The Role of Diabatic Processes in Driving Ocean Heat Content Changes

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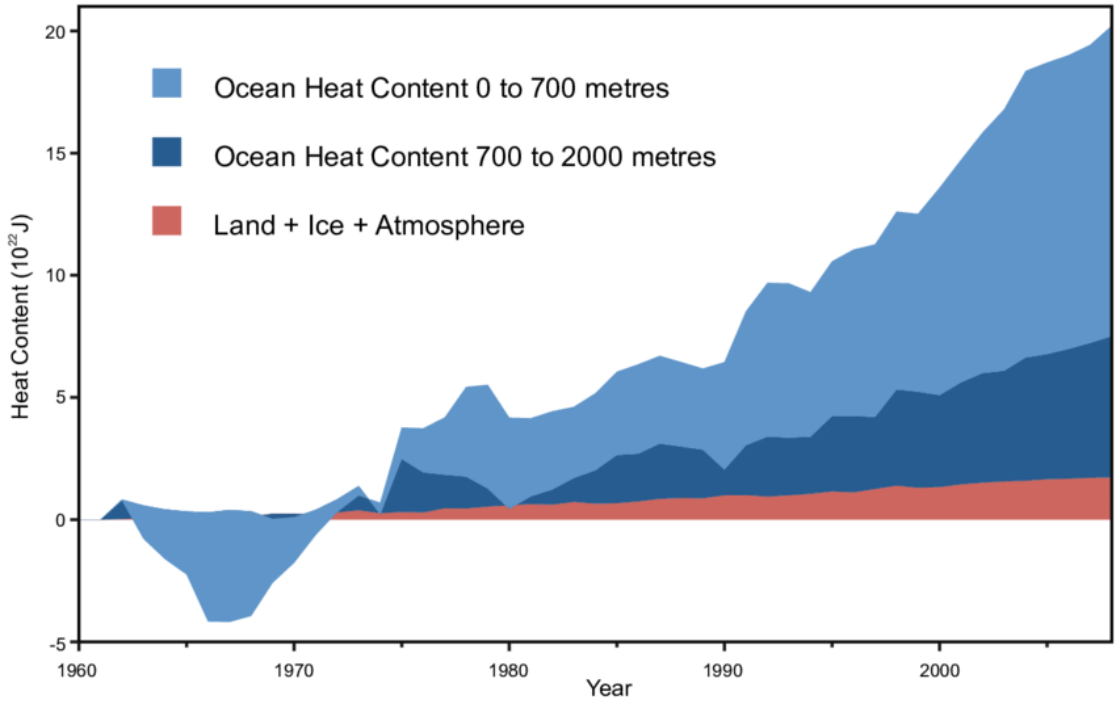
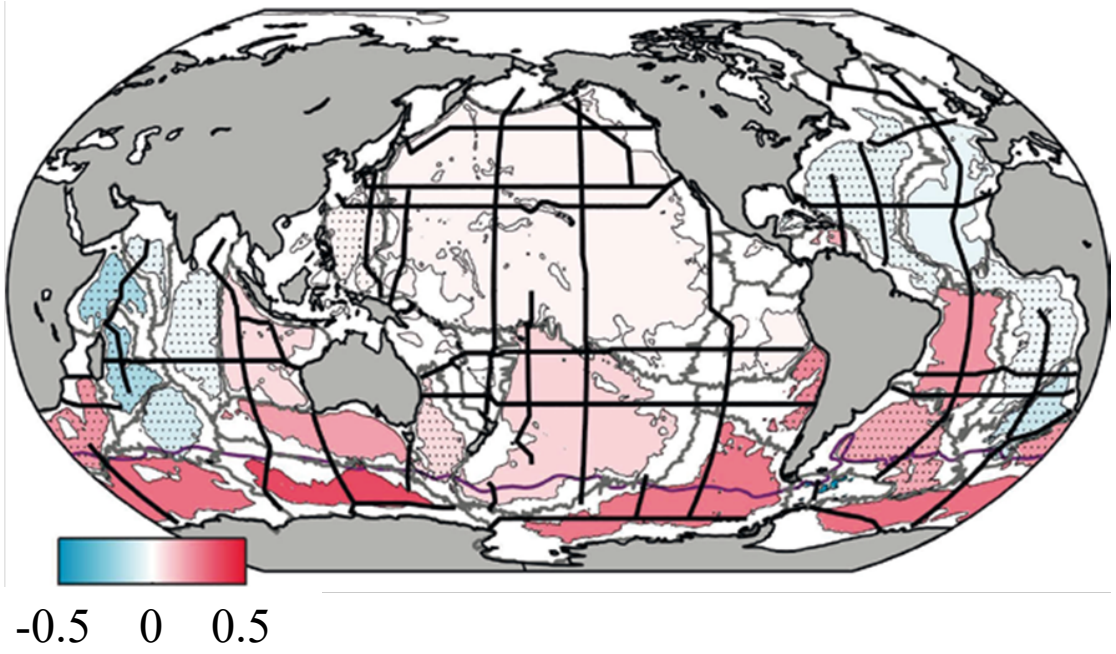
Importance of Ocean Heat Content



Nuccitelli et al., (2012)

- over 93% of energy into the ocean



IPCC SROCC, Ch. 5, Fig. 5.4b

- warming rate (°C per century) below 4000 m

An Overview

Project I: Diabatic Processes and the Warm Water Volume

- in review

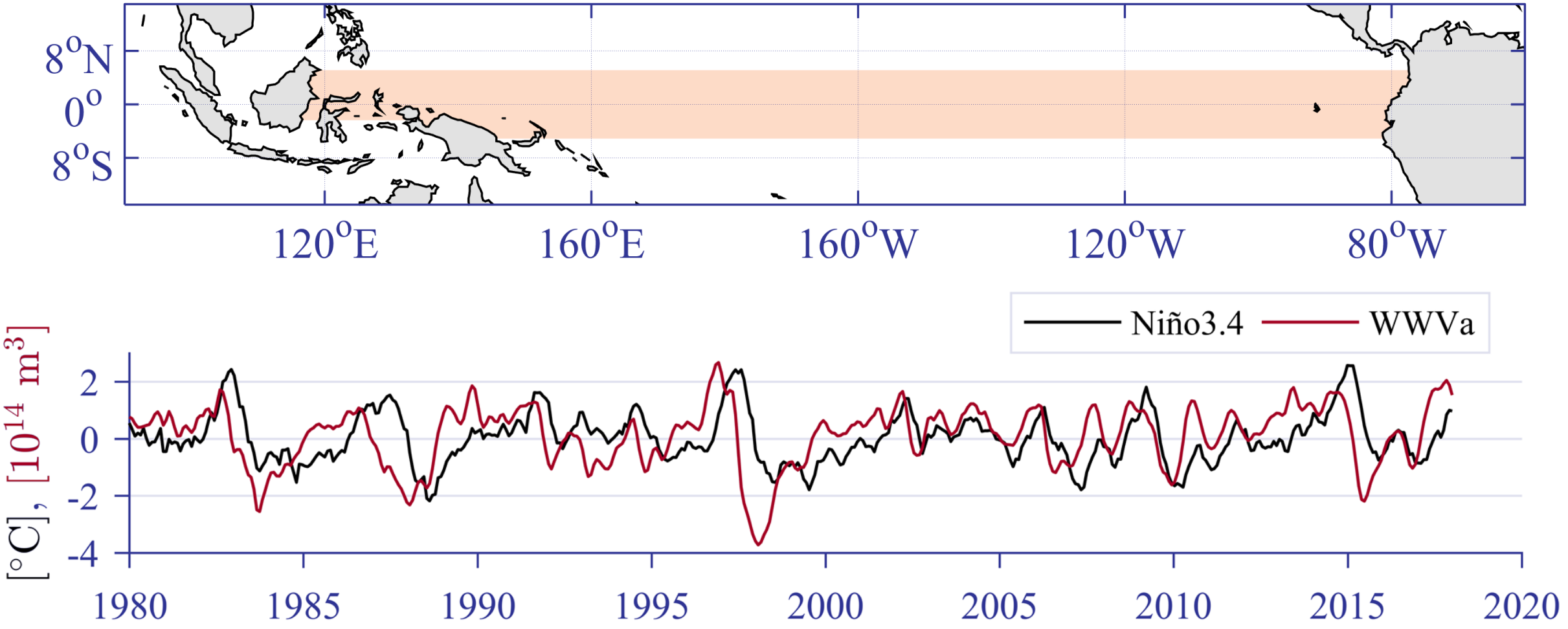
Project II: Basin-wide Decomposition of Anthropogenic Heat

