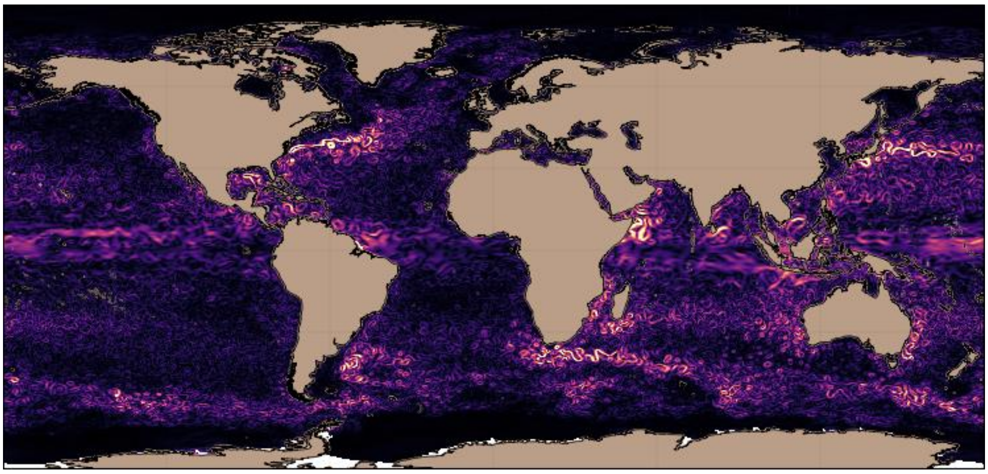
SSALTO/DUACS Experimental Product Handbook:

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

Dataset DOI: **10.24400/527896/a01-2024.007**



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

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1.0	2024/06/10		Creation of the document from existing document

List of Acronyms:

4DvarQG	mapping method
4DvarNET	mapping method
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
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 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 (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 instrument 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, and the 4DvarQG (Le Guillou et al., 2021) and the 4DvarNET mapping (Fablet et al., 2021, Beauchamp et al., 2023) methods for regional products. 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. . DOI: 10.24400/527896/a01-2024.007”

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

The products are distributed in v0.3 and v1.0 versions.

Version v0.3 is based on the nadir along-track dataset distributed in CMEMS and the SWOT Level-3 Ocean product v0.3 release (specifically referencing SWOT_L3_LR_SSH) during the 1-day (Calval) and 21-day (Science) phases of the mission. The SWOT_L3_SSH product combines ocean topography measurements from both the SWOT KaRIn and nadir altimeter instruments and consolidates them into a single variable on a 2 km spatial grid.

Version v1.0 is based on the nadir along-track data set distributed in CMEMS and the SWOT Level-3 Ocean product v1.0 release (specifically referencing SWOT_L3_LR_SSH) during the 1-day (Calval) and 21-day (Science) phases of the mission. The SWOT_L3_SSH product combines ocean topography measurements collected by both the SWOT KaRIn and nadir altimeter instruments and consolidates them into a single variable on 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 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/) for satellites SARAL/AltiKa, Cryosat-2, HaiYang-2B, Jason-3, Copernicus Sentinel-3A&B, Sentinel 6A, SWOT nadir, and SEA LEVEL products (V0.3 or v1.0) delivered by AVISO for SWOT L3 SSH Karin (DOI: https://doi.org/10.24400/527896/A01-2023.018)

Input product	Altimeter mission	Name of product	Name of dataset	DOI	Variable used
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

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.

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. (in prep).

2.1.2.2 4DvarQG products

The 4DvarQG mapping technique (Le Guillou et al., 2021, https://github.com/leguillf/MASSH) integrates a 4-Dimensional variational (4DVAR) scheme with a Quasi-Geostrophic (QG) model. It works by minimizing the discrepancy between the QG model and observational data. To ensure convergence during the minimization process, the method represents model error using a reduced wavelet basis.

4DvarQG products were generated over the North Atlantic basin ([25°N:50°N] [80°W: 10°W]).

2.1.2.3 4dvarNET products

The 4DvarNET mapping algorithm (Fablet et al., 2021, Beauchamp et al., 2023, https://github.com/CIA-Oceanix/4dvarnet-core) is a data-driven approach combining a data assimilation scheme associated with a deep learning framework. This neural network framework involves the joint training of the representation of the ocean dynamic, as well as of the solver of the data assimilation problem. The 4DvarNET algorithm is trained using a supervised learning strategy in an OSSE context, taking the SSH variable of an ocean model as ground truth. Once trained in OSSE, the 4DvarNET algorithm is ready to perform SSH reconstructions with real altimetric data as input. Here, 4DvarNET was trained on the eNATL60-BLB002 realistic high-resolution simulation (https://github.com/ocean-next/eNATL60) over a portion of the Gulfstream region ([32°N-47°N] [66°W:51°W]). Pseudo-observations were generated from this numerical simulation to represent the present-day nadir altimeter constellation as well as KaRin swath.

