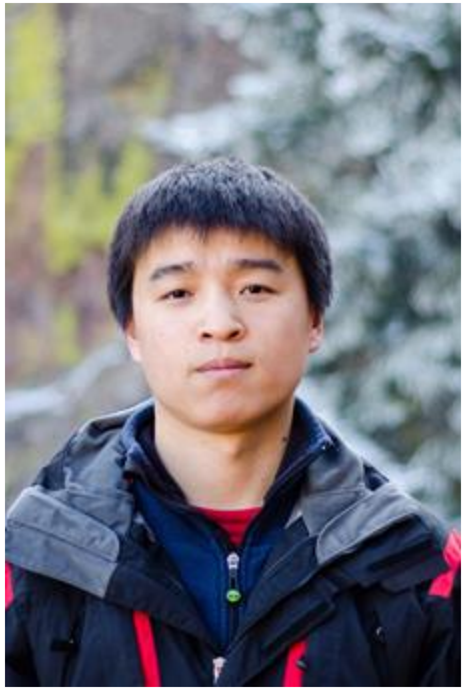
Welcome to the Paleoclimate Session!



Jiang Zhu
(NSF NCAR)

Samantha Stevenson
(UCSB)

Ran Feng
(UConn)

Time	Topic	Speakers
13:00–13:15	***WELCOME*** & Seawater isotopic signatures of Pliocene tropical ocean	Ran Feng
13:15–13:30	Vegetation-climate feedbacks in the Pleistocene using iCESM1.3 and BIOME4	Elke Zeller
13:30–13:45	Impact of aerosol changes on Earth's pre-anthropogenic radiative budget (*REMOTE*)	Irina Thaler
13:45–14:00	Investigating the Physical State of the Modeled Eocene Ocean After Full Equilibration (*REMOTE*)	Adam Aleksinski
14:00–14:15	The Influence of Tethys and Central American Seaway on Climate during the Miocene Climatic Optimum (*REMOTE*)	Hamida Ngoma Nadoya
14:15–14:30	Constraining Antarctic ice sheet stability during the Last Interglacial (*REMOTE*)	Joseph Schnaubelt
14:30–15:00	***BREAK***	
15:00–15:15	Persistently active El Niño–Southern Oscillation since the Mesozoic	Xiang Li
15:15–15:30	Angiosperm tree heights during the Cretaceous Terrestrial Revolution: Evidence from the Upper Campanian Jose Creek Formation, south-central New Mexico	Garland Upchurch
15:30–15:45	Reconciling model and proxy records in late Cretaceous ocean simulations	Maya Tessler
15:45–16:00	Advancing Deep-Time Climate Reconstruction with a New Online Paleoclimate Data Assimilation Approach in CESM	Feng Zhu
16:15–17:00	***WORKSHOP PLENARY***: Wrap-up & General discussion	

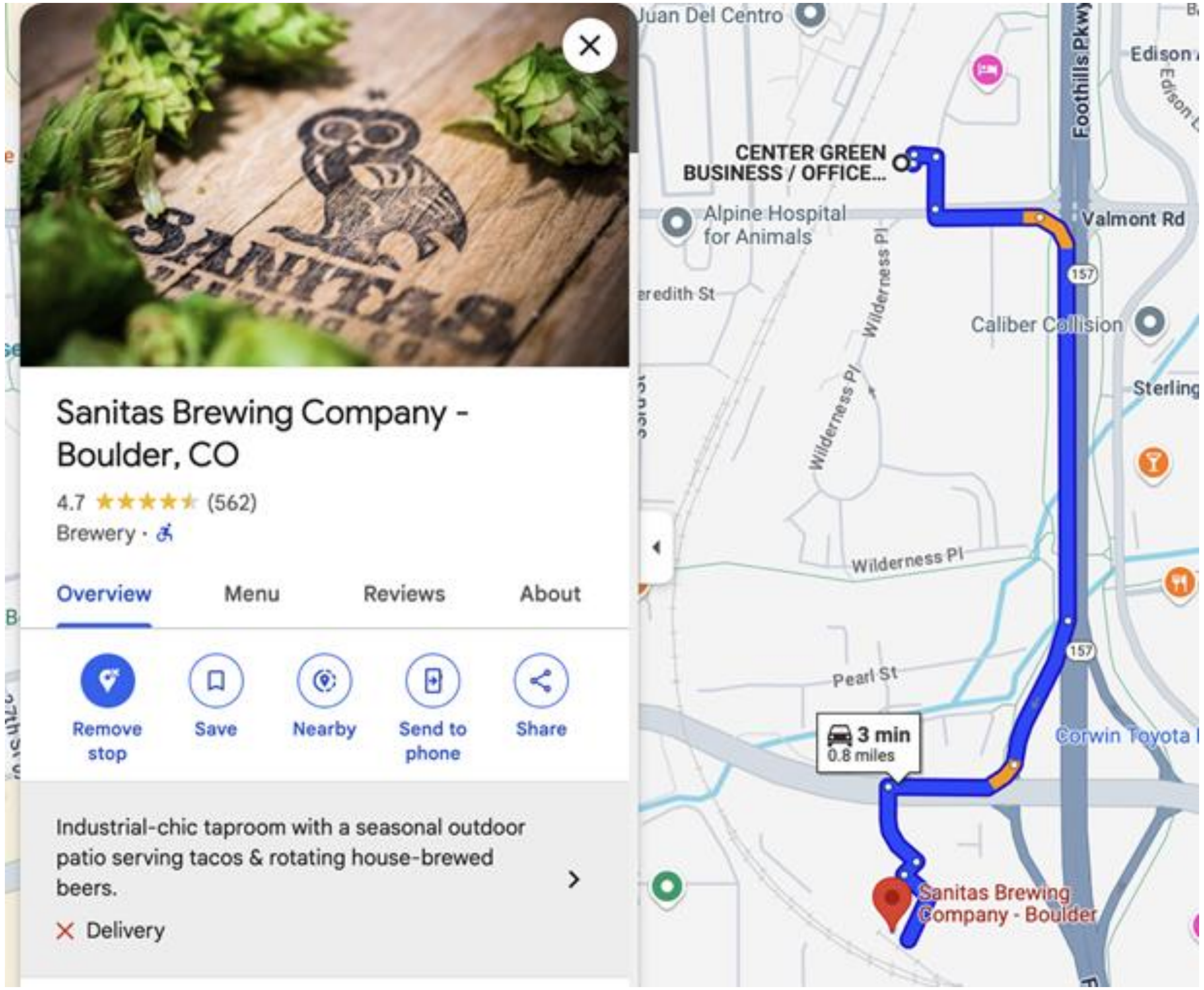
- **15’ for each talk incl. Q&A**
- **Reminder when 2’ left**
- **Questions for speakers?**
  - **In the room: walk to the microphone**
  - **Online: type your questions in Slido**

