Berichte
zur Polar- und Meeresforschung

670
2013

Reports on Polar and Marine Research

The Expedition of the Research Vessel "Polarstern" to the Antarctic in 2012 (ANT-XXIX/1)

Edited by
Holger Auel
with contributions of the participants

HELMHOLTZ GEMEINSCHAFT

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D-27570 BREMERHAVEN
Bundesrepublik Deutschland

ISSN 1866-3192

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Editor:
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Assistant editor:
Birgit Chiaventone

Die "Berichte zur Polar- und Meeresforschung" (ISSN 1866-3192) werden ab 2008 als Open-Access-Publikation herausgegeben (URL: http://epic.awi.de).

Since 2008 the "Reports on Polar and Marine Research" (ISSN 1866-3192) are available as open-access publications (URL: http://epic.awi.de)

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Please cite or link this publication using the identifier
hdl:10013/epic. 42556 or http://hdl.handle.net/10013/epic. 42556

ISSN 1866-3192

ANT-XXIX/1

26 October - 27 November 2012

Bremerhaven - Cape Town

Chief scientist
Holger Auel

Coordinator
Rainer Knust

Contents

1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Holger Auel, BreMarE UniHB

Mit dem Einlaufen in Kapstadt am 27. November 2012 geht der Fahrtabschnitt ANT-XXIX/1 nach 32 Tagen auf See sehr erfolgreich zu Ende. Insgesamt wurden Proben und Daten an 19 Stationen entlang der Fahrtroute gesammelt. Am Fuß des Walvis-Rückens wurde eine Tiefseeverankerung erfolgreich ausgewechselt, und viele en route Messungen und Gerätetests wurden durchgeführt. Im Rahmen des EUROPA-Programms – "European Universities & Research Onboard *Polarstern* in the Atlantic" wurde *Polarstern* zum ersten Mal als Plattform für eine internationale und interdisziplinäre Trainingsinitiative genutzt, welche 37 Masterstudierende, Doktoranden und Dozenten von elf verschiedenen Universitäten und Forschungsinstitutionen zusammen brachte. Dank der professionellen und sehr engagierten Unterstützung durch Kapitän Schwarze und seine Mannschaft konnten die verschiedenen wissenschaftlichen Programme an Bord sehr erfolgreich abgeschlossen werden. Ca. 87 Stunden Stationszeit standen während des Fahrtabschnitts zur Verfügung. Davon entfielen 52 Stunden auf biologische Beprobungen mit verschiedenen Planktonnetzen und dem optischen Plankton-Profiler LOKI, während 27 Stunden für ozeanographische Messungen mit der CTD und Verankerungsarbeiten aufgewendet wurden. Acht weitere Stunden wurden für hydroakustische Tests mit verschiedenen Echoloten genutzt.

SUMMARY AND ITINERARY

With the disembarkation in Cape Town on 27th November 2012, the cruise leg ANT-XXIX/1 very successfully reached its end after 32 days at sea. In total, samples and data were collected at 19 stations along the cruise track, a deep-sea mooring at the foot of Walvis Ridge was exchanged successfully and many en route measurements and equipment tests were conducted. In the framework of the EUROPA – "European Universities & Research Onboard *Polarstern* in the Atlantic" programme, for the first time, *Polarstern* was used for an international and interdisciplinary hands on-training initiative bringing together 37 master students, doctoral candidates and lecturers from eleven different universities and research institutions. Thanks to the professional and very committed support by Captain Schwarze and his crew, the different scientific programmes on board could be completed very successfully. About 87 hours of station time were available during the cruise leg, out of which 52 hours were used for biological sampling with different plankton nets and with the optical plankton profiler LOKI, while 27 hours were needed for oceanographic measurements with the CTD and mooring work. During further eight hours hydroacoustic tests with different echosounders were conducted.

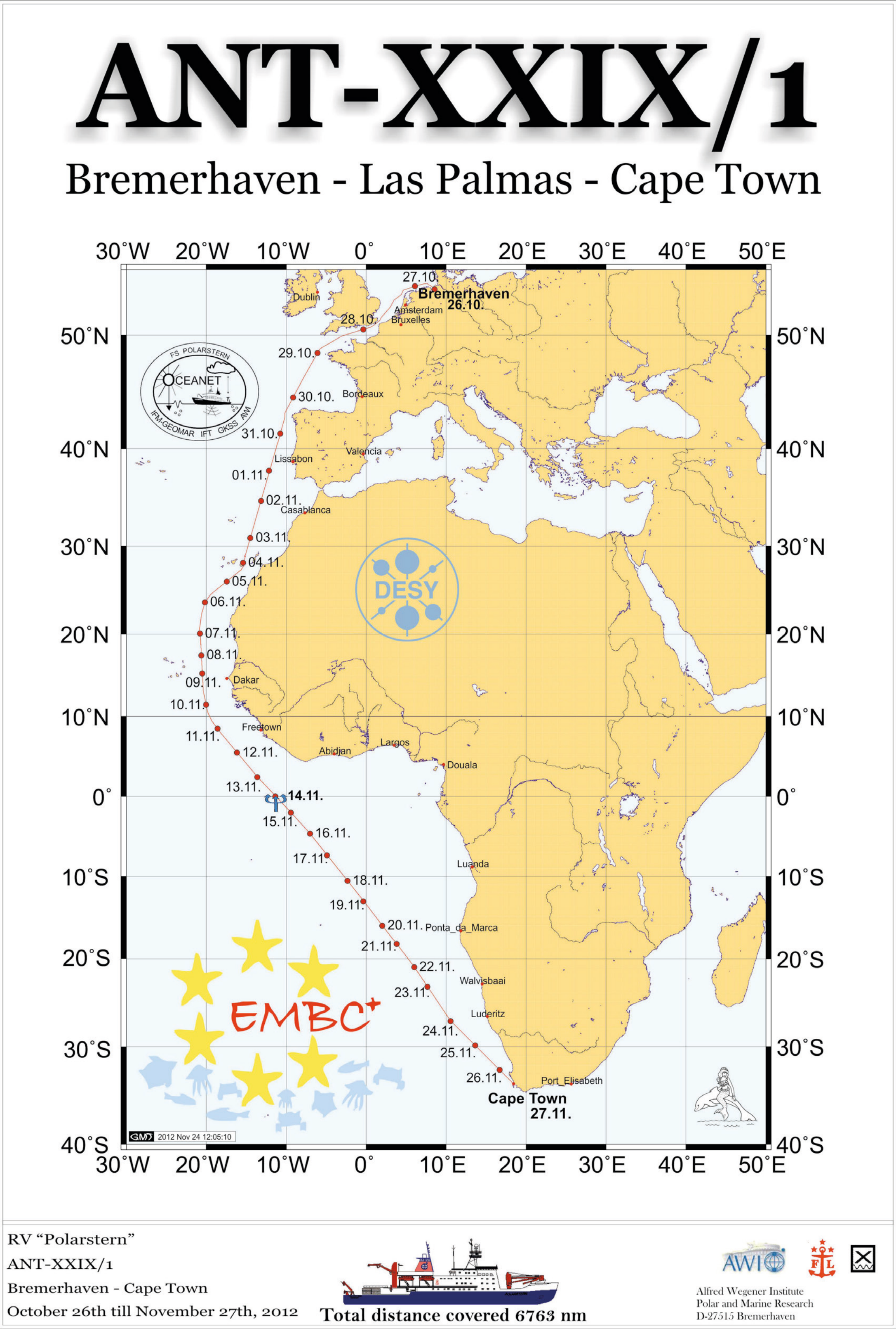

Abb. 1: Fahrtverlauf Polarstern-Expedition ANT-XXIX/1

Fig. 1: Cruise track Polarstern-expedition ANT-XXIX/1

2. WEATHER CONDITIONS

Harald Rentsch, Hartmut Sonnabend DWD

The research vessel *Polarstern* started sailing on its first leg of 29th expedition to Antarctica under the influence of an upper trough, which brought cold air from the North Sea towards Central Europe and caused an unstable stratification of the atmosphere. Together with bright weather and fresh winds we reached the English Channel. Here we got moist and cold air in connection with an upper trough and an intense low-pressure system. Rain showers and stronger winds up to Bft 6 were produced, but later on 29th October, when crossing the Biscay, we measured wind force 7-8 Bft and the sea reached nearly 3 m.

Already one day later a ridge of the high-pressure system nearby the Azores often caused sunny periods, even though the winds decreased very slowly. The ship sailed with a speed of 10 kn, on this way we could prevent higher swell-fields of 4 m, which would have approached from north-western Atlantic Ocean.

Therefore we measured winds only up to 6 Bft and waves did not exceed 2.5-3 m on 1st Nov. After that, a new frontal system nearby the Azores crossed our ships track. So, the south-westerly wind flow were strengthened for a time, brought us sometimes rain or showers and caused winds of 6 Bft, wave heights reached 3 m. On 4th November very convenient air temperatures of 26° C (sea-surface temperatures around 23° C) were measured during our short stay in the harbour of Las Palmas.

Already on 5th November the high-pressure system nearby the Azores was strengthened and spread towards south, at the same time the low-pressure system, which dominated the weather last weak, weakened rapidly. With it the north-easterly trade winds were weighty. At this moment a weak north-westerly wind flow of force 3 Bft caused a swell up to 2 m. On the following Wednesday the trade winds was built up very well and so wind force 5 to 6 Bft were recorded, in addition the swell raised up to 3 m at average. First, the temperature-inversion, caused by trade winds, was not so strong, so that there were often clear sky conditions and a guaranty for observation of beautiful sunsets.

On 8th November the well known trade winds from northeast reached the ship and together with wind force Bft 6 wave heights up to 4 m were measured and observed. At this time the high-pressure centre with 1,036 hPa were analysed west of Azores. In the period following the high- pressure weakened more and more and the high-centre moved southward. This caused trade winds to weaken too and its direction changed to easterly ones.

On 9th November for the first time of our cruise a thunderstorm-cluster was discovered, which was appreciated by hurricane-forecast centre in Miami as a becoming centre of a possible tropical depression. Such kind of cyclones could become low-pressure centres in the tropics which could possibly serve as a base for developing hurricanes of tropical waters.

On Sunday the weather situation changed completely south of Cap Verde at about 10° N and with the approaching of ITCZ (inner tropical convergence zone). There, the strong convection let to building up of cumulonimbus clouds, and some lightnings were often observed far away from the ship. This happened for first time during the night from 10th to 11th November when we crossed the latitude 9°N southward. On 12th November the new weak began within the ITCZ retried by convective processes with sea-surface temperatures of 29° C (Fig. 2.1). During the day time thunderstorms were observed surrounding the ship, and a tropical shower in the afternoon caused a rain-sum of 6.2 mm/h on *Polarstern*. Together with this the air temperatures dropped from 29° C to 23-24° C, the wind speed reached nearly 32 kn for a short time.

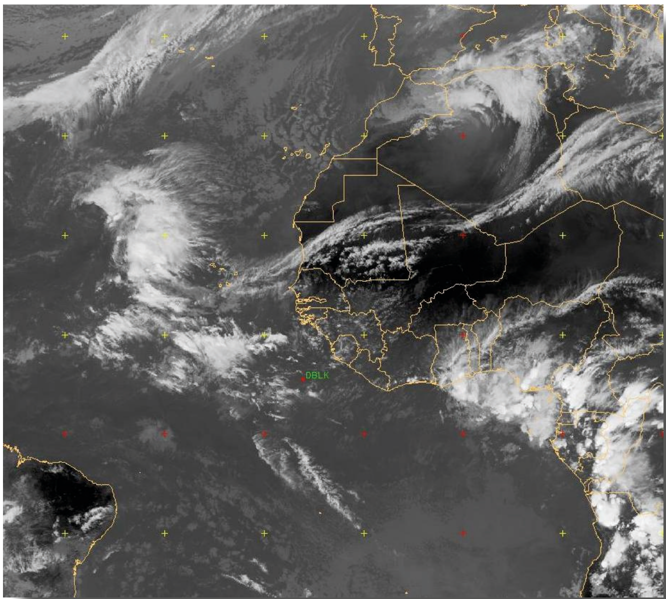

Fig. 2.1: IR-satellite picture METEOSAT 9 for 12.11.2012, 15:00 UTC. The position of the research vessel Polarstern is marked by its call sign DBLK.

Up to the middle of that week we had left the ITCZ and crossed the equator. Thus, the probability for thunderstorms and showers were reduced to below 10 %. Besides, the strengthening south-easterly trade winds of 4-5 Bft let to a stabilisation of the atmosphere, too. On our track southward the sea became slightly higher and reached nearly 2 m together with wind force 5 Bft after the middle of the week. At that time we found by our daily radio sounding an inversion of temperature between 800 and 1,000 m causing typical cloudiness for subtropics. Accordingly, our course against southern latitudes the climatologic conditions changed respectively during the week.

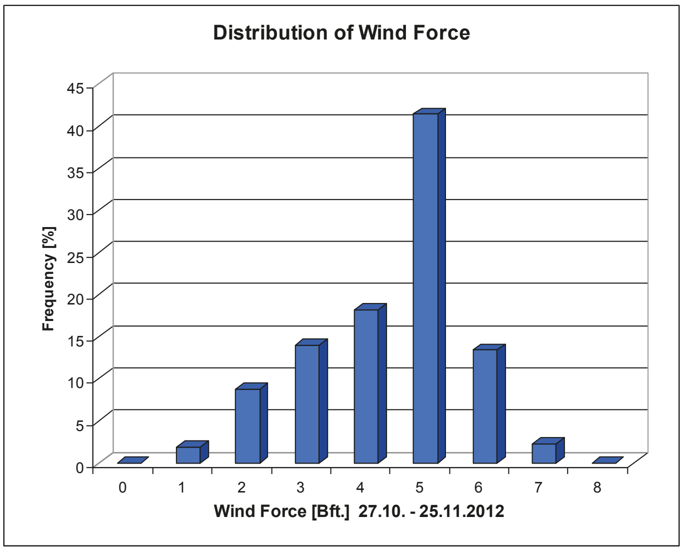

Fig. 2.2: Distribution of wind force during 15:00 UTC. The position of the research vessel Polarstern ANT-XXIX/1

This could be seen by decreasing of air- and sea-surface temperatures for instance. Additionally, the occurrence of cloud-types caused by a stable stratification of atmosphere had increased. During the last week of the journey we approached the highest zenith angle of the sun, which we reached on 22nd November, as the sun had a declination of around 20°S.

The direction and wind force of trade winds did not change at the beginning of second last week, but the already called inversion was strengthened day by day evoking mostly covered sky. This situation changed when stronger winds of Bft 7 flowed against our ship's course producing waves of up to 4.5 m. - This happened after the 21st of the month when we came closer to Namibia's coast.

During the next two days we had a weakening pressure-gradient, thus the trade winds abated to 5-6 wind forces and wave heights were measured at 2.5 m.

On Saturday 24th November, three days before entering the harbour of Cape Town, a cold front of a low which moved in sub-polar yet stream eastward and brought some rain-showers. At the same time the wind strengthened up to 7 Bft and the sea rose up to 3 m. During the weekend the wind exceeded wind force 8 at one time, the maximal-values of the total wave height were measured at 8 m, averaged to 4.5 m. Not before entering the EEZ (exclusive economic zone) of South Africa wind started abating. At arrival day on 27th November we had air-temperatures of 21°, often sunshine and a rather calm sea in the port of Cape Town.

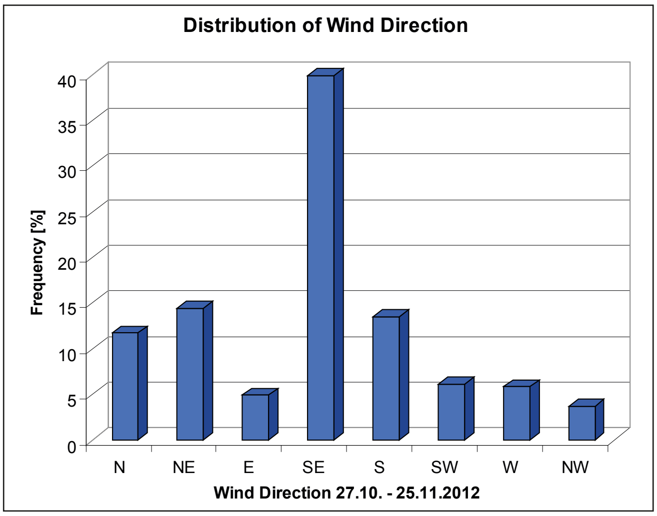

Fig. 2.3: Distribution of wind direction during ANT-XXIX/1

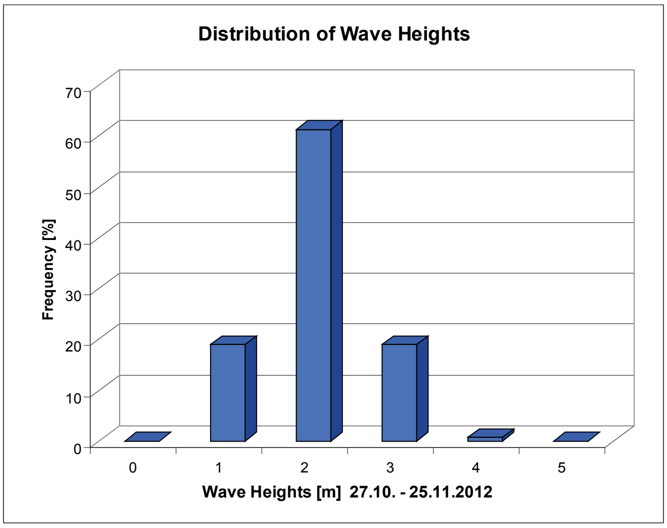

Fig. 2.4: Distribution of wave heights during ANT-XXIX/1

3. AUTONOMOUS MEASUREMENT PLATFORMS FOR ENERGY AND MATERIAL EXCHANGE BETWEEN OCEAN AND ATMOSPHERE (OCEANET)

Marlen Brückner[1], Ronny Engelmann[1], Thomas Kanitz[1], not on board: Andreas Macke[1]

[1]TROPOS

Objectives

Radiation & microwave remote sensing

The net radiation budget at the surface is an important regulator in the climate system of the earth. It is mainly influenced by the complex spatial distribution of temperature and liquid water content in the atmosphere. The complex three-dimensional (3D) microphysical structure of clouds causes systematic errors in active and passive remote sensing of clouds, if the cloud variability is not resolved in radiative transfer models (RTM). Consequently, the retrieved cloud radiative properties and the cloud radiative energy budget might be biased.

With the Atlantic transfers of *Polarstern* it is possible to perform simultaneously observations under tropical, subtropical and midlatitudinal conditions in both hemispheres. The radiation budget and the cloud properties were observed in high temporal and spatial resolution which provides realistic cloud-radiation interactions for use in remote sensing and climate models. Within the scope of the WGL-Project OCEANET the already existing broadband radiation measurements on *Polarstern* have been extended to spectral solar radiation measurements with the ship-based COmpact RAdiation measurement System (CORAS). CORAS simultaneously measures spectral resolved downward radiances and irradiances. Due to the spectral resolution of the spectrometers different contributions from different atmospheric gases and water vapor absorbing regions to the radiative quantities can be identified.

A microwave radiometer (HATPRO) provides continuously vertical profiles of humidity and temperature, as well as time series of liquid water path (LWP), integrated water vapor (IWV), and cloud base height over the Atlantic Ocean. In combination with the variability of the downward radiative quantities these time series makes it possible to observe small scale atmospheric structures and cloud inhomogeneities.

Lidar observations

The complexity of atmospheric aerosol particles expressed by their highly variable number concentration, size distribution, shape characteristic, chemical composition, and complex mixing behavior, as well as their large temporal and spatial (horizontal and vertical) variability, causes high uncertainties in our quantitative understanding of their role in climate-related processes and weather.

A new enhanced version of the portable lidar Polly performed 24/7 measurements aboard *Polarstern*, whenever the weather conditions were appropriate. This 3+2+2+1 Raman/polarization and water vapor lidar provides highly temporal resolved information about the vertical distribution of aerosols and water vapor. Aerosol particle optical properties in terms of the particle backscatter and extinction coefficient can be determined directly and serve as input for height-resolved inversion methods to estimate the main microphysical properties (e.g. size distribution) at any measured height. Thus, lofted free-tropospheric aerosol layers can be characterized separately from the marine boundary layer. Typical known free-tropospheric aerosols are anthropogenic emissions from North America, dust from the Saharan region or smoke from biomass burning in South America. These aerosols have been lifted up above land and are transported over the Atlantic Ocean for several days. During this transport aerosols influence the radiation budget of the earth. Thus, the height-resolved information as derived from lidar is a crucial input for radiative transfer calculations to determine the direct aerosol radiative effect more precisely. In addition, the height-resolved measurements offer the opportunity to determine the extent of simultaneous occurring clouds, as well as the clouds state of phase to investigate aerosol-cloud interactions and to determine the indirect aerosol radiative effect, which shows the highest uncertainties in climate research.

