ORCHESTRA/RoSES Discussion Session: What are the biases/uncertainties in CO_2 fluxes and concentrations?

Led by: Tom Bell (PML) with contributions from Aimee Coggins and Neill Mackay (University of Exeter) and Mingxi Yang (PML)

Rapporteur: Jenny Watts (University of Exeter)

This session focussed on the various sources of uncertainty and potential bias in estimates of air/sea CO_2 fluxes. The discussion covered all the component parts of the air/sea flux calculation (i.e. Flux, K and ΔCO_2). An accurate calculation of ΔCO_2 (the difference between ocean and atmosphere CO_2 concentration) requires measurements of seawater pCO_2, sea surface temperature (SST) and salinity. There was strong consensus that SST and salinity measurements should be routinely calibrated on UK ships that operate underway pCO_2 systems. Routine calibration has not been performed in the past and has led to significant errors in the calculation of ΔCO_2. The discussion also identified the need to improve estimates of the coefficients for calculating seawater carbonate system CO_2 fugacity. These coefficients are not well known in low temperature and/or low salinity conditions and may be a source of bias in certain regions.

Variability in seawater CO_2 may also be a source of uncertainty. High frequency variations driven by changes over small spatial scales are not well-resolved by traditional underway CO_2 systems. Seawater CO_2 variations in dynamic environments (e.g. coastal systems and across oceanographic fronts) can be large and are difficult to resolve. Vertical variations in near surface waters (i.e. < 5 m, the typical intake depth for the pumped seawater supply on most ships) may also represent a source of bias. Near surface stratification driven by low salinity meltwater or the formation of diurnal warm layers can result in large differences in the ΔCO_2 calculated with seawater from 5 m versus 0.5 m depth. It was also noted that the 'cool skin effect' has a considerable impact on seawater CO_2 concentration and air/sea flux and should not be ignored. A mooring dedicated to measuring the relevant parameters to calculate ΔCO_2 at a high frequency with sufficient vertical resolution would be extremely valuable.

Finally, an obvious source of uncertainty when calculating CO_2 fluxes is the choice of gas transfer parameterisation. Directly observed flux measurements using the eddy covariance technique are very useful for comparing with a) fluxes calculated using ΔCO_2 and other environmental parameters; and b) different model estimates of air-sea CO_2 fluxes.