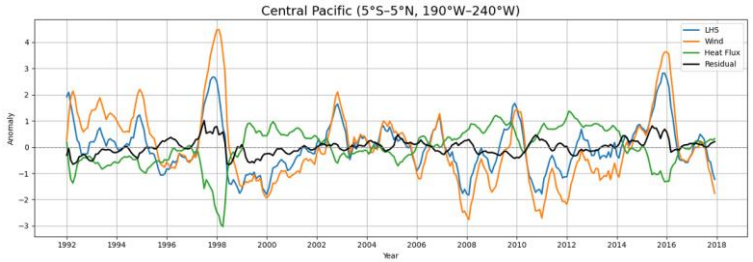

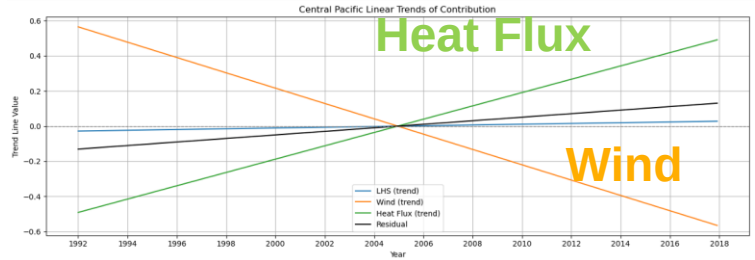

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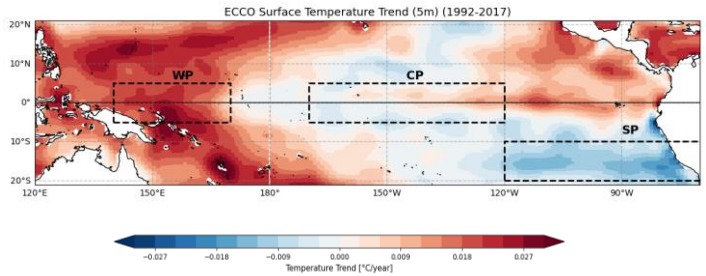

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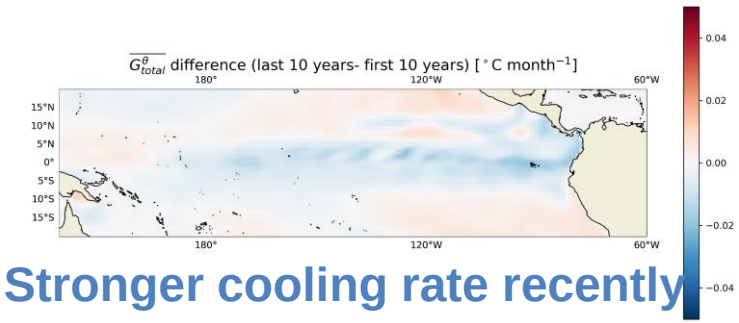
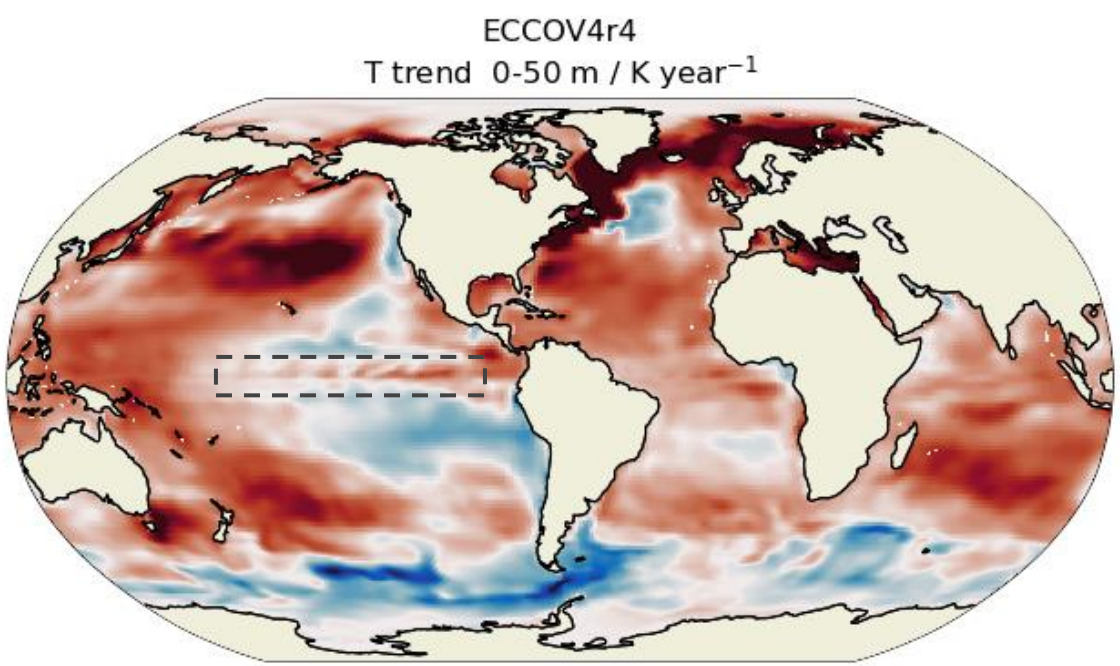


