GENERAL INTRODUCTION: PREVIMER, A FRENCH PRE-OPERATIONAL COASTAL OCEAN FORECASTING CAPABILITY.

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Abstract

Pre-operational system PREVIMER provides with coastal observations and forecasts along French coasts: currents, waves, sea levels, temperature, salinity, primary production and turbidity. These marine environmental data come from in situ observations, satellite images, and numerical models. They are centralized and archived in PREVIMER databases, then published on website (real time and historical data), and freely available to users, private companies as well as public administrations. This paper describes in details PREVIMER components and users.

Outlines of Previmer

The Previmer project was launched in 2006 in order to extend the French operational oceanography capability towards the coastal areas. The first phase (2006-2007) focused on various demonstrators (sea states, coastal circulation, primary production and water quality). The second phase (2008-2013) aimed at building infrastructures and tools in order to ensure a pre-operational service for the benefit of a wide community (private companies, public administrations, defense, and citizens).

Previmer relies on the partnership of several public organisms: Ifremer, SHOM and Météo-France. The Previmer Project provides observations, ocean hindcasts and forecasts in real time to the users of coastal areas. It has been identified in the State/Region contracts (CPER 2000-2006 and 2007-2013) of Brittany and funded jointly by the organisms and the Region. The development and their exploitation are performed within the scope of the public partnership (Ifremer, SHOM, Météo-France) with assistance of private companies. All the numerical simulations and the data processing uses the supercomputer Caparmor, hosted on the Ifremer center located in Brest. All the teams that collaborate to the project are located at Ifremer and SHOM. This project is coordinated by Ifremer and SHOM.

Previmer Components

The components of the Previmer project encompass various aspects involved and required for coastal operational oceanography:

❶ **in situ observations**: instrumental development, data acquisition, deployment and exploitation of optimized instrumental networks to produce specific coastal data,
❷ **modeling tools:** development and improvement of numerical models, hydrodynamical coupling (waves and circulation), sedimentological, biogeochemical models, data assimilation, chemical and toxicity risk analysis tools.
❸ **interface tools for users and advanced products** : satellite data processing, synthetic indicators, data, images, dissemination through internet, …
❹ **data center dedicated to coastal operational oceanography (CDOCO):** acquisition, quality control, dissemination of observations and model results, models implementation, daily production of services and products.

These components are coordinated by a management team which also ensures the valorization of the project.

❶ In situ observation

This task is focused on the development and acquisition of in situ instruments that must be reinforced to fill the gap in coastal observations networks. Here, sustainable and recurrent dedicated acquisitions are targeted to supply a database for analysis, validation and future data assimilation. For that purpose various observation sensors are on track:

- network of profilers (figure 1) fitted to coastal environment (shallow waters, high frequency dynamics, strong currents, intense fooling) from those deployed at global scale observation within ARGO or completely new concepts.
- Anchored multi-parametric platforms,
- Sensors mounted on trawlers, scientific or merchant fleet ships to pick up additional opportunity measurements,
- of the national tide gauges network (SHOM) with real time acquisition and transmission capacity,
- Extension of the CANDHIS network (CEREMA) of wave buoys.

The radar HF Observation which started at the very beginning of Previmer (2006) has been extended during the second phase of the project. Thus it gives a continuous database from then up to now of sea surface currents over the Iroise Sea, a work area of the project (See Beurret and Thomas, this issue). All the deployments of instruments were optimized considering a cost/benefit ratio with regards to investments and exploitation. All these systems and the data acquired are described by Charria et al (this issue).

Figure 1: Arvor-C profiler

❷ Modeling tools

This item concerns mostly the development and improvement of numerical ocean models used within the scope of Previmer (MARS, WaveWatch III® and HYCOM models). It deals with the integration of operational constraints requiring to evolve from research to operational tools (assessment of the numerical solution regarding available observation, confidence indicators, and descriptors of the state of the systems). It also includes the evolution of the state of the art of numerical modeling due to the progress in knowledge (mixing parameterization, wave/circulation interactions, data assimilation methods specific to the coastal zone, coherent interfacing with global numerical solutions like spectral nudging; for this last point, see Herbert et al this issue).

