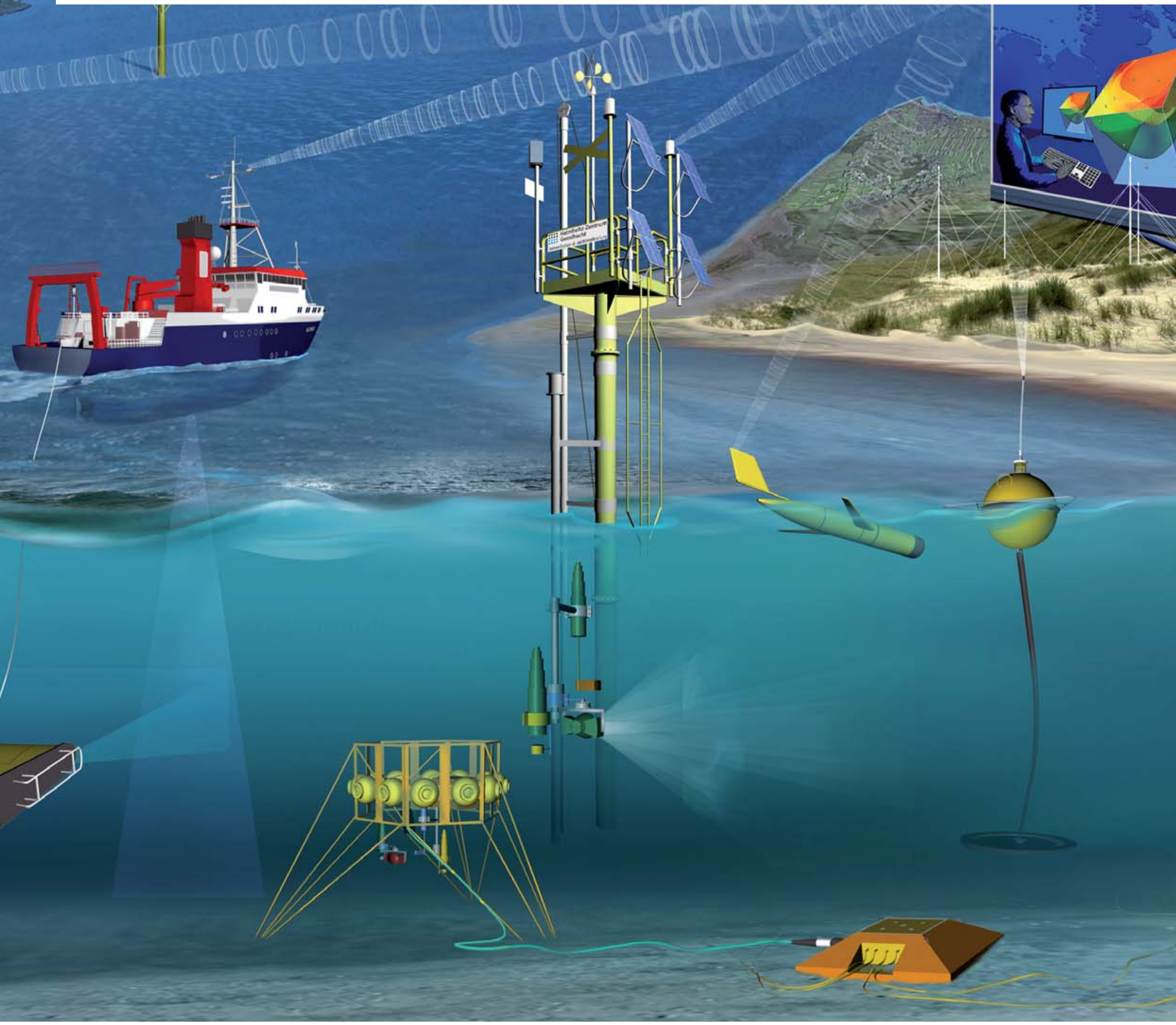
HELMHOLTZ-ZENTRUM GEESTHACHT

COSYNA
Progress Report 2012



COSYNA

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Content

Liebe COSYNA-Mitstreiter,

mit diesem Progress Report blicken wir auf ein weiteres erfolgreiches COSYNA-Jahr zurück. Mit Professor Dr. Burkard Baschek hat COSYNA seit Juli 2012 eine neue Leitung. Bei den Diskussionen über die zukünftige COSYNA-Perspektive rücken neben den bisherigen COSYNA-Produkten auch wissenschaftliche Anwendungen mehr in den Vordergrund. Zukünftig sollen die COSYNA-Produkte mehr fokussiert und auf Anwendungen für verschiedene Nutzer optimiert werden, dazu wird der mit dem BSH für Ende 2013 gemeinsam geplante Nutzerworkshop zu Offshore-Windenergieanlagen einen wichtigen Schritt beitragen.

Dieser COSYNA Progress Report für das Jahr 2012 spiegelt den aktuellen Stand wider. Viele gute, neue und wesentliche Fortschritte sind mit den Beobachtungssystemen und den Modellansätzen erzielt worden und hier belegt. Etwas ist aber anders als in den vergangenen Jahren: In vielen Teilberichten wird deutlich, dass die Aufbauphase in COSYNA im Wesentlichen abgeschlossen ist, viele Systeme im Jahr 2012 ausführlich getestet, in einzelnen Komponenten optimiert wurden und nun für den Routinebetrieb bereit sind. Und neu ist auch, dass jetzt erste Früchte aus gemeinsamen Auswertungen der COSYNA-Aktivitäten geerntet werden, wie im Bericht zu den SPM-Messungen dargestellt.

Als bewährte Messsysteme folgten im Jahr 2012 die FerryBoxen - mehr oder weniger - ihren Routen und wurden durch neu entwickelte hochpräzise pH- und Alkalinitäts-Sensoren und eine Durchfluss-PSICAM im automatischen Betrieb um neue attraktive Möglichkeiten für wissenschaftliche Fragestellungen bereichert. Die Glider liefen in ihrem zweiten Jahr in COSYNA fast schon im Dauerbetrieb, wurden in einzelnen Aspekten und besonders bzgl. der geforderten Vorhersagen für das Kollisionsrisiko mit Schiffen wesentlich verbessert. Von den Modellierern konnten daher erste Schritte zu Verwendung von Glider- und FerryBox-Daten für die Assimilation in Modelle getestet werden. Optimierung und Validierung der Radarmessungen wurden vorangetrieben, während die Fernerkundung per Satellit durch den Ausfall des ENVISAT- Satelliten MODIS-Daten in die Auswertungen integrieren muss.

Die neue Sensorik des Pfahls Spiekeroog vom ICBM wurde nach ausführlichen Tests im Labor für weitere Tests – auch des Datenmanagements und des backup-Systems - am Pfahl installiert. Zwei andere bereits existierende und von LNWKN betriebene Pfähle im Ostfriesischen Wattenmeer wurden mit Wellenradar ausgerüstet und liefern ihre Daten ebenfalls regelmäßig in die COSYNA-Datenbank. Für die Messsysteme HypOO, MOKI, Autosens und die integrativen Schadstoffsammler wurden im Jahr 2012 die Entwicklungen (fast) beendet, sie wurden im Labor und im Gelände getestet, die Methodik verfeinert und die Geräte für den Routineeinsatz vorbereitet.

Andererseits wurden in COSYNA ganz neu entwickelte, innovative Geräte zum ersten Mal eingesetzt: Die Landersysteme SedObs und NusObs konnten in Testkampagnen ihre Tauglichkeit unter Beweis stellen. Ein Highlight ist sicherlich auch der Einsatz der Unterwasserknoten vor Helgoland und - in vereinfachter Form durch das AWI - auf Spitzbergen, die seit Sommer 2012 regelmäßig Daten liefern. Landersysteme und Unterwasserknoten werden in den kommenden Jahren sicher für wichtige wissenschaftliche Ergebnisse gut sein.

Bei all diesem Messsystem, ob bewährt oder neu entwickelt, spielt nun der Routinebetrieb und die Qualitätssicherung der einlaufenden Daten eine entscheidende Rolle. Hier wurden die wesentlichen Absprachen getroffen und das Datenmanagement kann nun für die verschiedenen Messsysteme einheitlich umgesetzt werden.

Mit all‘ den hier berichteten Arbeiten und Ergebnissen ist die Grundlage für eine vertiefte Analyse des Küstensystems gelegt. Auf dieser Basis wünschen wir uns allen eine weitere fruchtbare Zusammenarbeit zur Erreichung der COSYNA-Ziele.

Dr. F. Schroeder C. Eschenbach

Improving measurements of suspended matter concentration

R. Röttgers / G. Flöser / K. Heymann / H. Krasemann / R. Riethmüller

Aims for 2012

Suspended particulate matter is measured within the Institute for Coastal Research by several departments and in many areas of the German Bight. Problems arise when concentrations fall below ~ 5 g m^{-3} because the filtered weight comes into the range of minor changes in the filter itself caused by the filtering and combusting procedure. We wanted to address this problem by a dedicated ship campaign using RV Heincke in November 2012.

Technical / Program Developments in 2012

Introduction

Mass concentration of suspended matter (SPMC) in the sea is one of the key parameters to be measured within COSYNA. Its spatial and temporal variation as determined from in-situ observations is best determined by proxies such as optical turbidity or acoustical backscatter intensity. In first approximation these proxies are linearly proportional to SPMC, but the proportional factor has to be determined from direct comparison with concentrations derived from filtration of water samples and weighing of the material retained by the filters. Especially for low SPMC, systematic errors caused by filtering and weighing, may lead to systematic under- or overestimation of SPMC. The same is valid also for the determination of the fraction of organic matter in the suspended material that is derived of loss-on-ignition (LoI) of the filtered material. The accurate determination of any systematic biases and the magnitude is even more important for studies that aim to relate the optical properties to the concentration of the SPM as needed e.g. for the accurate estimation of SPMC from ocean colour.
The amount of mass retained on the filter is strongly influenced by the mass of dissolved salt in seawater. Typical SPM masses that can be collected on filters before it is clogged are in the range of a few milligrams, reaching values of > 10 mg only in very turbid waters, e.g. in the Wadden Sea; mass of salt in these filters would alone amount to up to ca. 20 mg. Therefore, rinsing of the filters is required after sample filtration. As rinsing often does not remove all sea water, typically not at the glass-covered margin of the filter (Banse et al. 1963), a positive mass offset on the filter results. The offset is directly dependent on sea water salinity (Stavn et al. 2009). A second substantial error may be the loss of filter material during the extensive rinsing and combustion process, the latter done for the LoI method to separate the organic and inorganic fraction of the suspended matter. The systematic offset induced by salt water was reported to be about 1 mg (Stavn et al. 2009) and this would lead to a SPMC overestimation of 20 % in case 5 mg of SPM are collected. As masses after combustion are typically lower than SPM masses and masses of SPM on filters can be lower than 5 mg, the potential errors can be larger than 20 %. Measurements of the mass losses due to filtration and combustion have yet not been done systematically with natural samples. So far, very little has been published on these effects (Banse et al. 1963, Stavn et al. 2009 and references therein). In this study, the magnitude of the overall offset and the range of the related error were examined.

Methodology of offset determination

Traditionally, SPMC and LoI are determined from the analysis of a single sample, where LoI is the ratio of the particulate organic matter (POM) to SPM and calculated after the particulate inorganic matter (PIM) is determined, as POM = SPM - PIM. SPM and PIM concentrations are determined from filter weights of empty, sample loaded, and subsequent combusted filters, F_{empty}, F_{loaded}, and F_{ashed}, respectively, by

$$[\mathrm{SPM}] = \frac{F_{SPM}}{V} = \frac{F_{loaded} - F_{empty}}{V} \quad [g/m^{-3}]$$

and

$$[\mathrm{PIM}] = \frac{F_{PIM}}{V} = \frac{F_{ashed} - F_{empty}}{V} \quad [g/m^{-3}]$$

and
LoI by

$$LoI = \frac{[SPM]-[PIM]}{[SPM]} * 100 = \frac{F_{loaded} - F_{ashed}}{F_{loaded} - F_{empty}} * 100\,[\%]$$

The term $F_{SPM} = F_{loaded} - F_{empty}$ contains also the unknown contributions from retained salt and rinsing losses (offset$_{S+F}$), $F_{PIM} = F_{ashed} - F_{empty}$ any unknown losses during combustion (offset$_C$). These unknown contributions / losses were derived by filtering several sub-volumes (3 to 6) of the same sample. The mass retained on the filter and that lost during combustion should be proportional to the sub-volume plus or minus any volume-independent offset. The slope of a linear regression of mass on the filter or mass after combustion over filtered sub-volume yields SPM or PIM concentration of the sample and the intercept the so far unknown offsets:

$$F_{SPM}(V) \quad = \quad [SPM]*V + offset_{S+F}$$

$$F_{PIM}(V) \quad = \quad [PIM]*V + offset_{C}$$

The results are considered to enable more accurate and precise measurements of SPMC and LoI from filtering samples, allow mean corrections of historical "one-filter" data, as well as an estimation of the errors originating from the unknown offsets.

Lab experiments for salinity influence determination on SPM filtration

In a first lab experiment it was demonstrated that a mass offset results from retained salt in the margin of the filter and that filtration results in material losses are only visible when salt is removed completely. A NaCl solution was filtered through filters of different diameters. The retained mass shows a linear increase with the area at the filter margin covered by the glass funnel the filtration unit (Figure 1). If the margin of the filter is filled with pure water before filtration of sea water to prevent intrusion of sea water into the glass-covered filter margin, a significant material loss is detected. As a result, filling the filter with pure water before filtration is recommended to reduce salt retention.

In a second experiment, the concept of the above proposed "sub-volume-procedure" was experimentally tested with different masses of a mineral powder deposited on the filter when a salt offset is induced by filtering a dilute NaCl solution (i.e. 1.5 and 3.0 g/L) through. A strong linear correlation ($r^2 > 0.996$) is found for mineral masses deposited on the filter and the mass of the same filter determined after filtration of pure water and the NaCl solutions (Figure 2, Table 1). The results show that measurement accuracy (3 %) and precision (2 %) of this method can be high even when a large mass offset due to the salt is observed. This procedure was used on board of RV Heincke when determining suspended matter concentrations in the German Bight.

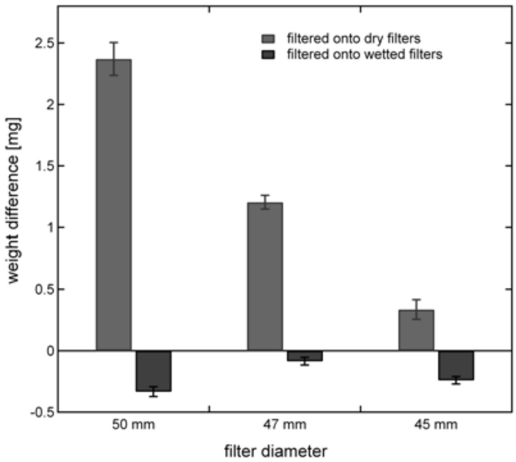


Figure 1: *Salt retention on glass microfiber filters of different diameter. Experiments were done by filtering NaCl solution onto dry filters and filters wetted before with pure water.*

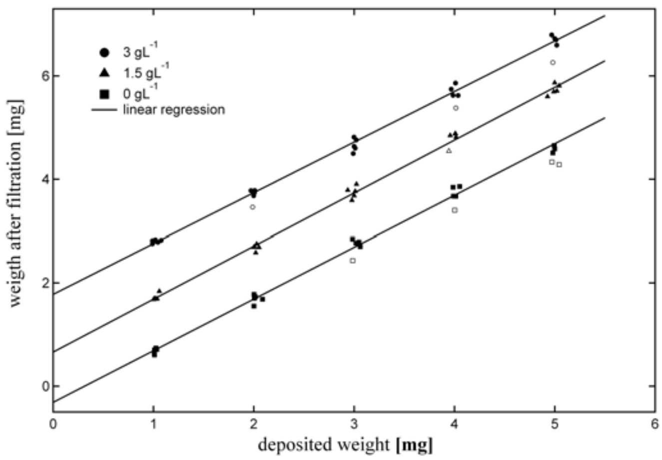


Figure 2: *Filtration of mineral powder suspension in water with several concentrations of salinity. Open symbols represent outliers disregarded for the regression analysis.*

Table 1: *Results of the linear regression analysis of data in Figure 2*

NaCl Solution	Slope	offset	R^2	df
0 g/L	1.00±0.02	-0.31±0.05	0.996	19
1.5 g/L	1.03±0.02	0.66±0.04	0.997	22
3.0 g/L	0.98±0.01	1.78±0.05	0.996	20

Determination of SPM and LoI error from experimental data

A cruise with RV Heincke in November 2012 was dedicated to the evaluation and assessment of SPM sampling methods used by the departments in the Institute of Coastal Research at HZG. Two filter types (Whatman GF/C and GF/F) and two water sampling devices (2-l suction samplers and 10-l Niskin samplers) were compared. Here, the results of the error determination of the LoI measurements are reported.

Usually, the filters (Whatman GF/C and GF/F, 47 mm Ø) are flushed with water, heated to 500 °C for one hour, weighed and then used for sampling. After sample filtration the filters are washed with purified water, dried, weighed, heated to 500 °C again in order to remove organic carbon, and then weighed again. LoI is then determined as given above.

The result is expected to be a rough estimate for the particulate organic matter content of the water sample. The heating of the filter before sampling is done because the heating process alters the filter structure and some percent of weight is lost in the process.

At each of the 30 stations during the Heincke cruise, one water sample was divided into four different volumes with which the standard SPM concentration and LoI determining process was performed. The offset, dependent on SPMC, is shown in Figure 3.

The offset is between -0.5 and 1 mg and seems to depend on SPMC, at least for the GF/C filters. For the upper end of the concentration interval (40 g m^{-3}), an error of -0.5 mg has to be compared to a SPM mass weight of 40 mg, which yields an error of ~ 1 %. At the lower end, however, the error is substantial and more measurements with higher precision are required.

Regarding the results of the LoI determination (Figure 4), the offset is between 0.2 and 0.6 mg for GF/C filters and decreases only slightly with suspended matter concentration. The values for GF/F filters are higher – between 0.3 and 1 mg, probably due to the greater thickness of the GF/F filter.

Since the offsets and scatters for SPMC and LoI determination are thus known in their dependence on SPM concentration, they can be used to correct historical SPMC and LoI measurements.

A particular example is given in Figure 5 where for all available SPM samples during the last 13 years a scatter plot LoI vs. SPMC was done. The error bars increase with decreasing SPMC and both, SPMC and LoI, grow more uncertain.

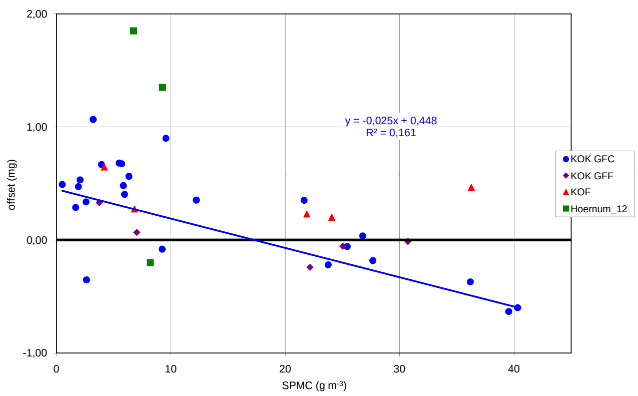


Figure 3: Offset of SPMC measurement regression lines during Heincke campaign 391, November 2012 and Prandtl campaign in the Hörnum Deep, August 2012. KOK refers to the department KOK sampling, KOF that of department KOF, and GFF / GFC to the respective filters. The blue regression line only takes into account the KOK GF/C data.

