Simulating the latest Cretaceous ocean

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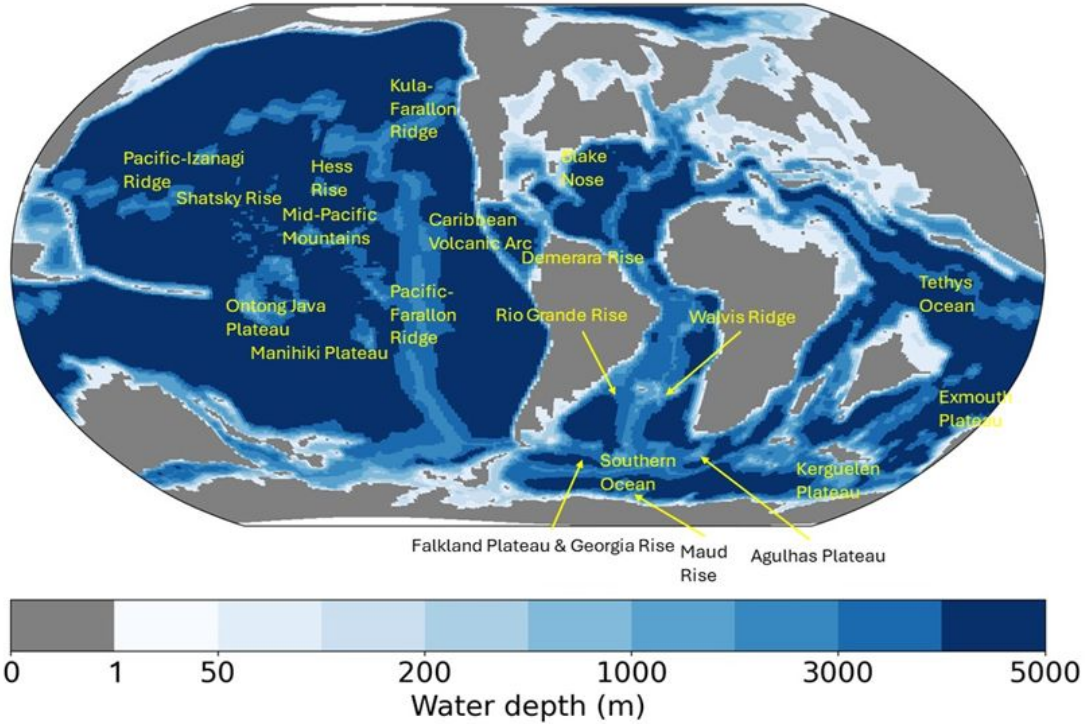
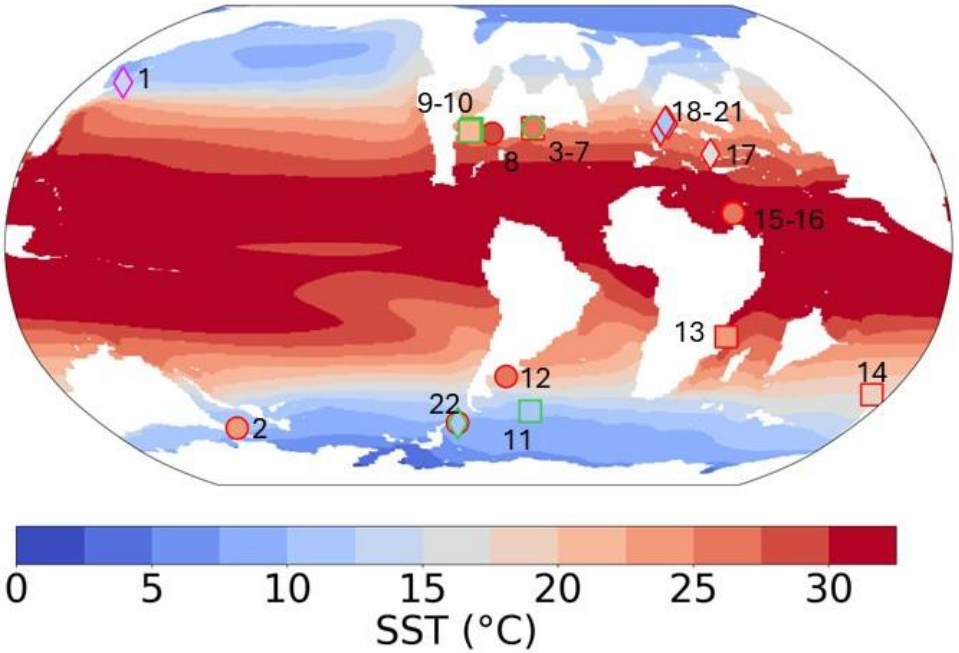
Model details

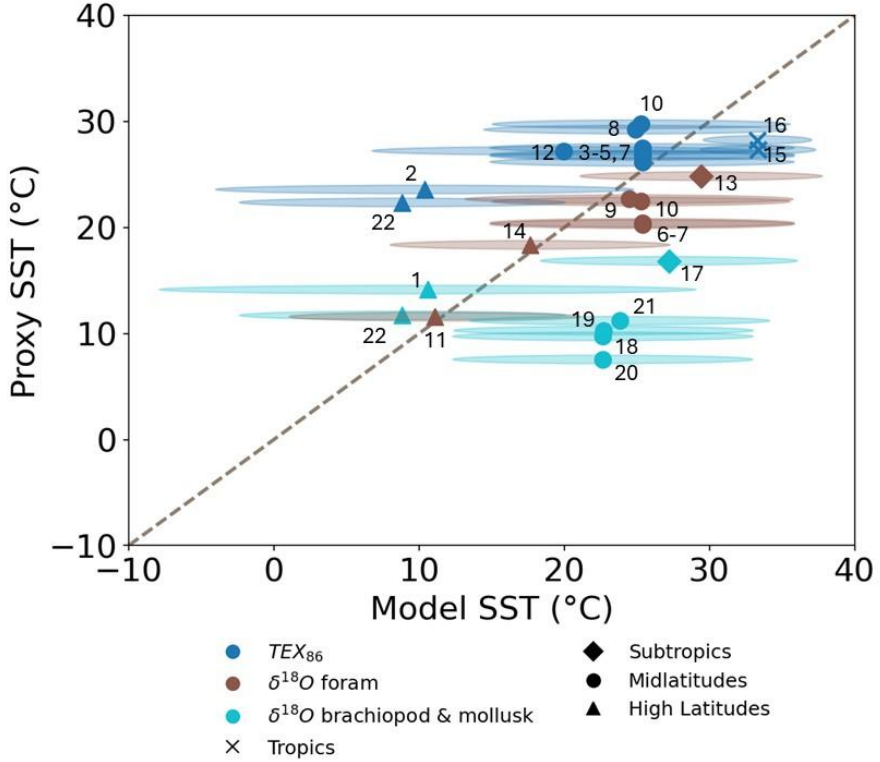
- CESM2: CAM4, POP2 with MARBL, CLM4, CICE4
- Model resolution 1° in the ocean and 1.9° in the land and atmosphere
- 5 PFTs, explicit carbon isotope fractionation
- Maastrichtian paleogeography from Markwich and Valdes (2004)
- CO_2: 850 ppm, CH_4: 2400 ppbl



How do simulated temperature profiles & circulation compare to proxies?

