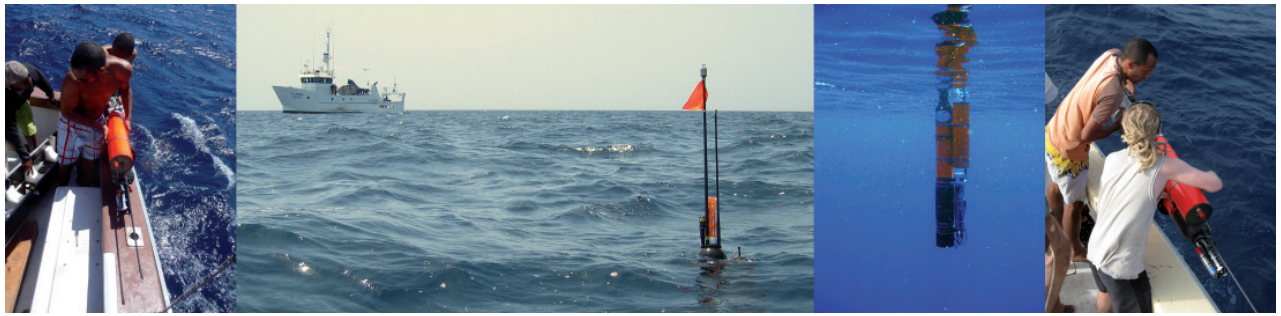
When Chemical Oceanographers go robotic – first high-quality CO_2 measurements from profiling float

Björn Fiedler, Peer Fietzek, and Arne Körtzinger,
Marine Biogeochemistry - Chemical Oceanography

An autonomous prototype profiler developed by IFM-GEOMAR is currently operating successfully at the recently established Cape Verde Ocean Observatory (CVOO) thereby complementing time-series activities at the site. Simultaneous CO_2 and O_2 in situ observations performed on the same platform are highly demanded by the scientific community (Keeling et al., 2010). A major step towards this aim has now been realized by the Chemical Oceanography department in RD2.

In the past, different approaches for autonomous observation of the world ocean's physical state have been followed, e.g. long-term moorings, buoys, and surface drifters. A more recent story of great success is the international ARGO programme which is maintaining a worldwide fleet of over 3000 autonomously operating, freely drifting robotic instruments. This network provides real-time data for temperature and salinity from the ocean's upper 2000 meters. Recently several efforts have been made to extend this platform to chemical sensors which would provide a research quality in marine biogeochemistry (Gruber et al., 2010). One successful example of this is the use of ARGO float for high-quality oxygen measurements (Körtzinger et al., 2004). Since then major improvements have been achieved in the sensor-based measurement of the CO_2 partial pressure (pCO_2) such that these instruments now start to become suitable for deployment on autonomous platforms such as profiling floats.

A successful collaboration of and initiated by IFM-GEOMAR with two German companies (Optimare, Bremerhaven & CONTROS, Kiel) has been established within the framework of the BMBF-funded project SOPRAN with the aim to realize autonomous pCO_2 measurements on a profiling float. The resulting prototype builds on a modified ARGO float (NEMO), equipped with an oxygen sensor (4330 Optode, Aanderaa, Norway, Bergen) and an externally mounted pCO_2 sensor (membrane-based nondispersive infrared sensor, CONTROS) with an additional battery pack. Redundant satellite telemetry (ARGOS & Iridium) provides a fast data link to shore and also permits bi-directional communication between operator and device which allows to change mission parameters en route. The float is designed to conduct missions for several months (depending on configuration and battery payload) and recovery can easily be done via remote control and GPS geolocation. The ambitious development of this device went through several steps and generations of prototypes which varied in different sensor payloads, instrument designs and software modifications. Former prototypes underwent thorough sea trials during field campaigns at CVOO and have led to the final instrument design (see figure panel below) which was deployed in the most recent mission described below.



Conducted field work with the new O_2/CO_2 float at the Cape Verde Ocean Observatory: An intensive partnership with colleagues from INDP Mindelo has been established.

