

# Characteristics of Mesoscale Eddies in an Eddy-Permitting Ocean Model and Reanalysis Data

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# Introduction

- Mesoscale eddies are large, rotating masses of water, typically around 100km wide.
- They are a critical part of the climate system and play a significant role in regulating the exchange of heat and carbon in the atmosphere.
- Transport heat, salt, carbon, and other nutrients around the ocean.

# Motivation

- 1 Climate projections with eddying ocean components have only recently started to be more widely used.
- 2 Despite their critical role in understanding and forecasting climate characteristics, these eddy-permitting models have not been explored to verify that resolved eddies are realistic.
- 3 We aim to investigate how realistic these resolved eddies are by comparing them to observed eddies in altimetry data.

# SSH Datasets

- 1 Absolute Dynamic Topography (ADT) field from the Sea Level DT2024 dataset ( $1/4^\circ$  resolution) [1].
- 2 The zos field from the ORAS5 Reanalysis ( $1/4^\circ$  resolution) [2].
- 3 The zos field from the the GFDL-OM4 ocean model [3].  
(Provided by A. Adcroft)
  - The GFDL-OM4 zos field is regridded from a nominally  $1/4^\circ$  native tripolar grid to the same regular  $1/4^\circ$  grid that the ADT and ORAS5 use.

# Eddy Detection and Tracking with py-eddy-tracker (PET)

- Detects local SSH min/max and then locates closed contours around the extrema.
- If certain criteria regarding the contours and extrema are met then it is classified as an eddy.
- Tracking procedure is based on overlap between effective contours.
- We use the same detection and tracking parameters as the META 3.2 DT dataset [4].

# Daily Eddy Detections and Eddy Trajectories

To address concerns about the resolution of the altimetry maps used we only consider eddies that live for at least 6 weeks and that are outside of the equatorial band  $15^\circ$  S -  $15^\circ$  N.

Metric	Cyclonic	Anticyclonic
Average Daily Eddy Detections (DEDs) per Year ADT	751,690	723,337
Average Daily Eddy Detections (DEDs) per Year ORAS5	609,354	573,036
Average Daily Eddy Detections (DEDs) per Year GFDL-OM4	565,268	587,301
Average Number of Tracks per Year ADT	8,115	7,582
Average Number of Tracks per Year ORAS5	5,871	5,448
Average Number of Tracks per Year GFDL-OM4	5,175	4,873

ORAS5 and GFDL-OM4 have  $\approx 20\%$  fewer DEDs and  $\approx 30\%$  fewer eddy trajectories.

# Eddy Census

Anomaly Cosine Correlation (ACC): 0.62 (ADT - ORAS5) and 0.53 (ADT - GFDL-OM4).

## Eddy Census

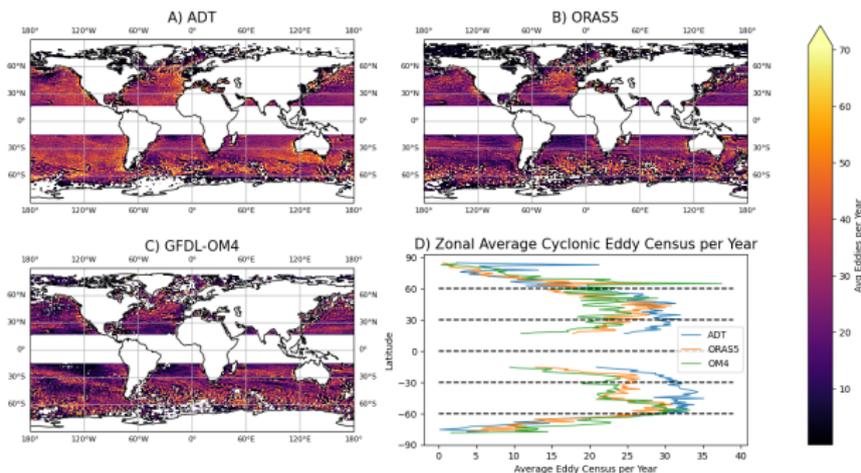
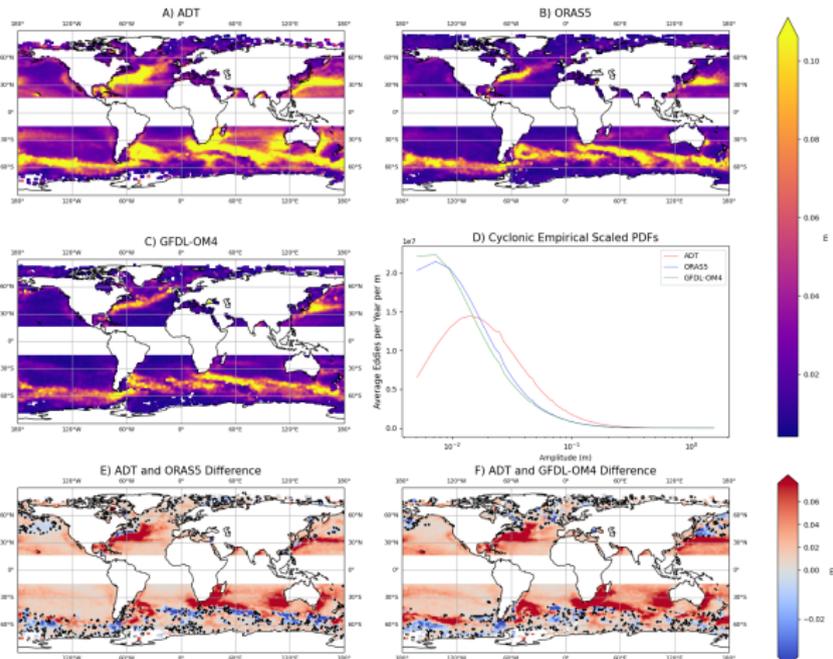


