MID-TERM REPORT

CMEMS Service Evolution 21-SE-CALL1

INCREASE

Innovation and Networking for the integration of Coastal Radars into European mArine SErvices

DATE (23/12/2017)

MID TERM REPORT

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FOREWORD

This document is the mid-term report for projects selected through the Service Evolution 21-SE-CALL1. As stated in the specifications of the call for tenders 21-SE-CALL1 “Mid-term and final reports shall provide a comprehensive description of the study results and a detailed analysis of the potential impact of these results on the CMEMS operational service.”

A single report is asked per project, even though the project could be carried out by a consortium. It should be sent by email to angelique.melet@mercator-ocean.fr (cc pierre-yves.letraon@mercator-ocean.fr).

Executive summary

High Frequency radar (HFR) is a land-based remote sensing instrument offering a unique insight to coastal ocean variability, by providing synoptic, high frequency and high resolution data at the ocean atmosphere interface. HFRs have become invaluable tools in the field of operational oceanography for measuring surface currents, waves and winds, with direct applications in different sectors and an unprecedented potential for the integrated management of the coastal zone. To boost the use of HFRs into CMEMS is becoming crucial to ensure the improved management of several related key issues as Marine Safety, Marine Resources, Coastal & Marine Environment, Weather, Climate & Seasonal Forecast.

In this context, INCREASE will set the necessary developments towards the integration of the existing European HFR operational systems into the CMEMS, following four main objectives: (i) Provide HFR quality controlled real-time surface currents and key derived products; (ii) Set the basis for the management of historical data and methodologies for advanced delayed mode quality-control techniques; (iii) Boost the use of HFR data for improving CMEMS numerical modelling systems; and (iv) Enable an HFR European operational node to ensure the link with operational CMEMS.

During the first year of INCREASE, the main results obtained includes (1) a review of the current methodology, products definition and bases for elaborating guidelines on the use of HFRs, (2) a updated and extended description of the European HFR network (3) a roadmap for HFR products evolutions in compliance with CMEMS needs. They have been obtained involving a wide community of experts through the organisation of a 3 day workshop. These outcomes have been reported in a technical deliverable (D1.1), in a review paper (Rubio et al. 2016) and in different communication events.

1 Introduction

Surface ocean circulation, usually highly influenced by winds, tides, buoyancy forces and, in the coastal areas, by complicated topography, is especially complex with processes which coexist (and interact) at different time and spatial scales. The accurate monitoring of ocean surface circulation is key for the effective integrated management of coastal areas (where many human activities concentrate); this is why coastal observatories are developing along the global ocean coasts[1].

Among the different measuring systems, coastal High Frequency Radar (HFR) is the unique technology that offers the means to map ocean surface currents over wide areas (reaching distances from the coast of over 200km) with high spatial (a few kms or higher) and temporal resolution (hourly or higher). Recent publications provide examples of the application of HFR technology to different sectors in relation with marine environment, safety and exploitation[2,3,4], although work is still needed to demonstrate its usefulness for existing and new applications and to stimulate its development.

Consequently, the European HFR systems are playing an increasing role in the overall operational oceanography marine services. Their inclusion into CMEMS is crucial to ensure the improved management of several related key issues as Marine Safety, Marine Resources, Coastal & Marine Environment, Weather, Climate & Seasonal Forecast.

1.1. Objectives of INCREASE project

INCREASE will set the necessary developments towards the integration of the existing European HFR operational systems into the CMEMS, following four main objectives:

(i) Provide HFR quality controlled real-time surface currents and key derived products

(ii) Set the basis for the management of historical data and methodologies for advanced delayed mode quality-control techniques

(iii) Boost the use of HFR data for improving CMEMS numerical modelling systems and

[1] e.g.IMOS:http://www.imos.org.au/; RuCOOL:http://rucool.marine.rutgers.edu/; CCO http://www.channelcoast.org/

[2] Bellomo et al., 2015. Toward an integrated HF radar network in the Mediterranean Sea to improve search and rescue and oil spill response: the TOSCA project experience. J Operational Oceano., pp. 1.13,.

[3] Paduan and Washburn 2013.HFR observation of Ocean Surface Currents.Annu.Rev.Mar.Sci.5:115–36

[4] Wyatt, L. R. 2014, “High frequency radar applications in coastal monitoring, planning and engineering”, Australian Journal of Civil Engineering, Vol. 12, No. 1.

(iv) Enable an HFR European operational node to ensure the link with operational CMEMS.

To this end, the work in INCREASE will be aimed to enable a homogenised integration of the existing European HFR operational systems into the CMEMS, following five main work lines:

i. Define and apply common data and metadata formats and quality control methodologies to ensure the integration of high quality HFR real time data into CMEMS (TAC, MFC) ;

ii. Set the methodologies for reprocessing existing data sets to obtain continuous surface coastal ocean current data sets (QUID, assimilation in reanalysis products);

iii. Develop key derived products (gap-filled data, short-term prediction and derived Lagrangian products) of added-value for CMEMS users (TAC);

iv. Boost the use of HFR data for improving CMEMS numerical modelling systems (MFC);

v. Enable an HFR European operational node to ensure the operational availability of HFR data and data products and the link with operational CMEMS (TAC, MFC)

This will be fulfilled through 4 technical work packages (WPs) and a WP devoted to the management of the project:

WP1: Towards the integration of HFR observing technology into CMEMS
WP2: Basis for HFR data assimilation into CMEMS models
WP3: HFR Products development
WP4: HFR Node
WP5: Management, the networking and communication activities.

1.2. Objectives of this report

This document will report progress of INCREASE project in the period March 2016 to December 2016.

During this period all the project work packages (WPs) have been started and tasks within them have progress following the work plan (see Figure 1). Only one WP1 has been concluded, with the accomplishment of M1.1 and the final version of D1.1 send to CMEMs at the same time than this report. The rest of WPs are in progress following the planned activities.

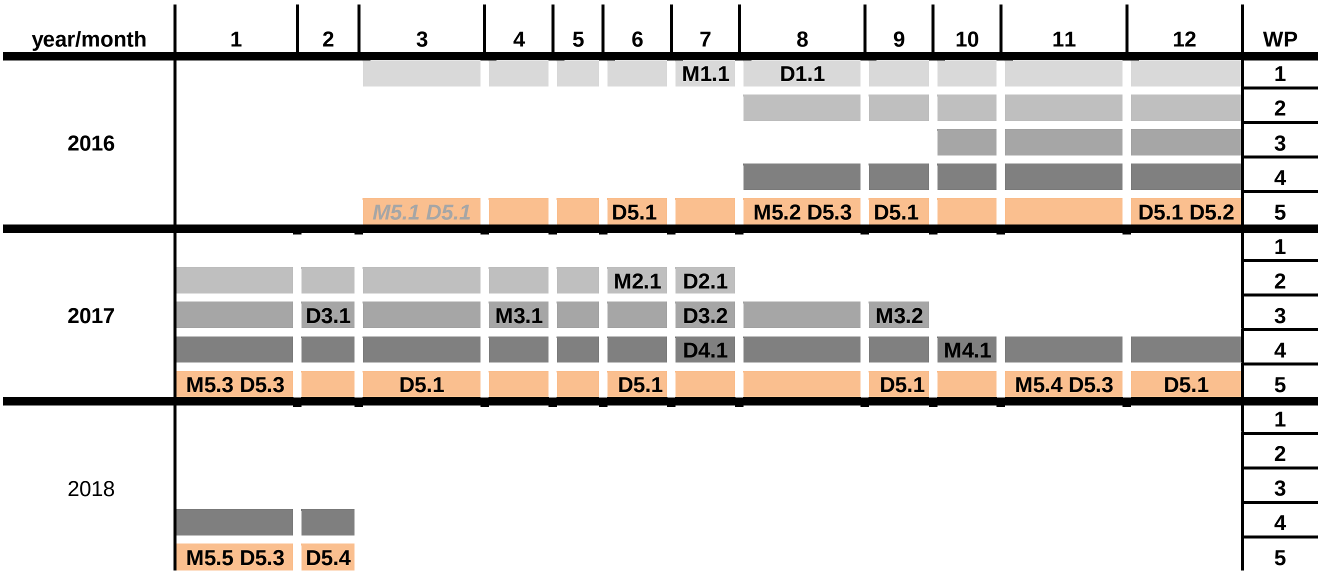


Figure 1- Timetable of INCREASE project main tasks and deliverables within the period 2016-2018

In the next section, the results concerning the main tasks and deliverables for the reporting period will be exposed, namely concerning:

M1.1: Methodology, products definition and bases for elaborating guidelines are set

D1.1: Report on European HFR systems development and roadmap for HFR products evolutions in compliance with CMEMS needs

M5.2: HFR expert workshop (INCREASE, EuroGOOS Task Team, CMEMS)

and D5.3: M5.3 meeting minutes

As reported in each of the quarterly reports (D5.1) several online meetings have been developed for coordination of the main tasks with the project partners. Additional results concerning scientific publications and participation in international conferences will be detailed in the next section.

2 Scientific results

2.1 Methodology, products definition and bases for elaborating guidelines (M1.1)

While all the radars share the same principles of operation, differences in signal transmission, reception and processing yield variations in metadata, quality control metrics and spatial registration. Even within the same type, HFRs may have different spatial ranges and resolutions, depending typically on the working frequency and bandwidth available. The main objective of this task has been to review the state of the art to be able to provide some specific guidelines towards the development of the European HFR network and towards the integration of this technology into CMEMS.

The main aspects that have been reviewed are:

i) Review of methodologies and procedures for basic products (radial and total standardized and quality controlled data).

Building on the successful experience of the RITMARE project and on the EuroGOOS strategy, in the framework of the European HFR community there are many ongoing efforts aiming at the homogenization of HFR data and metadata formats and of QA/QC procedures. These efforts are done in order to design and implement standards allowing for the establishment of an effective European HFR Network. In particular, the European project JERICO-Next (http://www.jerico-ri.eu/) is focusing on the definition of recommended common metadata and data models and Quality Control (QC) procedures for HFR data. In order to be suitable with the needs and the requirements of the European HFR community, INCREASE tasks towards the integration of HFR into CMEMs have been built on the work being done by these initiatives.

