

# Diabatic Contributions to Warm Water Volume Variability over ENSO Events

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# 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, ...

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- Meinen and McPhaden (2001): diabatic, vertical exchanges ~50% of WWV discharge in 1997/98
- Lengaigne et al (2012) model study: diabatic contribution varies
- Disagreement amongst other studies

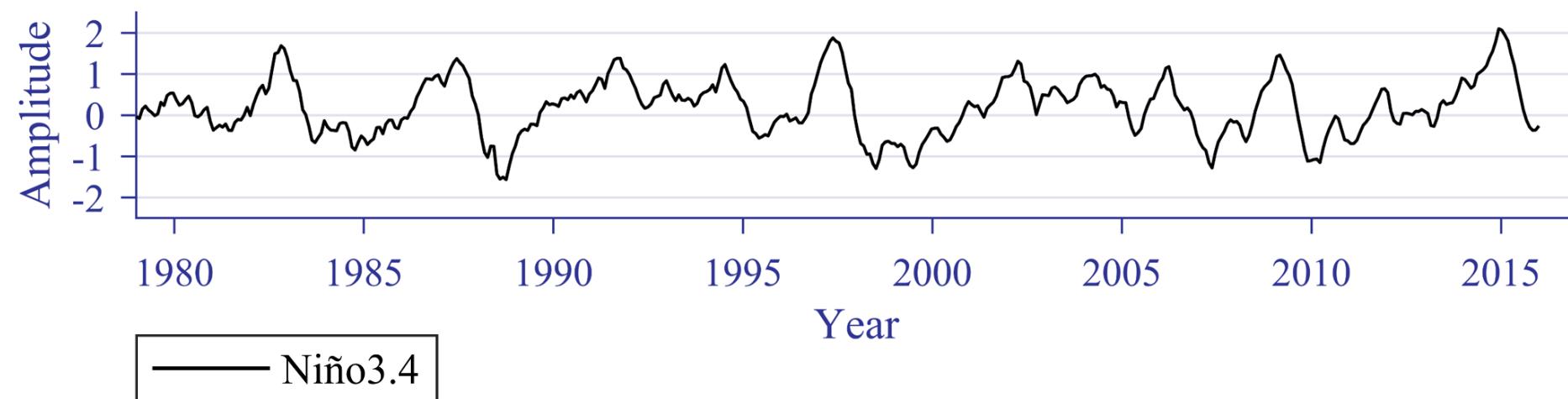
## Goals

- 1) Revisit the WWV budget using precise, online water-mass transformation diagnostics
- 2) Examine extreme El Nino/La Nina events and asymmetries

# The global ocean sea-ice model

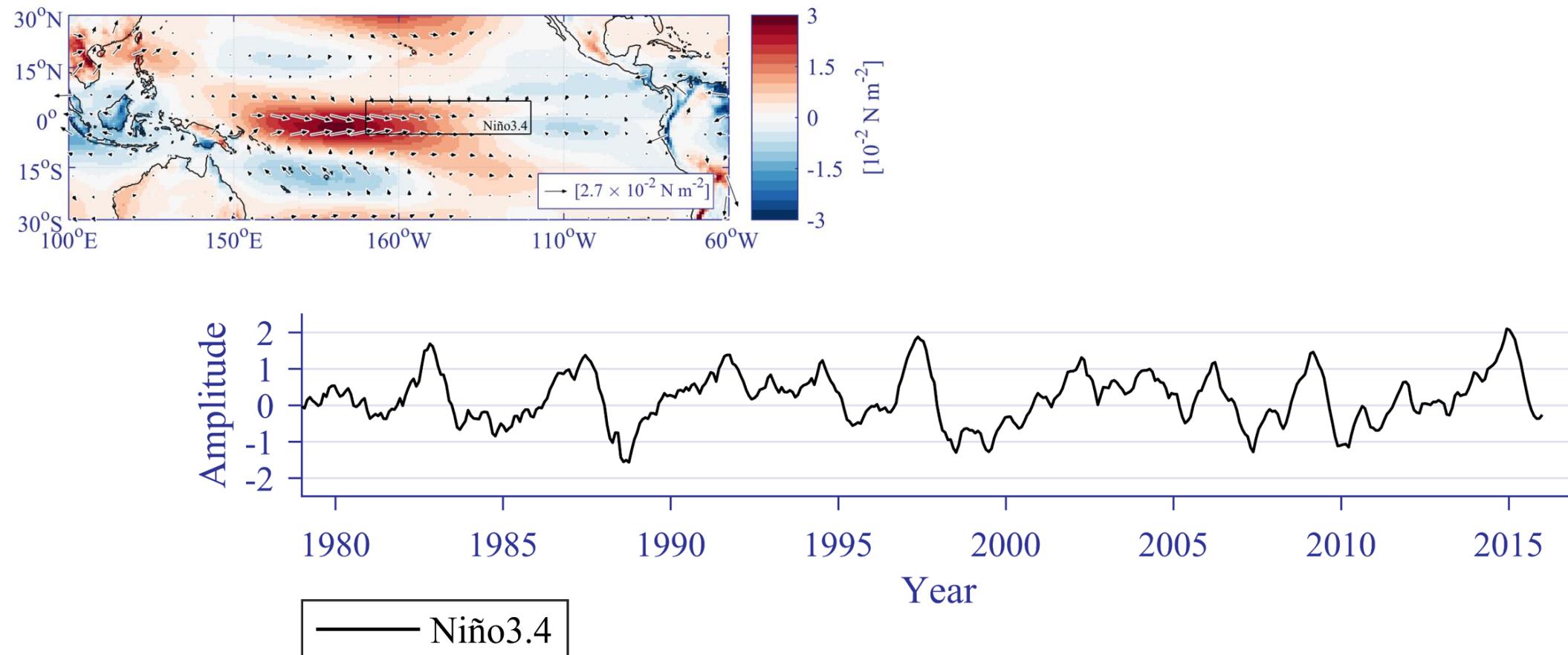
- MOM025
- $\frac{1}{4}^\circ$  resolution
- 50 vertical levels
- KPP vertical mixing
- precise temperature-space diagnostics (Holmes et al. 2019, JPO)

# Development of Idealized Atmospheric Forcing



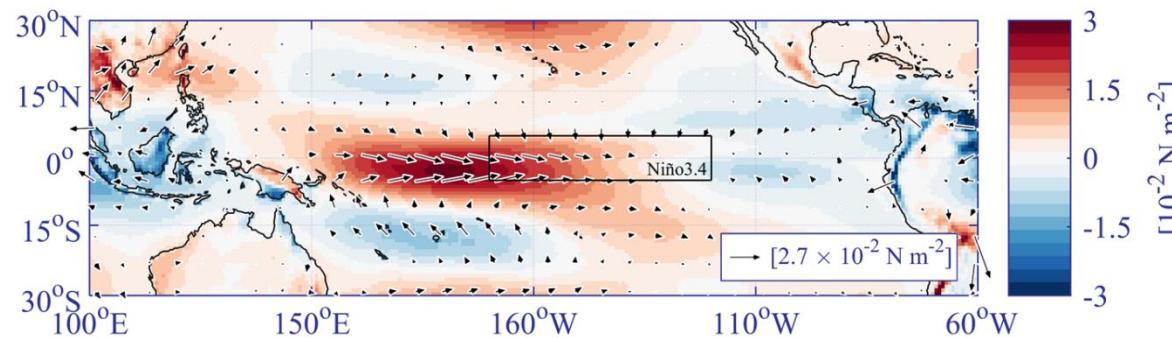
# Development of Idealized Atmospheric Forcing

a)  $X_{1,\vec{\tau}}$

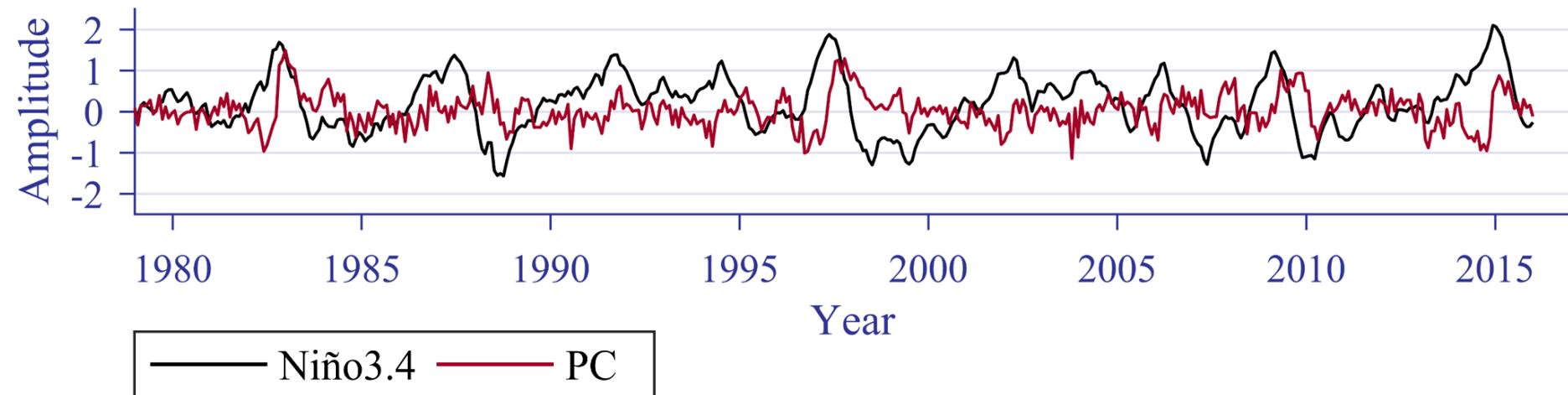
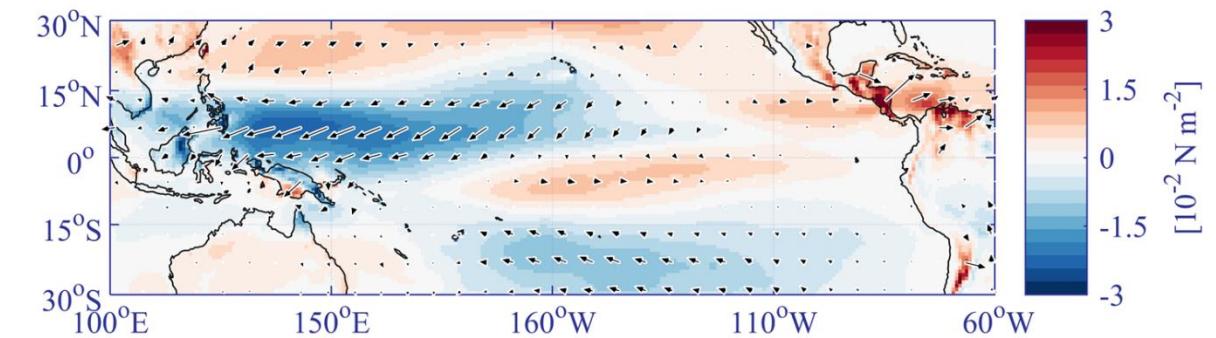


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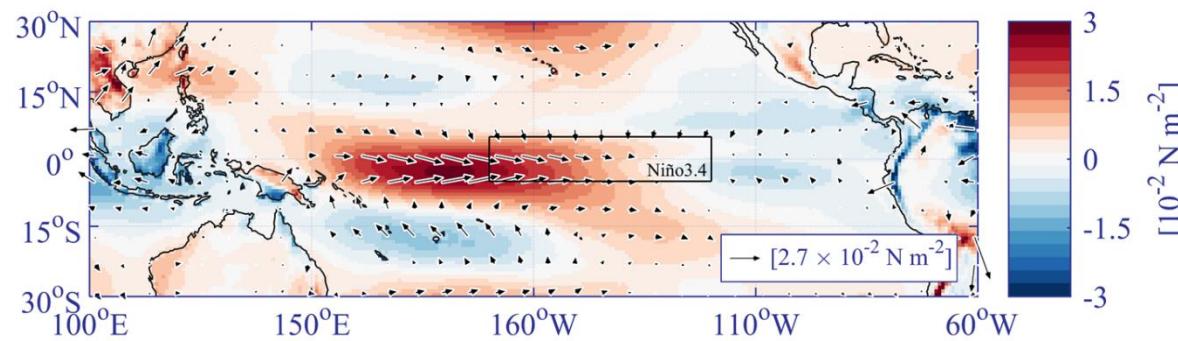


b)  $X_{2,\vec{\tau}}$

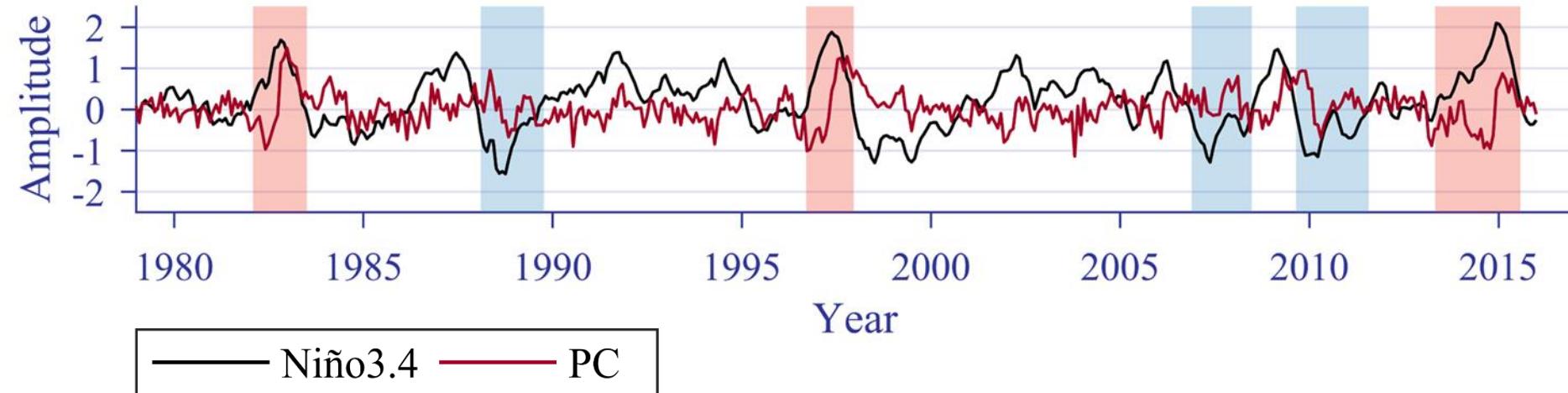
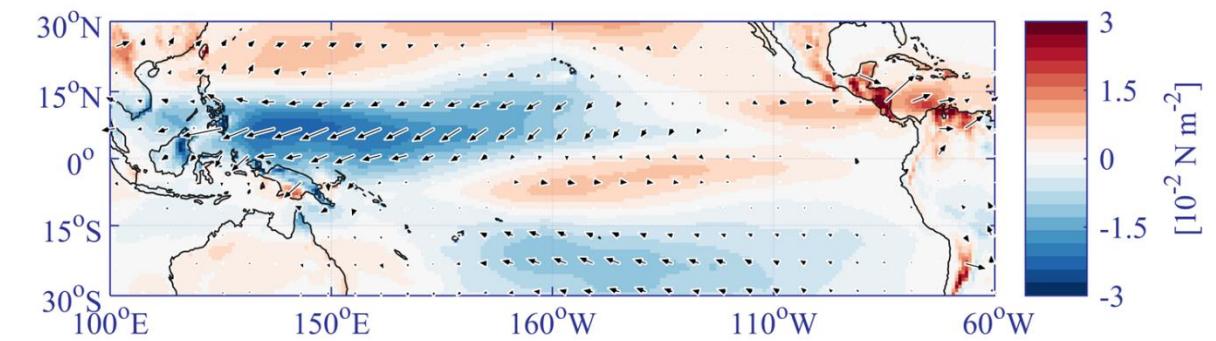


