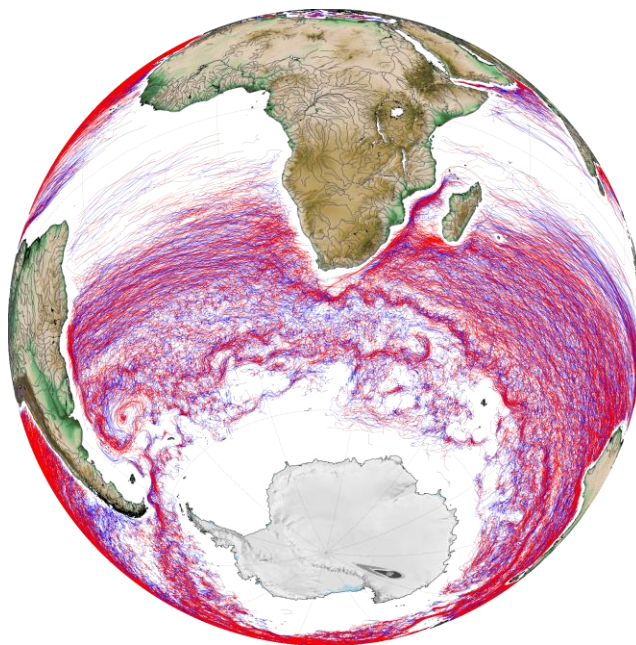




## Mesoscale Eddy Trajectory Atlas Product Handbook



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Reference: SALP-MU-P-EA-23126-CLS

Issue: 3 rev 3

Date: February 2021

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**Chronology Issues:**

Issue:	Date:	Reason for change:
1.0	2017/06/29	1 <sup>st</sup> issue
2.0	2018/09/20	New version META2018_exp (2.0exp)
3.0	2019/09/20	Addition of NRT experimental products (3.0exp)
3.1	2020/06/11	Minor corrections
3.2	2020/08/17	META2.0exp DT update : extension of the period with changes in the format
3.3	2021/02/23	META2.0exp DT update : extension of the period and renaming into META2.0 DT

## List of Acronyms:

<b>ADT</b>	Absolute Dynamic Topography (=SLA+MDT)
<b>AVISO+</b>	Archivage, Validation et Interprétation des données des Satellites Océanographiques
<b>C3S</b>	Copernicus Climate Change Service <a href="http://climate.copernicus.eu/">http://climate.copernicus.eu/</a>
<b>CLS</b>	Collecte Localisation Satellites
<b>CMEMS</b>	Copernicus Marine Environment Monitoring Service
<b>CNES</b>	Centre National d'Etudes Spatiales
<b>DUACS</b>	Data Unification and Altimeter Combination System
<b>FTP</b>	File Transfer Protocol
<b>MDT</b>	Mean Dynamic Topography (difference between Mean Sea Surface (MSS) and Geoid)
<b>META2018</b>	Mesoscale Eddy Trajectory Atlas - 2018 version
<b>NetCDF</b>	Network Common Data Format
<b>OSU</b>	Oregon State University
<b>SLA</b>	Sea Level Anomaly (a.k.a. sea surface height with respect to a mean sea surface)

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Mesoscale Eddies in Altimeter Observations of SSH web site at OSU, <http://wombat.coas.oregonstate.edu/eddies/>

Dudley B. Chelton, Michael G. Schlax, Roger M. Samelson, 2011: Global observations of nonlinear mesoscale eddies, *Progr. Oceanogr.*, 91 (2011) 167–216, [doi:10.1016/j.pocean.2011.01.002](https://doi.org/10.1016/j.pocean.2011.01.002)

Michael G. Schlax and Dudley B. Chelton, 2016: [The “Growing Method” of Eddy Identification and Tracking in Two and Three Dimensions](#), College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, Oregon, July 8, 2016

Mesoscale Eddy Trajectory Atlas Product Handbook, SALP-MU-P-EA-23126-CLS, issue 1.0 [https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/hdbk\\_eddytrajectory.pdf](https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/hdbk_eddytrajectory.pdf)

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

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## 1. Overview of this document

This document is the user manual for the Mesoscale Eddy Trajectory Atlas product, processed by CNES/CLS in the DUACS system. Several versions are distributed (details in 2.1.2), which are generated and quality-controlled following the methodology developed by D. Chelton and M. Schlax at the Oregon State University (USA) for version 2.0 in delayed-time and by E. Mason at the Instituto Mediterráneo de Estudios Avanzados (IMEDEA, Spain) for version 3.0exp in near-real-time. The algorithm benefits from upgrades added through these collaborations, and the Mesoscale Eddy Trajectory Atlas dataset is distributed by AVISO+.

This document describes

- **the delayed-time version 2.0** (DT 2.0) of this product (versioning for AVISO+ distributed product), released in September 2018 and updated as the available number of maps increase with time.
- **the near-real-time version 3.0 Experimental** (NRT 3.0exp) product, released in September 2019

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

### 2.1.1. Rationale

The mesoscale circulation is defined like a class of energetic phenomena of spatial scales ranging from about ten to several hundred kilometers and time scales ranging from a few days to several months. Its forcing mechanisms are mainly instabilities from the large-scale circulation and interactions between currents and bathymetry and the direct forcing by the wind.

Altimetry enables observations of such phenomena by measuring the sea surface topography around which currents swirl by the geostrophic balance between the pressure gradient force and the Coriolis acceleration. A best resolution is obtained with several satellites to study and understand eddies, with diameters ranging from 100 to 300 km (when the ground track separation at equator is about 315 km for Jason). The existence of at least two satellites operating simultaneously is therefore necessary for this type of research.

Analysis of Sea Level Anomalies from merged satellite data reveals the areas of high eddy activity, the number of eddies during those years, their horizontal scale and height. 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, nearly all of those eddies can transport heat, salts and nutrients trapped within them -- also as opposed to planetary waves that would not transport water parcels. Some regions see more anticyclonic eddies (positive sea level anomalies), like the

Tehuantepec and Papagayo eddy area, others more cyclonic eddies, such as seen in the Humboldt Current.

### 2.1.2. Versioning of the AVISO+ Eddy Atlas

#### In delayed-time:

- A dedicated dataset has been produced, for the 16-year period October 1992 - December 2008 by Chelton et al. in 2011 at Oregon State University [Chelton et al., 2011] with a weekly time step, thus enabling easy statistics and long-term studies. Each eddy was defined on the basis of connected pixels that satisfy specified criteria. The procedure was a 2-dimensional version of the method presented by Williams et al. [2011], modified as described by [Schlax & Chelton, 2016] .
- In the **version 1.0exp** delivered on AVISO+ in July 2017, some upgrades had been added to the algorithm previously used (e.g. upgrades from the Version 4 eddy dataset, 2014), an improved version of the eddy identification and tracking procedure was developed in collaboration between D. Chelton and CLS/DUACS.
- For the delivery of **delayed-time version 2.0 experimental** detailed in this handbook, the new version of input data has been taken into account (see section 3.1) and the tracking process has been improved and is detailed in section 3.2.4.
- The delayed-time version 2.0 experimental becomes **delayed-time version 2.0 (META2.0 DT)** in February 2021, with an temporal extension.

