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The link between eutrophication and acidification in the Black Sea: a modelling study

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The carbonate system properties of the Black Sea inner basin vertical profiles are compressed (upper 100 m) versions of their open ocean counterparts (upper 1000 m) because of very strong stratification confined into a shallow upper layer above the pycnocline. In addition, concentrations of its properties are much higher at all depths in the Black Sea than those observed in the oceans, as well as many other semi-enclosed and marginal sea systems. A one-dimensional coupled physical–biogeochemical model is used to elucidate the major processes controlling the carbonate system properties of the interior Black Sea. During the present post- eutrophication phase of the recent biogeochemical history of the Black Sea, high total alkalinity (TA), dissolved inorganic carbon content (DIC $\sim$ 3.0 mmol kg-1) and partial pressure of carbon dioxide (pCO_2 > 1000 μatm) accompanied with a very strong density stratification (> 3 kg m-3) promote a distinct two layer structure within the upper 100 m above the anoxic interface. Simulation results show that the upper 20m layer possesses an almost zero annual-mean surface CO_2 flux (0.04 mmol m-2 d-1) into the sea albeit strong seasonality in the carbonate system properties driven by changes in temperature, mixing, and biological processes. The average pCO_2 concentration in this layer exceeds pCO_2atm most of the year due to the contribution from its internal resources. Below 30m, heterotrophic processes generate a strong transitional zone with a thickness of 20m. This is followed by a roughly 50m thick layer extending down to the anoxic interface with maximum pCO_2 and DIC concentrations and minimum pH values. Nitrogen and phosphorus peaks and oxygen depletion also characterize this layer. These subsurface properties show marked differences in respect to their structures compared to early-eutrophication phase simulations.