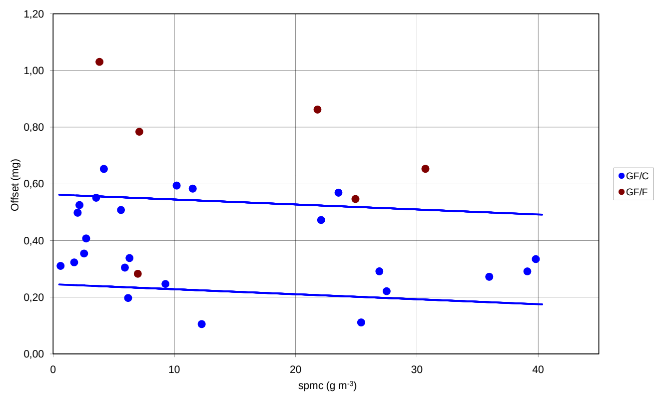


Figure 4: Offset of regression lines in Figure 3. The blue lines are the limits given by standard deviation.

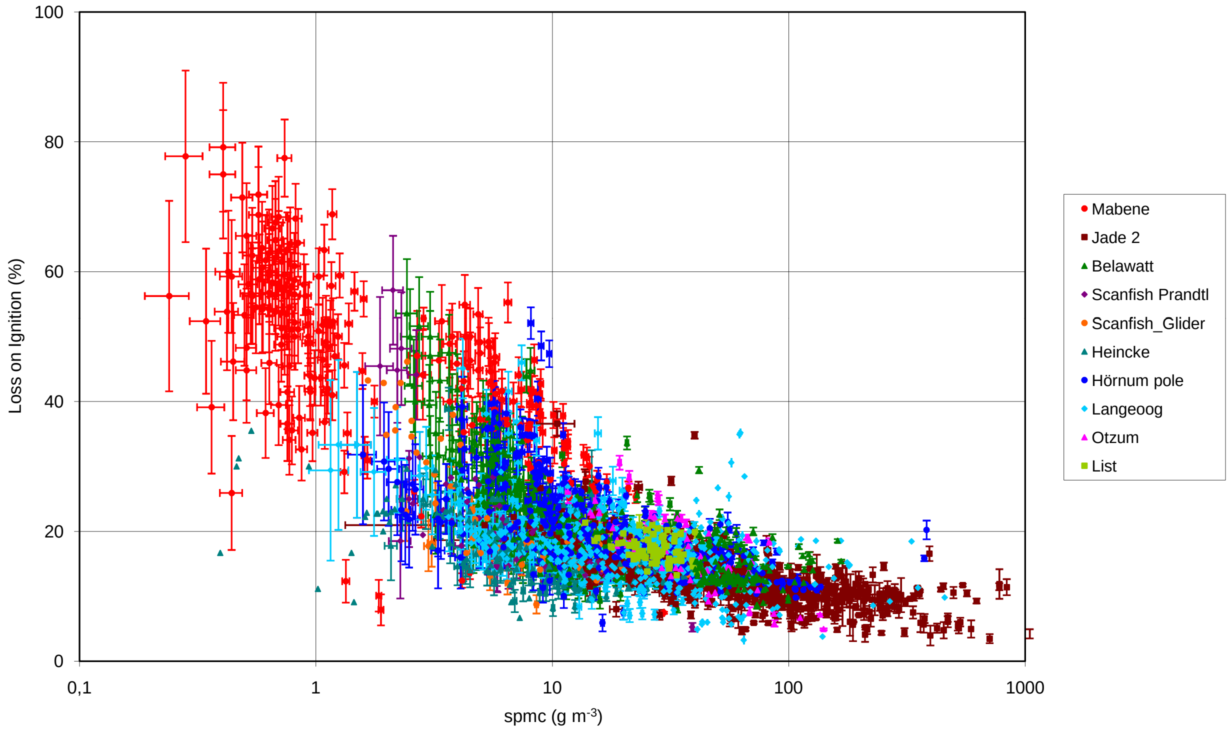


***Figure 5:** Loss on Ignition versus suspended matter concentration for all samples collected by the Institute of Coastal Research from 2000 - 2013.*

Problems

As has been shown above, the error bars grow large when SPM mass is small. One simple solution for this problem is to use larger water volumes for small concentrations. Using ~10 mg of SPM material is usually enough to guarantee a reliable measurement of SPM concentration and loss on ignition.

Perspectives for 2013

To further eliminate filtration errors, a series of experiments with filters is planned in order to elucidate the exact changes in the filter that lead to the mass loss described above. For this purpose, salinity, temperature and time for the combustion process will be varied to find out (1) whether the fall below zero in Figure 3 is statistically significant also for both filter types used and (2) whether the lost filter part of Figure 4 at larger concentrations (40-400 g m^{-3}) is also in the same range of magnitude.

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Stavn RH, Rick HJ, Falster AV (2009): Correcting the errors from variable sea salt retention and water of hydration in loss on ignition analysis: Implications for studies of estuarine and coastal waters. Est. Cost. Shelf Sci., 81, 575-582.

FerryBox

W. Petersen

Aims for 2012

- Continuous operation of three underway FerryBox systems in the North Sea aboard cargo ships and ferries respectively
- Continuous operation of the stationary FerryBoxes in Cuxhaven and on FINO3
- Field campaigns aboard research vessels with the FerryBox system
- Testing/optimization of new sensor developments for unattended operation within FerryBox systems
- Operation of automatic data quality assurance procedures for FerryBox data
- Contributions to the EU project JERICO
- Scientific applications of FerryBox data

Technical / Program Developments in 2012

- Test and optimization of new sensors for high precision pH and alkalinity (PhD thesis S. Aßmann), PSICAM (point-source integrating cavity absorption meter) as well as nutrient sensors (SIA, HZG development C. Frank) during COSYNA campaigns aboard RV Heincke
- Refit of existing FerryBox system from vessel TorDania and installation on a new vessel
- The FerryBox activities are imbedded within the EU project JERICO (www.jerico-fp7.eu).

Results (Highlights)

Underway FerryBox Systems

In 2012 the three underway FerryBox systems from HZG could not be operated the entire year. The vessel TorDania (route Immingham – Cuxhaven) has been stopped for operation since April 2012 and the FerryBox system had to be dismantled. A new vessel (Hafnia Seaways) operated by the same company at the same route was selected for continuation of FerryBox measurements. A new optimized and partly with new sensors equipped FerryBox system has been built by the company 4H-Jena and has been successfully tested in the lab and the installations aboard (water inlet, outlet, tube etc.) including a satellite communication for real time data transfer were accomplished. The planned final installation of the new FerryBox aboard Hafnia Seaways in November has been postponed because even this vessel will be moved to another route in 2013. Instead, a simpler FerryBox in previous times only used for ship campaigns has been installed and came into operation at the end of the year and will be on a route in the English Chanel from Rotterdam to Immingham.

In addition the route of the second vessel LysBris operated between Norway, Germany, England and Spain was changed by the ship company in May 2012. The new route is now between Norway, Belgium and England and does no longer call a port in Germany. This makes it much more difficult to maintain the system high frequently (on a fortnightly and monthly basis respectively). The operation of the nutrient analysers was not continued as these require much more maintenance than all other parameters. Nevertheless, the operation of the basic system including oxygen and pH could be successfully continued with only a few gaps by two-monthly maintenances carried out in Norway. The status of the FerryBox routes in 2012 is shown in Figure 1:

***Figure 1:** Operated routes in the North Sea in 2012 (green LysBris (from May 2012), orange: TorDania (until April 2012), red: FunnyGirl)*

FerryBox systems on fixed platforms

In 2012 the HZG FerryBoxes in Cuxhaven at the mouth of the Elbe River and on FINO3 have been operated. All data are averaged (10 min) and automatically quality checked and transferred to the COSYNA database in real-time via UTMS (Cuxhaven) or a satellite connection (FINO3). While the FerryBox in Cuxhaven was running only with small gaps including nutrient data the operation on the station FINO3 was several times interrupted either caused by power failures and subsequent problems with the FerryBox computer or by problems with the pump pumping seawater to the FerryBox. It turned out that the computer problems were caused by high humidity after long-term power failures in the cabinet in conjunction with high salt content in the air. A more encapsulated system for the electronic and computer will be necessary.

The successful installation of a FerryBox in a container in Spitsbergen by the Alfred Wegner Institute was supported by HZG by technical advices and installation of the data transfer procedures including QA for real time data in the COSYNA database.

Development and operation of new sensors

New pH and alkalinity sensor

As part of his PhD thesis Steffen Aßmann could finalize the development of a high precision pH and alkalinity sensor for underway systems.

By combination of these two parameters the entire carbon system can be quantified and can be applied to investigate issues such as ocean acidification or the exchange of CO_2 between ocean and atmosphere. Figure 2 shows as an application the saturation index of aragonite (calculated from pH and pCO_2) on a ship campaign in 2012.

The low values in the vicinity of the coast indicate possible dissolution effects on calcifying organisms. The reached accuracy and precision for the two sensors are depicted in Table 1.

***Table 1:** Specifications of pH and alkalinity sensor*

	pH	AT
Accuracy	± 0.003 (with CRM)	± 1 µmol/kg
Precision	± 0.0007	± 5 µmol/kg
Meas. cycle	1 min	5 min
Range	7.5–9.0	1.8–2.5 mmol/kg
Method	absolute	absolute

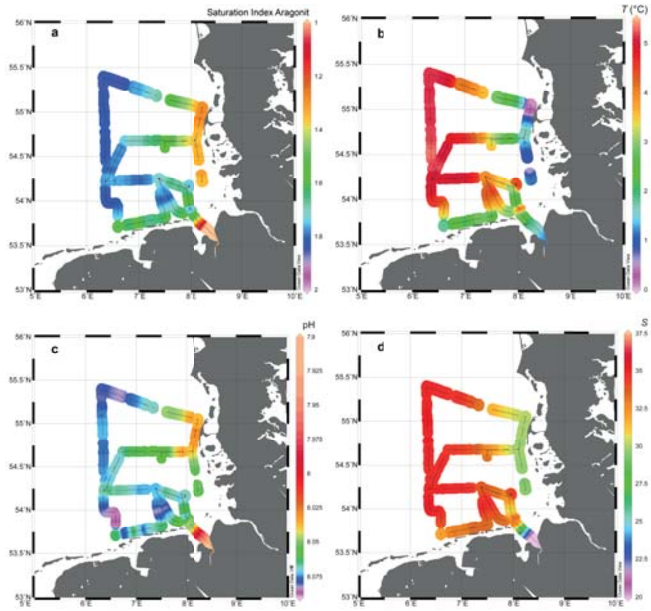

***Figure 2:** Contour plot of (a) saturation index of aragonite, (b) temperature, (c) pH and (d) salinity in the North Sea (RV Heincke, February 2012)*

Development of the flow-through PSICAM

In 2012 the data from operational use of a flow-through point source integrating cavity absorption meter (ft-PSICAM) system have been evaluated intensively and were compared with reference data from lab analysis. Figure 3 depicts the comparison of three different methods (fluorescence, conventional PSICAM and flow-through PSICAM) for chlorophyll-a determination on four different campaigns in different years and at different seasons. The high correlation with laboratory HPLC data clearly demonstrates the advantages of absorption measurements compared to fluorescence measurements as these are much less influenced by the algal species and their physiological state. With the conventionell PSICAM single bottle samples can be measured only and the cavity cell has been intensively cleaned after each measurement. In contrast the ft-PSICAM is operated in a continuous flow-through mode, with all the problems of contamination (e.g. yellow substances) of the cavity wall causing changes of reflectivity and hence degradation of reliability. The cell has only been cleaned after certain time intervals. However, even the absorption data from the flow-through PSICAM give more reliable results. Another advantage is, that these measurements deliver absolute values.

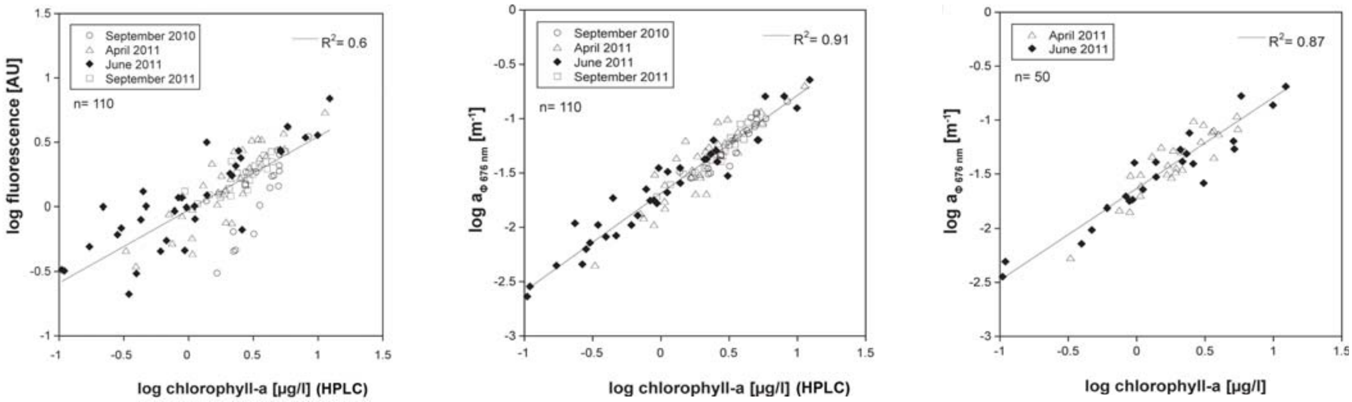

Figure 3: *Comparison of three different methods for chlorophyll-a determination from four different ship campaigns in 2010 and 2011 against laboratory HPLC measurements.* ***left panel:*** *Chl-a fluorescence,* ***middle panel:*** *Chl-a absorption with conventional PSICAM,* ***right panel:*** *Chl-a absorption from flow-through PSICAM*

Nutrient Analyser

The new developed SIA (sequential injection analysis) systems for nutrients have been extended to nitrate and nitrate. First unattended field test of the system were started at the end of 2012 in Cuxhaven. A final operation of the nutrient analyser aboard an underway system is still pending.

Data management and quality assessment

In 2012, the real time quality control measures already installed at the fixed platforms according to the recommendations of MyOcean and the EuroGOOS DATA-MEQ group for in-situ data near real time quality control (RTQC) have been implemented in underway FerryBox systems as well. These measures include checking of housekeeping parameters such as flow rate, speed of the ship and statistical information (e.g. variance, frozen values etc.) in order to get highly reliable data.

Problems

- The operation of the conventional nutrient analyzers from the company Systea requiring a lot of maintenance have been stopped aboard underway FerryBox systems because the vessels were out of use or did no longer call a harbor in Germany close to HZG.
- Even if the FerryBox works well on the station FINO3 the accessibility especially in the winter time may be a problem. Power failures and problems with the inlet pump led to several gaps in the time series over the year.
- Several changes of the vessels on the route Immingham – Cuxhaven led to an interruption of this route since April 2012.
- The very limited personal capacity is still a big problem operating all FerryBox systems with the necessary care. Thus, for instance quality control is often lagging behind due to personnel bottlenecks. As well scientific evaluations and applications of the large amount of FerryBox data could be improved by employing additional PhD students and/or PostDocs.

Perspectives for 2013

- Unattended operation of the new SIA nutrient analyser (nitrate, nitrite and phosphate) prototype aboard one of the vessels
- First unattended operation of the newly developed high precise pH and alkalinity sensor for measuring the carbon fluxes from the coast to the open sea
- Application of the new developed sampler for Gene probes (co-operation with AWI, K. Metfies)
- Scientific evaluation of FerryBox data with regards to oxygen, nutrients and pCO_2 (Postdoc from JERICO project)

Publications

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Long term observatory @ Pile Spiekeroog ICBM

T. Badewien

Aims for 2012

The long term observatory (LTO) "Pile Spiekeroog ICBM" has gathered environmental data for more than ten years. These measurements will be continued and integrated into COSYNA. The technical renewal of the research platform is going on and expected to be finished this year. First real-time data sets are already available at the COSYNA data portal. In the future, all data, including those derived from recently installed sensors, shall be made available in this way. New validation techniques aim at assuring the data quality. Here, first tests were run in 2012.

Technical / Program Developments in 2012

In 2012, all new sensors and instruments were purchased. Previous to installing the sensors, the data management and the backup system at the Pile Spiekeroog, the components were tested for several weeks in the laboratories in Wilhelmshaven and Oldenburg.
Two different temperature/conductivity sensors (Citadel CT-EK Teledyne RD-Instruments and Aanderaa Conductivity/Temperature Type 4120) were installed at the pile and tested for several months in order to determine the most suitable sensor. The data quality of both sensors during the test period was about equal. However, Teledyne RD-Instruments could not deliver the sensor within the desirable time span and could not manage the long-term drift of the sensor. In addition, the Aanderaa sensor fits better into the horizontal tubes at the pile. As a result, we decided to use the Aanderaa sensor.
During this period, we used the newly designed autonomous backup system for running the sensors and logging the data. This served also as a test for the backup system.
In summer 2012, we started to install the components for the renewal at the pile together with 4H-JENA engineering GmbH. To ensure continuous data acquisition, the old and the new sensors and data management system operated in parallel for more than six months.

In December 2012, we set up the new MySQL database at the ICBM server and implemented the data management tool InSiDa (provided by BDE Software Services GmbH).
First data were submitted to the COSYNA data portal in December 2012. The data were validated according to Figure 1. The nomenclature of the parameters follows the suggestions made by the OceanSITES network within GOOS (www.oceansites.org). The reference depth of the sensors was changed from the sea floor to long term mean of the sea level (NN, Normal Null) (Figure 2).
In order to exchange information and watch the progress of the work, technicians and scientists of the ICBM, the company 4H-Jena engineering GmbH and the HZG hold a video conference every two weeks.

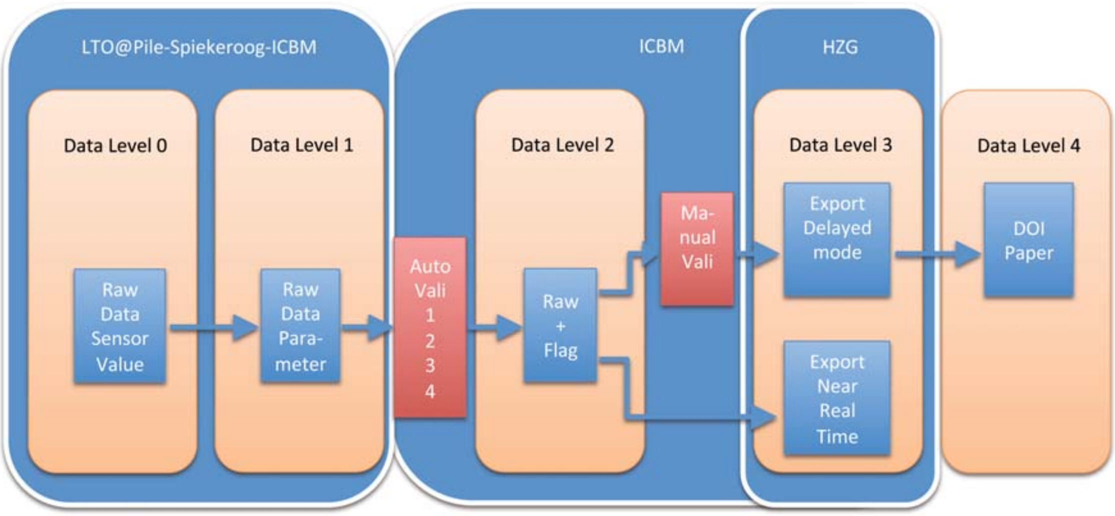


Figure 1: *Sketch of the data validation procedure.*

Results (Highlights)

The modular set up of the data management and backup system facilitated the data transfer and integration of new sensors and other components. This also ensures a highly flexible system for future developments. By adapting a TCP-network system, remote control and direct access to the data management system on the pile is improved. Several independent batteries back up the autonomous operation of the research platform and the data logging system even if the main power supply fails. The data management tool InSiDa was successfully implemented. The data are now transferred from the sensor to the database via digital interfaces.

Problems

Due to lack of space inside the pile, the new nutrient analysers could not be installed parallel to the old ones. During the laboratory test these sensors performed well. However, on site we encountered major problems with the power supply of the analysers, which could only recently be resolved. This led to a gap in nutrient data from September 2012 to March 2013. So far, the ADCP has not been integrated into the new data management system. Therefore, current data are not yet available in real time.

