Geophysical Research Abstracts
Vol. 19, EGU2017-6300, 2017
EGU General Assembly 2017

VO-ESD: a virtual observatory approach to describe the geomagnetic field temporal variations with application to Swarm data

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A complete description of the main geomagnetic field temporal variation is crucial to understand dynamics in the core. This variation, termed secular variation (SV), is known with high accuracy at ground magnetic observatory locations. However the description of its spatial variability is hampered by the globally uneven distribution of the observatories. For the past two decades a global coverage of the field changes has been allowed by satellites. Their surveys of the geomagnetic field have been used to derive and improve global spherical harmonic (SH) models through some strict data selection schemes to minimise external field contributions. But discrepancies remain between ground measurements and field predictions by these models. Indeed, the global models do not reproduce small spatial scales of the field temporal variations. To overcome this problem we propose a modified Virtual Observatory (VO) approach by defining a globally homogeneous mesh of VOs at satellite altitude. With this approach we directly extract time series of the field and its temporal variation from satellite measurements as it is done at observatory locations. As satellite measurements are acquired at different altitudes a correction for the altitude is needed. Therefore, we apply an Equivalent Source Dipole (ESD) technique for each VO and each given time interval to reduce all measurements to a unique location, leading to time series similar to those available at ground magnetic observatories. Synthetic data is first used to validate the new VO-ESD approach. Then, we apply our scheme to measurements from the Swarm mission. For the first time, a 2.5 degrees resolution global mesh of VO times series is built. The VO-ESD derived time series are locally compared to ground observations as well as to satellite-based model predictions. The approach is able to describe detailed temporal variations of the field at local scales. The VO-ESD time series are also used to derive global SH models. Without regularization these models describe well the secular trend of the magnetic field. The derivation of longer VO-ESD time series, as more data will be made available, will allow the study of field temporal variations features such as geomagnetic jerks.