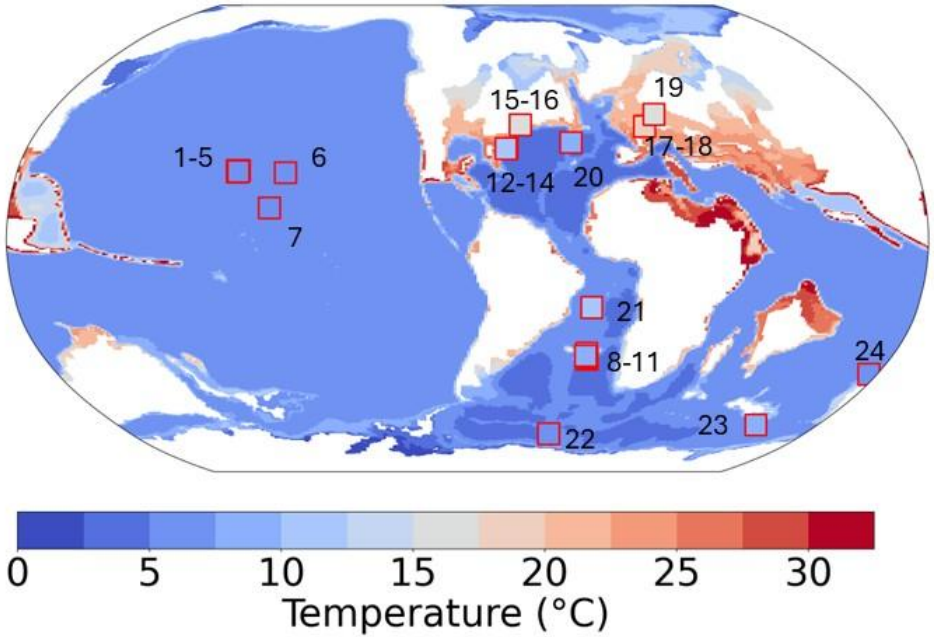
Proxy SSTs match well with simulated temperatures

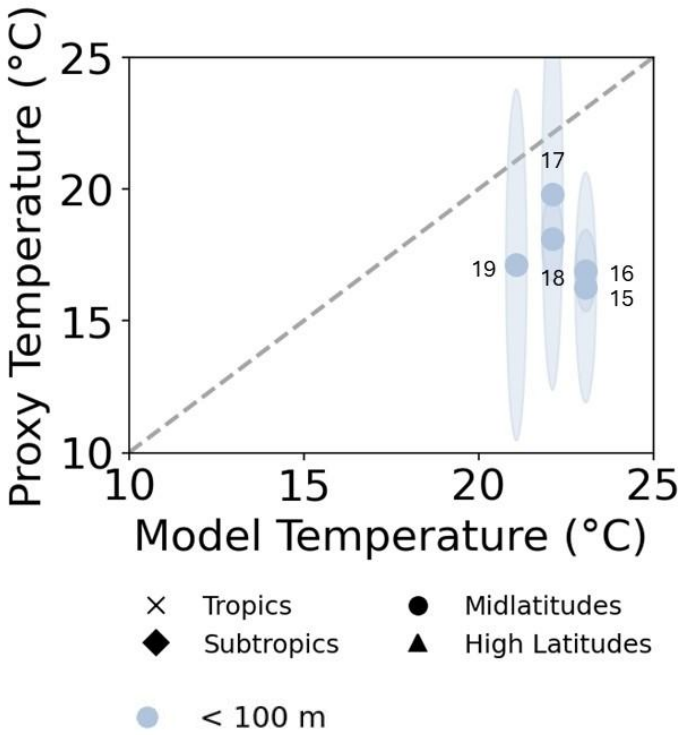




SST dataset: Judd et al., 2022

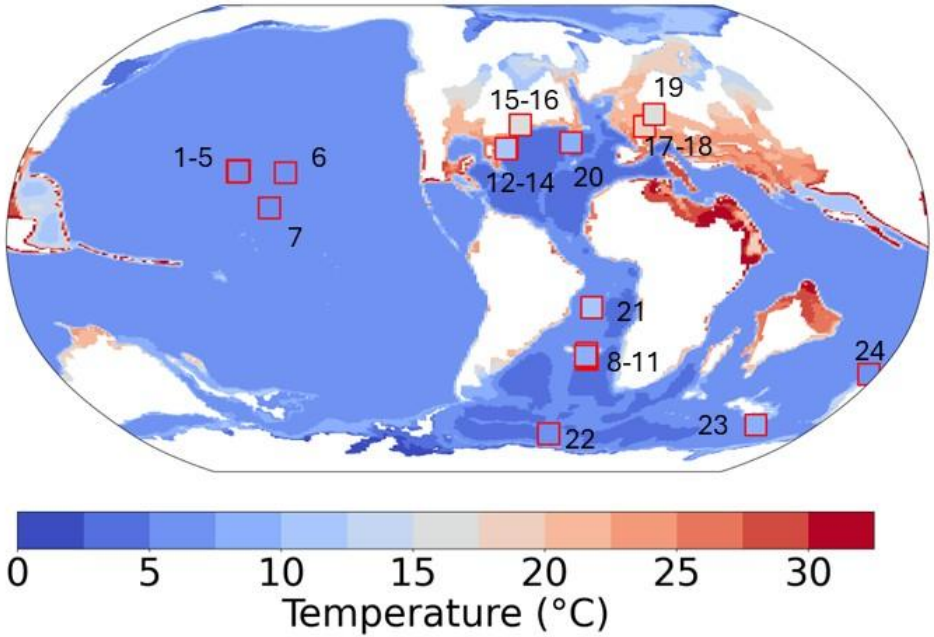
Shallow benthic simulated temperatures match well with proxies

