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A thousand ways to NOT model accretionary prisms with the Finite Difference Particle-in-cell method

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Brittle failure is the dominant mode of deformation in the upper crust. In numerical simulations, this phenomenon is generally accounted for by the simulation of plastic shear bands. However, the accurate numerical simulation of shear bands is a challenging problem in itself (May et al., 2016) which is made even more challenging by the need of simulating large deformation. A clear illustration of this problem is given in the numerical sandbox benchmark from Buiter et al (2016), where clearly different configurations of faults are modeled by different software or by the same software at a different resolution.

In this contribution, I use the staggered grid Finite Difference/Particle in Cell method to model the formation of an accretionary prism, using Sandbox-type boundary conditions and a viscoelastoplastic rheology. With the staggered grid, shear and normal stresses are not colocated. Therefore, any calculation with tensor invariants must involve interpolation of stresses, strain rates and material properties in one way or another and there is no clear optimal method. Here, I point out how subtle and less subtle implementation choices influence the solution. I test different schemes for interpolation, advection, stress rotation, stress limiting factor. Some implementations are clearly better than others, while different implementations can yield believable although different fault configurations. In the absence of analytical solution, I rely on numerical convergence to assess the quality of the results. I point out to some better and worse implementation choices and that for a given implementation there are a clear minimum space and time resolution beyond which the fault configuration ceases to change. The value of which can be determined from material properties and plastic strain rates.