

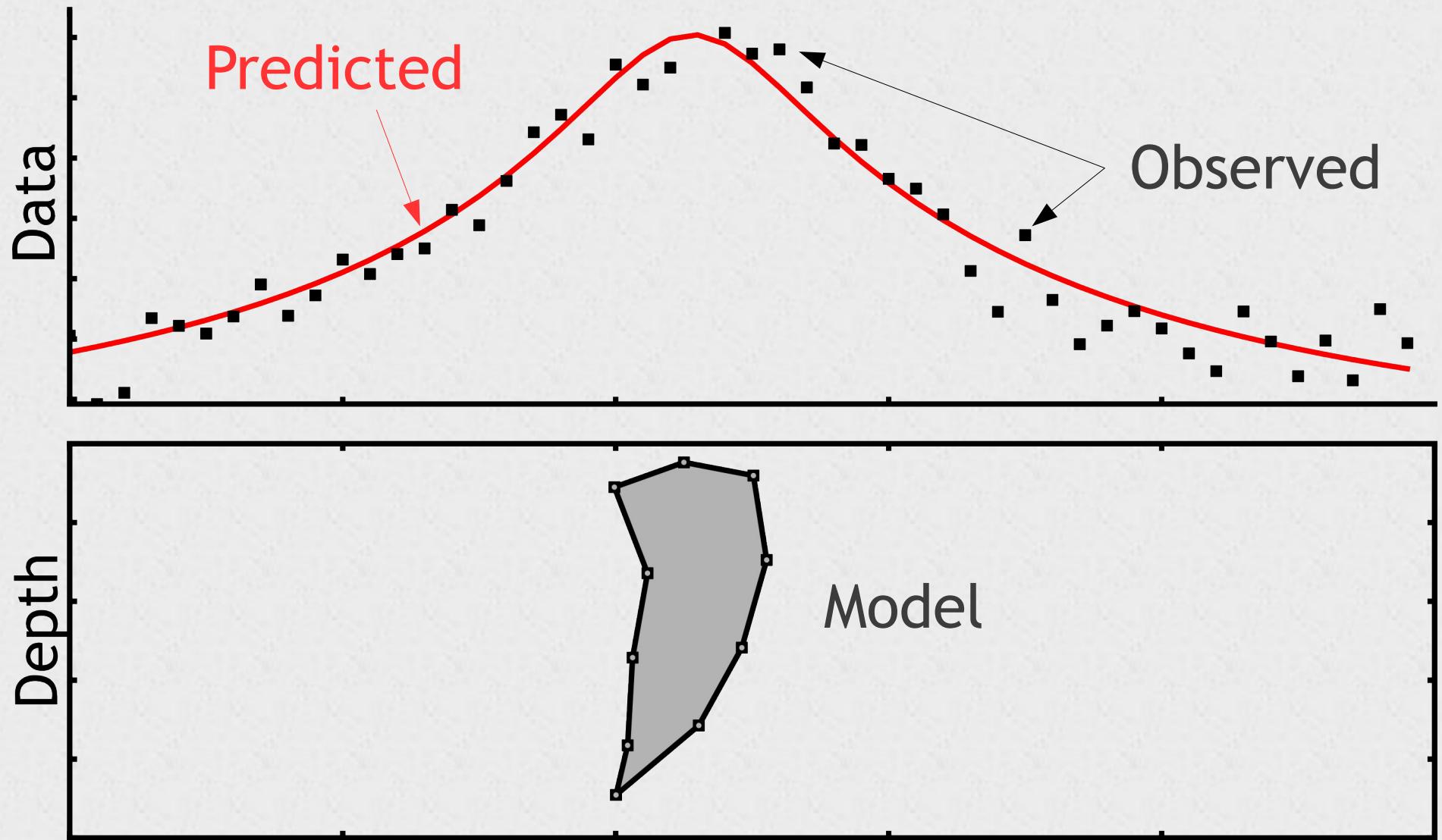
Rapid 3D inversion of gravity and gravity gradient data to test geologic hypotheses

