Ocean carbon storage uniquely linked to ocean heat

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Introduction

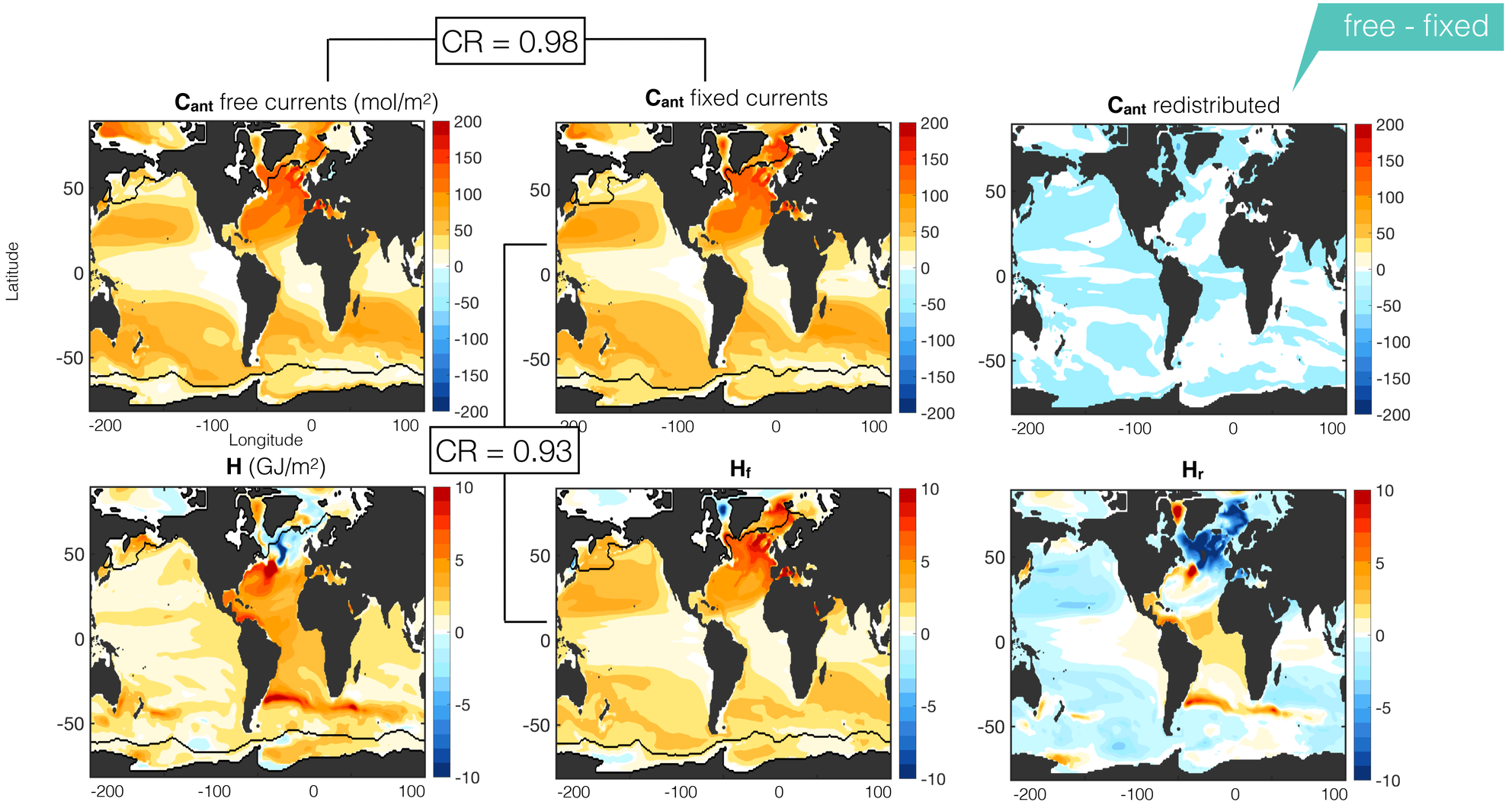
- ☑ *Background to:* Heat and carbon coupling reveals ocean warming due to circulation changes (2020)

