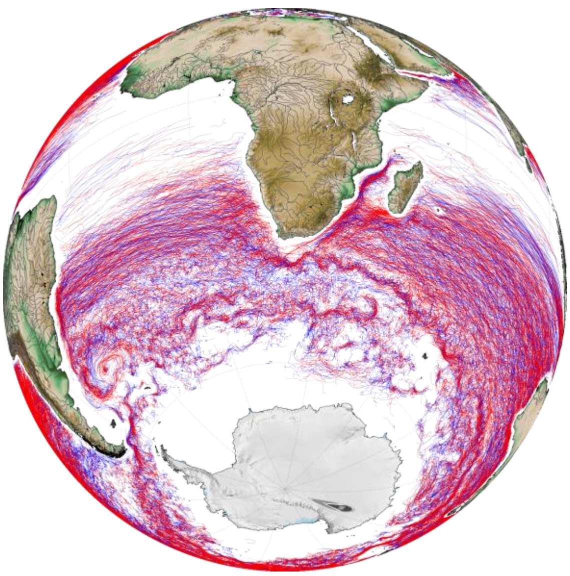
Mesoscale Eddy Trajectory Atlas Product Handbook

META3.2 Delayed Time

META3.2 DT allsat : 10.24400/527896/a01-2022.005.210802

META3.2 DT twosat : 10.24400/527896/a01-2022.006.210802



Reference: SALP-MU-P-EA-23561-CLS

Issue: 1 rev 0

Date: March 2022

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Chronology Issues:		
Issue:	Date:	Reason for change:
1.0	15/02/2022	1st issue

List of Acronyms:

ADT	Absolute Dynamic Topography (=SLA+MDT)
AVISO+	Archivage, Validation et Interprétation des données des Satellites Océanographiques
C3S	Copernicus Climate Change Service http://climate.copernicus.eu/
CLS	Collecte Localisation Satellites
CMEMS	Copernicus Marine Environment Monitoring Service
CNES	Centre National d'Etudes Spatiales
DUACS	Data Unification and Altimeter Combination System
FTP	File Transfer Protocol
MDT	Mean Dynamic Topography (difference between Mean Sea Surface (MSS) and Geoid)
NetCDF	Network Common Data Format
OSU	Oregon State University
PET	Py-Eddy-Tracker
SLA	Sea Level Anomaly (a.k.a. sea surface height with respect to a mean sea surface)

List of figures

Contents

1. Overview of this document

This document is the user manual for the **Mesoscale Eddy Trajectory Atlas DT** (META3.2 DT twosat and META3.2 DT allsat) products, processed by CNES/CLS in the DUACS system.

These versions are generated and quality-controlled following the methodology developed E. Mason at the Instituto Mediterráneo de Estudios Avanzados (IMEDEA, Spain). The algorithm benefits from upgrades added through this collaboration, and the META3.2exp DT twosat and META3.2exp DT allsat datasets are distributed by AVISO+.

This document describes the delayed-time version 3.2 Operational (3.2 DT) products, released in March 2022. Updates are provided as the number of available input maps increase with time or when a reprocessing is made.

The document is organized as follows:

- Chapter 2; presentation
- Chapter 3; processing: input data and method applied
- Chapter 4; the product description, with the different files provided, the nomenclature & the file format
- Chapter 5; how to download products.

2. The Mesoscale Eddy Trajectory Atlas

2.1. Rationale

The mesoscale circulation is defined as a class of energetic phenomena of spatial dimensions ranging from tens to hundreds of kilometers and spanning days to years. The mesoscale structures are mainly generated by currents instabilities, from the ocean large-scale circulation instabilities due to wind or topographic obstacles, creating variability around the ocean's mean state.

Altimetry enables observations of such phenomena by measuring the sea surface height, where currents swirl around local highs and lows through the geostrophic balance between the pressure gradient force and the Coriolis acceleration. The best resolution is obtained with several satellites to study and understand eddies, whose diameters range from 100 to 300 km, when the ground track separation at the Equator is about 315 km for Jason. The existence of at least two satellites operating simultaneously is therefore necessary for research on mesoscale features.

The analysis of Sea Surface Height (starting with Sea Level Anomalies, now more with Absolute Dynamic Topography) from merged satellite data reveals the areas of high eddy activity, the number of eddies per year, their horizontal scale and amplitude. Such a census helps understand ocean dynamics due to eddies, and to discriminate eddies' effect from other processes (like the Rossby waves). This reveals that most of the mesoscale features are "non-linear", i.e. that these features are coherent structures (as opposed to planetary waves that would be linear). Moreover, eddies can transport heat, salts and nutrients trapped within them if they rotate faster than they move-- also as opposed to planetary waves that would not transport water parcels. Some regions see more anticyclonic eddies (highs in the Sea Surface Height), like the Tehuantepec and Papagayo eddy area, others more cyclonic eddies, such as seen in the Humboldt Current.

2.2. Versioning of the AVISO+ Mesoscale Eddy Trajectory Atlas

The versioning of the different Mesoscale Eddy Trajectory Atlases is detailed on the AVISO+ website, where their specific name, DOI is available, date of release and temporal coverage are listed:

https://www.aviso.altimetry.fr/en/data/products/value-added-products/global-mesoscale-eddy-trajectory-product.html.

