Estimation of annual pCO_2 in the Seto Inland Sea

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Compared to the open ocean, studies of CO_2 (carbon dioxide) in seawater in coastal sea hasn't well conducted due to a lack of data accumulation. Understanding CO_2 dynamics in coastal seas is crucial in terms of ocean acidification, which harms marine ecosystems, and the CO_2 budget, which varies from place to place. However, it is difficult to measure directly. In this study, based on measured pCO_2(partial pressure of CO_2 in seawater) and related data, we construct models to estimate that from parameters relatively measurable by using Random Forest, a machine learning method. Utilizing these models, we clarified the seasonal variation of pCO_2 and annual CO_2 flux (sea-air CO_2 exchange) in the Seto Inland Sea and adjacent region.

We collected data during research cruises on Fukaemaru of the Graduate School of Maritime Science, Kobe University. These cruises was conducted winter (March) and Summer (July, August, September) from 1994 to 2010. We measured pCO_2, T (Seawater temperature, ℃), S (Salinity), DO (Dissolved Oxygen, mg/l), and pH from intake water 3m depth from sea surface. Additionally, we measured PCO_2 (partial pressure of CO_2 in atmosphere) and U (wind speed) from samples taken at a height of 10m from the surface. To construct estimate models, we divided the data into training data and test data, and inputting the training data into the random forest. Three separate models were developed for the Osaka Bay, Bisanseto, and other sea areas. Test data was inputted into each model to verify accuracy. Since more training data improves accuracy, we constructed models using all available measured data. We estimated pCO_2 by inputting data from the Seto Inland Sea Comprehensive Water Quality Survey, which covered the same years as measured data, with spring (April to June), summer (July to September), fall (October to December), and winter (January to March).

Validation of accuracy revealed RMSE (Root Mean Square Error) between measured pCO_2 and predicted pCO_2 in the Osaka Bay, Bisanseto, and other areas as 37.7, 43.6 and 19.8 respectively. These values were smaller than the RMSE reported in a comparable study using random forest in the Baltic Sea (Shuping, *et, al.*, 2019), also indicated errors of about 20%-30% relative to the variability of measured values, suggesting great estimates. Using measured data as training data, estimations showed that pCO_2 was lowest in winter, increasing from spring to summer, and summer and fall were similar levels. Throughout the year, pCO_2 in the Osaka Bay was the lowest, indicating high CO_2 consumption through high primary production. From spring to fall, pCO_2 in the bisanseto was highest. Hiuchi Nada and Harima Nada, adjacent to the Bisanseto tend to be stratified in summer, and hypoxic water masses generated by organic matter decomposition have been indicated in their bottom layers, suggesting the presence of high CO_2 water masses (Taguchi and Fujiwara, 2010). The elevated pCO_2 is considered due to the advection of those bottom water to the Bisanseto bottom layer, subsequently upwelling through mixing. From fall to winter, pCO_2 decreased significantly and its distribution changed greatly. This is thought to be due to the stratified area in the Bay and Nada region changing to a mixed zone from fall to winter, as well as the strong influence of water temperature. Calculations of the CO_2 flux throughout the year reveal that the Seto Inland Sea acts as a sink for CO_2.

Keywords: CO2, CO2 fluxes, the Seto Inland Sea, spatial distribution, seasonal variation, Random forest

