St3TART
FRM for Sentinel-3 Land Altimetry

Sentinel-3 Topography mission Assessment through Reference Techniques (St3TART)

TD-9 FRM Data Hub Data Filename Convention and Format Specification Document

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* *I = Inserted* *D = Deleted* *M = Modified*

Acronyms

ESA	European Space Agency
FRM	Fiducial Reference Measurements
GIS	Geographic Information System
RDBMS	Relational DataBase Management System
WGS	World Geodetic System
CRS	Coordinate Reference System

References

N°	Reference	Title
[RD1]	ESA-EOPG-CSCOP-SOW-29, Issue 1 Rev. 4 – 28/10/2020	Statement of Work - Sentinel-3 Topography mission Assessment through Reference Techniques (St3TART)
[RD2]	NOV-FE-0899-PR-002	Technical Proposal
[RD3]	NOV-FE-0899-PR-004	Implementation Proposal
[RD4]	ESA Contract No. 4000135181/21/I-DT	ESA Contract – Copernicus ground segment Sentinel-3 Topography mission Assessment through Reference Techniques (St3TART)
[RD5]	Eaton, B., Gregory J., Drach, B., Taylor, K., Hankin, S., Blower, J., Caron, J., … & Herlédan, S. (2021). NetCDF Climate and Forecast (CF) Metadata Conventions, Version 1.10, 10 September, 2021. https://cfconventions.org/cf-conventions/cf-conventions.html	
[RD6]	CF Standard Name Table (2021). Version 78, 21 September, 2021. https://cfconventions.org/Data/cf-standard-names/78/build/cf-standard-name-table.html	
[RD7]	Pekel, J., Cottam, A., Gorelick, N. et al. High-resolution mapping of global surface water and its long-term changes. Nature 540, 418–422 (2016), doi: https://doi.org/10.1038/nature20584	
[RD8]	Copernicus Marine In Situ NetCDF Format Manual, Version 1.42, March 30th 2021. https://doi.org/10.13155/59938	
[RD9]	Copernicus Marine Service - PRODUCT USER MANUAL For In Situ Products, Version 1.12, April 19th 2021. http://dx.doi.org/10.13155/43494	
[RD10]	BODC WEBSERVICES V2 (LIBRARIES) CL12. https://vocab.seadatanet.org/search	
[RD11]	http://www.oceansites.org/docs/oceansites_data_format_reference_manual_20140917.pdf	
[RD12]	https://seabass.gsfc.nasa.gov/wiki/Data_Submission	
[RD13]	CCI Data Standards – ref CCI-PRGM-EOPS-TN-13-0009	

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1. Introduction

1.1. Context

St3TART is an EU and ESA funded project that aims to generalize the concept of Fiducial Reference Measurements (FRM) for the Copernicus Sentinel-3 STM and to collect and distribute FRM data for the validation of the satellite mission over inland waters, sea ice and land ice.

The objective of the St3TART project is not only to collect existing data or measure new observations during field campaigns, but to ensure that these observations meet the criteria of FRM standards and can be used in an operational way for the validation of the Sentinel-3 Land topography mission.

In the framework of this project, a FRM Data Hub has been developed, to provide a centralized access to these FRM measurements. It aims to federate the Cal/Val community in sharing these reference observations in a free and accessible manner, with fully characterized and documented FRM processing and measurements.

1.2. Purpose and scope

This document is the Fiducial Reference Measurements (FRM) Data Hub Data filename convention and format specification for the "Sentinel-3 Topography mission Assessment through Reference Techniques (St3TART)" project, [RD1]. It will be maintained for the whole duration of the project, updated as necessary and reissued at every major change with ESA Technical Officer's approval.

The standardization covered in this document contains the Data filename convention and format specification which are relevant to all data files used and disseminated through the FRM Data Hub.

Hence, this document is expected to yield the following benefits:

- Increase ease of use (predictability of names and structure);
- Ensure reusability (using reliable, well-supported standards) by various actors and systems (or software solutions);
- Simplify the production of files meant to be disseminated via the data hub.

