Ocean technologies and new trends

in ocean observing

Laurent Delauney

IFREMER

Rapporteurs: C. Barrera, L. Cocquempot and A. King

Key messages

3 sessions with up to 181 attendees

Breakout Session 6 part 1 and 2 - Ocean Observing Technologies:

- Developments focuses on **Interoperability**, **integration** and RT **interactivity** (e.g. sampling Mngmt).
- Standardisation is still a **major concern** for efficient operations.
- **Direct** cooperation and involvement **with private sector** should be encouraged.
- TNA and JRA are **unique scenario** to improve technology, a real **win-win model.**
- Instruments : **Easiness** of use and handling, **low power**, **reliability**, unmanned vehicle **compatible**, **low cost** and adapted to **citizen science**.
- ASV => Huge **potential**, capability for **profiling**, capability for **air-sea interaction** measurements, **high TRL**, clear lack of network level
- Guidelines (best practices) is **key** to improve **quality** measurements (e.g.: pH).
- Emerging but mature technology : **Videometry** for coastal zone
- Synergies btw technologies, applications and goals is important for a **more powerful** and **efficient** activity approach.

Key messages

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Breakout Session 12 - New Trends in Ocean Observing:

- New and emerging trends for ocean observing:
  - Many non-traditional opportunities for new observations (fishing vessels, cargo ships, citizen science, education...)
  - Cost-effective and user-friendly sensors for more widespread ocean observing
  - Developing ocean culture/literacy and training (see EuroGOOS policy brief on ocean literacy - released today)
  - and much more...
- The need for democratizing data collection and sharing for future ocean observing
  - Engage as many stakeholders/users/producers related to the ocean in a collaborative process: We take care of what we know and understand better (awareness)
  - Consider the new skills required for the ocean observing community (e.g., dealing with big data, social sciences, and communication)

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Improved knowledge of ocean health and Climate

J. She

DMI

Rapporteur: A. Lara-Lopez

Key messages

Operational ecology, based on **co-evolution** and **integration** of **modelling** and **observational** technologies, is a major pillar for developing EuroGOOS ocean health service. EuroGOOS is at the beginning of operational ecology and will aim to provide better information products on high impact event forecasting, interim assessment and targeted scenario projections.

To do that we need

- Better **integration** of **BGC-BIO data providers** (environmental, fisheries, etc) with **ROOSs** to advance data provision and operational ecological service
- Need to intensify multidisciplinary **collaboration**
- **Expand** existing **monitoring** taking advantage of cost-effective **autonomous** technology and approaches such as analysing historical time series data (e.g. fisheries)
- Use of **models to fill gap**s in monitoring

Key messages

Operational marine climatology supports national solutions for Europe's Green Deal, UN SDG goals and EuroGOOS strategy and provide services such as climate indicators, and to support implementation of adaptation pathways (blue carbon, blue energy, green shipping. climate resilient aqua-farming, fisheries and coastal system)

- EuroGOOS/ROOS members are major national marine climate adaptation service providers, a **European marine partnership** has been established
- Develop in a **co-design** approach with **stakeholders**
- A seamless **multi-model ensemble approach** would be preferable
- **Synergy** between **EuroGOOS, C3S and CMEMS** on marine climate change adaptation
- **Consolidate** multidisciplinary **data and fit-for-purpose assessment of data**
- Continued **evolution of knowledge**: data and models to elaborate realistic scenarios
- Enhance **cooperation** with **climate community** and share national **best practices**
- External **funding** to **support** these activities and to **sustain** these services

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Advancements and synergies of European RIs and regional observatories

V. Cardin

OGS

Rapporteurs: G. Magnifico, A. Rubio

Key messages #1

- To align and i**ntegrate Europe's ocean observing capacity** for the long term, by strengthening coordination, strategy and sustainability in ocean observation with high-frequency, high-quality measurements from the surface of the ocean to the deeper parts using state-of-the-art technology (e.g., integrated, multi-platform marine observatories)
  - Current initiatives showcase (EirOOS, ILICO-COAST HF, Malta System, North Africa) **growing multiplatform and multidisciplinary integration (at multi-scale)** as a cornerstone to increase scientific and technical research capacity for monitoring and observing environmental and climate parameters.
- To structure, design, standardise and link national systems on common terms:
  - From Nations and/or Regions to pan-European approach (e.g., to connect national systems in EOOS)
  - Integrating **national infrastructures under a common structure** with well identified sub-systems ensuring coordination of different institution
  - Member States may need **regulations to support national integration** of ocean observation capabilities
- To ensure observations meet research, stakeholders and societal needs by optimising observation networks, fostering interactions between scientific communities involved, etc.
- To ensure **RIs long-term sustainability** (e.g., funding model, scientific excellence, trained personnel, international dimension, exploitation of data)
  - Important issue is to get the Nations involved to support the long-term observing systems
- To **balance the needs** of social demands and scientific challenges, so as between operational and scientific observations

