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1. Executive Summary

The JERICO network is constantly working to improve its core functionality, which is the ability to provide comprehensive observations of Europe's coastal seas and oceans. This means integrating new, promising observing technologies that can expand its spatial and temporal reach. This effort must include a specific data management fully committed to inform end-users and stakeholders about the quality and reliability of the data routinely delivered. While building the JERICO-Next project, High Frequency Radar (HFR) systems were identified as particularly attractive technology to complete the JERICO network. HFR technology offers the means to gather information on surface currents and sea state over wide areas with relative ease in terms of technical effort, manpower and costs.

HFR technology is rapidly expanding in Europe, as it is increasingly used to support decision-making by coastal ocean users and managers, and its current and wave data will be operationally distributed by the main data distribution services, i.e. Copernicus Marine In Situ Thematic Assembly Center (In Situ TAC), EMODnet Physics and SeaDataCloud (SDC). Moreover, in the next years it is expected that HFR surface current data will be systematically ingested in data assimilation processes necessary for predictive model adjustment. Thus, the unified implementation and coordination are needed for producing interoperable and high quality HFR data for scientific and societal applications.

Task 5.6 of JERICO-Next project deals specifically with defining common formats and Quality Control (QC) procedures for HFR data. A common data and metadata model and QC test battery for Near Real Time (NRT) current data from HFR were defined and implemented to ensure efficient and automated data discovery and interoperability across distributed and heterogeneous earth science data systems.

A first recommendation at European level to achieve the harmonization of HFR data management was published within JERICO-Next deliverable D5.13 and in the INCREASE deliverable D3.1 (http://www.cmems-increase.eu/static/INCREASE_Report_D3.1.pdf), defining data format, metadata structure, QC flagging scheme and QC tests.

The data model and the basic set of QC tests defined in JERICO-Next D5.13 and recovered in Copernicus Marine In Situ TAC Service Evolution INCREASE project (deliverable D3.1) have been further analyzed and improved, also in synergy with the work performed in Task 3.2. The work has been performed within an extended group including scientists from the HF radar European community as well as from the US IOOS and the Australian ACORN networks. Additional QC tests with respect to the basic set have been defined and the data model has been refined accordingly, also aiming at the full integration of In Situ TAC and SDC requirements.

This deliverable presents these improved recommendations that have been established taking into account: (1) the characteristics of HFR monitoring, considering that HFR surface current velocity data are somewhat unique in the oceanographic observation world since they are: i) two-dimensional ocean surface measurement; ii) derived from a fixed land-based remote sensor and iii) they are placed on a fixed grid; (2) the existing standards in non-EU networks (in particular in IOOS); (3) the existing standards in Europe for Marine Data Management (EuroGOOS DATAMEQ, EuroGOOS HFR Task Team, Copernicus Marine In Situ TAC, SeaDataNet's NODC network, EMODnet and its thematic portals, JCOMMOPS in-situ Observing Platforms).

2. Introduction

HFR is a unique technology that allows the mapping of ocean surface currents and wave fields (along with other variables) over wide areas with high spatial and temporal resolution. This technology has been applied to many different sectors such as basic and applied research in coastal oceanography and the marine environment, safety and exploitation of the seas (Paduan and Wahsburn, 2013, Rubio et al, 2017, Lorente et al, 2022, Reyes et al, 2022).

Integrated HFR networks providing real-time information with unified quality control have been operating in the United States (US-IOOS, http://www.ioos.noaa.gov/hfradar/) and in Australia (ACORN, http://www.ees.jcu.edu.au/acorn/), providing key information for scientific and societal needs. In Europe, although some countries have started to implement operational HFR systems in the coastal area, a unified HF coastal radar network has not been implemented yet.

In order to assess the implementation of a distributed system providing a research and operational access to HFR data, Task 5.6 (Definition of Quality Control procedures for HFR data, M1-M42) was planned to define: (i) a standardized data model for different levels of data products for HFR data implementation in European marine data infrastructures; (ii) a standard QC procedure established for the evaluation of delayed-mode and near real time HFR data.

The work in Task 5.6 was performed in close cooperation/contact with other major projects and existing marine data infrastructures dealing with coastal HFR data:

- SeaDataCloud for building historical products for reanalysis purposes and for standard improvements.
- EMODNet-Physics to be interoperable with the EMODNet portal and contribute to unlocking access to private data.
- EuroGOOS: for enhancing link with in situ observing system operators and downstream users (Task Teams and Working Groups) and following general recommendations of EuroGOOS DATAMEQ.
- Copernicus Marine In Situ TAC and the INCREASE (SE[1] 2016 call) project, which aims to the integration of existing European HFR operational systems into the In Situ TAC service and to the promotion of the use of HFR data for improving Copernicus Marine numerical modelling systems.

First recommendations on common HFR data model and QC procedures have been previously summarized in the JERICO-Next deliverable D5.13, which defines the European Common data and metadata model, detailing data format and mandatory QC tests. Also, in the framework of the INCREASE project, deliverable D3.1 reports a sensitivity study on the impact of threshold values for the mandatory QC tests

[1] CMEMS- Service Evolution 21-SE-CALL1

defined within JERICO- Next, with the aim of setting a methodology for the correct application of the tests in different regions.

In order to further refine and improve the standard schemes taking into account new specific issues and the precious experience of the HF radar operators, the HF radar community has kept alive the discussions about these topics in the framework of the JERICO-Next project and of the different ongoing initiatives and projects at European level aiming at being effective in the implementation of the coordinated development of coastal High Frequency Radar technology and its products, with the final goal of establishing the operational HFR European network.

All the discussions and activities have been carried on in strict collaboration with the US colleagues managing the US Integrated Ocean Observing System (IOOS) through the Radiowave Operators Working Group (US ROWG). Also, other important external contributions have been given by other networks, such as the Australian ACORN network. The deliverables D5.13 and INCREASE D3.1 have been shared with this wide international community and a fruitful review about the comparison and analysis of HF radar data and metadata schemes has taken place. Based on the results of this discussion, a set of modifications and improvements have been implemented on the mandatory QC procedures and on the common data model, and they are presented in this document. The core points of the discussions that led to the current improvements are detailed in the JERICO-Next deliverable D3.3.

Based on the QC and data model described in this document, operational tools and services have been developed to automatically ingest and harmonise data coming from different HFR data sources. In this framework, the European High Frequency Radar Node (EU HFR Node, https://www.hfrnode.eu/) was established in 2018 by AZTI, CNR-ISMAR and SOCIB, under the coordination of the EuroGOOS HFR Task Team (http://eurogoos.eu/high-frequency-radar-task-team/), as the focal point and operational asset in Europe for HFR data management and dissemination, also promoting networking between EU infrastructures and the Global HFR network. The EU HFR Node is fully operational since December 2018 in distributing: (i) tools and support for standardization to the HFR providers; (ii) Near Real Time (NRT) and Delayed Mode (DM) datasets of surface current measurements from HFR systems towards the main marine data portals.

The first part of this document (Section 3) provides background information on the present status of JERICO-Next HFRs related to data formats and sharing protocols, and on how JERICO-Next task is encompassed with the present efforts of the European community towards the constitution of a pan-European HFR network. The QC procedures to be applied to HFR data for the delivery of high-quality data are detailed in Section 4, while recommendations on the European Common data and metadata model for real-time HFR data are provided in Section 5. Section 6 is focused on the data model implementation and evolution, by describing the procedures for the data model documentation update, the feedback loop with user and the training, and the means for assessing the successful application of the data model. Finally, conclusions and next steps to implement the HFR data management are presented in the last sections.

3. JERICO-Next networking and international framework

Networking is essential to ensure that the potential of HFRs is fully exploited in the development of operational ocean monitoring systems in Europe. Although HFR is routinely used for real-time monitoring of ocean currents in many places along the European coasts, Europe still needs to develop the infrastructure to coordinate efforts to reach the added-value achieved by other HFR networks (i.e. US network), like: central archiving, homogenized protocols for data distribution, development of standards for quality assurance, control and data structures.

JERICO-Next worked at different levels towards the coordinated development of the coastal HFR technology and its products, in strict collaboration with the different European and international initiatives that are also contributing to this effort: EuroGOOS Ocean Observing HFR Task Team and GEO GLOBAL HFR Task, the INCREASE (CMEMS SE 2016 call) and SeaDataCloud projects and the Copernicus Marine In Situ TAC distribution service, that operationally distributes HFR current NRT data starting from April 2019.

Other existing initiatives are gathering national experts or international expert teams working in common in some regions through the European coasts. The work in progress in Europe is aligned with initiatives at international level, where the Group on Earth Observations (GEO) is coordinating international efforts to build a Global HFR Network for data sharing and delivery and to promote the proliferation of HFRs.

The role of HFR international networks and initiatives

Integrated HFR observatories providing real-time information with unified Quality Assessment and Quality Control standards are operating in the United States as part of the US-IOOS (http://www.ioos.noaa.gov/hfradar) (Harlan et al., 2010) and in Australia within the Australian Coastal Ocean Radar Network (ACORN) (Heron et al., 2008) (http://www.ees.jcu.edu.au/acorn). These networks support agencies for SAR applications and pollution mitigation (Harlan et al., 2011). The HFR networks operating in Asia and Oceania countries were recently censused by the 1st Ocean Radar Conference for Asia (ORCA) (Fujii et al., 2013).

The Group on Earth Observations (GEO) is coordinating international efforts to build a Global HFR Network for data sharing and delivery and to promote the proliferation of HFRs. NOAA (USA), with a small international co-chair group, has taken the lead in building this network and in promoting activities related to this task.

The Global HFR Network is collaborating to increase the numbers of coastal radars; ensure that HFR data is available in a single, standardized format; make/use a set of easy-to-use, standardized products; assimilate the data into ocean and ecosystem modeling; develop emerging uses of HFR.

The EuroGOOS Ocean Observing HFR Task Team

Since 1994, EuroGOOS has been coordinating the development and operation of (European) regional operational systems. Five systems are at present part of EuroGOOS: the Arctic (Arctic ROOS), the Baltic (BOOS), the North West Shelf (NOOS), the Ireland-Biscay-Iberian area (IBI-ROOS) and the Mediterranean (MONGOOS). EuroGOOS also contributes to the Global Ocean System as one GOOS Regional Alliance (GRA) of GOOS and in partnership with JCOMM. These regional assemblies are the key structures in which it is possible to discuss to promote active cooperation at different levels in order to maximize the efficiency of national resources and investments in operational oceanography. This is done via specific and thematic working groups that collect and express the best expertise on specific fields. Recent EU marine data infrastructures and EU Programs are widely based on EuroGOOS and ROOSes achievements.

In 2014, the EuroGOOS Ocean Observing Task Teams were launched to organize and develop different ocean observation communities and foster cooperation to meet the needs of the European Ocean Observing System. In particular, the HFR Task Team was set up to promote coordinated activities in Europe around the development and use of this coastal technology. The purpose of the HFR Task Team is to coordinate and join the technological, scientific and operational HFR communities at European level. The goal of the group is to reach the harmonization of systems requirements, systems design, data quality, improvement and proof of the readiness and standardization of HFR data access and tools.

In 2015, a pilot action coordinated by EMODnet Physics, with the support of the HFR Task Team, begun to develop a strategy of assembling HFR metadata and data products within Europe in a uniform way to make them easily accessible, and more interoperable. Further steps towards a HFR data network are oriented towards contributing to unlocking access to data and to supporting and organizing data sharing under open data policies, following EuroGOOS Data Management, Exchange and Quality (DATAMEQ) Working Group recommendations.

In order to enforce and support the operational ingestion of HFR data into Copernicus Marine In Situ TAC and SDC distribution services, in 2018 the HFR Task Team established the central European HFR node. The node is intended (i) to set up a data assembly center dedicated to link all the available data providers and collect and process HFR data; (ii) to develop and upgrade the software tools for the harmonization of data and metadata of HFR data coming from different sources; (iii) to apply data processing, both in real time and delayed mode, and to create and distribute catalogues of HFR data compliant with the requirements of Copernicus Marine In Situ TAC 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 very effective rule: if the data provider can set up the data flow according to the defined standards, the HFR central node only has to link and include the new catalog and data stream. If the data provider cannot setup the data flow (because of lack of experience, technical capacity, etc.), the HFR node works on harvesting the data from the provider, harmonizing and formatting these data and making them available.

All the software tools needed for the collection, QC and processing of HFR data according to the European QC model and the European data and metadata model presented in this document are freely available (and continuously maintained and updated) at https://github.com/LorenzoCorgnati/

The Copernicus Marine In Situ TAC

The Copernicus Marine In Situ TAC has been designed to respond to issues emerging in the environmental, business and scientific sectors. Using information from both satellite and in situ observations, it provides state-of-the-art analyses and forecasts daily, which offer an unprecedented capability to observe, understand and anticipate marine environment events. The In-Situ TAC was designed and developed on JCOMM and the EuroGOOS ROOSs experience and expertise, which was further developed during the MyOcean projects. MyOcean enabled to run a demonstration pre-operational service for 6 years that is now fully integrated and constituting the In Situ TAC.

The Copernicus Marine Service Evolution Call has supported the Innovation and Networking for the Integration of Coastal Radars into European mArine Services (INCREASE) project. Based on the progress of ongoing initiatives, INCREASE begun the developments necessary for the integration of existing European HFR operational systems into the In Situ TAC and promoted the use of HFR data for improving Copernicus Marine numerical modeling systems.

The INCREASE project provided (1) a review of the current methodology, products definition and bases for elaborating guidelines on the use of HFRs, (2) an updated and extended description of the European HFR network (3) a roadmap for HFR products evolutions in compliance with In Situ TAC needs. In particular, the main project outcomes are: (i) the definition of basic data products, data formats and QA/QC; (ii) the definition of advanced products and applications and (iii) the technical implementation and strategic development toward the operational ingestion of HFR data into In Situ TAC services.

The activities performed during the project have been very valuable to define the standard formats and procedures presented in this deliverable and, most importantly, to ensure that the recommendations that will be provided from JERICO-Next project are in agreement with the needs and expectations of the European HFR community and connected with other relevant international initiatives (GEO Global HFR).

Thanks to the results of the INCREASE project, Copernicus Marine In Situ TAC started to operationally ingesting and distributing HFR NRT current data from April 2019.

The SeaDataNet infrastructure

Another central European institution for ocean and marine data management is SeaDataNet (www.seadatanet.org). The SeaDataNet infrastructure network involves data centers of 35 countries, active in data collection. The networking of these professional data centers, in a unique virtual data management system, provides integrated data sets of standardized quality on-line historical data.

The SeaDataCloud project, launched in 2016, contributed to the integration and long-term preservation of historical time series from HFR into the SeaDataNet infrastructure. The main steps in the HFR SeaDataCloud subtask for the integration of the HFR historical data into the SeaDataNet architecture are: (i) definition of standard interoperable data and Common Data Index (CDI) derived metadata formats for historical radial and total velocity data; (ii) definition of QC standard procedures for historical radial and total velocity data, with particular focus on data versioning; (iii) design and implementation of an open tool (to be run on the cloud architecture) for the conversion of native HFR data (both radial and total velocity data) into the standard data and metadata formats and for the production of related CDIs; and (iv) implementation of prototype data access services for HFR in coordination with Copernicus Marine In Situ TAC.

Specific focus was also given to the definition of a data model for gridded data within the SDC transport formats. In this framework, tasks have been carried on to define a data model that integrates SDC CF extension requirements and In Situ TAC requirements.

The European Marine Observation and Data network: EMODnet

The European Marine Observation and Data network EMODnet was first coined in 2006 as a way to provide a sustainable focus for improving systematic observations (in situ and from space), interoperability and increasing access to data, based on robust, open and generic ICT solutions. The aim has always been to increase productivity in all tasks involving marine data gathering and management, to promote innovation and to reduce uncertainty about the behavior of the sea. EMODnet has been promoted as a key tool to lessen the risks associated with private and public investments in the blue economy, and facilitate more effective protection of the marine environment.

The development of EMODnet is a dynamic process so new data, products and functionality are added regularly while portals are continuously improved to make the service more fit for purpose and user friendly with the help of users and stakeholders. EMODnet Physics is one of the seven thematic lots, operating since 2010, and it is designed to be one access point to near real time and historical data on physical conditions of seas and oceans. EMODnet Physics is developed in cooperation and coordination with EuroGOOS and ROOSes and with other existing (major) European integrators infrastructures (Copernicus Marine and SeaDataNet). In this context, the coordination, integration and cooperation between EMODnet Physics and Copernicus Marine In Situ TAC (former MyOcean) has resulted in a better and stronger involvement of the providers, a continuous improvement of the available in situ data products (more and better data), an involvement of a wider audience (diversification) of intermediate users (easier – different data and product access).

In collaboration and coordination with EuroGOOS and its HFR Task Team, EMODnet Physics proactively worked on HFR data stream management, harmonization and organization and it is now connected and presenting data and data products from more than 30 antennas (http://www.emodnet-physics.eu/map/).

OTHER REGIONAL INITIATIVES

Other initiatives are gathering national or international expert teams working in common in a number of regions along the European coasts. In Italy, the Italian flagship project RITMARE has been focusing its efforts on the integration of the existing local observing systems, toward a unified operational Italian framework and on the harmonization of data collection and data management procedures (Corgnati et al., 2015; Serafino et al., 2012).

In the Iberian Peninsula, the working group IBERORED HF is an inter-institutional network created with the objective of improving the visibility and exploitation of data generated by HFRs on Iberian Peninsula shores. IBERORED HF is presently working towards providing data through homogenized formats/protocols, in line with the HFR TT efforts and international initiatives.

In Germany, HFR measurements taken in the German Bight are integrated into the pre-operational Coastal Observing System for Northern and Arctic Seas (COSYNA) system (Baschek et al., 2016), which includes a model-based forecasting capability.

In France the LEFE/GMMC working group ReNHFOR (Research and Networking for High Frequency Oceanographic Radar) is working to consolidate and advance the current state of knowledge of the technique, disseminate best practices for its implementation, and to structure the French contribution to a PanEuropean HFR network (Quentin et al., 2017 – submitted to the Mercator Newsletter).

