

## **ANNUAL REPORT ON MARINEMET, THE SPANISH PILOT COOPERATION PROJECT IN MARINE METEOROLOGY IN NORTH-WEST AFRICA**

*(December 2010)*

### **1. INTRODUCTION**

Within the framework of Spanish cooperation in Africa, in July 2009 in Dakar, Senegal, the Spanish State Meteorological Agency (AEMET) launched the pilot project MARINEMET with the authorization of all representatives of the Conference of Directors. This undertaking concerns four coastal countries from North-west Africa: Senegal, The Gambia, Mauritania and Cape Verde. It is a four-year pilot project, whose end goals are primarily based on the transfer of technology and knowledge.

On the Spanish side, two public institutions are working together with AEMET: the public body Puertos del Estado (OPPE) and the Universidad de Las Palmas de Gran Canaria (ULPGC). Moreover, with a view to facilitating cooperation and benefiting from the in-depth experience of the World Meteorological Organization (WMO), cooperation is being channelled through this institution.

All of the project information is spelled out in the Terms of Reference (ToRs). The project may be broken down into three main clusters:

1) Transfer of technology (software):

- Satellite products
- Deep water ocean modeling
- Ocean modeling for harbours

2) Transfer of technology (equipment):

- Tide gauges
- Automated weather stations
- PCs

3) Transfer of knowledge:

a. Documentation:

- Satellite products
- Deep water ocean modeling
- Ocean modeling for harbours

b. Training courses:

- Maritime meteorology training in Toulouse
- Maritime meteorology training in the UK-Met Office
- Specialized course on maritime meteorology in Las Palmas
- End user courses in Senegal, The Gambia, Mauritania and Cabo Verde
- Special on-site courses in equipment maintenance and management

## 2. PROJECT STATUS

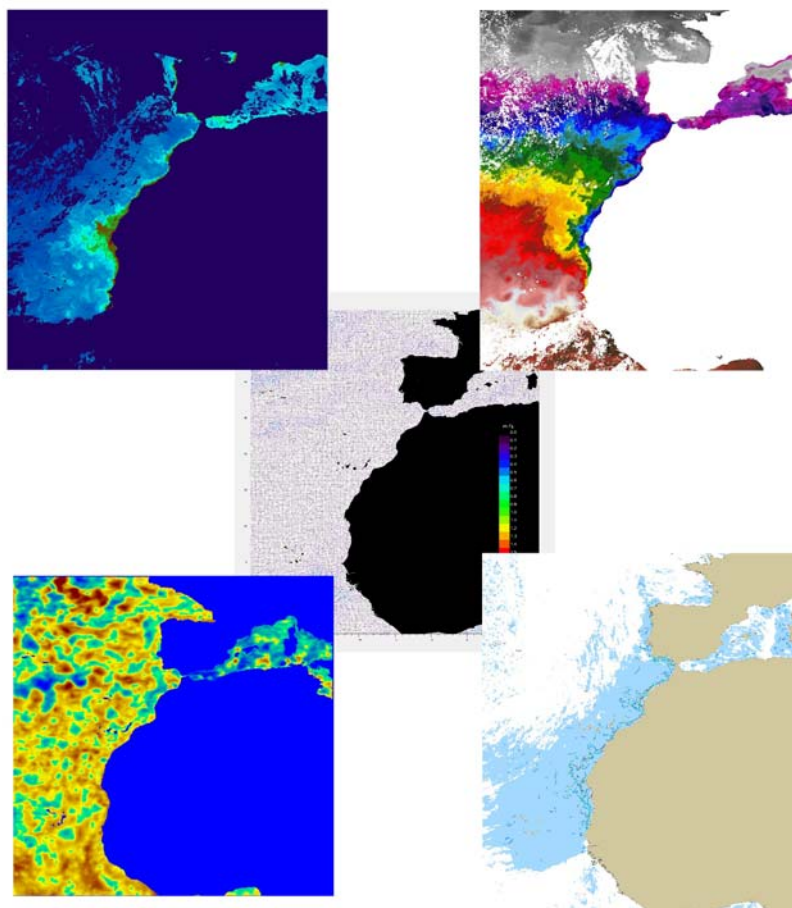
Work continued in 2010 to meet the goals laid out in the ToRs. This section gives the degree of execution for each of the tasks as well as the current status of each project component:

### **A. *TRANSFER OF TECHNOLOGY (software):***

#### **A.1. Satellite products:**

##### A.1.1. Virtual antenna

The virtual antenna uses the L1a files available at the Ocean Color Web (<http://oceancolor.gsfc.nasa.gov/>) to generate PNG images of geophysical products of interest, such as superficial sea temperature (SST), concentration of chlorophyll-a, and maps for real-time service depending on windows of interest. Figure 1 shows an example of operational PNG outputs from the virtual antenna plus the two products generated on the basis of GeoEYE Inc. data (anomalies in sea level and currents).



**Figure 1.** Example of operational PNG image outputs from the virtual antenna

At the beginning, the virtual antenna was based on the prediction of satellite passes over the MARINEMET window (as would have been the case with a real antenna). Initially, winorbit was used for the prediction of passes over the MARINEMET area, with manual downloading of orbital parameters for



the land and water satellites. With the planned passes, an IDL routine generated the L1a file names which were produced in the Ocean Color Web.

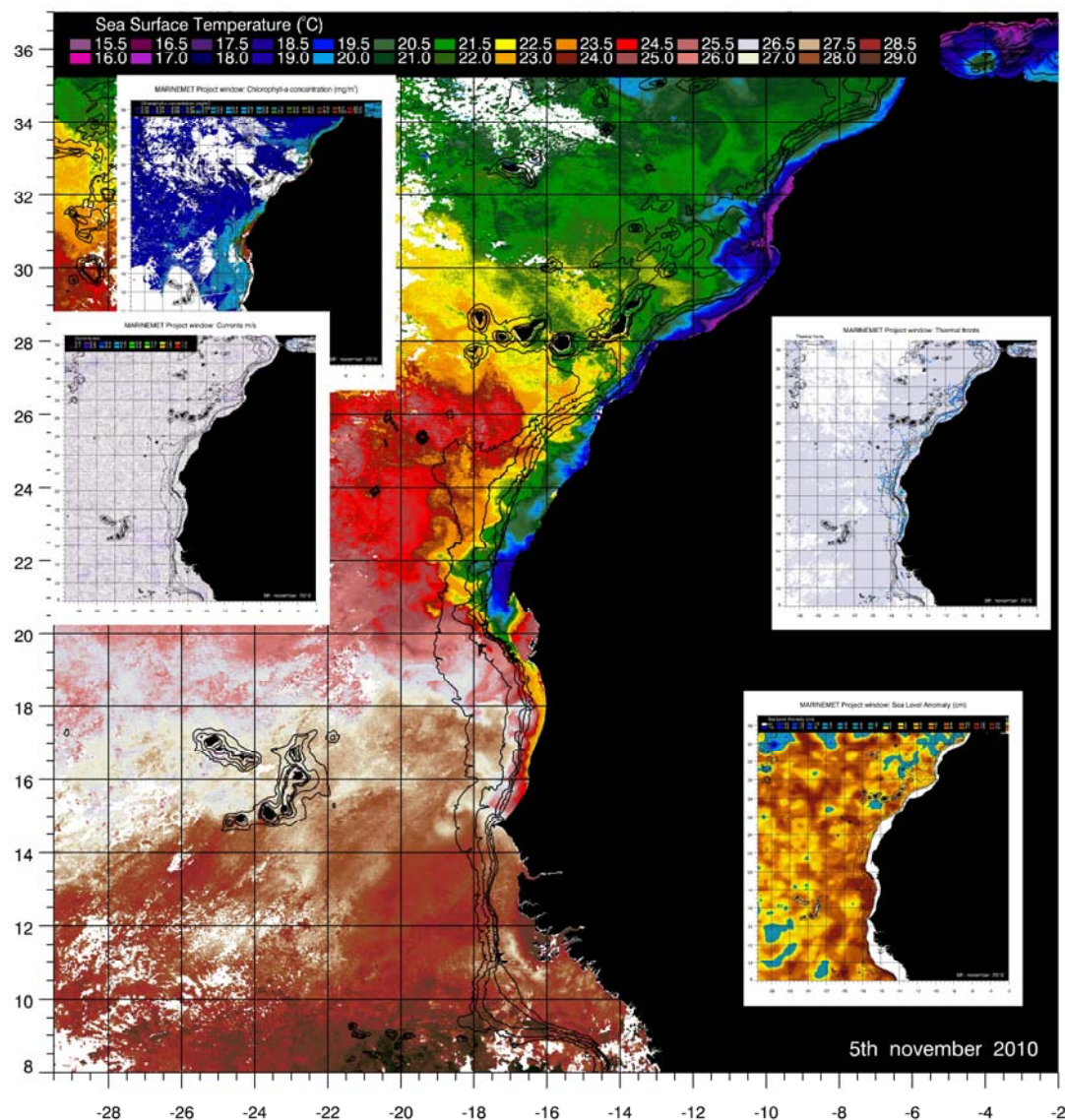
In order to use the entire virtual antenna within the same operative system, a migration was effected to the use of predict 2.2.3., and a tcl script was developed to handle the whole process. The script downloads the orbital parameters (<http://www.celestrak.com>) and calls the predict to generate the passes according to the spatial and temporal window of interest. Based on the passes planned by predict, the script generates the names of files to be downloaded. In addition to the migration to a single operating system, this features the added benefit of eliminating manual procedures.