Perspectives for 2013

The renewal of the pile will be completed. After that, the pile will continue to work in the operational mode.

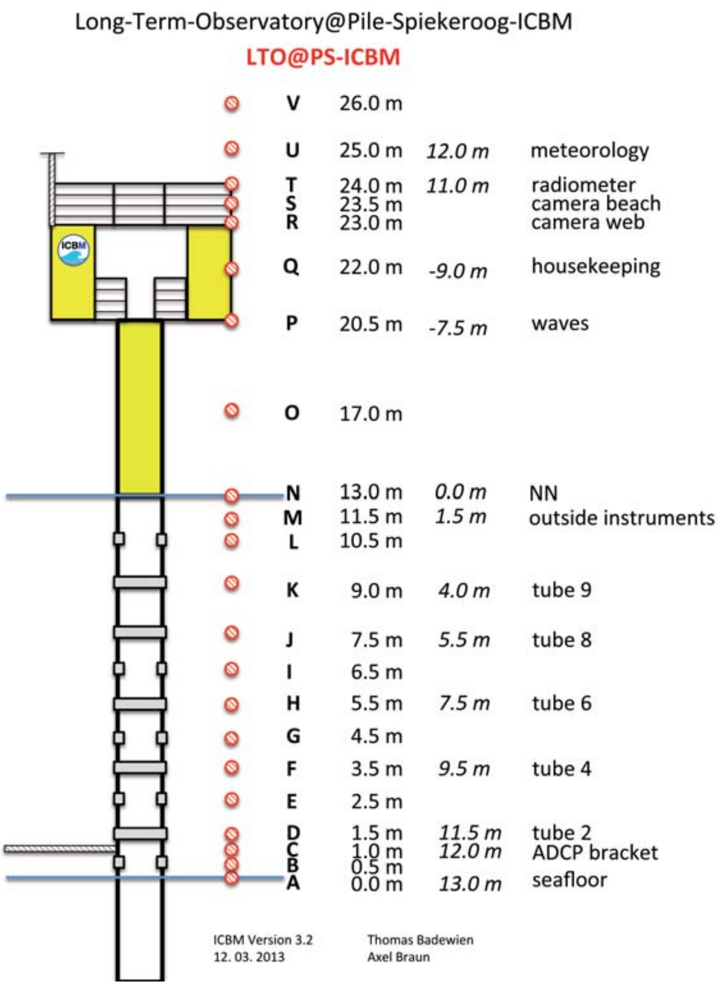


***Figure 2:** Locations of the sensors at the "Pile Spiekeroog ICBM" with reference to the long term mean sea level and labelling of the depths (letters A-V) used in the data management system.*

Radar wave gauges in the East Frisian Wadden Sea

M. Witting / C. Berkenbrink / A. Wurpts

Technical / Program Developments in 2012

The proposed COSYNA-contribution of Coastal Research Station (CRS) consists of the implementation of two wave gauge radar sensors on existing piles in the Lower Saxony Wadden Sea. The first pile “Ostfriesisches Wattenmeer” was equipped in spring 2012 and is delivering online data since 7th of June 2012.

The setup at the second pile “Leyhörn” couldn’t be established in 2012 because morphological changes at the site led to a bottom level as high as -0.1 m above NN which means, that the pile falls completely dry around mean water level and below. Moreover this situation makes it impossible to get reliable information regarding the Wadden Sea wave climate. As a result, an additional pile was built and set up at location Bantsbalje in early 2013, see following section “Pile Bantsbalje”.The detailed pile locations are given in the table below and are shown in Figures 1 and 4.

In the course of COSYNA both piles were equipped with the Wave Guide Radar by RACAC BV, Netherlands. The Wave Guide Radar measures the distance to the water surface several times per second. The frequency of the measurements allows for the detection of individual short crested waves and so for sea state analysis. It is a very accurate radar level gauge which is a compact, robust, maintenance-free, calibration-free, low power consumption device. Raw data of the radar sensor are transmitted to the Wave Guide Server. The Wave Guide Server facilitates commissioning, remote servicing, data collection, data processing, presentation and logging.

The server communicates with the radar via a serial link (RS232/RS485) and TCP/IP. The system is based on a low power processor, does not have any moving parts and is time synchronized.

Pile „Ostfriesisches Wattenmeer“

The pile “Ostfriesisches Wattenmeer” (COSYNA station identifier: Pile_NLWKN_Steinplate) is located between the islands Juist and Norderney. The respective tidal inlet consists of a big channel close to Norderney and two smaller channels close to Juist (Figure 1). The pile is located on a sandy shoal called Steinplate which partly falls dry during low water and is located between these two channel systems.

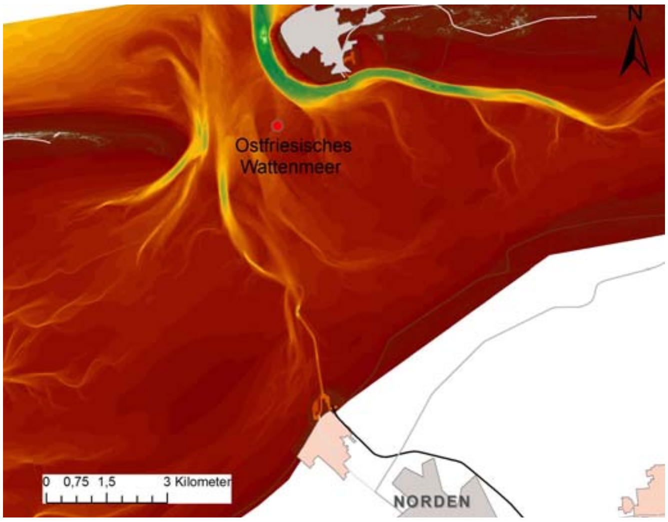
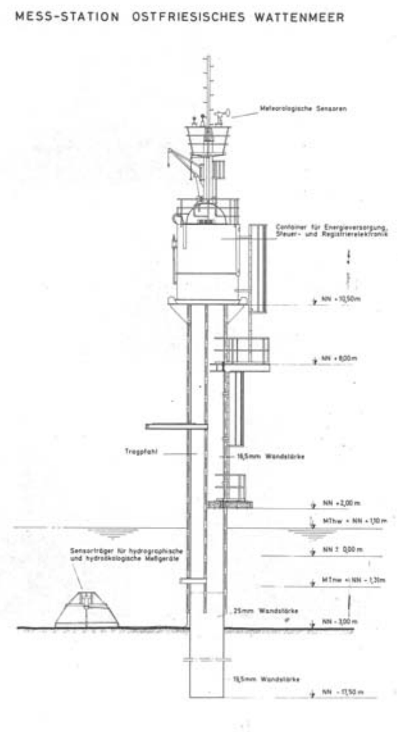


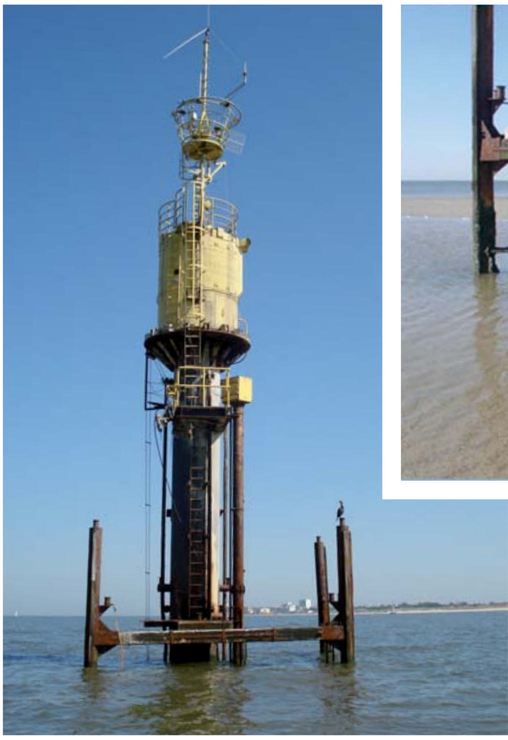
***Figure 1:** Location of pile Ostfriesisches Wattenmeer*

The pile was built in 1980 by Coastal Research Station, Norderney as a multi-purpose platform for various measurement systems. It is equipped with electricity (220 VAC) and can be reached by boat in a few minutes from the island Norderney. A wind gauge is working continuously through the year.

***Table 1:** Pile locations*

Geo. N	Geo. E	Other data	
„Ostfriesisches Wattenmeer”	53°41’13’’	7°8’32’’	wind (direction and speed)
„Leyhörn” (original location)	53°32’57,1’’	7°2’10,3’’	wind (direction and speed), air pressure, air temperature
„Bantsbalje“ (new location)	53° 33,985'	7° 0,898'	-





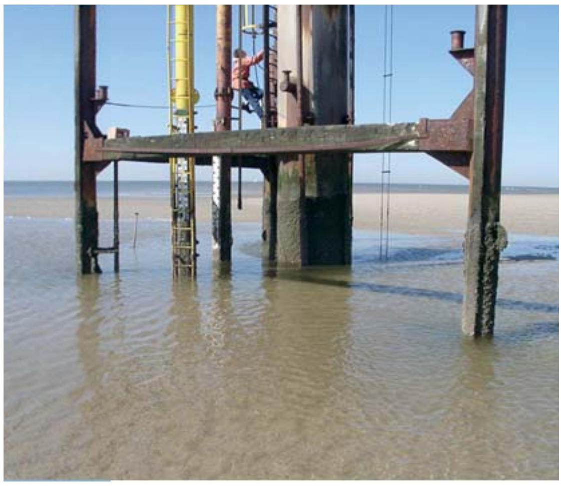


***Figure 3:** Foundation of pile "Ostfriesisches Wattenmeer" in 2012*

***Figure 2:** Schematic construction sketch and photograph of pile Ostfriesisches Wattenmeer*

Figure 2 left shows the situation in the 1980s; the bottom level at this location is very variable due to the high morphological activity in the whole inlet area. In 2012 the pile almost falls dry during low tide (Figure 3)

Data of the pile "Ostfriesisches Wattenmeer" are transmitted via directional wireless local area network (WLAN) to a server on the island Norderney from where the ftp upload to the COSYNA system is updated every 60 minutes. Data are available from 7th of June 2012.
The following parameters are transmitted to the COSYNA server (http://tsdata.hzg.de/index.cgi?seite=plot_form) and can be found there in the category "Pile", under the station name: "Pile_NLWKN_Steinplate":

Gauge	- 10-minutes mean water level
MeanPeriod	- T_{m02} mean wave period by spectral moments m_0 and m_2
Peak Frequenz	- f_p frequency of spectral peak period
WaveHeight	- H_{m0} – spectral wave height (significant spectral height)

Pile "Bantsbalje"

Because of the unfavourable situation of Leyhörn pile a new location "Bantsbalje" was established in early 2013 on a water jetted pile north to the original location of Leyhörn pile. The pile is equipped with solar panels that allow for a stand-alone operation of the radar and data transmission.

Data of the sensor are stored and processed on a Linux system (Radac wave server) which is operating onboard the pile. Data transfer is then routed via directional wireless local area network (WLAN) onshore and transferred to a fileserver system at Coastal Research Station's main building at Norderney from where the ftp upload of the controlled and reprocessed data to the COSYNA server takes place. Reprocessing and uploading is done by a MATLAB script. Data will likely be available from May 2013 based on hourly updates from this pile. Data extent will be the same as from the already operational pile "Ostfriesisches Wattenmeer".

The figure shows pile Leyhörn at the originally proposed location (see also Figure 4 right)

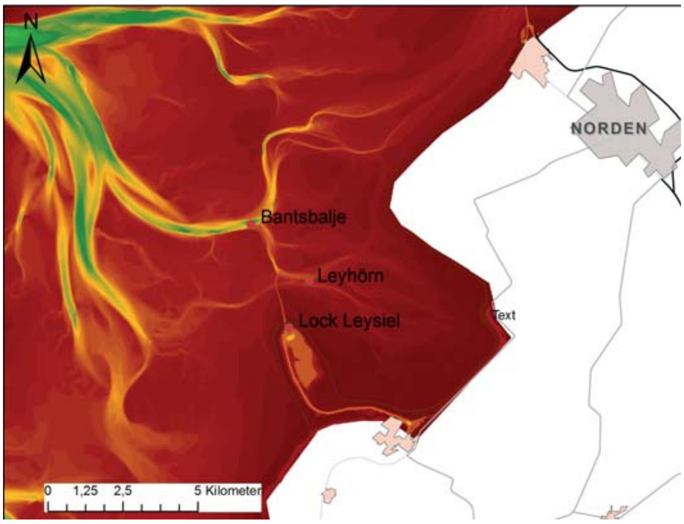
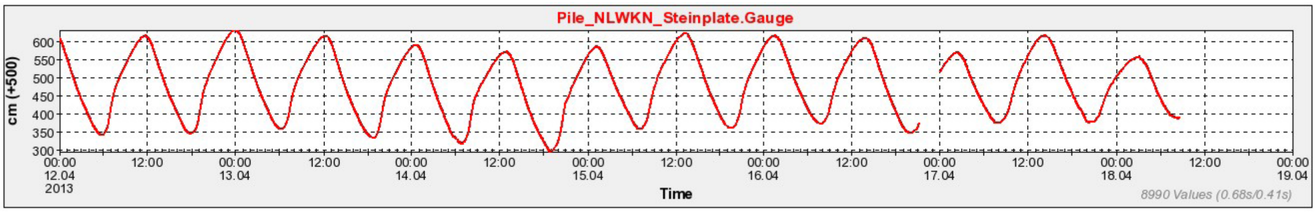


Figure 4: *left: Pile Bantsbalje with sensor arm solar panels and directional wireless antenna, right: Locations of piles Leyhörn and Bantsbalje, 2008 topography*

Figure 5: *The pile "Leyhörn" at originally proposed location close to the harbor inlet of Greetsiel.*

Results

Data delivery of the pile NLWKN_Steinplate is robust and the quality of the data is ranked with 2 (“probably good data”). Remarkably the intensity of the sea state e.g. wave height strongly correlates with the tidal water level (Figure 6). This is due to the fact that the pile is located in very shallow water on the tidal flat Steinplate.



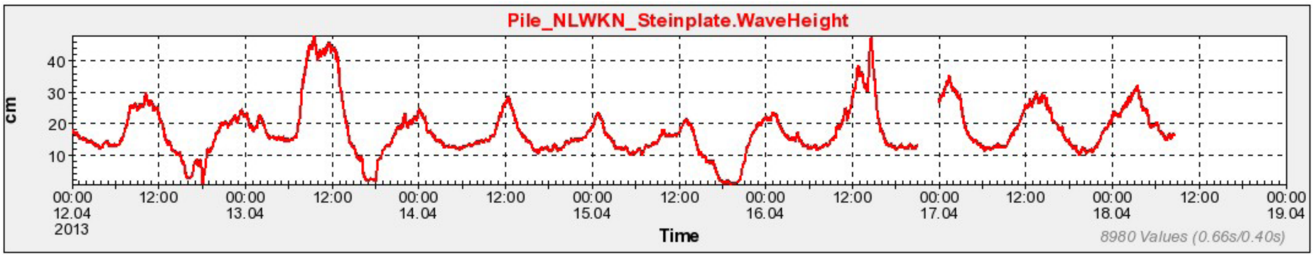


Figure 6: *Data of Pile_NLWKN_Steinplate, top: Water level , bottom:* H_{m0}

Problems

Due to the change of the pile location from the originally proposed location Leyhörn to the new location Bantsbalje the method of data transmission had to be changed. Leyhörn is connected to the mainland by wire, whereas Bantsbalje had to be linked by wireless network to the mainland. Considering the distance of 6 kilometers the main challenge was to cover that distance with a reliable WLAN system including a special beam antenna. Also an autonomous power supply had to be established.

Perspectives for 2013

Data comparison and validation of pile NLWKN_Steinplate with an ADCP device will likely be carried out in 2013. Furthermore the operational use of the pile “Bantsbalje” will be established in this year.

For Pile Bantsbalje an additional Ice Reinforcement in order to allow continuous all-year operation is planned to be applied during summer 2013.

In order to improve the evaluation of the measured wave data bathymetric survey will be carried out in the vicinity of both piles on a regular basis.

Data from pile Bantsbalje will be included into an ongoing investigation of wave transformation between the open sea and sheltered areas.

Gliders

L. Merckelbach / A. Werner / R. Kopetzky / B. Peters

Aims for 2012

1. a two-week dedicated experiment to compare glider derived water currents with HF-radar measured surface currents;
2. maintain an endurance transect between buoys NSB3, Ems and German Bight, using one glider at a time.

Technical / Program Developments in 2012

Lithium batteries

Instead of using battery packs built from alkaline cells, the gliders used battery packs built from lithium cells. Doing so it was found that the mission endurance increases from 3-4 weeks to 7-8 weeks. Despite higher material costs for lithium batteries, this is beneficial because of reduced efforts of glider preparation, recovery and redeployment.

Measures to increase safety at sea

During a mission, the Seewarndienst receives for each glider the coordinates of rectangular region in which the glider is forecasted to be. These coordinates are published via Navtex messages ("telex messages for ships" with information on obstacles, unusual activities etc.) with a life-time of 12 hours. The system was developed during the course of 2011 and evaluated in 2012. The system simulates the glider behaviour and the glider dynamics. The dynamics part models the speed and glider direction of the glider while it is advected by virtual coastal sea, provided by the output of the pre-operational GETM model. The behaviour model estimates the glider speed and direction of flight, based on the configuration files sent to the glider. The evaluation showed that occasionally the model chose the wrong waypoint, resulting in erroneous predicted glider tracks. The algorithm has been improved.

Virtual AIS for gliders

The Wasser-und-Schifffahrtsamt (WSA) and Wasser- und Schifffahrtsverwaltung (WSV) have concerns regarding the adverse effects of the use of gliders on the safety of shipping. Commonly, the Navtex messages with glider positional information are read by larger commercial vessels, which are unlikely to suffer damage in the case of a collision with a glider. Smaller, fast moving vessels may be more at risk, but Navtex information is unlikely to be accessed.

AIS (Automatic Identification System) has been designed to increase visibility between ships, augmenting radar, by transmitting messages with position and speed via VHF devices. Using AIS would reach most ships as AIS receivers are compulsory for large ships, and they are an increasing commodity on smaller ships. Due to technical constraints, AIS devices cannot be integrated into a glider. However, virtual AIS, where the messages are transmitted by a land station rather than the object itself, could provide positional information of gliders to ships.

The approach is that recent GPS positions available when the glider is at the surface are framed into an AIS message and broadcasted via existing infrastructure of WSV. Whilst underwater, predicted positions are broadcasted. The feasibility of a Kalman filter to estimate the glider's position has been examined. The authorities WSV and WSA agreed that subsurface times up to 4 hours would have an uncertainty that is still acceptable.

Results (Highlights)

Currents

While at the surface transmitting data via satellite, the glider behaves as a drifter. Using GPS data during this approximately 10-20 minute period, surface drifts can be estimated. Although issues remain on the effect of waves and wind on the glider drift, preliminary results indicate a good agreement between glider derived surface currents and HF radar surface current measurements for the two-week HF-radar comparison experiment (Figure 1). Depth averaged water currents can be estimated from glider data (GPS and dead reckoned tracks). Programmed to dive to different depths (15 m and 35+ m), the depth dependency (to some extent) can be assessed from the data of the two gliders.

Endurance transect

Using the gliders in an alternating scheme: „operating one, servicing the other", it was shown that an endurance transect can be maintained with the resources available. From April until the end of October a glider has been in service for almost all the time, except for the month May when the deployment had to be aborted due to a potential leak. An example of the data coverage (water temperature) is shown in Figure 2.

