Water isotopes in POP2

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Outline

- Project overview
- Water isotopes in POP2
  - Observational data
  - Restoring surface boundary condition
  - Prec+Evap+Roff+Virtual flux forcing
- Summary and future plan

1. Project overview

A Collaborative Proposal:
Development of an Isotope-Enabled CESM. . .

Objective: To enhance the CESM with the capability of simulating key isotopes and geotracers, including $\delta^{18}O$, δD, Pa/Th, $\delta^{14}C$, and $\delta^{13}C$.

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Funded by DOE (SciDAC BER ESM)

CAM5
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CLM4
W. Riley, C. Koven F. Joos, A. Bozbiyik

CPL7
M. Vertenstein

CICE
TBA

POP2
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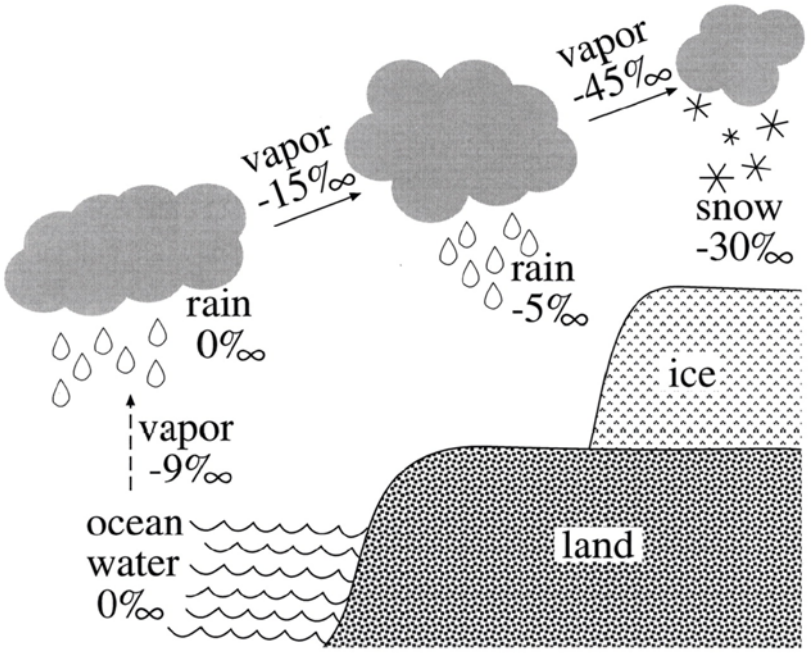
3. Water isotopes in POP2

- Major water isotopes: $H_2{}^{16}O$, $H_2{}^{18}O$ and HDO

$$\delta^{18}O = \frac{\left[(^{18}O/^{16}O)_{sample} - (^{18}O/^{16}O)_{VSMOW}\right]}{(^{18}O/^{16}O)_{VSMOW}} \times 1000\,‰$$

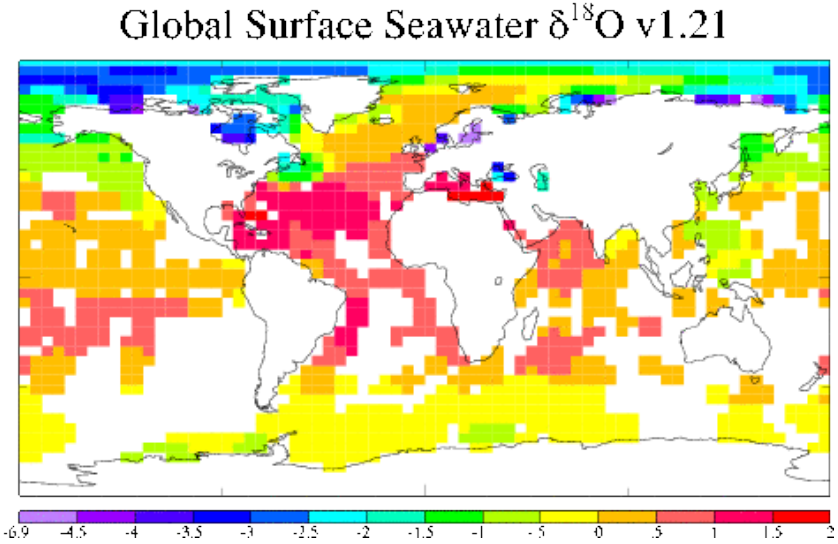
$H_2{}^{18}O$ depleted ← - $\delta^{18}O$ + → $H_2{}^{18}O$ enriched