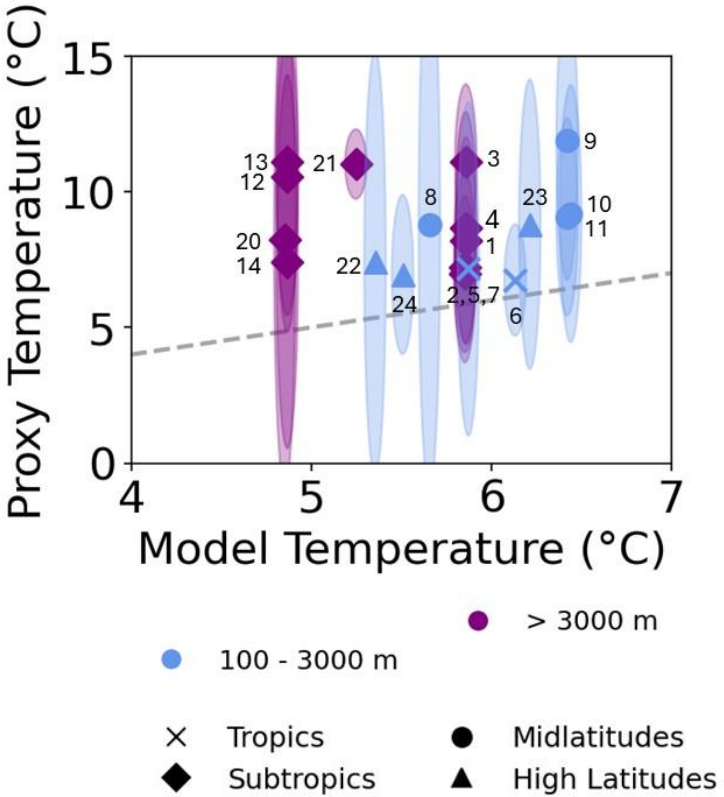




Proxy datasets: Friedrich et al. 2012, Hull et al. 2020, Barrera & Savin, 1999; Cramer et al., 2009; D'Hondt & Arthur, 2002; Friedrich et al., 2004, 2009; Li & Keller, 1999; MacLeod et al., 2005; Schmitz et al., 1992; Schmitz & Speijer, 1996; Vancoppenolle et al., 2022

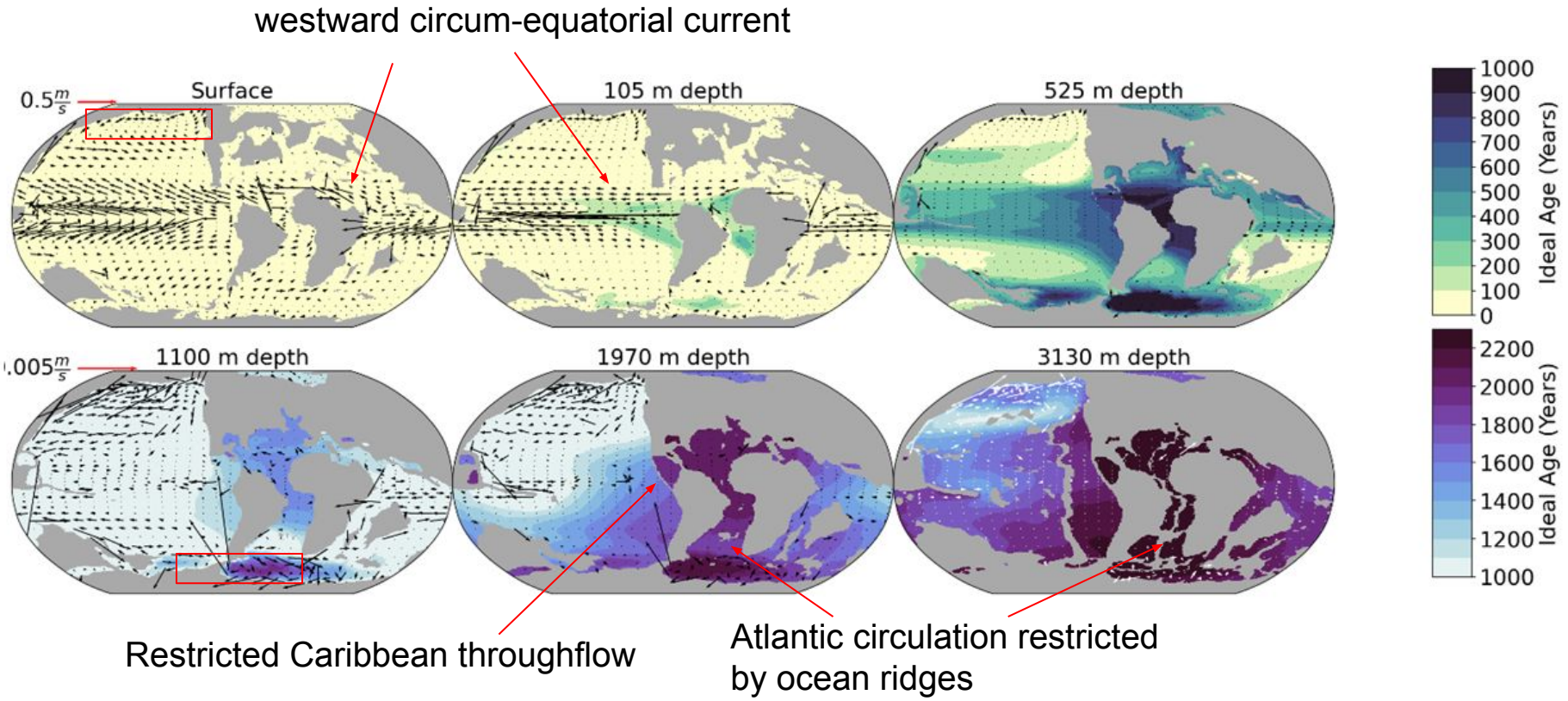
Deepest simulated benthic temperatures are colder than proxies