#### In near-real-time:

- The last delivery of **near-real-time version 3.0 experimental** is detailed also in this handbook. This version takes into account a different input time series (see section 3.1), the detection has been improved (see section 3.2.2.2), and is described in [Mason et al., 2014].

The eddy atlas is now routinely generated and quality-controlled by the DUACS team and distributed by AVISO+. The objective is to streamline the generation process and to reduce the latency of this product.

## 2.2. Acknowledgments

---

When using the products:

#### In delayed-time:

**Mesoscale Eddy Trajectory Atlas product in delayed-time 2.0**, please cite: "The altimetric Mesoscale Eddy Trajectory Atlas products were produced by SSALTO/DUACS and distributed by AVISO+ (<https://www.aviso.altimetry.fr/>) with support from CNES, in collaboration with Oregon State University with support from NASA".

#### In near-real-time:

**Mesoscale Eddy Trajectory Atlas product in near-real-time 3.0exp**, please cite: "The altimetric Mesoscale Eddy Trajectory Atlas products were produced by SSALTO/DUACS and distributed by AVISO+ (<https://www.aviso.altimetry.fr/>) with support from CNES, in collaboration with IMEDEA".

## 2.3. 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 [avis@altimetry.fr](mailto:avis@altimetry.fr).

## 3. Processing

### 3.1. Input data

---

The data used are described in Table 1.

Eddy product	Input data	variable	origin
Delayed-time version 2.0	"two-satellite" daily <b>Delayed Time</b> DUACS2018 version	Gridded Global <b>Sea Level Anomalies</b> (SLA)	Copernicus Climate Change Service (C3S) <a href="http://climate.copernicus.eu/">http://climate.copernicus.eu/</a>
Near-real-time version 3.0exp	"all-satellite" daily <b>Near Real Time</b> DUACS2018 version	Gridded Global <b>Absolute Dynamic Topographies</b> (ADT)	Copernicus Marine Service (CMEMS) <a href="http://marine.copernicus.eu/">http://marine.copernicus.eu/</a>

**Table 1: input products used**

Note that there are two differences between the DT and NRT versions:

1/ "two-satellite" versus "all-satellite" input products: indeed, the "two-satellite" time series is available only in Delayed-Time. The use of "all-satellite" product in NRT will allow a better sampling of the ocean at a given time. Indeed the focus on short period of time with a best sampling is in the interest of using a NRT product.

2/ SLA versus ADT input variables used: the use of ADT will avoid a) misinterpreting eddies with a permanent signature (see Figure 1) and b) that the displacement of large currents creates anomalies similar to eddies.

**This means that there is no continuity between NRT and DT products**



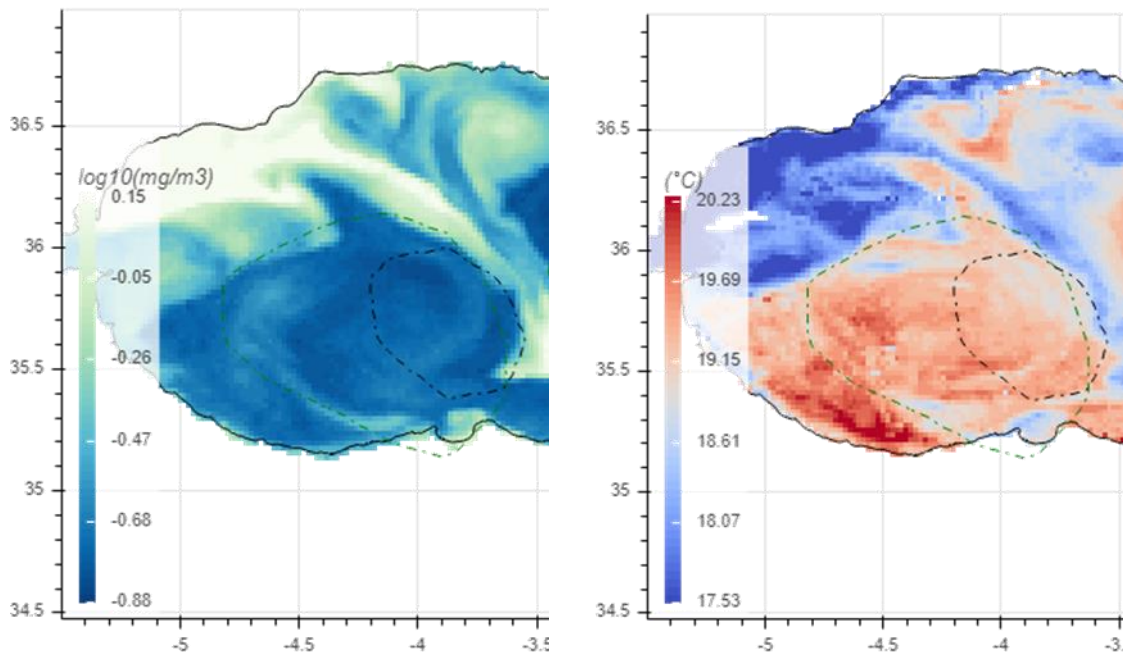


Figure 1: left, Ocean Color and right, SST. Superimposed with dashed lines, the eddy detected with SLA (smallest) and with ADT (biggest).

## 3.2. Algorithms

---

The algorithms used for this product are derived from

- for **DT 2.0** : the one implemented at Oregon State University and described in [\[Schlax & Chelton, 2016\]](#)
- for **NRT 3.0exp** : the one described in [\[Mason et al., 2014\]](#)

The main processing steps are described in this section. Some steps can vary from the papers cited above and some steps are the same (explicitly indicated).

This section highlights the improvements used for this version with respect to the previous one.

### 3.2.1. Filtering (same for DT2.0 and NRT3.0exp; same as in DT1.0exp)

The Sea Level Anomaly 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 was computed by smoothing using a second order Lanczos filter. The result was subtracted from the original SLA data to produce a grid which contains only mesoscale variability.

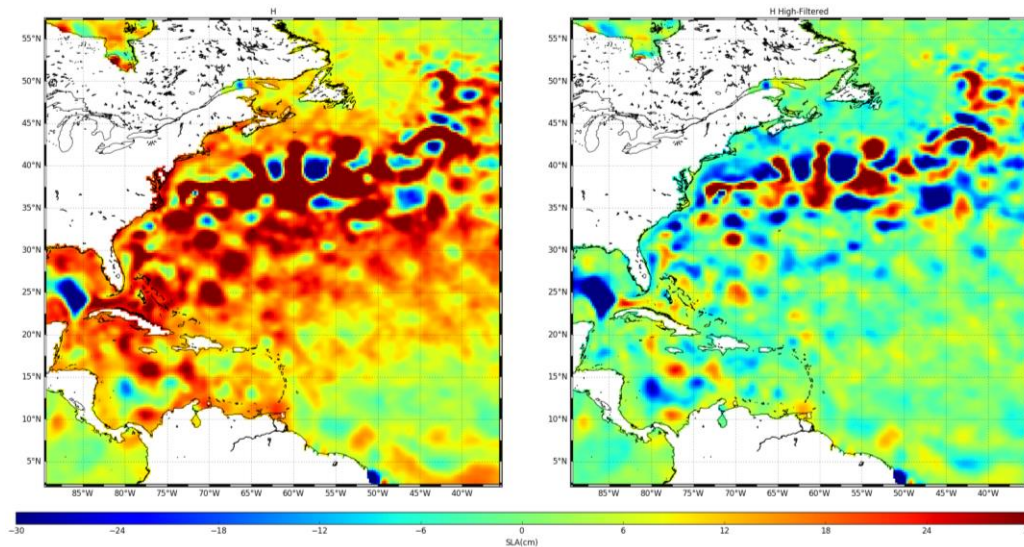


Figure 2: Left, initial sea level anomaly product. Right, the high-filtered version used for the DT 2.0 eddy detection.

