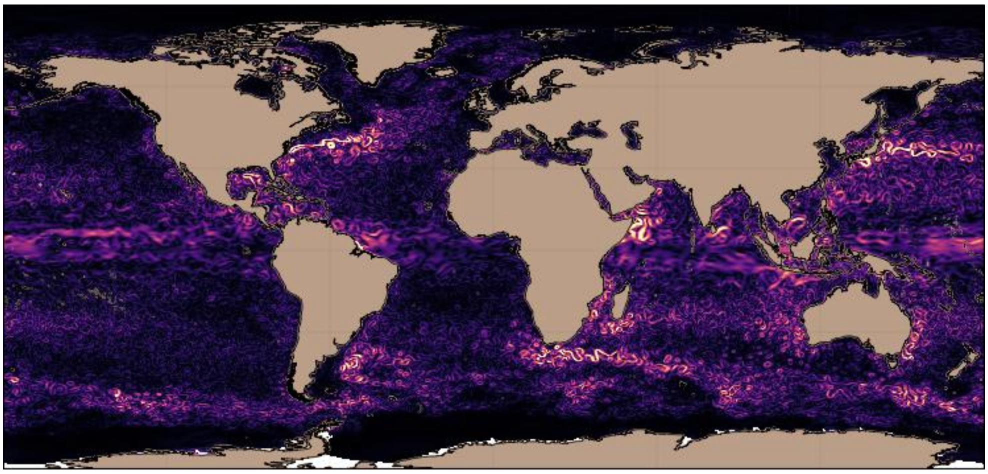
SSALTO/DUACS Experimental Product Handbook:

Gridded Sea Level Heights and geostrophic velocities computed with SWOT Level-3 products (using both KaRIn and nadir instruments) with MIOST

Dataset DOI: 10.24400/527896/a01-2025.001



Nomenclature: SALP-MU-P-EA-23661-CLS

Issue: 2 rev 1

Date: September 2025

Chronology Issues:			
Issue:	Date:	Validated by	Reason for change:
2.0	2025/05/14		Creation of the document from existing document with input v2.0.1 L3 data
2.1	2025/09/30		Temporal extension until 2025/06/30

List of Acronyms:

ADT	Absolute Dynamic Topography
Aviso+	Archiving, Validation and Interpretation of Satellite Oceanographic data
CMEMS	Copernicus Marine Environment Monitoring Service
Cnes	Centre National d'Etudes Spatiales
DUACS	Data Unification and Altimeter Combination System
ECMWF	European Centre for Medium-range Weather Forecasting
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
KaRIn	SWOT Ka-band Radar Interferometer
L3	Level-3 products (along-track)
L4	Level 4 products (gridded)
MIOST	Multiscale Interpolation Ocean Science Topography (Ubelmann et al. (2021, 2022))
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
SWOT	Surface Water Ocean Topography

Contents

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, geophysical 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 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 (SAR) coverage of Sentinel-3A/B and optimizing the LRM altimeter processing (retracking, editing, ...) will notably allow us to fully exploit the fine-scale content of the altimetric missions. The recent launch of SWOT offers an excellent opportunity to enhance the spatial resolution of the products and paves the way for new challenges in the utilization, validation, and integration of these data into mapping systems.

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, data-driven interpolation approaches or multiscale and multivariate interpolation. Finally, these improvements will benefit to downstream products: geostrophic currents, Lagrangian products, eddy atlas…

This document describes the Gridded (level4) Sea Level Heights and geostrophic velocities computed with Multiscale & Multivariate interpolation (Ubelmann et al., 2021) for the global ocean. This product takes input data from along-track and wide-swath SWOT remote sensing measurements, which are summarized in Table 1.

1.1 Acknowledgments

When using the experimental SSALTO/DUACS experimental products, please cite: " These products were processed by SSALTO/DUACS and distributed by AVISO (https://www.aviso.altimetry.fr) supported by CNES. Version 2.0.1. DOI: 10.24400/527896/a01-2025.001”

1.2 User’s feedback

This is an experimental product. Therefore, every question, comment, usage example and suggestion will help us improve the product. You are welcome to ask or send them to aviso@altimetry.fr .

