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The Expedition of the Research Vessel "Polarstern" to the Antarctic in 2011 (ANT-XXVIII/1)

Edited by
Saad El Naggar
with contributions of the participants

HELMHOLTZ
GEMEINSCHAFT

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ANT-XXVIII/1

28 October - 01 December 2011

Bremerhaven - Cape Town

Chief scientist

Saad El Naggar

Coordinator

Eberhard Fahrbach

Contents

1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Saad El Naggar
AWI

Am 28. Oktober 2011 trat FS *Polarstern* den ersten Fahrtabschnitt der 28. Antarktisreise ANT-XXVIII/1 von Bremerhaven nach Kapstadt an.

Während des gesamten Fahrtabschnitts fanden kontinuierliche Messungen der atmosphärischen und ozeanischen Eigenschaften, der Energie- und Stoffflüsse zwischen Ozean und Atmosphäre, der Aerosolkonzentration sowie zum Einfall kosmischer Teilchen statt. Die Fahrt wurde außerdem genutzt, um umfangreiche Tests von verbesserten Systemen zur Unterwassernavigation und Bathymetrie auszuführen und eine Verankerung für Walbeobachtungen im Südatlantik aufzunehmen und eine neue am gleichen Ort auszubringen.

Folgende Projekte wurden durchgeführt:

Autonome Messplattformen zur Bestimmung des Stoff- und Energieaustausches zwischen Ozean und Atmosphäre (OCEANET)

Um die Energie- und Stoffflüsse zwischen Ozean und Atmosphäre zu erfassen, wurde ein Beobachtungssystem genutzt, das speziell für den Einsatz auf Fracht- und Forschungsschiffen konzipiert und eingesetzt wird. Dabei wurde die Expertise verschiedener Institutionen zusammengeführt: IFM-GEOMAR (CO_2-/O_2-Flüsse, Photosynthese, Energiehaushalt, Fernerkundung), IfT (Aerosol -Lidar – Messungen, Meteorologie in OCEANET-Container), GKSS Forschungszentrum (Ferry Box), AWI Bremerhaven (CO_2-System, Infrastruktur von FS *Polarstern*) und MPI Hamburg und Universität Frankfurt/Main.

Chemische, physikalische und optische Charakterisierung mariner Aerosole

Austauschprozesse von Gas und mariner Aerosole sind bis jetzt nicht vollständig geklärt. Mit Hilfe eines LIDAR-Systems und parallelen Messungen an Bord *Polarstern* wurden während dieser Reise neue Messmethoden eingesetzt, um die Aerosole nach ihrer Größe zu analysieren und zu unterscheiden.

Aerosol-Messungen mit MICROTOPS

Parallel zur Aerosol-LIDAR-Messungen wurden tägliche Messungen von Aerosol-Optische Dichten mit Hilfe von MICROTOPS durchgeführt.

Untersuchung der Aufzuchtgebiete von Bartenwalen in der Südhemisphäre

Auf der Anfahrt nach Kapstadt wurde die Tiefseeverankerung AWI 247-1, verankert auf 20° 58.90�much S 05° 059.59‘ E vor Namibia nahe des Walfischrückens, durchgewechselt. Die Verankerung trägt einen passiv-akustischen Rekorder, Sonovault, um die Anwesenheit von großen Bartenwalen in diesem Gebiet zu dokumentieren, von dem man vermutet, dass es ein Aufzuchtgebiet junger Bartenwale ist.

Beobachtung von Seevögeln und marinen Säugern

Die Bestände und die räumliche Verteilung von Seevögeln und Meeressäugern wurden von einer Gruppe aus Belgien (Laboratory for Polar Ecology) durch visuelle Beobachtungen erfasst.

Messung kosmischer Teilchen zur Untersuchung ihrer Breiten- und Wetterabhängigkeit

Die kontinuierlichen Messungen kosmischer Teilchen (DESY) wurden fortgesetzt und erlauben Untersuchungen zum Zusammenhang zwischen Wolkenbildung und dem Fluss kosmischer Teilchen.

Aussetzen von ARGO Drift-Bojen

Sechs Argos-Bojen von IFREMER (Frankreich) wurden auf diesem Abschnitt zur Bestimmung globaler ozeanographischer und atmosphärischer Parameter ausgesetzt.

Erprobung und Tests des Fächersonars „HYDROSWEEP DS III“

Die Wandler des Fächersonars „Hydrosweep DS III“ wurden im Oktober 2011 ausgetauscht. Eine erneute Kalibrierung des Systems war nach dem Umbau erforderlich und wurde zwischen Bremerhaven und Las Palmas durchgeführt.

Tests und Kalibrierung des Unterwasser-Navigatuions-System Posidonia

Das Unterwasser-Navigations-System „Posidonia“ wurde mit einem mobilen Eisschutzfenster ausgestattet. Die hydroakustischen Eigenschaften des Systems wurden erneut ermittelt. Das System wurde kalibriert und ist einsatzbereit.

Erprobung des Multifrequenz-Echolotes EK60 nach Austausch der Wandler

Alle Wandler des Fischereiforschungslotes „EK 60“ wurden im Juni bzw. Oktober 2011 erneuert. Eine zusätzliche 18 kHz Einheit wurde ebenfalls installiert. Somit wurden die Arbeitsfrequenzen des Lotes auf fünf erweitert (18, 38, 70, 120, 200 kHz). Während des Fahrtabschnittes wurde die Funktionalität des Gerätes erfolgreich getestet

Nutzung global verfügbarer CTD-Daten-Banken zur Erstellung von Schall-Geschwindigkeits-Profilen

Zur Erstellung globaler Schallgeschwindigkeitsprofile wurden CTD-Daten-Banken eingesetzt. Um diese Methode zu validieren, wurden auf diesem Abschnitt berechnete und gemessene Schallgeschwindigkeitsprofile miteinander verglichen.

Einsatz einer Wellenboje zur Kalibrierung des Wellenradars „WAMOS“

Wellenhöhen wurden mit Hilfe einer Wellenboje gemessen und zur Kalibrierung des Wellenradars eingesetzt.

Erneuerung des Zentraldatenerfassungssystem „D-Ship“

Das zentrale Datenerfassungssystem an Bord „D-Ship“ wurde auf LINUX umgestellt, getestet und in Betrieb genommen.

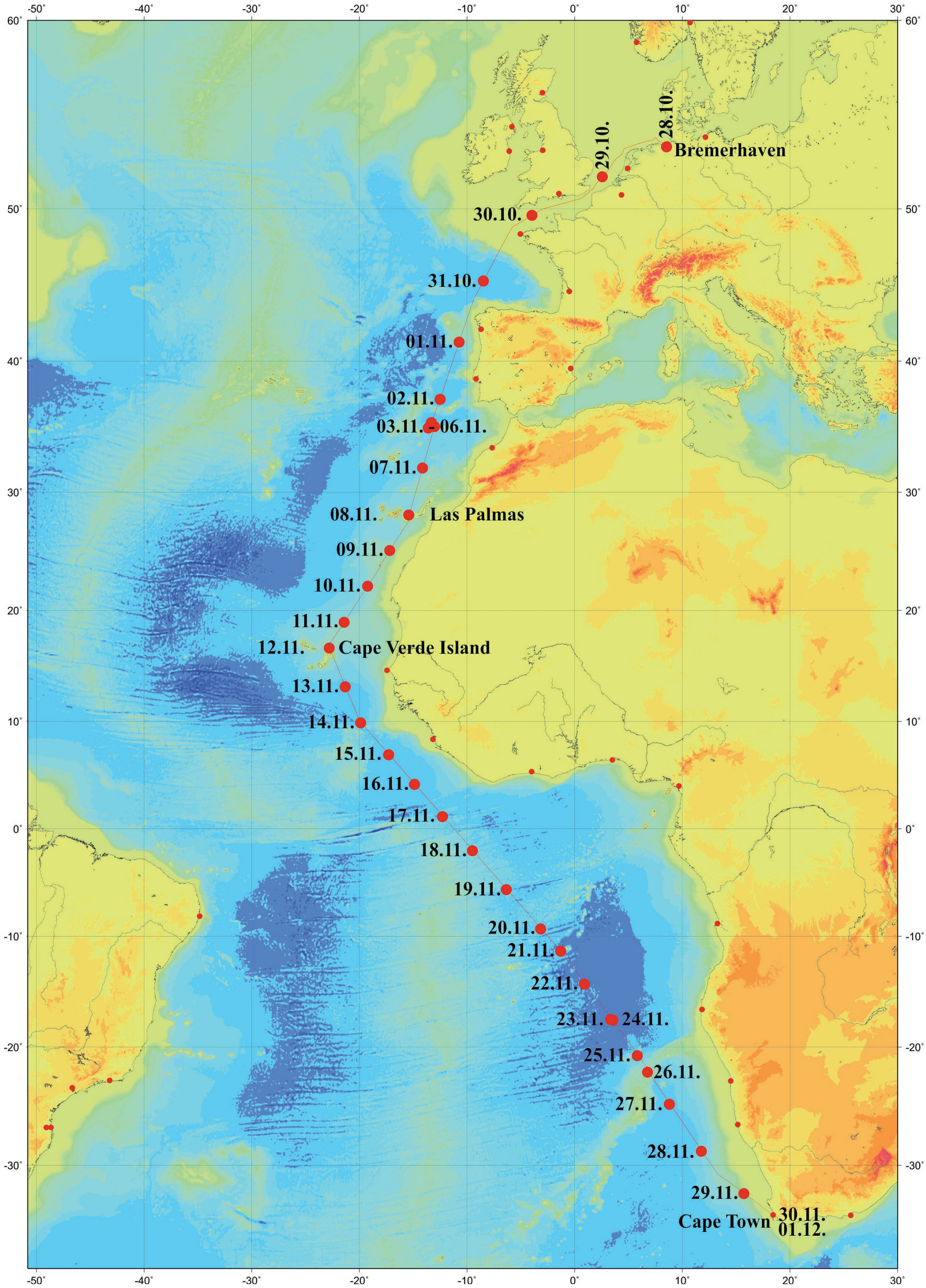

Abb. 1.1: Kurskarte der Polarstern Reise ANT-XXVIII/1

Fig. 1.1: Cruise track of Polarstern during the expedition ANT-XXVIII/1

ITINERARY AND SUMMARY

On October 28, 2011 *Polarstern* started her Atlantic transfer from Bremerhaven to Cape Town as the first leg of the 28th Antarctic cruise ANT-XXVIII/1.

During the cruise it was planned to perform continuous investigations of atmospheric and marine properties as well as to do research on energy and material fluxes between ocean and atmosphere, to carry out sea trials and tests of improved systems for underwater navigation and bathymetry, rate measurements of cosmic rays, and investigations to identify possible breeding grounds of whales in the Atlantic of the southern hemisphere.

The following programs were carried out:

Autonomous measurement platforms for energy and material exchange between Ocean and Atmosphere (OCEANET)

Monitoring of the energy and material exchange between ocean and atmosphere was performed by using an observation system developed for operational use onboard cargo and research vessels. The project is based on a network of expertise from IFM-GEOMAR (CO_2-/O_2-fluxes, photosynthetic status, energy budget, remote sensing), IfT (aerosols lidar measurements, meteorological measurements using the OCEANET Container), GKSS research center (ferry box), AWI Bremerhaven (CO_2-system, marine infrastructure of *Polarstern*), MPI Hamburg and University of Frankfurt/Main.

Chemical, physical, and optical characterization of marine aerosols on board Polarstern

Exchange of gases and aerosol particles between ocean and atmosphere is not well understood presently, although it has received considerable and intensive attention. New measurements were carried out using a LIDAR system to understand the formation mechanism of secondary fraction in marine aerosols particles and to characterize the optical properties of marine aerosols

Measuring the Aerosol Optical Depth (AOD) with the hand-held sun-photometer MICROTOP

In addition to the LIDAR aerosol measurements, optical thickness densities of aerosols were measured by using the MICOROTOPS.

Atlantic breeding grounds of mysticetes in the Southern Hemisphere

In the Angola basin an oceanographic mooring hosting an acoustic recorder (AWI) was recovered and a new one was deployed on the same location to enhance our knowledge of Atlantic breeding grounds of several species of baleen whales.

At-sea distribution of seabirds and marine mammals

Visual observations of seabirds and marine mammals were carried out by a group from Belgium (Laboratory for Polar Ecology) to determine the population distributions of those animals from higher to lower latitude.

Rate measurement of cosmic particles in dependence on latitude and weather conditions

Continuous rate measurements of cosmic particles (DESY) allow to investigate the influence of cloud formation on the cosmic particle flux.

Deployment of drifting ARGO floats

6 Argos floats were deployed during this cruise in co-operation between AWI and IFREMER (France) to measure global oceanographic and atmospheric parameters.

Sea trials and tests of the multibeam sonar "Hydrosweep DS III"

The multibeam sonar "Hydrosweep DS III" was modified by new soft and hardware to enhance the ahead sonar properties. Sea trials and tests were carried out during this cruise to develop the new beam former SPM II.

Sea trial and tests of the underwater navigation system "POSIDONIA 6000" after installation of mobile protective window

The ice protective window of the Underwater Navigation System "POSIDONIA 6000" was replaced by a mobile one. This new window is operated by a hydraulic system, which is able to open and close it during real operation in ice-covered areas. New calibration and tests were carried out.

Sea trials and tests of the multifrequency echosounder Simrad EK60 after replacement of all transducers and installation a new additional one (18 kHz)

The transducers of the multifrequency echosounder Simrad EK60 were replaced and an additional one (18 kHz) was installed. Sea trials and tests were carried out during this cruise.

Using existing globally available CTD-Data for deriving sound velocity profiles

Sound velocity profiles (SVP) are important parameters for multibeam sounder operations. Using the globally available CTD-data to derive global SVP will provide very useful tools to operate hydro-acoustic instruments. To validate this methodology the derived SVP were compared with those measured from board *Polarstern*.

Calibration of the eave and surface current monitoring system "WaMos" by using a Waverider Buoy

Waves' height measurements were carried out using a Waverider Buoy (Datawell) to calibrate the Wave Radar System installed on board (WaMos, Oceanwaves). The WaMos system is now calibrated and is operational. Wave heights and sea state could be now measured physically.

Upgrade the central data acquisition system "D-Ship"

The central data acquisition system "D-Ship" was upgraded to operate under LINUX. The system was installed and tested.

2. WEATHER CONDITIONS DURING ANT-XXVIII/1

Max Miller and Klaus Buldt DWD

During the first days of this expedition a vast high pressure area over Eastern Europe caused light to moderate westerly winds along our course and thus gave us a smooth start.

Approaching the English Channel on 29 October wind increased up to 5 - 6 Bft from southwest to south. These conditions remained until 31 October. Meanwhile a strong cyclone had developed off the coast of Newfoundland which influenced the weather on our course while moving east. On November 1, wind from south to southwest increased up to 7 Bft but as the cold front of the described low crossed our course even 8 - 9 Bft were measured for a short time. On our way through the Bay of Biscay to Cape Finisterre a sea state rolling in from west to west-northwest of around 3 meters was observed.

After the cold front had passed wind veered west with a force of 6 -7 Bft and gusts up to 10 Bft. Along with this heavy showers were observed.

Approaching the Posidonia test area at 35° N – 13° W on 3 November, a swell of about 6 -7 meters rolled in from northwest. The wind veered to northwest and reached its maximum of 8 - 9 Bft on 4 November. The swell remained unchanged until late afternoon of 5 November. At the end of our stay in the test area on 6 November the swell finally decreased down to 3 meters. Leaving this area and heading for Las Palmas de Gran Canaria wind went down to only 4 Bft.

After a short stay in Las Palmas on 8 November we set sail again in the afternoon proceeding further south. The north-easterly trade winds became dominating feature for the next days but until the evening of the 9th they only went up to 3-4 Bft. Later on they increased a little but 4 - 5 Bft were not exceeded. The swell rolling in from the north just reached a height of 2 to 2.5 meters.

In the evening of 13 November we approached the northern edge of the ITC. Already days before this area appeared to be very weak on the satellite images with only little amount of convective clouds. One light shower in the evening of that day was the only remarkable weather phenomenon that had been observed during the entire crossing. On 15 November an air temperature of 28.8° C was measured which indicated the maximum value of the cruise. On the same day the maximum value of the water temperature went up to 29.7° C

The Equator crossing took place on 17 November short after 21:00 UTC. At this time temperature had already gone down to 26° C with broken skies and south-easterly winds of just 3 Bft.

During the following days hardly anything changed. Until 20 November air temperatures slowly went down to 21° C. The south-easterly trade winds blew with 4 Bft but increased from 22 November to up to 6 Bft. In the night from 27 November to 28 the south-easterly trade winds increased to 7 - 8 Bft.

Due to the trade inversion mainly broken skies along with occasional drizzle or even light showers were observed. A swell of 3 to 3.5 meters rolled in from the south, decreasing down to 2 meters not before 29 November.

On 28 November wind veered to south and slowly decreased during the last days of the cruise to 5 Bft. Along with this broken, later scattered skies temperatures were observed of no more than 17° C.

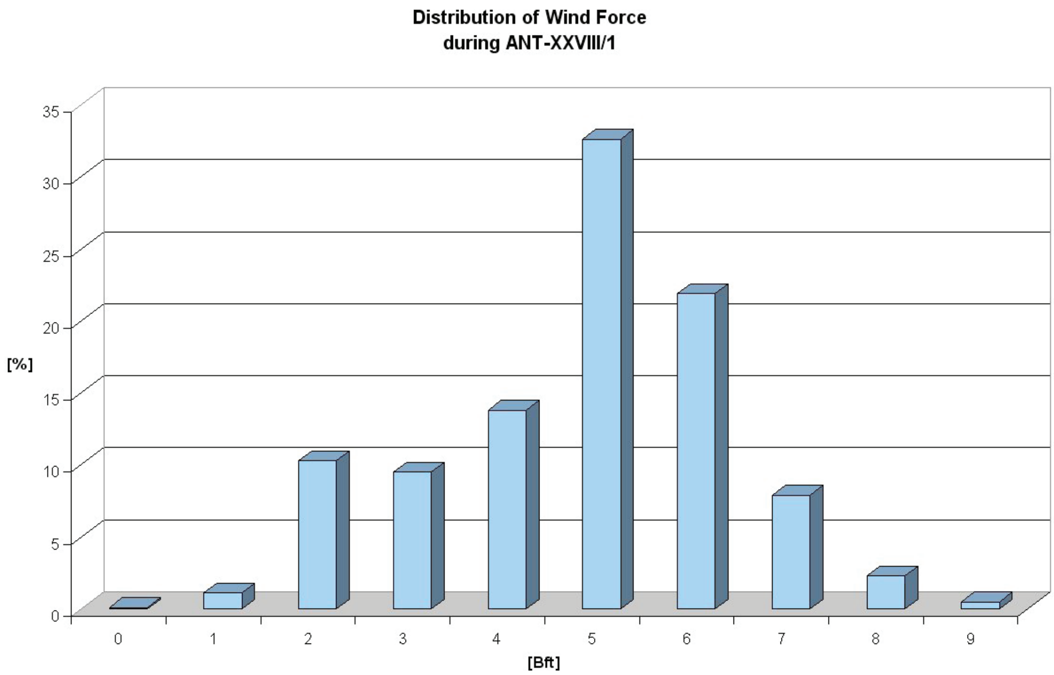

Fig. 2.1: Distribution of wind force during ANT-XXVIII/1

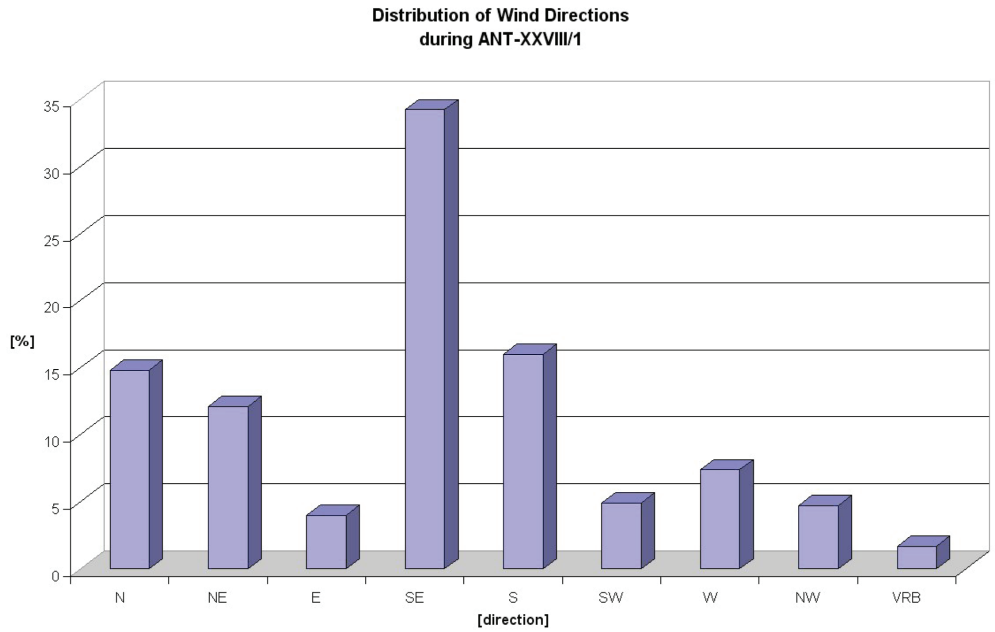

Fig. 2.2: Distribution of wind direction during ANT-XXVIII/1

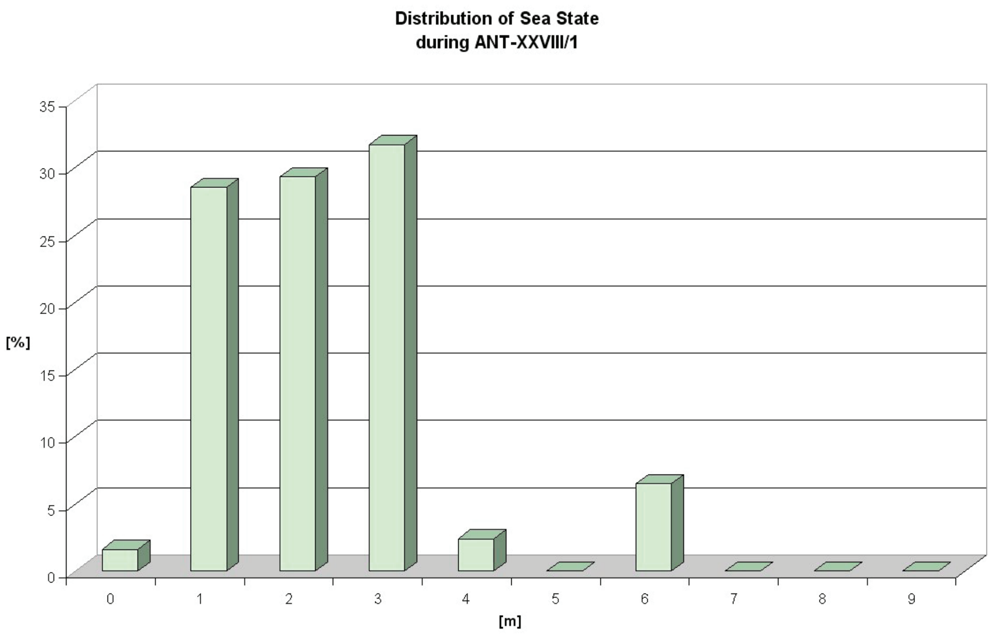

Fig. 2.3: Distribution of sea state during ANT-XXVIII/1

3. SCIENTIFIC PROGRAMMES

3.1 Autonomous Measurement Platforms for Energy and Material Exchange between Ocean and Atmosphere (OCEANET): Atmosphere

Veronika Wolf IfT

Objectives

Radiation and microwave remote sensing

Clouds are still one of the biggest problems in our understanding of the coupled ocean-atmosphere climate system. Knowledge about their spatial and temporal distribution is very important for weather and climate models. These models still have problems with predicting the inhomogeneous cloud patterns of those scales which are important for the radiance transfer processes. It is clear that these processes must be considered in radiative transfer parameterization. The radiation budget is a relevant process in the climate system. A key to adjust or to validate such parameterizations is to combine different observations of clouds and radiation with varying instruments. As there is not a lot of data available for maritime environments, the initiative OCEANET sets out to take measurements in those regions. This initiative has been started in 2004.