An extended description of the existing data and metadata formats has been provided (see D1.1) together with a proposed schema for different processing levels, independent on the specific QC procedures (see D1.1). An extended review of the QC standard for radial and total data in real time and delayed mode has also been provided, mostly based on the activity of the US Integrated Ocean Observing System (IOOS), that continues to establish written, authoritative procedures for the quality control (QC) of real-time data through the Quality Assurance/Quality Control of Real-Time Oceanographic Data (QARTOD) program[5].

[5] https://ioos.noaa.gov/wp-content/uploads/2016/06/HFR_QARTOD_Manual_05_26_16.pdf

ii) Review of methodologies and procedures for advanced products

A comprehensive review of different methodologies to obtain products derived from HF radar was performed. The main types of products explored where those related to:

- Gap-filling of current maps. Since the process from radials to totals leads to solutions that are not always a gap-free map of vectors, this is one of the most necessary “advanced” products to allow other applications derived from HF radar data. This is especially true when the total data are needed to compute trajectories using a Lagrangian. Several options for gap filling are reviewed, like: Open Mode Analysis (OMA) from radials[6] or Variational analysis[7].

- Short term prediction products. Simple approaches based for instance in empirical models can be used to forecast future currents based on a short time history of past observations, as an alternative (or complement) to assimilating HFR data in numerical models (e.g. [8]). These methods prove very interesting possibilities for users related to the SAR and oil spill applications.

- Operational Lagrangian products - Several papers on the effectiveness of trajectory predictions using currents derived from HFR were reviewed (e.g.[9,10]). They show the potential of HFR data for different sectorial applications

[6] Kaplan D. M. and Lekien F., 2007. Spatial interpolation and filtering of surface current data based on open-boundary modal analysis. J. Geophys Res.-Oceans 112(C12). doi:10.1029/2006JC003984

[7] Yaremchuk, M., Sentchev, A. (2011). A combined EOF/variational approach for mapping radar-derived sea surface currents, Cont. Shelf Res., 31, 7–8, 15, 758-768, doi:10.1016/j.csr.2011.01.009.

[8] Solabarrieta, L., Frolov, S., Cook, M., Paduan,J., Rubio, A., González,M., Mader, J., Charria, G. (2016). Skill assessment of HF radar-derived products for lagrangian simulations in the Bay of Biscay. J. Atmos. Oceanic Technol., in press, doi: 10.1175/JTECH-D-16-0045.1.

[9] Abascal A.J., Castanedo, S., Medina, R., Losada, I.J., Álvarez-Fanjul. E. (2009). Application of HF radar currents to oil spill modelling. Mar. Pollut. Bull. 58, 2, 238-248. doi: 10.1016/j.marpolbul.2008.09.020

[10] Bellomo L. , Griffa, A., Cosoli,S. , Falco P.,. Gerin,R, Iermano,I., Kalampokis,A., Kokkini, Z. , Lana, A., Magaldi,M. G., Mamoutos,I., Mantovani, C., Marmain,J., Potiris, E., Sayol, J. M., Barbin, Y., Berta, M., Borghini, M., Bussani, A., Corgnati, L., Dagneaux, Q., Gaggelli, J., Guterman, P., Mallarino, D., Mazzoldi, A., Molcard, A., Orfila, A., Poulain, P.-M., Quentin, C., Tintoré, J., Uttieri, M. Vetrano, A., Zambianchi, E., Zervakis V. (2015). Toward an integrated HF radar network in the Mediterranean Sea to improve search and rescue and oil spill response: the TOSCA project experience. J. Oper. Oceanogr., 8, 2, 95–107, doi: 10.1080/1755876X.2015.1087184

iii) HFR data management, existing infrastructures and identified needs

HFR data is in situ gridded data in time (big data) that has to be managed according its peculiarity, therefore the standard in situ data management infrastructure have to be empowered and updated to allow both Thematic Assembly Centres (TAC) and Marine Forecasting Centers (MFC) to assimilate and create new products including HFR data. So it will be necessary to design and develop the hardware and software infrastructures, as well as the data formats, file conventions, file dimension, file naming and labelling for both real time (i.e. the continuous data flow for latest days) and historical (i.e. the complete series) HFR data management.

Based on existing work, it was possible to define the basic HFR data management infrastructure, metadata and data formats.

iv) Present status of the European HFR community

In Europe, the use of HFR systems is growing with over 50 HFRs currently deployed and a number in the planning stage. In order to build an up-to-date inventory of operational HFR systems and operators the INCREASE team in close collaboration with the EuroGOOS HFR Task Team and the JERICO-Next project launched a European survey to diagnose the present status of different HFR systems available in Europe.

The survey consisted in 46 questions oriented to provide information on four axes:

- Contact people for each network or system
- Technical information on the network, number, names, locations, working parameters of the sites (including questions on maintenance procedures and experience of interference problems) (see Figure 2)
- Technical information about the data formats, sharing protocols and policies, QA/QC and processing
- Areas of application of the data and identified users (including specific questions related to data assimilation)

HFR NETWORK	Hook of Holland		German Bight	Gulf of Naples	Tirlig	Gulf of Manfredonia	SICOMAR	Calypso	Joe Doe	CALYPSO	SPLIT
COUNTRY	THE NETHERLANDS		GERMANY			ITALY			SLOVENIA	MALTA	CROATIA
OPERATOR	Rijkswaterstaat		Helmholtz-Zentrum Geesthacht	University of Naples	CNR-ISMAR		Consorzio LaMMA - CNR	University of Palermo	National Institute of Biology	University of Malta	Institute of Oceanography and Fisheries
Numbser of SITES	2										
Name of sites	Ter Heijde	Ouddorp									
Sites lat , lon coordinates	52,03	51,82									
	4,17	3,88									
Date of 1st deployment	01/10/2015										
Status	Ongoing										
Permanent installation?	yes										
Manufacturer	WERA*										
Type of radar	PA										
Temporal resolution (minutes)											
Spatial resolution of total velocity grid (m)											
Tansmit Fequency (MHz)	16,1										
Tansmit Bandwidth (KHz)	150										

HFR NETWORK	IBIZA CHANEL		DELTA DEL EBRO		ESTRECHO DE GIBRALTAR	GOLFO DE CÁDIZ	GALICIA	Ria de Vigo	Basque Country	National HF Network
COUNTRY					SPAIN					PORTUGAL
OPERATOR	SOCIB		Puertos del Estado				INTECMAR	University	AZTI	Instituto Hidrografico
Numbser of SITES	2									
Name of sites	FORM	GALF	SALOU	ALF						
Sites lat , lon coordinates	38,67	38,95	41,06	4						
	1,39	1,22	1,17							
Date of 1st deployment	01/06/2012		01/07/2014							
Status	Ongoing		Ong							
Permanent installation?	yes		y							
Manufacturer	CODAR		CO							
Type of radar	DF		D							
Temporal resolution (minutes)	60		6							
Spatial resolution of total velocity grid (m)	3000		30							
Tansmit Fequency (MHz)	13,5		13,5							
Tansmit Bandwidth (KHz)	90,069		90							

HFR NETWORK	MOOSE HF radar			Iroise		Torungen	Wave Hub HF Radar		BRAHAN		Ireland West Coast_Radars			
COUNTRY	FRANCE					NORWAY	UK				IRELAND			
OPERATOR	MIO, AMU-CNRS-IRD-UTLN			SHOM		Norwegian Meteorological Institute	Plymouth University		Marine Scotland Science		National University of Ireland			
Numbser of SITES	3			2		1	2		2		4			
Name of sites	Vila real de Santo António	ANTARES	DYFAMED	Pointe de Garchine	Pointe de Brézellec	Torungen	Pendeen	Perranporth	SUMB	NRON	Mutton Island	Spiddle	Inish Oirr	Loop Head
Sites lat , lon coordinates	37,18	42,95	43,50	48,50	48,07	58,40	50,16	50,34	59,85	59,39	53,25	53,24	53,06	52,56
	-7,44	6,00	7,25	-4,78	-4,66	8,79	-5,67	-5,18	-1,28	-2,38	9,05	9,30	9,52	9,92
Date of 1st deployment	01/08/2010	15/11/2011	01/09/2015	01/05/2006		25/05/2016	01/02/2011 and 01/04/2011		01/09/2013		01/03/2012		01/09/2015	
Status	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing		Ended on 09/08/2014	Ended on 09/01/2014	Ongoing			
Permanent installation?	yes	yes	yes	yes		yes	no		no		yes			
Manufacturer	CODAR	WERA*	CODAR	WERA		CODAR	WERA*		CODAR		CODAR			
Type of radar	DF	DF on 8 receiving antenna	DF	PA		DF	PA		DF		DF			
Temporal resolution (minutes)	60	60	90	10		60	60		60		60			
Spatial resolution of total velocity grid (m)	1500	3000	0	2000			1000		5000		300		2000	
Tansmit Fequency (MHz)	12,4698	16,175	13,45	12,4		13,5	12		4,5		25		13,5	
Tansmit Bandwidth (KHz)	99,259	50	50	100		75	350	375	36,8		500		49,6	

Figure 2: Snapshot of the tables showing the detail of information obtained by the survey concerning the technical characteristics of the EU HFR systems.

The survey was launched in June 17th and was sent to the EuroGOOS HFR Task Team expert's mail-list, including JERICO-Next collaborators and other identified key actors. It was closed July 27th, gathering responses from 28 European institutions and information on more than 70 HFR systems.

The first long-term installation registered was that of the Gulf of Naples at the end of 2004. From 2004 until 2009 a moderate growth rate of two new HFRs per year is observed. From 2009 to now, the rate has increased to around six new HFRs installed per year.