- now working on spin-up

Project I

Diabatic Contributions to Warm Water Volume Variability Over ENSO Events

Motivation



Reynolds et al. (2007); Meinen & McPhaden (2000)

Motivation

- Focus on adiabatic exchange (Ekman, Sverdrup dynamics) → e.g. Jin (1997), McGregor et al. (2013, 2014), Neske and McGregor (2018), Izumo et al. (2018), …

- Meinen and McPhaden (2001): diabatic, vertical exchanges ~50% of warm water volume discharge in 1997/98
- Lengaigne et al. (2012) model study: diabatic contribution varies

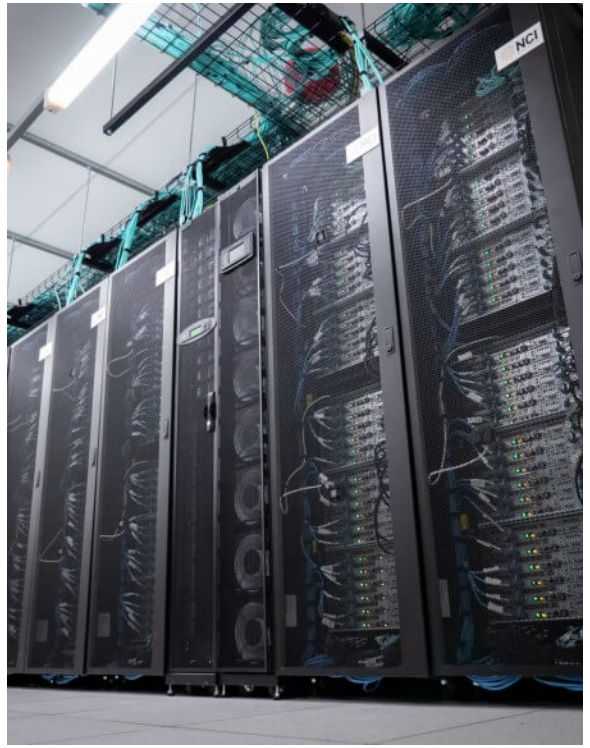
- Disagreement amongst studies: Brown and Fedorov (2010)

Project I: Goals

- Revisit the WWV budget using precise, online diagnostics
- Simulate ENSO variability over 1979-2016
- Examine extreme El Niño/La Niña events and asymmetries

The Global Ocean-Sea Ice Model

- ACCESS-OM2 (Kiss et al., 2019)
- ¼° horizontal resolution
- 50 vertical levels
- KPP vertical mixing (Large et al., 1994)
- JRA55-do 1958-2018 (Tsujino et al., 2018)
- Precise temperature-space diagnostics (Holmes et al., 2019a)



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The Warm Water Volume Budget

$$\frac{dWWV}{dt} = \underbrace{\mathcal{T}_{5°N+5°S} + \mathcal{T}_{ITF} + P - E + R}_{adiabatic\ fluxes} + \ \ldots$$

Eddy Mixing

Numerical Mixing

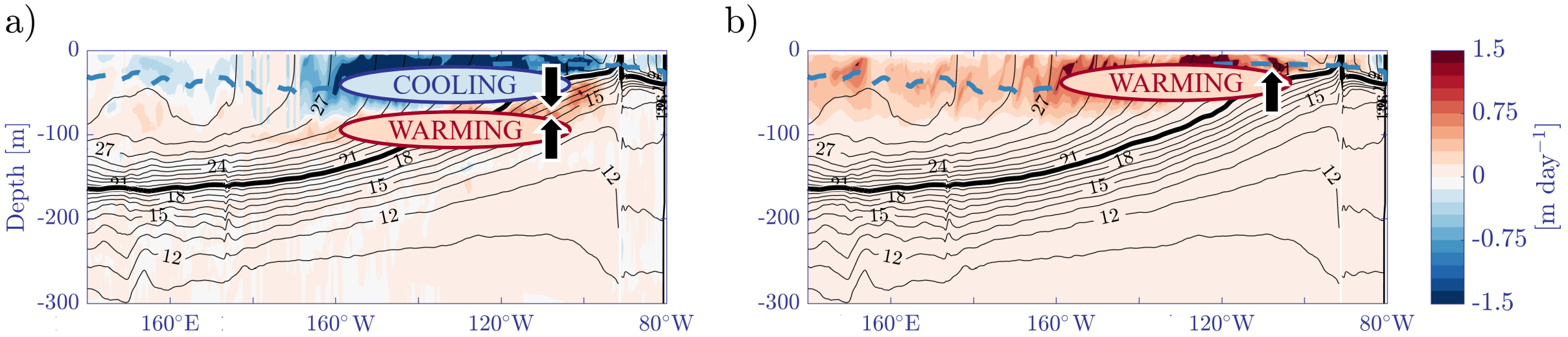
Surface Forcing **Vertical Mixing**

$$\underbrace{\frac{1}{\rho_0 \cdot C_p} \cdot \int\int \left.\frac{\partial \mathcal{F}}{\partial \Theta}\right|_{20°C} dA + \frac{1}{\rho_0 \cdot C_p} \cdot \int\int \left.\frac{\partial \mathcal{M}}{\partial \Theta}\right|_{20°C} dA + \mathcal{G}_{\mathcal{E}} + \mathcal{G}_{\mathcal{I}}}_{diabatic\ fluxes}$$

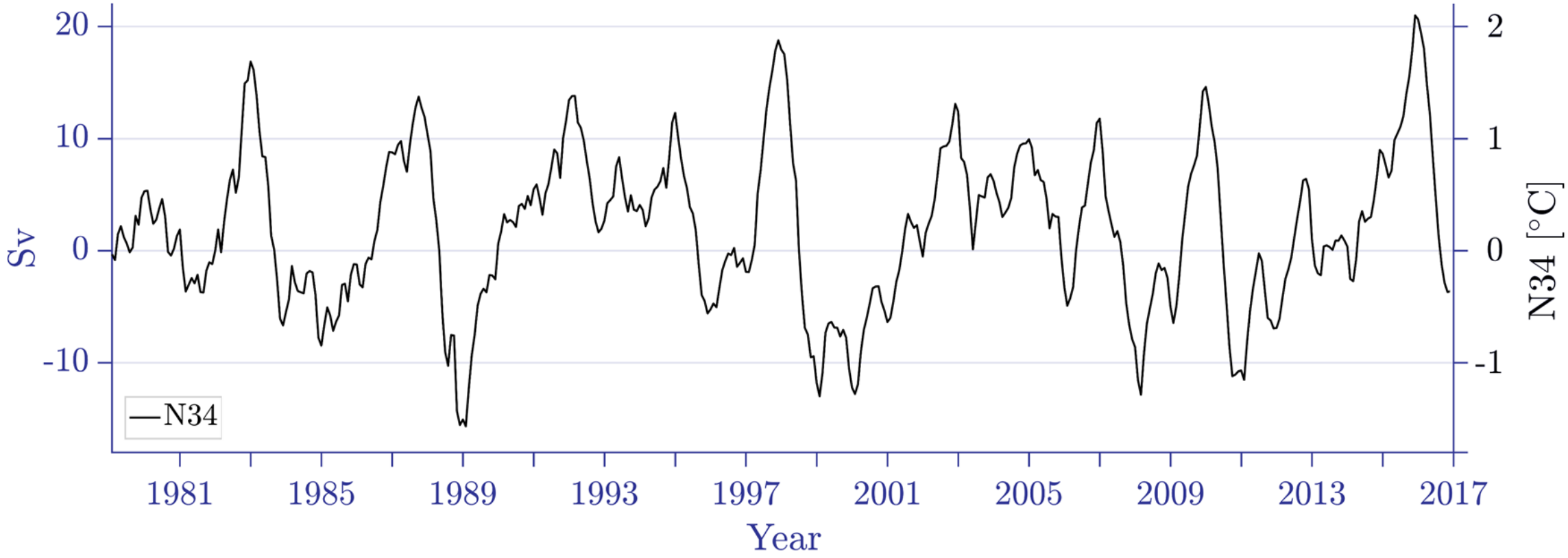
The Diabatic Volume Fluxes: September-November