Data collections have been properly organized from different sources of information at the CDOCO in order to be integrated to the validation process. These information are sea surface temperature, sea states, radiative thermal fluxes, ocean color (chlorophyll a as an indicator of the total biomass and water clearance, phytoplankton and suspended particulate matter) and in a next future sea surface salinity.

Most of the questions that coastal operational oceanography intends to address are multidisciplinary and require beyond the ocean physics parameters (currents, hydrology,…) descriptions of the state of the system on sedimentology and biogeochemistry (see for example Menesguen et al this issue).

Regarding the sea state description, many evolutions of WaveWatch III® have been conducted (see Ardhuin et al, this issue) in order to enhance its performance in the coastal area (unstructured grid with adaptive time stepping, wave breaking parametrisation…).. This numerical model has also been adapted to be interfaced with ocean and atmospheric circulation models thanks to numerical coupling kit (OASIS/PALM).

❸ Interface users tools

The project also aims at developing tools upstream and downstream of the numerical models. Upstream of the model, these tools (ie Bmgtools, see Theetten et al this issue) are designed to ease the building of new model configurations (generate model inputs such as atmospheric forcings, boundary conditions, river runoffs and in-situ observations) in order to be more efficient and shorten the time between their development and their operational use in particular in the context of environmental crisis or simply to minimize the development costs for new areas. Some user interfaces have been developed in order to integrate sedimentological, chemical or biogeochemical modules to the circulation models and to facilitate their broadcast and implementation for the project partners.

Downstream of the models, tool boxes, (e;g. like Vaccuum, Charria et al this issue), have been developed as generic tools to facilitate the assessment of model performances, to detect possible deficiencies at different levels of the forecasting process, generate quality indicators or advanced products (indicators, bulletin - http://www.previmer.org/newsletter-, trends, anomalies) that suit better the societal request of information. It has been developed in cooperation with the private partners of the project to target downstream services.

The access to all the data and results of the different applications (mapped and commented data) which represents the daily update of the environment state is given through a dedicated website (www.previmer.org, figure 2). It has been designed to fulfill a wide panel of user requirements. This site gives an access according to various criteria: the results can thus be viewed according to thematic criteria (sea level, current, wave, temperature ….), temporal criteria (short terms forecasts, present state, hindcasts), application criteria (according to the numerical model used) or geographical criteria.

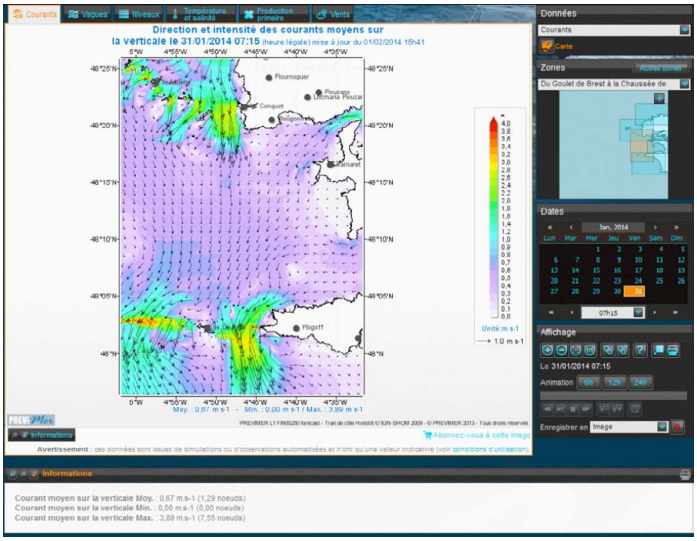


Figure 2: Website PREVIMER www.previmer.org: currents in Iroise Sea the 31st of January 2014 at 07:15

❹ Center for coastal operational oceanography

The operational center is divided into two parts: the data center for coastal operational oceanography (CDOCO) in real time itself and on the other hand a component which is in charge of the implementation and the supervision of all the modeling processes. For this purpose, it makes available in an optimal way all the information required for modeling according to the arrival time. This center also ensures a help to the Previmer users.

