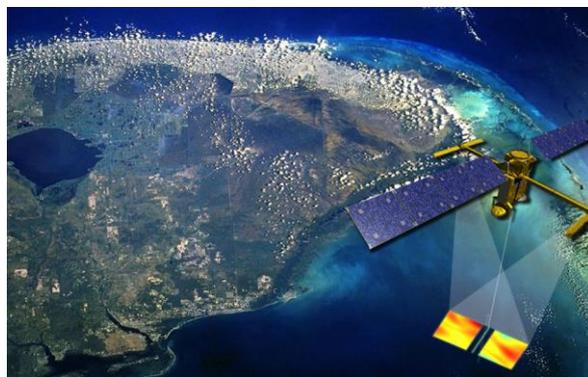




SSALTO/DUACS Experimental Product Handbook:

Gridded and along-track Sea Level Anomalies for the Arctic Ocean

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i.2

Chronology Issues:

Issue:	Date:	Validated by	Reason for change:
1.0	2022/03/18		Creation of the document from existent document

List of Acronyms:

Aviso+	Archiving, Validation and Interpretation of Satellite Oceanographic data
C3S	Copernicus Climage Change Service
CMEMS	Copernicus Marine Environment Monitoring Service
Cnes	Centre National d'Etudes Spatiales
DUACS	Data Unification and Altimeter Combination System
L3	Level-3 products (along-track)
L4	Level 4 products (gridded)
MSS	Mean Sea Surface
SALP	Service d'Altimétrie et de Localisation Précise
SAR(M)	Synthetic Aperture Radar (Mode)
Ssalto	Segment Sol multimissions d'ALTimétrie, d'Orbitographie et de localisation précise.
SLA	Sea Level Anomaly
SSH	Sea Surface Height

Contents

1	Introduction	1
1.1	Acknowledgments	2
1.2	User’s feedback	2
2	Gridded and along-track Sea Level Height dedicated to Arctic Ocean products	3
2.1	Versioning	3
2.2	Processing	3
2.3	Product description.....	3
3	Products accessibility.....	7
4	Contacts	8
5	Examples of files.....	9
5.1	Along-track products dedicated to Arctic Ocean.....	9
5.2	Gridded products dedicated to Arctic Ocean	11

1 Introduction

For 20 years, the DUACS system has been producing, as part of the CNES/SALP project, the Copernicus Marine Environment and Monitoring Service (CMEMS) and the Copernicus Climate Change Service (C3S), high quality multimission altimetry Sea Level products for oceanographic applications, climate forecasting centers, geophysic and biology communities... While the operational production of the Sea Level along track and maps is now generated as part as CMEMS and C3S, the development of a new experimental DUACS products started mid 2016 at CNES **aiming at improving the resolution of the current products and designing new products**. Using the global Synthetic Aperture Radar mode (SARM) coverage of Sentinel3A/B and optimizing the LRM altimeter processing (retracking, editing, ...) will notably allow us to fully exploit the fine-scale content of the altimetric missions. Thanks to this increase of real time altimetry observations we will also be able to improve Level-4 products by combining these new Level-3 products and new mapping methodology, such as dynamic interpolation. Finally, these improvements will benefit to downstream products: geostrophic currents, Lagrangian products, eddy atlas...

This document describes the gridded (level4) and along-track (level3) Sea Level Heights dedicated to Arctic Ocean.

