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Global ocean $CaCO_3$ -cycle models: are they fit for ocean acidification research?

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Ocean biogeochemical models are routinely applied to assess the net global impact of ocean acidification and warming on pelagic $CaCO_3$ cycling. The standard method to evaluate such models is to compare the distributions of either alkalinity or the $CaCO_3$ saturation horizon with respective observations. However, alkalinity, basically the charge balance of the major constituents of seawater, has a large conservative, non-biogeochemical component and deficient representation of ocean physics (circulation, evaporation and precipitation) can strongly impact on a model's alkalinity distribution. Likewise, a model's $CaCO_3$ saturation horizon is affected by complex interactions of ocean physics (e.g. T, S and CO_2 equilibrium conditions in outcrop regions) and integrated effects of the organic tissue pump and last, but not least, the patterns of $CaCO_3$ production and dissolution. Here we apply a global ocean biogeochemical model run into preindustrial steady state and featuring a number of idealized tracers, which capture explicitly the model's $CaCO_3$ dissolution signal, the effect from organic matter remineralisation on the carbon cycle, and the various preformed properties (O_2, DIC, alkalinity) and their disequilibria. In a twin-experiment approach we compare the suitability of a variety of potential measures of the $CaCO_3$ cycle, including bulk alkalinity, potential alkalinity, TA*, saturation horizon. We in particular demonstrate the sensitivity of some of these apparent measures of biogeochemical processes to the differences in model and ocean physics. Building on our twin-experiment we briefly analyse three OCMIP5 models and suggest that state-of-the-art global ocean $CaCO_3$ cycle models may be largely unconstrained in general and await careful data-based evaluation.