

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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- Lengaigne et al (2012) model study: diabatic contribution varies
- Disagreement amongst other studies

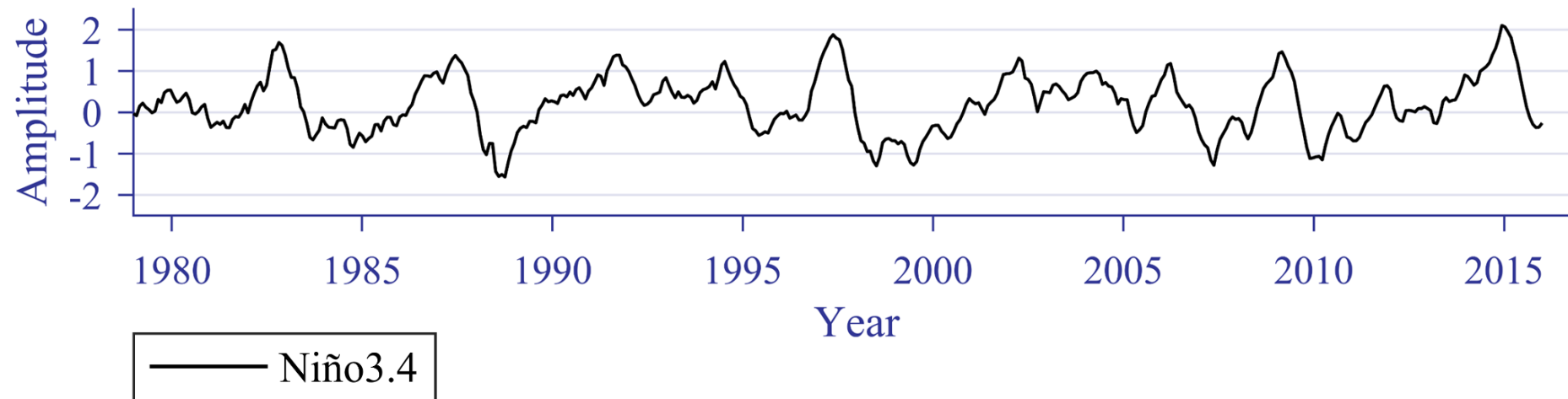
Goals

- 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

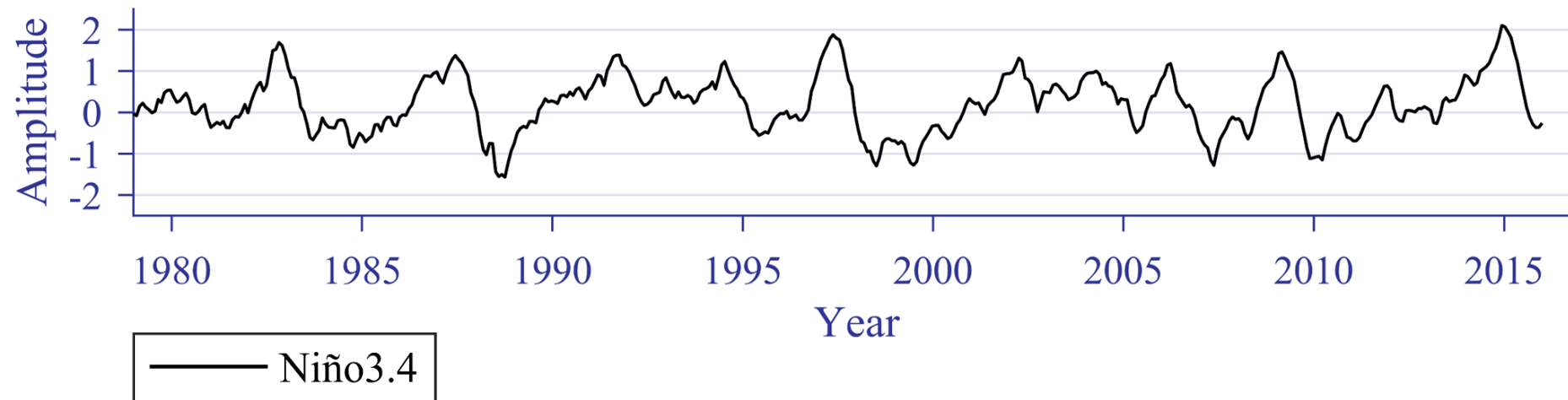
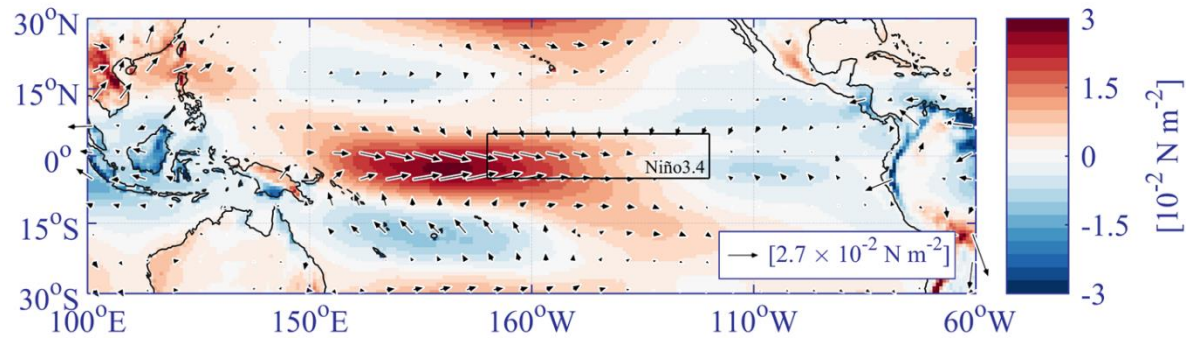
- MOM025
- $1/4^\circ$ resolution
- 50 vertical levels
- KPP vertical mixing
- precise temperature-space diagnostics (Holmes et al. 2019, JPO)

Development of Idealized Atmospheric Forcing



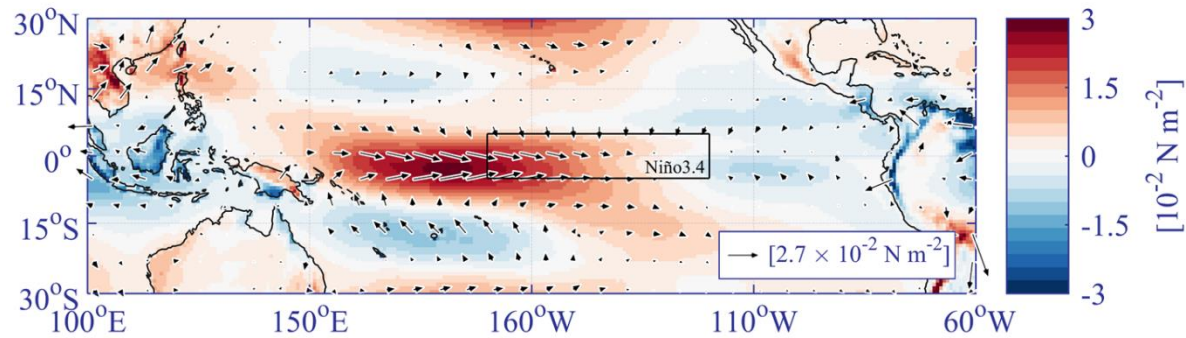
Development of Idealized Atmospheric Forcing

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

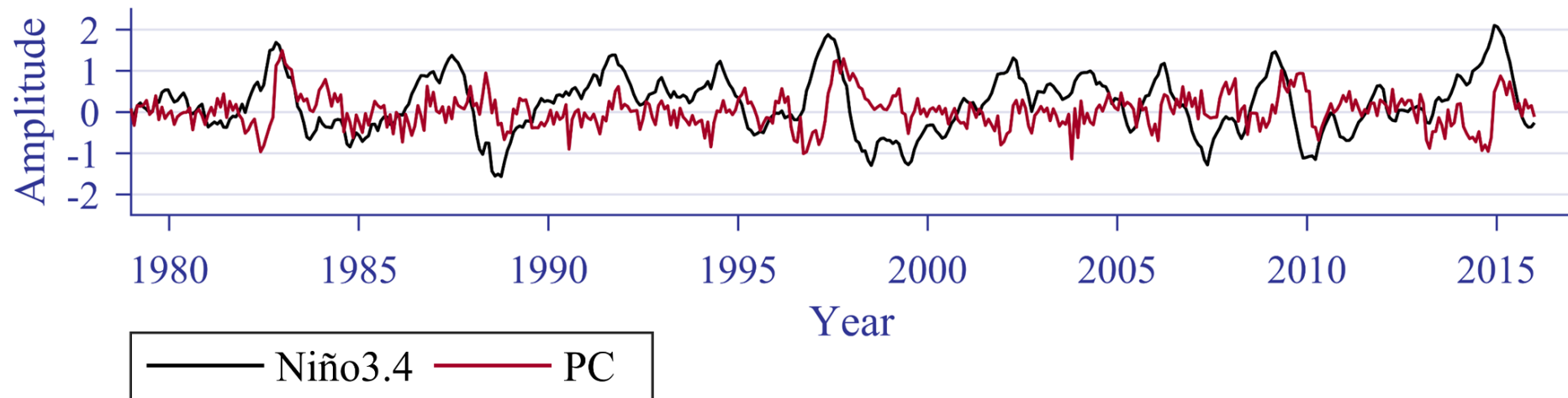
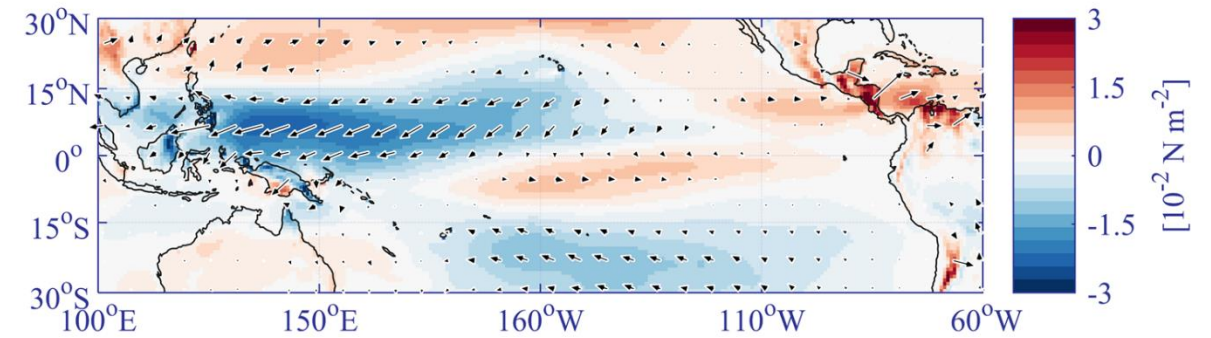


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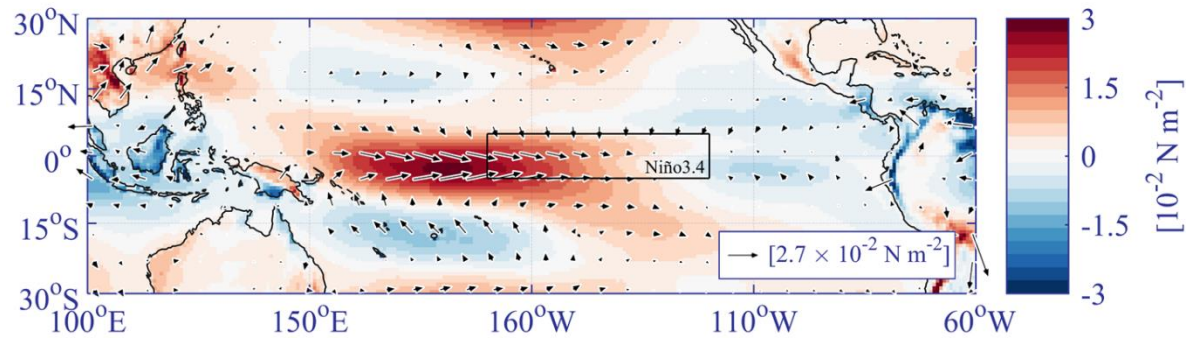


b) $X_{2,\vec{\tau}}$

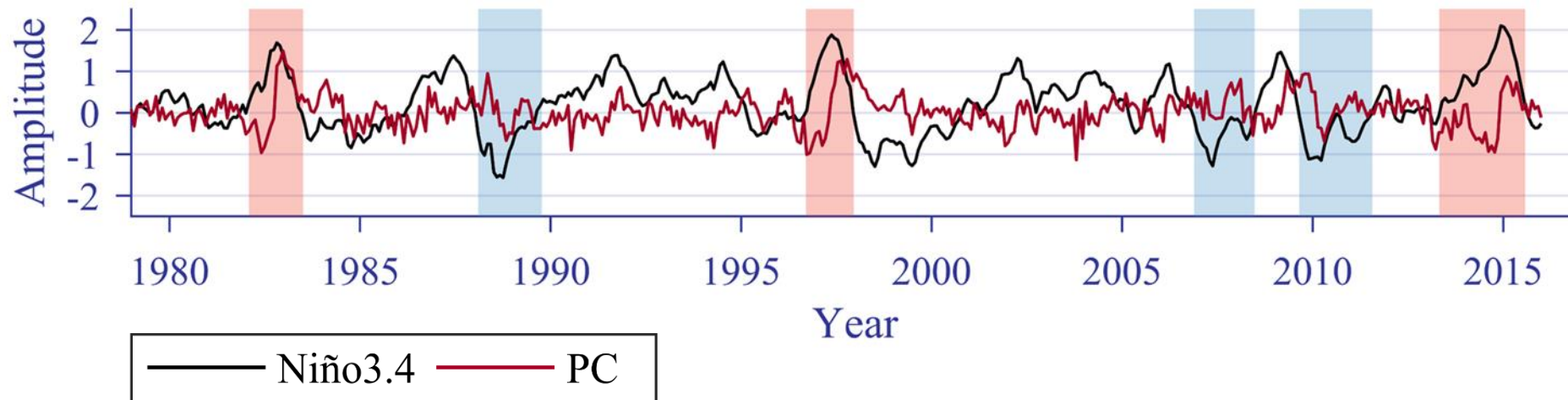
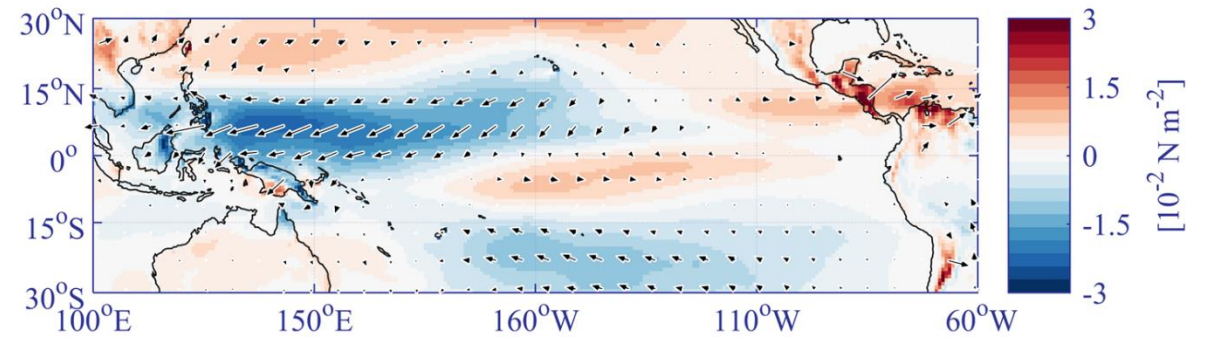


