Water Isotopic Imprints on the Pliocene Pacific Walker Circulation

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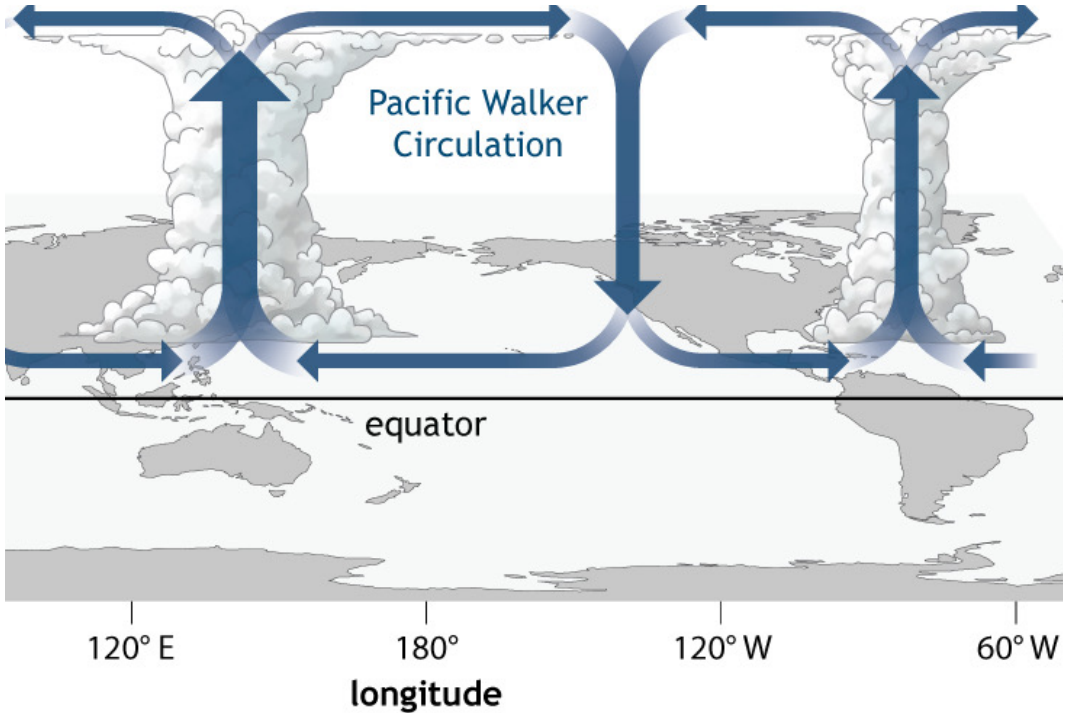
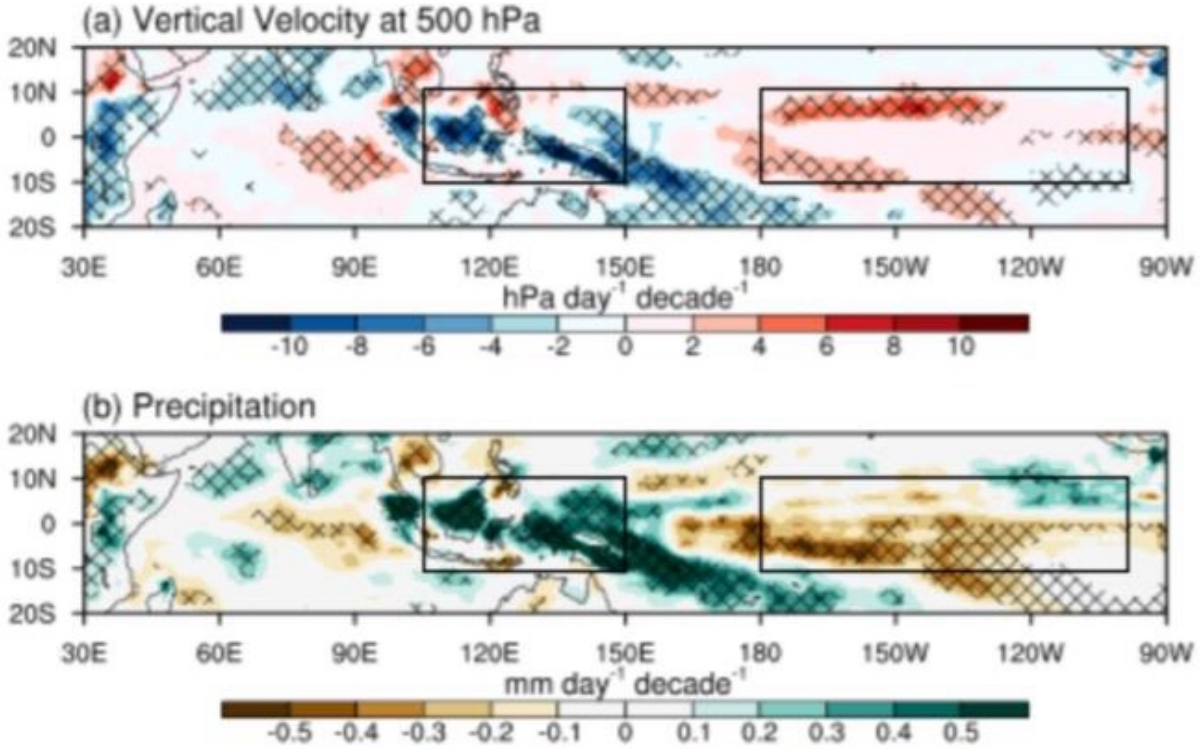
Water Isotopologues: Potential PWC Strength Proxy

- Weaking of PWC key climate model prediction
- Inconsistent instrumental observations



NOAA

- Circulation change matches with precipitation change -> Isotopic signal?