First CDOCO ensures collecting external data (Météo-France, SHOM, Direction de l'Eau, Mercator Océan, CETMEF…) with a conventional framework agreed by all the partners on a routine and sustainable basis. Data control procedures are applied according to international standards in order to guarantee the highest level of quality to the database thus built. Besides, the CDOCO ensures the archiving of the whole set of numerical results and products for retrospective analysis purposes.

The development of the CDOCO has been extended to operational treatments in order to gather, validate and provide the different time series required by the modeling activities:

- forcing data: meteorological forcings, open boundary and initial conditions (from Mercator Ocean), river runoffs (water, nutrients, sediments and organic matter),
- reference data: coast line, bathymetry, bottom sediment,
- in situ data: from campaigns, form operational networks. These are also archived in Coriolis database,
- satellite data: sea surface temperature, waves, water color, radiative thermal fluxes and wind products (archived at CERSAT).

The second part of the center for coastal operational oceanography is dedicated to the operational chains for the modeling processes. They are designed to facilitate the daily production of forecasts, analysis and advanced products derived from input data and model results. An effort has been put on the optimization of these chains, their safety and their ergonomics in order to ease their supervision and to reach the better service level agreement.

Project Targets in terms of spatial and temporal scales

The Previmer project is focused on coastal areas. The spatial scales targeted within the scope of the project start at the regional scale down to the scale of the bay or the estuaries or even to the scale of the shellfish production or coastal fisheries areas. The resolutions of the various models start from a few kilometers (for the Bay of Biscay -see Berger et al this issue- or the North Western Mediterranean Sea -see Garnier et al this issue-) down to several hundreds of meters (see Pineau-Guillou et al this issue) for the coastal zones. All the metropolitan areas are thus covered.

The temporal scales associated extend from the present time to forecast at J+4 (for the circulation) to J+9 (for wave fields). On the one hand, the refreshing of the information provided is performed once a day for circulation, twice a day for waves. On the other hand, the hindcasts produced within Previmer cover the whole period of the project (2006/2013). The time steps with which the numerical solution is stored and broadcasted are compatible with the high and low frequency of the phenomenon relevant in the coastal dynamics, from the seasonal frequency (thermal and haline fronts, stratification) to 15 minutes period (tidal currents, surges).

Previmer users

There are two types of PREVIMER users: those who access to information through the website, and those who access to digital products via a ftp server. Website allows viewing the data; it is quite difficult to describe who website users are, because they do not need to register. To access to numerical data, users need to register through a form, and receive access codes to download freely data. This methodology is not so much appreciated by users - who prefer to download data without registration, but allows collecting information about users and analysing who they are.

Website users

PREVIMER website www.previmer.org (figure 2) publishes results from models, in-situ observations and satellite images split into different thematic: currents, sea levels, waves, temperature and salinity, primary production and turbidity. Users do not need to register so it is quite difficult to get their profiles. We have some indirect returns, showing that their profiles are very different:
- researchers consulting satellite images to validate models,
- forecasters (meteorological or flood forecasting services) consulting surges,
- ship pilots consulting waves and currents,
- fishermen consulting temperature to find hot water veins for fishing bass,
- biologists consulting primary production in case of toxic blooms,
- scientists consulting environmental conditions before sea surveys…

The website traffic has permanently increased since 2006 (figure 3). In 2013, the traffic reaches an average of 4000 visitors per day, with some peaks exceeding 6000 users per day, particularly during storms. For example in 2013, we noticed peaks at these dates:
- 27th of October 2013, 6379 visitors (Christian storm),
- 23rd of December 2013, 5767 visitors (Dirk storm).

