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THE EUROGOOS HIGH FREQUENCY RADAR TASK TEAM: A SUCCESS STORY OF COLLABORATION. TO BE KEPT ALIVE AND MADE GROWING

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Abstract

High Frequency Radar (HFR) is the unique land-based remote sensing technology capable to map ocean surface currents and waves over wide coverages with high spatial and temporal resolution. HFR gained relevance in the integrated management of coastal zones and thus rapidly expanded in Europe (7 new systems per year since 2016), with over 68 sites currently running and 15 in the planning stage. In 2015, EuroGOOS launched the HFR Task Team (HFR-TT) with the aim of promoting HFR in Europe. This was the cornerstone of a fruitful and still ongoing path towards the coordinated development of HFR technology and the full exploitation of its potential. In fact, many initiatives in Europe followed up, aiming at building an operational HFR European network based on coordinated data management. The HFR-TT actions played an important role in the growth of operational installations in Europe, which were up to then managed in research-specific contexts and without a strong identity in the marine observation landscape. The achievements are promising: (i) the European HFR community took shape, (ii) a European operational HFR Node, best practices and operational tools were created for the production and distribution of standardized and quality-controlled data, and (iii) HFR data have been included in the main marine data portals (CMEMS-*In situ* TAC, SeaDataNet and EMODnet Physics). The European HFR Node was established in 2018 by AZTI, CNR-ISMAR and SOCIB, coordinated by the EuroGOOS HFR-TT, as the focal point in Europe for HFR data management and distribution, also ensuring the connection with the Global HFR network. The Node is fully operational since December 2018 and is now managing data from 15 European HFR networks and integrates and delivers US HFR network data.

Keywords: High Frequency Radar, HFR Task Team, HFR network, interoperability, Quality Control, ocean current, coastal observing system, European HFR Node, operational oceanography

1. Introduction

High Frequency Radar (HFR) is a land-based remote sensing technology (Crombie, 1955; Barrick *et al.*, 1977; Paduan and Washburn, 2013, Corgnati *et al.*, 2019a) capable of mapping coastal ocean surface currents (Paduan and Rosenfeld, 1996; Gurgel *et al.*, 1999), wave field parameters (Barrick, 1977; Wyatt, 1990; Gurgel *et al.*, 2006) and wind direction (Heron and Rose, 1986; Shen *et al.*, 2012; Kirincich, 2016) over wide areas (reaching distances from the coast of over 200 km) with high spatial (a few kms or higher) and temporal resolution (hourly or higher). Thanks to this unique insight to coastal ocean variability, HFRs became invaluable assets in the field of operational oceanography and offer an unprecedented potential for the integrated management of coastal zones, with direct applications in different sectors, such as Search and Rescue (Ullman *et al.*, 2006), monitoring of pollutants and biological quantities (Abascal *et al.*, 2009; Sciascia *et al.*, 2018), tsunami early warning (Lipa *et al.*, 2006; Gurgel *et al.*, 2011), marine traffic management (Breivik and Saetra, 2001), ship detection and tracking (Ponsford *et al.*, 2001; Maresca *et al.*, 2014). Moreover, HFR surface current data start to be systematically ingested in data assimilation processes necessary for predictive model adjustment (Paduan and Shulman, 2004; Barth *et al.*, 2008). The relevance of its applications made the HFR technology rapidly expanding in Europe (at a rate of 7 new systems per year since 2016), with over 69 HFR sites currently operating and 15 in the planning stage, as shown in Figure 1. A detailed review of the European and Global networks and HFR applications was provided in Rubio *et al.*, (2017) and Roarty *et al.*, (2019).

2. The EuroGOOS HFR Task team Effort

Since the HFR systems are playing an increasing role in the marine services, the coordinated development of the European HFR network and its products is essential to ensure the full exploitation of HFR potential within the European coastal operational oceanography and to guarantee the distribution of high quality HFR data for scientific, operational and societal applications.