4. The European common QC model for real-time HFR data

The European common data and metadata model for real-time HFR data requires real-time data to be mandatorily processed by the Quality Control (QC) tests listed in Table 1 (for radial velocity data) and in Table 2 (for total velocity data).

These mandatory QC tests are manufacturer-independent, i.e. they do not rely on particular variables or information provided only by a specific device.

These standard sets of tests have been defined both for radial and total velocity data and they are the required ones for labelling the data as Level 2B (for radial velocity) and Level 3B (for total velocity) data. Please refer to Appendix A for the processing level definition.

Each QC test will result in a flag related to each data vector which will be inserted in the specific test variable. These variables can be matrices with the same dimensions of the data variable, containing, for each cell, the flag related to the vector lying in that cell, in case the QC test evaluates each cell of the gridded data, or a scalar, in case the QC test assesses an overall property of the data.

An overall QC variable will report the quality flags related to the results of all the QC tests: **it is a “good data” flag if and only if all QC tests are passed** by the data. Please refer to Appendix B for the QC flagging scheme.

For some of these tests, HFR operators will need to select the best thresholds. Since a successful QC effort is highly dependent upon selection of the proper thresholds, this choice is not straightforward, and may require trial and error before final selections are made. These thresholds should not be determined arbitrarily, but based on historical knowledge or statistics derived from historical data.

Table 1 – Mandatory QC tests for radial velocity data

QC test	Meaning	QC variable type
Syntax	This test will ensure the proper formatting and the existence of all the necessary fields within the radial netCDF file. This test is performed on the netCDF files and it assesses the presence and correctness of all data and attribute fields and the correct syntax throughout the file.	N/A, it is a test on the netCDF file structure, not on data content.
Over-water	This test labels radial velocity vectors that lie on water with a good data” flag. Otherwise, the vectors are labelled with a “bad data” flag.	gridded
Velocity Threshold	This test labels radial velocity vectors whose module is smaller than a maximum velocity threshold with a “good data” flag. Otherwise, the vectors are labelled with a “bad data” flag.	gridded
Variance Threshold	This test labels radial velocity vectors whose temporal variance is smaller than	gridded

	a maximum variance threshold with a “good data” flag. Otherwise, the vectors are labelled with a “bad data” flag. This test is applicable only to Beam Forming (BF) systems. Data files from Direction Finding (DF) systems will apply instead the “Temporal Derivative” test reporting the explanation “Test not applicable to Direction Finding systems. The Temporal Derivative test is applied.” in the comment attribute.	
Temporal Derivative	This test compares the velocity of each radial vector with the velocity of the radial vector measured in the previous timestamp at the same location. Each vector for which the velocity difference is smaller than the specified threshold for normal operations, is labelled with a "good data" flag. Otherwise, the vector is labelled with a “bad data” flag.	gridded
Median Filter	This test evaluates, for each radial vector, the median of the modules of all vectors lying within a distance of <dLim> km. Each vector for which the difference between its module and the median is smaller than the specified threshold for normal operations (curLim), is labeled with a "good data" flag. Otherwise, the vector is labelled with a “bad data” flag.	gridded
Average Radial Bearing	This QC test labels all radial velocity vectors with a ‘good_data” flag if the average radial bearing of all the vectors contained in the radial lie within the specified range for normal operations. Otherwise, the vectors are labelled with a “bad_data” flag. The average radial bearing range for normal operation has to be defined within a time interval when the proper functioning of the device is assessed. The margin has to be set according to site-specific properties. This test is applicable only to DF systems. Data files from BF systems will have this variable filled with “good_data” flags and the explanation “Test not applicable to Beam Forming systems” in the comment attribute.	gridded
Radial Count	This test labels all radial velocity vectors with a “good data” flag if the number of velocity vectors contained in the radial is bigger than the minimum count specified for normal operations. Otherwise, the vectors are labelled with a “bad data” flag.	gridded

Table 2 – Mandatory QC tests for total velocity data.

QC test	Meaning	QC variable type
Syntax	This test will ensure the proper formatting and the existence of all the necessary fields within the total netCDF file. This test is performed on the netCDF files and it assesses the presence and correctness of all data and attribute fields and the correct syntax throughout the file.	N/A, it is a test on the netCDF file structure, not on data content.
Data Density Threshold	This test labels total velocity vectors with a number of contributing radial velocities bigger than the minimum number defined for normal operations with a “good data” flag. Otherwise, the vectors are labelled with a “bad data” flag.	gridded
Velocity Threshold	This test labels total velocity vectors whose module is smaller than a maximum velocity threshold with a “good data” flag. Otherwise, the vectors are labelled with a “bad data” flag.	gridded
Variance Threshold	This test labels total velocity vectors whose temporal variances for both U and V components are smaller than a maximum variance threshold with a “good data” flag. Otherwise, the vectors are labelled with a “bad data” flag. This test is applicable only to Beam Forming (BF) systems. Data files from Direction Finding (DF) systems will apply instead the “Temporal Derivative” test reporting the explanation “Test not applicable to Direction Finding systems. The Temporal Derivative test is applied.” in the comment attribute.	gridded
Temporal Derivative	This test compares the velocity of each total vector with the velocity of the total vector measured in the previous timestamp at the same location. Each vector for which the velocity difference is smaller than the specified threshold for normal operations is labeled with a "good data" flag. Otherwise, the vector is labelled with a “bad data” flag.	gridded
GDOP Threshold	This test labels total velocity vectors whose GDOP is smaller than a maximum GDOP threshold with a “good data” flag. Otherwise, the vectors are labelled with a “bad data” flag.	gridded

5. The European common data and metadata model for real-time HFR data

This section provides the recommendations to constitute the European Common data and metadata model for real-time HFR data.

The format specification ensures efficient and automated HFR data discovery and interoperability, with tools and services across distributed and heterogeneous earth science data systems.

The European Common data and metadata model for real-time HFR data is intended to be **the reference model for HFR data distribution in Europe**. It complies with **CF-1.11**.

The data model integrates the SDC requirements about the **SeaDataNet metadata services** (https://www.seadatanet.org/Metadata) for enforcing discovery and access of HFR data and for gaining visibility and valorization for the projects and the institutions producing HFR data.

The HFR related metadata directories constituting the SeaDataNet metadata services are:

- European Directory of Marine Organisations (**EDMO**): it contains up-to-date addresses and activity profiles of research institutes, data holding centres, monitoring agencies, governmental and private organisations, that are in one way or another engaged in oceanographic and marine research activities, data and information management and/or data acquisition activities (https://www.seadatanet.org/Metadata/EDMO-Organisations).
- European Directory of the Initial Ocean-Observing Systems (**EDIOS**): it gives an overview of the ocean measuring and monitoring systems operated by European countries. This directory includes discovery information on location, measured parameters, data availability, responsible institutes and links to data-holding agencies plus some more technical information on instruments (https://www.seadatanet.org/Metadata/EDIOS-Observing-systems).
- Common Data Index (**CDI**): it gives users a highly detailed insight in the availability and geographical spreading of marine data sets and it provides a unique interface for requesting access, and if granted, for downloading data sets from the distributed data centres across Europe (https://www.seadatanet.org/Metadata/CDI-Common-Data-Index).

EDMO, EDIOS and CDI entries are xml files to be prepared using Mikado software (https://www.seadatanet.org/Software/MIKADO). Entries have to be mailed to sdn-userdesk@seadatanet.org for ingestion.

Each HFR data provider is asked to have EDMO, EDIOS and CDI entries (mandatory entries).

SDC is also managing the following catalogs:

- European Directory of Marine Environmental Research Projects (**EDMERP**): it covers marine research projects for a wide range of disciplines. Research projects are described as metadata factsheets with their most relevant aspects. The primary objective is to support users in identifying interesting research activities and in connecting them to involved research managers and organizations across Europe (https://www.seadatanet.org/Metadata/EDMERP-Projects).
- European Directory of Marine Environmental Datasets (**EDMED**): it is a comprehensive reference to the marine data sets and collections held within European research laboratories, so as to provide marine scientists, engineers and policy makers with a simple mechanism for their identification. It covers a wide range of disciplines (https://www.seadatanet.org/Metadata/EDMED-Datasets).

EDMERP and EDMED entries are xml files to be prepared using Mikado software (https://www.seadatanet.org/Software/MIKADO). entries have to be mailed to sdn-userdesk@seadatanet.org for ingestion.

HFR data providers are invited to provide EDMERP and EDMED entries.

It has to be noted that comprehensive metadata description is a prerequisite for the full implementation of EuroGOOS providing an inventory of the continuously available data for operational models. It is also necessary for creating and giving an overview of marine monitoring programmes relevant for the Marine Strategy Framework Directive (MSFD) implementation.

5.1. Data format

The European common data and metadata model for real-time HFR data uses NetCDF (Network Common Data Form), a set of software libraries and machine-independent data formats that is the international standard for common data and it is the one adopted by the US HFR network.

The recommended implementation of **NetCDF** is based on the community-supported Climate and Forecast Metadata Convention (CF), which provides a definitive description of the data in each variable, and the spatial and temporal properties of the data. The used version is **CF-1.11** and it must be identified in the 'Conventions' attribute.

Any relevant metadata should be included whether it is part of the standard or not.

The European common data and metadata model for real-time HFR data adds some requirements to the CF-1.11 standard:

Where time is specified as a string, the ISO8601 standard "**YYYY-MM-DDThh:mm:ssZ**" is used; this applies to attributes and to the base date in the 'units' attribute for time. There is no default time zone; **UTC** must be used and specified.
Global attributes from Unidata's NetCDF Attribute Convention for Data Discovery (ACDD) are implemented.
INSPIRE directive compliance is recommended.
Variable names (short names) from SeaDataNet (SDN) P09 controlled vocabulary are used. The needed variables with no SDN P09 coded name were created as new 4-character-capitalized-letters names and requested for addition to the SDN P09 vocabulary.

The definition of the European common data and metadata model for real-time HFR data follows the guidelines of the DATAMEQ working group.

The recommended **data and metadata model** applies to both **real-time radial** velocity data and **real-time total** velocity data.

The European common format for HFR real-time data is **netCDF-4 classic model** format.

NetCDF-4 is the state-of-the-art version of the netCDF library and it has been launched in 2008 to support per-variable compression, multiple unlimited dimensions, more complex data types, and better performance, by layering an enhanced netCDF access interface on top of the HDF5 format.

At the same time, a format variant, netCDF-4 classic model format, was added for users who needed the performance benefits of the new format (such as compression) without the complexity of a new programming interface or enhanced data model.

It should be mentioned that both netCDF-3 and netCDF-4 libraries are part of a single software release and, as a consequence, if a netCDF-4 file conforms to the classic model then there are several easy ways to convert it to a netCDF-3 file (e. g. ncks –e infile.nc4 outfile.nc3). Consequently, in cases where netCDF-3 version is required by existing distribution services, the conversion will be easily implemented.

The components (dimensions, variables and attributes) of NetCDF data set are described in Sections 5.2 to 5.7.

5.2. Global attributes

The global attribute section of a netCDF file describes the contents of the file overall and allows for data discovery. All fields should be human-readable and use units that are easy to understand. Global attribute names are case sensitive.

The European common data and metadata model for real-time HFR data divides global attributes to be adopted for HFR data in three categories: Mandatory Attributes, Recommended Attributes and Suggested Attributes.

The **Mandatory Attributes** include attributes necessary **to comply with CF-1.11**. The global attributes required for the SDC Common Data Index (CDI) scheme and the SDC CF extension have been added as mandatory. In Table 3, Mandatory Attributes are listed in **bold type**.

The **Recommended Attributes** include attributes necessary **to comply with INSPIRE and Unidata Dataset Discovery conventions**. In Table 3, Recommended Attributes are listed in *italic type*.

The Suggested Attributes include attributes that can be relevant in describing the data, whether it is part of the standard or not.

Attributes are organized by function: Discovery and Identification, Geo-spatial-temporal, Conventions used, Publication information, and Provenance.

Table 3 – NetCDF global attributes.

Discovery and Identification		
Name	Example	Note
site_code	site_code="HFR-TirLig" (for totals produced by the HFR-TirLig network)	The site code identifies a defined area where observations are performed. Site codes must be defined homogeneously. The policy for HFR data is to define a site_code for the network, one code for each radar site as platform_code for the radial current data files and one platform_code for the total current data files. **The site_code must be set equal to the EDIOS Series id of the HFR network.** The EDIOS codes are managed by the SeaDataNet project; they are available at http://seadatanet.maris2.nl/v_edios_v2/search.asp **It is mandatory to have the prefix 'HFR-' in the EDIOS Series id (the use of '_' is forbidden, please use '-' instead).** If the EDIOS Series entry already exists, modifications of the id are possible writing to sdn-userdesk@seadatanet.org. If your observing system has no EDIOS codes, please write to sdn-userdesk@seadatanet.org to obtain them. **Mandatory.**

platform_code	platform_code="HFR-TirLig-Total" (for totals produced by the HFR-TirLig network) platform_code="HFR-TirLig-MONT" (for radials from MONT radar site: MONT radar site belongs to the HFR-TirLig network)	The platform_code is used for indexing the files, and for data synchronization between the distribution units. Therefore, it must be unique for each platform. Platform codes must be defined homogeneously. The policy for HFR data is to define a site_code for the network, one code for each radar site as platform_code for the radial current data files and one platform_code for the total current data files. **The naming convention shall be:** ***platform_code=<EDIOS Series id>-Total*** **for total current data files and:** ***platform_code= <EDIOS Series id>-<EDIOS Platform id>*** **for radial current data files.** **The second part of platform_code has to be set equal to the EDIOS Program id of the HFR site.** **The use of '_' is forbidden, please use '-' instead.** The EDIOS codes are managed by the SeaDataNet project; they are available at http://seadatanet.maris2.nl/v_edios_v2/search.asp If the EDIOS Platform entry already exists, modifications of the id are possible writing to sdn-userdesk@seadatanet.org. If your observing system has no EDIOS codes, please write to sdn-userdesk@seadatanet.org to obtain them. **Mandatory**.

wmo_platform_code	wmo_platform_code ="6103611" (for radials produced by the HFR-DeltaEbro-SALO station)	The WMO number is a unique identifier assigned by the World Meteorological Organization to observing platforms/stations and it is used to share data on the Global Telecommunication System (GTS). WMO numbers are only allocated for HFR stations, not for HFR networks. Thus, the wmo_platform_code attribute must be specified only for radial data files. Issuance of the WMO number for the platforms/stations of the GOOS in situ observing networks is delegated to the OceanOPS support centre. For enquiries and updates please contact support@ocean-ops.org *Recommended.*
wigos_id	wigos_id ="0-22000-0-6103611" (for radials produced by the HFR-DeltaEbro-SALO station)	The WIGOS id is a unique identifier assigned by the World Meteorological Organization to observing platforms/stations. It is used to document each iteration of the station installation and to share data on WMO Information System (WIS) 2.0 and/or other web-based data assembly and sharing systems. WIGOS ids are only allocated for HFR stations, not for HFR networks. Thus, the wigos_id attribute must be specified only for radial data files. Issuance of the WIGOS id for the platforms/stations of the GOOS in situ observing networks is delegated to the OceanOPS support centre. For enquiries and updates please contact support@ocean-ops.org *Recommended.*
oceanops_ref	oceanops_ref ="6103611_001" (for radials produced by a new installation of the HFR-DeltaEbro-SALO station)	The OceanOPS reference is the OceanOPS internal reference/identifier assigned by OceanOPS to observing platforms/stations. The OceanOPS reference serves as the mapping key when users upload a file and for m2m process. OceanOPS references are only allocated for HFR stations, not for HFR networks. Thus, the oceanops_ref attribute must be specified only for radial data files. Issuance of the OceanOPS references for the platforms/stations of the GOOS in situ observing networks is delegated to the OceanOPS support centre. For enquiries and updates please contact support@ocean-ops.org. *Recommended.*

data_mode	data_mode="R"	Indicates if the file contains real-time, provisional or delayed-mode data. The list of valid data modes is in Table 14. **Mandatory**.
DoA_estimation_method	DoA_estimation_method ="Direction Finding" (for radials) DoA_estimation_method ="MONT: Direction Finding, TINO: Direction Finding" (for totals combined from MONT and TINO radial stations)	Specifies if the system is Direction Finding or Beam Forming. Possible values are "Direction Finding" and "Beam Forming". For **total data**, it is recommended to specify the DoA estimation method for each contributing radial station as a **comma-separated list of pairs** ***<EDIOS Platform id>: value*** **Mandatory**.
calibration_type	calibration_type ="APM" (for radials) calibration_type ="MONT: APM, TINO: APM" (for totals combined from MONT and TINO radial stations)	Specifies if calibration has been performed. Possible values are: "None", "Ideal", "APM", "full", "internal", "physical", "AEA". For **total data**, it is recommended to specify the calibration type for each contributing radial station as a **comma-separated list of pairs** ***<EDIOS Platform id>: value*** **Mandatory**.
last_calibration_date	last_calibration_date ="2016-02-04T11:25:37Z" (for radials) last_calibration_date ="MONT: 2016-02-04T11:25:37Z, TINO: 2016-02-04T11:25:37Z" (for totals combined from MONT and TINO radial stations)	Reports the date of the last calibration. It must be specified as a string in the ISO8601 standard "YYYY-MM-DD-Thh:mm:ssZ". For **total data**, it is recommended to specify the last calibration date for each contributing radial station as a **comma-separated list of pairs** ***<EDIOS Platform id>: value*** **Mandatory**.
calibration_link	calibration_link ="carlo.mantovani@cnr.it" (for radials) calibration_link ="MONT: carlo.mantovani@cnr.it, TINO: carlo.mantovani@cnr.it" (for totals combined from MONT and TINO radial stations)	Indicates the link to a contact person able to provide data about the calibration. For **total data**, it is recommended to specify the calibration link for each contributing radial station as a **comma-separated list of pairs** ***<EDIOS Platform id>: value*** **Mandatory**.
title	title="Near Real Time Surface Ocean Velocity by TirLig"	Free format text describing the dataset, for use by human readers. Use the file name if in doubt. **Mandatory**.

