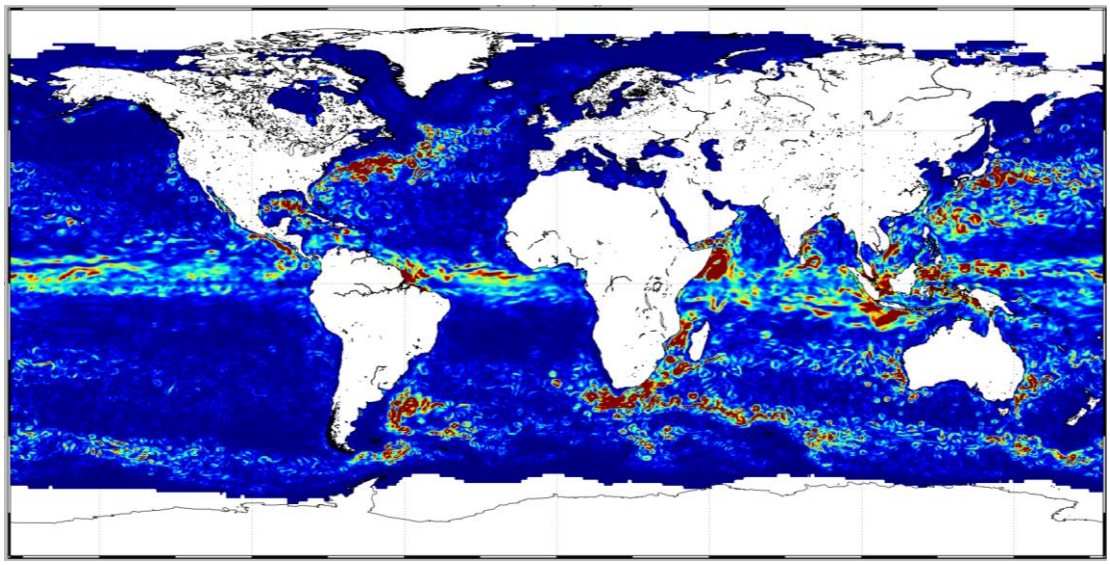
SSALTO/DUACS User Handbook:

Climatologies products



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List of Acronyms:

AVISO	Archiving, Validation and Interpretation of Satellite Oceanographic data
C3S	Copernicus Climate Change Service
CF	Climate Forecast
CMEMS	Copernicus Marine Environment and Monitoring Service
CNES	Centre National d 'Etudes Spatiales
COARDS	Cooperative Ocean/Atmosphere Research Data Service
DT	Delayed Time
DUACS	Data Unification and Altimeter Combination System
EKE	Eddy Kinetic Energy
NetCDF	Network Common Data Form
NRT	Near-Real Time
Opendap	Open-source Project for a Network Data Access Protocol
SLA	Sea Level Anomalies, aka Sea Surface Height with respect to a Mean Sea Surface

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1. Overview of this document

DUACS has been producing, as part of the Copernicus Marine Environment and Monitoring Service (CMEMS) and the Copernicus Climate Change Service (C3S), high quality multi-mission altimetry Sea Level products for oceanographic applications, climate forecasting centres, geophysics and biology communities... While the operational production of the Sea Level along track and grids is now part of CMEMS and C3S, development of new experimental DUACS products is disseminated through CNES/AVISO.

This document describes the following products distributed by Aviso+:

- **Global** monthly mean and Climatology Maps
- **Regional Europe** monthly mean and Climatology Maps

The set of variables in the products are the following :

- **EKE** (Eddy Kinetic Energy)
- **MSLA-H** (Sea Level Anomaly H, sea surface height above sea level)
- **MSLA-U** (Sea Level Anomaly U, surface geostrophic eastward sea water velocity assuming sea level for geoid)
- **MSLA-V** (Sea Level Anomaly V, surface geostrophic northward sea water velocity assuming sea level for geoid)
- **MADT-H** (Absolute Dynamics Topography H : sea surface height above geoid)
- **MADT-U** (Absolute Dynamics Topography U, surface geostrophic eastward sea water velocity)
- **MADT-V** (Absolute Dynamics Topography V, surface geostrophic northward sea water velocity)

Three kinds of means are proposed:

Monthly averaged corresponds to the daily maps of delayed-time data averaging month by month from January 1993. We obtain one file and one map per month since January 1993.