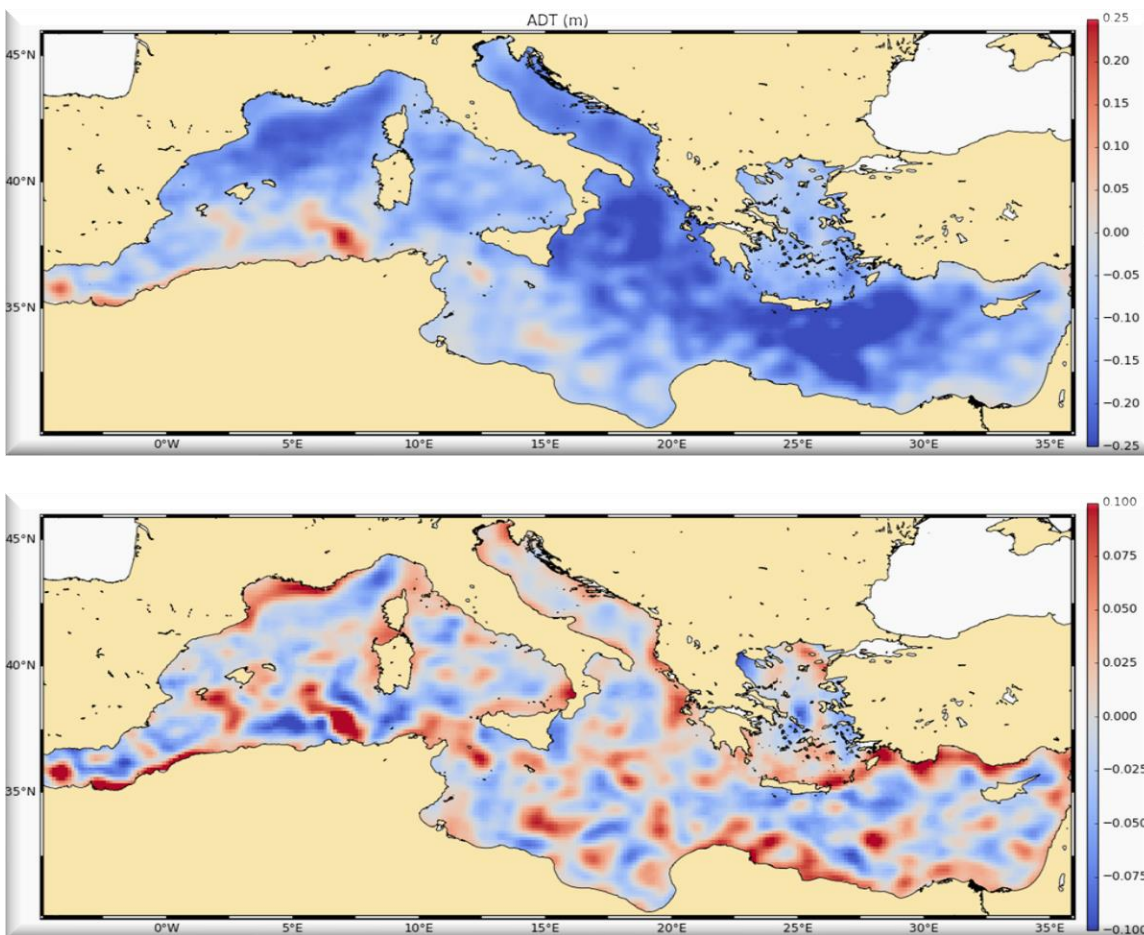


Figure 3: Top, initial ADT variable. Bottom, after the filter is applied as an input for NRT3.0exp eddy detection.

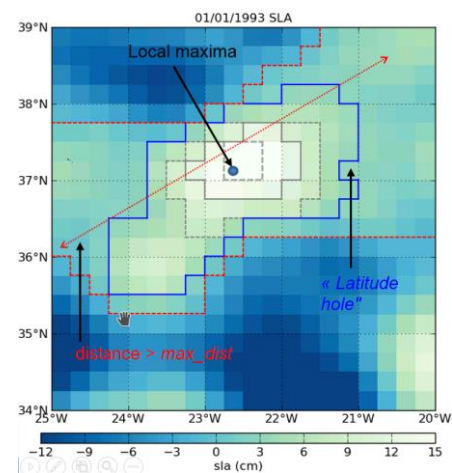
### 3.2.2. Detection

#### 3.2.2.1. DT 2.0 (same as in v1.0exp) described in Schlax and Chelton, 2016

After filtering, extrema of the Sea Level Anomaly field are detected to estimate eddy locations and properties.

On each local maximum and minimum, the algorithm searches the points around it to extend the area detected as an eddy, following some rules:

- tested area must be equal or smaller in amplitude than the area already defined,
- distance between the two remotest points must be less than a maximum likely diameter for an eddy: Distance max = 700 km for latitudes lower than  $\pm 25^\circ$  of latitude, or 400 km for latitudes higher than  $\pm 25^\circ$ .
- maximum Area = 2000 pixels
- no latitude holes on the edges and no hole within the interior of the area.



If the tested area isn't already included in the detection region of another eddy, an eddy is considered to be detected. Any further detection on this area is stopped.