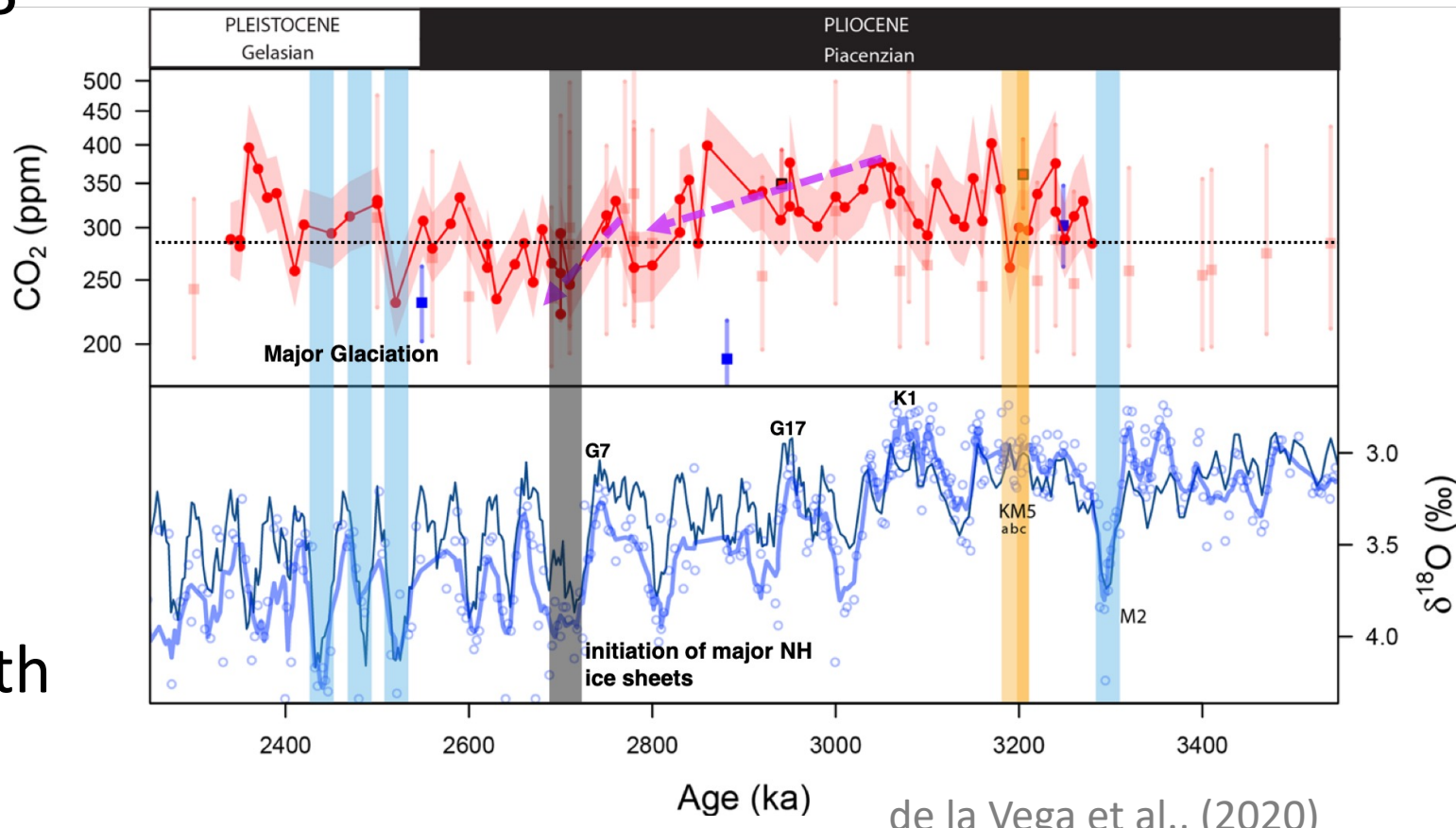


Chung et al., 2019

Late Pliocene Analog for PWC CO_2 sensitivity

- From Mid-Piancenzian (3.3 – 3.0 Ma) to the early Pleistocene (2.4 Ma) decline of CO_2 (400 – 280ppm)

- Aiming to understand the connection between CO_2 induced circulation strength change and δDp signal

