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Effect of model and observation errors on the joint reconstruction of mantle circulation and surface tectonics.

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Central to our understanding of mantle dynamics and surface tectonics is the accurate reconstruction of mantle circulation patterns, as deep in the past as possible. The complexity of the mantle convection models play a critical role. In particular their ability to generate plate-like tectonics at the surface. Indeed, interior dynamics of the Earth is directly linked to the surface tectonics. Convection models then provide a physical link between deep and surface processes and allow us to use inverse methods to estimate mantle circulation patterns from plate tectonic reconstructions.

In this contribution, we use the ensemble Kalman filter, a sequential data assimilation method that is especially suitable to perform high dimensional state estimation on systems with a strongly nonlinear dynamics like the Earth's mantle. This inverse method has been shown to accurately recover the circulation history in a 2D spherical annulus convective system featuring plate-like tectonics at its surface. However, before applying this technique to the Earth mantle, several questions remain unanswered. How will our imperfect modelling of mantle convection impact the reconstruction? How will the reconstruction be affected by gaps in plate tectonics reconstructions, either temporal or spatial?

To answer these questions, we test the ensemble Kalman filter on a series of mantle convection models that feature a plate-like surface and include additional complexities, such as a depth-dependent viscosity and continental rafts. Using observing system simulation experiments, we evaluate how the ensemble Kalman filter performs on these systems in the presence of model errors and with varying errors on observations and present an analysis on where mantle evolution is robustly reproduced.