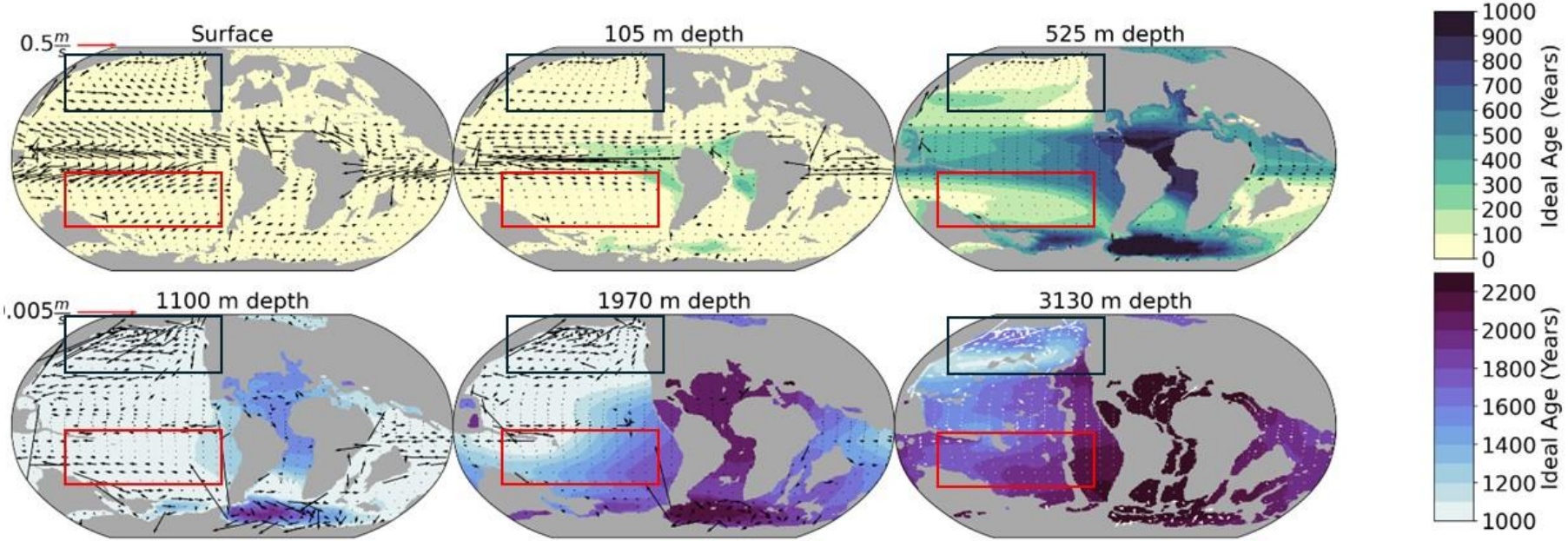


Sites in both basins show no overlap, but particularly the Atlantic

Circulation reproduces many features expected from εNd studies



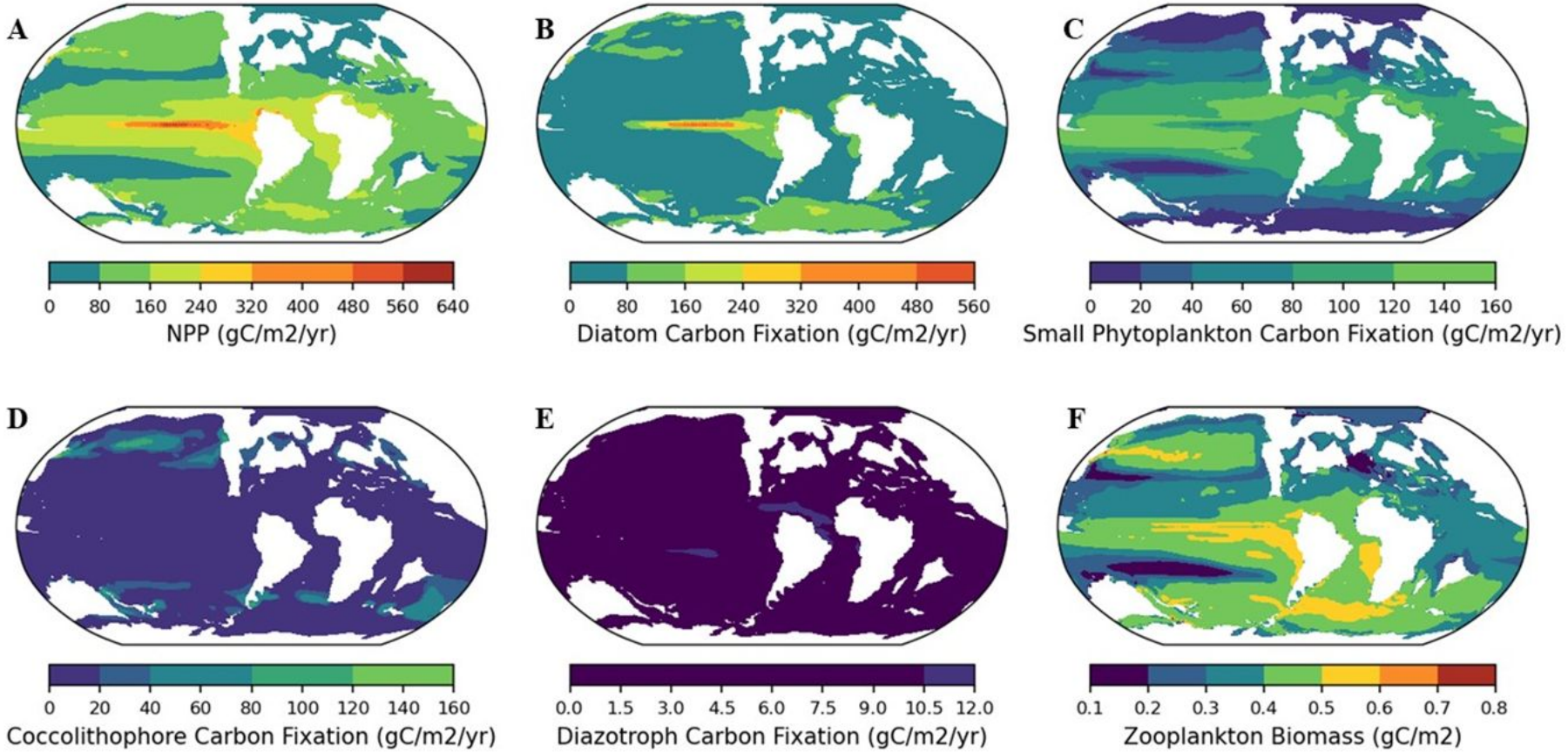
Deep water formation sites differs from other studies