Leonardo Uieda
Valéria C. F. Barbosa



Observatório Nacional
Rio de Janeiro, Brazil

Forward modeling

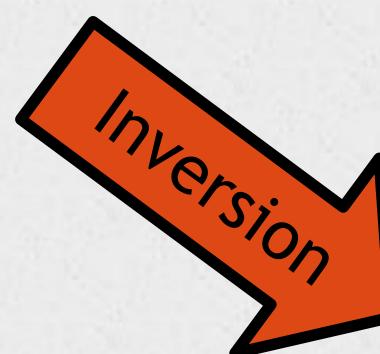
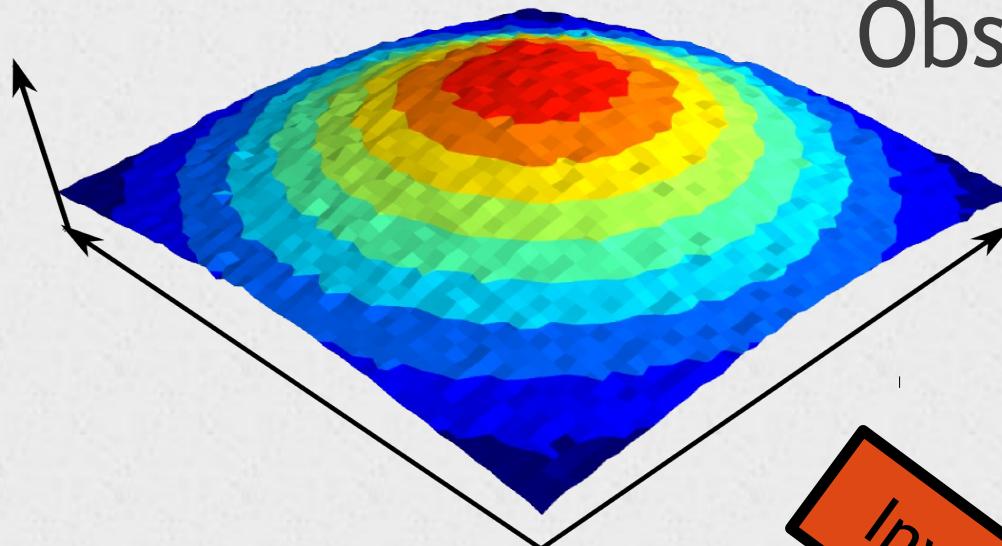


- ✓ Control
- ✓ Prior information
- ✓ Speed

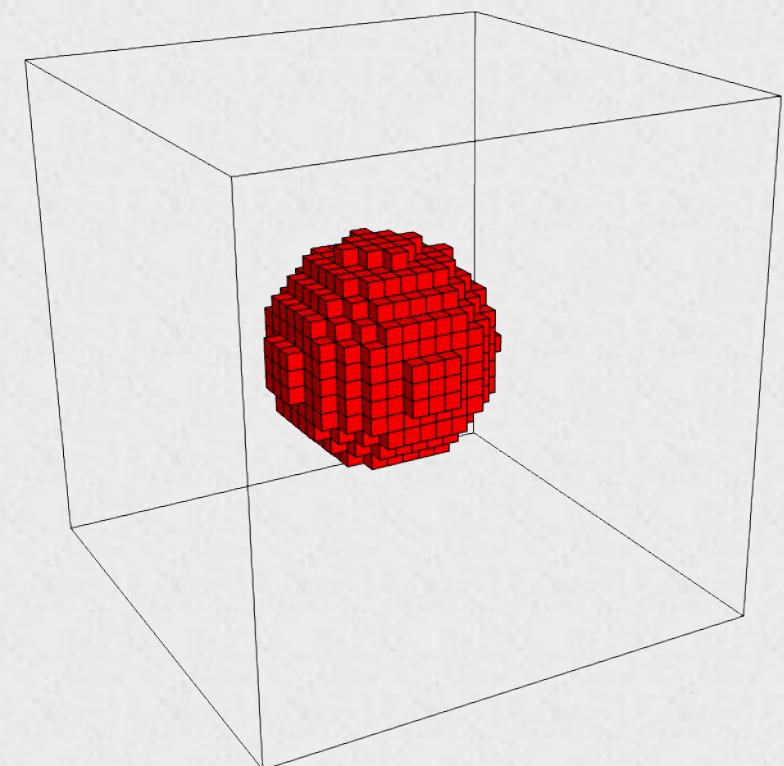
- ✗ Tedious
- ✗ 3D
- ✗ Gravity + Gradients

