ACO 2016

A connected ocean

The challenge of observation data integration

11-13 Oct 2016 - Brest, France

an international conference in the framework of the 10th edition of SEA TECH WEEK BREST-FRANCE

The ocean plays a major role in the earth climate, storing heat and carbon dioxide. Human activities put marine ecosystems under a growing pressure: ocean acidification and deoxygenation resulting from greenhouse gases in the atmosphere, marine pollution, or increased pressure by fishing. In order to build scenarios for the future and better manage our oceans, more accurate, complete, and integrated ocean observing systems are necessary. Ocean observation products have considerably increased in the past decades, in quality, quantity, and diversity. As new technologies and data processing tools are reshaping our knowledge of the ocean, integrating the data from observations into a coherent and standard managing system remains a huge challenge in our digital era.

At an international level there is already such "current efforts of scientists and engineers to design tools and methods to explore the «blue economy» of the ocean's depths and understand its critical interactions with the earth's ecosystem". For instance, the EU promotes projects around an Integrated Atlantic Ocean Observing System.

The challenge for future ocean knowledge and data integration sets the stage for this conference. Five sessions are planned:

- New autonomous approaches to the measurement of biogeochemical rates
- Interoperability standards for the marine environment
- Multimodal synergies in ocean studies
- Big Data infrastructure and analytics in ocean science
- Integrated observations of upwelling systems

Each session will bring together experts in three scientific fields: physical and biogeochemical ocean processes; new technologies and sensors for ocean observations; applied mathematics, computer science and data processing.

Sessions will be organised in an oral sequence with invited talks and short contributed orals, and a poster session. Additionnally, a few round tables will allow discussion of cross-cutting topics.

Conveners

Eric Desmond Barton, Instituto Investigaciones Marinas (CSIC), Vigo, Spain
Eric Delory, Plataforma Oceánica de Canarias (PLOCAN), Gran Canaria, Spain
Ronan Fablet, Telecom Bretagne, Brest, France
Kenneth G. Foote, Woods Hole Oceanographic Institution (WHOI), Woods Hole, USA
José Joaquín Hernández-Brito, Plataforma Oceánica de Canarias (PLOCAN), Gran Canaria, Spain
Sven Jullien, Telecom Bretagne, Brest, France
Richard Lampitt, National Oceanography Centre, Southampton, UK
Pascale Lherminier, Ifremer, Brest, France
Stan Matwin, Dalhousie University, Halifax, Canada
Tom O'Reilly, Monterey Bay Aquarium research Institute (MBARI), Moss Landing, USA
Antonio Turiel, Institut de Ciencies del Mar, Barcelona, Spain
Christoph Waldmann, Center for marine Environmental Sciences (MARUM), Bremen, Germany

http://aconnectedocean.sciencesconf.org/

TOWARDS AN INTEGRATED EU DATA SYSTEM WITHIN ATLANTOS

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The H2020 AtlantOS project started in June 2015 and aims to optimise and enhance the Integrated Atlantic Ocean Observing Systems (IAOOS). One goal is to ensure that data from different and diverse in-situ observing networks are readily accessible and useable to the wider community, international ocean science community and other stakeholders in this field. To achieve that, the strategy is to move towards an integrated data system within AtlantOS thatharmonises work flows, data processing and distribution across the in-situ observing network systems, and integrates in-situ observations in existing European and international data infrastructures (Copernicus marine service, SeaDataNet NODCs, EMODnet, OBIS, GEOSS) so called Integrators.

The targeted integrated system will deal with data management challenges for efficient and reliable data service to users:

- Quality control commons for heterogeneous and nearly real time data
- Standardisation of mandatory metadata for efficient data exchange
- Interoperability of network and integrator data management systems

Presently the situation is that the data acquired by the different in situ observing networks contributing to the AtlantOS projectare processed and distributed using different methodologies and means. Depending on the network data management organization, the data are either processed following recommendations elaborated y the network teams and accessible through a unique portal (FTP or Web), orare processed by individual scientific researchers and made available through National Data Centres or directly at institution level. Some datasets are available through Integrators, such as Copernicus or EMODnet, butconnected through ad-hoc links.

To facilitate the access to the Atlantic observations and avoid "mixing pears with apples",it has been necessary to agree on(1) the EOVs list and definition across the Networks, (2) a minimum set of common vocabularies for metadata and data description to be used by all the Networks, and (3) a minimum level of Near Real Time Quality Control Procedures for selected EOVs. Then a data exchange backbone has been defined and is being setting up to facilitate discovery, viewing and downloading by the users. Some tools will be recommended to help Network plugging their data on this backbone and facilitate integration in the Integrators. Finally, existing services to the users for data discovery, viewing and downloading will be enhanced to ease access to existing observations.

An initial working phase relying on existing international standards and protocols, involvingdata providers, both Networks and Integrators, and dealing with data harmonisation and integration objectives, has led to agreements and recommendations**.**The setup phase has started, both on Networks and Integrators sides, to adapt the existing systems in order to move toward this integrated EU data system within AtlantOS.

ON THE STABILITY AND SPATIO-TEMPORAL VARIANCE DISTRIBUTION OF SALINITY IN THE UPPER OCEAN

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Despiterecentadvances in oceanobservingarrays and satellite sensors, thereremainsgreatuncertainty in the large scale spatial variations of upperoceansalinity on the interannual todecadaltimescales. Consonant withbothbroad-scale surface warming and the amplificationof the global hydrological cycle, observed global multidecadalsalinity changes typically have focussed on the linearresponse to anthropogenic forcing but not on salinity variations due to changes in the staticstability and or variability due to the intrinsicocean or internalclimateprocesses. Here, we examine the staticstability and spatio-temporalvariability of upperoceansalinityacross a hierarchy of models and reanalyses. In particular, we partition the variance into time bands via application of singular spectral analysis, consideringsea surface salinity (SSS), the BruntVaisalafrequency (N^2) and the oceansalinity stratification in terms of the stabilizingeffect due to the haline part of N^2 over the upper 500m. Weidentifyregions of significantcoherent SSS variability, eitherintrinsic to the ocean or in response to the interannuallyvaryingatmosphere. Based on consistencyacrossmodels (CMIP5 and forcedexperiments) and reanalyses, weidentify the stabilizingrole of salinity in the tropics – typicallyassociatedwithheavyprecipitation and barrier layer formation, and the role of salinity in destabilizingupperocean stratification in the subtropical regionswhere large scaledensity compensation typicallyoccurs.

SEA ICE NAVIGATION RISK ASSESSMENT IN THE CANADIAN ARCTIC

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Abstract:

Maritime traffic volume in the Arctic is growing for several reasons: climate change is resulting in less ice in extent, duration, and thickness; economic drivers are inducing growth in resource extraction traffic, community size (affecting resupply) and adventure tourism. This dynamic situation, coupled with harsh weather, variable operating conditions, remoteness, and lack of straightforward emergency response options, demand robust risk management processes. The requirements for risk management for polar ship operations are specified in the new International Maritime Organization (IMO) Polar Code. The goal of the Polar Code is to provide for safe ship operations and protection of the polar environment by addressing the risk present in polar waters. Most of the information used to perform risk management in polar waters is attained in-situ, but increasingly is being augmented with open-access remote sensing information. Historical ice charts provided by Canadian Ice Service are analysed to produce Canadian Arctic sea ice navigation risks maps. The Polar Operational Limitations Assessment Risk Indexing System (POLARIS) combined with open-access historical ice information are used to support maritime risk assessment.

Euro-Argo : a new European Research Infrastructure for climate change research and operational oceanography

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In May 2014, the Euro-Argo research infrastructure became a new European legal entity (Euro-Argo ERIC). The objective is to organize a long term European contribution to the international Argo array of profiling floats. Argo is now the most important global in-situ observing system required to observe and understand the role of the ocean on the earth climate. Euro-Argo is also an essential component of the in-situ infrastructure required for the Copernicus Marine Core Service . Euro-Argo will thus develop European contribution to the Global Ocean Observing System (GOOS) and the Global Climate Observing System (GCOS). We will provide an overview of the development of Euro-Argo over the past years, detail the now agreed Euro-Argo long term organization, and provide some highlights on the work-plan for the years to come and the Argo extensions for the next decade especially to abyssal oceans and biogeochemical measurements. We will also illustrate some key achievements on the use of Argo in Europe both for operational oceanography, ocean and climate change research.

Various tools to stimulate interoperability in ocean monitoring as experienced by European Marine Research Infrastructures.

Jean-François Rolin (Ifremer), Xavier Bompais (Ifremer), George Petihakis (HCMR)

Standards, rules, label, handbooks, tutorials…the question of using the right tool to promote interoperability in ocean environment monitoring is often debated. Standards are long to develop, due to the necessary discussions which must lead to a consensus. Powerful client consortia and providers usually play a large role. The ocean measuring systems, de facto standards are frequently imposed by leading providers once they master the confidence of their clients. Rules such as synthetized by classification companies are able to disseminate the state of the art with a neutral position with respect to established provider. They bring confidence to the whole economical and regulation chains.

The Marine Research Infrastructures supported by the European Commission have been able to launch preliminary steps towards interoperability standards. It started with the collection and critical analysis of the state of the art at international scale. Handbooks of Best Practices are written from the experience of partners and can be checked towards experiences by a larger community through conferences, tutorials,… Expert groups are easy to establish from these handbooks and they can determine recommendations. Because of the risks taken with solutions which already led to failure, major mismatch, high cost of interfacing, etc, the Marine Research Infrastructure selects mandatory requirements. It is presented as a "Label" in order to help the regional managers to comply with the distributed RI efficiency. Broader application is then possible and may be proposed at international scale for standardization.

Examples are given through ESONET NoE, FixO3, JERICO and EMSO experience.

MEASURING IN WATER SUSPENDED PARTICLES BY STATISTICAL LEARNING OF OCEAN COLOUR SATELLITE DATA WITH MODELS OF OCEAN CURRENTS

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In the present study we propose the fusion of satellite ocean colour data with hydrodynamical models simulations, to retrieve the suspended particulate inorganic matter concentration (SPIM) in the water column. Satellite data are sought to be hourly sampling measurements of surface SPIM as acquired by a future geostationary satellite. Hydrodynamical models (WW3, NEMO) deliver time series of waves and circulation data. We applied the PROFHMM fusion methodology which uses Hidden Markov Models and classifications of observational data and required (hidden) parameters to learn how to emulate the response of a numerical model to a sequence of observational data. The learning of the sub-surface dynamics was performed on time series issued by the Regional Ocean Modeling System (ROMS) model, fitted with a sediment transport module of cohesionless particles. The classifications were performed with Self-Organizing Maps. For this case study, we have selected the highly dynamic waters of the English Channel to perform a twin experiment in order to validate the method. In this experiment, ROMS simulations are considered to be the hindcast of a “real ocean” and the benchmark against which we compare the reconstructions obtained. Additionally, a feasibility experiment is defined where satellite data are simulated (daylight, cloudy and noisy data) based on surface SPIM concentration given by the ROMS model.

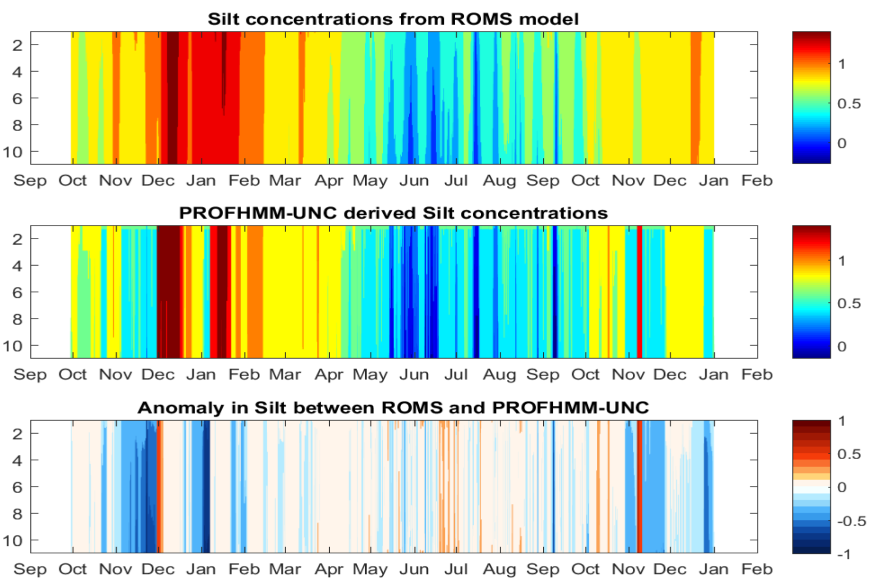

Fig. at 20 km East of isle of Wight, time series of vertical profiles of silt concentration, in log_{10}(mg/l), from ROMS and statistical model; with anomaly, in log_{10}(ratio). X-axis: months of years 2007-2008. Y-axis: ROMS sigma coordinates.

A new glider-mounted optical sensor of dissolved organic matter

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Traditional measurements of dissolved organic matter (DOM) in natural environment implies the collection of water samples that need to be further analyzed in the laboratory. The workload associated with this task generally prevent the temporal and spatial resolutions to be sufficient to address synoptic variations in biogeochemical rates. However, new techniques involving portable or submersible fluorometers have been employed in recent years to acquire real time and high frequency measurements of target DOM fluorophores in seawater. Data presented here are from one of these new generation sensors, the *MiniFluo*-UV (MFL), which is now fully operational on the European-built glider *SeaExplorer*. The two optical pathways used in the MiniFluo-UV target measurements in natural environment of tryptophan-like (TRY-) and phenanthrene-like (PHE-) compounds, that are, respectively, markers of biological activity and of hydrocarbon-like concentrations.

Data presented here are from a collection of glider campaigns realized in the Northwestern Mediterranean Sea during various oceanographic conditions. Two examples of MFL capabilities will be put forward here. First, TRY-like measurements within a phytoplankton bloom highlight a thin protein-like layer above the Chl-a maximum concentration, giving some insights on the vertical distribution of phytoplankton comunities within the bloom. Second, the use of PHE-like concentrations is proven to be a useful tool to characterize the anthropogenic pressure on coastal environment around major cities, river output or in the case of accidental contaminent spills. High resolution glider measurements allow to be effective in detecting synoptic variations in these events, such as submesoscale plankton dynamics, intense meteorological events or natural hazards.

INDEXMED PROJECTS: NEW TOOLS USING THE CIGESMED DATABASE ON CORALLIGENOUS FOR INDEXING, VISUALIZING AND DATA MINING BASED ON GRAPHS

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Abstract: Data produced by the CIGESMED project (Coralligenous based Indicators to evaluate and monitor the "Good Environmental Status" of the MEDiterranean coastal waters) have a high potential for use by several stakeholders involved in environmental management. A new consortium called IndexMed whose task is to index Mediterranean biodiversity data, makes it possible to build graphs in order to analyse the CIGESMED data and develop new ways for data mining of coralligenous data. This communication presents the prototypes under development that test the ability of graphs approach to connect biodiversity objects with non-centralized data. This project explores the ability of two scientific communities to work together. The uses of data from coralligenous habitat demonstrate the prototype functionalities and introduce new perspectives to analyse environmental and societal responses.

SEXTANT, A MARINE SPATIAL DATA INFRASTRUCTURE: IMPLEMENTATION OF OGC PROTOCOLS FOR THE DISSEMINATION OF MARINE DATA AT IFREMER

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At national and European levels, in various projects, data products are developed to provide end-users and stakeholders with homogeneously qualified observation compilation or analysis.