- ☑ *Goal:* use ocean carbon storage patterns to infer how circulation changes affect ocean heat storage

- ☑ *Crucial:* **Anthropogenic carbon storage patterns are unchanged when ocean circulation changes**

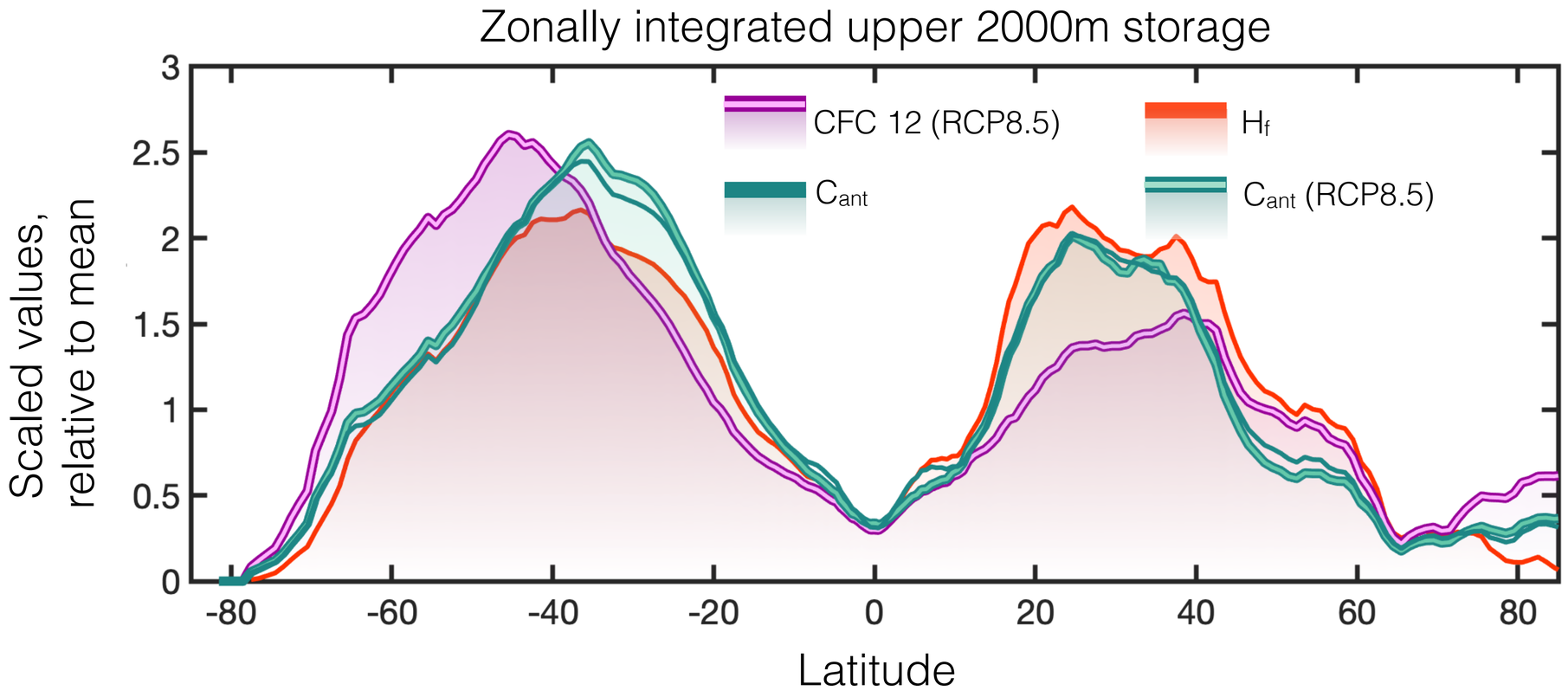
Heat and carbon storage

1%CO_2 simulation with ESM2M:



Carbon and CFC storage

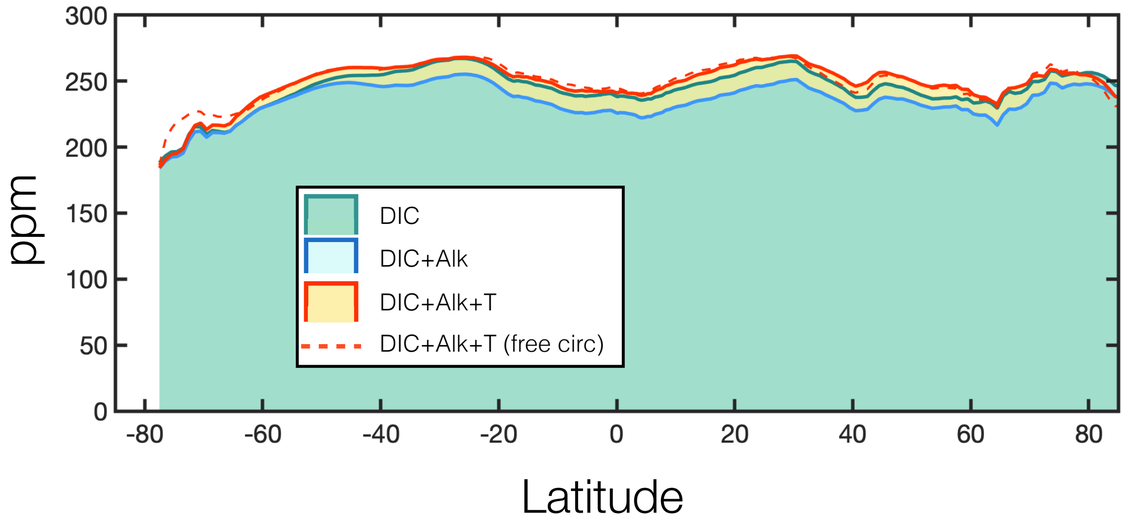
- ☑ Compare C_{ant} and to other atmospheric gas: CFCs (Chlorofluorocarbons)
- ☑ Compare 1%CO_2 simulation to RCP8.5 experiment (which has CFCs)



