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Reports on Polar and Marine Research

The Expedition PS110 of the Research Vessel POLARSTERN to the Atlantic Ocean in 2017/2018

Edited by

Frank Niessen

with contributions of the participants

HELMHOLTZ
GEMEINSCHAFT

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Titel: Polarstern im Duncan Dock des Kapstädter Hafens mit dem wolkenverhangenen Tafelberg im Hintergrund. (Foto: Frank Niessen, AWI)
Cover: Polarstern in Duncan Dock of the Port of Cape Town with cloud-covered Table Mountain in the back. (Photo: Frank Niessen, AWI)

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PS110

20 December 2017 - 14 January 2018

Bremerhaven - Cape Town

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Contents

1. ÜBERBLICK UND FAHRTVERLAUF

Frank Niessen AWI

Polarstern hat Bremerhaven am 20.12.2017 pünktlich mit dem Nachmittagshochwasser bei dichtem Nebel und ruhiger See verlassen, um die Überfahrt PS110 nach Kapstadt mit Hafenanlauf in Las Palmas anzutreten. An Bord befanden sich 44 Mitglieder der Besatzung und 9 Wissenschaftler. Mit dabei waren außerdem 4 Ingenieure und Techniker von Firmen, die Restarbeiten aus der Werftzeit zu erledigen hatten und 2 Inspektoren der Reederei Laeisz. Die relativ geringe Anzahl an Wissenschaftlern auf PS110 ist der langen Werftzeit im Herbst und dem ungewöhnlich späten Beginn sowie der Kürze der Überfahrt nach Kapstadt zuzuschreiben. Bereits vorab wurde ein sehr enger Zeitplan vorgegeben, der - von wenigen Stunden mit Stopps für wichtige Gerätetest abgesehen - keine Stationszeit für wissenschaftliche Forschungen zuließ, um eine rechtzeitige Ankunft in Kapstadt zu gewährleisten. Die Situation wurde noch verschärft, da aufgrund der Nebelsituation in Bremerhaven die Bordhubschrauber nicht rechtzeitig eingeflogen werden konnten, und so kurz entschlossen zusätzlich Le Havre im Englischen Kanal angelaufen werden musste, um dort die mit LKW antransportierten Hubschrauber am 23.12. zu übernehmen. Neben der Erfassung einiger Routineparameter in Luft und Wasser entlang der Fahrtroute bestand die wissenschaftliche Hauptaufgabe von PS110 darin, neue oder erneuerte Geräte zu testen und für die nachfolgenden Expeditionen einsatzfähig zu machen. Es gab keine wissenschaftlichen Stationen.

Von Bremerhaven bis Las Palmas wurden von der Atmosphärengruppe des AWI Installationen und Tests einer neuen Radiosonde für die Atmosphärenforschung durchgeführt. Daneben wurde ein neu installiertes Upgrade der PARASOUND-Anlage ab dem Englischen Kanal bis nach Las Palmas im Dauerbetrieb überprüft. Zudem fanden während der gesamten Überfahrt Routinearbeiten des DWD in der Bordwetterwarte statt, bei der neben der Stammbesetzung zu Ausbildungs- und Erfahrungszwecken ein zusätzlicher Meteorologe des DWD beteiligt war. Von den Hafenanläufen abgesehen lief das reparierte Bordmagnetometer auf der gesamten Überfahrt im Dauerbetrieb. Am Nachmittag des Heiligen Abend befand sich *Polarstern* in der nördlichen Biskaya, die mit moderatem Seegang besinnliche Feierlichkeiten an Bord zuließ.

Am 28.12. erreichte *Polarstern* den Hafen von Las Palmas de Gran Canaria. Hier gingen drei Kollegen der Atmosphärenphysik, sowie sieben Ingenieure, Techniker und Inspektoren nach erfolgreicher Arbeit von Bord. Ein Kollege aus der Logistik des AWI wurde eingeschifft. Außerdem wurde der Aufenthalt genutzt, um zu bunkern, bevor *Polarstern* am Abend des 28.12. Las Palmas wieder verlassen hat. Zur Jahreswende befand sich das Schiff querab der Kapverden.

Ein Schwerpunkt der Arbeiten zwischen Las Palmas und Kapstadt bestanden in Tests eines neuen Multifrequenzlots sowie eines Mini-ROVs, wozu die wenigen Stunden an verfügbarer Schiffszeit bei verschiedenen Stopps entlang der Route genutzt und am 6.1.2018 mit dem letzten Aufstoppen erfolgreich beendet wurden. Bei gut geeigneten Ablagerungsbedingungen am Meeresboden zwischen den Kanaren und dem Südende des Sierra Leone Beckens, sowie vom Walfischrücken westlich von Namibia bis kurz vor Erreichen Kapstadts wurde ein Testprogramm für neue PARASOUND-Funktionen durchgeführt und dokumentiert. Eine geringe Abweichung des direkten Kurses nach Kapstadt führte *Polarstern* am 8.1. auf eine

Position nordwestlich von St. Helena, um dort Daten zur Neu-Kalibrierung des reparierten Bordmagnetometers aufzuzeichnen. Dazu wurde eine Doppeldrehkreises unweit der südatlantischen Insel gefahren, auf der das GFZ-Postdam ein magnetisches Observatorium betreibt, so dass die Kalibrierung gegenüber dem Erdmagnetfeld vor Ort mit Landmessungen validiert werden kann.

Am Morgen des 14.1.2018 erreichte *Polarstern* den Hafen von Kapstadt. Insgesamt betrug die zurückgelegte Distanz 6.868 Seemeilen. Der enge Zeitplan konnte eingehalten und alle geplanten Tests erfolgreich durchgeführt werden. Dies ist nicht zuletzt den relativ ruhigen Wetterbedingungen während der gesamten Reise zu verdanken, die eine optimale Anpassung der Schiffsgeschwindigkeit an die Zeitplanung zuließen.

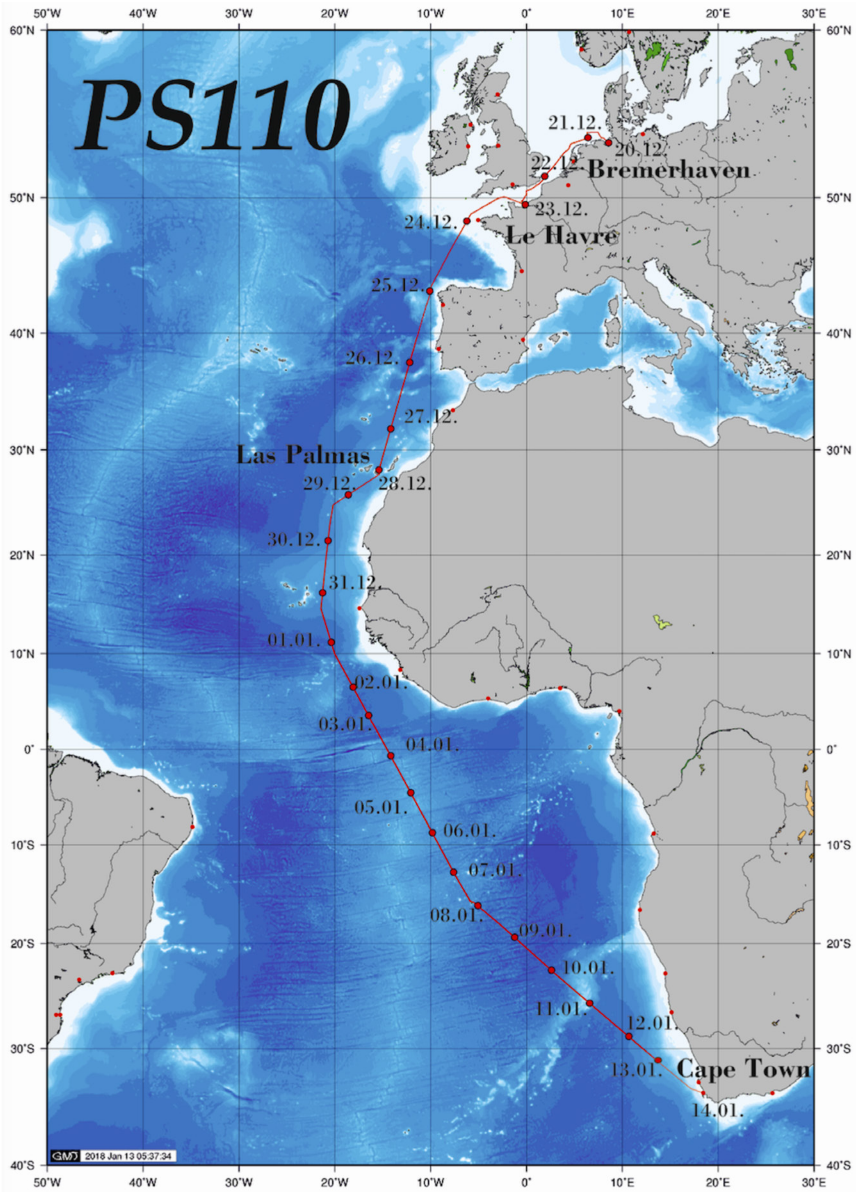

Fig. 1.1: Fahrtverlauf während der Expedition PS110 (erstellt vom Systemmanager der Polarstern). Siehe https://doi.pangaea.de/10.1594/PANGAEA.888748 für eine Darstellung des master tracks in Verbindung mit der Stationsliste für PS110.

