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Assimilation of SWARM and CHAMP data under realistic spatial and temporal core flow constraints

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We assimilate geomagnetic data from both ground-based and virtual observatories (from CHAMP and SWARM satellite records) to simultaneously build models of the magnetic field and of fluid motions at the core surface.

We consider data cleaned from external magnetic field contributions, equally distributed in space and time. We use spatial constraints from geodynamo simulations and dense observation error covariance matrices. We use an augmented state ensemble Kalman filter that allows to estimate uncertainties on core motions and the magnetic model as a function of length and time-scales.
The model is time-stepped using stochastic equations coherent with the occurrence of geomagnetic jerks.

The algorithm is applied to observations over the period 2000-2017. It gives reasonable solutions in terms of misfit to the data. The geomagnetic model obtained is in agreement with alternative models such as CHAOS or COV-OBS.
We retrieve the eccentric westward gyre, and core motions are essentially in agreement with the quasi-geostrophic approximation - with local violation under Indonesia.
The method is able to provide probability densities for core flows, magnetic field and secular variation forecasts both at the core surface and at observatory locations.