ID12- EXPANDING OCEAN-MONITORING CAPABILITIES IN THE MACARONESIA WITH UNMANNED MOBILE PLATFORMS

C. BARRERA[118], C.WALDMANN[27], R. CALDEIRA[115], MJ RUEDA[122], J. HERNÁNDEZ[119]
AND O. LLINÁS[120]

Abstract

The Macaronesia is a vast area playing a key role in the East boundary of the Central North-Atlantic ocean-circulation system. Despite a significant research activity in ocean monitoring for decades using a wide range of observing systems and methodologies, the area is still under-sampled, mainly due access and coverage constrains, as well as the observation sustainability. Ocean gliders offer a new approach in terms of capacity and sustainability, allowing undertake ocean-monitoring in spatiotemporal scales hitherto unavailable. The present work shows preliminary results from the latest mission with buoyancy-driven and surface ocean gliders in the area, whose main goal focuses on to improve and expand ocean observation capabilities strengthening glider endurance lines between archipelagos, as part of the global ocean-observation strategy conducted by the Marine & Maritime Network (R3M), as regional contribution directly aligned with European and international initiatives and strategies in the North Atlantic basin.

Key words: Ocean, monitoring, glider, Macaronesia, robotics, marine, technology

INTRODUCTION

In-situ ocean monitoring is still difficult and costly for a large number of chief reasons, despite current advances on key marine technology fields. Oceans have a complex 3D-structure and their behavior is governed by a wide variety of processes. Long-term monitoring of them also poses substantial technical and logistic challenges. World oceans are constantly shifting in ways that impact on every face of our society. To keep open-ocean and coastal communities, economies, and ecosystems healthy requires to monitor key physical, chemical, and biological parameters to assess how these areas (offshore and coastal, from surface to seafloor) are changing in order to take the right decisions for them and the environment.

From a global and multidisciplinary perspective, currently is possible to link databases holding information from in-situ ocean observation with modelling tools and to use them for supporting forecasts ocean states according to end-users needs. Conflicts between commerce, leisure, research and development, environmental protection and the management of living resources are increasing. The social and economic costs of unsuitable informed decisions are growing accordingly. A global integrated system of ocean observations and analysis is still needed to provide the information (data products) required by the society to fill the existing key gaps in this context.

The Group on Earth Observations, GEO, is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS. GEO was launched in response to calls for action by the 2002 World Summit on Sustainable Development and by the G8 (Group of Eight) leading industrialized countries. These high-level meetings recognized that international collaboration is essential for exploiting the growing potential of Earth observations to support decision making in an increasingly complex and environmentally stressed world.

GEO has released GEOSS on the basis of a 10-Year Implementation Plan for the period 2005 to 2015 in order to define a vision statement for GEOSS, its purpose and scope, expected benefits, and the nine "Societal Benefit Areas" of disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity. GEO is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS. GOOS (Global Ocean Observing System) is the oceanographic component of GEOSS.

THE ATLANTOS PROJECT

AtlantOS is a project supported by the European Union's Horizon-2020 research and innovation programme, under the Call BG-8 Developing in-situ Atlantic Ocean Observations for a better management and sustainable exploitation of the maritime resources. It is a 4-year project, with a budget of 21 M€, involving 62 partners from 18 countries (13 EU and 5 non-EU), plus supporters. The overarching objective of AtlantOS is to achieve a transition from a loosely-coordinated set of existing ocean observing activities to a sustainable, efficient and fit-for-purpose Integrated Atlantic Ocean Observing System (IAOOS), by defining requirements and systems design, improving the readiness of observing networks and data systems, and engaging stakeholders around the Atlantic; and leaving a legacy and strengthened contribution to the Global Ocean Observing System (GOOS) and the Global Earth Observation System of Systems (GEOSS).

The project is organized along work packages on: i) observing system requirements and design studies, ii) enhancement of ship-based and autonomous observing networks, iii) interfaces with coastal ocean observing systems, iv) integration of regional observing systems, v) cross-cutting issues and emerging networks, vi) data flow and data integration, vii) societal benefits from observing /information systems, and viii) system evaluation and resource sustainability. Engagement with wider stakeholders including end-users of Atlantic Ocean observation products and services will also be key throughout the project. The AtlantOS initiative contributes to achieving the aims of the Galway Statement on Atlantic Ocean Cooperation signed in 2013 by the EU, Canada and the US, launching a Transatlantic Ocean Research Alliance to enhance collaboration to better understand the Atlantic Ocean and sustainably manage and use its resources.

