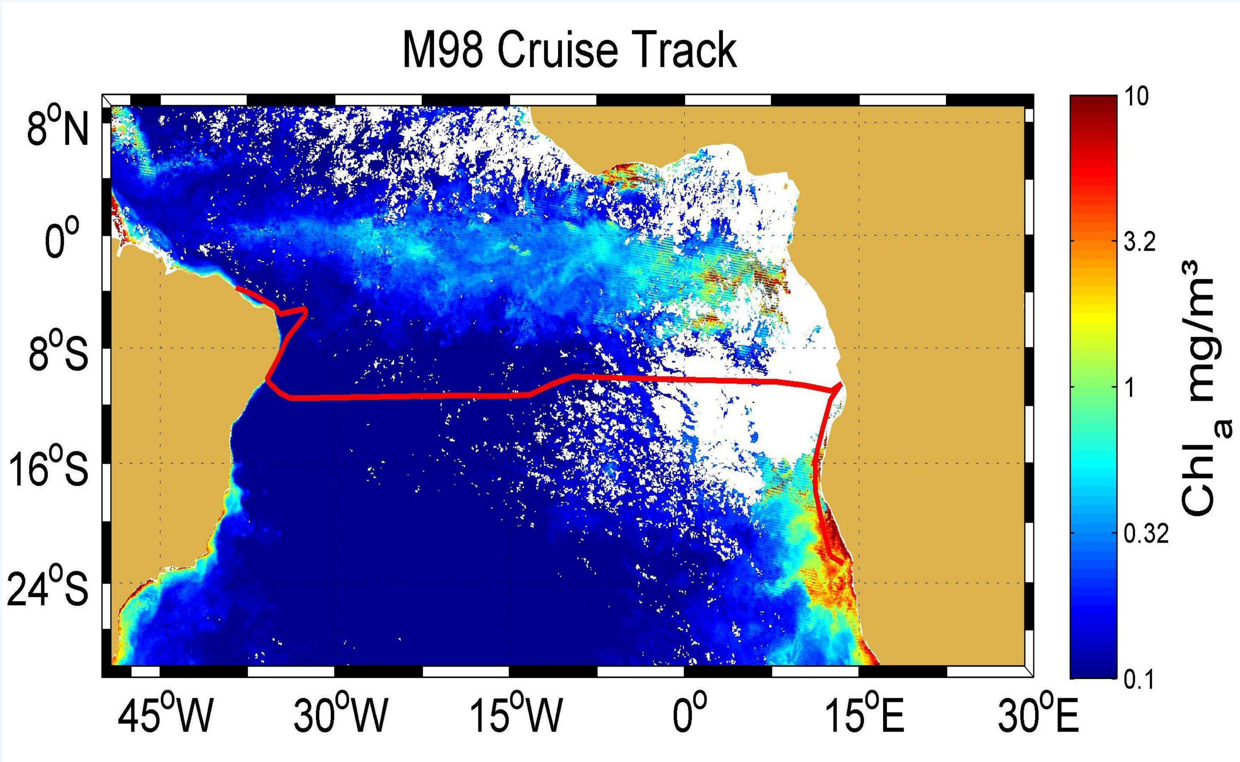
Interpretation of CO_2 fluxes using outputs from the OceanFlux Greenhouse Gases project