Pending the fully operational Web project ([www.afrimet.org/marinemet](http://www.afrimet.org/marinemet)), the recipient countries were e-mailed maps of the service in real time. In the beginning, these were sent manually by e-mail, but this process was subsequently automated by means of a tcl script. At the moment, each recipient country receives the maps corresponding to its window. All of the windows are available on the Web.

The map-generating routines were modified to improve the aspect. The changes were made in IDL, and affected all windows for the generation of MARINEMET maps (overall project window), Mauritania, Cape Verde and Senegal – The Gambia.

Figure 2 shows a map of superficial sea temperature corresponding to the overall project window with the other four products displayed as insets.

# MARINEMET Project window: Sea Surface Temperature (°C)



**Figura 2.** Sample of real-time maps corresponding to the overall MARINEMET window

The virtual antenna separates the operational part from the real-time service part. Users had to be able to rerun the services in real time a posteriori in order to keep them as historical data. It was necessary to adapt all maps to new formats and eliminate bugs or breaks in the processes due to various causes. Accordingly, real-time routines were modified and new ones were added to allow users to rerun on an a posteriori basis the service maps and pictures from the products in real time for past events, as if they were in real time. These changes made it possible to select intervals of dates to be rerun.

The changes affected the processing of all SST products, concentration of chlorophyll-a and thermal fronts. They included new tcl scripts and changes to IDL routines.

The bulk of data processing was done using the capacities of SeaDas. The second largest part consisted of the processes which ran on IDL. In the beginning, these processes were developed on IDL, which was why the first version of the virtual antenna used IDL. A powerful but expensive tool, IDL is a commercial software, which is why it did not dovetail with the project philosophy. It was planned to migrate all IDL processes to open source tools.

Consideration was given to the option of GDL (<http://gnudatalanguage.sourceforge.net/>), since this was a free version of IDL language. However, after a trial period, GDL was rejected as a result of its incomplete development – it had non-implemented functions that were necessary for the virtual antenna processes.

The option chosen was R-Cran (<http://www.r-project.org/>). R is a statistical programming language which has grown exponentially in recent years. It is an entirely free tool with countless packages developed by a huge community of contributors. Although it was originally a purely statistical tool, packages have been developed allowing outputs from results for a broad variety of fields. Two basic processes which were initially developed in IDL have migrated to R:

- Generation of PNGs based on the binary data generated in the processing chain SeaDas/tcl. The last stage of IDL-based processing includes a data filter and provides for image generation. This process is under development.

- Generation of maps based on the real-time PNG images of products. This process is well along, and routines must be adjusted to rerun real-time maps of the service a posteriori. The quality and design of the maps generated is the same as with IDL. This aspect should be stressed, as the products generated since the change are equivalent to the previous ones. They have been developed for SST, the concentration of chlorophyll-a and thermal fronts. There are no plans to migrate the generation of maps of SLA and currents. These are provided on a paying basis and this service is due to be phased out in 2011, which means that neither they nor any processes associated with the project development are to be transferred.

The entire system was reinstalled with the update to Mandriva 2010.0. The update of the operating system was scheduled to coincide with the update to ENVI 47/IDL 71 and to SeaDas 6.1. These updates were first tested on a trial computer, where the necessary changes were made to the procedures in order to update the system that is the operational supplier of the service.

Updating to SeaDas 6.1 entailed modifying some procedures via changes in processing utilities. One major change was due to changes in the quality flags for the products obtained via SeaDas.

It was planned to migrate the system from Mandriva to Kubuntu. Kubuntu is the operating system which will be used for the development of State harbours within the framework of MARINEMET, and it seemed appropriate to use the same system with a view to standardizing transfers.

#### A.1.2. Changes to satellite products not obtained via the virtual antenna

As with the products obtained from the virtual antenna, changes were also needed to recover the unrealized real-time services of the two products (SLA and currents) which did not come from it.

Given that these products were from an antenna which was subject to the payment of an annual fee, once the pilot project was finalized they could not be transferred free of charge to the countries involved in the project. They were therefore distributed up until the end of 2010 and shall remain in the database, but will no longer be provided as of 2011.

#### A.1.3. User support

Part of the work also consisted of answering questions asked by the contact persons in the recipient countries. Various product-related questions were answered, and for example blank maps were prepared that were the same as the ones from the real-time services. Other questions were answered using the technical documentation that had been prepared. Some questions were postponed in the hope that, if technical assistance was necessary in addition to the documentation, they would be settled once the project was operational via the Web and migration from IDL to R had taken place. Any additional adjustments required from users would be taken up in R so that they would be freely available to the recipient countries.

#### A.1.4. Technical reports

The second half of 2009 marked the launching of the preparation of technical documentation related to the satellite products generated. Initially, the information was to be contained in a single document, which contained the following clusters:

- The theoretical foundations for obtaining and processing the different geophysical variables obtained via remote sensing.
- The structure, nomenclature and characteristics of the databases for the products generated.
- A description of the possible applications of each product.

The reports were adapted and divided up according to the required new situation, leading to the generation of four separate documents:

- **Product guide**: This is a simple document which describes the products as they appear in the database. It basically describes the nomenclature codes used to identify each product. In addition, it describes how to extract geophysical and spatial information from the products. It has already been distributed.

- **Interpretation of products**: This is aimed at the end users of the information provided by the project. It is not very complex in terms of contents, as it endeavours to ensure a direct, rapid understanding of satellite products and related concepts. This document lets the user understand what each product involves, how to interpret it, and how to use it to meet his needs. It has already been distributed.

- **Product fundamentals:** This document is aimed at users with a higher level of training and knowledge. It allows end users to become acquainted with and understand the fundamentals and subsequent obtainment of each satellite product. It has already been distributed.

- **Operational maintenance:** This document has not yet been developed and will be aimed to the technical experts who will have to maintain the system once it has been transferred. It describes all the processes of the processing chain such as system management, maintenance, debugging, etc. It will be supplied with the system transfer. The documentation for managing and maintaining the Website shall be prepared together with this document with the transfer of procedures.

#### A.1.5. Real-time service and processing and operational product archiving

Coinciding with the start of the project (July 2009), daily maps of the real-time service for the body of geophysical variables began to be available. Each MARINEMET service consists of a set of five maps (one for each geophysical variable) of the different geographical zones in each country participating in the project. Thus, maps for surface sea temperature, concentration of chl<sub>a</sub>, thermal fronts, sea level anomalies and surface currents were created for windows covering the different recipient countries: Mauritania, Senegal-The Gambia and Cape Verde, as well as for an overall window which covers the entire zone of interest to the project.

The geophysical products have been archived ever since the project began. They are generated on the basis of the procedures which form part of the virtual antenna created. The product descriptions are spelled out in the corresponding technical documentation archives.

These services and products are archives and can be accessed via the project Website.



## **A.2. Deep water ocean modeling:**

A large share of the tasks developed throughout 2010 focused on readjusting modeling to the new boundary conditions of the ECMWF wave prediction model. Until now, spectral work resolution was 25 frequencies / 24 spatial directions. Following the latest update (October 2009), this has been boosted to 36 frequencies / 36 spatial directions.

Below is a brief description of the problems encountered, the solutions proposed and the outcome of their application, when this was possible.

A.2.1. Problems encountered: there were three main problems linked to the enhanced spectral resolution:

- Instability of model outputs. Appearance of spurious features.
- Longer run times for the prediction cycle (~ 100%)
- Longer data transfer times from ECMWF

A.2.1.1. **Model instability**: in terms of model output, instability takes two forms:

- Appearance of a wave with significantly overstated heights in concrete areas.
- Improbable vector fields for swells and wind sea.

One example of the former situation is persistently seen on the coast of Mauritania, to the north of Nouakchott, in situations of moderate wind (Figures 3-6).