Note that the META3.2 DT products will be updated several times per year. To track these updates, a DOI will be attributed to each temporal extension to follow the FAIR (Findability, Accessibility, Interoperability, and Reusability) principles. The META3.2 DT DOIs will have a basic shared sequence and a specific suffix :

Dataset	Date of release	Total DOI	Shared sequence	Suffix
META3.2 DT allsat	March 2022	10.24400/527896/a01-2022.005.210802	10.24400/527896/a01-2022.005	.210802
META3.2 DT twosat	March 2022	10.24400/527896/a01-2022.006.210802	10.24400/527896/a01-2022.006	.210802

Table 1 : Example of the DOI construction of the META3.2 DT products

2.3. Acknowledgments

When using the **Mesoscale Eddy Trajectory Atlas** products, please cite in the text the following exemple, with the proper DOI, CITATION, DATE OF DOWNLOAD and MONTH & YEAR:

For META3.2 DT allsat, released in March 2022:

"The altimetric Mesoscale Eddy Trajectory Atlas product (META3.2 DT allsat, **DOI**: 10.24400/527896/a01-2022.005.210802; (Pegliasco et al., 2022)) was produced by SSALTO/DUACS and distributed by AVISO+ (https://www.aviso.altimetry.fr/) with support from CNES, in collaboration with IMEDEA. This atlas was downloaded the **DATE OF DOWNLOAD**, and covers the period from January 1993 to **MONTH & YEAR**."

For META3.2 DT twosat, released in March 2022:

"The altimetric Mesoscale Eddy Trajectory Atlas product (META3.2 DT twosat, **DOI**: 10.24400/527896/a01-2022.006.210802; (Pegliasco et al., 2022a)) was produced by SSALTO/DUACS and distributed by AVISO+ (https://www.aviso.altimetry.fr/) with support from CNES, in collaboration with IMEDEA. This atlas was downloaded the **DATE OF DOWNLOAD**, and covers the period from January 1993 to **MONTH & YEAR**."

The total citation is : Auteurs, Date, Titre, http://DOIxx, see in 6. Bibliography.

2.4. 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.

3. Processing

3.1. Input data

The data used are described in Table 2.

Eddy product	Input data	Variable	Origin
Version 3.2 **DT twosat**	**"two-satellite"** daily **Delayed Time** DUACS2021 version	Gridded Global **Absolute Dynamic Topographies** (ADT)	Copernicus Climate Change Service (C3S) http://climate.copernicus.eu/
Version 3.2 **DT allsat**	**"all-satellite"** daily **Delayed Time** DUACS2021 version https://doi.org/10.48670/moi-00148	Gridded Global **Absolute Dynamic Topographies** (ADT)	Copernicus Marine Service (CMEMS) http://marine.copernicus.eu/

Table 2: Input products used

Note that DT versions differ by the input product used. The "two-satellite" maps are built using at most two altimetric missions, with the Topex-Poseidon and Jason satellites on the same long-term ground tracks, and a second satellite mission, mainly on the ERS-Envisat-Saral-Sentinel-3A ground tracks. As the sampling and the represented scales are stable throughout time, this dataset is considered to be homogeneous in time in terms of climate signals and mesoscale content. The "all-satellite" maps are built with all the available satellites at a given time, improving the small scales representation in the maps due to the diversity of the tracks' location and the different repetition periods of the altimetric missions.

Warning : no continuity is guaranteed between the **META3.2 NRT** and **META3.2 DT allsat** products. The trajectory number may differ due to the construction of the files.

3.2. Algorithm

The algorithm used for these products is derived from Mason et al. (2014) and further described in Pegliasco et al. (2022b).

The main processing steps are described in this section.

3.2.1. Filtering

The Sea Surface Height field includes a wide range of features, ranging from small to large-scale ones. Eddies are identified as features with diameters of 100-300 km, so the first step is to remove larger scale variability using a low pass filter. Large-scale variability is computed by smoothing the Absolute Dynamic Topography (ADT) field with a first order Lanczos filter with a half-power cutoff wavelength of 700 km. The result is subtracted from the original ADT map to produce a high-pass filtered grid which contains only mesoscale variability (Figure 1).