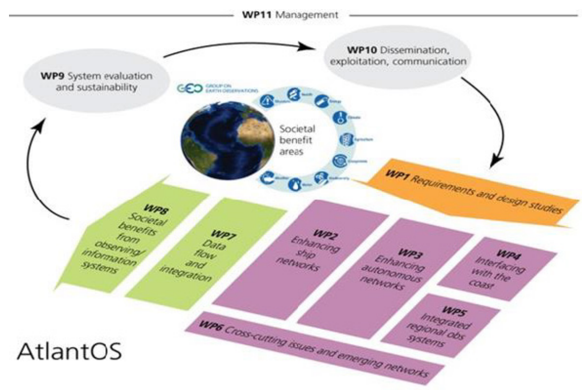

Fig. 1. AtlantOS project architecture and work flow.

The operational approach of AtlantOS includes a specific chapter (WP3 – Enhancing autonomous networks) related to ocean glider, as cutting-edge technology for a most sustainable and cost-effective ocean-observation capacity (Fig 1).

A. The role of PLOCAN in AtlantOS

PLOCAN, the Oceanic Platform of the Canary Islands is a Spanish multipurpose technical-scientific service infrastructure, suited by a set of large facilities that provide support to research, technological development and innovation in the ocean. The aim of PLOCAN is to build an infrastructure to promote marine science and technology of excellence and facilitate access to ocean areas while always safeguarding the environment. PLOCAN is a joint initiative of the Government of the Autonomous Region of the Canary Islands and the Spanish National Government (Ministry of Science and Innovation). PLOCAN's main role in AtlantOS refers to ocean-observation activities in the East-Central North-Atlantic area by the use of different autonomous and ship-based technologies, with special focus at ESTOC (European Station of Time-Series in the Ocean–Canary Islands). In order to accomplish the goals according to the task along the different work-packages, a wide range of ocean-platforms are used, being one of them ocean-gliders from the glider-fleet owned by PLOCAN.

B. Ocean-glider technology

Ocean-gliders technologyrepresents a new operational step in regards autonomous monitoring of physical and biochemical seawater parameters at surface and across the water column. Buoyancy-

driven (underwater) and surface-vehicles (ASV) are the two main families of ocean-gliders nowadays available and widely used by for different purposes. Underwater gliders (Fig 2) are autonomous vehicles that profile vertically by controlling buoyancy. By the other hand, ASV are platforms able to gather energy from the ocean (mainly wind of wave power) as motion-source. Gliders propel themselves by changing buoyancy and using wings to produce forward motion. Buoyancy is changed by varying the vehicle volume typically by O (100 cc) to create a buoyancy force of about 1 N. Wing lift balances the across-track buoyant force while the forward buoyant force balances drag. The ratio of horizontal speed O (25 cm/s) to vertical speed (glide slope) equals lift over drag and is typically 2 to 4, much less than for an aeronautical glider. Energy for gliding is supplied at the bottom of each dive cycle where work is performed to increase vehicle volume. On an O (1 km) deep-dive cycle lasting several hours, the O (10 kJ) energy used to change buoyancy implies a power usage for propulsion of about 0.5W. The saw-tooth flight-paths of gliders naturally sample the ocean both vertically and horizontally.

In both cases, profilers and surface technologies are open platforms able to carry on different sensor payload configurations, according to end-user needs, being the two main limitations: power and size/weight ratio. Water temperature, conductivity, dissolved oxygen, pigments, turbidity, nutrients, ocean-currents and meteorological are some examples of oceanographic parameters able to be monitored by these cutting-edge autonomous ocean-platforms.

Fig. 2. Buoyancy-driven glider technology example (Slocum G2. Teledyne Marine).

Buoyancy-driven and ASV gliders have become since some years ago part of the wide-range of ocean-platforms addressed to monitor the area of interest for PLOCAN and partners across the East-Central North Atlantic, as technical approach of the R3M -Maronesia Marine and Maritime Network- [6], the regional monitoring strategy in support to the main international ocean-observations programs and initiatives.

