Towards including atmospheric CO_2 data from the oceanic community into the global high-accuracy atmospheric CO_2 network

Penelope A. Pickers[1], Nathalie Lefèvre[2], Vassilis Kitidis[3], Colm Sweeney[4], David R. Munro[5], Britton B. Stephens[6], Denis Diverrès[7], Dave Lowry[8], Rebecca Fisher[8], Rebecca Brownlow[8], Gordon Brailsford[9], Kim I. Currie[10], Zhaohui Chen[1], Parvadha Suntharalingam[1] and Ute Schuster[11]

[1] Centre for Ocean and Atmospheric Sciences, School of Environmental Sciences, University of East Anglia, Norwich, UK
[2] Sorbonne Universités (UPMC, Univ Paris 06)-IRD-CNRS-MNHN, LOCEAN, Paris, France
[3] Plymouth Marine Laboratory, Plymouth, UK
[4] Earth System Research Laboratory, National Oceanic and Atmospheric Administration, Boulder, Colorado, USA
[5] Institute of Arctic and Alpine Research (INSTAAR), University of Colorado, Boulder, Colorado, USA
[6] National Center for Atmospheric Research, Boulder, Colorado, USA
[7] IRD, centre de Bretagne, BP 70, 29280 Plouzane, France
[8] Department of Earth Sciences, Royal Holloway University of London, Egham, UK
[9] National Institute of Water and Atmospheric Research, Wellington, New Zealand
[10] National Institute of Water and Atmospheric Research, Dunedin, New Zealand
[11] Department of Geography, University of Exeter, Exeter, UK

There are currently more than 100 sites making high-accuracy measurements of atmospheric CO_2, and yet oceanic regions remain severely under-sampled. Many of these oceanic regions, however, are relatively densely sampled by underway systems deployed on research vessels and ships of opportunity that typically measure the dry mole fraction of CO_2 of both air equilibrated with surface seawater and the overlying atmosphere. The accuracy of the atmospheric CO_2 data from these ship-based underway CO_2 systems ($uwCO_{2atm\text{-}dry}$) does not typically meet the rigorous standards of the atmospheric community, as set out in the World Meteorological Organization recommendations. Improving and validating the quality of $uwCO_{2atm\text{-}dry}$ data will most likely provide mutual benefits to both the oceanic and atmospheric communities. For example, we find that incorporating $uwCO_{2atm\text{-}dry}$ data into an atmospheric CO_2 inversion in the North Atlantic region leads to a reduction in the posterior CO_2 flux uncertainty when compared to using GLOBALVIEW-CO2 data (https://www.esrl.noaa.gov/gmd/ccgg/globalview/co2/co2_intro.html). Improved $uwCO_{2atm\text{-}dry}$ data quality may also enable the oceanic community to more easily identify offsets/biases between measurements made by different ships that are then combined into global data products, such as the Surface Ocean CO_2 Atlas (http://www.socat.info/).

Here, we quantify the offsets between $uwCO_{2atm\text{-}dry}$ data and high-accuracy CO_2 measurement system data from five ships. We compare these CO_2 offsets to those from the Cucumbers intercomparison programme (http://cucumbers.uea.ac.uk/), to determine whether some $uwCO_{2atm\text{-}dry}$ data can already be reliably included in atmospheric CO_2 inversions. We also show the results of a 'Target Tank' comparison exercise between two systems installed on the Cap San Lorenzo container ship, which indicate that incomplete sample air drying can be the dominant contributor to inaccuracies in $uwCO_{2atm\text{-}dry}$ data. Lastly, we make several recommendations for improving the quality of $uwCO_{2atm\text{-}dry}$ data, which we hope will facilitate more discussion and collaboration between atmospheric and oceanic communities regarding atmospheric CO_2 measurement.