The multichannel microwave radiometer HATPRO (Humidity And Temperature PROfiler) provides continuous vertical temperature and humidity profiles, the liquid water path and the integrated water vapour with a high temporal resolution. The downward radiation was measured by one pyrgeometer for longwave (thermal infrared) radiation and three pyranometers for shortwave (solar) radiation. Two of the pyranometers had been installed for the second time within the OCEANET project. They make use of the photo electric principle and so they respond much faster than the previous ones. It still has to be studied if it is possible to get information about the atmospheric conditions and clouds by evaluating the fluctuation of the incoming shortwave radiation.

The combination of these measurement instruments makes it possible to observe small-scale atmospheric structures and inhomogeneous cloud patterns.

Work at sea

The atmospheric OCEANET container was placed on the port side on the helicopter deck aboard *Polarstern*. The instruments continuously measured throughout the whole way from Bremerhaven to Cape Town. The following instruments were used on this cruise (Fig. 3.1.1):

- A waterproof all-sky digital camera manufactured by IFM-GEOMAR took an image of the sky every 15 seconds at daytime and every 15 minutes at nighttime. This high temporal resolution allows a detailed analysis of cloud type and coverage and their roles in the radiation budget over the sea surface.
- A Kipp&Zonen pyrgeometer CG 4 and a pyranometer CM 21 provided from IFM-GEOMAR and two faster pyranometers which work with the photo electric principle measured the down ward radiation.
- A multichannel microwave radiometer (HATPRO by Radiometer Physics) observed the temperature and humidity profiles, the liquid water path and the integrated water vapour of the atmosphere. An absolute calibration using liquid nitrogen was performed before the start in Bremerhaven.
- Standard meteorological measurements, such as temperature, humidity, pressure, or position of the ship were carried out as well.

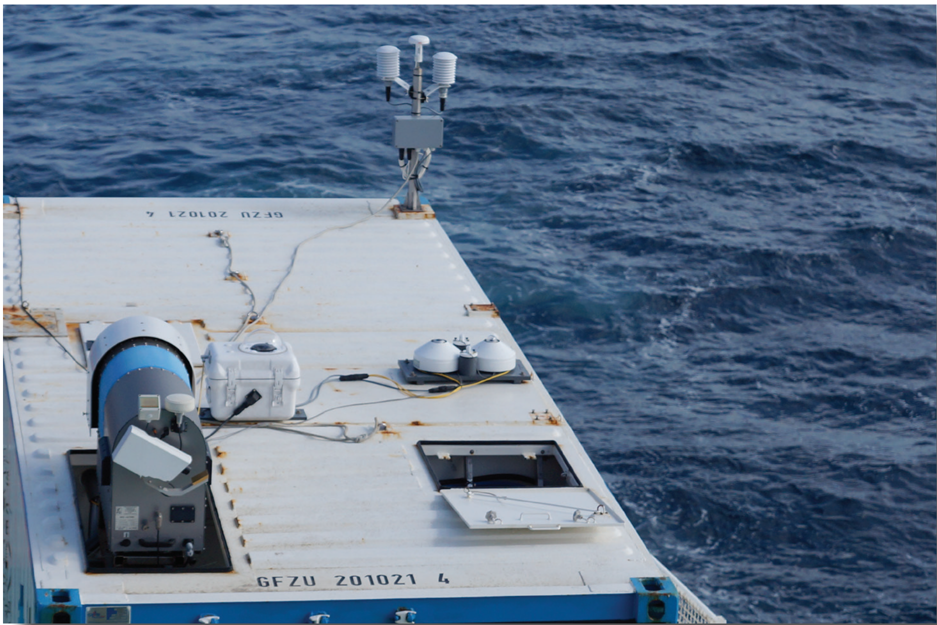

Fig. 3.1.1: a) all-sky camera, b) three pyranometers and one pyrgeometer, c) multichannel microwave radiometer, d) standard meteorology (Massart, N. 2011)

Preliminary results

Fig. 3.1.2 shows the temporal temperature profile along the cruise. The corresponding water vapour mixing ratio (WVMR) is shown in Fig. 3.1.3. *Polarstern* crossed the equator on 17 November 2011 at 9 pm. A dry and warm air layer advected from the Sahara, above the trade wind inversion can be seen at around 20° North. At the Intertropical Convergence Zone ITCZ (10° - 5° North) the highest temperature and humidity of this cruise were observed. Fig. 3.1.4 presents the humidity profile which combines temperature and WVMR. Very low humidity was observed around

20° North and the highest values in the ITCZ. All these figures are based on data from the HATPRO microwave radiometer. A more detailed analysis will follow which will combine the data of the board ceilometer, the radio sounding and the all-sky camera.

HATPRO has been operated on *Polarstern* for already five years on all Atlantic transects between Bremerhaven and Cape Town or Punta Arenas (and vice versa), providing a unique dataset of clouds and water vapour over the open ocean in many climatic regions (tropics, trade-wind zones, mid-latitudes). Therefore, a further step will be a first climatological evaluation of all these cruises.

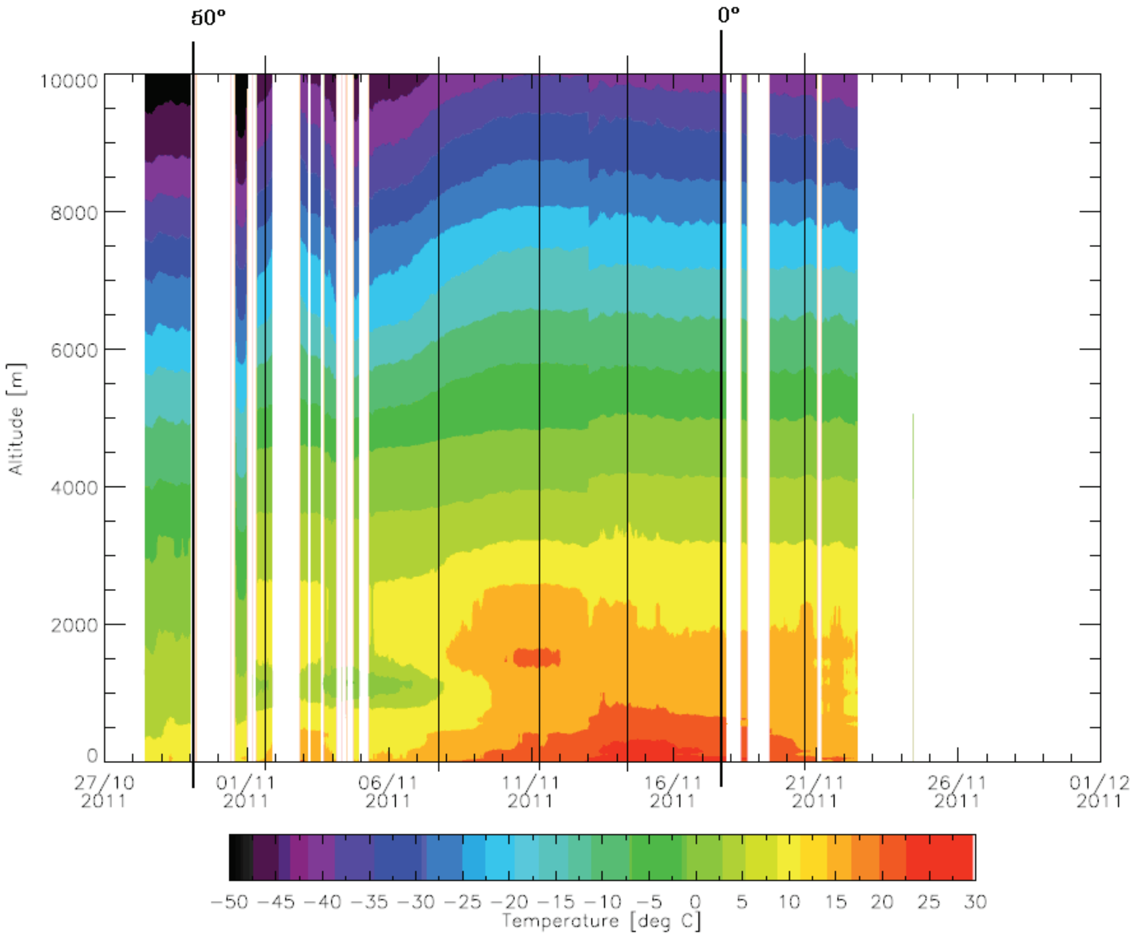

Fig. 3.1.2: Temporal temperature profile along the cruise from the HATPRO microwave radiometer (Wolf, V. 2011)

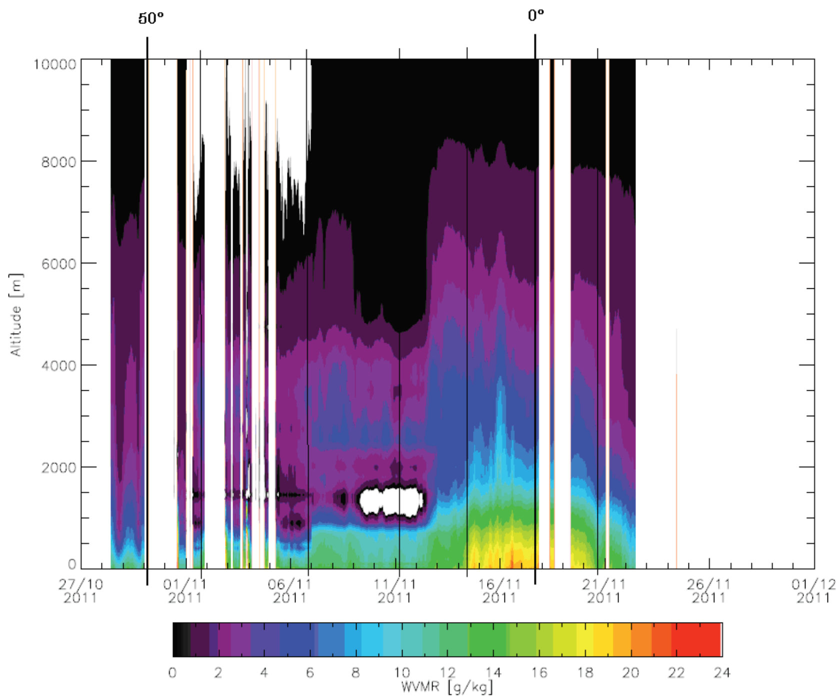

Fig. 3.1.3: Temporal water vapour mixing ratio profile along the cruise from the HATPRO microwave radiometer (Wolf, V. 2011)

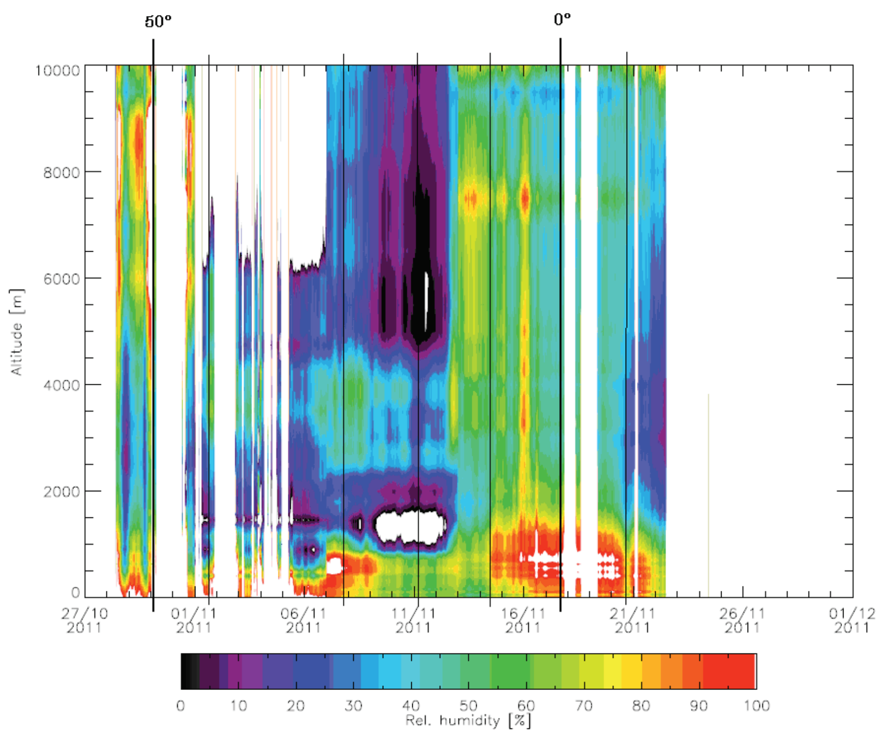

Fig. 3.1.4: Temporal humidity profile along the cruise from the HATPRO microwave radiometer (Wolf, V. 2011)

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3.2 Chemical and Physical Characterization of Marine Aerosols on Board Polarstern

Zhijun Wu[1], Laurent Poulain[1], Shan Huang[1], Friederike Höpner[1], Julia Wenzel[1], Michael Schäfer[1] (IfT), Monika Kohn[2]

[1]IfT
[2]IAU

Objectives

Our measurements on board are to:

1) better understand the formation mechanism of secondary fraction in marine aerosols,

2) investigate the interaction between sub-micron marine aerosols and water vapor under sub- and super- saturated as well as under cooling conditions, and

3) characterize the optical properties of marine aerosols.

Work at sea

The physical laboratory container (Fig. 3.2.1) of IfT equipped with a number of scientific equipment (Table 3.2.1) was operated by seven scientists during the ANT- XXVIII/1 leg from Bremerhaven to Cape Town

Fig. 3.2.1: IfT physical laboratory container

Tab. 3.2.1: Scientific equipment on board *Polarstern*

Instruments	Time resolution	Data availability
Scanning mobility particle sizer (SMPS)+ Aerodynamic Particle Sizer (APS)	10 min	30, Oct.-29, Nov.
Humidity Tandem Differential Mobility Analyzer (H-TDMA)	5 min	30, Oct.-29, Nov.
Cloud Condensation Nuclei Counter (CCNc)	45 min	30, Oct.-29, Nov.
Electrostatic Aerosol Collector (EAC)	Off-line	100 filters
Multi Angle Absorption Photometer (MAAP)	1 min	30, Oct.-29, Nov.
Integrating Nephelometer	1 min	30, Oct.-29, Nov.
Particle Soot Absorption Photometer (PSAP)	1 min	30, Oct.-29, Nov.
High-resolution Time of Flight aerosol mass spectrum (HR-ToF-AMS)	2 min	30, Oct.-29, Nov.
DIGITEL filter sample	24 h	35 filters

The measurements can be categorized as three groups:

Aerosol physical properties measurements:

A SMPS combining with an APS were performed to measure the particle number size distribution between 10 nm and 20 mm with a time resolution of 10 min. The interaction between particles and water vapor under sub- and super- saturated conditions are respectively determined by HTDMA (RH = 90 %) and CCNc (RH from 100.07 to 100.7 %). Within these two instruments the hygroscopic growth and the activation behavior of the particles, which mean their probability of forming cloud droplets, can be determined. Additionally, ability of marine aerosol to form Ice Nuclei (IN) was investigated using an Electrostatic Aerosol Collector (EAC) from IAU, Frankfurt. Marine aerosols were collected on silicon wafers and will be analysed later by the Frankfurt Ice Nuclei Deposition Freezing Experiment (FRIDGE) at EAC to estimate the IN density formation of the collected marine aerosols. FRIDGE is a static vacuum vapor diffusion chamber, which is used for the activation, growth and distribution of IN as a function of undercooling (-8° C to -18° C) and super saturation (between 100 - 120 % saturation over ice). Some of the probes will be sent to the Technical University of Darmstadt for analysis of the composition and morphology of IN by electron microscopy.

Optical property measurements:

An Integrating Nephelometer, a MAAP and a PSAP were operated simultaneously to characterize the particle optical property. These three instruments can provide the information on the particle scattering and absorption coefficient and the black carbon concentration.

Chemical property measurements:

The chemical compositions of marine aerosols were measured using both on-line and off-line systems. The Aerodyne 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 2 min. 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. Parallel to the AMS, PM1 particles were sampled using a Digitel DHA-80 high volume sampler. Sampling was performed every day during 24h from midnight to midnight (UTC). Each PM1 sample was collected on pre-backed quartz fiber filters. The filters will be transported to Leipzig to be analyzed by state-of-the-art analytical instruments to determine the chemical composition of the collected particles.

At the beginning of the cruise, we set up the container and calibrated all instruments. The quality-control protocol was carried out to insure the high-quality data acquisition during the whole campaign. During most of the time of the cruise the air was free of contamination due to the wind coming on head. We had enjoyed successful measurements until 29 November when we started to pack the container. A rough summary of data availability is given in the last column of Table 3.2.1. The online instruments collected the data continuously except for performing calibration. Interestingly, three new particle formation (NPF) events (an example shown in Fig. 3.2.2) were captured by our measurements. NPF recently has been recognized as a potentially significant contributor to CCN, however, up to now, the mechanisms of atmospheric nucleation and particle subsequent growth especially in open ocean have remained unclear. Our observations provide a chance to gain insight into the particle formation process in marine boundary layer.

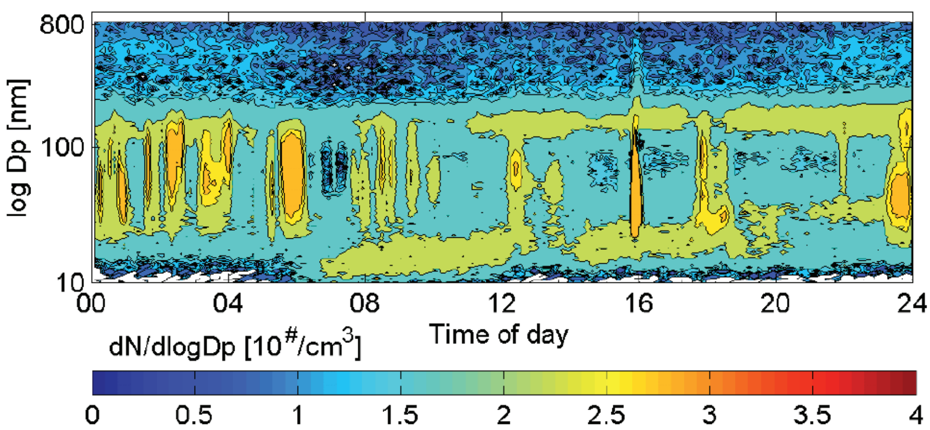

Fig. 3.2.2: Particle number size distribution during a NPF event

Expected results

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

A detailed analysis on AMS data will provide chemical information of aerosol particles such as the inorganic and organic size distribution, 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 and activation measurements can provide information about the particle mixing state, the growth factor, the critical diameter for the activation, and the cloud droplet number distribution of the aerosol particles. Ice Nuclei Measurements are expected to get a good overview for the distribution and behaviour of marine aerosol particles in ice crystallization processes.

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.

3.3 Measuring of Aerosol Optical Depth (AOD) with the hand-held Sun-photometer MICROTOPS

Cornelia Kampmann MPI

Introduction

In the current expedition on *Polarstern* (ANT-XXVIII/1) we set out to gather new data on atmospheric (column) aerosol optical properties over maritime environments along the route from Bremerhaven, Germany, to Cape Town, South Africa. Atmospheric aerosols are small particles ranging from a few nanometers to tenths of micrometer in size, with contributions from a variety of sources. Maritime aerosol is usually a mixture of near surface sea-salt contributions from sea-spray and advected contributions from continental sources, including pollution, biomass burning or wind-blown dust.

The global exploration of aerosol properties in the atmosphere is important as aerosol is highly variable in space and time. Added importance comes from the fact that a fraction of today's atmospheric aerosol is anthropogenic. Thus, in efforts to understand current climate and to project future climates the aerosol impacts on atmospheric change must be considered. Their two key effects can be described as follows: First, they play an important role in the formation of clouds. Some aerosol particles can serve as so-called cloud condensation nuclei, which in increasing numbers accelerate the cloud droplet formation, modify the properties of clouds and can even affect the hydrological cycle (indirect effect). Second, they influence the Earth's radiative energy balance, mainly by scattering and absorbing solar radiation (direct effect). This direct effect allows to quantify the aerosol column load by measuring the reduced solar transmissivity.

The solar transmissivity of the atmosphere can be determined by comparing the measured solar radiation reaching the ground (I) with the solar radiation outside of the atmosphere (Io), which is known for a given location and time. This transmissivity is usually simultaneously measured at different solar wavelengths to yield extra information on the average aerosol size and on armospheric water vapour. The parameter to describe the vertically normalized solar atmospheric transmissivity in terms of its exponential decay factor is the (solar) optical depth. The optical depth attributed to aerosol (aside from trace-gases or molecular scattering at cloud-free conditions) is termed the Aerosol Optical Depth (AOD).

As solar radiation is the key factor in the Earth's climate system, it was intended to continually monitor the AOD during the cruise ANT-XXVIII/1 along the coast of Western Europe and Africa. The data will advance our knowledge of the spatial and temporal distribution of aerosols and their composition.

All measurements contributed to the database of the AERONET Maritime Aerosol Network. All collected data can be downloaded from the AERONET website: http://aeronet.gsfc.nasa.gov.

Method

The AOD was measured with a hand-held sun-photometer called MICROTOPS which is connected to a GPS instrument. The sun-photometer measures the direct solar irradiance in 5 different spectral channels: 380 nm, 440 nm, 675 nm, 870 nm, 936 nm. Hereby, the additional water absorption at 936 nm compared to 870 nm provided estimates for the water vapour column. To determine at any given time the needed data for the sun-elevation (also to set reference data for the incoming solar irradiance at the top of the atmosphere) a GPS instrument supplied data on the global position during the measurement.

For the measurements it is important that the solar disk is completely free of clouds so that the entire solar attenuation by absorption and scattering can be attributed to the aerosol particles (after subtracting known contributions from molecular scattering and trace-gases). From the derived AOD the amount of aerosol can be determined and from the AOD spectral dependence, which provides general information on aerosol size, the type of aerosol can be addressed. Fig. 3.3.1 shows the MICROTOPS and the GPS instrument. In order to achieve the most reliable results, a series of 5 - 10 scans was taken whenever the view to the sun was unobstructed (by clouds or obstacles). Between two series, a break of at least 2 minutes had to elapse so that the series could clearly be differentiated.

Fig. 3.3.1: To the left: GPS instrument, to the right: MICROTOPS

Results

Measurements were conducted throughout the day whenever the sun was free of clouds. This varied between as little as 5 scans per day and up to 338 scans. During the cruise from 28 October – 30 November 2011 (34 days), it was possible to take measurements on 23 days.

The results are plotted in Fig. 3.3.2. The AOD is given as the daily average for 500 nm (values interpolated). It can be seen that the marine air is generally very clean. Off the Spanish coast and down to around 19°N, values of AOD are lower than 0.1, showing that the atmosphere hardly contains any contamination.

South of about 19°N, the AOD increases slightly to values above 0.2 and 0.3. This rise can most likely be attributed to particles being carried by air from the African continent, either from the Saharan desert or biomass burning.

