Observatório Nacional

SBGf

AMPLITUDE OF THE MAGNETIC ANOMALY VECTOR IN LOW LATITUDES VIA EQUIVALENT LAYER

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August, 2019

SUMMARY

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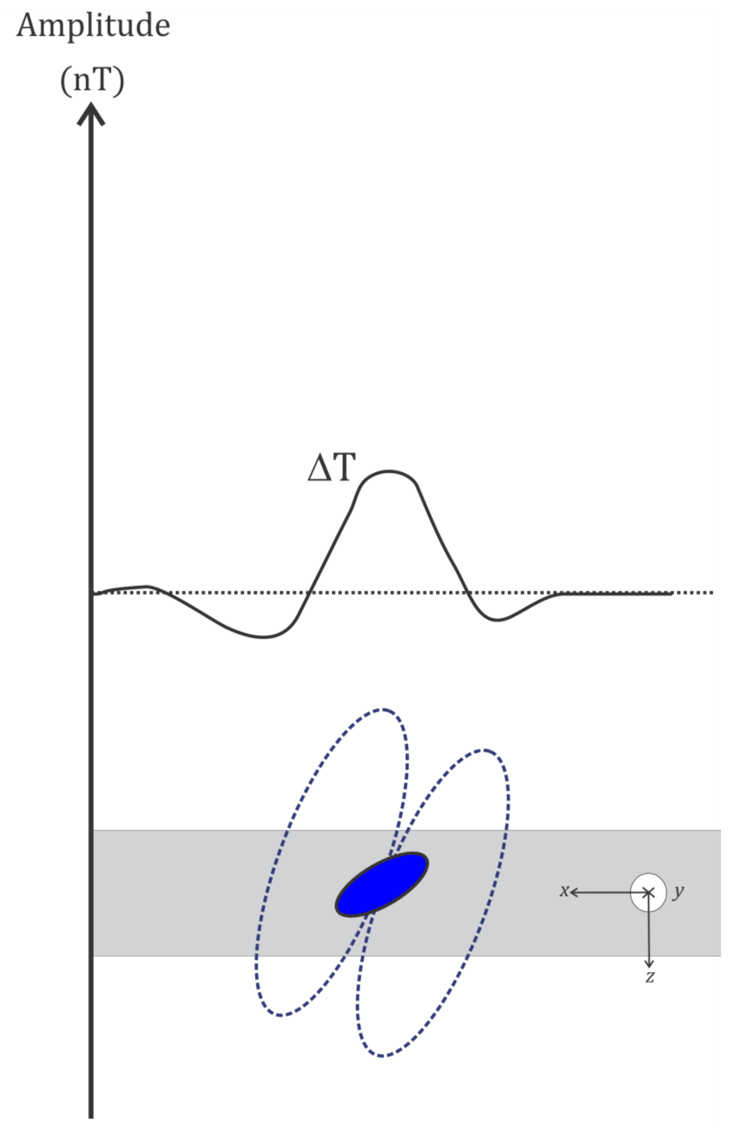
TOTAL-FIELD ANOMALY

The total-field anomay (ΔT) data have been used for geologic interpretation and exploration of mineral deposits over the years.



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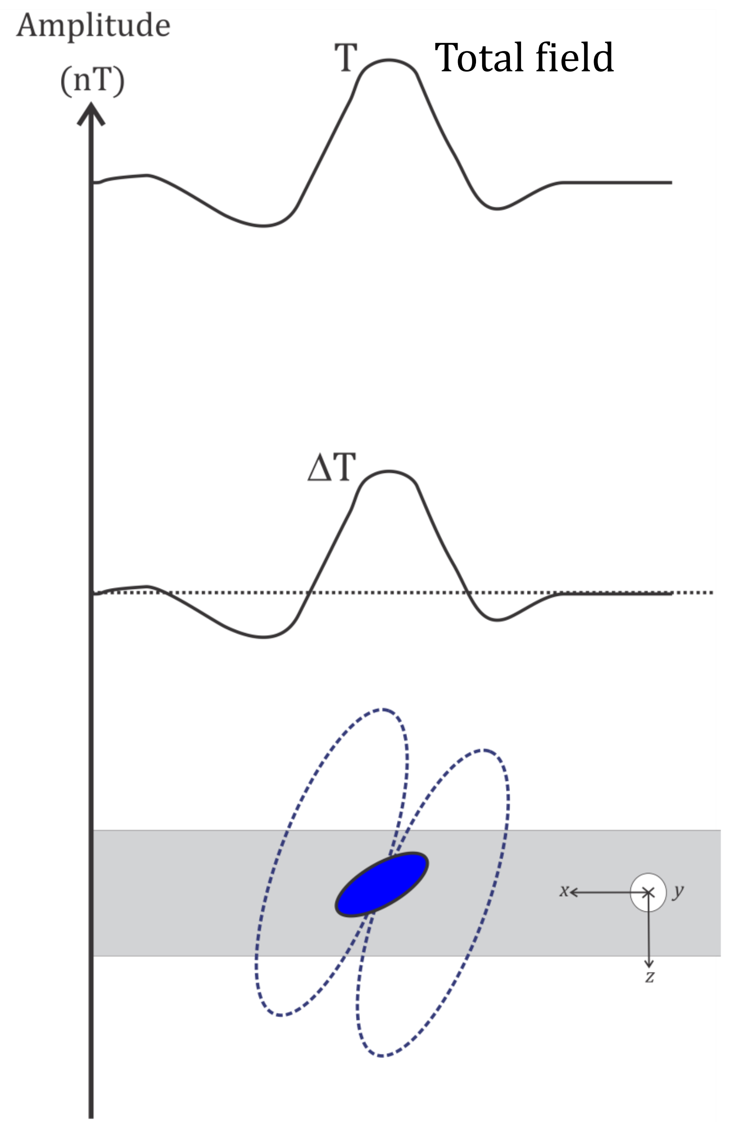

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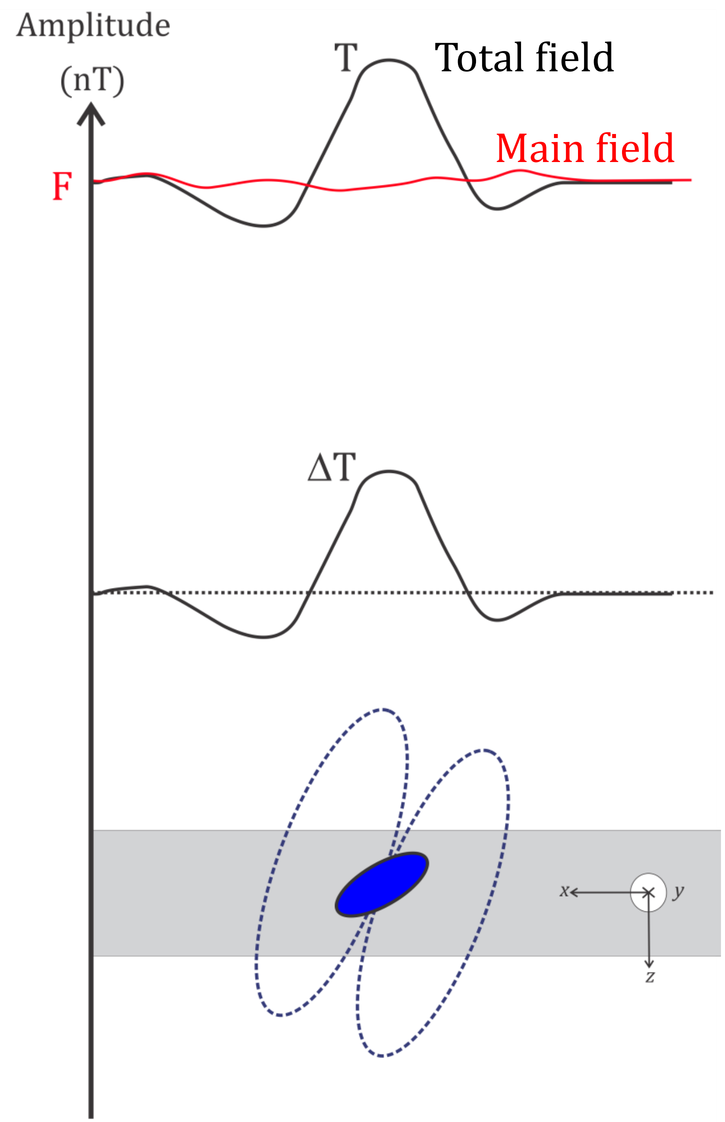

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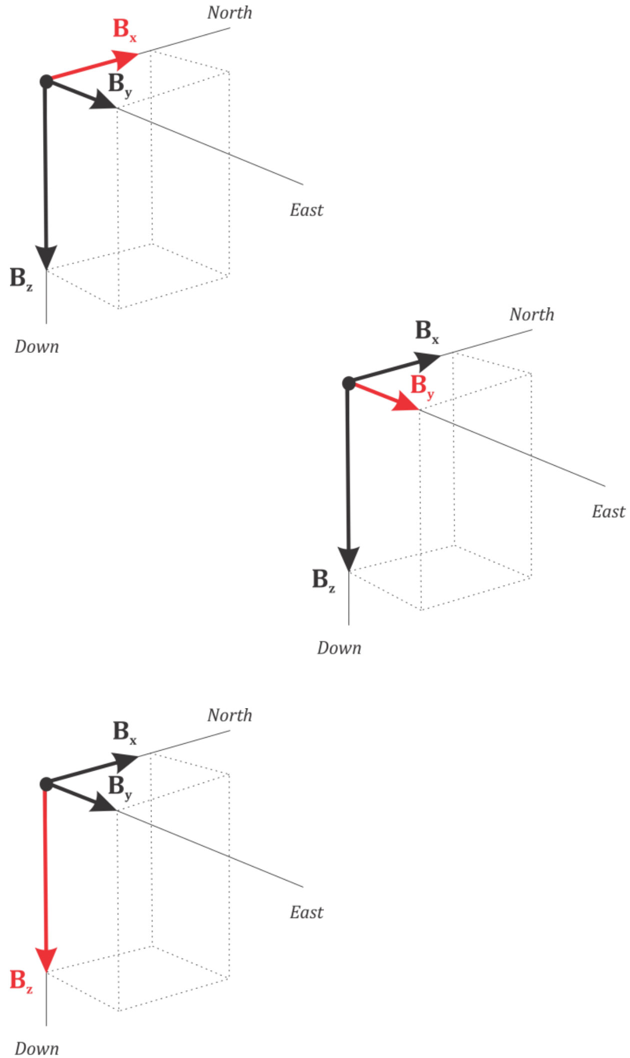
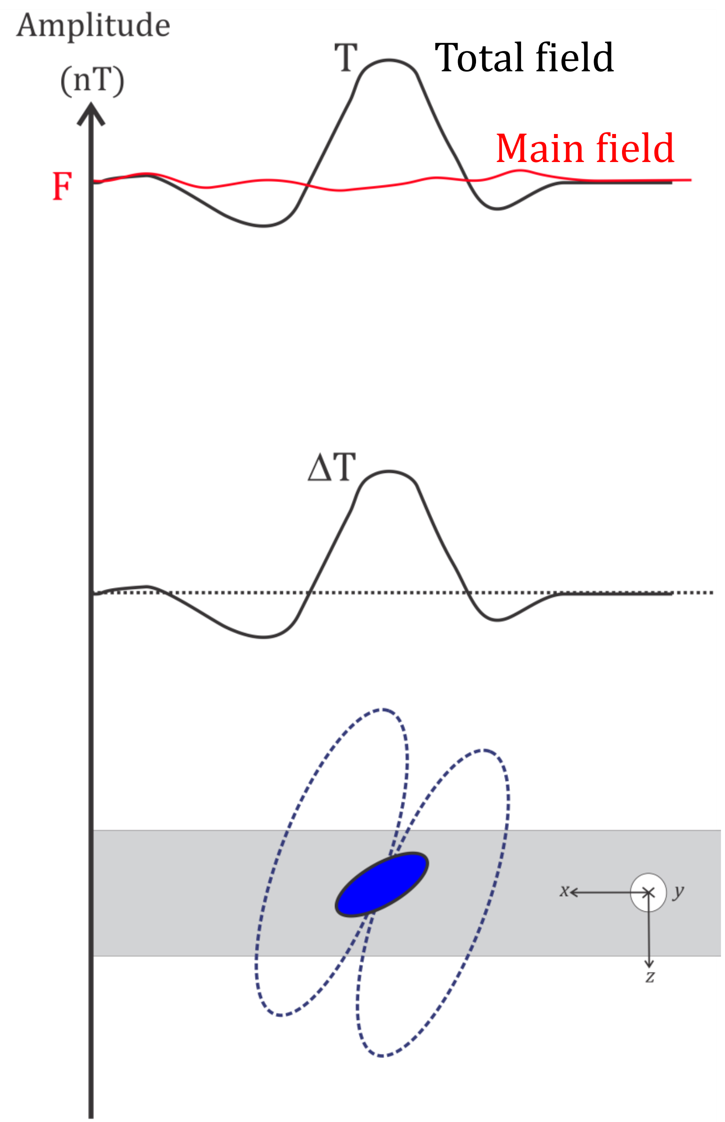
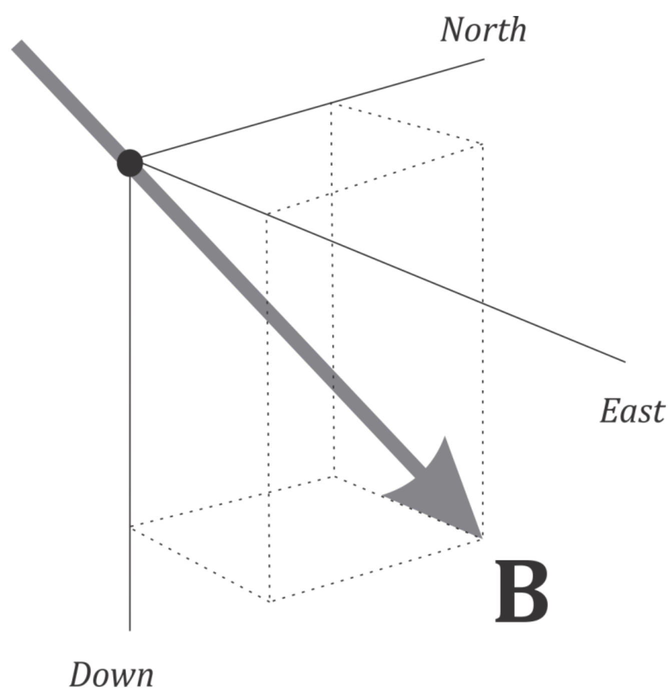




AMPLITUDE OF THE MAGNETIC ANOMALY VECTOR

$$|\mathbf{B}| = \sqrt{\mathbf{B_x^2} + \mathbf{B_y^2} + \mathbf{B_z^2}}$$



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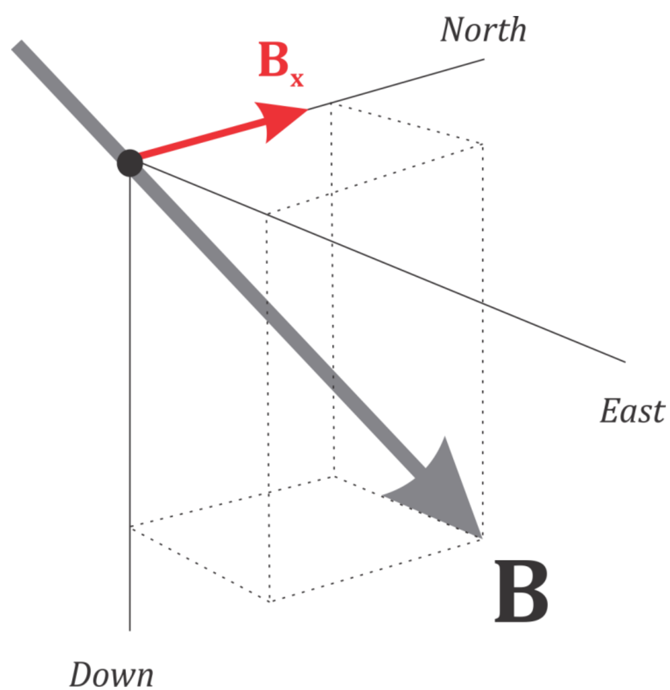

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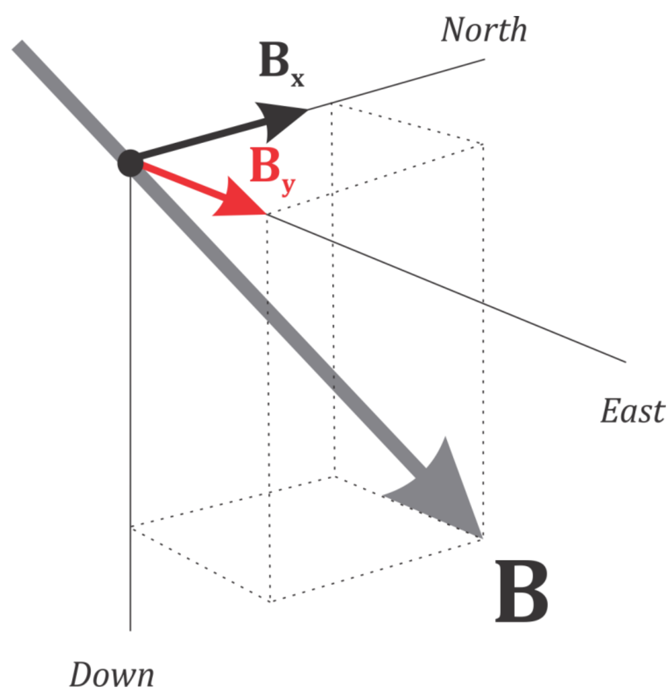

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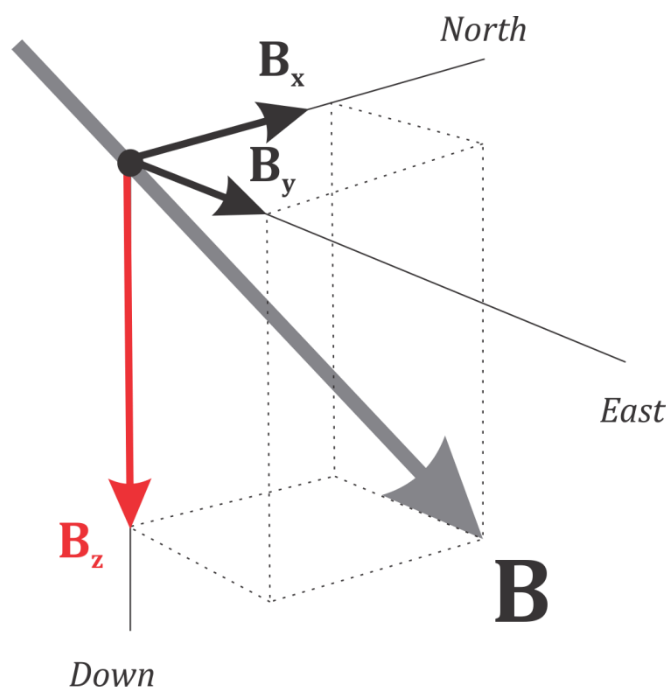

AMPLITUDE OF THE MAGNETIC ANOMALY VECTOR

$$|\mathbf{B}| = \sqrt{\mathbf{B}_x^2 + \mathbf{B}_y^2 + \mathbf{B}_z^2}$$

- Fourier filtering
- Equivalent layer

SUMMARY

2.1 FOURIER FILTERING

$$\mathcal{F}\{\mathbf{B}_\alpha\} = \mathcal{F}\{\boldsymbol{\Delta}\mathbf{T}\}\,\mathcal{F}\{\psi_\alpha\}$$

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Total-field anomaly

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$\hat{\mathbf{F}}$: Direction of the main magnetic field F (I_0, D_0)

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$$\mathbf{k} = (jk_x\,, jk_y, |k|\,)$$

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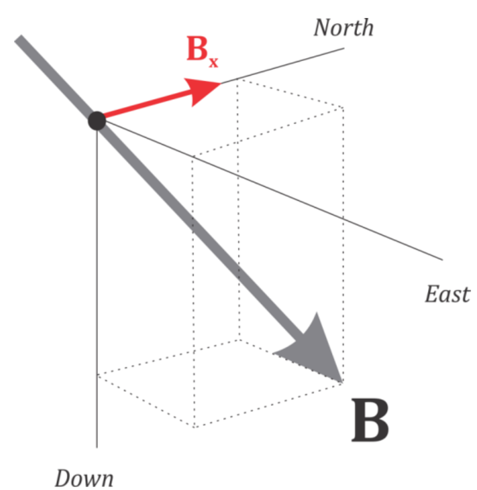
$$\mathcal{F}\{\psi_x\} = \frac{j\,k_x}{|k|\hat{f}_z + j(\hat{f}_x k_x + \hat{f}_y k_y)}$$



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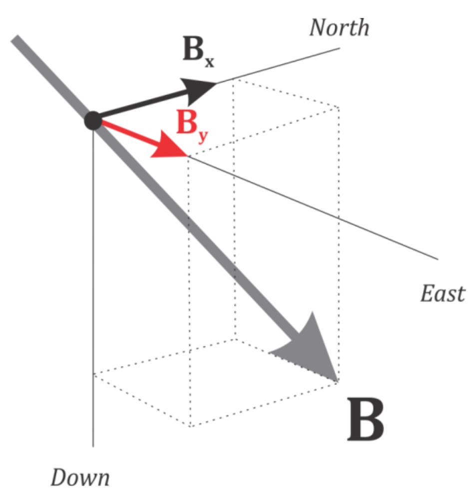