summary	summary="The dataset consists of maps of total velocity of the surface current in the North-Western Tyrrhenian Sea and Ligurian Sea averaged over a time interval of 1 hour around the cardinal hour."	Longer free format text describing the dataset. This attribute should allow data discovery for a human reader. A paragraph of up to 100 words is appropriate. **Mandatory**.
source	source="coastal structure"	The method of production of the original data. **For HFR data, the term "coastal structure" from the SeaVoX Platform Categories (L06) list must be used.** **Mandatory**.
source_platform_category_code	source_platform_category_code="17"	SeaDataNet vocabulary L06 (SeaVoX) reports platform categories, as a code and a label. **For HFR data the code "17" must be used.** **Mandatory**
institution	institution="National Research Council of Italy – Institute of Marine Science. S.S. Lerici"	Specifies institution where the original data was produced. **In case of multiple institutions, their names must be specified as a comma-separated list**. **Mandatory**.
institution_edmo_code	institution_edmo_code="134"	The EDMO codes are managed by the SeaDataNet project; they are available at http://seadatanet.maris2.nl/edmo/ If your institution has no EDMO code, please write to sdn-userdesk@seadatanet.org to obtain one. **In case of multiple institutions, their EDMO codes must be specified as a comma-separated list**. **Mandatory**.
institution_references	institution_references="https://www.puertos.es"	Specifies the website of the institution where the original data was produced. **In case of multiple institutions, their websites must be specified as a comma-separated list**. **Mandatory**.
data_assembly_center	data_assembly_center="European HFR Node"	Institution in charge of the aggregation and distribution of data. **Mandatory**.

id	id="HFR-TirLig-Total_2023-09-01T00:00:00Z" (for totals produced by the TirLig network) id="HFR-Ibiza-FORM_2024-03-15T22:00:00Z" (for radials from FORM radar site that belongs to the HFR-Ibiza network)	The "id" attribute is intended to provide a globally unique identification for each dataset. **The id must contain the platform_code and the data time stamp specified as a string in the ISO8601 standard "YYYY-MM-DD-Thh:mm:ssZ".** **The naming convention must be:** **id=platform_code_ YYYY-MM-DD-Thh:mm:ssZ** **Mandatory**
project	project="RITMARE, Jerico-Next"	The scientific project that produced the data. **In case of multiple projects, their names must be specified as a comma-separated list**. *Recommended.*
project_edmerp_code	project_edmerp_code="12058, 12227" (EDMERP codes for RITMARE and Jerico-Next projects)	The EDMERP code of the scientific project that produced the data. Each project should have its own EDMERP entry. The EDMERP codes are managed by the SeaDataNet project; they are available at http://seadatanet.maris2.nl/v_edmerp/search.asp If your projects have no EDMERP codes, please write to sdn-userdesk@seadatanet.org to obtain them. **In case of multiple projects, their EDMERP codes must be specified as a comma-separated list**. *Recommended.*
naming_authority	naming_authority="eu.hfrnode"	The organization that manages data set names. The **reverse-DNS naming is recommended** for the naming authority attribute. *Recommended.*
keywords	keywords="OCEAN CURRENTS, SURFACE WATER, RADAR, SCR-HF"	Provide comma-separated list of terms that will aid in discovery of the dataset. *Recommended.*
keywords_vocabulary	keywords_vocabulary="GCMD Science Keywords"	Please use one of 'GCMD Science Keywords', 'SeaDataNet Parameter Discovery Vocabulary' or 'AGU Index Terms'. *Recommended.*

comment	comment="HF radar measurements of ocean velocity are radial in direction relative to the radar location and representative of the upper 0.3-2.5 meters of the ocean."	Miscellaneous information about the data or methods used to produce it. Any free format text is appropriate. *Recommended*.
data_language	data_language="eng"	The language in which the data elements are expressed.
data_character_set	data_character_set="utf8"	The character set used for expressing data.
metadata_language	metadata_language="eng"	The language in which the metadata elements are expressed.
metadata_character_set	metadata_character_set="utf8"	The character set used for expressing metadata.
topic_category	topic_category=oceans"	ISO 19115 topic category.
network	network="ISMAR HFR-TirLig"	A grouping of sites based on common shore-based logistics or infrastructure. Free text is appropriate.
Geo-spatial-temporal		
data_type	data_type="HF radar total current data" (for total current data files) data_type="HF radar radial current data" (for radial current data files)	Copernicus Marine In Situ TAC NetCDF files family of data. Possible values are "HF radar radial current data" or "HF radar total current data". **Mandatory**.
geospatial_lat_min	geospatial_lat_min="43.5"	The southernmost latitude of the bounding box containing data, a value between -90 and 90 degrees. It may be string or numeric, but string is strongly recommended. **Mandatory**.
geospatial_lat_max	geospatial_lat_max="44.2"	The northernmost latitude of the bounding box containing data, a value between -90 and 90 degrees. It may be string or numeric, but string is strongly recommended. **Mandatory**.
geospatial_lat_resolution	geospatial_lat_max="1.5"	The resolution in latitude of the geographical grid hosting data. It may be string or numeric, but string is strongly recommended. **Mandatory**.
geospatial_lat_units	geospatial_lat_units="degree_north"	Must conform to udunits. If not specified, then "degree_north" is assumed. **Mandatory**.

geospatial_lon_min	geospatial_lon_min="9.1"	The westernmost longitude of the bounding box containing data, a value between -180 and 180 degrees. It may be string or numeric, but string is strongly recommended. **Mandatory**.
geospatial_lon_max	geospatial_lon_max="10.5"	The easternmost longitude of the bounding box containing data, a value between -180 and 180 degrees. It may be string or numeric, but string is strongly recommended. **Mandatory**.
geospatial_lon_resolution	geospatial_lat_max="1.5"	The resolution in longitude of the geographical grid hosting data. It may be string or numeric, but string is strongly recommended. **Mandatory**.
geospatial_lon_units	geospatial_lon_units="degree_east"	Must conform to udunits. If not specified, then "degree_east" is assumed. **Mandatory**.
geospatial_vertical_min	geospatial_vertical_min="0"	The minimum depth of measurements. It may be string or numeric, but string is strongly recommended. **Mandatory**.
geospatial_vertical_max	geospatial_vertical_max="1"	The maximum depth of measurements. For HFR data, it must be set as the radar system's maximum integration depth, according to operating frequency. It may be string or numeric, but string is strongly recommended. **Mandatory**.
geospatial_vertical_resolution	geospatial_vertical_resolution="0.48"	Vertical resolution of the measurement. For HFR data, it must be set as the radar system's maximum integration depth, according to operating frequency. It may be string or numeric, but string is strongly recommended. *Recommended.*
geospatial_vertical_units	geospatial_vertical_units="m"	Units of depth. If not specified, then "m" is assumed. **Mandatory**.
geospatial_vertical_positive	geospatial_vertical_positive="down"	Indicates which direction is positive; "up" means that z represents height, while a value of "down" means that z represents pressure or depth. If not specified then "down" is assumed. **Mandatory**.

time_coverage_start	time_coverage_start="2016-10-16T23:30:00Z"	Start date of the data in UTC. Time must be specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ". **Mandatory**.
time_coverage_end	time_coverage_end="2016-10-17T00:30:00Z"	Final date of the data in UTC. Time must be specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ". **Mandatory**.
time_coverage_resolution	time_coverage_resolution="PT1H"	Interval between records. ISO8601 standard must be used: PnYnMnDTnHnMnS. **Mandatory**.
time_coverage_duration	time_coverage_duration="PT1H"	Duration of the time coverage of the data. ISO8601 standard must be used: PnYnMnDTnHnMnS. **Mandatory**.
area	area="Mediterranean Sea"	Geographical coverage. Try to specify the European sea where the HFR is working. *Recommended*.
reference_system	reference_system="EPSG:4806" (in case of WGS84)	ESPG coordinate reference system. *Recommended*.
cdm_data_type	cdm_data_type="grid"	The Unidata CDM (common data model) data type used by THREDDS. Possible values are: "point", "profile", "section", "station", "station_profile", "trajectory", "grid", "radial", "swath", "image". For HFR data "grid" must be used. *Recommended*.
Conventions used		
format_version	format_version="v3"	Version of the data model release. **Mandatory**.
Conventions	Conventions="CF-1.11, EuroGOOS European HFR Node"	Names of the conventions followed by the dataset. The attribute Conventions must be reported as follows: "CF-1.11, EuroGOOS European HFR Node ". **Mandatory**.
netcdf_version	netcdf_version="4.9.3"	NetCDF version used for the dataset. *Recommended*.
netcdf_format	netcdf_format="NETCDF4_CLASSIC"	NetCDF format used for the dataset.

Publication information		
update_interval	update_interval="void"	Update interval for the file, in ISO8601 interval format: PnYnMnDTnHnM, where elements that are 0 may be omitted. Use "void" for data that are not updated on a schedule. **Mandatory**.
citation	citation="These data were collected and made freely available by the EuroGOOS European HFR Node. These data were collected and made freely available by OGS, ARPA FVG, NIB and ARSO and the programs that contribute to it. Data is processed by OGS, ARPA FVG, NIB and ARSO."	The citation to be used in publications using the dataset. If the data are pushed to the European HFR Node for distribution, the citation statement must be reported as follows: "These data were collected and made freely available by the EuroGOOS European HFR Node." An additional citation statement can be appended to the "citation" attribute. **Mandatory**.
distribution_statement	distribution_statement="These data follow Copernicus standards; they are public and free of charge. User assumes all risk for use of data. User must display citation in any publication or product using data. User must contact PI prior to any commercial use of data."	Statement describing data distribution policy. **Mandatory**
publisher_name	publisher_name="EuroGOOS European HFR Node"	Name of the institution/person responsible for data publication. **Mandatory**.
publisher_email	publisher_email="info@hfrnode.eu"	Email address of the institution/person responsible for data publication. **Mandatory**.
publisher_url	publisher_url="https://www.hfrnode.eu"	Website of the institution/person responsible for data publication. **Mandatory**.
license	license=" HF radar sea surface current velocity dataset by CNR-ISMAR is licensed under a Creative Commons Attribution 4.0 International License. You should have received a copy of the license along with this work. If not, see http://creativecommons.org/licenses/by/4.0/."	A statement describing the data distribution license. Creative Commons licenses are recommended. **Mandatory**.

acknowledgment	acknowledgment=" ISMAR HF Radar Network has been established within RITMARE, Jerico-Next and IMPACT projects. The network has been designed, implemented and managed through the efforts of ISMAR S.S. Lerici."	A place to acknowledge various types of support for the production of this data. **Mandatory.**
qc_manual	qc_manual=" Recommendation Report 2 on improved common procedures for HFR QC analysis: http://dx.doi.org/10.25607/OBP-944"	The name of the manual describing the quality control procedure applied to this data. The attribute qc_manual must be reported as follows: "Recommendation Report 2 on improved common procedures for HFR QC analysis: http://dx.doi.org/10.25607/OBP-944". **Mandatory**.
references	references=" Recommendation Report 2 on improved common procedures for HFR QC analysis: http://dx.doi.org/10.25607/OBP-944"	The name of the manual describing the data model applied to this data. The attribute references must be reported as follows: "Recommendation Report 2 on improved common procedures for HFR QC analysis: http://dx.doi.org/10.25607/OBP-944". **Mandatory**.
Provenance		
date_created	date_created="2016-11-11T15:35:32Z"	The date on which the data file was created. Time must be specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ". **Mandatory.**
history	history=" Data collected at 2024-03-26T09:00:00Z. netCDF file created at 2024-03-26T11:05:06Z by the European HFR Node."	Provides an audit trail for modifications to the original data. It should contain a separate string for each modification, with each string containing a timestamp. The timestamps must be specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ". **Mandatory.**
date_modified	date_modified="2024-03-12T16:38:21Z"	The date on which the data file was last modified. Time must be specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ". **Mandatory.**

processing_level	processing_level="3B"	Level of processing and quality control applied to data. Valid values are listed in Table 12. **Mandatory**.
contributor_name	contributor_name=" Lorenzo Corgnati, Carlo Mantovani"	A comma-separated list of the names of any individuals or institutions that contributed to the creation of this data. **Mandatory**.
contributor_role	contributor_role=" Data manager, HFR infrastructure manager"	A comma-separated list of the roles of any individuals or institutions that contributed to the creation of this data. **Mandatory**.
contributor_email	contributor_email=" lorenzo.corgnati@sp.ismar.cnr.it, carlo.mantovani@cnr.it"	A comma-separated list of the email addresses of any individuals or institutions that contributed to the creation of this data. **Mandatory**

5.3. Dimensions

NetCDF dimensions provide information on the size of the data variables, and additionally tie coordinate variables to data. CF recommends that if any or all of the dimensions of a variable have the interpretations of "date or time" (T), "height or depth" (Z), "latitude" (Y), or "longitude" (X), then those dimensions should appear in the relative order T, Z, Y, X in the variable's definition.

In the specific case of HFR radial data files, if the radial measurements are taken by the instruments based on a polar geometry (e.g. Codar .ruv files), the X and Y axis dimension shall be "bearing" (Y) and "range" (X). In this case, latitude and longitude shall be present in the netCDF file as data variable.

Table 4 – NetCDF dimensions.

Name	Example	Comment
TIME	TIME = 1	Number of time steps.
DEPTH	DEPTH = 1	Number of depth levels. Use 1 for HFR data.
LATITUDE	LATITUDE = 78	Dimension of the LATITUDE coordinate variable.
LONGITUDE	LONGITUDE = 106	Dimension of the LONGITUDE coordinate variable.
BEAR	BEAR = 73	Dimension of the BEAR coordinate variable (bearing away from instrument).
RNGE	RNGE = 46	Dimension of the RNGE coordinate variable (range away from instrument).
STRINGx	STRINGx = x	Length in characters of the strings used in the data file. It is mandatory that the string length dimension STRINGx has the value of x.
MAXSITE	MAXSITE = 50	Maximum number of antennas. Set it as an upper bound.
MAXINST	MAXINST = 2	Maximum number of collaborating institutions. Set it as an upper bound.
REFMAX	REFMAX = 3	Maximum number of external resource linkages. Set it as an upper bound.

Since HFR data have only one depth layer of measurement, i.e. the surface layer, the dimension DEPTH must have size equal to 1 and value equal to 0 meters.

If non-physical variables are present in the data file, e.g. the codes of the sites contributing to a total velocity data, related non-physical dimensions may be defined to expose the variables in the model.

If needed, more than one STRINGx dimension can be defined, provided that the string length dimension STRINGx has the value of x.

5.4. Coordinate variables

NetCDF coordinates are a special subset of variables. Coordinate variables orient the data in time and space; they may be dimension variables or auxiliary coordinate variables (identified by the 'coordinates' attribute on a data variable).

Coordinate variables have an "axis" attribute defining that they represent the X, Y, Z, or T axis. The only exception is the crs variable, that is an ancillary coordinate variable required by the **SDC CF extension**.

As with data variables, the European common data and metadata model for real-time HFR data recommends variable names and requires specific attributes for coordinate variables: units, axis, and, where available, standard_name are mandatory and are listed in **bold type** in Table 5. If standard_name is not available, long_name is mandatory.

Coordinate variables and variable attributes required in the SDC CF extension have been added as mandatory. In particular, the SDN extensions to CF were concerned with providing storage for standardized semantics and metadata included in the SDN profiles format. The standardized semantics are included as four **mandatory** parameter attributes for each data or coordinate variable, which are:

- sdn_parameter_urn – this is the URN for the parameter description taken from the P01 vocabulary.
- sdn_parameter_name – this is the plain language label (Entryterm) for the parameter taken from the P01 vocabulary at the time of data file creation.
- sdn_uom_urn – this is the URN for the parameter units of measure taken from the P06 vocabulary.
- sdn_uom_name - this is the plain language label (Entryterm) for the parameters' units of measure, taken from the P06 vocabulary at the time of data file creation.

According to **SDC CF extension**, the ancillary_variables attribute is mandatory and must be set as the list of QC variables related to the specific variable.

Missing values are not allowed in coordinate variables. All attributes in this section are highly recommended.

The data types reported in Table 5 are mandatory.

Table 5 – Required syntax for netCDF coordinate variables.