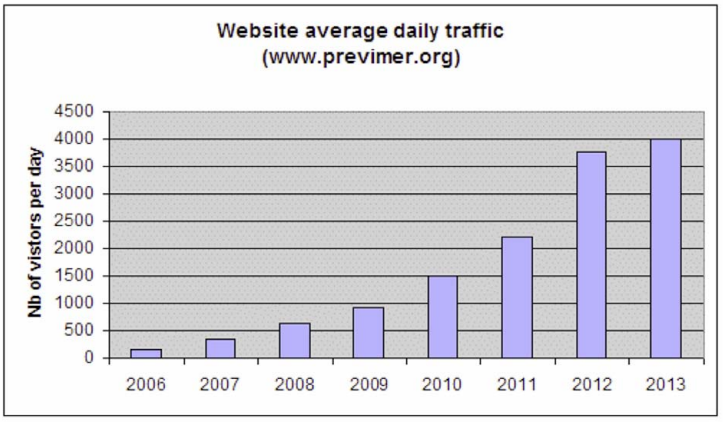


Figure 3: Website www.previmer.org: average daily traffic

Users access to PREVIMER website in order to visualize mainly results from models (forecast and hindcast): observations (including satellite and in-situ) represents only 5% of consulted pages, wave models 71%, hydrodynamic models 22% and biogeochemical models 2%. The most viewed pages are wave models; however, concerning digital products, we will see in next part that it tends to reverse: users first ask for hydrodynamic models (46%), and wave models are only in second position (39%).

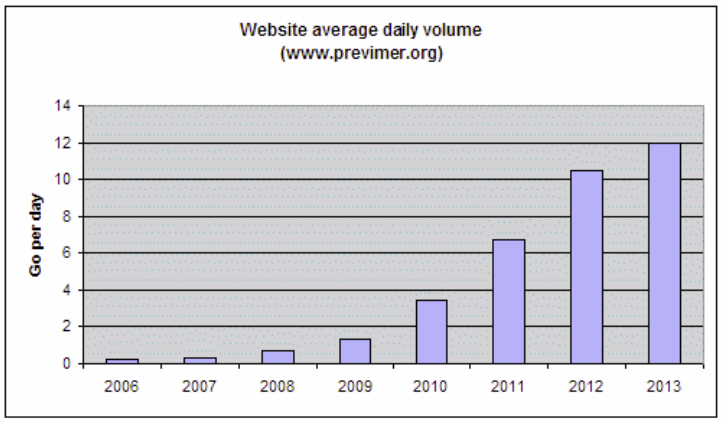


Figure 4: Website www.previmer.org: average daily volume

Concerning website daily volume, it has never stopped increasing since 2006 (figure 4). The average daily volume of web consultations reaches 12Go in 2013.

Numerical products users

Numerical products are described in PREVIMER products catalogue (PREVIMER Project team, 2014). They include:

- analysis and forecasts: results from hydrodynamic, wave and biogeochemical models,
- observations: currents from High Frequency radars over Iroise sea,
- atlases: harmonic constituents of tidal water levels and currents along Atlantic and English Channel French coasts (Pineau-Guillou 2013),
- hindcasts: sea-states hindcast HOMERE (1994-2013) over the Channel and the Bay of Biscay (Boudière et al. 2013).
- 38 products are registered in the catalogue, there are described in table 1.

