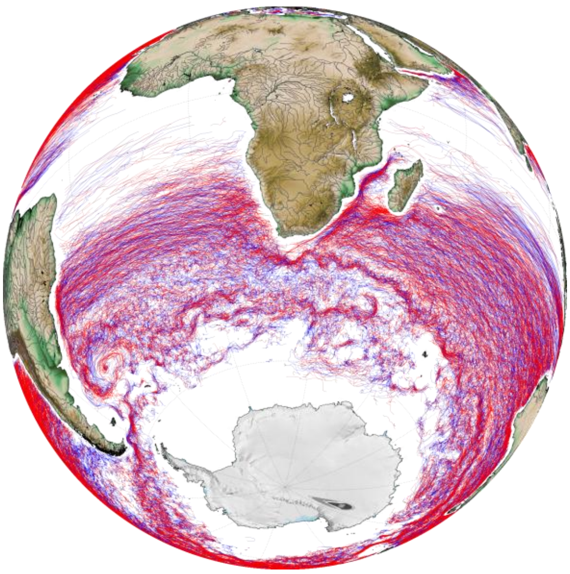
Mesoscale Eddy Trajectory Atlas Product Handbook

META4.0 Delayed Time: Networks

META4.0 DT allsat : 10.24400/527896/a01-2026.001



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Chronology Issues:		
Issue:	Date:	Reason for change:
1.0	01/02/2026	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)

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1. Overview of this document

This document is the user manual for the **Mesoscale Eddy Trajectory Atlas DT** (META4.0 Networks) products, processed by CNES/CLS in the DUACS system.

This version is generated by the py-eddy-tracker algorithm, version 3.6.1 (Antoine Delepoulle, et al., 2022). The META4.0 Networks dataset is distributed by AVISO+.

This document describes the delayed-time version 4.0 (4.0-Networks) product, released in February 2026. This version provides a new organization of the dataset, using networks.

The document is organized as follows:

- Chapter 2; presentation
- Chapter 3; processing: input data and method applied
- Chapter 4; 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 their cores if they rotate faster than they move--also as opposed to planetary waves that would not transport water parcels. Describing the interactions between eddies (i.e., merging and splitting events) is necessary to better understand how mesoscale eddies transport water.

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, 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.

META4.0 – Networks is an experimental dataset and will not be update temporally.

2.3. Acknowledgments

When using the **Mesoscale Eddy Trajectory Atlas** 4.0 - Networks product, please cite in the text the following example, with the DOI, CITATION, DATE OF DOWNLOAD and MONTH & YEAR:

"The altimetric Mesoscale Eddy Trajectory Atlas product (META4.0 DT allsat, **DOI**: 10.24400/527896/a01-2026.001; (Gamot, Delepoulle, Nencioli, Pujol, & Dibarboure, Mesoscale Eddy Trajectory Altlas META4.0-Networks all satellites: version META4.0 DT allsat)) was produced by SSALTO/DUACS and distributed by AVISO+ (https://www.aviso.altimetry.fr/) with support from CNES. This atlas was downloaded the **DATE OF DOWNLOAD**, and covers the period from January 1993 to **MONTH & YEAR**."

2.4. User's feedback

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 1.

Eddy product	Input data	Variable	Origin
Version 4.0 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 1: Input product used

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.

3.2. Algorithm

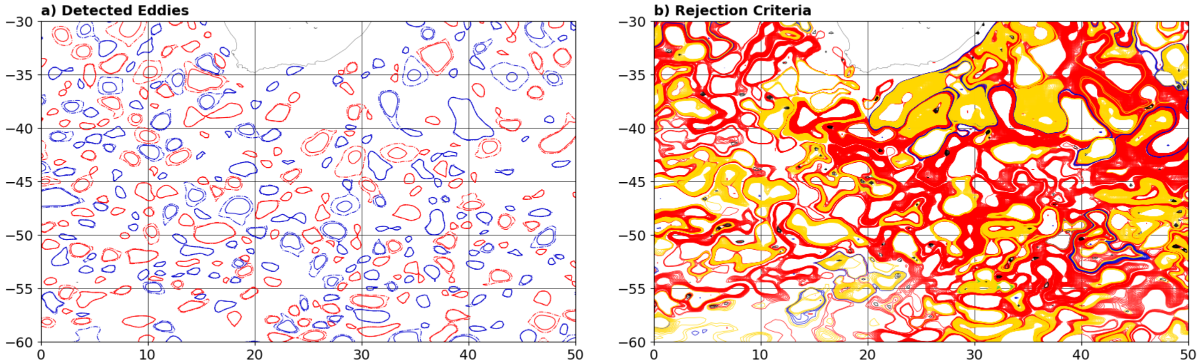
The algorithm used for these products is derived from Mason et al. (2014) and further described in (Pegliasco, et al., 2022) and (Gamot, Delepoulle, Nencioli, Pujol, & Dibarboure, 2026).