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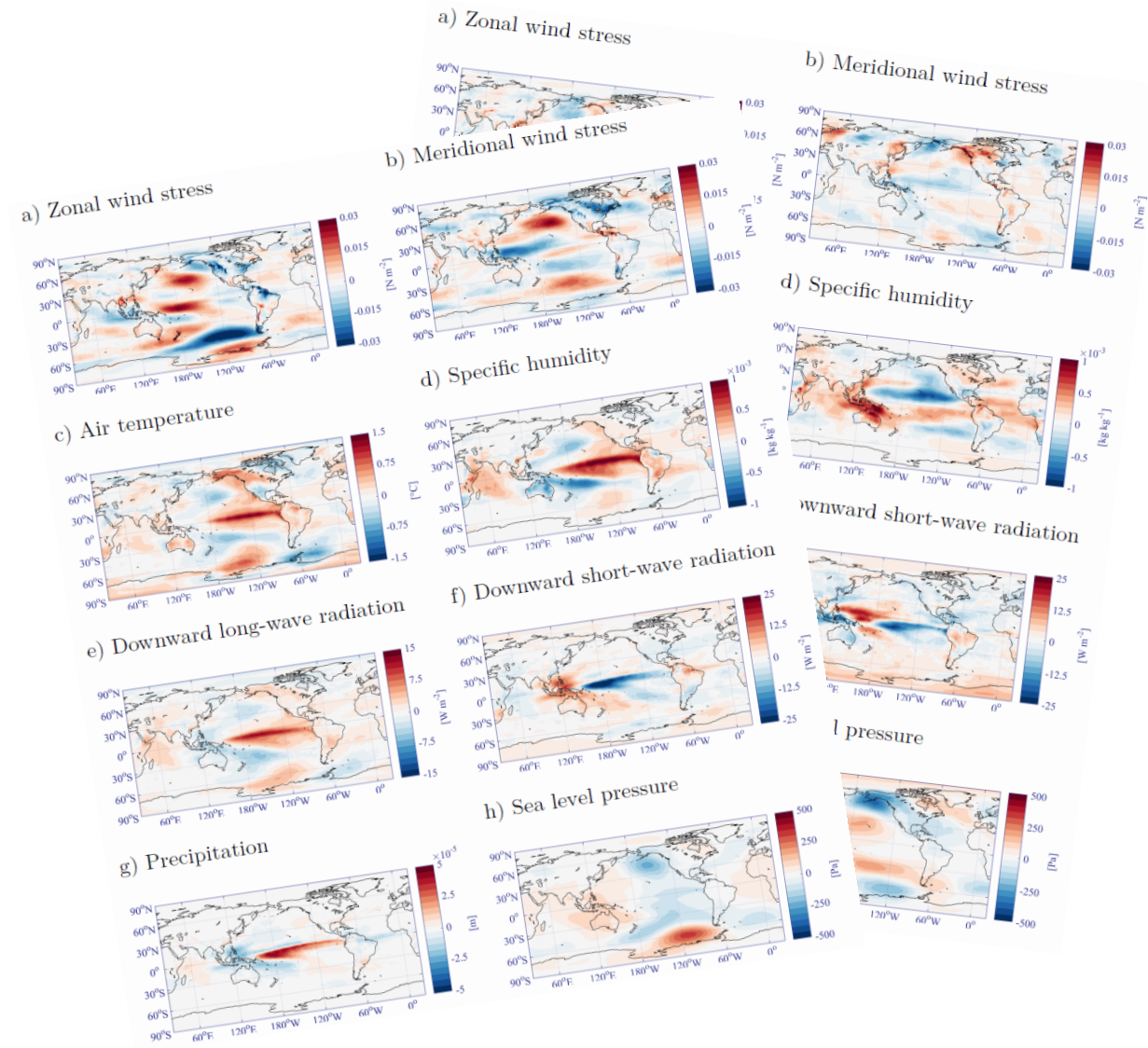
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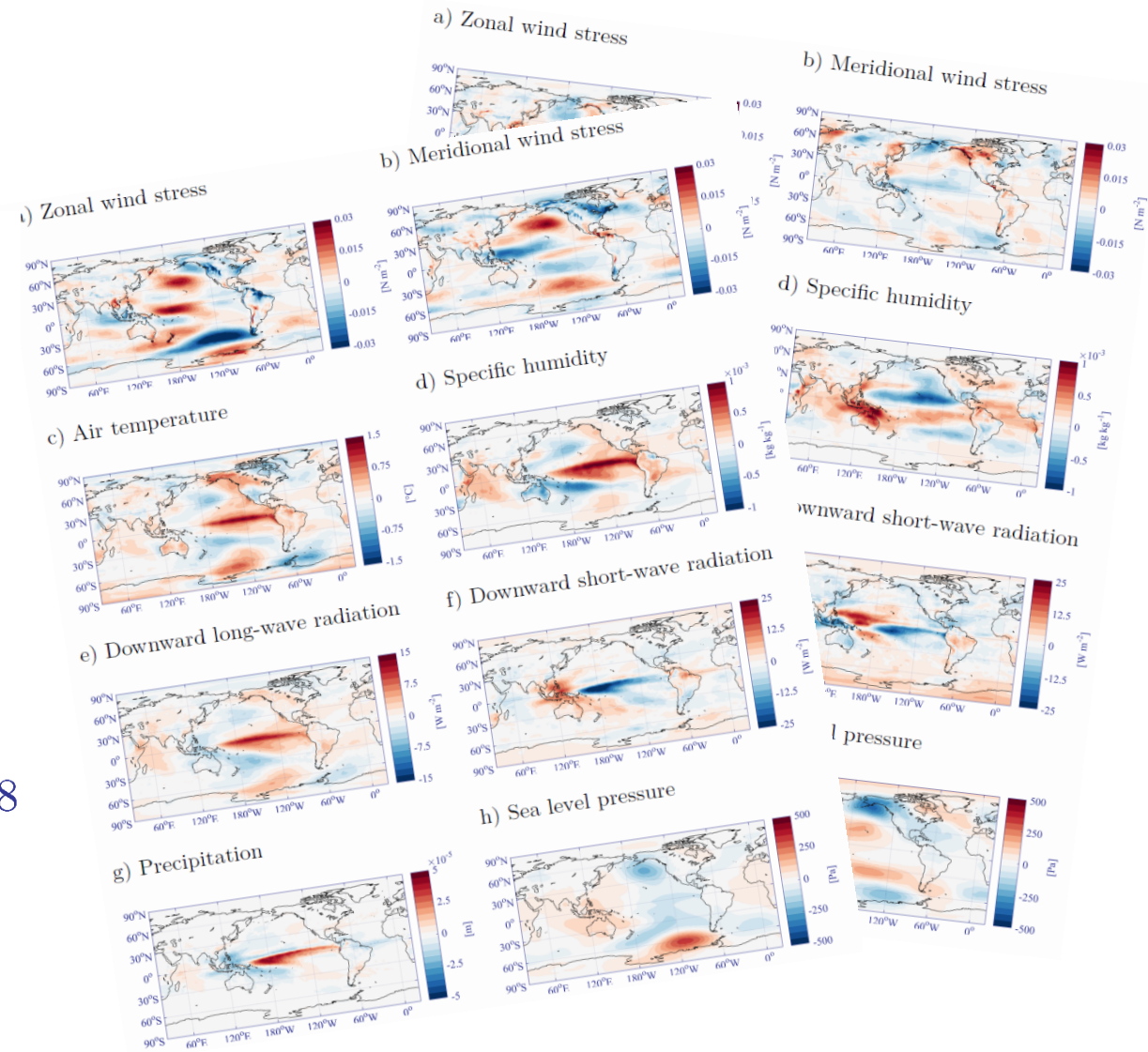
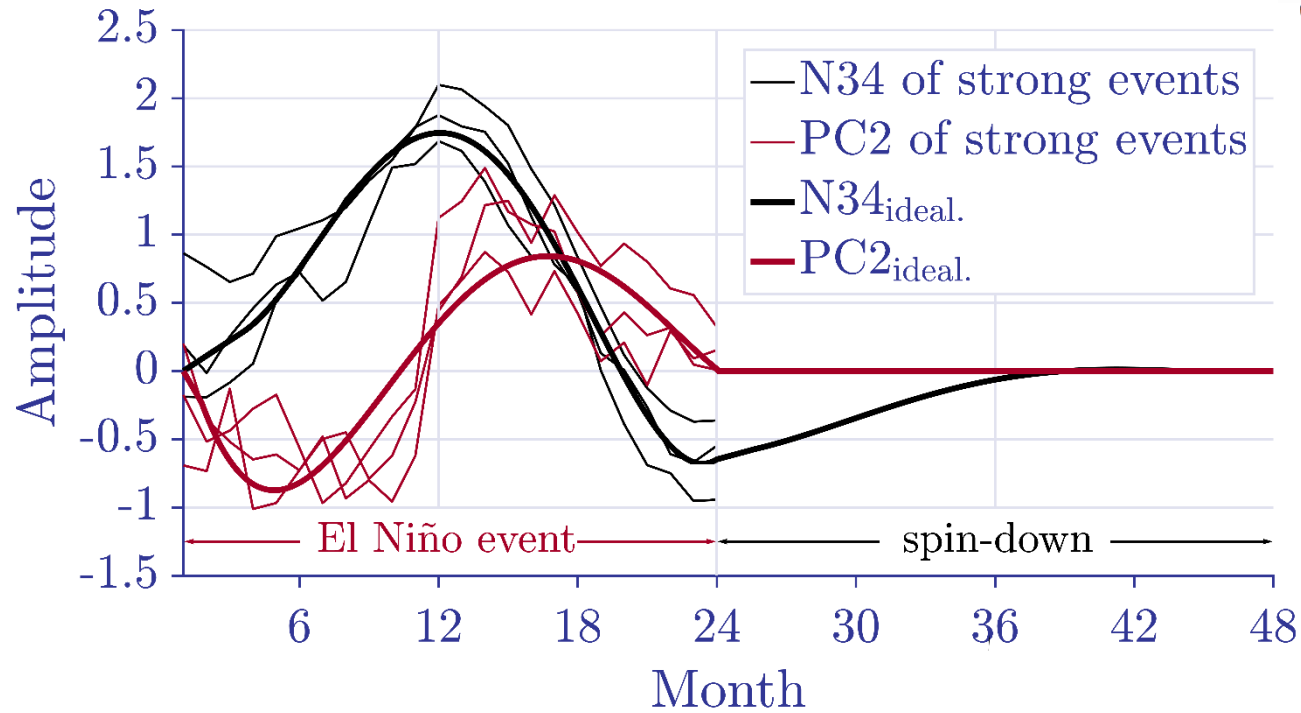
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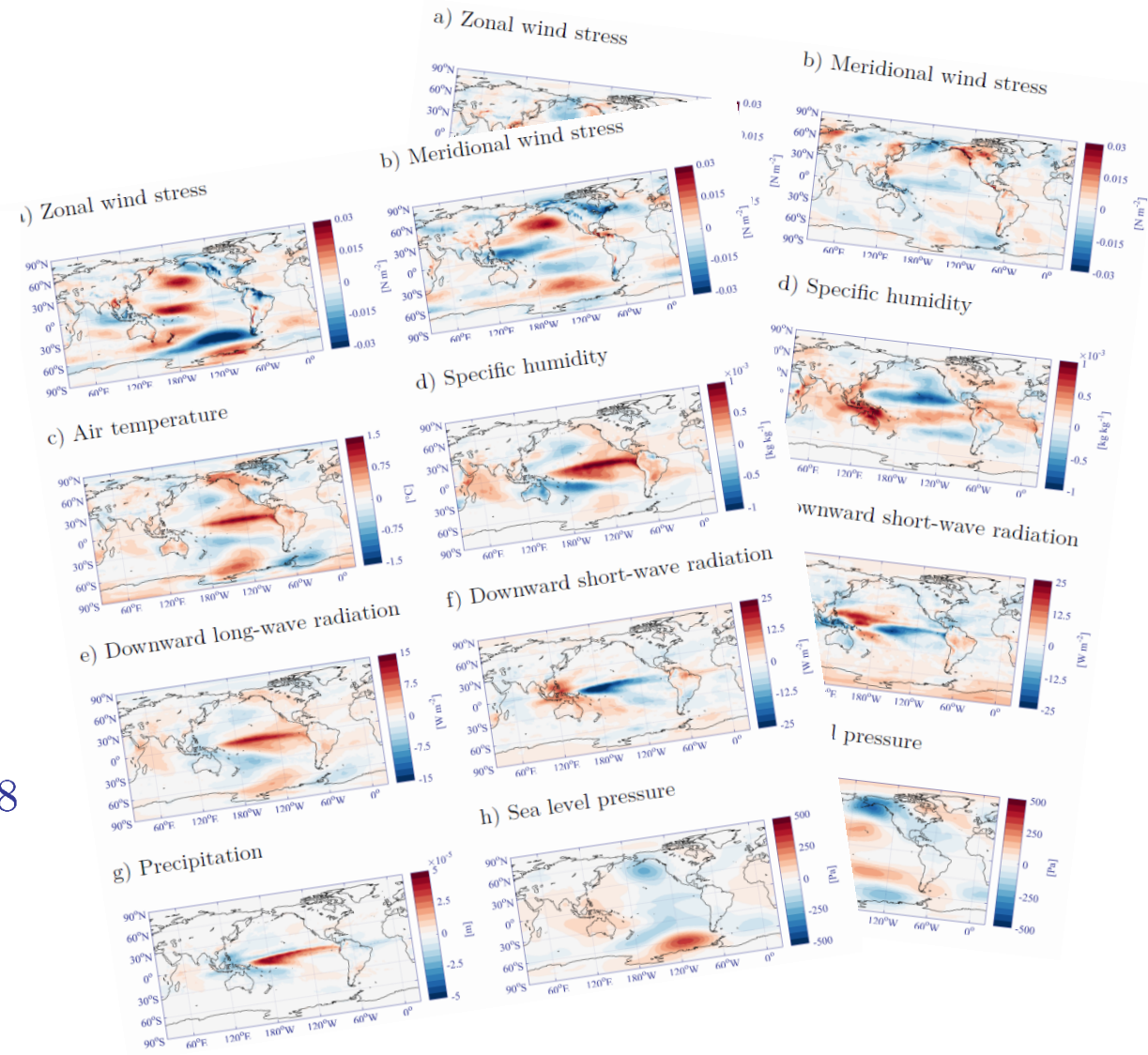
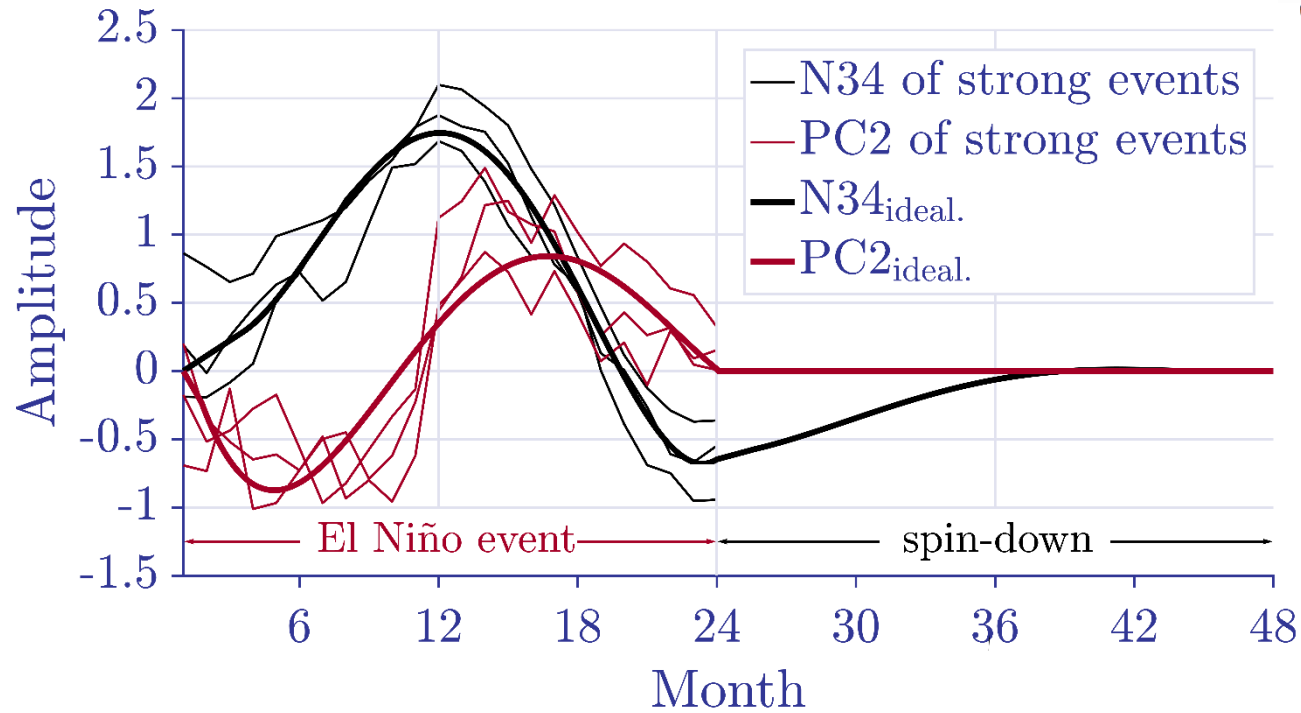
Idealized Atmospheric Forcing



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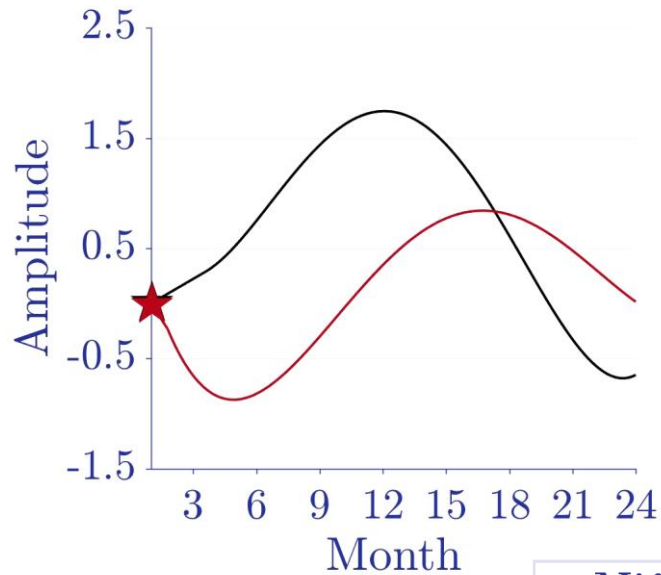
→ wind stress, surface heat and freshwater fluxes

Evolution of atmospheric perturbation

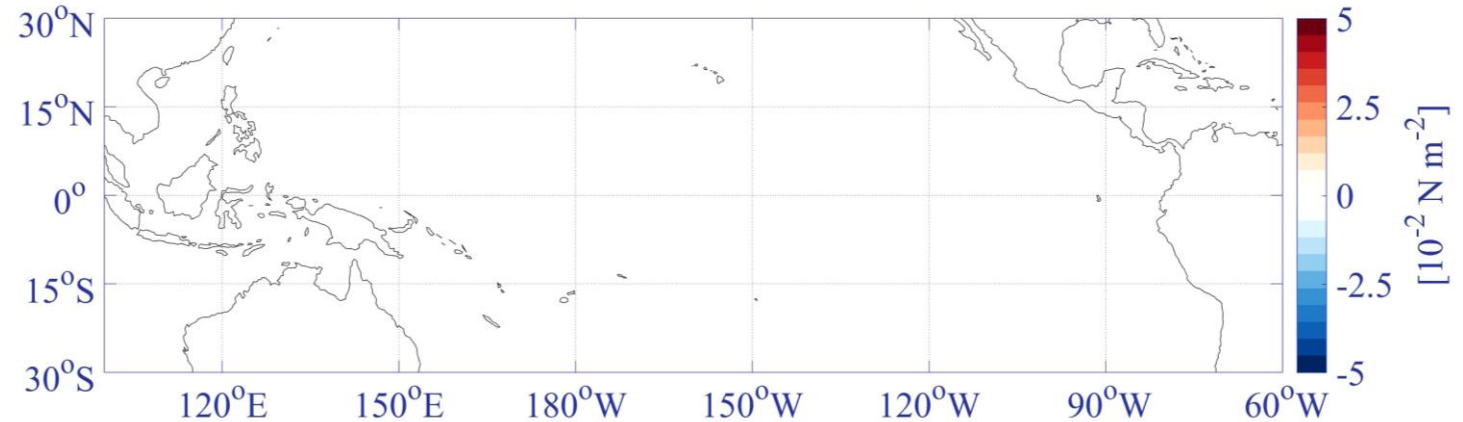
$$\textit{atm. forcing} = \underbrace{\textit{clim. forcing}}_{CNYF} + \underbrace{\textit{perturbation forcing}}_{\textit{patterns} \times \textit{time series}}$$