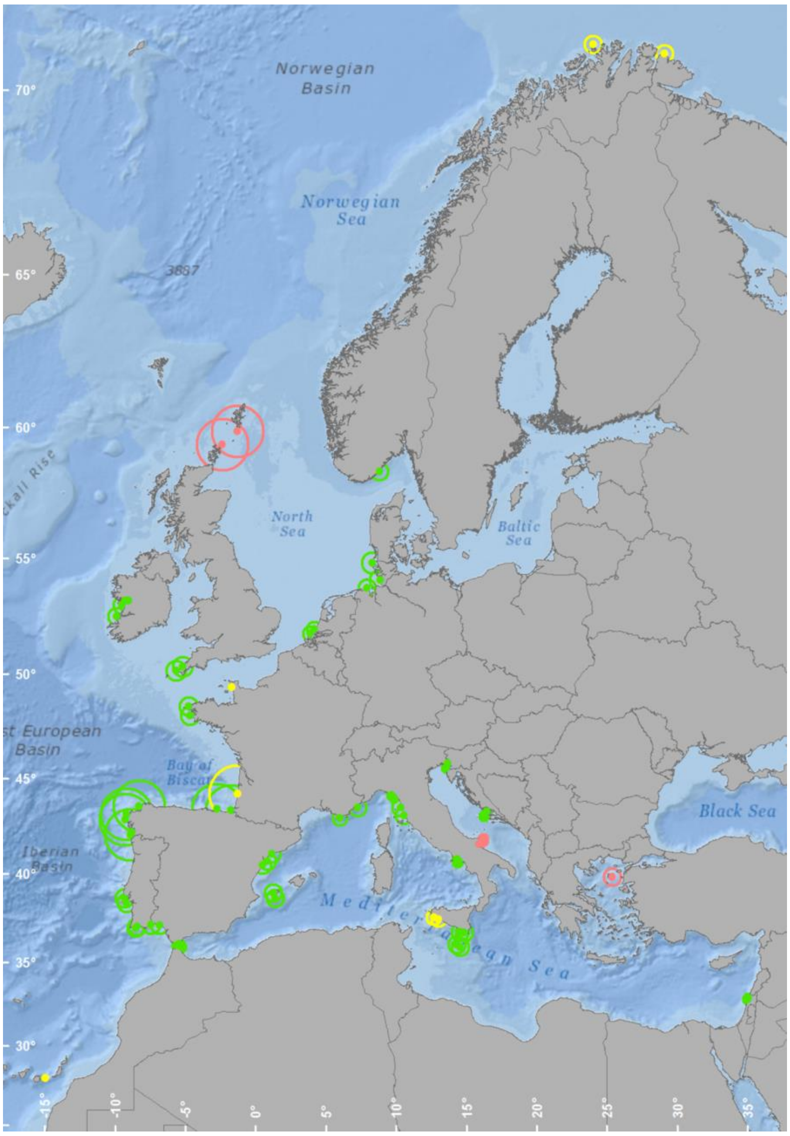


Figure 3: Map with the location of the 73 European HFR sites listed in the survey and their theoretical radial range (represented by the circles scaled to typical radial range associated to the frequency of operation of each of the systems). Green: ongoing (52); red: past or no longer providing operational data (9); yellow: future installations (12).

Concerning the application of the HF European radars the survey suggested that the most popular identified user of the data is Academia, followed by European or National Maritime Safety Agencies and Weather Services (Figure 5). Concerning scientific research, the most popular research lines are those related to Lagrangian approaches to surface transport and connectivity, data assimilation and small scale and mesoscale ocean processes (Figure 4).

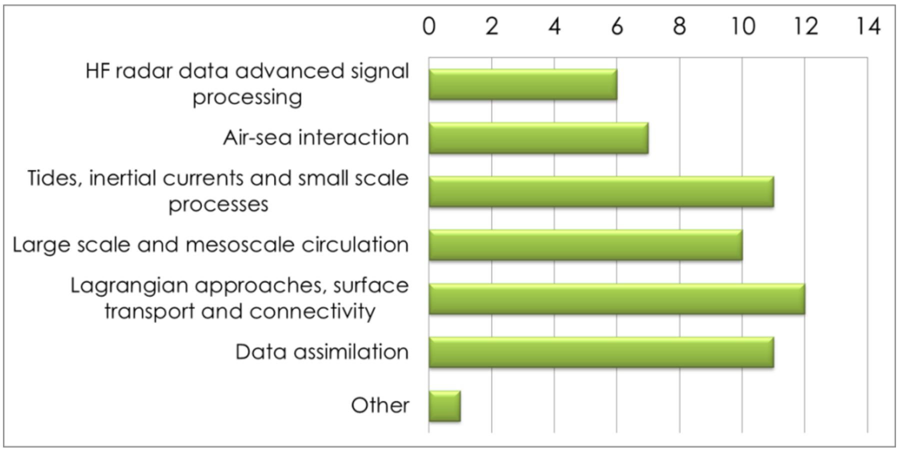


Figure 4: HFR related research lines listed by the european surveyed institutions. From 23 operators 15 chose at least one of the available options. Multiple choice was enabled, so one institution could identify more than one research line.

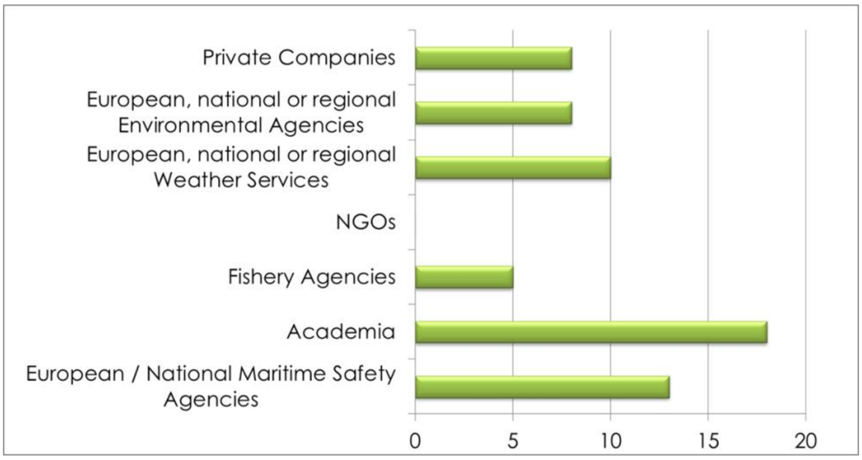


Figure 5: European HFR data or products users as identified by the surveyed institutions. 20 out of 23 institutions operating HFRs chose at least one option among those displayed (multiple choices were enabled, so one institution could identify more than one user).

Since the information gathered during the review processes and trough the survey were considered of high interest for the whole HFR community, it has been used produce two additional publications and two communications in different forums, as specified in section 5 of this document.

2.2 Report on European HFR systems development and roadmap for HFR products evolution (D1.1)

These results have been also used to build develop the roadmap for HFR products evolutions in compliance with CMEMS needs. The review and the roadmap are comprehensively described in the report D1.1.

A first version of the deliverable D.1.1 was delivered early September 2016 following the initial timetable. This first version contained mainly the results from M1.1. A final version has been produced after the INCREASE experts meeting (D5.3, September 2016, see next subsection) and discussions with the MFCs at the Service Evolution Coordination Meeting (December 2016). The final version of D1.1 will be delivered Mid-January.

2.3 HFR expert workshop (M5.2) and meeting minutes (D5.3)

A second element towards the definition of this roadmap has been the organization of the HF Radar expert workshop, which has taken place in Italy (La Spezia) on 13th-15th September 2016. This meeting gathered EuroGOOS HFR Task Team members, CMEMS representatives, main HFR technological providers, US and Australian communities representatives or other active HFR actors to work on:

- ✓ making a diagnostic of the present development of European HFR systems (existing systems, operators, existing products);
- ✓ reviewing and setting methodologies for basic and HFR derived products;
- ✓ reviewing CMEMS needs and objectives and how HF Radars can fit into them;
- ✓ designing a roadmap for the establishment of a European HFR network.

47 international experts from 29 different institutions and 14 countries participated to the meeting (the list of attendants is provided in subsection 6.1).

In addition to sessions where individual presentations addressed the previous points, three parallel discussion groups where organized about the following topics:

- GROUP1: Basic products: Data format and QA/QC
- GROUP2: Advanced products and applications
- GROUP3: Technical implementation and strategic development

The elements to build this last part of the deliverable were gathered after this meeting, and used to produce the meeting minutes (D5.3). The minutes were sent to all the WS participants, including CMEMS, on 19th October 2016 and can be found online with all the presentations provided at: https://azti.box.com/v/EuroGOOSHFRTTINCREASEexpWS

3 Identified issues and risks

An important effort has been performed for organising the HFR Experts Workshop (M5.2), and there is very few budget left for organising the Implementation Expert Users Workshop, planned end of 2017 and mostly oriented to end-users (M5.4).

Conversation with the SE coordination team has started to find a reduced cost solution for the execution this second workshop and to reduce the risks concerning its feasibility. An option that has been discussed is to use an existing framework to add that workshop as a side event. One possibility could be the CMEMS week in September 2017 in Brussels.

In January 2017, the details on the objectives and contents will be provided to CMEMS for deciding about this possibility.

4 Potential impacts for CMEMS and transfer towards CMEMS

WHAT will be obtained from INCREASE?

HFR is today recognized internationally as a cost-effective solution to provide mapping of ocean surface currents over wide areas with high spatial and temporal resolution that are needed for many applications for issues related to ocean surface drift or hydrodynamical characterization. Other R&D lines open interesting perspective for others variables like wave or surface wind data. The European HFR systems are playing an increasing role in the overall operational oceanography marine services. So, the basic and advanced products developed in INCREASE, based on the real-time 2D monitoring of shelf/slope surface circulation, will impact directly on key issues of CMEMS (Marine Safety, Marine Resources, Coastal & Marine Environment, Weather, Climate & Seasonal Forecast).

Direct products will be potentially implemented at the end of this project in InSitu TAC. Others will be used in Sea Level TAC for data intercomparison and integration, and in different MFCs for quality assessment (QUID, real-time indicators) or through data assimilation. The performed inventory of the operational HFR systems in Europe (Mader et al, 2016) includes 51 sites (in 20 networks) with potential impact in CMEMS. The MFC meshes overlap so one HFR station could impact in different MFC areas. The potential impact of the currently available data is distributed as follow: MED-MFC (17 stations), IBI-MFC (9 stations), NWS-MFC (3 stations). These numbers will grow at a mid/long term scale, because countries like Portugal, France or UK are establishing plans for developing their networks.

Moreover, the covered areas allow a fundamental assessment in the buffer zone between CMEMS and downstream coastal tools. The products based on the real-time 2D monitoring of shelf/slope surface circulation will deliver key information for assessing the boundary conditions applied in the coastal models of intermediate users.

