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Assimilating water column and satellite data for marine export production estimation

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Abstract. Recent advances in satellite retrieval methodology now allow for estimation of particular organic carbon (POC) concentration in ocean surface waters directly from satellite-based optical data. Because of the good coverage, these data reveal small-scale spatial and temporal concentration gradients and document the evolution of surface water POC as well as the underlying driving biogeochemical processes throughout the seasons. Water column nutrient data also reveal biogeochemical activity. However, because of the scarcity of data, the deduction of temporal changes of particle production and export is not possible in most parts of the ocean. Here we present first results from a new study combining both data streams, thereby exploiting the high spatio-temporal resolution of surface POC concentrations from satellite optical sensors with water column nutrient data having sparser coverage but providing information throughout the entire water column. We use a medium-resolution global model with steady-state 3-D circulation that has been optimized by fitting to a large number of hydrographic parameters and tracers, including CFCs and natural radiocarbon. Production and export of POC is allowed to vary monthly, and the magnitudes of the monthly export fluxes are determined by fitting the model to satellite POC data as well as water column nutrient data using the adjoint method. Two cases have been investigated: (1) the production rate of POC is set to be proportional to export production (EP) and the seasonal changes are assumed sinusoidal (meridionally varying amplitude and phase), and (2) the POC production rate is linked to primary production rates (literature). Both cases were run with the same initial state and model settings, and show total cost function decreases of 12 and 95%, respectively. The POC misfit term alone decreased by 75 and 99.8%. The integrated annual global POC exports of the two cases are 9.9 and 12.3 Gt C yr⁻¹, respectively. Overall, the remaining POC and phosphate misfits of both solutions are considered too large, and the difference fields still exhibit significant systematic geographical patterns. This indicates that the present model runs are too simplistic and do not fully explain the data. Further, more refined model setups are needed.

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