Your name, select CG1 South room

An Informal Happy Hour— All Are Welcomed!

Slido QR code

5:30pm
Sanitas Brewing Company, 3550 Frontier Ave ste a, Boulder, CO 80301
Meet in front of the building for carpooling



PWG resources

https://www.cesm.ucar.edu/working-groups/paleo

Or Google search "cesm pwg"

Simulations

Recent / Notable

- PaleoWeather: An Accelerated Scientific Discovery Project (ASD)
- PaleoPPE: A Suite of Perturbed Parameter Ensembles under a Wide Range of Temperatures
- Paleoclimate-Calibrated CESM2 and simulations (with FAQ and Diagnostic Plots)
- CESM2-CISM2 Transient Last Interglacial
- CESM2 Last Glacial Maximum
- CESM2 CMIP6-PMIP4 simulations for midHolocene and lig127k
- PlioMIP2 (CMIP6-PMIP4) simulations with CESM2, CESM1.2, and CCSM4
- CESM1.1 Last Millennium Ensemble Project
- TraCE21 Project, 21ka to present
- iTraCE: isotope-enabled CESM1.3, 19ka to 11ka
- CESM1.2 Pennsylvanian (~300Ma) UMich, UOregon

NSF-2103055

Do proxy $\delta^{18}O_{sw}$ support strengthened Pacific Walker Circulation in response to the Plio to Pleistocene CO_2 decline?

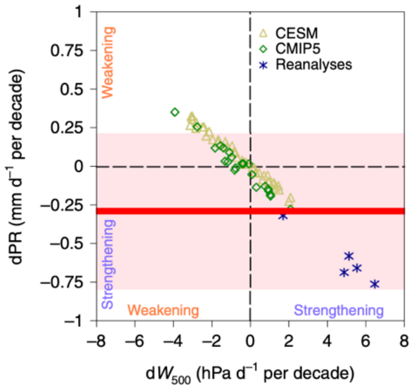
Ran Feng[1], Theodor Mayer[1], Tripti Bhattacharya[2], Heather Ford[3], David Fastovich[2], Erin McClymont[4], Sze Ling Ho[5]

1. University of Connecticut, 2. Syracuse University, 3. Queen Mary College, University of London, 4. Durham University, 5. National Taiwan University

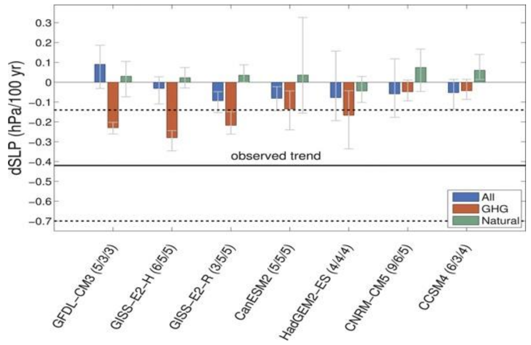


Weakened Pacific Walker Circulation (PWC) in response to CO_2 increase

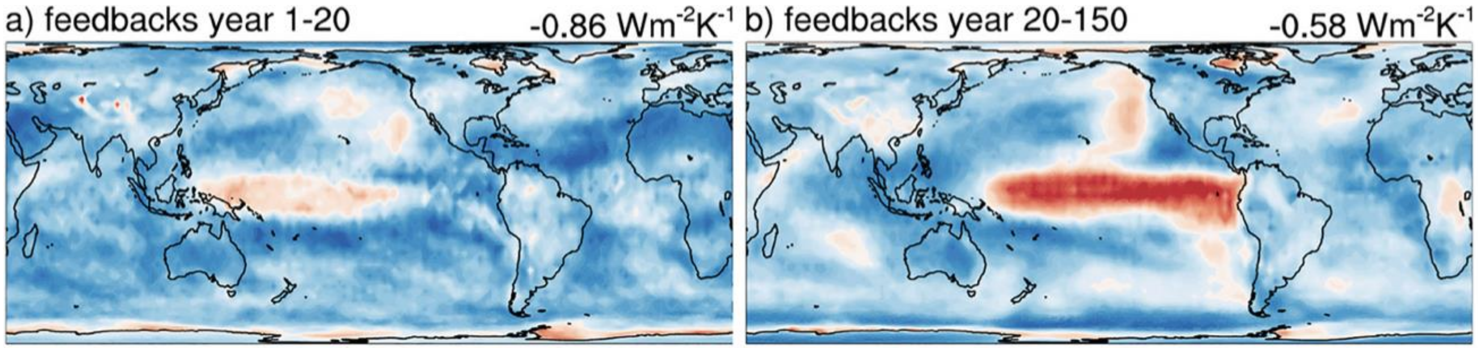
- First discovered by Knutson and Manabe (1995 J. Clim.)
- Persistent feature across many generations of CMIPs
  - e.g., Vecchi et al., (2007, J. Clim.); Chung et al., (2019, Nat. Clim. Chan)
- Hard to validate
  - Internal variability
  - Transient response
  - Cooling due to aerosol forcing in the NH



Chung et al., 2019, Nat. Clim.



