SIMULATED GEOMAGNETIC REVERSALS: HOW REALISTIC ARE THEY?

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Self-consistent numerical dynamos models are very successful in modeling several properties of the geomagnetic field, including reversals. These simulations can help to understand to underlying dynamics of these interesting processes, which is not directly accessible by geomagnetic data. The numerical models, however, have the content themselves with running at unrealistic parameters. For example, the diffusivities are typically many orders of magnitude too larger in order to damp small scale structures that can not be resolved numerically. It is thus essential to test these models against geomagnetic data in general and paleomagnetic in particular when dealing with reversals and the long time-scale behavior. We have analyzed several reversing models to infer some common reversal characteristics. Numerical reversals are a three stage process: First, plume-like outflows in the equatorial region or at higher latitudes produce significant inverse field and step-wise degrade the predominant dipole. Reversals and also global excursions are typically connected with a decrease of the dipole moment to about 20% of its mean values. Lesser decreases results in 'local' excursions where transient or inverse directions are only detected at a smaller fraction of sites. The second stage is a period where the field is dominated by higher harmonics and changes rather fast. Finally, the dipole grows again with opposite polarity. The starting slow degradation is also observed in paleomagnetism, but the second low-dipole period seems not a common feature. Also, in paleomagnetic data the dipole recovers typically faster after the reversal than it had decrease before while both processes have a comparable duration in the simulations. Though the overall reversal process tends to last longer in the computer models than in the geodynamo, the latitudinal dependence of durations agrees with paleomagnetic findings. The simulations also suggest some additional features that can be tested with paleomagnetic data: Reversals as well as excursion are rarely simple dipole swings but typically involve several polarity changes. Also, excursions tend to be more pronounced at low and high latitudes where the upwellings produce more inverse field but may be hard to discern from the background variation at mid latitudes. The simulations thus predict that fewer transitional and reversal direction should be found at mid-latitude regions. We have also analyzed the statistics of chron durations in our simulations and find that a log-normal or power-law probability distribution function is most likely. This is somewhat surprising; since these distributions require a long-term memory we have no explanation for. However, a log-normal statistics has also been suggested for the paleomagnetic record.

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