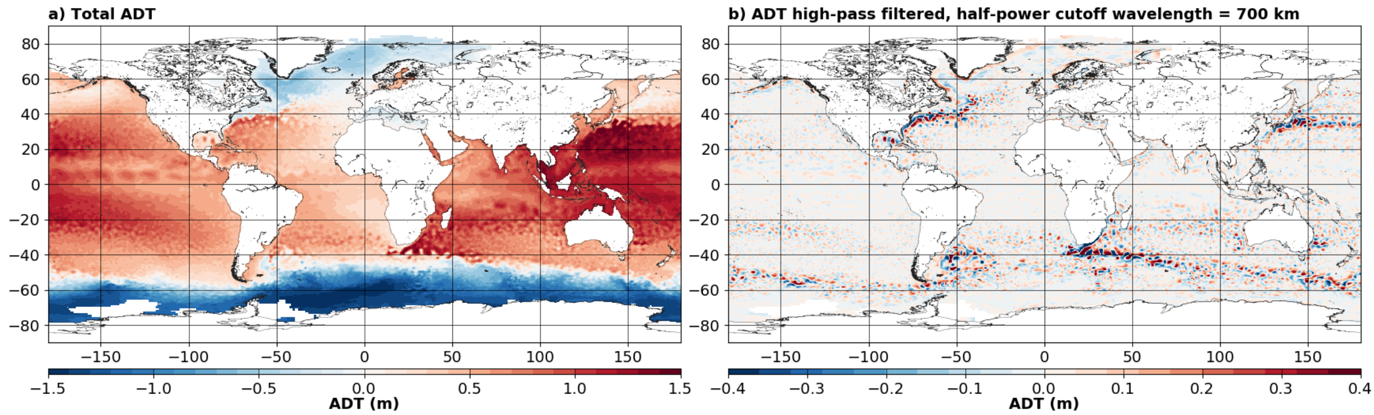

Figure 1: Filter applied on the Absolute Dynamic Topography for an all-satellites map. a) initial ADT map. b) resulting high pass filtered ADT used for the DT 3.2 eddy detection.

3.2.2. Detection

The detection is made in two steps:

1/ ADT closed contours are scanned between -100/100 cm with a 0.2 cm interval. Closed contours in agreement with the defined criteria (shape error ≤ 70%, amplitude ≤ 0.4cm, only one extremum, 5 ≤ Npixel ≤ 1000, no masked pixels within a contour, only pixels with SSH values under (below) the interval for cyclones (anticyclones)) are selected and registered as Cyclonic or Anticyclonic Eddies, the other contours are rejected (Figure 2).

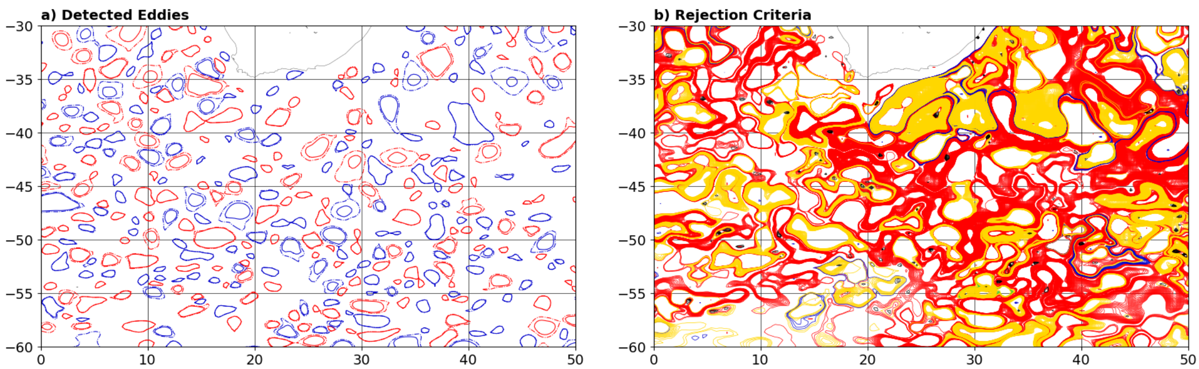

Figure 2 : Eddy detection. a) Selected contours for Anticyclones (red) and Cyclones (blue). b) rejected contours colored with their rejection criteria (red : shape error, yellow : amplitude related criteria, blue : masked value in the contour, black : outside the pixel number limits).

The full explanation can be found in Pegliasco et al. (2022b).

2/ Each contour is regularly oversampled by multiplying the original number of points by 10. The center of the eddy is defined as the center of the circle which fits best with the contour of the maximum speed (Figure 3). The corresponding radius is then calculated as the radius of this best fit circle. The center of the eddy can differ from the position of the SSH extremum, corresponding to the center of the SSH smaller contour.

