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Global ocean climatology of the 13C Suess effect and preindustrial δ13C

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We present the first observationally based estimate of the full global ocean 13C Suess effect since preindustrial times. This was constructed by using Olsen and Ninnemann's [2010] back-calculation method to calculate the 13C Suess effect with data from 29 cruises spanning the world ocean. We find a strong 13C Suess effect in the upper 1000 m of all basins, with strongest decrease in the Subtropical Gyres of the Northern Hemisphere, where δ13C has decreased by more than 0.8‰ since the industrial revolution. At greater depths, a significant 13C Suess effect can only be detected in the northern parts of the North Atlantic Ocean. The magnitude of the 13C Suess effect is correlated with the concentration of anthropogenic carbon, but their relationship varying strongly between water masses, reflecting the degree to which source waters are equilibrated with the atmospheric 13C Suess effect before sinking. From the 13C Suess effect estimates, we have estimated the preindustrial δ13C (δ13CPI) along the 29 sections. Further, we developed regional multilinear regression equations, which were applied on the World Ocean Atlas data to construct the δ13CPI climatology, which reveals the natural δ13C distribution in the global ocean. Compared to the modern distribution, the preindustrial δ13C spans a larger range of values, and we find that in some regions in the high northern latitudes, the gradient in modern ocean δ13C is completely reversed compared to the preindustrial. Maximum δ13CPI, of up to 1.8‰ are found in the subtropical gyres of all basins, in the upper and intermediate waters of the North Atlantic, as well as in mode waters with a Southern Ocean origin. Particularly strong gradients occur at intermediate depths, revealing a strong potential for using δ13C as a tracer for changes in water mass geometry at these levels. Further, we identify a much tighter relationship between δ13C and Apparent Oxygen Utilization (AOU) than between δ13C and phosphate that occurs because both δ13C and AOU, in contrast to phosphate, are partly reset when waters are ventilated in the Southern Ocean. This makes δ13C a robust proxy for past changes in ocean oxygen content and ventilation. Our δ13CPI climatology has strong applications in paleo-sciences, and can be used for example for improved model evaluation, interpretation of sediment δ13C records, and core top comparison.

Olsen, A., and U. Ninnemann (2010), Large δ13C gradients in the preindustrial North Atlantic revealed, Science, 330(6004), 658-659, doi:10.1126/science.1193769.