Eddy identification from along track altimeter data using deep learning: EDDY project

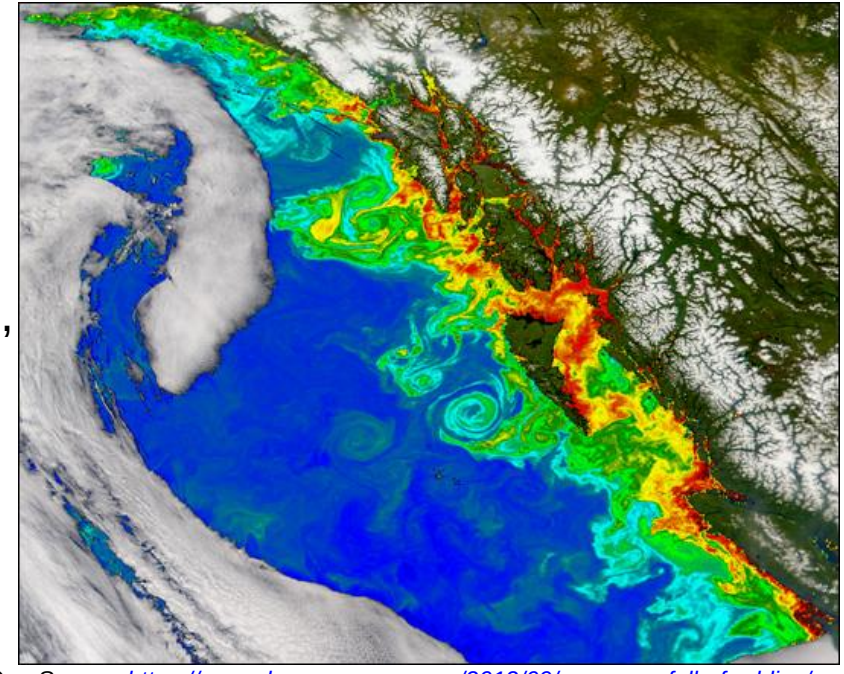
Adili Abulaitijiang[1],Eike Bolmer[2], Ribana Roscher[2,3],
Jürgen Kusche[1], Luciana Fenoglio-Marc[1], Sophie Stolzenberger[1]

1 Astronomical, Physical and Mathematical Geodesy (APMG) Group, Institute of Geodesy and Geoinformation (IGG), University of Bonn, Germany
2 Remote Sensing Group, Institute of Geodesy and Geoinformation (IGG), University of Bonn, Germany
3 Data Science in Earth Observation, Technical University of Munich, Germany

Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation

Introduction

- Ocean eddies are cyclonically or anticyclonically rotating water masses.
- Eddies enable vertical transfer of heat, and also global scale heat transfer.
- Mesoscale eddies are of radius >100 km, with a lifespan weeks to months.
- Eddies appear to be highs or lows on Sea surface temperature (SST) and salinity (SSS), as well as sea surface height (SSH) anomaly maps
- Monitoring eddies is important for marine biologists and commercial fishery.



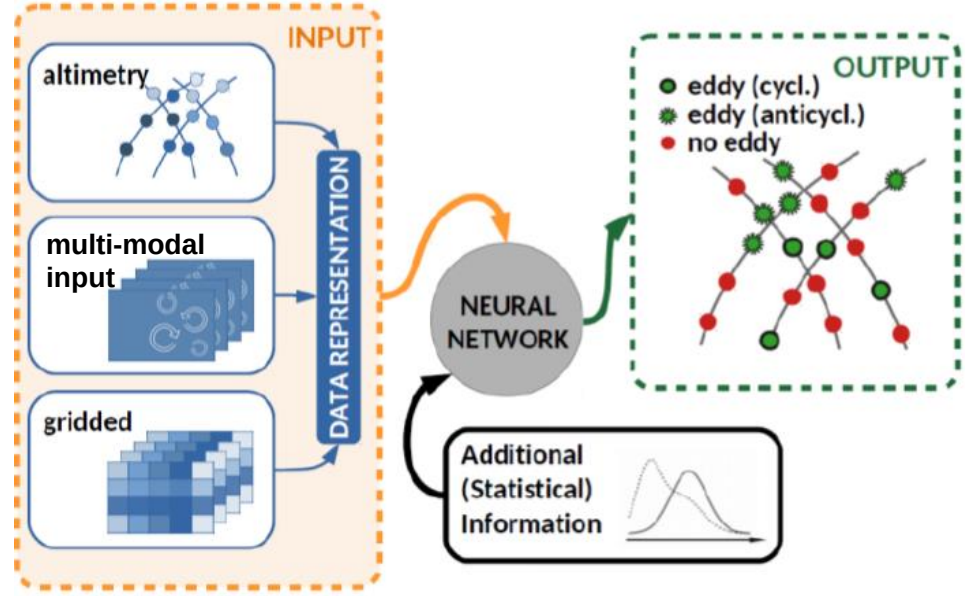
Source: https://www.deepseanews.com/2012/09/an-ocean-full-of-eddies/