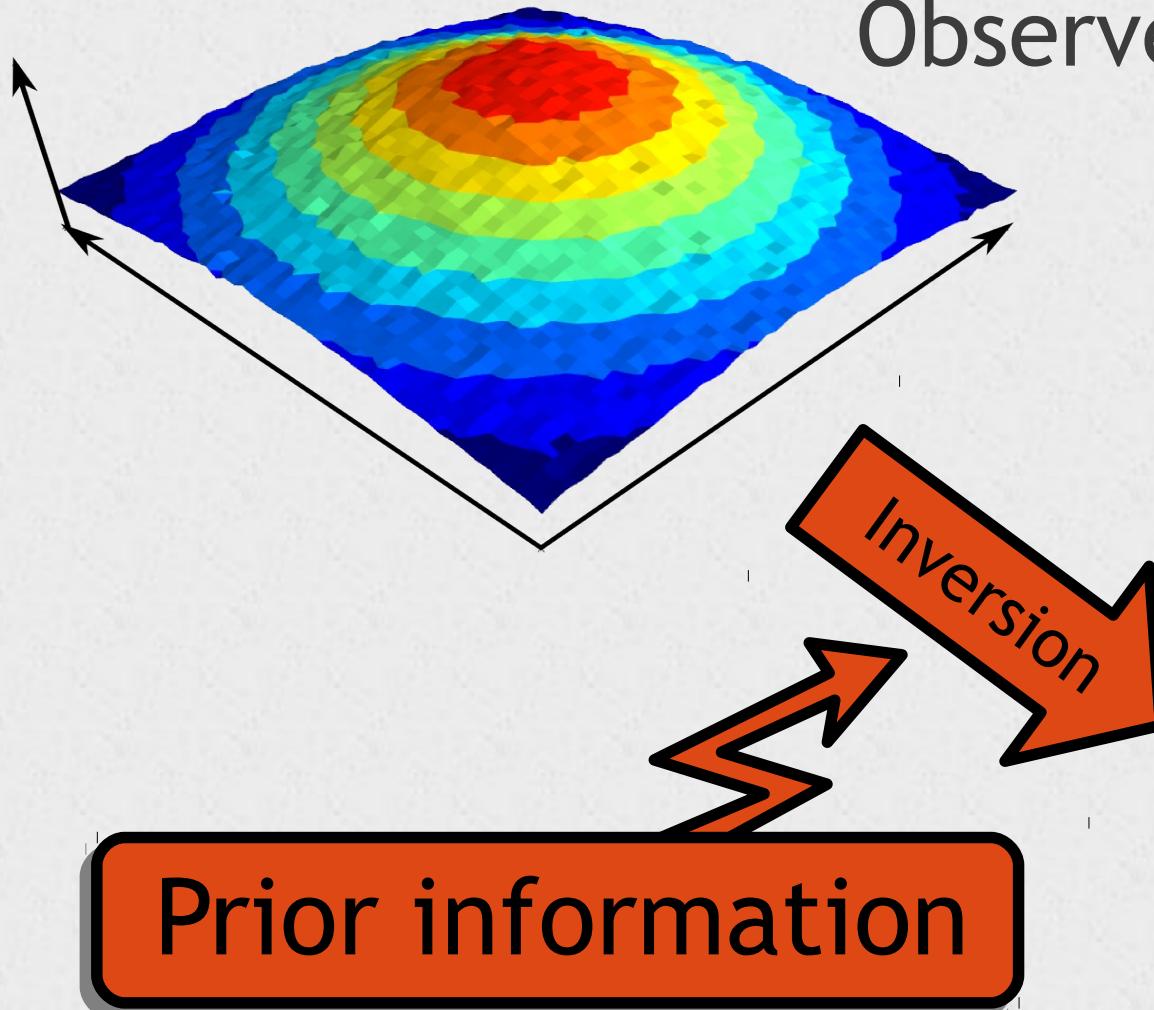
Geophysical inversion

