Ocean Surface Topography Science Team (OSTST) meeting 2022

Global assessment of mesoscale eddies with TOEddies; Comparison between multi-datasets and co-location with in-situ measurements

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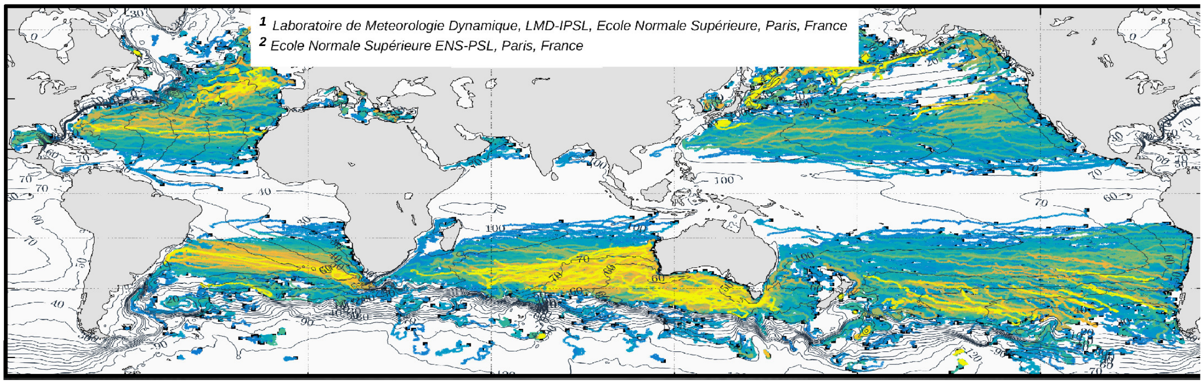
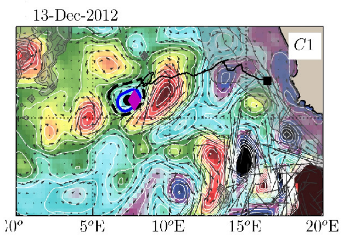


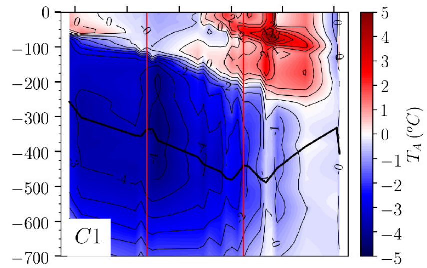
Hello, I am Artemis and I would like to present you part of our work on global assessment of mesoscale eddies from multi-datasets and especially with the TOEddies global eddy database.

Mesoscale eddies

- shape the oceanic seascape – typical scales of O(~100km horizontally) and O(1-1000m vertically)
- displacement and tilting of isopycnals due to rotation (uplifting/deepening) -impact on phytoplakton distribution
- ability to capture and transport waters masses from the area of their formation



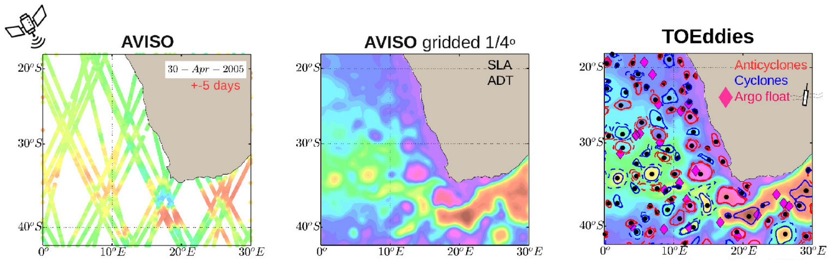
(Ioannou et al. 2022)



the mesoscale eddies accurate description requires both **horizontal and vertical information!**

I would like to start with these figures that show on the left the sea surface topography of the ocean for a given day together with the tracking of a cyclonic eddy that has pinched off the Benguela upwelling current system (BCUS). On the right we have the vertical evolution of the temperature anomaly as detected for this cyclone from several Argo floats trapped in its core (**Ioannou et al.**, **2022**).
Motivation to our work is the fact that the accurate description of mesoscale dynamics requires combined and complex information on the horizontal and vertical ocean!
Till now most eddy identification and tracking techniques usually extract only horizontal information on mesoscale eddies based on satellite altimetry.

