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Surface and deep ocean connectivity inferred from robust extraction of coherent sets in ocean flow using models and sparse, scattered, and incomplete float data with transfer operator and dynamic Laplacian methods.

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Transport and mixing properties of the ocean's circulation is crucial to dynamical analyses, and often have to be carried out with limited observed information. Finite-time coherent sets are regions of the ocean that minimally mix (in the presence of small diffusion) with the rest of the ocean domain over the finite period of time considered. In the purely advective setting (in the zero diffusion limit) this is equivalent to identifying regions whose boundary interfaces remain small throughout their finite-time evolution. Finite-time coherent sets thus provide a skeleton of distinct regions around which more turbulent flow occurs. Well known manifestations of finite-time coherent sets in geophysical systems include rotational objects like ocean eddies, ocean gyres, and atmospheric vortices. In real-world settings, often observational data is scattered and sparse, which makes the difficult problem of coherent set identification and tracking challenging. I will describe mesh-based numerical methods [3] to efficiently approximate the recently defined dynamic Laplace operator [1,2], and rapidly and reliably extract finite-time coherent sets from models or scattered, possibly sparse, and possibly incomplete observed data. From these results we can infer new chemical and physical ocean connectivities at global and intra-basin scales (at the surface and at depth), track series of eddies, and determine new oceanic barriers.

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