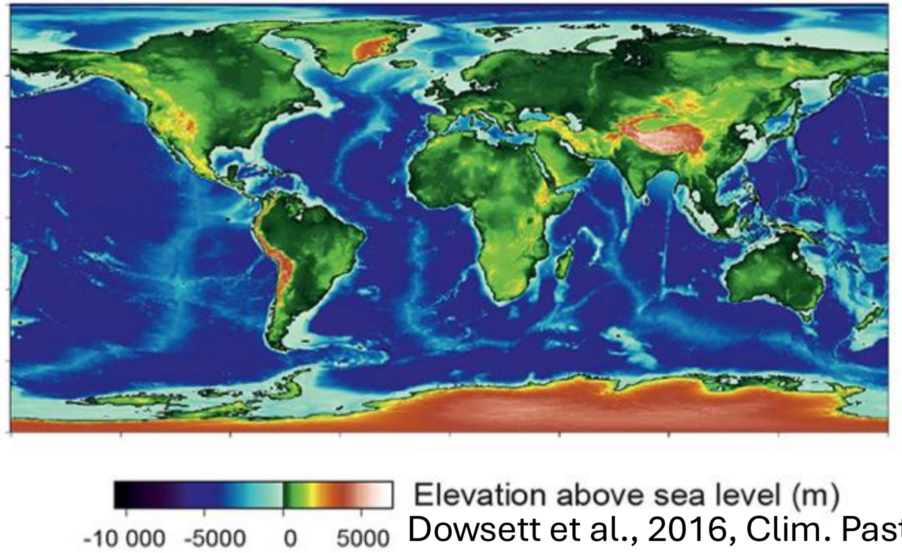
DiNezio et al., 2013, J. Clim.



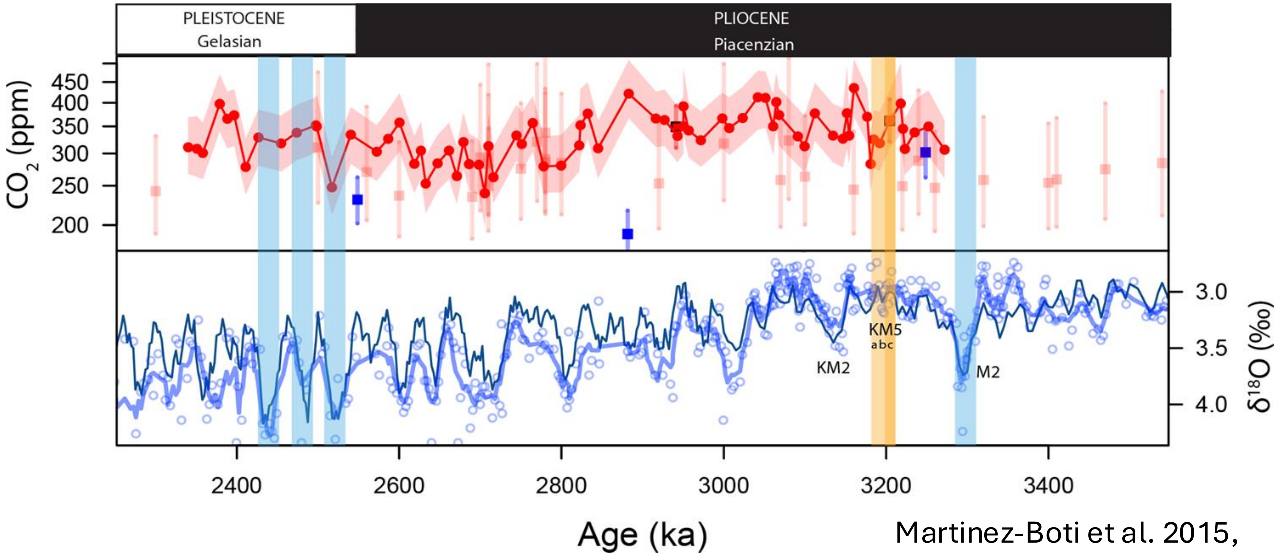
Rugenstein et al., 2019, GRL
Heede et al., 2023, GRL

Mid-Piacenzian as an analog for future climate change

- Mean CO_2 ~400 ppm (de la Vega et al., 2020, Nat. Comm.)
- Similar to present-day geography and topography
- CO_2 decline (Martinez-Boti, 2015, Nature; de la Vega, 2020, Nat. Comm.)
  - Cooling and intensification of the Northern hemisphere glaciation

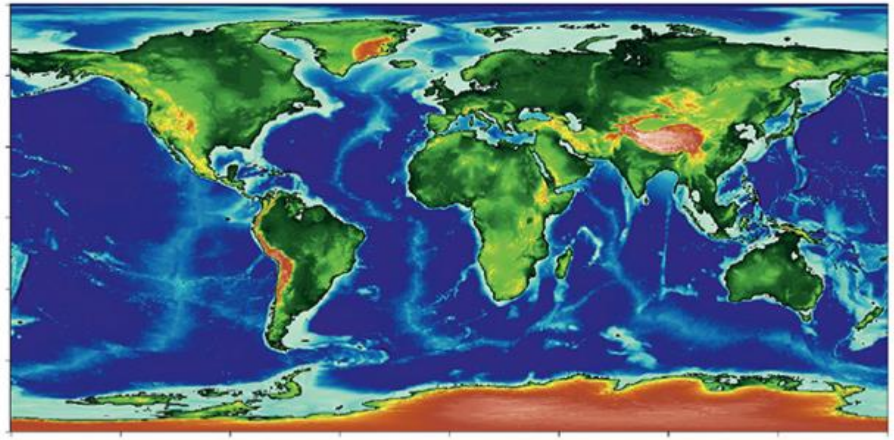


Dowsett et al., 2016, Clim. Past



Martinez-Boti et al. 2015, Nature, de la Vega, 2020, Nat. Comm.