WHEN will be available the data products from HFRs?

The INCREASE project will provide demonstrators of key solutions for the implementation of new products based on HFRs. Following the objective of the Service Evolution framework, these implementations could start in 2018 in the Phase two of CMEMS Operational Tasks.

Moreover, INCREASE has established the link between CMEMS and HFR Task Team that is coordinating the roadmap for developing the use of this technology in Operational Oceanography in Europe. This will allow first to better take into account CMEMS needs in the design of the HFR European network and secondly to optimize the "*time to service*" of R&D performed in this field.

HOW to facilitate the uptake of the R&D results by the CMEMS operational centres?

INCREASE works on involving CMEMS Service Evolution and Operational teams during the project. First, INSTAC, MFCs and SE coordination have been represented in the Workshop organized in La Spezia (Sep2016). Then the Deliverable D1.1 aims to help the transfer of information to CMEMS. Finally, after the feed-back received at the Bergen Coordination meeting, INCREASE team will continue interactions with INSTAC and will reinforce the link with SeaLevel TAC (led by CLS) for deeply studying interactions between satellite and HFR products. Connection with MFCs will follow in particular with the Data Assimilation community.

Moreover, INCREASE is working on ensuring that the development activities performed for the CMEMS service evolution will be related with major projects and organizations dealing with coastal data:

- SeaDataCloud for building historical products for reanalysis purposes and for standard improvements
- JERICO-Next for coastal network expertise
- EMODnet-Physics to be interoperable with the EMODnet central portal, contribute to unlocking access to private data, and to be interoperable with the AtlantOS project.
- EuroGOOS: Enhance link with in situ observing system operators and downstream users (Task Teams and Working Groups).

5 Communications

5.1 Past communications

Several communications have been done using the results of INCREASE project, and those obtained in collaboration with other ongoing initiatives (EuroGOOS HFR Task Team, JERICO_NEXT project, EMODnet)

1. The review paper entitled “HF Radar Activity in European Coastal Seas: Next Steps Towards a Pan-European HF Radar Network” has been accepted for publication in the Research Topic “Horizon Scan 2017: Emerging Issues in Marine Science” of Frontiers in Marine Science.

Authors: Rubio, A., Mader, J., Corgnati, L., Mantovani, C., Griffa, A., Novellino, A., Quentin, C., Wyatt, L., Schulz-Stellenfleth, J., Horstmann, J., Lorente, P., Zambianchi, E., Hartnett, M., Fernandes, C., Zervakis, V., Gorringe, P., Melet, A., Puillat, I.

Expected publication: January 2017

2. The complete survey results have been published at EuroGOOS website. Reference: Mader J., Rubio A., Asensio J.L, Novellino A., Alba M., Corgnati L., Mantovani C., Griffa, A., Gorringe P., Fernandez V. (2016). The European HF Radar Inventory, EuroGOOS publications

Available at: http://eurogoos.eu/download/publications/EU_HFRadar_inventory.pdf

3. The abstract entitled “Joint Efforts Towards European HF Radar Integration” was presented in the session “OS13B Toward an International Coastal Ocean Radar Network: Technology Development, Research Demonstration, and Operational Applications II Posters” of the AGU- Fall Meeting, San Francisco, USA, 12 December 2016.

Authors: Mader, J., Rubio, A., Griffa, A., Mantovani, C., Corgnati, L., Novellino, A., Schulz-Stellenfleth, J., Quentin, C., Wyatt, L., Ruiz, M.I., Lorente, P., Hartnett, M., Gorringe, P.

Abstract available at: https://agu.confex.com/agu/fm16/meetingapp.cgi/Paper/174583

Poster available at:

https://agu.confex.com/agu/fm16/mediafile/Handout/Paper174583/poster_AGU_vf.pdf

4. A. Rubio participated in the French Renhfor project meeting, giving an update of INCREASE results and the progress towards a unified HFR European network. Brest, 27 October 2016.

5. A. Rubio participated in the 5th Meeting of the GEO Global HF Radar Task held in San Francisco, USA, on the 12th December 2016. Agenda of the meeting and presentations to be published soon at: https://rucool.marine.rutgers.edu/geohfr/meetings.html.

Fifth Meeting of
The Global High Frequency Radar Network

San Francisco, California USA

Location: San Francisco Marriott Marquis
780 Mission Street
San Francisco, CA 94103

Yerba Buena Ballroom
Salon 14 & 15

Agenda

Monday, December 12, 2016	
6:00 pm to 6:15 pm	Ice Breaker, Marriot Marquis
6:15 pm to 6:30 pm	Opening Remarks, Hugh Roarty
6:30 pm to 6:45 pm	Update from Europe, Anna Rubio
6:45 pm to 7:00 pm	Update from Asia, Dongxiao Wang
7:00 pm to 7:15 pm	Update from the Middle East, Libe Washburn
7:15 pm to 7:30 pm	Update from the Americas
7:30 pm to 7:45 pm	HF Radar as a New Observing Element of GOOS
7:45 pm to 8:00 pm	ITU Bands and National Efforts Discussion
8:00 pm	Meeting Ends

Special Thanks to
Dr. Dongxiao Wang from the
South China Sea Institute of Oceanology, CAS
for sponsoring the refreshments.

GROUP ON EARTH OBSERVATIONS

BLUE PLANET Oceans and Society

Figure 6 –Agenda of the last GEO Global HF radar meeting. The slides presented can be consulted in subsection 6.2

5.2 Future communications

Two possible main forums for INCREASE communication next year are:

1 - European Geophysical Union EGU2017, Vienna, 23–28 April 2017, where three different session could be of special interests:

- ✓ Copernicus Marine Environment Monitoring Service (CMEMS) (OS4.6)

  Convener: Angelique Melet
  Co-Conveners: S. Ciavatta , Ananda Pascual , Giovanni Coppini , Emanuela Clementi

- ✓ Interdisciplinary Events/Big Data in the Geosciences: Surface Drifters for Addressing Big Questions and Applications in Interdisciplinary Ocean Science (IE3.7/OS1.23)
  Convener Inga Koszalka, Co-conveners Joe Lacasce, Annalisa Griffa

- ✓ Oceanography at coastal scales. Modelling, coupling and observations (OS2.3)
  Convener: Dr. Agustín Sánchez-Arcilla from UPC (Barcelona, Spain) Co-conveners: Emil Stanev from HZG (Geesthacht, Germany) and Sandro Carniel from CNR-ISMAR (Venice, Italy)

- ✓ Session Earth & Space Science Informatics (ESSI); Community-driven challenges and solutions dealing with Informatics (ESSI1): Informatics in Oceanography and Ocean Science (ESSI1.1) Conveners: Giuseppe M.R. Manzella, Dick Schaap and Antonio Novellino

2 - ROW2017 International Radiowave Oceanography workshop Lüneburg SEPTEMBER 2017

3 - Radiowave Operators Working Group (ROWG) 14-15 March 2017 Texas A&M University, Galveston, Texas)

5.3 Project Highlight and figure (for communication purposes)

High Frequency radar (HFR) is a land-based remote sensing instrument offering a unique insight to coastal ocean variability, by providing synoptic, high frequency and high resolution data at the ocean atmosphere interface. HFRs have become invaluable tools in the field of operational oceanography for measuring surface currents, waves and winds, with direct applications in different sectors and an unprecedented potential for the integrated management of the coastal zone. The use of HFRs into CMEMS is crucial to ensure the improved management of several related key issues as Marine Safety, Marine Resources, Coastal & Marine Environment, Weather, Climate & Seasonal Forecast.

During the first year of INCREASE, the main results obtained include (1) a review of the current methodology, products definition and bases for elaborating guidelines on the use of HFRs, (2) a updated and extended description of the European HFR network (3) a roadmap for HFR products evolutions in compliance with CMEMS needs. The work done concerning this points, in collaboration with other ongoing initiatives and projects at the EuroGOOS HFR Task Team and the project JERICO_NEXT has led to a publication in Frontiers in Marine Science. The paper offers an overview of the European HFR activities (Figure 3 can be used here) and discusses relevant steps towards the expansion of this technology in Europe.

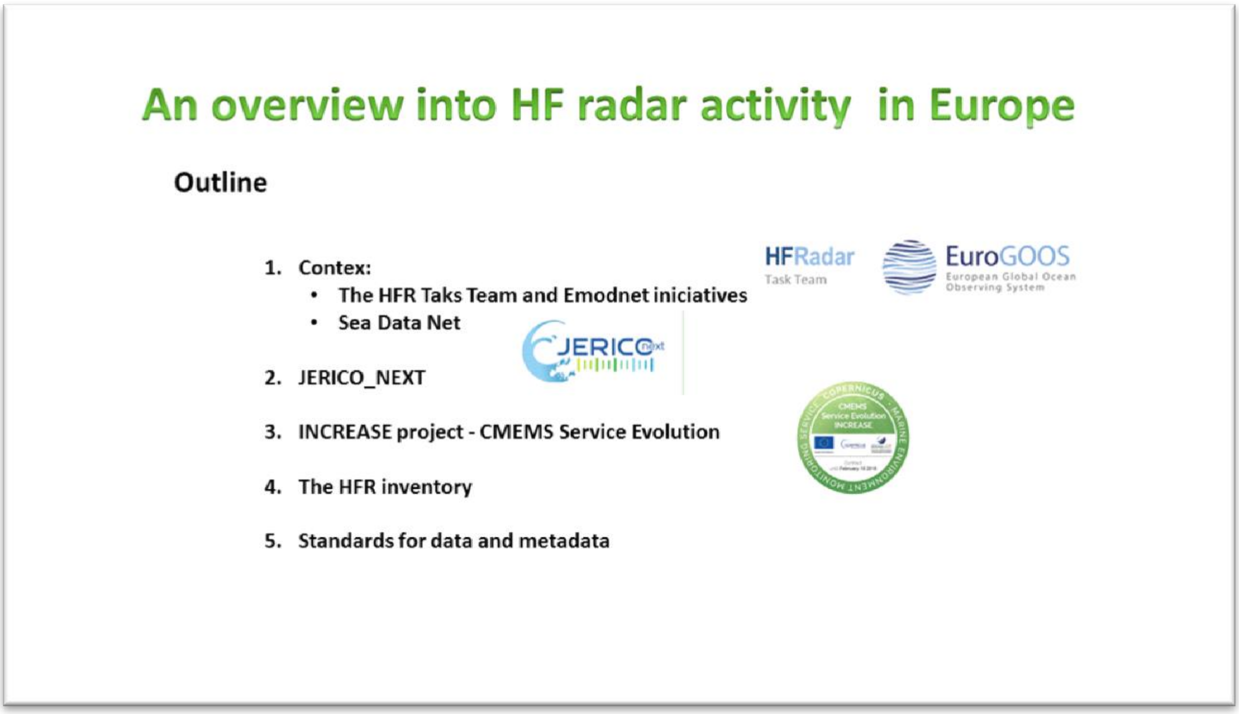
Suggested figure caption: Map with the location of the 73 European HFR sites listed in the survey and their theoretical radial range (represented by the circles scaled to typical radial range associated to the frequency of operation of each of the systems). Green: ongoing (52); red: past or no longer providing operational data (9); yellow: future installations (12). Adapted from Rubio et al. (2017)

