Global Calibration of Benthic Foraminiferal Carbon Isotope Ratios

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Data

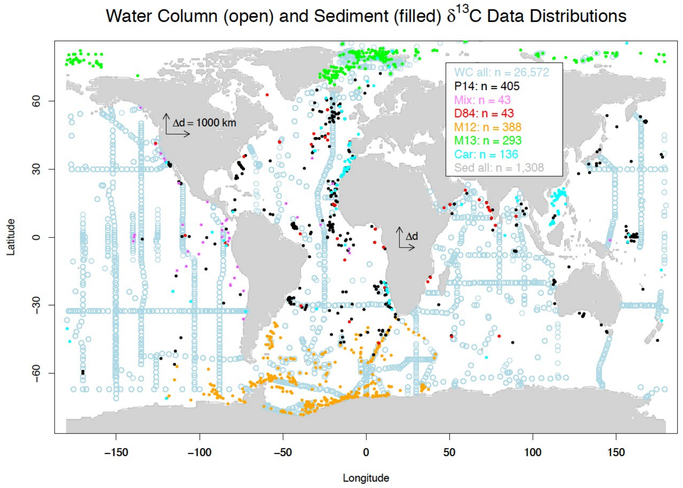

Fig. 1: Data distribution. Water column (WC) measurements of $\delta^{13}C_{DIC}$ updated from Schmittner et al. (2013). Foram data are from the compilation of **fossil** shells from Peterson et al. (2014; P14), Duplessy et al. (1984; D84), Mix (unpublished), and Cartapanis (unpublished; Car) as well as the polar compilations from mostly **living** forams by Mackensen (2012; M12) and Mackensen (2013; M13).

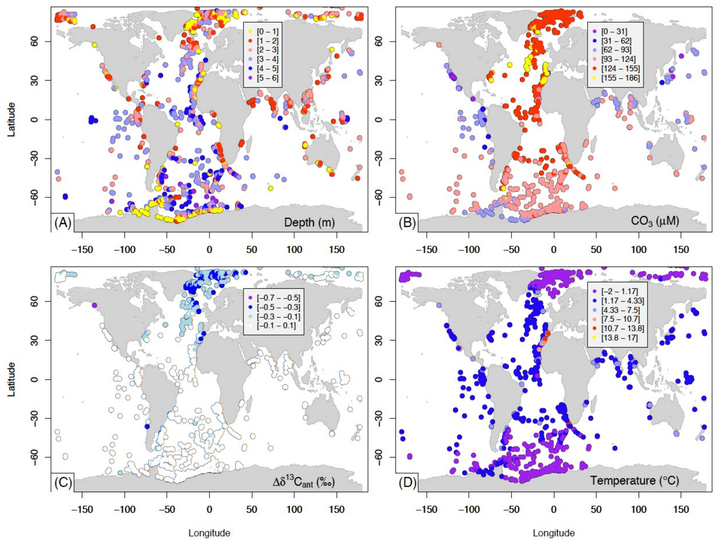

Fig. 2: Depth, CO_3, anthropogenic $\delta^{13}C$, and temperature. CO3 and temperature data were used from the same samples as the water column measurements filled in with climatologies (GLODAP, WOA05).

Research Questions

- How well does $\delta^{13}C$ measured in foram (cibicides) shells ($\delta^{13}C_{cib}$) represent water column $\delta^{13}C_{DIC}$?
- Are there carbonate ion and other complicating effects?
- What are the errors and uncertainties?

Methods

- Mapping of WC to sediment core locations using great circle horizontal distances Δd = 1,000 km (default) and Δd = 500 km and vertical distance Δz=z/5 (default) and dz=z/10.
- Anthropogenic $\delta^{13}C$ (Suess Effect, SE) was removed from WC and living foram data using model results (SE=M; Schmittner et al., 2013).
- Multiple linear regression analysis $\delta^{13}C_{cib}=\mathbf{a}+\mathbf{b}\delta^{13}C_{DIC}+\mathbf{c}CO_3^{2-}+\mathbf{d}T+\varepsilon$ considering carbonate ion (CO_3^{2-}) and temperature (T) effects and neglecting errors in $\delta^{13}C_{DIC}$.

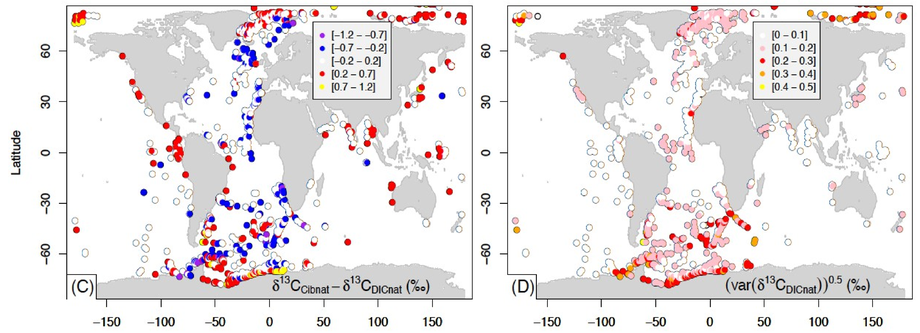

Fig. 4: Left: difference between foram and WC data (σ = 0.32 ‰). Right: standard deviation of WC data mapped on sediment core locations as an estimate of the WC data error (σ_{WC} = 0.13 ‰).