Eddy monitoring

- Eddy identification and tracking via SSH and SST
- For now, ONLY from gridded multi-mission SSH maps (Chelton et al. 2007,2011; Mason et al. 2014)!
- **Gridding inevitably lead to the loss of spatial (e.g. amplitude) and temporal resolution**
- Eddy identification can only be a delayed-time product with a lag of one to two months

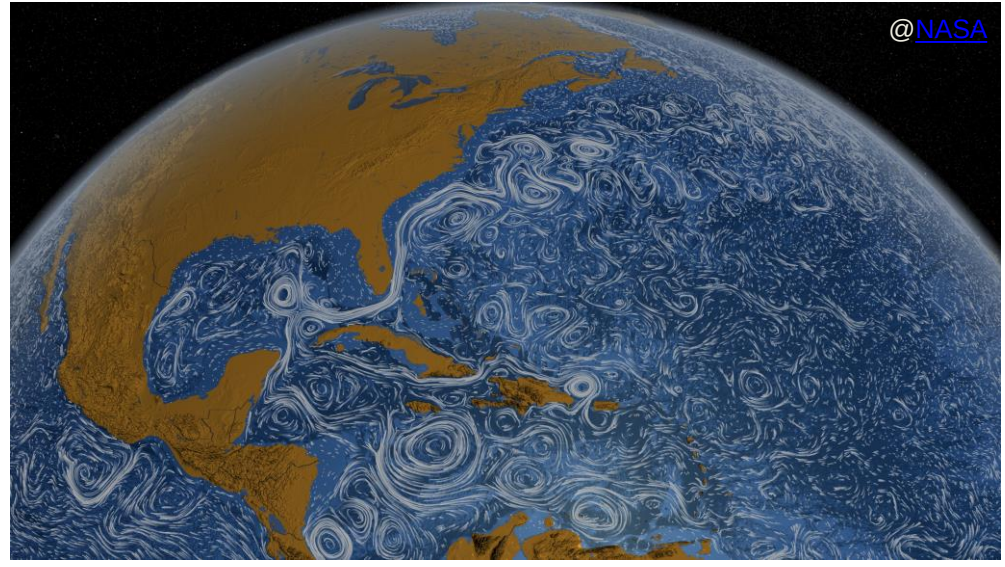
EDDY project

- Aim to develop eddy identification methods **directly from along track altimetry data**
- **Develop deep learning architecture** which integrate multi-modal remote sensing data like SSH and SST
- Near-real-time eddy classification and tracking may be achievable.
- Kick off in April 2021, with 3 year funding from DFG.



Preliminary results

- Started with single-modal training with SSH, gridded maps
- py-eddy-tracker[1] (Mason et al. 2014) → open source and fast eddy detection
- Study area in the Gulf Stream with one year of data (365 days)