Type, name, dimension, attributes	Comment
double TIME(TIME); TIME:**standard_name** = “time”; TIME:**units** = “days since 1950-01-01T00:00:00Z”; TIME:**axis** = “T”; TIME:**calendar** = “standard”; TIME:**long_name** = “Time”; TIME:**ancillary_variables** = “TIME_QC”; TIME:**sdn_parameter_name** = “Elapsed time (since 1950-01-01T00:00:00Z)”; TIME:**sdn_parameter_urn** = “SDN:P01::ELTJLD01”; TIME:**sdn_uom_name** = “Days”; TIME:**sdn_uom_urn** = “SDN:P06::UTAA”;	Date and time (UTC) of the measurement in days since midnight, 1950-01-01. Example: Noon, Jan 1, 1950 is stored as 0.5.
float LATITUDE(LATITUDE); LATITUDE:**standard_name** = “latitude”; LATITUDE:**units** = “degree_north”; LATITUDE:**axis**=”Y”; LATITUDE:**long_name** = “Latitude ”; LATITUDE:**grid_mapping** = crs; LATITUDE:**ancillary_variables** = “POSITION _QC”; LATITUDE:**sdn_parameter_name** = “Latitude north”; LATITUDE:**sdn_parameter_urn** = “SDN:P01::ALATZZ01”; LATITUDE:**sdn_uom_name** = “Degrees north”; LATITUDE:**sdn_uom_urn** = “SDN:P06::DEGN”;	Latitude of the measurements. Units: degrees north; southern latitudes are negative. Example: 44.4991 for 44° 29’ 56.76’’ N
float LONGITUDE(LONGITUDE); LONGITUDE:**standard_name** = “longitude”; LONGITUDE:**units** = “degree_east”; LONGITUDE:**axis**=”X”; LONGITUDE:**long_name** = “Longitude”; LONGITUDE:**grid_mapping** = crs; LONGITUDE:**sdn_parameter_name** = “Longitude east”; LONGITUDE:**sdn_parameter_urn** = ”SDN:P01::ALONZZ01”; LONGITUDE:**sdn_uom_name** = “Degrees east”;	Longitude of the measurements. Units: degrees east; western latitudes are negative. Example: 16.7222 for 16° 43’ 19.92’’ E

LONGITUDE:**sdn_uom_urn** = “SDN:P06::DEGE”; LONGITUDE:**ancillary_variables** = “POSITION_QC”;	
short crs; crs:**grid_mapping_name** = "latitude_longitude" ; crs:**epsg_code** = "EPSG:4326" ; crs:**semi_major_axis** = 6378137. ; crs:**inverse_flattening** = 298.257223563 ;	Coordinate reference system. These values have to be set for WGS84.
float DEPTH(DEPTH); DEPTH:**standard_name** = “depth”; DEPTH:**units** = “m”; DEPTH:**positive** =<Q> DEPTH:**axis**=”Z”; DEPTH:reference=<R>; DEPTH:**long_name** = “Depth”; DEPTH:**sdn_parameter_name** = “Depth below surface of the water body”; DEPTH:**sdn_parameter_urn** = “SDN:P01::ADEPZZ01”; DEPTH:**sdn_uom_name** = “Metres”; DEPTH:**sdn_uom_urn** = “SDN:P06::ULAA”; DEPTH:**ancillary_variables** = “DEPTH_QC”;	Depth of measurements. <Q>: “Positive” attribute may be ”up” (atmospheric, or oceanic relative to sea floor) or ”down” (oceanic). <R>: The depth reference default value is “sea_level”. Other possible values are : “mean_sea_level”, “mean_lower_low_water”, “wgs84_geoid” Example: 0 for a measurement related to sea surface.
float BEAR(BEAR); BEAR:**units** = “degree_true”; BEAR:**axis**=”X”; BEAR:**long_name** = “Bearing away from instrument”; BEAR:**sdn_parameter_name** = “Bearing”; BEAR:**sdn_parameter_urn** = “SDN:P01::BEARRFTR”; BEAR:**sdn_uom_name** = “Degrees true”; BEAR:**sdn_uom_urn** = “SDN:P06::UABB”; BEAR:**ancillary_variables** = “POSITION_QC”;	Bearing of the measurement. Units: degree_true; valid values between 0 and 360 degrees. Example: 44.4991 for 44° 29’ 56.76’’ from instrument.
float RNGE (RNGE); RNGE:**units** = “km”; RNGE:**axis**=”Y”; RNGE:**long_name** = “Range away from instrument”;	Range of the measurement. Units: kilometers.

RNGE:**sdn_parameter_name** = "Range (from fixed reference point) by unspecified GPS system"; RNGE:**sdn_parameter_urn** = "SDN:P01::RIFNAX01"; RNGE:**sdn_uom_name** = "Kilometres"; RNGE:**sdn_uom_urn** = "SDN:P06::ULKM"; RNGE:**ancillary_variables** = "POSITION_QC";	

Notes on coordinate variables:

TIME: by default, the time word represents the center of the data sample or averaging period. The base date in the 'units' attribute for time is represented in ISO8601 standard "**YYYY-MM-DDThh:mm:ssZ**".

DEPTH: the depth coordinate may be positive in either upward or downward direction, which is defined in its "positive" attribute. Since HFR data have only one depth layer of measurement, i.e. the surface layer, the value of DEPTH must be equal to 0 meters.

The default depth reference is "sea_level" (free sea surface).

The latitude and longitude datum is WGS84. This is the default output of GPS systems.

BEAR and RNGE: bearing and range are the coordinate variables for radial velocity data measured on a polar geometry (e.g. Codar .ruv files). For these radial data, LATITUDE and LONGITUDE are data variables since they are evaluated starting from bearing and range. In order to distribute radial netCDF files as gridded data via THREDDS catalogs, **every gridded variable in the netCDF file of radial data must have the "coordinates" attribute with value "TIME DEPTH LATITUDE LONGITUDE".** Thus, the coordinates of data and QC variables for radials measured on a polar geometry shall be (TIME, DEPTH, BEAR, RNGE) and **RNGE dimension shall have the 'axis' attribute set to 'X' and BEAR dimension shall have the 'axis' attribute set to 'Y'.** The coordinates of data and QC variables for radials measured on a cartesian grid shall be (TIME, DEPTH, LATITUDE, LONGITUDE) and **LONGITUDE dimension shall have the 'axis' attribute set to 'X' and LATITUDE dimension shall have the 'axis' attribute set to 'Y'.**

5.5. SDN namespace variables

The SDN extensions to CF were concerned with providing storage for standardized semantics and metadata included in the SDN profiles format. In addition to extending coordinate variables and attributes within variables (see Section 5.4, Section 5.6 and Section 5.7), there are a number of SDN namespace variables that form part of the SeaDataCloud extension. These variables are listed and explained in Table 6.

All variables in this section are **mandatory**.

The data types reported in Table 6 are mandatory.

Table 6 – Required syntax for netCDF SDN namespace variables.

Type, name, dimension, attributes	Comment
char SDN_CRUISE(TIME, STRINGx); **SDN_CRUISE:long_name = "Grid grouping label";**	Array (which can have a dimension of 1 for single object storage) containing text strings identifying a grouping label for the data object to which the array element belongs. **It must be set equal to the 'site_code' global attribute (see Table 3).** Example: SDN_CRUISE = "HFR-TirLig"
char SDN_STATION(TIME, STRINGx); **SDN_STATION:long_name = "Grid label";**	Array of text strings identifying the data object to which the array element belongs. **It must be set equal to the 'platform_code' global attribute (see Table 3).** Example: SDN_STATION = "HFR-TirLig-Total" (for totals produced by the TirLig network) SDN_STATION = "HFR-TirLig-MONT" (for radials from MONT radar site belonging to the HFR-TirLig network)
char SDN_LOCAL_CDI_ID(TIME, STRINGx); **SDN_LOCAL_CDI_ID:long_name = "SeaDataNet CDI identifier";**	Array of text strings containing the local identifier of the Common Data Index (CDI) record associated with the data object to which the array element belongs. **It must be set equal to the 'id' global attribute (see Table 3).** Example: SDN_LOCAL_CDI_ID = " HFR-TirLig-Total_2024-03-27T14:00:00Z" (for totals produced by the HFR-TirLig network)

	SDN_LOCAL_CDI_ID = " HFR-TirLig-PFIN_2024-03-27T14:00:00Z" (for radials from PFINradar site belonging to the HFR-TirLig network)
short SDN_EDMO_CODE(TIME, MAXINST); **SDN_EDMO_CODE:long_name = "European Directory of Marine Organisations code for the CDI partner";** **SDN_EDMO_CODE:units="1"**	Integer array containing keys identifying the organisation hosting the Download Manager (CDI_partner) given in the European Directory of Marine Organisations (EDMO). **It must be set equal to the 'institution_edmo_code' global attribute (see Table 3).** The EDMO codes are managed by the SeaDataNet project; they are available at http://seadatanet.maris2.nl/edmo/ If your institution has no EDMO code, please write to sdn-userdesk@seadatanet.org to obtain one. Example: SDN_EDMO_CODE = 134
char SDN_REFERENCES(TIME, STRINGx); **SDN_ REFERENCES:long_name = "Usage metadata reference";**	Link to a single landing page or an XHTML document providing additional information. Example: SDN_REFERENCES = " https://thredds.hfrnode.eu:8443/thredds/NRTcurrent/HFR-TirLig/HFR-TirLig_catalog.html " ;
char SDN_XLINK(TIME, REFMAX, STRINGx); **SDN_ XLINK:long_name = "External resource linkages";**	Array of text strings containing a URI (URN or URL) pointing to a web resource such as a usage metadata document for the data object to which the array element belongs. If URNs such as DOIs are used then the namespace (e.g. 'doi:' for DOI) must be included. Each string is formatted according to the following model: **<sdn_reference xlink:type="URN" xlink:role="text" xlink:href="URI"/>** The xlink:href is **mandatory**, whilst xlink:type and xlink:role are optional. It is either a URL or a URN including namespace. The xlink:type attribute specifies the XML document type using the URN of that document type in the L23 vocabulary. For example, SDN:L23::CDI specifies a Common Data Index document. The xlink:role indicates the purpose of the document. The following roles are allowed: isDescribedBy CDI document or controlled vocabulary concept document

	isObservedBy CSR document or EDIOS series document Example: SDN_ XLINK = "<sdn_reference xlink:href=\" https://thredds.hfrnode.eu:8443/thredds/NRTcurrent/HFR-TirLig /HFR-TirLig_catalog.html \" xlink:role=\"\" xlink:type=\"URL\"/>" ;

Notes on SDN namespace variables variables:

The SDN approach was to keep duplication of information to a minimum through the provision of external linkages to additional information. Initially, the intention was to follow the DOI model and provide a mechanism to link the SDN data file to a single 'landing page' or an XHTML document providing additional information. The intention was that this page could include additional links to other XML documents, such as the CDI. The SDN_REFERENCES variable was introduced for this purpose. This is a character array for each instance (i.e. normally one per file for SDN) in which a URI is stored. This is either the landing page URL or a URN including namespace such as a DOI.

However, this was considered insufficient as there was no information in the data files to inform software agents what to expect at the end of the URI and insufficient control over landing page content to guarantee that it would be provided elsewhere. Consequently, the SDN_XLINK character array was introduced. This allows any number (the REFMAX dimension) of strings to be associated with each instance.

5.6. Data variables

Data variables contain the actual measurements and information about their quality, uncertainty, and mode by which they were obtained.

Mandatory and recommended variable names are listed in Table 7. Mandatory variables are marked in **bold type**.

When an appropriate **CF standard name** is available, it is required to be used; if no such name exists in the CF standard, the standard_name attribute should not be used. In those cases, the **long_name** attribute must be used. Please refer to the CF Standard Names table online for authoritative information (definitions, canonical units) on standard names.

It is recommended that variable names are 4-character-capitalized-letters names. They are not strictly standardized, however; one should use the CF standard_name attribute to query data files. Note that a single standard_name may be used more than once in a file, but variable names are unique.

Data variables required in the **SDC CF extension** have been added as mandatory.

Table 7 – Mandatory and recommended data variables for radial and total velocity data.

Radial velocity data		
Variable name	standard_name	long_name
RDVA	radial_sea_water_velocity_away_from_instrument	Radial sea water velocity away from instrument
DRVA	direction_of_radial_vector_away_from_instrument	Direction of radial vector away from instrument
EWCT	surface_eastward_sea_water_velocity	Surface eastward sea water velocity
NSCT	surface_ northward_sea_water_velocity	Surface northward sea water velocity
ESPC		Radial standard deviation of current velocity over the scatter patch
ETMP		Radial standard deviation of current velocity over coverage period
ERSC		Radial sea water velocity spatial quality count
ERTC		Radial sea water velocity temporal quality count
HCSS		Radial variance of current velocity over coverage period
EACC		Radial accuracy of current velocity over coverage period
XDST		Eastward distance from instrument
YDST		Northward distance from instrument
SPRC		Radial sea water velocity cross spectra range cell
NARX		Number of receive antennas
NATX		Number of transmit antennas
SLTR	deployment_latitude	Receive antenna latitudes
SLNR	deployment_longitude	Receive antenna longitudes
SLTT	deployment_latitude	Transmit antenna latitudes
SLNT	deployment_longitude	Transmit antenna longitudes
SCDR		Receive antenna codes
SCDT		Transmit antenna codes
Total velocity data		
Variable name	standard_name	long_name
EWCT	surface_eastward_sea_water_velocity	Surface eastward sea water velocity
NSCT	surface_ northward_sea_water_velocity	Surface northward sea water velocity
EWCS		Standard deviation of surface eastward sea water velocity

NSCS		Standard deviation of surface northward sea water velocity
GDOP		Geometrical dilution of precision
CCOV		Covariance of surface sea water velocity
UACC		Accuracy of surface eastward sea water velocity
VACC		Accuracy of surface northward sea water velocity
NARX		Number of receive antennas
NATX		Number of transmit antennas
SLTR	deployment_latitude	Receive antenna latitudes
SLNR	deployment_longitude	Receive antenna longitudes
SLTT	deployment_latitude	Transmit antenna latitudes
SLNT	deployment_longitude	Transmit antenna longitudes
SCDR		Receive antenna codes
SCDT		Transmit antenna codes

The required syntax for data variables is reported in Table 8: replace <PARAM> with any of the variable names indicated in Table 7.

Mandatory attributes are listed in **bold type**, however, the European data and metadata model for real-time HFR data recommends using all other attributes for adding meaningful information, unless technical reasons make this impossible. Variable attributes required in the SDC CF extension have been added as mandatory. In particular, the SDN extensions to CF were concerned with providing storage for standardized semantics and metadata included in the SDN profiles format. The standardized semantics are included as four **mandatory** parameter attributes for each data or co-ordinate variable, which are:

- sdn_parameter_urn – this is the URN for the parameter description taken from the P01 vocabulary.
- sdn_parameter_name – this is the plain language label (Entryterm) for the parameter taken from the P01 vocabulary at the time of data file creation.
- sdn_uom_urn – this is the URN for the parameter units of measure taken from the P06 vocabulary.
- sdn_uom_name - this is the plain language label (Entryterm) for the parameters' units of measure, taken from the P06 vocabulary at the time of data file creation.

According to **SDC CF extension**, the ancillary_variables attribute is mandatory and has to be set as the list of QC variables related to the specific variable.

Please refer to Table 9 for the SDN namespace variable attributes required for SDC CF extension.

<A>: standardized attributes.

<B>: attributes whose values are set following the European data and metadata model for real-time HFR data rules.

<C>: attributes whose value is free text, set by the data provider.

Table 8 – Required syntax for netCDF data variables.

Type, name, dimension, attributes	Comment
data_type <PARAM>(TIME, DEPTH, LATITUDE, LONGITUDE);	or data_type <PARAM>(TIME, DEPTH, RNGE, BEAR); or data_type <PARAM>(RNGE,BEAR); or data_type <PARAM>(TIME,MAXSITE); or data_type <PARAM>(TIME,MAXSITE,STRINGx); or data_type <PARAM>(TIME,STRINGx); or data_type <PARAM>(TIME,MAXINST); or data_type <PARAM>(TIME,REFMAX,STRINGx); or data_type <PARAM>(TIME);
<PARAM>:standard_name = <A>;	standard_name: required. Existing standard name in CF.
<PARAM>:**units** = <A>;	units: required.
<PARAM>:**_FillValue** = <B>;	_FillValue: required. Fill values must be chosen according to the variable data type (int, float, double).
<PARAM>:**coordinates** = <B>;	coordinates: lists the coordinate variables for the measurement value as a space-delimited list: **"TIME DEPTH LATITUDE LONGITUDE"**.
<PARAM>:**long_name** = <B>;	long_name: required. Text; should be a useful label for the variable.
<PARAM>:**valid_min** = <B>; <PARAM>:**valid_max**= <B>;	valid_min: required. A number specifying the minimum valid value for the variable. valid_max: required. A number specifying the maximum valid value for the variable. valid_min and valid_max must have the same data type of the data variable.
<PARAM>:comment = <C>;	comment: Text; useful free-format text.
<PARAM>:add_offset = <B>;	add_offset: offset value to be added to all the values of the variable. It must have the same data type of the data variable.
<PARAM>:scale_factor = <B>;	scale_factor: scaling value to be multiplied to all the values of the variable. It must have the same data type of the data variable.

<PARAM>:**sdn_parameter_name** = <A>;	sdn_parameter_name is the plain language label (Entryterm) for the parameter taken from the P01 vocabulary at the time of data file creation.
<PARAM>:**sdn_parameter_urn** = <A>;	sdn_parameter_urn is the URN for the parameter description taken from the P01 vocabulary
<PARAM>:**sdn_uom_name** = <A>;	sdn_uom_name is the plain language label for the parameters' units of measure, taken from the P06 vocabulary at the time of data file creation.
<PARAM>:**sdn_uom_urn** = <A>;	sdn_uom_urn is the URN for the parameter units of measure taken from the P06 vocabulary.
<PARAM>:**ancillary_variables** = <B>;	ancillary_variables: name of the flag channel for the variable. The list of all related QC variables must be indicated.