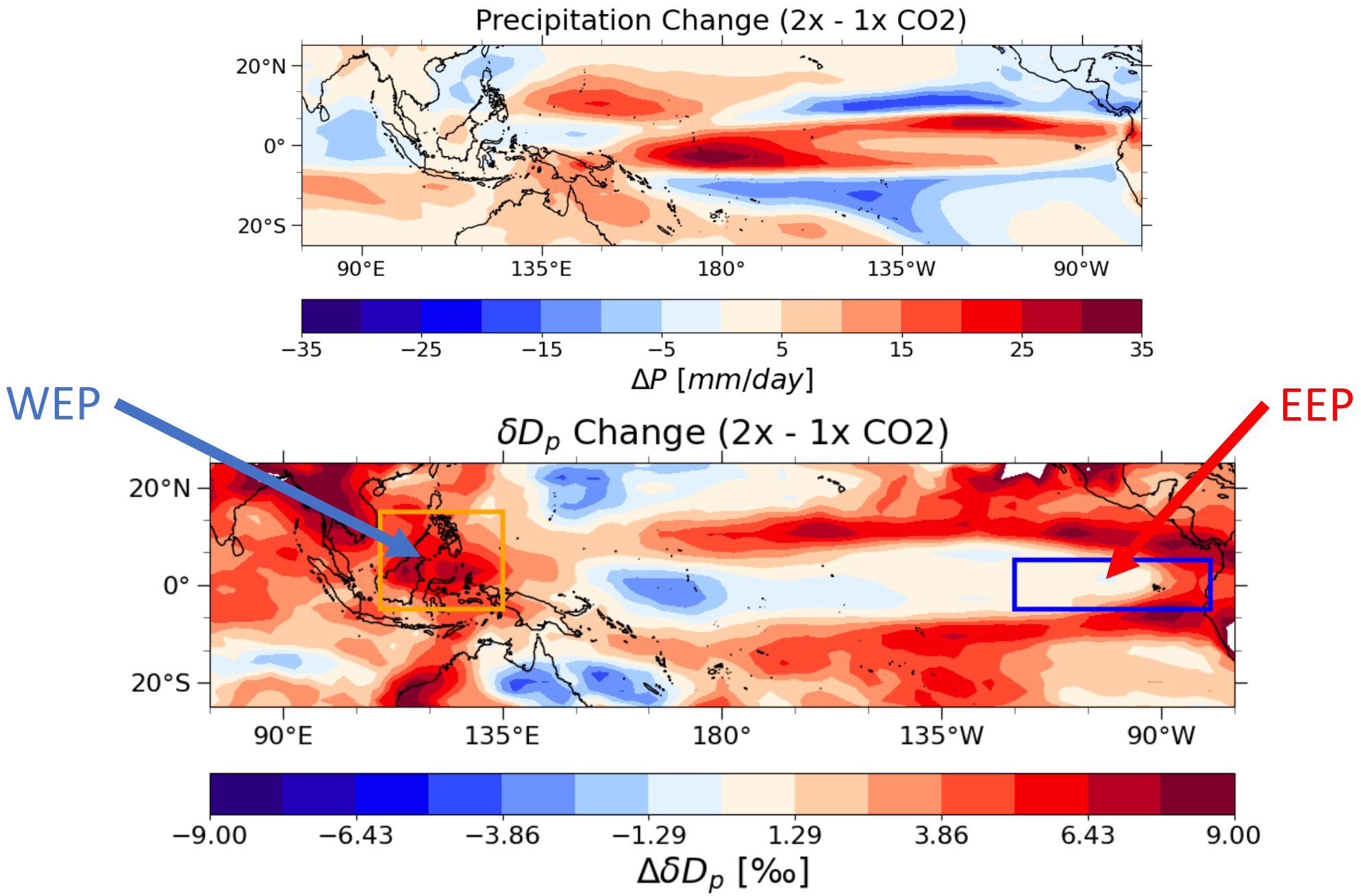


de la Vega et al., (2020)

