Comparison of methods used in 3-D density inversion from airborne gradiometry

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Outline

- *Background Introduction*
- *Methods used in 3-D density inversion*
- *Simulation test and field application*
- *Conclusion and discussion*

Background introduction

The advantageous of airborne gradiometry

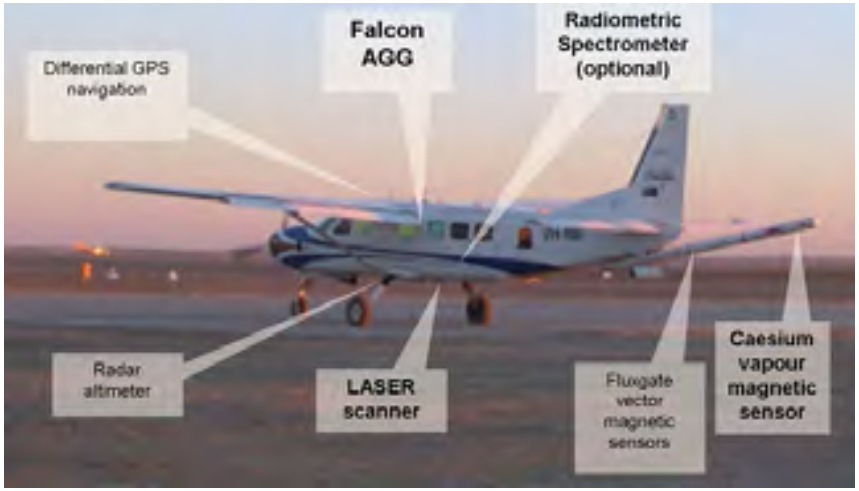


Figure 1: Airborne gradiometry system

- *High resolution of observation*
- *Fast and cost effective surveying*
- *More components result*

Forward modelling and inversion problem

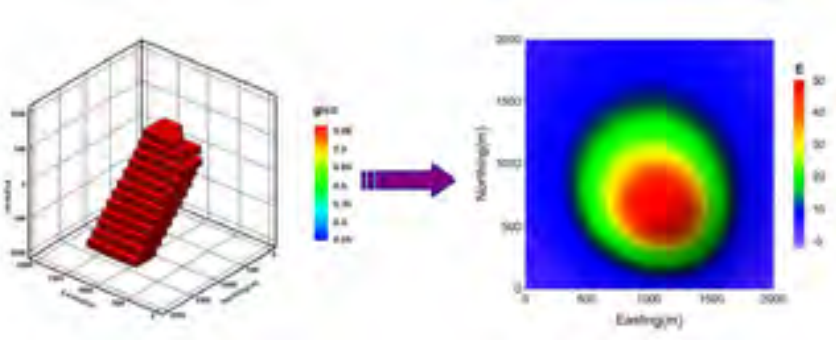


Figure 2: Forward modelling

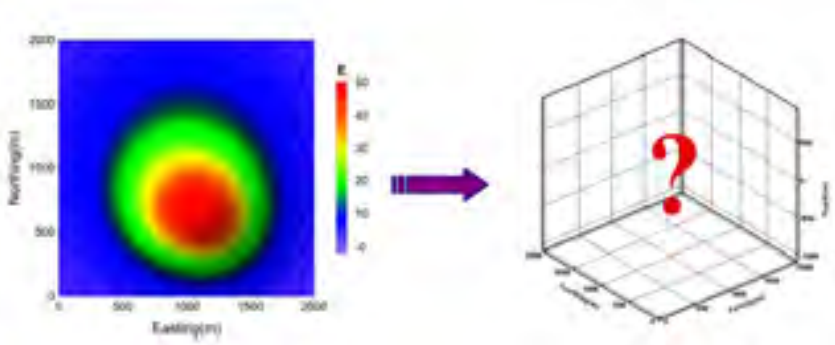


Figure 3: Inversion problem

Methods used in 3-D density inversion

3-D density inversion with constraint

$$\left\|A\rho - d\right\|^2 + \lambda\left(w_s\left\|w(z)\rho\right\|^2 + w_x\left\|\frac{\partial w(z)\rho}{\partial x}\right\|^2 + w_y\left\|\frac{\partial w(z)\rho}{\partial y}\right\|^2 + w_z\left\|\frac{\partial w(z)\rho}{\partial z}\right\|^2\right) \rightarrow \min \quad (1)$$