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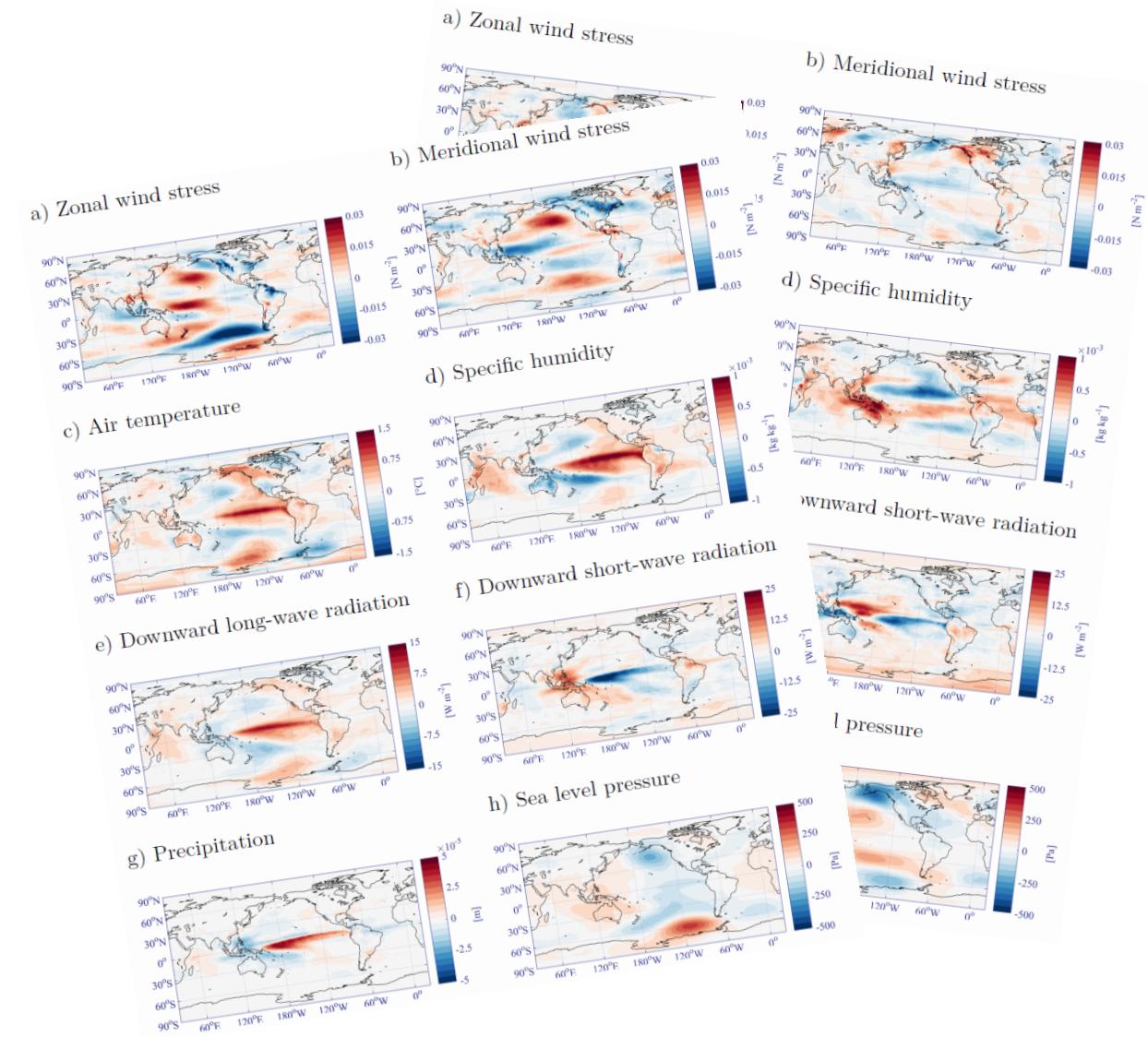
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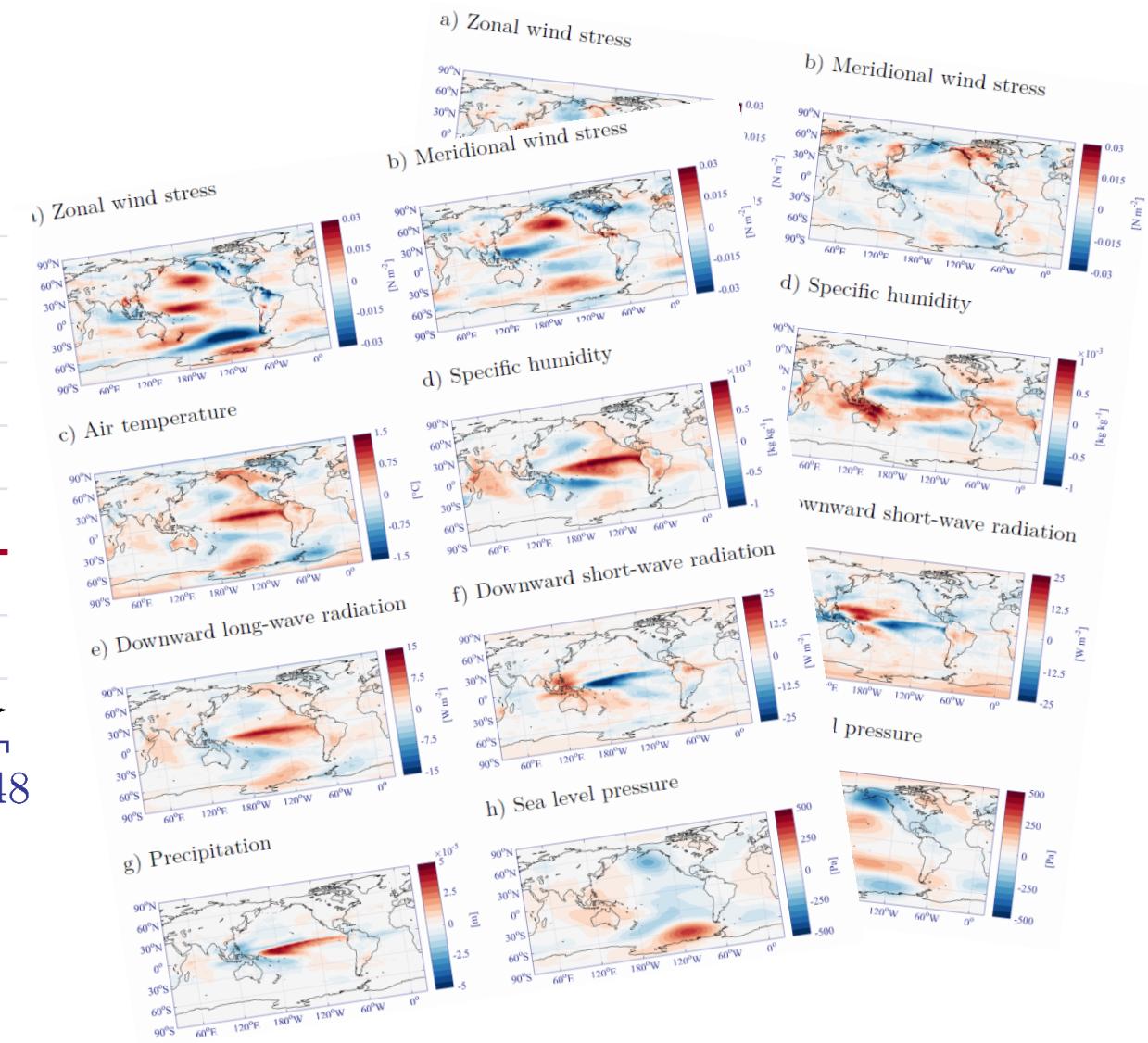
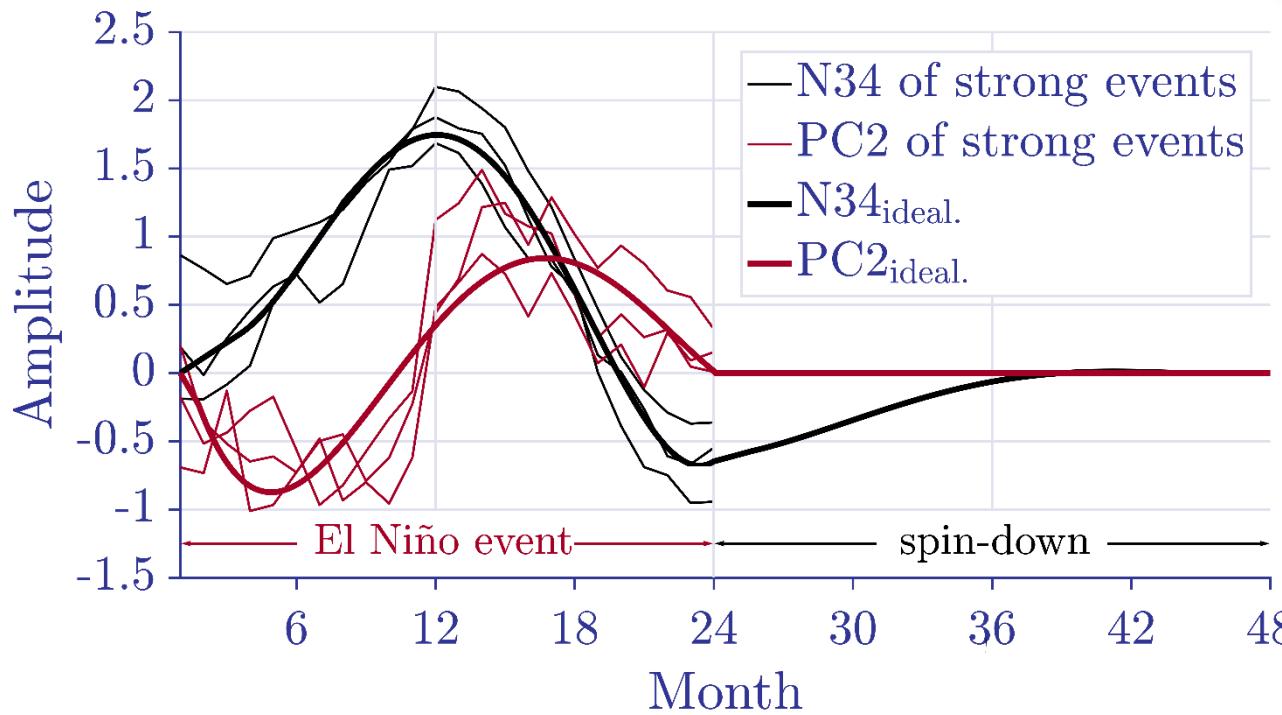
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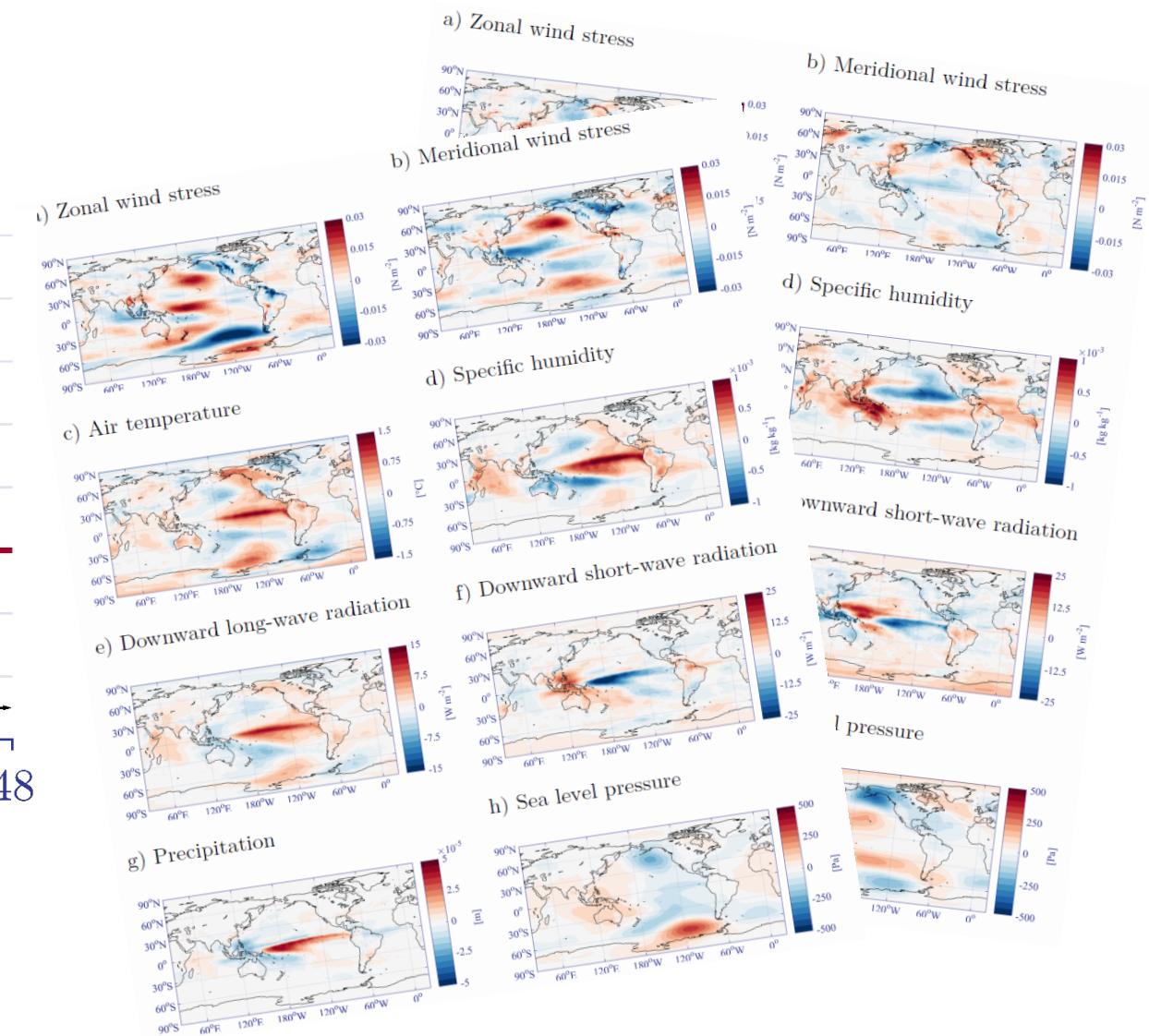
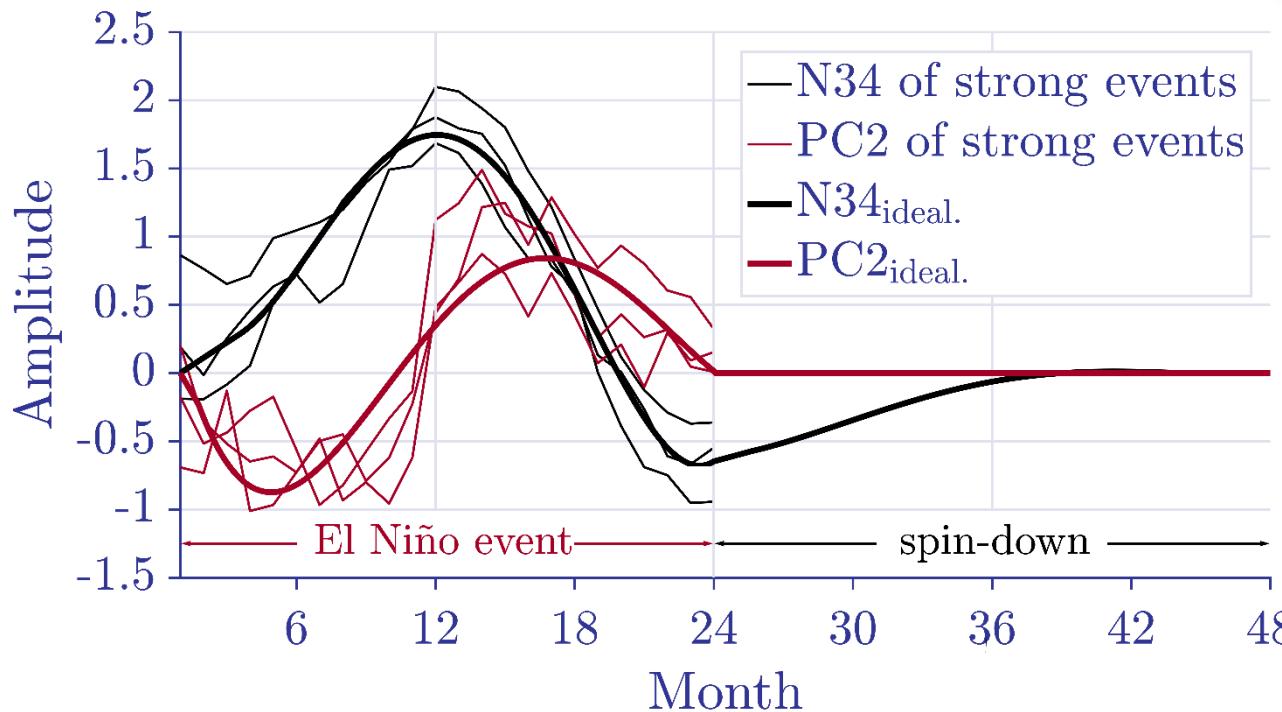
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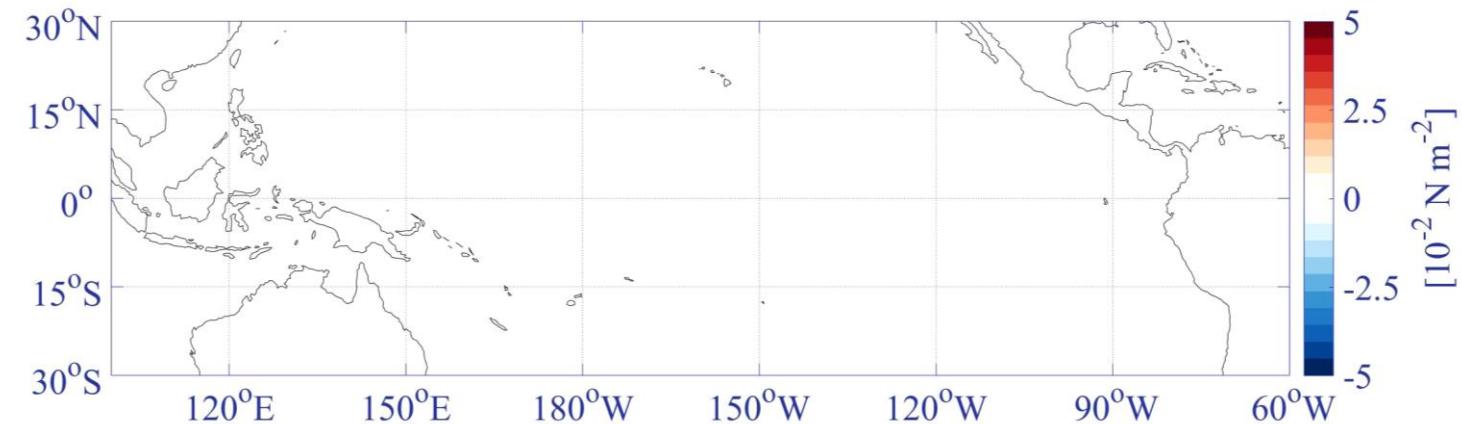
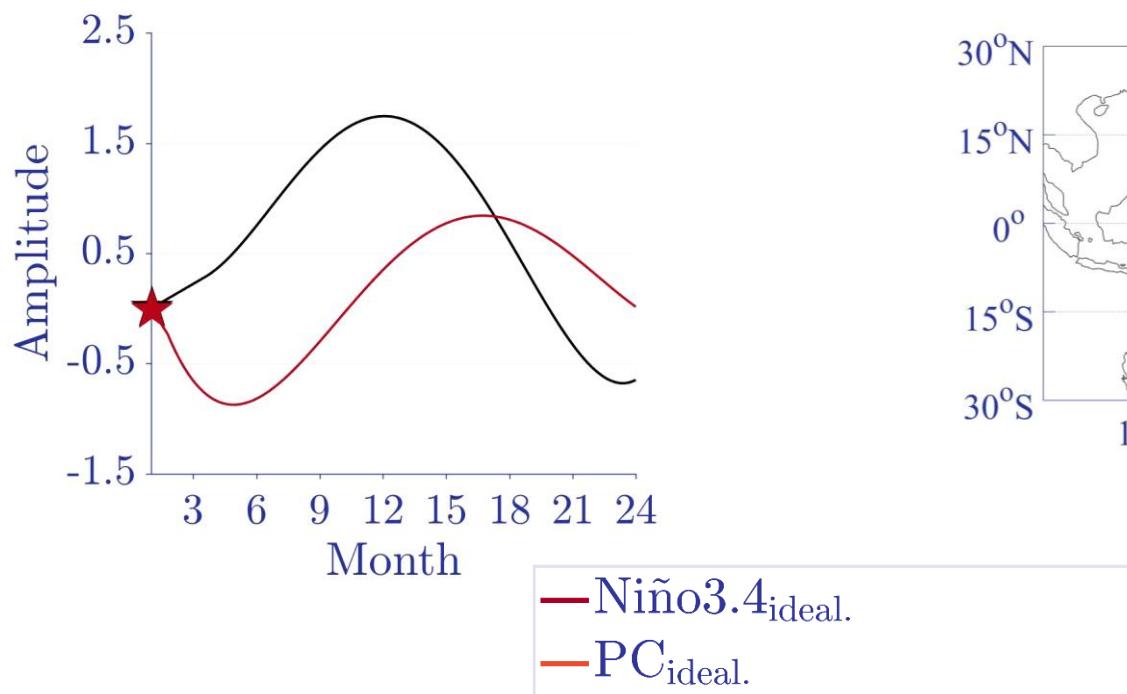
→ wind stress, surface heat and freshwater fluxes

