

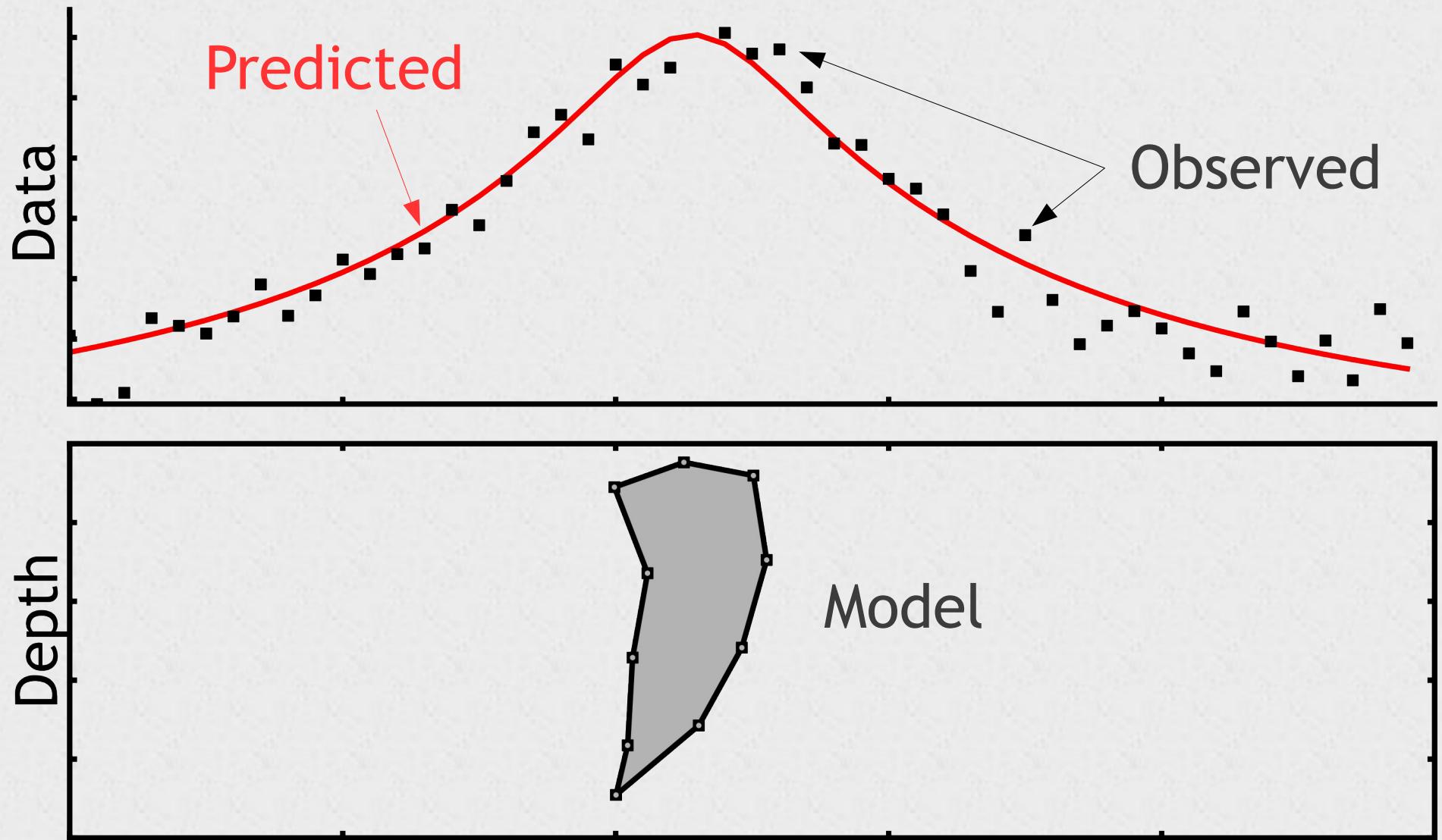
Rapid 3D inversion of gravity and gravity gradient data to test geologic hypotheses

Leonardo Uieda
Valéria C. F. Barbosa



Observatório Nacional
Rio de Janeiro, Brazil

Forward modeling

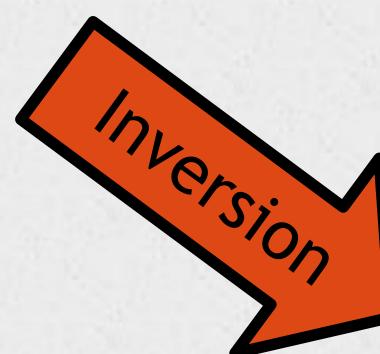
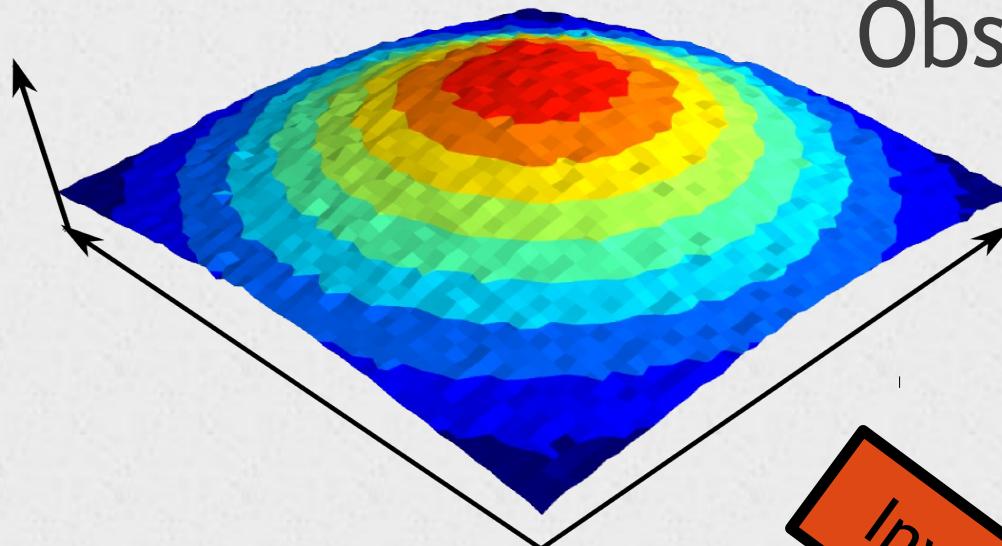


- ✓ Control
- ✓ Prior information
- ✓ Speed

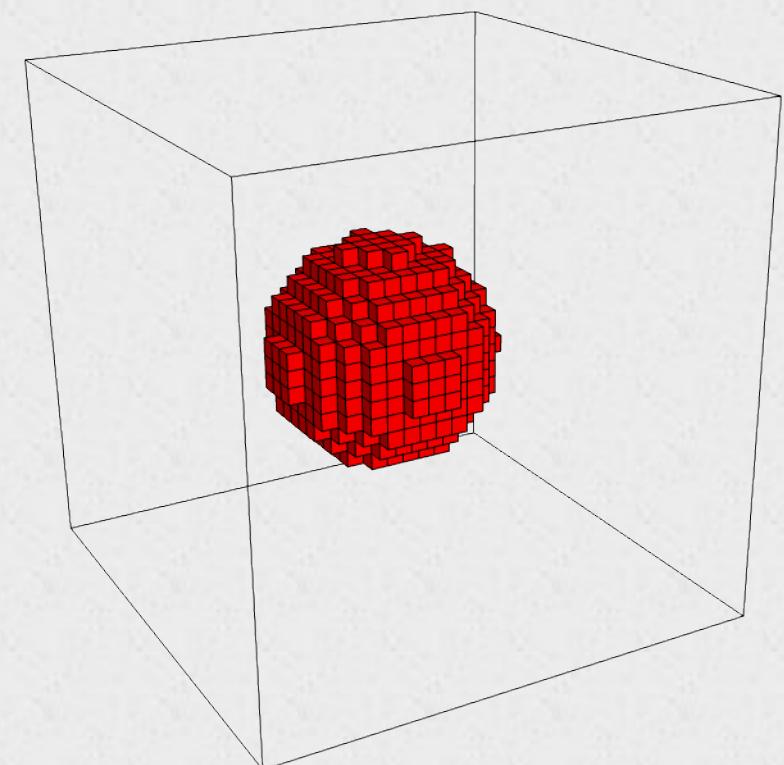
- ✗ Tedious
- ✗ 3D
- ✗ Gravity + Gradients

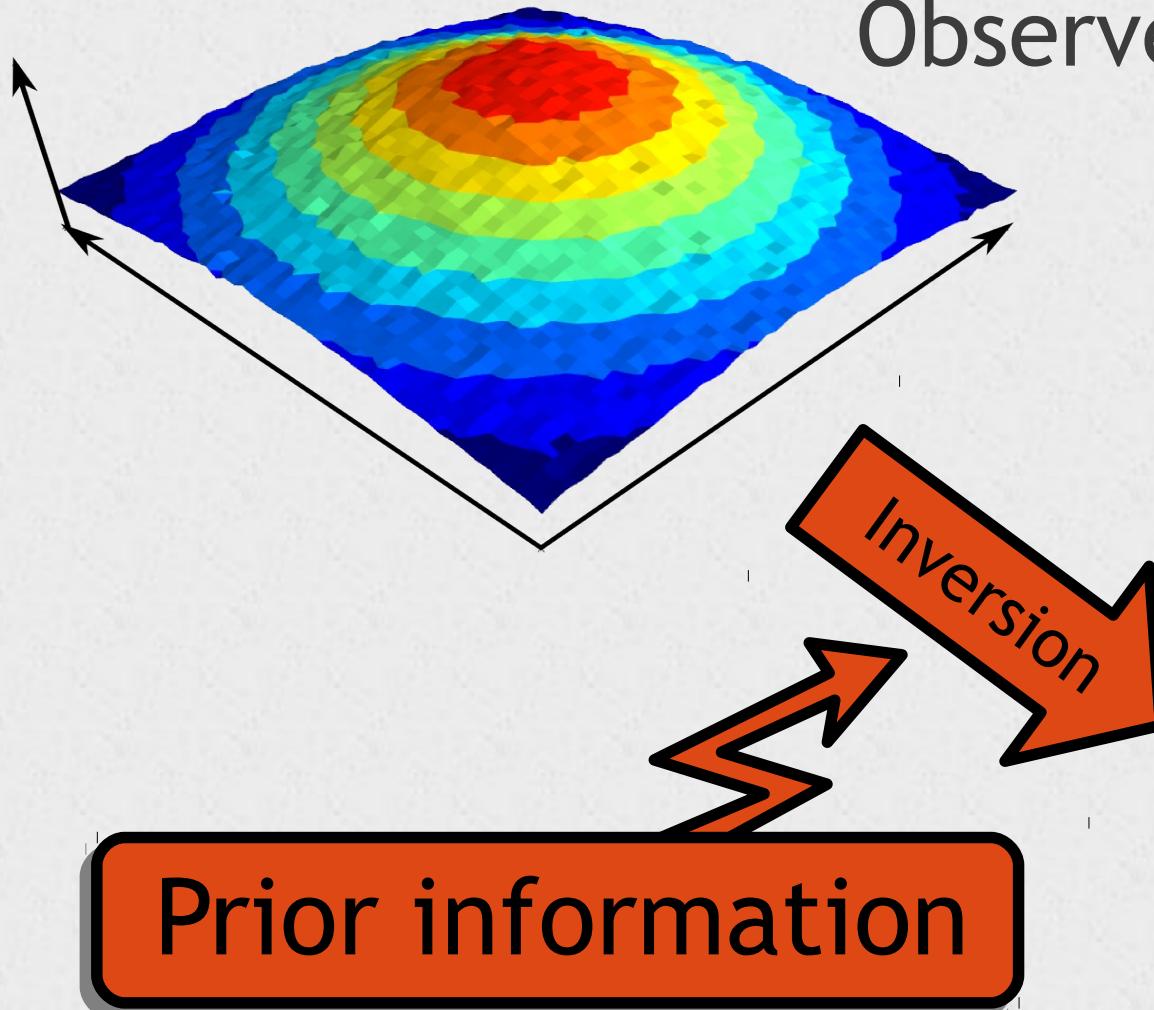
Geophysical inversion

Observed data



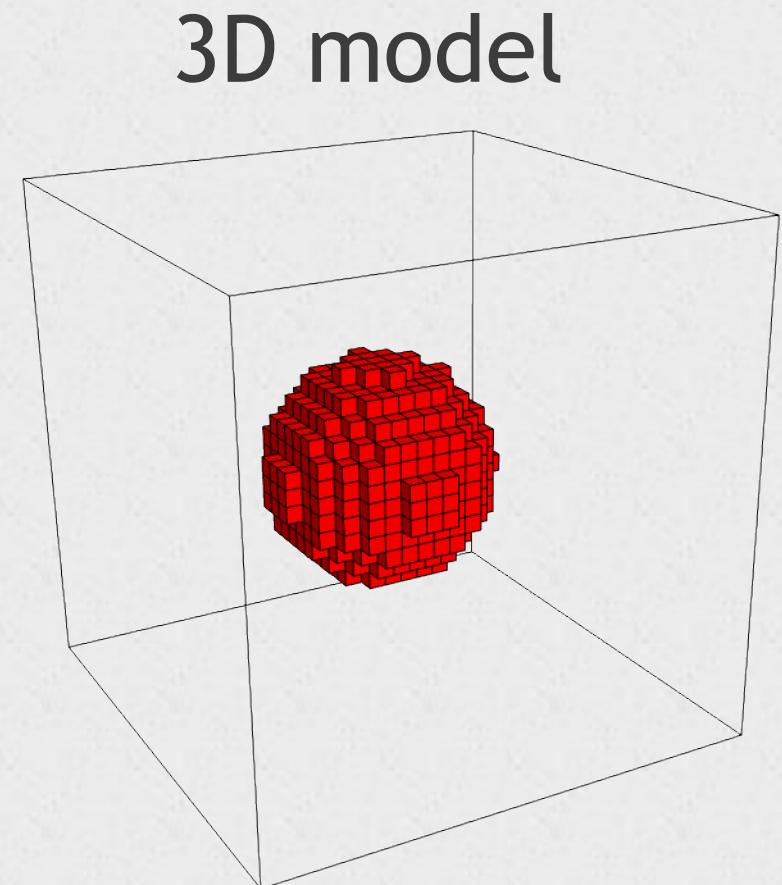
3D model





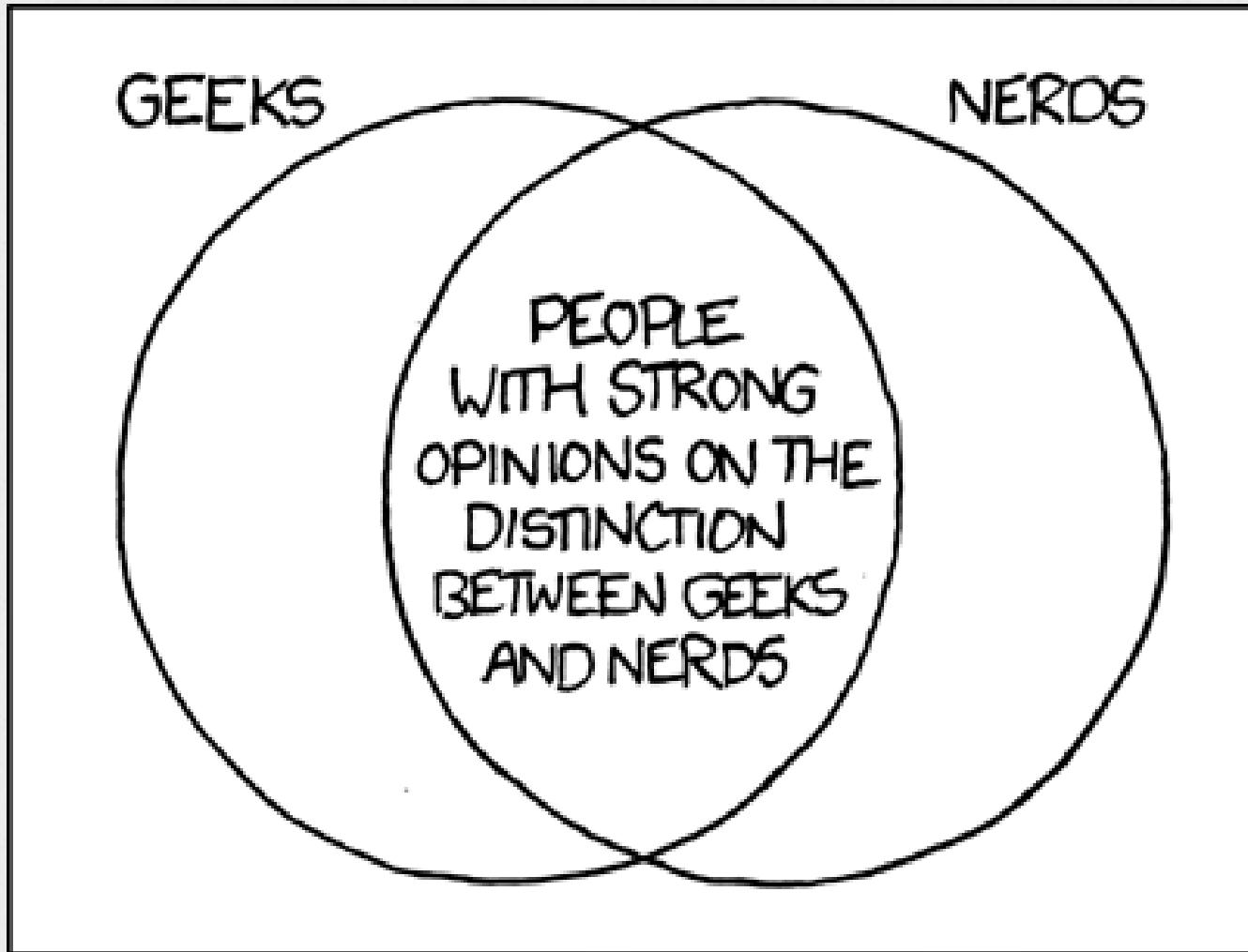
Regularization:

- Damping
- Smoothness



-  Control
-  Prior information
-  Speed
-  Automatic fit
-  3D
-  Gravity + Gradients

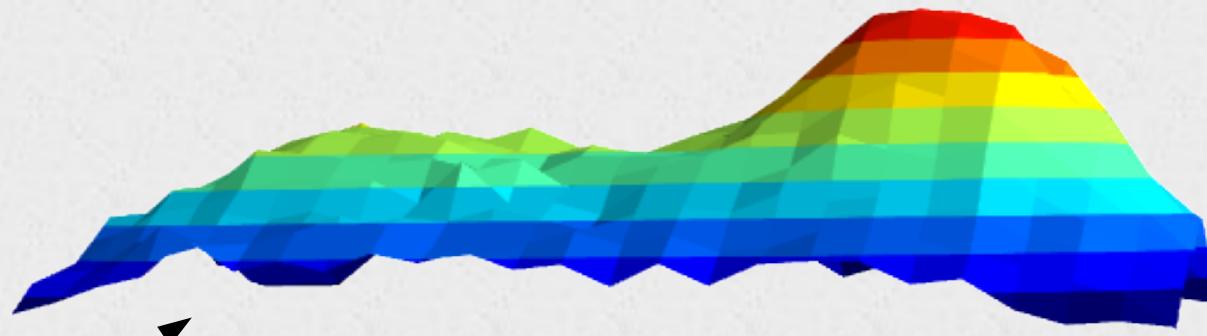
Something in the middle



Source <http://xkcd.com/747>

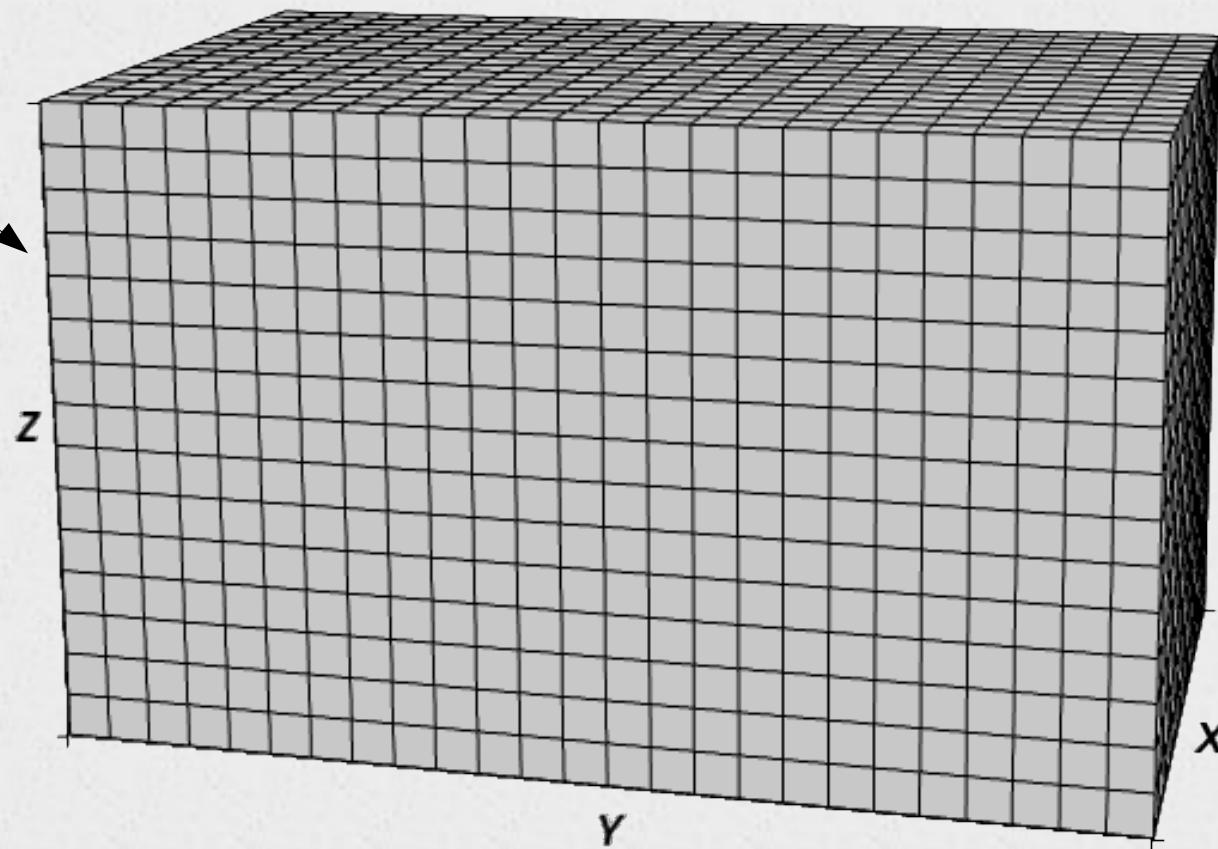
Planting anomalous densities

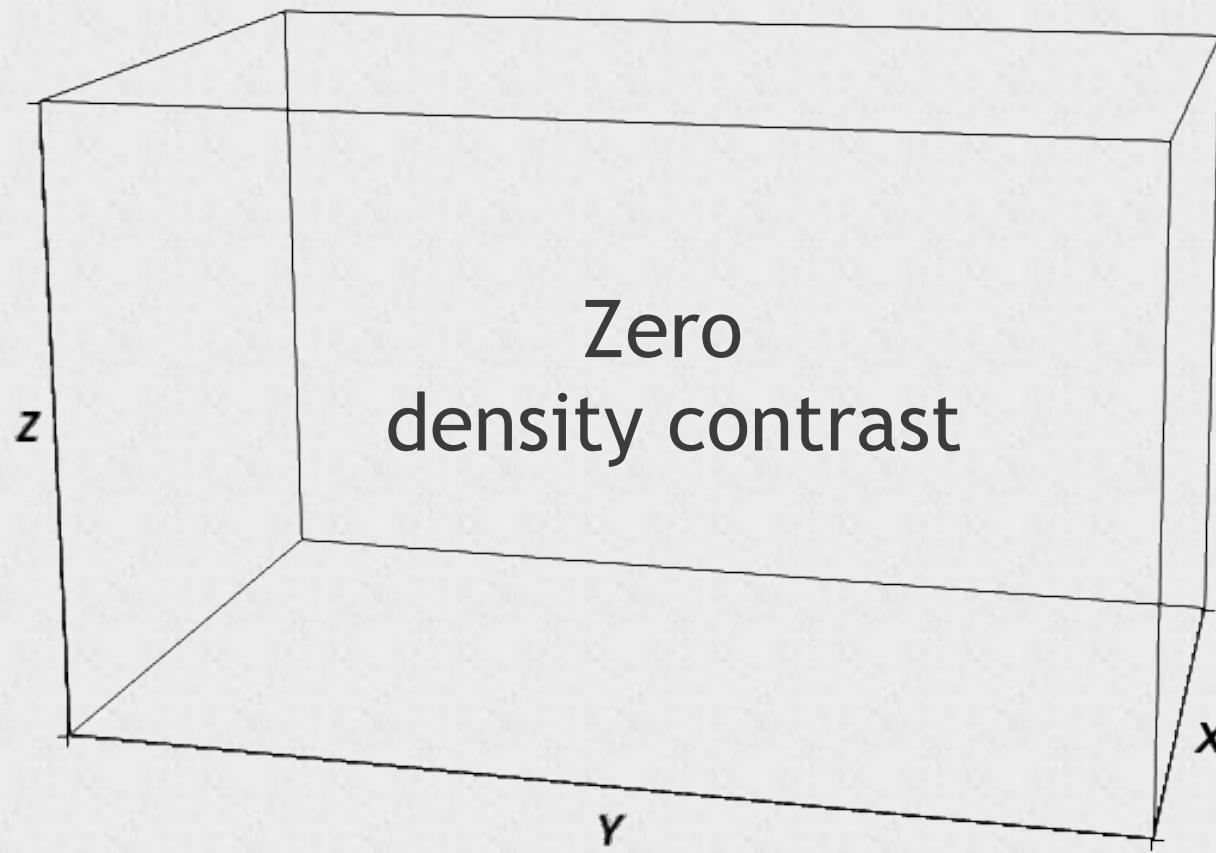
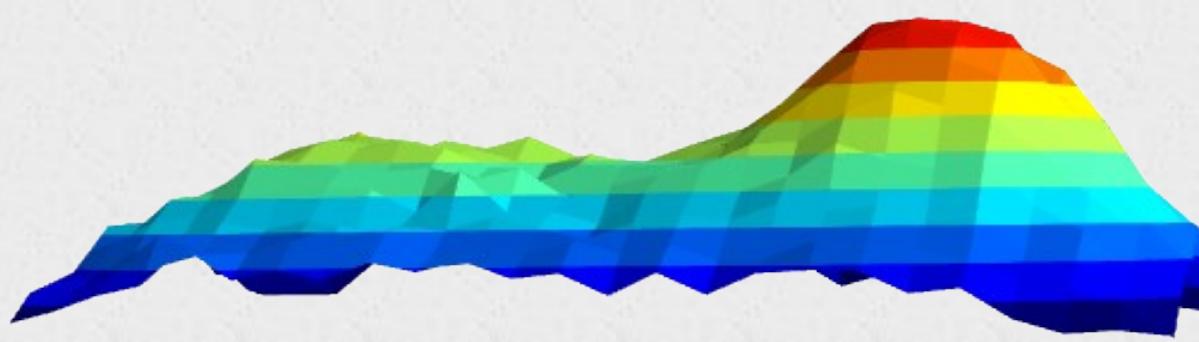
Uieda and Barbosa (2012)

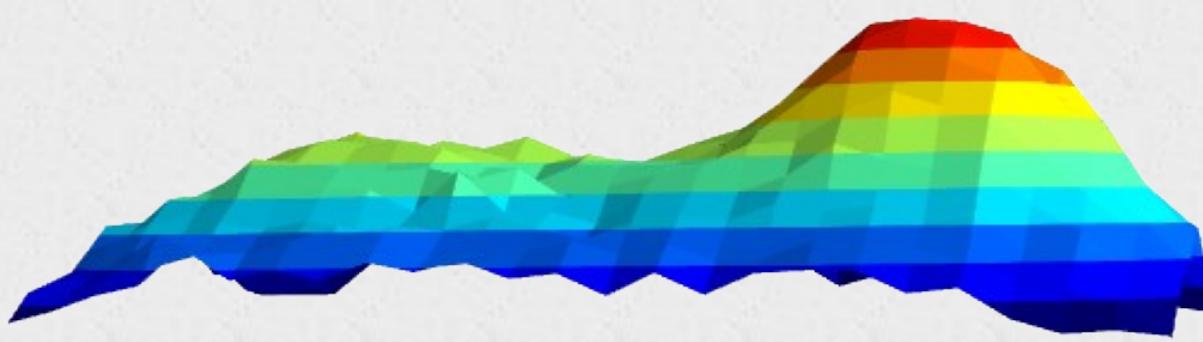


Observed data

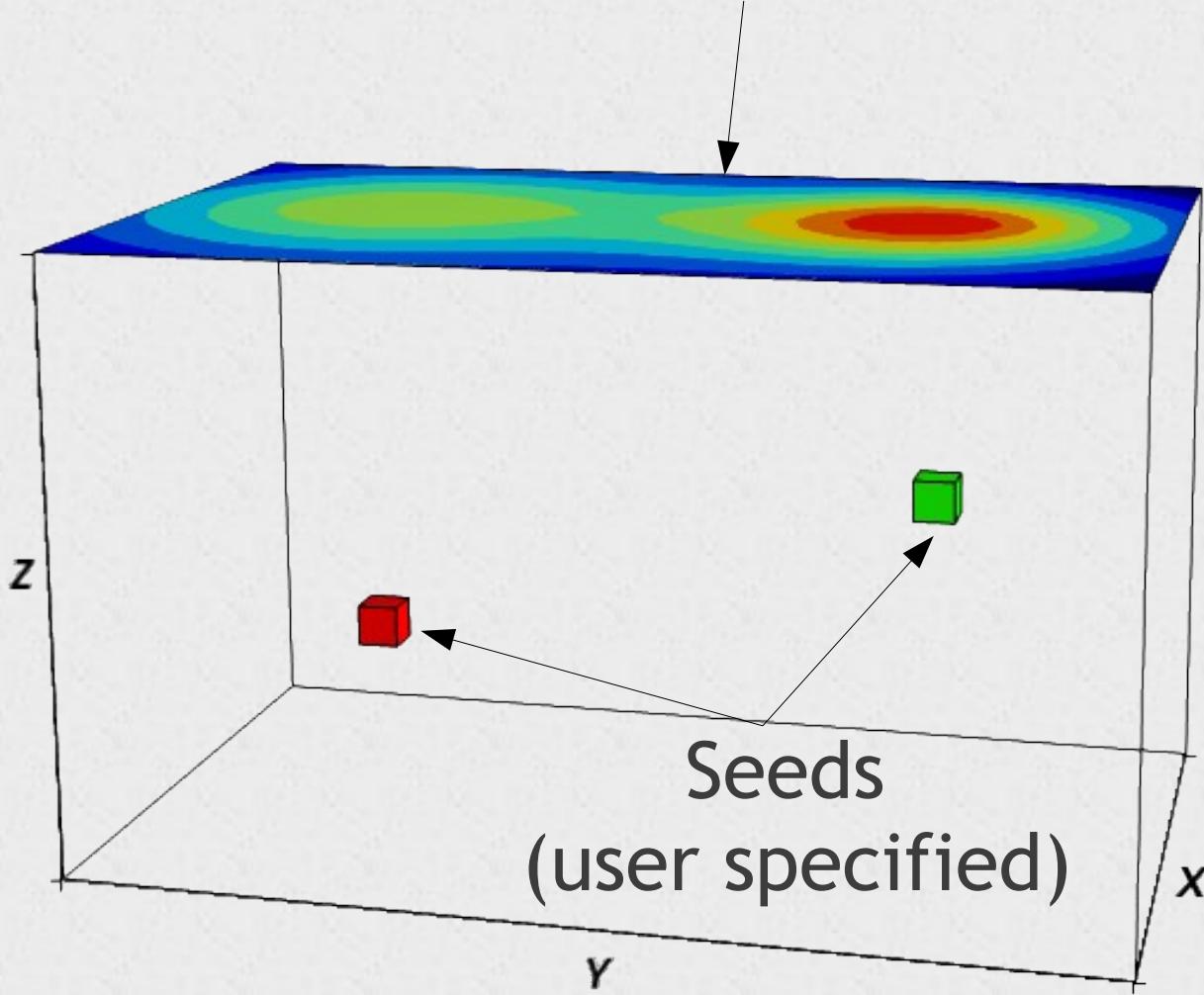
Mesh



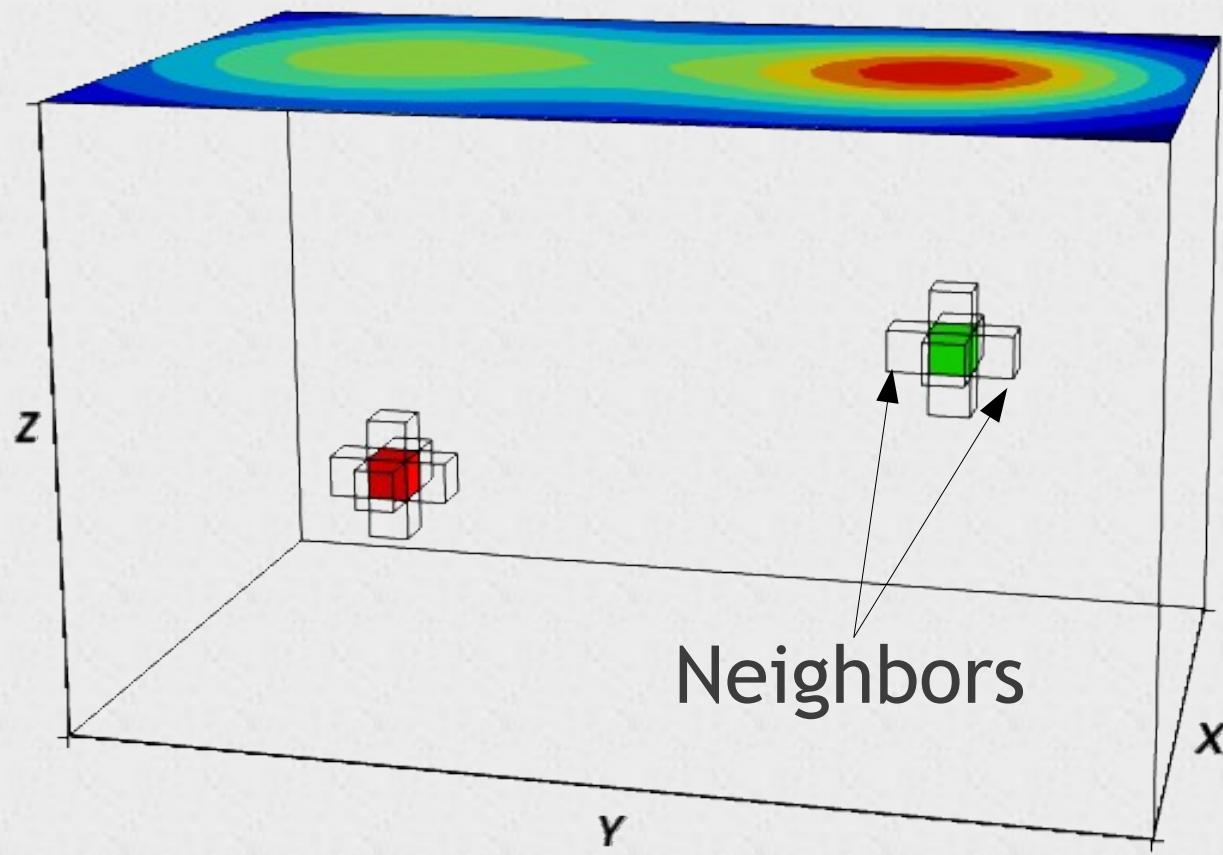
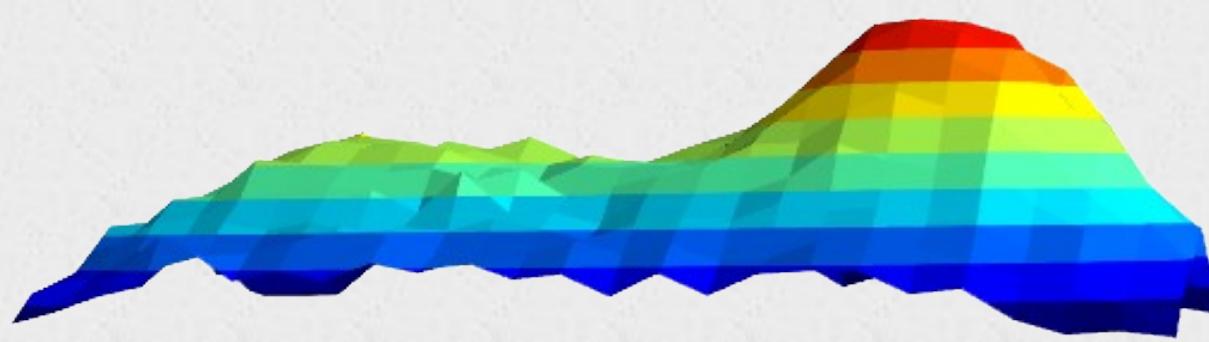