Vertical Mixing

Surface Forcing



Interannual Variability of the Diabatic Fluxes



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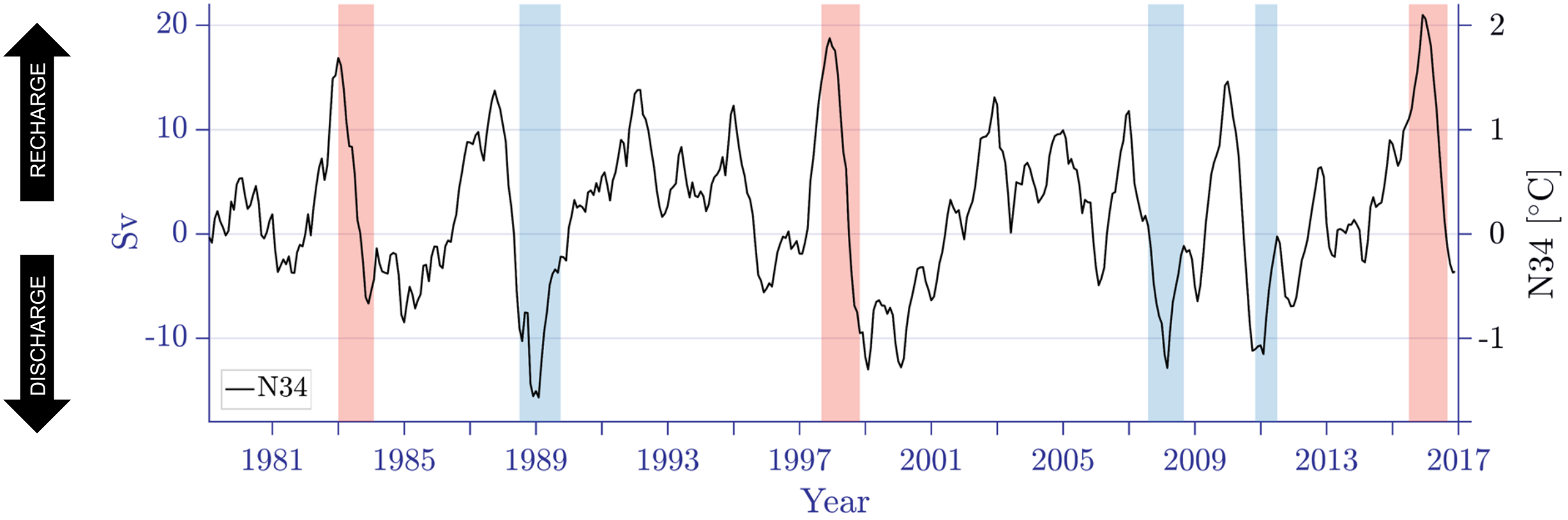

El Niño: discharge

La Niña: recharge

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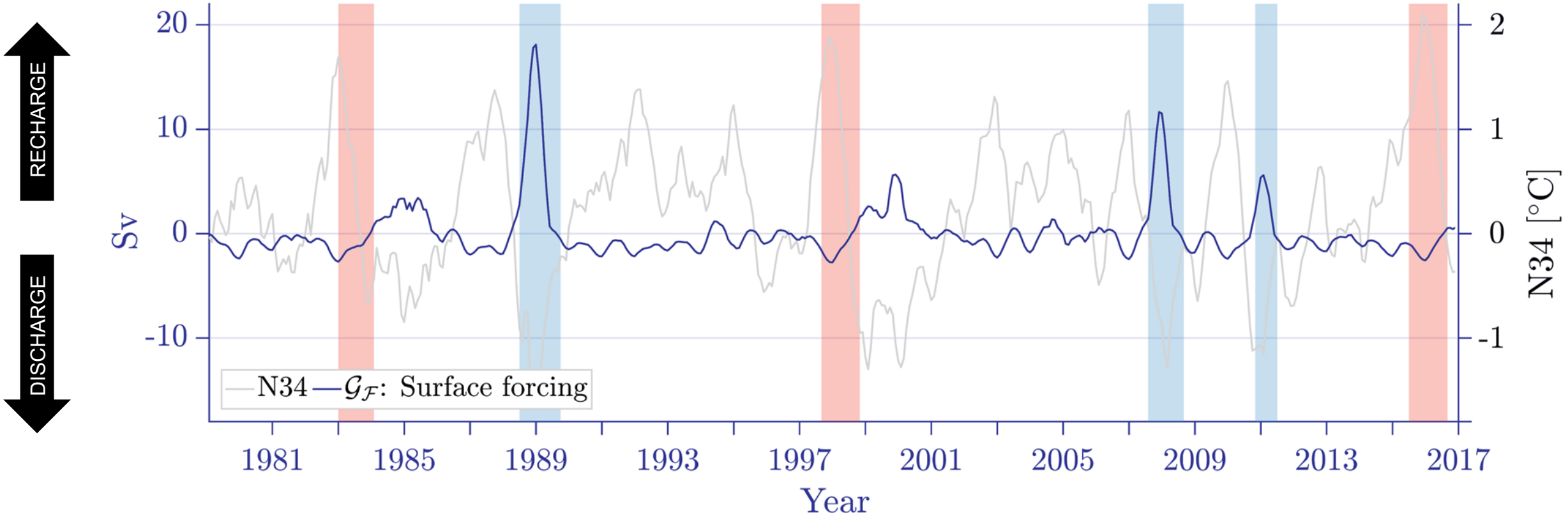
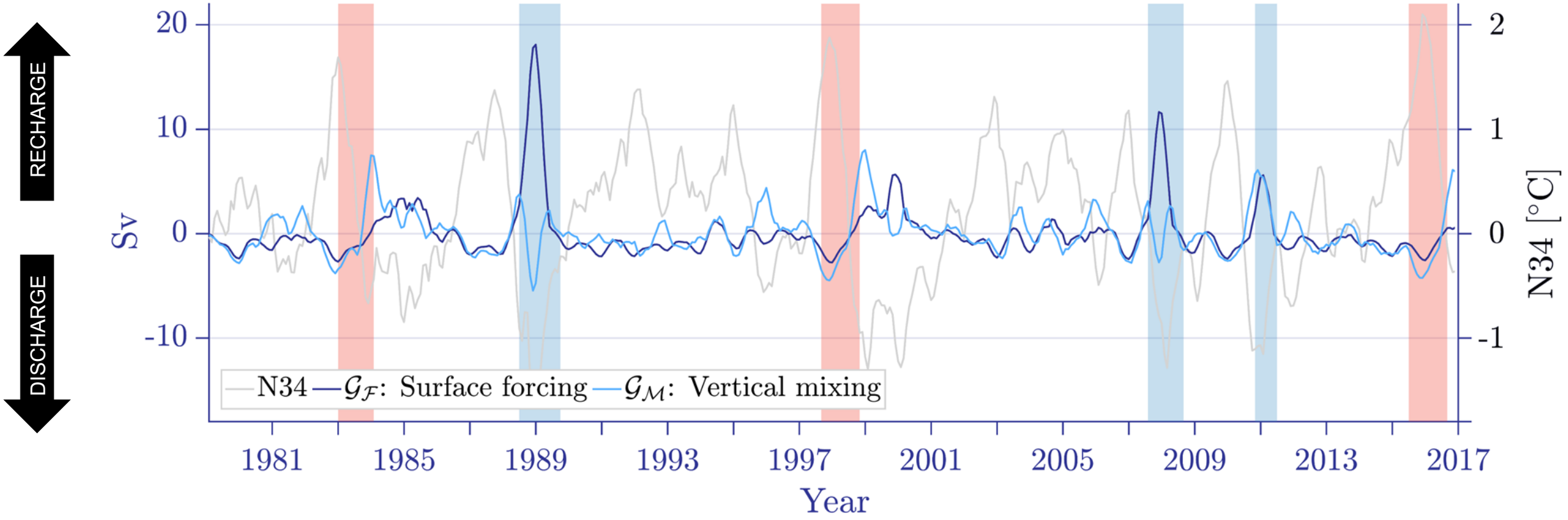