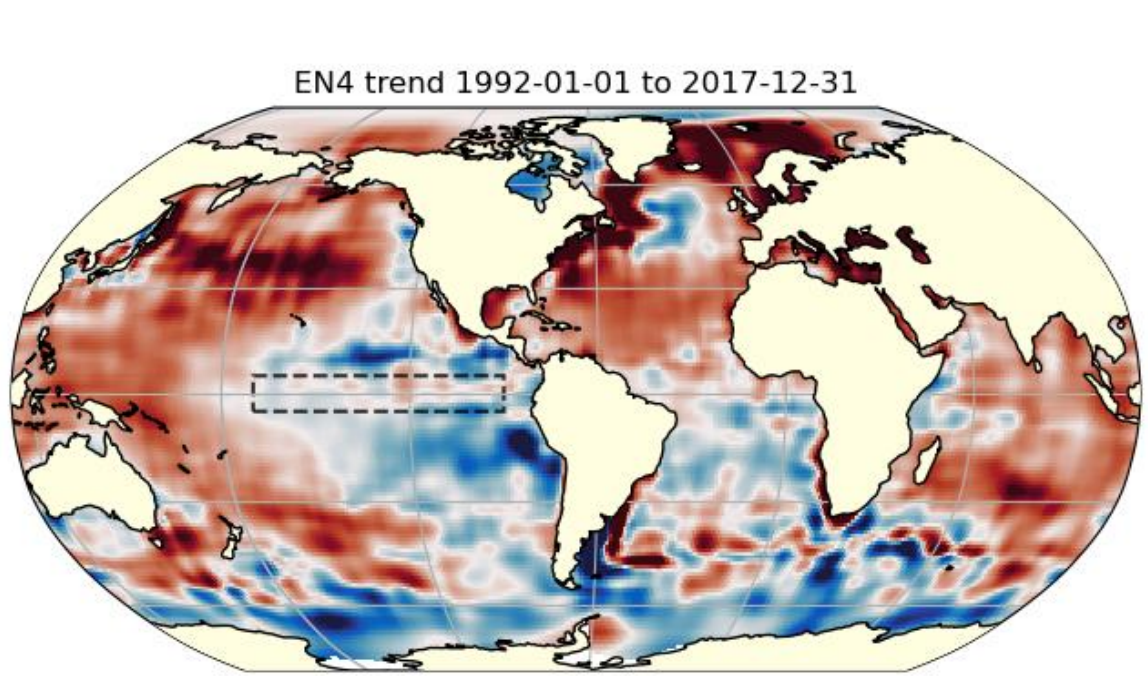
Stronger cooling rate recently

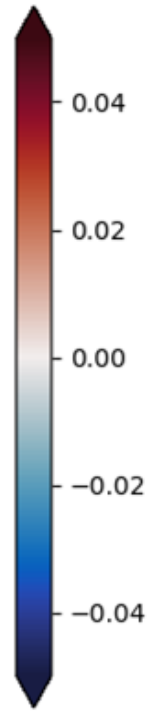
Go ECCO!

However, we want to chase a “terribly small” signal (quoting Ichiro)

