SeaDataNet data management protocols for HF Radar data

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Deliverable number	Short title
D9.12	SDN protocols for HF Radar data

Long title

SeaDataNet data management protocols for HF Radar data

Short description

This document specifies the QC standard procedures, the standard interoperable data and metadata format and the derived CDI metadata format for historical radial and total velocity data measured by HF Radars. These standard procedures and formats are necessary for the ingestion of historical HF Radar current data into SDN catalogues.

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History

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0.2	A. Novellino (ETT), R. Cramer (BODC)	2019-03-16	General revision of the document
1.0	L. Corgnati (CNR)	2019-03-22	Revision of the document structure
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1.3	S. Jousset (SHOM), V. Cariou (SHOM)	2019-05-02	General revision of the document
1.4	M. Fichaut (IFREMER)	2019-05-02	Final edits
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1. Introduction

High Frequency Radar (HFR) is the unique land-based remote sensing technology that allows the mapping of sea currents fields over wide areas with high spatial and temporal resolution. HFR products are applied in many sectors such as research in coastal oceanography and marine environment, safety, coastal management, fishery, navigation and renewable energy (Paduan and Washburn, 2013, Rubio et al., 2017, Corgnati et al., 2018, Sciascia et al., 2019). Already identified as a relevant emerging technology in the framework of Global Ocean Observation System, HFR data are going to be systematically assimilated by models for forecast assessment and adjustment.

In the last decade, HFR technology has started rapidly expanding in Europe. The European HFR network, with over 62 HFR antennas currently operating and a number in the planning stage (Rubio et al, 2017) and with a growing rate of 7 new systems per year since 2016, is the second widest worldwide.

In 2014, EuroGOOS launched the HFR Task Team to achieve the harmonization of system requirements and design, data quality and standardization of HFR data access and tools. In 2015, a pilot action coordinated by EMODnet Physics, begun to develop a strategy for assembling HFR metadata and data products within Europe in a uniform way to make them easily accessible, and more interoperable. Recently, the Copernicus Marine Environment Monitoring Service (CMEMS) Service Evolution Call supported the INCREASE project, which set the bases for the integration of existing European HFR operational systems into the CMEMS-INSTAC (In Situ Thematic Assembly Center). In parallel, EU project JERICO-NEXT is working to provide procedures and methodologies to enable HFR data to comply with the international standards regarding their quality and metadata, within the overall goal of integrating the European coastal observatories.

The results of these integrated efforts is the de-facto establishment of the European HFR Network Node (EU HFR NN). This infrastructure (hardware, software and expertise) is enabling the HFR data management and dissemination according to common standards and common formats. The operational Near Real Time (NRT) data stream from HFR is already included in EMODnet Physics (since 2015) and in CMEMS-INSTAC (since April 2019). The European common data and metadata model for NRT HFR-derived current data is defined and implemented, compliant with Climate and Forecast Metadata Convention version 1.6 (CF-1.6), OceanSITES convention, CMEMS-INSTAC requirements and INSPIRE directive. Furthermore, the list of the Quality Control (QC) tests to be applied to NRT HFR current data is defined according to both the (European) DATAMEQ working group recommendations on real-time Quality Check procedures and the Quality Assurance/Quality Control of Real-Time Oceanographic Data (QARTOD) manual defined by the US Integrated Ocean Observing System (IOOS).

In this framework, it was decided to adopt the SeaDataNet infrastructure for the integration and long-term preservation of historical time series from HFR, which was undertaken as part of the EU SeaDataCloud project. This activity includes the definition and mapping of the Common Data Index (CDI) derived metadata formats and QC standard procedures for historical HFR data management.

By supervising the full HFR data management chain, the EU HFR NN can assure central archiving, homogenized protocols for data distribution, development of standards for quality assurance, control and data structures. The EU HFR NN acts as the focal point with European HFR data providers, the key EU networking infrastructures and the Global HFR network.

This document describes the activities carried on under the coordination of the EU HFR NN and in collaboration with the European, US and Australian HFR community for the definition of the QC standard procedures, the standard interoperable data and metadata format and the derived CDI metadata format for historical radial and total velocity data measured by HF Radars. These standard procedures and formats will enable the ingestion of historical HFR current data into SDN catalogues.

2. Background and definitions

SeaDataCloud (SDC) is the project that is updating and extending the marine information system infrastructure developed by the SeaDataNet (SDN) network of National Oceanographic Data Centres (NODCs) under the previous EU SeaDataNet projects.

SDC project is based on the SDN infrastructure, with the aim to make data accessible and via a cloud environment and allow processing in a cloud VRE, and as such has the name SeaDataCloud.

Whilst there is potential for confusion, the terms SDN and SeaDataCloud can simply be distinguished: SeaDataNet is the community/network and the infrastructure, while SeaDataCloud is the current project undertaken by the SDN network for upgrading its standards and infrastructure. For this reason we speak about SDN community standards. SDN introduced mandatory aspects for data file format specifications under the SDN namespace (beginning with SDN_). This terminology has been respected, i.e. with the SDN mandatory variable, and global, attributes that are all under the SDN namespace - prefixed with SDN_.

The SDC project defines the data file format used for data exchange in SDN framework. As an example, for profile, trajectory and time-series data feature types, ODV (Ocean Data View) and NetCDF format are mandatory, whereas MEDATLAS is optional. For gridded data format, i.e. the HFR data file format, several aspects have to be considered in the definition of the SDN HFR grid format:

i) Conventions already exist that are producing gridded data that is Climate and Forecast (CF) compliant.

ii) The types of grid will likely expand over time; we are referring here to simple geographic grids or such grids as a depth profile along a track.

iii) The distributed data model of SDN is complemented as part of SeaDataCloud by a Replication Manager and a SeaDataCloud Import Manager that facilitate the replication of unrestricted data to the cloud, and restricted data from the centre to the user via the cloud. In practice this means that SeaDataCloud will be able to validate the data files in the cloud, which it was unable to do previously.

iv) The SeaDataCloud Replication Manager may currently expect Profile data to be available as ODV or netCDF files. The ODV files are tightly defined as such that a netCDF file may be converted into a SDN ODV profile file by the loss of non-mandatory metadata (variable and global attributes). ODV is for profiles/timeseries only. There is no SeaDataNet ODV grid specification.

As stated in SDC deliverable D8.6b “Datafile formats netCDF-CF grid”, the only mandatory data transport format for grid feature type is the NetCDF format. HFR data are gridded data remotely sensed by fixed coastal land-based platforms, thus the only mandatory data transport format for HFR data is the NetCDF format.

Recommendations:

i) This specification aims to reduce complexity and keep things as simple as possible. In particular, work already carried out under the SDN profile data transport file formats is respected as much as possible:

   a) the SDN extensions to CF are used,

   b) the spatio-temporal considerations are respected where possible,

   c) the spatio-temporal considerations are allowed to be freer when other existing conventions require it,

d) variables are required for SDN_LOCAL_CDI_ID and SDN_EDMO_CODE.

ii) The file format should use the netCDF-4 classic model, although the use of netCDF-3 is allowed, especially since it may be in use for existing data files and/or conventions.

iii) The CF extensions for parameters and their units must make use of the NERC Vocabulary Service (version 2).

iv) Being a component of SeaDataNet, whilst metadata may be allowed within the netCDF grid file (particularly if it comes from other conventions), it is mandatory for each gridded data file to have an associated SeaDataNet Common Data Index (CDI) record.

v) In order to aid in data discovery through the SeaDataNet CDI records, all grid files may only contain one spatial definition; multiple grids within a grid file (e.g. geographic grids separated by a depth or time component) are allowed, although it is recommended that these are separated into separate files:

a) to provide a better level of data discovery granularity,

b) to reduce the individual file sizes,

c) improve the potential work flow using these data files.

3. Vocabulary URN versioning

In line with the SDN data file formats for profiles, the SeaDataNet data file format for grids makes use of Version 2 of the NERC Vocabulary server (NVS2) http://seadatanet.maris2.nl/v_bodc_vocab_v2/welcome.asp. Since the NVS1 has been deprecated, use of NVS2 is mandatory.

4. Current SeaDataNet metadata catalogues

The current SeaDataNet (SDN) metadata catalogues are listed below, with abbreviations used within this document.

- **Common Data Index (CDI)** - provides users with a highly detailed insight in the availability and geographical spreading of marine data sets that are managed by the SDN data centres.
- **Cruise Summary Report (CSR)** - reports on cruises or field experiments at sea.
- **European Directory of the Initial Ocean-Observing Systems (EDIOS)** - overview of the ocean measuring and monitoring systems operated by European countries.
- **European Directory of Marine Environmental Data (EDMED)** - comprehensive reference to the marine data sets and collections held within European research laboratories.
- **European Directory of Marine Environmental Research Projects (EDMERP)** - marine research projects in Europe.
- **European Directory of Marine Organisations (EDMO)** - addresses and activity profiles of organisations within the European marine sphere.

SDN metadata entries are XML files to be prepared using MIKADO software (available with documentation at https://www.seadatanet.org/Software/MIKADO). Entries have to be mailed to sdn-userdesk@seadatanet.org for ingestion.

5. Long term stewardship of HFR data historical timeseries

In line with one of the main objectives of the current work package, i.e. to expand SeaDataNet capability for handling different data types, this document details the activities carried on towards the integration and long-term preservation of historical time series from HFR data into the SeaDataNet infrastructure.

The European common QC, data and metadata models for Near Real Time (NRT) HFR data have been implemented according to the standards of the Open Geospatial Consortium (OGC) for access and delivery of geospatial data, and are compliant with the Climate and Forecast Metadata Convention CF-1.6, with the Unidata NetCDF Attribute Convention for Data Discovery (ACDD), with the OceanSITES convention, with the CMEMS IN-SITU TAC conventions (Copernicus-InSituTAC-SRD-1.3.1, CopernicusInSituTAC-ParametersList-3.1.0) and with the INSPIRE directive. The definition of the European common data and metadata model for real-time HFR data follows the guidelines of the DATAMEQ working group and fulfills the recommendations given by the Radiowave Operators Working Group (US ROWG).

The model specifies the file format, the global attribute scheme, the dimensions, the coordinate, data and Quality Control (QC) variables and their syntax, the QC procedures and the flagging policy.

The chosen file format is the **netCDF-4 classic model** with the recommended implementation based on the community-supported CF-1.6.

Global attributes from Unidata's NetCDF Attribute Convention for Data Discovery (ACDD) are implemented and they are divided in three categories:

- **Mandatory Attributes** for compliance with CF-1.6, OceanSITES and CMEMS IN-SITU TAC conventions;
- **Recommended Attributes** for compliance with INSPIRE directive;
- **Suggested Attributes** that can be relevant in describing the data.

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

Variables are divided in three categories:

- **Coordinate Variables** orienting the data in time and space (they may be dimension variables or auxiliary coordinates);
- **Data Variables** containing the actual measurements and information about how they were obtained;
- **QC variables** containing the Quality Control flag values resulting from the QC tests performed on the data.

Variable short names from the SeaDataNet (SDN) P09 controlled vocabulary are used. CF-1.6 standard_names are required, when available.

Please refer to the EU H2020 project Jerico-Next deliverable D5.13 (http://www.jerico-ri.eu/download/jerico-next-deliverables/JERICO-NEXT-Deliverable-5.13_V1.pdf) for the full description of the first release of the European common QC, data and metadata model for NRT HFR current data.

For the definition of the QC model, a battery of mandatory QC tests has also been defined, in order to ensure the delivery of high quality data, to describe in a quantitative way the accuracy of the physical

information and to detect suspicious or unreliable data. Please refer to Section 8 for details about the European common QC model.

6. Mapping the HFR data and metadata model to CDI

In order to define standard interoperable data and Common Data Index (CDI) derived metadata formats for historical HFR current data, the structure of the European common data and metadata model for NRT HFR current data has been mapped on the structure of the SDN Common Data Index.

This mapping checks for the presence in the HFR standard data model of the attributes and elements required by the CDI scheme and to identify the gaps to be filled for the implementation of an automatic procedure for the creation of the CDIs of historical HFR current datasets.

Table 1 details the aforementioned mapping, highlighting the attributes and elements already present in the HFR data model and the ones to be added to the model in order to comply with the CDI scheme. The CDI mandatory fields are reported in bold characters. The table also reports the variable reference within MIKADO software (column 2).