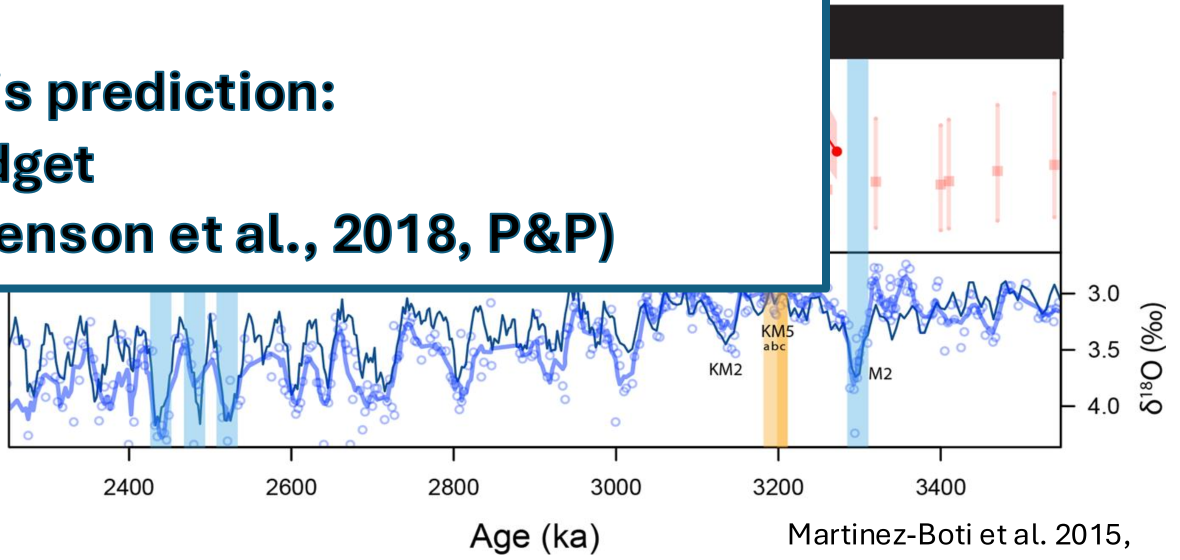
Mid-Pliocene as an analog for future climate change



- Mean CO_2 ~400 ppm (de la Vega et al., 2020, Nat. Comm.)
- Similar to present-day geography and topography
- Globa… to PI: … 2020,…
- CO_2 d… Natur… Comm…)
- Cooling and intensification of the Northern hemisphere glaciation

- **PWC is expected to strengthen in response to CO_2 decline and glaciation (DiNezio et al., 2022)**
- **Using $\delta^{18}O$ ($\delta^{18}O_{sw}$) to validate this prediction:**
  - **Precipitation-evaporation budget**
  - **Advection and diffusion (Stevenson et al., 2018, P&P)**

Clim. Past



Martinez-Boti et al. 2015, Nature, de la Vega, 2020, Nat. Comm.

Experiments

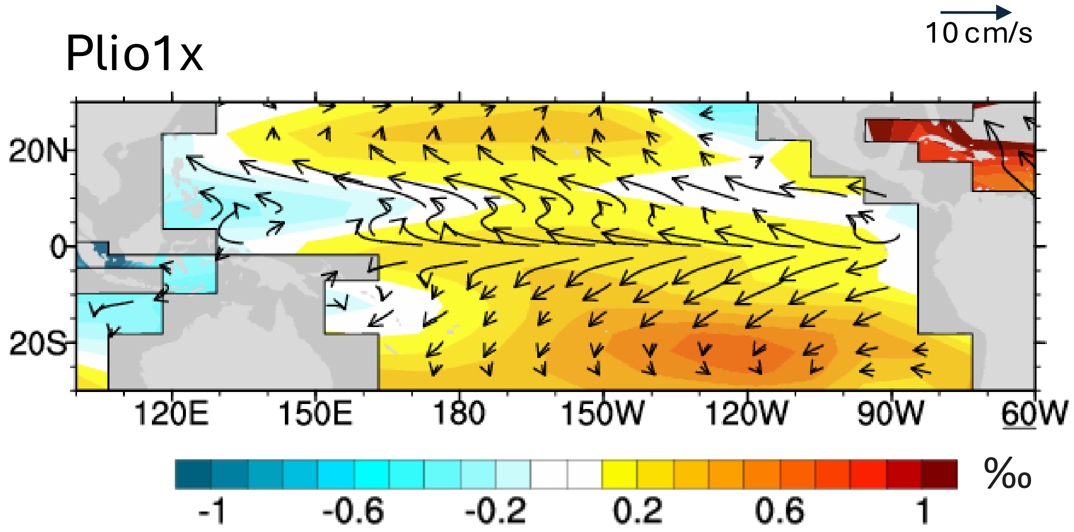
- Coupled experiments with iCESM1.2 (iCESM1.3) (Brady et al., 2019)
  - 0.9 x 1.25° horizontal resolution for atmosphere and land
  - 1° resolution for the ocean and sea ice
- All experiments were run with mid-Piacenzian boundary conditions (Dowsett et al., 2016, Clim. Past.; Haywood et al., 2016, Clim. Past.)
  - Plio at 284.7 ppm CO_2
  - Plio at 400 ppm CO_2

Experiment ID	Model configuration	CO_2 level
Plio1.4x, Plio1x	Fully coupled atmosphere, ocean land and sea ice	400 ppm, 284.7 ppm

Mayer et al. In prep.

