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Geodynamo simulations: tools to understand and forecast the geomagnetic field evolution

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The past two decades have seen an extensive development of numerical geodynamo simulations as tools to understand the mechanisms through which the magnetic field of internal origin of our planet is generated. Though these are still run at parameter regimes far from that of the Earth's core, the similarity of their output with the various observables of the field, secular variation, and underlying core flows has strengthened the prospect to use these simulations as analysis and forecasting tools for the geomagnetic field evolution. In this presentation, I will report on recent progress in geomagnetic data assimilation, an emerging discipline which blends together the high-quality satellite data such as these obtained by the Swarm mission, and state-of-the art numerical geodynamo simulation with an Earth-like output. The outcome of data assimilation is an estimate of the internal geodynamo structure, which sheds light into the mechanisms currently responsible for the geomagnetic dipole decay and the extension of the South Atlantic geomagnetic anomaly. Starting from such estimates obtained at present, ensemble-based techniques akin to those used in meteorology can help to estimate how the present field will evolve in the future. For the next century, our operational forecasts predict a further dipole decay of about 1 microtesla at Earth's surface, together with a similar deepening and a westward motion of the South Atlantic anomaly.