This document encompasses:

- Filename convention;
- Format specification.

1.3. Standard Applicability

This standard must be followed for every file hosted on the FRM Data Hub.

2. Filename convention

The aim of the FRM Data Hub is to offer a centralized access to FRM measurements. That's why the filename convention shall cover main characteristics of FRM measurements.

Based on the existing file-naming conventions, the filename shall contain at least the following elements:

- Surface Type (SS)
- Geographic Area (GGG_ggg)
- Sensor type (SSS)
- Platform type (PPP)
- Platform_id (ppppppppp)
- Processing Level (LX)
- Temporal period (YYYYMMDDThhmmss_YYYYMMDDThhmmss)
- Version

Therefore, the filename will look like this:

SS_GGG_ggg_SSS_PPP_ppppppp_ LX_YYYYMMDDThhmmss_YYYYMMDDThhmmss _VX.Y.nc

The paragraphs below list the different component values.

2.1.1. Surface type

The surface type designs which type of surface the measures address.

It can take the following values:

Code	Meaning
SI	SeaIce
LI	LandIce
IW	InlandWaters

Table 1 - Surface types

2.1.2. Geographic Area

The geographic area indicates the area where the measures have been taken. Each type of surface will have a specific description, however it's always composed of 2 trigrams.

For Inland waters: the ISO3 country code and the 3 first letters of the lake/river name are used to this end.

Examples:

Code	Meaning
FRA_Gar	Garonne River, France
FRA_Rhi	Rhine River, France
ITA_Por	Po River, Italy
GER_Rhi	Rhine River, Germany

Table 2 - Geographic area – inland waters

For sea ice: prefix ARC/ANT, followed by 3 letters for the local sea name.

Code	Meaning
ARC_Gre	Greenland Sea in Arctic ocean

Table 3 - Geographic area - sea ice

For land ice: ISO3 country code + 3 letters of the name of the region.

Code	Meaning
ANT_Ell	Ellsworth land in Antartica

Table 4 - Geographic area - land ice

2.1.3. Sensor type

The sensor type describes if the sensor used to get the measurement is a fixed or moving sensor.

Code	Meaning
FIX	Fix sensor
MOV	Moving sensor

Table 5 - Sensor types

2.1.4. Platform type

The platform type describes the platform on which the sensor is installed.

Code	Meaning
ARB	AirBorne
DSB	Drifting Surface Buoy
HLC	Helicopter
HUM	Human
MOO	Mooring
RIS	River Station
UAV	Drone
VES	Vessel

Table 6 - Platform type

2.1.5. Platform ID

The platform_ID allows to identify each platform as a unique one. For example, it will enable users to differentiate 2 micro-stations installed on the same site, or 2 ice-T buoys deployed during the same campaign.

For vorteX.io micro-stations, the platform_id is the name of the micro-station (as visible in Maelstrom web interface).

For ice-T buoy, the platform_id is the identifier of the ice-T buoy (e.g. NPEO2011)

For airbone, the platform_id is the call sign.

For drone, the platform_id is the drone identifier (e.g. VTX-1AA).

2.1.6. Processing level

The processing level enables user to know if the data has been post-processed or not.

The values are the following:

L0: raw data

L1: post-processed data

L2: FRM data

2.1.7. Temporal period

The temporal period describes the time period covered by the file, from first measurement date to last measurement date.

The temporal period will be given in the following format: YYYYMMDDThhmmss_YYYYMMDDThhmmss, in UTC.

2.1.8. Version

The version describes the dataset version. Some datasets can be reprocessed, and in that case, it's important to distinguish the first dataset version from the following ones. Note that there is no need to increase the version number if the data are not changed.

3. Format specification

3.1. File type

All datasets hosted on the FRM data hub will be of NetCDF type. It has two main advantages:

- The self-documented nature of these files eases the publication and viewing of metadata. It also means it is not possible for users to lose said metadata;
- NetCDF files are ubiquitous in earth sciences. Therefore, they are fully supported by an extremely wide array of software solutions (QGIS, Panoply, ncview, nco, cdo, etc.) and libraries in most common languages (Fortran, C/C++, Python, Java, etc.).