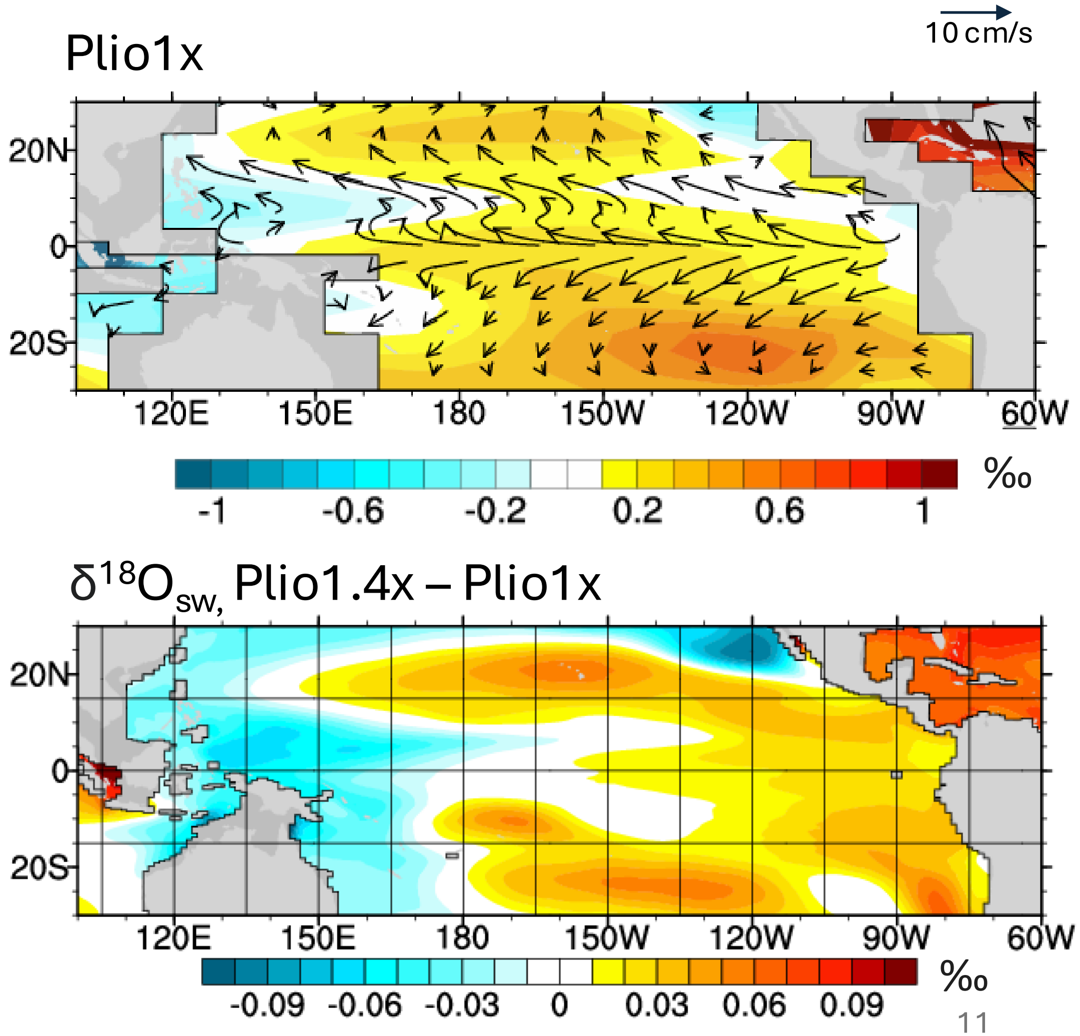
Simulated mean state of $\delta^{18}O_{sw}$

- $\delta^{18}O_{sw}$ is relatively low in the WEP compared to EEP due to the strong input of freshwater flux with relatively low $\delta^{18}O$.



Simulated $\delta^{18}O_{sw}$ changes during the late Pliocene

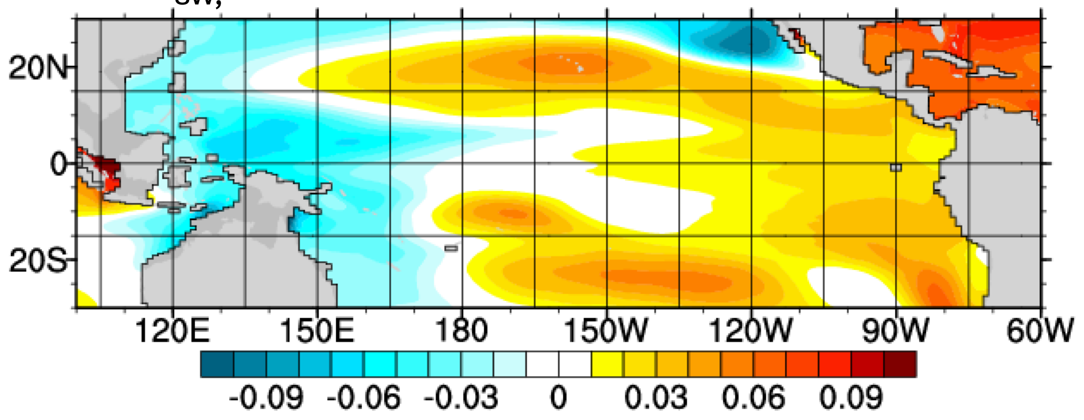
- $\delta^{18}O_{sw}$ decreases in the WEP, but increases in the EEP with increasing CO_2.