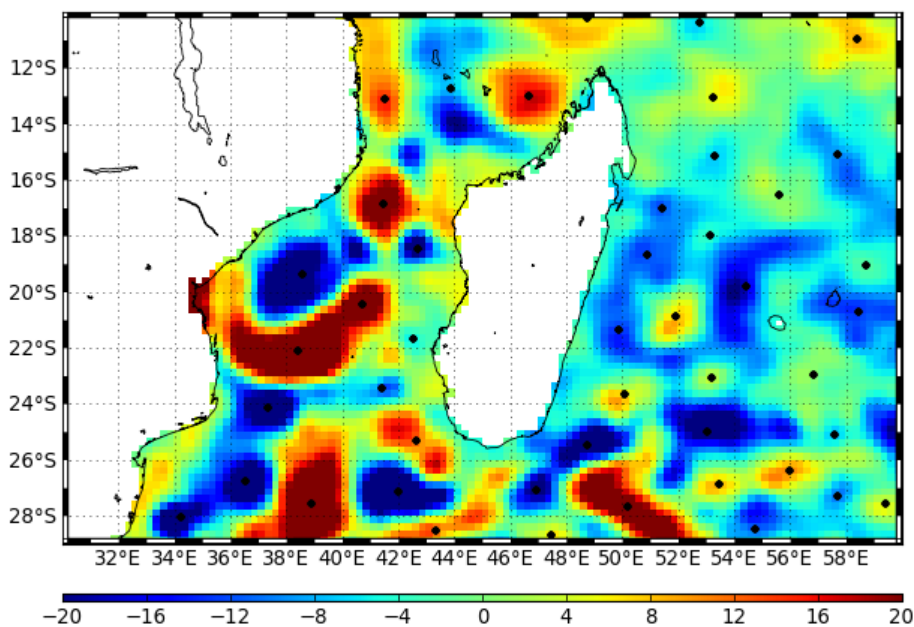


Figure 4: Eddy detections: black dots are eddies observation centers



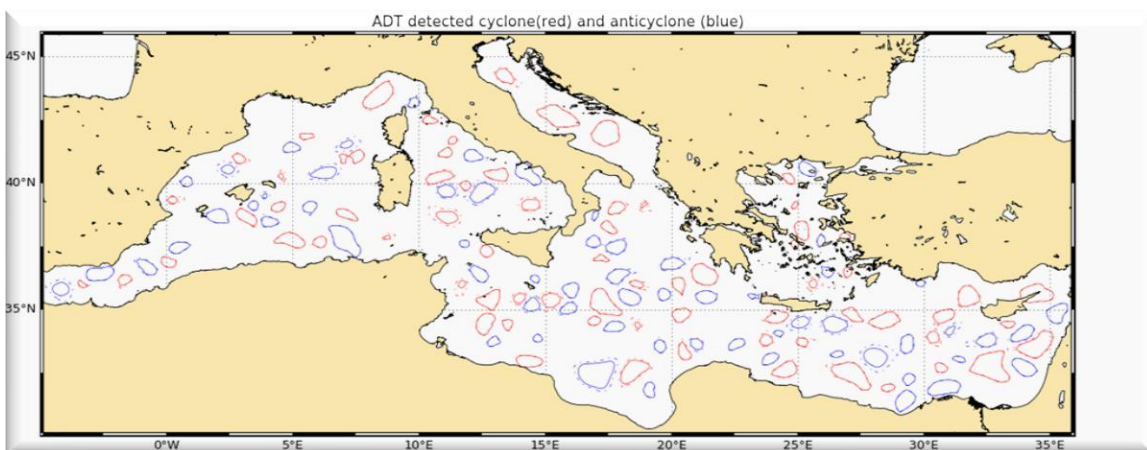
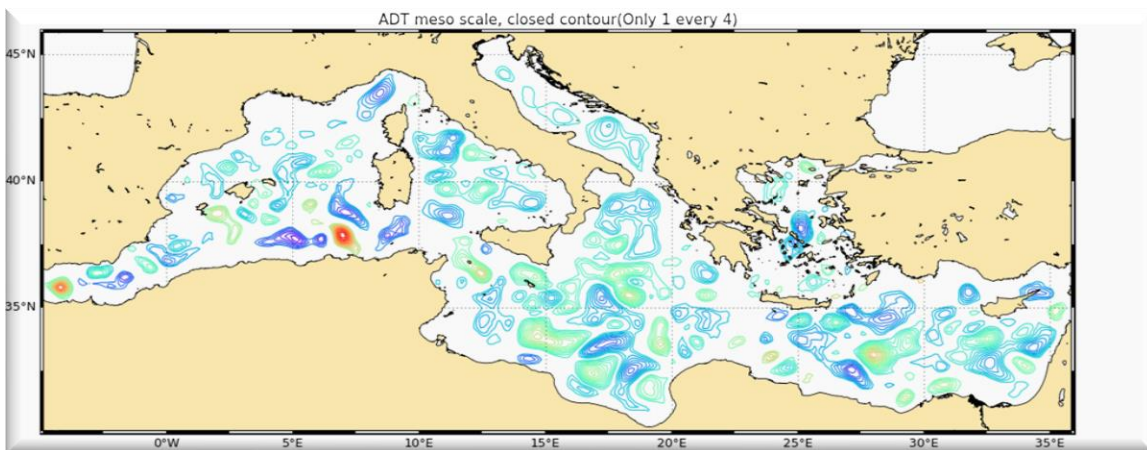
### 3.2.2.2. NRT 3.0exp (new version, described in Mason et al., 2014)

The detection is made in two steps:

1/ By the identification of ADT closed contours in a “tracking area” between -100/100 cm and at each interval, closed contours are identified and analyzed (see Figure 5 top). An eddy is identified if some characteristics follow some criteria. The full explanation can be found in [\[Mason et al., 2014\]](#).

2/ Next, the center of the eddy is defined as the center of the circle which fits best with the contour of the maximum speed. The corresponding radius is then calculated as defined in [\[Mason et al., 2014\]](#).

3/ new characteristics are calculated as described in Table 2.



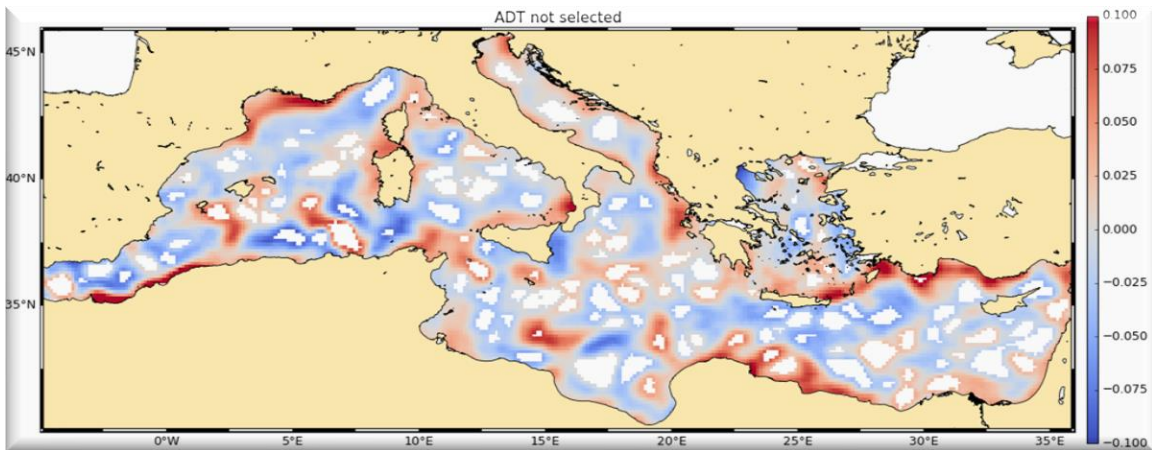


Figure 5: Top, contours analysed by the NRT 3.0exp algorithm, middle, final eddies detected, bottom, mask of the eddies in the ADT.