La Niña: large positive contribution of surface forcing

Interannual Variability of the Diabatic Fluxes



El Niño: both surface forcing & vertical mixing deplete WWV

La Niña: large positive contribution of surface forcing

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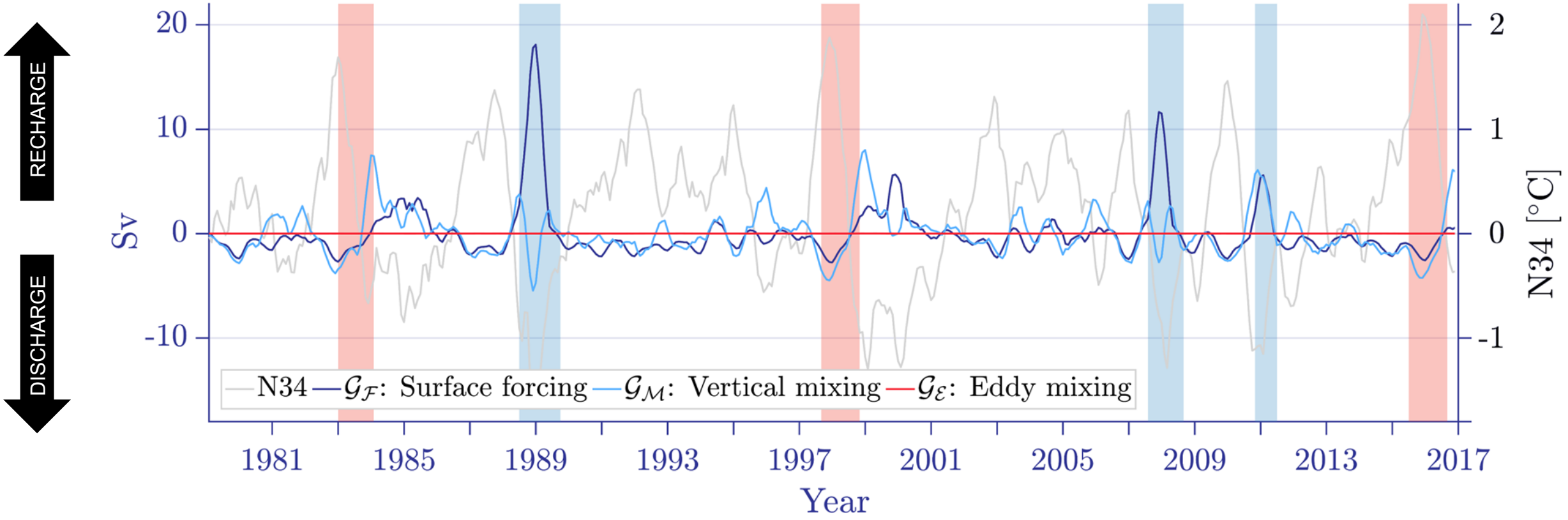

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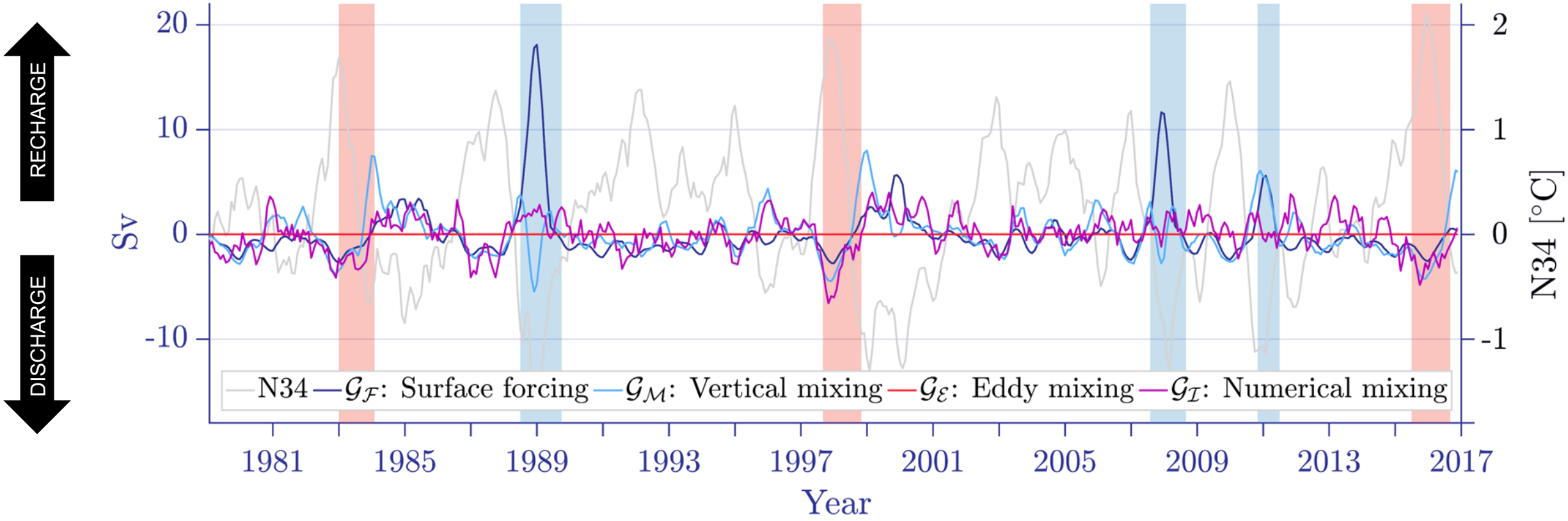

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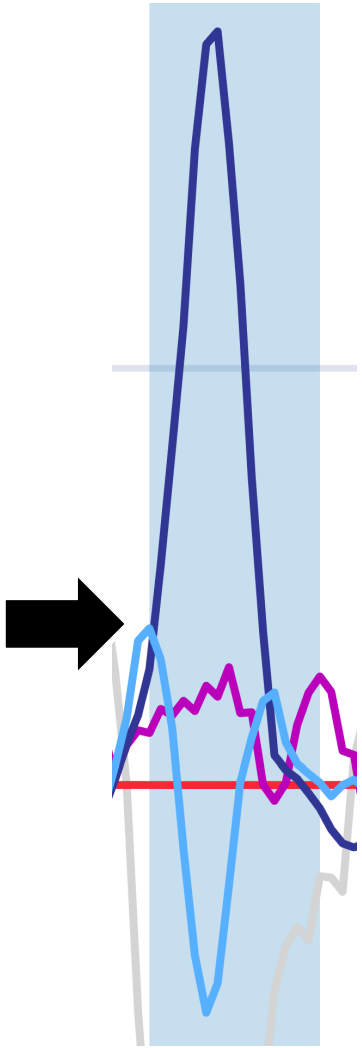
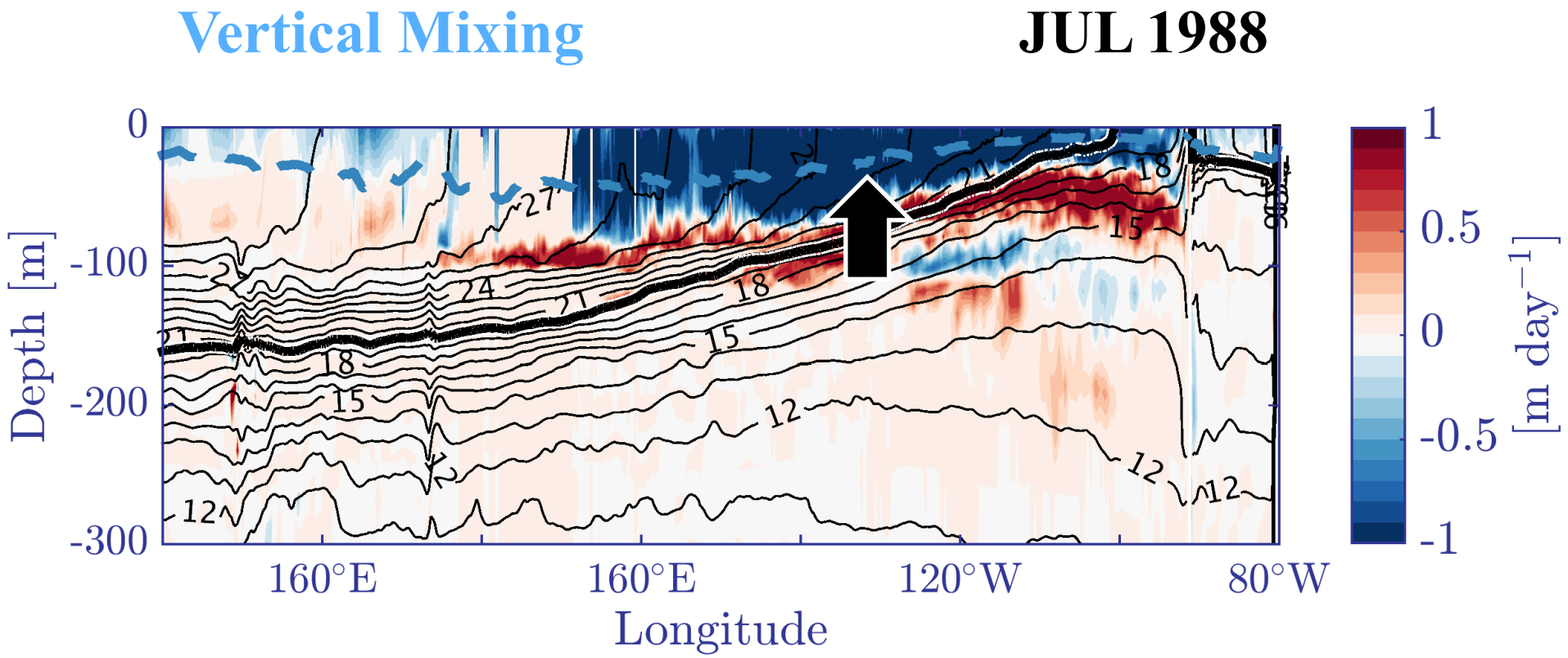
Diabatic Fluxes during La Niña 1988/89





