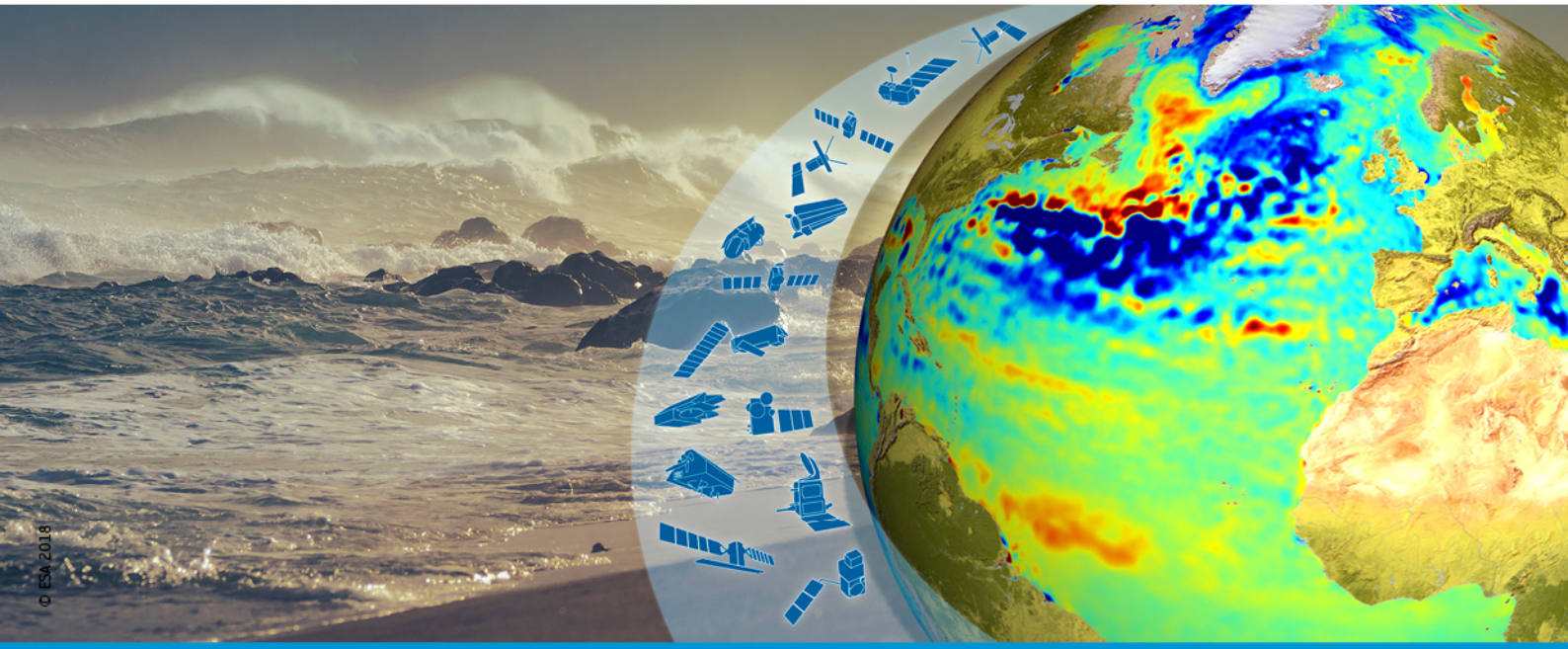
→ ATLANTIC FROM SPACE WORKSHOP



ABSTRACT BOOK

23–25 January 2019 | National Oceanography Centre | Southampton, UK

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- Victor Silva, Foundation for Science and Technology, Portugal

3. Abstracts

Session A1: Supporting and Strengthening Innovation Clusters in the Atlantic Region

The role of space applications in the context of the Atlantic region and the ESA Atlantic kick-start initiative

Mugellesi R.[1]
[1]*Esa*

The Atlantic and its resources are recognized as being essential for addressing the multiple challenges that will be faced in the decades to come being key source of food, energy, minerals, jobs and transport. The challenge is promoting sustainable development of Atlantic economic sectors with high growth potential as the marine aquaculture, the ocean renewable energy exploiting the potential of tides and waves, the seabed mining, the hydrocarbon exploration and production and the bio-economy. Emerging Atlantic industries are in particular characterised by the key role played in their operations by cutting-edge science and technologies, moving increasingly to high level of automation and benefiting from satellite technology, tracking and imaging.

The focus of the presentation is on the application of space data for the development of services within emerging ocean industries while managing the Atlantic in a responsible and sustainable way. Several applications supporting the Atlantic economic development as Seabed mining, concerned with the retrieval of minerals occupying the ocean floor, renewable Ocean energy from waves and tides and Marine aquaculture will be presented. In particular, these applications will demonstrate the value of satellite data in the development of services integrating new and existing navigational tools for enhancing the safety of ships at the sea through better organization and exchange of data between ships and shore. Investigating the use of Integrated Atlantic multi-use platforms as joint location of offshore industries capturing the synergies offered by the use of different ocean-based technologies, renewable energy (wind, wave, etc.), marine aquaculture, maritime transport and logistics, marine research, biotechnology deployed on the same site. AI techniques can contribute in important ways to a more effective enforcement and conservation of Atlantic ecosystem by making possible to extract valuable information from the huge data volumes and allowing to monitor, model, and manage the environmental systems.

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AtlanticGEOSS: Cooperation for a better understanding of the Atlantic

Catarino N.[1]*, Moutinho J.*[2]
[1]*DEIMOS,* [2]*AIR CENTRE*

In 2015 the UN members agreed upon a new set of strategies to promote a sustainable development, defining 17 Sustainable Development Goals (SDGs) to be achieved over the next 15 years. Earth Observation (EO) data and monitoring systems have proven to be an effective solution for a deepened understanding of the marine environment and, as a result, a better response to emerging challenges. The AtlanticGEOSS is an initiative proposed in the context the Atlantic Research Centre (AIR-Centre), focusing on an integrated approach for Earth Observation based services. It will be proposed as an official GEO Initiative to the Group of Earth Observations in 1Q19.

The goals of the AtlanticGEOSS are to develop an integrated EO framework that promotes collaboration and growth within the Atlantic countries, and to engage with communities to identify and potentiate opportunities for EO information and services, serving the region's societal needs.

The AtlanticGEOSS is focused on Marine, Maritime and Coastal application areas, such as monitoring marine biodiversity and protected areas, fishing and aquaculture, and marine spatial planning. Geographically, the initiative is based on the extension to the South Atlantic of the Galway Statement - the Belém Statement, signed between the EC, South Africa and Brazil. The initiative comprises institutions from many Atlantic states from Europe, Africa and America, in order to facilitate the creation of value-added services for federated users in support to decision-making processes.

The four pillars of the AtlanticGEOSS are 1) federating user needs for the Atlantic leveraged mostly on the AIR-Centre extensive network; 2) matching the user needs with solid Earth observation technologic and scientific players in Atlantic bordering countries; 3) engaging International and National Funding Institutions to support the initiatives with highest impact; 4) promote dedicated capacity building to ensure the local and widespread sustainability of the activities.

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Atlantic Blue Smart Clustering

Espiñeira Guirao T.[1], Ruiz de la Rosa M.[1], Caballero A.[1]
[1]Atlantic Cities

Marine Park is a collaborative space for the development of marine innovation projects and start ups with its business related to the sea and the Blue economy. This center is managed by a private non-profit association, Emerge, and two public entities collaborate with it, the City of Las Palmas de Gran Canaria, through the Sea City of department and the Government of the Canary Islands, through Sodecan

Its location next to the beach of Las Alcaravaneras and near the third largest port in Spain, the La Luz and Las Palmas, allows to test products and services with low cost and global scalability, making numerous companies both local or international (i.e. United States or Israel) are interested in their business model and are currently collaborating in multiple fields.

Among those collaborations, the Protoatlantic INTERREG Atlantic Area project project that brings together similar centers from five countries of the European Atlantic Arc in order to scale and cooperate their entrepreneurial vision, generating a network of centers business and European start-ups linked to the blue economy.

ProtoAtlantic will develop a model for the prototyping and exploitation of innovative ideas in the maritime sector. The project will focus on three well-defined sectors: Renewable Energy, Marine Robotics and Blue biotechnologies.

ProtoAtlantic will identify product innovation capacity in the maritime sector willing to address emerging markets in a co-creation model with start-up communities, research centres, universities and Local Authorities. The project exploits existing co-working facilities and blue acceleration programs specialized in the marine sector and replicates success stories.

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How Pre-Commercial Procurement Can Boost Innovation in Earth Observation Applications: The Marine-EO Project

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Marine-EO, a Horizon2020 funded project in its second year of implementation by a consortium of maritime countries - Portugal (Azores and Mainland), Spain, Norway and Greece - teams up a group of five maritime authorities (the Buyers Group) and four prestigious scientific and technical organizations with significant experience in Earth Observation and maritime affairs.

The consortium faces the challenge of acquiring competitive Copernicus based innovative maritime awareness services, through a Pre-Commercial Procurement (PCP) process that encompasses two thematic areas –Environmental Monitoring and Security.

Solutions found by the private entities competing in this process are expected to contribute to the Common Information Sharing System and other relevant frameworks related to maritime awareness.

In summary, the project fosters the development of satellite-based innovative products and services, while simultaneously enabling public authorities to (i) pursue a shared and comprehensive approach to maritime security risk analysis and (ii) to make an informed and timely decision, benefitting from cost efficiency GEOINT (geospatial-intelligence) production.

Successful implementation of the PCP will allow for a large-scale deployment of innovative solutions linked to the use of European Structural and Investment Funds.

Several “High-Level Scenarios” will be prepared for the post-Marine-EO period to provide the EU’s EO maritime surveillance services cooperation umbrella.

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AIR Centre: Stimulating the Use of EO Tools for Decision-Making in the Atlantic

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[1]AIR Centre, [2]GEO Blue Planet

Atlantic countries and regions, namely small Atlantic islands and emerging economies, need to be ready to take complete advantage of the prolific amount of Earth observation data that is available from multiple satellite missions as well as other observational platforms, and convert them efficiently into services that can support decision-making for end users. Within this context, how can Earth Observation support sustainable development in the Atlantic region and what is the role of the AIR Centre?

Recognising that Earth observations are a means to an end, the AIR Centre acknowledges that there are many existing long lasting national and international organisations and programmes aimed at developing Earth observation capacity, such as ESA, Copernicus, GOOS, INPE, SANSA, GEO Blue Planet, UNOOSA, to name only a few. The AIR Centre is poised to work with and along all of these initiatives and will not replace nor duplicate the existing efforts.

The AIR Centre is ideally placed to enable a process whereby the needs in terms of data, information and

services of the Atlantic Ocean countries are identified. These requirements can be of local, national or regional scales and can stretch between many different sectors of society.
The AIR Centre therefore aims to set-up a collaborative framework to identify, consolidate, sustain, stimulate, promote and build capacity for existing EO based services of use for Atlantic Ocean countries; new EO based services which can be implemented from existing EO data; and future EO based services to be developed with novel EO datasets and platforms.
The AIR Centre's comprehensive approach to Earth observation will therefore include: partnering with global/regional actors; participating in global/regional networks; understanding user needs; supporting the integration of satellite imagery, in-situ observation data through assimilative, predictive numerical models; stimulating new sensing technologies and methods; fostering cutting-edge data science: artificial intelligence, deep learning, deploying new satellite constellations; promoting capacity and institution building; providing new services and products, and disseminating useful information
This presentation aims to inform about the AIR Centre's Earth observation programmatic strategy; to communicate priority areas of needs for Earth Observation-based services; and to discuss medium to long term implementation roadmap.

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The Oceanic Platform of the Canary Islands (PLOCAN) – Leading Test Facilities for Marine and Maritime Research, Technological Development and Innovation

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The Oceanic Platform of the Canary Islands (PLOCAN) is a joint initiative between the Spanish and the Canary Islands governments, with the support of the European Regional Development Fund. It represents a multipurpose service centre with land-based and sea-based novel infrastructures to support research, technology development an innovation in the marine and maritime sector. Its mission is to promote long-term observation and sustainability of the ocean, providing a cost-effective combination of services, such as observatories, test site, base for underwater vehicles, training and innovation hub.
PLOCAN has extensive experience in research and development activities in fields such us Ocean and Wind Energy, Ocean Observing and Monitoring Systems, including autonomous vehicles and the management of metoceanographic data. In particular, PLOCAN contributes with the hosting of equipment, devices and marine technologies, for testing, validation and demonstration activities and/or any other necessary experiments in its marine test site. The housing services imply rights and regulated conditions to use the facilities and its 23Km2 of marine test area, as well as associated services such as transport, installation, maintenance, monitoring, decommissioning, permits, accommodation, and insurance among others.

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Atlantic Youth Creative Hubs - Social innovation for young people through design, creative thinking, digital technologies and Maker Cultures.

Raud O.[1]
[1]Plymouth College of Art
Atlantic Youth Creative Hubs (AYCH) is a European project funded by the Interreg Atlantic Area programme, aiming at building a model of social innovation for young people supporting social entrepreneurship, employment and education in the Creative Industries and the wider economy. In this presentation Oli Raud will highlight how this project and the practice of Plymouth College of Art respond to the marginalisation of arts and creative subjects in education and the crucial role of creativity in innovation that is both inclusive and rich in transdisciplinarity.
Specifically he will talk about how the AYCH project has chosen a number of themes that include challenges linked to sustainable development, social innovation, environment and climate change, circular economies, waste, mobility, mental health and (un)employment, among other societal issues of our time, so that young people from across the Atlantic Area can employ their creativity, design and technological skills to present solutions to theses challenges. "As all partners of the AYCH project share borders, they also share a responsibility to develop new solutions centred on human and natural capital that will benefit us and future generations".
He will go on to explore how AYCH provides a platform to take risks and create agency among young people to be the change that is needed in the world. Also, how as technology is increasingly democratised and easy-to-access – 3D printing, IoT, VR etc. (all of which are taught as part of AYCH), so must education be. A major driving force of AYCH is the development of an education programme that takes the ethos, values and elements of Higher Education but it is brought out of the institutions and delivered in non-formal settings, thus making it no longer the reserve of just fee-paying students. We believe this is the way that the most change can be affected, for the most amount of people

and really gives credence to the notion that education is for all and in an knowledge economy, a skilled and creative workforce and citizens is arguably our most important asset. “This project is not just about Smart Cities, it’s about Smart Citizens”

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Session S1 Open Ocean and Coastal Processes

Bathymetry Improvement and Tidal Modelling in the North-East Atlantic Ocean

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Coastal processes (tidal currents, storm surges, waves) are highly dependent on bathymetry and directly impact offshore and coastal activities and studies. Many studies and applications lie on a growing modelling effort of the ocean and the limited accuracy of bathymetry, especially on the continental shelves, contributes to degrade numerical model performance despite significant use of in-situ and satellite measurements assimilation. In particular, the tidal models are very sensitive to the bathymetry accuracy on the shelves, where the ocean tides show the largest amplitudes and are strongly non-linear. The increase in the grid resolution, together combined with local model tuning, is one of the means to improve the tidal model performance in the coastal regions and large improvements have been achieved thanks to this approach. However, increasing the resolution of the model grid implies consistent bathymetry quality and accuracy, which is today the main limiting factor to high resolution tidal modelling.

Better knowledge of the tides has a direct impact on the quality of the satellite altimetry sea surface heights and of all derived products such as the altimetry-derived geostrophic currents, the mean sea surface, the mean dynamic topography and the geoid. It is also of particular interest for boundary conditions of high resolution ocean circulation modelling on the shelves. Finally, accurate tidal models are highly strategic information for ever-growing maritime and industrial activities in the coastal regions.

Various sources of bathymetry data exist but many regions remain not well known because of too sparse measurements, data access limitation or large temporal variability of the seabed dynamics. In this context, CNES funded a project that aimed to improve the bathymetry and the tides in the North-East Atlantic continental shelves. The work was divided in several steps: 1) an inventory of existing datasets and methods to derive the bathymetry on the shelves; 2) the integration of the collected datasets into a reference global bathymetry dataset; 3) the evaluation of this new bathymetry dataset through hydrodynamic modelling and the production of a high resolution regional tidal model. This paper will present the main results obtained within this project.

Observing and predicting internal wave interactions between the Amazon plume and the equatorial currents in the tropical West Atlantic

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The tropical Atlantic Ocean off the Amazon River mouth comprises a complex and important earth system where multi-scale ocean processes combine and are ultimately determinant to the earth climate. For instance, rich nutrients of the Amazon River are discharged and entrained into the North Brazil Current (NBC) which flows along the shelf, approximately north-westwards. The NBC is constrained, in the upper 100 m of the water column, by the opposing Atlantic North Equatorial Counter-Current (NECC) flowing eastwards near the surface at about 6°N. Eddies are formed along the shelf break and at the confluence of the NBC and NECC, contributing to shelf-ocean exchange processes. The NECC transports the productive water across the Atlantic towards the western African coast, ultimately feeding the Guinea Current. Satellite measurements of the "plume" area in the Atlantic have been used to estimate the size of the associated atmospheric carbon sink (Cooley et al., 2007). This large scale picture is accompanied with mixing processes at fine scales, for which internal waves (of tidal and much shorter periods) are believed to play a significant role. These are large amplitude internal solitary waves (ISWs) with vertical displacements of the order of 100 m that become highly nonlinear, with large vertical velocities and heat fluxes that exceed 1000 times the background unperturbed upper-ocean (Shroyer, 2009).

In the framework of the AMAZOMIX project lead by the French (Laboratoire d'Etudes en Géophysique et Océanographie Spatiales, LEGOS), an in situ sampling program is being planned off the Amazon River mouth and into the deep western tropical Atlantic. The main goal is to survey mixing and turbulent processes, and contributions thereof for biological and biogeochemical processes as well as for the local ecosystems. In particular, internal waves will be measured to assess how dissipation at generation sites compare with that along their propagation paths. Satellite observations and modeling will complement the in-situ observations. We reveal that the Amazon shelf break is a powerful hotspot for intense ISWs. Satellite Synthetic Aperture Radar (SAR) data show their two-dimensional horizontal structure and yielded important results concerning their generation and propagation characteristics. Two distinct generation sites were identified off the shelf slopes, each associated with a different pathway of ISWs, but both consistent with an energetics analysis exhibiting high Internal Tide (IT) conversion rates (provided from the Hybrid Coordinate Ocean Model – HYCOM). These largescale waves are characterized by their elevated propagation speeds and remote appearance several hundred kms away from the nearest forcing bathymetry. These large distances are explained in light of a late disintegration of the IT, based on standard parameters governing the balance between nonlinear and dispersion effects, and the decrease of the waveguide (i.e. thermocline) thickness along a pronounced density front. Furthermore, we propose a method to retrieve ISW amplitudes from SAR altimeter measurements (Sentinel-3) and derive current profiles in the water column based on sea level displacements and our knowledge of density climatology. The method, as well as other important questions, will benefit from the dedicated in situ measurements from AMAZOMIX.

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Observational challenges for studying coastal eddies: an application case in the Bay of Biscay

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Recent work has demonstrated the recurrent presence of coastal eddies (diameter about 50 km) in the area covered by a land-based HF radar (HFR) in the SE Bay of Biscay. These eddies can persist during several weeks and play a significant role in the export of coastal rich waters towards the open ocean. The study of their surface properties at high temporal and spatial resolution is possible thanks to the continuous monitoring of surface currents within the HFR footprint area. Their observation using satellite measurements is also possible, although limited by the discontinuous coverage and resolution of the data. These rapidly evolving eddies can be detected by the altimetry; nevertheless, the low spatio-temporal resolution of the data does not always enable to map accurately the associated surface geostrophic currents. In the periods of low cloud coverage, visible and satellite IR data offer further possibilities, when combined with an appropriate theoretical framework as: the use of sequences of images to retrieve the velocity field that originated the motion of the observed tracers, or the use single SST maps to derive high-resolution surface currents using an approach based in the Surface Quasi-

geostrophic (SQG) approximation. Lower-resolution but more repetitive maps can be constructed using microwave remote sensing data, as AMSRE SST or L-band SSS, that are not affected by the presence of clouds. Within the framework of SQG it is possible to retrieve the three-dimensional dynamics of the eddy, if environmental and dynamical conditions are the appropriate.

These eddies could be more frequent than commonly thought, and thus may play a very significant role in the transport of water masses in the Atlantic. But in the absence of an extensive network of HFRs along the basin coast, this idea is speculative. The use of remote sensing maps to extract dynamic information about these coastal processes could help filling this gap. In this work, we investigate the range of application of SQG to solve and describe coastal eddies, comparing with measurements from the SE Bay of Biscay HFR and we discuss the prospect of extending this approach to the whole Atlantic coastal area.

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Opportunities for Coastal Risk Applications offered by SAR-mode Satellite Altimetry

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It is well established that global sea-level is increasing and that large-scale weather patterns are changing. However, across large parts of the world, there is a lack of observational data on which to implement evidence-based approaches to coastal adaptation. Satellite altimetry provides several decades of sea level, winds and waves data that are highly relevant to these problems.