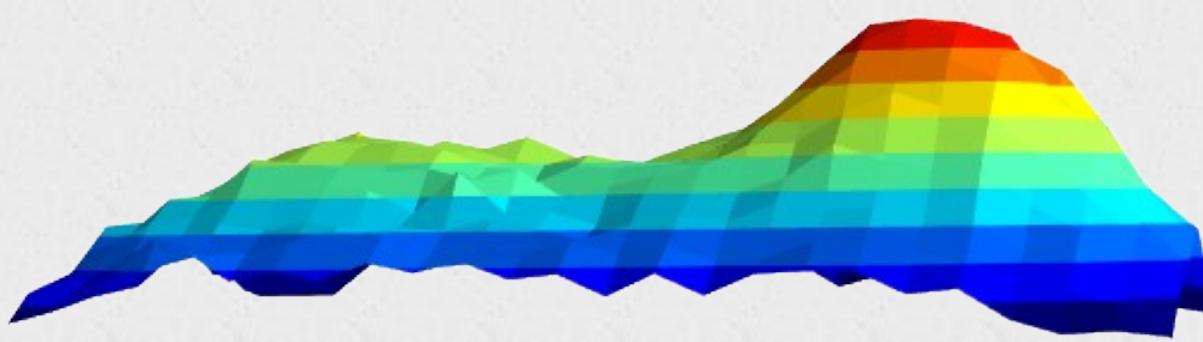


Predicted data

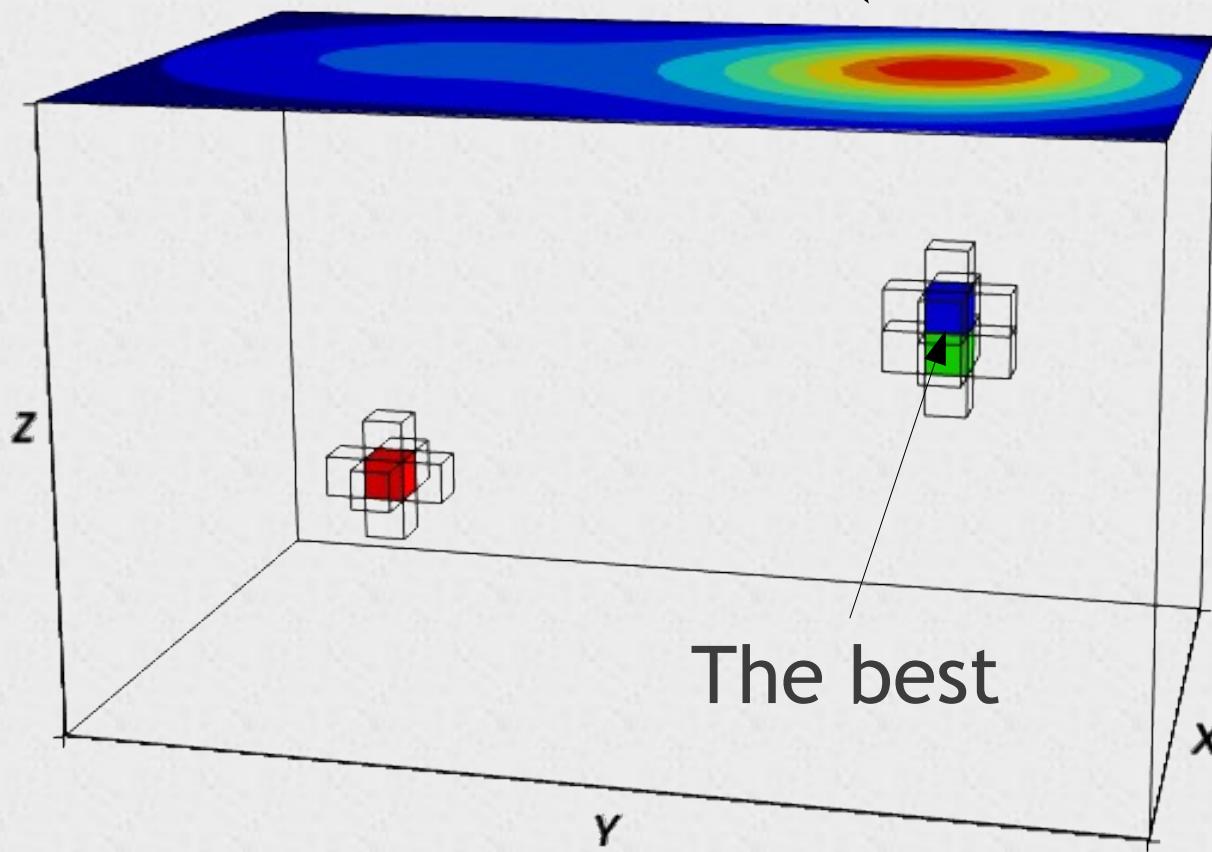


Seeds
(user specified)

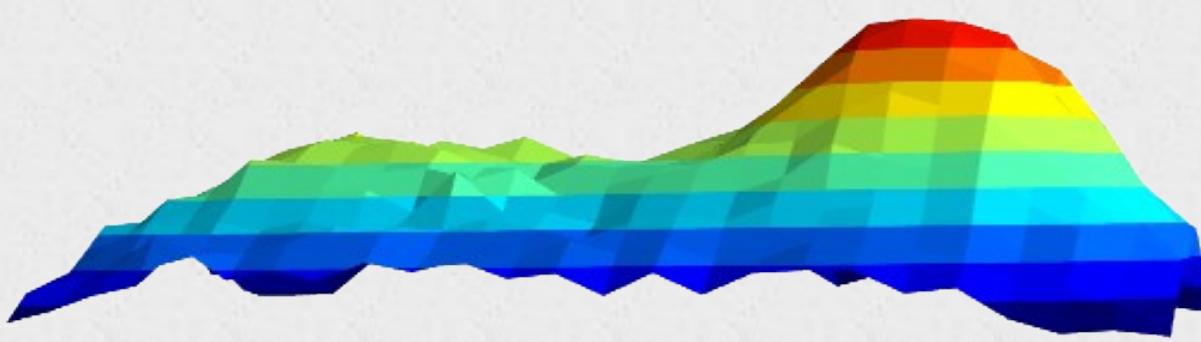




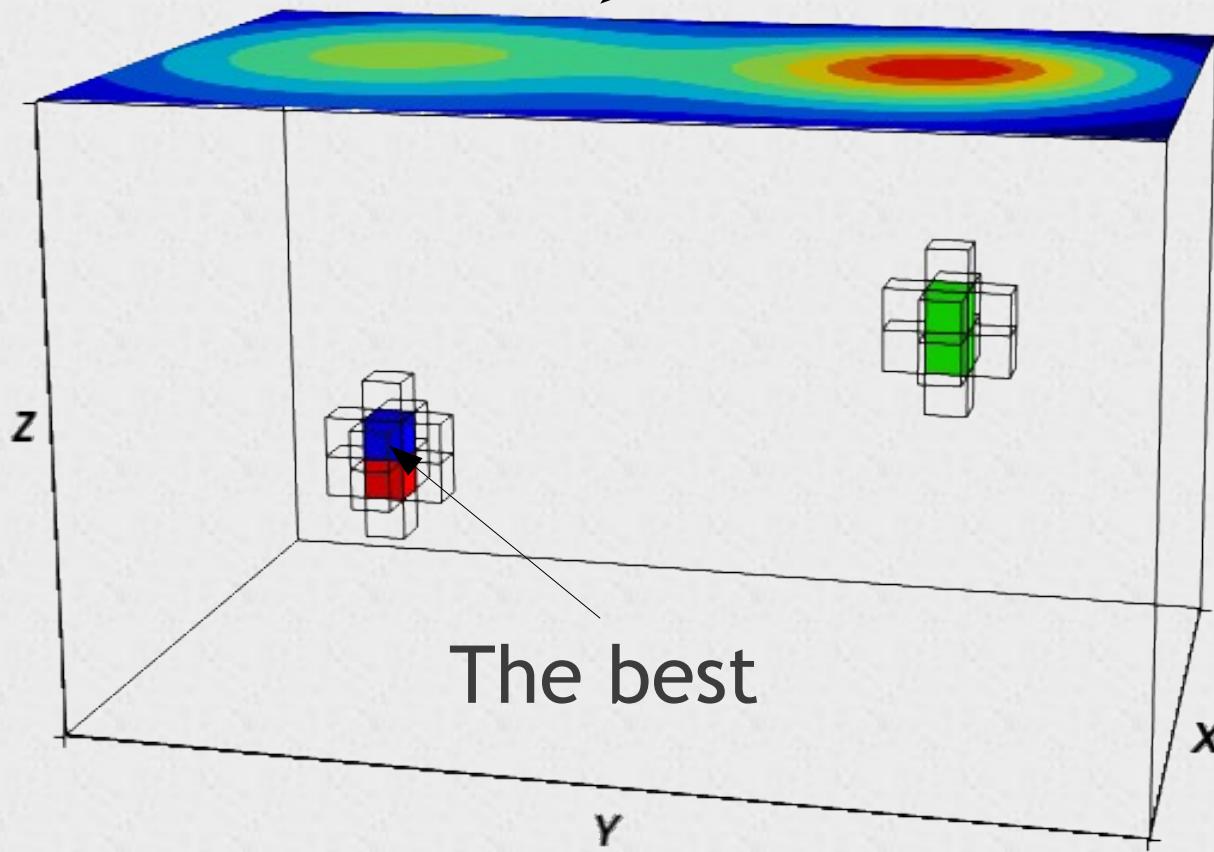
New predicted data

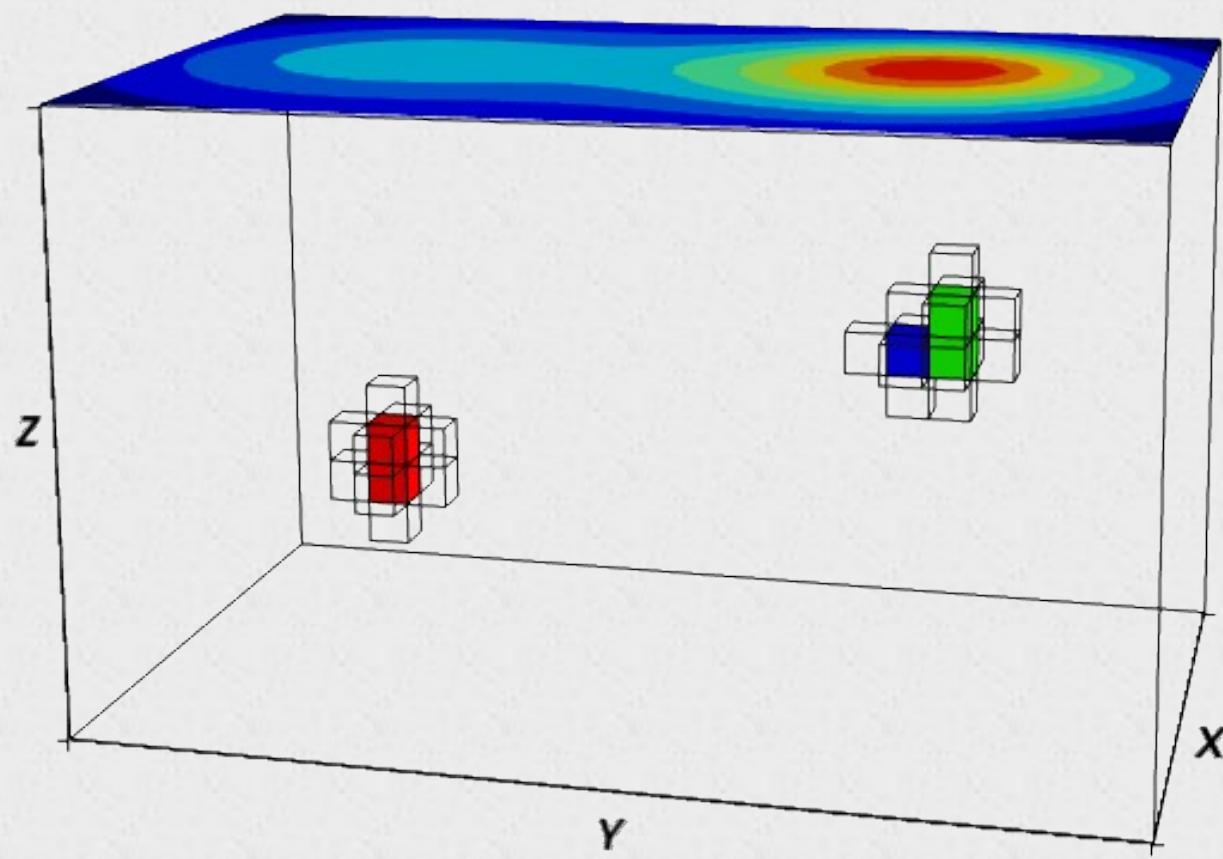
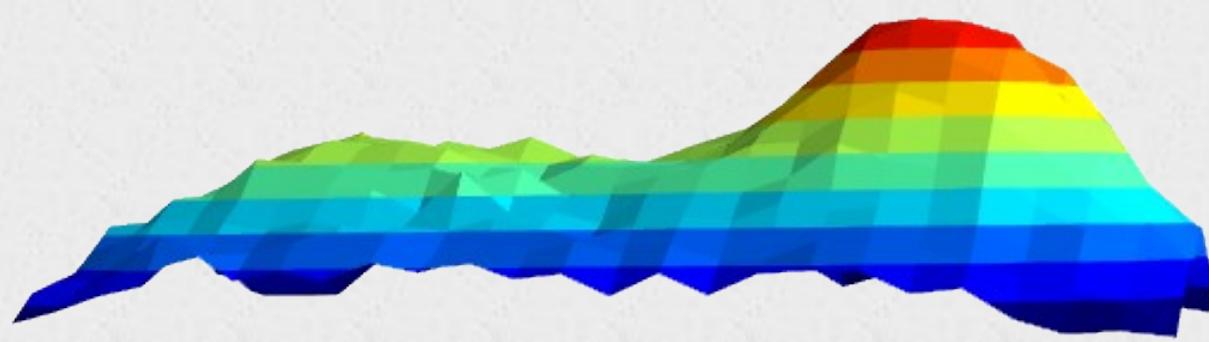


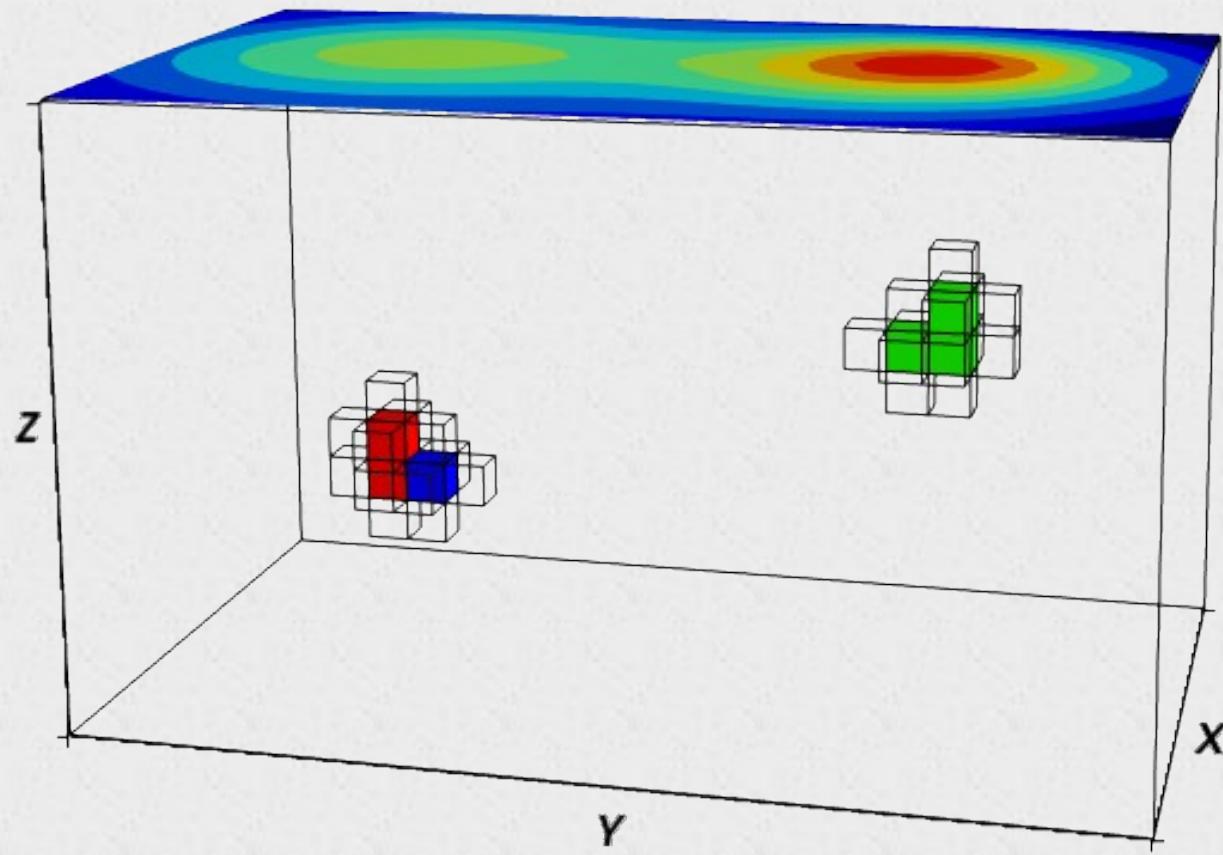
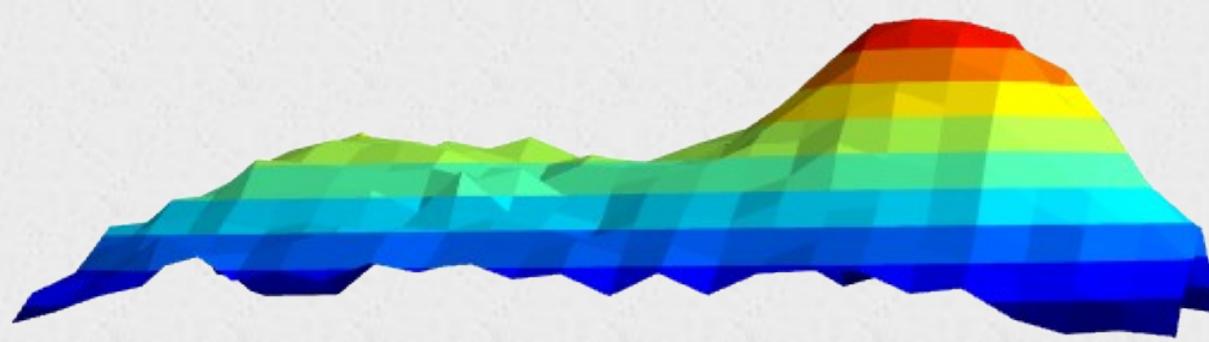
The best

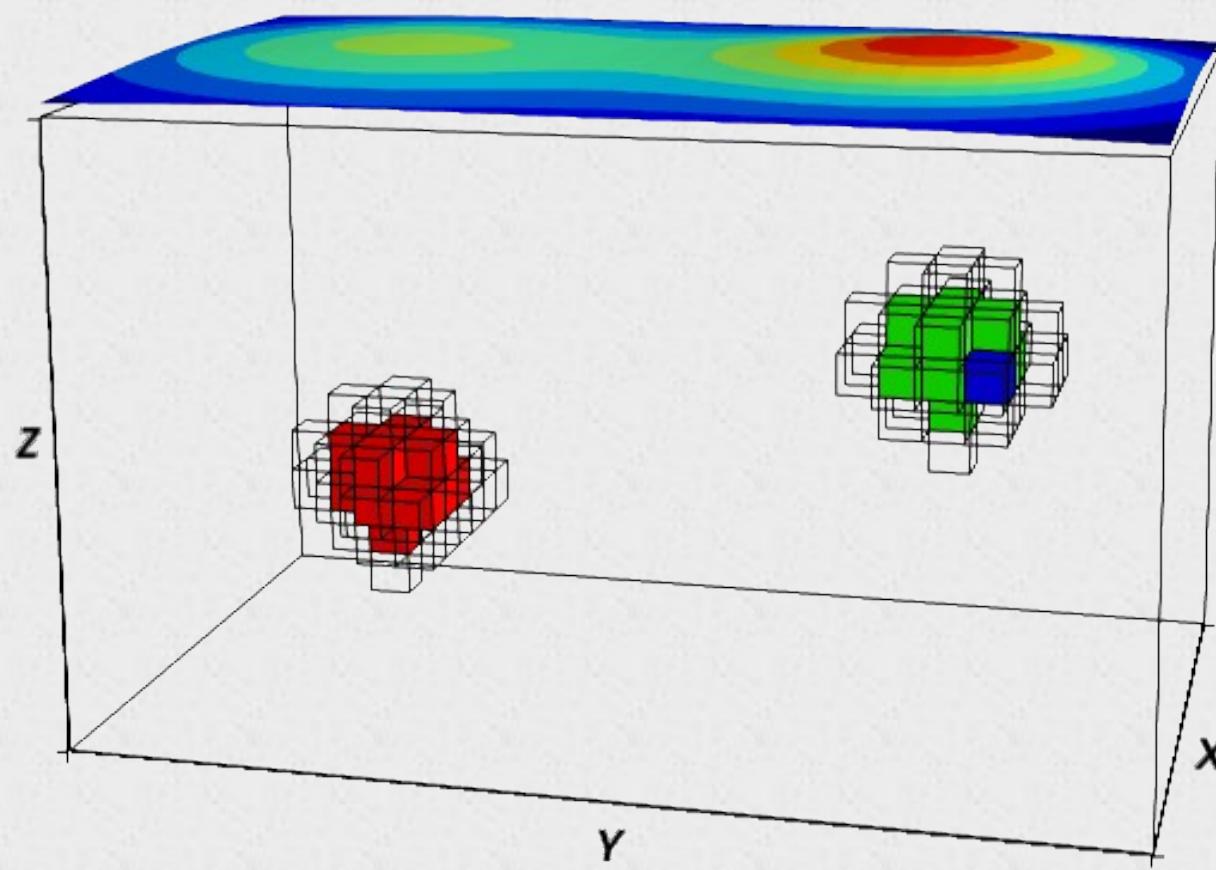
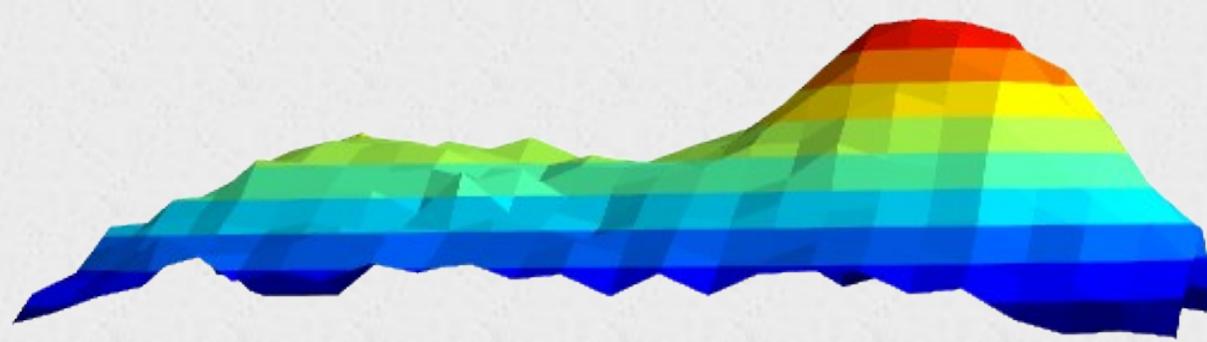