Work at sea

The OCEANET-Container was located on the helicopter deck on *Polarstern* (Fig. 3. 1). The measurements were performed underway and continuously. The following individual instruments were combined in the container:


Fig. 3.1: OCEANET-Container on the helicopter deck of Polarstern during ANT-XXIX/1 (photo: M. Brückner, C. Schwerdt)

OCEANET-Atmosphere

- For the broadband radiation measurements an upward looking Kipp&Zonen pyrgeometer CG 4 and pyranometer CM 21 supported from GEOMAR were used on this cruise.
- A full sky imager with a camera system manufactured at GEOMAR was installed to obtain every 15 seconds whole sky images from the current atmospheric situation. This provides detailed information about the existing cloud coverage as well as the cloud type with a high temporal resolution.
- The spectral radiation measurements of downward irradiance and radiance were obtained from CORAS. The optical inlets were installed at the top of the container (Fig. 3.2). The measured radiation was transported to a spectrometer box in the container by optical fibers. The spectrometer splits up the radiation according to the wavelengths. The spectral range from CORAS is 350-2,000 nm. Under good weather conditions, CORAS was calibrated each day with a small Ulbricht-integrating sphere. It creates diffuse radiation from a directionally orientated radiation. To obtain the background noise in the data also a dark calibration was performed.

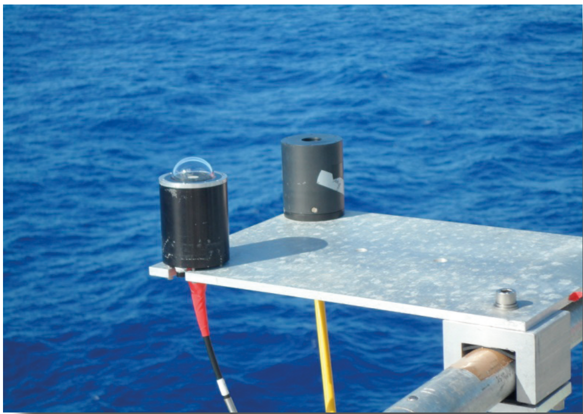

Fig. 3.2: Optical inlets from CORAS for spectral radiance (right) and irradiance (left) during ANT-XXIX/1 (photo: M. Brückner)

Information about the vertical distribution of aerosols was conducted with the multiwavelength Raman/polarization lidar Polly-OCEANET (Fig. 3.3). The system was operated 24/7, whenever the weather conditions were appropriable. Neutral density filters were adjusted to the current aerosol conditions, respectively the backscatter intensity. Calibrations of the depolarization sensitive channels were performed each day. The multichannel microwave radiometer HATPRO was calibrated in Bremerhaven with liquid nitrogen. It performs continuously observations of atmospheric humidity and temperature profiles, as well as the IWV and the LWP.

Standard meteorology devices for obtaining temperature, pressure and humidity, as well as the position, speed and course of *Polarstern* were operated in cooperation with the German Weather Service.

Fig. 3.3: The multiwavelength Raman/polarization lidar Polly-OCEANET during ANT-XXIX/1 (photo: M. Brückner)

Preliminary and expected results

- 2d structure of the clear sky atmosphere and corresponding net radiation budget.
- Horizontal structure of the cloud water path and its effect on the downwelling shortwave and longwave radiation
- Vertical structure of temperature and humidity as well as its variability for validation of satellite products
- Vertical profiles of tropospheric aerosols and their effect on radiation
- Turbulent fluxes of momentum, sensible, and latent heat

Figure 3.4 shows the time series of downward spectral radiance and irradiance in the visible range (VIS) at pixel 500 (600 nm) for November 19th 2012. On this day there were only a few shallow cumulus clouds present which can be identified by the enhancement of radiance or irradiance. The enhancement results from the diffuse contribution of cloud edge scattering.

The scientific goal of this part of the project is to compare the observation on *Polarstern* with different model calculations of the radiative quantities. With the aid of observed and modelled spectral transmitted radiance cloud properties such as cloud optical thickness (τ) and effective radius (r_{eff}) were retrieved. The vertical cloud structure is obtained from the microwave radiometer measurements. The all sky camera provides information on the horizontal cloud variability. To quantify 3D cloud effects on the cloud transmissivity 3D Monte-Carlo radiative transfer simulations will be used. The simulated cloud transmissivity will be compared to simulations with a plan parallel RTM and the measurements of CORAS. Furthermore, cloud optical thickness and effective radius, will be retrieved by using both 3D

Monte-Carlo and plan parallel radiative transfer simulations. Differences in the retrieved cloud properties will be systematically classified by cloud fraction and cloud vertical inhomogeneities derived from all sky camera, lidar and microwave radiometer.

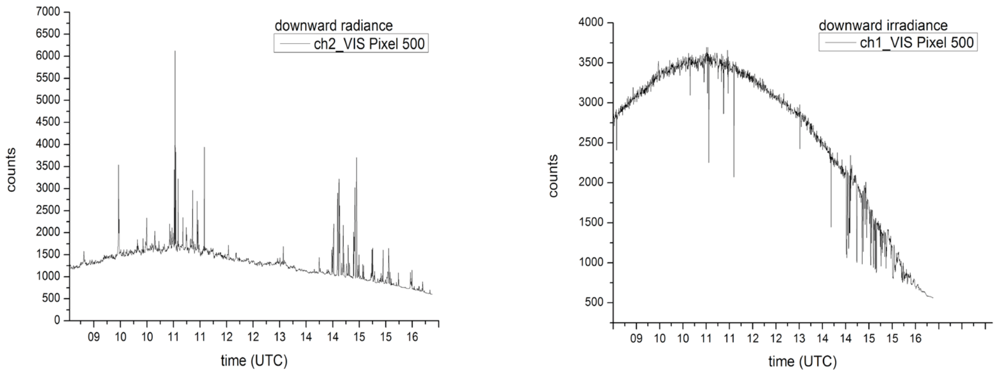

Fig. 3.4: Time series of downward radiance (left) and irradiance (right) for VIS at pixel 500 obtained from a measurement on Polarstern on November 19th 2012 (preliminary and uncorrected data)

Figure 3.5 shows the height time display of the lidar measurement from 4 November to 6 November 2012. Complex aerosol layers (green coloring) were observed up to 5 km height until 10 November 2012. Embedded clouds (white coloring) were mostly at the top of the aerosol layers and showed virgae (5 November, 4:00 UTC) most probably because of heterogeneous ice nucleation.

The ship borne lidar measurements aboard *Polarstern* during the meridional transatlantic cruises have been performed since 2009. An unique data set has gained and offers the opportunity to contrast the aerosol conditions in the northern and southern hemisphere. Especially, in the barely investigated southern hemisphere the remote oceanic measurements aboard *Polarstern* fill a gap in the knowledge of the global aerosol distribution. One goal in this analysis is to determine the anthropogenic contribution to the atmospheric aerosol load and related radiative impacts on the Earth's radiation budget. This influence is caused by the aerosols directly by scattering and absorbing radiation, but also via aerosol-cloud interaction indirectly. Another purpose of the collected data is the validation of satellite applications to improve data algorithms of cloud-aerosol discrimination in terms of thin low boundary layer clouds and to improve the separation of optical dense lofted aerosol layers and the thin non-absorbing marine boundary layer.

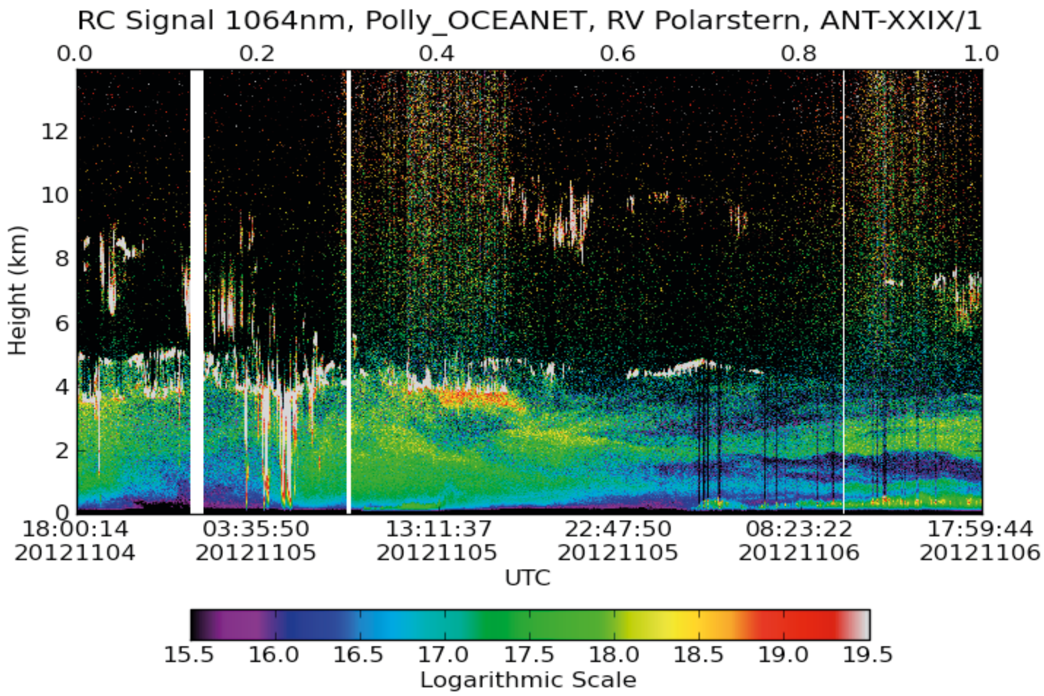

Fig. 3.5: Vertical Profile of the lidar measurement from 4 November to 6 November 2012 during ANT-XXIX/1

Data management

The data processing will be carried out at TROPOS and Leipzig Institute for Meteorology (LIM), respectively. Some of the instruments will be calibrated in the home laboratory to determine the calibration parameters for correct data sets. This will properly take several months. After post processing the complete data sets are available for other cruise participants on request.

4. CHEMICAL, PHYSICAL AND OPTICAL CHARACTERIZATION OF MARINE AEROSOLS

Maik Merkel[1], Shan Huang[1], Michael Leistert[1], not on board: Alfred Wiedensohler[1], Andreas Macke[1]

[1]TROPOS

Objectives

The exchange of gases and aerosols between ocean and atmosphere has received considerable and intensive attention, but it is not well understood currently. Aerosol particles play an important role in the global climate change because of their effects on the radiation budget. This is particularly true for aerosols from marine environments. For this reason, the measurements on board *Polarstern* are to 1) better understand the formation mechanism of secondary fraction in marine aerosol particles, 2) investigate the interaction between sub-micron marine aerosols and water vapour under sub- and super-saturated as well as undercooling conditions, and 3) characterize the optical properties of marine aerosols.

Work at sea

To achieve the foregoing objectives, the physical laboratory container of TROPOS equipped with a number of scientific instruments was operated by three scientists during the ANT-XXIX/1 leg from Bremerhaven to Cape Town.

The chemical composition of marine aerosols was measured using on-line systems. The Aerodyne High-Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS) provides quantitative measurements of the size resolved non refractory chemical composition of the submicron ambient aerosol at a typical time resolution of two minutes. Due to the 600 °C surface temperature of the vaporizer, the AMS can only measure the non-refractory part of the particles. Soot, crustal material and sea-salt cannot be detected.

Particle Number Size Distribution from 10 nm to 20 µm in diameter is measured by a Scanning Mobility Particle Sizer (SMPS) combined with an Aerodynamic Particle Sizer (APS). Both instruments have a time resolution of 5 minutes. The interaction between particles and water vapour are respectively determined by Hygroscopicity Tandem Differential Mobility Analyzer (HTDMA; relative humidity was 90 %). With this instrument the hygroscopic growth of the particles can be measured. Additionally, an Integrating Nephelometer and a Multi Angle Absorption Photometer (MAAP) as well as a Particle Soot Absorption Photometer (PSAP) were operated simultaneously to characterize the particle optical properties. They can measure the particle scattering and absorption coefficient and the black carbon concentration. Table 1 shows a summary of scientific equipment to determine the properties of the marine aerosol on board *Polarstern*.

Tab. 4.1: Scientific instruments on board *Polarstern*

Instruments	Time Resolution	Data availability
Scanning Mobility Particle Sizer (SMPS)+ Aerodynamic Particle Sizer (APS)	5 min	27.10.-25.10.2012
Humidity Tandem Differential Mobility Analyzer (H-TDMA)	5 min	29.10.-25.10.2012
Multi Angle Absorption Photometer (MAAP)	1 min	28.10.-25.10.2012
Integrating Nephelometer	1 min	28.10.-25.10.2012
Particle Soot Absorption Photometer (PSAP)	1 min	28.10.-25.10.2012
High-resolution Time of Flight aerosol mass spectrometer (HR-ToF-AMS)	2 min	28.10.-25.10.2012

At the beginning of the cruise, the container was set up and all instruments were calibrated. The quality-control protocol was carried out to insure the high-quality data acquisition during the whole campaign.

For the most time of the campaign the wind was coming from ahead and brought ship contamination-free air. Especially when the ship stopped at the daily station time, an influence of contamination from the ship exhaust could be seen frequently. Beside this, the measurements were successful until November 25, when the packing of the instruments started. A rough summary of data availability is given in the last column of Table 4.1.

Preliminary (expected) results

Based on the on-line measurements, the size-dependent chemical and physical properties of near-surface marine will be obtained.

A detailed analysis on AMS data will provide chemical information of aerosol particles such as the ratio of oxygen to carbon, the relative abundance of hydrocarbon-like structures, and a variety of molecular fragments. Therefore, to some extent, we can gain insight into the formation mechanism of marine aerosols, especially organic fraction.

The hygroscopic growth measurements can provide information about the particle mixing state and the growth factor of the aerosol particles. By combining the data to the chemical measurements a closure study will be performed.

The light extinction at ambient humidity can be predicted from *in-situ* measurements of dry and humidified particle number size distributions, light scattering and absorption coefficients, and size-resolved chemical composition. Optical properties of aerosol particles and *in-situ* physical and chemical measurements as well as columnar optical property measurements can be used to establish a connection between *in-situ* ground and columnar aerosol properties.

During the cruise ANT-XXIX/1 the ambient aerosol originated mainly from marine sources. Figure 4.1 shows an example of the particle number size distribution as a function of time and particle diameter, which was measured between November 14 and November 20, 2012. Total particle number concentrations were in between 150 and 400 particles per cm³ representing clean marine aerosols. The number size distribution was bimodal for almost the whole time. The maximum on November 19 resulted from the turning of the ship during the station time, when some exhaust air and plume from the vessel was caught.

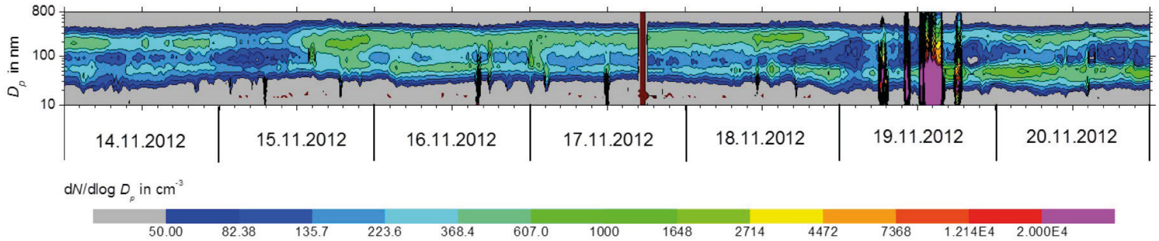

Fig. 4.1: Particle number size distribution measured by the SMPS for 7 days showing different aerosol particles and number concentrations

Figure 4.2 is showing the first results of the chemical particle composition measured by AMS. After passing the equator (November 14 to 20), sulfate showed an obvious increase, taking about 70 % of total mass concentration of submicrometer non-refractory marine particles, followed by organics and ammonium. Nitrate and chloride were close to zero mainly because of their refractory properties.

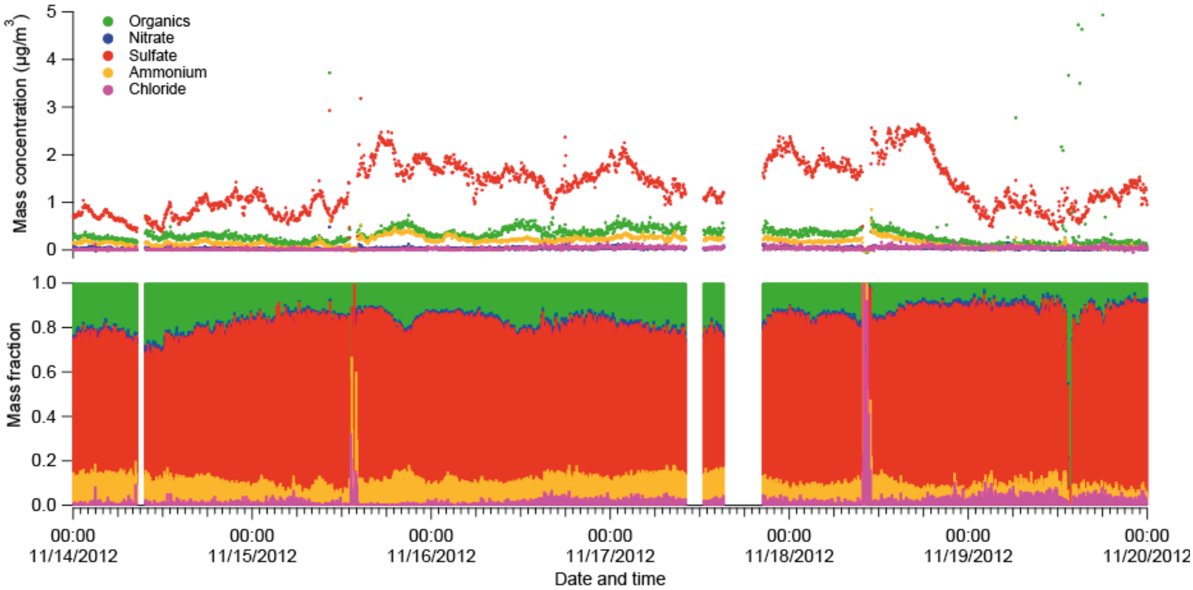

Fig. 4.2: Particle mass concentration and mass fraction for the chemical compounds Organics (Org), Nitrate (NO_3), Sulphate (SO_4), Ammonium (NH_4) and Chloride (Chl)

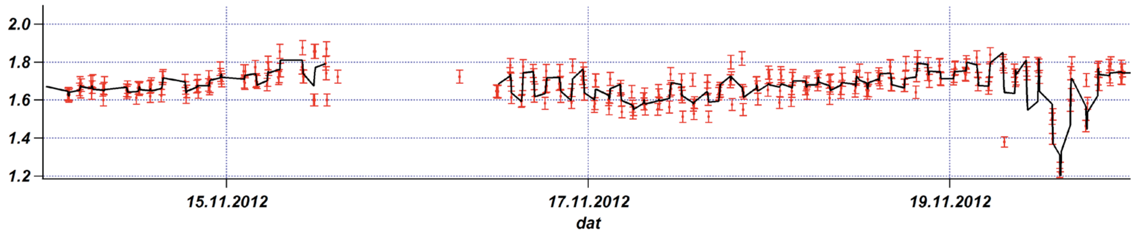

Fig. 4.3: Growth factor for 100 nm particles measured with the HTDMA for the time period November 14 to 20.

The growth factor for particles with a diameter of 100 nm is shown in Figure 4.3. It correlates well with the mass fraction of sulphate and organics. A higher mass fraction of sulphate results in a higher value for the growth factor. For most organic compounds the growth factor decreases with higher mass fraction. The reason is the higher hygroscopicity of ammonium sulphate (mean growth factor is 1.7) in contrast to the organics, where the mean growth factor is only 1.2.