Identifying eddies based on satellite altimetry



(Laxenaire et.al 2018)

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Satellite altimetry remains a powerful tool to monitor continuously the oceanic surface. Multiple satellites tracks that cross a given area are combined to provide in an optimum way the daily oceanic topography fields. From this altimetric observation dynamical information for mesoscale eddies can be derived based on the different automatic detection and tracking algorithms used. The question that remains is "which global Atlas should we use?"

which **global eddy Atlas** to use?

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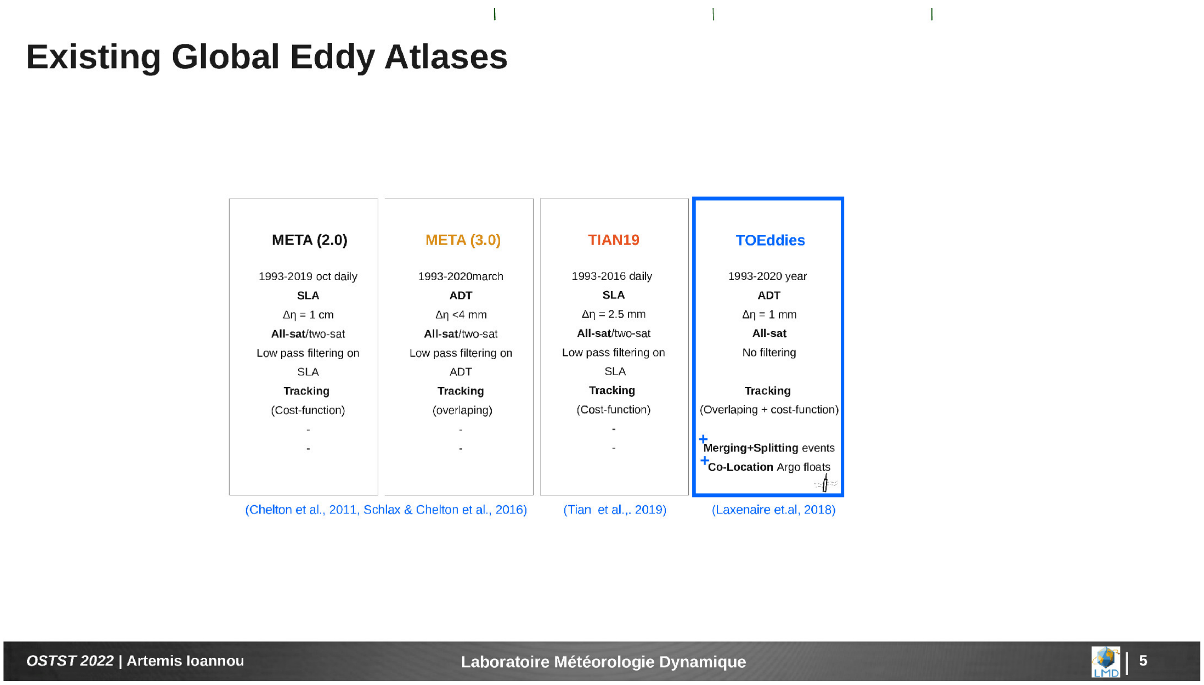
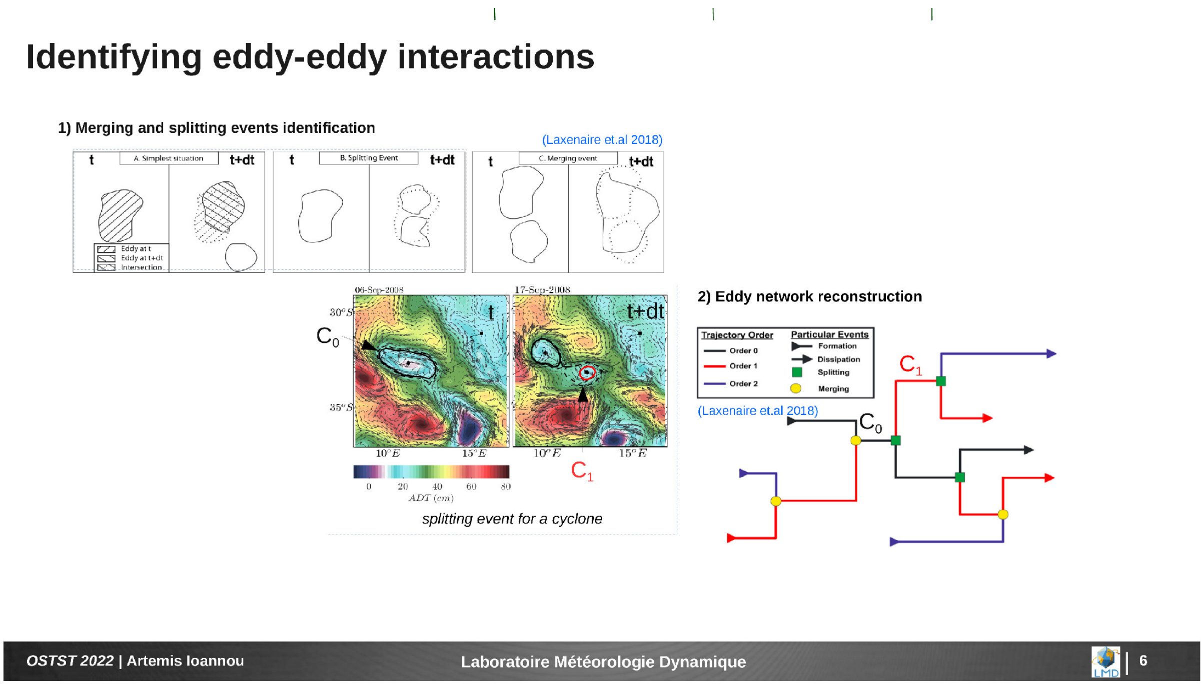
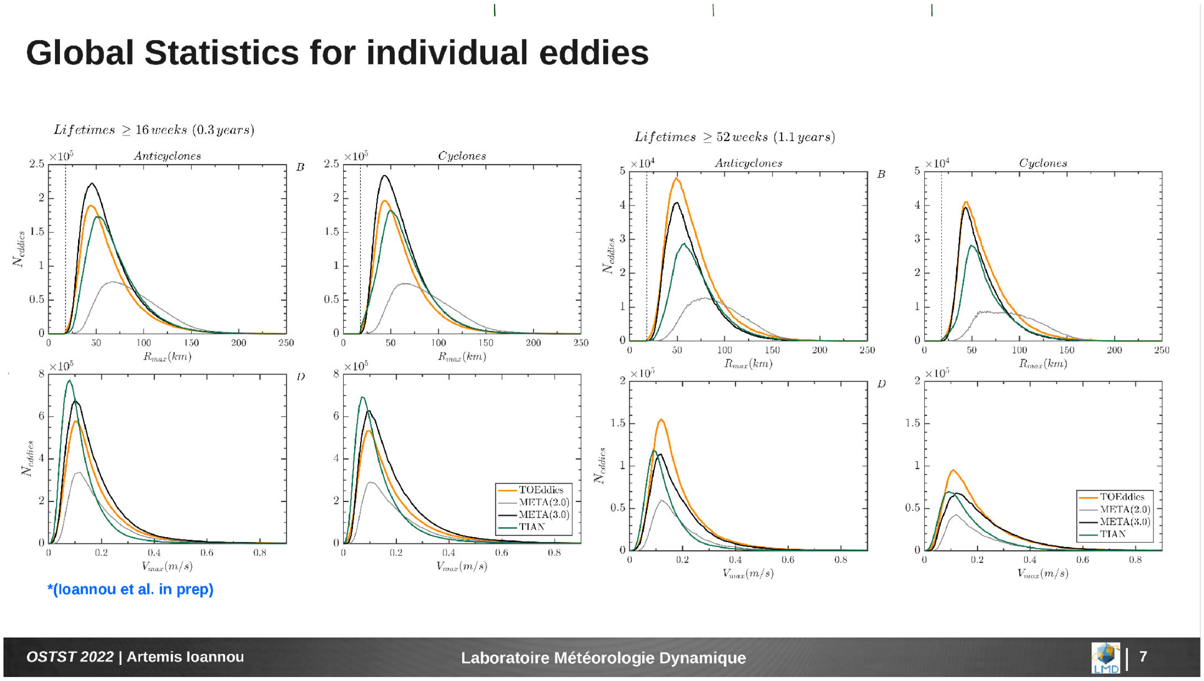