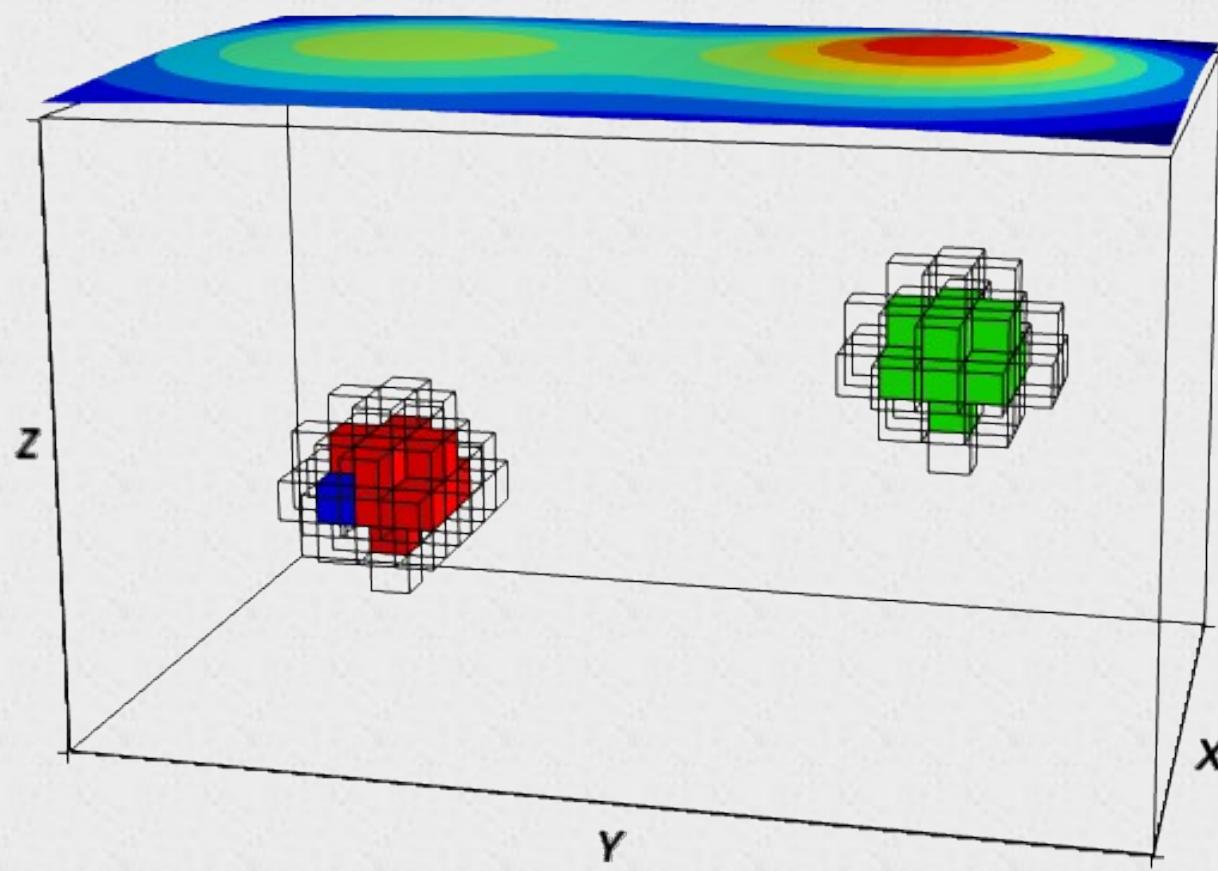
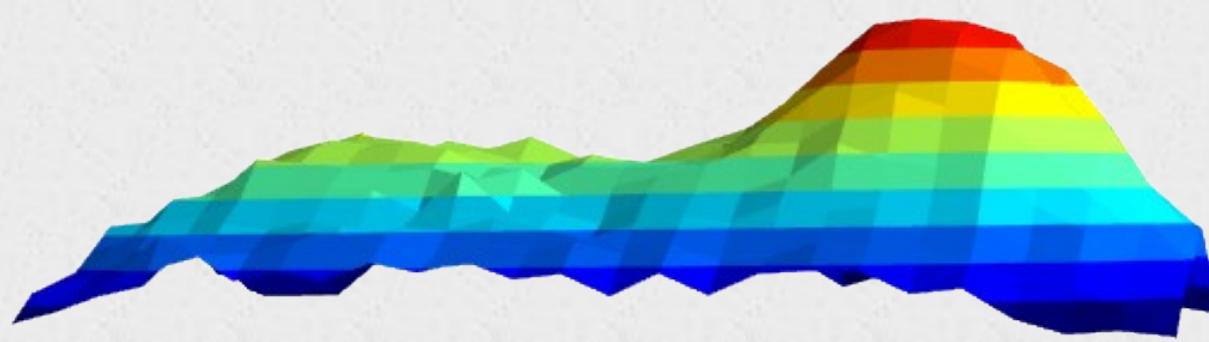
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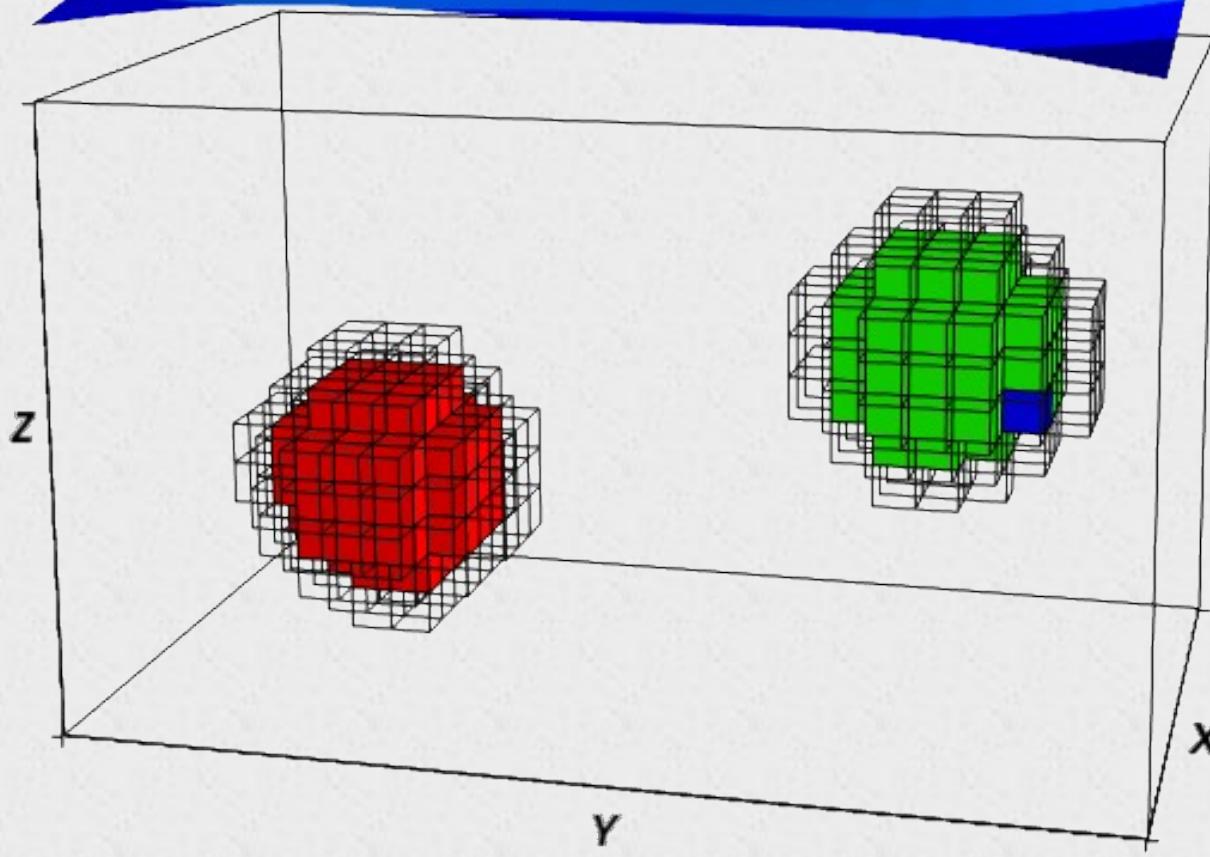
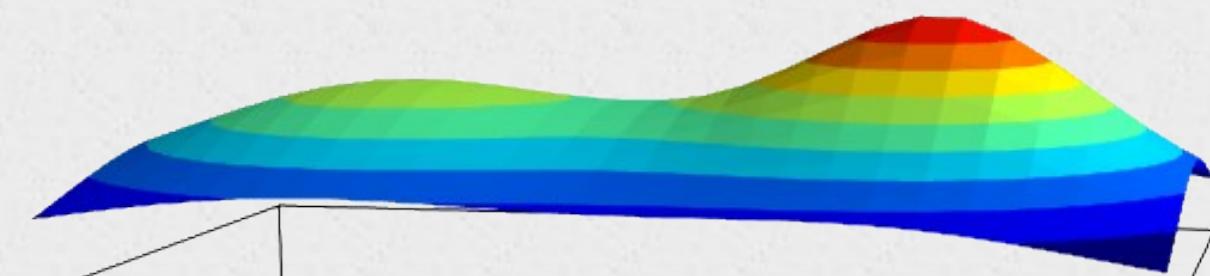
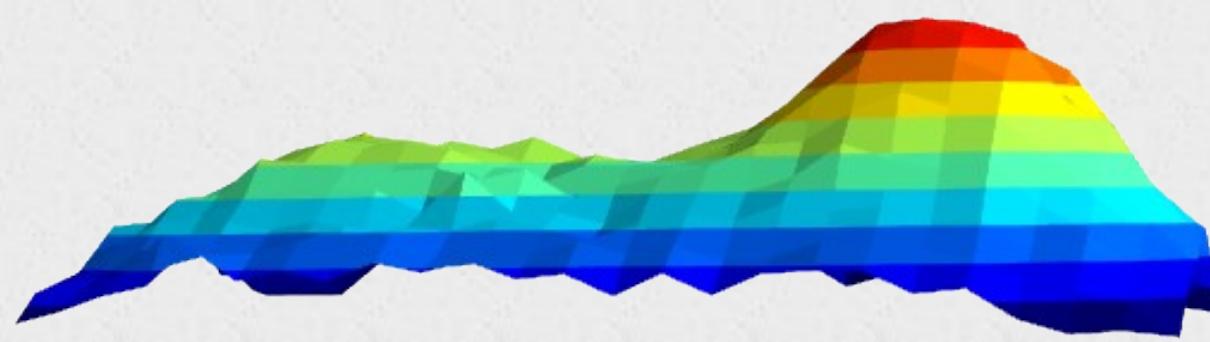


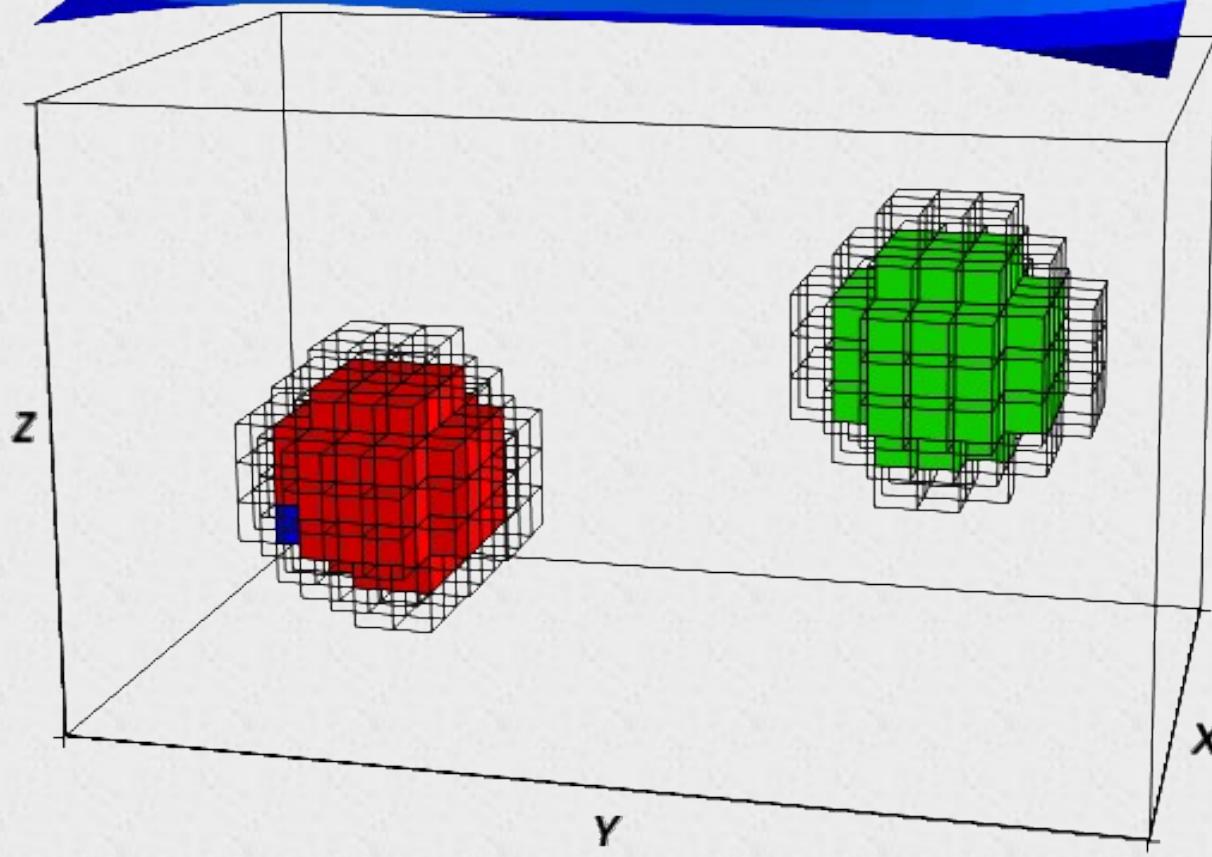
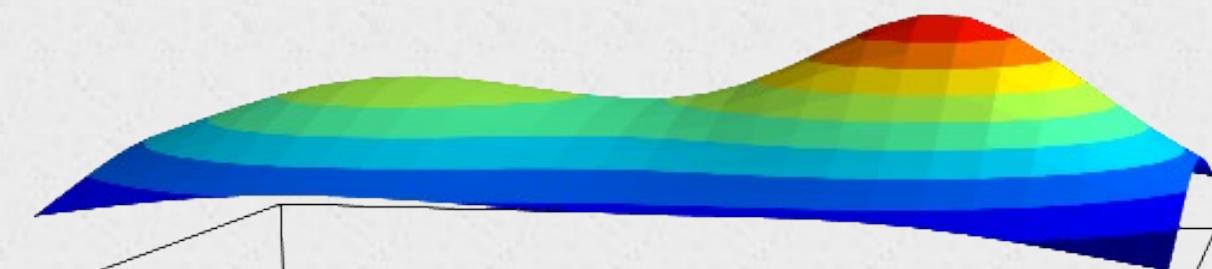
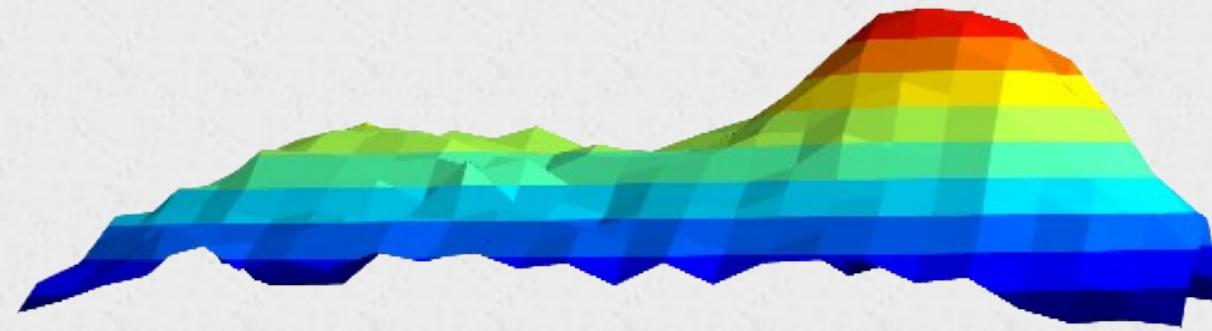


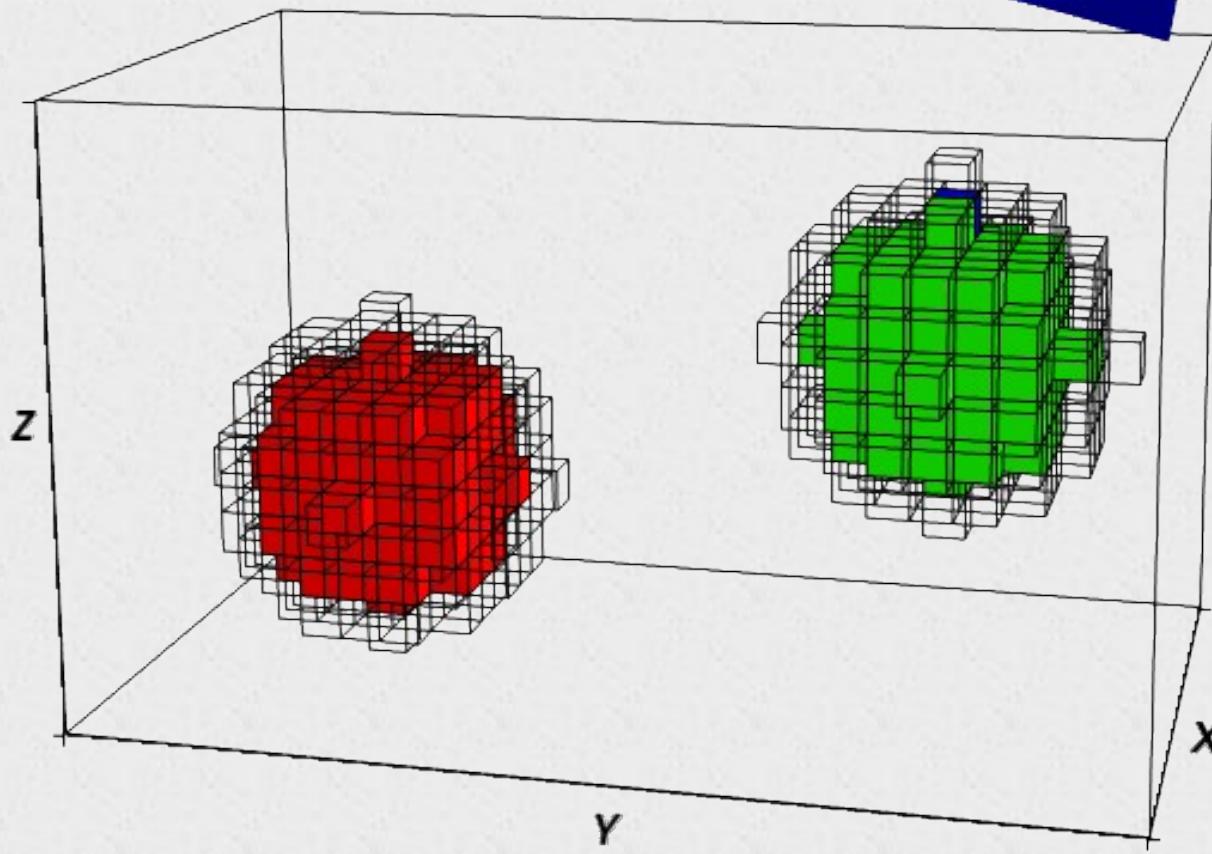
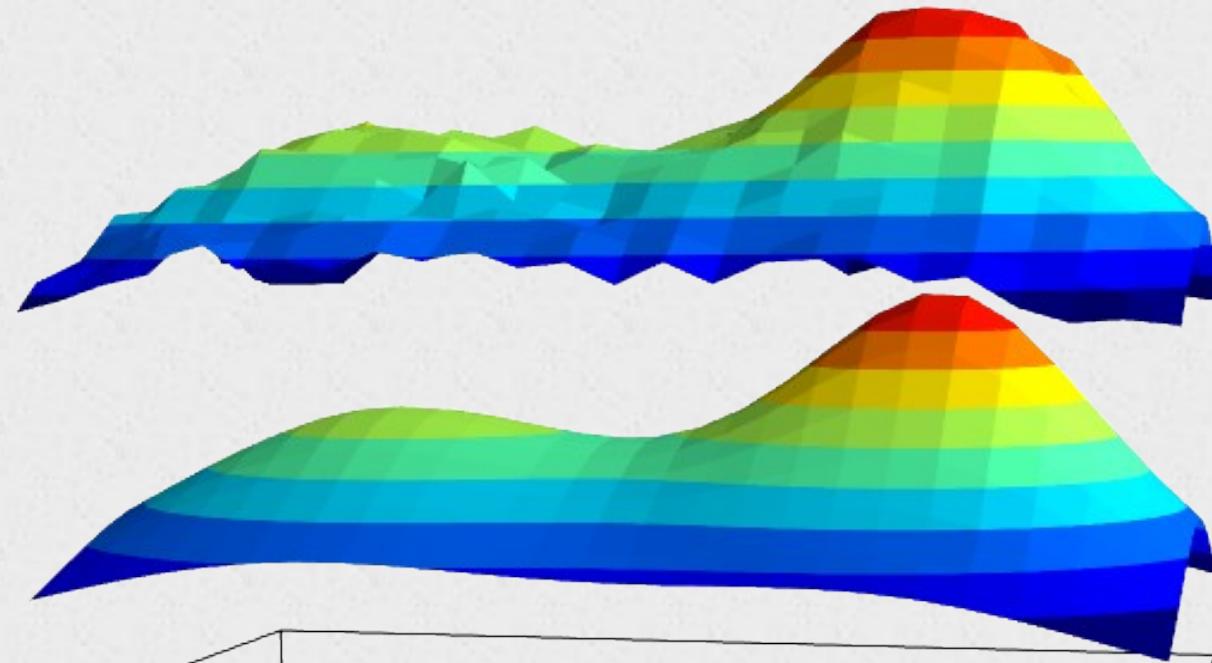


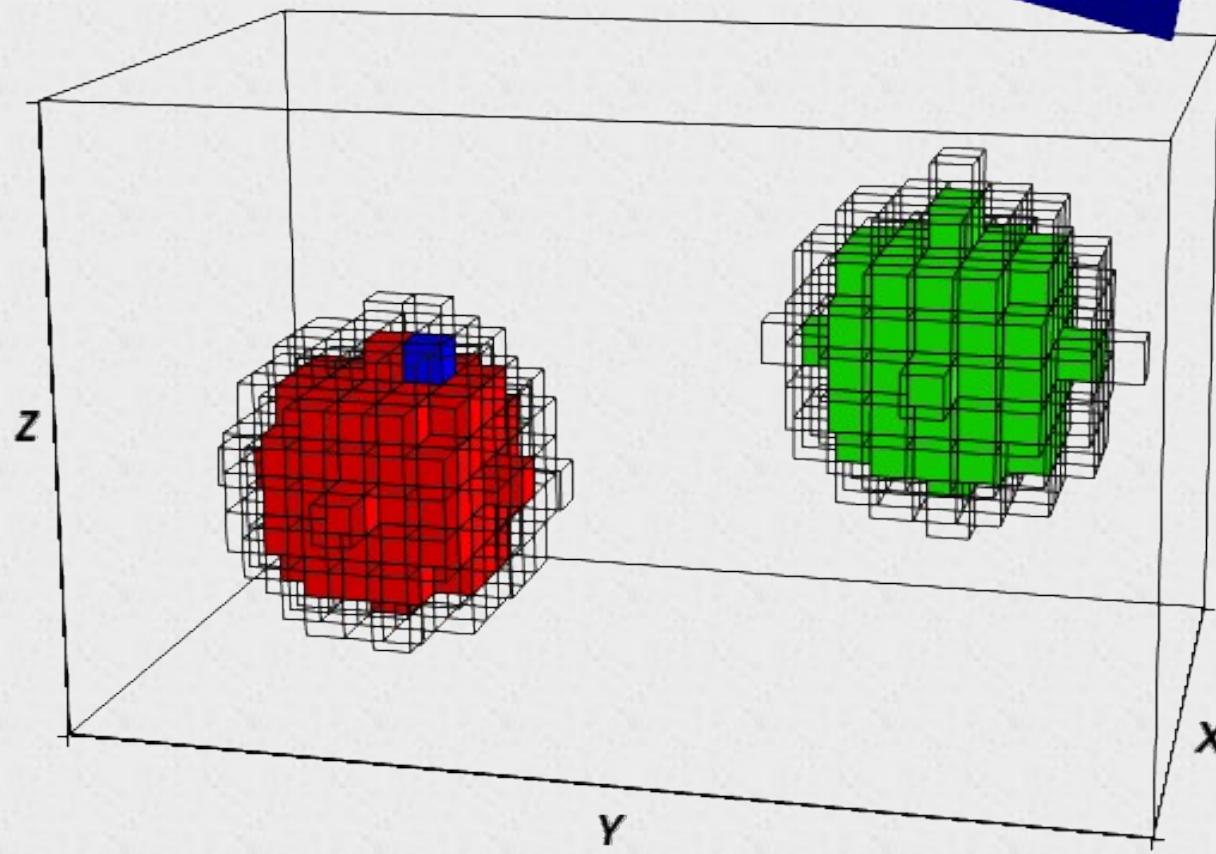
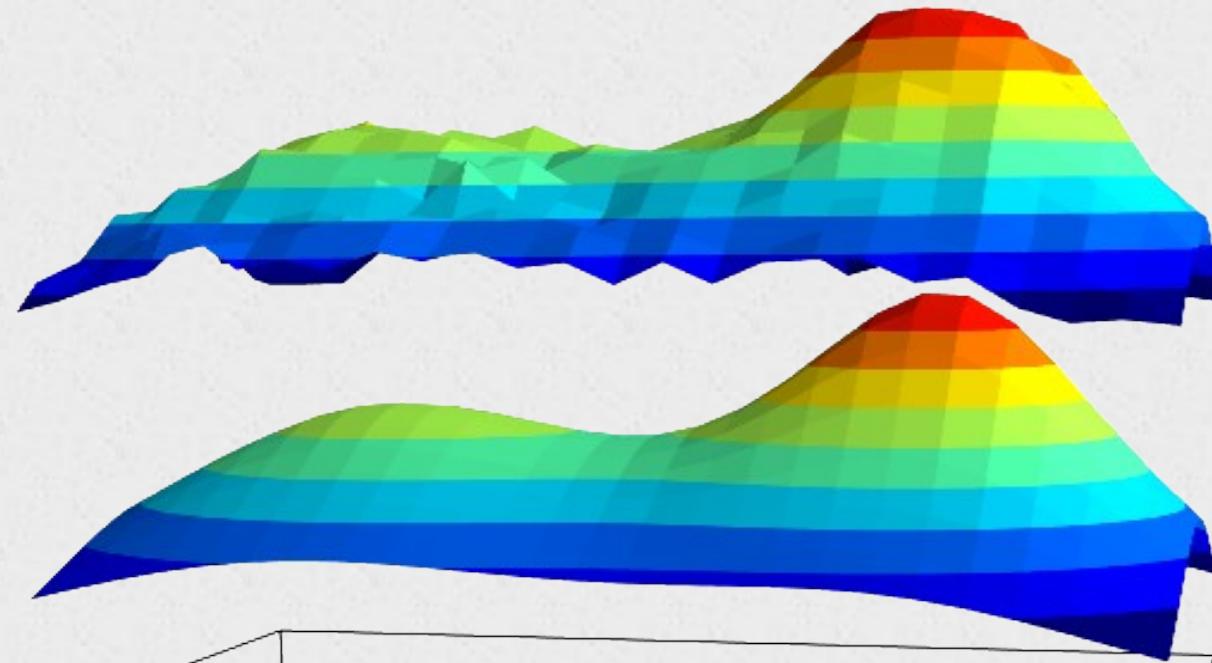




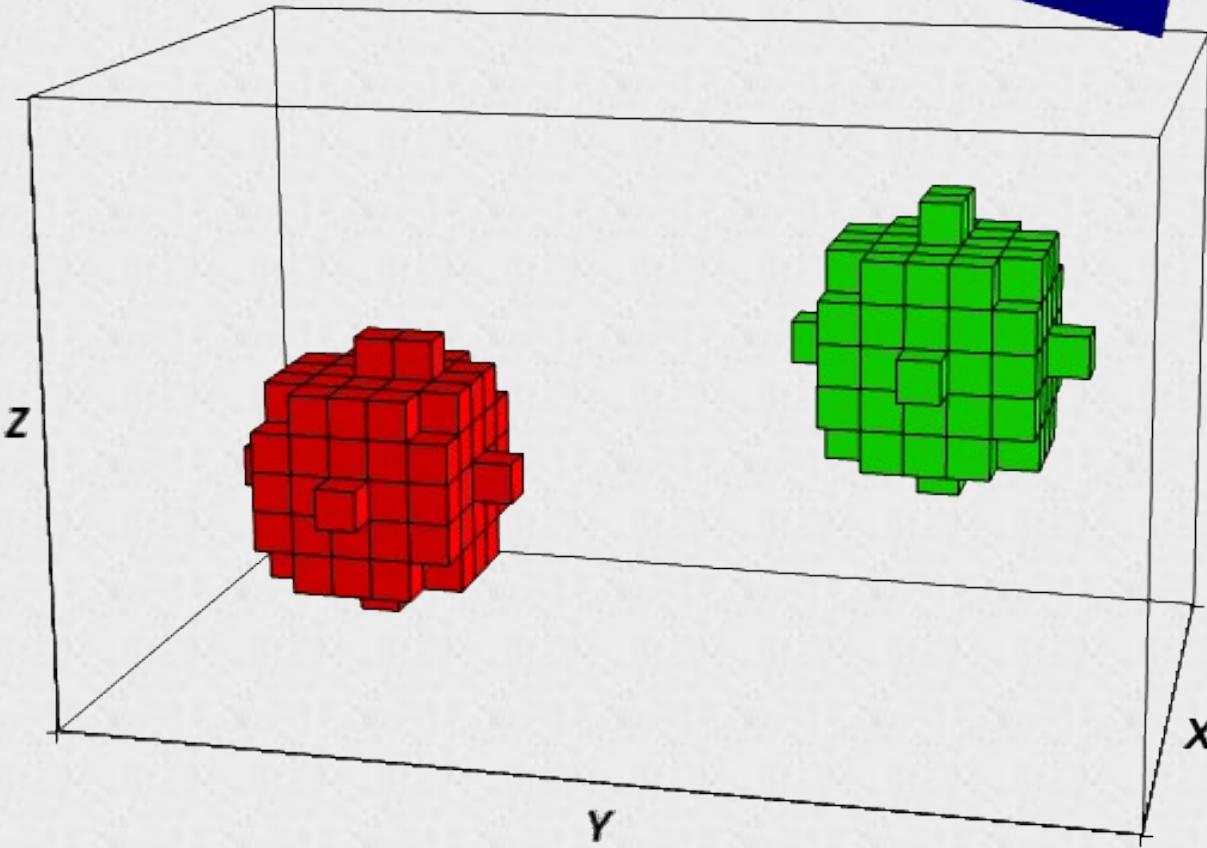








Fit!



Seeds = Skeleton



Source <http://www.sciencebuzz.org>

Inversion → Body



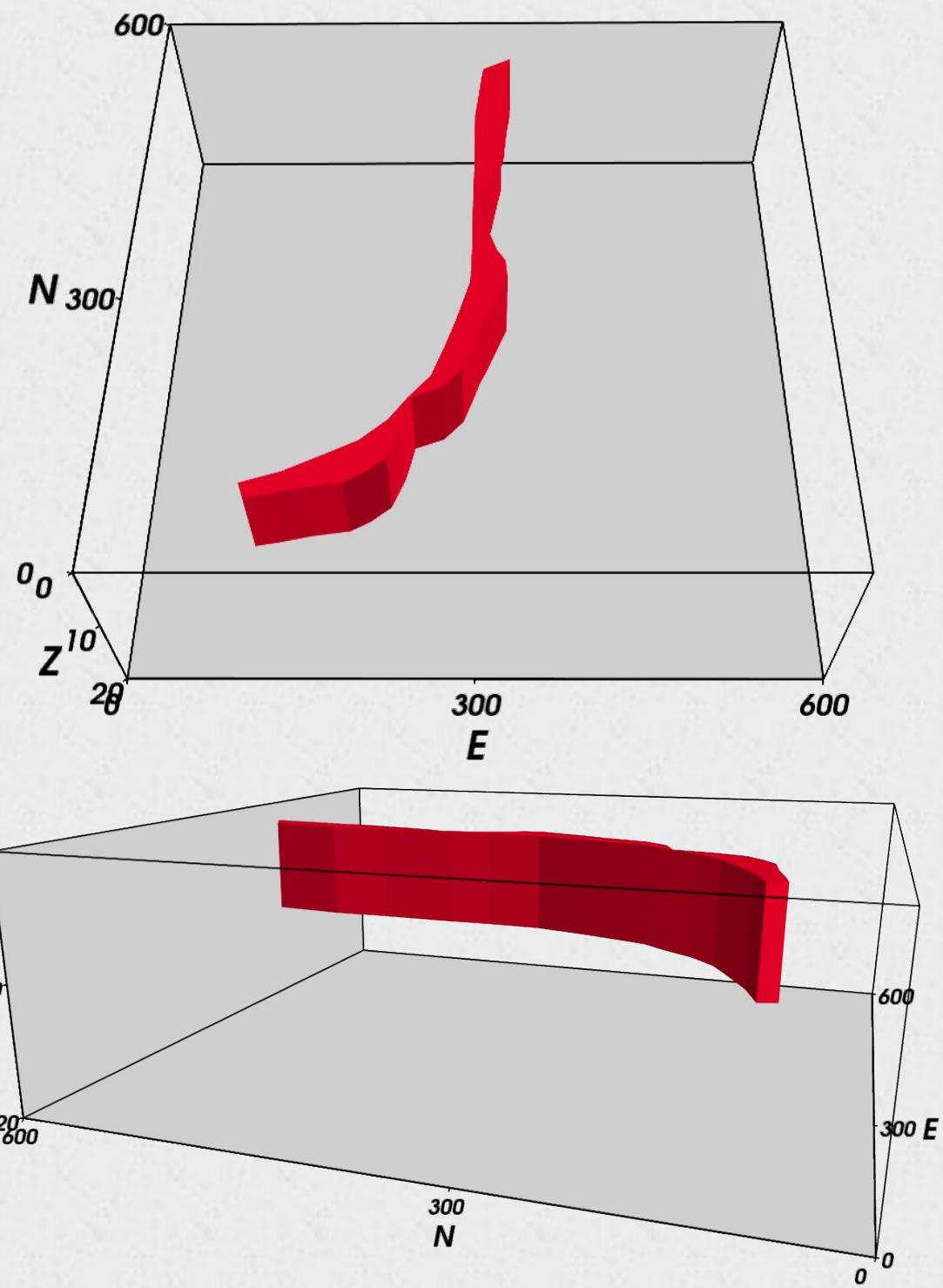
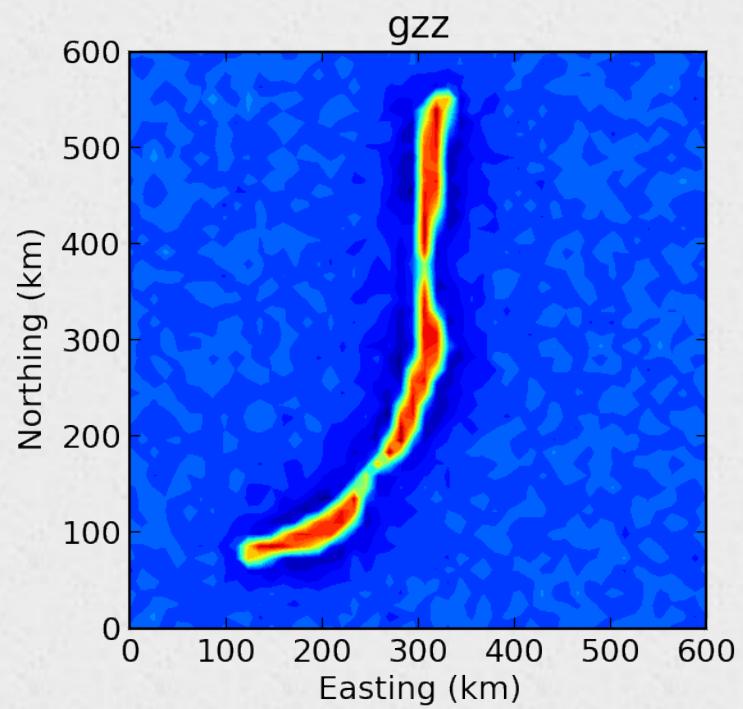
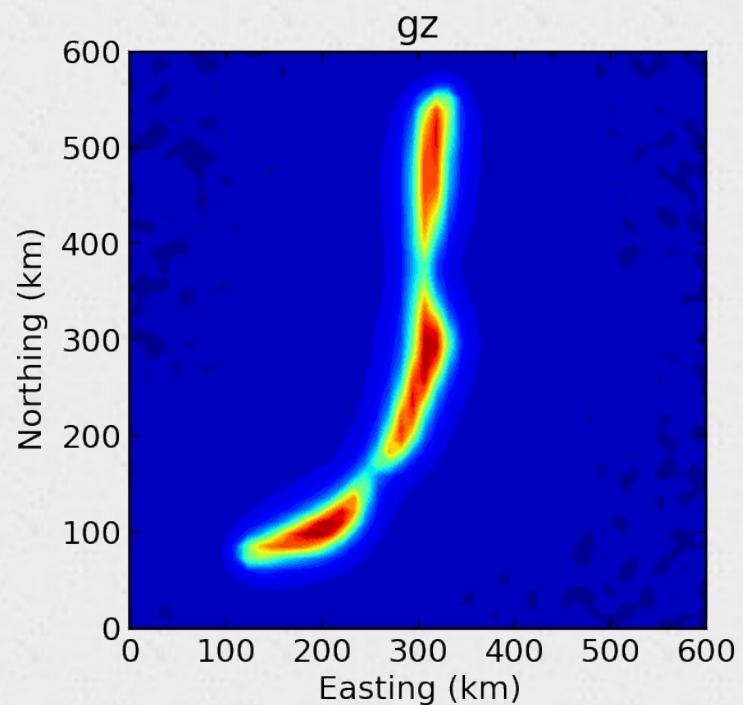
- ✓ Control
- ✓ Prior information
- ✓ Speed
- ✓ Automatic fit
- ✓ 3D (only need skeleton)
- ✓ Gravity + Gradients