Seasonal mean corresponds to the daily maps of delayed-time data averaging season by season. We obtain one file and one map per season (JFM - AMJ - JAS- OND).

Climatological monthly are calculated by averaging the daily maps of delayed-time data over a same month from January 1993 up to the last extension of the Delayed-time products. We obtain one data file and one map for each month.

1.1. Acknowledgments

When using the SSALTO/DUACS products, please cite: “Those products were processed by SSALTO/DUACS and distributed by AVISO+ (https://www.aviso.altimetry.fr) with support from CNES”

1.2. User's feedback

Each 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.

1.3. Format

All the products are distributed in NetCDF with COARDS CF standards.

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. Application Programming Interfaces (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. SSALTO/DUACS system

2.1. Introduction

Figure 1 is an overview of the processing steps necessary to produce L4 altimetry products data.

DUACS processing is described in details in [Taburet et al., 2019] & [Pujol et al.,2016]. Many informations can be found here: http://duacs.cls.fr

We will focus here on the means computation. This corresponds to the global gridded product result in the Figure 1 below (derivative products). For information on other aspects of the processing, please refer to [Taburet et al., 2019] & [Pujol et al.,2016] or http://duacs.cls.fr.

The version of the altimetry products used corresponds to the DUACS DT2021. For a complete description please refer to CMEMS product :

https://resources.marine.copernicus.eu/product-detail/SEALEVEL_GLO_PHY_L4_MY_008_047/INFORMATION

or

https://resources.marine.copernicus.eu/product-detail/SEALEVEL_EUR_PHY_L4_MY_008_068/INFORMATION