The optical properties of the measured marine aerosols are represented in the absorption coefficient (measured by a MAAP at a wavelength of 637 nm) and the backscattering coefficients that were measured by a Nephelometer for three different wavelengths (blue 450 nm, green 550 nm and red 700 nm). For marine aerosols the absorption and the backscattering coefficients have lower values. Due to the properties of marine aerosol particles approximately 95 % of radiation will be scattered forward. This result was also confirmed during the cruise ANT-XXIX/1.

Data management

All data processing will be carried out in the home laboratory at TROPOS. The online measurements of aerosol particles might need some months to insure the quality of the data set. As soon as the data are available they can be used by other cruise participants after request.

5. MEASUREMENT OF COSMIC PARTICLES

Carolin Schwerdt[1] [1]DESY

Objectives

The goal of the project is the measurement of cosmic particles in dependence on different parameters as air pressure, temperature in atmosphere and latitude.

At sea level we measure mostly muons. Muons are decay products of secondary's produced by primary cosmic particles which continuously rain down on our planet from space. Primary cosmic rays are charged particles, in particular protons, but also helium, heavier elements and electrons, and come from the sun or from galactic and extragalactic sources. Reaching the earth, they collide and interact with the atoms of the upper atmosphere in heights of 20 to 30 km. Thereby new particles are produced which can again collide with the atoms in the air or they can decay. Decay products are lighter charged particles, like muons (generated in heights of 15 to 25 km) and electrons, or uncharged neutrinos and gamma-rays.

The sun is a source of relatively low energy protons. Since the sun's activity will reach its maximum in 2013/14, an increase of eruptions will lead to higher particle radiation.

The cosmic particle detector consists of two scintillation counters working in coincidence mode and gives a signal if a charged particle, mostly a muon, is crossing both scintillators. In addition there are three other sensors to measure the GPS coordinates and time, the temperature and air pressure near by the detector. A python program running on a Linux notebook steers data taking and storage on disk.

Work at sea

With the expedition ANT-XXIX/1 the experiment is conducted for a third time. The scientific goals are:

- Measurement of the number of cosmic muons in dependence on the latitude. The rate is expected to decrease with decreasing distance to the equator since the magnetic field of the earth guides the low energy particles to the poles. This geomagnetic effect will be measured. Existing data does not show the not expected results. To understand this in detail, more data will be needed.
- The use of the weather measurement stations on board (especially OCEANET and the weather balloon) for the investigation of the influence of meteorological parameters on the intensity of the cosmic radiation.

- The preparation of a common station consisting of a muon detector (DESY) and a neutron monitor (Univ. Kiel, DESY and North-West Univ. South Africa) for long-term investigations of the sun's activity and for an early warning system of sun eruptions. Such eruptions of high particle intensities influence the "cosmic weather" and especially electronics systems installed on earth or in satellites. There is a net of detectors installed in different countries and at research stations in Antarctica for an early warning system of such dangerous events. With the *Polarstern* installation it would be possible to extend these measurements to the ocean area.
- The test of an improved detector generation and the study of their characteristics under operation conditions.

Preliminary results

Figure 5.1 shows the measured number of muons per hour in dependence on the latitude for two different detectors. Detector 1 (Dori) takes data in time period from 19/10/2012 0:00 until 25/11/2010 0:00 and Detector 2 (Mayer) in time period from 27/10/2012 0:00 until 25/11/2010 0:00.

Both measurements showed the same trend: a minimum near the equator and an increase number of muons to higher latitude.

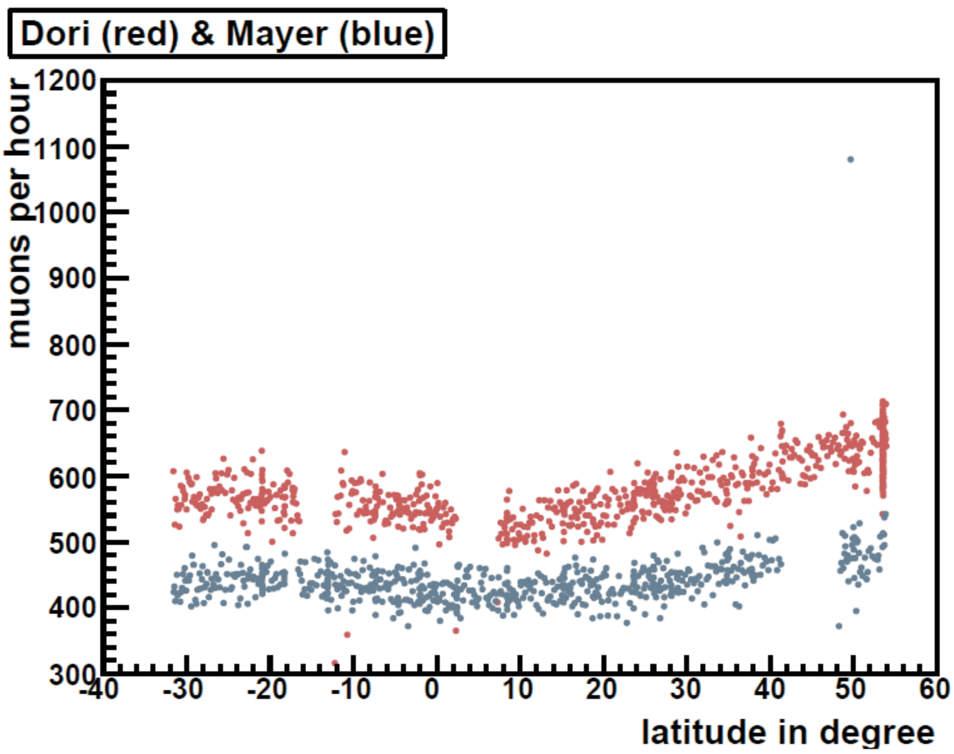

Fig. 5.1: Measured number of muons per hour in dependence on the latitude (two detectors)

Further first investigations showed an influence of meteorological parameters on the intensity of the cosmic particles at sea level. In order to correct the data from these atmospheric variations, Dori measured in Bremerhaven one week while *Polarstern* was still in the shipyard and no position changes influence the measurement. Figure 5.2 and 5.3 shows the anti-correlation between counting rate and surface pressure as well as surface temperature for this time period.

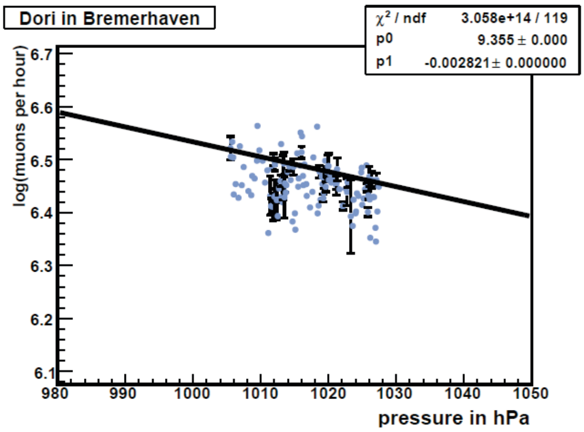

Fig. 5.2: Muon rate vs. pressure at sea level

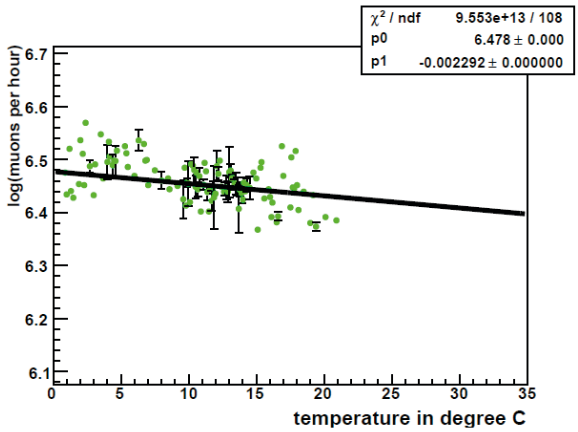

Fig. 5.3: Muon rate vs. temperature at sea level

Using these determined values the muon rate can be corrected to an air pressure of 1015 hPa and temperature of 10° C. Figure 5.4 shows the correction. There is seen a clear decrease of the rate going from north to the equator region and an increase from equator region to Cape Town. This should be effected by the geomagnetic effect.

The following topics will be studied with the taken data:

- investigation if the observed fluctuations of the muon rate during the day is caused by statistical fluctuations which could be reduced by using larger scintillation detectors.
- the influence of other meteorological parameters than air pressure and temperature (e.g. humidity, cloud density) and the influence of meteorological parameters in higher layers of the atmosphere on the muon rate.

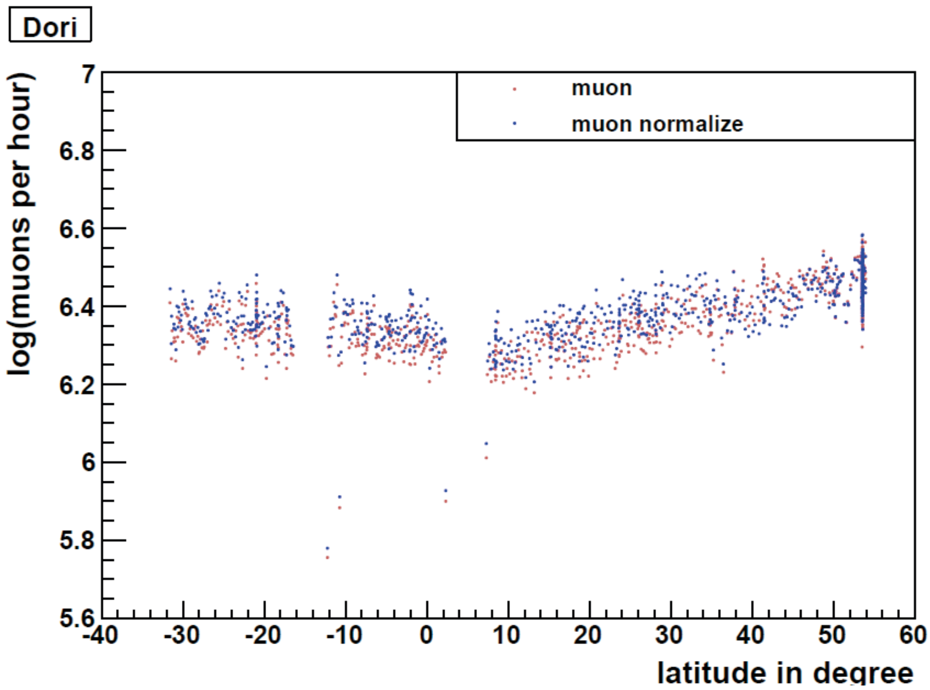

Fig. 5.4: Log of muon rate measured with Dori (red) and normalized log of muon rate (blue) in dependence of latitude

Data management

The data collected at this and at future cruises will be made available via a web-interface at DESY (http://physik-begreifen-zeuthen.desy.de/). They also will be used for school and student projects and for training programs of teachers.

6. SEA OF CHANGE: EUKARYOTIC PHYTOPLANKTON COMMUNITIES IN THE ATLANTIC

Katrin Schmidt[2], Michael Ginzburg[1], not on board: Thomas Mock[2], Klaus Valentin[1]

[1]AWI; [2]UEA

Objectives

Warming of the ocean temperature could lead to a change in phytoplankton communities and a shift in their ecological niche. It is expected that many sea-ice phytoplankton species won't be able to adapt because the predicted environmental changes will occur on a time scale too fast for evolutionary processes. Thus, it is more likely that species well adapted to the low-temperature Arctic environment (e.g. psychrophiles) will be replaced by intruders from lower-latitudes outside the Arctic Circle, a process that may already be underway. Despite the severity of current climate changes caused by global warming, there is a significant lack of fundamental data about phylogenetic and functional diversity in eukaryotic phytoplankton communities from the Atlantic to the Polar Ocean. These data are urgently needed in addition to those from intruder communities to identify differences in phylogenomic metabolism of both groups, which will help to make predictions about changes in biogeochemical cycles of elements in a warmer and ice-free Arctic Ocean. We therefore conduct the first targeted metagenomic and metatranscriptomic study of eukaryotic phytoplankton communities from Atlantic currents to high Arctic water masses. A comparison between DNA and mRNA will enable us to identify whether a change in community composition is reflected in metabolism underpinning biology driven cycles of CO_2 and other trace gases relevant for climate (e.g. DMS). All sequencing results will be analyzed in the context of environmental conditions (e.g. temperature, nutrients, CO_2, DMS) that have shaped these communities.

Work at sea

We sampled seawater of the chlorophyll maximum by a CTD/rosette sampler at 18 stations during a transect from Bremerhaven to Cape Town. The water samples we gained from the rosette sampler were filtered for DNA, RNA as well as pigments and nutrients. Filtration for RNA and pigment had to be rather quick to avoid degradation or physiological changes due to the sampling process. Therefore, we set the filtration time to a maximum of 1 hour to also gain enough biomass on our filter membranes.

All samples are preserved or frozen at -20° C or -80° C.

During the 18 stations we were able to collect 320 samples that will be analysed at the home institute. The DNA and RNA will be isolated, sequenced and the data processed at the JGI. Cultivation of microalgae from the different stations, was so far, not successful but we hope to isolate some species later on.

Preliminary (expected) results

We expect to be sequencing a diverse community of eukaryotic phytoplankton (>3 µm) with a relatively high level of polymorphisms even within a single genome because of large populations of which at least some do not reproduce by sexual recombination. Some of these genomes might have a higher degree of repeats (e.g. *Emiliania huxleyi*) and considerable heterozygosity between homologous chromosomes (e.g. *Fragilariopsis cylindrus*). However, we do not intent to reconstruct genomes, we will rather use the metagenome reads for phylogenomic reconstruction of community diversity (taxonomical and functional) and for mapping the metatranscriptome reads. Metatranscriptome sequencing will be based on polyA selected mRNA. We expect to be sequencing cDNA of reduced diversity and complexity compared to DNA.

The first impression of our samples shows a very poor yield. If this is going to be confirmed by quality analysis, we will need to sample again the Atlantic earlier in springtime. In order to improve our data set we will also include the Antarctic, which needs to be sampled to complete the latitudinal transect.

Data management

Once the samples are analysed, all data will be available via the Data Publisher for Earth & Environmental Science PANGAEA (www.pangaea.de).

7. EUROPA – EUROPEAN UNIVERSITIES & RESEARCH ONBOARD *POLARSTERN* IN THE ATLANTIC

Introduction

The main purpose of the EUROPA – "European Universities & Research Onboard *Polarstern* in the Atlantic" initiative was practical training of master students and Ph.D. candidates in state-of-the-art methods in marine research. Samples and data obtained during the cruise will be the basis for several master theses and at least two Ph.D. theses. As such, it is expected that data will be published within two years after the cruise. Certain geo-referenced data sets will be archived in and made accessible through the Data Publisher for Earth & Environmental Science PANGAEA (www.pangaea.de). For details, see the respective descriptions for the EUROPA sub-projects.

7.1 Physical Oceanography: water masses, structure and circulation in the Atlantic Ocean

Argiro Adamopoulou[1], Hilde van de Sande[1], Lisa Brunelli[1], Carlos Gil[1], Jörg Walter[3], Frank Shillington[2]

[1]EMBC
[2]UCT
[3]OPTIMARE

Objectives

Physical parameters such as temperature and salinity define water masses and their circulation patterns through density differences between water bodies. Water masses and circulation are of extreme importance for the distribution of nutrients and coupled with other biological parameters, such as oxygen and chlorophyll, determine the distributions of organisms in the water column. The surface water characteristics are seasonally and latitudinally dependent and mixing of water is mainly wind driven. On the other hand, deep water masses are driven by density variations; cold and dense waters sink beneath warmer and less dense water, driving deep ocean circulation.

Our research project focused on the study of different abiotic and biotic factors, i.e. temperature and salinity, oxygen, fluorescence and depth. Our four week cruise followed the eastern part of the Atlantic Ocean, along the western coast of Africa. The aim of our study was to record the physical factors at different latitudes in order to identify water masses and their distribution. In addition we also focused on patterns of these parameters in the water column. Moreover the measurements of biological parameters such as oxygen and fluorescence of chlorophyll help to identify distribution patterns of pelagic organisms.

Work at sea

During the cruise the CTD/Rosette (CTD/RO) was deployed at 18 different stations from 37°N to 30°S, going through a range of different latitudes. Fourteen out of the 18 stations were shallow stations during which the CTD was down-casted to 700 meters. The CTD/RO was deployed to 200 m depth at 5 stations, and to 2,500 m at 1 station. In addition to the recording of the different parameters, the device was also equipped with 24 Niskin bottles that were triggered to sample water at different depths. These water samples were then used for other studies, for instance to measure the content of chlorophyll in the DCM (Depth of Chlorophyll Maximum). Associated with every bottle the CTD recorded the punctual information about the parameters at the location at which it was triggered. The deployment of the CTD/RO and its operational procedures were controlled from the winch room. The data collected from the CTD were readily visualized during the down-cast, afterwards they were processed with a software in order to be imported in ODV (Ocean Data View); a program that allowed us to visualize in plots and graphs the different parameters measured.

Preliminary results

Our results show variations in the parameters measured over a range of different latitudes and depths. Both scatter and section plots were obtained by visualizing the data with ODV and further modelling of the data allowed us to acquire additional information about water mass properties and movement (such as geostrophic currents). From our analysis we were able to identify the different water masses and currents present along the transect. Some of our results were coherent to historical data collected in the same region, while others were more difficult to correlate possibly due to limitation in spatial resolution as well as other factors.

Data management

Hydrographical data obtained during the cruise are available through the Data Publisher for Earth & Environmental Science PANGAEA.

For CTD measurements please visit
http://doi.pangaea.de/10.1594/PANGAEA.817254

For *en route* measurements with the thermo-salinograph please visit
http://doi.pangaea.de/10.1594/PANGAEA.808836

7.2 Trends in primary production and nitrogen cycle along the cruise track

Theresa Schwenke[1], Mathieu Rembauville[2], Frank Dehairs[3]

[1]BreMarE UniHB, [2]UPMC, [3]VUB

Objectives

The EUROPA *Polarstern* cruise ANT-XXIX/1 from Bremerhaven to Cape Town crossed many latitudes and therefore offered an ideal opportunity to study how environmental variables influence the utilization of different N-nutrients by phytoplankton and what is the consequence on the nitrogen cycle. Crossing oligotrophic waters, particular attention was dedicated to study the production regime. Another aim was also to assess the distribution of phosphate, nitrate and ammonium from 0 to 700 m along the track of the cruise.

Work at sea

Regular sampling along the cruise track (measuring N-nutrient concentrations and uptake rates) provided quantitative information about those processes and their geographical variability. The distribution of macro-nutrients (nitrate, ammonium, phosphate) over latitude and depth in the eastern Atlantic Ocean was investigated in relation to the oxygen concentration in order to understand how the biogeochemistry and the oceanic circulation interact in the development of oxygen minimum zones. By incubations, the relation between primary production and physical variables such as light penetration, temperature, salinity and oxygen concentration was studied. Isotope-enriched nutrients ($^{15}NO_3^-$, $^{15}NH_4^+$, $^{15}N_2$) were used to measure the relative contribution of new production (especially the fraction of new production based on atmospheric N_2 fixation) and regenerated production to the total primary production. Parallel to CTD profiles, vertical profiles of PAR and natural fluorescence were measured from 0 to 150 m using a PNF 300-A sensor (Biospherical Instruments Inc.)

Preliminary (expected) results

Results related to isotopic enrichments will be provided by further analysis after the cruise. Phosphate distribution showed a dome-like distribution between 20°N and 20°S due to upwelling. Ammonium accumulation in the subsurface layer was observed in areas characterized by a deep mixed layer depth. Finally, the latitudinal gradient in the physical properties of the water column drove the production along the cruise track. The cruise passed through a seasonal gradient, from autumn/early winter in the northern hemisphere to end of winter/spring in the southern hemisphere. Further analysis of nitrate concentrations and isotopically labeled N_2 fixation will explain the expected increase in the N/P Redfield ratio in the Eastern part of subtropical North Atlantic gyre. Analysis of the $H^{13}CO_3^-$ uptake will confirm the trend in primary production observed from PNF calculations.

Data management

Biogeochemical data of the cruise will be archived at VUB, contact person: Prof. Dr. Frank Dehairs.

