Briefing Paper

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Making Technologies for Ocean Observing accessible

Introduction

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The sheer size of the world's oceans precludes the extensive deployment of observing stations with a multitude of instruments to track a wide range of parameters; the costs and complexity of the system would be far too great. A similar challenge existed for climate observing. In response, the climate research community worked together with meteorological services, which play a substantial role in shaping the market for climate data, to establish the Global Climate Observing System (GCOS). This collaboration helped prioritize observing by focussing on the systematic, sustainable observation of a limited set of critical variables, the so-called Essential Climate Variables (see figure 1). A framework was defined that allows for an efficient observing system planning and resourcing that fully takes the technical feasibility and budget constraints of operational implementation into account. The ocean observing community is now heading down a similar path with the Essential Ocean Variables, however, the challenges facing this community are quite different. For example, unlike in the case of weather and climate, there is only a much smaller market for ocean data. While the market is characterized by many

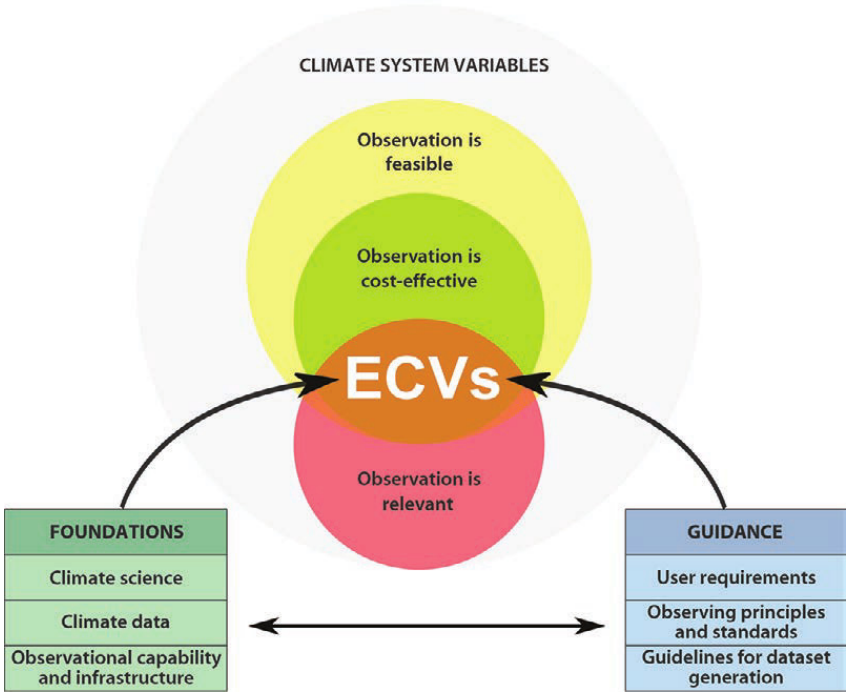

***Figure 1**: Schematic of the ECV concept (Stephan Bojinski, AMS 2014)*

innovative activities, whereby the scientific community works with small and medium-sized enterprises (SMEs) and and start-ups to develop and test newest technologies, the larger efforts tend to be more fragmented by commercial sector. As a result, investment is difficult and many developments often go unknown to the broader observing community. To address the latter issue, AtlantOS has collaborated with the EU H2020 project COLUMBUS to make developments known in the observing community. A second challenge is the interoperability of technologies or the harmonization of the data they collect. For example, data on microplastics must be harmonized between technology types so that data collected by one sensor, on a particular day and in a particular location are compatible with data collected elsewhere and at a different time. The benchmarks by which such developments occur are often diverse and non-standardized. In future, a systematic planning process will require that observing methodologies are objectively assessed and best practices, like standard operating procedures, introduced fully in line with the ECV process.

This briefing paper summarizes some recent activities of the EU H2020 project AtlantOS to promote the discussion about new technologies, sharing instruments and real-time data, the AtlantOS 'Sensors an Instrumentation Roadmap', and ocean best practices in technologies.

Evolving and Sustaining Ocean Best Practices in regard to Metrological and Data Handling Principles?

Jay Pearlman (Institute of Electrical and Electronics Engineers, France)

Innovations in ocean observing are important across the value chain from sensing to creating useful information for applications and marine management. Ways to use these innovations effectively are codified in 'best practice' documentations. The effective transmission of best practices is thus an increasing and pressing concern of global science. However, the process is still fragmented, and results are difficult to sustain. There is a clear need for a consolidated open access repository for ocean observation best practices that would provide consistent access to a wide range of such practices. With the expanding observation community, traditional mentoring approaches, particularly in developing countries, need to be complemented by documentation of practices that are discoverable, easy to access and with granular search capabilities.