The main processing steps are described in this section.

3.2.1. 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 ≤ 0.4 cm, 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 (



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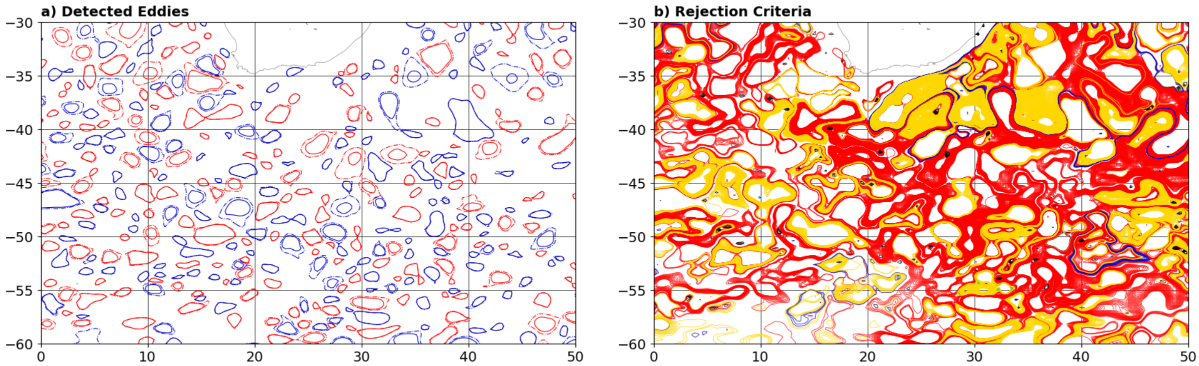

Figure 1: Eddy detection. a) Selected contours for Anticyclones (red) and Cyclones (blue). b) rejected contours colored with their rejection criteria (red : shape error, yellow : amplitude related criteria, blue : masked value in the contour, black : outside the pixel number limits).

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

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 2). 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.

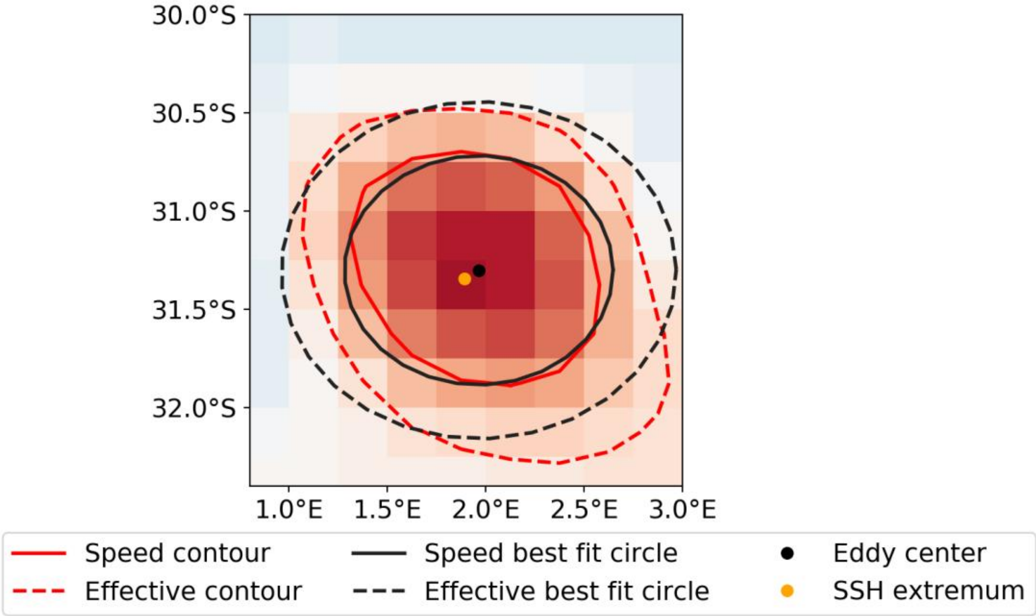

Figure 2 : Contours and associated circles for an Anticyclone. The SSH extremum corresponds to the center of the smallest SSH contour

3/ The contours are then sampled using the Visvalingam & Whyatt algorithm to obtain 20 points preserving the shape of the original contour (Visvalingam & Whyatt, 2017).

