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Rendevous with a satellite

March 17 - 23, 2014

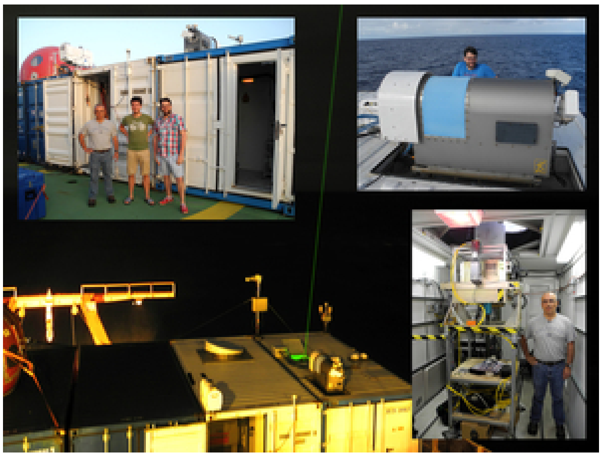

Figure 1: The OCEANET and cloud radar containers on the helicopter deck, together with the scientists operating the instruments. © Sebastian Bley, TROPOS.

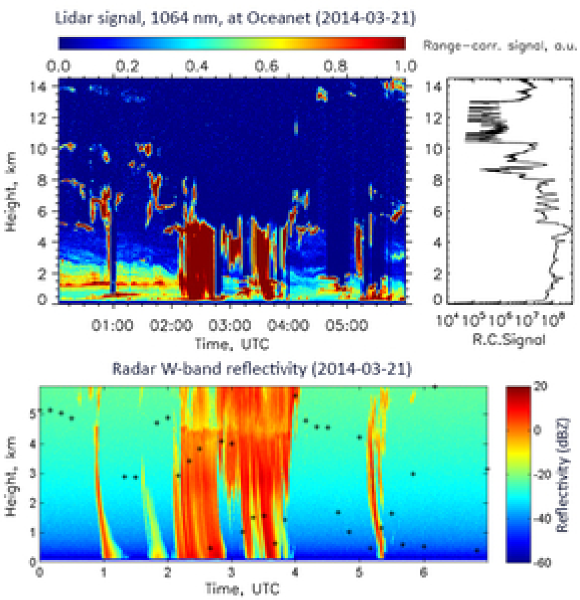

Figure 2: Visualization of the lidar and radar measurements taken on March 21st, 2014. © Sebastian Bley, TROPOS, Sergio Pezoa, NOAA.

Coming from the southern trade wind region, RV Polarstern passed a major portion of the tropics during the second week of our cruise. In consequence, the cloud regime changed from scattered cumulus clouds to deep convective systems and back to nearly cloud-free conditions north of 5°N at the end of this week. In that region, however, visibility was strongly reduced by a smoke and dust plume blown out onto sea from the African continent. The reason for this plume can probably be found in the traditional burning of biomass in the savannas of Western Africa.

This change of atmospheric properties and clouds is the central focus of the OCEANET project, which is the biggest experiment on board of Polarstern during this cruise. Again, a measurement container constructed especially for this project is on board, which has been built and is operated by scientists from Leipzig. It carries out observations of the atmosphere, specifically aerosol particles, clouds and atmospheric radiation. For the evaluation of climate models, and the determination of their uncertainties, spatially and temporally highly resolved measurements of these characteristics are required.

The OCEANET container is equipped with a number of remote sensing instruments. Vertically resolved profiles of aerosol particles, clouds, and water vapor are measured by a laser using the lidar principle. The laser emits laser pulses in ultraviolet, visible and infrared wavelength ranges, which are scattered back by air particles, cloud droplets, ice crystals and water vapor, and subsequently collected by a telescope. Due to different scattering properties, we are able to distinguish between ice and water clouds as well as between different aerosol types, e.g. desert dust, smoke and sea salt. After measuring solely sea salt during the beginning of the cruise, we have recently observed the previously mentioned aerosol layer originating from the African continent. In addition we found cirrus clouds in heights above 12 km in the equatorial regions. A microwave radiometer situated on top of the container measures the atmospheric emission in millimeter and centimeter ranges. From this emission temperature and humidity profiles as well as the integrated cloud liquid water path can be derived. Additionally we are running a weather station of the German Meteorological Service, short- and long wave radiation measurements, and a fisheye cloud camera. These observations can be compared to previous results in order to determine characteristic values and to identify interesting variations. As additional benefit of this transfer cruise, it is possible to investigate the variability of these measurements across several climate zones.

