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Forward and Backward Lagrangian Particle Tracking in Ensemble Flow Fields

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Ocean ensemble data assimilation systems generate ensembles of independent velocity field realizations after every assimilation cycle. Lagrangian tracking of passive tracers within such a framework is challenging due to the exponential growth in the number of particles that arises from describing the behavior of velocity over time as a set of possible combinations of the different realizations. This contribution addresses the problem of efficiently advecting particles, forward and backward in time, in ensemble flow fields, whose statistics are prescribed by an underlying assimilated ensemble. To this end, a parallel adaptive binning procedure that conserves the zeroth, first and second moments of probability is introduced to control the growth in the number of particles. The adaptive binning process offers a tradeoff between speed and accuracy by limiting the number of particles to a desired maximum. To validate the proposed method, we conducted various forward and backward particle tracking experiments within a realistic high-resolution ensemble assimilation setting of the Red Sea, focusing on the effect of the maximum number of particles, the time step, the variance of the ensemble, the travel time, the source location, and history of transport.