Experimental approach

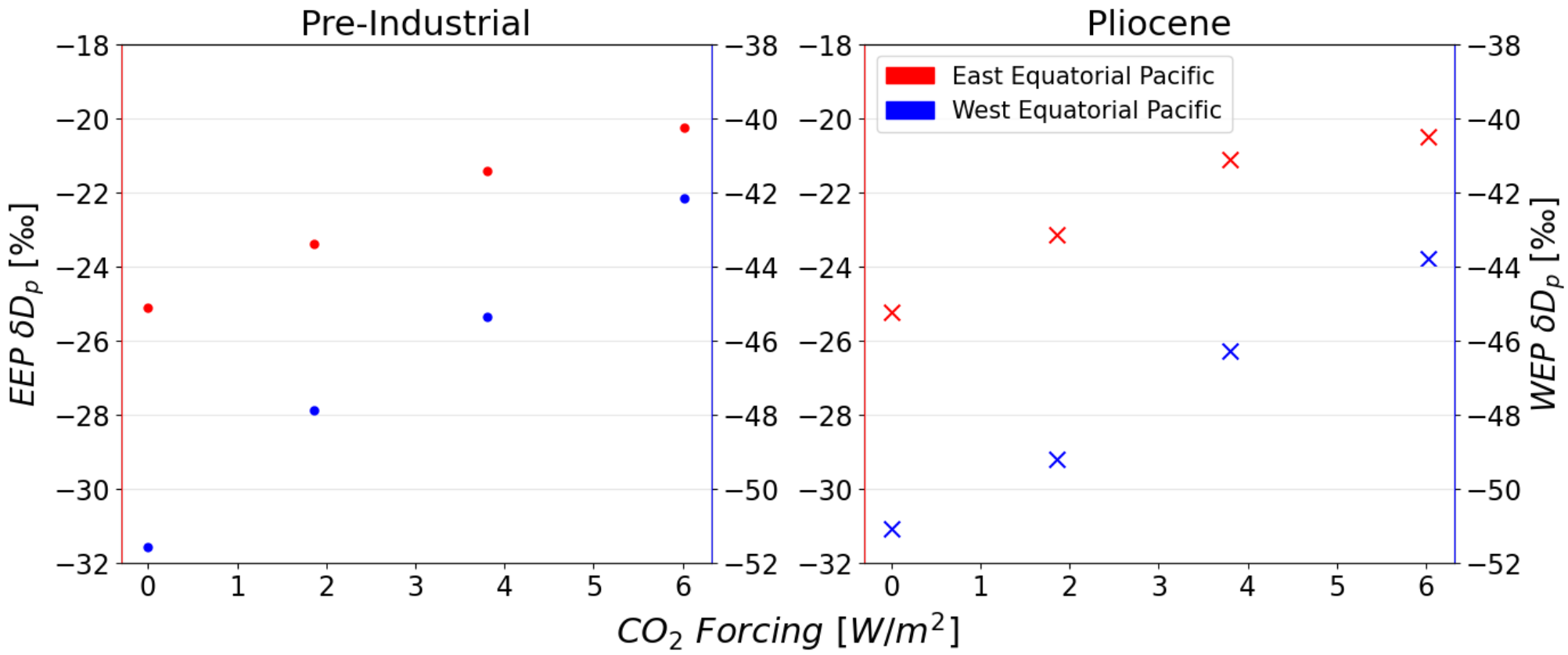
- Model: Isotope tracking-enabled Community Earth System Model version 1.2 (Brady et al., 2019)
- Resolution: 1.9 x 2.5° atmosphere, ~1° ocean
- Mixed layer ocean
  - Ocean heat content considered for upper layer only
- Online water tagging
  - Water vapor origination, transport, and condensation tracking
- Simulation sets with 1x, 1.4x(400pm), 2x, 3x PI CO_2 for Pre-industrial and Pliocene boundary conditions
- 60 years runtime

Relationship between δD_{p} and PWC strength


Precipitation Change (2x - 1x CO2)
20°N
0°
20°S
90°E
135°E
180°
135°W
90°W
−35
−25
−15
−5
5
15
25
35
ΔP [mm/day]
WEP
EEP
δD_p Change (2x - 1x CO2)
20°N
0°
20°S
90°E
135°E
180°
135°W
90°W
−9.00
−6.43
−3.86
−1.29
1.29
3.86
6.43
9.00
ΔδD_p [‰]

