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Predicting the evolution of the SAA by characterisation and modelling of reversed flux patches

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The South Atlantic Anomaly (SAA) is the region at the Earth's surface where the intensity of the magnetic field is very low, typically 30,000 nT and lower. Satellites operating in this region are relatively prone to upsets due to solar winds and cosmic rays. The SAA is related to regions at the core-mantle boundary (CMB) where the sign of the radial magnetic field is opposite to that of the dipole state, also known as reversed flux patches (RFPs). Reversed flux patches are time-dependent properties and have changed significantly in number, location and total area over the past four centuries. In general, such temporal variation in the magnetic field $\mathbf{B}$ is governed by the induction equation:

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{u} \times \mathbf{B}) + \eta \nabla^2 \mathbf{B} \tag{1}$$

with $\mathbf{u}$ and η the core fluid flow velocity and magnetic diffusivity respectively. The second term on the right hand side corresponds to magnetic diffusion and is thought to be small compared to the first, advective term. It is therefore neglected in most studies. However, it has been suggested that RFPs can be explained by the diffusion of a radially expelled toroidal field (Bloxham, 1986). Thus, when explaining RFP evolution, it is well possible that magnetic diffusion plays a sigfinicant role and can therefore not be neglected. Additionally, diffusion could have a stronger control on secular variation than previously thought, as the outer part of the core might be stratified (Pozzo et al., 2012).

In this presentation, I will first describe my method of defining the magnetic equator and RFPs. The RFP evolution for the past four centuries, obtained with those methods and the `gufm1` field model (Jackson, 2000) as well as its implications for the SAA will then be shown. My results indicate that the ratio of RFP area to the total CMB area has increased greatly and that this growth has predominantly taken place at the Southern hemisphere. More importantly, I will show that the largest part of the dipole moment decay is due to RFP growth, indicating that RFPs are dominant in controlling dipole decay. Then, I will present results of numerical diffusion models to demonstrate to what extent diffusion is responsible for these changes. Lastly, a comparison between advection and diffusion will be given, by showing a spatial distribution of how well either mechanism explains secular variation.

References

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