3.2.2. 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 2: Characteristics of eddies for META4.0 DT all sat (the full variables are detailed in section 4).

3.2.3. Networking

After performing the eddy detection on several consecutive days, we apply a procedure to build the networks. Note that networks represent mesoscale eddies and their interactions. The vocabulary employed is thus different from the "single-trajectory point of view" that was used during years to describe mesoscale eddies. The tracking scheme is described in details in (Gamot, Delepoulle, Nencioli, Pujol, & Dibarboure, 2026) and differs strongly from the (Mason, Pascual, & McWilliams, 2014) tracking.

Successive eddies are aggregated in networks, where segments represent the temporal evolution of individual eddies and nodes between segments correspond to merging or splitting events.

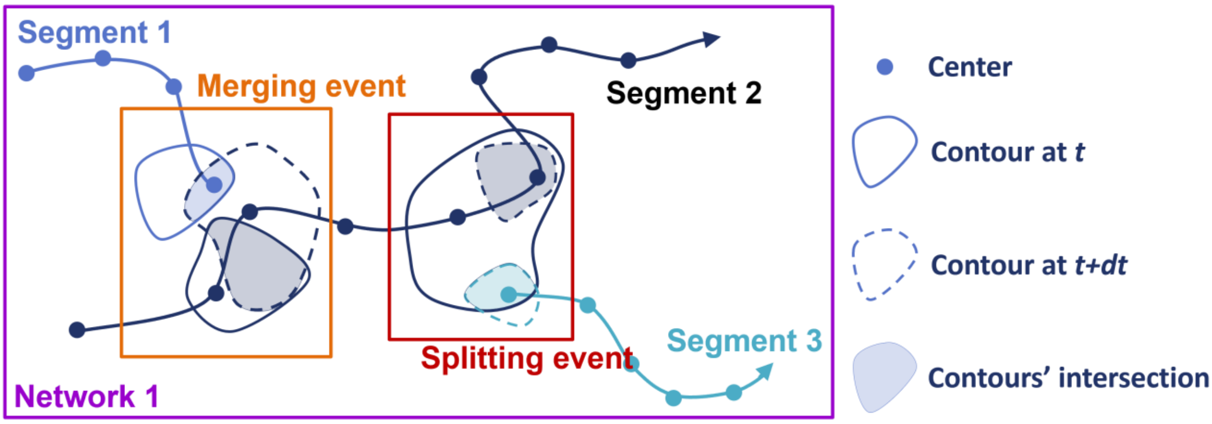

Figure 3 : Representation of a network. Segments are composed of consecutive eddy observations represented by their centers. A merging event corresponds to two eddy observations a time *t* that merge in one eddy observation at time *t+dt*, with an overlap of their contours. A splitting event corresponds to on eddy observation at time *t* split in two eddy observations at time *t+dt*, with an overlap of their contours. The considerations on what segment stops, start or continues during an event are detailed below.

<u>Grouping of eddies in networks:</u>

Between two maps, we search for eddy candidates to aggregate into networks. Eddies of the same polarity (Anticyclones or Cyclones) belong to the same network as their effective contours overlap. The search is made from time t to time $t + Ndt$, with N = 7 and dt = 1 day. At each time step t, the individual eddies effective contours are considered. The search is made for the N following days. When an eddy candidate contour overlaps with the current eddy contour, it is aggregate with the network of the current eddy if the overlap ratio, defined as the ratio between the overlapping area and the union of the two eddies' area, is over 10 % (Eq.1).

$$Overlap\ Ratio_{union}(\%) = 100 \times \frac{Area\ (Eddy_t)\ \cap Area\ (Eddy_{t+dt})}{Area\ (Eddy_t)\ \cup Area\ (Eddy_{t+dt})} \qquad \text{Eq. (1)}$$

Nevertheless, when a small eddy is embedded in a large one, which can occur during splitting and merging events where eddies experience large variations of their sizes and surface characteristics, the overlap ration based on union might be below 10 %. A second overlap ratio is computed as the ratio between the overlapping area and the union of the minimal area of the two eddies (Eq. 2). The threshold is set to 99 % to prevent the aggregation of small overlaps at the contours' periphery. This is the only case where the overlap ratio is not based on the union of the eddies' areas.

