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Research Project – Inversion of gravity data using a dual minimum support method

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Ground gravity surveying has proven to be a valuable tool in mining exploration. Several inversion schemes have been proposed to solve the inverse problem. Building upon the work of Li & Oldenburg (2003)[i] and Last & Kubik (1983)[ii], we propose a *dual minimum support* inversion algorithm. We seek a solution that can allow for both sharp and gradual changes in physical properties while remaining stable as noise level increases. Our new objective function can be expressed in compact notation as:

$$minimize\ \boldsymbol{\varphi} = \|\mathbf{G}\ \mathbf{m} - \mathbf{d}\|_2 + \alpha_\nabla \left\| \frac{\nabla \mathbf{m}}{(\nabla m)^{2-p} + \boldsymbol{\varepsilon}} \right\|_2 + \alpha_c \left\| \frac{\mathbf{m}}{(m)^{2-q} + \boldsymbol{\varepsilon}} \right\|_2$$

where **G** is the forward operator, **m** is the discretized model, **d** the observed data and [β, α, ε] are constants. The first term controls the misfit between observed and predicted data, the second term imposes a constraint on the gradient and the last term penalizes small model values. The inversion can recover sharp boundaries between anomalies while preserving continuous features.

To illustrate the capability of the algorithm we have inverted a synthetic example. The model consists of two blocky anomalies surrounded by a continuous, intrusive-like feature over a uniform background density (Fig-1). The survey design mimics a ground gravity survey of 400 observation stations over a 20 x 20 m grid spacing. Data were corrupted with 5% Gaussian noise.

For comparison, two solutions were computed using the standard UBC-GRAV3D inversion package and the *dual minimum support* algorithm. Both solutions predict the data to the same misfit level. The model recovered from the *dual minimum support* scheme is superior on various levels.

1. **The geometry and physical property of individual anomalies are better recovered.**
2. **The algorithm has reproduced almost perfectly the raw data, suppressing only the random noise.**

[i] Li, Y. Oldenburg, D.W. 2003 Fast inversion of large-scale magnetic data using wavelet transforms and a logarithmic barrier method. Geophysical Journal International **152**: 251-265

[ii] Last, B.J. Kubik, K. 1983. Compact Gravity Inversion. Geophysics, **48** (6): 713-721

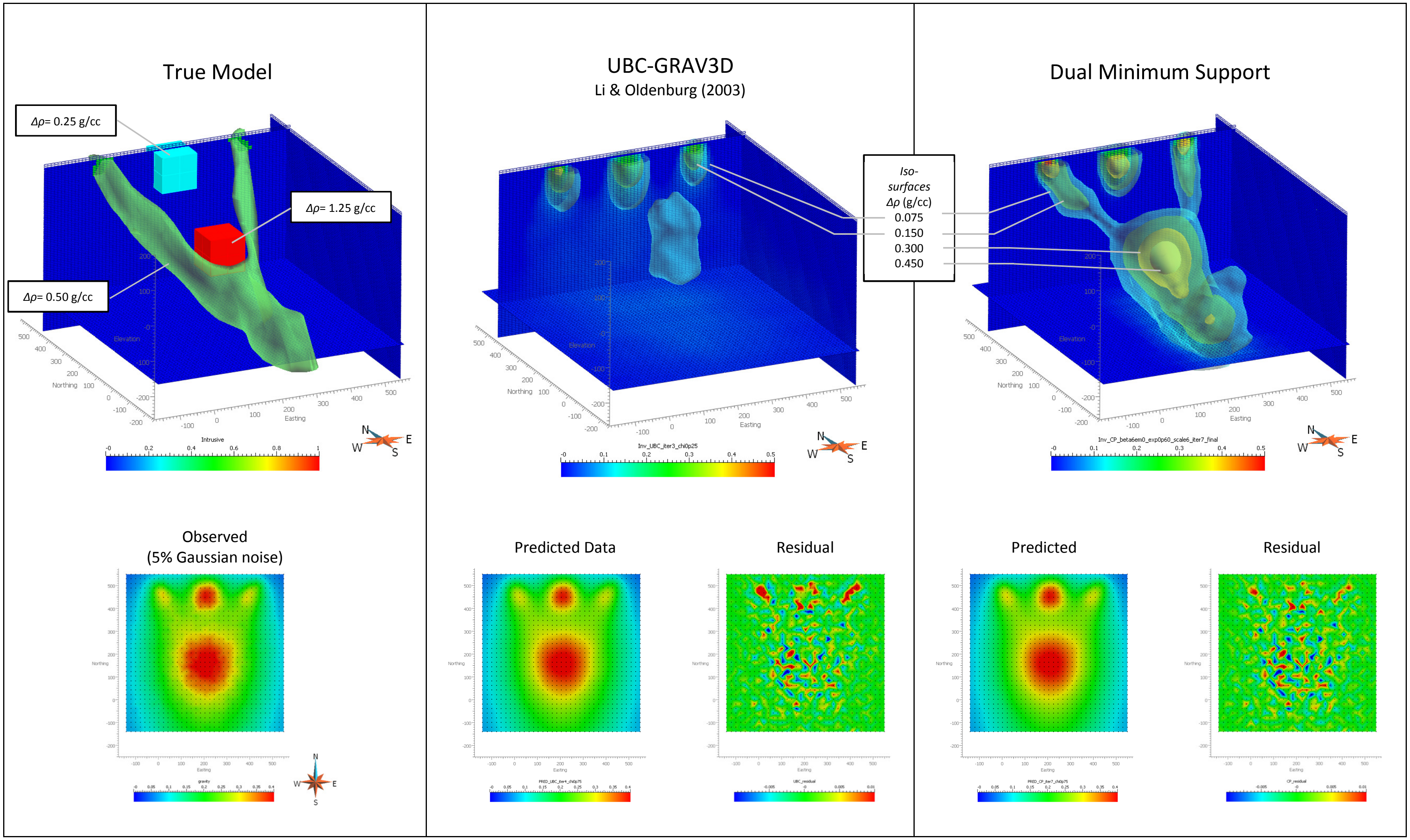

Figure 1: Synthetic model (left) and recovered density models using UBC-GRAV3D (center) and the *dual minimum support* algorithm (right).