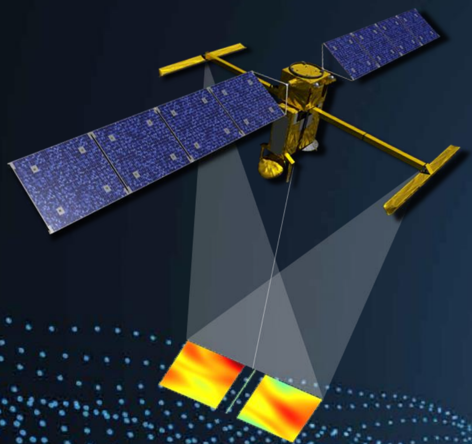
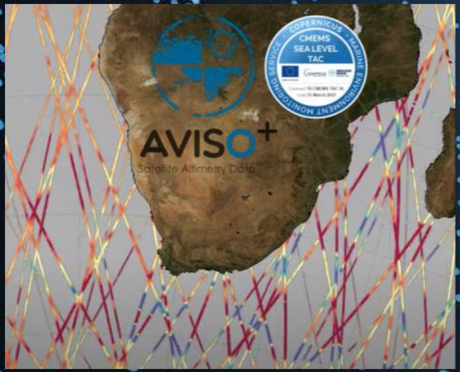
A New Global Mesoscale Eddy Trajectories Atlas Derived from Altimetry : Presentation and Future Evolutions

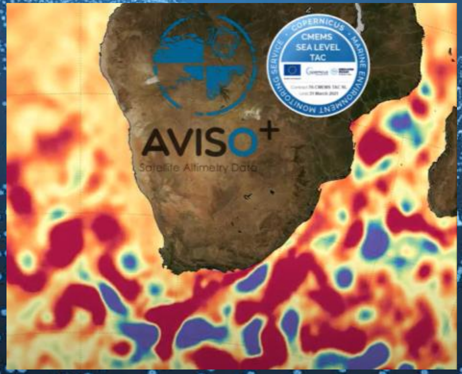
Cori Pegliasco, Antoine Delepoulle, Clément Busche, Rosemary Morrow, Yannice Faugère, Gerald Dibarboure



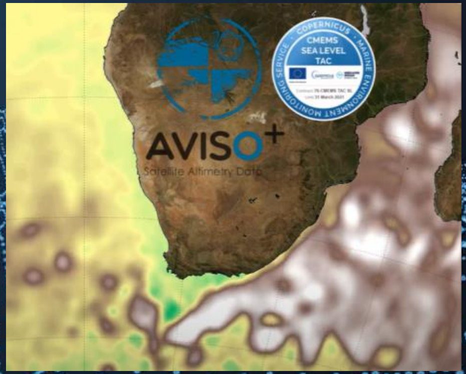
Along-track SLA



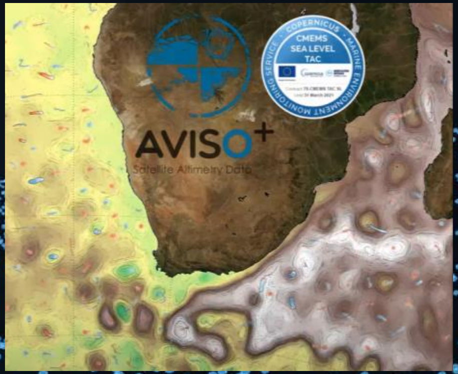
Gridded SLA



Gridded ADT



Eddies



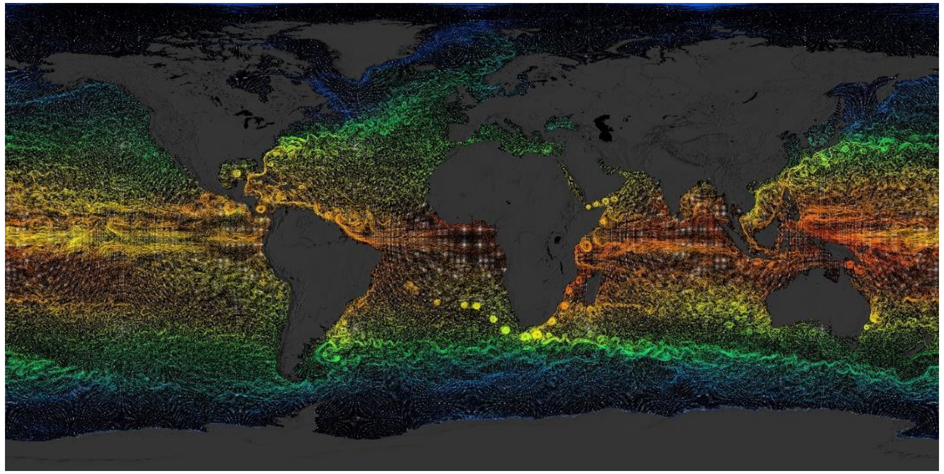
Outline

- Context
- Mesoscale Eddy Trajectory Atlas
  - from META2.0 to META3.1exp
  - from META3.1exp to META3.2
- Evolution to a representation with Networks
- Conclusions

Context

Context : Why and how study mesoscale eddies?

Currents colored by Sea Surface Temperature



Credit : NASA/Goddard Space Flight Center Scientific Visualization Studio

Transport capacity :

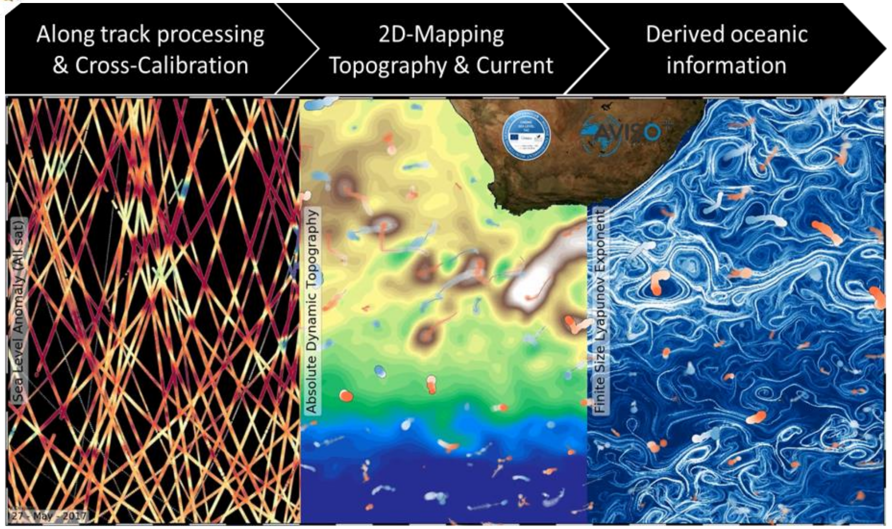
Mesoscale eddies that rotate faster than they move can transport water over long distances, and thus participate to the redistribution of heat, salt, biology and chemical components around the globe.

Typical size and duration

Mesoscale eddies range from tens to hundreds of kilometers, and span days to years.

Kinetic Energy

Mesoscale eddies participate to more than 50% of the kinetic energy in the ocean, more than the mean currents.



Altimetry maps :

Altimetry satellites provide data since 1993 at global scale, merged into 2D daily maps of Sea Surface Height (SSH) with a resolution of 0.25° x 0.25°.

Mesoscale eddies detection :

Cyclonic Eddies are associated with **lows** in the SSH.

Anticyclonic Eddies are associated with **highs** in the SSH.

Searching for local extrema in the SSH field is often used to detect the centers of mesoscale eddies.

META : Mesoscale Eddy Trajectory Atlas

Available on the **AVISO+** website : https://www.aviso.altimetry.fr/en/data/products/value-added-products/global-mesoscale-eddy-trajectory-product.html

META2.0 :

Input maps : Sea Level Anomaly (C3S, DT2018)

Detection scheme : based on Chelton et al., 2011 (Oregon State University)

Tracking scheme : Closest eddy in a restricted area

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META2

Don't use it anymore

Input maps : Se… (C3S, DT2018)

Detection scheme … Chelton et al., 2011 (Oregon State University)

Tracking schem… in a restricted area

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Detection scheme n Chelton et al., 2011 (Oregon State University)

Tracking schem in a restricted area

Don't use it anymore

META3.1exp – META3.2 :

Input maps : Absolute Dynamic Topography (C3S & CMEMS, **DT2018, DT2021**)

Detection scheme : based on Mason et al., 2014 (Py-Eddy-Tracker)

Tracking scheme : eddies' contours overlap

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Tracking schem… in a restricted area

Recommended for scientific applications

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AVISO+
Satellite Altimetry Data

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META4.0exp – Networks :

Input maps : Absolute Dynamic Topography (CMEMS, DT2021)

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Management of the interactions : merging and splitting events

AVISO+
Satellite Altimetry Data

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Available on the **AVISO+** website : https://www.aviso.altimetry.fr/en/data/products/value-added-products/global-mesoscale-eddy-trajectory-product.html

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Don't use it anymore

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Try it!

