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# Geographical localisation of the geomagnetic secular variation

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Directly observed changes in Earth's magnetic field occur most prominently at low latitudes beneath the Atlantic hemisphere, while the Pacific is comparatively quiet. This striking hemispheric asymmetry in geomagnetic secular variation is a consequence of the geographical localisation of intense, westward moving, magnetic flux patches at the core surface. Despite its successes in explaining the main morphological properties of Earth's magnetic field, self-consistent numerical modelling of the geodynamo has so far failed to reproduce this field variation pattern. Furthermore its magnetohydrodynamic origin, an essential pre-requisite for predicting the field evolution over the future decades, has been unclear. In this presentation we report on results obtained with numerical dynamos where we modify the treatment of mechanical boundary conditions, and impose heterogeneous thermochemical boundary control from either, or both, the inner-core boundary and the core-mantle boundary. In addition to presenting an Earth-like magnetic field morphology, these new numerical models also reproduce the morphology and localization of geomagnetic secular variation. In our models, the conservation of the angular momentum in the coupled inner-core / outer core / mantle system (the inner core and the mantle being held together by gravitational coupling) creates a westward columnar gyre circling around the inner core, which localises the secular variation in a narrow latitudinal band. An additional heterogeneous thermochemical boundary control distorts this gyre (the strongest distortion being obtained with inner core heterogeneous control) and localises the field changes in a hemispherical longitudinal sector. The two effects combine to recreate the observed localisation of geomagnetic secular variation in both longitude and latitude as a reult of a westward, columnar, eccentric gyre that penetrates throughout the outer core in a manner reminiscent of recent flow inversions. We also characterise the azimuthal drift of magnetic field structures using a Radon transform method, and find overall agreement between the model and geomagnetic data previously processed in the same way. Our results suggest that conservation of angular momentum and heterogeneous thermochemical boundary control in the coupled inner core / outer core / mantle system are central to understanding how Earth's magnetic field currently evolves.