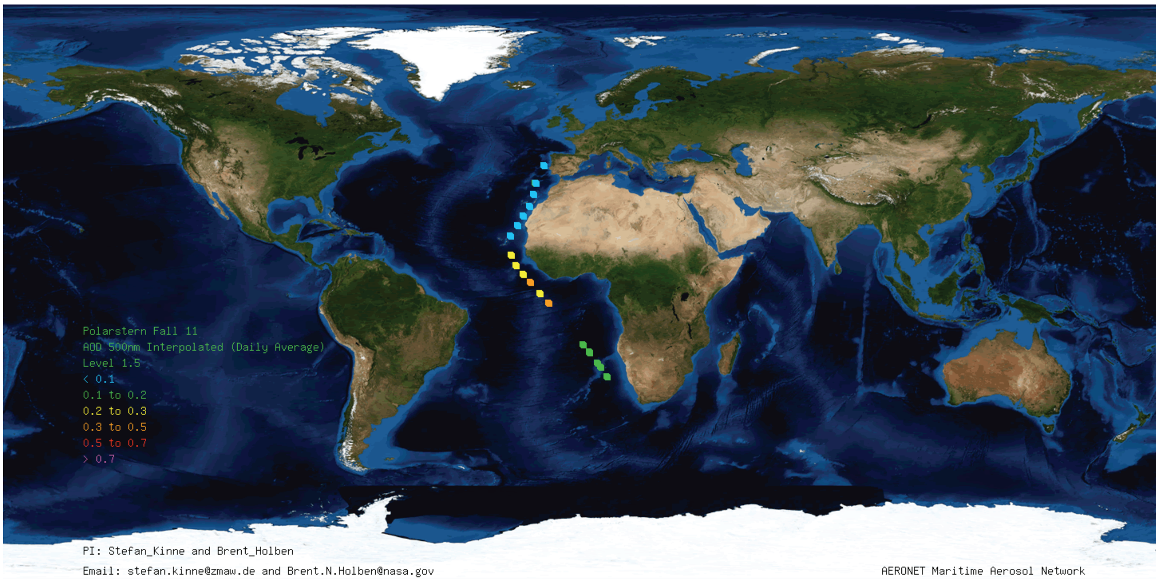

Fig. 3.3.2: AOD measurements at 500 nm (downloaded from the AERONET website)

Conclusion

As part of the AERONET Maritime Aerosol Network, we took measurements of the AOD on the route from Bremerhaven to Cape Town on board of *Polarstern*. All results from the measurements are freely available from the AERONET Maritime Aerosol Network website. At the MPI-M, the data will be processed and integrated into the aerosol climatology compiled by Stefan Kinne. This climatology is used in the global climate model ECHAM of the MPI-M.

3.4 Atlantic Breeding Grounds of Mysticetes (Baleen Whales, Bartenwale) of the South Hemisphere. MAPS: Marine Mammal Perimeter Surveillance

Rainer Graupner[1],
not on board: Stefanie Rettig[2],
Matthias Monsees[2], Gerd Rohardt[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 unraveling the stock structure of a given species. However, visual long-term observations in open ocean regions are impossible to execute. This problem may be 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, an exploratory deep-sea mooring AWI 247-1, containing a novel passive acoustic recorder, was deployed in fall 2010. This mooring shall be recovered and replaced by an identical mooring, AWI 247-2, during this expedition.

Work at sea

Mooring AWI 247-1 was recovered on 25.11.2011, 13:23-16:09 UTC (it had been deployed on 20.11.2010 11:40 at 20°58.90'S 005°059.59'E). Towards the end of the recovery, parts of the top end of the mooring, including rope and the top floatation, were lost for unknown reasons. Possibly, the non-floating rope had been dragged into the ship's propellers and was cut apart. The top floatation, including its attached ARGOS beacon, was sighted drifting away but could not be recovered. The lower part of the mooring, including the acoustic recorder, CTD and release units were recovered successfully.

The mooring AWI 247-2 was deployed at 20°57.8'S 005°58.6'E on 25.11.2010 18:27 at a depth of 4240 m (Fig. 3.4.1). It again contained a develogic SonoVault passive acoustic monitoring recorder (SN 1008) at 741 m, and a Sea-Bird Electronics CTD Microcat SBE 37, sn 8129 directly below the recorder. The SonoVault had been started already in Bremerhaven end of September when it was set to record to 24-bit WAV format (5 minute duration per file) at a sample rate of 5333 Hz. Amplification was set to a maximum of "7", equaling 48 dB re 1µPa. 3 days before the deployment the system performance was checked. The recorder was still running and one SDHC Card was already full. By that time, the internal clock of the SonoVault was running fast by almost 11 minutes. The drift was considered acceptable for this application and was left uncorrected.

Preliminary results

Mooring AWI 247-1 served three purposes: a) as first field test of the prototype of a SonoVault acoustic recorder, b) as field test of a rope shackle as alternative mooring technology to reduce mooring noise and corrosion damage, and c) to acquire CTD data to understand the oceanographic variability at the depth of the SOFAR channel.

a) The SonoVault recorder was recovered mechanically intact and up and running, however the software had failed to save data to the 32 GB SDHC cards. The SonoVault clock was late by 34 minutes. Noting that the software version 1.1 had been released by the manufacturer only hours before the instrument was deployed, the manifestation of serious bugs did not come as a surprise. Nevertheless, the deadline helped to push the instrument development forward and meanwhile substantial modifications have been applied to both SonoVault electronics and software which address these and other problems as identified in the meantime.

b) The results of the rope shackle field test were most promising. No chafing was observed after the one year deployment for both the rope shackle, as well as the knot. Essential to this success is in our view the stainless steel thimbles which terminate the connecting ropes (Fig. 3.4.2).

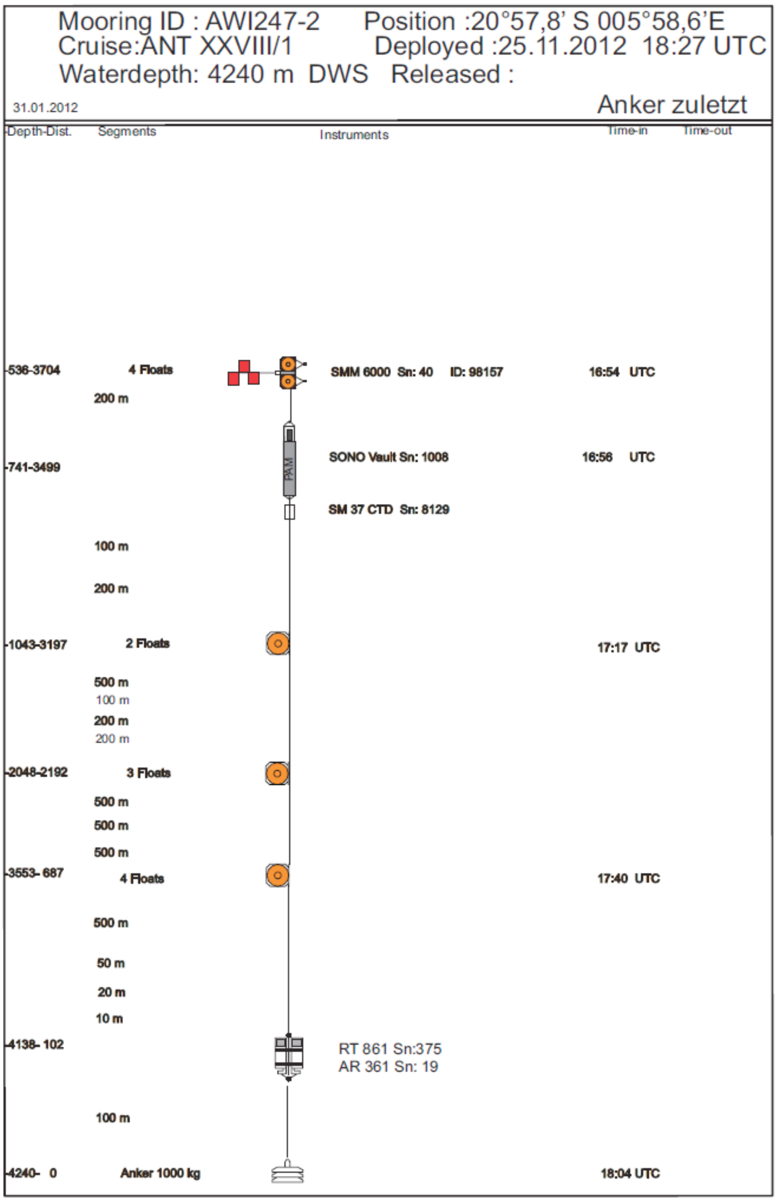

Fig. 3.4.1: Schematic of deployed mooring AWI 247-2 including final instrument depth

Fig. 3.4.2: Knot (top) and rope shackle (bottom) as recovered after a one year deployment

c) The CTD recorded data once per hour for the entire deployment period. Plots of the preliminary temperature, salinity and pressure time series are depicted in Fig. 3.4.3 .

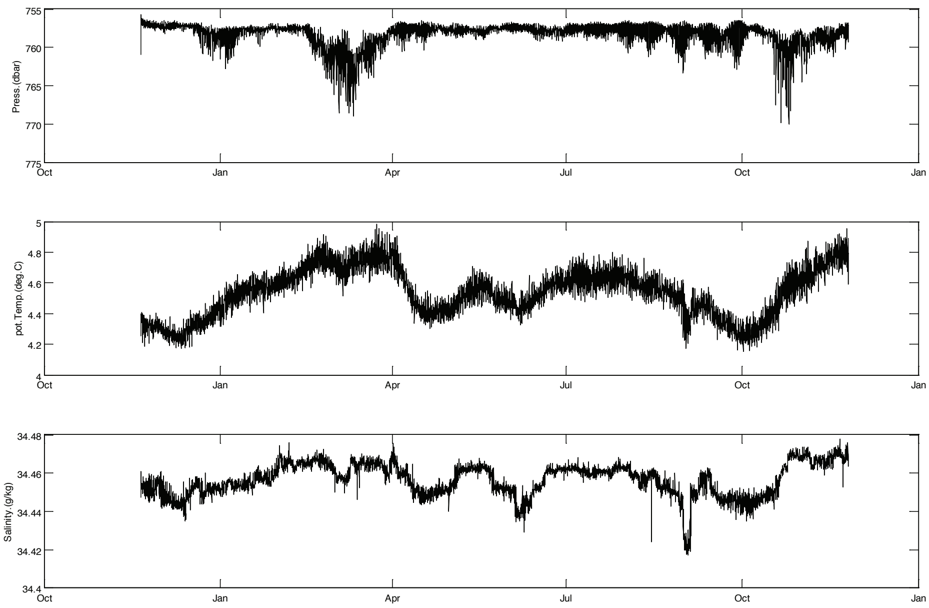

Fig. 3.4.3: Pressure, potential temperature and salinity time series (raw data) of the period 20. Nov 2010 – 25. Nov 2012 at mooring 247-1

3.5 At-sea Distribution of Seabirds and Marine Mammals

Philippe Goffart, Xavier Vandevyvre, Nadine Massart, Claude Joiris (not on board)
PolE

Introduction

Due to their position at the top of food chains in marine ecosystems and their sensitivity to the modifications of their environment, seabirds and sea mammals can be regarded as good indicators of the richness and health of sea life.

The aims of this study are :

- to quantify the at-sea distribution of seabirds and marine mammals between Bremerhaven and Cape Town. It is the first time that such a count has been done on this transect from the *Polarstern* and especially in a full transect. Censuses already exist for some restricted areas (Bay of Biscay, Cape Town, Atlantic Islands surroundings)
- to ensure a « long-time survey » allowing better knowledge of movements and distribution for some localized and migratory species. For example, the wintering grounds of Cape Verde Shearwater (*Calonectris edwardsii*) are still unknown, movements of most of the Beaked Whales (Ziphiidae) and Pygmy & Dwarf Sperm Whales (*Kogia breviceps* & *K. sima*) are very poorly known.

Although distribution of seabirds and marine mammals is already relatively well known between Bremerhaven and Canary Islands, winter censuses are occasional and can therefore bring some surprises especially in Northern Atlantic Sea (e.g. where disappears the Zino's Petrel – *Pterodroma feae* - during winter?). Furthermore, huge gaps remain further south, between Cape Verde Islands and Namibia, including the Gulf of Guinea.

Fig. 3.5.1: Cory's Shearwater (Calonectris diomedea).
Photo: Nadine Massart / PolE

Methods

Counts were made by 30 minutes, from sunrise to sunset and only when the boat was moving, this to avoid the attraction of the boat during its stops. Every individual detected with naked eyes is counted and optics (binoculars x10 and telescopes x30) were used to confirm the species identification Coordinates and hour were noticed at the beginning of each count. Potential explaining variables such as depth, salinity, water temperature (taken as proxies for more direct parameters like prey availability) were also recorded. Moreover, visibility was also noted as a covariable, as it can biased the count results.

Figs. 3.5.2 and 3.5.3: Bird detection and identification on the deck of the Polarstern.
Photos: Nadine Massart / PolE

Preliminary results

Sampling results

First results are given hereafter, from the first date (29/10/2011) to the 23th November 2011 (off coast of Namibia). Results of the last week of the cruise will be integrated in a more complete version of this report. Three climatic zones were distinguished from their distinct climate and bird fauna: the north temperate zone, the tropical zone and the south temperate zone (see Table 1 for first and last coordinates and dates). In all, 437 units of transect counts were done between these two dates, representing 218,5 hours of counting.

The main quantitative results obtained for seabirds and sea mammals are summarized in Table1. Note that the results for the last zone are partial as the last week has not been integrated. Along this cruise, more seabird and sea mammal species have been found in the north temperate zone (32 spp. and 8 spp. respectively). But, when looking at the numbers by transect, at least for seabirds, the highest figures have been obtained in the tropical zone.

Tab. 3.5.1: Main results of transect counts for seabirds and sea mammals given by general climatic zone and in total. First and last geographical position and date considered are indicated.

	North temperate zone	**Tropical zone**	**South temperate zone**	**Total**
First position	52N54,1 / 3E51,6	16N52,8 / 22W49,5	8S33,0 / 3W21,0	
First date	29/10/2011	12/11/2011	20/11/2011	
Last position	18N41,4 / 21W36,0	6S32,9 / 5W36,1	17S3,07 / 3E30,5	
Last date	11/11/2011	19/11/2011	23/11/2011	
Number of transect units	190	155	92	437
Number of counting hours	95	77,5	46	218,5
Seabirds				
Number of species	35	26	10	50
Number of occurrences	302	270	88	660
Number of individuals	1217	1055	266	2538
Mean number of species by transect	1,59	1,74	0,96	1,51
Mean number of individuals by transect	6,41	6,81	2,89	5,81
Median number of individuals by transect	2	4	1	2
Maximal number of individuals by transect	108	157	16	157
Sea mammals				
Number of species	8	4	2	12
Number of individuals	58	143	2	203

Fig. 3.5.4: Cory's Shearwater (Calonectris diomedea scopoli).
Photo: Nadine Massart / PolE

Species lists

Birds

Table 3.5.2 synthetizes the results ventilated by species. The most frequently contacted species has been the Cory's Shearwater (*Calonectris diomedea*) (photos 3.5.1, 3.5.4 & 3.5.8).

Tab. 3.5.2: Results of transect counts for seabird species by general climatic zone and in total.

	North temperate zone	Tropical zone	South temperate zone	Total
Fulmarus glacialis	1	-	-	1
Pterodroma macroptera	-	-	17	17
Pterodroma feae	3	-	-	3
Bulweria bulwerii	1	5	1	7
Calonectris diomedea	228	159	-	387
Calonectris edwardsii	-	141	-	141
Puffinus gravis	105	32	-	137
Puffinus griseus	-	1	-	1
Puffinus baroli	2	-	-	2
Puffinus lherminieri	-	4	-	4
Oceanites oceanicus	2	4	11	17
Pelagodroma marina	4	-	-	4
Fregetta grallaria	-	1	13	14
Oceanodroma castro	77	293	-	370
Oceanodroma leucorhoa	1	5	214	220
Oceanodroma sp	11	8	2	21
Phaeton aethereus	-	10	-	10
Phaeton lepturus	-	2	-	2
Phaeton sp.	-	1	-	1

	North temperate zone	**Tropical zone**	**South temperate zone**	**Total**
Sula bassana	362	-	-	362
Sula sula	-	1	-	1
Sula leucogaster	-	28	-	28
Catharacta skua	21	-	-	21
Catharacta maccormicki	-	1	-	1
Stercorarius pomarinus	3	-	-	3
Stercorarius parasiticus	7	7	1	15
Stercorarius longicaudus	1	6	4	11
Stercorarius sp.	1	4	1	6
Branta bernicla	23	-	-	23
Gavia arctica	1	-	-	1
Phalaropus fulicarius	73	7	-	80
Larus canus	9	-	-	9
Larus melanocephalus	3	-	-	3
Larus argentatus	5	-	-	5
Larus fuscus	11	-	-	11
Larus michahellis	3	-	-	3
Larus marinus	62	-	-	62
Larus ridibundus	10	-	-	10
Larus minutus	5	-	-	5
Larus tridactyla	134	-	-	134
Larus sabini	1	-	-	1
Sterna arctica	1	1	2	4
Sterna anaethetus	-	4	-	4
Sterna fuscata	-	325	-	325
Sterna sandvicensis	1	-	-	1
Sterna maxima	-	1	-	1
Anous stolidus	-	4	-	4
Alca torda	1	-	-	1
Uria aalge	36	-	-	36
Alcidae sp.	8	-	-	8
Total	**1217**	**1055**	**266**	**2538**

Fig. 3.5 5: Brown Booby (Sula leucogaster), immature

Fig. 3.5.6 and 3.5.7: Red-footed Booby (Sula sula), immature. Photos: Philippe Goffart / PolE

Marine mammals

The results obtained for sea mammals are summarized in Table 3.5.3. In total, occurences of sea mammals were very scarce and the majority of species have been seen only once, but nearly all observations concerned groups of individuals (up to 80 for *Stenella longirostris*).

Tab. 3.5.3: Results of transect counts for sea mammals species by general climatic zone and in total.

	North temperate zone	Tropical zone	South temperate zone	Total
Physeter macrocephalus	1	3	1	**5**
Mysteceti sp.	-	-	1	**1**
Globicephala macrorynchus	-	20	-	**20**
Grampus griseus	18	40	-	**58**
Ziphiidae sp.	1	-	-	**1**
Tursiops truncatus	3	-	-	**3**
Steno bredanensis	4	-	-	**4**
Delphinus delphis	2	-	-	**2**
Stenella longirostris	-	80	-	**80**
Stenella coeruleoalba	7	-	-	**7**
Stenella frontalis	9	-	-	**9**
Delphinidae sp.	13	-	-	**13**
Number of species	8	4	2	**12**
Total	**58**	**143**	**2**	**215**

Abundances of seabirds

The graph in Fig. 3.5.8 gives the frequency distribution of the results of seabird counts. Note the rather high frequency of zero counts, representing more than 25 % of all transect bouts.

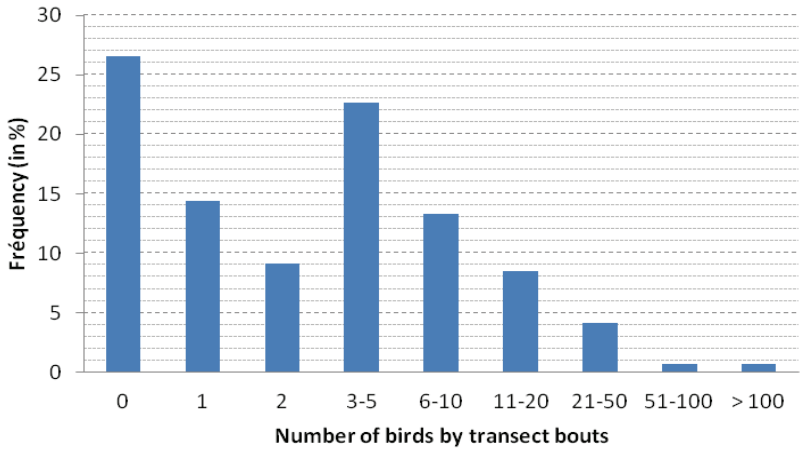

Fig. 3.5.8: Number of birds counted by transect bouts of 30 minutes

The graph of Fig. 3.5.9 show that zero counts were more numerous during the afternoon, a result that can likely be explained by the lower flight activity of the members of the order of procellariformes (petrels, storm-petrels, shearwaters…) after noon.

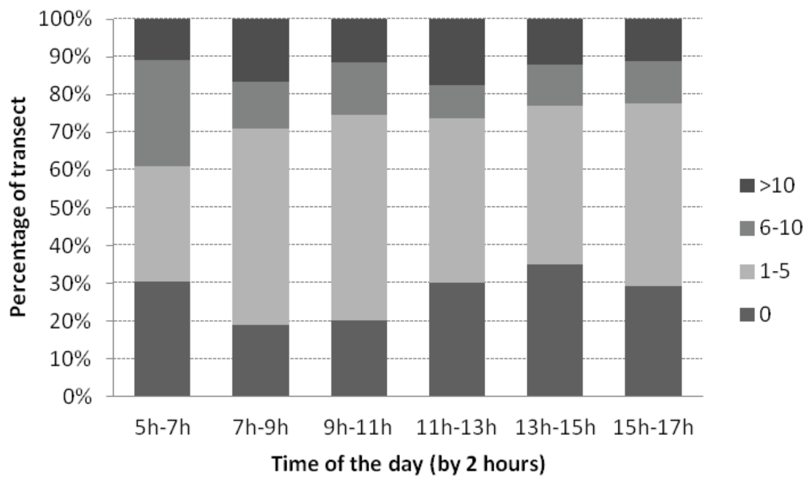

Fig. 3.5.9: Frequency distribution of seabird counts results in relation to time of the day. Numbers of individuals are spread in four classes detailed on the right

Concentrations zones

Along the cruise, concentrations of seabirds (and also marginally marine mammals) have been found in the vicinity of four land, thus quite close to continental shelfbreaks, where there might be "upwellings":

- off the Spanish coast (Galicia)
- around Gran Canaria
- around Cape Verde
- off the Guinean coast

Other places with shelfbreak and potential upwellings and seabirds concentrations have been crossed by night and have been then probably overlooked during our cruise.

Prospects

Evaluation of all the data will be done later when all the data of the present cruise and the cruise ANTXVII-5, from Punta Arenas and Bremerhaven, will be integrated into the datafile and verified. This analysis will try to find correlations between seabirds (and marine mammals) densities and environmental variables. It will be achieved by Oria Jamar for her Master Thesis.

It is a bit too early to discuss the interest of a regular monitoring renewed annually from the *Polarstern* along the Atlantic, as the analysis of all the data of this first trial has to be completed. However, this seems an interesting opportunity which will be studied in future reports.

Fig. 3.5.10. Cory's Shearwater (Calonectris diomedea)
Photo: Philippe Goffart / PolE

3.6 Rate Measurement of Cosmic Particles in Dependence on Latitude and Weather Conditions

Achim Stoessl, DESY
Michael Walter (not on board)

Objectives and work at sea

Rate Measurement of cosmic Particles in Dependence on Latitude and Weather Conditions

Galactic cosmic rays are high-energy charged particles, mainly protons, doubly ionized helium, and other fully ionized nuclei originating in the galaxy and bombarding the Earth from all directions. They are a direct sample of material from far beyond the solar system. Measurements by various particle detectors have shown that the intensity varies on different timescales, caused by the Sun's activity and geomagnetic variation. The role of Interplanetary Coronal Mass Ejections (ICMEs) in causing Forbush decreases, and Corotating Interaction Regions causing recurrent decreases in the GCR intensity observed at Earth, has been well established since the last twenty years. However, these interplanetary disturbances cause space weather effects, which warrant a more detailed study. Most of the research on GCR intensity variations are based on the analysis of ground-based neutron monitors and muon telescopes. Their measurements as explained in what follows depend on the geomagnetic position, and the processes in the Earth's atmosphere. Beside the modulation of cosmic rays in the heliosphere there are two possible lines of defense: while the atmosphere shields life against cosmic radiation uniformly, the Earth magnetosphere acts as a rigidity filter. Before the primary particles can enter the atmosphere they are subject to the deviations in the magnetic field in the vicinity of the Earth, and as a consequence the intensity of charged particles on top of the atmosphere is reduced with respect to interplanetary space.