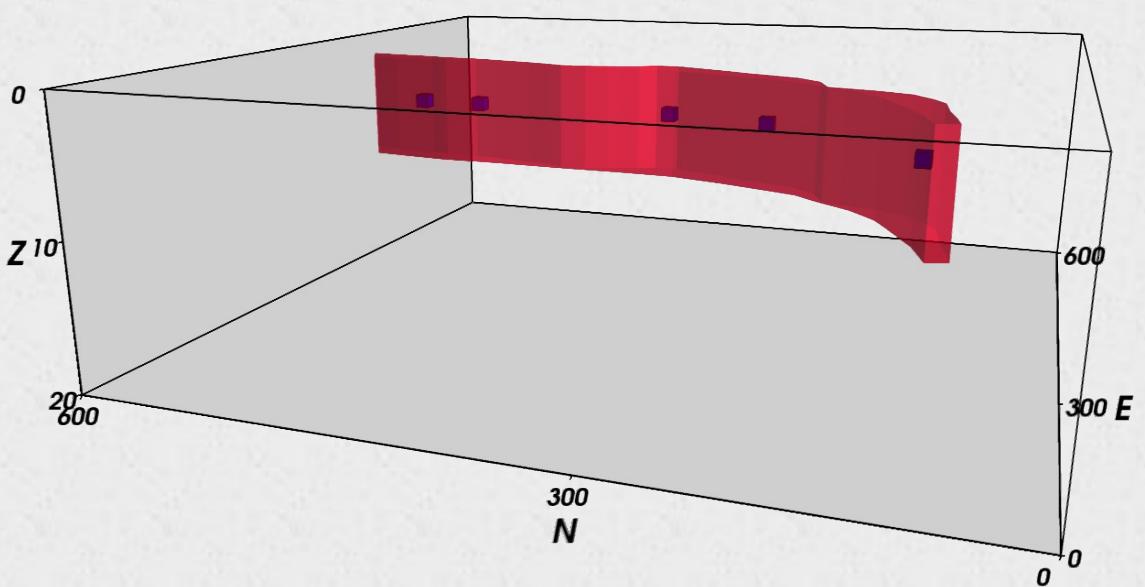
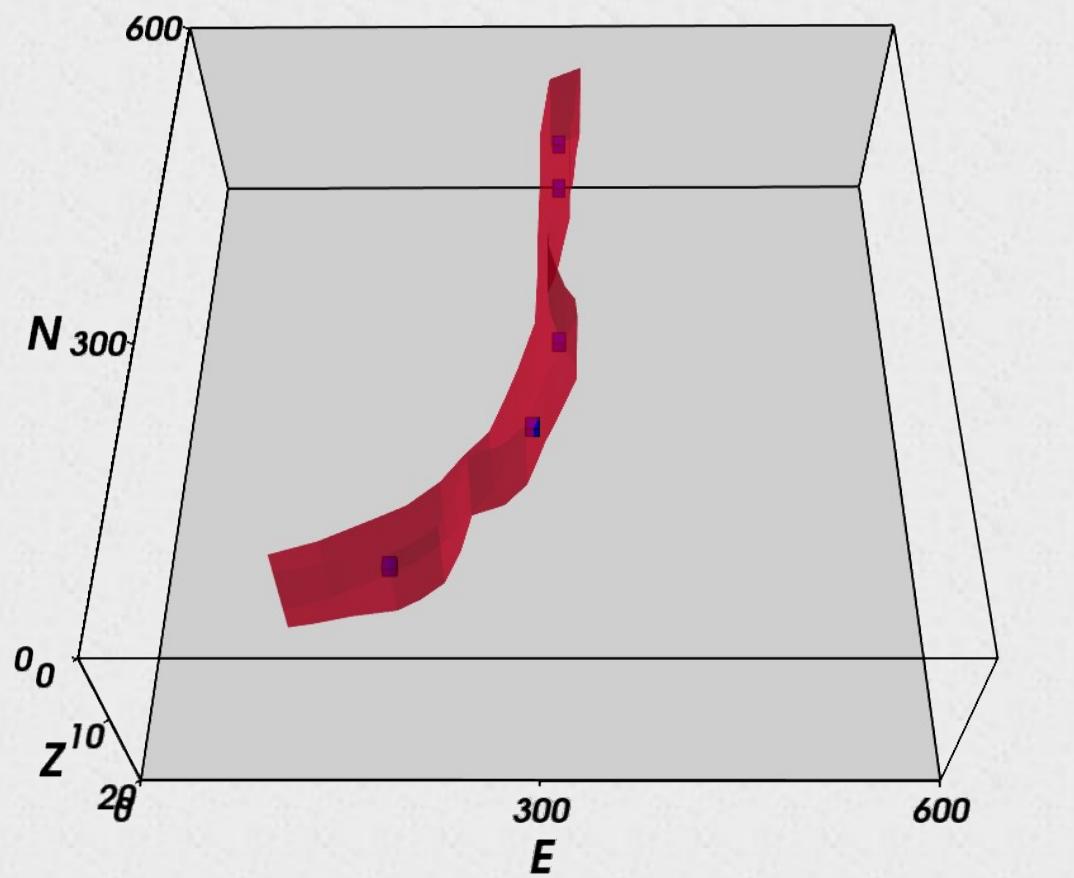
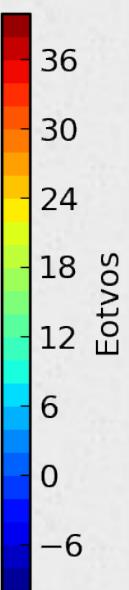
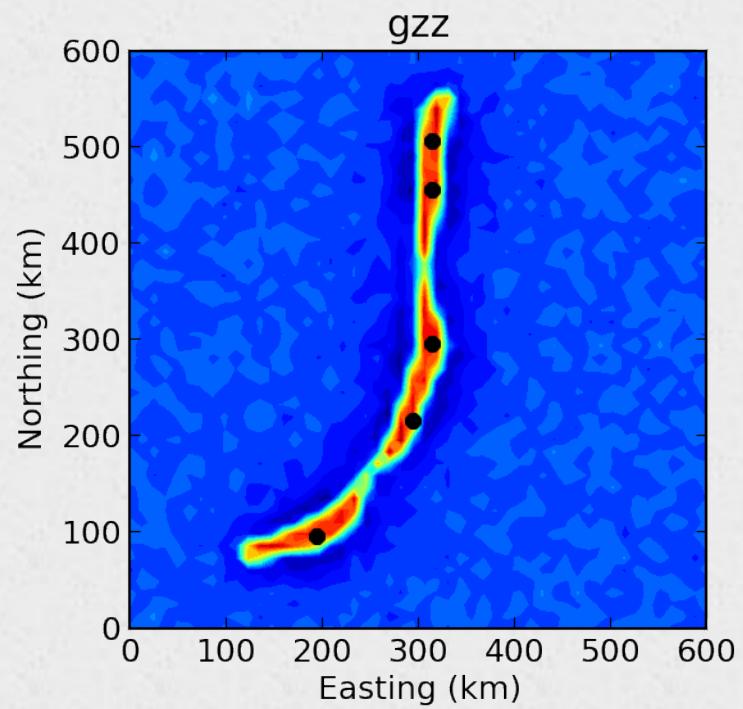
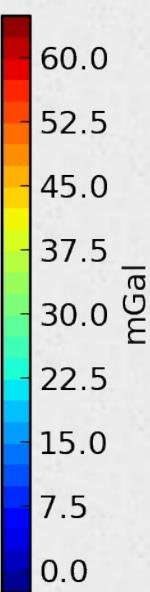
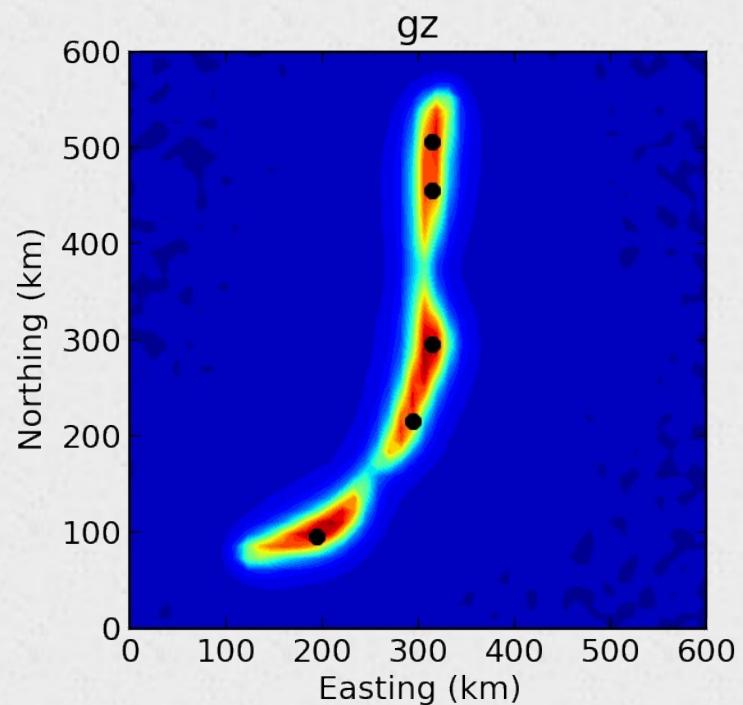
Seeds

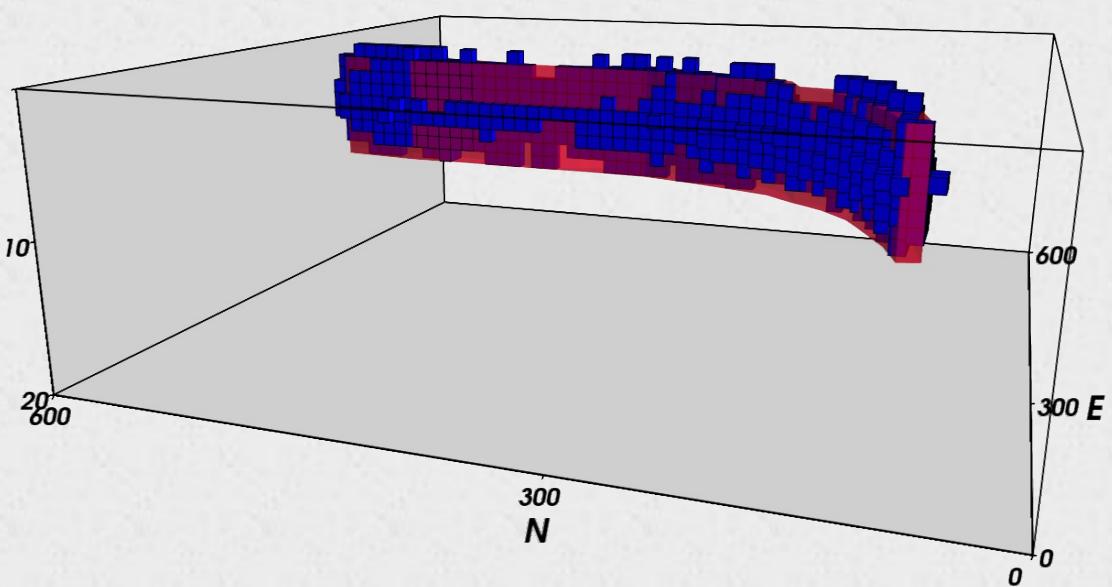
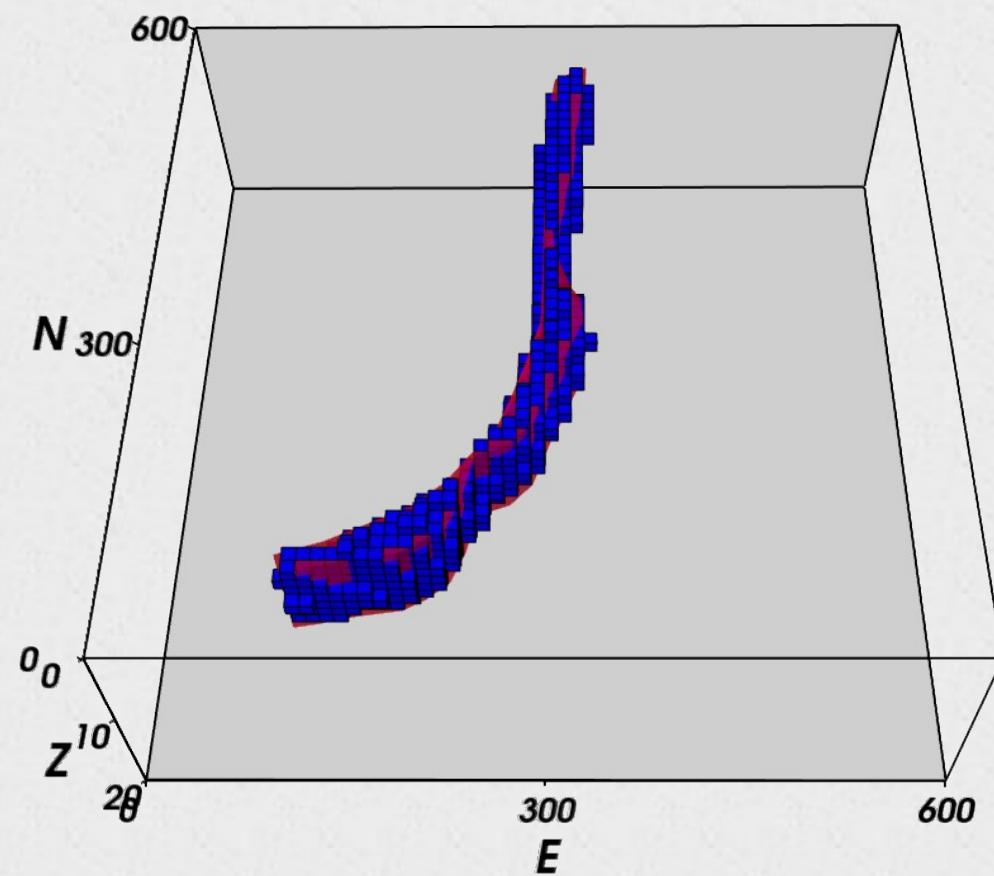
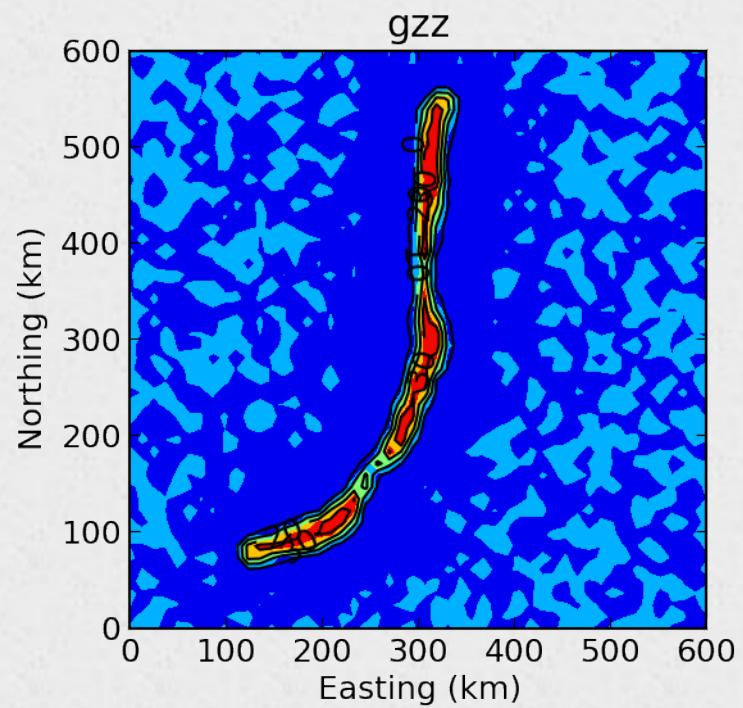
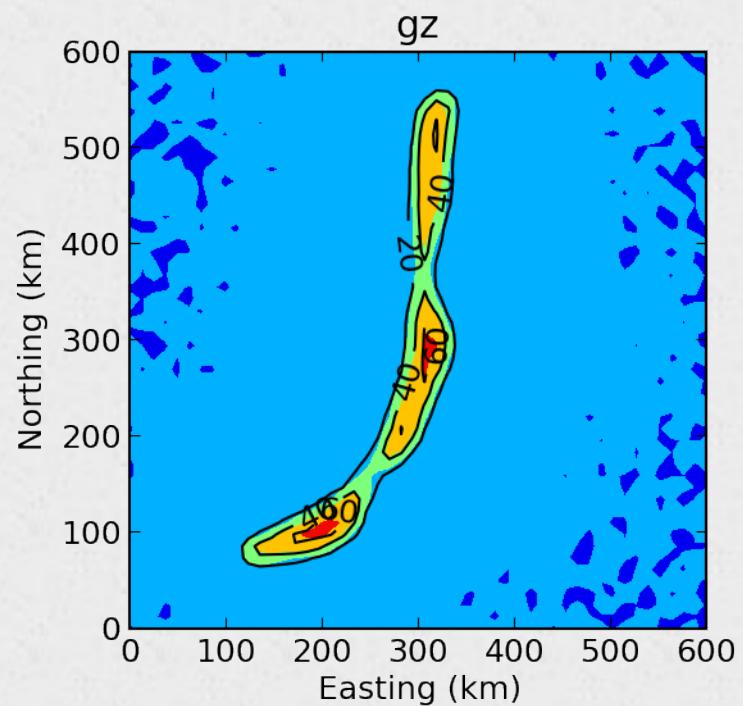


Example applications

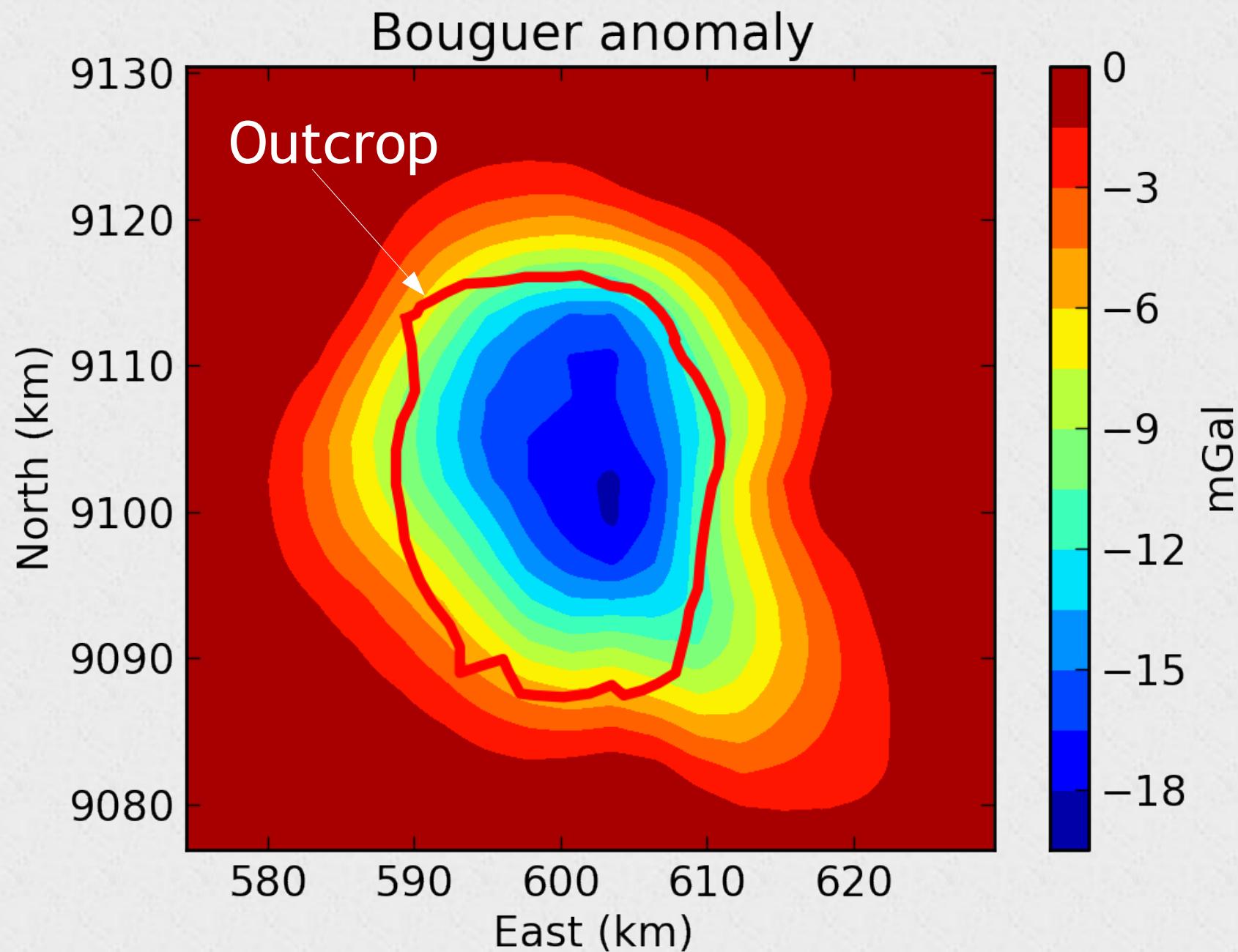
Synthetic data



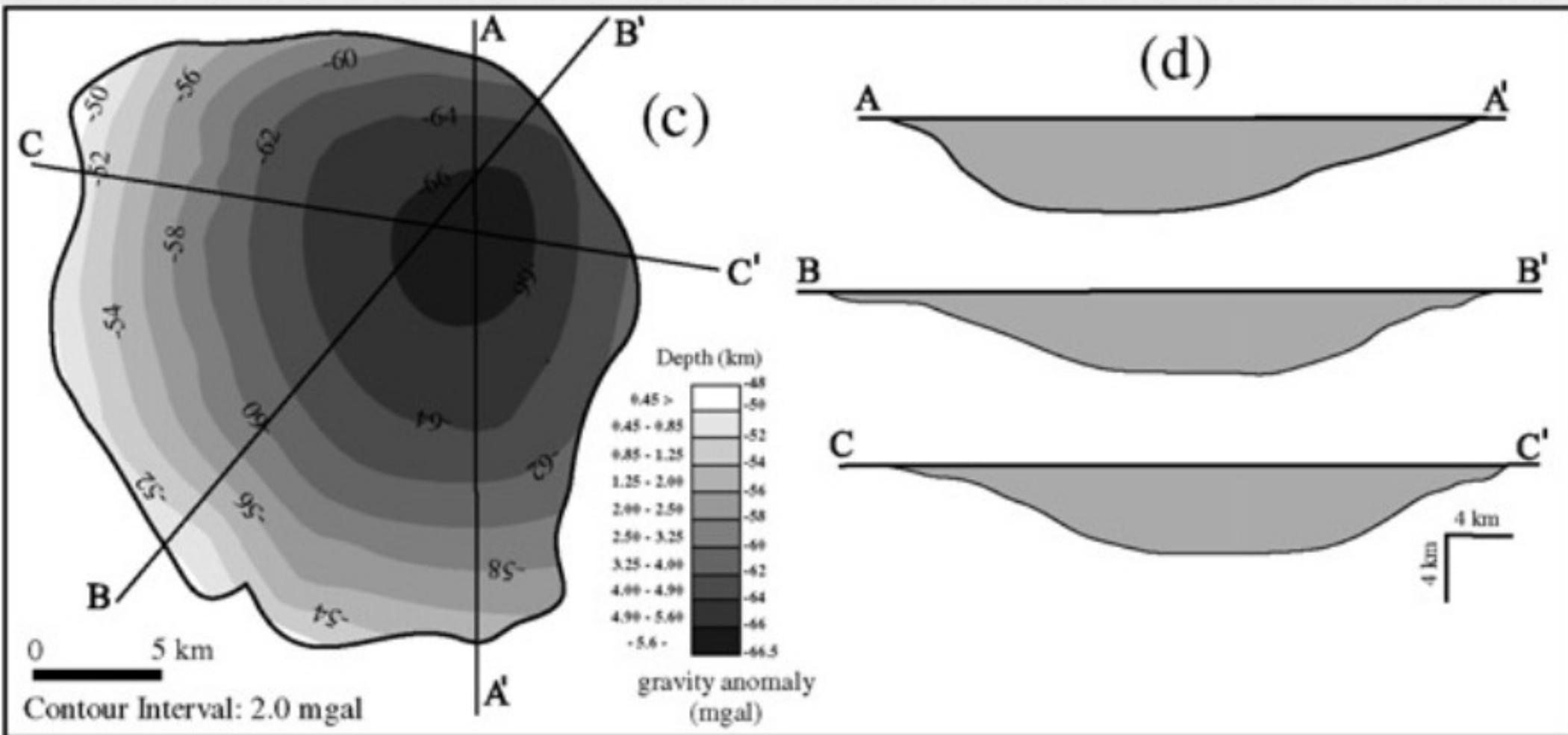


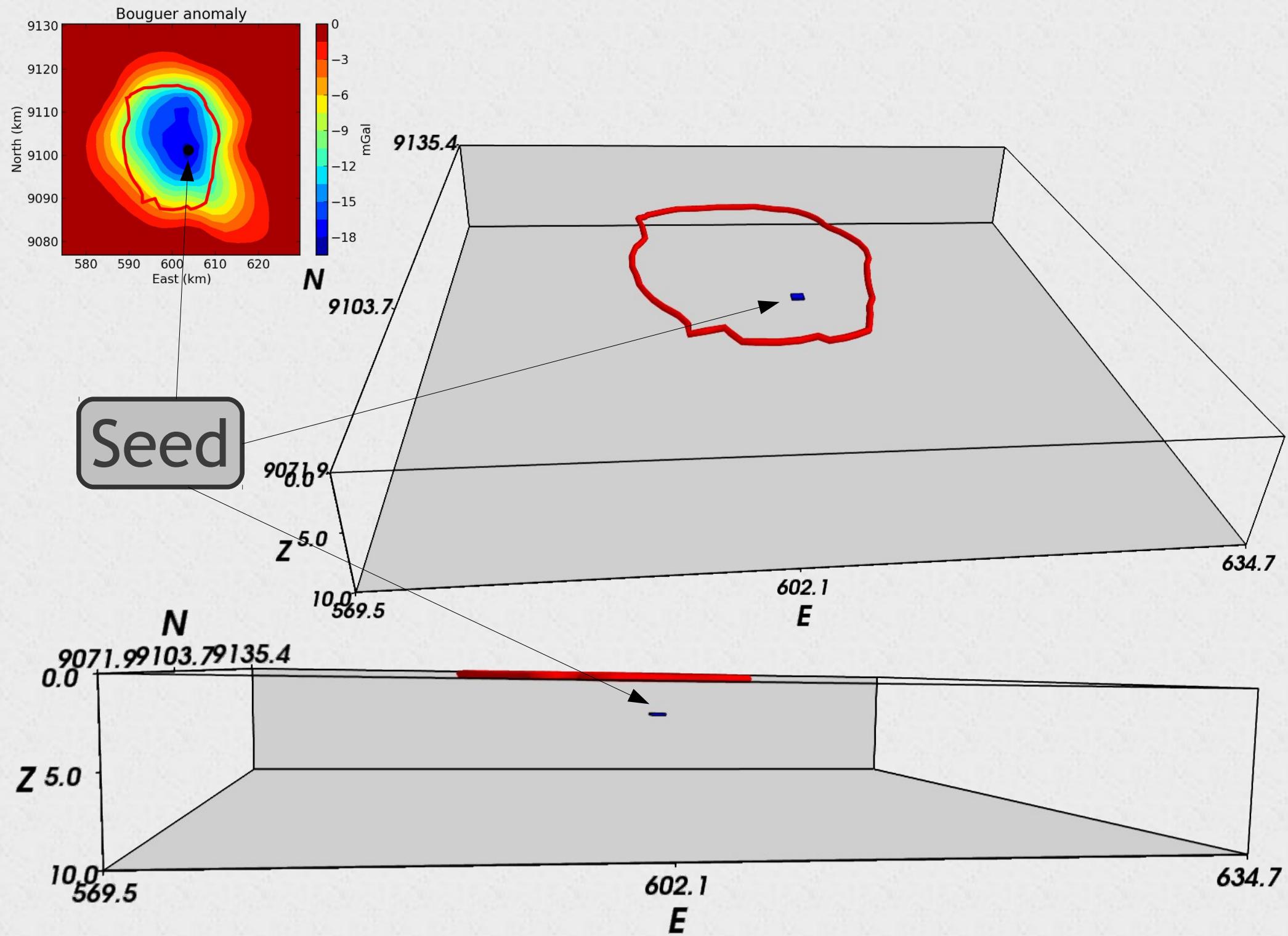


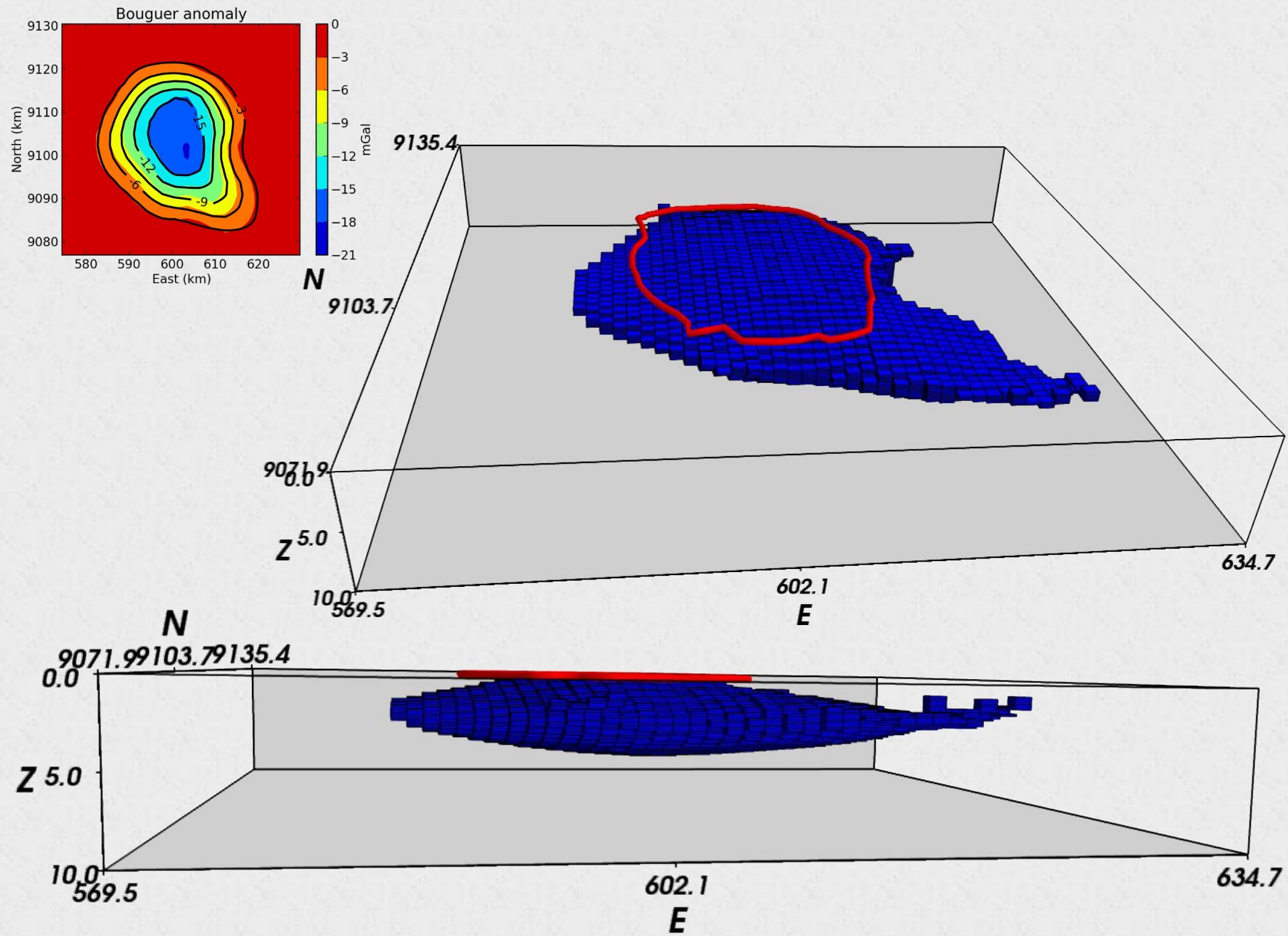
Redenção granite



Oliveira et al. (2008)