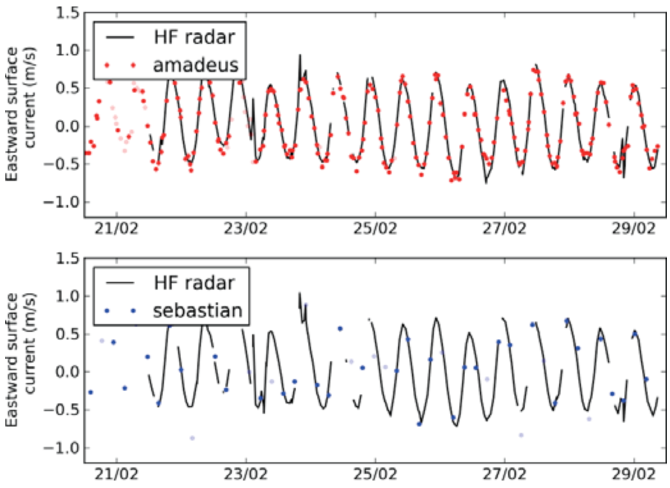


Figure 1: *A comparison between eastward surface currents as measured from HF radar and derived from surface drift of the gliders, operated along a 10 nm long transect a few miles northwest from Helgoland. Top panel shows data for glider Amadeus, whereas the bottom panel shows data for glider Sebastian.*

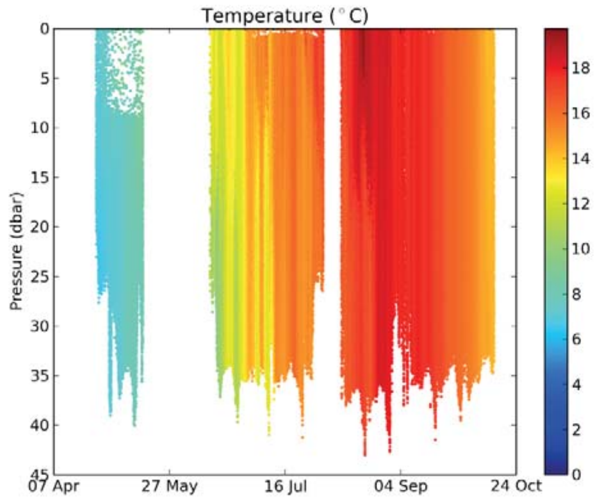


Figure 2: *Temperature data recorded by gliders Amadeus and Sebastian during the endurance transect from April to October 2012.*

Problems

As per requirement of WSA glider Amadeus had to be equipped with a warning flash light *a posteriori*. During one of the test dives, a leak was signalled, and the deployment was aborted. Inspection in the lab, however, did not reveal traces of a leak (salt crystals), and the fitting of the flash light was not the cause for the leak. Most likely water drops may have entered the glider during its final assembly in the lab and triggered the leak-detect sensor.

A technical failure of the fin of glider Sebastian caused the mission to end three weeks prematurely. The failure caused the glider to drift out of control. Due to its position fairly far off-shore (about 200 km), a prompt recovery using a ship was not possible so that the recovery using a helicopter was opted for. A successful recovery was planned and executed within three days.

Perspectives for 2013

Virtual AIS

Following up upon the positive evaluation of the Kalman filter-based position prediction model, the model is to be implemented and assessed during a real mission. Based on these findings the complete virtual AIS solution is scheduled to be implemented in co-operation with WSV by the end of the year.

Suspended sediment analysis

A master student from the University of Hamburg uses the glider data glider data of 2012 and partially 2011 to analyse sediment resuspension patterns in the German Bight. In the analysis also Scanfish data concurrently collected will be taken into account.

Publications

Merckelbach LM (2013): On the probability of underwater glider loss due to collision with a ship, Journal of Marine Science and Technology, 18 (1), 75-86.

COSYNA near bed observation systems: The lander SedObs

C. Winter

Aims for 2012

With the aim to acquire high quality data on geophysical processes and biological-physical process interactions at the sea bed and the lower water column the objectives for COSYNA lander operation in 2012 were the testing and application of hydroacoustic and optical instruments and sensors and further development of measuring procedures. During this year different laboratory experiments with several instruments have been performed and the new complete lander system SedObs (Sediment Dynamics Observation System) has been used in several ship based measuring campaigns. The lander was deployed in North Sea waters during two campaigns with RV Heincke (HE371 and HE383) at locations near and at Helgoland and in two campaigns with RV Senckenberg (Table 1). Lander operation was optimized and resulted in six successful deployments. The duration of the deployments varied between two consecutive tidal cycles and up to 12 tides. It must be noted that the set-up of the lander system strictly requires trained personnel. An absolute minimum of two experienced scientists / technicians plus the help of others is required for the handling of the equipment.

A range of environmental and hydrodynamic conditions were met: The lander was deployed in shallow water depths (< 20 m) in fine to coarse sand environments during very mild to considerably rough weather conditions. It was stable during a storm (Hs > 3 m) in 12 m water depth. In co-operation with other COSYNA partners the lander has been deployed in joint campaigns with the lander system NusObs (cf. Oehler et al.) and at the location of the COSYNA Underwater Node Helgoland (cf. Fischer et al.).

Besides the technical developments and optimization that were scheduled for 2012 the main objectives of the year were the launching of third party funded scientific projects in order to raise financial means for technical support and scientific analysis of lander data, and the application for ship time.

Technical / Program Developments in 2012

Due to sophisticated equipment and the long term experience of involved scientists and the crews of the research ships the handling of the lander is straightforward: The transport of the system to the ship, its assembly, launching, recovery and dis-assembly has been trained and optimized. Especially the most critical acoustic release of pop-up buoys, which introduce the recovery of the lander by release of a leash and chain, has been proven very reliable.

Besides the technical optimizations (see below) and the proof of concept of the lander system, in the year 2012 scientific project initiatives were followed: Since the start of the new MARUM funding period from November 2012 a research project focuses on “Organic-matter remineralization and nutrient turnover in permeable sandy sediments”. This project will mainly be based on SedObs lander data and is performed in co-operation with MPI Bremen. Under the lead of HZG (Emeis et al.) the large BMBF research project FONA NOAH was launched in April 2013. In the sub project “turbulence and smallscale morphodynamics” a PhD position and part of an engineer position are funded which focus on lander operation and scientific data analysis.

Table 1: *COSYNA Lander SedObs campaigns in 2012*

Deployment	Ship	Location	Coordinates		Deploy	Recover	hours
SedObs 005	H371	Helgoland	7° 56.25	54° 11.4	21.02.2012 13:48	23.02.2012 11:50	46.03
SedObs 006	H383	Helgoland	7° 59.7	54° 10.16	23.06.2012 16:35	24.06.2012 18:00	25.42
SedObs 007	H383	Helgoland	7° 57.24	54° 10.55	25.06.2012 10:58	26.06.2012 10:53	23.92
SedObs 008	H383	Helgoland	7° 52.17	54° 11.97	26.06.2012 09:32	02.07.2012 18:31	152.98
SedObs 009	SNG	Helgoland	7° 57.48	54° 10.38	04.07.2012 07:21	05.07.2012 15:45	32.40
SedObs 010	SNG	Spiekeroog	7° 44.76	53° 48.2	04.09.2012 10:24	10.09.2012 14:00	147.60

Figure 1: *Lander SedObs at deployment 008 near COSYNA underwater node Helgoland. Photo by C. Walcher (AWI)*

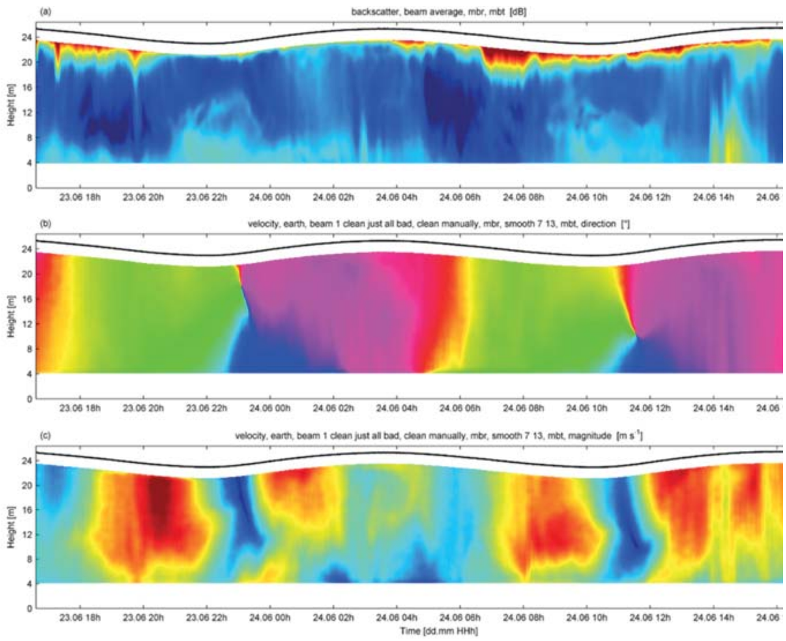


Figure 2: *Upward looking ADCP data. Corrected backscatter (a), velocity direction (b), velocity magnitude (c) at station HE383/011-1.d*

In co-operation with other MPI, HZG and AWI colleagues, the author has successfully applied for ship time with medium size research ship RV Heincke as PI in 2013 (16 days) and 2014 (14 days). Additional Heincke ship time can be used as several other similar proposals were granted. In co-operation with Senckenberg Institute Wilhelmshaven additional ship time (small research ship) is provided.

Results (Highlights)

The combination of different sensors for the near-bed observation of hydrodynamics, sediment transport and morphodynamics is of great scientific potential. The so far preliminary deployments revealed very interesting findings, which will be the basis of further in-depth research. This e.g. comprises the quantification of a 50fold increase of near bed turbulence during a short storm period when compared to mild weather conditions. A scientific highlight was the identification of another hydrodynamic feature of tidal rotation: Local hydro- and suspended matter dynamics in the water column during lander deployment SedObs006 (see Table 1) are measured by the upward looking 6900 kHz ADCP as given in Figure 2. The lander was deployed shortly after high water, and two tidal cycles are recorded. Increased acoustic backscatter in the uppermost measured part of the water column indicates some wave action in the first ebb period (vel directions ~250°), and on June 24th. Tidal circulation at this point reveals a pattern, in which the upper part of the water column abruptly turns from ebb to flood in clockwise direction, whereas the lower half of the water column turns anti-clockwise with a gradual (about 4 hrs duration) turn of the tidal currents. Whereas a pronounced slack water period (very low velocities) appears in the upper water column, at the lower part the tidal currents do not break down. The rotation from ebb to flood direction is anti-clockwise throughout the whole water column, and coincides with low current velocities (slack water). The role of the introduced shear at the interface between the different rotational cells on turbulent mixing is currently analysed.

Problems

So far most of the instruments and sensors which form the SedObs system operate as planned and without problems. However some issues have been identified and partly solved:
Launcher / releaser: The releaser is powered by explosive cartridges which are triggered by an electric pulse. In field conditions the set-up and functioning as delivered were not working satisfactory; thus the power supply and operation was modified. Additionally the releaser was combined with a 3D compass device for better control of the lander position (direction / tilt) before its release.
Recovery: The system is optimized for water depths < 25 m. The depth is limited by the length of the chain which is used for the recovery. Alternatively high capacity ropes have been tested.
ME 3D Profiler: Data acquired by this instrument for the hydro-acoustic scanning of the domain below the lander is most important for the envisaged scientific focus on turbulent bursts and their impact on the sea bed. Unfortunately the instrument so far is very unreliable and shows unpredictable functioning / malfunctioning cycles. Intense laboratory tests were performed. The instrument was sent back to the manufacturer to Guernsey UK twice for warranty repairs. Only in March 2013 the first successful operation was made.
ADCP: The standard ADCPs work very well, but ADCP operation has several degrees of freedom which call for the optimization of operation settings. Laboratory testing and optimization has been performed.
Consumables: The current layout of the lander system combines self-contained autonomous instruments that run on individual power supply and record to instrument specific data storage. As only some of the instruments allow operation on rechargeable batteries, the use of custom build specific battery packs is economically expensive (~700 € / deployment) and ecologically questionable. Currently a central data acquisition and power supply is under development at MARUM.

Perspectives for 2013

In 2013 the lander system will be used in the ship cruise HE 395 for the characterization of several representative areas in the German bight in March. Two cruises with RV Senckenberg in May and September are envisaged, which will focus on lander measurements within the framework of the NOAH (start in April 2013) and MARUM (start in November 2012) projects. The 16 days Heincke cruise HE 412 (lead C. Winter) will take place in October / November 2013 and will combine COSYNA / NOAH / MARUM interests.
In April / May a joint campaign at the COSYNA underwater node in Helgoland will be performed. In co-operation with P. Fischer (AWI) some SedObs sensors will be launched for a four week deployment. The aims are to optimize ADCP settings for the quantification of water column turbulence and suspended matter transport and the characterization of a phytoplankton bloom by high temporal resolution.

Publications

Despite the compilation of high potential scientific data, so far no papers based on lander data have been published. However, productivity is envisaged based on the two scientific projects which were recently launched.

NusObs – An underwater observatory for nutrients and suspension

T. Oehler / R. Martinez / M. Schlüter

Aims for 2012

The underwater observatory NusObs (Nutrient and Suspension Observatory) was developed to measure the exchange of solutes (nutrients, oxygen) between the sediment and the water column. NusObs was delivered in March 2012 to the Alfred Wegener-Institute in Bremerhaven and tested during two cruises (He383, He386) on RV Heincke in summer 2012. The major aim was to test and improve the handling of the lander (deployment and recovery), the sampling techniques with the benthic chambers and the sensors systems (CTD, ADCP). Furthermore in-situ incubations should be carried out on different sedimentological and biological habitats in the German Bight. Figure 1 shows NusObs during a deployment on cruise Heincke 383.

Technical / Program Developments in 2012

In summer 2012 NusObs was tested and deployed for the first time on cruise He383. The handling of the chain worked well. Some problems occurred with the releasing mechanisms of the pop-up buoy. Consequently a second backup pop-up buoy was added on top of the lander after that cruise.
Technical problems occurred with the chamber electronics causing a malfunction of one of the chamber motors. Even worse one syringe sampler had a problem with its engine shaft. All problems were fixed in close collaboration with the manufacturer “KUM” in Kiel.
The lander frame and the chambers were reworked at the AWI workshop for an easier and more sophisticated handling. Cable ducts were placed on top of the lander and some parts of the benthic chambers were redesigned. Three underwater cameras were mounted on the lander to monitor the biological and sedimentological habitats the lander is placed on. A nitrate sensor was purchased and is under development to be connected to the benthic chambers.

Successful deployments were carried out on cruise He395 in March 2013. During that cruise the lander deployment and recovery worked straight forward without any problems. The chamber electronics, the chamber sampling techniques and all sensors (CTD, ADCP) worked sophisticated.

Results (Highlights)

The major aim of NusObs is to carry out in-situ incubations with two benthic chambers. Figure 2 shows the time series of oxygen and pH in one of the chambers together with the sediment which was collected with the chambers. The profiles show a clear decrease in the oxygen concentrations together with a change in pH towards more acidic conditions. This

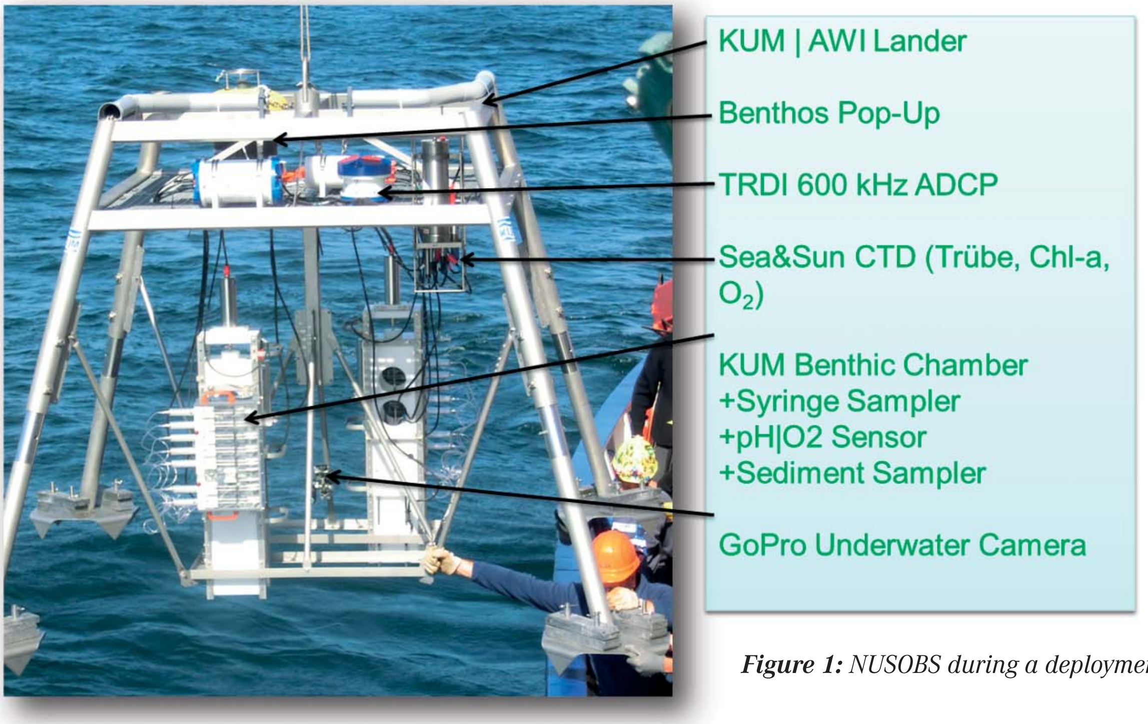


Figure 1: *NUSOBS during a deployment on cruise He383*

is most likely due to the consumption of oxygen by micro-organisms and the subsequent release of acidic compounds. The sediment was not affected by benthic macro organisms.

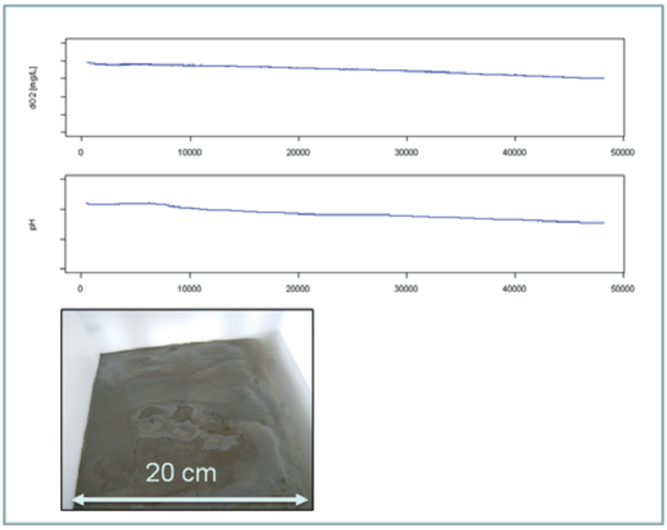


Figure 2: *Time series of oxygen and pH within one of the benthic chambers measured on cruise He386. The sediment was collected with a shutter, which moves under the benthic chamber at the end of the deployment.*

Figure 3 shows first results of the TRDI 600 kHz ADCP which is mounted on top of NusObs. The data were acquired over a 24 hour tidal cycle on cruise Heincke 386. The different colours show the different directions of the current velocities in the water column above the lander.

Problems

One major problem is that the chambers might get problems penetrating hard sediments (gravel and coarse sand), which might lead to the destruction of parts of the chamber engine. Furthermore the syringe samplers get only seven discrete water samples for each chamber. Another problem is that bad weather conditions might delay the deployment or recovery of NusObs.

Perspectives for 2013

A second syringe sampler will be connected to each benthic chamber. Furthermore the injection port of the syringe sampler will be used to inject tracers into the chambers (e.g. bromide for the quantification of bioirrigation). The nitrate sensor is under development and will be connected to one of the benthic chambers.

