MoSST_DAS: the first working geomagnetic data assimilation system

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The Earth possesses an internal magnetic field (geomagnetic field) generated by convection in the outer core (geodynamo). Previous efforts have been focused along two distinct paths: (1) numerical geodynamo modeling to understand the origin of the geomagnetic field, and the mechanisms of geomagnetic secular variations (SV); and (2) geomagnetic field modeling to map the spatial/temporal variations of the field from geomagnetic data, and to derive core properties, e.g. inversion of core flow near the core-mantle boundary (CMB). Geomagnetic data assimilation is a new approach emerged over the past 5 years: surface observations are assimilated with geodynamo models for better understanding of the core dynamical state, and accurately prediction of SV.

In collaboration with several geomagnetic research groups, we have developed the first working geomagnetic data assimilation system, MoSST_DAS, that includes the MoSST numerical dynamo model; 7000 years of geomagnetic field maps from several field models utilizing satellite and ground observatory data, historical magnetic records and archeo/paleo magnetic data; and an ensemble based optimal interpolation (OI) assimilation algorithm. With this system, we have demonstrated clearly that the assimilated core dynamical state is substantially different from those of pure geodynamo simulations. Ensemble assimilation runs also show the convergence of the assimilated solutions inside the core, suggesting that the simulation state is pulled closer to the truth via data assimilation. The forecasts from this system are also very accurate: the 5-year forecast of the geomagnetic field agrees very well with the observations; and the 5-year secular variation forecast is more accurate than the IGRF SV forecast models in the past. Using geomagnetic records up to 2009, we have made an SV forecast for the period from 2010-2015, and is a candidate SV model for IGRF-11.