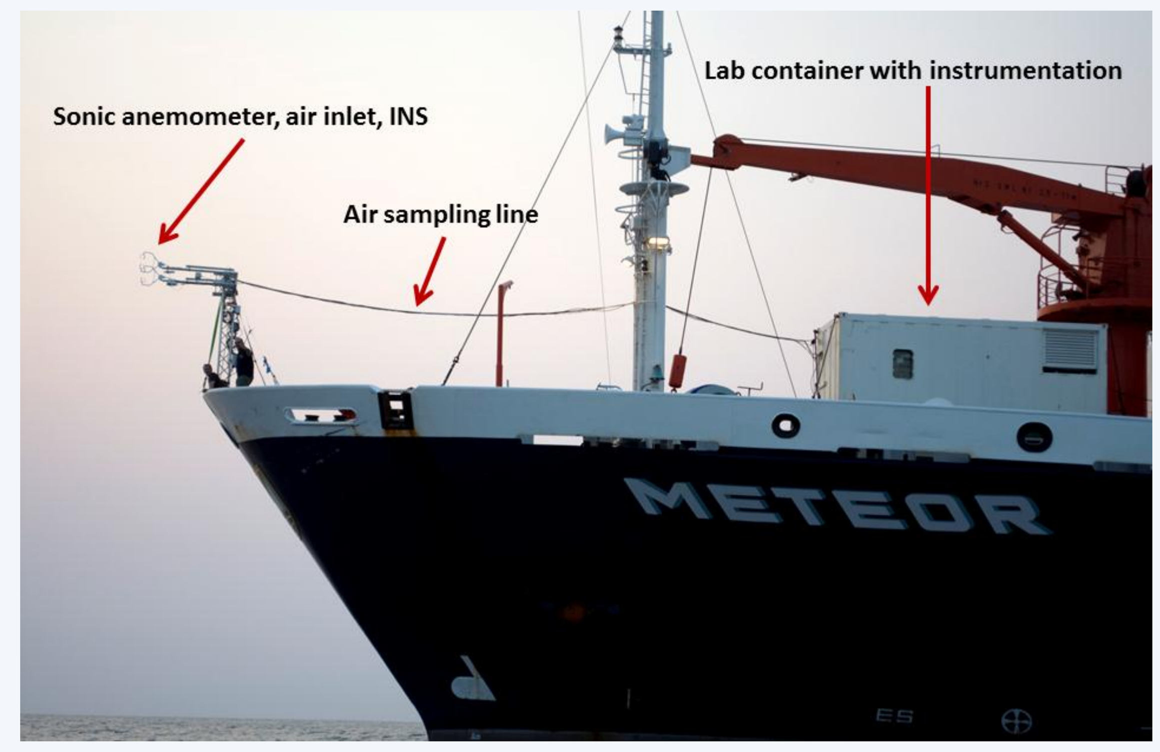
T. Steinhoff, A. Zavarsky, and C.A. Marandino
GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