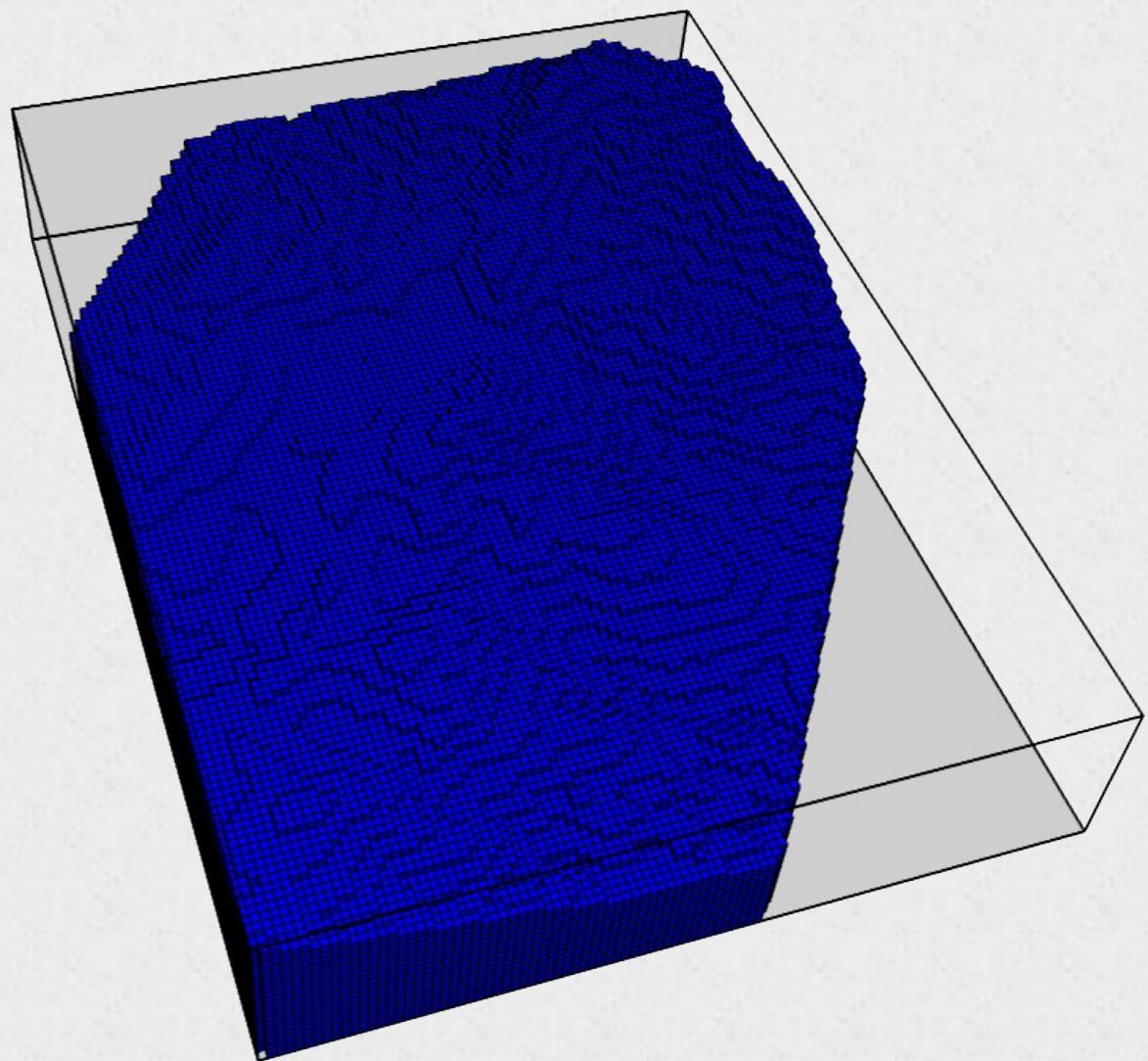
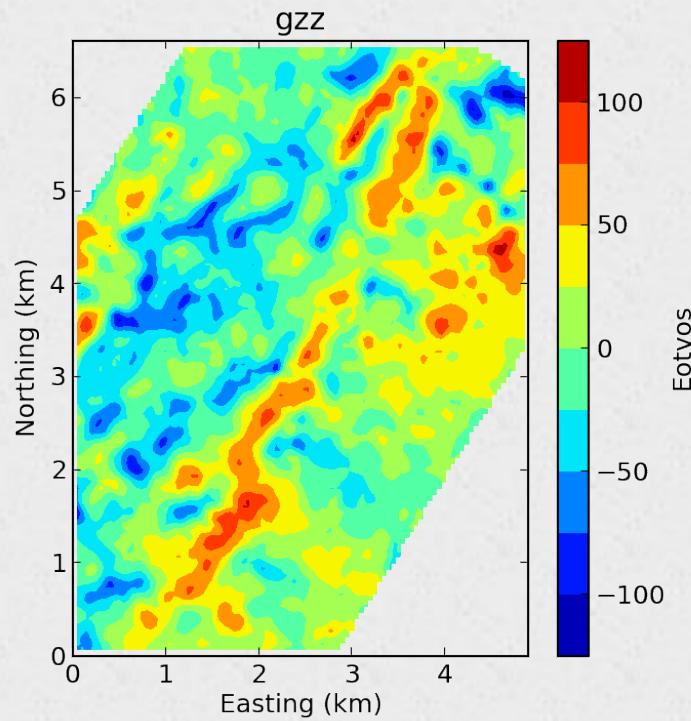
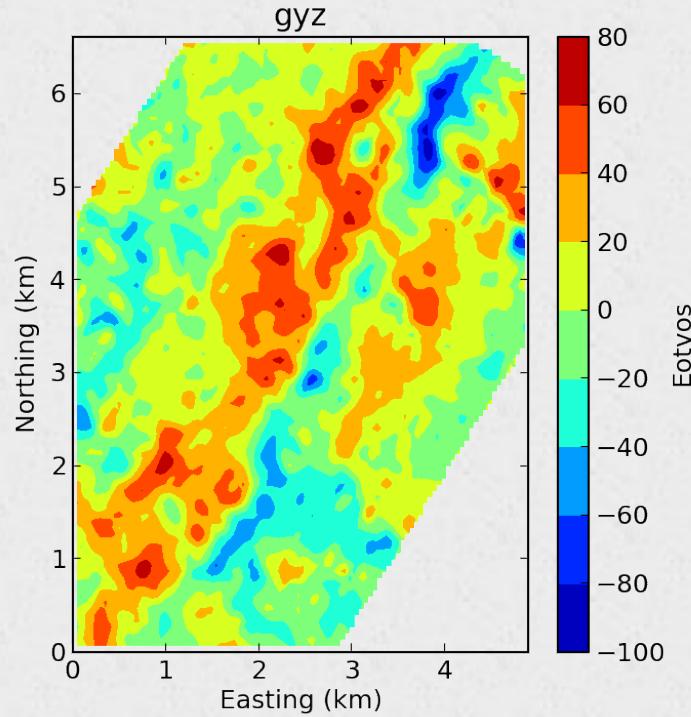




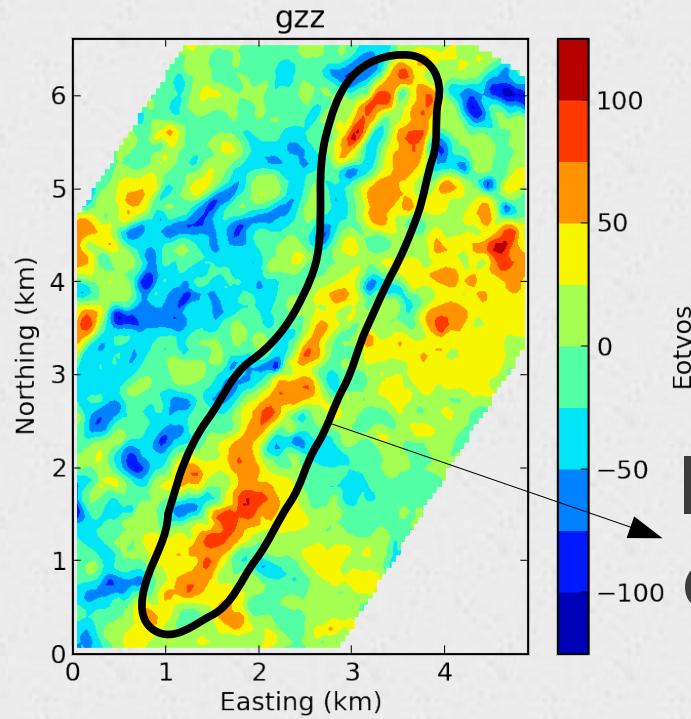
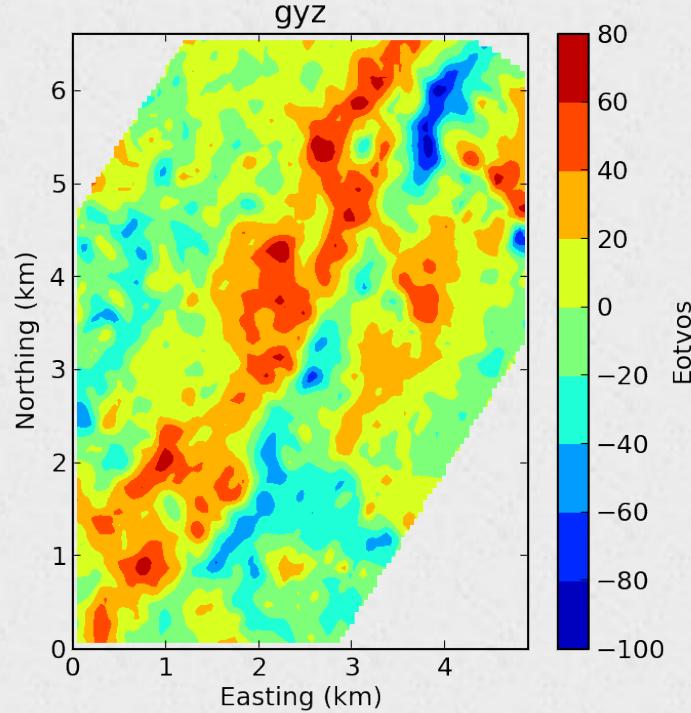


Quadrilátero Ferrífero

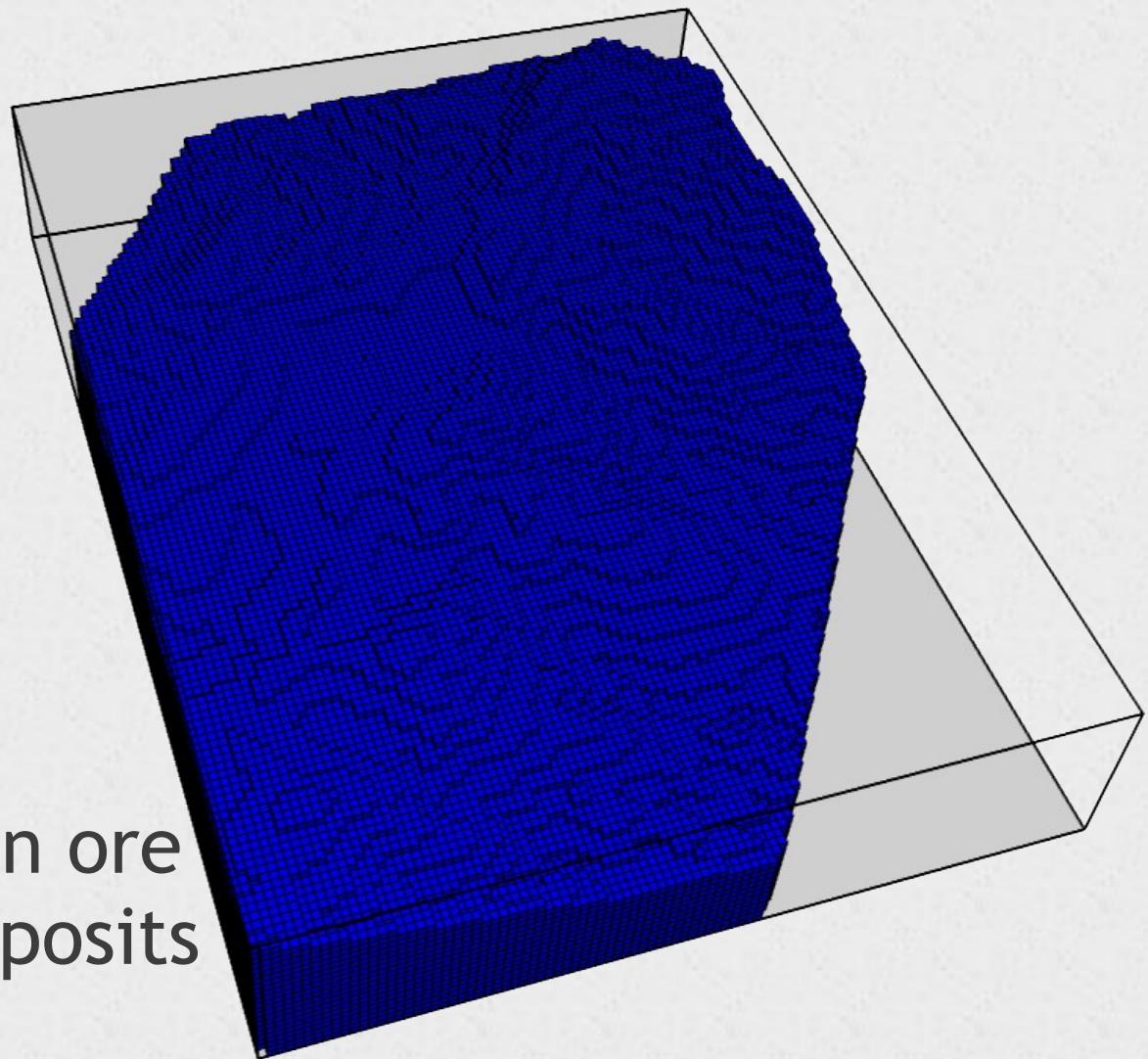
Complex geology and topography



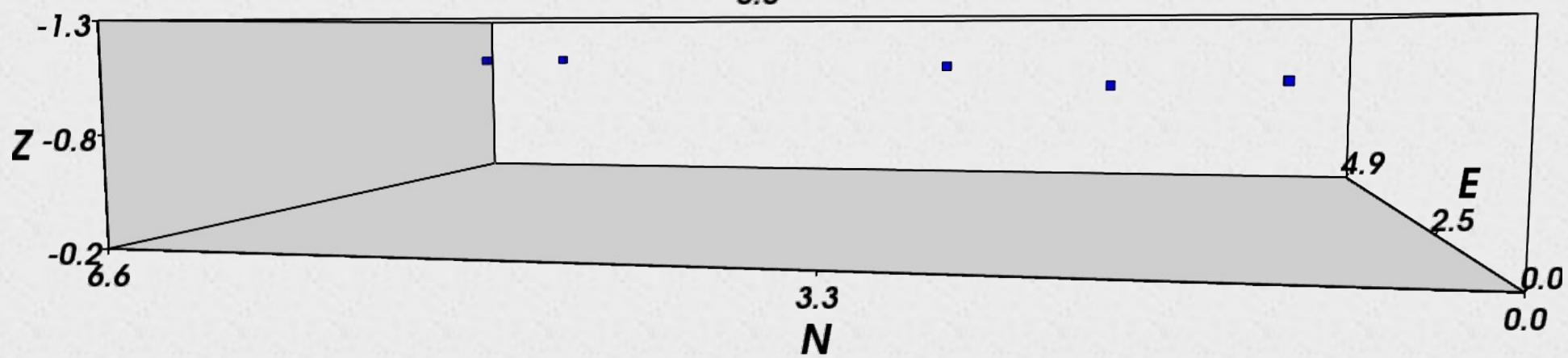
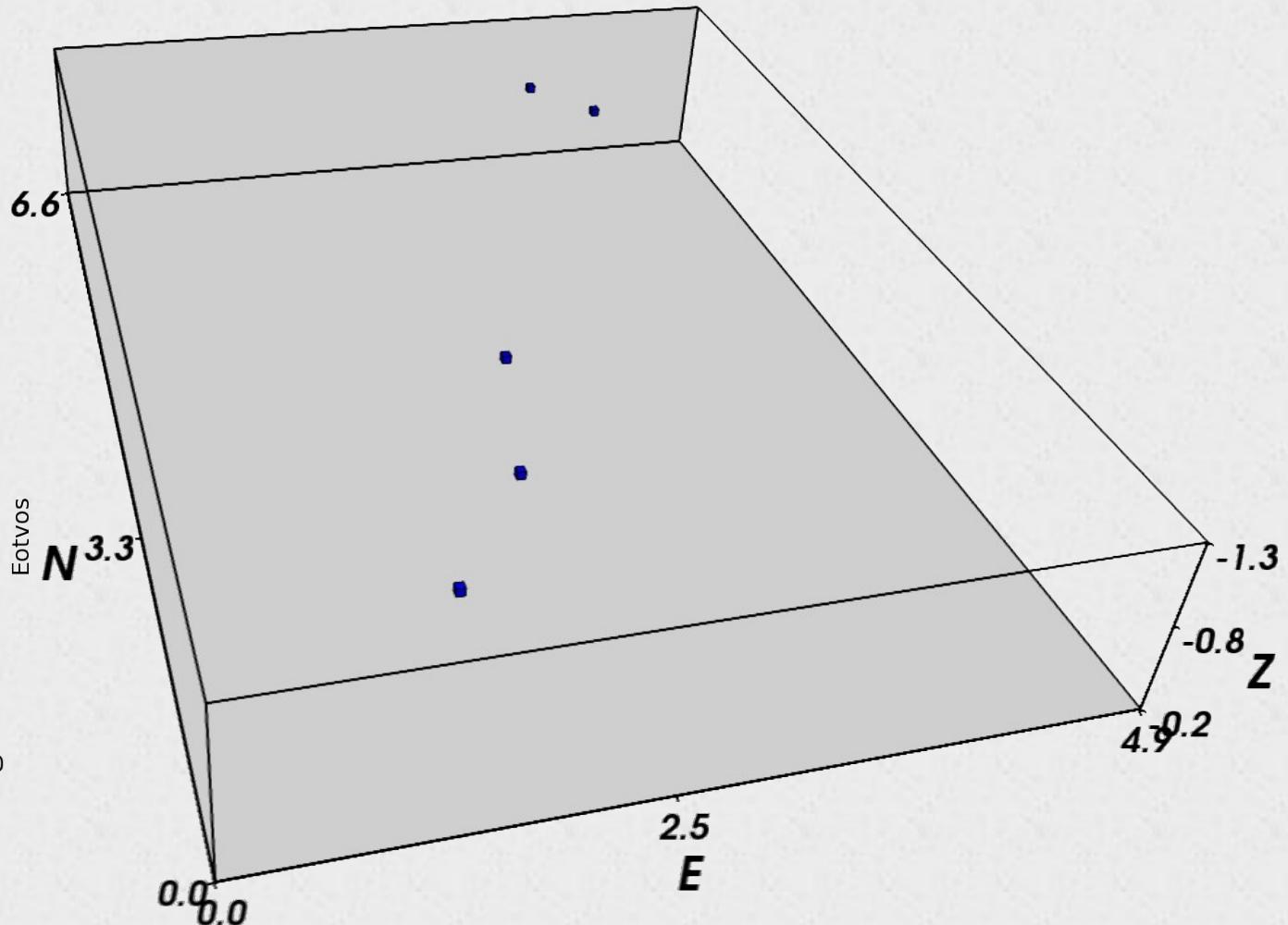
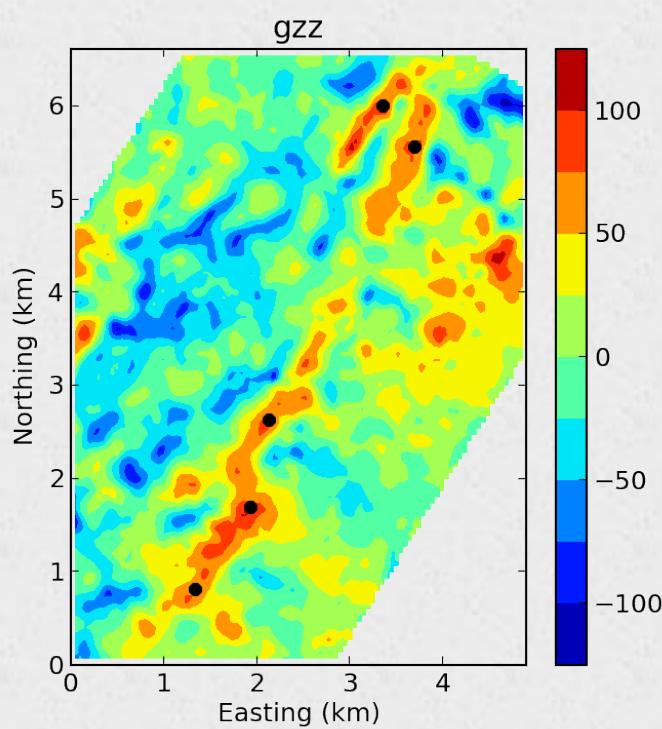
Complex geology and topography