Deuterium Signal and CO_2 increase

Varying rate of enrichment between eastern and western pacific



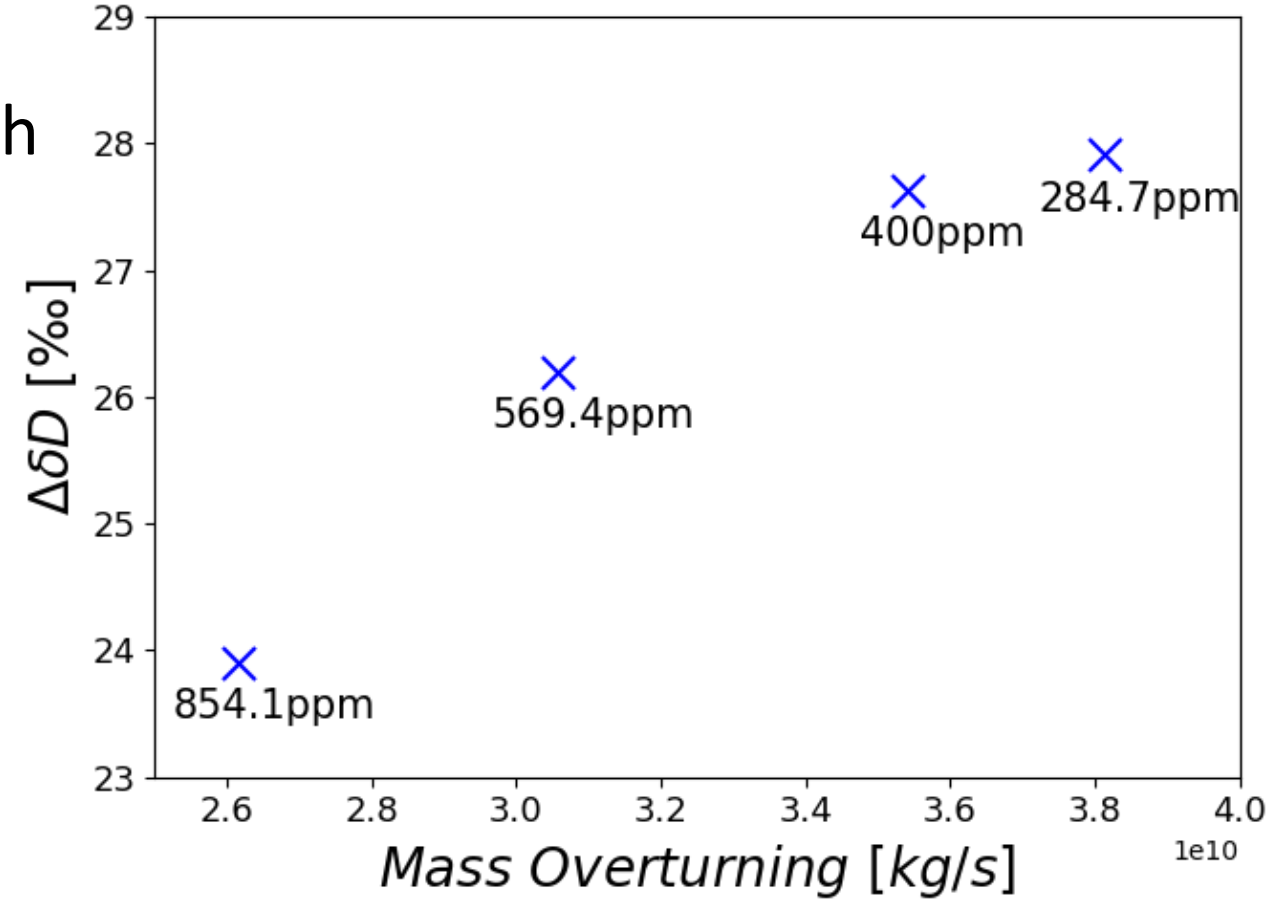
δD_p and PWC strength

PWC strength calculated as the mass overturning given by the maximal zonal mass streamfuction.

$$zsf = \frac{1}{g}\int_{\varphi_1}^{\varphi_2} a \int_0^{2\pi} a\cos\varphi\,\omega^* d\theta\, d\varphi \qquad \omega^* = \omega - [\omega]$$

$\Delta\delta D_p$ = **EEP**δD_p - **WEP**δD_p
Mass Overturning = PWC Strength

Decrease of the isotopic difference following circulation weakening
-> PWC Strength Proxy