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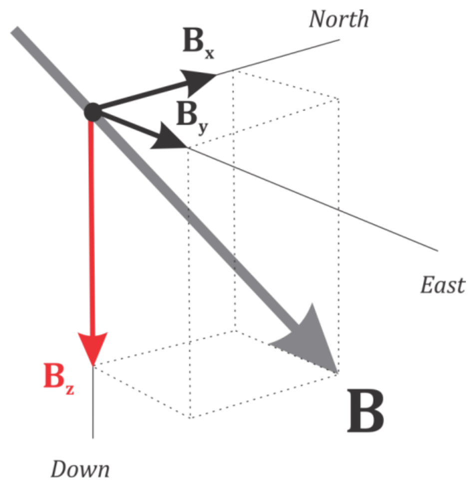
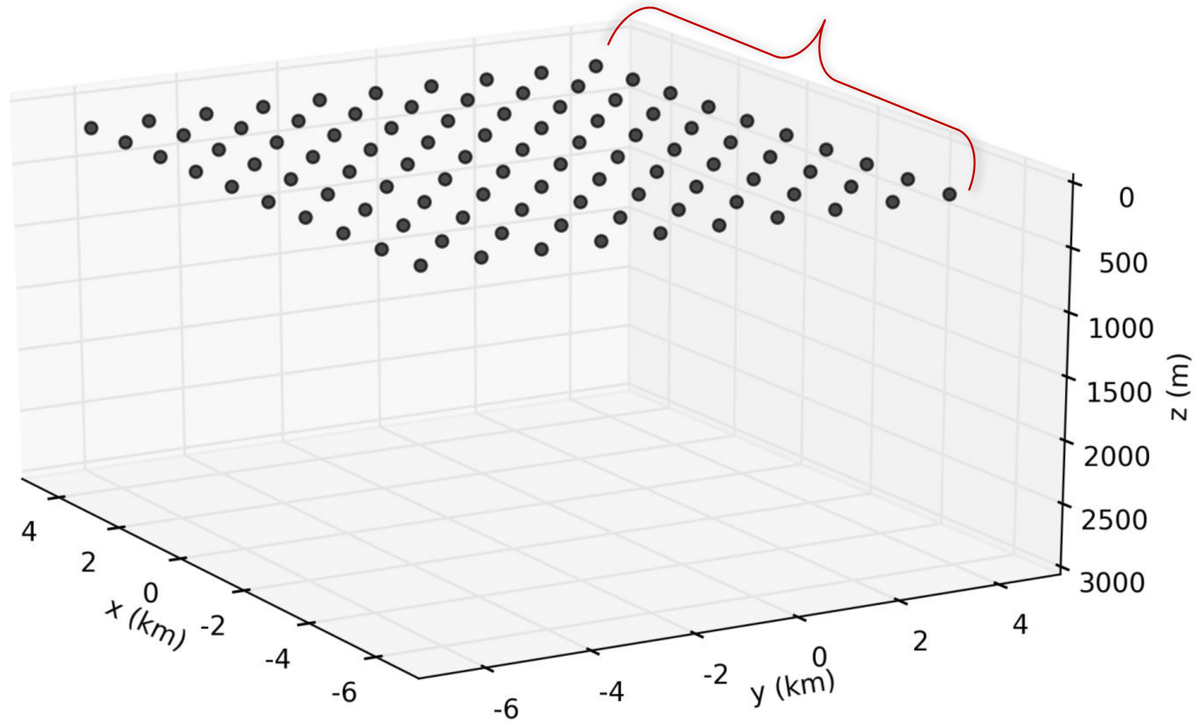
Fourier filter

$$\mathcal{F}\{\psi_z\} = \frac{1}{|k|\hat{f}_z + j(\hat{f}_x k_x + \hat{f}_y k_y)}$$



2.2 EQUIVALENT LAYER

Set of observation points
of a potential field:



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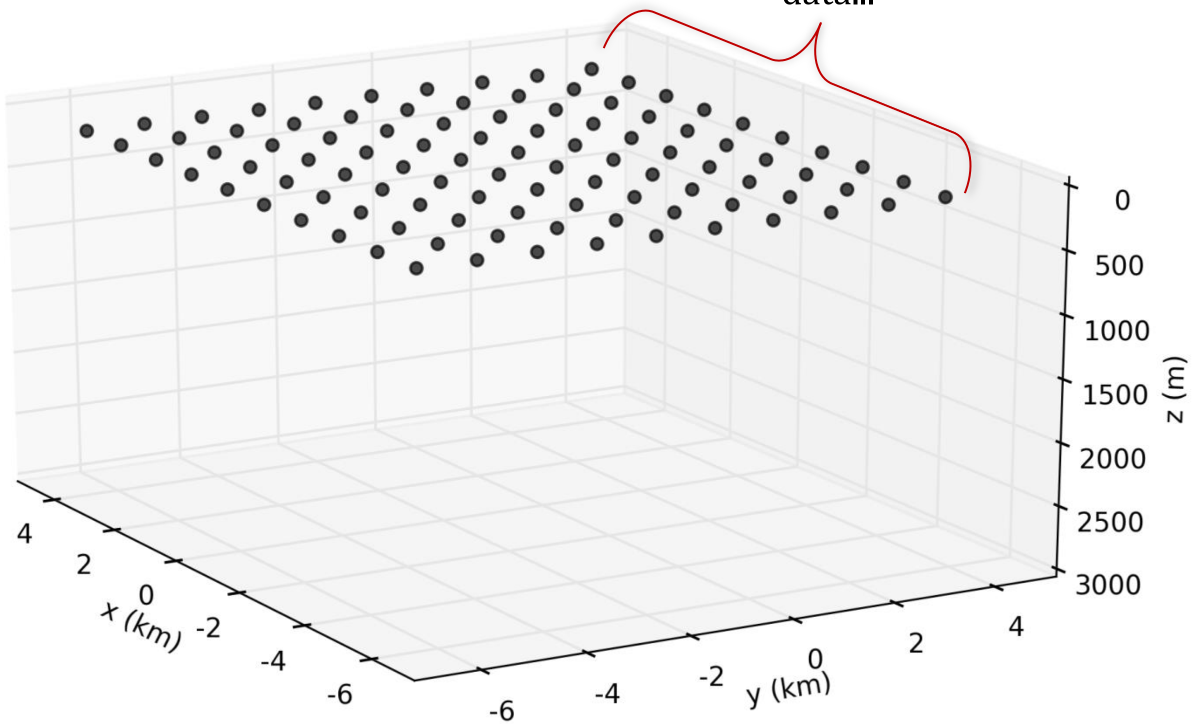
Total-field anomaly data...



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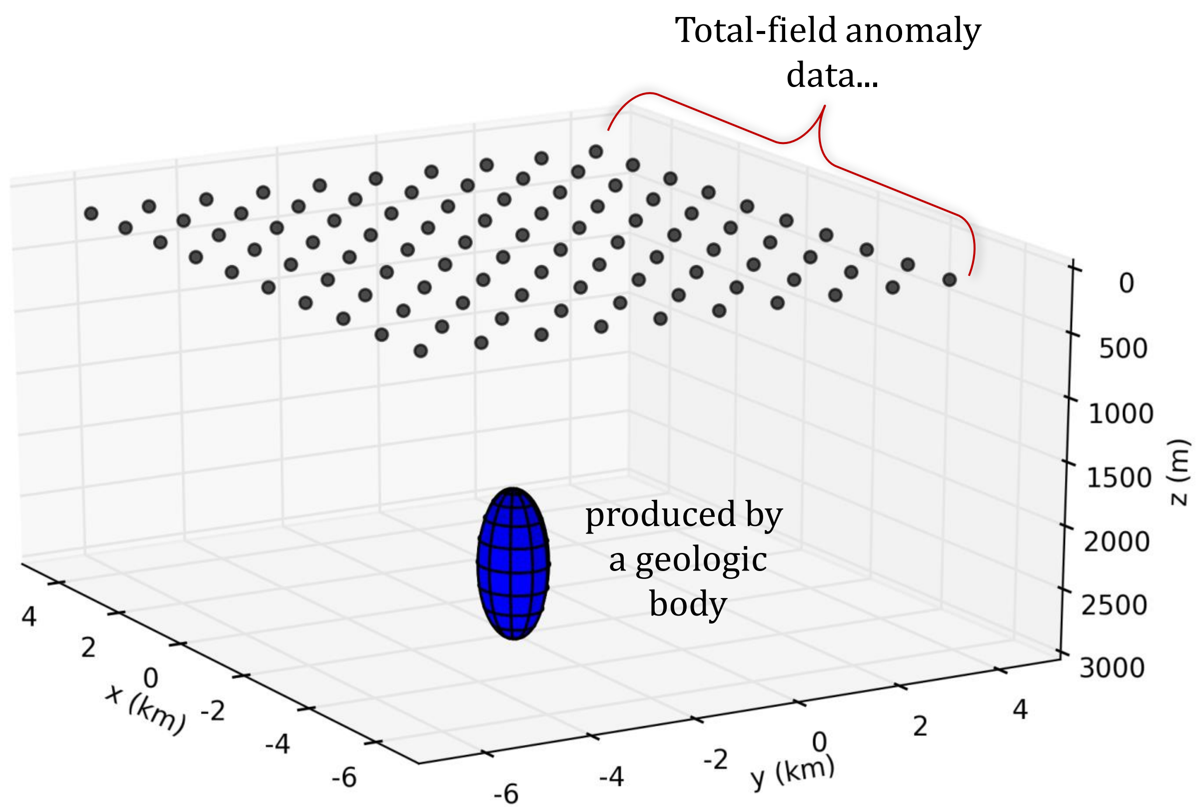

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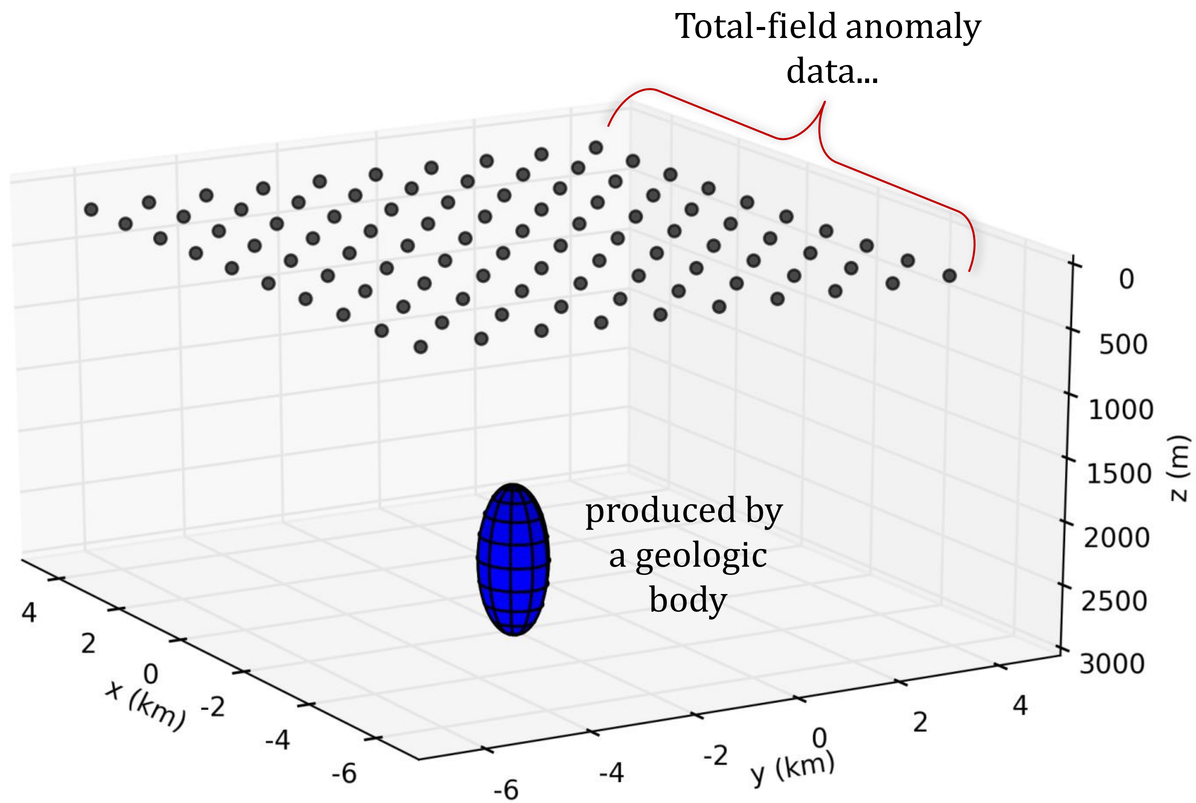
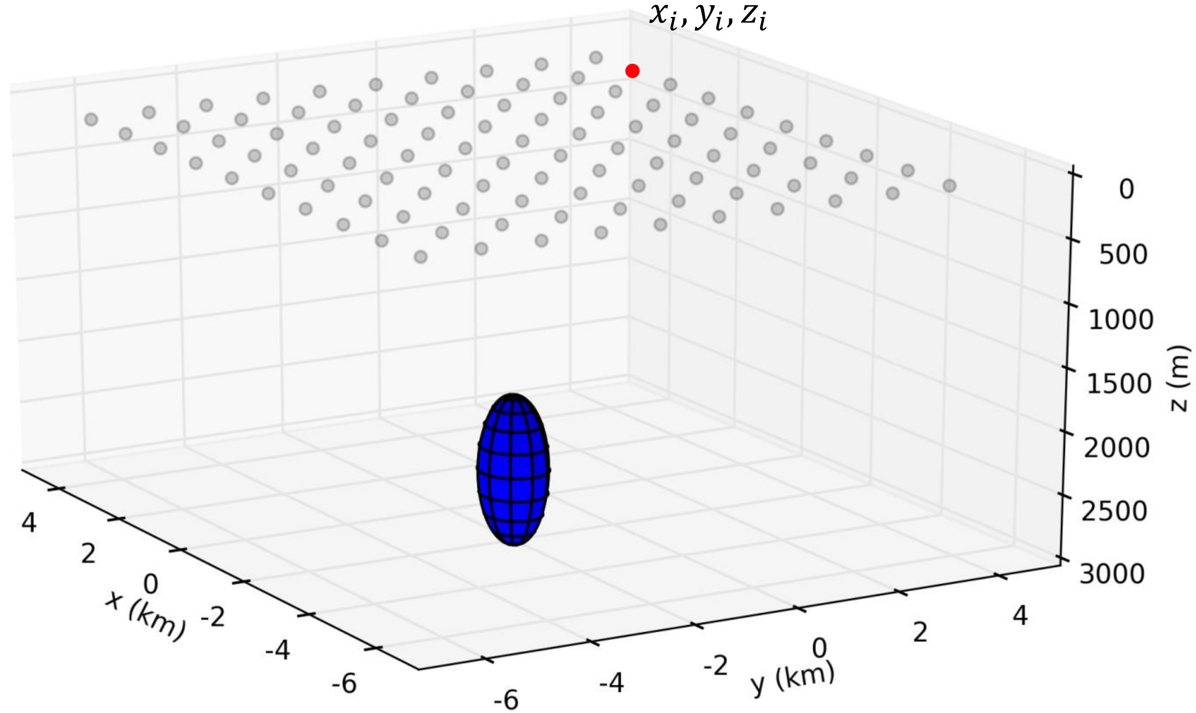


$$\mathbf{d^o} = [d_1^o, \cdots, d_N^o]^T$$

2.2 EQUIVALENT LAYER

Position of the ith observation point

x_i, y_i, z_i



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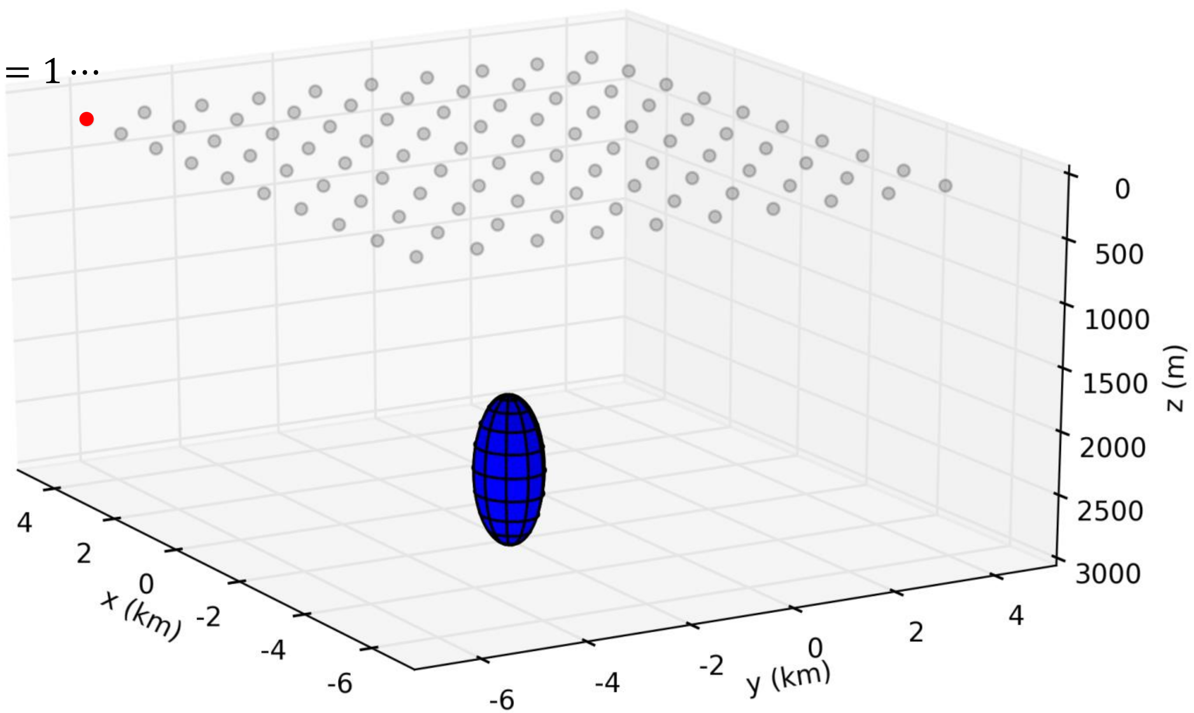
$i = 1 \cdots$



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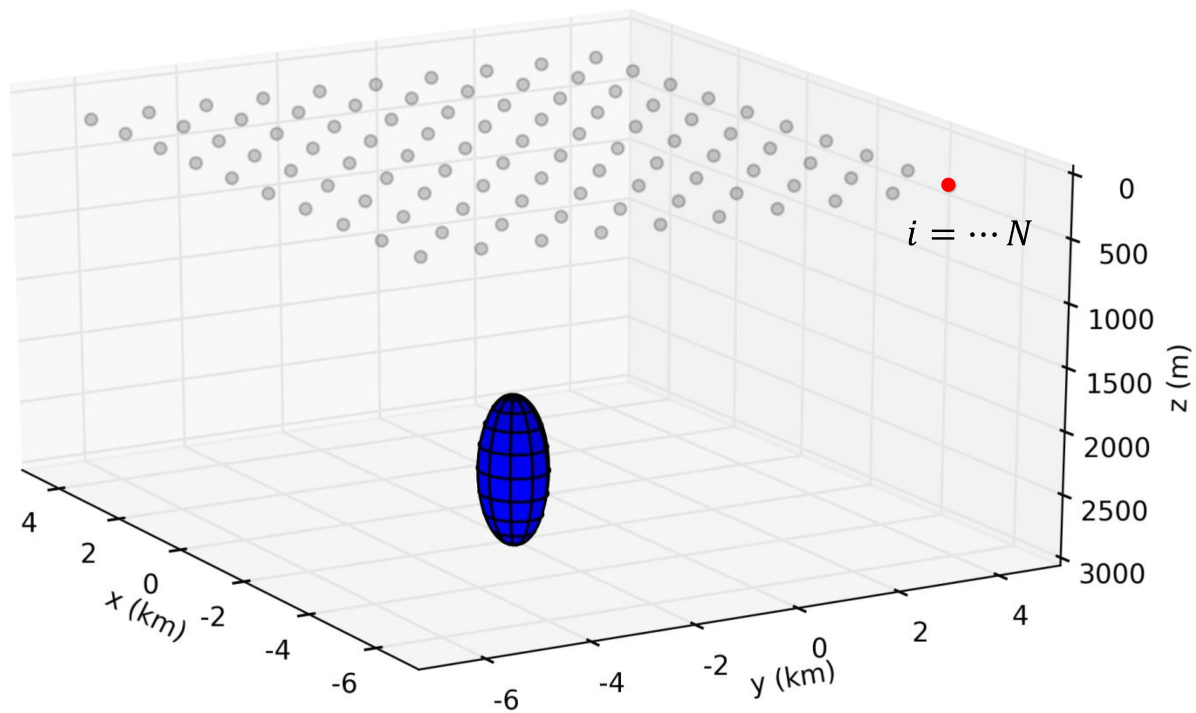

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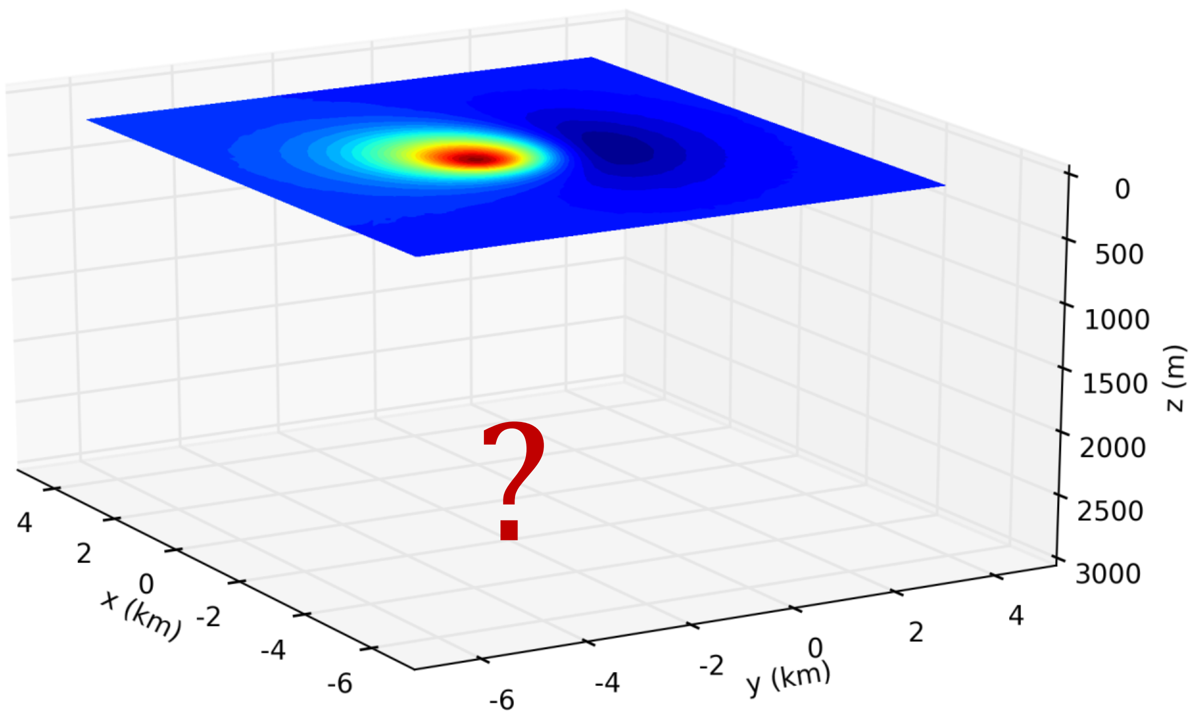

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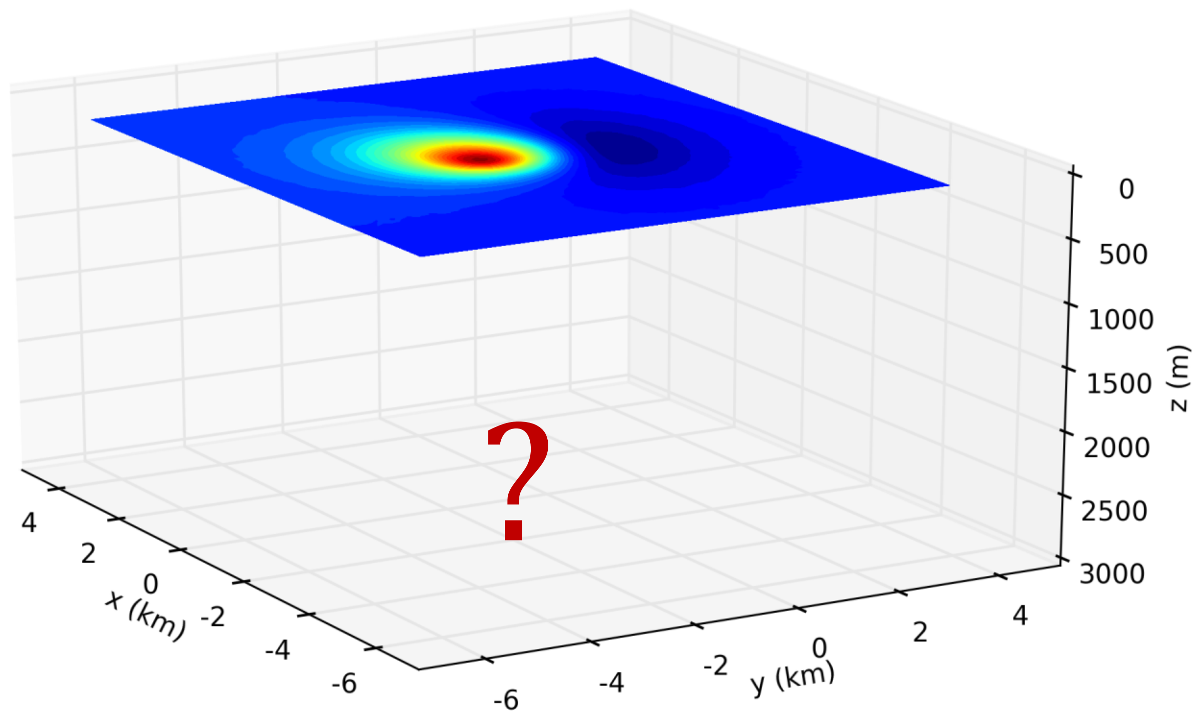

The equivalent layer can be used to estimate information about the physical property distribution of the geologic body.

