Sea Ice thickNess inter-comparison eXerciSe (SIN'XS)

Assessment User Manual (D3.3): How to submit data to SIN'XS project? - V2.2

For the attention of: Mr. Jérôme BOUFFARD (ESA)
Mr. Alessandro DI BELLA (ESA)
Scientific Advisory Committee of the SIN'XS project

	Function	Name	Signature	Date
Prepared by	Project manager/ Project Team	Caroline RIBERE/ Sara FLEURY Valentin LUDWIG Christian HAAS Eric MUNESA Jaoudat SABALBAL		03/05/24
Approved by	Deputy CEO	Mahmoud EL HAJJ		03/05/24

NOVELTIS
153 rue du Lac – 31670 Labège – France
Tél. : +33 (0)562 88 11 11 – Fax : +33 (0)562 88 11 12 – E-mail : noveltis@noveltis.fr

Distribution list

INTERNAL	EXTERNAL	
Name	**Name**	**Company / Organisation**
Documentation NOVELTIS	Jérôme BOUFFARD	ESA
Richard BRU	Alessandro DI BELLA	ESA
Project Team	All members from the SIN'XS project	
	All members from the Scientific Advisory Committee (SAC) of the SIN'XS project	

Document status

Sea Ice thickNess inter-comparison eXerciSe Assessment User Manual (D3.3): How to submit data to SIN'XS project?			
Issue	**Revision**	**Date**	**Reason for the revision**
1	0	11/04/2023	Initial version
1	1	01/08/2023	Revised version following ESA comments
1	2	05/10/2023	Revised version following the update of the submission form
2	0	10/11/2023	Revised version for RBR2
2	1	09/02/2024	Revised version for D&VR2 also taking into account ESA RBR2 review
2	2	30/04/2024	Revised version taking into account comments from partners and the changes in the submission form

Modification status				
Issue	Rev	Status *	Modified pages	Reason for the modification
1	1	M	12, 13, 14, 15	Updates of global attributes and time dimension description following ESA review
1	2	M	8, 9, 10, 11	Update of Figure 1 and Figure 2
2	0	M	8, 9, 10, 11	Update of Figure 1 and Figure 2
2	0	M	16, 17	Update of paragraph 5.3.1 to include compatibility with NetCDF file viewers (e.g., NASA's Panoply)
2	0	M	24, 25, 26	Update of Annex 1 according to up-to-date SIN'XS product specifications
2	1	M	14-16	Update of Table 4 concerning global attributes
2	1	M	21	Update of Figure 3 concerning the Maturity Matrix
2	1	I	23-26	Update of Section 6 with additional information concerning the Maturity Matrix
2	2	M	7-10, 14, 15	Update of Global Attributes, corrected typo, updated screenshots in the intro of section 2, added information on data and grid formats

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

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1. Context

The SIN'XS project, led by NOVELTIS in collaboration with AWI, LEGOS and UCL, is a three-year activity (May 2022 – May 2025) funded by ESA in the framework of the Polar Science Cluster, with the objective to foster collaborative research and interdisciplinary networking actions regarding sea-ice and snow thickness.

In light of rapid changes of the Arctic and Antarctic sea ice cover, continued and improved observations, understanding and predictions of its thickness are particularly important for a range of fields from climate studies to offshore operations in ice. Systematic and accurate ice thickness observations are now available from several satellite missions. Numerical models offer another way to obtain sea-ice thickness at a spatial and temporal coverage that is needed for climatological studies. However, these approaches differ in used processing algorithms and assumptions, temporal and spatial coverage and resolution, and applicability to stakeholder needs like modelling and assimilation, numerical weather prediction, and ship routing. These differences between products have so far complicated the consistent use of the various data products, and there is little consensus about Arctic and Antarctic Sea ice thickness variability and change.

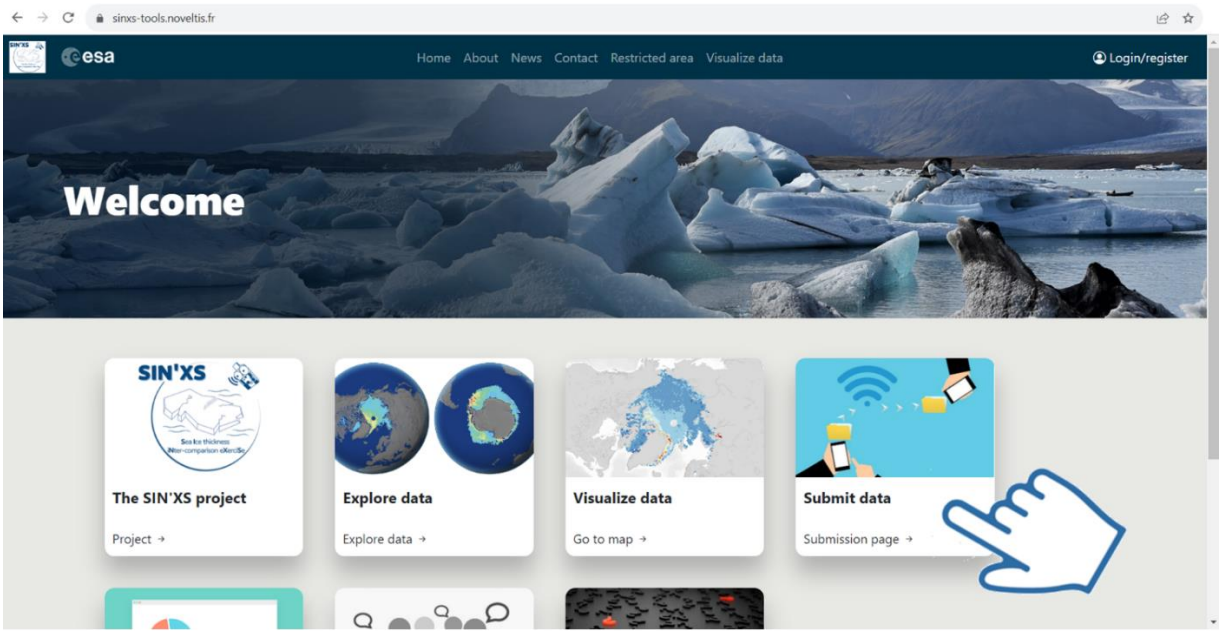
The Sea Ice-thickness product iNter-comparison eXerciSe (SIN'XS) will identify some of these gaps by carrying out in-depth inter-comparisons of a wide range of satellite ice thickness products from altimetry and other methods, in close collaboration with an international community of scientific and operational sea ice experts, and in partnership with the WMO Global Cryosphere Watch (GCW). Numerical models shall also be included into SIN'XS. Furthermore, the submission of reference/ground-truth ice and snow thickness measurements is solicited.

It will develop joint protocols for the inter-comparison of ice and snow thickness products and their validation, using established approaches from the GEO/CEOS Quality Assurance framework for Earth Observation (QA4EO) and by further developing a framework for Fiducial Reference Measurements (FRMs).

