COSYNA, A GERMAN INITIATIVE FOR AN INTEGRATED COASTAL OBSERVING SYSTEM

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ABSTRACT

This paper describes the concept and present status of the German "Coastal Observation System for Northern and Arctic Seas" COSYNA. A major challenge of COSYNA is to tightly merge data from a dense observational network and modeling via data assimilation. The integrated system will focus on daily-to-weekly processes providing objective measures of uncertainty in the state estimates and forecasts. Funded by the German Helmholtz Association COSYNA will be implemented and operated by partners from the German Marine Research Consortium under coordination of GKSS. COSYNA will intensively use platforms-of-opportunities to participate in externally financed infrastructure of power, broadband communication and maintenance logistics. Adding to the running governmental monitoring, COSYNA seeks to pinpoint the German role in the international development of marine monitoring and long-term observational strategies in cooperation and agreement with the German Federal Maritime and Hydrographic Agency.

1. NATIONAL AND INTERNATIONAL FRAME

The development of an integrated coastal observing system for the German Bight is one of the focal issues of German marine research in the next decade. A major challenge of the "Coastal Observation System for Northern and Arctic Seas" (COSYNA) is to tightly combine data from a dense observational network with modeling via data assimilation. The integrated system will focus on daily-to-weekly processes providing objective measures of uncertainty in the state estimates and forecasts. In the longer run it will also cover seasonal and inter-annual time scales and should contribute to identify climate-induced changes and anthropogenic cause-and-effect chains in the North Sea ecosystem.

COSYNA was put forward by the German Marine Research Consortium (KDM) as a national task to improve substantially the observational basis of the German Bight system in a regular and systematic way [1]. The Helmholtz Association granted the GKSS Research Centre via an investment funding of 12.4 Million € for a large scale facility to co-ordinate and execute the construction of the "Coastal Observing System for Northern and Arctic Seas" COSYNA from 2007 to 2012 (Phase I). The context of the observatory is set by the North Sea Research carried out in the last two decades [2] and the emerging changes of the system so far attributed to joint effects of climate changes and intensified human usage of the North Sea. In this way, COSYNA represents the German contribution to an anticipated North Sea wide coastal observatory as put forward by European initiatives such as EMECO (www.emecogroup.org) or EMODNET [3].

2. LOCAL CONDITIONS AND SCIENTIFIC CONTEXT

The waters of the German Bight are characterized by comparably shallow depths of 20 to 30 m, significant hydrodynamic energy input from tidal currents and waves and mixing of riverine waters [2]. Depending on the season and weather situation, transient stratification and fronts emerge. At the coastal margin, the Wadden Sea with its barrier islands and intertidal flats acts as a highly variable filter and sink for particulate material and is expected to influence also geochemical processes within the German Bight [4]. Nutrients enter mainly through the rivers, but in the case of nitrogen with a comparable magnitude also across the air-sea boundary. The presence of large harbours results in dense ship traffic with transport of dangerous goods. The construction of large wind mill power plants within the Bight is just in its initial phase. Erosive forces from currents and waves and storm surges threaten the coastlines and these are therefore artificially stabilized and protected by dikes. Sea level rise may influence the import/export balance between the Wadden Sea and the German Bight, but may also impact the ground water table. At the same time, the Wadden Sea area from shore to the 10 m isobath is a protected nature conservation area and, therefore, serves as an attractive recreation area throughout the year.

Scientifically there is a high need to acquire a better knowledge to what extent subregions of the North Sea

are controlled by external or internal dynamics, to close budgets as much as possible and to generate comprehensive and homogeneous long-term time series of system key state variables to separate natural internal system fluctuations from long-term trends and to detect their probable causes [2]. Scientific core questions comprise the

- relevant temporal and spatial scales that control the ecosystem development
- climate and anthropogenic induced changes in physical or bio-geochemical processes
- exchange of energy and matter between the Wadden Sea and other compartments of the open North Sea
- local and remote effects of the planned offshore wind mills on the physical dynamics, sediment transport and biological processes.