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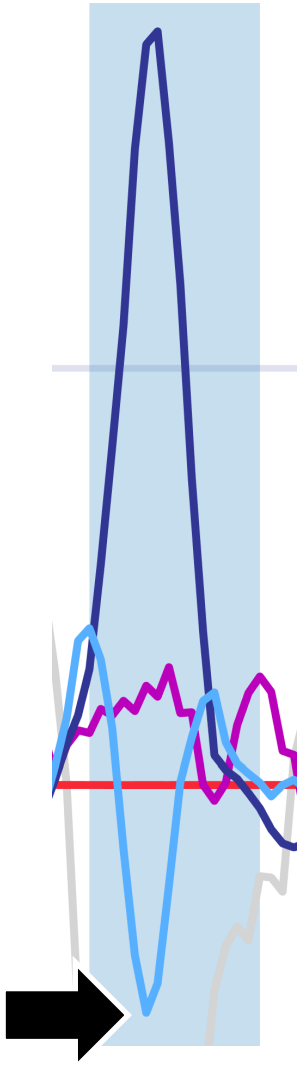
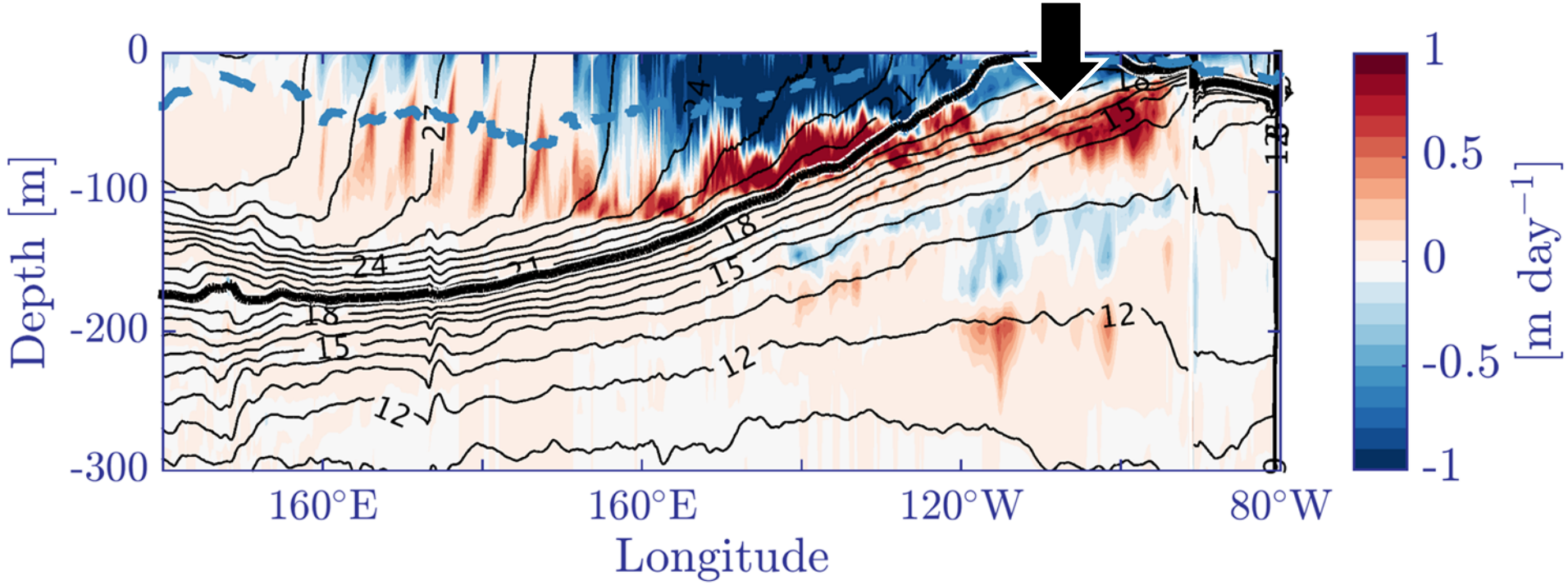


Vertical Mixing

DEC 1988



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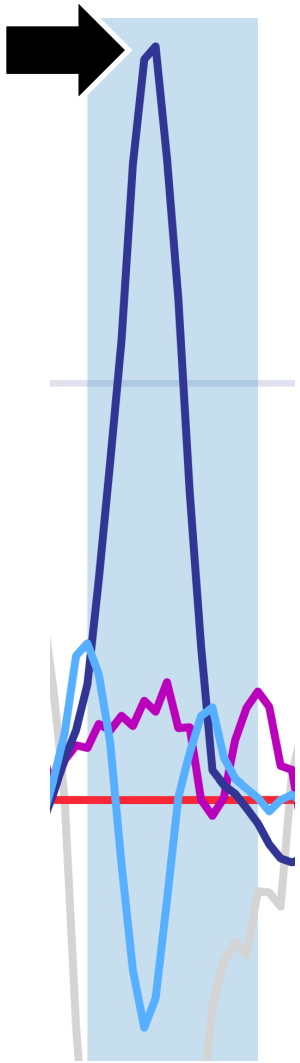

Surface Forcing

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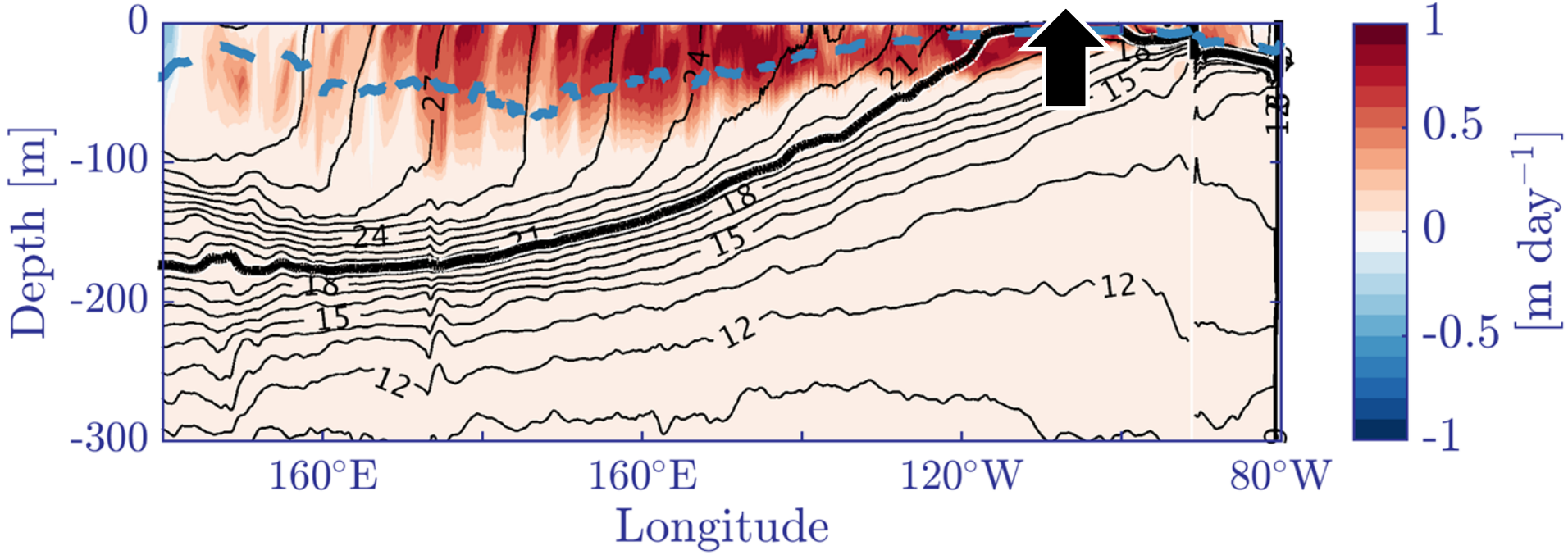