$$Overlap\ Ratio_{minimal\ area}\ (\%) = 100 \times \frac{Area\ (Eddy_t)\ \cap Area\ (Eddy_{t+dt})}{\min\ (Area\ (Eddy_t), Area\ (Eddy_{t+dt}))} \qquad \text{Eq. (2)}$$

When the N days have been scanned, the search is made for the next time step (Figure 4b,c). When a contour has an overlap with several current contours, the corresponding eddies previously associated in independent networks are aggregated in a unique network (Figure 4d). This allows the aggregation of eddies experiencing merging and splitting events. Each eddy observations is associated with potential previous and next observations.

Each network has a unique number for identification, associated with its aggregated eddies. When several networks are aggregated in one, the network with the best last overlap ratio gives its identification number to all the eddies aggregated in the new unique network. Individual observations without overlap have 0 for network number to be easily separated from the tracked eddies.

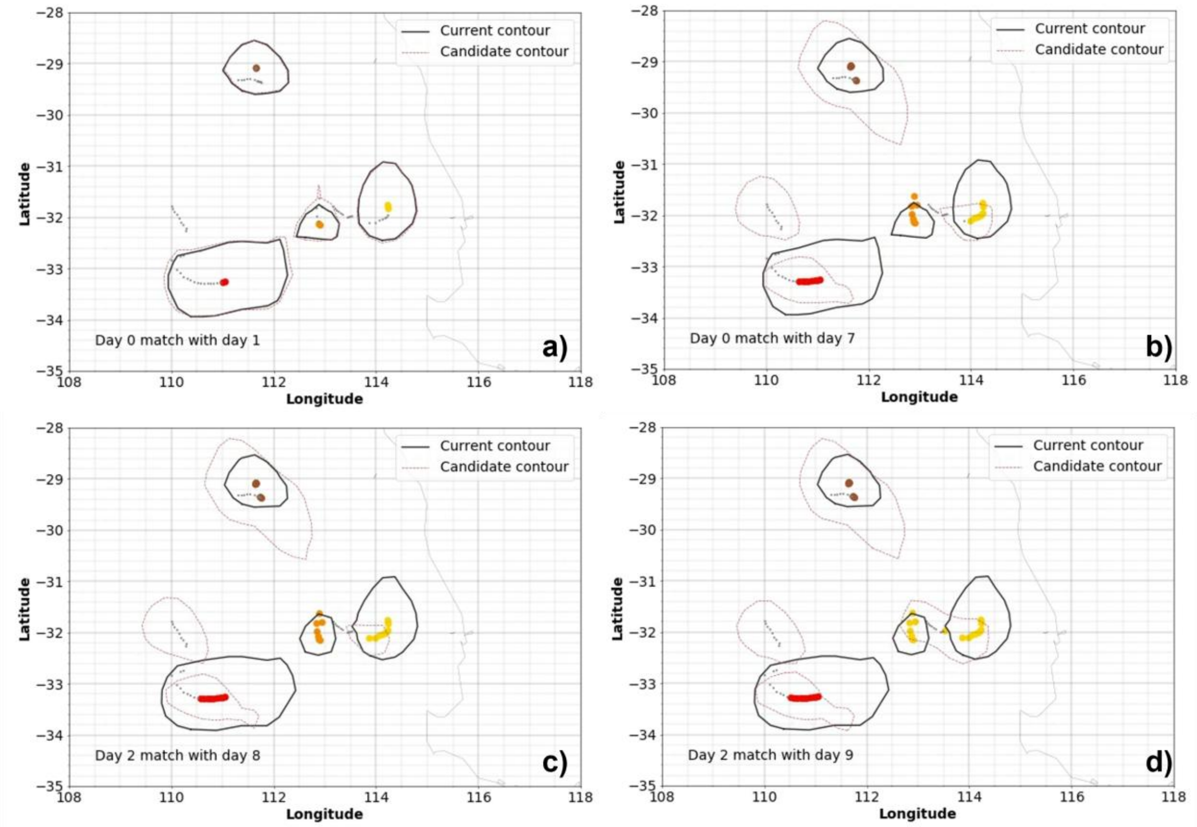

Figure 4 : Eddies aggregation in networks. Eddy centers are represented in dots, each color correspond to an independent network. Grey dots are for not already associated eddies. a) 4 eddies at day 0 are detected, the search for overlapping contours at day 1 find 4 matching eddies associated with each network. b) The search is made at day 0 from day 1 to day 7 and each matching eddy is associated to the corresponding network. c) On day 2, the search at day 8 still aggregate 4 independent networks. d) The search from day 2 to day 9 finds a unique overlap joining the yellow and orange networks. They are aggregated in a unique network colored in yellow as the day 2 yellow eddy has a better overlap with the day 9 eddy than the day 2 orange eddy.