THE MACARONESIA AND R3M

The Macaronesia region is a wide ocean area with more than 5.5 million Km2 located in the East-Central North Atlantic that comprises four main archipelagos: Açores, Madeira, Canary Islands and Cape Verde (Fig. 3). All them clearly show a common volcanic (hotspot) origin which gives them similarities concerning biodiversity, although there is a climate variation due to their latitudinal distribution. The status of outermost region, the land fragmentation of each archipelago in islands as bounded units and the external dependence, are structural features that have conditioned and decisively influenced the development of human activities and the availability of resources. Despite this, Macaronesia has a clear and strategic international interest for all major socio-economic sectors within the marine maritime fields, which require information as derived product from the marine environment observations in a continuous and efficient way.

The R3M (Macaronesia Marine and Maritime Network) is a regional (linked globally) initiative aimed to increase the quantity and quality of marine environment observations across its four main archipelagos (Açores, Madeira, Canary Islands and Cape Verde), in order to understand and predict both the phenomena that take place on it and the related environmental and socioeconomic impact. The R3M is an integrative and synergic tool, making compatible and accessible to potential end-users (commercial and recreational navigation, harbors, safety & security, oil & gas, aquaculture, wastewater, tourism, marine research, water sports, ocean energies, protected areas, weather agencies, national and regional governments, etc.) all the marine environment observations [time series observations gathered by different "in-situ" and remote sensing platforms from cutting-edge and conventional methodologies], regardless of the institution or company that carry them out. The initiative includes technological developments for all types of required instruments and tools, aiming to make them more accessible both on a technical and economical point of view. The R3M has been built "from base to top", starting from the specific end-users towards general users, while keeping the goals and rules established by national and international agencies.

LATEST PERFORMED MISSIONS

A. MADEIRA-CANARIES TRANSECT -This glider mission was conducted and led by PLOCAN as part of its tasks committed within AtlantOS project work plan. The Instituto Hidrografico (IH) of Lisbon and the Madeira's Ocean Observatory (OOM) joined the mission as partners from the operational, scientific and strategic point of view in the Macaronesian context. The main goal of the mission was to evaluate cooperation capabilities between the abovementioned partners, looking for a permanent glider-endurance line between Madeira and Gran Canaria, as well as to identify new oceanographic features from water masses and associated processes from a high-frecuency sampling tool as it represents such type of autonomous platform, in comparison to the ship-based techniques used up to know as most common methodology for ocean observation in this area.

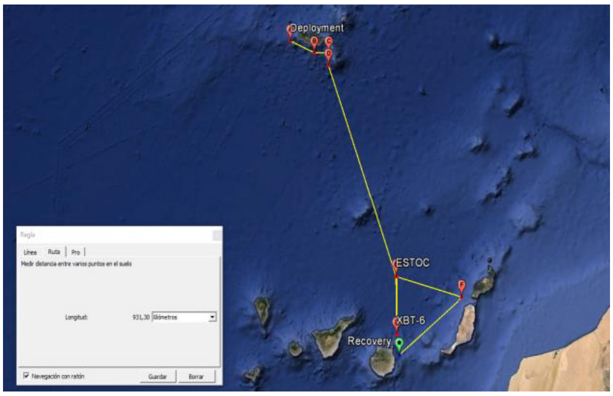

Fig. 3. Full glider path described across the mission.

A Slocum G2 glider owned by PLOCAN with a dedicated sensor-payload configuration (CTD, dissolved oxygen, turbidity and chlorophyll) was shipped to Madeira, place where the mission was started. After some last mission settings and verifications, the glider was deployed southwards Funchal from the Portuguese Navy's "NRP-Zaire" with the support of a Madeira's SAR rubber-boat. The nearly 1000 kilometers of glider-path between launching to recovery locations After 26 days of mission, the glider was successfully recovered northwards Gran Canaria from Spanish-Armada's "Meteoro" patrol-boat (Fig. 5). was divided in three areas (Fig. 3). An initial segment crossing the Island of Madeira, a second segment from Madeira to ESTOC site and the third and final one was conducted between Gran Canaria and Fuerteventura Islands. Piloting tasks were conducted from PLOCAN premises and data display was available along the mission through the glider portal web-tool. Additional data and modeling supporting piloting tasks were provided by OOM.