Ifremer has developed a spatial data infrastructure for marine environment, called Sextant, in order to manage, share and retrieve these products for its partners and the general public. Thanks to the OGC and ISO standard and INSPIRE compliance, the infrastructure provides a unique framework to federate homogeneous descriptions and access to marine data products processed in various contexts, at national level or European level for DG research (SeaDataNet), DG Mare (EMODNET) and DG Growth (Copernicus MEMS).

The discovery service of Sextant is based on the metadata catalogue, using Geonetwok. The data description is normalized according to ISO 191XX series standards and Inspire recommendations. Access to the catalogue is provided by the standard OGC service, Catalogue Service for the Web (CSW 2.0.2).

Data visualization and data downloading are available through standard OGC services, Web Map Services (WMS) and Web Feature Services (WFS). Several WMS and WFS services are provided within Sextant, according to marine themes, regions and projects. Depending on the file format, WMTS services are used for large images, such as hyperspectral images, or NcWMS services for gridded data, such as climatology models.

The next step is to develop new functions to improve the visualization and access to data: data filtering, heatmap of data distribution and online spatial processing with WPS services.

E-SCIENCE PLATFORM FOR OCEAN DATA AND KNOWLEDGE MANAGEMENT

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Ocean scientists study how environmental changes and human activities are directly impacting oceans and marine life. Oceanographers study a range of physical ocean parameters to understand coastal flooding, migration of marine animals, desalination of coasts and so on. Whereas marine biologists study the behavior of marine life to understand the dynamics of marine life colonies, migration patterns, food sources and so on. These two scientific communities (termed as ocean scientists) need to collaborate at some point to establish causal and functional relationships between the ocean's physical and biological parameters in order to develop a holistic understanding of oceans and marine life.

With the availability of real-time multi-modal data capture devices, a large volume of oceanographic and marine animal detection data is being generated for scientific analysis and model-based simulations. The typical data challenge faced by the ocean science research community is to conveniently and effectively source, store, share, represent, integrate, analyze and visualize ocean-related data and analytics. The scientific collaboration challenge is how to effectively link the relatively sparse observations on marine life with the voluminous ocean data to perform scientific experiments involving both ocean and marine life parameters.

We have developed a prototype E-Science platform for ocean data and knowledge management that offers a suite of services to (a) select and share multi-modal data collected from different geographic sites; (b) design and execute complex experiments by composing specialized experimental workflows—an experiment workflow may entail a systematic arrangement of multiple services, such as data/knowledge collection, simulation models, analytics and visualization; (c) *publish* simulation models for potential use by collaborating researchers; (d) *perform* analytics and simulations using user-defined simulation models; (d) *visualize* multiple data layers at a geographic location and simulation results of models via various globe-based, 2D and 3D plots and animations; (e) *catalogue* experiment-specific data and knowledge future experiments and analytics. A key aspect of our platform is the use of semantics web based data modeling—i.e. ontologies to model marine life and oceanographic data sources in order to achieve semantics based data and knowledge integration. This is intended to integrate observation-based research programs with high-level knowledge-based models to potentially establish the causal, associative and taxonomic relations between raw data and modeled observations. Our E-Science platform is a cloud-based services-oriented data and knowledge management architecture.

SENSOR WEB ENABLEMENT STANDARD INTEGRATED SERVICES SUPPORTING OBSERVATORY OPERATORS, FROM SENSOR PURCHASE TO DATA PRESERVATION AND PUBLICATION

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In marine sciences, the diversity of observed properties (from water physic to contaminants in observed in biological individuals or sediment) and observation methodologies (from manned sampling and analysis in labs to large automated networks of homogeneous platforms) requires different expertises and thus dedicated scientific program (e.g. ARGO, EMSO, …). However, all of them requires similar IT services to support the maintenance of their network (instrument model documentation, calibrations, deployment strategy, spare part management...) and their data management.

Upstream the current scope of the well established European marine data management infrastructures (NODCs, ROOSs), a range of services are available or under-development to support scientific programs and observation operators in this perspective. They are integrated together by implementing the Sensor Web Enablement standards and will improve the quality, cost-effectiveness, and latency of data integration in the data management infrastructures.

The solution's corner-stone, sensor nanny, is a collaborative environment enabling data providers to describe their observatory and drop or synchronize observation results “on the cloud”.
The application provides an on-line editor to graphically describe, literally draw, their observatory. The observatory description is composed by the user from a palette of hundreds of pre-defined sensors or hardware which descriptions is extracted in sensorML from the Fixo3-yellow pages (http://www.esonetyellowpages.com/).
In addition, the data providers can safe-guard their observation results by uploading or synchronising in real-time local data resources. The users can thus share their data on-line with their partners. The native format for the observatory and observation descriptions are sensorML and O&M from the OGC/Sensor Web Enablement suite applying profiles discussed in Ocean Of Tomorrows and ODIP projects.
The observatory descriptions and observation data are indexed so to be very fluently browsed, filtered and visualized in a portal. This has been demonstrated with up to 2.5 millions observation points from French research vessels, ARGO profiling floats and EMSO-Azores deep sea observatory.
The key components used for the development are owncloud for the file synchronization and sharing and elasticSearch for the scalable indexation of the observatories and observations.

The foreseen developments aim at handling instrument maintenance support (calibration, spare parts) based on LabCollector. Within JERICO-NEXT and AtlantOS further observation networks (e.g. HF radars) will be integrated. Tools for sharing data in NODCs, ROOSes and publish datasets as DOIs are also being developed.

Secure Data Communication Protocol for sub-sea cabled observatory

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In the development of a sub-sea cabled observatory, the security of data communication can be a big challenge to provide baseline requirements that will improve the security of data communication between sensors and data base hosts. Information security depends highly on cryptography, which is costly. Low computing devices can not afford using such security mechanisms and need other approaches. A possible choice is to use paired security boxes allowing secret sharing. Devices that share a secret may communicate safely without the need for heavy cryptography. These devices are still limited by the possible messages, which makes them easy targets for pattern analysis.

This contribution investigates an appropriate data encoding to secure data transmission. We propose a new security strategy based on an dynamic shared secret. The dynamic part is based on the hazardous messages and values communicating from one device to the other eliminating any possible pattern. The security boxes can be used no matter what the system specifications are nor what communication protocol is being used. Robustness analyses are required to make sure the objectives of this approach are achieved as intended.

Linked Ocean Big Data: Exploring connections between marine datasets in a Big Data world

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TOWARD SUSTAINED AND ENHANCED OBSERVATIONS IN THE EASTERN TROPICAL ATLANTIC BASED ON THE PIRATA NETWORK.

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From 1997, the PIRATA program has maintained meteo-oceanic buoys in the tropical Atlantic. This program, successfully conducted thanks to close collaborations between US, Brazil and France, needs yearly dedicated cruises for servicing the mooring network.

At the beginning these annual cruises were an opportunity to get some Essential Oceanic Variables (temperature, salinity, currents), but now a number of additional parameters of interest are acquired thanks to different collaborations. Such parameters are of interest for satellite data and numerical simulations validation, physical/biogeochemical processes…

We will first present the PIRATA network evolution and then show the enhancement of measurements acquired during PIRATA yearly dedicated cruises, in particular in the Eastern tropical Atlantic. Difficulties in maintaining some of these measurements on the long term will also be discussed, in relation with the EU AtlantOS program objectives.

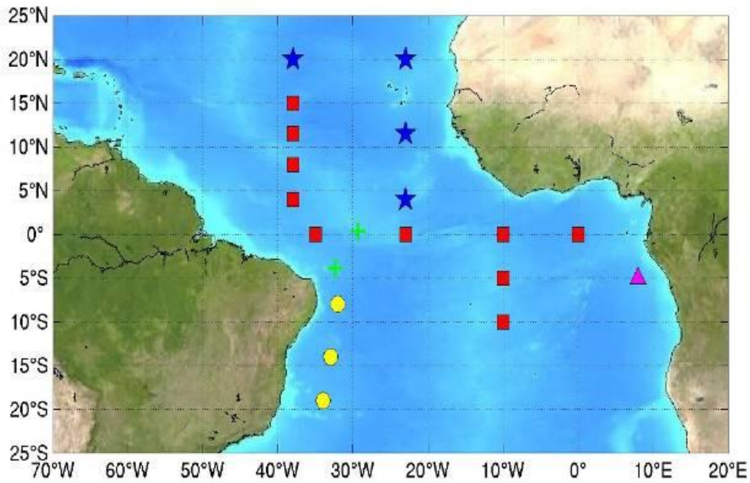

Figure: The present PIRATA met-oceanic buoys network in the tropical Atlantic.

ADCP observations of migration patterns of zooplankton in theCretan Sea

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An upward looking 75kHz ADCP deployed in the Cretan Sea for2.6 years at a depth between 350m and 500m, recorded persistentvertical diurnal migration of zooplankton. The analysis of the verticalvelocity and the trails of volume backscatter revealed seasonal alterationsmodulated by local sunrise/sunset times. The ascending and descendingzooplankton burst speeds, observed in the 200-350m layer, vary from 3 cm/s to 6 cm/s, in the course of the year. Movementdownwards is faster than upwards by 1 cm/s onaverage. The highest burst speeds are recorded in early summer, a period of lowfood availability and short night-time. The vertical extend of the feedinglayer, identified by slow upward motion and increase of volume backscatter,changes seasonally from 160 m to less than 80 m up to the surface, and itsbottom coincides with the seasonal variation of the deep chlorophyll maximum.Moonlight significantly affects the feeding depth too; full moon is accompaniedby the deepening of the bottom of the feeding layer by more than 50 m.The variability of the permanent deep scattering layer found at 450 m, which consists of migrating and non-migrating organisms, suggeststhat the non-migrating organisms prey on the migrating organisms.

NEW INSIGHTS ON THE UPPER LAYER CIRCULATION IN THE GULF OF GUINEA.

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The oceanic circulation in the upper layers of the north of the Gulf of Guinea is analyzed, as inferred from in situ observations and numerical simulations. This particular region, in spite of the presence of a coastal upwelling and its impact on resources and regional climate, is still poorly documented. Cruises carried out in the framework of different international programs (e.g. EGEE/AMMA, PIRATA) allowed to show in the north if the Gulf of Guinea the existence of an eastward flowing undercurrent, found under the Guinea Current, named the Guinea UnderCurrent (GUC). Numerical results from high resolution simulation allowed the description of the seasonal variability of this current. We also depict the fate and the sources of the GUC based on selected trajectories from numerical particle tracking. The results reveal several new insights which help us to clarify still open questions on the regional circulation dynamics in the Gulf of Guinea. In particular, lagrangian experiments show that the GUC is not an extension of the North Equatorial UnderCurrent and confirm that this current does not penetrate into the Gulf of Guinea. On the other hand, preliminary results from a second investigation of cooling processes observed in the southeast of the Gulf of Guinea, as inferred from an interannual high resolution model and in-situ and satellite data will also be presented.

A novel approach dedicated to build a climate oceanographic observatory in the central South Pacific: THOT (TaHitian Ocean Time series)

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Through various physical, chemical and biological processes as well as their synergetic interactions, oceans play a key-role in the modulation of climate system and carbon cycle. Ocean dynamic in French Polynesia (central South Pacific) is involved in El Niño Southern Oscillation (ENSO) which is the dominant mode of interannual variability in the Pacific with strong effects at global scale. It also modulates the decadal oscillation of the Pacific Ocean and longer-term trends. Furthermore, being part of the South Pacific subtropical gyre, variability of the French Polynesia waters is representative of those in the subtropical gyres of the global ocean. To observe and characterize climate changes in this region, the deployment of long-lasting oceanographic survey stations is necessary to follow the evolution of oceanographic key parameters (e.g., density, O2, phytoplankton biomass). However, presently there is no long-term open ocean observatory in the central South Pacific.

The objective of the TaHitian Ocean Time-series (THOT) project is to set up an open-ocean oceanographic station to observe and improve the understanding of climate changes in the French Polynesia waters as representative of subtropical gyre and Pacific scales. This project will be part of existing international programs on climate and ocean observations (e.g., Bio-ARGO) and will complement long-term observations for global ocean.

The deployment of a mooring station, such as those already existing, is complex in French Polynesia due to its geographical, scientific, logistical and technological remote context. Thus the originality of THOT is to set up within the next two years a long-lasting station to observe climate changes based on the development and the deployment of a wave glider able to get back and replace a physical-biogeochemical profiling float to its initial position every few days. Meanwhile, four standard bio-argo floats will be regularly deployed in the area of interest offshore Tahiti.

IS DEEP LEARNING RELEVANT FOR OCEAN REMOTE SENSING DATE? A CASE STUDY ON SATELLITE-DERIVED SST DATA.

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Keywords: data-driven approaches, deep learning, downscaling, super-resolution, SST

Deep learning (DL) is a branch of machine learning (ML) that attempts to learn a set of representations from the data. Instead of being hand-designed, data representations are learnt through an unsupervised hierarchical feature extraction process. This process involves a deep architecture that consists in multiple inter-connected layers of linear or non-linear transformation units that are able to automatically extract prominent higher-level features from the data. In the computer vision domain, typical CNNs (Convolutional Neural Networks) architectures use convolutions as transformation units. By exploiting large-scale image datasets (typically over several millions of images), deep learning techniques have started to greatly outperform typical ML methods for object recognition and image classification tasks, and have been consequently increasingly popular in the computer vision domain. Their application has been recently extended to image restoration problems such as denoising, deblurring or super-resolution.

In this study, we address the application of deep learning (and particularly CNNs) architectures to ocean remote sensing data, with the objective to judge their relevance within the context of the analysis and reconstruction of ocean dynamics from satellite-derived observations. As case-study, we focus on the downscaling problem on satellite-derived SST (Sea Surface Temperature) data. By treating a SST field as a 2D image, we used a CNN architecture specifically designed for image super-resolution, called SRCNN (Super Resolution Convolutional Neural Network), to learn a set of convolutional filters layers that transform a low-resolution SST field into a high-resolution one. The SRCNN architecture consists in three layers of convolutional filters:

1) The first layer extracts high-dimensional vectors as representations of overlapping patches of the low-resolution SST.
2) The second layer nonlinearly maps each vector onto another one that corresponds to a patch from the high-resolution SST.
3) The third layer aggregates the high-resolution patch-wise representations to generate the high-resolution SST.

To learn the convolution filters described above, a large number of patches is extracted from a high-resolution ground truth SST (HR-SST), as well as for the low-resolution SST (LR-SST). The HR-SST and the LR-SST serve, respectively, as the output and the input of the network described above. The filters are learned from a gradient-based minimization of the Mean Squared Error (MSE) between HR and LR patches. Given a low-resolution SST, the latter is then re-scaled to the high-resolution size by bicubic interpolation, and the three layers of the filters learnt above are successively applied to get the final high-resolution SST.

Experimental results on a large-scale dataset of high-resolution SST fields (10-years OSTIA SST time series) have been performed, including a comparison to classical interpolation techniques. We also compare different learning strategies for the CNN. Our results show significant gains (more than 3.2dB in PSNR) for the SRCNN-based downscaling. They also suggest that deep learning models learned for generic image datasets may not be relevant for a direct application to ocean remote sensing data. This study advocates for future work further addressing the learning of deep representations from ocean remote sensing and/or simulation datasets and their applications to prediction, reconstruction and assimilation issues as part of data-driven analysis strategies.

