Teddy: Creating daily semantic segmentation maps of classified eddies using SLA along-track altimetry data

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Mesoscale eddies, which are rotating currents in the ocean with horizontal scales ranging from 10 km to 100 km and above, are of interest to marine biologists, oceanographers, and geodesists for their impact on water mass, heat, and nutrient transport. Typically, gridded sea level anomaly (SLA) maps processed from multiple radar altimetry missions are used to detect eddies. However, the operational processors create multi-mission SLA grid maps with a lower effective spatiotemporal resolution than their grid spacing and temporal resolution, leading to inaccurate eddy detection.

To address this issue, we are investigating the use of higher-resolution along-track SLA data to infer daily two-dimensional segmentation maps of cyclonic, anticyclonic, or non-eddy areas with greater accuracy than using processed SLA grid map products. Because of repeat cycles between 10 and 35 days and cross-track spacing of a few 10 km to a few 100 km, ocean eddies are visible in altimeter observations but are typically covered by only a few ground tracks with locations changing continuously each day. This makes the spatiotemporal context within the input data highly variable. Conventional convolutional neural networks (CNNs) rely on data without varying gaps or jumps in time and space to use the intrinsic spatial or temporal context of the observations. Therefore we address this challenge with a deep neural network that utilizes the spatiotemporal context information within the modality of along-track data and can output a two-dimensional segmentation map from data of varying sparsity instead. We have developed an architecture, Teddy, that uses a transformer module [1] to encode and process the spatiotemporal information along with the ground track’s SLA data that produces a sparse feature map. This is then fed into a sparsity invariant CNN [2] to infer a two-dimensional segmentation map of classified eddies. The reference data used to train Teddy is produced by an open-source geometry-based approach (py-eddy-tracker [3]).

Our focus is on how we have implemented this approach to derive two-dimensional segmentation maps of classified eddies with our deep neural network architecture Teddy from along-track altimetry. In addition, we present results and limitations for the classification of eddies using only along-track SLA data from the multi-mission level 3 product of the Copernicus Marine Environment Monitoring Service (CMEMS) within the 2017 - 2019 period for the Gulf Stream region. Our results show that using our methodology, we
can create two-dimensional maps of classified eddies from along-track data without using preprocessed SLA grid maps.