Fig. 1.1: Cruise Track of the expedition PS110 (courtesy of Polarstern system manager). See https://doi.pangaea.de/10.1594/PANGAEA.888748 to display the master track in conjunction with the list of stations for PS110.

SUMMARY AND ITINERARY

On Dec. 20, 2018, in dense fog at calm sea, *Polarstern* left Bremerhaven on time to start its transit to Cape Town (PS110) including a planned port call at Las Palmas, Canary Islands. On board were 44 crew members and 9 scientists together with 4 engineers and technicians of companies to carry out remaining work from the ship-yard time in Bremerhaven. In addition, two inspectors of Shipping Company Laeisz were on board. The relatively small number of scientists of PS110 was due to the long ship-yard time in autumn resulting in late departure from Bremerhaven and short transit time to Cape Town. In order to meet the schedule and to ensure a due arrival in Cape Town, the cruise's working plan was tight, which did not allow time for scientific stations except for a few hours reserved for testing of equipment. Even more strain on the schedule was caused by the need for an additional port call in Le Havre on Dec. 23. This became essential in order to take on board the helicopters transported by truck. Due to fog they had been unable to fly to Bremerhaven prior to PS110 departure. In addition to a few scientific parameters measured routinely in air and sea water, the main objectives of PS110 were to test new, upgraded and repaired equipment to be available for use on forthcoming expeditions. There were no scientific stations.

Between Bremerhaven and Las Palmas the Atmosphere Group of AWI installed and tested a new radiosonde system for atmospheric data requisition. Also, a newly implemented upgrade of the sub-bottom profiler PARASOUND was tested in permanent operation from the English Channel to Gran Canaria. During the entire cruise, routine work was carried out in the weather station on board by the DWD. An additional DWD meteorologist joined the cruise for educational purpose and to gain experience. Except for port-call times, the freshly repaired, hull-mounted magnetometer system was collecting test data during the entire expedition. On the afternoon of Christmas Eve, *Polarstern* was in the northern Bay of Biscay, which, with its calm sea state, allowed contemplative celebrations on board.

On Dec. 28, *Polarstern* reached the port of Las Palmas de Gran Canaria. Three colleagues of the Atmospheric Physics Group, seven engineers, technicians and inspectors left the ship after successful completion of their work. One colleague of the AWI Logistics came on board. Also, the port call was used for bunkering before *Polarstern* left Las Palmas in the evening of Dec. 28. At the turn of the year, the ship was off the Cape Verde Islands.

Between Las Palmas and Cape Town, one main focus of work was on testing a new multi-frequency echosounder and a Mini-ROV. This involved using up the few hours of ship time for stops along the track, which was successfully finished at the last stop on Jan. 6, 2018. With well-suitable depositional conditions at the sea floor from the Canary Islands to the southern end of Sierra Leone Basin as well as from the Walvis Ridge off the coast of Namibia to Cape Town, a serious of tests were carried out and documented using the new functions of the sub-bottom profiler PARASOUND. With a small deviation from the direct course to Cape Town, *Polarstern* reached a position northwest of the Island of St. Helena on Jan. 8 in order to perform a new calibration of the repaired magnetometer system of the ship. A double circle was navigated close to the island, where the GFZ-Potsdam operates a magnetic observatory. The land data of the Earth magnetic field had been used to validate the shipboard calibration. On the morning of Jan. 14, 2018, *Polarstern* reached the port of Cape Town. The total distance sailed was 6868 nautical miles. The tight schedule was fulfilled and all planned tests were carried out successfully. To a large extent this became possible due to the relatively calm weather conditions during the entire cruise, which allowed optimal adjustment of ship speed to the tight schedule.

2. WEATHER CONDITIONS DURING PS110

Max Miller, Juliane Hempelt, Holger Jens DWD

On early Wednesday afternoon, December 20, 2017, 13:00 pm, *Polarstern* left Bremerhaven for the campaign PS110. Light south-westerly winds, 6° C and dense fog were observed.

A strong high over the Bay of Biscay was the dominant feature and a weak warm front over North Sea moved east. Therefore mild and moist air masses reached northern Germany. A following weak cold front caused improving visibility off the East Frisian Islands on Thursday (Dec. 21), but couldn't end the foggy conditions ashore. Passing the English Channel light and variable winds, mist and fog patches were prevailing, too. Saturday afternoon (Dec. 23) we entered the harbour of Le Havre for 2 hours at moderate to fresh south-westerly winds.

On Sunday (Dec. 24) we reached the northern end of the Bay of Biscay at southwest 5 to 6 Bft and visibility had improved clearly. A strong cold front approached from East Atlantic. During the night to Monday winds from southwest to south freshened steadily and peaked at an upper Bft 8 noon on Monday (Dec. 25) forcing a sea state of 3.5 m. After the cold front had crossed us off Cape Finisterre on early Monday afternoon winds veered northwest and abated Bft 7 to 6.

Heading towards Las Palmas *Polarstern* got closer to the Azores high and mostly fresh winds veered north to northeast.

Noon on Thursday (Dec. 28) we reached Las Palmas and left the harbour in the early evening. During the following days *Polarstern* steamed the northern Trade Wind Zone at Bft 5 to 6 Bft. Only at first sailing along the Canary Islands north-easterly winds peaked temporarily at Bft 7. Heading south dust from Sahara became more and visibility decreased around 10 km.

On Tuesday (Jan. 02) *Polarstern* entered the Intertropical Convergence Zone (ITCZ) at light and variable winds. First showers and thunderstorms could be observed from Tuesday evening on.

Already on Thursday (Jan. 04) we reached the southern Trade Wind Zone first at Bft 4 and a light swell of 1 to 1.5 m. From Saturday (Jan. 06) on the Trade Winds increased to a mean wind force 5 Bft and the swell up to 2 to 2.5 m.

Approaching Cape Town the pressure gradient intensified a bit between the subtropical high over South Atlantic and a low over South Africa. From Thursday (Jan. 11) on winds veered south and peaked temporarily at Bft 6.

On Sunday morning, January 14, 2018, *Polarstern* reached Cape Town at light and variable winds, 15° C and sunshine.

For further statistics see attached files (Fig. 2.1 – Fig. 2.4).

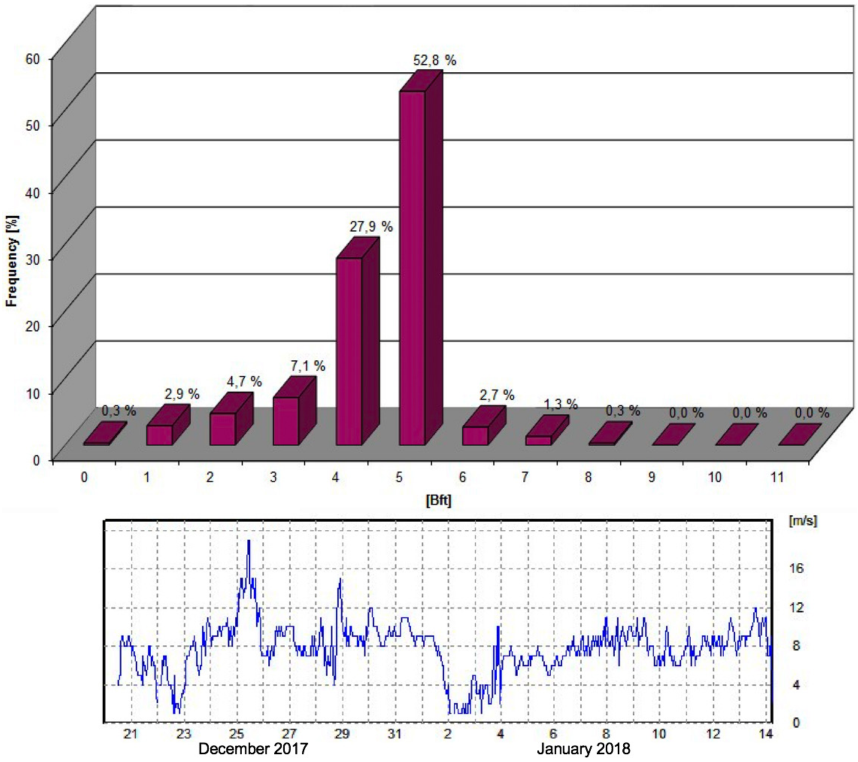

Fig. 2.1: Wind force during PS110: Distribution (upper diagram) and situation per day (lower diagram)