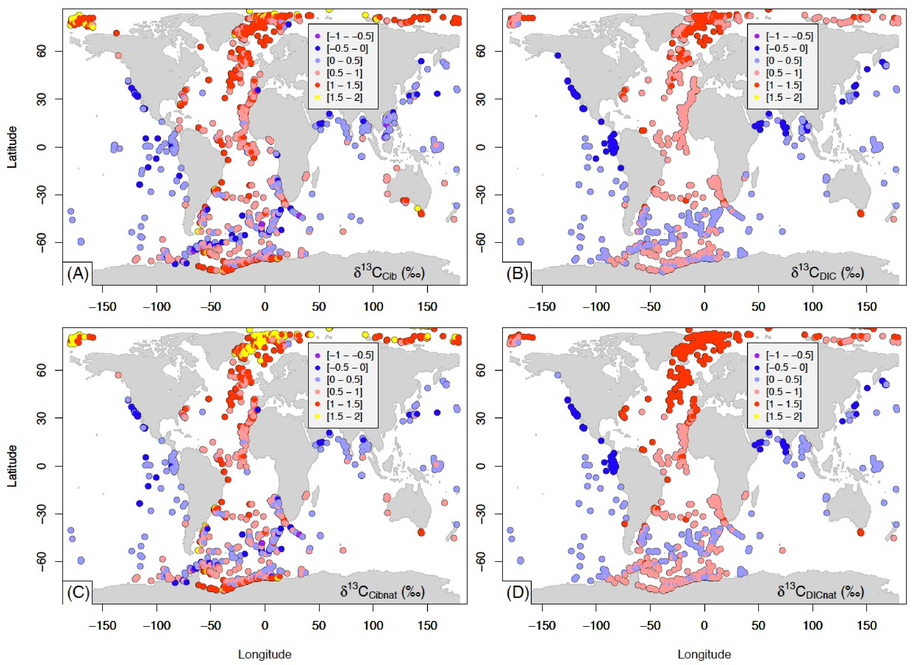

Fig. 3: Sediment (left) and WC (right) data. Top: raw data. Bottom: corrected for anthropogenic effects.

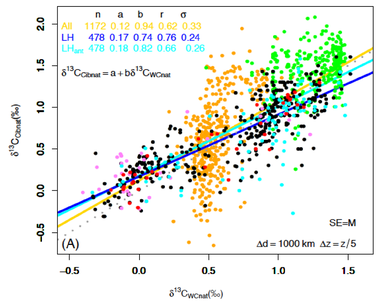

Fig. 5: Linear regressions neglecting carbonate ion, temperature, and pressure effects.

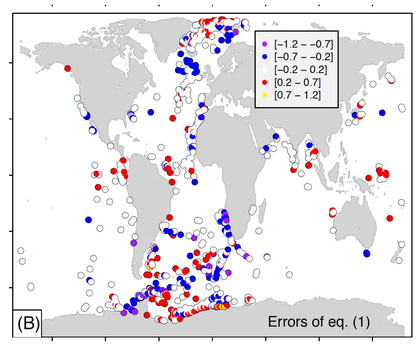

Fig. 6: Errors of eq. (1). σ = 0.29 ‰. Compare with Fig. 4C.

Results

- Carbonate ion, temperature, and pressure effects are affecting $\delta^{13}C_{cib}$, consistent with experimental and theoretical studies, and should be accounted for according to the following equation:

$$\delta^{13}C_{DIC} = -0.50 + 0.94 \cdot \delta^{13}C_{Cib} + 3.1\times10^{-3} \cdot CO_3 - 1.2\times10^{-3} \cdot T + 5.8\times10^{-5} \cdot z$$

(the depth dependence has been deduced by regressing the residuals to z) (errors decrease by ~10% Figs. 4 & 7)

- Errors are 0.2-0.3 ‰, except in the South Atlantic where they are larger ~ 0.4 ‰

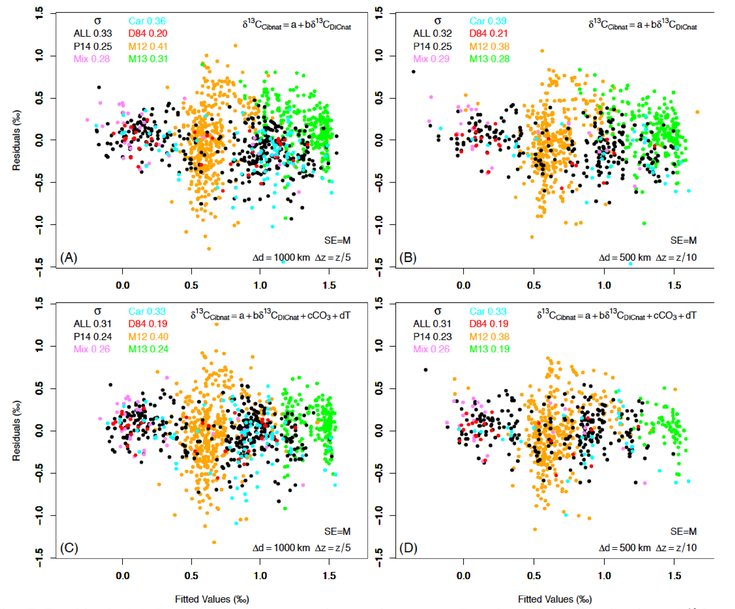

Fig. 7: Residuals (ε) from the linear regression analyses as a function of the fitted values $\delta^{13}C_{cib}$.

References:

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