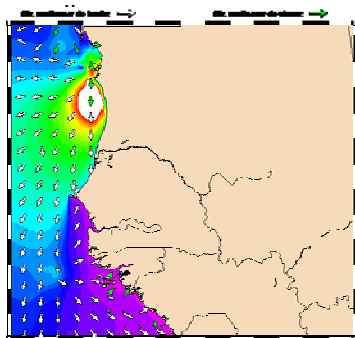


Figure 3 Wave H+72 / past 04/10/2010 00UTC

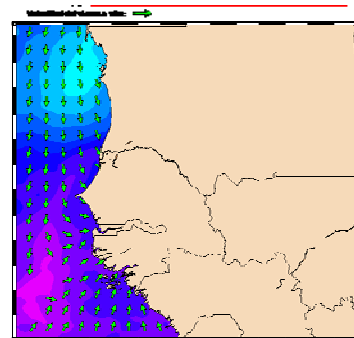


Figure 4 Wind H+72 / past 04/10/2010 00UTC

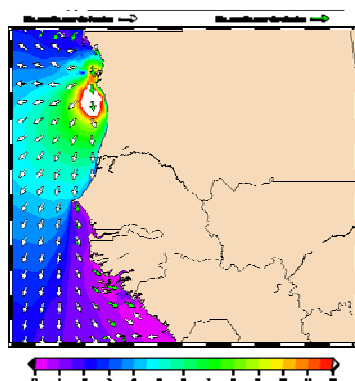


Figure 5 Wave H+72 / past 09/05/2010 00UTC

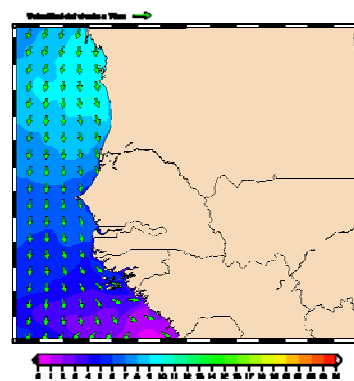


Figure 6 Wind H+72 / past 09/05/2010 00UTC

This same phenomenon can be seen, albeit in a less pronounced form, in other parts of the African coast and in the Canary Islands (Figura 7 and Figure 8).

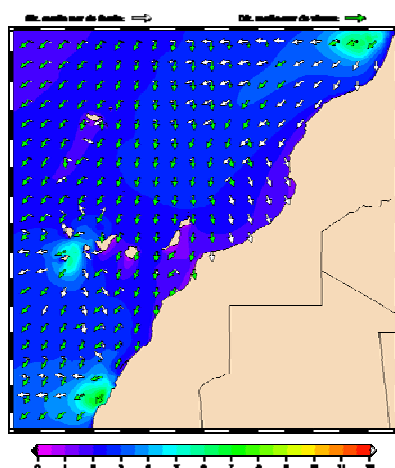


Figura 7 Wave H+72 / past 16/05/2010 00UTC

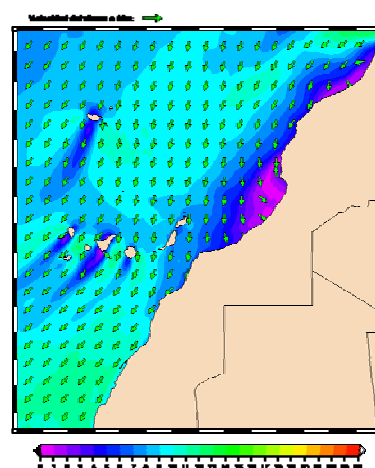


Figure 8 Wind H+72 / past 16/05/2010 00UTC

The abnormal vector fields often feature pronounced divergence and failure to distinguish between swells and wind sea. This is sometimes observed in the Canary Islands, both in the main domain and in nesting (Figure 9 and Figure 10).

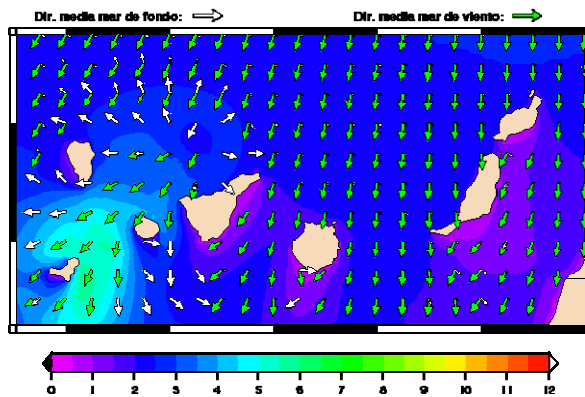


Figure 9. Wave H+72 past 16/05/2010 00UTC

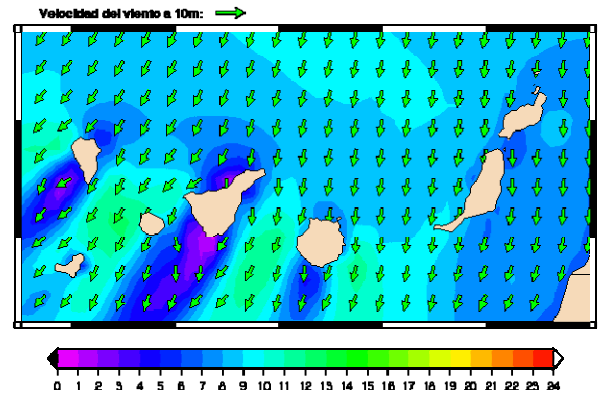


Figure 10. Wind H+72 past 16/05/2010 00UTC

A.2.1.2. **Longer run times:** in all of the simulations, the same configuration was used, which serves as a reference for estimating calculation time.

The prediction cycle, which goes from H-12 to H+72 for the model for the African coast with a spatial resolution of five minutes requires around two hours of CPU. With f36d36 spectrums, more than four hours are necessary.

A.2.1.3. **Longer transfer times for boundary conditions:** boundary conditions are available as files which contain the spectrums as grid points on the domain boundary. Each complete prediction cycle requires 45 files (between wind data and boundary conditions), which means that with the f36d36 configuration we need to transfer around 55 Mb (more than twice as much as before). Although this problem is not as serious as the previous ones, it must be kept in mind, because it could cause unacceptable delays in the prediction cycle. It is still not known what type of communication line will be available in the final location.

#### A.2.2. Attempts to resolve the instability with a spectral resolution of f36d36:

In principle, it was thought that the model might be showing abnormal results due to an *inconsistency in the configuration parameters*. For example, the first direction of the spectrums might have been explicitly assigned in the code, during the development phase. Given that these are not parameters that are frequently changed, the problem could have gone unnoticed.

For example, the first spectral direction could have been prescribed directly in the code with a value of 7.5°. However, in all of the references, the direction vector is defined generically. Despite a thorough search, no evidence was found that this was the case.

Subsequently, it was considered that the *propagation time should perhaps be reduced*, despite the fact that its current configuration complied with the CFL criterion. However, in the version of the code with which we are working, this parameter cannot have values of less than one minute. And this is precisely the value obtained since modeling began. To reduce propagation times to less than one minute, the code for the model would have to be altered, which does not seem wise if we wish to maintain model integrity. What is more, such a reduction would further increase run time, which is already relatively long.

Next, possible *problems relating to bathymetry* were analyzed, which were suggested by the persistence of spurious features in localized areas of the domain. The application used two bathymetric grids which were originally built resampling the GEBCO bathymetry of 1' of resolution (hereinafter GEBCO1M):

- Cape Verde: 5' (CBV5M)
- African coast: 2.5' (AFR2.5M, due to nesting of the Canary Islands)

At present, there is a new version of the GEBCO bathymetry with a nominal resolution of 30'' (GEBCO30S). In this revision, we also used a recent version of the interpolation software. We selected the region of **Banc d'Arguin** on the Mauritanian coast to make some comparisons. In Figure 11 and Figure 12, we can see more details in the new version (in colour, depths between 0 and 200 m).

