M3 MULTI-PARAMETER OBSERVATIONS FROM COASTAL WATERS TO THE DEEP SEA: FOCUS ON QUALITY CONTROL AND SENSOR STABILITY

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Decades of technical development in electronics, telecommunication, optics and acoustics measuring techniques have opened new possibilities for multi-parameter monitoring of the marine environment. This presentation will give examples on how fixed multi-parameter platforms are used in a wide variety of applications ranging from shallow coastal on-line observatories down to measuring in the deepest Ocean trenches. Focus will be on long-term (years) stability and the challenge to maintain satisfactory quality control throughout the deployments. Parameters that will be discussed include: Currents, Conductivity/Salinity, Temperature, Pressure and Oxygen. The performance of emerging technologies e.g. optical sensors to monitor pCO2 will also be discussed.
Examples from two deep-sea (4000 m) current meter inter-comparisons will be given. In these different technologies and instrument brands have been compared. The difficulties in measuring currents and obtaining satisfactory quality control when there are no absolute references will be demonstrated. Dynamic environments where the instruments move and tilt might impede on the quality when measuring currents. Methods to compensate for this will be discussed and results from tow tank test where the speed of the moving trolley gives an accurate absolute reference will be shown.
Oxygen is a prime parameter to measure in open ocean oceanographic studies to better grasp the effects of on-going climate changes. Decreasing trends in absolute oxygen concentrations at two deep-sea sites will be presented. The challenge of quality control when sampling at several thousand meters and potential artifacts will be discussed.
In the Koljoefjord an on-line observatory was installed in April 2011 to assess and model the dynamics of a system of fjords on the Swedish west coast. The observatory consists of a main hub, which is cable connected (old fiber optic ROV cable) to communication and power system on land (see figure and photos on next pages). The node is prepared to host four experimental modules communicating either with Ethernet or serial protocol. When installed in April 2011 one monitoring module with approximately 30 sensors was connected. Later approximately another 15 sensors have been added. Data are stored internally in the instruments and the node, and are also available online and retrieved in real-time to the PANGEA database (http://www.pangaea.de/). Remote control over the main hub is implemented and has been used for adjusting measurement system parameters over the Internet. A web display is developed for checking, plotting and quality control of the data coming in: http://mkononets.dyndns-home.com:8080/
Parameters measured at multiple levels of the observatory include Horizontal and Vertical Currents, Conductivity/Salinity/Density, Temperature, Oxygen, pCO2, Water level, Waves, Turbidity, Chlorophyll A, pH, ORP, FDOM and Cyanobacteria. Measurement intervals that have been used have varied from 2-30 min. The observatory is deployed close to a sampling site of a monthly survey program run by SMHI (Swedish Meteorological and Hydrological Institution). For comparing current speed measurements with surface currents and mixing wind data from a nearby weather station (at the Sven Loven Marine Research Center run by University of Gothenburg) is assimilated into the observatory plots.
The environment is dynamic. Tidal oscillations result in strong variations in the intermediate layer. Within a few hours temperature can vary with up to 10 C, salinity with up to 3 PSU and oxygen with up to 70% air saturation. This and because the depth of sensors and reference water sampling are not always the same differences occur frequently between observatory and reference data. Outside the intermediate layer (close to surface and deeper) agreement to reference data is generally good. A possible source of errors appears at low oxygen where reference Winkler data gave higher values probably due to contamination during sampling. Reference data are invaluable in helping to identify this type of interference and to plan how frequently sensors should be cleaned. Fast and efficient methods have been developed to verify the biofouling status of the sensors and to lift and clean the observatory. The later procedure normally takes no more than one hour and no divers or ROVs are required.
Another function of the Koljoefjord observatory is to serve as a test and development facility for instruments and sensors. The observatory can provide power and has free ports with Ethernet/RS232/RS422/AiCaP/Analog communication.
New pCO2 optodes have/are being tested on the observatory demonstrating excellent long-term stability and, as expected, a high anti-correlation with oxygen measured at the same level.

M3 INTEROPERABILITY DEVELOPMENTS FOR NEXT GENERATION MULTIFUNCTIONAL OCEAN SENSOR SYSTEMS IN NEXOS

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Abstract
Sensor technology is rapidly advancing, enabling smaller and less expensive instruments to monitor Earth's environment. It is expected that many more kinds and quantities of networked environmental sensors will be deployed in coming years. This work presents an approach for the smart configuration and integration of marine sensors into an interoperable Sensor Web infrastructure such that the overall life cycle cost of sensors and observing systems is reduced and data has greater societal and scientific value. In this paper some of the objectives related to sensor interface included in the project proposal NeXOS (Next generation, Cost-effective, Compact, Multifunctional Web Enabled Ocean Sensor Systems Empowering Marine, Maritime and Fisheries Management), under the European Commission's Ocean of Tomorrow call FP7-OCEAN-2013.2, are presented.

INTRODUCTION
European marine policy makers stated in the "Ostend Declaration" of 2010 that the major challenge is now to support the development of a truly integrated and sustainably funded European Ocean Observing System (EOOS) to monitor key ocean processes.
This would form the European component of the Global Ocean Observing System (GOOS), and would continuously monitor the European seas from near-coastal to open ocean, and surface waters to seafloor. Fixed and mobile observing platforms would be used to offer real-time, or near real-time, open and standard downstream services to the public and private sectors.
This system would re-establish Europe as a global leader in marine science and technology, as well as support effective management of the European maritime

environment. To achieve this, more long-term measurements of key parameters are required, but the costs and unreliability of ocean sensors remain a major problem. The increasing maturity of observing technology enables adaptive observing systems, which increase access while reducing costs. Following this trend, new oceanographic observing systems are needed, which can measure several parameters with enhanced reliability.