### 3.2.3. Estimation of eddy characterization

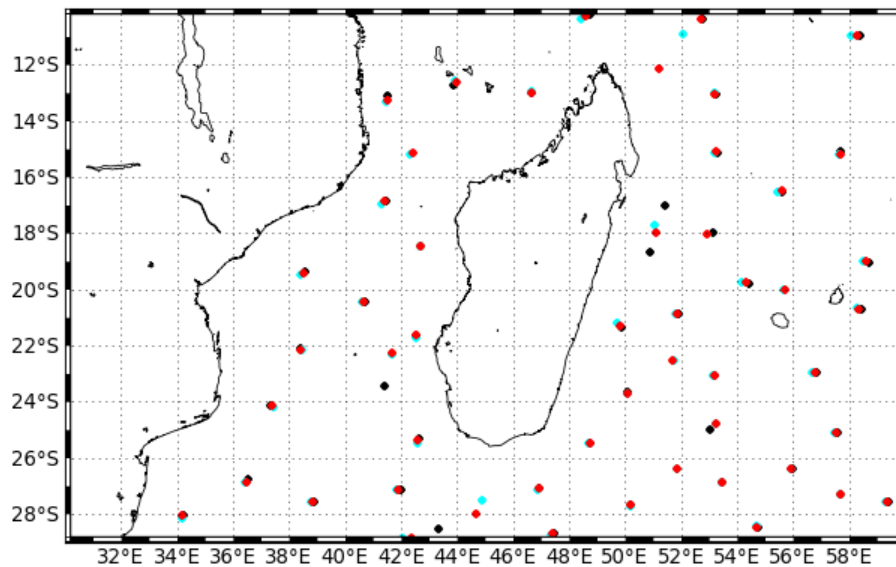
After the detection, we compute an estimate of different eddy characteristics, provided as variables within the dataset:

characteristic	value	DT 2.0 (same as in v1.0exp)	NRT 3.0exp
<b>Amplitude</b>	$ \text{sla}(\text{max\_local}) - \text{sla}(\text{edge\_pix}) $	Yes	Yes
<b><u>Radius speed</u></b>	Radius of a circle whose area is equal to that enclosed by the contour of maximum circum-average geostrophic speed	Yes	<u>Yes</u>
<b><u>Speed average</u></b>	Average geostrophic speed of the contour defining the speed radius	Yes	Yes
<b>Speed profile</b>	Profile speed average values from effective contour inwards to smallest inner contour		Yes
<b>Effective contour</b>	Largest contour of the detected eddy		Yes
<b>Speed contour</b>	Speed contour of the detected eddy		Yes

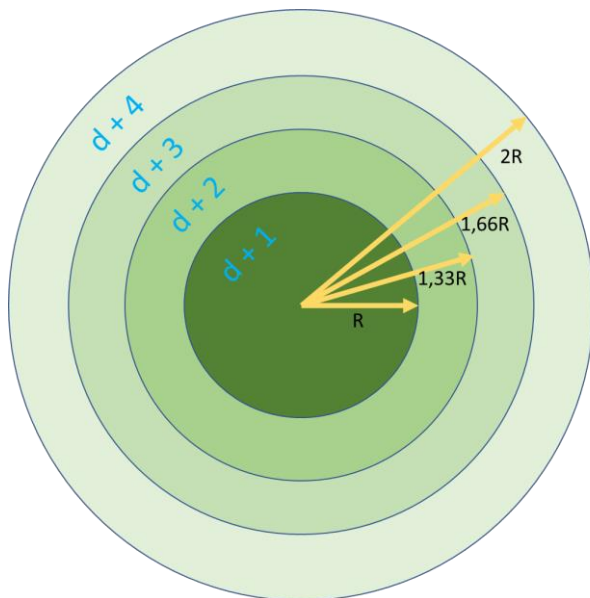
Table 2: characteristics of eddies for DT and NRT (the full variables are detailed in section 4)

### 3.2.4. Tracking

#### 3.2.4.1. DT 2.0 and NRT 3.0exp (new compared to 1.0exp)



**Figure 6: Eddy tracking; each color corresponds to a different day**



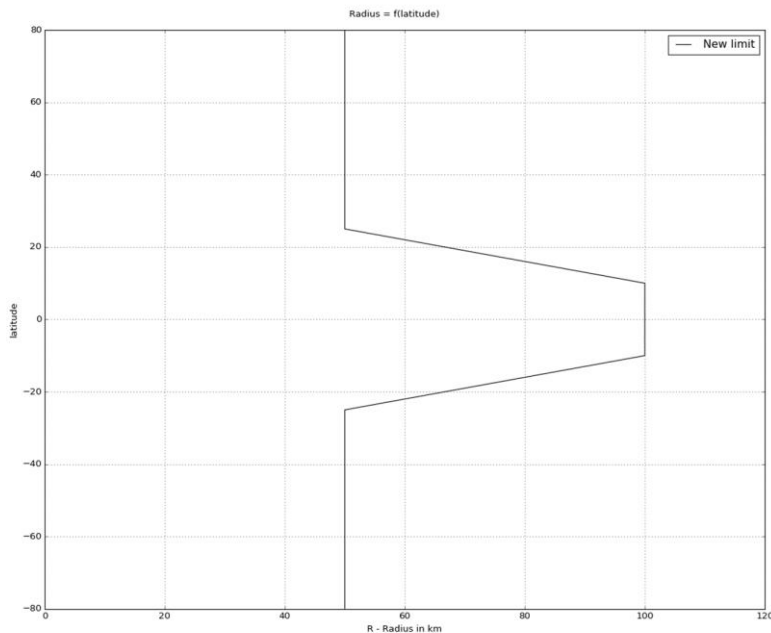
After performing detection on several consecutive days, we apply a procedure to build the trajectories over time of the detected eddies.

To search for next observation on  $D+1$ , we build a circle of radius  $R$  that encompass an area to find linked observations. If several observations are found within this circle, a cost function is applied, which must be minimized to link two observations and consider they are two different positions of the same eddy.

The cost function depends on the amplitude and position (to compute distance) variables.

If no observation linked to the eddy is found in  $D+1$  map, the research process is done on Day+2 and until  $D+4$  maps with circles of growing radius as shown on the figure.

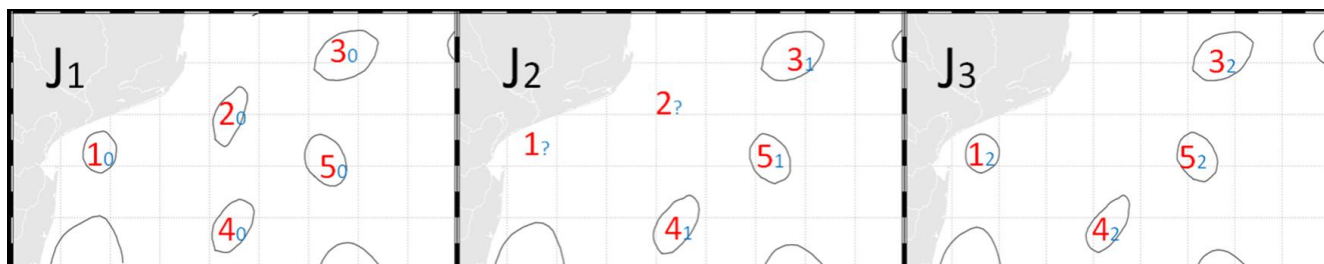
The radius R depends on the latitude (Figure 7)



**Figure 7: The radius is varying with the latitude**

Loss of the eddy position on one map:

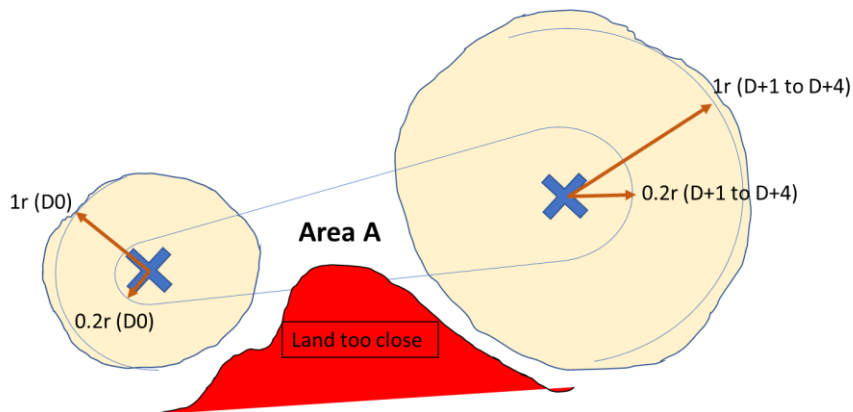
The tracking procedure allows the loss of one to three consecutive observations as illustrated in Figure 8. This can happen sometimes due to identification thresholds criteria and/or map quality. Then, the lost eddy is reconstructed using interpolation. This information is given in the file in the variable 'observation\_flag'.