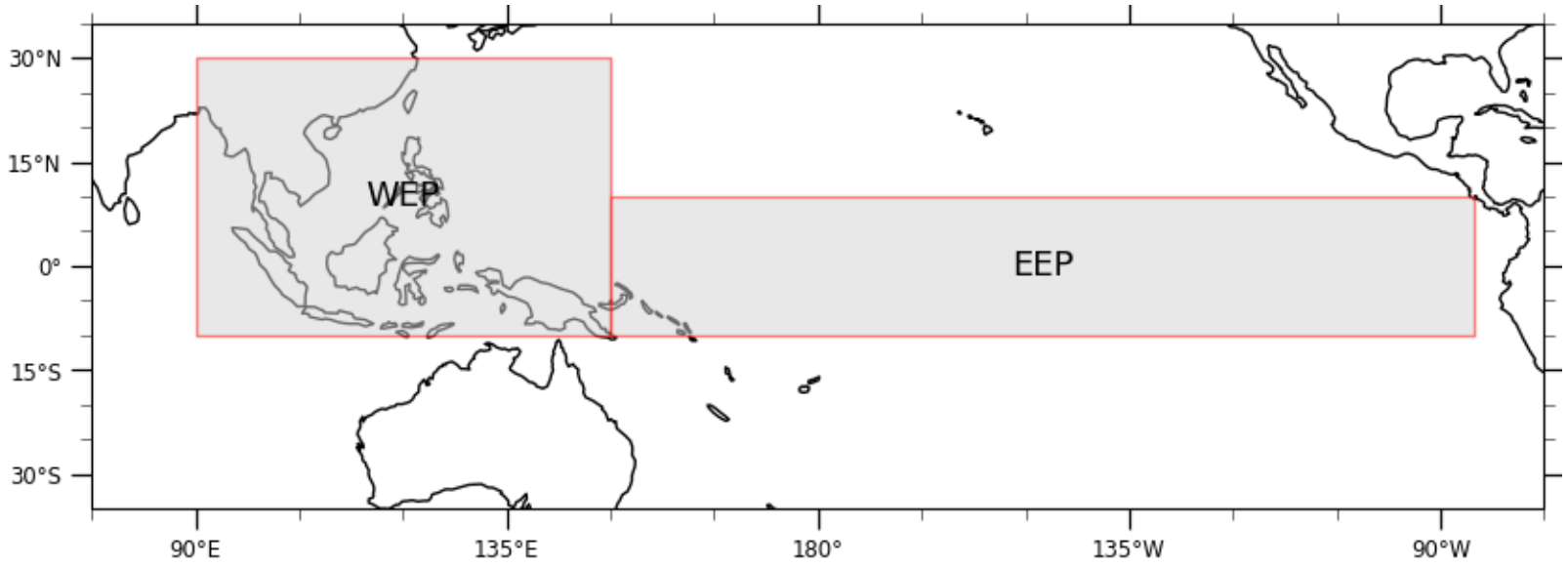


Dynamic linkage between δD_{p} and PWC strength

Water Tagging

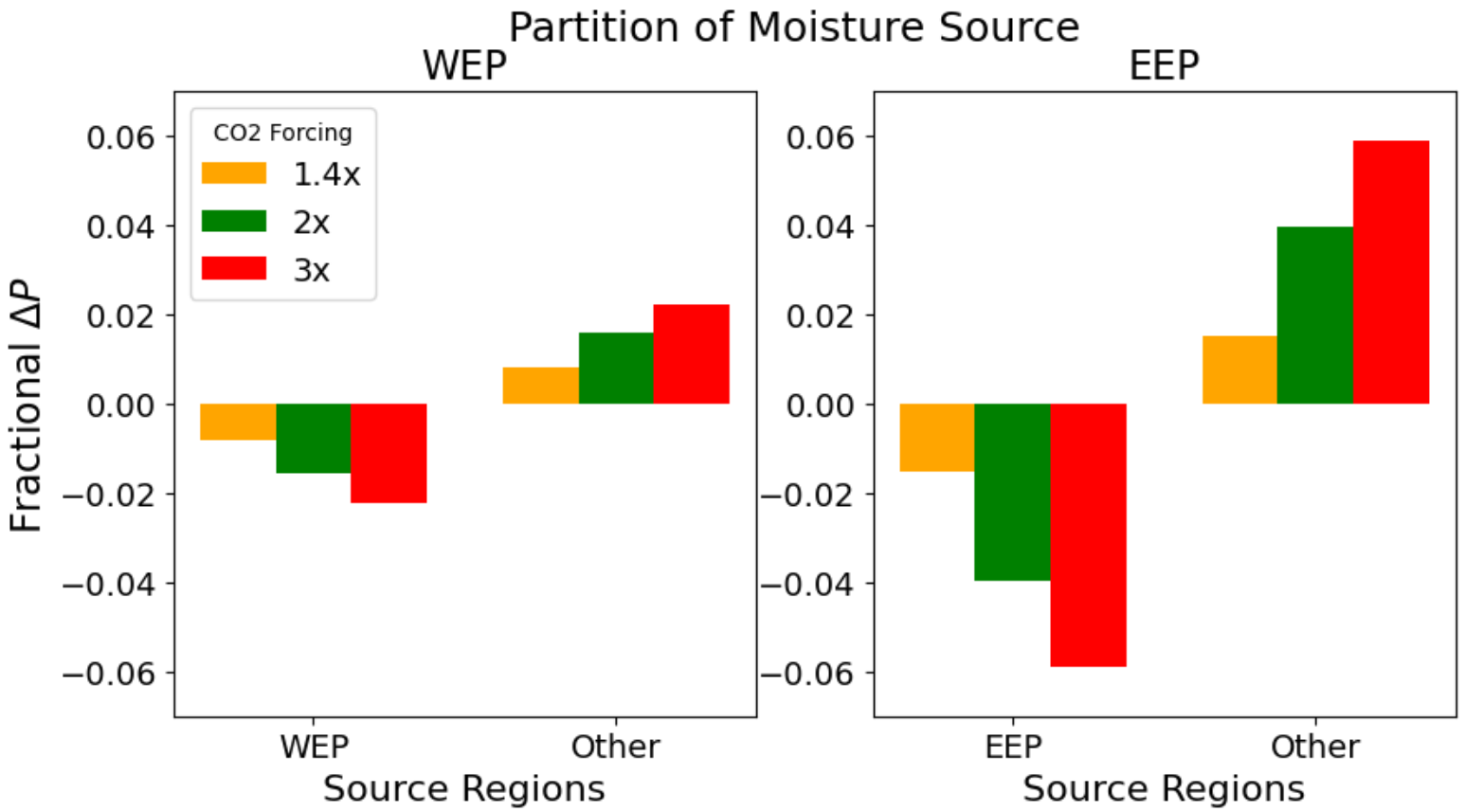
Allows for tracking of water isotopologues through the hydrological cycle

Looking at moisture recycling of WEP and EEP



Fractional Precipitation Change

- Fractional decrease of locally sourced moisture
- Compensation through moisture convergence
- Much stronger in the Eastern Pacific



Conclusion

- Contrast between WEP and EEP can be used as PWC strength proxy
- Difference in the rate of δD_p changes is linked to varying rates of change in moisture convergence towards eastern and western equatorial Pacific

Future Work

- Coupled simulations
  - Ocean dynamics changes and oceanic signatures of PWC
  - Sensitivity to early Pleistocene glaciation

Additional Material

Signal decomposition

$$\delta D_p = \sum_{i=0}^{N} \left(\delta D_{p,i} \times \frac{p_i}{p_{total}} \right)$$

Tabor et al., (2018)

Signal at sink region

Signal coming from source(s)