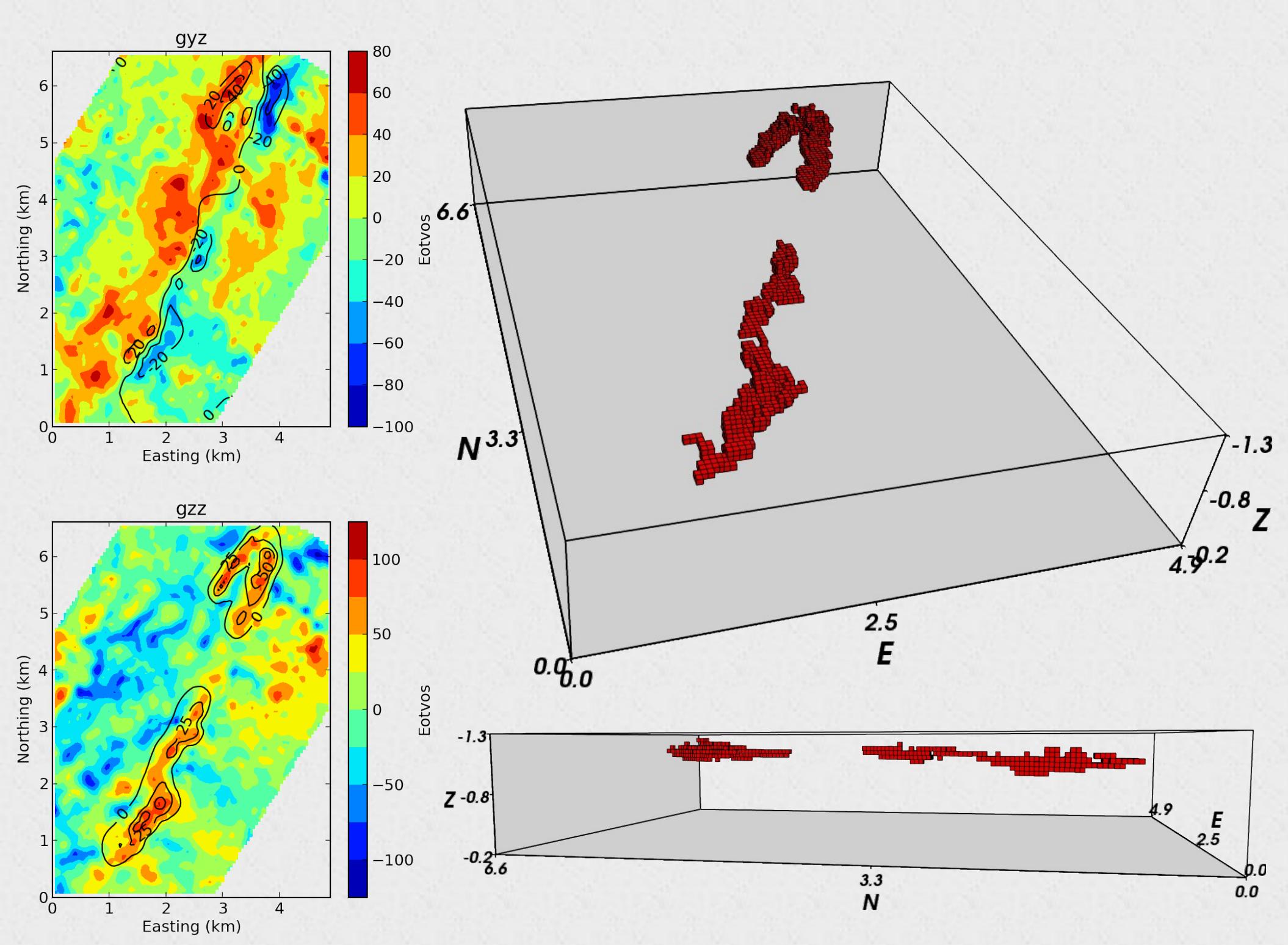


Iron ore
deposits



Seeds



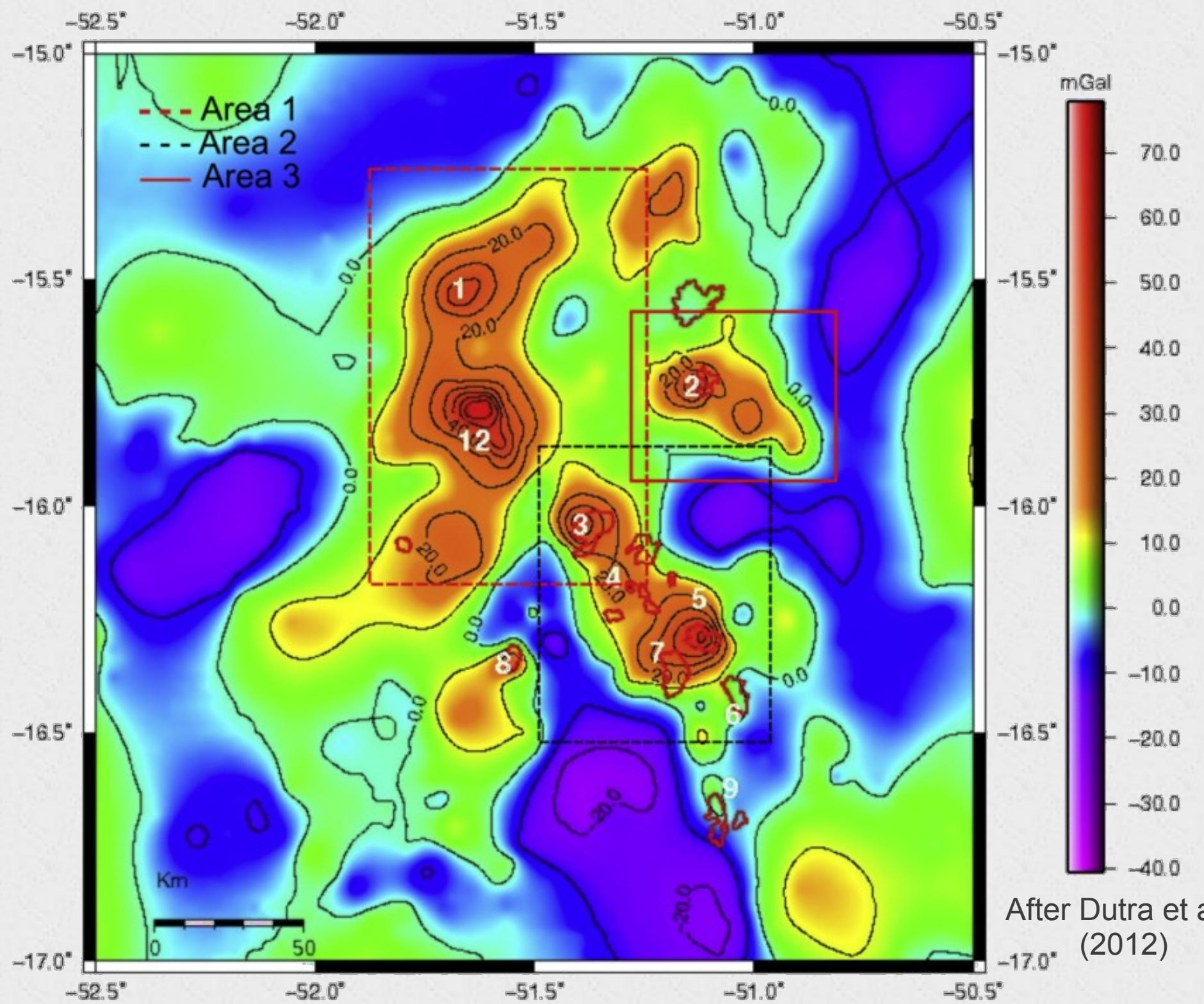


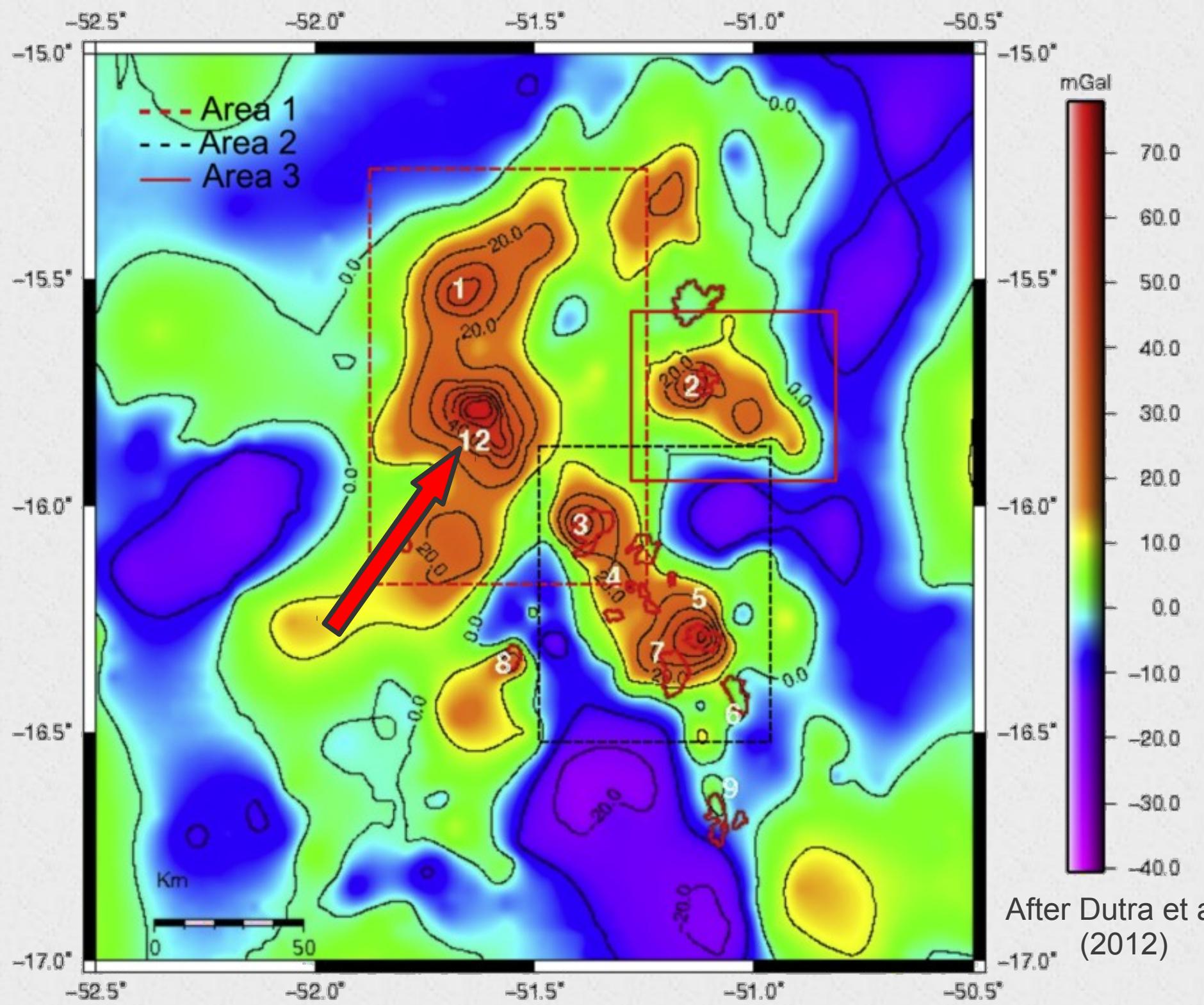
Hypothesis testing

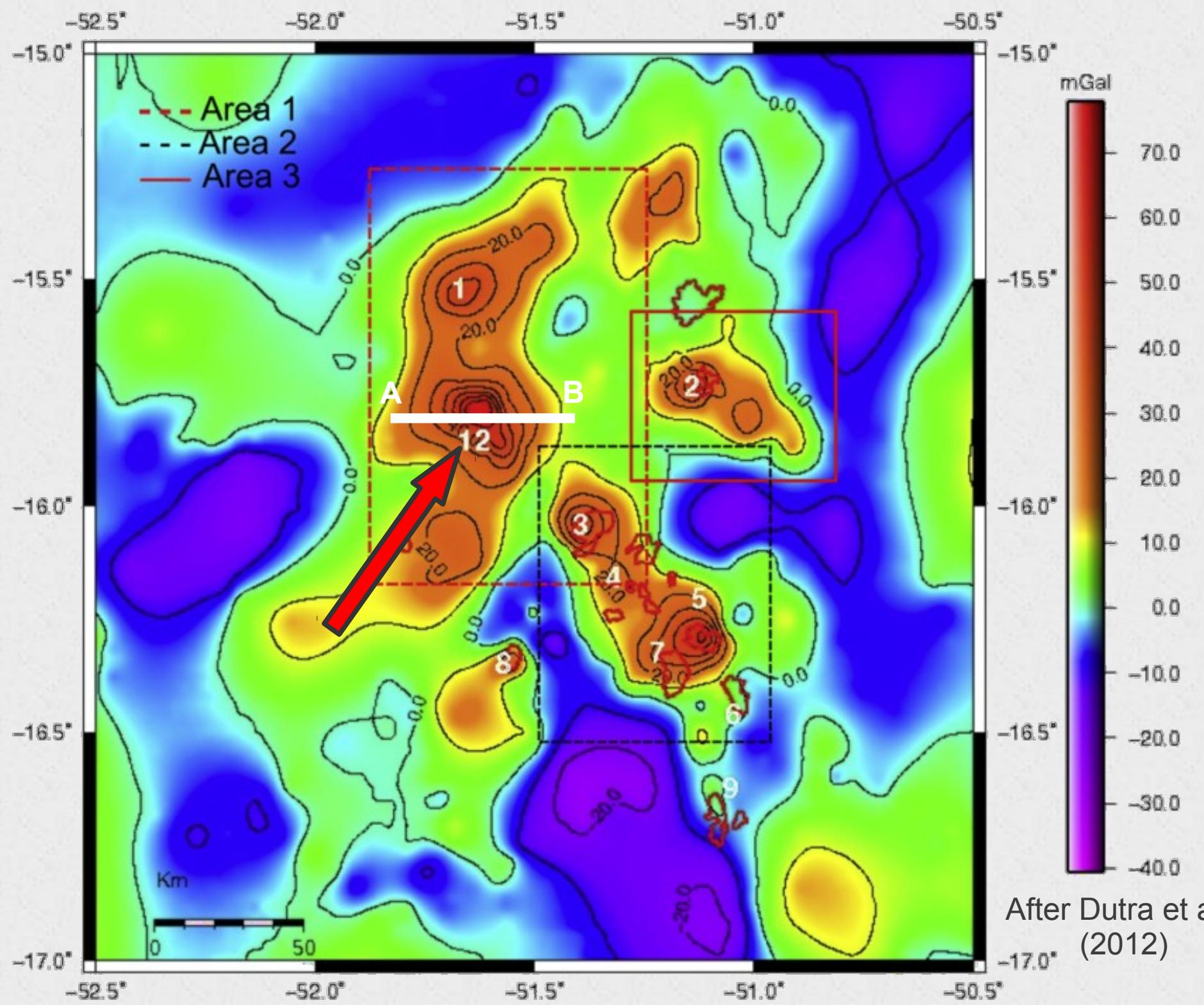
Registro do Araguaia
intrusion

Registro do araguaia

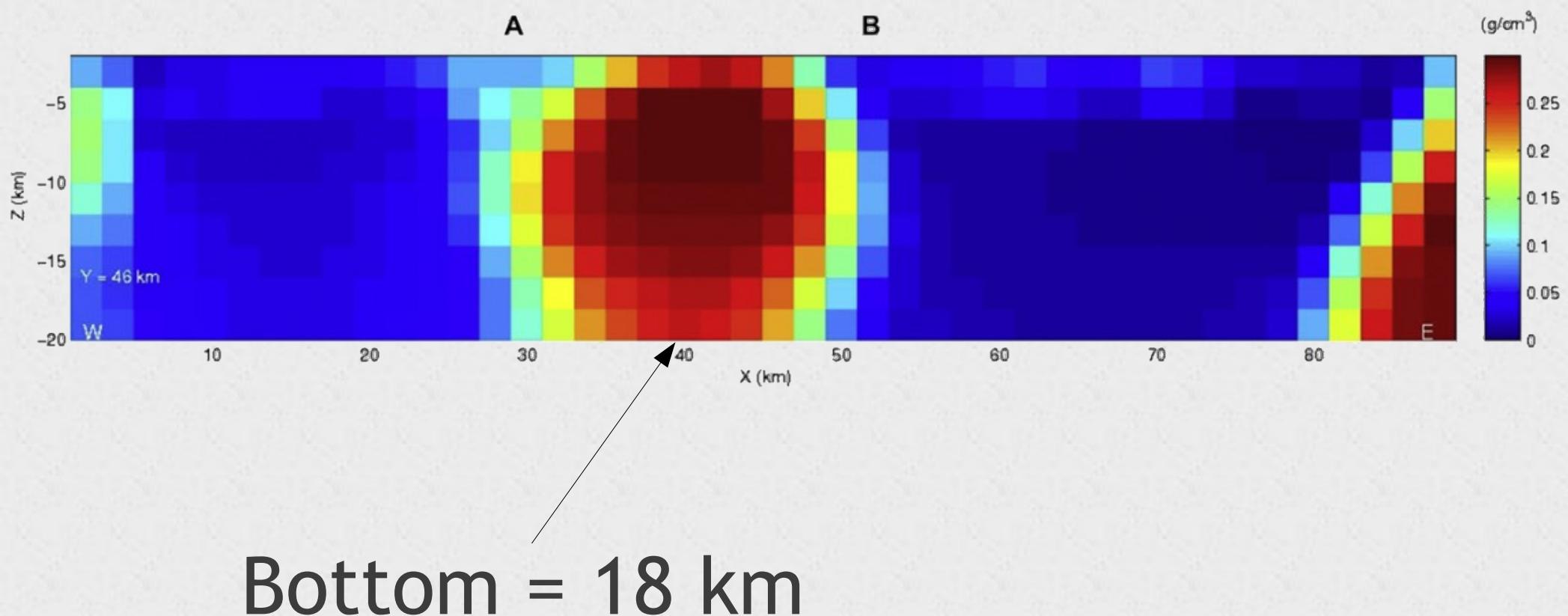
- Non-outcropping
- Alkaline intrusion
- Density contrast $\approx 300 \text{ g.cm}^{-3}$



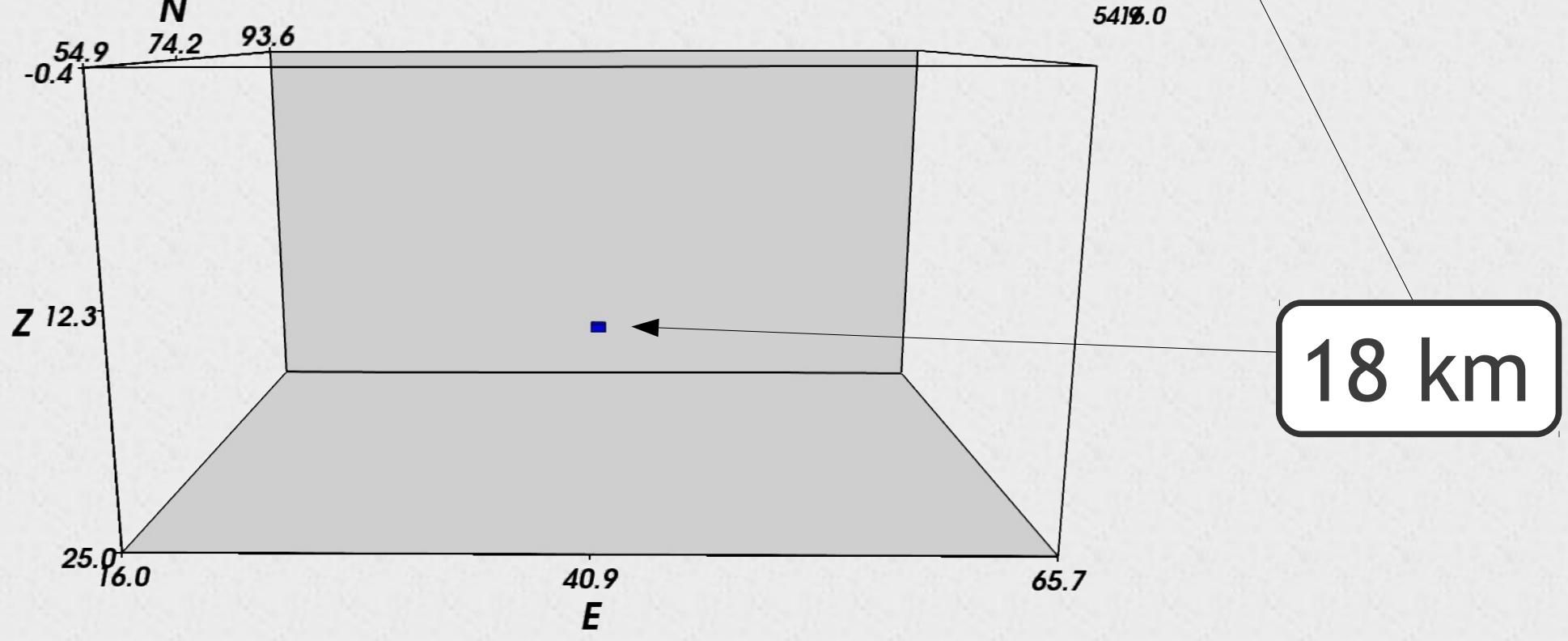
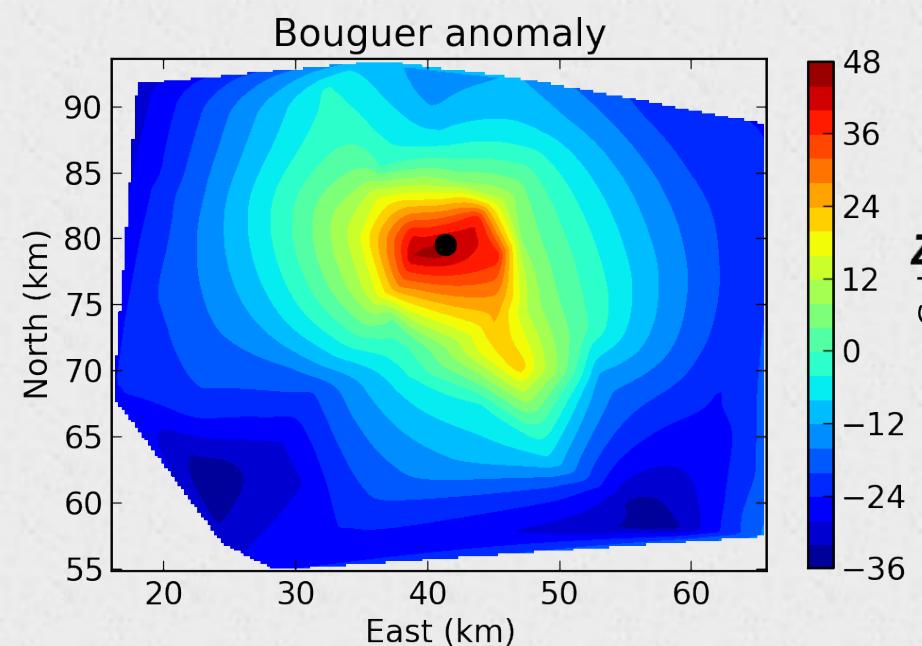


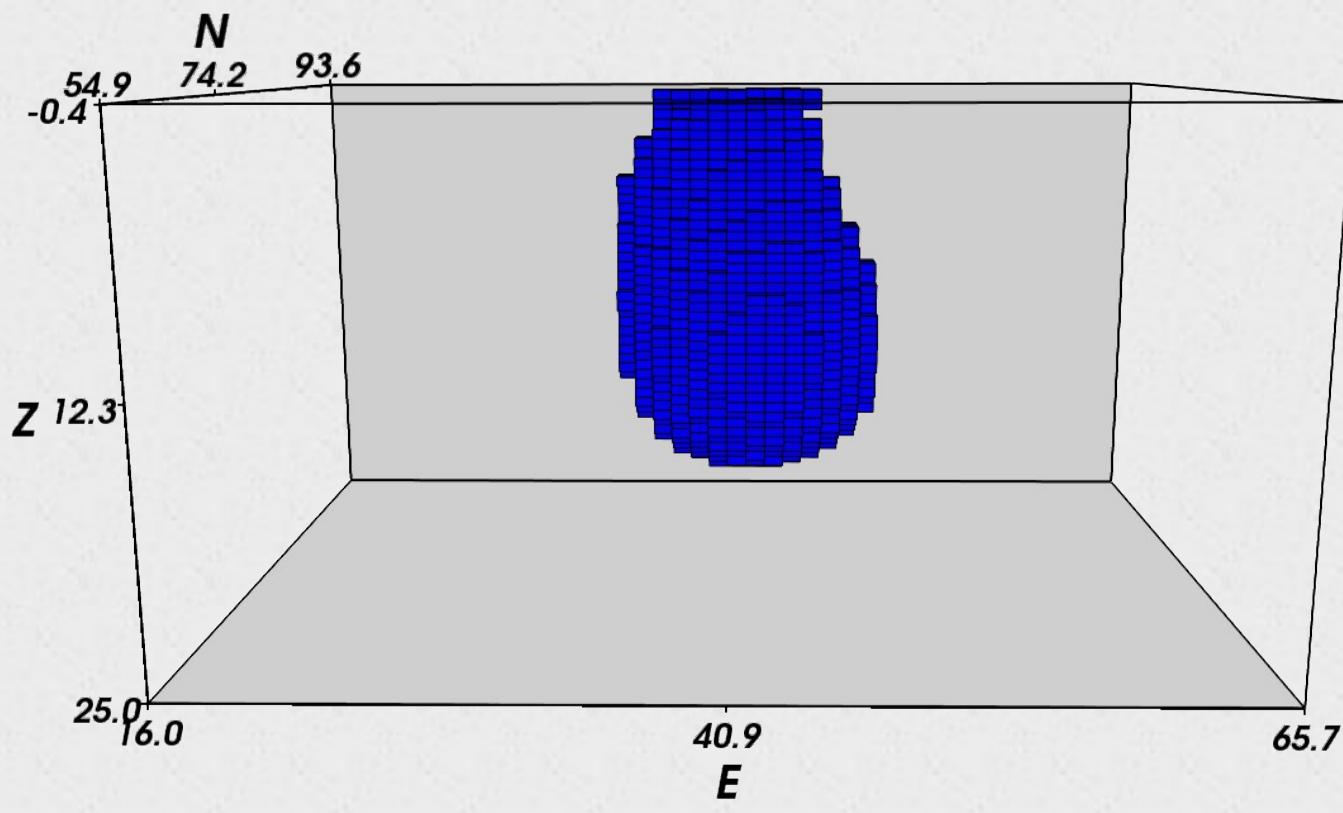
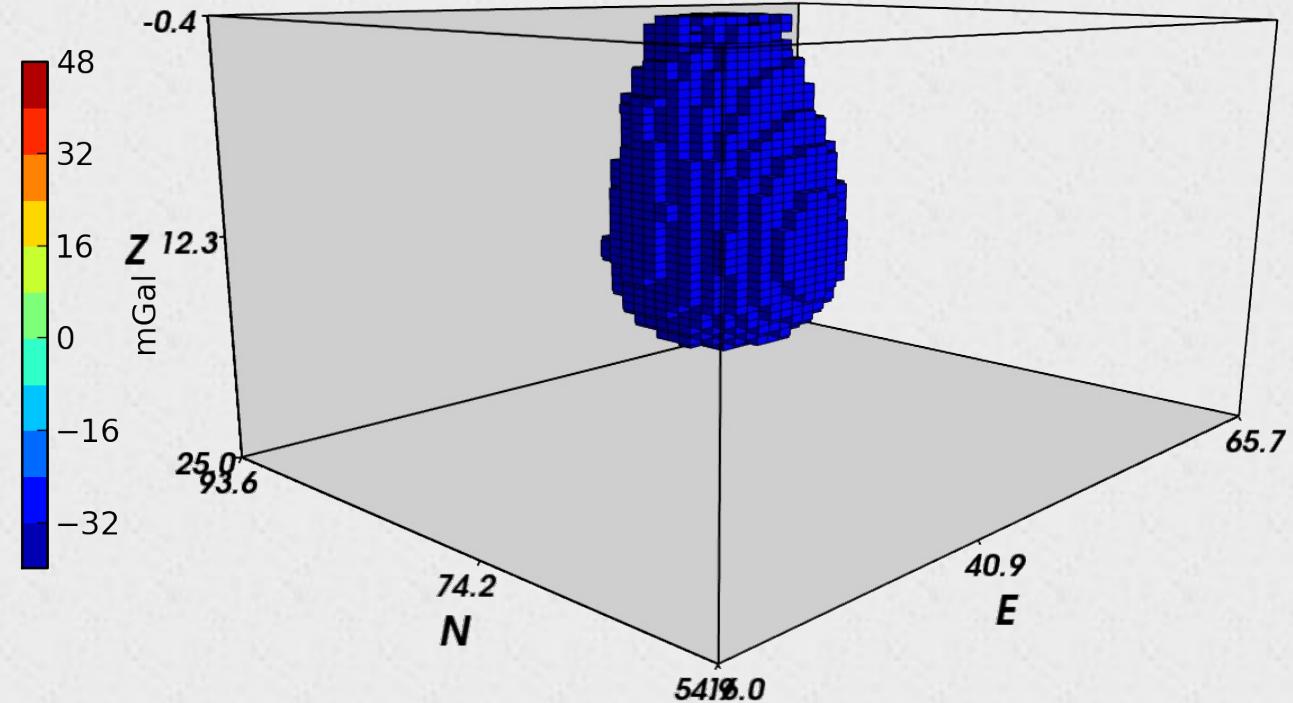
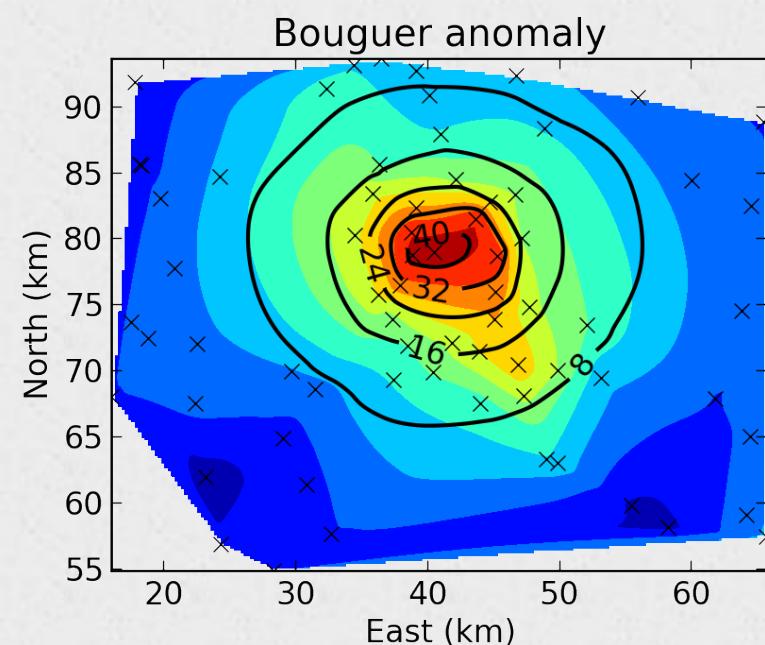


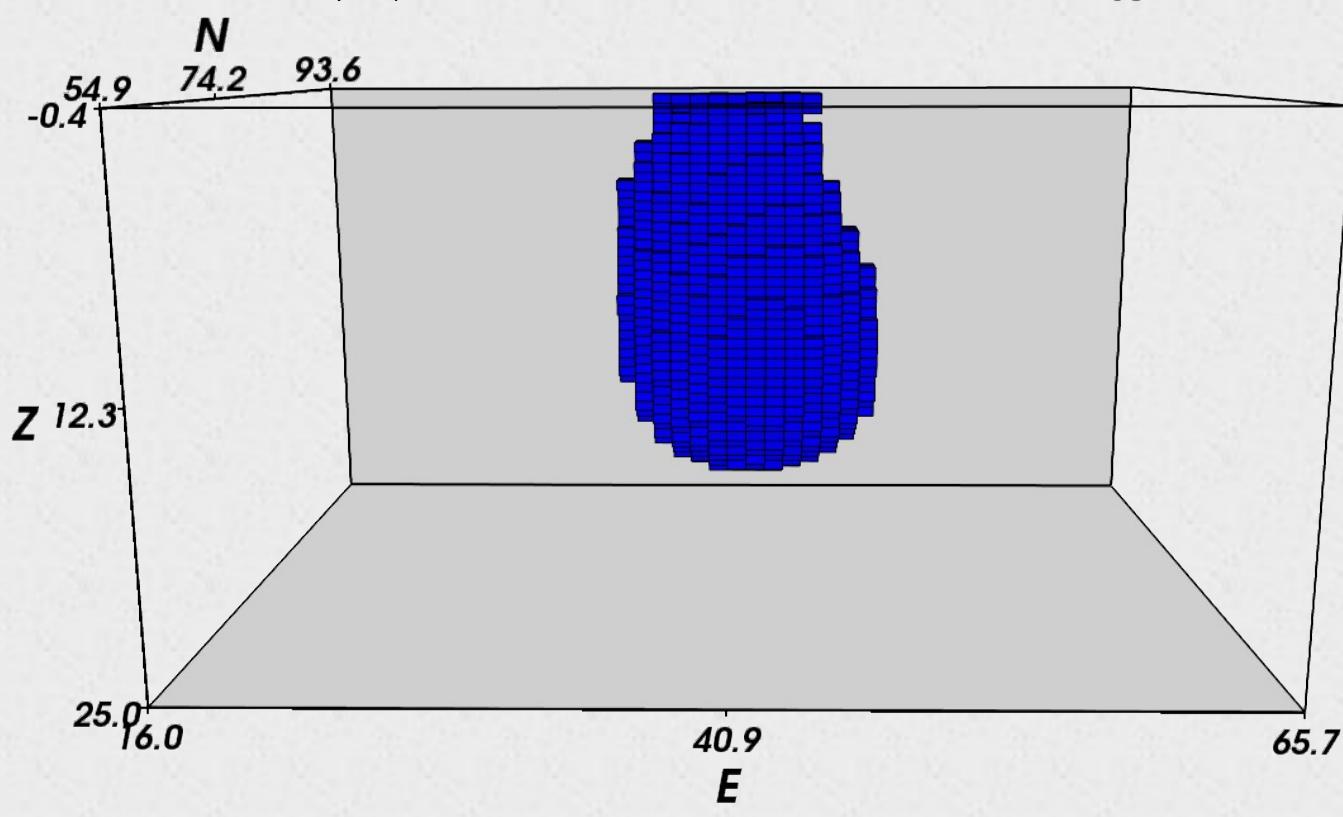
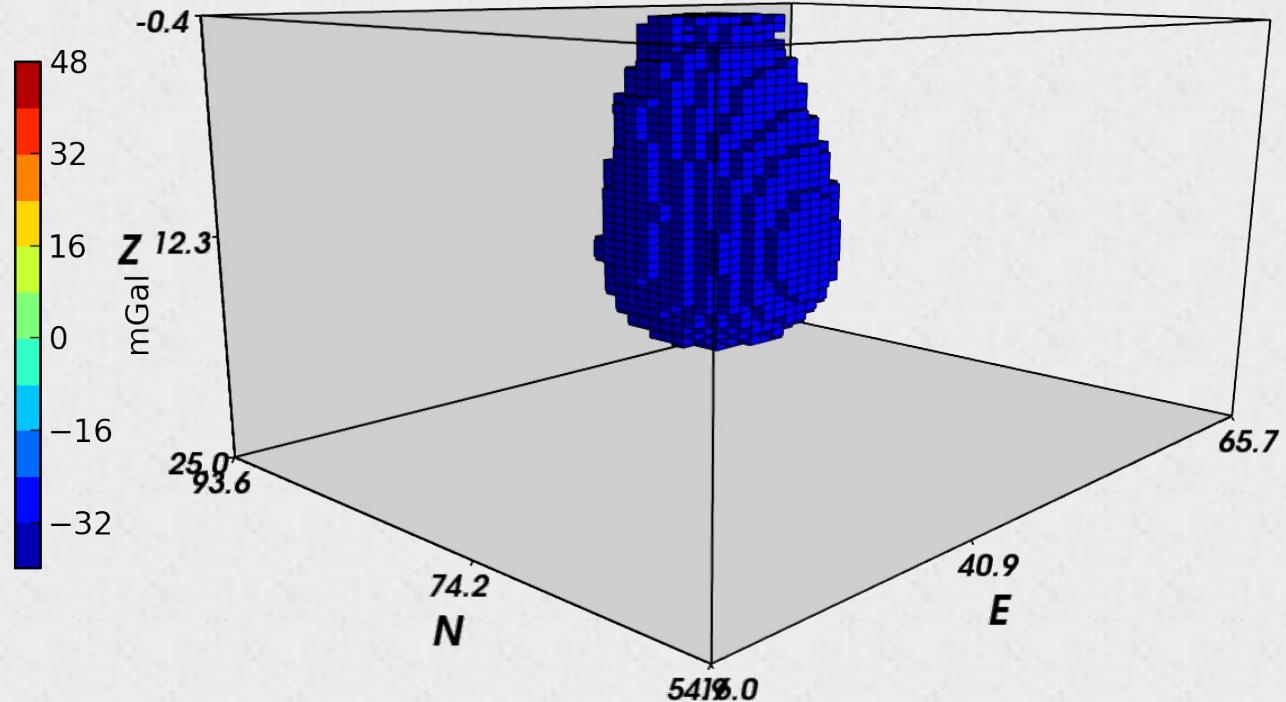
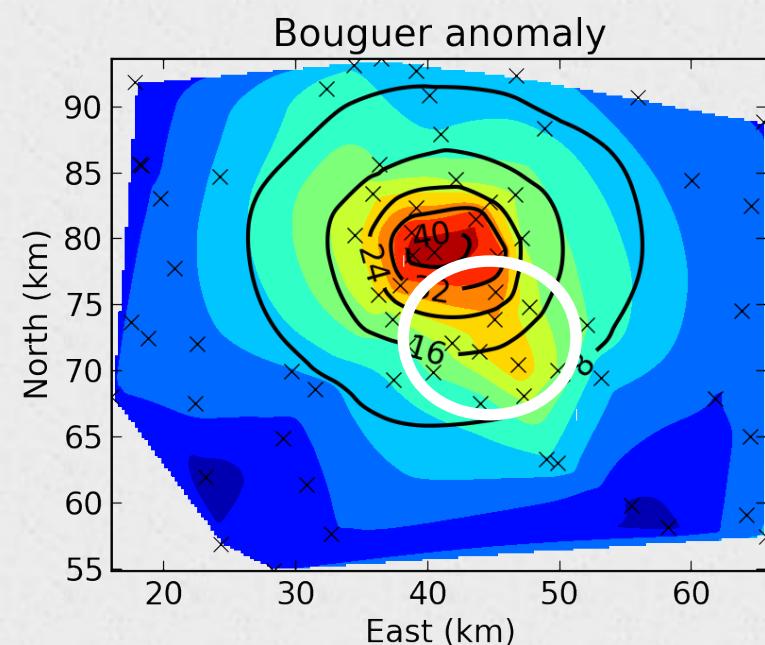
3D gravity inversion (Dutra et al., 2012)