The Ocean Best Practices (OBP) System supported by AtlantOS includes the full spectrum of best practices from sensors and platforms to modeling and analyses to data management and user support. The infrastructure includes the OBP Repository at IOC/IODE (www.oceanestpractices.net) and a peer review structure including a "Best Practices in Ocean Observing" Research Topic in the Frontiers in Marine Science Journal (www.frontiersin.org/research-topics/7173/best-practices-in-ocean-observing). With the use of modern semantic search and natural language processing, the OBP repository will open new paths for discovering, accessing and using best practices.

The benefits for ocean observing and use of ocean information include improved consistency and interoperability among measurements on a local to global scale, increased dialog and cooperation among experts and a reliable base to make comparisons of observations. Best practices benefit day-to-day operations by reducing duplication of efforts and unneeded repetition of learning processes. By improving operational consistency and documenting measurement procedures, they provide a better foundation for reaching back to historical data.

Sensors and Instrumentation Roadmap

Andrew K.R. Morris and Doug Connelly (National Oceanography Centre, United Kingdom)

The Sensors and Instrumentation Roadmap is a resource for ocean observation system developers, and for the wider oceanographic, technical and business communities that have an interest in how marine measurement technology will develop in the future. It collates predictions of the maturity of various oceanographic sensors and instruments as a function of time using the widely used 'Technology Readiness Level' (TRL) scale and a simple to use spreadsheet. This roadmap was created to support international co-operation for the integration and improvement of ocean observing. The roadmap is a tool that can be used by the oceanographic community to communicate what sensors and instrumentation are available and, crucially, what is in development and could support the measurement of various Essential Ocean Variables. Expected benefits of the roadmap include: improved ability by observational communities to plan the design, deployment and maintenance of observing systems; improved cost estimation for ocean observation systems; improved foresight of metrology capability for platform developers (e.g. vehicles); and improved dissemination and take up of ocean technologies. These benefits will lead to improved market conditions and dissemination pathways for sensor and instrumentation developers. Such improvements help underpin the efficient development and integration of Atlantic observing systems, and similar systems across the globe. Currently the roadmap is implemented as a MS Excel file and has grown to over 140 entries from over 40 companies or institutes. It is the intention of the roadmap delivery team to provide an update every six months for the duration of the AtlantOS project, and further if there is sustained interest from the oceanographic community. If you would like to be included as part of this regular consultation please contact us at atlantoswp6@noc.ac.uk. The roadmap is freely available and sharing with interested groups is encouraged.