Table 9 - Mandatory and recommended SDN namespace data variable attributes for radial and total velocity data

Radial velocity data				
Variable name	sdn_parameter_name	sdn_parameter_urn	sdn_uom_name	sdn_uom_urn
TIME	"Elapsed time (since 1950-01-01T00:00:00Z)"	"SDN:P01::ELTJLD01"	"Days"	"SDN:P06::UTAA"
BEAR	"Bearing"	"SDN:P01::BEARRFTR"	"Degrees true"	"SDN:P06::UABB"
RNGE	"Range (from fixed reference point) by unspecified GPS system"	"SDN:P01::RIFNAX01"	"Kilometres"	"SDN:P06::ULKM"
DEPTH	"Depth below surface of the water body"	"SDN:P01::ADEPZZ01"	"Metres"	"SDN:P06::ULAA"
LATITUDE	"Latitude north"	"SDN:P01::ALATZZ01"	"Degrees north"	"SDN:P06::DEGN
LONGITUDE	"Longitude east"	"SDN:P01::ALONZZ01"	"Degrees east"	"SDN:P06::DEGE"
RDVA	"Current speed (Eulerian) in the water body by directional range-gated radar"	"SDN:P01::LCSAWVRD"	"Metres per second"	"SDN:P06::UVAA"
DRVA	"Current direction (Eulerian) in the water body by directional range-gated radar"	"SDN:P01::LCDAWVRD"	"Degrees True"	"SDN:P06::UABB"
EWCT	Eastward current velocity in the water body"	"SDN:P01::LCEWZZ01"	"Metres per second"	"SDN:P06::UVAA"
NSCT	Northward current velocity in the water body"	"SDN:P01::LCNSZZ01"	"Metres per second"	"SDN:P06::UVAA"
ESPC	""	""	"Metres per second"	"SDN:P06::UVAA"
ETMP	""	""	"Metres per second"	"SDN:P06::UVAA"
ERSC	""	""	"Dimensionless"	"SDN:P06::UUUU
ERTC	""	""	"Dimensionless"	"SDN:P06::UUUU

HCSS	“Current speed standard deviation in the water body”	“SDN:P01::SDSAZZ01”	“Metres per second”	“SDN:P06::UVAA”
EACC	“”	“”	“Metres per second”	“SDN:P06::UVAA”
XDST	“”	“”	“Kilometres”	“SDN:P06::ULKM”
YDST	“”	“”	“Kilometres”	“SDN:P06::ULKM”
SPRC	“”	“”	“Dimensionless”	“SDN:P06::UUUU
NARX	“”	“”	“Dimensionless”	“SDN:P06::UUUU
NATX	“”	“”	“Dimensionless”	“SDN:P06::UUUU
SLTR	“Latitude north”	“SDN:P01::ALATZZ01”	“Degrees north”	“SDN:P06::DEGN
SLNR	“Longitude east”	”SDN:P01::ALONZZ01”	“Degrees east”	“SDN:P06::DEGE”
SLTT	“Latitude north”	“SDN:P01::ALATZZ01”	“Degrees north”	“SDN:P06::DEGN
SLNT	“Longitude east”	”SDN:P01::ALONZZ01”	“Degrees east”	“SDN:P06::DEGE”
SCDR	“”	“”	“Dimensionless”	“SDN:P06::UUUU
SCDT	“”	“”	“Dimensionless”	“SDN:P06::UUUU

Total velocity data				
Variable name	sdn_parameter_name	sdn_parameter_urn	sdn_uom_name	sdn_uom_urn
TIME	“Elapsed time (since 1950-01-01T00:00:00Z)”	“SDN:P01::ELTJLD01”	“Days”	“SDN:P06::UTAA”
LATITUDE	“Latitude north”	“SDN:P01::ALATZZ01”	“Degrees north”	“SDN:P06::DEGN”
LONGITUDE	“Longitude east”	”SDN:P01::ALONZZ01”	“Degrees east”	“SDN:P06::DEGE”
DEPTH	“Depth below surface of the water body”	“SDN:P01::ADEPZZ01”	“Metres”	“SDN:P06::ULAA”
EWCT	Eastward current velocity in the water body”	“SDN:P01::LCEWZZ01”	“Metres per second”	“SDN:P06::UVAA”
NSCT	Northward current velocity in the water body”	“SDN:P01::LCNSZZ01”	“Metres per second”	“SDN:P06::UVAA”
EWCS	“Eastward current velocity standard deviation in the water body”	“SDN:P01::SDEWZZZZ”	“Metres per second”	“SDN:P06::UVAA”
NSCS	“Northward current velocity standard deviation in the water body”	“SDN:P01::SDNSZZZZ”	“Metres per second”	“SDN:P06::UVAA”
CCOV	“”	“”	“Square metres per second squared”	“SDN:P06::SQM2”
GDOP	“”	“”	“Dimensionless”	“SDN:P06::UUUU”
UACC	“”	“”	“Metres per second”	“SDN:P06::UVAA”
VACC	“”	“”	“Metres per second”	“SDN:P06::UVAA”
NARX	“”	“”	“Dimensionless”	“SDN:P06::UUUU”
NATX	“”	“”	“Dimensionless”	“SDN:P06::UUUU”
SLTR	“Latitude north”	“SDN:P01::ALATZZ01”	“Degrees north”	“SDN:P06::DEGN”
SLNR	“Longitude east”	”SDN:P01::ALONZZ01”	“Degrees east”	“SDN:P06::DEGE”
SLTT	“Latitude north”	“SDN:P01::ALATZZ01”	“Degrees north”	“SDN:P06::DEGN”
SLNT	“Longitude east”	”SDN:P01::ALONZZ01”	“Degrees east”	“SDN:P06::DEGE”
SCDR	“”	“”	“Dimensionless”	“SDN:P06::UUUU”
SCDT	“”	“”	“Dimensionless”	“SDN:P06::UUUU”

Notes on the “coordinates” attribute:

> There are two methods used to locate data in time and space. The preferred method is for the data variable to be declared with dimensions that are coordinate variables, e.g. EWCT(TIME, DEPTH, LATITUDE, LONGITUDE). Alternatively, a variable may be declared with fewer dimensions, e.g. EWCT (TIME). In the latter case, the “coordinates” attribute of the variable provides the spatiotemporal reference for the data. The value of the “coordinates” attribute is a blank separated list of the names of auxiliary coordinate variables; these must exist in the file, and their sizes must match a subset of the data variable’s dimensions; scalar coordinates do so by default.

Even if CF conventions prefer the use of coordinate variables as dimensions, because it conforms to COARDS (Cooperative Ocean-Atmosphere Research Data Service) convention and because it simplifies the use of the data by standard software, in order to comply with SDC CF extension data model, the European common data and metadata model for NRT HFR data mandates to declare the variables with all their dimensions and also to have the “coordinates” attribute filled with the list of dimensions.

5.7. Quality Control variables

Since in HFR data the quality control values vary along one or more axes of the data variables, they are provided as separate numeric flag variables, with at least one dimension that matches the 'target' variable.

When QC information is provided as a separate flag variable, CF-1.11 requires that these variables carry the "flag_values" and "flag_meanings" attributes. These provide a list of possible values and their meanings.

QC variables can also exist not linked to a target physical variable (e.g. GDOP threshold QC variable linked to GDOP variable), but also as standalone variables reporting the results of a specific QC test, e.g. Over-water test (see Section 4).

No CF-1.11 standard names exist for QC variables, thus long names have to be used. **QC variables must be of type byte**.

Table 10 lists the mandatory QC variables to include in the data file.

Table 10 – Mandatory QC variables for radial and total velocity data.

Radial velocity data		
Variable name and data type	long_name	Variable dimensionality
byte TIME_QC	Time quality flag	scalar
byte POSITION_QC	Position quality flag	gridded
byte DEPTH_QC	Depth quality flag	scalar
byte QCflag	Overall quality flag	gridded
byte OWTR_QC	Over-water quality flag	gridded
byte MDFL_QC	Median filter quality flag	gridded
byte VART_QC	Variance threshold quality flag	gridded
byte CSPD_QC	Velocity threshold quality flag	gridded
byte AVRB_QC	Average radial bearing quality flag	gridded
byte RDCT_QC	Radial count quality flag	gridded
Total velocity data		
Variable name and data type	long_name	Variable dimensionality
byte TIME_QC	Time quality flag	scalar
byte POSITION_QC	Position quality flag	gridded
byte DEPTH_QC	Depth quality flag	scalar
byte QCflag	Overall quality flag	gridded
byte VART_QC	Variance threshold quality flag	gridded

byte GDOP_QC	GDOP threshold quality flag	gridded
byte DDNS_QC	Data density threshold quality flag	gridded
byte CSPD_QC	Velocity threshold quality flag	gridded

Table 11 describes how to provide QC information as a separate variable. The term <QC_VAR> represents the QC variables listed in Table 10.

Required attributes are listed in **bold type**, however, the European data and metadata model for real-time HFR data recommends that all other attributes be used and contain meaningful information, unless technical reasons make this impossible.

<A>: standardized attributes.

<B>: attributes whose values are set following the European data and metadata model for real-time HFR data rules.

<C>: attributes whose value is free text, set by the data provider.

Table 11 – Required syntax for netCDF QC variables.

Type, name, dimension, attributes	Comment
byte <QC_VAR> (TIME, DEPTH, LATITUDE, LONGITUDE);	or Short <QC_VAR> (TIME, DEPTH, RNGE, BEAR); or Short <QC_VAR> (TIME);
<QC_VAR>:**long_name** = <A>;	long_name: required. Type char, fixed value.
<QC_VAR>:**units** = <A>;	units: required.
<QC_VAR>:**_FillValue** = <B>;	_FillValue: required. Fill values must be chosen according to the QC variable data type (i.e. byte).
<QC_VAR>:**valid_min** = <B>; <QC_VAR>:**valid_max**= <B>;	valid_min: required. A number specifying the minimum valid value for the variable. valid_max: required. A number specifying the maximum valid value for the variable. valid_min and valid_max must have the same data type of the data variable.
<QC_VAR>:**flag_values** = <B>	flag_values: required. Fixed values listing the possible values of the QC variable.
<QC_VAR>:**flag_meanings** = <B>	flag_meanings: required. List of fixed values providing the meanings of the possible values for the QC variable.
<QC_VAR>:coordinates = <B>	coordinates: lists the coordinate variables for the measurement value as a space-delimited list: **"TIME DEPTH LATITUDE LONGITUDE"**.
<QC_VAR>:comment = <C>;	comment: Text; useful free-format text.

<QC_VAR>:**conventions** = <B>;	conventions: required. The list of conventions defining the QC test related to the variable.

6. Data model implementation and evolution: verification, update, feedback and training

The EuroGOOS HFR Task Team and its operational asset, the European HFR Node, are committed in promoting the multi-institutional adoption and use of the European QC, data and metadata model for real-time HFR data, in sustaining it and its related experience and in fostering its implementation, particularly for operational systems. These goals are pursued via specific procedures for regularly reviewing and updating the data model documentation, for providing feedback loops with users, for providing training on the data model application and for providing means for assessing the correct adoption of the data model.

6.1. Review and update of the data model documentation

In order to promote and sustain the multi-institutional adoption and use of the European QC, data and metadata model for real-time HFR data, its documentation is published in the Ocean Best Practices System - OBPS (https://www.oceanbestpractices.org/), that is a public and sustained repository.

The present document is available on OBPS at https://repository.oceanbestpractices.org/handle/11329/1441

The European HFR community is engaged, under the coordination of the EuroGOOS HFR Task Team, in evolving the data model documentation for keeping it updated, effective and operational to changing technologies and user/operator requirements. The review/update procedure takes place via periodic meetings within the EuroGOOS HFR Task Team and the European HFR Node and via biannual meetings with the international community of HFR manufacturers, operators and users.

6.2. Feedback loop with the users

For best practices to evolve, a feedback loop with users is needed. A feedback loop is a five-step process that involves gathering feedback from users, acknowledging the feedback, analyzing the results, taking necessary action, and updating users on the new changes.

To this aim, the present document is also published on GitHub for providing user feedback loop, support and troubleshooting. GitHub is a collaborative environment that allows for tracking capabilities for versions, comments, users etc. Everyone can publish comments and proposals for reviews and updates, as well as read comments from everyone. The authentication mechanism for users enables to track the evolution of comments, reviews and updates.

The present document is available on GitHub at:
https://github.com/LorenzoCorgnati/European_standard_HFR_data_model

6.3. Training

The EuroGOOS HFR Task Team organizes biannual meetings that gathers the international community of HFR manufacturers, operators and users. During these meetings, training sessions are organized for sharing the best practices and the operational procedures already in place and for promoting updates and progress in the diverse frameworks of the HFR operations.

Please refer to the EuroGOOS European HFR Node website for getting information on the training and accessing training materials: https://hfrnode.eu

6.4. Assessment of the data model implementation

In order to assess the successful application of the European QC, data and metadata model for real-time HFR data, the data providers can assess the compliance of the produced data with the QC, data and metadata model described in this document.

A formal verification can be performed at the European HFR Node level, mainly by joining the operational workflow provided by the node.

A format checker tool is not yet published. The European HFR Node is in the process of developing it.

7. Conclusions and next steps

This manual describes the European common HFR data and metadata model and a common real-time QC model. The way to achieve this consensus has been led by the JERICO-RI HFR community receiving inputs from a wider group of operators worldwide and from the main components of the European marine data infrastructures.

By following the recommendations described in the manual, any HFR operator will be able to produce data in a standard format and to be immediately integrated in the European HFR operational workflow and to be distributed by Copernicus Marine In Situ TAC, SeaDataNet and EMODnet distribution services.

The manual allows HFR operators to produce HFR quality-controlled real-time surface currents data and key derived products and sets the basis for the management of historical data and methodologies for advanced delayed mode quality-control techniques.

This achievement will be realized in particular through the EuroGOOS DATAMEQ working group and the EuroGOOS HFR Task Team.

Moreover, these organizations will keep open discussions and reviews to maintain and refine the data model and the QC model.

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9. Useful links

In the following, useful links to the reference conventions applied by the European common data and metadata model for real-time HFR data are listed.

- NetCDF Best Practices: unidata.ucar.edu/software/netcdf/docs/BestPractices.html
- NetCDF Climate and Forecast Metadata Convention 1.11, including the CF standard names: cfconventions.org
- Udunits package as implemented by CF: unidata.ucar.edu/software/udunits/
- ISO8601 description: http://en.wikipedia.org/wiki/ISO_8601
- Unidata NetCDF Attribute Convention for Dataset Discovery (ACDD): http://wiki.esipfed.org/index.php/Category:Attribute_Conventions_Dataset_Discovery
- INSPIRE convention: http://inspire.ec.europa.eu/index.cfm/pageid/101
- http://inspire.ec.europa.eu/documents/Metadata/MD_IR_and_ISO_20131029.pdf
- NODC NetCDF Templates: http://www.nodc.noaa.gov/data/formats/netcdf/
- Online CF compliance checker: https://compliance.ioos.us/index.html
- The SeaDataNet P09 controlled vocabulary: http://vocab.nerc.ac.uk/collection/P09/current/
- EPSG, used for the coordinate reference frames: http://www.epsg.org/
- QARTOD manual: https://repository.oceanbestpractices.org/handle/11329/288.2
- OceanSITES convention manual: http://www.oceansites.org/docs/oceansites_data_format_reference_manual.pdf
- Copernicus Marine In Situ TAC Documentation: https://marineinsitu.eu/documentation/
- INCREASE project deliverable D4.1: http://www.cmems-increase.eu/static/INCREASE_Report_D4.1_vf.pdf
- Repository containing the software tools needed for the collection, QC and processing of HFR data according to the European QC model and the European data and metadata model: https://github.com/LorenzoCorgnati/
- EuroGOOS European HFR Node: https://www.hfrnode.eu/

A. Processing Levels

This table describes the processing levels for the identification of the different data produced during the processing workflow of a HFR system. The definition of these processing levels is manufacturer-independent, i.e. the level schema is suitable to all the most common HFR.

The string values are used as an overall indicator (i.e. one summarizing all measurements) of each data file in the processing_level attribute.

Processing Level	Definition	Products
LEVEL 0	Reconstructed, unprocessed instrument/payload data at full resolution; any and all communications artifacts, e.g. synchronization frames, communications headers, duplicate data removed.	Signal received by the antenna before the processing stage. (No access to these data in Codar systems)
LEVEL 1A	Reconstructed, unprocessed instrument data at full resolution, time-referenced and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing.	Spectra by antenna channel
LEVEL 1B	Level 1A data that have been processed to sensor units for next processing steps. Not all instruments will have data equivalent to Level 1B.	Spectra by beam direction
LEVEL 2A	Derived geophysical variables at the same resolution and locations as the Level 1 source data.	HFR radial velocity data
LEVEL 2B	Level 2A data that have been processed with a minimum set of QC.	HFR radial velocity data
LEVEL 2C	Level 2A data that have been reprocessed for advanced QC.	Reprocessed HFR radial velocity data
LEVEL 3A	Variables mapped on uniform space-time grid scales, usually with some completeness and consistency	HFR total velocity data
LEVEL 3B	Level 3A data that have been processed with a minimum set of QC.	HFR total velocity data
LEVEL 3C	Level 3A data that have been reprocessed for advanced QC.	Reprocessed HFR total velocity data
LEVEL 4	Model output or results from analyses of lower level data, e.g. variables derived from multiple measurements	Energy density maps, residence times, etc.

Table 12 – Processing levels for HFR data.

B. Quality Control indicators

The quality control flags indicate the data quality of the data values in a file, following the ARGO QC flag scale. The byte codes in column 'Code' are used only in the QC variables to describe the quality of each measurement, the strings in column 'meaning' are used in the attribute flag_meanings of each QC variable to describe the overall quality of the parameter.

When the numeric codes are used, the flag_values and flag_meanings attributes are required and should contain lists of the codes (comma-separated) and their meanings (space separated, replacing spaces within each meaning by '_').

Code	Meaning	Comment
0	unknown	No QC was performed
1	good data	All QC tests passed
2	probably good data	These data should be used with caution
3	potentially correctable bad data	These data are not to be used without scientific correction or re-calibration
4	bad data	Data have failed one or more QC tests
5	value changed	Data may be recovered after transmission error
6	-	Not used
7	nominal value	The provided value is not measured but comes from a priori knowledge (instrument design or deployment), e.g. instrument target depth
8	interpolated value	Missing data may be interpolated from neighbouring data in space or time
9	missing value	

Table 13 – *Argo quality control flag scale*

C. Data mode

The possible values for the global attribute "data_mode" are defined as follows:

Value	Meaning
R	Real-time data. Data coming from the (typically remote) platform through a communication channel without physical access to the instruments, disassembly or recovery of the platform.
P	Provisional data. Data obtained after instruments have been recovered or serviced; some calibrations or editing may have been done, but the data is not thought to be fully processed. Refer to the history attribute for more detailed information.
D	Delayed-mode data. Data published after all calibrations and quality control procedures have been applied on the internally recorded or best available original data. This is the best possible version of processed data.
M	Mixed. It indicates that the file contains data in more than one of the above states.

Table 14 – Valid data modes.