7.3 Biodiversity and activity of microbial biofilms in niches in the ocean (BAMBINO)

Marina Zure[2&3], Maria Papadatou[1], Chloé Maréchal[1], Jens Harder[3]

[1]EMBC, [2]MARES, [3]MPI

Objectives

Marine microbes can be found in all oceanic habitats, from several kilometers below the seafloor to the top millimeter of the ocean surface. Due to the vast metabolic diversity, marine microorganisms play key roles in marine food webs and are responsible for the cycling of nutrients. Marine microbes can be found as free-living or attached to particles and higher organisms (e.g. aggregates and zooplankton). During the EUROPA cruise, the main goal of the BAMBINO project was to collect samples along the transect in the Atlantic Ocean and to analyze the diversity of free living and particle-associated bacteria using culture independent methods.

Fig. 7.3.1: Manta-Trawl to be deployed over the starboard side of Polarstern

Work at sea

For that purpose water samples were collected from different depths with the CTD-rosette and larger particles were collected with a Manta trawl (Fig. 7.3.1) from the surface. The aim for the CTD samples was to filter water with different pore-size membranes to obtain fee living bacteria (0.2 µm fraction) and the particle associated bacteria (8 µm fraction). The Manta trawl was used to collect surface particles of biological and anthropogenic origin. In addition to the BAMBINO project, the ballast water tank was sampled over time to investigate the microbial diversity and its environmental condition.

Preliminary (expected) results

During the cruise, a large sample collection was obtained and further data analysis will provide insight into the bacterial diversity of the Atlantic Ocean. The molecular analysis will include amplification of the 16S rRNA gene for the diversity analysis of bacterial species with the universal bacterial and Planctomycete specific 16S rRNA primers and construction of clone libraries. In addition, the 18S rRNA gene will be amplified for the analysis of the eukaryotic species, to which bacteria are attached to.

Data management

Scientific samples and data of the cruise will provide the basis for two EMBC master theses and, in addition, they will form part of a MARES Ph.D. thesis.

7.4 Latitudinal and vertical trends of copepod abundance, species composition and biodiversity throughout the Atlantic Ocean

Md. Ashraful Islam[1], Maya Bode[2]

[1]EMBC
[2]BreMarE Uni HB

Objectives

Copepods play important roles in the oceanic food chain. Previous study on abundance and species composition of copepods in the central Atlantic Ocean provide sparse data. To study the abundance and species composition of copepods, samples were collected during the expedition ANT-XXIX/1 on a latitudinal transect (37°49'N to 18°14'S) in the Atlantic Ocean between November 01 and November 22, 2012.

Work at sea

Stratified zooplankton hauls were carried out at 16 stations with a multiple opening-closing net between 2,000 m water depth and the surface. Samples were analysed at *in-situ* temperature of 4° C. Larger individuals of copepods were sorted out manually. The remains of the samples were fixed in 4 % buffered formalin for further study on abundance of mesozooplankron community composition. Identification up to species level was conducted under a dissecting microscope. Copepod samples were preserved at -80° C for biochemical analyses.

Preliminary results

Sea surface temperature increased from station 1 to station 9 and decreased further south to station 16. The abundance of calanoid copepods was highest in the surface layer (0-100 m). At station 8, abundance was very high due to the occurrence of very high numbers of *Undinula vulgaris*. Total abundance was higher between 15°N and 2°S. Species richness was lower north of the equator and higher towards the south. *Pleuromamma* species showed a diel vertical migration with higher abundances at the surface during the night.

Data management

Zooplankton samples and data collected during the cruise will form part of a Ph.D. thesis at BreMarE Uni HB. After publication, geo-referenced data will be archived and made publicly available via the Data Publisher for Earth & Environmental Science PANGAEA.

7.5 Energy budget of dominant zooplankton species – temperature-dependent respiration and egg production rates

Cora Albrecht[1], Marina Giunio[1&2], Lies Vansteenbrugge[3], Lena Teuber[1]

[1]BreMarE Uni HB
[2]MARES
[3]Uni Gent

Objectives

The transfer cruise ANT-XXIX/1 from Bremerhaven to Cape Town was an opportunity to sample and explore zooplankton communities. The objectives of the project "Zooplankton Energy Budget" were to investigate the influence of abiotic factors such as temperature and depth on metabolism and energy allocation of selected zooplankton species. The aims were (a) to measure respiration rates in zooplankton species along the transect, (b) to measure respiration rates in zooplankton species sampled at different depths, and (c) to quantify egg production in the most abundant surface species.

Work at sea

Samples were collected using a Multinet Maxi with casts down to 2,000 m, Bongo net (0-200 m) and Manta trawl (surface). Animals used in the experiments came from 14 different stations, with temperatures ranging from 4.2 to 28.5° C. A total of 288 respiration experiments with 42 copepod species had been performed using a 10-channel optode respirometer in order to establish individual oxygen consumption at *in-situ* temperature. 20 egg production experiments were carried out using 13 species from the surface layer. Healthy females were placed in incubation bottles with surface water kept at *in-situ* temperature. Eggs were counted and measured after one day of incubation.

Preliminary results

Respiration measurements showed a significant correlation between depth and respiration rate: zooplankton species occurring in deeper layers had lower respiration rates than surface species, as it was expected. A significant impact of temperature on the respiration rates was proven and higher respiration rates with increasing temperature were established both in different species as well as in individuals of the same species. Q_{10} values were calculated for several species in order to prove the temperature impact on metabolic activity and the link to life-cycle strategies. Q_{10} values fit with literature data showing a range of 1.4 to 5.

Three copepod species produced eggs in five experiments, but the number of eggs was insufficient for any valuable conclusion regarding energy allocation.

Data management

Respiration rates, expressed in mg O_2 (mg DM)$^{-1}$ h^{-1}, were calculated in order to obtain comparable values for different species occurring at different depths and latitudes. The data set will be used for two Ph.D. theses in combination with frozen samples destined for biochemical analysis to test metabolic pathways.

7.6 LOKI, a high-resolution vertical profiler for zooplankton communities

Joy Smith[1&2], Hans-Jürgen Hirche[3]

[1]BreMarE Uni HB
[2]MARES
[3]AWI

Objectives

The aim of the work on this cruise was to study the vertical distribution of zooplankton in relation to environmental parameters, especially oxygen concentration, with LOKI, an optical zooplankton sensor, that consists of a camera system, a control unit, and a battery pack for autonomous deployment (Schulz et al. 2010). A built-in CTD including an Optode allows combining images with environmental parameters. A plankton net (0.6 m mouth opening, 200 µm mesh) concentrates the organisms before they pass the camera. This is necessary to obtain a representative sample also in regions with low zooplankton density.

Work at sea

During the cruise a total of 12 samples was obtained in the depth range of 400 to 800 m (Table 7.1). On each station, between 2,000 and 5,000 objects were imaged. The imaged objects were collected after passage through the imaging system and will be counted and determined under the microscope to aid image analysis. Images of key taxa were analysed with the help of taxonomists and were used to prepare a catalogue for later annotation of images to taxa. Furthermore, selected species classified before by taxonomists were imaged and also added to the catalogue.

As the samples were collected in different hydrographic domains and zoogeographic regions, we expect an interesting regional comparison. In a wider context the profiles obtained during this cruise in the south-eastern Atlantic will be compared with those from the south-eastern Pacific. Special emphasis will be on the oxygen minimum zones, which were more pronounced in the Pacific, as there oxygen concentrations close to zero were often encountered, whereas during this cruise lowest values were around 50 µmol kg^{-1}.

Preliminary results

A surprising observation during this cruise was the relatively high abundance of Rhizaria, which often formed large aggregates packed with remains of copepods in various stages of decomposition. It is unclear, however, whether these copepods were captured alive by the rhizarians or were already dead, possibly due to lack of oxygen.

Data management

After removal of double images with the built-in double filter, the LOKI data files will be stored in the Data Publisher for Earth & Environmental Science PANGAEA.

Reference

Schulz J, Barz K, Ayon P, Lüdtke A, Zielinski O, Mengedoht D, Hirche HJ (2010) Imaging of plankton specimens with the lightframe on-sight keyspecies investigation (LOKI) system. Journal of the European Optical Society, 5, 1001JS

Tab. 7.1: LOKI Stations

Sta LOKI	Sta PS	Date Nov	Latitude	Longitude	LOKI depth	Time depth	Time deck
LOKI 1	PS 81/04	5	26°02,9´N	17°27,4´W	400	11:35	11:59
LOKI 2	PS 81/05	6	23°40,9´N	20°09,3´W	400	14:32	14:55
LOKI 3	PS 81/09	11	8°29,0´N	18°36,2´W	750	12:37	13:15
LOKI 4	PS 81/10	13	2°24,4´N	13°37,1´W	800	12:22	13:05
LOKI 5	PS 81/11	15	2° 2,6‘ S	9° 25,7‘ W	500	10:57	11:27
LOKI 6	PS 81/12	16	4°39,7´S	7°03,5´W	500	10:47	11:14
LOKI 7	PS 81/13	17	7°23,7´S	4°54,3´W	500	9:36	10:04

Sta LOKI	Sta PS	Date Nov	Latitude	Longitude	LOKI depth	Time depth	Time deck
LOKI 8	PS 81/14	19	13°05,9´S	0°21,2´W	800	12:13	13:04
LOKI 9	PS 81/15	20/21	17°17,0´S	2°58,8´E	500	23:10	23:44
LOKI 10	PS 81/16	21	18°14.5´S	3°47,8`E	500	9:47	10:20
LOKI 11	PS 81/17	22	20°59,7´S	5°59,7É	700	16:55	17:31
LOKI 12	PS 81/18	23	22°38,6´S	7°11,5É	500	6:27	06:55

7.7 Macrozooplankton and ichthyoplankton biodiversity: latitudinal trends in species composition throughout the Atlantic Ocean

Christina Hörterer[1], Lisa Mevenkamp[1], Maciej Wolowicz[2], Elvira Morote[3]

[1]EMBC
[2]Uni Gdansk
[3]UAlg

Objectives

The food web of the open ocean consists of three groups, the phytoplankton, zooplankton and the nekton. Zooplankton is a very important food source for commercially harvested marine organisms. Anthropogenic activities influence this food web and change the biodiversity of the system. In this project, we studied the latitudinal distribution and biodiversity of macrozooplankton (Arthropoda, Cnidaria, Chaetognatha, Mollusca, Ctenophora and Chordata) with special focus on pteropods and ichthyoplankton.

Work at sea

Samples were collected on the ANT-XXIX/1 cruise from Bremerhaven to Cape Town at 17 stations by using a towed Bongo net (mesh size 300 µm). A subsample was analysed and fish larvae, arthropods and siphonophors were identified to the lowest taxonomic level possible. Abundances and diversity indices were calculated.

Preliminary results

We found a trend of an increasing diversity towards the equator from both hemispheres but with the peak at approximately 10° in all studied groups. The maxima in the abundance may be positively related to areas of high primary production, like upwelling regions. We also found a possible negative correlation of abundance and biodiversity. Pteropods showed a high variability in abundance related to diversity. To conclude, macrozooplankton distribution was related to biotic factors, such as productivity, and to abiotic factors such as different water masses. To measure species diversity, we calculated Shannon index (H’), Simpson index (SI) as well as Hills indices N1 (exp(H’)) and N2 (1/SI) using the program Primer 6 (Version 6.1.6.).

7.8 Molecular Genetics: DNA Barcoding

Anouk Neuhaus[1], Lucía Páiz[2], Marta Rodrigues[1], Marc Kochzius[2], Eva Garcia Vazquez[3]

[1]EMBC
[2]VUB
[3]Uni Oviedo

Objectives

The aim of the project during the ANT-XXIX/1 cruise was to collect zooplankton samples for DNA barcoding, population genetic and phylogenetic studies. DNA Barcoding is a tool used to identify organisms, using a small segment of mitochondrial DNA (approx. 648 bp); the most commonly used gene is cytochrome oxidase subunit I. As this technique is employed worldwide, some samples, e.g. different invertebrates and fish larvae, were used to test the universality of commonly used primers to amplify the COI gene in invertebrates. Also another aim was to perform different experiments in order to test the viability of DNA after being exposed to UV radiation and acidification.

Work at sea

Samples were collected using a Bongo net with a mesh size of 500 µm from a depth of 200 m to the surface. During this cruise, we performed the first steps of DNA Barcoding for macrozooplankton samples (i.e. DNA extraction and PCR), attempted to demonstrate the universality of primers for different taxa (e.g. fish larvae, copepods), and tested the viability of DNA extraction from different types of processed seafood (frozen, canned, cooked, smoked) compared to fresh samples. Also, we examined the effects of potentially harmful treatments to DNA. *A posteriori*, the samples will be sent to sequencing to correctly identify the organisms.

Preliminary results

At 15 stations 948 fish larvae, 416 invertebrates and 2981 copepod specimens were collected. DNA extraction of 36 individuals from different invertebrate taxa, 444 fish larvae and 240 *Euchaeta marina* was performed. The universality of primers was not significantly rejected, i.e. we could not prove that the primers were working with different efficiency for different taxa. However, this might be due to the small sample size as a trend was shown that with Folmer primers the DNA of some invertebrates for instance can be amplified more successfully than that of others. Comparisons among processed seafood showed that less processed samples presented better DNA quality than highly processed seafood. Acidic pH and UV light exposure induced DNA degradation in three different groups of organisms. While pH effects were principally coupled with the dose of exposure affecting all species equally, UV light degradation was species-species.

Data management

All tissue samples and DNA extractions will be stored at Free University of Brussels (VUB) and University of Oviedo. Genetic samples of several zooplankton taxa obtained during the cruise will be the basis for a master thesis at VUB.

7.9 Invasion via Ballast Waters

Julia Schmidt-Petersen[1], Deni Ribičić[1], Anastasija Zaiko[2]

[1]EMBC
[2]KU

Objectives

Ballast waters are one of the main vectors for transferring species worldwide. A large variety of organisms has already been transferred over long distances in ballast tanks as well as hull fouling. These events caused billion dollars of economic loss and severe environmental problems (Hewitt and Campbell, 2010). In this study we examine the physical and biological dynamics inside a moderate sized ballast water tank (70 m³) on a long-term voyage (more than 30 days) across different climatic zones, and will give an indication on the potential of the different taxa to be introduced to a non-native environment. Furthermore, microbiology samples were taken in order to determine microbial composition and to investigate how much it differs from the original composition. Additionally, environmental samples of the ballast water will be analyzed molecularly, using next generation sequencing of the „barcoding" CO1 locus, which will be carried out later at the University of Oviedo.

Work at sea

Sampling was carried out daily, via a water pump from the ship's ballast water tank. A total of 200 L was filtered through a 55 µm plankton net. On one occasion we had the possibility to open the manshole of the ballast tank and sample directly with a plankton net inside the tank. On 17 November 2012, further sampling had to be stopped because of a leakage of an adjacent oil tank into the ballast water tank. After filtration, organisms were stained with neutral red dye, for two hours, in order to distinguish between dead and alive specimens. To determine microbial composition, 200 ml of ballast water were filtered through 0.2 µm pore size filter and deep frozen for later analysis at the Max Planck Institute for Marine Microbiology. For next generation sequencing of the „barcoding" CO1 locus, samples were collected on a membrane of 12 µm pore size and preserved in 96 % alcohol for sequencing at the University of Oviedo.

In a series of experiments, potential ballast water treatments (UV light, increased salt concentration, oxygen depletion) and the impact of ballast water on different copepod species were tested.

Preliminary results

The ballast water temperature was following changes in sea surface temperature, reaching a maximum of 15° C above the initial temperature and a decrease thereafter. Oxygen concentration decreased to anoxic conditions (from 7.3 mg/l to 0.3 mg/l). pH showed a decrease as well (from 7.9 to 7.1). The density of organisms in the ballast water tank decreased during the voyage. After 6 days of sampling almost no organisms were recorded. On the day of the oil spill, 122 alive specimens of ciliates were found. Two different sampling methods were compared. More animals were sampled with the manhole sampling method than via the ballast water pump. Experiments gave a preliminary idea of the effectiveness of different ballast water treatments (replacement of oxygen, UV light, increased salinity) on the calanoid copepod *Scolecitrix sp*.

Data management

The main objectives of the ballast water project were education and training. Samples and data are stored at Klaipeda University, contact person: Dr. Anastasija Zaiko.

Reference

Hewitt C & Campbell M (2010) The relative contribution of vectors to the introduction and translocation of invasive marine species, pp56 - 70.

7.10 Atlantic marine top predators

Roberto Buonomo[1], Simon Jungblut[1], Holger Auel[2]

[1]EMBC
[2]BreMarE Uni HB

Objectives

The top predator project was conducted from about 50°N to 25°S and included continuous sighting surveys for seabirds and cetaceans with the objective to describe abundances, distributional ranges and species composition along the cruise track. Different hypotheses were tested including the relation with primary production and plankton abundance, the presence of top predator hot spots in certain areas and abundance minima in subtropical regions.

Work at sea

Observations and counting surveys were set up with a continuous observation effort from sunrise to sunset. The work took place at the vessels bridge or at the monkey island and involved a minimum of two observers at any time with the help of trained volunteers. Surveys stopped during station work and whenever the vessel was not moving with cruise speed along the transect. Seabirds were counted in 30 minutes intervals along the transect, while the distance line transect technique, estimating perpendicular distances from transects, was adopted for the counting of marine mammals.

Preliminary results

Seabirds were found to be more abundant in the area of the English Channel, Canary Islands and Cape Verde Islands. The lowest abundance was found in pelagic areas and with larger distance from the coast. Furthermore, species composition defined different areas which reasonably agreed with the biogeographical provinces as defined by the Marine Ecoregions of The World. There were too few cetacean sightings to allow for a species-specific analysis and sightings had to be grouped into larger taxonomic groups reflecting different detection probabilities. The density for all dolphins was estimated. Larger whales were only sighted between 45°N and 20°N.

No relation with the productivity of lower trophic levels or abiotic factors could be proven, neither for seabirds, nor for cetaceans, due to the high variability and low sighting numbers. The start of the seabirds breeding season and the migration of cetaceans on the southern hemisphere could have played a role for the uneven distribution.

Data management

The main objectives of the top predator survey were education and training. No scientific data have been recorded.

8. HYDROSWEEP DS 3 SYSTEM TEST AND TRAINING UNDER EXPEDITION CONDITIONS

Boris Dorschel[1], Ralf Krocker[1], Nadja Sandhop[1], Sören Krägefsky[1]
Saad El Naggar[2] (not on board)

[1]AWI
[2]Laeisz

Objectives

Following the update from the ATLAS HYDROSWEEP DS 2 to the new version DS 3 in 2010, the functionality for on-route Cmean estimation became unavailable. To compensate for this loss, an alternatively the Cmean calculation procedure from crossing multibeam profiles was made available. The general functionality of this method was confirmed during cruise ARK-XXVII/2. The objective for this cruise, ANT-XXIX/1, is however to assess the quality of this method by comparing the estimated Cmean with directly measured sound velocities in the water column derived from CTD casts.

The second objective of the cruise was to provide training for B. Dorschel and N. Sandhop on the Hydrosweep DS 3 system under expedition conditions.

Work at sea

In order to test the new Cmean procedure, crossing multibeam profiles were recorded from a flat area of seabed north of Gran Canary (Fig. 8.1). For comparison and for quality control, before recording the Hydrosweep profiles, a CTD cast was performed down to 2,000 m water depth at 28° 56.17'N / 15° 9.31'W.

After the CTD, the first profile was recorded from 28° 55.92N / 15° 9.55W to 28° 50.33N / 15° 11.33W. The cross line was recorded from 28° 54.24N / 15° 14.33W to 28° 52.56N / 15° 7.44W. During profiling, the ship travelled at a constant speed of 8kts. An assessment of quality of the Cmean will be performed by ATLAS Hydrographic after the cruise.

For the training objective, the DS 3 multibeam system and the Parasound sediment echosounder were constantly operated until Las Palmas. From Las Palmas to Cape Town, the multibeam system was operated during daytime only to avoid interferences with the EK60 echosounder operated at night.

Preliminary (expected) results

The multibeam data of the Cmean test and the corresponding CTD data will be provided to ATLAS Hydrographic for processing and analysis in order to improve this functionality. It is expected that the data will allow for an improvement and refinement of this method.

After the expedition, the trainees were confident in operating the DS 3 multibeam echosounder and were familiar with the data handling and workflows from system setup to the final outputs of cleaned and edited bathymetric data.