In order to be able to handle and assess the manifold of expected datasets which will be used for the SIN'XS inter-comparison exercise, certain minimum requirements must be met by each submitted dataset. These requirements are described in the following subsections and pertain to the global/variable attributes, variable names following the ***CCI Data Standard*** and the ***Climate and Forecast*** (CF) ***Metadata Conventions***, as well as the used grid specifics and the data format of the data to be used.

2. How to submit?

If you are interested in submitting data, please connect with your credentials (or register) to the SIN'XS webpage at https://sinxs-tools.noveltis.fr/ and click on the **"Submit data"** button.



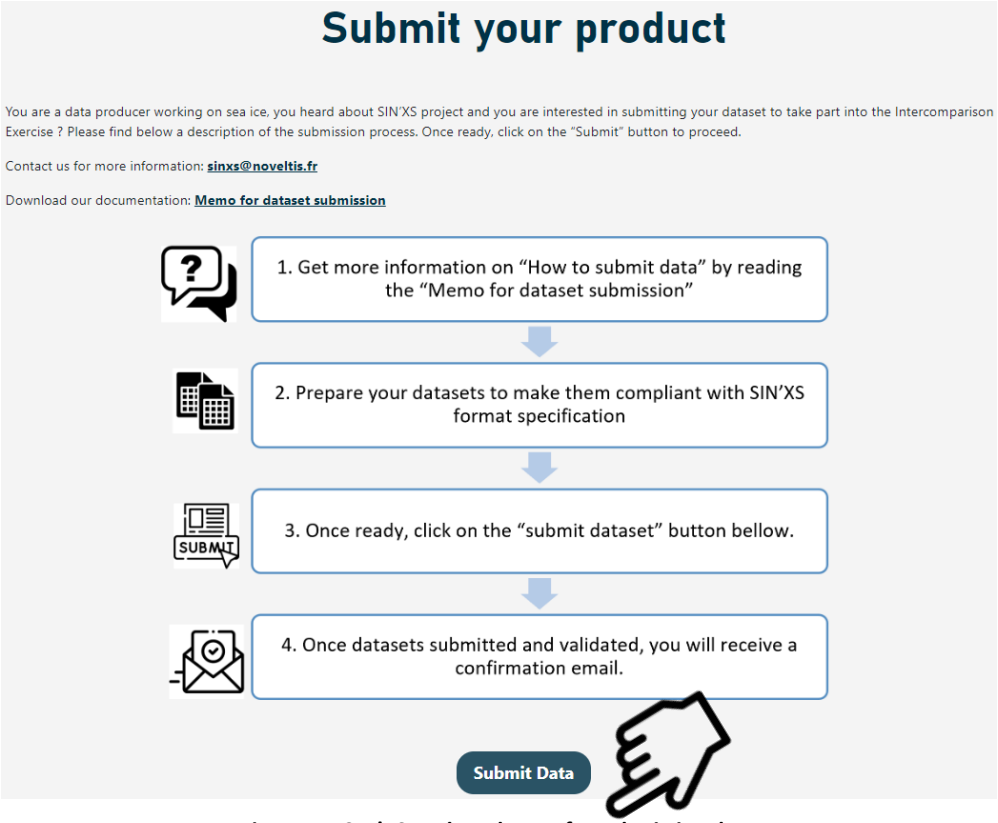


Figure 1 – SIN'XS tools webpage for submitting data

To submit data, you will need to fill in a form with all the information needed to qualify your products. Below is an example of form, allowing you to prepare all required information before submitting.

Submit Data

Fields with * are mandatory

First name

Last name

Email

Organization

Name of the product: *
Please use the following naming structure:
SINXS_PROVIDER_HH_VAR_PTF_Mission_ YYYYMMDD_YYYYMMDD_VX.Y

Code	Description	Examples
SINXS	Name of the project (always SINXS)	SINXS
PROVIDER	Original provider	LEGOS, AWI, DTU, etc.
HH	Hemisphere: NH for the North Hemisphere, SH for the South Hemisphere	NH, SH
VAR	Main variable, among the following variables: CF trigrams in the Table 1	RFB
PTF	Type of platform used to acquire the dataset (CF list below). Can also be "CLI" for climatology, or "MOD" for model. CF trigrams in Table 3	SAT, HLC, ARB
MISSION	Name of the mission (if PTF = SAT), of the project (for observations), or of the model. If PTF = HYB, the different missions may be separated by a "-".	CS2, SMOS-CS2, OIB, PIOMAS
YYYYMMDD_ YYYYMMDD	Temporal period covered by the file from first measurement date to last measurement date, in UTC	20220601_220701
VX.Y	Dataset version	V1.2

Measured variables included in your product (geophysical variable measured by the sensor): *

Memo for dataset submission

Parameter	Standard Name	Trigram	Examples
Sea Ice Thickness	sea_ice_thickness	SIT	field measurement, Altimetry (Laser and Radar), Passive microwave radiometry, models
Sea ice Freeboard	sea_ice_freeboard	SFB	field measurement
Snow Thickness	snow_thickness	SNT	snow radar, field measurement, buoys
Radar Freeboard	radar_freeboard_ku radar_freeboard_ka	RFB	Altimetry: CS2, S3, Env, ERS1/2, ASIRAS, etc. Altimetry: Saral/AltiKa, Karen
Total Freeboard	total_freeboard	TFB	IS2, airborne lidars
Sea-Ice Draft	sea_ice_draft	SID	Upward Looking Sonars (ULS) on Moorings or Mammals
Total Sea Ice Thickness	total_sea_ice_thickness	TST	Airborne ElectroMagnetic sensors

radar_freeboard_ku
radar_freeboard_ka
snow_thickness
sea_ice_draft

Calculated variables derived from the measured variables included in your product: *

Memo for dataset submission

radar_freeboard_ku
radar_freeboard_ka
snow_thickness
sea_ice_draft

Select the category of your product: *

Category	Description
SIT-E1	Numerical Model
SIT-E2	Satellite Observations
SIT-E2a	Ku-Band Radar Altimetry
SIT-E2b	Ka-Band Radar Altimetry or Laser Altimetry
SIT-E2c	Passive Microwave
SIT-E2d	Hybrid (CS2/IS2 or CS2/SMOS, etc...)
SIT-E2e	Scatterometer/SAR
SIT-E2f	Thermal Infrared
SIT-3	Other (ice thickness observation regression, etc...)
SNT-1	Climatology based in-situ observations
SNT-2	Satellite Observations (Single Sensor or Hybrid)
SNT-3	Snow Model
SIT-R1	Airborne laser or Radar Altimetry
SIT-R2	Airborne Electromagnetic or Induction Sounding
SIT-R3	Airborne Electromagnetic or Induction Sounding + Laser/Radar Altimetry
SIT-R4	Upward Looking Sonar (moored, submarine)
SIT-R5	Ice Mass Balance Buoys
SIT-R6	Visual/Direct Observations

Does your product come from Observation or Model?*

○ Observation ○ Model

Select the data source of your product (ex: OIB, TFMRA50, SAMOSA, ...): *

Geographic coverage of the product: *

○ Arctic ○ Antarctic

Start date global temporal coverage of the product: *

yyyy-mm-dd

End date global temporal coverage of the product: *

yyyy-mm-dd

Has the product been regridded in the final format of SINXS specification (EASE2)? *

○ Yes ○ No

Which method has been used for regridding? *

DOI of the product or of a paper describing the product

Product documentation (only .pdf accepted)

Choisir un fichier Aucun fichier choisi

Based on the SIN'XS Maturity Matrix (aligned with WMO standards), what would you suggest to be the maturity levels of your product? (1 = AD HOC // 6 = OPTIMAL):
For detailed information concerning the scores, please refer to section 6 of the "Memo for dataset submission" document.