3.2. Conventions

Additionally, all datasets must adhere to [RD5] (Climate and Forecast convention version 1.10) which provides a very robust framework regarding dataset standardization. In concrete terms, this convention carefully describes all the metadata that should be included (and how they should be included) in a NetCDF dataset to maximize its usefulness, clarity and portability.

Overall, the CF convention has the following benefits:

- The standard is open and easy to apply and understand;
- It defines a norm for attributes and their content, thus maximizing compatibility with many software solutions (QGIS, Panoply);
- It also provides a resource to standardize variable names and units ([RD6] CF Standard Name Table), thus greatly facilitating the exploration of all datasets.

In order to make this convention as generic as possible, it has been decided to use global attributes coming from existing standards, such as the “Copernicus Marine In Situ NetCDF Format Manual” [RD8] and the “CCI Data Standards” [RD13].

3.3. Dimensions

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

3.4. Global Attributes

The global attribute section of a NetCDF file describes the overall content of the file and allows for data discovery. All fields should be human-readable and use units that are easy to understand.

Some attributes are required for FRM Data Hub Database: it’s specified in the “level” column. It’s recommended to complete as many attributes as possible, as it gives important information to users.

Global attribute names are case sensitive.

It’s possible to add global attributes if needed.

The list of global attributes for FRM Data Hub is the following:

Global attribute name	Global attribute description	Level (to be updated lately if needed)
title	Few meaningful words describing the dataset content	mandatory
summary	Longer free-format text describing the dataset. This attribute should allow data discovery for a human reader. A paragraph of up to 100 words is appropriate	mandatory
institution	The name of the platform's institution	mandatory
institution_references	The references of the platform's institution (blank separated list)	Optional
contact	The contact emails for questions or feedback on the dataset (blank separated list)	Mandatory
project	the scientific project that produced the data: Name of the project (Client between brackets). For St3TART, it shall be "St3TART (ESA)"	Mandatory
date_created	The date on which the data was created	Optional
date_update	The date on which this file was last updated	Mandatory
featureType	Describes the geometry type wherever applicable	Optional
area	Geographic coverage	Optional
platform_type	Platform type (code as in the filename)	mandatory
platform_name	Corresponds to the platform_id of the filename	mandatory
sensor_type	Indicates if the sensor is fixed or moving. Please complete by FIX or MOV	mandatory
sensor	Name and type of sensor (free text)	mandatory
time_coverage_start	Start date of the data in UTC.	Optional
time_coverage_end	Final date of the data in UTC.	Optional
key_variable	Indicates the key primary variable in the file. It should be identified using the variable id in the file.	Mandatory
data_type	Indicates the type of data of the primary variable. It shall be either "FRM calculated" or "Sensor measured"	Mandatory
Processing_level	Indicates the processing level of the primary variable in the file. • L0: raw data • L1: post-processed data • L2: FRM data	optional
Conventions	The name of the conventions followed by the dataset (blank separated list)	optional
references	Published or web-based references that describe the data or methods used to produce it (blank separated list).	optional
citation	The citation to be used in publications using the dataset	optional
doi	DOIs (Digital Object Identifier) related to data aggregated in this file	optional
licence	Describe the restrictions to data access and distribution	optional

Table 7 - Global attributes

3.5. Variables

NetCDF variables include data measured by instruments, parameters derived from the primary measurements and coordinate variables. Each variable has a specific set of attributes, some of which are mandatory.

3.5.1. Coordinate Reference System

In order to maximize compatibility with most Geographic Information Systems, each dataset shall contain a “crs” (Coordinate Reference System) variable declaring the projection used in this dataset.