The coastal zone presents significant challenges to altimetry that call for specialised processing. In this paper we present recommendations from recent projects that developed and applied improved altimeter products for Coastal Risk applications.

First, we review results and recommendations from the ESA-funded SCOOP project which evaluated different SAR altimeter processing schemes to achieve the best performance near the coast.

We then present recent applications of coastal altimetry in two projects funded by the UK Space Agency, where output from the NOC ALES-based altimetry processor were exploited for coastal risk assessment in UK regional seas and the South-West Indian Ocean.

Thus, Sea Level Space Watch is a demonstration service designed to support agencies in the UK responsible for flood defences and the preservation of coastal habitats threatened by sea level change. C-RISe delivers a Coastal Risk Information Service for the South West Indian Ocean, providing information on sea level, winds and wave heights derived from satellite altimetry and scaatterometry. This Overseas Development Assistance project also features capacity building and training workshops on the use of marine satellite data to quantify coastal hazards and their incorporation into local decision making. Although C-RISe is currently focussed on the SW Indian Ocean, the service concept offers interesting possibilities elsewhere, particularly to Small Island Developing States in the Atlantic zone facing similar problems.

The paper will present an overview of these services and initial recommendations and lessons-learned from Use Cases and training programmes.

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UPorto activities in Earth Observation - a contribute to a better monitoring of open-ocean and coastal sea level

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Amongst the various EO techniques, satellite altimeters have the distinct capability of observing the open ocean repeatedly, continuously and globally, with centimetre-level accuracy. However, as altimeters have been designed to observe the open ocean, particular problems arise in coastal regions, due to several factors, namely the large size of the altimeter footprint and of its accompanying microwave radiometer, when they sense land, simultaneously with water, that possesses a completely different surface backscatter and emissivity. This brings additional difficulties to the retrieval of accurate sea surface parameters (sea surface height - SSH, backscatter and significant wave height) and in the modelling of the range and geophysical corrections required to account for the phenomena that affect the measured SSH. The monitoring of coastal sea level, of upmost importance for efficient management of the sensitive coastal zone, requires high level altimeter products provided at the highest possible rate, using state-of the-art retracking algorithms and tuned corrections to the altimeter range.

For the last two decades, the University of Porto (UPorto) has been involved in satellite altimetry studies focused on the development of methodologies to improve altimeter range and geophysical corrections in the coastal zone and their application mainly in the North-Atlantic Ocean. This paper aims at presenting a

survey of the activities of the UPorto, Faculty of Science's (FCUP) team in these topics of great relevance for the building of a coastal sea level dataset for the Atlantic Ocean.

Altimeter studies have been focused on the development of methods to derive accurate SSH datasets over coastal and inland water regions. Of particular relevance has been the implementation of the GPD+ (GNSS-derived Path Delay Plus) algorithm to retrieve continuous (valid over all surface types), consistent and accurate wet tropospheric corrections (WTC) for all altimeter missions that span the main satellite altimeter era, since 1991.

The GPD+ WTC have been selected for use in the generation of products from the ESA Climate Change Initiative Sea Level (SL-cci) project, being currently made publicly available by AVISO, in addition to the UPorto webpage. The correction is being computed operationally and made available in CryoSat-2 level 2 products, being also present in Envisat V3.0 products.

Additional work has been carried out in the retrieval of accurate tropospheric corrections for inland water applications and on the sea state effect on altimeter range, the sea state bias.

These activities have taken place in the scope of various national and ESA funded projects, in strict collaboration with national and international institutions, e.g., Instituto Hidrográfico, FCUL, Univ. Açores, NOC, SAtOC, CLS, etc.. National and Interreg Spanish cross-border projects in the scope of which various EO studies have been conducted in the North Atlantic include: SATFISH, POCUS, RAIA, ASH, etc.. ESA sponsored projects include OCEAN EYE, COASTALT, SL_cci, CP4O, SHAPE and SCOOP.

A summary of these activities is presented as well as the UPorto contribution, in the context of collaborative national and international efforts, to a better monitoring of the Atlantic Ocean, with focus on the coastal zone and the regional sea level.

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Regional sea level and sea state change in the Atlantic from space

Fenoglio L.[1], Brockmann J.[2], Stolzenberger S.[1], Uebbing B[1.], Rietbroek R.[1], Kusche J.[1], Schuh W[2.], Karegar M.[1]
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Satellite remote sensing is an increasingly useful tool to globally monitor and analyse essential variables and climate change impacts from drought and inundation monitoring to long-term sea level and ocean circulation changes. Within the Atlantic context, we address contribution and limitation of remote sensing to the three issues: (1) relative coastal sea level and sea state, (2) regional sea level budget near Greenland and (3) ocean circulation.

First topic is the change in relative sea level (RSL) and sea state at the coast. Tide gauges are the primary source of coastal observations and satellite altimetry provides complementary measurements relative to the Earth ellipsoid connecting coastal to open sea processes. Studies along the North-Eastern Atlantic show a good agreement between altimetry and VLM-corrected tide gauges with sea level trend differences smaller than 1 mm/yr in mean and RMS differences of few centimetres. Challenging are coasts with few or without tide gauges, where altimetry is the only source for the analysis of sea level and extremes (e.g., 20/50year return period), which enhance the vulnerability. Needed are a further reduction of the coastal gap, below the 2-3 Km corresponding to the enhanced Conventional (CA) and Delay Doppler (DDA) altimetry, and improved accuracy and precision. These appear feasible by enhanced SAR processing (fully focused SAR) and by new technologies, like the "swath-altimetry" (SWOT mission) and the Synthetic Aperture Radar imaging.

Secondly, we address the interaction of Greenland North East glaciers with the surrounding ocean. Focus are the 79°N glacier and the North East Greenland Ice Stream NEGIS (GROCE/BMBF). More than 25% of global sea level rise is caused by mass loss of Greenland ice sheet, driven by the warming of the North Atlantic. The challenge is to quantify the impact of the increased freshwater flux on the regional sea level budget. We analyse the gravimetric mass change with GRACE and SWARM data, sea level changes with satellite altimetry and changes in modelled sea surface height, temperature and salinity through simulations of the AWI FESOM model driven by the corresponding freshwater flux.

Finally we address the challenges in the determination of models for the mean sea surface, the mean dynamic ocean topography and the dynamic ocean topography. These surfaces are the reference for sea level change

and can be related to the steady-state ocean currents and to the changes in the current system. The established approaches typically derive gridded snapshots of the surfaces and therefore do not continuously describe changes in time. They also do not account for uncertainties in the observations. Moreover, the combination of different observations (currents, slopes, etc.) sensitive to a given functional is not straightforward. To address these challenges, we model the three surfaces by parametric finite elements. New observations, e.g. surface currents (SAR and SKIM), can be easily integrated in the model. Moreover, due to the parametric nature, extrapolation to the coastlines become possible, where a connection with tide gauges can be studied.

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Sea level trends and variability on the European shelf based on 2D statistical reconstruction and altimetry

Rasmussen T.[1], Madsen K.[1], Høyer J.[1]
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Increasing sea level has many implications on the shallow European shelf. Examples are an increased risk of flooding and changes to the design basis of offshore structures. For these and other reasons it becomes increasingly important to be able to plan for future sea level rises. A key factor in this is to be able to describe and understand the past sea level and trends of this. Several questions appear, among these: i) Satellite altimetry is widely used to calculate sea level trends, but can these products be used in regions close to the coast? ii) How does the trends from satellite compare with in-situ measurements?

The ESA Sea Level CCI product constitutes high quality monthly sea level variability and trend analysis for the open ocean. However, it is commonly used in the coastal zone. Here, we assess the quality in the coastal zone of the European shelf by comparing the monthly variability of the CCI with that of the statistical model and of independent tide gauges from PSMSL, taking land rise information into account. The aim is to determine the quality of the Sea level CCI and based on this; asses where it can be considered reliable. Finally, the trends of the statistical reconstruction, the independent tide gauges, and the altimetry are compared.

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Ocean data analysis and dynamical systems: applications and perspectives

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There exists nowadays an increasing amount of ocean data, available from different sources such as satellite altimeter observations of the ocean surface, radar or quasi true color images, or accurate numerical simulations of ocean velocity fields. The availability of accurate observations and ocean velocity fields, which are representative of the ocean state, open new possibilities to address important ocean challenges. We will describe two selected ocean applications, based on the analysis of ocean velocity data with dynamical system tools called Lagrangian Coherent Structures, that confirm the synergy and success of this combination.

The results described in [1] have confirmed that Lagrangian Coherent Structures provided a dynamical template that allowed an effective glider path planning for Silbo, one of the first transoceanic autonomous underwater vehicle missions that took place in the North Atlantic, and supported achieving unprecedented speed ups of the glider. Additionally the evolution of the fuel spill subsequent to the sinking of the Oleg Naydenov fishing ship in the Gran Canaria coast, Spain in April 2015, confirmed that quasi true color images jointly with this dynamical template, accurately described the long-time behavior of fuel blobs, identifying potentially dangerous regions for these types of oil spill disasters and the arrival points of oil slicks to the coast [2].

Finally we will briefly discuss prospective applications of these tools in coastal waste monitoring and Atlantic atmospheric contexts.

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The Atlantic Ocean And Factors Relating to Cyclogenesis

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The Atlantic Ocean has a unique feature. In the different hemispheres, it has completely different results of cyclogenesis. For example, in the Northern Hemisphere we observe hurricanes of varying severity, often leading to significant destruction. But in the Southern Hemisphere these hurricanes are practically absent. As we know, in the Atlantic Ocean specific water circulation influences the temperature background of surface waters. Temperature is one of the most important characteristics of cyclogenesis formation. However, we observe the absence of tropical cyclones when the ocean surface is warm enough for hurricanes creation. Apparently there is clearly the presence of another possible factor - salinity. Salinity is the main component of another parameter – density of water. Water circulation is dependant on water density. The author used the data of the Aquarius/SAC-D mission, launched on June 10, 2011. The mission was a joint venture between NASA and the Argentinean Space Agency (CONAE). The mission featured the sea surface salinity sensor Aquarius and was the first mission with the primary goal of measuring sea surface salinity (SSS) from space. Using these data we can understand why in different hemispheres with huge salinity in both hemispheres we observe the different result in hurricanes formation.

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Accuracy assessment of Sentinel-3A, MODIS-Aqua and VIIRS ocean colour products in the Atlantic Ocean.

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The Copernicus Atlantic Meridional Transect for Sentinel Fiducial Reference Measurements (AMT4SentinelFRM) collected high FRMs for the validation of a range of Sentinel-1, -2A, -2B, -3A and -3B products during annual voyages between the UK and the South Atlantic during September to November 2016 and 2017. AMT4SentinelFRM builds on the Atlantic Meridional Transect programme which has been running for 28 years and was established in 1995 in collaboration with NASA, as an independent platform to validate SeaWiFS Ocean Colour data. It not only provided vital FRMs for the duration of the SeaWiFS mission, but also served as a developmental and inter-comparison platform for selecting the most accurate ocean-colour algorithm for SeaWiFS. AMT4SentinelFRM has now developed the programme into a multi-sensor, multi-mission platform for satellite validation. In this paper we validate Sentinel-3A OLCI, VIIRS and MODIS-Aqua algorithms in the Atlantic Ocean including the oligotrophic, open ocean waters of the north and south Atlantic oligotrophic gyres, the productive waters of the Celtic Sea, south America and equatorial upwelling zone, coastal regions of the North Sea, western English channel and Patagonian shelf. We firstly quantify differences between sensors used on the different campaigns, then present an uncertainty budget for the radiometric measurements. Finally we evaluate a range of different atmospheric correction processors for Sentinel-3A OLCI to identify the most accurate in different regions. For the Atlantic Ocean, traditional analysis of water samples for HPLC Chlorophyll-a are complemented with an underway measurement system that collects along track particulate absorption measurements to estimate surface chlorophyll concentration with high accuracy (± 10% relative error). These quasi-continuous measurements maximise the spatial and temporal frequency of data acquisition to 40,000 underway minute-binned optical measurements, which in turn enhances the number of potential in situ match-ups with satellite data to approximately 300 match-ups. This allows us to assess problems related to the spatial-resolution of the sensor and provides data for a comprehensive comparison with NASA VIIRS and MODIS-Aqua satellites.

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Retroflection structures and transports as inferred from satellite-derived salinity maps

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Three major examples of western boundary retroflection regions occur in the tropical and South Atlantic: the North Brazil Current Retroflection, the Brazil-Malvinas Confluence and the Agulhas Current Retroflection. These three regions are characterized by the offshore diversion of a major boundary current, which sets the intensity of the returning limb of the Atlantic meridional overturning circulation. Here, we combine the Soil Moisture and Ocean Salinity (SMOS) sea-surface salinity (SSS) satellite products (generated at the Barcelona Expert Center) with high-resolution numerical model and in situ measurements, in order to quantify the seasonal changes in surface currents and transports. The analysis of the model data shows that

the largest horizontal SSS gradients coincide with those areas of highest velocities, with the median velocity vector being 90º anticlockwise (clockwise) from the horizontal SSS gradient in the northern (southern) hemisphere. The application of these results to the SSS satellite data allows obtaining water velocity and salt flux patterns, which are then used to estimate what fraction of the western boundary water and salt transports get retroflected.

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Improved satellite sea surface salinity maps to further the understanding of the Southern Ocean dynamics

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The Southern Ocean (SO), directly connected to the global ocean through the Atlantic, the Indian and the Pacific basins, may be responsible for transporting vast amounts of salt, heat and nutrients across basins, which in turn might have a direct influence in the global climate. According to the Coupled Model Intercomparison Project Phase 5 (CMIP5) predictions, a freshening around the Antarctic coast which can change the ocean dynamics around the Antarctic Peninsula is possible. However these predictions are hampered by the limited number of in situ temperature and salinity observations. the development of reliable satellite observation systems for sea surface salinity (SSS) and sea surface temperature at high southern latitudes can therefore contribute to improve the CMIP5 inter-annual variability and trends, as well as the understanding of the dynamics associated with the SO seasonal and intra-seasonal variability.

The Barcelona Expert Centre (BEC) has generated an enhanced SO SSS dataset (2011-2018) from the Soil Moisture and Ocean Salinity (SMOS) mission. The new SMOS SSS product is validated in the SO region against both in situ and an ocean reanalysis (ARMOR), model (GLORYS), and climatology (WOA) data. The in situ database comprises a suite of Fiducial Reference Measurements (FRM) which include ARGO floats, marine mammals observant and ship based observations (e.g., CTD, TSG, etc.) which have been collected by different research vessels (e.g. the Astrolabe, Hesperides, Agulhas, Agulhas II, and Akademik Treshnikov) over their Southern Ocean crossings. We have assessed the SMOS salinity fields in three different bands: Subantarctic, Antarctic and Subpolar bands. ARMOR, GLORYS, WOA and SMOS are in good agreement in the Subantarctic and Antarctic bands (with SMOS discrepancies of +/-0.1 psu). In the Subpolar bands SMOS is in better agreement with GLORYS than with ARMOR and WOA. In this region both, GLORYS and SMOS show fresher salinity fields and larger salinity variations than WOA and ARMOR. Regarding comparison with TSG, SMOS is able to capture fresh and saline plumes in the Weddell Sea, which are not captured by any of the other analysed products (ARMOR, GLORYS and WOA).

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Arctic and North Atlantic Sea Surface Salinity retrieval.

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The sparse number of in-situ measurements of Sea Surface Salinity (SSS) in the Arctic Ocean renders remote sensing platforms an invaluable tool to retrieve such variable. Recently, the Barcelona Expert Center (BEC) has deployed their version 2 of SSS Arctic data retrieved from Soil Moisture and Ocean Salinity mission (SMOS). The new salinity maps cover the 2011-2017 period in time and from 50°N to the North Pole in space, with a space-time resolution of 25 km and 9 days [1]. This spatial coverage includes zones of the North Atlantic Ocean of special interest. It is worth noting, the Hudson Bay, whose drainage basin collects most of the Canadian fresh water; the Greenland Sea and the Labrador Sea, of great climatological interest since they receive directly the freshwater supplied by melting processes; and the North Sea, that accounts important international, commercial fisheries and currently contains the highest number of offshore oil rigs in the world.

The Arctic and North Atlantic regions are challenging zones to retrieve SSS from remote sensing measures, mainly due to the low sensitivity of SSS to the L-band Brightness Temperatures (TB) measured by satellites when sea surface temperature is too low. Even worse, the eastern part of North Atlantic is highly contaminated by Radio Frequency Interferences (RFI) emitted in L-band as result of human activity.

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Additionally, close to the coast SMOS is affected by the so-called Land-Sea contamination due to the large difference of TB between the land and the ocean. Despite of those challenges, the current BEC product provides good spatial coverage --even close to the ice edge-- and rather accurate values.

The regional comparison between the SSS retrieved from SMOS and the close-to surface salinities provided by Argo profiles provides for the North Atlantic region (defined by a latitude range of [50°N:60°N] and a longitude range of [50°W:20°W]) a mean difference of 0.01 psu and a standard deviation (STD) of 0.35 psu; for the Denmark Strait the STD is reduced to 0.24 psu, and a mean difference of 0.03 psu; and for the Northern Sea we obtain a mean of -0.05 psu and STD of 0.29 psu.

The discharge of the main Arctic rivers (Mackenzie and Ob) is also better characterized with this new version of the BEC product, as compared with previous remote sensed SSS Arctic products.

BEC – together with ARGANS Ltd. and Home Nansen Environmental and Remote Sensing Center (NERSC)-- is involved in the recent ESA's Arctic+ Salinity project. The primary objectives of Arctic+ Salinity are to explore, develop and validate novel approaches to enhance SSS measurements on the Arctic from SMOS and SMAP (Soil Moisture Active Passive) missions and to better observe and characterize Arctic salinity dynamics and its links with Arctic processes (ocean circulation, E-P), especially its connection to land-ocean fresh water fluxes at regional scale. In the context of this project, BEC will implement, among others, new noise reduction techniques in the retrieved SSS with the aim of improving general quality especially close to the coast. Therefore, we expect to show also the improvements attained so far, in mesoscale salinity changes due to freshwater fluxes in semi-enclosed regions like the North Sea.

[1] E. Olmedo et al. "Seven Years of SMOS Sea Surface Salinity at High Latitudes: Variability in Arctic and Sub-Arctic Regions", Remote Sensing, 2018, 10,1772 doi:10.3390/rs10111772

Monitoring and surveillance of fishing activity in the central Atlantic.

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Earth Observation data are increasingly used to understand the dynamic ocean environment. These data are used by fishing vessels to target appropriate fishing grounds, and by science and management to understand and predict the distribution of target species, the activity of fleets which target them, and increasingly provide a means to monitor and survey the activities of fishing vessels in or near 'real time'. The information that satellite data provide can be used to design appropriate fisheries management measures (including spatial, temporal, species and gear restrictions), assess their ongoing effectiveness and ensure compliance. For example, designation of large expanses of the ocean as Marine Protected Area (MPA) is increasingly advocated and realised. However, the effectiveness of such MPAs, requires improvements to vessel monitoring and enforcement capability. Drawing on data from a three-year study of Ascension Island the role Earth Observation data in applied monitoring and assessment of fisheries is illustrated, as well as how these data can be used to inform models used in fisheries management.

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The offshore New European wind atlas

Karagali I.[1], Badger M.[1], Hasager C.[1]
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The New European Wind Atlas (NEWA) is a joint effort of research agencies from eight European countries, leading to the creation and publication of a European wind atlas in electronic form. One of the main objectives of the NEWA project is to create an offshore wind atlas extending 100 km from the European coasts. To achieve this, mesoscale models along with various observational datasets are utilised. Satellite wind retrievals from scatterometers and Synthetic Aperture Radar (SAR) instruments were used to calculate offshore wind resources at 10 m and later extrapolated to 100 m.

The aim of this study is to demonstrate the use and applicability of EO data for ocean surface winds for wind energy related applications

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Rheticus® Marine: Sentinel and Copernicus data for operative and continuous monitoring of coastal

waters and resources

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[1]Planetek Italia S.r.l.

Rheticus® Marine is an automatic cloud-based geo-information service designed by Planetek Italia to deliver fresh and accurate satellite-based data and information for the monitoring of coastal seawater quality and marine resources. It is based on satellite open data, such as the ones from AQUA/TERRA, Sentinel-2 and Sentinel-3 missions and from E.U. CMEMS.

At European level the Marine Strategy Framework Directive (MSFD) requires Member States to reach Good Environmental Status (GES) through the evaluation and improvement of 11 qualitative Descriptors among which Eutrophication. Rheticus® Marine uses CMEMS derived historical series of water quality parameters to identify sea areas that are homogeneous in terms of eutrophic behaviour and so are eligible for the determination of the MSFD zones where to perform the assessment of the GES. The designed service is tailored according to the needs expressed by the Italian authorities responsible for the MSFD implementation and it has obtained a high successful feedback from them.