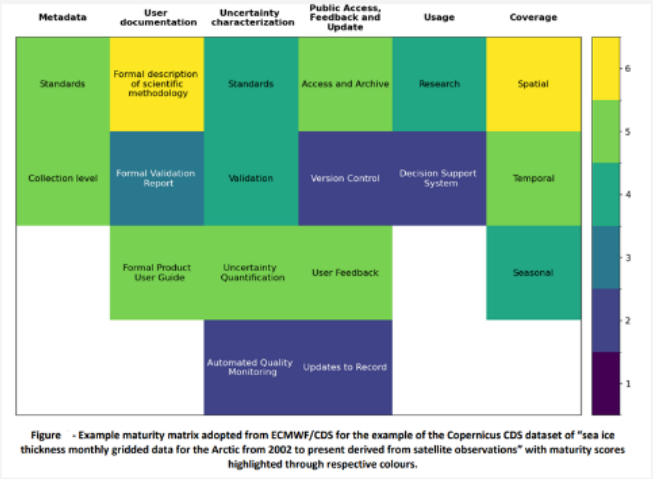


Figure - Example maturity matrix adopted from ECMWF/CDS for the example of the Copernicus CDS dataset of "sea ice thickness monthly gridded data for the Arctic from 2002 to present derived from satellite observations" with maturity scores highlighted through respective colours.

Metadata

Standards:

Collection Level:

User documentation

Methodology Description:

Validation Report:

User Guide:

Uncertainty characterisation

Standards:

Validation:

Uncertainty quantification:

Quality monitoring:

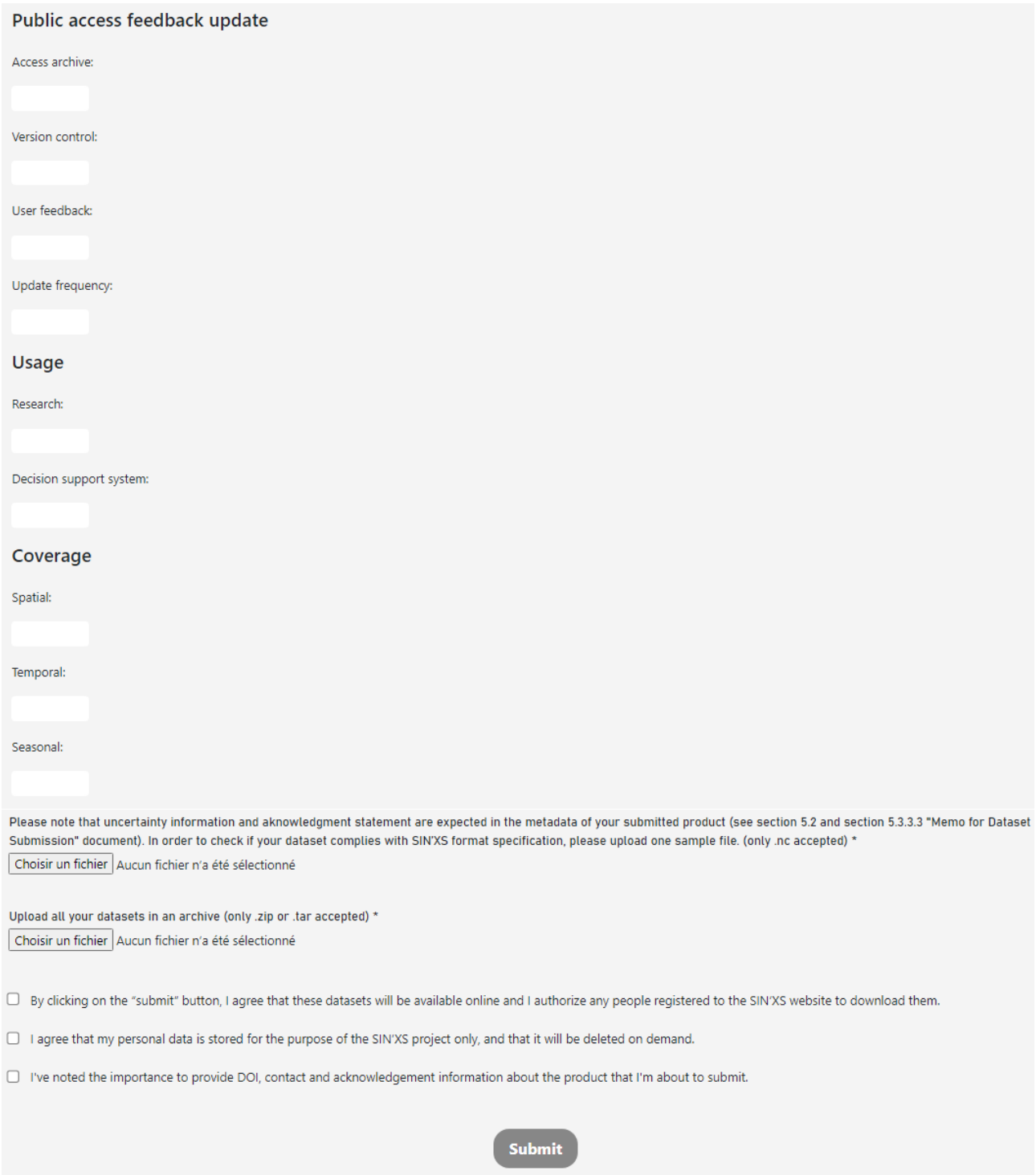


Figure 2 – Submission form

3. Variables of interest

There are two types of variables that will be considered within the project: the main parameters, and the associated physical measurements.

The main variable is the **Sea-Ice Thickness**, as it has been recognised as an Essential Climate Variable. The inter-comparison exercise will mainly focus on this variable. As we will need Snow Thickness products to calculate SIT from real measurements, the **Snow Thickness** is also considered as a main parameter.

In addition, the SIN'XS project will consider the variables corresponding to the real measurements that are used to calculate SIT, namely:

Table 1 – List of variables of interest for SIN'XS

Parameter	Standard Name	Trigram (for filename convention)	Examples
Sea Ice Thickness	sea_ice_thickness	SIT	Field measurement, Altimetry (Laser and Radar), Passive microwave radiometry, Models
Sea ice Freeboard	sea_ice_freeboard	SFB	Field measurement
Snow Thickness	snow_thickness	SNT	Snow radar, field measurement, buoys
Radar Freeboard	radar_freeboard_ku radar_freeboard_ka	RFB	Altimetry: CS2, S3, Env, ERS1/2, ASIRAS, etc. Altimetry: Saral/AltiKa, Karen
Total Freeboard	total_freeboard	TFB	IS2, airborne lidars
Sea-Ice Draft	sea_ice_draft	SID	Upward Looking Sonars (ULS) on Moorings or Mammals
Total Sea Ice Thickness	total_sea_ice_thickness	TST	Airborne ElectroMagnetic sensors

4. Filename convention

The SIN'XS project will allow to gather multiple datasets from various data providers. These datasets will be used for the inter-comparison exercise, but they will also be available for download to any users. In order to facilitate the handling of these products, it has been necessary to define a filename convention. Therefore, any submitted dataset shall respect this filename convention.