Synergies between along-track altimeter data and sea surface tracer fields using convolutional models: application to the reconstruction of mesoscale sea surface currents

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In the last two decades, multi-satellite measurements of altimeter-derived Sea Surface Height (SSH) and multisensor measurements of Sea Surface Temperature (SST) have provided a wealth of information about ocean circulation and atmosphere-ocean interactions. As a depth-integrated quantity dependent upon the density structure of the water column, altimeter SSH estimations capture mesoscale structures, horizontal scales of 50 km to few hundred kilometers, and allow for the retrieval of surface currents using the geostrophy balance. This emerging and rich mesoscale circulation further stirs the large-scale SST fields. Accordingly, our picture of upper ocean dynamics has considerably evolved towards a complex system characterized by strong interactions, whose spatio-temporal variability extends over a wide range of scales. Several studies rationalize and demonstrate that fields of SST can become an active tracer coupled to the dynamics leading to strong correlations with SSH fields. Such a framework can possibly guide the investigation and implementation of improved statistical means to optimally combine existing multi-altimeter SSH measurements with other satellite medium to high-resolution observations.

From a theoretical point of view, mesoscale upper ocean dynamics are expected to be consistent with the geostrophy turbulence theory and to reveal dynamical modes governed by a linear transfer function between SSH and SST fields. In our previous work, we developed an observation-driven study to investigate such local relationships between SSH, SST and surface currents, stated as convolutional models. Here, we further explore such convolutional models and their potential for the reconstruction of high-resolution sea surface currents (compared to classical surface currents derived from an optimal interpolation of along-track altimeter data). Our approach relies on a joint analysis of low-resolution altimeter-derived SSH fields, high-resolution SST fields and along-track altimeter data. Whereas previous works mostly investigated Fourier-based spectral representations, we consider here convolutional models, which are more appropriate for an application to irregularly sampled data, such as along-track altimeter data. As case-study, we consider realistic numerical simulations for a region south of Balearic islands, which involve complex mesoscale dynamics. Our numerical experiments demonstrate the relevance of the proposed approach for an improved reconstruction of surface currents in the range [10km-100km] from the synergy between SSH fields, SST fields and along-track altimeter data. We evaluate the relative contribution of the different tracer fields in this improvement, and analyse the temporal variabilities of the proposed models and reconstructions. These results strongly suggest to combine different tracers, for instance both low-resolution SSH and high-resolution SST, as inputs to the convolutional models to reach significant improvements (relative gain greater than 10% in SSH RMSE compared to classical optimal interpolation). Interestingly, the estimation of the spectral characteristics of the reconstructed fields is also significanly improved.

This work opens new avenues in the context of the future SWOT mission, which will provide additional datasets for the calibration and analysis of the proposed convolutional models. Applications to real observation datasets will also provide the basis for future work.

Standard-based middleware for marine sensor networks

Daniel Mihai Toma, Enoc Martinez, Joaquin del Rio, Tom O'Reilly

Advances in information and communicationtechnologies, are bringing new opportunitiestothefield of middleware systemsorientedto marine monitoringsolutionsthat are both open and interoperable. A fundamental challengeistodesign a plug-and-workframeworkthat, either as componentsor as individual elements, can be incorporated in a simple wayintodifferent marine monitoringsystems. Therefore, the middleware systemsdemandstandardizedsolutionsto be cost-effective and totakeadvantage of interoperability and standardizedoperation. Moreover, thereisanincreasingdemandfordevelopingthese marine sensingsystemsbasedon Sensor Web architectures; complexnetworks of web-enabledsensorsthatcollect data which can be discovered and accessedusingstandardizedprotocols and service interfaces. TheOpen GeospatialConsortium (OGC)isbuilding a Sensor Web Enablement (SWE) standardsframeworkfor open communication,datainteroperabiliity, and fastreliablenetworkaccesstosensors and platforms. Thisworkpresentsanimplementation of thisstandard in a middleware marine monitoringplatformbasedon OGG-PUCK, SensorML and SOS (Sensor ObservationService).

Wireless network on coastal topologies: Parallel simulation of radio coverage on cellular systems

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Key words: coastal topology, CUDA, parallel processing, radio link, wireless sensor network.

1 Computing radio coverages for ocean shores

Each rocky shore is an ecosystem where it is critical to understand, protect and preserve biodiversity in the context of climate changes. Efficient autonomous observatories can be developed and deployed to collect data with benefits for environment management, thanks to compact electronic devices and new radio systems.

Wireless sensor networks (WSN) offer attractive solutions for observation because of the large availability of physical sensor devices, and compact radio link transceivers, for example Modtronix inAIR9b in Fig. 1 [3]. Radio links enable communications between sensors, gateways, and information systems on permanent or periodic basis [4]. In the case of marine environments such as shores

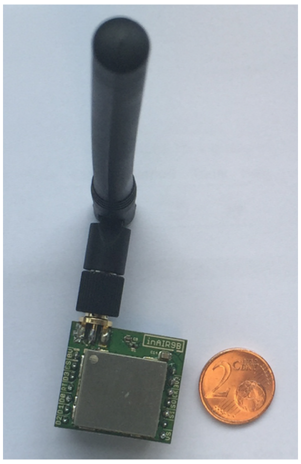

Fig. 1: LoRa transceiver inAIR9b: Semtech's chip sx1276, 868-915 MHz [2].

or islands, it is practically difficult to design radio sensor deployments having an accurate *coverage*. *Coverages* are the way to specify where information is accessible, whatever it is either radio signal, biological, or physical influences. Therefore computing coverage is essential for monitoring purposes and can take various forms. The case of marine shores is difficult because of complex topologies, with rocks of various shape and elevations interleaved with the sea. Managing the sea from radio buoys is another element.

This paper relates on a work principles and results oriented to exploration of radio link capabilities, taking into account sea shore geography topologies. By modeling geography into cell systems, it becomes possible to simulate many physical phenomena such as wave effects, rain effects, pollution, etc. It is also possible to model the natural behavior of WSN radio signal propagation. This define the ability of signals coming from one point to reach another point (*Line of Sight*, LoS).

As an example, the results of the LoS computation are shown in Fig. 2, where cells highlighted with pink color can communicate with the P1 emitter.

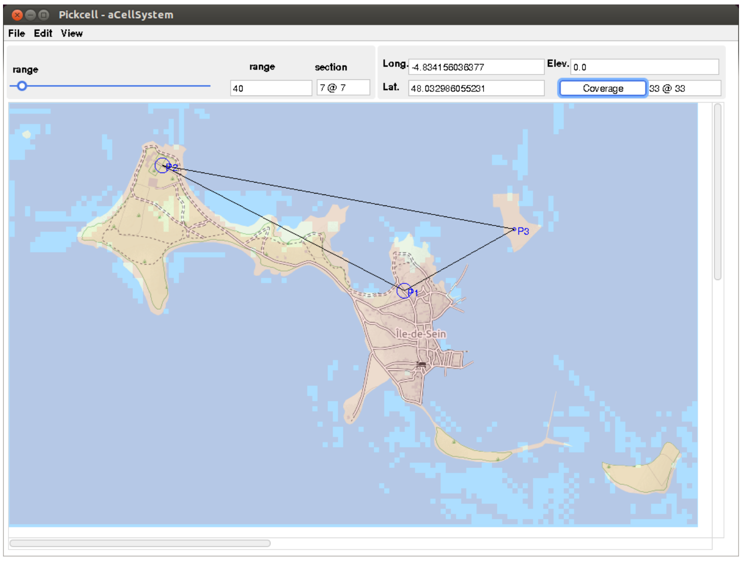

Fig. 2: Example of a coverage for *Ile de Sein*: cells are illuminated by a WSN consisting of 3 nodes with P1 as a master. There are 9971 cells under the communication coverage of this WSN corresponding to 89.58% area. The Pickcell window displays geolocation and elevation at a mouse position, the cell size in pixels and meters (33 meters in this case). The positions of P1, P2, P3 were decided manually, each selection showing immediately the cover of the respective selection.

Computing covers in presence of obstacles is known to be a compute intensive task, in the complexity class of 3D image synthesis because emitted rays must be compared to each other point in an image taking obstacles into account. We explain and discuss a massive parallel execution led on cellular systems representing the geographic zone. Computations were firstly achieved on communicating processes suitable for multicore processors, then they were ported on Graphics Processing Units (GPU) producing performances in the real time order.

The tools developed allow to select arbitrary study zones from a specific map browser called *QuickMap*[1]. As a result, automatic and manual coverage computations were applied to a set of archipelagoes. Practical results are given in terms of performances and functional results section 2.

2 Line of sight communication

2.1 Concurrent simulation of radio propagation

The cellular approach is based on splitting an image (or abstract data representation) into a discrete regular cell systems. When the physical space description is obtained, we are interested to compute reachable cells in line of sight from emitting positions.

Each cell is thus represented by a process, either in software (Occam *thread* processes) or in hardware (processing elements in a graphic accelerator). Processes are connected by channels that allow to send or receive information from neighbour nodes according to a chosen neighborhood: (W, N, E, S) as example, or a more complete *Moore* neighborhood with 8 nodes.

Simulation is achieved in a lock-step fashion by cycling on a synchronous parallel program: communicate with neighbors, observe local status (sensing), decide about a new status and prepare next cycle communications. This mechanism define a physical machine as a distributed product of automata of any shape.

Line of sight represents a ray broadcast in any direction from an emitter. The ray propagation can be stopped by ground topology (hills, valley). Cellular simulation mimics the physical behavior, by propagating the signal inside a tree rooted at the emitter cell, and covering all the Space in concentric circles. Each new step in the algorithm cover a new circle, and the computation finish in $2log(n)$ steps where n is the number of cells. During ray propagation, the elevation ground profile is collected into *routes* that are completed progressively based on positions and elevations. Each cell can decide if the emitter is visible or not by comparing its elevation to the received profile.

This algorithm can be identified as a synchronous Breadth First Search [6], while radio propagation estimation follows technical rules described in [7] and [10].

2.2 Practical effects

In practice, for execution, the lab tools allocate cells in the accelerator memory and represent channel connectivity by data structures. The execution itself is done by a so-called *CUDA kernels* sweeping the node system. We have been able to map and execute systems with as many as 70000 cells. The level of effective parallelism is high: common GPUs have several hundred of processors, thus the computations finish at impressive speed (see Table 1).

Using these tools is easy and allows to investigate case study in short delays. As a demonstration, 6 complex shores were explored with a variety of geographic resolutions, system sizes, and cell sizes. The table 1 summarize the results. Computation delays are compatible with a fast mobile that needs to guess what is happening below or beside, provided that geographic data have been stored previously.

[1] Tool designed by Pierre-Yves Lucas that can handle a variety of tile systems for maps or satellite imaging

Name of place	Size of cell (m)	Number of cells	Number of emitters	Number of visible cells	Percentage coverage	Execution time (ms)
Sept Iles	38	43610	3	39064	89.58%	365.39
Scyllies	191	12544	3	10523	83.89%	81.219
Ile de Sein	33	10988	3	9971	90.74%	63.98
Chausey	33	32802	2	27594	84.12%	174.48
Brest bay	76	55986	2	49694	88.76%	304.55
I'ile Saint-Nicolas	38	34965	3	33131	94.75%	285.46

Table 1: For six different experimental areas, *Size of cell* column indicates the actual sizes in meter. The third column gives total of cells in cell systems. In the next columns, statistics show how many cells would be visible and percentage coverage associated with figure of deployed emitters. The computation times, which depend on both the number of cells and the number of emitters, were evaluated, as shown in the last column of this table.

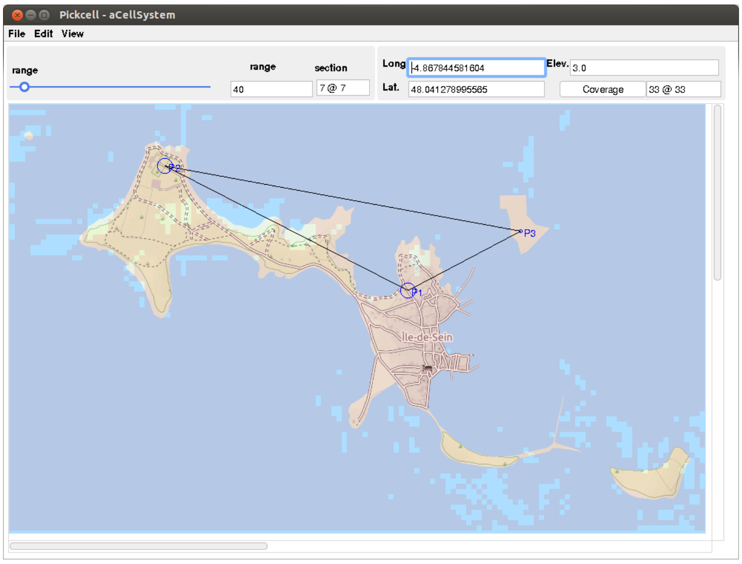

Fig. 3: An experiment with the offset 5 meters of elevation for emitters was employed for the WSN in Ile de Sein. This can be described as the height of transceiver antennas. Consequently, the total of cells within the coverage of the WSN increases up to 10385 cells corresponding to 94.51% area. This result proves that the elevation is a key factor in LoS communications

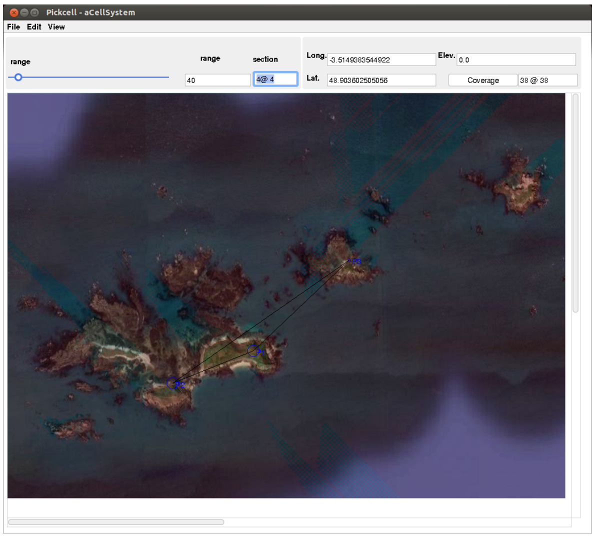

Fig. 4: In this figure, a satellite photo tile is used to present a possible sensor deployment on Sept Iles archipelago. Quickmap tool provides several type of maps such as OpenStreetMap, Thunderforest, Google map, etc. (for more details see Fig. 5). Moreover, Pickcell tool also allows to process on images, for example weather radar images, X-ray/MRI images, to model and simulate physical facts based on cellular methods.

2.3 Coverage exploration

Our tools provide two ways in order to determine emitter positions: manual selection or coverage exploration strategy.

In manual mode, each time an emitter is located on map (Quickmap/Pickcell) the coordinate (longitude, latitude) and elevation of this point are used as parameters to execute the LoS algorithm on GPUs. The obtained result are cells within the LoS communication range of this root associated with received power signal. These values are fetched back into Pickcell to show corresponding communication coverage. Another cell in this coverage can be chosen to put next emitters or repeaters as planning a wireless network. Due to a large number of cells and complexity of simulation, this process needs high computing power to perform in real time. A video clip to describe this process can be accessed at the following link: *https://youtu.be/iO94UiFx7KE*

For coverage exploration, the highest point to put the first emitter is found out by program automatically. The values of this point are also send to the CUDA procedure running on GPUs to determine a set of cells under its coverage. This coverage area is shown on Pickcell and then a cell in the area is selected to put the next emitter based on one of different strategies such as maximum distance from the previous emitter, maximum number of invisible neighbours, so on. The process continue in the same way until all cells are highlighted.