Data management

The data collected during the cruise will be stored in the AWI data repository Data Publisher for Earth & Environmental Science PANGAEA.

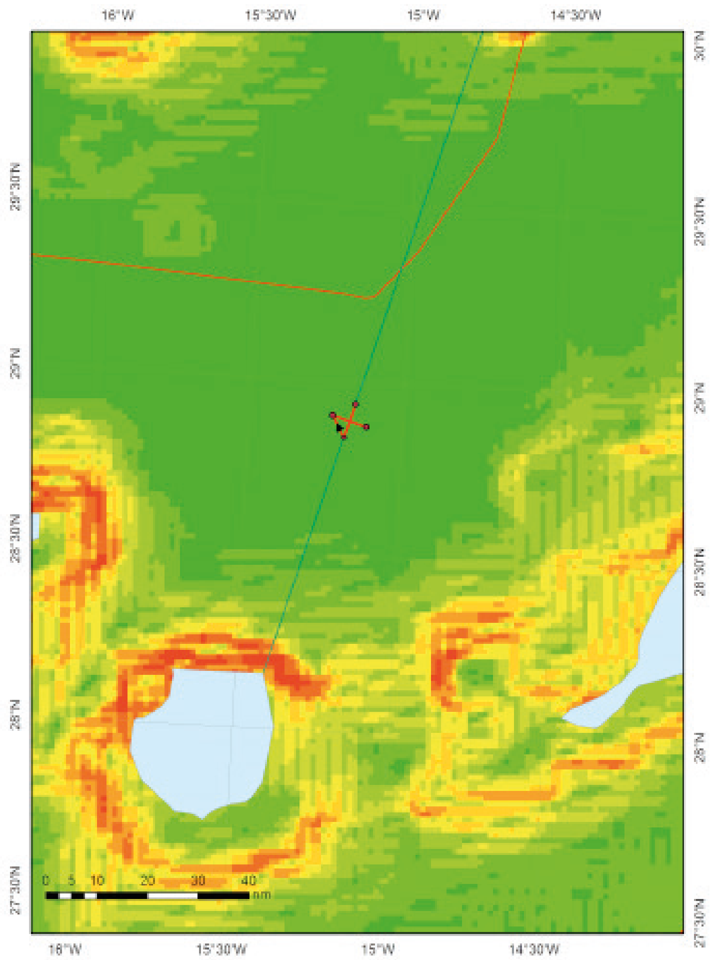

Fig. 8.1: Crossing Hydrosweep profiles. These profiles were used to test the Cmean functionality in the Hydrosweep DS 3 version. The image background is a an inclination image of the seabed north of the Canary Islands derived from GEBCO bathymetry.

9. SEA TRIALS OF THE NEWLY DEVELOPED SYSTEM FOR CALIBRATION OF THE MULTIFREQUENCY FISHERY ECHO SOUNDER SIMRAD EK60 ON BOARD *POLARSTERN*

Sören Krägefsky[1], Helmut Muhle[4], Olaf Hüttebräucker[4], Andre Stelljes[1], Erich Dunker[1] (not on board), Saad El Naggar[2] (not on board), Thomas Hanken[3] (not on board), Norbert Rieper[3] (not on board), Heiko Lilienthal[3] (not on board)

[1]AWI
[2]SELNA/Laeisz
[3]ISITEC
[4]Fielax

Introduction and objectives

Active hydroacoustic measurements allow for surveying the distribution of organisms in the size range of small macrozooplankton to large nekton with a very high temporal and spatial resolution. This cannot be achieved with any other survey method. Multifrequency echosounder measurements are routinely used for biomass stock estimates and are a highly valuable tool for behavioural studies (e.g. for surveying vertical migration behaviour and species interaction within the water column). In fishery science, hydroacoustic surveys are defined as the standard stock assessment tool for purpose of fisheries management, including krill stock assessment and management in the Antarctic Ocean. On board *Polarstern*, a Simrad EK60 scientific multifrequency echosounder with frequencies of 18, 38, 70, 120, 200 kHz is used for these survey tasks.

The backscatter characteristics of different marine organisms is a function of their shape, size and material properties and sound frequency, causing characteristic species or group specific differences in backscattering properties at different frequencies. These differences are used for species (or organism group) discrimination and identification.

In order to be able to compare measurements at the different frequencies for species identification and to derive reliable stock estimates, a proper calibration of the echosounder is needed. The Simrad EK60 calibration is performed by measuring the backscattering strength (target strength) of a series of copper sphere with known target strength. For a reliable calibration, a sufficient number of measurements covering the full area of the sound beam are required.

Due to the shape and dimensions of *Polarstern*, it is not possible to perform a calibration in the standard way by moving the copper sphere with three connected lines lowered at one location at starboard and two locations at backboard or vice versa (triangle configuration) without any further supporting/guiding structure. Only the deployment of three "plumblines" (ropes with 15 kg weights attached) carrying rings for guiding the single lines toward the plain of calibration enables stable placement and targeted movement of the small sphere within the sound beam. Coupling of the "plumblines" by the connected lines attached to the copper

sphere are supposed to minimise uncontrolled movement of the copper spheres caused by ships roll and pitch (Fig. 9.1). Until recently, moving of the calibration spheres was done by fishing reels veering out or heaving the line.
The "plumbline" technique allows for a reliable calibration of the Simrad EK60 echosounder on board *Polarstern*, and has been a strong improvement of the calibration procedure. This calibration method is however still a very time consuming and demanding task, particularly under the harsh, polar condition.

In order to shorten the ship time needed for calibration and to improve the handling, we developed a new calibration system (Fig. 9.1, Fig. 9.2), consisting of electronically controlled underwater winches. Due to the synchronised software-controlled operation of these winches, it is possible to exactly control the position of the calibration sphere in the sound beam of the echo sounder under the ships hull.

Underwater winches again are lowered and hieved by electrical winches positioned on deck (Fig. 9.2). The cable of the decks-winch is also used for power supply, data communication and control of the underwater winch. The underwater winch system is encased in a torpedo shaped housing serving as weight and winch protection. It also minimizes the drag and guarantees the free movement of the line connecting the underwater winch with the calibration sphere. Optical markers on this line serve as position markers allowing for measuring the length of the line heaved or veered out. .

First tests and trials were carried out during the cruise ANT-XXVII/4. The first evaluation of functioning and performance of the calibration system under field conditions required a redesign of the soft- and hardware. This redesigned system was then tested during the cruise ANT-XXIX/1 between Las Palmas and Cape Town (04.11.2012 – 27.11.2012).

Work at sea

Tests of the redesigned calibration system were performed on 07.11.2012, 11.11.2012 and 19.11.2012 during regular station work. Concurrent deployment of additional equipment allowed however only basic system tests (handling during deployment, checking the functioning of the mechanical and electrical parts and testing the performance of the data communication between underwater winches and deck units). The basic tests also included test calibrations with calibration spheres. During these tests, actual calibration sphere were lowered beneath the ship and moved by means of the three winches. During these test calibrations, the operation of the software, functioning and performance of the optical cord-length and marker detection, and synchronisation behaviour of the underwater winches during targeted movement of the calibration sphere were tested and improved.

On 19.11.2012 after regular station work without other station activities, a full calibration of the Simrad EK60 multifrequency echosounder was performed with the new calibration system.

Results

The new calibration system is easy and fast to deploy and to handle. The test however also revealed a few malfunctions of the system. One problem concerned the data communication between winches, deck units and control software via the ships network. Operating the system in a separate network fixed these problems.

A second problem was a malfunction of the optical detection of length markers. The optical detection of the cord-length worked however very reliable.

The test and the successful calibration of the Simrad EK60 (38, 70, 120 and 200 kHz) have shown, that the new calibration systems works well. The new calibration system furthermore significantly simplifies and fastens the calibration of the multifrequency echosounder. Good sea state and wind conditions and free manoeuvrability of the ship are however required to minimise the shear between ocean currents and ship to perform a successful calibration of the Simrad EK60.

Data management

No data were recorded for scientific purpose.

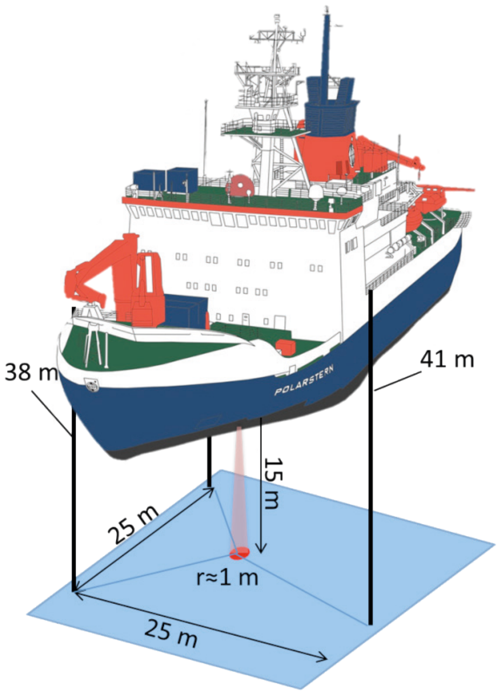

Fig. 9.1: Calibration set-up. Location of the three underwater winches or 'plumblines' (black vertical lines) and the resulting plain of calibration (blue area). Blue thin lines represent the lines connected to the calibration sphere. The red circle marks the sound beam area (radius ca. 1 m) at 15 m depth below the hull.

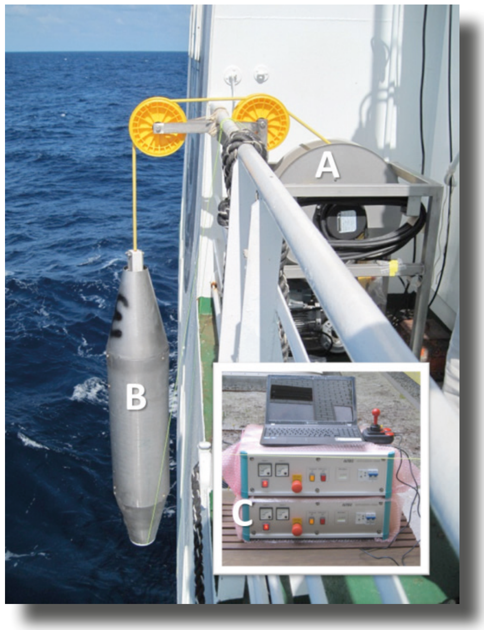

Fig. 9. 2: Cable winch (A), underwater winch with casing (B) and deck units

10. FURTHER CALIBRATION OF THE WAVE AND SURFACE CURRENT MONITORING SYSTEM "WAMOS II" BY USING A WAVERIDER BUOY AND SYNOPTICAL OBSERVATIONS

Saad El Naggar[2] (not on board), Sören Krägefsky[1], Ralf Krocker[1], Hartmut Sonnabend[5], Olaf Hüttebräucker[4], Helmut Muhle[4], Katrin Hessner[3] (not on board), Heiko Borgert[3] (not on board)

[1]AWI
[2]Laeisz
[3]OceanWaves
[4]Fielax
[5]DWD

Objectives

Wave and Surface Current Monitoring System (WaMos II) from "OceanWaves" which based on X-Band-RADAR was installed on *Polarstern* on 08.06.2011 in Bremerhaven. Due to the specific radar configurations and settings needed for WaMos II operation, an own X-Band radar (5 feet Antenna) was specially installed on the top platform, star port, in addition to the existing standard X-Band navigation radar (Fig. 10.1).

WaMos II was developed to provide waves and current parameters on-line and was installed on board to compare measured and observed parameters with the objective to use it for automatic sea states observations in the future.

Initial calibrations of the system were necessarily needed, due to the variability of reflected radar signal on the sea surface by different wave heights and sea conditions.

A Waverider buoy from "Datawell, Netherland" Type DWR-G 4, GPS-based (Fig. 10.2 and Tab. 10.1), was used by different locations and sea conditions to measure waves parameter nearby the ship (more than one mile). Both data sets were compared and system parameters were adjusted step by step by approximations.

First system calibrations were carried out on *Polarstern* during ANT-XXVIII/1 (28.10.2011 - 01.12.2011) on the way from Bremerhaven to Cape Town, using the system configuration described above.

System parameters were further tuned during ANT-XXVIII/2 and the final version of the software was installed in October 2012 in Bremerhaven, establishing additional data input for wind speed and wind direction (10 minutes averaged) and setting up a new system configuration.

New calibrations and tests were carried out during ANT-XXIX/1 (27.10.2012 - 27.11.2012) between Bremerhaven and Cape Town.

The mean objectives of this sea trial were the optimising of the system and testing its reliability for autonomous operations by comparison of different data sets obtained by measuring systems and others by synoptical observations.

Work at sea
WaMos-System was full operational during the cruise and all system components were checked and set according to manual and instructions at begin of each buoy deployment campaign.

Waverider buoy was prepared for deployments and radio data communication. Two data sets were obtained from the buoy by using direct transmission via radio (about 27 MHz) and by storing the data on board of the buoy. Both data sets of the Waverider buoy were used for WaMos comparison. Data sets of WaMos and of the buoy were visually compared on board and reported to the company OceanWaves.

Synoptical observations of the sea state were carried out every three hours during day Time by the DWD personals and compared to those measured by WaMos system. During the buoy deployment campaign, the synoptical sea state observation and comparison were done every 30 minutes

All data sets and protocols were sent to OceanWaves after each buoy deployment (Tab. 2) and used for comparison and calibration.

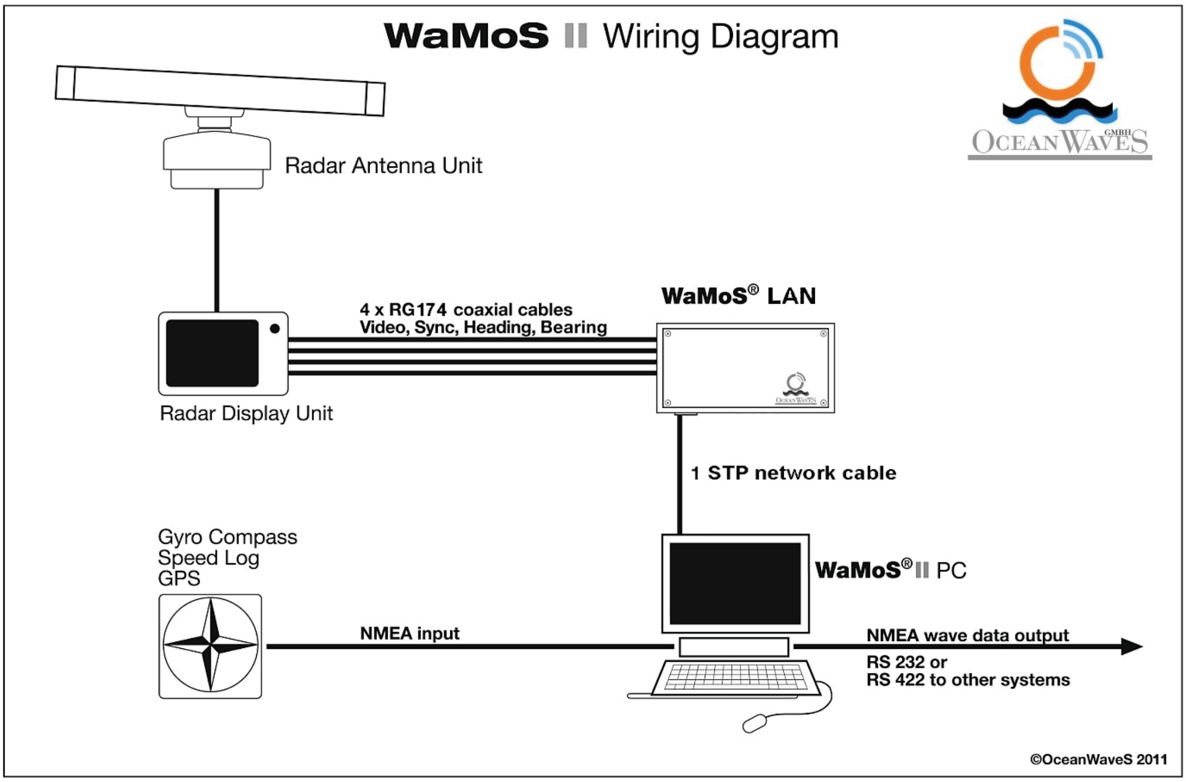

Fig. 10. 1: WaMos II configurations

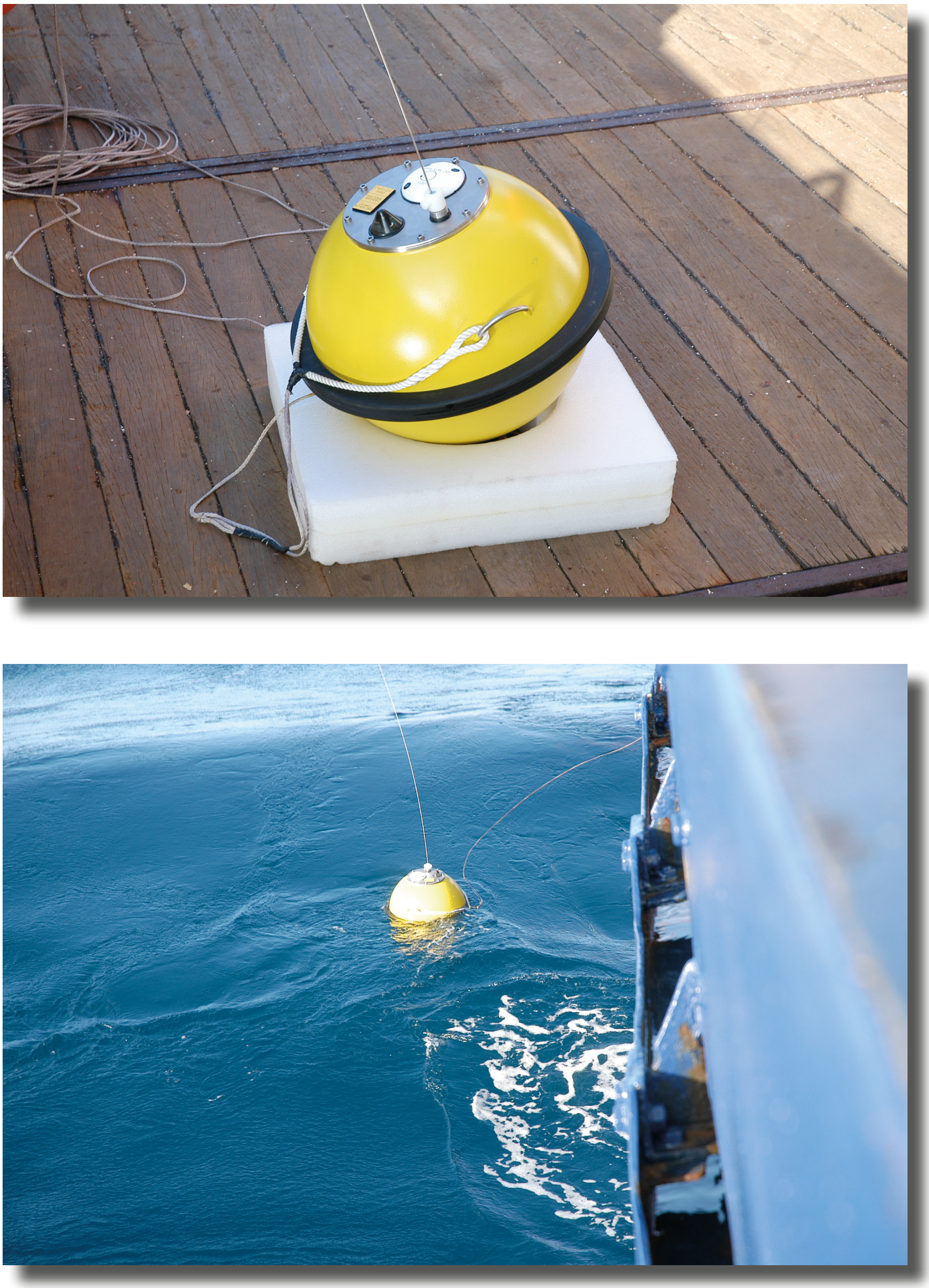

Fig. 10.2: Waverider buoy DWR-G4

Tab. 10.1: Technical specifications of Datawell buoy type DWR-G4

Wave motion sensor	Sensor	single GPS (not differential)
	Precision	1-2 cm, all directions (1σ) (excluding GPS antenna pitch and roll motion)
	Periods	heave 1.6 s -100 s direction 1.6 s -100 s (free-floating) 1.6 s - 20 s (moored)
	Calibration	not required ever
	Exclusion	GPS signals do not penetrate through water, occasional data gaps may occur
	Exclusion	not resistant to SA (Selective Availability, may be switched on by US Department of Defence for strategic reasons)
Wave data	Data	north, west, vertical
	Resolution	1 cm (north 2 cm, LSB "north" is GPS data gap indicator)
	Range	–20 m - +20 m
	Rate	1.28 Hz
	Reference	WGS84
Spectral data	Frequency resolution	0.005 Hz below 0.10 Hz and 0.010 Hz above
	Frequency range	0.025 Hz - 0.60 Hz
	Direction resolution	1.5º
	Direction range	0º - 360º
Standard features	Datalogger	Compact Flash Module 512 Mb
	Flashlight	4 high intensity LEDs, colour yellow (590 nm), pattern 5 flashes every 20 seconds
	GPS position	every 30 min, precision 10 m
Options	HF transmitter	frequency range 25.5 MHz - 35.5 MHz (35.5-45.0 MHz on request) transmission range: line of sight (hand-held receiver) 25 Km (receiver with ground-plane antenna) line of sight (receiver with portable antenna)
	GSM	mobile communication
	Argos	satellite communication
	Water temperature	range −5 - +46 °C, resolution 0.05 °C, accuracy 0.2 °C
	Hull painting	Brantho Korrux "3 in 1"paint system (no anti-fouling)
	Synthetic case	multiple use high quality packing case
	Mooring	up to several 100 m depth, up to 1 m/s currents
General	Hull diameter	0.40 m (0.46 including fender)
	Material	stainless steel (AISI316)
	Weight	17 Kg
	Batteries	operational life 30 days, 1 section of 4 batteries, type Datacell RC25GS (green). Rechargeable batteries on request
	Receiver	RX-C, RX-D or Warec (older Warecs may need modification)