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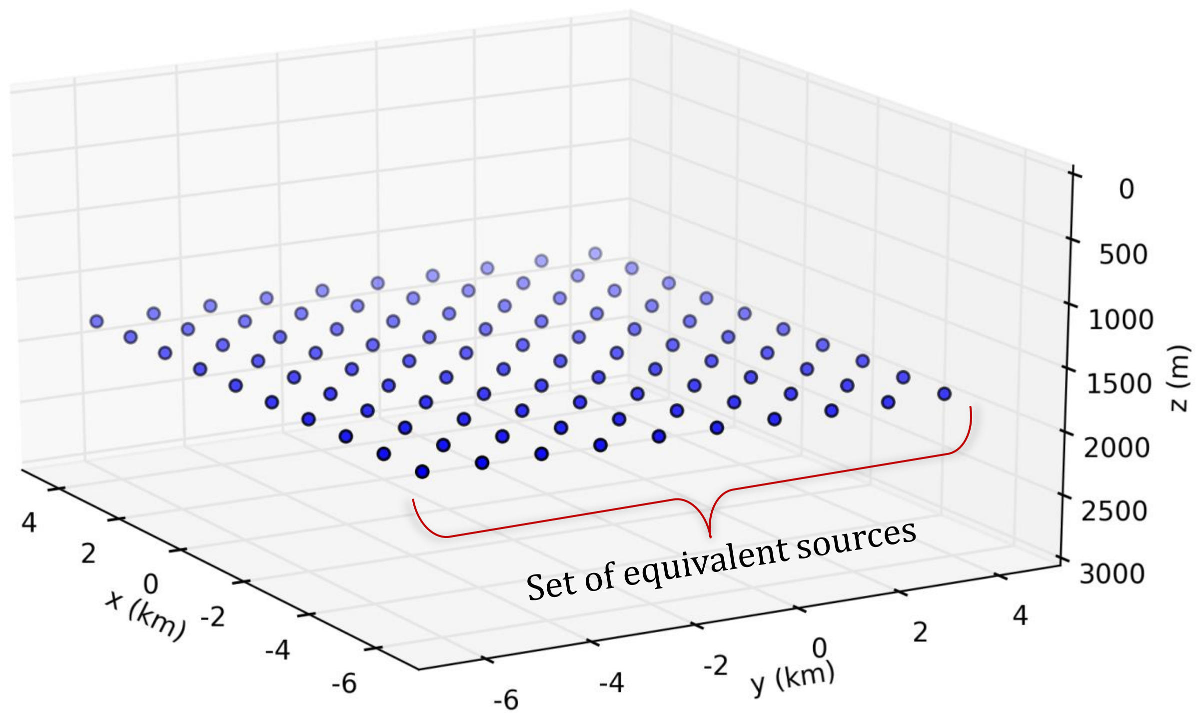

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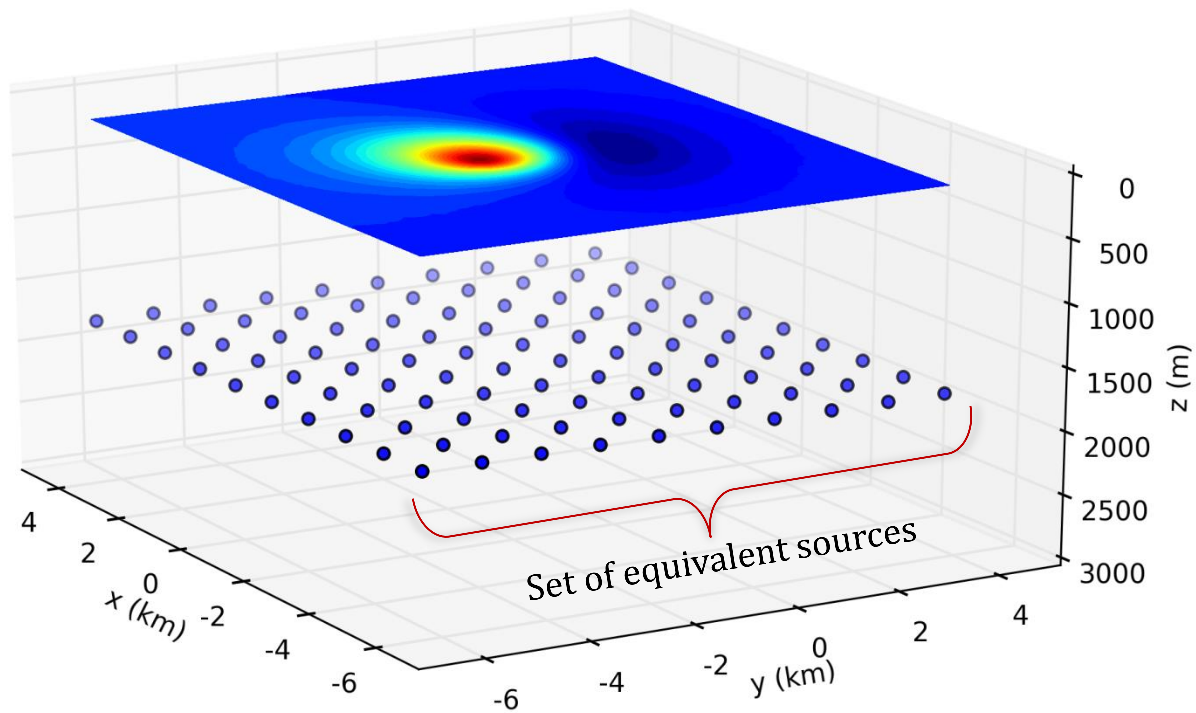

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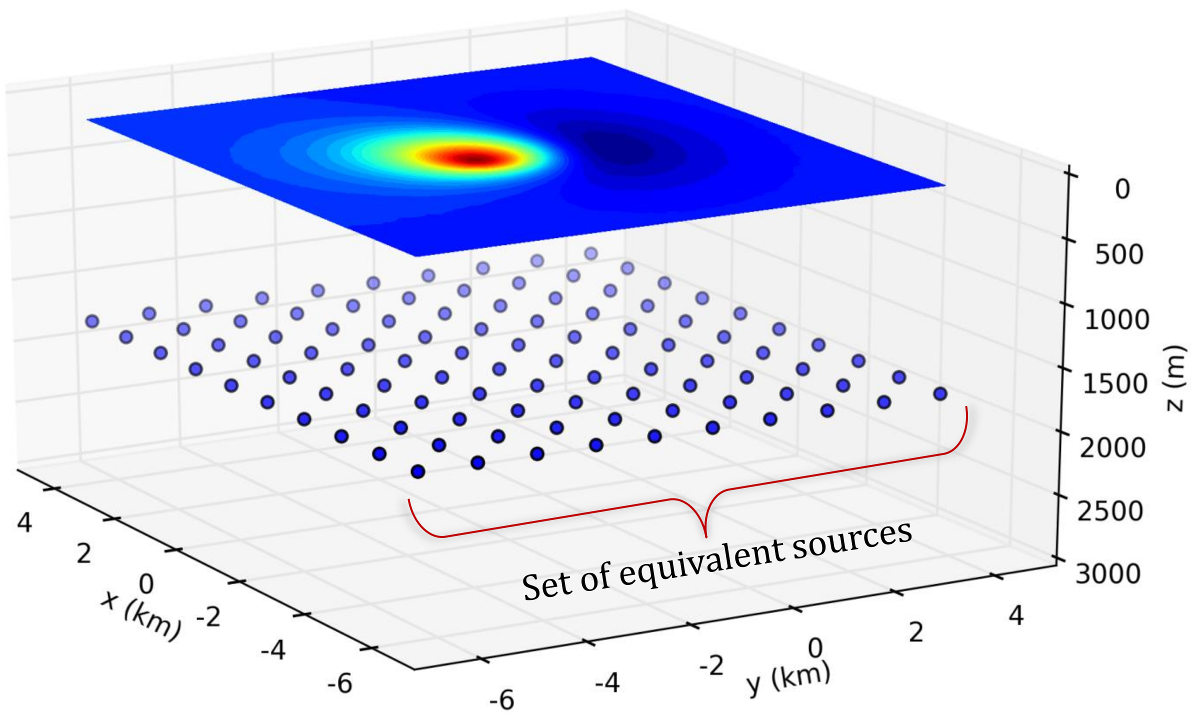

$$\mathbf{d}(\mathbf{p}) = [d_1, \cdots, d_N]^T$$

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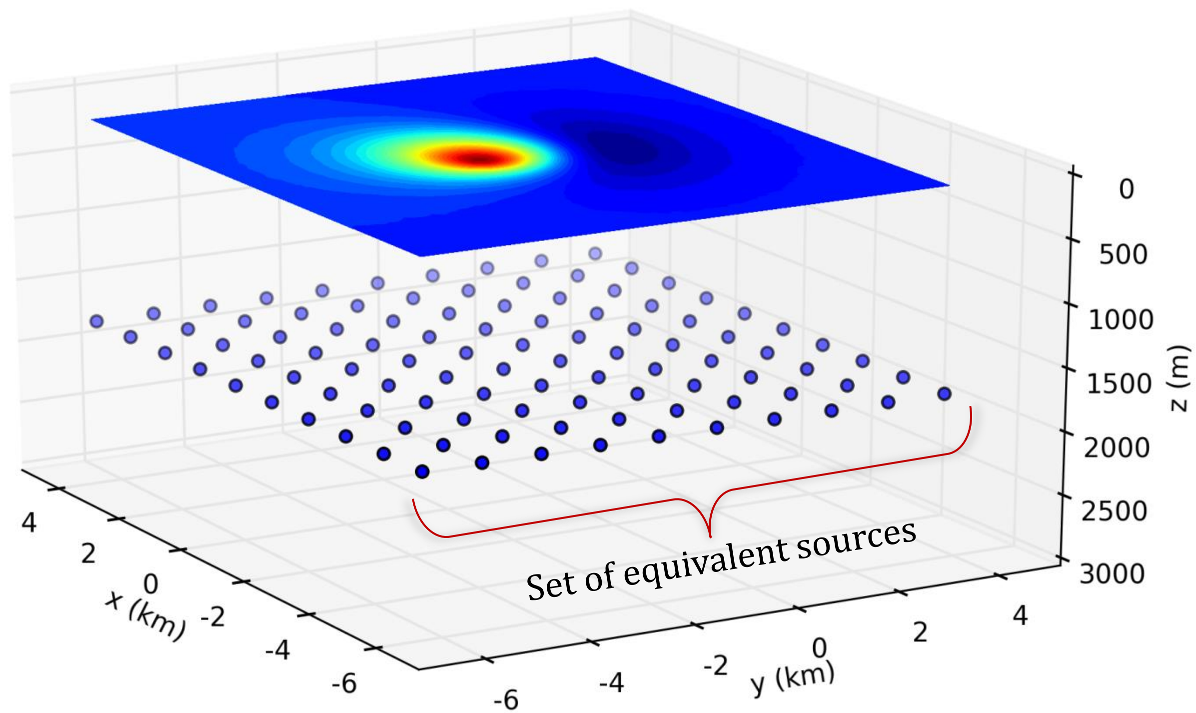

$$d_i(\boldsymbol{p}) = \sum_{l=1}^{M} p_l \, g_{il}$$

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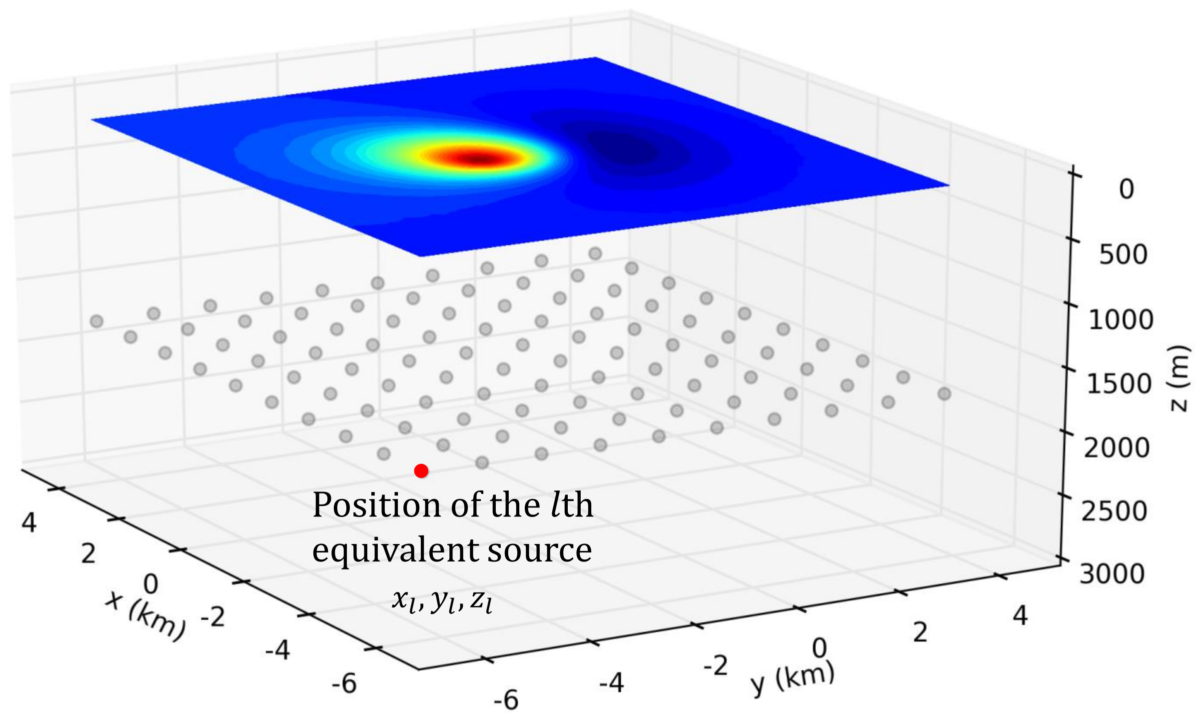

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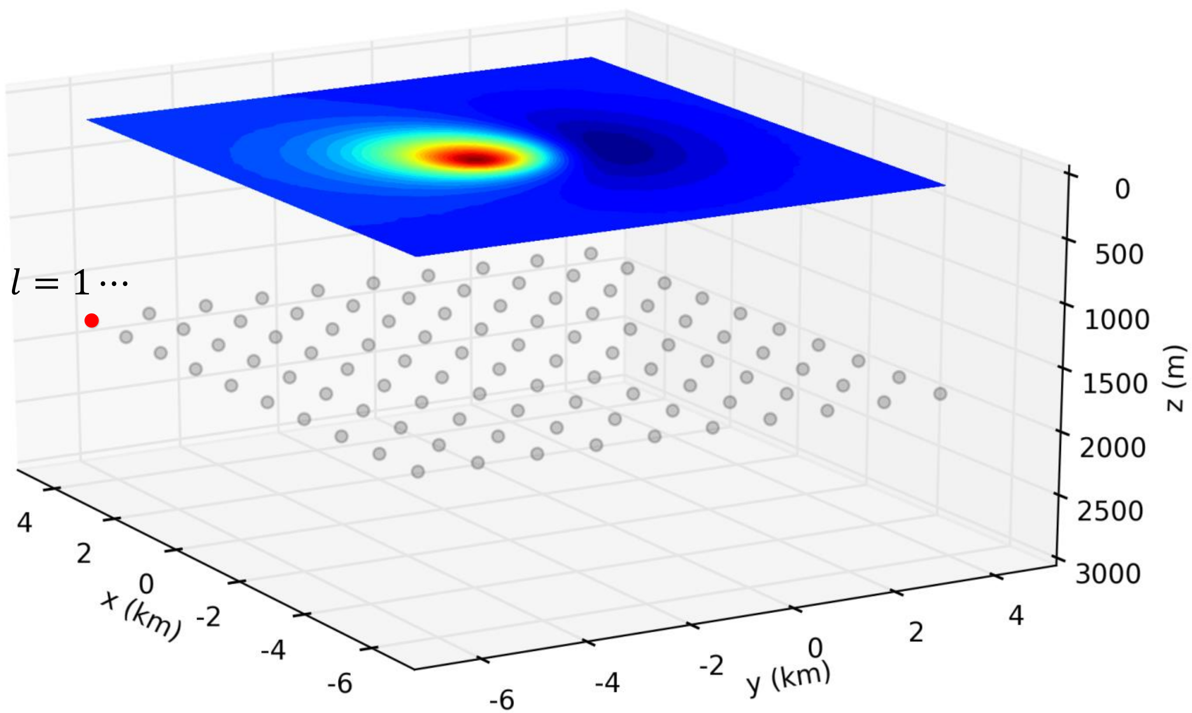

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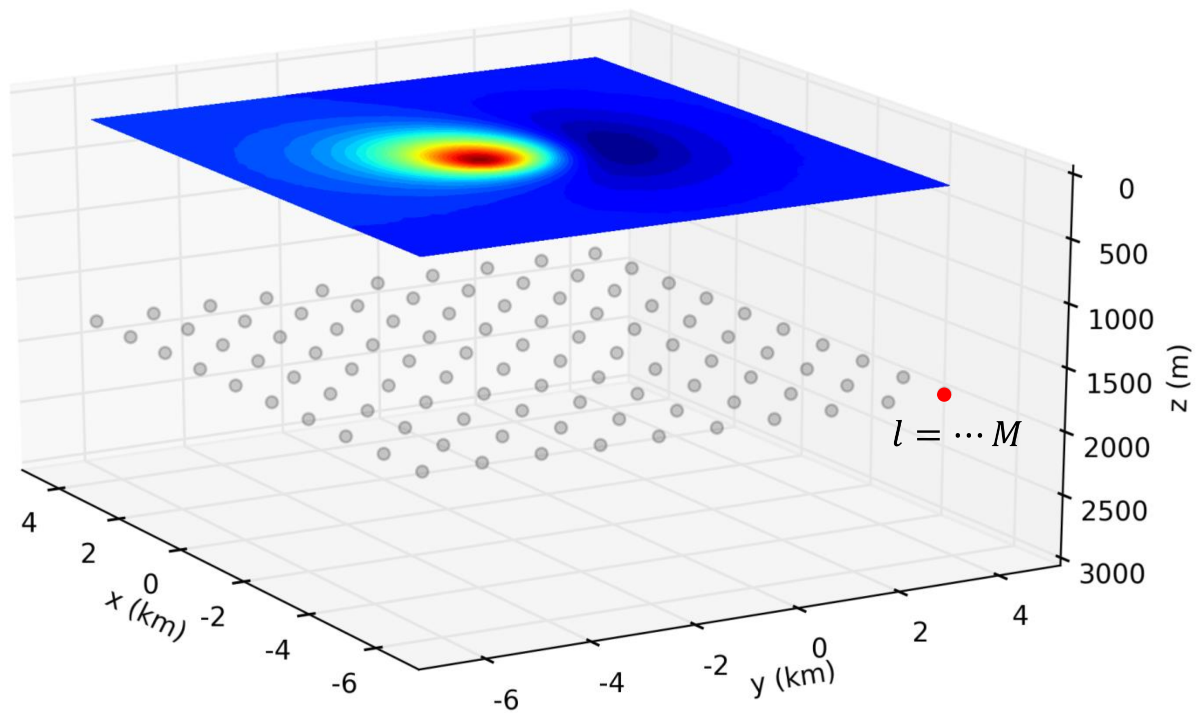

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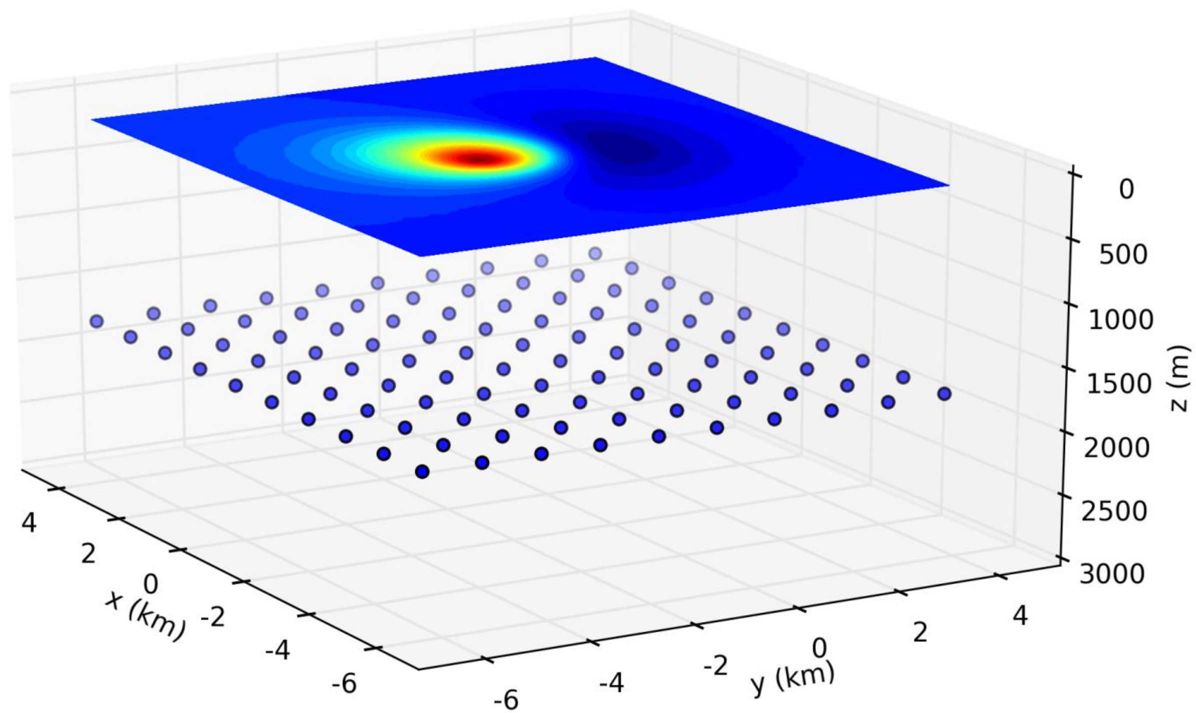

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Magnetic moment intensity associated to lth equivalent source