Figure: Cyclonic Eddy Census.

# Eddy Amplitude

- Global means:
  - ADT: 6.04 cm
  - ORAS5: 4.14 cm
  - GFDL-OM4: 3.64 cm
- Anomaly Cosine Correlation (ACC):
  - ADT-ORAS5: 0.79
  - ADT-GFDL-OM4: 0.67

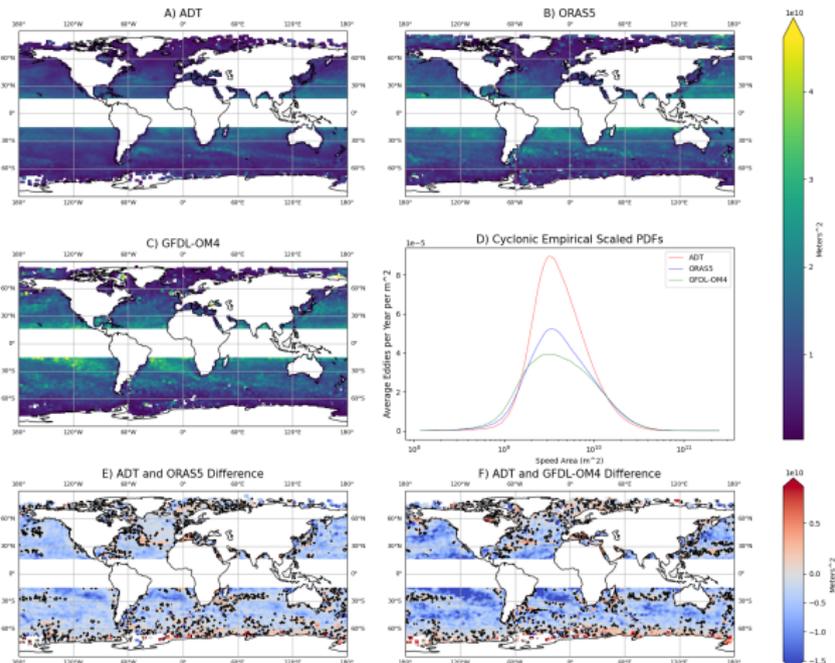
## Amplitude



# Eddy Area

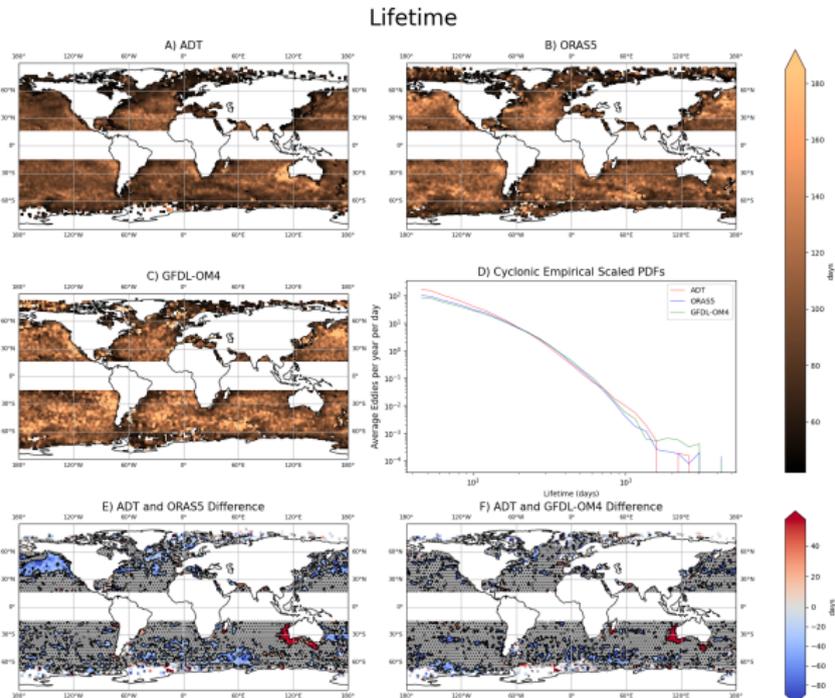
- Global means:
  - ADT:  $9.41e+03$   $\text{km}^2$
  - ORAS5:  $1.23e+4$   $\text{km}^2$
  - GFDL-OM4:  $1.23e+4$   $\text{km}^2$
- Anomaly Cosine Correlation (ACC):
  - ADT-ORAS5: 0.8
  - ADT-GFDL-OM4: 0.67