As the search is made for 7 days, the aggregation procedure allows the loss of 1 to 6 consecutive observations. This can happen sometimes due to identification thresholds criteria and/or map quality, especially during merging and splitting events. No virtual observations are reconstructed to fill the gaps, contrary to the previous META datasets (Pegliasco, et al., 2022).

Segmentation of the networks:

After the aggregation step, each network is inspected and divided into segments if necessary. Starting for the oldest eddy observation in the network, the algorithm associates the eddy candidate at the following time within the network to the first segment, and so on until no more candidates exist. If other eddy observations exist within the network, not already associated with a segment, the algorithm select the oldest eddy observation and repeat the previous step, until all the eddy observations within the network have a segment number.

When the eddy observations of a specific network are consecutive in time with only one candidate at the following time, the network is constituted of one unique segment (Figure 5).

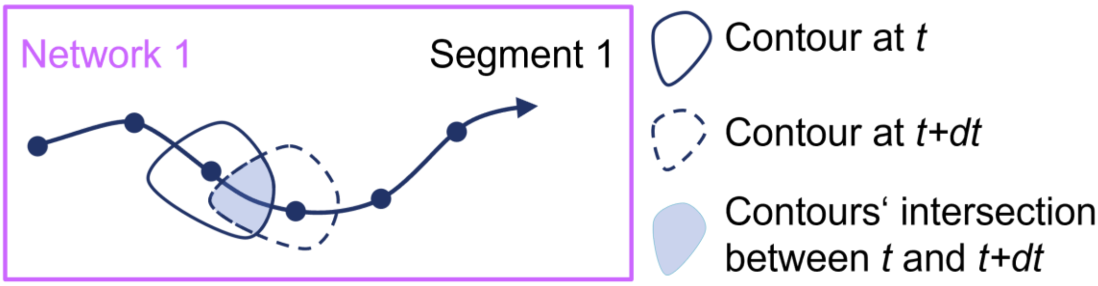

Figure 5 : A network constituted of one segment composed of consecutive eddy observations. Eddy observations centers are represented by points.

When more than one candidate are present at the following time, the current segment is experiencing a splitting event: one eddy splits in several structures (Figure 6a). The candidate with the highest overlap ratio is chosen to continue the current segment. The other candidate(s) are referenced as split from the current segment (S2).

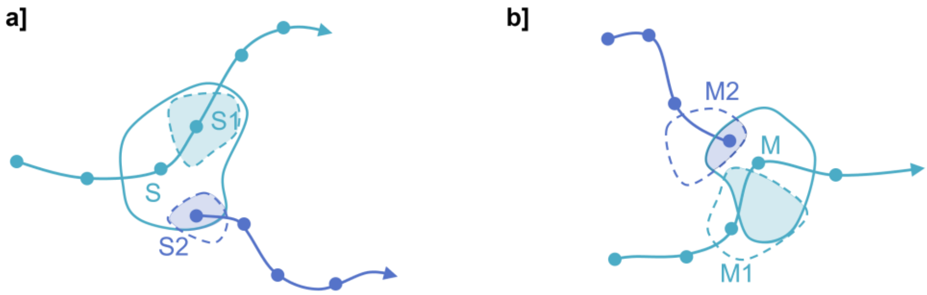

Figure 6 : Scheme of a] a splitting event, and b] a merging event. The last observation before the splitting is referenced as S, S1 is the observation after splitting with the highest overlap ratio with S, and S2 is the first observation of the segment generated by the splitting. The first observation after the merging is referenced as M, M1 is the last observation before the merging with the highest overlap ratio with M, and M2 is the last observation of the segment ended by the merging.

When the next eddy observation (M) of the current eddy is already referenced with another eddy observation, it means the segments are experiencing a merging event (Figure 6b). The eddy observation with the lowest overlap ratio with M is considered as ending its segment (M2).

