TECHNICAL NOTE 1.4:

Measurement of Air-Sea Carbon Fluxes using the CO_2-Pro Atmosphere Instrument

Measurement of the magnitude of ocean CO_2 flux both spatially and temporally in the World's oceans is important to understanding carbon cycling and predicting future changes in ocean chemistry and global climate. It is well known that the oceans play a major role in sequestering CO_2 from the atmosphere, leading to a decrease in the pH of ocean waters and depletion of the carbonate ion. The magnitude and direction of CO_2 flux varies in time and space due to biological, physical, and chemical processes,

The air-sea CO_2 flux can be estimated from:

$F = kS\Delta\ pCO_2$

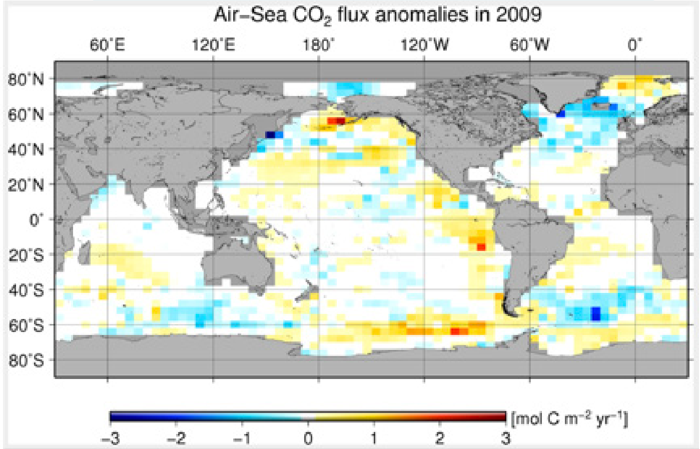
where F is the flux, ΔpCO_2 is the difference in water and air CO_2 (pCO_2 SW – pCO_2 air), S is the solubility of CO_2 in the water at the in situ temperature and salinity (see Wanninkhof and McGillis, 1999), and k is the CO_2 gas transfer velocity.

Boutin et al (2009) describe in detail air-sea CO_2 transfer velocity calculations and estimates. The gas transfer velocity is strongly related to wind speed, however, uncertainties exist in this relationship across the full spectrum of wind speeds.

Variability in surface water pCO_2 occurs both spatially and temporally over a range of scales, and so estimates of pCO_2 SW from other parameters indirectly remains challenging. This limits accurate CO_2 fluxes to space and time where direct measurements of both surface water pCO_2 and air CO_2, in combination with surface water temperature and salinity and air wind speed have been made in unison.

In the open ocean, surface water movement is dominated by wind stress and allows for flux to be calculated accurately based on the gas transfer velocity determined from wind speed. In riverine and estuarine systems, turbulence in the water can be generated from topography and changes in runoff dynamics, leading to uncertainly in the gas transfer velocity. across the oceans. Other complicating factors include wind, fetch and whether the sea state is fully developed.

Currently, global maps of air-sea CO_2 flux through time with limited resolution and substantial uncertainty are created form computer models with limited data. These maps provide limited predictions or information for coastal waters where CO_2 dynamics are exponentially more complex than the open ocean. How coastal waters affect the global carbon budget is still poorly known and not well quantified. More long-term data collection will be needed to assess the role coastal waters play



https://www.pmel.noaa.gov/co2/story/Surface+CO2+Flux+maps

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TECHNICAL NOTE 1.4: Measurement of Air-Sea CO_2 Fluxes

