



## **Sensitivity of different formulations of the seawater $\text{CaCO}_3$ saturation state ( $\Delta\text{CO}_3$ , $\Omega$ ) to ocean acidification: implications for pelagic $\text{CaCO}_3$ dissolution in ocean biogeochemical models**

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The saturation state of seawater with respect to  $\text{CaCO}_3$  can usually be expressed in two different ways, either as the difference of the in situ carbonate ion concentration to saturation ( $\Delta\text{CO}_3 = \text{CO}_3 - \text{CO}_{3,\text{sat}}$ ) or as the ratio ( $\Omega = \text{CO}_3 / \text{CO}_{3,\text{sat}}$ ). Since both formulations refer to the same phenomenon, the deviation from equilibrium, they are usually considered as equally applicable. However, a difference in the pressure (depth) dependent sensitivity of both expressions to ocean acidification (change in  $\text{CO}_3$ ) may result in an underestimation (overestimation) of the vulnerability of deep (shallow) ocean calcifying organisms when using  $\Omega$ . According to a simple sensitivity analysis, the change of  $\Omega$  at depth has only 1/3 of the effect that would be seen at the sea surface for the same amount of  $\text{CO}_3$  change. When applied for the calculation of  $\text{CaCO}_3$  dissolution kinetics, e.g. in ocean biogeochemical models, this results in a three-times slower  $\text{CaCO}_3$  dissolution reaction at depth, although finally the same amount of  $\text{CaCO}_3$  would be dissolved. This slow-down may even grow when non-linear dissolution kinetics (higher reaction rate orders) are applied. In a sensitivity study an ocean biogeochemical model is used, exploring the parameter space of  $\text{CaCO}_3$  dissolution kinetics as given in the literature. Forced by a 1-4x $\text{CO}_2$  scenario including stabilization thereafter, we find that the resulting reduction in  $\text{CaCO}_3$  export at the millennial time scale varies between two and more than 10 percent, which means that there are significant differences in the impact on particle ballasting, depending on the kinetic expression applied.