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Geomagnetic field evolution during reversals and excursions: Comparing Bayesian inversion results from the Matuyama/Brunhes reversal and the Laschamp excursion

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Since the last geomagnetic reversal, 780,000 years ago, the Earth's magnetic field repeatedly dropped dramatically in intensity. This has often been associated with large variations in local field direction, but without a persistent global polarity flip. The structure and dynamics of geomagnetic excursions, and especially the difference between excursions and polarity reversals, have remained elusive so far. For the best documented excursion, the Laschamp event at 41,000 years BP, firstly discovered by Norbert Bonhommet, we have reconstructed the evolution of the global field morphology by using a Bayesian inversion of several high-resolution palaeomagnetic records. In this excursion scenario inverse magnetic flux patches at the core-mantle boundary emerge near the equator and then move poleward. Contrary to the situation during the last reversal, these flux patches do not cross the hydrodynamic boundary of the inner-core tangent cylinder. While the last geomagnetic reversal began with a substantial increase in the strength of the non-dipolar field components, prior to the Laschamp excursion, both dipolar and non-dipolar field decay at the same rate. Such coherent decrease of dipolar and non-dipolar components is also observed for the Iceland basin excursion. This result suggests that the nature of an upcoming geomagnetic field instability, whether it develops into a reversal or excursion, can be predicted several hundred years in advance.