3 A summary of NetGen/Pickcell tool flow

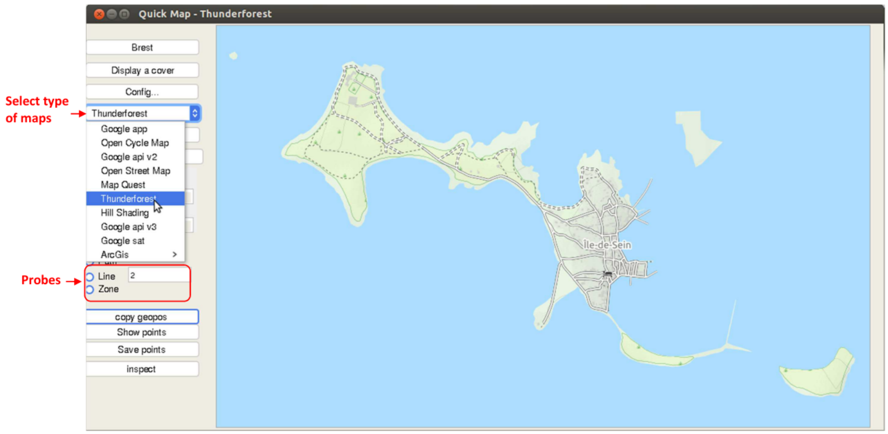

Fig. 5: Quickmap: a map browser allowing to select several kind of maps, change tile and walk anywhere.

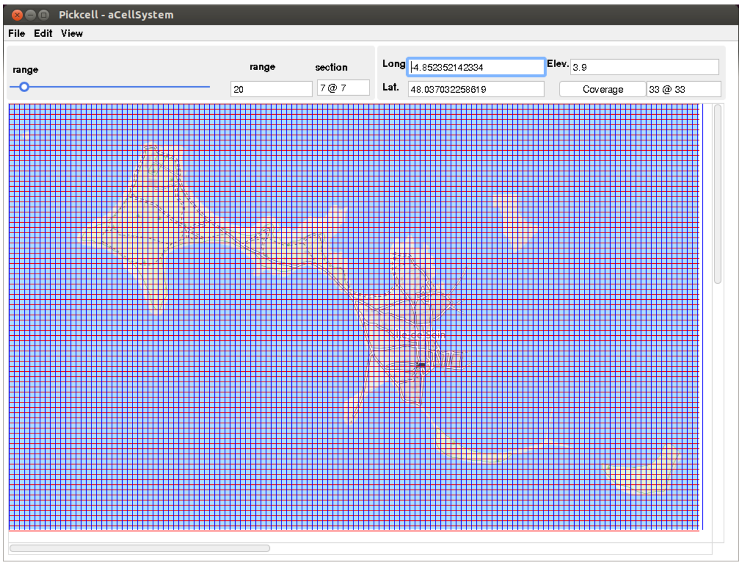

Fig. 6: Cell system: (x, y, z), distance, range.

PickCell/NetGen is a set of tools sharing abstract models for network of sensors and physical simulation. They also share software generators for concurrent executions [9] that are compatible and mergeable.

Pickcell allows the analysis of a geographical zone, in the form of geo-localized cells in 2 dimensions. The cells are defined on a browser of maps. The cell systems can be produced with additional information such as elevation, geological data. The cells let the computation of radio signals line of sight taking into account the obstacles. The common flow proceeds top down from space to modeling and simulation as follows:

- *Space* descriptions are selected from maps, photographs, measures, human body model, nano-architecture model.
- *Cell partition of Space* regular segments are produced keeping geo-metric references (possibly geo coordinates).
- *Cell subsystems* are produced by grouping based on criteria (colors, elevation, and other data).
- *Cellular automata* are built by connecting neighbor cells according to a connectivity pattern (Von Neumann, Moore).
- *Cell behavior* describes physical evolution data with transitions and physical neighborhood influences.
- *WSN sensor systems* are networks of measure points with geometric references, wireless communication capabilities, estimated coverage ranges.
- *WSN behavior* is logical behavior of sensors cooperating inside networks, achieving local perception and contributing to distributed algorithms.

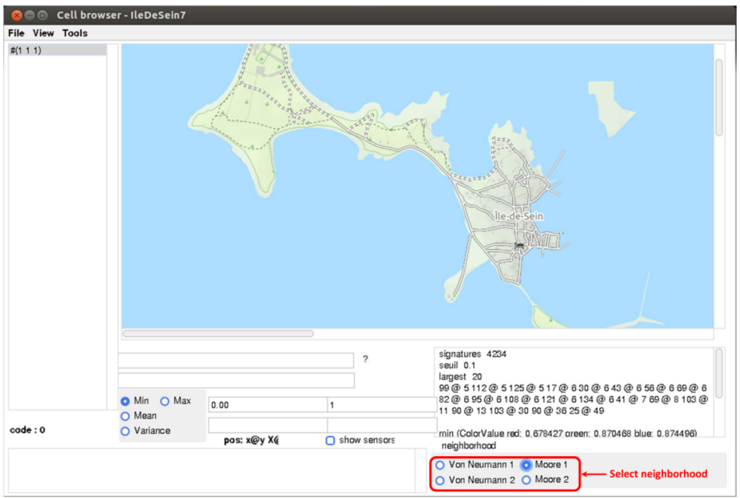

Fig. 7: Cell weaving and simulation synthesis. Cell system specification produces automatically.

Merging network and physical simulation defines a cyber-physical machine model embedding physical reality, perception, distributed decision, and possible physical control on real world. Many applications can come from this approach such as flooding, pollution, wild life simulations.

4 Perspective in simulation

Line of sight has been investigated to support long range radios such as LoRa [2]. LoRa protocol has been experimented on range above 10 kilometers.

Because the design of sensor networks and the simulation of physical processes share the same internal model and share generators. It is possible to build compositions of simulations. This is done using a methodology called High Level Architecture (HLA) [5].

We thus expect to be able to handle practical physical simulations for sea applications in relation with sensor system design for remote locations.

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Toward networked automatic coastal observatories: architecture and applications of vision sensors
extended abstract

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We describe principles and applications of a small environment sensing station with emphasis on vision analysis. Such cameras can be used to monitor coastal ecology, from insects, birds to fish or vessels. Local processing is done in the station using a parallel architecture as an accelerator to produce local diagnostics and avoid transmitting huge amount of data to remote centers. High performance computing methodologies also allow to obtain flexibility for counting, tracking, classifying mobile objects of different kinds..

1 Application fields in wild life and environment

1.1 Context description

Automatic observation of living species is on the agenda for several reasons. First, there are fears for effects of climate change for several genus, and it is important to understand evolution of the situation related to species and environment. Second, there is a significant development of genus without predators which unbalance some environments. For example, insect pests cause extensive damage in several tropical countries: brown planthoppers in Vietnam, or locusts in Africa.

Building automatic observatory can be of great help for knowledge and risks managements. This paper explains some technical difficulties and their potential solutions, with a special focus on vision systems oriented to diagnostics. The general orientation are set of programmable small autonomous communicating systems than can do these *local diagnostic* and emit synthetic information toward remote databases.

We will start by explanations about several application fields that we plan to investigate.

1.2 Application fields

1.2.1 Insect monitoring

Research is active on subjects such as statistical counting of insects in flights [14], or tracking moving insects [11] moving in 3D for over few second, or tracking and analyzing behaviors of insect colonies [5]. These works use cameras to track mobile insects in real time to better understand their behaviors and to help to model them as well.

High speed cameras [2] have been used to capture honey bees in flight at 6,000 frames per second at the resolution 512x512. It was observed that the aerodynamics of honeybee flight are determined by low stroke amplitude (90^o) and high wingbeat frequency (230 Hz). This work suggests that the peculiar kinematics of bees may reflect some special features of their flight muscles.

1.2.2 Bird monitoring

Seabirds and marine environment health have a close relationship since sea bird population changes are the result of climate changes, pollution, low breeding rates. To better understand ecosystem, the project 'Monitoring nesting seabirds' [30] in West Wales was carried out in order to estimate the position of birds nesting on a cliff-face using computer vision approach. The project provides automatic tools to monitor widelife, especially Skomer Guillemots and other seabirds, so that clearer and more reliable information of nesting bird is collected for decision making.

One of contributions of this project is to classify flying birds automatically [4]. This work allows extracting from appearance features to motion features of observed birds. In addition, normal Bayes network and Support Vector Machine (SVM) methods are used to classified bird features. Experiment shows that the classification time is around 20ms, which is suitable for real time applications.

Nevertheless, this work seems not to take into account some factors. First, it does not consider the feature extraction time which may consume much more time than the classification phase. Besides, the overall time for processing an image frame is not mentioned as well. This overall time is important because it can help to estimate the average frame rate to better measure the execution time of the system.

A bird image dataset is constructed to be a premise of automatic bird detection classification [32] for ecological investigations. In the dataset, 32,000 individuals are annotated by using a still camera with a telephoto setup in which the average size of birds in the image is around 25 pixels. From this work, some machine learning algorithms can be applied in order to classify bird species.

1.2.3 Underwater monitoring

Cameras can be put underwater to follow fish behaviors and trajectories [7]. The idea is to help marine specialists to detect environmental changes deduced from the unusual trajectories of fish. Although there are challenges of underwater environments and trajectory data, this work proposes a method, which provide better results than state of art methods, to detect unusual fish trajectories.

A system to track multiple fish [10] is proposed to confront with low-contrast and low-frame-rate underwater stereo cameras. This system uses histogram back projection approach on double local-thresholded images to segment fish shape accurately. Due to the low frame rate of cameras, a modified multiple-target Viterbi data association is used to deal with poor motion continuity and frequent entrance/exit of the field of view for fish targets. The proposed system gets 88% success rate in term of fish tracking in low conditions and gives 6% of mean absolute percentage error in fish length measurement under the low-contrast environment.

1.2.4 Plants observation

In [26], an approach to quantify the tree leaf area index (LAI) at ecosystem scale using upward pointing cameras is proposed. It was applied to oak-savanna ecosystem in California to identify phenological and abnormal events and to estimate seasonal to interannual variability of tree LAI at ecosystem. Upward pointing cameras are used instead of other devices since they are inexpensive, fast and accurate in monitoring ecosystem under forest canopies. In addition, they are able to validate LiDAR derived gap fraction and to match fields between LiDAR and photos taken from cameras.

An hyperspectral camera analyzes the spectrum of plant leaves to identify the plant water stress [19]. It helps automating on-the-go mapping of plant stress so that people can intervene and ease problems before exceeding critical threshold. Experimental results indicate that this solution can help decision making for plant stress detection and management.

1.2.5 Boat monitoring

An imaging method [8] to detect the speed and other information of boats moving on a wide surface using a single camera was proposed in Venice to notify boat drivers the speed of their boats created. The truth is that vessels and motor boats cross the channels too fast and generate huge sea waves which erode the city's docks. That causes a lot of damage to the city and its ecosystem. From the data collection of the operation of this system during 2 continuous years, it is observed that speeds of vessels are in the controllable level in the monitoring area of the camera.

This solution can be realized using radar data analysis [15] but it is much more expensive. Moreover, it is difficult to recognize small boats with radar based techniques since their spectrum is similar to the wave's spectrum.

2 Sensing station proposal

A sensing station can be built from following components:

- Autonomous system node. An autonomous sensor [3] is a device that is generally able to perform its task without being connected to a control unit. The emergence of application fields requires the increase of computational capabilities with suitable power consumption in the sensor node. Raspberry pi [24], NVIDIA Jetson Tk1 [20] are examples of such devices that are able to deal with new challenges of application fields (table 1).

	Raspberry PI 3.0	Jetson Tk1
SoC	Broadcom BCM2837	Tegra K1 SOC
CPU	4× ARM Cortex-A53, 1.2GHz	2.32GHz ARM quad-core Cortex-A15
GPU	Broadcom VideoCore IV	NVIDIA Kepler "GK20a" GPU with 192 SM3.2 CUDA cores
RAM	1GB LPDDR2 (900 MHz)	2GB DDR3L 933MHz EMC x16
Power	800 mA, 4.0 W	12W in peak GFXBench 3.0 Performance

Figure 1: Raspberry Pi 3.0 and NVIDIA Jetson Tk1 specifications.

- Radio link and network organization. Sensor nodes connected each other mostly using radio connection in a network topology. By integration of radio transceiver, each sensor node is able to transmit its messages to a distant destination. For instance, Zigbee [1] can transmit a message roughly 50m while LORA [27] is able to reach tens of kilometers destinations at low data rate.

- Sensors. The sensing station consists of sensors such as temperature, accelerator, or even more specific ones such as acoustic and vision. Using data from sensors, the sensing station is able to carry out its task locally (local processing) and transmit output to a data center via radio links. In this case, embedded graphic processing units (GPUs) may be necessary to accelerate the processing.

- Suitable power consumption with high performance. For example, Raspberry Pi 3.0 consumes typically 800mA, 4W in it tasks while Jetson Tk1 requires 12W in peak GFXBench 3.0 Performance Metrics. However, table 1 suggest that Jetson Tkl would have better compute performance than Raspberry Pi due to internal parallelism.

Due to these considerations, it is appears that a station with high performance, low power consumption, parallel computing with GPU emerges as a suitable choice.

3 Efficient parallel image processing

3.1 Graphics Processing Unit

Principle of Graphics Processing Unit (GPU) is to handle the image as lines which are available in local shared memory. Lines are processed as a whole, or as a set of chunks (locally parallel, globally sequentially). The software program tools bind the real sequence of computation and process by decomposing these computation using a set of basic methods such as data parallel handling, reduction to make decision, streaming.

Typical images size can reach the order of 10,000 by 10,000 pixels, therefore, typical processing needs adequate computation efficiency. An effective method was to address this problem in the context of parallel computing. In fact, the structure of image data may suggest a parallel approach to carry out the processing (an image consists of pixels, each pixel has 4 or 8 neighbors). In addition, the nature of some image processing algorithms is also parallel such as: morphology, connected component labeling.

Parallel image processing approach can be used to deal with the following problems:

- Objects counting. It can help to count dense moving objects such as: insects, birds. Objects can be static or mobile. For example, figure 2 represents a Brown Planthopper (BPH) counting result in an insect light trap.

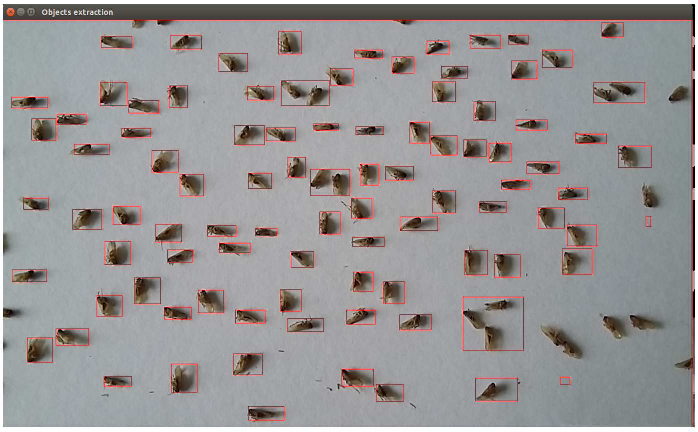

Figure 2: Brown Planthopper counting (93/106 individuals - accuracy 88%). The image is taken at 1280x720 resolution with around 50cm distance. In average, each individual has 52.08x30.67 pixels shape and contributes roughly 1063.7 pixels in the image.

- Moving objects tracking. The approach can be useful in multiple objects tracking. It can accelerate to help tracking 10 to hundreds objects.
- Classification. It is able to speed up species classification. For example, it can identify the species of flying birds (figure 3).