GEOMAR

Setup and cruise track

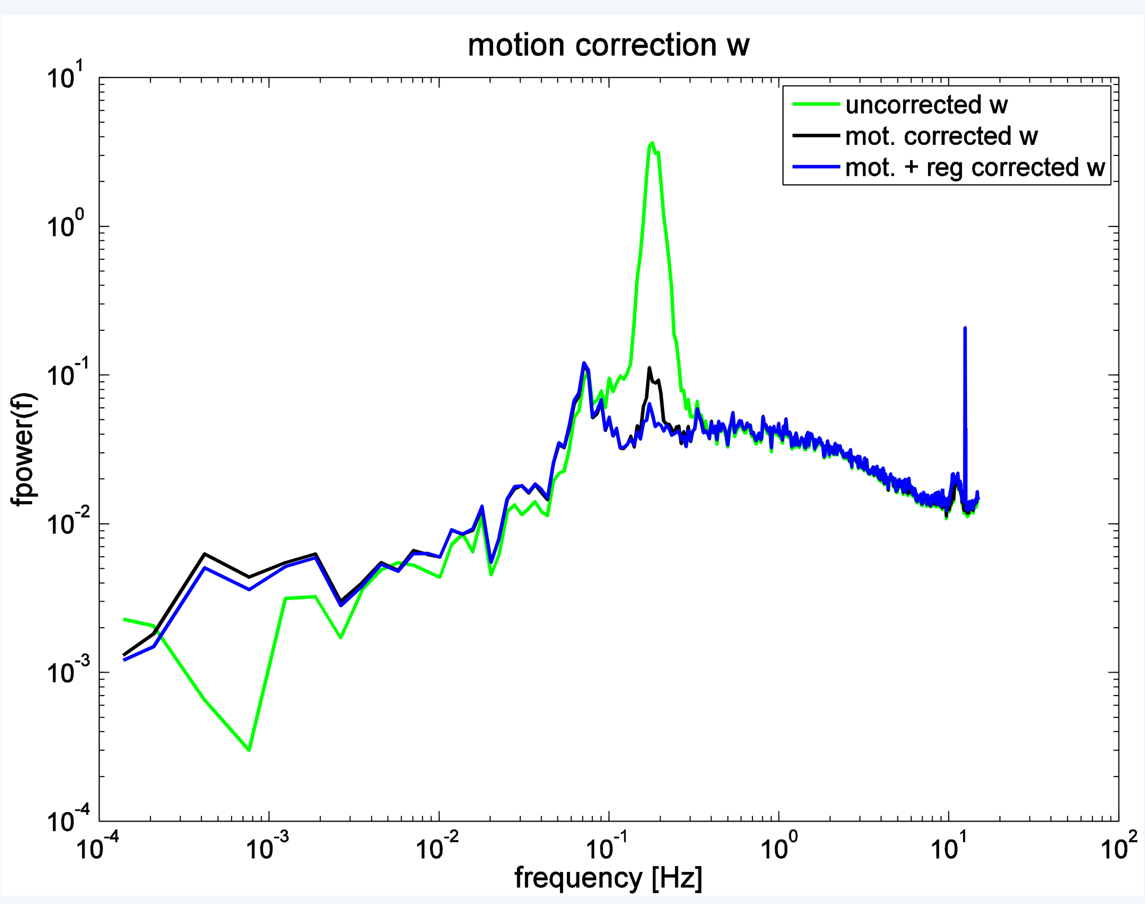


During the Meteor cruise, M98 (July, 1st – July, 29th; Fortaleza/Brasil – Walvis Bay/Namibia, figure left), CO_2 fluxes were measured both with the bulk method and the eddy covariance method. Seawater was pumped from 5 m depth and pCO_2 was measured using an equilibrator based system (General Oceanics). For the eddy covariance measurements air was sampled through a ½" 15 m tube from the bow mast. The air was pumped at a flow rate of 16 l min^{-1}. A CSAT-3 sonic anemometer was used to measure 3D wind speeds and a GPS and inertial navigation system (INS) were used for motion correction. All met equipment and inlets were placed on a tower approximately 10 m above the sea surface (figure right). All instrumentation and data acquisition systems were housed in a 20 foot container placed on the bow.



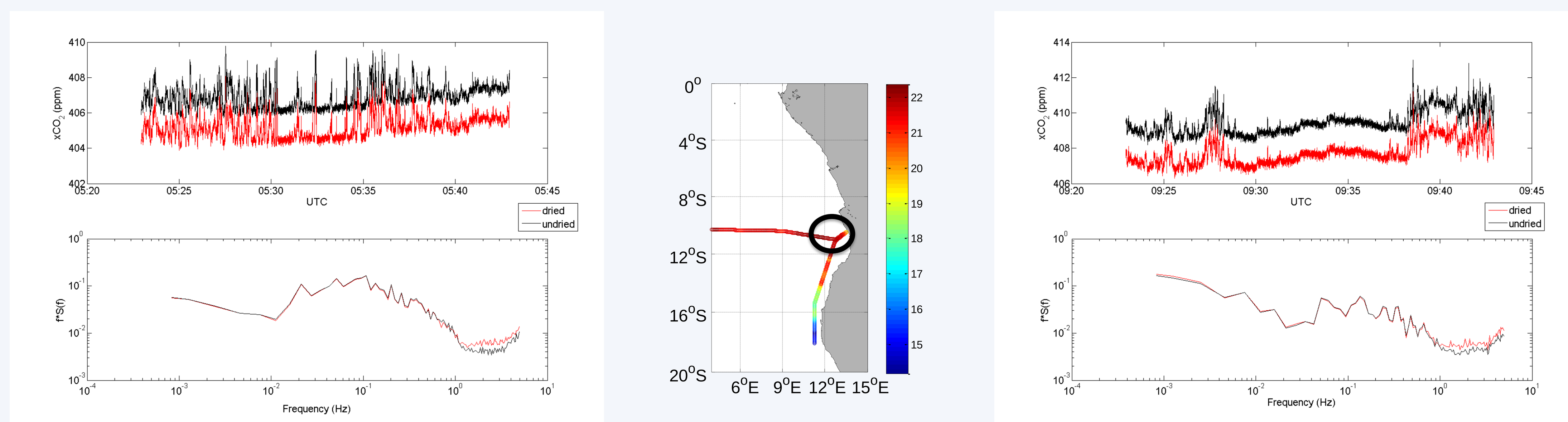
Wind data correction

- Measured winds must be corrected for ship motion
- Remove motion contamination with GPS and INS data
- Additionally apply multilinear regression between winds and motion signals



Motion correction for vertical wind component (w). Green - without correction, black - motion correction, blue - additional regression.