# Evolution of atmospheric perturbation

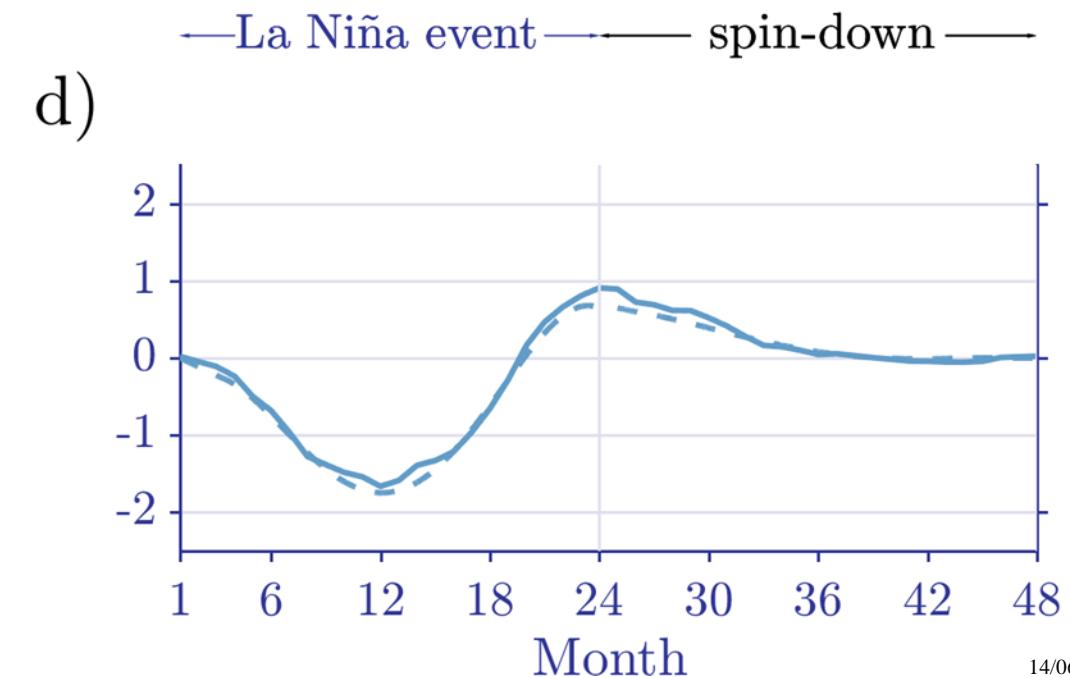
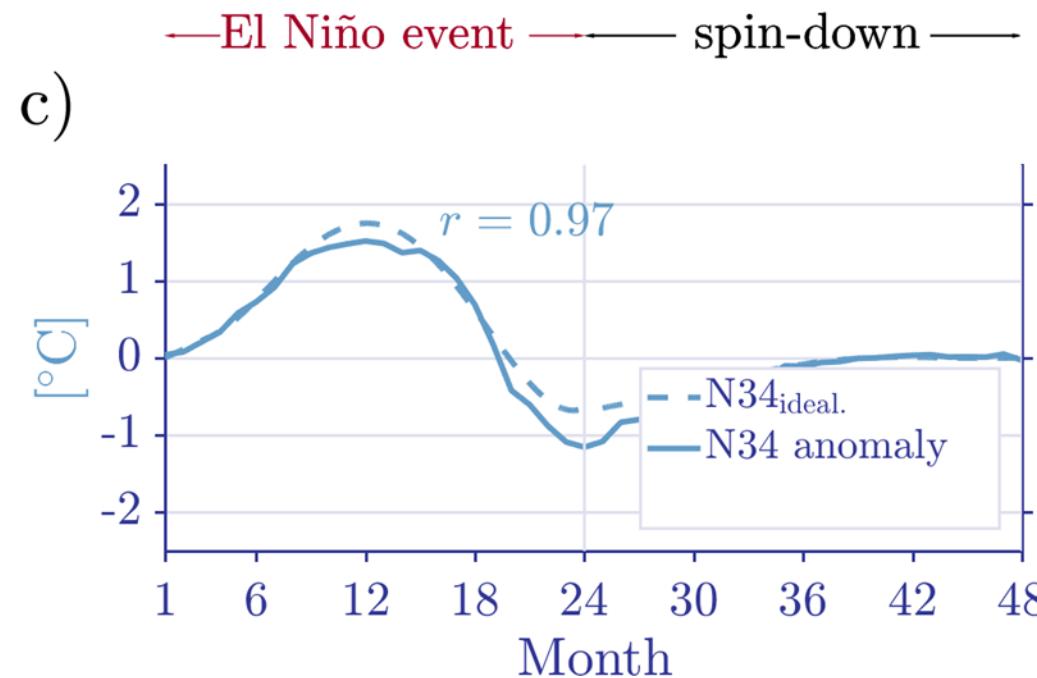
$$atm. \ forcing = \underbrace{clim. \ forcing}_{CNYF} + \underbrace{perturbation \ forcing}_{patterns \times time \ series}$$

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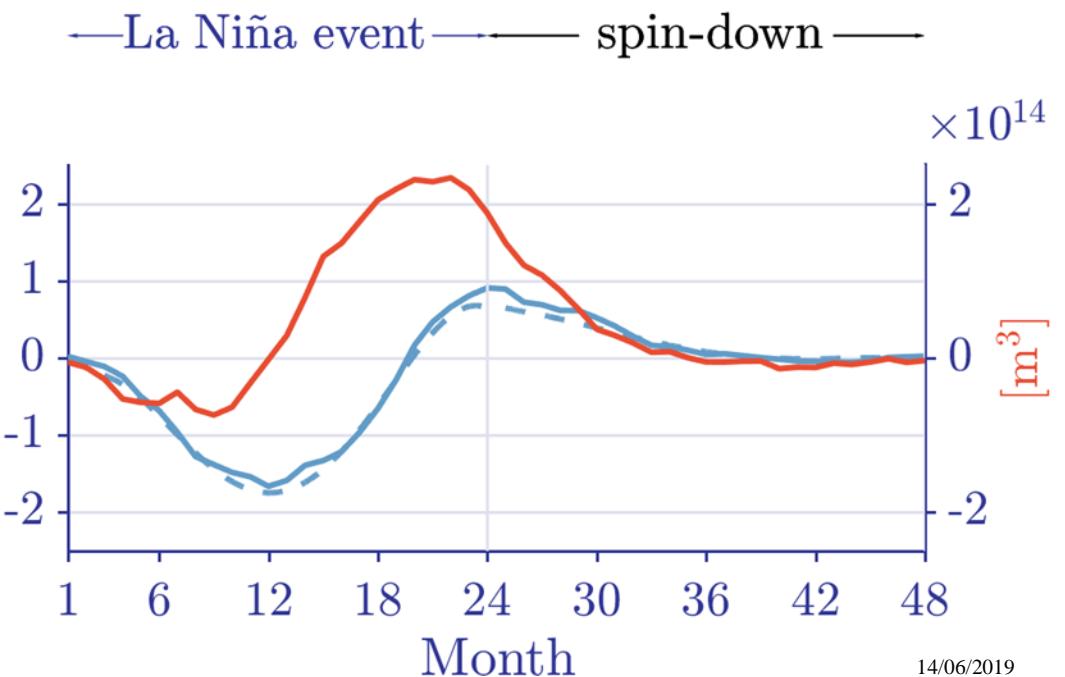
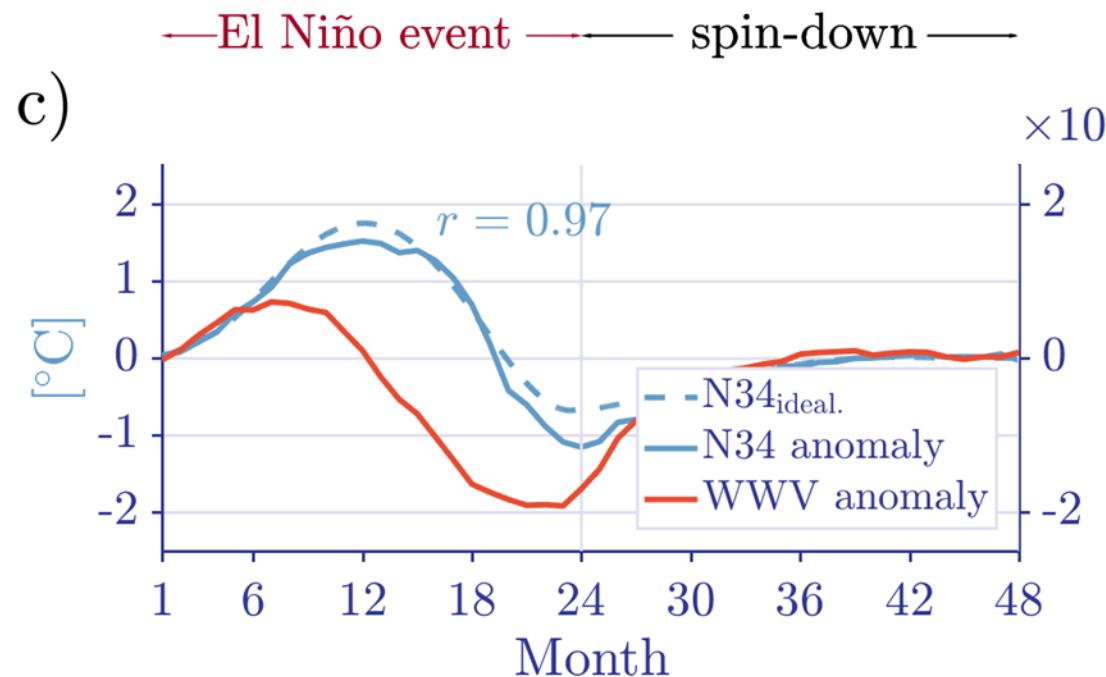
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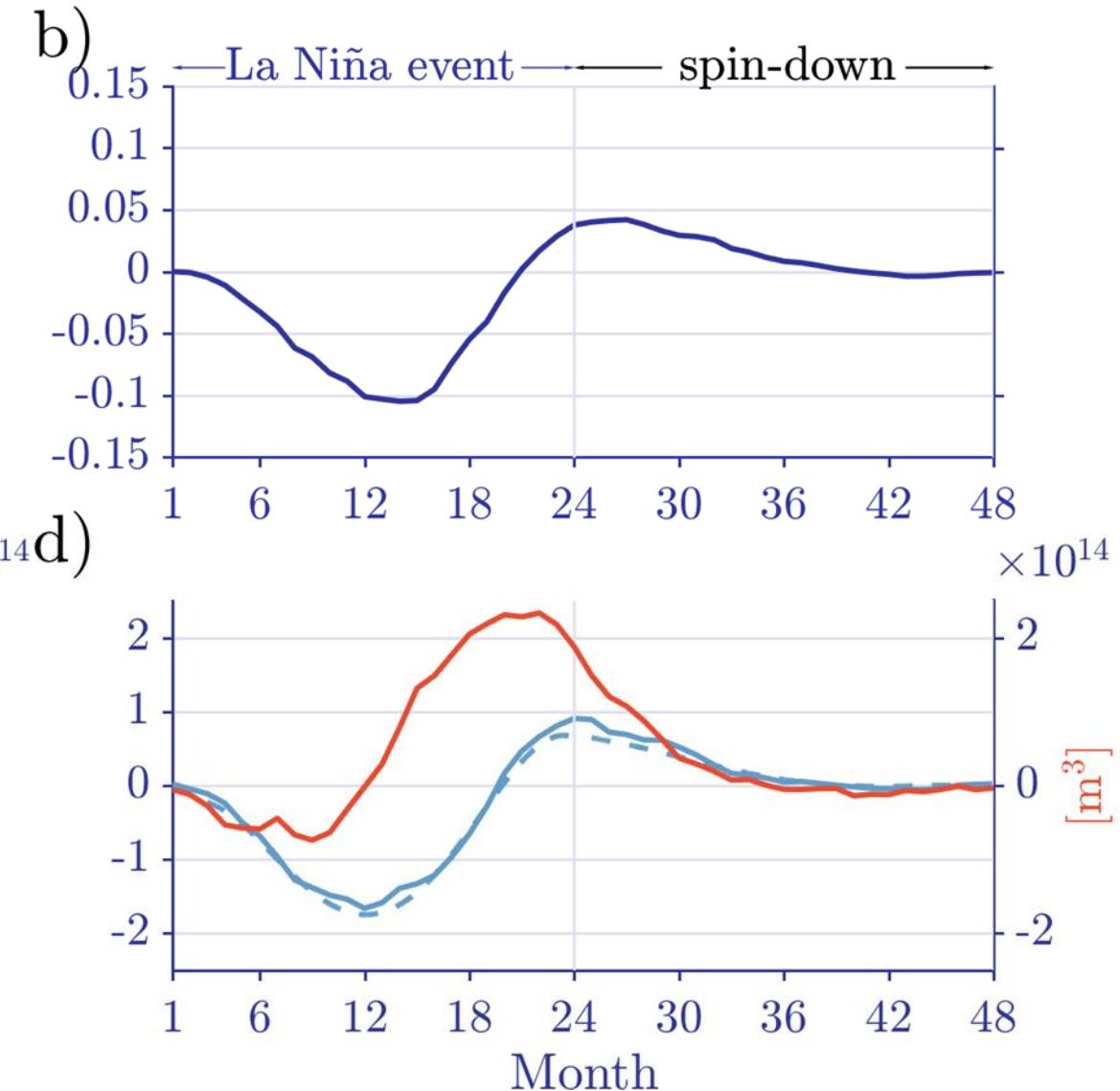
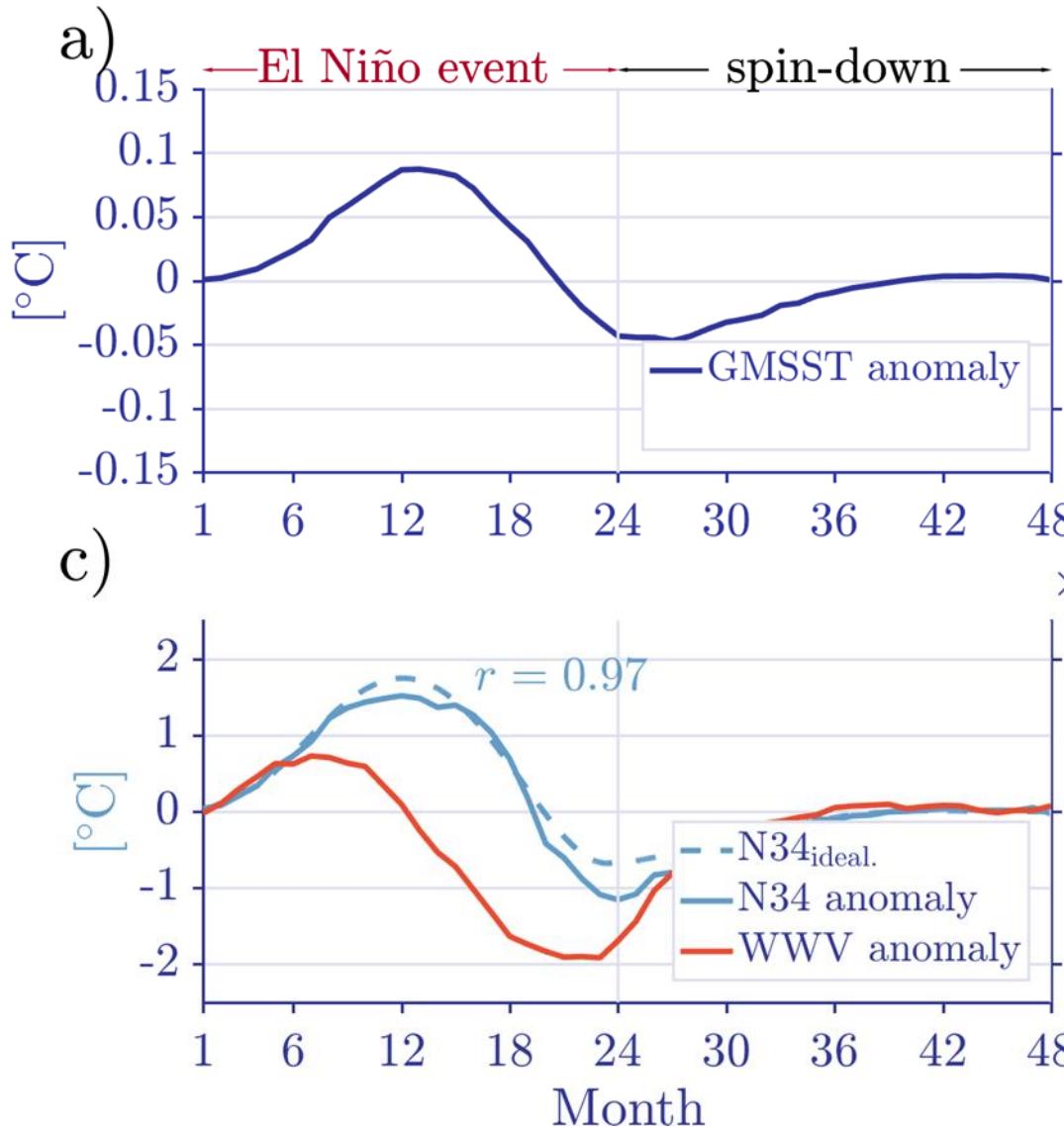
# El Niño and La Niña Time Series