META4.0exp – Networks :

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Management of the interactions : merging and splitting events

Mesoscale Eddy Trajectory Atlas

- from META2.0 to META3.1exp
- from META3.1exp to META3.2

From META2.0 to META3.1exp

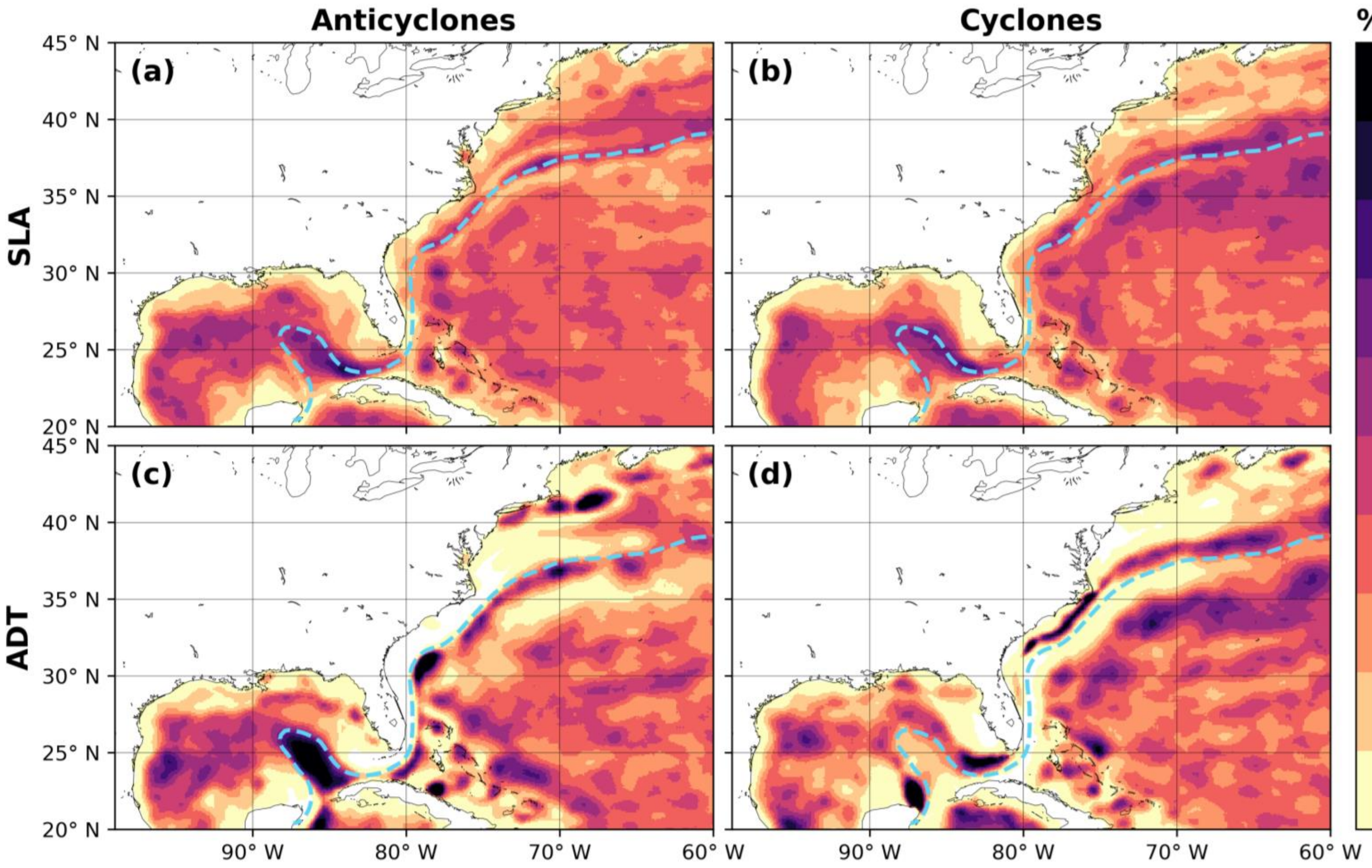
Changes in the pre-processing :

SLA → ADT : Detection on the absolute dynamic topography maps allow a better representation of the recurrent and quasi permanent eddies

1000 km → 700 km wavelength for the filter : Gradients filtered, large-scale efficiently removed

Reference : Pegliasco, C., Delepoulle, A., Mason, E., Morrow, R., Faugère, Y., Dibarboure, G., 2022. 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

From META2.0 to META3.1exp



Percentage of time spend by each pixel within anticyclones detected in (a) SLA and (c) ADT maps and within cyclones detected in (b) SLA and (d) ADT maps. The dashed blue line follows the velocity maximum of the current.

Sea Level Anomaly : Anticyclonic Eddies and Cyclonic Eddies are **almost homogeneous** in both the Gulf of Mexico and the Gulf Stream regions.

Absolute Dynamic Topography : Anticyclonic Eddies and Cyclonic Eddies have **distinct preferential locations** in agreement with the know structures :

- Anticyclonic Loop Current Eddies flanked by Frontal Loop Current Cyclonic Eddies in the Gulf of Mexico
- Alternance of Cyclonic and Anticyclonic Eddies bands related to small recirculations near the Gulf Stream vein and to large detached eddies at larger distance

Reference : Pegliasco, C., Delepoulle, A., Mason, E., Morrow, R., Faugère, Y., Dibarboure, G., 2022. 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

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Changes in the detection scheme :

Oregon State University → Py Eddy Tracker :

- Amplitude threshold : 1 – 45 cm → 0.4 cm
- Extremum authorized : multiple → only one
- Contours are available

Changes in the tracking scheme :

Restricted area → overlap of contours

Shorten the long lifetime threshold : 28 days → 10 days

- Increase of the number of detected eddies :
  ~30 million → ~75 million

~20 million eddies in META2.0 are similar in META3.1exp

- Large META2.0 eddies with 2 extrema are artefact structures and are not present in META3.1exp

Illustration : https://www.youtube.com/watch?v=4Vs3ZJNMViw

- Contours allow better colocation of external data

Reference :

Pegliasco, C., Delepoulle, A., Mason, E., Morrow, R., Faugère, Y., Dibarboure, G., 2022. 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

Mesoscale Eddy Trajectory Atlas

- from META2.0 to META3.1exp

- from META3.1exp to META3.2

From META3.1exp (ADT maps DT2018) to META3.2 (ADT maps DT2021)

Altimetry maps are built from the altimetry data and gridded products are at the end of a long processing chain.

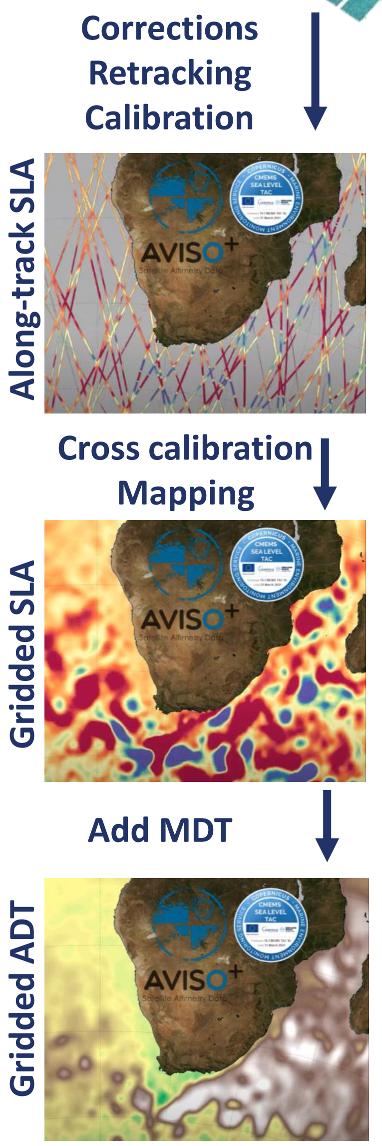
Regularly, the parameters of the processing chain are modified to improve the quality of the altimetry maps.

Recently, the processing version changed from DT2018 to DT2021 **[1]** are :

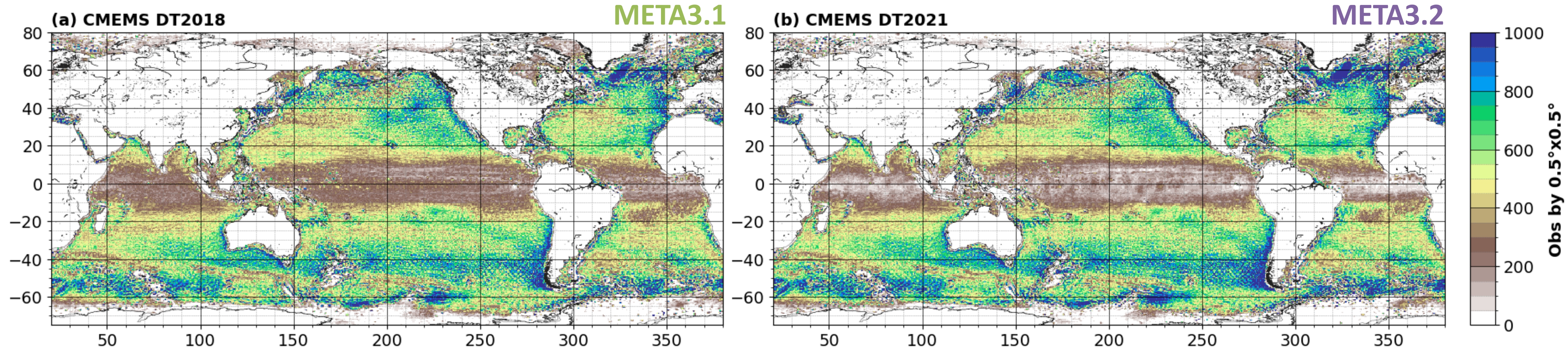
- New Mean Dynamic Topography (MDT) resolving shorter scales
- New Internal Tides correction
- Evolution of the correlation scales (Lx, Ly, Lt)
- Improvement of the ice-sea transition
- Changes in the energy near the Equator

