OPGC candidate models for IGRF-14

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Products:

- IGRF core field model for epoch 2025.0
- Secular Variation model for period 2025-2030

1. Data

We use satellite vector data from the SWARM-A and SWARM-C satellites for the era spanning 14th of September 2023 to 14th September 2024.

We use the latest calibration of the MAG LR (SW_OPER_MAGA_LR_1B_XX) versions.

Data files are downloaded by ftp swam-diss.eo.esa.int under the file directory: Level1b/Latest_baselines/

We use RC and Kp magnetic indices. The RC index internal and external indices are downloaded from: http://www.spacecenter.dk/files/magnetic-models/RC/

Kp indices are retrieved from: https://omniweb.gsfc.nasa.gov/form/dx1.html

2. Data selection and correction

We use 20s data sampling on both satellites. We split the data set between high and mid latitudes data at the magnetic quasi-dipole latitudes below +/-55°. We use vector measurements only (no scalar data) at all latitudes.

Mid-latitude data are selected according to their local time between 22LT-6LT. The high latitude measurements are selected according to the sunlit and we selected measurements 5° below the sun horizon.

Both Swarm A and B datasets are selected according to the magnetic activity. The measurements for |RC| < 20 nT and |dRC/dt|<= 5nt/hour are kept as well as measurements corresponding to Kp <=3o.

All vector measurements are corrected for the lithospheric field to SH degree 130 with the Swarm data L2 product: SW_OPER_MLI_SHA_2E_00000000T000000_99999999T999999_0801.ZIP

3. Model parameterization

We make the classical assumption that satellite measurements take place in a region free from electric currents. The magnetic scalar potential is split into internal and external components. The internal source field are assumed to be the time varying core field, the remaining static lithospheric field and an internally induced counterpart of the external field.

The external field is assumed to be of magnetospheric origin after night-time data selection in the mid latitude and dark-region selection in the poles. No parameterization for the ionospheric field in the polar region is considered.

The internal field is described in a geographic Earth-Centered Earth-Fixed (ECEF) coordinate system by the classical spherical harmonic expansion. The main field is derived to SH degree 16. The time variation, i.e the secular variation, is assumed linear to SH degree 10 and null for larger SH degrees.

The central epoch, 7 February 2024 (or 2024.10 in decimal year), is computed automatically by the median data of the entire dataset after data selection and correction.

We estimate a static external field in the GSM coordinate to SH degree 1 and a static external field in the SM coordinate system to SH degree 1.

The external field time dependency of the SM external field is parameterized with external part of the RC index and the internal response with the internal part RC of the index.

The inverse problem is solved in the least-squares sense with the Huber weighting scheme without any regularization.

4. Derivation of the IGRF 2025.0 and the SV candidate models for epoch 2025-2030

The internal Gauss coefficients Gnm centered at the central epoch (7 February 2024) are projected to epoch 1st of January 2025 using the linear secular variation model:

$$\mathrm{Gnm}(2025.0) = \mathrm{Gnm}(2024.10) + (2025.0 - 2024.10)\mathrm{dGnm/dt}$$

The time-varying part of the model estimated from satellite data covering September 2023 to 14th September 2024 is our candidate model for epoch 2025-2030.