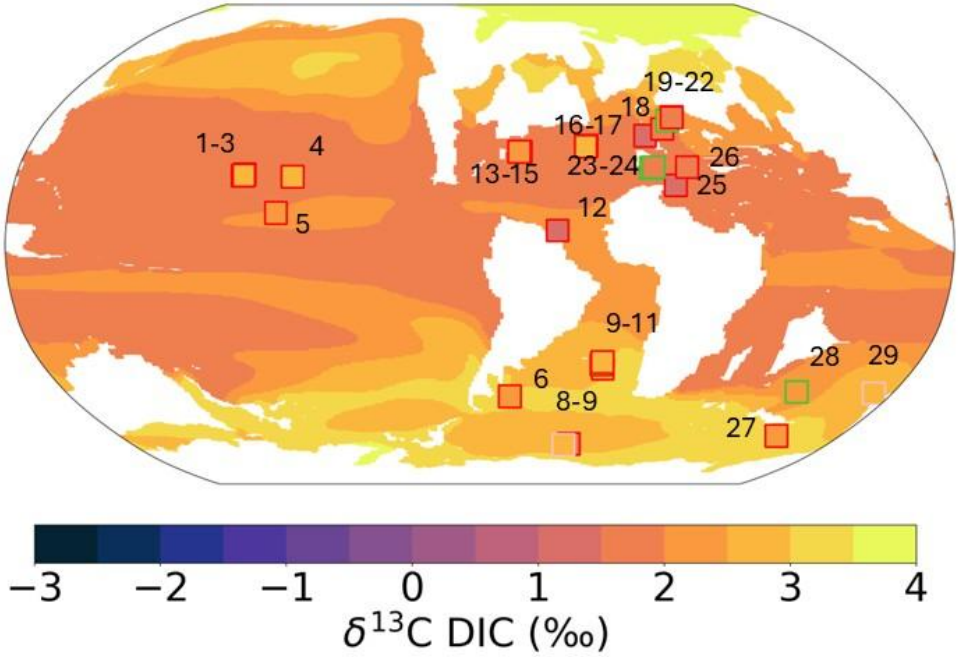
high N. Pacific coast = cold SSTs = sinking

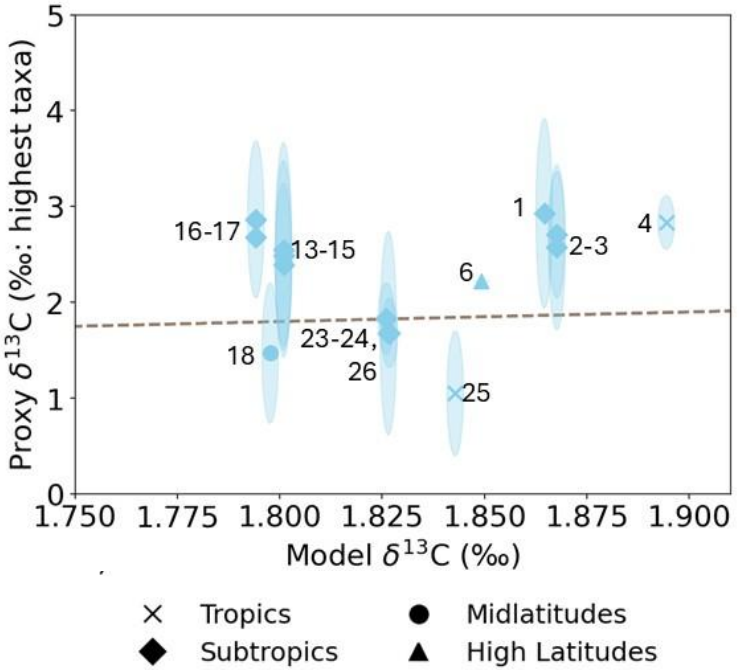
How do MARBL & explicit carbon isotope simulation measure up in deep time?

Diatoms drive productivity & carbon export



Surface carbon isotopes show general agreement





Proxy datasets: Alegret et al., 2012; Barrera & Savin, 1999; Batenburg et al., 2018; Falzoni et al., 2016; Friedrich et al., 2004; Hull et al., 2020; MacLeod et al., 2005; Mosher et al., 2007; Oberhänsli, 1986; Schmitz et al., 1992; Schmitz & Speijer, 1996; Schönfeld et al., 1991; Sepúlveda et al., 2019; Sinnesael et al., 2016