Here is an example for one of the most widely used projections (WGS 84, EPSG 4326):

```
int crs;
  :grid_mapping_name = " latitude_longitude";
  :longitude_of_prime_meridian = 0.0;
  :semi_major_axis = 6378137.0;
  :inverse_flattening = 298.257223563;
  :crs_wkt = "GEOGCS["WGS 84",DATUM["WGS_1984",SPHEROID["WGS
84",6378137,298.257223563,AUTHORITY["EPSG","7030"]],AUTHORITY["EPSG","6326"]],PRIMEM[
"Greenwich",0,AUTHORITY["EPSG","8901"]],UNIT["degree",0.0174532925199433,AUTHORITY["E
PSG","9122"]],AXIS["Latitude",NORTH],AXIS["Longitude",EAST],AUTHORITY["EPSG","4326"]]
";
```

Figure 1: Coordinate Reference System declaration in a NetCDF variable

Additionally, in accordance with the CF convention, variables based on a given crs should contain a grid_mapping declaration pointing to the crs variable (e.g. grid_mapping = "crs").

3.5.2. Coordinate variables

The coordinate variables guide data in time and space. For this purpose, they have an “axis” attribute defining that they point in X, Y, Z, and T dimensions.

Default values are not allowed in coordinate variables apart from Z axis.

3.5.3. Data variables

All data variables within FRM Data Hub datasets must use names [RD6] (CF Standard Name Table) whenever possible as well as the corresponding units. For instance, Sea Ice Thickness variables must be called “sea_ice_thickness” with the unit “m” as a variable in the datasets, not sit, seathick, thickness or any other name.

3.5.3.1. Local attributes

Data variables contain the actual measurements and indicators about their quality, uncertainty, and method through which they were obtained.

There are different options as to how the indicators are specified, whether in attributes or separate variables, which are outlined after this paragraph. The physical parameter variables are standardized in “CF Standard Name Table” [RD6].

The attributes in bold font are mandatory. The others are optional.

If the value of an attribute is not known, then the attribute is omitted (no fill value for attribute).

Local attribute name	Local attribute description	Interest for St3TART Data Hub	Level
standard_name	Provides a unique identifier for the variable's name	Very high	mandatory
long_name	The variable's name as it would be used in a plot or a document	Very high	mandatory
units	The units used in this variable	Very high	mandatory
_FillValue	Declares the data value representing the absence of data (where applicable)	High	mandatory
scale_factor	The data are to be multiplied by this factor after the data are read by the application that accesses the data.	Very high	mandatory
add_offset	This number is to be added to the data after it is read by the application that accesses the data. If both scale_factor and add_offset attributes are present, the data are first scaled before the offset is added. The attributes scale_factor and add_offset can be used together to provide simple data compression to store low-resolution floating-point data as small integers in a netCDF file. When scaled data are written, the application should first subtract the offset and then divide by the scale factor.	Very high	mandatory
grid_mapping	Declares the corresponding CRS variable	Very high	mandatory
valid_min	valid_min: Minimum value for valid data (add_offset and scale_factor applied)	High	optional
valid_max	valid_max: Maximum value for valid data (add_offset and scale_factor applied)	High	optional
comment	comment: Any free-format text with comments as appropriate	High	optional
coordinates = "TIME LATITUDE LONGITUDE "	coordinates: Required, if a data variable does not have 4 coordinates in its definition.	High	optional

Table 8 - Local attributes

3.5.3.2. Uncertainty variables

As uncertainty of measurements is a very important aspect for FRM, all data variables shall have associated uncertainty variables.

By default, there shall be at least one uncertainty variable per variable, and its name shall be "*variable_standard_name*_uncertainty"

Example: for sea_ice_thickness, the uncertainty variable shall be named sea_ice_thickness_uncertainty.

The "*VARIABLE* _uncertainty" variable can be constant if there is only one value of uncertainty for all measurements.

In some cases, it may be possible to distinguish the different sources of uncertainties. To take it into account, 3 additional uncertainty variables can be defined (but are not mandatory);

- *variable_standard_name*_uncertainty_systematic: to cover effects that lead to errors that are common from observation to observation

- *variable_standard_name*_uncertainty_random: to cover effects that lead to errors that are independent from observation to observation
- *variable_standard_name*_uncertainty_structural: to cover errors that vary in ways between 'systematic' and 'random'.