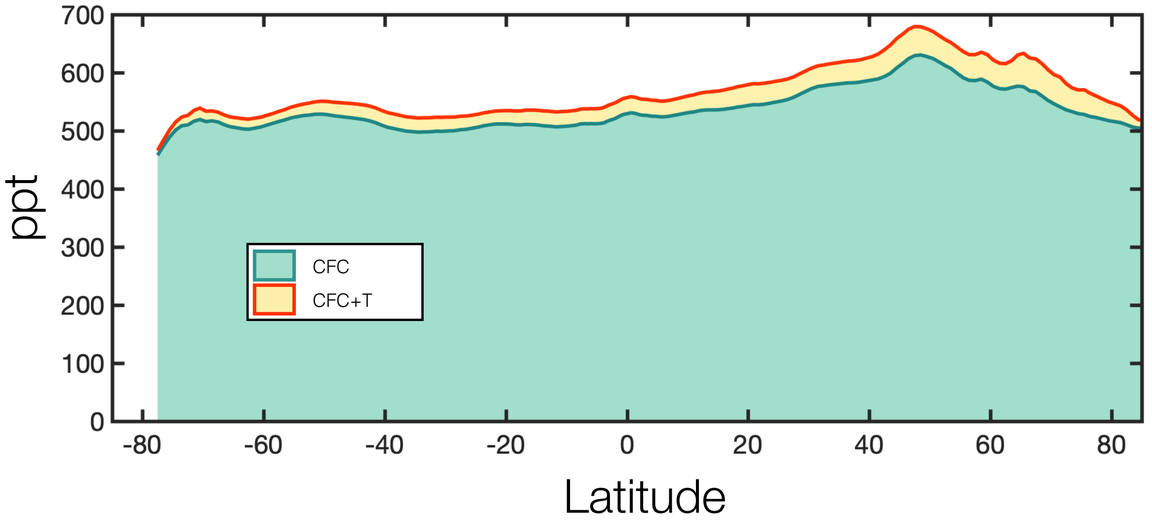
Carbon and CFC storage

- ☑ Ocean uptake of atmospheric gasses is driven by air-sea difference in partial pressure:
- ☑ Atmospheric gasses are **well-mixed**

Change in ocean pCO_2



Change in ocean pCFC-12

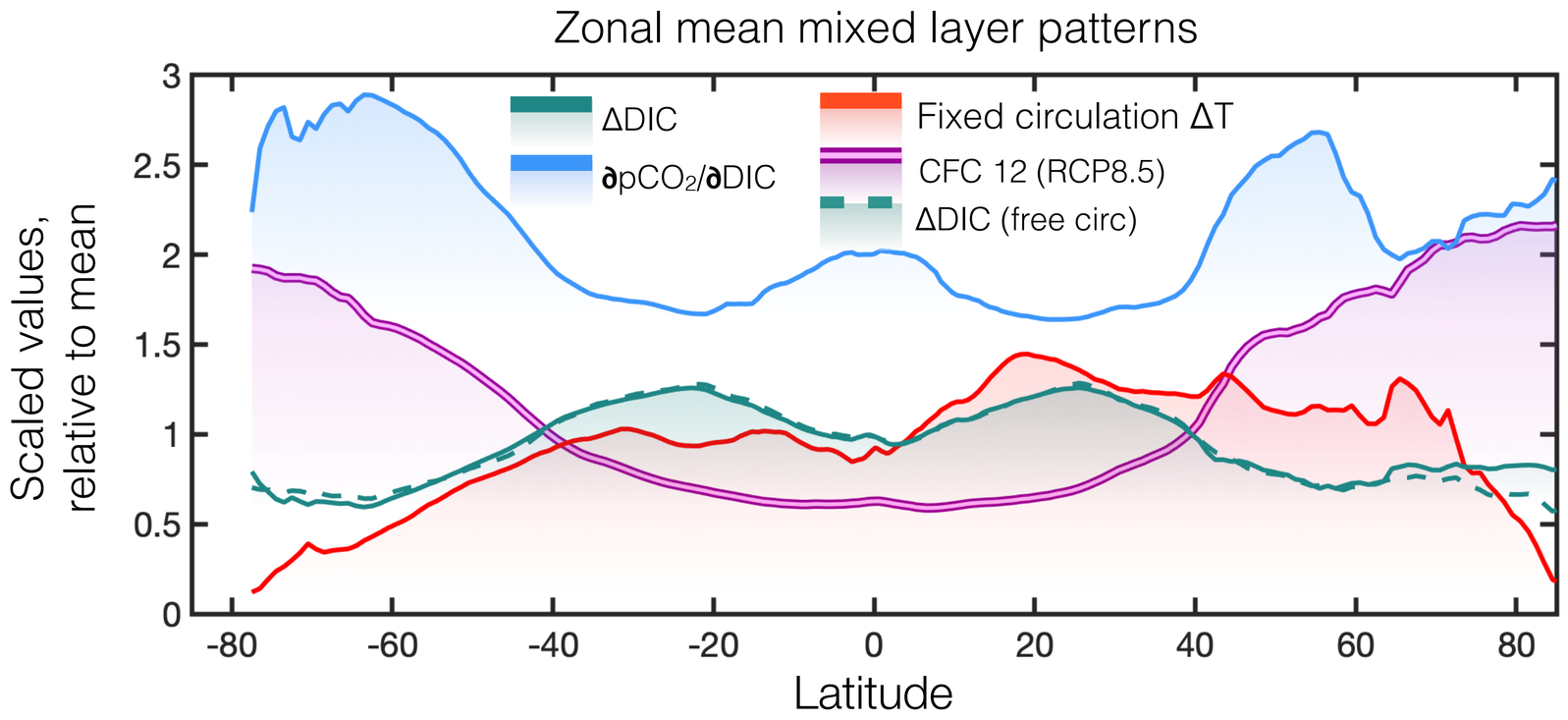


Carbon and CFC storage

partial pressure and concentration relationship:

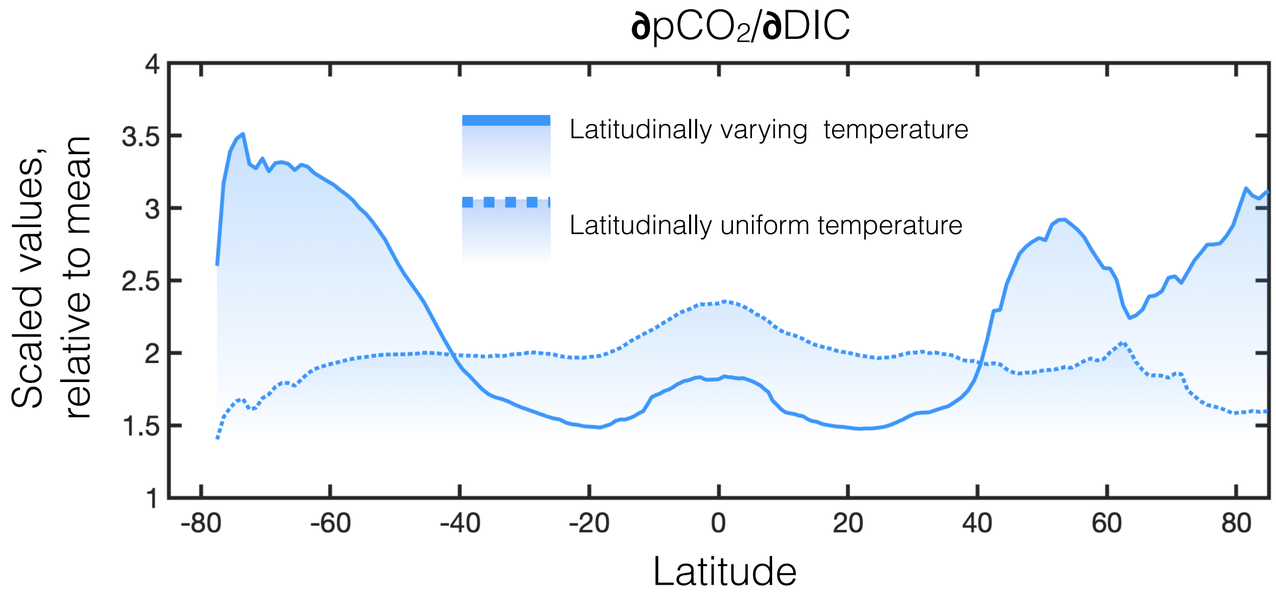
$$\Delta pCO_2 \approx \frac{\partial pCO_2}{\partial DIC}\Delta DIC = \frac{R \times pCO_2}{DIC}\Delta DIC \qquad \Delta pCFC \approx \frac{\partial pCFC}{\partial CFC}\Delta CFC$$

sensitivity term



Temperature dependence

- How does the sensitivity relate to temperature?
- Effect of spatially-varying ocean temperature can be removed:



From T-dependence in R (due to DIC)