Tab. 10.2: Waverider buoy deployments during ANT-XXIX/1

Buoy Deployment				Buoy Recovery			
Date	Time UTC	Latitude	Longitude	Date	Time UTC	Latititude	Longitude
31.10.12	07:30	41° 24,28'N	10° 45,26'W	31.10.12	15:15	41° 23,87 N	10° 41,29 W
06.11.12	07:45	23° 37,62'N	20° 10,93'W	06.11.12	14:10	23° 34,52'N	20° 8,33'W
09.11.12	7:50	15° 11.02'N	20° 30.29'W	09.11.12	14:10	15° 10,85'N	20° 32,07'W
11.11.12	7:50	8° 28,55'N	18° 37,45'W	11.11.12	16:30	8° 29,60'N	18° 35,67'W
17.11.12	7:50	7° 22,37'S	4° 55,14'W	17.11.12	12:40	7° 22,13'S	4° 57,79' W
19.11.12	7:50	13° 5,96'S	0° 19,32'W	19.11.12	18:20	13° 4,40'S	0° 25,81'W
22.11.12	10:50	20° 58,52'S	5° 59,07'E	22.11.12	18:15	20° 57,49'S	5° 54,52'E

Tab.10.3: Example of buoy measurements on 22.11.2012; 12:00 UTC

Results of Buoy Measurements on 22.11.2012; 12:00 UTC		
Symbol	**Name**	**Value**
T	Transmission Index	2
Hm0	Significant Waveheight	329.000 cm
Tz	Zero-Upcross Period	7.273 s
Smax	Maximum Spectral Density	1.2900E+1 m^2/Hz
TRef	Reference Temperature	0.00 ° C
TSea	Sea Surface Temperature	0.00 ° C
Bat	Battery Status	1
Mem	Memory Status	0
BLE	Battery Life Expectancy	7 weeks
Av	Vertical-Accelerometer Offset	0.00000 m/s^2
Ax	X-Accelerometer Offset	0.00000 m/s^2
Ay	Y-Accelerometer Offset	0.00000 m/s^2
Ori	Orientation	0.000°
Incl	Magnetic Field Inclination	0.000°
GPS	GPS Flags	3
Lat	Latitude	20° 58.262' S
Lon	Longitude	5° 58.197' E

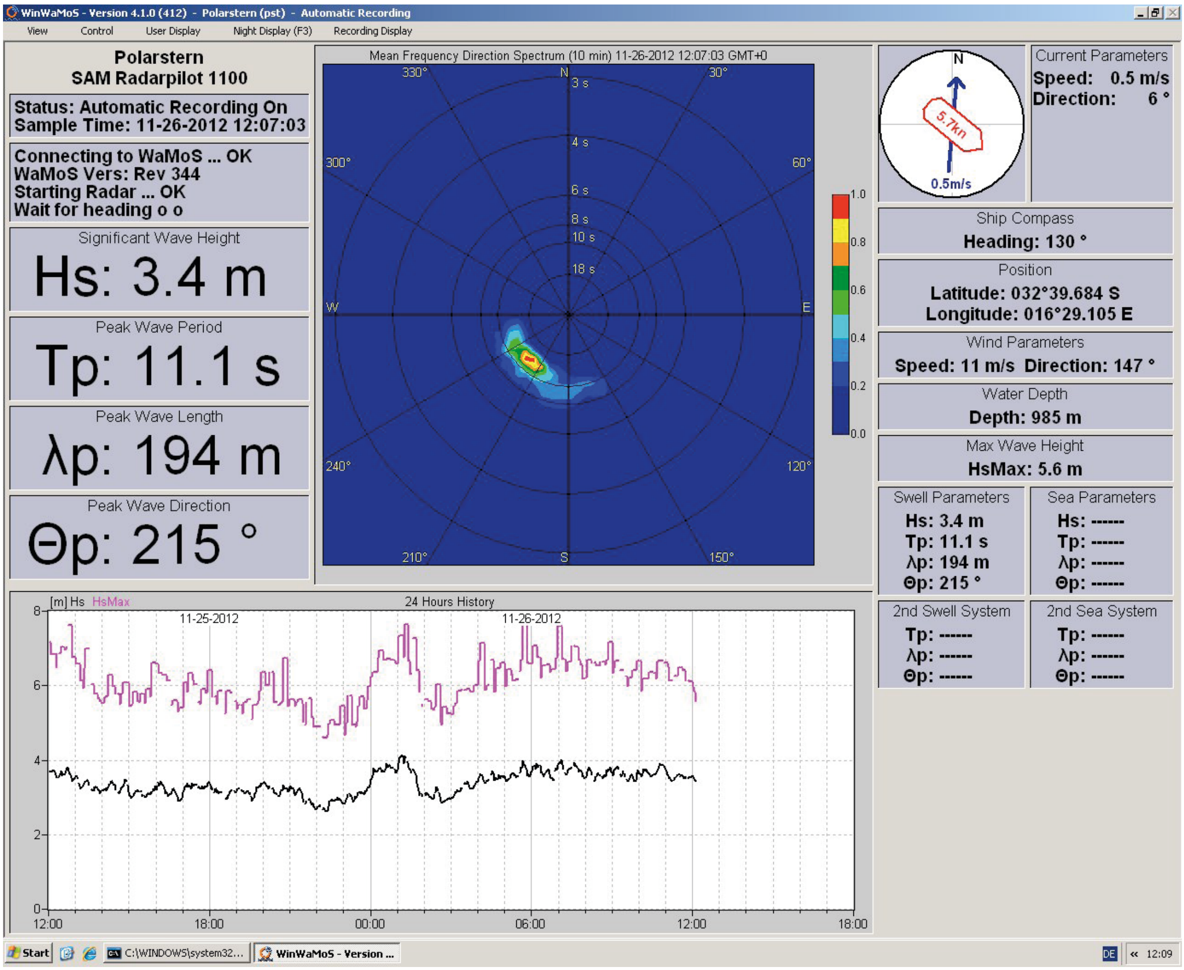

Fig. 10.3: WaMos display on 26.11.2012, 12:07 UTC, as example

Preliminary results

The visual comparison of WaMos and Buoy systems on board during the cruise shows that the WaMos was working properly, delivering reliable wave height, wave period, wave direction and wave length information. The provided sea states were in good agreements with the observed one. No changes in the system configuration or parameters were required. The actual system parameters are now valid for sea state determination (significant peak waves).

Figure 10.3 is presenting an example for the normal operation of WaMos system during the cruise and Tab. 10.3 shows an example of the received buoy data via radio during buoy deployment campaign.

Results of Buoy Measurements on 22.11.2012; 12:00 UTC		
Symbol	**Name**	**Value**
T	Transmission Index	2
Hm0	Significant Waveheight	329.000 cm
Tz	Zero-Upcross Period	7.273 s
Smax	Maximum Spectral Density	1.2900E+1 m^2/Hz
TRef	Reference Temperature	0.00 ° C
TSea	Sea Surface Temperature	0.00 ° C
Bat	Battery Status	1
Mem	Memory Status	0
BLE	Battery Life Expectancy	7 weeks
Av	Vertical-Accelerometer Offset	0.00000 m/s^2
Ax	X-Accelerometer Offset	0.00000 m/s^2
Ay	Y-Accelerometer Offset	0.00000 m/s^2
Ori	Orientation	0.000°
Incl	Magnetic Field Inclination	0.000°
GPS	GPS Flags	3
Lat	Latitude	20° 58.262‘ S
Lon	Longitude	5° 58.197‘ E

Preliminary data analysis done by OceanWaves is shown in Fig. 10.4 and Fig 10.5. Buoy and WaMos data are fitting well within the accuracy of both systems. The by WaMos system measured significant wave height (Hs), significant wave direction (θ) and significant time period (Tp), were compared to the same parameters obtained by synoptical observations of the sea states. All measured and observed parameters were fit very well within the accuracy of the observations.

The WaMos system was additionally able to distinguish between different sea states, which were not recognized by the visual observations. In Fig. 10.5 true wind speed and wind direction are plotted in addition to the waves data.

The most deviations between WaMos and buoy measurements are occurred by low wind speed, where the sea clutter (see days, 6.11. and 11.11.2012) was disappeared and the reflected radar signals was too low for detections. Those show the system’s limitations.

Further investigations are still necessary to complete the software, especially for current measurements. A fine tuning of the system and completing the software for direct data outputs are still required.

Data Management
No scientific data were recorded. The data were used for calibrations, tests and verification of the “WAMOS II” system only.

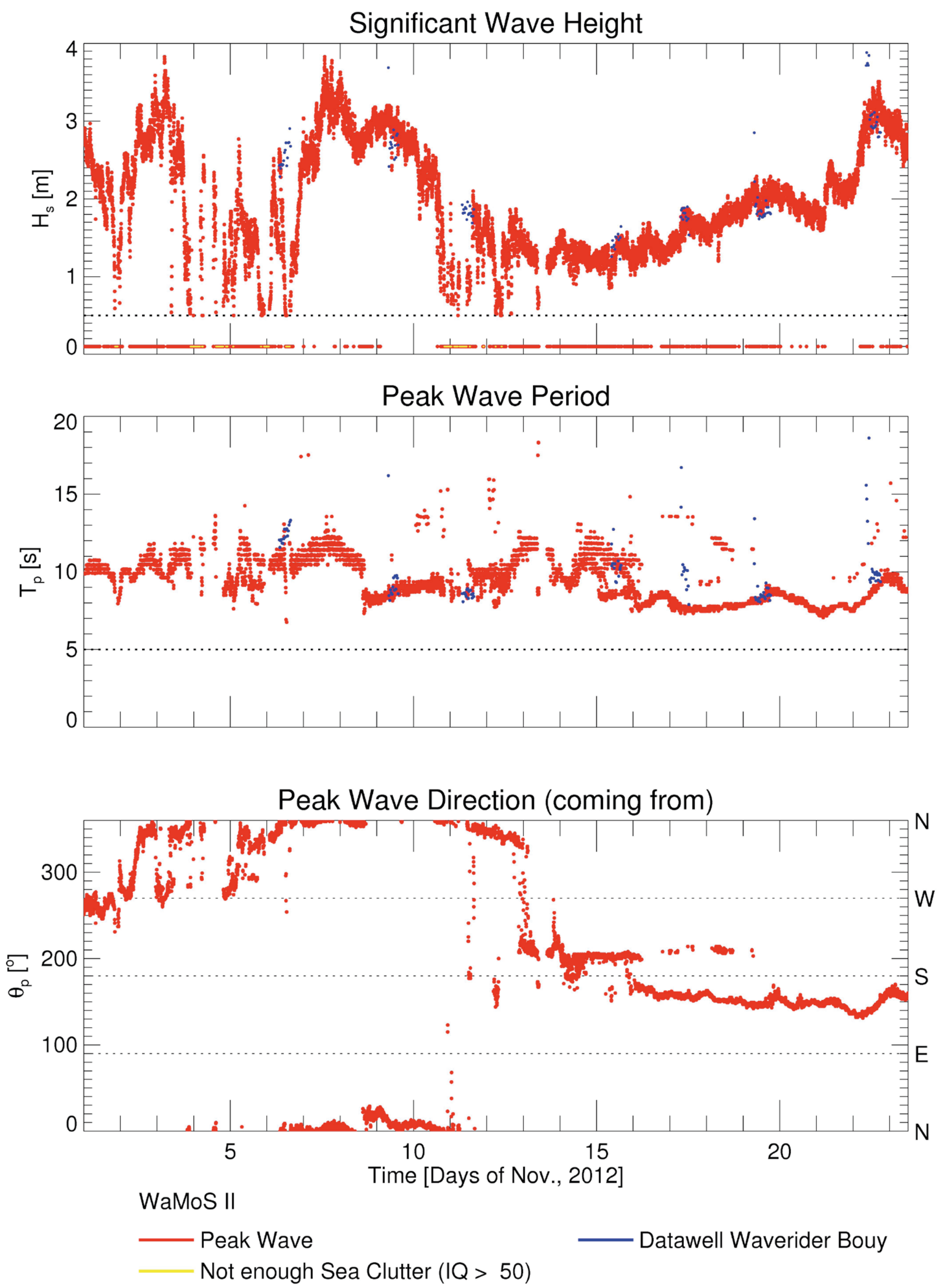

Fig. 10.4: Comparison of WaMos and buoy data for significant wave height, wave period and wave direction for November 2012. Red dots are WaMos data and blue dots are buoy data.

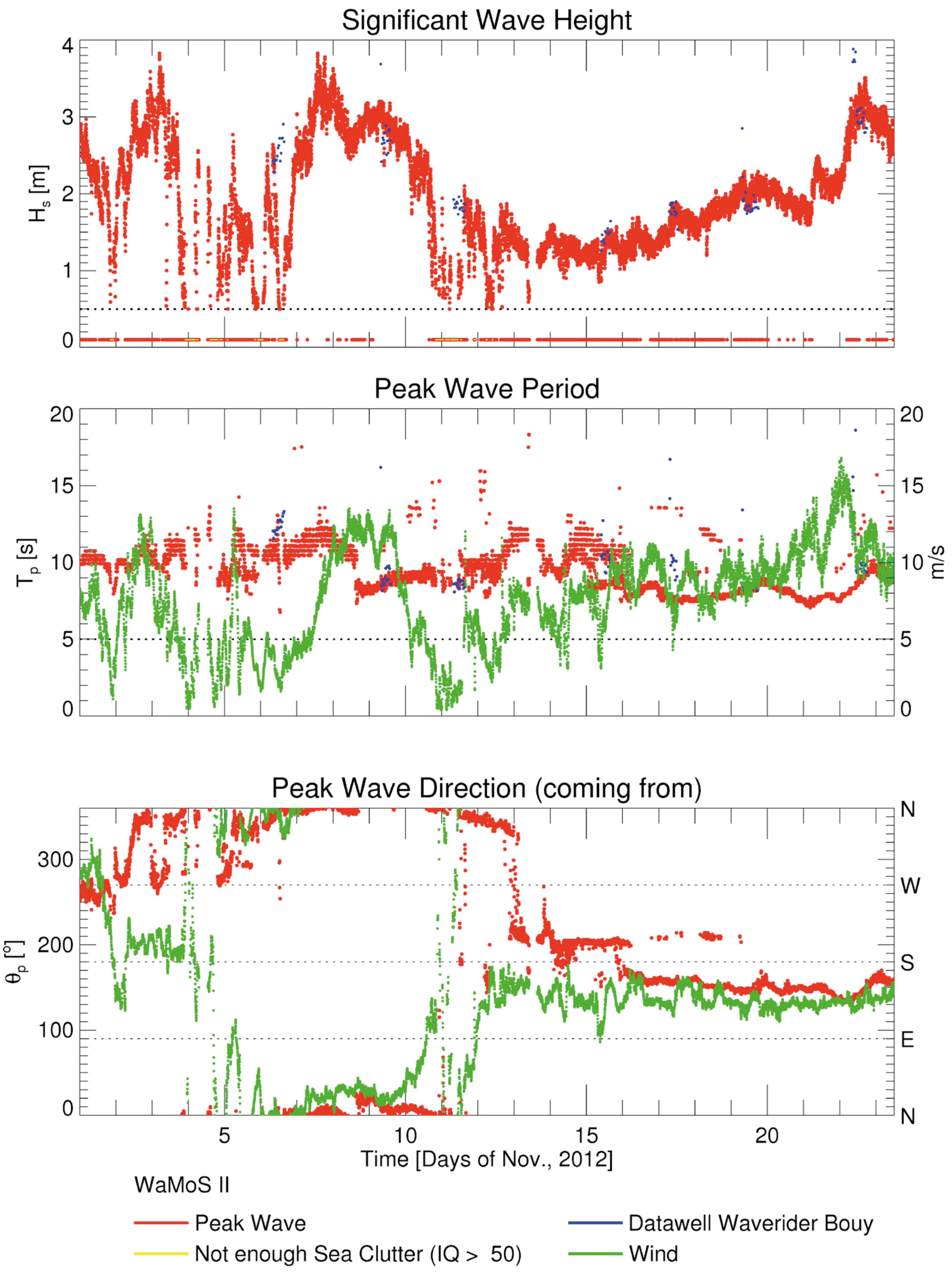

Fig. 10.5: Comparison of WaMos and buoy data for significant wave height, wave Period and wave direction for November 2012 including true wind data. Red dots are WaMos data, blue dots are buoy data and green dots are wind data.

11. TEST OF THE NEW HARDWARE OF THE UNDER-WATER NAVIGATION SYSTEM "POSIDONIA / USBL-BOX" DURING ANT-XXIX/1

Saad El Naggar[2] (not on board),
Sören Krägefsky[1], Ralf Krocker[1], Olaf
Hüttebräucker[3], Helmut Muhle[3]

[1]AWI
[2]Laeisz
[3]Fielax

Objectives

The company IXSEA is providing an updated hardware for the underwater positioning system (POSIDONIA). Initial tests with this USBL-Box were executed during *Polarstern* cruise ANT-XXVIII/1 and an improvement of the signal detection of the tracked transponder, compared to the currently installed system POSIDONIA 6000, was observed. After these tests, the system's firmware was updated to fix some bugs and to improve the graphic display of targets. During this cruise the amended IXSEA USBL-Box was tested again.

The main objectives of the sea trials were to develop the firm ware of the USBL-Box in cooperation between AWI and IXSEA to improve the layout, the graphic display, the calibration procedure and finally to adopt many useful features missed, which was used by POSIDONIA 6000 and especially for mooring's deployment and recovery.

Work at sea

USBL-Box was successfully installed and tested in Bremerhaven in June 2012. The system was not used during Arctic expedition (ARK-XXVII), due to the fact that at that time the USBL-Box was not ready for mooring works, ROV, and AUV operations.

Many sea trials and tests were carried out during ANT-XXIX/1 by using special transponder and releaser, to verify the functionality of the system and to compare the USBL-Box with POSIDONIA 6000.

The transponder was prepared for mounting on the CTD frame and was used on many times during the CTD casts to save ship time.

Furthermore, a range test was performed using the AWI-Mooring (AWI-247-2) located at (20° 57.8' S; 05° 58.6' E), to assess the maximum distance and the best direction in which the signals can be still received. Those are needed for AUV, ROV and mooring operations.

New graphic software developed by AWI and MARUM were used to provide an independent display platform and to improve the system features.

The gathered navigation data and the data describing the quality of signal detection will be sent to IXSEA for subsequent evaluation.

Preliminary results

The USBL-Box was fully operational for tracking the target transducer. Signal to Noise ratios were within specification up to 6,000 m range. However, there was a communication failure of release and other commands. The used front-end software displaying position information and status information still needs a lot of further developments to meet the requirements for reliable visualisation and practical use.