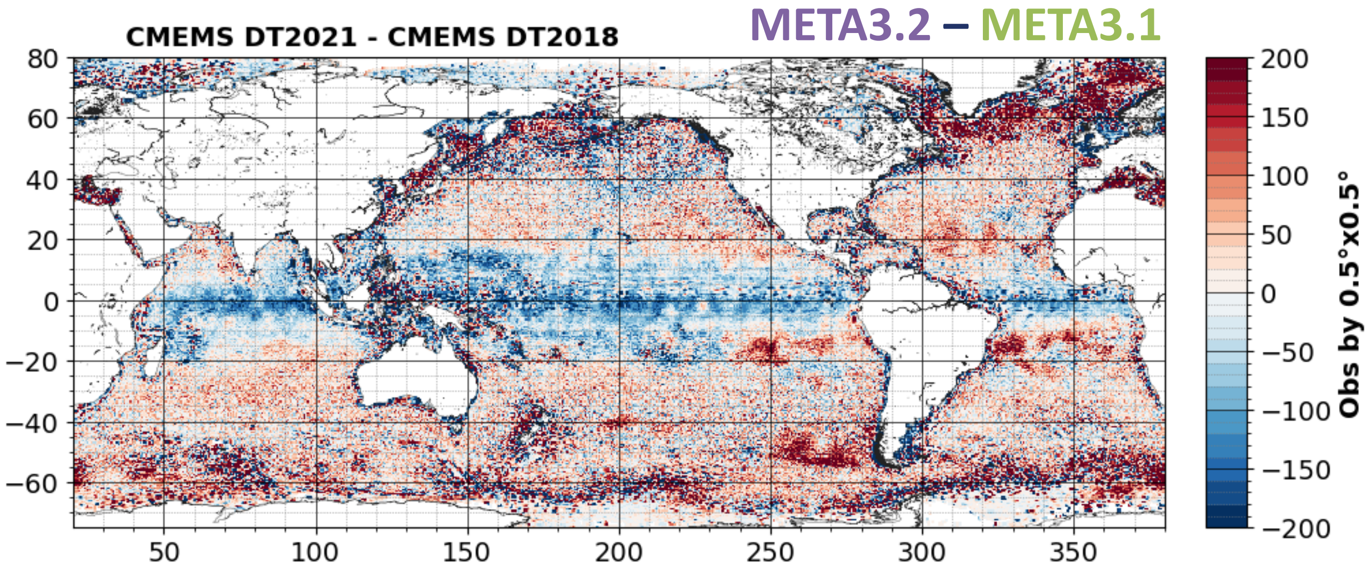
Statistics from **META3.1exp** illustrates the content of the **DT2018** maps, and **META3.2** illustrates the **DT2021** maps for the all-satellites version.

The maps available on the Copernicus Marine Service website are produced with the DT2021 reprocessing.



[1] Global Delayed Time SSH maps
SEALEVEL_GLO_PHY_L4_MY_008_047
https://doi.org/10.48670/moi-00148
https://catalogue.marine.copernicus.eu/documents/QUID/CMEMS-SL-QUID-008-032-068.pdf



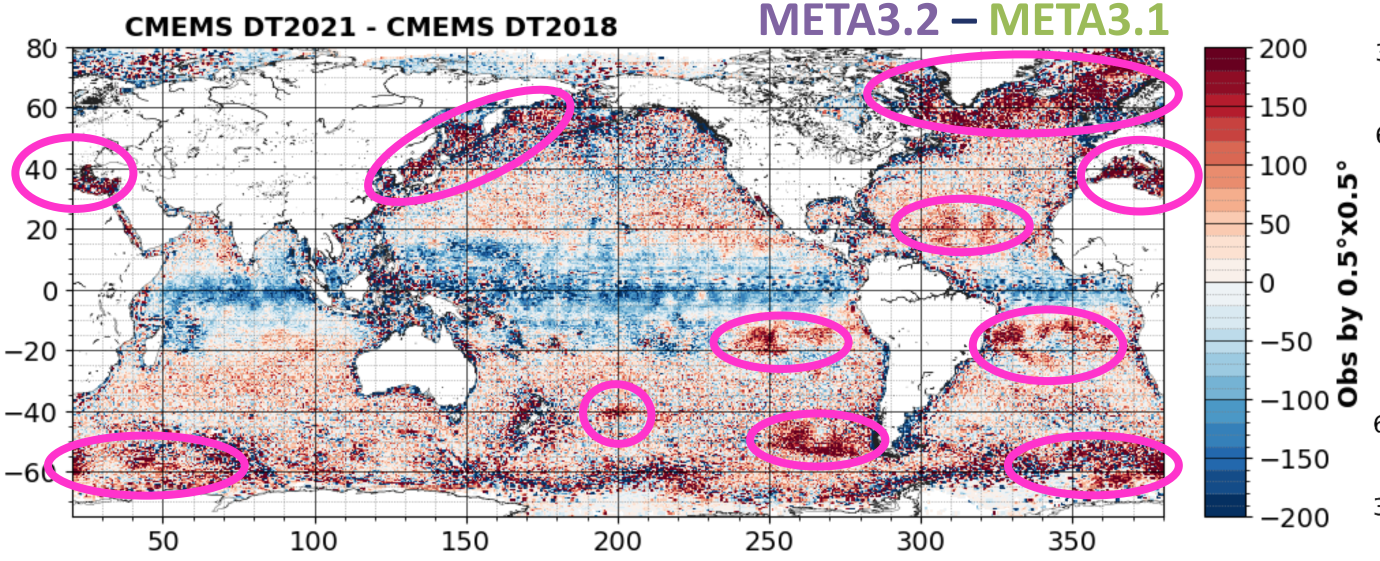


Top : number of eddy observations **centers** part of trajectories lasting more than 10 days in 0.5°x0.5° boxes, detected from (a) **DT2018** and (b) **DT2021** Absolute Dynamic Topography daily maps from January 1993 to March 2020.

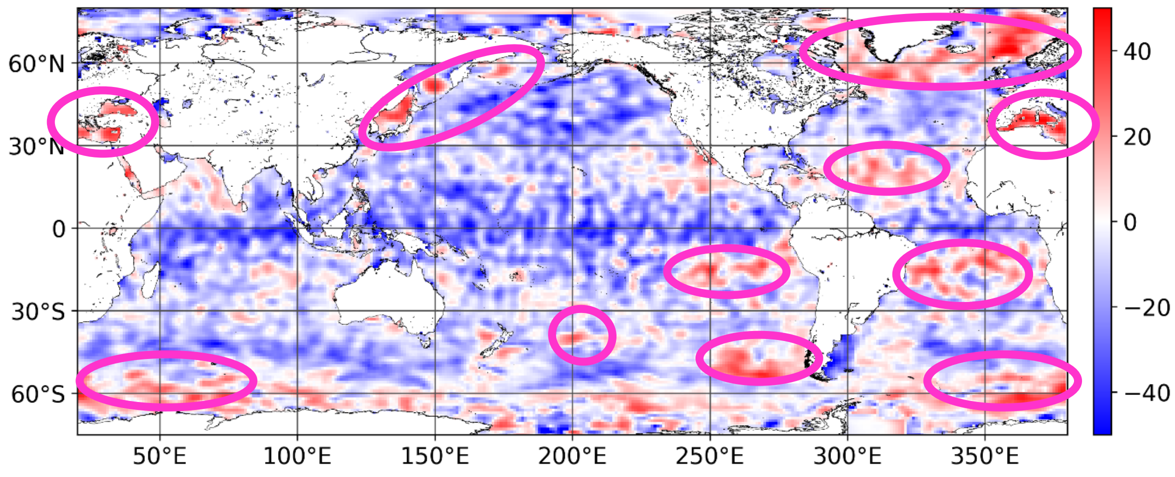
Bottom : Difference of **DT2021** and **DT2018**. Red correspond to more eddy observations in from **DT2021** (**META3.2**), blue to more eddy observations in **DT2018** (**META3.1**).

From META3.1exp (DT2018) to META3.2 (DT2021) : Lx and Ly changes

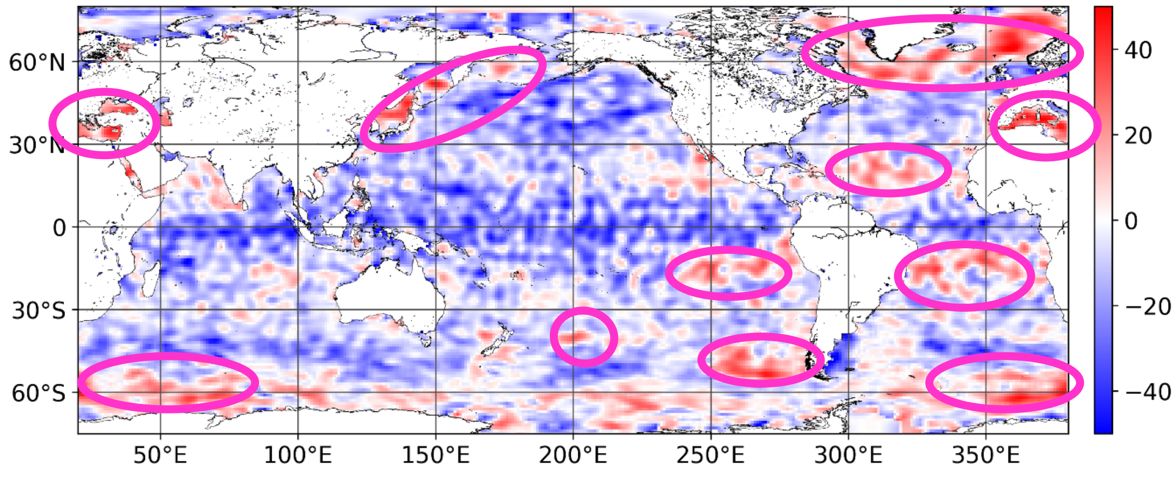
META3.2 – META3.1



Diff Lx (DT2018 – DT2021)/DT2018 (%)