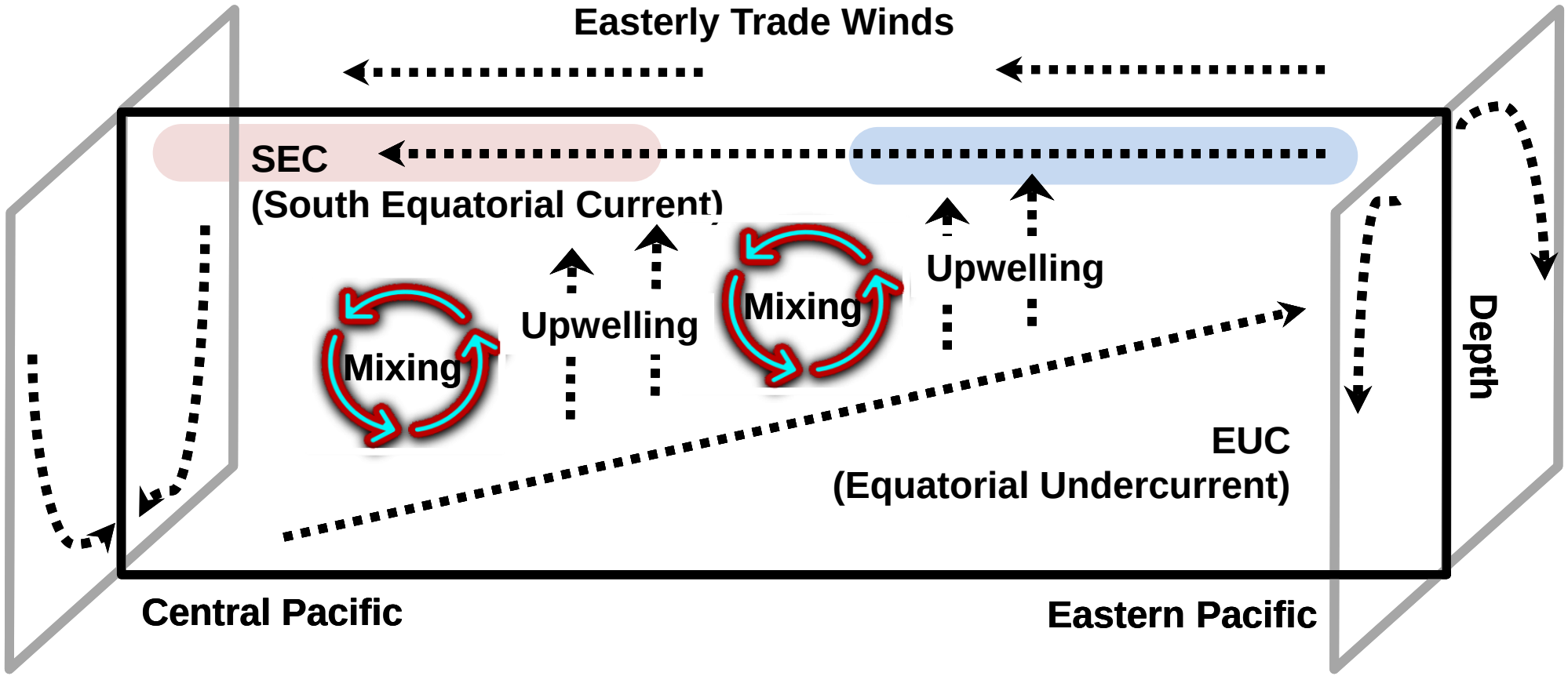
How to make the eastern Pacific cooler!







