EUROSITES EUROPEAN NETWORK OF DEEP OCEAN OBSERVATORIES

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ABSTRACT

This paper reviews EuroSITES, a European FP7 Collaborative Project which is integrating and enhancing Europe's existing fixed-point deep ocean observatory infrastructure. EuroSITES is driven by science excellence, best practice and clear societal relevance. The high resolution *in situ* multidisciplinary time-series datasets produced are of climatically and environmentally relevant variables from the euphotic zone to the seafloor beneath. Many of the EuroSITES datasets are available in near real-time as the network moves from research towards an operational network. As a result, EuroSITES data is a vital data provider to the *in situ* component of MyOcean (European Marine Core Services) as well as contributing to the the Global Earth Observation System of Systems (GEOSS) through OceanSITES and GOOS. EuroSITES also supports the Research and Development of innovative ocean observation technology. Specific science missions include the measurement of deep ocean oxygen consumption, and pH. These all aim to progress European ocean observation technology beyond the current state-of-the-art. Working closely with other relevant projects including ESONET, EuroSITES will bring about a major advance in the way the European community monitors the ocean interior, seafloor and sub-seafloor.. EuroSITES also has a strong international context as the European component of the OceanSITES network of open oceanreference stations. An "Oversight Committee" of leading international scientists and key end users of the data act as a vital advisory panel for the project.

1. INTRODUCTION

EuroSITES is a network of the 9 fixed-point deep ocean observatories around Europe (www.eurosites.info). These observatories are all in waters deeper than 1000 m but monitor the full water column from the euphotic zone to the deep ocean. The observatoriesproduce multidisciplinary (physical to biogeochemical) high resolution time-series data on environmentally and climatically important variables. These long-term datasets offer vital insights into the seasonal and inter-annual variability in hydrography, nutrient

supply and resultant productivity. The seafloor components are also key for monitoring natural hazards and examining the effects of environmental perturbation e.g. the effect of earthquakes on subsurface fluid migration and to increase our understanding of the role of benthic ecosystems as indicators of climate change. EuroSITES supports best practice and interoperability and follows the OceanSITES international network (reviewed in [1] for a common data policy and a standard data format for *in situ* ocean time-series data. This enables regional and larger-scale comparisons of the datasets so that results can be related to larger scale environmental and climatic drivers to understand the global Ocean response to climate change. This will greatly increase the contribution of *in situ* fixed-point ocean data both to the Global Ocean Observing System (GOOS) and to the Global Earth Observation System of Systems (GEOSS). EuroSITES therefore has a clear societal relevance as a key *in situ* ocean data provider for producing services and products to society on the oceans' response to climate change and role in regulating global climate. This is an ever growing connection which is expected to increase over the coming years as the technology enables more variables to be transmitted in near real-time and global models develop still further to incorporate multidisciplinary biogeochemical datasets. This paper reviews the key science questions driving the EuroSITES time-series, some result highlights and the research and development which EuroSITES

supports to increase the *in situ* ocean observation. The role of EuroSITES as a key data provider for societal services and products is also addressed as a developing area along with the importance of knowledge transfer, outreach to a wide range of users including the general public.

EuroSITES observatories are located in key areas of the ocean which are critical for understanding both local and regional and global scientific questions (Fig. 1). The main scientific motivations for fixed-point time-series ocean observation cross multiple disciplines from physical oceanography (ocean circulation, turbulent mixing, ocean dynamics) to biogeochemistry (ocean-atmosphere gas exchanges, productivity, ecosystems) and geological and natural hazards (plate-scale and ocean geodynamics and flui-rock interactions). The EuroSITES network consists of nine core observatory sites and three associated research sites (See Fig. 1). The network is driven by research with the view to becoming an operational network in the future. Some key scientific results are presented in additional contributions from individual sites in these proceedings (Annex) [2,3,4,5,6,7,8] and in a community white paper on benthic biological time-series [9]. These include a sixty year time-series of temperature and salinity from the Norwegian Sea (Station M) [1] and over twenty years of full depth multidisciplinary measurements from the NorthEast Atlantic Porcupine Abyssal Plain (PAP) site [6]

Figure 1. EuroSITES location map of 9 core observatories (blue) and associated research sites (green).

2. RESEARCH AND DEVELOPMENT: BEYOND STATE-OF-THE-ART

Many ocean variables are currently undersampled in the global Ocean. Many of these lack autonomous sensors for long-term deployment. For this reason, EuroSITES is supporting the Research and Development of innovative ocean observation technology. Specific science missions being carried out include the measurement of deep ocean oxygen consumption, mesozooplankton and pH. These all aim to progress European ocean observation technology beyond the current state-of-the-art. For instance, oxygen is a key variable for understanding a wide range of oceanic processes. However, oxygen is not currently an "Essential Climate variable" as defined by the UN Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). EuroSITES partner CNRS have developed a mid-water respiration chamber, called the Deep-IODA, for monitoring oxygen consumption in the mesopelagic layer. These data are critical for understanding the fate of organic matter and the role of the ocean as a sink for carbon. Another variable, pH is a key measurement for understanding the role of the oceans as a sink for pCO_2 and the implications of higher pCO_2 and increasing acidity of the oceans on the biodiversity and fucntioing of ecosystems. However, there is currently a lack of sensors capable of continuous and autonomous long-term monitoring of ocean acidity. EuroSITES is funding University of Las Palmas to develop and trial a photometric pH sensor for long-term deployment in the deep ocean and to date the results are extremely encouraging that this will shortly become a standard variable.