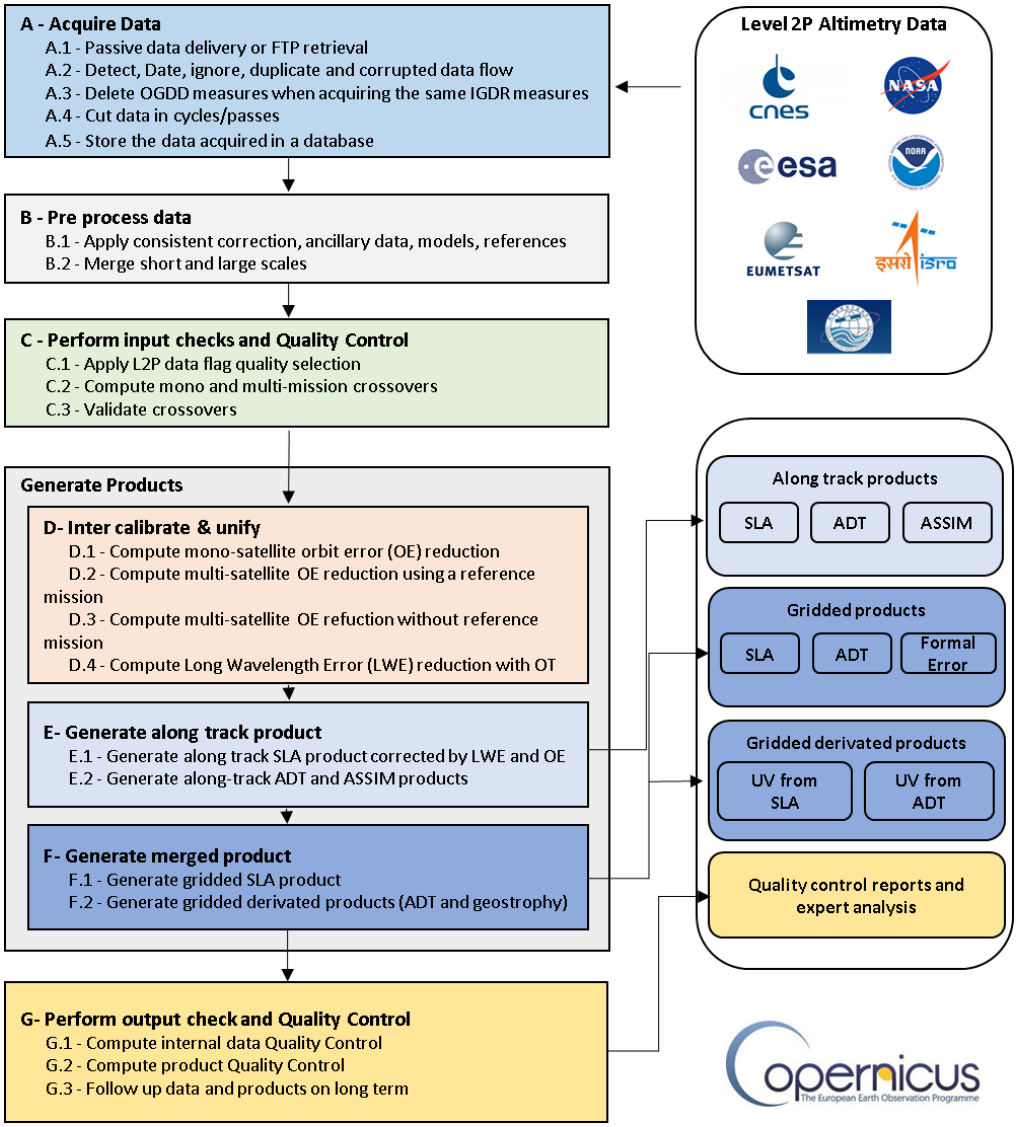

Figure 1 : DUACS processing sequences

2.2. Processing steps

2.2.1. Computation of MADT-H, MSLA-H, MSLA-UV and MADT-UV products

Processing of Merged Absolute Dynamic Topography products and Merged Sea Level Anomalies products are described in the following CMEMS documentation:

https://catalogue.marine.copernicus.eu/documents/PUM/CMEMS-SL-PUM-008-032-068.pdf

and

https://catalogue.marine.copernicus.eu/documents/QUID/CMEMS-SL-QUID-008-032-068.pdf

2.2.2. Eddy Kinetic Energy (EKE) computation

Coherent mesoscale eddies capture almost 80% of the total kinetic energy (KE) in the ocean, based on altimeter observations ([Richardson et al.,1983]; [Klein et al.,2019]). Thus, the surface gridded Eddy KE (EKE) derived from the SLA field, based on the geostrophic relationship, is commonly used to analyze the mesoscale eddies and their variabilities.

The Eddy Kinetic Energy is computed as:

$$eke = \frac{(u^2 + v^2)}{2}$$

here u and v correspond to the geostrophic velocities derived from sea level anomalies component of:

- CMEMS SEALEVEL_GLO_PHY_L4_REP_OBSERVATIONS_008_047 for the global product.
- CMEMS SEALEVEL_EUR_PHY_L4_MY_008_068 for Europe product.

2.2.3. Computation of monthly and seasonal means and climatologies

For the three kinds of means proposed:

- Monthly means variables correspond to an averaged by month since January 1993.
  The monthly means are computed using all the grids of the given month. A specific variable in the NetCDF file (*climatology_bnds*) is set to indicate the temporal boundaries of the mean.

  The date of the monthly grids is arbitrarily set to the 15th of the month.

- Seasonal means correspond to the sea level anomalies averaged by season (JFL-AMJ-JAS-OND) since January 1993
- .Climatological monthly data are calculated by averaging over a same month for all the years. We obtain one file and one map for each month.

3. Description of the product

The temporal range of this series corresponds to that of the DT sea-level products in CMEMS/C3S ("MY" for CMEMS).