$w(z)$ is the depth weighting function:

$$w\left(z_j\right) = \frac{1}{\left(z_j + z_0\right)^{\beta/2}} \quad (2)$$

Eq.(1) is equal to:

$$\begin{cases} \overline{A}\overline{\rho} = d \\ \rho = W_A^{-1}\overline{\rho} \end{cases} \quad (3)$$

where $\overline{\rho} = W_A\rho$, $\overline{A} = AW_A^{-1}$,

$$W_A = \sqrt{w_s}D_s w(z) + \sqrt{w_x}D_x w(z) + \sqrt{w_y}D_y w(z) + \sqrt{w_z}D_z w(z).$$

Methods used in 3-D density inversion

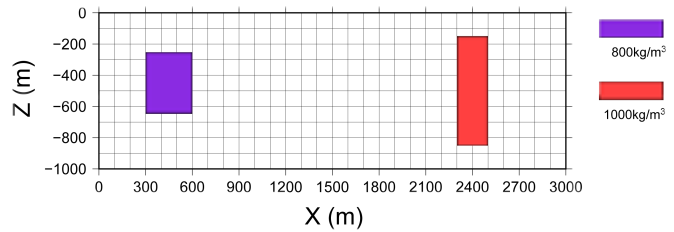
Methods selection

From Eq.(3), main problem is how to deal with this equation:

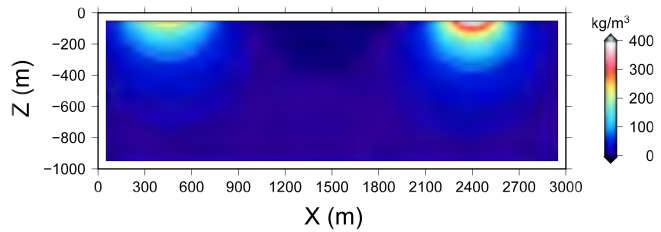
$$\overline{A}\overline{\rho} = d \tag{4}$$

- *Tikhonov regularization*
- *Simultaneous Iterative Reconstruction Technique* (*SIRT*)
- *Wavelet compression combining with Least Squares QR-decomposition* (*LSQR*)

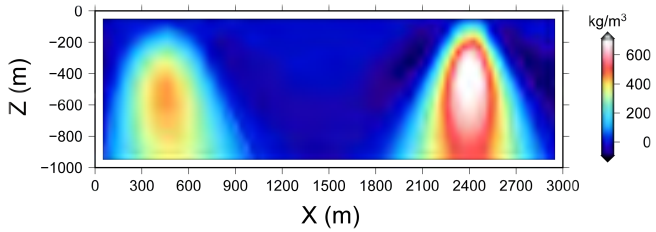
Simulation test



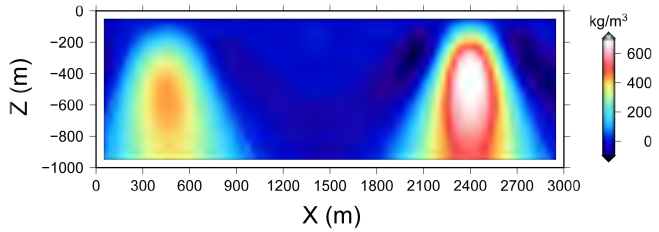
(a) Simulation model



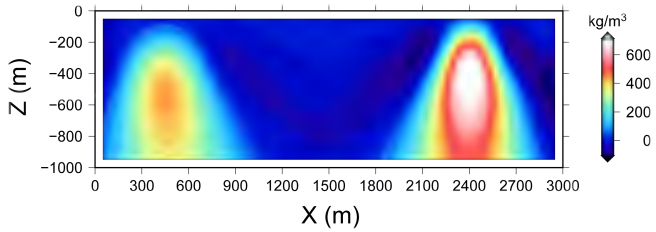
(b) Tikhonov I



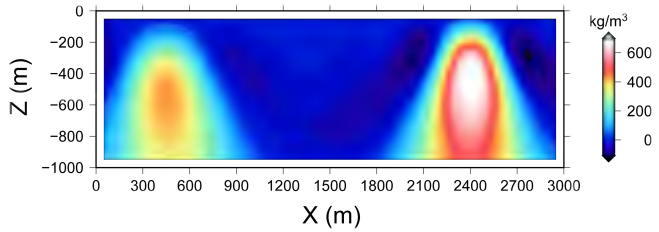
(c) Tikhonov II



(d) SIRT



(e) Wavelet+LSQR(0%)