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

SINXS_PROVIDER_HH_VAR_PTF_Mission_ YYYYMMDD_YYYYMMDD_VX.Y

Table 2 – Filename convention

Code	Description	Examples
SINXS	Name of the project (always SINXS)	SINXS
PROVIDER	Original provider	LEGOS, AWI, DTU, etc.
HH	Hemisphere: NH for the North Hemisphere, SH for the South Hemisphere	NH, SH
VAR	Main variable, among the following variables: CF trigrams in the Table 1	RFB
PTF	Type of platform used to acquire the dataset (CF list below). Can also be "CLI" for climatology, or "MOD" for model. CF trigrams in Table 3.	SAT, HLC, ARB
Mission	Name of the mission (if PTF = SAT), of the project (for observations), or of the model. If PTF = HYB, the different missions may be separated by a "-".	CS2, SMOS-CS2, OIB, PIOMAS
YYYYMMDD_ YYYYMMDD	Temporal period covered by the file from first measurement date to last measurement date, in UTC	20220601_ 220701
VX.Y	Dataset version	V1.2

List of platforms:

Table 3 – List of platforms

Trigram	Type of platform
AEM	Airborne Electromagnetic Measurement
CLI	Climatology
DSB	Drifting Surface Buoy
HLC	Helicopter
HYB	Hybrid
HUM	Human
MOD	Numerical model
MOO	Mooring
SAT	Satellite
UAV	Drone
VES	Vessel

5. Data format

5.1. General description

All data must be submitted in the ***Network Common Data Format*** (*NetCDF*), either as single or multiple files containing monthly means. Except for exceptional cases, such as single position timeseries (e.g., moorings, polar stations), gridded data are expected.

The provided variables should have 3 dimensions: time, xc, yc, even if the size of the time dimension is equal to 1.

All submitted data is expected to use the Lambert Azimuthal Equal Area based **EASE2** grid (doi:10.3390/ijgi1010032) with a spatial resolution of 12.5 km or 25 km for the Arctic (EPSG: 6931) as well as the Antarctic (EPSG: 6932). We use a subset of the grid which is originally provided by NSIDC. The rationale is to focus on the latitudes polewards of 50°N/50°S, while the NSIDC extent goes down to the equator. CDO grid files and netCDF files with the x/y coordinates are available at https://sinxs-tools.noveltis.fr/data_tools/regrid.html.

Users are kindly asked to adhere to this grid extent (356x356 pixels for 25 km grid spacing, 712x712 pixels for 12.5 km grid spacing).

Other grid formats will be converted into EASE version 2.0 for the project. Instructions for regridding are provided on the page: https://sinxs-tools.noveltis.fr/data_tools/regrid.html.

The files must contain monthly means, calculated on the 15th of the current month.

5.2. Global attributes

All required global attributes in each submitted *netCDF* file are shown in Table 4. These follow the ***CCI Data Standards v2.3*** (https://climate.esa.int/sites/default/files/CCIDataStandards_v2-2_CCI-PRGM-EOPS-TN-13-0009.pdf) and also align with ***CF Metadata Conventions v1.10*** for variable attributes. The use of the CF Conventions compliance checker is strongly encouraged (https://cfconventions.org/conventions.html). **Mandatory attributes are in bold.**

Table 4 – Recommended attributes by provided dataset from the community following the CCI Data Standards

Global Attribute	Description	Example content
title	Succinct description of the dataset.	Radar freeboard 20 Hz
institution	Where the data was produced, use names from CCI common vocabulary.	LEGOS, OMP, Toulouse, France
source	Original data source(s): name of the satellite (separated by comma if several) or of the model, or of the project for in-situ data.	MERIS FR L1B version 4.02, MERIS RR L1B version 4.02, SPOT VGT P version 3.0
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 modification arguments.	2021-06-11 12:22:43 - Creation 2021-07-11 12:22:43 – Reprocessed with version 2.1 of the algorithm XX
references	References to algorithm, ATBD, technical note describing dataset.	http://www.esa-landcover-cci.org/

Global Attribute	Description	Example content
Conventions	The CF Version e.g. CF-1.8.	CF-1.8
product_version	The product version of this data file.	1.3
DOI	If any.	
format_version	The data format used e.g. "CCI Data Standards v2.x".	CCI Data Standards v2.3
summary	A paragraph describing the dataset.	This dataset contains Level-3 monthly global radar freeboard data, acquired through Cryosat-2.
keywords	A comma separated list of key words and phrases.	satellite,observation,ocean
file_name	The name of the file.	filename.nc
comment	Miscellaneous information about the data.	These data were produced by LEGOS.
creator_name	The creator's name.	LEGOS, people's name.
creator_url	The creator's url.	https://www.legos.omp.eu/
contact_email	The contact's email.	ctoh_products@legos.obs-mip.fr
project	The scientific project that produced the data.	SIN'XS
geospatial_lat_min	Decimal degrees north, range -90 to +90).	-90
geospatial_lat_max	Decimal degrees north, range -90 to +90).	90
geospatial_lon_min	Decimal degrees east, range -180 to +180).	-180
geospatial_lon_max	Decimal degrees east, range -180 to +180).	180
time_coverage_start	Format yyyymmddThhmmssZ	20200601T000000Z
time_coverage_end	Format yyyymmddThhmmssZ	20200701T000000Z
license	Describes the restrictions to data access and distribution.	ESA CCI Data Policy: free and open access
platform	Satellite name, e.g. Envisat; when possible, use names from CCI common vocabulary list. Separated by commas if more than one, and use angled brackets for a platform series, e.g. 'Envisat,	CryoSat-2

Global Attribute	Description	Example content
	NOAA-<12,14,16,17,18>, Metop-A’	
sensor	Sensor name, e.g. SRAL, SIRAL, AltiKa, when possible, use names from CCI common vocabulary. Separated by commas if more than one	SIRAL
spatial_resolution	A free-text string describing the grid resolution of the product.	12,5 km
key_variables	A comma separated list of the key primary variables in the file, i.e. those that are appropriate for the SIN’XS project. These should be identified using the variable ids in the file.	radar_freeboard_20hz
production_date	Date of the production of this file, in format yyyymmddThhmmssZ	20210611T000000Z
reference_ellipsoid		WGS84
acknowledgment_statement	Statement to be put into acknowledgments if dataset is used in a publication.	*Institute* is acknowledged for the provision of SIT data between YYYYMMDD and YYYYMMDD.

5.3. 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.

5.3.1. 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.