Key messages #2

- RIs are **key players of the EOOS development** towards a **coordinating framework** designed to align and integrate Europe's ocean observing capacity for the long term:
  - **To identify the gaps** to be filled
  - **To create synergies and collaboration** opportunities amongst the different RIs (e.g., **sharing plans** of operational activities to achieve better efficiency and cooperation, **integrating monitoring strategies** for filling the knowledge gaps, **reducing the environmental impact** of observing system, **joint actions** to develop new sensors, developing i**nteroperable methods to deliver comparable data**, collaborative **training opportunities**, s**takeholders engagement** strategy)
  - **ENVRI cluster collaboration and BEERi**: common fora where RIs can work together by sharing knowledge and lessons learned, developing joint solutions, reducing duplication of work and costs

- **Collaboration ad different level (JERICO case)**:
  - **Regional**: integration of approaches (sharing of knowledge, methods and activities)
  - **EU**: Use cases from regions to EU (sharing of technologies, best practices, joint workshops)
  - **Boards of RIs**: joint EU proposals, new countries, MoUs, etc.

Key messages #3

- **High quality information** about marine research infrastructures is essential for ocean science and technology development: identification of capabilities, gaps and opportunities, decision-making on development and funding priorities, and education and training are examples of activities needing that type of information (**EurOcean case**, RI Database)
- **Support projects** (even if small) are important to advance also for well-established RI (**EURO-ARGO case**, extension of Argo in shallow coastal areas)
- Research vessels coordination Entity as a platform where other RIs can cooperate/collaborate **(EUROFLEETS RI case)**
- RIs can play an important role in **supporting the industrial development** in Europe **(GROOM II case)**

Integrate to avoid duplication (see also requests from next calls Horizon Europe) and look outside Europe (message from EMSO ERIC)

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Integrating and Managing of Ocean data

S. Pouliquen

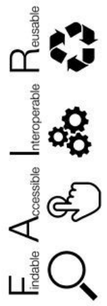
IFREMER

Rapporteurs: R. Nair , Y. Voynova and Corine Lochet

Key messages

Session 2 provided implementation of FAIR principles all along the value chain from data acquisition to services to users

- Standards are progressing (OGC API family) and InternetOfThings provides new opportunities presently tested at the level of data service to users
  => partnership with manufacturers to implement such protocols on observing platforms still need to be developed
- Coordination between operators of platforms facilitate FAIR principles implementation along the full value chain : development of best practices in agreement with European and international standards, organisation of dataflow, integrated access through networks portals , provision of FAIR services
- Implementation of FAIR services facilitates the development of integrated products, national and transnational coordination as well as support transdisciplinary applications



Key messages

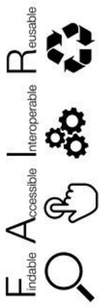
Session 8 addressed two topics Metrology and Network organisation

GOOS and GCOS require high quality EOV and ECV with high level of quality . To achieve those require we need :

- to strengthen the links between national institutes, ocean metrology laboratories, standardization boddies and industry in support of Marine Research Infrastructures.
- to promote metrology as a transversal service for the oceanographic community, Research Infrastructures , citizen science and industry . Demonstration will be carried on through the H2020 MINKE project which is intended to further integrate oceanographic data within the global framework for Measurements.

Moving from scientific experiments, or national monitoring facilities to European or International integrated networks

- allow joint development of common standards for data and metadata and facilitate data interoperability
- encourage best practices at all level of the value chain,
- allow development of common realtime and historical data streams for the network observations with appropriate accuracy to meet different user needs
- enhance the FAIRness of the data and services provided and facilitate data and product re-usability by wider community
- enhance visibility and join management of the observing system implementation and usage through monitoring services such as OceanOps.



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Advancements in ocean modelling

G. El-Serafy

Deltares

Rapporteurs: A. Orfila, M. Ruiz-Villarreal, V. Fernández

Modelling is being used to provide information to different users at regional level decision makers and at coastal users for specific sectors (eg. public, scientific, coastal protection, pollution, ports, military...).

- a 2km resolution ROMS implementation in the WMed Sea validated with HFRadar, glider and satellite with scientific and operational applications.
- Service accessible in a free public basis for public, private and research.
- real time products for military and civil uses.

Challenges: improve co-design and market uptake.

The general trend is coupling ocean component with waves nesting with CMEMS and downscaling towards high resolution applications.

- Forecast accurately storm effects including wave setup and storm surge.
- High resolution modelling nesting

Challenges: is still room for improvement regarding coupling.

At the coast, several systems study biogeochemical processes as well as sediment transport including beach evolution.