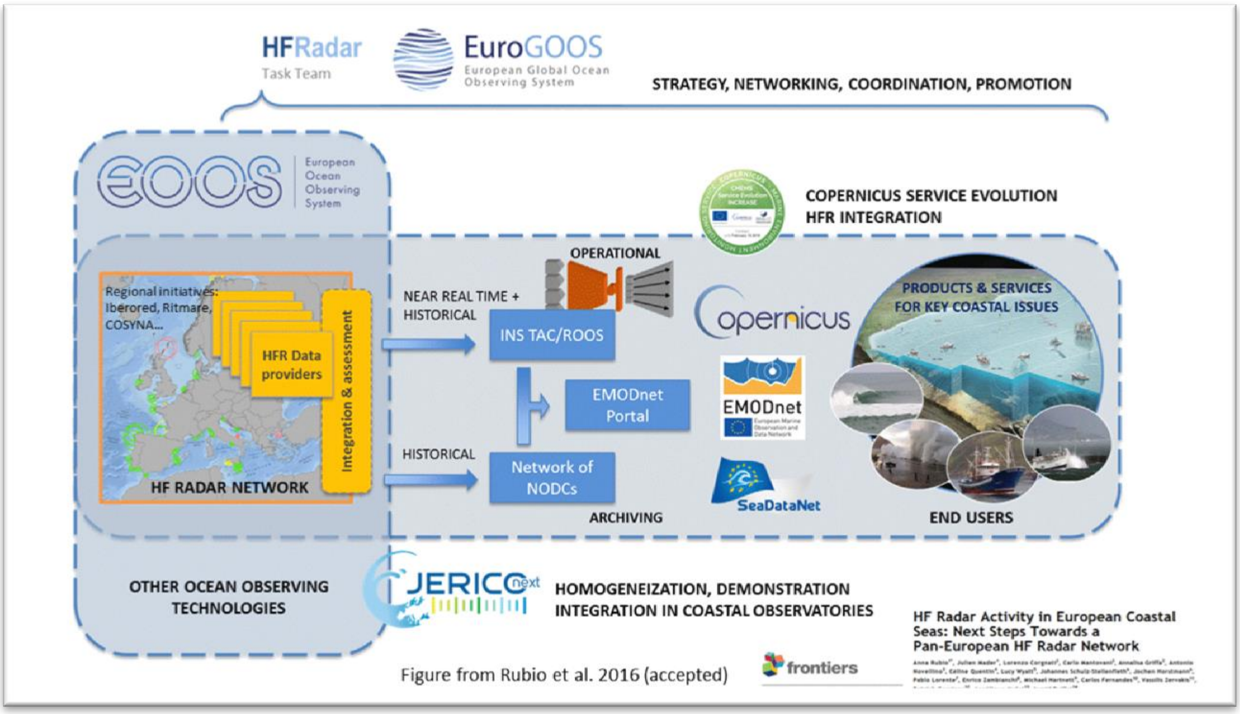
6 Miscellaneous

6.1 INCREASE HF radar experts workshop: Attendants list

NAME	INSTITUTION
Simone Cosoli	ACORN (Australian COastal Radar Network)
Julien Mader	AZTI
Anna Rubio	AZTI
Jose Luis Asensio	AZTI
Angélique Melet	CMEMS / Mercator Océan
Bruno Levier	CMEMS / Mercator Océan
Loic Petit De La Villeon	CMEMS instac / IFREMER
Stéphane Tarot	CMEMS instac / IFREMER
Carlo Brandini	CNR Ibimet & LaMMA Consortium
Carlo Mantovani	CNR-ISMAR
Lorenzo Corgnati	CNR-ISMAR
Annalisa Griffa	CNR-ISMAR
Maristella Berta	CNR-ISMAR
Marcello Magaldi	CNR-ISMAR
Roberta Sciascia	CNR-ISMAR
Laura Barbieri	CNR-ISMAR
Stefano Taddei	Consorzio LaMMA - Laboratorio di Monitoraggio e Modellistica Ambientale per lo sviluppo sostenibile
Lohitzune Solabarrieta	DeustoTech
Enrico Zambianchi	DiST, Università Parthenope and CoNISMa
Pierpaolo Falco	Dpt. Science and Technology, University of Naples "Parthenope
Marco Uttieri	Dpt. Science and Technology, University of Naples "Parthenope"
Antonio Novellino	ETT
Marco Alba	ETT
Patrick Gorringe	EuroGOOS
Leif Petersen	Helzel/WERA
Johannes Schultz-stellenfleth	HZG
Jochen Horstmann	HZG
Alejandro Orfila	IMEDEA
Carlos Fernandes	Insituto Hidrografico
Maurizio Demarte	Italian Hydrographic Office
Marta Pratellesi	Italian Hydrographic Office
Cosmo Peluso	Italian Hydrographic Office
Céline Quentin	MIO
Michael Hartnett	National University of Ireland
Vlado Malacic	NIB
Branko Cermelj	NIB
Pablo Lorente	Puertos del Estado
Andrés Alonso-Martirena	Qualitas/CODAR
Jorge Sánchez	Qualitas/CODAR
Pia Andersson	SMHI
Emma Reyes	SOCIB
Adam Gauci	University of Malta (CALYPSO)
Giuseppe Ciraolo	University of Palermo (CALYPSO)
Fulvio Capodici	University of Palermo (CALYPSO)
Lucy Wyatt	University of Sheffield
Jeff Paduan	USA/IOOS, NPS
Mark Otero	USA/IOOS, Scripps

6.2 Slides presented in the GEO Global Meeting and Renhfor project meeting



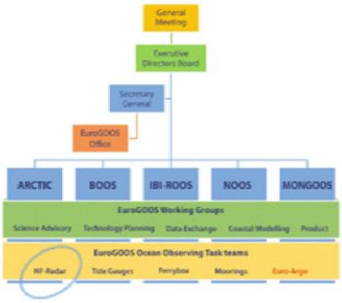


Context: the European HFR community

The HF radar Task Team

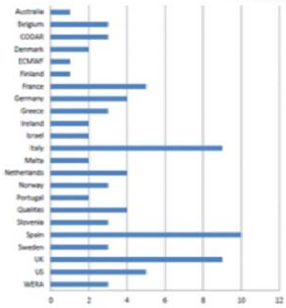
HFRadar Task Team

EuroGOOS European Global Ocean Observing System



HFR TASK TEAM
Chair: Julien Mader (AZTI)
Core group (2013): Antonio Novellino (ETT), Annalisa Griffa (CNR-ISMAR), Johannes Schulz-Stellenfleth (HZG), Maribel Ruiz (Puertos del Estado), Lucy Wyatt (Univ. Sheffield), Céline Quentin (MIO-Toulon), Anna Rubio (AZTI)...

Number of Individuals on HFR TT Mailing List By Country/Organization/Company

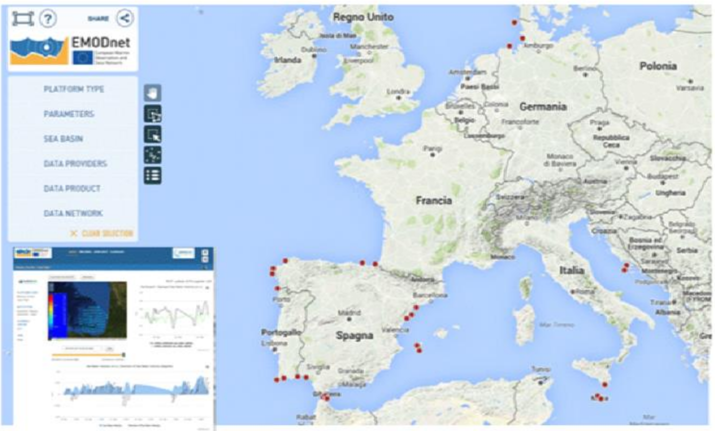


84 individuals from 23 countries represented on the mailing List

EuroGOOS Task Teams are operational networks of observing platforms. They promote scientific synergy and technological collaboration among European observing infrastructures. Task Team members exchange open source tools, collaborate in areas of common interest, and jointly make European data available to the EuroGOOS ROOS regional data portals, which in turn are feeding data to EMODnet and Copernicus Marine Service, CMEMS.