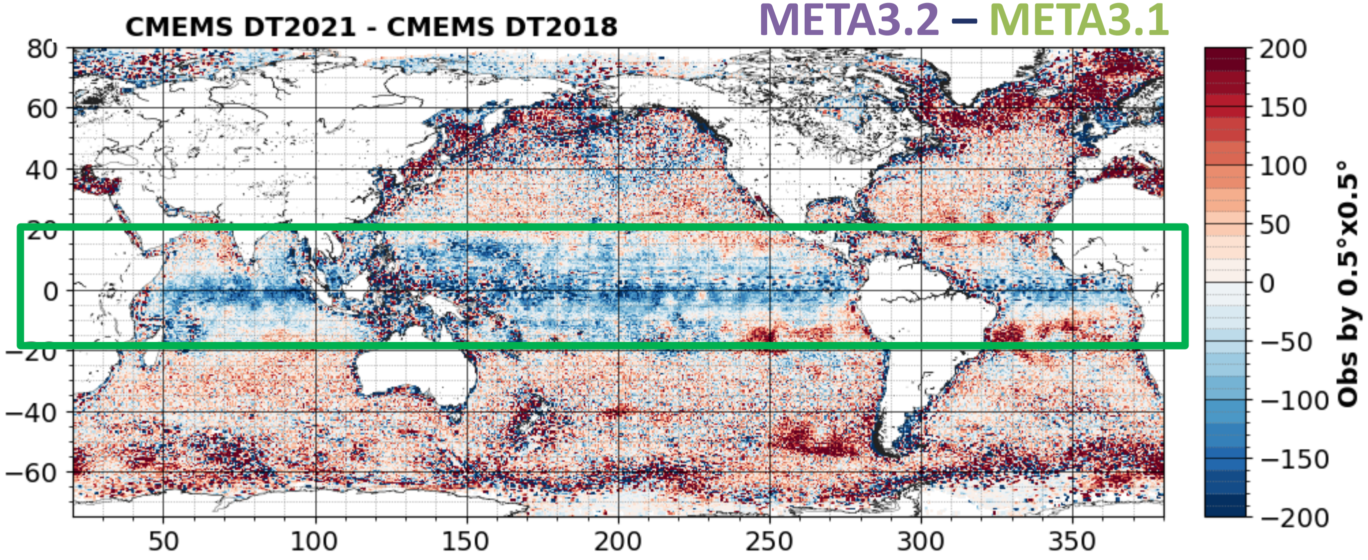
Diff Ly (DT2018 – DT2021)/DT2018 (%)



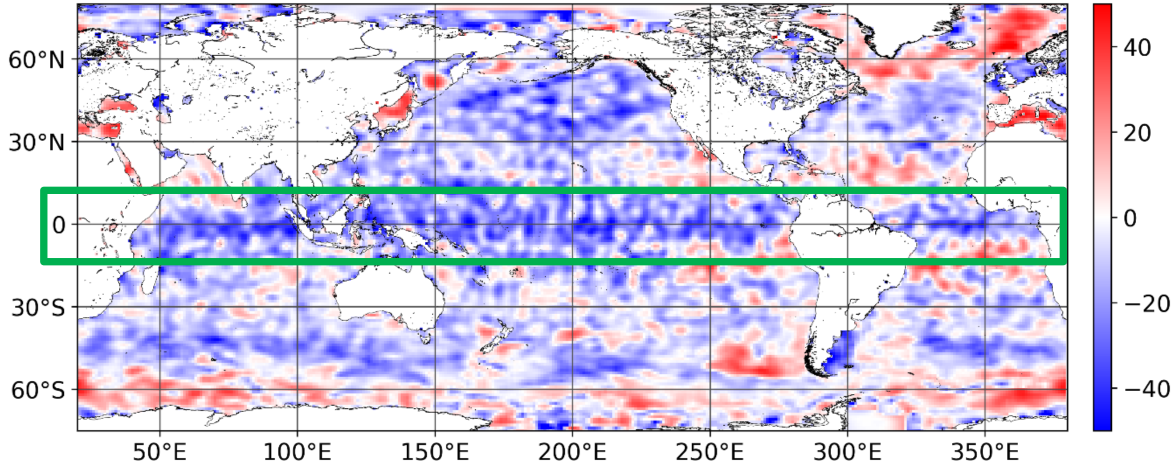
Lx and Ly are the longitude and latitude decorrelation scales used to produce the maps.

From META3.1exp (DT2018) to META3.2 (DT2021) : Lx and Ly changes

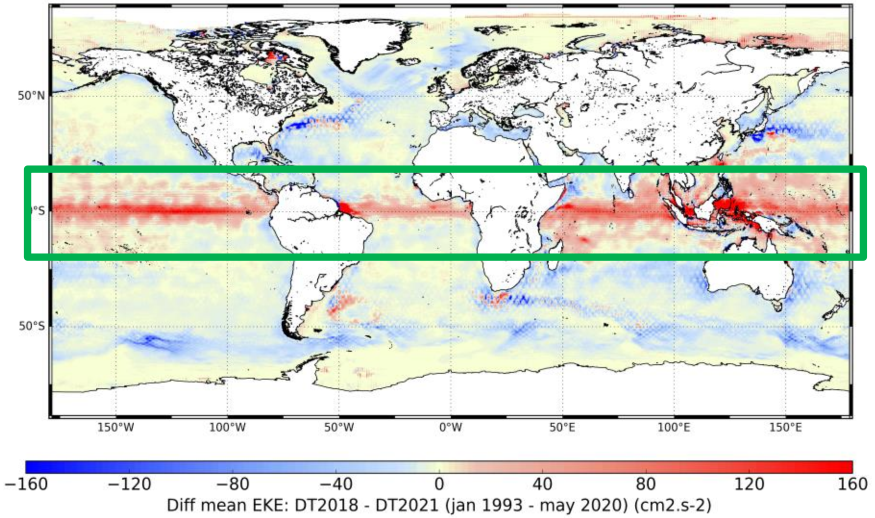
META3.2 – META3.1



Diff Lx (DT2018 – DT2021)/DT2018 (%)



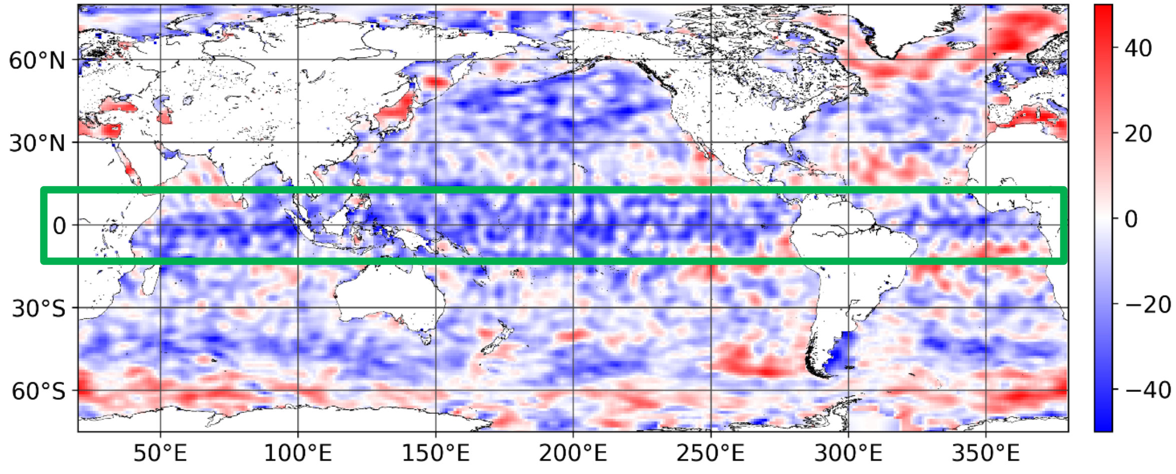
Diff of mean EKE DT2018 – DT2021



More EKE in DT2021

More EKE in DT2018

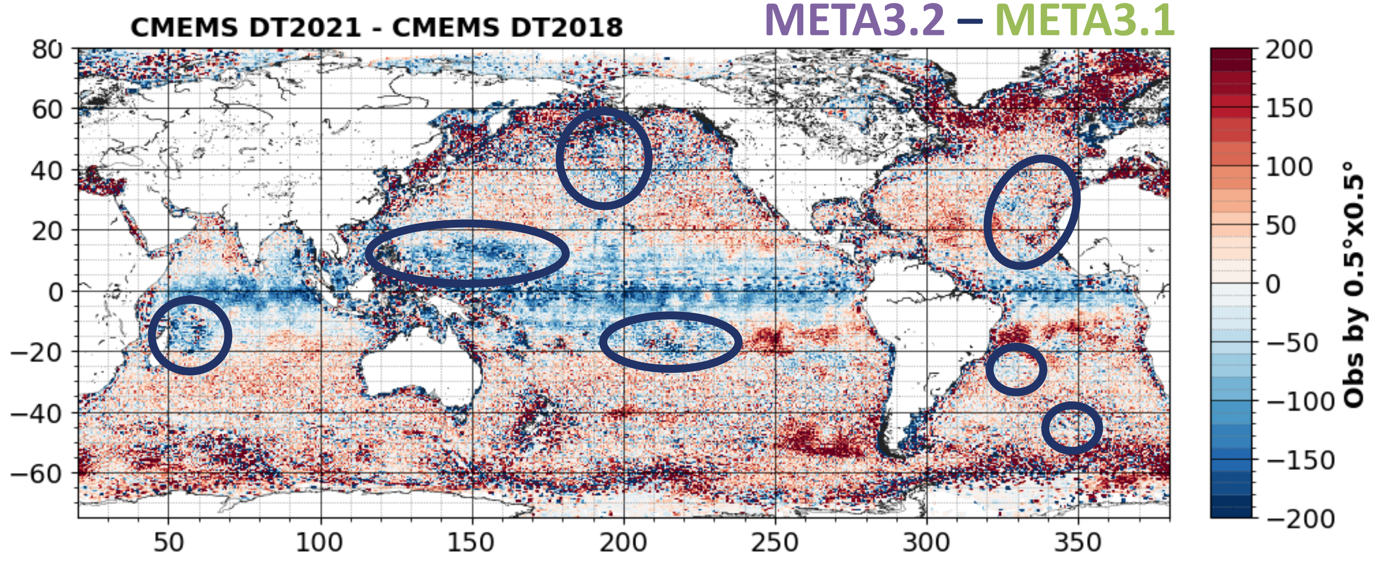
Diff Ly (DT2018 – DT2021)/DT2018 (%)

