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Evaluating our understanding of the biological carbon pump using the transport matrix method and global nutrient distributions.

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Global net primary production by marine phytoplankton plays a key role in the Earth system, fuelling the marine ecosystem and supporting resources such as fisheries. A fraction of the resulting organic material sinks out of the euphotic zone as 'export production', sequestering large amounts of carbon at depth, away from the atmosphere. Model studies have demonstrated that atmospheric pCO_2 concentrations can be very sensitive to small changes in the depth at which this organic material is remineralised into CO_2 and nutrients. The accuracy of parameterisations for remineralisation has often been assessed by direct comparison of simulated and sparse observed fluxes of sinking material. The consequences of remineralisation, i.e. the global distribution of inorganic nutrients, provide a much stronger test of our knowledge concerning the impact of remineralisation on ocean nutrient cycles because they are much more densely sampled. In this study, we investigate how alternative paradigms for the Biological Carbon Pump (BCP) have distinctive signatures in the consequent global distribution of nutrients. We compare several combinations of parameterisations for export production and remineralisation within two different representations of ocean circulation using the Transport Matrix Method (Khatiwala, 2007). Export production is represented using an NPZD-DOP model (Kriest et al., 2010) and three remote sensing-derived estimates while remineralisation is represented by either constant or spatially variable values of the Martin's curve exponent (Martin et al., 1987). In order to evaluate the ability of each export-remineralisation combination to correctly represent the BCP, we introduce a set of diagnostics to allow the intercomparison between in-situ data and simulations. These diagnostics are based on both nutrient fields and water masses and are designed to minimize the influence of biases originating from the representation of ocean circulation on the model-observation intercomparison.

References

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