Hypothesis 1



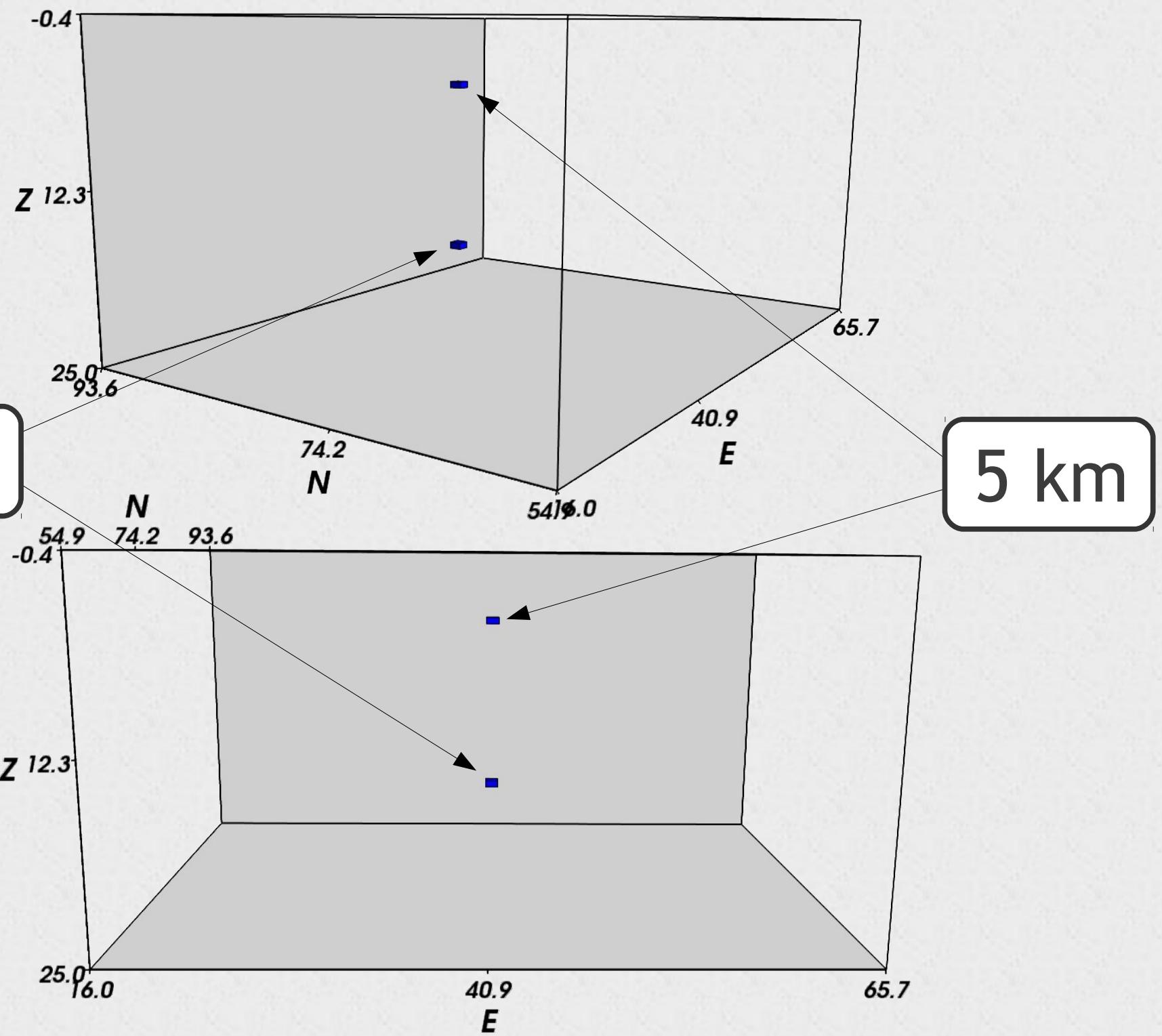


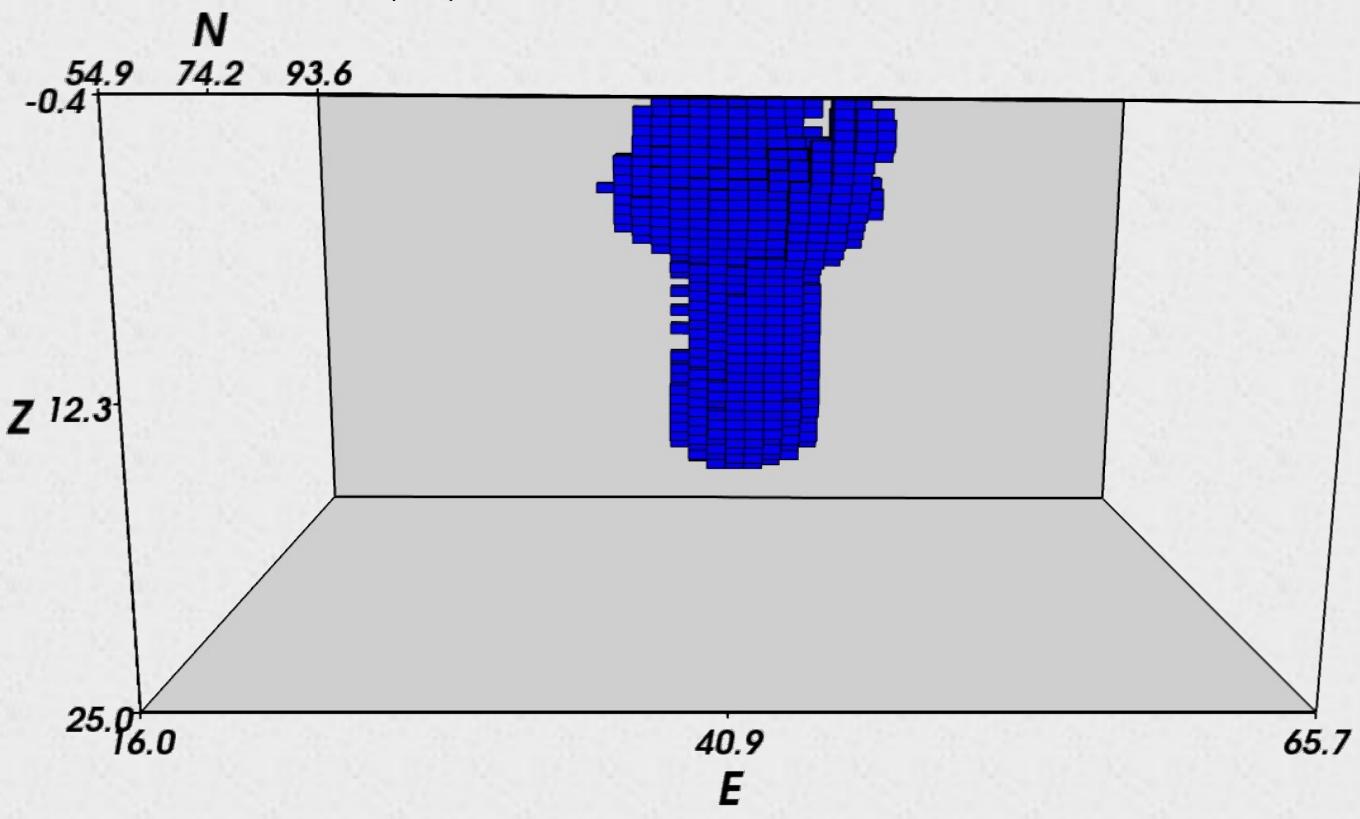
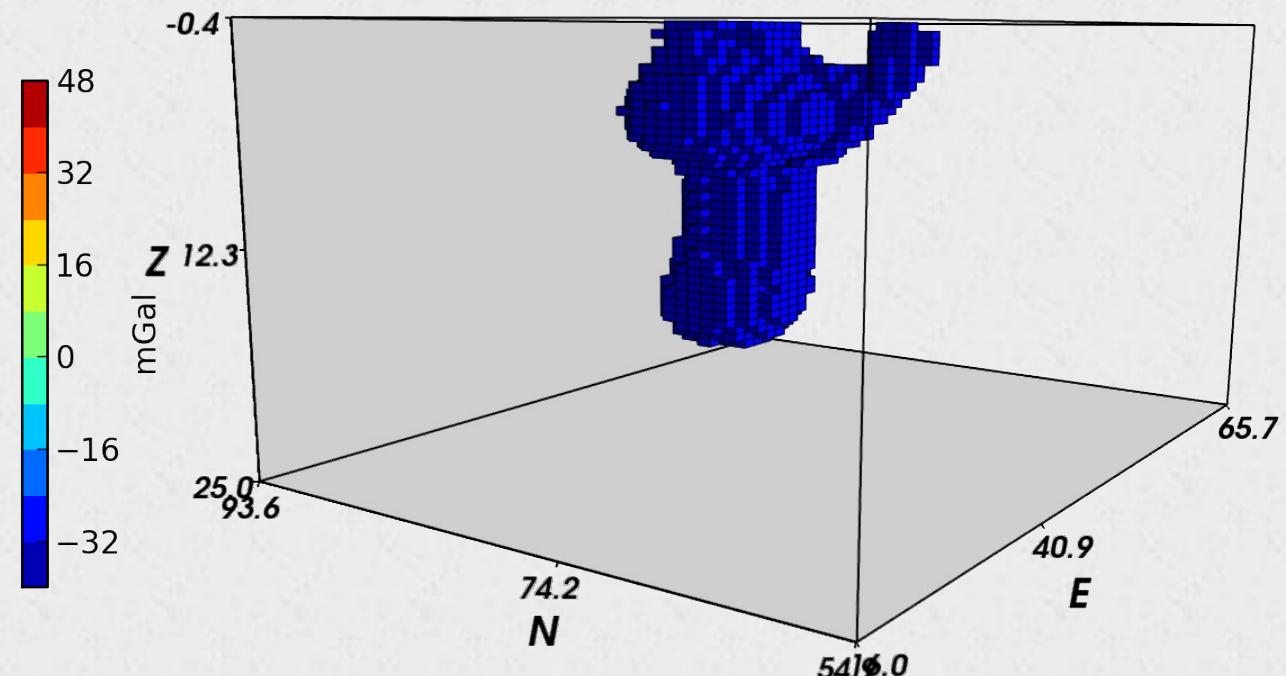
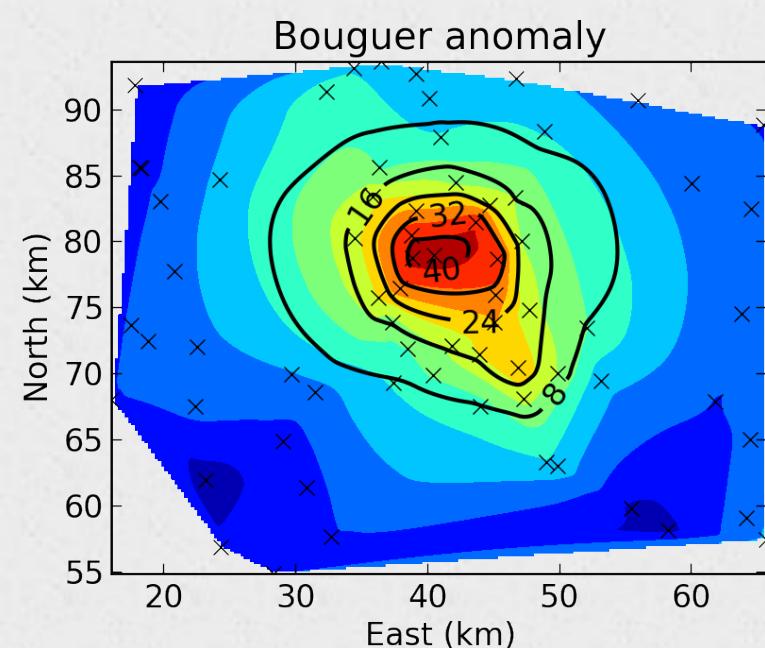


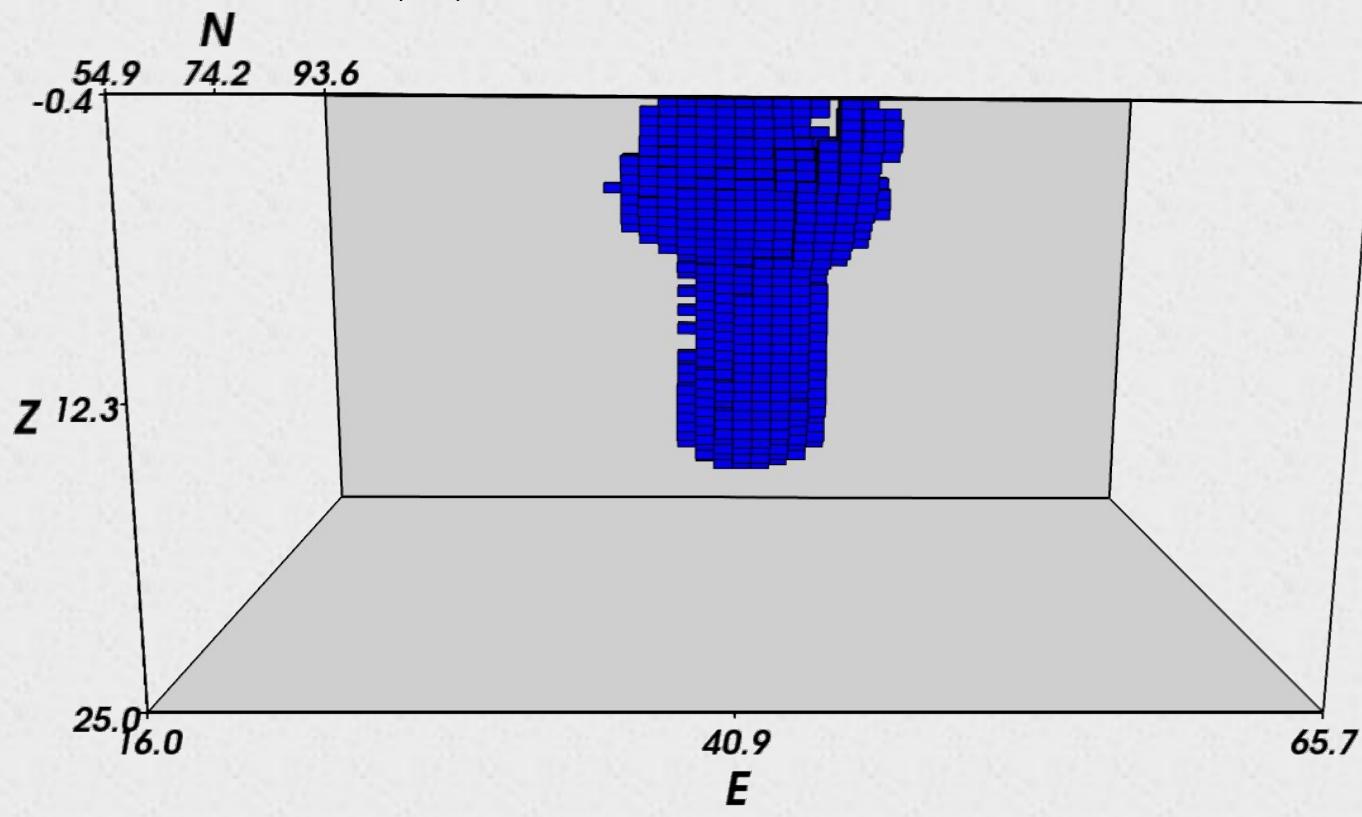
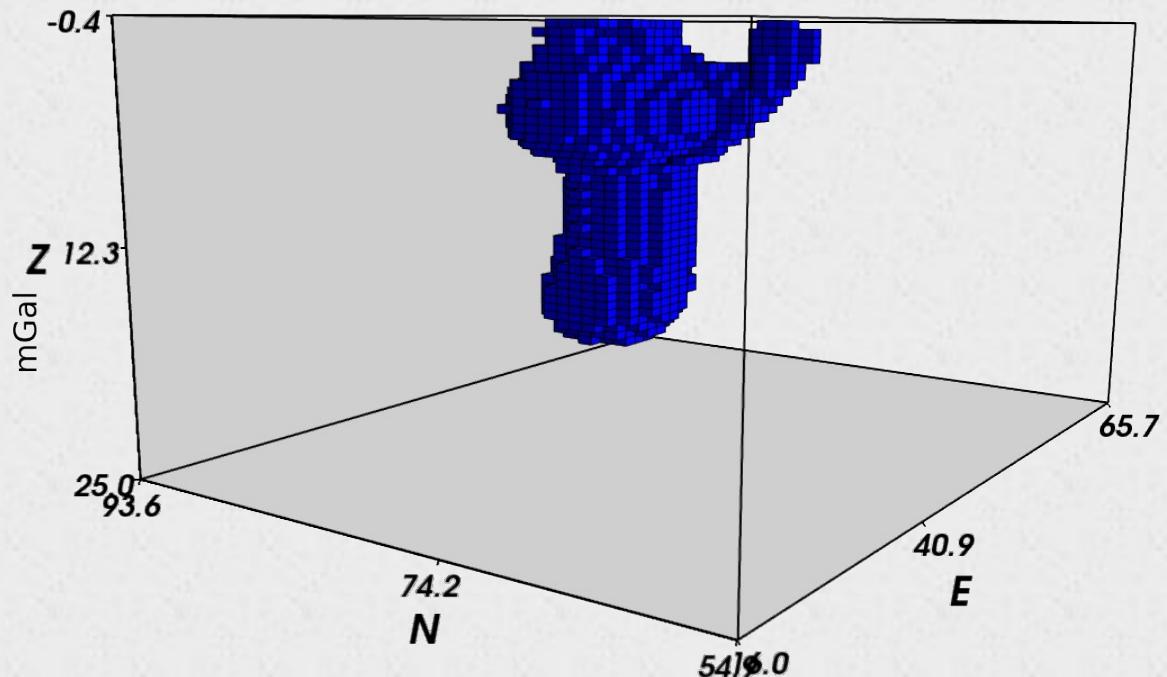
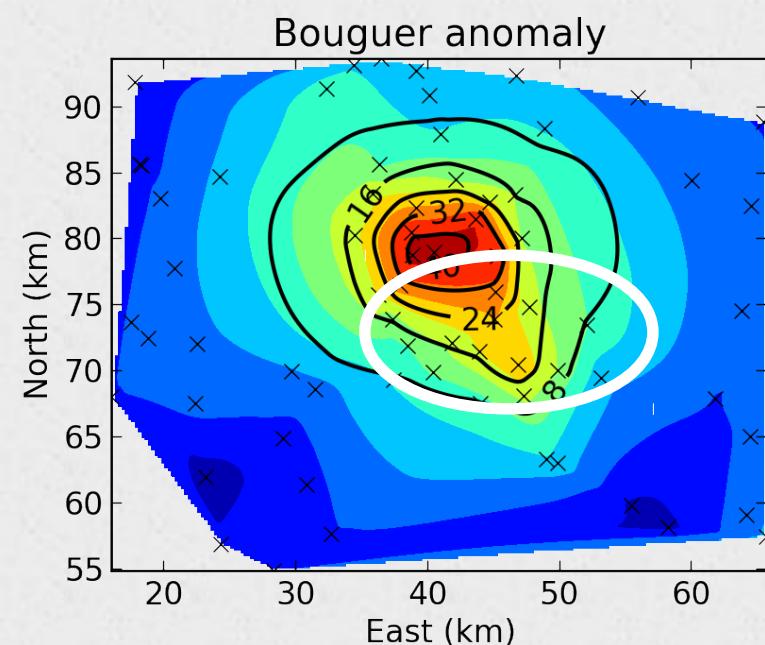
Hypothesis 1

Hypothesis 1

Hypothesis 2



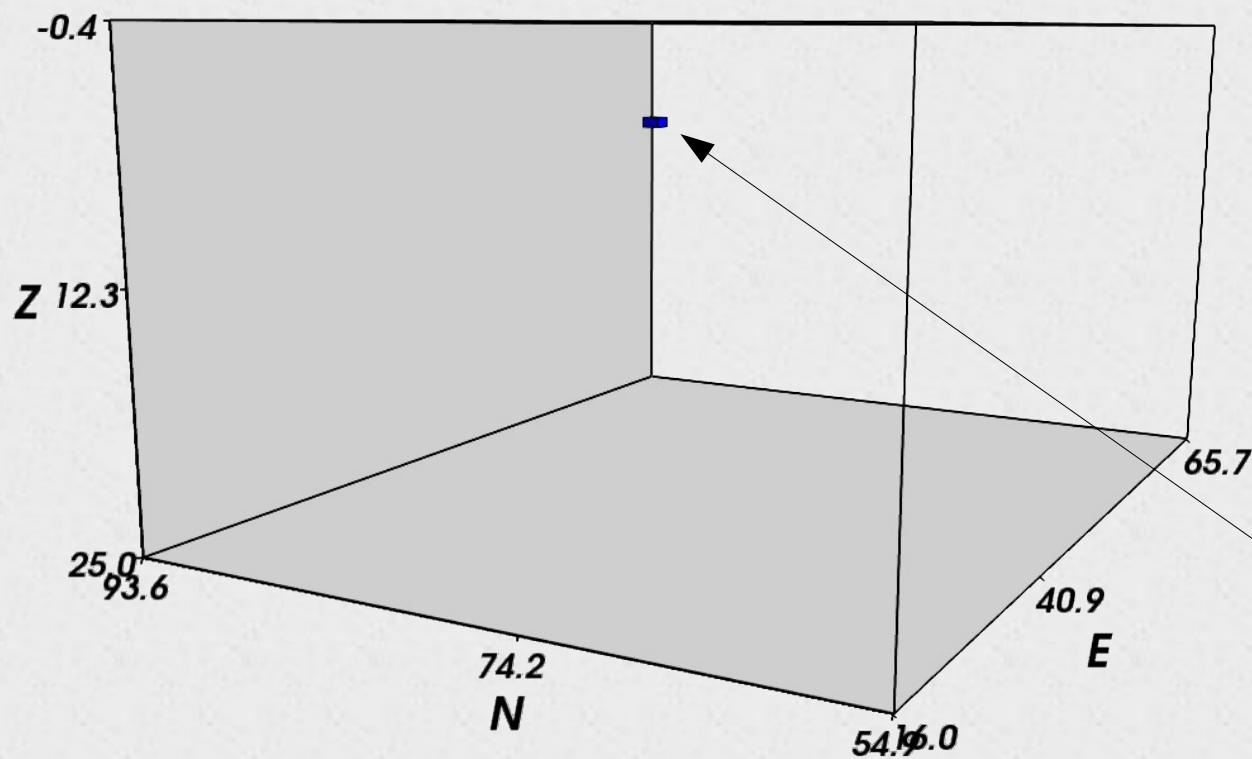




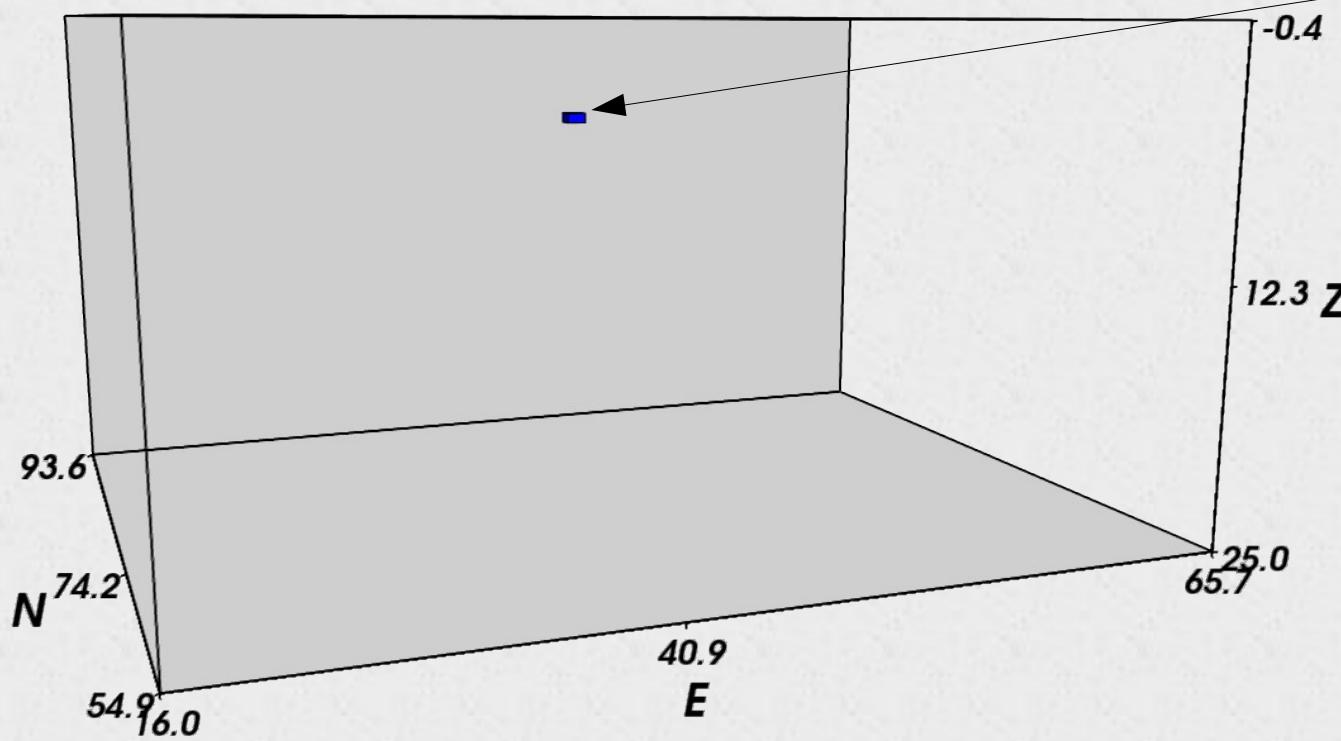
Hypothesis 2

Hypothesis 2

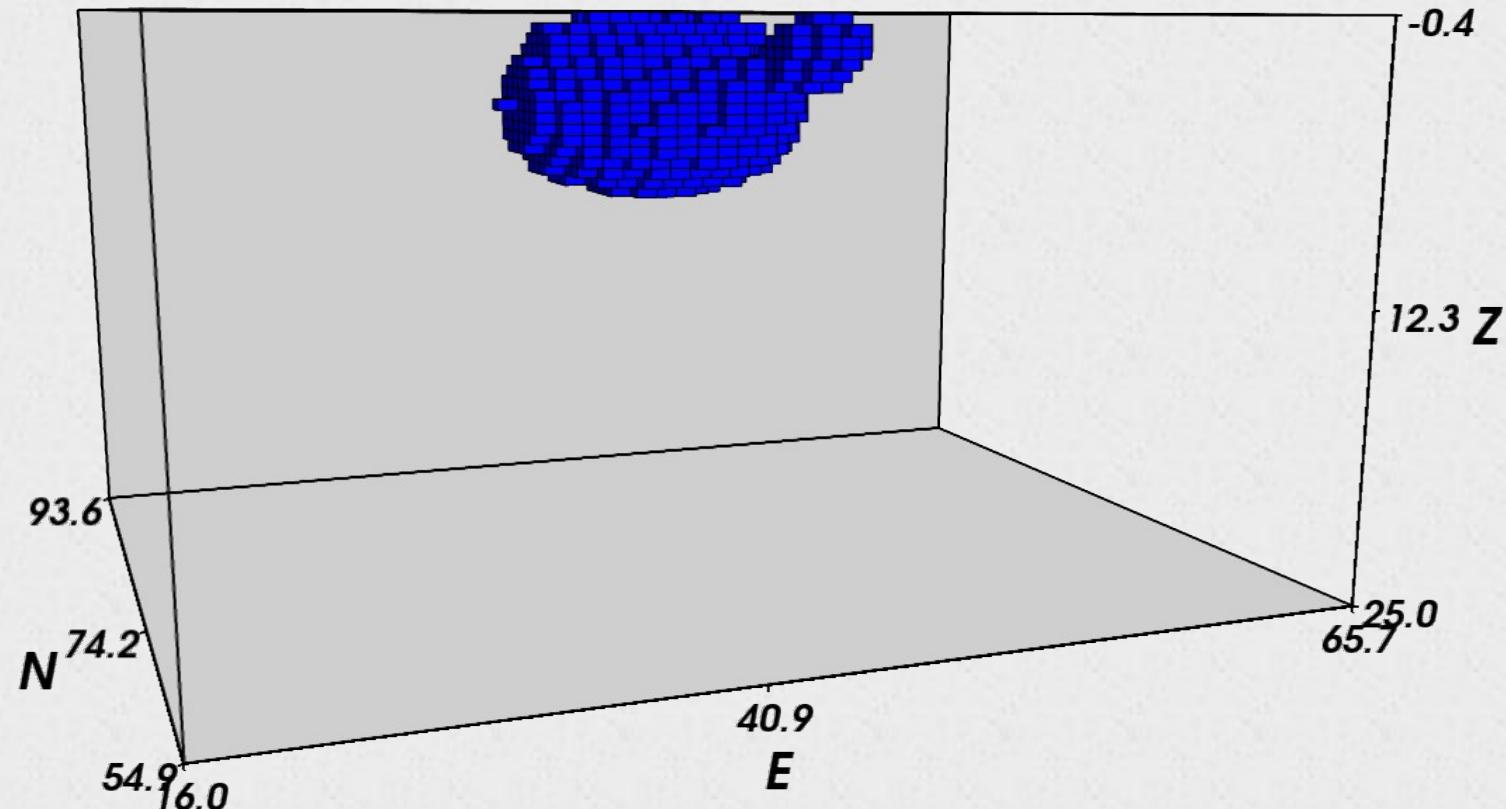
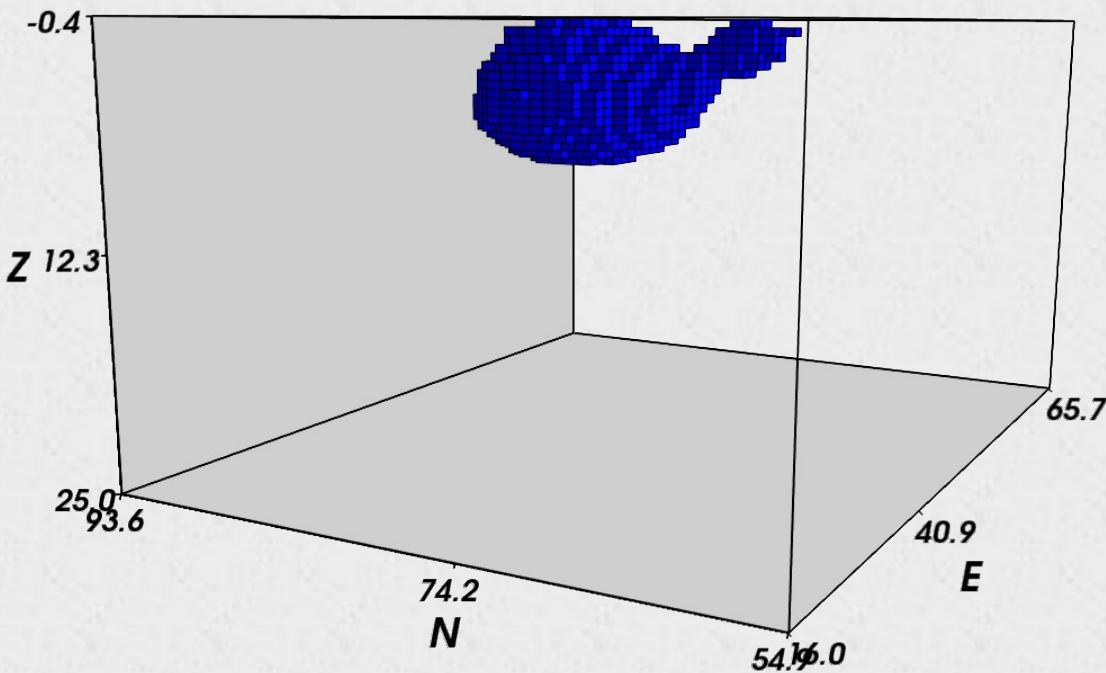
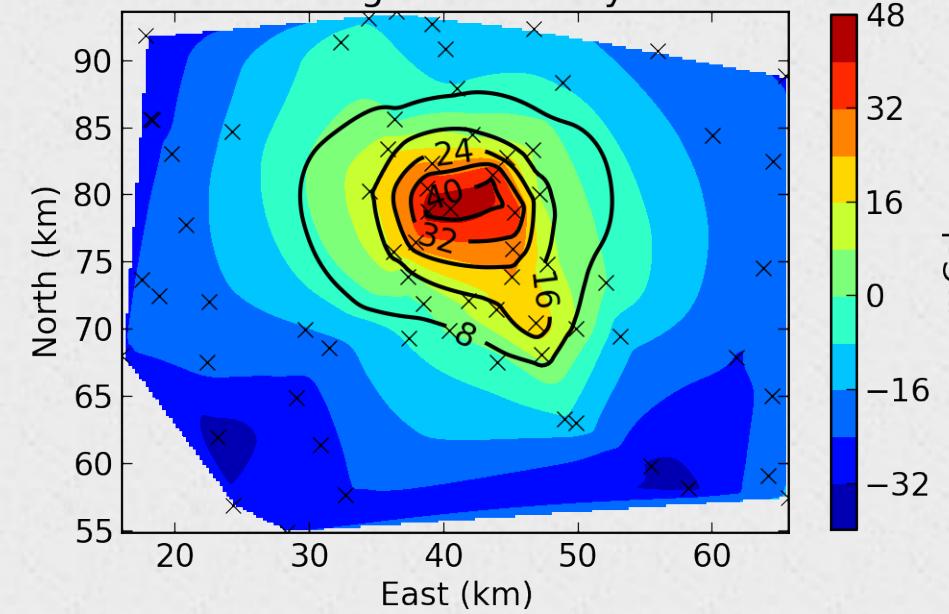
Hypothesis 3