2 Gridded products

This new product corresponds to version 2.0.1 and is derived from the nadir along-track NRT and DT/MY datasets available through CMEMS, as well as the SWOT Level-3 Ocean product v2.0.1 (specifically, SWOT_L3_LR_SSH). It covers both the 1-day (CalVal) and 21-day (Science) mission phases. The SWOT_L3_SSH product integrates ocean surface topography measurements from the SWOT KaRIn and nadir altimeter instruments, combining them into a single variable mapped onto a 2 km spatial grid.

Thus, the gridded product versions presented here are consistent with the SWOT Karin L3 reprocessed versions. 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 file ('product_version' attribute).

2.1 Processing

2.1.1 Input data

The input data used to compute the gridded products are the

- for satellites SARAL/AltiKa, Cryosat-2, HaiYang-2B, Jason-3, Copernicus Sentinel-3A&B, Sentinel 6A, SWOT Nadir
  - NRT (Near-Real-Time) Nadir along-track (or Level-3) SEA LEVEL products (DOI: https://doi.org/10.48670/moi-00147) delivered by the Copernicus Marine Service (CMEMS, http://marine.copernicus.eu/). The gridded product is based on NRT L3 Nadir datasets for the period from July 1, 2024, to December 31, 2024.
  - MY (Multi-Year) Nadir along-track (or Level-3) SEA LEVEL products (DOI: https://doi.org/10.48670/moi-00146) delivered by the Copernicus Marine Service (CMEMS, http://marine.copernicus.eu/). The gridded product is based on MY L3 Nadir datasets for the period from March 28, 2023, to June 30, 2024.
- for SWOT KaRIn : the SEA LEVEL products L3_LR_SSH (V2.0.1) delivered by AVISO for Expert SWOT L3 SSH KaRin (DOI: https://doi.org/10.24400/527896/A01-2023.018) for the period from March 28, 2023 to December 31, 2024.

Input product	Altimeter mission	Name of product	Name of dataset	DOI	Variable used
DT Nadir Altimetry global products	SARAL/AltiKa	CMEMS products: SEALEVEL_GLO_PHY_L3_NRT_008_044	cmems_obs-sl_glo_phy-ssh_my_al-l3-duacs_PT1S	10.48670/moi-00146	sla_unfiltered
	Cryosat-2		cmems_obs-sl_glo_phy-ssh_my_c2n-l3-duacs_PT1S		
	HaiYang-2B		cmems_obs-sl_glo_phy-ssh_my_h2b-l3-duacs_PT1S		
	Jason-3		cmems_obs-sl_glo_phy-ssh_my_j3n-l3-duacs_PT1S		
	Copernicus Sentinel-3A		cmems_obs-sl_glo_phy-ssh_my_s3a-l3-duacs_PT1S		
	Copernicus Sentinel-3B		cmems_obs-sl_glo_phy-ssh_my_s3b-l3-duacs_PT1S		
	Copernicus Sentinel-6A		cmems_obs-sl_glo_phy-ssh_my_s6a-hr-l3-duacs_PT1S		
	SWOT Nadir		cmems_obs-sl_glo_phy-ssh_my_swon-l3-duacs_PT1S & cmems_obs-sl_glo_phy-ssh_my_swonc-l3-duacs_PT1S		
NRT Nadir Altimetry global products	SARAL/AltiKa	CMEMS products: SEALEVEL_GLO_PHY_L3_NRT_008_044	cmems_obs-sl_glo_phy-ssh_nrt_al-l3-duacs_PT1S	10.48670/moi-00147	sla_unfiltered
	Cryosat-2		cmems_obs-sl_glo_phy-ssh_nrt_c2n-l3-duacs_PT1S		
	HaiYang-2B		cmems_obs-sl_glo_phy-ssh_nrt_h2b-l3-duacs_PT1S		
	Jason-3		cmems_obs-sl_glo_phy-ssh_nrt_j3n-l3-duacs_PT1S		
	Copernicus Sentinel-3A		cmems_obs-sl_glo_phy-ssh_nrt_s3a-l3-duacs_PT1S		
	Copernicus Sentinel-3B		cmems_obs-sl_glo_phy-ssh_nrt_s3b-l3-duacs_PT1S		
	Copernicus Sentinel-6A		cmems_obs-sl_glo_phy-ssh_nrt_s6a-hr-l3-duacs_PT1S		
	SWOT Nadir		cmems_obs-sl_glo_phy-ssh_nrt_swon-l3-duacs_PT1S		
Wide swath Altimetry global products	SWOT KaRIn	AVISO product: SWOT_L3_LR_SSH	-	10.24400/527896/A01-2023.018	ssha_unfiltered