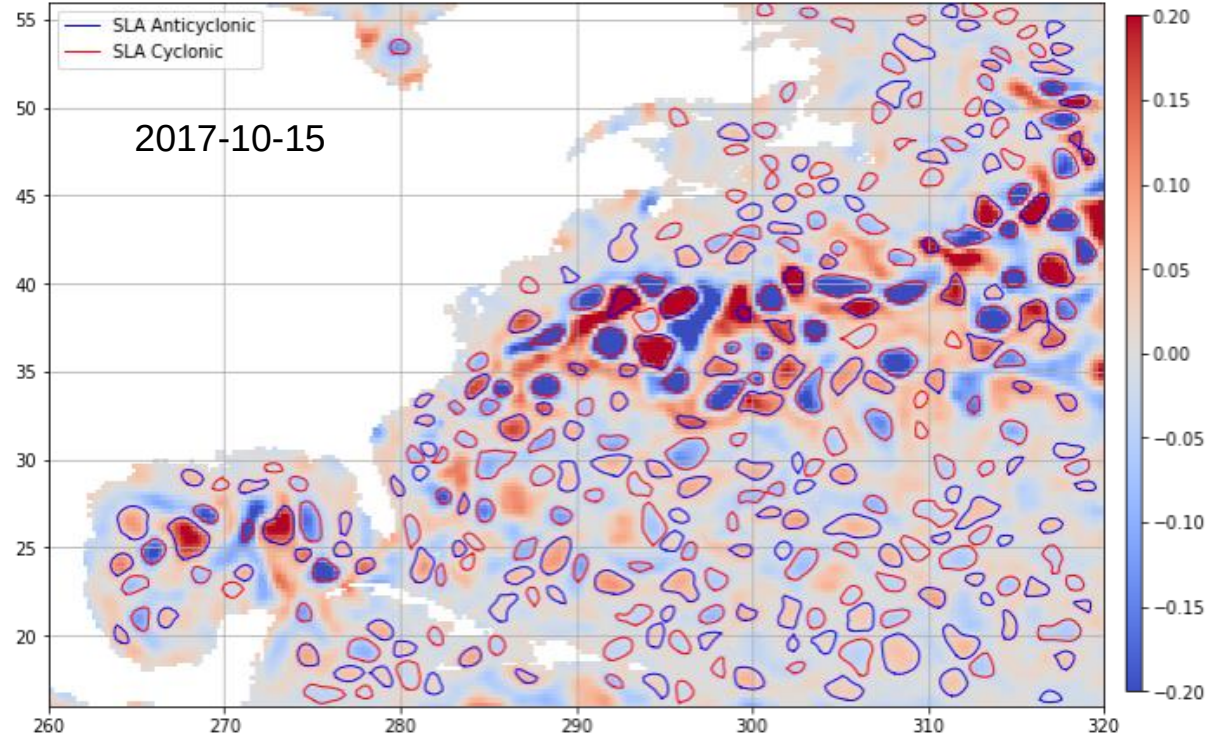


1 https://github.com/AntSimi/py-eddy-tracker

Reference dataset

- Gridded datasets from CMEMS
- Eddy detection from py-eddy-tracker with and without Okubo-Weiss method