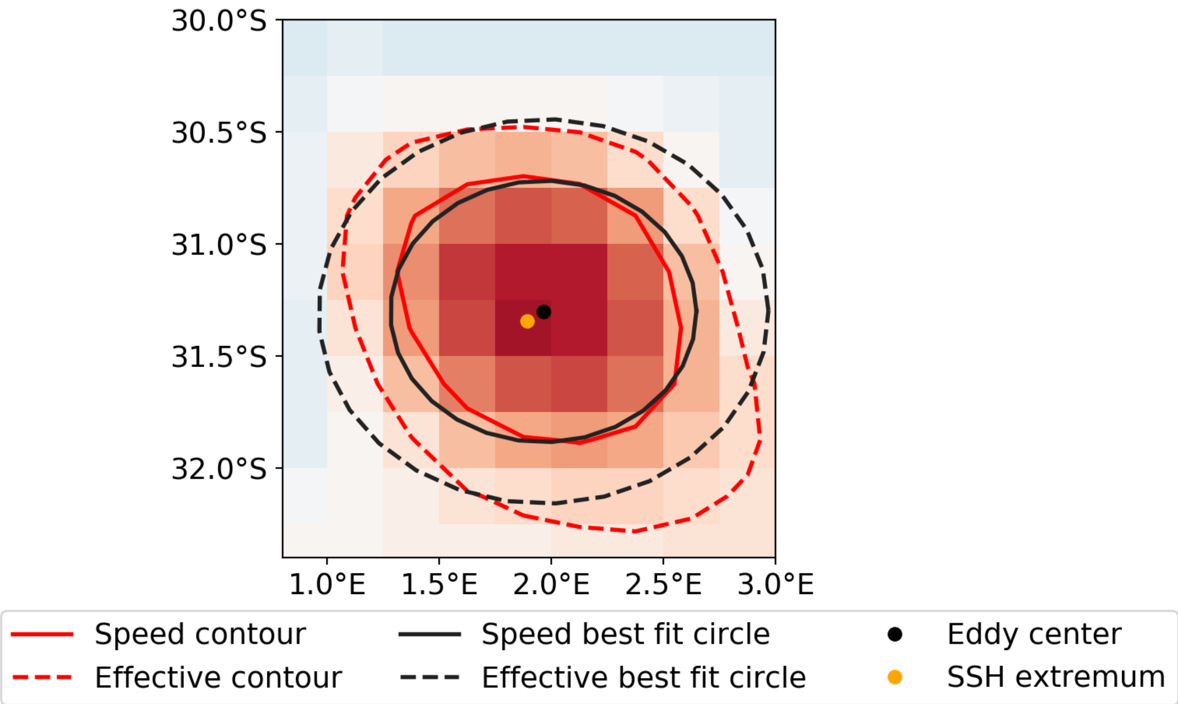

Figure 3 : Contours and associated circles for an Anticyclone. The SSH extremum corresponds to the center of the smallest SSH contour

3/ The contours are then sampled using the Visvalingam & Whyatt algorithm to obtain 20 points preserving the shape of the original contour (Visvalingam and Whyatt, 1992).

3.2.3. Estimation of eddy characteristics

After the detection, we compute an estimate of different eddy characteristics, provided as variables within the dataset:

Characteristic	Value
Center position	Longitude and latitude of the center of the best fit circle with the contour of maximum circum-average geostrophic speed
Amplitude	|SSH(local_extremum) – SSH(outermost_contour)|
Speed radius	Radius of the best fit circle with the contour of maximum circum-average geostrophic speed
Speed average	Average geostrophic speed of the contour defining the speed radius
Speed profile	Profile speed average values from effective contour inwards to smallest inner contour
Effective contour	Largest contour of the detected eddy
Speed contour	Contour of maximum circum-average geostrophic speed for the detected eddy

Table 3: Characteristics of eddies for META3.2 DT allsat and twosat (the full variables are detailed in section 4)

3.2.4. Tracking

After performing detection on several consecutive days, we apply a procedure to build the trajectories over time of the detected eddies.

Tracking procedure :

The tracking scheme is described in details in Pegliasco et al. (2022b) and differs from the Mason et al. (2014) tracking. Between two maps, we search for candidates to associate to the trajectories as eddies whose effective contours are overlapping (Figure 4). Here the eddy candidate is retained if the overlap ratio, defined as the ratio between the overlapping area and the union of the two eddies' area, is more than 5%.

$$Overlap\ Ratio = 100 \times \frac{Area\ (Eddy_t)\ \cap Area\ (Eddy_{t+dt})}{Area\ (Eddy_t)\ \cup Area\ (Eddy_{t+dt})}$$

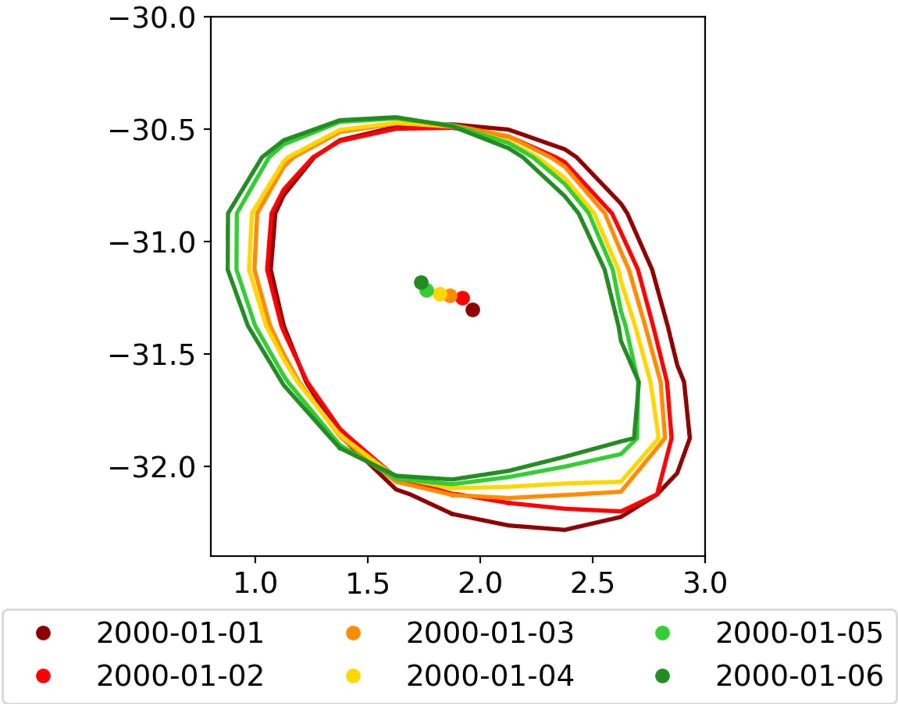

Figure 4 : Successive eddy contours and centers associated in a trajectory.

Loss of the eddy position on one or several maps:

The tracking procedure allows the loss of one to four consecutive observations as illustrated in Figure 5. This can happen sometimes due to identification thresholds criteria and/or map quality. Then, the lost eddy is reconstructed using interpolation. This information is given is the file in the variable 'observation_flag'.