(f) Wavelet+LSQR(90%)

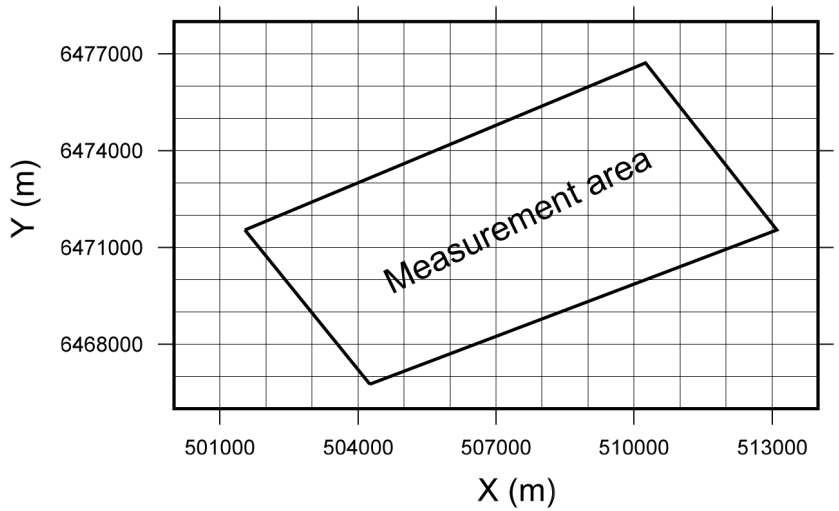
Figure 4: Comparison of inversion result from different methods

Simulation test

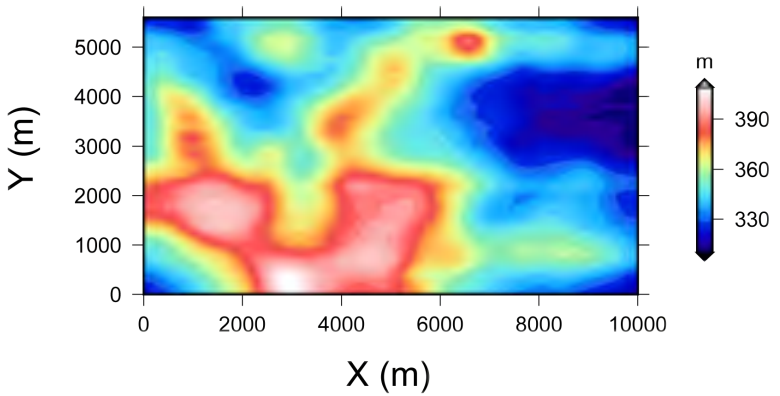
Table 1: Statistics of CPU time consuming