Observed data



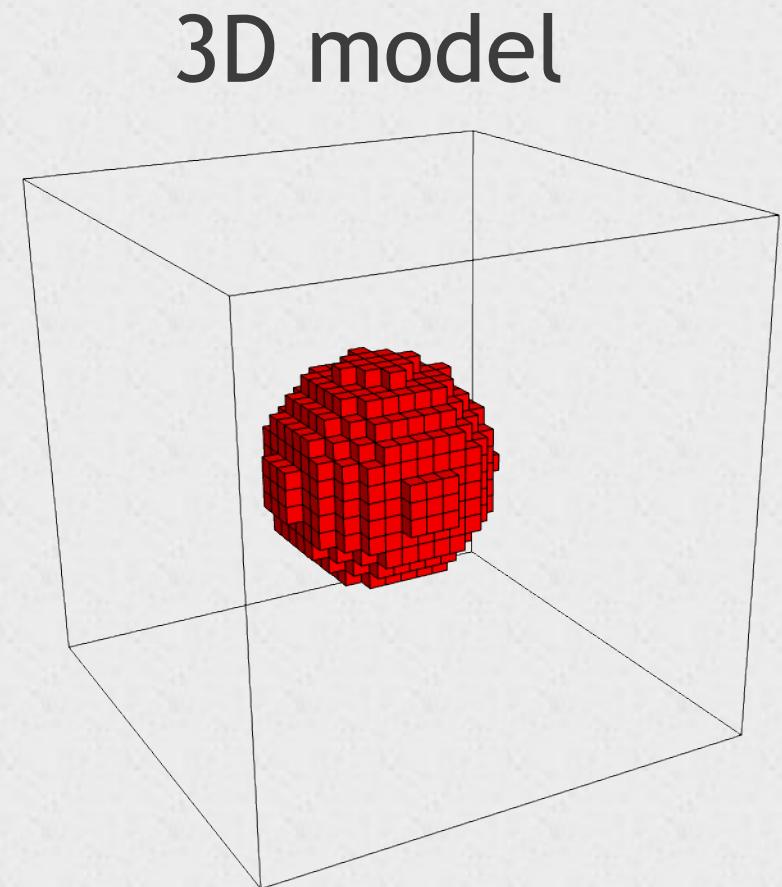
3D model