Table 1: List of input data and their definition.

2.1.2 Processings

2.1.2.1 MIOST products

The global maps produced here are based on the multiscale and multivariate MIOST (Multiscale Inversion of Ocean Surface Topography) mapping approach, as described in Ubelmann et al. (2021, 2022). This method is able of accounting for various modes of variability of the ocean surface topography (e.g., geostrophic, barotrope, equatorial waves dynamic …) by constructing several independent components within an assumed covariance model. Here, we used the geostrophic mode to depict the geostrophically balanced evolution of sea surface height (SSH) as well as the barotrope and equatorial wave mode to capture residual high frequency signal (e.g., Tropical Instability Waves and Poincaré Waves) withing the 10°S and 10°N band from the altimetry constellation. Unlike the previous release, this new version includes an additional mode to represent coherent internal tides over a six-month period, aiming to absorb residual internal tide signals in the L3 dataset. This enhancement has proven effective within the mapping protocol, significantly reducing mapping errors compared to earlier versions. Furthermore, this release introduces a new *a priori* noise estimation for SWOT KaRIn measurements, which contributes to improved accuracy, particularly in the intertropical region.Similar to the optimal interpolation techniques used in operational context (e.g., Le Traon et al, 1998, 2003; Ducet et al., 2000; Pujol et al., 2016), MIOST operates within a linear and gaussian framework. To address practical considerations, the inversion problem is formulated within a reduced subcomponent space, allowing the accommodation of numerous observations in extensive spatio-temporal windows. This is beneficial for handling multiple signals of varying scales in both time and space. This mapping method has already been tested in both idealized (Ubelmann et al., 2021) and real observational systems (Ubelmann et al., 2022, Ballarotta et al., 2023), demonstrating its capability to map the surface topography and currents at global scale. It is noteworthy that in generating the SSH maps for this study, a Delayed-Time (DT) mode processing was adopted. This mode incorporates both past and future observations for a specific date to constrain the interpolation process.

More information about the method and assessment results for the experimental gridded products presented here are described in Ballarotta et al. (2025).

2.1.2.2 Sea Ice mask

Additionally, a sea-ice mask has been implemented in polar regions to exclude sea-level values resulting from extrapolation by the MIOST system. This mask is derived from OSI SAF CDR V3.0 products (OSI-450_a) up to 2020, and from OSI SAF ICDR V3.0 interim products (OSI-430-a) from 2021 onwards (Lavergne et al., 2019). The masking is based on a 15% sea-ice concentration threshold.

2.2 Product description

2.2.1 Geographical characteristics

The MIOST gridded products cover the entire global ocean (e.g., Figure 1a). Boundaries have been defined as follows:

Area	Geographical coverage	Spatial resolution
Global (MIOST)	90°S-180°W/90°N-180°E	1/8°

Table 2. Geographical characteristics of gridded SLA computed with MIOST.