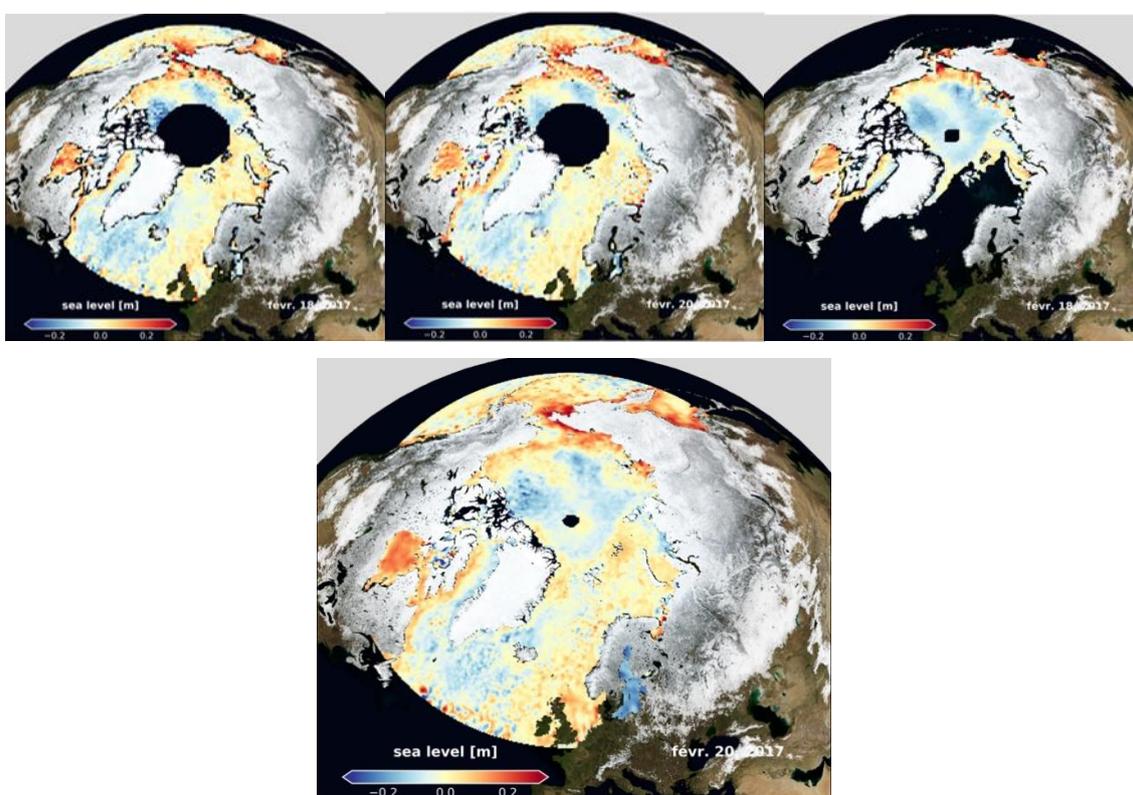


Figure 1: SLA maps (m) on Feb 20th 2017 over the Arctic Ocean for each mission SARAL/AltiKa, Sentinel-3A and Cryosat-2 (top) and for the multimission product (bottom)

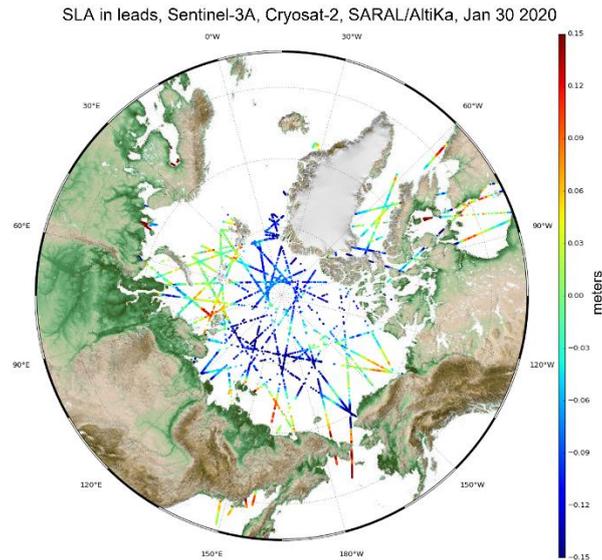


Figure 2: Along-track Sea Level Anomalies in leads for Copernicus Sentinel-3A, Cryosat-2 and SARAL/AltiKa on January 30th 2020.