A second set of questions deal with pre-operational aspects of coastal observatories, such as the

- forecasting efficiency of physical and biological key state variables by means of a dense observational network, data assimilation and state-of-the-art modeling and the
- required temporal and spatial resolution, and accuracy and precision in observation and modeling.

3. OBSERVATIONAL LAYOUT

The planned layout of COSYNA (s. Fig. 1) comprises installations at selected fixed or mobile platforms to provide the necessary coverage for a characterisation of the highly dynamic, interconnected and heterogeneous environments. This layout also implies vertical system coverage from the benthic boundary layer through the water column to the water-air interface.

COSYNA will intensively use platforms-of-opportunities such as North Sea ferries, cargo ships and offshore platforms. This participation with externally financed infrastructure of power and broadband communication and maintenance logistics will enable a cost effective construction of the system and maintain its operational mode over a long-term period.

Backbone of COSYNA is a network of fixed platforms located at strategic locations of the German EEZ ("reference points"): The western and eastern margin of the German Bight will be covered by stations that shall be mounted on the existent research platforms and planned offshore wind mills. In this way, offshore wind energy conversion will not only be an object of research, but also a fundamental prerequisite for long-term observations. In several basins of the Wadden Sea sensor systems installed on poles are already operating [5]. A new station shall be placed in forefront of the East Frisian islands to provide at least one set of realistic boundary conditions at the Wadden Sea-German Bight interface. To monitor variations in the fluxes from the Elbe river one station will be placed close to its mouth. The fixed stations will provide high resolution time series from several minute averages down to bursts with a frequency of several Hertz to capture the temporal dynamics over scales from turbulence to inter-annual variations. It is foreseen to equip them with a common set of parameters to achieve homogeneous information over the whole system. (see Table I). In proximity to selected reference points underwater nodes will be moored that will be, among others, connected to benthic landers that measure fluxes across the sediment/water boundary layer over shorter time spans. In a similar way gas exchange across the air/water boundary layer shall be measured at one or two locations. This arrangement complements the MARNET monitoring stations that are operated by BSH (s. Fig. 1).

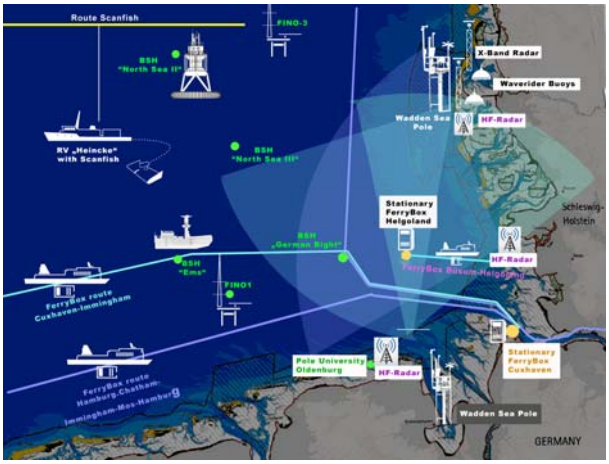

Figure 1. Principle layout of COSYNA in the German Bight

The spatial heterogeneity present in the German Bight will be captured by moving platforms. FerryBoxes, installed on ships-of-opportunity, are already measuring larger parts of the North Sea [6, 7]. An additional FerryBox between the mainland and the island of Helgoland observes the transition of the Elbe estuary to the German Bight. To add information about vertical distributions ship surveys with an undulating towed scan-fish will be carried out several times a year. Among others, the results will be the basis to operate systems (1) that connect the fixed stations at the western and eastern across-shore margins to quantify the fluxes that enter and leave the German Bight and (2) that scan systematically the inner parts of the bight in case of storm events and situations of significant vertical stratification and the emergence of plumes. As this can not be guaranteed by research vessels alone, the feasibility of autonomous underwater vehicles either

actively propelled or as gliders [8], will be investigated under the prevailing conditions of shallow waters, tidal currents, high waves and dense ship traffic.