For measuring the muon component of GCR, a detector was installed on *Polarstern*, wich consists of two scintillation counters working in coincidence mode. The mean muon rate per hour was recorded for every day, as well as the position, atmospheric pressure and temperature. Also other weather data, available from the ship's own database will be used in the ongoing analysis. The detector is equipped with newly available silicon photomultipliers. These were tested under the conditions of this cruise. The detector performed well and had a total uptime of 97 % during the time of the travel. The test of the new silicon photomultipliers was successful, however their sensitivity was found to be strongly temperature dependent. This can be corrected for with the measured temperatures, and might have only little impact on the analysis. Indications of a geomagnetic cut-off near the equatorial region have been seen, a reduction of the muon rate has been observed. In the ongoing data analysis it will now be searched for indications of solar activity by comparison the measured muon rates with NASA data. Also the data will be analyzed to find correlations with the available weather data. A first preliminary plot shows the recorded muon rates during the cruise. Note that the large daily variation of the muon rate has its reason in the temperature dependence of the silicon photomultipliers and will be corrected. At the time *Polarstern* crossed the equator, which was in the evening of the 17th of November, and also for the previous days, the rate average has found to be lower, which might indicate the geomagnetic cut-off. However this has to be carefully investigated and compared with the weather data.

The detector is ready and operational and will continue data taking during the whole cruise ANT-XXVIII.

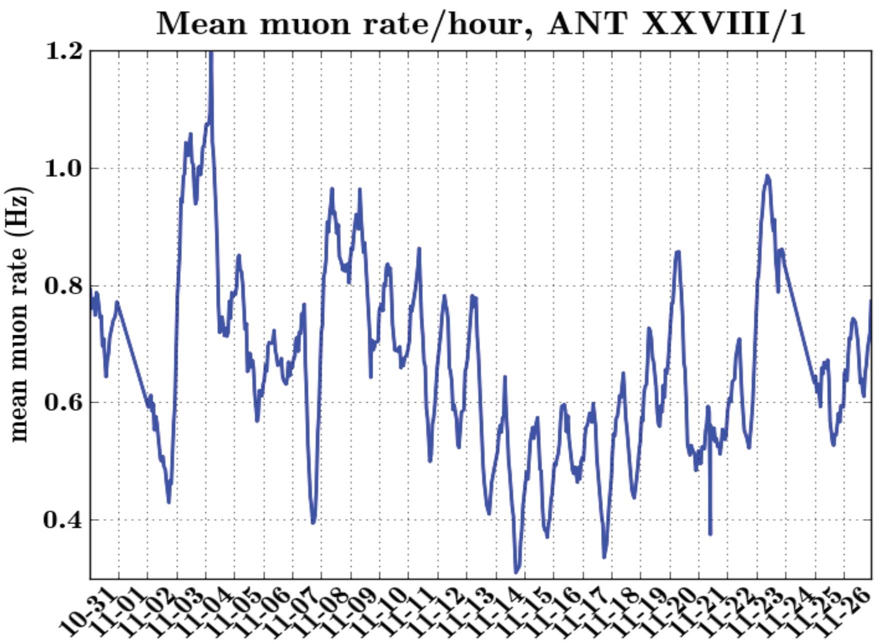

Fig. 3.6.1: Mean muon rate/hour during ANT-XXVII/1

3.7 Deployment of Drifting ARGO Floats

Nathanaële Lebreton[1] (not on board), Andreas Macrander[2], Saad El Naggar[2], Rainer Graupner[3]

[1]IFREMER
[2]AWI
[3]Optimare

Objectives

Drifting ARGO floats for IFREMER, France, were transported from Bremerhaven to Cape Town during this cruise in co-operation between AWI and IFREMER to measure global oceanographical and atmospherical parameters.

In addition 6 ARVOR floats were deployed during ANT-XXVIII/ 1 on the planned transit course track.

Work at sea

- Preparing the floats for deployment
- Transmission tests
- Deployment

Results

The deployment data of the floats are listed in the table 3.7.1:

Tab. 3.7.1: Deployments data of ARVOR floats

PROVOR, ARVOR Floats, 1000dbar, deployed during ANT-XXVIII/1				
Serial Number	**ID-Argos**	**Deployment**	**Latitude**	**Longitude**
		Date; Time UTC		
OIN-08-AR-01	78635	01.11.2011; 18:08	40° 28,91' N	011° 6,44' W
OIN-08-AR-03	78636	10.11.2011; 12:57	22° 0,02' N	019° 18,79' W
OIN-08-AR-04	63705	13.11.2011; 20:11	12° 0,11' N	020° 49,92' W
OIN-08-AR-05	78658	17.11.2011; 21:01	0° 0,15' N	011° 17,36' W
OIN-08-AR-06	93929	20.11.2011; 16:39	10° 0,26' S	002° 34,51' W
OIN-08-AR-08	93931	25.11.2011; 07:23	19° 59,87' S	005° 16,51' E

3.8 Sea Trials and Tests of the Multibeam Sonar "Hydrosweep DS III"

Ralf Krocker[1], Saad El Naggar[1], Daniel Damaske[1], Jörn Ewert[2], Ralf Alfke[2]

[1]AWI
[2]Atlas Hydrographic

Introduction and objectives

Due to the replacement of three transducer segments (receiver arrays) of the multibeam echosounder system Hydrosweep DS 3 during last shipyard stay, the correct system operation and functionality were examined and the set-up parameters were re-calibrated. Furthermore the development status of the new signal processing module (SPM-MK2) was assessed and modifications were applied. Additional developments for the new functionality of Forward Looking followed by detailed tests were accomplished. This work was conducted by system engineers from the manufacturing company ATLAS Hydrographic GmbH, Bremen.

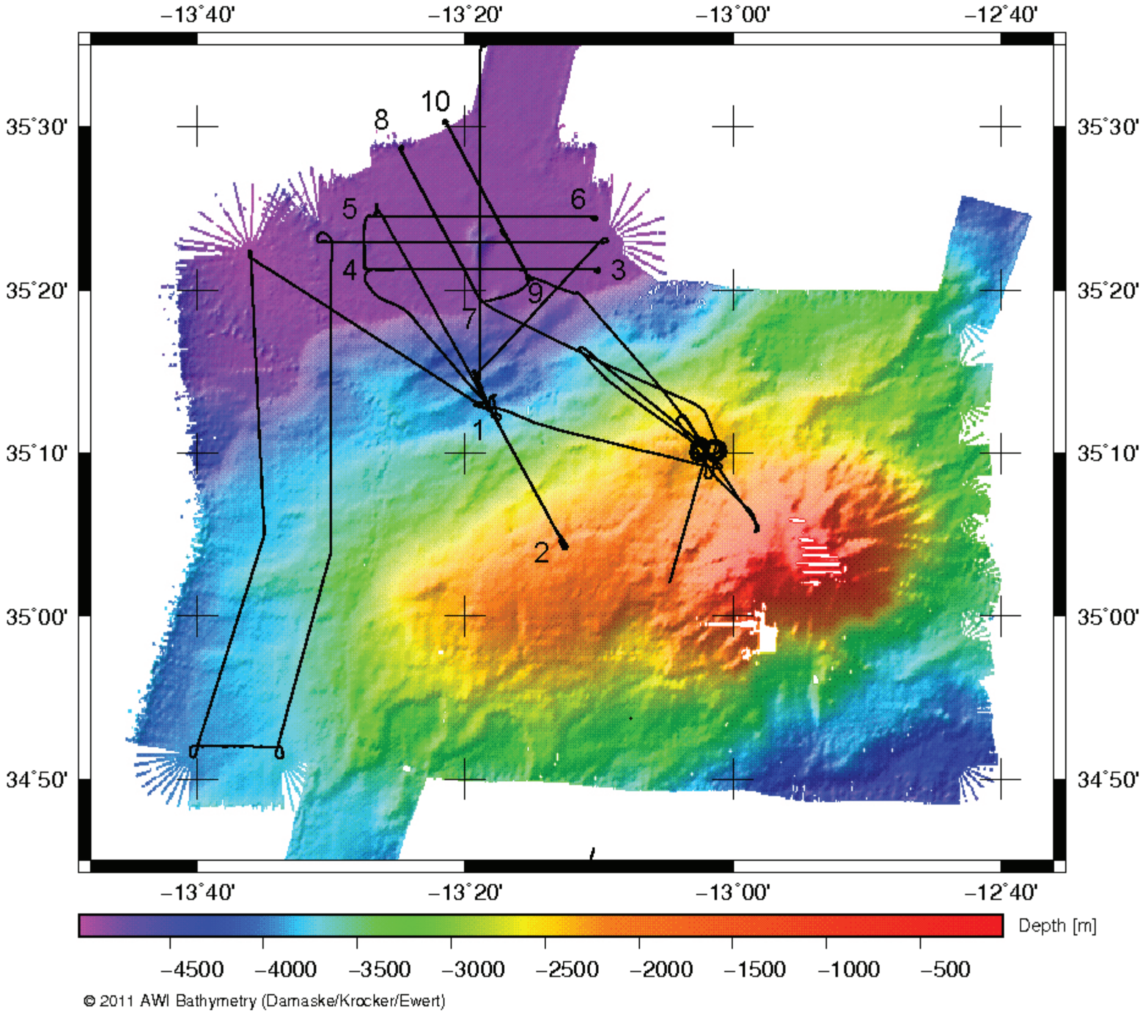

Fig. 3.8.1: Colour coded depths map of Ampere Seamount compiled from swath sonar measurement of cruises ANT-IX/4 and ANT-XXVIII/1. The annotated numbers indicate the start and end point of the Hydrosweep calibration lines. The tracks near the top of the mount were sailed in due to the POSIDONIA system calibration.

Multibeam system calibration

There are several different types of systematic and random errors that can influence the accuracy and precision of multibeam measurements, which can make both the online presentation and the final map product incorrect. In the course of the system calibration possible excentricity errors between the different sensors involved (navigation, attitude, timing) and alignment errors were checked. For this purpose a survey was conducted at the base and at the slope of Ampere Seamount as shown in Fig. 3.8.1. Due to bad weather conditions the calibration was postponed until appropriate sea state lowered. An alternate area for calibration was not available on transit to Las Palmas. The waiting period was used to enlarge the existing survey data from cruise ANT-IX/4 by sailing north-south profiles in the west of the seamount. The wave heights of observed four to six meter during subsequent calibration are critical for the quality of calibration. For this reason, the time latency calibration was not executed and the value from ANT-XXVII/1 calibration was adopted in this case.

The Pitch-Offset is the orientation error between transducer and motion sensor (MINS) relating to the ships lateral axis (Y) and is defined as rotation angle around Y-axis. The profile between point 1 and 2 was surveyed four times in opposite direction for detection of pitch-offset. The value was detected to be -0.04° regarding to MINS 1.

The Heading-Offset (Yaw) is the orientation error between transducer and motion sensor (MINS) relating to the ships vertical axis (Z) and is defined as rotation angle around Z-axis. It was detected on profiles from point 3 to 4 and 5 to 6, whereat the small pike between the profiles was surveyed in same direction ones by port beams and ones by starboard beams. This survey was executed one time in each direction. Because of poor results caused by the bad weather conditions, this calibration was repeated on profiles from point 7 to 8 and 9 to 10. These tracks were planned to head directly against and with the wind and the swell. The yaw angle was detected to be -0.20° regarding to MINS 1. Previously this value was set to 0°.

During profile between points 7 and 8 in the part north of the pike, the Roll-Offset was also detected. The profile was sailed four times in opposite direction. The Roll-Offset is the orientation error between transducer and motion sensor (MINS) relating to the ships length axis (X) and is defined as rotation angle around X-axis. The value was not set to zero initially but the value of 0.21° was kept, because a roll error affects previously executed pitch and heading calibration. Therefore, the new value is the difference to the initial value and was detected to be 0.01° regarding to MINS 1.

The new calibration values were announced in the ships technical information system 'Confluence'. The documentation of the sonar system Hydrosweep DS 3 was also updated.

Accuracy Check for Multi-Beam Echo Sounder Systems

Because of bad weather conditions the quality assessment of the new SPM MK2 could not be executed before arriving in Las Palmas and was therefore executed later in the area between positions 17° 25' S, 3° 20' E and 17° 39' S, 3° 34' E as shown in Fig. 3.8.2. This area was initially covered by five profiles in vertical and five profiles in horizontal direction with distances of 3.5 arc minutes (~ nautical miles) to define the reference surface. The profiles were sailed with ships speed of ten knots. This reference surface was crossed by six profiles diagonally, four with new SPM MK2 and two with the old SPM. These profiles were sailed with ships speed of eight knots. The analysis of this survey will be finished after the cruise and will be published separately.

The new functionality of Forward Looking was tested under several conditions. The general feasibility could be confirmed, but the parameter optimization and adjustment of user interface could not be finished.

At the end of the cruise the old SPM was reinstalled because the new SPM-MK2 was not finally approved. Depth depending parameters are actually not optimized and the user interface is not save enough against erroneous input of operators. On cruise ANT-XXVIII/5 the finally settings will be found and the sea acceptance test will be executed.

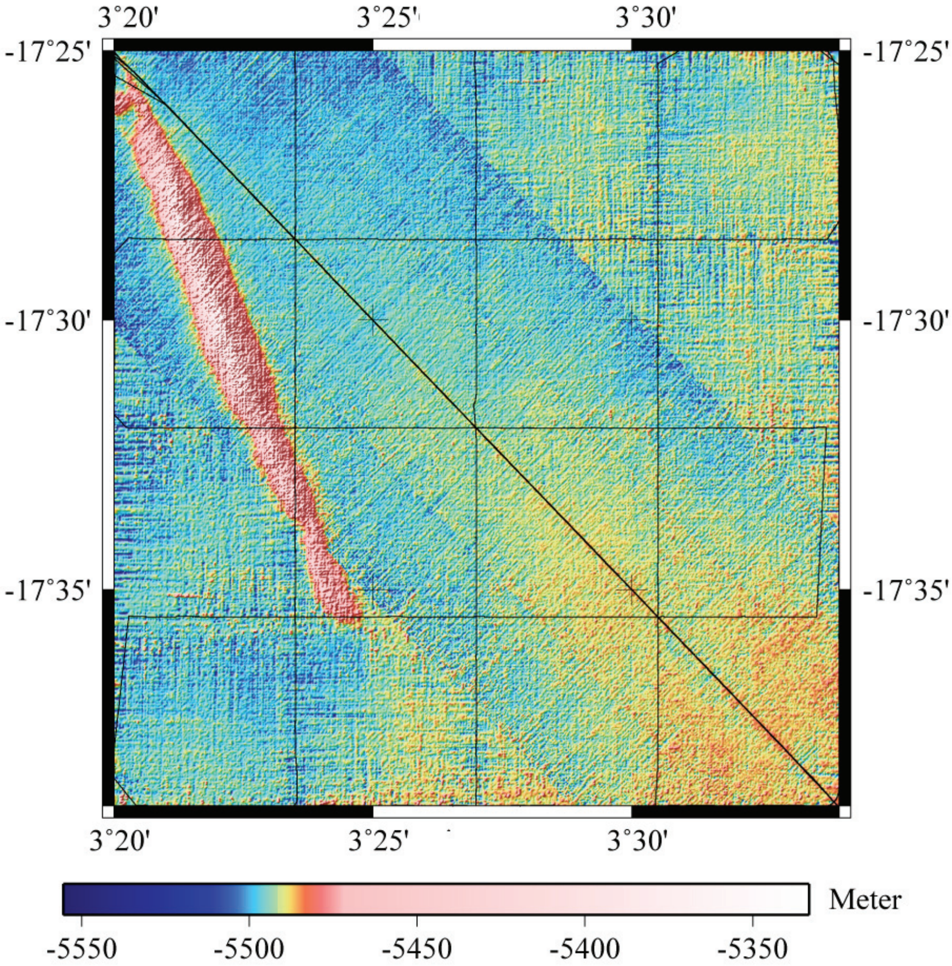

Fig. 3.8.2: Surveyed area for Accuracy Check for Multi-Beam Echo Sounder System. The horizontal and vertical lines indicate the track lines surveyed for reference field definition. The profiles from diagonal lines were surveyed for finally quality assessment.

Gierloff Emden Seamount

During cruise ANT-XVIII/1 in the year 2000, a seamount was detected, which is not shown in nautical charts (INT-21 and INT-203). Because the profile of ANT-XVIII/1 cruise did not cover the top of the mount, a small survey was conducted. The shallowest depth could be detected to be 412 meter at position 11° 26′ 17″ S / 001° 17′ 47″ E. The diameter at the base of the conic shaped mount is about 20 nautical miles (37 kilometres). Fig. 3.8.3 shows the colour coded bathymetry of cruises ANT-XVIII/1 and ANT-XXVIII/1. Our proposed name "Gierloff-Emden Seamount" was accepted by GEBCO Sub Committee on Undersea Feature Names (SCUFN) in September 2011.

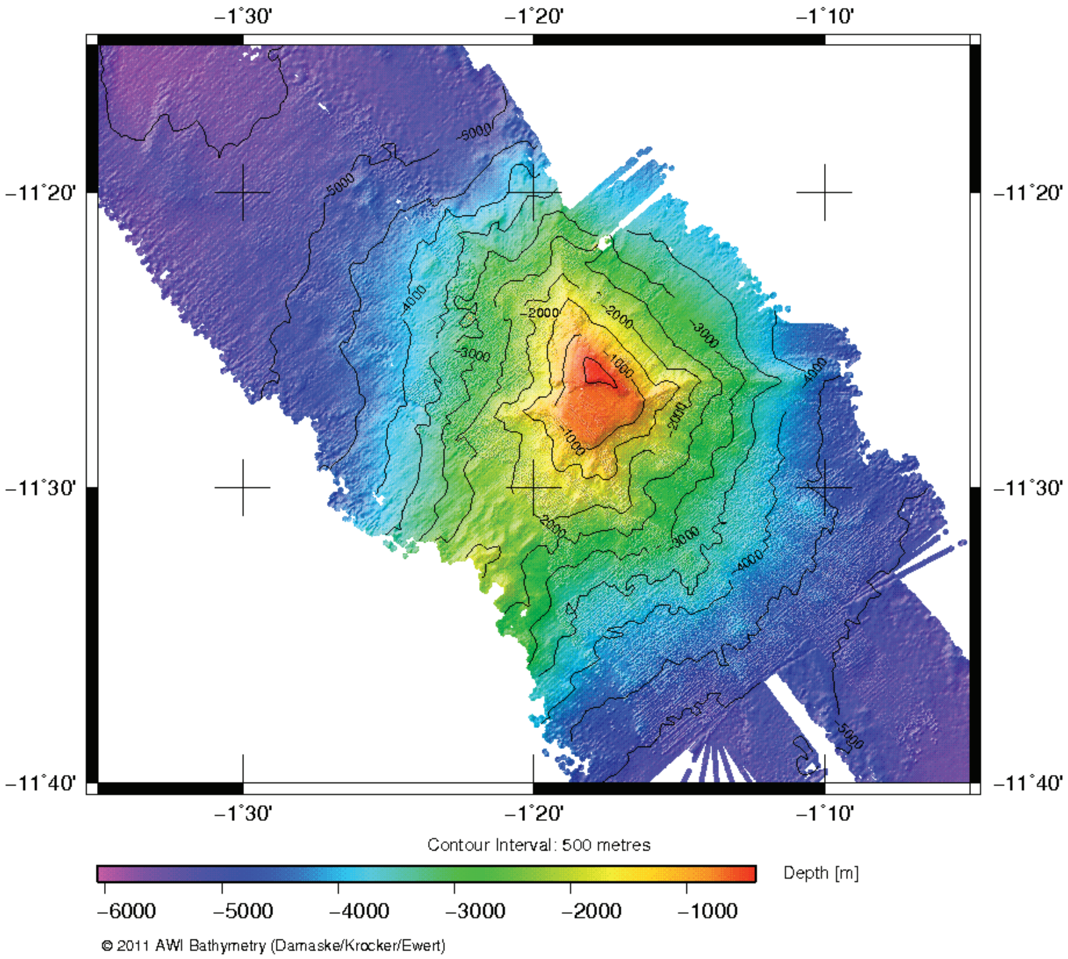

Fig. 3.8.3: The new survey of Gierloff-Emden Seamount was conducted to expand existing data of cruise ANT-XVIII/1. The image shows the colour coded topography of both cruises.

Sound velocity profiles

For calibration of the sonar system Hydrosweep DS 3 and the POSIDONIA system, precise sound velocity profiles must be applied. For that purpose several profiles were measured by Seabird SBE CTD–Sensor and by Valeport Sound Velocity Profiler (SVP). Table X.1 lists the station information of this casts.

The downcasts only were applied to sonar measurements. For swath sonar bathymetry the profiles were applied to software applications ATLAS Hydromap Control and HYPACK/HYSWEEP and additionally in post processing software CARIS HISP/SIPS.

On station PS79/008-1 both CTD and SVP sensor were mounted on one cable. So both datasets can be used for comparison as shown in Fig. 3.8.4. The red line indicates the SBE-CTD profile, the green line the Valeport-SVP profile. Both sensors are measuring not the depth directly but the pressure. The depth can then calculation from pressure; see Saunders (1981). Valeport-SVP is measuring the sound velocity directly, i.e. the time of a sound signal needed to travel along a predefined distance. The Seabird-SBE is measuring conductivity, temperature and pressure. For the calculation of resulting sound speed the formula of Chen and Millero (1977) was applied. Both profiles show the same shape, but with a depth dependent increasing offset.

Tab. 3.8.1: Station information of CTD and SVP casts, taken from Station Book ANT-XXVIII/1

Date	Station PS79/	Type	Latitude	Longitude	Max. Depth
31.10.2011	001-2	CTD	45° 19.1' N	8° 36.8' W	2543 m
01.11.2011	002-2	CTD	40° 30.6' N	11° 06.2' W	2033 m
02.11.2011	003-1	SVP	35° 35.0' N	13° 18.7' W	2500 m
03.11.2011	005-1	SVP	35° 12.3' N	13° 17.9' W	2500 m
05.11.2011	008-1	CTD +SVP	35° 10.4' N	13° 02.0' W	2383 m
23.11.2011	024-1	SVP	17° 24.7' S	3° 19.0' E	2500 m
26.11.2011	031-1	SVP	22° 10.3' S	6° 45.8' E	2500 m

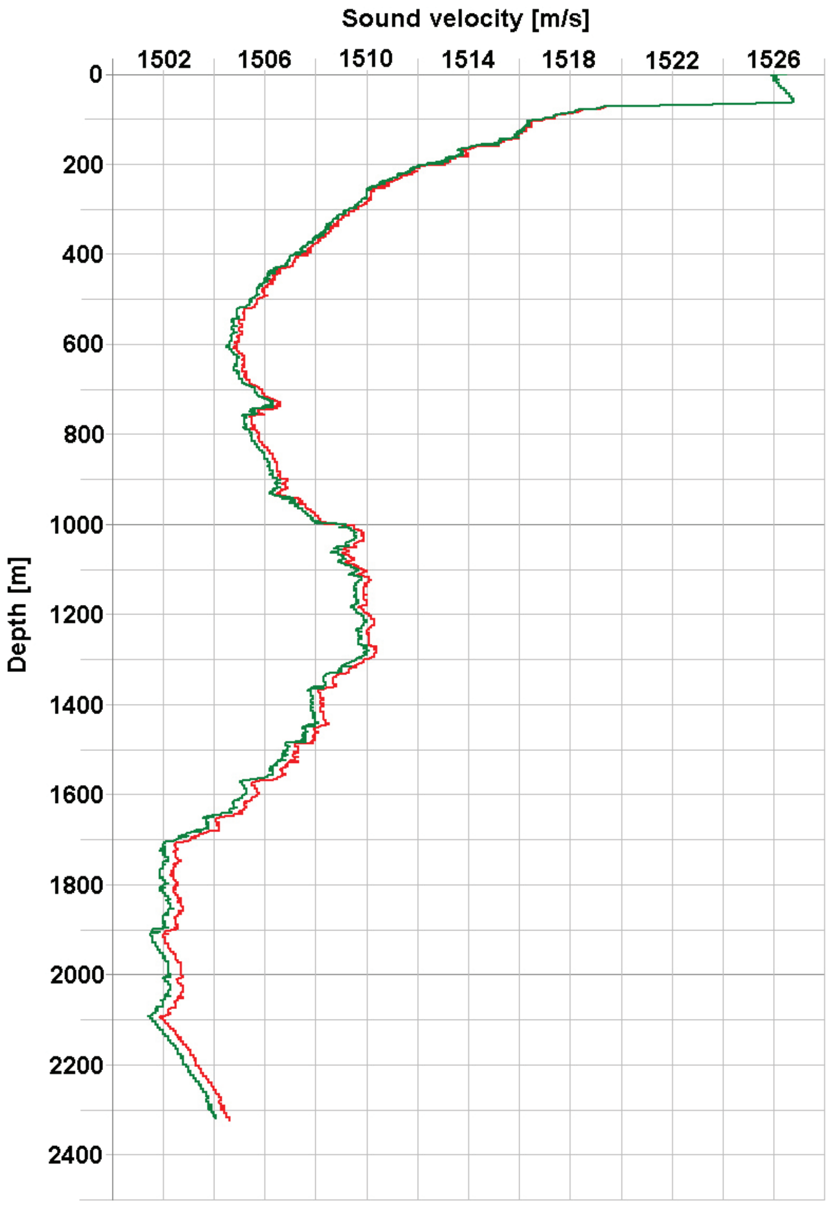

Fig. 3.8.4: Sound velocity profiles of Seabird SBE (red line) and Valeport SVP (green line) of station PS79/008 1

References

Chen-Tung Chen and Frank J. Millero, Speed of sound in seawater at high pressures, Journal of the Acoustical Society of America, 1977, vol. 62, no. 5, pp. 1129-1135

Peter M. Saunders, Practical Conversion of Pressure to Depth, Journal of Physical Oceanography, 1981, vol. 11, no. 4, pp. 573-574

3.9 Sea Trial and Tests of the Underwater Navigation System „POSIDONIA 6000" after Installation of a Mobile Protective Window

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Objektives and history

The underwater navigation system POSIDONIA was upgraded during the ship yard stay of *Polarstern* in Bremerhaven between 20.05.08 and 12.06.08.