Unfortunately, the cooperation between AWI and IXSEA during this expedition was very poor due to the fact that most of the personnel responsible for IXSEA were on holiday.

The collected data will be sent to IXSEA for evaluation. Further sea trials and development will be carried out during the next cruises.

Data management

No scientific data were recorded. The sea trial was carried out in limited form due to limitations in ship's time.

12. MAPS: MARINE MAMMAL PERIMETER SURVEILLANCE

Jörg Walter[1]
not on board: Stefanie Rettig[2], Matthias Monsees[2], Gerd Rohardt[2], Ilse van Opzeeland[2], Olaf Boebel[2]

[1]OPTIMARE
[2]AWI

Objectives

Stationary, long-term observations of marine mammals focus on the temporal variation of marine mammal presence. Of particular interest are observations in marine mammal breeding grounds, which are aimed at unravelling the stock structure of a given species. However, visual long-term observations in open ocean regions are impossible to execute. This problem is overcome by use of passive acoustic recordings, exploiting the fact that many cetaceans vocalize extensively during their breeding period. To gather information about blue and fin whale presence in their hypothesized Atlantic winter and breeding locations near the Walvis Ridge some hundreds of miles off the Namibian coast, a deep-sea mooring, AWI 247, hosting a passive acoustic recorder is maintained by AWI since 2010. The second deployment of this mooring AWI 247-2 was to be recovered and replaced by an identical mooring, AWI 247-3, during this expedition to continue this time-series.

Work at sea

Mooring AWI 247-2 was recovered on 22.11.2012, 06:12-08:23 UTC (it had been deployed at 20°57.8'S 005°58.6'E on 25.11.2011 18:27). The entire mooring was recovered successfully.

Mooring AWI 247-3 (Fig. 12.1) was deployed at 20°58.5'S 005°59.1'E on 22.11.2012 09:13 – 10:44 at a depth of 4,236 m. It again hosted a develogic SonoVault passive acoustic monitoring recorder (SN 1019) at approximately 737 m depth, and a Sea-Bird Electronics CTD Microcat SBE 37 directly below the recorder. The SonoVault had been started already in Bremerhaven in late September when it was set to record to 24-bit WAV format (5 minute duration per file) at a sample rate of 5,333 Hz. Amplification was set to "4", equaling 30 dB re 1µPa. 3 days before the deployment the system performance was checked. The "to be deployed" recorder was still running and one SDHC Card was already full. By that time, the internal clock of the SonoVault was running late by 23 seconds. The drift was considered acceptable for this application and was left uncorrected.

Preliminary results

The SonoVault recorder (SN 1008) of ANT 247-2 was recovered mechanically intact but not running. Inspection of its data record revealed that it had recorded data since its startup in Bremerhaven (including the transit period aboard *Polarstern*) until 25.08.2012. The very last files recorded contained electronic noise, a symptom likely related to low battery voltage. Nevertheless, it continuously recorded acoustic data for about 9 months (Fig. 12.2), between 10 Hz and slightly over 2 kHz, confirming the (acoustic) presence of blue, fin and humpback whales (Fig. 12.3) along with the ominous bioduck signal and frequently the signatures of distance air-gun shots used in seismic exploration. For further information on data processing please refer to the cruise report *Polarstern* expedition ANT-XXIX/2.

Data management

All passive acoustic data will be transferred to the AWI silo and made accessible through the Data Publisher for Earth & Environmental Science Pangaea.

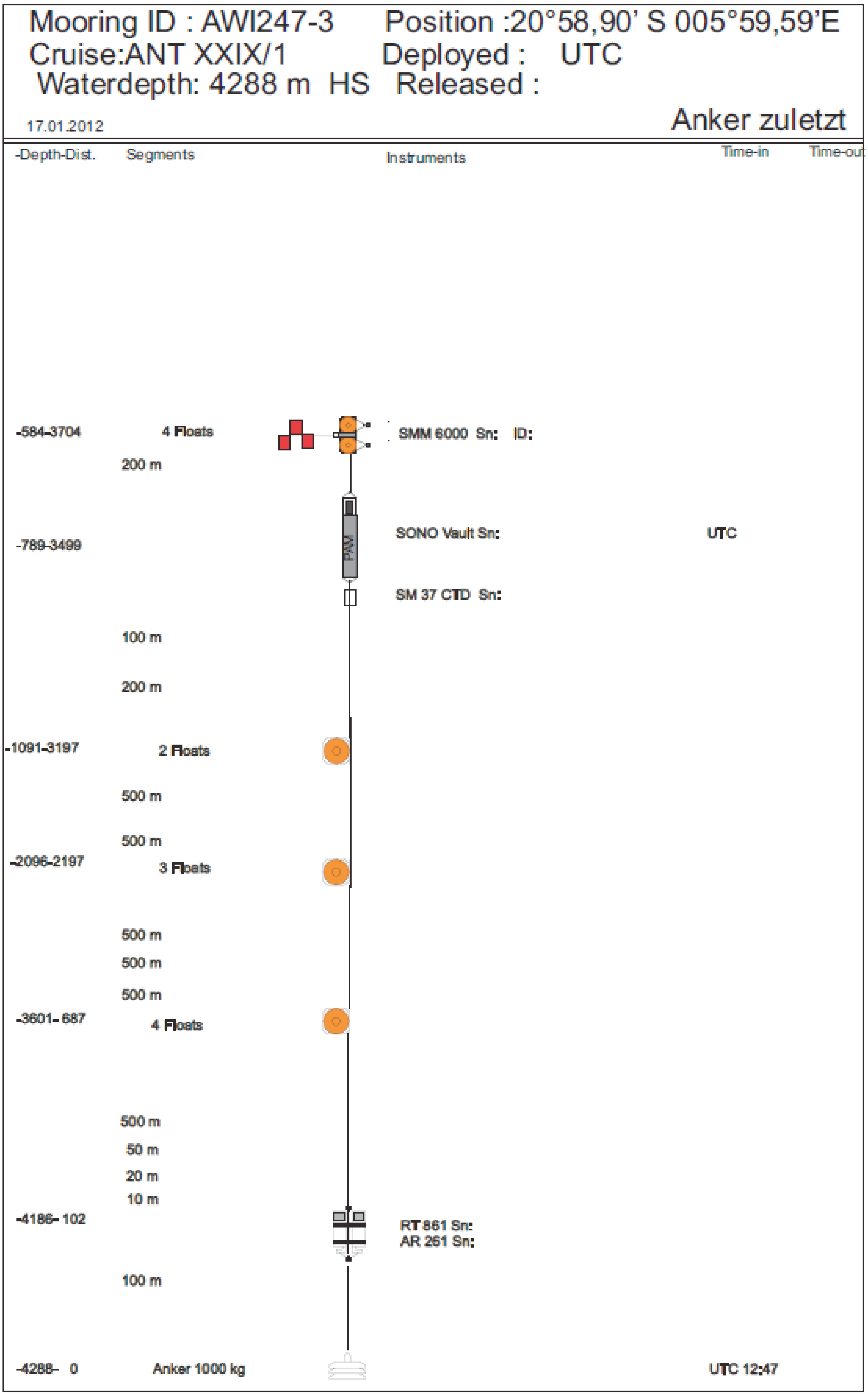

Fig. 12.1: Schematic of mooring AWI 247-3. Final instrument depths are approximately 52 m shallower than indicated, as the depth at time of deployment was 4,236 m, rather the 4,288 m assumed for this plot. Position is nominal, for correct position see bridge protocol.

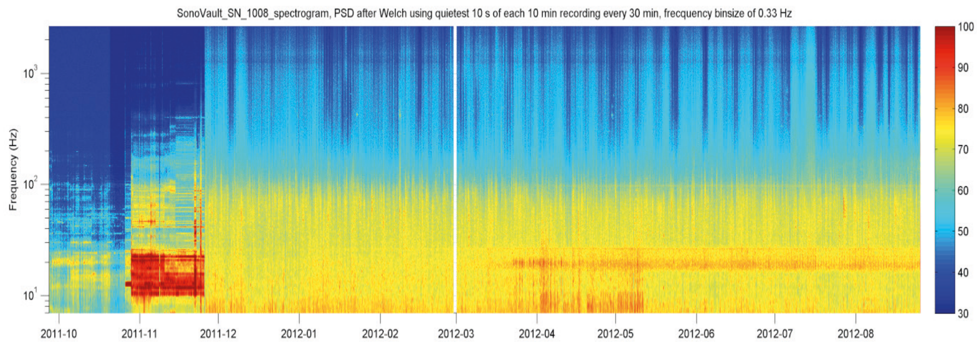

Fig. 12.2: Long term spectrogram of acoustic recordings by SonoVault SN 1008. Data prior to deployment (22.11.2012) was recorded on the ship during transit from Bremerhaven to the deployment site.

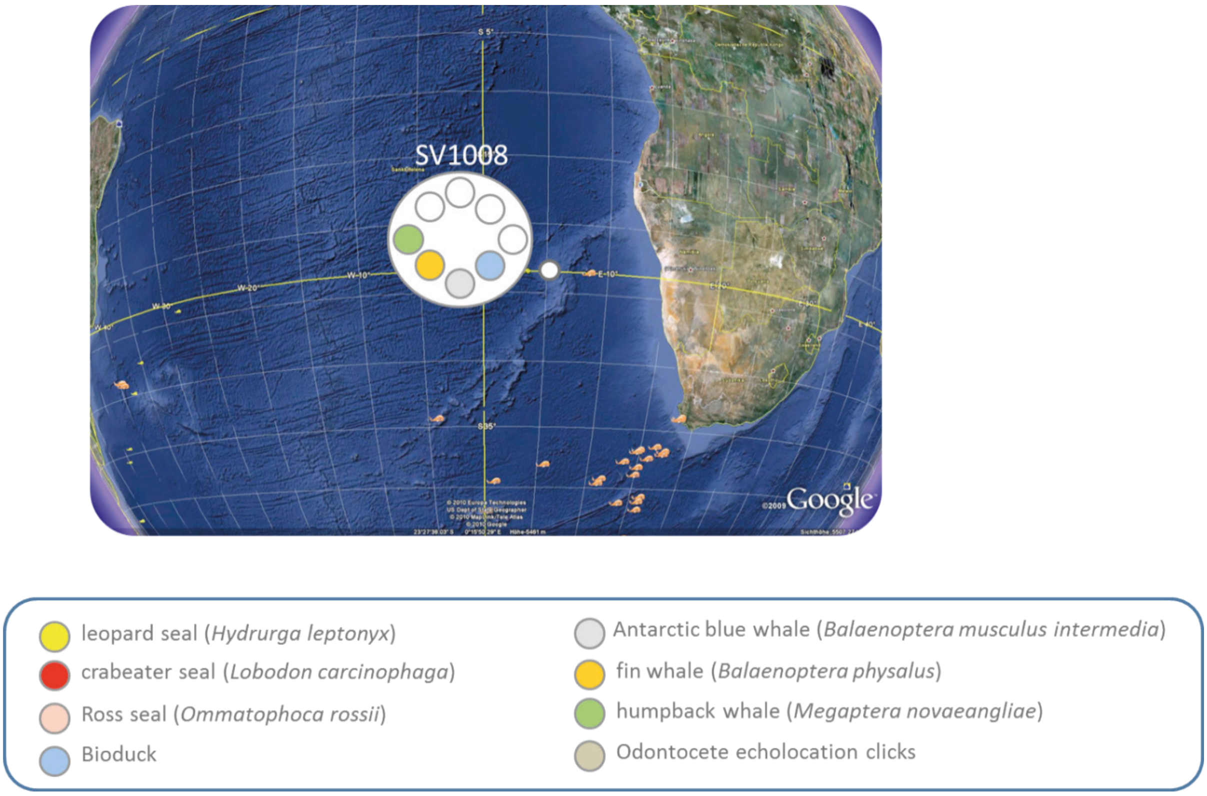

Fig. 12.3: Preliminary marine mammal acoustic biodiversity map showing the species composition recorded by SonoVault SN 1008 at AWI247-2 on the northern edge of Walvis Ridge in the Southern Angola Basin.

13. DOAS MEASUREMENTS

Not on board: Johannes Lampel[1], Jens Tschritter[1], Udo Frieß[1], Ulrich Platt[1]
[1]IfU

Objectives

Reactive halogen species (RHS) such as bromine oxide (BrO) or iodine oxide (IO) play a major role in the chemistry of ozone in both, the troposphere, and the lower stratosphere and thus possibly influence the ozone budget on a global scale. To estimate their overall influence, several measurement campaigns in the Marine Boundary Layer were conducted during the last years by the Institute of Environmental Physics Heidelberg. Due to their high reactivity and thus their short lifetime of several seconds, they have to be measured *in-situ* or via remote sensing methods, such as DOAS, **D**ifferential **O**ptical **A**bsorption **S**pectroscopy. Possible release mechanism of RHS are emissions from sea salt aerosols, photolytic destruction of halocarbons or anorganic precursors from the ocean (v. Glasow 2007). Read et al., (2008) first observed background concentrations of IO and BrO in the tropical MBL, Großmann et al., (2012) also showed via using chemistry models that the observed IO concentrations on the western pacific cannot be explained only by emissions of halocarbons, a strong I_2 source also had to be postulated.

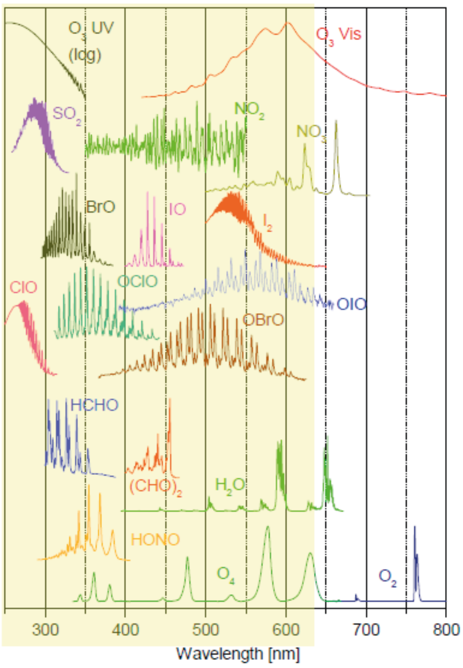

Fig. 13.1: Cross sections in the UV/ visible spectral range. The range covered by the MAXDOAS instrument onboard Polarstern is marked in yellow.

The continuous measurements onboard of *Polarstern* allow to set up global maps of the distribution of trace gases. These can be used to complement satellite measurements, which usually are less sensitive in the troposphere.

Work at sea

The used MAX-DOAS system allows remote sensing measurements of *BrO, SO_2, IO, NO_2, formaldehyde, glyoxal, water vapour and ozone* among others. It can provide profile information about these trace gases in the troposphere using radiative transfer modelling methods based on the absorption of O_4. Additionally it provides overall column density information about the above mentioned trace gases in the stratosphere. The MAX-DOAS system needs sunlight for measurements. One measurement sequence for one tropospheric profile takes approximately 15 minutes.

The measurements during ANT XXIX started in the harbour of Bremerhaven on Oct 25th 2012. Two days later the unsupervised system failed due to a broken USB Hub. Finding the problem and repairing it (this was done by FIELAX personal) took until *Polarstern* was south of Cape Verde on Nov 9th 2012. The measurements continued until reaching the port of Cape Town on Nov 26th 2012. In total the setup measured during 21 days.

MAX-DOAS uses the DOAS (**D**ifferential **O**ptical **A**bsorption **S**pectroscopy) Principle described in Platt et al., (2008). MAX-DOAS uses scattered sunlight, which effectively travelled for several kilometers in the troposphere before it reaches the instrument. This way it is possible to obtain long enough lightpaths to be able to measure absorptions of trace gases present at mixing ratios of a few ppt. Modelling of the light paths is necessary to obtain actual concentrations. (Frieß et al., 2006) This information can then be used to retrieve concentration profiles of the respective trace gas.

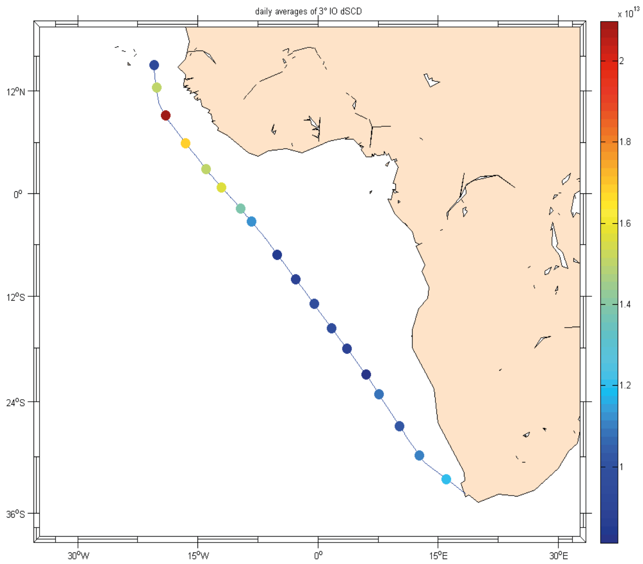

Fig. 13.2: Preliminary results of the DOAS measurements

Preliminary results

First evaluations showed that the repair work was successful and that the spectrometer was running as stable as before on the remaining part of the cruise leg until Cape Town. NO_2 was only detected close to shipping routes and/or towns. Preliminary analysis of iodine monoxide agrees with values obtained during previous cruises and observations from (Read et al. 2008). Radiative transfer modelling to obtain actual mixing ratios still needs to be done. The slant column densities of IO observed south of Cape Verde Island are corresponding to mixing ratios of about 0.5-2ppt, depending on the actual conditions for the radiative transfer.

Data management

The raw measurement data is currently permanently stored on the measurement PC itself, on *Polarstern's* data server and on a single PC at the Institute of Environmental Physics in Heidelberg. Preliminary evaluations together with the raw measurement data are stored also at the measurement data server in the Institute of Environmental Physics in Heidelberg, which is regularly backed up by the Universitätsrechenzentrum (University Computing Center) Heidelberg.
For further details, please contact one of the authors.