CDI FIELD	MIKADO var	HFR data model attribute
cdi-identifier	**$**	id
ISO 19139 header xml header	**not available**	default
METADATA CREATING ORGANISATION	**var01**	institution_edmo_code
METADATA CREATION-DATE	**not available**	date_created
Metadata Standard Name	**not available**	default
Metadata Standard Version	**not available**	default
MEASURING AREA TYPE	**var02**	feature_type
SPATIAL REPRESENTATION HORIZONTAL RESOLUTION VERTICAL RESOLUTION TIME RESOLUTION	 var47, var48 var45, var46 var21, var22	 grid_resolution geospatial_vertical_resolution time_coverage_resolution
DATUM OF COORDINATE SYSTEM	var03	reference_system
Metadata Extension info	**not available**	default
NAME/ALTERNATIVE NAME OF THE DATASET	**var04**	title
DATASET-ID	**var05**	id
REVISION-DATE OF DATASET	**var06**	date_modified
IDENTIFIER	**$**	id
ORIGINATORS OF THE DATASET	**var07**	institution_edmo_code
ABSTRACT ON DATASET	**var08**	summary
ORGANISATION MANAGING THE DATASET	**var09**	institution_edmo_code
RESOURCE MAINTENANCE	not available	update_interval
INSPIRE reference	**not available**	default values

CDI FIELD	MIKADO var	HFR data model attribute
PARAMETERS	**var10**	P02 keywords: RFVL, ACFL
INSTRUMENT and POSITIONING SYSTEM	var11	L05 code 303 (surface current radars)
PLATFORM	**var12**	source, source_platform_category_code
PROJECTS	var13	project (EDMERP codes)
Use Limitation	**not available**	text description of limit of use
DATASET ACCESS RESTRICTIONS	**var14**	"LS" (License SeaDataNet) or "UN" (Unrestricted) if it is preferred
STATION NAME and/or CRUISE NAME	**var15** **var16** **var17** **var18** **var19** **var20**	cruise name = site_code station name = platform_code
EDMED REFERENCE	var80	EDMED codes
CSR Reference	var81	Not applicable
SPATIAL RESOLUTION	var45, var46	grid_resolution (for total data)
Dataset Language	**not available**	data_language
Character set	**not available**	"utf8"
Main theme of the dataset	**not available**	"oceans"
GEOGRAPHICAL COVERAGE **WEST** **EAST** **SOUTH** **NORTH**	 **var24** **var25** **var26** **var27**	 geospatial_lon_min geospatial_lon_max geospatial_lat_min geospatial_lat_max
TRACKS (Curves)	var60 var62 var63	Not applicable
AREAS (surfaces)	var70 var72 var73	Not applicable

CDI FIELD	MIKADO var	HFR data model attribute
START AND END DATE (AND TIME)	**var28** **var29**	time_coverage_start time_coverage_end
MINIMUM DEPTH OF OBSERVATION MAXIMUM DEPTH OF OBSERVATION WATER DEPTH VERTICAL DATUM	var30 var31 var35 var34	geospatial_vertical_min geospatial_vertical_max geospatial_vertical_units vertical datum
ORGANISATION DISTRIBUTING THE DATASET	**var36**	institution_edmo_code
Dataformat version	**var37** **var38**	"CF4"
DISTRIBUTION INFO / SERVICE BINDINGS **Data size** **Distribution website** **Distribution protocol** **Database reference** **Distribution method**	 **var39** **var40** **var42** **var41** **var43**	Link to THREDDS catalog
Data Quality Information Scope Report – Name Report – Date Report – Comment Report – Status Lineage	 not available var95 var96 var97 var98 not available	 processing_level list of each QC test applied on data with related date

Table 1: Mapping of the SDN CDI scheme with the European common data and metadata model. The CDI mandatory fields are reported in bold characters. The table also reports the variable reference within MIKADO software (column 2).

Table 1 shows that all the information needed to fill the CDI fields are either present in the European common data and metadata model or are fixed string specific to the HFR measurements. Thus, the integration of HFR CDI is formally accomplished and it is practically realized via the software tools created for the automatic creation of the CDIs of historical HFR current datasets. The code of these tools is attached to the deliverable and it is shared on public repository.

7. Mapping the HFR data and metadata model to SDN data transport format requirements

The integration and long-term preservation of historical time series from HFR data into the SeaDataNet infrastructure require, besides the definition and the operational creation of standard interoperable CDI derived metadata, the operational generation of historical HFR datasets complying with the SDN data transport format requirements. Since the only mandatory data transport format for grid feature type is the NetCDF format, the structure of the European common data and metadata model for NRT HFR current data has been mapped towards the structure of the SDN CF extension requirements.

This mapping checks for the presence in the HFR standard data model of the attributes, data and syntax elements required by the SDN CF extension and to identify the gaps to be filled for the definition and implementation of the HFR-specific SDN data transport format.

7.1. Global attributes

Table 2 details the mapping of the global attributes between the two profiles. The table details which attributes have to be added into the HFR netCDF data profile for SDN compliance (yellow highlight), which attributes are present in the SDN CDI profile (green highlight), which attributes are mandatory for the SDN CDI profile (orange highlight), which attributes are mandatory for the specific CF profile (purple highlight).

Global Attribute	NRT HFR CF profile	SDC CF extension profile
site_code	Mandatory	CDI CRUISE NAME
platform_code	Mandatory	CDI STATION NAME
data_mode	Mandatory	
DoA_estimation_method	Mandatory	
calibration_type	Mandatory	
last_calibration_date	Mandatory	
calibration_link	Mandatory	
title	Mandatory	CDI NAME/ALTERNATIVE NAME OF THE DATASET
summary	Mandatory	CDI ABSTRACT ON DATASET
source	Mandatory	CDI PLATFORM
source_platform_category_code	Mandatory	CDI PLATFORM
institution	Mandatory	
institution_edmo_code	Mandatory	CDI METADATA CREATING ORGANISATION, ORIGINATORS OF THE DATASET, ORGANISATION MANAGING THE DATASET, ORGANISATION DISTRIBUTING THE DATASET
data_assembly_center	Mandatory	
naming_authority	Recommended	
id	Mandatory	CDI cdi-identifier, DATASET-ID, IDENTIFIER
project	Mandatory	CDI PROJECTS (EDMERP code)
keywords	Recommended	
keywords_vocabulary	Recommended	
comment	Recommended	
data_language	INSPIRE	CDI ISO 19139 header xml header
data_character_set	INSPIRE	
metadata_language	INSPIRE	
metadata_character_set	INSPIRE	
topic_category	INSPIRE	
network		

Global Attribute	NRT HFR CF profile	SDC CF extension profile
data_type	Mandatory	
feature_type	Mandatory	MEASURED AREA TYPE
area	Recommended	
geospatial_lat_min	Mandatory	CDI GEOGRAPHICAL COVERAGE SOUTH
geospatial_lat_max	Mandatory	CDI GEOGRAPHICAL COVERAGE NORTH
geospatial_lat_units	Recommended	
geospatial_lat_resolution	Recommended	
geospatial_lon_min	Mandatory	CDI GEOGRAPHICAL COVERAGE WEST
geospatial_lon_max	Mandatory	CDI GEOGRAPHICAL COVERAGE EAST
geospatial_lon_units	Recommended	
geospatial_lon_resolution	Recommended	
geospatial_vertical_min	Mandatory	CDI MINIMUM DEPTH OF OBSERVATION
geospatial_vertical_max	Mandatory	CDI MAXIMUM DEPTH OF OBSERVATION
geospatial_vertical_positive	Recommended	
geospatial_vertical_units	Mandatory	CDI MINIMUM DEPTH OF OBSERVATION AND MAXIMUM DEPTH OF OBSERVATION
geospatial_vertical_resolution	Mandatory	CDI SPATIAL REPRESENTATION VERTICAL RESOLUTION
time_coverage_start	Mandatory	CDI START AND END DATE (AND TIME)
time_coverage_end	Mandatory	CDI START AND END DATE (AND TIME)
time_coverage_duration	Recommended	
time_coverage_resolution	Mandatory	CDI SPATIAL REPRESENTATION TIME RESOLUTION
cdm_data_type	Recommended	
reference_system	Mandatory	CDI DATUM OF COORDINATE SYSTEM
grid_resolution	Mandatory	CDI SPATIAL RESOLUTION
format_version	Mandatory	
Conventions	Mandatory	Mandatory
netcdf_version	Recommended	

Global Attribute	NRT HFR CF profile	SDC CF extension profile
netcdf_format		
update_interval	Mandatory	CDI RESOURCE MAINTENANCE
citation	Mandatory	
distribution_statement	Mandatory	
publisher_name	Mandatory	
publisher_email	Mandatory	
publisher_url	Mandatory	
license	Mandatory	
acknowledgment	Mandatory	
creator_name	Recommended	
creator_email	Recommended	
creator_url	Recommended	
references	Recommended	
date_created	Mandatory	CDI METADATA CREATION-DATE
history	Mandatory	
date_modified	Mandatory	REVISION DATE OF DATASET
date_update	TO BE ADDED equal to date_modified	Mandatory
date_issued		
processing_level	Mandatory	
contributor_name	Mandatory	
contributor_role	Mandatory	
contributor_email	Mandatory	

Table 2: Mapping of the global attributes between the European common data and metadata model for NRT HFR current data and the SDN CF extension profile. The yellow highlight means that the element has to be added into the HFR netCDF profile for SDN compliance, the green highlight means that the element is present in the SDN CDI profile, the orange highlight means that the element is mandatory in the SDN CDI profile, the purple highlight means that the element is mandatory in CF profile.

7.2. Dimensions and coordinate variables

Table 3 reports the mapping of the coordinate variables between the European common data and metadata model for NRT HFR data and the SDN data transport format profile. The table details which elements have to be added into the HFR netCDF data profile for SDN compliance (yellow highlight), which elements have to be added into the SDN netCDF data profile for HFR data (blue highlight), which elements are present in the SDN CDI profile (green highlight), which elements are mandatory for the SDN CDI profile (orange highlight), which elements are mandatory for the specific CF profile (purple highlight).

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Variable name	NRT HFR CF profile	SDC CF extension profile
Radial and Total Velocity data		
TIME:standard_name	"time"	“time”
TIME:units	"days since 1950-01-01T00:00:00Z"	(1) “days since -4713-01-01T00:00:00Z” or (2) UT as ISO8601 format
TIME:axis	"T"	“T”
TIME:long_name	"time of measurement UTC"	“Chronological Julian Date”
TIME:calendar	"Julian"	“julian”
TIME:sdn_parameter_urn	TO BE ADDED as “SDN:P01::ELTJLD01”	“SDN:P01::ELTJLD01”
TIME:sdn_parameter_name	TO BE ADDED as “Elapsed time (since 1950-01-01T00:00:00Z)”	“Elapsed time (since 1950-01-01T00:00:00Z)”
TIME:sdn_uom_urn	TO BE ADDED as “SDN:P06::UTAA”	“SDN:P06::UTAA”
TIME:sdn_uom_name	TO BE ADDED as "Days"	“Days”
TIME:bounds		
TIME:valid_min		CF optional
TIME:valid_max		CF optional
TIME:QC_indicator		OceanSites optional
TIME:QC_procedure		OceanSites optional

Variable name	NRT HFR CF profile	SDC CF extension profile
TIME:ancillary_variables	TO BE ADDED as “TIME_SEADATANET_QC"	“TIME_SEADATANET_QC”
TIME:comment		
LATITUDE:standard_name	"latitude"	“latitude”
LATITUDE:units	"degrees_north"	“degrees_north”
LATITUDE:axis	"Y"	“Y”
LATITUDE:long_name	"Latitude"	“Latitude”
LATITUDE:reference	"WGS84"	
LATITUDE:valid_min		CF optional
LATITUDE:valid_max		CF optional
LATITUDE:ancillary_variables	TO BE ADDED as “POSITION_SEADATANET_QC"	“POSITION_SEADATANET_QC”
LATITUDE:sdn_parameter_urn	TO BE ADDED as “SDN:P01::ALATZZ01”	“SDN:P01::ALATZZ01”
LATITUDE:sdn_parameter_name	TO BE ADDED as "Latitude north"	"Latitude north"
LATITUDE:sdn_uom_urn	TO BE ADDED as “SDN:P06::DEGN”	“SDN:P06::DEGN”
LATITUDE:sdn_uom_name	TO BE ADDED as "Degrees north"	"Degrees north"
LATITUDE:grid_mapping	TO BE ADDED as "crs"	“crs”
LATITUDE:QC_indicator		OceanSites optional
LATITUDE:QC_procedure		OceanSites optional

Variable name	NRT HFR CF profile	SDC CF extension profile
LATITUDE:uncertainty		OceanSites optional
LATITUDE:comment		OceanSites optional
LONGITUDE:standard_name	"longitude"	"longitude"
LONGITUDE:units	"degrees_east"	"degrees_east"
LONGITUDE:axis	"X"	"X"
LONGITUDE:long_name	"Longitude"	"Longitude"
LONGITUDE:reference	"WGS84"	
LONGITUDE:valid_min		CF optional
LONGITUDE:valid_max		CF optional
LONGITUDE:ancillary_variables	TO BE ADDED as “POSITION_SEADATANET_QC"	“POSITION_SEADATANET_QC”
LONGITUDE:sdn_parameter_urn	TO BE ADDED as ”SDN:P01::ALONZZ01”	”SDN:P01::ALONZZ01”
LONGITUDE:sdn_parameter_name	TO BE ADDED as "Longitude east"	"Longitude east"
LONGITUDE:sdn_uom_urn	TO BE ADDED as “SDN:P06::DEGE”	“SDN:P06::DEGE”
LONGITUDE:sdn_uom_name	TO BE ADDED as "Degrees east"	"Degrees east"
LONGITUDE:grid_mapping	TO BE ADDED as "crs"	"crs"
LONGITUDE:QC_indicator		OceanSites optional
LONGITUDE:QC_procedure		OceanSites optional