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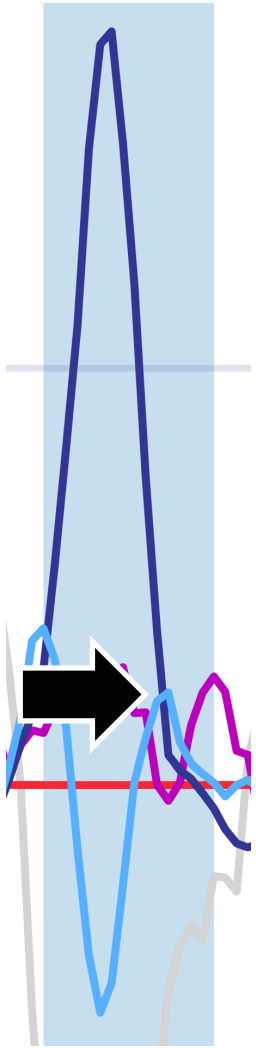
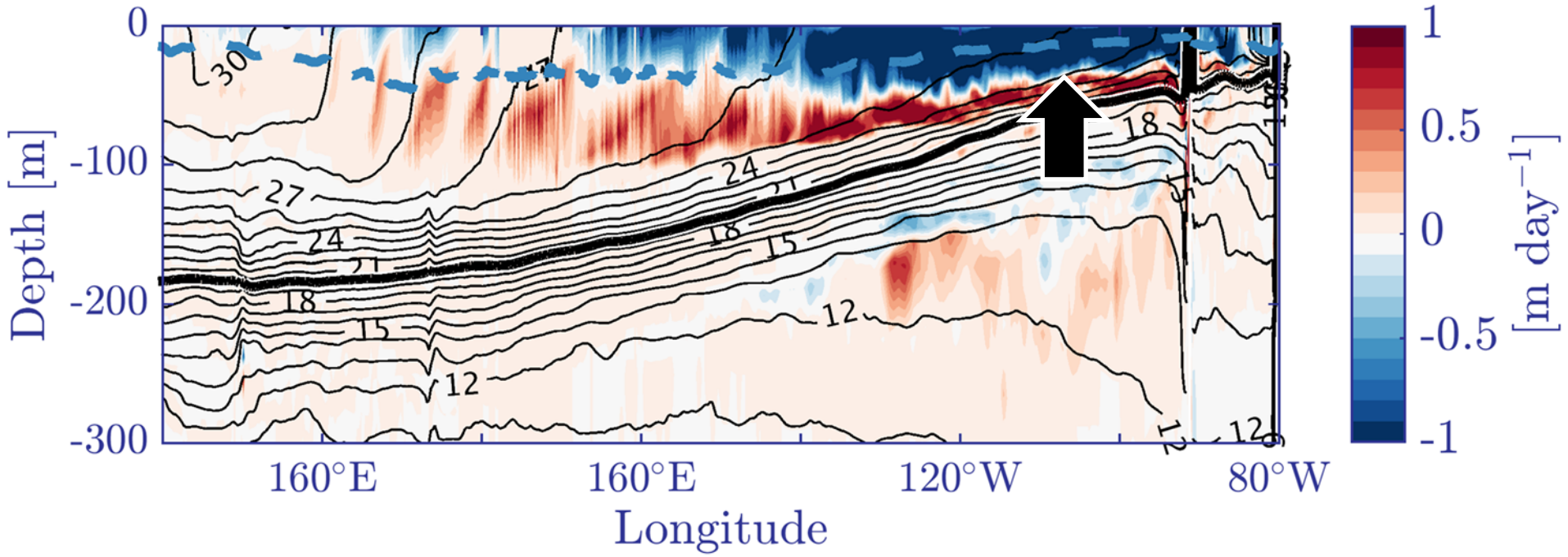


Vertical Mixing

JUL 1989



Project I: Take Home Messages

- In-depth analysis of individually calculated upper ocean heat/volume fluxes during ENSO in ACCESS-OM2

- Adiabatic volume fluxes mostly symmetric between events; diabatic fluxes show a strong asymmetry and peak three to six months earlier

- The large event-to-event variability in the surface forcing flux is linked to the shoaling of the 20°C isotherm in the eastern equatorial Pacific

Project II

Basin-wide Decomposition of Anthropogenic Ocean Heat Content

Project I: Take Home Messages

Goal: understand where the additional heat has been taken up and where it has gone

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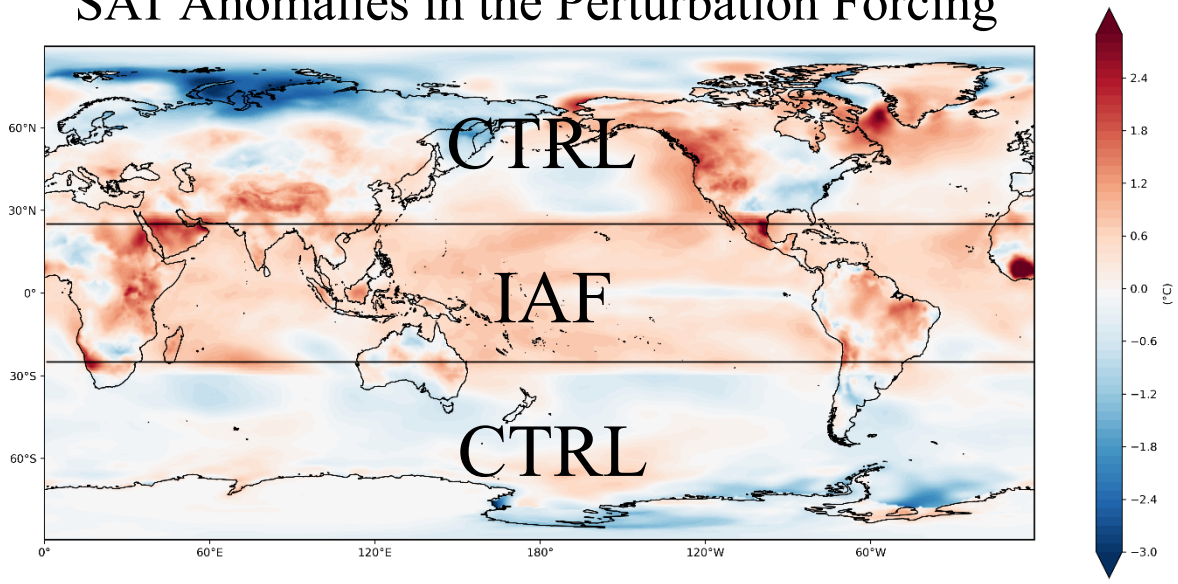
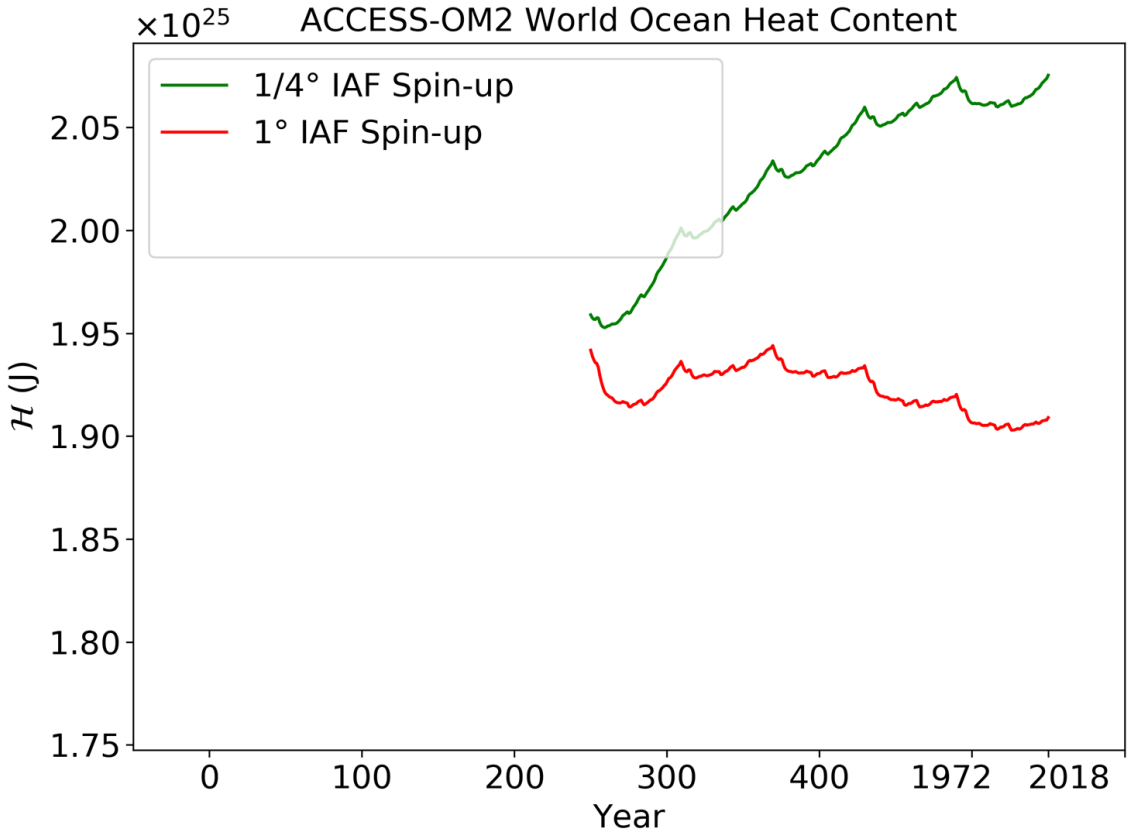
- ACCESS-OM2 model
- idealised simulations where we add interannual forcing over specific regions