Please find below example for north and south projections, with the grids recommended for SIN’XS (see § 5.1).

```
int crs;
:grid_mapping_name = "lambert_azimuthal_equal_area";
:long_name = "NSIDC_NH_EASE2_25km";
:false_easting = 0.0;
:false_northing = 0.0;
:latitude_of_projection_origin = 90.0;
:longitude_of_projection_origin = 0.0;
:longitude_of_prime_meridian = 0.0;
```

```
:semi_major_axis = 6378137.0;

:inverse_flattening = 298.257223563;

:crs_wkt = "PROJCS[\"WGS 84 / NSIDC EASE-Grid 2.0 North\",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\",0.017453292519
9433,AUTHORITY[\"EPSG\",\"9122\"]],AUTHORITY[\"EPSG\",\"4326\"]],PROJECTION[\"Lambert
_Azimuthal_Equal_Area\"],PARAMETER[\"latitude_of_center\",90],PARAMETER[\"longitude_o
f_center\",0],PARAMETER[\"false_easting\",0],PARAMETER[\"false_northing\",0],UNIT[\"m
etre\",1,AUTHORITY[\"EPSG\",\"9001\"]],AXIS[\"Easting\",SOUTH],AXIS[\"Northing\",SOUT
H],AUTHORITY[\"EPSG\",\"6931\"]]";

:spatial_ref = "PROJCS[\"WGS 84 / NSIDC EASE-Grid 2.0 North\",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\",0.017453292519
9433,AUTHORITY[\"EPSG\",\"9122\"]],AUTHORITY[\"EPSG\",\"4326\"]],PROJECTION[\"Lambert
_Azimuthal_Equal_Area\"],PARAMETER[\"latitude_of_center\",90],PARAMETER[\"longitude_o
f_center\",0],PARAMETER[\"false_easting\",0],PARAMETER[\"false_northing\",0],UNIT[\"m
etre\",1,AUTHORITY[\"EPSG\",\"9001\"]],AXIS[\"Easting\",SOUTH],AXIS[\"Northing\",SOUT
H],AUTHORITY[\"EPSG\",\"6931\"]]";

:srid = "urn:ogc:def:crs:EPSG::6931";

:GeoTransform = "-9000000.0 25000.0 0 9000000.0 0 -25000.0";
```

```
int crs;

:grid_mapping_name = "lambert_azimuthal_equal_area";

:long_name = "NSIDC_SH_EASE2_25km";

:false_easting = 0.0;

:false_northing = 0.0;

:latitude_of_projection_origin = -90.0;

:longitude_of_projection_origin = 0.0;

:longitude_of_prime_meridian = 0.0;

:semi_major_axis = 6378137.0;

:inverse_flattening = 298.257223563;

:crs_wkt = "PROJCS[\"WGS 84 / NSIDC EASE-Grid 2.0 South\",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\",0.017453292519
9433,AUTHORITY[\"EPSG\",\"9122\"]],AUTHORITY[\"EPSG\",\"4326\"]],PROJECTION[\"Lambert
_Azimuthal_Equal_Area\"],PARAMETER[\"latitude_of_center\",-
90],PARAMETER[\"longitude_of_center\",0],PARAMETER[\"false_easting\",0],PARAMETER[\"f
alse_northing\",0],UNIT[\"metre\",1,AUTHORITY[\"EPSG\",\"9001\"]],AXIS[\"Easting\",NO
RTH],AXIS[\"Northing\",NORTH],AUTHORITY[\"EPSG\",\"6932\"]]";

:spatial_ref = "PROJCS[\"WGS 84 / NSIDC EASE-Grid 2.0 South\",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\",0.017453292519
```

```
9433,AUTHORITY[\"EPSG\",\"9122\"]],AUTHORITY[\"EPSG\",\"4326\"]],PROJECTION[\"Lambert
_Azimuthal_Equal_Area\"],PARAMETER[\"latitude_of_center\",-
90],PARAMETER[\"longitude_of_center\",0],PARAMETER[\"false_easting\",0],PARAMETER[\"f
alse_northing\",0],UNIT[\"metre\",1,AUTHORITY[\"EPSG\",\"9001\"]],AXIS[\"Easting\",NO
RTH],AXIS[\"Northing\",NORTH],AUTHORITY[\"EPSG\",\"6932\"]]";

:srid = "urn:ogc:def:crs:EPSG::6932";

:GeoTransform = "-9000000.0 25000.0 0 9000000.0 0 -25000.0";
```

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"). In order to maximize compatibility with a number of file viewers (e.g. NASA's Panoply) and GIS software (QGIS for instance), some attributes are somewhat duplicated.

5.3.2. Mandatory dimensions and attributes per variable

The main parameters should have 3 dimensions: time, latitude and longitude (in this order), which respectively represent the middle time of the data and its coordinates.

A number of mandatory dimensions should be contained in the datasets uploaded. These are listed in Table 6 below, which also compiles comments on the attributes of each of them.

Finally, we recommend to provide center of cell coordinates (in meters) that correspond to each data point. These values being constant they could possibly be provided in an independent file in order to avoid their duplication in several files (e.g., if the data are split in monthly files).

Table 5 – Set of mandatory and non-mandatory attributes expected per variable in NetCDF files

Variable	Attributes	Mandatory or not
time(time)	units = "seconds since YYYY-MM-DD' or 'days since YYYY-MM-DD"	mandatory
xc(xc)	units = "meters" long_name = "x coordinate of projection (eastings)" standard_name = "projection_x_coordinate"	mandatory
yc(yc)	units = "meters" long_name = "y coordinate of projection (northings)" standard_name = "projection_y_coordinate"	mandatory
latitude(yc, xc)	units = "degrees_north" long_name = "latitude of grid cell center" standard_name = "latitude"	recommended if pertinent
longitude(yc, xc)	units = "degrees_east" long_name = "longitude of grid cell center" standard_name = "longitude"	recommended if pertinent

5.3.3. Data variables

5.3.3.1. Variable names

The SIN'XS consortium requires all data providers to use variable names that align with standard names for the key variables of Sea Ice Thickness and Snow Thickness following the ***CF Standard Names Table*** where respective entries exist. Otherwise, necessary naming suggestions were added. All variable names are summarized in Table 6.

Table 6 –- CF Standard Names (bold) and suggestions relevant to the SIN'XS project and data submission

Parameter	Standard Name
Sea Ice Thickness	**sea_ice_thickness**
Sea ice Freeboard	**sea_ice_freeboard**
Snow Thickness	snow_thickness
Radar Freeboard	radar_freeboard_ku, radar_freeboard_ka,
Total Freeboard	total_freeboard
Total sea ice thickness (Sea Ice Thickness + Snow Thickness)	total_sea_ice_thickness
Sea-Ice Draft	**sea_ice_draft**

5.3.3.2. Local attributes for the variables

Data variables contain the actual measurements and indicators about their quality, uncertainty, and mode 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***".

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 this attribute).

