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Plate-Mantle Interaction Modelling using Parallel Fast Multipole Boundary Element Method and Multigrid Finite Differences

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Causal relationships linking plate and mantle interactions are still poorly understood after several decades of research despite strong observational evidence and advances in tomographic imaging, mineral physics and geodynamic modelling. Little advances have been done in the full coupling of the regional tectonic scale of the single subduction zone because of the technical implementation of the intrinsic multi-scaling nature of the problem. The employment of modern techniques as the Boundary Element Method, able to model the direct interaction of mesoscale phenomena with the global feedback of the 3D globe, may represent a breakthrough in the field. Such numerical methods, however, require a less trivial implementation then the classical FD and FE methods employed in geodyanamics. Therefore, in order to solve the problem of computational scalability, one must be able to overcome the limitations of classical methods. The Fast Multipole is a revolutionary approach that tackles the difficulty of handling the intricate volume meshes and high resolution data by reducing the total number of points to a multiple of N^2, instead of N^3, where N is the 1D number of division. This approach was recently tested and applied at various scales using KD trees for fast identification of near and far-field interacting elements, and implemented with MPI parallelized code on distributed memory architectures. As the method is based on a free-surface, it allows easy volume mesh sampling of physical quantities and enables direct integration with Multigrid Finite Difference study of heat advection and diffusion within the mantle.