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Inter-annual variation of the air–sea CO2 balance in the southern Baltic Sea and the Kattegat

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We estimated the net annual air–sea exchange of CO2 using high-quality monitoring data from the Gotland Sea, Bornholm Sea, and Kattegat for the 1993–2007 period. Sea surface partial pressure of CO2 (pCO2w), was calculated from pH, total alkalinity, temperature, and salinity. The pCO2w, daily wind speed, and three parameterizations of the gas transfer velocity (k) were used for the flux calculations. Direct pCO2 measurements from research cruises and data collected with an automated pCO2 measurement system deployed on a cargo ship were used to validate the calculated pCO2 data. The uptake and release of CO2 over the southern Baltic Sea and the Kattegat display large seasonal and inter-annual variations as well as regional differences. We demonstrate that regions in the southern Baltic Sea and the Kattegat alternate between being sinks (–) and sources (+) of CO2 within the +4.5 to –5 mol m–2 y–1 range. The average air–sea exchange over the period was –0.07 mol m–2 y–1 in the Gotland Sea, +0.86 mol m–2 y–1 in the Bornholm Sea, and –0.52 mol m–2 y–1 in the Kattegat. The choice of k varied the air–sea exchange by a factor of two, and large inter–annual and regional variations in the air–sea balance were obvious. The variability of the air–sea exchange was mainly controlled of variations in biological production, sea surface temperature, and wind speed. To improve estimates of the air–sea exchange of CO2, uncertainties in the gas transfer velocity and in the stability constants must be reduced. To calculate an annual mean, it is particularly important to capture events such as the onset of biological production in spring, the pCO2w minima in summer, and the pCO2w maximum in winter.