High-resolution coastal carbon dynamics: Addressing knowledge gaps in the Belgian Part of the North Sea

Keppens Maurie[1], Roobaert Alizée[1], Van Langen Rosón Andrea[1], Van Langen Rosón Andrea[2], Neukermans Griet[2] and Landschützer Peter[1]

[1] Flanders Marine Institute (VLIZ), Jacobsenstraat 1, 8400 Ostend, Belgium
E-mail: maurie.keppens@vliz.be
[2] Faculty of Biology, Ghent University, Krijgslaan 281 (S8), 9000 Gent, Belgium

The dynamics of the carbon cycle in coastal zones are not yet fully understood at the temporal and spatial scales required for regional carbon budget assessments. Gaining a deeper understanding is crucial for e.g., identifying human-driven changes to the carbon cycle or effectively monitoring carbon dioxide (CO_2) removal initiatives. The advanced monitoring infrastructure in the Belgian part of the North Sea (BPNS) presents a unique opportunity to address this knowledge gap. It provides in-situ CO_2 data from buoys, research vessels, and other sources with good spatial and temporal coverage, enabling near-real-time estimates of atmospheric CO_2 uptake and/or release in the region.

Here, we employ a feedforward neural network approach to estimate the background carbon budget in the BPNS with unparalleled spatial (1 km) and temporal (1 day) resolution, covering the period from 2014 to 2024. To do so, we compiled all partial pressure of CO_2 (pCO_2) in-situ observations from the Surface Ocean CO_2 Atlas (SOCAT) and the Integrated Carbon Observation System (ICOS) for the BPNS, along with various predictor variables from satellite observations and physical oceanographic reanalysis products, which are known to control pCO_2 variability in the BPNS (e.g., sea surface temperature, salinity, suspended particulate matter, and chlorophyll-a)

First results show that our pCO_2 reconstruction demonstrates favourable predictive performance, with an R^2 above 0.80, effectively capturing local spatial patterns and seasonal variability. Sensitivity analysis identified sea surface temperature as the most influential predictor, followed by chlorophyll-a and suspended particulate matter. This underscores the importance of both thermal and non-thermal processes in driving the spatial and temporal variability of pCO_2 levels in the BPNS. The pCO_2 seasonal cycle highlights a significant drop in pCO_2 after winter and a peak after summer. While sea surface salinity plays a smaller role overall as a predictor, it displayed a pronounced local influence near the Scheldt estuary plume, emphasizing the unique role of river plumes in regional carbon dynamics in the coastal ocean. Finally, our new pCO_2 reconstruction allows us to evaluate the CO_2 exchange with the atmosphere in the BPNS at high spatial and temporal resolution.

Keywords
CO_2 Fluxes; Belgian Part of The North Sea; Partial Pressure Of CO_2; Feedforward Neural Network; Coastal Zones

Pre-doc presentation