Newly designed hard and software were installed and tested at harbour in Bremerhaven.

New acoustic array and window were fix-installed nearby the moon pool in addition to the mobile acoustic array.

A complete new electronic cabinet was installed, modified and tested.

The first operational test under real conditions at sea was carried out during the cruise ARK XXIII/1+2.

A final sea trial and calibration were planned to be carried out during the cruise ANT-XXV/1 on the way to Las Palmas in the mean time between 03.11.08 and 10.11.08 at water depth of more than 3,000 m.

The planned calibration and sea trials were not carried out during ANT-XXV/1 due to the technical problems occurred to the system. The system was faulty and not operational.

The system was repaired by IXSEA in Bremerhaven during the ship-yard stay of *Polarstern*, 24.05.09 to 20.06.09, where the damaged acoustic array and window were replaced by new components.

Posidonia was successfully used during ARK XXIV cruise, but the new acoustic array was not useable, due to the diffraction occurred by the protection window. The system was not able to locate the target correctly and within the expected error bias.

A new sea trial and calibration were done on both Posidonia systems during ANT-XXVI/1 and on the way between Bremerhaven and Las Palmas (16.10.09 – 27.10.09). The acoustic array, which was fixed and newly installed was not fully operational and it could not be calibrated. The protection window underwent a lot of disturbances by transponder positioning. Farther investigations were necessary to improve the acoustical characteristic of the fixed array.

During ANT-XXVI/4 on the way from Las Palmas to Bremerhaven (08.05.2010 – 17.05.2010) new calibration tests were carried out on the new Posidonia system after removal of the protective window in Punta Arenas on April 2010.

The main objectives here were to eliminate the effects of the protective window on the system, to check and to calibrate the system without the protective window.

The sea trials at this time showed that the fitted acoustic array works properly without the pprotection window. Positioning data obtained here were within the specifications and good enough to carry out the calibration.

The housing of the acoustic array was modified during the ship yard stay of *Polarstern* in Bremerhaven (17.05.10 – 10.06.10) and the acoustic window was reinstalled again.

A new calibration and trials including calibration of the mobile acoustic array and the modified acoustic window were done during ANT-XXVII/1 on the way Bremerhaven - Las Palmas on 03.11.10 and 04.11.2010 nearby the Ampèr Sea mount at location 35° 10.477’ N; 13° 02.139’ W and at water depth of 2,356 m.

The navigation platforms MINS I were replaced by MINS II in the mean time 10.10.2010 and 25.10.2010 in Bremerhaven. A recalibration of all Posidonia’s acoustic arrays was therefore necessary and carried out on this cruise.

The tests showed that the modified acoustic window was still affecting the accuracy and the functionality of the system. About 30 % of target locations were wrong. Under these conditions the system was not usable for ROV applications.

The fixed protective window was replaced by a mobile Polyethylene window during the ship yard stay of *Polarstern* in Bremerhaven (20.05.11 – 15.06.11).

The mobile window can now be moved hydraulically by two hydraulic cylinders and allows the use of the acoustic array during operations. The system was used successfully during ARK XXVII/1 for mooring deployments and recovery. During ARK XXVII/2 the fixed acoustic array was electronically damaged during ROV operation and was replaced on October 2011 by a new one.

New calibration and sea trials including the modified acoustic window were carried out during ANT-XXVIII/1 on the way Bremerhaven - Las Palmas and at “Ampére Seamount Area” and at water depth of 2,360 m.

The outcome of the sea trials provided a new data set on the acoustical characteristics of the new system like accuracy, range, symmetry and range limitations.

IXSEA has recently developed the Posidonia 6000 system to Posidonia USBL-Box including hard and software of second generation. A performance test on the Posidonia USBL-Box is also carried out after calibration of Posidonia 6000 system.

Comparisons of test results for both systems are here presented.

Work at sea

- System installation and operation check were carried out
- Sound velocity profile was measured up to 2,000 m water depth using the new Sound Velocity Profiler (SVP) and CTD and was used for the calibration (Fig. 3.9.1).
- Transponder mooring using one transponder (Fig. 2) was prepared and deployed on 05.11.2011, 10:51 UTC, at surface position 35° 10.47’ N; 13° 02.13’ W. The final position at sea floor was reached at 11: 17 UTC, at 35° 10.45’ N; 13° 02.13’ W.
- Water depth was 2,359 m.

- Sea trials were carried out according Fig. 3.9.3 two times for the fix acoustic array.
- Mooring recovery was completed on 06.11.2011; 17:56 UTC.
- Data analysis and validations were carried out during the cruise.

Second mooring for calibration of the Mobile Acoustic Array and to test the new Posidonia USBL-Box was carried out on 26.11.2011 at 20° 10,41 S; 06° 46,21 E in the time between 03:00 and 18:00 UTC.

Principle of calibration

Test preparations

Actual Sound Velocity Profile (SVP) was carried out at mooring location using the SVP Sonde and CTD-Profile (Fig. 3.9.1). This profile was used in the system during the first calibration.

Mooring configuration was prepared accordingly (Fig. 3.9.2) and was deployed by using the calibration transponder.

Test performing

The calibration of a POSIDONIA system consists in measuring the bias of the antenna relative to the ship's axes. This is done by performing a statistical calculation on a set of transponder position measurements. This calculation provides heading, roll and pitch offsets.

The set of positions is obtained by doing a 8 shape with the ship above the transponder position (Fig. 3.9.3). No matter where start point of the measurement is. The orientation of the figure or the sail direction is also relative.

The diameter of the circles composing the figure of 8 depends on the depth of the transponder (60 to 70 % of the transponder depth). To obtain good calibration accuracy, it is recommended to deploy the transponder between 2,000 and 2,500 m (best compromise between a wide enough Fig. to get good results and a moderate range to get a high SNR and, consequently, a high positioning accuracy).

After having performed one figure of 8, the calibration offsets are calculated and entered in the system. Then, a second figure of 8 is made to confirm the accuracy of the measurement. If the results of the second figure are not as good as expected, other figures can be performed.

Results

General conditions during the first calibration and tests on 05.11.2011:

System used:

- POSIDONIA 6000; Abyss 1.49
- Fix Flush Acoustic Array, 80 cm Ø
- Transponder: RT 861 B1S; SN 204

Date:	05.11.2011 and 06.11.2011
Transponder Position:	35° 10.45' N; 13° 02.13' W
Transponder depth:	2359 m
Water temperature:	20.9° C
Air temperature:	17.8° C
Sea state:	4 m Swell (decreasing)
Wind speed:	10.6 m/s (decreasing)
Wind direction:	330°

Track circle diameter:	about 1800 m
Ship speed during measurement:	3 Knots
All other acoustic systems were OFF	

Start of Tests:	05.11.2011; 11:17 UTC
End of Tests:	06.11.2010; 18:00 UTC
Station number	PS 79/10 – 1

Mooring configuration (Fig. 3.9.2):

One transponders RT 861 B1S; SN 204

Calibration of the Fix Acoustic Array

Used Acoustic Array:	Fix Array with mobile protective window
Used Posidonia system:	New system POSIDONIA 6000, ABYSS 1.49

The first calibration track for this configuration was carried out according to Fig. 6. and the mobile protective window was open.

Very good positioning performance was found. Only about 10 % of positions were out of expected range. The first data set here was good enough to perform very good calibration.

Calculation of the first calibration parameters was carried out using the ABYS-procedure. The calibration was successful. Accuracy was about ± 20 m (see Fg. 3.9.7)

Verification of parameter set was carried out by repeating the ship's track in 8 shapes. No significant change of parameter set was found. Only the heading offset was increased by 0.30°.

Range tests were carried out according to Fig. 3.9.3 and Fig. 3.9.4. The results show that the maximum horizontal distances to the transponders, where the system was able to produce reliable positioning, was about 4,000 m. Considering the transponder depth of 2,359 m, those means that the system is able to work within 120° cone (60° to each side).

The following calibration parameter set was found for the fix acoustic array:

Parameter	**First Parameter Set (window is open)**	**Final Parameter Set** After Verifications
Heading	- 0.26°	**- 0.56°**
Roll	+ 0.21°	**+ 0.21°**
Pitch	+ 0.69°	**+ 0.69°**

Calibration of the mobile acoustic array

Due to problems with the moon pool lock the "Mobile Flush Acoustic Array, 70 cm Ø" could not be used during the first calibration on 05.11.2011. The moon pool cover was repaired in Las Palmas and the test here was carried out on 25.11.2011.

General conditions during the second calibration and tests on 26.11.2011:

System used:

- POSIDONIA 6000; Abyss 1.49
- Mobile Flush Acoustic Array, 70 cm Ø, Moon Pool installation
- Transponder: RT 861 B1S; SN 204 and RT 861 B1S; SN 124

Date:	26.11.2011
Transponder Position:	22° 10.39' S; 06° 46.25' E
Transponder depth:	2834 m
Water temperature:	18.2° C
Air temperature:	17.7° C
Sea state:	3 m Swell
Wind speed:	11.6 m/s
Wind direction:	134°
Track circle diameter:	about 1800 m
Ship speed during measurement:	3 Knots
All other acoustic systems are OFF	
Start of Tests:	26.11.2011; 14:30 UTC
End of Tests:	26.11.2011; 16:33 UTC
Station number	PS 79/034 – 2

Mooring configuration (Fig. 3.9.2):

Two transponders RT 861 B1S; SN 204, RT 861 B1S; SN 124

Used Acoustic Array:	Mobile array, moon pool installation
Used Posidonia system:	New Posidonia system 6000, ABYSS 1.49

New sound velocity profile up to 2,500 m was at first measured (Fig. 3.9.9). The first calibration track for this configuration was carried out according to Fig. 3. Very good positioning performance was found. Only about 10 % of positions were out of expected range. The first data set here was good enough to perform good calibration.

Calculation of the first calibration parameters was carried out using the ABYS-procedure. The calibration was successful. Accuracy was about ± 20 m (see Fig. 3.9.10). Verification of parameter set was not carried out, due to the missed time.

Here are the results of mobile acoustic array calibration:

Parameter	Parameter Set Old	Parameter Set New
Heading	- 0.38°	**-0.53°**
Roll	+ 0.09°	**-0.03°**
Pitch	- 0.02°	**+0.05°**

Calibration of the Fix Acoustic Array using the Posidonia USBL-BOX

Used Acoustic Array:	Fix Array with mobile protective window
Used Posidonia system:	USBL-BOX with Software Version: V1.1.3.10

General conditions and weather parameter are mentioned above for the second calibration done on 26.11.2011.

Date:	26.11.2011
Start of test:	08:38 UTC
End of test:	12:52 UTC
Station number:	PS 79/034-1

The sound velocity profile (Fig. 3.9.9) was used. The first calibration track for this configuration was carried out according Fig. 3.9.6. The mobile protective window was open. Very good positioning performance was found. Only about 10 % of positions were out of expected range. The first data set here was good enough to perform very good calibration.

Calculation of the first calibration parameters was carried out using the USBL-Box calibration tools. The calibration was successful and the accuracy was about ± 15 m (see Fg. 3.9.11)

Verification of parameter set was carried out by repeating the ship's track in 8 shapes. No significant change of parameter set was found (Fig. 3.9.12). The final new parameters were calculated and compared to the ones derived from the same fix acoustic array using the Posidonia 6000 (Table below). The parameter fit very good.

Range tests were carried out according to Fig. 3.9.3. The results show that the maximum horizontal distances to the transponders, where the system still was able to produce reliable positioning, was more than 5,000 m.

The following calibration parameter sets were found for the fix acoustic array using different Posidonia systems:

Parameter	**Final Parameter Set** Using Posidonia 6000	**Final Parameter Set** Using USBL-Box
Heading	- 0.56°	- 0.56°
Roll	+ 0.21°	+ 0.35°
Pitch	+ 0.69°	- 0.65°
Accuracy	+- 20 m	+- 15 m

Conclusion

The acoustical characteristic of the Fix Acoustic Array was significantly improved by opening the protective window. Posidonia systems cannot be effectively operated behind a protective window due to the refractions of the acoustics waves throw the window and to the reflections between array and the inner side of the window (multi pass). The tests show that the system could be used in emergency cases behind the closed window, but it is not reliable and not good enough for ROV operations under these conditions.

The hydraulically controlled mobile window provides sufficient ice protection for the acoustic array and at the same time provides reliable operations due to extensive investigations on construction, hardware and software.

After considerable investigations and long term development, the fix installed acoustic array and the Posidonia 6000 system are now full operational, and can be used without any limitation for mooring, ROV and AUV operations also in ice-covered area saving a lot of ship time and works.

Comparing the towed Posidonia systems tested on this cruise with the old one reveals that the new Posidonia USBL-Box is reliable, provides more accuracy, has better signal/noise ratio and is able to operate at a longer range than the old system. Calibration parameters derived from both systems for the same antenna were very similar (see last table). The software of the new system (USBL-Box) has to be redesigned again or radically improved to meet the high requirements of mooring operations.

Finally we would like to thank all colleagues from AWI, Laeisz, Fielax and IIXSEA, who encouraged and assisted us to complete this long term work.

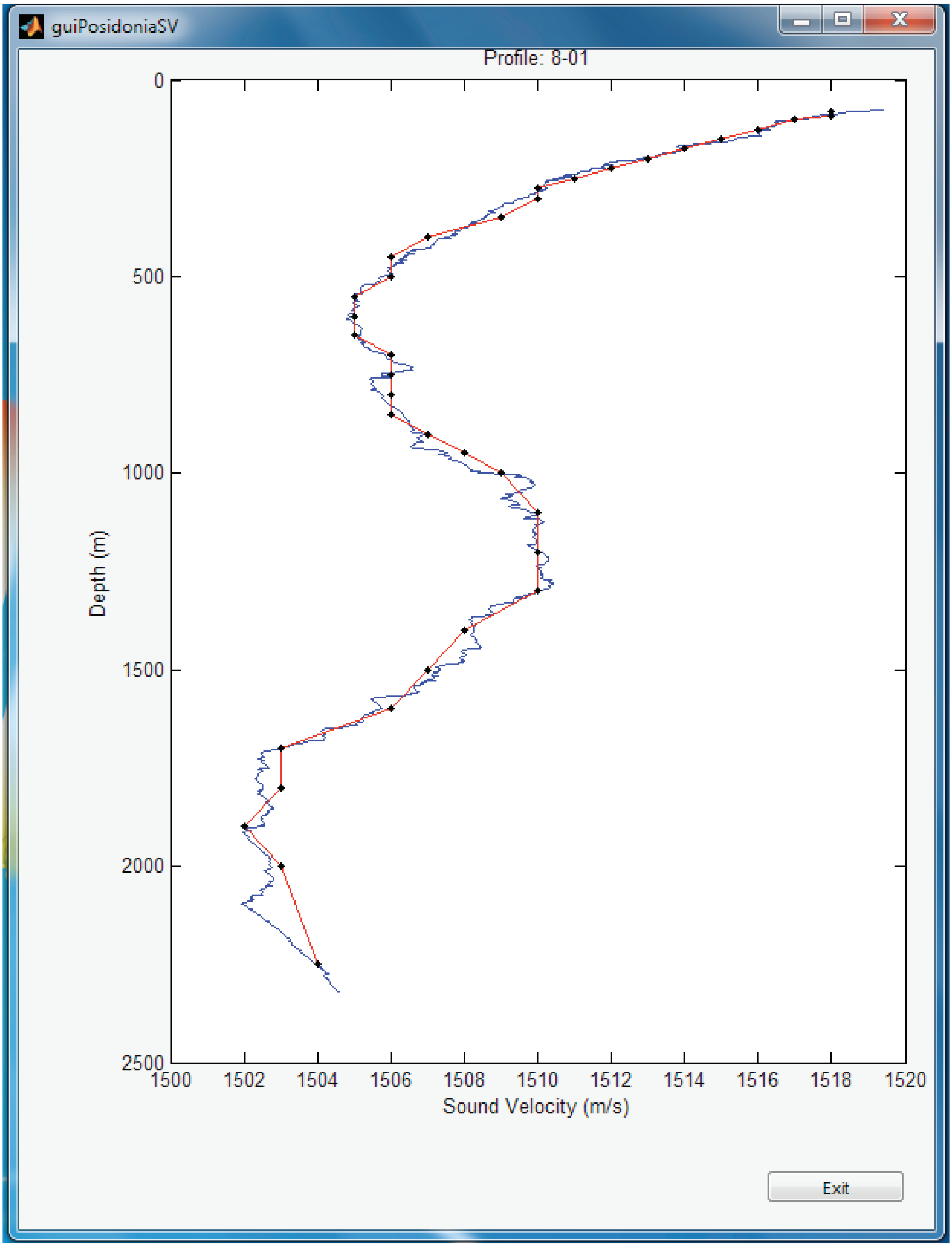

Fig. 3.9.1: Sound velocity profile for first calibration on 05.11.2011 and at 35° 10.45' N; 13° 02.13' W

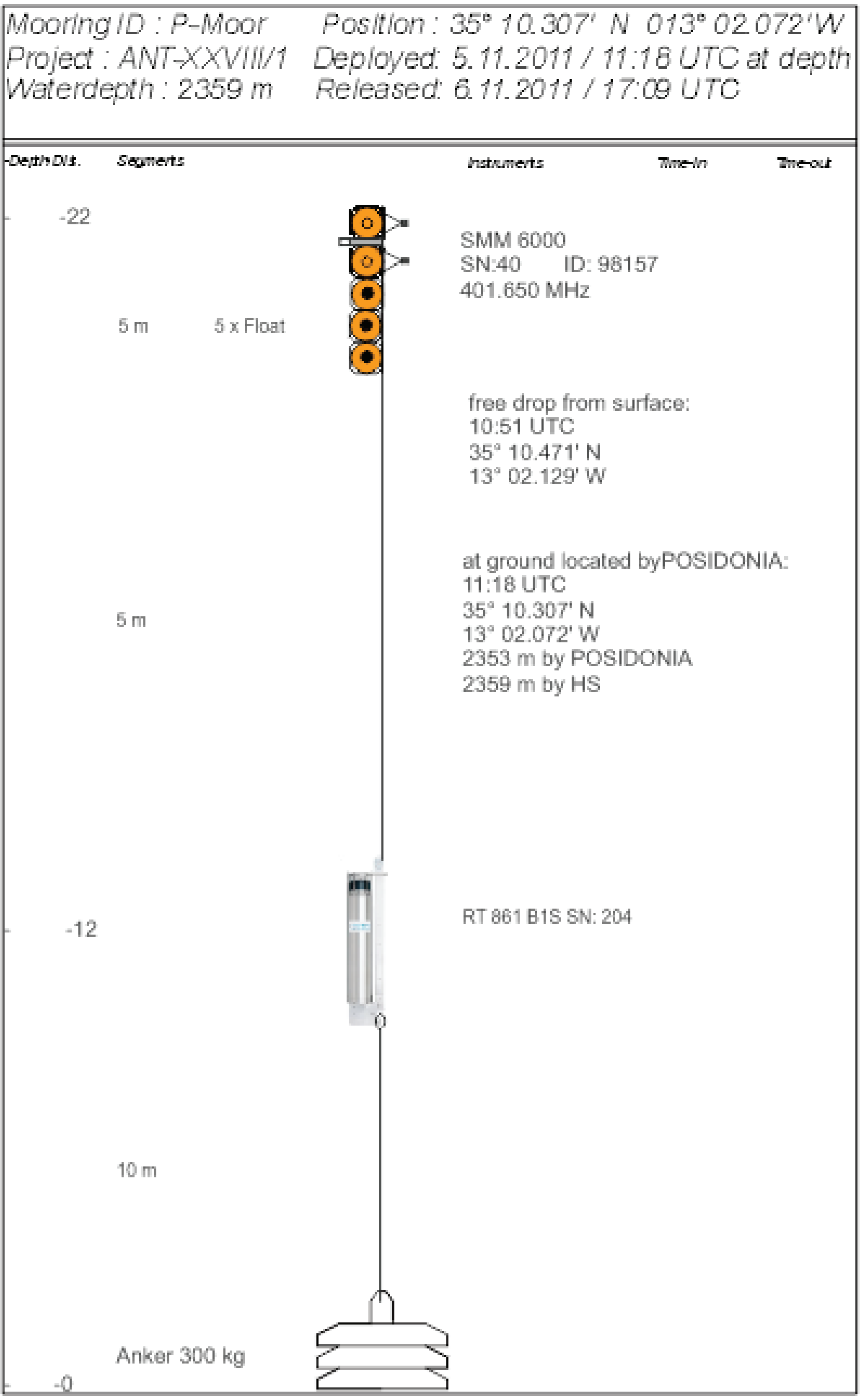

Fig. 3.9.2: Mooring configuration

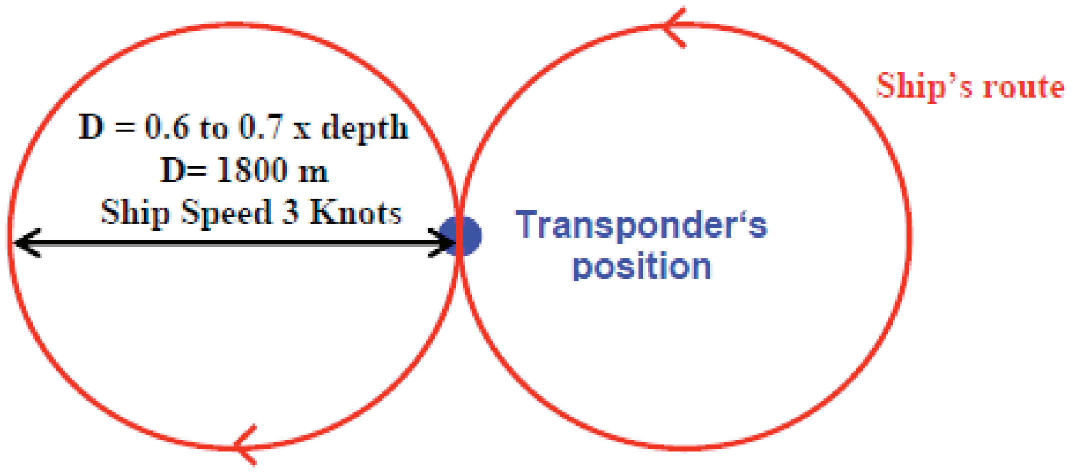

Fig. 3.9.3: Ship's track performed over the transponder as 8 shapes

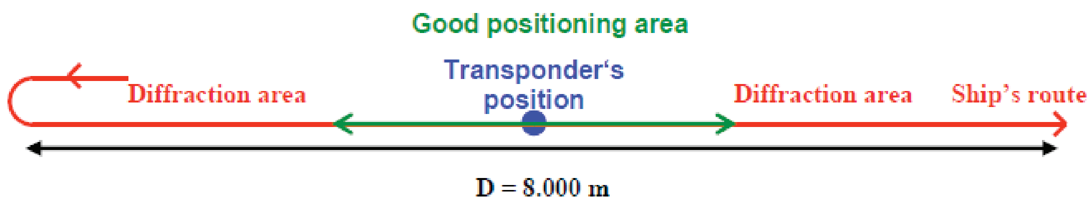

Fig. 3.9.4: Line Track over the Transponder

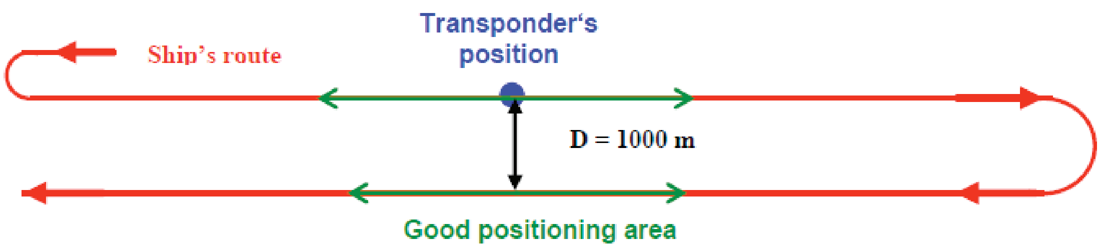

Fig. 3.9.5: Line Track at distance of 1000 m parallel to the first line track in Fig. 3.9.4