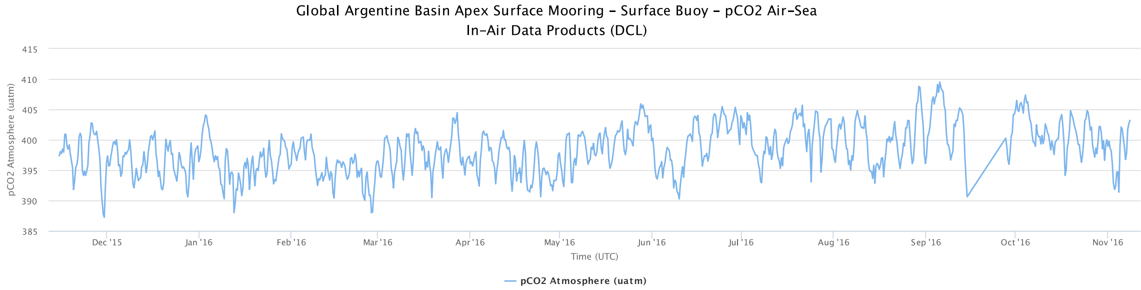
More measurements in time and space are required to not only quantify air-sea CO_2 fluxes, but also to understand future changes.

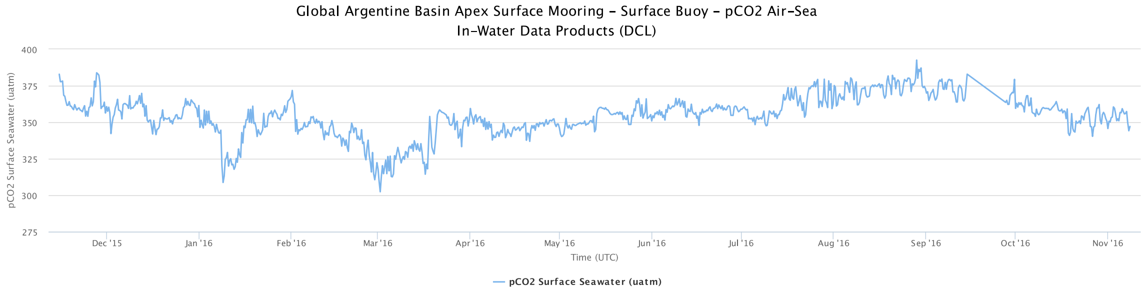
The CO_2-Pro Atmosphere™ submersible pCO_2 sensor is designed for use by scientists for applications where long-term, stable measurements of surface CO_2 are required. It's compact size and ease of use allow for simple integration into most stationary and mobile monitoring platforms, from buoys to VOS, to ASVs.

The CO_2-Pro Atmosphere™ measures the partial pressure of CO_2 gas in both the surface water and air above the surface. An internal zeroing feature provides drift correction for stable and accurate long-term measurements. Designed for use on buoys, the rugged unit is comprised of a CO_2-Pro™ that mounts under the buoy for water measurement connected to a weatherproof box that is used to sample air from above the sea surface. Alternating measurements of pCO_2 in air and water using one detector provide accurate data for reliable surface flux calculations. The instrument is well-suited for integration into shipboard flow-through systems.

The CO_2-Pro Atmosphere operates through permeation of gases dissolved in liquids through a patented supported semi-permeable tubular membrane to a non-dispersive infrared detector (NDIR). The NDIR sensor is factory calibrated using trace gases from the NOAA ESRL GMD Central Calibration Laboratory (http://www.esrl.noaa.gov/gmd/ccl/).

The CO_2-Pro Atmosphere was chosen as the air-sea pCO_2 instrument for the Coastal and Global Scale Nodes component of the US OOI, Ocean Observatories Initiative. An example of some of the data collected from one of the measurement nodes is shown below for the Argentine Basin, a sink for CO_2 during most of the year. Daily air CO_2 levels fluctuate between 390 and 405 µatm, and surface waters range from 300 to 395 µatm.





References:
Boutin, J., Quilfen, Y., Merlivat, L., Piolle, J. F. 2009. Global average of air-sea CO_2, transfer velocity from QuikSCAT scatterometer wind speeds. Journal of Geophysical Research, v.114, C04007, doi: 10.1029/2007JC004168.

Wanninkhof, R., McGillis, W.R. 1999. A cubic relationship between air-sea CO_2 exchange and wind speed. Geophys Res Lett., 26: 1889-1892. https://doi.org/10.1029/1999gl900363

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