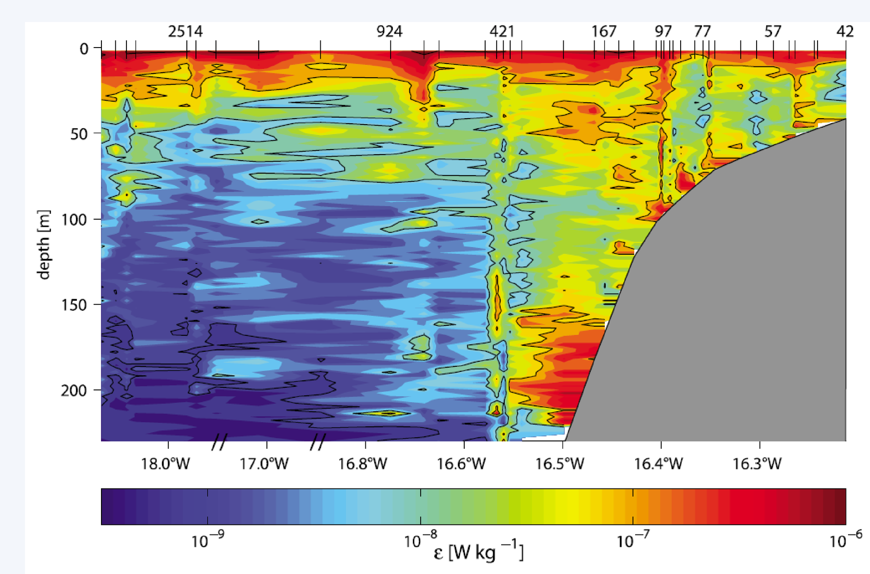
Air sea gas exchange and diapycnal fluxes



Due to the topography and wind regimes off Angola, coastal upwelling was observed. Upwelling transports deeper water with e.g. higher CO_2 levels to the surface and causes supersaturation of CO_2 with respect to the atmosphere, thus triggering fluxes between the mixed layer (ML) and the atmosphere. The ML CO_2 budget is not only driven by biogechemical process but also by diapycnal mixing (measured by micrstructure sonde), which is most pronounced along the shelf break. The diapycnal flux is calculated as follows:

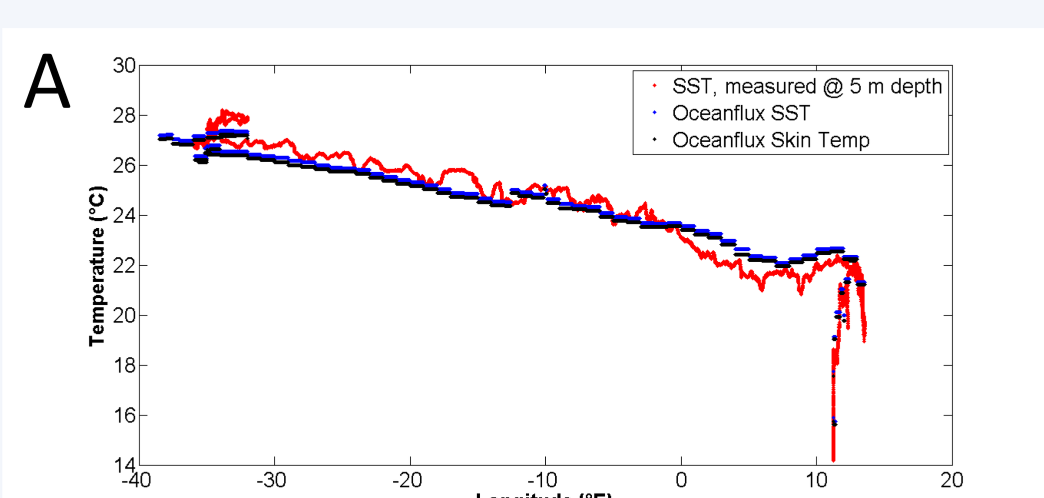
$$\text{Flux}_{dia} = \frac{d[CO_2]}{dz}, K_p \propto \varepsilon$$