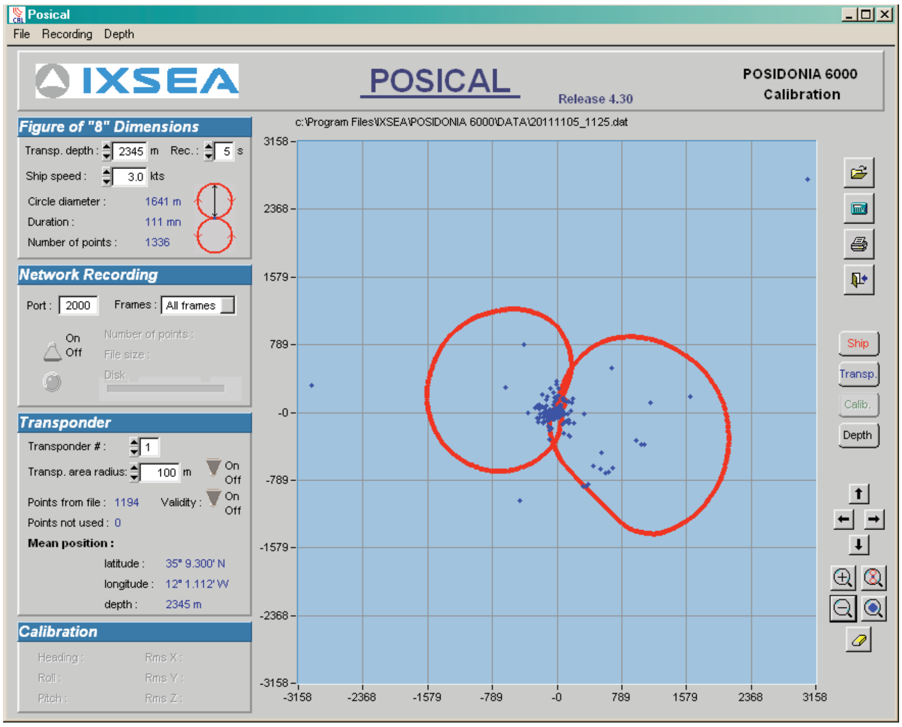

Fig. 3.9.6: Calibration of the Fix Flush Acoustic Array. Red line = Ship's track, Blue dots = Detected transponder positions

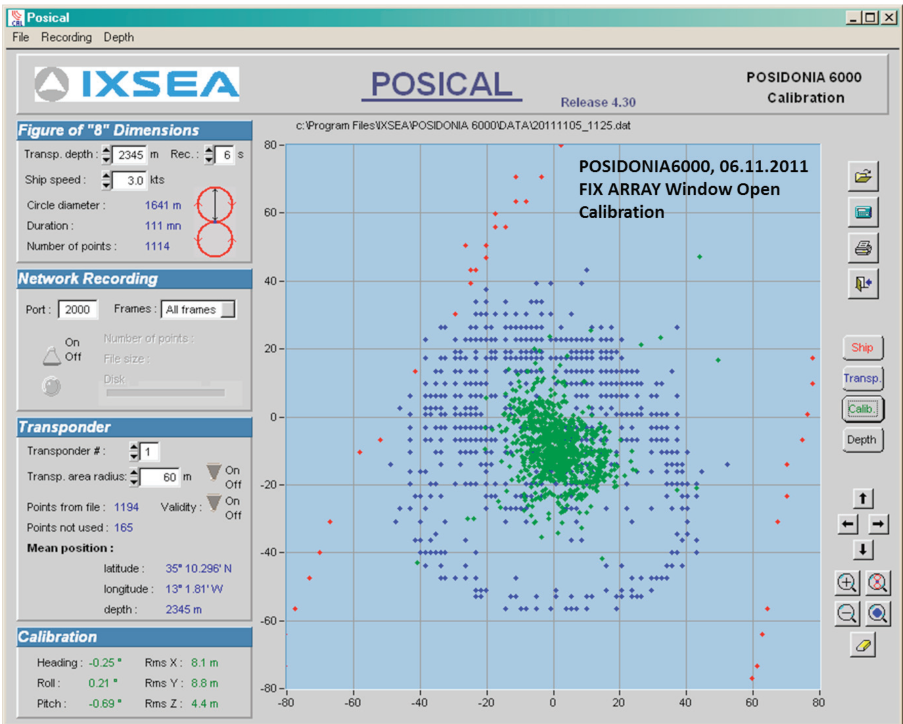

Fig. 3.9.7: Calibration of mobile Array, First Loop (8 Shape), First calculation. Blue dots are positions before correction and green dots are recalculated positions after the correction. Positioning distributions were reduced to ± 20 m.

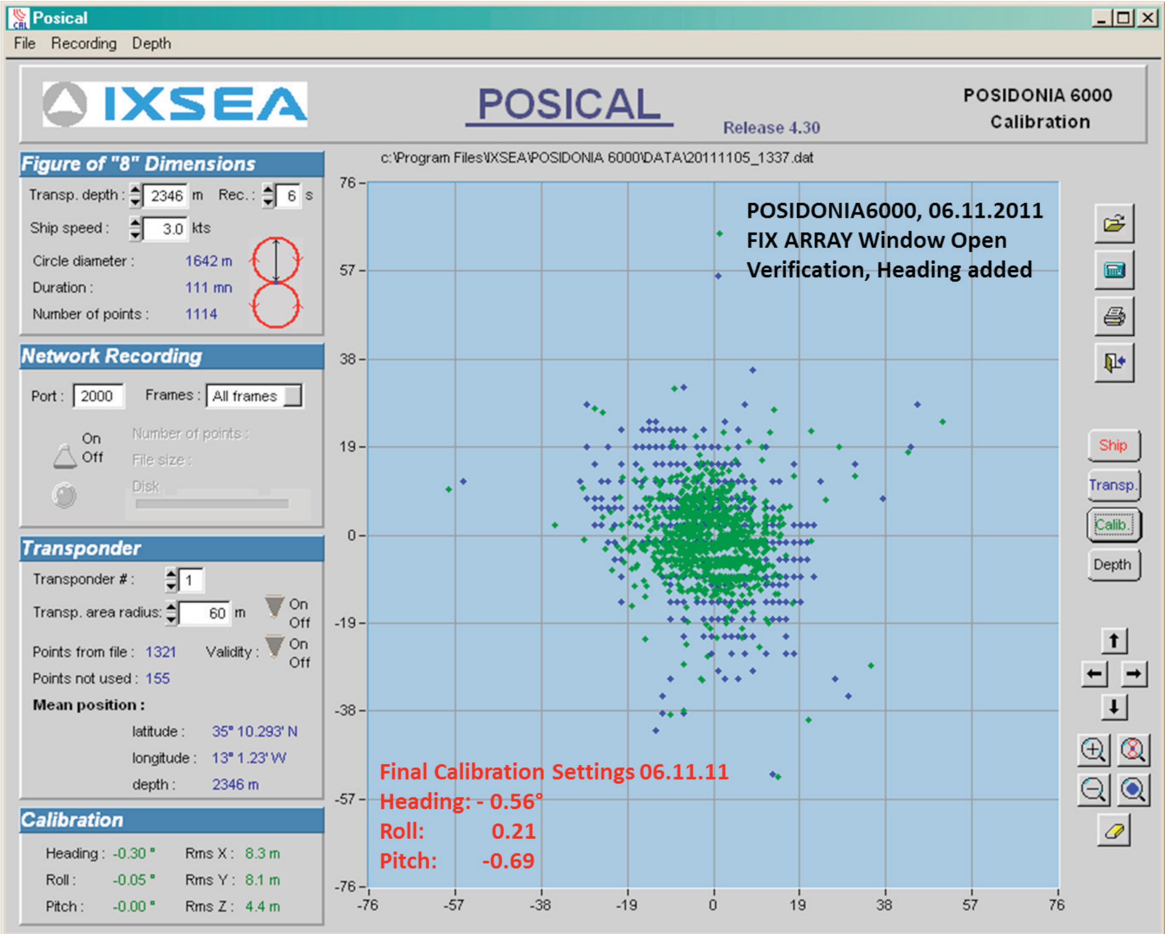

Fig. 3.9.8: Final calibration and verification of Fix Acoustic Array after second 8-loop. Final derived and valid calibration parameters are in (red).

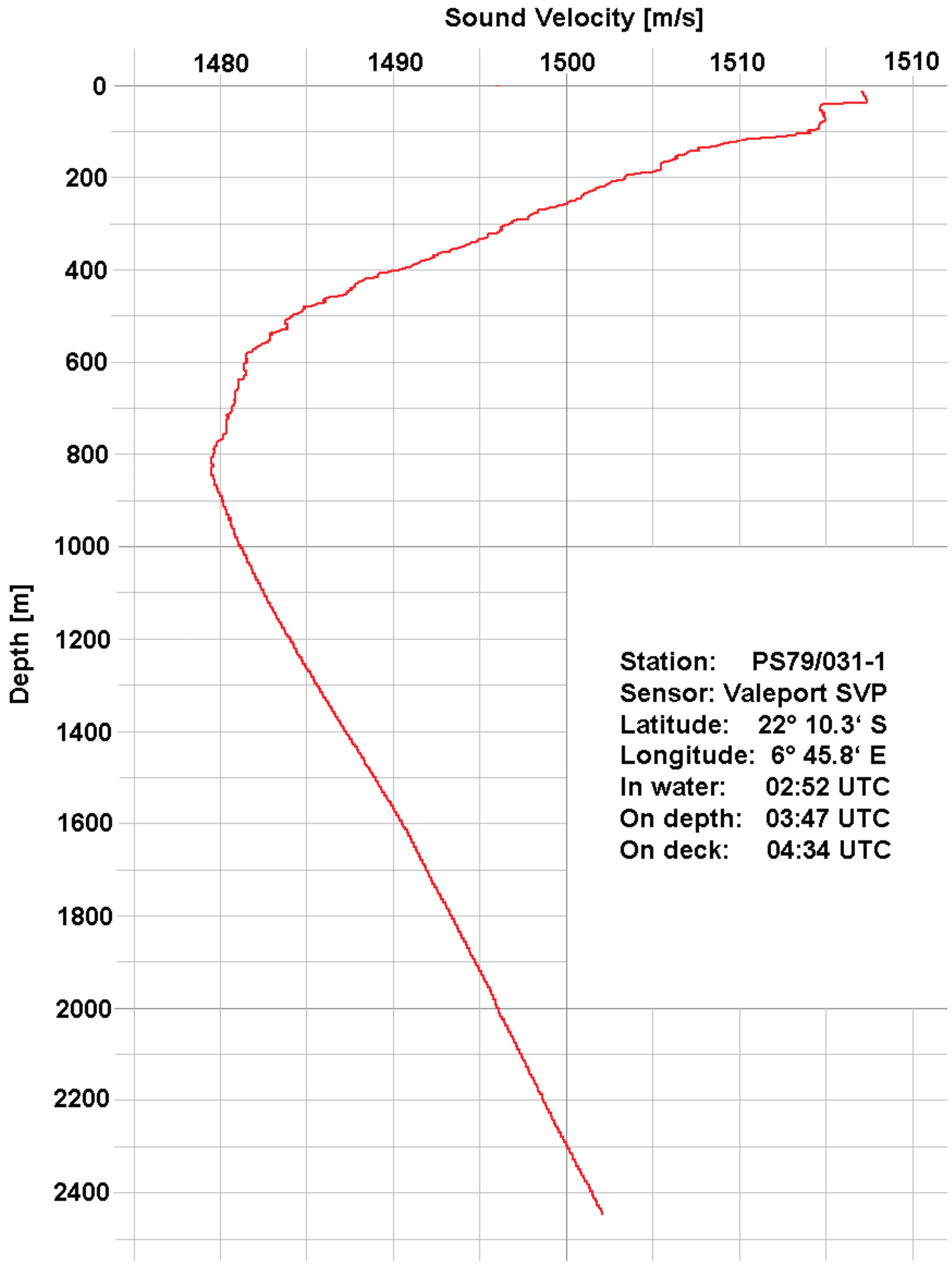

Fig. 3.9.9: Sound velocity profile for the second calibration measured by SVP on 25.11.2011

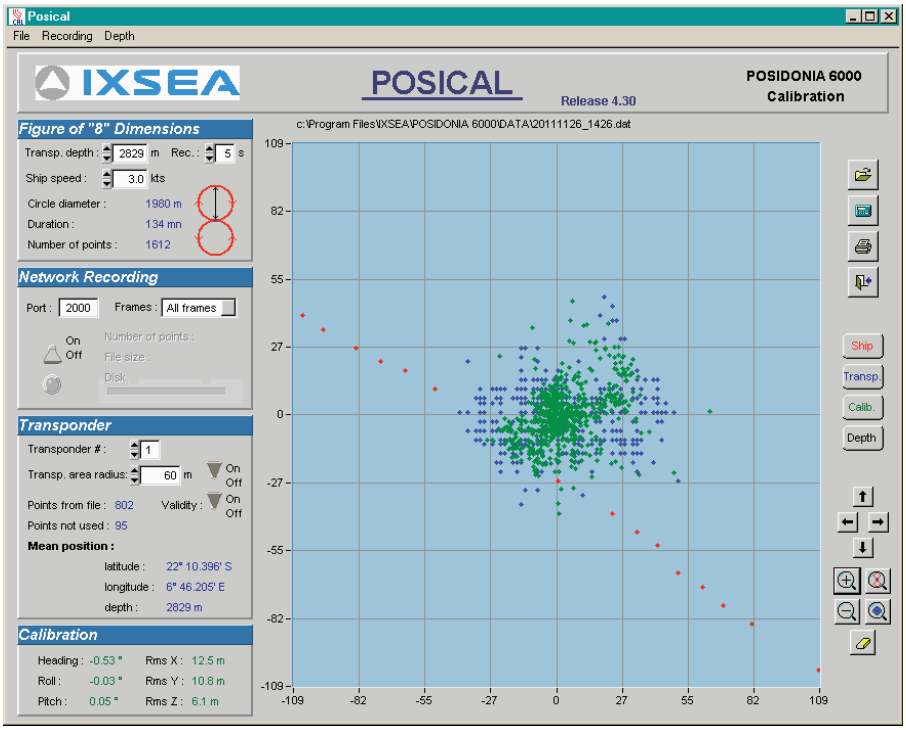

Fig. 3.9.10: Calibration of the Mobile Acoustic Array on 25.11.2011. Blue dots are positions before correction and green dots are recalculated positions after the correction. Positioning distributions were reduced from 35 to ± 25 m.

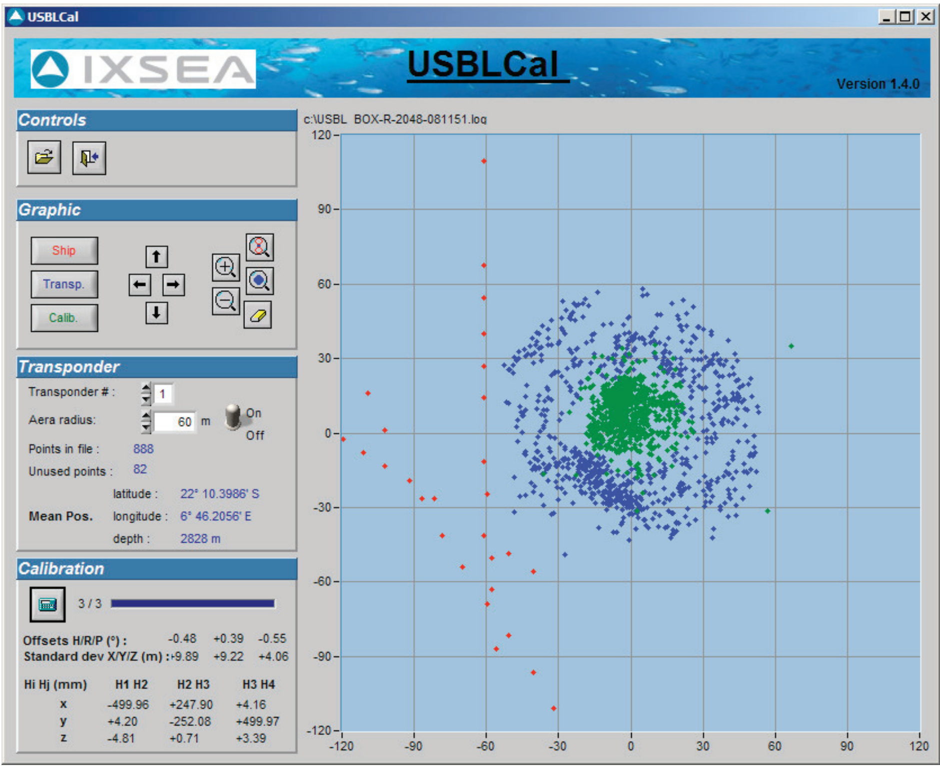

Fig. 3.9.11: Calibration of the Fix Acoustic Array on 26.11.2011using USBL-Box. Blue dots are positions before correction and green are recalculated positions after the correction. Positioning distributions were reduced from 50 to ± 15 m.

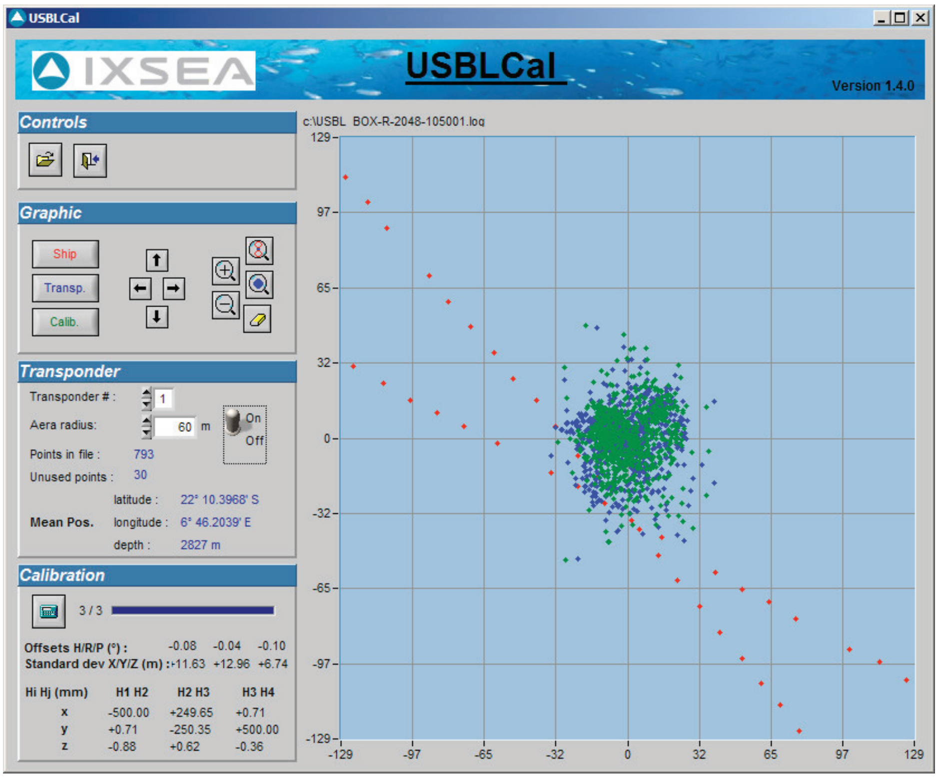

Fig. 3.9.12: Second calibration of the Fix Acoustic Array on 26.11.2011using USBL-Box. Blue dots are positions before correction and green dots are recalculated positions after the correction. Positioning distributions were not really reduced.

3.10 Sea Trials and Tests of the Multifrequency Echosounder Simrad EK60 after Replacement of all Transducers and Installation of a New Additional One (18 kHz)

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Objectives

Transmission of sound and listening to echoes based on sound scattering caused by inhomogeneities, particles and organisms, is the principle of a set of basic measuring techniques applied in physical and biological marine science. Active hydroacoustic measurements allow surveying the distribution of organisms in the size ranging from small macrozooplankton to large nekton with a very high temporal and spatial resolution. 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 scientific multifrequency echosounder (Simrad EK60) is used for these survey tasks. During the last two dock overhauls old EK60 transducers were replaced with new ones and an additional 18 kHz transducer was installed, extending the set of operating frequencies to 18, 38, 70, 120, 200 kHz. Besides enhancements of the water column survey abilities, the installation of the new 18 kHz transducer now allow bottom detection down to at least 5,000 m.

The aim during the cruise was to test the performance of the new transducers, check for cross interference, and integrating the bottom depth measurements of the Simrad EK60 system (18 and 38 kHz) into the DSHIP data system of *Polarstern*. Furthermore, it was planned to set up post-processing software (Echoview 5.0) for live-viewing and analysis of the data measured with the Simrad EK60 at remote PCs within the *Polarstern* data network.

Work at sea

During the cruise extensive measurements were performed with different configurations of the EK60echosounder, including measurements with single transducer in passive and active mode, and installation of different sets of transducers. A detailed error analysis was done in order to identify sources of noise present in the data record measured with 120 kHz transducer.

The post-processing and data analysis Software Echoview 5.0 (Ver. 5.0.82) was installed on the Simrad EK60 Operation PC and on a second computer in network. Logging and data analysis software was configured for Live-viewing and data analysis via network.

Results

Performance and functioning of the new EK60 transducer

Also with the new set of operating frequencies of the Simrad EK60, the measurements at different frequencies do not interfere with each other. The replacement of the old transducers caused a significant improvement of the performance in terms of the effective measuring range and noise floor level at 70 kHz and particularly at

200 kHz. The noise present in the measurements with 120 kHz transducer is not caused by other echosounding devices, however, seems to be self-noise.

Bottom detection

Integration of the bottom depth measurements of the Simrad EK60 into the DSHIP data system via the NMEA protocol broadcasted by the Simrad EK60 and the definition of a valid bottom depth ("system depth") according a ranked list of source echosounders (Navigation Echosounder, Hydrosweep, Parasound, DWS, Simrad EK60) is functioning properly.