1.1 Acknowledgments

When using this experimental SSALTO/DUACS product, please cite: "This product was processed by SSALTO/DUACS (DOI: 10.24400/527896/a01-2020.001) and distributed by AVISO+ (<https://www.aviso.altimetry.fr>) with support from CNES"

1.2 User's feedback

The product is an experimental product. Therefore, each and every question, comment, example of use, and suggestion will help us improve the product. You're welcome to ask or send them to aviso@altimetry.fr.

2 Gridded and along-track Sea Level Height dedicated to Arctic Ocean products

2.1 Versioning

Those products are distributed in version 01_01 (only gridded products) and 01_02 (gridded and along-track products). The differences between the two versions are the following:

- Temporal extension of all missions and multimission product
- The version 01_02 of SARAL/AltiKa grid begins on 2016/05/29
- The input data of SARAL/AltiKa mission are in GDR-F version instead of GDR-E for version 01_01
- The input data of Cryosat-2 are in Baseline D instead of Baseline C for version 01_01

It is foreseen to deliver new versions of some products: for any new future version delivered, you will be informed via the AVISO+ user service, by email and on the website. The version number is indicated in the ftp folder and in the file ('product_version' attribute).

2.2 Processing

DUACS Experimental Arctic Ocean products provide sea level height from 50°N up to 88°N including the ice-covered region thanks to the use of sea level within the leads (open water area within a fracture of sea ice).

Sea level from 3 satellites (Sentinel-3, Cryosat-2 and SARAL/AltiKa) are used separately to produce 3 mono-mission gridded products and are then combined through optimal interpolation to produce the multi-mission gridded product. The information about input data, processing and validation can be found in Prandi et al., 2021.

Along-track sea level anomaly product is also available within the leads. The same corrections and editing as the gridded product are applied (Prandi et al., 2021). Then cross-calibration is performed to reduce long wavelength error. It is based on Optimal Interpolation (Le Traon et al, 2003) and contributes to reducing geographically correlated errors between the missions. The data is finally filtered and subsampled to deliver a 5Hz (~1 km) resolution product. The product is only available in the ice-covered region and can be used in association with DUACS DT21 open ocean dataset (delivered by the Copernicus Marine Service with the name SEALEVEL_GLO_PHY_L3_MY_008_062, doi: [10.48670/moi-00146](https://doi.org/10.48670/moi-00146)) to cover all the northern hemisphere (after adding 9.6 cm to the leads sea level height due to differences of corrections).

2.3 Product description

2.3.1 Geographical characteristics

All products cover all latitudes greater than 50°N with differences between the missions:

- SARAL/AltiKa and Sentinel-3A have a polar observation gap north of 82°N,
- CryoSat-2 covers latitudes up to 89,5°N, but not the open ocean at lower latitudes, due to the use of SAR measurements only,
- The multi-mission product covers the maximum area where data is available.

The along-track product is only available within the leads (open water area within a fracture of sea ice) and only covers the ice-covered region. After adding 9.6 cm to this dataset, it can be used in association with DUACS open ocean dataset (delivered by the Copernicus Marine Service with the

SSALTO/DUACS Experimental products Handbook

Issue : 1.0 - Date : 18/03/2022 - Nomenclature: SALP-MU-P-EA-23555-CLS 4

name SEALEVEL_GLO_PHY_L3_MY_008_062, doi: [10.48670/moi-00146](https://doi.org/10.48670/moi-00146)) to cover all the northern hemisphere.

2.3.2 Temporal availability and grid characteristics

One file per mission is delivered for gridded products. One file per day for each mission is delivered for along-track products.