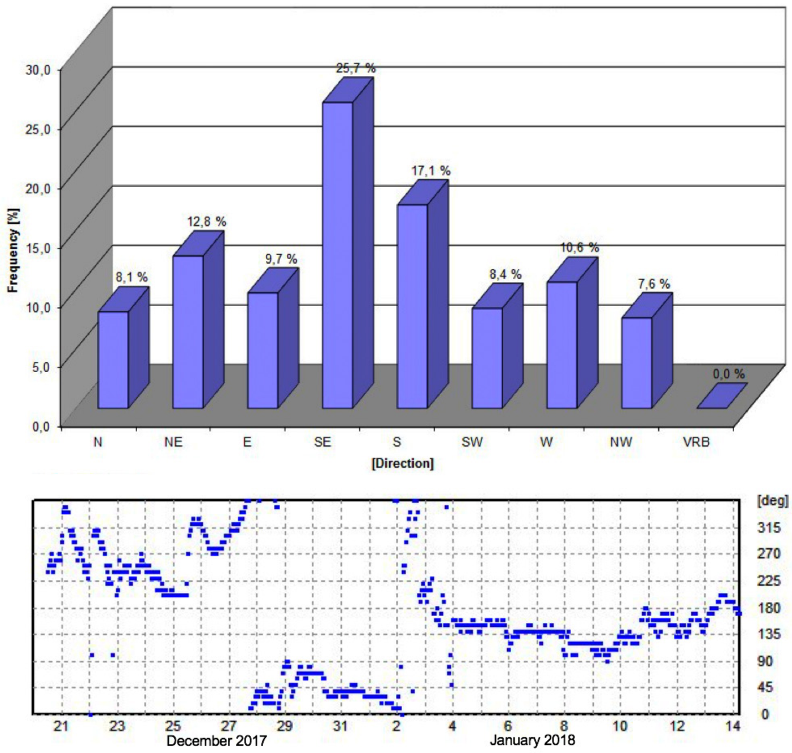

Fig. 2.2: Wind direction during PS110: Distribution (upper diagram) and situation per day (lower diagram)

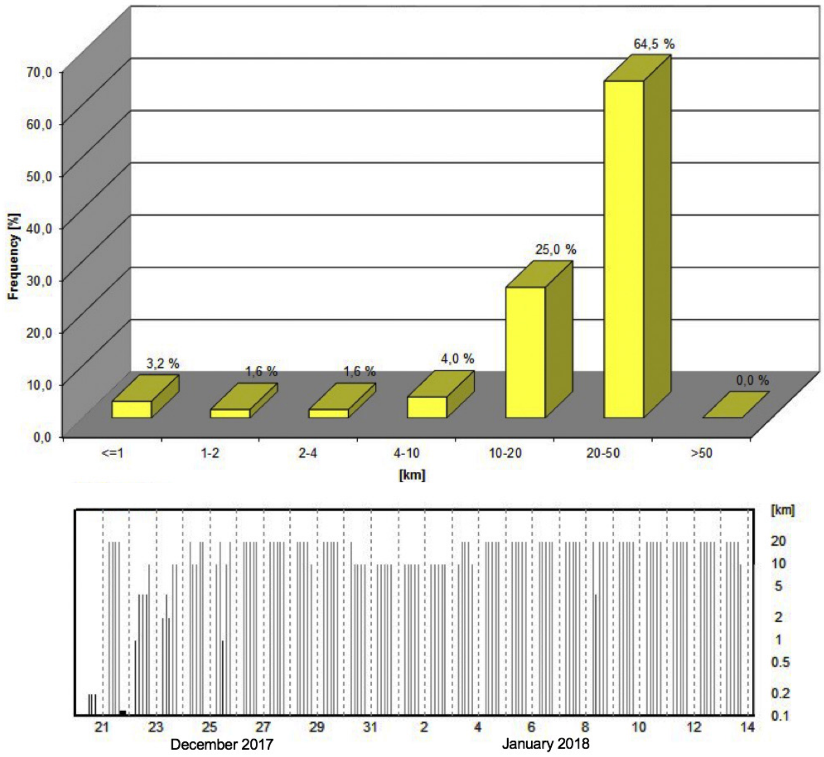

Fig. 2.3: Visibility during PS110: Distribution (upper diagram) and situation per day (lower diagram)

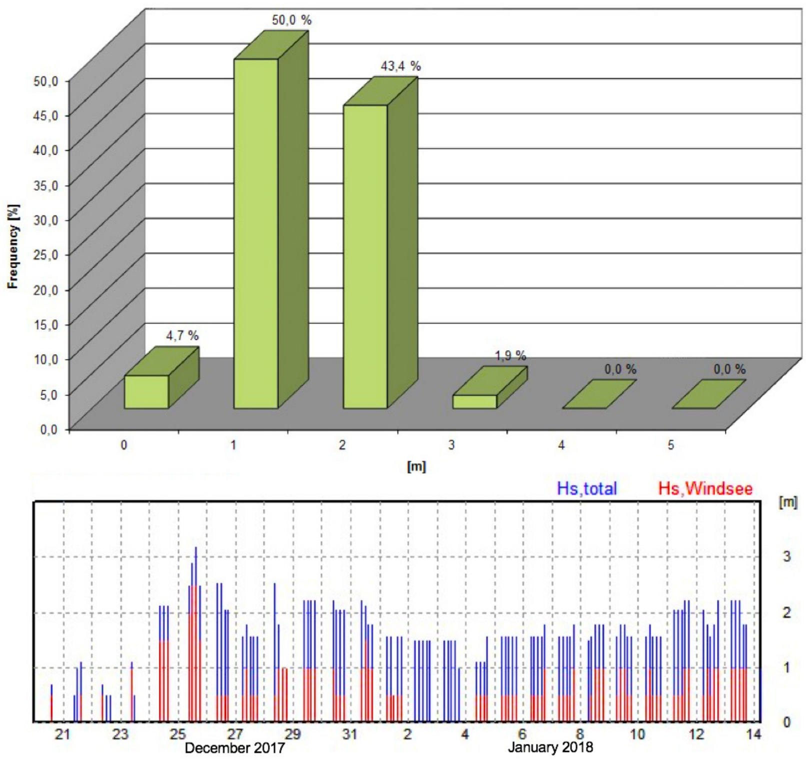

Fig. 2.4: Sea state during PS110: Distribution (upper diagram) and situation per day (lower diagram)

3. UPGRADE OF HARD- AND SOFTWARE OF THE RADIO SOUNDING SYSTEM ON POLARSTERN

Levin Probst[1], Jürgen Graeser[2], Holger Deckelmann[2],

[1]AWI
[2]AWI-P

Grant-No. AWI_PS110_00

Objectives

On this cruise, the currently installed radio sounding system is being upgraded to the MW41 system. To be compatible with the new software, both processing PC's (operating and spare) will be replaced by new hard- and software programmed for the special needs onboard *Polarstern*. Both DIGICORA (operating and spare) systems will get a software upgrade.

Work at sea

Validation of the results generated by the new system under real use conditions, as well as monitoring the behaviour of the new software is carried out to prevent misbehaviour in the future. In addition, verification of the system interaction with the network was completed, and any early-stage problems were fixed..

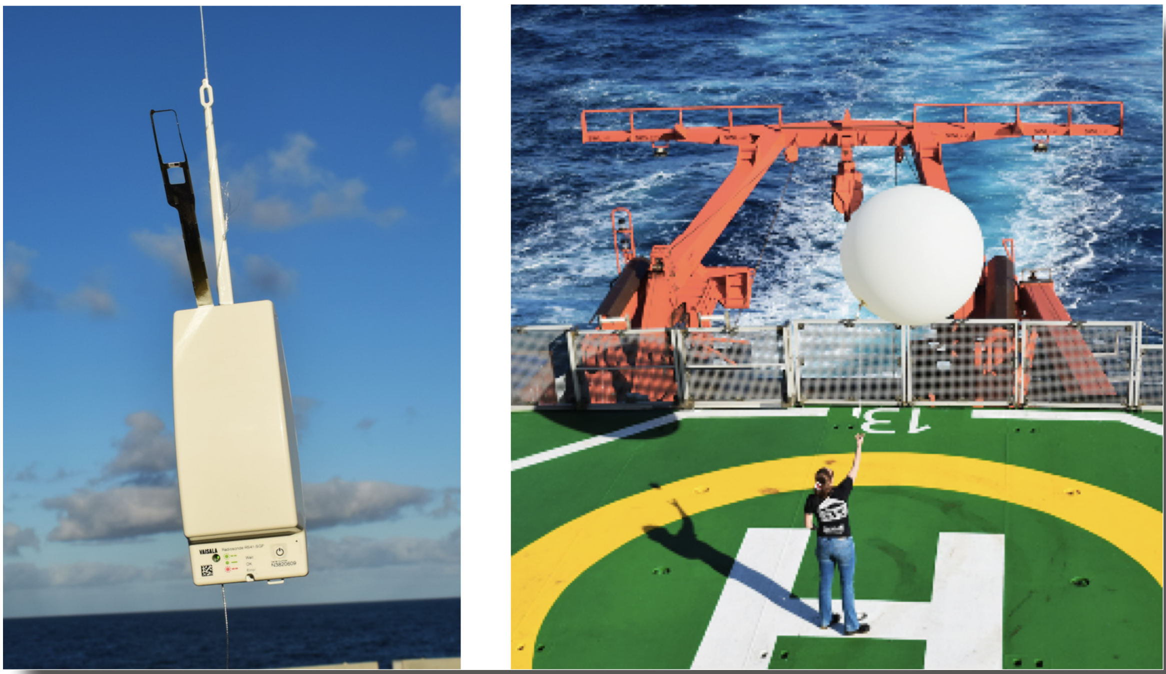

Fig. 3.1: The Vaisala radio sonde RS41 (left) and radiosonde launch from the helicopter deck on board Polarstern, 27.12.2017 (right)

Preliminary results

The firm and software upgrade was successfully performed without any installation problems. The new setup allows an almost complete automated operation. The preparation and conditioning of the radiosonde does not need user interaction anymore. Surface observations can now be applied directly from DSHIP by using a simulated automated weather station. For fast analysis different types of data products are now generated during sounding every 5 minutes and can be downloaded on request. The raw data (that should not be used for scientific papers) can also be supplied automatically to computers of interested scientists after every sounding. Finally, it is now possible to generate data products that meet the specific requirements of the scientific users.