4DvarNET products were generated over the North Atlantic basin ([25°N:50°N] [80°W: 10°W]).

2.2 Product description

2.2.1 Geographical characteristics

The MIOST gridded products cover the entire global ocean (e.g., Figure 1a). The 4DvarNET and 4DvarQG gridded products cover a portion of the North Atlantic basin (Figure 2a & b). Boundaries have been defined as follows:

Area	Geographical coverage	Spatial resolution
Global (MIOST)	80°S-0°W/90°N-360°E	1/10°
Regional (4DvarNET & 4DvarQG)	25°N-80°W/50°N-10°W	4DvarNET: 1/8°, 4DvarQG: ~1/10°

Table 2. Geographical characteristics of gridded SLA computed with MIOST, 4DvarNET & 4DvarQG.

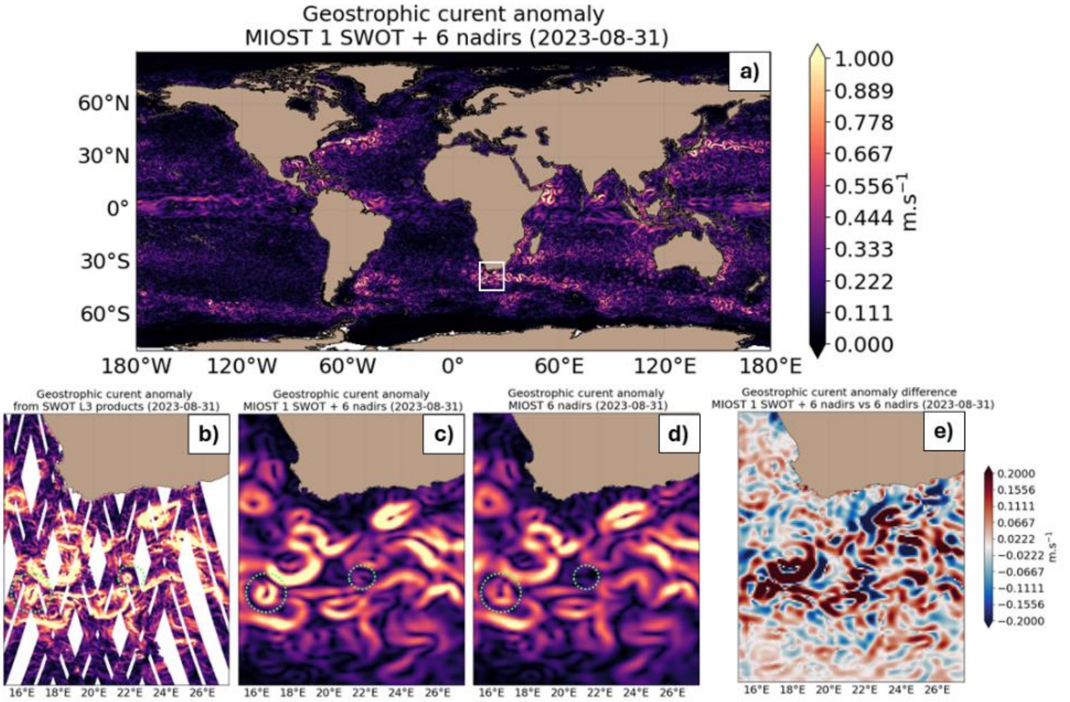

Figure 1: Example of geostrophic current reconstruction on 2023-08-31 with MIOST at a) global scale, b) view from Karin L3 products over the Agulhas region, c) from MIOST reconstruction integration 1SWOT and 6 nadirs, d) from MIOST reconstruction integration 6 nadirs and e) the difference in MIOST reconstructions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