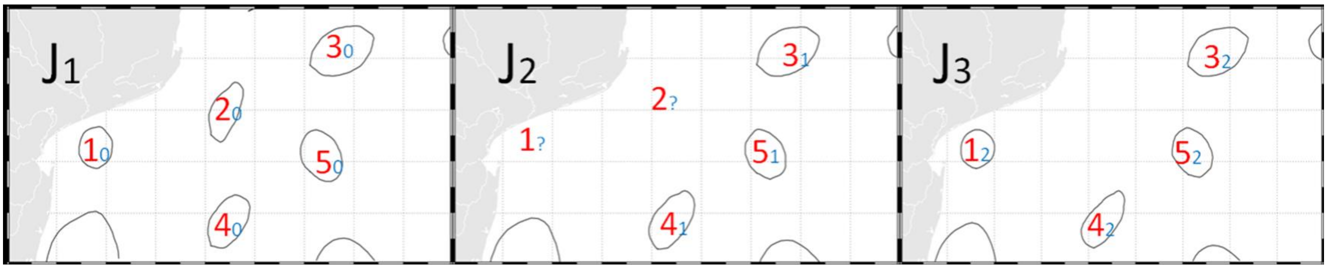

Figure 5: Tracking procedure : the eddy number 1 is kept because an association is found on map J3, contrary to the eddy number 2 where no association is found on the last map.

Lifetime selection

All the detected eddies are delivered, separated whether their type (Cyclonic or Anticyclonic) and their lifespan (longer or strictly shorter than 10 days) (See Section 4.2). The lone eddies, detected but not associated with any other eddy, are also delivered.

3.3. Statistical analysis for DT products

A series of plots is provided for comparison with the plots available in Chelton et al. (2011) for the different METAs distributed by CLS:

META3.2 DT twosat : link of the pdf report

META3.2 DT allsat : link of the pdf report

4. Description of the product

4.1. Product general content and specifications

Covered period	Spatial coverage	Delivery format	Update
01/01/1993 – 02/08/2021, the end date is updated every year	-180 to 540°E* 90°S to 90°N	6 NetCDF files , 3 for Anticyclones, 3 for Cyclones: The trajectories lasting more than 10 days, the trajectories lasting strictly less than 10 days, and the untracked eddies.	Every year

Table 4: Characteristics of the META3.2 DT twosat and allsat.

*The negative longitudes maintain continuity in longitude for the trajectories crossing the Prime Meridian to the West, the longitudes above 360°E are for the trajectories crossing the Prime Meridian to the East.

4.2. Nomenclature of files

As described in Table 4, there are 6 files for each version:

META3.2_DT_twosat_Anticyclonic_long_%Y%m%d_%Y%m%d.nc
META3.2_DT_twosat_Cyclonic_long_%Y%m%d_%Y%m%d.nc
META3.2_DT_twosat_Anticyclonic_short_%Y%m%d_%Y%m%d.nc
META3.2_DT_twosat_Cyclonic_short_%Y%m%d_%Y%m%d.nc
META3.2_DT_twosat_Anticyclonic_untracked_%Y%m%d_%Y%m%d.nc
META3.2_DT_twosat_Cyclonic_untracked_%Y%m%d_%Y%m%d.nc

META3.2_DT_allsat_Anticyclonic_long_%Y%m%d_%Y%m%d.nc
META3.2_DT_allsat_Cyclonic_long_%Y%m%d_%Y%m%d.nc
META3.2_DT_allsat_Anticyclonic_short_%Y%m%d_%Y%m%d.nc
META3.2_DT_allsat_Cyclonic_short_%Y%m%d_%Y%m%d.nc

META3.2_DT_allsat_Anticyclonic_untracked_%Y%m%d_%Y%m%d.nc
META3.2_DT_allsat_Cyclonic_untracked_%Y%m%d_%Y%m%d.nc

4.3. NetCDF

The products are stored using the NetCDF CF format. NetCDF (network Common Data Form) is an interface for array-oriented data access and a library that provides an implementation of the interface. The NetCDF library also defines a machine-independent format for representing scientific data. Together, the interface, library, and format support the creation, access, and sharing of scientific data. The NetCDF software was developed at the Unidata Program Center in Boulder, Colorado. The NetCDF libraries define a machine-independent format for representing scientific data. Please see Unidata NetCDF pages for more information on the NetCDF software package: http://www.unidata.ucar.edu/packages/netcdf/

NetCDF data is:

- Self-Describing. A NetCDF file includes information about the data it contains.
- Architecture-independent. A NetCDF file is represented in a form that can be accessed by computers with different ways of storing integers, characters, and floating-point numbers.
- Direct-access. A small subset of a large dataset may be accessed efficiently, without first reading through all of the preceding data.
- Appendable. Data can be appended to a NetCDF dataset along one dimension without copying the dataset or redefining its structure. The structure of a NetCDF dataset can be changed, though this sometimes causes the dataset to be copied.
- Sharable. One writer and multiple readers may simultaneously access the same NetCDF file.

The NetCDF version provided here is version 4 “classic”.