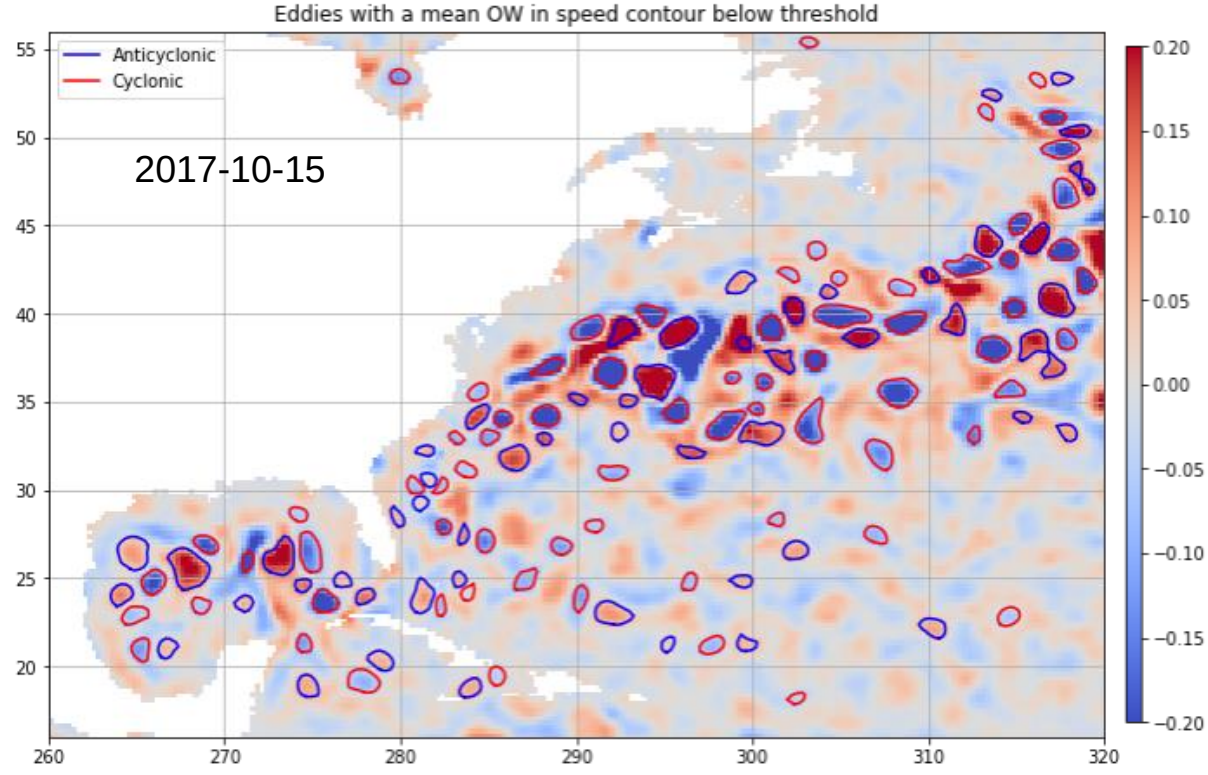
Eddy type	# of eddies
Anticyclonic (all)	142
Anticyclonic (with OW)	56
Cyclonic(all)	157
Cyclonic(with OW)	72



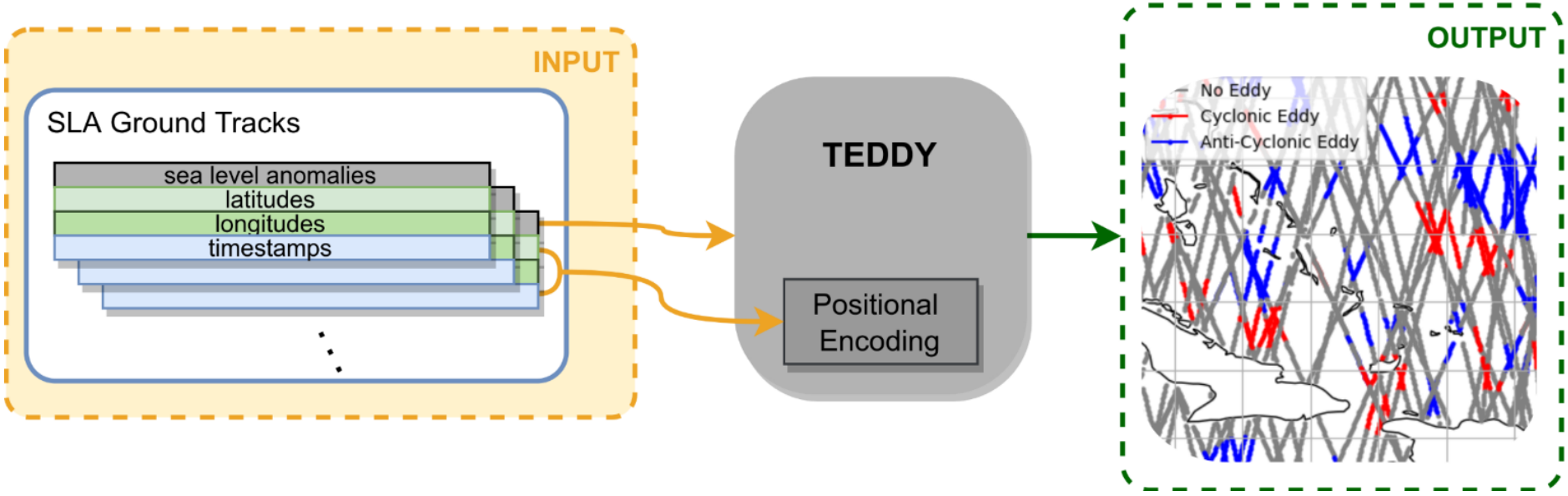
Reference dataset

- Gridded datasets from CMEMS
- Eddy detection from py-eddy-tracker with and without Okubo-Weiss method