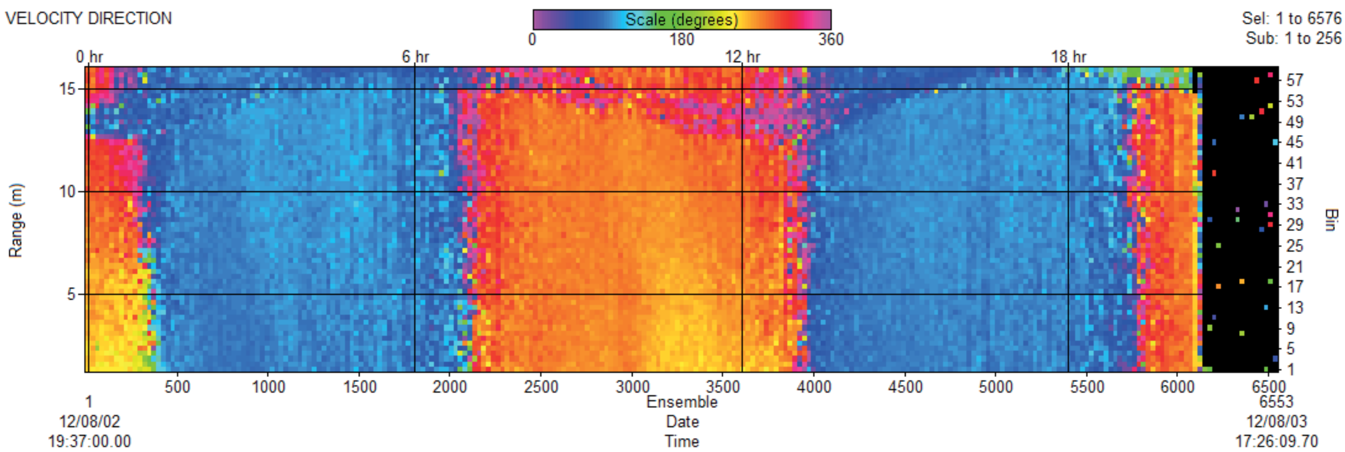


Figure 3: *Time series of oxygen and pH within one of the benthic chambers measured on cruise He386*

hypOO

O. Zielinski

Aims for 2012

In-situ observations of coastal, shelf sea and Arctic waters in the face of climate change and environmental monitoring is of high relevance. Using hyperspectral sensing technology we carried out field campaigns to test and improve observation methods for ocean colour essential climate variables. Objectives included (i) assessing the variations in above-water and underwater calibrated radiometry information for North Sea and Arctic waters, (ii) analysing how their end-products inferred from remote sensing reflectance vary, (iii) validating and improving sensitivity of our bio-optical models. Refurbishment of the hyperspectral sensors Spiekeroog time series station as well as the improvement of the radiometer and camera setup installation onboard RV Heincke.

Technical / Program Developments in 2012 and Results

A novel empirical approach (Figure 1) to quality control of automated hyperspectral optical observations was successfully developed. In this approach a camera system is used along with the radiometers to obtain sea surface and sky images simultaneously. The sea surface images are then analysed using a sunglint image detection algorithm (Figure 2) to determine if an image; (a) has least visible/detectable white pixel or sunglint presence of excess glint, (b) has too much or detectable white pixels or sunglint (Garaba et al. 2012). We use bio-geophysical and hyperspectral radiometric measurements from German Bight (GB), North Sea (NS), Inner Seas (ISS), Irish Sea (IS) and Celtic Sea (CS) to generate bio-optical models. The remote sensing reflectance measured is transformed into discrete Forel-Ule numerical indices (FUI), 1 (indigo-blue, oligotrophic) to 21 (cola brown, hyper-eutrophic). We present a novel approach of estimating which of the three main colour producing seawater agents control the perceived colour of seawater. Results show that ocean colour products, i.e. reflectance and perceived colour of seawater, can be used to infer environmental properties (like Chl-a, CDOM, SPM, Secchi depth and salinity) with good accuracy for investigated waters (Figure 3, Figure 4, see Garaba et al., submitted).

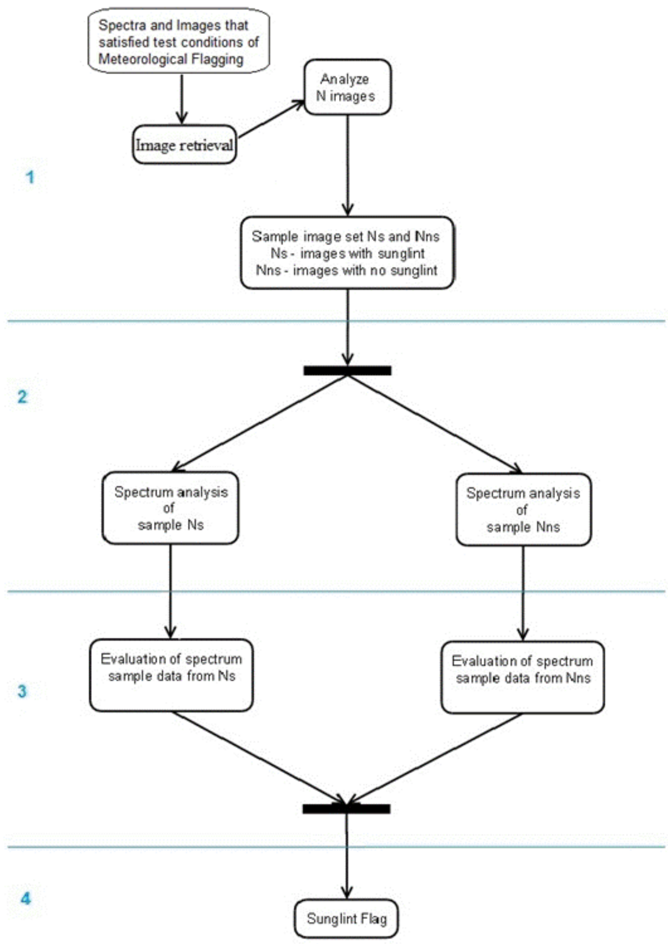


Figure 1: *A simplified activity diagram showing the 4 steps involved in generating the new sunglint flag. 1) Automated sunglint image detection and sorting of spectra into Nns – image set without sunglint or Ns – sunglint-affected image set. 2) Analysis of the two spectra sets (λ = 320 – 950 nm). 3) Specific spectra analysis in visible λ = 320 – 700 nm and near infra-red λ = 700 – 950 nm range. 4) Performance test and identification of effective sunglint flagging criteria.*

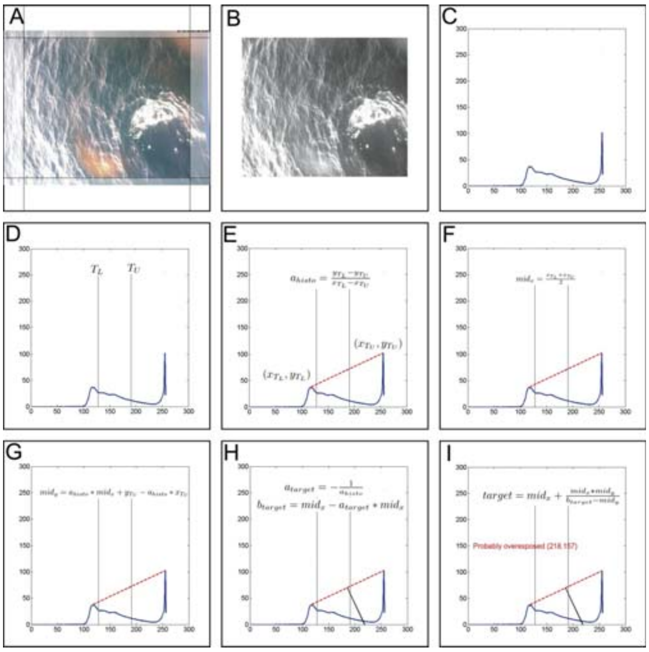


__Figure 2:__ Schematic diagram of the automated sunglint image detection algorithm. A) Cropping original sea surface image. B) Converting cropped image to greyscale. C) Extract grey level histogram of cropped and converted image. D) Define lower (T_L) and upper (T_U) threshold. E) Find position and magnitude of local maxima of darker (x_{TL}, y_{TL}) and brighter (x_{TU}, y_{TU}) colours and calculate slope of line segment. F-G) Calculate midpoint (mid_x, mid_y) of line segment between (x_{TL}, y_{TL}) and (x_{TU}, y_{TU}). H) Calculate slope and intercept of the target line being perpendicular to the previously calculated slope line crossing the midpoint (mid_x, mid_y). I) Calculate target line's crossing with abscissa. If and only if this value is larger than T_U, the image is tagged as probably overexposed.

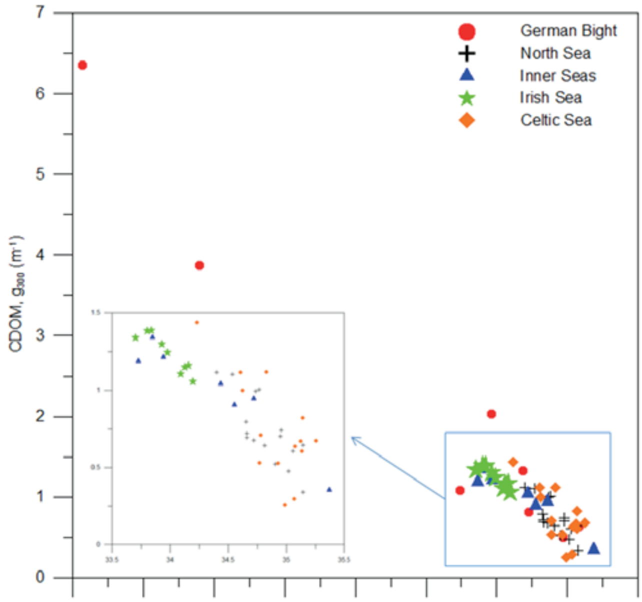


__Figure 3:__ Relationship between CDOM and salinity for the German Bight (●), North Sea (+), Inner Seas (▲), Irish Sea (★) and Celtic Sea (◆). Insert shows the high salinity stations excluding German Bight.

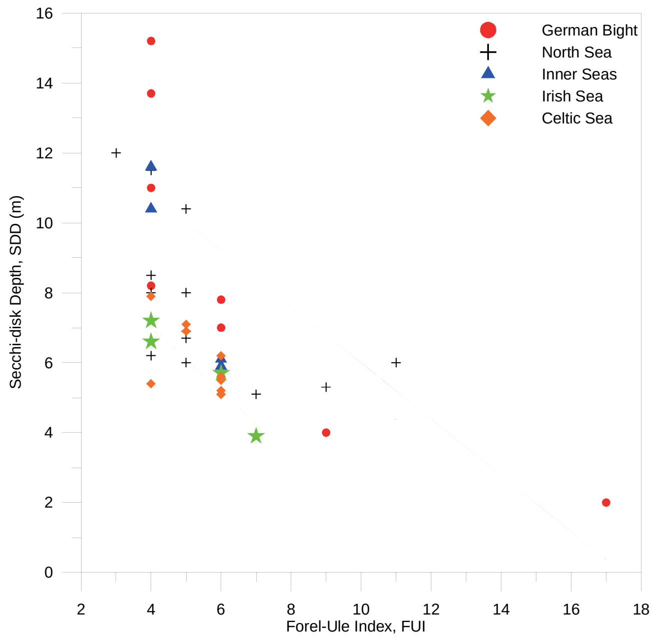


__Figure 4:__ Forel-Ule Index and Secchi-disk Depth plot for the German Bight (●), North Sea (+), Inner Seas (▲), Irish Sea (★) and Celtic Sea (◆). The trend line colour matches the station colour.

Problems

In hyperspectral above-water radiometry we still have the challenge of glint contamination and limited light during winter and night episodes. Sunglint image detection algorithm still needs more validation due to local conditions for each observation. Installation of the camera system onboard RV Heincke proved to be difficult, due to instable network connections at the present position of the system (front mast). An alternative position (above the bridge) was successfully tested during HE392 (November 2012) and will be realised in 2013 pre-operationally. In our previous observations the measurement interval was set at 15 minutes. Results show that this is unfortunately not a sufficient time interval as the observed processes are rapidly dynamic and our dataset therefore does not fully explain e.g. perceivable colour changes.

Perspectives for 2013

Improvements of the in-situ measurements are planned by combining above-water observations with in-water radiometric observations. In-water measurements are important for understanding and quantifying external influences, e.g. glint influence and seawater constituents. Inherent optical properties will also be used in solving radiative transfer problems in HydroLight modelling software essential procedure in performing optical closure tasks. We also aim to evaluate the accuracy and sources of error in our field campaigns, i.e. performing in-house instrument calibration, measuring at close-to-ideal sensor setup and environmental conditions. In 2013 datasets from the camera system, in alternative position, and radiometers onboard RV Heincke will be collected within a five minute interval to detect even rapidly changing processes. Using in-situ measurements of ocean colour essential climate variables our goal is to enhance sensitivity of our developed bio-optical models

Publications

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MOKI

H.-J. Hirche

Aims for 2012

The main aim for 2012 was to finalize the development of the optical head and to deploy the whole system on the underwater-node Helgoland.

Main goals for 2012 were

- Development of different types of imaging heads
- Tests of imaging heads in the laboratory and in the field (Kongsfjord, Spitsbergen)
- Construction of mechanical frame for attachment of MOKI on COSYNA underwater node
- Electrical connection to the underwater node (power supply and data transfer)
- Adaptation and integration of MOKI to COSYNA underwater node

Results (Highlights)

- Manufacturing and successful field test of imaging head in the Kongsfjord
- Construction of mechanical frame for attachment of MOKI on COSYNA tetrapod
- Setup of complete MOKI system (Figure 1)

Problems

- MOKI device was completed in September 2012
- Final attachment depends on operational capability of COSYNA underwater node

Perspectives for 2013

- Final deployment and test operation at COSYNA underwater node
- Development and test of other types of imaging heads
- Further development of concepts for data analysis and image analysis

Figure 1: *MOKI system with imaging head and attachment frame*

Automated nucleic acid biosensor system for observing phytoplankton - AUTOSENS

K. Metfies

Measurement Strategy within COSYNA

We applied for an automated nucleic acid biosensor system that allows carrying out analyses of phytoplankton with high resolution in time and space. In combination with the FerryBox system such a biosensor system is supposed to generate regular information on the occurrence of phytoplankton key species in the North Sea.

Aims for 2012

For 2012 it was planned to integrate a fully automated filtration module (AUTOFIM) with the FerryBox in Cuxhaven and test the device in the field. Furthermore, it was planned to develop a connection between the automated filtration module and the biosensor module (as described in the original grant application).
Construction and production of a first manually controlled prototype of the filtration module were accomplished by iSiTEC GmbH in Bremerhaven in 2011.

Technical / Program Developments in 2012

Technical developments planned for the first half of 2012 involved the automation of the manually controlled prototype, including the development of software control for AUTOFIM (Figure 1). The connection of the resulting automated AUTOFIM device to the FerryBox in Cuxhaven and field testing was planned for the second half of 2012.

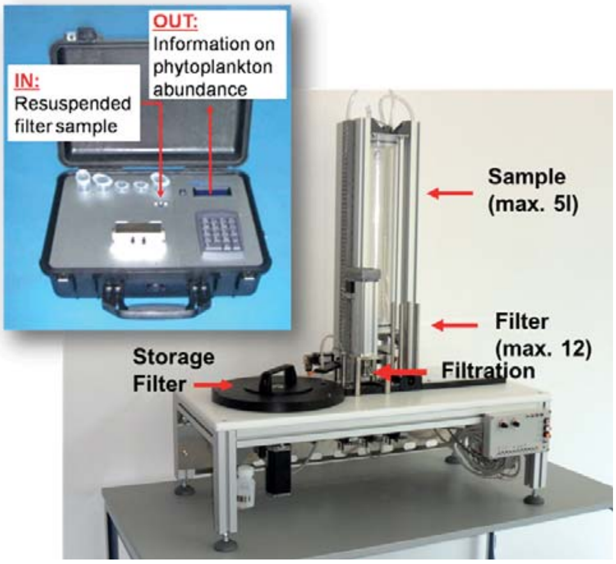

***Figure 1:** Photos of the currently available nucleic acid biosensor and the manually controlled first prototype of AUTOFIM.*

Results (Highlights)

Filtration Unit AUTOFIM

The manually controlled prototype of AUTOFIM was automated in 2012. A control-software for the device and the software connection to the FerryBox system was developed and successfully tested. The filtration module can be operated via "remotedesktop" (Figure 2).

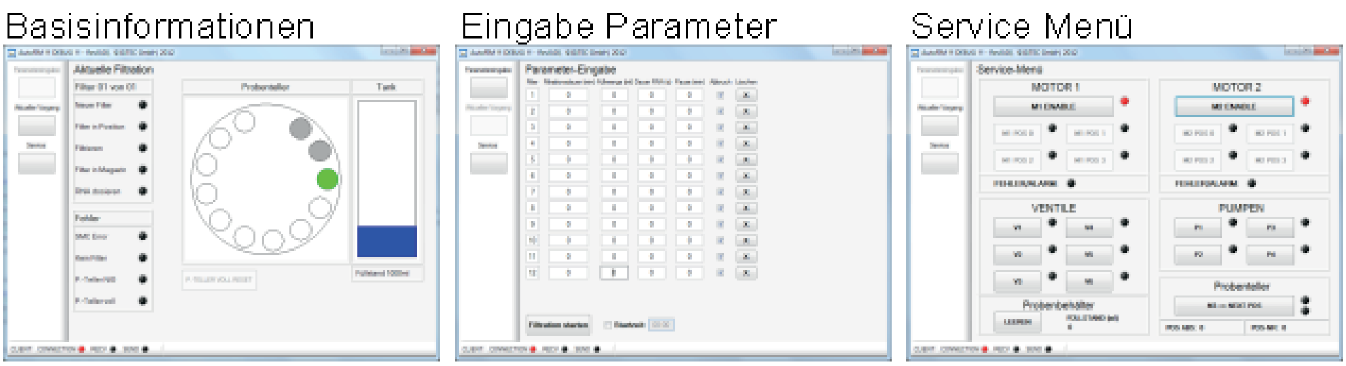

***Figure 2:** Screen shots of the AUTOFIM software control. The first screen shot (Basisinformation) provides basic information on the current status of the filtration, including information on the fluid level in the sample reservoir, the number of filters in the storage roundel and the time that passed by since start of the current filtration. The second screenshot (Eingabe Parameter) displays the part of the menu for the definition of the filtration parameter (sample volume, duration of the filtration etc.). Finally, the third screenshot presents the service menu, which allows manual operation of the pumps in the filtration system, e.g. for cleaning of the filtration unit.*

The optimized third prototype of the filtration module was linked to the FerryBox in Cuxhaven in 2012. The device has been tested successfully and is now used for regular sampling.

Connection Biosensor and AUTOFIM

In 2012 intensive experiments have been carried out in order to evaluate if the application of ultrasound could facilitate the sample preparation and the transfer of the collected material from the filter into the biosensor system. Currently, the samples are transferred manually into the biosensor system after they have been re-suspended with analysis-buffer. Prior to the injection into the biosensor system the samples have to be filtrated through a 0.2 µm filter in order to remove cell debris that disturbs the analyses.

Our experiments revealed that the application of ultrasound to the cells collected on a filter significantly improves the removal of sample material. Based on this observation a concept to design the connection between AUTOFIM and the biosensor system was developed. The concept is based on three steps. In the first step analysis-buffer is applied to the cells on the filter. Subsequently ultrasound is applied to the cells to support cell breakage and to insure that all material on the filter is re-suspended. The resulting analyses-mix is transferred into the microfluidics system of the biosensor by suction through the filter.

Probe Development and Field Testing

Target species were identified by their appearance and contribution to the phytoplankton composition in the Southern North Sea. Species were chosen as target species that regularly occur with high abundances or occur only sporadically with low abundances.