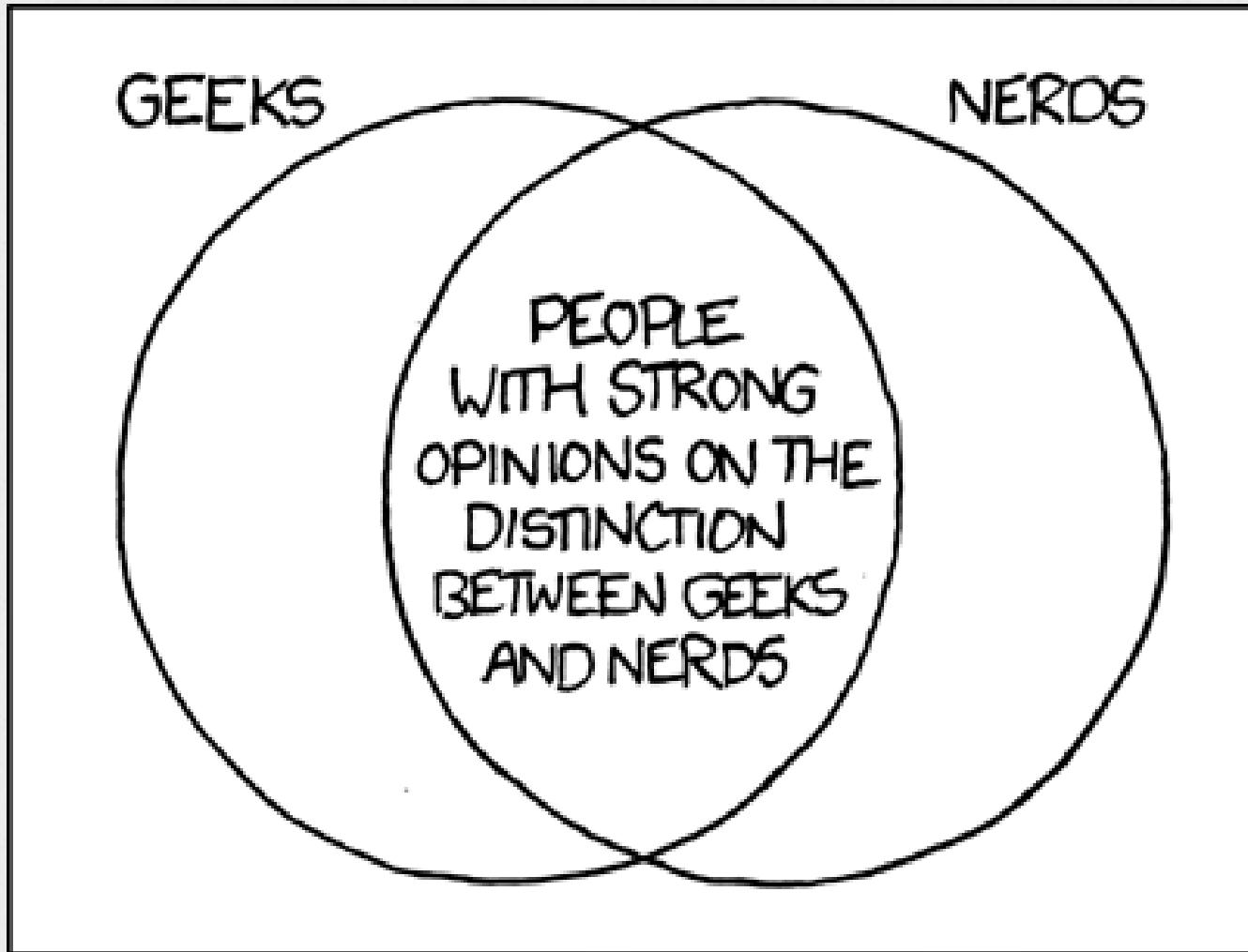
Regularization:

- Damping
- Smoothness



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

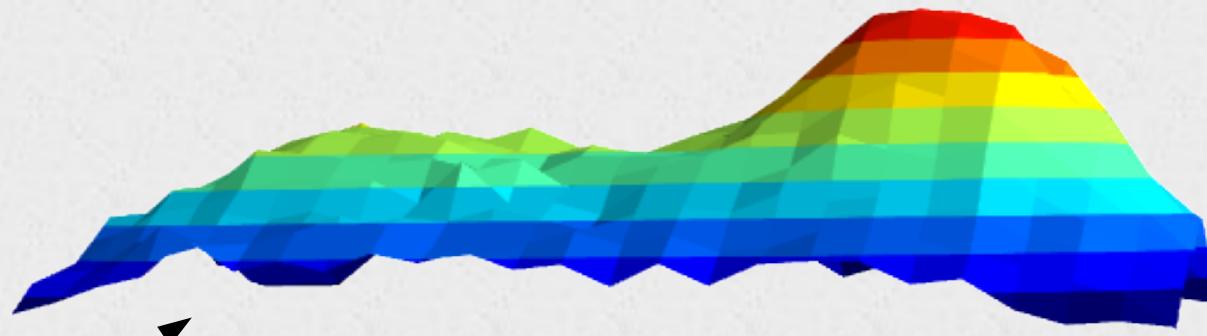
Something in the middle



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