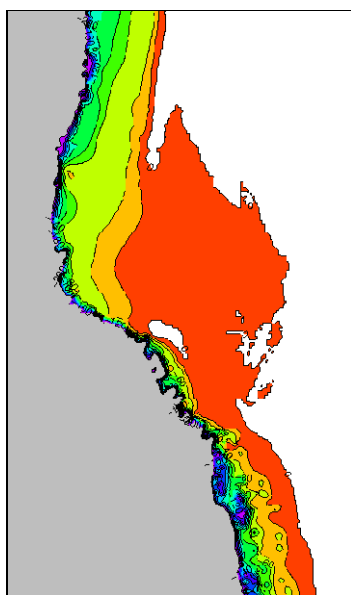


Figure 11. GEBCO1M

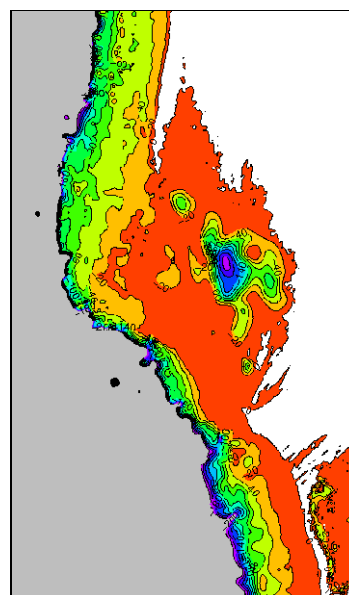


Figure 12. GEBCO30S

Using the new bathymetry, let us now repeat some past data for the model in order to compare the results. The instability in the zone of **Banc d'Arguin** is still present, albeit with minor differences (Figure 13, Figure 14, Figure 15 and Figure 16). This suggests that the bathymetry gradients might be producing these undesired effects.

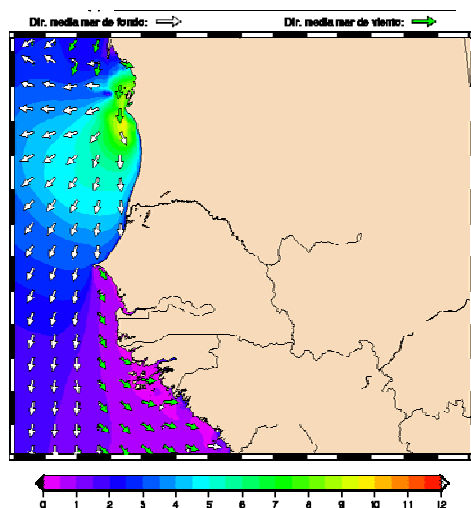


Figure 13. BEFORE

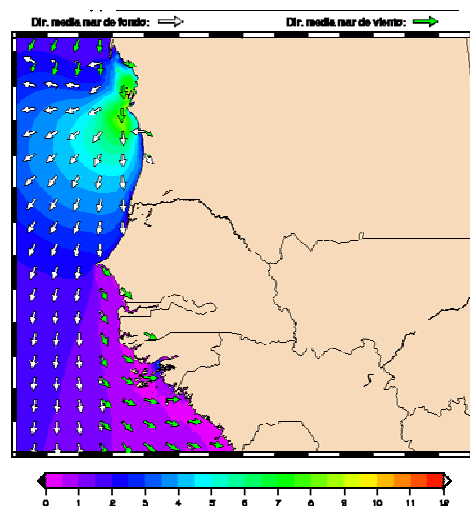


Figure 14. AFTER

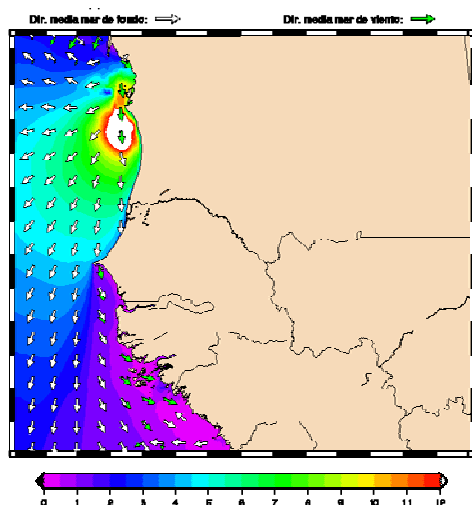


Figure 15. BEFORE

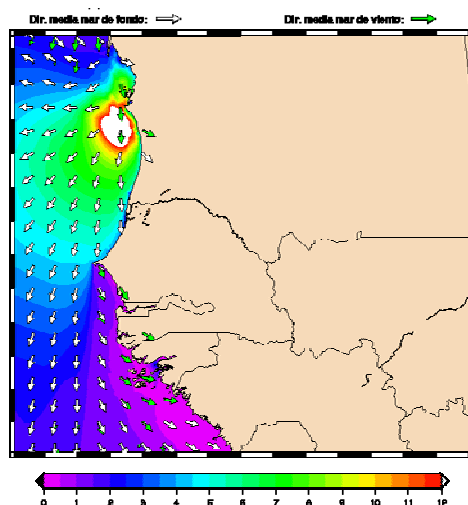


Figure 16. AFTER

There was also an improvement with the updated bathymetry in certain coastal regions. However, the results are not easy to interpret, as the changes are not always seen and do not appear to affect all zones alike.

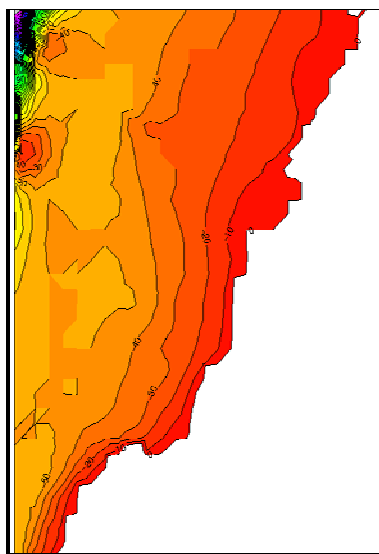


Figure 17. Bathymetry BEFORE

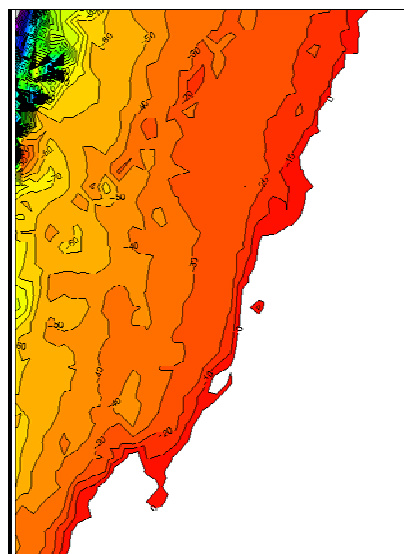


Figure 18. Bathymetry AFTER

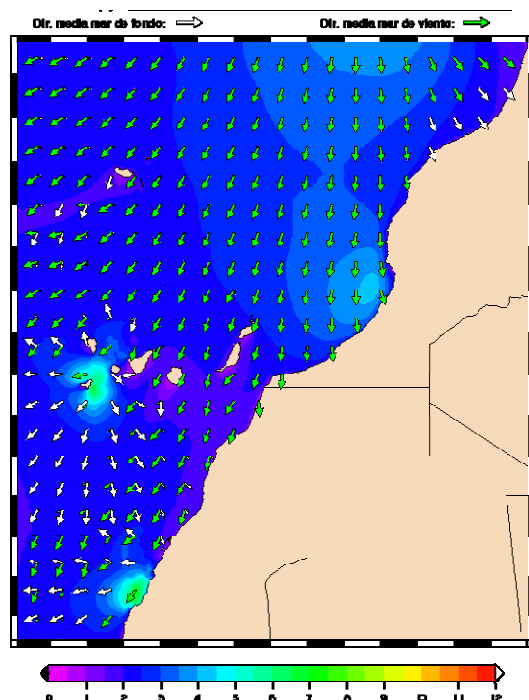


Figure 19. BEFORE

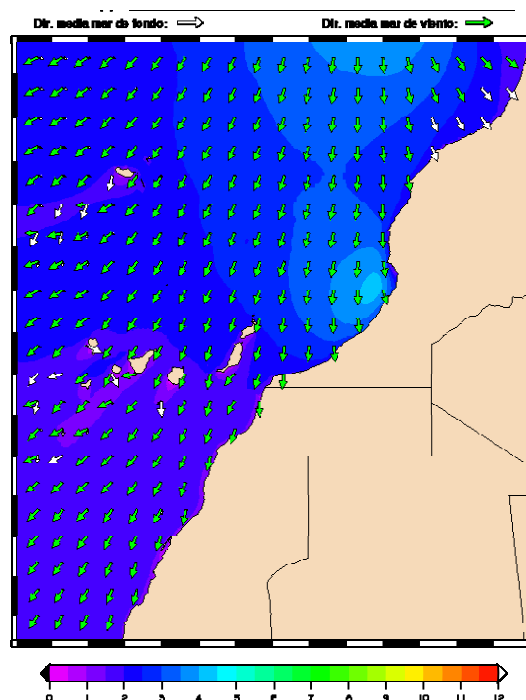


Figure 20. AFTER

Merely recalculating the bathymetry using more recent resources does not resolve the problems. Let us then proceed to modify regions with a steep bathymetric gradient to see how this affects prediction. In Figure 21, the inset is for a region with depths of more than 150 in the middle of a continental platform where the average value does not exceed 15 m.