Variable name	NRT HFR CF profile	SDC CF extension profile
LONGITUDE:uncertainty		OceanSites optional
LONGITUDE:comment		OceanSites optional
DEPH:standard_name	"depth"	
DEPH:units	"m"	
DEPH:positive	"down"	
DEPH:axis	"Z"	
DEPH:reference	"sea_level"	
DEPH:long_name	"Depth of measurement"	
DEPTH:standard_name	The variable DEPH will be changed in DEPTH. All present attributes are ok. SDN required ones will be added (see below).	“depth”
DEPTH:units		“meters”
DEPTH:positive		“down”
DEPTH:axis		“Z”
DEPTH:long_name		“Depth”
DEPTH:ancillary_variables	TO BE ADDED as “DEPTH_SEADATANET_QC"	“DEPTH_SEADATANET_QC”
DEPTH:sdn_parameter_urn	TO BE ADDED as “SDN:P01::ADEPZZ01”	“SDN:P01::ADEPZZ01”
DEPTH:sdn_parameter_name	TO BE ADDED as "Depth below surface of the water body"	"Depth below surface of the water body"
DEPTH:sdn_uom_urn	TO BE ADDED as “SDN:P06::ULAA”	“SDN:P06::ULAA”

Variable name	NRT HFR CF profile	SDC CF extension profile
DEPTH:sdn_uom_name	TO BE ADDED as "Metres"	"Metres"
crs:grid_mapping_name	TO BE ADDED as "latitude_longitude"	"latitude_longitude"
crs:epsg_code	TO BE ADDED as "EPSG:4326"	"EPSG:4326"
crs:semi_major_axis	TO BE ADDED as 6378137.0	6378137.0
crs:inverse_flattening	TO BE ADDED as 298.257223563	298.257223563
Radial Velocity data		
BEAR:units	"degrees_true"	TO BE ADDED for gridded data (HFR radial)
BEAR:axis	"Y"	
BEAR:long_name	"Bearing away from instrument"	
BEAR:ancillary_variables	TO BE ADDED as "POSITION_SEADATANET_QC"	
BEAR:sdn_parameter_urn	TO BE ADDED as "SDN:P01::BEARRFTR"	
BEAR:sdn_parameter_name	TO BE ADDED as "Orientation (horizontal relative to true north) of measurement device {heading}"	
BEAR:sdn_uom_urn	TO BE ADDED as SDN:P06::UABB"	
BEAR:sdn_uom_name	TO BE ADDED as "Degrees true"	
RNGE:units	"km"	TO BE ADDED for gridded data (HFR radial)
RNGE:axis	"X"	

Variable name	NRT HFR CF profile	SDC CF extension profile
RNGE:long_name	"Range away from instrument"	
RNGE:ancillary_variables	TO BE ADDED as “POSITION_SEADATANET_QC"	
RNGE:sdn_parameter_urn	TO BE ADDED as “SDN:P01::RIFNAX01”	
RNGE:sdn_parameter_name	TO BE ADDED as “Range (from fixed reference point) by unspecified GPS system”	
RNGE:sdn_uom_urn	TO BE ADDED as “SDN:P06::ULKM”	
RNGE:sdn_uom_name	TO BE ADDED as "Kilometers"	

Table 3: Mapping of the coordinate variables between the European common data and metadata model for NRT HFR current data and the SDN CF extension profile. The yellow highlight means that the element has to be added into the HFR netCDF profile for SDN compliance, the blue highlight means that the element has to be added into the SDN netCDF data profile for HFR data, the green highlight means that the element is present in the SDN CDI profile, the orange highlight means that the element is mandatory in the SDN CDI profile, the purple highlight means that the element is mandatory in CF profile.

7.3. 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, there are a number of SDN namespace variables that form part of the SeaDataCloud extension. These variables are:

- SDN_CRUISE: 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.
- SDN_STATION: array of text strings identifying the data object to which the array element belongs.
- SDN_LOCAL_CDI_ID: 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.
- SDN_EDMO_CODE: integer array containing keys identifying the organisation hosting the Download Manager (CDI_partner) given in the European Directory of Marine Organisations (EDMO).
- SDN_XLINK: 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.
- SDN_REFERENCES: link to a single landing page - an XHTML document providing additional information.

All the four variables have to be added into the HFR netCDF data profile for SDN compliance.

Table 4 shows the mapping of the SDN namespace variables between the European common data and metadata model for NRT HFR data and the SDN data transport format profile. The table details which elements have to be added into the HFR netCDF data profile for SDN compliance (yellow highlight), and which elements are mandatory for the specific CF profile (purple highlight).

Variable name	NRT HFR CF profile	SDC CF extension profile
SDN_CRUISE:long_name	TO BE ADDED AS "Data group label"	Mandatory
SDN_STATION:long_name	TO BE ADDED AS "Data label"	Mandatory
SDN_LOCAL_CDI_ID:long_name	TO BE ADDED AS "SeaDataNet CDI identifier"	Mandatory
SDN_EDMO_CODE:long_name	TO BE ADDED AS "European Directory of Marine Organisations code for the CDI supplier"	Mandatory
SDN_XLINK:long_name	TO BE ADDED AS "External resource linkages"	Mandatory
SDN_REFERENCES:long_name	TO BE ADDED AS "Usage metadata reference"	Mandatory

Table 4: Mapping of the SDN namespace variables between the European common data and metadata model for NRT HFR current data and the SDN CF extension profile. The yellow highlight means that the element has to be added into the HFR netCDF profile for SDN compliance, the purple highlight means that the element is mandatory in CF profile.

7.4. Data variables

Table 5 reports the mapping of data variables between the European common data and metadata model for NRT HFR data and the SDN data transport format profile. The table details which elements are mandatory for the specific CF profile (purple highlight).

Variable name	NRT HFR CF profile	SDN CF extension profile
Radial Velocity data		
RDVA	Mandatory	
DRVA	Mandatory	
EWCT	Mandatory	
NSCT	Mandatory	
ESPC	Recommended	
ETMP	Recommended	
ERSC	Recommended	
ERTC	Recommended	
HCSS	Recommended	
EACC	Recommended	
XDST	Recommended	
YDST	Recommended	
SPRC	Recommended	
NARX	Recommended	
NATX	Recommended	
SLTR	Recommended	
SLNR	Recommended	
SLTT	Recommended	
SLNT	Recommended	
SCDR	Recommended	
SCDT	Recommended	
Total Velocity data		
EWCT	Mandatory	
NSCT	Mandatory	
EWCS	Mandatory	
NSCS	Mandatory	
GDOP	Mandatory	

Variable name	NRT HFR CF profile	SDN CF extension profile
CCOV	Recommended	
UACC	Recommended	
VACC	Recommended	
NARX	Recommended	
NATX	Recommended	
SLTR	Recommended	
SLNR	Recommended	
SLTT	Recommended	
SLNT	Recommended	
SCDR	Recommended	
SCDT	Recommended	

Table 5: Mapping of the data variables between the European common data and metadata model for NRT HFR current data and the SDN CF extension profile. The purple highlight means that the element is mandatory in CF profile.

7.5. Quality Control variables

Table 6 shows the mapping of the QC variables between the European common data and metadata model for NRT HFR data and the SDN data transport format profile. The table details which elements have to be added into the HFR netCDF data profile for SDN compliance (yellow highlight) and which elements are mandatory for the specific CF profile (purple highlight).

Variable name	NRT HFR CF profile	SDN CF extension profile
Radial and total velocity data		
TIME_SEADATANET_QC	TO BE ADDED	Mandatory
POSITION_SEADATANET_QC	TO BE ADDED	Mandatory
DEPTH_SEADATANET_QC	TO BE ADDED	Mandatory
Radial Velocity data		
Qcflag	Mandatory	
OWTR_QC	Mandatory	
MDFL_QC	Mandatory	
VART_QC	Mandatory	
CSPD_QC	Mandatory	
AVRB_QC	Mandatory	
RDCT_QC	Mandatory	
Total Velocity data		
Qcflag	Mandatory	
VART_QC	Mandatory	
CSPD_QC	Mandatory	
GDOP_QC	Mandatory	
DDNS_QC	Mandatory	

Table 6: Mapping of the QC variables between the European common data and metadata model for NRT HFR current data and the SDN CF extension profile. The yellow highlight means that the element has to be added into the HFR netCDF profile for SDN compliance, the purple highlight means that the element is mandatory in CF profile.

7.6. Variable attributes

Table 7 reports the mapping of the variable attributes between the European common data and metadata model for NRT HFR data and the SDN data transport format profile. The table details which elements have to be added into the HFR netCDF data profile for SDN compliance (yellow highlight) and which elements are mandatory for the specific CF profile (purple highlight).

Metadata fieldname	NRT HFR CF profile	SDN CF extension profile
Data variables		
subject		ODV
object		ODV
units	Mandatory	ODV NetCDF
instrument		ODV
fall_rate		ODV
sdn_parameter_urn	TO BE ADDED	NetCDF
sdn_parameter_name	TO BE ADDED	NetCDF
sdn_uom_urn	TO BE ADDED	NetCDF
sdn_uom_name	TO BE ADDED	NetCDF
long_name	Mandatory	NetCDF
coordinates	Mandatory	NetCDF
_FillValue	Mandatory	NetCDF
standard_name	CF where available	NetCDF
valid_range	Mandatory	
valid_min		CF optional
valid_max		CF optional
comment	Recommended	
add_offset	Mandatory	
scale_factor	Mandatory	
grid_mapping		
source		
references		
cell_methods		
ancillary_variables	TO BE ADDED	NetCDF
QC variables		
long_name	Mandatory	Mandatory
units	Mandatory	

Metadata fieldname	NRT HFR CF profile	SDN CF extension profile
_FillValue	Mandatory	57b (ASCII 9)
valid_range	Mandatory	
flag_values	Mandatory	Mandatory
flag_meanings	Mandatory	Mandatory
comment		
add_offset		
Conventions	TO BE ADDED	Mandatory
sdn_conventions_urn	TO BE ADDED	SDN:L20::

Table 7: Mapping of the variable attributes between the European common data and metadata model for NRT HFR current data and the SDN CF extension profile. The yellow highlight means that the element has to be added into the HFR netCDF profile for SDN compliance, the purple highlight means that the element is mandatory in CF profile.

8. Definition of the SDN data transport format for HFR current data

The mappings described in Section 6 and 7 allowed for the refinement of the European common data and metadata model for NRT HFR current data by integrating SDN requirements for CDI scheme and CF extension. As detailed in this section, the result is the final version of the European common data and metadata model for HFR current data that is the SDN data transport format for HFR current data. The data model is also described in the EU H2020 project Jerico-Next deliverable D5.14.

The European common data and metadata model for HFR data is intended to be the unique model for HFR data distribution in Europe, thus it integrates CMEMS and SeaDataNet requirements. Thus, it complies with CF-1.6, OceanSITES, CMEMS IN-SITU TAC conventions (Copernicus-InSituTAC-SRD-1.4, CopernicusInSituTAC-ParametersList-3.1.0) and to the SDN CF extension requirements.

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

Appendix A) and Appendix B) report examples of the header of radial and total netCDF files in the SDN data transport format for HFR current data.

8.1. Data format

Since it is the SDN data transport format for a gridded data type, the European common data and metadata model for HFR data is based on NetCDF (Network Common Data Form).

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-1.6 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 HFR data adds some requirements to the CF-1.6 standard, to fulfil the requirements of CMEMS-INSTAC and SDN CF extension.

In particular:

- 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 have been created as new 4-character-capitalized-letters names and they have been 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 radial velocity data and 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 (e.g. CMEMS IN-SITU TAC), the conversion will be easily implemented.

The components (dimensions, variables and attributes) of NetCDF data set are described in Sections 8.2 to 8.6.

8.2. Dimensions and coordinate variables

NetCDF dimensions provide information on the size of the data variables, and additionally the coordinate variables to data. CF recommends that if any or all 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.

Table 8 lists the dimensions of the data variables for the netCDF HFR data, while Table 9 lists the coordinate variables for the netCDF HFR data.

Name	Comment
TIME	Number of time steps.
DEPTH	Number of depth levels.
LATITUDE	Dimension of the LATITUDE coordinate variable.
LONGITUDE	Dimension of the LONGITUDE coordinate variable.
crs	Coordinate reference system
BEAR	Dimension of the BEAR coordinate variable (for radial data)
RNGE	Dimension of the RNGE coordinate variable (for radial data)
STRINGx	Length in characters of the strings used in the data file.
MAXSITE	Maximum number of antennas.
MAXINST	Maximum number of collaborating institutions.
REFMAX	Maximum number of external resource linkages.

Table 8: List of the dimensions of the data variables for netCDF HFR data.

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

The latitude and longitude datum is WGS84.

BEAR (bearing away from the instrument) and RNGE (range away from the instrument) are the coordinate variables for radial velocity data measured on a polar geometry (e.g. Codar .ruv files). In this case, 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, every gridded variable in the netCDF file of radial data must have the “coordinates” attribute with value “TIME DEPTH LATITUDE LONGITUDE”.

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’.

If non-physical variables are present in the data file, e.g. the processing parameters of the HFR device generating the data or 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.