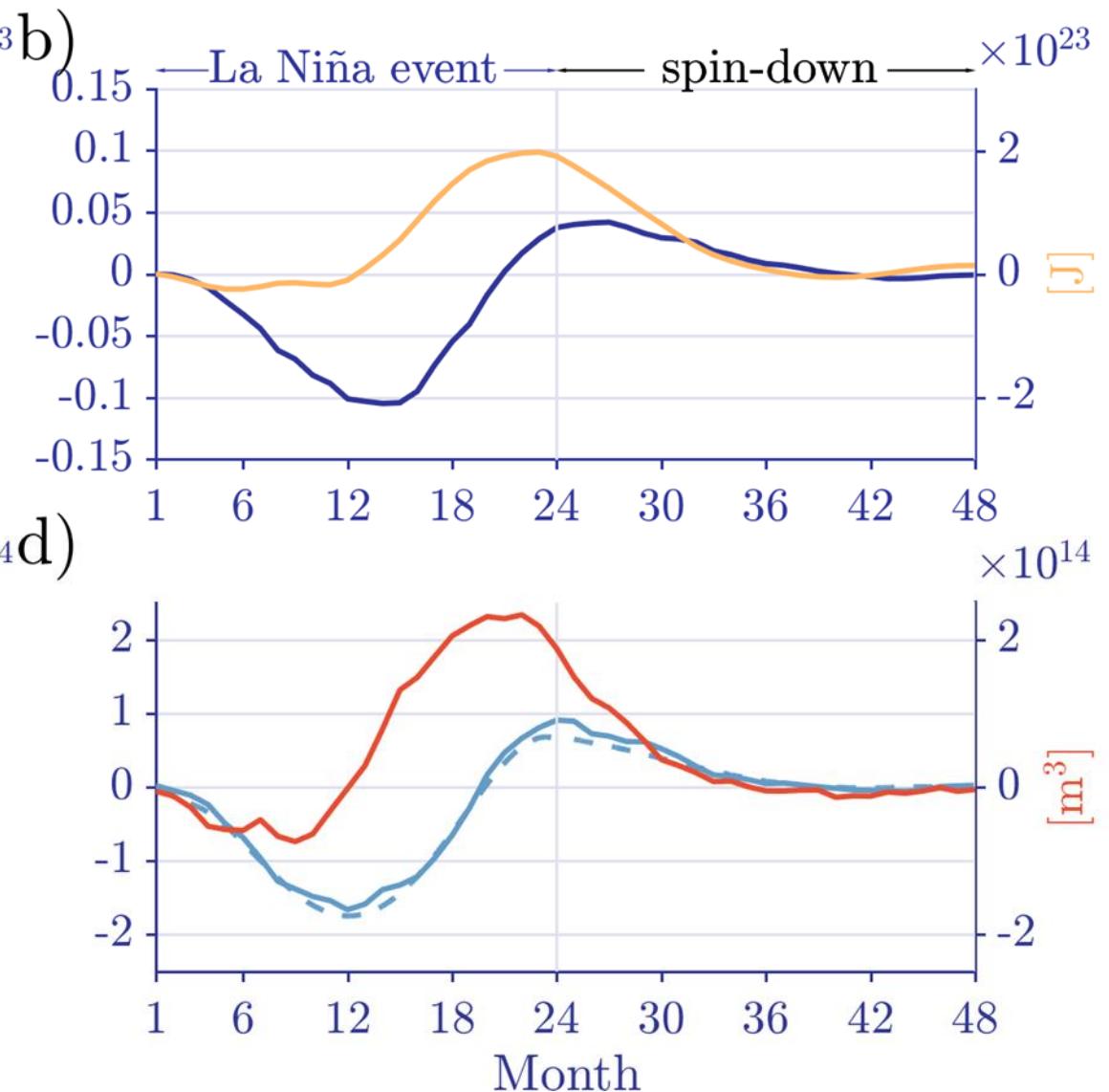
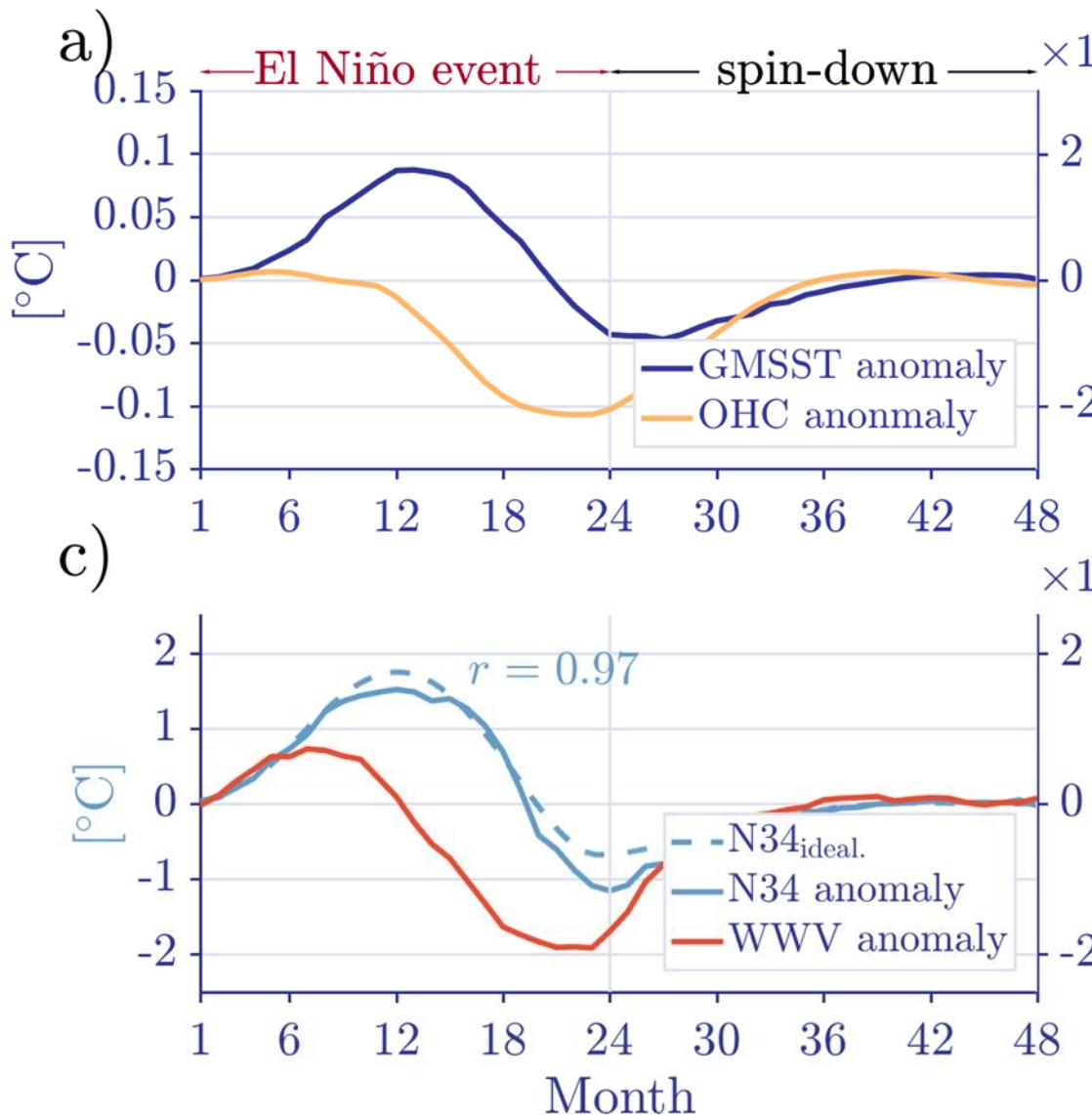
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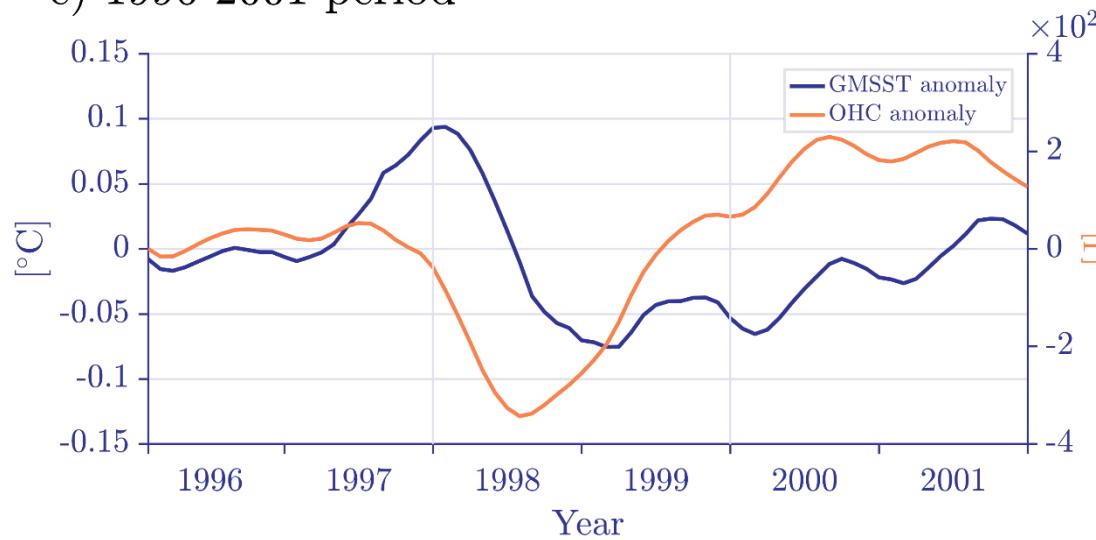


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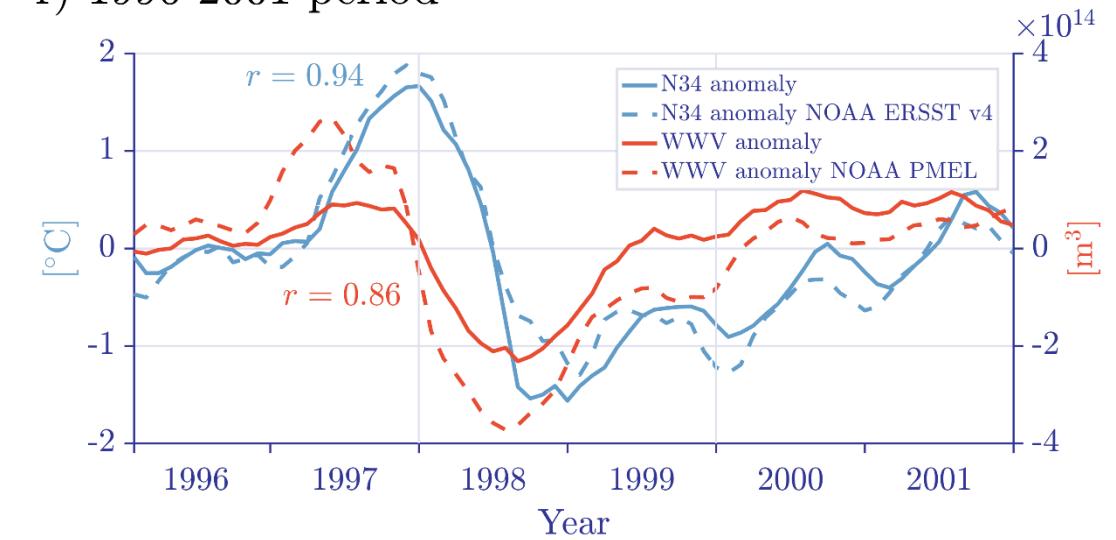


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e) 1996-2001 period

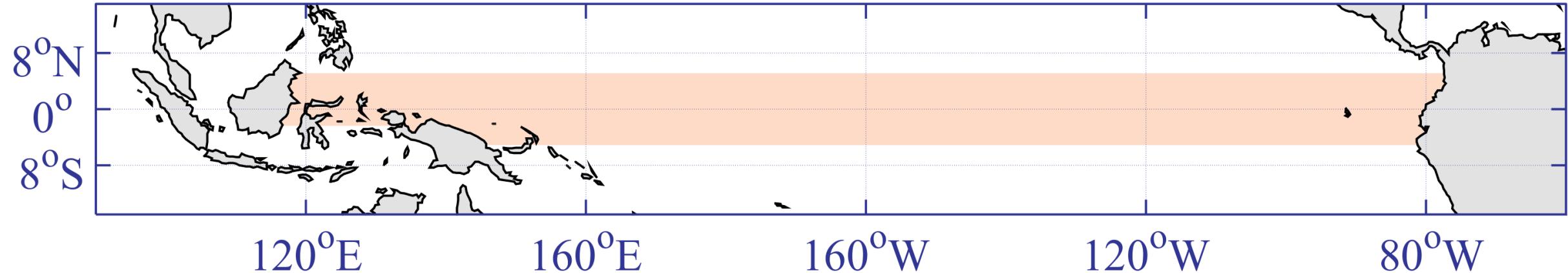


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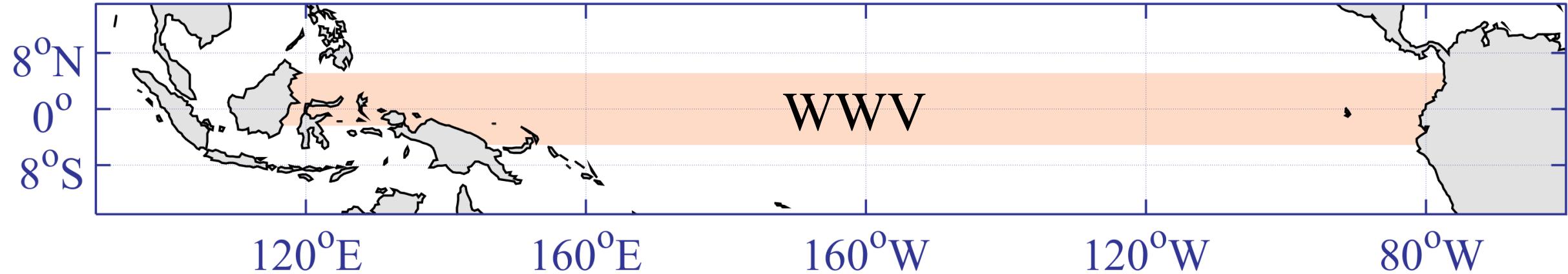


# The Warm Water Volume Balance

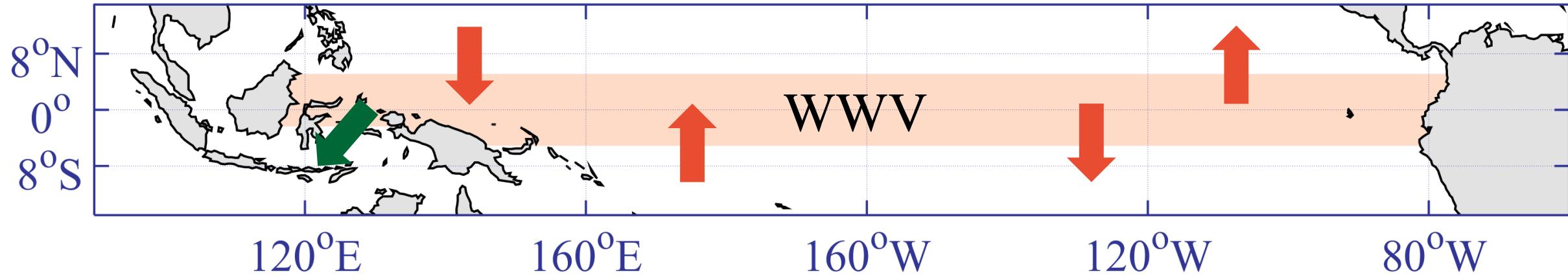
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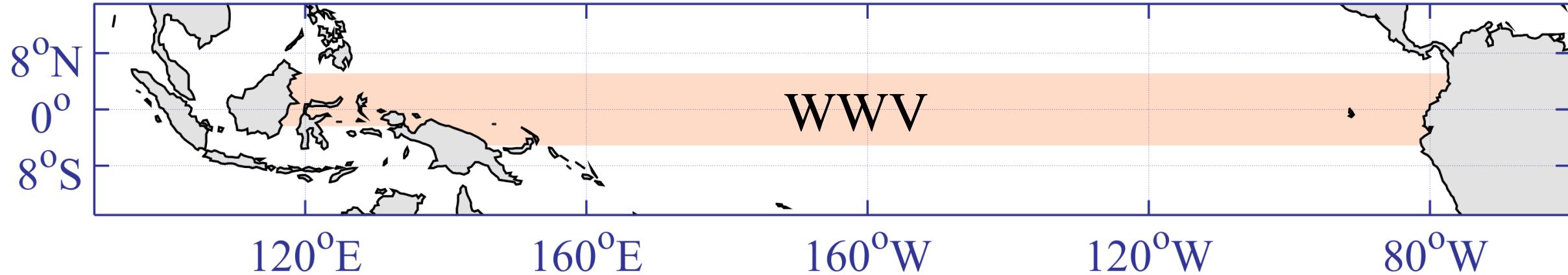


# The Warm Water Volume Balance



- adiabatic processes

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- adiabatic processes
- diabatic processes

# The Diabatic Volume Fluxes

Vertical mixing:  $\mathcal{G}_{\mathcal{M}}$

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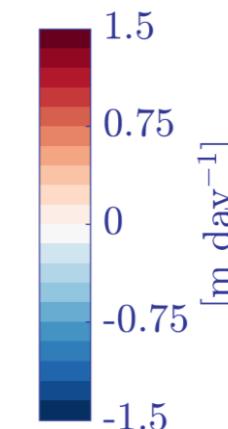
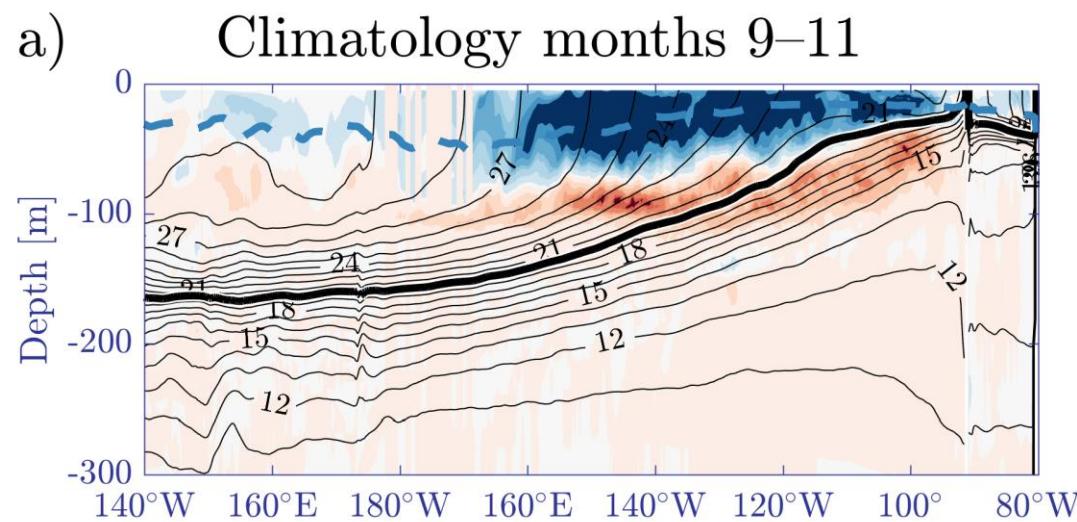
Surface forcing:  $\mathcal{G}_{\mathcal{F}}$

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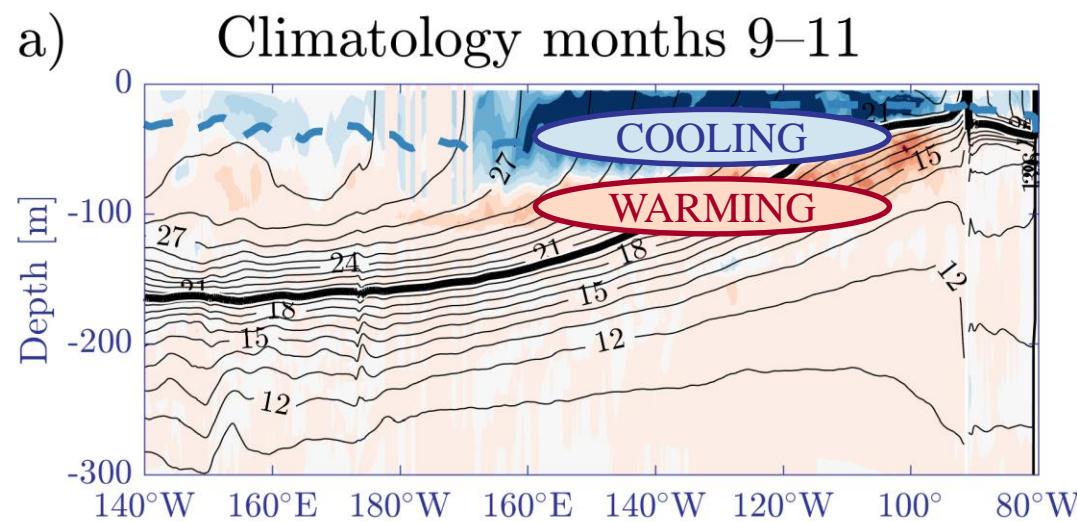