We select few global eddy atlases that are currently available and provide global information on mesoscale eddies. There is a variety of different techniques that are implemented. Some of the main different criteria that are used to characterize the mesoscale eddy field are highlighted here.
In our work we choose TOEddies database to characterize and follow mesoscale eddies! This is because TOEddies uses daily satellite observations of Absolute Dynamic Topography instead of Sea Level Anomalies, implements the smallest eddy persistence criterion (η = 1 mm) as well as it has been tested against an independent dataset of drifters (**Laxenaire et al., 2018**). It additionally provides information on splitting and merging events and co-location with Argo floats.

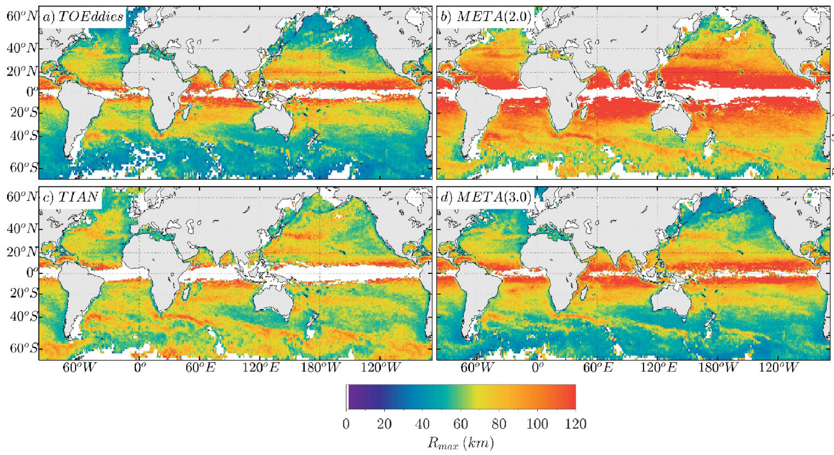


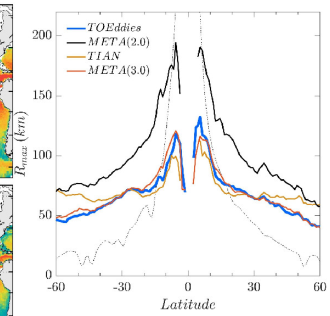
TOEddies is among the few algorithms (**Le Vu et al.**, **2018**; **Cui et al.**, **2019**) that is able to identify such eddy-eddy interactions. By assigning orders to eddy trajectories a complex eddy network is created that allows for an original assessment of the main eddy routes. It additionally combines vertical information on eddies by co-locating available Argo-floats measurements with the eddy positions. If you want to find out more about TOEddies Atlas your are welcome to go the poster APO2022_009 !



A statistical comparison on the main eddy characteristics from the different Atlases is shown here. On the left all mesoscale eddies with more than 16 weeks are taken into account and on the right eddies of lifetimes more than 52 weeks. TOEddies is able to detect more long-lasting eddies that are characterized also by increased velocities in comparison with the other datasets.

Global Spatial Statistics of Eddy Scales





*(Ioannou et al. in prep)