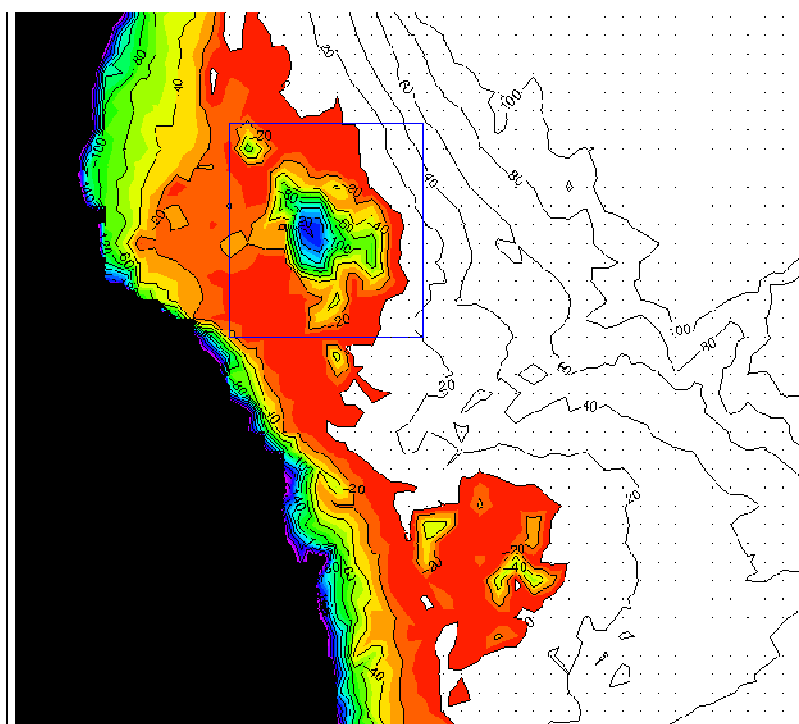
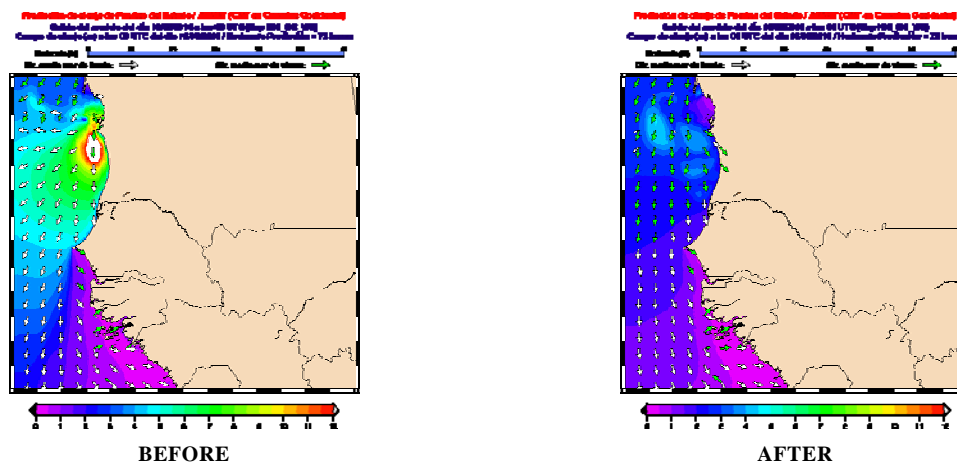


Figure 21. "Abnormal" deep zone as of 19.75/20.7/-17.0/-16.1 N/S/W/E

Let us now replace the depths for the inset by an average for the region. The change is through the configuration of the model (PREPROC), not made directly on the grid.

The effect is significantly reduced, but the problem is not completely solved. In the example shown, regions of several hundred square kilometers appear with a wave of 4-5 m, which is probably spurious.



#### A.2.3. Return to the original spectral configuration for resampling.

Given that in mode f36d36 modeling is not satisfactory, let us opt to revert to the original spectral configuration of f25/d24. To this end, the spectrums corresponding to the 24 directions are interpolated based on the 36 provided by ECWAM. The process is effected by recombining the energy intervals in such a way that this is kept in the transformation.

This operation results in the disappearance of the undesired effects mentioned earlier, and verification against provisional data from buoys yields the usual scores.

#### A.2.4. Change of Fortran compiler

Tests were carried out using the INTEL Fortran compiler. It was found that run times were drastically shortened, making it the ideal choice for our purposes.

This compiler offers a licensing arrangement that is free for non-commercial purposes. There is a need to check whether its use within the framework of this project would meet all of the conditions.

#### A.2.5. Data for the automated wave prediction systems SAPO)

The necessary adjustments were made for the routine production of boundary conditions for the three SAPOs envisaged for the project (Nouakchott, Dakar and Mindelo).

After each pass, the wind fields and the necessary boundary conditions are automatically generated for each of the applications.



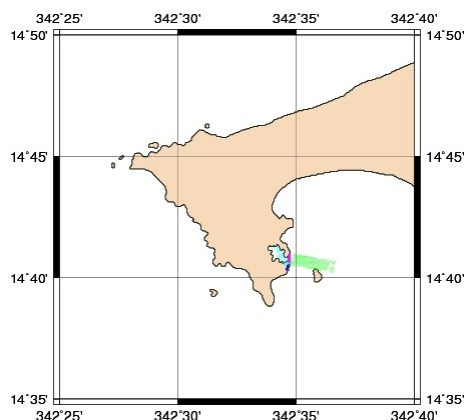
#### A.2.6. Verification

During the last quarter, work was done on an objective verification system which compares predictions with the observations of the PE buoy network. Similarly, an attempt is being made to include the JASON altimetry in the process.

#### A.3. Ocean modeling for harbours: in 2010, the following activities were developed:

A.3.1. Compilation of the bathymetric information available on the north-west coast of Africa: To implement the SAPOs, bathymetric information is needed, both to decide on the limit where we will define the SAPOs and to run the model. Precisely what is needed is an ASCII file (text file) with bathymetry in a spatial resolution of 200x200m, covering an area of 30x30Km around the harbour.

The countries in which SAPOs were to be installed (Mauritania, Senegal and Cape Verde) were asked send any information they had on the zone, in any format. Only Senegal sent bathymetric files, but they did not contain sufficient information for the SAPO (Figure 22).



**Figure 22.** Bathymetric information sent by Senegal (in colour)

**GEBCO bathymetry (bathymetry from the British Oceanographic Data Centre)**: these are free, and may be downloaded directly from the Website. There are two files with data in netCDF: “GEBCO One Minute Grid”, from 2008, and “GEBCO\_08\_Grid”, from 2009 with a resolution of 30”. When both bathymetries are displayed, we can see (Figure 23 and 3) that near the coast, there are zones with abnormal depths of more than 200 meters.

The problem is that the GEBCO data come from probes supplemented by satellite data in zones with no probes and are not suitable for shallow waters. We therefore ended up opting for navigational charts to ensure proper bathymetry.

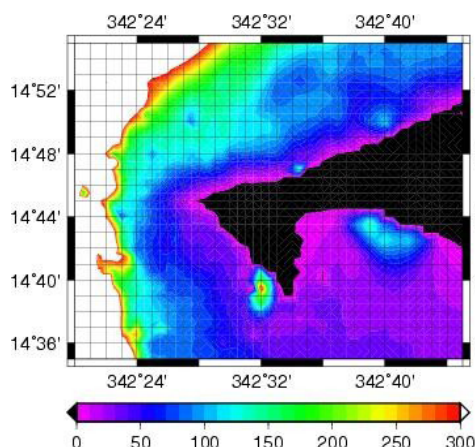


Figure 23. Bathymetry GEBCO \_08 near Dakar

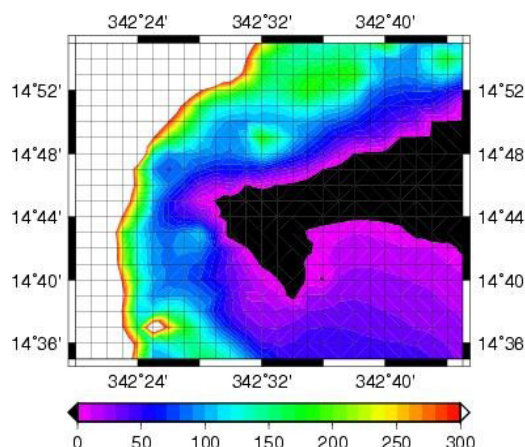


Figure 24. "GEBCO One-Minute Grid" on Dakar

**Digitization of navigational charts:** after studying the various forming options for maps, it was felt that the only available option was to digitize existing paper-based charts. Both UKHO and SHOM have charts for the zone.