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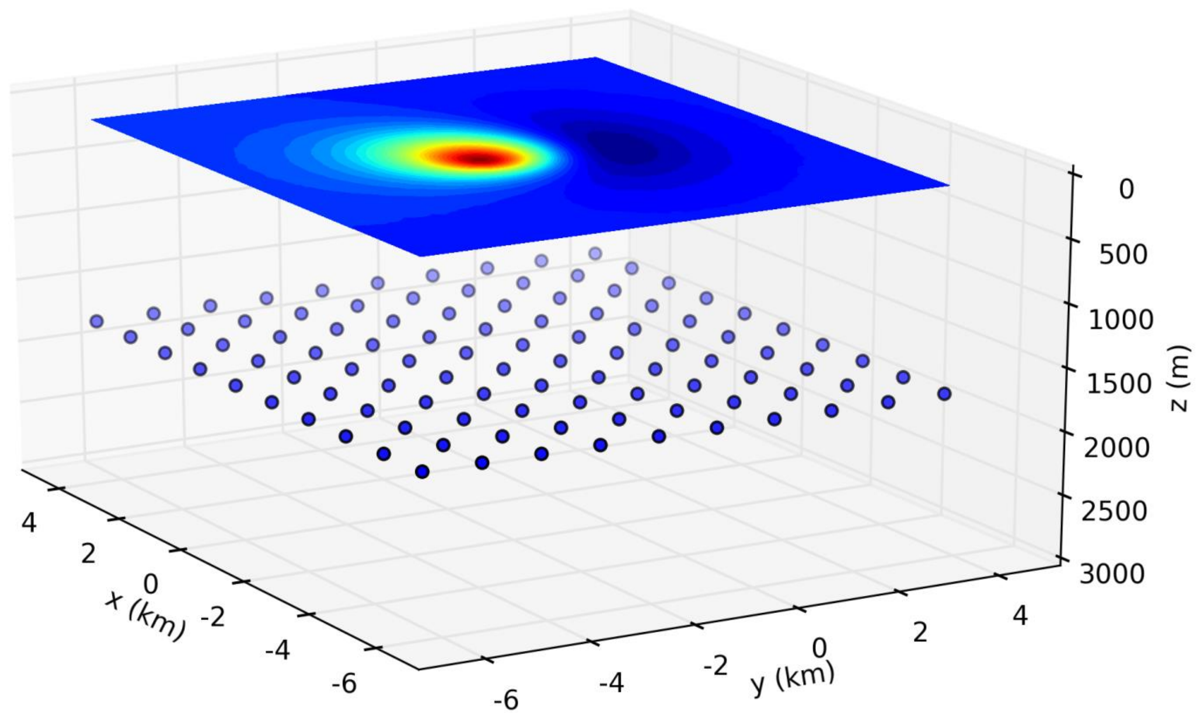

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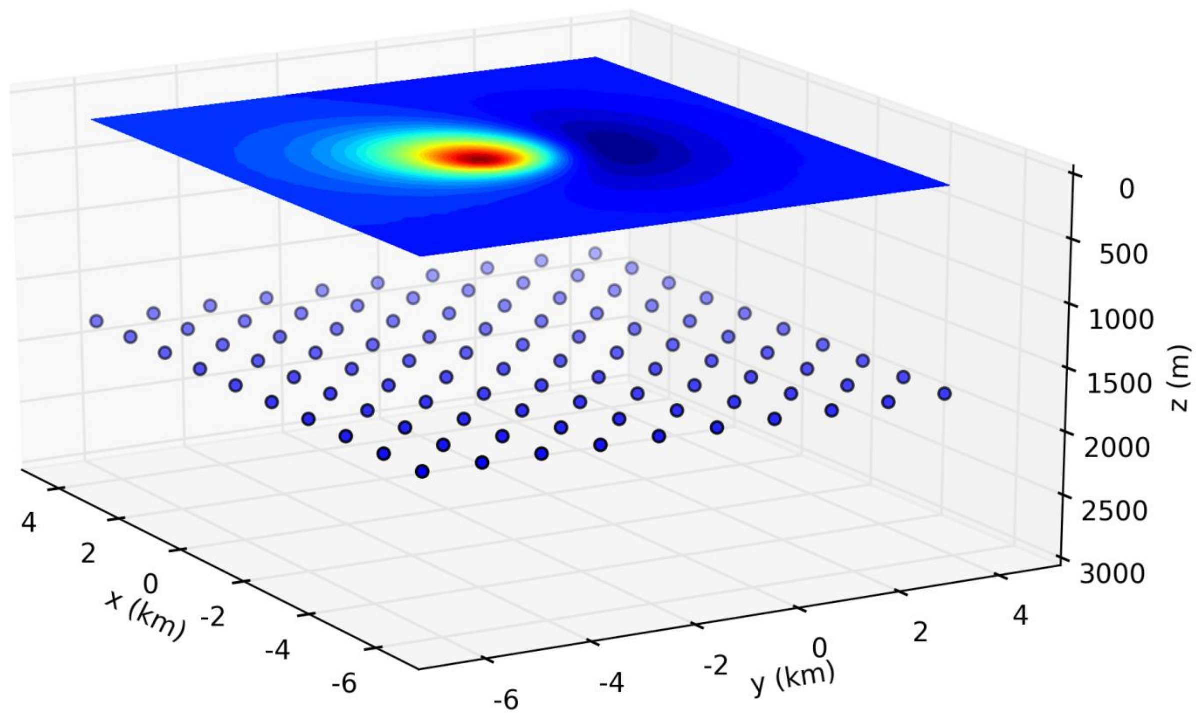

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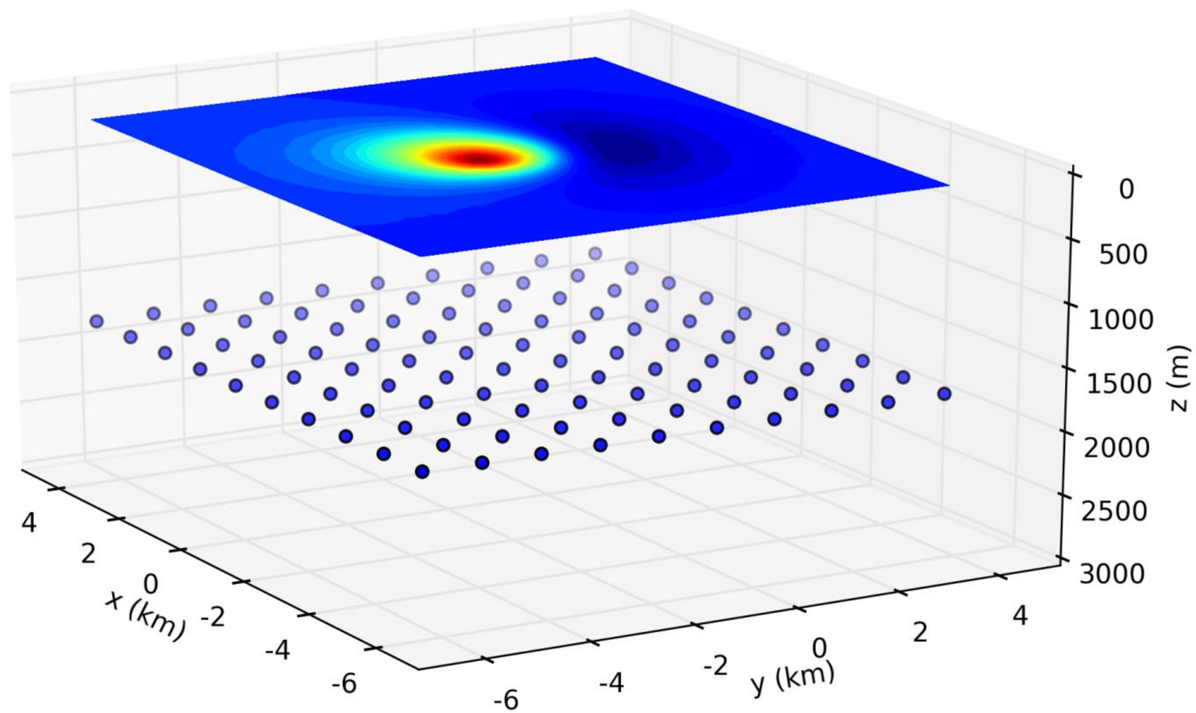

$$d_i(\boldsymbol{p}) = \sum_{l=1}^{M} p_l g_{il} \longrightarrow \mathbf{H_{il}} \rightarrow \partial^2 r^{-1}$$

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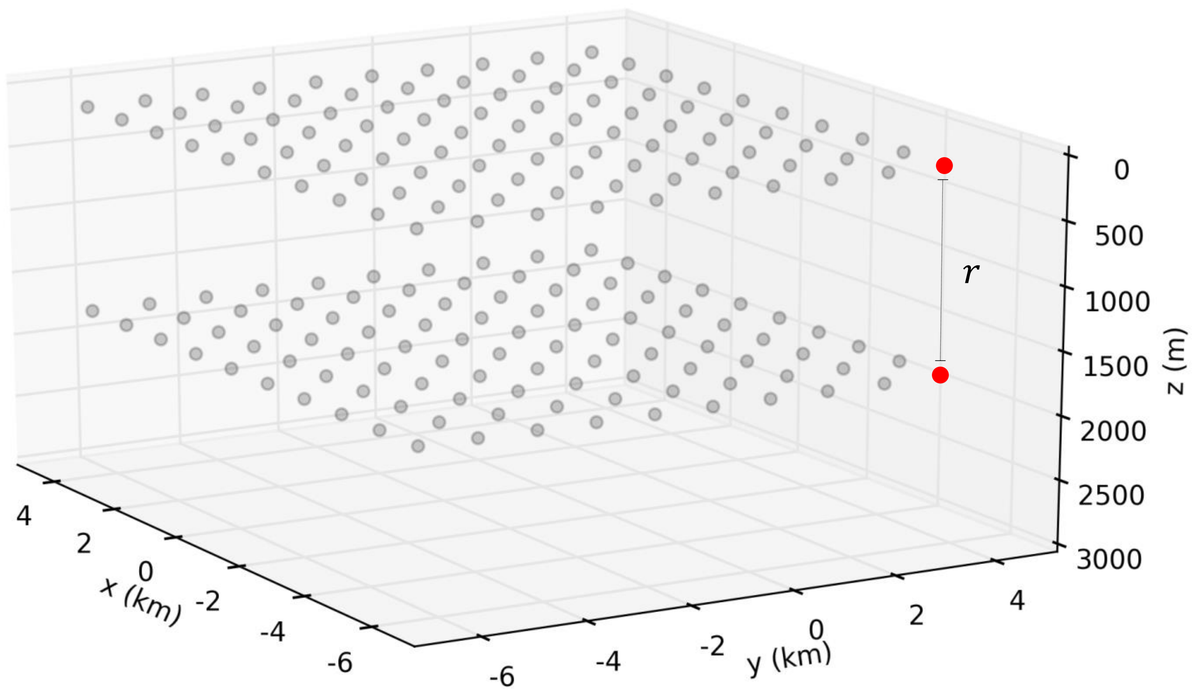

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Minimizing the difference between the observed $\mathbf{d^o}$ and predict data $\mathbf{d}(\mathbf{p})$:

$$\left\|\mathbf{d}(\mathbf{p}) - \mathbf{d^o}\right\|_2^2$$

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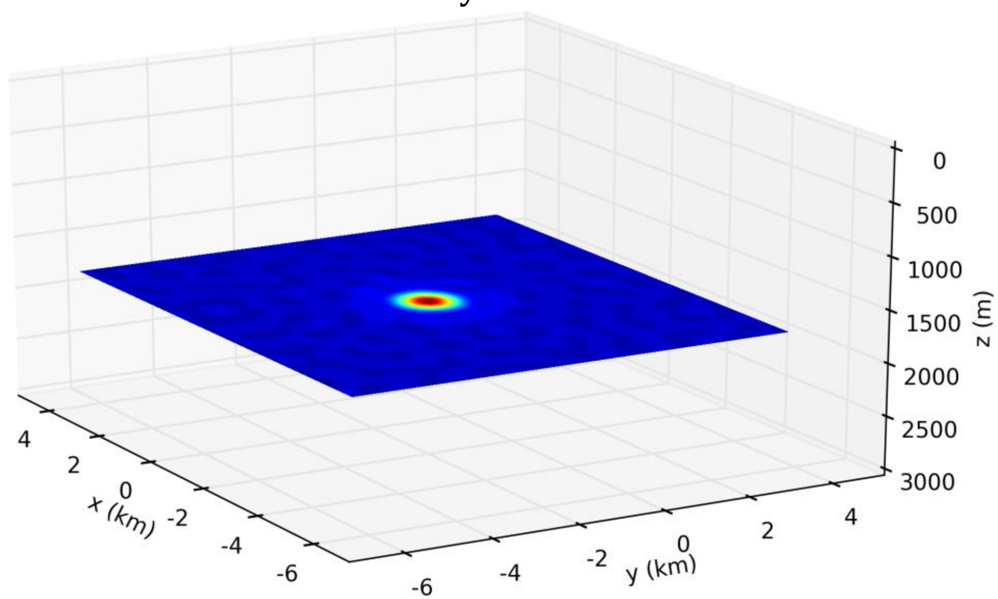
Stable estimate of the magnetic moment intensity distribution



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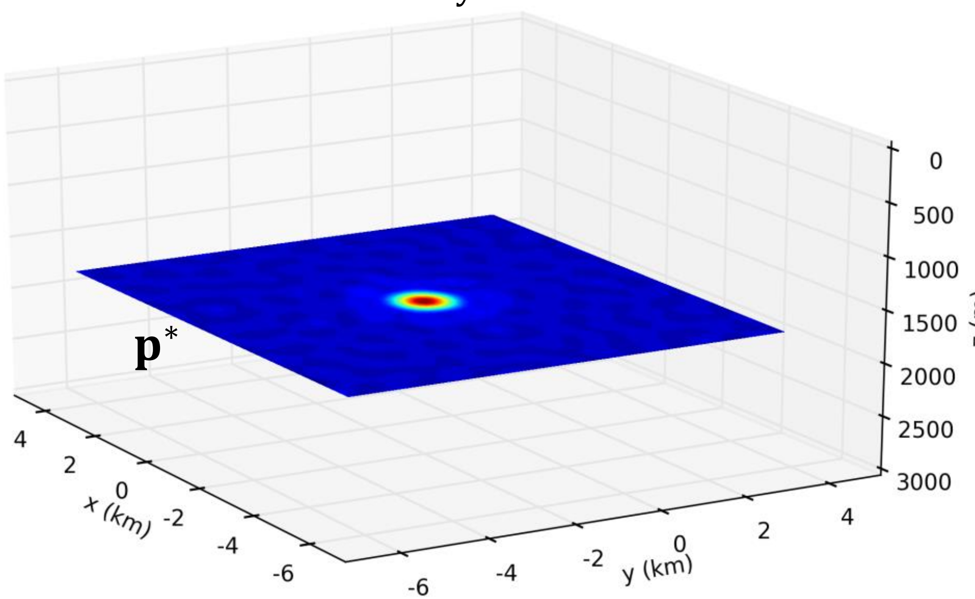

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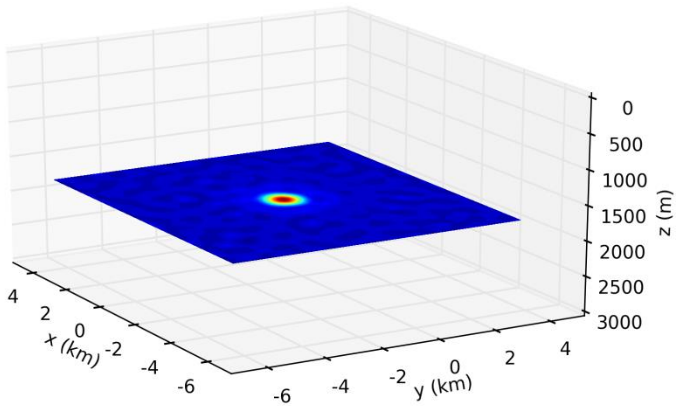
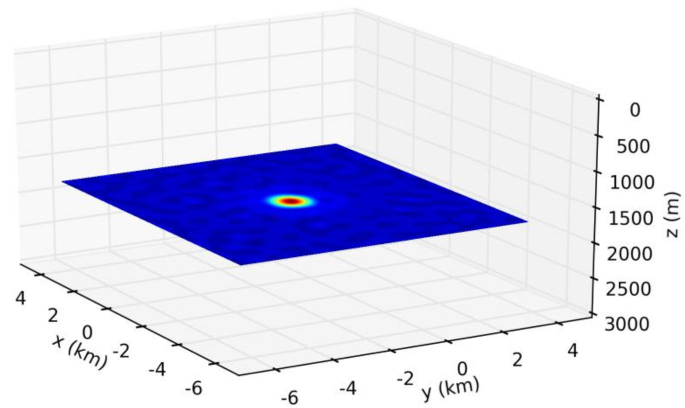
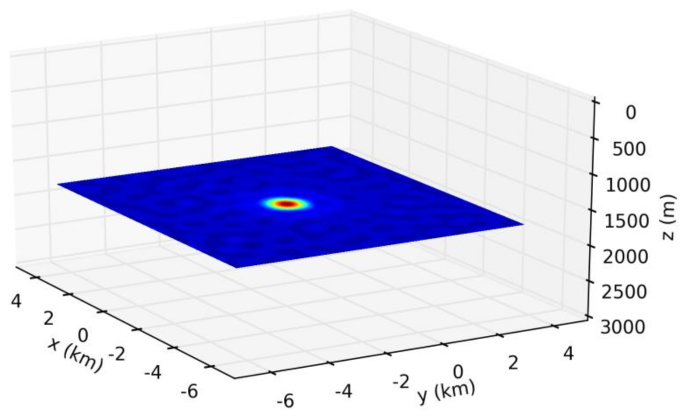
The stable estimate of $\mathbf{p}^*$ allows to transform the total-field anomaly into $\mathbf{B}_\alpha$:







$$\mathbf{B}_\alpha = \mathbf{T}^\alpha \mathbf{p}^*$$

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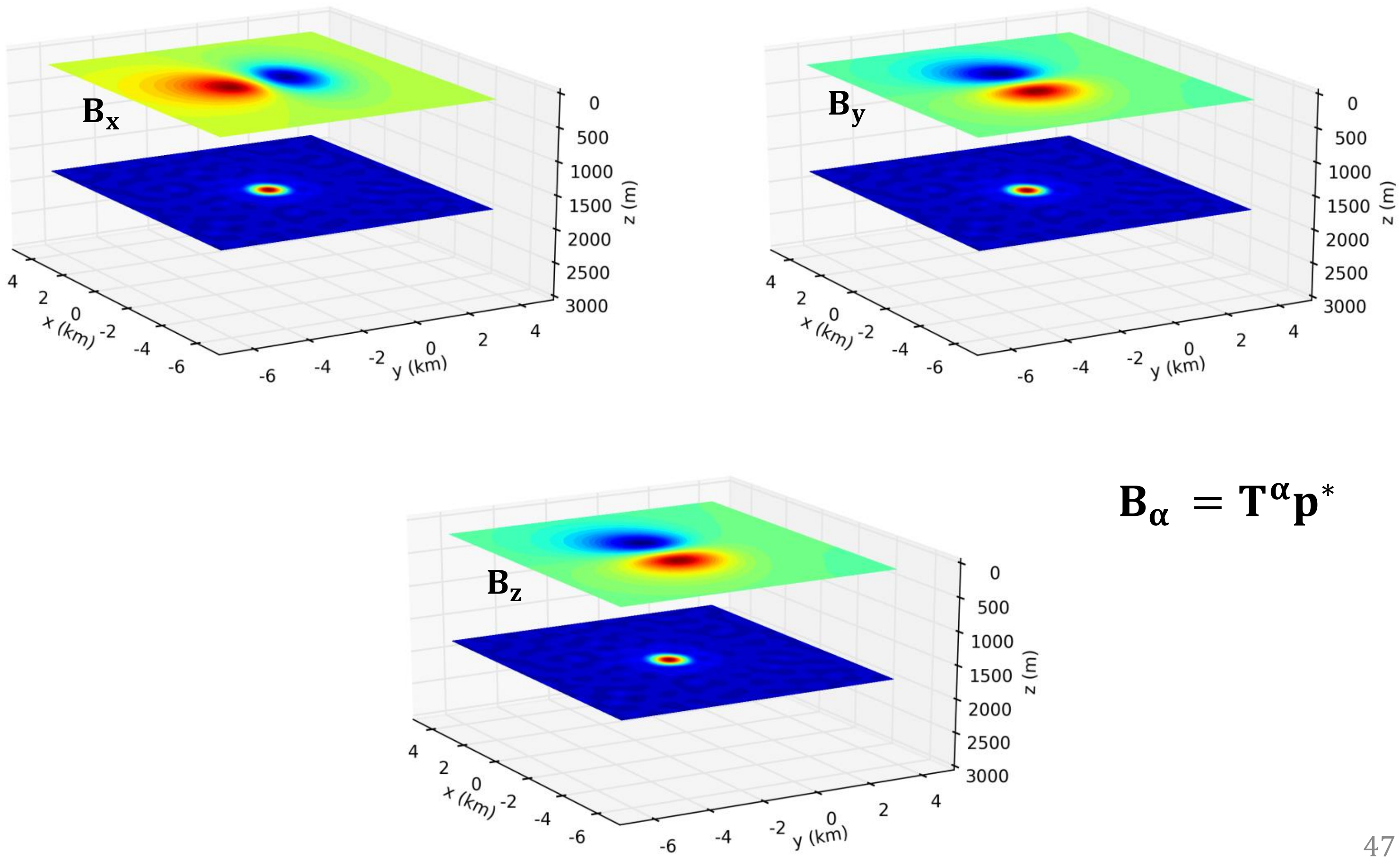

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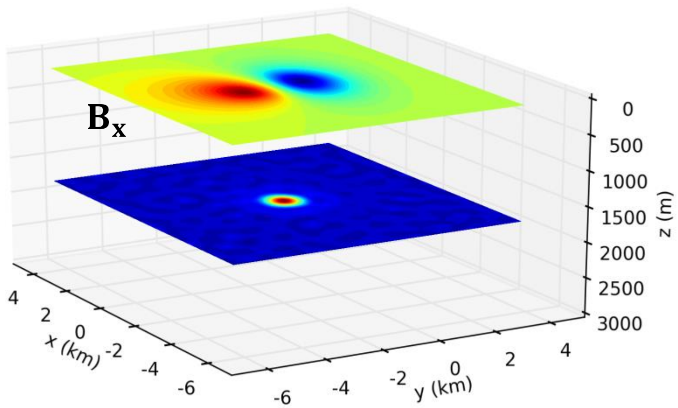