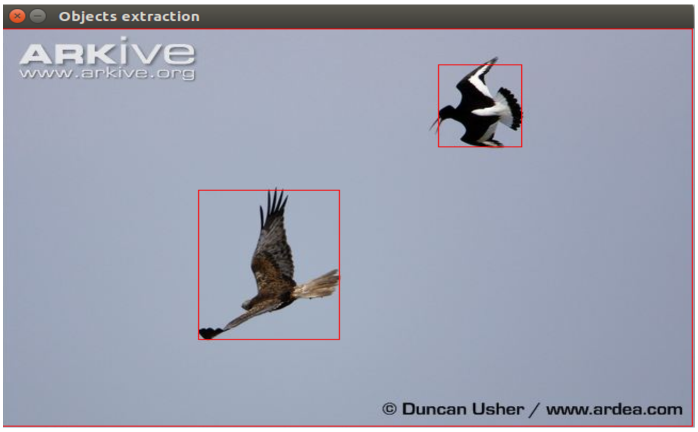

Figure 3: Flying bird classification.

3.2 Technical references

Parallel image processing can be reached thanks to GPUs since the architecture of GPUs is data parallelism [16] of which varying aspects relate to the memory capacity, the number of processors, feed rates.

In most cases, data retrieved from camera is mapped is mapped directly to the GPU and is processed there.

Some examples of parallel vision applications are:

- A solution inferring D faces from a single frontal image using automatically extracted 2-D landmarks is proposed in [9]. This work uses RANSAC [12] and Perspective-n-Point (PnP) to estimate the 3D head pose by allowing a large range of poses when the head moves. Experiment shows that this method is able to run in real time thanks to the acceleration of GPU (15 frames per second - FPS).
- GPU is also used to speed up the performance in Real Time Image-Based Tracking of 4D Ultrasound Data [21]. This method allows tracking the location of the probe wrt. anatomy without using external devices. Implementation of the method is carried out in a fast GPU (8.2FPS) so that the probe can be tracked in real time.
- Real time performance can be reached by the GPU implementation of a novel model-based method for tracking the six-degrees-of-freedom (6DOF) pose of multiple rigid objects. The method archives the framerate at 40Hz when using a 500,000 data samples to track 150 objects in 640x480 images. Using an extensive benchmark dataset, the method shows increased performance (in accuracy, robustness, and speed) as compared to state-of-the-art methods.

3.3 Parallel vision architectures

The key point of vision applications is the relation between the pixel matrix sensor and the processing unit. In practice, there are 3 types of cameras as shown in figure 4:

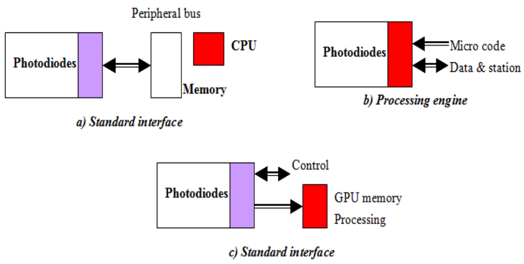

Figure 4: 3 vision approaches: (a) standard camera with separated vision matrix and processing unit, (b) smart sensor with photodiode matrix and processing on the same chip, (c) camera assembly with DMA between the vision matrix and a graphics processing unit memory (GPU).

Fig. 4a illustrates the architecture of widespread cameras as used in mobile phones, as example. They are inexpensive and follow standardization of access interfaces. In principle, a camera has a sensor matrix which is isolated with a processing unit. A micro-controller can control the structure of the image, resolution, acquisition speed in frames per second. This affects the quality of videos relevant to the end user.

Other cameras for industrial controls integrate the processor (a parallel processor) and the sensor array (fig. 4b). The analysis can thus be carried out directly into the camera without rendering image format. These cameras can recognize tens of thousands of objects per second, without significant energy expenditure and they also allow the development of machine learning techniques.

Halfway between these two techniques, devices in figure 4c) are able to control the acquisition of image segments by sending them directly to a GPU.

What is important in the concept of parallel vision (case 2 and 3) is that pixels appear in lines, or group of lines, that are processed as a whole: there are no sequential loop over a line, but concurrent processing of several pixels. This result from the architecture properties and virtualizing the processing array.

3.4 Example algorithm for the counting case

Figure 5 depicts a workflow useful to count objects such as birds, insects, vessels in an image. The context of this workflow is in an insect trap where insects are attracted. Periodically, a camera takes an image of the trap and allows to sample the insect densities locally.

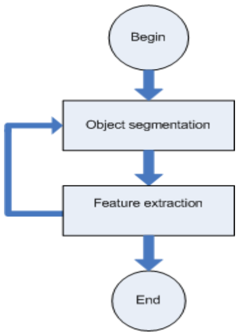

Figure 5: A workflow for counting object density in an insect trap.

3.4.1 Object segmentation

Object segmentation from an image input is to detect pixels of an object as 255 (white) while others are 0 (black). The watershed algorithm [25] is used to implement this task.

The idea is to consider the input image as a topographical surface where pixels with high intensity are peaks and others become valleys. Water is flooded from one valley to another. When water rises, depends on peaks nearby, different valleys tend to merge. Barriers used to prevent the merger may give the segmentation results.

However, it may be oversegmented due to noise and some irregular pixels, thus, a marker based watershed algorithm is used to mark which pixels is are merged and which are not. The idea behind is to label regions that are been sure as foreground with a color and regions that are been sure as background with another color while regions are not been sure anything with 0. Then, the watershed algorithm is applied and the result can be archived.

Figure 6 depicts the background and the marker for the result obtained in figure 2.

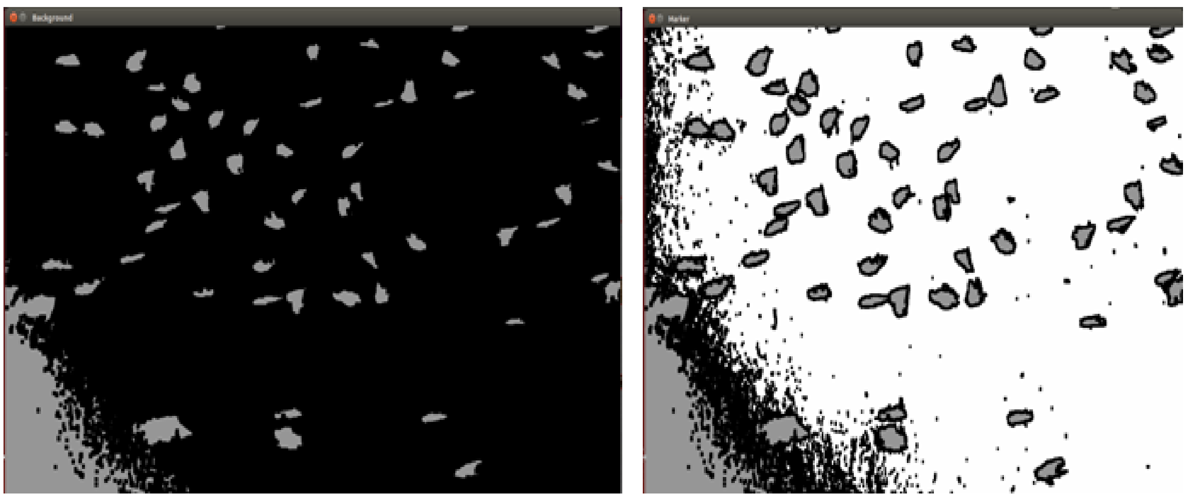

Figure 6: Background (left) and marker (right) for the image in figure 2.

The algorithm is shown as follow:

ALGORITHM: OBJECT SEGMENTATION
INPUT: source: input image
OUTPUT: result: image output where foreground is white, background is black

```
        grayscale = toGrayScale(source);
        binary = threshold(grayscale, t);// binarize image with a threshold t
        erode (binary, foreground); // remove noise and emerge foreground
        // Background is obtained by dilating binary and thresholding

        getbackground(binary, background);
        //marker
        marker = foreground+background;
        //watershed
        result = doWatershed(source, marker);
}
```

3.4.2 Feature extraction

The segmentation phasis results in a binary image output used for the second phasis processing. Actually, this phasis is to label pixels that belongs to an object as a group and extract features of each group. The connected component labeling algorithm [13] is used to implement this phase.

In the described experiment, color histogram (16 bins for each channel red, green, blue), size (width, height) and area (number of pixels that the object possesses) are considered as object features. Therefore, the feature vector of an object has 51 values.

Due to lack of available data collection, this work assumes that all objects appear in an image belong to a species. However, if insect data is collected and managed, it will be possible to create a dataset (e.g tens thousands individuals per species) by using these above features. Thus, the number of objects in an image provides the quantity of necessary insects (e.g result in figure 2).

Note : the experiment was coded as a sequential algorithm in advance of a project that will start september 2016.

4 Background and perspectives

Sea shores, and especially archipelagos, represent rich environments where observation is difficult. The paper layout proposes a set of observation domains, and situation objectives that could be managed by autonomous networked systems: counting, classifying, tracking. The first diagnostic is that low power sensing nodes could sample these aspects efficiently under the condition of parallel processing availability.

Shores are also places where communication infrastructure are likely to be absent. As a result distributed algorithms must manage knowledge synthesis and transmissions, satellite or plane collection are examples.

We advocate a design method based on networked smart sensor nodes acting as cyber physical device, able to manage interactions between the information system and the physical aspects, including estimation and simulation of the physical situation.

A local analysis is supported in each node with the example of insect/bird counting using watershed and connected component labeling algorithms. It is also shown that local computation can be supported by an architecture for high performance vision suitable to handle object recognition using parallel algorithms.

Many applications can benefit from approaches similar to integrated vision, as example sound analysis.

Cyber physical characteristics can also be assessed by the possible control from sensors. It is known that physical measurements often depend on several basic parameters, and sensors may also affect these measurements. For instance, it is possible to emit light signals of different colors and different intensities to sound environment. It is also possible to rotate the light signals, a camera, a microphone or a speaker. It can be seen that measurements, control devices, recognition, form an indivisible whole which can be classified in the cyber-physic domain.

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STANDARDS FOR INTEROPERABLE MARINE SENSORS: TECHNOLOGIES AND ADOPTION

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A marine sensor is usually physically connected and integrated with a "platform" such as a buoy or an autonomous vehicle that provides power, processing, data storage and telemetry capability. In general each kind of sensor defines its own specific command protocol, and very often its own data format. Sensor "driver" software on the platform must issue specific commands recognized by the sensor to configure, control, and acquire data from the device and so a different driver is required for each kind of sensor on the platform. Moreover different drivers are usually needed for the same sensor on different platforms, due to differences in platform operating systems and resources. Platform software may process and store the acquired sensor data onboard, and also may transfer the data to some other location (e.g. shore) for further processing, analysis, and display; these processing components must be aware of the sensor's data format in order to parse and interpret the data. Thus considerable engineering time and money may be required to develop these software components. The use of standard instrument protocols, data formats and/or metadata that describe protocols and formats can reduce the software development effort, since driver and data processing components can then be more generic and applicable to more than one kind of sensor.

In addition to software development costs, considerable time may be needed to install sensors onto a platform, even after the drivers and data processing software is already written. E.g. each device must be physically plugged into a specific serial port, its driver configured for that port, and baud rate configured to enable communication between sensor and driver. Each sensor's identity must be noted so that data retrieved by the driver is correctly associated with the device's serial number, calibration coefficients, firmware version and other characteristics. Errors made during this installation process might be obvious (e.g. baud rate mismatch) or subtle (e.g. incorrect instrument serial number) - in either case consequences can be costly in time and data quality. Installation procedures could be more efficient and reliable if standard automated methods to detect and identify sensors installed on a port could be developed.

In this presentation we describe several existing and emerging sensor standards that aim to increase system interoperability and reliability and to lower software development and operation cost. We describe their implementation and use in some marine observation systems today. We also discuss how to understand and reduce the barriers to standards adoption by users and manufacturers.

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The knowledge of how an observable property becomes a measured observation must be captured at each stage of its creation. Sensor-based observationsare made through the use of applied technologies, each with specific limitations and capabilities. Each instrument model produces observations with disparate issues relating todata quality. Environmental sensors typically provide a variety of options that can be configured differently for each unique deployment, affecting the observational results.

A recently funded NSF EarthCube project, called X-DOMES (Cross-Domain Observational Metadata for Environmental Sensing), has begun to create tools and registries and to develop a community of practice for sensor manufacturers and stakeholders to facilitate the capture of metadatawhere it is best understood: by the sensor manufacturers and people collecting and processing the data. This knowledge is captured in representations that enable both syntactic and semantic interoperability through the use of broadly adopted and evolving standards (W3C Semantic Web; OGC SensorML)as well as controlled vocabulary and other knowledge representation development initiatives (e.g., W3C Semantic Sensor Network ontology).

By capturing the information (metadata) at each stage of its generation, a more complete description ofsensor and processingprovenance can be communicated. Machine-harvestable, standards-based encoded metadata, enriched by linked data mechanismssupported by Semantic Web technologies can more effectively be shared across disciplinary and geopolitical boundaries. The use ofthese standards-based sets of shared tools, workflows, and practices also enables automated harvesting and translation to other community-adopted formats and protocols, thus promoting interoperability in our data management systems.

Keywords: data quality; provenance; W3C; OGC; SensorML; Semantic Web; metadata; sensors; interoperability

Maximization of the power of the ultra-wide band "UWB" signal sent to the human body while respecting the Federal Communications Commission "FCC" constraints

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Abstract

The object of this work is to maximize the power of the ultra-wide band "UWB" signal sent to the human body while respecting the Federal Communications Commission "FCC" constraints. The signal is formed by monocycle Gaussian pulses and characterized by their central frequency "fc", their period repetition pulse "PRI" and their amplitude "A".

Maximize the signal power with FCC constraints means trying getting close to the DPS (Density Power Spectrum) of those Gaussian mono-cycles to 41.3 dBm in ultra-wide band frequency domain with FCC constraints respect. For that, we can use the random variables theory to determine the optimum characteristics of the signal. We have also imposed 0.025 as a maximum duty cycle between the central frequency and PRI (Pulse Repetition Intervals) to avoid the overlap between pulses.

This signal is used to be sent towards the human body to detect the heart beatings. To see the waveform near the heart, we have firstly modeled the human body as composed of four semi-infinite layers. Those layers are characterized by their complexity relative dielectric constant, their thickness and their electrical conductivity. Secondly, we use the Finite Difference Time Domain (FDTD) to model the UWB propagation channel. This method is an efficient tool to predict the electromagnetic field distribution along the propagation channel.

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Title: ANALYZING SEASONAL, INTERANNUAL AND EXTREME CLIMATE VARIABILITY IN THE CARIBBEAN SEA UPWELLING SYSTEM OFF COLOMBIA

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As products of ocean observation have increased, the integration of the globally distributed data in poorly instrumented zones provide new valuable information about their oceanography. This is the case of the Caribbean upwelling system off Colombia, where the long-term mean annual cycle and interannual variability of air-ocean interactions were investigated by means of *in situ* measurements, satellite observations and oceanic and atmospheric reanalysis models. Variables of interest such as the sea surface temperature (SST), sea surface salinity (SSS), the mixed layer depth (MLD), the upper layer heat budget, ocean currents, waves and surface winds were analyzed and correlated to known local and remote forcing including the Caribbean Low Level Jet (CLLJ) and El Niño Southern Oscillation (ENSO) dynamics, respectively. Then, a detailed Extreme Value Analysis (EVA) of winds and waves was performed by comparing three distinct methods; Block Maxima, Peaks-Over-Threshold (POT) and the Method of Independent Storms (MIS).

The seasonal cycle in this Caribbean upwelling systemdepends on the intensity of the zonal winds and the location of the CLLJ.Interannual oscillations in this region are associated with the extreme phases of ENSO. However, other factors, such as a Quasi-Biennial Oscillation (QBO) and the North Atlantic Oscillation (NAO) influence this regionand induce changes in the air-sea interactions.