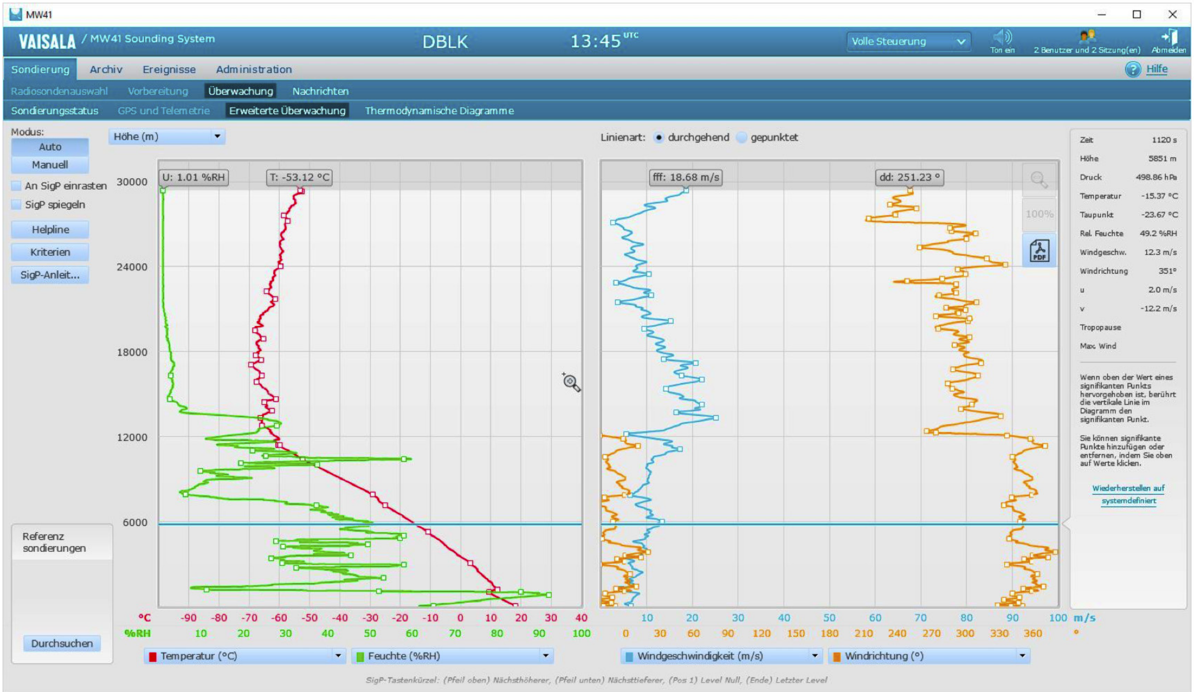

Fig. 3.2: The front-end of the new radiosounding software MW41 shows detailed information about the sounding progress and the status of the sonde. Profile of the radiosonde launch of 27.12.2017

With the new input form, it is now possible to set and change the required parameters of the sounding, e.g. operator, weather conditions at launch, balloon pretreatment etc. These parameters are supplied for the generated different data types that are produced during, as well as at the end of the sounding. If there are special occurrences on a sounding, the operator is now able to remark these in a specific comment field during sounding.

All processes have been tightly aligned to the requirements of the weather observation staff onboard *Polarstern* and they were introduced to get to know the differences and improvements of the new system. The sounding system can now be used with two different types of radiosondes and their different ground check sets.

In addition to the upgrade, the weather balloon ascending speed has been recalibrated to 5 m/s.

Data management

No scientific data were produced during the cruise.

4. PARASOUND SEDIMENT ECHOSOUNDER UPGRADE PS3MK2: TESTING AND ADAPTATION

Frank Niessen, Sabine Hanisch AWI

Grant-No. AWI_PS110_00

Objectives

On *Polarstern*, the ship-mounted parametric echosounder PARASOUND is a highly sophisticated acoustic tool for exploring marine sedimentary environments and for surveying sea-floor and sub-bottom sampling stations during expeditions in both hemispheres. In June 2017, the standard system PS3-P70 was successfully upgraded to PS3MK2-P70 by Teledyne RESON which includes significant modifications in both hardware and software components. In addition to modifications of software (Atlas) Hydromap Control (AHC), which came along with the update, also an updated version of software (Atlas) ParaStore (APS) was installed one day before departure of PS110. This was followed by a further developed version installed via satellite connection during the cruise. These modifications required intensive testing at sea in different sedimentary environments, where PARASOUND data from previous expeditions existed, such as along the track of PS110 from Bremerhaven to Cape Town. One major modification in hardware and software is the implementation of the "Frequency-Modulated (Chirped) Wave" for water depth of more than 150 m in addition to the previously used "Continuous Wave". A major objective was to carry out numerous tests in different environments to explore optimal adjustments for pulse control, pulse extensions and frequency ranges in order to achieve better penetration and/or resolution of sub-bottom data. Further objectives are (i) a reliability test for long-term operation after a major electronic failure during the previous expedition PS109, and (ii), the documentation of different and newly available features of the system in form of a completely revised version of the PARASOUND operator manual, originally provided by Müller-Michaelis et al. (2008) and subsequently edited by Teledyne RESON (Bremen).

Work at sea

For the purpose of system testing PARASOUND was mostly in continuous operation from the North Sea to Las Palmas, and on parts of the track from Las Palmas to Cape Town. This work included:

1. Application of major changes in software AHC and APS
2. Documentation of handling new software components (AHC, APS) for users on board.
3. Adjustments of previously used settings ("Continuous Wave") in new software windows for "Single Pulse", "Quasi-Equidistant" (QED) and "Pulse Train" transmissions
4. Testing numerous variations in continuous-wave mode using different slider settings in shallow water (frequency range, pulse length, pulse width)

5. Testing numerous variations in frequency modulated mode using different slider settings in deep water (frequency range, pulse length, pulse width)

6. Documentation of problems software bugs, tentative improvements

Handling new software components

Here we provide a brief summary of the particulars listed above under 1 and 2. For any details of the updated PARASOUND software components (AHC and APS) the reader is referred to the revised operator manuals (Hanisch & Niessen 2018 a, b) now available on board of *Polarstern* and from the authors on request.

AHC: In particular, the windows “Basic Settings” and to a minor extent “Watch Keeping” have changed. During operation, the watch keeper will have to switch between both windows frequently for system control. Under “Basic Settings”, “Pulse Type” is now extended from “Continuous Wave” to “Frequency Modulated (Chirped)”. The former is recommended up to 150 m water depth, the latter for deeper water. Once under “Settings” the “Transmission Sequence” is set and the “Transmission Source Level” is put to maximum (which way ever), the “Pulse Characteristics” have to be activated. If so, adjustments of the system are listed on the screen under “Current Pulse Characteristics”. For PHF, SHF and SLF, settings of Band Width, Frequency and Pulse Resolution as well as Pulse Length and Number of Periods per Pulse are indicated and can be changed by sliders (Pulse Control, Pulse Extension, PHF Frequency, SLF Frequency). Thus, numerous different settings can be adjusted and care has to be taken how to use the sliders. In general, the following rules are valid:

(a) The system only accepts changes which are technically feasible. This means not all changes of sliders result in changes indicated in “Current Pulse Characteristics”.

(b) Low (left) and high (right) Pulse Control (major) and Pulse Extension (minor) adjustments result in higher resolution and higher penetration, respectively.

(c) The optimal PHF frequency is achieved if the quotient of (SLF/2 + PHF)/SLF is an integer value, e.g. (4kHz/2 + 18kHz) / 4kHz = 5.

(d) Running “Continuous wave” the sum of PHF and SLF should not exceed 26.