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

Variable name	Description	Units
TIME	Time of measurement	days (since 1950-01-01T00:00:00Z)
LATITUDE	Latitude of the data position	Degrees North
LONGITUDE	Longitude of the data position	Degrees East
DEPTH	Depth of measurement	m
BEAR	Bearing away from instrument	Degrees true
RNGE	Range away from instrument	km
crs	Coordinate reference system	dimensionless

Table 9: List of the coordinate variables for netCDF HFR data.

The mandatory attributes for coordinate variables are:

- **standard_name**
- **units**
- **axis**
- **long_name**
- **ancillary_variables** - list of QC variables related to the specific variable
- **sdn_parameter_urn** – URN for the parameter description taken from the P01 vocabulary
- **sdn_parameter_name** – plain language label (Entryterm) for the parameter taken from the P01 vocabulary at the time of data file creation
- **sdn_uom_urn** – URN for the parameter units of measure taken from the P06 vocabulary
- **sdn_uom_name** - plain language label (Entryterm) for the parameters' units of measure, taken from the P06 vocabulary at the time of data file creation
- **calendar** – only for variable TIME
- **grid_mapping** (='crs') – only for LATITUDE and LONGITUDE variables
- **positive** – only for DEPTH variable

The crs variable has a particular syntax. The mandatory attribute for the crs variable are:

- **grid_mapping_name** = "latitude_longitude" ;
- **epsg_code** = "EPSG:4326" ;
- **semi_major_axis** = 6378137. ;
- **inverse_flattening** = 298.257223563 ;

8.3. 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, there are a number of SDN namespace variables that form part of the SeaDataNet extension. These variables are listed and explained in Table 10.

Variable	Comment
SDN_CRUISE	Text string identifying the grouping label for the data object to which the data row belongs. For HFR data it is set equal to the site_code attribute, that is the EDIOS Series id of the HFR network.
SDN_STATION	Text string identifying the data object to which the data row belongs. For HFR data it is set equal to the platform_code attribute.
SDN_LOCAL_CDI_ID	The local identifier of the Common Data Index record associated with the data row.
SDN_EDMO_CODE	The key identifying the organization responsible for assigning the local CDI given in the European Directory of Marine Organizations (EDMO).
SDN_REFERENCES	Link to a single landing page - an XHTML document providing additional information.
SDN_XLINK	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.

Table 10: List of the SDN namespace variables for netCDF HFR data.

The mandatory attributes for SDN namespace data variables are:

- **long_name**

8.4. 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 11 for total velocity data and in Table 12 for radial velocity data. Mandatory variables are marked in bold characters.

Total velocity data		
Variable name	*Description*	*Units*
EWCT	**Surface Eastward Sea Water Velocity** (gridded maps of the surface current velocity component averaged over a time interval around the cardinal hour)	**m/s**
NSCT	**Surface Northward Sea Water Velocity** (same as EWCT)	**m/s**
EWCS (or UACC for phased array systems)	**Standard Deviation Of Surface Eastward Sea Water Velocity**	**m/s**
NSCS (or VACC for phased array systems)	**Standard Deviation Of Surface Northward Sea Water Velocity**	**m/s**
CCOV	Covariance of Surface Sea Water Velocity (for data measured by Codar systems)	m^2/s^2
GDOP	**Geometrical Dilution Of Precision (QC-related parameter)**	**dimensionless**
UACC (or EWCS for direction finding systems)	**Accuracy of Surface Eastward Sea Water Velocity**	**m/s**
VACC (or NSCS for direction finding systems)	**Accuracy of Surface Northward Sea Water Velocity**	**m/s**
NARX	Number of Receive Antennas	dimensionless
NATX	Number of Transmit Antennas	dimensionless
SLTR	Receive Antenna Latitudes	Degrees North
SLNR	Receive Antenna Longitudes	Degrees East
SLTT	Transmit Antenna Latitudes	Degrees North
SLNT	Transmit Antenna Longitude	Degrees East
SCDR	Receive Antenna Codes	dimensionless
SCDT	Transmit Antenna Codes	dimensionless

Table 11: List of the data variables for netCDF HFR total data.

Radial velocity data		
Variable name	*Description*	*Units*
LATITUDE	**Latitude of the data position**	**Degrees North**
LONGITUDE	**Longitude of the data position**	**Degrees East**
RDVA	**Radial Sea Water Velocity Away From Instrument**	**Metres per second**
DRVA	**Direction of Radial Velocity Away From Instrument**	**Degrees True**
EWCT	**Surface Eastward Sea Water Velocity** (gridded maps of the surface current velocity component averaged over a time interval around the cardinal hour)	**Metres per second**
NSCT	**Surface Northward Sea Water Velocity** (same as EWCT)	**Metres per second**
ESPC (or HCSS for phased array systems)	Radial Standard Deviation Of Current Velocity over the Scatter Patch	Metres per second
ETMP (or EACC for phased array systems)	Radial Standard Deviation Of Current Velocity over the Coverage Period	Metres per second
HCSS (or ESPC for direction finding systems)	Radial Variance of Current Velocity Over Coverage Period	m^2/s^2
EACC (or ETMP for direction finding systems)	Radial Accuracy of Current Velocity Over Coverage Period	Metres per second
NARX	Number of Receive Antennas	dimensionless
NATX	Number of Transmit Antennas	dimensionless
SLTR	Receive Antenna Latitudes	Degrees North
SLNR	Receive Antenna Longitudes	Degrees East
SLTT	Transmit Antenna Latitudes	Degrees North
SLNT	Transmit Antenna Longitudes	Degrees East
SCDR	Receive Antenna Codes	dimensionless
SCDT	Transmit Antenna Codes	dimensionless

Table 12: List of the data variables for netCDF HFR radial data.

The mandatory attributes for data variables are:

- **units**

- **_FillValue**
- **coordinates**
- **long_name**
- **valid_range**
- **sdn_parameter_urn** – URN for the parameter description taken from the P01 vocabulary
- **sdn_parameter_name** – plain language label (Entryterm) for the parameter taken from the P01 vocabulary at the time of data file creation
- **sdn_uom_urn** – URN for the parameter units of measure taken from the P06 vocabulary
- **sdn_uom_name** - plain language label (Entryterm) for the parameters' units of measure, taken from the P06 vocabulary at the time of data file creation
- ancillary_variables - list of QC variables related to the specific variable

The recommended attributes for data variables are:

- standard_name – only if available in CF vocabularies
- comment
- add_offset
- scale-factor

8.5. Quality Control variables

Quality Control (QC) variables contain the results of the QC tests to be perfomed on data prior to their distribution. Please refer to Section 8 for the list of the QC tests.

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-1.6 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.

QC variables (TIME_SEADATANET_QC, POSITION_SEADATANET_QC and DEPTH_SEADATANET_QC) for coordinate variables have been added as mandated by the CMEMS-INSTAC profile. These variables are named according to the SDN CF Extension.

No CF-1.6 standard names exist for QC variables; thus, long names are used. QC variables are of type byte.

Mandatory QC variables for total velocity data are listed in Table 13.

Mandatory QC variables for radial velocity data are listed in Table 14.

Total velocity data		
Variable name	*Long name*	*Variable dimensionality*
TIME_SEADATANET_QC	Time SeaDataNet Quality Flag	scalar
POSITION_SEADATANET_QC	Position SeaDataNet Quality Flags	gridded
DEPTH_SEADATANET_QC	Depth SeaDataNet Quality Flag	scalar
QCflag	Overall Quality Flags	gridded
VART_QC	Variance Threshold Quality Flags	gridded
GDOP_QC	GDOP Threshold Quality Flags	gridded
DDNS_QC	Data Density Threshold Quality Flags	gridded
CSPD_QC	Velocity Threshold Quality Flags	gridded

Table 13: List of the QC variables for netCDF HFR total data

Radial velocity data		
Variable name	*Long name*	*Variable dimensionality*
TIME_SEADATANET_QC	Time SeaDataNet Quality Flag	scalar
POSITION_SEADATANET_QC	Position SeaDataNet Quality Flags	gridded
DEPTH_SEADATANET_QC	Depth SeaDataNet Quality Flag	scalar
QCflag	Overall Quality Flags	gridded
OWTR_QC	Over-water Quality Flags	gridded
MDFL_QC	Median Filter Quality Flags	gridded
VART_QC	Variance Threshold Quality Flags	gridded
CSPD_QC	Velocity Threshold Quality Flags	gridded
AVRB_QC	Average Radial Bearing Quality Flag	scalar
RDCT_QC	Radial Count Quality Flag	scalar

Table 14: List of the QC variables for netCDF HFR radial data

The mandatory attributes for QC variables are:

- **long_name**
- **units**
- **_FillValue**

- **valid_range**
- **flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b;**
- **flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain";**
- **sdn_conventions_urn = "SDN:L20::";**
- **coordinates** (only for radials measured on polar geometry)

The recommended attributes for QC variables are:

- comment
- add_offset
- scale-factor

8.6. 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 SDN data transport format for HFR current data divides global attributes in three categories: Mandatory Attributes, Recommended Attributes and Suggested Attributes.

The Mandatory Attributes include attributes necessary to comply with CF-1.6, OceanSITES and CMEMS IN-SITU TAC conventions (Copernicus-InSituTAC-SRD-1.4, CopernicusInSituTAC-ParametersList-3.1.0). In Table 15, Mandatory Attributes are listed in bold type.

The Recommended Attributes include attributes necessary to comply with INSPIRE and Unidata Dataset Discovery conventions. In Table 15 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. In Table 15, Suggested Attributes are listed in plain type.

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

Notes on global attributes:

- The file dates, date_created and date_modified, are our interpretation of the ACDD file dates. Date_created is the time stamp on the file, date_modified may be used to represent the 'version date' of the geophysical data in the file. The date_created may change when e.g. metadata is added or the file format is updated, and the optional date_modified MAY be earlier.
- Geospatial extents (geospatial_lat_min, max, and lon_min, max) are preferred to be stored as strings for use in the GDAC software, however numeric fields are acceptable.

Discovery and Identification	
Name	*Meaning*
site_code	The site code identifies a defined area where observations are performed. Site codes are defined in a homogeneous way. The policy for HFR data is to define a site_code for the network and one platform_code for the total current data files. **The site_code is set equal to the EDIOS Series id of the HFR network.** **It is mandatory to have the prefix 'HFR-' in the EDIOS Series id (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
platform_code	The platform_code is used for indexing the files, and for data synchronization between the distribution units (the regions of the insitu TAC). Therefore, it has to be unique for each platform, and common among the INSTAC. Platform codes are defined in a homogeneous way. 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 is: *platform_code=<EDIOS Series id>-Total*** **for total current data files** The EDIOS codes are managed by the SeaDataNet project; they are available at http://seadatanet.maris2.nl/v_edios_v2/search.asp
data_mode	Indicates if the file contains real-time, provisional or delayed-mode data.
DoA_estimation_method	Specifies if the system is Direction Finding or Beam Forming. Possible values are "Direction Finding" and "Beam Forming".
calibration_type	Specifies if calibration has been performed. Possible values are: "None", "Ideal", "APM", "full", "internal", "physical", "AEA".
last_calibration_date	Reports the date of the last calibration. It must be specified as a string in the ISO8601 standard "YYYY-MM-DD-Thh:mm:ssZ". UTC must be used, and specified.

calibration_link	Indicates the link to a contact person able to provide data about the calibration.
title	Free format text describing the dataset, for use by human readers.
summary	Longer free format text describing the dataset. This attribute should allow data discovery for a human reader.
source	The method of production of the original data. **The term "coastal structure" from the SeaVoX Platform Categories (L06) list is used for HFR data.**
source_platform_category_code	SeaDataNet vocabulary L06 (SeaVoX) reports platform categories, as a code and a label. **For HFR data the code "17" is used.**
institution	Specifies institution where the original data was produced.
institution_edmo_code	The EDMO codes are managed by the SeaDataNet project; they are available at http://seadatanet.maris2.nl/edmo/
data_assembly_center	Institution in charge of the aggregation and distribution of data.
id	The "id" attribute is intended to provide a globally unique identification for each dataset. **The id contains 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 is: id=platform_code_ YYYY-MM-DD-Thh:mm:ssZ**
project	The scientific project that produced the data. Each project must 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
naming_authority	The organization that manages data set names. The **reverse-DNS naming** is used for the naming authority attribute.
keywords	Provide comma-separated list of terms that will aid in discovery of the dataset.
keywords_vocabulary	GCMD Science Keywords 'SeaDataNet Parameter Discovery Vocabulary' or 'AGU Index Terms'.
comment	Miscellaneous information about the data or methods used to produce it. Any free format text is appropriate.