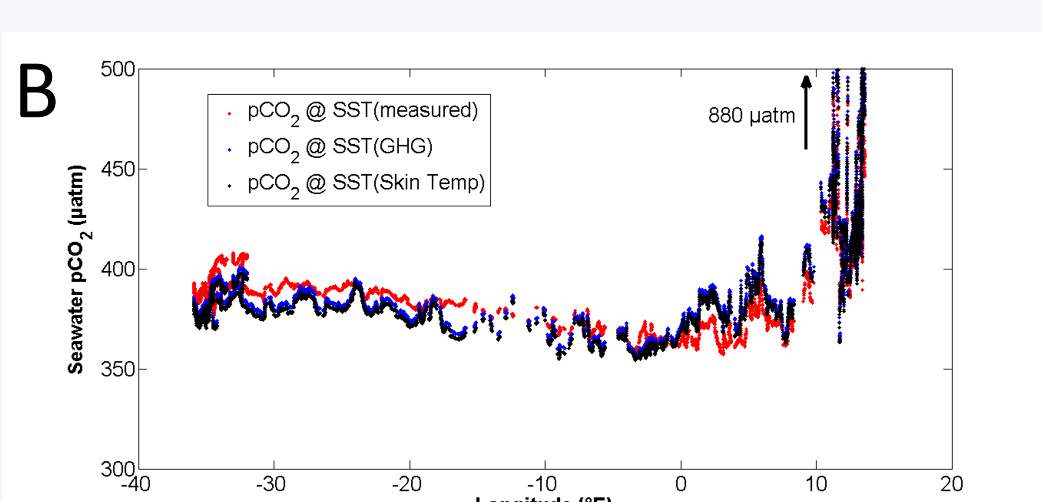
Using both the diapycnal flux and the sea to air flux should result in a precise budget of the mixed layer CO_2 content.



Schafstall et al., J. Geophys. Res., 2010.

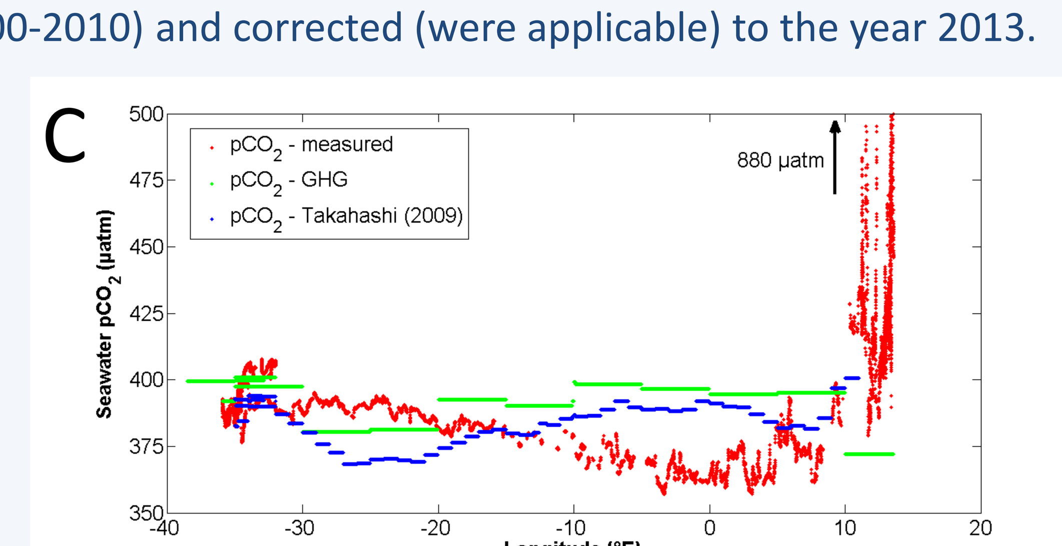
Comparing in-situ data with Oceanflux GHG data





Panel A shows the measured sea surface temperature (SST) during the cruise and the temperature data from GHG project (skin temperature and SST). Panel B shows the in-situ pCO_2 at measured SST and for the GHG temperature data (using the temperature dependency of Takahashi et al. (1993)).

The Oceanflux GHG aims to to develop and validate new and innovative products combining field data, satellite observation, and models. Here the field data were compared to monthly mean data that were calculated from 10 years worth of monthly global data (2000-2010) and corrected (were applicable) to the year 2013.