The "comment" local attribute of "*VARIABLE* _uncertainty" variable shall give a link towards a document describing how uncertainties have been calculated.

3.5.3.3. Fill value conventions for variables

The _FillValue variable attribute is mandatory. It is set to the default value of the variable type.

See https://Linkwww.unidata.ucar.edu/software/netcdf/docs/netcdf_8h.html

- NC_FILL_INT (-2147483647)
- NC_FILL_FLOAT (9.9692099683868690e+36f)
- NC_FILL_DOUBLE (9.9692099683868690e+36)
- NC_FILL_BYTE ((signed char)-127)

4. Annex 1- Existing standards for filename convention

In order to define the most adequate filename convention, the first task was to search for existing standards for FRM or in-situ measurements.

Several standards have been defined on different programs. We will focus on 3 main filename conventions, that describe ocean in-situ data products:

- The CMEMS in-situ data product user manual is the one that seems to be the nearest to our needs.
- The OceanSITES data file naming convention is also interesting.
- Finally, the SEABASS file naming convention has also been reviewed.

4.1. CMEMS in-situ data file naming

In the CMEMS in-situ database (CF [RD8]), data are organized in 4 directories, depending on the time period covered by the dataset.

"Latest" corresponds to daily files with 30 last days history. "Monthly" corresponds to files containing all data for a complete month. "History" contains the complete series of observations and "Reference" corresponds to complete series of observations scientifically reviewed or "gold standard" observations with proper calibration and error associated with the data.

The table below presents the naming convention for these 4 kinds of files.

Directory	Naming convention	Meaning
latest	RR_XX_YY_CODE_YYYYMMDD.nc *i.e GL_TS_TS_FKJB_20180702.nc*	• RR: region bigram (see reference table 2) • XX: file type (see reference table 3) • YY: data type (see reference table 4) • CODE: platform code[1] • timestamp (YYYYMMDD or YYYYMM for daily and monthly files respectively) • <_ZZZ>: optional information • .nc: NetCDF file name suffix
monthly	RR_XX_YY_CODE_YYYYMM.nc *i.e GL_TS_TS_FKJB_201806.nc*	
history	RR_XX_YY_CODE<_ZZZZ>.nc *i.e GL_TS_TS_FKJB.nc*	
reference (optional)	RR_XX_YY_CODE<_ZZZZ>.nc *i.e GL_TS_TS_FKJB.nc*	

Table 9 – CMEMS file name convention

In this table we can note that there are 5 types of standardized information within this filename convention:

- The identifier of the region
- The file type
- The data type
- The platform code
- The timestamp (only for latest/monthly files).

The reference tables corresponding to each field are the following:

CODE	Meaning
AR	Arctic
BO	Baltic Sea (BOOS)
BS	Black Sea
GL	Global Ocean
IR	Iberia Biscay Ireland (IBI-ROOS)
MO	Mediterranean sea (MONGOOS)
NO	North West Shelf (NOOS)

Table 11 – Region bigrams

CODE	Meaning
TS	timeseries, trajectories
PR	profiles
TV	total velocity (for HF radars)
RV	radial velocity (for HF radars)
WS	wave spectra

Table 10 - File type bigrams

CODE	Meaning
BO	botte samples
CO	Autonomous underway pCO2 data
CT	vessel CTDs
DB	drifting buoys
DC	drifting buoy reporting calculated sea water current
FB	ferrybox
GL	glider
HF	HF radar
ML	mini loggers for fishery observing system
MO	fixed buoys, mooring time series, fixed observations
PF	profiling floats
RF	river flows
SD	saildrone
SF	scanfish (towed CTDs)
SM	Sea mammals data
TG	tide gauges
TS	ship underway data, thermosalinographers
TX	Thermistor chain data
VA	Vessel mounted ADCPs
XB	XBT, XCTD or MBT profiles
XX	Not yet identified

Table 12 - Data type bigrams

4.2. SeaDataNet naming convention

SeaDataNet is a standardized infrastructure for managing the large and diverse datasets collected by the oceanographic fleets and the automatic observation systems. The SeaDataNet infrastructure network and enhance the currently existing infrastructures, which are the national oceanographic data centres or data focal points of 34 countries, active in data collection. SeaDataCloud project (2016-2020), aims at considerably advancing SeaDataNet Services and increasing their usage, adopting cloud and High Performance Computing technology for better performance.

