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Multidiurnal warm layer and inhibited gas exchange in the Peruvian upwelling regime

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Upper ocean observations off Peru from December 2012 to February 2013 are used to study the air-sea gas exchange in coastal upwelling regions. Observations include high-resolution profiles of nitrous oxide (N2O) in the topmost 10 meters far from ship's influence, ship based N2O profiles and underway transects, hydrography data from lowered CTD, microstructure probe profiles, and glider transects.

We observed distinct vertical N2O gradients in the topmost 10 m of the Peruvian upwelling regime. These gas gradients are associated with periods of persistent stratification in the oceanic top layer of longer than 24 hours up to several days ('multidiurnal warm layer'). The persistent stratification inhibits gas exchange between the ocean boundary layer and deeper layers, resulting in N2O depletion at the surface by outgassing. This can lead to systematic error, when estimating oceanic gas emissions from measured concentrations a few meters below the surface.

Surface layer vertical gradients of N2O were found in the high-resolution profiles far from the ship, and were also indicated in the ship based profiles. Stronger vertical N2O gradients were found associated with higher N2O concentrations, and higher N2O concentrations were found associated with stratified surface layers not eroded by night time convection. From 250 days of glider measurements, persistent surface layer stratification was found to be a frequent feature in the Peruvian upwelling regime.

The findings have direct implications for air-sea gas exchange estimations in upwelling regions. In the here studied case of ship based N2O concentration measurements at 5 to 10 m depth, emissions will be overestimated and the bias will be strongest at places where the impact on the total emission estimate is largest.