Mission	Version	Type	Start dates	End dates	Time steps for gridded products	Spatial resolution
SARAL/AltiKa	Version 01_01	Gridded	2013/03/28	2019/08/24	10 days, but two consecutive dates are not independent as a result of 30 days averages.	Gridded: 75km
	Version 01_02	Gridded	2016/05/29	2020/07/27		
		Along-track	2016/06/01	2020/07/29		
Sentinel-3A	Version 01_01	Gridded	2016/07/15	2019/05/01		
	Version 01_02	Gridded	2016/06/28	2020/06/27		
		Along-track	2016/07/01	2020/06/30		
CryoSat-2	Version 01_01	Gridded	2010/07/30	2019/04/24		
	Version 01_02	Gridded	2010/07/20	2020/12/24		
		Along-track	2016/06/01	2020/07/29		
Mutli-mission	Version 01_01	Gridded	2016/07/01	2019/04/29	3 days, but two consecutive dates are not independent	25km
	Version 01_02	Gridded	2016/07/01	2020/06/28		

Table 1: Temporal availability and characteristics of Arctic Ocean SLA.

2.3.3 Nomenclature

This is the generic model of filename :

For along-track leads files:

`dt_arctic_<mission>_leads_phy_l3_<dataset_date>_<production_date>.nc`

For gridded files:

`dt_arctic_<mission>_<version>_sea_level_datebegin_dateend.nc`

The products name components are:

- The type of data timeliness dt=delayed-time
- <mission> is either saral, sentinel3a, cryosat2, mutlimission
- <dataset_date> is the date of the measurement
- <production_date> is the date of production
- <version> is v1.1 or v1.2

2.3.4 Format

All the products are distributed in NetCDF with norm CF.

NetCDF (Network Common Data Form) is an open source, generic and multi-platform format developed by Unidata. An exhaustive presentation of NetCDF and additional conventions is available on the following web site:

<http://www.unidata.ucar.edu/packages/netcdf/index.html>.

All basic NetCDF conventions are applied to files.

Additionally the files are based on the attribute data tags defined by the Cooperative Ocean/Atmosphere Research Data Service (COARDS) and Climate Forecast (CF) metadata conventions. The CF convention generalises and extends the COARDS convention but relaxes the COARDS constraints on dimension and order and specifies methods for reducing the size of datasets. A wide range of software is available to write or read NetCDF/CF files. API made available by UNIDATA (<http://www.unidata.ucar.edu/software/netcdf>):

- C/C++/Fortran
- Java
- MATLAB, Objective-C, Perl, Python, R, Ruby, Tcl/Tk.

2.3.4.1 Dimensions

Along-track products:

The defined dimensions are:

- **time:** number of measurements in current file.

Gridded products:

The products use the EASE2 grid file format, so latitudes/longitudes do not directly map to grid cells and cannot be used as dimensions.

The defined dimensions are:

- **time:** number of grids in current file.
- **u :** grid cell index in the u direction
- **v :** grid cell index in the v direction

2.3.4.2 Data Handling Variables

You will find hereafter the definitions of the variables defined in the product:

Name of variable	Type	Content	Unit
time	double	Time of measurements	days since 1950-01-01 00:00:00 UTC
latitude	int	Latitude value of measurements	degrees_north
longitude	int	Longitude value of measurements	degrees_east
cycle	short	Cycle the measurement belongs to	-
track	short	Track in cycle the measurement belongs to	-
sla_filtered	short	Filtered Sea Level Anomaly relative to a mean sea surface	meters
sla_unfiltered	short	Unfiltered Sea Level Anomaly relative to a mean sea surface	meters
dac	short	Dynamic Atmospheric Correction	meters
ocean_tide	short	Ocean tide model	meters
lwe	short	Long wavelength error	meters

Table 2: Overview of data handling variables in along-track Arctic Ocean NetCDF file (for leads and ocean files).

Name of variable	Type	Content	Unit
time	float	Time of measurements	days since 1950-01-01 00:00:00 UTC
latitude	float	Latitude value of measurements	degrees_north
longitude	float	Longitude value of measurements	degrees_east
sla	float	Sea Level Anomaly relative to a mean sea surface	meters
std_sla	float	standard deviation of sea level anomaly	meters
number_sla	ushort	number of sea level anomaly observations	counts

Table 3. Overview of data handling variables in gridded Arctic Ocean NetCDF file.