data_language	The language in which the data elements are expressed.
data_character_set	The character set used for expressing data.
metadata_language	The language in which the metadata elements are expressed.
metadata_character_set	The character set used for expressing metadata.
topic_category	ISO 19115 topic category.
network	A grouping of sites based on common shore-based logistics or infrastructure.
Geo-spatial-temporal	
data_type	Copernicus In Situ NetCDF files family of data.
feature_type	Description of the spatio-temporal shape of the data held in the netCDF using a vocabulary specified in CF 1.6. **The value used for HFR data is "surface".**
geospatial_lat_min	The southernmost latitude, a value between -90 and 90 degrees. It may be string or numeric, but string is strongly recommended.
geospatial_lat_max	The northernmost latitude, a value between -90 and 90 degrees. It may be string or numeric, but string is strongly recommended.
geospatial_lon_min	The westernmost longitude, a value between -180 and 180 degrees. It may be string or numeric, but string is strongly recommended.
geospatial_lon_max	The easternmost longitude, a value between -180 and 180 degrees. It may be string or numeric, but string is strongly recommended.
geospatial_vertical_min	The minimum depth of measurements. It may be string or numeric, but string is strongly recommended.
geospatial_vertical_max	The maximum depth of measurements. It may be string or numeric, but string is strongly recommended.
time_coverage_start	Start date of the data in UTC. Time is specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ".
time_coverage_end	Final date of the data in UTC. Time is specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ".
area	Geographical coverage.

geospatial_lat_units	Conforms to udunits. If not specified, then “degrees_north” is assumed.
geospatial_lon_units	Conforms to udunits. If not specified, then “degrees_east” is assumed.
geospatial_vertical_resolution	Vertical resolution of the measurement. For HFR data it is set as the maximum integration depth of the radar system, according to operating frequency.
geospatial_vertical_units	Units of depth. If not specified, then “m” is assumed.
geospatial_vertical_positive	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.
time_coverage_resolution	Interval between records. ISO8601 standard is used: PnYnMnDTnHnMnS.
time_coverage_duration	Duration of the time coverage of the data. ISO8601 standard is used: PnYnMnDTnHnMnS.
reference_system	EPSG coordinate reference system.
grid_resolution	Resolution of the grid for total velocity data.
cdm_data_type	The Unidata CDM (common data model) data type used by THREDDS. e.g. point, profile, section, station, station_profile, trajectory, grid, radial, swath, image; Grid is used for gridded HFR data.
Conventions used	
format_version	Version of the data model release.
Conventions	Names of the conventions followed by the dataset. The attribute Conventions is reported as follow: “CF-1.6, OceanSITES-Manual-1.2, Copernicus-InSituTAC-SRD-1.4, CopernicusInSituTAC-ParametersList-3.1.0, “. Additional conventions can be appended at the list.
netcdf_version	NetCDF version used for the dataset.
netcdf_format	NetCDF format used for the dataset.
Publication information	
update_interval	Update interval for the file, in ISO8601 interval format: PnYnMnDTnHnM, where elements that are 0 may be omitted. **“void” is used for HFR data that are not updated on a schedule.** Used by inventory software.

citation	The citation to be used in publications using the dataset. The citation statement has to be reported as follows: “These data were collected and made freely available by the Copernicus project and the programs that contribute to it.” An additional citation statement can be appended to the “citation” attribute.
distribution_statement	The distribution statement has to be reported as follows: “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.”
publisher_name	Name of the person responsible for metadata and formatting of the data file.
publisher_email	Email address of the person responsible for metadata and formatting of the data file.
publisher_url	Web address of the institution or of the data publisher.
license	A statement describing the data distribution policy; it may be a project- or DAC-specific statement, but must allow free use of data.
acknowledgment	A place to acknowledge various types of support for the project that produced this data.
Provenance	
date_created	The date on which the data file was created. Version date and time for the data contained in the file. (UTC). Time is specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ”.
history	Provides an audit trail for modifications to the original data. It should contain a separate line for each modification, with each line beginning with a timestamp, and including user name, modification name, and modification arguments. The time stamp is specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ”.
date_modified	The date on which the data file was last modified. Time is specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ”

date_update	Timestamp specifying when the contents (i.e. its attributes and/or values) of the file were last changed Time is specified as a string according to the ISO8601 standard: "YYYY-MM-DDThh:mm:ssZ" The value is set equal to the "date_modified" one.
processing_level	Level of processing and quality control applied to data. The radar_total data delivered correspond to LEVEL 3B data and radar radial data correspond to LEVEL 2B, following the definition of the processing levels for the identification of the different data produced during the processing workflow of a HFR. Level 2B and 3B are surface currents mapped on uniform space-time grid scales and that have been processed with a minimum set of QC.
contributor_name	A semi-colon-separated list of the names of any individuals or institutions that contributed to the creation of this data.
contributor_role	The roles of any individuals or institutions that contributed to the creation of this data, separated by semi-colons.
contributor_email	The email addresses of any individuals or institutions that contributed to the creation of this data, separated by semi-colons.

Table 15: List of the global attributes for netCDF HFR radial and total data

8. Quality Control procedures for high quality HFR current 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 16 (for total velocity data) and in Table 17 (for radial 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 Table 18 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.

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. Each data provider can decide the threshold definition strategy according to his experience on the monitored area and must explain it in the QC variable "comment" attribute.

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 radials bigger than the threshold with a "good data" flag and total velocity vectors with a number of contributing radials smaller than the threshold with a "bad data" flag.	gridded
Velocity Threshold	This test labels total velocity vectors whose module is bigger than a maximum velocity threshold with a "bad data" flag and total vectors whose module is smaller than the threshold with a "good data" flag.	gridded
Variance Threshold	This test labels total vectors whose temporal variance is bigger than a maximum threshold with a "bad data" flag and total vectors whose temporal variance is smaller than the threshold with a "good 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	For each grid cell, the current timestamp velocity vector is compared with the previous and next ones. If the differences are bigger than a threshold (specific for each grid cell and evaluated on the basis of the analysis of one-year-long time series), the present vector is flagged as bad_data, otherwise it is labelled with a good_data flag. Since this method implies a one-hour delay in the data provision, the current hour file should have the related QC flag set to 0 (no QC performed) until it is updated to the proper values when the next hour file is generated.	gridded
GDOP Threshold	This test labels total velocity vectors whose GDOP is bigger than a maximum threshold with a "bad data" flag and the vectors whose GDOP is smaller than the threshold with a "good data" flag.	gridded

Table 16: Mandatory QC tests for HFR 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 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 vectors that lie on land with a “bad data” flag and radial vectors that lie on water with a “good data” flag.	gridded
Velocity Threshold	This test labels radial velocity vectors whose module is bigger than a maximum velocity threshold with a “bad data” flag and radial vectors whose module is smaller than the threshold with a “good data” flag.	gridded
Variance Threshold	This test labels radial vectors whose temporal variance is bigger than a maximum threshold with a “bad data” flag and radial vectors whose temporal variance is smaller than the threshold with a “good 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	For each radial bin, the current timestamp velocity vector is compared with the previous and next hour ones. If the differences are bigger than a threshold (specific for each radial bin and evaluated on the basis of the analysis of one-year-long time series), the present vector is flagged as bad_data, otherwise it is labelled with a good_data flag. Since this method implies a one-hour delay in the data provision, the current hour file should have the related QC flag set to 0 (no QC performed) until it is updated to the proper values when the next hour file is generated.	gridded
Median Filter	For each source vector, the median of all velocities within a radius of <RCLim> and whose vector bearing (angle of arrival at site) is also within an angular distance of <AngLim> degrees from the source vector's bearing is evaluated. If the difference between the vector's velocity and the median velocity is greater than a threshold, then the vector is labelled with a “bad_data” flag, otherwise it is labelled with a “good_data” flag.	gridded

QC test	Meaning	QC variable type
Average Radial Bearing	This test labels the entire datafile with a 'good_data" flag if the average radial bearing of all the vectors contained in the data file lies within a specified margin around the expected value of normal operation. Otherwise, the data file is labelled with a "bad_data" flag. The value of 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 site-specific properties. This test is applicable only to DF systems. Data files from Beam Forming (BF) systems will have this variable filled with "good_data" flags (1) and the explanation "Test not applicable to Beam Forming systems" in the comment attribute.	scalar
Radial Count	Test labelling radial data having a number of velocity vectors bigger than the threshold with a "good data" flag and radial data having a number of velocity vectors smaller than the threshold with a "bad data" flag.	scalar

Table 17: Mandatory QC tests for HFR radial velocity data.

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 18: Processing levels for HFR data

9. Conclusions

This document describes the SDN data transport format for HFR current data and the common real-time QC model for HFR current data. The way to achieve this consensus has been led by the European HFR community through the joint effort of many initiatives, 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 this document, any HFR operator is able to produce data in a standard formats that can be immediately integrated in the European HFR operational system and hence distributed by CMEMS-INSTAC, SDN and EMODnet distribution services.

This document 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 (that will be updated whenever needed in the framework of EuroGOOS DATAMEQ working group).

10. References

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11. List of acronyms

Acronym	Definition
ACDD	Attribute Convention for Data Discovery
AEA	Transmission line impedance analysis based on AEA technology manufacturer
APM	Antenna Pattern Measurements
BF	Beam Forming
CDI	Common Data Index (SeaDataNet catalogue)
CDM	Common Data Model
CF	Climate Forecast
CMEMS	Copernicus Marine Environmental Monitoring Services
CSR	Cruise Summary Report (SeaDataNet Catalogue)
DAC	Data Assembling Centre
DATAMEQ	Data Management, Exchange and Quality (Working Group – EuroGOOS)
DF	Direction Finding
DNS	Domain Name System
DOI	Digital Object Identifier
EC	European Commission
EDIOS	European Directory of Initial Ocean observing Systems (SeaDataNet catalogue)
EDMED	European Directory of Marine Environmental Data sets (SeaDataNet catalogue)
EDMERP	European Directory of Marine Environmental Research Projects (SeaDataNet catalogue)
EDMO	European Directory of Marine Organisations (SeaDataNet catalogue)
EPSG	European Petroleum Survey Group
EU	European Union
GAC	Global Assembling Centre
GDOP	Geometric Dilution Of Precision
HF	High Frequency
HFR	High Frequency Radar
INCREASE	INtegration of Coastal Radars into European mArine SErvices

INSPIRE	Infrastructure for Spatial Information in Europe
INSTAC	IN-Situ Thematic Assembling Centre
IOOS	Integrated Ocean Observing System
ISO	International Standards Organisation
JERICO	Joint European Research Infrastructure network for Coastal Observatories
NERC	Natural Environment Research Council
NRT	Near Real Time
ODV	Ocean Data View
OGC	Open Geospatial Consortium
PI	Principal Investigator
QARTOD	Quality Assurance/quality control of Real-Time Oceanographic Data
QC	Quality Checks
QF	Quality Flag
ROWG	Radiowave Operators Working Group (US working Group)
SDC	SeaDataCloud (H2020 European project)
SDN	SeaDataNet (Research Infrastructure)
SRD	System Requirements Document
THREDDS	THematic Real-time Environmental Distributed Data Services
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
URN	Uniform Resource Name
UTC	Coordinated Universal Time
XHTML	eXpendable BathyThermograph
XML	eXtended Markup Language