Aiming at this ambitious goal, in 2015 EuroGOOS launched the HFR Task Team to coordinate community building of the European HFR networks, while promoting scientific synergy and technological collaboration among European ocean observing infrastructures. The roadmap towards a pan-European HFR network was based on: (i) networking activities; (ii) HFR data standardization, by ensuring data availability in standard interoperable formats; (iii) HFR standard data integration in the main marine data portals; (iv) development of specific advanced products and tailored services based on HFR data; (v) engagement of end-users; (vi) provision and promotion of operational tools, assessment metrics and methodologies.

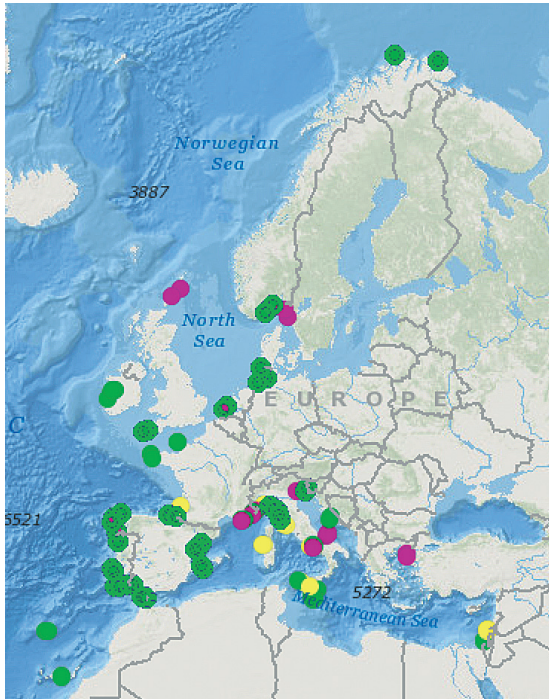


Fig. 4. Distribution of HFR systems in Europe. The operational systems are plotted in green, future installations in yellow and past deployments in purple. Source: <https://eurogoos.eu/high-frequency-radar-task-team/>

This first step proved to be very fruitful and followed up in many initiatives in Europe. In 2015, a pilot action coordinated by EMODnet Physics, started a strategy for assembling HFR metadata and data products within Europe in a uniform way to make them easily accessible, and more interoperable. The EU H2020 project JERICO-NEXT, launched in 2015, provided procedures and methodologies to enable HFR data to comply with the international standards regarding quality and metadata, within the overall goal of integrating the European coastal observatories. In 2016, the EU H2020 project SeaDataCloud (SDC) started contributing to the integration and long-term preservation of historical time series from HFR into the SeaDataNet infrastructure, by defining standard interoperable data and Common Data Index (CDI) derived metadata formats and Quality Control (QC) standard procedures for historical data (Cognati et al., 2019b). In the same year, the Copernicus Marine Environment Monitoring Service (CMEMS) Service Evolution Call supported the INCREASE project, which set the bases for the integration of existing European HFR operational systems into the CMEMS-INSTAC (*In situ* Thematic Assembly Center). At present, the EU H2020 projects JERICO-S3 and EuroSea are continuing these efforts for further expanding the network harmonization as well as the network integration and improvement, respectively.

Indeed, these integrated efforts boosted the European HFR network and enabled the harmonization of system requirements and design, data quality and standardization of

HFR data access and tools (Mantovani *et al.*, 2020). The European common data and metadata model for real-time surface current HFR data was defined and implemented (Corgnati *et al.*, 2018), compliant with Climate and Forecast Metadata Convention version 1.6 (CF-1.6), OceanSITES convention, CMEMS-*In situ* TAC requirements and INSPIRE directive. The list of the QC tests to be applied to HFR data was defined according to the DATAMEQ working recommendations on real-time QC and building on the Quality Assurance/Quality Control of Real-Time Oceanographic Data (QARTOD) manual produced by the US Integrated Ocean Observing System (IOOS).

Finally, the inclusion of HFR data into CMEMS-*In situ* TAC (Verbrugge *et al.*, 2020), EMODnet Physics and SDC Data Access (Corgnati *et al.*, 2019b) was decided to ensure the improved management of several related key issues as Marine Safety, Marine Resources, Coastal & Marine Environment, Weather, Climate & Seasonal Forecast, as showcased in many published Use Cases (e.g., <https://marine.copernicus.eu/services/use-cases>).