Product type	Product name	Geographical Area	Resolution
Hydrodynamic models MARS3D	PREVIMER_F1-MARS3D-MANGAE2500	Bay of Biscay & English Channel	2500 m
	PREVIMER_F2-MARS3D-MENOR1200	North West Mediterranean Sea	1200 m
Biogeochemical models ECOMARS3D	PREVIMER_B1-ECOMARS3D-MANGA4000	Bay of Biscay & English Channel	4000 m
Hydrodynamic models MARS2D	PREVIMER_L1-MARS2D-ATLNE2000	North East Atlantic	2000 m
	PREVIMER_L1-MARS2D-MANGA700	Bay of Biscay & English Channel	700 m
	PREVIMER_L1-MARS2D-MANE250	Eastern Channel	250 m
	PREVIMER_L1-MARS2D-MANW250	Western Channel	250 m
	PREVIMER_L1-MARS2D-FINI250	Finistère	250 m
	PREVIMER_L1-MARS2D-SUDBZH250	South Brittany	250 m
	PREVIMER_L1-MARS2D-AQUI250	Aquitaine	250 m
Hydrodynamic models HYCOM	PREVIMER_HYCOM-MANGASC60	Bay of Biscay & English Channel	~1800 m
Wave models WAVEWATCH III (regular grids)	PREVIMER_WW3-NORGAS-2MIN	Bay of Biscay & English Channel	~3700 m
	PREVIMER_WW3-MENOR-2MIN	North West Mediterranean Sea	~3700 m
	PREVIMER_WW3-PDC-200M	Pas de Calais	200 m
	PREVIMER_WW3-SUDBZH-200M	South Brittany	200 m
	PREVIMER_WW3-LOIRE-200M	Loire	200 m
	PREVIMER_WW3-AQUITAINE-200M	Aquitaine	200 m
	PREVIMER_WW3-NORMANDIE-200M	Normandy	200 m
	PREVIMER_WW3-COTENTIN-200M	Cotentin	200 m
	PREVIMER_WW3-ARMOR-200M	North Brittany	200 m
	PREVIMER_WW3-FINIS-200M	Finistère	200 m
	PREVIMER_WW3-ROUSSILLON-200M	Roussillon	200 m
	PREVIMER_WW3-LANGUEDOC-200M	Languedoc	200 m
	PREVIMER_WW3-PROVENCE-200M	Provence	200 m
	PREVIMER_WW3-CHARENTES-200M	Charentes	200 m
	PREVIMER_WW3-ANTILLES-3MIN	West Indies	~5500 m
	PREVIMER_WW3-POLYNESIE-3MIN	Polynesia	~5500 m
	PREVIMER_WW3-CALEDONIE-3MIN	Caledonia	~5500 m
	PREVIMER_WW3-REUNION-180M	Reunion	180 m
Wave models WAVEWATCH III (unstructured grids)	PREVIMER_WW3-NORGAS-UG	Bay of Biscay & English Channel	Up to 200 m
	PREVIMER_WW3-MENOR-UG	North West Mediterranean Sea	Up to 200 m
	PREVIMER_WW3-IROISE-UG	Iroise	Up to 200 m
	PREVIMER_WW3-REUNION-UG	Reunion	Up to 200 m
Wave spectra WAVEWATCH III	PREVIMER_WW3-SPECTRA-1D	Global	-
	PREVIMER_WW3-SPECTRA-2D	Global	-
Current HF Radar Observations	SHOM_COURANT_RADARS-HF-VIGICOTE	Iroise sea	
Harmonic constituents atlases	PREVIMER_L1-ATLAS-HARMONIQUES	North East Atlantic	Up to 250 m
Sea-states hindcast HOMERE (1994-2013)	PREVIMER_HOMERE-NGUG	Bay of Biscay & English Channel	Up to 200 m

Table 1: PREVIMER products

General introduction: previmer, a french pre-operational coastal ocean forecasting capability.

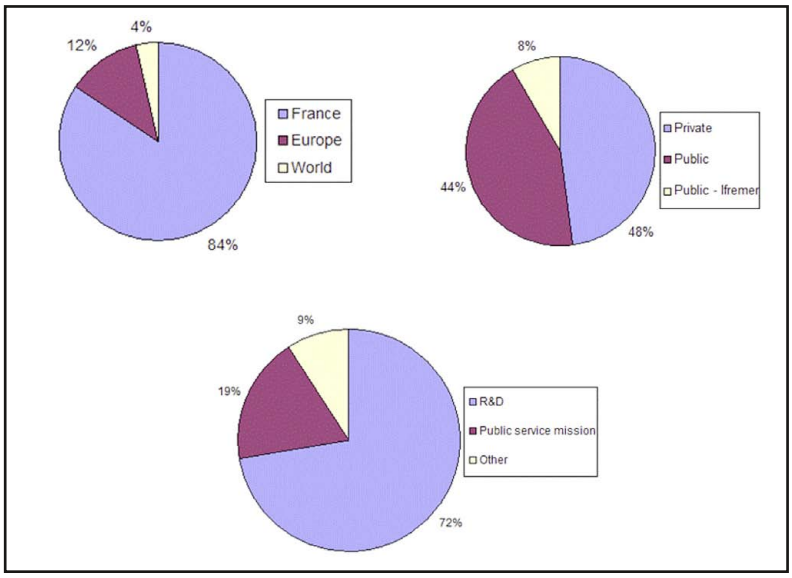


Figure 5: Origin of numerical products users

Users need to register to access to numerical products; they receive access codes and can access to data through ftp and OpenDap. PREVIMER registered 262 requests between February 2010 and December 2013, which means around 70 requests per year. Those registered between February 2010 and August 2012 (141 requests) have been analyzed, results are presented below.