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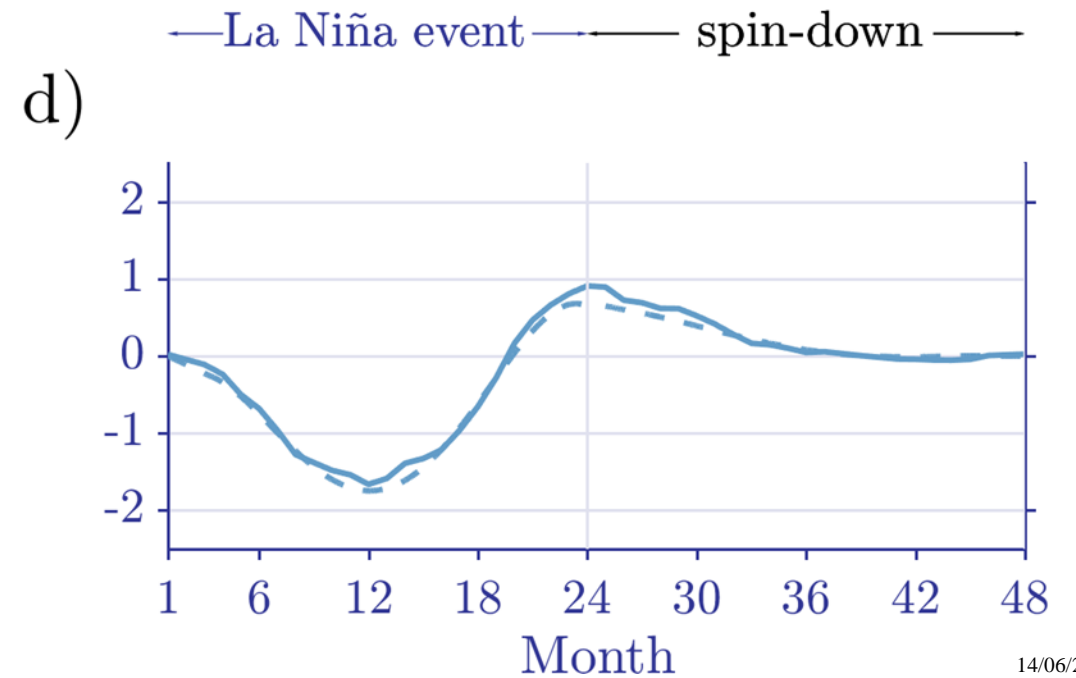
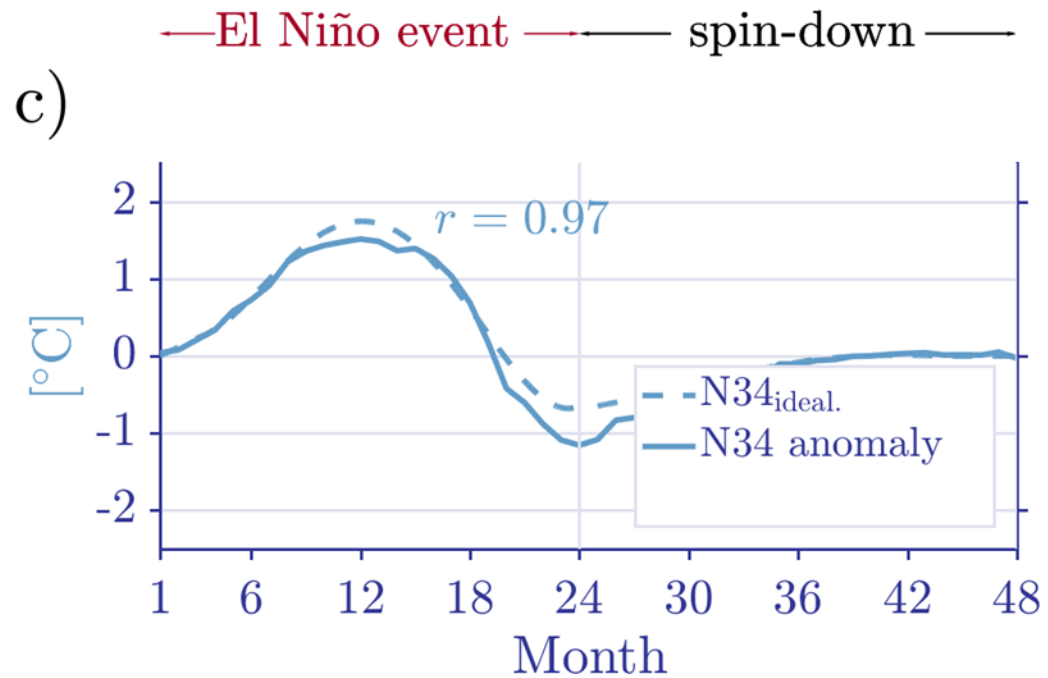
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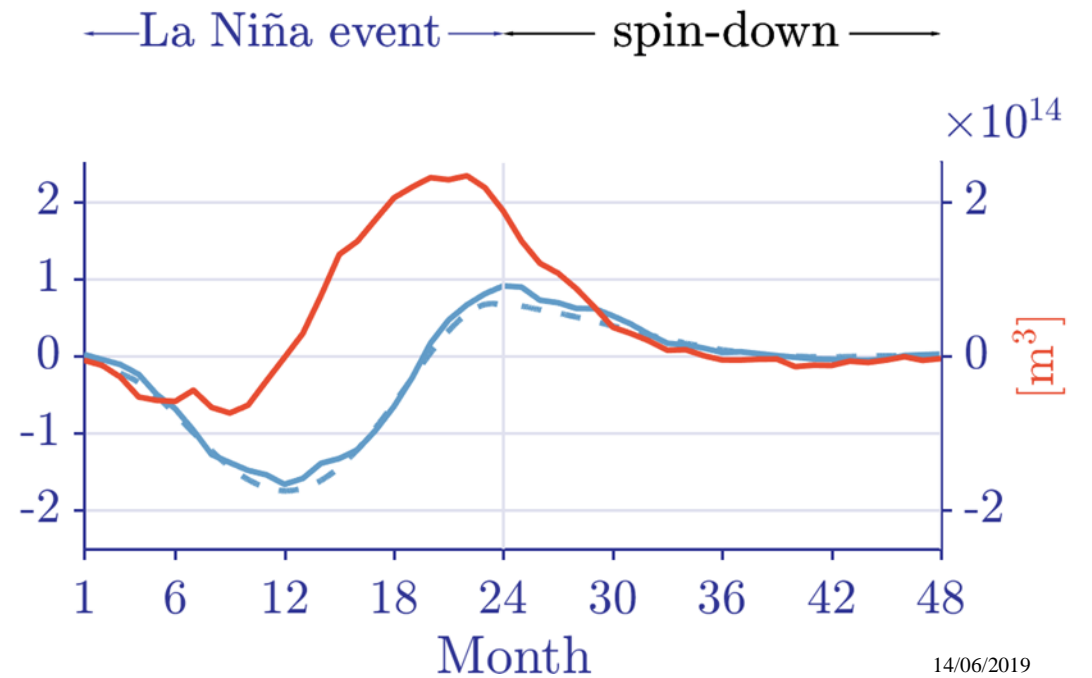
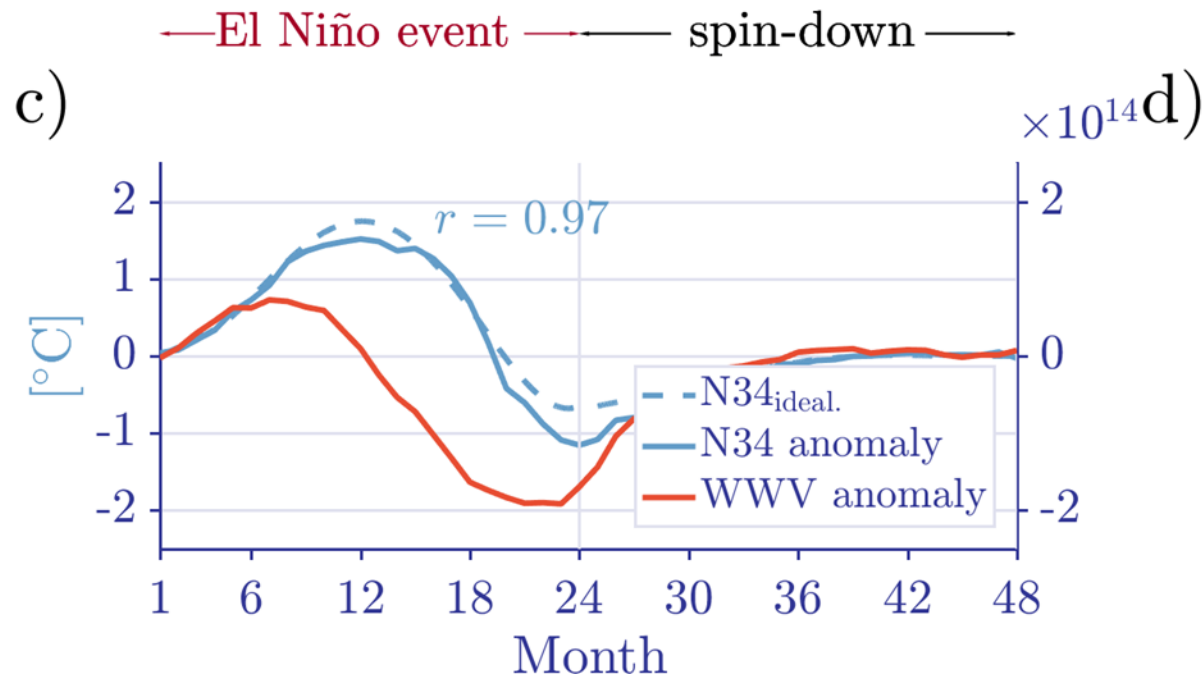
— Niño3.4_{ideal.}
 — PC_{ideal.}



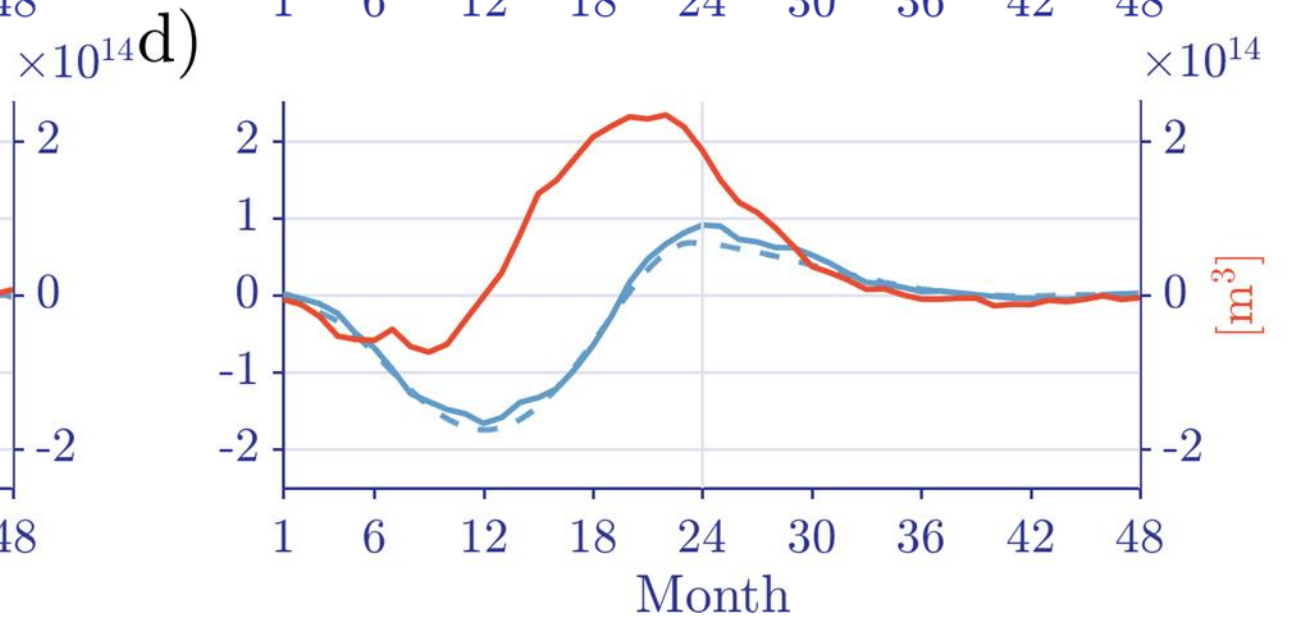
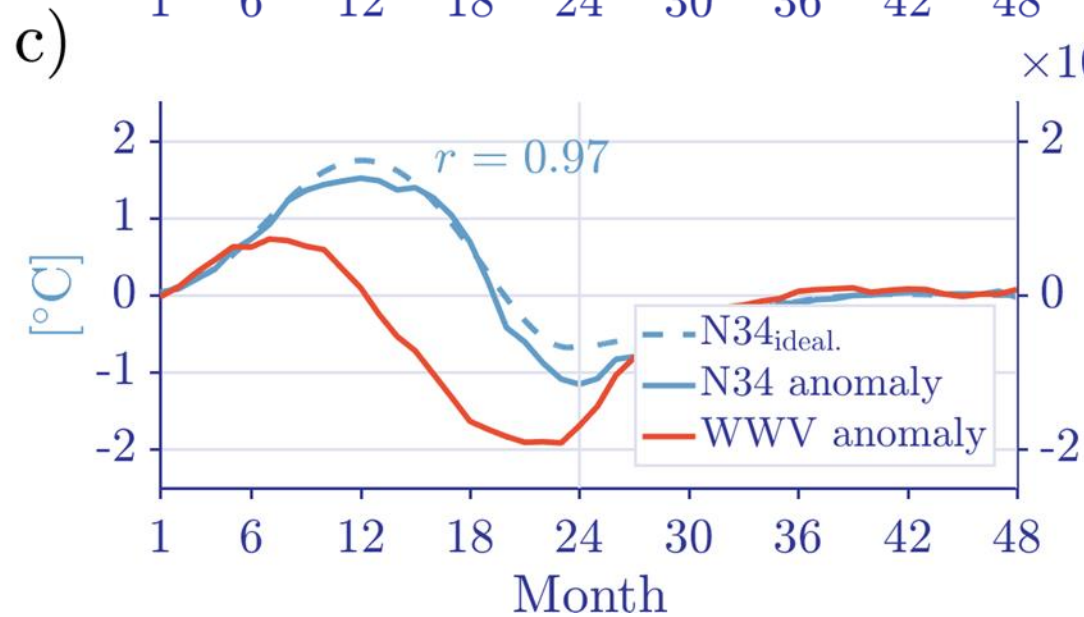
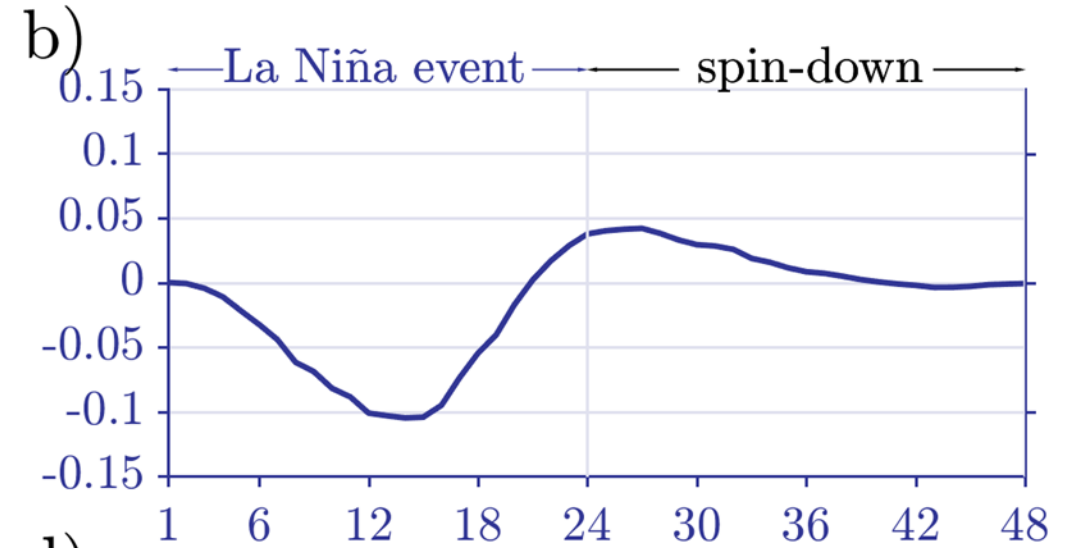
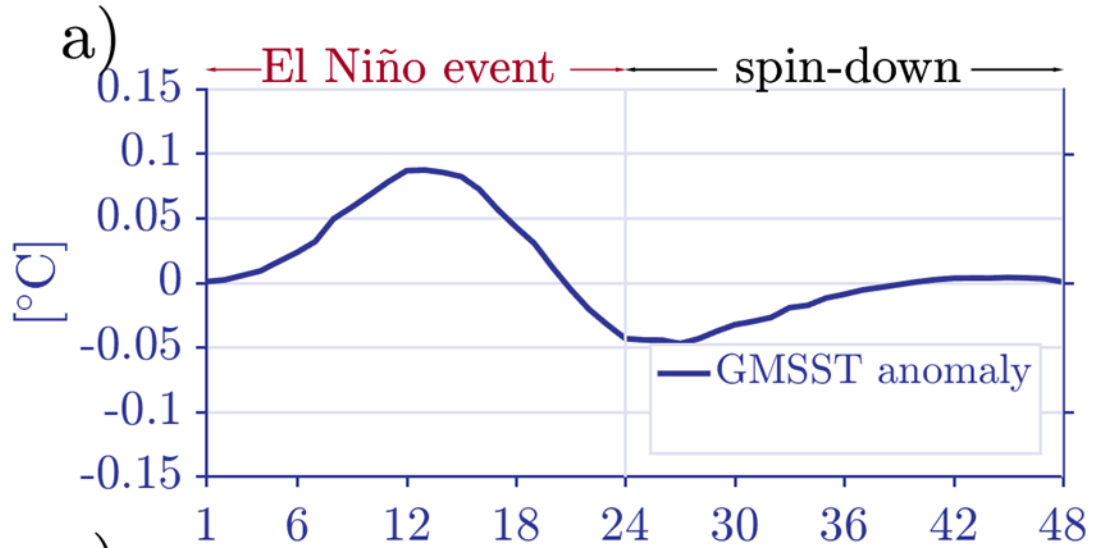
El Niño and La Niña Time Series



