Modelling the uptake and release of carbon dioxide in the Baltic Sea surface water

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Abstract

We present and analyse a fully coupled physical–biogeochemical model of the uptake and release of carbon dioxide in the Baltic Sea. The modelling includes the interaction between physical (stratification, temperature, salinity, penetration of solar radiation, and ice), chemical (total alkalinity, pH, dissolved inorganic carbon, oxygen, and nutrients), and biological processes (plankton and dissolved organic carbon (DOC)). These processes have been built into an advanced process-oriented coupled basin ocean model that has been extensively explored and validated for the Baltic Sea.

The model captures major physical–chemical and biological response patterns, as evaluated based on observations from the central Baltic Sea, and illustrate the need to include fractional nutrient release in the photic zone for consistency with CO_2 observations. The study indicates that long-term values of the water partial pressure of carbon dioxide were above atmospheric values before industrialization, with a net release of CO_2 to the atmosphere. Seasonal variability increased in the modern industrialization era with the inclusion of eutrophication, making the Baltic Sea both a sink and source of CO_2 to the atmosphere. Modelling long-term variations in pH indicates the existence of stable conditions before industrialization and slight decrease due to increased atmospheric carbon dioxide concentrations during industrialization. Eutrophication effects may have damped acidification, but have caused increased seasonal pH variability with low values occurring during winter season.