(e) In the Chirped mode, the SLF frequency is the middle frequency of the chirp. This together with +/- (SLF Band With/2) defines the chirped frequency range. PHF +/- (PHF Band Width/2) should not be higher and lower than 26 and 18 kHz, respectively. The higher the SLF Band Width the better is the result of the chirp correlation (penetration combined with resolution).

Once “Pulse Characteristics” are set and the “Transmission Sequence” is either “Quasi-Equidistant” (QED) or “Pulse Train” the “Minimum Time Interval between Pulses” and/or the “Maximum Number of Pulses” need to be set. The system will adjust the settings automatically as closely to the requirements as possible. In QED mode, the pulses are now put for each sounding according to the actual water depth and not in about one-minute intervals like in the previous version of HMC. This means that the depth control of the system is critical at any time. For QED pulses a time interval between pulses of 2,000 ms is a good standard. Non-profitable pulse intervals result in noisy seismograms (PHF) and can cause severe problems in case PARASOUND PHF depths are used as System Depth Source (Watch Keeping). In case of changes in water depth during operation it may be necessary for the watch keeper to change the Interval between Pulses/Number of Pulses frequently to avoid noise in the PHF echogram window.

In case profiling runs from deep to shallow water (e.g. continental-margin situation), it is no longer necessary to switch from QED to Single Pulse. QED becomes a special case of Single-Pulse mode if settings only allow for one pulse in the water column (Number of Pulses = 1). The time Interval between Pulses can then be used to adjust the ping rate and thus the lateral resolution and/or the amount of data acquired. In such case it can be lower than for Single Pulse mode if required.

APS: There are three major modifications:

(a) For the data storage under Acquisition Control only one directory has to be selected. All specific data folders needed for storage will then be created by the system automatically and data will be stored accordingly. This includes all data formats (ASD, PS3, SEG-Y).

(b) For PS3 and SEG-Y storage there are now more options in terms of navigation-coordinate formats in the headers (Lat/Lon or UTM).

(c) There is now the possibility to define profiles. Thus, all PS3 and SEG-Y data files now have a prefix “profile 0”. By clicking on a newly introduced icon in the uppermost part of the main window of APS a new profile is defined after which data is stored as “profile 1” etc.

Preliminary results

In terms of system crashes the reliability of the system under expedition conditions is very good. PS110 experienced only one crash of AHC / Hydromap Server on 24.12.2017, so far for not-identified reasons. A complete operation log of AHC has been recorded and was submitted to Teledyne RESON (Bremen) for further analysis.

On the basis of previously available documentation (“How to switch it on” and “Eine Kurzanleitung zum Atlas PARASOUND System P70”) updates were produced including screenshots of the modified software windows and adjustments (Hanisch & Niessen 2018 a, b).

For the purpose of data comparisons, and/or if wanted, adjustments of previously used settings (prior to upgrade) in new software windows for “Single Pulse”, QED and “Pulse Train” transmission are relatively straight forward. PHF and SLF frequencies should be set by sliders to e.g. 18 and 4 kHz, respectively. The pulse type should be “Continuous Wave” and shape “Rectangular” regardless of water depth. Sliders for Pulse Control/Extension should be set to achieve 2 periods per pulse under “Current Pulse Characteristics”. With these settings, the system should run under the conditions used during previous cruises regardless of Transmission Sequence (“Single Pulse”, QED, “Pulse Train”).

For shallow water in the area between Le Havre and the shelf break, we had tested numerous variations in “Continuous-Wave” mode using different slider settings (Pulse Control / Pulse Extension) at constant PHF and SLF frequencies (18 and 4 kHz, respectively). The settings are summarized in Table 4.1. The results are summarized in Fig. 4.1. In general, it can be concluded that slider positions higher than position 3 and 4 (Pulse Control / Pulse Extension, respectively) out of 10 from the left do not gain additional information but only degrades resolution. However, to fully understand the potential of different settings, further experiments should be carried out at different types of sedimentary conditions. Changes in Pulse Control and Pulse Extension have the character of major modifications and fine tuning of pulse characteristics, respectively.

Tab. 4.1: Different settings tested in shallow-water mode of operation. PHF/SLF frequencies were 18 kHz and 4 kHz, respectively, pulse shape rectangular. Bottom TVC was switched off and amplitude clip kept on 50 mV. Recorded on 23 Dec 2017 (UTC hours-h and minutes-m in table).

No.	h	m	Pulse Control	Pulse Extension	No. of Pulses
1	10	10	1	1	1
2	10	11	1	2	2
3	10	14	1	3	3
4	10	15	1	4	4
5	10	16	1	5	4
6	10	17	1	6	5
7	10	18	1	7	6
8	10	19	1	8	6
9	10	20	1	9	7
10	10	21	1	10	8
11	10	22	1	1	1
12	10	23	2	1	1
13	10	24	3	1	1
14	10	25	4	1	1
15	10	26	5	1	2
16	10	27	6	1	2
17	10	28	7	1	3
18	10	29	8	1	6
19	10	30	9	1	6
20	10	31	10	1	12
21	10	32	1	1	1
22	10	35	2	2	2

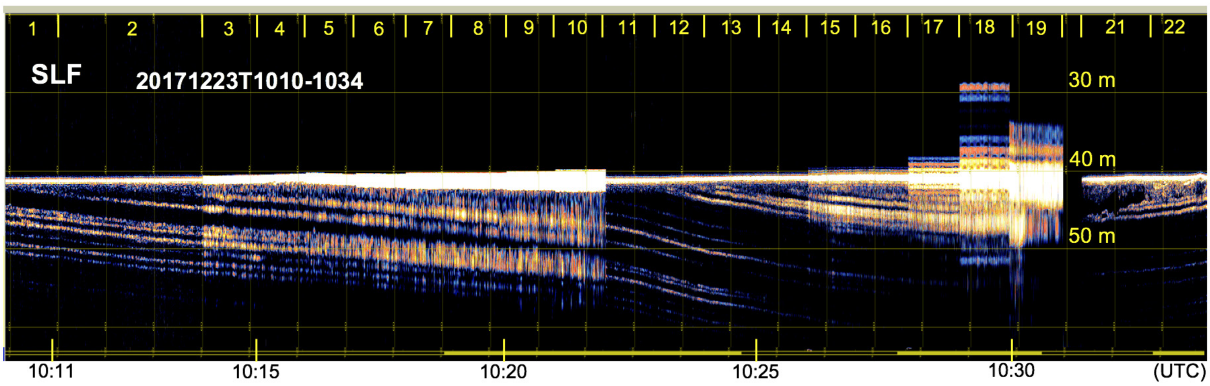

Fig. 4.1: Results of testing different settings (Tab. 4.1) in SLF echogram window. Horizontal scale is time (UTC). Yellow and black bars at figure bottom indicate 1 km distance each. Yellow numbers at top of figure refer to numbers with different settings listed in Tab. 4.1. For location use time code (yyyymmddT(ime)hhmm-hhmm) in general track data of the cruise (https://doi.pangaea.de/10.1594/PANGAEA.888748).

For deep water in the Cape Verde Basin, we have tested numerous variations in "Frequency-Modulated" and "Continuous-Wave" modes using different slider settings (Pulse Control / Pulse Extension) at variable PHF and SLF frequencies. These settings and results are summarized in Table 4.2 and Fig. 4.2, respectively. Some variations of settings only result in subtle modification in seismograms but others lead to major and clearly visible changes. In general, some preliminary conclusion can be drawn.

- The improvement of using chirped pulsed compared to continuous wave are small but noticeable. The results of chirped pulses gain both slightly higher penetration and resolution for similar settings of frequencies and pulse lengths.
- For SLF of 4 kHz modulated from different PHF (e.g. 18 or 22 kHz) and otherwise same settings, the difference in seismograms is subtle although it appears slightly better with higher than 18 kHz PHF.
- SLF frequencies of 5 kHz and higher (chirped middle frequencies) result in significant loss of penetration. SLF frequencies of 2 kHz and lower (chirped middle frequencies) do not gain significant penetration but result in worse signal to noise ratios.
- Pulse length of 7 and higher (number of periods) do not gain significant penetration but result in worse resolution, in particular in near-surface reflectors.

