



Is ALK-DIC a suitable proxy of seawater carbonate ion concentration in the framework of global climate model evaluation?

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The property ALK-DIC, the concentration difference of alkalinity and total dissolved inorganic carbon in seawater has recently been used as a metric for the data-based evaluation of ocean climate and carbon cycle models. The rationale behind this is that ALK-DIC is thought to serve as a good approximation of the carbonate ion concentration, $[CO_3^{2-}]$. Since $[CO_3^{2-}]$ is inversely related to the Revelle Factor, it is considered a good proxy of the buffer capacity of seawater and hence the chemical capacity of the ocean to take up atmospheric CO_2 . ALK-DIC has hence been suggested as an easy to calculate metric to judge a model's chemical potential to take up atmospheric CO_2 in comparison with the real ocean. Since $[CO_3^{2-}]$ is also an important property controlling the dissolution of $CaCO_3$, computing ALK-DIC in the deep ocean might also help to evaluate $CaCO_3$ cycle modules in ocean biogeochemical models.

In this study, the distribution of ALK-DIC and $[CO_3^{2-}]$ in observations of the ocean (GLODAP-data) and ocean model output available from six models contributing to the Climate Model Intercomparison Project (CMIP5) is compared and the potential of ALK-DIC to serve as a suitable proxy of $[CO_3^{2-}]$ in the context of data-based model evaluation is explored.

In most of the surface ocean (GLODAP observational dataset) ALK-DIC is by 35-45% larger than $[CO_3^{2-}]$ with the important exception of the Southern Ocean where the difference is smaller. This difference decreases further in the interior ocean and can even turn sign, for example in oxygen minimum zones where $[CO_3^{2-}]$ becomes slightly larger than ALK-DIC. While overall patterns of the evaluated CMIP5 models are similar to observations, distinct differences are observed. For example, minimum ALK-DIC in observations is usually close to zero while extremely negative values are observed in some of the CMIP5 models (e.g. -156 $\mu\text{mol/kg}$ in IPSL-CM5A-LR, and up to -418, -426, and -450 $\mu\text{mol/kg}$ in GFDL-ESM2M, MPI-ESM-LR and NorESM1-ME, respectively). Possible causes are discussed and the incomplete implementation of processes affecting ocean alkalinity is suggested as the most likely cause.