4.4. Structure and semantic of NetCDF files

Variable name	Description	Standard name	Dimensions	Units or Type
NetCDF-CF **Dimensions:** **Obs : Each detected trajectory is stored end-to-end on one dimension "obs" (an index). The "track" variable numbers the eddy trajectories, and thus allows to separate trajectories.** **Nbsamples : 20** **It is the number of points to store information. If there are more or less than 20 points constituting the uavg_profile, the information is interpolated to be stored in the file. For contours, the original number of points is first multiplied by 10 with a linear spacing, and then resampled with the Visvaligam & Whyatt algorithm.**				
amplitude	Magnitude of the height difference between the extremum of SSH within the eddy and the SSH around the effective contour defining the eddy edge		(Obs)	m
coast_association	Cost value to associate one eddy with the next observation		(Obs)	float
effective_area	Area enclosed by the effective contour in m^2		(Obs)	m^2
effective_contour_ height	SSH filtered height for effective contour		(Obs)	m
effective_contour_ latitude	Latitudes of effective contour		(Obs, Nbsamples)	Degrees_north
effective_contour_ longitude	Longitudes of effective contour		(Obs, Nbsamples)	Degrees_east
effective_contour_ shape_error	Error criterion between the effective contour and its best fit circle		(Obs)	%
effective_radius	Radius of the best fit circle corresponding to the effective contour		(Obs)	m
inner_contour_ height	SSH filtered height for the smallest detected contour		(Obs)	m
latitude	Latitude center of the best fit circle	latitude	(Obs)	Degrees_north

latitude_max	Latitude of the inner contour		(Obs)	Degrees_north
longitude	Longitude center of the best fit circle	longitude	(Obs)	Degrees_east
longitude_max	Longitude of the inner contour		(Obs)	Degrees_east
num_contours	number of contours selected for this eddy		(Obs)	integer
num_point_e	Number of points for effective contour before resampling		(Obs)	integer
num_point_s	Number of points for speed contour before resampling		(Obs)	integer
observation_flag	Flag indicating if the value is interpolated between two observations or not (0: observed eddy, 1: interpolated eddy		(Obs)	boolean
observation_number	Observation sequence number, days starting at the eddy first detection		(Obs)	ordinal
speed_area	Area enclosed by the speed contour in m²		(Obs)	m²
speed_average	Average speed of the contour defining the radius scale “speed_radius”		(Obs)	m/s
speed_contour_height	SSH filtered height for speed contour		(Obs)	m
speed_contour_latitude	Latitudes of speed contour		(Obs, Nbsamples)	Degrees_north
speed_contour_longitude	Longitudes of speed contour		(Obs, Nbsamples)	Degrees_east
speed_contour_shape_error	Error criterion between the speed contour and its best fit circle		(Obs)	%
speed_radius	Radius of the best fit circle corresponding to the contour of maximum circum-average speed		(Obs)	m
time	days since 1950-01-01 00:00:00 UTC	time	(Obs)	Days
track	Trajectory identification number		(Obs)	ordinal
uavg_profile	Speed averaged values from the effective contour inwards to the smallest contour, evenly spaced points		(Obs, Nbsamples)	m/s

5. How to download a product

5.1. Registration

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

- if not registered on AVISO+, please, fill the form and select the product '**Mesoscale Eddy Trajectory Atlas product**' on http://www.aviso.altimetry.fr/en/data/data-access/registration-form.html
- if already registered on AVISO+, please request the addition of this '**Mesoscale Eddy Trajectory Atlas product**' on your personal account on https://www.aviso.altimetry.fr/en/my-aviso-plus.html

5.2. Access Services

Note that once your registration is processed (see above), AVISO+ will validate your registration by e-mail as soon as possible (within 5 working days during working hours, Central European Time). The access information will be available in your personal account on https://www.aviso.altimetry.fr/en/my-aviso-plus.html.

6. Bibliography

Chelton, D.B., Schlax, M.G., Samelson, R.M., 2011. Global observations of nonlinear mesoscale eddies. Prog. Oceanogr. 91, 167–216. https://doi.org/10.1016/j.pocean.2011.01.002

Mason, E., Pascual, A., McWilliams, J.C., 2014. A New Sea Surface Height–Based Code for Oceanic Mesoscale Eddy Tracking. J. Atmospheric Ocean. Technol. 31, 1181–1188. https://doi.org/10.1175/JTECH-D-14-00019.1

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Pegliasco, C., Delepoulle, A., Mason, E., Morrow, R., Faugère, Y., Dibarboure, G., 2022b. META3.1exp: a new global mesoscale eddy trajectory atlas derived from altimetry. Earth Syst. Sci. Data 14, 1087-1107. https://doi.org/10.5194/essd-14-1087-2022

Visvalingam, M., Whyatt, J.D., 1992. Line generalisation by repeated elimination of the smallest area. Cartogr. Inf. Syst. Res. Group University of Hull.