Eddy type	# of eddies
Anticyclonic (all)	142
Anticyclonic (with OW)	56
Cyclonic(all)	157
Cyclonic(with OW)	72



TEDDY - Deep learning architecture

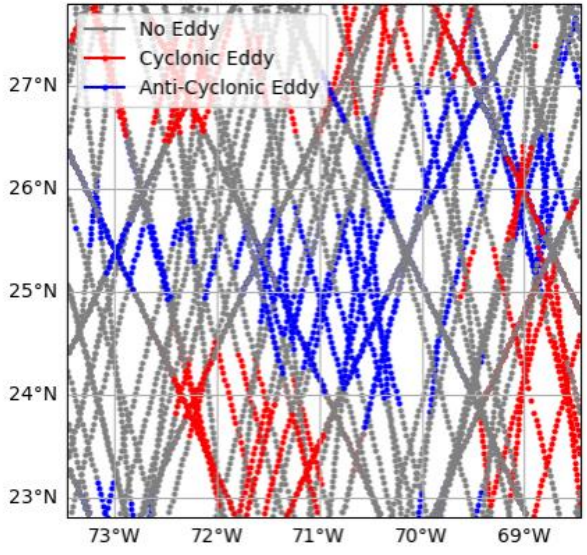


For details, Re-visit

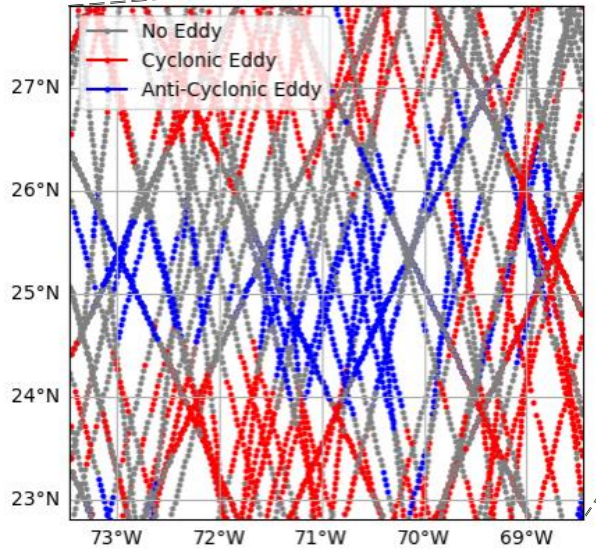
Eike et al., Session ITS2.7/AS5.2, Monday, 23 May, 16:15 - 16:20
Machine learning-based identification and classification of ocean eddies

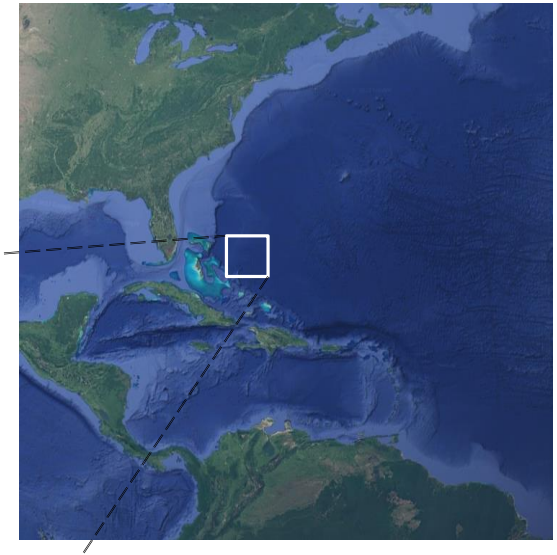
TEDDY predictions

Reference



Prediction





Eddy identification from the first 40 days of 2017 multi-mission data

Remarks and outlook

- EDDY project aims to classify eddies directly from along track altimetry data.
- We aim to eventually classify and track eddies from ground tracks with a higher resolution and accuracy.
- We obtained promising results from single-modal training and eddy identification in the Gulf Stream.