A) Radial velocity data file header example

```
netcdf HFR-TirLig-TINO_2019_04_01_1100 {
dimensions:
        TIME = 1 ;
        BEAR = 73 ;
        RNGE = 51 ;
        DEPTH = 1 ;
        MAXSITE = 1 ;
        MAXINST = 1 ;
        REFMAX = 1 ;
        STRING4 = 4 ;
        STRING10 = 10 ;
        STRING15 = 15 ;
        STRING36 = 36 ;
        STRING70 = 70 ;
        STRING131 = 131 ;
variables:
        float TIME(TIME) ;
                TIME:long_name = "Time of measurement UTC" ;
                TIME:standard_name = "time" ;
                TIME:units = "days since 1950-01-01T00:00:00Z" ;
                TIME:calendar = "Julian" ;
                TIME:axis = "T" ;
                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_SEADATANET_QC" ;
        float BEAR(BEAR) ;
                BEAR:axis = "X" ;
                BEAR:long_name = "Bearing away from instrument" ;
                BEAR:units = "degrees_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_SEADATANET_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_SEADATANET_QC" ;

float DEPTH(DEPTH) ;

DEPTH:long_name = "Depth of measurement" ;

DEPTH:standard_name = "depth" ;

DEPTH:units = "m" ;

DEPTH:axis = "Z" ;

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_SEADATANET_QC" ;

float LATITUDE(BEAR, RNGE) ;

LATITUDE:standard_name = "latitude" ;

LATITUDE:long_name = "Latitude" ;

LATITUDE:units = "degrees_north" ;

LATITUDE:valid_range = -90.f, 90.f ;

LATITUDE:FillValue = 9.96921e+36f ;

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_SEADATANET_QC" ;

float LONGITUDE(BEAR, RNGE) ;

LONGITUDE:standard_name = "longitude" ;

LONGITUDE:long_name = "Longitude" ;

LONGITUDE:units = "degrees_east" ;

LONGITUDE:valid_range = -180.f, 180.f ;

LONGITUDE:FillValue = 9.96921e+36f ;

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_SEADATANET_QC" ;

short crs ;

crs:grid_mapping_name = "latitude_longitude" ;

crs:epsg_code = "EPSG:4326" ;

crs:semi_major_axis = 6378137. ;

crs:inverse_flattening = 298.257223563 ;

char SDN_CRUISE(TIME, STRING10) ;

SDN_CRUISE:long_name = "Grid grouping label" ;

char SDN_STATION(TIME, STRING15) ;

SDN_STATION:long_name = "Grid label" ;

char SDN_LOCAL_CDI_ID(TIME, STRING36) ;

SDN_LOCAL_CDI_ID:long_name = "SeaDataCloud CDI identifier" ;

SDN_LOCAL_CDI_ID:cf_role = "grid_id" ;

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, STRING70) ;

SDN_REFERENCES:long_name = "Usage metadata reference" ;

char SDN_XLINK(TIME, REFMAX, STRING131) ;

SDN_XLINK:long_name = "External resource linkages" ;

float RDVA(TIME, DEPTH, BEAR, RNGE) ;

RDVA:valid_range = -10.f, 10.f ;

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:_FillValue = 9.96921e+36f ;

RDVA:scale_factor = 1.f ;

RDVA:add_offset = 0.f ;

RDVA:sdn_parameter_name = "Current speed (Eulerian) in the water body by directional range-gated radar" ;

RDVA:sdn_parameter_urn = "SDN:P01::LCSAWVRD" ;

RDVA:sdn_uom_name = "Metres per second" ;

RDVA:sdn_uom_urn = "SDN:P06::UVAA" ;

RDVA:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

RDVA:ancillary_variables = "QCflag, OWTR_QC, MDFL_QC, CSPD_QC, RDCT_QC" ;

float DRVA(TIME, DEPTH, BEAR, RNGE) ;

DRVA:valid_range = 0.f, 360.f ;

DRVA:standard_name = "direction_of_radial_vector_away_from_instrument" ;

DRVA:long_name = "Direction of Radial Vector Away From Instrument" ;

DRVA:_FillValue = 9.96921e+36f ;

DRVA:add_offset = 0.f ;

DRVA:units = "degrees_true" ;

DRVA:scale_factor = 1.f ;

DRVA:sdn_parameter_name = "Current direction (Eulerian) in the water body by directional range-gated radar" ;

DRVA:sdn_parameter_urn = "SDN:P01::LCDAWVRD" ;

DRVA:sdn_uom_name = "Degrees True" ;

DRVA:sdn_uom_urn = "SDN:P06::UABB" ;

DRVA:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

DRVA:ancillary_variables = "QCflag, OWTR_QC, MDFL_QC, AVRB_QC, RDCT_QC" ;

float EWCT(TIME, DEPTH, BEAR, RNGE) ;

EWCT:valid_range = -10.f, 10.f ;

EWCT:standard_name = "surface_eastward_sea_water_velocity" ;

EWCT:long_name = "Surface Eastward Sea Water Velocity" ;

EWCT:_FillValue = 9.96921e+36f ;

EWCT:scale_factor = 1.f ;

EWCT:add_offset = 0.f ;

EWCT:units = "m s-1" ;

EWCT:sdn_parameter_name = "Eastward current velocity 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:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

EWCT:ancillary_variables = "QCflag, OWTR_QC, MDFL_QC, CSPD_QC, VART_QC, AVRB_QC, RDCT_QC" ;

float NSCT(TIME, DEPTH, BEAR, RNGE) ;

NSCT:valid_range = -10.f, 10.f ;

NSCT:standard_name = "surface_northward_sea_water_velocity" ;

NSCT:long_name = "Surface Northward Sea Water Velocity" ;

NSCT:_FillValue = 9.96921e+36f ;

NSCT:scale_factor = 1.f ;

NSCT:add_offset = 0.f ;

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:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

NSCT:ancillary_variables = "QCflag, OWTR_QC, MDFL_QC, CSPD_QC, VART_QC, AVRB_QC, RDCT_QC" ;

float ESPC(TIME, DEPTH, BEAR, RNGE) ;

ESPC:valid_range = -1000.f, 1000.f ;

ESPC:long_name = "Radial Standard Deviation of Current Velocity over the Scatter Patch" ;

ESPC:units = "m s-1" ;

ESPC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

ESPC:_FillValue = 9.96921e+36f ;

ESPC:scale_factor = 1.f ;

ESPC:add_offset = 0.f ;

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" ;

float ETMP(TIME, DEPTH, BEAR, RNGE) ;

ETMP:valid_range = -1000.f, 1000.f ;

ETMP:long_name = "Radial Standard Deviation of Current Velocity over Coverage Period" ;

ETMP:units = "m s-1" ;

ETMP:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

ETMP:_FillValue = 9.96921e+36f ;

ETMP:scale_factor = 1.f ;

ETMP:add_offset = 0.f ;

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" ;

short NARX(TIME) ;

NARX:long_name = "Number of Receive Antennas" ;

NARX:valid_range = 0s, 1s ;

NARX:_FillValue = -32767s ;

NARX:scale_factor = 1s ;

NARX:add_offset = 0s ;

NARX:units = "1" ;

NARX:sdn_parameter_name = "" ;

NARX:sdn_parameter_urn = "" ;

NARX:sdn_uom_name = "Dimensionless" ;

NARX:sdn_uom_urn = "SDN:P06::UUUU" ;

short NATX(TIME) ;

NATX:long_name = "Number of Transmit Antennas" ;

NATX:valid_range = 0s, 1s ;

NATX:_FillValue = -32767s ;

NATX:scale_factor = 1s ;

NATX:add_offset = 0s ;

NATX:units = "1" ;

NATX:sdn_parameter_name = "" ;

NATX:sdn_parameter_urn = "" ;

NATX:sdn_uom_name = "Dimensionless" ;

NATX:sdn_uom_urn = "SDN:P06::UUUU" ;

float SLTR(TIME, MAXSITE) ;

SLTR:long_name = "Receive Antenna Latitudes" ;

SLTR:standard_name = "latitude" ;

SLTR:valid_range = -180.f, 180.f ;

SLTR:_FillValue = 9.96921e+36f ;

SLTR:scale_factor = 1.f ;

SLTR:add_offset = 0.f ;

SLTR:units = "degrees_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:coordinates = "TIME MAXSITE" ;

float SLNR(TIME, MAXSITE) ;

SLNR:long_name = "Receive Antenna Longitudes" ;

SLNR:standard_name = "longitude" ;

SLNR:valid_range = -90.f, 90.f ;

SLNR:_FillValue = 9.96921e+36f ;

SLNR:scale_factor = 1.f ;

SLNR:add_offset = 0.f ;

SLNR:units = "degrees_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:coordinates = "TIME MAXSITE" ;

float SLTT(TIME, MAXSITE) ;

SLTT:long_name = "Transmit Antenna Latitudes" ;

SLTT:standard_name = "latitude" ;

SLTT:valid_range = -180.f, 180.f ;

SLTT:_FillValue = 9.96921e+36f ;

SLTT:scale_factor = 1.f ;

SLTT:add_offset = 0.f ;

SLTT:units = "degrees_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:coordinates = "TIME MAXSITE" ;

float SLNT(TIME, MAXSITE) ;

SLNT:long_name = "Transmit Antenna Longitudes" ;

SLNT:standard_name = "longitude" ;

SLNT:valid_range = -90.f, 90.f ;

SLNT:_FillValue = 9.96921e+36f ;

SLNT:scale_factor = 1.f ;

SLNT:add_offset = 0.f ;

SLNT:units = "degrees_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:coordinates = "TIME MAXSITE" ;

char SCDR(TIME, MAXSITE, STRING4) ;

SCDR:long_name = "Receive Antenna Codes" ;

SCDR:units = "1" ;

SCDR:_FillValue = "" ;

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:units = "1" ;

SCDT:_FillValue = "" ;

SCDT:sdn_parameter_name = "" ;

SCDT:sdn_parameter_urn = "" ;

SCDT:sdn_uom_name = "Dimensionless" ;

SCDT:sdn_uom_urn = "SDN:P06::UUUU" ;

byte TIME_SEADATANET_QC(TIME) ;

TIME_SEADATANET_QC:long_name = "Time SeaDataNet Quality Flag" ;

TIME_SEADATANET_QC:valid_range = 48b, 65b ;

TIME_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

TIME_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

TIME_SEADATANET_QC:comment = "OceanSITES quality flagging for temporal coordinate." ;

TIME_SEADATANET_QC:_FillValue = -127 ;

TIME_SEADATANET_QC:scale_factor = 1s ;

TIME_SEADATANET_QC:add_offset = 0s ;

TIME_SEADATANET_QC:units = "1" ;

TIME_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";

byte POSITION_SEADATANET_QC(TIME, DEPTH, BEAR, RNGE) ;

POSITION_SEADATANET_QC:long_name = "Position SeaDataNet Quality Flags" ;

POSITION_SEADATANET_QC:valid_range = 48b, 65b ;

POSITION_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

POSITION_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

POSITION_SEADATANET_QC:comment = "OceanSITES quality flagging for position coordinates" ;

POSITION_SEADATANET_QC:_FillValue = -127 ;

POSITION_SEADATANET_QC:scale_factor = 1s ;

POSITION_SEADATANET_QC:add_offset = 0s ;

POSITION_SEADATANET_QC:units = "1" ;

POSITION_SEADATANET_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

POSITION_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";

byte DEPTH_SEADATANET_QC(TIME) ;

DEPTH_SEADATANET_QC:long_name = "Depth SeaDataNet Quality Flag" ;

DEPTH_SEADATANET_QC:valid_range = 48b, 65b ;

DEPTH_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

DEPTH_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

DEPTH_SEADATANET_QC:comment = "OceanSITES quality flagging for depth coordinate." ;

DEPTH_SEADATANET_QC:_FillValue = -127 ;

DEPTH_SEADATANET_QC:scale_factor = 1s ;

DEPTH_SEADATANET_QC:add_offset = 0s ;

DEPTH_SEADATANET_QC:units = "1" ;

DEPTH_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";

byte QCflag(TIME, DEPTH, BEAR, RNGE) ;

QCflag:long_name = "Overall Quality Flags" ;

QCflag:valid_range = 48b, 65b ;

QCflag:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

QCflag:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

QCflag:comment = "OceanSITES quality flagging for all QC tests." ;

QCflag:_FillValue = -127 ;

QCflag:scale_factor = 1s ;

QCflag:add_offset = 0s ;

QCflag:units = "1" ;

QCflag:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

QCflag:sdn_conventions_urn = "SDN:L20::";

byte OWTR_QC(TIME, DEPTH, BEAR, RNGE) ;

OWTR_QC:long_name = "Over-water Quality Flags" ;

OWTR_QC:valid_range = 48b, 65b ;

OWTR_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

OWTR_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

OWTR_QC:comment = "OceanSITES quality flagging for Over-water QC test." ;

OWTR_QC:_FillValue = -127 ;

OWTR_QC:scale_factor = 1s ;

OWTR_QC:add_offset = 0s ;

OWTR_QC:units = "1" ;

OWTR_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

OWTR_QC:sdn_conventions_urn = "SDN:L20::";

byte MDFL_QC(TIME, DEPTH, BEAR, RNGE) ;

MDFL_QC:long_name = "Median Filter Quality Flags" ;

MDFL_QC:valid_range = 48b, 65b ;

MDFL_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

MDFL_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

MDFL_QC:comment = "OceanSITES quality flagging for Median Filter QC test. Threshold set to 5 km, 30 deg, 1 m/s, " ;

MDFL_QC:_FillValue = -127 ;

MDFL_QC:scale_factor = 1s ;

MDFL_QC:add_offset = 0s ;

MDFL_QC:units = "1" ;

MDFL_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

MDFL_QC:sdn_conventions_urn = "SDN:L20::";

byte VART_QC(TIME, DEPTH, BEAR, RNGE) ;

VART_QC:long_name = "Variance Threshold Quality Flags" ;

VART_QC:valid_range = 48b, 65b ;

VART_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

VART_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

VART_QC:comment = "OceanSITES quality flagging for Variance Threshold QC test. Test not applicable to Direction Finding systems. The Temporal Derivative test is applied. Threshold set to 1 m/s." ;

VART_QC:_FillValue = -127 ;

VART_QC:scale_factor = 1s ;

VART_QC:add_offset = 0s ;

VART_QC:units = "1" ;

VART_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

VART_QC:sdn_conventions_urn = "SDN:L20::";

byte CSPD_QC(TIME, DEPTH, BEAR, RNGE) ;

CSPD_QC:long_name = "Velocity Threshold Quality Flags" ;

CSPD_QC:valid_range = 48b, 65b ;

CSPD_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

CSPD_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

CSPD_QC:comment = "OceanSITES quality flagging for Velocity Threshold QC test. Threshold set to 1.2 m/s." ;

CSPD_QC:_FillValue = -127 ;

CSPD_QC:scale_factor = 1s ;

CSPD_QC:add_offset = 0s ;

CSPD_QC:units = "1" ;

CSPD_QC:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

CSPD_QC:sdn_conventions_urn = "SDN:L20::";

byte AVRB_QC(TIME) ;

AVRB_QC:long_name = "Average Radial Bearing Quality Flag" ;

AVRB_QC:valid_range = 48b, 65b ;

AVRB_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

AVRB_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

AVRB_QC:comment = "OceanSITES quality flagging for Average Radial Bearing QC test. Thresholds set to [150-360] deg." ;

AVRB_QC:_FillValue = -127 ;

AVRB_QC:scale_factor = 1s ;

AVRB_QC:add_offset = 0s ;

AVRB_QC:units = "1" ;

AVRB_QC:sdn_conventions_urn = "SDN:L20::";

byte RDCT_QC(TIME) ;

RDCT_QC:long_name = "Radial Count Quality Flag" ;

RDCT_QC:valid_range = 48b, 65b ;

RDCT_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

RDCT_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

RDCT_QC:comment = "OceanSITES quality flagging for Radial Count QC test. Thresholds set to 200 vectors." ;

RDCT_QC:_FillValue = -127 ;

RDCT_QC:scale_factor = 1s ;

RDCT_QC:add_offset = 0s ;

RDCT_QC:units = "1" ;

RDCT_QC:sdn_conventions_urn = "SDN:L20::";

// global attributes:

:site_code = "HFR-TirLig" ;

:platform_code = "HFR-TirLig-TINO" ;

:data_mode = "R" ;

:DoA_estimation_method = "Direction Finding" ;

:calibration_type = "APM" ;

:last_calibration_date = "2018-09-27T00:00:00Z" ;

:calibration_link = "carlo.mantovani@cnr.it" ;

:title = "Near Real Time Surface Ocean Velocity by HFR_TirLig" ;

:summary = "The data set 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. 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 = "National Research Council - Institute of Marine Science, S.S. Lerici" ;

:institution_edmo_code = "134" ;

:data_assembly_center = "European HFR Node" ;

:id = "HFR-TirLig-TINO_2019-04-01T11:00:00Z" ;

:data_type = "HF radar radial data" ;

:feature_type = "surface" ;

:geospatial_lat_min = "43.5" ;

:geospatial_lat_max = "44.23" ;

:geospatial_lon_min = "9.2" ;

:geospatial_lon_max = "10.5" ;

:geospatial_vertical_max = "4" ;

:geospatial_vertical_min = "0" ;

:time_coverage_start = "2019-04-01T10:30:00Z" ;

:time_coverage_end = "2019-04-01T11:30:00Z" ;

:format_version = "v2.1" ;

:Conventions = "CF-1.6, OceanSITES-Manual-1.2, Copernicus-InSituTAC-SRD-1.4, CopernicusInSituTAC-ParametersList-3.1.0, Unidata, ACDD, INSPIRE" ;

:update_interval = "void" ;

:citation = "These data were collected and made freely available by the Copernicus project and the programs that contribute to it. Data collected and processed by CNR-ISMAR within RITMARE, Jerico-Next and IMPACT projects. " ;

: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." ;

:publisher_name = "European HFR Node" ;

:publisher_url = "http://eurogoos.eu/" ;

:publisher_email = "euhfrnode@azti.es" ;

: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/." ;

: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." ;

:date_created = "2019-04-01T15:19:51Z" ;

:history = "2019-04-01T11:00:00Z data collected. 2019-04-01T15:19:51Z netCDF file created and sent to European HFR Node" ;

:date_modified = "2019-04-01T15:19:51Z" ;

:date_update = "2019-04-01T15:19:51Z" ;

:processing_level = "2B" ;

:contributor_name = "Lorenzo Corgnati; Carlo Mantovani" ;

:contributor_role = "metadata expert; HFR expert" ;

:contributor_email = "lorenzo.corgnati@sp.ismar.cnr.it; carlo.mantovani@cnr.it" ;

:project = "RITMARE, Jerico-Next, IMPACT and SICOMAR Plus" ;

:naming_authority = "it.cnr.ismar" ;

: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" ;

:topic_category = "oceans" ;

:network = "ISMAR_HFR_TirLig" ;

:area = "Mediterranean Sea" ;

:geospatial_lat_units = "degrees_north" ;

:geospatial_lon_units = "degrees_east" ;

:geospatial_lat_resolution = "0.00048345" ;

:geospatial_lon_resolution = "0.00035539" ;

:geospatial_vertical_resolution = "4" ;

:geospatial_vertical_units = "m" ;

:geospatial_vertical_positive = "down" ;

:time_coverage_duration = "PT1H" ;

:time_coverage_resolution = "PT1H" ;

:reference_system = "EPSG:4806" ;

:cdm_data_type = "Grid" ;

:netcdf_version = "4.3.3.1" ;

:netcdf_format = "netcdf4_classic" ;

:metadata_contact = "lorenzo.corgnati@sp.ismar.cnr.it" ;

:metadata_date_stamp = "2019-04-01T15:19:51Z" ;

:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table Version 1.6" ;

:sensor = "CODAR SeaSonde" ;

:institution_reference = "http://www.ismar.cnr.it/" ;

:references = "High Frequency Radar European common data and metadata model Reference Card: all you need to know about High Frequency Radar (HFR) data harmonization at a glance. http://www.marineinsitu.eu/wp-content/uploads/2018/02/HFR_Data_Model_Reference_Card_v1.pdf" ;

:software_name = "HFR_Combiner" ;

:software_version = "v3.1" ;

:date_issued = "2019-04-01T15:19:51Z" ;

:UUID = "7496DDDE-1574-40ED-9EBA-D4CA9681EA7C" ;

:manufacturer = "CODAR Ocean Sensors. SeaSonde" ;

:RangeStart = "2" ;

:RangeEnd = "45" ;

:RangeResolutionKMeters = "0.994500" ;

:RangeResolutionMeters = "" ;

:AntennaBearing = "282.0 True" ;

:ReferenceBearing = "0 True" ;

:AngularResolution = "5 Deg" ;

