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Fast computation of macrodispersion coefficients for transport in ergodic velocity fields

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Macrodispersion coefficients are defined by the large time half slope of the one-particle dispersion or, according to a Green-Kubo formula, by the sum of local dispersion coefficients and time integrals of velocity correlations sampled on trajectories of the advection-dispersion process. The computation of ensembles of transport realizations and the need to go to the large time limit often constitute a numerical challenge in simulation studies. Owing to the ergodicity of the velocity space random field, the numerical burden can be reduced to a great extent. The proposed method provides ergodic estimates of macrodispersion coefficients by sums of velocity correlations on paths of increasing but finite lengths on a single trajectory of the advection-dispersion process. The path correlations are computed by dividing the trajectory in segments of equal time intervals, by computing in every interval products of velocities sampled at increasing time lags up to the length of the interval, and finally by taking the arithmetic mean for each time lag. The estimates converge towards the exact macrodispersion coefficients if the mean and correlation of the "Lagrangian" velocity field, constructed by sampling all the realizations of the Eulerian field with a single trajectory of the local dispersion, are ergodic quantities, as for instance in the case of Gaussian fields. The convergence with respect to the path length is rather fast and the computing time, of the order of minutes, is about two orders of magnitude smaller than for methods based on ensemble averaging and large time limit. This path decomposition method is not only an easy way to estimate macrodispersion coefficients but it also constitutes an efficient and expeditious test for the ergodicity of the random field generators.