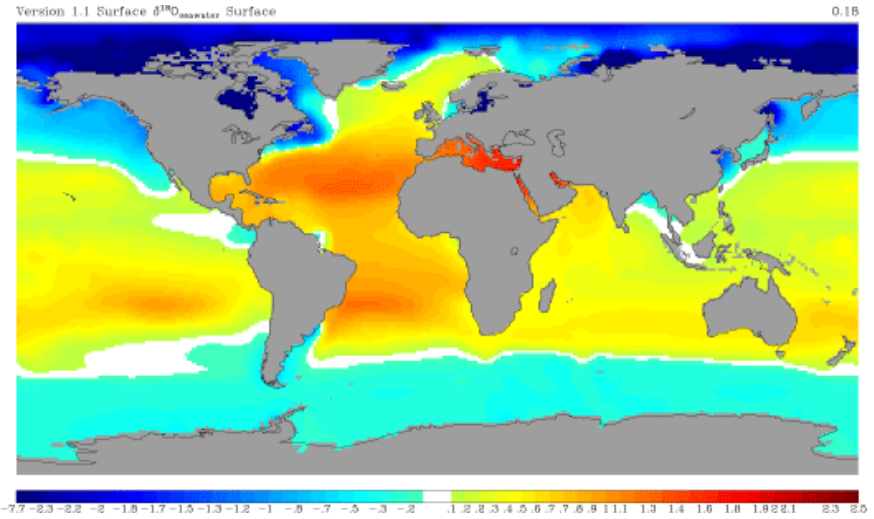
- Fractionation occurs when evaporation and condensation happens.
- CAM tracks specific humidity for each water type.
- POP tracks $\delta^{18}O$ and δD as passive tracers in the ocean interior (no interaction with the ecosystem)



3.1. Water isotopes in POP2: Observational data

- NASA GISS Global Seawater Oxygen-18 Database
- A collection of over 26,000 seawater O-18 values made since about 1950
- 3D gridded data, 33 Levitus levels, at 1°x1° resolution





Schmidt, G.A., G. R. Bigg and E. J. Rohling. 1999. "Global Seawater Oxygen-18 Database - v1.21" http://data.giss.nasa.gov/o18data/

