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Influence of vertical temperature contrasts and diel cycles on near-surface seawater pCO_2

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While the oceanic mixed layer is sometimes assumed to be of vertically-uniform temperature, it is well-known that considerable temperature gradients (>0.1C/m) can develop within its upper few meters, particularly in the tropics during daytime. Given that the partial pressure of CO_2 in seawater (pCO_2sw) is strongly temperature-dependent, ceteris paribus (all else being equal), we would expect to observe sizeable corresponding vertical pCO_2sw gradients under such situations. If prevalent and persistent, such gradients could affect the accuracy of large-scale air-sea CO_2 flux estimates since, while intended to be representative of the sea surface skin, the pCO_2sw measurements used to compute these are typically from underway systems sampling at 2-4m depth. Vertical variability in pCO_2sw could thus be an important but as yet, poorly quantified uncertainty in air-sea CO_2 flux estimates.

As a first step towards assessing this uncertainty, we derive a global gridded monthly climatology for the peak daily vertical temperature contrast between the upper (0-2m) and lower (2-10m) sea surface and compute the corresponding vertical pCO_2sw differences these would cause, ceteris paribus. The latter are an estimate of the temperature-driven pCO_2 contrast we would expect to find in a given month between the upper sea surface and the sampling depth of an underway system at the time of the peak temperature contrast in the daily cycle. In addition, we construct a monthly climatology for the amplitude of diel variation in upper sea temperature and compute the corresponding diel pCO_2sw amplitudes these would generate, ceteris paribus.

While these analyses reveal the locations and months for which vertical temperature contrasts and diel cycles are likely to exert a strong influence on pCO_2sw, temperature is only one factor influencing this carbonate chemistry parameter. In situ measurements are required to reveal the actual dynamics of pCO_2sw under the influence of all competing factors. To this end, we have recently integrated a pCO_2 optode onto a Slocum underwater glider. We present preliminary pCO_2sw data from an initial open ocean deployment with this vehicle in the Labrador Sea. We have found that stable pCO_2sw measurements can be obtained while the glider is drifting at the surface, thus reducing the need to consider the influence of vertical variability upon air-sea fluxes computed from such data.