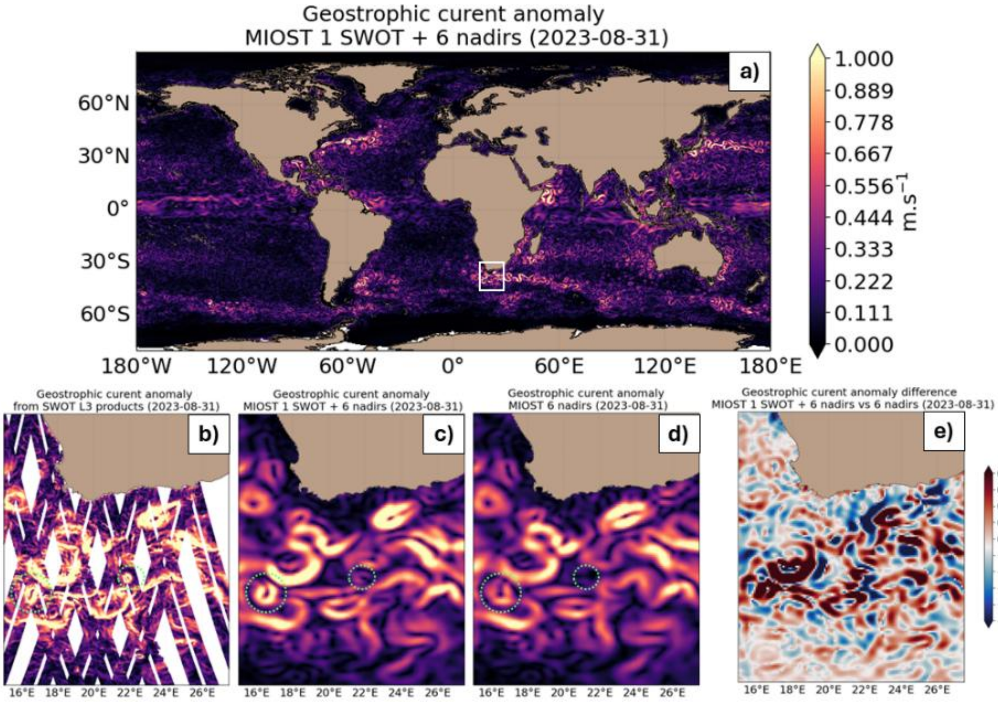


Figure 1: Example of geostrophic current reconstruction on 2023-08-31 with MIOST at a) global scale, b) view from Karin L3 products over the Agulhas region, c) from MIOST reconstruction integration 1SWOT and 6 nadirs, d) from MIOST reconstruction integration 6 nadirs and e) the difference in MIOST reconstructions between integration 1SWOT and 6 nadirs vs 6 nadirs only

2.2.2 Temporal availability

One file per day is delivered.

Two datasets are produced: one considering the CAVAL phase of SWOT and one considering the SCIENCE phase of SWOT

area	Start dates	End dates
Global CALVAL v2.0.1	2023/03/28	2023/07/10
Global SCIENCE v2.0.1	2023/07/11 (note that between 11 and 27 jul., the files contain only SWOT Nadir and other altimeters)	2025/06/30

Table 3 Temporal availability of gridded SLA with MIOST Interpolation.

2.2.3 Nomenclature

This is the generic model of filename:

dt_<zone>_allsat_phy_<begin_date>_ <prod_date>.nc

The products name components are:

- The type of data timeliness dt=delayed-time
- <zone>=area (global)
- allsat means that all the available missions are taken into account.
- The begin and production dates of the data: <begin_date>_<prod_date>

2.2.4 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/Atmopshere Reasearch 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.

2.2.4.1 Dimensions

The defined dimensions are:

- **time:** number of grids in current file (one grid for one day).
- **Latitude:** number of grid points in latitude
- **Longitude:** number of grid points in longitude
- bounds: for graphical needs

2.2.4.2 Data Handling Variables

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

Name of variable	Type	Content	Unit
time	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
latitude_bounds	double	latitude values at the north and south bounds of each pixel.	degrees_north
longitude_bounds	double	longitude values at the north and south bounds of each pixel.	degrees_east
sla	int	Sea Level Anomaly relative to a mean sea surface	Meters
adt	int	Absolute dynamic topography	meters
ugosa	int	Geostrophic velocity anomalies: zonal component	meters/second
vgosa	int	Geostrophic velocity anomalies: meridian component	meters/second
ugos	int	Absolute geostrophic velocity: zonal component"	meters/second
vgos	int	Absolute geostrophic velocity: meridian component"	meters/second

Table 4. Overview of data handling variables in gridded NetCDF file.