The aggregation step can associate eddies composing different segments but not at the beginning or the end of the segments. The association is inspected during the segmentation step and not identified as a merging or a splitting event. The two segments can be dissociated later in two independent networks.

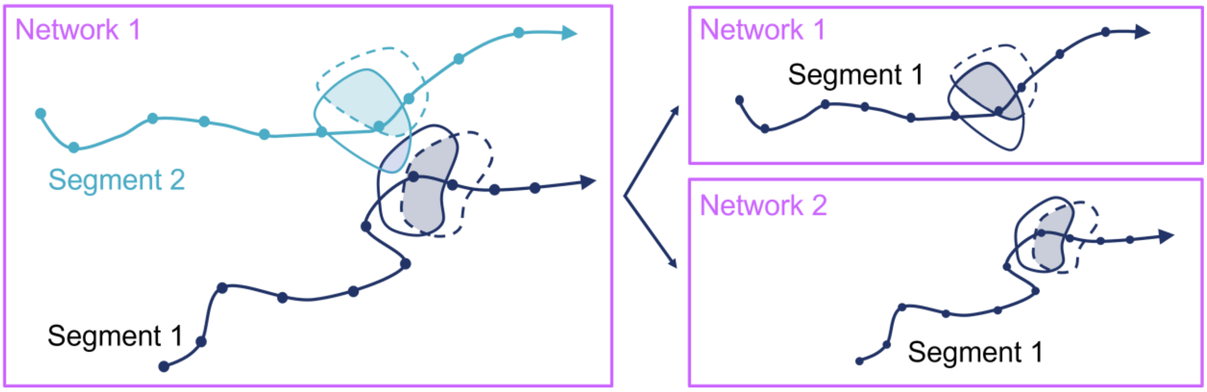

Figure 7 : Example of eddy association not related to a merging or splitting event dissociated in two independent networks.

Sensibility of the parameters :

Different values have been tested for the aggregation and segmentation parameters, namely the overlap ratio and the maximum days for association N.

Visual inspection of the networks generated with different N and overlap ratios showed that for eddy association, the union-based overlap ratio led to the discard eddies due to too large variation of the eddies' size, even if one eddy is totally include in the other. To manage this situation, we use the minimal area overlap ratio in addition to the union overlap ratio when the latest is small (Figure 8a). Using only the minimal area overlap ratio was not suitable because during a merging or a splitting event, two small eddies might be embedded within a larger eddy. This results in two minimal area overlap ratios at 100 % that prevent the choice between the segments to start, stop, or continue. The threshold for the union overlap ratio has been increased from 5 % (as in the previous META3.2 datasets) to 10 % to prevent the association of eddies with small overlap that result in more geometrical than physical eddy interactions (Figure 8b).

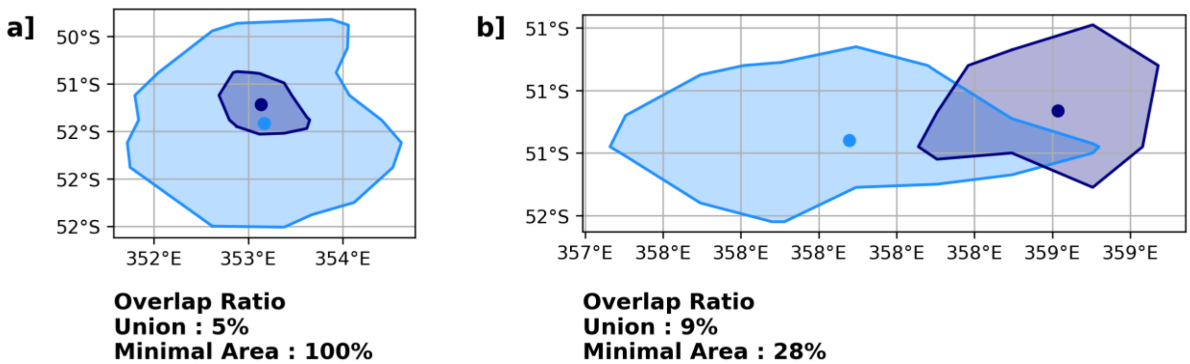

Figure 8 : Example of a] a small eddy embedded within another eddy but failing the union overlap ratio threshold and b] a "geometrical" interaction close to the union overlap ratio threshold. The Minimal Area overlap ratio in a] allows the eddy association but prevents it in b]. Points represent the eddies' centers. Light blue shading and points represent the eddies' contours and centers at *t*, dark blue shading and points represent the eddies' contours and centers at *t+dt*.