Our Hypotheses and A Set of “Crazy” Experiments



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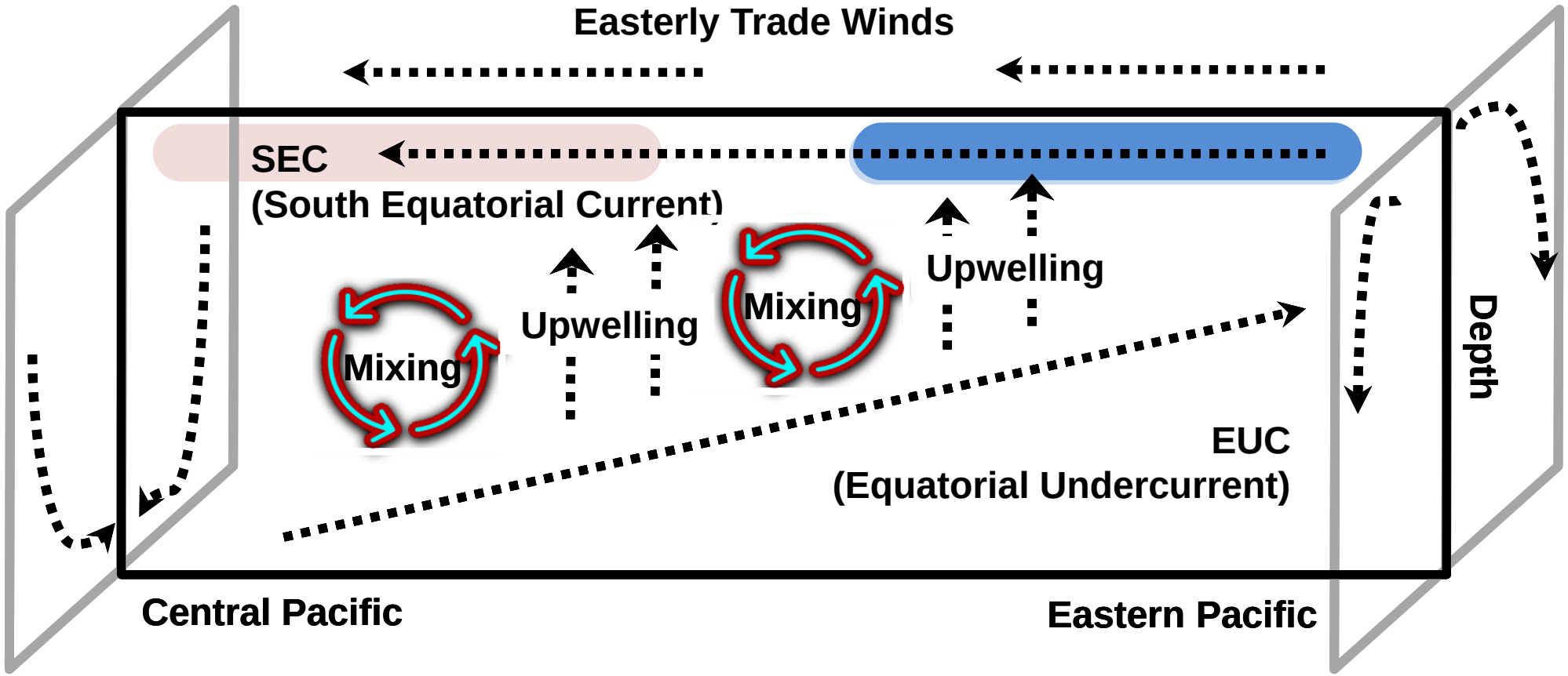
Hypothesis#1: Increase the wind to directly amplify wind-driven circulation



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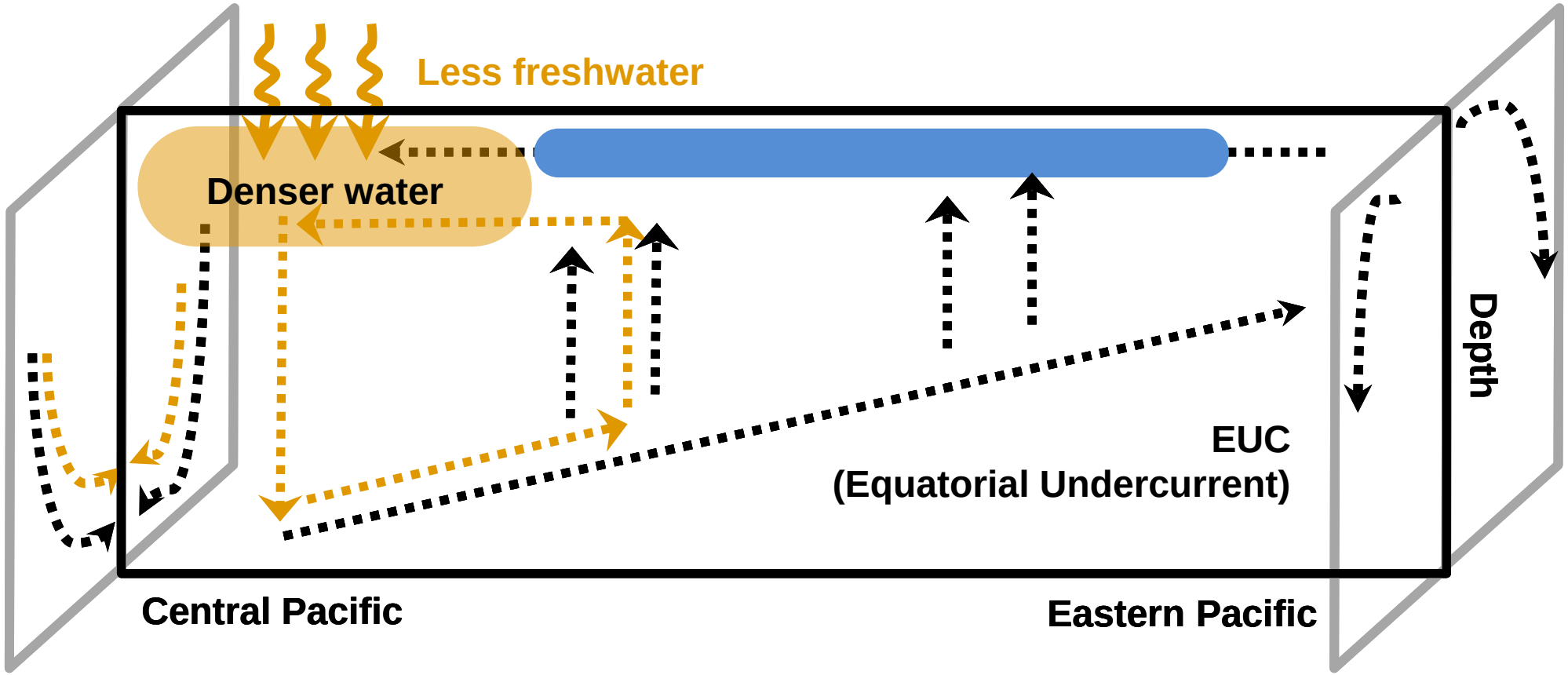
Hypothesis#1: Increase the wind to directly amplify wind-driven circulation

