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Global coastal ocean CO_2 trends over the 1982–2020 period

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The development of high-quality controlled databases of sea surface partial pressure of CO_2 (pCO_2) combined with robust machine learning-based mapping methods that fill pCO_2 gaps in time and space, enable us to quantify the oceanic air-sea CO_2 exchange and its spatiotemporal variability only based on *in-situ* observations (pCO_2-products). However, most existing pCO_2-products do not explicitly include the coastal ocean or have a spatial resolution that is too coarse (e.g., 1°) to capture the highly heterogeneous spatiotemporal dynamics of pCO_2 in these regions thus limiting our ability to resolve long-term trends and the interannual variability of the coastal air-sea CO_2 exchange (FCO_2).

To address this limitation, we updated the global coastal pCO_2-product of Laruelle et al. (2017) using a 2-step machine learning interpolation technique (relying on Self Organizing Maps and a Feed Forward neural Network) combined with the most extensive monthly time series for coastal waters from the Surface Ocean CO_2 Atlas (SOCAT), spanning from 1982 to 2020 to reconstruct monthly high spatial resolution (0.25°) continuous coastal pCO_2 maps. This updated coastal pCO_2-product is then used to reconstruct the temporal evolution of the global coastal FCO_2 based on observations.

Our results show that since 1982, the extended coastal ocean, covering an area of 77 million km² in this study, has been acting as an atmospheric CO_2 sink, removing -0.4 Pg C yr^{-1} (-0.2 Pg C yr^{-1} with a narrower coastal domain roughly equivalent to continental shelves) from the atmosphere. Moreover, the intensity of this CO_2 sink has been increasing over time at a rate of 0.1 Pg C yr^{-1} per decade (0.03 Pg C yr^{-1} $decade^{-1}$ in the narrower domain). The long-term change in the air-sea CO_2 flux is largely driven by the air-sea pCO_2 gradient, dominated by the sea surface pCO_2, however wind speed and sea-ice coverage play significant roles, regionally. This new coastal pCO_2-product provides a valuable constraint for understanding the strengthening of the global coastal ocean CO_2 sink, fill the coastal gap in synthesis studies such as the Global Carbon Budget and serves as a benchmark for evaluating emerging results of ocean biogeochemical models.