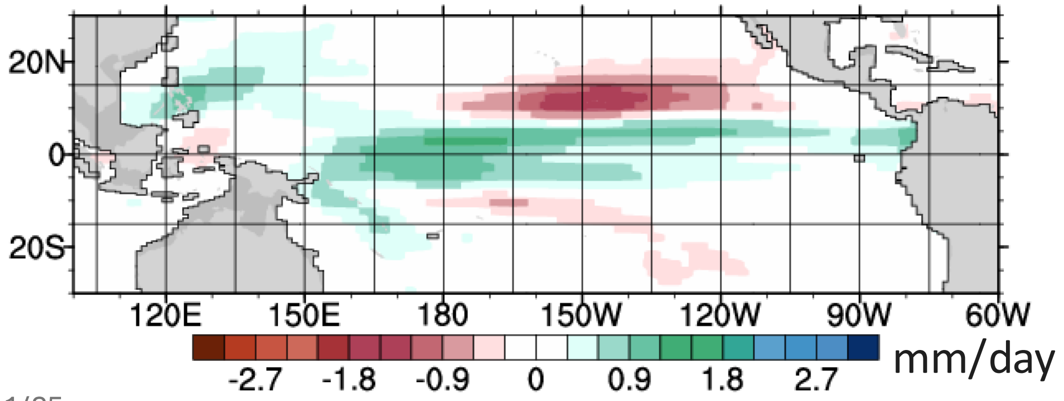
$\delta^{18}O_{sw}$ changes not explained by $\delta^{18}O_p$ flux or precipitation flux

- Precipitation $\delta^{18}O$ flux is consistent with wet-gets-wetter and dry-gets-drier response of precipitation flux

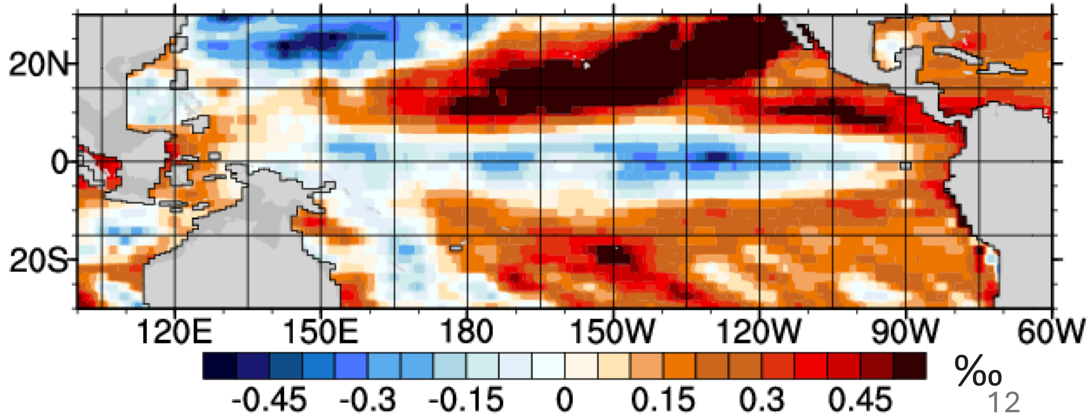
$\delta^{18}O_{sw}$, Plio1.4x – Plio 1x



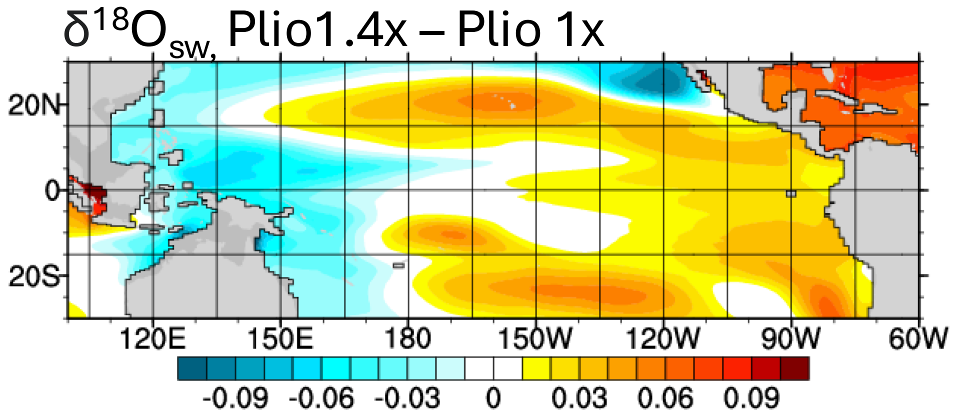
Precip flux, Plio1.4x – Plio 1x



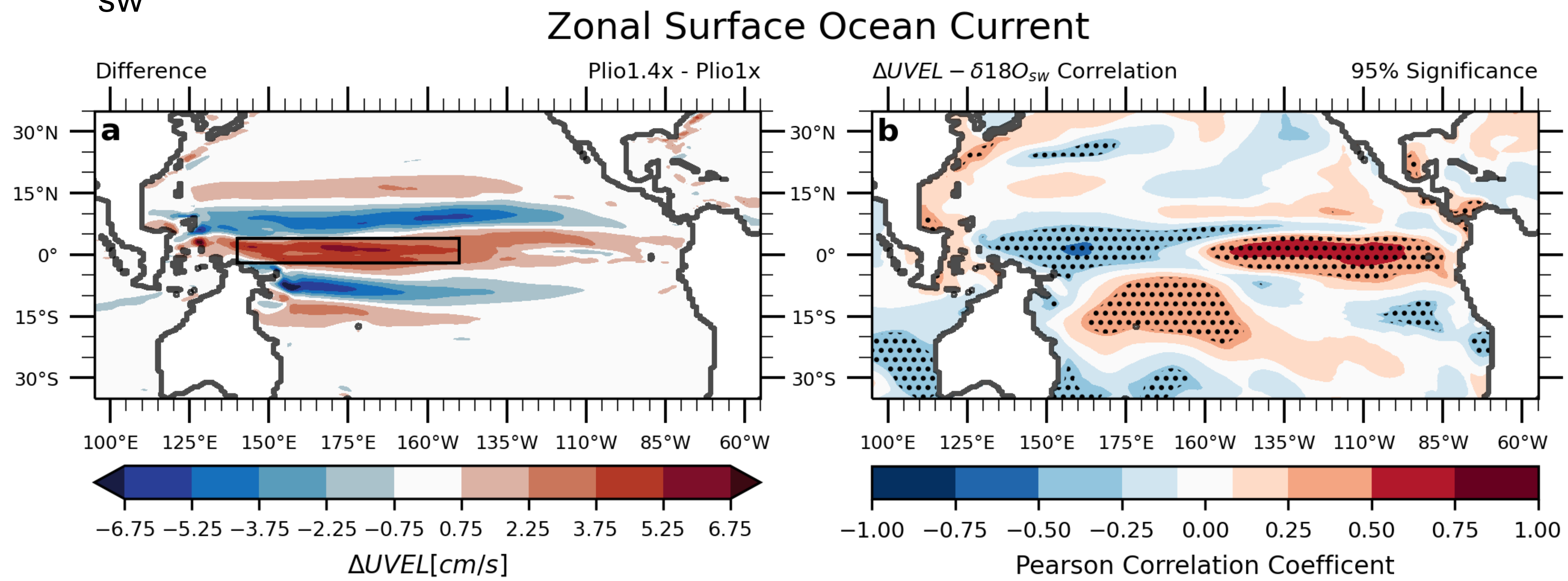
$\delta^{18}O_p$ flux, Plio1.4x – Plio 1x