Context: the European HFR community

Successful pilot action for connecting HFR systems with a homogenized THREDDS catalogue (EMODnet Physics framework)



IBIROOS, EMODnet, ETT, intecmar, azti tecnalia, euskalmet, CNR Consiglio Nazionale delle Ricerche, ISMAR Istituto di Scienze Marine, SOCIB, Helmholtz-Zentrum Geesthacht, Puertos del Estado, CALYPSO, University of Malta, Institut za oceanografiju i ribarstvo Split

Context: the European HFR community

Sea Data Net – Sea Data Cloud

HFR SeaDataCloud subtask

SeaDataNet

Integration of the HFR historical data into the SeaDataNet architecture:

- definition of standard interoperable data and CDI derived metadata formats for historical radial and total velocity data

- definition of QC standard procedures for historical radial and total velocity data, with particular focus on data versioning

- design and implementation of an open tool (to be run on the cloud architecture) for the conversion of native HF radar data (both radial and total velocity data) into the standard data and metadata formats and for the production of related CDIs

- implementation of prototype data access services for HF radar (e.g. OGC) in coordination with CMEMS

Task to be performed by the joint collaboration CNR-ISMAR and CNR-ISAC

HF RADAR ACTIVITIES in JERICO_NEXT

JERICO next | Home | Project Information | TNA | News | Events | Virtual Access | Data Access | Contact | Previous FP7 Project

HF Radar activities

WP2: Harmonisation of technologies and methodologies: technical strategy (NA)

Task 2.3: Harmonizing new network systems

Objective: *Integrating HF-radar systems and cabled coastal observatories*

WP3. JRA1- Innovations in Technology and Methodology

Objective: *To improve the quality of current estimates and to integrate the surface information from HF radar with vertical information from the other components of the coastal observing system to improve 4D transport estimates.*

Task 3.2 Developments on current observations from HF radars

WP4. JRA2- JERICO Valorisation through applied joint research

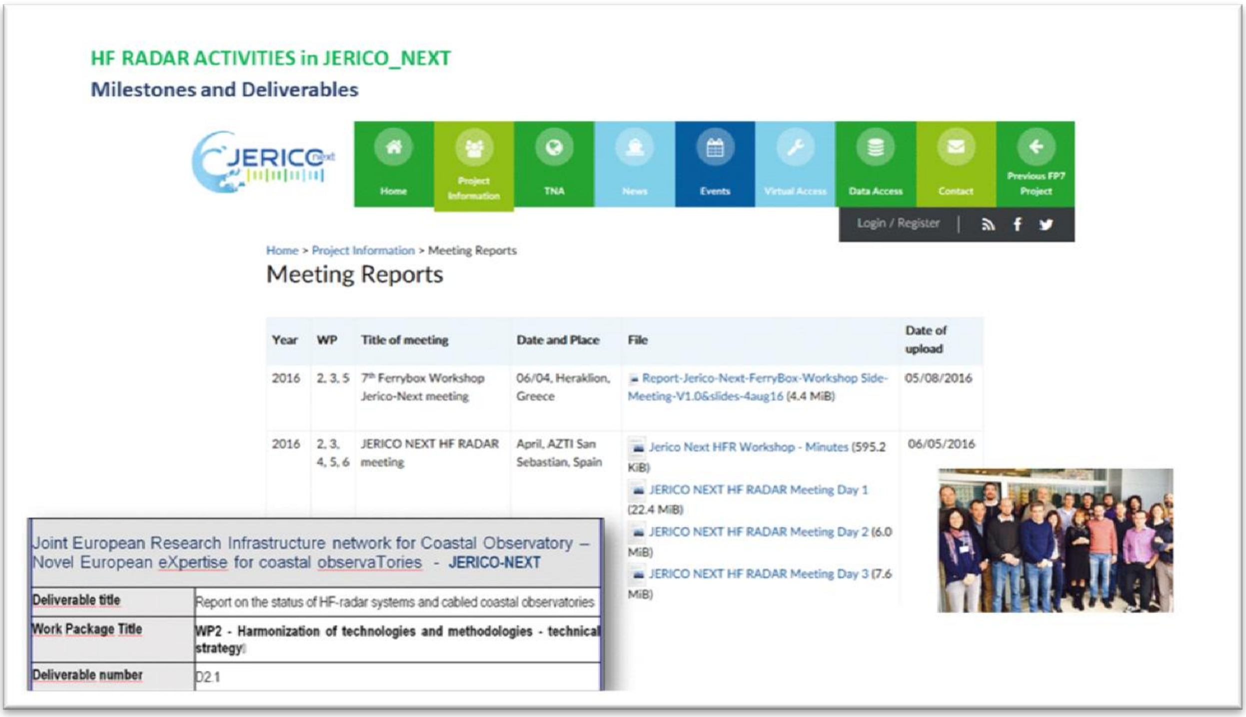
Task 4.4: JRAP #4 (hydrography): 4D characterization of trans-boundary hydrography and transport

WP5: Data management

Task 5.5: Coordinated implementation of Quality Assessment and Quality Control procedures for HF Radar data access

WP6: Virtual access

Objective: *To provide free of charge "virtual access" to data and information that will enable scientists to carry out high quality research using data from a variety of coastal observation systems*



HF RADAR ACTIVITIES in JERICO_NEXT
Milestones and Deliverables
JERICO next
Home
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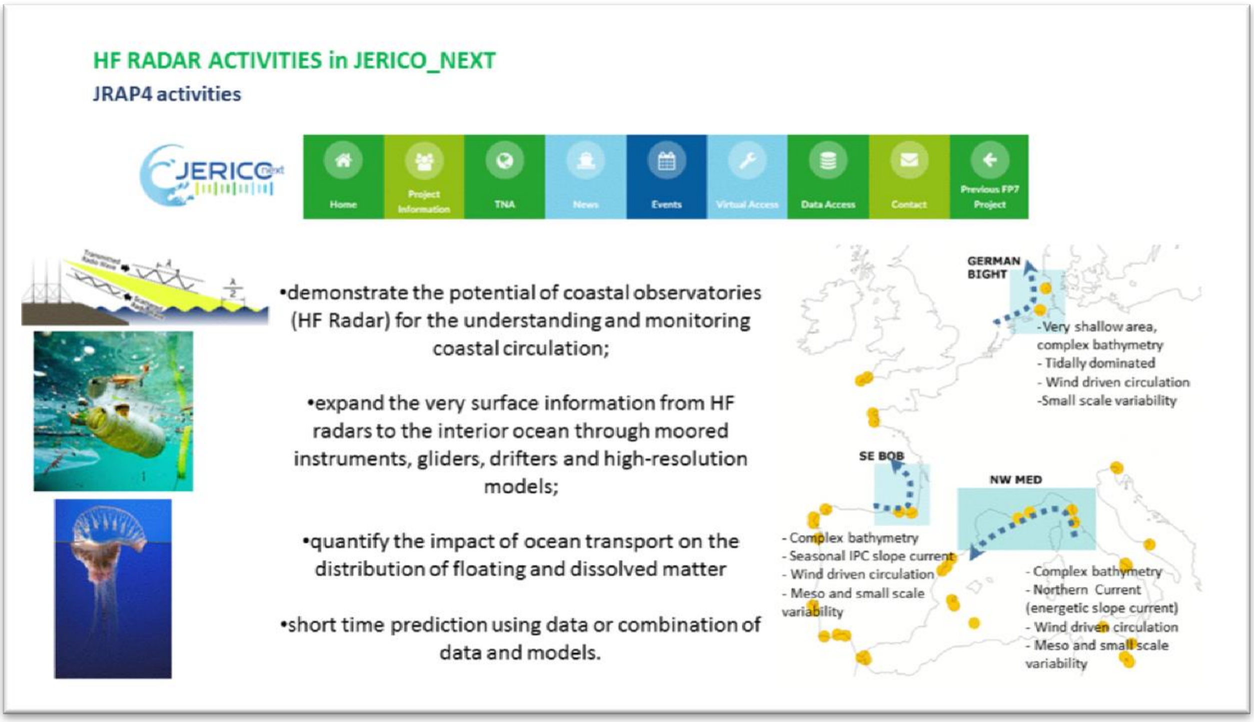
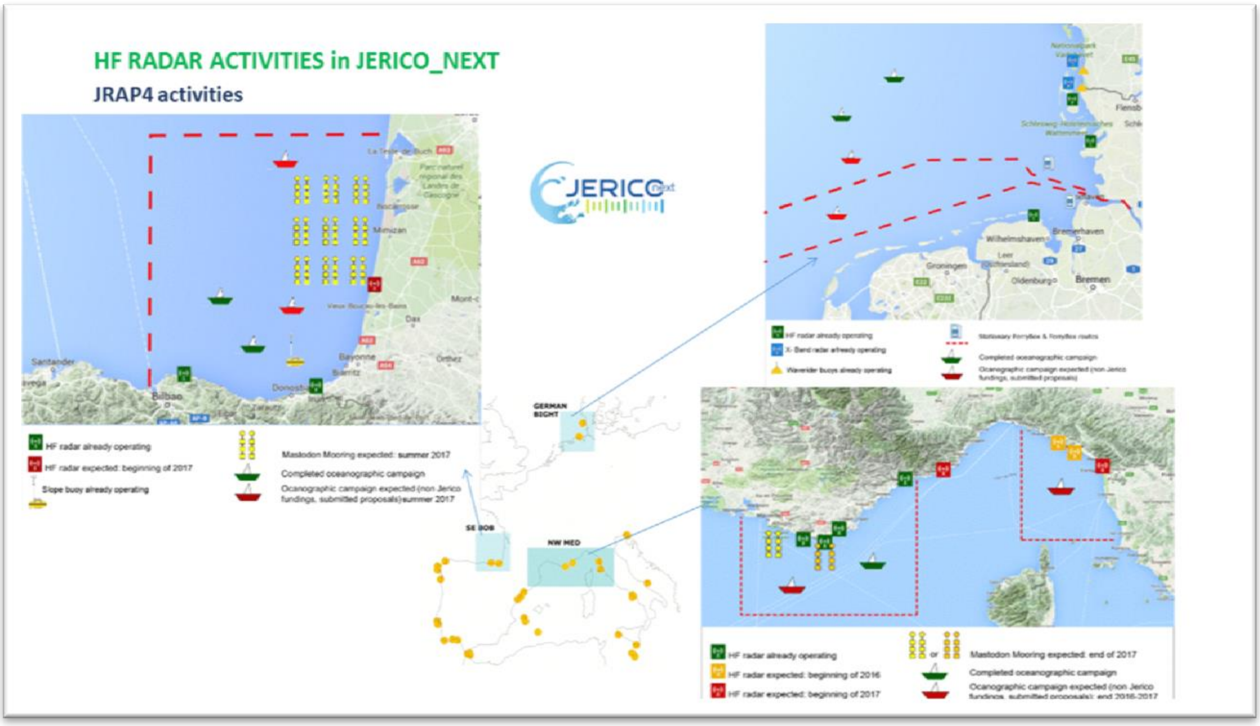
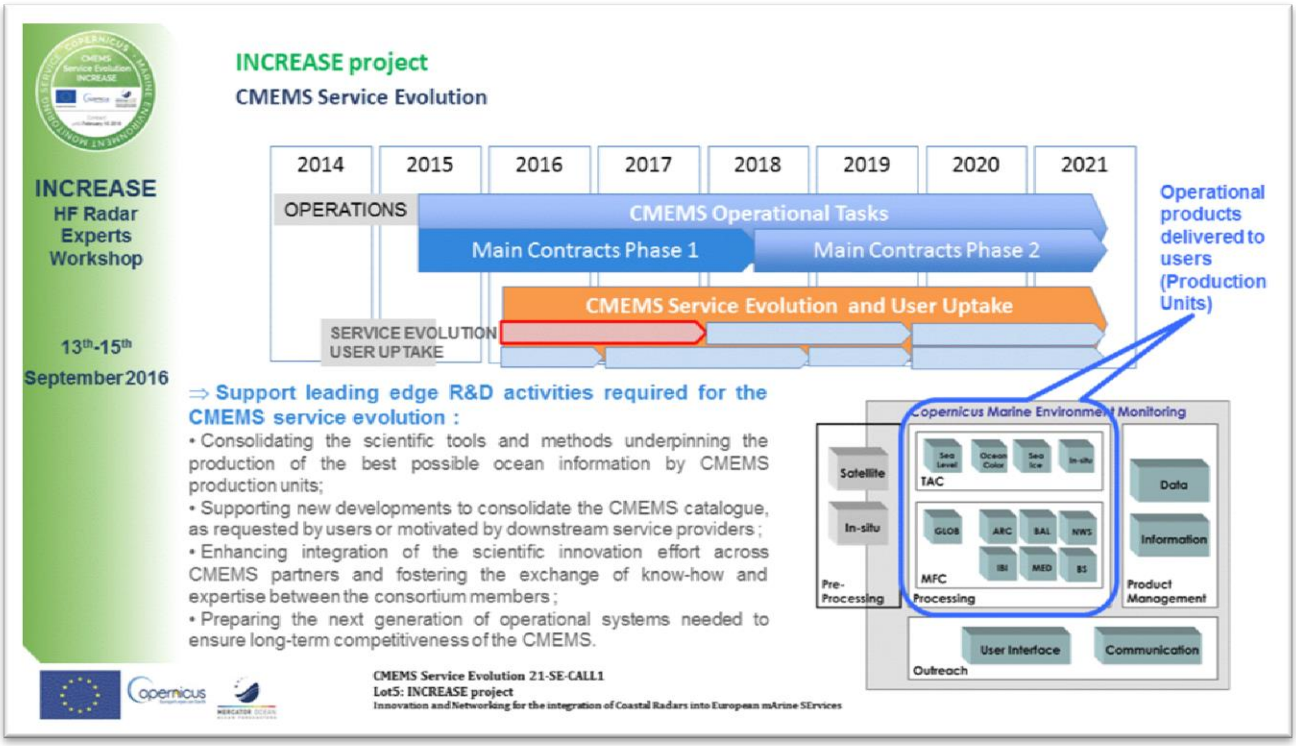
Events
Virtual Access
Data Access
Contact
Previous FP7 Project
Login / Register
Home > Project Information > Meeting Reports
Meeting Reports
Year | WP | Title of meeting | Date and Place | File | Date of upload
2016 | 2, 3, 5 | 7th Ferrybox Workshop Jerico-Next meeting | 06/04, Heraklion, Greece | Report-Jerico-Next-FerryBox-Workshop Side-Meeting-V1.0&slides-4aug16 (4.4 MiB) | 05/08/2016
2016 | 2, 3, 4, 5, 6 | JERICO NEXT HF RADAR meeting | April, AZTI San Sebastian, Spain | Jerico Next HFR Workshop - Minutes (595.2 KiB) JERICO NEXT HF RADAR Meeting Day 1 (22.4 MiB) JERICO NEXT HF RADAR Meeting Day 2 (6.0 MiB) JERICO NEXT HF RADAR Meeting Day 3 (7.6 MiB) | 06/05/2016
Joint European Research Infrastructure network for Coastal Observatory – Novel European eXpertise for coastal observaTories - JERICO-NEXT
Deliverable title | Report on the status of HF-radar systems and cabled coastal observatories
Work Package Title | WP2 - Harmonization of technologies and methodologies - technical strategy
Deliverable number | D2.1



