[C4] Finding Lagrangian coherent structures using community detection

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Lagrangian coherent structures (LCSs) are the most influential invariant sets in the extended phase space of nonautonomous dynamical systems, forming the backbone of mixing and transport. The available methods for detecting LCSs require a dense set of trajectory data. In many cases, e.g., data-driven oceanography, such dense information is unavailable from direct measurements. Here, we use network theory to detect LCSs from a sparse set of trajectories. The fluid elements whose trajectories are known form the nodes of the network. We define the network edges as the relative dispersion between fluid elements. We then apply the method of modularity maximization from network analysis to identify LCSs at multiple scales. To obtain a detailed spatiotemporal description of LCSs, we also consider a multilayer version of modularity maximization on a multilayer representation of a temporal network constructed from numerical and observational data. Being based on relative dispersion, our method can be performed on a sparse set of trajectory data. We illustrate this on drifter data measured by an ocean drifter data set.