3. Weekly Report M98, Fortaleza-Walvis Bay

1.7.-28.7.2013

On the way from Brazil to Angola the work concentrated on underway measurements of currents, sea surface temperature and salinity, upper ocean (upper 350m) temperature and salinity with the underway CTD system and, particularly, chemistry. So we let the chemistry group, which focuses with their measurements on this part of the cruise, present their work in the 3rd weekly report:

During the transit of the last week, the chemistry underway systems, from the Chemical Oceanography department at GEOMAR and run by Tobias Steinhoff, Damian Arevalo-Martinez, Alex Zavarsky, Ellen Schweizer, and Christa Marandino (Figure 1), have been working non-stop, providing information about the air-sea concentration gradients of climate relevant trace gases, namely CO_2, N_2O, DMS, and acetone. In addition, during the first two weeks of the cruise, the TRASE-EC team was working tirelessly, night and day, to assemble and test the eddy covariance (EC) DMS, acetone, and CO_2 air-sea gas exchange systems to be ready for this transit. The goal of this work is to directly and simultaneously measure the air-sea flux of the aforementioned gases in conjunction with their air-sea concentration gradients in order to derive the gas transfer coefficient (k). This value is typically parameterized as a function of horizontal wind speed and often is the cause of large deviation in computed ocean emissions for a variety of trace gases. Direct measurements of flux can both aid in understanding the biogeochemical cycling of atmospherically important trace gases and provide better parameterizations of k to improve calculations using measured concentrations.

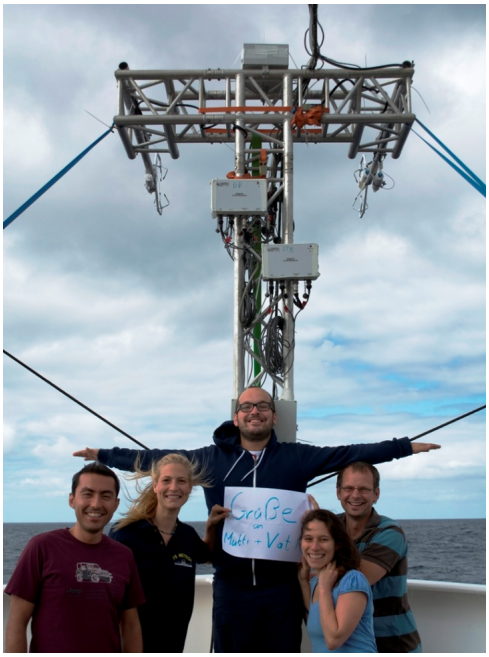

Figure 1: GEOMAR Chemical Oceanography group standing on the Meteor's bow by the eddy covariance mast. The mast is outfitted with two sonic anemometers to measure 3-D wind speed, a motion sensor to correct the measured winds for ship motion, and two gas inlets for the DMS/acetone and CO_2 sensors.

The EC flux is computed as the covariance between the turbulent fluctuations in vertical wind speed and the turbulent fluctuations of the trace gas of interest. This requires rapid, sensitive measurements of the vertical wind speed and the gas, free of the flow distortion introduced by the ship infrastructure. The wind is measured with a Campbell CSAT-3 sonic anemometer, which also detects the sensible heat flux. The gas measurements for DMS and acetone are performed using an atmospheric pressure chemical ionization mass spectrometer and for CO_2 a Licor 7200. Typical measurement frequencies are between 5-10 Hz for the gases and 30-50 Hz for the winds. The data must be time synchronized for covariance computations. To further complicate the problem, the measured vertical wind is influenced by the motion of the ship, what we know (and feel) as the pitch, roll, and yaw. Therefore, a motion sensing device, much like that on space crafts and airplanes, is also attached to the mast to measure the 3-D acceleration and angular rates of the ship.

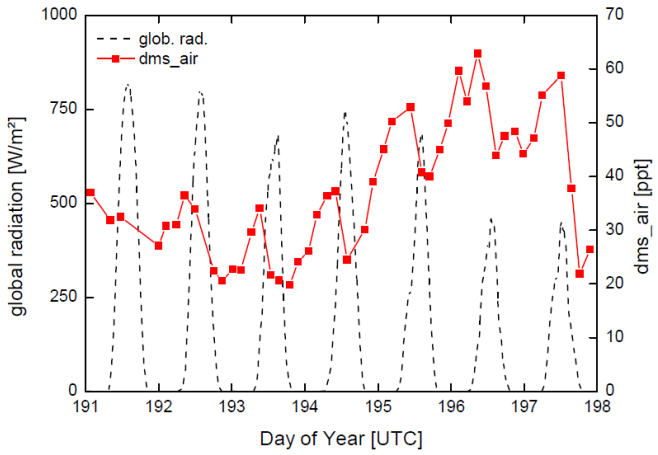

Figure 2: Atmospheric measurements of DMS. DOY 191 corresponds to 11.07.2013. The expected diurnal cycle of DMS in the atmosphere can be seen when compared to shipboard measurements of global radiation.