Another relevant sector for which Rheticus® Marine provides operational services is Aquaculture. By real time monitoring and forecasting of relevant water quality parameters (obtained from MODIS and Sentinel-3/OLCI sensors, integrating and improving CMEMS products) Rheticus® Marine supports the daily decision activities of Aquaculture farms. Furthermore it includes a model – based on machine learning algorithm trained with historical data from CMEMS and the farms operators – which can predict the level of growth of the mussels/fishes and so support the decision of the best time to harvest in order to maximize profits. A pilot project is currently running in the Adriatic sea.

A further application is the support to Desalination Plants: by combining Sentinel-2 and Sentinel-3 data, Rheticus® Marine provides real time alerts to plants' operators about the occurrence of algae blooms together with other water quality parameters in the coastal areas and in the proximity of the plant's water intake. This allows users to take opportune timely decisions to avoid damages and/or interruptions of plant operation as well as to abide their duties concerning the monitoring and reduction of the impact of their operations to coastal areas. A Pilot project was successfully run in United Arab Emirates.

Within EUGENIUS, a H2020 project that provides viable market based Earth Observation services in different European regions, Planetek is responsible of the marine service portfolio consisting of the mentioned Rheticus® Marine services, entirely based on Sentinel/Copernicus data.

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On the improvements on wave forecasting in North Atlantic ocean

Aouf L.[1]
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Ocean waves generated by North atlantic storms can induce severe damages on european coasts as it was the case during the winter of 2013/2014. The brittany buoy managed by Meteo-France has recorded more than five times significant wave heights exceeding 10 meters. This work presents the recent improvement implemented for the regional wave model MFWAM dedicated to the north Atlantic ocean. We will discuss firstly the impact of the assimilation of altimeters and SAR directional wave spectra from open ocean to coastal zones. Secondly we will analyse the results on coupling between waves and ocean models developed in the frame of Copernicus Marine Service for Iberian-Biscay-Ireland (CMEMS-IBI) domain. Example of better sea surface height forecast is well observed when coupling processes are accounted during storms events Petra and Hercules in 2014. other examples regarding to the impact of ocean/waves coupling on key parameters such as sea surface temperature and surface currents will be also discussed.

Thirdly, we will discuss the impact of wind forcing from different atmospheric systems (IFS and ARPEGE) on swell forecast in the channel during storms.

Further comments and conclusions will be commented during the final presentation.

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Wave climate analysis for the North Sea

Karagali I.[1], Badger M.[1], Hasager C.[1]
[1]DTU Wind Energy

Renewable energies are growing rapidly, particularly in the North Sea. Offshore wind farms are installed at various regions of the Dutch, British, German, Danish and Belgian exclusive economic zones (EEZ). Furthermore, wave energy converters are also under. An important aspect both for wave energy converters but also for the Operation & Maintenance activities on offshore wind farms is the wave climate. ESA's GlobWave Altimeter Multimission SWH product was used to derive long-term monthly statistics of significant wave height for the North Sea. The aim of this presentation is to demonstrate the outcome and its relevance for offshore wind and wave energy applications.

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Using Sentinel-1 to detect aquaculture structures in Spain

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Aquaculture are a very valuable asset for many coastal countries and in the future they will play an important role in food security. Satellite remote sensing can improve the temporal and geo-spatial analysis of such marine facilities. Detecting platforms used for fish and shellfish farming provides a way to monitor assets and check they do not get damaged by storms. It also allows to identify illegal placement of structures in areas which should not host farms.

In this work, we want to evaluate the potential of a new methodology that uses Synthetic Aperture Radar (SAR) data. This is called intensity Dual-Pol Ratio Anomaly Detector (iDPolRAD). Extensive work has been carried out on detecting ships using SAR. However, the identification of smaller and non-metallic targets is still challenging especially when the sea conditions are rough. This work presents the very first test of the iDPolRAD with aquaculture structures.

The algorithm is based on the observation that the most of the maritime targets exhibit a different polarimetric behaviour compared to the sea. Specifically, the cross polarization channel and the ratio between cross- and co-polarizations (here referred to as depolarization ratio) increases. One of the reason is that complex targets (e.g. shellfish platforms) will provide scattering which will resemble Volume scattering or reflections from planes (mostly wet surfaces) with random orientations. They are therefore expected to have a polarimetric backscattering that is different from the one of the sea which is surface scattering.

We tested the iDPolRAD on a large amount of Sentinel-1. The test site is in the coastal area near Vigo, Spain. This is an area intensely exploited for the production of mussels with hundreds of platforms. The iDPolRAD seems able to increase the contrast between the sea background and the platforms allowing the identification of more platforms.

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Building a Fishery Support Service

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The balance between the need to assure food security to an increasing world population and a sustainable exploitation of fish stocks is a key societal pressing issue, translated into several targets of UN's SDG14 and SDG12.

The development of integrated fishery support services based in EO and non-EO data sources will help public authorities and fishing companies towards these objectives by: a) characterizing and spatially quantifying fishing pressures; b) linking fishing activities to catch/landing registers and environmental parameters providing information on fishing yields and potential fishing areas.

The baseline necessary to develop this service is: a) engaged end users willing to co-design and adopt the service; b) inclusion of algorithms/applications provided by expert partners, applicable to different regions/fish species; c) access to EO (e.g environmental/sea state parameters) and non-EO (e.g. e-log-books or landing declarations) datasets; d) access to cloud processing resources to develop and operationalize algorithms/applications; e) components to support operations (e.g. user management, data analytics and geoportal).

Deimos aims to develop such a service, in collaboration with key partners with expertise in fisheries, oceanography and ocean biology. A demo application was developed with the Portuguese Hydrographic Institute (Hidrográfico) to characterize potential fishing areas of sardine and mackerel in Portuguese coastal areas, based in EO sea state and environmental parameters, using information on fish landings provided by fishing authorities. It's available at simocean.pt, and ready to be co-developed with an extended end-users group. Another demo will be developed together with the Portuguese Institute of Sea and Atmosphere for deep waters pelagic species (tuna and swordfish) in the Northeast Atlantic.

This follows the work being developed collaboratively by Deimos (SIMOcean, Co-ReSyF, NextGEOSS, Marine-EO and SAGA), providing access points to marine datasets, and to a range of pre-operational and R&D services, from support to harbor navigation to coastal bathymetry and algae monitoring.

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Managing Atlantic Ocean resource availability and exploitation: Maritime vessel detection and behavioural analysis to identify uncooperative vessels associated with oil pollution and illegal, unreported and unregulated fishing (IUU)

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The make-up of the Atlantic, its bordering countries, and others who utilise the Atlantic's resource and marine traffic access, together hold a complex and inter-connected set of needs. These needs are often at tension with one another, so as competition increases, may require overarching and bilateral management.

Illegal, unreported and unregulated fishing (IUU) is itself a complex subject. In the maritime environment there are various systems designed to allow a vessel to make known its location heading and other parameters. Monitoring of IUU fishing requires a variety of data sources to detect vessels in protected and licensed areas, account for cooperative vessels and focus in on uncooperative vessels.

Traditional VHF Automatic Identification System (AIS), marine radar, vessel or shoreline reporting, aerial imaging alone are insufficient and ineffective is managing vast areas of ocean. Correlating satellite imaging and satellite AIS and further combining the resultant detections with behavioural analysis fills the gap left by patrols and ground-based systems, thereby disrupting uncooperative behaviours of the vessels' owners and providing evidential records for prosecutions where the behaviours of uncooperative vessels persist.

In this application domain, Telespazio VEGA & e-GEOS exhibit considerable experience and proprietary technology provides a well-trodden and robust modular Maritime Surveillance Platform - SEonSE (Smart Eyes on the Seas) http://www.e-geos.it/SEonSE/

SEonSE supports the detection of vessels with failed or malfunctioning GPS and/or transmitting equipment; vessels that deliberately deactivate their AIS to avoid detection; vessels that, because of their smaller size, are not under the obligation of having an on-board positioning system; as well as sport fishing vessels.

SEonSE identifies abnormal behaviours, such as trawlers in areas where trawling is forbidden; the presence of vessels in environmental protected areas; ships stationary in unusual locations; and ships sharing an unusually proximal location to one another.

SEonSE may also identify oil spills and their characteristics; relevant met-ocean information; and correlate these to obtain with high confidence the vessel and/or platform polluters.

The operational use of satellite-derived analytics for maritime applications allows worldwide ocean and sea monitoring, irrespective of whether the area is within the range of coastal surveillance systems; the behaviour of ships is cooperative or uncooperative; and the time of day.

Where detections and behavioural analysis is required in near real-time (NRT), it is possible to utilise ground-station antenna to receive, downlink, and process satellite imagery at local processing environments in the form of a Cosmo Commercial User Terminal (CUT). The Cosmo CUT provides direct reception of imagery from the COSMO-SkyMed constellation and the COSMO central archives located in Matera.

In a Cosmo CUT environment, SEonSE detections and behavioural analysis may provide rapidly distributed notifications, with specific situational awareness calls-to-action, to multiple stakeholders across the Atlantic. This NRT processing environment facilitates a greater number of interceptions, prosecutions and acts as a potent discouraging measure.

Session A3 Maritime Transport and Port Development

Implementation of Blue Growth Strategy in Port of Vigo

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Port of Vigo is located on the Norwest of Spain, specifically in the inner of the Bay of Vigo which provide excellent natural conditions for navigation. It is highly specialized in the movement of general merchandise diverse high-valued. Total port traffic of 4,233,680 t representing a "good's industrial value" of M 11,783.05 € and a turnover of M 25,078 €.

Presentation will introduce briefly basic port features as infrastructures, traffic lines, cargo and load/unload operative. Subsequently, it will be described the main tasks of the Sustainability and Development Department. Environmental management will be detailed focus on the efficient use of energy and resources. Port of Vigo manage high amounts of residuals daily, 80 % of them are valorised. There is also a strong compromise to reduce energy consume and increase the percentage of renewable sources.

All these activities are conducted within the context of the European Commission Strategy "Blue Growth",

encouraging the investment and technological innovation in areas related to Marine Economy. Indeed, Port of Vigo has pioneered in Europe the integral implementation of Blue Growth strategy as a collective effort by all the port's users, under the principle that Blue Economy must be forest equally by all stakeholders. Efforts are conducted to promote competitiveness, efficiency and sustainability in all the activities, installation and services.

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Atlantic Port Cities : Looking Back to the Sea

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[1]Atlantic Cities

The Port Cities of the Atlantic Area are dependent on large markets and remote centers of decision, reason why they see weakened their power of leadership. Also, due to the radial design of railway and road systems, the relationships
with the hinterland they have not reached a critical mass. In these circumstances, the economic activity located in the ports of the Atlantic Arc cities is conditioned by the liberalization and internationalization of the economy, by the economic strategies of the large maritime operators, but also by the strategies of the Port Authorities themselves and the cities in which they are located. Other factors that must be taken into account
are the industrial decline in areas where heavy industries once flourished, the necessary reorganization of port soils, changes in maritime transport and the development of logistics. However, from an urban point of view, the fight against
climate change and the defense of sustainable development are the fundamental factors that determine the reorientation of port-city relations.

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Unprecdented coverage of the earth Including ports and other important Maritime Areas

Jawad A.[1]
[1]Planet Labs Gmbh

Planet has launched more than 200 satellites to space and currently operates RapidEye, Dove and 13 SkySat satellites—the largest constellation ever deployed. This is enabled by a highly automated and scalable mission control and operations, as well as by the largest network of ground stations operated by any imaging company. This imagery is automatically processed via Planet's data pipeline and Platform, and made available to users visual or analytic purposes. Planet's proposed solution involves integrating imagery with machine learning based analytics and high resolution imagery to better understand movement and vessel activity at ports, to survey key areas of geopolitical interest for activity or change or provide additional detail on identified maritime objects of interest. Planet applies deep learning techniques to perform advanced imagery analytics to data collected by the Dove constellation. Leveraging this unique constellation provides a deep temporal and spatially broad data set covering the entire earth's landmass including ports and maritime areas globally.

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TOPVOYS - Tools for Optimizing Performance of Voyages at Sea

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The main goal of the TOPVOYS project is to develop, test, implement and provide reliable voyage optimization capitalizing on new advances in observation-based tools and decision support system. This is based on a comprehensive view and understanding of the major challenges and deficiencies with respect to ship routing. As such, TOPVOYS aims to advance: (i) searching, accessing, downloading, processing and analyzing of near real time satellite data for surface current retrievals; (ii) operational use of sensor synergy and visualization platform; (iii) automated tools and machine-learning system for routing planning and optimization; (v) voyage undertakings and ship performance monitoring; and (vi) post-voyage analyses and assessment. The involvement of shipping companies in the consortium ensures clear hands on user requirements as well as ability to efficiently test, assess and refine the quality of the tools. The voyage optimization will have valuable impact on fuel savings and reduction in CO2, NOx and SOx emissions. These are highly compliant with the IMO regulations and the new CO2 reporting requirement for ships entering/leaving EU ports. Fuel savings and emission reductions will, moreover, clearly have a positive impact on the green environment and blue economy and altogether contribute to the United Nations Sustainable Development Goals, in particular to #7: Affordable and Clean Energy; #12: Responsible Consumption and Production; #13: Climate Action; and #14 Life Below Water.

The TOPVOYS (Tools for Optimizing Performance of VOYages at Sea) project is funded under the MarTERA program (ERA-NET Cofund) with their partners including Research Council of Norway (RCN), French

Ministry of Environment, Energy and the Sea (MEEM), South African Department of Science and Technology (DST). The project has a duration of 36 months and kicked-off in October 2018.

Session S2 Biogeochemical Oceanography

Decadal reanalysis of biogeochemical indicators and fluxes in the North East Atlantic ecosystem

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In this paper we present the first decadal reanalysis simulation of the biogeochemistry of the North East Atlantic, along with a full evaluation of its skill and value. An error-characterized satellite product for chlorophyll (from the ESA's Climate Change Initiative - Ocean Colour) was assimilated into a coupled physical-biogeochemical model, applying a localized Ensemble Kalman filter. The results showed that the reanalysis improved the model predictions of assimilated chlorophyll in 60% of the study region. Model validation metrics showed that the reanalysis had skill in matching a large dataset of in situ observations for ten ecosystem variables. Spearman rank correlations were significant and higher than 0.7 for physical-chemical variables (temperature, salinity, oxygen), ~0.6 for chlorophyll and nutrients (phosphate, nitrate, silicate), and significant, though lower in value, for partial pressure of dissolved carbon dioxide (~0.4). The reanalysis captured the magnitude of pH and ammonia observations, but not their variability. The value of the reanalysis for assessing ecosystem environmental status and variability has been exemplified in two case studies. The first shows that between 340,000-380,000 km2 of shelf bottom waters were oxygen deficient potentially threatening bottom fishes and benthos. The second application confirmed that the shelf is a net sink of atmospheric carbon dioxide, but the total amount of uptake varies between 36-46 Tg C yr-1 at a 90% confidence level. These results indicate that the reanalysis output dataset can inform the management of the North East Atlantic ecosystem, in relation to eutrophication, fishery, and variability of the carbon cycle.

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The Assimilation of Phytoplankton Functional Types for Operational Forecasting in the Northwest European Shelf

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Using a large dataset collected in the North Atlantic, we developed a method to estimate the chlorophyll concentration of four phytoplankton groups (phytoplankton functional types, PFTs) from ocean colour satellite data. The PFTs were chosen to match those used in the ERSEM model. The method incorporates the influence of sea surface temperature, also available from satellite data, on model parameters and on the partitioning of microphytoplankton into diatoms and dinoflagellates. The method was validated using independent dataset and adapted to provide per-pixel uncertainty estimates. The estimated concentrations for PFTs surface chlorophyll were assimilated to physical-biogeochemical model (NEMO-FABM-ERSEM) and used for operational forecasting of biogeochemistry in the North-West European (NWE) Shelf. PFTs Data Assimilation (DA) was compared with total chlorophyll DA and the reference run. We show that apart of improving the total chlorophyll, PFTs DA has potential to also improve the representation of phytoplankton community structure both in the reanalysis and in the 5-day forecast. By validating the results with in situ data have shown that PFTs DA has significant positive impact on pCO2 (with potential impact on carbon cycle).

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Earth Observation for Management of Marine Ecosystems Resources and Natural Capital

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Ecosystem-based stewardship of marine resources has to be knowledge based. Ocean-colour remote sensing provides our only window into the marine ecosystem for acquisition of relevant data on synoptic scales. But to optimize the use of Earth observation from satellites, we also need access to in situ data. For the North Atlantic Ocean, we have the richest data sets anywhere in the world of the in situ information that complements EO data to give excellent retrieval of useful products from ocean-colour imagery. For example, to estimate primary production, the most

fundamental property for any discussion of marine resources, including fisheries, we need in situ data on photosynthesis parameters. The largest repository of such data is that assembled for the North Atlantic. Similarly, for high-latitude data on the marine ecosystem, the most complete data bank is that for the North Atlantic; it is vital for forecasting ecosystem changes as the Arctic ice cover diminishes. Therefore, the Atlantic Ocean provides us with the best of all study areas for investigating how to optimize the use of EO data to address questions relating to ecosystem services and natural capital in a changing climate, especially in high latitudes. In addition, there are many related scientific questions that can also be addressed to the best effect in the North Atlantic. These include the role of picoplankton in the marine ecosystem, the relation between chlorophyll and carbon in phytoplankton, and the assignment of photosynthesis parameters in operational mode using EO. All in all, the North Atlantic is the prime study area to broaden the range of applications of EO data in management of marine resources and natural capital, and to increase the quality of the products for the benefit of society. This work benefited from earlier ESA projects (OC-CCI, MAPPS, PPP and POCO).

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Deriving Ocean Monitoring Indicators over the Atlantic Ocean from the Copernicus Marine Environment Monitoring Service Ocean Colour time series

Pardo S.[1], Sathyendranath S.[1], Davies J.[1], Steele C.[1], Taylor B.

[1]Plymouth Marine Laboratory

The Copernicus Marine Environment Monitoring Service (CMEMS) is the Copernicus EU information service dedicated to the observation of the marine environment and the dissemination of satellite Earth Observation and in-situ data for the global ocean, with an emphasis in the European regional seas. In particular, the CMEMS Ocean Colour Thematic Assembly Centre (OC- TAC) is responsible for the production of a suite of state-of-the-art ocean colour products for the Atlantic Ocean, such as chlorophyll concentration and remote sensing reflectances. In this work we analyse the CMEMS OC-TAC 20-year (1997-2017) chlorophyll concentration time series, based on the global, multisensor, climate-grade Ocean Colour dataset produced by ESA's Ocean Colour Climate Change Initiative (OC-CCI). To obtain the most accurate possible representation of the phytoplankton dynamics in the regional seas, the OC-TAC develops regional chlorophyll algorithms that are then applied to OC-CCI remote sensing reflectances. The resulting dataset has been proven to be fit for climate research (Mélin, 2017), allowing us to investigate regional annual and interdecadal variability, to compute climatologies from which anomalies can be detected, and to derive long-term trends. We exploit these long time series to also study the trends in the spatial extent of the Atlantic Ocean oligotrophic gyres, and to assess the relationship between chlorophyll concentration and climate indices such as the North Atlantic Oscillation. These results are extended yearly and released within the Ocean Colour contribution to the CMEMS Ocean State Report, and will be available as Ocean Monitoring Indicator (OMI) products as part of the CMEMS catalogue coinciding with its next release.

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New statistics to bridge temporal and spatial scales of biological production in the ocean

Jonsson B.[1]

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Most current approaches to study primary production in the pelagic ocean either focus on narrow domains in time and space or are based on the concept that stocks can be used to estimate fluxes. While the latter approach has been highly successful in satellite oceanography when approaching questions that focuses on long time scales (seasonal -- decadal), it is of limited use to explore faster processes. There is also a tendency to approach biological processes in the ocean with the assumption that physical advection and dispersal is irrelevant to a first order. To address these challenges, we suggest a couple of new approaches to analyze satellite derived data.

In this presentation I will present work where we apply Lagrangian approaches to bridge different temporal and spatial scales and include physical transport. The approach allows for directly assessing changes in satellite derived fields and to assess links between planktonic community structure, productivity, and export efficiency across different ocean biomes. I will also suggest a new method to asses the dominating timescales of variability in phytoplankton biomass and its potential implications on ecosystem efficiency.

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Marine Biogeochemistry and Bio-optics along the Irish continental shelf

Croot P.[1,4], Cusack C.[2], Grassie A.[1], Jordan C.[1], Mullins M.[1,4], Nicholas S.[1,3,4], O'Donnell C.[2]

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Biogeochemical and Bio-optical measurements have been made during the summers of 2016-2018 along the Northwest European continental shelf, from the Celtic Sea to the Herbridean islands, as part of a combined field and remote sensing study into the biogeochemistry of this region. Current research themes are as follows: (i) Nutrient controls on primary productivity. (ii) The influence of Irish rivers on CDOM in this region (iii) Development of a regional algorithm for chlorophyll (Sentinel 3). (iv) Determination of origin of natural surface slicks (Sentinel 1) and (v) Harmful Algal bloom detection (Sentinel 1 and 3). This presentation will provide an overview of the project along with preliminary results from the most recent survey of the summer of 2018. Fieldwork is performed during the annual WESPAS (Western European Shelf Pelagic Acoustic Survey) expedition carried out by the Marine Institute onboard the RV Celtic Explorer. This work forms part of the Marine spoke activities of the SFI research iCRAG (Irish Centre for Research in Applied Geosciences).

