A Closer Look at Coastal Waters

Alizée Roobaert uses machine learning

to map shallow seas carbon absorption.

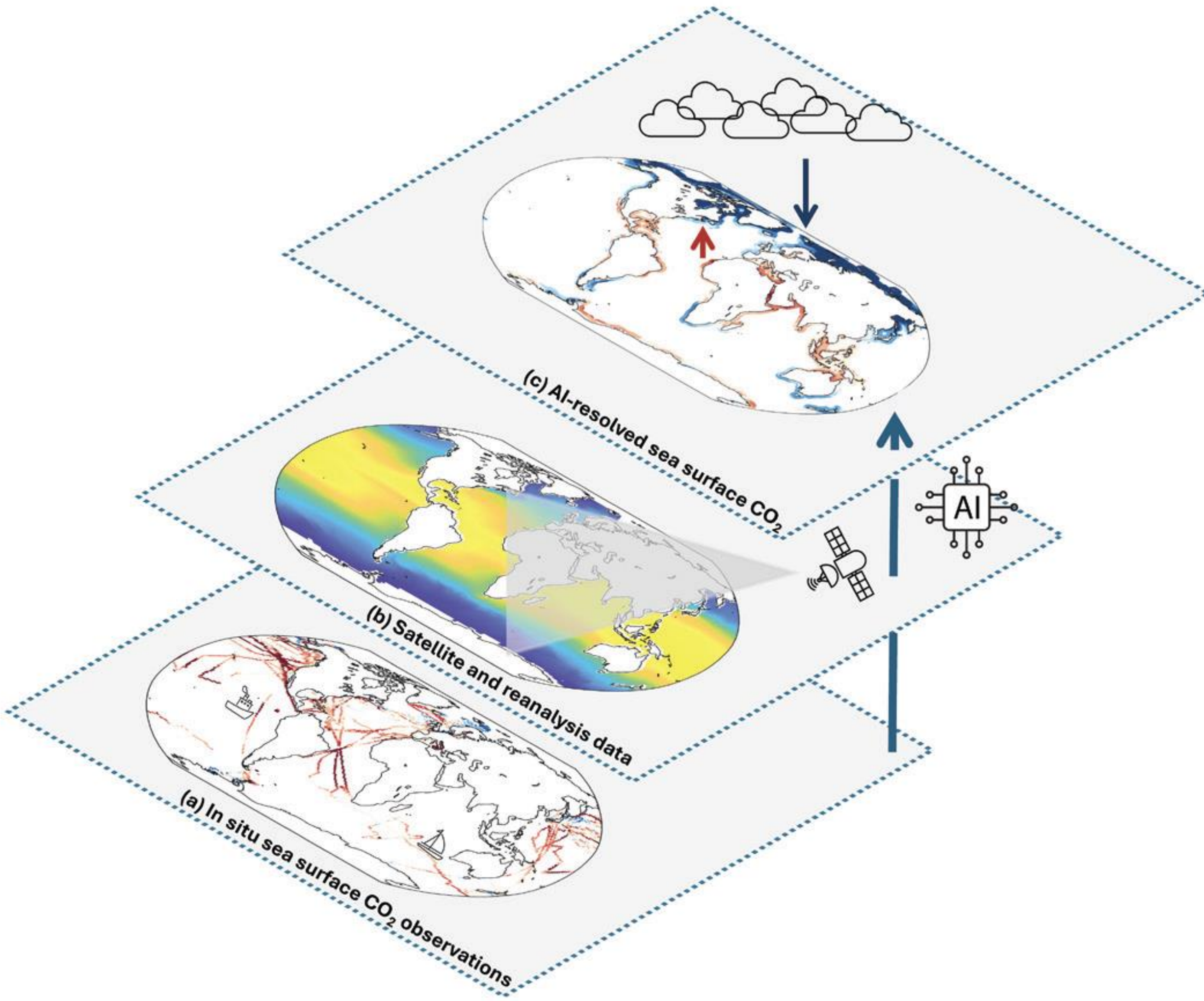
The world's oceans absorb about one-quarter of human carbon dioxide (CO2) emissions—but while that process is well-studied in the open oceans, surprisingly little is known about the contributions of coastal waters. "It's just too complicated—you've got all the river discharges, interactions with nearby land, different water depths," says AI Prize finalist Alizée Roobaert, a researcher in the Past, Present and Future Marine Climate Change group at the Flanders Marine Institute (VLIZ). "There have been local studies, but uncertainty remains about how much CO2 is absorbed globally by coastal oceans, and how that changes over time."

To solve that problem, Roobaert collaborated with the BGeoSys group at Université Libre de Bruxelles to divide the world's coastal waters into cells measuring 0.25 degrees—about 28 kilometers per side at the equator. Roobaert then layered in global data, mostly from satellite imaging, covering variables such as sea surface temperature, salinity, and chlorophyll-a concentrations, plus approximately 18 million observations taken by ships or buoys in coastal waters, including measurements of changing sea-surface CO2 concentrations. The result: a sprawling patchwork of high-resolution data covering the entire ocean, but with CO2 measurements only available for a subset of cells.

Next, Roobaert used machine learning to tease out complex relationships between the variables, and to gradually fill in the blanks. "Once the algorithm understands how variables interact, it can reconstruct the missing CO2 measurements," Roobaert explains. The result: global maps of coastal CO2 absorption over time that's approximately 10X more accurate, and significantly more detailed, than any previous effort. "This is the most advanced observation-based method we currently have to estimate the global contribution of coastal waters to CO2 absorption," Roobaert says.

In addition to improving our understanding of coastal waters' contribution to the marine carbon cycle, Roobaert's high-resolution maps provide more accurate insights into the air-sea carbon exchange for specific regions. "For the blue economy, this kind of data is critical—you need to understand how coastal waters feed into the carbon cycle in order to quantify the impact of human activities," Roobaert says.

Now, Roobaert and the VLIZ team are working to strengthen her solution. One current focus is developing even more detailed CO2 maps for the North Sea, at a resolution of just 1 kilometer. Other goals include layering in data on ocean depth, to create a four-dimensional map detailing how carbon spreads through the water column over time. “What truly drives me is knowing that my work helps close critical data gaps and contributes to a better understanding of the ocean’s role in the global carbon cycle,” Roobaert says. “We’re using AI to have a real global impact, and that keeps me motivated.”



GRAPHIC: ADAPTED FROM TKTK BY A. FISHER/SCIENCE

Artificial intelligence (AI) approach for assessing how all coastal systems exchange CO2 with the atmosphere with the highest accuracy. The method consists of developing a bridge via a combination of two artificial neural networks that establish complex non-linear relationships between (a) discrete in situ sea sur-face CO2 observations collected in the coastal ocean and (b) complete sea surface satellite and reanalysis data. These relationships are then applied to resolve sea

CO_2 and the CO_2 exchanges with the atmosphere in coastal regions and periods of the year lacking in data (c).