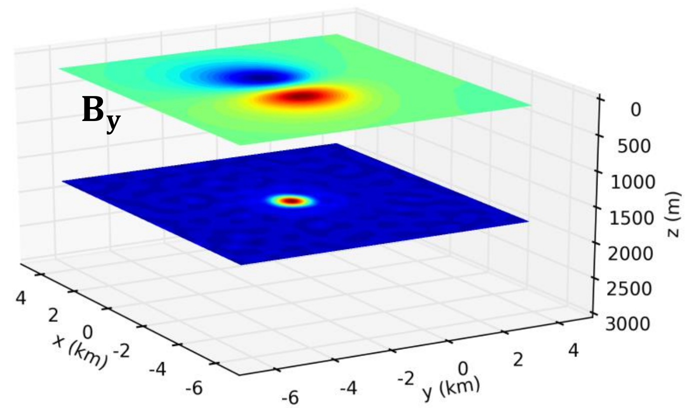

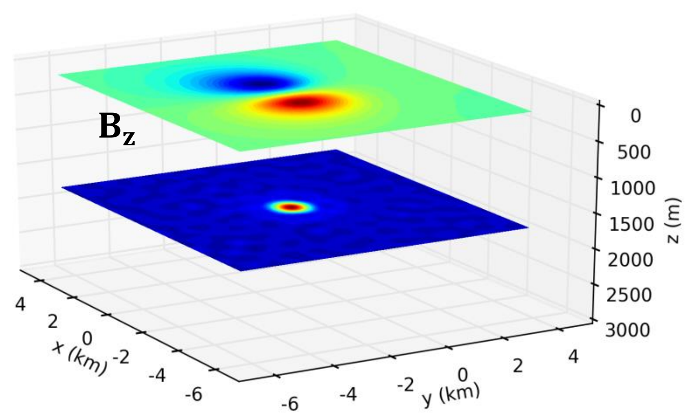

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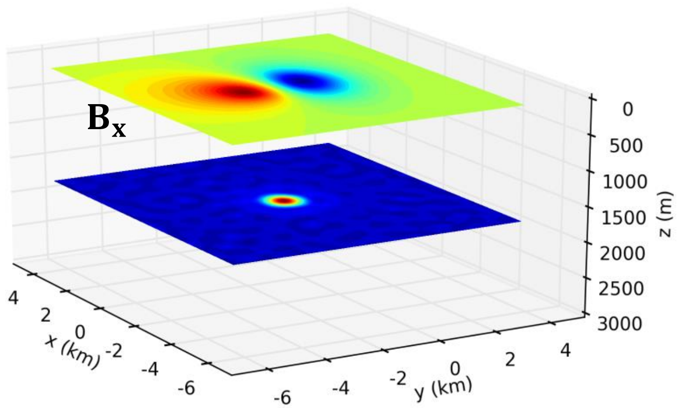
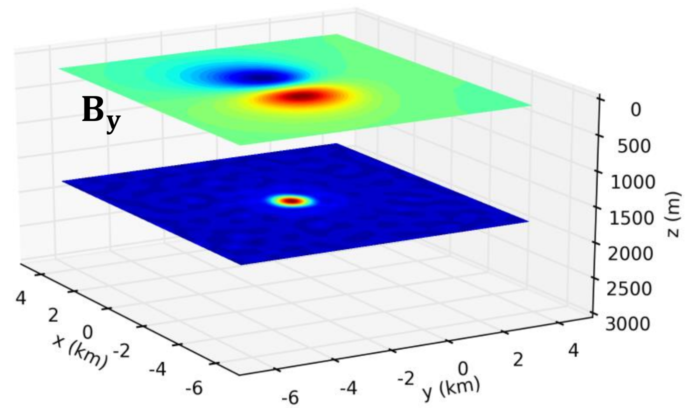
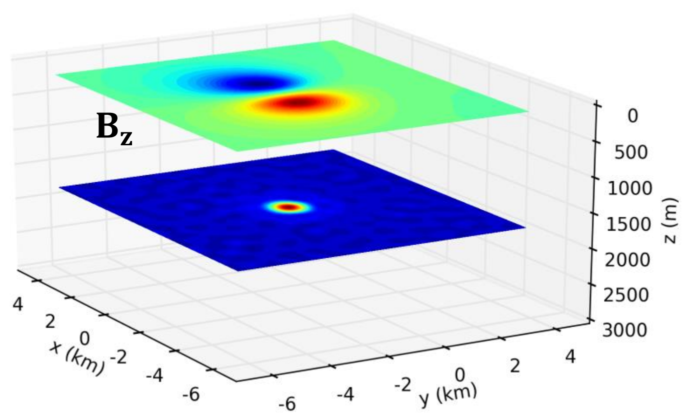




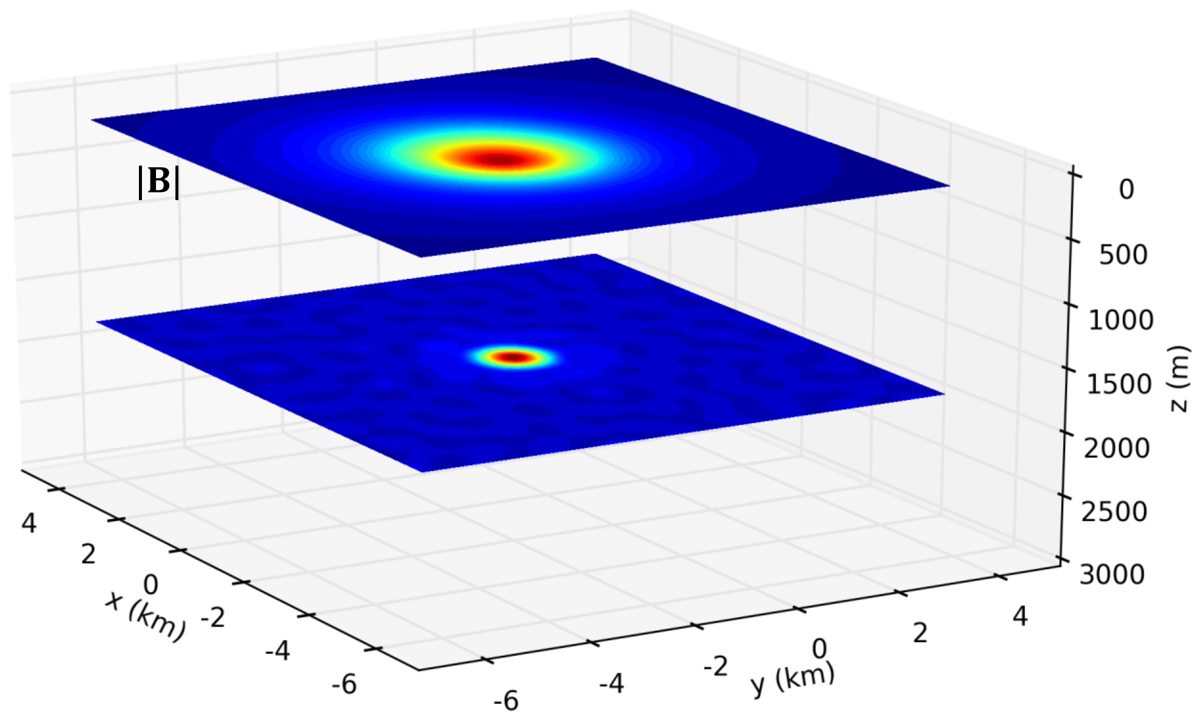


$$\mathbf{B}_\alpha = \mathbf{T}^\alpha \mathbf{p}^*$$

$\mathbf{H}_{\mathbf{il}}^{\alpha}$: αth row of matrix $\mathbf{H}_{\mathbf{il}}$

2.2 EQUIVALENT LAYER

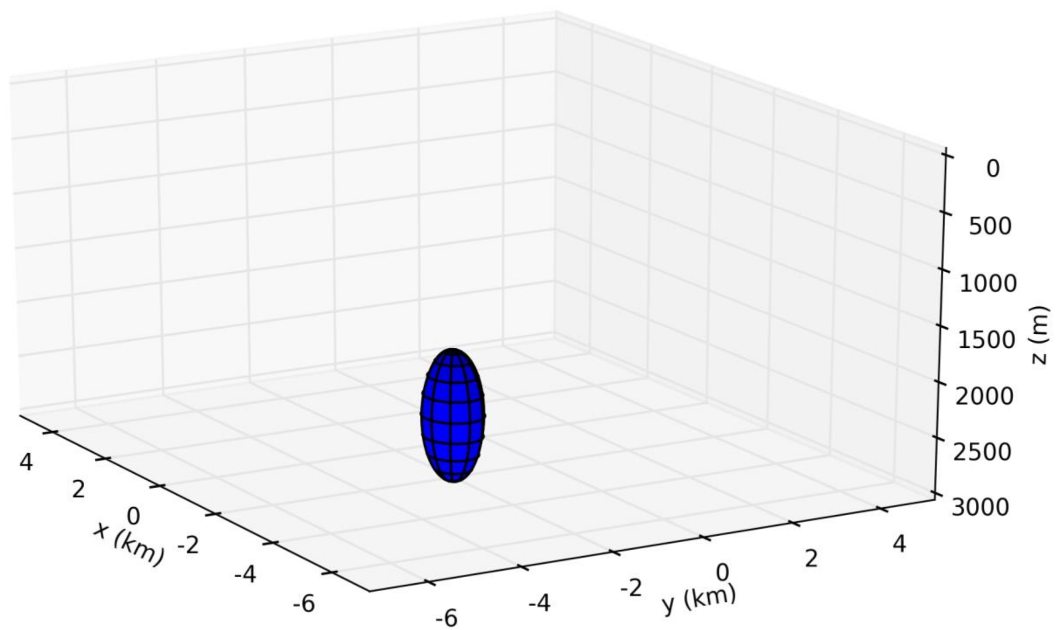
Finally, is possible to obtain the amplitude of the magnetic anomaly vector.



SUMMARY

INFORMATION ABOUT THE SOURCE

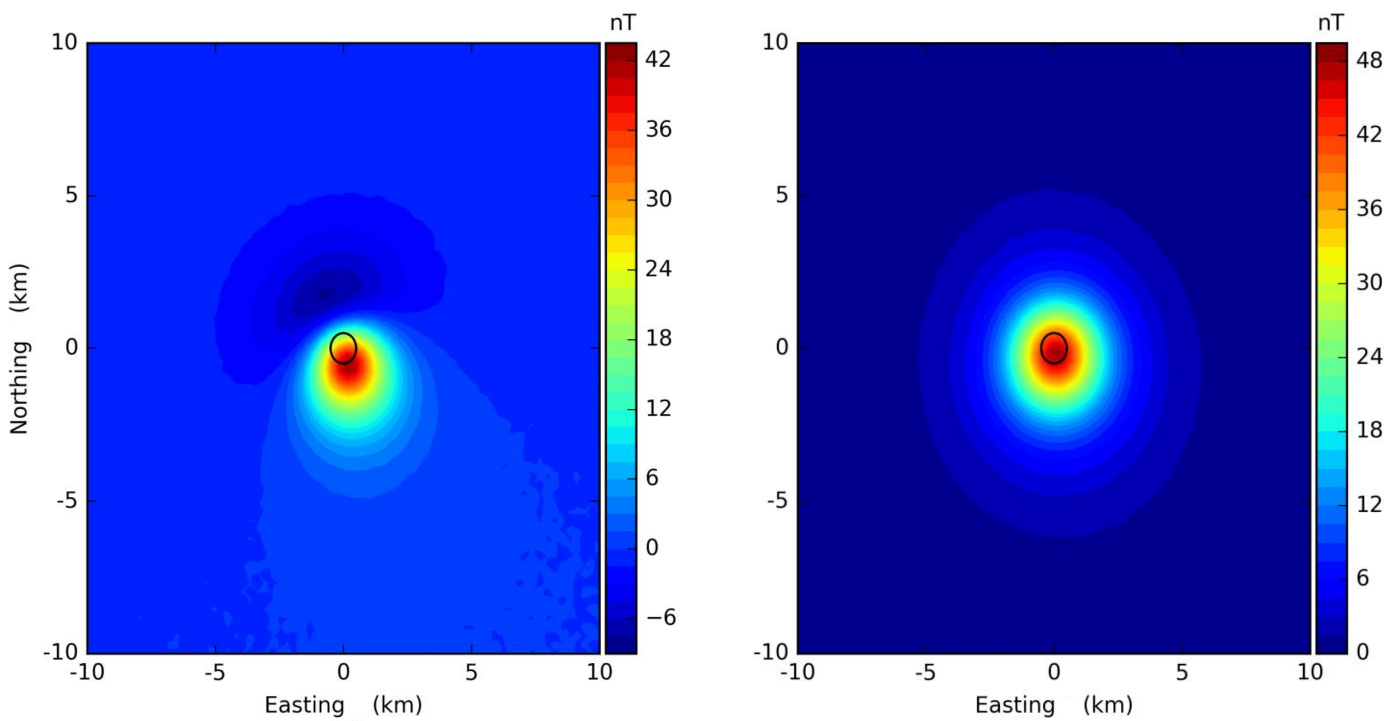
Magnetization intensity	Radius	x	y	z
5 A/m	500 m	0 km	0 km	2 km



3.1 TEST 1

Field at a high latitude; only induced magnetization $(I_0 = I = 60°; D_0 = D = -20°)$

1. Total-field anomaly and true amplitude of the magnetic anomaly vector



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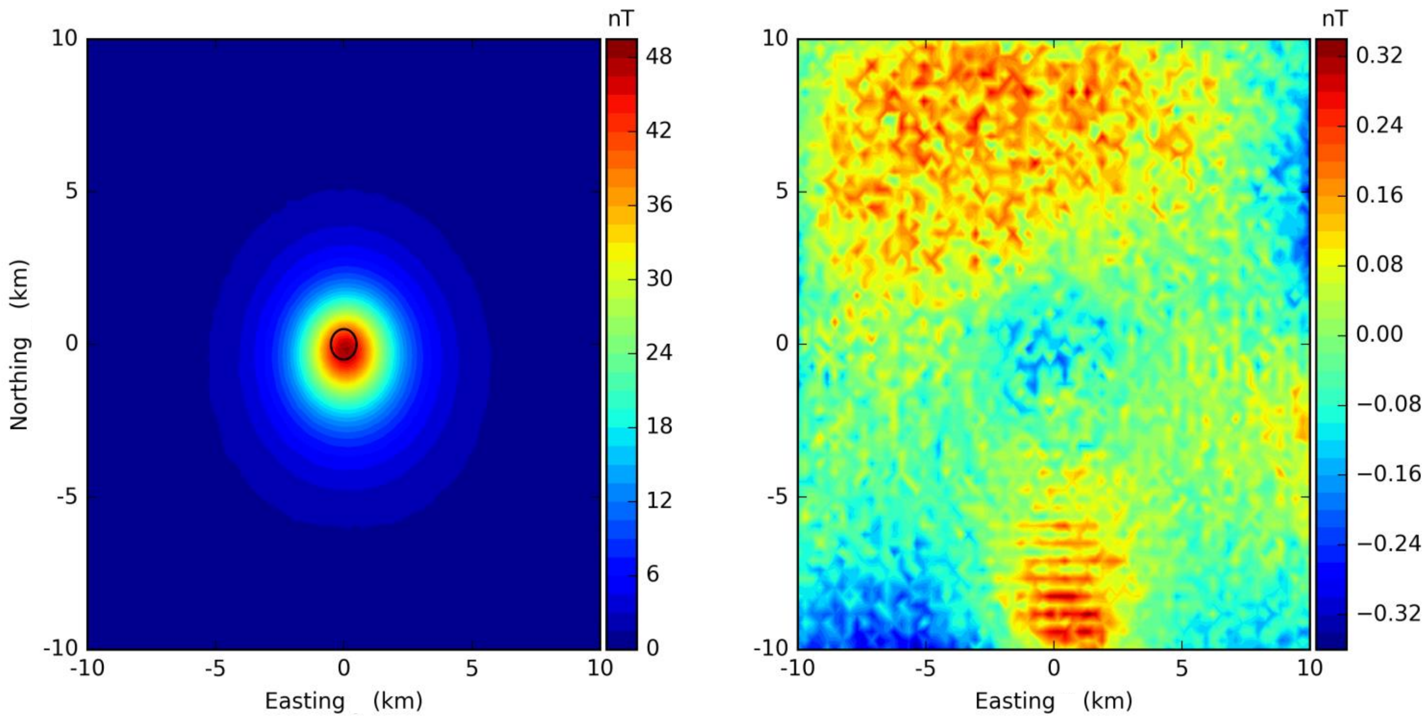
2. Amplitude of the magnetic anomaly vector via Fourier filtering



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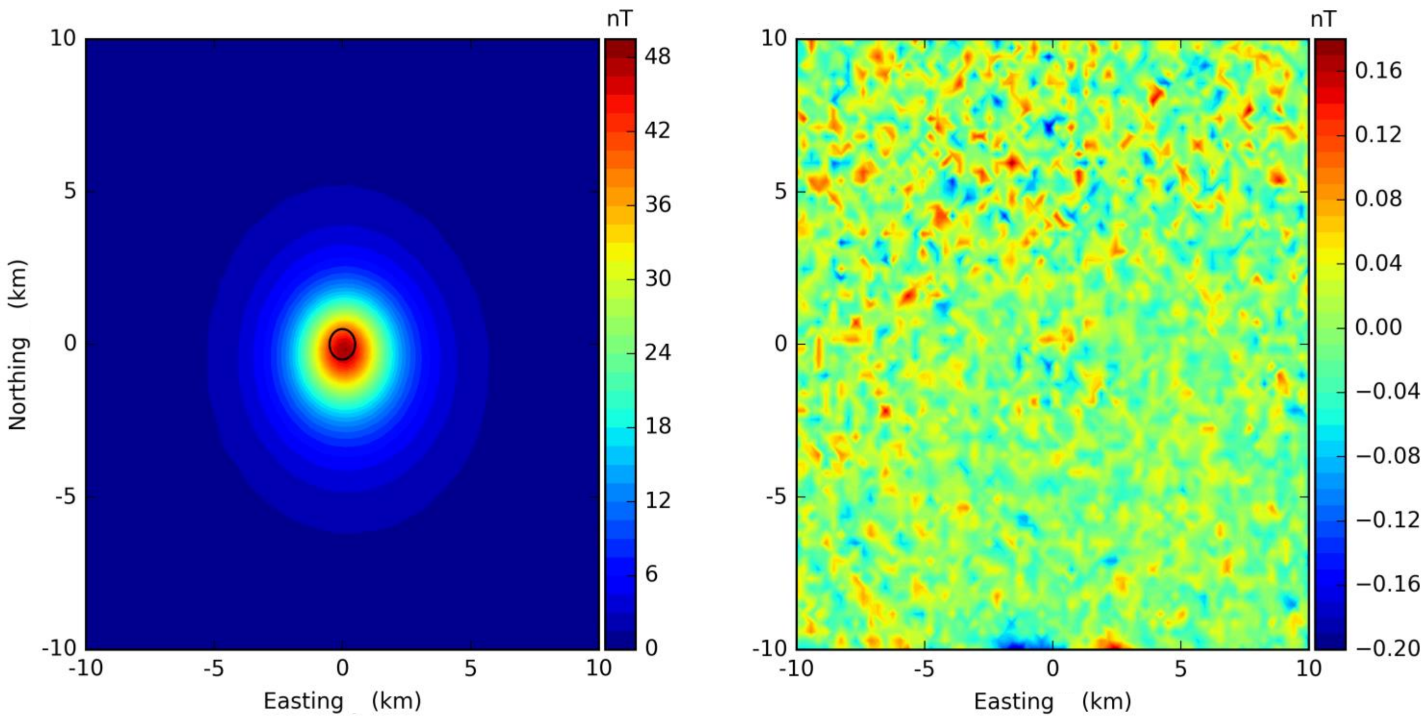
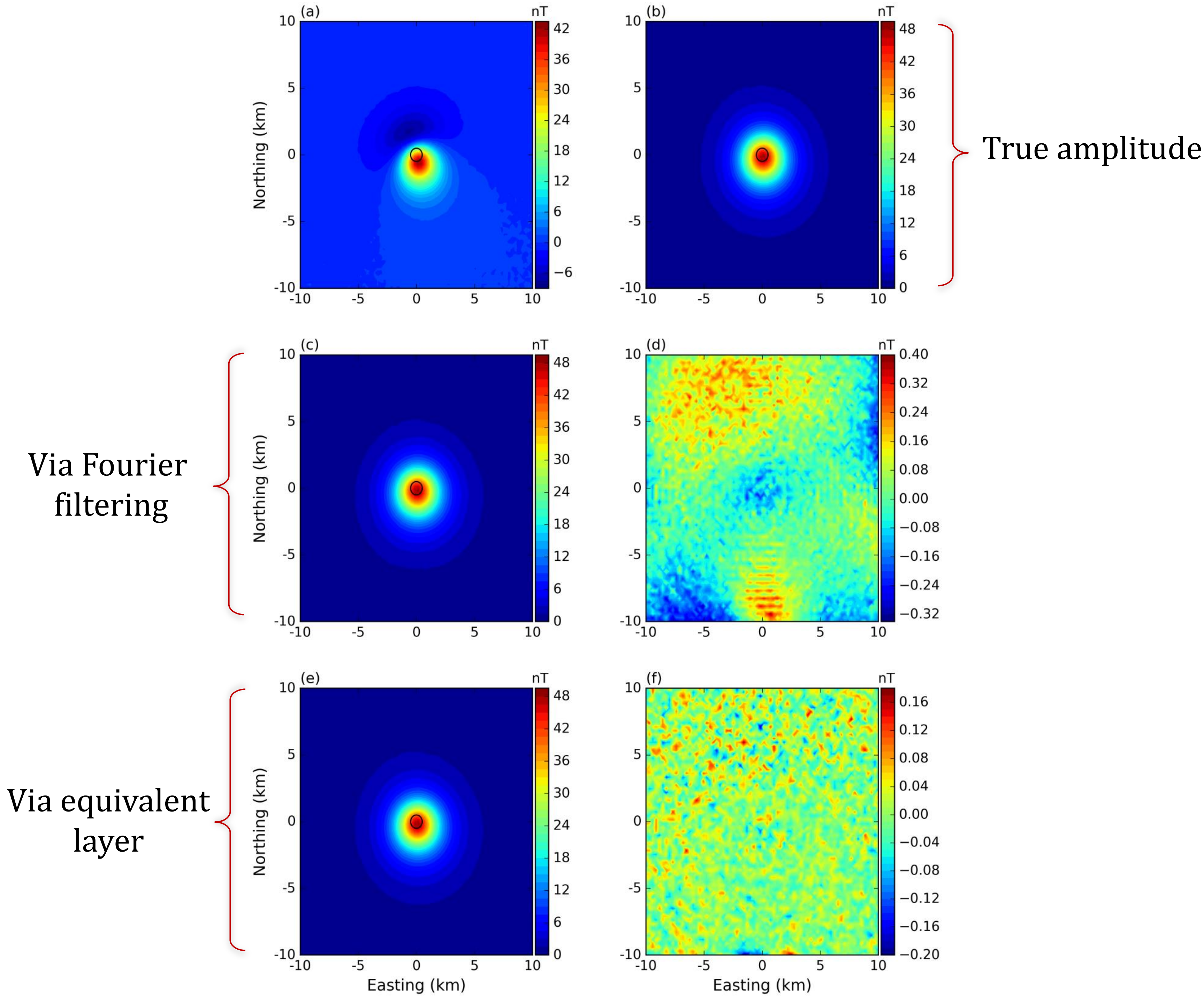
3. Amplitude of the magnetic anomaly vector via equivalent layer