```
:SpatialResolution = "5 Deg" ;
:PatternResolution = "1.0 deg" ;
:TransmitCenterFreqMHz = "26.275000" ;
:DopplerResolutionHzPerBin = "0.001953125" ;
:FirstOrderMethod = "0" ;
:BraggSmoothingPoints = "2" ;
:BraggHasSecondOrder = "1" ;
:RadialBraggPeakDropOff = "63.100" ;
:RadialBraggPeakNull = "39.810" ;
:RadialBraggNoiseThreshold = "8.000" ;
:PatternAmplitudeCorrections = "2.9585  4.4432" ;
:PatternPhaseCorrections = "32.60  35.60" ;
:PatternAmplitudeCalculations = "3.4286  2.9217" ;
:PatternPhaseCalculations = "149.40  -76.50" ;
:RadialMusicParameters = "40.000 20.000 2.000" ;
:MergedCount = "7" ;
:RadialMinimumMergePoints = "2" ;
:FirstOrderCalc = "1" ;
:MergeMethod = "1 MedianVectors" ;
:PatternMethod = "1 PatternVectors" ;
:TransmitSweepRateHz = "2.000000" ;
:TransmitBandwidthKHz = "-150.727203" ;
:SpectraRangeCells = "63" ;
:SpectraDopplerCells = "1024" ;
}
```

B) Total velocity data file header example

```
netcdf HFR-TirLig-Total_2019_04_01_1100 {
dimensions:
        TIME = 1 ;
        LATITUDE = 41 ;
        LONGITUDE = 46 ;
        STRING50 = 50 ;
        MAXINST = 1 ;
        STRING200 = 250 ;
        REFMAX = 1 ;
        DEPTH = 1 ;
        MAXSITE = 50 ;
        STRING15 = 15 ;
variables:
        float TIME(TIME) ;
                TIME:long_name = "Time of measurement UTC" ;
                TIME:standard_name = "time" ;
                TIME:units = "days since 1950-01-01T00:00:00Z" ;
                TIME:calendar = "Julian" ;
                TIME:axis = "T" ;
                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_SEADATANET_QC" ;
        float LATITUDE(LATITUDE) ;
                LATITUDE:long_name = "Latitude" ;
                LATITUDE:standard_name = "latitude" ;
                LATITUDE:units = "degrees_north" ;
                LATITUDE:axis = "Y" ;
                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_SEADATANET_QC" ;

float LONGITUDE(LONGITUDE) ;

LONGITUDE:long_name = "Longitude" ;

LONGITUDE:standard_name = "longitude" ;

LONGITUDE:units = "degrees_east" ;

LONGITUDE:axis = "X" ;

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_SEADATANET_QC" ;

short crs ;

crs:grid_mapping_name = "latitude_longitude" ;

crs:epsg_code = "EPSG:4326" ;

crs:semi_major_axis = 6378137. ;

crs:inverse_flattening = 298.257223563 ;

char SDN_CRUISE(TIME, STRING50) ;

SDN_CRUISE:long_name = "Grid grouping label" ;

char SDN_STATION(TIME, STRING50) ;

SDN_STATION:long_name = "Grid label" ;

char SDN_LOCAL_CDI_ID(TIME, STRING50) ;

SDN_LOCAL_CDI_ID:long_name = "SeaDataCloud CDI identifier" ;

SDN_LOCAL_CDI_ID:cf_role = "grid_id" ;

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, STRING200) ;

SDN_REFERENCES:long_name = "Usage metadata reference" ;

char SDN_XLINK(TIME, REFMAX, STRING200) ;

SDN_XLINK:long_name = "External resource linkages" ;

float DEPTH(DEPTH) ;

DEPTH:long_name = "Depth of measurement" ;

DEPTH:standard_name = "depth" ;

DEPTH:units = "m" ;

DEPTH:axis = "Z" ;

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_SEADATANET_QC" ;

double EWCT(TIME, DEPTH, LATITUDE, LONGITUDE) ;

EWCT:_FillValue = 9.96920996838687e+36 ;

EWCT:long_name = "Surface Eastward Sea Water Velocity" ;

EWCT:standard_name = "surface_eastward_sea_water_velocity" ;

EWCT:units = "m s-1" ;

EWCT:scale_factor = 1. ;

EWCT:add_offset = 0. ;

EWCT:ioos_category = "Currents" ;

EWCT:coordsys = "geographic" ;

EWCT:sdn_parameter_name = "Eastward current velocity 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:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

EWCT:valid_range = -10., 10. ;

EWCT:ancillary_variables = "QCflag, VART_QC, CSPD_QC, DDNS_QC, GDOP_QC" ;

double NSCT(TIME, DEPTH, LATITUDE, LONGITUDE) ;

NSCT:_FillValue = 9.96920996838687e+36 ;

NSCT:long_name = "Surface Northward Sea Water Velocity" ;

NSCT:standard_name = "surface_northward_sea_water_velocity" ;

NSCT:units = "m s-1" ;

NSCT:scale_factor = 1. ;

NSCT:add_offset = 0. ;

NSCT:ioos_category = "Currents" ;

NSCT:coordsys = "geographic" ;

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:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

NSCT:valid_range = -10., 10. ;

NSCT:ancillary_variables = "QCflag, VART_QC, CSPD_QC, DDNS_QC, GDOP_QC" ;

double EWCS(TIME, DEPTH, LATITUDE, LONGITUDE) ;

EWCS:_FillValue = 9.96920996838687e+36 ;

EWCS:long_name = "Standard Deviation of Surface Eastward Sea Water Velocity" ;

EWCS:units = "m s-1" ;

EWCS:valid_range = -10., 10. ;

EWCS:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

EWCS:scale_factor = 1. ;

EWCS:add_offset = 0. ;

EWCS:sdn_parameter_name = "Eastward current velocity standard deviation in the water body" ;

EWCS:sdn_parameter_urn = "SDN:P01::SDEWZZZZ" ;

EWCS:sdn_uom_name = "Metres per second" ;

EWCS:sdn_uom_urn = "SDN:P06::UVAA" ;

EWCS:ancillary_variables = "QCflag, VART_QC" ;

double NSCS(TIME, DEPTH, LATITUDE, LONGITUDE) ;

NSCS:_FillValue = 9.96920996838687e+36 ;

NSCS:long_name = "Standard Deviation of Surface Northward Sea Water Velocity" ;

NSCS:units = "m s-1" ;

NSCS:valid_range = -10., 10. ;

NSCS:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

NSCS:scale_factor = 1. ;

NSCS:add_offset = 0. ;

NSCS:sdn_parameter_name = "Northward current velocity standard deviation in the water body" ;

NSCS:sdn_parameter_urn = "SDN:P01::SDNSZZZZ" ;

NSCS:sdn_uom_name = "Metres per second" ;

NSCS:sdn_uom_urn = "SDN:P06::UVAA" ;

NSCS:ancillary_variables = "QCflag, VART_QC" ;

double CCOV(TIME, DEPTH, LATITUDE, LONGITUDE) ;

CCOV:_FillValue = 9.96920996838687e+36 ;

CCOV:long_name = "Covariance of Surface Sea Water Velocity" ;

CCOV:units = "m2 s-2" ;

CCOV:valid_range = -10., 10. ;

CCOV:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

CCOV:scale_factor = 1. ;

CCOV:add_offset = 0. ;

CCOV:sdn_parameter_name = "" ;

CCOV:sdn_parameter_urn = "" ;

CCOV:sdn_uom_name = "Square metres per second squared" ;

CCOV:sdn_uom_urn = "SDN:P06::SQM2" ;

CCOV:ancillary_variables = "QCflag" ;

double GDOP(TIME, DEPTH, LATITUDE, LONGITUDE) ;

GDOP:_FillValue = 9.96920996838687e+36 ;

GDOP:long_name = "Geometrical Dilution Of Precision" ;

GDOP:units = "1" ;

GDOP:valid_range = -20., 20. ;