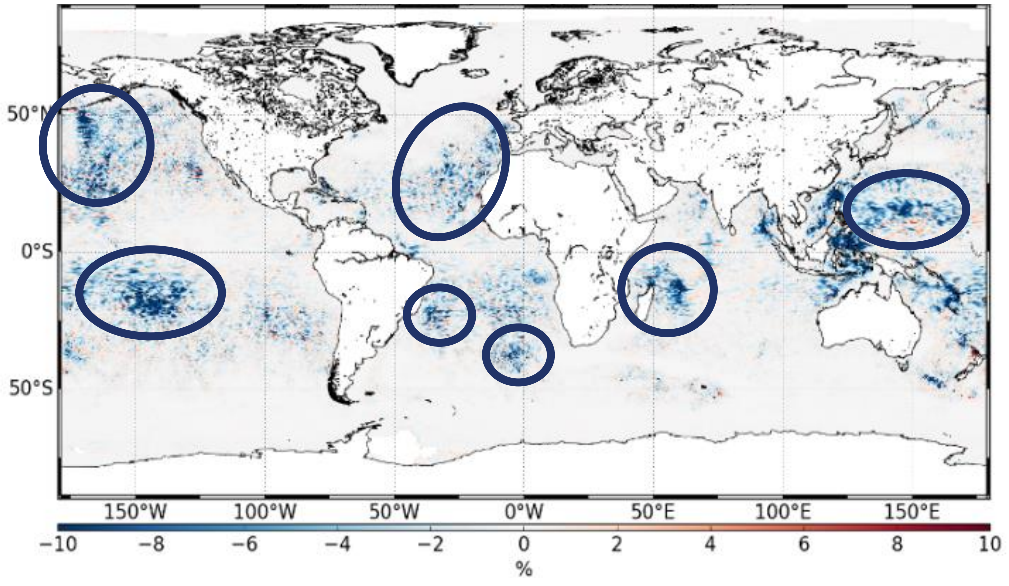


From META3.1exp (DT2018) to META3.2 (DT2021) : internal tides correction

EKE reduction (%) when applying Internal Tide correction
DT2021 – DT2018
12/04/2014 - 31/12/2015

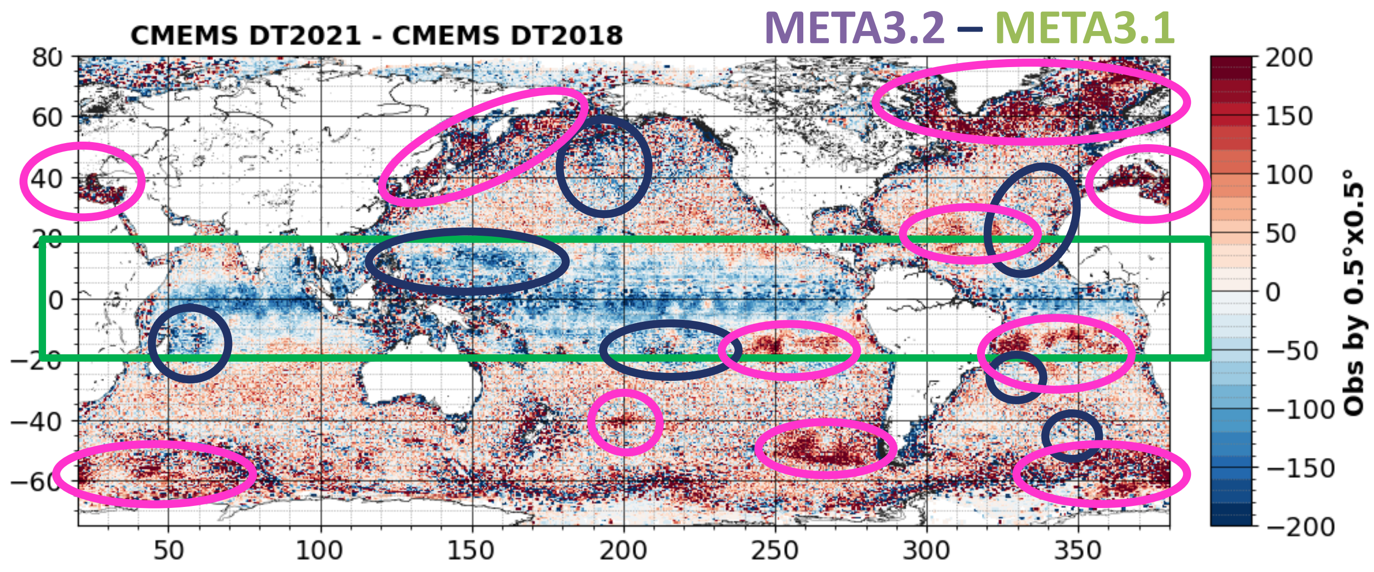
META3.2 – META3.1





Less EKE due to the Internal Tide correction in **DT2021** → Less detected eddies in **META3.2**

From META3.1exp (DT2018) to META3.2 (DT2021) : summary



→ More eddies are detected in **META3.2** due to a better representation of the mesoscale from Lx and Ly adjustments in DT2021

→ Less eddies are detected in **META3.2** in the Equatorial Band because of the reduction of the EKE in the DT2021 reprocessing due to the increase of the decorrelation scales

→ Less eddies are detected in **META3.2** in the areas where the internal tide correction decreases the EKE in DT2021

Evolution to a representation with Networks

Use META3.2 detected eddies

META4.0exp – Networks : construction

Eddy association : overlap of the contours

- Test if

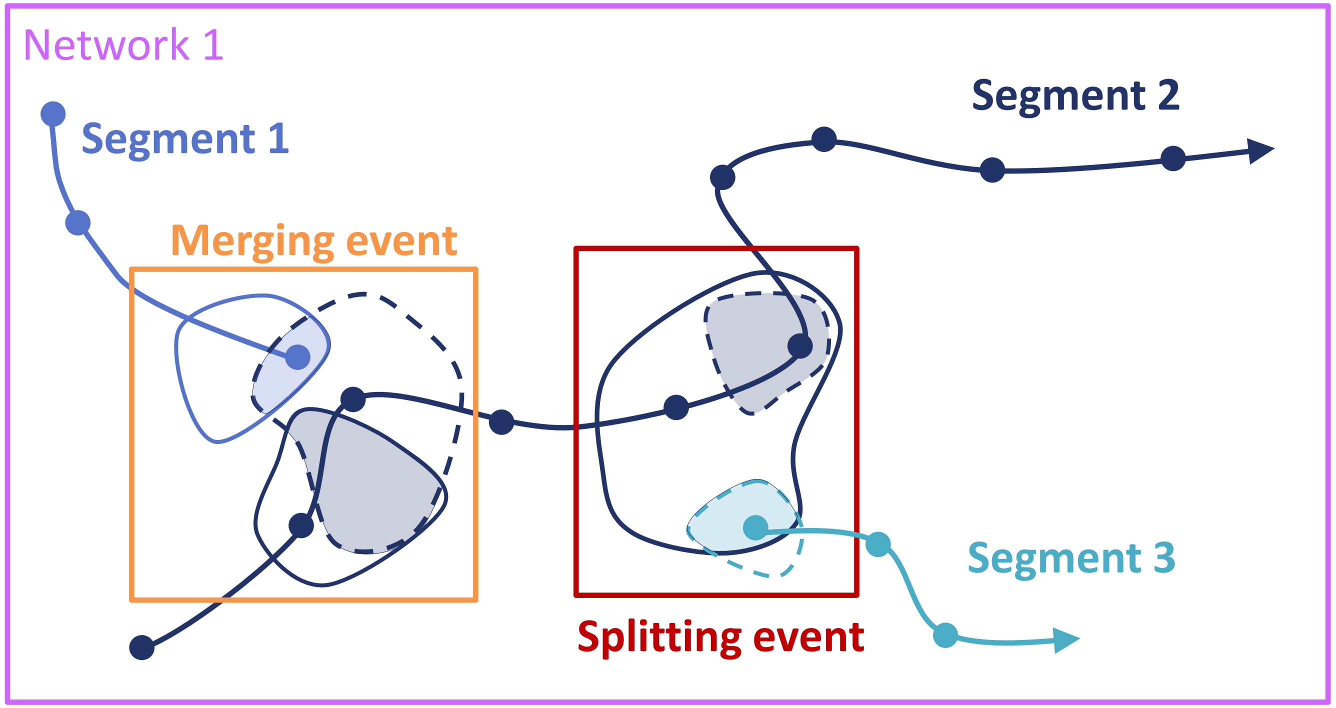
$$Overlap\ Ratio_{union} = \frac{\text{Area}\,(\text{Eddy}_t)\ \cap \text{Area}\,(\text{Eddy}_{t+dt})}{\text{Area}\,(\text{Eddy}_t)\ \cup \text{Area}\,(\text{Eddy}_{t+dt})} \geq\ 10\ \%$$

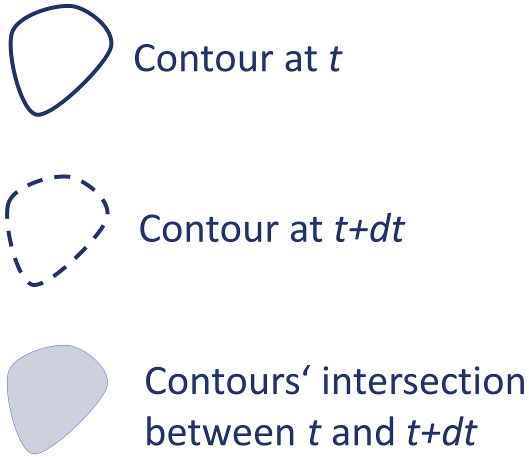
- If not, test

$$Overlap\ Ratio_{minimal\ area} = \frac{\text{Area}\,(\text{Eddy}_t)\ \cap \text{Area}\,(\text{Eddy}_{t+dt})}{\min(\text{Area}\,(\text{Eddy}_t),\text{Area}\,(\text{Eddy}_{t+dt}))} \geq 99\ \%$$