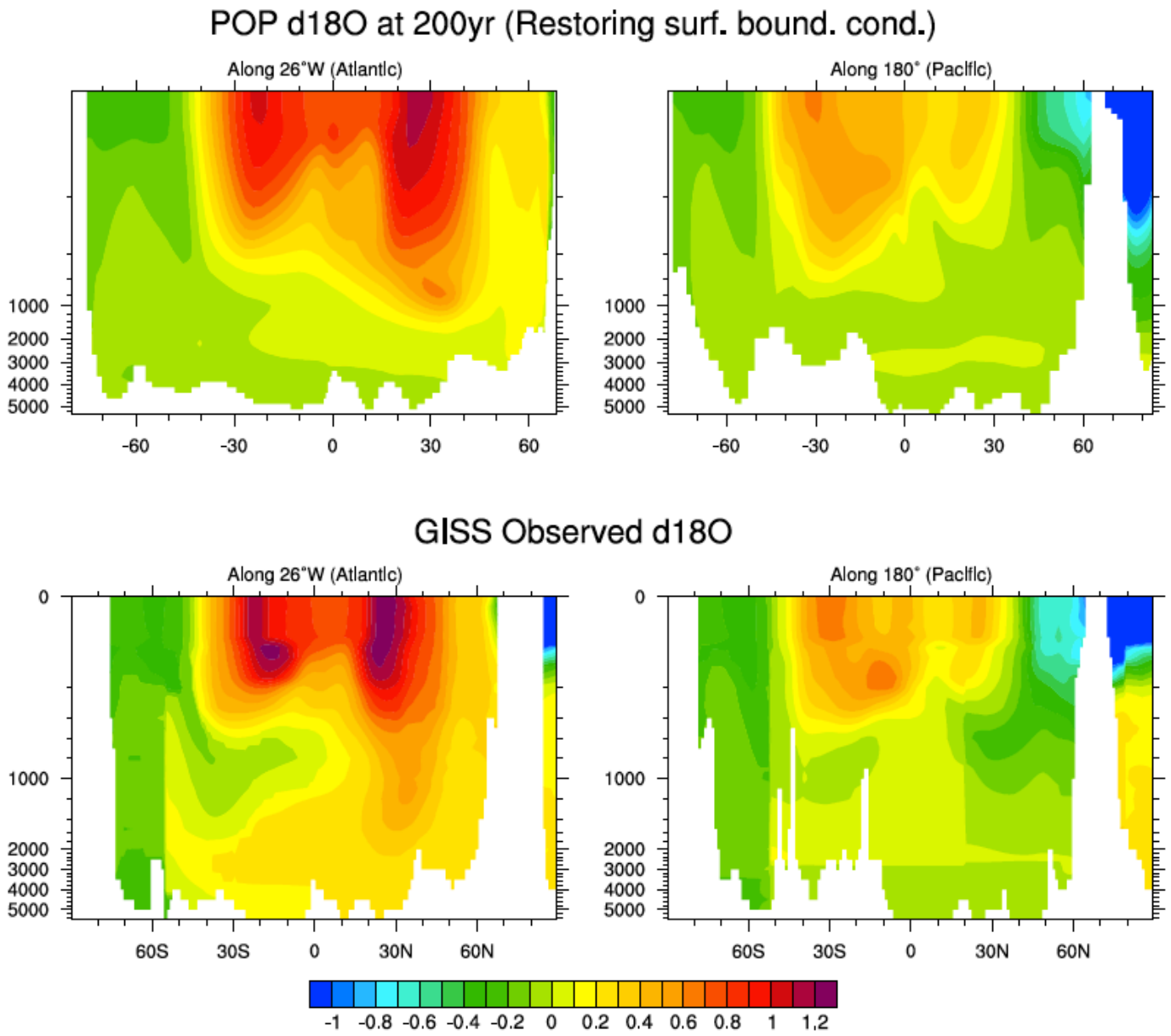
3.2. Water isotopes: Restoring BC

- Restoring surface boundary condition (Paul et al. 1999): to test the ocean interior dynamics

$$F_{\delta_W} = \frac{H}{\tau}(\delta_W^* - \delta_W)$$

- τ – relaxation time scale (= 30 d)
- H – upper ocean depth (1st layer)
- δ^*_W – prescirbed delta values (GISS Observation)
- Initial values = 0, run for 200 yr