Table 7 – Local attributes description

Local attribute name	Local attribute description	Level
standard_name	Provides a unique identifier for the variable's name	mandatory
long_name	The variable's name as it would be used in a plot or a document	mandatory
units	The units used in this variable	mandatory
_FillValue	Declares the data value representing the absence of data (where applicable)	mandatory
scale_factor	The data are to be multiplied by this factor after the data are read by the application that accesses them.	optional
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.	optional
grid_mapping	Declares the corresponding CRS variable	mandatory
valid_min	valid_min: Minimum value for valid data (add_offset and scale_factor applied)	optional
valid_max	valid_max: Maximum value for valid data (add_offset and scale_factor applied)	optional
comment	comment: Any free-format text with comments as appropriate	mandatory
sea_ice_variable_type	sea_ice_thickness, radar_freeboard_ku, etc.	mandatory
source_type	measured |computed | auxiliary (used for the computation)	mandatory
coordinates	For the main parameters should be: (latitude, longitude)	mandatory

5.3.3.3. Uncertainty variables

Ideally, 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 uncertainty. 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 estimated.

5.3.3.4. 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)

6. Documentation – Maturity Matrix

In order to evaluate the different datasets' maturity, a Maturity Matrix (MM) will be produced for each registered data set. This maturity matrix will partly use/validate the information collected from the self-assessment provided by the data provider during dataset registration.

All MMs will be made available to all users via the SIN'XS website with all information on the scoring in full transparency.

An example of Maturity Matrix is presented below, with the detail of how to calculate the score of one of the boxes.

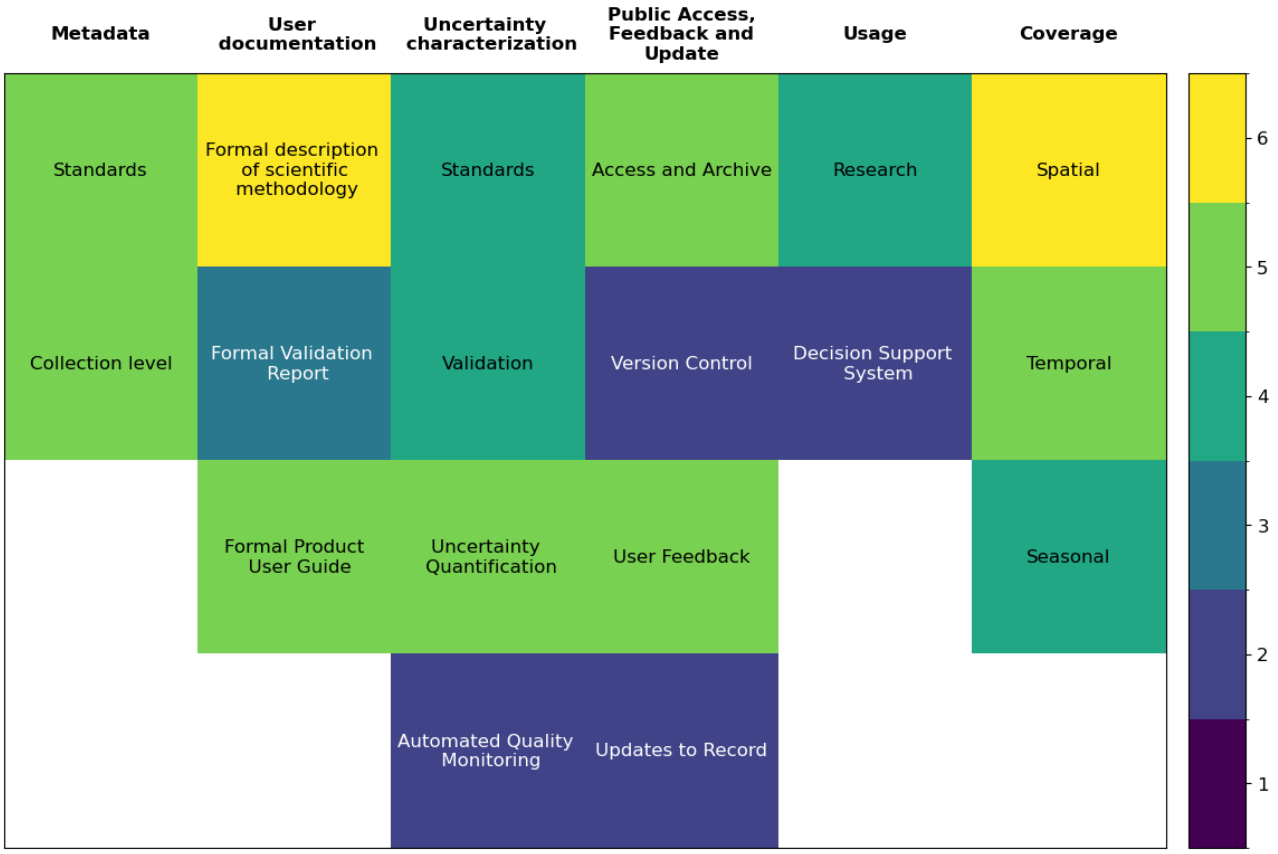


Figure 3 – Example maturity matrix adopted from ECMWF/CDS for the Copernicus CDS dataset of "sea ice thickness monthly gridded data for the Arctic from 2002 to present derived from satellite observations", with maturity scores highlighted through respective colours.

The full set of score parameters and their respective score definitions have been described below with the Scientific Advisory Committee of the project and the project team, and they will potentially be extended and/or adjusted in future iterations but will be aligned with WMO standards.

6.1. Metadata

6.1.1. Standards

Score	Description
1	Not assigned
2	Not assigned
3	No standardisation applied
4	Metadata standards identified and/or defined but not systematically applied
5	Score 4 + standards systematically applied at file level and collection level by data provider. Meets international standards for the dataset.
6	Score 5 + metadata standard compliance systematically checked by data provider.

6.1.2. Collection level

Score	Description
1	None: there are no standardized attributes on the collection level of the dataset.
2	Limited: there is only a very limited set of standardized attributes on the collection level of the dataset.
3	Sufficient: the standardized attributes on the collection level of the dataset are sufficient to understand the data's origins without further documents.
4	Enhanced: as for score 3, but with more information on metadata (for example, how to obtain raw data (level 0 in case of satellites) and the necessary information to process those data).
5	Complete: as for score 4, but all the available information on data is provided with the data using a defined standard.
6	Complete and regularly updated: updates are provided when new metadata become available.

6.2. User documentation

6.2.1. Formal description of scientific methodology

Score	Description
1	Upon request: the scientific description is limited and not publicly available without contacting the data provider or only from non-peer-reviewed literature.
2	Paper submitted: the scientific description is comprehensive but not publicly available without contacting the data provider or only from non-peer-reviewed literature. There is a methodological journal paper submitted but not yet published.
3	Paper published: the scientific description is comprehensive but not publicly available without contacting the data provider or only from non-peer-reviewed literature. There is a peer reviewed methodological journal paper published.
4	Technical description available: the scientific description is comprehensive and publicly available in the form of a technical description (e.g. ATBD). There is also a peer reviewed methodological journal paper published.
5	Technical description available and regularly updated: As score 4, but with regular updates.
6	Several papers published: as score 5, with a number of peer-reviewed methodological journal papers published in parallel with the dataset updates.