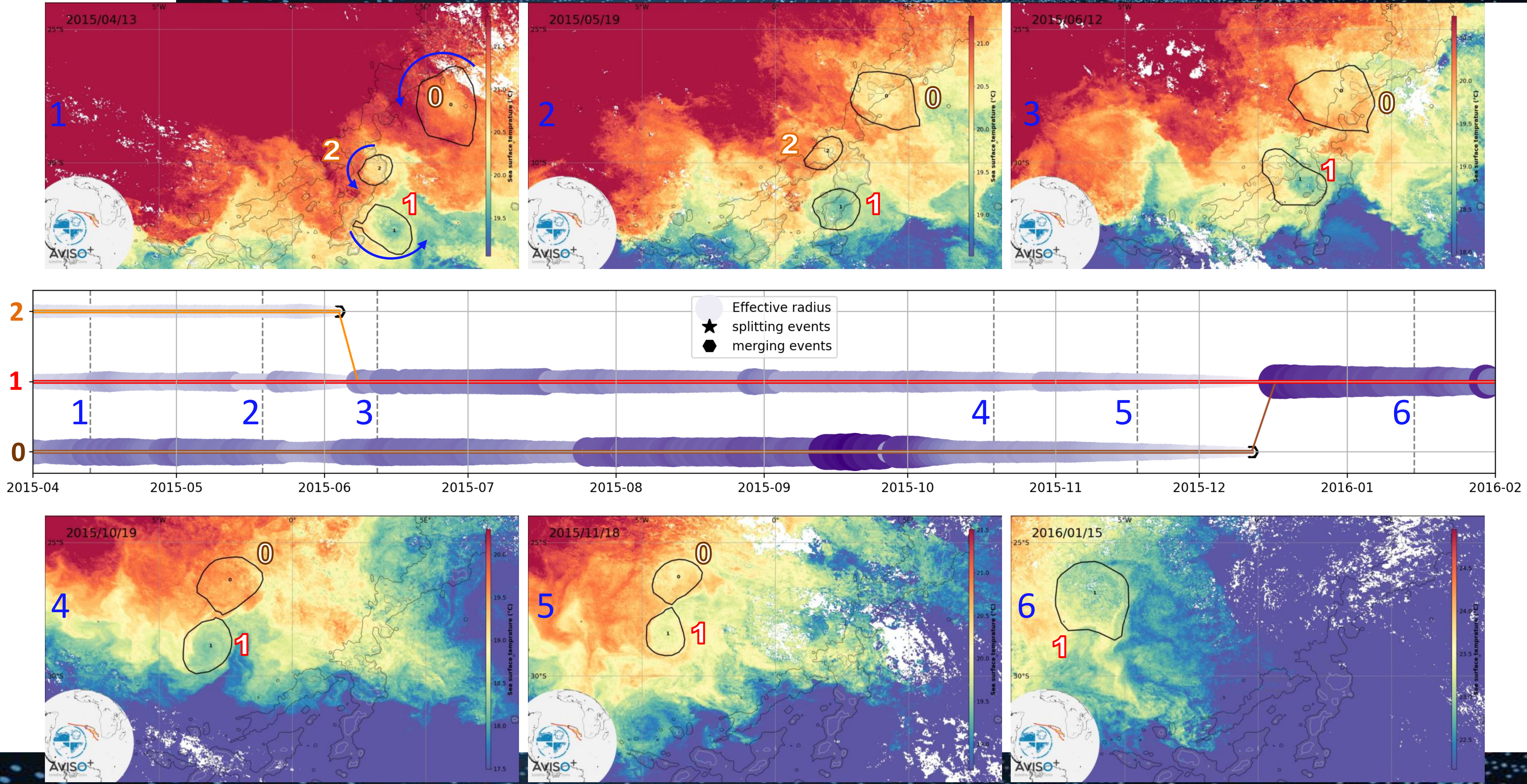
Network with a unique segment

Network experiencing a merging and a splitting event





Aghulas Merging 2015/2016 with SST in °C (https://youtu.be/d4Wur6FjpeY)



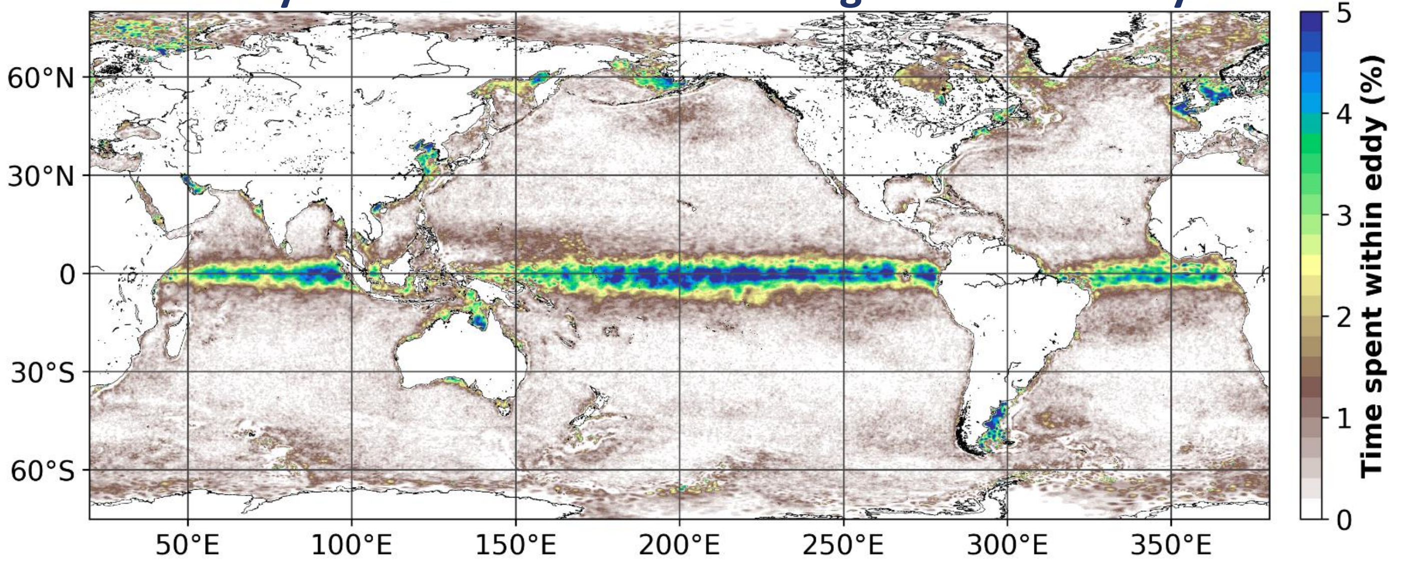
META4.0exp – Networks : global statistics

For the period 1993 – 2022 :
~2.1 million networks
~2.8 million segments
~72 million detected eddies (~2,5 million by year)

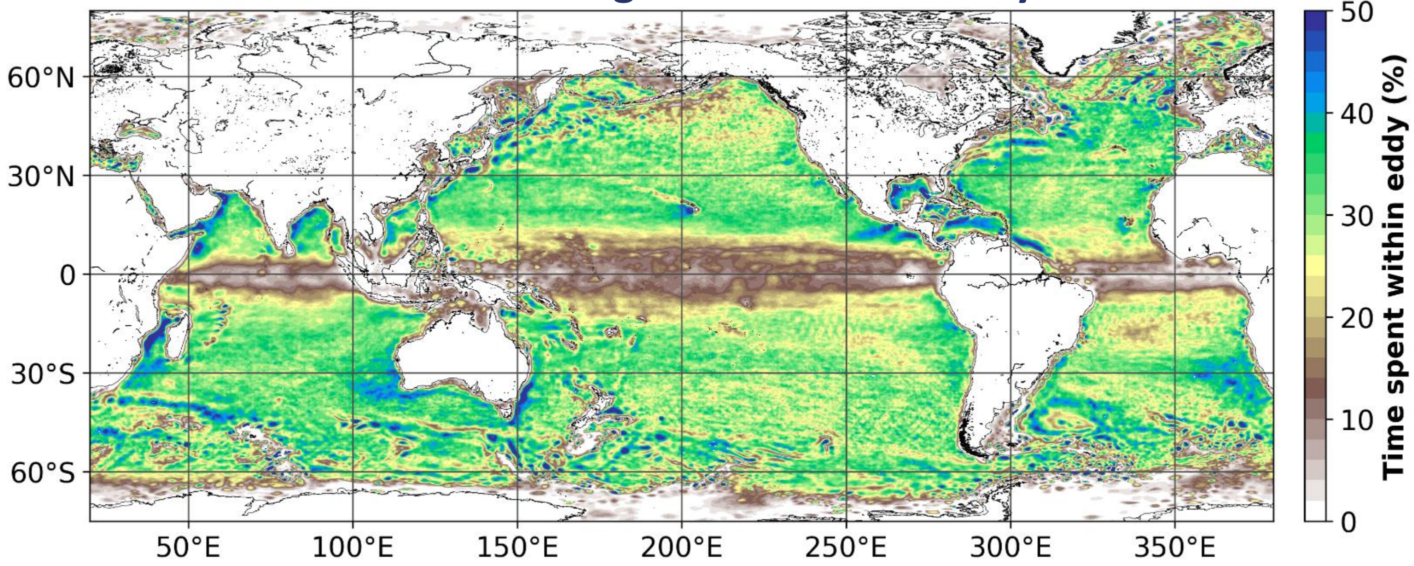
Lonely eddies and networks lasting less than 10 days :
~0.9 million networks
~1.1 million segments
~4 million detected eddies (5% of the dataset)
Location :
- In the Equatorial Band
- In shallow areas
- At high latitudes