3.1. Structure and semantic of NetCDF maps (L4) files

In addition to the conventions described above, the files are using a common structure and semantic:

- 4 Dimensions are defined:
  - **time**: date of the map (15th of the month)
  - **latitude** : contains the latitude of grid points
  - **longitude**: contains the longitude of grid points
  - **nv**: used for mapping conventions
- the variables used for all grids are defined below:
  - **float time** : contains the time in days since 1950-01-01 00:00:00 UTC
  - **float climatology_bnds :** temporal limits of map selection
  - **float latitude** : contains the latitude for each measurement
  - **float longitude** : contains the longitude for each measurement
  - **float lat_bnds** : contains the min and max in latitude of each box
  - **float lon_bnds** : contains the min and max in longitude of each box

- **int crs** : used for mapping conventions
- **int eke** : Mean eke computed from geostrophic velocities of the sea level anomalies
- **or**
- **int adt:** Averaged Absolute Dynamic Topography
- **or**
- **int ugos:** Averaged Absolute geostrophic velocity: zonal component
- **or**
- **int vgos:** Averaged Absolute geostrophic velocity: meridian component
- **or**
- **int sla:** Averaged Sea Level Anomalies
- **or**
- **int ugosa:** Averaged Absolute geostrophic velocity anomalies: zonal component
- **or**
- **int vgosa:** Averaged Absolute geostrophic velocity anomalies: meridian component
- **int nv** : Vertex

- global attributes:
  - the global attributes gives information about the creation of the file.

Example of a data header:

```
netcdf dt_global_allsat_eke_y2021_m07 {
dimensions:
        time = 1 ;
        latitude = 720 ;
        longitude = 1440 ;
        nv = 2 ;
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" ;
                time:bounds = "climatology_bnds" ;
        float climatology_bnds(time, nv) ;
        float latitude(latitude) ;
                latitude:axis = "Y" ;
                latitude:bounds = "lat_bnds" ;
                latitude:long_name = "Latitude" ;
                latitude:standard_name = "latitude" ;
                latitude:units = "degrees_north" ;
                latitude:valid_min = -89.875 ;
                latitude:valid_max = 89.875 ;
```

float lat_bnds(latitude, nv) ;
lat_bnds:comment = "latitude values at the north and south bounds of each pixel." ;
lat_bnds:units = "degrees_north" ;
float longitude(longitude) ;
longitude:axis = "X" ;
longitude:bounds = "lon_bnds" ;
longitude:long_name = "Longitude" ;
longitude:standard_name = "longitude" ;
longitude:units = "degrees_east" ;
longitude:valid_min = 0.125 ;
longitude:valid_max = 359.875 ;
float lon_bnds(longitude, nv) ;
lon_bnds:comment = "longitude values at the west and east bounds of each pixel." ;
lon_bnds:units = "degrees_east" ;
int nv(nv) ;
nv:comment = "Vertex." ;
nv:long_name = "Number of cell vertices" ;
nv:units = "1" ;
int crs ;
crs:comment = "This is a container variable that describes the grid_mapping used by the data in this file. This variable does not contain any data; only information about the geographic coord inate system." ;
crs:grid_mapping_name = "latitude_longitude" ;
crs:inverse_flattening = 298.257 ;
crs:semi_major_axis = 6378136.3 ;
int eke(time, latitude, longitude) ;
eke:_FillValue = -2147483648 ;
eke:long_name = "Averaged Eddy Kinetic Energy 2021/07" ;
eke:standard_name = "specific_kinetic_energy_of_sea_water" ;
eke:cell_methods = "time: mean within years" ;
eke:scale_factor = 0.0001 ;
eke:units = "cm2/s2" ;
eke:coordinates = "longitude latitude" ;
eke:grid_mapping = "crs" ;

// global attributes:
:cdm_data_type = "Grid" ;
:comment = "Monthly Mean of Sea Level Anomalies referenced to the [1993, 2012] period" ;

:date_issued = "2022-02-28 11:59:33Z" ;

:time_coverage_resolution = "P1M" ;

:creator_email = "aviso@altimetry.fr" ;

:product_version = "7.0" ;

:references = "www.aviso.altimetry.fr" ;

:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;

:creator_url = "http://www.aviso.altimetry.fr" ;

:keywords = "Oceans > Ocean Topography > Sea Surface Height" ;