Bottom detection by the Simrad EK60 at 18 kHz works well even in areas with deep ocean sea floor (down to 5,600 m during this cruise). During the test, incorrect measurements are caused by interference from other echosounders (Hydrosweep). Current measurements show a systematic offset of about 3 m between DWS and Simrad EK60 (18 kHz).

Set-up of post-processing software

Live-viewing and, to a certain degree, near real-time data analysis for survey purpose (e.g. computation of differences in Sv values at different frequencies) via data network of *Polarstern* is possible now.

3.11 Using Existing Globally Available CTD-Data for Deriving Sound Velocity Profiles

Daniel Damaske AWI
Hans-Werner Schenke (not on board)

Objectives

Adequate Sound Velocity Profile/s (SVP) during bathymetric surveying - especially during transit cruises of *Polarstern* - are crucial for improving results and avoiding depth and positioning errors due to refraction. In deep sea operation areas, the error is up to hundred meters. In consequence of restricted ship time during *Polarstern* cruises, CTD-casts for deriving SVP cannot always be performed sufficiently. Therefore, with this project it is planned to test a new approach to bypass the lack of *in-situ* CTD-data acquired on sea by using existing globally available CTD-data from several oceanographic projects and different oceanographic instruments. The World Ocean Database (WOD) collects and provides a large amount of available oceanographic data, including the data of the project ARGO, which can be processed with the software package Ocean Data View 4.4.2 (ODV) (Schlitzer, 2011).

On board ODV provides the operator with a tool to study changes in physical properties (conductivity, temperature and pressure) of ocean seawater vertically and horizontally. Thus, it can be used to derive and interpolate SVP. Abrupt changes of sound speeds in the water column are observed especially in *Polarstern* deep sea operation areas during Southern Ocean transits when passing oceanic fronts of the Antarctic Circum Polar Current (ACC). Sudden changes in seawater physical properties without adapting the SVP can result in poor bathymetric measurement accuracy. Due to the lack of a cross fan calibration function, a method to determine the mean sound velocity of the water column within the currently installed Hydrosweep DS3 (upgraded from DS2 to DS3 in the year 2010), this approach enhances the quality of a bathymetric survey. In addition many regions of the ocean are still undersampled, which can be visualized in the ODV software. The operator is informed, if a new CTD cast should be performed during the cruise or if the existing CTD data (derived SVP) is still adequate enough for the current task.

Work at sea

Preparation and Interpolation of Sound Velocity Profiles

Previous to ANT-XXVIII/1, data from the World Ocean Database (WOD) (URL: http://www.nodc.noaa.gov/OC5/SELECT/dbsearch/dbsearch.html) were downloaded and processed on board. The WOD data contain High-resolution Conductivity-Temperature-Depth / XCTD data (CTD), Autonomous Pinniped Bathythermograph data (APD), Glider data (GLD), Ocean Station Data (OSD), Undulating Oceanographic Recorder data (UOR) and Profiling float data (PFL). The availability of PFL-data has been increasing rapidly, especially since the network of the international project ARGO was fully established in 2007. Nevertheless, the CTD-data still represent the highest amount of data. This will probably change within the next years and be surpassed by the availability of PFL-data from the project ARGO.

After importing the WOD data into ODV, the data are converted to an ODV-collection, which stores the data in a dense format, optimized for irregularly spaced, variable length data, and it provides fast data access (Schlitzer, 2011). In total, 1,403,325 CTD-profiles could be imported into ODV and saved as a ODV-collection. The ODV-collection enables the user to interpolate the sound speed of the water column for the desired position.

Testing the usability of interpolated sound velocity profiles for multibeam systems

To verify the interpolated SVP from WOD data for the usability for multibeam systems it is necessary to compare the data with statistical methods and apply the SVP on bathymetric data. Three CTD-casts performed during ANT-XXVIII/1 are selected to compare the on-board *in-situ* measurements with the interpolated data. To include the influence of seasonal changes of the water column, only WOD data from the 19th of October till the 16th of November of all available years were selected and used for interpolating the sound speed. The time period of about two weeks before and two weeks after the CTD-casts was selected to maintain the data density for an adequate interpolation.

Preliminary results

Comparison of SVP from CTD-casts and interpolated WOD data

Three CTD-stations during the cruise were selected to compare the sound speed in the water column derived from *in-situ* measured CTD-cast on board with interpolated SVP for these positions (fig. 3.11.1). All correlated graphs show a very strong correlation.

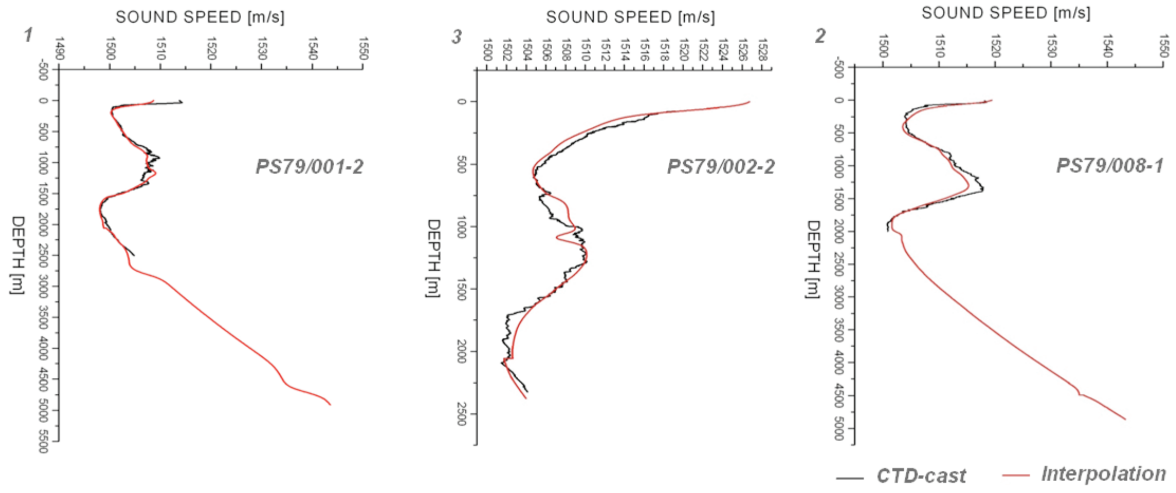

Fig. 3.11.1 Comparison of sound velocities throughout the water column from CTD-stations and interpolated results. The SVP are derived and interpolated with ODV from the available WOD data from the 19th of October till the 16th of November (all years)

Applying the interpolated sound velocity profiles on bathymetric data

A small survey in the east of the Ampere Seamount was performed during the cruise, which turned out to be a good area to apply the different SVP on the bathymetric data set. With the Software CARIS 7.0, three SVP were applied to enable the SVP correction; the measured SVP from the CTD-cast on station PS79/008-1, the interpolated SVP from WOD data and an SVP which has the sound speed of 1,500 m/s for each depth (default value / SVP, when no SVP is uploaded into CARIS). The selected tracks are in opposite direction to each other and the swaths are overlapping which makes the refraction errors using 1,500 m/s as default value clearly visible for this case. Fig. 3.11.2 shows the bathymetry with all three applied SVP.

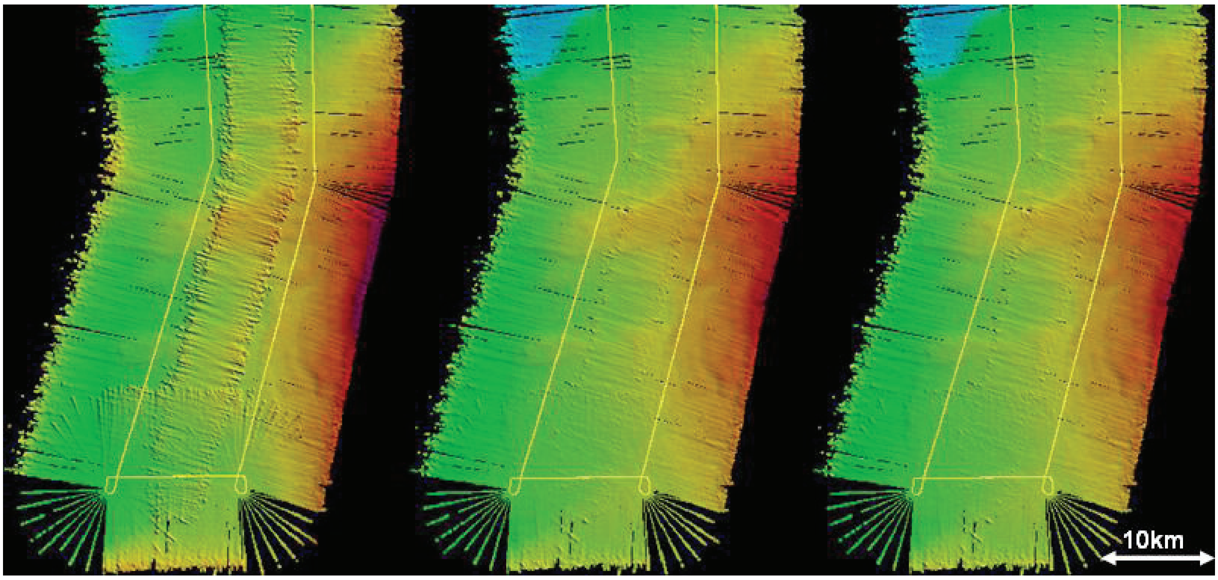

Fig. 3.11.2 Comparison of all applied SVP on the same bathymetric dataset. left; „1,500 m/s SVP", middle: „CTD-Cast SVP", right; „interpolated SVP"

It can be seen that refraction errors occur without applying a measured or interpolated SVP, which is especially visible at the edges of the swath. Overall the map quality becomes poor. The error to true depth is about -50 m in average in the nadir beam and about 125 m in average at the edges. Using an interpolated SVP enhances the quality of the bathymetric map significantly. Compare to the SVP from the CTD-cast, almost no difference is visible. The vertical difference is about +10 cm in the nadir beam and about -25 cm in average at the edges.

Development of a workflow process and advantages for Polarstern

During the cruise the workflow processes for bathymetric work were developed, showing how the operator of the Hydrosweep DS3 multibeam system can use WOD data with ODV. The operator of the Hydrosweep DS3 system can save ship time, since an interpolated SVP from WOD data is sufficient for the current task and no CTD-casts are needed for bathymetric measurements. Overall, it can assist further *Polarstern* cruise participants to improve bathymetric maps. However, *in-situ* CTD-data are still the best choice to maintain the best bathymetric data quality. All these findings are not restricted only to *Polarstern* and can be applied to other research vessels and multibeam systems. Within the scope of this project, the analyses cannot be fully addressed but need further comprehensive studies to support its findings to be applied in general bathymetry-related scientific work. Finally, however, it can be noted that SVP from WOD data are a reasonable alternative to *in-situ* CTD/SVP casts in deep sea areas.

References

Schlitzer (2011): Ocean Data View, http://odv.awi.de

3.12 Calibration of the Wave and Surface Current Monitoring System "WaMos" by Using a Waverider Buoy

Saad El Naggar[1], Klaus Buldt[2],
Werner Dimmler[3], Helmut Muhle[3],
Sören Hüttemann[4], Katrin Hessner[4]

[1]AWI
[2]DWD
[3]Laeisz, Fielax
[4]OceanWave

Objectives

Wave and Surface Current Monitoring System (WaMos II) of the company "OceanWaves" 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 the system operation, an own X-Band radar (5 feet Antenna) was specially installed on the top platform, star port (Fig.3.12.1).

WaMos II was developed to provide waves and current parameter on-line and was installed here to compare measured and observed parameters in aspect to use it in the future for synoptical weather observations.

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.

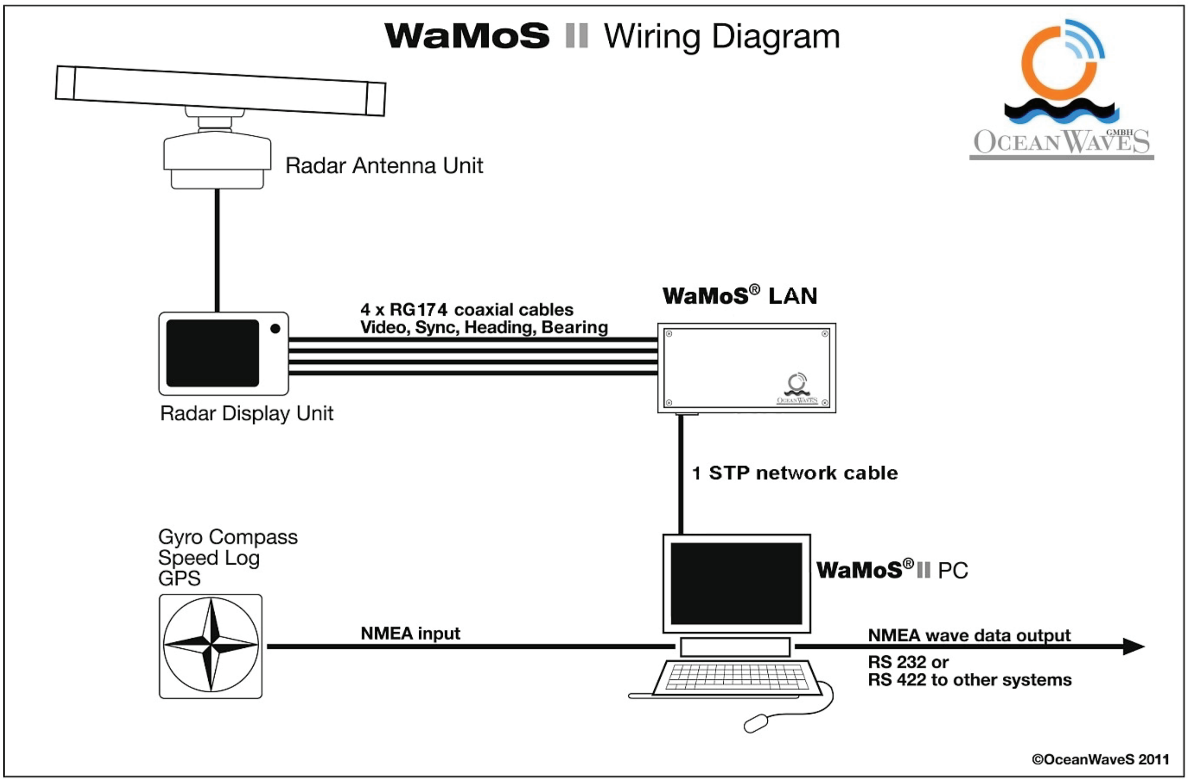

Fig. 3.12.1: WaMos configurations

A Waverider buoy of the company Datawell (Netherland) Type DWR-G 4, GPS-based (Fig. 3.12.2 and Tab. 3.12.1), was used by different locations and sea conditions to measure the waves parameter nearby the ship (more than one miles). Both data sets were compared and system setting was done step by step of approximations.

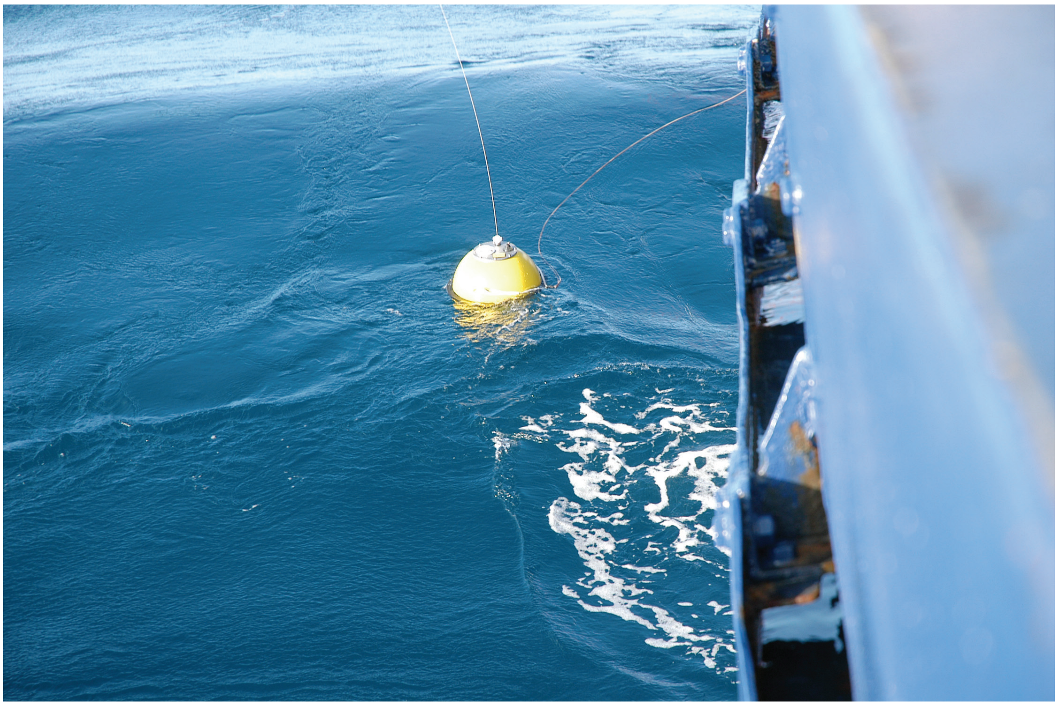

Fig. 3.12.2: Waverider buoy DWR-G4

Tab. 3.12.1: 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)

Work at sea

WaMos-System was operational during the cruise and all system components were checked and set according to manual and instructions at begin of each measurement.

Waverider buoy was prepared for deployments and 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 were used for calibrations. Data sets of WaMos and of Buoy were visually compared on board and reported to the company OceanWaves. All data sets were sent to OceanWaves after each buoy deployment (Tab. 3.12.2) and used for the calibration.

Tab. 3.12.2: Waverider Buoy deployments during ANT-XXVIII/1

Buoy Deployment				**Buoy Recovery**			
Date 2011	Time UTC	Latitude	Longitude	Date 2011	Time UTC	Latititude	Longitude
31.10.	13:00	45° 19,17' N	008° 37,10' W	31.10.	17:08	45° 18,91' N	008° 36,10' W
01.11.	15:48	40° 29,80' N	011° 06,37' W	01.11.	17:46	40° 29,50' N	011° 06,21' W
05.11.	10:14	35° 10,40' N	013° 01,73' W	05.11.	16:57	35° 05,24' N	012° 58,17' W
06.11.	09:12	35° 20,71' N	013° 14,97' W	06.11.	15:12	35° 20,71' N	013° 14,97' W
11.11.	13:04	18° 50,24' N	021° 30,00' W	11.11.	16:24	18° 49,47' N	021° 30,82' W
12.11.	07:27	16° 53,33' N	022° 48,81' W	12.11.	10:15	16° 53,31' N	022° 48,96' W
15.11.	14:30	06° 36,34' N	017° 01,55' W	15.11.	17:33	06° 37,43' N	017° 03,36' W
21.11.	08:58	11° 35,15' S	001° 09,09' W	15.11.	17:00	11° 34,56' S	001° 13,54' W
23.11.	15:30	17° 31,60' S	003° 26,94' E	24.11.	14:38	17° 24,01' S	003° 14,70' E

Results

Visual comparison of WaMos and Buoy systems on board is shown in Figures 3.12.3 and 3.12.4. The significant waves peaks determined by WaMos befor calibration, were almost higher than which determined by the buoy. After parameter corrections, the WaMos system was working properly. Wave period and wave length were visually in both system not reliable.

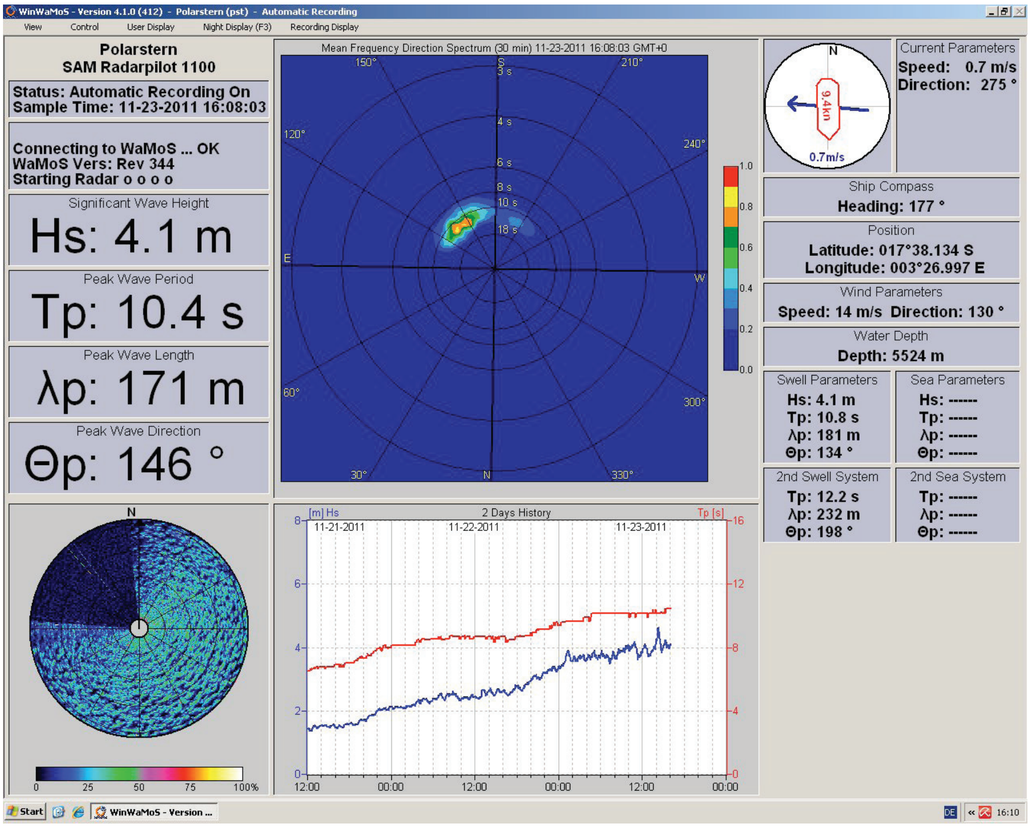

Fig. 3.12.3: WaMos display on 23.11.2011, 16:08 UTC

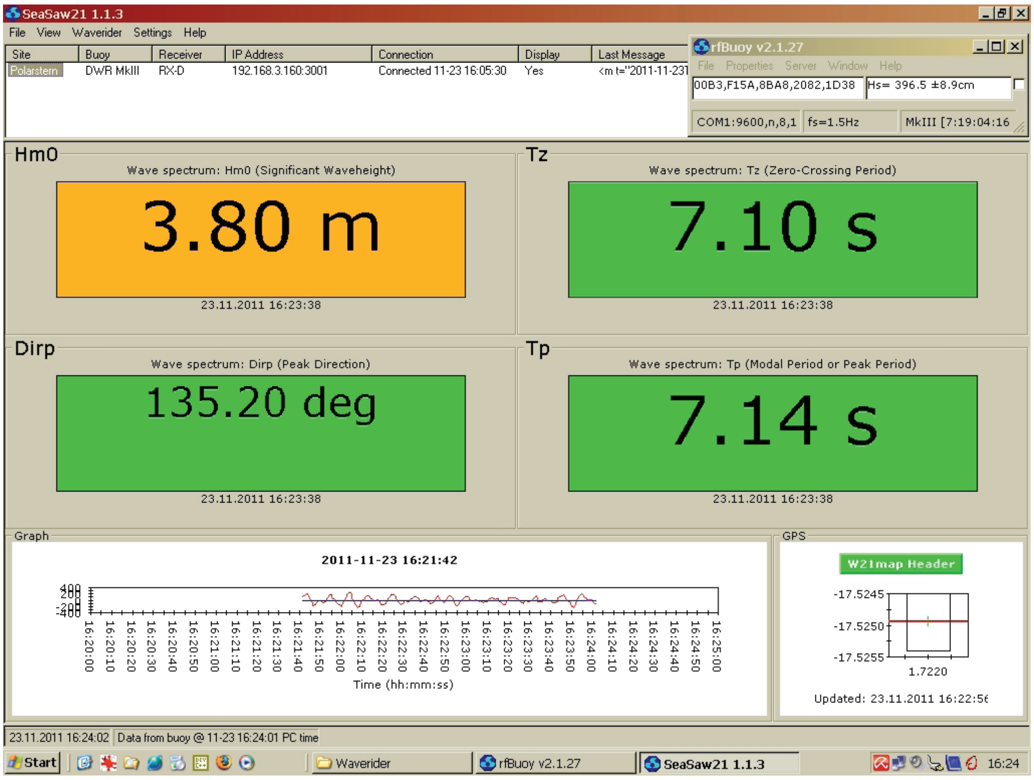

Fig. 3.12.4: Buoy display on 23.11.2011, 16:21 UTC

Data comparison done by OceanWaves is shown in Fig. 3.12.5. Buoy and WaMos data were fitting well within the accuracy of both systems.