2.3.4.3 Attributes

Additional attributes may be available in files. They are providing information about the type of product or the processing and parameter used.

3 Products accessibility

The products are available via the authenticated **Aviso+ FTP (online products)**:

- You first need to register via the Aviso+ web portal and sign the License Agreement: <https://www.aviso.altimetry.fr/en/data/data-access/registration-form.html>
- You have to choose the product “**Ssalto/Duacs Experimental products: along-track and gridded Sea Level Heights and velocities**” in the list of products

A login /Password will be provided via email with all the necessary information to access the products.

4 Contacts

For more information, please contact:

Aviso+ User Services
CLS
11 rue Hermès
Parc Technologique du canal
31520 Ramonville Cedex
France
E-mail: aviso@altimetry.fr
On Internet: <https://www.aviso.altimetry.fr/>

The user service is also interested in user feedbacks; questions, comments, proposals, requests are much welcome.

5 Examples of files

5.1 Along-track products dedicated to Arctic Ocean

```
netcdf dt_arctic_s3a_leads_phy_l3_20200630_20220310.nc {
dimensions:
    time = 19156 ;
variables:
double time(time) ;
    time:axis = "T" ;
    time:calendar = "gregorian" ;
    time:long_name = "Time of measurement" ;
    time:standard_name = "time" ;
    time:units = "days since 1950-01-01 00:00:00" ;
int longitude(time) ;
    longitude:add_offset = 0. ;
    longitude:long_name = "Longitude of measurement" ;
    longitude:scale_factor = 1.e-06 ;
    longitude:standard_name = "longitude" ;
    longitude:units = "degrees_east" ;
int latitude(time) ;
    latitude:add_offset = 0. ;
    latitude:long_name = "Latitude of measurement" ;
    latitude:scale_factor = 1.e-06 ;
    latitude:standard_name = "latitude" ;
    latitude:units = "degrees_north" ;
short cycle(time) ;
    cycle:coordinates = "longitude latitude" ;
    cycle:long_name = "Cycle the measurement belongs to" ;
    cycle:units = "1" ;
short track(time) ;
    track:long_name = "Track in cycle the measurement belongs to" ;
    track:units = "1" ;
short sla_unfiltered(time) ;
    sla_unfiltered:_FillValue = 32767s ;
    sla_unfiltered:add_offset = 0. ;
    sla_unfiltered:comment = "The sea level anomaly is the sea surface height above mean sea surface height; the uncorrected sla can be computed as follows: [uncorrected sla]=[sla from product]+[dac]+[ocean_tide]+[internal_tide]+[lwe]" ;
    sla_unfiltered:coordinates = "longitude latitude" ;
    sla_unfiltered:long_name = "Sea level anomaly not-filtered subsampled with dac, ocean_tide and lwe correction applied" ;
    sla_unfiltered:scale_factor = 0.001 ;
    sla_unfiltered:standard_name = "sea_surface_height_above_sea_level" ;
    sla_unfiltered:units = "m" ;
short sla_filtered(time) ;
    sla_filtered:_FillValue = 32767s ;
    sla_filtered:add_offset = 0. ;
    sla_filtered:comment = "The sea level anomaly is the sea surface height above mean sea surface height; the uncorrected sla can be computed as follows: [uncorrected sla]=[sla from product]+[dac]+[ocean_tide]+[lwe]" ;
    sla_filtered:coordinates = "longitude latitude" ;
    sla_filtered:long_name = "Sea level anomaly filtered subsampled with dac, ocean_tide and lwe correction applied" ;
    sla_filtered:scale_factor = 0.001 ;
    sla_filtered:standard_name = "sea_surface_height_above_sea_level" ;
    sla_filtered:units = "m" ;
```

