Life-time independent approach to Lagrangian vortices detection

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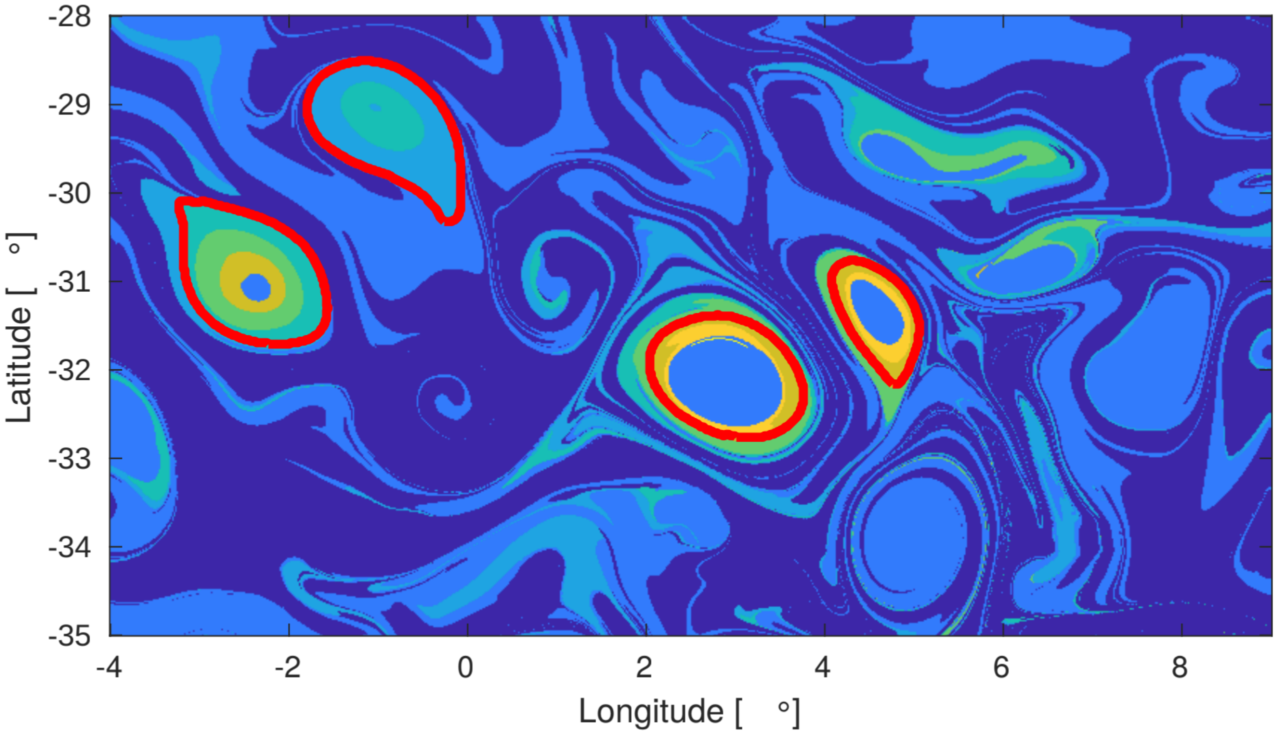
Lagrangian coherent structures (LCSs) are differentiated surfaces of trajectories in a dynamical system that exert significant effects on adjacent trajectories over a finite-time interval. These LCSs are mainly structured into three physical shapes, in the geophysical fluid dynamics field these structures are referred to as mesoscale and submesoscale filaments, jets and eddies. These latter structures are omnipresent in the ocean and usually exhibit different properties to their surroundings. They are known to stir and mix surroundings water masses as well as by their ability to trap and carry water properties in a coherent manner. In the present work, we are interested in those that remain coherent despite their chaotic environment. Such mesoscale eddies have an important role to play in climate change arising from their influence on the circulation by transporting temperature and salinity. As these mesoscale eddies have a remarkable impact on the global circulation, their systematic and precise detection has been of great concern over the last decade. Several Lagrangian vortex definitions have been introduced in the literature together with their automatic detection. Indeed, These methods identify and extract such eddies in a very coherent manner. However, they suffer from a conceptual point of view; they all require the sought eddies life-time to be exactly equal to the time interval of particles’ advection. For example, by choosing a time interval of six months, such methods only extract eddies that do exist and remain coherent exactly six months. Thus, these methods miss several eddies that have existed within the time interval of advection but have life-times different from 6 months. In the present work, we present a life-time independent method that is able to lump eddies occurring over different time intervals into the same scalar field. Here, we reveal that such eddies can be identified based on the frequency-domain representation of their trajectories. We then identify and extract coherent vortices as material surfaces along which particles’ trajectories share similar frequency components and life-time. The present method identifies all coherent eddies in an automatic manner, showing high eddies’ monitoring capacity. We illustrate our new method by identifying and extracting Lagrangian coherent eddies in different fluid flows.