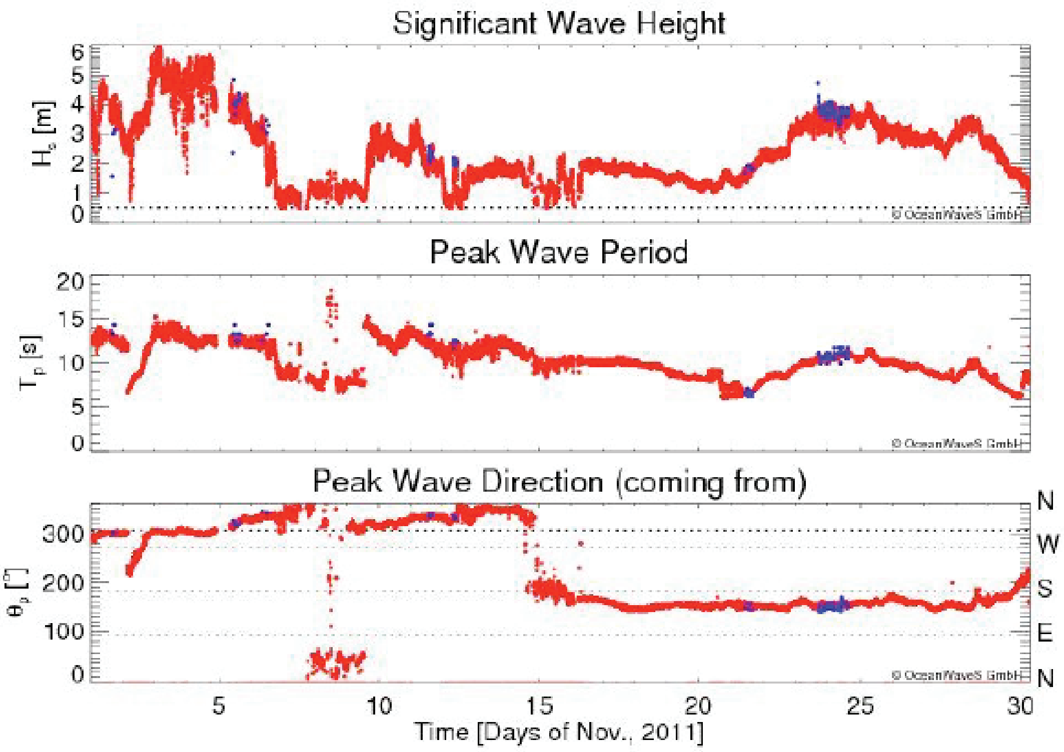

Fig. 3.12.5: Comparison of Buoy and WaMos data for peak wave period and peak wave directions for November 2011. Red lines are WaMos data and blue dots are buoy data.

The final correction parameter were done and implemented in the final software version by OceanWaves after completing the cruise.

Further investigations are necessary to complete the software, especially for current determinations and to check the final software version.

3.13 Upgrade of the Central Data Acquisition System "D-Ship"

Tim Tomczak Werum
Peter Gerchow AWI

Modular data management system is installed on board of *Polarstern* in a client/ server architecture called DSHIP. The system was buildt and supported by the company "WERUM" Systems AG. Scientific instruments are connected via network connections and supply their data to the system via NMEA0183-compliant datagrams.

In parallel to storing the acquired data, the system also distributes data online throughout the whole network to have them displayed by the DSHIP Display clients.

The station book component is used to record and document specific information regarding the activities and actions on scientific stations. The station book typically is the starting point for various analyses of acquired data.

The data acquired and stored on the vessel can be exported by the users into standard text file format. Especially for this purpose, DSHIP provides an export Web-interface where the user can select the parameters to export, define the time range and the export format and start the export process. The export process itself is executed in the background, and the user will be informed by an e-mail when it has completed successfully.

The DSHIP-Archive component provides the capabilities to setup and run archiving functionalities on board a vessel as well as setting up a shore-based long-term archive for the vessels data.

The DSHIP system automatically creates archive sets at the end of the cruise, which will be transferred, onto portable media to take them back to the shore-based archive system located in the AWI. Since the archive sets contain all data of a defined of a cruise, the shore-based archive contains all data a vessel has ever acquired along with all station book information and all configuration information.

The DSHIP system was installed in September of 2000 on board of *Polarstern* and as a shore-based system in the AWI. In between all data of further data acquisition systems were converted into the DSHIP shore-based system. So *Polarstern* data are now available starting from 1993.

In 2000 the DSHIP system was designed on server hardware supplied by Sun Microsystems with SPARC processor architecture using the operating system SUN Solaris. When Sun Microsystems was taken over by Oracle the possibility in replacing the old server with these SPARC processor with new ones seemed to become a unpromising solution. So AWI decided to upgrade the DSHIP system from SUN Solaris/Sparc to a LINUX based operation system installed on common hardware-server.

The upgrade procedure in hard- and software was carried out during the last ship yard stay in Bremerhaven (07.10.2011 – 28.10.2011) by the company "WERUM".

During the cruise ANT-XXVIII/1 between Bremerhaven and Las Palmas (28.10. 2011 – 09.11. 2011) a full sea trials and functionality tests under real working conditions were carried out.

Work at sea

At sea the following tests were done:

- System configuration check and sensors data import
- Parameter check and validation
- Sensors integration and update
- Functionality testes

- Data bank validations
- Data validations
- Data export functionality
- Interfacing and data telegrams checks
- Documentation

On November 8 the sea acceptance test (SAT) was carried out successfully. The next step will be the upgrading of the shore-based system.

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
Atlas Hydrographic	Atlas Hydrographic Kurfürstenallee 130 28211 Bremen Germany
AWI	Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft Postfach 120161 27515 Bremerhaven Germany
DESY	Deutsches Elektronen-Synchrotron DESY Platanenallee 6 15738 Zeuthen Germany
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg Germany
Fielax	Fielax Gesellschaft für wissenschaftliche Datenverarbeitung mbH Barkhausenstr. 4 27568 Bremerhaven Germany
GKSS	GKSS Research Center Max-Planck-Straße 1 21502 Geesthacht Germany
HZB	Helmholtz-Zentrum Berlin für Materialien und Energie Hahn-Meitner-Platz 1 14109 Berlin Germany

	Address
IAU	Institut für Atmosphäre und Umwelt Institute for Atmospheric and Environmental Sciences J.W.Goethe-Universität Altenhöferallee 1 60438 Frankfurt am Main Germany
IFREMER	IFREMER Technopole de Brest-Iroise , B.P. 70 29280 Plouzané France
IFM-GEOMAR	Leibniz-Institute for Marine Sciences Düsternbrooker Weg 20 24105 Kiel Germany
IfT	Institute for Tropospheric Research Permoserstraße 15 04318 Leipzig Germany
Laeisz	Reederei F. Laeisz (Bremerhaven) GmbH Brückenstr. 25 D-27568 Bremerhaven Germany
MPI	Max-Planck-Institut für Meteorologie Bundesstrasse 53, 20146 Hamburg Germany
OceanWaves	OceanWaves GmbH Hansekontor Vor dem Bardowicker Tore 6b D-21339 Lüneburg Germany
Optimare	Optimare Am Luneort 15a 27572 Bremerhaven Germany

	Address
PolE	Laboratory for Polar Ecology Rue du Fodia 18 B-1367 Ramillies Belgium
University of Hamburg	University of Hamburg, Institute for Biogeochemistry, 20146 Hamburg Germany
University of Heidelberg	Institute of Environmental Physics University of Heidelberg Im Neuenheimer Feld 229 69120 Heidelberg Germany
Werum	Werum Software & Systems AG Wulf-Werum-Str. 3 21337 Lüneburg Germany

A.2 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
Alfke	Rolf	Atlas Hydro	Engineer
Bult	Klaus	DWD	Technician
Damaske	Daniel	AWI	Student, Geology
Döscher	Henning	HZB	Physicist
El Naggar	Saad	AWI	Chief Scientist, Physicist
Ewert	Jörn	Atlas Hydro	Engineer
Gerchow	Peter	AWI	Engineer
Goffart	Philippe	PolE	Biologist
Graupner	Rainer	Optimare	Technician
Höpner	Friederike	IfT	Student, Meteorology
Huang (Mrs)	Shan	IfT	PhD student, Meteorology
Kampmann	Cornelia	MPI	Meteorologist
Kapfhammer	Meriam	AWI	Student, Geography
Kohn	Monika	IAU	Student, Meteorology
Krägefsky	Sören	AWI	Biologist
Krocker	Ralf	AWI	Geophysicist
Massart	Nadine	PolE	Photographer
Miller	Max	DWD	Meteorologist
Poulain	Laurent	IfT	Chemist
Rohardt	Gerd	AWI	Oceanographer
Schäfer	Michael	IfT	Meteorologist
Springer	André	Atlas Hydro	Engineer
Stößl	Achim	DESY	Physicist
Tomczak	Tim	Werum	Engineer
Vandevyvre	Xavier	PolE	Technician
Wenzel	Julia	IfT	Student, Meteorology
Wolf	Veronika	IfT	Student, Meteorology
Wu	Zhijun (Mr.)	IfT	Chemist

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

Name	Rank
Pahl, Uwe	Master
Spielke, Steffen	1. Offc.
Ziemann, Olaf	Ch. Eng.
Peine, Lutz	2. Offc.
Hering, Igor	2. Offc.
Lambrecht, Wolfgang	Doctor
Koch, Georg	R. Offc.
Kotnik, Herbert	2. Eng.
Schnürch, Helmut	2. Eng.
Westphal, Henning	3. Eng.
Brehme, Andreas	Elec. Eng.
Dimmler, Werner	ELO
Fröb, Martin	ELO
Muhle, Helmut	ELO
Winter, Andreas	ELO
Feiertag, Thomas	ELO
Clasen, Burkhard	Boatsw.
Neisner,Winfried	Carpenter
Schultz, Ottomar	A.B.
Burzan, G.-Ekkehard	A.B.
Schröder, Norbert	A.B.
Moser, Siegfried	A.B.
Hartwig-L., Andreas	A.B.
Kretzschmar, Uwe	A.B.
Kreis, Reinhard	A.B.
Schröter, René	A.B.
Beth, Detlef	Storek.
Becker, Holger	Mot-man
Fritz, Günter	Mot-man
Krösche, Eckard	Mot-man
Dinse, Horst	Mot-man
Watzel, Bernhard	Mot-man
Fischer, Matthias	Cook
Tupy, Mario	Cooksmate
Martens, Michael	Cooksmate
Dinse, Petra	1. Stwdess
Hennig, Christina	Stwdess/N.
Streit, Christina	2. Stwdess

Name	Rank
Hischke, Peggy	2. Steward
Wartenberg, Irina	2. Stwdess
Hu, Guo Yong	2. Steward
Chen, Quan Lun	2. Stwdess
Ruan, Hui Guang	Laundrym.
Seibel, Sebastian	Apprent.
Strauß, Erik	Apprent.
Boche, Martin	Supercargo

A.4 STATIONSLISTE / STATION LIST PS 79

Station PS 79 -	**Date**	**Time (start)**	**Time (end)**	**Gear**	**Position (Lat.)**	**Position (Lon.)**	**Depth (m)**
PS79/ 0001-1	31.10.2011	13:07	17:08	Buoy	45°17,89�much N	8°37,10‵ W	4865,3
PS79/ 0001-2	31.10.2011	14:55	16:28	CTD/RWS	45°18,95‵ N	8°36,90‵ W	4859,2
PS79/ 0002-1	01.11.2011	15:48	17:51	Buoy	40°29,80‵ N	11° 6,37‵ W	4876,4
PS79/ 0002-2	01.11.2011	16:15	17:40	CTD	40°30,70‵ N	11° 6,32‵ W	4882,6
PS79/ 0002-3	01.11.2011	18:08	18:08	FLOAT	40°28,91‵ N	11° 6,44‵ W	4882,9
PS79/ 0003-1	02.11.2011	19:43	21:24	SVP	35°34,99‵ N	13°18,79‵ W	4824,7
PS79/ 0004-1	02.11.2011	22:10	0:34	HS_PS	35°35,14‵ N	13°18,84‵ W	4824,2
PS79/ 0004-2	03.11.2011	0:45	2:00	HS_PS	35°15,06‵ N	13°18,92‵ W	4146,5
PS79/ 0004-3	03.11.2011	2:13	5:08	HS_PS	35°22,91‵ N	13° 9,97‵ W	4823,0
PS79/ 0004-4	03.11.2011	5:29	9:16	HS_PS	35°22,99‵ N	13°29,98‵ W	4818,2
PS79/ 0004-5	03.11.2011	9:31	10:18	HS_PS	34° 52,00‵ N	13°33,95‵ W	3763,8
PS79/ 0004-6	03.11.2011	10:34	14:21	HS_PS	34° 51,95‵ N	13°39,99‵ W	3901,4
PS79/ 0004-7	03.11.2011	14:29	16:36	HS_PS	35°22,03‵ N	13°36,12‵ W	4847,1
PS79/ 0005-1	03.11.2011	16:54	18:27	SVP	35°12,33‵ N	13°17,92‵ W	3855,8
PS79/ 0006-1	03.11.2011	19:29	20:32	HS_PS	35°12,52‵ N	13°17,98‵ W	3895,4
PS79/ 0006-2	03.11.2011	20:44	22:05	HS_PS	35° 4,98‵ N	13°12,92‵ W	2126,0
PS79/ 0006-3	03.11.2011	23:07	0:08	HS_PS	35°12,99‵ N	13°18,38‵ W	3946,8
PS79/ 0006-4	04.11.2011	0:28	2:02	HS_PS	35° 4,99‵ N	13°12,96‵ W	2120,5
PS79/ 0006-5	04.11.2011	2:47	3:44	HS_PS	35°12,46‵ N	13°17,97‵ W	3887,2
PS79/ 0006-6	04.11.2011	4:04	5:55	HS_PS	35° 4,98‵ N	13°13,00‵ W	2115,2
PS79/ 0006-7	04.11.2011	8:36	10:13	HS_PS	35°21,26‵ N	13°26,82‵ W	4857,3
PS79/ 0006-8	04.11.2011	10:32	12:59	HS_PS	35°21,29‵ N	13°10,92‵ W	4859,3
PS79/ 0006-9	04.11.2011	13:34	15:07	HS_PS	35°24,53‵ N	13°27,08‵ W	4860,8

Station PS 79 -	Date	Time (start)	Time (end)	Gear	Position (Lat.)	Position (Lon.)	Depth (m)
PS79/ 0006-10	04.11.2011	15:23	17:50	HS_PS	35°24,52‘ N	13°10,96‘ W	4859,2
PS79/ 0007-1	04.11.2011	18:12	18:46	SVP	35°24,51‘ N	13°26,88‘ W	4853,5
PS79/ 0007-2	04.11.2011	20:36	21:43	HS_PS	35°12,59‘ N	13°18,07‘ W	4853,5
PS79/ 0007-3	04.11.2011	21:59	23:25	HS_PS	35° 5,09‘ N	13°13,09‘ W	4853,5
PS79/ 0008-1	05.11.2011	8:20	10:04	CTD/RWS	35°10,52‘ N	13° 2,05‘ W	2364,2
PS79/ 0009-1	05.11.2011	10:14	16:57	Buoy	35°10,40‘ N	13°1,73‘ W	2354,2
PS79/ 0010-1	05.11.2011	10:34	11:17	Mo	35°10,47‘ N	13° 2,06‘ W	2361,5
PS79/ 0010-2	05.11.2011	11:25	15:55	MTC	35°10,34‘ N	13° 2,04‘ W	2359,2
PS79/ 0010-3	05.11.2011	20:30	0:54	MTC	35° 9,53‘ N	13°1,99‘ W	2306,5
PS79/ 0011-1	06.11.2011	3:11	5:01	HS_PS	35°19,48‘ N	13°18,92‘ W	4848,8
PS79/ 0011-2	06.11.2011	5:13	7:05	HS_PS	35°28,45‘ N	13°24,77‘ W	4865,4
PS79/ 0011-3	06.11.2011	7:37	8:35	HS_PS	35°21,06‘ N	13°15,41‘ W	4856,7
PS79/ 0013-1	06.11.2011	9:12	13:40	Buoy	35°20,71‘ N	13°14,97‘ W	4861,2
PS79/ 0011-3	06.11.2011	9:20	11:11	HS_PS	35°20,97‘ N	13°15,38‘ W	4859,4
PS79/ 0011-4	06.11.2011	11:27	13:18	HS_PS	35°29,89‘ N	13°21,17‘ W	4866,5
PS79/ 0013-2	06.11.2011	15:16	17:09	MTC	35°10,30‘ N	13° 2,08‘ W	2359,2
PS79/ 0014-1	09.11.2011	19:57	20:58	HS_PS	23° 58,07‘ N	18° 2,37‘ W	2553,2
PS79/ 0014-2	09.11.2011	21:51	22:55	HS_PS	23° 56,54‘ N	18°10,09‘ W	2645,0
PS79/ 0015-1	10.11.2011	12:56	12:57	FLOAT	22° 0,05‘ N	19°18,76‘ W	3568,7
PS79/ 0016-1	11.11.2011	13:03	16:24	Buoy	18° 50,27‘ N	21°29,96‘ W	3198,3
PS79/ 0017-1	12.11.2011	7:27	10:15	Buoy	16° 53,33‘ N	22°48,81‘ W	1652,4
PS79/ 0017-2	12.11.2011	7:43	8:41	HS_PS	16° 52,98‘ N	22°49,97‘ W	1412,1
PS79/ 0017-3	12.11.2011	8:56	9:57	HS_PS	16° 55,50‘ N	22°55,03‘ W	1222,3
PS79/ 0018-1	13.11.2011	20:11	20:11	FLOAT	12° 0,11‘ N	20°49,92‘ W	4880,5
PS79/ 0019-1	15.11.2011	14:29	17:33	Buoy	6°36,37‘ N	17°1,58‘ W	4887,7

Station PS 79 -	Date	Time (start)	Time (end)	Gear	Position (Lat.)	Position (Lon.)	Depth (m)
PS79/ 0020-1	17.11.2011	21:01	21:01	FLOAT	0° 0,15` N	11°17,36` W	4751,2
PS79/ 0021-1	20.11.2011	16:37	16:39	FLOAT	10° 0,15` S	2°34,60` W	4705,7
PS79/ 0022-1	21.11.2011	0:29	4:34	HS_PS	11°12,03` S	1°35,98` W	5167,5
PS79/ 0022-2	21.11.2011	4:54	6:46	HS_PS	11°36,38` S	1°12,05` W	4834,5
PS79/ 0022-3	21.11.2011	7:04	8:55	HS_PS	11°22,73` S	1°20,92` W	2637,7
PS79/ 0023-1	21.11.2011	8:58	16:59	Buoy	11°35,15` S	1°10,53` W	4819,0
PS79/ 0022-4	21.11.2011	9:16	11:35	HS_PS	11°33,92` S	1° 9,09` W	4883,5
PS79/ 0022-5	21.11.2011	11:45	12:54	HS_PS	11°20,71` S	1°18,84` W	3032,2
PS79/ 0022-6	21.11.2011	13:41	14:33	HS_PS	11°23,03` S	1°13,42` W	3577,7
PS79/ 0022-7	21.11.2011	14:46	15:12	HS_PS	11°28,28` S	1°18,32` W	1560,0
PS79/ 0024-1	23.11.2011	9:14	10:52	SVP	17°24,90` S	3°19,96` E	5460,0
PS79/ 0025-1	23.11.2011	11:11	12:34	HS_PS	17°24,98` S	3°20,00` E	5443,5
PS79/ 0025-2	23.11.2011	12:59	14:24	HS_PS	17°38,99` S	3°23,54` E	5447,0
PS79/ 0025-3	23.11.2011	14:48	16:17	HS_PS	17°25,09` S	3°26,97` E	5517,3
PS79/ 0026-1	23.11.2011	15:29		Buoy	17°31,56` S	3°26,95` E	5515,4
PS79/ 0026-1	24.11.2011		14:38	Buoy	17°24,01` S	3°14,70` E	5912,8
PS79/ 0025-4	23.11.2011	16:42	19:42	HS_PS	17°38,87` S	3°30,46` E	5509,8
PS79/ 0025-5	23.11.2011	19:45	20:59	HS_PS	17°39,01` S	3°33,66` E	5511,3
PS79/ 0025-6	23.11.2011	21:17	22:31	HS_PS	17°35,49` S	3°20,34` E	5511,5
PS79/ 0025-7	23.11.2011	22:49	0:06	HS_PS	17°31,99` S	3°33,67` E	5517,4
PS79/ 0025-8	24.11.2011	0:26	1:46	HS_PS	17°28,62` S	3°20,05` E	5514,7
PS79/ 0025-9	24.11.2011	2:06	3:24	HS_PS	17°25,10` S	3°33,94` E	5516,1
PS79/ 0025-10	24.11.2011	3:33	5:56	HS_PS	17°25,02` S	3°19,99` E	5515,3
PS79/ 0025-11	24.11.2011	6:05	8:22	HS_PS	17°39,03` S	3°33,99` E	5512,4
PS79/ 0025-12	24.11.2011	9:34	11:44	HS_PS	17°25,01` S	3°19,87` E	5508,6

Station PS 79 -	Date	Time (start)	Time (end)	Gear	Position (Lat.)	Position (Lon.)	Depth (m)
PS79/ 0025-13	24.11.2011	11:51	13:59	HS_PS	17°38,65�much S	3°33,65‵ E	5515,7
PS79/ 0025-14	24.11.2011	15:10	17:10	HS_PS	17°24,97‵ S	3°19,97‵ E	5516,9
PS79/ 0027-1	25.11.2011	7:23	7:24	FLOAT	19° 59,83‵ S	5°16,49‵ E	5182,9
PS79/ 0028-1	25.11.2011	13:24	16:08	Mo (year)	20° 58,87‵ S	5°59,59‵ E	4237,5
PS79/ 0029-1	25.11.2011	16:09	18:54	Mo (year)	20° 57,25‵ S	5°57,47‵ E	4247,7
PS79/ 0030-1	26.11.2011	2:36	2:41	Mo (short time)	22°10,40‵ S	6°45,81‵ E	2846,0
PS79/ 0031-1	26.11.2011	2:52	04:34	SVP	22°10,34‵ S	6°45,78‵ E	2848,2
PS79/ 0032-1	26.11.2011	6:02	7:36	Mo (short time)	22°10,76‵ S	6°45,77‵ E	2836,7
PS79/ 0033-1	26.11.2011	7:36	17:51	Mo (short time)	22°10,39‵ S	6°46,25‵ E	2846,7
PS79/ 0034-1	26.11.2011	8:38	12:52	MTC	22°10,39‵ S	6°46,17‵ E	2847,0
PS79/ 0034-2	26.11.2011	14:27	15:09	MTC	22°10,97‵ S	6°46,19‵ E	2847,0
PS79/ 0034-3	26.11.2011	15:10	16:32	MTC	22°10,43‵ S	6°46,24‵ E	2847,0

Abbreviations of gear:

CTD/RWS	CTD/rosette water sampler
HS_PS	HydroSweep/ParaSound profile
Mo	Mooring
MTC	Magnetic Turn Circle
SVP	Sound Velocity Profiler

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