- Coupling waves, current, :and morphology.
- Biogeochemical dynamics at high resolution (30m).

Challenges: to include wave and sediment transport and water quality

Validation and use of data assimilation plays an important role to assess the accuracy of the forecast.

- Good agreement with in situ data. Preoperational system.
-***Challenges***: data availability from Satellites and validation high resolution with coarse data; computational effort

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Improved Services and Products

E. Álvarez

Puertos del Estado

Rapporteurs: S. Legrand, B. Pérez and J. Mader

Session # 4: Extreme events and hazard forecasting: (one session, 6 speakers)

Findings:

- There is an **increasing number of tools for improving forecasts applied to disaster risk reduction** (e.g. storm surge, search and rescue, oil spill), by means of higher resolution models often based on CMEMS parent models
- **Uncertainty** on the **meteorological forcing, lateral boundary conditions and river input** still critical for sea level forecasts and coastal models
- **Pollution risk assessment studies** provide **important output for policy-makers** at those areas with increasing maritime traffic and hydrocarbon exploitation

Messages**:**

- **Relocability** concept is important for coastal ocean modelling, by means of **automatic downscaling tools** and specific input data to deal with coastal to local processes. Need to advance in this direction.
- It is needed to **improve storm surge/flooding forecasts by including wave-related processes** (fully coupled models) and even higher frequency processes such as infragravity waves, use of **unstructured grids** and **ensemble or multi-model** techniques
- Convenience of collaboration for a **European database of extreme events from historical tide gauge records**, following the approach in several countries (e.g, France). Message sent to the EuroGOOS Coastal Working Group and the EuroGOOS Tide Gauge Task Team

Copernicus Marine Products and Services: (2 sessions with 65 and 40 participants respectively)

- Session #1: tremendous progresses made by the regional MFCs over the last 6 years:

  - All MFCs deliver **NRT and multi-year products** for hydrodynamics, waves (new), biogeochemistry (new in some MFCs) and when relevant sea-ice, with a higher spatial resolution and for larger horizon.
  - Developments are often (if not always) **driven by user requirements**. Very significant **increase in number of users**
  - New processes have been added or improved such as tide (Arctic and Med), rivers discharge (Arctic and Black Sea) and carbon cycle (pCO_2, pH and total alkalinity (Med and Baltic)).
  - Enhancement of sub-systems interactions and consistencies (**model coupling**), improvement of **data assimilation techniques** and **assimilation of new data sets,** including bio-ARGO profiles.
  - Sometimes **unstructured mesh models** are used to resolve narrow straits (Black Sea) or improve model resolution where needed (new sea-ice model in Arctic-MFC).
  - In all MFCs, validation is a constant point of attention.

- Session #2: recently established multi-observations TAC:

  - Mission : using multivariate **data fusion techniques and artificial neural networks** to build 2D and 3D global ocean states from in-situ and satellite observations. **Complementary approach** to models that largely preserves the mesoscale features present in the satellite images
  - Currently **4 physical products and 2 BGC products** both in NRT and multi-years reprocessing mode:
    - temperature, salinity, density, geostrophic and quasi-geostrophic currents, mixed layer depth
    - pCO_2, fCO_2, pH, nutrients profiles, POC and CHL-a (here also key contribution of bio-ARGO profiles)

User-oriented products: Key factors for the impact of products

Harmonisation of input data is promoted at Regional level allowing co-development and transfer of tools:

- **Transfer of tools** between coastal observatories (success story from IBIROOS, MyCOAST project - M.Ruiz).
- CMEMS products, **harmonized at regional scale**, allow to produce Ocean Monitoring Indicators. (A.de Pascual-Collar)
- **Harmonized HF Radar** Products applied in multidisciplinary fields (MONGOOS, E.Reyes)

Development of **Toolboxes** applied to specific fields and **shared** in the overall community:

- Coastal risks - flooding, search and rescue, sea pollution... (IBIROOS MyCOAST project, M.Ruiz)
- Marine Renewable Energy - Resource evaluation, planning, etc. (ResourceCODE, N.Raillard)
- Sea Level forecast (ARIMA model in Black Sea, E. Mihailov)
- Search & Rescue (ADRIFT in Irish seas, D.Pereiro)

Integrated approaches and **co-design with final user** allows new tools and advances:

- Integration of environmental data and End-users oriented design allow the implementation of the **Ecosystem Based Fisheries Management** (Heat waves and fisheries D.Alvarez-Berastegui):
- Coastal water quality with **land-sea continuum modelling** (Western Channel Observatory, R.Torres)
- **Traffic density** data integrated in Marine Spatial Planning, Risk Assessment and Emergencies management (SICOMARPLUS, Sardinia-Corsica, G.Quattrocchi)
- Use of **data mining** for classification of Water Mass Patches (V. Quilfen)