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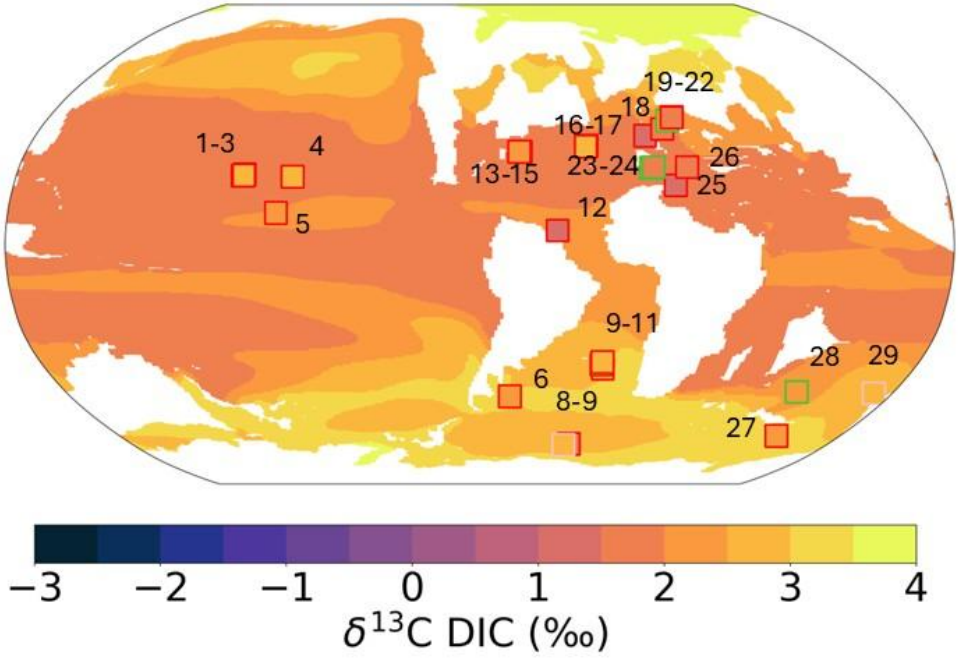
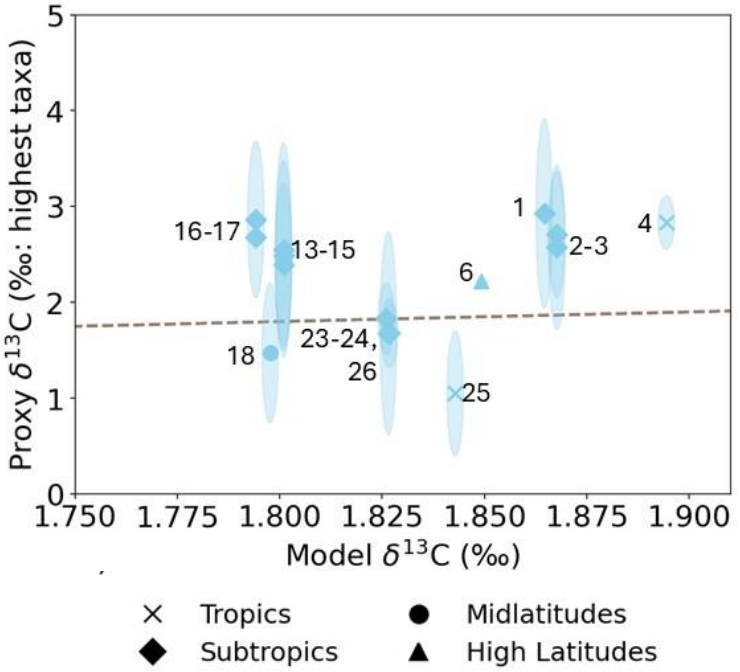
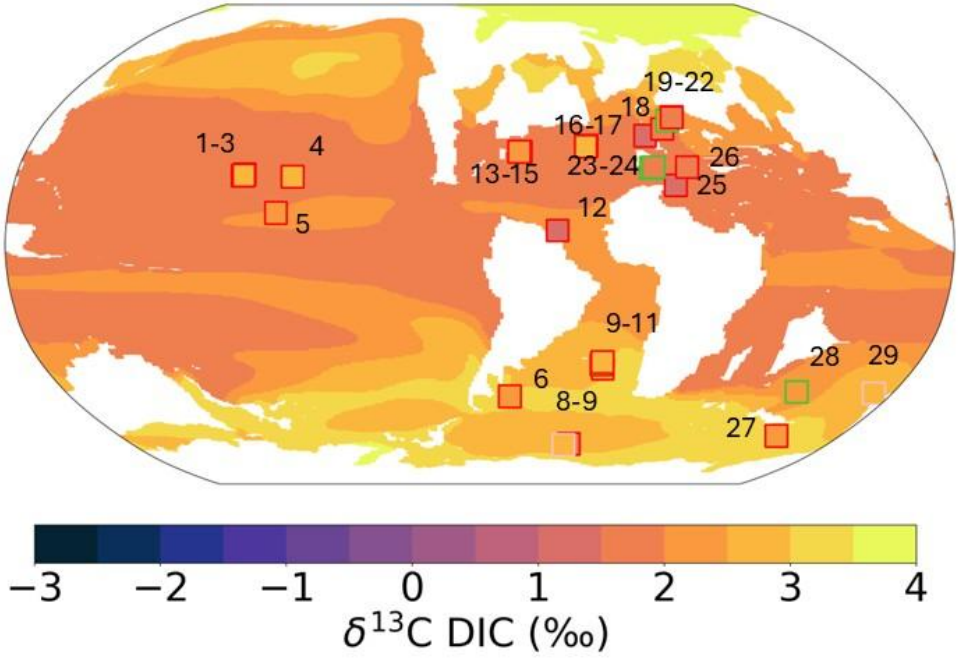
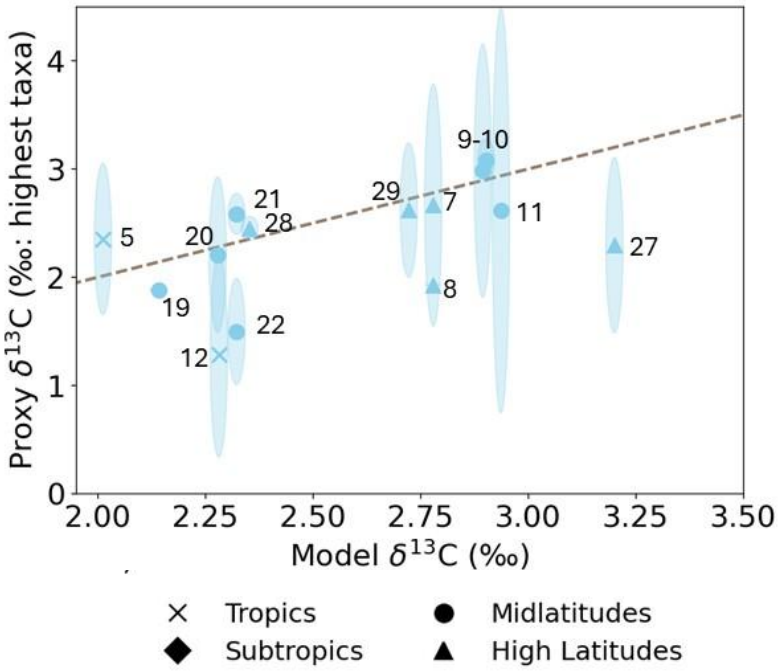




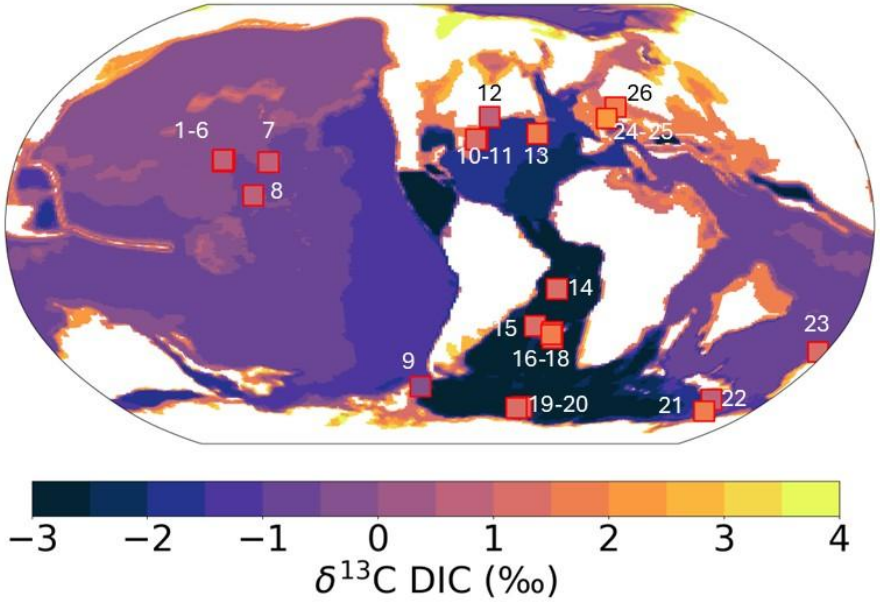
Values from highest taxa assessed for agreement