3. SOCIETAL RELEVANCE: COMMUNICATION AND SERVICES

There is an ever growing demand for real-time marine data acquisition within the scientific community, the offshore industry, policy makers, the general public and educators. These data are essential for environmental monitoring, infrastructure inspection and forecasting systems (e.g. fisheries, tsunamis and earthquakes). In situ Deep water (>1000m) fixed-point observatories across Europe are particularly vital as one mooring can produce multidisciplinary time-series from multiple depths simultaneously. This is essential both for validating upper ocean data produced from

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remote sensing techniques but also to provide data from the deeper ocean (> 30m depth) which are not visible by satellite and are not sampled on transects by ships of opportunity. In the future, gliders and profiling floats may take the place of moorings since they offer more flexibility and a higher level of depth resolution. However, moorings currently offer one of the best approaches to provide long-term time-series from less accessible areas of the open ocean (e.g. RAPID, EuroSITES and OceanSITES moorings). In contrast to gliders and profiling floats they can also carry large instruments and provide high energy supplies. They can also collect samples such as of sinking particles, of zooplankton and or water all of which can be analysed after mooring recovery. EuroSITES produces time-series data of a core set of climatically and environmentally important variables. These include temperature, salinity, currents and biogeochemistry (e.g. chlorophyll-a, nitrate, pCO_2 and O_2). Many of these are defined as "Essential climate variables" for the sub-surface (*in situ*) ocean as defined by the UN Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). These variables can be used both as local indicators (e.g. temperature time series, mixed layer depth) as well as large scale indicators (e.g. ocean mass transport fluctuations between observatories). As many of the datasets are available in near real-time, EuroSITES data are increasingly being used to produce services and products for society. One example is that

temperature and salinity data from the TENATSO ocean time-series (Cape Verde) have been used by in an ocean circulation model (MERCATOR) for fisheries management. EuroSITES is therefore seen as a key up-stream data provider for MyOcean (European Marine Core Services) [10]. A key aspect of EuroSITES is the dissemination of knowledge and communication of scientific results to a wider audience including policy makers and the general public. Led by Océanopolis-SOPAB, several tools have been developed so far to make the science carried out accessible (e.g. Fact Sheets, a film and a dedicated outreach website http://outreach.eurosites.info/)

4. EUROPEAN AND INTERNATIONAL CONTEXT

Integrating and enhancing observatories both regionally and vertically into a coherent and mutually supportive network, EuroSITES, as the European component to OceanSITES [1] will form an essential contribution towards the visions of the Global Ocean Observing System (GOOS). EuroSITES will complement and link with other existing European and International initiatives to contribute to the subsea component of GMES (Marine Core Services) and to the future vision of GEOSS as a fully integrated operational global observing system. In particular, EuroSITES will contribute to Task AR-09-03c and other tasks (e.g. ST-09-02) have also been identified. There are many levels at which interaction and collaboration currently exists between the EU and

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US ocean observational community. This may be at the infrastructure level (shared instrumentation, maintenance, common data management etc) through international projects including OceanSITES. Other collaborations may simply be networks of scientists from EU and US working together towards common scientific objectives (e.g.Arctic science). One region identified as a potential site for a demonstration of joint EU/US ocean observation activity is the Irminger Sea, North Atlantic. In this region a European time-series, the Central Irminger Sea (CIS) site, has been in operation since September 2002. This site is a core site within both the EuroSITES and OceanSITES networks. In addition, the North American Ocean Observatories Initiative (OOI) has identified this region (60°N, 39°W) as a future 'global node' for development of a long-term with both fixed and mobile assets planned [11]. The multi-scale observatory is intended to resolve mesoscale processes and will be modular and moveable offering flexibility to observe different areas of the oceans if the sites of special scientific interest change as a result of global change. An important component of the EuroSITES project is the international Oversight Committee. This acts as a key advisory panel and driver throughout the duration of the project, involving leading international scientists and key end users of ocean observational data such as the modelling community, data managers and outreach specialists.

5. FUTURE DIRECTIONS

Fixed-point moored observatories are a vital component in today's global observing system. These technologies, along with gliders and floats offer some of the best ways of obtaining full depth simultaneous multidisciplinary measurements of the in situ ocean (> 30m depth). There is no doubt that the potential for societal benefit from these datasets in terms of products and services will increase exponentially as technological advancement and innovation enable still more variables to be measured autonomously in near real-time. However, sustaining these time-series through long-term funding commitments and moving towards an operational network is an ongoing challenge. The services which rely on these datasets are funded centrally by regional funds (e.g. the European Commission). However, the infrastructure and skills (personnel) to sustain these systems is largely left for member states to fund.

Without integration of funding for the ocean observing systems, there is a danger that nations will enforce different priorities. The result will be the re-emergence of a fragmented, heterogeneous and inefficient system compared to the standardised, integrated network which we are currently moving.

6. REFERENCES

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