Hypothesis#2: Decrease warm pool freshwater flux to trigger density-driven circulation change!



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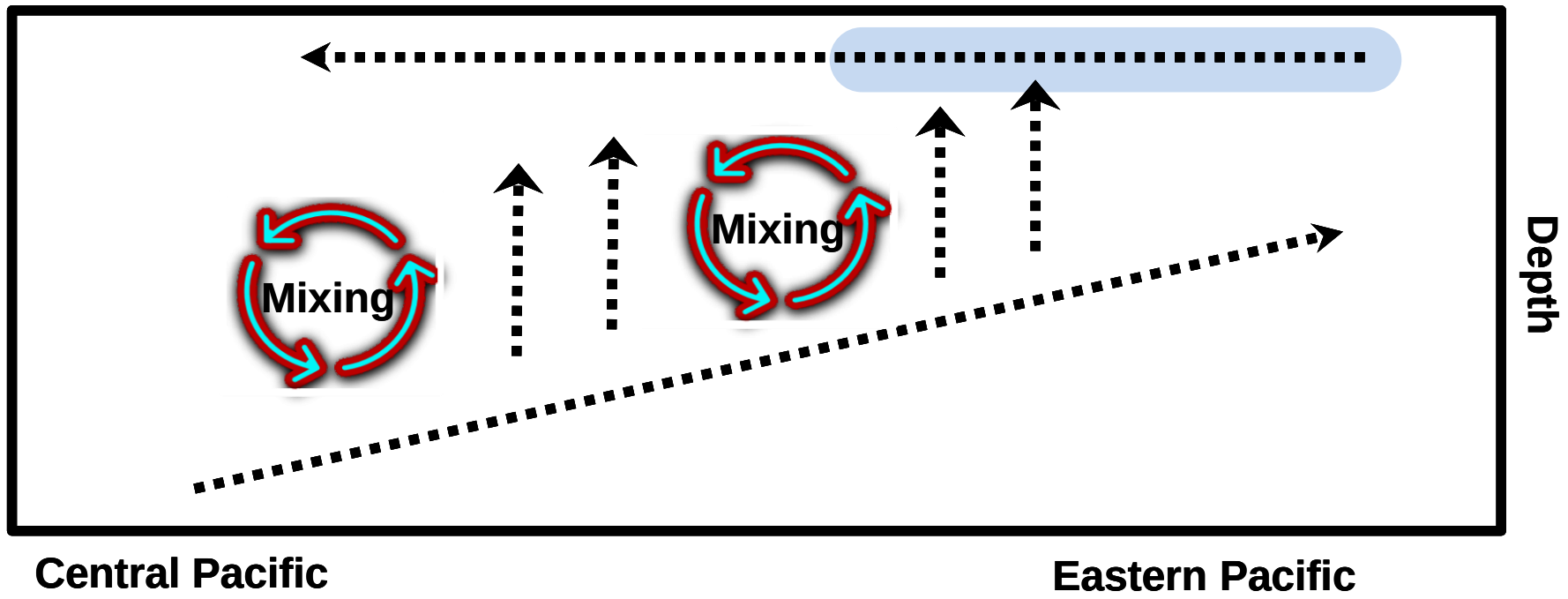