## Speed Area



# Eddy Lifetime

- Global means:
  - ADT: 93.5 days
  - ORAS5: 104.7 days
  - GFDL-OM4: 109.8 days
- Anomaly Cosine Correlation (ACC):
  - ADT-ORAS5: 0.23
  - ADT-GFDL-OM4: 0.09

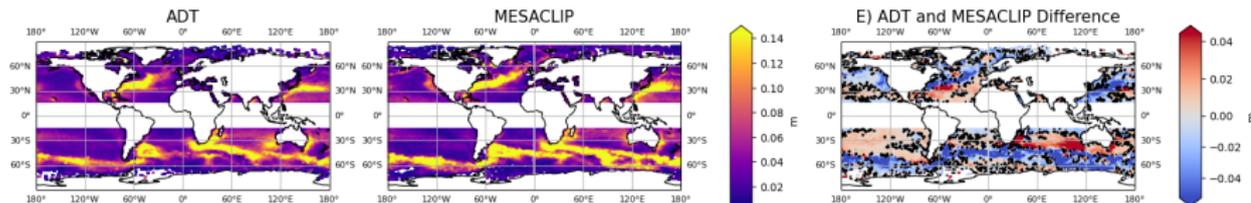


# Conclusion and Future Work

- Concluding Thoughts:
  - $1/4^\circ$  have substantial room for improvement.
  - Eddies are larger, weaker, and live too long.
  - In some cases does a moderate job at capturing the regional behavior of eddy characteristics.
- Future Work:
  - Investigating high resolution models (MESACLIP).
  - Once a high resolution ocean model has been validated as accurately resolving eddies, use it to assess impact of climate change on eddies.
  - Possibly develop model parameterizations to better capture eddy behavior.

# MESACLIP Eddy Amplitude

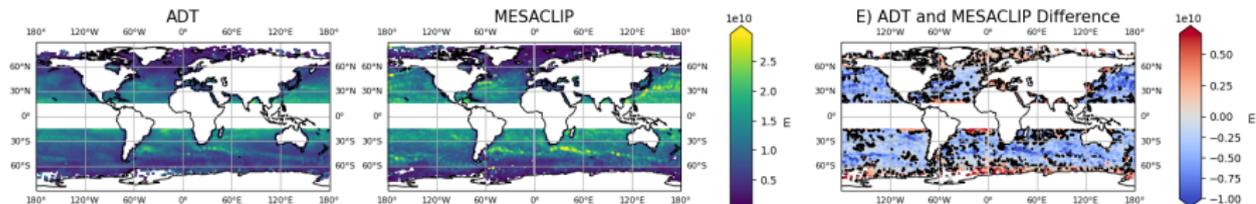
## Amplitude



- Global Means: 6.04 cm (ADT) and 7.2 cm (MESACLIP)
- ACC: 0.86

# MESACLIP Eddy Area

## Speed Area



- Global Means:  $9.41e+03 \text{ km}^2$  (ADT) and  $1.205e+4 \text{ km}^2$  (MESACLIP)
- ACC: 0.77

# Bibliography

- [1] Copernicus Climate Change Service (C3S) Climate Data Store (CDS). *Sea level gridded data from satellite observations for the global ocean from 1993 to present (vDT2024)*. Version vDT2024. Accessed on 2025-06-09. 2024. URL: <https://doi.org/10.24381/cds.4c328c78>.
- [2] E.U. Copernicus Marine Service Information (CMEMS). Marine Data Store (MDS). *Global Ocean Ensemble Physics Reanalysis*. Accessed on 2025-06-09. 2024. URL: <https://doi.org/10.48670/moi-00024>.
- [3] Alistair Adcroft, Whit Anderson, V Balaji, et al. "The GFDL global ocean and sea ice model OM4. 0: Model description and simulation features". In: *J. Adv. Model. Earth Syst.* 11.10 (2019), pp. 3167–3211. DOI: <https://doi.org/10.1029/2019MS001726>.
- [4] C. Pegliasco, C. Busché, and Y. Faugère. *Mesoscale Eddy Trajectory Atlas META3.2 Delayed-Time two satellites: version META3.2 DT twosat*. 2022. URL: <https://doi.org/10.24400/527896/A01>.