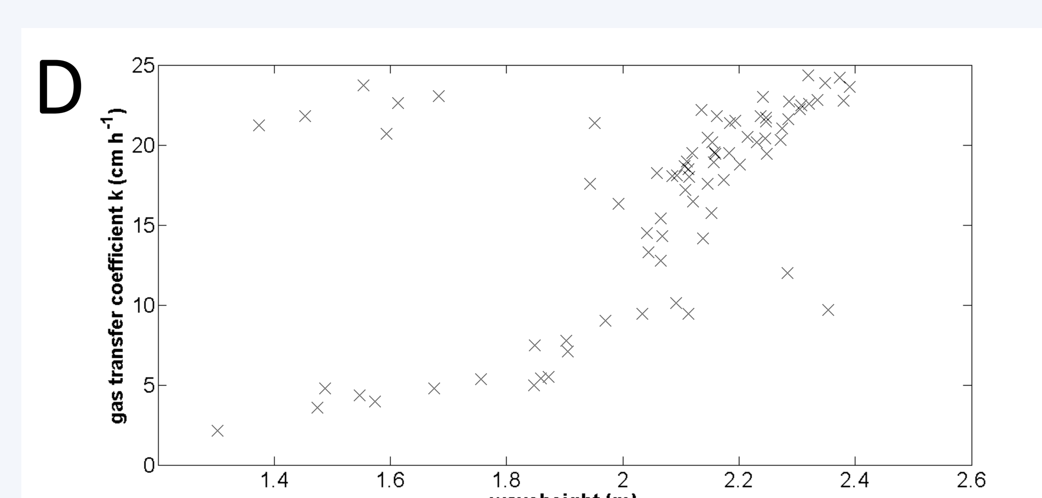


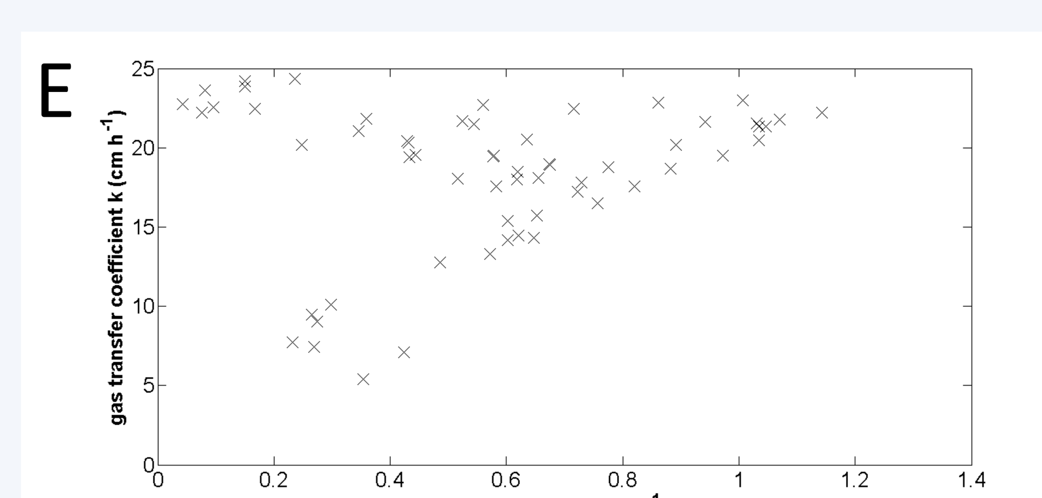
Panel C shows different pCO_2 data for the specific month. The GHG data are based on the climatology of Takahashi et al. (2009) corrected to the SST calculated by the Oceanflux GHG.

A significant difference in the various data products is observed. This may be due to the following reasons:

- Problems with in -situ measurements
- Problems with the application of the Takahashi climatology
- Interannual variability

The in-situ measurements were made following international standards, including the use of different calibaration gases, and have been quality controlled. In addition, atmospheric CO_2 was measured with the same instrument and compared well with the expected values.





During future data workup we will compare the k values derived from direct EC flux measurements with different products from Oceanflux GHG (e.g. waveheight (D), precipitation (E)) to validate our measurements and identify parameters other than wind speed that influence the k value.

Contact: C. Marandino, cmarandino@geomar.de

HELMHOLTZ GEMEINSCHAFT