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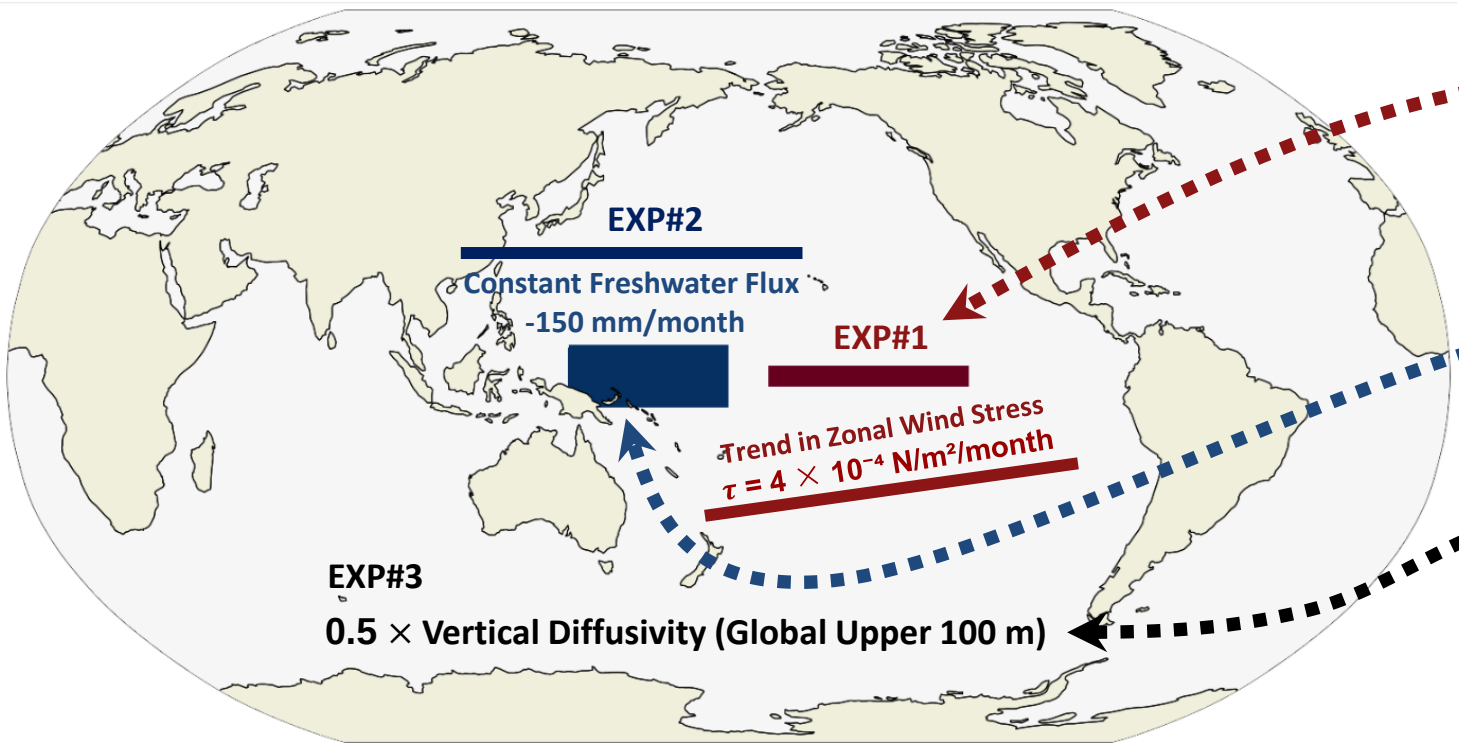


EXP#1 Windy

Imposing a zonal wind strengthening trend by
4×10^{-4} N/m²/month

EXP#2 Salty

Imposing a constant freshwater flux
by -150 mm/month

EXP#3 Lowdiff

Halving the background vertical diffusivity
in global upper upper 100m

Results from Experiments

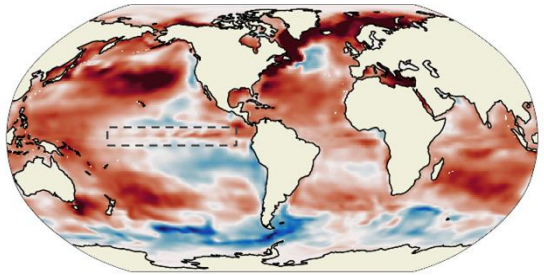
So which experiment gives us the cooling trend?

Luckily, all!

