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MEDUSA-2.0: an intermediate complexity biogeochemical model of the marine carbon cycle for climate change and ocean acidification studies

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Abstract. MEDUSA-1.0 (**M**odel of **E**cosystem **D**ynamics, nutrient **U**tilisation, **S**equestration and **A**cidification) was developed as an "intermediate complexity" plankton ecosystem model to study the biogeochemical response, and especially that of the so-called "biological pump", to anthropogenically driven change in the World Ocean (Yool et al., 2011). The base currency in this model was nitrogen from which fluxes of organic carbon, including export to the deep ocean, were calculated by invoking fixed C:N ratios in phytoplankton, zooplankton and detritus. However, due to anthropogenic activity, the atmospheric concentration of carbon dioxide (CO_2) has significantly increased above its natural, inter-glacial background. As such, simulating and predicting the carbon cycle in the ocean in its entirety, including ventilation of CO_2 with the atmosphere and the resulting impact of ocean acidification on marine ecosystems, requires that both organic and inorganic carbon be afforded a more complete representation in the model specification. Here, we introduce MEDUSA-2.0, an expanded successor model which includes additional state variables for dissolved inorganic carbon, alkalinity, dissolved oxygen and detritus carbon (permitting variable C:N in exported organic matter), as well as a simple benthic formulation and extended parameterizations of phytoplankton growth, calcification and detritus remineralisation. A full description of MEDUSA-2.0, including its additional functionality, is provided and a multi-decadal spin-up simulation (1860–2005) is performed. The biogeochemical performance of the model is evaluated using a diverse range of observational data, and MEDUSA-2.0 is assessed relative to comparable models using output from the Coupled Model Intercomparison Project (CMIP5).

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