:keywords_vocabulary = "NetCDF COARDS Climate and Forecast Standard Names" ;

:institution = "CNES, CLS" ;

:license = "http://www.aviso.altimetry.fr/fileadmin/documents/data/License_Aviso.pdf" ;

:geospatial_vertical_resolution = "point" ;

:creator_name = "SSALTO/DUACS" ;

:source = "Altimetry measurements" ;

:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table v37" ;

:date_modified = "2022-02-28 11:59:33Z" ;

:summary = "Delayed Time Level-4 monthly mean of Eddy Kinetic Energy from sea surface height above Mean Sea Surface products from multi-satellite observations over Global Ocean." ;

:project = "SSALTO/DUACS: Data Unification and Altimeter Combination System" ;

: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." ;

:contact = "aviso@altimetry.fr" ;

:geospatial_vertical_positive = "down" ;

:title = "DT merged all satellites Global Ocean Ocean Gridded Monthly Mean of Eddy Kinetic Energy L4 product" ;

:geospatial_vertical_units = "m" ;

:processing_level = "L4" ;

:history = "2022-02-28 11:59:33Z: Created by DUACS DT V7.0" ;

:date_created = "2022-02-28 11:59:33" ;

:Conventions = "CF-1.6" ;

:geospatial_lat_min = -89.875 ;

:geospatial_lat_max = 89.875 ;

:geospatial_lon_min = 0.125 ;

:geospatial_lon_max = 359.875 ;

:geospatial_vertical_min = "0.0" ;

:geospatial_vertical_max = "0.0" ;

:geospatial_lat_units = "degrees_north" ;

:geospatial_lon_units = "degrees_east" ;

:geospatial_lat_resolution = 0.25 ;

:geospatial_lon_resolution = 0.25 ;

4. How to download a product

4.1. Registration

To access data, registration is required. During the registration process, the user shall accept using licenses for the use of AVISO+ products and services.

Register at:

http://www.aviso.altimetry.fr/en/data/data-access/registration-form.html

and select the product "**MSLA Heights: Climatologies and means**"

or, if already registered on AVISO+, connect to your account on the web site to add the product "**MSLA Heights: Climatologies and means**".

4.2. Access Services

The data access on the FTP server is authenticated **with a FTP client** on:
ftp-access.aviso.altimetry.fr/

Note that once your registration is processed (see above), AVISO+ will send you your own access (login/password) by e-mail as soon as possible (within 5 working days during working hours, Central European Time).

The datasets are also accessible on a Thredds Data Server

5. References

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.

Taburet, G., Sanchez-Roman, A., Ballarotta, M., Pujol, M.-I., Legeais, J.-F., Fournier, F., Faugere, Y., and Dibarboure, G.: DUACS DT2018: 25 years of reprocessed sea level altimetry products, Ocean Sci., 15, 1207–1224, https://doi.org/10.5194/os-15-1207-2019, 2019.

Richardson, P. L. (1983), Eddy kinetic energy in the North Atlantic from surface drifters, J. Geophys. Res., 88(C7), 4355– 4367, doi:10.1029/JC088iC07p04355.

Klein, P., Lapeyre, G., Siegelman, L., Qiu, B., Fu, L.-L., Torres, H., et al. (2019). Ocean-scale interactions from space. Earth and Space Science, 6, 795– 817. https://doi.org/10.1029/2018ea000492

Guillaume Taburet and Marie-Isabelle Pujol, SL-TAC team (2022). Quality Information Document, Sea Level TAC DUACS products CMEMS-SL-QUID-008-032-068.pdf

Faugère, Y., Taburet, G., Ballarotta, M., Pujol, I., Legeais, J. F., Maillard, G., Durand, C., Dagneau, Q., Lievin, M., Sanchez Roman, A., and Dibarboure, G.: DUACS DT2021: 28 years of reprocessed sea level altimetry products, EGU General Assembly 2022, Vienna, Austria, 23–27 May 2022, EGU22-7479, https://doi.org/10.5194/egusphere-egu22-7479, 2022


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