Networks lasting at least 10 days :
~1.2 million networks
~1.7 million segments
~68 million detected eddies
Location :
- In the major currents
- In known eddy favorable areas
- Very few in the Equatorial Band

Lonely eddies and networks lasting less than 10 days



Networks lasting at least than 10 days



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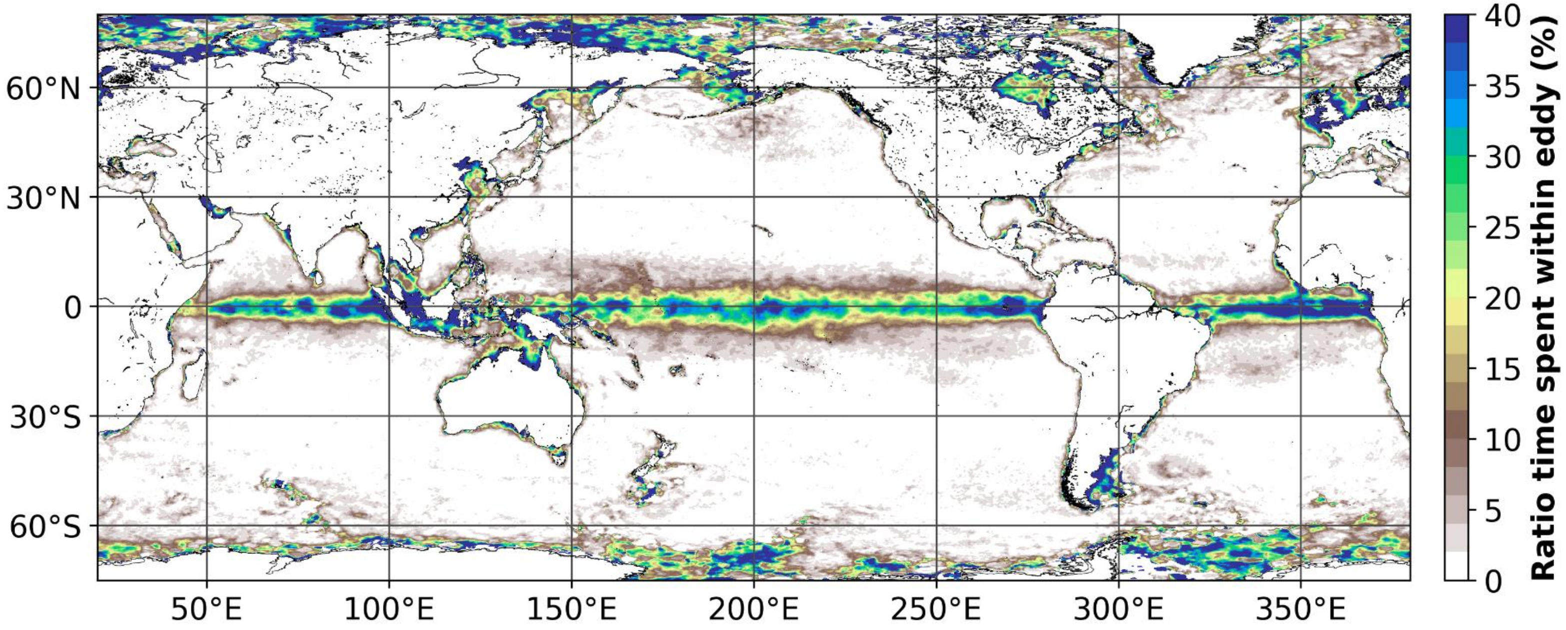
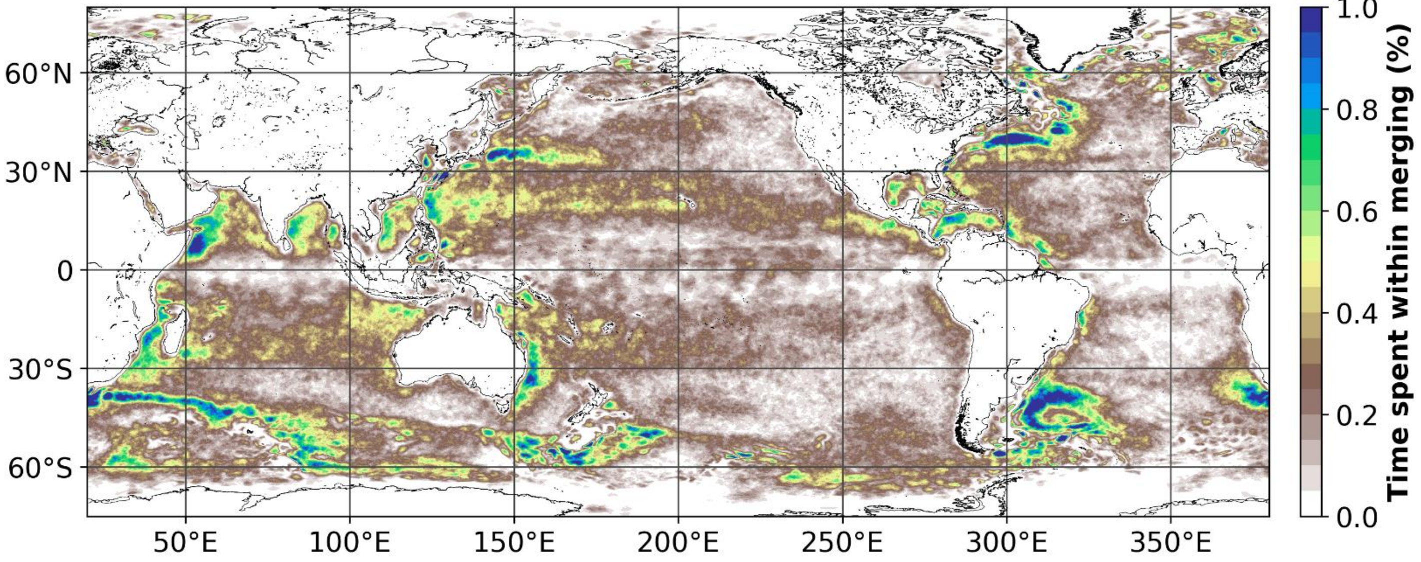
Ratio short / all networks



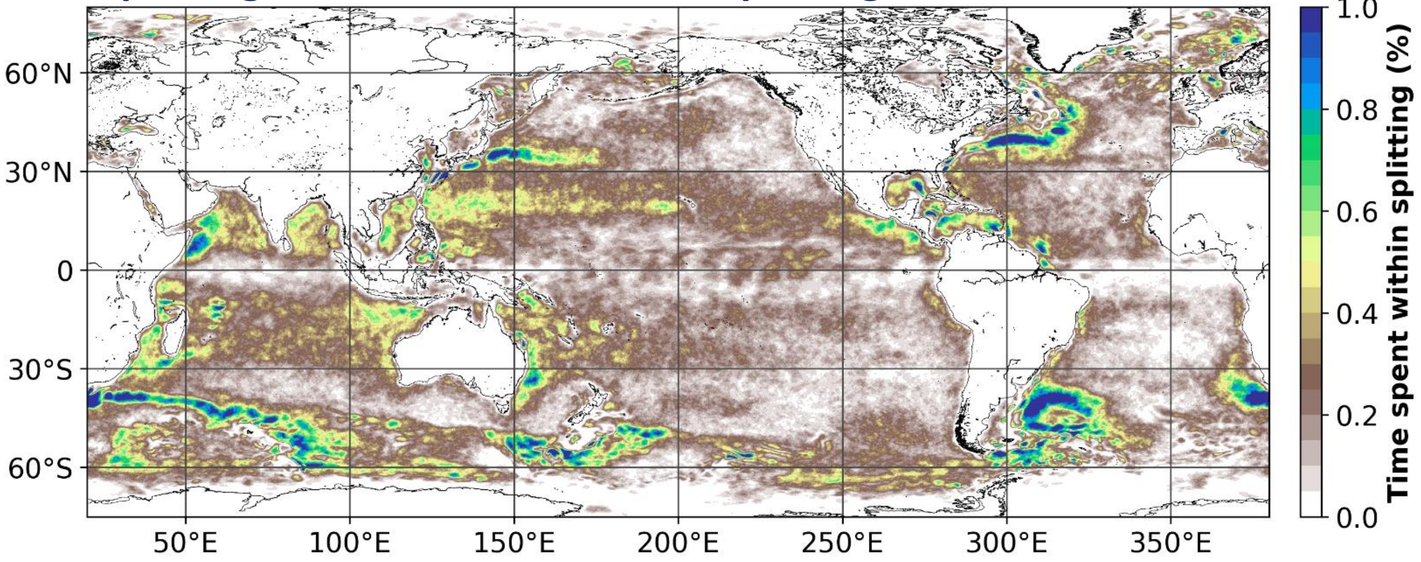
META4.0exp – Networks : global statistics

Interactions in networks lasting more than 10 days :
83% Networks with no interactions
~280 000 merging events
~280 000 splitting events
~95% of the events occur in networks lasting more than 30 days

Merging events eddies after merging



Splitting events : eddies before splitting



Conclusions

Conclusions : publication and accessibility

META2.0 → **META3.1exp – META3.2**

Don't use it anymore

Publication in ESSD https://doi.org/10.5194/essd-14-1087-2022

META3.1exp : A new Global Mesoscale Eddy Trajectories Atlas derived from altimetry