D. Radial velocity data file header example

```
netcdf HFR-DeltaEbro-SALO_2024_03_26_0900 {
dimensions:
TIME = 1 ;
DEPTH = 1 ;
RNGE = 91 ;
BEAR = 72 ;
MAXSITE = 1 ;
STRING4 = 4 ;
STRING13 = 13 ;
STRING18 = 18 ;
STRING39 = 39 ;
MAXINST = 1 ;
STRING104 = 104 ;
REFMAX = 1 ;
STRING165 = 165 ;
variables:
double TIME(TIME) ;
TIME:axis = "T" ;
TIME:long_name = "Time" ;
TIME:standard_name = "time" ;
TIME:units = "days since 1950-01-01T00:00:00Z" ;
TIME:calendar = "standard" ;
TIME:sdn_parameter_name = "Elapsed time (since 1950-01-01T00:00:00Z)" ;
TIME:sdn_parameter_urn = "SDN:P01::ELTJLD01" ;
TIME:sdn_uom_name = "Days" ;
TIME:sdn_uom_urn = "SDN:P06::UTAA" ;
TIME:ancillary_variables = "TIME_QC" ;
float DEPTH(DEPTH) ;
DEPTH:axis = "Z" ;
DEPTH:long_name = "Depth" ;
DEPTH:standard_name = "depth" ;
DEPTH:units = "m" ;
DEPTH:positive = "down" ;
DEPTH:reference = "sea_level" ;
DEPTH:sdn_parameter_name = "Depth below surface of the water body" ;
DEPTH:sdn_parameter_urn = "SDN:P01::ADEPZZ01" ;
DEPTH:sdn_uom_name = "Metres" ;
DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
DEPTH:ancillary_variables = "DEPTH_QC" ;
float RNGE(RNGE) ;
RNGE:axis = "Y" ;
```

```
RNGE:long_name = "Range away from instrument" ;
RNGE:units = "km" ;
RNGE:sdn_parameter_name = "Range (from fixed reference point) by unspecified GPS system" ;
RNGE:sdn_parameter_urn = "SDN:P01::RIFNAX01" ;
RNGE:sdn_uom_name = "Kilometres" ;
RNGE:sdn_uom_urn = "SDN:P06::ULKM" ;
RNGE:ancillary_variables = "POSITION_QC" ;
float BEAR(BEAR) ;
BEAR:axis = "X" ;
BEAR:long_name = "Bearing away from instrument" ;
BEAR:units = "degree_true" ;
BEAR:sdn_parameter_name = "Bearing" ;
BEAR:sdn_parameter_urn = "SDN:P01::BEARRFTR" ;
BEAR:sdn_uom_name = "Degrees true" ;
BEAR:sdn_uom_urn = "SDN:P06::UABB" ;
BEAR:ancillary_variables = "POSITION_QC" ;
short ESPC(TIME, DEPTH, RNGE, BEAR) ;
ESPC:_FillValue = -32767s ;
ESPC:long_name = "Radial standard deviation of current velocity over the scatter patch" ;
ESPC:valid_min = -32000s ;
ESPC:valid_max = 32000s ;
ESPC:units = "m s-1" ;
ESPC:sdn_parameter_name = "" ;
ESPC:sdn_parameter_urn = "" ;
ESPC:sdn_uom_name = "Metres per second" ;
ESPC:sdn_uom_urn = "SDN:P06::UVAA" ;
ESPC:ancillary_variables = "QCflag VART_QC" ;
ESPC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
ESPC:add_offset = 0. ;
ESPC:scale_factor = 0.001 ;
short ETMP(TIME, DEPTH, RNGE, BEAR) ;
ETMP:_FillValue = -32767s ;
ETMP:long_name = "Radial standard deviation of current velocity over coverage period" ;
ETMP:valid_min = -32000s ;
ETMP:valid_max = 32000s ;
ETMP:units = "m s-1" ;
ETMP:sdn_parameter_name = "" ;
ETMP:sdn_parameter_urn = "" ;
ETMP:sdn_uom_name = "Metres per second" ;
ETMP:sdn_uom_urn = "SDN:P06::UVAA" ;
ETMP:ancillary_variables = "QCflag VART_QC" ;
ETMP:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
ETMP:add_offset = 0. ;
```

ETMP:scale_factor = 0.001 ;
short MAXV(TIME, DEPTH, RNGE, BEAR) ;
MAXV:_FillValue = -32767s ;
MAXV:long_name = "Radial sea water velocity away from instrument maximum" ;
MAXV:standard_name = "radial_sea_water_velocity_away_from_instrument" ;
MAXV:valid_min = -10000s ;
MAXV:valid_max = 10000s ;
MAXV:units = "m s-1" ;
MAXV:sdn_parameter_name = "Speed of water current in the water body by high frequency radar and cell averaging" ;
MAXV:sdn_parameter_urn = "SDN:P01::HFRDCRSP" ;
MAXV:sdn_uom_name = "Metres per second" ;
MAXV:sdn_uom_urn = "SDN:P06::UVAA" ;
MAXV:ancillary_variables = "QCflag MDFL_QC CSPD_QC VART_QC" ;
MAXV:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
MAXV:add_offset = 0. ;
MAXV:scale_factor = 0.001 ;
short MINV(TIME, DEPTH, RNGE, BEAR) ;
MINV:_FillValue = -32767s ;
MINV:long_name = "Radial sea water velocity away from instrument minimum" ;
MINV:standard_name = "radial_sea_water_velocity_away_from_instrument" ;
MINV:valid_min = -10000s ;
MINV:valid_max = 10000s ;
MINV:units = "m s-1" ;
MINV:sdn_parameter_name = "Speed of water current in the water body by high frequency radar and cell averaging" ;
MINV:sdn_parameter_urn = "SDN:P01::HFRDCRSP" ;
MINV:sdn_uom_name = "Metres per second" ;
MINV:sdn_uom_urn = "SDN:P06::UVAA" ;
MINV:ancillary_variables = "QCflag MDFL_QC CSPD_QC VART_QC" ;
MINV:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
MINV:add_offset = 0. ;
MINV:scale_factor = 0.001 ;
short ERSC(TIME, DEPTH, RNGE, BEAR) ;
ERSC:_FillValue = -32767s ;
ERSC:long_name = "Radial sea water velocity spatial quality count" ;
ERSC:valid_min = 0s ;
ERSC:valid_max = 127s ;
ERSC:units = "1" ;
ERSC:sdn_parameter_name = "" ;
ERSC:sdn_parameter_urn = "" ;
ERSC:sdn_uom_name = "Dimensionless" ;
ERSC:sdn_uom_urn = "SDN:P06::UUUU" ;

ERSC:ancillary_variables = "QCflag" ;
ERSC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
short ERTC(TIME, DEPTH, RNGE, BEAR) ;
ERTC:_FillValue = -32767s ;
ERTC:long_name = "Radial sea water velocity temporal quality count" ;
ERTC:valid_min = 0s ;
ERTC:valid_max = 127s ;
ERTC:units = "1" ;
ERTC:sdn_parameter_name = "" ;
ERTC:sdn_parameter_urn = "" ;
ERTC:sdn_uom_name = "Dimensionless" ;
ERTC:sdn_uom_urn = "SDN:P06::UUUU" ;
ERTC:ancillary_variables = "QCflag" ;
ERTC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
int XDST(TIME, DEPTH, RNGE, BEAR) ;
XDST:_FillValue = -2147483647 ;
XDST:long_name = "Eastward distance from instrument" ;
XDST:valid_min = 0 ;
XDST:valid_max = 1000000 ;
XDST:units = "km" ;
XDST:sdn_parameter_name = "" ;
XDST:sdn_parameter_urn = "" ;
XDST:sdn_uom_name = "Kilometers" ;
XDST:sdn_uom_urn = "SDN:P06::ULKM" ;
XDST:ancillary_variables = "QCflag OWTR_QC MDFL_QC CSPD_QC VART_QC" ;
XDST:coordinates = "LATITUDE LONGITUDE" ;
XDST:add_offset = 0. ;
XDST:scale_factor = 0.001 ;
int YDST(TIME, DEPTH, RNGE, BEAR) ;
YDST:_FillValue = -2147483647 ;
YDST:long_name = "Northward distance from instrument" ;
YDST:valid_min = 0 ;
YDST:valid_max = 1000000 ;
YDST:units = "km" ;
YDST:sdn_parameter_name = "" ;
YDST:sdn_parameter_urn = "" ;
YDST:sdn_uom_name = "Kilometers" ;
YDST:sdn_uom_urn = "SDN:P06::ULKM" ;
YDST:ancillary_variables = "QCflag OWTR_QC MDFL_QC CSPD_QC VART_QC" ;
YDST:coordinates = "LATITUDE LONGITUDE" ;
YDST:add_offset = 0. ;
YDST:scale_factor = 0.001 ;
short SPRC(TIME, DEPTH, RNGE, BEAR) ;

SPRC:_FillValue = -32767s ;
SPRC:long_name = "Radial sea water velocity cross spectra range cell" ;
SPRC:valid_min = 0s ;
SPRC:valid_max = 127s ;
SPRC:units = "1" ;
SPRC:sdn_parameter_name = "" ;
SPRC:sdn_parameter_urn = "" ;
SPRC:sdn_uom_name = "Dimensionless" ;
SPRC:sdn_uom_urn = "SDN:P06::UUUU" ;
SPRC:ancillary_variables = "QCflag OWTR_QC MDFL_QC CSPD_QC VART_QC" ;
SPRC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
byte OWTR_QC(TIME, DEPTH, RNGE, BEAR) ;
OWTR_QC:_FillValue = -127b ;
OWTR_QC:long_name = "Over-water quality flag" ;
OWTR_QC:conventions = "EuroGOOS European HFR Node" ;
OWTR_QC:valid_min = 0b ;
OWTR_QC:valid_max = 9b ;
OWTR_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
OWTR_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
OWTR_QC:comment = " Over Water QC Test - Test applies to each vector. Thresholds=[GeoPandas \"naturalearth_lowres\"]" ;
OWTR_QC:units = "1" ;
OWTR_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
byte CSPD_QC(TIME, DEPTH, RNGE, BEAR) ;
CSPD_QC:_FillValue = -127b ;
CSPD_QC:long_name = "Velocity threshold quality flag" ;
CSPD_QC:conventions = "EuroGOOS European HFR Node" ;
CSPD_QC:valid_min = 0b ;
CSPD_QC:valid_max = 9b ;
CSPD_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
CSPD_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
CSPD_QC:comment = " Velocity Threshold QC Test - Test applies to each vector. Threshold=[maximum velocity=1.0 (m/s)]" ;
CSPD_QC:units = "1" ;
CSPD_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
byte VART_QC(TIME, DEPTH, RNGE, BEAR) ;
VART_QC:_FillValue = -127b ;
VART_QC:long_name = "Variance threshold quality flag" ;
VART_QC:conventions = "EuroGOOS European HFR Node" ;

VART_QC:valid_min = 0b ;
VART_QC:valid_max = 9b ;
VART_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
VART_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
VART_QC:comment = " Variance Threshold QC Test not applicable to Direction Finding systems. Temporal Derivative QC Test - Test applies to each vector. Threshold=[velocity difference threshold=1.0 (m/s)]" ;
VART_QC:units = "1" ;
VART_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
byte MDFL_QC(TIME, DEPTH, RNGE, BEAR) ;
MDFL_QC:_FillValue = -127b ;
MDFL_QC:long_name = "Median filter quality flag" ;
MDFL_QC:conventions = "EuroGOOS European HFR Node" ;
MDFL_QC:valid_min = 0b ;
MDFL_QC:valid_max = 9b ;
MDFL_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
MDFL_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
MDFL_QC:comment = " Median Filter QC Test - Test applies to each vector. Thresholds=[distance limit=5.0 (km) velocity-median difference threshold=1.0 (m/s)]" ;
MDFL_QC:units = "1" ;
MDFL_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
byte AVRB_QC(TIME, DEPTH, RNGE, BEAR) ;
AVRB_QC:_FillValue = -127b ;
AVRB_QC:long_name = "Average radial bearing quality flag" ;
AVRB_QC:conventions = "EuroGOOS European HFR Node" ;
AVRB_QC:valid_min = 0b ;
AVRB_QC:valid_max = 9b ;
AVRB_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
AVRB_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
AVRB_QC:comment = " Average Radial Bearing QC Test - Test applies to entire file. Thresholds=[minimum bearing=150.0 (degrees) - maximum bearing=275.0 (degrees)]" ;
AVRB_QC:units = "1" ;
AVRB_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
byte RDCT_QC(TIME, DEPTH, RNGE, BEAR) ;
RDCT_QC:_FillValue = -127b ;
RDCT_QC:long_name = "Radial count quality flag" ;
RDCT_QC:conventions = "EuroGOOS European HFR Node" ;
RDCT_QC:valid_min = 0b ;

RDCT_QC:valid_max = 9b ;
RDCT_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
RDCT_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
RDCT_QC:comment = " Radial Count QC Test - Test applies to entire file. Threshold=[minimum number of radial vectors=200]" ;
RDCT_QC:units = "1" ;
RDCT_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
byte QCflag(TIME, DEPTH, RNGE, BEAR) ;
QCflag:_FillValue = -127b ;
QCflag:long_name = "Overall quality flag" ;
QCflag:conventions = "EuroGOOS European HFR Node" ;
QCflag:valid_min = 0b ;
QCflag:valid_max = 9b ;
QCflag:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
QCflag:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
QCflag:comment = " Overall QC Flag - Test applies to each vector. Test checks if all QC tests are passed." ;
QCflag:units = "1" ;
QCflag:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
float LONGITUDE(RNGE, BEAR) ;
LONGITUDE:_FillValue = 9.96921e+36f ;
LONGITUDE:standard_name = "longitude" ;
LONGITUDE:long_name = "Longitude" ;
LONGITUDE:units = "degree_east" ;
LONGITUDE:valid_min = -180.f ;
LONGITUDE:valid_max = 180.f ;
LONGITUDE:sdn_parameter_name = "Longitude east" ;
LONGITUDE:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
LONGITUDE:sdn_uom_name = "Degrees east" ;
LONGITUDE:sdn_uom_urn = "SDN:P06::DEGE" ;
LONGITUDE:grid_mapping = "crs" ;
LONGITUDE:ancillary_variables = "POSITION_QC" ;
float LATITUDE(RNGE, BEAR) ;
LATITUDE:_FillValue = 9.96921e+36f ;
LATITUDE:standard_name = "latitude" ;
LATITUDE:long_name = "Latitude" ;
LATITUDE:units = "degree_north" ;
LATITUDE:valid_min = -90.f ;
LATITUDE:valid_max = 90.f ;
LATITUDE:sdn_parameter_name = "Latitude north" ;

