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Ensemble Assimilation of Geodynamic Observations Into Mantle Circulation Models

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Recent advances in mantle convection modeling led to the release of a new generation of convection codes, able to generate self-consistently plate-like tectonics at their surface. Those models physically link mantle dynamics to surface tectonics. By combining these models with plate tectonic reconstructions, it is possible to estimate the structure and evolution of the temperature field of the mantle. So far, the assimilation of plate tectonic reconstructions was done by imposing specific boundary conditions in the model (force balance, imposed velocities...). These techniques, although insightful to test the likeliness of alternative tectonic scenarios, do not allow the full expression of the dynamical feedback between mantle convection and surface tectonics.
We developed an Ensemble Kalman Filter, which is a sequential data assimilation technique able to assimilate plate tectonics reconstructions in a numerical model while simultaneously letting this dynamical feedback develop self-consistently. This technique also takes into account errors in plate tectonics reconstructions, and computes the error on the final estimation of mantle circulation.
To validate this technique, we resort to synthetic experiments. First, we compute a reference evolution of a convective system, then synthetic observations are extracted from this evolution. Finally we apply the data assimilation algorithm to the series of synthetic observations, in order to reconstruct the reference evolution. We will present the data assimilation algorithm we developed, the results of these synthetic experiments and discuss future applications.