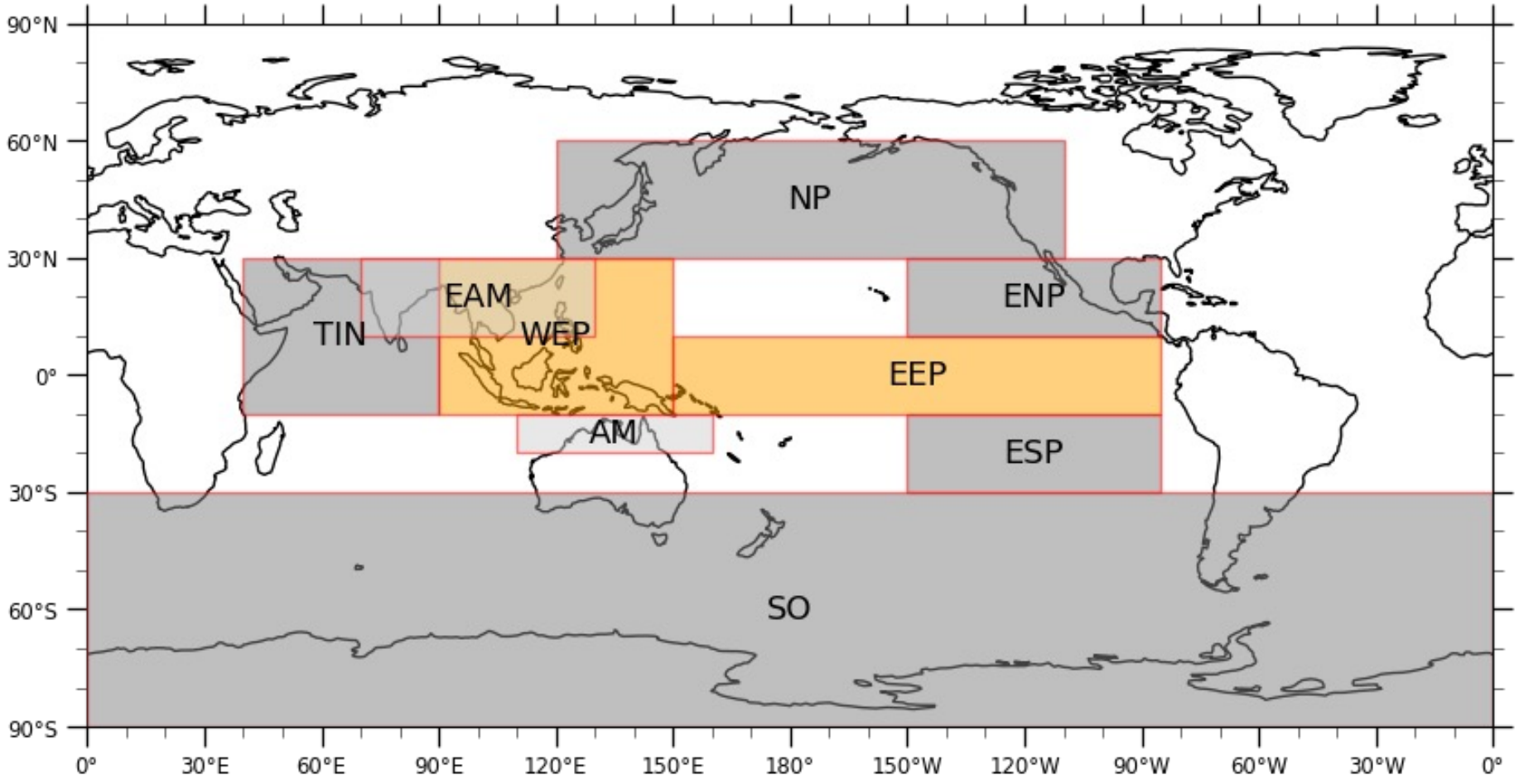
Fractional Precipitation

The change in δD_p can be divided into two components: precipitational amount change and source signal change