Most of the hard work needed to obtain these measurements is at the beginning, for setup, and at the end, with the data analysis. It has been found in the past that keeping short gas sampling lines is better for the measurements, so most of the instrumentation is housed in a 20 foot container placed on the bow. All gas inlets and meteorological instruments are placed on a mast at the very front of the ship approximately 11 m above sea level, in order to sample undisturbed turbulent fluctuations. The gas sampling tubing, cables providing power, and cables returning the analog and digital data streams must be laid out and fixed between the mast and the container. The instruments on the mast and the data acquisition must be tested before the mast can be raised, since it is difficult to work at this location during ship transit. Once the system is running, the collected data requires several steps of manipulation and correction before the flux can be determined. Corrections for the ship motion, the loss of high frequency content in the sampling lines, and the effects of flow distortion must be performed. Quality control on both the water side and air side gas measurements must be done before determining the periods for which the flux will be computed. The TRASE-EC team has already commandeered the ship's

conference room to work on the Matlab code needed to analyze the data. Chances are, you can find the team there at all times of the day, except after 20:00, when the conference room takes on a more relaxing air as the movie screening room. Then the flux weary can get their much-needed rest! Figures 2 and 3 give a preview of some of the data that has come out of the chemistry underway systems until now.

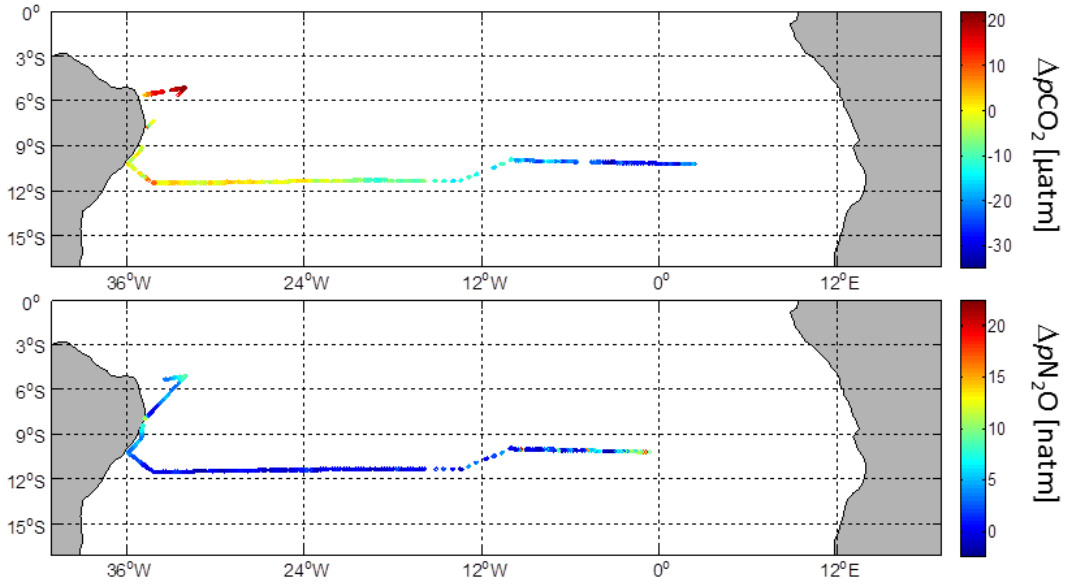

Figure 3: Underway measurements of the CO_2 and N_2O air-sea concentration gradient. The first measurements off Fortaleza are from 2.7.2013 and the latest measurements are from 19.7.2013. We are now entering a region where CO_2 is becoming undersaturated and N_2O oversaturated. This change in the gradient means that the EC flux of CO_2 should be easier to detect now rather than earlier in the cruise.

The rest of the science team continues with underway CTD measurements, data analysis and is preparing for the measurements in Angolan waters. These measurements will start on Sunday afternoon with the first CTD at the continental slope and will continue with mooring work to measure the eastern boundary current, a CTD section as well as with shipboard and glider microstructure measurements. Daily seminars by the scientists and students on board reflect the variety of research topics addressed by M98.

Greetings from the tropics,
Peter Brandt and the participants of M98