LATITUDE:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
LATITUDE:sdn_uom_name = "Degrees north" ;
LATITUDE:sdn_uom_urn = "SDN:P06::DEGN" ;
LATITUDE:grid_mapping = "crs" ;
LATITUDE:ancillary_variables = "POSITION_QC" ;
int DRVA(TIME, DEPTH, RNGE, BEAR) ;
DRVA:_FillValue = -2147483647 ;
DRVA:valid_min = 0 ;
DRVA:valid_max = 360000 ;
DRVA:standard_name = "direction_of_radial_vector_away_from_instrument" ;
DRVA:long_name = "Direction of radial vector away from instrument" ;
DRVA:units = "degree_true" ;
DRVA:sdn_parameter_name = "Direction (from) of radial vector relative to instrument and True North in the water body by high frequency radar" ;
DRVA:sdn_parameter_urn = "SDN:P01::HFRVWD01" ;
DRVA:sdn_uom_name = "Degrees True" ;
DRVA:sdn_uom_urn = "SDN:P06::UABB" ;
DRVA:ancillary_variables = "QCflag OWTR_QC MDFL_QC AVRB_QC RDCT_QC" ;
DRVA:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
DRVA:add_offset = 0. ;
DRVA:scale_factor = 0.001 ;
short RDVA(TIME, DEPTH, RNGE, BEAR) ;
RDVA:_FillValue = -32767s ;
RDVA:valid_min = -10000s ;
RDVA:valid_max = 10000s ;
RDVA:standard_name = "radial_sea_water_velocity_away_from_instrument" ;
RDVA:units = "m s-1" ;
RDVA:long_name = "Radial sea water velocity away from instrument" ;
RDVA:sdn_parameter_name = "Speed of water current in the water body by high frequency radar and cell averaging" ;
RDVA:sdn_parameter_urn = "SDN:P01::HFRDCRSP" ;
RDVA:sdn_uom_name = "Metres per second" ;
RDVA:sdn_uom_urn = "SDN:P06::UVAA" ;
RDVA:ancillary_variables = "QCflag OWTR_QC MDFL_QC CSPD_QC VART_QC RDCT_QC" ;
RDVA:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
RDVA:add_offset = 0. ;
RDVA:scale_factor = 0.001 ;
short EWCT(TIME, DEPTH, RNGE, BEAR) ;
EWCT:_FillValue = -32767s ;
EWCT:valid_min = -10000s ;
EWCT:valid_max = 10000s ;
EWCT:standard_name = "surface_eastward_sea_water_velocity" ;
EWCT:long_name = "Surface eastward sea water velocity" ;

```
EWCT:units = "m s-1" ;
EWCT:sdn_parameter_name = "Eastward velocity of water current in the water body" ;
EWCT:sdn_parameter_urn = "SDN:P01::LCEWZZ01" ;
EWCT:sdn_uom_name = "Metres per second" ;
EWCT:sdn_uom_urn = "SDN:P06::UVAA" ;
EWCT:ancillary_variables = "QCflag OWTR_QC MDFL_QC CSPD_QC VART_QC AVRB_QC RDCT_QC" ;
EWCT:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
EWCT:add_offset = 0. ;
EWCT:scale_factor = 0.001 ;
short NSCT(TIME, DEPTH, RNGE, BEAR) ;
NSCT:_FillValue = -32767s ;
NSCT:valid_min = -10000s ;
NSCT:valid_max = 10000s ;
NSCT:standard_name = "surface_northward_sea_water_velocity" ;
NSCT:long_name = "Surface northward sea water velocity" ;
NSCT:units = "m s-1" ;
NSCT:sdn_parameter_name = "Northward current velocity in the water body" ;
NSCT:sdn_parameter_urn = "SDN:P01::LCNSZZ01" ;
NSCT:sdn_uom_name = "Metres per second" ;
NSCT:sdn_uom_urn = "SDN:P06::UVAA" ;
NSCT:ancillary_variables = "QCflag OWTR_QC MDFL_QC CSPD_QC VART_QC AVRB_QC RDCT_QC" ;
NSCT:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
NSCT:add_offset = 0. ;
NSCT:scale_factor = 0.001 ;
short crs ;
crs:grid_mapping_name = "latitude_longitude" ;
crs:epsg_code = "EPSG:4326" ;
crs:semi_major_axis = 6378137. ;
crs:inverse_flattening = 298.257223563 ;
byte NARX(TIME, MAXSITE) ;
NARX:_FillValue = -127b ;
NARX:long_name = "Number of receive antennas" ;
NARX:valid_min = 0b ;
NARX:valid_max = 127b ;
NARX:units = "1" ;
NARX:sdn_parameter_name = "" ;
NARX:sdn_parameter_urn = "" ;
NARX:sdn_uom_name = "Dimensionless" ;
NARX:sdn_uom_urn = "SDN:P06::UUUU" ;
byte NATX(TIME, MAXSITE) ;
NATX:_FillValue = -127b ;
NATX:long_name = "Number of transmit antennas" ;
NATX:valid_min = 0b ;
```

```
NATX:valid_max = 127b ;
NATX:units = "1" ;
NATX:sdn_parameter_name = "" ;
NATX:sdn_parameter_urn = "" ;
NATX:sdn_uom_name = "Dimensionless" ;
NATX:sdn_uom_urn = "SDN:P06::UUUU" ;
int SLTR(TIME, MAXSITE) ;
SLTR:_FillValue = -2147483647 ;
SLTR:long_name = "Receive antenna latitudes" ;
SLTR:standard_name = "deployment_latitude" ;
SLTR:valid_min = -90000 ;
SLTR:valid_max = 90000 ;
SLTR:units = "degree_north" ;
SLTR:sdn_parameter_name = "Latitude north" ;
SLTR:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
SLTR:sdn_uom_name = "Degrees north" ;
SLTR:sdn_uom_urn = "SDN:P06::DEGN" ;
SLTR:add_offset = 0. ;
SLTR:scale_factor = 0.001 ;
int SLNR(TIME, MAXSITE) ;
SLNR:_FillValue = -2147483647 ;
SLNR:long_name = "Receive antenna longitudes" ;
SLNR:standard_name = "deployment_longitude" ;
SLNR:valid_min = -180000 ;
SLNR:valid_max = 180000 ;
SLNR:units = "degree_east" ;
SLNR:sdn_parameter_name = "Longitude east" ;
SLNR:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
SLNR:sdn_uom_name = "Degrees east" ;
SLNR:sdn_uom_urn = "SDN:P06::DEGE" ;
SLNR:add_offset = 0. ;
SLNR:scale_factor = 0.001 ;
int SLTT(TIME, MAXSITE) ;
SLTT:_FillValue = -2147483647 ;
SLTT:long_name = "Transmit antenna latitudes" ;
SLTT:standard_name = "deployment_latitude" ;
SLTT:valid_min = -90000 ;
SLTT:valid_max = 90000 ;
SLTT:units = "degree_north" ;
SLTT:sdn_parameter_name = "Latitude north" ;
SLTT:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
SLTT:sdn_uom_name = "Degrees north" ;
SLTT:sdn_uom_urn = "SDN:P06::DEGN" ;
```

```
SLTT:add_offset = 0. ;
SLTT:scale_factor = 0.001 ;
int SLNT(TIME, MAXSITE) ;
SLNT:_FillValue = -2147483647 ;
SLNT:long_name = "Transmit antenna longitudes" ;
SLNT:standard_name = "deployment_longitude" ;
SLNT:valid_min = -180000 ;
SLNT:valid_max = 180000 ;
SLNT:units = "degree_east" ;
SLNT:sdn_parameter_name = "Longitude east" ;
SLNT:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
SLNT:sdn_uom_name = "Degrees east" ;
SLNT:sdn_uom_urn = "SDN:P06::DEGE" ;
SLNT:add_offset = 0. ;
SLNT:scale_factor = 0.001 ;
char SCDR(TIME, MAXSITE, STRING4) ;
SCDR:long_name = "Receive antenna codes" ;
SCDR:sdn_parameter_name = "" ;
SCDR:sdn_parameter_urn = "" ;
SCDR:sdn_uom_name = "Dimensionless" ;
SCDR:sdn_uom_urn = "SDN:P06::UUUU" ;
char SCDT(TIME, MAXSITE, STRING4) ;
SCDT:long_name = "Transmit antenna codes" ;
SCDT:sdn_parameter_name = "" ;
SCDT:sdn_parameter_urn = "" ;
SCDT:sdn_uom_name = "Dimensionless" ;
SCDT:sdn_uom_urn = "SDN:P06::UUUU" ;
char SDN_CRUISE(TIME, STRING13) ;
SDN_CRUISE:long_name = "Grid grouping label" ;
char SDN_STATION(TIME, STRING18) ;
SDN_STATION:long_name = "Grid label" ;
char SDN_LOCAL_CDI_ID(TIME, STRING39) ;
SDN_LOCAL_CDI_ID:long_name = "SeaDataNet CDI identifier" ;
short SDN_EDMO_CODE(TIME, MAXINST) ;
SDN_EDMO_CODE:long_name = "European Directory of Marine Organisations code for the CDI partner" ;
SDN_EDMO_CODE:units = "1" ;
char SDN_REFERENCES(TIME, STRING104) ;
SDN_REFERENCES:long_name = "Usage metadata reference" ;
char SDN_XLINK(TIME, REFMAX, STRING165) ;
SDN_XLINK:long_name = "External resource linkages" ;
byte TIME_QC(TIME) ;
TIME_QC:_FillValue = -127b ;
TIME_QC:long_name = "Time quality flag" ;
```

```
TIME_QC:conventions = "EuroGOOS European HFR Node" ;
TIME_QC:valid_min = 0b ;
TIME_QC:valid_max = 9b ;
TIME_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
TIME_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
TIME_QC:comment = "Quality flagging for temporal coordinate." ;
TIME_QC:units = "1" ;
byte POSITION_QC(TIME, DEPTH, RNGE, BEAR) ;
POSITION_QC:_FillValue = -127b ;
POSITION_QC:long_name = "Position quality flag" ;
POSITION_QC:conventions = "EuroGOOS European HFR Node" ;
POSITION_QC:valid_min = 0b ;
POSITION_QC:valid_max = 9b ;
POSITION_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
POSITION_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
POSITION_QC:comment = "Quality flagging for position coordinates." ;
POSITION_QC:units = "1" ;
POSITION_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
byte DEPTH_QC(TIME) ;
DEPTH_QC:_FillValue = -127b ;
DEPTH_QC:long_name = "Depth quality flag" ;
DEPTH_QC:conventions = "EuroGOOS European HFR Node" ;
DEPTH_QC:valid_min = 0b ;
DEPTH_QC:valid_max = 9b ;
DEPTH_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
DEPTH_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
DEPTH_QC:comment = "Quality flagging for depth coordinate." ;
DEPTH_QC:units = "1" ;

// global attributes:
:site_code = "HFR-DeltaEbro" ;
:platform_code = "HFR-DeltaEbro-SALO" ;
:wmo_platform_code = "6103611" ;
:wigos_id = "0-22000-0-6103611" ;
:oceanops_ref = "6103611" ;
:data_mode = "R" ;
:doa_estimation_method = "Direction Finding" ;
```

:calibration_type = "APM" ;
:last_calibration_date = "2023-10-19T00:00:00Z" ;
:calibration_link = "plorente_externo@puertos.es" ;
:title = "Near Real Time Surface Ocean Radial Velocity by HFR-DeltaEbro-SALO" ;
:summary = "The data set consists of maps of radial velocity of the sea water surface current collected at Salou (SALO) site in the Ebro River Delta (NE Spain). Data are averaged over a time interval of 1 hour around the cardinal hour. HF-RADAR measurements of ocean velocity are radial in direction relative to the radar location and representative of the upper 0.3-2.5 meters of the ocean." ;
:source = "coastal structure" ;
:source_platform_category_code = "17" ;
:institution = "PUERTOS DEL ESTADO" ;
:institution_edmo_code = "2751" ;
:institution_references = "http://www.puertos.es" ;
:data_assembly_center = "European HFR Node" ;
:id = "HFR-DeltaEbro-SALO_2024-03-26T09:00:00Z" ;
:project = "N/A" ;
:project_edmerp_code = "" ;
:naming_authority = "eu.hfrnode" ;
:keywords = "OCEAN CURRENTS, SURFACE WATER, RADAR, SCR-HF" ;
:keywords_vocabulary = "GCMD Science Keywords" ;
:comment = "Total velocities are derived using least square fit that maps radial velocities measured from individual sites onto a cartesian grid. The final product is a map of the horizontal components of the ocean currents on a regular grid in the area of overlap of two or more radar stations." ;
:data_language = "eng" ;
:data_character_set = "utf8" ;
:metadata_language = "eng" ;
:metadata_character_set = "utf8" ;
:metadata_contact = "lorenzo.corgnati@sp.ismar.cnr.it" ;
:metadata_date_stamp = "2024-03-26T10:47:08Z" ;
:topic_category = "oceans" ;
:network = "HFR-DeltaEbro" ;
:data_type = "HF radar radial current data" ;
:geospatial_lat_min = "39.5851" ;
:geospatial_lat_max = "41.2331" ;
:geospatial_lat_resolution = "0.014981291" ;
:geospatial_lat_units = "degree_north" ;
:geospatial_lon_min = "0.06352" ;
:geospatial_lon_max = "2.0781" ;
:geospatial_lon_resolution = "0.00035276942" ;
:geospatial_lon_units = "degree_east" ;
:geospatial_vertical_min = "0" ;
:geospatial_vertical_max = "0.8841941282883076" ;
:geospatial_vertical_positive = "down" ;

:geospatial_vertical_resolution = "0.8841941282883076" ;
:geospatial_vertical_units = "m" ;
:time_coverage_start = "2024-03-26T08:30:00Z" ;
:time_coverage_end = "2024-03-26T09:30:00Z" ;
:time_coverage_resolution = "PT1H" ;
:time_coverage_duration = "PT1H" ;
:area = "Ebro River Delta (NE Spain)" ;
:reference_system = "EPSG:4326" ;
:cdm_data_type = "grid" ;
:format_version = "v3" ;
:Conventions = "CF-1.11, EuroGOOS European HFR Node" ;
:netcdf_format = "NETCDF4_CLASSIC" ;
:netcdf_version = "4.9.3" ;
:update_interval = "void" ;
:citation = "These data were collected and made freely available by the EuroGOOS European HFR Node. Data collected and processed by Puertos del Estado." ;
:distribution_statement = "These data are public and free of charge. User assumes all risk for use of data. User must display citation in any publication or product using data. User must contact PI prior to any commercial use of data." ;
:publisher_name = "European HFR Node" ;
:publisher_url = "https://www.hfrnode.eu/" ;
:publisher_email = "euhfrnode@azti.es" ;
:license = "These data follow Copernicus standards. They are public and free of charge. User assumes all risk for use of data. User must display citation in any publication or product using data. User must contact PI prior to any commercial use of data. HF radar sea surface current velocity dataset by Puertos del Estado is licensed under a Creative Commons Attribution 4.0 International License. You should have received a copy of the license along with this work. If not, see http://creativecommons.org/licenses/by/4.0/." ;
:acknowledgment = "The network has been designed, implemented and managed through the efforts of Puertos del Estado. Installation was performed by ACUAMED (formally Aguas de las Cuencas Mediterráneas), which is a Spanish public company responsible for the construction, operation and acquisition of all types of hydraulic works as determined by the Government of Spain." ;
:date_created = "2024-03-26T10:47:08Z" ;
:history = "Data measured at 2024-03-26T09:00:00Z. netCDF file created at 2024-03-26T10:47:08Z by the European HFR Node." ;
:date_modified = "2024-03-26T10:47:08Z" ;
:processing_level = "2B" ;
:contributor_name = "MARIA ISABEL RUIZ, PABLO LORENTE;" ;
:contributor_role = "RESEARCH MANAGEMENT, MANAGEMENT" ;
:contributor_email = "maribel@puertos.es, plorente@puertos.es;" ;
:creator_name = "Lorenzo Corgnati" ;
:creator_email = "lorenzo.corgnati@sp.ismar.cnr.it" ;
:creator_url = "https://www.hfrnode.eu/" ;
:creator_type = "person" ;

:manufacturer = "Codar" ;
:sensor_model = "Codar" ;
:qc_manual = "Recommendation Report 2 on improved common procedures for HFR QC analysis: http://dx.doi.org/10.25607/OBP-944" ;
:doi = "" ;
:software_name = "EU_HFR_NODE_NRTprocessor" ;
:software_version = "v3" ;
:references = "Recommendation Report 2 on improved common procedures for HFR QC analysis: http://dx.doi.org/10.25607/OBP-944" ;
}

E. Total velocity data file header example

```
netcdf HFR-NAdr-Total_2024_03_26_1400 {
dimensions:
TIME = 1 ;
DEPTH = 1 ;
LATITUDE = 20 ;
LONGITUDE = 22 ;
MAXSITE = 150 ;
STRING4 = 4 ;
STRING8 = 8 ;
STRING14 = 14 ;
STRING35 = 35 ;
MAXINST = 50 ;
STRING81 = 81 ;
REFMAX = 1 ;
STRING142 = 142 ;
variables:
double TIME(TIME) ;
TIME:axis = "T" ;
TIME:long_name = "Time" ;
TIME:standard_name = "time" ;
TIME:units = "days since 1950-01-01T00:00:00Z" ;
TIME:calendar = "standard" ;
TIME:sdn_parameter_name = "Elapsed time (since 1950-01-01T00:00:00Z)" ;
TIME:sdn_parameter_urn = "SDN:P01::ELTJLD01" ;
TIME:sdn_uom_name = "Days" ;
TIME:sdn_uom_urn = "SDN:P06::UTAA" ;
TIME:ancillary_variables = "TIME_QC" ;
float DEPTH(DEPTH) ;
DEPTH:axis = "Z" ;
DEPTH:long_name = "Depth" ;
DEPTH:standard_name = "depth" ;
DEPTH:units = "m" ;
DEPTH:positive = "down" ;
DEPTH:reference = "sea_level" ;
DEPTH:sdn_parameter_name = "Depth below surface of the water body" ;
DEPTH:sdn_parameter_urn = "SDN:P01::ADEPZZ01" ;
DEPTH:sdn_uom_name = "Metres" ;
DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
DEPTH:ancillary_variables = "DEPTH_QC" ;
float LATITUDE(LATITUDE) ;
LATITUDE:axis = "Y" ;
```

LATITUDE:standard_name = "latitude" ;
LATITUDE:long_name = "Latitude" ;
LATITUDE:units = "degree_north" ;
LATITUDE:sdn_parameter_name = "Latitude north" ;
LATITUDE:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
LATITUDE:sdn_uom_name = "Degrees north" ;
LATITUDE:sdn_uom_urn = "SDN:P06::DEGN" ;
LATITUDE:grid_mapping = "crs" ;
LATITUDE:ancillary_variables = "POSITION_QC" ;
float LONGITUDE(LONGITUDE) ;
LONGITUDE:axis = "X" ;
LONGITUDE:standard_name = "longitude" ;
LONGITUDE:long_name = "Longitude" ;
LONGITUDE:units = "degree_east" ;
LONGITUDE:sdn_parameter_name = "Longitude east" ;
LONGITUDE:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
LONGITUDE:sdn_uom_name = "Degrees east" ;
LONGITUDE:sdn_uom_urn = "SDN:P06::DEGE" ;
LONGITUDE:grid_mapping = "crs" ;
LONGITUDE:ancillary_variables = "POSITION_QC" ;
short UACC(TIME, DEPTH, LATITUDE, LONGITUDE) ;
UACC:_FillValue = -32767s ;
UACC:long_name = "Accuracy of surface eastward sea water velocity" ;
UACC:units = "m s-1" ;
UACC:valid_min = -10000s ;
UACC:valid_max = 10000s ;
UACC:sdn_parameter_name = " " ;
UACC:sdn_parameter_urn = " " ;
UACC:sdn_uom_name = "Metres per second" ;
UACC:sdn_uom_urn = "SDN:P06::UVAA" ;
UACC:ancillary_variables = "QCflag VART_QC" ;
UACC:add_offset = 0. ;
UACC:scale_factor = 0.001 ;
short VACC(TIME, DEPTH, LATITUDE, LONGITUDE) ;
VACC:_FillValue = -32767s ;
VACC:long_name = "Accuracy of surface northward sea water velocity" ;
VACC:units = "m s-1" ;
VACC:valid_min = -10000s ;
VACC:valid_max = 10000s ;
VACC:sdn_parameter_name = " " ;
VACC:sdn_parameter_urn = " " ;
VACC:sdn_uom_name = "Metres per second" ;
VACC:sdn_uom_urn = "SDN:P06::UVAA" ;

VACC:ancillary_variables = "QCflag VART_QC" ;
VACC:add_offset = 0. ;
VACC:scale_factor = 0.001 ;
short GDOP(TIME, DEPTH, LATITUDE, LONGITUDE) ;
GDOP:_FillValue = -32767s ;
GDOP:long_name = "Geometrical dilution of precision" ;
GDOP:units = "1" ;
GDOP:valid_min = -20000s ;
GDOP:valid_max = 20000s ;
GDOP:comment = "The Geometric Dilution of Precision (GDOP) is the coefficient of the uncertainty, which relates the uncertainties in radial and velocity vectors. The GDOP is a unit-less coefficient, which characterizes the effect that radar station geometry has on the measurement and position determination errors. A low GDOP corresponds to an optimal geometric configuration of radar stations, and results in accurate surface current data. Essentially, GDOP is a quantitative way to relate the radial and velocity vector uncertainties. Setting a threshold on GDOP for total combination avoids the combination of radials with an intersection angle below a certain value. GDOP is a useful metric for filtering errant velocities due to poor geometry." ;
GDOP:sdn_parameter_name = "Dilution of precision " ;
GDOP:sdn_parameter_urn = "SDN:S06::S0600236" ;
GDOP:sdn_uom_name = "Dimensionless" ;
GDOP:sdn_uom_urn = "SDN:P06::UUUU" ;
GDOP:ancillary_variables = "QCflag GDOP_QC" ;
GDOP:add_offset = 0. ;
GDOP:scale_factor = 0.001 ;
byte DDNS_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;
DDNS_QC:_FillValue = -127b ;
DDNS_QC:long_name = "Data density threshold quality flag" ;
DDNS_QC:conventions = "EuroGOOS European HFR Node" ;
DDNS_QC:valid_min = 0b ;
DDNS_QC:valid_max = 9b ;
DDNS_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
DDNS_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
DDNS_QC:comment = " Data Density Threshold QC Test - Test applies to each vector. Threshold=[minimum number of contributing radial velocities=3]" ;
DDNS_QC:units = "1" ;
byte CSPD_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;
CSPD_QC:_FillValue = -127b ;
CSPD_QC:long_name = "Velocity threshold quality flag" ;
CSPD_QC:conventions = "EuroGOOS European HFR Node" ;
CSPD_QC:valid_min = 0b ;