Session A4 Safety and Security of Maritime Transport and Port Development

Challenges for Maritime Traffic Monitoring within the North Atlantic and Arctic – How can Space Technology provide solutions ?

Lynch R.[1]*, Looney M.*[1]*, Shanahan P.*[1]
[1]*Cork Institute Of Technology*

It has been widely acknowledged that the North Atlantic and Arctic regions pose a number of challenges for maritime stakeholders not only in relation to the harsh conditions typically associated with these environments, but also the significant lack of communications coverage from geostationary satellites. From a maritime traffic management perspective, in the event of a vessel operating within the Arctic requiring search and rescue assistance, the limited communication network, poor infrastructure, and design limitations of satellite communications equipment pose a number of challenges for vessels seeking assistance from rescue agencies operating within the Arctic and North Atlantic regions.

For Atlantic stakeholders operating vessels within the North Atlantic and Arctic regions, the lack of accuracy in relation to hydrographic data and survey results impairs the ability of industry partners to operate safely within these regions. The absence of accurate navigational knowledge and the ongoing ever increasing environmental changes within the Arctic are suggested to be so pronounced that they have been identified despite incomplete and uncoordinated observing capabilities. Such drastic and conspicuous change, further highlights the volatile and ever evolving nature of these regions. Furthermore, this lack of adequate and coordinated pan-Arctic observation currently limits society's capability to identify, respond to and predict the geographic extent and severity of ongoing changes. A robust Arctic observation network is therefore needed to address these limitations.

Emissions from vessels and the monitoring thereof continues to be a challenge for industry stakeholders. With numerous research sources forecasting significant increases in marine traffic density across all spectrums within these environmentally sensitive areas, the management of pollution control in the absence of monitoring technology developments, is likely to pose a number of challenges for industry stakeholders and the broader societal needs within these regions.

In relation to policy, while governing bodies and international agreements such as the Polar Code play a critical role in Arctic governance, it is individual countries that will continue to have the most influence within the region. All five Arctic nations have advanced detailed national Arctic strategies within the past six years, a sign of the increased attention the region is receiving on a national stage.

It has been widely suggested and supported that the advent of suitable space technology could, play a role in addressing the aforementioned challenges and indeed many others. Increased satellite coverage, earth observation developments, and technology innovations could play a major a role in providing safe and secure marine traffic within the North Atlantic and Arctic.

This thematic presentation will therefore set out to present some of the current challenges for Atlantic stakeholders in relation to safety and security, while also outlining policy considerations. Partners from the ARCSAR project, an EU funded initiative tasked with establishing the first Arctic and North Atlantic Security and Emergency Preparedness Network, will discuss how space technology could potentially play a major role in providing safe and secure marine vessel management and monitoring.

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Vessel Monitoring Based on Dual-Polarization Sar Images and Ais Data

Pelich R.[1], Chini M.[1], Hostache R.[1], Matgen P.[1], Lopez-Martinez C.[1], Eiden G.[2], Ries P.[2]
[1]Luxembourg Institute of Science and Technology (LIST), [2]LuxSpace

Vessel monitoring is made possible by combining information from different data sources that are generally divided in cooperative and non-cooperative sensors. In this study we showcase the utility of coupling Synthetic Aperture Radar (SAR) images, as a source of non-cooperative data, and Automatic Identification System (AIS) data flows, as cooperative data. The Sentinel-1 sensor acquires systematically SAR images over areas of maritime interests and presents several assets such as the open access policy data or the availability of complex dual polarization data. The latter one leads to the scientific research and following development of new SAR vessel detection algorithms. Over areas of maritime surveillance interest, Sentinel-1 is acquiring data in the VV-VH polarization configuration. In this study we explore several polarimetric descriptors derived from the VV-VH configuration, namely the complex VV-VH coherence and descriptors derived from the Eigenvalue decomposition of the VV-VH covariance matrix. Then, we perform a complete validation of the detection performances of the VV-VH coherence descriptor issued from the processing of several S1 images and the use of AIS data as ground truth. For the experimental results, we focus on Sentinel-1 Interferometric Wide Swath images with a resolution of 20m, acquired over different areas including both coastal and open sea areas. For the coastal areas, we propose a coastline delineation algorithm based on the bimodal distribution given by the different backscattering values of the sea and land areas.

Session S3 Atmospheric Dynamics, Transport and Energy exchange

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Potential of Sentinel-2 to monitor Arctic sea ice

Oppelt N.[1]
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The development of the Artcic sea ice, especially during the Arctic summer, is a critical element coupling the ocean and the atmosphere and influencing marine ecology, particularly in the context of climate change. Besides the use of radar, coarse resolution satellite missions are commonly used; higher spatial resolution missions, however, play a minor role. In this context, and although optical remote sensing is temporally limited by the seasonal availability of sunlight, the Sentinel-2 (S-2) mission offers potential to retrieve geophysical parameters such as spectral albedo of snow and ice as well as information about melt processes with a spatial resolution < 30m. With a spatial coverage reaching up to almost 84° north and a high revisit rate (up to one per day), S-2 can even cope with frequent cloud cover in the Arctic.

The spatial, spectral and radiometric setting of the MSI instrument enables observations of sea ice parameters on a new level of detail. The high spatial resolution allows detailed mapping of sea ice features such as melt ponds, ridges and leads, which span a range of meters to tens of meters. Moreover, coupling S-2 data and bio-optical models allow the assessment of pond extent, depth and optically active water constituents such as chlorophyll. Expeditions with the RV Polarstern in 2017 and 2018 confirmed that the combination of enhanced spectral, spatial and resolution allows a monitoring of Arctic sea ice with its high-contrast spatial pattern of open water, snow and ice. These two expeditions served as a pilot for the international drift experiment MOSAiC (2019-2020), where spectral sea ice and pond measurements will be conducted during the summer months in the far north of the Atlantic ocean.

Currently, geographical coverage is limited to areas close to the shoreline, leaving large areas of the Arctic Ocean unrecorded. Yet, geographical coverage may be extended on request. We therefore want to demonstrate the potential of S-2 for Arctic research and further discuss the possibilities to monitor the Arctic sea ice operationally.

The Surface Ocean-Lower Atmosphere Study (SOLAS): Contributing to our understanding of air/sea exchange in the Atlantic

Bell T.G.[1], Yang, M. [1], Smyth T. [1], Suntharalingham P. [1], Marandino C. [1], Kortzinger A. [1], Gier J[1]. and Miller L.[1]
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The Surface Ocean–Lower Atmosphere Study (SOLAS) is an international research initiative that aims to improve understanding of the key biogeochemical-physical interactions and feedbacks between the ocean and atmosphere. SOLAS research focuses on quantifying the air-sea interactions that occur across a broad spectrum of time and space scales and their role in the regulation

of global change. This talk will briefly introduce the major research themes within SOLAS. The second part of the talk will then discuss the value of air-sea carbon dioxide flux measurements using data collected at the Penlee Point Atmospheric Observatory and during the most recent Atlantic Meridional Transect (AMT) cruise.

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Changing Air-Sea Freshwater Fluxes and Ocean Salinity: From Wet gets Wetter to the Big Fresh Blob

Josey S.[1]
[1]*Noc*

Recent developments in global datasets and model representation of the ocean-atmosphere freshwater flux (E-P), and its connection to ocean salinity will be reviewed and some new results using the latest products (e.g. ERA5) will be presented. Particular consideration will be given to the use of datasets and models to investigate salinity changes since 1950 and their connection to changing E-P. The robustness of the wet gets wetter / dry gets drier paradigm according to which salinity increases (decreases) in evaporation (precipitation) dominated regions will be assessed with particular reference to signals that are common across different datasets. The most robust signal will be shown to be that of increased E-P in the southern hemisphere subtropical that is closely linked to increasing salinity in these regions.

In addition, variability on shorter interannual to decadal timescales within the SMOS era beginning in 2010 will be considered with a particular focus on Atlantic Tropical and mid-high latitude processes. Early analysis of observations from the SMOS satellite that revealed new aspects of Tropical Atlantic sea surface salinity (SSS) variability will be revisited and placed in the context of subsequent work. In particular, the out-of-phase seasonal compensation between eastern and western basin SSS regions of strong variability identified with the first few years of SMOS data will be reassessed together with the driving processes E-P and river outflow (R). Finally, salinity signals at higher latitudes – especially the subpolar gyre – in recent years will be discussed including potential links of an unusually low salinity feature (the Big Fresh Blob) to the 2014-16 cold anomaly (Josey et al., 2018).

Josey, S. A., J. J.-M. Hirschi, B. Sinha, Duchez, A., J. P. Grist and R. Marsh, 2018: The Recent Atlantic Cold Anomaly: Causes, Consequences and Related Phenomena, Annual Reviews of Marine Science, doi.org/10.1146/annurev-marine-121916-063102.

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Use of Satellite Data to Support Ocean Wind and Wave Forecasting - A Review

Abdalla S.[1]*, De Chiara G.*[1]*, Bidlot J.*[1]
[1]*ECMWF*

Reliable information regarding marine wind and wave data is very essential for a vast range of coastal and marine activities. Advanced numerical weather prediction (NWP) models are run at weather forecasting centres to provide this information as forecast (future state), analysis (almost current state) or reanalysis (past state). ECMWF is a world leader in the NWP field using the Integrated Forecast System (IFS) which is a comprehensive atmospheric forecasting-system software simulating the dynamics, thermodynamics and composition of the Earth's fluid envelope and interacting parts of the Earth-system. The system includes an atmospheric, an ocean wave, an ocean circulation and a sophisticated data assimilation components. The current ECMWF model configuration discretises the Earth surface into a grid with a resolution as fine as 8 km (for the atmospheric forecast model but lower resolutions for the other components). This resolution is refined every 5 or so years and the next resolution is expected to be around 5 km. This resolution is suitable for a wide range of applications.

In order to achieve the best analyses and forecasts, IFS relies on high quality observations to estimate the initial state. Operational satellite measurements using instruments like Radar Altimeters (RA) for wind speed and significant wave height, Synthetic Aperture Radar (SAR) for waves (and possibly wind) and Scatterometers (SCAT) for wind velocity vectors have been available since early 1990's. Such data have been assimilated in IFS since then.

Although IFS has a global domain, observations in the Atlantic Region, especially in its northern part, are very important. Many ECMWF member states are within that region.

The importance of the currently available observations in the Atlantic Region for the marine wind and wave analysis and forecast will be reviewed. The current gaps in the satellite data availability in the region and the future needs for such data will be identified

Session A5 Protecting the Ocean

Measuring Marine Litter and Microplastics

Campbell J.[1]

[1] *UN Environment Statistician*

In the last 50 years, plastic production has increased more than 22-fold while the global recycling rate of plastics in 2015 was only an estimated 9% . This rise in plastic production and unmanaged plastic waste has resulted a growing threat to marine environments with an estimated 5-13 million tons of plastic from land-based sources ending up in marine environments . The importance of marine plastics has been recognized in the Sustainable Development Goals through a target related to marine litter (SDG target 14.1). However, there are large gaps in knowledge in terms of understanding marine litter and microplastics: a reliable figure for the volume of plastics entering the ocean, the accumulated volume of plastics in the marine environment, mapping of the source and sink location of plastics and basic data on microplastic is currently lacking. There is a need to use existing data from remote sensing, citizen science and in situ monitoring to better understand marine litter and microplastics; however, much of the research in this field is at an initial stage and only data related to beach litter is available in many regions . This presentation will provide an update on the current state of marine litter and microplastic data and data efforts, including opportunities for using satellite data and global models to better understand the state and flow of marine litter and microplastics.

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Optical Methods for Marine Litter Detection (OPTIMAL): From User Requirements to Roadmap Design for Marine Plastic Detection System

Martinez-Vicente V.[1], Lindeque P.[1], Clark J.[1], Corradi P.[2]

[1]Plymouth Marine Laboratory, [2]European Space Agency - ESTEC

This work summarises the findings from the ESA funded OPTIMAL project. The main aim was to produce recommendations for a scientific and technical roadmap for the development of a mission for remote sensing detection of marine litter, with a focus on marine plastics. The study comprised: 1) definition of the observational needs; 2) evaluation of potential for marine plastic detection from current technology; 3) synthesis and evaluation of options to progress.

The definition of observational needs was done through consultation with the marine plastic community by a user workshop. One of the conclusions was the identification of two important observational scenarios for marine plastics detection: 1) plastics accumulated on shore, and 2) micro and macro plastics in the upper layer of the ocean. Following these recommendations, experimental and modelling work was designed and carried out to evaluate current optical remote sensing capability relevant to those scenarios. This included satellite, aircraft and in-situ observations and laboratory measurements of microplastics optical properties. This study is particularly relevant to the Atlantic, as it has been supported by in-situ observations of microplastic abundance during the Atlantic Meridional Transect (AMT) cruise. Synthesis of these results have been fed into a design roadmap design for a marine plastic detection system, and preliminary conclusions will be presented here.

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Observational Limitations for Marine Litter Monitoring: Earth Observation to the Rescue

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Marine Litter (ML) is a major environmental issue requiring deeper insights from the scientific community for policy makers and enforcers to manage and mitigate these contaminants (GESAMP WG40, R&S93; Kershal et al, 2015). However, data gathered for ML applications at the oceans and coastal areas is very limited, and only a tiny fraction of the surface has been actually surveyed (Cozar et al, 2014; Minutes from SCOR “Flotsam” Working Group). Moreover, sampling is generally not performed routinely at time scales representative of the ML dynamics. Recent studies have proven how important a good sampling is to properly evaluate the ML budget found at our oceans (Lebreton et al, 2018).

Due to the lack of data, community is relying on the modelling of litter behaviour at the oceans, in order to estimate plausible scenarios of spatial and temporal variability of ML (Lebreton et al, 2018; Eriksen et al, 2014; Van Sebille et al, 2012). Most of those efforts are based on considering floating plastic as passive Lagrangian drifters to simulate their displacement and identify their main accumulation zones and time scales. However, data gaps and differences into the assumptions for initial conditions lead to large differences in the results (Van Sebille et al, 2015). Thus, there is a clear need to increase the information of marine litter at the surface of the oceans to properly resolve the scenarios.

The potential use of Earth Observation (EO) to detect, quantify and track ML has gathered the interest of the scientific community (Workshop on Mission Concepts for Marine Debris Sensing, Honolulu, 2016; Maximenko et al, 2016, Maximenko et al, 2018). Remote sensing can

bring what is required to better understand the extension of the ML issue and its dynamics, henceforth supporting environmental agencies and regulatory organisms. The international community addresses these scientific questions in a white paper presented at the decadal OceanObs 2019 (Maximenko et al, 2018). This community paper highlights the need for an observational system for ML, including Earth Observation as one of the technologies with best characteristics for this task.

Regardless, given the heterogeneity of ML, remote sensing is likely to provide only partial information, depending on the marine domain and the characteristics of ML in it. Modelling will be required under any scenario for ML management (Workshop in Remote Sensing for Marine Litter, ESA-ESTEC 2017). The combination of in situ data and EO data from operational services -like Copernicus- can be coupled with numerical models to bring a better understanding of the ML dynamics and budgets (Lebreton et al, 2018, Brach et al, 2018, van Sebille et al, 2015), questions that remain largely unexplored so far.

However, ML modelling scenarios have shown a high dependency of our knowledge and capability to resolve the physical dynamics od the ocean (Van Sebille et al, at Challenger 2018, Newcastle, UK), which is still not well resolved in many cases (Hart-Davis et al, 2018). Particularly, sub-mesoscale phenomena have significant relevance in the results, and a lack of resolution makes difficult to obtain accurate results for litter transport and landing areas. Stokes transport, usually discarded in most hydrodynamical models for the oceans, have also an important role into the spatial dynamics of ML. These factors point towards a considerable need of increasing our knowledge of ocean physical dynamics, at least at eddy-resolving spatial scales, and with better appreciation of the sea state. Such data would be required to constrain the solutions provided by the models.

In addition, it is necessary to bring EO to obtain direct - or indirect- measurements of ML, so to help with the existing poor sampling and better connect ML dynamics with ocean dynamics. Recently, Sentinel-2 data have proven to provide a limited capability to report on ML accumulations (UKSA/SSGP – GeoInt Service for Marine Litter, GML), which is now being further investigated and coupled with models for the Mediterranean Sea (ESA/ESRIN – EO Track of Marine Litter). In situ data is also being brought to the scene for the European North Atlantic, also coupled with models (CMEMS – LitterTEP). These initiatives are thought to put in value the existing information and support our understanding of requirements for an EO approach to ML. Defining the ideal remote sensing solution is also being tackled (ESA/ESTEC – Remote Sensing for Marine Litter - RESMALI), in which a feasibility study is taking place to produce a mission concept with potential to provide optimal observation of ML from space.

In this presentation, the authors try to connect these different aspects of ML monitoring for the European Atlantic, which is highly dependent on the availability of EO data from multiple sources and variables. Results of these four projects are shown, aiming to identify the existing gaps and the need of international effort to fill them. In particular, results include the limitations we have in ML behaviour forecasting coming both from EO data and model constrains, as well as for a direct observation of ML. These aspects are being considered for the definition of an EO Mission Concept specific for ML.

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Marine Litter Monitoring

Lux M.[1], Sahuc E.[1], Denisselle M.[1], Cancet M.[1]
[1]Noveltis

Marine litter is a global concern, affecting all the oceans of the world. Every year, millions and millions of tons of litter end up in the ocean worldwide, causing environmental, economic, health and aesthetic problems. The IFADO (Innovation in the Framework of the Atlantic Deep Ocean) project aims to create new marine services to support the European Marine Strategy Framework Directive implementation with the North Atlantic Ocean as a study case. As part of this project, it is of decisive importance to identify convergence zones, pathways and main sources of marine litter in the North Atlantic Ocean. This information is essential in the perspective of preventive and cleaning actions.

The North Atlantic gyre is notably composed by the Gulf Stream on the west boundary, the North Atlantic Current, the Canary current on the south-east European coast and the North Equatorial Current. In this system, the subtropical gyre is known to be a great convergence zone. The Lagrangian particle modelling tool Opendrift, developed at the Norwegian Meteorological Institute, has been used to evidence convergence areas. The tool was fed with global ocean current maps derived from satellite observations (GlobCurrent products) or computed by an ocean circulation model (CMEMS analyses), and different scenarios of marine litter release were modelled in the North Atlantic Ocean. Indicators were developed to highlight the preferential residence zones and pathways for plastic particles. The goal was to understand the fate of plastic particles released from land (80% of marine litter that end up in the ocean are coming from land: beaches littering, river discharge...) and the trajectories of particles floating far offshore (shipping and fishing litter).

This presentation is dedicated to the capabilities of ocean current products derived from satellite observations to simulate plastic particles trajectories at a basin scale in order to validate pathways and convergence zones of floating marine litter. Comparison to results obtained with modelled ocean current shows a good consistency of both products. A time residence indicator has been built to highlight the convergence zones. Correlations between release and stranding of particles are explored in some regions of interest to help define a monitoring strategy. Further improvement of the approach are needed in order to take into account the degradation and sinking of marine litter. Moreover, indicators and diagnostics need to be enriched with analysis and statistics of the connectivity between sources and impacted areas (stranding, accumulation zones…).

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Plastic litter detection from space: current knowledge and lessons learned from the Plastic Litter Project 2018

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Marine litter is a global problem affecting all the oceans of the world. Millions of plastics end up in the seas affecting the marine ecosystem. Several initiatives have been planned from global players towards detection, monitoring and cleaning. State of the art techniques is needed for the detection and quantification of the marine plastics in the sea water. Satellite images and Unmanned Aerial Systems (drones) and satellites can be used in this direction. Already, the scientific community and space agencies are working towards the specifications of sensors detecting and quantifying marine litter.

Here, we present the lessons learned from Plastic Litter Project 2018, a test project on detecting artificial plastic targets on the sea surface, using satellite images and Unmanned Arial Systems (drones). The project designed to examine the ability of marine litter detection from the European satellites Sentinel-2 and Sentinel-1. Drones used to detect and quantify the volume of the litter on the sea surface with dedicated cameras. Three payloads used on drones for marine litter mapping: RGB, multi-spectral and thermal cameras. Inter-comparison between data from satellites and drones released the advantages and disadvantages of the detecting systems.

Three plastic “targets” created, 10 x 10 m wide, containing: a) 3700 plastic bottles, b) 138 plastic bags and c) 200 sqm fishing net from the Marine Remote Sensing Group (https://mrsg.aegean.gr), Department of Marine Studies, University of the Aegean. The experiment was devoted to the Word Environment Day, 5th June.