Full observational coverage of water surface parameters is achieved by remote sensing techniques. Two types of land-based radar systems will deliver fields of currents and waves throughout the German Bight. X-band radar will be mounted at exposed locations of the barrier islands that are threatened by steady erosion. Hourly fields of local currents, waves and the bathymetry are provided covering a range of some nautical mile at a horizontal resolution down to 20 m [9, 10]. Continuous two-dimensional current and wave fields will be provided throughout most of the German Bight using three HF-radar WERA systems (s. Fig.1) [11]. These data are enhanced by space-borne data from SAR satellites crossing the North Sea regularly. Optical remote sensing, using presently MERIS/ENVISAT, detects the ocean water colours. Dedicated algorithms convert the radiation density spectra into concentrations of mineral suspended sediments, chlorophyll-a and yellow substance [12].

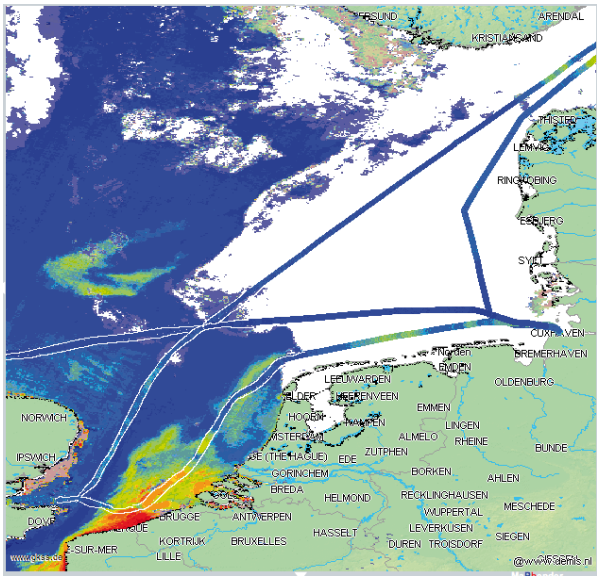

Figure 2. FerryBox measurements of chlorophyll-fluorescence from March 16, 2009. Superimposed is an ENVISAT MERIS picture, processed for chlorophyll from the same day. A first spring bloom can be seen near the Belgian coast. Even when clouds over the German Bight prevent satellite measurements, in-situ measurements from the FerryBox provide reliable data.

4. DATA MANAGEMENT

Data of the near-coast platforms will be transmitted in real-time to the GKSS computer centre using GPRS or UMTS. For platforms located more than twenty miles offshore and without connection to broadband cable, transmission via satellite (e.g. *Iridium*) may be required. These "primary data" are stored in a relational data base. This will act as a long-term data archive of COSYNA that later also contains data of different processing levels.

The primary data can be publicly visualized and downloaded in near real-time via a Web-browser. The OGC standard Sensor Observing Service (SOS) [13] will be installed and most COSYNA data will be openly available. The near real-time preparation of the primary data for pre-operational purposes will require a complex "daemon" that has to cope with data of quite different space-time structure and to perform a broad set of data quality check procedures.

5. PRESENT STATUS

COSYNA is presently operating in its pilot phase (2007-2009) and concentrates on the consolidation of systems and methods already in use at GKSS. Three pile systems are operating in the North Frisian and the East Frisian Wadden Sea. A set of wave rider buoys delivers directional wave spectra along the island chain. Two X-Band radar systems are monitoring local bathymetric changes at the northern and the southern hook of the North Frisian island of Sylt. Two HF Radar stations are in operation at the North Frisian coast, a third station just started operation. FerryBoxes are operating on three ship lines covering large parts of the North Sea and the inner German Bight. Satellite images from MERIS/ENVISAT provide regularly distributions of Chlorophyll-a and suspended matter. Wind and wave fields are provided from ASAR/ENVISAT. Uncorrected primary data are visualised promptly on the World Wide Web (http://www.coastlab.org, http://www.cosyna.de). They are provided either in form of time series or maps that can be downloaded freely (s. Fig. 2).

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