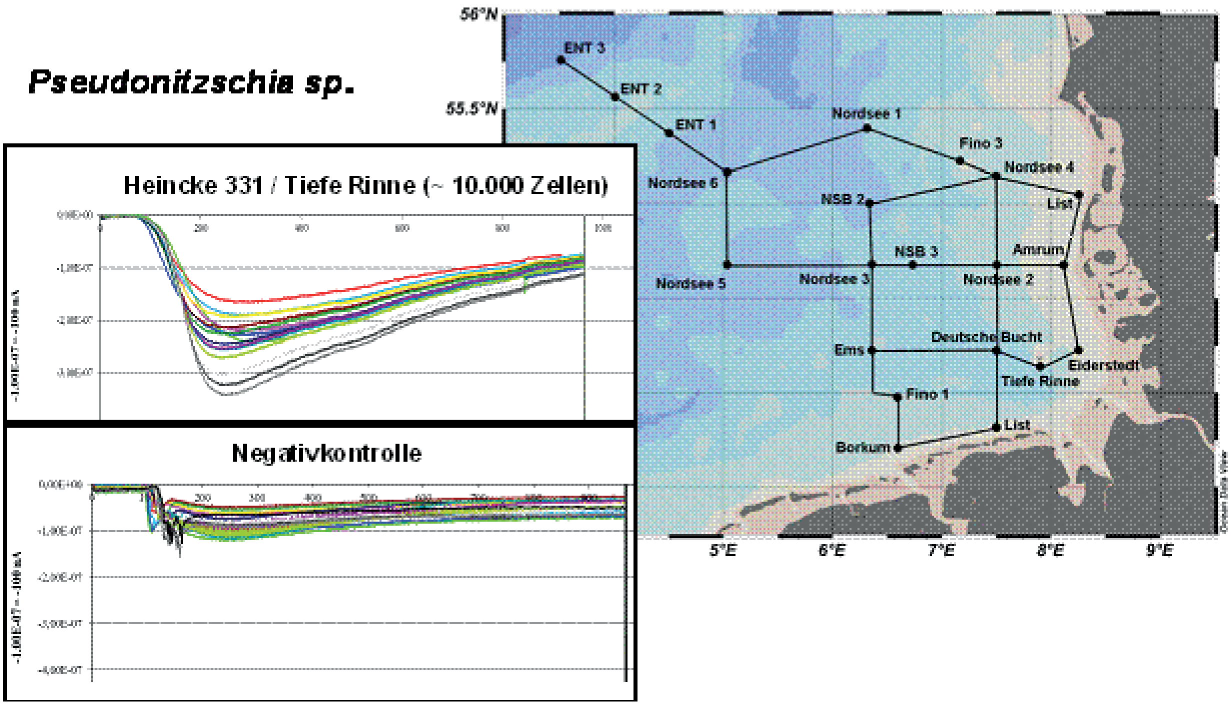

__Figure 3:__ Screen shots of biosensor measurements. The applicability of a probe set for the surveillance of the genus Pseudonitzschia sp. in field samples with the nucleic acid biosensor was determined. It was possible to measure a signal that is ~3fold higher than the negative control. Cell numbers during Heincke cruise 331 at the station Tiefe Rinne were determined by light microscopy.

Target Species:

1. *Chaetoceros calcitrans*
2. *Chaetoceros debilis*
3. *Chaetoceros socialis*
4. *Ceratium furca*
5. *Ceratium fusus*
6. *Leptocylindrus danicus*
7. *Leptocylindrus minimus*
8. *Odontella aurita*
9. *Odontella sinensis*
10. *Paralia sulcata*
11. *Prorocentrum micans*
12. *Pseudonitzschia seriata*
13. *Pseudoditzschia delicatissima*
14. *Pseudonitzschia pseudodelicatissima*

Molecular probes have been designed for all target species. In total 33 specific probes are available. The probe sets for *Pseudonitzschia* sp. and *Chaetoceros socialis* work in the biosensor format (Figure 3), other probes are under testing. The probe set for *Pseudonitzschia* sp. was tested for its applicability in the biosensor system to survey *Pseudonitzschia* sp. in field samples. Data generated with the biosensor are evaluated in comparison to data generated with other methods, e.g. light microscopy.

Problems

An automation of the filtration process requires determining the end of the filtration process, either when the filtration is completed or if the filter is blocked. In the course of the automation of AUTOFIM we observed that it was not possible to determine the end of a filtration procedure in the current set. Originally it was planned to determine the end of the filtration procedure by measuring the pressure change related to air passing the filter, if the sample reservoir is empty. Testing of the filtration revealed that air is not capable to pass the filter if it is wet. An alternative method for the determination of filtration end has been found in the form of a sensor that optically detects air-bubbles in the inlet pipe of the filtration chamber.

Perspectives for 2013

In 2013 the connection of sample material collected with AUTOFIM will be designed, produced and tested. The resulting module will be integrated with the currently available semi-automated biosensor system. This involves the production of a new biosensor that includes the ultrasound based sample preparation. The device should be available by the end of 2013. It is planned to integrate the system with the FerryBox and AUTOFIM. A fully automated nucleic acid biosensor that works with the FerryBox system will be available in the fourth quarter of 2013.

In parallel to the technical developments we will analyse field samples collected in the North Sea during COSYNA-Heincke cruises in 2010 and 2011 and samples collected with AUTOFIM on a regular basis with the currently available semi-automated biosensor.

Integrative sampling approaches for the analysis of chemical contamination

A. Prange / D. Pröfrock / H. Helmholz

Locations “Seebäderbrücke” Cuxhaven and underwater node “Margate” near Helgoland

Aims for 2012

The aim for 2012 was the implementation of the re-designed infrastructure at Cuxhaven and Helgoland. The developed techniques should enable the long term field testing of different types of passive samplers. The first data set generated in 2011 should be verified.

Technical / Program Developments in 2012

The main technical developments at both stations were the capacity extension of the technical infrastructure. The number of positions for different kinds of modular designed sampling equipment was increased from eight to sixteen. In addition, the elevator design (maximum reachable depth) at Cuxhaven has been modified to assure that the equipment is continuously submerged even at extreme tide events. In 2012 the continuous operation of the sampling system could be maintained and an on-going second sampling series was started at the beginning of May.
The improvements allow now the deployment of passive samplers for inorganic contaminants such as Chemcatcher ®–metal and Diffusive Gradients in Thin Films (DGT) devices) beside polymeric sheet based samplers (see Figure 1).
In order to get a comprehensive image of the contamination level in different environmental compartments specific traps for the sampling of SPM have been installed to measure particle bound contamination levels during the deployment period, while active samplers (*Mytilus* spec.) were continuously used to determine the bioavailable part of pollution as well as potential associated effects.

Results (Highlights)

Starting in May 2012 a periodical sampling (every 6 weeks) has been performed. Both locations were sampled simultaneously. Basic physiological data like condition index, gonadosomatic index and energy budgets gave hints on a different fitness of the Blue Mussels at these two stations (see Figure 2).
The sampling and handling of the mussels were further improved. It could be shown that a depuration period of 24 h in filtrated seawater of the specific sampling location after the sampling is necessary to obtain comparable and reliable results. In particular, results for SPM related elements such as Mo, Fe, Al or Mn were strongly influenced by this procedure. This is in particular important for the samples originating from Cuxhaven due to the high SPM content in the estuary area.

In parallel multi-element analysis of mussel tissue indicated elevated levels of relevant contaminants such as Pb, Cd in mussels sampled at Cuxhaven. The mussels also showed a relatively fast response to the changing environmental conditions as observable especially directly after the transplantation. Additionally water samples from both locations were analysed to correlate the concentration levels with the measured body burdens.

Figure 1: Sampling station at Cuxhaven equipped with integrative (different types of passive and active) sampler

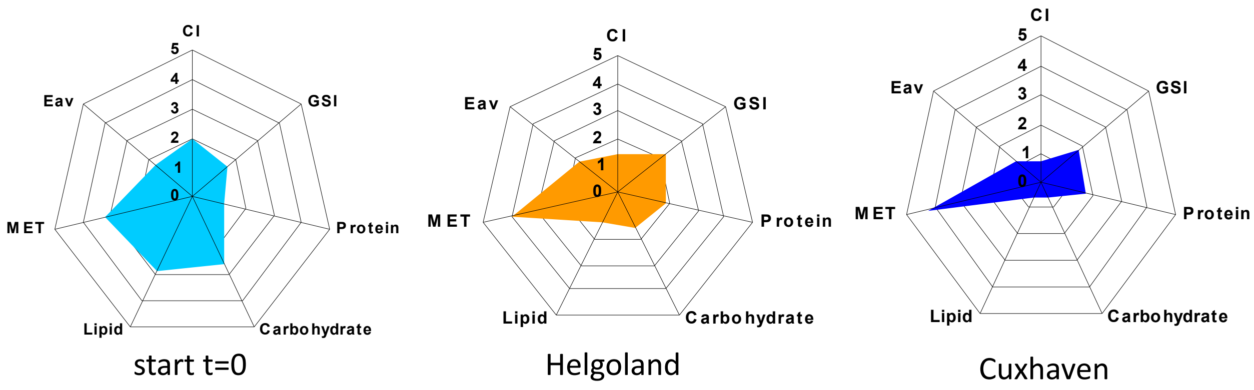

Figure 2: Associated biometric and bioanalytical measurements like Condition Index (CI), Gonadosomatic Index (GSI), Mitochondrial electron transfer (MET), basic nutrients (proteins, carbohydrates, lipids) accumulated to available energy (Eav) indicate the diminished physiological status of the transplanted mussels in the charged regions Z-transformed values for start (t = 0), reference station Helgoland and charged station Cuxhaven at t = 8 month

Problems

The most important challenge that arises during the year was related to the development of a biofilm and the massive growth of hydrozoa and barnacles on all surfaces of the sampling equipment, which necessitate a regular cleaning procedure. Especially at the Helgoland station a predatory impact of crustaceans reduces the number of available organism for the planned investigation at the end of the deployment period. In addition, the starting material showed a reduced fitness compared to the starting material deployed in 2011, which leads to divergent physiological indices.

Perspectives for 2013

Minor improvements of the technical infrastructure will be necessary in order to further optimize the handling and to prevent the frequently observed biofouling. Laboratory experiments will be conducted to test the performance of passive sampler and calibrate diffusion processes. The results will help to further evaluate the field experiments. It is planned to start a new campaign at the beginning of May. The data set for chemical contamination will be accomplished by analyzing SPM and water samples.

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COSYNA underwater nodes

P. Fischer / B. Baschek / M. Grunwald / F. Schroeder / M. Boer / R. Loth / J. K. Stöhner / T. Boehme

Aims for 2012

After two years of planning and extensive soft- and hardware construction, the prototype of the COSYNA underwater node was assembled and built about 400 m North of Helgoland in 10 m water depth in the UW-experimental field "MarGate" of the AWI. Parallel, a second smaller node system "RemOs1" together with a FerryBox system was built up in Spitsbergen (AWIPEV- research base) at 79°N to test the feasibility for operating such complex observatory systems also in remote Arctic areas over a distance of 3000 km.

The following milestones were planned for 2012:

1. Set-up of the prototype of the COSYNA UW-node off Helgoland and extensively testing the system under pre-operational conditions.
2. Testing different single sensors and complex sensor units (lander systems) to be operated online at the COSYNA node system off Helgoland.
3. Set-up of a small COSYNA UW-node system with reduced capacities (RemOs1) together with a FerryBox in an Arctic fjord system (Spitsbergen / NyAlesund 79°N).
4. Extensive tests of the functionality and stability of the prototypes under real conditions.

Technical / Program Developments in 2012

1. Set-up of the first prototype of the COSYNA UW-node off Helgoland and extensively testing the system under pre-operational conditions:

- In March 2012, the combined fiber-optic / 1000V power cable was laid on the sea bed with support of the Wasser- und Schifffahrtsamt Helgoland (WSA) and the AWI ship crew (Figure 1).
- In June 2012, the node rack was exposed in the "MarGate" field by the RV Heincke (Figure 2).
- In July 2012, the UW-node system itself including the backup battery pack (for 24 h emergency operation after power shut-down) was installed by the AWI divers (Figure 3).

2. Testing different single sensors and complex sensor units to be operated at the node system off Helgoland.

- After a month of testing the node system itself, in August 2012, the COSYNA standard lander unit with a CTD and an ADCP was installed at the node (Figure 4).
- In December, the installation of the complex sensor unit "MOKI" started.

Figure 1: *The Wasser- und Schifffahrtsamt Helgoland (WSA) together with the AWI ship crew laid out the 1000V power and fiber optic underwater cable.*

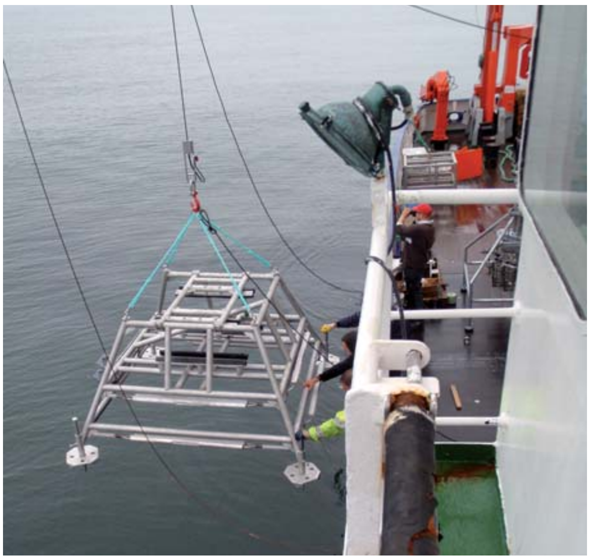

Figure 2: *Exposing the node rack in the MarGate field by the RV Heincke.*

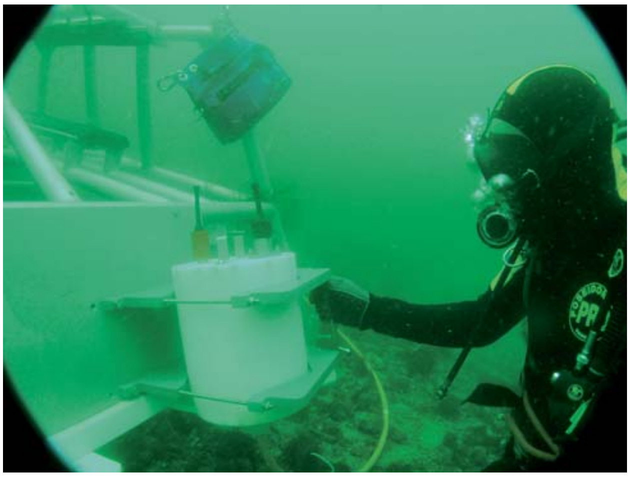

Figure 3: *Installing the UW-node system itself and the backup battery pack off Helgoland by the AWI divers.*

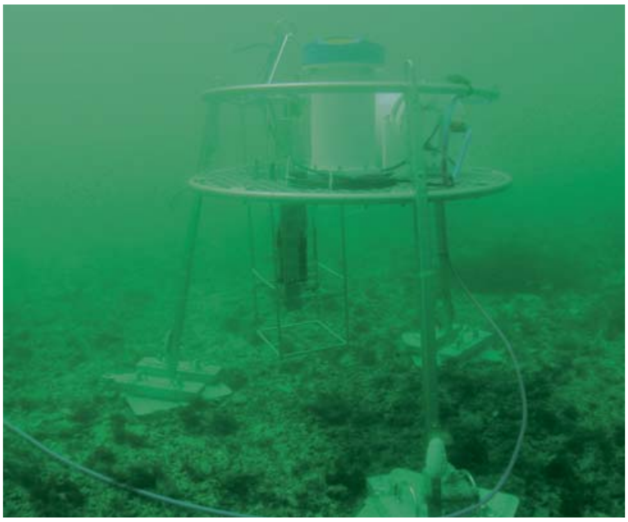

Figure 4: *The COSYNA standard lander with a CTD and an ADCP.*

Figure 5: *The remote controlled Arctic node system (RemOs1) in NyAlesund (79°N) in 10 m water depth including a CTD, an ADCP and a complex stereo-optical measuring device for fish and jellyfish.*

Figure 6: *The Arctic FerryBox in NyAlesund (79°N) with the international installation team.*

3. Set-up of a small COSYNA UW-node system with reduced capacities (RemOs1) together with a FerryBox in an Arctic fjord system (Spitsbergen / NyAlesund 79°N).

- In Mai 2012, the Arctic node system (RemOs1; Figure 5) and the FerryBox (Figure 6) were installed in NyAlesund in 10 m water depth including a CTD, an ADCP and a complex stereo-optical measuring device for continuous fish and jellyfish assessments.

4. Extensive tests of the functionality and stability of the COSYNA hard- and software itself as well as the used commercial components like cable connections, sensors and sensor units have been performed. Furthermore, the stability and capacity of the online-data transfer and system control especially in remote areas like Spitsbergen have been tested.

Results (Highlights)

For both, the Helgoland and the Spitsbergen system, the year 2012 was planned to prove that the general concept of the COSYNA UW-node system works under the harsh North Sea and polar condition. The rack of the node and the lander passed this test without any objections. The node system itself worked well but had some failures with respect to power supply and data connection. The reasons of these failures were tracked down and identified and technological improvements have been implemented or are in planning for 2013. The control software also worked well so that the final version will be ready in 2013. An important part of the system is the data transfer and data handling concept of the continuous data stream (24h sampling with up to 1Hz for an unlimited time) from the sensors, which are attached to the two node systems in Helgoland and Spitsbergen. This is done in close co-operation with the COSYNA working group “Data management” (Breitbach & Gandrass)

In 2012, the COSYNA standard sensors (CTD and ADCP) were set to operational mode off Helgoland and Spitsbergen providing a continuous data stream for the COSYNA priority variables category 1 (water temperature, salinity, pressure (tide cycle), current (direction and speed), turbidity, chlorophyll-a (fluorescence) and oxygen. These data were successfully integrated in the COSYNA time-series database (category underwater node) and are online accessible under: http://tsdata.hzg.de/index.cgi.

Problems

The main problems occurring during 2012 were related to the power supply. Both systems (Helgoland and Spitsbergen) had to be recovered at least one time due to a major problem in the power lines, i.e. with the connectors used. These problems lead to multiple system shutdowns for days or (in the case of Spitsbergen) for 2 month because it happened during winter when no support team was on site.

Another problem, which emerged during the test phase, was that some sensors only worked fine for a certain time (3 - 4 month) and then started to show problems especially with the data connections. This problem is not yet fully solved but may be in close dependence to the above-described power problematic.

At last, some problems occurred when trying to connect certain sensors to the node system via RS422 communication protocol. In one occasion, this was not possible at all and a conversion to RS232 was necessary to connect this sensor properly.

Perspectives for 2013

In 2013, the described technological problems, which could not be solved so far will be addressed and solved. This will be done in the first half of 2013 so that the second half-year of 2013 can be used for a final test phase of the entire system. To the end of 2013, the node systems is expected to be completed and in fully operational mode.

Another main task in 2013 is the integration of new projects to the node systems at Helgoland and Spitsbergen. The two systems have already caused a stir in the German and European science community and four applications of international research groups have been announced which plan to become part of the COSYNA UW-node community with own scientific proposals.

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Validation and quality control of HF current fields in the German Bight

J. Seemann / F. Ziemer / M. Cysewski

Aims for 2012

To obtain a high-quality COSYNA Product 1 it is essential to validate and optimize the HF system (WERA) in the German Bight. Therefore in 2010 an ADCP was installed onboard of the RV L. Prandtl for automatic data acquisition during all travels. Due to the limitation of use of this research ship to calm sea states, the availability of ADCP data on a ship track in deep water (> 15 m water depth) was sparse. From the acquired ADCP data set it was concluded that in shallow water a comparison between ADCP and HF current is not conductive, because the sloping bathymetry and crossing gullies and shipways modulate the near-surface current on a small spatial scale, and the currents on the ship track are not representative for the whole radar resolution cell the ship is passing [1]. On a ship track between Buesum and Helgoland the bias between both sensors was less than 20 cm/s which is in the error bound expected from a ship-borne ADCP [2]. It has to be taken into account that the HF radar integrates the current over the top 1m layer of the water column [3] and the ADCP measurements are from a water depth of 2.50 m. To obtain validation data for the full spatial coverage of the HF system, extended to the deeper water, an ADCP was mounted onboard of the RV Heincke during a campaign in September 2011. The data have been analyzed in 2012.

By closer inspection of the HF data it became obvious that the radial current values of the westward sector of the Wangerooge station are of minor data quality. To improve the quality of this station, the antenna array was recalibrated using a radio transmitter onboard of the L. Prandtl during a passage from Cuxhaven to Langerooge in September 2012. Based on the calibration results an improved beam forming algorithm was implemented by the HF-Radar developer Klaus-Werner Gurgel from the Institut für Meereskunde, University of Hamburg.

