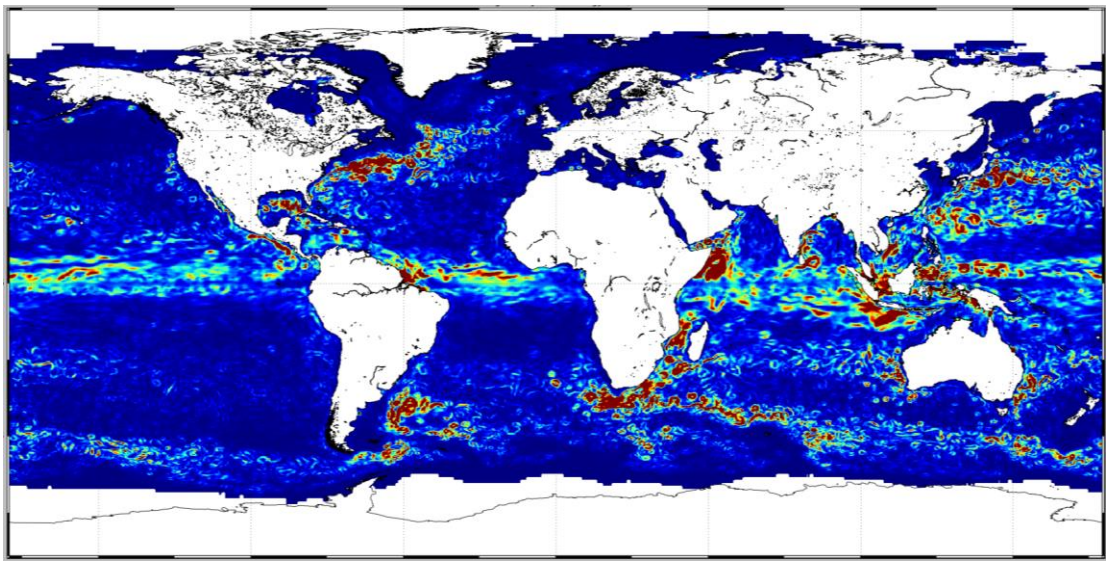
SSALTO/DUACS User Handbook:

Eddy Kinetic Energy (EKE) monthly mean products



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Chronology Issues:		
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1.0	2021/06/25	1st issue

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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 Eddy Kinetic Energy (EKE) monthly means.
- Regional Black Sea Eddy Kinetic Energy (EKE) monthly means.
- Regional Mediterranean Sea Eddy Kinetic Energy (EKE) monthly means.

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 information can be found here: http://duacs.cls.fr

We will focus here on the Eddy Kinetic Energy and the monthly mean computation. This corresponds to process F.2 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 DT2018 [Taburet et al., 2019].