3. The European HFR Node

CMEMS-*In situ* TAC, EMODnet Physics and SDC operate through a decentralized architecture based on National Oceanographic Data Centres (NODC), Production Units (PUs) organized by region for the global ocean and the six European seas and a Global Distribution Unit (DU). HFR data are *in situ* gridded data in time (big data), therefore the standard *in situ* data management infrastructures must be organized and adapted to allow INSTAC PUs, other CMEMS Thematic Centres (TAC) and Marine Forecasting Centers (MFC) to efficiently manage this type of data. Given the importance of HFR data type and the diversity with the already available data streams and quality check procedures, the implementation of the HFR data stream must come together with the development of a centralized European competence and assembly centre.

To face these challenges, the European HFR Node was established in 2018 by AZTI, CNR-ISMAR and SOCIB, under the coordination of the EuroGOOS HFR Task Team, as the focal point and operational asset in Europe for HFR data management and dissemination, also ensuring the connection with the Global HFR network. The mission of the Node is: (i) to be a data management centre dedicated to link all the available data providers and collect HFR data; (ii) to develop and share the software tools for HFR data harmonization, documentation and best practices for HFR operations; (iii) to apply data processing, both in real time and delayed mode, and create catalogs of HFR data compliant with the requirements of CMEMS-*In situ* TAC, EMODnet Physics and SDC. Its implementation is based on a hierarchical infrastructure to facilitate management and integration of any potential data provider according to a simple and highly effective rule: if the data provider can set up the data flow according to the defined standards, the HFR central node only checks and distributes the data. If the data centre cannot setup the data flow (because of lack of experience, technical capacity, etc.), the HFR node harvests the data from the provider, harmonizes and

formats these data and makes them available. In fact, the architecture of the Node is based on a centralized database, fed and updated by the providers (supported by the Node) via a webform (<http://150.145.136.36>). The database contains updated metadata of the HFR networks and the needed information for processing/archiving the data. The guidelines on how to set the data flow from HFR providers to the EU HFR Node are thoroughly described in Reyes et al., (2019).

The EU HFR Node became fully operational in December 2018 by providing tools and support for standardization to the HFR operators and in distributing standardized and quality-controlled Near Real Time (NRT) and delayed-mode HFR radial and total current data towards the major European Marine Data Portals. In the European framework, the EU HFR Node is now managing data from 12 HFR networks (built of 42 HFR sites, representing almost 40% of the European Network), as shown in Figure 2, belonging to 8 countries included in 3 different ROOSes (i.e., MONGOOS, NOOS and IBIROOS), from two diverse HFR system types (i.e., Direction Finding and Phased Array), being most of them permanent installations. By end 2021, it is expected to manage 20 networks (i.e., 50 HFR sites). Additionally, the EU HFR Node implements since June 2020 the integration and distribution of Global data on the aforementioned platforms, using the US network as a pilot case (see Figure 2).

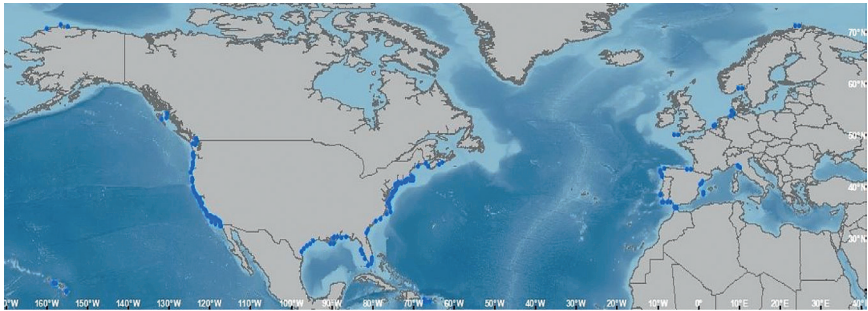


Fig. 4. Distribution of HFR systems managed by the European HFR Node.

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