SSALTO/DUACS Experimental products Handbook

Issue : 1.0 - Date : 18/03/2022 - Nomenclature: SALP-MU-P-EA-23555-CLS 10

```
short dac(time) ;
    dac:_FillValue = 32767s ;
    dac:add_offset = 0. ;
    dac:comment = "The sla in this file is already corrected for the dac; the uncorrected sla can be computed as
follows: [uncorrected sla]=[sla from product]+[dac]" ;
    dac:coordinates = "longitude latitude" ;
    dac:long_name = "Dynamic Atmospheric Correction" ;
    dac:scale_factor = 0.001 ;
    dac:units = "m" ;
short ocean_tide(time) ;
    ocean_tide:_FillValue = 32767s ;
    ocean_tide:add_offset = 0. ;
    ocean_tide:comment = "The sla in this file is already corrected for the ocean_tide; the uncorrected sla can be
computed as follows: [uncorrected sla]=[sla from product]+[ocean_tide]" ;
    ocean_tide:coordinates = "longitude latitude" ;
    ocean_tide:long_name = "Ocean tide model" ;
    ocean_tide:scale_factor = 0.001 ;
    ocean_tide:units = "m" ;
short lwe(time) ;
    lwe:_FillValue = 32767s ;
    lwe:add_offset = 0. ;
    lwe:comment = "The sla in this file is already corrected for the lwe; the uncorrected sla can be computed as
follows: [uncorrected sla]=[sla from product]+[lwe]" ;
    lwe:coordinates = "longitude latitude" ;
    lwe:long_name = "Long wavelength error" ;
    lwe:scale_factor = 0.001 ;
    lwe:units = "m" ;

// global attributes:

:Conventions = "CF-1.6" ;
:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
:cdm_data_type = "Swath" ;
:comment = "Sea surface height measured by altimeters; with additional corrections; the proposed sla is already corrected
for dac, ocean_tide and lwe; [uncorrected sla]=[sla from product]+[dac]+[ocean_tide]+[lwe]" ;
:contact = "aviso@altimetry.fr" ;
:creator_email = "aviso@altimetry.fr" ;
:creator_name = "ARCTIC_OCEAN_PROTOTYPE" ;
:creator_url = "https://www.aviso.altimetry.fr" ;
:date_created = "2022-03-10 13:37:03Z" ;
:date_issued = "2022-03-10 13:37:03Z" ;
:date_modified = "2022-03-10 13:37:03Z" ;
:geospatial_lat_max = 81.423402 ;
:geospatial_lat_min = 57.383929 ;
:geospatial_lat_resolution = 0.00150800000000118 ;
:geospatial_lat_units = "degrees_north" ;
:geospatial_lon_max = 359.983817 ;
:geospatial_lon_min = 0.043578 ;
:geospatial_lon_resolution = 0.04808600000000121 ;
:geospatial_lon_units = "degrees_east" ;
:geospatial_vertical_max = 0. ;
:geospatial_vertical_min = 0. ;
:geospatial_vertical_positive = "down" ;
:geospatial_vertical_resolution = "point" ;
:geospatial_vertical_units = "m" ;
:history = "2022-03-10 13:37:03Z: Creation" ;
:institution = "CNES, CLS" ;
:keywords = "Oceans > Ocean Topography > Sea Surface Height" ;
:keywords_vocabulary = "NetCDF COARDS Climate and Forecast Standard Names" ;
:license = "https://www.aviso.altimetry.fr/fileadmin/documents/data/License_Aviso.pdf" ;
:platform = "Sentinel-3A" ;
:processing_level = "L3" ;
```

```

:product_version = "vFeb2022" ;
:project = "DUACS R&D" ;
:source = "Sentinel-3A measurements" ;
:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table v37" ;
string :summary = "Delayed-Time Level-3 sea surface height measured in the leads by Sentinel-3A altimetry observations
over Arctic region (lat>50°N).";
:time_coverage_duration = "P09:08:34" ;
:time_coverage_end = "2020-06-30 23:38:57Z" ;
:time_coverage_resolution = "P0.25" ;
:time_coverage_start = "2020-06-30 00:00:00Z" ;
:title = "DT Sentinel-3A Arctic Ocean Along track Sea Surface Height L3 product in the leads" ;netcdf

