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Ensemble data assimilation for the reconstruction of mantle circulation

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The surface tectonics of the Earth is the result of mantle dynamics. This link between internal and surface dynamics can be used to reconstruct the evolution of mantle circulation. This is classically done by imposing plate tectonics reconstructions as boundary conditions on numerical models of mantle convection. However, this technique does not account for uncertainties in plate tectonics reconstructions and does not allow any dynamical feedback of mantle dynamics on surface tectonics to develop. Mantle convection models are now able to produce surface tectonics comparable to that of the Earth to first order. We capitalize on these convection models to propose a more consistent integration of plate tectonics reconstructions into mantle convection models. For this purpose, we use the ensemble Kalman filter. This method has been developed and successfully applied to meteorology, oceanography and even more recently outer core dynamics. It consists in integrating sequentially a time series of data into a numerical model, starting from an ensemble of possible initial states. The initial ensemble of states is designed to represent an approximation of the probability density function (pdf) of the a priori state of the system. Whenever new observations are available, each member of the ensemble states is corrected considering both the approximated pdf of the state, and the pdf of the new data. Between two observation times, each ensemble member evolution is computed independently, using the convection model. This technique provides at each time an approximation of the pdf of the state of the system, in the form of a finite ensemble of states. We perform synthetic experiments to assess the efficiency of this method for the reconstruction of mantle circulation.