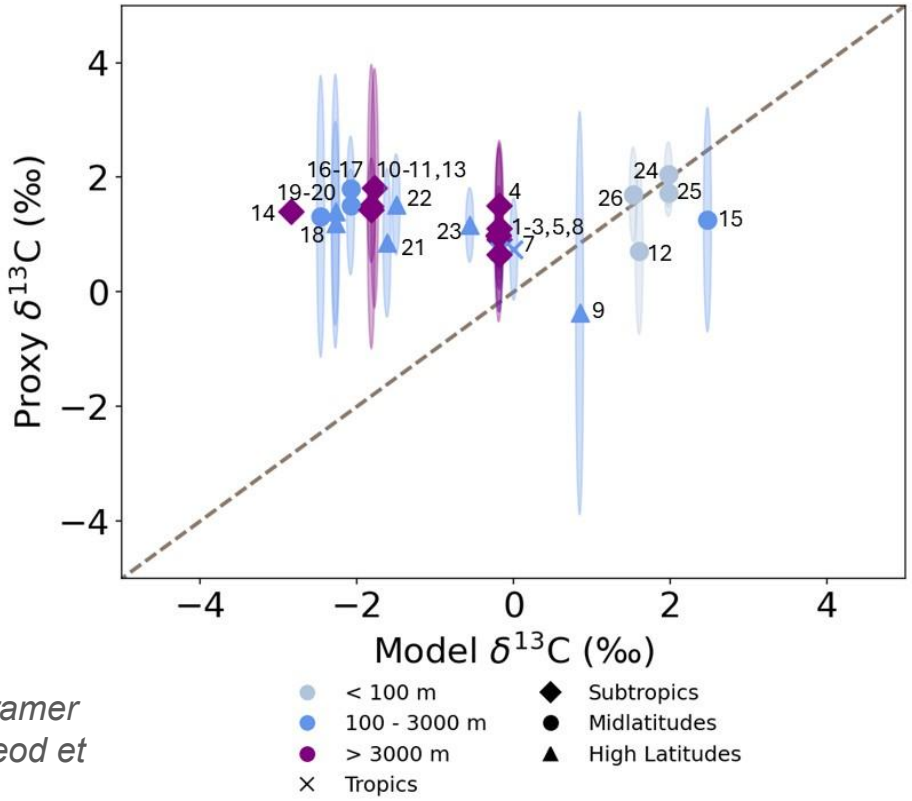
Surface carbon isotopes show general agreement





Simulated benthic carbon isotopes are biased in bathymetry-restricted areas





Proxy datasets: Alegret et al., 2012; Barrera & Savin, 1999; Cramer et al., 2009; D'Hondt & Arthur, 2002; Huber et al., 2018; MacLeod et al., 2005; Schmitz et al., 1992; Schmitz & Speijer, 1996; Vancoppenolle et al., 2022