Concerning the origin of users (figure 5), they come mainly from France (84%), but also from Europe (12%) and out of Europe (4%). There is a good repartition between private sector (48%) and public sector (52%). It appears that 8% of users come from Ifremer; however, this figure is largely underestimated because many Ifremer users access directly to PREVIMER data, without filling the PREVIMER form (and are not registered). Users are mainly involved in R&D activities (72%), only 19% are in charge of public service mission.

Concerning the type of products (figure 6), main part of requests concern hydrodynamic models (46%), followed by wave models (39%), observations (8%) and biogeochemical models (7%). The wave models are the most consulted on website, but are not the most downloaded (hydrodynamic models are the first downloaded). Among hydrodynamic models, the Bay of Biscay and Channel MARS3D model is the most downloaded (39%), then North West Mediterranean Sea MARS3D model (33%), followed by MARS2D high resolution models (28%). Users are mainly interested in delayed time (67%) instead of real time (33%).

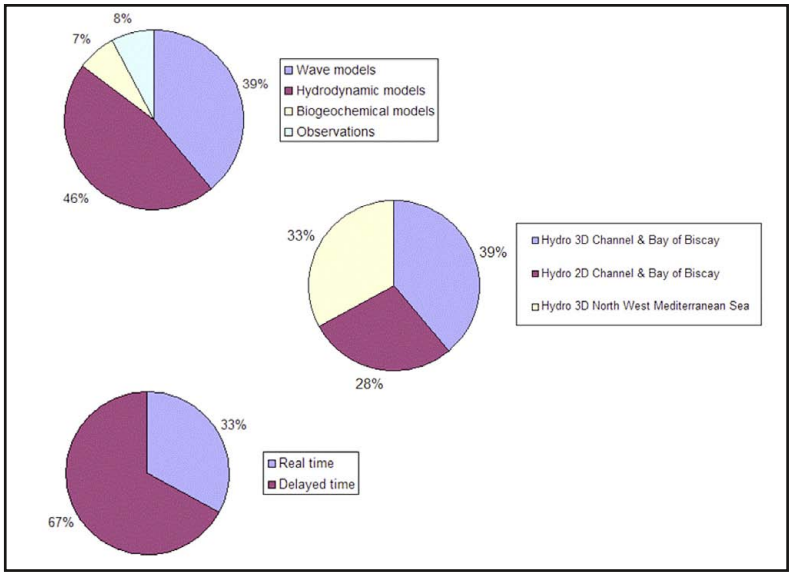
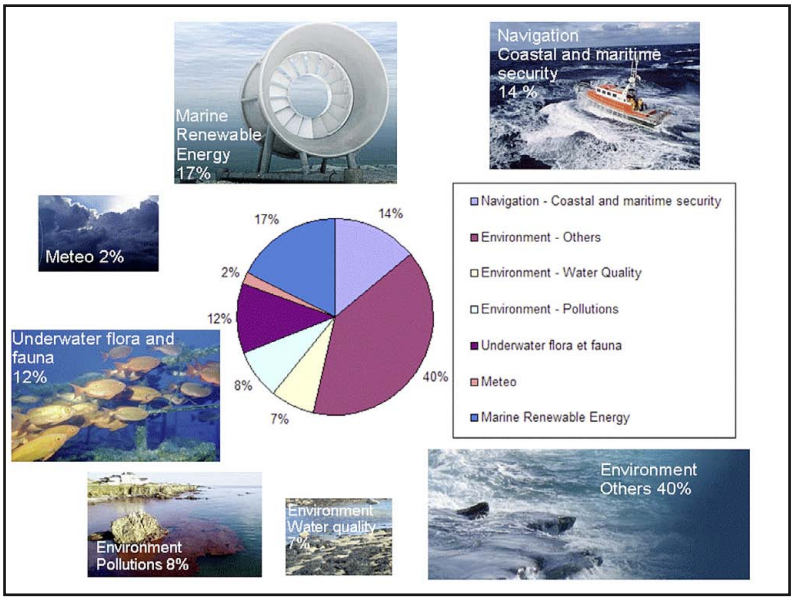