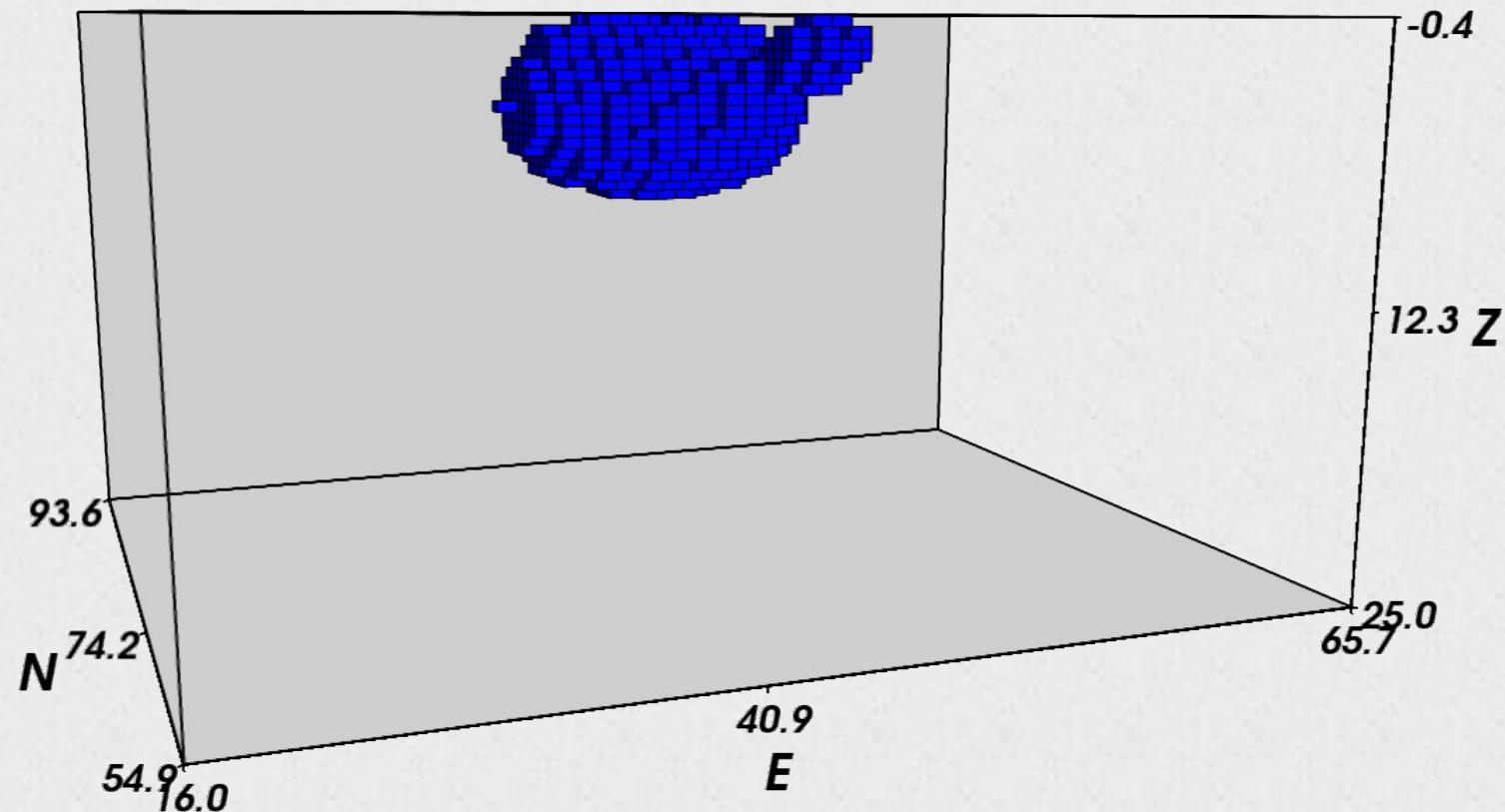
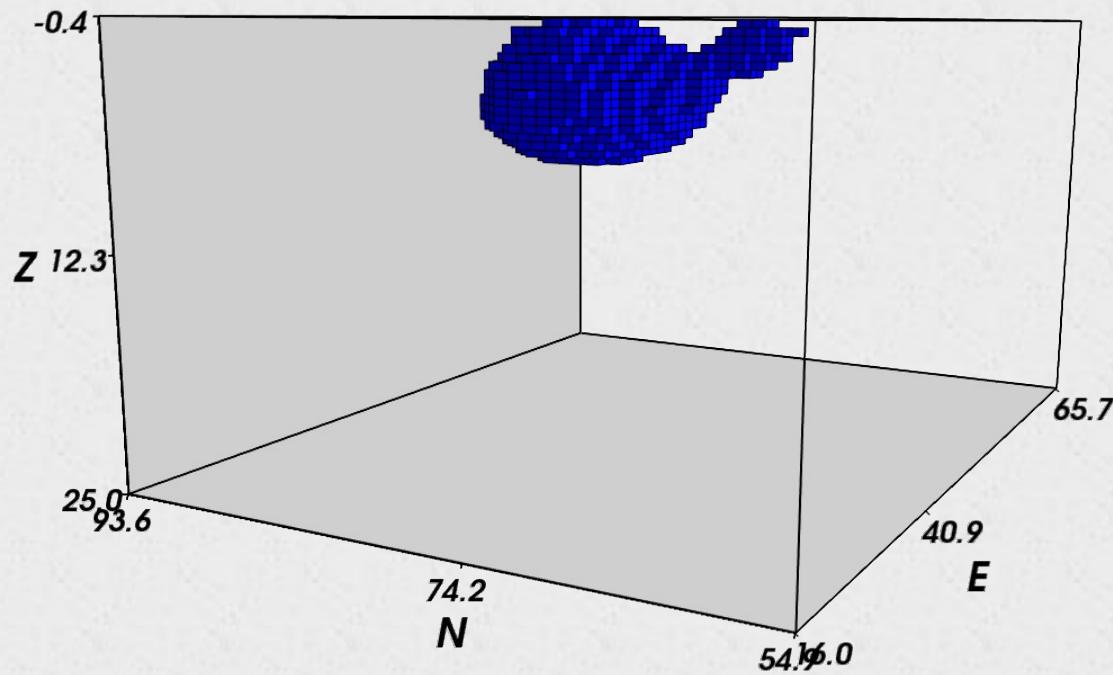
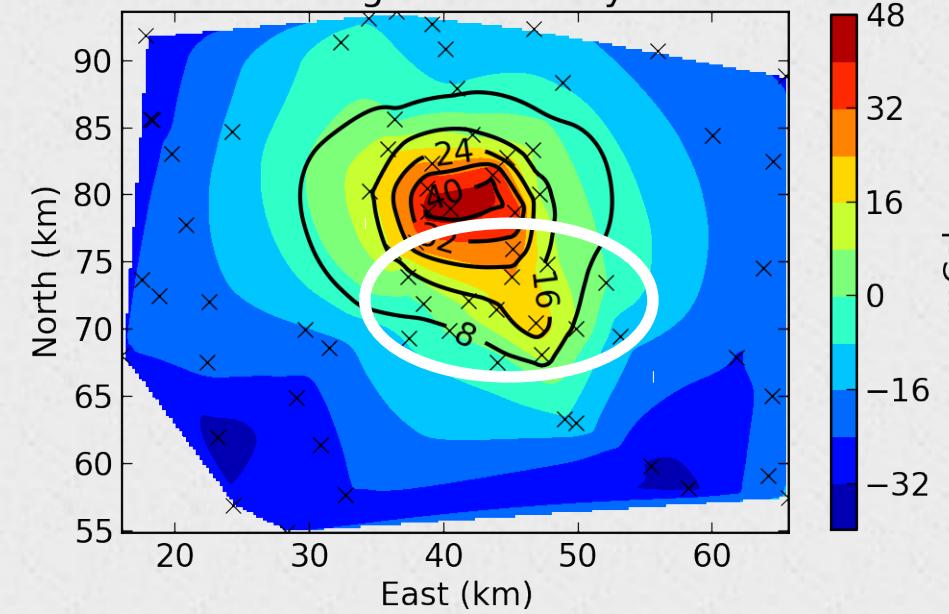
5 km



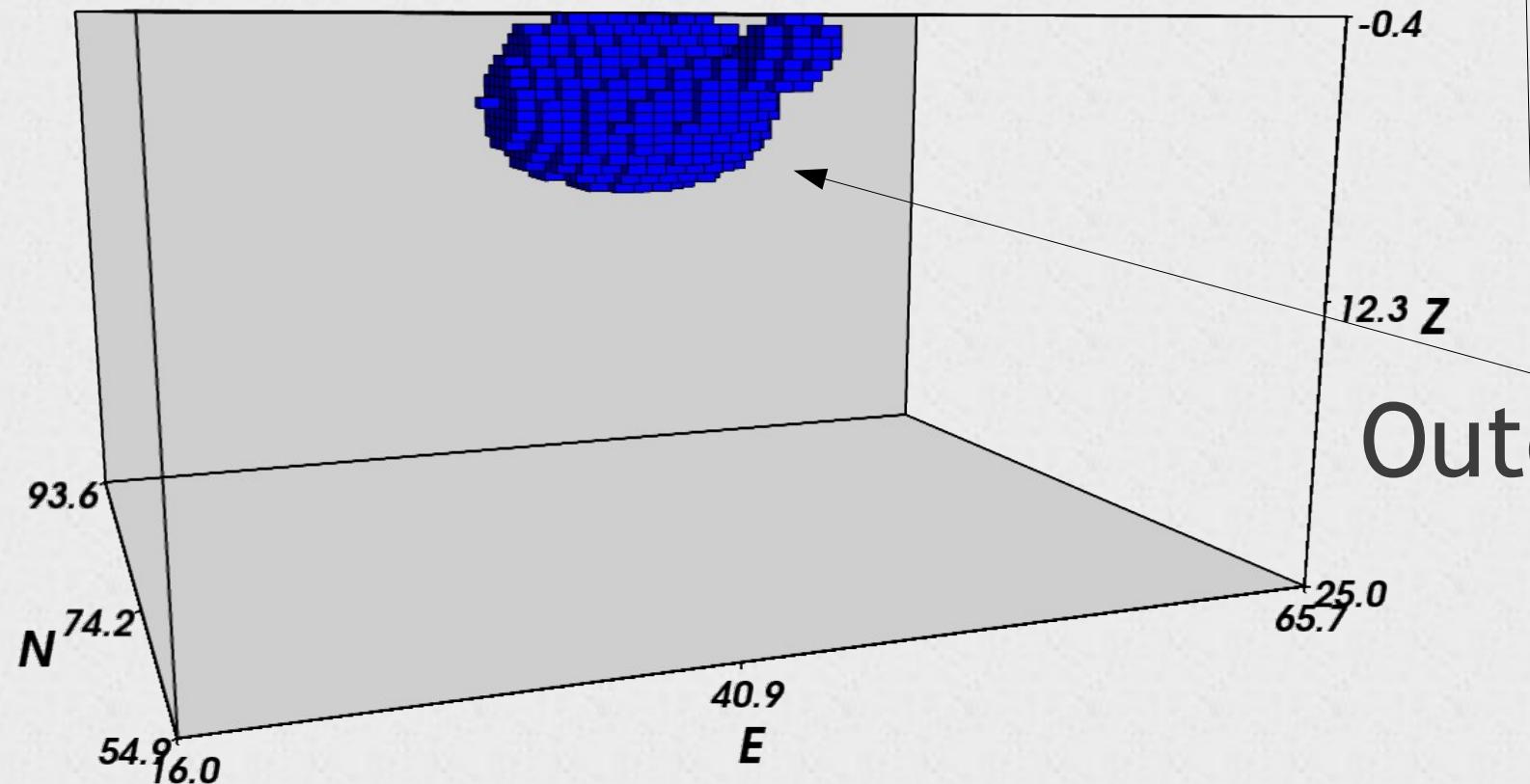
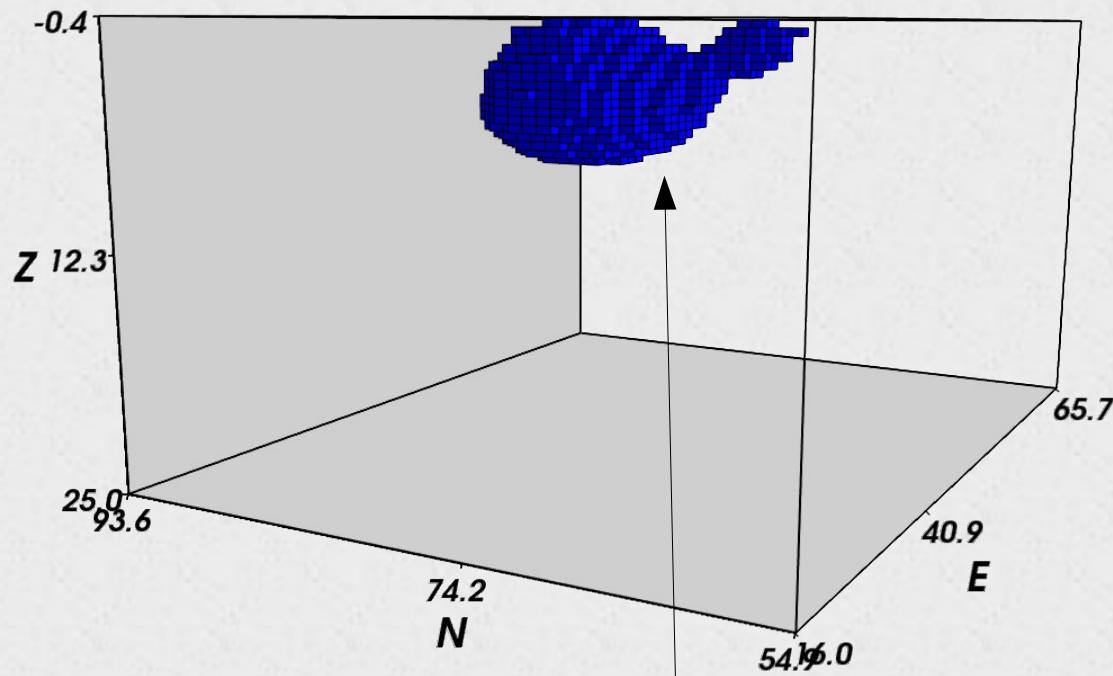
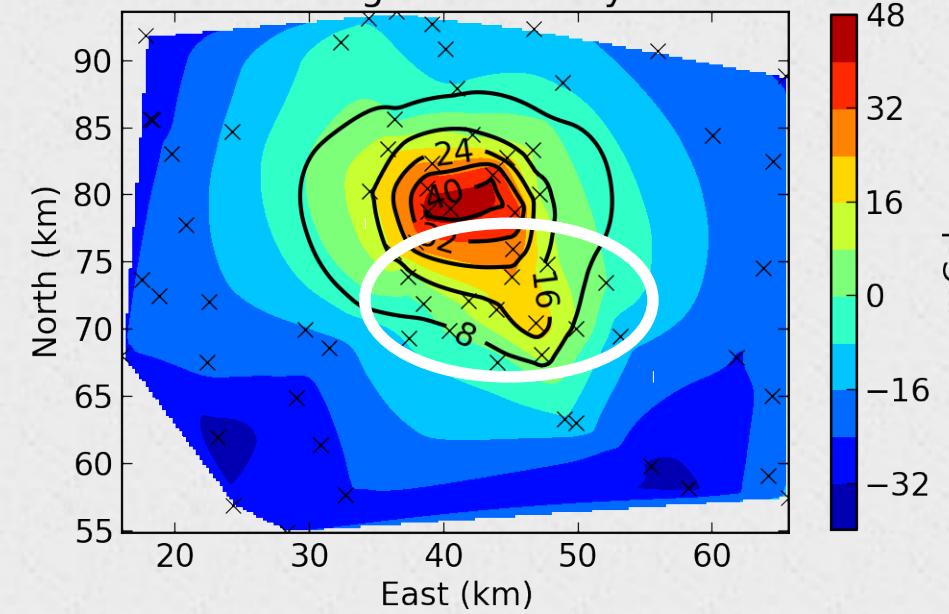
Bouguer anomaly



Bouguer anomaly



Bouguer anomaly

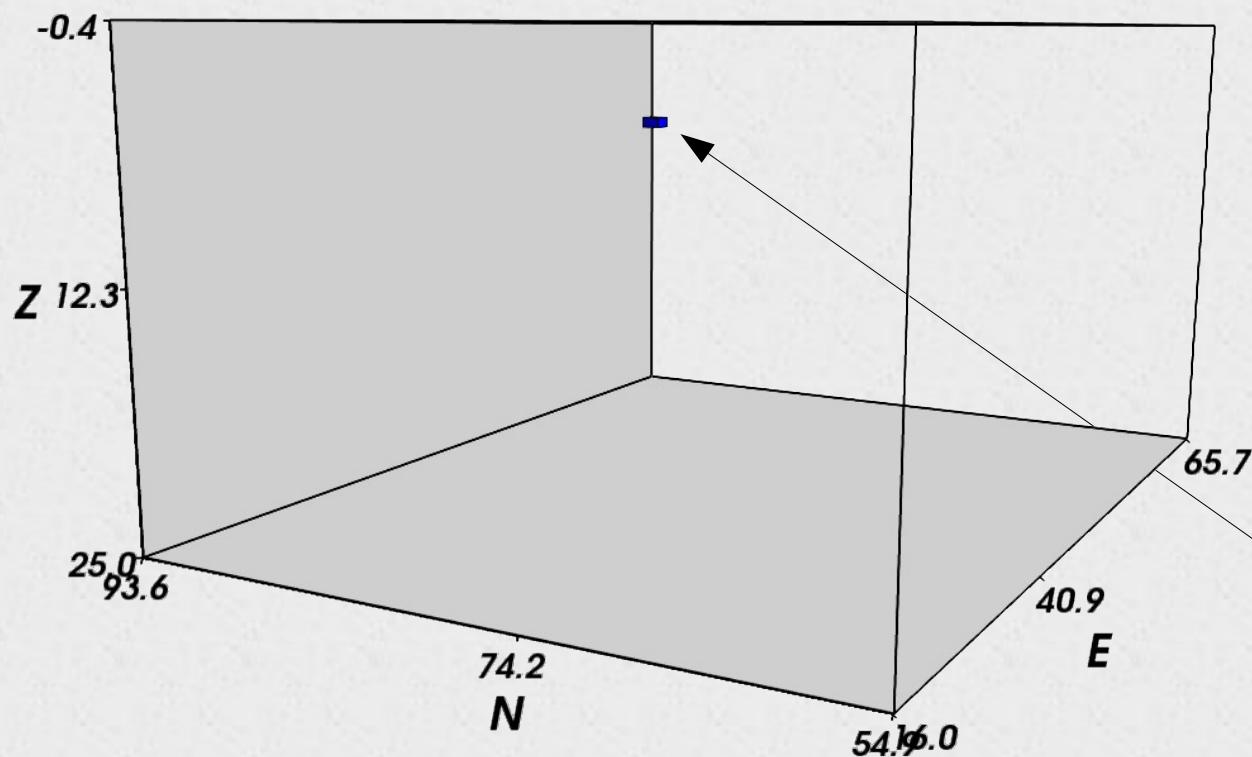


Outcropping

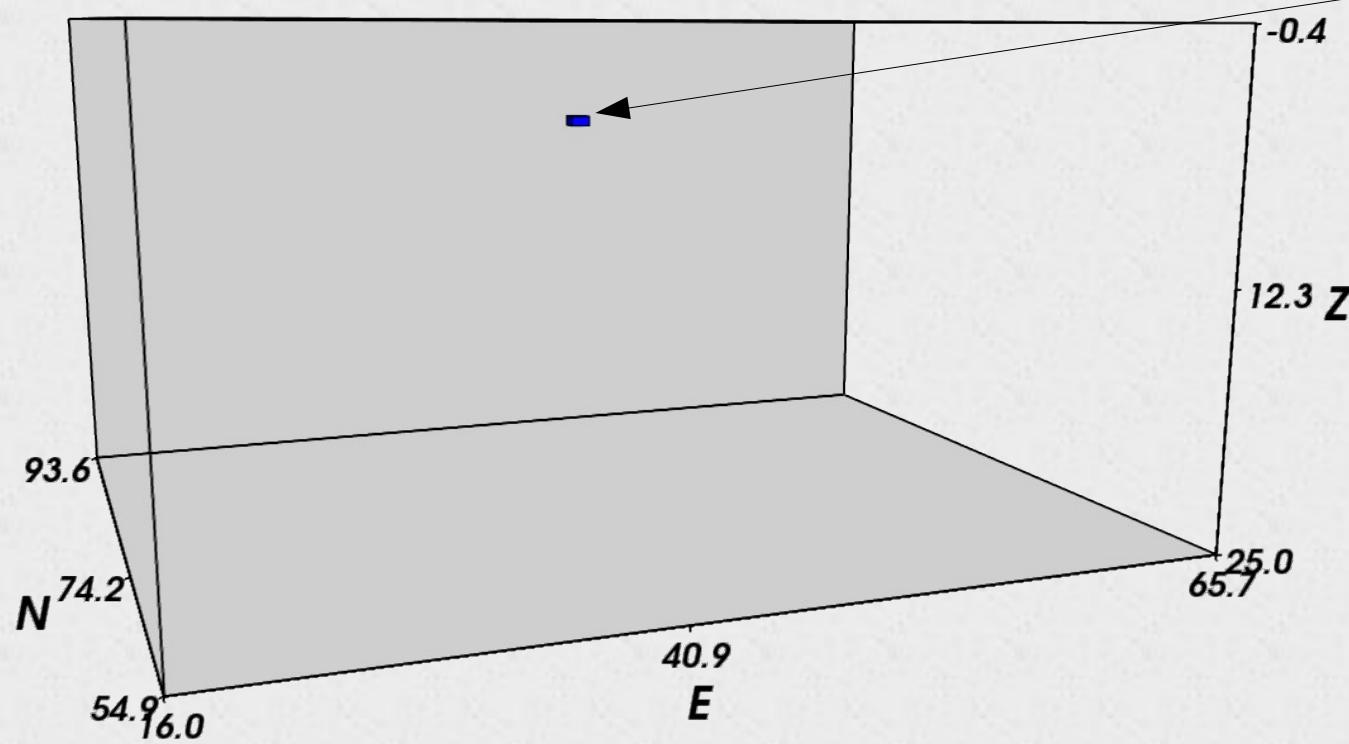
Hypothesis 3

Hypothesis 3

Hypothesis 4



5 km

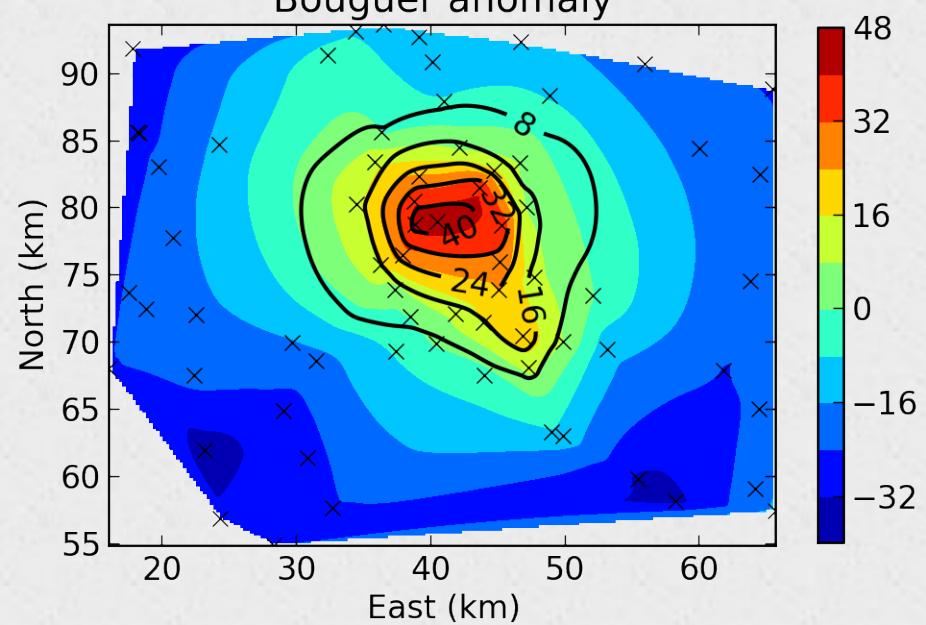


Density



500 g.cm⁻³

Bouguer anomaly



-0.4

mGal
Z 12.3

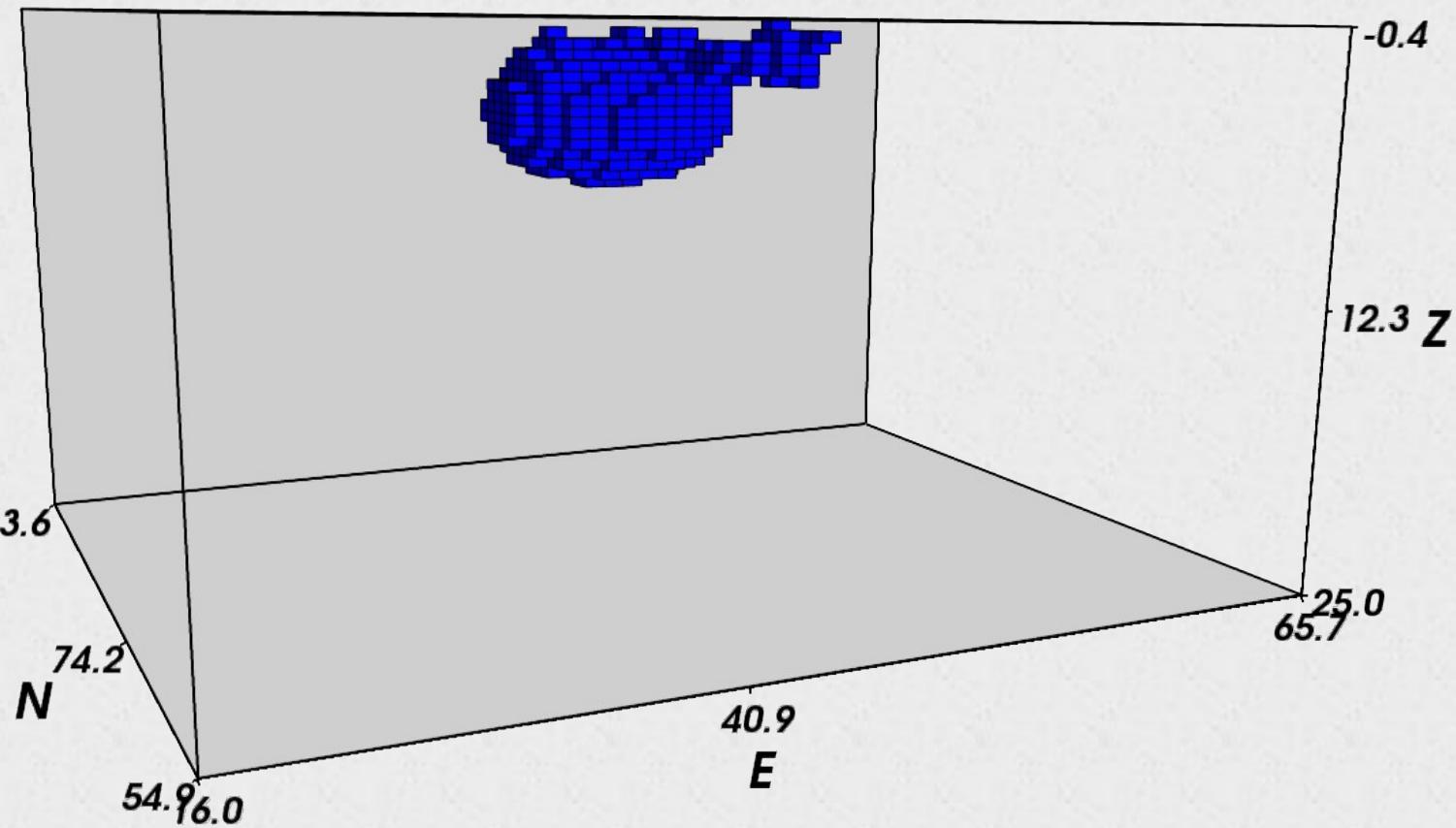
25.0
93.6

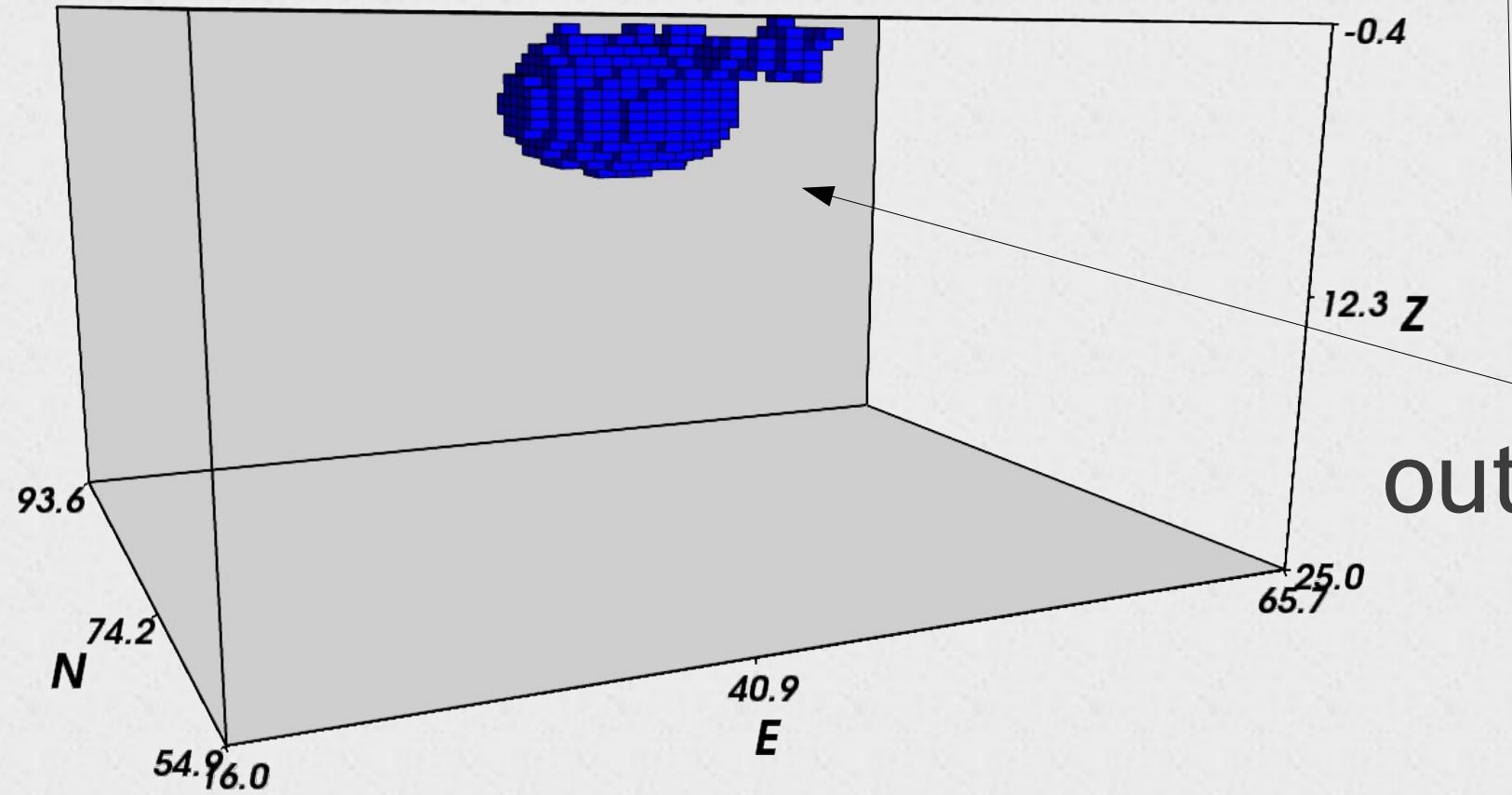
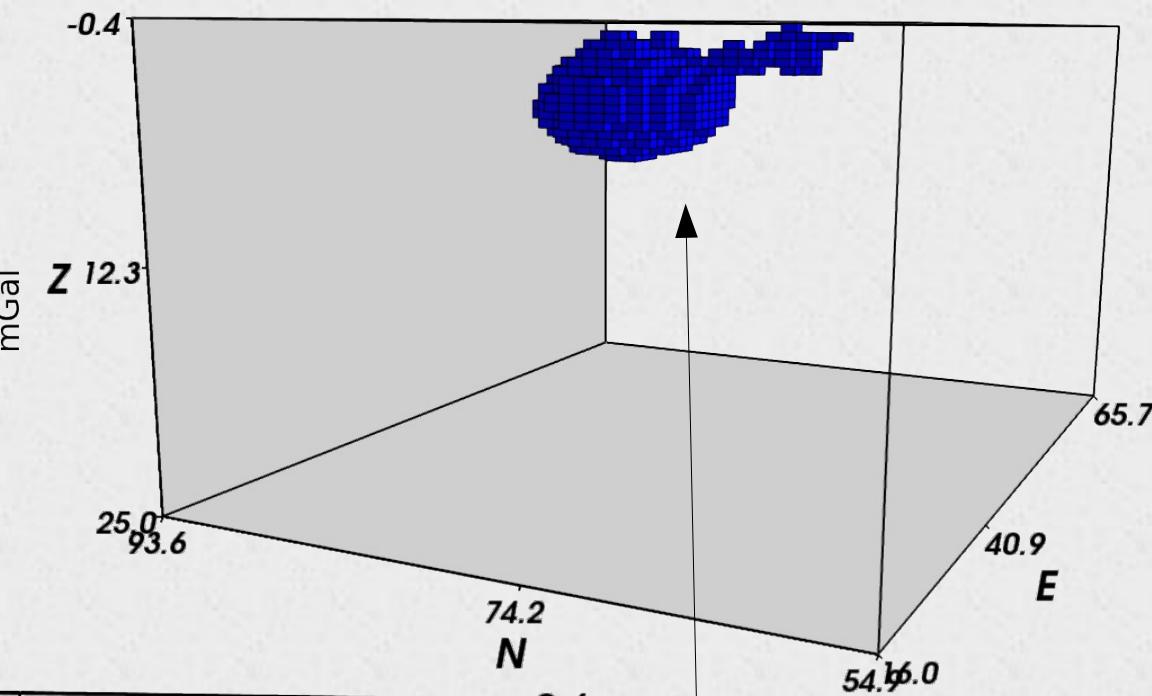
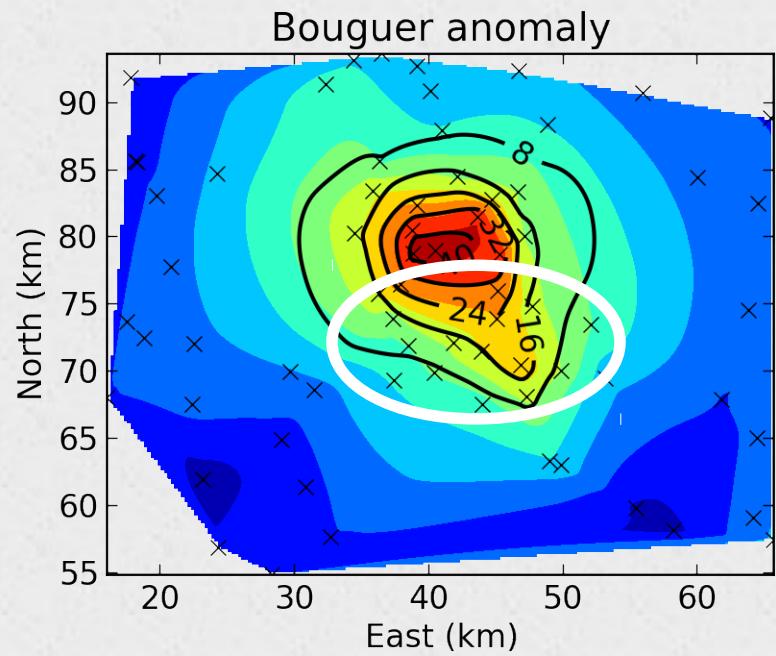
74.2
N

54.9
6.0

40.9
E

65.7





Not
outcropping

Hypothesis 4

Hypothesis 4

Conclusion

- 3D forward modeling = hard!
- Traditional 3D inversion = not flexible
- Planting densities = fast + flexible

Open-source project

Fatiando a Terra

Geophysical modeling and inversion



www.fatiando.org