Technical / Program Developments in 2012

The analysis of ADCP data from the September 2011 campaign has been done as a cross-validation. Figure 1 presents exemplarily the differences between HF, ADCP and a two-dimensional (vertically integrated) numerical model GETEM from 22 September 2011.

The ADCP data are acquired from a water depth of 5.50 m. The current vectors fit best between the HF and the model data. The ADCP currents differ from the HF and model data, with the value magnitude of the difference vector up to 40 cm/s. The reason was identified as the circulation around the ship body. The ship speed during the cruise was 4-5 m/s. A closer analysis has shown that the ADCP vertical current profile is influenced up to 10 m water depth at a ship speed > 4 m/s. Comparison of the Heincke ADCP with the bottom mounted ADCP at the FIN03 site from the BSH show that for slow ship speeds (< 3 m/s) this effect vanishes. Comparison between the 10 m ADCP depth layer with the near-surface current measures by the HF is not an option because of vertical current gradients, resulting i.e. from the bottom friction.

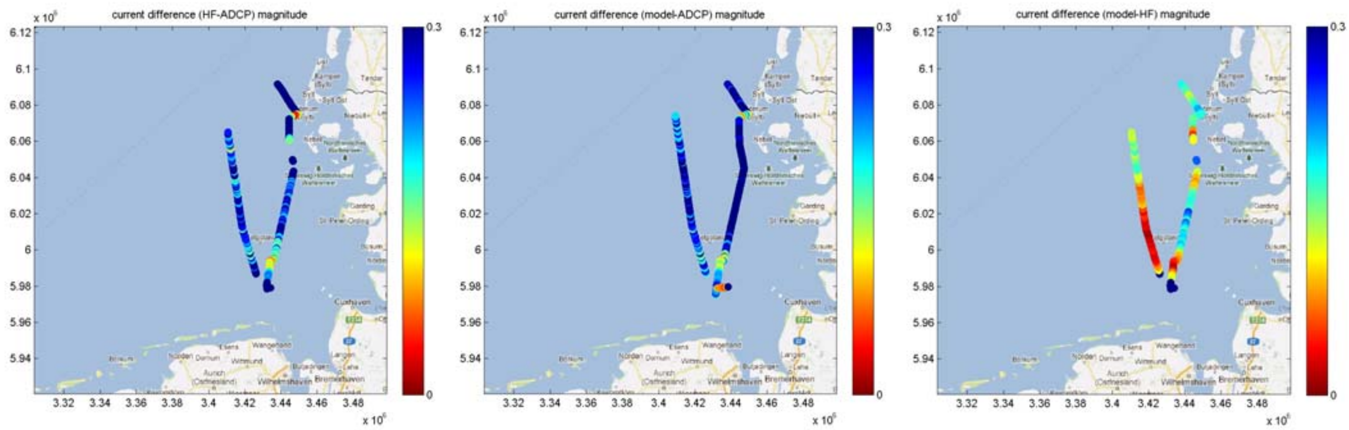

***Figure 1:** Magnitude of the current difference vector in m/s: HF-ADCP (left), model-ADCP (center), and model-HF (right).*

Results (Highlights)

The analysis of the calibration data for the Wangerooge station has indicated a high power level of the side lobes of the receiving antenna array. Both the signal from the main and the side lobe generate an additional peak in the radar Doppler spectrum. For HF wave measurements this effect is severely limiting because this side lobe peak may be interpreted as second-order Bragg scattering from the surface waves, resulting in a faulty significant wave height. Current measurements may be affected as well. The new beam forming algorithm worked out by K.W. Gurgel suppresses the side lobes at the expense of azimuthal resolution of the antenna array. The optimized software was installed at the Wangerooge station in the first week of May 2013. First results are promising, but require a closer inspection over a longer period of time.

Problems

The punctual and areal validation of the HF system is essential for COSYNA Product 1. Therefore additional effort has to be taken for this subject.

Perspectives for 2013

For autumn 2013 it is planned to deploy a waverider buoy with a horizontal current sensor in the overlapping area of the three radar stations. The use of drifters to validate the surface current spatially is under discussion.

Publications

[1] Seemann J, Ziemer F, Cysewski M, Flampouris S, Gurgel K-W, and Schlick T:“HF radar based current observation system in the German bight“, Oceans 2011 conference proceedings, 2011.

[2] Yoshikawa Y, Masuda A, Marubayashi K, Ishibashi M, Okuno A (2006): On the accuracy of hf radar measurement in the tsushima strait. Journal of Geophysical Research,111, C04009–C04019.

[3] StewartRH Joy JW (1974): Hf radio measurements of surface currents. Deep-Sea Research, 21, 1039–1049.

Remote sensing

R. Röttgers / R. Doerffer / K. Heymann / H. Krasemann / H. Örek

Aims for 2012

- Analysis of optical data of Lena River, and validation of MERIS algorithm for the Arctic
- Solving of some technical problems encountered in 2011
- Field campaign for validation in Artic waters

Technical / Program Developments in 2012

- Adaptation and validation of the Case 2 water algorithm to Arctic coastal waters. These waters are characterized by extreme high Gelbstoff contents due to high discharge of humic substances from Siberian tundras. This influences not only the method of calculating water constituents from water-leaving-reflectance but also the atmospheric correction coupled to the water reflectance. A high precision of the determination of total absorption length is necessary to gain a reasonable result for chlorophyll contribution to the absorption which might be masked to high degree by Gelbstoff absorption.
- Angle problems found in 2011 in the Case2 algorithm, when performing atmospheric correction and in-water constituents concentrations, were solved by revising the calculus for algorithms for atmospheric correction. In addition the water constituent retrieval was further improved.

Results (Highlights)

Results of the Lena campaign in 2011 were processed, analyzed, and used to construct a bio-optical model for the Lena River delta (Örek et al. 2013). The model was used to adjust the HZG/Case 2 water algorithm to these optically extreme Arctic waters. Figure 1 shows an example of the optical data set, the relationship between suspended matter concentration and light absorption at 442 nm. Similar relationships were established for chlorophyll and Gelbstoff concentration to the relevant optical parameter.

An algorithm based in this bio-optical model was constructed and is used to process remote sensing scenes from the Lena River (Figure 2) and the Lena Delta (Figure 3). The algorithm was validated with in-situ measurements (one example is shown in Figure 3). Validation for Arctic waters outside of the Lena Delta were planned but will now be made in a field campaign in 2013.

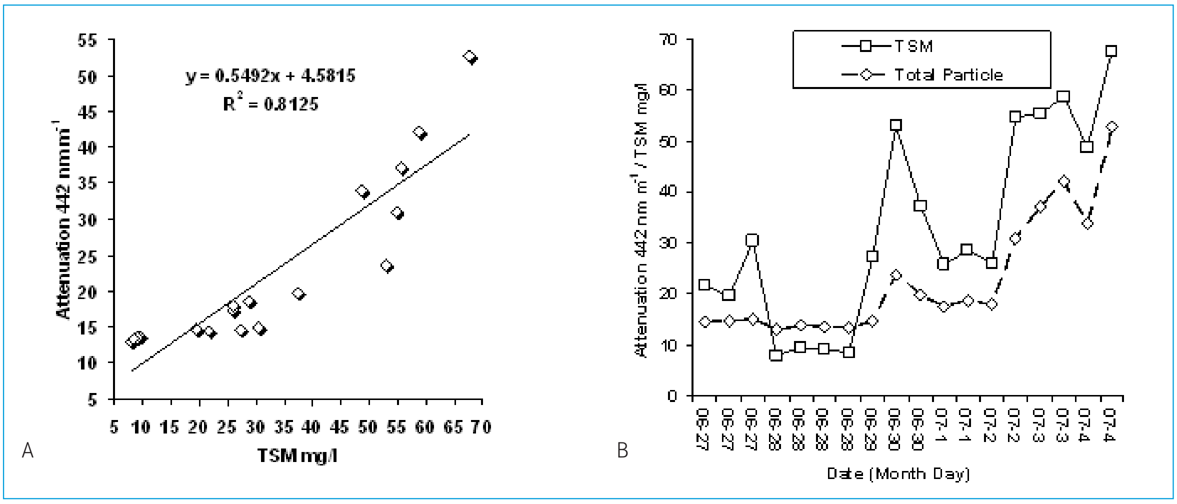

Figure 1: *Co-variation of TSM mg l^{-1} and Light Attenuation m^{-1} at 442 nm (A) for Lena River water in June/July 2011, and temporal variation of the TSM values mg l^{-1} and Attenuation m^{-1} at 442 nm (B).*

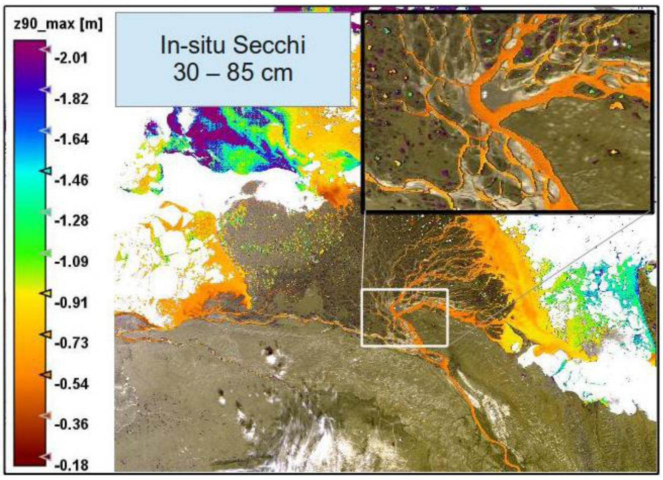

Figure 2: *Lena River optical depth from remote sensing compared to in-situ values.*

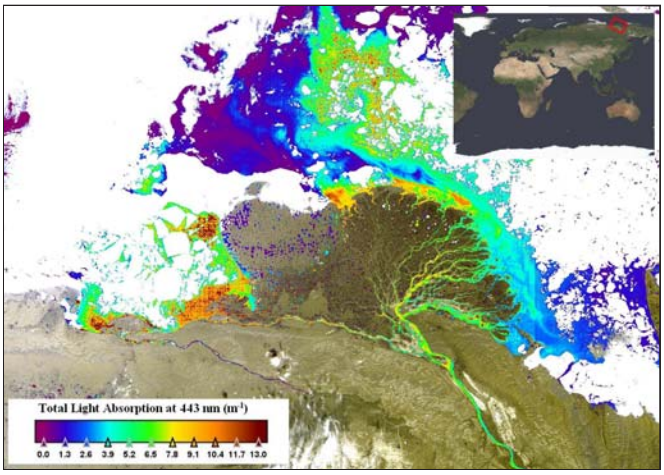

Figure 3: *Lena Delta Satellite Scene – Total Light Absorption derived by HZG-Case2-Algorithm*

Problems

- ENVISAT stopped data transmission in April 2012. MODIS/Aqua data are currently the only source for validated optical remote sensing data of the ocean, but no algorithm is available for MODIS that provides retrievals for suspended matter concentrations and Gelbstoff, and current chlorophyll retrievals are not specific for coastal waters.
- Laptev Sea campaign postponed to 2013.

Perspectives for 2013

- Adaptation of the MERIS-case 2 water algorithm to MODIS data, to enable calculation of suspended matter and Gelbstoff concentrations and to improve chlorophyll retrievals from MODIS and VIIRS data.
- Laptev Sea campaign in August 2013 to collect optical data and perform validation outside the Lena Delta.

Publications

Röttgers R, Gehnke S (1012): Measurement of light absorption by aquatic particles: improvement of the quantitative filter technique by use of an integrating sphere approach. Appl. Opt. 51, 1336-1351.

Hieronymi M, Macke A (2012): On the influence of wind and waves on underwater irradiance fluctuations. Ocean Sci., 8, 455-471. www.ocean-sci.net/8/455/2012/ doi:10.5194/os-8-455-2012.

Örek H, Doerffer R, Röttgers R, Boersma M, Wiltshire KH (2013): A bio-optical model for remote sensing of Lena water. Biogeosciences Discuss., 10, 4887–4925. www.biogeosciences-discuss.net/10/4887/2013/, doi:10.5194/bgd-10-4887-2013.

Heim B, Abramova E, Doerffer R, Günther F, Hölemann J, Kraberg A, Lantuit H, Loginova A, Martynov F, Overduin PP, Wegner C (2013): Ocean Colour remote sensing in the Southern Laptev Sea: evaluation and applications. Biogeosciences Discuss., 10, 3849-3889.

Numerical modelling and data assimilation

E. V. Stanev / A. Behrens / S. Grayek / J. Schulz-Stellenfleth / J. Staneva / K. Wahle

Aims for 2012

One of the main goals in 2012 was the update of wave model WAM.
In 2011 the effect of changing water levels and currents onto wave modelling results using WAM were studied intensively. The code of the GETM/GOTM hydrodynamic model was modified to account for wave forcing effects. The aim for 2012 was to validate the influence of these modifications.
For the assimilation of currents from HF radar focus was on the following issues:

- optimization of the data quality control
- extension of the forecast period
- application for drift calculations

Work on the integrated SST/SSS product was continued. Furthermore the consequences following from a missing near real-time data access and the locally restricted impact of FerryBox data are assessed. This investigation may lead to a refinement of the original product definition concerning the capability to run it pre-operationally.

Technical / Program Developments in 2012

The pre-operational COSYNA wave forecast system that is running twice a day on the regional scale for the North Sea and on the local scale for the German Bight has been updated to the new wave model version WAM Cycle 4.5.4. That newest version of WAM includes several new options and improvements and is well prepared now for coupling with hydrodynamic models. It is able to take into account time dependent fields for depth, ice and currents and calculates required parameters for the coupling as the radiation stress tensor, wave force and stokes drift. Furthermore the North Sea wave model in the meantime takes advantage of boundary values at its open boundaries of much finer spatial resolution as before. The delivery of boundary values from the global wave model of the DWD (spatial resolution: 0.75 * 0.75°) has been replaced by those obtained from the new regional wave model EWAM (Figure 1) of the DWD with its spatial resolution of 0.1 * 0.05°.

The availability of a longer time series of HF radar data allowed performing some robust statistics, e.g. concerning tidal parameters. These statistics are an important component in the further improvement of data quality control procedures required for data assimilation. As an example Figure 2 shows M2 tidal ellipses estimated for the entire year of 2011 as derived from HF radar data (left) and numerical model data (right). The blue and red colours in the right plot refer to counter clockwise (ccw) and clockwise (cw) rotation of the current vectors.

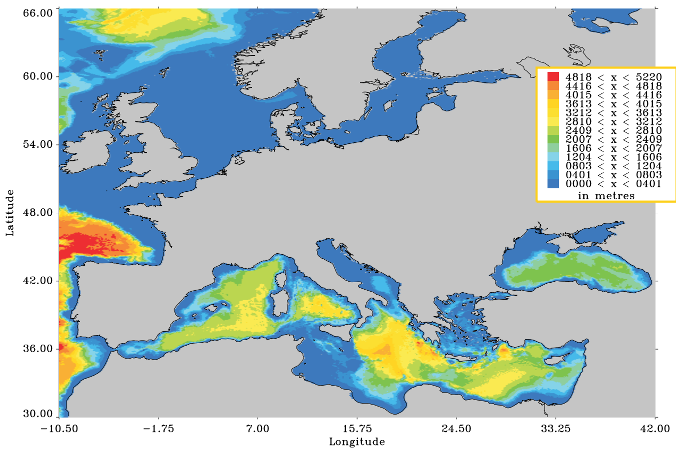

Figure 1: *Depth distribution the model grid of the regional wave of the German Weather Service (DWD : Deutscher Wetterdienst)*

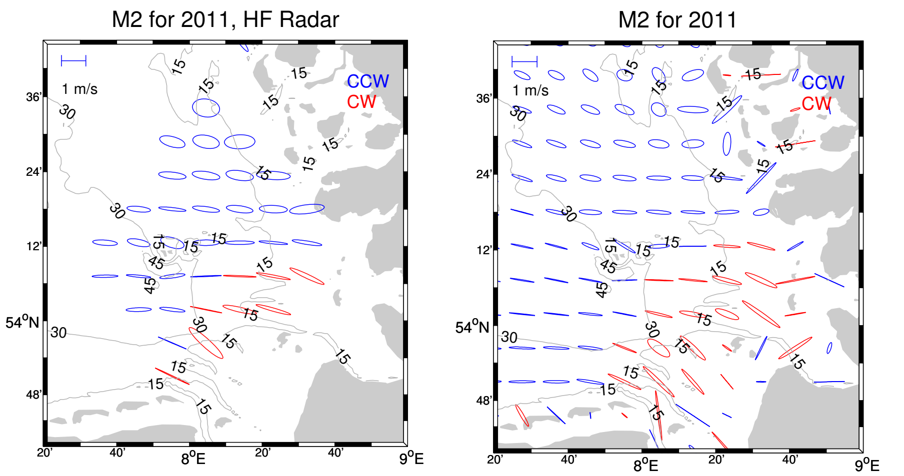

Figure 2: *Tidal ellipses estimated from HF radar data (left) and numerical model data (right) for 2011. Red ellipses indicate clockwise and blue ellipses counter clockwise rotation. Isobaths are shown for 15 m, 30 m and 45 m water depth.*

An additional study was performed making use of the fact that one region is covered by all three HF radar antenna stations. Because the estimation of 2D current vectors only requires two radial components a couple of consistency checks have been done in this area. In particular some improved estimates of the observation errors were obtained.
To analyse the potential for the extension of the forecast horizon a spectral analysis was applied to the difference of radar observations and model results. To deal with data gaps the Lomb algorithm was applied to estimate a continuous spectrum. It turned out that the spectrum has large spatial variations showing strong correlations with the bathymetry. It was found that the largest potential for an extension of the forecast period is to be expected in some of the deeper water areas where time scales of 30 hours and above, which are related to errors of atmospheric forcing, make stronger contributions. Currently procedures to realize an analysis procedure with spatial varying forecast periods are investigated.

Steps towards glider data assimilation
Observations provided by the gliders “Amadeus” and “Sebastian” were analysed and compared with numerical model results. In particular the following measurements were investigated:

- surface current estimates obtained with the glider
- salinity profile measurements
- temperature profile measurements

Potential impacts of glider data in an assimilation system were investigated using a statistical approach where the background statistics for salinity and temperature is used as a proxy for the model error covariance matrix. The observed seasonal variations are currently analysed.
A further focus of the work is on a stratification event that took place in July 2011. The ability of the model to reproduce the vertical profiles for salinity and temperature in this case is analysed using different turbulence parameterisations.
In 2012 the development of the stand-alone Optimal Interpolation Kalman Filter tool for the assimilation of surface values of temperature and salinity into the hydrodynamical model was brought to a level, which finally enables us to run the system in a stable pre-operational mode. The modifications of the original framework from 2011 span: the detachment of the covariance matrix localisation for individual observation platforms; a revised covariance matrix setup resulting in an improved physical stability of the created reconstructions; the automation of the observation data pre-processing and its integration in the pre-operational string of the framework; the numerical parallelisation of the expensive matrix calculations using OpenMP.

Results (Highlights)

The new wave model system runs continuously twice a day on 42 processing units of a sun linux cluster at 0 and 12 UTC and provides a 24 hour forecast respectively. A corresponding example of the distribution of the significant wave height and the total wave direction in the model grids for the North Sea and the nested German Bight is shown in Figure 3.