**Figure 8: procedure to detect a tracking on a particular eddy: the eddy number 1 is kept because an association has been found on map D+3, contrary to the eddy number 2 where no association is found on the last map.**

Contamination by land:

The tracking process takes into account the proximity of the land in the trajectory of the eddy. When the two positions are defined at D0 and D+1 or more, an area A is defined as a function of the radius r of the eddy. The trajectory is stopped if some land is found in the area A.



**Figure 9: The association of two consecutive observations takes into account the contamination by land in the trajectory: if the land is inside the defined area A, the tracking is stopped**

	DT 2.0	NRT 3.0exp
After this tracking, a filter is applied to remove tracks shorter than	28 days	14 days



### 3.3. Product Statistical analysis for DT 2.0

A series of plots is provided for comparison with the plots available in Chelton et al. [2011], but based on the new DUACS SLA product distributed by C3S from 2018:

[https://www.aviso.altimetry.fr/fileadmin/documents/data/products/value-added/aviso\\_validation\\_report\\_eddy\\_tracking\\_2.0.pdf](https://www.aviso.altimetry.fr/fileadmin/documents/data/products/value-added/aviso_validation_report_eddy_tracking_2.0.pdf)

## 4. Description of the product

### 4.1. Product general content and specifications

Eddy product	Covered period	Spatial coverage	Delivery format	Update
Delayed-time version 2.0	01/01/1993 – 15/10/2019, the end date is updated every year	-45 to 373°E* - 77°S to 80°N	One NetCDF file (cyclonic and anticyclonic eddies in the same file)	Each year
Near-real-time version 3.0exp	01/01/2018 – ongoing with 15 days of latency	0 to 360°E - 82.5°S to 82.5°N	Two Netcdf files (one for cyclonic eddies and one for anticyclonic eddies).	Daily

**Table 3: characteristics of the products delivery**

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

Note that the numbering of the eddies may differ from one day to another one so this variable should not be taken as the basis for comparison between files.

### 4.2. Nomenclature of files

#### 4.2.1. DT 2.0

`eddy_trajectory_dt_2.0_%Y%m%d_%Y%m%d.nc` includes the whole time series of the data processed for the version 2.0

#### 4.2.2. NRT 3.0exp

`eddy_trajectory_nrt_3.0exp_cyclonic_%Y%m%d_%Y%m%d.nc` and

`eddy_trajectory_nrt_3.0exp_anticyclonic_%Y%m%d_%Y%m%d.nc`

include the whole time series of the data processed for the version 3.0exp. Each day, the second date increments to update the period of coverage.

### 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

##### 4.4.1. DT 2.0

All the eddies detected are stored in a unique file.

Each detected track is stored end-to-end on one dimension "obs" (an index). The "track" variable numbers the eddy track, and thus allows to separate tracks.

Variable name	Description	Standard _name	Dimensi ons	Units
<b>eddy_trajectory_dt_2.0_%Y%m%d_%Y%m%d.nc</b>				
<b>NetCDF-CF</b>				
<b>Obs : Each detected track is stored end-to-end on one dimension "obs" (an index). The "track" variable numbers the eddy track, and thus allows to separate tracks.</b>				
<b>amplitude</b>	magnitude of the height difference between the extremum of SLA within the eddy and the SLA of the contour defining the eddy perimeter		(Obs)	m
<b>cyclonic_type</b>	rotating sense of the eddy : -1 is Cyclonic and 1 is Anticyclonic		(Obs)	-1 or 1
<b>latitude</b>	eddy center latitude	latitude	(Obs)	Degrees _north
<b>longitude</b>	eddy center longitude	longitude	(Obs)	Degrees _east
<b>observation_number</b>	observation sequence number, days from eddy first detection		(Obs)	ordinal
<b>observation_flag</b>	flag indicating if the value is interpolated between two observations or not (0: observed, 1: interpolated)		(Obs)	boolean
<b>speed_average</b>	average speed of the contour defining the radius scale "speed_radius"		(Obs)	m/s
<b>speed_radius</b>	radius of a circle whose area is equal to that enclosed by the contour of maximum circum-average speed		(Obs)	m
<b>time</b>	days since 1950-01-01 00:00:00 UTC	time	(Obs)	Days
<b>track</b>	eddy identification number		(Obs)	ordinal

#### 4.4.2. NRT 3.0exp

All the eddies detected are stored in two files: cyclonic and anticyclonic.

Variable name	Description	Standard_name	Dimensions	Units
eddy_trajectory_nrt_3.0exp_cyclonic_%Y%m%d_%Y%m%d.nc eddy_trajectory_nrt_3.0exp_anticyclonic_%Y%m%d_%Y%m%d.nc				
<b>NetCDF-CF</b>				
<b>Dimensions:</b>				
<b>Obs :</b> Each detected track is stored end-to-end on one dimension "obs" (an index). The "track" variable numbers the eddy track, and thus allows to separate tracks.				
<b>Nbsamples : 50</b>				
<b>It is the number of points to store information:</b> if there is more or less than 50 points constituting a contour or the uavg_profile, the information is interpolated to be stored in the file				
<b>latitude</b>	observation latitude	latitude	(Obs)	Degrees _north
<b>longitude</b>	observation longitude	longitude	(Obs)	Degrees _east
<b>time</b>	days since 1950-01-01 00:00:00 UTC	time	(Obs)	Days
<b>track</b>	eddy identification number		(Obs)	ordinal
<b>observation_number</b>	observation sequence number, days from eddy first detection		(Obs)	ordinal
<b>observation_flag</b>	flag indicating if the value is interpolated between two observations or not (0: observed, 1: interpolated)		(Obs)	boolean
<b>amplitude</b>	magnitude of the height difference between the extremum of ADT within the eddy and the ADT around the contour defining the eddy perimeter		(Obs)	meters
<b>num_contours</b>	number of contours selected for this eddy		(Obs)	ordinal
<b>effective_contour_latitude</b>	Latitudes of effective contour		(Obs, Nbsamples)	Degrees _north
<b>effective_contour_longitude</b>	Longitudes of effective contour		(Obs, Nbsamples)	Degrees _east
<b>effective_contour_height</b>	ADT filtered height for effective contour		(Obs)	meters

<b>effective_contour_shape_error</b>	Error criterion of fit on effective contour	(Obs)	%
<b>effective_radius</b>	radius of a circle whose area is equal to that enclosed by the effective contour	(Obs)	meters
<b>speed_contour_latitude</b>	Latitudes of speed contour	(Obs, Nbsamples)	Degrees_north
<b>speed_contour_longitude</b>	Longitudes of speed contour	(Obs, Nbsamples)	Degrees_north
<b>speed_contour_height</b>	ADT filtered height for speed contour	(Obs)	meters
<b>speed_average</b>	average speed of the contour defining the radius scale "speed_radius"	(Obs)	m/s
<b>speed_radius</b>	radius of a circle whose area is equal to that enclosed by the contour of maximum circum-average speed	(Obs)	km
<b>speed_contour_shape_error</b>	Error criterion of fit on speed contour	(Obs)	%
<b>inner_contour_height</b>	ADT filtered height for inner contour	(Obs)	meters
<b>uavg_profile</b>	speed average values from effective contour inwards to smallest inner contour	(Obs, Nbsamples)	m/s
<b>latitude_max</b>	longitude of amplitude max	(Obs)	
<b>longitude_max</b>	longitude of amplitude max	(Obs)	

---

## 5. How to download a product

### 5.1. Registration

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To access data, registration is required. During the registration process, the user shall accept using licenses for the use of AVISO+ products and services. This product is available for non-commercial uses only.