GDOP:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;

GDOP:scale_factor = 1. ;

GDOP:add_offset = 0. ;

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 = "" ;

GDOP:sdn_parameter_urn = "" ;

GDOP:sdn_uom_name = "Dimensionless" ;

GDOP:sdn_uom_urn = "SDN:P06::UUUU" ;

GDOP:ancillary_variables = "QCflag, GDOP_QC" ;

byte TIME_SEADATANET_QC(TIME) ;

TIME_SEADATANET_QC:_FillValue = -127 ;

TIME_SEADATANET_QC:long_name = "Time SeaDataNet Quality Flag" ;

TIME_SEADATANET_QC:units = "1" ;

TIME_SEADATANET_QC:valid_range = 48b, 65b ;

TIME_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

TIME_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

TIME_SEADATANET_QC:comment = "OceanSITES quality flagging for temporal coordinate." ;

TIME_SEADATANET_QC:scale_factor = 1s ;

TIME_SEADATANET_QC:add_offset = 0s ;

TIME_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";

byte POSITION_SEADATANET_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;

POSITION_SEADATANET_QC:_FillValue = -127 ;

POSITION_SEADATANET_QC:long_name = "Position SeaDataNet Quality Flags" ;

POSITION_SEADATANET_QC:units = "1" ;

POSITION_SEADATANET_QC:valid_range = 48b, 65b ;

POSITION_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

POSITION_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

POSITION_SEADATANET_QC:comment = "OceanSITES quality flagging for position coordinates." ;

POSITION_SEADATANET_QC:scale_factor = 1s ;

POSITION_SEADATANET_QC:add_offset = 0s ;

POSITION_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";

byte DEPTH_SEADATANET_QC(TIME) ;

DEPTH_SEADATANET_QC:_FillValue = -127 ;

DEPTH_SEADATANET_QC:long_name = "Depth SeaDataNet Quality Flag" ;

DEPTH_SEADATANET_QC:units = "1" ;

DEPTH_SEADATANET_QC:valid_range = 48b, 65b ;

DEPTH_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

DEPTH_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

DEPTH_SEADATANET_QC:comment = "OceanSITES quality flagging for depth coordinate." ;

DEPTH_SEADATANET_QC:scale_factor = 1s ;

DEPTH_SEADATANET_QC:add_offset = 0s ;

DEPTH_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";

byte QCflag(TIME, DEPTH, LATITUDE, LONGITUDE) ;

QCflag:_FillValue = -127 ;

QCflag:long_name = "Overall Quality Flags" ;

QCflag:units = "1" ;

QCflag:valid_range = 48b, 65b ;

QCflag:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

QCflag:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

QCflag:comment = "OceanSITES quality flagging for all QC tests." ;

QCflag:scale_factor = 1s ;

QCflag:add_offset = 0s ;

QCflag:sdn_conventions_urn = "SDN:L20::";

byte VART_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;

VART_QC:_FillValue = -127 ;

VART_QC:long_name = "Variance Threshold Quality Flags" ;

VART_QC:units = "1" ;

VART_QC:valid_range = 48b, 65b ;

VART_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

VART_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

VART_QC:comment = "OceanSITES quality flagging for variance threshold QC test. Test not applicable to Direction Finding systems. The Temporal Derivative test is applied.Threshold set to 1.2 m/s. " ;

VART_QC:scale_factor = 1s ;

VART_QC:add_offset = 0s ;

VART_QC:sdn_conventions_urn = "SDN:L20::";

byte GDOP_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;

GDOP_QC:_FillValue = -127 ;

GDOP_QC:long_name = "GDOP Threshold Quality Flags" ;

GDOP_QC:units = "1" ;

GDOP_QC:valid_range = 48b, 65b ;

GDOP_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

GDOP_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

GDOP_QC:comment = "OceanSITES quality flagging for GDOP threshold QC test. Threshold set to 2." ;

GDOP_QC:scale_factor = 1s ;

GDOP_QC:add_offset = 0s ;

GDOP_QC:sdn_conventions_urn = "SDN:L20::";

byte DDNS_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;

DDNS_QC:_FillValue = -127 ;

DDNS_QC:long_name = "Data Density Threshold Quality Flags" ;

DDNS_QC:units = "1" ;

DDNS_QC:valid_range = 48b, 65b ;

DDNS_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

DDNS_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

DDNS_QC:comment = "OceanSITES quality flagging for Data density threshold QC test. Threshold set to 3 radials." ;

DDNS_QC:scale_factor = 1s ;

DDNS_QC:add_offset = 0s ;

DDNS_QC:sdn_conventions_urn = "SDN:L20::";

byte CSPD_QC(TIME, DEPTH, LATITUDE, LONGITUDE) ;

CSPD_QC:_FillValue = -127 ;

CSPD_QC:long_name = "Velocity Threshold Quality Flags" ;

CSPD_QC:units = "1" ;

CSPD_QC:valid_range = 48b, 65b ;

CSPD_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;

CSPD_QC:flag_meanings = "no_quality_control good_value probably_good_probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

CSPD_QC:comment = "OceanSITES quality flagging for Velocity threshold QC test. Threshold set to 1.2 m/s." ;

CSPD_QC:scale_factor = 1s ;

CSPD_QC:add_offset = 0s ;

CSPD_QC:sdn_conventions_urn = "SDN:L20::";

short NARX(TIME) ;

NARX:_FillValue = -32767s ;

NARX:long_name = "Number of Receive Antennas" ;

NARX:units = "1" ;

NARX:valid_range = 0s, 50s ;

NARX:scale_factor = 1s ;

NARX:add_offset = 0s ;

NARX:sdn_parameter_name = "" ;

NARX:sdn_parameter_urn = "" ;

NARX:sdn_uom_name = "Dimensionless" ;

NARX:sdn_uom_urn = "SDN:P06::UUUU" ;

short NATX(TIME) ;

NATX:_FillValue = -32767s ;

NATX:long_name = "Number of Transmit Antennas" ;

NATX:units = "1" ;

NATX:valid_range = 0s, 50s ;

NATX:scale_factor = 1s ;

NATX:add_offset = 0s ;

NATX:sdn_parameter_name = "" ;

NATX:sdn_parameter_urn = "" ;

NATX:sdn_uom_name = "Dimensionless" ;

NATX:sdn_uom_urn = "SDN:P06::UUUU" ;

float SLTR(TIME, MAXSITE) ;

SLTR:_FillValue = 9.96921e+36f ;

SLTR:long_name = "Receive Antenna Latitudes" ;

SLTR:standard_name = "latitude" ;

SLTR:units = "degrees_north" ;

SLTR:valid_range = -90.f, 90.f ;

SLTR:coordinates = "TIME MAXSITE" ;

SLTR:scale_factor = 1.f ;

SLTR:add_offset = 0.f ;

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" ;

float SLNR(TIME, MAXSITE) ;

SLNR:_FillValue = 9.96921e+36f ;

SLNR:long_name = "Receive Antenna Longitudes" ;

SLNR:standard_name = "longitude" ;

SLNR:units = "degrees_east" ;

SLNR:valid_range = -180.f, 180.f ;

SLNR:coordinates = "TIME MAXSITE" ;

SLNR:scale_factor = 1.f ;

SLNR:add_offset = 0.f ;

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" ;

float SLTT(TIME, MAXSITE) ;

SLTT:_FillValue = 9.96921e+36f ;

SLTT:long_name = "Transmit Antenna Latitudes" ;

SLTT:standard_name = "latitude" ;

SLTT:units = "degrees_north" ;

SLTT:valid_range = -90.f, 90.f ;

SLTT:coordinates = "TIME MAXSITE" ;

SLTT:scale_factor = 1.f ;

SLTT:add_offset = 0.f ;

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" ;

float SLNT(TIME, MAXSITE) ;

SLNT:_FillValue = 9.96921e+36f ;

SLNT:long_name = "Transmit Antenna Longitudes" ;

SLNT:standard_name = "longitude" ;

SLNT:units = "degrees_east" ;

SLNT:valid_range = -180.f, 180.f ;

SLNT:coordinates = "TIME MAXSITE" ;

SLNT:scale_factor = 1.f ;

SLNT:add_offset = 0.f ;

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" ;

char SCDR(TIME, MAXSITE, STRING15) ;

SCDR:_FillValue = "" ;

SCDR:long_name = "Receive Antenna Codes" ;

SCDR:units = "1" ;

SCDR:sdn_parameter_name = "" ;

SCDR:sdn_parameter_urn = "" ;

SCDR:sdn_uom_name = "Dimensionless" ;

SCDR:sdn_uom_urn = "SDN:P06::UUUU" ;

char SCDT(TIME, MAXSITE, STRING15) ;

SCDT:_FillValue = "" ;

SCDT:long_name = "Transmit Antenna Codes" ;

SCDT:units = "1" ;

SCDT:sdn_parameter_name = "" ;

SCDT:sdn_parameter_urn = "" ;

SCDT:sdn_uom_name = "Dimensionless" ;

SCDT:sdn_uom_urn = "SDN:P06::UUUU" ;

// global attributes:

:site_code = "HFR-TirLig" ;

:platform_code = "HFR-TirLig-Total" ;

:data_mode = "R" ;

:DoA_estimation_method = "Direction Finding" ;

:calibration_type = "APM" ;

:last_calibration_date = "2018-09-27T00:00:00Z" ;

:calibration_link = "carlo.mantovani@cnr.it" ;

:title = "Near Real Time Surface Ocean Velocity by HFR_TirLig" ;

:summary = "The data set 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. 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 = "National Research Council - Institute of Marine Science, S.S. Lerici" ;

:institution_edmo_code = "134" ;

:data_assembly_center = "European HFR Node" ;

:id = "HFR-TirLig-Total_2019-04-01T11:00:00Z" ;

:data_type = "HF radar total data" ;

:feature_type = "surface" ;

:geospatial_lat_min = "43.5" ;

:geospatial_lat_max = "44.23" ;

:geospatial_lon_min = "9.2" ;

:geospatial_lon_max = "10.5" ;

:geospatial_vertical_min = "0" ;

:geospatial_vertical_max = "4" ;

:time_coverage_start = "2019-04-01T10:30:00Z" ;

:time_coverage_end = "2019-04-01T11:30:00Z" ;

:format_version = "v2.1" ;

:Conventions = "CF-1.6, OceanSITES-Manual-1.2, Copernicus-InSituTAC-SRD-1.4, CopernicusInSituTAC-ParametersList-3.1.0, Unidata, ACDD, INSPIRE" ;

:update_interval = "void" ;

:citation = "These data were collected and made freely available by the Copernicus project and the programs that contribute to it. Data collected and processed by CNR-ISMAR within RITMARE, Jerico-Next and IMPACT projects. " ;

: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." ;

:publisher_name = "European HFR Node" ;

:publisher_url = "http://eurogoos.eu/" ;

:publisher_email = "euhfrnode@azti.es" ;

: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/." ;

: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." ;

:date_created = "2019-04-01T15:20:16Z" ;

:history = "2019-04-01T11:00:00Z data collected. 2019-04-01T15:20:16Z netCDF file created and sent to European HFR Node" ;

:date_modified = "2019-04-01T15:20:16Z" ;

:date_update = "2019-04-01T15:20:16Z" ;

:processing_level = "3B" ;

:contributor_name = "Lorenzo Corgnati; Carlo Mantovani" ;

:contributor_role = "metadata expert; HFR expert" ;

:contributor_email = "lorenzo.corgnati@sp.ismar.cnr.it; carlo.mantovani@cnr.it" ;

:project = "RITMARE, Jerico-Next, IMPACT and SICOMAR Plus" ;

:naming_authority = "it.cnr.ismar" ;

: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" ;

:topic_category = "oceans" ;

:network = "ISMAR_HFR_TirLig" ;

:area = "Mediterranean Sea" ;

:geospatial_lat_units = "degrees_north" ;

:geospatial_lon_units = "degrees_east" ;

:geospatial_lat_resolution = "0.018" ;

:geospatial_lon_resolution = "0.024879" ;

:geospatial_vertical_resolution = "4" ;

:geospatial_vertical_units = "m" ;

:geospatial_vertical_positive = "down" ;

:time_coverage_duration = "PT1H" ;

:time_coverage_resolution = "PT1H" ;

:reference_system = "EPSG:4806" ;

:grid_resolution = "2" ;

:cdm_data_type = "Grid" ;

:netcdf_version = "4.3.3.1" ;

:netcdf_format = "netcdf4_classic" ;

:metadata_contact = "lorenzo.corgnati@sp.ismar.cnr.it" ;

:metadata_date_stamp = "2019-04-01T15:20:16Z" ;

:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table Version 1.6" ;

:sensor = "CODAR SeaSonde" ;

:institution_reference = "http://www.ismar.cnr.it/" ;

:date_issued = "2019-04-01T15:20:16Z" ;

:software_name = "HFR_Combiner" ;

:software_version = "v3.1" ;

:references = "High Frequency Radar European common data and metadata model Reference Card: all you need to know about High Frequency Radar (HFR) data harmonization at a glance. http://www.marineinsitu.eu/wp-content/uploads/2018/02/HFR_Data_Model_Reference_Card_v1.pdf" ;

}