2.2.4.3 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 c**an be accessed via FTP/SFTP and a THREDDS Data Server (TDS)**

CNES AVISO FTP/SFTP access (with AVISO+ credentials):

- FTP: ftp://ftp-access.aviso.altimetry.fr:21
- SFTP: ftp://ftp-access.aviso.altimetry.fr:2122
    - Path: /duacs-experimental/dt-phy-grids/l4_karin_nadir/v2.0.1

CNES AVISO THREDDS Data Server access:

https://tds%40odatis-ocean.fr:odatis@tds-odatis.aviso.altimetry.fr/thredds/catalog/dataset-duacs-experimental-dt-phy-grids-nadirs-and-wide-swath/v2.0.1/catalog.html

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 Gridded Sea Level Anomalies computed with Multiscale Interpolation

```
netcdf dt_global_allsat_phy_l4_20241222_20250331 {
dimensions:
	longitude = 2880 ;
	latitude = 1440 ;
	time = 1 ;
	bounds = 2 ;
variables:
	float longitude(longitude) ;
		longitude:_FillValue = NaNf ;
		longitude:axis = "X" ;
		longitude:bounds = "lon_bnds" ;
		longitude:long_name = "Longitude" ;
		longitude:standard_name = "longitude" ;
		longitude:units = "degrees_east" ;
		longitude:valid_max = 179.9375 ;
		longitude:valid_min = -179.9375 ;
	float latitude(latitude) ;
		latitude:_FillValue = NaNf ;
		latitude:axis = "Y" ;
		latitude:bounds = "lat_bnds" ;
		latitude:long_name = "Latitude" ;
		latitude:standard_name = "latitude" ;
		latitude:units = "degrees_north" ;
		latitude:valid_max = 89.9375 ;
		latitude:valid_min = -89.9375 ;
	float time(time) ;
		time:_FillValue = NaNf ;
		time:axis = "T" ;
		time:long_name = "Time" ;
		time:standard_name = "time" ;
		time:units = "days since 1950-01-01" ;
		time:calendar = "gregorian" ;
	int sla(time, latitude, longitude) ;
		sla:_FillValue = -2147483647 ;
		sla:ancillary_variables = "err_sla" ;
		sla:comment = "The sea level anomaly is the sea surface height above mean sea surface; it is
referenced to the [1993, 2012] period; see the product user manual for details" ;
		sla:grid_mapping = "crs" ;
		sla:long_name = "Sea level anomaly" ;
		sla:standard_name = "sea_surface_height_above_sea_level" ;
		sla:units = "m" ;
		sla:coordinates = "longitude latitude" ;
		sla:scale_factor = 0.0001 ;
	int ugosa(time, latitude, longitude) ;
		ugosa:_FillValue = -2147483647 ;
		ugosa:ancillary_variables = "err_ugosa" ;
		ugosa:comment = "The geostrophic velocity anomalies are referenced to the [1993, 2012] period" ;
		ugosa:grid_mapping = "crs" ;
		ugosa:long_name = "Geostrophic velocity anomalies: zonal component" ;
		ugosa:standard_name =
"surface_geostrophic_eastward_sea_water_velocity_assuming_sea_level_for_geoid" ;
		ugosa:units = "m/s" ;
		ugosa:coordinates = "longitude latitude" ;
		ugosa:scale_factor = 0.0001 ;
	int vgosa(time, latitude, longitude) ;
```

```
		vgosa:_FillValue = -2147483647 ;
		vgosa:ancillary_variables = "err_vgosa" ;
		vgosa:comment = "The geostrophic velocity anomalies are referenced to the [1993, 2012] period" ;
		vgosa:grid_mapping = "crs" ;
		vgosa:long_name = "Geostrophic velocity anomalies: meridian component" ;
		vgosa:standard_name =
"surface_geostrophic_northward_sea_water_velocity_assuming_sea_level_for_geoid" ;
		vgosa:units = "m/s" ;
		vgosa:coordinates = "longitude latitude" ;
		vgosa:scale_factor = 0.0001 ;
	int adt(time, latitude, longitude) ;
		adt:_FillValue = -2147483647 ;
		adt:comment = "The absolute dynamic topography is the sea surface height above geoid; the adt is
obtained as follows: adt=sla+mdt where mdt is the mean dynamic topography; see the product user manual for