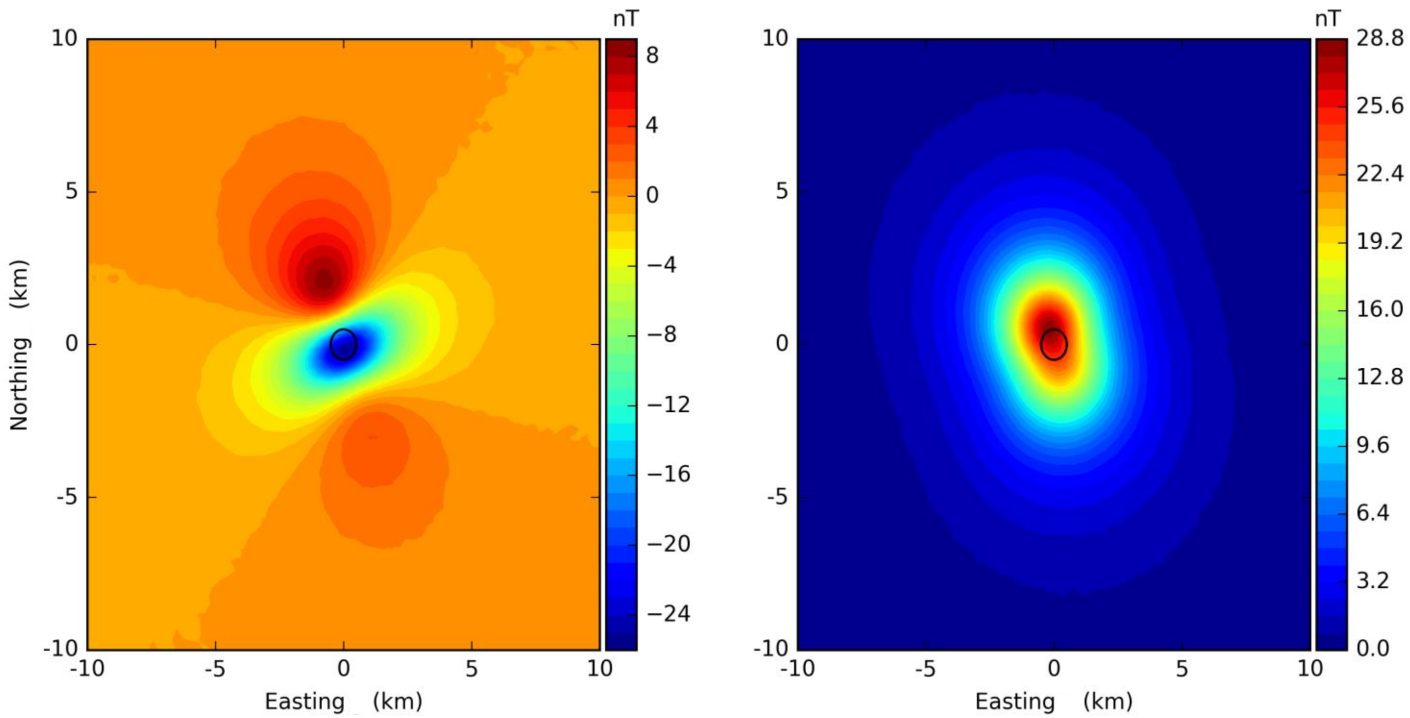


(a)
(b)
(c)
(d)
(e)
(f)
nT
Northing (km)
Easting (km)
True amplitude
Via Fourier filtering
Via equivalent layer

3.2 TEST 2

Field at a low latitude; only induced magnetization $(I_0 = I = -8°; D_0 = D = -20°)$

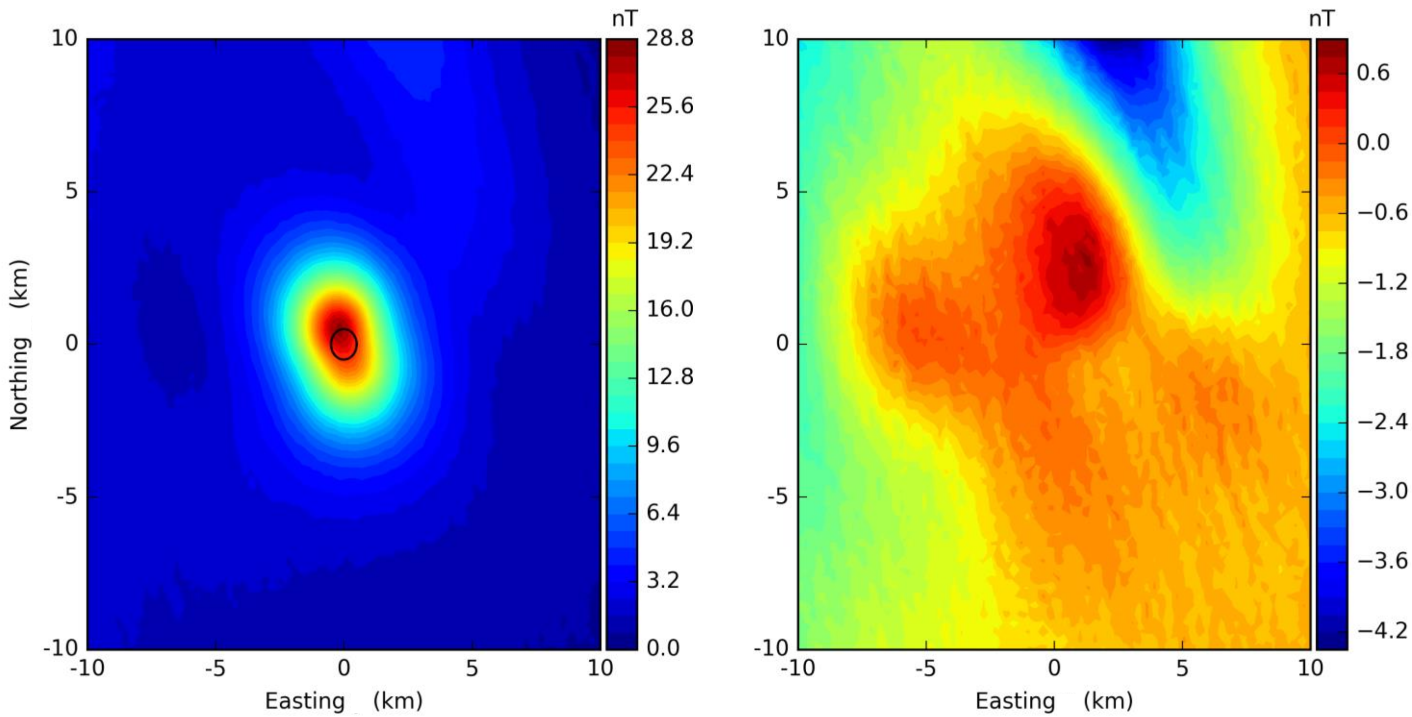
1. Total-field anomaly and true amplitude of the magnetic anomaly vector



3.2 TEST 2

Field at a low latitude; only induced magnetization $(I_0 = I = -8°; D_0 = D = -20°)$

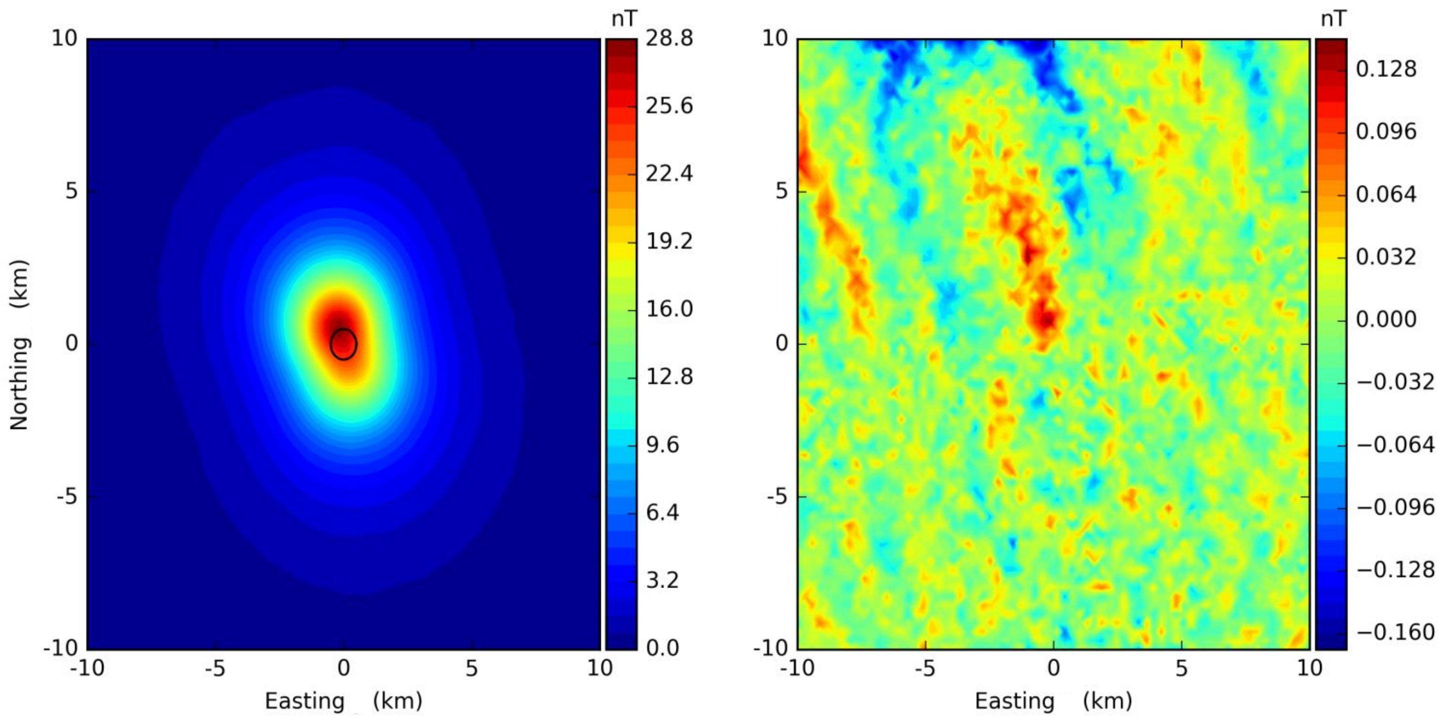
2. Amplitude of the magnetic anomaly vector via Fourier filtering



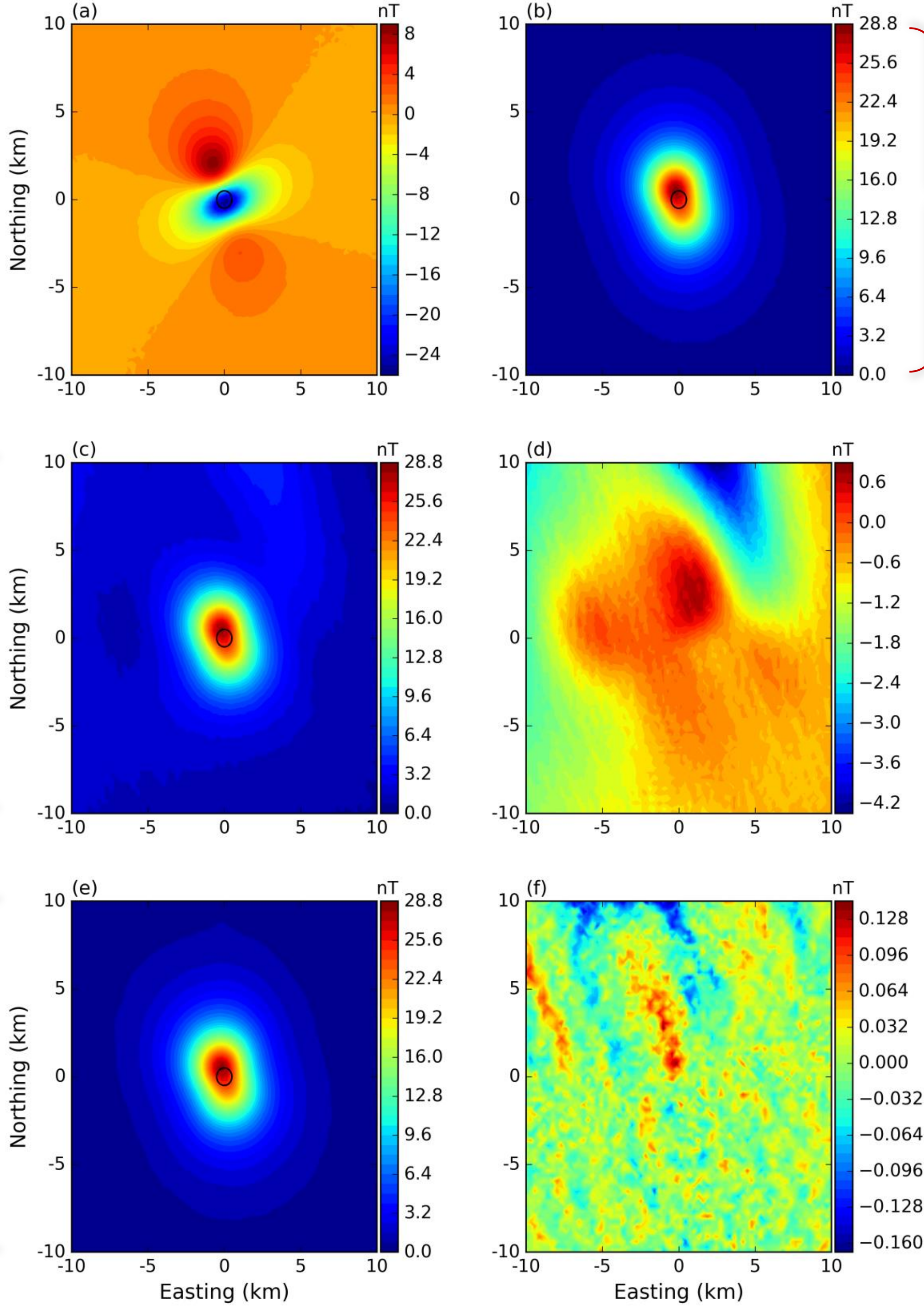
3.2 TEST 2

Field at a low latitude; only induced magnetization $(I_0 = I = -8°; D_0 = D = -20°)$

3. Amplitude of the magnetic anomaly vector via equivalent layer



True amplitude



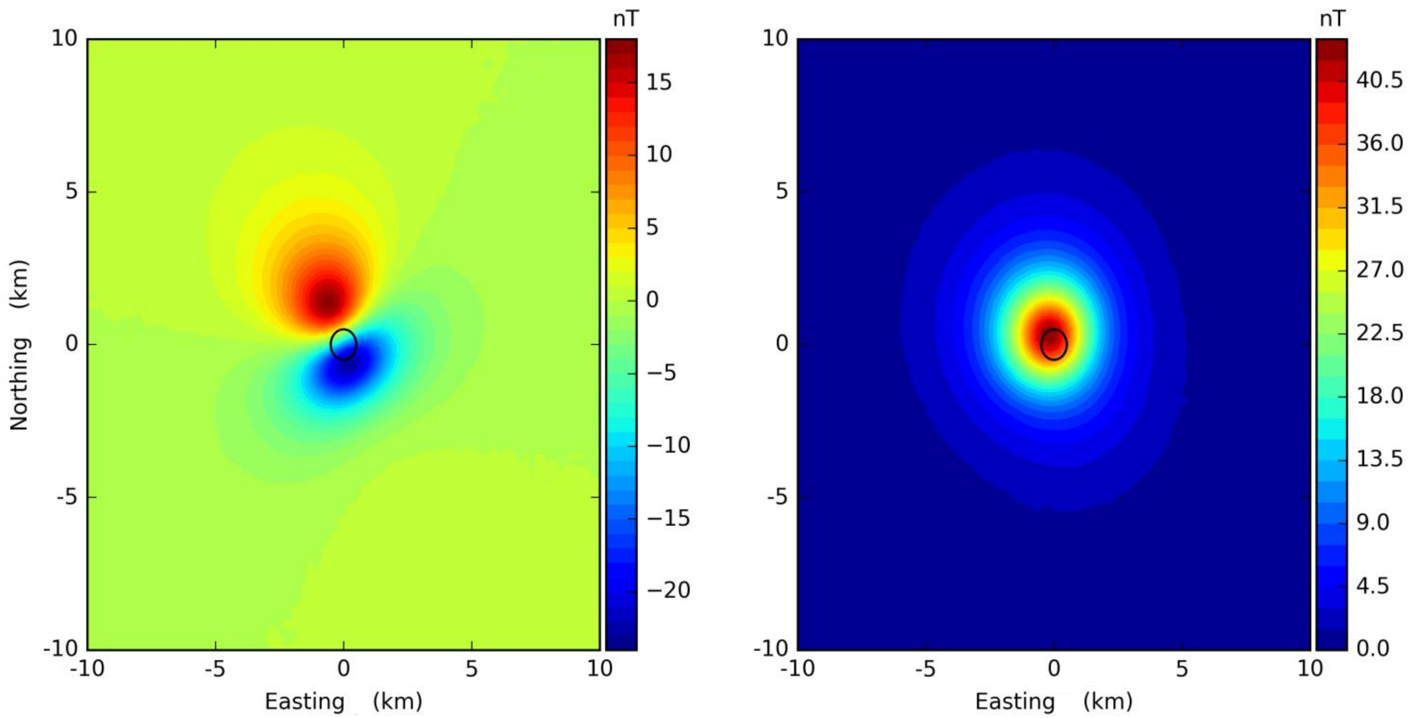
Via Fourier filtering

Via equivalent layer

3.3 TEST 3

Field at a low latitude; induced and remanent magnetization ($I_0 = -8°, D_0 = -20°$; $I = -45°, D = -30°$)

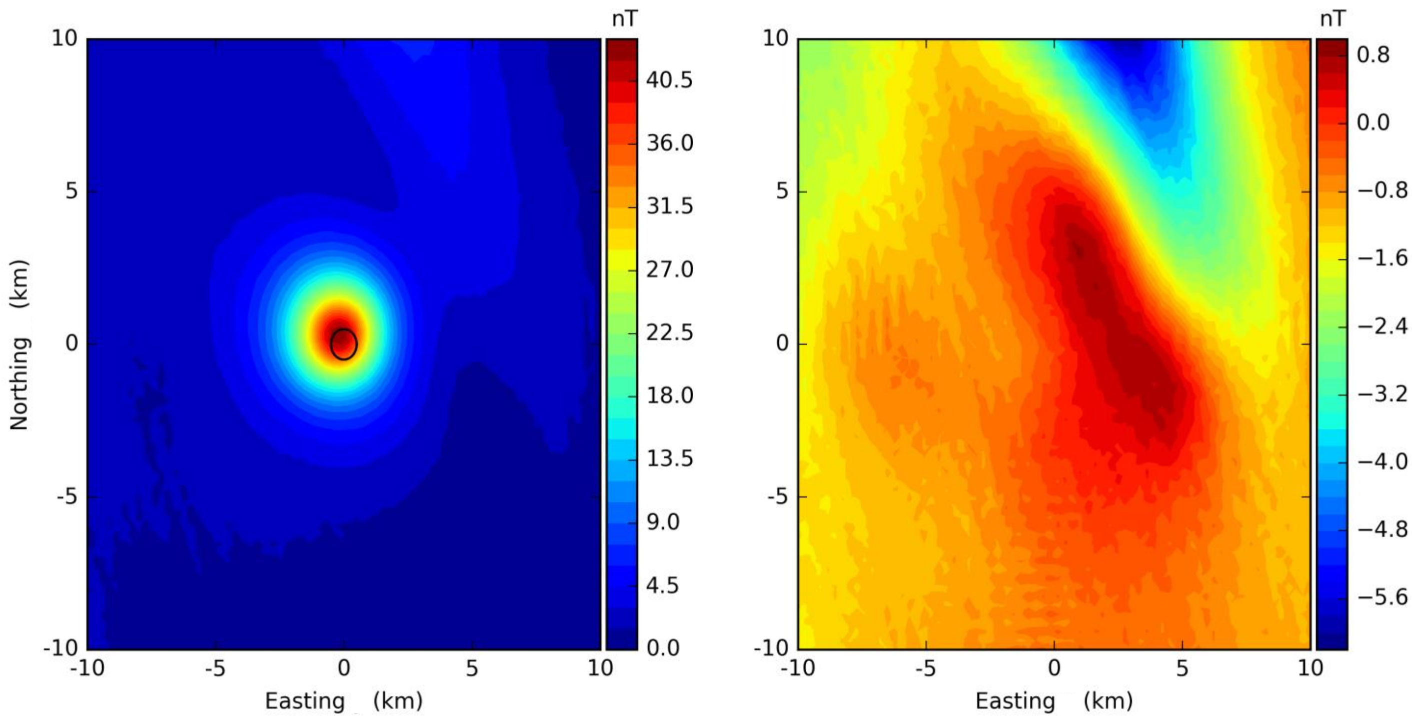
1. Total-field anomaly and true amplitude of the magnetic anomaly vector



3.3 TEST 3

Field at a low latitude; induced and remanent magnetization ($I_0 = -8°, D_0 = -20°$; $I = -45°, D = -30°$)

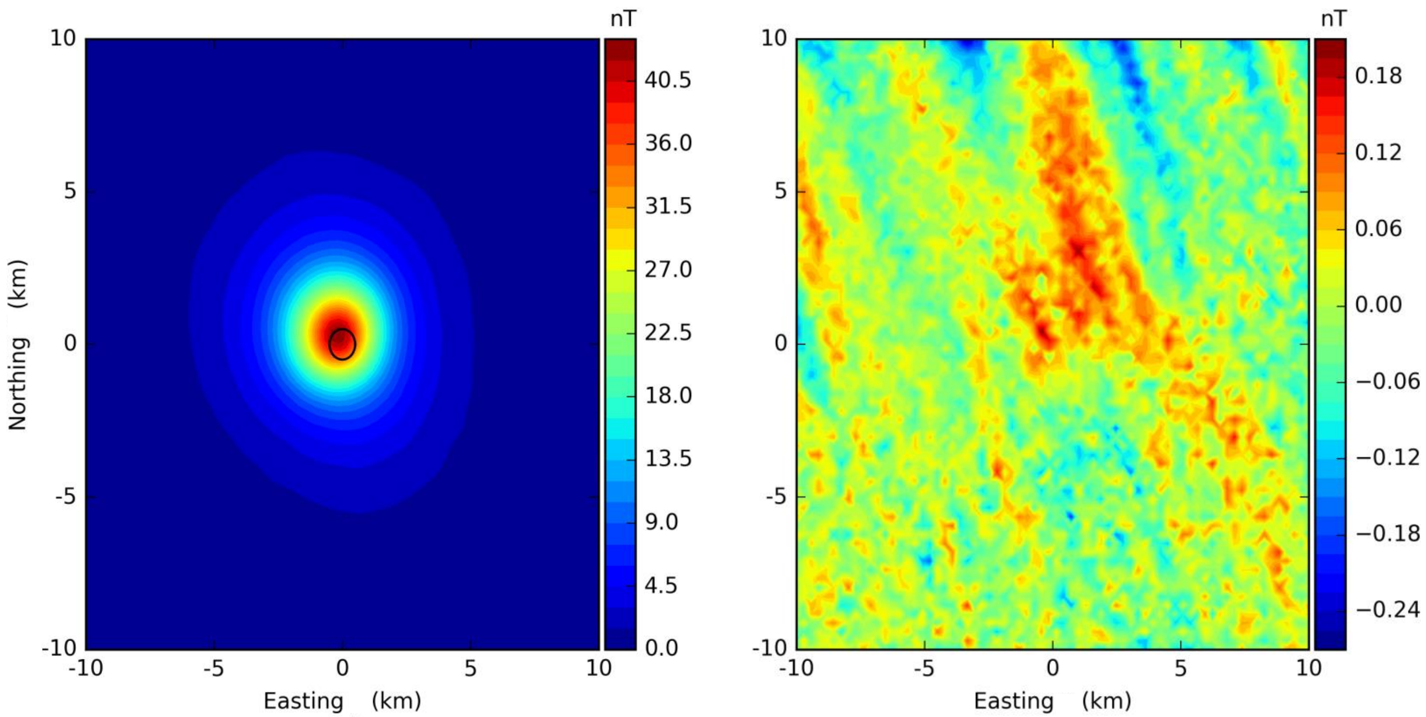
2. Amplitude of the magnetic anomaly vector via Fourier filtering



