Towards a French roadmap for global ocean observing in preparation for the UN decade of ocean science for sustainable development (2021-2030)

Context

France has a particular situation with regard to the ocean: present in most of the world's seas and at all latitudes, with 11 million km^2 under national sovereignty or jurisdiction, it is the second-largest state in terms of an exclusive marine economic zone. This makes France strongly concerned by the sustainable use and conservation of the oceans, which is translated in a significant international commitment. Ocean science is also at the heart of the French involvement in international climate negotiations, following on from COP21 in Paris.

France is remarkably involved in ocean research in many areas of interest to the ocean, with recognized skills in several fields: physical, chemical and biogeochemical oceanography; ocean-atmosphere and ocean-lithosphere interfaces, and land-sea continuum; ocean, weather and climate model development; biology, ecology and evolution of marine biodiversity; maritime economics and ocean governance; etc. These skills are supported by robust research infrastructures: marine stations, observatories and laboratories; observation networks (littoral, coastal, open sea and deep sea) using in situ observation systems; satellites; technological research capacities to develop in situ and space observation instruments; an oceanographic fleet capable of projecting into the World Ocean; high-performance information systems.

In this context, French research institutions, including CNRS, Ifremer and IRD, are currently working together to establish an ambitious national roadmap to contribute to the UN decade of ocean science for sustainable development. Global ocean observation is one of the pillars of this roadmap.

French ocean observation infrastructures and networks

Over the last decades, French research public institutions have joined forces to develop an international strategy to acquire the data needed to monitor, understand and manage ocean processes and alterations, in the context of weather forecasting, fisheries and coastal management, and climate, biodiversity and ocean changes. This effort aimed in particular at analyzing the main mechanisms at work and quantifying their role. France supported sustained observations, considering that, taken at a regular frequency that depends on the mechanism studied and the long-term cost/benefit ratio, they are essential to size the processes involved and their evolution. French institutions are therefore key players in regional observing systems that integrate measurements of ocean dynamics and air-sea interactions, biogeochemistry and biology, across ocean regions, from coastlines to the open ocean. They are connected to many international organizations (Ocean Climate Platform, European Marine Board, IPBES...) and very involved in the management of research infrastructures with a European or global dimension (JERICO ; EMBRC ; Euro-ARGO and ARGO ; EMSO; ICOS; Euro-GOOS and GOOS...).

In addition to the acquisition of long-term data sets of Essential Ocean Variables and Essential Climate Variables, French research institutions have invested massively in numerical modeling, to support the IPCC and operational systems such as Mercator Ocean International and CMEMS[1], which are at the forefront of international developments in this field.

[1] Copernicus Marine Environment Monitoring Service

Towards a national roadmap in 2020

The strategy proposed by French research institutions builds on the expertise developed in their laboratories to make a significant contribution to knowledge of the ocean and its transfer to decision makers and managers, and to promote the adaptation of societies to ocean changes. In a context of global change, a better understanding of marine ecosystems, ocean dynamics and ocean-atmosphere or ocean-lithosphere interfaces requires multidisciplinary, integrated, systemic and multi-scale observations. It also requires an ambitious data policy and multi-parameter and multi-scale modeling. While France is already very involved in these subjects through various infrastructures and programs, many challenges remain to be tackled in order to move towards a more integrated observation, including biological approaches ("augmented" observatories), but also more sustainable, consuming less energy, supporting data sharing, storage and calculation resources, etc.

This challenge will be based on the following four pillars:

- *Parameters*: specific efforts to identify and integrate ocean parameters to be measured and study of their functional links in response to major meteorological and climate challenges and for a sustainable ocean; development of new sensors;
- *Tools*: consolidation (i.e. interoperability, network operations) of existing observing techniques (from sensors to robots and satellites), and development of new concepts;
- *Data*: collection, processing, qualification and banking of data, in an open-source scientific context (FAIR principles), and development of innovative systems for the analysis of this data;
- *Modeling*: coupled modeling (physics - biology - chemistry) and multi-interfaces modeling (littoral–coastal-open ocean, atmosphere-sea ice, continental ice-land, water column-seabed), using analyses, re-analyses and multi-factorial approaches, with the help of data mining and artificial intelligence methods.

The development of "augmented" observatories will allow to address the ocenanic exposome. Marine ecosystems are under chemical, biological and physical pressures that can alter ecosystem services. Knowledge of the oceanic exposome and its effects is required for better protection / conservation of marine life and associated services.

In addition to its contribution to the global observation, the French scientific community plans to strengthen its research efforts in three main zones with specific challenges :

- Overseas territories: vulnerable witnesses to ongoing changes
- The deep ocean: the last frontier to explore
- The Arctic Ocean: A rapidly changing ecosystem with coveted resources

Moreover, as the effects of climate change are exacerbated in tropical regions, France will also (1) promote sustainable in situ measurements to observe these changes and their impacts in developing countries; (2) support research capacity building to ensure a level of expertise to observe climate and ocean variables, and manage the corresponding local infrastructures by promoting the participation of scientists from the South in high-level international committees; (3) support fair and equitable partnerships to address these issues.

In summary, French research institutions are currently coordinating their efforts to support more integrated, sustainable and energy-efficient observation of the ocean, accompanied by the implementation of data sharing worldwide, in order to efficiently contribute to the Ocean Decade strategic action plan towards "The Ocean we need for the Future we want".

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