Ocean margins as an increasing sink for the atmospheric carbon dioxide

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The partial pressure of carbon dioxide (pCO_2) in the open ocean has increased following that of the atmosphere, a process leading to ocean acidification (OA) with negative impacts on marine organisms and ecosystems. However, previous researchers speculated that pCO_2 in coastal oceans may not follow this pattern. Using a recently available global database, we report that the wintertime pCO_2 increase in coastal oceans has lagged behind the atmospheric increase in recent decades, resulting in an increase in the air-sea pCO_2 gradient and a likely strengthening of the coastal ocean sink for anthropogenic CO_2. We postulate that the increase in air-sea pCO_2 gradient resulted from a much smaller pCO_2 increase in the coastal ocean than in the atmosphere as a consequence of a faster CO_2 exchange rate of the coastal oceans with the subsurface deep ocean than with the atmosphere. This fast cross-shelf exchange dilutes the accumulation of anthropogenic CO_2 in coastal waters. To illustrate this mechanism, we used a simple box model, which assumes constant physical and biological parameters but allows the atmospheric pCO_2 to increase according to RCP6.0 until 2100. Simulations show that surface water pCO_2 increase in the coastal ocean is well behind that of the atmospheric pCO_2 when the cross-shelf water exchange rate is between 0.25-2.0% per day or the water residence time is between 1.5 and 12 months. Field data and model simulations also suggest that the coastal ocean has switched from a source to a sink of CO_2 for the atmosphere within the past few decades. We note while as a baseline OA trend, the coastal ocean would be less impacted by anthropogenic CO_2 acidification, air-sea pCO_2 gradient will widen and the coastal ocean CO_2 sink will continue to increase with time. Thus, as the open ocean's capacity for uptake of anthropogenic CO_2 may level off or even decrease in coming decades, the coastal ocean will become an increasingly important pathway for global ocean CO_2 uptake and subsequent ocean acidification via cross-margin export to the deep open ocean.