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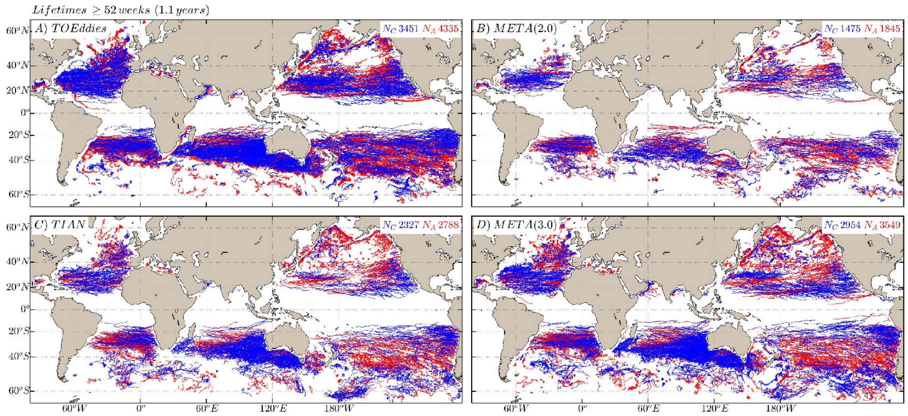
The geographical distribution of the radii of eddies is shown in this figures in order to identify areas of main differences between the datasets. For a suitable comparison, zonal averages of the eddy radius are computed in the right panel. In all datasets, smaller eddies are detected near the poles while larger ones near the equator following the first baroclinic Rossby Radius which varies strongly with latitude. Nevertheless the absolute values of the eddy radius differ between the datasets with TOEddies and META3.0 to agree better on eddy scales.

Dynamical evolution of long-lived eddies



*(Ioannou et al. in prep)

Mesoscale eddies can be large, intense but also long-lived and long-propagating. This Figure compares the eddy trajectories globally with lifetimes more than 52 weeks. Blue colors indicate cyclonic trajectories and red anticyclonic. In all datasets, the majority of long-lived eddies are found to propagate westward, while eastward propagating eddies and they correspond mainly to eddies tracked in the Antarctic Circumpolar Current (ACC) and in the North Atlantic (above 40N). The number of anticyclonic trajectories exceeds the number of the cyclonic ones in all datasets. However, in total numbers TOEddies Atlas tracks more eddies.

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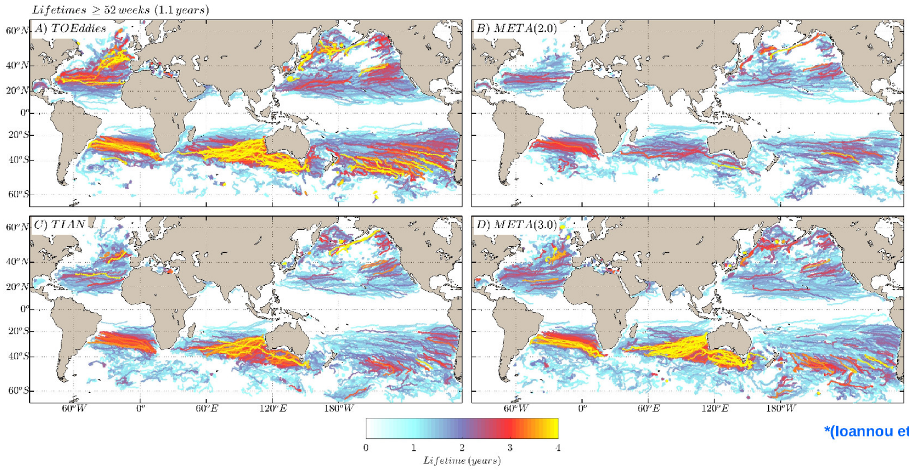
Comparing lifetimes of eddies



*(Ioannou et al. in prep)

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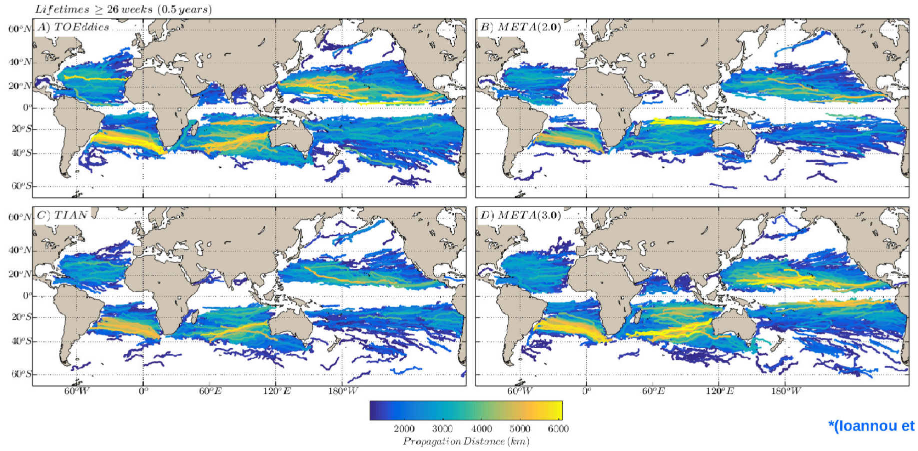
Eddy trajectories are also sorted here based on their estimated lifetimes. Every dataset seems to identify a slightly different overview of the main eddy trajectories. Such differences are especially marked in the North Atlantic as well as the North and South Pacific.