```

5.2 Gridded products dedicated to Arctic Ocean

```

netcdf dt_arctic_s3a_sea_level {
dimensions:
    time = 71 ;
    u = 240 ;
    v = 240 ;
variables:
    float time(time) ;
        time:axis = "T" ;
        time:calendar = "gregorian" ;
        time:long_name = "Time" ;
        time:standard_name = "time" ;
        time:units = "days since 1950-01-01 00:00:00" ;
    float latitude(u, v) ;
        latitude:axis = "Y" ;
        latitude:long_name = "Latitude" ;
        latitude:standard_name = "latitude" ;
        latitude:units = "degrees_north" ;
        latitude:valid_min = 50.00255f ;
        latitude:valid_max = 9.96921e+36f ;
    float longitude(u, v) ;
        longitude:axis = "X" ;
        longitude:long_name = "Longitude" ;
        longitude:standard_name = "longitude" ;
        longitude:units = "degrees_east" ;
        longitude:valid_min = -179.5018f ;
        longitude:valid_max = 9.96921e+36f ;
    float sla(time, u, v) ;
        sla:long_name = "Sea Level Anomaly" ;
        sla:coordinates = "time latitude longitude" ;
        sla:standard_name = "sea_surface_height_above_sea_level" ;
        sla:units = "m" ;
    float std_sla(time, u, v) ;
        std_sla:long_name = "Sea Level Anomaly Standard Deviation" ;
        std_sla:coordinates = "time latitude longitude" ;
        std_sla:units = "m" ;
    ushort number_sla(time, u, v) ;
        number_sla:long_name = "Sea Level Anomaly Number" ;
        number_sla:coordinates = "time latitude longitude" ;
        number_sla:units = "count" ;

// global attributes:
    :Conventions = "CF-1.7" ;
    :Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
    :cdm_data_type = "Grid" ;

```

SSALTO/DUACS Experimental products Handbook

Issue : 1.0 - Date : 18/03/2022 - Nomenclature: SALP-MU-P-EA-23555-CLS 12

```
:comment = "Sea Level Anomaly measured by Altimetry and derived variables" ;
:contact = "aviso@altimetry.fr" ;
:creator_email = "aviso@altimetry.fr" ;
:creator_name = "ARCTIC_OCEAN_PROTOTYPE" ;
:creator_url = "https://www.aviso.altimetry.fr" ;
:geospatial_lat_max = 9.96921e+36f ;
:geospatial_lat_min = 50.00255f ;
:geospatial_lat_units = "degrees_north" ;
:geospatial_lon_max = 9.96921e+36f ;
:geospatial_lon_min = -179.5018f ;
:geospatial_lon_units = "degrees_east" ;
:geospatial_vertical_max = 0. ;
:geospatial_vertical_min = 0. ;
:geospatial_vertical_positive = "down" ;
:geospatial_vertical_resolution = "point" ;
:geospatial_vertical_units = "m" ;
:history = "Created on 2020-01-13 15:52:54Z by ARCTIC_OCEAN_PROTOTYPE" ;
:institution = "CLS,CNES" ;
:keywords = "Oceans>Ocean Topography>Sea Surface Height" ;
:keywords_vocabulary = "NetCDF COARDS Climate and Forecast Standard Names" ;
:platform = "Sentinel-3A" ;
:processing_level = "L2p" ;
:product_version = "1.1" ;
:project = "CNES AltiDoppler Glaciologie" ;
:reference = "http://aviso.altimetry.fr" ;
:source = "Altimetry measurements" ;
:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table
v37" ;
:time_coverage_duration = "P700.0D" ;
:time_coverage_resolution = "P10.0D" ;
:time_coverage_end = "2018-06-15 12:00:00Z" ;
:time_coverage_start = "2016-07-15 12:00:00Z" ;
:title = "DT mono-satellite sea level gridded product" ;
:Grid = "Subset of Northern Hemisphere 75km EASE2 Grid" ;
```

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