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Uncertainty Estimation for Magnetic Maps

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Magnetic maps depict spatial variations in the Earth's magnetic field. These variations occur at a wide range of scales and are produced via a variety of physical processes related to factors including structure and evolution of the Earth's core field and the geologic distribution of magnetic minerals in the lithosphere. Mankind has produced magnetic maps for 100's of years with increasing fidelity and accuracy and there is a general understanding (particularly among the geophysicists who produce and use these maps) of the approximate level of resolution and accuracy of these maps. However, few magnetic maps, or the digital grids that typically underpin these maps, have been produced with accompanying uncertainty quantification. When uncertainty is addressed, it is typically a statistical representation at the grid or survey level (e.g., +-10 nT overall uncertainty based on line crossings for a modern airborne survey) and not at the cell by cell local level.

As magnetic map data are increasingly used in complex inversions and in combination with other data or constraints (including in machine learning applications), it is increasingly important to have a handle on the uncertainties in these data. An example of an application with need for detailed uncertainty estimation is the use of magnetic map information for alternative navigation. In this application data from an onboard magnetometer is compared with previously mapped (or modeled) magnetic variations. The uncertainty of this previously mapped information has immediate implications for the potential accuracy of navigation.

We are exploring the factors contributing to magnetic map uncertainty and producing uncertainty estimates for testing using new data collection in previously mapped (or modeled) map areas. These factors include (but are likely not limited to) vintage and type of measured data, spatial distribution of measured data, expectation of magnetic variability (e.g., geologic or geochemical environment), statistics of redundant measurement, and spatial scale/resolution of the magnetic map or model. The purpose of this talk is to discuss the overall issue and our initial results and solicit feedback and ideas from the interpretation community.