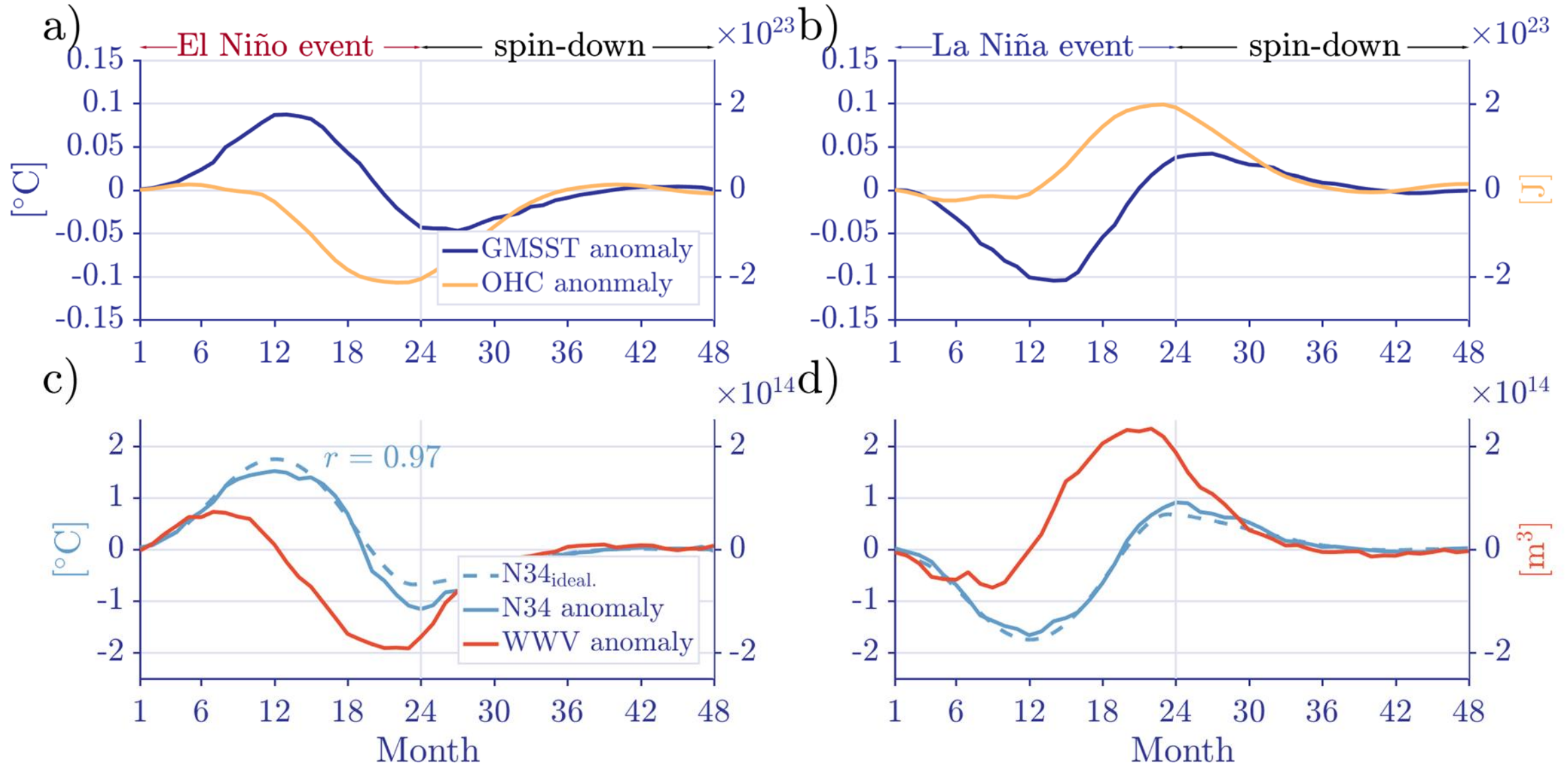
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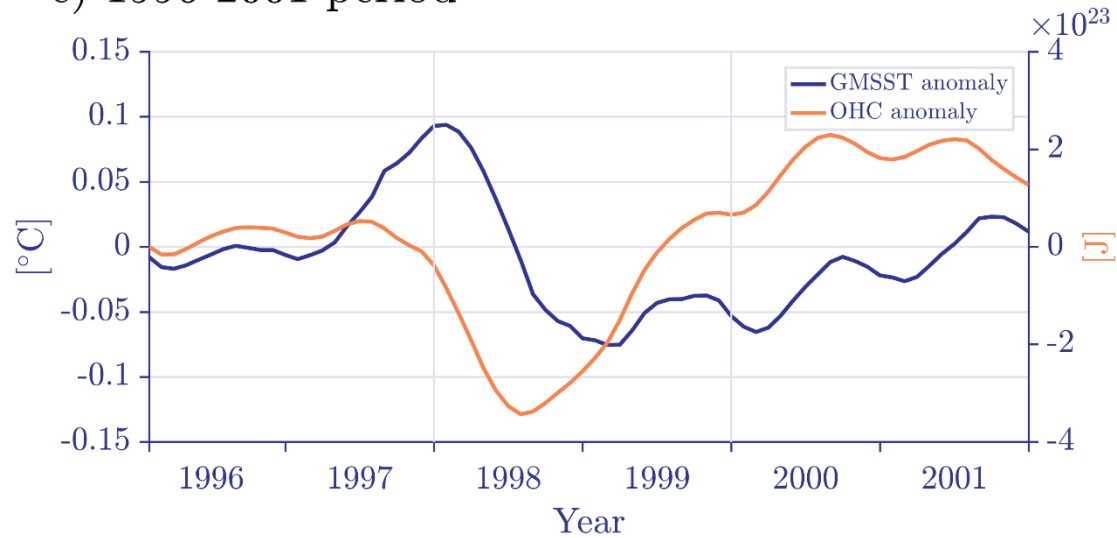


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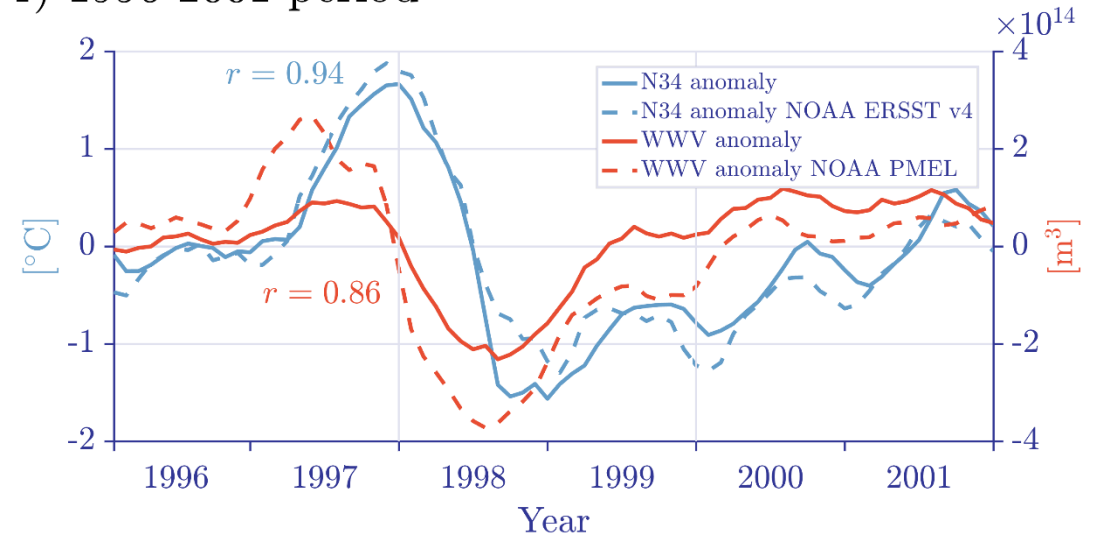


El Niño and La Niña Time Series

e) 1996-2001 period

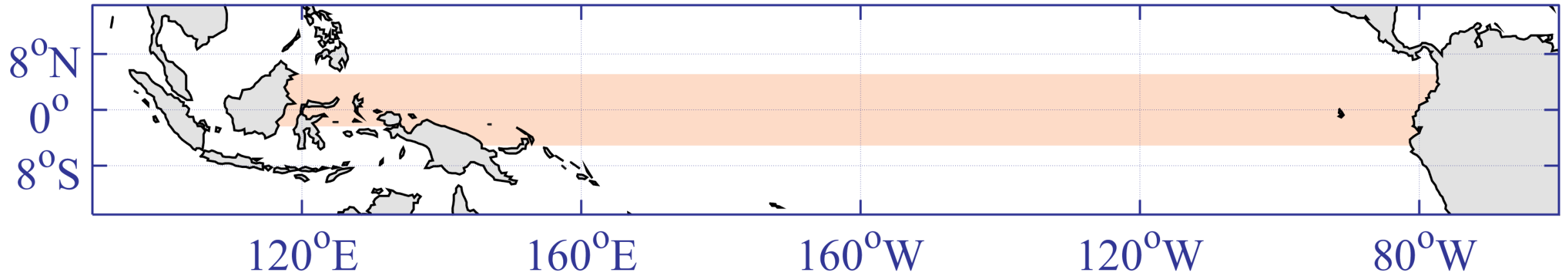


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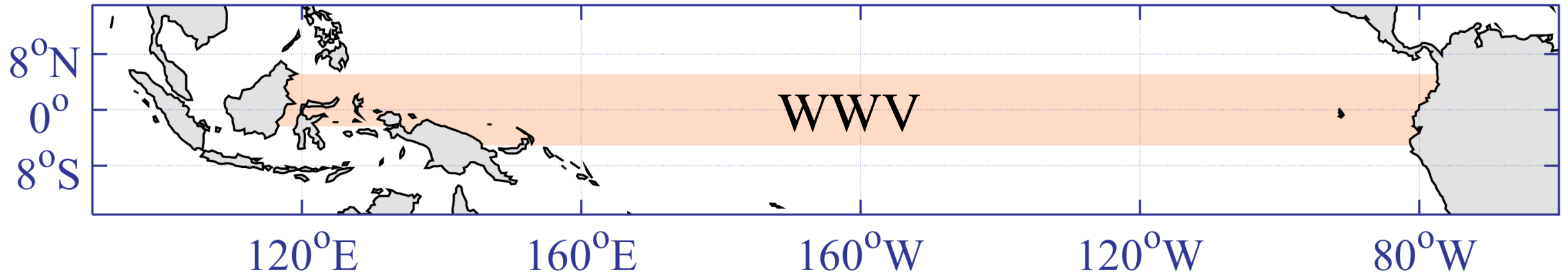


The Warm Water Volume Balance

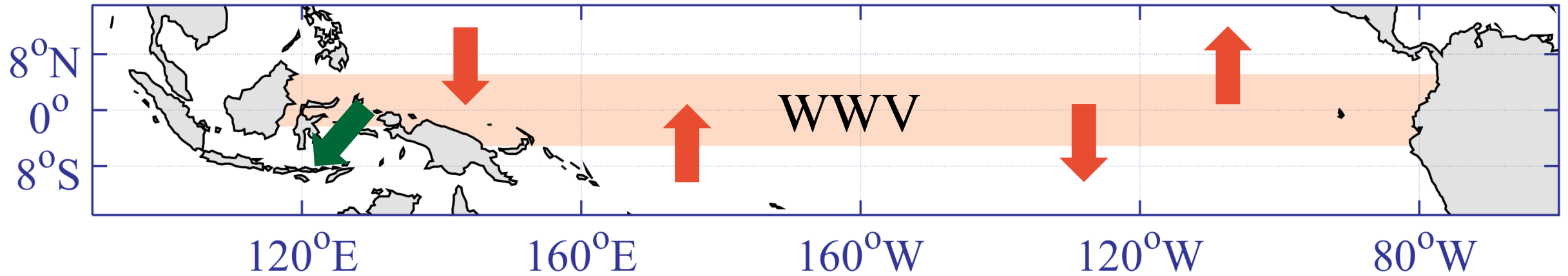
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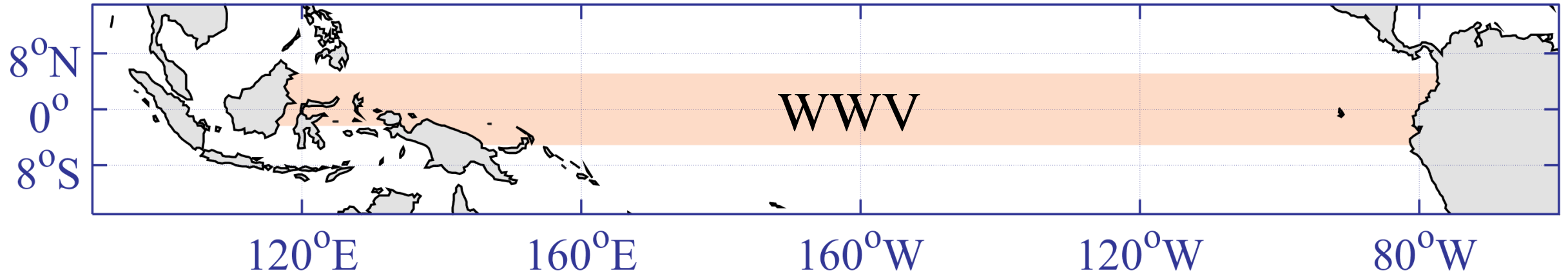


The Warm Water Volume Balance



- adiabatic processes

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- diabatic processes

The Diabatic Volume Fluxes

Vertical mixing: \mathcal{G}_M

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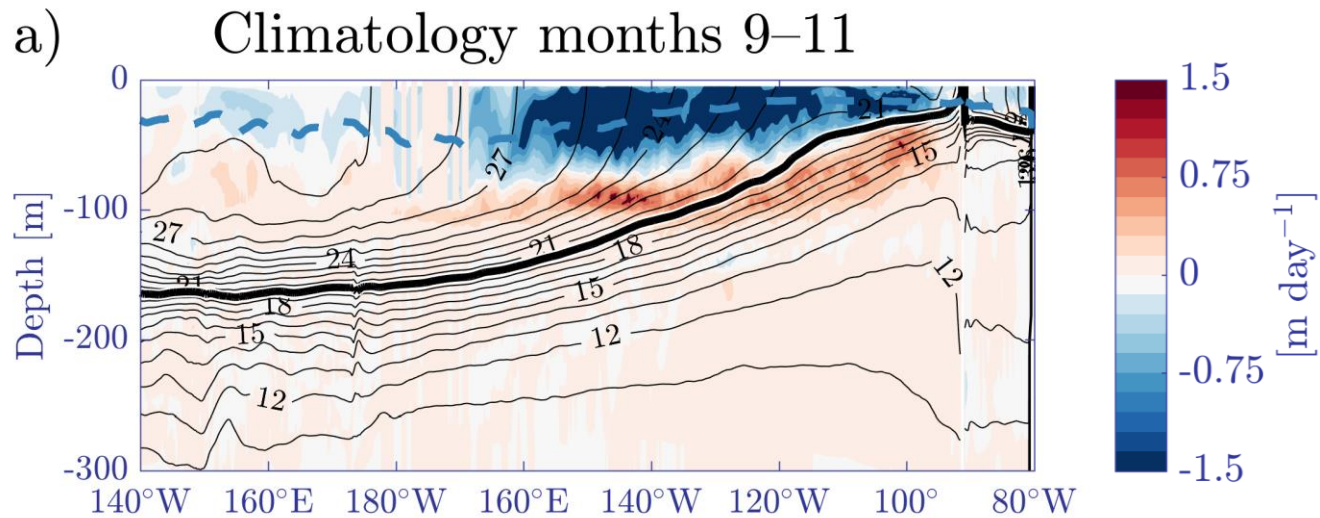
Surface forcing: \mathcal{G}_F

+ numerical mixing: \mathcal{G}_I

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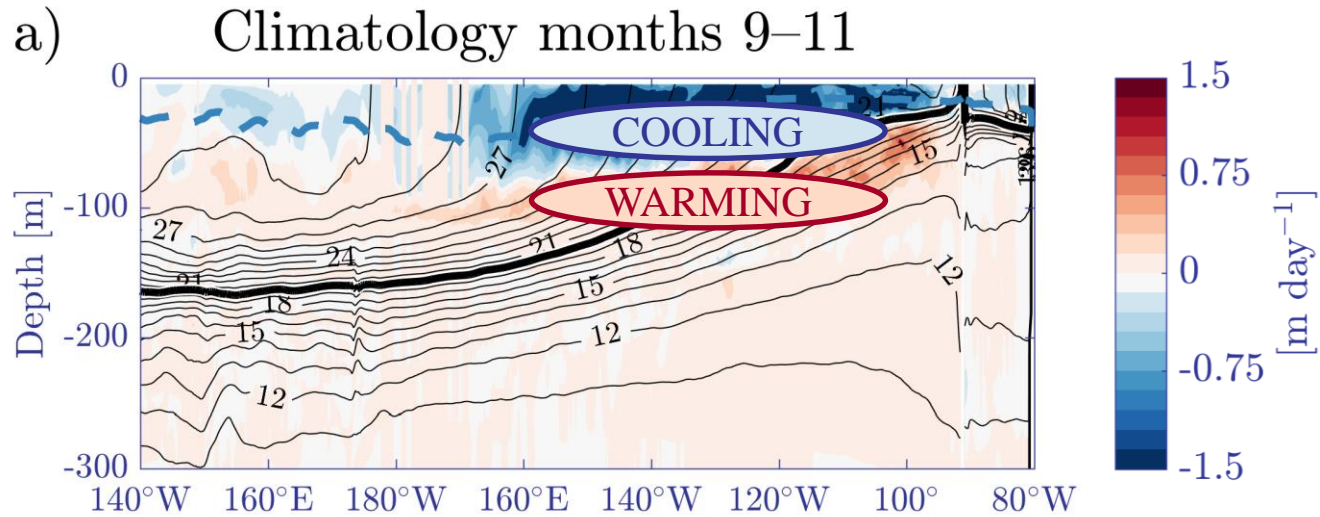