Image analysis and image processing algorithms used to evaluate the ability of satellites to detect marine litter on the sea surface. Targets were clearly detected in the Sentinel-2 image, and spectral signatures were calculated for each target and each pixel of the target. The percentage coverage of plastic per pixel and their difference on the spectral signature were examined. UAV data compared with satellite images and spectral differences were highlighted. Atmospheric correction on satellite images limits the spectral difference of the plastics and limits their detection. This experiment proved the usefulness of satellite technology in fighting marine litter and deliveries the need for more extensive experiments on the cumulative oceans areas.

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Beach Litter Monitorization via Drone Remote Sensing

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This communication is about "LitterDrone" project. LitterDrone is funded via the Blue-Labs program of the European commission and it aims to make a contribution to solve the problem of marine litter. Part of this problem is monitoring stranded marine litter on beaches (measuring number and type of litter elements). Monitoring results can be used to infer data on litter origin and on the influence of tides, currents and human activity. OSPAR convention is a joint European
initiative that tries to unify forces against marine pollution. Part of this convention implies that contracting parties (countries) must monitor periodically stranded marine litter on beaches. Spain has signed the convention in January 1994. Litter monitoring in Spain is nowadays implemented by human personnel counting (& picking) litter items in certain beaches at certain times (4 campaigns each year, one for each season). LitterDrone project aims to create a new and/or complementary methodology based on obtaining images from drone flights (creating orthomosaics of RGB and multiespectral images) and developing software to analyze such images to obtain results comparable to those of the manual sampling.
LitterDrone project is being developed by a consortium constituted by the University of Vigo, project leader, the company Grafinta S.A. and the Spanish Association of Marine Litter (AEBAM). The project has the support of ECOEMBES and the collaboration of "Parque Nacional Marítimo-Terrestre de las Islas Atlánticas de Galicia" (PNIAG).
Images are obtained with a UAV/RPA platform using auto-pilot over the section of interest. A photogrammetry application is used to integrate all captured image in a single global one (ortho-mosaic). Commercial software Photomodeler has been used, although there exist other options, including open-source.
Ortho-photos are processed with a CV (computer vision) application developed by ourselves. CV is mainly used because of the lack of most discriminant hyperspectral information due to the kind of cameras we are using (Sony RGB photo-camera & MicaSense RedEdge 5-band multiespectral camera).
Processing is done in two stages: first detection (colorimery), then recognition of most common objects (learned classes arerecognized using bayesian like recognizer). Human operator must revise classification results.
Satellite images could be a future line.

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Scientific Research During Round-the-World Sailing Race: Unique Opportunities for Data Collection, Outreach and Advocacy

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Gaps in scientific knowledge and the challenges of measuring the distribution of microplastic pollution in our vast ocean are compounded by the absence of a standardised methodology for accurate estimation of marine microplastic concentrations and a single platform for data sharing. For other oceanographic parameters, such as dissolved carbon dioxide and sea surface temperature, the challenges of acquiring in-situ measurements from remote areas mean that extensive areas are essentially unsampled and our understanding of critical variables remains difficult to validate.
A unique campaign to combine scientific sampling with elite sailing was undertaken during the 2017-18 Volvo Ocean Race. The initiative capitalised on the often remote route of the extreme round-the-world race to generate an internally consistent picture of microplastic distribution using a pioneering combination of sampling and analysis techniques. Direct measurements of oceanographic and environmental variables were recorded and drifter buoys were deployed in areas otherwise difficult to access for sampling. Furthermore, the high-profile race provided access to a global audience and a platform to promote awareness of ocean science.
The race research delivered in-situ measurements of salinity, temperature and chlorophyll-a to contribute to

calibration and validation of satellite-based measurements. Using Raman spectroscopy microplastic particles were detected in 93% of samples collected along the route, including some of the most remote locations sampled. The highest concentrations recorded were in the South China Sea and near the south European coast.
Here we report on the distribution of microplastic along the race route and how the very successful collaboration demonstrated the efficacy of racing yachts as vessels of opportunity to capture high-quality oceanographic data. We will also describe how the cross-sector outreach of the race and its successful Sustainability Programme elevated the scientific research to a headline position, helping to prompt advocacy for ocean health by governments, industry, business leaders and media.

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Survey of Earth Observation activities conducted at the University of Lisbon on the Northeast Atlantic

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Ocean colour (OC) remote sensing (RS) is a powerful tool to study phytoplankton communities in synoptic temporal and spatial scales. From estuaries to the open ocean, knowledge on phytoplankton is crucial to understand the biogeochemical cycles and ecosystems functioning.
This work presents a survey of Earth Observation (EO) activities conducted at the Faculty of Sciences University of Lisbon (FCUL), focused on satellite OC data in the Northeast Atlantic, in collaboration with IPMA, Instituto Hidrográfico (IH), and CIMA-UAlgarve.
Validation activities of OC satellite products for the Iberia coast started in 2005. FCUL has been involved in setting up and curating in situ data bases for OC applications at a global scale, for the ESA projects Coastcolour and Ocean Colour Climate Change Initiative (OC-CCI).
Applications of EO to support Aquaculture are being dealt under national and European projects, for site selection, monitoring, or precocious alert of harmful algal blooms. Ongoing research on the detection of phytoplankton functional groups (PFT) will be integrated in this line of research.
EO data is a crucial tool for MSFD (Marine Strategy Framework Directive) implementation. After an initial assessment carried out in 2012, new analyses for the InterReg Atlantic Area are under development within iFADO (Innovation in the framework of the Atlantic Deep Ocean, coordinated by IST, www.ifado.eu.
The need to reach an excellency level in Portuguese EO research is addressed in H2020 project Portwims (www.portwims.org), with participation of young researchers in oceanographic cruises, for example in Atlantic Meridional Transect, contributing for obtaining high-quality fiducial reference measurements, as well as addressing a key-question regarding the potential role of Saharan dust in promoting ocean productivity and influencing the marine carbon cycle (www.dustco-online.com).
FCUL led the Sophia training project (https://www.sophia-mar.pt/en) targeting staff from governmental organisms, enhancing their skills on the use of RS data, particularly in the context of MSFD.
In summary, FCUL EO research, in close collaboration with other national and international institutions, is using RS, addressing fundamental to applied science, as well promoting the use of EO data for EU policies. The group activities suit perfectly within the objectives of this workshop.

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The importance of advancing deep-ocean science of the North-Atlantic

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The Portuguese Exclusive Economic Zone (EEZ) is about to be extended to an area that covers more than ten times its continental size. It is a big ocean territory not yet well mapped nor understood that adds to the countries' responsibilities in terms of fulfilling EU directives towards the establishment of the Good Environmental Status (GES) of the marine waters. At the heart of GES is the monitoring of the different ocean components (physical, biogeochemical, and biological and ecosystems) for the purposes of discovery, understanding, management and protection. Improved understanding is critical to improve predictive capabilities and provide sustainable environmental stewardship of the ocean. Such understanding requires vastly expanded monitoring capabilities.
Towards this goal there are some ongoing initiatives in Portugal, which are aligned with EU objectives. In particular, the European Multidisciplinary Seafloor Observatory – Portugal (EMSO-PT) project seeks to contribute to the monitoring of the deep-ocean and to the development of innovative technological solutions for ocean exploration. EMSO-PT carries prototypical elements of a Deep Ocean Observing Strategy (DOOS),

and contributing to the Global Ocean Observing System (GOOS). This presentation focuses on two example applications, understanding of regional ocean circulation and heat content changes in the context of climate change, or seafloor ecosystem disruptions in the context of pollution and seabed mining.

Ocean exploitation, namely mineral and biodiversity resources, is highly dependent on our knowledge of the deep-ocean environment, including sediment transport and ecosystems characterisation. Existing in-situ measurements are extremely sparse and therefore much denser observing networks must be implemented. Towards that direction, new efficient and affordable sensors and platforms are needed fostering state-of-the-art technological developments. Technological advances are needed that are scalable to global ocean monitoring, but that can be developed and demonstrated in a regional setting.

Various connections have been established between extreme meteorological events and deep-ocean circulation changes. Availability of high-resolution satellite data and mapping of meteo-oceanographic conditions are key ingredients for improving our understanding of the connections between surface and deep-ocean dynamics and for the development of realistic oceanographic models that can reproduce deep-ocean circulation patterns. Due to their complexity, these models increasingly require extreme-scale high-performance computing (HPC) infrastructure, novel algorithmic approaches that are being developed in computational science and engineering, as well as an advanced cyberinfrastructure for deploying cutting-edge data analytics tools.

Because of its relevance, deep ocean science in the North Atlantic, in all its facets sketched above, is one of the research foci that the UT Austin-Portugal program seeks to promote. This program, based on a joint effort between UT Austin and Portuguese universities, envisages to advance a pressing research agenda in areas of emerging international attention and relevance.

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Combining EO and In-situ Data for Atlantic Coastal Applications

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TechWorks Marine provides clients with world-class solutions to monitor the marine environment. Since 2008, the company has developed capacity in the area of remote sensing and developing value added tools for the existing client base. As a provider of in situ real time turbidity data, the company has provided information on protection of areas with high concentrations of fish farms (e.g. salmon farming) from algal blooms and jellyfish swarms, monitoring of dredging and dumping of dredge spoil at sea; planning and construction of wastewater treatment plants and long-term planning of port activities.

TechWorks Marine are currently developing a prototype web portal and app service CoastMADE (Monitoring and Assessing Dredging Environments) which combines turbidity information from satellite and in-situ data. This will provide stakeholders with detailed real time and historical information on the status of relevant dredging locations (e.g. ports and harbours) and potential effects on nearby aquaculture sites. The service will be designed for the stakeholders interested in supporting Atlantic economic development. These are a combination of industry and government organisations, including aquaculture companies, dredging companies, ports, environmental agencies and local and regional councils.

The combination of large scale monitoring via satellite and localised real time data from TechWorks Marine's buoys will provide an optimised decision support system, created via user-driven requirements. Validation of the satellite data is performed using TechWorks Marine's in situ turbidity measurements and the Copernicus Marine Environment Monitoring Service in situ data. We view these activities as the start of a much larger national and international development for us in the area of Marine Earth Observation.

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Marine Environmental Status Monitoring Service for Public Marine Authorities

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The Marine Strategy Framework Directive (MSFD) provides an ambitious and comprehensive framework for the definition, monitoring and achievement of a Good Environmental Status (GES) of the EU's marine waters. Currently, quantitative baseline information from satellite, in-situ and model products is available for most MSFD descriptors but it's scattered over multiple data sources (e.g. CMEMS, Sentinel Data Hub, Copernicus Data Warehouse, EMODNET, SeaDataNet) and in different formats.

The objective of the Marine Environmental Status Monitoring service, to be developed in partnership by IPMA and Deimos, is to provide to Public Marine Authorities (PMAs) easier and better access to these

oceanographic, climatological and environmental information to support them in their MSFD related operational monitoring obligations. The development will be driven by a set of user requirements defined by PMAs from Portugal, Spain, Greece and Norway in the scope of the H2020 Marine-EO project.
The service will provide a single access point to long time series of biotic and abiotic parameters relevant to the environmental status characterization of marine areas: sea state (e.g. SST, wave and wind characterization) and water quality (e.g. salinity, chlorophyll-a and suspended matter concentrations, turbidity). Output products will be customizable to the needs of the user: definition of the AOIs to cover, which parameters to monitor, required indicators for each parameter (e.g. weekly average, % of change, anomaly to a reference period), definition of possible alert thresholds and definition of classification schemes for environmental assessment thematic maps.
Its development is based on the legacy of other data access, processing, visualization and retrieval cloud platforms developed by Deimos: SIMOcean and Co-ReSyF. Those platforms provide currently single access points to key marine and coastal datasets and to a wide range of pre-operational and R&D services and applications, from support to harbor navigation and fisheries to coastal bathymetry and altimetry.

Session D1-D2 Data and Technologies - Platforms and Applications

Towards Quality-assured EO-based Climate Services in the Atlantic Region

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Climate change provides business and society with one of the major challenges of our time. Climate data and services can facilitate strategic decisions and provide valuable approaches to risk management, and assessment and evaluation of climate action towards a climate-resilient, low-carbon and sustainable society and economy.
Europe has made large investments in satellite earth observation data products, which make a critically important contribution to our ability to measure the effects of climate change, and the knock on impact of that to the public and private sector. Moreover, such data sets offer global coverage and are freely available. We outline the two major European Earth Observation-based climate data programmes, with Telespazio VEGA UK (a Leonardo and Thales company) acting as prime contractor in both cases:
- Climate Change Initiative (CCI) Open Data Portal (ODP), funded as part of the Global Monitoring of Essential Climate Variables (GMECV) element of the European Space Agency's Earth Watch programme.
- Climate Data Store, developed as part of the Copernicus Climate Change Service (C3S), which is operated by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of, and funded by, the European Commission
The ODP provides access to a wide range of climate variables, with data from 14 ECV's across land, atmosphere and ocean domains, and a further 9 ECV's being developed, The first version of the CDS was released in June 2018, with an initial set of ECV data-sets available and further ECV's currently being added. CCI and C3S have complimentary objectives, with the CCI providing the cutting edge science, and the CDS providing an operational service for ECV data that can be used in value-added climate services to create societal and business benefit. The various data access protocols (Web, API, Toolsets) will be described In both initiatives, which will be important in the context of interfacing to this wealth of data sets from an Atlantic Regional Earth Observation Exploitation Platform. Both a land and ocean-based climate service will also be highlighted within the C3S that utilise data provisioned from the CDS.
Furthermore, the concept of data quality will be introduced and the importance of supplying suitable meta-data, often within the data itself, to allow the provision of information such as uncertainty, traceability, and availability. The objective is not to characterise a data-sets as "good" or "bad", but to allow users to make informed choices about data usage, including as part of a decision making process in a climate service. These concepts are being realised through the Evaluation and Quality Control (EQC) part of the C3S, including through a project led by Telespazio VEGA UK where a best practice quality assurance framework will be defined, and climate services assessed against this framework spanning the following sectors: Energy, Water, Agriculture & Forestry, Health, Transport, Coastal Areas, Tourism, Insurance, Infrastructure, Disaster Risk.
The presentation will conclude by making some suggestions of fundamental considerations for an Atlantic Regional Earth Observation Exploitation Platform in the context of climate data / services, and associated data quality.

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EO_MAMMALS - a Tool Towards the Sustainability of the Whale-Watching activity

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The Canary Islands, Spain are considered one of the best hotspots in the world to see wild marine mammals. Of the approximately 90 species in the world, 31 can be found in the Archipelago. EO data has been extensively used over the years for assisting in the management of marine mammal populations either by establishing protected areas where stakeholders' activity will be reduced, or by minimizing the impact of anthropogenic threats. It is considered a basic and essential tool for the conservation of the species both by researchers and the government. Satellite measurements of ocean colour are the principal remote-sensing tool for measuring ocean productivity and its response to climate change/variability. Consequently, sea surface chlorophyll-a concentrations (measured as ocean colour) are often used as proxy for primary productivity. Remotely sensed environmental parameters have the potential to identify biological hotspots for cetaceans and to therefore establish or better manage areas of marine conservation priority. The ESA project, "EO_MAMMALS", led by PLOCAN and with the collaboration of GMV and Univ. St. Andrews, will use the Sentinel S3A and S3B data to model cetacean presence. The region of interest is an area heavily targeted by the whale watching industry and centered around a zone of special conservation. The results of analysis will be incorporated in a governmental application used by different types of stakeholders such a general public, research, industry and government, as a tool for the management of marine protected areas. Finally, for future applications, this study could be extrapolated to other Macaronesian areas as well as worldwide.

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EMODnet: Your Gateway to Marine Data in Europe

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Marine data are needed for many purposes: for acquiring a better scientific understanding of the marine environment, but also, increasingly, for decision-making as well as supporting ocean and coastal economic developments and business opportunities. Data must be of sufficient quality to meet the specific users' needs. It must also be accessible in a timely manner in appropriate formats.
And yet, despite being critical, this timely access to high-quality data proves challenging. Europe's marine data have traditionally been collected by a myriad of entities with the result that much of our data are scattered in unconnected databases and repositories. Even when data are available, often they are not compatible, making the sharing of the information and data-aggregation impossible.
To tackle those problems in 2007 the European Commission through its Directorate General for Maritime Affairs and Fisheries (DG MARE) initiated the development of the European Marine Observation and Data network (EMODnet) in the framework of the EU's Integrated Maritime Policy and Marine Knowledge 2020 Strategy and in support of Blue Growth. Today EMODnet is comprised of more than 150 organisations which gather marine data, metadata and data products and make them more accessible for a wider range of users.
In this presentation, we will highlight the challenges we are facing in accessing high-quality marine data and will expose the best practices EMODnet is putting in place to make these more accessible for a wide range of users in the context of blue growth. Specific attention will be given to data sets which are relevant for the Atlantic Region with a number of use cases and examples.

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New methods for SST retrieval in aerosol-laden atmospheres

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For many months of the year, a substantial portion of the Atlantic is subject to significant aerosol burden due to uplift and transport of desert particles by trade winds. These have a significant effect of the ability of most thermal infrared sensors to provide an accurate retrieval of sea surface temperature (SST). While the relatively narrow dual-view portion of the Sentinel-3 SLSTR instrument provides a measure of robustness, SSTs from wide-swath single-view polar-orbiting (e.g. MODIS, VIIRS, AVHRR) and geostationary sensors (GOES, Meteosat) are subject to significant contamination because the currently applied regression retrieval algorithms have little to no inherent skill in addressing the problem. A new physically based retrieval method is presented that employs a deterministic approach to solving the inverse problem. The incorporation of aerosol information in the fast forward model is readily achieved by use of profile information for various species (dust, soot, sulphate,

salt) and size distributions that are operationally available from various numerical weather prediction centres (e.g. ECMWF, NCEP). The various aerosol types and sizes are tailored to fit the aerosol model in the fast radiative transfer. However, use of this information is not sufficient to fully address the problem, since the aerosol amounts are often in error. The solution is to include the total column aerosol in the retrieval vector (along with SST and total column water vapour, TCWV). Doing this provides substantial benefit, even under low aerosol loadings, since aerosol-related perturbations in top-of-atmosphere brightness temperature can now be assigned to the correct state variable, rather than degrading the accuracy of SST (or TCWV). The result is not only an improved accuracy in the presence of aerosols, but also a gain in the algorithm sensitivity and therefore the total information from the satellite measurement. Aspects of the suitability of various sensors for such an approach are discussed, including case studies with MODIS, and the prospects for use with VIIRS, GOES ABI, SEVIRI, AVHRR, and the forthcoming METimage instrument

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EO Big Data Platform for Marine Applications

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In the last 6 years DEIMOS has been driving the Big Data approach of "bring processing to the data" which started from FP7 SenSyF, FP7 ENTICE, H2020 Co-ReSyF, EEAGrants SIMOcean, ESA Hydrology TEP and continuing with H2020 NextGEOSS, H2020 BETTER, H2020 MELOA, H2020 Marine-EO.

Throughout all these projects DEIMOS developed the building blocks of an exploitation Platform and has integrated on different Cloud platforms more than 20+ EO Downstream Services from more than 30+ partners, addressing different thematic domains with focus on food security, marine environment monitoring, coastal research and hydrology. DEIMOS has also gained expertise developing platform agnostic core services to facilitate the Service Providers; for example - federated user authentication and authorisation service, platform analytics services, data catalogues, user interfaces and services orchestration.

In the current context, the main objectives of an EO Big Data Platform for Marine Applications are to unlock the potential of the innovative Value Added Services using marine, EO data and information; to facilitate efficient access to Copernicus data and information through user friendly interfaces leveraged by scalable exploitation software tools powered by Big Data Technologies based on open software and standards; to ensure resilience and reliability of the overall data dissemination and exploitation services; to facilitate the uptake of the use of Copernicus and Marine data by non-traditional user communities. The platform aims to offer services encapsulating the complexity of the ICT and data layers, creating analysis ready data for the service providers.

To meet these objectives the platform relies on the capabilities delivered by the different Copernicus DIAS, linked with initiatives lead by ESA, GEO, OGC, CEOS focused on the development of interoperable cross-functional processing chains. The ESA Common Architecture linked with the OGC activities is one of the key enablers for the evolution of this platforms that will be closely followed.

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Marine EO Service HUB – an innovative, high-performing operational geo-information portal for monitoring marine environmental status, detecting threats to fish farms, tracking vessels and icebergs

Iasillo D.[2], Bollanos S.[2], Ceriola G.[1], Coppini G.[3], Mysłakowski K.[4], Bauna T.[5], Kaljord A.[5]
[1]Planetek Italia, [2]Planetek Hellas, [3]CMCC, [4]Creotech, [5]KSAT

The Marine Environment Monitoring is a complex cross-cutting area where Earth Observation (EO) technology can provide major contribution. MARINE-EO pre-commercial procurement (PCP) aims to establish EO-based services for the thematic areas of Marine monitoring (Lot 1) and Maritime Security (Lot 2), covering sea-basins of Mediterranean, North Atlantic and Arctic.