3.2. Water isotopes: Restoring BC



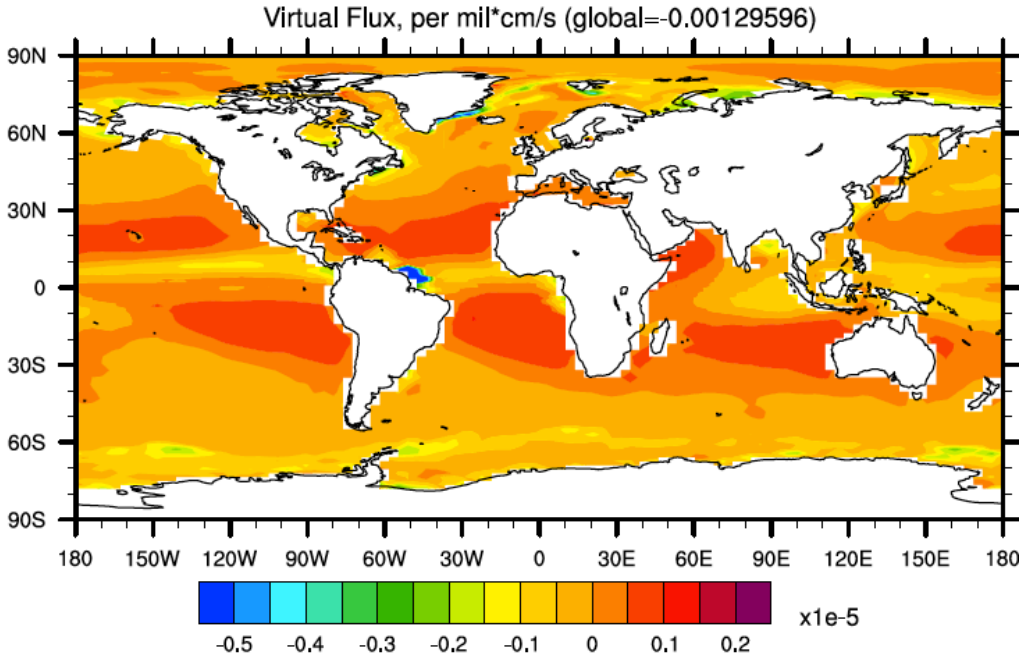
3.3. Water isotopes: PER flux forcing

- $\delta^{18}O$ flux to the ocean surface (Delaygue et al. 2000)

$$F_\delta = E(\delta_W - \delta_E) - P(\delta_W - \delta_P) - R(\delta_W - \delta_R)$$
$$= (E - P - R)\delta_W - (E\delta_E - P\delta_P - R\delta_R)$$

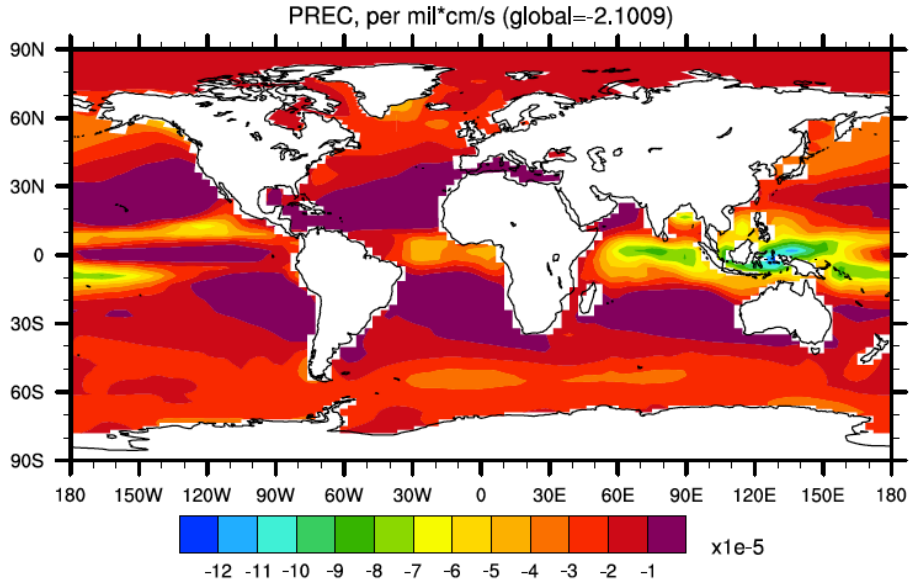
Virtual Flux

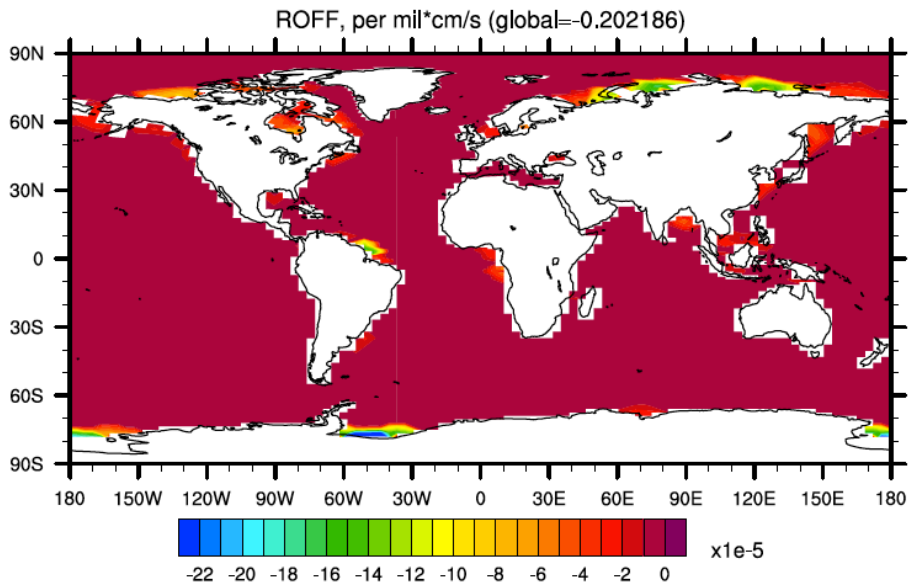
- Unit: per mil * cm/s
- Negative flux = loosing heavy water/gaining light water