Tab. 4.2: Different settings tested in deep-water mode of operation (QED, time interval 1,360 ms). Bottom TVC was switched off and amplitude clip kept on 1,200 mV. Recorded on 31 Dec 2017 (UTC hours-h and minutes-m in table).

h	m	Chirp	Cont. Wave	Pulse Cont	Pulse Ex	PHF Frequ	SLF Frequ	Pulse Length	No. Periods
13	22	x		2	2	19.5	3	2	4
	25	x		2	2	19	2	2	4
	28	x		2	2	17.5	1	4	4
	30	x		2	2	18	4	1	4
	34	x		2	2	17.5	5	0.8	4
	36	x		2	2	21	6	0.83	5
	38	x		2	2	18	4	1	4
	41	x		2	2	19.25	3.5	1.14	4
	46	x		2	2	22	4	1	4
	50	x		2	2	19.25	3.5	1.14	4
	52	x		1	1	19.25	3.5	0.86	3
	54	x		2	1	19.25	3.5	0.86	3
	56	x		4	1	19.25	3.5	1.14	4
	58	x		4	3	19.25	3.5	2	7
14	0	x		6	3	19.25	3.5	4	14
	2	x		2	2	19.25	3.5	1.14	4
	5		x	2	2	19.25	3.5	0.57	2
	8		x	2	2	19	2	1	2
	11		x	2	2	19.25	3.5	0.57	2
	13		x	2	2	18	4	0.5	2
	16		x	2	2	22	4	0.5	2
	18		x	1	1	18	4	0.25	1
	21		x	7	1	18	4	0.75	3
	26	x		2	2	19.25	3.5	1.14	4

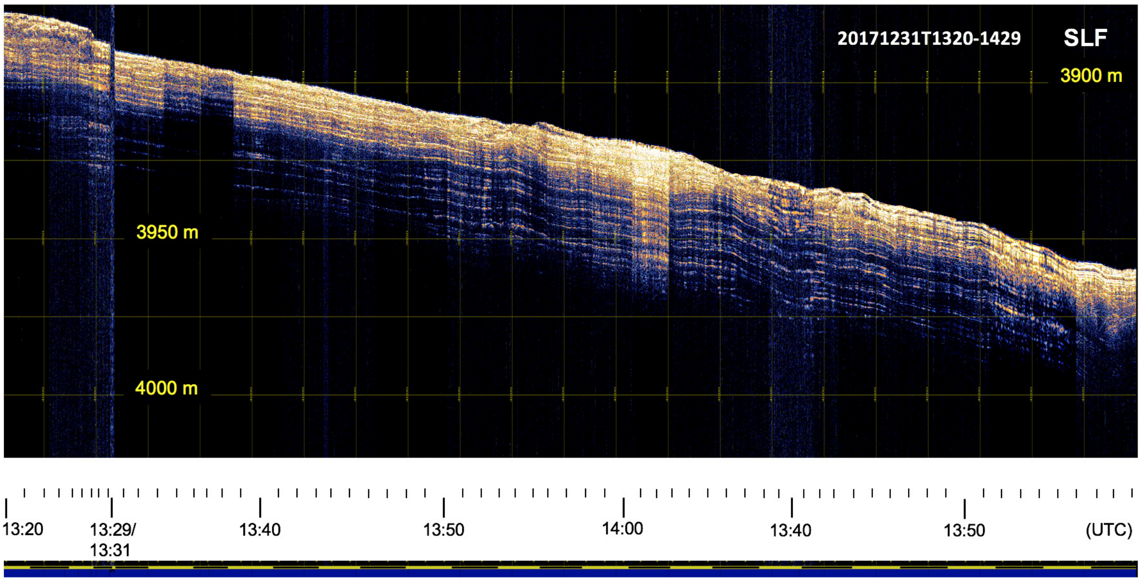

Fig. 4.2: Results of testing different settings (Tab. 4.2) in SLF echogram window. Horizontal scale is time (UTC). Yellow and black bars at figure bottom indicate 1 km distance each. For location use time code (yyyymmddT(ime)hhmm-hhmm) in general track data of the cruise (https://doi.pangaea.de/10.1594/PANGAEA.888748).

During PS110, several distinctive features were documented (brief description, screenshots), which were observed during tests and application of new software compounds of AHC and APS. Most of the details need to be worked up after the cruise and will be communicated with the manufacturer Teledyne RESON in Bremen to better understand the system and/or resolve problems. One major problem observed during the cruise was the depth control of PARASOUND in QED mode of pulsing. This problem is not entirely new and has been observed, analyzed and described during PS98 and PS105 (transit Las Palmas Bremerhaven, Kuhn et al. 2018, Knust in prep.). During PS110, we used manual, PARASOUND PHF or SLF depth control. Using PHF often created problems in deep water (> 4,000 m), because there was noise in the data acquisition window of similar amplitude to the sea floor so that correct sea-floor and water-depth detection failed. This can result in total loss of sub-bottom data. Apparently, the noise comes from the water column as reflections of pulses ahead of time with respect to received pulses reflected back from the sea floor. The noise is being picked up by the returning pulses (from sea floor) on the way back to the ship. An example and analysis are presented in Fig. 4.3. It is advisable to run the system in Single Pulse mode (Data Acquisition Window = Full Water Column) for a few minutes and visualize PHF and SLF data for the entire water column in echogram windows in order to analyze the reflection within the water column and better understand the noise situation. This can help to adjust the required "Number of Pulses" and/or the "Minimum Time Interval between Pulses" in a way that the noise will not be acquired (recommendation: 1,200 ms or higher).

Data management

No scientific data were stored after the cruise because the purpose of work was purely equipment testing. Since PARASOUND settings were changed frequently, recordings are not suitable for scientific interpretation including the data presented in the figures of this report.

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Müller-Michaelis A, Pulm PV, Weiß BJ (2008) Kurzanleitung zum Atlas PARASOUND-System P70, Version 1.1-08, 39p.

Hanisch S, Niessen F (2018a) How to use TELEDYNE PARASOUND SYSTEM P70, Kurzanleitung nach dem PARASOUND-Upgrade auf PS106, Mai 2017, 15. Januar 2018, PS 110, 32p.

Hanisch S, Niessen F (2018b) PARASOUND How to switch it on - Starteinstellungen – Wache, Überarbeitung und Ergänzung der Kurzanleitung "How to switch it on" nach dem PARASOUND Upgrade vom Mai 2017 (PS106) während PS110 vom 20.12.2017 bis 15.1.2018, 19p.

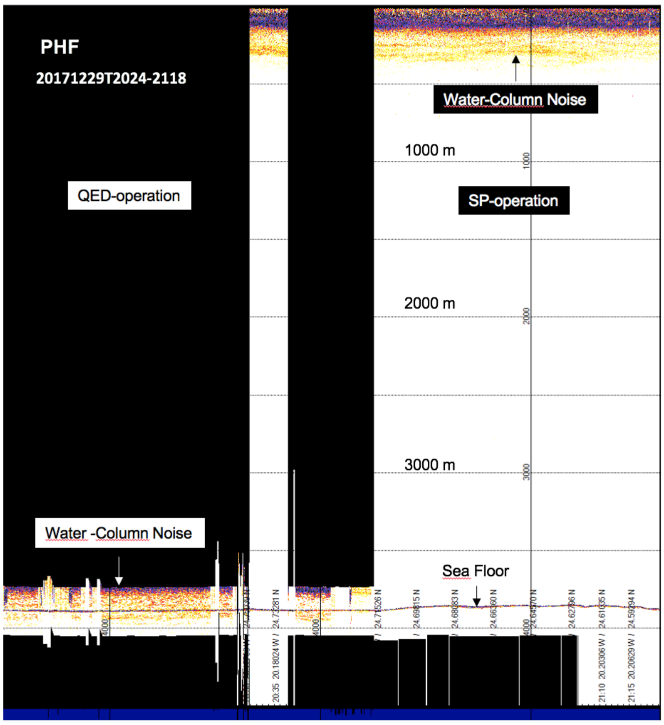

Fig. 4.3: Analysis of noise in the PHF reception window. For Quasi-Equidistant (QED) mode of operation there is a strong noise recorded close to the sea floor. This noise is similar to noise in the upper water column likely reflected from different water masses as visible if the whole water column is recorded in Single-Pulse (SP) mode. For location use time code (yyyymmddT(ime)hhmm-hhmm) in general track data of the cruise (https://doi.pangaea.de/10.1594/PANGAEA.888748).

Abbreviations

AHC	Atlas Hydromap Control (software)
APS	Atlas ParaStore (software)
ASD	Atlas Sounding Data (formate)
PHF	Primary High Frequency
PS3	Export format of PARASOUND data
SHF	Secondary High Frequency
SLF	Secondary Low Frequency
QED	Quasi EquiDistant
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator

5. CALIBRATION AND TESTING OF THE SHIP-MOUNTED MAGNETOMETER SYSTEM ON POLARSTERN

Conrad Kopsch[1] (not on board), Frank Niessen[2], Graeme Eagles[2] (not on board)

[1]ESYS
[2]AWI

Grant-No. AWI_PS110_00

Objectives

During *Polarstern* expeditions, the ship-mounted vector magnetometer system is routinely used for surveying geomagnetic anomalies. The system is installed in the "crow's nest" platform above the bridge, and consists of two vector magnetometers (3-component digital fluxgate magnetometers). These devices, developed by MAGSON GmbH (Berlin) and specially adapted for use on *Polarstern* are installed vertically offset from one another, allowing the calculation of field gradients. The system was de-installed for maintenance and re-engineering in October-November 2017, and was reinstalled on board prior to leg PS110. For accurate determination of geomagnetic components it is necessary to detect and remove transient interferences from the magnetosphere and ionosphere together with temporary induced and permanent remanent magnetization effects caused by the ferromagnetic ship and its cargo. This required a complete reset, re-calibration and test of the system at sea during PS110. The general functioning of the system was tested successfully during the shipyard sea-trial in the North Sea a few days before departure of PS110.