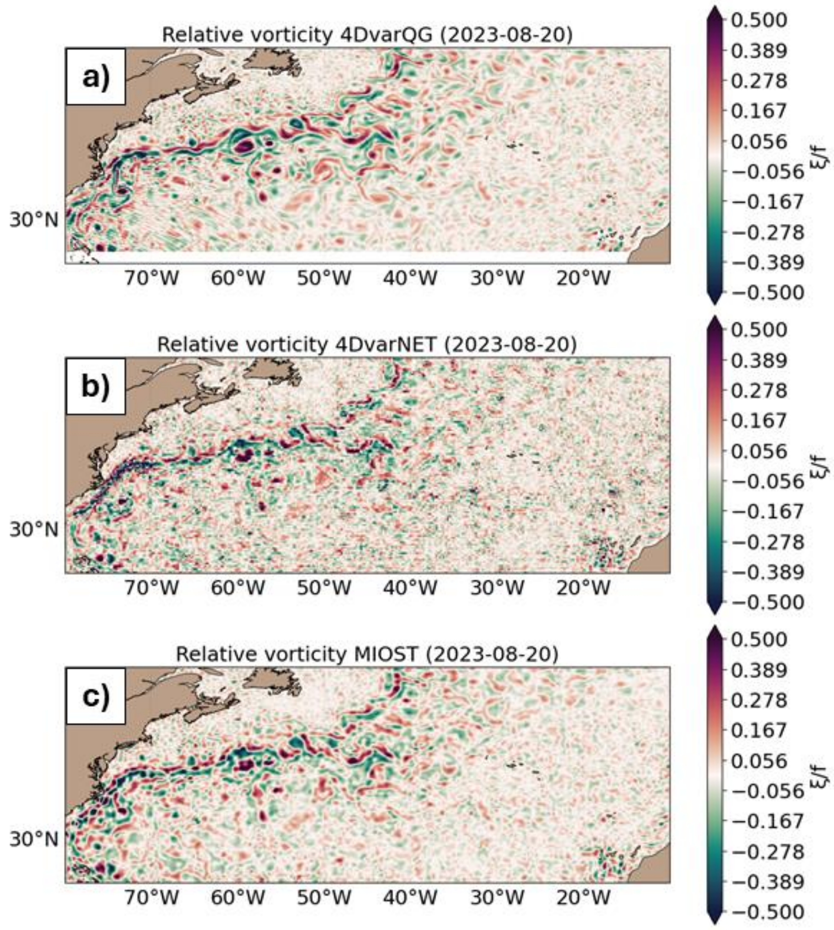

Figure 2: Example of surface relative vorticity maps over the North Atlantic basin, computed for a) the 4DvarQG solution, b) the 4DvarNET solution and c) the MIOST solution.

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 v0.3	2023/03/28	2023/07/10
Global SCIENCE v0.3	2023/07/11 (note that between 11 and 27 jul., the files contain only SWOT Nadir and other altimeters)	2023/11/30
Global CAL	2023/03/28	2023/07/10

VALv1.0		
GlobalSCIENCEv1.0	2023/07/11 (note that between 11 and 27 jul., the files contain only SWOT Nadir and other altimeters)	2024/05/01

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 or north-atlantic)
- 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
relative_vorticity	int	Relative vorticity field normalized by Coriolis derived from velocity	--

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 **can be accessed via FTP/SFTP and a THREDDS Data Server (TDS) using AVISO+ credentials**.

- 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 Gridded Sea Level Anomalies computed with Multiscale Interpolation

```
netcdf dt_global_allsat_phy_l4_20230617_20240501 {
dimensions:
	longitude = 3600 ;
	latitude = 1701 ;
	time = 1 ;
	bounds = 2 ;
variables:
	double longitude(longitude) ;
		longitude:axis = "X" ;
		longitude:long_name = "Longitude" ;
		longitude:units = "degrees_east" ;
		longitude:valid_max = 359.9 ;
		longitude:valid_min = 0. ;
		longitude:bounds = "lon_bnds" ;
		longitude:standard_name = "longitude" ;
	float latitude(latitude) ;
		latitude:axis = "Y" ;
		latitude:bounds = "lat_bnds" ;
		latitude:long_name = "Latitude" ;
		latitude:standard_name = "latitude" ;
		latitude:units = "degrees_north" ;
		latitude:valid_max = 89.9999999999903 ;
		latitude:valid_min = -80. ;
	float time(time) ;
		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 relative_vorticity(time, latitude, longitude) ;
		relative_vorticity:_FillValue = -2147483647 ;
		relative_vorticity:coordinates = "longitude latitude" ;
		relative_vorticity: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:
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		: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 = "2024-05-01T00:00:00Z" ;
		:date_issued = "2024-05-01T00:00:00Z" ;
		:date_modified = "2024-05-01T00:00:00Z" ;
		:geospatial_lat_max = 90. ;
		:geospatial_lat_min = -80.1 ;
		:geospatial_lat_resolution = 0.1 ;
		:geospatial_lat_units = "degrees_north" ;
		:geospatial_lon_max = 359.9 ;
		:geospatial_lon_min = 0. ;
		:geospatial_lon_resolution = 0.1 ;
```

```
            :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 = "2024-05-01T00:00:00Z: 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 = "v0.3" ;
            :project = "DUACS R&D" ;
            :references = "https://www.aviso.altimetry.fr/en/home.html" ;
            :software_version = "v2024.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" ;
            :coordinates = "latitude_bounds longitude_bounds" ;
            :time_coverage_start = "2023-06-17T12:00:00Z" ;
            :time_coverage_end = "2023-06-17T12:00:00Z" ;
}
```

Bibliography

Ballarotta et al., in prep: Integrating wide swath altimetry data into Level-4 multi-mission maps

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

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.