3.3. Water isotopes: PER flux forcing

- $P\delta_P$: isoCAM3 preindustrial monthly-mean climatology
- $R\delta_R$: ROFF_F * δ_P





3.3. Water isotopes: PER flux forcing

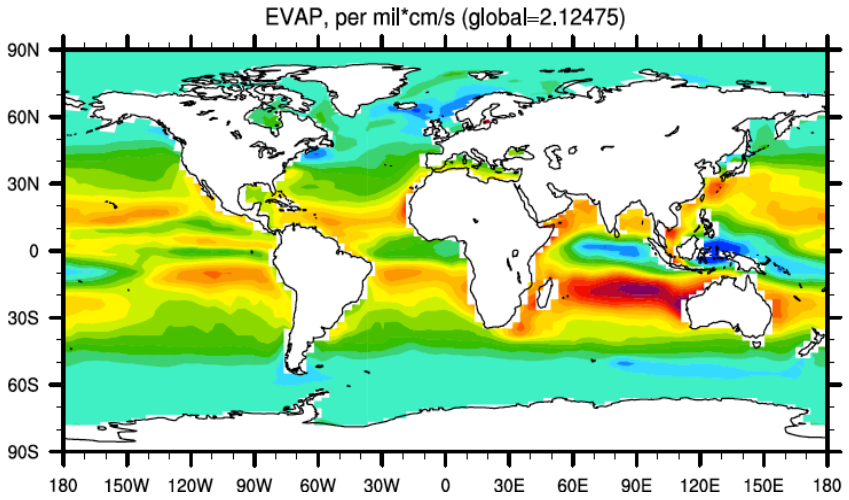
$$\delta_E = \frac{1-K}{1-h}\left[\alpha_{WV}(\delta_W + 10^3) - h(\delta_A + 10^3)\right] - 10^3$$

- Schmidt et al. (1999)
- K = 0.006 is the kinetic fractionation parameter
- α_{WV} = f(TS) water to vapor fractionation factor
- h – near-surface relative humidity (isoCAM)

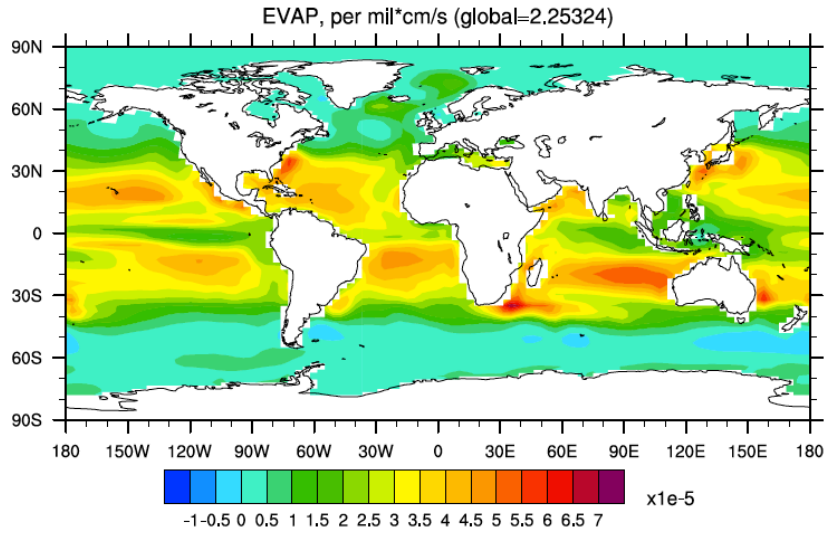
  (where h > 0.8, h = 0.8)
- δ_A – delta value of marine air (isoCAM)