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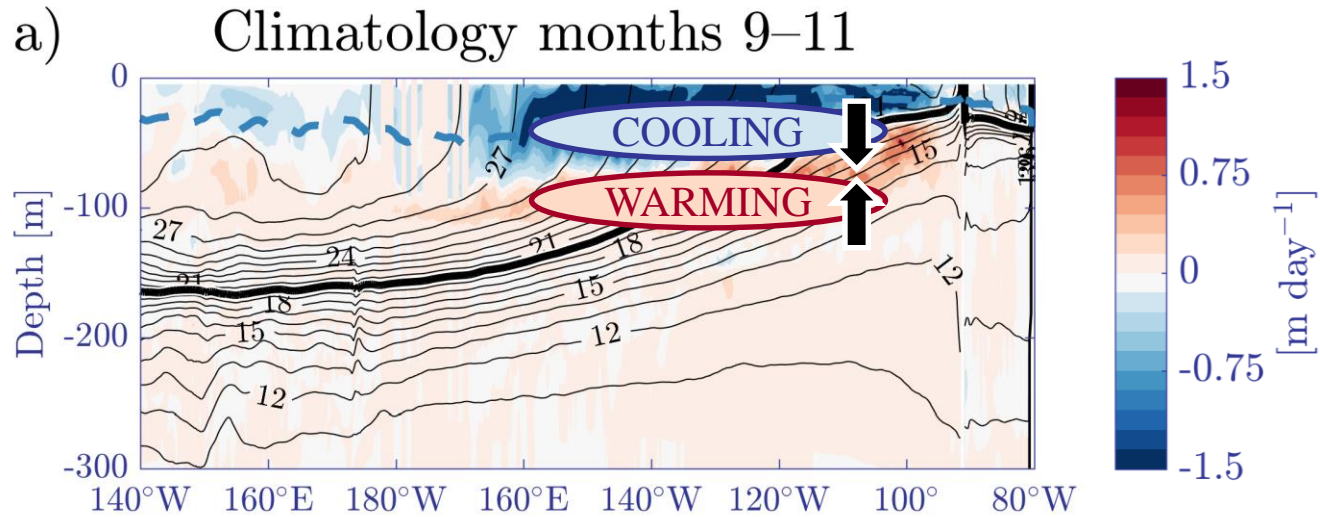
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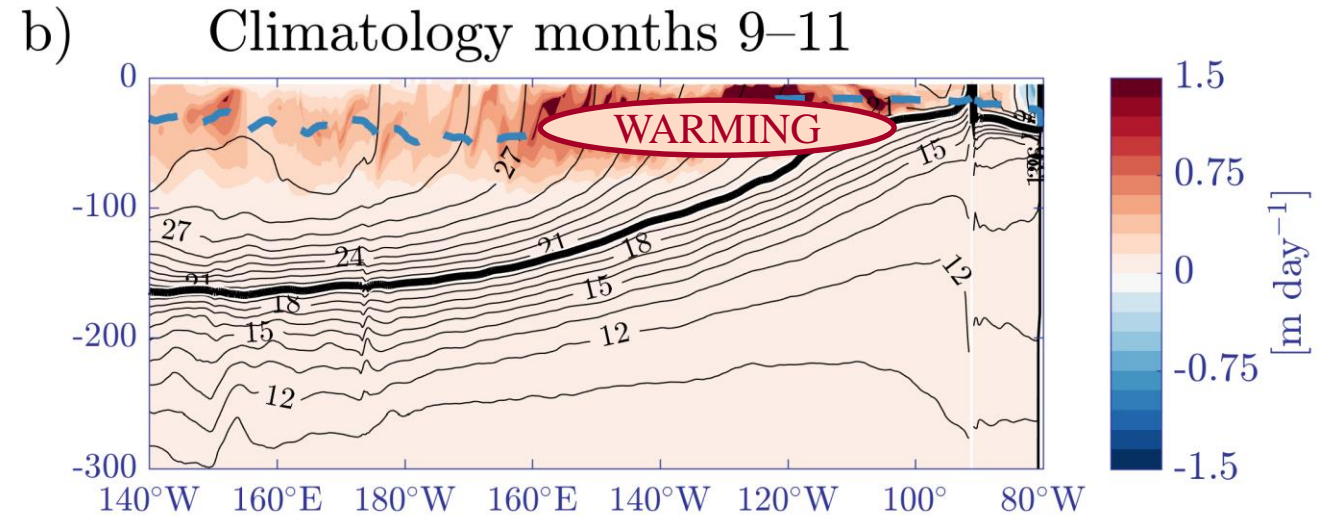
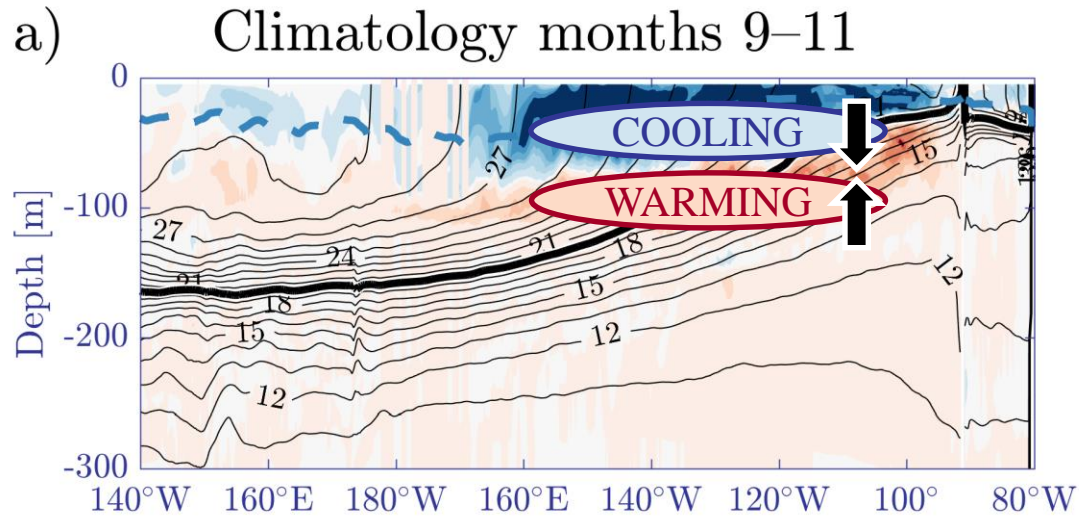
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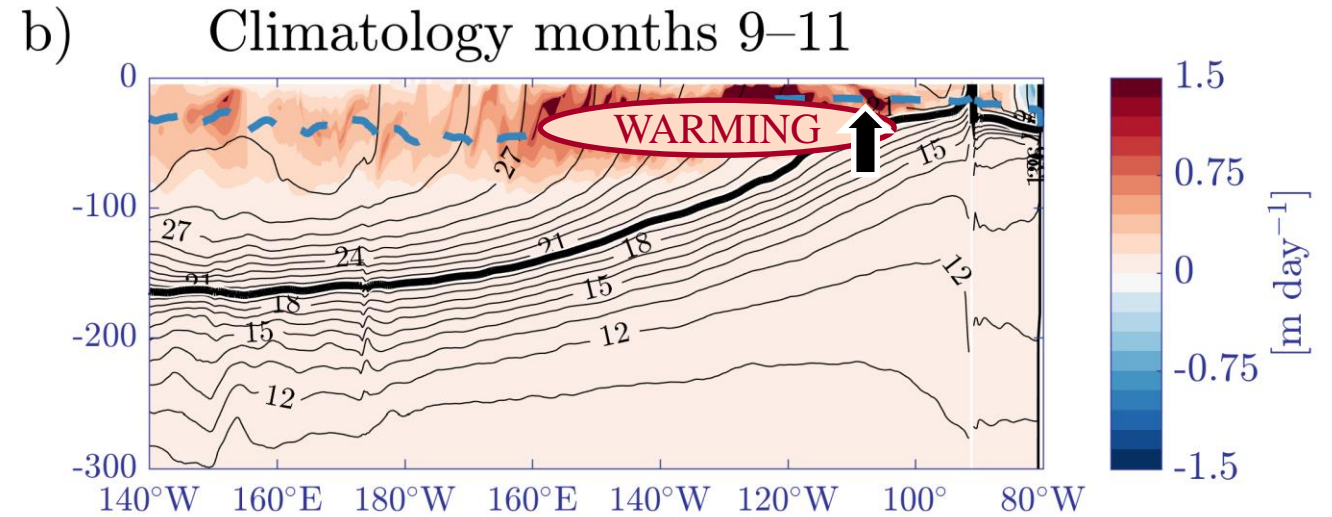
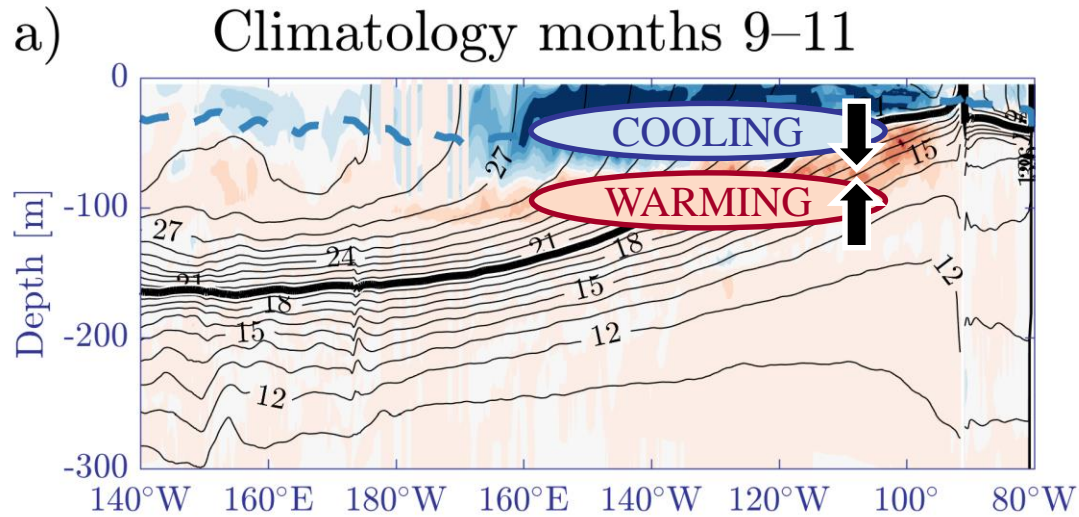
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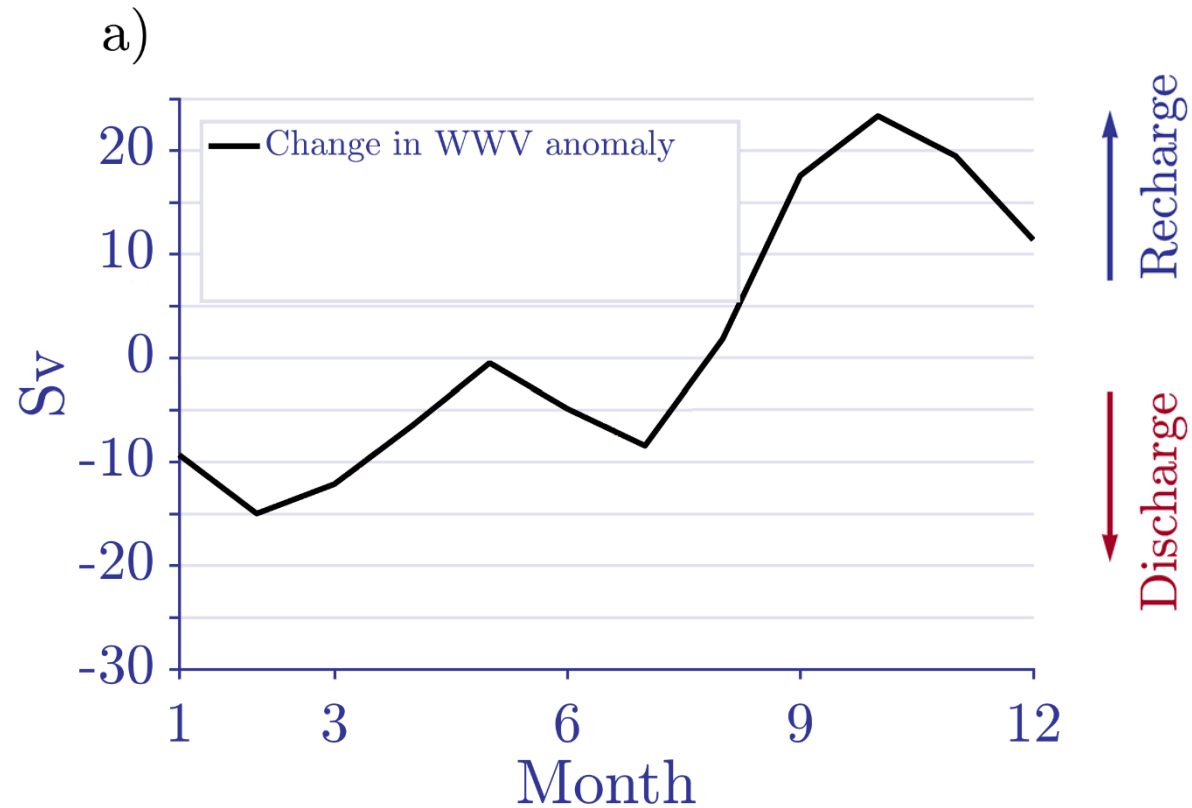
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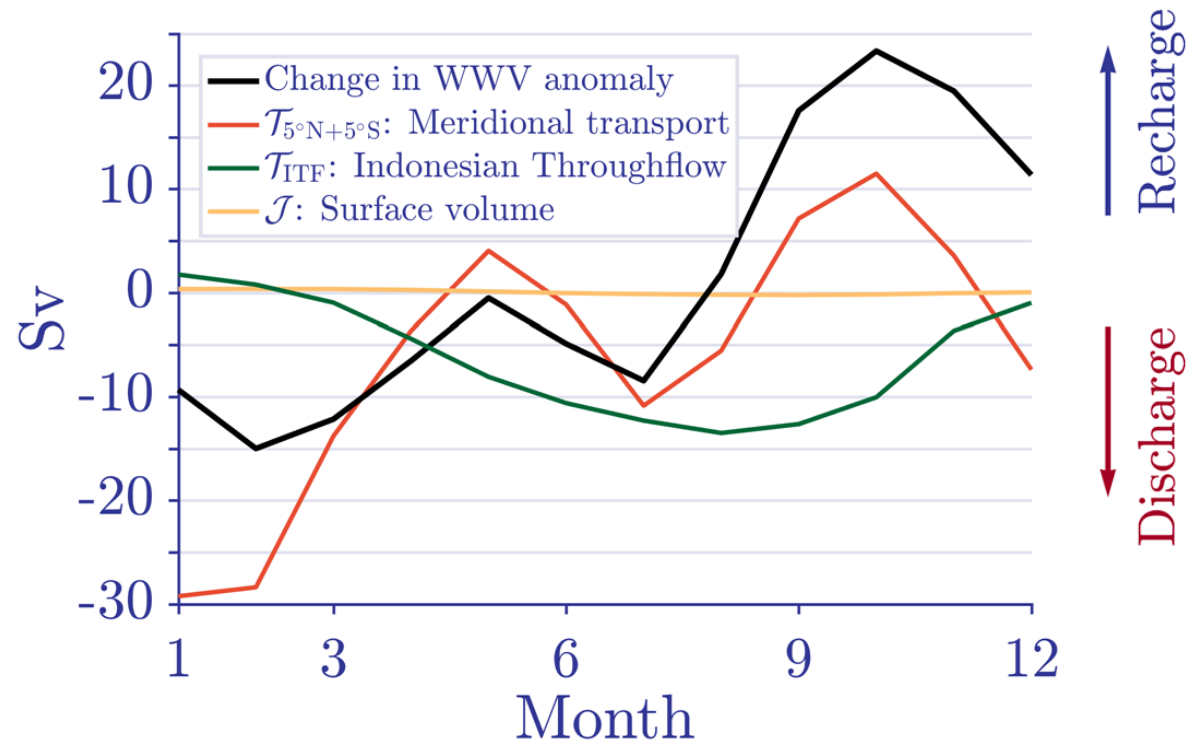


The climatological WWV budget



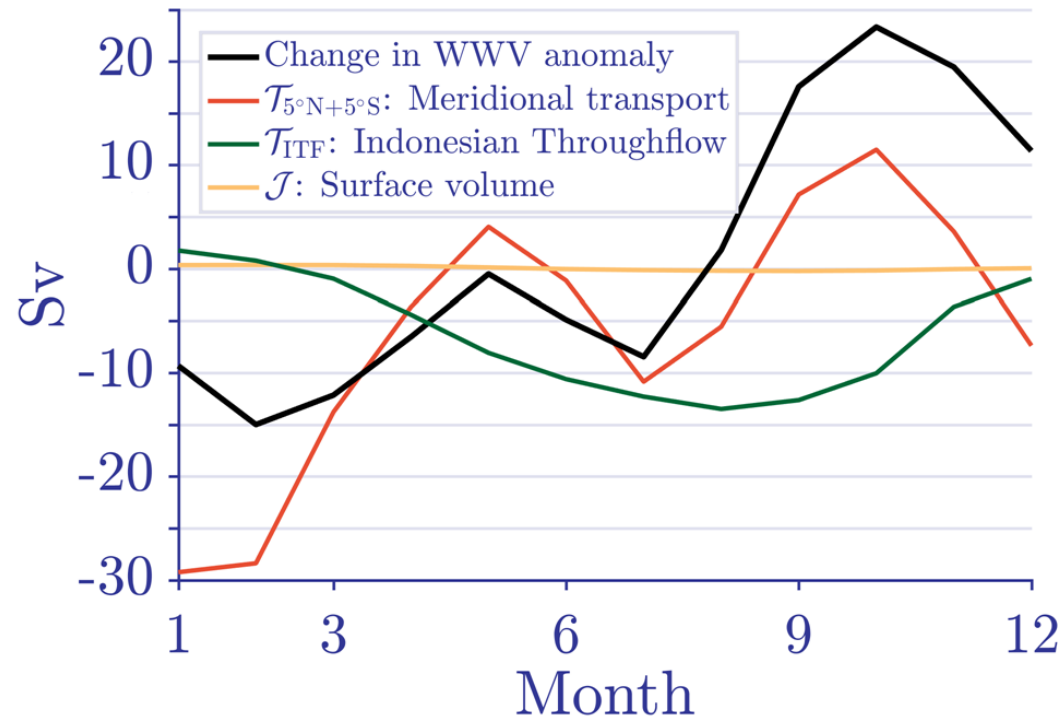
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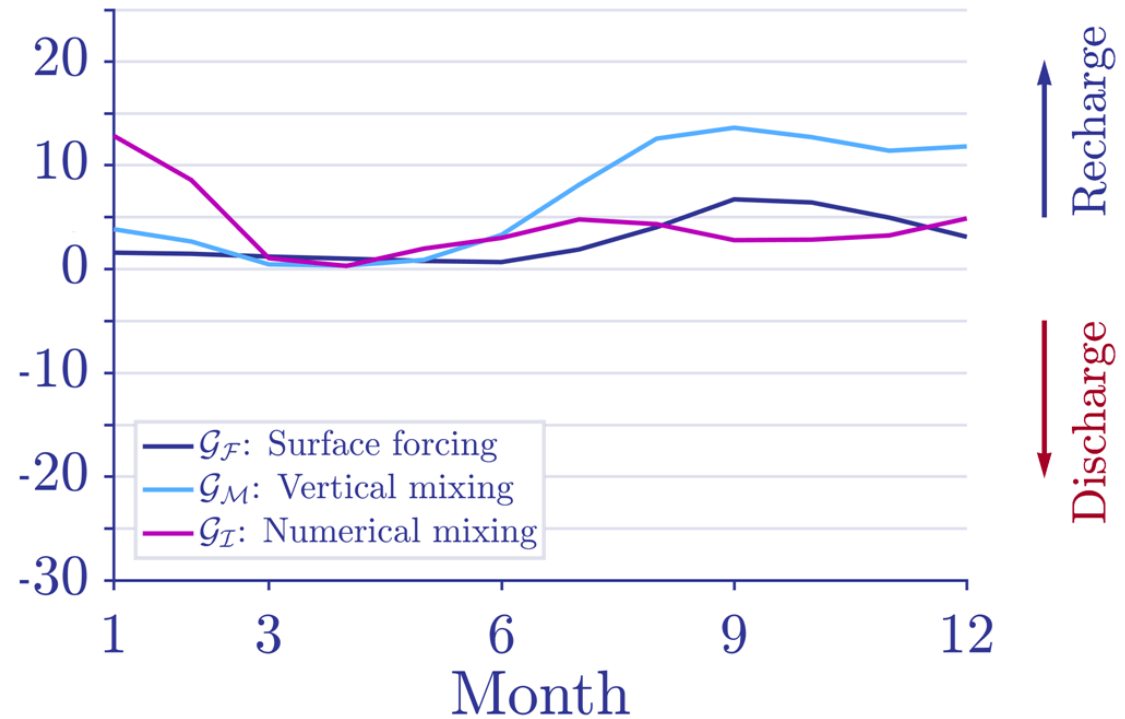


