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Detection and Tracking of Ocean Carbon Regimes Through Machine Learning

Our research focuses on detecting and tracking ocean carbon regimes, which are useful tools for understanding the impacts of climate change on ocean carbon uptake. Geoscientific datasets in Earth System Sciences often contain local and distinct statistical distributions at a regional scale. This poses a significant challenge in applying conventional clustering algorithms for data analysis. Based on the observed limitations of prominent methods, in our study, we propose a framework that enhances well-established unsupervised machine-learning methods tailored to applications on geoscientific datasets. We define a carbon uptake regime as a region characterized by common relationships between the carbon uptake and its drivers, as simulated by a multi-annual hydrodynamic model simulation. As a first step, we compute multivariate linear regressions capturing local spatial relations between carbon dioxide uptake and its drivers to discover such regimes. This is followed by an agglomerative hierarchical clustering constructed upon the collection of regional multivariate linear regression models. To overcome the emerging limitations of a global cut for partitioning, which is inadequate to capture the local statistical distributions, we present a novel, straightforward and adaptive approach to detect and visualize ocean carbon uptake regimes in this work. This method relies on the distance-variance selection technique and detects multiple local cuts on the dendrogram by considering both the compactness and similarity of the clusters. Detecting meaningful and well-defined carbon uptake regimes is vital for their tracking over time. The tracking is performed through a simple yet effective approach where summary structures derived from the clusters are traced over time. Applied over longer time scales, this novel method will enable marine scientists to effectively monitor the impacts of climate change on the ocean carbon cycle more.

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