Wave forcing has a significant impact on hydrodynamic modeling results under stormy conditions in the coastal areas of the German Bight. Noteworthy are strong wave generated alongshore currents near the Frisian Islands. Under conditions where currents and waves are parallel wave setup is observed in the tidal channels.
Additionally, redistribution of SPM under extreme wave conditions (storm 'Britta') was investigated.
The results will be published in two papers, which are in preparation.
The developments made in 2012 for the assimilation of SST and SSS enable us to access now the full capacity of the used data assimilation method, which proved especially valuable for the state estimates of surface temperature. By detaching the covariance matrix localisation, which was already introduced in 2011, for individual observation platforms we were able to improve the transition of synoptic features into the state reconstructions and make the whole procedure less restrictive in its requirements of temporal-spatial data availability. Analysis from the „Operational Sea Surface Temperature and Sea Ice Analysis” (OSTIA) data-set still provide the basis for the state reconstruction of surface temperature fields. However, this relatively coarse resolution data can now be enriched with a maximum of flexibility by high resolution observations from the FerryBox system or other remote sensing platforms (e.g. AVHRR or AMSR) without an additional pre-processing of the data. The individual temporal-spatial availabilities, correlation length scales and accuracy estimates of the observation

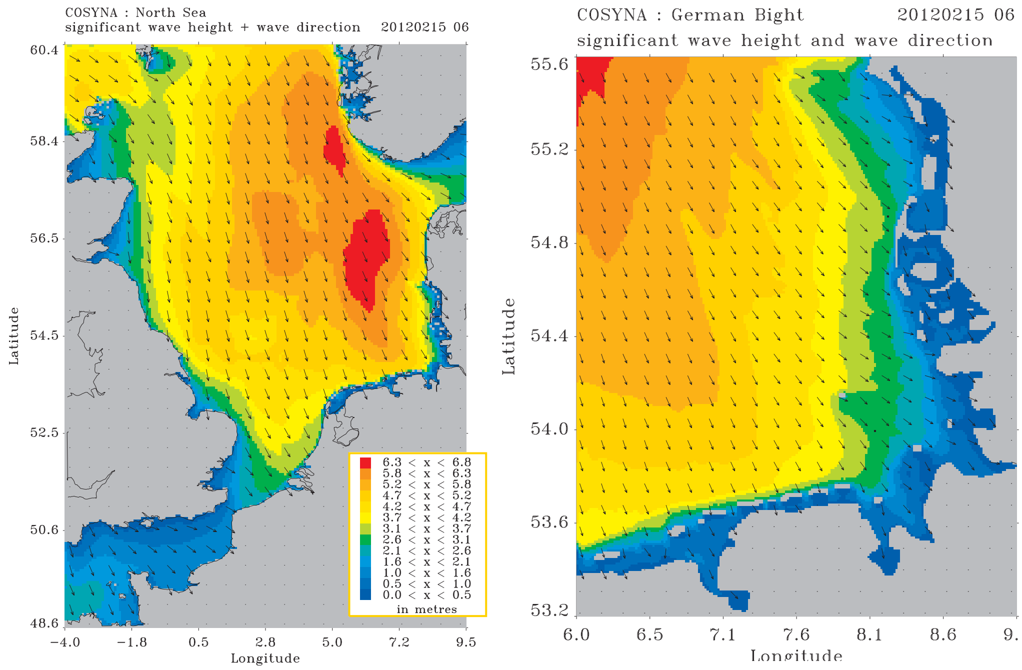

Figure 3: *Distribution of significant wave height and total wave direction in the model grids for North Sea (left picture) and German Bight (right picture)*

platforms are taken into account on a statistical basis during the state reconstruction process. The increased requirements of the assimilation tool in terms of computational time are covered by the numerical parallelisation of the expensive calculations and assure its 'real-time' operability.

Problems

There is still some work required to improve the quality control for HF radar data. For this task and for the validation of the surface current product there is still a lack of suitable independent in-situ observations.

Investigations of different observation data-sets covering the same parameters and time periods showed that there might be significant mismatches between the individual parameter estimates which are not sufficiently covered by the respective error estimations (e.g. available observation error estimations seem to be too stable in time). One consequence of this issue is that it detaches the temporal variability of the state reconstructions of the data assimilation from a natural variability range of the parameter. However, this does not inflict any drawbacks for the results from the data assimilation on a statistical or technical level.

Perspectives for 2013

The two-way coupled wave-hydrodynamic model will be set-up for the German Bight and will be run for a test period in parallel to the pre-operationally uncoupled models.

Further discussed unsolved issues from 2011 concerning data assimilation: validation of analysis results of SST with FerryBox and MARNET data and from other sources; implementation of an analysis scheme for depth profile information as, e.g., provided by glider systems, which have become available in 2011.

Publications

Schulz-Stellenfleth J, Stanev EV, Staneva J: HF radar-based surface current hindcasts and forecasts in tidal basins: focus on intra-tidal time scales. Ocean Modelling (subm.)

Stanev EV, Ziemer F, Schulz-Stellenfleth J, Seemann J, Staneva J, Gurgel KW: Melding HF radar surface currents and numerical modelling: Tidal hindcasts and forecasts. Journal of Atmospheric and Oceanic Technology (subm.)

Data management & quality assurance

G. Breitbach / J. Gandraß

Aims for 2012

- New portal version combines data display and quality information
- Visible comparison between time-series of remote-sensing observations with in-situ observation at a fixed location
- Further development of near real-time and delayed mode quality control procedures

Technical / Program Developments in 2012

The COSYNA Oracle database runs on a new hardware. Time-series of maps which could be visualised only outside the portal before are now integrated into the COSYNA data portal (http://codm.hzg.de/codm).

Results (Highlights)

The main outcome of the COSYNA data management is the COSYNA data portal (Figure 1) which enables the user to view and download data from various sources.

To realise that the CF standard names as a common vocabulary for the parameters are introduced into the COSYNA metadata. The specialised internal names for these parameters (also called observed property) is mapped to the CF standard name which fits best. An example is shown in Figure 2 where the observed property chlorophyll_concentration_in_sea_water deduced from MERIS satellite data is compared to data deduced from a fluorescence measurements of a FerryBox in a ship of opportunity.

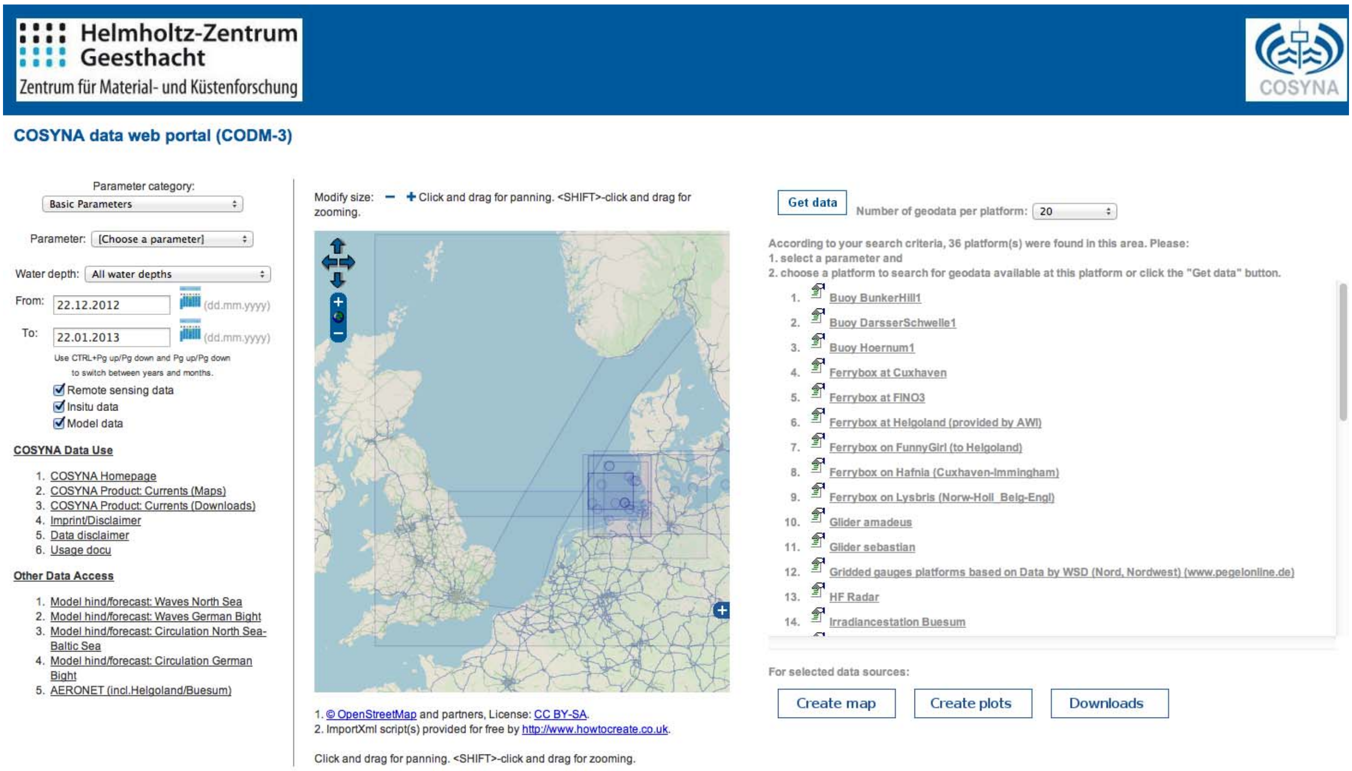

Figure 1: *Initial view of the COSYNA data portal.*

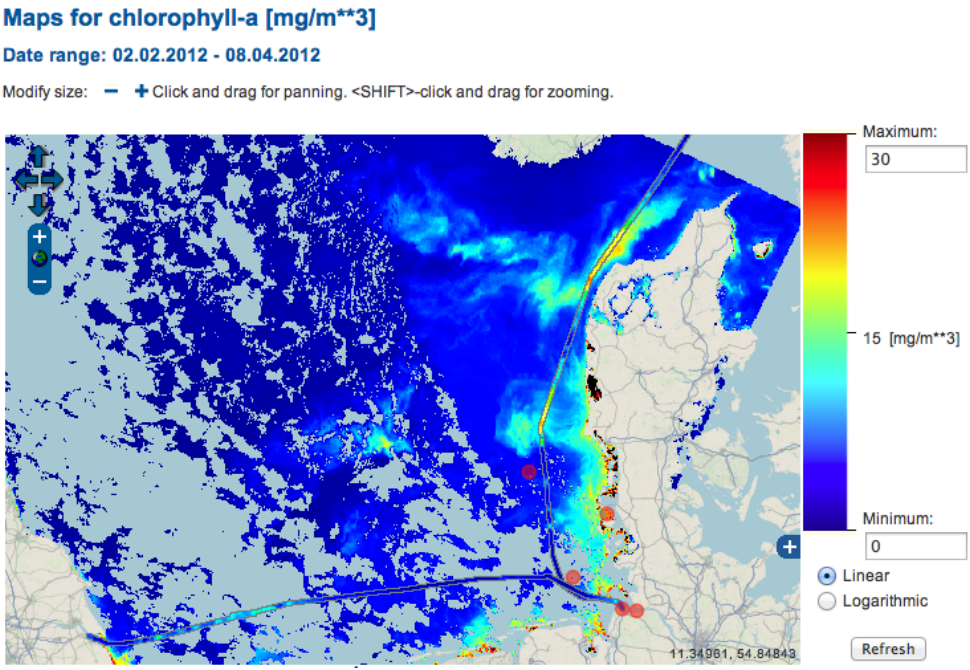

Figure 2: *Comparison between Chlorophyll deduced from Ocean colour from Meris and fuorescence from FerryBox.*

The MERIS data are from one of the last MERIS scences at the end of March 2012. FerryBox data are within 24 hours around the date of the MERIS scene. Despite of the different methods the observed chlorophyll structures are in good agreement.
It is possible to plot the data with conditions on quality flags within the portal now.
Time series of maps could be plotted as normal time series at a selectable location and could be compared with time series of in-situ measurements at the same location.
Agreed real-time quality procedures were applied to the data from poles and FerryBoxes.
The MARNET data from BSH are included into the COSYNA time series database and could be searched and visualised within the COSYNA data portal.

Problems

With the end of ENVISAT data transfer at April 2012 the use of MERIS as remote sensing tool is stopped. The application of MODIS as the new tool until the start of SENTINEL II acquired the development of new procedures in data management. The development will be finished in the first quarter 2013.
Quality control procedures for gliders are developed within the EU project GROOM and need to be applied to the COSYNA glider.

Perspectives for 2013

- Development of a visualisation tool for 3-D moving in-situ platforms like a glider.
- Development of a metadata structure which includes COSYNA web-service URLs in a metadata element named observedProperty
- Development of product pages which will give a deeper insight into complex COSYNA products.
- An intercalibration experiment will be organized.

Publications

Breitbach G, Krasemann H (2012): Web Services as Building Blocks for an Open Coastal Observing System. European Geosciences Union General Assembly 2012. Wien (A), 22.-27.04.2012.

Science-stakeholder interaction

C. Eschenbach

Aims for 2012

- In order to prepare the next steps of interaction with potential and future users of COSYNA products a thorough analysis of the status quo was to be undertaken.
- As in the previous years, the key point of COSYNA in- and outreach is how to reach the scientific community, potential users and the general public with new insights resulting from COSYNA work.

Conceptual Developments in 2012

Phase concept and overview of past user interactions in COSYNA

The particular purpose of interaction with potential or future users of COSYNA products is to ensure COSYNA products are useful and applicable. In order to turn COSYNA data into relevant knowledge for society, a two-way information flow was initiated and is to be maintained where the users themselves can provide feedback and input to COSYNA.
First, phases relevant for user interaction during product development were to be identified. The development of a pre-operational integrated COSYNA product comprises technological and conceptual aspects, and can be divided into six phases (Figure 1).

The (1) idea for a specific product is to be based on a thorough analysis of demands of potential user groups. After rough scheduling of the product, the idea needs be assessed internally by staff members and externally by potential users. During the (2) planning phase questions such as When?, Who?, How?, and What with? are discussed and decided. According to the resulting plan (3) measuring and (4) modelling resources are employed, making quality assured data, appropriate models, and data assimilation procedures available. With these pre-requisites the product is (5) realized by either assimilating the data into the models or employing other routine procedures and validating the outcomes with independent data sets. The technical result of this phase is the reliable production of "good" parameter fields for the German Bight. (6) During the last phase the parameter fields are made available via internet and after external validation and user assessment the pre-operational COSYNA product is ready for use. The application in political or management actions by authorities and other users is subject to other driving forces and not part of COSYNA.

The whole product development can be divided into two main challenges, (A) a conceptual part comprising the development of the product idea, the planning phase and the implementation of the product. During these phases user-interaction is required, while the other phases are mainly (B) a mathematical-technological challenge.

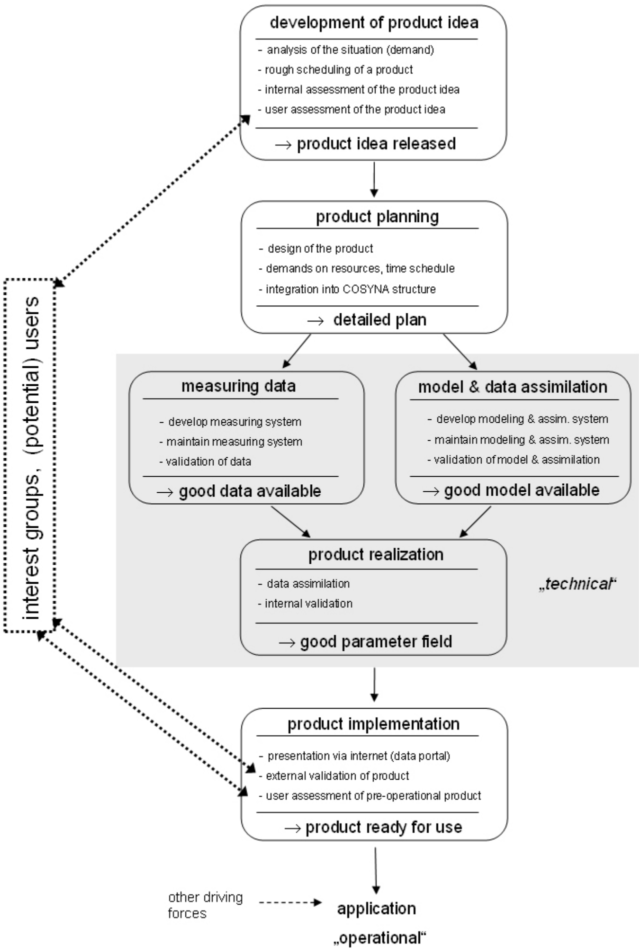

Figure 1: Phase concept for the development of a pre-operational integrated COSYNA product and main launching points for user interactions. Each phase is described by its name (headline), the activities and the resulting milestone. A conceptual part and a mathematical-technological part (grey background), comprising three phases each, can be distinguished.

From the phase concept three main steps for user interaction can be identified.

- Not before the user feedback on the product idea is positive the idea is to be released
- External validation of the product encourages confidence in the product
- Future users should assess the product during the implementation phase

Several activities concerning these steps have been carried out in COSYNA to date (detailed description in Eschenbach 2013): Potential users of COSYNA products include authorities, associations (nature conservation, tourism), science, and industry (e.g. offshore energy companies). During COSYNA's early stages a survey on user requirements identified six parameters to be most useful to the greatest number of users. These are meteorological data, current, waves, bathymetry, turbidity and water temperature. Past user interactions, such as workshops and external evaluation of the first integrated product "Pre-operational Surface Current Fields" have contributed to improving products and their usability.

Results (Highlights)
Inreach and outreach activities in 2012

The focus of this report is on activities conducted or initiated by COSYNA project management. Other activities such as scientific publications, participation in conferences and trade exhibitions or the further developments of the COSYNA data portal are reported in the respective sections.

COSYNA publishes several print products in German and English and supports a website that informs about research activities and results. All the print products are available for download at the COSYNA website (www.cosyna.de).

Annual Progress Report

The Annual Progress Report 2011 on selected results, approach to problems and planned activities of the various COSYNA workings groups and sub-projects was completed in June 2012. The report attracted a great deal of attention by internal and external partners and stakeholders and was widely read.

COSYNA Website

The up-dating and re-designing of the COSYNA website is an ongoing process that was continued in 2012. In addition, a great many of conceptual considerations and proposals for the planned fundamental relaunch of the HZG website – including the COSYNA website – was developed and discussed. Already now the COSYNA website was visited by more than 500 different visitors / month and the number of visits increased from 600 in the beginning to more than 900 later in the year 2012.

COSYNA Newsletter

A new achievement in 2012 was the COSYNA newsletter that provides information on activities, events and recent publications. The newsletter was issued three times in 2012 (May, September, December) and addresses the COSYNA community as well as the general public. The newsletters gained lively interest and positive feedback from many external partners and potential COSYNA users.

COSYNA App

An interactive COSYNA app was developed and commissioned together with the Public Relations department at HZG. The first version was designed for iPad and next versions will address other tablet PCs and smartphones. The app provides short texts and pictures on the COSYNA measuring systems, models and products. A highlight is that users can access the near-real time data from the various stations with one click via internet. The app directly aims at reaching an interested audience in the public. A pioneering key user of the COSYNA app is the Natureum Niederelbe in Balje, Germany (http://www.natureum-niederelbe.de/) that provides information about the estuarine landscape elements, habitats and life, including human activities. A COSYNA exhibit including the app was launched with the re-opening of the museum in March 2013 and is located in the museum's entrance hall (Figure 2). More copies are planned for science centres and museums and one is displayed at the Institute of Coastal Research, HZG.

Problems

When the new perspectives - coming along with new COSYNA leader Prof. B. Baschek - have been discussed and focused the interaction with stakeholders can be intensified.

Perspectives for 2013

Acceptance and use of COSYNA products can probably be increased by developing innovative tools tailored to specific applications and different user groups. Such tools could be apps or daily short reports on the current state and forecasts of the marine environment on the website. New and different products and communication & interaction concepts may be required if there are changes in the anthropogenic uses and resulting man-made pressures in the coastal waters of the North Sea. The planned intensification of offshore wind farming is one example which may trigger such change.

Publications

C. Eschenbach (2013): Coastal Observing System for Northern and Arctic Seas: User interactions in COSYNA. LOICZ INPRINT 2012/3, 9-16.

Figure 2: *The COSYNA exhibit in the Natureum during the re-opening event of the Museum.*

COSYNA

Coastal Observation System for Northern and Arctic Seas

Website: www.cosyna.de

COSYNA data portal: www.coastlab.org

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