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Sediment core modelling on a global basis for improving Earth system models

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Calibration of Earth system models through data from analysis of the marine paleo-climatic sediment core record is attractive as the geological data contains physical, chemical, and biological information about global change over long time intervals. A sediment module for implementation in Earth system models was developed. This module allows to create synthetic sediment cores under each marine model grid point, and to "recover" sediment cores for comparison with observations. As an example, we employ the ocean in the glacial low CO_2 world as an inverted paleo-analogue to the evolving high CO_2 world. Potential changes of parameters governing marine biogeochemistry are estimated through fitting results from a coarse resolution biogeochemical ocean general circulation model to sediment core data and ice core data over the last climatic cycle. A variation of biomass on land is accounted for in addition. The results from the non-linear three-dimensional model are projected onto a linear response model for an inverse fitting procedure. As observational data sets atmospheric pCO_2, weight-percentages of $CaCO_3$ and opal, as well as benthic and planktonic $\delta^{13}C$ of $CaCO_3$ are considered. The approach shows that no simple unambiguous relationship between single governing biogeochemical parameters and pCO_2 (or temperature) can be inferred. Nevertheless - within the framework of the study - estimates for combined glacial/interglacial changes in biogeochemical parameters (such as the particle export rain ratio, sea surface temperature, and carbon over-/underconsumption) can be derived. The results can be used for calibrating the sensitivity of Earth system models to natural physical and biogeochemical forcing.