At present, arrangements are being made for this digitization.

#### A.3.2. Implementation of the automated wave prediction systems (SAPOs) for three harbours in Senegal, Mauritania and Cape Verde.

A SAPO is a 72-hour wave prediction system on a local scale, developed specifically for harbours and their immediate surroundings. The system is based on the SWAN model and takes into consideration the changes the wave undergoes as it nears the coast.

**A.3.2.1. Section of boundary conditions and wind fields. SAPO limits:** The wind fields and boundary conditions that will be used come from WAM Africa, which was configured by AEMET. WAM Africa is forced with wind fields at 10 m altitude from the ECMWF's operational passes (at 00h UTC and 12h UTC). Spatial resolution was 0.125° and temporal resolution was 6 hours. The SAPO will use the same wind fields.

The output from WAM Africa will give us data for the boundary conditions with a resolution of 5'.

The selection of limits for the integration of the SWAN will depend on the boundary conditions, the wind fields and bathymetry, given that the model factors in the changes undergone by the wave as it nears the coast, hence, when we are in shallow waters (depth < 200 metres).

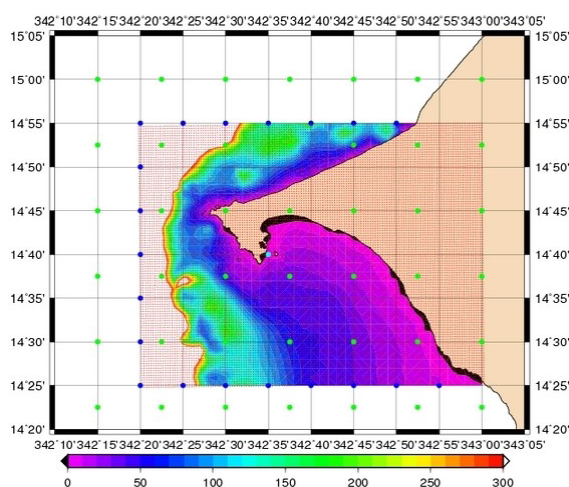


Figure 25. Integration limits for the Dakar SAPO

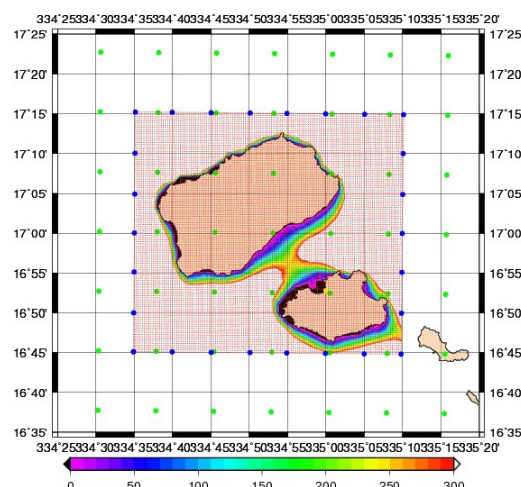


Figure 26. Integration limits for the Mindelo SAPO

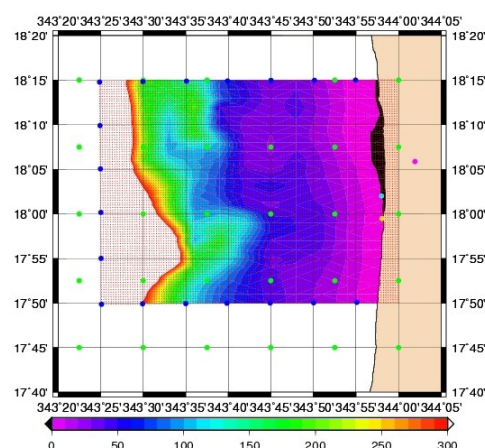


Figure 27 Integration limits for the Nouakchott SAPO

- SWAN output
- WAM wind data
- Boundary conditions

The red dots are the SWAN data output, which has a resolution of 500x500 meters. The bathymetry which can be seen (Figure 25, Figure 26 and Figure 27) is that of GEBCO which, although it contains anomalies, is useful for seeing where the deep waters start (SAPO limit).

Once the wind data and boundary conditions have been defined, these WAM Africa outputs will be used.

#### A.3.2.2. Execution of SWAN. Graphic outputs of the model.

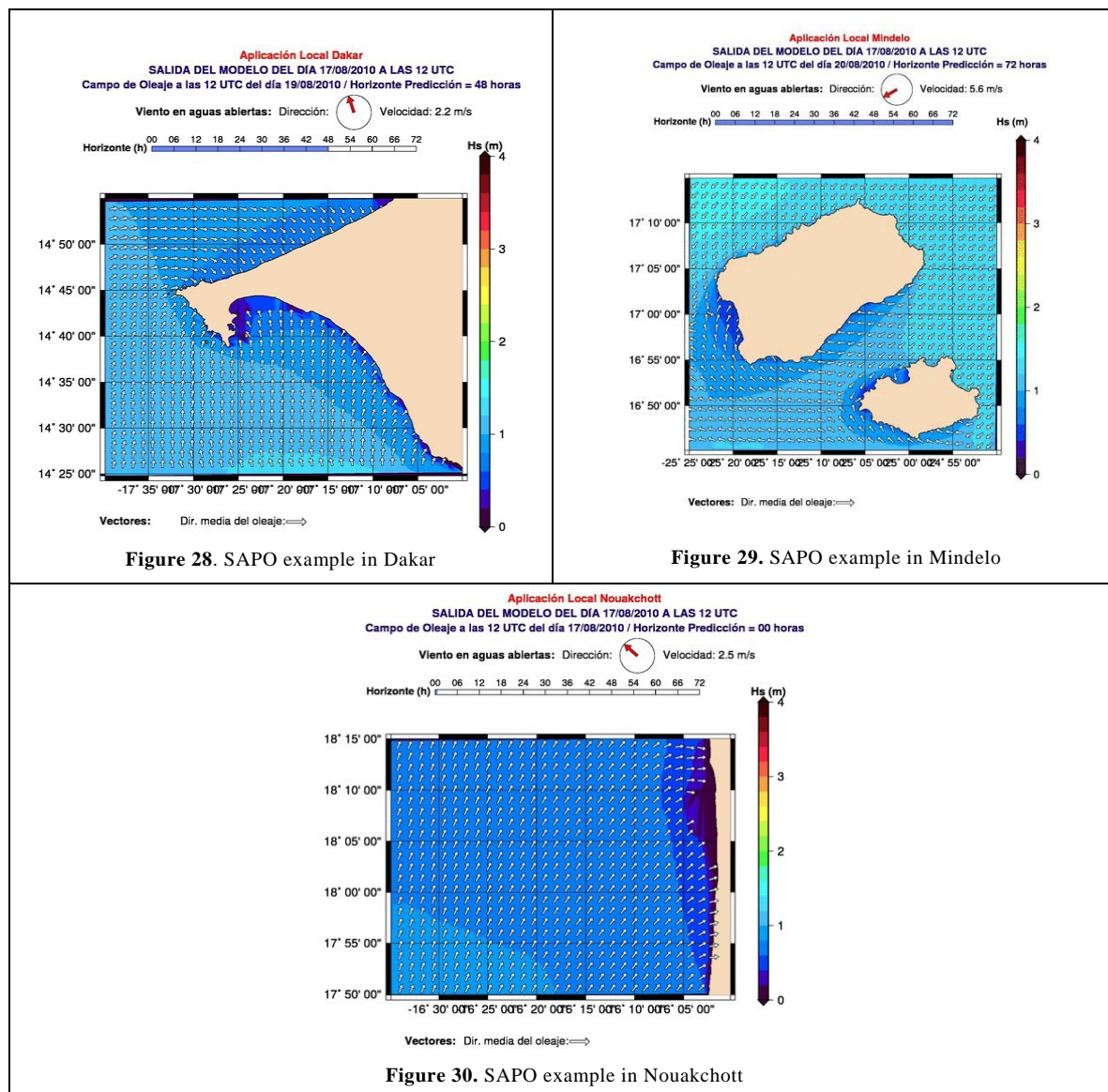
The digital wave model for implementing the SAPOs is the SWAN 4072.

By way of example, with some boundary conditions from WAM Africa and using GEBCO bathymetry, while awaiting the digitized bathymetry, the model was run for the three SAPOs.

In the future, once the system is fully operational, the following outputs will be generated for wave modeling on the port scale:

- Temporal verification series (.gif format).

- Wave maps (72 maps per wave, one for our hour of the prediction horizon, in gif format: Figure 29 and Figure 30)
- Html table with data at a given point.