6.2.2. Formal validation report

Score	Description
1	None: no validation report available.
2	Limited: validation information is limited and not publicly available without contacting the data provider or only from non-peer-reviewed literature.
3	Comprehensive, but not yet publicly available: validation information is comprehensive but not publicly available without contacting the data provider or only from non-peer-reviewed literature. There is a journal paper on product validation submitted but not yet published.
4	Comprehensive and available: inter-comparison report is comprehensive and publicly available. There is a peer reviewed journal paper on product validation published.
5	As score 4, with a published data assessment report.
6	As score 5, with comprehensive validation, e.g., error covariance, validation of qualitative uncertainty estimates published.

6.2.3. Formal product user guide

Score	Description
1	Not assigned
2	None: no formal user guide.
3	Limited: limited user guide available upon request.
4	Comprehensive, not publicly available: comprehensive user guide available upon request.
5	Comprehensive and publicly available: as score 4, but publicly available.
6	Publicly available and maintained: there is a regularly updated comprehensive formal Product User Guide for the dataset publicly available.

6.3. Uncertainty Characterisation

6.3.1. Standards

Score	Description
1	None: no standard uncertainties recognised.
2	Identified: nomenclature for uncertainties is used, but not yet consistently applied.
3	Applied: as for score 2, but with nomenclature applied and documented in validation report/user guide.
4	Reference data for uncertainties are identified.
5	Partly traceable: as for score 4, but with (limited) traceability of uncertainty calculations.
6	Fully traceable: as for score 5, with fully traceable uncertainty calculations.

6.3.2. Validation

Score	Description
1	None: no validation done.
2	Limited: validation based on a small set of reference data.
3	Representative: validation based on a representative set of reference data.
4	Compared with CDRs: as for score 3, with comparisons to Climate Data Records (CDRs).
5	International assessment: as for score 4, with participation in an international data assessment.
6	Extensive assessment: as for score 5, with participation in multiple international data assessments and incorporated feedback.

6.3.3. Uncertainty Quantification

Score	Description
1	None: no uncertainty quantification.
2	Limited: limited uncertainty quantification of systematic and random effects.
3	Comprehensive: Comprehensive uncertainty quantification of systematic and random effects.
4	Quality flags: as for score 3, with quality information/flags available.
5	Error covariance quantified: as for score 4, with quantified spatio-temporal error covariances.
6	Validated uncertainties: as for score 5, with validation of the uncertainties.

6.3.4. Automated Quality Monitoring

Score	Description
1	Not assigned
2	None: no automated quality monitoring.
3	Methods defined: there is a document defining the automated quality monitoring for the dataset.
4	Partly implemented: routines for automated quality monitoring are partially implemented.
5	Fully implemented: routines for automated quality monitoring are fully implemented.
6	Results publicly available: results of automatic quality monitoring are reported and publicly available.

6.4. Public Access, Feedback and Update

6.4.1. Access and Archive

Score	Description
1	Restricted availability: only available when contacting the data provider and only under certain circumstances.
2	Limited availability: only available when contacting the data provider.
3	Archived: not available without contacting the data provider, but different versions of data are archived.
4	Publicly available: the dataset is publicly available. The different versions of data including documentation are archived by the data provider.
5	Source code archived: as for score 4, but with source code archived.
6	Source code publicly available: as for score 5, with the score code being publicly available.

6.4.2. Version Control

Score	Description
1	Not assigned
2	None: no information on version control available.
3	Preliminary: preliminary information on version control of documentation, data and/or metadata available for the dataset.
4	Full: there is full information on version control of documentation, data and/or metadata available for the dataset.
5	Traceable: as for score 4, but with documented and traceable version control information.
6	Documentation, data and metadata are traceably version-controlled.

6.4.3. User Feedback

Score	Description
1	None: there is no information on the handling of feedback available for the dataset.
2	Personalised: data provider reaches out personally to users.
3	Public: there is a public reach-out/feedback form/contact point for collecting feedback for the dataset.
4	Interactive: as for section 3, but with regular events, groups, 2-way feedback mechanisms, etc. organized by the data provider.
5	Documented: as for score 4, with the feedback documented and incorporated into data production, including third-party quality assessment.
6	Reactions: there are immediate reactions on feedback, for example by producing interim data products (operational continuation of a climate data record employing the same procedures).

6.4.4. Updates to Record (frequency)

Score	Description
1	Not assigned
2	None: no updates available.
3	Irregular: no information on updating schedule.
4	Regular: regular updates with improved methodology available.
5	Operational: operational updates available, depending on the availability of input data and including improved methodology.
6	Interim products: as for score 5, with immediate production of interim products.

6.5. Usage

6.5.1. Research

Score	Description
1	None: no research available with this dataset.
2	Benefits identified: no research published, but possible benefits identified.
3	Usability demonstrated: peer reviewed paper(s) available concerning the usability of the datasets.
4	Usage demonstrated: peer reviewed paper(s) available in which the dataset is used.
5	Reference product (specific applications): peer reviewed paper(s) available using the dataset as a reference for specific applications.
6	Reference product (research fields): peer reviewed paper(s) available using the dataset as a reference for entire research fields.

6.5.2. Decision Support System

Score	Description
1	None: no described decision support system with this dataset.
2	Benefits identified: no described decision support system with this dataset, but potential benefits are identified.
3	Benefits emerging: the dataset is used in decision supporting systems, with the benefits emerging.
4	Benefits discussed: the dataset is used in decision support systems and benefits are emerging. Furthermore, the societal and/or economic benefits are discussed.
5	As for score 4, but with the benefits demonstrated.
6	Influence demonstrated: as for score 5, but with the dataset further societal and/or economic developments.

6.6. Usage

6.6.1. Spatial

Score	Description
1	N/A
2	N/A
3	Point measurements (e.g. in-situ, mooring)
4	Line measurements (e.g. airborne, buoy tracks)
5	Large-scale with gaps (most of polar region of respective hemisphere when averaged monthly)
6	Large-scale (entire polar region of respective hemisphere when averaged monthly)

6.6.2. Temporal

Score	Description
1	Days to weeks
2	Weeks to months
3	One or more years (can be limited to winter months)
4	10 or more years (can be limited to winter months)
5	More than 20 years (can be limited to winter months)
6	More than 30 years (can be limited to winter months)

6.6.3. Seasonal

Score	Description
1	N/A
2	Single day(s)
3	Single week(s)
4	Several month(s)
5	Entire winter season
6	Year-round