The maximum days for association N between two consecutive eddy observations was set to 7 days after a visual inspection of different cases. During merging and splitting process, eddies tend to not be detected due to the detection criteria (amplitude threshold of 0.4 cm, only one extremum within the contour, shape error test over 70 %, at least 5 pixels crossed by the contours) as they decrease in size and might be elongated.

Note on the vocabulary employed:

The management of interactions between eddies in not only an algorithmic evolution, the vocabulary changes also. Eddies starting a segment can have a previous observation (from a splitting event) or no previous observation. The eddy generation come from different physical processes et should be considered separately. The termination of a segment can be from merging with another eddy or from dissipation in the environment, which are also two separated processes. This differentiation was not made in the case of eddy trajectories described by a start ("birth", "generation"), an end ("dissipation", death") and a spanning ("lifetime"). Eddies and eddy trajectories referenced also often the same physical object, whereas "eddy trajectory" includes the temporal evolution but "eddies" can be a specific observation at a specific time. With the organisation in networks and segments experiencing merging and splitting events, generation or dissipation can be multiple and lead by different physical processes. The lifetime of a segment or a network can still be the temporal difference between the last and the first eddy observations constituting them, but as the linear temporal evolution is removed using "eddy" as a generic term should be avoided.

Eddy observation: one eddy detected at a time t.

Candidate: eddy observation having an overlap with the considered eddy observation.

Segment: consecutive eddy observations during a certain amount of time (lifetime of the segment). Segments can start from the splitting of an eddy observation or by generation from the oceanic environment. Segments can end by merging or by dissipation into the oceanic environment.

Network: ensemble of segments linked by merging and splitting events. Networks can be composed of a unique segment. The lifetime of the network is defined as the number of days from the first to the last eddy observation within the network, even if they are not associated with the same segment.

Merging event: a segment merges with another one. Two eddy observations have a unique eddy observation M for candidate. The eddy observation with the highest overlap ratio with M is the primary (M1), the other is secondary (M2). M1 and M form part of the same segment and M2 is the last eddy observation of the merged segment. Note that this description does not include the temporal dimension of the event, which is progressive and not instantaneous.

Splitting event: a segment splits from another one. Two eddy observations are candidates from a unique eddy observation S. The eddy observation with the highest overlap ratio with S is the primary (S1), the other is secondary (S2). S and S1 form part of the same segment and S2 is the first eddy observation of the split segment. Note that this description does not include the temporal dimension of the event, which is progressive and not instantaneous.

4. Description of the product

4.1. Product general content and specifications

Covered period	Spatial coverage	Delivery format	Update
01/01/1993 - 08/09/2023, the end date is updated every year	0° to 360° 90°S to 90°N	2 NetCDF files , 1 for Anticyclones, 1 for Cyclones	Every year

Table 3: Characteristics of the META4.0 DT allsat.

4.2. Nomenclature of files

As described previously, there are 2 files:

META4.0_DT_allsat_Anticyclonic_19930101_20230908.nc
META4.0_DT_allsat_Cyclonic_19930101_20230908.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. TheNetCDF 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 : 30 It is the number of points to store information. If there are more or less than 30 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
next_cost	Next cost for next observation		(Obs)	ordinal
next_obs	Index of next observation in a merging case		(Obs)	integer
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
previous_cost	Previous cost for previous observation		(Obs)	ordinal
previous_obs	Index of previous observation in a splitting case		(Obs)	integer
segment	Segment number inside a network		(Obs)	ordinal
speed_area	Area enclosed by the speed contour in m^2		(Obs)	m^2
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	Network 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 is:

HTTPS (without credentials)

- https://data.aviso.altimetry.fr/aviso-gateway/data/META4.0_DT/

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

- ftp://ftp-access.aviso.altimetry.fr:21
- sftp://ftp-access.aviso.altimetry.fr:2221
  - /value-added/eddy-trajectory/delayed-time/META4.0_DT_allsat

CNES AVISO THREDDS Data Server access (with AVISO+ credentials):

- https://tds-odatis.aviso.altimetry.fr/thredds/catalog/dataset-duacs-rep-value-added-eddy-trajectory/META4.0_DT_allsat/catalog.html

