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An Equivalent Source Method for Modelling the Global Lithospheric Magnetic Field

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Summary
We produce a new model of the global lithospheric magnetic field based on 3-component vector field observations at all latitudes from the CHAMP satellite using an equivalent source technique.

Method
A regularized iteratively reweighted least squares algorithm is applied. Data error covariance matrices are implemented, including both the latitude dependence of data error variances \(\sigma^2\) (Fig.1) and covariances \(C\) between the vector field components due to unmodelled sources. The regularization norm \(R\) is defined to be the Euclidean length of the model solution. Our scheme iteratively minimizes:

\[
\Theta(m_l) = (d - Gm_l)^T W_{l-1}^{-1} (d - Gm_l) + \lambda R(m_l)
\]

Huber weighting ensures a robust solution in the presence of non-Gaussian data errors

\[
H_{l-1} = \min\left(\frac{1.5}{d - Gm_{l-1}/\sigma^2}, 1\right)
\]

Equivalent Source Method
The equivalent potential field sources \(m\) (monopoles) are arranged in an icosahedron grid (Fig.2), consisting of \(K = 30722\) vertices and midpoints, placed at a depth of 100km below the Earth’s surface. The derived model can be transformed into a spherical harmonic representation by:

\[
g_{l}^{\min} = \sum_{k=1}^{K} m_{k}, P_{l}^{m} (\cos \theta_k) \cos (\phi_k)
\]

\[
h_{l}^{\min} = \sum_{k=1}^{K} m_{k}, P_{l}^{m} (\cos \theta_k) \sin (\phi_k)
\]

Results and Outlook
The presented model has a power spectrum that compares well to CHAOS-4, MF7 and CMS (cf. Poster EGU2014-6883) models to degree \(n = 100\) (Fig.4). Ongoing investigations concern non-quadratic regularization using maximum entropy. Looking forward, we plan to explore local grid refinement options in order to incorporate aeromagnetic survey data.