The SeaDataCloud naming convention depends on the type of product. However, all products have at least the fields marked with (*). CF [RD10]

Table 13 – Sea DataNet naming convention

CODE	Meaning
[PRO]	Project (*)
[REG]	Region (*)
[PROD]	Product (*)
[P]	Parameter (*)
[VX]	Version
[YYYY1]_[YYYY2]	Time coverage
[R]	Resolution (1/2° = 050)
[T]	Temporal resolution (m=monthly, s=seasonal)

The definition of Project, region, product and parameters are proper to SeaDatanet.

Example for the list of regions and products:

Table 14 - SeaDataNet regions

CODE	Meaning
GLO	Global Ocean
ARC	Arctic Ocean
BAL	Baltic Sea
BLS	Black Sea
MED	Mediterranean sea
NAT	North Atlantic Ocean
NWS	North West Shelf

Table 15 - SeaDataNet products

CODE	Meaning
DATA	Regional Data Collections
CLIM	Climatologies

It’s interesting to note that in this convention, the focus is on the region, the type of data and the observed parameters.

4.3. OceanSITES in-situ data file naming

The mission of OceanSITES is to collect, deliver and promote the use of high-quality data from long-term, high-frequency observations at fixed locations in the open ocean.

According to [RD11], almost all OceanSITES NetCDF files are named using this convention:

CODE	Meaning
OS	OceanSITES prefix
[PlatformCode]	Platform code from the OceanSITES catalogue
[DeploymentCode]	Deployment code (unique code for deployment date or number)
[DataMode]	Data Mode: - R: real-time data - P: provisional data - D: delayed mode data - M: mixed delayed mode and real-time data
[PARTX]	An optional user defined field for identification of data

Table 16 - OceanSITES naming convention

PlatformCode and DeploymentCode are unique codes given by OceanSITES.

In this convention, the geographic information and type of data will be found in the OceanSITES platform catalog.

The only information given by this file convention is the data mode.

It seems less appropriate to what is needed for FRM Data Hub.

4.4. SEABASS in-situ data file naming

The NASA Ocean Biology Processing Group (OBPG) maintains a local repository of in-situ oceanographic and atmospheric data to support their regular scientific analyses. The SeaWiFS Project originally developed this system, SeaBASS, to catalog radiometric and phytoplankton pigment data used for their calibration and validation activities. To facilitate the assembly of a global dataset, SeaBASS was expanded with oceanographic and atmospheric data collected by participants in the SIMBIOS Program, under NASA Research Announcements NRA-96 and NRA-99, which has considerably aided in minimizing spatial bias and maximizing data acquisition rates.

The file naming guidelines for this program are the following (CF [RD12])

- File names must not contain spaces or special characters except for hyphens, underscores, and periods.
- SeaBASS file names must end in ".sb" suffix.
- File names (before the suffix) are recommended to end in _R#, where # is the release number starting with 1 in most cases (e.g., myfile_R1.sb).
    - If preliminary files are submitted (i.e., /data_status=preliminary such that they are likely to be revised in the future), then it is recommended their name includes "_R0" to indicate their tentative status
- File names must be unique within a submission, and ideally should be completely unique in SeaBASS.
- It is strongly recommended they are formed using descriptive patterns incorporating information or abbreviations of the:
    - measurement type,
    - cruise name,
    - date,
    - depth or other information.

In this convention, we can find some elements in common with CMEMS convention: the measurement type, information on the cruise, and date of data.