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Magnetic and velocity fields in the core interior inferred from magnetic observations

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The changes in the Earth's magnetic field on a wide range of time and space scales reflect the various time and space scales of core processes. We focus here on the rapid variations of the geomagnetic field ranging from years to centuries, referred to as the geomagnetic secular variation, recorded in magnetic data timeseries. We use magnetic data in the form of field models: time-varying spherical harmonic descriptions of the core field over timescales depending on the incorporated data. The core field is then isolated from the other sources of magnetic field and is easily downward continued to the core-mantle boundary. In this study, we use published magnetic field models at the core-mantle boundary based, at least partly, on satellites data. We focus on the issue of relating those observations with the state of the core. We describe Earth's core processes at secular variation timescales with a quasi-geostrophic model of core dynamics. The quasi-geostrophic approximation relies on the prevalence of rotation forces over magnetic forces in the bulk of the fluid on those short timescales. Within this framework, the magnetohydrodynamics takes place in the equatorial plane, the velocity field being described with both a non-zonal streamfunction and the zonal azimutal velocity, and the magnetic field with a single magnetic scalar potential. At the core-mantle boundary, the equatorial flow interacts with the radial magnetic field at the core surface, through the radial component of the magnetic induction equation. That component of the model connects the dynamics and the observations. Retrieving core state variables from magnetic observations is an inverse problem which we solve dynamically with a variational data assimilation scheme. Variational data assimilation seeks to minimize an objective function, by computing its sensitivity to its control variables through the integration of the adjoint model. The produced estimates are then consistent with the underlying dynamics. We determine to which extent the dynamical inversion enables the determination of characteristics of the magnetic field (strength, shape, temporal evolution) in the bulk of the core: this quantity is only connected to the magnetic field model through the dynamics. By the time of the meeting, we will show preliminary maps of the time-dependent velocity field and magnetic field in the core interior that best explain the magnetic model in our dynamical framework.