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Dynamics of air-sea CO_2 fluxes based on FerryBox measurements and satellite-based prediction of pCO_2 in the Western English Channel

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Since April 2012, we installed an autonomous FerryBox system on a Voluntary Observing Ship (VOS), which crosses the Western English Channel (WEC) between Roscoff and Plymouth on a daily basis. High-frequency data of sea surface temperature (SST), salinity (SSS), fluorescence, dissolved oxygen (DO) and partial pressure of CO_2 (pCO_2) were recorded for two years across the all-year mixed southern WEC (sWEC) and the seasonally stratified northern WEC (nWEC). These contrasting hydrographical provinces strongly influenced the spatio-temporal distributions of pCO_2 and air-sea CO_2 fluxes. During the productive period (from May to September), the nWEC acted as a sink for atmospheric CO_2 of -5.6 mmolC m-2 d-1 and -4.6 mmolC m-2 d-1, in 2012 and 2013, respectively. During the same period, the sWEC showed significant inter-annual variability degassing CO_2 to the atmosphere in 2012 (1.4 mmolC m-2 d-1) and absorbing atmospheric CO_2 in 2013 (-1.6 mmolC m-2 d-1). In 2012, high-frequency data revealed that an intense and short (less than 10 days) summer phytoplankton bloom in the nWEC contributed to 31% of the total CO_2 drawdown during the productive period, highlighting the necessity of pCO_2 high-frequency measurements in coastal ecosystems.

Based on this multi-annual dataset, we developed pCO_2 algorithms using multiple linear regression (MLR) based on SST, SSS, chlorophyll-a (Chl-a) concentration, time, latitude and mixed layer depth to predict pCO_2 in the two hydrographical provinces of the WEC. MLR were performed based on more than 200,000 underway observations spanning the range from 150 to 480 μatm. The root mean square errors (RMSE) of the MLR fit to the data were 17.2 μatm and 21.5 μatm for the s WEC and the nWEC with correlation coefficient (r^2) of 0.71 and 0.79, respectively. We applied these algorithms to satellite SST and Chl-a products and to modeled SSS estimates in the entire WEC. Based on these high-frequency and satellite approaches, we will discuss the main biogeochemical processes driving the air-sea CO_2 fluxes in the WEC and adjacent coastal seas.