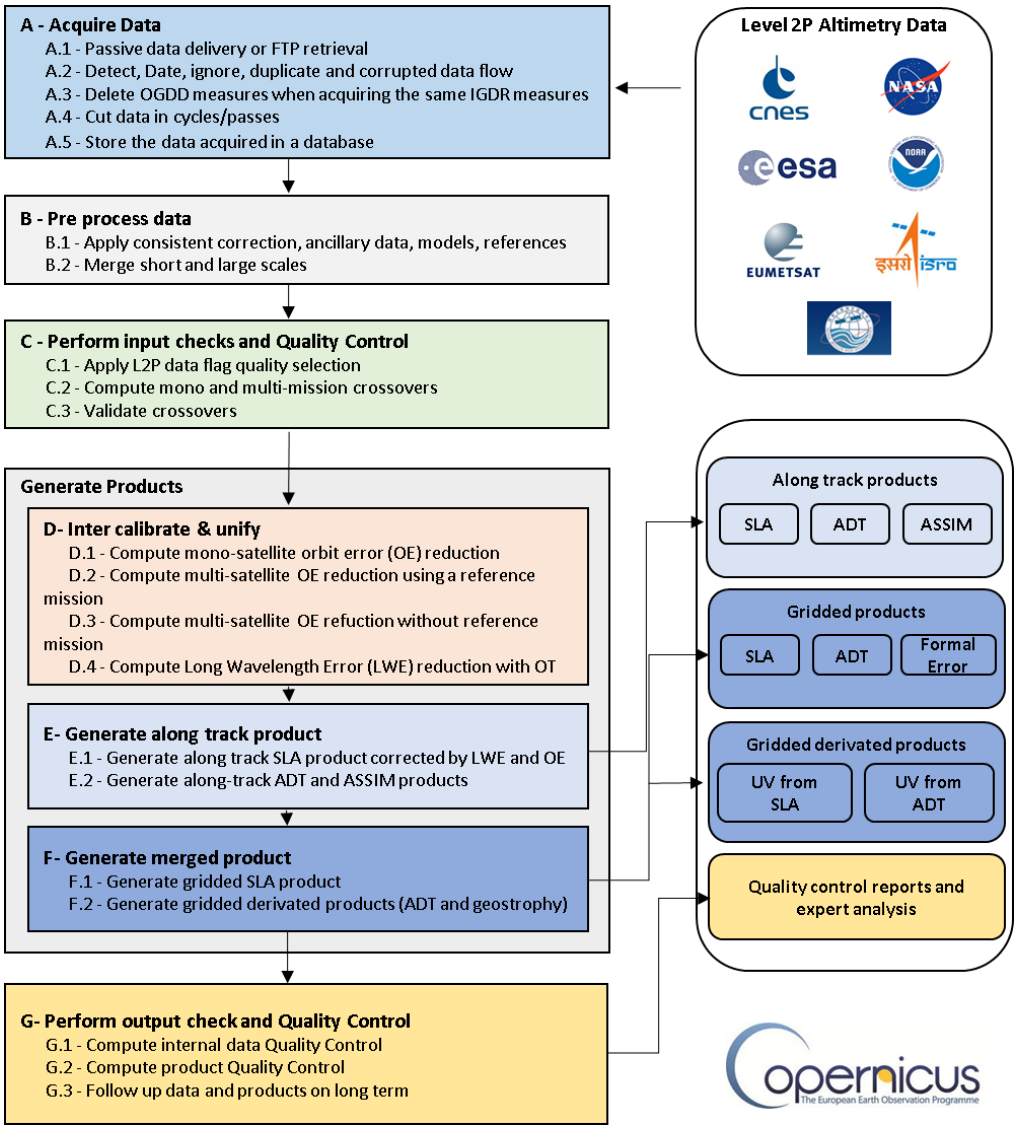

Figure 1 : DUACS processing sequences

2.2. Processing steps

2.2.1. 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_BS_PHY_L4_REP_OBSERVATIONS_008_042 for the regional Black Sea product.
- CMEMS SEALEVEL_MED_PHY_L4_REP_OBSERVATIONS_008_051 for the regional Mediterranean Sea product

2.2.2. Monthly means

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.

3. Description of the product

The temporal range of this series corresponds to that of the DT sea-level products in CMEMS/C3S ("REP" 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 for eke averaging
  - **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** : contains the mean eke computed from geostrophic velocities of the sea level anomalies
- **int nv** : Vertex

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

Example of NetCDF gridded file:

```
netcdf dt_global_allsat_msla_eke_y2020_m05 {
dimensions:
        time = 1 ;
        lat = 720 ;
        lon = 1440 ;
        nv = 2 ;
variables:
        float time(time) ;
                time:long_name = "Time" ;
                time:standard_name = "time" ;
                time:units = "days since 1950-01-01 00:00:00" ;
                time:calendar = "gregorian" ;
                time:axis = "T" ;
                time:bounds = "climatology_bnds" ;
        float climatology_bnds(time, nv) ;
        float lat(lat) ;
                lat:long_name = "Latitude" ;
                lat:standard_name = "latitude" ;
                lat:units = "degrees_north" ;
                lat:bounds = "lat_bnds" ;
                lat:axis = "Y" ;
                lat:valid_min = -89.875 ;
                lat:valid_max = 89.875 ;
        float lat_bnds(lat, nv) ;
                lat_bnds:comment = "latitude values at the north and south bounds of each pixel." ;
                lat_bnds:units = "degrees_north" ;
        float lon(lon) ;
                lon:long_name = "Longitude" ;
                lon:standard_name = "longitude" ;
                lon:units = "degrees_east" ;
                lon:bounds = "lon_bnds" ;
                lon:axis = "X" ;
```

lon:valid_min = 0.125 ;

lon:valid_max = 359.875 ;

float lon_bnds(lon, 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:units = "1" ;

int crs ;

crs:grid_mapping_name = "latitude_longitude" ;

crs:semi_major_axis = 6371000. ;

crs:inverse_flattening = 0 ;

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 coordinate system." ;

int eke(time, lat, lon) ;

eke:_FillValue = -2147483648 ;

eke:long_name = "Averaged Eddy Kinetic Energy 2020/05" ;

eke:standard_name = "eddy_kinetic_energy_from_sea_surface_height_above_sea_level" ;

eke:cell_methods = "time: mean within years" ;

eke:scale_factor = 0.0001 ;

eke:units = "cm2/s2" ;

eke:coordinates = "lon lat" ;

eke:grid_mapping = "crs" ;

// global attributes:

:cdm_data_type = "Grid" ;

:comment = "Monthly Mean of Eddy Kinetic Energy from SLA referenced to the [1993, 2012] period" ;

:date_issued = "2020-12-09 15:14:07Z" ;

:time_coverage_resolution = "P1M" ;

:creator_email = "aviso@altimetry.fr" ;

:product_version = "6.4" ;

: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 v28" ;

:date_modified = "2020-12-09 15:14:07Z" ;

: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 = "2020-12-09 15:14:07Z: Created by DUACS DT V6.4 - 2016-07-18T12:03:09Z: Change of some attributes" ;

:date_created = "2020-12-09 15:14:07" ;

: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

or, if already registered on AVISO+, connect to your account on the web site to add a product.

4.2. Access Services

The data access on the FTP server is authenticated on ftp://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). If you don't enter your login/password, you will only be able to access to the anonymous FTP, where you will not find the data you're interested in.

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


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