Recommended for scientific applications

Eddy dataset

Product	Satellite	DOI	Authenticated access service	Frequency	Data period	Handbook
Merged version 3.2 delayed-time	allsat	10.24400/527896/a01-2022.005.220209	see your MY AVISO+	yearly	From Jan 1993 to February 2022	Handbook
	twosat	10.24400/527896/a01-2022.006.220209				
	allsat	10.24400/527896/a01-2022.005.210802	Available on demand (aviso@altimetry.fr)	-	From Jan 1993 to August 2021	Handbook (1rev0)
	twosat	10.24400/527896/a01-2022.006.210802				

Data access on AVISO : https://www.aviso.altimetry.fr/en/data/products/value-added-products/global-mesoscale-eddy-trajectory-product/meta3-2-dt.html

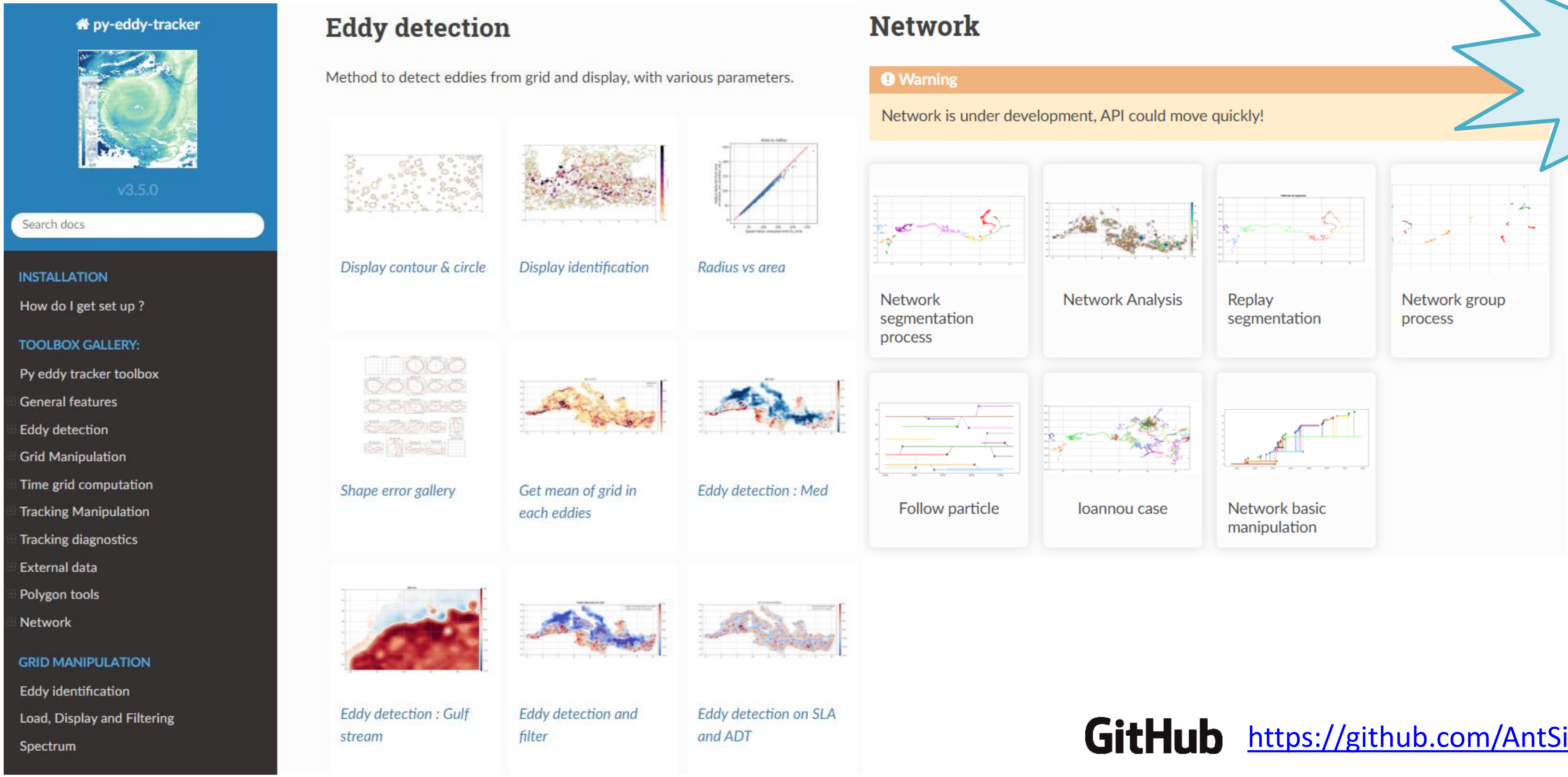
- Regular temporal updates
- DOIs for the different versions
- Handbook
- Newsletter when a new dataset is released

Conclusions : publication and accessibility

META4.0exp – Networks

Online documentation :

[Welcome to py-eddy-tracker's documentation! — py-eddy-tracker v3.6.0+27.g9d408e5.dirty documentation]


py-eddy-tracker

v3.5.0

Search docs

INSTALLATION

How do I get set up ?

TOOLBOX GALLERY:

Py eddy tracker toolbox

General features

Eddy detection

Grid Manipulation

Time grid computation

Tracking Manipulation

Tracking diagnostics

External data

Polygon tools

Network

GRID MANIPULATION

Eddy identification

Load, Display and Filtering

Spectrum

Eddy detection

Method to detect eddies from grid and display, with various parameters.

Display contour & circle | *Display identification* | *Radius vs area* | *Shape error gallery* | *Get mean of grid in each eddies* | *Eddy detection : Med* | *Eddy detection : Gulf stream* | *Eddy detection and filter* | *Eddy detection on SLA and ADT*

Network

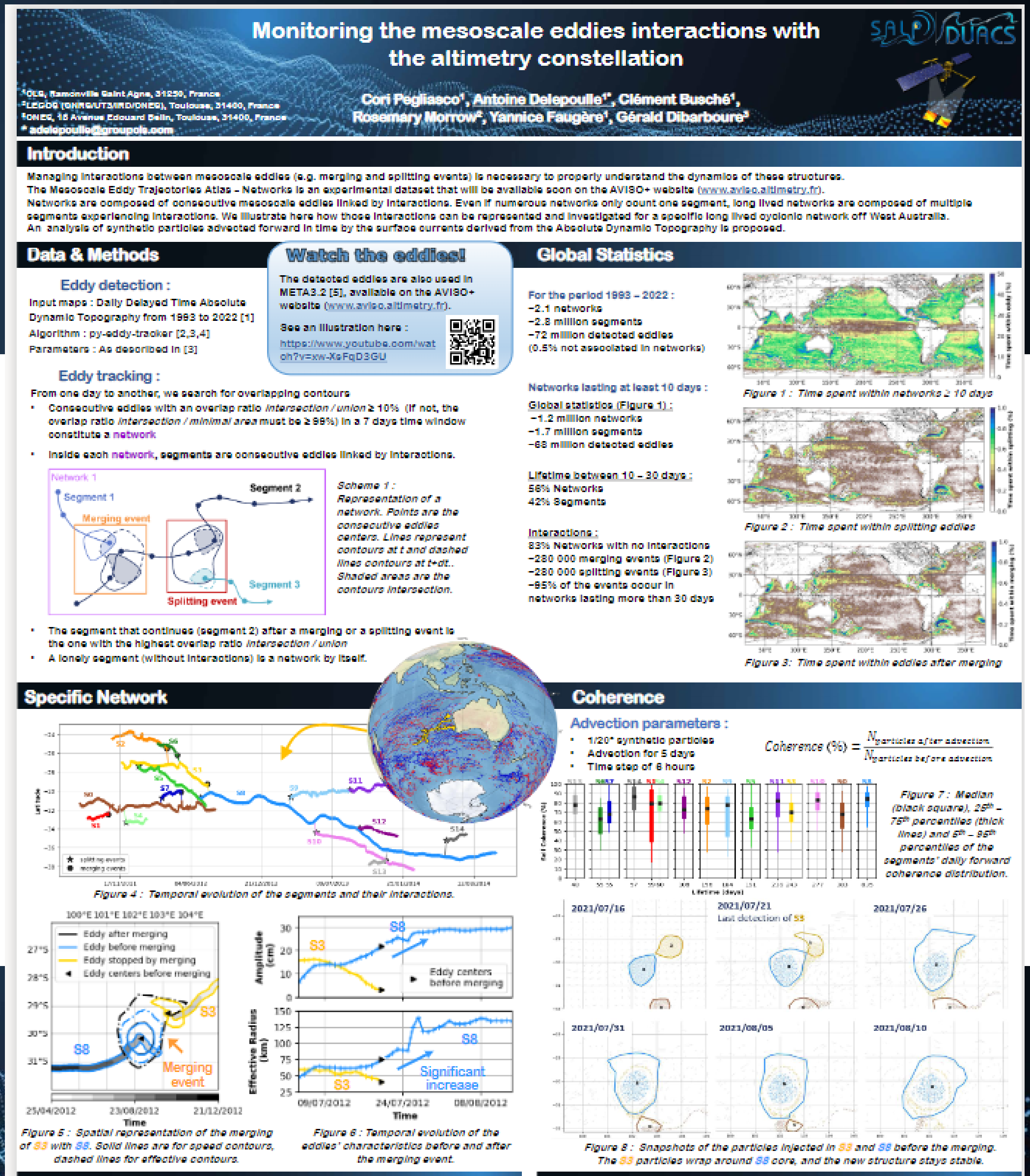
Warning

Network is under development, API could move quickly!

Network segmentation process | Network Analysis | Replay segmentation | Network group process | Follow particle | Ioannou case | Network basic manipulation

Try it!

GitHub https://github.com/AntSimi/py-eddy-tracker



Questions ?

More informations about networks :
poster SC32022_009 - Monitoring the mesoscale eddies interactions with the altimetry constellation

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