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# Time-Domain Parallelization for Geodynamic Modeling

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Computational Geodynamics heavily relies on parallel algorithms to speed up calculations. Such a tendency is continuously growing over time as the available parallel resources increase. One of the most widely used approaches in parallel Geodynamic codes is spatial decomposition, where the physical computational domain is subdivided into smaller domains that are attributed to one processor or to a set of processors. Each sub-domain carries out its own calculation in parallel and exchanges information periodically with other sub-domains. Such an approach is efficient as long as the size of the sub-domains is large enough so that computational time remains larger than the communication time. However, when the size of the sub-domains becomes too small, the speed-up stagnates, which puts bounds on the maximum performances of the algorithm.
I present here an approach named **Parareal** [1], which is based on time-domain decomposition. This method has been successfully applied to solve ODEs and time-dependent systems of PDEs in different scientific areas, including wave propagation and finite Prandtl number fluid dynamics. However the **Parareal** algorithm has not been applied in Geodynamic studies where motions relevant to the Earth and other planetary mantles are that of an infinite Prandtl number convective fluid. In that case the time-dependence of the mass and momentum equations is only implicit, due to thermal and/or viscous couplings with the explicitly time-dependent energy equation. This requires a number of modifications to the original algorithm.
This **Parareal** approach can be applied in addition to spatial domain decomposition or to any other parallel algorithm, therefore allowing easily an additional increase in speed-up by a factor of 5-10 and in principle, an unbounded speed-up increase with increasing number of processors.

**References**
[1] Lions, J-L., Maday, Y. and Turicini, G. (2001), Résolution d'EDP par un schéma en temps "pararéel"., CRAS, 332, 661-668.