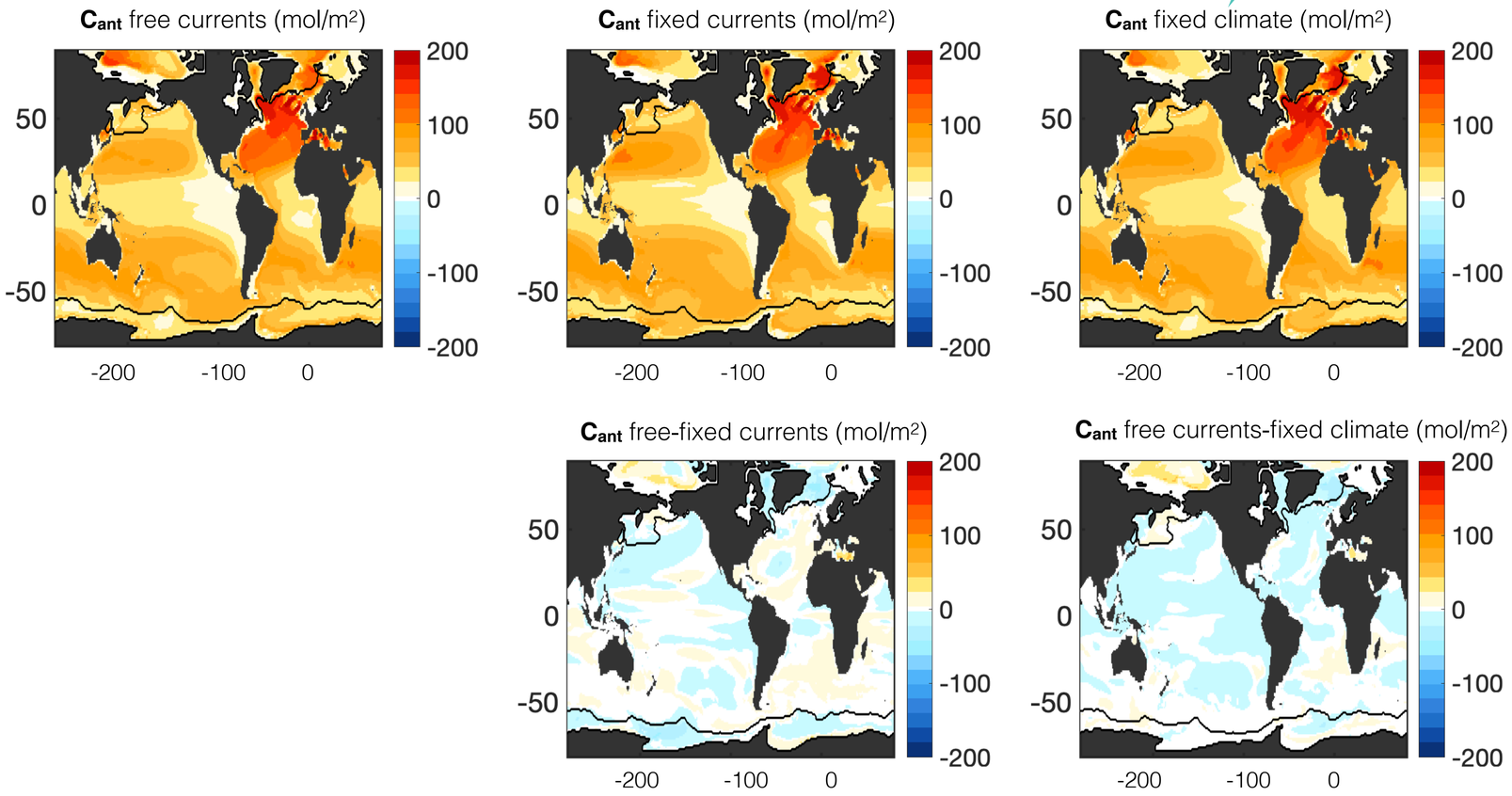
$$\frac{\partial pCO_2}{\partial DIC} = \frac{R \times pCO_2}{DIC}$$

- Surface DIC changes correlate with mean state SSTs (CR = 0.80)