Comparing long-propagating eddies

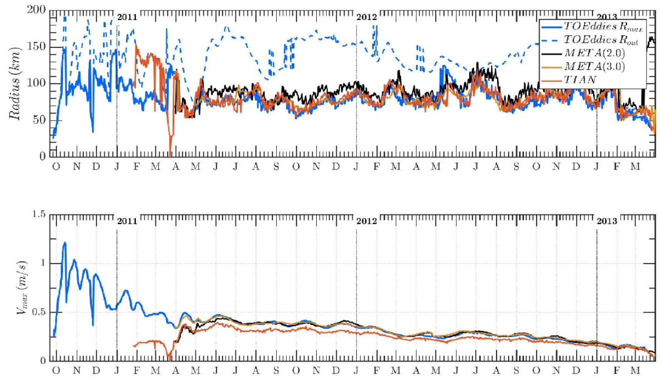


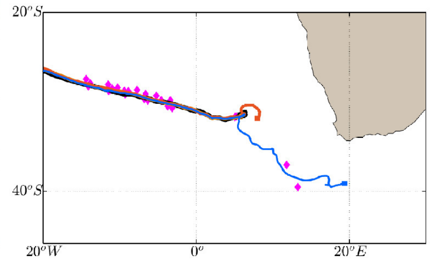
*(Ioannou et al. in prep)

similarity percentages between the datasets remain less than 25%

Eddy trajectories are also sorted based on their estimated propagation distance. Only eddies tracked for more than 26 weeks are considered. We tested the similarity of different eddy trajectories comparing similar spatiotemporal evolution of eddies. The similarity percentages remain less than 25% between the datasets. Similarities were found even lower for cyclonic trajectories.

A specific eddy example

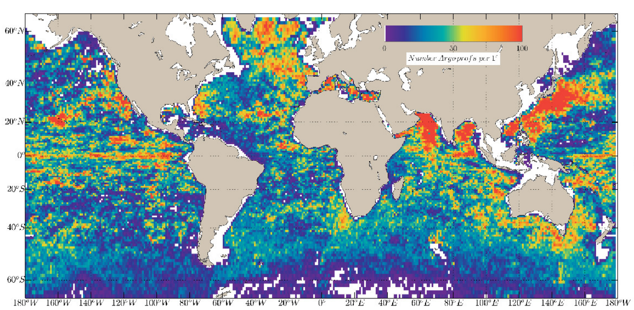


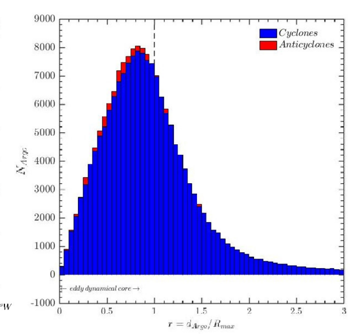


This is an example of a single anticyclone as tracked from the different algorithms. TOEddies can follow the anticyclone longer and provide more information on its dynamical evolution. Moreover it provides information on the available Argo-floats (magenta points).