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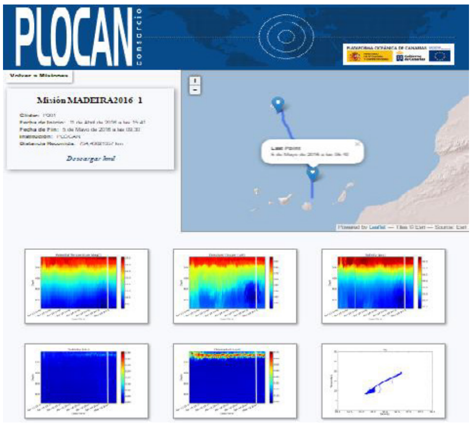

Fig. 4. PLOCAN glider portal tool.

Fig. 5. Glider recovery-maneuver from "Meteoro" patrol-boat.

Satellite derived observations including SSH and SLA from AVISO, SST from GHRSST, Ocean Surface Currents derived from satellite altimeter and Scatterometer data (OSCAR), monthly averages of Chlorophyll-a from MODIS-Aqua, NCEP wind and wave forecast using WAVEWATCH III, and forcing winds from GFS have been used as product-tool. MERCATOR-IBI36 hydrodynamic regional model forecast based on NEMO application updated daily to plot SSH, SST, SSS, ocean-current vectors over flow speed.

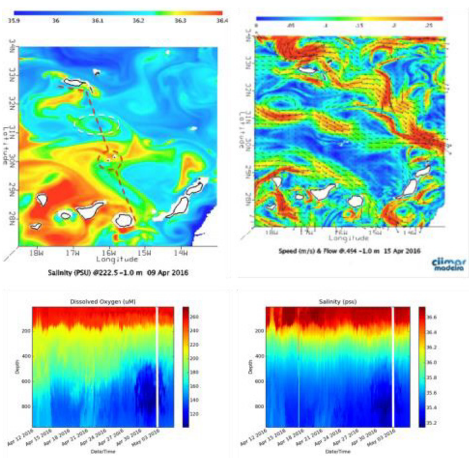

Fig.6 . Derived product-tools and preliminar derived results.

B. MSM61 – Oceanographic cruise MSM61 aboard the German research vessel RV/Maria S. Merian to study the physical and bio-geo-chemical characterization of the outstanding ecosystem of the Senghor Sea Mount located Northwards Cape Verde Archipelago, and to assess the operational response and capability of new, autonomous oceanic observation technologies in real operational scenarios. The study is part of AtlantOS and includes deploying and operating a range of autonomous observation equipment and platforms, such as multi-parameter modules anchored in the water column and on the seabed, autonomous surface marine vehicles (gliders) - SV2 and SV3 Wave Gliders - and profilers (Slocum G2-1000), all fitted with specific sensor equipment for taking samples and data in-situ, in response the scientific and technical needs and objectives set for the mission and the project.

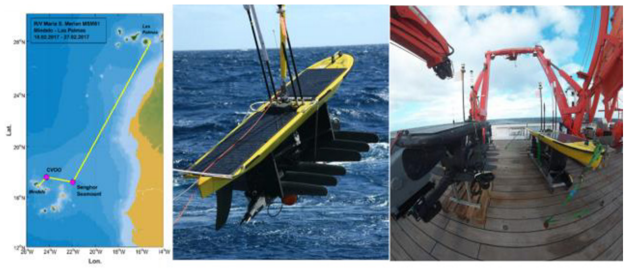

Fig. 7. Mission path, Wave Glider unit and MSM deck view.

C. CHALLENGER MISSION – The Challenger One is an international program initiative where PLOCAN cooperates with Teledyne Marine and Rutgers University in regards a Slocum G2 glider unit, under the name of Silbo, that attempts to circumnavigate the North Atlantic basin, for scientific and technological purposed. Deployed in Ireland in May 2017, after 178 days of navigation across the Macaronesia, Silbo reached Gran Canaria on November 2017, where is expected a maintenance and battery replacement before to be re-deployed. Glider data from the Challenger Mission is flowing to Global Telecom System and is being assimilated by European and American global ocean forecast models. The glider data has been used to assess the predictive skill between the American and European operational global ocean forecast models.

Fig.8 . Silbo after recovery and path described in this leg.

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