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Global coastal ocean CO₂ trends over the 1982–2020 period

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The development of high-quality controlled databases of sea surface partial pressure of CO₂ (pCO₂) combined with robust machine learning-based mapping methods that fill pCO₂ gaps in time and space, enable us to quantify the oceanic air-sea CO₂ exchange and its spatiotemporal variability only based on *in-situ* observations (pCO₂-products). However, most existing pCO₂-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 pCO₂ in these regions thus limiting our ability to resolve long-term trends and the interannual variability of the coastal air-sea CO₂ exchange (FCO₂).

To address this limitation, we updated the global coastal pCO₂-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 CO₂ Atlas (SOCAT), spanning from 1982 to 2020 to reconstruct monthly high spatial resolution (0.25°) continuous coastal pCO₂ maps. This updated coastal pCO₂-product is then used to reconstruct the temporal evolution of the global coastal FCO₂ 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 CO₂ 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 CO₂ 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 CO₂ flux is largely driven by the air-sea pCO₂ gradient, dominated by the sea surface pCO₂, however wind speed and sea-ice coverage play significant roles, regionally. This new coastal pCO₂-product provides a valuable constraint for understanding the strengthening of the global coastal ocean CO₂ 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.