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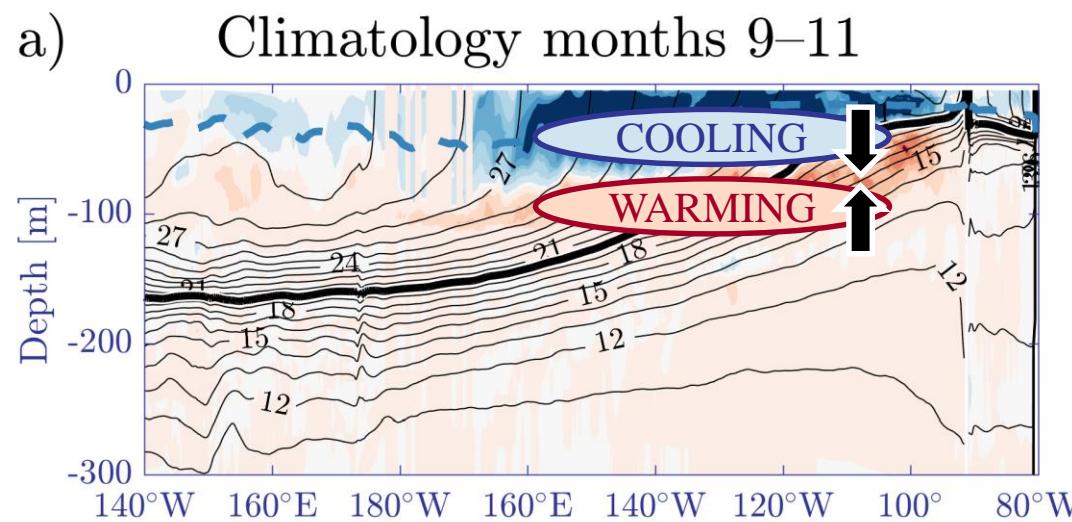
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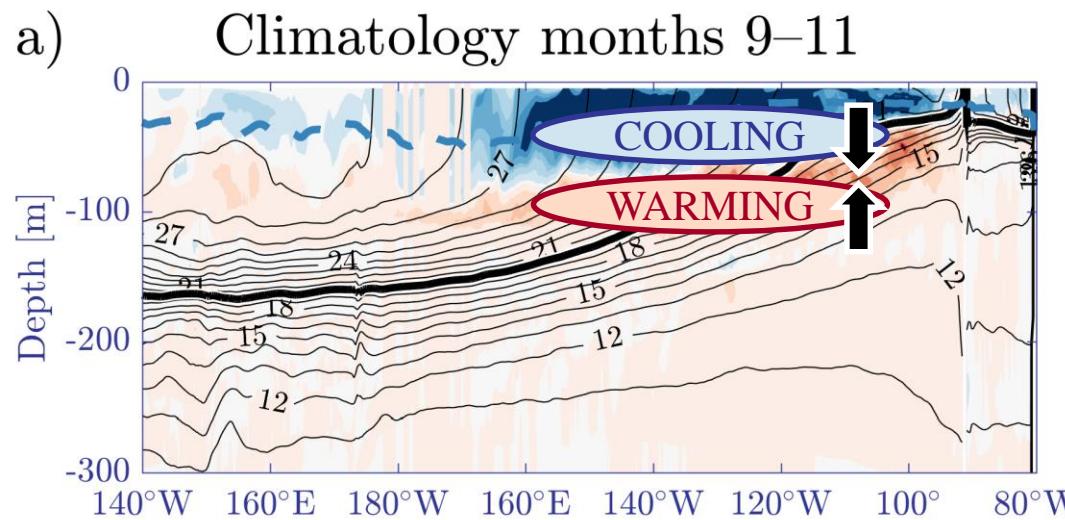
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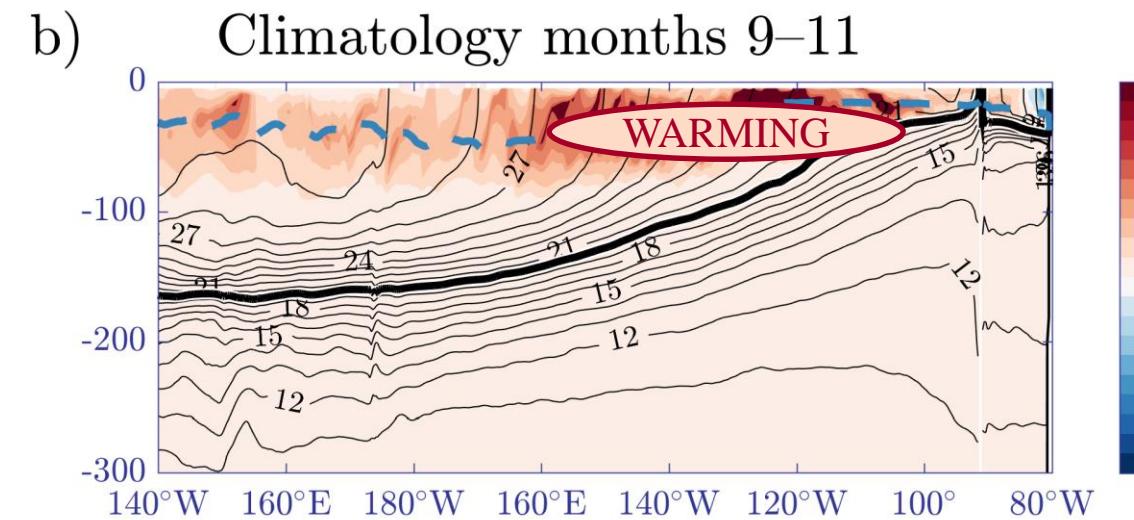


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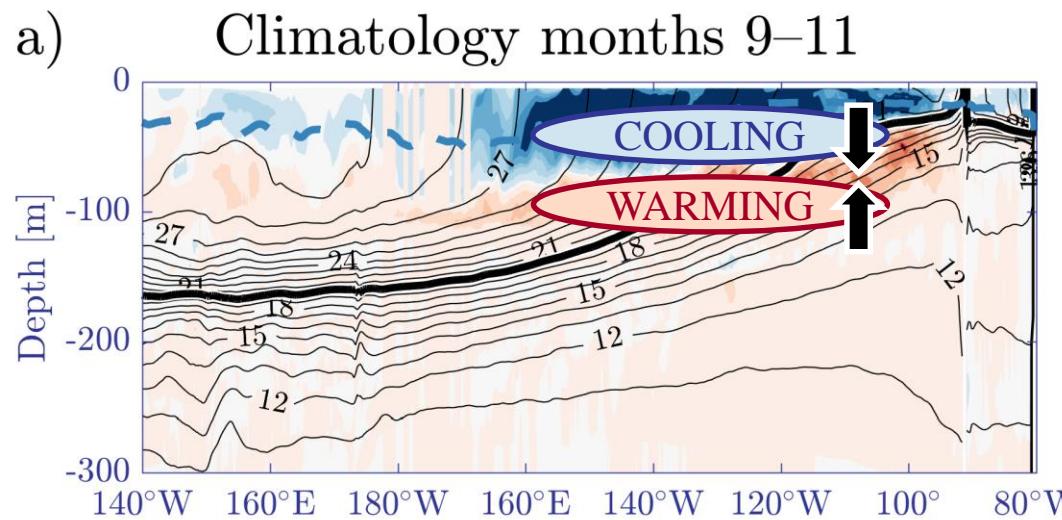


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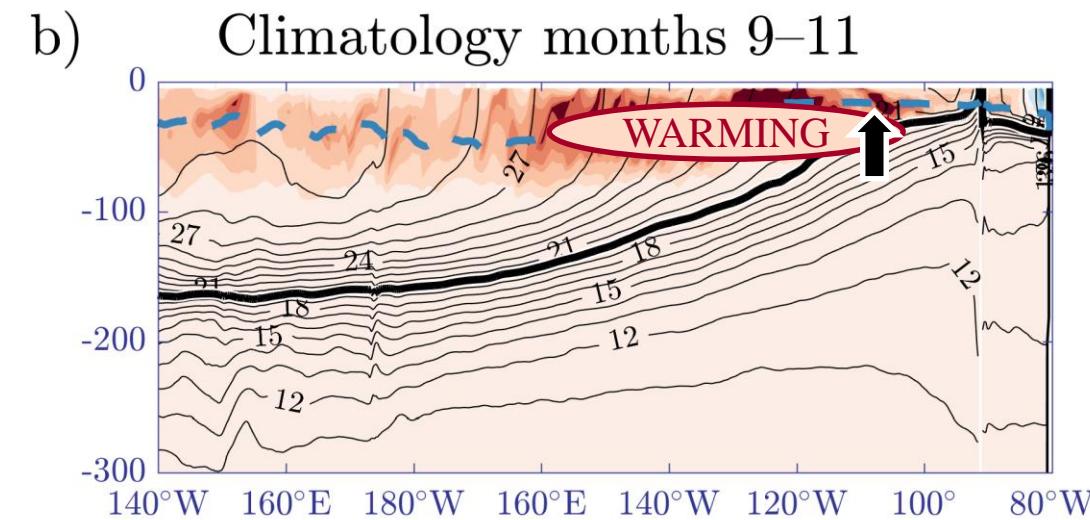


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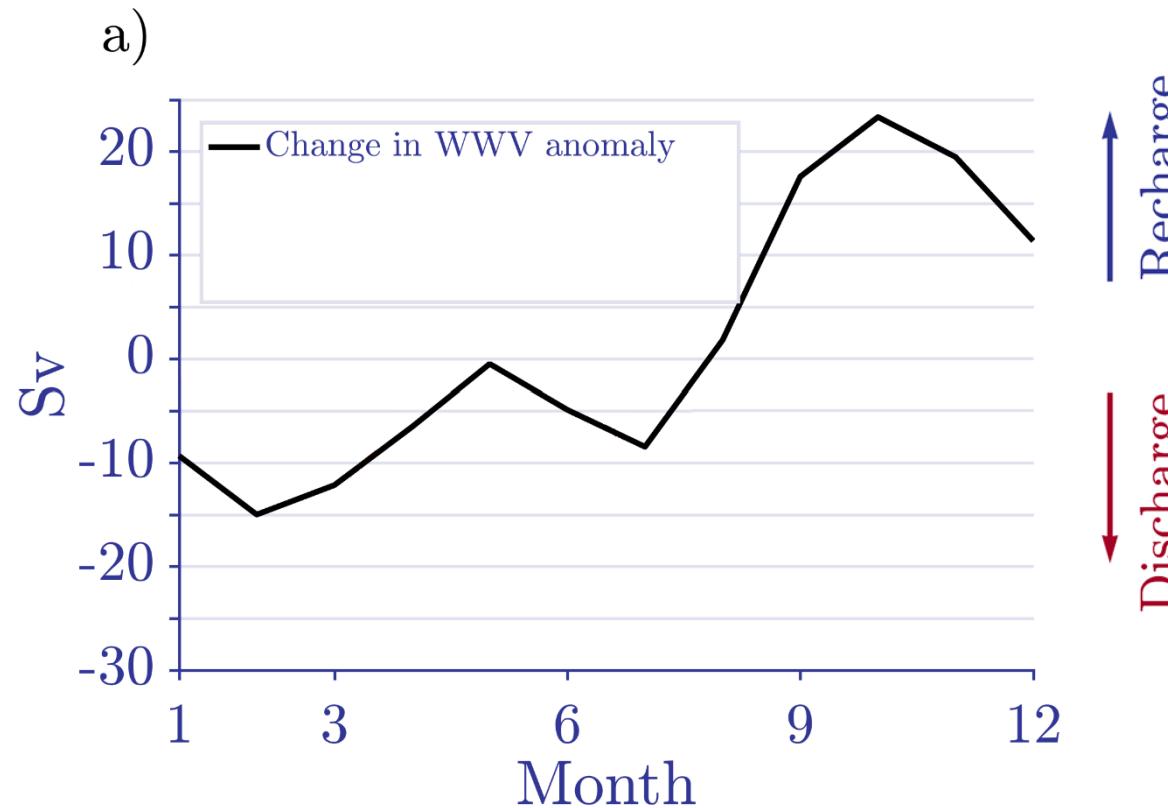
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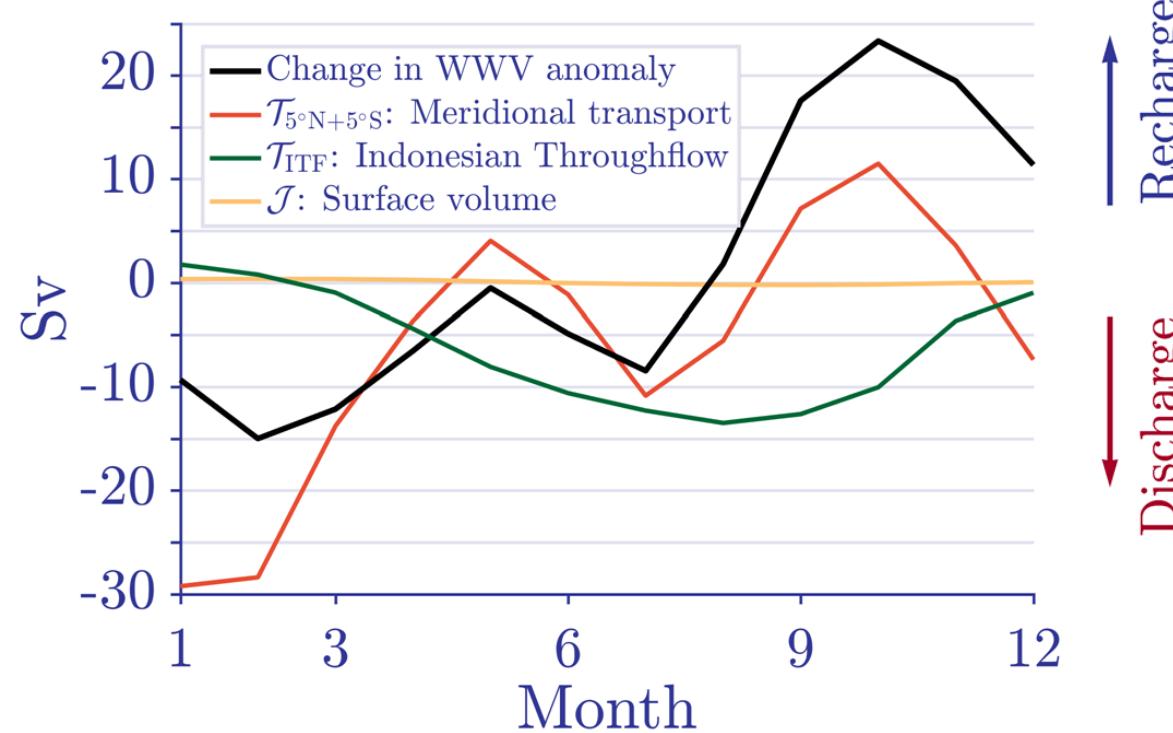
# The climatological WWV budget



↑ Recharge  
↓ Discharge

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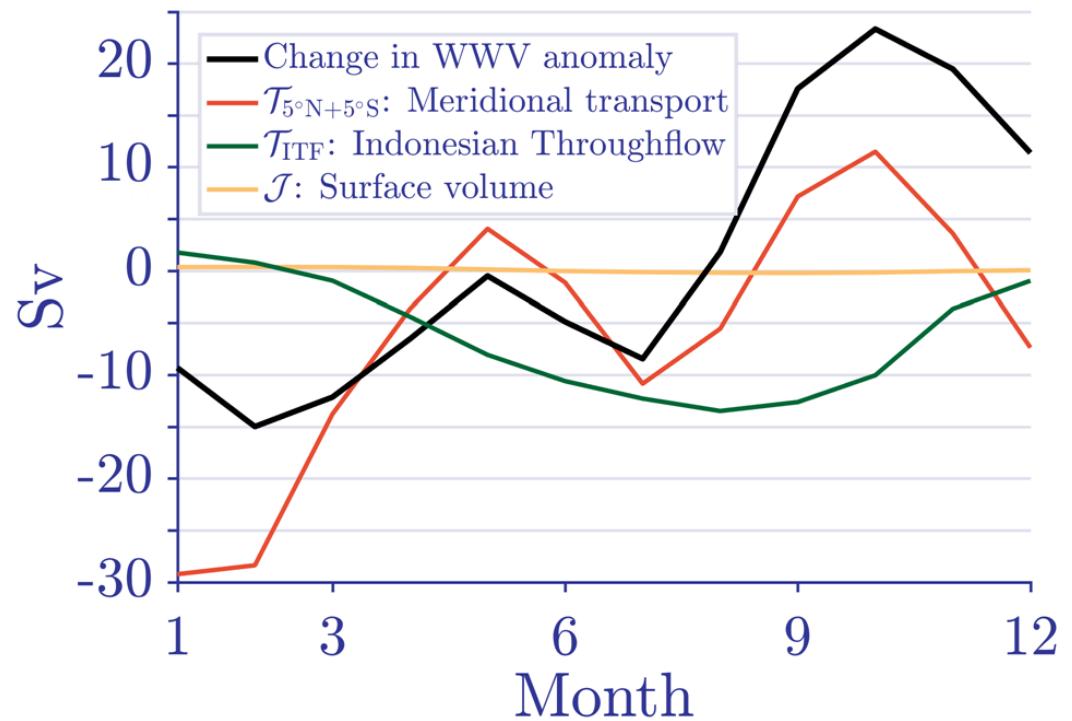
a) Adiabatic fluxes