Annex 1: CDL for SIN'XS NetCDF format

This section presents an example of the CDL for SIN'XS NetCDF format (more info on CDL here).

```
netcdf SINXS_AWI_NH_SIT_HYB_CS2-SMOS_20230101_20230131_V205 {
dimensions:
      time = UNLIMITED ; // (1 currently)
      xc = 360 ;
      yc = 360 ;
      nv = 2 ;
variables:
      double sea_ice_thickness(time, xc, yc) ;
            sea_ice_thickness:_FillValue = 9.96920996838687e+36 ;
            sea_ice_thickness:standard_name = "sea_ice_thickness" ;
            sea_ice_thickness:long_name = "Sea-ice thickness from merged
Cryosat-2 and SMOS measurements" ;
            sea_ice_thickness:units = "m" ;
            sea_ice_thickness:scale_factor = 1LL ;
            sea_ice_thickness:add_offset = 0LL ;
            sea_ice_thickness:grid_mapping = "crs" ;
            sea_ice_thickness:comment = "" ;
            sea_ice_thickness:sea_ice_variable_type = "sea_ice_thickness" ;
            sea_ice_thickness:source_type = "measured" ;
            sea_ice_thickness:coordinates = "latitude, longitude " ;
      double sea_ice_thickness_uncertainty(time, xc, yc, nv) ;
            sea_ice_thickness_uncertainty:_FillValue = 9.96920996838687e+36 ;
            sea_ice_thickness_uncertainty:standard_name = "Sea-ice thickness
uncertainty" ;
            sea_ice_thickness_uncertainty:long_name = "Uncertainty of the sea-
ice thickness from merged Cryosat-2 and SMOS measurements" ;
            sea_ice_thickness_uncertainty:units = "m" ;
            sea_ice_thickness_uncertainty:scale_factor = 1LL ;
            sea_ice_thickness_uncertainty:add_offset = 0LL ;
            sea_ice_thickness_uncertainty:grid_mapping = "crs" ;
            sea_ice_thickness_uncertainty:comment = "" ;
            sea_ice_thickness_uncertainty:sea_ice_variable_type =
"sea_ice_thickness_uncertainty" ;
            sea_ice_thickness_uncertainty:source_type = "computed" ;
            sea_ice_thickness_uncertainty:coordinates = "latitude, longitude " ;
      int64 time(time) ;
            time:units = "days since 2023-01-15 12:00:00" ;
            time:calendar = "proleptic_gregorian" ;
      int64 time_bnds(nv) ;
            time_bnds:units = "days since 2023-01-01 00:00:00" ;
            time_bnds:calendar = "proleptic_gregorian" ;
      float longitude(xc, yc) ;
            longitude:_FillValue = NaNf ;
      float latitude(xc, yc) ;
            latitude:_FillValue = NaNf ;
      int64 crs ;
            crs:grid_mapping_name = "lambert_azimuthal_equal_area" ;
            crs:longitude_of_prime_meridian = 0. ;
            crs:semi_major_axis = 6378137. ;
            crs:inverse_flattening = 298.257223563 ;
            crs:crs_wkt = "PROJCS[\"WGS 84 / NSIDC EASE-Grid 2.0
North\",GEOGCS[\"WGS84\",DATUM[\"WGS_1984\",SPHEROID[\"WGS84\",6378137,298.25722
3563,AUTHORITY[\"EPSG\",\"7030\"]],AUTHORITY[\"EPSG\",\"6326\"]],PRIMEM[\"Greenw
```

```
ich\",0,AUTHORITY[\"EPSG\",\"8901\"]],UNIT[\"degree\",0.0174532925199433,AUTHORI
TY[\"EPSG\",\"9122\"]],AUTHORITY[\"EPSG\",\"4326\"]],PROJECTION[\"Lambert_Azimut
hal_Equal_Area\"],PARAMETER[\"latitude_of_center\",90],PARAMETER[\"longitude_of_
center\",0],PARAMETER[\"false_easting\",0],PARAMETER[\"false_northing\",0],UNIT[
\"metre\",1,AUTHORITY[\"EPSG\",\"9001\"]],AXIS[\"Easting\",SOUTH],AXIS[\"Northin
g\",SOUTH],AUTHORITY[\"EPSG\",\"6931\"]]" ;
            crs:proj4_string = "+proj=laea +lat_0=90 +lon_0=0 +x_0=0 +y_0=0
+datum=WGS84 +units=m +no_defs +type=crs" ;
      float xc(xc) ;
            xc:_FillValue = NaNf ;
            xc:units = "km" ;
            xc:long_name = "x coordinate of projection (eastings)" ;
            xc:standard_name = "projection_x_coordinate" ;
      float yc(yc) ;
            yc:_FillValue = NaNf ;
            yc:units = "km" ;
            yc:long_name = "y coordinate of projection (northings)" ;
            yc:standard_name = "projection_y_coordinate" ;

// global attributes:
            :title = "Sea-ice thickness from altimetry and passive microwave
measurements" ;
            string :institution = "Alfred-Wegener-Institut Helmholtz Zentrum für
Polar und Meeresforschung (AWI), http://www.awi.de" ;
            :source = "Altimetry: Cryosat-2, Passive Microwave: SMOS" ;
            :history = "Tue Feb 21 11:12:14 2023 creation of original weekly
file, Thu Sep 28 18:30:09 2023 monthly averaging for submission to SIN\'XS" ;
            :references = "Ricker, R., Hendricks, S., Kaleschke, L., Tian-Kunze,
X., King, J., and Haas, C.: A weekly Arctic sea-ice thickness data record from
merged CryoSat-2 and SMOS satellite data, The Cryosphere, 11, 1607-1623,
https://doi.org/10.5194/tc-11-1607-2017, 2017." ;
            :Conventions = "CF-1.6" ;
            :product_version = "205" ;
            :DOI = "to_be_filled" ;
            :format_version = "CCI Data Standards v2.3" ;
            :summary = "This datasets contains monthly averages of hybrid
Cryosat-2/SMOS sea-ice thickness measurements. Weekly sea-ice thickness has been
calculated using an optimal interpolation scheme described in Ricker et al.,
2016 (see attribute \'reference\'). Data are provided on the EASE2 grid at 25 km
resolution." ;
            :keywords = "satellite, sea-ice thickness, altimetry, passive
microwave, hybrid, Cryosat-2, SMOS" ;
            :file_name = "SINXS_AWI_NH_SIT_HYB_CS2-
SMOS_20230101_20230131_V205.nc" ;
            :keywords_vocabulary = "Sea-ice thickness, Cryosat-2, SMOS, hybrid,
radar altimeter, passive microwave" ;
            :comment = "This is a first example what a netCDF file which is
compliant with the SIN\'XS requirements would look like. netCDF attributes are
based on the weekly files\' attributes where applicable." ;
            string :creator_name = "Alfred-Wegener-Institut Helmholtz Zentrum
für Polar und Meeresforschung (AWI), http://www.awi.de" ;
            :creator_url =
"https://data.meereisportal.de/relaunch/thickness.php" ;
            :contact_email = "cs2smos-support@awi.de" ;
            :project = "CS2SMOS PDS: SMOS & CryoSat-2 Sea Ice Data Product
Processing and Dissemination Service" ;
            :geospatial_lat_min = 16.623929977417 ;
```

```
            :geospatial_lat_max = 90. ;
            :geospatial_lon_min = -180. ;
            :geospatial_lon_max = 180. ;
            :time_coverage_start = "20230101" ;
            :time_coverage_end = "20230131" ;
            :license = "to_be_filled" ;
            :platform = "Cryosat-2, SMOS" ;
            :sensor = "SIRAL (Synthetic Aperture Interferometric Radar
Altimeter) aboard Cryosat-2, MIRAS (Microwave Imaging Radiometer using Aperture
Synthesis) aboard SMOS." ;
            :spatial_resolution = "25 km" ;
            :key_variables = "sea_ice_thickness" ;
            :production_date = "20230928T183009" ;
            :reference_ellipsoid = "WGS84" ;
}
```