EVA results differed broadly from the three methods applied and when using various threshold values, hence the importance of evaluating for each specific database and station the one method that yielded the higher correlation coefficient of the model values vs. the observed data. Return periods of the extreme events occurring in this upwelling system indicate that significant wave heights could reach up to 4.5 m and surface winds could be around 35 to 40 m s^{-1}. During the analyzed period (1987-2011) nearly 60 (90) extreme wind (wave) events were quantified in the region, lasting around 60 (90 hours). During the annual cycle most extreme events occurred during the January-March months when winds are strongest and not during the hurricane season as was expected.

FIRST YEAR OF AN OCEAN-ATMOSPHERE MOORING IN THE SENEGALESE COASTAL UPWELLING.

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The Joint International Laboratory ECLAIRS set up an oceanographic and meteorological buoy, dedicated to monitoring and analysis of the short and long-term changes in climate, atmosphere and marine environment within the Senegal coastal upwelling. The buoy "MELAX" was deployed early 2015 in the heart of the Senegalese upwelling by 30m-depth at (14,20'N, 17,14'W). Data collected are, for the atmosphere, surface wind, solar radiation, humidity and rain, and for the ocean, temperatures, salinity, and currents (from the surface to the bottom) and oxygen. We present the first year and a half of observations, in particular the relationship between wind, sea surface temperatures, and hydrology. Satellite and model data are used to provide a larger-scale context to the local monitoring.

Synchronization Experiences at Obsea-UPC

Joaquin del Rio,Daniel MihaiToma, OriolPallares

Data acquisition requires a precise time stamping. Land applications can use GPS network in order to synchronize the data acquisition time reference. For marine applications, there GPS signal is unavailable other techniques for time sharing must be use. This presentation will be about different experiences about synchronization at the shallow water cabled observatory Obsea (www.obsea.es) in Western Mediterranean in Spain. The use and implementation of protocols like NTP (networkd time protocol) or PTP (Precision Time Protocol Std. 1588 IEEE) will be shown. Also PTP based implementations for wireless sensor networks (RF link) and underwater sensor networks with (acoustic link) will be explained.

Automation for In Situ Multi-Stressor Biogeochemical Experiments

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*Speaker

AUTOMATED TECHNIQUES FOR STUDYING PHYTOPLANKTON DYNAMICS IN MARINE WATERS

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Marine observation is moving towards greater automation when monitoring biogeochemical properties of the sea. Within the different biotic compartments, phytoplankton represents the basis of main food webs and mediates the main biogeochemical cycles, participating in the regulation of climate. Automated *in situ* approaches provide new insights into phytoplankton dynamics by allowing the study of changes in phytoplankton abundance, biomass and/or diversity, at high spatial and temporal resolution, which are of the outmost importance especially in marine coastal systems, submitted to anthropogenic and global pressures. When implemented in automated environmental monitoring platforms, as fixed stations, moorings, research vessels and/or ships of opportunity, these combined approaches can represent early-warning systems of plankton changes, as the occurrence of blooms and, in particular, of harmful algal blooms (HAB), of special interest in areas of fishing, aquaculture and tourism. Therefore, there is an urgent need to improve the operability and discrimination of automated techniques addressing phytoplankton diversity (at taxonomical and/or functional levels), distribution and/or productivity. Innovative optical sensors have been explored in previous studies, as in the DYMAPHY (2010-2014) cross-border European project. Within the Joint European Research Infrastructure network for Coastal Observatories – Novel European expertise for coastal observatories (JERICO-Next – H2020, 2015-2019), scientists are applying automated observation techniques for addressing phytoplankton dynamics, based on phytoplankton single cell or bulk optical characteristics, in several European coastal and shelf seas, at high resolution, in (near) real-time. Image in flow, single-cell optical analysis (pulse shape-recording flow cytometry) and a combination of optical bulk techniques (spectro-photometry, spectro-fluorometry, fluorescence induction) are being critically compared, in order to better define their applicability in different case studies, in different marine systems.

FixO3 Network Project: Integration, harmonisation, innovation

Richard Lampitt* and the FixO3 Project Consortium

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The Fixed point Open Ocean Observatories (FixO3) Network project is an European project coordinated by the National Oceanography Centre (NOC), which objective is to integrate 23 in situ platforms operated by European organizations and to improve access to data and services they provide for the broad ocean community. Started in September 2013, FixO3 has produced several outputs useful for scientists, industry and policy-makers beyond the project partners. In this poster we present the main project activities, outcomes and how to access the project data and results.

Title:
GAMBUSIA – A METALANGUAGE FOR INSTRUMENTS WITH SERIAL INTERFACE

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Marine environment monitoring System are equipped with different types of sensors related to different disciplines. To perform specific data acquisition is necessary to develop a driver / software / firmware for each sensor integrated in the system.

This kind of approach limits the system flexibility expecially in case of addition of a new sensor. That process in fact involves the update of the entire control software / firmware. For this reason it is important to optimize the time and simplify the work required to integrate new sensors.

This document present GAMbUSIA (GenerAl purpose Metalanguage for instrUments with Serial InterfAce) wich aim to improve code reuse and system flexibility. GAMbUSIA is a metalanguage, based on eXtensible Markup Language (XML), with which it is possible to describe the communication protocol at a high level and use (and reuse) this description instead to develop everytime an *ad-hoc* driver. In order to evaluate this solution, we used GAMbUSIA to create an Oceanographic Bottom Pressure Recorder sensor description and used it in our acquisition system.

The advantage of this solution is that GAMbUSIA does not force the manufacturers of instrumentation to achieving compatibility between their devices in order to operate properly. Also It’s backward compatible with older versions of sensors, and user’s don’t need to develop any hardware, and/or a new software driver.

Underwater Observatory for the Seafloor Ecosystem Monitoring using a Video System

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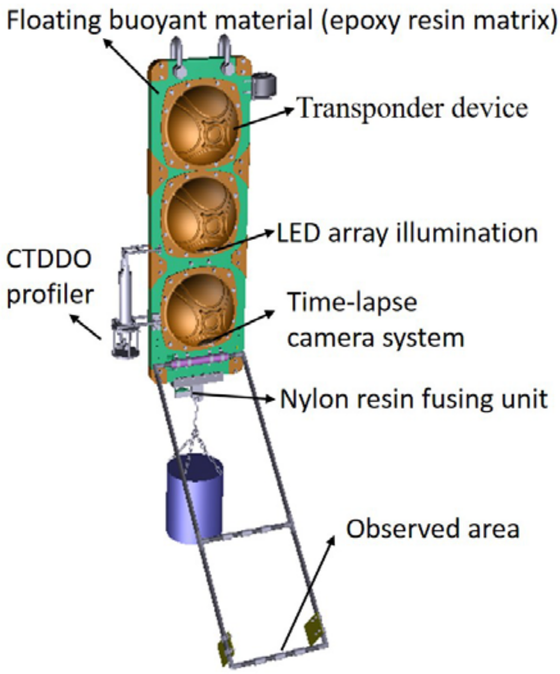
For the purpose of monitoring on the dynamic response of seafloor ecosystems caused by survey or mining missions of mineral deposits, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is planning to install new habitat assessment methods. A continuous monitoring operation of periodic variations of surrounding ecosystem at mineral deposits is essential for acquiring baseline data and knowledge towards proposal of an appropriate methodology for underwater environmental impact assessment.

We were involved in development of a small lander for low-price and usability. The free fall type hadal zone research lander called "Edokko Mark1" consists of 3 glass spheres and wireless connectable rubber bridge, and an observation equipment and levitation transponder device can be installed in the glass sphere. The "Edokko Mark1" lander of early-stage technology was intended for use in one day diving. Also, in a round trip to the seafloor, it corresponded to a depth of 8000m. The "Edokko Mark1" lander was carried out a demonstration test in 2013 at off Boso Peninsula, the Japan Trench. However, for long period observation of seafloor ecosystems at mineral deposits, the lander is required long-term mooring. Further, a variety of organisms at seafloor can be confirmed from the captured images. To carry out the evaluation of the seafloor environment from a video image, the development of analytical techniques were required.

We have been developing a strong observatory lander to corrosion with taking the opportunity to commercialization. Here, key features on the development of new "Edokko Mark1" lander and demonstration of a methodology for underwater environmental impact assessment are overviewed.

The "Edokko Mark1" lander is composed of pressure-resistant glass florat with a built-in observational equipment as shown in Figure (manufactured by Okamoto Glass Co., Ltd.) in the three combined form (Time-lapse camera system, LED array illumination synchronized with camera system, and Transponder device). Observational equipment resistant to corrosion because it's in the glass spheres, but the peripheral parts may cause corrosion. To prevent deterioration by corrosion, framework made by the resin of floating buoyant material. As a result, the increased buoyancy, it was made possible the attachment of CTD-DO profiler. In addition, the weight and the framework is connected by nylon resin disconnected parts, prevented the missing article due to corrosion. These improvements, under hydrothermal deposit environment, will be able to realize the mooring of four months.



Rapid ecotoxicological bioassay using delayed fluorescence in the marine cyanobacterium*Cyanobium* sp. (NIES-981)

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A general method for testing the toxicity of chemicals on algae was described in the 1984 OECD test guidelines (algal growth inhibition test TG201), in which growth inhibition at 72 h after exposure is used to estimatethe effective concentration (i.e., EC_{50}) of chemical. Although this test reliably and directly measures algal growth, it is timeconsuming and expensive because it requires counting the cells every 24 h for up to 72 h of exposure, or more, using an electronic particle counter or under a microscope.

The use of delayed fluorescence (DF) intensity as an endpoint for rapid estimation of the effective concentration (EC_x) has been reported as an alternative to standard growth inhibition (at 72 h after exposure) in some fresh water algae including *Pseudokirchneriellasubcapitata*. In marine algae, theapproach of bioassaying using DF measurements hasnot been performed yet. A DF-based bioassay would provide marine environmental risk assessment with many benefits such as rapidity, sensitivity, and reproducibility.

In this study, in order to develop a new bioassay method using DF for marine algae, we selected marine cyanobacterium *Cyanobium* sp. (NIES-981) as a test algal species, which is closely related to genera *Synechococcus*/*Prochlorococcus* known as major primary producer in marine environment. Based on comparisons of the standard growth test and a test with a24-h time periodusing DF intensity, we conclude that DF intensity is useful as an endpoint for rapid estimation of EC_{50} in *Cyanobium*sp..

GÉOSCIENCES MARINES
GÉOMORPHOLOGIE DU LITTORAL
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Université Bretagne Sud

Morphodynamics of a mixed-sediments (sand and mud) macrotidal estuarine beach under contrasted energy conditions (Vilaine estuary, France)

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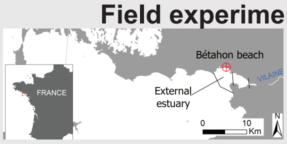
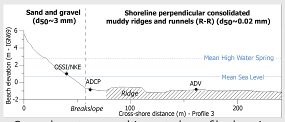
Introduction

Estuary and bay beaches are important areas for human activities. Morphological and sedimentary variations, like mud-infilled, occur on these environments due to multiple forcings. Betahon beach (South Brittany, France) is an estuarine intermediate beach (Low Tide Terrace) which is exposed to a permanent input of clay/silt sediments. This mixed sediments (sand and mud) beach present a reflective sandy-gravelly upper part and a large dissipative mudflat in the lower part. Seasonal monitoring of the beach shows variable topography and morphology of the mudflat. Muddy Ridges and Runnels (R-R) system, perpendicular to shoreline, can occur. This pattern can be totally in-filled by liquid mud and mudflat can increase of 60 cm above the ridge during low energy conditions. On a vertical section, mudflat sediments show alternation of sandy and muddy shapes, introducing the hypothesis of two cohesive and non-cohesive sediments dynamics. In order to identify these processes, two field experiments (6 days long) have been conducted during high/moderate and low energy conditions. These experiments were involved topography, hydrodynamic measurements and photography on a cross-shore central profile. Based on seasonal observations and field experiments, the objective of this work is to develop a preliminary conceptual model of the the dynamics of the central part of this atypical mixed beach, along a cross-shore profile.

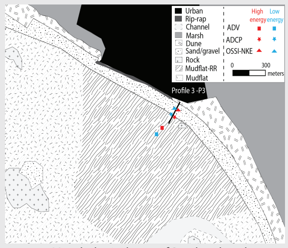
Field experiments - Environment



Location of Betahon beach in Vilaine estuary (France)



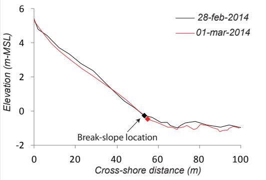
Cross-shore topographic centrale profile ; location of instruments on reflective and dissipative parts



Morphological map of Betahon beach ; Location of hydrodynamic intruments

RESULTS - Topography, sediments and currents

Dynamic under high energy conditions (storm)

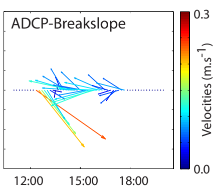


Beach profile reaches its new equilibrium after a daily storm - seaward moving (1.1m) of break-slope and erosion of the mudflat ridge

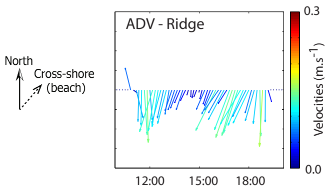
Ridges and Runnels eroded and destructured


A runnel filled by ripple-marked coarsed sediments from upper reflective beach

Mean currents during a storm tide - Hs maximum=0.75m

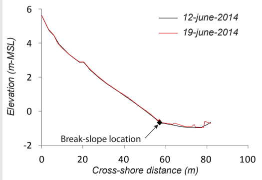


Long-shore preferential flow corridor between breakslope and mudflat cliff-like. Spinning currents



All-tide long «bed return flows» over a ridge of mudflat

Dynamic under low energy conditions

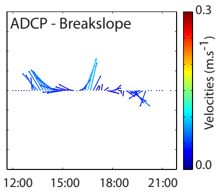


Unsignificant topographic variations of beach profile after 5 days of low energy conditions - landward migration (0.2 m) of break-slope

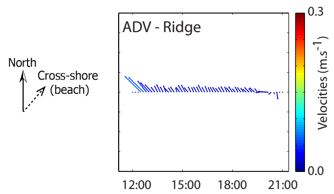
Flatened mudflat with runnels totally infilled by fluid mud (+4.9 cm of fluid mud during field experiment)


Infilling of runnels to breakslope by fine silty cohesive sediments

Mean currents during a tide - Hs maximum=0.13m



Longshore currents in a preferential flow corridor ; onshore/cross-shore currents at high tide



Onshore/longshore currents almost the entire tide; ebb component of tide weaks and time-reduced

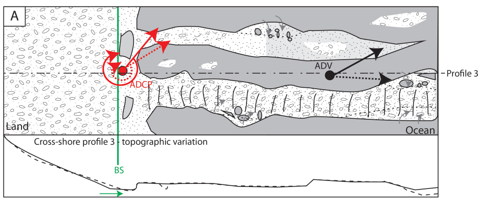
CONCEPTUAL MODEL - Cross-shore profile morphodynamic

A- High energy conditions

- Classical adjustement of upper reflective profile with sediment transport to breakslope. Breakslope moves seaward (Masselink *et al.,* 2006)

- Over the mudflat, all-tide long strong bed-return flows, off-shore directed, lead to infill mudflat runnels by coarser sediments (Le Hir *et al.,* 2000). Currents are chanelized tendencies stronger in runnels (Williams *et al.,* 2008). Cohesive sediments can be transported seaward. Shoreline perpendicular flanks of mud ridges are eroded and rolled by waves to form mud pebbles (Anthony, 2008). R-R system is hardly eroded and destructured.