Results from Experiments

Upper 50 m Temperature Trend during 1992-2017

ECCO V4r4



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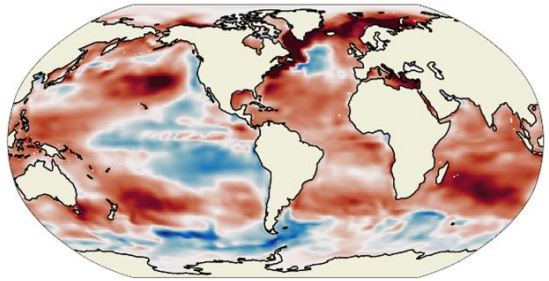
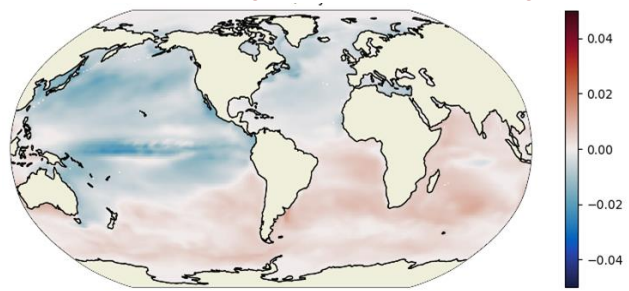
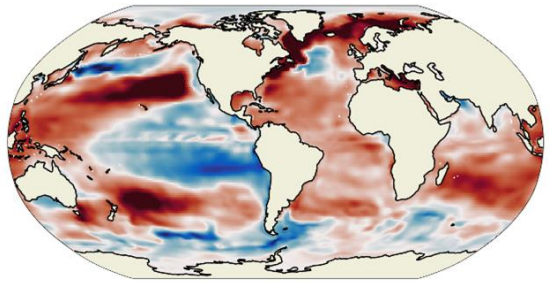


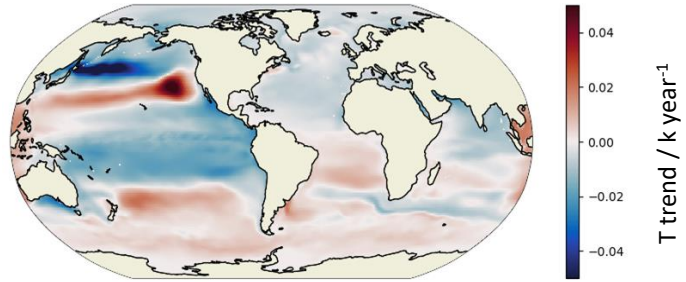
Difference (EXP#1 – V4r4)



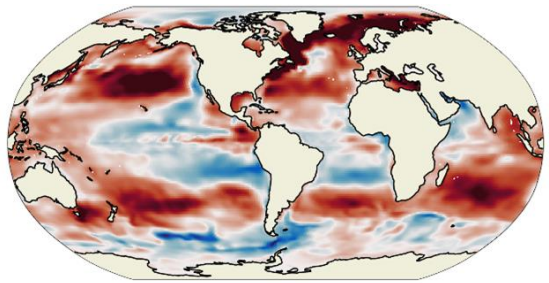
EXP#2 Salty



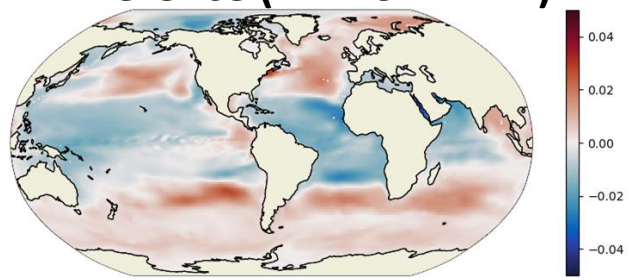
Difference (EXP#2 – V4r4)