For the first time, a cloud radar is also on board during this cruise as a complement to the OCEANET measurements. This instrument has been developed and is operated by colleagues from the NOAA Earth System Research Laboratory. Similar to

the lidar, it sends out pulses with a power of 1740 W. These pulses do however have a frequency of 94GHz in the microwave spectral region. Together with the calibrated reflectivity from cloud droplets, the instrument also records the vertical velocity of the droplets based on the Doppler effect up to a height of 6 km, with the purpose to understand the dynamics and microphysical properties of cloud droplets. The radar is mounted on a stabilized platform, a gyro records ship pitch, roll and heave to compensate the ship motion to ensure that the radar is pointing vertically with an accuracy of 0.5 degrees.
Since 2006, the cloud radar CLOUDSAT and the cloud-aerosol lidar CALIOP fly in space as part of the A-train, a constellation of currently 5 earth-observing satellites. As they provide measurements similar to ours from space, a comparison with our ship-borne observations can help to better understand the accuracy and consistency of the datasets. Some important differences have to be recognized, however: our ship travels at a cruise speed of 10.5 knots, while the sub-satellite point moves with roughly 6 km per second. Due to its height of 690 km above sea surface, the satellite instruments can only distinguish coarser cloud structures, with horizontal resolutions of up to 300 m for the lidar and 1.5 km for the radar. To achieve an optimal comparison, our course has been adjusted in such a way that Polarstern has reached the ground track of the A-Train 1-2 hours before an overflight. We have then followed the track for the next 3-4 hours, with the satellites catching up and overtaking the ship during that time. As the ground track is only known 2-4 weeks in advance with sufficient accuracy, this strategy has required short-term adjustments to the ship's route, which could successfully be made thanks to the excellent support by the ship’s crew. Up to now, we have realized 4 such overflights during the past 2 weeks, and two further overflights are planned for our way to Las Palmas. A preliminary comparison of the GPS waypoints indicates that we have matched the course of the satellite ground track with an accuracy of about 50 m, which is significantly better than our expectations.

Figure 3: Sampling of the ocean surface film layer from a zodiac. © Hartwig Deneke, TROPOS.

Towards the goal of better understanding air-sea interaction and specifically the exchange of organic matter, the surface film layer of the Atlantic's ocean surface is again being investigated during this cruise. Samples are taken at the surface by dipping a glass plate vertically into the ocean, pulling it slowly back out, and wiping the surface film with a teflon glass wiper into small plastic bottles. Reference samples are taken with a telescope pole in 2 m depth. To exclude an influence by our ship, these samples are collected from a zodiac, which is brought to water during a stop of Polarstern around noon time. The water and surface film samples are frozen on board and will be chemically analyzed at TROPOS after the cruise. The analysis of samples taken during previous cruises has revealed the enhanced content of a chemical substance in the surface film, which is currently being investigated as a potentially important factor in the formation of clouds. These investigations will be continued and extended during this cruise. An overview of complementary analyses of the chemical composition of marine aerosol and air samples carried out during the cruise will be given in next week's report.

Figure4: Neptun and his wife Thetis visiting our ship on a zodiac. © Christina Streit, Laeisz.

Besides the normal scientific routine, another highlight of this cruise occurred during this week. On the morning of the 19th of March, RV Polarstern crossed the equator. Neptune himself came on board and overlooked the baptism of previously unbaptized cruise participants. Figure 4 shows him together with his lovely wife Thetis on a zodiac paying his visit to our ship.

On behalf of all cruise participants, best regards from Polarstern,

Hartwig Deneke
(Chief scientist)