HF RADAR ACTIVITIES in JERICO_NEXT
JRAP4 activities
JERICO next
Home
Project Information
TNA
News
Events
Virtual Access
Data Access
Contact
Previous FP7 Project
•demonstrate the potential of coastal observatories (HF Radar) for the understanding and monitoring coastal circulation;
•expand the very surface information from HF radars to the interior ocean through moored instruments, gliders, drifters and high-resolution models;
•quantify the impact of ocean transport on the distribution of floating and dissolved matter
•short time prediction using data or combination of data and models.
GERMAN BIGHT
-Very shallow area, complex bathymetry
- Tidally dominated
- Wind driven circulation
-Small scale variability
SE BOB
- Complex bathymetry
- Seasonal IPC slope current
- Wind driven circulation
- Meso and small scale variability
NW MED
- Complex bathymetry
- Northern Current (energetic slope current)
- Wind driven circulation
- Meso and small scale variability

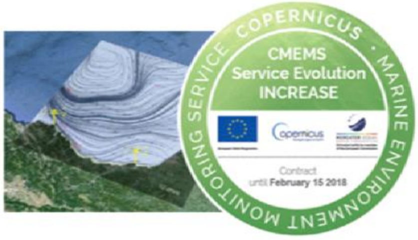

HF RADAR ACTIVITIES in JERICO_NEXT
JRAP4 activities
JERICO next
HF radar already operating
HF radar expected: beginning of 2017
Slope buoy already operating
Mastodon Mooring expected: summer 2017
Completed oceanographic campaign
Oceanographic campaign expected (non Jerico fundings, submitted proposals) summer 2017
GERMAN BIGHT
SE BOB
NW MED
HF radar already operating
HF radar expected: beginning of 2016
HF radar expected: beginning of 2017
Mastodon Mooring expected: end of 2017
Completed oceanographic campaign


INCREASE project
CMEMS Service Evolution
INCREASE
HF Radar
Experts
Workshop
13th-15th
September 2016
2014
2015
2016
2017
2018
2019
2020
2021
OPERATIONS
CMEMS Operational Tasks
Main Contracts Phase 1
Main Contracts Phase 2
CMEMS Service Evolution and User Uptake
SERVICE EVOLUTION
USER UPTAKE
Operational products delivered to users (Production Units)
⇒ Support leading edge R&D activities required for the CMEMS service evolution :
• Consolidating the scientific tools and methods underpinning the production of the best possible ocean information by CMEMS production units;
• Supporting new developments to consolidate the CMEMS catalogue, as requested by users or motivated by downstream service providers;
• Enhancing integration of the scientific innovation effort across CMEMS partners and fostering the exchange of know-how and expertise between the consortium members;
• Preparing the next generation of operational systems needed to ensure long-term competitiveness of the CMEMS.
Copernicus Marine Environment Monitoring
Satellite
In-situ
Pre-Processing
TAC
MFC
Processing
Data
Information
Product Management
User Interface
Communication
Outreach
CMEMS Service Evolution 21-SE-CALL1
Lot5: INCREASE project
Innovation and Networking for the integration of Coastal Radars into European mArine SErvices

INCREASE project

Mar2016-Feb2018 (CMEMS service Evolution Lot5)

Innovation and Networking for the integration of Coastal Radars into European mArine SErvices



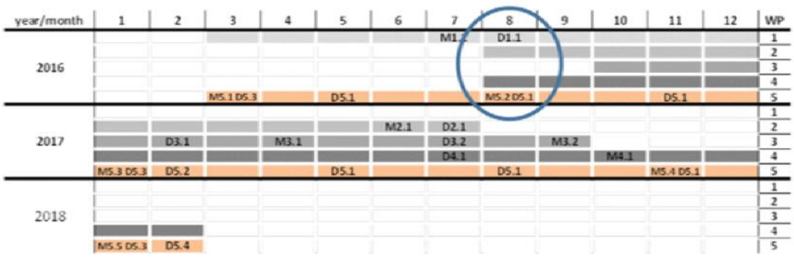
INCREASE aims to set the necessary developments for the integration of the existing European HFR operational systems into the CMEMS, following four main objectives:

- ❑ Provide <u>HFR quality controlled real-time surface current data for direct use and through key derived products</u> (gap-filled data, filtered data, short-term prediction and derived Lagrangian products)
- ❑ Set the <u>basis for the management of historical data and methodologies for reprocessing existing data sets</u>, using advanced delayed mode quality-control techniques, to obtain the best possible continuous surface coastal ocean observations
- ❑ <u>Boost the use of HFR data for improving CMEMS numerical modeling systems</u>, through validation, model-data blending and data assimilation.
- ❑ <u>Enable an HFR European operational node to ensure the operational availability of HFR data</u> and data products and the link with operational CMEMS

INCREASE project

Main Work Lines and Milestones

WP1: Towards the integration of HFR observing technology into CMEMS M1.1; <u>D1.1: Report on European HFR systems development and roadmap for HFR products evolutions in compliance with CMEMS needs</u>
WP2: Basis for HFR data assimilation into CMEMS models; M2.1; D2.1 :Guidelines towards increasing HFR data assimilation capacities into CMEMS
WP3: HFR Products development; M3.1-2: Basic and advanced products v0 are ready;D3.1: Protocols on QA best practices, QC for radial and total data ; D3.2: Tool for interoperable radial and total data production, tool for combination of radial data with different spatial resolutions
WP4: HFR Node; M4.1: HFR Node working infrastructure; D4.1: Recommendation and guideline to set up the hardware and software tools to provide HFR data to the HFR Node
WP5: Coordination;M5.1:Online KOM; M5.2: HFR expert WS; M5.3+5: Mid-term /final review meeting CMEMS (MFC+TAC);M5.4: Implementation expert users WS (CMEMS users);D5.1-4 :Reports, minutes



INCREASE HFR EXPERTS WORKSHOP

4. Workshop objectives

INCREASE HF Radar Experts Workshop

13th-15th September 2016

INCREASE HF Radar Experts Workshop
Sep 13-15, La Spezia

Objectives :

To report on European HFR systems development and roadmap for HFR products evolution in compliance with CMEMS needs:

- To make a diagnostic of the present development of European HFR systems (existing systems, operators, existing products)
- To review and set methodologies for basic and advanced HFR derived products
- To review CMEMS needs and objectives and how HF Radars can fit into them
- To design a roadmap for the establishment of a European HFR network

https://azti.box.com/v/EuroGOOSHFRTTINCREASEexpWS

47 people

NAME	INSTITUTION
Simone Cosoli	ACORN (Australian COastal Radar Network)
Julien Mader	AZTI
Anna Rubio	AZTI
Jose Luis Asensio	AZTI
Angélique Melet	CMEMS / Mercator Océan
Bruno Levier	CMEMS / Mercator Océan
Loic Petit De La Villeon	CMEMS instac / IFREMER
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Lorenzo Corgnati	CNR-ISMAR
Annalisa Griffa	CNR-ISMAR
Maristella Berta	CNR-ISMAR
Marcello Magaldi	CNR-ISMAR
Roberta Sciascia	CNR-ISMAR
Laura Barbieri	CNR-ISMAR
Stefano Taddei	Consorzio LaMMA - Laboratorio di Monitoraggio e Modellistica Ambientale per lo sviluppo sostenibile
Lohitzune Solabarrieta	DeustoTech
Enrico Zambianchi	DIST, Università Parthenope and CoNISMa
Pierpaolo Falco	Dpt. Science and Technology, University of Naples "Parthenope
Marco Uttieri	Dpt. Science and Technology, University of Naples "Parthenope"
Antonio Novellino	ETT
Marco Alba	ETT
Patrick Gorringe	EuroGOOS
Leif Petersen	Helzel/WERA
Johannes Schultz-stellenfleth	HZG
Jochen Horstmann	HZG
Alejandro Orfila	IMEDEA
Carlos Fernandes	Insituto Hidrografico
Maurizio Demarte	Italian Hydrographic Office
Marta Pratellesi	Italian Hydrographic Office
Cosmo Peluso	Italian Hydrographic Office
Céline Quentin	MIO
Michael Hartnett	National University of Ireland
Vlado Malacic	NIB
Branko Cermelj	NIB
Pablo Lorente	Puertos del Estado
Andrés Alonso-Martirena	Qualitas/CODAR
Jorge Sánchez	Qualitas/CODAR
Pia Andersson	SMHI
Emma Reyes	SOCIB
Adam Gauci	University of Malta (CALYPSO)
Giuseppe Ciraolo	University of Palermo (CALYPSO)
Fulvio Capodici	University of Palermo (CALYPSO)
Lucy Wyatt	University of Sheffield
Jeff Paduan	USA/IOOS, NPS
Mark Otero	USA/IOOS, Scripps

HFRadar Task Team · EuroGOOS · JERICO-NEXT

THE EUROPEAN HFR SURVEY

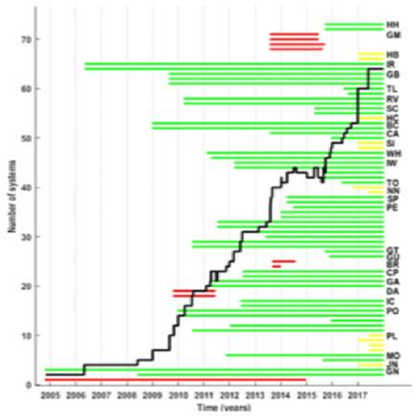
- ✓ 46 questions on four axes: Contact people; Technical information on the network; Technical information about the data formats, sharing protocols and policies, QA/QC and processing ; Areas of application of the data and identified users
- ✓ Launched in June 17th and closed July 27th, gathering responses from 28 EU institutions and more than 70 HFR systems.

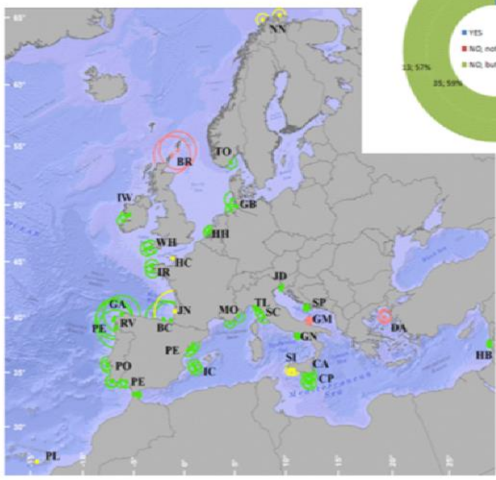
HFR NETWORK	Hook of Holland		German Bight	Gulf of Naples	TirLig	Gulf of Manfredonia	SICOMAR	Calypso	Joe Doe	CALYPSO	SPLIT
COUNTRY	THE NETHERLANDS		GERMANY	ITALY					SLOVENIA	MALTA	CROATIA
OPERATOR	Rijkswaterstaat		Helmholtz-Zentrum Geesthacht	University of Naples	CNR-ISMAR		Consorzio LaMMA - CNR	University of Palermo	National Institute of Biology	University of Malta	Institute of Oceanography and Fisheries
Numbser of SITES	2										
Name of sites	Ter Heijde	Oudd[illegible]									
Sites lat., lon coordinates	52,03 / 4,17	51,82 / 3,88									
Date of 1st deployment	01/10/2015										
Status	Ongoing										
Permanent installation?	yes										
Manufacturer	WERA*										
Type of radar	PA										
Temporal resolution (minutes)											
Spatial resolution of total velocity grid (m)											
Tansmit Fequency (MHz)	16,1										
Tansmit Bandwidth (KHz)	150										

HFR NETWORK	IBIZA CHANEL		DELTA DEL EBRO		ESTRECHO DE GIBRALTAR	GOLFO DE CÁDIZ	GALICIA	Ría de Vigo	Basque Country	National HF Network
COUNTRY	SPAIN									PORTUGAL
OPERATOR	SOCIB				Puertos del Estado		INTECMAR	University	AZTI	Instituto Hidrografico
Numbser of SITES	2									
Name of sites	FORM	GALF	SALOU	AL[illegible]						
Sites lat., lon coordinates	38,67 / 1,39	38,95 / 1,22	41,06 / 1,17							
Date of 1st deployment	01/06/2012		01/07/2014							
Status	Ongoing		On[illegible]							
Permanent installation?	yes									
Manufacturer	CODAR		CO[illegible]							
Type of radar	DF									
Temporal resolution (minutes)	60									
Spatial resolution of total velocity grid (m)	3000		3[illegible]							
Tansmit Fequency (MHz)	13,5		13,5							
Tansmit Bandwidth (KHz)	90,069		90							

HFR NETWORK	MOOSE HF radar			Iroise		Torungen	Wave Hub HF Radar		BRAHAN		Ireland West Coast_Radars			
COUNTRY	FRANCE					NORWAY	UK				IRELAND			
OPERATOR	MIO, AMU-CNRS-IRD-UTLN			SHOM		Norwegian Meteorological Institute	Plymouth University		Marine Scotland Science		National University of Ireland			
Numbser of SITES	3			2		1	2		2		4			
Name of sites	Vila real de Santo António	ANTARES	DYFAMED	Pointe de Garchine	Pointe de Brézellec	Torungen	Pendeen	Perranporth	SUMB	NRON	Mutton Island	Spiddle	Inish Oirr	Loop Head
Sites lat , lon coordinates	37,18 / -7,44	42,95 / 6,00	43,50 / 7,25	48,50 / -4,78	48,07 / -4,66	58,40 / 8,79	50,16 / -5,67	50,34 / -5,18	59,85 / -1,28	59,39 / -2,38	53,25 / 9,05	53,24 / 9,30	53,06 / 9,52	52,56 / 9,92
Date of 1st deployment	01/08/2010	15/11/2011	01/09/2015	01/05/2006		25/05/2016	01/02/2011 and 01/04/2011		01/09/2013		01/03/2012		01/09/2015	
Status	Ongoing	Ongoing	Ongoing	Ongoing		Ongoing	Ongoing		Ended on 09/08/2014	Ended on 09/01/2014	Ongoing			
Permanent installation?	yes	yes	yes	yes		yes	no		no		yes			
Manufacturer	CODAR	WERA*	CODAR	WERA		CODAR	WERA*		CODAR		CODAR			
Type of radar	DF	DF on 8 receiving antenna	DF	PA		DF	PA		DF		DF			
Temporal resolution (minutes)	60	60	90	10		60	60		60		60			
Spatial resolution of total velocity grid (m)	1500	3000	0	2000			1000		5000		300		2000	
Tansmit Fequency (MHz)	12,4698	16,175	13,45	12,4		13,5	12		4,5		25		13,5	
Tansmit Bandwidth (KHz)	99,259	50	50	100		75	350	375	36,8		500		49,6	

THE EUROPEAN HFR SURVEY





Number of connected networks/sites

REFERENCES:

- Mader et al. (2016). The European HF Radar Inventory, EuroGOOS publications (Available at http://eurogoos.eu/download/publications/EU_HFRadar_inventory.pdf)
- Rubio et al. (ACCEPTED) **HF Radar Activity in European Coastal Seas: Next Steps Towards a Pan-European HF Radar Network. Frontiers in Marine Science**
- Joint Efforts Towards European HF Radar Integration-https://agu.confex.com/agu/fm16/meetingapp.cgi/Paper/174583

DATA INTEROPERABILITY: STANDARD FOR DATA AND METADATA (L. Corgnati CNR-ISMAR)

DATA FORMAT

Double production:
- **netCDF 4** as standard
- **netCDF 3** for CMEMS real-time data ingestion

METADATA STRUCTURE

- **CF-1.6** compliancy (mandatory)
- **OceanSites** compliancy for CMEMS real-time data ingestion (mandatory)
- **INSPIRE** compliancy (recommended)

QC FLAGGING SCHEME

- **IODE** scheme

QC TESTS

Radial data:
- **Syntax**
- **Over water**
- **Variance threshold**
- **Velocity threshold**

Total data:
- **Data density threshold**
- **Balanced contributing radials**
- **GDOP threshold**
- **Variance threshold**

	Mar 2016	Jun 2016	Sep 2016	Dec 2016	Mar 2017	June 2017
Data format						
Metadata structure						
QC flagging scheme						
QC tests						