CSPD_QC:valid_max = 9b ;
CSPD_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
CSPD_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
CSPD_QC:comment = " Velocity Threshold QC Test - Test applies to each vector. Threshold=[maximum velocity=1.0 (m/s)]" ;
CSPD_QC:units = "1" ;
byte VART_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;
VART_QC:_FillValue = -127b ;
VART_QC:long_name = "Variance threshold quality flag" ;
VART_QC:conventions = "EuroGOOS European HFR Node" ;
VART_QC:valid_min = 0b ;
VART_QC:valid_max = 9b ;
VART_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
VART_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
VART_QC:comment = " Variance Threshold QC Test - Test applies to each vector. Threshold=[maximum variance=1.0 (m2/s2)]" ;
VART_QC:units = "1" ;
byte GDOP_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;
GDOP_QC:_FillValue = -127b ;
GDOP_QC:long_name = "GDOP threshold quality flag" ;
GDOP_QC:conventions = "EuroGOOS European HFR Node" ;
GDOP_QC:valid_min = 0b ;
GDOP_QC:valid_max = 9b ;
GDOP_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
GDOP_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
GDOP_QC:comment = " GDOP Threshold QC Test - Test applies to each vector. Threshold=[GDOP threshold=2.0]" ;
GDOP_QC:units = "1" ;
byte QCflag(TIME, DEPTH, LATITUDE, LONGITUDE) ;
QCflag:_FillValue = -127b ;
QCflag:long_name = "Overall quality flag" ;
QCflag:conventions = "EuroGOOS European HFR Node" ;
QCflag:valid_min = 0b ;
QCflag:valid_max = 9b ;
QCflag:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;

QCflag:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
QCflag:comment = " Overall QC Flag - Test applies to each vector. Test checks if all QC tests are passed." ;
QCflag:units = "1" ;
short EWCT(TIME, DEPTH, LATITUDE, LONGITUDE) ;
EWCT:_FillValue = -32767s ;
EWCT:valid_min = -10000s ;
EWCT:valid_max = 10000s ;
EWCT:standard_name = "surface_eastward_sea_water_velocity" ;
EWCT:long_name = "Surface eastward sea water velocity" ;
EWCT:units = "m s-1" ;
EWCT:sdn_parameter_name = "Eastward velocity of water current in the water body" ;
EWCT:sdn_parameter_urn = "SDN:P01::LCEWZZ01" ;
EWCT:sdn_uom_name = "Metres per second" ;
EWCT:sdn_uom_urn = "SDN:P06::UVAA" ;
EWCT:ancillary_variables = "QCflag VART_QC CSPD_QC DDNS_QC GDOP_QC" ;
EWCT:add_offset = 0. ;
EWCT:scale_factor = 0.001 ;
short NSCT(TIME, DEPTH, LATITUDE, LONGITUDE) ;
NSCT:_FillValue = -32767s ;
NSCT:valid_min = -10000s ;
NSCT:valid_max = 10000s ;
NSCT:standard_name = "surface_northward_sea_water_velocity" ;
NSCT:long_name = "Surface northward sea water velocity" ;
NSCT:units = "m s-1" ;
NSCT:sdn_parameter_name = "Northward current velocity in the water body" ;
NSCT:sdn_parameter_urn = "SDN:P01::LCNSZZ01" ;
NSCT:sdn_uom_name = "Metres per second" ;
NSCT:sdn_uom_urn = "SDN:P06::UVAA" ;
NSCT:ancillary_variables = "QCflag VART_QC CSPD_QC DDNS_QC GDOP_QC" ;
NSCT:add_offset = 0. ;
NSCT:scale_factor = 0.001 ;
short crs ;
crs:grid_mapping_name = "latitude_longitude" ;
crs:epsg_code = "EPSG:4326" ;
crs:semi_major_axis = 6378137. ;
crs:inverse_flattening = 298.257223563 ;
byte NARX(TIME, MAXSITE) ;
NARX:_FillValue = -127b ;
NARX:long_name = "Number of receive antennas" ;
NARX:valid_min = 0b ;

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NARX:valid_max = 127b ;
NARX:units = "1" ;
NARX:sdn_parameter_name = "" ;
NARX:sdn_parameter_urn = "" ;
NARX:sdn_uom_name = "Dimensionless" ;
NARX:sdn_uom_urn = "SDN:P06::UUUU" ;
byte NATX(TIME, MAXSITE) ;
NATX:_FillValue = -127b ;
NATX:long_name = "Number of transmit antennas" ;
NATX:valid_min = 0b ;
NATX:valid_max = 127b ;
NATX:units = "1" ;
NATX:sdn_parameter_name = "" ;
NATX:sdn_parameter_urn = "" ;
NATX:sdn_uom_name = "Dimensionless" ;
NATX:sdn_uom_urn = "SDN:P06::UUUU" ;
int SLTR(TIME, MAXSITE) ;
SLTR:_FillValue = -2147483647 ;
SLTR:long_name = "Receive antenna latitudes" ;
SLTR:standard_name = "deployment_latitude" ;
SLTR:valid_min = -90000 ;
SLTR:valid_max = 90000 ;
SLTR:units = "degree_north" ;
SLTR:sdn_parameter_name = "Latitude north" ;
SLTR:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
SLTR:sdn_uom_name = "Degrees north" ;
SLTR:sdn_uom_urn = "SDN:P06::DEGN" ;
SLTR:add_offset = 0. ;
SLTR:scale_factor = 0.001 ;
int SLNR(TIME, MAXSITE) ;
SLNR:_FillValue = -2147483647 ;
SLNR:long_name = "Receive antenna longitudes" ;
SLNR:standard_name = "deployment_longitude" ;
SLNR:valid_min = -180000 ;
SLNR:valid_max = 180000 ;
SLNR:units = "degree_east" ;
SLNR:sdn_parameter_name = "Longitude east" ;
SLNR:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
SLNR:sdn_uom_name = "Degrees east" ;
SLNR:sdn_uom_urn = "SDN:P06::DEGE" ;
SLNR:add_offset = 0. ;
SLNR:scale_factor = 0.001 ;
int SLTT(TIME, MAXSITE) ;
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SLTT:_FillValue = -2147483647 ;
SLTT:long_name = "Transmit antenna latitudes" ;
SLTT:standard_name = "deployment_latitude" ;
SLTT:valid_min = -90000 ;
SLTT:valid_max = 90000 ;
SLTT:units = "degree_north" ;
SLTT:sdn_parameter_name = "Latitude north" ;
SLTT:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
SLTT:sdn_uom_name = "Degrees north" ;
SLTT:sdn_uom_urn = "SDN:P06::DEGN" ;
SLTT:add_offset = 0. ;
SLTT:scale_factor = 0.001 ;
int SLNT(TIME, MAXSITE) ;
SLNT:_FillValue = -2147483647 ;
SLNT:long_name = "Transmit antenna longitudes" ;
SLNT:standard_name = "deployment_longitude" ;
SLNT:valid_min = -180000 ;
SLNT:valid_max = 180000 ;
SLNT:units = "degree_east" ;
SLNT:sdn_parameter_name = "Longitude east" ;
SLNT:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
SLNT:sdn_uom_name = "Degrees east" ;
SLNT:sdn_uom_urn = "SDN:P06::DEGE" ;
SLNT:add_offset = 0. ;
SLNT:scale_factor = 0.001 ;
char SCDR(TIME, MAXSITE, STRING4) ;
SCDR:long_name = "Receive antenna codes" ;
SCDR:sdn_parameter_name = " " ;
SCDR:sdn_parameter_urn = " " ;
SCDR:sdn_uom_name = "Dimensionless" ;
SCDR:sdn_uom_urn = "SDN:P06::UUUU" ;
char SCDT(TIME, MAXSITE, STRING4) ;
SCDT:long_name = "Transmit antenna codes" ;
SCDT:sdn_parameter_name = " " ;
SCDT:sdn_parameter_urn = " " ;
SCDT:sdn_uom_name = "Dimensionless" ;
SCDT:sdn_uom_urn = "SDN:P06::UUUU" ;
char SDN_CRUISE(TIME, STRING8) ;
SDN_CRUISE:long_name = "Grid grouping label" ;
char SDN_STATION(TIME, STRING14) ;
SDN_STATION:long_name = "Grid label" ;
char SDN_LOCAL_CDI_ID(TIME, STRING35) ;
SDN_LOCAL_CDI_ID:long_name = "SeaDataNet CDI identifier" ;
```

short SDN_EDMO_CODE(TIME, MAXINST) ;
SDN_EDMO_CODE:_FillValue = -32767s ;
SDN_EDMO_CODE:long_name = "European Directory of Marine Organisations code for the CDI partner" ;
SDN_EDMO_CODE:units = "1" ;
char SDN_REFERENCES(TIME, STRING81) ;
SDN_REFERENCES:long_name = "Usage metadata reference" ;
char SDN_XLINK(TIME, REFMAX, STRING142) ;
SDN_XLINK:long_name = "External resource linkages" ;
byte TIME_QC(TIME) ;
TIME_QC:_FillValue = -127b ;
TIME_QC:long_name = "Time quality flag" ;
TIME_QC:conventions = "EuroGOOS European HFR Node" ;
TIME_QC:valid_min = 0b ;
TIME_QC:valid_max = 9b ;
TIME_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
TIME_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
TIME_QC:comment = "Quality flagging for temporal coordinate." ;
TIME_QC:units = "1" ;
byte POSITION_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;
POSITION_QC:_FillValue = -127b ;
POSITION_QC:long_name = "Position quality flag" ;
POSITION_QC:conventions = "EuroGOOS European HFR Node" ;
POSITION_QC:valid_min = 0b ;
POSITION_QC:valid_max = 9b ;
POSITION_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
POSITION_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;
POSITION_QC:comment = "Quality flagging for position coordinates." ;
POSITION_QC:units = "1" ;
byte DEPTH_QC(TIME) ;
DEPTH_QC:_FillValue = -127b ;
DEPTH_QC:long_name = "Depth quality flag" ;
DEPTH_QC:conventions = "EuroGOOS European HFR Node" ;
DEPTH_QC:valid_min = 0b ;
DEPTH_QC:valid_max = 9b ;
DEPTH_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
DEPTH_QC:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed value_below_detection nominal_value interpolated_value missing_value" ;

DEPTH_QC:comment = "Quality flagging for depth coordinate." ;
DEPTH_QC:units = "1" ;

// global attributes:
:site_code = "HFR-NAdr" ;
:platform_code = "HFR-NAdr-Total" ;
:data_mode = "R" ;
:doa_estimation_method = "AURI: Beam Forming, IZOL: Beam Forming, PIRA: Beam Forming, TRI1: Beam Forming" ;
:calibration_type = "AURI: Full, IZOL: Full, PIRA: Full, TRI1: Full" ;
:last_calibration_date = "AURI: 2015-01-12T00:00:00Z, IZOL: 2023-01-01T00:00:00Z, PIRA: 2015-01-10T00:00:00Z, TRI1: 2022-07-10T00:00:00Z" ;
:calibration_link = "AURI: ddeponte@ogs.it, IZOL: branko.cermelj@nib.si, PIRA: matjaz.licer@gov.si, TRI1: simone.martini@apra.fvg.it; radar.hfl@arpa.fvg.it" ;
:title = "Near Real Time Surface Ocean Total Velocity by HFR-NAdr-Total" ;
:summary = "The data set consists of maps of total velocity of the surface current in the Gulf of Trieste (Northern Adriatic Sea) averaged over a time interval of 30 minutes. Surface ocean velocities estimated by HF Radar are representative of the upper 0.3-2.5 meters of the ocean." ;
:source = "coastal structure" ;
:source_platform_category_code = "17" ;
:institution = "Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, NIB - Nacionalni inštitut za biologijo, Ministry of the Environment, Climate and Energy, Slovenian Environment Agency - ARSO, ARPA FVG" ;
:institution_edmo_code = "120, 1229, 1755, 1010" ;
:institution_references = "https://www.ogs.it/, http://nettuno.ogs.trieste.it/jungo/hazadr/wera.html, https://www.nib.si/mbp/en/oceanographic-data-and-measurements/other-oceanographic-data/hf-radar-2, https://www.arso.gov.si/, https://www.osmer.fvg.it/mare.php?ln=" ;
:data_assembly_center = "European HFR Node" ;
:id = "HFR-NAdr-Total_2024-03-26T14:00:00Z" ;
:project = "" ;
:project_edmerp_code = "" ;
:naming_authority = "eu.hfrnode" ;
:keywords = "OCEAN CURRENTS, SURFACE WATER, RADAR, SCR-HF" ;
:keywords_vocabulary = "GCMD Science Keywords" ;
:comment = "Total velocities are derived using least square fit that maps radial velocities measured from individual sites onto a cartesian grid. The final product is a map of the horizontal components of the ocean currents on a regular grid in the area of overlap of two or more radar stations." ;
:data_language = "eng" ;
:data_character_set = "utf8" ;
:metadata_language = "eng" ;

:metadata_character_set = "utf8" ;
:metadata_contact = "lorenzo.corgnati@sp.ismar.cnr.it" ;
:metadata_date_stamp = "2024-03-26T15:05:05Z" ;
:topic_category = "oceans" ;
:network = "GULF OF TRIESTE (GOT)" ;
:data_type = "HF radar total current data" ;
:geospatial_lat_min = "45.5269" ;
:geospatial_lat_max = "45.7833" ;
:geospatial_lat_resolution = "1.5" ;
:geospatial_lat_units = "degree_north" ;
:geospatial_lon_min = "13.375" ;
:geospatial_lon_max = "13.7806" ;
:geospatial_lon_resolution = "1.5" ;
:geospatial_lon_units = "degree_east" ;
:geospatial_vertical_min = "0" ;
:geospatial_vertical_max = "0.48720900946498574" ;
:geospatial_vertical_positive = "down" ;
:geospatial_vertical_resolution = "0.48720900946498574" ;
:geospatial_vertical_units = "m" ;
:time_coverage_start = "2024-03-26T13:45:00Z" ;
:time_coverage_end = "2024-03-26T14:15:00Z" ;
:time_coverage_resolution = "PT30M" ;
:time_coverage_duration = "PT30M" ;
:area = "Mediterranean Sea - Gulf of Trieste (GOT)" ;
:reference_system = "EPSG:4326" ;
:cdm_data_type = "grid" ;
:format_version = "v3" ;
:Conventions = "CF-1.11, EuroGOOS European HFR Node" ;
:netcdf_format = "NETCDF4_CLASSIC" ;
:netcdf_version = "4.9.3" ;
:update_interval = "void" ;
:citation = "These data were collected and made freely available by the EuroGOOS European HFR Node. These data was collected and made freely available by OGS, ARPA FVG, NIB and ARSO and the programs that contribute to it. Data is processed by OGS, ARPA FVG, NIB and ARSO." ;
:distribution_statement = "These data are public and free of charge. User assumes all risk for use of data. User must display citation in any publication or product using data. User must contact PI prior to any commercial use of data." ;
:publisher_name = "European HFR Node" ;
:publisher_url = "https://www.hfrnode.eu/" ;
:publisher_email = "euhfrnode@azti.es" ;
:license = "HF radar sea surface current velocity dataset by OGS, NIB and ARSO is licensed under the access to the data and usage are as specified in the SeaDataNet data

policy and licence agreement (https://www.seadatanet.org/content/download/1695/file/SeaDataNet%20Data%20Policy.pdf)." ;
:acknowledgment = "The HF Radar Network network has been designed,implemented and managed throughthe efforts of OGS-Trieste, ARPA FVG, NIB-Slovenia and ARSO-Slovenia." ;
:date_created = "2024-03-26T15:05:05Z" ;
:history = "Data collected at 2024-03-26T14:00:00Z. netCDF file created at 2024-03-26T15:05:05Z by the European HFR Node." ;
:date_modified = "2024-03-26T15:05:05Z" ;
:processing_level = "3B" ;
:contributor_name = " Laura Ursella, Branko Čermelj, Daniela Turk; Matjaž Ličer, Cardin Vanessa, Davide Lombardo, Deponte Davide, Simone Martini, Federico Pittaluga, Giorgio Bolzon, Damir Dezeljin" ;
:contributor_role = "Principal investigator, Principal investigator, Principal investigator, investigator, investigator, investigator, radar technician, investigator, radar technician, data manager, data manager;" ;
:contributor_email = "lursella@ogs.it, branko.cermelj@nib.si, daniela.turk@gov.si, Matjaz.Licer@nib.si, vcardin@ogs.it, dlombardo@ogs.it, ddeponte@ogs.it, simone.martini@arpa.fvg.it, federico.pittaluga@arpa.fvg.it, gbolzon@ogs.it, damir.dezeljin@dezo.org" ;
:creator_name = "Lorenzo Corgnati" ;
:creator_email = "lorenzo.corgnati@sp.ismar.cnr.it" ;
:creator_url = "https://www.hfrnode.eu/" ;
:creator_type = "person" ;
:manufacturer = "AURI: WERA, IZOL: WERA, PIRA: WERA, TRI1: WERA" ;
:sensor_model = "AURI: WERA, IZOL: WERA, PIRA: WERA, TRI1: WERA" ;
:qc_manual = "Recommendation Report 2 on improved common procedures for HFR QC analysis: http://dx.doi.org/10.25607/OBP-944" ;
:doi = "" ;
:software_name = "EU_HFR_NODE_NRTprocessor" ;
:software_version = "v3" ;
:references = "Recommendation Report 2 on improved common procedures for HFR QC analysis: http://dx.doi.org/10.25607/OBP-944" ;
}