Figure 6: Type of numerical products repartition



Concerning activities sectors (figure 7), the main sector is from far environment (40%, not taking into account water quality and pollutions, counted separately), then Marine Renewable Energy (17%), followed by navigation and maritime security (14%), underwater flora and fauna (12%), pollutions (8%), water quality (7%) and meteo (2%). Some examples of requests are presented in table 2. All these activities have not the same real-time constraints: activities with the more constraints are pollutions (64% of these requests ask to access to real-time data) and navigation and maritime security (42% of these requests ask to access to real-time data), whereas for activities like underwater flora and fauna, only 13% of these requests ask to access to real-time data.

Figure 7: Activity sectors repartition

In 2013, a user satisfaction survey has been sent to users, 30 of them answered, with a good representation of private (46%) and public (54%) sectors. We noticed that only 71% of users have exploited the data they had asked; this is mainly du to problem linked with data format (some users do not know how to deal with NetCdf format) or data volume (often large volumes), or by lack of time from users. For those who have exploited data, 94 % of them are satisfied with data, and 88% find essential that this service goes on.

Activity sector	Organism	Object
Navigation Coastal and maritime security	Météo-France	Acces to modeled surges, in the context of Vigilance Waves Submersion
	Ministry of Ecology / CEREMA (ex-CETMEF)	Development of Le Havre maritime harbour
	ACTIMAR	PREVICOT project : routes optimization in the Mediterranean Sea
Environment	Ifremer Arcachon	Boundary conditions for Arcachon basin modeling
	ACRI	Statistic modeling of suspended matters concentrations in Bay of Biscay
Underwater flora and fauna	Ifremer Brest	Predictive cartography of coastal benthic habitats : application to laminaria algae of Breton sublittoral
	Ifremer Boulogne	Rational management of living marine resources
Renewable Marine Energy	Ifremer Brest	Climatologic characterization of testing sites for study and sizing of offshore wind turbines
	EDF	Setting up of tidal current turbines farm on Paimpol-Bréhat site
Environment / Water Quality	Rivage Pro Tech	Coastal numerical modelling of bathing water quality in Basque Country
	Rivage Pro Tech / Lyonnaise des eaux	Realization of bathing water quality profile for Carantec commune, North of Finistère
Environment / pollutions	Ifremer Bastia	Simulation tests of microplastics becoming depending on currents
	CEDRE	Crisis management in case of accidental pollution

Table 2: Example of PREVIMER users needs

Conclusion

Pre-operational system PREVIMER provides coastal observations and forecasts along French coasts. These marine environment data are disseminated to users, thanks to website and services - allowing access to digital outputs. Website is very popular, and visited by about 4000 visitors per day. Catalogue of products describes available data; 262 requests have been registered between February 2010 and December 2013. Requests come from public (52%) and private (48%) sectors; they are mainly in charge of R&D activities (72%). Users are more interested in delayed mode (67%) than real time (only 33%). Data are used for many activity sectors; a large part of requests (17%) concerns marine renewable energy sector.

PREVIMER feedback conference took place the 17th of September 2013, at Ifremer Brest (Lecornu et al. 2013); half a day was dedicated to users and allowed showing many PREVIMER applications. According to users satisfaction survey realized in 2013, 94 % of users who exploited data were satisfied with it, and 88% of users find essential that PREVIMER service goes on.

Acknowledgements

The authors wish to thank the users who answered the satisfaction survey. They wish also to thank the many users who participated to PREVIMER feedback conference (17th of September 2013, Ifremer Brest, more than 140 participants), and particularly those who deliver their feedback at the users' session: EDF, CEREMA (ex-CETMEF), Rivages Pro Tech, Actimar.

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