  (where δ_A < -16, δ_A = -16)

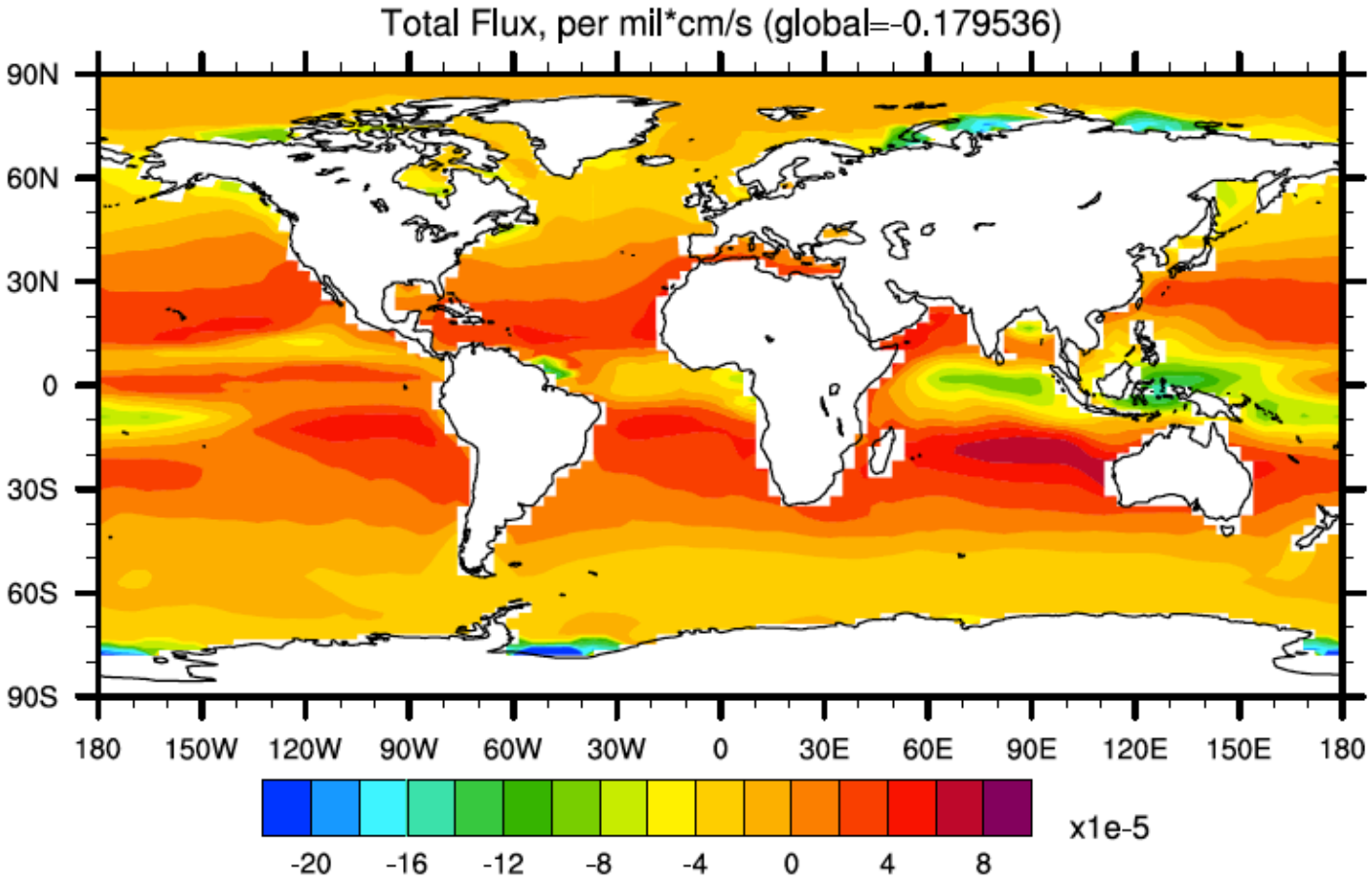
POP2, dynamic $E^*\delta_E$, Year 200



isoCAM3 $E^*\delta_E$ ann climatology

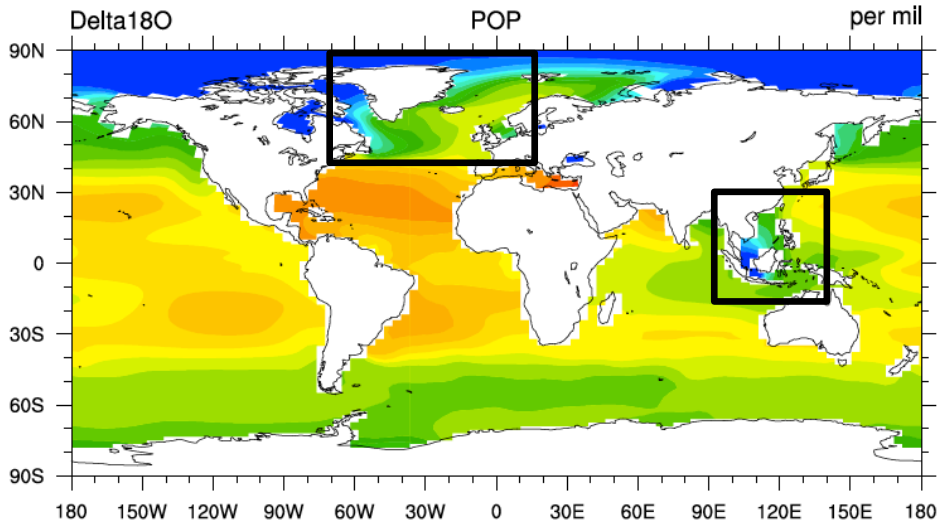


3.3. Water isotopes: PER flux forcing

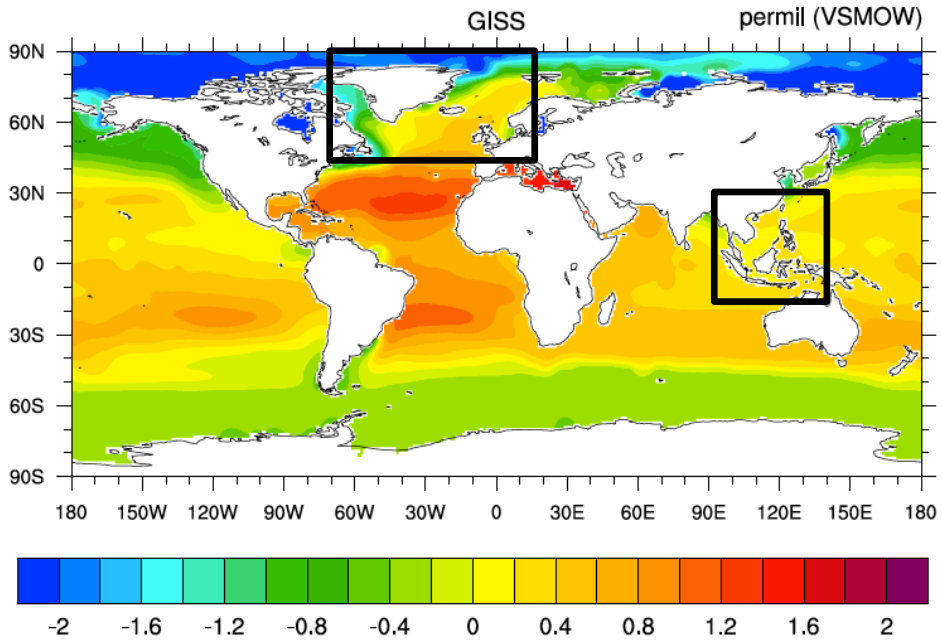