References

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v. Glasow R (2008) Atmospheric chemistry: sun, sea and ozone destruction. Nature, 453(7199), 1195-1196

APPENDIX

A.1 PARTICIPATING INSTITUTIONS

A.2 CRUISE PARTICIPANTS

A.3 SHIP'S CREW

A.4 STATION LIST

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

	Address
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven/Germany
BreMarE Uni HB	Bremen Marine Ecology Centre for Research & Education Universität Bremen (FB 2) Postfach 330 440 28334 Bremen/Germany
DESY	Deutsches Elektronen-Synchrotron DESY in der Helmholtz Gemeinschaft Notkestraße 85 22607 Hamburg/Germany
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg/Germany
EMBC	International M.Sc. Programme in Marine Biodiversity and Conservation http://www.embcplus.org
IfU	Institut für Umweltphysik Universität Heidelberg Im Neuenheimer Feld 229 69121 Heidelberg/Germany
KU	Klaipeda University Herkaus Manto Str. 84 LT-92294 Klaipėda/Lithuania
MARES	ERASMUS MUNDUS Joint Doctoral Programme in Marine Ecosystem Health and Conservation http://www.mares-eu.org
MPI	Max Planck Institute for Marine Microbiology Celsiusstrasse 1 28359 Bremen/Germany

	Address
OPTIMARE	OPTIMARE Systems GmbH Am Luneort 15a 27572 Bremerhaven/Germany
TROPOS	Leibniz-Institut für Troposphärenforschung e.V. Permoserstraße 15 04318 Leipzig/Germany
UAlg	Universidade do Algarve Campus da Penha 8005-139 Faro/Portugal
UCT	University of Cape Town MA-RE Marine Research Institute Private Bag X3 Rondebosch 7701 Cape Town/RSA
UEA	University of East Anglia School of Environmental Science Norwich Research Park Norwich, Norfolk NR4 7TJ/UK
Uni Gdansk	University of Gdansk Jana Bażyńskiego 1A Gdansk/Poland
Uni Gent	Ghent University Marine Biology Section Krijgslaan 281, building S8 B-9000 Gent/Belgium
Uni Oviedo	University of Oviedo Calle Doctor Fernando Bongera, s/n 33006 Oviedo/Spain
UPMC	Pierre-and-Marie-Curie University 4 Place Jussieu F-75005 Paris/France
VUB	Vrije Universiteit Brussel Pleinlaan 2 1050 Brussels/Belgium

A.2 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
Auel	Holger	BreMarE UniHB	Chief Scientist, biological oceanography
Adamopoulou	Argiro	EMBC	M.Sc. student, marine biodiversity
Albrecht	Cora Rabea	BreMarE UniHB	M.Sc. student, marine biology
Bode	Maya	BreMarE UniHB	Ph.D. candidate, zooplankton ecology
Brückner	Marlen	TROPOS	Atmospheric science
Brunelli	Lisa	EMBC	M.Sc. student, marine biodiversity
Buonomo	Roberto	EMBC	M.Sc. student, marine biodiversity
Dehairs	Frank	VUB	Biogeochemistry
Dorschel	Boris	AWI	Hydroacoustics, bathymetry
Engelmann	Ronny	TROPOS	Atmospheric science
Garcia Vazquez	Eva	Uni Oviedo	Molecular genetics
Gil Fernandez	Carlos	EMBC	M.Sc. student, marine biodiversity
Ginzburg	Michael	AWI	B.Sc. student, marine primary production
Giunio	Marina	BreMarE UniHB / MARES	Ph.D. candidate, zooplankton ecology
Gräser	Jürgen	AWI	Meteorology technician
Harder	Jens	MPI	Marine microbiology
Hirche	Hans-Jürgen	AWI	Zooplanktology
Hoerterer	Christina	EMBC	M.Sc. student, marine biodiversity
Huang	Shan	TROPOS	Atmospheric science
Islam	Md. Ashraful	EMBC	M.Sc. student, marine biodiversity
Jokat	Jürgen	AWI	Vessel acoustics

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**
Jungblut	Simon	EMBC	M.Sc. student, marine biodiversity
Kanitz	Thomas	TROPOS	Atmospheric science
Kochzius	Marc	VUB	Molecular genetics
Krägefsky	Sören	AWI	Hydroacoustics
Krocker	Ralf	AWI	Hydroacoustics, bathymetry
Leistert	Michael	TROPOS	Atmospheric science
Maréchal	Chloé	EMBC	M.Sc. student, marine biodiversity
Merkel	Maik	TROPOS	Atmospheric science
Mevenkamp	Lisa	EMBC	M.Sc. student, marine biodiversity
Morote	Elvira	UAlg	Ichthyology
Neuhaus	Anouk	EMBC	M.Sc. student, marine biodiversity
Páiz-Medina	Lucia	VUB	M.Sc. student, molecular genetics
Papadatou	Maria	EMBC	M.Sc. student, marine biodiversity
Rembauville	Mathieu	UPMC	M.Sc. student, biological oceanography
Rentsch	Harald	DWD	Meteorologist
Ribicic	Deni	EMBC	M.Sc. student, marine biodiversity
Rodrigues	Fernanda Marta	EMBC	M.Sc. student, marine biodiversity
Sandhop	Nadja	AWI	Student hydroacoustics
Schmidt	Katrin	AWI	Ph.D. candidate, marine primary production
Schmidt-Petersen	Julia	EMBC	M.Sc. student, marine biodiversity
Schulze	Reinhard	AWI	Vessel acoustics
Schwenke	Theresa	BreMarE UniHB	M.Sc. student, marine biology
Schwerdt	Carolin	DESY	Cosmic particles
Shillington	Frank	UCT	Physical oceanography

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**
Smith	Joy	BreMarE UniHB / AWI / MARES	Ph.D. candidate, zooplankton ecology
Sonnabend	Hartmut	DWD	Wetterfunker
Stelljes	Andre	AWI	Hydroacoustics technician
Teuber	Lena	BreMarE UniHB	Ph.D. candidate, zooplankton ecology
van de Sande	Hilde	EMBC	M.Sc. student, marine biodiversity
Vansteenbrugge	Lies	Uni Gent	Ph.D. candidate, zooplankton ecology
Walter	Jörg	OPTIMARE	CTD & mooring technician
Wolowicz	Maciej	Uni Gdansk	Marine zoology
Zaiko	Anastasija	KU	Ballast water ecology
Zure	Marina	BreMarE UniHB / MPI / MARES	Ph.D. candidate, marine microbiology

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
1	Schwarze, Stefan	Master
2	Grundmann, Uwe	1. Offc.
3	Farysch, Bernd	Ch. Eng.
4	Fallei, Holger	2. Offc.
5	Lesch, Florian	2. Offc.
6	Pohl, Klaus	Doctor
7	Hecht, Andreas	R. Offc.
8	Grafe, Jens	2. Eng.
9	Minzlaff, Hans-Ulrich	2. Eng.
10	Holst, Wolfgang	3rd Eng
11	Scholz, Manfred	Elec. Eng.
12	Fröb, Martin	ELO
13	Himmel, Frank	ELO
14	Hüttebräucker	ELO
15	Muhle, Helmut	ELO
16	Nasis, Ilias	ELO
17	Riess, Felix	ELO
18	Voy, Bernd	Boatsw.
19	Reise, Lutz	Carpenter
20	Bäcker, Andreas	A.B.
21	Hagemann, Manfred	A.B.
22	Koltzau, Knut	A.B.
23	Scheel, Sebastian	A.B.
24	Schmidt, Uwe	A.B.
26	Winkler, Michael	A.B.
27	Preußner, Jörg	Storek.
28	Elsner, Klaus	Mot-man
29	Pinske, Lutz	Mot-man
30	Plehn, Markus	Mot-man
31	Schütt, Norbert	Mot-man
32	Teichert, Uwe	Mot-man
33	Müller-Homburg, R.-D.	Cook
34	Martens, Michael	Cooksmate
35	Silinski, Frank	Cooksmate
36	Czyborra, Bärbel	1. Stwdess
37	Wöckener, Martina	Stwdess/N.
38	Arendt, René	2. Steward
39	Gaude, Hans-Jürgen	2. Steward
40	Möller, Wolfgang	2. Steward
41	Silinski, Carmen	2. Stwdess
42	Sun, Yong Sheng	2. Steward
43	Yu, Kwok Yuen	Laundrym.
44	Hetkämper, Hendrik	Apprent.

A.4 STATIONSLISTE / STATION LIST PS 81

PLA refers to the Manta Trawl neuston net towed at the surface.

Station	Date	Time	Gear	Action	Position Lat	Position Lon	Water depth [m]
PS81/001-1	01.11.2012	08:31	CTD/RO	max depth 713 m	37° 49,71‘ N	12° 5,12‘ W	5052
PS81/001-2	01.11.2012	08:37	PAR	max depth	37° 49,66‘ N	12° 5,12‘ W	5052
PS81/001-3	01.11.2012	09:40	MN	max depth 805 m	37° 49,39‘ N	12° 5,18‘ W	5051
PS81/001-4	01.11.2012	10:43	BONGO	max depth 500 m	37° 49,46‘ N	12° 6,22‘ W	5051
PS81/001-5	01.11.2012	11:57	PLA	max depth	37° 49,94‘ N	12° 9,32‘ W	5050
PS81/002-2	02.11.2012	08:18	PAR	max depth	34° 52,68‘ N	13° 7,98‘ W	3257
PS81/002-1	02.11.2012	08:26	CTD/RO	max depth 709 m	34° 52,68‘ N	13° 7,94‘ W	3253
PS81/002-3	02.11.2012	09:23	MN	max depth 800 m	34° 52,57‘ N	13° 7,95‘ W	3273
PS81/002-4	02.11.2012	10:27	BONGO	max depth 500 m	34° 51,38‘ N	13° 8,03‘ W	3425
PS81/002-5	02.11.2012	11:04	PLA	max depth	34° 49,88‘ N	13° 8,02‘ W	3566
PS81/003-1	04.11.2012	00:56	CTD/RO	max depth 2.538 m	28° 56,21‘ N	15° 9,25‘ W	3589
PS81/003-2	04.11.2012	01:58	HS_PS	profile start	28° 56,29‘ N	15° 9,42‘ W	3589
PS81/003-2	04.11.2012	03:45	HS_PS	profile end	28° 52,58‘ N	15° 7,44‘ W	3588
PS81/004-1	05.11.2012	08:34	BONGO	max depth 500 m	26° 2,48‘ N	17° 28,47‘ W	3497
PS81/004-3	05.11.2012	09:23	PAR	max depth 150 m	26° 2,93‘ N	17° 27,50‘ W	3492
PS81/004-2	05.11.2012	09:33	CTD/RO	max depth 712 m	26° 2,95‘ N	17° 27,50‘ W	3494
PS81/004-4	05.11.2012	10:38	MN	max depth 800 m	26° 2,92‘ N	17° 27,50‘ W	3491
PS81/004-5	05.11.2012	11:36	LOKI	max depth 400 m	26° 2,85‘ N	17° 27,36‘ W	3485
PS81/004-6	05.11.2012	12:09	PLA	max depth	26° 2,78‘ N	17° 27,10‘ W	3489
PS81/005-1	06.11.2012	07:58	BUOY	max depth	23° 37,90‘ N	20° 11,33‘ W	3896
PS81/005-2	06.11.2012	08:32	BONGO	max depth 500 m	23° 38,97‘ N	20° 11,21‘ W	3888
PS81/005-3	06.11.2012	09:51	PLA	max depth	23° 40,72‘ N	20° 11,15‘ W	3880
PS81/005-5	06.11.2012	10:32	PAR	max depth 150 m	23° 41,38‘ N	20° 10,81‘ W	3869
PS81/005-4	06.11.2012	10:57	CTD/RO	max depth 2.033 m	23° 41,33‘ N	20° 10,61‘ W	3869
PS81/005-6	06.11.2012	12:58	MN	max depth 2.002 m	23° 41,17‘ N	20° 9,92‘ W	3860
PS81/005-7	06.11.2012	14:32	LOKI	max depth 400 m	23° 40,76‘ N	20° 9,17‘ W	3857
PS81/005-1	06.11.2012	15:49	BUOY	on deck	23° 34,52‘ N	20° 8,33‘ W	3900
PS81/006-1	07.11.2012	08:30	PLA	max depth	20° 32,09‘ N	20° 51,95‘ W	3960
PS81/007-1	07.11.2012	22:28	CTD/RO	max depth 734 m	18° 45,35‘ N	20° 42,34‘ W	3225
PS81/007-2	07.11.2012	23:27	MN	max depth 800 m	18° 45,62‘ N	20° 42,81‘ W	3223
PS81/007-3	08.11.2012	00:41	BONGO	max depth 500 m	18° 47,06‘ N	20° 43,40‘ W	3226
PS81/008-1	09.11.2012	07:49	BUOY	in the water	15° 10,84‘ N	20° 30,26‘ W	4006
PS81/008-2	09.11.2012	08:23	BONGO	max depth 500 m	15° 12,14‘ N	20° 30,44‘ W	4003
PS81/008-3	09.11.2012	09:06	PLA	max depth	15° 13,86‘ N	20° 30,81‘ W	3995
PS81/008-5	09.11.2012	09:57	PAR	max depth 150 m	15° 15,02‘ N	20° 30,97‘ W	3991
PS81/008-4	09.11.2012	10:22	CTD/RO	max depth 2.033 m	15° 15,15‘ N	20° 31,05‘ W	3992
PS81/008-6	09.11.2012	12:20	MN	max depth 2.009 m	15° 15,14‘ N	20° 31,34‘ W	3992

Station	Date	Time	Gear	Action	Position Lat	Position Lon	Water depth [m]
PS81/008-1	09.11.2012	14:08	BUOY	on deck	15° 10,85' N	20° 32,07' W	4013
PS81/009-1	11.11.2012	07:53	BUOY	in the water	8° 28,55' N	18° 37,45' W	4737
PS81/009-3	11.11.2012	08:46	PAR	max depth 150 m	8° 28,54' N	18° 37,10' W	4737
PS81/009-2	11.11.2012	08:50	CTD/RO	max depth 2.239 m	8° 28,56' N	18° 37,09' W	4736
PS81/009-4	11.11.2012	10:47	MN	max depth 2.017 m	8° 28,97' N	18° 36,70' W	4736
PS81/009-5	11.11.2012	12:36	LOKI	max depth 750 m	8° 29,02' N	18° 36,21' W	
PS81/009-6	11.11.2012	14:58	BONGO	max depth 300 m	8° 29,44' N	18° 36,12' W	4887
PS81/009-7	11.11.2012	15:40	PLA	max depth	8° 29,33' N	18° 35,08' W	4888
PS81/009-1	11.11.2012	16:31	BUOY	on deck	8° 29,60' N	18° 35,67' W	4887
PS81/010-2	13.11.2012	08:16	PAR	max depth 150 m	2° 24,40' N	13° 36,11' W	5090
PS81/010-1	13.11.2012	08:45	CTD/RO	max depth 2.035 m	2° 24,39' N	13° 36,30' W	5091
PS81/010-3	13.11.2012	10:44	MN	max depth 2.028 m	2° 24,27' N	13° 36,70' W	5091
PS81/010-4	13.11.2012	12:23	LOKI	max depth 802 m	2° 24,36' N	13° 37,25' W	5091
PS81/010-5	13.11.2012	15:40	BONGO	max depth 300 m	2° 24,92' N	13° 37,10' W	5061
PS81/010-6	13.11.2012	16:21	PLA	max depth	2° 23,98' N	13° 36,04' W	5087
PS81/011-1	15.11.2012	08:17	BONGO	max depth 300 m	2° 2,33' S	9° 25,83' W	4043
PS81/011-3	15.11.2012	09:00	PAR	max depth 120 m	2° 2,63' S	9° 25,41' W	4037
PS81/011-2	15.11.2012	09:06	CTD/RO	max depth 713 m	2° 2,63' S	9° 25,47' W	4038
PS81/011-4	15.11.2012	10:04	MN	max depth 803 m	2° 2,66' S	9° 25,56' W	4038
PS81/011-5	15.11.2012	10:57	LOKI	max depth 501 m	2° 2,64' S	9° 25,80' W	4038
PS81/011-6	15.11.2012	11:41	PLA	max depth	2° 2,72' S	9° 25,75' W	4037
PS81/012-1	16.11.2012	08:16	BONGO	max depth 300 m	4° 39,45' S	7° 4,40' W	4218
PS81/012-3	16.11.2012	08:54	PAR	max depth 120 m	4° 40,01' S	7° 3,67' W	4214
PS81/012-2	16.11.2012	08:59	CTD/RO	max depth 711 m	4° 39,99' S	7° 3,65' W	4214
PS81/012-4	16.11.2012	09:53	MN	max depth 808 m	4° 39,77' S	7° 3,55' W	4211
PS81/012-5	16.11.2012	10:47	LOKI	max depth 501 m	4° 39,69' S	7° 3,44' W	4212
PS81/012-6	16.11.2012	11:26	PLA	max depth	4° 39,81' S	7° 3,10' W	4011
PS81/013-1	17.11.2012	07:51	BUOY	in the water	7° 22,37' S	4° 55,14' W	4837
PS81/013-2	17.11.2012	08:10	BONGO	max depth 300 m	7° 22,96' S	4° 54,75' W	4842
PS81/013-4	17.11.2012	08:51	PAR	max depth 120 m	7° 23,67' S	4° 54,27' W	4830
PS81/013-3	17.11.2012	08:55	CTD/RO	max depth 712 m	7° 23,68' S	4° 54,29' W	4834
PS81/013-5	17.11.2012	09:36	LOKI	max depth 500 m	7° 23,73' S	4° 54,42' W	4687
PS81/013-6	17.11.2012	10:36	MN	max depth 806 m	7° 23,79' S	4° 54,61' W	4613
PS81/013-7	17.11.2012	11:14	PLA	max depth	7° 23,98' S	4° 54,54' W	4535
PS81/013-1	17.11.2012	12:39	BUOY	on deck	7° 22,13' S	4° 57,79' W	4282
PS81/014-1	19.11.2012	07:52	BUOY	max depth	13° 5,96' S	0° 19,32' W	5288
PS81/014-3	19.11.2012	08:15	PAR	max depth 120 m	13° 6,30' S	0° 19,14' W	5004
PS81/014-2	19.11.2012	08:43	CTD/RO	max depth 2.032 m	13° 6,34' S	0° 19,24' W	5004
PS81/014-4	19.11.2012	10:36	MN	max depth 2.032 m	13° 6,01' S	0° 20,05' W	5004
PS81/014-5	19.11.2012	12:19	LOKI	max depth 800 m	13° 5,81' S	0° 21,58' W	
PS81/014-6	19.11.2012	16:40	BONGO	max depth 300 m	13° 5,75' S	0° 23,54' W	5339
PS81/014-7	19.11.2012	17:04	PLA	max depth	13° 6,14' S	0° 22,87' W	5465
PS81/014-1	19.11.2012	18:19	BUOY	on deck	13° 4,40' S	0° 25,81' W	5523

Station	Date	Time	Gear	Action	Position Lat	Position Lon	Water depth [m]
PS81/015-1	20.11.2012	21:21	CTD/RO	max depth 710 m	17° 16,99' S	2° 58,67' E	5463
PS81/015-2	20.11.2012	22:17	MN	max depth 806 m	17° 17,01' S	2° 58,79' E	5462
PS81/015-3	20.11.2012	23:12	LOKI	max depth 500 m	17° 16,93' S	2° 58,84' E	5462
PS81/015-4	21.11.2012	00:01	BONGO	max depth 300 m	17° 17,06' S	2° 59,31' E	5462
PS81/015-5	21.11.2012	00:27	PLA	max depth	17° 17,28' S	3° 0,03' E	5463
PS81/016-2	21.11.2012	07:16	PAR	max depth 120 m	18° 15,00' S	3° 47,92' E	5432
PS81/016-1	21.11.2012	07:18	CTD/RO	max depth 708 m	18° 15,00' S	3° 47,91' E	5433
PS81/016-3	21.11.2012	08:04	REL	max depth 400 m	18° 14,97' S	3° 47,78' E	5433
PS81/016-4	21.11.2012	08:58	MN	max depth 807 m	18° 14,58' S	3° 47,79' E	5433
PS81/016-5	21.11.2012	09:50	LOKI	max depth 500 m	18° 14,49' S	3° 47,84' E	5433
PS81/016-6	21.11.2012	10:28	PLA	max depth	18° 14,41' S	3° 48,02' E	5433
PS81/016-7	21.11.2012	11:17	REL	max depth 400 m	18° 14,21' S	3° 48,79' E	5433
PS81/016-8	21.11.2012	12:35	BONGO	max depth 300 m	18° 13,33' S	3° 48,45' E	5347
PS81/017-1	22.11.2012	06:12	MOORY	AWI 247-2 released	20° 57,57' S	5° 57,75' E	4237
PS81/017-1	22.11.2012	06:17	MOORY	AWI 247-2 surfaced	20° 57,48' S	5° 57,66' E	4237
PS81/017-1	22.11.2012	08:23	MOORY	on deck	20° 57,15' S	5° 58,52' E	4241
PS81/017-2	22.11.2012	09:13	MOR	AWI 247-3 deployment	20° 57,19' S	5° 57,48' E	4245
PS81/017-2	22.11.2012	10:44	MOR	on ground	20° 58,54' S	5° 59,07' E	4236
PS81/017-3	22.11.2012	10:55	BUOY	max depth	20° 58,47' S	5° 59,05' E	4235
PS81/017-4	22.11.2012	11:35	BONGO	max depth 300 m	20° 59,06' S	5° 59,61' E	4234
PS81/017-6	22.11.2012	12:57	PAR	max depth 120 m	20° 59,22' S	5° 59,80' E	4233
PS81/017-5	22.11.2012	13:29	CTD/RO	max depth 2.030 m	20° 59,25' S	5° 59,77' E	4233
PS81/017-7	22.11.2012	15:21	MN	max depth 2.005 m	20° 59,45' S	5° 59,70' E	4233
PS81/017-8	22.11.2012	17:34	LOKI	max depth 700 m	20° 59,76' S	5° 59,85' E	4232
PS81/017-3	22.11.2012	18:15	BUOY	on deck	20° 57,49' S	5° 54,52' E	4258
PS81/018-1	23.11.2012	06:27	LOKI	max depth 500 m	22° 38,60' S	7° 11,48' E	2681
PS81/018-2	23.11.2012	07:14	CTD/RO	max depth 204 m	22° 38,67' S	7° 11,55' E	2642
PS81/019-1	24.11.2012	06:11	CTD/RO	max depth 203 m	26° 26,50' S	9° 58,87' E	4696

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