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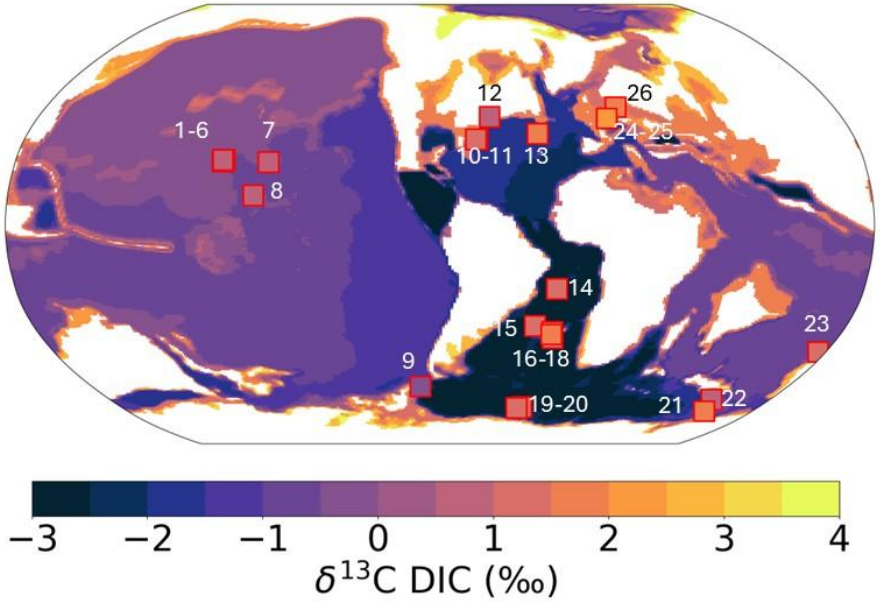
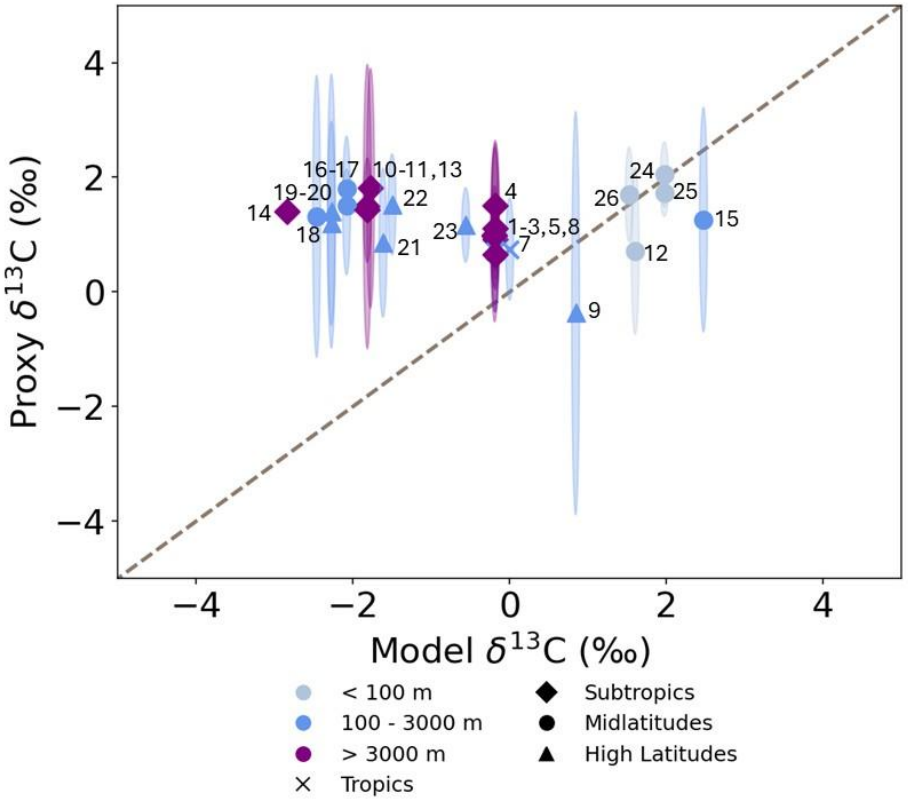
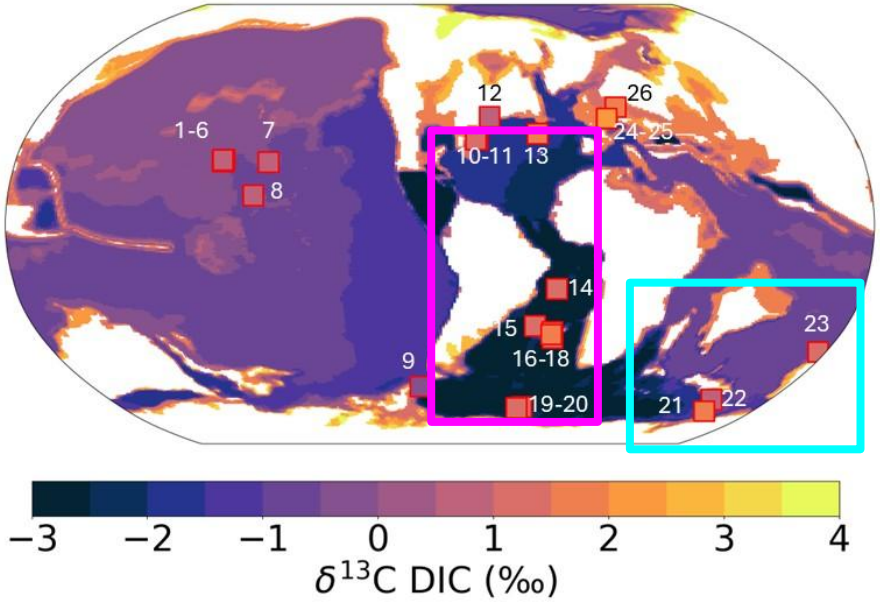
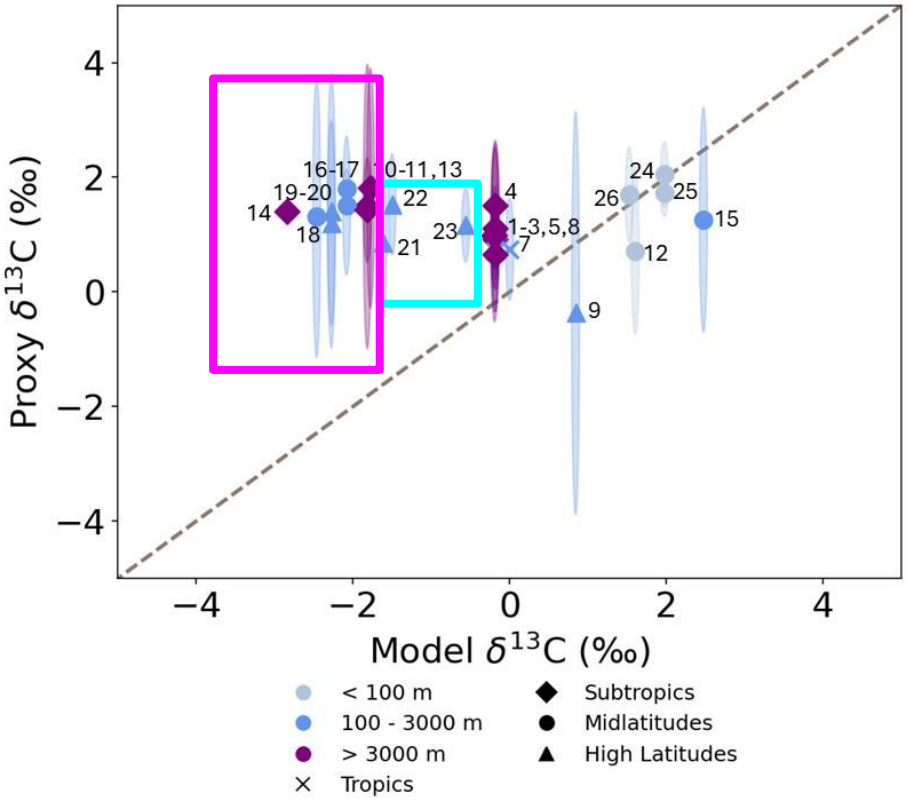




Pacific and shallow North Atlantic sites show general agreement

Simulated benthic carbon isotopes are biased in bathymetry-restricted areas





Deeper Atlantic and Southern Ocean simulated isotopes are very low

Conclusions

- CESM2 with MARBL & explicit carbon isotope fractionation matches well with proxy evidence at 850 ppm CO_2
- Cold deepest ocean temperatures, North Pacific deep water formation likely due to position of North Pacific coast
- Mismatch in benthic $\delta^{13}C$ likely due to bathymetric restriction: higher-resolution simulations or fix to MARBL oxygenation issue needed

Collaborators: Cheryl Harrison, Clay Tabor, Joshua Coupe, Nicole Lovenduski, Ken MacLeod, Victoria Garza, Shixiong Hu, Sid Mitra, Julio Sepúlveda, Rachel Wheatley, Robert Kelleher, Serena Dameron

Thank you!