Co-location of eddies with Argo floats

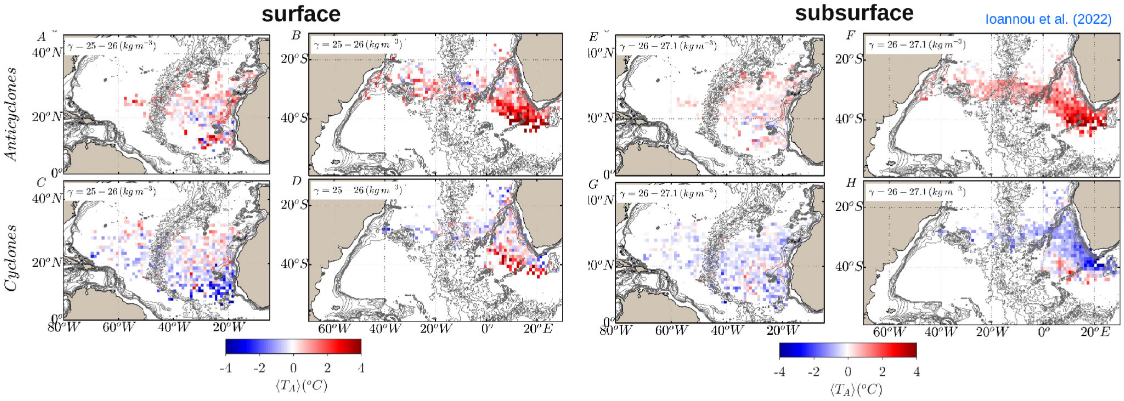
- More than 1.100.000 co-localized argo profiles
- 30% of Argo floats sample eddies (~49/51% of which detected inside cyclones/anticyclones)





The total global Argo-float distribution is shown here. More than 1 million Argo profiles are co-localised with eddies. The relative position of the Argo floats from the estimated eddy centers is shown on the right figure. The largest percentage of Argo measurements sample eddies inside their dynamical core at radial distances less than R_{max} .

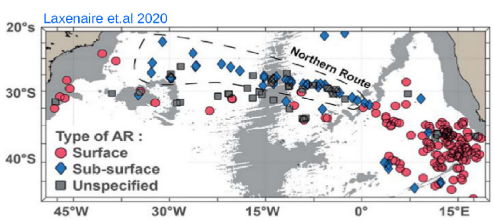
Surface vs Subsurface Connectivity signal

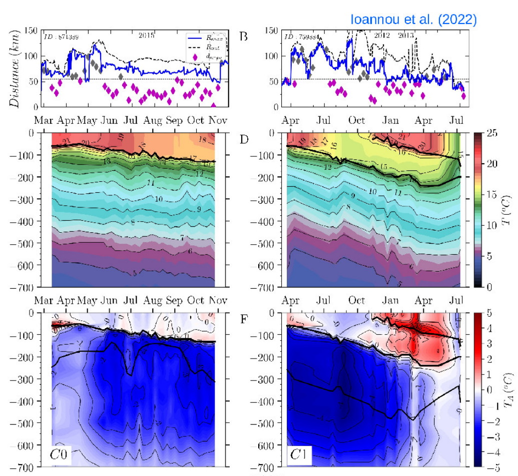


This combined (horizontal+vertical) information on mesoscale eddies allows us to investigate connectivity provided by eddies in surface but also the subsurface. This is shown in these figures for an eddy network build for mesoscale eddies associated with eastern upwelling origins (**Ioannou et al., 2022**). We found strong anomalies in subsurface layers!

Transitioning from surface to subsurface

- Surface signal of Agulhas Rings attenuates while subsurface one remains
- similar behavior found for BCUS cyclones





These are some specific examples of Agulhas anticyclones (**Laxenaire et al., 2018, 2019, 2020**) and BCUS cyclones (**Ioannou et al., 2022**) found to slowly transition to subsurface layers. This introduces a new challenge when identifying mesoscale eddies from satellite observations as the altimetric signal can capture as well as surface-intensified eddies and subsurface-intensified ones!

Conlusions & prespectives

TOEddies

1993-2020 year
ADT
$\Delta\eta$ = 1 mm
All-sat
No filtering

Tracking
(Overlaping + cost-function)

+ **Merging+Splitting** events
+ **Co-Location** Argo floats

- **TOEddies** is able to provide more relevant information on mesoscale eddies including
  - Dynamical evolution of eddy trajectories
    - Complex eddy-eddy interactions
      (eddy network instead of single eddy)
      - Co-location with Argo floats - vertical information

there is a significant part of the mesoscale in the **subsurface! You can explore it with TOEddies!**

Happy to discuss further!If you have any question just send me an email!

Thank you!

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References

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