Register at:

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

or, if already registered on AVISO+, request the addition of this product on your personal account on [https://www.aviso.altimetry.fr/no\\_cache/en/my-aviso-plus.html](https://www.aviso.altimetry.fr/no_cache/en/my-aviso-plus.html)

and select the product:

**“Mesoscale eddy trajectory atlas product (restricted licence)”**

### 5.2. Access Services

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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/no\\_cache/en/my-aviso-plus.html](https://www.aviso.altimetry.fr/no_cache/en/my-aviso-plus.html).

## Appendix A - Product header

### 5.3. DT 2.0

dimensions:

obs = 27880804 ;

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:min = 0.01 ;

amplitude:max = 0.486 ;

amplitude:description = "magnitude of the height difference between the extremum of SLA within the eddy and the SLA of the contour defining the eddy perimeter" ;

amplitude:add\_offset = 0LL ;

amplitude:scale\_factor = 0.001 ;

byte cyclonic\_type(obs) ;

cyclonic\_type:comment = "Cyclonic -1; Anti-cyclonic +1" ;

cyclonic\_type:long\_name = "Rotating sense of the eddy" ;

cyclonic\_type:min = -1b ;

cyclonic\_type:max = 1b ;

cyclonic\_type:longname = "rotating sense of the eddy" ;

cyclonic\_type:description = "Cyclonic : -1; Anticyclonic : +1" ;

float latitude(obs) ;

latitude:\_FillValue = NaNf ;

latitude:axis = "Y" ;

latitude:comment = "Latitude center of the fitted circle" ;

latitude:long\_name = "Eddy Center Latitude" ;

latitude:standard\_name = "latitude" ;

latitude:units = "degrees\_north" ;

latitude:min = -77.3222f ;

latitude:max = 79.7605f ;

latitude:description = "Eddy center latitude" ;

float longitude(obs) ;

longitude:\_FillValue = NaNf ;

longitude:axis = "X" ;

longitude:comment = "Longitude center of the fitted circle" ;

longitude:long\_name = "Eddy Center Longitude" ;

longitude:standard\_name = "longitude" ;

longitude:units = "degrees\_east" ;

longitude:min = -47.548f ;

longitude:max = 372.9487f ;

longitude:description = "Eddy center longitude" ;

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 = 1848US ;
  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:min = 0.0097 ;
    speed_average:max = 3.0876 ;
    speed_average:add_offset = 0LL ;
    speed_average:scale_factor = 0.0001 ;
  ushort speed_radius(obs) ;
    speed_radius:comment = "Radius of a circle whose area is equal to that enclosed by
the contour of maximum circum-average speed" ;
    speed_radius:long_name = "Speed Radius" ;
    speed_radius:units = "m" ;
    speed_radius:min = 7050. ;
    speed_radius:max = 403200. ;
    speed_radius:add_offset = 0LL ;
    speed_radius:scale_factor = 50. ;
  int time(obs) ;
    time:axis = "T" ;
    time:comment = "Date of this observation" ;
    time:long_name = "Time" ;
    time:standard_name = "time" ;
    time:min = 15706 ;
    time:max = 25633 ;
    time:units = "days since 1950-01-01" ;
    time:calendar = "proleptic_gregorian" ;
  uint track(obs) ;
    track:comment = "Trajectory identification number" ;
    track:long_name = "Trajectory number" ;
    track:min = 0U ;
    track:max = 379974U ;
```

```
// global attributes:
```

```
:title = "Mesoscale Eddy Trajectories Atlas in Altimeter Observations of SLA" ;
:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
:comment = "Surface product; mesoscale eddies" ;
:framework_used = "https://github.com/AntSimi/py-eddy-tracker" ;
:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata
Convention Standard Name Table" ;
:date_created = "2020-12-15T16:25:59Z" ;
:time_coverage_duration = "P9928D" ;
:time_coverage_start = "1993-01-01T00:00:00Z" ;
:time_coverage_end = "2020-03-07T00:00:00Z" ;
```



```

:institution = "CNES/CLS in collaboration with Oregon State University" ;
:project = "SSALTO/DUACS" ;
:creator_url = "http://www.avisio.altimetry.fr" ;
:creator_email = "avisio@altimetry.fr" ;
:license =
"http://www.avisio.altimetry.fr/fileadmin/documents/data/License_Avisio.pdf" ;
:summary = "This dataset contains mesoscale eddy trajectories atlas from two-satellite
C3S SLA maps over the global ocean" ;
:input_product_reference = "https://www.avisio.altimetry.fr/en/data/product-
information/updates-and-reprocessing/ssaltoduacs-delayed-time-reprocessing.html" ;
:product_version = "2.0" ;

```

#### 5.4. NRT 3.0exp

---

