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Unsupervised clustering of Lagrangian trajectories in the Labrador Current

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Lagrangian studies are a widely-used and powerful way to analyse and interpret phenomenons in oceanography and atmospheric sciences. Such studies can be based on dataset either consisting of real trajectories (e.g. oceanic drifters or floats) or of virtual trajectories computed from velocity outputs from model or observation-derived velocities. Such data can help investigate pathways of water masses, pollutants or storms, or identify important convection areas to name a few. As many of these analyses are based on large volumes of data that can be challenging to examine, machine learning can provide an efficient and automated way to classify information or detect patterns.

Here, we present an application of unsupervised clustering to the identification of the main pathways of the shelf-break branch of the Labrador Current, a critical component of the North Atlantic circulation. The current flows southward along the Labrador Shelf and splits in the region of the Grand Banks, either retroflecting north-eastward and feeding the subpolar basin of the North Atlantic Ocean (SPNA) or continuing westward along the shelf-break, feeding the Slope Sea and the east coast of North America. The proportion feeding each area impacts their salinity and convection, as well as their biogeochemistry, with consequences on marine life.

Our dataset is composed of millions of virtual particle trajectories computed from the water velocities of the GLORYS12 ocean reanalysis. We implement an unsupervised Machine Learning clustering algorithm on the shape of the trajectories. The algorithm is a kernalized k-means++ algorithm with a minimal number of hyperparameters, coupled to a kernalized Principal Component Analysis (PCA) features reduction. We will present the pre-processing of the data, as well as canonical and physics-based methods for choosing the hyperparameters.

The algorithm identifies six main pathways of the Labrador Current. Applying the resulting classification method to 25 years of ocean reanalysis, we quantify the relative importance of the six pathways in time and construct a retroflection index that is used to study the drivers of the retroflection variability. This study highlights the potential of such a simple clustering method for Lagrangian trajectory analysis in oceanography or in other climate applications.