The MARINE-EO (PCP) is led by the National Centre for Scientific Research "Demokritos" (NCSRD) in Greece, where the Directorate-General for Maritime Policy (DGPM-Portugal) DGPM is appointed to act on behalf of a buyers group as Lead Procurer, and also the Spanish Guardia Civil (GUCI), the Hellenic Centre for Marine Research (HCMR), the Regional Fund for Science and Technology (FRCT) in Portugal and the Norwegian Coastal Administration (NCA).

Planetek Hellas, prime of a Consortium, with Planetek Italia, CMCC, KSAT and Creotech, has been awarded the MARINE-EO PCP Lot 1 project (Phase 1 and Phase 2 – in progress). The developed service will serve as a single access point (common web-based platform) where the buyers group (e.g. MARINE -EO's partners & other MARINE Authorities/Agencies) and other End-Users can access the following three added-value downstream services:

- Ocean biotic and abiotic parameters, climatological information and historical statistics
- Fish farm monitoring

- Arctic based services

The first two services will make use of a wide set of EO based products from Copernicus under free and open license and data obtained from other freely available satellite missions in order to obtain relevant parameters on the quality of sea areas of interest. These two services will provide routinely a set of products focused on environmental monitoring and assessment of specific areas of interest, located in the marine regions of the Mediterranean Sea (Greece, Spain), the North Atlantic Ocean (Portugal – Mainland and Azores) and the Norwegian Sea (Norway). The third service will leverage on KSAT expertise to make available to the users fast and high reliable information to support concerned authorities as well as ships navigators on board the ship and private industries. This service will be running on the area covered by NAVAREA under the responsibility of Norway.

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Innovations For Maritime Economy In The Polish National Space Program For 2019-2021

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[1]Polish Space Agency

Satellite data has become, especially in recent years, an increasingly popular tool for monitoring the marine environment. This is related to the intensive development of research methods based on satellite remote sensing, a significantly increasing number of measuring instruments placed on satellite platforms, as well as easier access to data obtained with their help. This significantly increases the affordability of information relating to large areas and impossible to obtain in a different way. Often these data are made available without the need to involve significant resources by their potential recipients, as is the case with the European Copernicus program. In the case of the marine environment, which by its nature is hardly available and its monitoring usually requires the involvement of an expensive measurement and observation infrastructure, it makes it an attractive source of information for science, maritime administration and maritime economy enterprises. The value of data obtained this way will be the greater that they can be freely combined into larger resources with data from other sources already in the possession of particular stakeholders of the maritime sector. The aim of activities related to the use of this data should be to provide intelligent information (system) services, enabling the extraction of useful information for decision making and effective operations at the operational level, and discovering facts and building new knowledge for planning long-term activities at the strategic level, both by individual entities, as well as regions or the whole country.

In the National Space Program for 2019-2021 several activities are planned, as a result of which a maritime information infrastructure will be systematically developed combining different dedicated systems of the national maritime sector, including specialized equipment, information services and processes supported by it, high-quality digital research and economic resources, including satellite data and in-situ data, as well as expert resources. This infrastructure will enable comprehensive management of the Polish maritime area and solving current problems related to its operation and security. The article presents the planned streams of actions leading to this goal.

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Using the EO Exploitation Platform Common Architecture to Integrate an Atlantic Regional Platform within the Network of EO Resources

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The availability of free and open data, such as from the Copernicus Sentinel fleet, together with the availability of affordable computing resources, create an opportunity for the wide adoption and use of Earth Observation (EO) data in all fields of our society. ESA's "EO Exploitation Platforms" initiative aims at facilitating adoption with the paradigm shift from "bring the data to the user" (i.e. user downloads data locally) to "bring the user to the data" (i.e. move user exploitation to hosted environments with collocated computing and storage). This leads to a platform-based ecosystem that provides infrastructure, data, compute and software as a service. The resulting Exploitation Platform is where scientific and value adding activities are conducted, to generate targeted outputs for end-users.

The goal of the "Common Architecture" is to define and agree the technical interfaces for the future exploitation of Earth Observation data in a distributed environment. The Common Architecture will thus provide the interfaces to facilitate the federation of different EO resources into a "Network of EO Resources". The "Common Architecture" will be defined using open interfaces that link the different resources (building blocks) so that a user can efficiently access and consume the disparate services of the "Network of EO Resources".

The Common Architecture is very relevant to envisaged regional exploitation platforms. Implementation of the reference architecture in such a platform will enable integration into an evolving powerful interoperable ecosystem e.g Thematic Exploitation Platforms or the

Copernicus DIAS's. It would therefore enable new developments for regionally focussed platforms to build on top of existing capabilities, avoiding duplication of effort and focussing only on the additional regional needs.

Telespazio VEGA UK (a Leonardo and Thales company) will lead the definition of the Common Architecture through an open process of public discussion and consensus building with the EO community. It will be promoted as a Reference Architecture that will be designed to meet a broad set of use cases that cover Federated Identity Management, Processing & Chaining, and Data Access and Management. Leveraging free and open source software, a reusable Reference Implementation will be developed and deployed operationally, to act as a validation of the architecture and to provide an existing solution to third-parties.

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Provision of Near Real Time Optical and SAR-based Satellite Services for the Atlantic

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Currently, the Atlantic region lacks a crucial capacity offered by Earth Observation: Near-Real Time (NRT) provision of satellite optical imagery. From a market-based perspective, in 2015 optical data represented 84% of the commercial data market, while SAR data represented 16% . In the meantime, data fusion is becoming a prominent trend in EO applications, with data from multiple sources bringing valuable services to users.

Hence, EDISOFT and UNINOVA jointly propose to establish an Atlantic NRT Optical and SAR-based satellite services provision from the Azores, with data fusion capabilities (SAR+Optical).

EDISOFT is already providing NRT SAR-based Maritime Surveillance services to EMSA since 2007, through its Santa Maria Ground Station in the Azores. Presently, EDISOFT is acquiring and processing all spacecraft modes from Sentinel-1 and Radarsat-2, as well as delivering value added products for oil spill and vessel, feature, behaviour and change detections.

UNINOVA has been applying AI techniques on ESA projects since 2002, including novel data fusion methods which perform temporal and spatial, multi-source and heterogeneous data fusion. Applied to SAR and Optical-based Satellite data, a new range of products can be explored.

Several applications and EO services would be available through the proposed Optical and SAR data NRT availability, ranging from environmental (pollution, marine plastics) and security (regional safety and security related activities), to Fishery control and Search and Rescue services, thus contributing to an Atlantic EO platform for data collection, management and exchange.

Session A6 Maritime Spatial Planning and Blue Economy

Data from space: for better Maritime Spatial Planning and a thriving and sustainable Blue Economy

Ronco J.[1]

[1] European Commission

More and more economic sectors and activities are competing for space at seas. At the same time, there is a compelling need to protect marine ecosystems. Maritime Spatial Planning can tackle these challenges by promoting the sustainable use of sea space. The EU has adopted a framework, the Maritime Spatial Planning Directive, to ensure that maritime areas are managed in an integrated manner. A key feature of the Directive is that Maritime Spatial Planning should be based on the ecosystem-based approach, for which best available scientific knowledge about the ecosystem and its dynamics should be used.

Data and information delivered by Earth Observation are of critical importance for the implementation of Maritime Spatial Planning. The contribution of earth observation systems is not only needed for knowledge on the state, and monitoring of, the marine environment, but also for the planning and management of economic activities at sea. As regards the latter, aquaculture provides a good example of a sector that benefits from high quality data and information on the state and variability of the marine environment. Another sector for which earth observation systems could provide a substantial contribution is the off-shore wind energy sector. Measuring wind speeds from space could help unleash the huge potential of some maritime areas for the production of clean, renewable energy at sea.

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Satellite SAR Winds for Offshore Wind Farm Planning and Wind Farm Wake Interaction

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The development of offshore wind energy in Europe is rapid. There was a record of 3,148 MW of net new installed capacity in 2017. Today Europe has more the 16 GW total installed offshore wind capacity. Furthermore, new projects in the pipeline worth €7.5bn reached Final Investment Decision in 2017. The cost of offshore wind energy has decreased very fast. There is now already three offshore wind farms in planning through tenders at zero subsidy. Wind energy is competitive and will continue to help UN SDG be achieved globally. The offshore wind in Europe can power entire Europe with electricity but to develop this there is need for marine spatial planning. Satellite EO data is very useful for this. In particular, Synthetic Aperture Radar with high resolution and all-weather capabilities gives the surface winds at high spatial resolution. SAR winds are used to quantify the offshore wind farm wake effects. As example one of the so-called third generation wind farm lay-outs (i.e. large irregular lay-out) of the Anholt wind farm has been investigated recently. The wind resource observed from SAR (Envisat) prior to construction of the wind farm and the wake effect of the wind farm after construction (Sentinel-1) are compared and show the influence of the wind farm to the neighboring area. The reduction in wind speeds can also be calculated by numerical models but SAR data gives additional information. SAR data and model results compare well. The Anholt offshore wind farm - as many other offshore wind farms - is located in the coastal zone where the influence of landmasses is significant on the wind, hence on the energy production. The comparison of produced energy at the turbines with what is observed from SAR is good.

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ESA EO4SD: Marine & Coastal Resources Management, EO-derived information for Blue Economies

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The Blue Economy approach to sustainable development supports economic growth and improvement of livelihoods, whist ensuring the continued health of coastal and marine ecosystems and the services they provide. For countries to benefit they must understand the environment and available resources and have the tools to monitor and manage them effectively. However, collecting data in marine environments can be difficult and expensive. Earth observation (EO) provides a relatively low-cost means of acquiring information essential to evidence-based planning and management.

Earth Observation for Sustainable Development, Marine and Coastal Resources (EO4SD-Marine) is a recent addition to the ESA EO4SD programme, which aims to achieve a step change in the uptake of satellite-based environmental information in development programmes supported by International Financing Institutions (IFIs). In a partnership with six other European organisations, the UK's National Oceanography Centre is working with ESA, IFIs and their Client States to define and deliver services for five world regions, including the Caribbean and West Africa - Gulf of Guinea.

In the Caribbean we are working with two initiatives; Caribbean Oceans and Aquaculture Sustainability FaciliTy (COAST) and the Caribbean Regional Oceanscape Project (CROP), to strengthen capacity for ocean governance and coastal and marine geospatial planning in the countries of the Organisation of Eastern Caribbean States (OECS). In West Africa we are working with the West Africa Coastal Areas Management Programme (WACA) to strengthen resilience of coastal communities along the Atlantic coast from Mauritania to Gabon. This will be achieved through provision of EO-derived services including, inter alia: aquaculture site selection; benthic and coastal habitat mapping; coastal bathymetry; marine pollution detection and monitoring; and spatial planning support.

Here we present an overview of project implementation, with emphasis on the Atlantic regions, including details of services in support of Blue Economies and details of capacity building activities.

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Ocean and Coastal Information in Support of Marine Resources and Biodiversity in the Macaronesia, Sao Tome and Principe Region

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The AIR Centre, in coordination with the GEO Blue Planet, Future Earth Coasts and the Marine Biodiversity Network (MBON), is organising a number of cross-sectoral and cross-disciplinary meetings to better understand the information needs of governments, businesses, researchers and civil society to foster the sustainable use of marine resources and to enhance

local and regional capacity for job creation and innovation in the blue economy in the Macaronesia and Sao Tome and Principe region.
The objective of these meetings can be summarised as follows: to gather needs and requirements from cross-sectorial user communities; inform local and regional stakeholders about Earth Observation (EO) technology and methods for deriving EO ocean and coastal information for use in sustainable fisheries management, aquaculture site selection and management and biodiversity monitoring; support local and regional decision makers to make use of EO ocean and coastal information to assess marine and coastal spatial planning options; identify potential marine, coastal and biodiversity initiatives for the AIR Centre and relevant partners to conduct in the Atlantic region; map capacity needs in the region for using EO ocean and coastal information, and ;identify gaps and promote capacity and institution building initiatives in the region.
These meetings are providing a very diversified initial set of information needs for using, developing and/or expanding EO ocean and coastal information services and products for fisheries, aquaculture, biodiversity and marine spatial planning. This process is seen as a first stepping stone into a series of Atlantic regional workshops aimed at the systematic development of innovative user-oriented Earth observation services and products as well as the identification of new initiatives for the AIR Centre to pursue, such as workshops covering other topical and regional areas (as the Southern-West and Southern East Atlantic).
The organisation committee of this workshop includes AIR Centre, GEO Blue Planet Initiative, Future Earth Coasts, GEO MBON, ESA, UNOOSA, Ocean Science Center Mindelo (OSCM), Regional Government of Azores, Azores Regional Foundation for Science and Technology (FRCT), Oceanic Platform of the Canary Islands (PLOCAN), Ministry of Maritime Economy of Cape Verde, and Ministry of Education, Culture and Science of Sao Tome and Principe.

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Satellite Applications in the Blue Economy

Vernile A.[1]
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Blue Economy is a concept that comprises the rise of an ad hoc governance to determine related policies that help the sustainable use of oceanic and sea resources. Blue economy seeks to promote an economic growth of coastal and non-coastal countries. Blue economy means talking about preservation of natural resources, of marine and cultural heritage, energy, food, transport, logistics, and climate change. In addition to this, seas and oceans are also strategically important for the security of the non-terrestrial borders.
The safeguarding of our seas and oceans is today studied widely. The World Bank, European Commission, United Nations are supporting initiatives and policies in this sense. Just to mention one, the United Nations included the conservation and sustainable use of the oceans, seas and marine resources among the Sustainable Development Goals.
The European Countries are also taking measures regarding the blue economy. Including its outlying regions, the EU has the world's largest maritime territory. The Blue economy is worth €500 billion per year to the European economy and supports 5.4 million jobs. For this reason, since 2012, the European Commission has undertaken a series of steps to translate into actions the measures proposed in the Blue Growth Strategy.
In this dynamic and complex system, space has an important role. Space systems are vital tools to support knowledge and economic activities, improving the knowledge of the marine environment and guaranteeing innovation and disrupting new technologies.
The aim of the paper is to outline the existing interaction between the space and maritime domain and the way this relation stimulates economic development and social growth. The focus will be put on the downstream applications for the maritime domain in the light of the sustainable development of the coastal countries. The paper will be contextualized in the European framework of Horizon 2020 activities, considering also the growing involvement of Copernicus data. The paper will also give the picture of the uses of satellite data for humanitarian purposes, considering the massive migrant flows from the North Africa shores that involves Europe.

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Tailored Spatial Risk and Resource Management - A Conceptual Framework for Public Health in Costal Regions

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The conceptual framework for tailored risk and resource management focusses on regional and local spatial decision support with mobile devices.
Applied on red tide, costal regions and fishery is used describe the key elements of the conceptual IT-environment.

Furthermore capacity building and the application of Open Educational Resources (OER) are addressed to improve risk literacy.
Global Navigation Satellite System and remote sensing are integrated at the client and server side of the IT framework even for the regional adaption of OER for capacity building.
Finally a conclusion of an integrated approach for the IT-framework, standards and capacity building are presented.

Session S4 Regional Climate Modelling, Extreme Events and Climate Resiliency

A view of Atlantic Climate from ESA CCI Inventories

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The Climate Change Initiative (cci.esa.it) is a major Programme of the European Space Agency spanning 14 years (2010-2024), whose objective is to realise the full potential of the long-term global Earth Observation archives of Essential Climate Variables (ECVs), in support of climate studies and of the IPCC process. The programme investigates 22 Essential Climate Variables over the Ocean, Atmosphere, Cryosphere and Land domains, aiming at deriving climate-quality time series of the ECVs and therefore furthering our knowledge of the climate system and impacting on the decision making process about mitigation and adaptation strategies. Cross-ECV studies and Knowledge Exchange activities are also an important part of the programme. The ESA CCI inventories constitute a very rich reservoir of information to investigate climate processes at basin and regional scale, for instance over the Atlantic. In this presentation we will demonstrate, with several examples drawn from the various CCI studies, the detailed view of climate processes ranging from oceanic and atmospheric circulation to biogeochemistry and to sea ice dynamics in the Atlantic section of the Arctic and Southern ocean. All the data are publicly available alongside analysis and visualisation toolboxes.

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Observing the AMOC from space

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The Atlantic Meridional Overturning Circulation (AMOC) is a critical component of the global climate system, transporting heat northwards throughout the Atlantic and sequestering anthropogenic carbon in the deep ocean. Under global warming the AMOC is predicted to decline with potential impacts on sea level, hurricane formation, storm tracks, temperatures and precipitation in the North Atlantic region. As a result, a number of basin-wide in situ observing systems have been deployed, such a RAPID 26˚N in the subtropical gyre (from 2004) and more recently OSNAP in the subpolar gyre (from 2014), to detect changes that may be occurring. To obtain a meridionally coherent picture of the changing AMOC would require in situ measurements at many locations. As this would be costly, satellite observations have been used to study the AMOC. In particular, altimetric sea surface height and gravimetric bottom pressure measurements have been employed, either on their own or in combination with in situ data, such as that from Argo floats. Here we will review the satellite measurements of AMOC made to-date, noting their benefits and limitations, and then discuss the requirements for improved AMOC observation from space in the future.

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North Atlantic Extratropical cyclones extreme waves from satellite altimetry observations.

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The north Atlantic Ocean is regularly traversed by extratropical cyclones and winter low pressure systems originated in the Western part of the basin that can potentially generate dangerous extreme sea states. The region where these extreme sea states occur is linked to the tracks of the low-pressure systems in the north Atlantic basin. The variability of this storm tracks presents a primary dipole pattern with centers in the extreme northeastern Atlantic and west of Portugal. Extreme sea states are usually generated by storms that can traverse whole ocean basins and generate high-energy swells that can propagate for thousands of kilometers. Additionally, rogue waves are a recognized source of extreme waves that needs to be considered when designing for operation at sea.
This study aims at the spatial distribution of the mean wave significant wave height inside the extratropical cyclones. The study covers a 20 year period based on all satellite missions available.

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POSTERS

New paradigm for Climate Resilience programs over the Atlantic region.

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[1]Gmv

Climate Resilience is understood as the ability to anticipate, absorb, accommodate or recover from climate change in a timely and efficient manner. In order to address Climate Resilience over the Atlantic region, we propose an innovative and efficient approach: to promote satellite based environmental information in the regional and global programs.

This new paradigm is primarily based on supporting third-party entities operating in the area: instead of providing external support in terms of projects, resources, knowledge and team; we consider that the effort should evolve towards local / regional bodies (with a traditional label of 'limited') executing autonomously self-sustainable operations.

Our implementation plan is structured along 4 pillars:

•Development of a prominent knowledge of the downstream stage of the chain (Climate Resilience related indicators and monitoring procedures) and a network of points of contacts at all levels (local, national, regional, international) that can complement project knowledge from different views.

•Implementation of an experienced and skilled capacity building plan with insights in local heterogeneities (cultural, procedural, knowledge heritage, R&D capacity) to properly shell the message.

•Rely on outstanding, mature and operationally ready technological solutions.

•Definition of a set of use cases that can be easily reproduced by the local / regional agencies (the real receivers of capacity building) from a technological (adapted to the available ICT resources) and technical (adapted to the available knowledge) point of view.

Climate Change is a world-class problems, which requires of long-term and sustainable approaches for defining resilience actions at local level. In order to minimize the dependency of local/regional agencies of external organizations, we propose an approach based on transferring knowledge to most relevant and deserved actors (regional agencies, local service providers…) with a clear benefit to make them capable of guiding long-term exploitation of EO-based services over the Atlantic region.

ESA EarthObservation How can #EarthObservation better contribute to the monitoring of the #Atlantic region? We want you to tell us! Send your abstract and be an active part of @esa's Atlantic from Space workshop:https://www.eo4atlantic.info/QuickEventWeb

Ferreira Campos M.[1]
[1]esa

It is smart to transform, gather all the images of space satellites into data, it is better to understand and measure some economic indicators of localized regions.The goal is to get more images, videos, airplanes and satellites can make new images, photos of roads , cities, climates and can be used as a series of special data sources, increases learning ability and incredible opportunities for geospatial information, and scientific, transforms into new skills help understand society, geopolitics, economics.

Space is an area of great worldwide interest for research and achievement. Space technology, images, videos, data has enormous power to make and inspire worldwide interest

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SMOS Sea Surface Salinity contribution to the Land-Marine Boundary Development and Analysis (LAMBDA) project

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The LAMBDA project is a MERCATOR Ocean funded initiative which aims to improve the COPERNICUS Marine Environment Monitoring Service (CMEMS) Monitoring and Forecasting Centres (MFCs) thermohaline circulation in coastal areas by a better characterization of the land-marine boundary conditions in the Iberia Biscay Ireland (IBI) region.