## WEB PAGE DEVELOPMENT

All of these products - satellites, deep water modeling and harbour modeling - will be available on the Web page of the pilot project <http://www.afrimet.org/marinemet>. This is a page under development that will be the basic operating tool for the project, and will serve for the distribution of products and services. A decision was taken to work with the Joomla technology (<http://www.joomla.org>). Joomla is an open source content management system allowing on-line development of websites and applications. This system was chosen for two main reasons: first, it is an open tool, with everything that this implies when the time comes to transfer the application, and second, the web applications developed in this environment are relatively easy to maintain and transfer.

A choice was made to instal. a content manager which is based on Joomla and runs on a MySQL database. The development of the application, in addition to using free software, must be redistributable (able to run independently of the hardware and server). The portal, which is under development, will be available in the three official project languages: English, French and Spanish) (Figure 31 shows a screen shot of the project's Web portal). It will contain general information on the project, technical documents, the various information services in real time, as well as the database for the various products and services that will be generated throughout the life of the project.

To manage the product images, a specific component has been developed to integrate them into the Joomla content system. The Eclipse development kit will be used for this purpose, and the Joomla API will serve to authorize secure access routines to the database.

The functioning of the development component begins with the product images received via ftp, a process which checks the upload directory from time to time. When it comes across images, it classifies them according to type and creates the data structure for their insertion into the database. The process ends by turning the images into thumbnails so they can be visualized on the web page and copies the original in another folder. The development of this Joomla component can be divided into three separate phases:

- The capture logic for the files received and classification (distinction as to type of file, product, data, window, ... according to the file name).
- Routines for insertion into the database.
- The user interface (how the products are displayed).

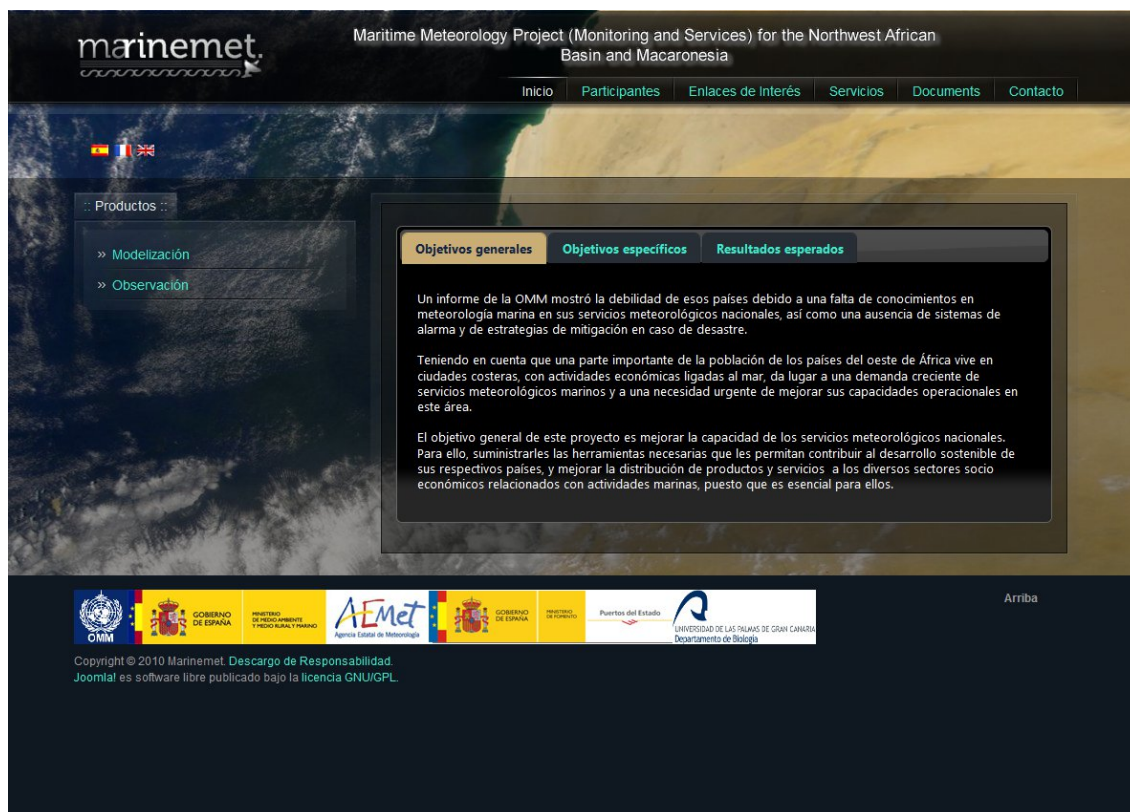
Capture logic and classification: The directory is printed when data are uploaded, analyzing the file names with the names of the previously defined patterns which make it possible to identify and classify them. The classification algorithm may be adjusted to fit new products, provided that a similar logic is maintained when files are received. At present, the logic is being developed for insertion into satellite products, and work is underway on the logic required for the insertion of modeling products for both deep waters and harbours.



The necessary fields are created in the database for the various products. The algorithms for insertion into the Joomla database are adapted to insert registries based on data structures created in the previous phase (classification). As with the insertion logic, routines have been prepared for the satellite products, while the preparation for ocean modeling products is ongoing.

### 8.2.3. User interface

Routines have been created to convert the images received into a reduced format so that they may be displayed via the website, respecting the links which make it possible to download them in their original size. Also under development are access routines for the database to extract the required data (product search) in each subsection.



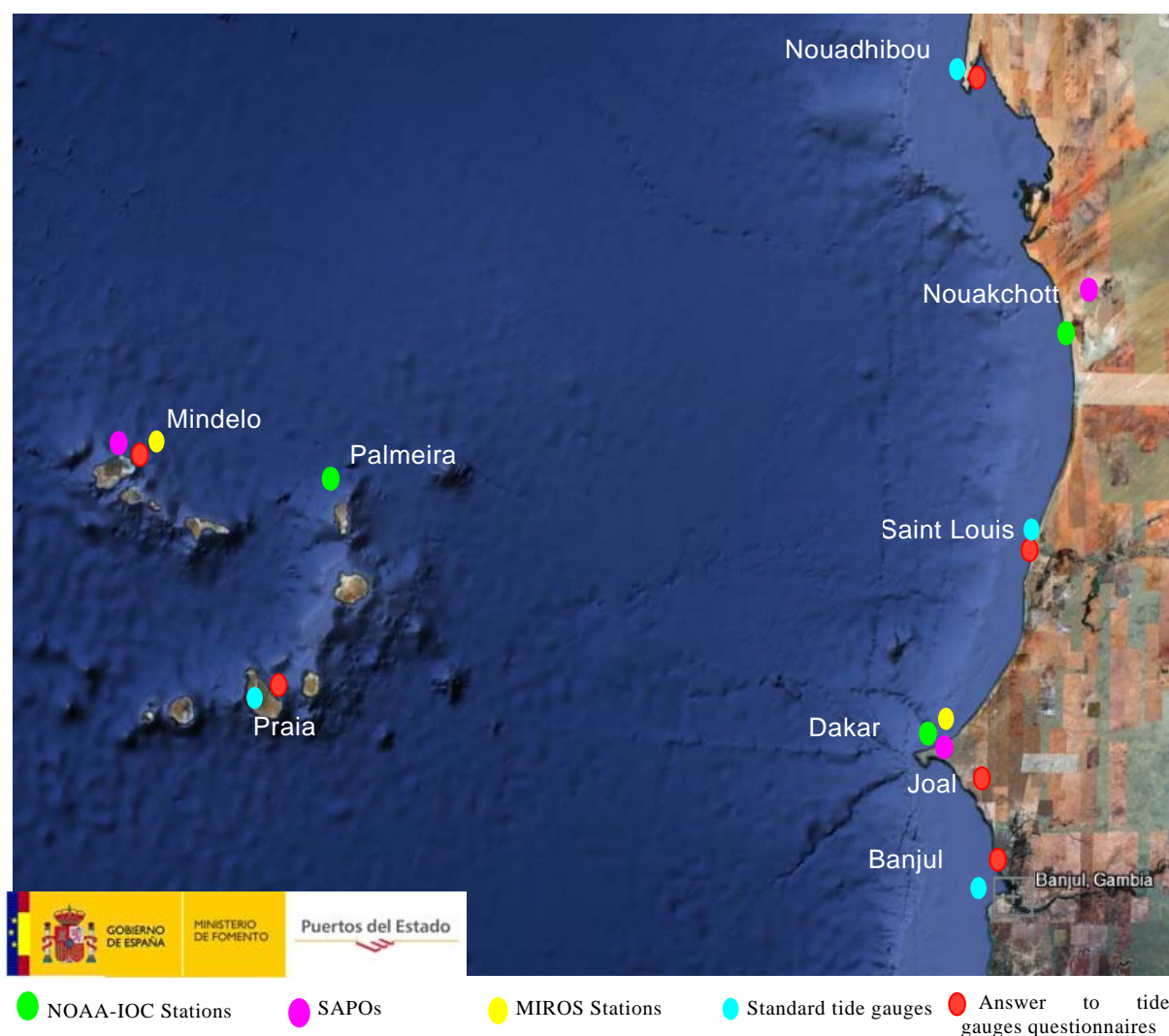
**Figure 31.** Screen shot of the Web portal for the Marinemet project