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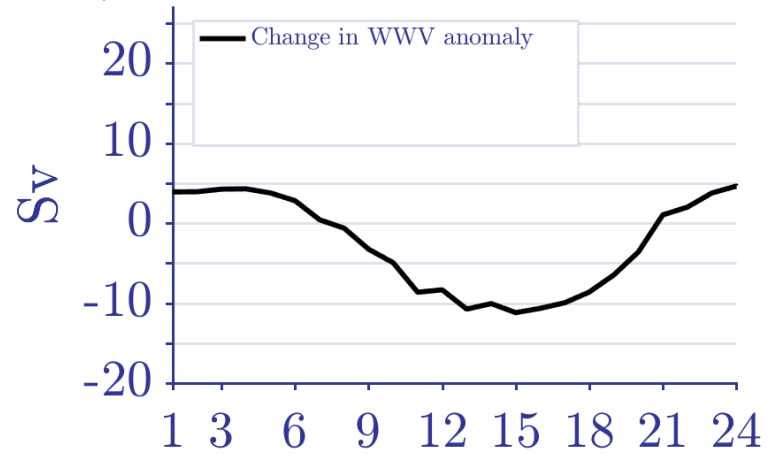


b) Diabatic fluxes

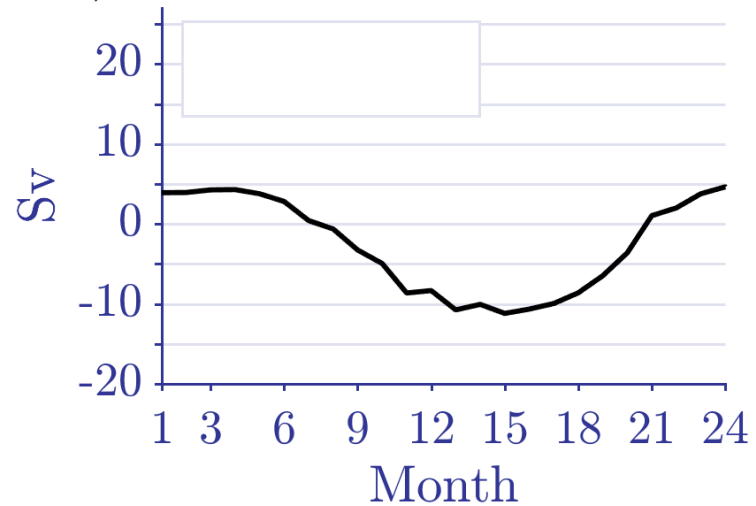


The WWV Balance during ENSO

a) El Niño:

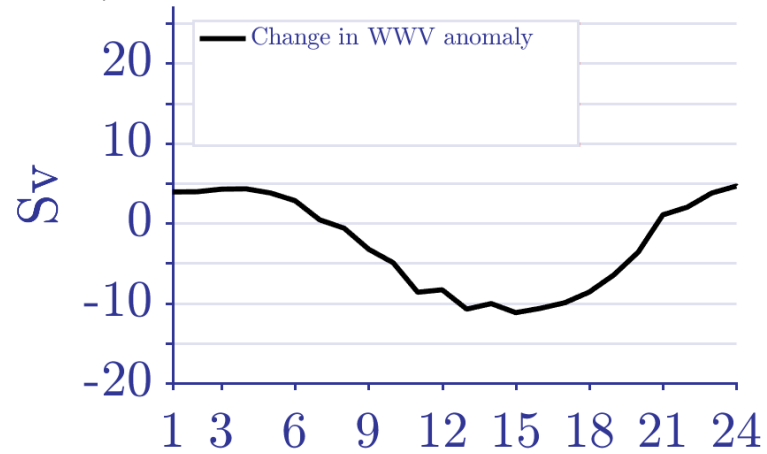


b) El Niño:

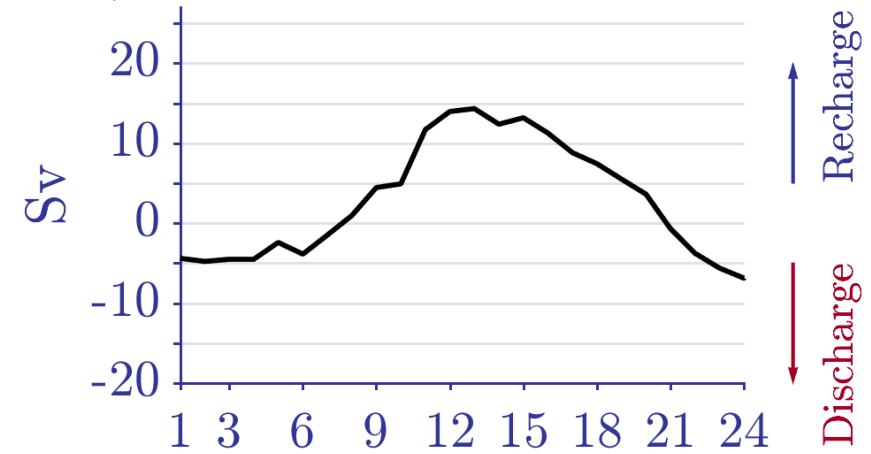


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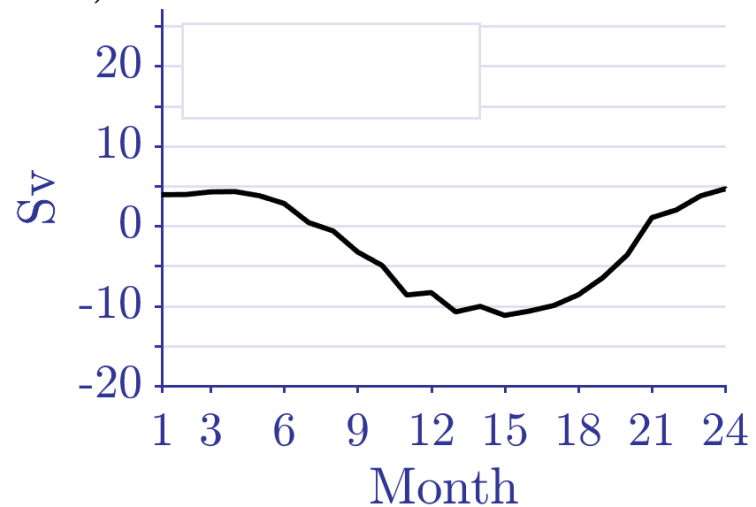
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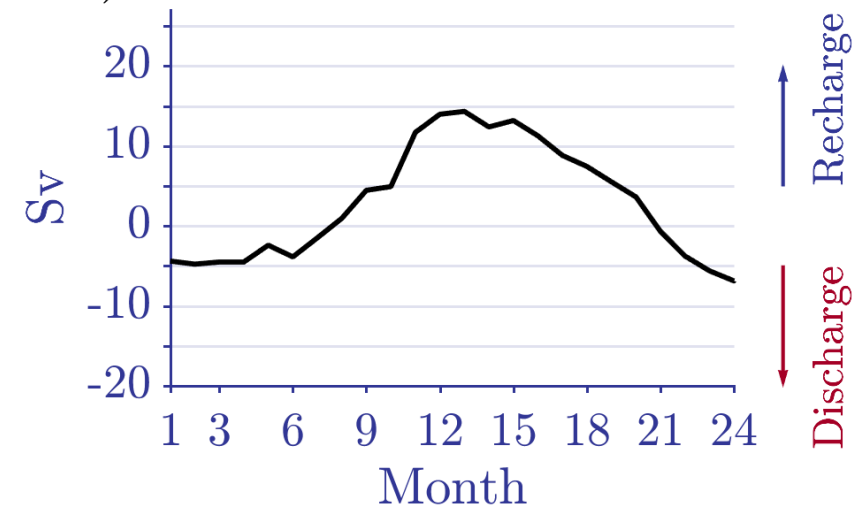
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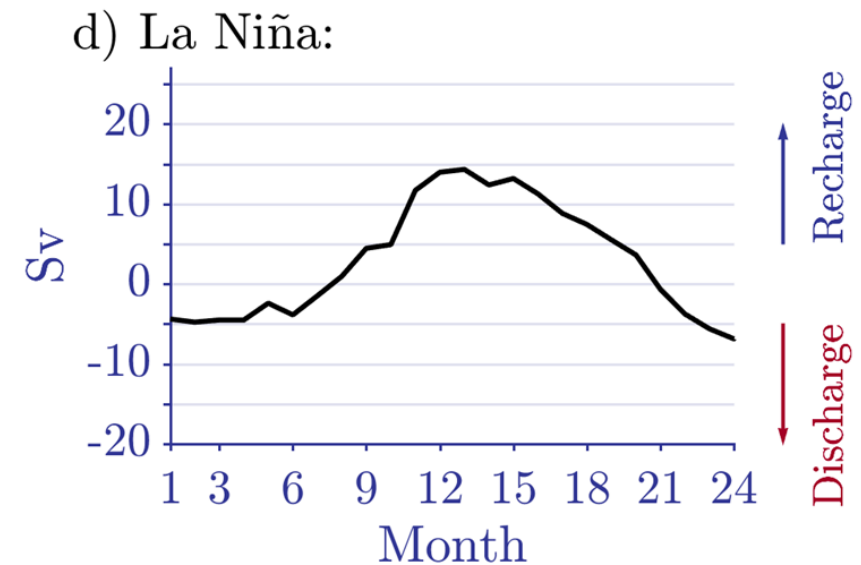
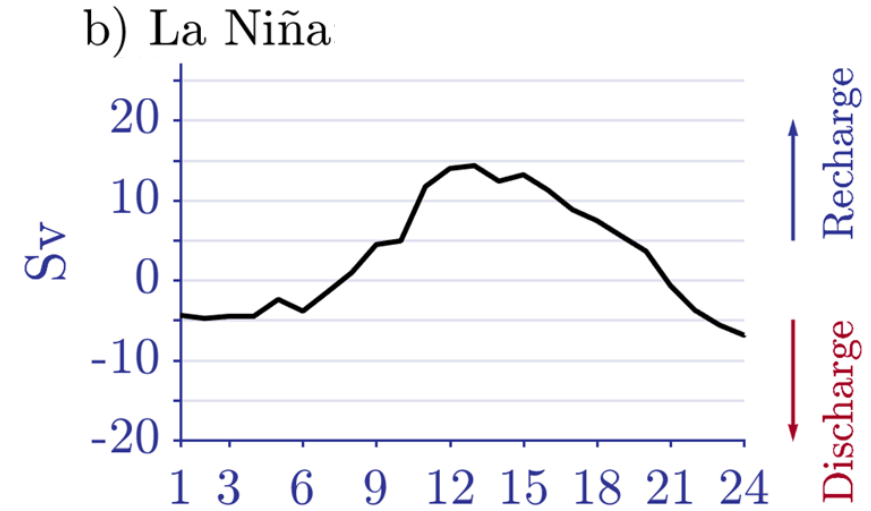
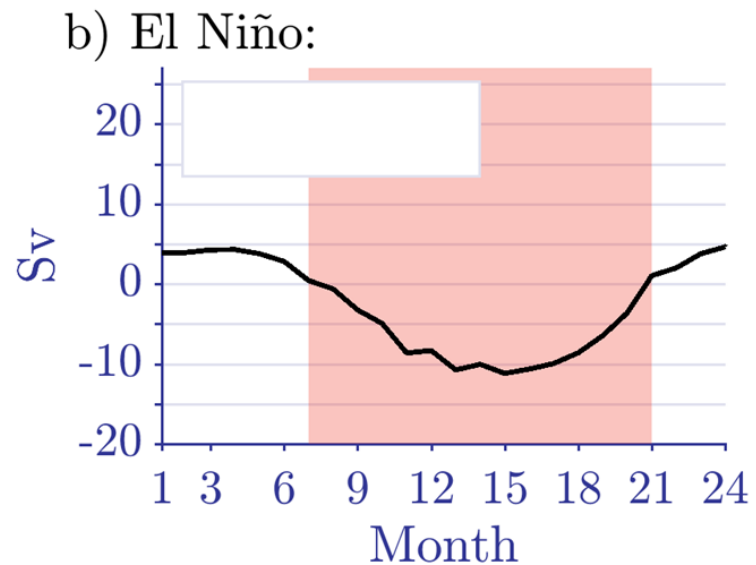
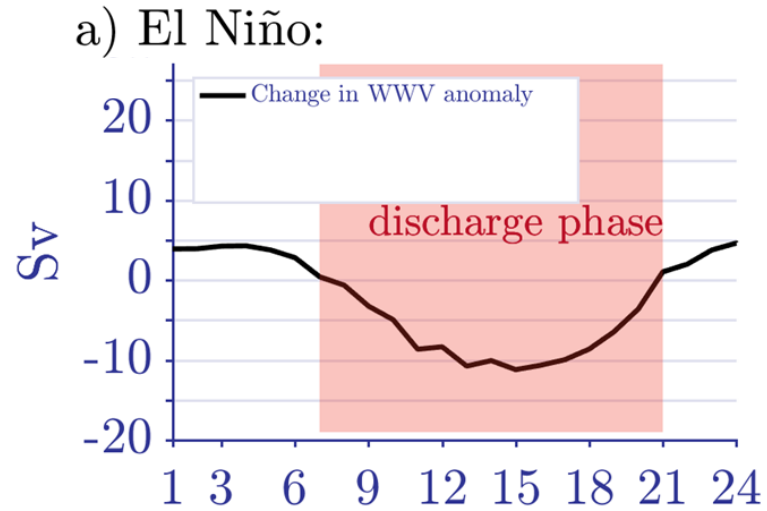
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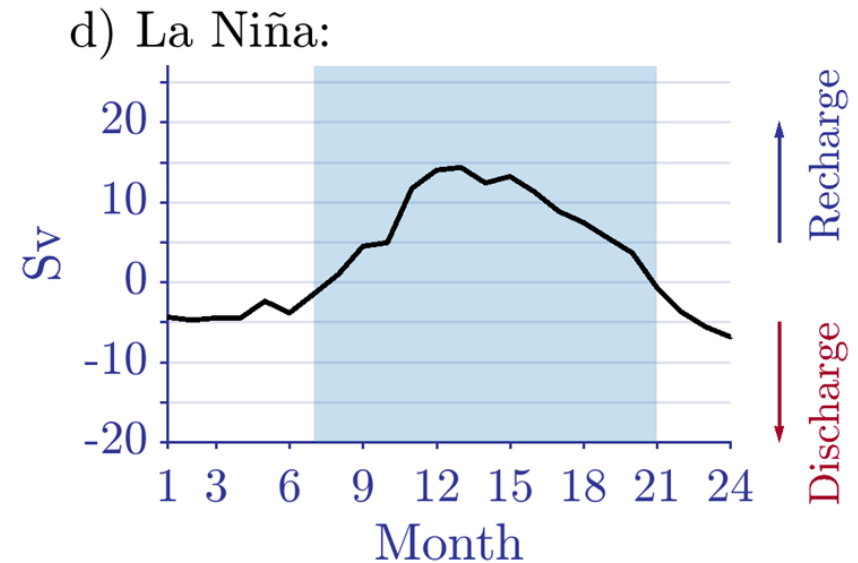
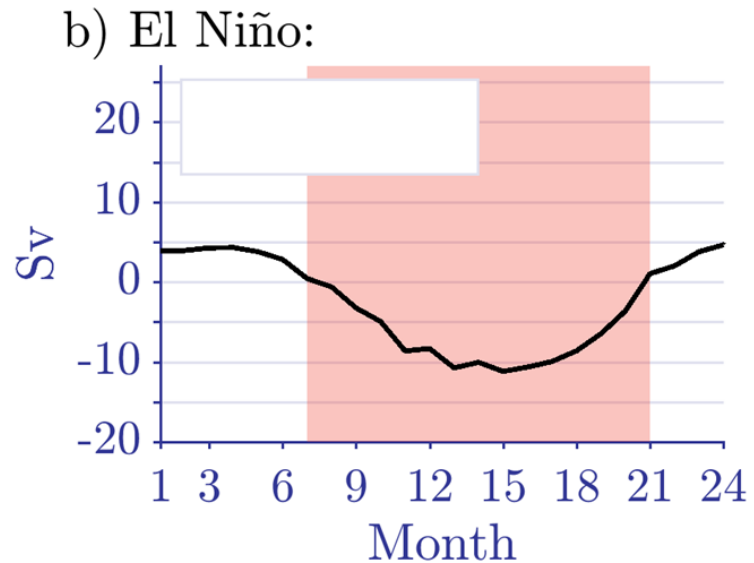
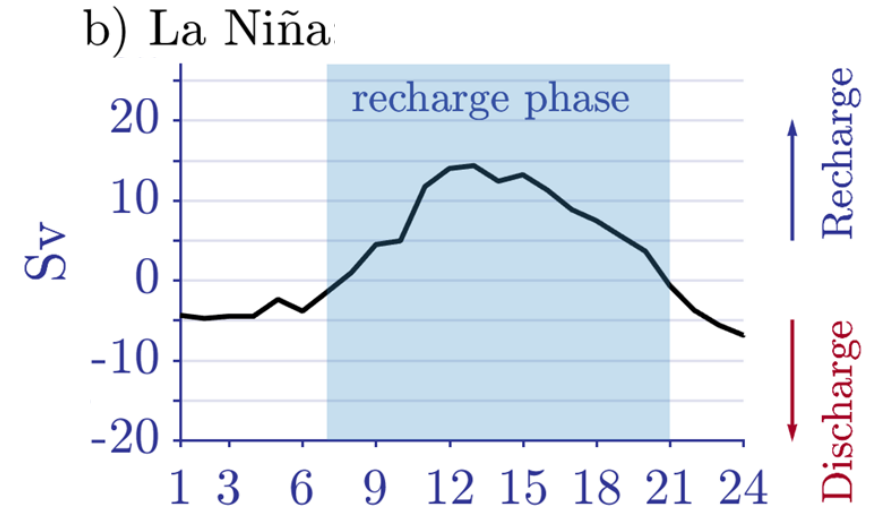
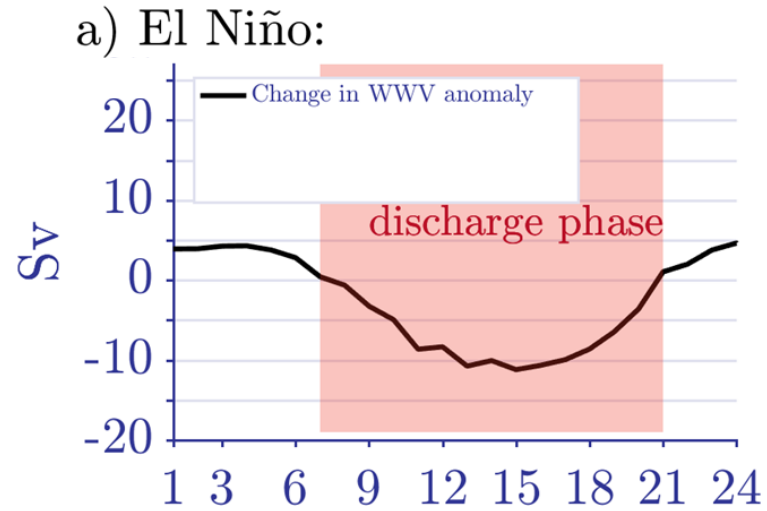
d) La Niña:



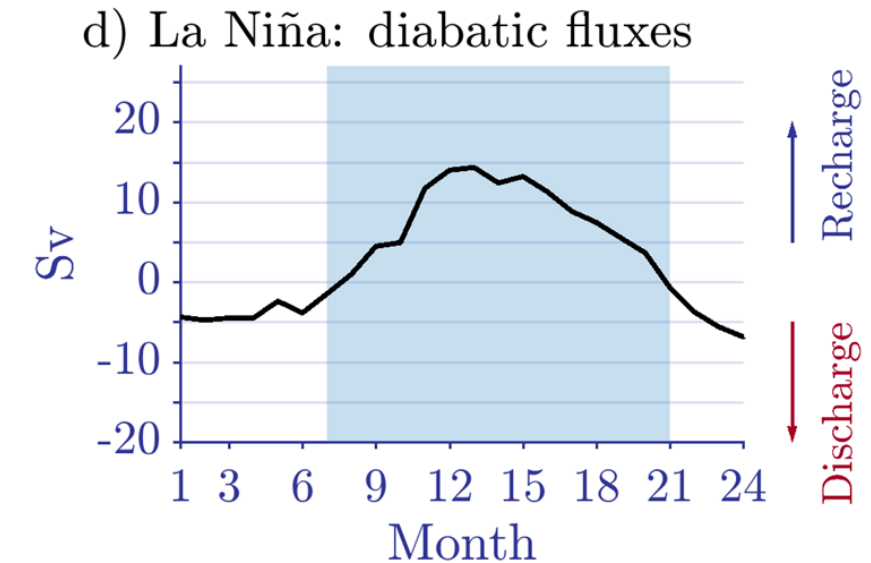
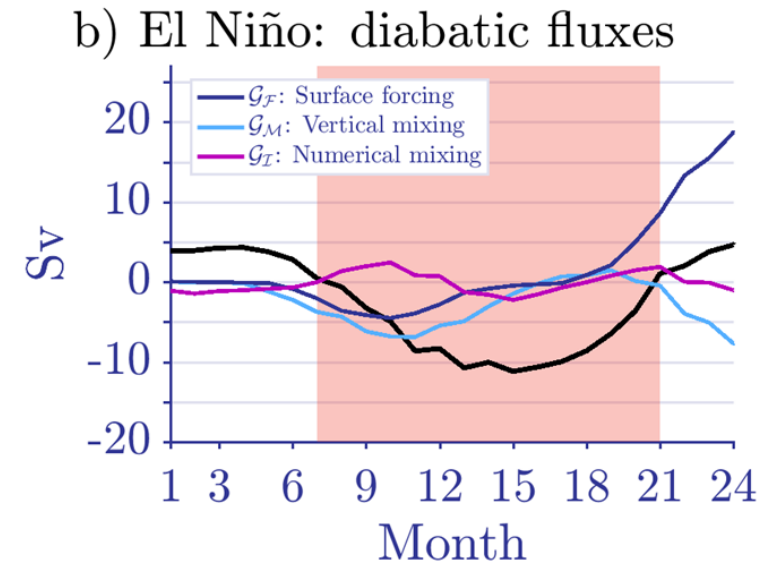
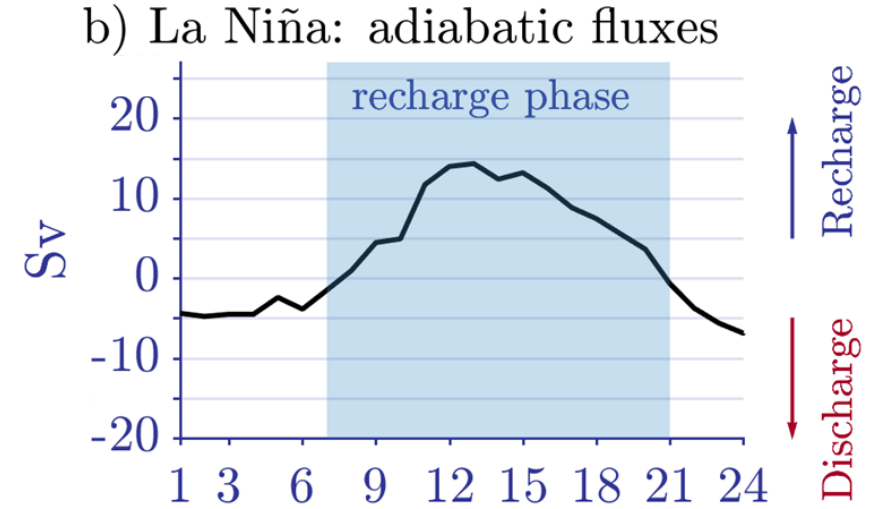
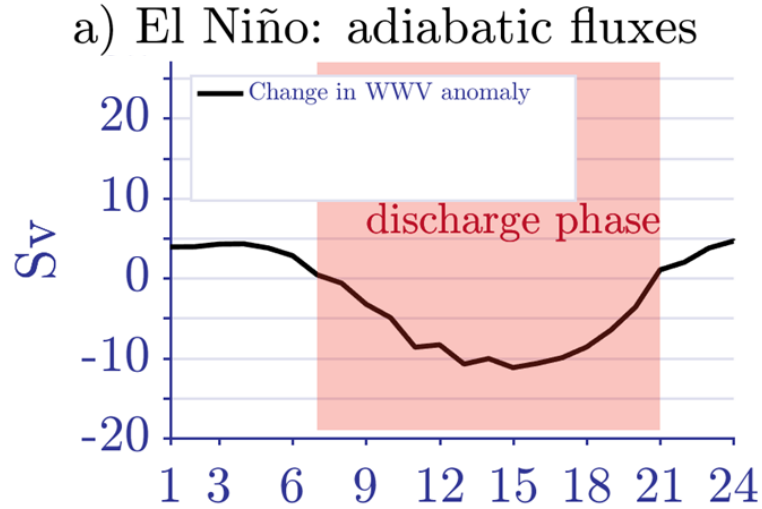
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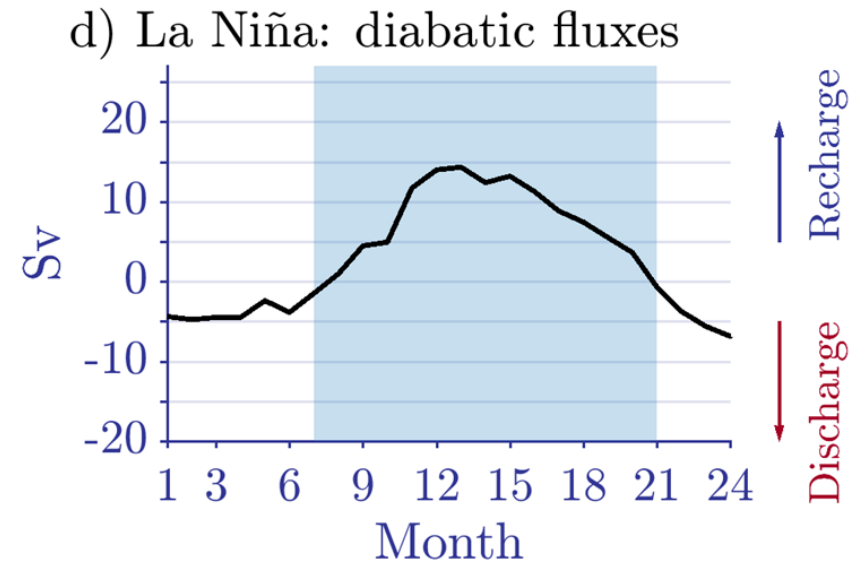
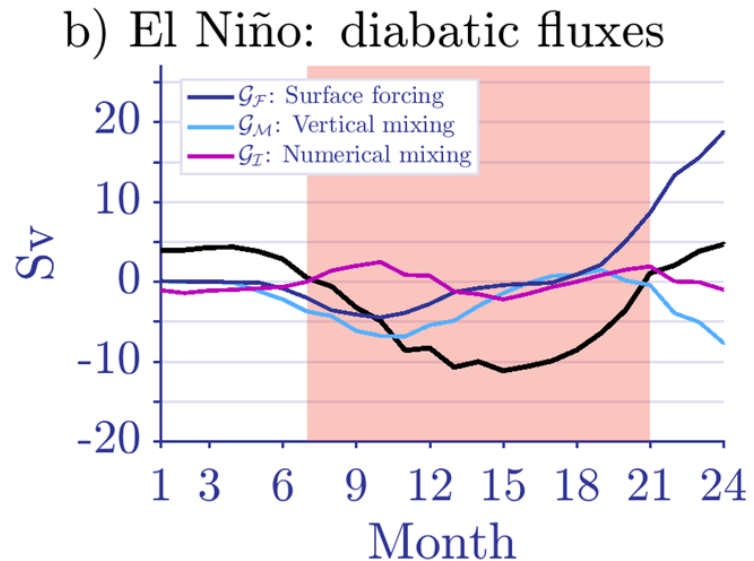
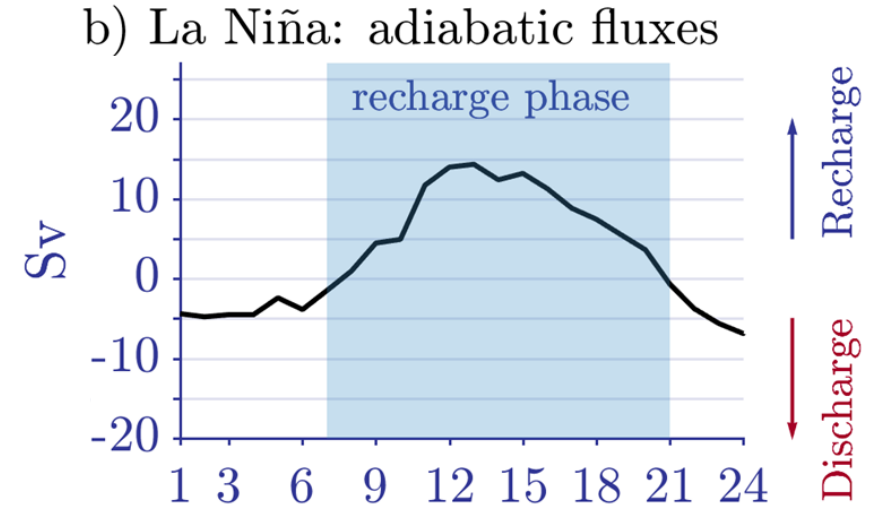
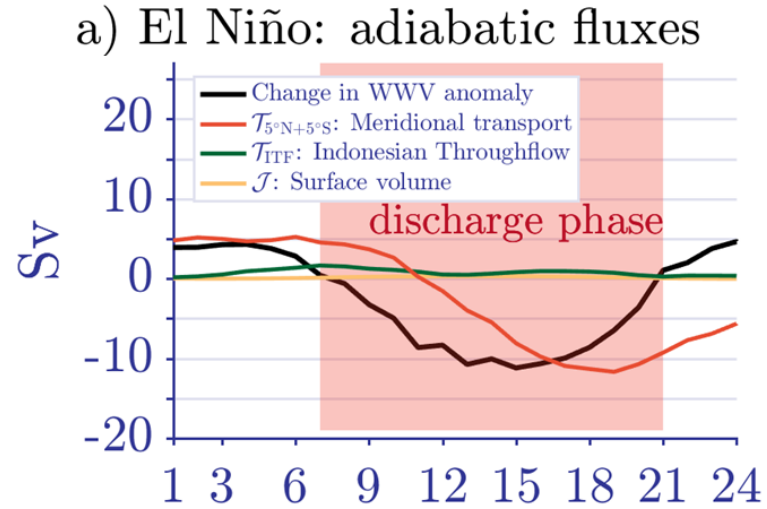
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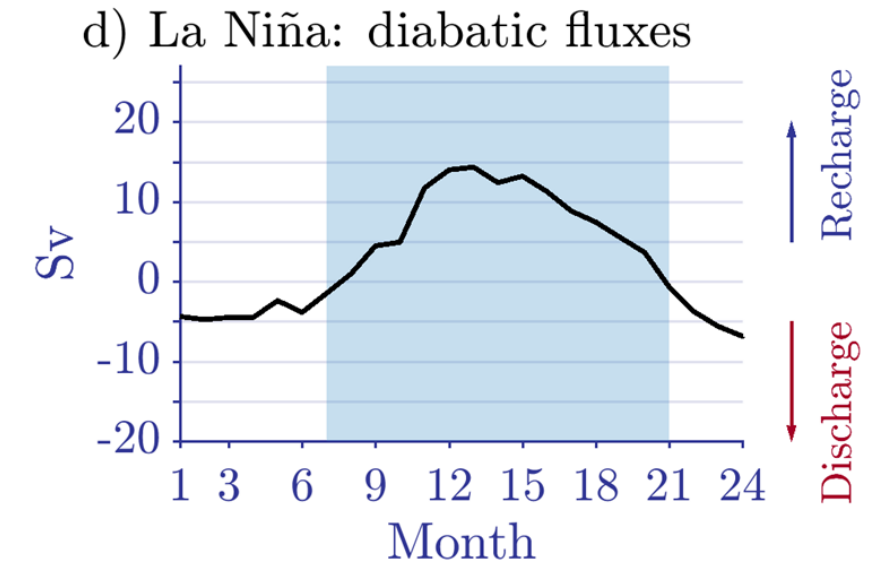
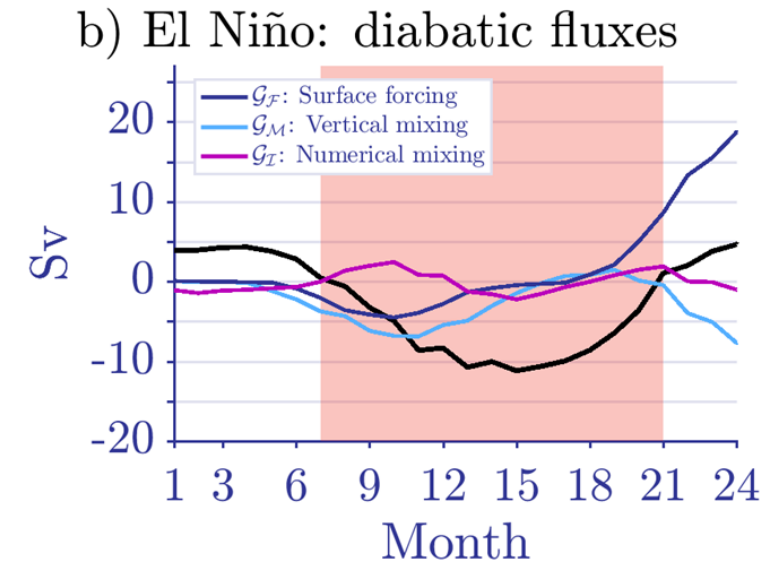
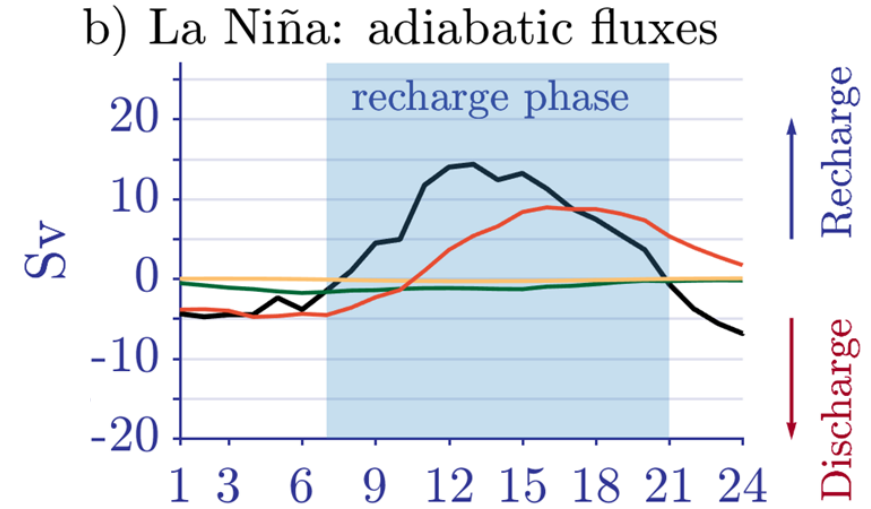
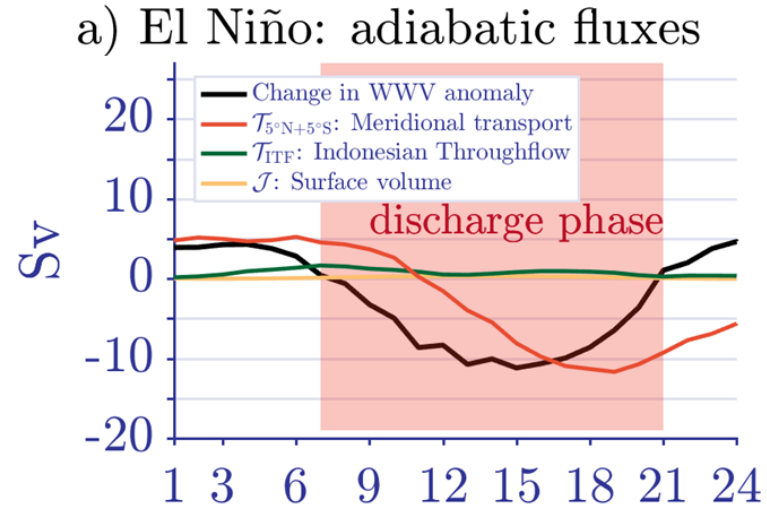
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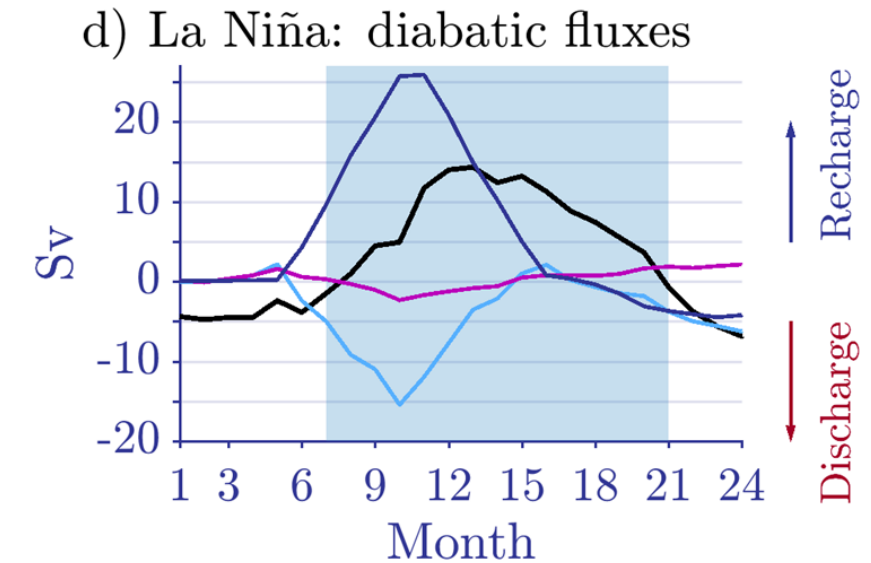
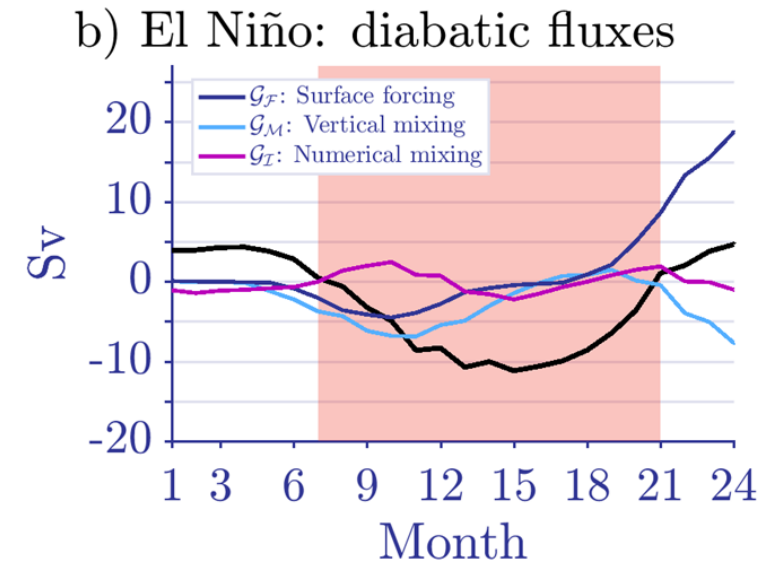
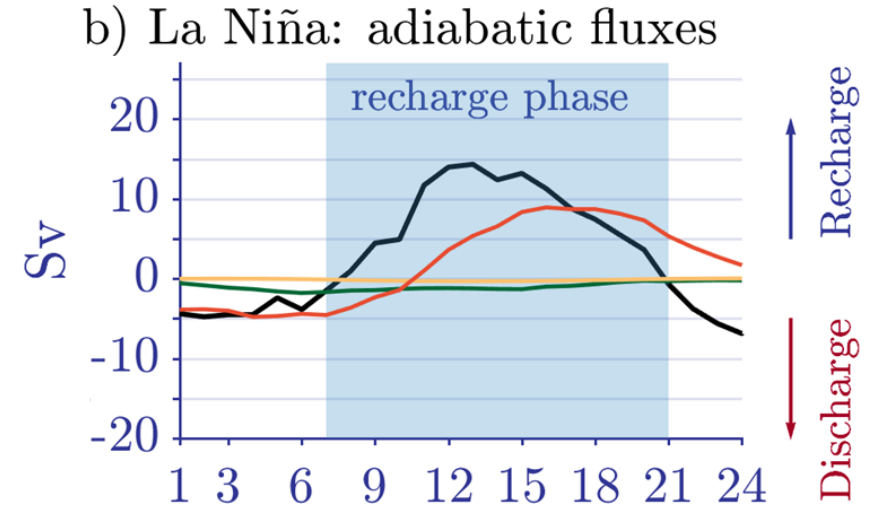
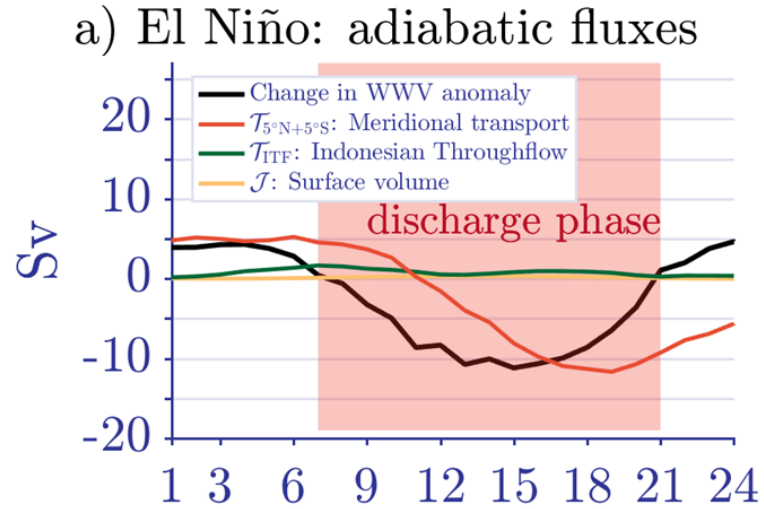
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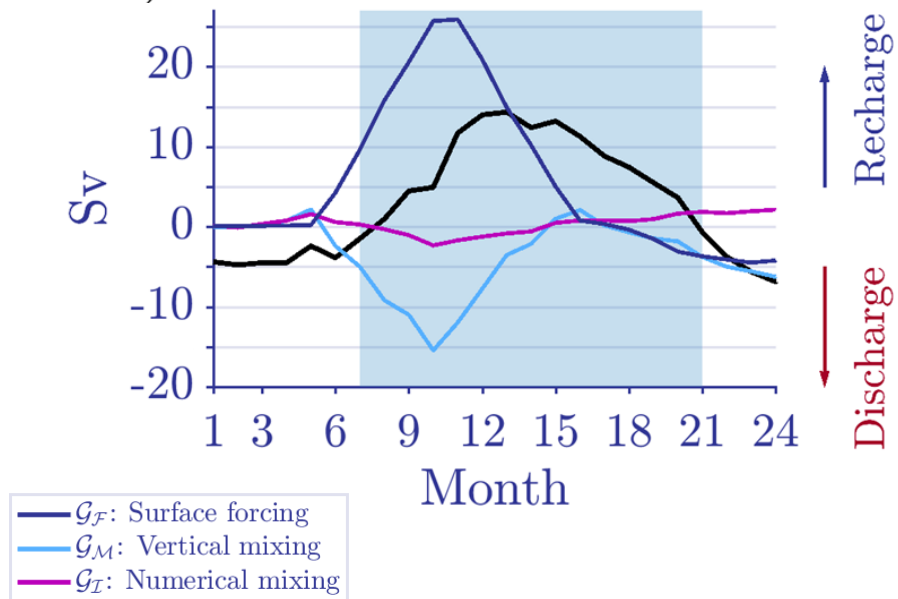


