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Through the northern trade wind belt
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Figure 1: Meeting of the research vessels Polarstern (in front) and Meteor (in the background) on Sunday 23rd of March 2014, at 21°N and 11° W. © Dominik Nachtsheim, AWI.

After crossing the equator last week, RV Polarstern is now traveling through the northern trade wind belt. There, a rare encounter took place – already at the very end of the previous reporting period: two German research vessels met in the middle of the ocean. Contacts between cruise participants had revealed that Polarstern would cross the research area of the RV Meteor, which is investigating currents and exchange processes in the oxygen minimum zone off the coast of West Africa. An exact place and time for the meeting was quickly agreed upon, at 13:00 o'clock UTC and at 21°N 11°W. When Polarstern arrived at that point, Meteor was just finishing station work to release a glider into the ocean. Zodiacs were quickly brought into the water, and used for frequent shuttle transfers between the vessels. Both the scientists and the crew took the opportunity to visit the other ship, and learn about the instruments, the work carried out on board, and the scientific goals of the expeditions. After 4 hours and a welcome break from the daily routine on board, Polarstern continued its cruise in northerly direction towards home.

Figure 2: Aerosol container on the top deck, including a photo of the colleagues carrying out the aerosol and air analyses. © Maik Merkel, TROPOS, and Simon Jungblut, PoIE.

As already mentioned in last week's report, the OCEANET project focuses on the exchange of fluxes and energy between the ocean and the atmosphere. In addition to the daily water samples of the surface micro layer, continuous measurements of aerosols are carried out in a container on the top deck. Inside this aerosol container, several instruments determine the physical and chemical properties of aerosol particles. All measurements are focused on investigating the sources and formation pathways of airborne particles to enhance our knowledge about the underlying processes. The starting point of the analysis is a mobility spectrometer, which provides information about the particle number size distribution of the ambient air. This allows the determination of the number of particles starting with small particles with diameters of only 10 nm up to sea salt particles with diameters larger than 1 µm in the marine boundary layer. It enables a characterization of the lower tropospheric aerosol including information about its sources, e.g. whether it is of marine origin or the result of biomass burning from the Western African savannas. When our cruise leg started from Cape Town, the aerosol was of marine origin from the Antarctic region, as revealed by back trajectories. The total particle number concentration was lower than 100 particles per cubic centimeter – in urban areas number concentrations of some thousand particles per cm^3 are typical. After passing the equator, the total particle number increased significantly due to the continental influence of Africa, and transport of aerosol by the northern trade winds. Mineral dust as significant part of the

mixed aerosol was likely observed during this time period.
Based on this measurement, the activation of aerosol particles and their ability to form cloud condensation nuclei is investigated with another spectrometer. The results provide information about which particles of a given size can become cloud droplets at values of oversaturation ranging from 0.1 to 1 percent. The formation of clouds including their lifetime in particular over oceans is not yet completely understood.
For investigating the optical parameters of the marine aerosols, three additional instruments are found in the aerosol container. The absorption coefficient is measured by two absorption photometers at wavelengths of 530nm and 637nm. They allow the determination of the amount of soot contained in the aerosol. Especially after crossing the equator, this value increased significantly due to the continental influence by biomass burning. The scattering behavior is investigated with a nephelometer. Different backscattering signals at blue, green and red wavelengths allow conclusions about particle shape and density.
For the chemical characterization of the aerosol, filter samples are taken with a “Digitel High Volume Sampler” on top of the container covering 24-hour periods. After the expedition the filters will be analyzed in the laboratories of TROPOS in Leipzig. The same procedure is applied to daily or twice-daily denuder measurements, which sample chemical substances such as amines in the gas phase. The measurements are supported by continuous records of relevant atmospheric gases like ozone, nitrogen oxides and sulfur dioxide.

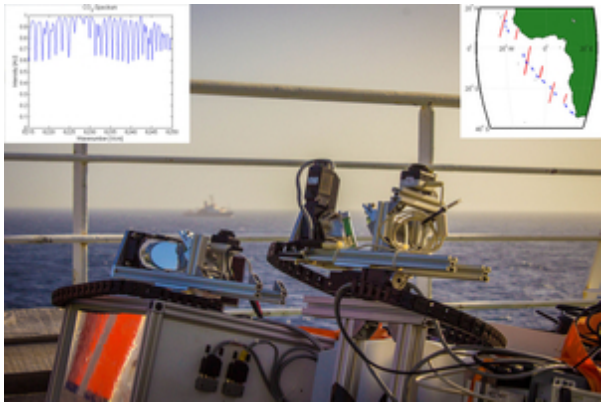

Figure 3: Two sun trackers of the greenhouse gas instruments on the top deck of Polarstern. RV Meteor is seen in the background. An observed CO2 spectrum is shown in the top left corner, while a map with the location of Polarstern measurements (blue) and coincident satellite overpasses (red) is shown in the top-right corner. © Friedrich Klappenbach, KIT IMK-ASF

Additional chemical investigations are carried out with impactors on the observation deck. They separate airborne particles according to their aerodynamic size, and collect them on foils which are later analyzed for chemical compounds and stable isotopes (nitrogen and sulfur). Particles of different size generally have different chemical composition. Samples collected so far indicate that during the Polarstern cruise on the South Atlantic, no aerosol influenced by continental origin was found. North of the equator, however, the air mass was substantially influenced by the African continent: the larger particles showed evidence of mineral dust, whereas the smaller particles can likely be attributed to burning processes due to their grey color. In addition, air samples are taken using evacuated metal flasks, which will be analyzed for volatile organic compounds in Germany. Prior measurements have shown that gaseous ammonia (NH_3) and particulate ammonium (NH_4^+) coexist in the lower atmosphere over the ocean. These components are collected on filters on board (3 NH_3 absorption filters behind an NH_4^+ particle filter) and later analyzed for their stable nitrogen isotopes. The results can provide hints towards the ammonia reaction pathways in the atmosphere.
As source and sink the ocean has a strong impact on the climate gases CO_2 and N_2O. Ratios of stable isotopes ($^{13}C/^{12}C$ and $^{15}N/^{14}N$) can give valuable hints for characterization of the exchange rates between air and water. Therefore, air samples from the atmospheric boundary layer and from air in equilibrium with sea surface water are taken and later analyzed for these isotope ratios.
Carbon dioxide and methane are also in the focus of three scientists from Karlsruhe. They came on board Polarstern in the search of sources and sinks of these greenhouse gases, which are the main contributors to global warming. With a spectroscopic analysis of direct sunlight, the scientists are capable of retrieving the amount of carbon dioxide and methane between the sun and their instrument. A novel instrument constructed especially for this purpose is tested on board. “At first we had trouble with electronics that kept failing due to sea salt. But with the support of the crew we were able to quickly solve this problem”, comments Friedrich Klappenbach from the Karlsruhe Institute of Technology (KIT). The scientists are happy about the outcome of the campaign up to now. “I am really excited about the parallel measurements during the satellite overpasses” Klappenbach continues. To validate the measurements taken from space with the Japanese satellite GOSAT, the colleagues from Japan adjusted the scanning mode of the satellite to obtain a maximum number of coincident measurements with the ones on Polarstern. But before these data can be compared, they have to be subjected to a careful analysis. “This will take some time and is planned to be done after the campaign.” Until the end of the cruise, the scientists from Karlsruhe hope for ongoing good weather, as this is needed for their measurements on the top deck. On this deck, also some other sun-related measurements are conducted, which will be presented in the next weekly report.

Kind regards from all Polarstern cruise participants,
Hartwig Deneke