Work at sea

The onboard-magnetic system and D-Ship data storage were switched on shortly after departure from Bremerhaven (20.12.2017, 14:00 UTC) and switched off shortly before arrival in Cape Town (14.01.2018, 08:00 UTC). Data acquisition was paused during port calls in Le Havre and Las Palmas. In addition to monitoring data acquisition of the system en-route, it is necessary to let the vessel perform calibration loops. A first calibration loop ("northern hemisphere") was performed successfully during the shipyard sea-trial in the North Sea prior to PS110. The data acquired during these loops are needed to detect changes in the local magnetic field caused by its interaction with the magnetically-susceptible ship and its cargo, and/or slow changes in the magnetization of the hull itself. This is only possible if the magnetic field of the earth is known at the location and time of the turning circle. To know it, under normal conditions, the International Geomagnetic Reference Field (IGRF) of the Earth is interrogated. The IGRF is, however, a model based on interpolation between measurements made at magnetic observatories, and its inaccuracy increases with distance from the nearest measurement. For a sophisticated new calibration of the system it is therefore preferable to perform the calibration loops in the neighbourhood of a geomagnetic observatory. With this in mind, the vessel performed a calibration loop about 7 nm north-west of the island of St Helena, where the Helmholtz Centre GFZ-Potsdam operates a geomagnetic observatory (15.961°S, 5.747°W). The figure-eight shaped loop was completed at a constant speed of 5 kn to trace out one left-handed and one right-handed loop, each with a diameter of 2 nm (Fig.5.1). The sampling rate of the geomagnetic system is 1 second.

Preliminary results

The magnetic data acquisition operated successfully and in correct synchronization with shipboard navigation data and data storage. The PS110-participation of magnetic specialist, engineer Conrad Kopsch, was cancelled due to the fault-free operation of the system during the ship trial prior to PS110. Because of this, the determination of calibration coefficients from the data acquired during the calibration loops has been shifted to post-cruise times. Nonetheless, we are leaving behind a fully operational and soon-to-be calibrated shipboard magnetic observation system for forthcoming *Polarstern* expeditions.

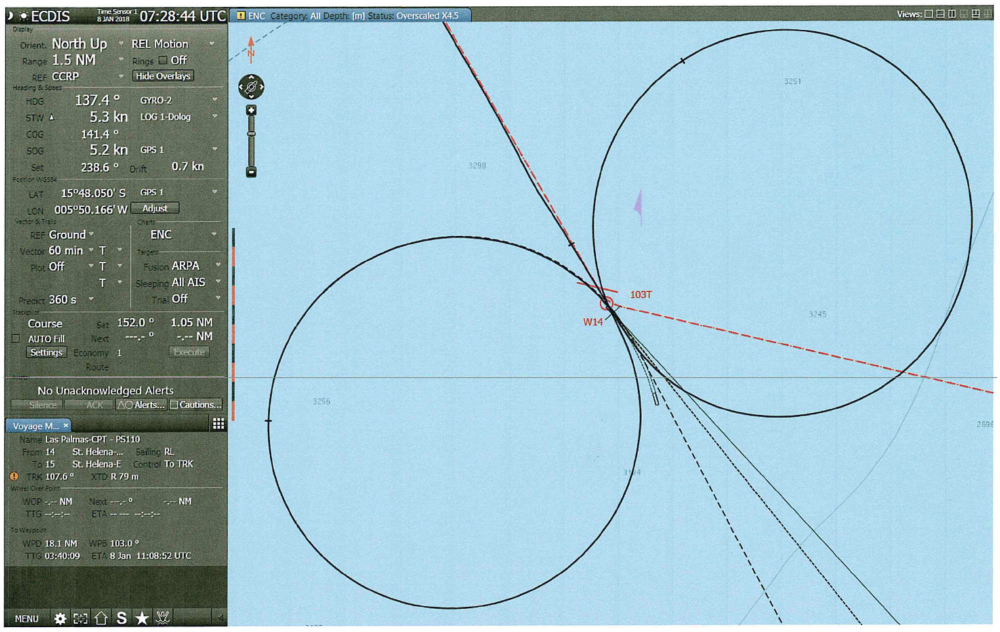

Fig. 5.1 Calibration loop near St. Helena (screenshot of the ship's navigational system)

Data management

During PS110 magnetic acquisition, data are transferred from the magnetometers to an industrial PC located in the ships data centre via a fibre optic cable. The PC also receives navigation data through the data network of the vessel. Data output is twofold, (i) as graphical plots onto the display of the PC and, (ii), into the main ship-data base (DShip) for further download according to calibration requirements. No scientific data were recorded.

6. TESTING OF THE SHIP-MOUNTED AND MOBILE SCIENTIFIC MULTI-FREQUENCY ECHOSOUNDER SIMRAD EK80 AND COMPARATIVE EXAMINATION OF THE NOISE FLOOR LEVEL

Sören Krägefsky[1], Olaf Hüttebräucker[2]

[1]AWI
[2]Laeisz

Grant-No. AWI_PS110_00

Measurements with Simrad EK60 are the international quasi standard for stock assessment of fish and krill. This echosounder is no longer commercially available and has been replaced by the Simrad EK80. Besides measurements in continuous wave mode ("EK60 mode"), the EK80 allows for operation in frequency modulation mode (FM mode), potentially allowing a highly improved species identification based on scattering response of surveyed organisms over a wide frequency band. In addition, measurements in FM mode should allow specific de-noising of the data record in the future.

Objective of the work at sea is to test the performance of the ship-mounted Simrad EK80 and a mobile Simrad EK80 WBT tube after major firmware and software update, implementing among others new signal forms during operation. Additional aim is the examination of the self-noise of the echosounders and assessment of the impact of ships noise on measurements in different measuring modes.

Work at sea

Measurements with the ship-mounted Simrad EK80 had been performed during ship transit with a set of signal-form settings in active and passive mode. At one stop, the Simrad EK80 WBT tube (mobile Simrad EK80) had been deployed to the side of the ship while the ship was slowly drifting with the current. A small sphere attached with lines to the mounting frame of the mobile Simrad EK80 served as a reference target for the measurements. Measurements had been performed with different signal form settings in active and passive mode. Alternating measurements were performed with the ship-mounted Simrad EK80. During these measurements comparative measurements had been made by means of a hydrophone bow side near the ship-mounted EK80 transducer and near the mobile EK80 during active and passive operation.

Preliminary results

In total 230 hours of measurement had been performed and recorded with the ship-mounted Simrad EK80 in passive and active mode and with different signal form settings. About 2 hours of measurements at station were performed and recorded with a mobile Simrad EK80 in passive and active mode. At the same time, measurements had been carried out and recorded with hydrophone (OceanSonic IcListen HF) allowing for ambient sound measurements in the frequency range up to 200 kHz. Analysis of the recorded data will allow an assessment of the Performance of ship-mounted and a mobile (WBT tube) scientific multi-frequency echosounder Simrad EK80 after major firmware and software update, of their self-noise and of the impact of ships noise on measurements.

Data management

No scientific data were produced during the cruise.

7. TESTING OF A MINI ROV (BLUEROV2) WITH WATERLINK SYSTEM OPERATED FROM SHIP'S WORKING BOAT

Sören Krägefsky[1], Olaf Hüttebräucker[2], Ilias Nasis[2]

[1]AWI
[2]Laeisz

Grant-No. AWI_PS110_00

Objectives

BlueROV2 is an open-source Mini ROV with a high propulsions performance showing very active development in underwater positioning and maneuvering of the vehicle. This Mini ROV, among others, may serve as a working (e.g. line deployment) and inspection tool during demanding echosounder calibration exercises. Objective of the work at sea is to test the performance of the Waterlink underwater positioning system and maneuvering performance of the BlueROV2 while being operated from ship's working boat and exposed to ship's sound.

Work at sea

Tests of the performance of the Waterlink underwater positioning system and of the BlueROV2 maneuvering performance had been performed with help of a small boat, carrying the hydrophone array of the Waterlink underwater positioning system. The tests included defined travel to different positions in the horizontal and vertical plane performed at different distances to the ship and with different orientations relative to the flow direction.

Preliminary results

The performance of the Waterlink underwater positioning system, BlueROV2 maneuvering performance and operational capability operated with the small boat had been assessed. The BlueROV2 is able to locate itself and hold position against significant currents. The underwater positioning system delivered stable and reliable position information of the vehicle. Performance of the Mini-ROV seems to be adequate for being used as a tool e.g. during calibration task of the ship-mounted echosounders.

Data management

No scientific data were produced during the cruise.