Internal pathways

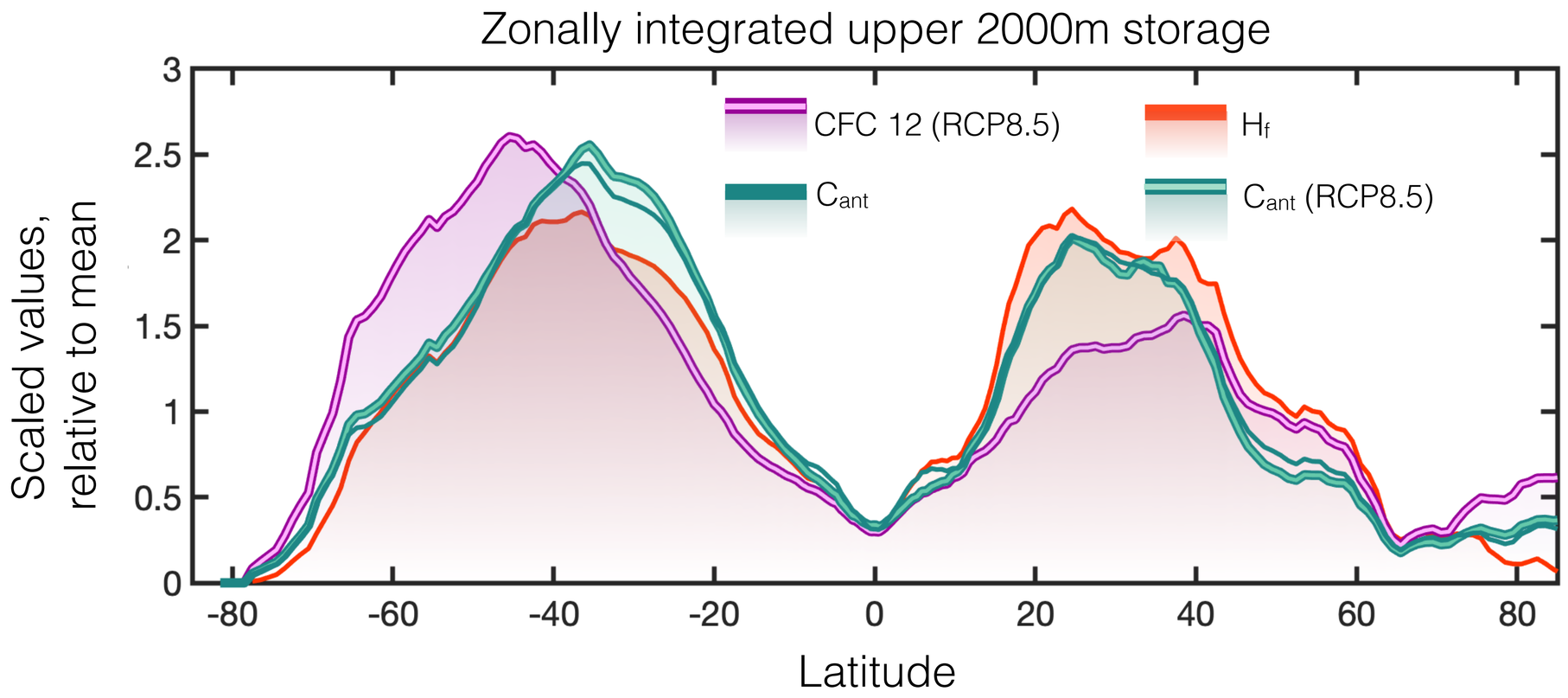
- [x] CFC is purely passive tracer, so deep ocean storage due to only physics
- [x] Effects of biology on carbon is small:

CO_2 is non-radiative gas



Carbon and CFC storage

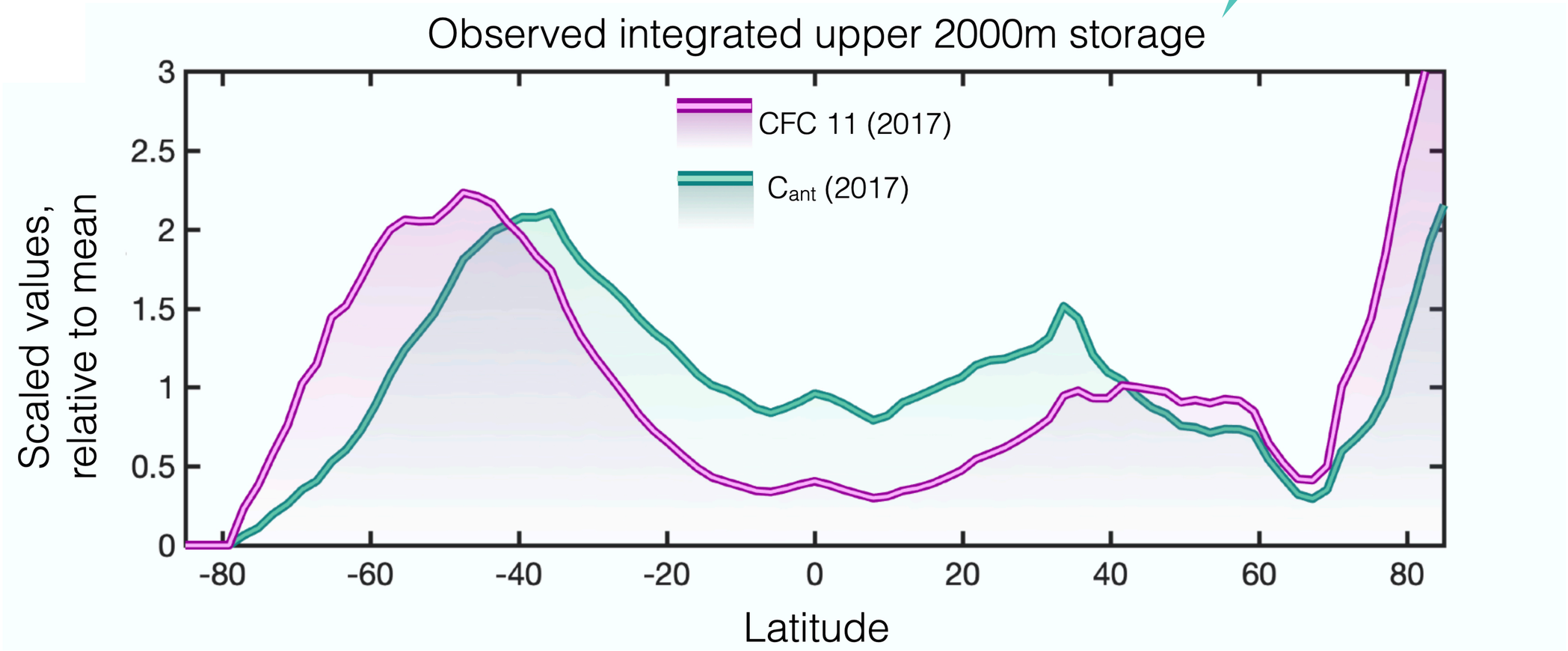
- **Correlation** of surface C_{ant} and fixed circulation T-changes leads to **similar storage**
- **Anti-correlation** of surface CFC and fixed circulation changes leads to **dissimilar storage**



Observations

☑ Similar storage patterns in observations:

Updated from DeVries et. al. 2014



Conclusions

- ☑ Ocean carbon storage is uniquely similar to fixed circulation heat storage

But why?

- ☑ Since atmospheric gasses are well-mixed, ocean partial pressure of gasses is forced to be *mostly* homogeneous

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- ☑ The sensitivity of the ocean tracer concentration to partial pressure determines surface pattern of storage - set by mean state

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- ☑ Changes in ocean internal pathways appear to less influential on column-integrated storage patterns than surface concentration patterns