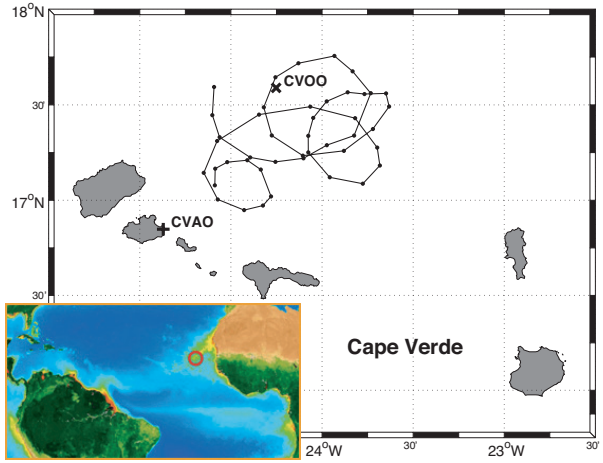


Figure 1: Trajectories of the profiling float during its 8-week lasting mission between CVOO and CVAO.

In cooperation with our partner in Cape Verde (Instituto Nacional de Desenvolvimento das Pescas, INDP) an 8-week campaign was conducted at CVOO from Nov. 2010 to Jan. 2011 during which the instrument recorded 44 profiles in the upper 200 meters of the water column (Fig. 1). Every 31 hours the instrument reached the surface in order to transmit data to Kiel. Each profile contains high resolution data for CO_2 partial pressure, oxygen, salinity, temperature, and pressure. The quality of pCO_2 data was assured by automated zero-point calibrations before and after each profile. Accuracy of oxygen data is given through a precise lab-based sensor calibration prior to deployment and through measurements of atmospheric oxygen concentrations after each profile at the surface.

The data obtained during this mission (Fig. 2), which to our knowledge represent the

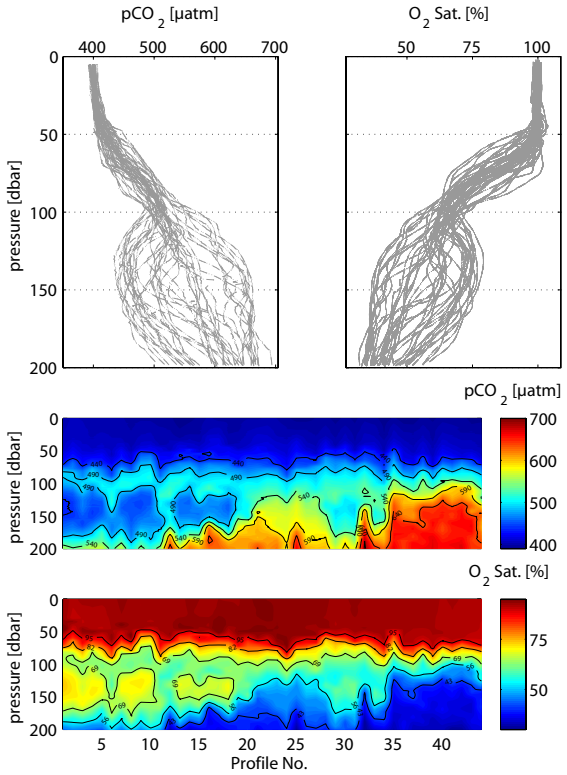


Figure 2: Obtained (raw) data for pCO_2 and O_2 resolves small scale features at CVOO. Data quality underlines the feasibility of this in situ approach.

first combined vertical profiles of CO_2 and O_2 performed ever by an autonomous profiling device, demonstrate a remarkable precision and robustness and will allow for a detailed view into the carbon and oxygen dynamics in the Eastern Tropical North Atlantic. In conjunction with the Cape Verde Atmospheric Observatory (CVAO), which is located downwind of the region of our float observations, both CVAO as well as CVOO can be linked with each other in a direct approach.

The next float mission is already underway at this moment and further missions will be carried out subsequently as an innovative part of the time series observations at Cape Verde.

References:

Gruber, N., A. Körtzinger, A. Borges, H. Claustre, S. C. Doney, R. A. Feely, M. Hood, M. Ishii, A. Kozyr, P. Monteiro, Y. Nojiri, C. L. Sabine, U., D. W. R. Wallace, and R. Wanninkhof, 2010: Toward an Integrated Observing System for Ocean Carbon and Biogeochemistry at a Time of Change. In: Hall, J., D. E. Harrison, and D. Stammer, Eds.: *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society*, Venice, Italy. ESA Publication WPP-306, 18 pp, DOI:10.5270/OceanObs09.

Keeling, R. F., A. Körtzinger, and N. Gruber, 2010: Ocean Deoxygenation in a Warming World. *Annual Review of Marine Science*, **2**, 199-229, DOI: 10.1146/annurev.marine.010908.163855.

Körtzinger, A., J. Schimanski, U. Send, and D. W. R. Wallace, 2004: The Ocean Takes a Deep Breath. *Science*, **306** (5700), 1337, DOI: 10.1126/science.1102557.