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

	Address
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
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ESYS	ESYS GmbH Schwedter Str. 43A 10435 Berlin Germany
Laeisz	Reederei F. Laeisz Bremerhaven GmbH Bartelstr. 1 27570 Bremerhaven Germany

A.2 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung / Discipline
Deckelmann	Holger	AWI-P	Technician	Atmospheric Physics
Graeser	Jürgen	AWI-P	Technician	Atmospheric Physics
Hanisch	Sabine	AWI	Geographer	Hydroacoustics
Hempelt	Juliane	DWD	Technician	Meteorology
Jens	Holger	DWD	Physicist	Meteorology
Krägefsky	Sören	AWI	Biologist	Logistics
Miller	Max	DWD	Physicist	Meteorology
Niessen	Frank	AWI	Geologist	Geophysics
Probst	Lewin	AWI	Engineer	Atmospheric Physics

A.3 SCHIFFSBESATZUNG / SHIP'S CREW
BREMERHAVEN - LE HAVRE

	Name	Rank
1	Schwarze, Stefan	Master
2	Grundmann, Uwe	Chief Mate
3	Langhinrichs, Moritz	1st Mate
4	Fallei, Holger	2nd Mate
5	Fischer, Tibor	2nd Mate
6	Ziemann, Olaf	Au Chief
7	Grafe, Jens	2nd Eng
8	Haack, Michael Detlev	2nd Eng.
9	Krinfeld, Oleksandr	2nd Eng.
10	Brehme, Andreas	E-Eng.
11	Redmer, Jens	E-Eng.
12	Christian, Boris	Chief ELO
13	Frank, Gerhard	ELO
14	Himmel, Frank	ELO
15	Hüttebräucker, Olaf	ELO
16	Nasis, Ilias	ELO
17	Rudde-Teufel, Claus	Ships doc
18	Loidl, Reiner	Bosun
19	Reise, Lutz	Carpen.
20	Brück, Sebastian	MP Rat.
21	Klee, Phillip	MP Rat.
22	Scheel, Sebastian	MP Rat.
23	Bäcker, Andreas	AB
24	Hagemann, Manfred	AB
25	Wende, Uwe	AB
26	Winkler, Michael	AB
27	Preußner, Jörg	Storek.
28	Lamm, Gerd	MP Rat
29	Rhau, Lars-Peter	MP Rat
30	Schünemann, Maria	MP Rat
31	Schwarz, Uwe	MP Rat
32	Teichert, Uwe	MP Rat
33	Schnieder, Sven	Cook
34	Möller, Wolfgang	Cooksm.
35	Silinski, Frank	Cooksm.
36	Czyborra, Bärbel	Chief Stew.
37	Wöckener, Martina	Nurse
38	Arendt, Rene	2nd Stew.
39	Chen, Dansheng	2nd Stew.
40	Dibenau, Torsten	2nd Stew.
41	Golla, Gerald	2nd Stew.
42	Silinski, Carmen	2nd Stew.
43	Sun, Yong Sheng	Laundrym.
44	Schulz, Fabian	Apprent.

A.3 SCHIFFSBESATZUNG / SHIP'S CREW
LE HAVRE - LAS PALMAS

	Name	Rank
1	Schwarze, Stefan	Master
2	Grundmann, Uwe	Chief Mate
3	Langhinrichs, Moritz	1st Mate
4	Fallei, Holger	2nd Mate
5	Fischer, Tibor	2nd Mate
6	Ziemann, Olaf	Au Chief
7	Grafe, Jens.	2nd Eng.
8	Haack, Michael	2nd Eng.
9	Krinfeld, Oleksandr	2nd Eng.
10	Brehme, Andreas	E-Eng.
11	Christian, Boris	Chief ELO
12	Frank, Gerhard	ELO
13	Himmel, Frank	ELO
14	Hüttebräucker, Olaf	ELO
15	Nasis, Ilias	ELO
16	Rudde-Teufel, Claus	Ships doc
17	Loidl, Reiner	Bosun
18	Reise, Lutz	Carpen.
19	Brück, Sebastian	MPRat.
20	Klee, Phillip	MP Rat.
21	Scheel, Sebastian	MP Rat.
22	Bäcker, Andreas	AB
23	Hagemann, Manfred	AB
24	Wende, Uwe	AB
25	Winkler, Michael	AB
26	Preußner, Jörg	Storek.
27	Lamm, Gerd	MP Rat
28	Rhau, Lars-Peter	MP Rat
29	Schünemann, Mario	MP Rat
30	Schwarz, Uwe	MP Rat
31	Teichert, Uwe	MP Rat
32	Schnieder, Sven	Cook
33	Möller, Wolfgang	Cooksm.
34	Silinski, Frank	Cooksm.
35	Czyborra, Bärbel	Chief Stew
36	Wöckener, Martina	Nurse
37	Arendt, Rene	2nd Stew.
38	Chen, Dansheng	2nd Stew.
39	Dibenau, Torsten	2nd Stew.
40	Golla, Gerald	2nd Stew.
41	Silinski, Carmen	2nd Stew.
42	Sun, Yong Sheng	Laundrym.
43	Schulz, Fabian	Apprent.

A.4 STATIONSLISTE / STATION LIST

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS110_0_ Underway-5	2017-12-20	13:00	53.57018	8.54987	3.4	WST	profile start	
PS110_0_ Underway-1	2017-12-24	07:33	49.14807	-5.12363	96	ADCP_150	profile start	
PS110_0_ Underway-1	2017-12-28	07:56	28.48524	-15.27111		ADCP_150	profile end	
PS110_0_ Underway-4	2017-12-24	09:56	48.85837	-5.83284	108	PCO2_ SUB	profile start	
PS110_0_ Underway-4	2017-12-28	07:56	28.48590	-15.27092		PCO2_ SUB	profile end	
PS110_0_ Underway-3	2017-12-24	09:56	48.85728	-5.83378	108	PCO2_GO	profile start	
PS110_0_ Underway-3	2017-12-28	07:56	28.48670	-15.27068		PCO2_GO	profile end	
PS110_0_ Underway-8	2017-12-25	07:54	44.17630	-9.55840	161	TSG_ KEEL_2	profile start	
PS110_0_ Underway-8	2017-12-28	07:55	28.48849	-15.27014		TSG_ KEEL_2	profile end	
PS110_0_ Underway-6	2017-12-25	15:12	42.53460	-10.28903		TSG_ KEEL	profile start	
PS110_0_ Underway-6	2017-12-28	07:56	28.48722	-15.27053		TSG_ KEEL	profile end	
PS110_0_ Underway-7	2017-12-28	18:24	28.07419	-15.35402	516	TSG_ KEEL_2	profile start	
PS110_0_ Underway-7	2018-01-13	11:08	-31.77378	14.83746	2313	TSG_ KEEL_2	profile end	
PS110_0_ Underway-10	2017-12-28	18:25	28.07037	-15.35262	523	TSG_ KEEL	profile start	
PS110_0_ Underway-10	2018-01-13	11:08	-31.77351	14.83701	2313	TSG_ KEEL	profile end	
PS110_0_ Underway-12	2017-12-28	18:26	28.06678	-15.35128	487	PCO2_ SUB	profile start	
PS110_0_ Underway-12	2018-01-13	07:35	-31.38935	14.18208	2911	PCO2_ SUB	profile end	
PS110_0_ Underway-11	2017-12-28	18:27	28.06565	-15.35087	494	PCO2_GO	profile start	
PS110_0_ Underway-11	2018-01-13	07:35	-31.38891	14.18130	2913	PCO2_GO	profile end	
PS110_0_ Underway-2	2017-12-28	18:27	28.06440	-15.35042	494	FBOX	profile start	
PS110_0_ Underway-2	2018-01-13	07:35	-31.38828	14.18019	2914	FBOX	profile end	
PS110_0_ Underway-9	2017-12-28	18:38	28.03201	-15.33402	754	ADCP_150	profile start	
PS110_0_ Underway-9	2018-01-13	11:07	-31.77314	14.83635	2313	ADCP_150	profile end	
PS110_1-1	2018-01-02	13:10	6.34770	-17.99210	4829	Test	station start	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS110_1-1	2018-01-02	14:37	6.33669	-17.99246	4831	Test	station end	
PS110_2-1	2018-01-04	13:21	-0.85214	-14.07445		Test	station start	
PS110_2-1	2018-01-04	13:57	-0.84843	-14.07747		Test	station end	
PS110_3-1	2018-01-06	13:07	-8.91138	-9.72377	3815	Test	station start	
PS110_3-1	2018-01-06	13:44	-8.90968	-9.72615	3816	Test	station end	
PS110_4-1	2018-01-08	05:06	-15.80223	-5.83524	3269	MAG	profile start	
PS110_4-1	2018-01-08	07:33	-15.80756	-5.83189	3251	MAG	profile end	
PS110_0_ Underway-13	2018-01-13	07:39	-31.39723	14.19499	2919	PCO2_GO	profile start	
PS110_0_ Underway-13	2018-01-13	07:40	-31.39861	14.19728	2920	PCO2_GO	profile end	

Gear abbreviations	Gear
ADCP_150	ADCP 150kHz
FBOX	FerryBox
MAG	Magnetometer
PCO2_GO	pCO2 GO
PCO2_SUB	pCO2 Subctech
TSG_KEEL	Thermosalinograph Keel
TSG_KEEL_2	Thermosalinograph Keel 2
Test	Test
WST	Weatherstation

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