3.3 TEST 3

Field at a low latitude; induced and remanent magnetization ($I_0 = -8°, D_0 = -20°;$ $I = -45°, D = -30°$)

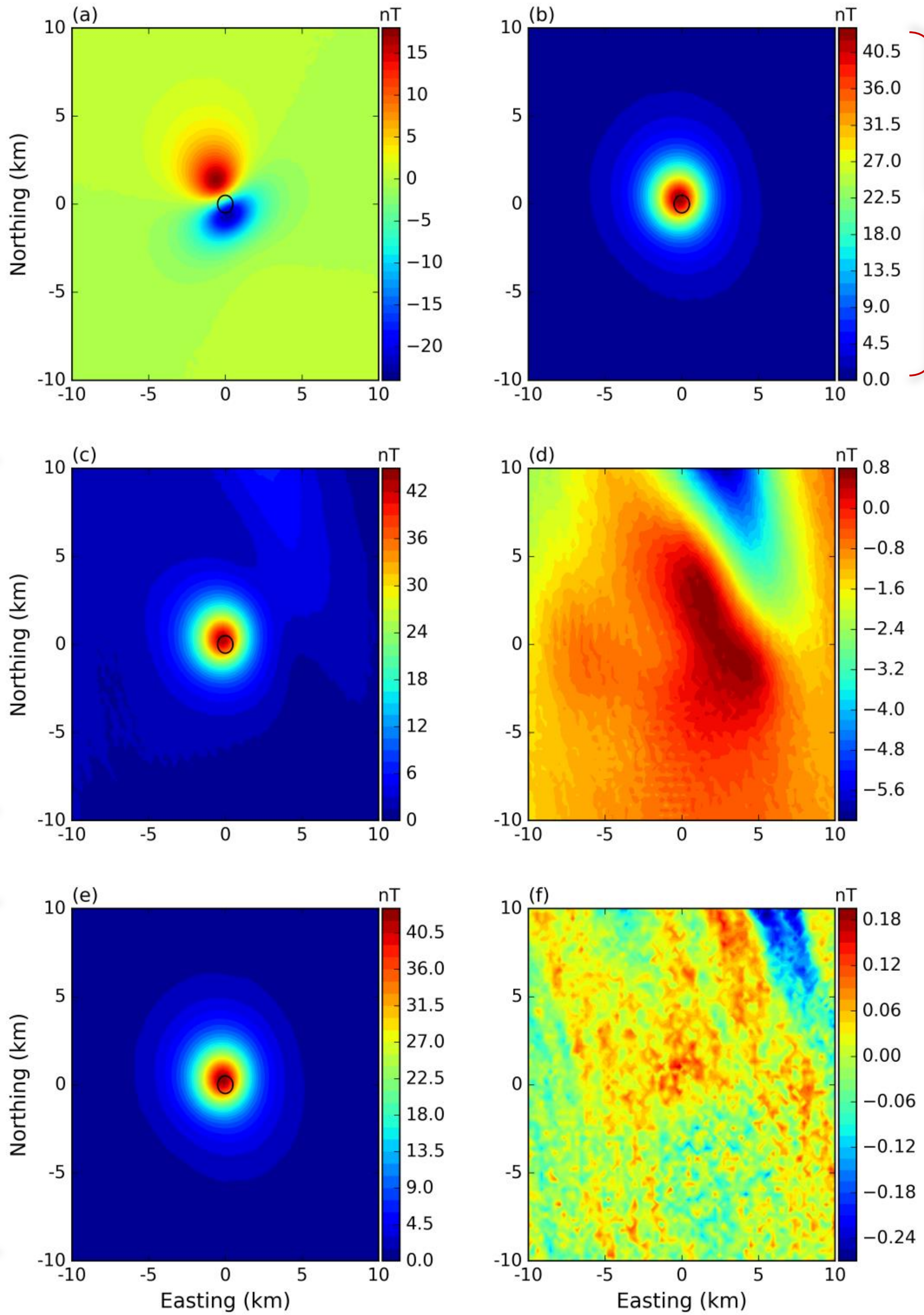
3. Amplitude of the magnetic anomaly vector via equivalent layer



True amplitude

Via Fourier filtering

Via equivalent layer

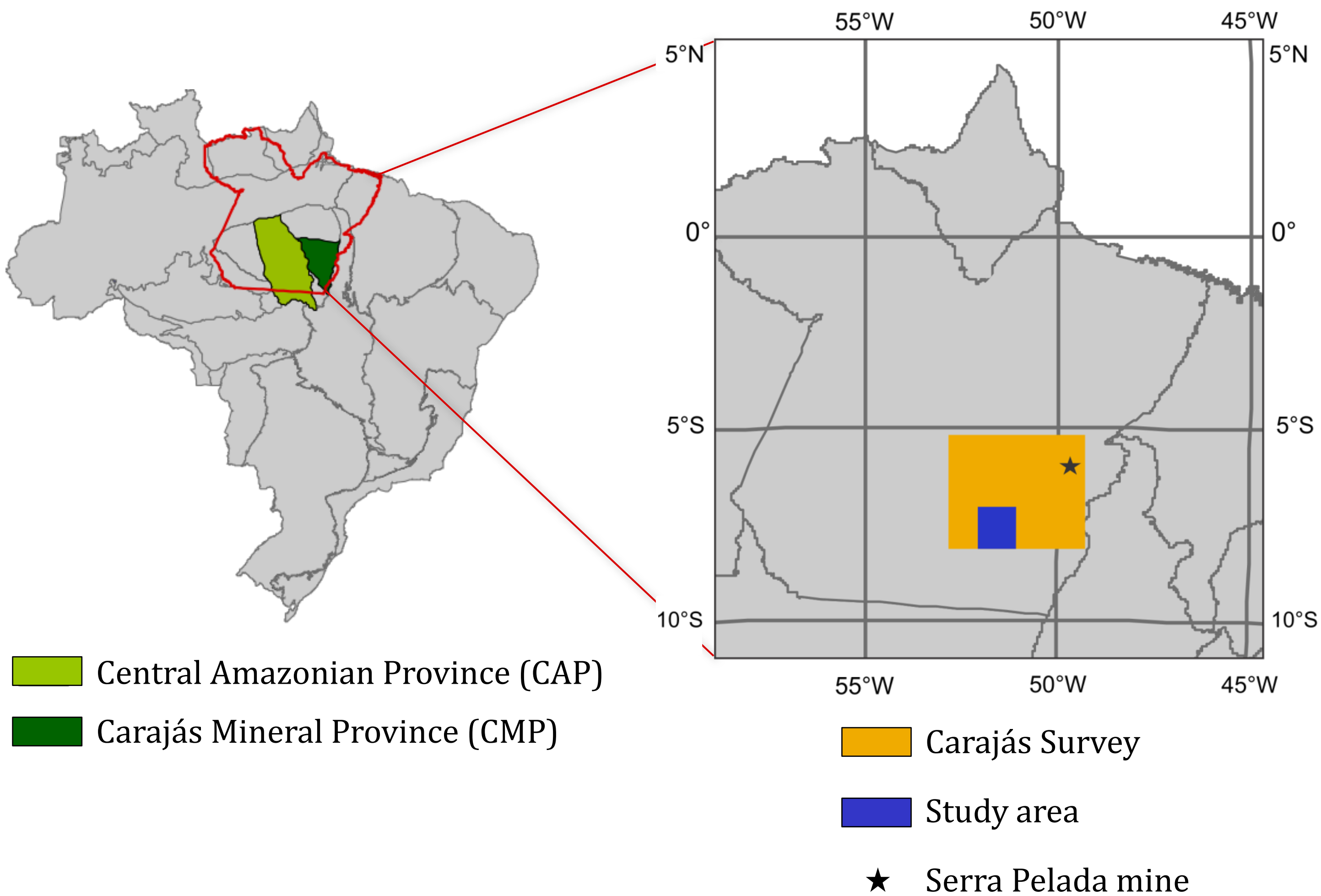


SUMMARY

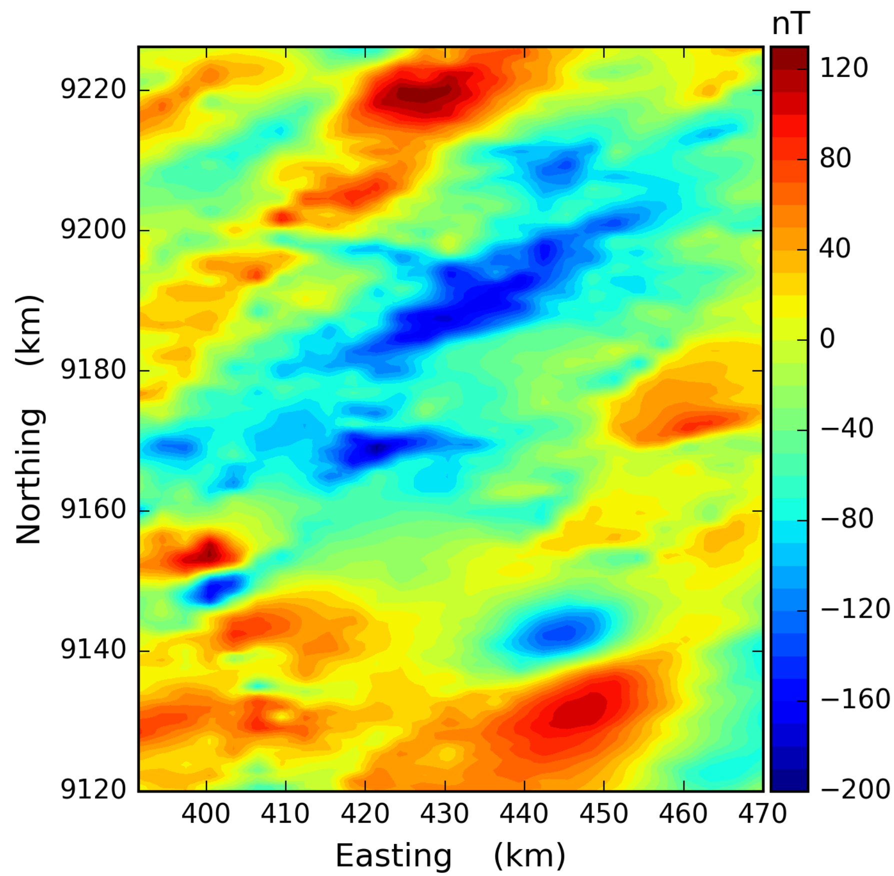
STUDY AREA


70°W
65°W
60°W
55°W
50°W
45°W
40°W
35°W
5°N
0°
5°S
10°S
15°S
20°S
25°S
30°S
75°W
70°W
65°W
60°W
55°W
50°W
45°W
40°W
35°W
30°W

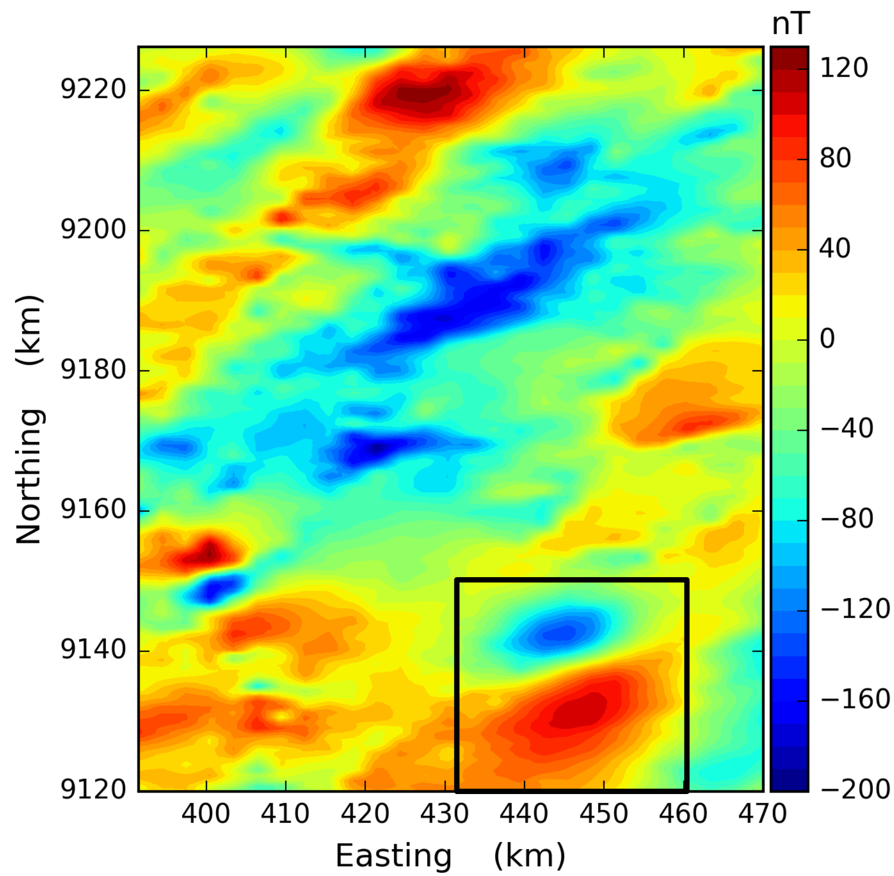
STUDY AREA


Central Amazonian Province (CAP)
Carajás Mineral Province (CMP)
55°W
50°W
45°W
5°N
0°
5°S
10°S
Carajás Survey
Study area
Serra Pelada mine

OBSERVED DATA: TOTAL-FIELD ANOMALY



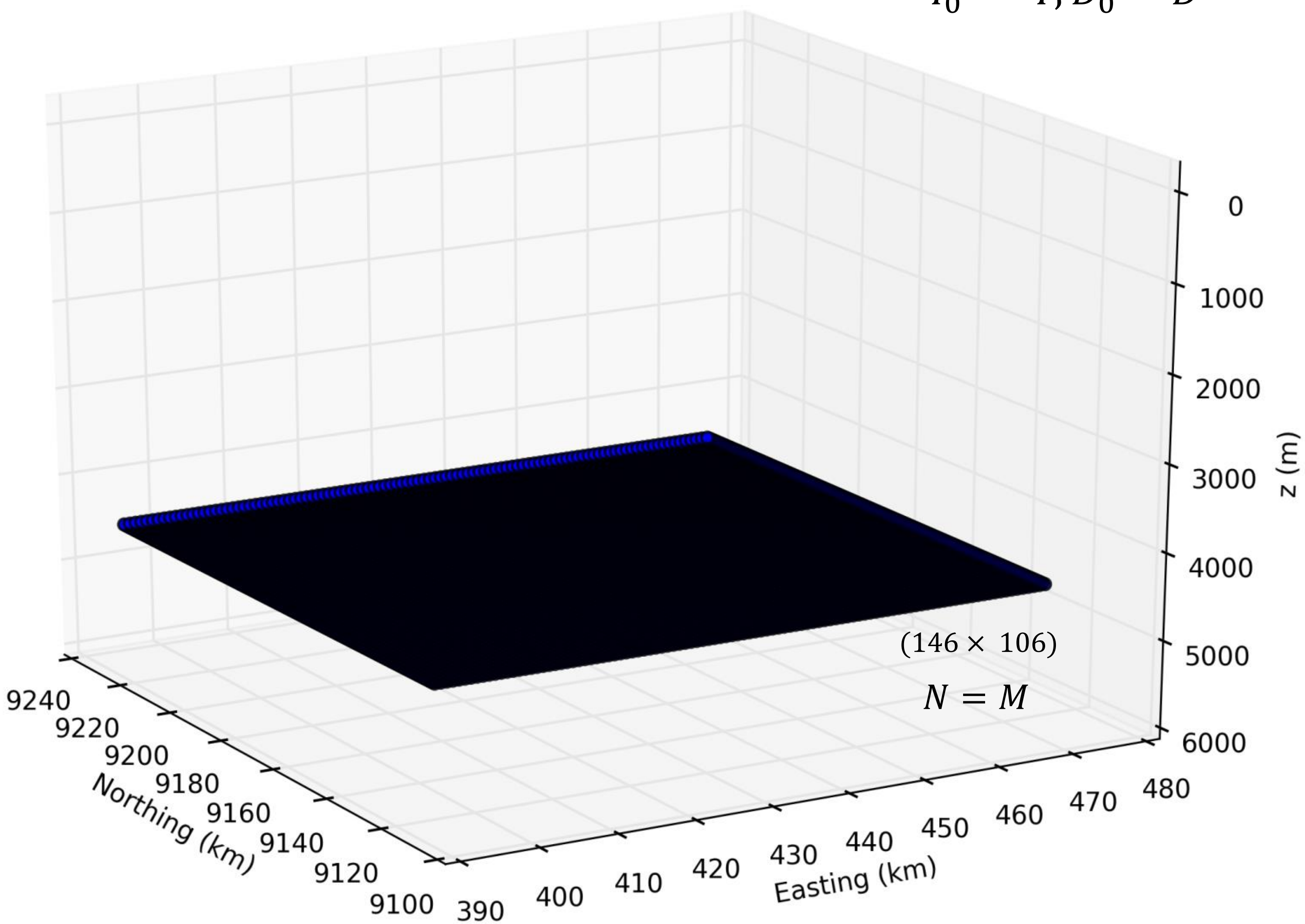
OBSERVED DATA: TOTAL-FIELD ANOMALY



EQUIVALENT LAYER

$$I_0 = -8°, D_0 = -20°$$

$$I_0 = I; D_0 = D$$



(146×106)

$N = M$

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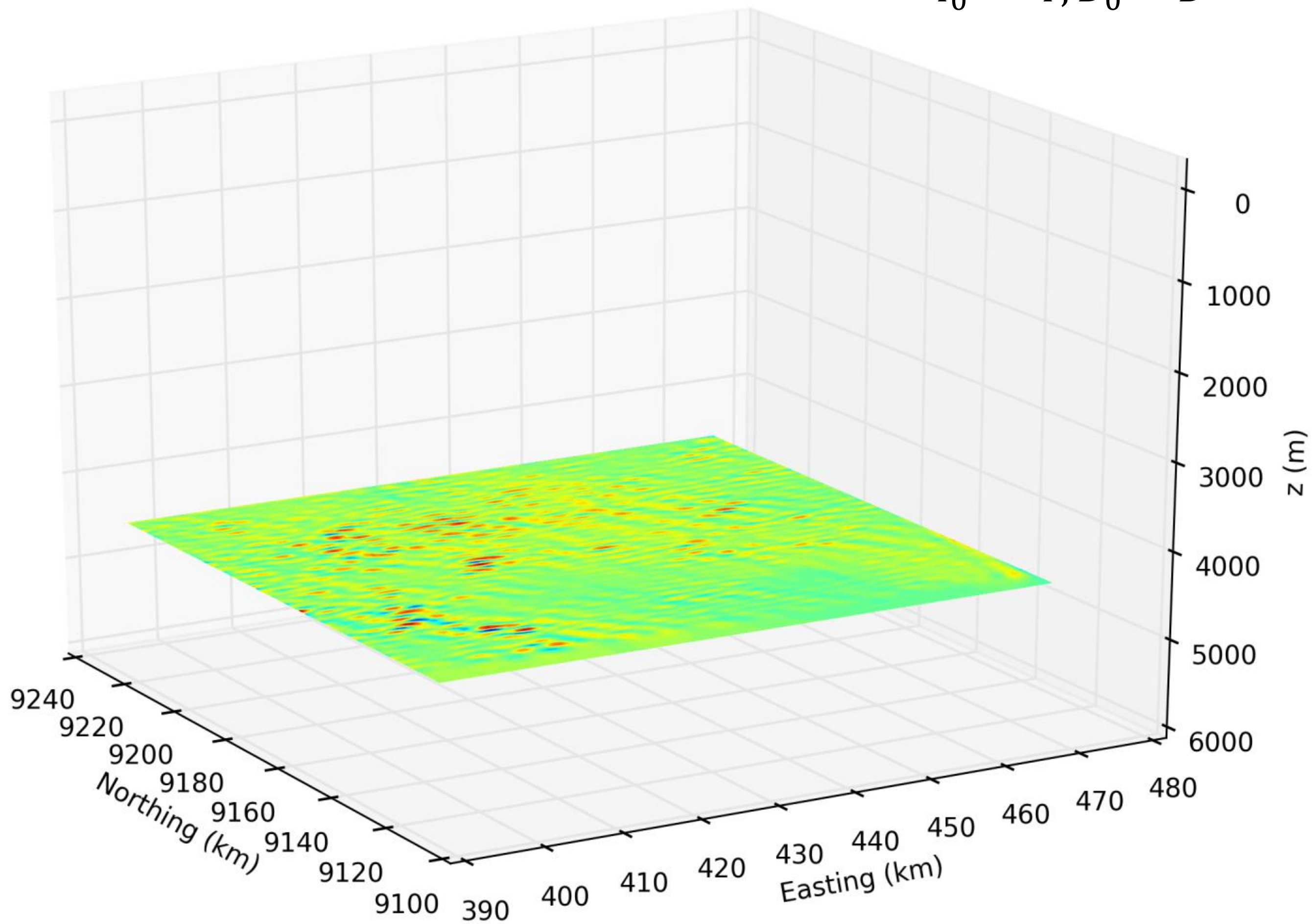