- Near breakslope, currents follow a preferential flow corridor between breakslope to mudflat shoreline parrallel cliff-like of ridges. Bed return flows and spinning currents are also observed.

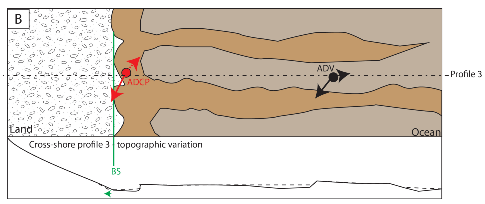


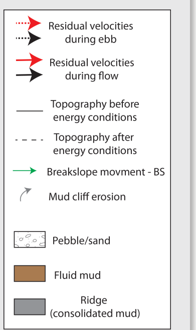
B- Low energy conditions

- Unsignificant morphological variations of upper beach profile. Breakslope moves landward with increasing tide range.

- Over the mudflat ridge, almost all-tide long weak long-shore currents are on-shore directed. Swash bores (no breakers) «wash» and put in suspension fluid mud over the 1 km mudflat. Runnels are filled by water first. When water reaches breakslope and overtops the ridge, sediment begin to settle down (Bassoulet *et al.*, 2000, Anthony, 2008). Cohesive sediments are transported also onshore and trapped near breakslope and runnels when water retreats. Ebb component, virtually nil, don't allows offshore migration of sediments.

- Near breakslope, long-shore currents are a little stronger and follow the preferential flow corridor. Onshore currents are detected during high-tide.





Conclusion

The particular mixed-sediments estuarine beach of Betahon shows two contrasted dynamics. In its central part, during high energy events, upper beach coarser non-cohesive sediments are transported to fill runnels on mudflat due to strong bed return flows. Under low energy conditions, runnels are filled by fine cohesive sediments leading to an accretion of the mudflat. Succession of high/moderate and low energy conditions can also explain the alternated shape of sand and mud identified on a vertical sediment section in the mudflat. These preliminary results will help to understand seasonal dynamics of this beach, coupling short-terms and monthly topographic monitoring, Kite Aerial Photography with structure-from-motion photogrametric analyse, core-drilling and mud shear resistance field experiments.

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Analog interpolation method for mapping along-track ocean altimetry

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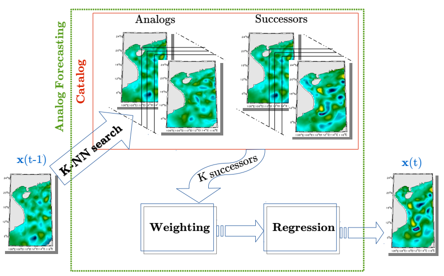
Abstract

In this work, we investigate the utility of historical datasets to along-track sea level altimetry mapping. We state the problem as a missing data interpolation issue and present a data-driven strategy that enhances mesoscale data. Our data-driven strategy starts by considering the Optimal Interpolation solution for the large-scale component of the field, then uses the Analog Data Assimilation framework to estimate the fine-scale component of the field.

Analog Data Assimilation

Analog Forecasting



Analog Data Assimilation

- Combining Analog Forecasting with stochastic filters
- In this work, we use the Analog Kalman Filter and Smoother (AnEnKS) with the locally-increment forecasting method (see [1],[2] for details)
- A patch based representation is considered in this work

Multi-scale decomposition

$$\begin{cases} X &= \bar{X} + dX_1 + \xi \\ \bar{X} &\propto \mathcal{G}\left(\bar{X}^b, \Gamma\right) \\ dX_1 &\propto \mathcal{M}_1 \\ Y &= \mathcal{H}\left(X, \Omega\right) + \eta \end{cases} \quad (1)$$

- $\bar{X}$ represents the large-scale component of the field X
- dX_1 refers the finest scale of X
- Optimal Interpolation (OI) is more relevant for the reconstruction of $\bar{X}$
- dX_1 is reconstructed using Analog Data Assimilation

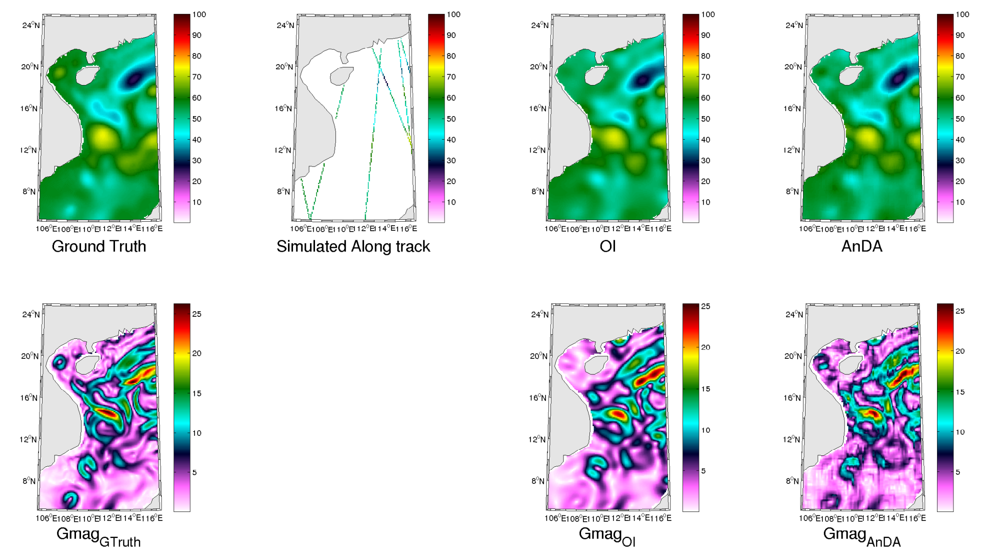
Co-Authors & Affiliations

- Ronan Fablet: **Telecom Bretagne/ LabSTICC**
- Miao Sun, Ge Chen and Tianfeng Lin: **Ocean University of China**

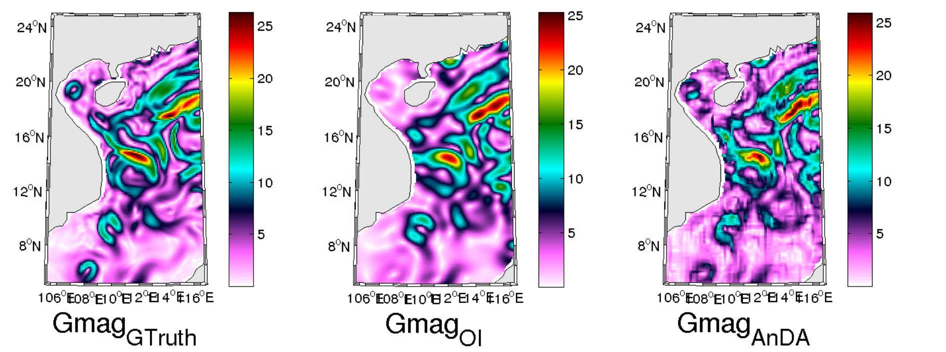
3. Application to mapping along-track ocean altimetry

We consider 50 years of 3-daily SSH data from 1963 to 2013 using the Ocean General Circulation Model (OGCM) for the Earth Simulator. The coverage of the model is 75°S-75°N with a horizontal resolution of $1/10°$. Our region of interest is the region of the South China Sea (105°E to 117°E, 5°N to 25°N).

We used along-track data from 4 satellites (Jason2, Cryosat2, Saral/AltiKa, HY-2A) at the year 2014 formerly provided by Archiving, Validation and Interpretation of Satellite Oceanographic (AVISO+), and currently distributed by Copernicus Marine and Environment Monitoring Service (CMEMS).



4. Diagnostic



$RMSE_{OI}$: 0.033, $RMSE_{AnDA}$: 0.031 for a seq of 122 images and 10×10 patches

- A cross-validation step can be run before the simulation to fix the number K of nearest analogs
- Choosing suitable kernels for data considered helps improving identification of skillful analogs

5. Conclusion / future work

- ✓ Demonstrating the potential of exploiting the wealth of archived datasets to perform state-space estimation in a **data-driven** way and this without having access to explicit model equations
- ✓ Successfully enhancing Optimal Interpolation mapping of along-track Sea Level Altimetry data.
- Exploring dynamically adapted kernels to improve analogs selection, and investigate other regression methods and dealing with the curse of dimensionality by exploring dimension reduction methods

Acknowledgments

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New Methods for Mesoscale Eddy Detection and Tracking

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Introduction

Mesoscale eddies are the swirling water with scales ranging from ten kilometers to hundreds of kilometers. They are ubiquitous in the world ocean and play a major role in the kinetic energy balance of the ocean, its primary production, trophic transfers as well as ocean-atmosphere interactions. Thus the accurate detection and tracking of eddies is a key preliminary step. Here, we investigate novel strategies, based on deep learning models, namely Convolutional Neural Networks (CNNs), and on Hausdorf similarity.

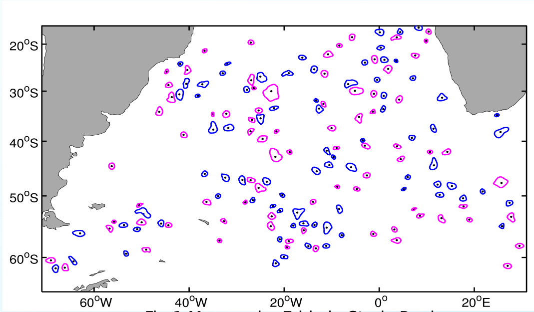

Fig 1 Mesoscale Eddy in Study Region

Eddy Detection

We state eddy detection in SLA maps as a supervised machine learning issue and explore Convolutional Neural Networks, which are currently the state-of-the-art models for image recognition. It involves two main steps :

1. The creation of a ground-truth dataset of eddy and non-eddy examples, given by local SLA pactches as illustrated below. We exploit [Mason,2014] to build such a dataset from 1996 to 2013 SLA time series in the South Atlantic ocean.

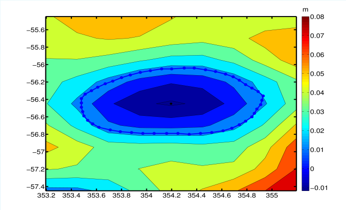
Fig 2 Extracted Cyclonic Eddy

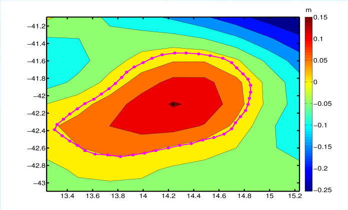
Fig 3 Extracted Anticyclonic Eddy

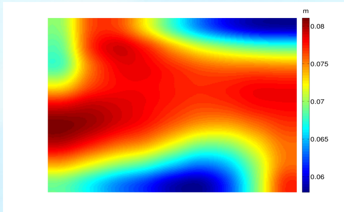
Fig 4 Extracted non-Eddy

2. The training of CNNs using this ground-truth database. We explore different CNNS from the computer vision literature, namely LeNet, GoogleNet and ALexNet which relate to different complexity levels (from a few thousands of parameters to several million of parameters)

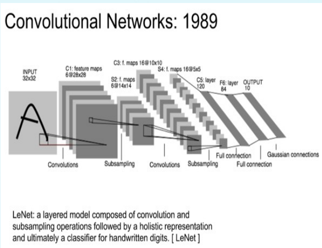

Fig 5 LeNet Framework

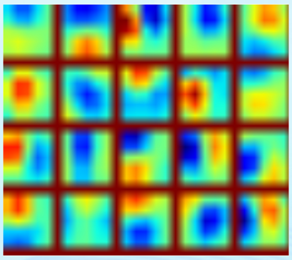
Fig 6 Features extracted by Filters

Tabel 1 Accuracy Comparison

Framework Name	Classification Accuracy
LeNet (Full Dataset)	97.235%
AlexNet (Part Dataset)	96.81%
GoogleNet (Part Dataset)	97.212%

A Hybrid Tracking of Mesoscale Eddies in Global Ocean

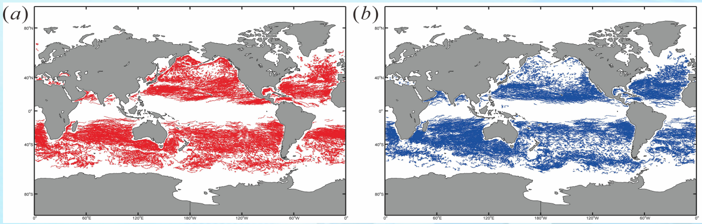

Fig 8 Mesoscale Eddy Tracking Paths (2015/01/01 -2015/11/27)

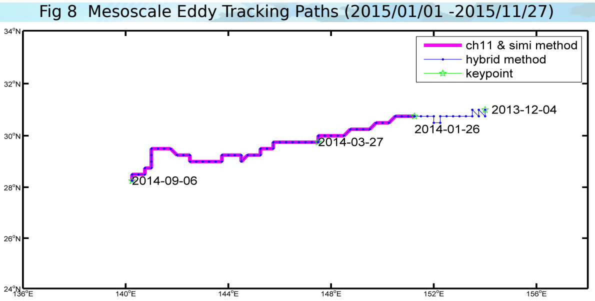

Fig 9 Mesoscale Eddy Tracking Paths Comparison

Mesoscale eddies are identified using SLA-based algorithm. While the tracking method is a hybrid algorithm integrating the physical and geometrical properties of each eddy. Adopting Hausdorff Distance (HD) to evaluate the boundary variation while matching. We validate the algorithm with reported eddies and make a comparison with other tracking methods. The mean lifespan of the hybrid tracking result is 2 days longer than other methods.

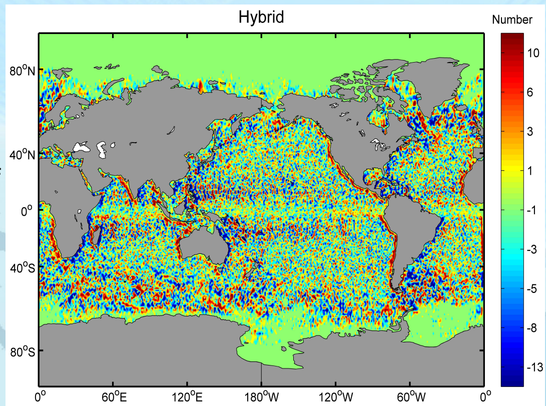

Fig 10 Sources and Sinks of Global Mesoscale Eddies

Reference

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3 .LeCun, Yann, et al. "Gradient-based learning applied to document recognition." Proceedings of the IEEE 86.11 (1998): 2278-2324.

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Analog assimilation for high-dimensional state-spaces

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1. Abstract

In this work, we address a **exemplar-based missing data interpolation** technique, referred to as analog assimilation, for **high-dimensional** state-space. We introduce a novel model, which combines a **patch-based** representation to a **multiscale and PCA-based decomposition**. We demonstrate its relevance through an application to the reconstruction of SST field from irregularly-sampled observations.

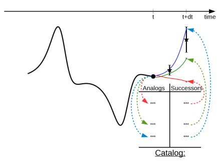
2. Multiscale Analog Assimilation

Multiscale and PCA-based decomposition

$$x = \bar{x} + \sum_{l=1}^{L} dx_l \quad \text{with} \begin{cases} \bar{x} \propto \mathcal{G}(\Gamma) \\ dx_l(t)(\mathcal{P}_r) = \sum_{k=1}^{N_D} \alpha_{t,r,k} B_k^l \end{cases} \tag{1}$$

where $\mathcal{P}_r$ refers to a $W \times W$ patch around spatial position r; B_k^l refers to PCA basis.