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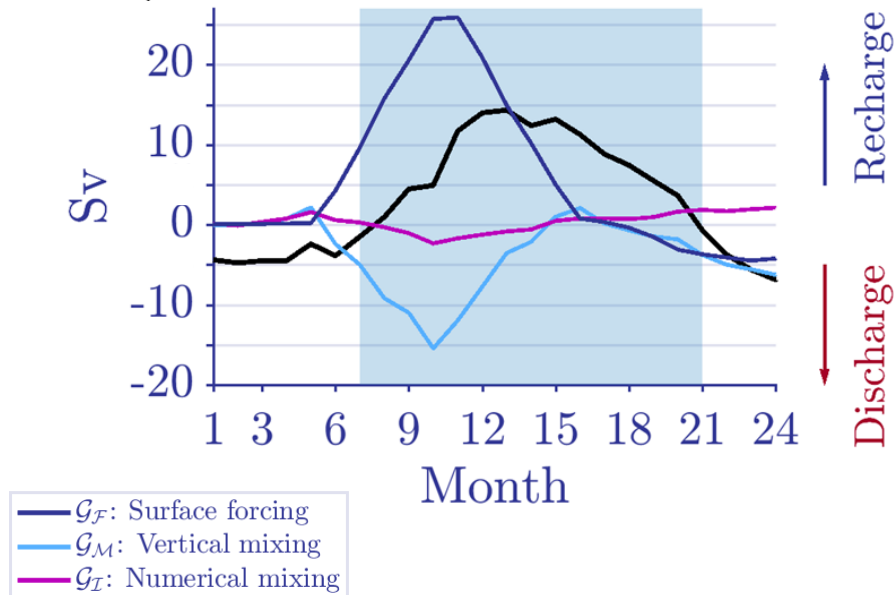
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d) La Niña: diabatic fluxes

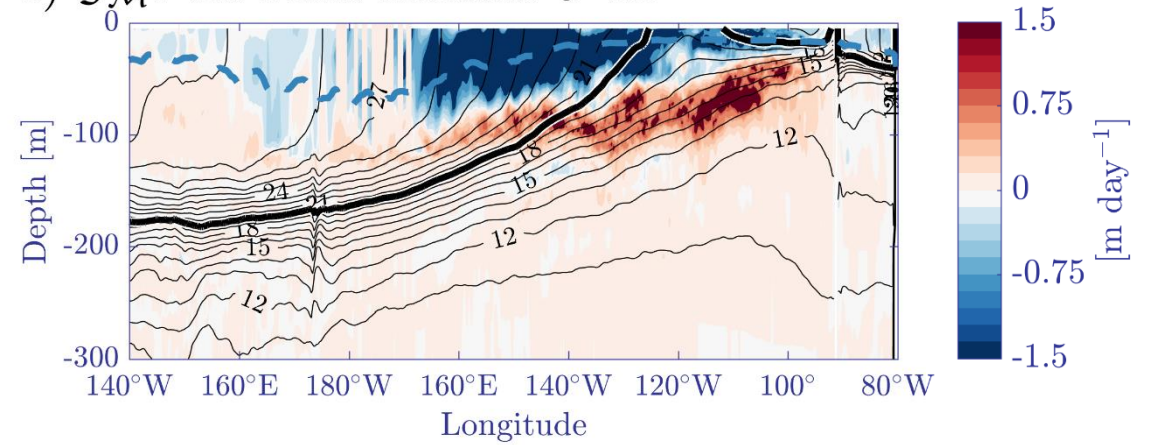


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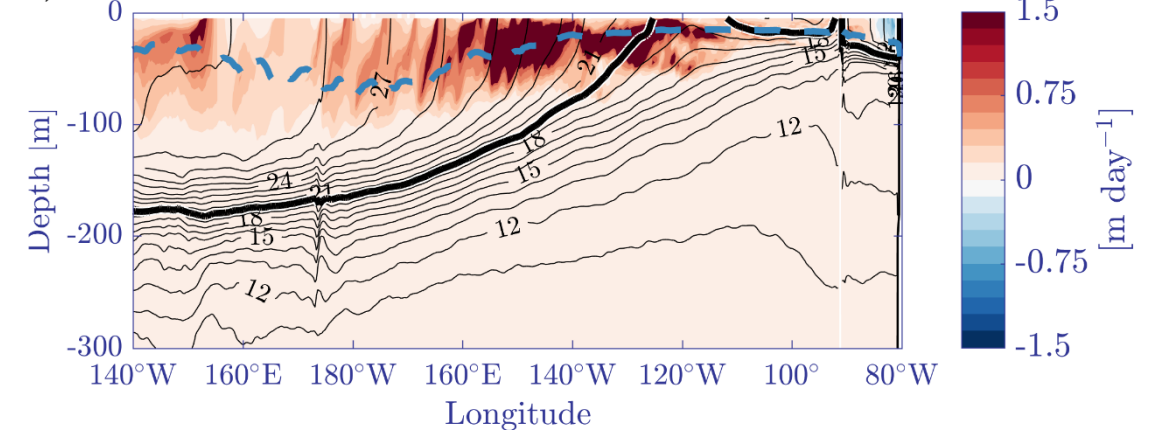
d) La Niña: diabatic fluxes



e) \mathcal{G}_M : La Niña months 9–11



f) \mathcal{G}_F : La Niña months 9–11



Take – Home Messages

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

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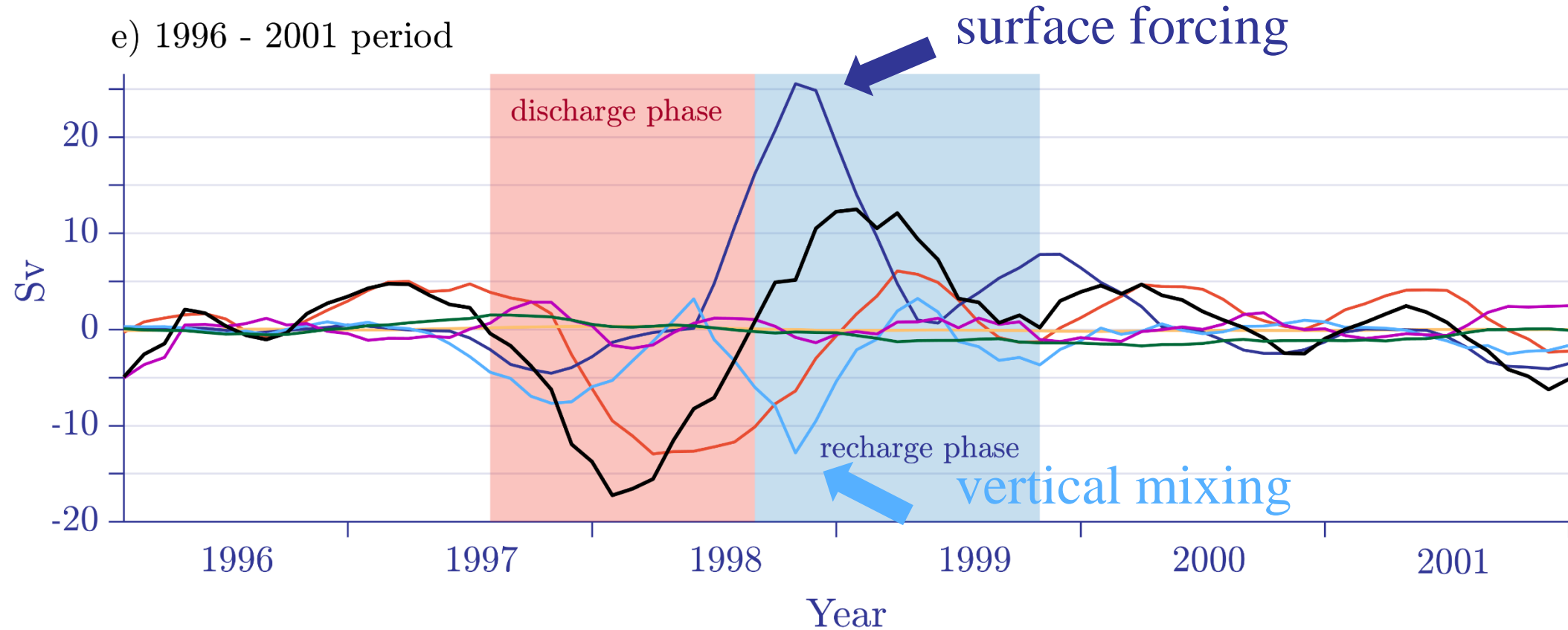
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- Initial changes dominated by diabatic fluxes, followed by adiabatic transport later
- Adiabatic transport largely symmetric between El Niño and La Niña
- Strong asymmetry in diabatic fluxes caused by upward shift of 20°C isotherm

12:43.27 min

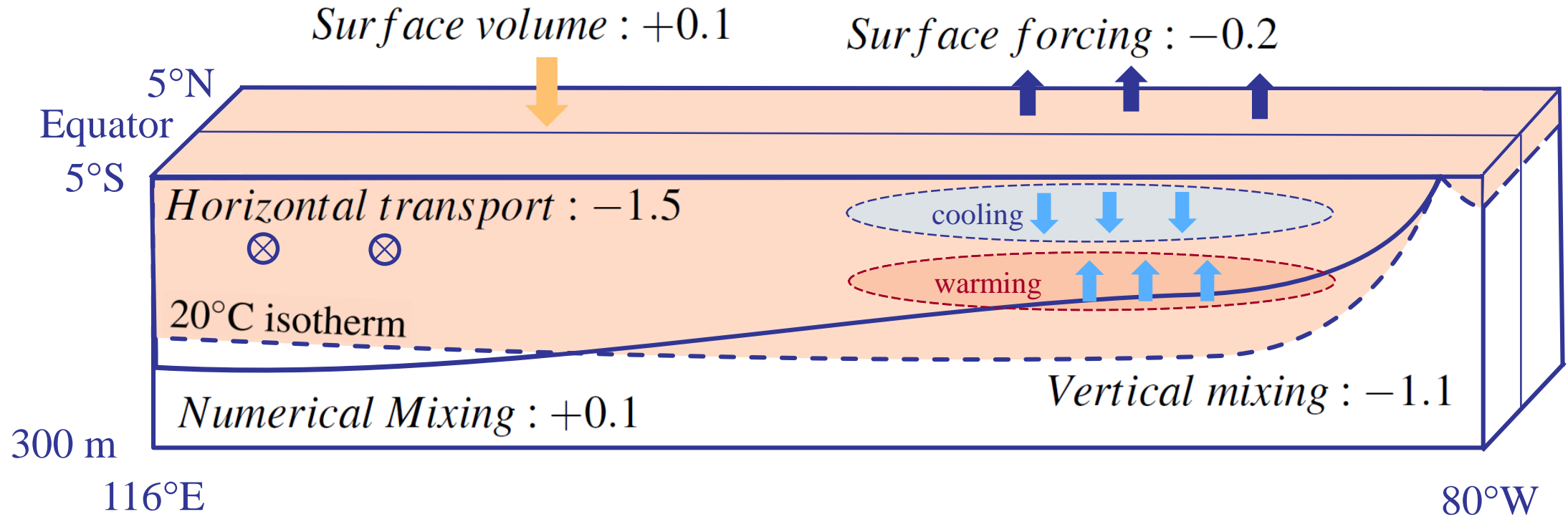
WWV Balance Terms throughout ENSO



El Niño Discharge

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

total WWV change: -2.5



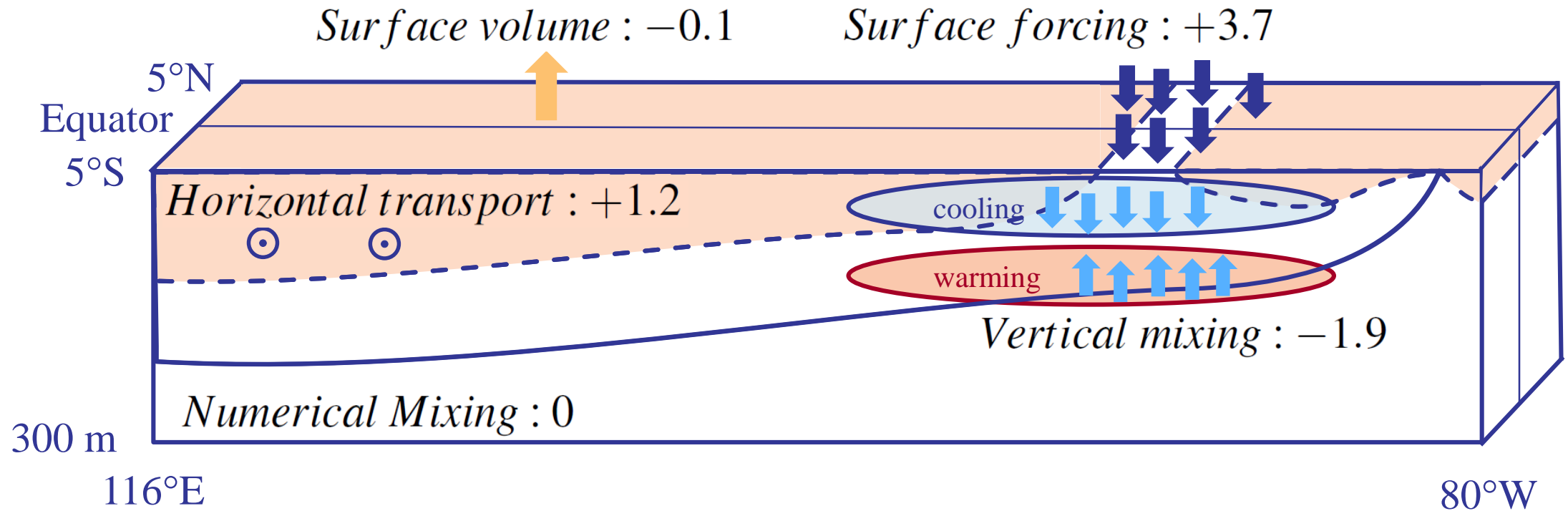
diabatic: 40%

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%