6. Bibliography

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7. Appendix A. Product header

```
ncdump -h META4_DT_allsat_cyclonic.nc
netcdf META4_DT_allsat_cyclonic {
dimensions:
	obs = 31338295 ;
	NbSample = 30 ;
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 = 1.4944 ;
	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 = 7.742959e+07f ;
		effective_area:max = 1.018091e+12f ;
	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 = -1.594f ;
		effective_contour_height:max = 1.926f ;
	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 = 1.5 ;
		effective_contour_shape_error:max = 77.5 ;
	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 = 5800. ;
		effective_radius:max = 641300. ;
	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 = -1.658f ;
		inner_contour_height:max = 1.914f ;
	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 = -77.90765f ;
        latitude:max = 83.56052f ;
    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 = -77.87957f ;
        latitude_max:max = 83.62168f ;
    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 = 1.493061e-06f ;
        longitude:max = 360.f ;
    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 = 1.373293e-05f ;
        longitude_max:max = 360.f ;
    float next_cost(obs) ;
        next_cost:comment = "" ;
        next_cost:long_name = "Next cost for next observation" ;
        next_cost:min = 0.f ;
        next_cost:max = 1.f ;
    int next_obs(obs) ;
```

```
		next_obs:comment = "Index of next observation in a merging case" ;
		next_obs:long_name = "Next observation index" ;
		next_obs:min = -1 ;
		next_obs:max = 31338294 ;
	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 = 748US ;
	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 = 9US ;
		num_point_e:max = 217US ;
	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 = 9US ;
		num_point_s:max = 171US ;
	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 = 0b ;
	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 = 0US ;
	float previous_cost(obs) ;
		previous_cost:comment = "" ;
		previous_cost:long_name = "Previous cost for previous observation" ;
```

```
            previous_cost:min = 0.f ;
            previous_cost:max = 1.f ;
      int previous_obs(obs) ;
            previous_obs:comment = "Index of previous observation in a splitting
case" ;
            previous_obs:long_name = "Previous observation index" ;
            previous_obs:min = -1 ;
            previous_obs:max = 31338293 ;
      uint segment(obs) ;
            segment:comment = "Segment number inside a group" ;
            segment:long_name = "Segment Number" ;
            segment:min = 0U ;
            segment:max = 137U ;
      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 = 7.742959e+07f ;
            speed_area:max = 6.346711e+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 = 5.5672 ;
      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 = -1.608f ;
            speed_contour_height:max = 1.926f ;
      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 = 1.5 ;
        speed_contour_shape_error:max = 90.5 ;
    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 = 5800. ;
        speed_radius:max = 544000. ;
    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 = 26913. ;
    uint track(obs) ;
        track:comment = "Trajectory identification number" ;
        track:long_name = "Trajectory number" ;
        track:min = 0U ;
        track:max = 1004982U ;
    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:
        :title = "META 4.0 Cyclonic Dataset" ;
        :institution = "CLS, CNES" ;
        :project = "DUACS" ;
        :doi = "10.24400/527896/a01-2026.001" ;
        :references =
"https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/hdbk_META4.pd
f" ;
        :contact = "aviso@altimetry.fr" ;
        :Conventions = "CF-1.8, ACDD-1.3" ;
        :cdm_data_type = "Trajectory" ;
        :featureType = "Network" ;
        :geospatial_lat_min = -77.9076461791992 ;
        :geospatial_lat_max = 83.5605163574219 ;
        :geospatial_lon_min = 1.49306094954227e-06 ;
        :geospatial_lon_max = 360. ;
        :keywords = "ocean eddies, mesoscale, altimetry, DUACS, trajectories,
networks" ;
        :track_extra_variables =
"lat_max,lon_max,next_cost,next_obs,virtual,n,previous_cost,previous_obs,segme
nt,track" ;
        :track_array_variables = 30LL ;
```

```
        :array_variables =
"contour_lat_e,contour_lon_e,contour_lat_s,contour_lon_s,uavg_profile" ;
        :Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
        :comment = "Surface product; mesoscale eddies" ;
        :framework_used = "https://github.com/AntSimi/py-eddy-tracker" ;
        :framework_version = "0+untagged.750.gbfd8915.dirty" ;
        :standard_name_vocabulary = "NetCDF Climate and Forecast (CF)
Metadata Convention Standard Name Table" ;
        :rotation_type = -1LL ;
        :history = "Created on 2026-02-10" ;
}
```

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