# Assessing the robustness of long-term field variations in the palaeomagnetic record

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Deciphering long-term variations in the magnetic field has important implications for elucidating the connection between the magnetic field and deep interior processes. However, long-term field variations are difficult to discern because they require large amounts of data globally distributed in both space and time. Despite these challenges, datasets such as these have been accumulated for periods of time throughout Earth history that are thought to represent distinctive geodynamo regimes including superchrons, and periods of hyper-reversal activity. Potential biasing of palaeosecular variation (PSV) due to imperfect spatial and temporal sampling is challenging to determine robustly. Here, we synthesise the results of a major collaboration in palaeomagnetic field behaviour taking place before, during and after the 2017 Nordic Palaeomagnetic Workshop in Leirubakki, Iceland. Specifically, we employ numerical geodynamo models to ascertain whether our previously claimed long-term variations in Mesozoic palaeomagnetic behaviour are robust. We assess the effects of spatial and temporal data distributions on calculated palaeosecular variation behaviour (specifically, the Model G description of McFadden et al., 1988) by downsampling 42 geodynamo simulations, mimicking the spatial sampling for the Cretaceous Normal Superchron, the Middle Jurassic (both from Doubrovine et al., 2019), and the last 10 Ma (Cromwell et al., 2019), and comparing these results to those from a uniform “yin-yang” grid (Kageyama and Sato, 2004). We find that between different spatial sampling, similar distributions of the Model G *a* (characterising dispersion at the equator, similar to equation used in Doubrovine et al., 2019) and field strength (virtual dipole moment, VDM) can be reproduced, but Model G *b* (latitude-dependent dispersion, similar to equation used in Doubrovine et al., 2019) is less well-determined, especially when mid and high-latitude sites are sparse. For all three spatial grids, calculated Model G *b* values were underestimated compared to the uniform grid. These findings add support to the inverse relationship between field strength and reversal rate, recently reassessed in Kulakov et al. (2019), and additionally suggest that the minimal variation observed between Model G *a* between the CNS, Mid-Jurassic, and past 10 Myr is robust (Doubrovine et al., 2019). Although we can say that Model G *b* is likely underestimated in datasets where mid and high-latitude sites are sparse, it is difficult to know the amount by which it is underestimated. Overall, we find that the most robust parameters for determining changes in field behaviour where data are limited are VDM and Model G *a*. It is important to note that for the three time periods assessed here, we cannot presently distinguish between PSV regimes, unlike for median VDM. This suggests that VDM may be a more powerful proxy for reversal frequency than PSV, with implications for studies of Precambrian field behaviour where precise estimates of reversal frequency may be extremely difficult to obtain.

Keywords: Paleomagnetism, Long-term magnetic field behavior, Geodynamo simulations, Paleosecular variation