```

netcdf eddy_trajectory_nrt_3.0exp_cyclonic_20180101_20190820 {
dimensions:
  obs = 1963946 ;
  NbSample = 50 ;
variables:
  ushort amplitude(obs) ;
    amplitude:description = "Magnitude of the height difference between the extremum of
ADT within the eddy and the ADT around the contour defining the eddy perimeter" ;
    amplitude:longname = "amplitude" ;
    amplitude:units = "m" ;
    amplitude:scale_factor = 0.001 ;
    amplitude:add_offset = 0LL ;
    amplitude:min = 0.004 ;
    amplitude:max = 1.239 ;
  float cost_association(obs) ;
    cost_association:description = "Cost value to associate with the next observation" ;
    cost_association:longname = "cost_value_to_associate_with_next_observation" ;
    cost_association:min = 0. ;
    cost_association:max = 0. ;
  float effective_contour_height(obs) ;
    effective_contour_height:description = "ADT filtered height for effective contour" ;
    effective_contour_height:longname = "effective contour height" ;
    effective_contour_height:units = "m" ;
    effective_contour_height:min = -0.706f ;
    effective_contour_height:max = 0.198f ;
  short effective_contour_latitude(obs, NbSample) ;
    effective_contour_latitude:axis = "X" ;
    effective_contour_latitude:description = "Latitudes of effective contour" ;
    effective_contour_latitude:longname = "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:description = "Longitudes of effective contour" ;
    effective_contour_longitude:longname = "effective contour longitudes" ;
    effective_contour_longitude:units = "degrees_east" ;
    effective_contour_longitude:scale_factor = 0.01 ;
    effective_contour_longitude:add_offset = 180LL ;
ubyte effective_contour_shape_error(obs) ;
    effective_contour_shape_error:description = "Error criterion of fit on effective
contour" ;
    effective_contour_shape_error:longname = "effective contour 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 = 4.5 ;
    effective_contour_shape_error:max = 55. ;
ushort effective_radius(obs) ;
    effective_radius:description = "Radius of a circle whose area is equal to that enclosed
by the effective contour" ;
    effective_radius:longname = "effective radius scale" ;
    effective_radius:units = "m" ;
    effective_radius:scale_factor = 50. ;
    effective_radius:add_offset = 0LL ;
    effective_radius:min = 9100. ;
    effective_radius:max = 248750. ;
float inner_contour_height(obs) ;
    inner_contour_height:description = "ADT filtered height for inner contour" ;
    inner_contour_height:longname = "inner contour height" ;
    inner_contour_height:units = "m" ;
    inner_contour_height:min = -1.142f ;
    inner_contour_height:max = 0.176f ;
float latitude(obs) ;
    latitude:axis = "Y" ;
    latitude:description = "Observation latitude" ;
    latitude:longname = "latitude of measurement" ;
    latitude:standard_name = "latitude" ;
    latitude:units = "degrees_north" ;
    latitude:min = -78.16272f ;
    latitude:max = 83.04803f ;
float latitude_max(obs) ;
    latitude_max:axis = "Y" ;
    latitude_max:description = "Observation latitude" ;
    latitude_max:longname = "latitude of amplitude max" ;
    latitude_max:standard_name = "latitude" ;
    latitude_max:units = "degrees_north" ;
    latitude_max:min = -78.12547f ;
    latitude_max:max = 83.12267f ;
float longitude(obs) ;
    longitude:axis = "X" ;
    longitude:description = "Observation longitude" ;
```

---

```
longitude:longname = "longitude of measurement" ;
longitude:standard_name = "longitude" ;
longitude:units = "degrees_east" ;
longitude:min = -11.32053f ;
longitude:max = 362.679f ;
float longitude_max(obs) ;
longitude_max:axis = "X" ;
longitude_max:description = "Observation longitude" ;
longitude_max:longname = "longitude of amplitude max" ;
longitude_max:standard_name = "longitude" ;
longitude_max:units = "degrees_east" ;
longitude_max:min = 4.272083e-05f ;
longitude_max:max = 360.f ;
ushort num_contours(obs) ;
num_contours:description = "Number of contour selected for this eddy" ;
num_contours:longname = "number of contour" ;
num_contours:units = "ordinal" ;
num_contours:min = 1US ;
num_contours:max = 614US ;
byte observation_flag(obs) ;
observation_flag:description = "Flag indicating if the value is interpolated between two
observations or not (0: observed, 1: interpolated)" ;
observation_flag:longname = "virtual_position" ;
observation_flag:units = "boolean" ;
observation_flag:min = 0b ;
observation_flag:max = 1b ;
ushort observation_number(obs) ;
observation_number:description = "Observation sequence number, days from eddy
first detection" ;
observation_number:longname = "observation number" ;
observation_number:units = "ordinal" ;
observation_number:min = 0US ;
observation_number:max = 596US ;
byte segment_size(obs) ;
segment_size:min = 0b ;
segment_size:max = 0b ;
ushort speed_average(obs) ;
string speed_average:description = "Average speed of the contour defining the radius
scale speed_radius"
speed_average:longname = "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 = 4.0077 ;
float speed_contour_height(obs) ;
speed_contour_height:description = "ADT filtered height for speed contour" ;
speed_contour_height:longname = "speed contour height" ;
speed_contour_height:units = "m" ;
speed_contour_height:min = -0.706f ;
speed_contour_height:max = 0.198f ;
```

---

```
short speed_contour_latitude(obs, NbSample) ;
    speed_contour_latitude:axis = "X" ;
    speed_contour_latitude:description = "Latitudes of speed contour" ;
    speed_contour_latitude:longname = "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:description = "Longitudes of speed contour" ;
    speed_contour_longitude:longname = "speed contour longitudes" ;
    speed_contour_longitude:units = "degrees_east" ;
    speed_contour_longitude:scale_factor = 0.01 ;
    speed_contour_longitude:add_offset = 180LL ;
ubyte speed_contour_shape_error(obs) ;
    speed_contour_shape_error:description = "Error criterion of fit on speed contour" ;
    speed_contour_shape_error:longname = "speed contour 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 = 3.5 ;
    speed_contour_shape_error:max = 88. ;
ushort speed_radius(obs) ;
    speed_radius:description = "Radius of a circle whose area is equal to that enclosed by
the contour of maximum circum-average speed" ;
    speed_radius:longname = "speed radius scale" ;
    speed_radius:units = "m" ;
    speed_radius:scale_factor = 50. ;
    speed_radius:add_offset = 0LL ;
    speed_radius:min = 9100. ;
    speed_radius:max = 247250. ;
int time(obs) ;
    time:axis = "T" ;
    time:calendar = "proleptic_gregorian" ;
    time:description = "Date of this observation" ;
    time:longname = "Time" ;
    time:standard_name = "time" ;
    time:units = "days since 1950-01-01 00:00:00" ;
    time:min = 24837 ;
    time:max = 25433 ;
uint track(obs) ;
    track:description = "Eddy identification number" ;
    track:longname = "track number" ;
    track:units = "ordinal" ;
    track:min = 0U ;
    track:max = 60638U ;
ushort uavg_profile(obs, NbSample) ;
    uavg_profile:description = "Speed average values from effective contour inwards to
smallest inner contour" ;
    uavg_profile:longname = "radial profile of uavg" ;
    uavg_profile:units = "m/s" ;
```

```
uavg_profile:scale_factor = 0.0001 ;  
uavg_profile:add_offset = 0LL ;
```

```
// global attributes:
```

```
:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;  
:comment = "Surface product; mesoscale eddies" ;  
:creator_email = "aviso@altimetry.fr" ;  
:creator_url = "https://www.aviso.altimetry.fr" ;  
:date_created = "2019-08-20T04:07:27Z" ;  
:framework_used = "https://bitbucket.org/emason/py-eddy-tracker" ;  
:input_product_reference = "https://www.aviso.altimetry.fr/en/data/products/value-  
added-products/global-mesoscale-eddy-trajectory-product.html" ;  
:institution = "CLS/CNES in collaboration with IMEDEA" ;  
:license =  
"https://www.aviso.altimetry.fr/fileadmin/documents/data/License_Aviso.pdf" ;  
:product_version = "3.0.exp" ;  
:project = "SSALTO/DUACS" ;  
:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata  
Convention Standard Name Table" ;  
:summary = "This dataset contains eddy atlas from all-satellite NRT CMEMS maps over  
global ocean (SEALEVEL_GLO_PHY_L4_NRT_OBSERVATIONS*)" ;  
:time_coverage_duration = "P597D" ;  
:time_coverage_end = "2019-08-20T00:00:00Z" ;  
:time_coverage_start = "2018-01-01T00:00:00Z" ;  
:title = "Mesoscale Cyclonic Eddies in Altimeter Observations of ADT" ;
```