Analog Assimilation



$$\begin{cases} dx_l(t) & \propto & \mathcal{M}\left(dx_l(t-1), \mathcal{C}\right) \\ y_l(t) & = & \mathcal{H}\left(dx_l(t), \Omega(t)\right) + \eta \end{cases} \tag{2}$$

- Observation operator $\mathcal{H}$ embeds the linear mapping associated with $\{B_k^l\}$
- Combining **analog method** $\mathcal{M}$ in N_D dimensional PCA space and sequential **ensemble Kalman smoother** to assimilate the residual observation sequence.
- Independent assimilation of individual patches $\mathcal{P}_r$

3. Application to Sea Surface Temperature

To numerically evaluate the reconstruction of SST field, we use SST OSTIA product delivered by daily by UK Met Office with a 0.05° spatial resolution (approx. 5km) from January 2008 to December 2015. It is considered as high-resolution gap-free SST reference.

Using the missing data patterns from METOP infrared sensor, we generate realistic SST observation series over year 2015 associated with a cloud-induced irregular space-time sampling

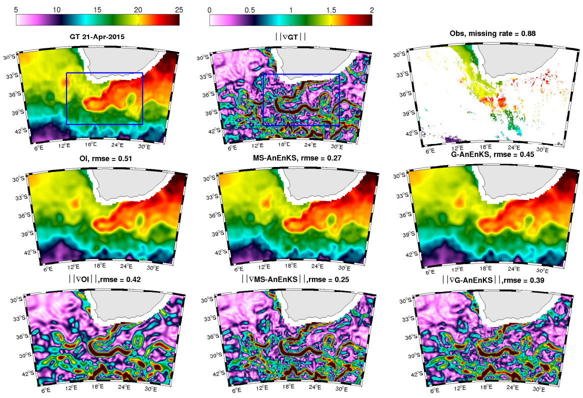
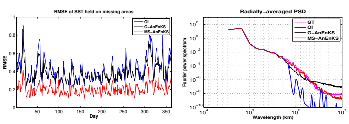


Figure 1: Reconstruction of a SST field (April 21, 2015) in region off South Africa: first row, reference SST field, associated gradient magnitude, observed missing data pattern; second row, interpolated SST fields; and associated gradient magnitude fields (third row).

4. Diagnostic



- Ability to reconstruct fine-scale details from very partial observations
- RMSE with lower standard deviation depicts robustness to the temporal variability of the missing data patterns.
- Suitable analog forecasting strategies can improve identification of skillful analogs.

5. Conclusion & Future Work

- ✓ Outperform the state-of-the-art approach, namely optimal interpolation, and a PCA-based technique.
- ✓ Multiscale patch-based and PCA-constrained setting demonstrate feasibility and efficiency in high-dimensional fields.
- Applications to satellite-derived data from analog priors derived from realistic high-resolution numerical simulations.

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[2] R. Lguensat, P. Tandeo, P. Ailliot and R. Fablet, The Analog Data Assimilationm, *Submitted*, 2016.

Co-Authors and Affiliations

- Redouane Lguensat, Ronan Fablet: Telecom Bretagne/ LabSTICC

Acknowledgments

We would like to thank the Copernicus Marine Environment Monitoring Service (CMEMS) for providing the OSTIA SST data. This study was supported by "Agence Nationale de la Recherche", Labex Cominlabs **SEACS** and TeraLab **TIAMSEA** project)

POSSIBLE IMPACTS OF SEAFLOOR MINING ON PHYTOPLANKTON COMMUNITIES AT HYDROTHERMAL FIELDS

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There is growing awareness of the potential for future mining of seafloor massive sulfide (SMS) deposits containing appreciable quantities of Copper (Cu), lead (Pb), zinc (Zn), and other precious metals. Most of these metals are present as insoluble sulfide minerals on the seabed; however, they may become oxidized and be transformed to labile forms after mechanical crushing during their extraction. While seafloor mining operations, including transport of the ores from seafloor to mining vessel, will be well-designed to minimize environmental impacts, risks of accidental leakages of subsidiary metal-contaminated seawaters from the ores to the marine ecosystem will remain.

In our presentation, we will discuss the potential leaching of toxic metals from SMS ores (black-, pyrite massive-, and barite ore) collected at hydrothermal fields in the Okinawa Trough, Japan; we will also report the responses of marine phytoplankton cultures and natural phytoplankton assemblages exposed to toxic metal eluates found in the ores. We observed considerable Zn, Pb, Mn, Cd, and Cu leaching from the powdered ore samples during batch tests that involved shaking at a liquid–solid ratio of 10 for 6 h. Released metal amounts roughly correlated with their solid phase concentrations; however, Cu and Cd amounts released from the pyrite ore comprised approximately 10% and 30% of the total Cu and Cd in the solid phase, respectively, and were higher than might have been expected, based on their solid phase concentrations. Results from incubations of eight phytoplankton species indicated that the pyrite ore eluate was the most toxic and all species ceased to grow when the eluate concentration exceeded 1%; at this level, the Cu and Cd concentrations were ca. 0.6 and 0.15 ppm, respectively. While the Pb levels in the eluate from the black ore were higher than those in the pyrite, the black ore eluate was less toxic for all species. As well as the laboratory exposure experiment outlined above, we did an onboard experiment and tested the response of a natural phytoplankton assemblage to the same eluate from the pyrite ore (with a final concentration of 0.2%), witnessing a sharp decrease in chlorophyll *a* and changes in the community structure within one day.

We would like to discuss with ACO2016 participants the environmental risks associated with mining activities and to share ideas about suitable impact mitigation strategies and monitoring systems that could be used at mining sites.

MEASURING SECONDARY PRODUCTION FROM A MOORING

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There are now numerous long-term observatories in both openocean and coastal waters (fix03 partners). These moorings measure multiple parameters, temperaturesalinity, biogeochemicalvariables such as nitrate, CO2 and primary production by quantifying chlorophyll. Export is measured using sediment traps and benthic photography. Fisheries data is recorded via the national fisheries programmes.At coastal sites zooplankton may be measured by taking snapshots with net hauls and these may be weekly. However at open ocean sites, often only serviced annually,such an infrequent snapshot provides insufficient data to identify trends either seasonal or interannual. Whilst the excellent CPR programme by SAFOS provides towed data, it is still infrequent at a particular location and it is problematic to tie it in with the variables monitored at the mooring.

To fill this gap we need an instrument that will measuresecondaryproduction at a fixed point, over a long period of time, for example a year. Secondary production is not as simple as measuring the animals present, because of the longevity of zooplankton. Even passively, they can cover considerable distances in the year that some may live. To measure secondary productionwe should measure a process or rate rather than a stationary state. Faecal pellets would provide one measure, defecation is a useful measure in its own right,but can also be linked into consumptionand gives indication on which zooplankton are actively feeding atthat location. It is also encompasses all groups including gelatinous zooplankton, a group which is increasingly coming to prominence with respect changing oceans and community structure.

An alternative to faeces would be to measure some biochemical signature in the particle flux, chitobiase or AARS might provide a number of actively moultingcrustaceans and similar indicators may be identifiable for other zooplankton groups.

This poster seeks to refine the requirements, restrictions and options for such an instrument. It is our hope that we promote active discussion and ultimatelydraw up specifications that would be required of an instrumentmeasuring secondary production.

NON-NEGATIVE DECOMPOSITION OF SEA SURFACE DYNAMICS FROM MULTI-SOURCE OCEAN REMOTE SENSING DATA

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The growing availability of multi-source ocean remote sensing data is a key factor for improving our understanding of upper ocean dynamics, ocean circulation and atmospheric-ocean interactions. Following an ongoing body of work that investigates mesoscale upper ocean dynamics from linear couplings between SST (sea surface temperature) and SSH (sea surface height), we propose a novel observation-driven framework for the identification and characterization of sea surface dynamical modes. It relies on a multi-modal decomposition of SST-SSH relationships. Our findings suggest that upper ocean dynamics may be decomposed as the superimposition of several dynamical modes, rather than mutually exclusive ones as investigated in previous work. Our study stresses the relevance of a non-negative bi-modal additive decomposition to capture the complex space-time variability of mesoscale upper ocean dynamics.

Analog interpolation method for mapping along-track ocean altimetry

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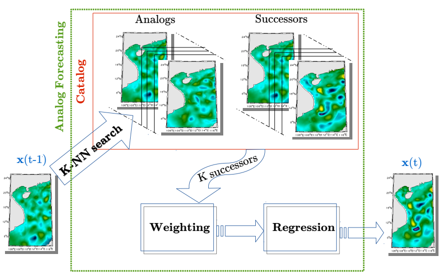
Abstract

In this work, we investigate the utility of historical datasets to along-track sea level altimetry mapping. We state the problem as a missing data interpolation issue and present a data-driven strategy that enhances mesoscale data. Our data-driven strategy starts by considering the Optimal Interpolation solution for the large-scale component of the field, then uses the Analog Data Assimilation framework to estimate the fine-scale component of the field.

Analog Data Assimilation

Analog Forecasting



Analog Data Assimilation

- Combining Analog Forecasting with stochastic filters
- In this work, we use the Analog Kalman Filter and Smoother (AnEnKS) with the locally-increment forecasting method (see [1],[2] for details)
- A patch based representation is considered in this work

Multi-scale decomposition

$$\begin{cases} X &= \bar{X} + dX_1 + \xi \\ \bar{X} &\propto \mathcal{G}\left(\bar{X}^b, \Gamma\right) \\ dX_1 &\propto \mathcal{M}_1 \\ Y &= \mathcal{H}\left(X, \Omega\right) + \eta \end{cases} \quad (1)$$

- $\bar{X}$ represents the large-scale component of the field X
- dX_1 refers the finest scale of X
- Optimal Interpolation (OI) is more relevant for the reconstruction of $\bar{X}$
- dX_1 is reconstructed using Analog Data Assimilation

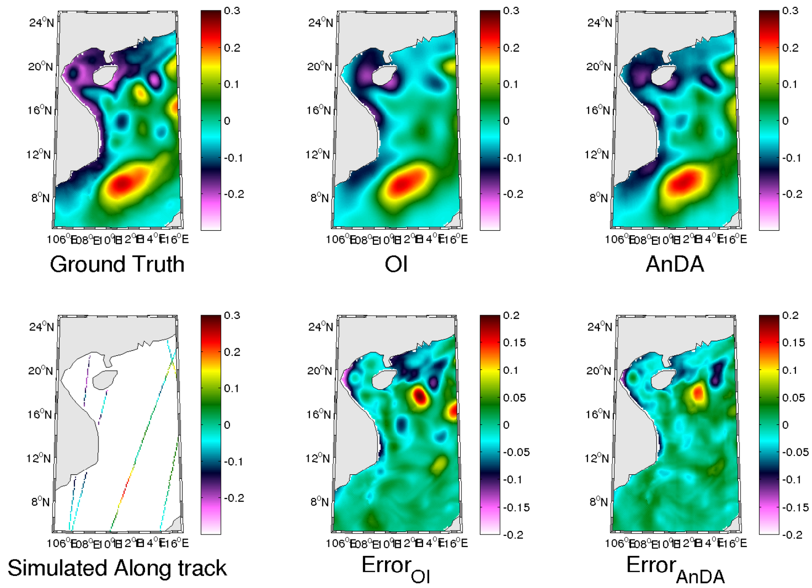
Co-Authors & Affiliations

- Ronan Fablet: **Telecom Bretagne/ LabSTICC**
- Miao Sun, Ge Chen and Tianfeng Lin: **Ocean University of China**

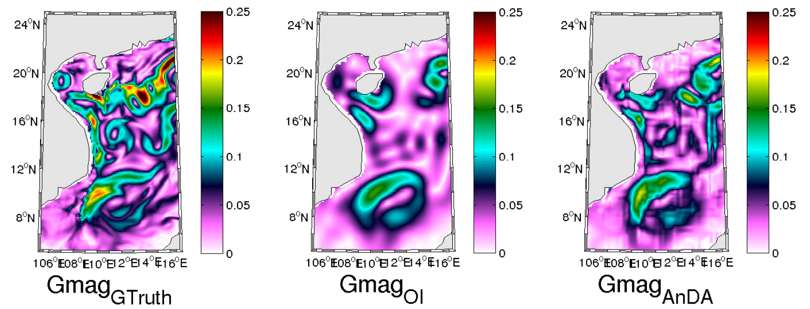
3. Application to mapping along-track ocean altimetry

We consider 50 years of 3-daily SSH data from 1963 to 2013 using the Ocean General Circulation Model (OGCM) for the Earth Simulator. The coverage of the model is 75°S-75°N with a horizontal resolution of 1/10°. Our region of interest is the region of the South China Sea (105°E to 117°E, 5°N to 25°N).

We used along-track data from 4 satellites (Jason2, Cryosat2, Saral/AltiKa, HY-2A) at the year 2014 formerly provided by Archiving, Validation and Interpretation of Satellite Oceanographic (AVISO+), and currently distributed by Copernicus Marine and Environment Monitoring Service (CMEMS).



4. Diagnosis



$RMSE_{OI}$: 0.033, $RMSE_{AnDA}$: 0.028 for a seq of 122 images and 20×20 patches

- A cross-validation step can be run before the simulation to fix the number K of nearest analogs
- Choosing suitable kernels for data considered helps improving identification of skillful analogs

5. Conclusion / future work

- ✓ Demonstrating the potential of exploiting the wealth of archived datasets to perform state-space estimation in a **data-driven** way and this without having access to explicit model equations
- ✓ Successfully enhancing Optimal Interpolation mapping of along-track Sea Level Altimetry data.
- Exploring dynamically adapted kernels to improve analogs selection, and investigate other regression methods and dealing with the curse of dimensionality by exploring dimension reduction methods

Acknowledgments

This work was supported by ANR (Agence Nationale de la Recherche) grant ANR-13-MONU-0014 and Labex Cominlabs (project SEACS)

References

[1] P. Tandeo et al, Combining analog method and ensemble data assimilation: application to the Lorenz-63 chaotic system, Machine Learning and Data Mining Approaches to Climate Science, 2014
[2] R. Lguensat, P. Tandeo, P. Ailliot and R. Fablet, The analog data assimilation. *Submitted*, 2016

CHANGES IN THE ECOSYSTEM STRUCTURE OF THE ALGAE SARGASSUM IN THE TROPICAL ATLANTIC OCEAN

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Since 2011, mass strandings of the brown algae Sargassum (Sargassum Natans and Fluitans) have been reported along the West Indies, the Caribbean and the West Africa coasts. These strandings have important consequences for the marine ecosystems, the biology, the water quality, the health of the population and the tourism. As such, it is important to understand and identify the causes of the bloom and strandings of the Sargassum algae in the tropical Atlantic Ocean. Recent studies have highlighted the North Equatorial Recirculation Region of the Atlantic Ocean (NERR, located between the North Equatorial Counter Current and the equator) as one new tank of Sargassum pelagic algae. In this work, we use observational datasets of hydrological parameters and seasonal climatology of ocean conditions (winds, ITCZ position, SST, surface currents, rivers discharge, nutrients, Chlorophyll, climate indices) in order to investigate climate trends or events and their potential feedback on the recent bloom and mass strandings of the Sargassum. The analysis of the Amazon and Oricono Rivers discharge, indicates that the volume of water flowing is not the dominant control of the changes in the Sargassum ecosystem. However, a good agreement is found between nutrient inputs, predicted by a linear regression model based in particular on the surface runoff, and the Sargassum bloom of the years 2011, 2012 and 2014. Results further suggest that the subsurface intake of nutrients from the equatorial upwelling, the increase of both SST in the western basin and the zonal velocity, have contributed in the bloom and the mass strandings of the Sargassum algae in the Atlantic Ocean.

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