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On the advantage of a divergence-free velocity interpolation for particle-in

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The Particle-in-cell (PIC) method is found to be the most flexible and robust method to model the geodynamic problems with chemical heterogeneity. The initial equally distributed particles, however, can disperse and cluster due to the inaccuracy of the particle velocity interpolation. Our models with analytical solution show this problem is independent of the choice of numerical stokes solver. Instead, it is caused by the fact that the different components of the velocity field are interpolated independently without considering the divergence of the velocity.By introducing a conservative velocity interpolation (divergence free for incompressible flow), our model results demonstrate that the dispersion and clustering of the particles are significantly reduced both in steady state flow problems and time-dependent flow problems. The new interpolation is able to maintain a more steady number of particles in any computation cell, without the need for very high particle densities or re-seeding during the calculation.Our results show that this method improves the particle distribution when used in common geodynamic settings with sharp viscosity such as subduction dynamics and lithosphere dynamics, both in 2D and 3D. Thus, the potential application of this improved particle displacement method and its extension in compressible flow is very promising.