7. Appendix A. Product header

Note that META3.2 DT allsat and META3.2 DT twosat have the same variables, only the global attributes related to the SSH input differ.

```
ncdump -h Anticyclonic.nc
netcdf Anticyclonic {
dimensions:
	obs = 33889945 ;
	NbSample = 20 ;
variables:
	ushort amplitude(obs) ;
		amplitude:comment = "Magnitude of the height difference between the extremum of SSH within the eddy and the SSH around the effective contour defining the eddy edge" ;
		amplitude:long_name = "Amplitude" ;
		amplitude:units = "m" ;
		amplitude:scale_factor = 0.0001 ;
		amplitude:add_offset = 0LL ;
		amplitude:min = 0.004 ;
		amplitude:max = 1.1545 ;
	float cost_association(obs) ;
		cost_association:comment = "Cost value to associate one eddy with the next observation" ;
		cost_association:long_name = "Cost association between two eddies" ;
		cost_association:min = 0.f ;
		cost_association:max = 0.9499999f ;
	float effective_area(obs) ;
		effective_area:comment = "Area enclosed by the effective contour in m^2" ;
		effective_area:long_name = "Effective area" ;
		effective_area:units = "m^2" ;
		effective_area:min = 1.008727e+08f ;
		effective_area:max = 5.274425e+11f ;
	float effective_contour_height(obs) ;
		effective_contour_height:comment = "SSH filtered height for effective contour" ;
		effective_contour_height:long_name = "Effective Contour Height" ;
		effective_contour_height:units = "m" ;
		effective_contour_height:min = -0.484f ;
		effective_contour_height:max = 1.018f ;
	short effective_contour_latitude(obs, NbSample) ;
		effective_contour_latitude:axis = "X" ;
		effective_contour_latitude:comment = "Latitudes of effective contour" ;
		effective_contour_latitude:long_name = "Effective Contour Latitudes" ;
		effective_contour_latitude:units = "degrees_east" ;
```

```
            effective_contour_latitude:scale_factor = 0.01 ;
            effective_contour_latitude:add_offset = 0LL ;
      short effective_contour_longitude(obs, NbSample) ;
            effective_contour_longitude:axis = "X" ;
            effective_contour_longitude:comment = "Longitudes of the effective contour" ;
            effective_contour_longitude:long_name = "Effective Contour Longitudes" ;
            effective_contour_longitude:units = "degrees_east" ;
            effective_contour_longitude:scale_factor = 0.01 ;
            effective_contour_longitude:add_offset = 180. ;
      ubyte effective_contour_shape_error(obs) ;
            effective_contour_shape_error:comment = "Error criterion between the effective
contour and its best fit circle" ;
            effective_contour_shape_error:long_name = "Effective Contour Shape Error" ;
            effective_contour_shape_error:units = "%" ;
            effective_contour_shape_error:scale_factor = 0.5 ;
            effective_contour_shape_error:add_offset = 0LL ;
            effective_contour_shape_error:min = 3. ;
            effective_contour_shape_error:max = 83.5 ;
      ushort effective_radius(obs) ;
            effective_radius:comment = "Radius of the best fit circle corresponding to the
effective contour" ;
            effective_radius:long_name = "Effective Radius" ;
            effective_radius:units = "m" ;
            effective_radius:scale_factor = 50. ;
            effective_radius:add_offset = 0LL ;
            effective_radius:min = 8450. ;
            effective_radius:max = 485750. ;
      float inner_contour_height(obs) ;
            inner_contour_height:comment = "SSH filtered height for the smallest detected
contour" ;
            inner_contour_height:long_name = "Inner Contour Height" ;
            inner_contour_height:units = "m" ;
            inner_contour_height:min = -0.354f ;
            inner_contour_height:max = 1.138f ;
      float latitude(obs) ;
            latitude:axis = "Y" ;
            latitude:comment = "Latitude center of the best fit circle" ;
            latitude:long_name = "Eddy Center Latitude" ;
            latitude:standard_name = "latitude" ;
            latitude:units = "degrees_north" ;
            latitude:min = -77.79635f ;
            latitude:max = 84.65783f ;
      float latitude_max(obs) ;
            latitude_max:axis = "Y" ;
```

```
            latitude_max:comment = "Latitude of the inner contour" ;
            latitude_max:long_name = "Latitude of the SSH maximum" ;
            latitude_max:standard_name = "latitude" ;
            latitude_max:units = "degrees_north" ;
            latitude_max:min = -90.f ;
            latitude_max:max = 84.63362f ;
      float longitude(obs) ;
            longitude:axis = "X" ;
            longitude:comment = "Longitude center of the best fit circle" ;
            longitude:long_name = "Eddy Center Longitude" ;
            longitude:standard_name = "longitude" ;
            longitude:units = "degrees_east" ;
            longitude:min = -47.46416f ;
            longitude:max = 368.233f ;
      float longitude_max(obs) ;
            longitude_max:axis = "X" ;
            longitude_max:comment = "Longitude of the inner contour" ;
            longitude_max:long_name = "Longitude of the SSH maximum" ;
            longitude_max:standard_name = "longitude" ;
            longitude_max:units = "degrees_east" ;
            longitude_max:min = -47.38823f ;
            longitude_max:max = 368.3737f ;
      ushort num_contours(obs) ;
            num_contours:comment = "Number of contours selected for this eddy" ;
            num_contours:long_name = "Number of contours" ;
            num_contours:min = 1US ;
            num_contours:max = 578US ;
      ushort num_point_e(obs) ;
            num_point_e:description = "Number of points for effective contour before
