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Examination of magnetic map variability and uncertainty: crustal magnetic anomalies in oceanic areas

Richard Saltus[1], Arnaud Chulliat[1], Brian Meyer[1], and Martin Bates[2]
[1]CIRES, University of Colorado, Boulder, CO, USA
[2]Sander Geophysics Ltd, Ottawa, Canada

To paraphrase a common model aphorism: “all magnetic maps are wrong, some are useful”. In other words, all maps of the Earth’s magnetic field are subject to uncertainty, both observationally and dynamically. Depending on the intended use of the map, this uncertainty will have varying implications. For those of us who build and use magnetic maps it is important to gain understanding of the uncertainty in these maps to ensure that they are clearly presented and suitable for a given use.

Uncertainty evaluation is a general challenge that affects all magnetic maps and models, but here we concentrate on maps of magnetic anomalies (i.e., perturbations of the Earth’s main field primarily due to variations in magnetic minerals in the crust and shallow mantle) in oceanic areas.

Magnetic anomaly maps for oceanic regions are typically representations of gridded data. The grids are built from available data which generally consists of marine trackline data with a range of ages, collection parameters and uncertainty in original observations. Data coverage and trackline geometries are highly variable around the world. For example, near-shore regions in the Northern Hemisphere tend to be well sampled, whereas open ocean portions of the Southern Hemisphere are poorly sampled.

Quantification of cell by cell uncertainty for magnetic anomaly grids can be subdivided into two regimes: cells containing data and cells without data. For cells containing data, factors such as point-wise observation uncertainty, number of observations, and spatial distribution of data, can be analysed to estimate grid value uncertainty. For interpolated cells, factors such as distance to nearest data cells, local field behavior, and uncertainty in surrounding cells are relevant.

Using NOAA/NCEI trackline marine data for portions of the Caribbean Sea and North Atlantic we are constructing and testing uncertainty models and methods for representing this uncertainty for a variety of magnetic map uses. For a marine magnetic anomaly grid of a portion of the North Atlantic at a 4 km grid interval (the same grid interval used by our global EMAG2 magnetic anomaly compilation), the calculated cell level uncertainty ranges from 20 nT to 150 nT with a mean value of 90 nT. This mean value is similar to the average grid uncertainty of 100 nT/cell that we estimated for marine areas of EMAG2v3. Different gridding approaches, including kriging or minimum curvature algorithms, yield variations in individual cell values, but these variations fall

within our estimated uncertainty ranges.