Given the general priority for all, monitoring strategies addressing observing systems and sensor technologies to create mechanisms and technologies with greater societal and scientific value, a new sensor system is proposed to be developed that will include innovations in data accessibility, reliability, sustainability, interoperability and multifunctionality for key ocean variables. In addition, the new development will address protocol specifications to improve the processes of marine data acquisition. The protocol specifications will be developed based on existing standards that enable (1) the pull of stored marine sensor data, and (2) the real-time push for marine sensor data aligned with the OGC publish/subscribe activities. The lightweight design of those specifications based on existing solutions will foster their utilization in practice.

II. Smart Sensor Design

A new hardware and software architecture called "Smart Electronic Interface for Sensor Interoperability" (SEISI), to enable interoperable Web access to marine sensors is proposed. The architecture will satisfy international standards, defined by ISO, OGC, and the INSPIRE directive, to enable integration of marine sensors with existing observing systems. As shown in Figure 1 the SEISI will provide a multifunctional interface for many types of current sensors and instruments, as well as new multifunctional detectors.

Today oceanographic instruments provide proprietary instrument protocols based on standard physical layers like RS232, RS485, CANbus, etc. Therefore the design of a smart interface is proposed in order to provide communication and synchronization with proprietary oceanographic instruments, data processing and a standard communication interface with upper layers such as end users and the ocean observing system.

First, a modular sensor instrument frontend will provide communication and synchronization with actual oceanographic instruments. Three main modules compose this task:

. An analogue frontend that provides signal conditioning and analog to digital converter capabilities for different types of sensors. This module will take into account the accuracy, precision, impedance coupling and frequency sampling characteristics needed for several types of marine sensors.

· A point to point frontend will provide a modular design that is able to communicate with digital instruments when a point to point link is used e.g. RS232, SPI, I2C.

· A Multidrop frontend will provide a modular design able to communicate with digital instruments when a multi-drop link is used e.g. RS485, RS422, CAN-Bus, USB.

Secondly, the SEISI core will be developed in order to fulfill the following design goals:

· Low power consumption to enable use in battery powered platforms;
· High processing performance to allocate specific applications and services for sensor data processing;
· Positioning capabilities through a GPS interface or external positioning information;
· Compactness to facilitate the integration in present platforms;
· High accuracy time stamping capabilities using synchronization protocols (e.g. IEEE Std. 1588 Precision Time Protocol);
· Remotely reconfigurable and upgradable
· Adaptable to new sensor developments

Thirdly, the SEISI will be the "open door" to access instrument data and instrument configuration using interoperable standards avoiding end users interaction with proprietary protocols. The objective of this task is to design and program an interface communication frontend capable of interfacing with upper communication layers following open standards such as the SWE framework from OGC or IEEE 1451 Smart Transducer Interface Standards. This interface will be modular, providing the instruments with different interface communication capabilities such as Ethernet, CANBus or even point to point for simple applications or for very low power observation platforms.

CONCLUSION

A new multifunctional Web Enabled Ocean Sensor System architecture is proposed in order to enable future development of cost efficient fixed and mobile observing platforms for real-time or near real-time providing open and standard downstream services to the public and private sectors. The design and development of a Smart Electronic Interface for Sensor Interoperability (SEISI) is also proposed in order to provide communication and synchronization with proprietary oceanographic instrument, data processing and a standard communication interface with upper layers.

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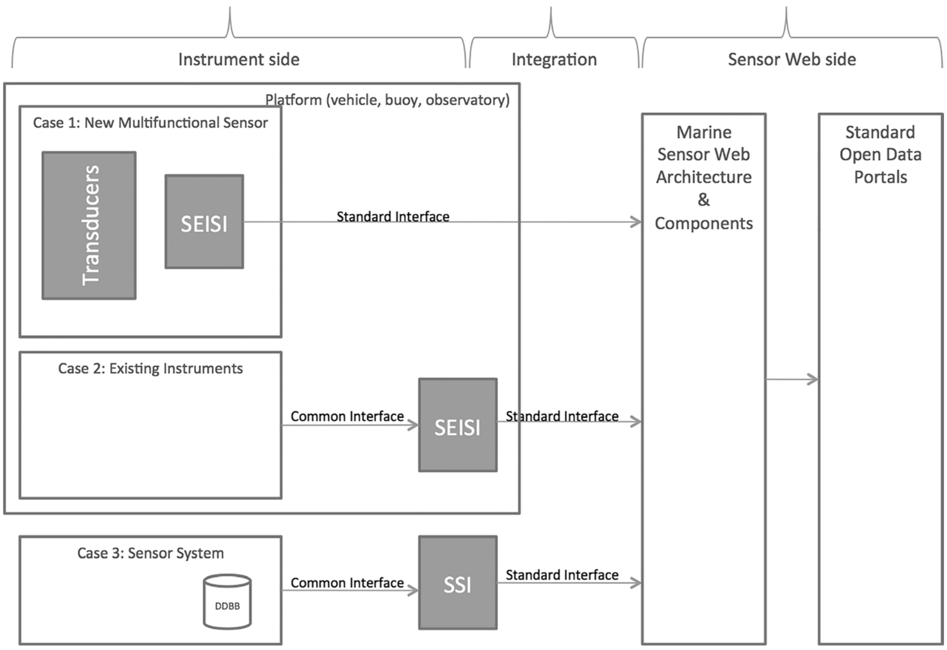

Figure 1 Oceanographic observing systems based on SEISI