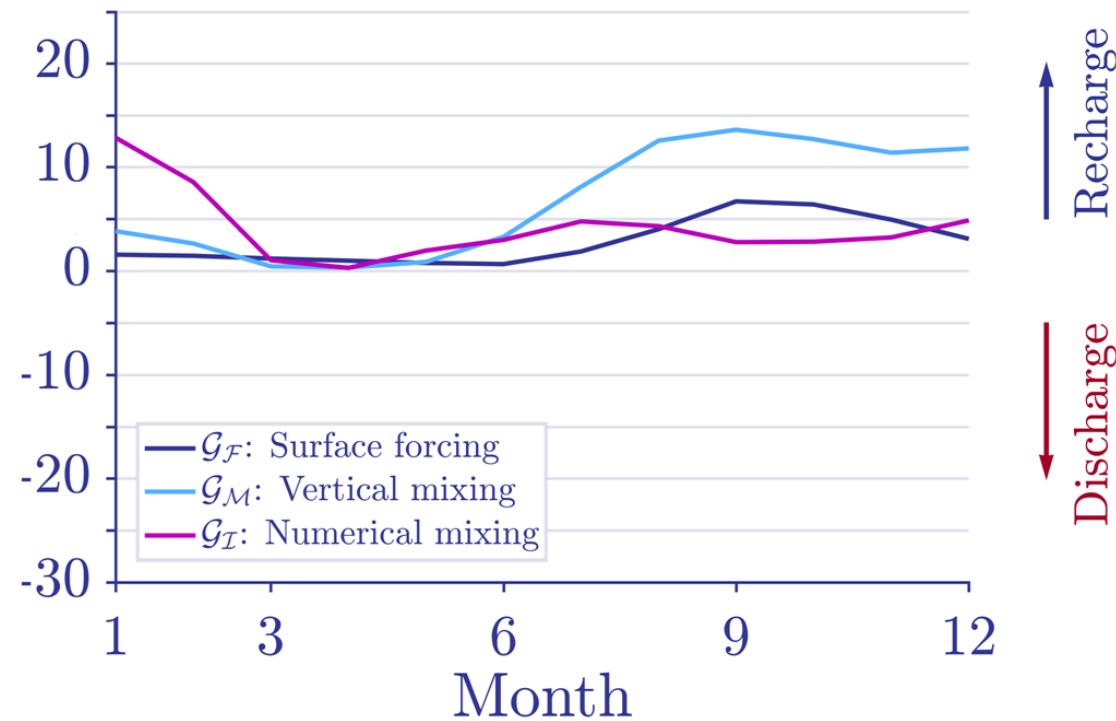
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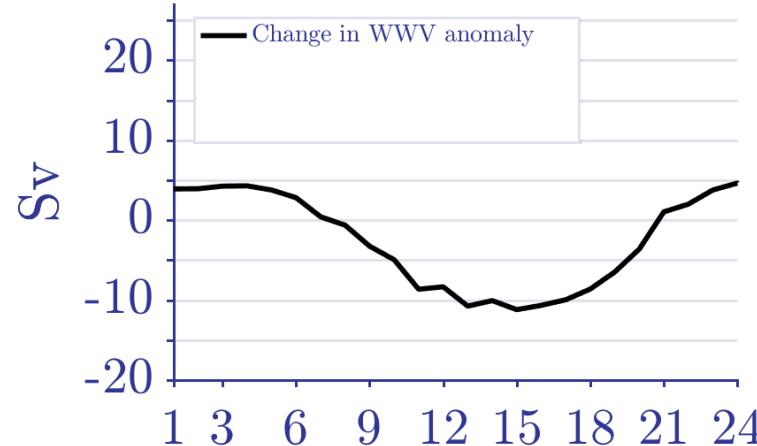


b) Diabatic fluxes

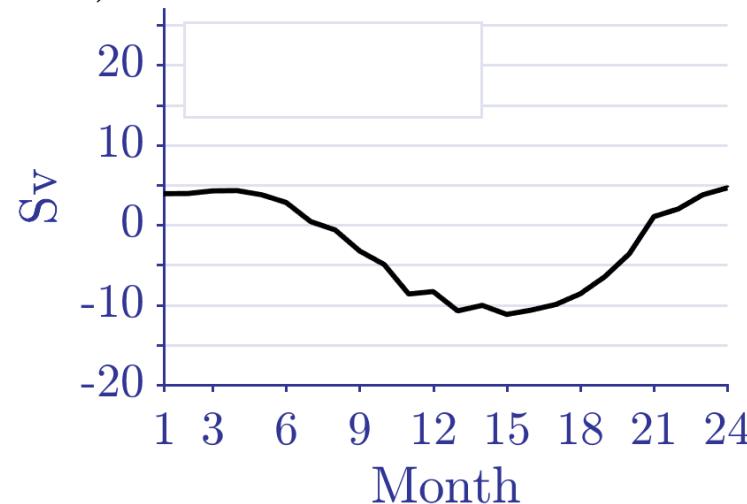


# The WWV Balance during ENSO

a) El Niño:

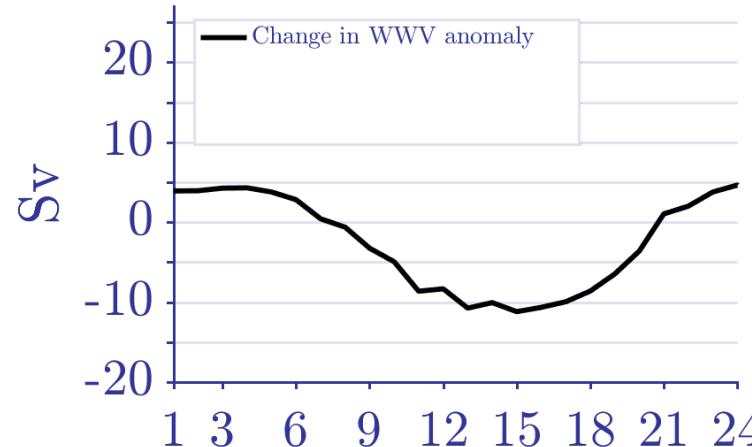


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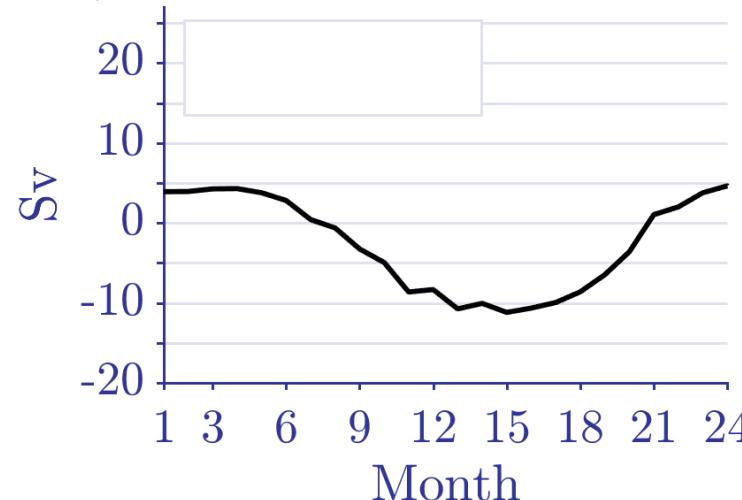


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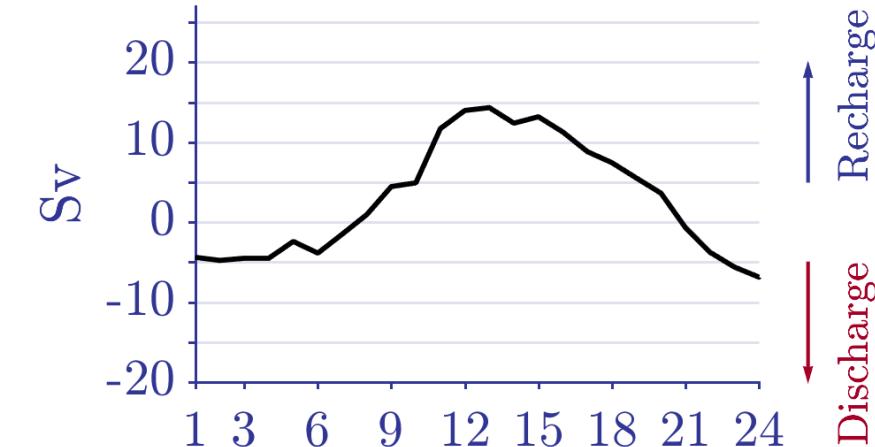
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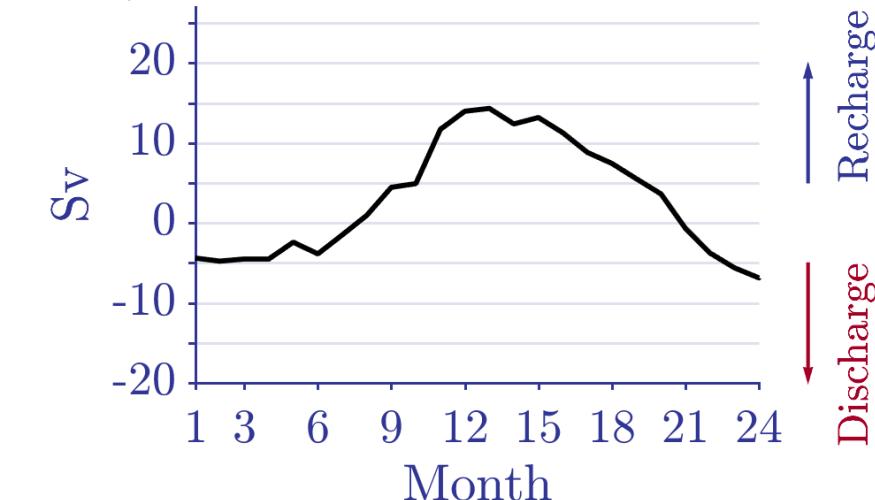
b) El Niño:



b) La Niña:



d) La Niña:



↔ Recharge

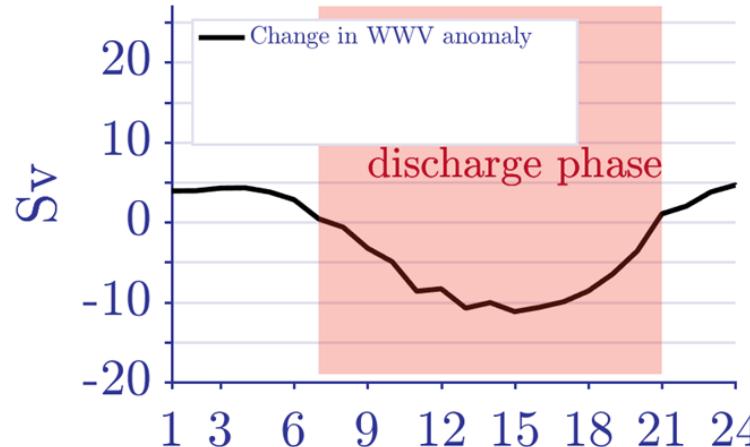
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↔ Recharge

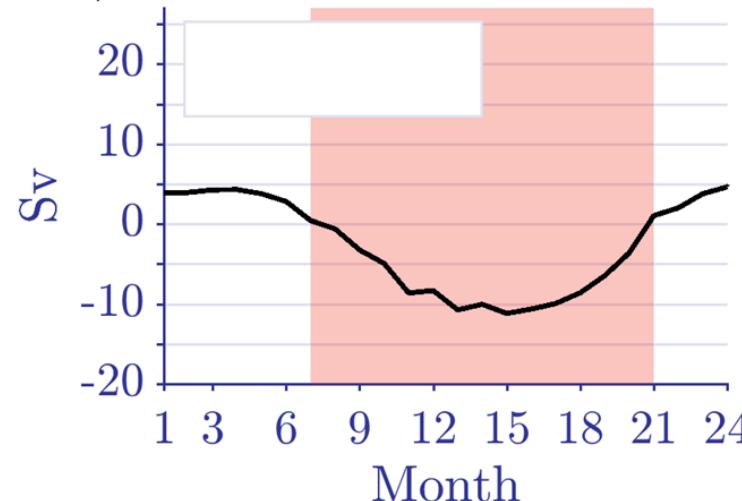
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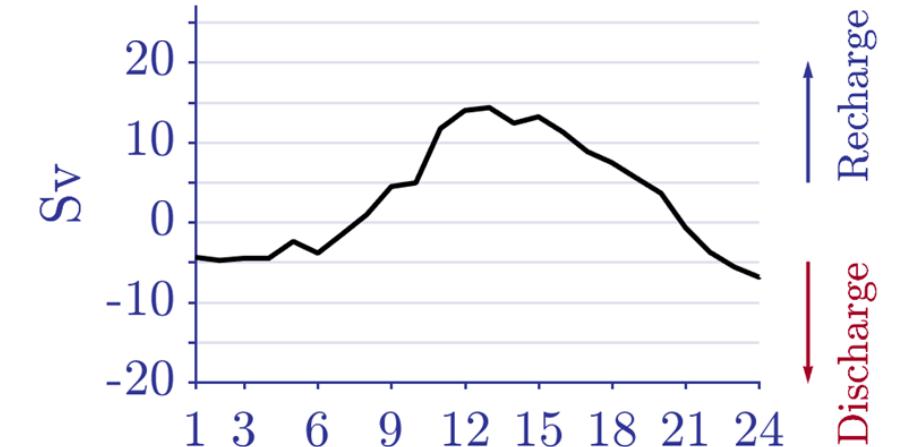
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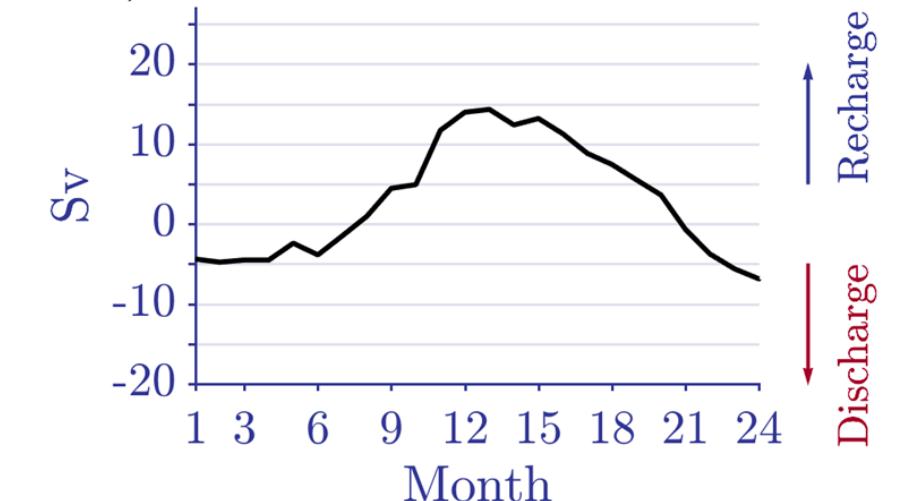
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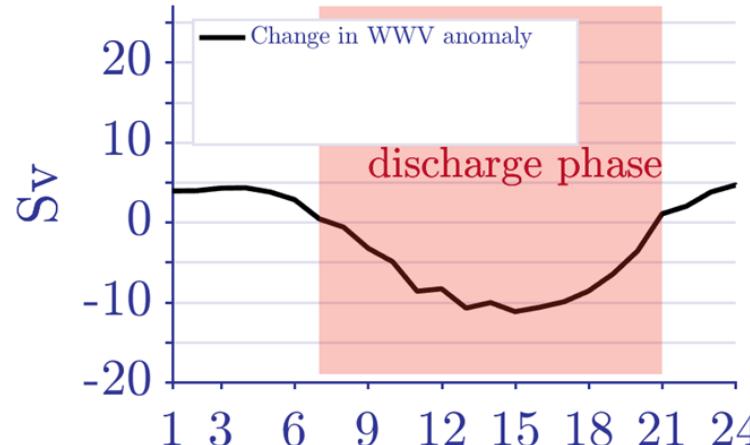


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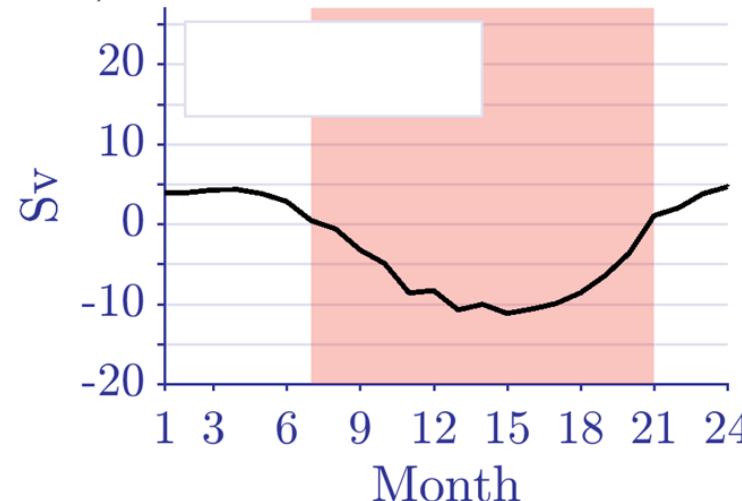


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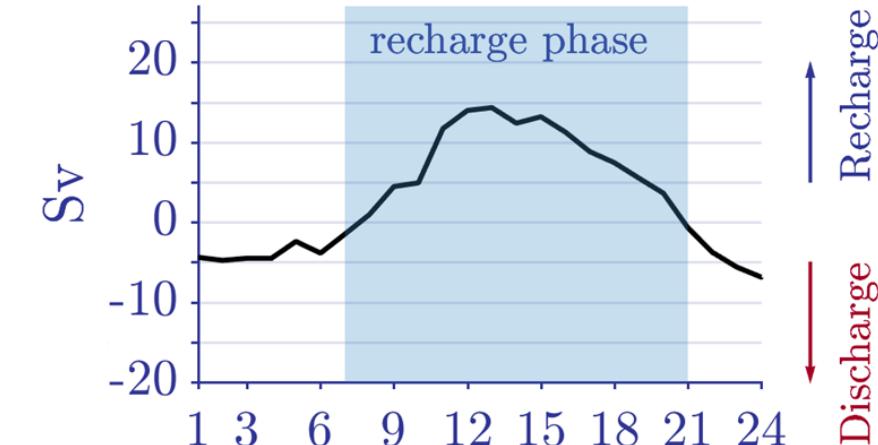
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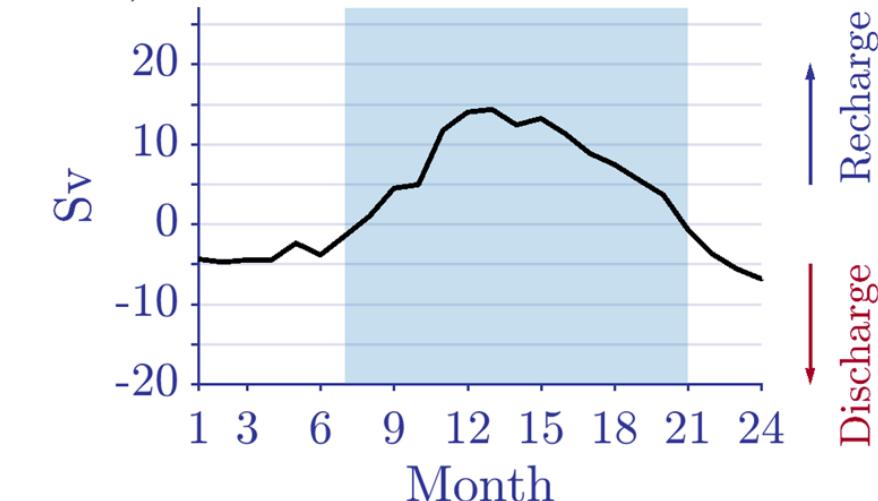
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d) La Niña:



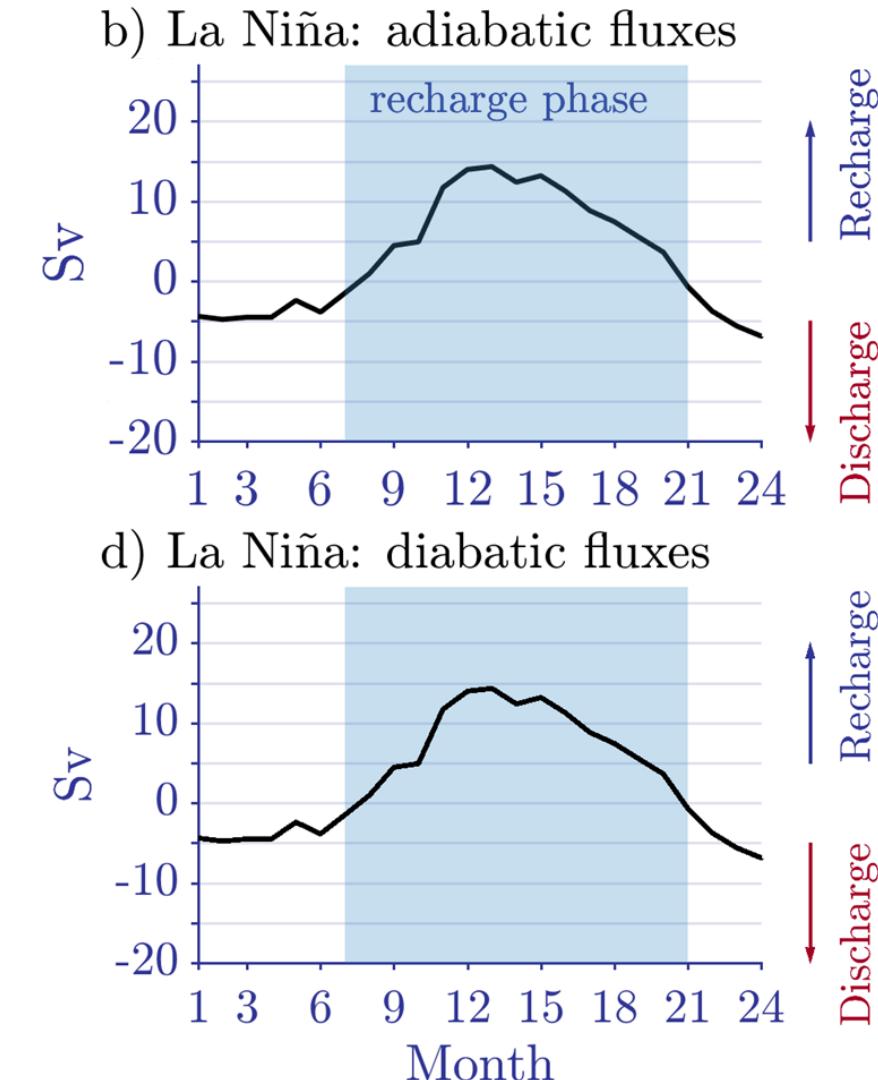
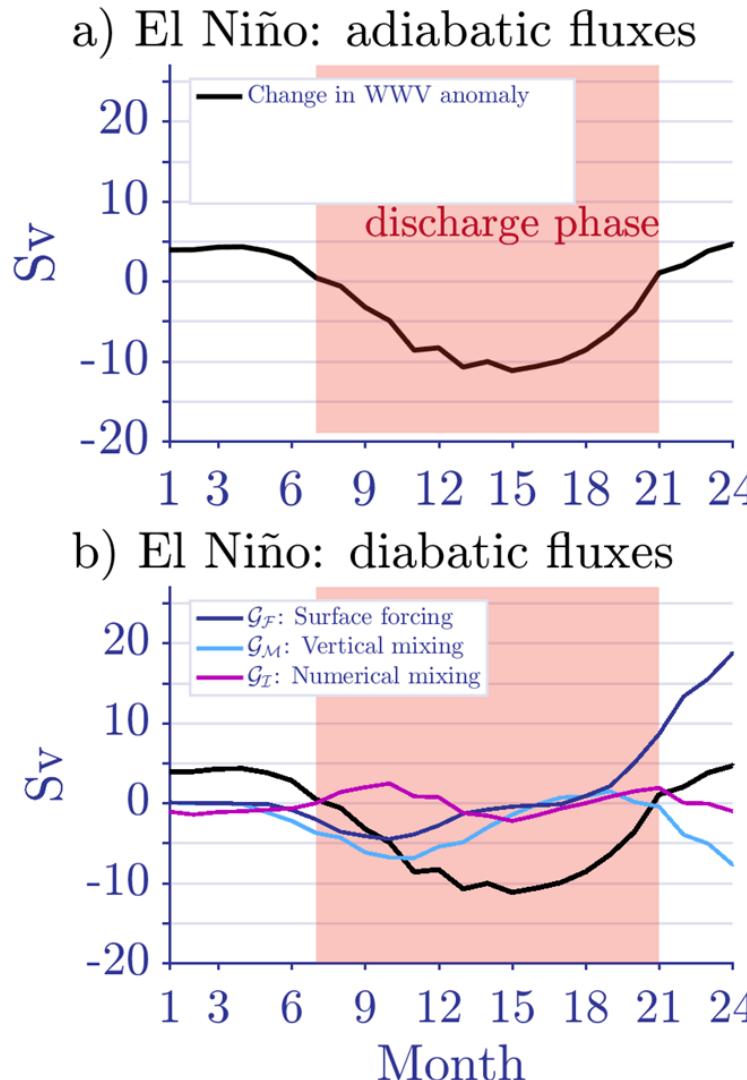
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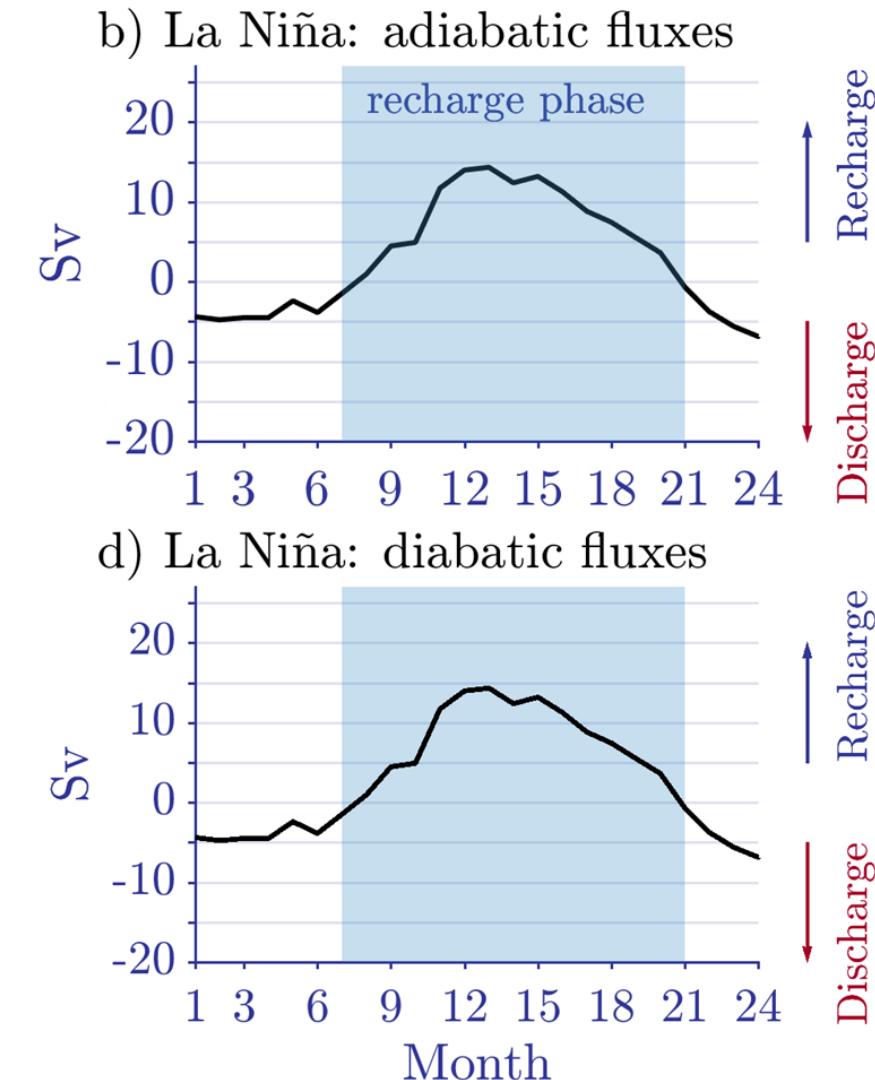
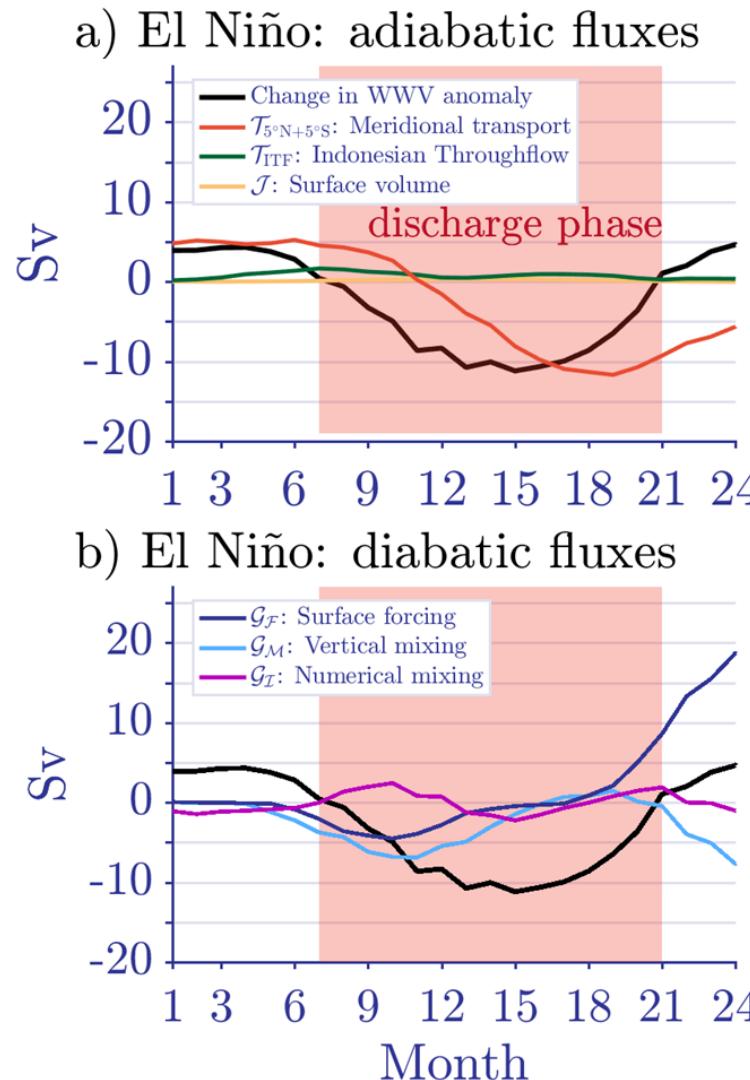
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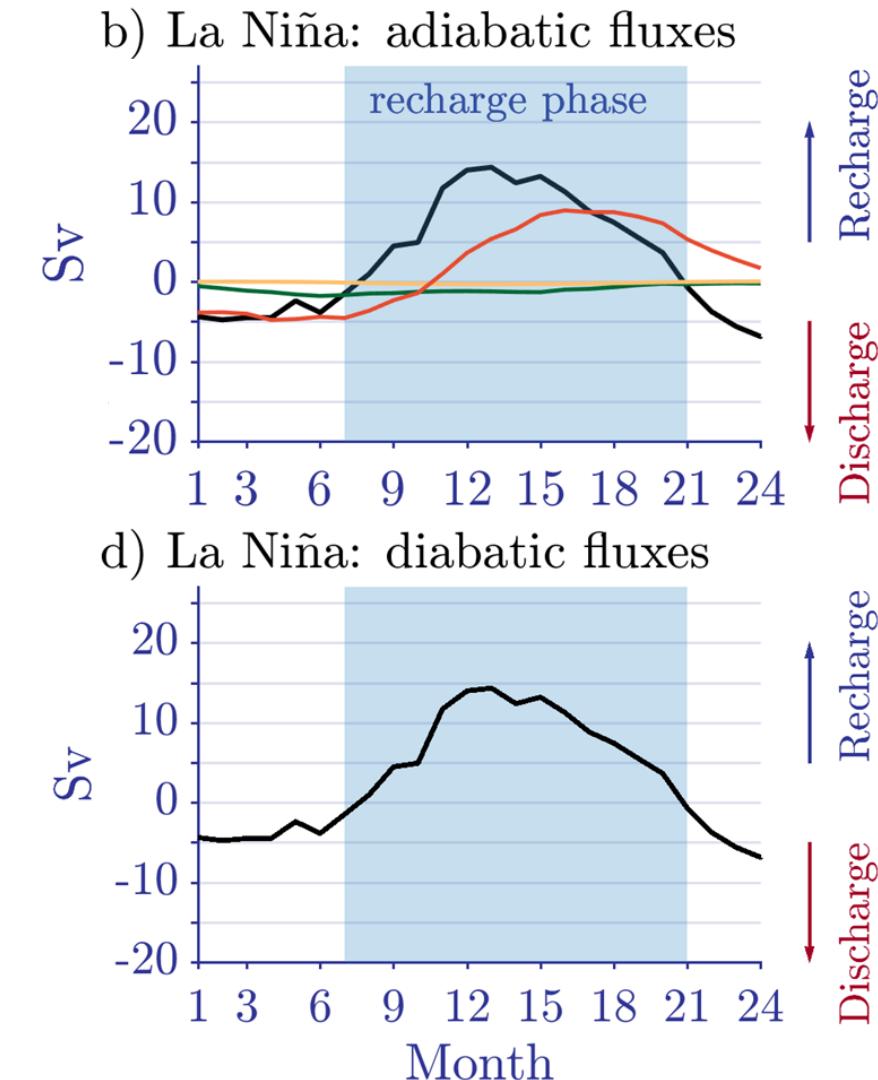
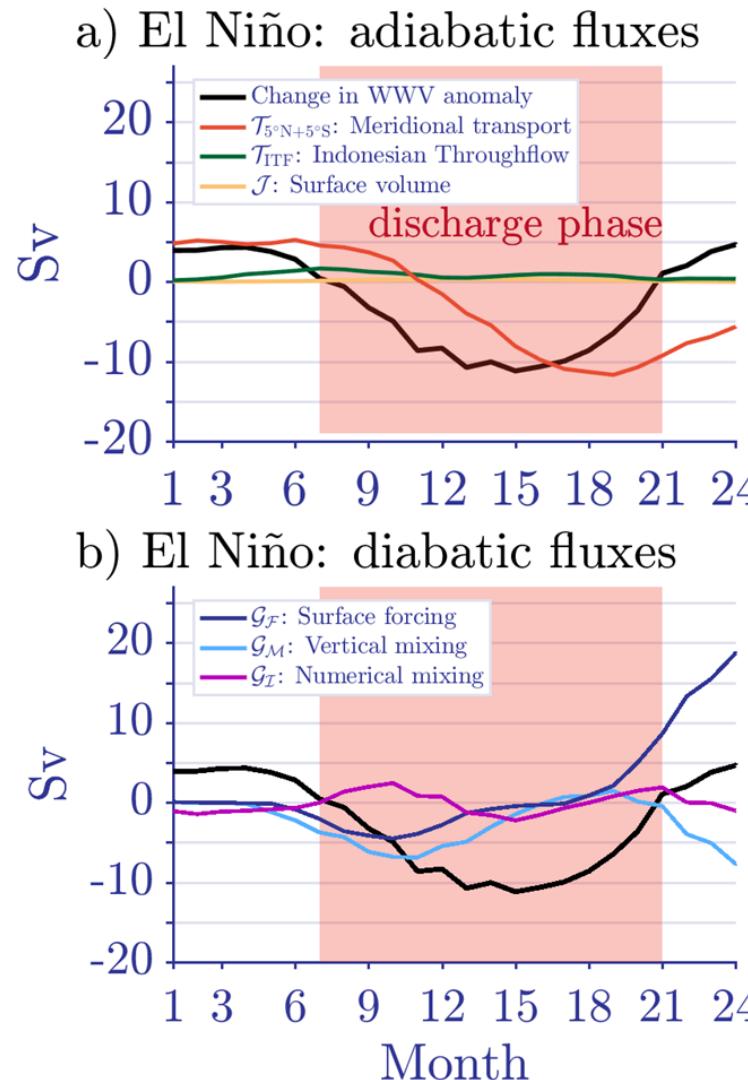
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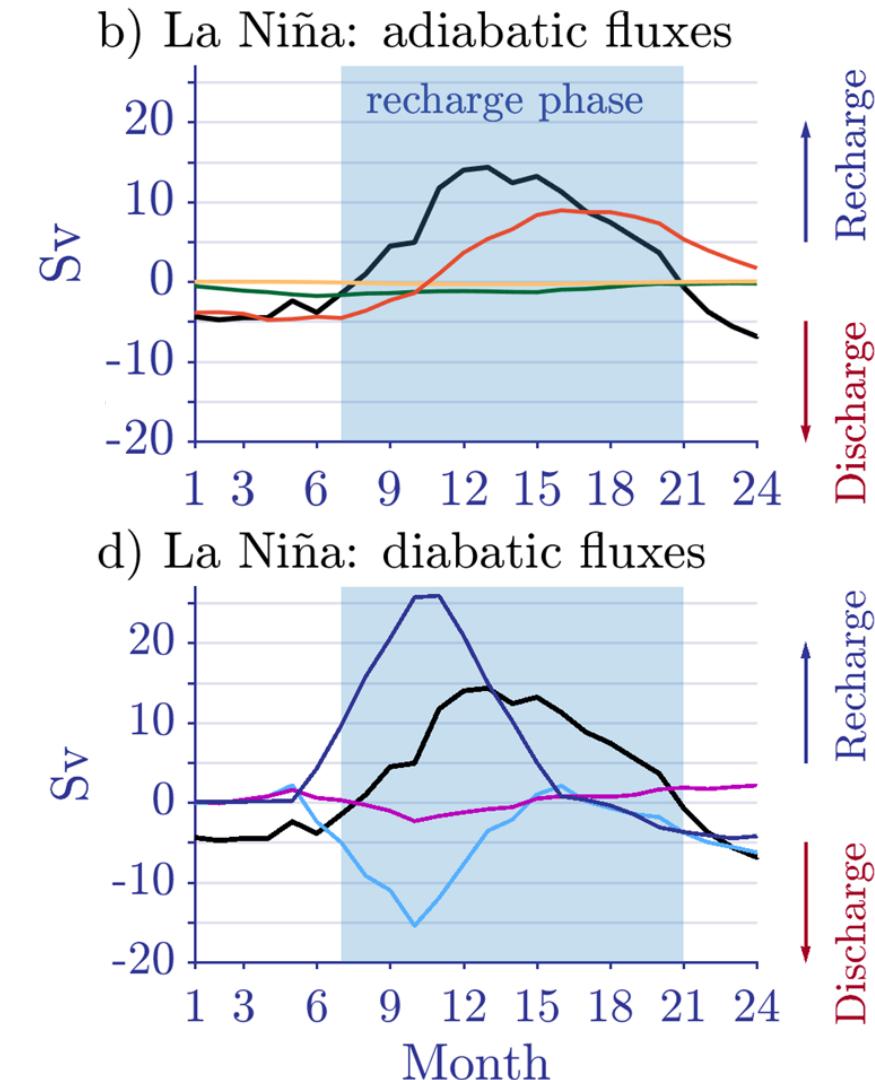
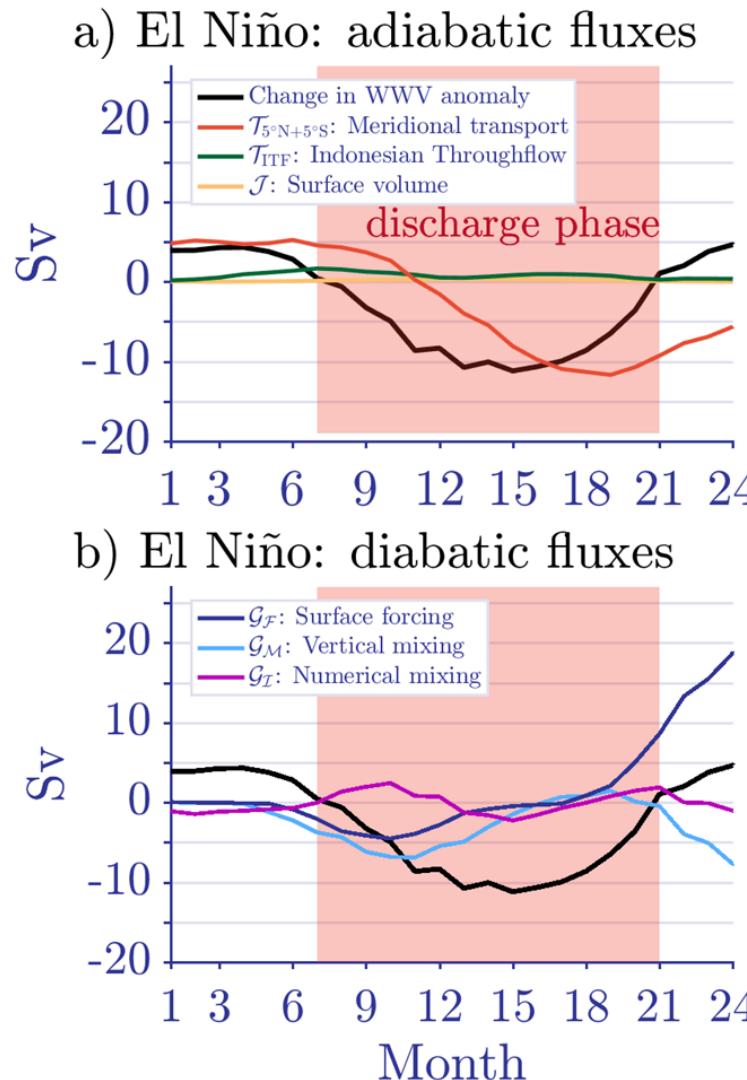
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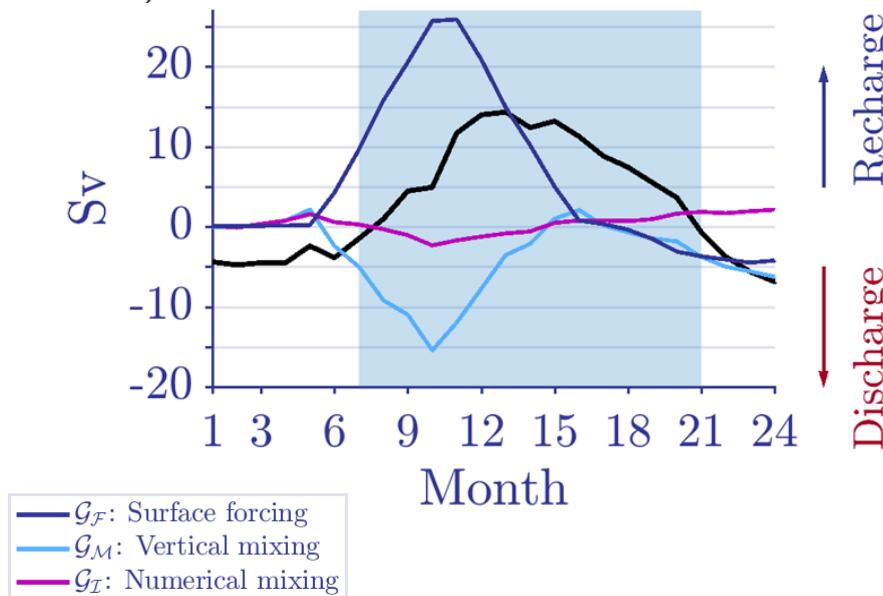