Strongly correlated zonal current strength and $\delta^{18}O_{sw}$ variability



- Strong correlation between equatorial zonal current strength and $\delta^{18}O_{sw}$



Calculation of proxy $\delta^{18}O_{sw}$

- Carbonate $\delta^{18}O$ from a plankton foraminifera shell ($\delta^{18}O_{pf}$) is a function of both $\delta^{18}O_{sw}$ and seawater temperature:

$$T = 16.5 - 4.8 * (\delta^{18}O_{pf} - \delta^{18}O_{sw} + 0.27) \text{ (Bemis et al. 1998)}$$

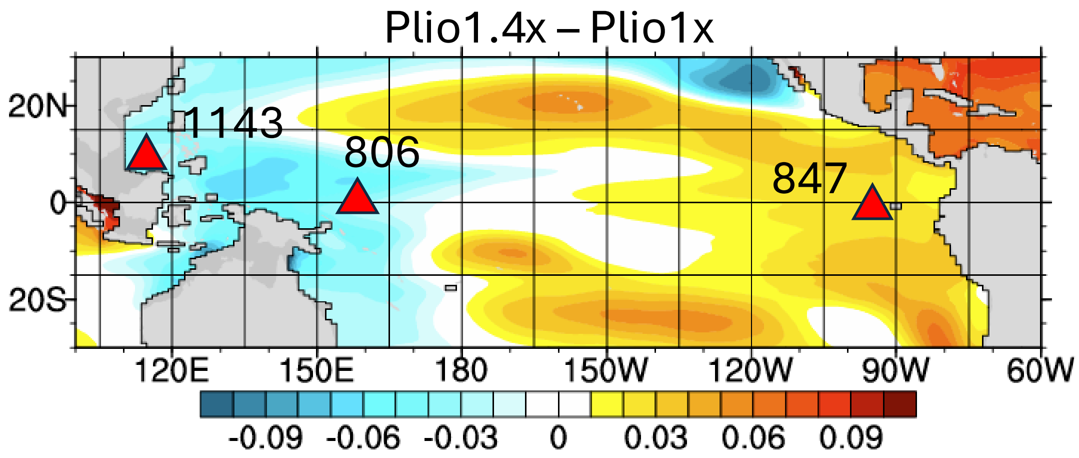
- Seawater temperature can be estimated with independent Mg/Ca ratio from the same shell:

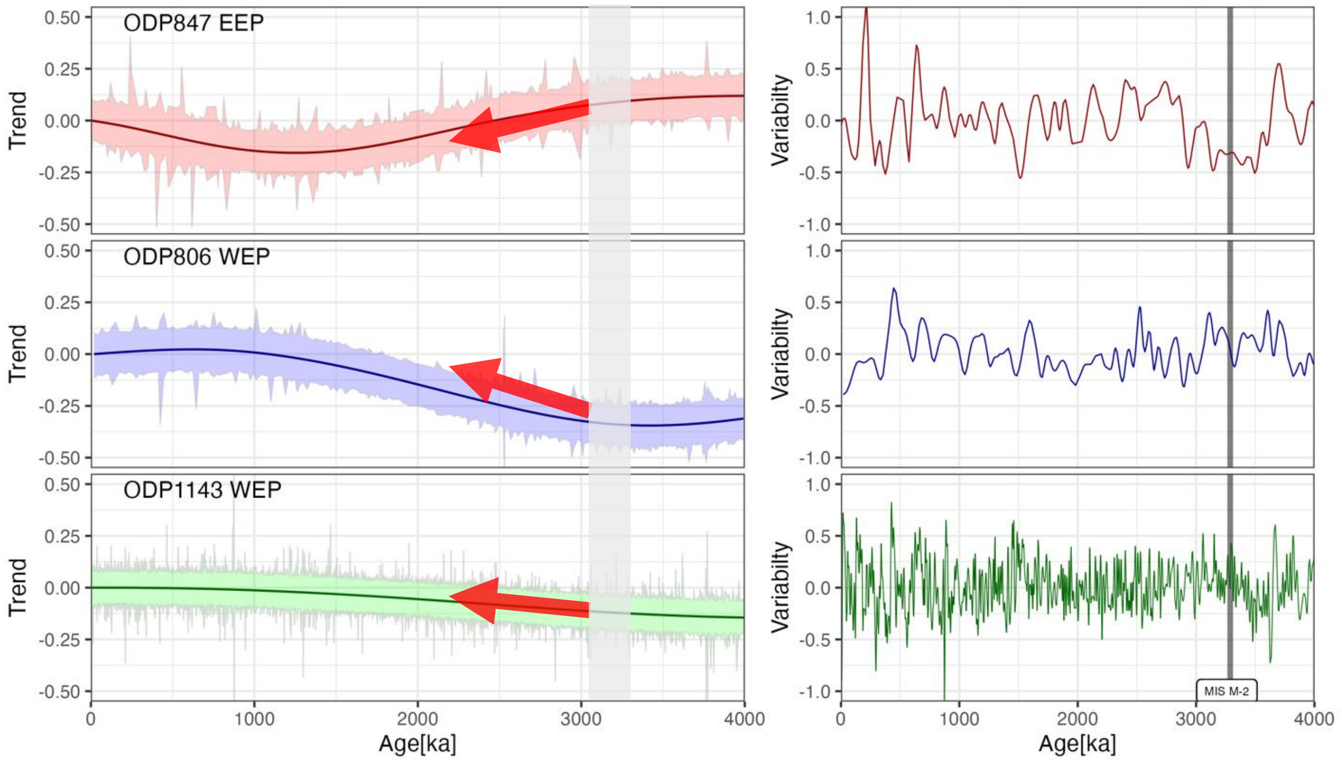
$$\mathrm{Mg/Ca} = 0.449 * \exp(0.09 * \mathrm{T}) \text{ (Anand et al., 2003)}$$