3.3. Water isotopes: PER flux forcing

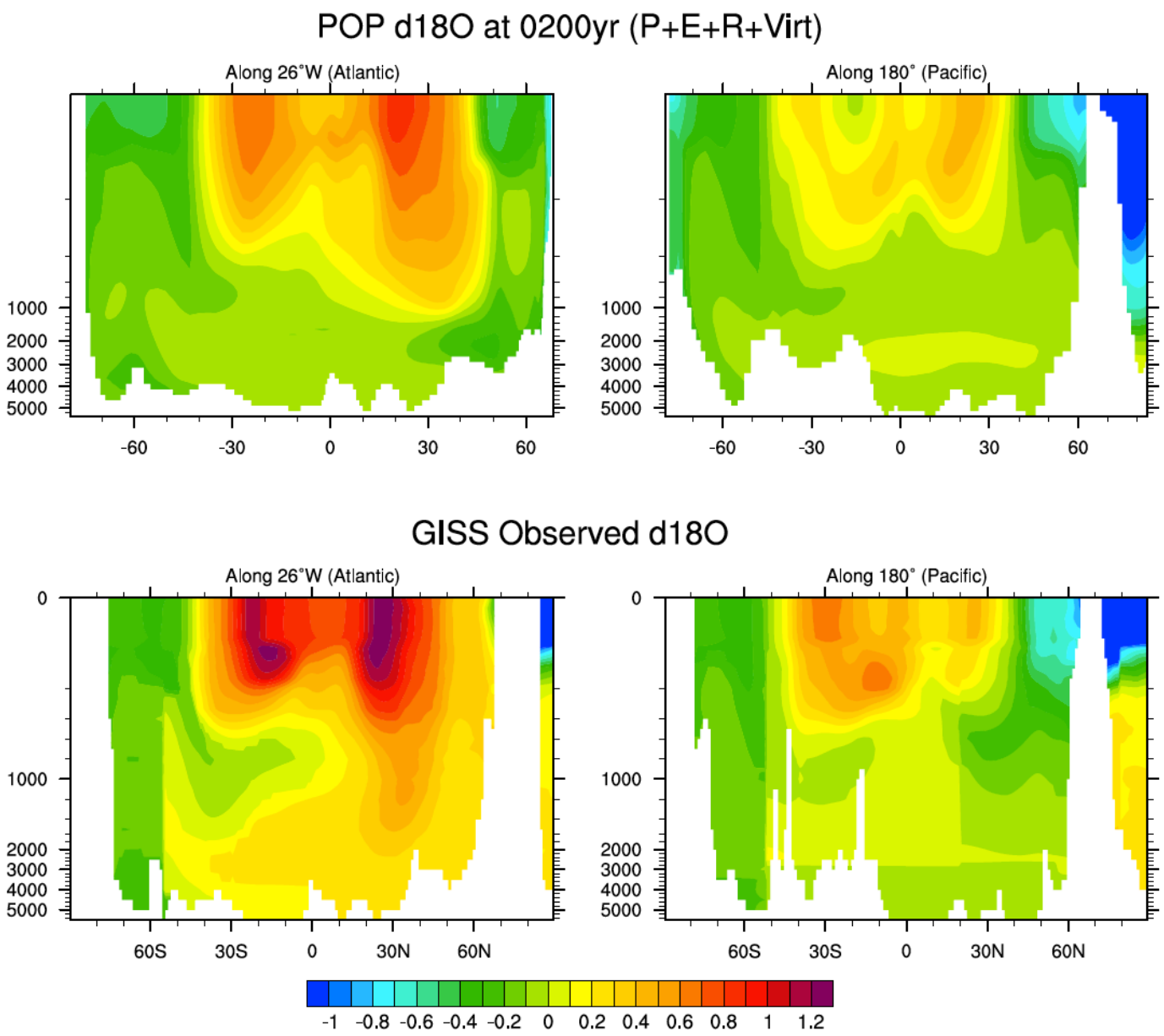
POP2 simulation
Year 200



GISS
Observations



3.3. Water isotopes: PER flux forcing



4. Summary and future plan

- Water isotopes: restoring boundary condition => realistic interior dynamics
- P+E+R+V flux forcing
- Future plan
  1) To add melt water flux
  2) To add HDO, using the same method
  3) Ready to couple with other components -> to move the evp flux computation into coupler
  4) Paleoclimate applications (e.g. LGM, north/south water source)