EGU25-15911, updated on 28 Oct 2025
https://doi.org/10.5194/egusphere-egu25-15911
EGU General Assembly 2025

The Belgian Part of the North Sea as a test case to monitor human activities and climate change effects on the coastal carbon system

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The global ocean comprises – together with the terrestrial biosphere – the most significant sink for man-made carbon dioxide (CO_2). It is estimated that 10-15% of the annual marine net CO_2 uptake CO_2 occurs in coastal seas. however, for most coastal regions, the exchange of CO_2 at the air-sea interface and its temporal variation are to-date insufficiently constrained by observations and not fully introduced in global and regional carbon budgets. This is largely due to the complexity of the processes at play and the resulting spatial heterogeneity of CO_2 source and sink regions that require a dense network of measurements that is currently missing in most ocean regions. Better understanding of the regional air-sea CO_2 dynamics is crucial to assess the effect of human activities, understanding the impact of extreme events, and monitoring the success of emission reductions.

Besides being a significant element of the carbon cycle, coastal seas are heavily impacted by human activities and increasingly used to test and implement marine carbon dioxide removal (mCDR) approaches, which require reliable observations to support their monitoring, reporting, and verification (MRV). The Belgian part of the North Sea offers a unique site to test the requirements and design of a fit-for-purpose monitoring system; the Belgian coast is among the densest observed coastal regions for CO_2, largely due to a combination of its small size and the intense monitoring efforts.

Through the VLAIO-funded BERNARDO project, we intensify our monitoring activities in the Belgian Part of the North Sea and build a contemporary coastal carbon budget that can serve as a present-day baseline to monitor effects of human activities and climate extremes. We expanded the ICOS observing network with ship-based biogeochemical parameters, new sampling platforms, such as Uncrewed Surface Vehicles (USVs), remote sensing data, and machine learning reconstructions to monitor the exchange of CO_2 at the air-sea interface and its redistribution at the Belgian Part of the North Sea and provide spatially explicit maps at kilometer spatial and daily temporal scale.

Together with industry partners, we propose use cases to test whether our monitoring system is capable of detecting and attributing carbon emissions from common human activities taking place

in the Belgian part of the North Sea such as aquaculture, bottom disturbing or CO2 uptake enhancing activities. The project will thus inform about Marine Spatial Planning requirements that can be adopted to benefit net air-sea CO2 exchange. Additionally, the high-resolution nature of the carbon maps allows to better understand the effects of extreme events, such as marine heat waves on the coastal carbonate system.