details" ;
		adt:grid_mapping = "crs" ;
		adt:long_name = "Absolute dynamic topography" ;
		adt:standard_name = "sea_surface_height_above_geoid" ;
		adt:units = "m" ;
		adt:coordinates = "longitude latitude" ;
		adt:scale_factor = 0.0001 ;
	int ugos(time, latitude, longitude) ;
		ugos:_FillValue = -2147483647 ;
		ugos:grid_mapping = "crs" ;
		ugos:long_name = "Absolute geostrophic velocity: zonal component" ;
		ugos:standard_name = "surface_geostrophic_eastward_sea_water_velocity" ;
		ugos:units = "m/s" ;
		ugos:coordinates = "longitude latitude" ;
		ugos:scale_factor = 0.0001 ;
	int vgos(time, latitude, longitude) ;
		vgos:_FillValue = -2147483647 ;
		vgos:grid_mapping = "crs" ;
		vgos:long_name = "Absolute geostrophic velocity: meridian component" ;
		vgos:standard_name = "surface_geostrophic_northward_sea_water_velocity" ;
		vgos:units = "m/s" ;
		vgos:coordinates = "longitude latitude" ;
		vgos:scale_factor = 0.0001 ;
	double longitude_bounds(longitude, bounds) ;
		longitude_bounds:_FillValue = NaN ;
	double latitude_bounds(latitude, bounds) ;
		latitude_bounds:_FillValue = NaN ;

// global attributes:
		:description = " Miost analysis " ;
		:Conventions = "CF-1.6" ;
		:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
		:cdm_data_type = "Grid" ;
		:comment = "Sea Surface Height measured by Altimetry and derived variables" ;
		:contact = "" ;
		:creator_email = "" ;
		:creator_name = "" ;
		:creator_url = "https://www.aviso.altimetry.fr/en/home.html" ;
		:date_created = "2025-03-31T00:00:00Z" ;
		:date_issued = "2025-03-31T00:00:00Z" ;
		:date_modified = "2025-03-31T00:00:00Z" ;
		:geospatial_lat_max = 89.9375 ;
		:geospatial_lat_min = -89.9375 ;
		:geospatial_lat_resolution = 0.125 ;
		:geospatial_lat_units = "degrees_north" ;
		:geospatial_lon_max = 179.9375 ;
		:geospatial_lon_min = -179.9375 ;
		:geospatial_lon_resolution = 0.125 ;
```

```
		: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 = "2025-03-31T00:00:00Z: Creation" ;
		:institution = "CLS, CNES" ;
		:keywords = "Oceans > Ocean Topography > Sea Surface Height" ;
		:keywords_vocabulary = "NetCDF COARDS Climate and Forecast Standard Names" ;
		:license = "" ;
		:platform = "Altika Drifting Phase, Cryosat-2, Haiyang-2B, Jason-3, Sentinel-3A, Sentinel-3B,
Sentinel-6A, SWOT" ;
		:processing_level = "L4" ;
		:product_version = "v1.0" ;
		:project = "DUACS R&D" ;
		:references = "https://www.aviso.altimetry.fr/en/home.html" ;
		:software_version = "v2025.CNES" ;
		:source = "Altimetry measurements" ;
		:ssalto_duacs_comment = "The reference mission used for the altimeter inter-calibration processing
is Topex/Poseidon between 1993-01-01 and 2002-04-23, Jason-1 between 2002-04-24 and 2008-10-18,
OSTM/Jason-2 between 2008-10-19 and 2016-06-25, Jason-3 since 2016-06-25." ;
		:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard
Name Table v37" ;
		:summary = "Experimental SSALTO/DUACS Delayed-Time Level-4 sea surface height and derived
variables measured by multi-satellite altimetry observations over Global Ocean." ;
		:time_coverage_duration = "P1D" ;
		:time_coverage_resolution = "P1D" ;
		:title = "DT merged all satellites Global Ocean Gridded Experimental SSALTO/DUACS Sea Surface
Height L4 product and derived variables" ;
		:time_coverage_start = "2024-12-22T12:00:00Z" ;
		:time_coverage_end = "2024-12-22T12:00:00Z" ;
		:doi = "10.24400/527896/a01-2025.001" ;
		:coordinates = "latitude_bounds longitude_bounds" ;
}
```

