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Can Paleointensities be Used to Test the Geocentric Axial Dipole?

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The Geocentric Axial Dipole (GAD) model is central to many aspects of geophysics, including plate tectonics and paleoclimate. But its validity is by no means firmly established, particularly for the Precambrian. One test that has met with some success involves the distribution of paleomagnetic inclination angles. It works because any given field morphology has its own distinct probability density function (PDF) against which data compilations can be tested. Here, we investigate a second possible test using published paleointensity data. Once again, any given field morphology has a specific PDF. Likely field models consist of an underlying GAD on which is superimposed modest ($\pm$10%) quadrupole and octupole components. Intensity distributions differ from their inclination counterparts in that intensity can have variable bounds. This means that paleointensity PDF's tend to have more complicated shapes than the corresponding inclination PDF's, often with multiple maxima and minima. We use the CALS10k compilation and computational geodynamo models to explore how the paleointensity test performs with observational and modelling data in which the Gauss coefficients are well constrained. To investigate the potential of the paleointensity test for longer geological time intervals, we use the PINT database. The resulting observational models are compared to results from dynamo models that exhibit polarity reversals and excursions. The dynamo models can have modestly non-dipolar field morphologies, depending on heat flow boundary conditions and inner core sizes that model the evolution of the convective state of the core. Compared to the inclination test, the paleointensity test can potentially offer greater discrimination between models. However, non-uniqueness issues and paucity of data, particularly for the Precambrian, may severely limit its effectiveness.