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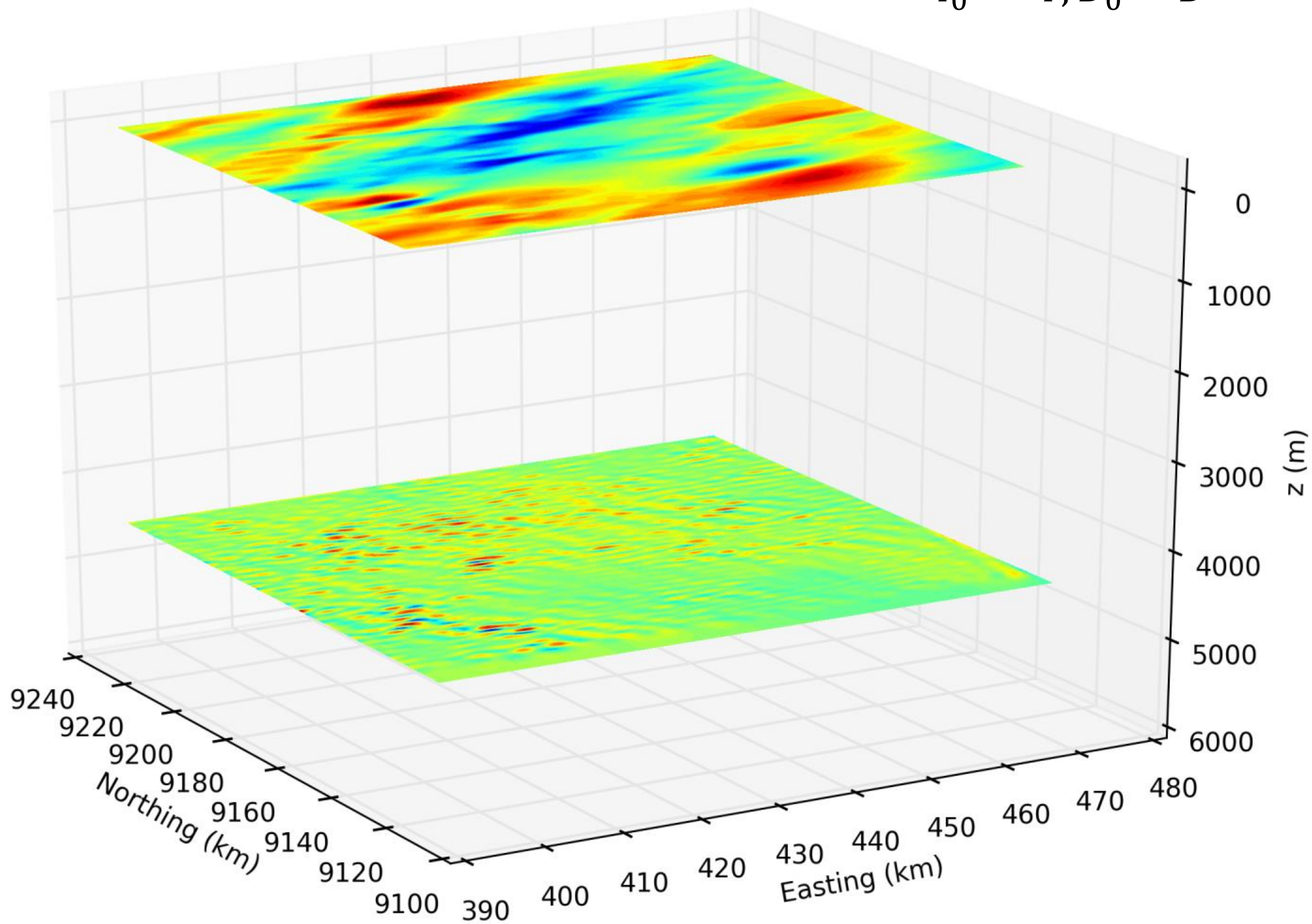
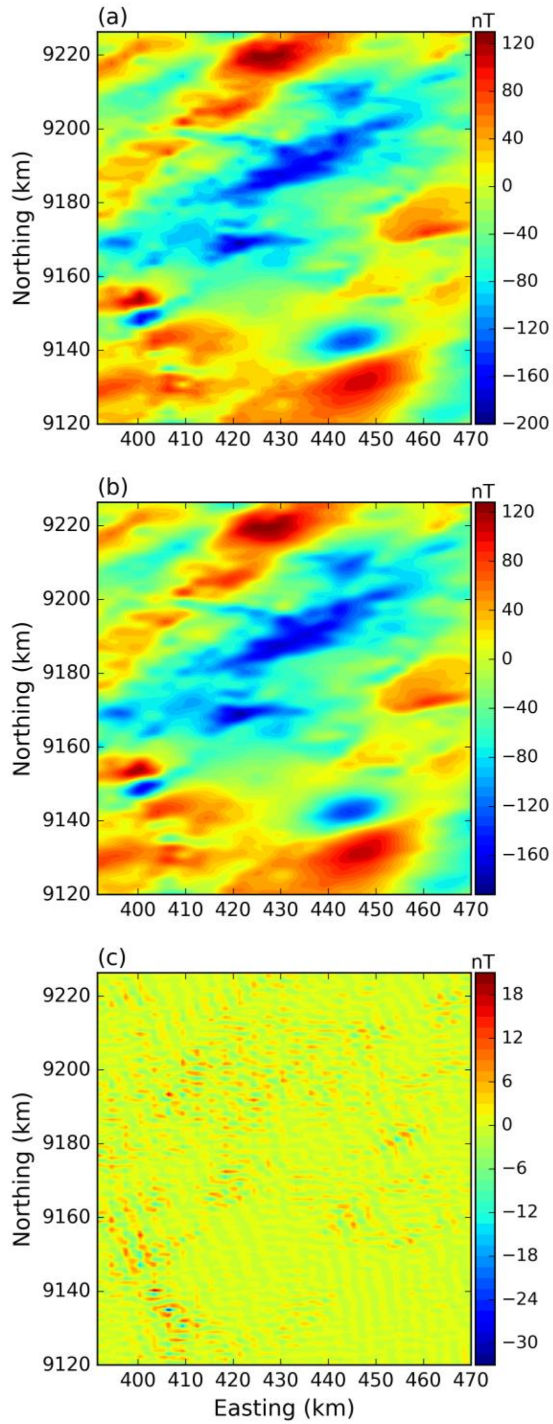


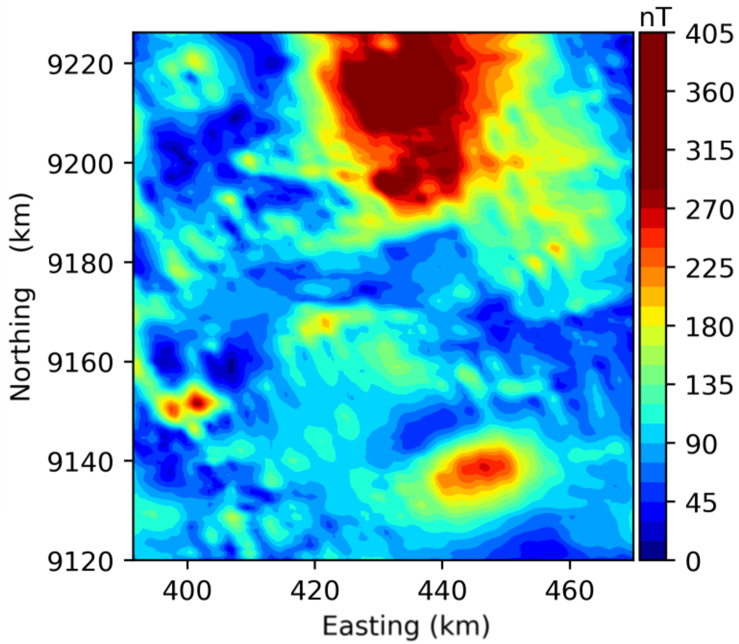


True total-field anomaly

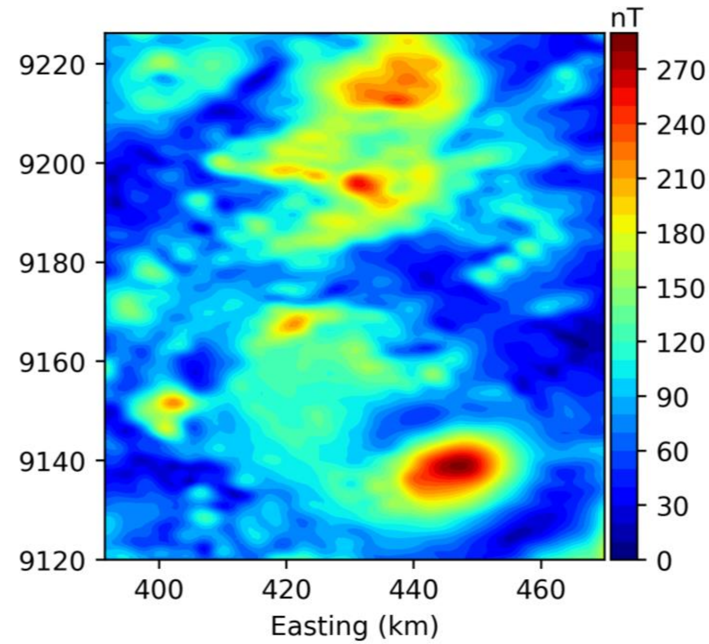
Predict total-field anomaly

AMPLITUDE OF THE MAGNETIC ANOMALY VECTOR

Fourier filtering



Equivalent layer



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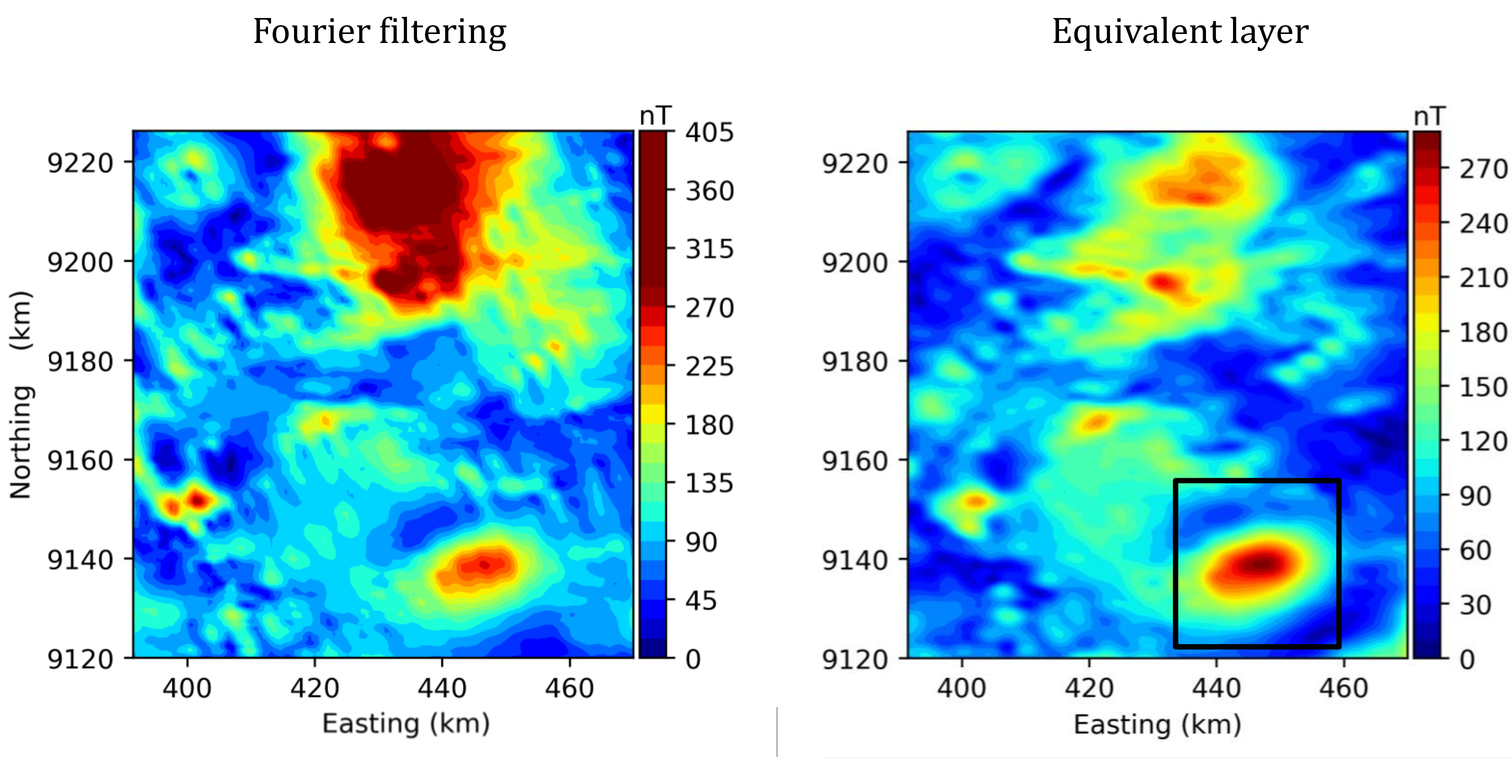
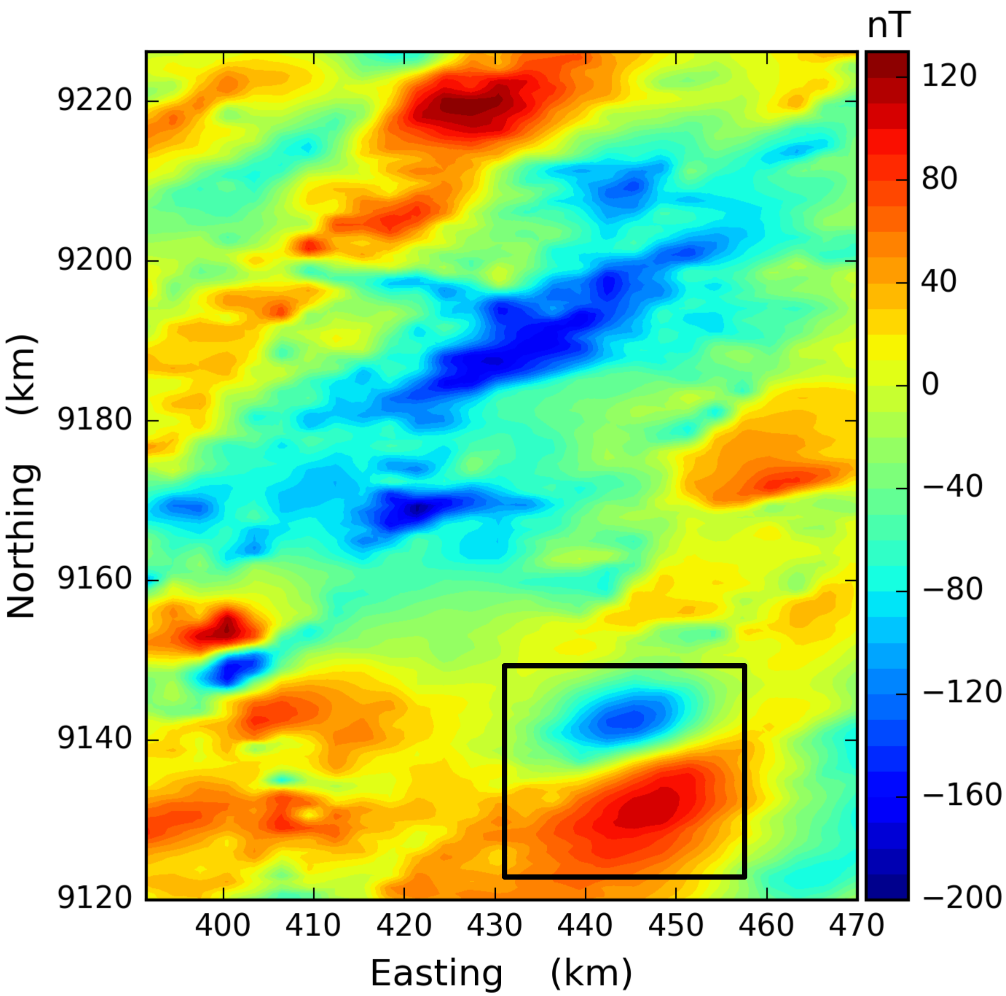
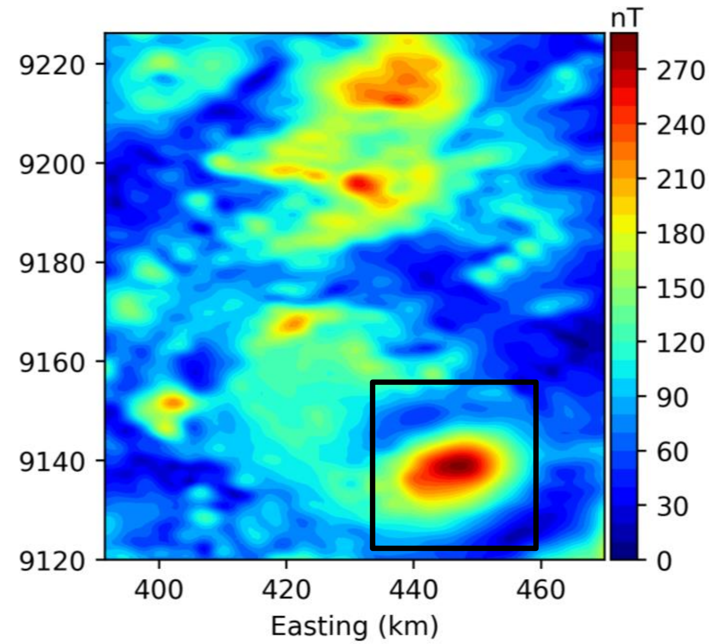




Equivalent layer



INTRODUCTION

METHOD

2.1. Fourier filtering

2.2. Equivalent layer

SYNTHETIC TESTS

3.1. Test 1

3.2. Test 2

3.3. Test 3

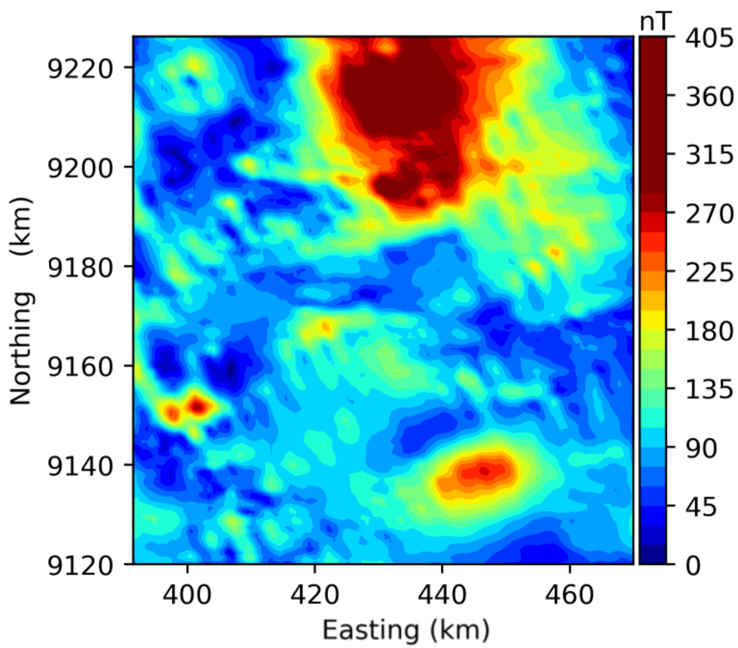
APPLICATION TO REAL DATASET

CONCLUSIONS

ACKNOWLEDGMENTS

AMPLITUDE OF THE MAGNETIC ANOMALY VECTOR

Fourier filtering



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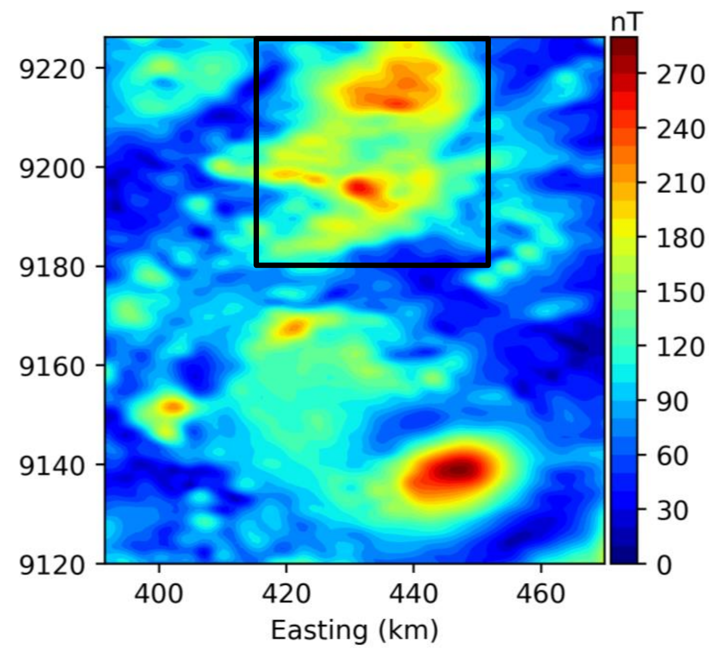

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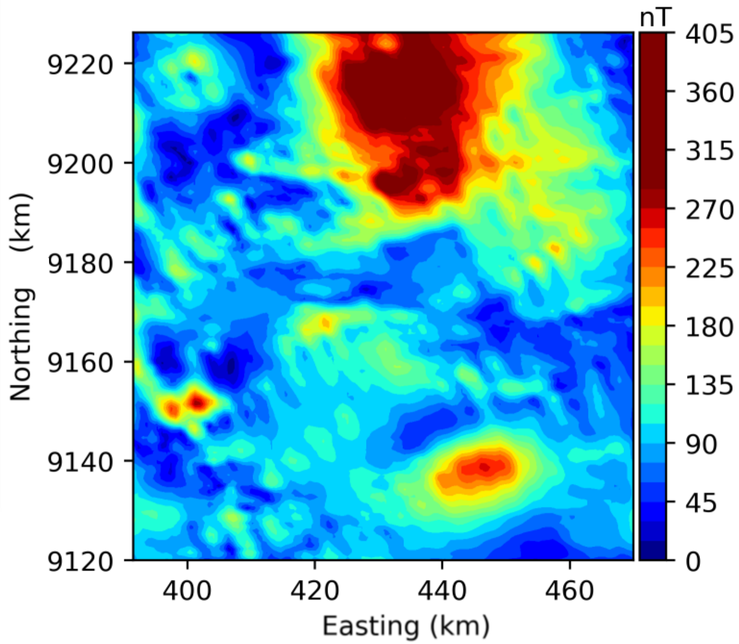
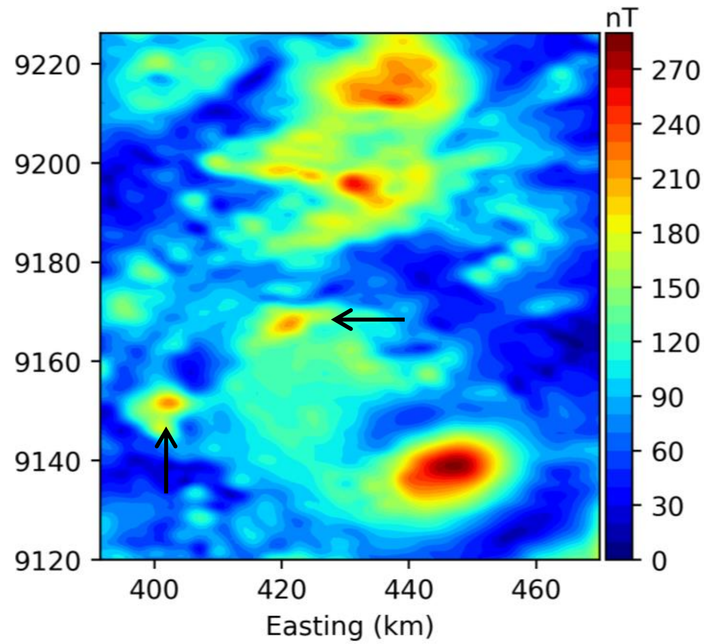
Fourier filtering



Equivalent layer



SUMMARY

We use Fourier filtering and equivalent layer technique to obtain the amplitude of the magnetic anomaly vector:

1. At high latitudes both methods yield excellent results;
2. At low latitudes some instabilities show up:
   i. Artifacts and striations appear in the direction of declination;
   ii. Synthetic tests and real dataset application shows that the equivalent layer technique is more stable.
3. The transformed amplitude of the magnetic anomaly vector indicates a possible correspondence with the local geology;
4. The inversion and qualitative interpretations of the amplitude of the magnetic anomaly vector (computed by the equivalent layer) can be used as an alternative to the traditional methods.

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1 INTRODUCTION

2 METHOD

3 SYNTHETIC TESTS

4 APPLICATION TO REAL DATASET

5 CONCLUSIONS

6 ACKNOWLEDGMENTS

CAPES

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

FAPERJ
Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro

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PINGA
Grupo de problemas inversos em geofísica

CPRM
Serviço Geológico do Brasil