Keywords: Lagrangian coherent structures , Vortex dynamics, Mesoscale eddies, Lagrangian vortex detection, Coherent water transport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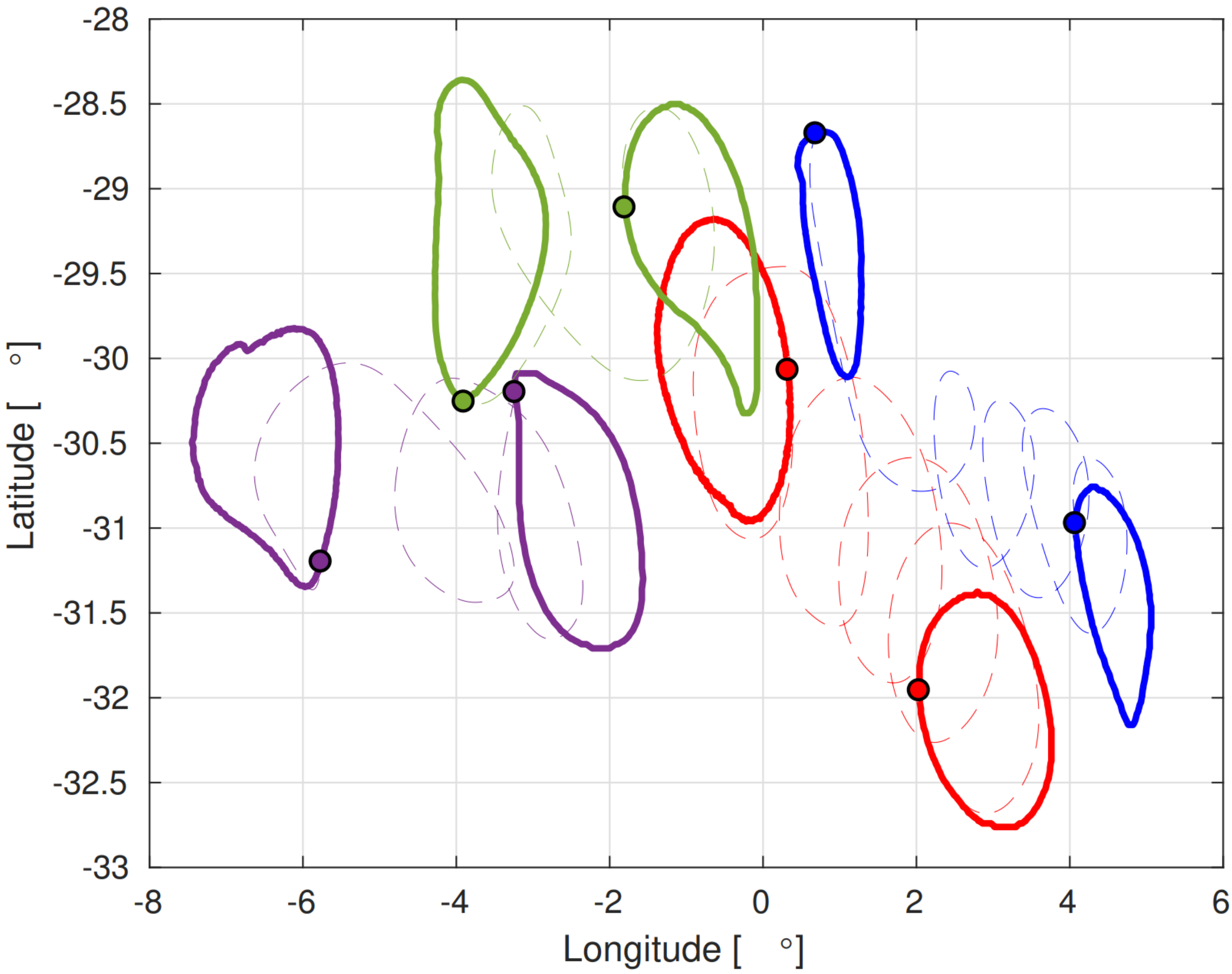
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