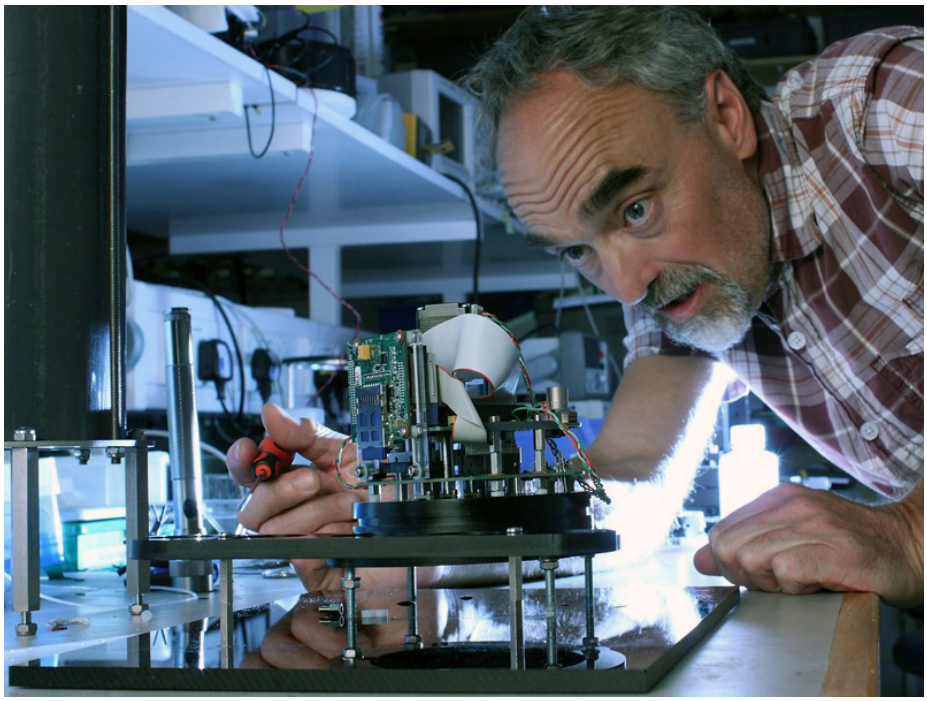

***Figure 2**: Martin Arundell of the National Oceanography Centre working on some of the technology included in the roadmap. Credit: NOC.*

Sharing instruments and real-time data across Atlantic observing systems

Eric Delory (PLOCAN - Plataforma Oceánica de Canarias, Gran Canaria)

The landscape and number of requirements for integrating ocean observing is vast and a plethora of technological solutions have been proposed and implemented for sharing observational data across observing networks and to deliver data to users in a way to be properly exploited for hind-now-forecast of the state of the ocean. The community has managed to reach consensus on a subset of solutions for, e.g. fixed open-ocean data, with harmonised access and formats for a number of variables. In the past two decades, the advent of new sensor and system technologies, which leads to an increasing use of autonomous systems, fixed or mobile, also driven by an increasing number of variables, the diversity of sensing technologies, from platforms to sensors, allowing for real-time data delivery, has made a quantum leap. Several of these technologies have now reached high Technical Readiness Level and a degree of standardisation and interoperability can now be envisaged, in order to simplify sharing of instruments and data across operators and users, allowing for broader adoption and reducing the particularly high integration costs. While several solutions will likely emerge in the near future with the Internet of Things, in AtlantOS we propose to showcase a methodology that has been under scrutiny for about a decade and has proven effective, based on the Open Geospatial Consortium (OGC) Sensor Web Enablement (SWE) suite of standards. These have been applied on newly developed compact multifunctional sensors, where an added layer of interoperability was implemented to standardize sensor and real-time data integration in an end-to-end fashion. The solutions can now be deployed on commercial platforms like ARGO floats and gliders, allowing for plug-and-play sensor connection, sensor discovery on on-line mapping tools through standard metadata and data access and delivery to human users or machines.

The next steps are to further engage with developers and manufacturers. Thus, sensor and platform developers and manufacturers are invited to join us on an interoperability experiment, promoted by the AtlantOS group on 'Cross-cutting issues and emerging networks' and several other initiatives. A training workshop took place on 15 March 2018 at Oceanology International 2018. For those interested in learning more and in the field experiment please contact eric.delory@plocan.eu

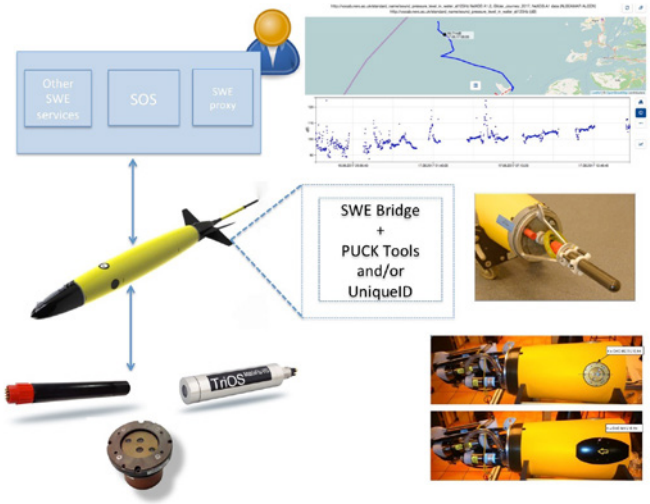

***Figure 3**: : Interoperability standard solutions for sharing real-time data and instruments, here with optical and acoustic sensors installed on a commercial European glider (Sea Explorer, Alseamar), can deliver data and metadata in a harmonized communication and visualization framework (adapted from the NeXOS project for AtlantOS).*

The H2020 EU project AtlantOS pools the effort of 57 European and 5 non-European partners from 18 countries to collaborate on optimising and enhancing Atlantic Ocean observing. The project has a budget of € 21 Million for 4 years (April 2015 – June 2019) and is coordinated by GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany (Prof. Martin Visbeck).

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