The project has special regards in the salinity fields and it explores the capacities of watershed numerical modeling and its coupling to mesoscale regional ocean models. Currently hydrological models are not generally coupled to coastal and regional ocean models because, even if regarded as a powerful and useful tool, they do not fully accomplish to estimate accurately the right volume of water reaching the coastal zone for many reasons including water management activities such as human consumption, irrigation, etc. For this reason,

many coastal and ocean models continue to use river climatologies as boundary conditions for representing such an active boundary.
Since continuous salinity observations in the coastal area are scarce, Soil Moisture and Ocean Salinity (SMOS) Sea Surface Salinity (SSS) maps could provide a robust source of salinity information for validation the current and the enhanced models resulting from this project. In this talk we want to present the preliminary results of the inter-comparison between the SSS dynamics captured by SMOS
in the Portuguese Coast and the one described by the MOHID model developed by the Marine Environment and Technology Center (MARETEC) which assimilates an extensive data base of river discharge. The results of this study show that, interannual and seasonal salinity variations are consistent between model and satellite remote sensed salinity. Although this SMOS product does not capture the most coastal pixel salinity dynamics, the time evolution of the main coastal mesoscale structures described by the model are consistent with the ones captured by SMOS. We have compared both salinity data sets with coastal salinity in situ data provided by Instituto Portugues do Mar e da Atmosfera (IPMA) and Insituto Superior Tecnico (IST) of Lisbon. The performances of both salinity data sets (model and satellite) are similar in terms of correlation coefficient with respect to in situ data.

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ITT Baltic+ Salinity Dynamics: Quality assessment of the preliminary SMOS SSS fields in the Baltic Sea.

Olmedo E.[1], González-Gambau V.[1], Martínez J.[1], Gabarró C.[1], Turiel A.[1], Alenius P.[2], Tuomi L.[2], Roiha P.[2], Arias M.[3], Catany R.[3], Fernández D.[4]
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The Baltic+ Salinity Dynamics project is an European Space Agency funded initiative which aims at advancing research and consolidating existing developments towards the generation of a dedicated SSS products suited for Baltic Earth research (https://www.baltic-earth.eu/organisation/bewg_salinity/index.html). The Baltic Sea is one of the most challenging regions for the satellite Sea Surface Salinity (SSS) retrieval. Nowadays, the availability of SMOS SSS products is quite limited over this region (temporal and spatially) due to several technical limitations related to the low sensitivity of L-band TB at SSS changes in cold waters, land-sea and ice-sea contamination, and high contamination by Radio-Frequency Interferences (RFI) sources. The assessment of the quality of the SMOS SSS products in the Baltic Sea is also an issue. On one hand, the basin is strongly stratified and therefore, differences between the first centimeters (SMOS measurements) and the few meters (measurements provided by in situ) can be noticeable. On the other hand, the basin is very shallow and then, the near surface vertical salinity gradient must be estimated from different sources. There are also seasonal salinity variations in the surface, which are caused by melting of ice and spring floods from rivers. Thus, the representativeness of satellite salinity must be assessed. Besides, some parts of the Baltic Sea such as the Gulf of Finland have estuarine regimes and therefore exhibit relatively strong horizontal salinity gradients.
In the recent years, the BEC team has developed innovative algorithms for improving the quality of brightness temperatures and sea surface salinities. The application of these techniques has led to the generation of regional SMOS SSS products over some critical areas such as the Mediterranean Sea (http://bec.icm.csic.es/ocean-experimental-dataset-mediterranean/). The work proposed in Baltic+Salinity is focused on the refinement of the above-mentioned methodologies for developing a dedicated SMOS SSS product, suitable for the needs of the Baltic research community.
In this work we show a quality assessment of the current state of the art satellite SSS dataset for the Baltic Sea when we compare with the available in situ data sets.

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Altimetry and Gravimetry for estimating the Meridional Overturning Circulation

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The ocean meridional overturning circulation is a large-scale circulation in the Atlantic and the primary driver of heat content and deep ocean carbon storage. Its transport and variability are key elements in the climate system; climate models predict a slowdown of the MOC over the coming century with far-reaching impacts. Since 2004, the MOC has been continuously observed using in situ observations at 26N in the Atlantic (RAPID, http://www.rapid.ac.uk), using tall subsurface moorings to measure ocean currents, temperature and salinity, from which net northward volume transport is calculated at all depths. Using gridded altimetry in the Atlantic, we show that over 80% of the interannual variability of the top 1100 m ocean transports can be recovered. Combining these with surface wind-driven transports and the Gulf Stream transport through the

Florida Straits, over 90% of the interannual variability of the MOC at 26N can be explained. Separately, gravimetry from GRACE can be used to recover the interannual variability of the deep ocean transports (3000-5000m). Together, these two satellite data sets can be used to investigate the large-scale ocean circulation and its response to changing atmospheric forcing. These studies demonstrate the potential of satellite-based data sets for monitoring the variability of the large-scale ocean circulation, verified by the in situ observations at 26N, but with the potential to be used more broadly.

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Coastal bathymetry estimation from an ensemble of Sentinel-1 images

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In this study, coastal bathymetry is estimated from long swell parameters retrieved from Synthetic Aperture Radar (SAR) images acquired by the Sentinel-1 satellites. The method relies on the adjustment of long swell to the bottom topography, which can be mathematically expressed through the linear dispersion relation.

The algorithm tracks the shoaling waves to the wave breaking zone, using the wavelength and wave direction retrieved from the 2D directional spectra applied at consecutive sub-images. Upon inverting the linear wave dispersion relation, the depth is calculated from the mean wavelength obtained for each sub-image, assuming the wave period retrieved at the first offshore position, which is computed using a mean depth from an independent bathymetric source. Depth computed at the centre of the sub-images is then resampled to a uniform grid, giving rise to an output bathymetric model.

Test and validation of this methodology has been performed across different regions along the Portuguese coast. The algorithm can easily be applied to different coastal areas across the Atlantic, as long as wave conditions are favourable. Methodologies to compute satellite-derived bathymetry such as the one presented here can be particularly useful in shallow coastal areas where the traditional hydrographic surveying methods are not performed regularly. The determination of the bathymetry using space-borne SAR imagery can be used not only to retrieve the mean bottom topography but also to detect new underwater structures, such as banks, reefs or bars, which is quite important for the safety of navigation.

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Fishing areas characterization using satellite and in-situ data

Lamas L.[1], Oliveira P.[2], Pinto J.[1], Almeida S.[1], da Silva A.[1], Almeida N.[3]
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This study explores the relationship between SST, Chl-a concentration and catches of European Sardine (Sardina pilchardus) and Atlantic Chub Mackerel (Scomber colias) over shelf areas for two consecutive years. Satellite-derived products of SST and Chl-a were related with fishing data (locations, catches, etc.) from the purse sein fleet operating off the south and southwestern Portuguese coasts from January 2014 to December 2015. Daily charts based on the statistical relations between SST, Chl-a and fishing activity data are included in the SIMOcean (System for Integrated Monitoring of the Ocean) platform, an Open Data platform designed to manage and exploit datasets and products related to human activities and the environment, that were originally scattered among different institutes. In the platform, the user is able to visualize, in an integrated environment, areas where the conditions are equivalent to those of higher catches together with several oceanographic datasets and products (e.g., surface currents and thermal fronts).

The methodology presented here may be extended to other sources of fishing data, in particular open ocean fishing, and other oceanographic data and products, such as ocean fronts, convergence zones, eddies, etc. It is particularly tempting to try to apply it to the tuna and other great pelagic fisheries, if adequate changes are made in the choices of variables to relate with the catches. This can be particularly valuable for coastal communities across the Atlantic that are strongly dependent on the fishing industry, as high-value information can be provided to allow higher efficiency and a better management of fishing operations.

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Tropical Atlantic dynamics as inferred from statistics and satellites

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The tropical Atlantic Ocean houses a large variability of dynamics such as large scale and mostly zonal currents, narrow coastal currents, tropical wave propagations and eddy formations. Consequently, embedded in a strong seasonal signal, the variability of the tropical Atlantic ocean is complex both in time and space. Many mechanisms of this tropical Atlantic variability are still

under debate such as the tropical wave influence over the basin or the western boundary activity. This study aims to give a new picture of the space and time variability of this region using statistical tools applied to satellite measurements such as the radar altimeters (TOPEX/Poséïdon/Jason1-2-3 series...), the Soil Moisture and Ocean Salinity (SMOS) radiometer, and the Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) products. These satellite missions give global data sets of Sea Level Anomalies (SLA) and Absolute Dynamic Topography (ADT), Sea Surface Salinity (SSS) and Sea Surface Temperature (SST), completed by modelled wind stresses, between 70°W-20°E, 15°N-15°S, and from 2010 to 2016. Using analytical methods from the statistical and machine learning field, like the Self-Organizing Map (SOM), the Hierarchical Ascendant Classification (HAC) or the Empirical Mode Decomposition, it is possible to classify the different phenomena located in that area and to identify their characteristics. Furthermore, this kind of approach enables to study the way the different variables interact among these different dynamics. The results will particularly focus on the dynamics of the North Equatorial CounterCurrent, the South Equatorial Current, and the North Brazil Current, respectively, and their links with the InterTropical Convergence Zone, the tropical wave activity, the eddy field and the Amazon river run off.

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Towards a monitoring service of economically impacting processes at the ocean-continent interfaces in the Atlantic

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It is widely recognised that, although the countries bordering the Atlantic Ocean generate an income approaching half of the global one, the potential exists for further growth, particularly with the contribution of African and South American countries. Economic options taken inside the continents almost invariably have consequences at the land-ocean interface, and ultimately at the sea itself. With this lesson in mind, a choice of strategic scientific targets is suggested for the Atlantic that may foster effective cooperation between science and decision making towards a sustainable development in the bordering countries.

One way science can assist decision makers evaluate their options is through monitoring different (physical, geological, biological) variable fields in areas where impacts can be anticipated. The first area one may think of is the nearshore – the narrow interface extending a few kilometres to both sides of the coastline, where most economic activities take place. Scientific topics to be addressed are, among others:

- acquisition, and continuous update, of nearshore topo-bathymetry;
- longshore sediment transport; and
- freshwater contribution to nearshore and shelf dynamics.

In the cases above, EO is likely to play an important role, particularly at large scales. A great step forward occurred when the International Hydrographic Organization (IHO) recognized that Satellite Derived Bathymetry (SAD) has "the potential to make substantial improvements to otherwise inadequate charts". This is true although deriving littoral bathymetry from colour or SAR requires high resolution sensors and clear skies or a regular swell.

But science may also contribute to improve economic results, and there are some examples of fisheries through oceanography. Fisheries for large pelagic species, namely tuna, are known to be frequently driven by rapid temperature surveys, leading to identification of fronts around which fish schools are believed to aggregate. With small pelagic, present tendencies tend to combine different variables and try to understand environment related species behavioural strategies through the fishing fleet catch data.

EO derived fields do require ground truth for calibration and validation purposes, and this calls for adequate sensors, and adequate methods, for in situ measurements (including salinity). This is an issue of the highest importance, particularly when dealing with new EO sensors.

A robust Data Service is required with interoperability characteristics and capability to accommodate data of different origins in a common Catalogue. Specific services, easily accessible through a Geoportal, should be possible to derive for different stakeholders, making life easy to all users, particularly the less experienced ones. The Geoportal should accommodate discussion fora, with easy access to the Catalogues.

Building a service from this approach requires a cooperative transnational infrastructure capable of acting as a hub for dialogue with all data providers and users, as well as procurer and canvasser on behalf of all stakeholders. Aiming at effectively putting science at the service of common economic development, the Atlantic International Research Centre, AIR Centre (www.aircentre.org), has all potential to play such role.

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Variability of coastal circulation in the Gulf of

Guinea using altimetry data

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The Gulf of Guinea (GG) in the Tropical Atlantic ocean is characterized by a strong seasonal variability of oceanic surface conditions. The open ocean surface circulation is predominantly zonal with the presence of the South Equatorial Current (SEC) flowing westward. Along the northern coast, an intense eastward coastal current is observed : the Guinea Current. Due to the paucity of in situ measurements, the time and space variability of this surface circulation in the GG remains poorly documented. For instance, the presence of a short-lived, narrow westward coastal current, interacting with the Guinea current, has been evocated but not clearly demonstrated. The link between this variability and other oceanic phenomena (such as upwellings) has not yet been clearly established, as well as its impact on the West African Monsoon. The aim of this study is to provide a synoptic view of the seasonal and interannual variability of this surface circulation in the GG and to highlight the different connections with other oceanic and atmospheric features if any. The approach is mainly based on altimetry data using either gridded multi-satellite products or coastal along-track products available over the period 1993-2015. In situ measurements such as Acoustic Doppler Current Profiler measurements obtained during oceanographic campaigns (Equalant 1999, Equalant 2000, EGEE2, PIRATA 2012 and PIRATA 2014), satellite Sea Surface Temperature (SST) information, and tide gauge data complete our data sets.

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Monitoring Eastern Atlantic Coastal Zones with Space-based Multi-Sensors;the case of Northern Europe and Western Africa

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The world's coastal zones are currently under serious threat because of coastal erosion and flooding, extreme events, urbanization, pollution, sand extraction, salinization of estuaries and coastal aquifers, etc. These hazards are expected to increase due to the combined effects of sea level rise, climate change, and increasing human activities. The response of coastal environments to natural and direct/indirect anthropogenic forcing factors depends on the characteristics of the forcing agents, as well as on the internal properties of the land-sea interfaces, in particular the highly dynamical coastal systems. The latter remain poorly known and mostly un-surveyed at a global scale. To better understand changes affecting coastal zones and to provide crucial information to decision-makers involved in adaptation to and mitigation of environmental risks, coastal observations of various types need to be collected and analyzed. The near-global observations from space of many coastal parameters are a fundamental complement to existing in situ coastal observing systems (e.g., regional tide gauge networks, moorings, ship surveys, gliders) that still remain relatively sparse or even inexistent in some regions. Here we stress the need for systematic monitoring of the world coastal zones, with emphasis on space observations of both forcing agents (e.g., sea level, winds, waves and currents, storm surges, river runoff, sediment supply and transport, vertical land motions, land use) and coastal response (e.g., shoreline position, estuaries morphology, land topography at the land-sea interface and coastal bathymetry). In the context of this workshop, we focus on two regions of the Eastern Atlantic, i.e., Northern Europe and Western African coasts. In Northern Europe, 75 % of the shorelines are in erosion. Even if this region is well covered by tide gauges, understanding and modeling the complex interactions between meteorological, hydrological and oceanic processes impacting these coastal zones, definitely need complementary observations, in particular from space. Concerning Western Africa, the coastal zone consists of a narrow, low-lying coastal belt where a large percentage of the population lives in coastal megacities situated at sea level, hence highly exposed to sea level rise. There is currently a crucial lack of information about coastal sea level rise, its causes and its impacts along African coastal zones. It could be considered as a pilot region for the development of synergetic use of various space-based observations from the Sentinels and other missions (e.g., retracked and SAR altimetry for coastal sea level and coastal currents; altimetry and SAR + optical imagery for river runoff in estuaries, shoreline and wetland evolution, topography of coastal lagoons; ocean color sensors for sediment transports and shallow coastal water properties, etc.). Need for development of in situ infrastructures like tide gauges and GNSS receivers to systematically monitor very local sea level and vertical crustal motions will also be discussed.

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The Assimilation of optical absorption by phytoplankton functional types in the North West European Shelf

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We developed a new optical module within the ERSEM ecosystem model to improve the representation of

biogeochemistry in the North-West European (NWE) Shelf. The new module allowed us to use the newly developed optical absorption data for the ERSEM phytoplankton functional types (PFTs) and to assimilate them into the NEMO-FABM-ERSEM model.

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Analysing bio-geochemical fluxes in the North Atlantic using physical data assimilation products

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We use physical re-analysis product based on NEMO model and the RAPID data array to run offline coupled biogeochemical model (ERSEM) in the North Atlantic domain. We assess the impact of the RAPID array assimilation on the estimate of biogeochemical carbon pump in the North Atlantic. The ecosystem model runs are validated using the available Earth Observation data.

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Satellite-Based Evaporation, Latent Heat Flux and Freshwater Flux products From HOAPS: Results From Uncertainty Analysis and From Joint Analysis With SSS Data

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The global water and energy cycle is a key component of the global climate system as they describe and link many important processes such as evaporation, latent heating, cloud formation and precipitation. The difference between precipitation and evaporation yields the freshwater flux, which indicates if a particular region of the Earth receives more water through precipitation than it loses through evaporation or vice versa. A profound understanding of the water and energy cycle is a key prerequisite for understanding the Earth's climate and for successful climate modelling and model evaluation on global and regional scale.

The Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data (HOAPS) data record is a fully satellite based climatology of precipitation, evaporation, latent heat flux, freshwater budget, and other variables over the global ice-free oceans. The latest HOAPS version 4 includes uncertainty estimates for parameters related to evaporation and latent heat flux. All geophysical parameters are derived from passive microwave radiometers, except for the SST, which is taken from AVHRR measurements. The HOAPS data products were generated by EUMETSAT's CM SAF and are available at http://wui.cmsaf.eu.

After a short introduction to the HOAPS 4 data record the uncertainty estimates for flux-related parameters are presented and we show results from comparisons to various other data records with a specific focus on the assessment of the stability and uncertainty estimates. Finally, we show results from an analysis of freshwater flux and water vapour transport which will be jointly analysed with sea surface salinity.

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Hazards Features in the Atlantic Ocean

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A tropical cyclone (hurricane) is one of the strongest atmospheric hazards.It is accompanied with very strong winds, heavy rain, high ocean waves and damaging storm surge which can produce extensive coastal flooding. The appearance of a tropical cyclone is also accompanied by multi-hazard conditions. Several centuries ago it was noticed that the appearance of a tropical cyclone is associated with such primary hazard as earthquakes and volcanoes. So, we can say that the tropical cyclone is not only the cause of other hazards (secondary hazards), but can itself be created "at list in part" by those very same hazards (primary hazards). This is the "multi-hazard" effect.

In this presentation the authors analysed the features of primary hazards in the Atlantic Ocean.

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Exploring the use of satellite data to improve numerical modelling for deep-ocean mining applications

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European oceans present extensive deep-ocean areas rich in mineral resources that can be used, among others, in communication, high-tech and defence applications. Deep-ocean mining is, therefore, becoming an attractive and economically viable solution to provide metals and minerals for the worldwide industry.

A large percentage of these resources can be found in polymetallic nodules and iron-manganese crusts located at the sea bottom, in particular in the proximity

of mud volcanoes and hydrothermal vents, areas whose sensitive ecosystems are still poorly studied and understood. The sediment-laden plumes and their associated trace elements released to the water column due to the mining procedures, can change the biogeochemical equilibrium of the surrounding area, modifying deep-ocean life-support services. The impacts can damage the local ecosystems and their effects can persist in a long term time scale.

There is a large consensus in the scientific community that before starting deep-ocean mining, environmental and management guidelines and regulatory frameworks must be established. To push these rules, numerical models are key tools, as they allow the simulation of scenarios that can reveal the risks associated with deep-ocean mining activities.

However, to build accurate numerical model solutions, reliable data is needed. In contrast to coastal systems, there is a lack of sea bottom monitoring activities. To improve the deep-ocean dynamics knowledge, in-situ and remote sensing observations must be available. Satellite sensors provide sea surface observations at various spatial and temporal scales. Satellite data can also be used to estimate the bottom topography, internal waves and ocean interior thermal and thermohaline structures as well as subsurface flow fields through specific algorithms and techniques. In fact, satellite products can also be of inestimable value to track the sediment plumes associated with extracted material processed on-board mining ships that discharge the undesired sediments at the surface.

This study builds on the findings of previous research dedicated to the implementation of numerical modelling tools to forecast the sediment-laden plume dispersion, enhancing the importance of satellite data to improve modelling results. Better models will contribute to support the definition of deep-ocean mining standards, the establishment of guidelines for a sustainable exploitation and the identification of additional risks associated with extreme meteo-oceanographic conditions during mining operations.

Acknowledgements: This work was performed at the Interdisciplinary Centre for Marine and Environmental Research (CIIMAR) supported by Norte2020 and FEDER (Coral - Sustainable Ocean Exploitation - Norte-01-0145-FEDER-000036, Research line BLUE TOOLS - Tools and Technologies for management of Deep Sea resource exploitation).

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Forecasting winds for wind energy using Aeolus

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Wind farms in Europe contributes a growing share of the energy each year. The fast expansion of wind energy both offshore and on land calls for best possible forecasting of winds. This means with better temporal and spatial resolution. The forecasting is used for predicting from minutes to days ahead the energy in the grid. The transmission system operators will schedule the balancing of plant (spinning reserve) but also end-users such as private customers can choose to charge electrical vehicles at suitable times. Forecasting is relevant for all variable resources such as wind, wave and solar. The next steps in wind energy forecasting is expected to be based on assimilation of wind vector information from the Aeolus satellite into weather forecasting. A pilot study is started at DTU Wind Energy by using available ground-based lidars measuring the wind profile from the ground to few kilometers in the atmosphere. First step will be to compare the Aeolus profile data and the observations, while next step will be to assimilate Aeolus data to weather forecast modelling. It is of great interest in many regions of the world with installed wind capacity to improve forecasting of winds. Furthermore, the mapping of global offshore wind resource may potentially be improved especially in regions where Aeolus is expected to add much new data such as tropics and other areas with relatively sparse radiosoundings available.