Time (s)	Tikhonov	SIRT	Wavelet+LSQR(0%)	Wavelet+LSQR(90%)
T	229	150	134	124

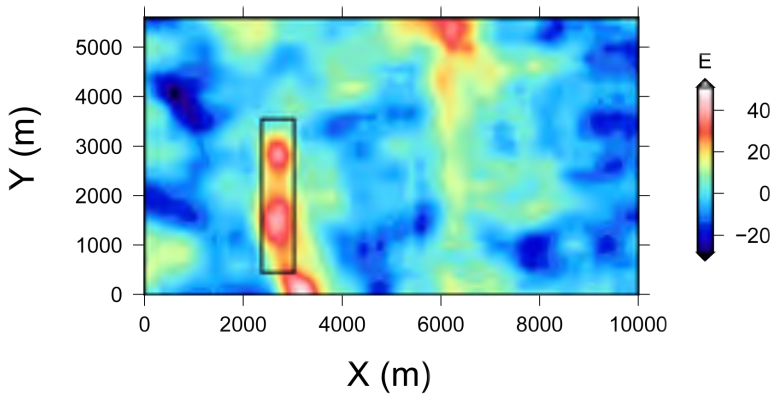
Field application



(a) Measurement area in Kauring



(b) Flight hight



(c) Vertical gravity gradient

Figure 5: Original observation of inversion area

Field application

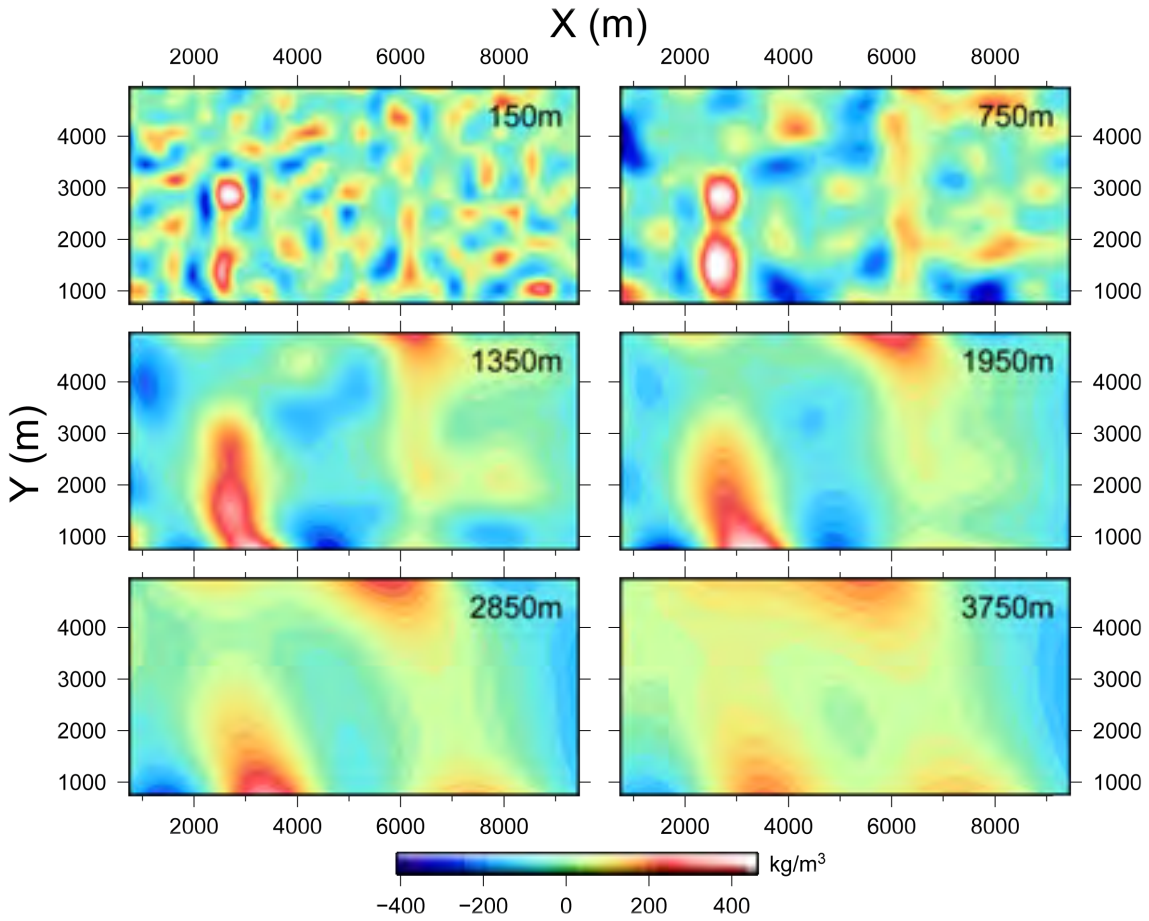
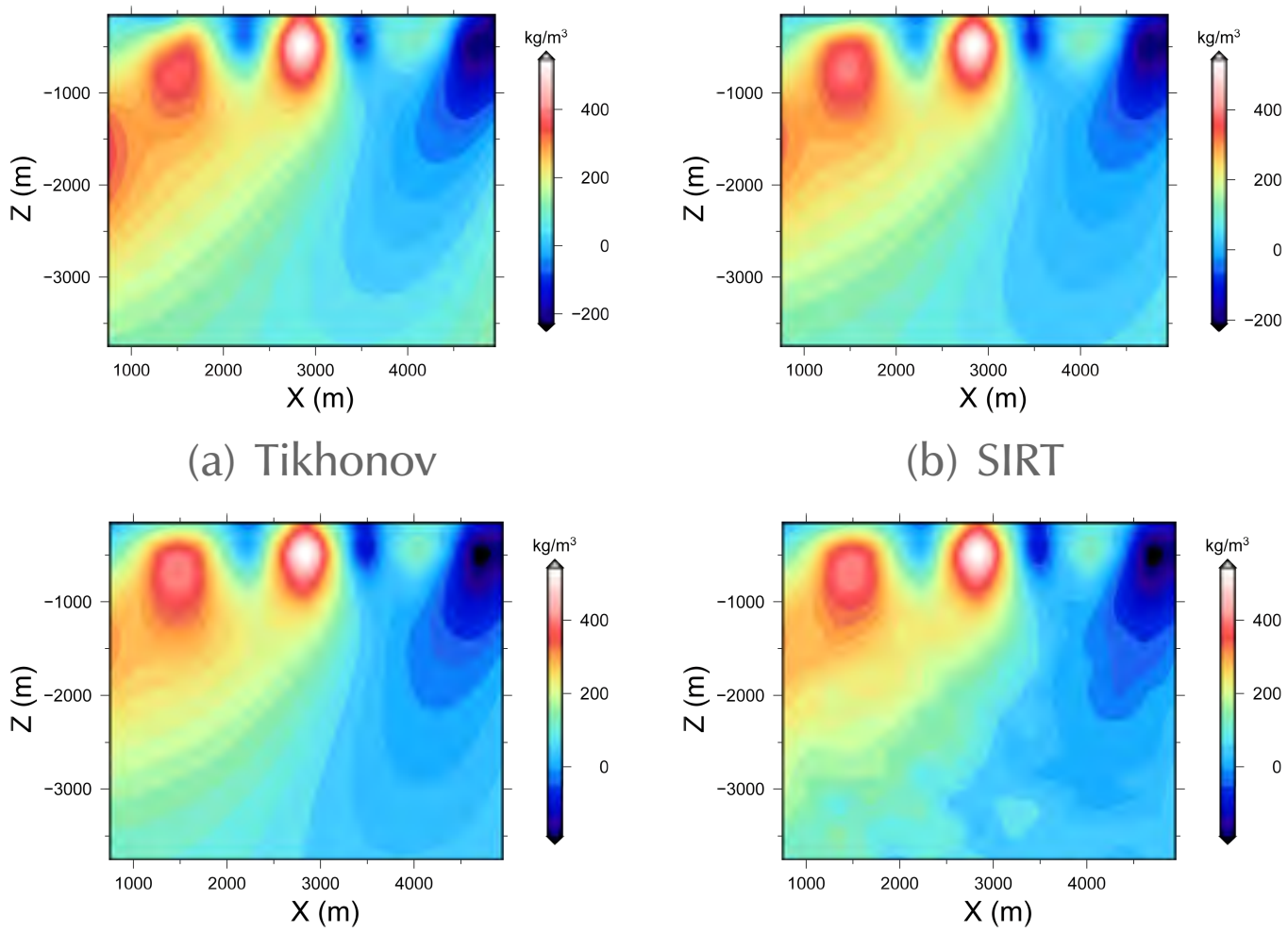


Figure 6: Layers result in different depths

Field application



(a) Tikhonov

(b) SIRT

(c) Wavelet+LSQR(0%)

(d) Wavelet+LSQR(85%)

Figure 7: Slice of potential deposit

Conclusion and discussion

- *Iteration methods can obtain the close result from Tikhonov method. Meanwhile, they can save computation time and memory storage.*
- *The challenge is still existed in the density inversion problem. The constraint is not excellent, how to find the optimal function or combine other kinds of data for the inversion is the work in future...*

Thanks for your attention!