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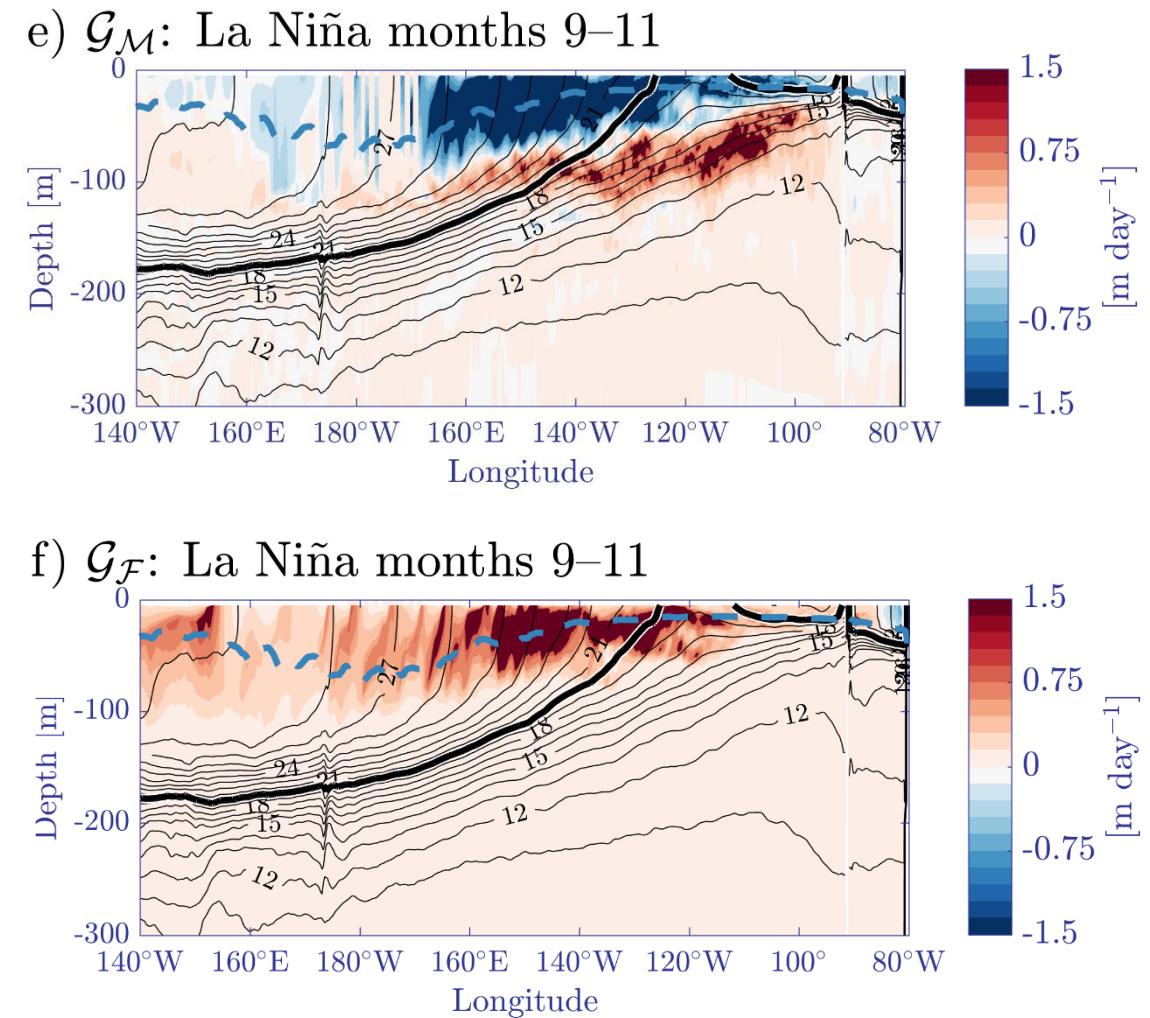
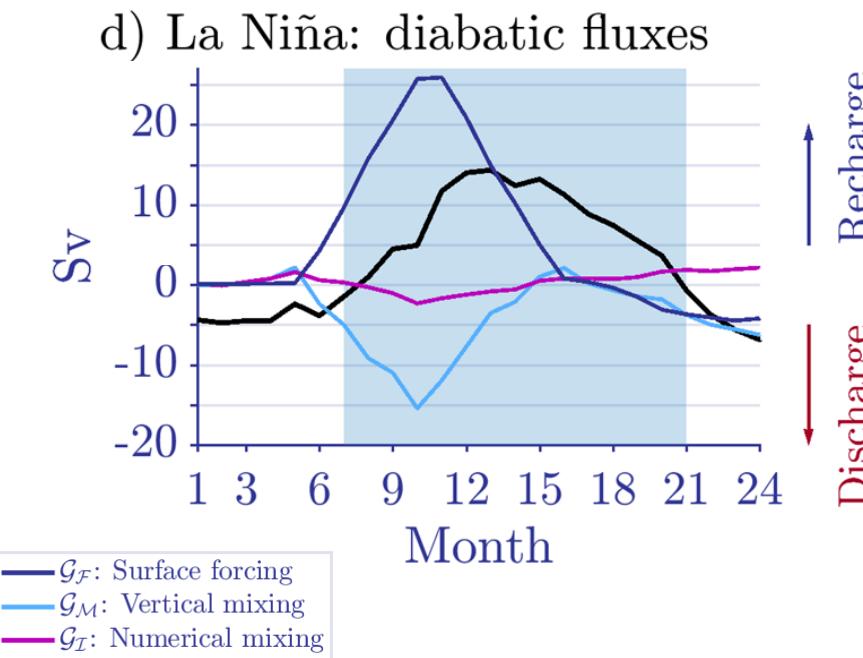


# The WWV Balance during ENSO

d) La Niña: diabatic fluxes



# The WWV Balance during ENSO



## Take – Home Messages

- Initial changes dominated by diabatic fluxes, followed by adiabatic transport later

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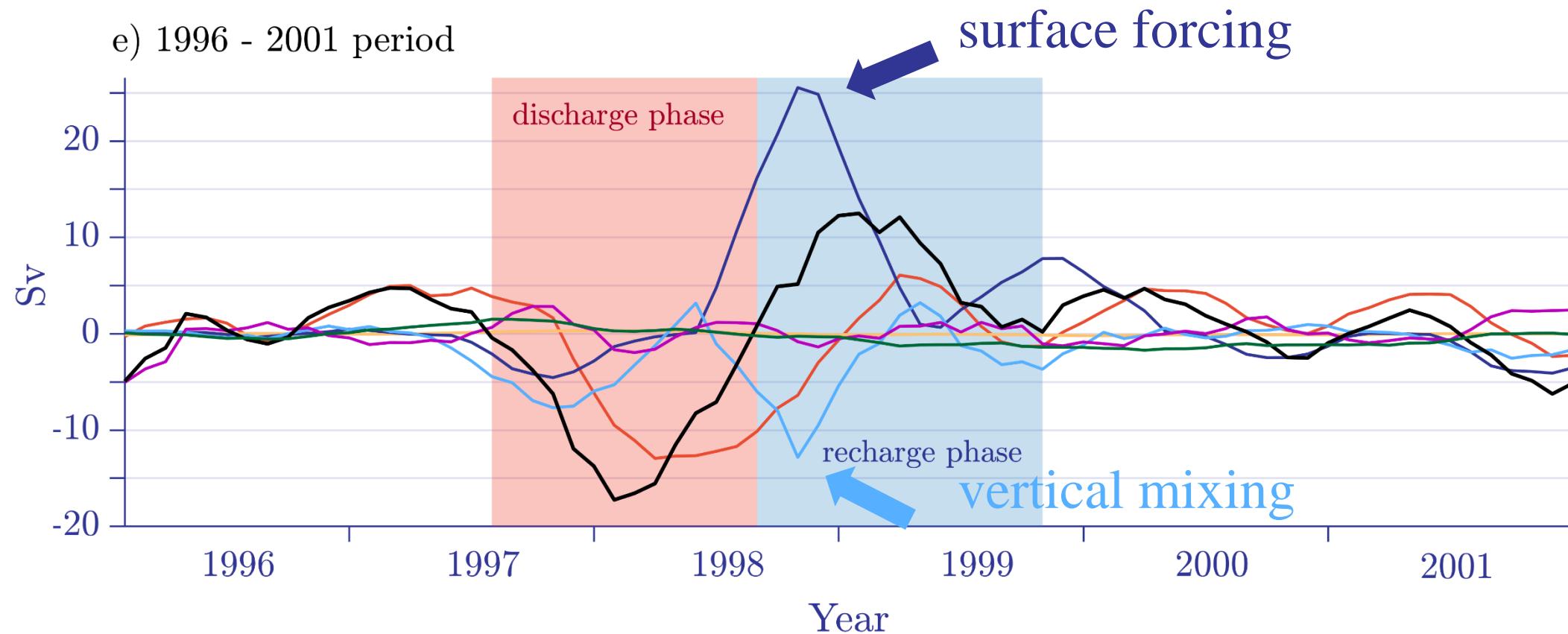
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- Adiabatic transport largely symmetric between El Niño and La Niña

## Take – Home Messages

- Initial changes dominated by diabatic fluxes, followed by adiabatic transport later
- Adiabatic transport largely symmetric between El Niño and La Niña
- Strong asymmetry in diabatic fluxes caused by upward shift of 20°C isotherm

12:43.27 min

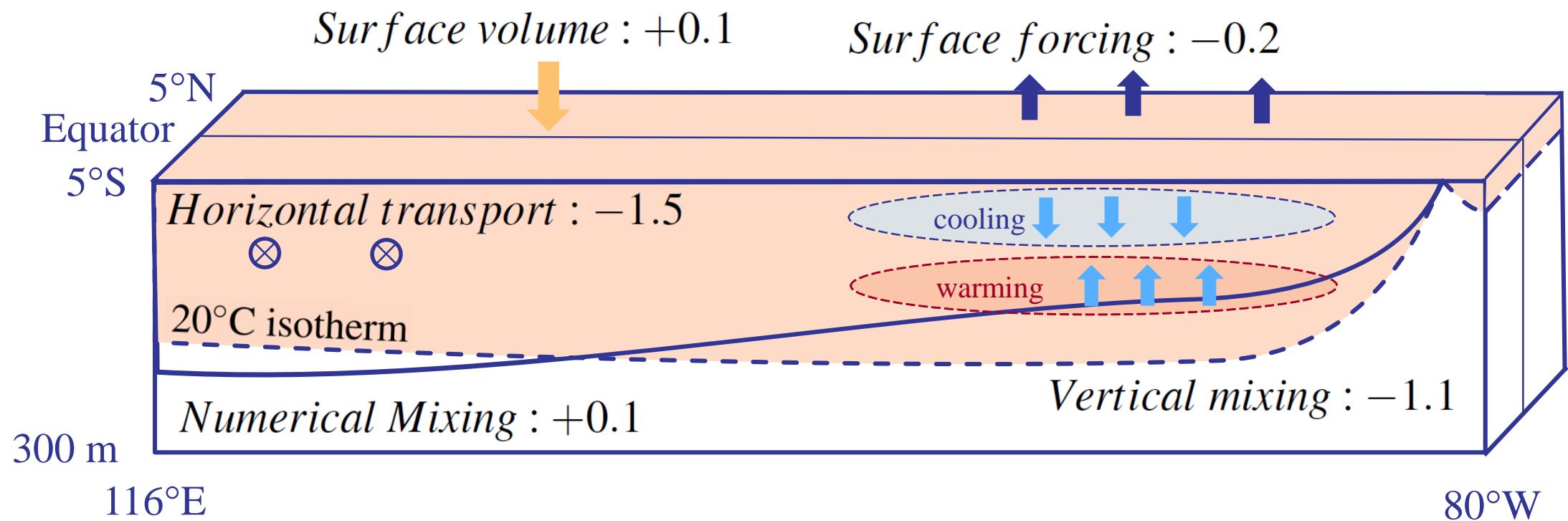
# WWV Balance Terms throughout ENSO



# El Niño Discharge

All units: [ $\times 10^{14} \text{ m}^3$ ]

total WWV change:  $-2.5$



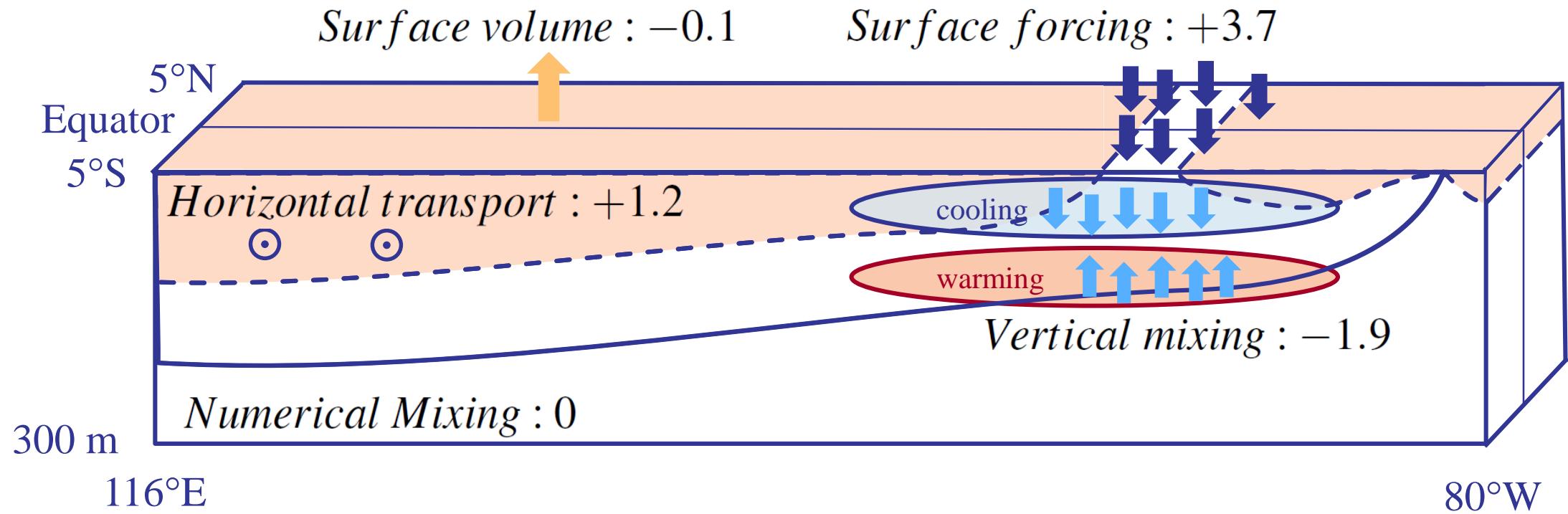
diabatic: 40%

adiabatic 60%

# La Niña Recharge

All units: [ $\times 10^{14} \text{ m}^3$ ]

total WWV change: +2.9



diabatic: 60%

adiabatic 40%

# Take-Home

El Niño



diabatic: 40%

adiabatic 60%

La Niña



diabatic: 60%

adiabatic 40%