6 Bibliography

Ballarotta, M., Ubelmann, C., Bellemin-Laponnaz, V., Le Guillou, F., Meda, G., Anadon, C., Laloue, A., Delepoulle, A., Faugère, Y., Pujol, M.-I., Fablet, R., and Dibarboure, G.: Integrating wide-swath altimetry data into Level-4 multi-mission maps, Ocean Sci., 21, 63–80, https://doi.org/10.5194/os-21-63-2025, 2025.

Beauchamp, M., Febvre, Q., Georgenthum, H., and Fablet, R.: 4DVarNet-SSH: end-to-end learning of variational interpolation schemes for nadir and wide-swath satellite altimetry, Geosci. Model Dev., 16, 2119–2147, https://doi.org/10.5194/gmd-16-2119-2023, 2023.

Ducet N., P.Y. Le Traon and G. Reverdin, Global high-resolution mapping of ocean circulation from the combination of T/P and ERS-1/2. J. Geophys. Res., 105, 19, 477-19, 498, 2000

Fablet, R., Beauchamp, M., Drumetz, L., and Rousseau, F.: Joint Interpolation and Representation Learning for Irregularly Sampled Satellite-Derived Geophysical Fields, Front. Appl. Math. Stat., 7, 655224, https://doi.org/10.3389/fams.2021.655224 , 2021

Lavergne, T., Sørensen, A. M., Kern, S., Tonboe, R., Notz, D., Aaboe, S., Bell, L., Dybkjær, G., Eastwood, S., Gabarro, C., Heygster, G., Killie, M. A., Brandt Kreiner, M., Lavelle, J., Saldo, R., Sandven, S., and Pedersen, L. T.: Version 2 of the EUMETSAT OSI SAF and ESA CCI sea-ice concentration climate data records, The Cryosphere, 13, 49–78, https://doi.org/10.5194/tc-13-49-2019 , 2019.

Le Guillou, F., Metref, S., Cosme, E., Ubelmann, C., Ballarotta, M. Le Sommer, J. Verron, J. Mapping Altimetry in the Forthcoming SWOT Era by Back-and-Forth Nudging a One-Layer Quasigeostrophic Model, J. Atmos. Oceanic Technol., 38, 697–710, https://doi.org/10.1175/JTECH-D-20-0104.1 , 2021

Le Traon P.-Y., F. Nadal, N. Ducet, An Improved Mapping Method of Multisatellite Altimeter Data, J. Atmos. Oceanic Technol. 15, 522-534, 1998

Pujol, M.-I., Faugère, Y., Taburet, G., Dupuy, S., Pelloquin, C., Ablain, M., and Picot, N.: DUACS DT2014: the new multi-mission altimeter data set reprocessed over 20 years, Ocean Sci., 12, 1067–1090, https://doi.org/10.5194/os-12-1067-2016, 2016.

Ubelmann, C., Dibarboure, G., Gaultier, L., Ponte, A., Ardhuin, F., Ballarotta, M., & Faugère, Y.: Reconstructing ocean surface current combining altimetry and future spaceborne Doppler data. Journal of Geophysical Research: Oceans, 126, e2020JC016560. https://doi.org/10.1029/2020JC016560, 2021

Ubelmann, C., Carrere, L., Durand, C., Dibarboure, G., Faugère, Y., Ballarotta, M., Briol, F., and Lyard, F.: Simultaneous estimation of ocean mesoscale and coherent internal tide sea surface height signatures from the global altimetry record, Ocean Sci., 18, 469–481, https://doi.org/10.5194/os-18-469-2022, 2022.