Dynamic Parallelization of Multi-Dimensional Lagrangian Random Walk, Mass-Transfer Particle Tracking Schemes

Lucas Schauer

Department of Applied Mathematics and Statistics, Colorado School of Mines

Abstract

Lagrangian particle tracking schemes allow a wide range of flow and transport processes to be simulated accurately, but a major challenge is numerically implementing the inter-particle interactions in an efficient manner. Our work improves upon a multi-dimensional, parallelized domain decomposition (DDC) strategy for mass-transfer particle tracking (MTPT) methods. We show that this can be efficiently parallelized by employing large numbers of CPU cores to accelerate run times. Static DDC methods fix each core's area of responsibility for the duration of the simulation and provide ample speedup when particle density is approximately constant throughout the domain. However, this type of decomposition does not guarantee sufficient load balance in simulations with, say, a highly heterogeneous velocity field. In this work, we investigate and compare different procedures for dynamically decomposing the domain to address work imbalance amongst cores. In theory, each method presents some advantages over the other, based on trade offs between on-node work and inter-node communication. These new techniques we discuss provide significant speedup over their serial versions, and we observe further advantages than with their parallelized predecessors.