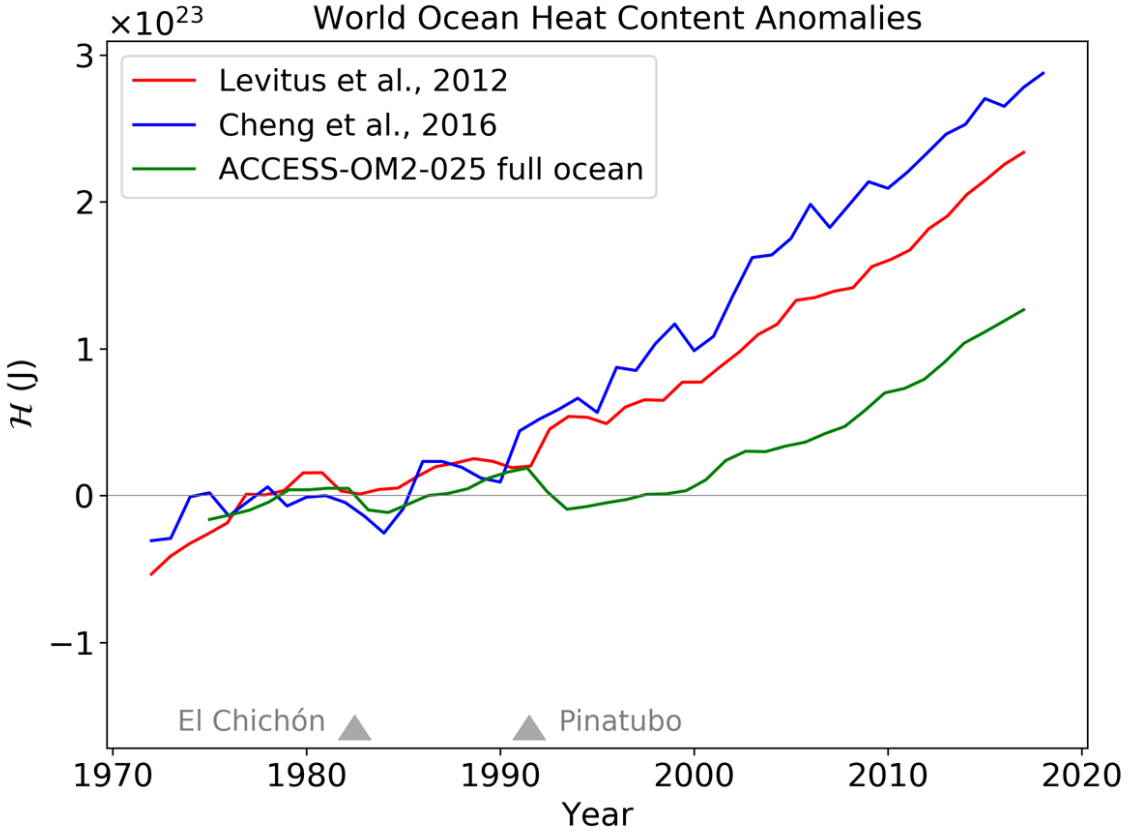
SAT Anomalies in the Perturbation Forcing



Project II: Basin-wide Decomposition of Anthropogenic Heat

Goal: understand where the additional heat has been taken up and where it has gone