- Solving above equations to get $\delta^{18}O_{sw}$ using Paleo-Seawater Uncertainty (PSU) Solver (Thirumalai et al., 2016) and propagate uncertainty

Signal decomposition

- Empirical Mode Decomposition of proxy $\delta^{18}O_{sw}$:
  - **Internal variability**: non-monotonic components in the time series
  - **Trends**: monotonic component
- From mid-Piacenzian to early-Pleistocene:
  - **Increase** of proxy $\delta^{18}O_{sw}$ in the WEP and **decrease** of proxy $\delta^{18}O_{sw}$ in the EEP





Long-term evolution of E-W $\delta^{18}O_{sw}$ contrast

- Pacific equatorial current strength index using the long-term trends from the EMD:

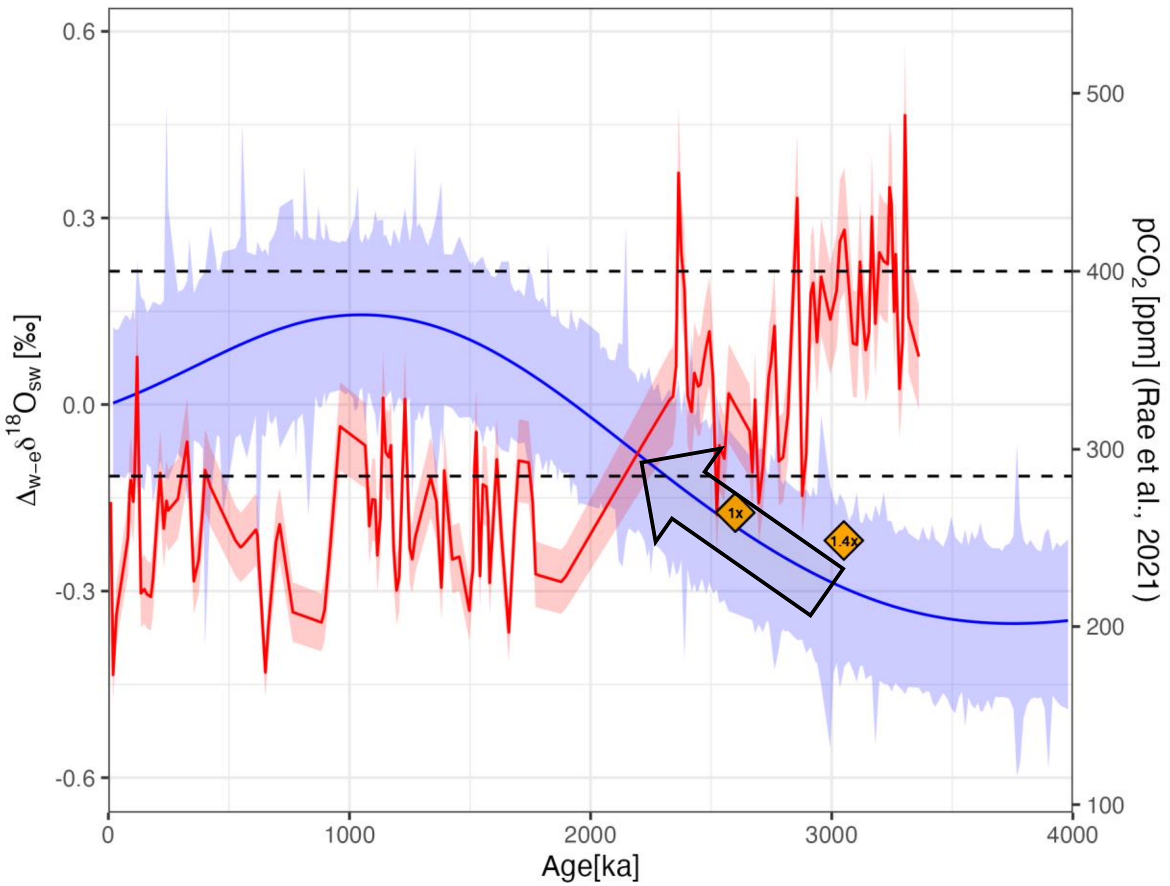
$$\Delta_{w-e}\delta^{18}O_{sw} =$$

$$\text{mean } \delta^{18}O_{sw}(\text{ODP806, ODP1143}) - \delta^{18}O_{sw}(\text{ODP847})$$

  - Low $\Delta_{w-e}\delta^{18}O_{sw}$: weaker current
  - high $\Delta_{w-e}\delta^{18}O_{sw}$: stronger current

Changes of proxy $\Delta_{w-e}\delta^{18}O_{sw}$ support strengthened equatorial current and PWC from late Pliocene to early Pleistocene

Model-data comparison of $\Delta_{w-e}\delta^{18}O_{sw}$



Thanks for your attention!

Questions?