EXP#3 Lowdiff

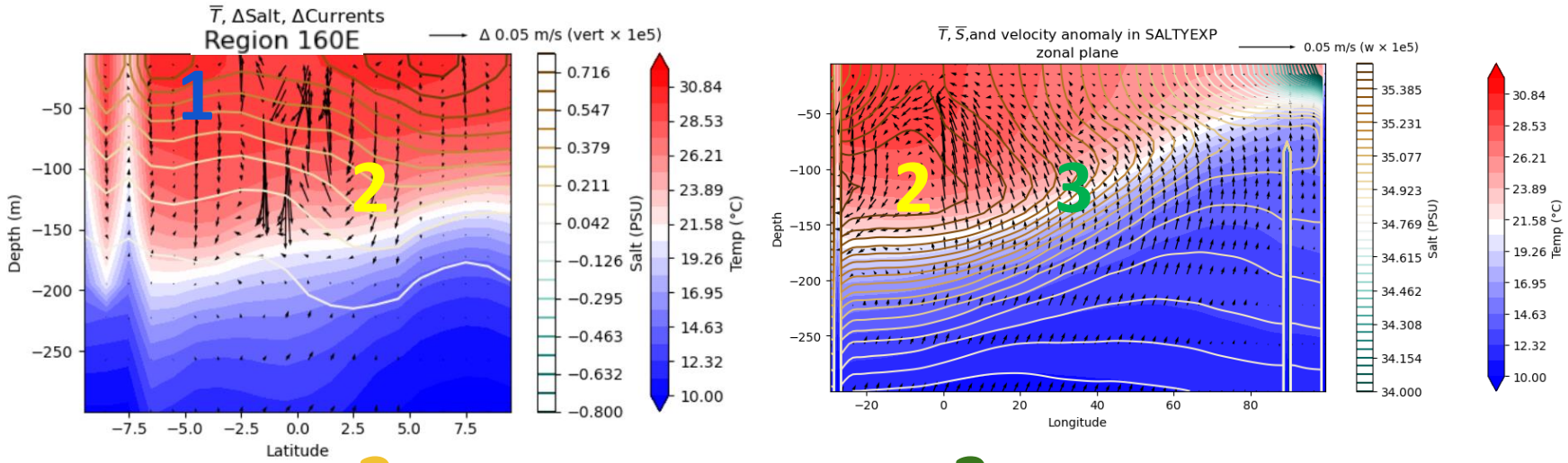


Difference (EXP#3 – V4r4)



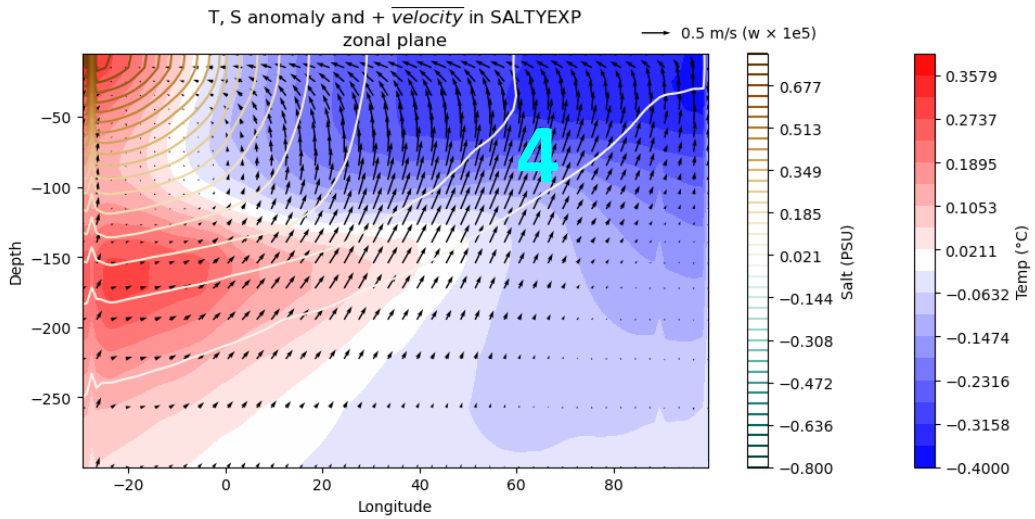
Results from Experiments

One example:
EXP#2 Salty



1 **2** **3** **4**

Salinity anomaly WP => Increased western downwelling => Upwelling at the east (continuity)=> Eastern Pacific Cooling!



Project Reflection

- **What were the challenges?**
  - ✓ Some of us just shifted from MATLAB and NCL to Python!
  - ✓ Two weeks are too short for conducting decent experiments!
- **What did you learn?**
  - ✓ ECCO is as amazing as expected!
- **What new skills did you acquire?**
  - ✓ Closing the budget elegantly. EMU.
- **If you had another week, how would you continue your project?**
  - ✓ Physical interpretations of our sensitivity experiments and test these using EMU tools.
  - ✓ We would continue our project on the beach (quoting Hugo!)

Project Reflection

Behind the project

Q: Why is there a shark in our team logo?

A: A miscommunication between human and AI

B. AI's deliberate error

C. Somebody in our group needs to improve their ENGLISH!


ECCO
SUMMER
SCHOOL
NASA
Credit to Yue!
crocodile