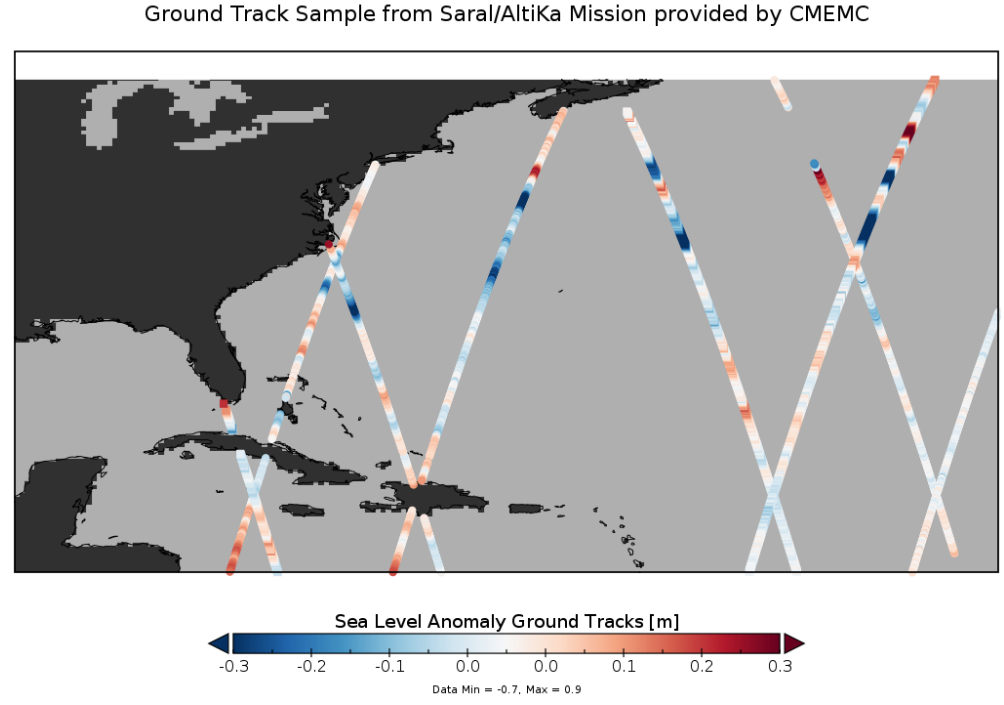
- We adopt multi-modal training and classification in the next phase.
- SWOT mission data will be a valuable addition to the training set in 2023.

References

- Mason, E., Pascual, A., & McWilliams, J. C. (2014). A new sea surface height–based code for oceanic mesoscale eddy tracking. *Journal of Atmospheric and Oceanic Technology*, *31*(5), 1181-1188.
- Chelton et al. (2007). Global observations of large oceanic eddies. *Geophys. Res. Lett*., 34, L15606.
- Chelton et al. (2011). Global observations of nonlinear mesoscale eddies. *Prog. Oceanogr.,* 91(2), 167-216.
- Okubo (1970). Horizontal dispersion of floatable particles in the vicinity of velocity singularities such as convergences. *Deep Sea Res. Oceanogr. Abstr.*, 17(3), 445-454.
- Weiss (1991). The dynamics of enstrophy transfer in two-dimensional hydrodynamics. *Physica D,* 48(2), 273-294.
- Franz, K., Roscher, R., Milioto, A., Wenzel, S., and Kusche, J. (2018). Ocean eddy identification and tracking using neural networks. In *IEEE IGARSS 2018* (pp. 6887-6890).
- Drees, L., Kusche, J., and Roscher, R. (2020). Multi-Modal Deep Learning with Sentinel-3 Observations for the Detection of Oceanic Internal Waves, ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., V-2-2020, 813–820.
- Lguensat et al. (2018). EddyNet: A deep neural network for pixel-wise classification of oceanic eddies. In *IEEE IGARSS 2018* (pp. 1764-1767).

Classification from along track altimetry - Input Data

- Sea Level Anomaly Ground Tracks (Level 3) from multiple missions from CMEMS
- 01.01.2017 - 31.12.2017
- Processed reference data using the py-eddy-tracker product of 2D grid data



EDDY project concept

A deep leaning neural network learns and integrates along track and gridded altimetry dataset along with other multi-modal inputs like SST and multi-spectral images