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Monitoring Atlantic Sub-Tidal Kelp Forests Remotely From Orbit

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Kelps are autotrophic ecosystem engineers in the Atlantic temperate coastal environments, and play critically important roles from both an ecological and economic perspective. The many species of the Order Laminariales colonise a diversity of littoral environments and provide an important underwater habitat to hundreds to thousands of species of invertebrates, fishes, and other algae. Kelp have also been harvested historically for the production of fertiliser but in recent years their commercial potential in areas such as the food, textile and pharmaceutical industries has become an active area of investment in the marine sector. Only recently however have these kelp forests being acknowledged as playing an important role in the carbon cycle of the oceans, with recent studies suggesting that collectively they absorb significant amounts of atmospheric carbon dioxide. This

new insight is offset by concern that this oceanic natural resource is under threat due to the effects of climate change and widespread unsustainable harvesting practices. In situ monitoring kelp forests in terms of biomass and diversity is a time consuming, costly and resource intensive activity, with only limited spatial regions capable of being studied at any one time, with these activities strongly dependent on national funding constraints and priorities along those Atlantic coasts harbouring kelp ecosystems.

The availability of regularly sampled Earth Observation data offers great potential in being able to implement such monitoring programmes from orbit. Previous studies have demonstrated the capability of Landsat data to characterise kelp forests in the clear waters off the California, South African and Australian coasts, and the availability of both Sentinel and higher cadence Planet Labs Dove constellation data provide significantly greater opportunities to obtain clear-sky images of kelp biomass concentrations in temperate/cold-temperate coastal areas of the Atlantic. Practical realisation of such a remote sensing monitoring capability necessitates the inclusion of ways of dealing with the enhanced turbidity of these waters, in addition to compiling suitable ground truth data to underpin any extrapolations derived from orbital data, as well as ways and means of automating the acquisition, analysis and communication of such monitoring data products to scientists, regulatory authorities, industry and the wider public, and in so doing better understand and manage this invaluable Atlantic natural resource. In this contribution we describe how such an approach is being implemented as part of a recently funded project by the Irish Government's Environmental Protection Agency to study the diversity and resilience of kelp ecosystems off the Irish coast.

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CryoRoute - Generating Globally-Optimized Naval Routes in the Arctic Ocean

Saadat A.[1]

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CryoRoute is a software package developed by the University of Windsor Space & Aeronautics Team (WinSAT), made to generate an optimal route for naval vessels travelling through the Arctic ocean with varied sea ice thickness (SIT). Using current methods stated by the Canadian Coast Guard, vessels travelling through polar regions obtain SIT data locally through visual inspections, ice analysis charts, on-board radar systems, or other means to deviate their path towards lighter ice areas. To address long-term deviation problems, CryoRoute generates a globally-optimized naval route based on SIT maps extracted from CryoSat-2 data provided by the Center for Polar Observation and Modelling (CPOM). With the inclusion of Automatic Identification System (AIS) naval positions and the Polar Operational Limit Assessment Risk Indexing System (POLARIS), a route is calculated with a specialized A* pathfinding algorithm. The resulting paths are computed based on minimizing expedition duration, distance, overall fuel consumption, and assessed risk from varied ice thickness to the vessel. Therefore, CryoRoute is anticipated to provide a better alternative for naval navigation in addition with conventional methods for expeditions in the North Arctic regions.

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Coastal bathymetry assessment through EO data – A work in progress at Portuguese Hydrographic Institute

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[1]*IHPT*

The coastal zones are very dynamic, extensive and exposed to numerous meteo-oceanographic processes hindering the continuous update of bathymetric information. The increase in Earth Observation (EO) programs, in particular the European Copernicus Programme, opens the opportunity to freely use EO data for a better understanding of the coastal environment.

Since 2015, the Portuguese Hydrographic Institute (IHPT) is committed to the study of satellite derived bathymetry (SDB) methodologies, conscious that SDB is a cross-cutting issue in all IHPT acting areas. The motivation started with the statement presented at 5th Extraordinary Conference of the International Hydrographic Organization (IHO), October 2014: “SDB has the potential to make substantial improvements to otherwise inadequate charts (…)”. Since January 2016 IHPT has also been part of the 3-year H2020 Coastal Water Research Synergy Framework (Co-ReSyF) project, improving the operational capacity to compute SDB’s, using multispectral and SAR (Synthetic Aperture Radar) imagery. In March 2018, based on the research and operational capabilities developed before, was operationally provided the first IHPT’s SDB product to the Portuguese National Maritime Authority to support the decision making after the Spanish flag cargo ship “Betanzos” ran aground in Bugio’s sandbar, since updated hydrographic data wasn’t available at that time.

Since 2015 an enormous progress has been achieved in SDB operational capabilities. From now on it is our intention to continue the studies towards an updating

operational service for coastal bathymetry to support littoral management and risk assessment.

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What Is the Potential of Satellite Data in Mapping Plastic Litter Hotspots?

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During the Atlantic from Space Workshop, Protecting the Ocean topic, I would like to present work on the evaluation of satellite data in mapping macro litter, especially polymers. It is estimated that there is going to be more waste plastic than fish in the sea by 2050 (The New Plastics Economy, 2016). Plastics account for almost 100% of floating litter. Fluxes of litter in the sea vary, depending on the proximity to urban activities, coastal uses, wind and ocean currents. These factors cause accumulation of marine litter in oceanic convergence zones and on the seafloor (Galgani et al., 2015). Due to the spatial and temporal variability of marine litter, it is important to develop a cost-effective, repeatable and fast method that can map plastic hotspots. Estimating plastic hotspots over time is needed for efficient monitoring programs, management and reduction measures. Although remote sensing data such as UAV imagery has increasingly been used to monitor litter, there is still a knowledge gap in the potential usage of satellite data for litter mapping. This research is a part of the CleanAtlantic project, which tackles marine litter problems in the eastern Atlantic region, involving 13 European institutes. The objective of this work is to assess the feasibility of open-source (Sentinel 1 and 2, possibly high-resolution data from SSGP) and commercial (WorldView-3) satellite data in automated identification of polymers in coastal areas and sea surface. To test this, average spectral signatures of different surface types are compared to polymers across time series. The study areas are carefully selected to allow for positional validation of polymer/litter objects visible from the satellite imagery. Results from the assessment of the polymer spectral signatures will serve as input data for the object based image classification, together with NDVI, surface roughness, RGB and hydrocarbon index (Garaba and Dierssen, 2018). The most suitable method of polymer identification is under development, therefore preliminary results and challenges will be presented at the workshop.

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Intertidal habitats monitoring using Earth Observation data and Machine Learning techniques

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This poster introduces ESA TEMITH project (Total Ecosystem Management of the InterTidal Habitats), starting in January 2018, involving partners from Deimos Space UK, University of Portsmouth and Deimos Engenharia.

Intertidal habitats rank amongst the most productive ecosystems providing bird habitat and feeding areas, commercial fish nursery grounds, as well as other ecosystem services including nutrient cycling and coastal protection. Seagrasses, mud flats and saltmarshes are some of the world's most protected habitats. However, this protection has failed to prevent accelerating global loss due to over exploitation, direct damage and numerous other stressors including algal mats, pollution and marine litter. What is more, poor availability of relevant in-situ data, makes the monitoring of intertidal habitats challenging, costly and inefficient.

Within this project, high-resolution optical Earth Observation data (such as Sentinel-2, Planet, WorldView and UAV) in conjunction with Convolutional Neural Networks and Deep Learning based feature extraction tools will be applied to assess the threats that have significant impact on the function and quality of intertidal habitats. The main threats to be analysed within the project are: sediment disturbance caused by human activities, sewage plume characteristics, litter accumulation points and algal mats detection.

The project will focus on the Solent Region of the South of England. This region is one of the most protected and exploited intertidal regions in the world.

The TEMITH system will utilise proven elements of the architecture already existing in Deimos: the SIMOcean visualisation platform (System for Integrated Monitoring of the Ocean) and EO platform Service4EO.

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Marine litter modelling and hotspots detection in the Atlantic Area.

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Plastic production has increasingly grown for the last thirty years. One of the most accusable consequences of this tendency is its impact the plastic pollutants on the open ocean. The degradation process from macroplastics (sizes higher than 5 mm) into microplastics (sizes lower than 5mm), is faster than in

other conditions due to the action of salinity, solar radiation and mechanical stress.

The detection of the main debris sources, and the location of the points where marine litter is accumulated (hotspots), are two fundamental issues in order to minimize this problem. We require the use of Lagrangian models to predict the macroplastic trajectories. However, many aspects can turn the tracking model into a difficult task, such as the absence of well defined initial conditions, the unknown descriptions for some dynamical process involved in the marine litter and the absence of real-time monitoring data.

In this way, the Non-Linear Physics Group from to the University of Santiago de Compostela has been working in this field along the last years. One of the most large-scale projects we take part in is the Interreg Clean Atlantic project, developing a modelling tool which included most of the dynamical processes as transport by currents, windage, Stokes drift, sinking and refloating between others. All these phenomena play an important role in marine litter transport, across the Atlantic area. This tool is intended to run large ensembles of simulations of millions of marine litter particles. Through this, we define regional maps of hotspots which represents the highest probability for accumulation, both on coastal and open ocean areas under different emission scenarios.

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Detecting Microplastics Pollution in the North Atlantic Using Sentinel-1 Sar Images

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Over the last 60 years the increase in chemical and plastic pollution have a significant pressure on the ocean health [1]. The present extent of plastic pollution according to several research papers has already filled all five subtropical ocean gyres - in the Indian, North Atlantic, North Pacific, South Atlantic and South Pacific oceans [2]. Plastic pollution signifies an enormous threat to marine life and ecosystems, because plastic fragments can be ingested by marine animals and fish and transferred via food chain to humans.

The aim of this research is to investigate the applicability of Sentinel-1 SAR data to detect and map ocean surfactants, with the hypothesis that they are related to microplastics pollution. The investigation areas for plastic (microplastics) pollution are across North Atlantic, including area of Hudson Bay in Canada as clean reference. The North Atlantic oceans are chosen because of high microplastics count, according to microplastics inventory mentioned in [4], [5], [6]. According to [7], the Hudson Bay has a low micro plastic count.

The radar images are showing distinct dark signatures in areas of North Atlantic oceans. These signatures show dependency on a certain range of winds, starting from 0.12 to maximum of 4.44 ms–1, measured by Aquarius and CERSAT scatterometer. No significance with presence of chlorophyll-a are found. The areas with dark signatures are located in areas of high concentrations of microplastics over the North Atlantic according to [7].

The research is still on-going, with the final aim to develop a machine learning algorithm (using a supervised classifier and convolutional neural network) able to separate the backscattering from surfactants, sea-slicks and bio-films. The machine learning algorithm will be aided by textual image analysis, results of modelling of the surfactants accumulation mechanism based on oceanographic processes (eddies) and knowledge on microplastics and surfactants behaviour from lab experiments.

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A new altimetry data validation approach based on Data Mining and Machine Learning techniques

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Data mining techniques allow scientists to extract and evaluate efficiently tendencies from large databases. In that context, the purpose of this study was to explore the potential of Data Mining and Machine Learning (ML) methods to assess the validity of altimetry measurements over ocean and compare their performances with the historical editing criteria.

Currently, the detection of spurious data in radar altimetry measurements relies on a legacy data editing method consisting in checking whether the value of several altimetric parameters is outside a validity domain defined by minimum and maximum thresholds. This historical editing method is described in the data user manuals and in the CALVAL reports of altimetric missions. It has been developed and used by the community of experts over the last 20 years.

Our study considered mainly clustering and classification techniques to assess the validity of 1 Hz SLA (Sea Level Anomalies) from 1 cycle of standard JASON-3 GDR data. A representative composite repeat cycle of data was created from data regularly sampled over one year, and the entire data set was manually annotated to produce a training and validation dataset .Unsupervised and supervised learning techniques were tested to compare their respective performances: PCA (Principal Component Analysis), Decision Trees, Random Forests, Logistic Regression, Support Vector Machines (SVM), and Naïve Bayes.

Filtering, standardization, principal component analysis and segmentation where applied to select discriminating parameters and to build reliable classifiers.

Finally, measurements validity was determined from their classification in specific groups. Confusion matrices, ROC curves and other performance indicators such as precision, recall, F-score were produced for validation purposes in order to compare the performances of the standard "editing" criterion with the ML methods. The first conclusions of our work highlight a correct classification with unsupervised learning models as well as the excellent performances of the supervised models. The best performance was obtained with the Random Forests, with 99.3% of data correctly classified

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Remote Sensing as Data Source for a Generalized Micrometeorological Simulation and its Application in the Context of a Coastal River Basin Restoration

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We present results of a voxel-based micrometeorological model for urban environments that we developed coupling several simple simulations of atmospheric transmittance, cloud cover, atmospheric optics, heat transfer and a wind flow model based on lattice-Boltzmann methods with specially tailored boundary conditions. Joint use of available public local datasets and satellite data is demonstrated. The initial test case is for a volumetric 4 m grid covering the coastal city of Corunna (Spain) as mean to evaluate environmental comfort for pedestrians.

This model is being extended and runs are shown along with derived indices demonstrating the characterization of some aspects of the Monelos river's basin restoration.

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The EO4Atlantic Pathfinder Regional Exploitation Platform

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In 2014, the European Space Agency (ESA) launched the Earth Observation (EO) Exploitation Platforms (EPs) initiative, a set of R&D activities that in the first phase aimed to create an ecosystem of interconnected Thematic Exploitation Platforms (TEPs). Each TEP addresses a particular stakeholder sector, such as forestry or hydrology. This initiative was extended in 2016 to include the development of Regional Exploitation Platforms (REPs), where each REP is concerned with the provision of multi-thematic information services focused on a particular geographic region. The EO4Atlantic REP was a pathfinder project tasked with the identification and assessment of requirements to support a full implementation of a REP focused on the Atlantic region.

EO4Atlantic addressed three canonical use case scenarios; access to and manipulation of large EO datasets, access to existing customized information services, and development of customized information services. Phase 1 began in November 2016, and was concerned with user requirements definition for an Atlantic REP, along with a review of current software

capabilities. Phase 2 began in May 2017, where its activities included implementation of the prototype EO4Atlantic platform service chain, platform service trials, and the elaboration of a roadmap for a full EO4Atlantic platform.
Utilization of the platform and underlying infrastructure was monitored during the service trial period, with subsequent analysis focusing on user activity, data product usage, and EO4Atlantic service utilization. Interviews were also conducted with service trial users for prototype evaluation. An overview of future issues to be addressed in a full EO4Atlantic platform implementation was provided, addressing data storage, access, processing, analysis, and transmission of information. Finally, a roadmap for operational implementation of a full EO4Atlantic platform was proposed, based on step changes and stakeholder issues, infrastructure and service capability evolution, and required funding options. We present an overview of these key project findings

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NEODAAS EO Activities in the Atlantic

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The UK NERC Earth Observation Data Analysis Service (NEODAAS) is based in the Plymouth Marine Laboratory and provides EO data, services and information to environmental science communities. This includes value-added information and EO products in near-real time, as well as time series and other information from the global archive of data available from ESA, Eumetsat, NOAA and NASA.
An EO-based, near-real time, analysis and guidance service operated by NEODAAS provides up-to-date information on dynamic features, like oceanic fronts, eddies or algal blooms. This service helps guide sampling on research vessels or deployments of marine autonomous vehicles (such as gliders), and is important since research vessels may cost ~€25,000 per day to operate. Operational near-real time production covers a number of regions in Atlantic and European coastal waters, based on medium resolution sensors such as Sentinel 3 OLCI and high resolution Sentinel 1 and 2: data are available via the web and browsers based on OGC standards.
NEODAAS also operationalises science outputs for wider exploitation by the community leveraging research and development from EC, ESA, NERC and Copernicus projects. An example is on marine phytoplankton phenology that is being turned into a service for the end-user community including fisheries scientists (investigating food prey, match/mismatch), climate scientists interested in impacts of ocean change on biology or ocean modellers who can use phenology for validation of model hindcasts.
This presentation will describes activities focussed on marine science in the Atlantic such as the annual Atlantic Meridional Transect, which is being utilised to provide Fiducial Reference Measurements to evaluate sensors such as Sentinel 3 OLCI A and B; guidance of research cruises and glider-deployments in the southern Atlantic; results of operational data production in NE Atlantic waters; and results from R&D operationalised for wider community exploitation.

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The Research and User Support (RUS) Service: an innovative platform for Sentinel data users

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[1]NOVELTIS, [2]C-S, [3]Along-Track, [4]SERCO
With large volumes of data acquired every month, the Copernicus satellites provide essential information for analysing and monitoring our environment. However, technical and knowledge barriers may affect user's uptake of such a wealth of information. The RUS (Research and User Support for Sentinel Core Products) Service funded by the EC and managed by ESA began operations in October 2017 and aims to support overcoming such issues. A scalable cloud environment offers the possibility to remotely store and process data by bringing data and associated processing closer to the user. An integral part of the solution is the exploitation and adaptation of the platform, Free and Open-Source Software (FOSS). In addition, technical and scientific support (including training sessions) are provided to simplify exploitation of Copernicus data. The RUS Service is specially addressed to users from Copernicus countries who are willing to discover and use Copernicus core products and datasets. Other users willing to access the Service for large dataset processing should first liaise with RUS to check their eligibility. The service is free. Commercial and operational activities cannot be carried out through the RUS Service.
The RUS service provides access to Virtual Machines (VM) with preinstalled toolboxes making it possible to process the Sentinel data and possibly third party missions. The VM permits also to download and store the Sentinel data. In relation with the upcoming EO44Atlantic activities, the radar and optical data from Sentinel-1/2/3 are relevant. The SNAP toolbox permits to process SAR data (Sentinel-1), optical imagery for coastal and open ocean studies with Sentinel-2/MSI and Sentinel-3 OLCI for ocean biogeochemical processes

and with Sentinel-3/SLSTR for Sea Surface Temperature. The BEAT toolbox is also made available to handle the Sentinel-3 radar altimeter and radiometer observations. Regular training sessions and webinars, in particular for ocean applications, are organised to support the user uptake of satellite data.

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Innovation in the Framework of the Atlantic Deep Ocean

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The European Atlantic Area (EAA) has a significant surface area which hinders detailed in-situ characterization/monitoring due to extremely high costs involved in such a process. The implementation of the Marine Strategy Framework Directive (MSFD) within the EAA is therefore very challenging.

To address these challenges, the iFADO (Innovation in the Framework of the Atlantic Deep Ocean) project started in 2017 for a duration of 4 years. It is an Interreg Atlantic Area project which main objective is integrating technologies, including remote sensing, numerical modelling and in-situ monitoring, to provide decision support tools for relevant MSFD authorities. The iFADO project works with modern technology in terms of data gathering and processing for the provision of sustainable services to the blue economy by fostering regional co-operation between the public sector, university/research centres, commercial sector and the general public.

The poster session will consist of a presentation of the iFADO project and outline the challenges of MSFD implementation, the need for innovative solutions, particularly in remote sensing, and the benefit of Research/Industry collaboration.

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Assimilation of ocean-colour phytoplankton functional types to improve the reanalysis of the North East Atlantic marine ecosystem

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We assimilated plankton functional types (PFTs) derived from ocean colour into a marine ecosystem model, to improve the reanalysis simulation of biogeochemical indicators and emerging properties in the North East Atlantic. Error-characterized chlorophyll concentrations of four PFTs (diatoms, dinoflagellates, nanoplankton and picoplankton), as well as total chlorophyll for comparison, were assimilated into a coupled physical-biogeochemical model applying a localized Ensemble Kalman filter. The ocean-colour PFT data were derived from the ESA's Climate change Initiative – Ocean Colour product V3.0, in the framework of the Service Evolution project TOSCA of the Copernicus Marine Environment Monitoring Service. The reanalysis simulations spanned the years 1998 to 2003. The skill of the reference and reanalysis simulations in estimating ocean colour and in situ biogeochemical data were compared by using robust statistics. The reanalysis outperformed both the reference and the assimilation of total chlorophyll in estimating the ocean-colour PFTs (except nanoplankton), as well as the not-assimilated total chlorophyll, leading the model to simulate better the plankton community structure. Crucially, the reanalysis improved the estimates of not-assimilated in situ data of PFTs, as well as of phosphate and pCO2, impacting the simulation of the air-sea carbon flux. However, the reanalysis increased further the model overestimation of nitrate, in spite of increases in plankton nitrate uptake. The method proposed here is easily adaptable for use with other ecosystem models that simulate PFTs, for, e.g., reanalysis of carbon fluxes in the global ocean and for operational forecasts of biogeochemical indicators in shelf-sea ecosystems.