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A Next Generation Ocean Carbon Isotope Model for Climate Studies

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The $^{13}C/^{12}C$ of dissolved inorganic carbon ($\delta^{13}C$ DIC) carries valuable information on ocean biological C-cycling, air-sea CO_2 exchange, and circulation. Paleo-reconstructions of oceanic ^{13}C from sediment cores provide key insights into past as changes in these three drivers. As a step toward full inclusion of ^{13}C in the next generation of Earth system models, we implemented ^{13}C-cycling in a 1° lateral resolution ocean-ice-biogeochemistry Geophysical Fluid Dynamics Laboratory (GFDL) model driven by Common Ocean Reference Experiment perpetual year forcing. The model improved the mean of modern $\delta^{13}C$ DIC over coarser resolution GFDL-model implementations, capturing the Southern Ocean decline in surface $\delta^{13}C$ DIC that propagates to the deep sea via deep water formation. The model is used here to quantify controls on modern and anthropogenic $\delta^{13}C$ DIC as well as to test their sensitivity to wind speed/gas exchange parameterizations.
We found that reducing the coefficient for air-sea gas exchange following OMIP-CMIP6 protocols reduces deep sea modern $\delta^{13}C$ DIC by 0.2 permil and improves the depth-integrated anthropogenic $\delta^{13}C$ DIC relative to previous gas exchange parameterizations. This is because the $\delta^{13}C$ DIC of the endmembers ventilating the deep sea and intermediate waters are highly sensitive to
the wind speed dependence of the air-sea CO_2 gas exchange. Additionally, meridional gradients of surface modern $\delta^{13}C$ DIC are better resolved with OMIP-CMIP6. While this model was initially constructed to study the anthropogenic ^{13}C response, it has promising applications toward longer time scales. For example, BLING 13 C includes controls on the biological C-pump thought to be important in the glacial ocean: light and iron limitation, and controls on ^{13}C of organic matter formation, and thus on ocean $\delta^{13}C$ DIC and its vertical gradient, that depend on pCO_2 .