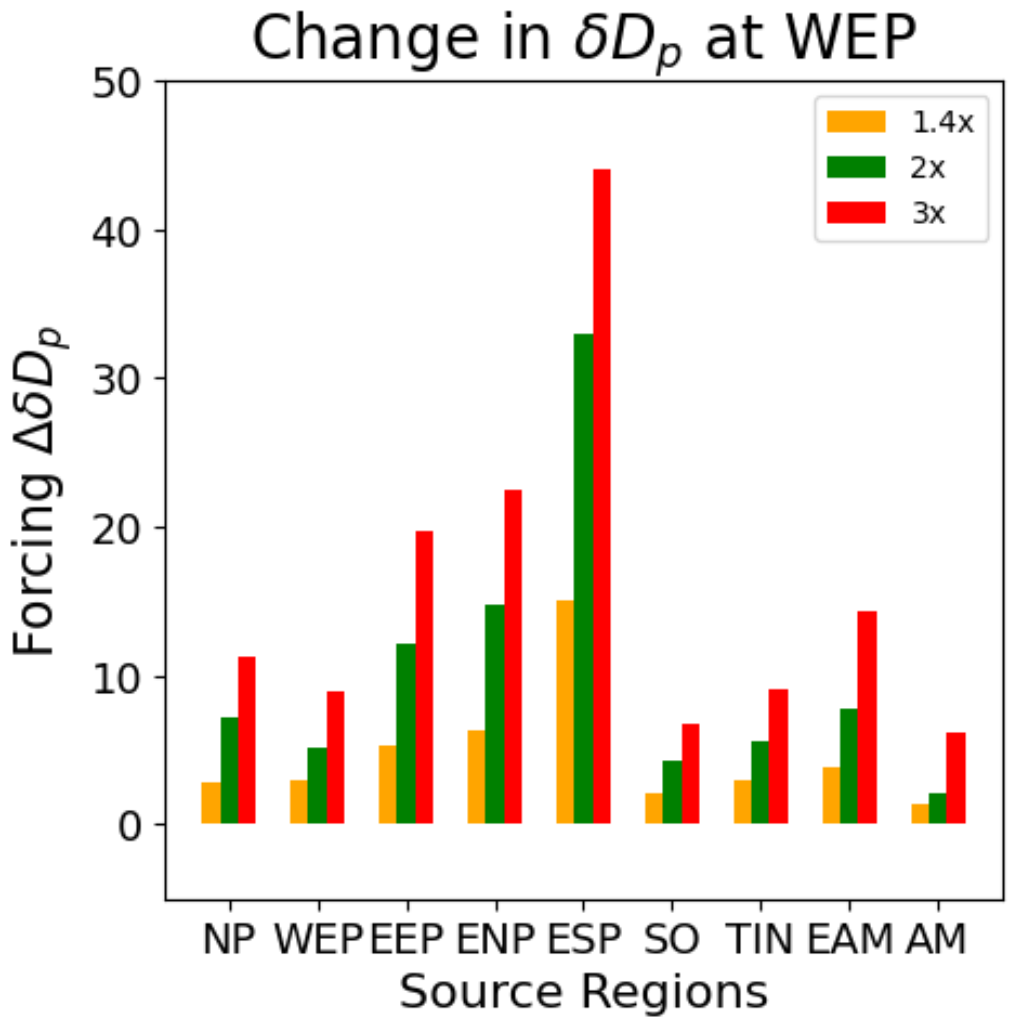
Regions for water tagging

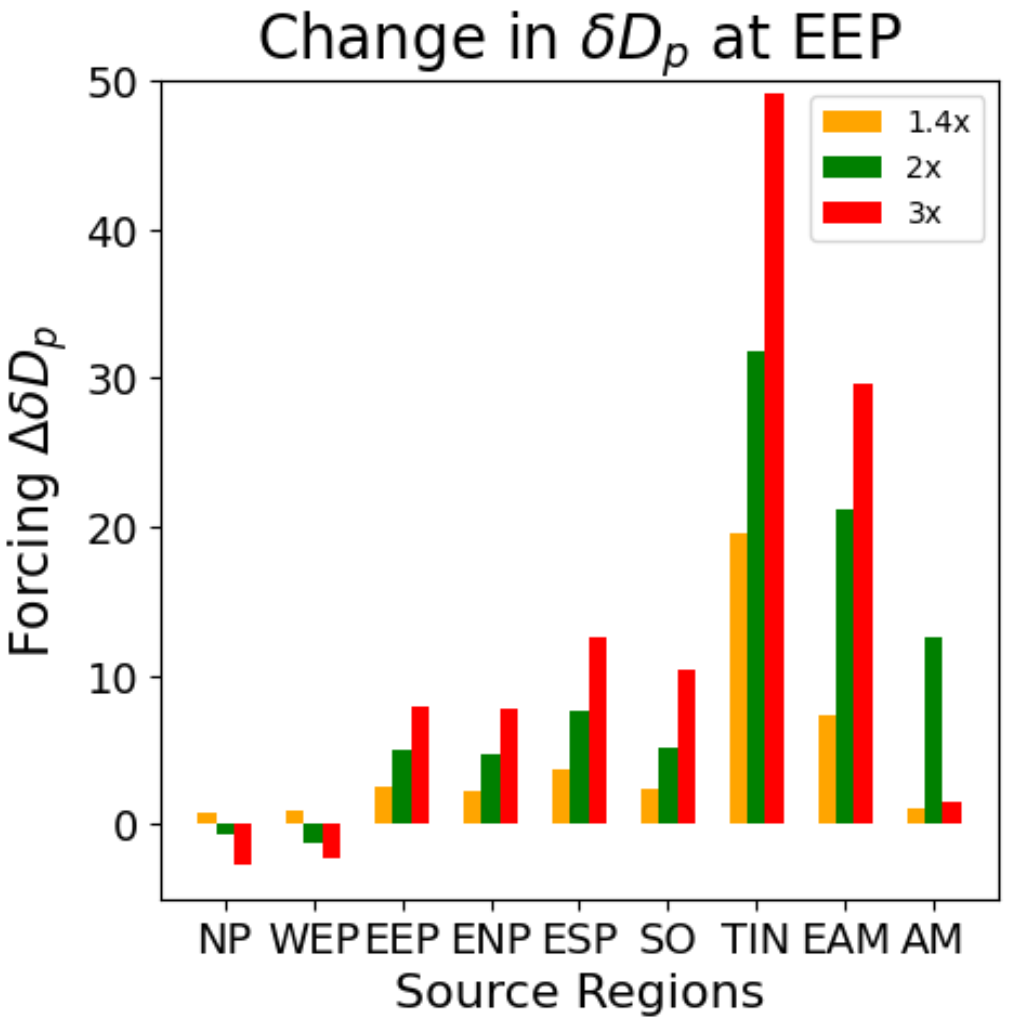
Ocean: grey
Land: lightgrey

WEP and EEP
Sink Regions



Source δD_p Signal Change





Fractional Precipitation Pattern Change