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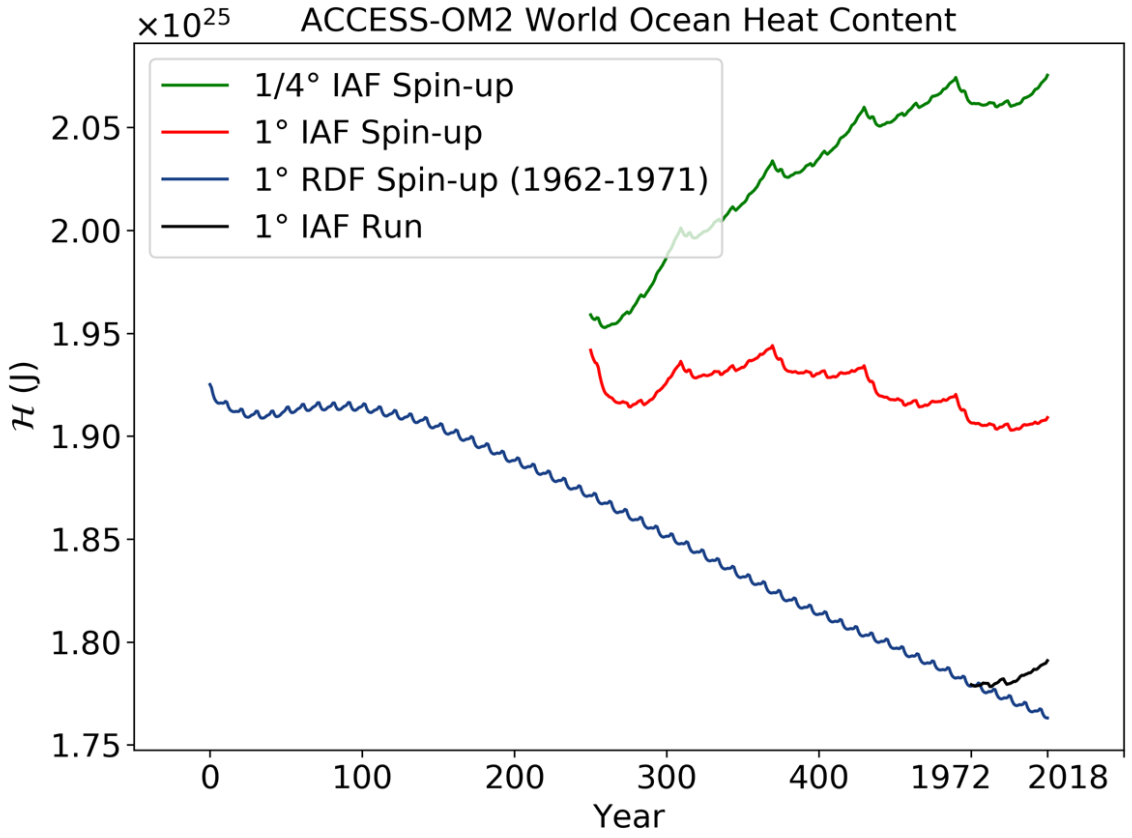
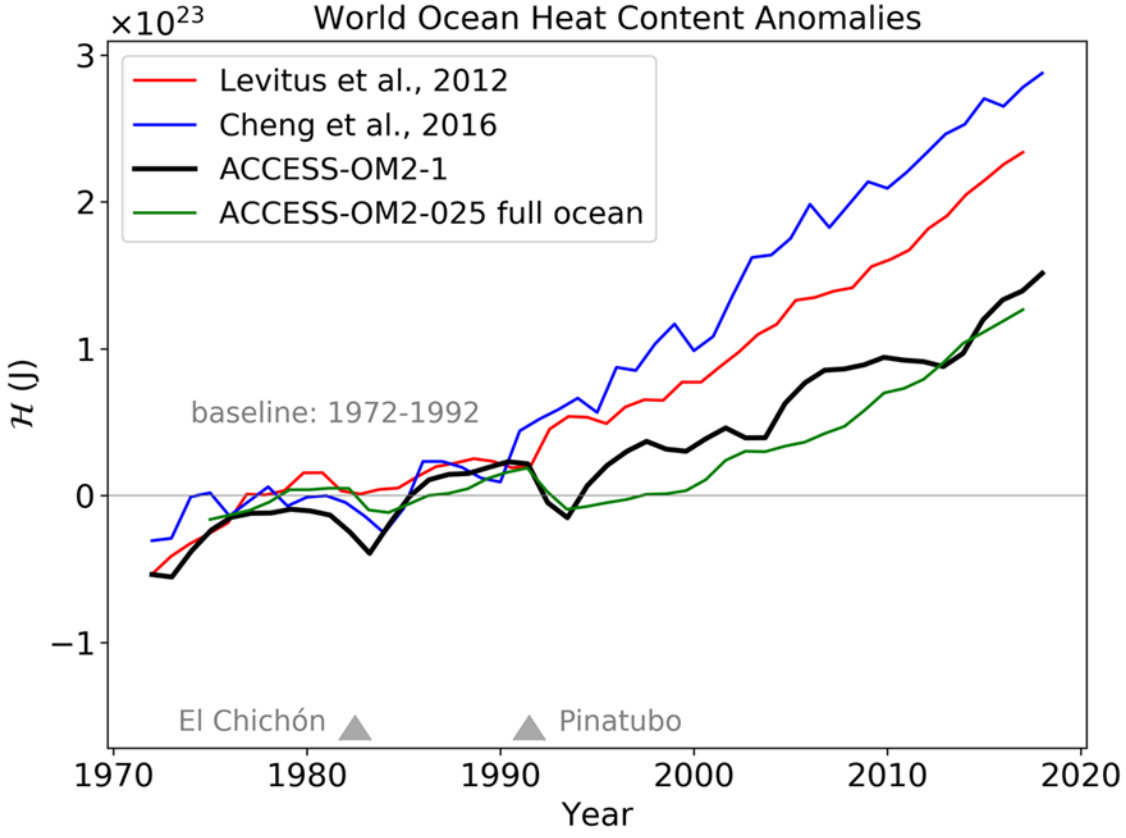
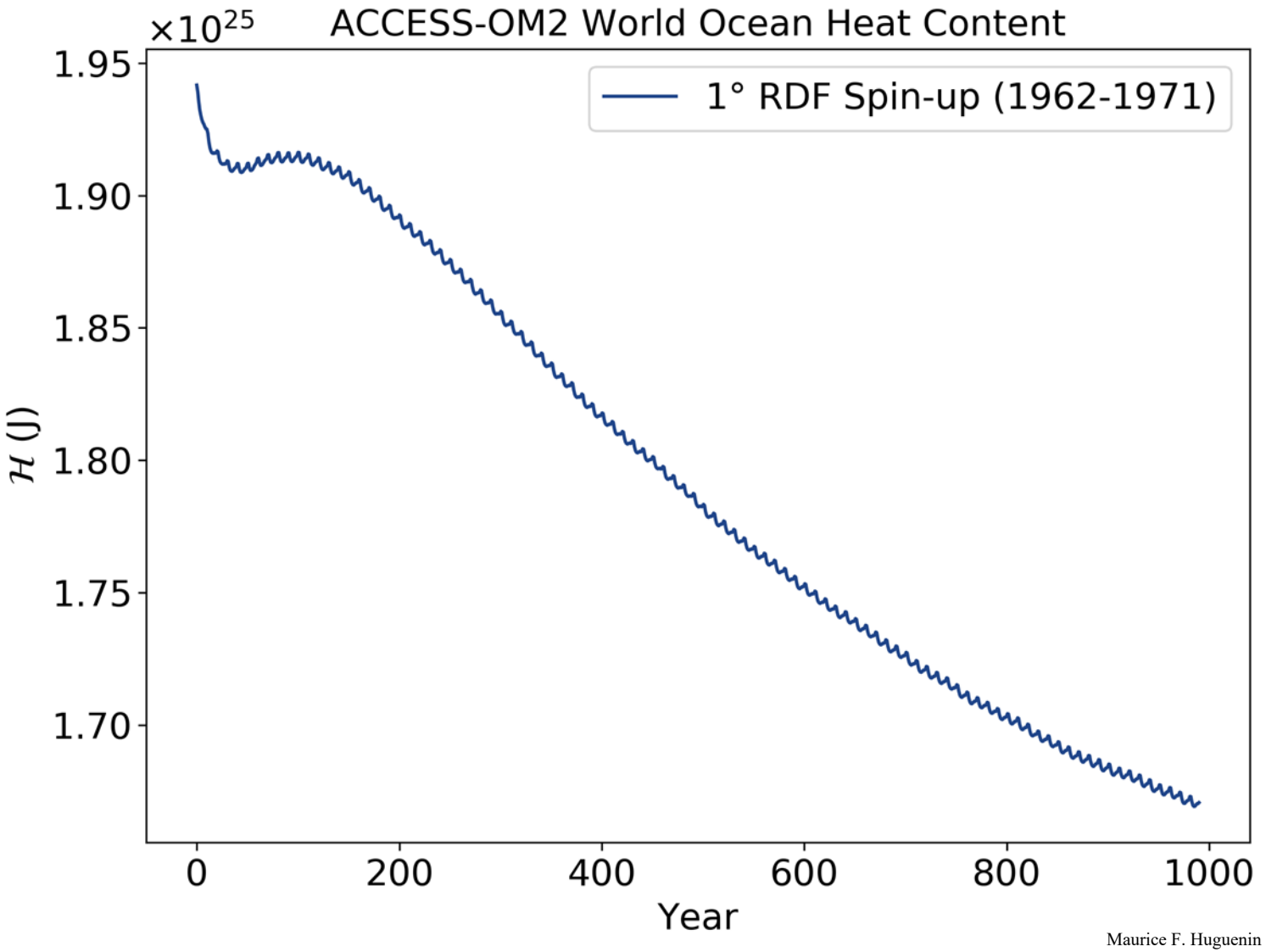


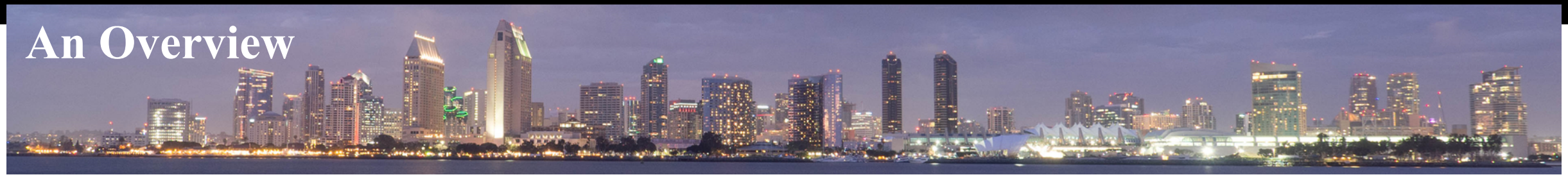


Project II: Basin-wide Decomposition of Anthropogenic Heat

- spin-up now at 1030 years



An Overview



Project I: Diabatic Processes and Warm Water Volume Changes Over ENSO

Take-Home:

- Analysed upper ocean heat/volume fluxes during ENSO
- Adiabatic fluxes: symmetric, diabatic fluxes: asymmetric & peak earlier
- Large event-to-event variability in surface forcing linked to the shoaling of the 20°C isotherm in the East

Project II: Basin-wide Decomposition of Anthropogenic Heat

Goal: understand where the additional heat has been taken up and where it goes

- New repeat-decade spin-up (1962–1971)
- Focused experiments with interannual forcing only over tropics, high-latitudes and individual ocean basins
- Analyse role of surface forcing and vertical mixing in recent OHC changes