# Lagrangian Flow Network: theory and applications

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The last two decades have seen important advances in the Lagrangian description of transport and mixing in fluid flows driven by concepts from dynamical systems theory [1]. In the meantime, Network Theory approaches continue arousing scientific interests and have been successfully used, among other, for geophysical systems with climate networks. Linking the network formalism with transport and mixing phenomena in geophysical flows, we develop a new paradigm which we call Lagrangian Flow Network [2]. It consists in analyzing a directed, weighted, spatially embedded and time-dependent network which describes the material fluid flow among different locations [2, 3]. We relate theoretically dispersion and mixing characteristics, classically quantified by Lyapunov exponents, to the degree of the network nodes and then to a family of network entropies defined from the network adjacency matrix [2]. Among possible applications, this new framework allows studying the connectivity and structural complexity of marine populations by providing a systematic characterization of larval transport and dispersal [4, 5, 6]. The simulated networks are composed of an ensemble of oceanic sub-regions which are interconnected through the transport of larvae by ocean currents (Fig. 1).

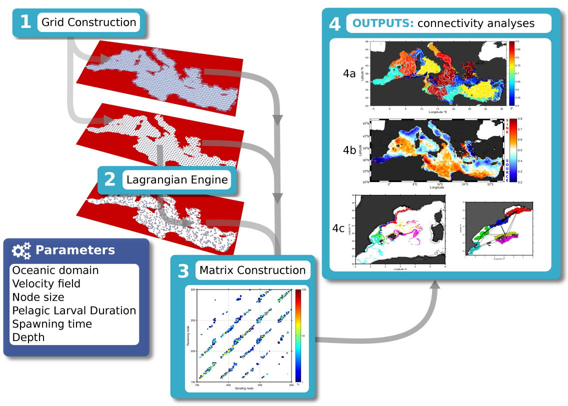


Figure 1: Simplified diagram of the Lagrangian Flow Networks set-up with 4 modules (light blue boxes). Key parameters (dark blue box) are the domain of interest, the velocity field (from any ocean model), the node size, the starting dates (e.g. release of contaminant or spawning event), the vertical layer of the model (depth of dispersion) and the tracking time (drift duration or pelagic larval duration).

The analysis of such networks allows the identification of hydrodynamical provinces (coherent oceanic regions, i.e. areas internally well mixed, but with little fluid or larvae interchange between them)[4] and the computation of connectivity proxies measuring retention and exchange of larvae at multiple scales [5]. These diagnostics, whose sensitivity and robustness have been tested [6], provide useful information to design management and protection plans for marine ecosystems.

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