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Understanding the causes and consequences of past marine carbon cycling variability through models

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Abstract. On geological time-scales, the production and degree of recycling of biogenic carbon in the marine realm and ultimately its removal to sediments, exerts a dominant control on atmospheric CO_2 and hence variability in climate. This is a highly complex system involving a myriad of interconnected biological, chemical, and physical processes. For this reason alone, linking observations, often highly abstracted in the form of proxies, to the primary processes involved and ultimately to explanatory hypotheses for specific geological events and transitions, is challenging. The past few decades has seen a progressive improvement in theoretical and process-based understanding of the various components that make up the marine carbon cycle and hand-in-hand with this, the development of numerical model representations of the complete system. Models have also been designed and/or adapted with paleoclimate questions in mind and applied to quantitatively explore the role of the marine carbon cycle in both perturbations and long-term geologic evolutionary trends in global climate, and possible feedbacks between them. However, we must ask whether paleoclimate models incorporate sufficiently appropriate representations of the dynamics and sensitivities of the marine carbon cycle, and indeed, whether in the geological context, we really know what these dynamics are.

Here we provide a comprehensive overview of how marine carbon cycling and the biological carbon pump is treated in available paleoclimate models, with the aim of critically evaluating their ability to help interpret past marine carbon cycle and climate dynamics. To this end, we first provide an overview of commonly used paleoclimate models and some of their associated paleo-applications,