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Development of new geomagnetic index forecasts using a Markov chain method

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Forecasts of geomagnetic indices such as Kp and ap are important in space weather since, together with solar index information, they can be used to drive forecast models of the radiation belts, magnetosphere, thermosphere and ionosphere. These indices act as a proxy for space weather effects which would otherwise have to be represented by process-based models that are both computationally expensive and limited by current understanding of the relevant physical processes and coupling mechanisms.

A range of statistical methods have been used to forecast geomagnetic indices, including neural networks, autoregressive and moving average approaches. However, probabilistic forecasts of geomagnetic disturbances are challenging because of the paucity of observational data. Here, we present a new approach based on Markov chains, which have previously been used to forecast a range of meteorological phenomena. The Markov chain model considers current geomagnetic conditions and uses a matrix of transition probabilities to predict the future geomagnetic state. The approach is well-suited to indices such as Kp which often show abrupt increases at the onset of geomagnetic storms, followed by a gradual return to lower values. Here, we present the initial results of this technique in producing statistical, probabilistic forecasts at lead times of 1-4 days, including a discussion of optimal methods of calculating and updating the transition probabilities. We also present a verification of the results against reference forecasts (including climatology). Our results suggest that the Markov chain approach provides a straightforward way to enhance current operational forecasting capabilities, and can be applied more generally as a benchmark against which to compare more complex physics-based models.