## B. TRANSFER OF TECHNOLOGY (software):

**B.1. Tide gauges:** to determine the location and quantity of tide gauges to be installed, at the technical project meeting held in July 2009 in Dakar, the focal points were asked to fill out questionnaires with a view to choosing sites with the data obtained. The distribution which the experts deemed most appropriate was presented and adopted at the Conference of Directors in February 2010 in Banjul, and is as follows:

- 1 Miros type station (measuring sea roughness) in Dakar, Senegal
- 1 Miros type station (measuring sea roughness) in Mindelo, Cape Verde
- 1 standard station in Nouadhibou, Mauritania
- 1 standard station in Praia, Cape Verde
- 1 standard station in Saint-Louis, Senegal
- 1 standard station in Banjul, The Gambia

Figura 32. shows the location of the different types of tide gauges:



**Figura 32.** Distribution of tide gauges



The procurement of these tide gauges includes training on their maintenance and management, which will be provided on site.

In the autumn of 2010, WMO sent the technical specifications for the tide gauges to various firms so that they could tender bids. In early December, bids were tendered, and these are now being evaluated. The company which wins the contract for installing and maintaining the tide gauges will start work as soon as the best bid has been selected.

### **B.2. Automated weather stations**

In 2010, no progress was made on the procurement of automated weather stations owing to budget constraints. This expenditure item will be tackled in 2011 once it is clear what the budget is for international cooperation.

### **B.3. PCs**

Plans call for the procurement and installation of seven PCs in connection with the MARINEMET project. One PC was purchased in 2009, and is currently being used by one of the consultants. The other six PCs are to be purchased in the course of 2011.

## ***C. TRANSFER OF KNOWLEDGE***

### **C.1. Documentation. Technical reports**

The technical reports prepared and distributed are described in subsection A.1.4. During the development of the project, reports will be prepared as need be, and a general transfer report will be prepared once the project ends.

### **C.2. Training courses:**

The courses programmed in the ToRs are the following:

- Maritime meteorology training in Toulouse: attended by representatives of Senegal, Mauritania and Cape Verde;
- Maritime meteorology training in the UK-Met Office: attended by the focal point from The Gambia;
- Specialized maritime meteorology course in Las Palmas: to be conducted once all of the equipment has been installed, probably in June 2012;
- End user courses in Senegal, The Gambia, Mauritania and Cape Verde: first half of 2013;
- Special on-site courses equipment is being set up.

### **3. DRAFT INDICATIVE SCHEDULE OF ACTIVITIES FOR THE MARITIME METEOROLOGY PROJECT IN THE NORTHWEST COAST OF AFRICA**

*(July 2009 – July 2013)*

*Updated on 22 December 2010*

Action	Country	In charge	Institutions	Start/ Finish
Recruit Type I consultant	Spain Geneva	Irene Sanz Edgar Cabrera	AEMET ULPGC WMO	July 2009/ June 2013
Recruit Type II consultant	Spain Geneva	Irene Sanz Edgar Cabrera	AEMET ULPGC WMO	July 2009/ December 2010
Recruit Type III consultant	Spain Geneva	Irene Sanz Edgar Cabrera	AEMET PE WMO	November 2009/ June 2013
Recruit Type IV consultant	Spain Geneva	Irene Sanz Edgar Cabrera	AEMET RSMC WMO	July 2009
Conduct exhaustive study of communications from the countries of the north-west coast of Africa: Mauritania, Senegal, The Gambia and Cape Verde (delay)	Spain Geneva Senegal	Malamine Sonko	AEMET PE WMO RSMC	July 2009 / November 2009
Prepare ToRs for procurement, maintenance, installation and training relating to: <ul style="list-style-type: none"> <li>Automated weather stations</li> <li>Tide gauges</li> </ul>	Spain Senegal Geneva	Irene Sanz Malamine Sonko Edgar Cabrera	AEMET PE WMO ANAMS	EMAS: evaluate for 2011 due to adjustments in the budget for TIDE GAUGES: bids tendering opened in December 2010



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Prepare ToRs for procurement, maintenance, installation and training relating to: <ul style="list-style-type: none"><li>SAPOs</li></ul>	Spain Senegal Geneva	Irene Sanz Malamine Sonko Edgar Cabrera	AEMET PE OMM ANAMS	Received in Spain June 2012
Run training course in Toulouse at the National School of Meteorology and at the Operational Centre for Marine Forecasting of Meteo-France.	Senegal Mauritania Cape Verde	Irene Sanz Edgar Cabrera	Meteo-France	September 2009 / October 2009
Run English-language training course at the UK-Met-Office.	The Gambia	Irene Sanz Edgar Cabrera	Met-Office	May-June 2010
Prepare a web product.	Spain	Irene Sanz	AEMET ULPGC	July 2009-December 2012
Provide training in Web maintenance and management to ensure its use is understood at the end of the project. Senegal in cooperation with Spain (for the duration of the project).	Spain Senegal	Irene Sanz	AEMET ULPGC	Dicember 2012
Manually prepare satellite products to ensure they are understood by the countries for which they will provide details.	Spain	Irene Sanz	AEMET ULPGC	Continuous process as new products are being developed
Prepare a document with the bathymetric information available in each of the countries in which the SAPOs are to be installed, explaining the characteristics of this information.	Senegal Mauritania Cape Verde	Sory Diallo Ould Mohamed L. Sidi Angelo Cardoso	SMHNs	Noviembre 2009
Study existing bathymetric information, digitize navigational charts as need be, standardize information by combining various sources, and interpolate said information in a uniform network, for the three SAPOs.	Spain Senegal Mauritania Cape Verde	Irene Sanz	AEMET PE	September 2010 March 2011
Design the application (networks, boundary conditions) and adapt the programmes and procedures that configure the SAPO to each application, for the three SAPOs.	Spain	Irene Sanz	AEMET PE	September 2010



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Transfer information and implement the application in the SAPO computer. Establish communications for boundary conditions and wind fields. Ensure system is operational.	Spain	Irene Sanz	AEMET PE	June 2012
Validate SAPO results and make necessary adjustments to ensure proper functioning.	Spain	Irene Sanz	AEMET PE	January 2013
Conduct an on-site study of the piers selected for the installation of the tide gauges	Spain Senegal Mauritania Cape Verde The Gambia	Irene Sanz	AEMET PE	Once the equipment procurement bid has gone to the winning firm, because the study will involve the firm's staff
Handle equipment procurement and provide the necessary economic and logistic conditions for training.	Spain Geneva	Irene Sanz Edgar Cabrera	AEMET OMM	First half of 2011
Have technical experts do prior preinstallation visits and field visits.	Spain	Irene Sanz	PE Bid-winning firm	Once the contract has been awarded and before the equipment has been received
Install six tide gauges.	Spain Senegal Mauritania Cape Verde	Irene Sanz One person from each country responsible for this equipment	AEMET PE	Once the equipment is available
Integrate data from the tide gauges.	Spain	Irene Sanz	AEMET PE	Once the equipment has been installed and communications are possible.



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Install ten automated weather stations.	Spain Senegal Mauritania Cape Verde	Irene Sanz One person from each country responsible for this equipment	AEMET OMM	Date to be set depending on budgets
Run a training course for meteorologists in Las Palmas.	Spain	Irene Sanz Edgar Cabrera	AEMET PE ULPGC OMM	One week in June 2012
Run an equipment management and maintenance course: SAPOs, tide gauges and automated weather stations.	Senegal Mauritania Cape Verde The Gambia	Irene Sanz Person responsible for the equipment in each country	AEMET PE OMM	Once the equipment has been installed
Run a training course for end users.	Senegal Mauritania Cape Verde Gambia	Irene Sanz Edgar Cabrera Focal points in each country	AEMET OMM SMHNs	First half of 2013

AEMET: State Meteorological Agency – SPAIN-

PE: Puertos del Estado – SPAIN-

ULPGC: Universidad Las Palmas de Gran Canaria – SPAIN-

WMO: World Meteorological Organization – GENEVA-

RSMC: Regional Specialized Meteorological Centre - SENEGAL-

ANAMS: National Meteorological Agency of Senegal – SENEGAL -