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Forward and inverse modelling of the geomagnetic secular variation

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Looking back at more than one decade of global, continuous, satellite-based vector measurements of Earth's magnetic field, it is undeniable that its temporal variations are much better resolved now than they were at the turn of the century. The satellite images have shed new light onto the peculiar geographical distribution of the geomagnetic secular variation, which is heterogeneous both in longitude and latitude. This puzzling pattern of secular variation has long been thought to result from coupling between the Earth's fluid core, where the geodynamo resides, with its adjacent layers, the mantle and the inner core. Forward numerical modelling of the geodynamo remains a tool of choice for exploring this hypothesis. In contrast, inverse modelling of the geodynamo is a much younger discipline, which aims at extracting the geophysical information contained in the secular variation data by optimally combining this data with dynamical numerical models.

In this presentation, I will first present forward modelling results highlighting the bottom-up control of Earth's inner core on the geographical localisation of the geomagnetic secular variation. The resulting coupled Earth Dynamo model will then be used in a second part as a statistical prior to retrieve images of Earth's core dynamical state over the historical period 1840-2010. I will discuss several internal dynamical structures found both in the forward and the inverse approaches, such as a giant eccentric columnar gyre circling around the inner core and accounting for the hemispherical pattern of geomagnetic secular variation, and its underlying convective density anomaly structure.