resampling" ;
            num_point_e:long_name = "number of points for effective contour" ;
            num_point_e:units = "ordinal" ;
            num_point_e:min = 10US ;
            num_point_e:max = 287US ;
      ushort num_point_s(obs) ;
            num_point_s:description = "Number of points for speed contour before
resampling" ;
            num_point_s:long_name = "number of points for speed contour" ;
            num_point_s:units = "ordinal" ;
            num_point_s:min = 10US ;
            num_point_s:max = 219US ;
      byte observation_flag(obs) ;
            observation_flag:comment = "Flag indicating if the value is interpolated between
two observations or not (0: observed eddy, 1: interpolated eddy)" ;
```

```
            observation_flag:long_name = "Virtual Eddy Position" ;
            observation_flag:min = 0b ;
            observation_flag:max = 1b ;
      ushort observation_number(obs) ;
            observation_number:comment = "Observation sequence number, days starting at
the eddy first detection" ;
            observation_number:long_name = "Eddy temporal index in a trajectory" ;
            observation_number:min = 0US ;
            observation_number:max = 2446US ;
      float speed_area(obs) ;
            speed_area:comment = "Area enclosed by the speed contour in m^2" ;
            speed_area:long_name = "Speed area" ;
            speed_area:units = "m^2" ;
            speed_area:min = 3.877861e+07f ;
            speed_area:max = 3.962951e+11f ;
      ushort speed_average(obs) ;
            string speed_average:comment = "Average speed of the contour defining the
radius scale “speed_radius”" ;
            speed_average:long_name = "Maximum circum-averaged Speed" ;
            speed_average:units = "m/s" ;
            speed_average:scale_factor = 0.0001 ;
            speed_average:add_offset = 0LL ;
            speed_average:min = 0. ;
            speed_average:max = 6.4435 ;
      float speed_contour_height(obs) ;
            speed_contour_height:comment = "SSH filtered height for speed contour" ;
            speed_contour_height:long_name = "Speed Contour Height" ;
            speed_contour_height:units = "m" ;
            speed_contour_height:min = -0.438f ;
            speed_contour_height:max = 1.018f ;
      short speed_contour_latitude(obs, NbSample) ;
            speed_contour_latitude:axis = "X" ;
            speed_contour_latitude:comment = "Latitudes of speed contour" ;
            speed_contour_latitude:long_name = "Speed Contour Latitudes" ;
            speed_contour_latitude:units = "degrees_east" ;
            speed_contour_latitude:scale_factor = 0.01 ;
            speed_contour_latitude:add_offset = 0LL ;
      short speed_contour_longitude(obs, NbSample) ;
            speed_contour_longitude:axis = "X" ;
            speed_contour_longitude:comment = "Longitudes of speed contour" ;
            speed_contour_longitude:long_name = "Speed Contour Longitudes" ;
            speed_contour_longitude:units = "degrees_east" ;
            speed_contour_longitude:scale_factor = 0.01 ;
            speed_contour_longitude:add_offset = 180. ;
```

```
	ubyte speed_contour_shape_error(obs) ;
		speed_contour_shape_error:comment = "Error criterion between the speed contour and its best fit circle" ;
		speed_contour_shape_error:long_name = "Speed Contour Shape Error" ;
		speed_contour_shape_error:units = "%" ;
		speed_contour_shape_error:scale_factor = 0.5 ;
		speed_contour_shape_error:add_offset = 0LL ;
		speed_contour_shape_error:min = 2. ;
		speed_contour_shape_error:max = 95.5 ;
	ushort speed_radius(obs) ;
		speed_radius:comment = "Radius of the best fit circle corresponding to the contour of maximum circum-average speed" ;
		speed_radius:long_name = "Speed Radius" ;
		speed_radius:units = "m" ;
		speed_radius:scale_factor = 50. ;
		speed_radius:add_offset = 0LL ;
		speed_radius:min = 5900. ;
		speed_radius:max = 456100. ;
	uint time(obs) ;
		time:axis = "T" ;
		time:calendar = "proleptic_gregorian" ;
		time:comment = "Date of this observation" ;
		time:long_name = "Time" ;
		time:standard_name = "time" ;
		time:units = "days since 1950-01-01 00:00:00" ;
		time:scale_factor = 1.15740740740741e-05 ;
		time:add_offset = 0LL ;
		time:min = 15706. ;
		time:max = 26146. ;
	uint track(obs) ;
		track:comment = "Trajectory identification number" ;
		track:long_name = "Trajectory number" ;
		track:min = 0U ;
		track:max = 791262U ;
	ushort uavg_profile(obs, NbSample) ;
		uavg_profile:comment = "Speed averaged values from the effective contour inwards to the smallest contour, evenly spaced points" ;
		uavg_profile:long_name = "Radial Speed Profile" ;
		uavg_profile:units = "m/s" ;
		uavg_profile:scale_factor = 0.0001 ;
		uavg_profile:add_offset = 0LL ;

// global attributes:
		:track_extra_variables = "lat_max,lon_max" ;
```

```
        :track_array_variables = 20LL ;
        :array_variables =
"contour_lat_e,contour_lon_e,contour_lat_s,contour_lon_s,uavg_profile" ;
        :title = "Anticyclonic" ;
        :Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
        :comment = "Surface product; mesoscale eddies" ;
        :framework_used = "https://github.com/AntSimi/py-eddy-tracker" ;
        :framework_version = "v3.6.0" ;
        :standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata
Convention Standard Name Table" ;
        :date_created = "2022-03-22T17:41:33Z" ;
        :time_coverage_duration = "P10441D" ;
        :time_coverage_start = "1993-01-01T00:00:00Z" ;
        :time_coverage_end = "2021-08-02T00:00:00Z" ;
}
```

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