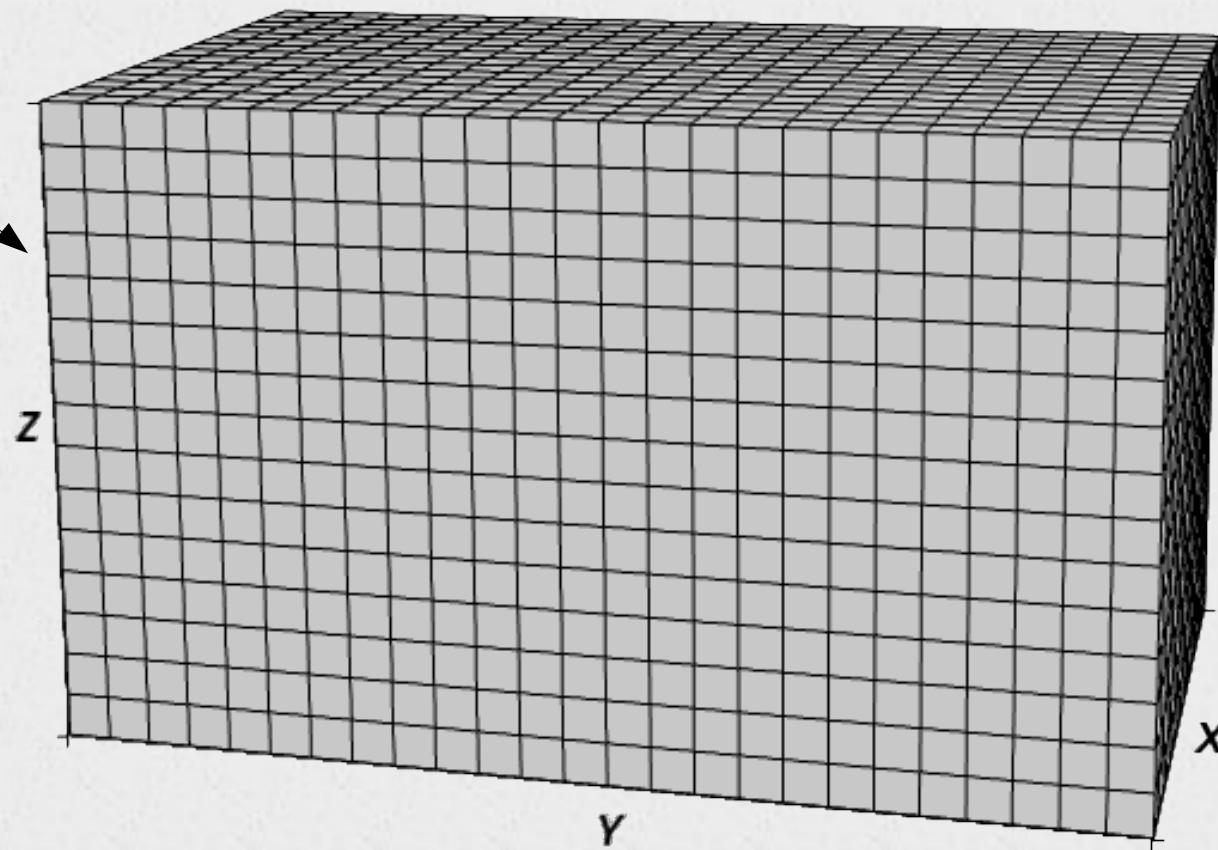
Planting anomalous densities

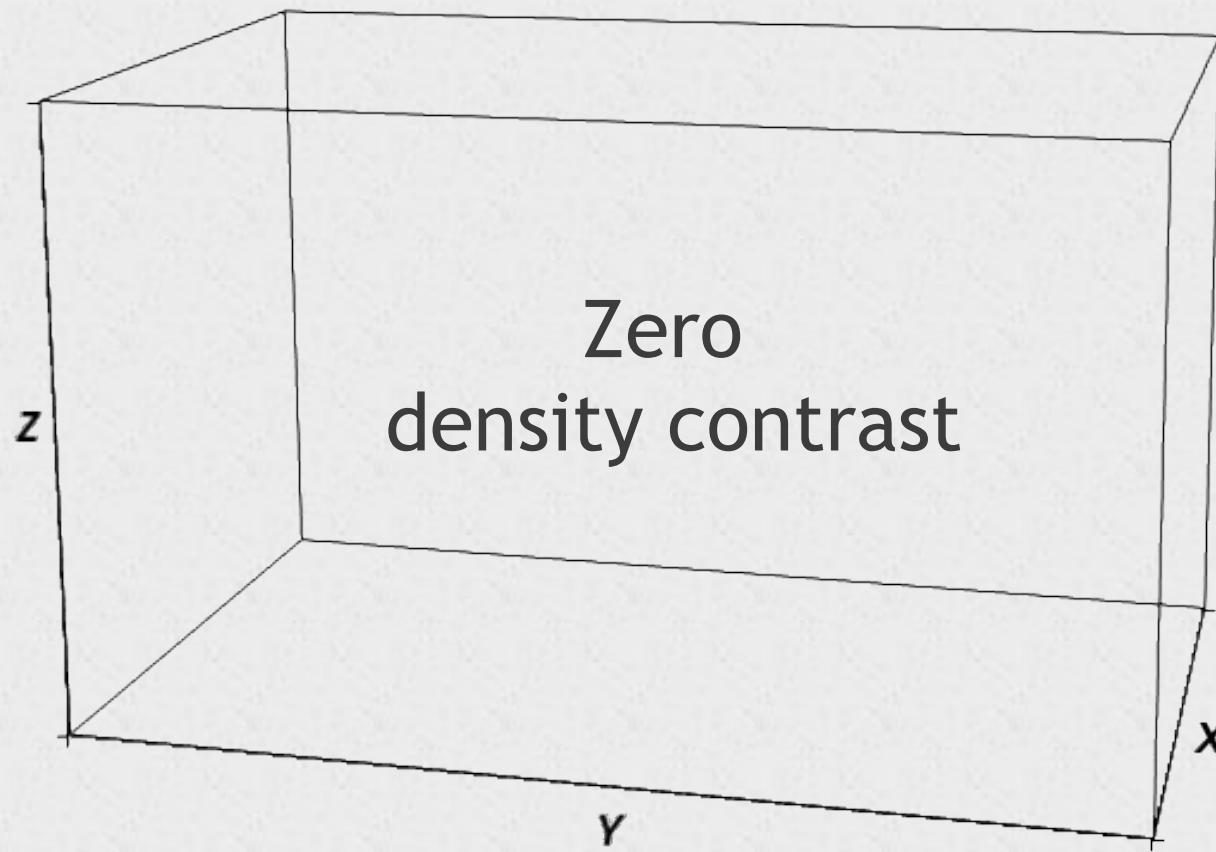
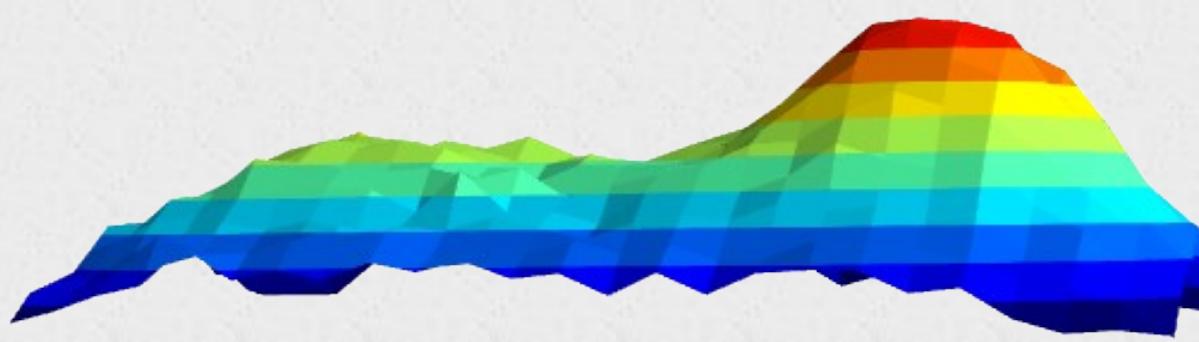
Uieda and Barbosa (2012)

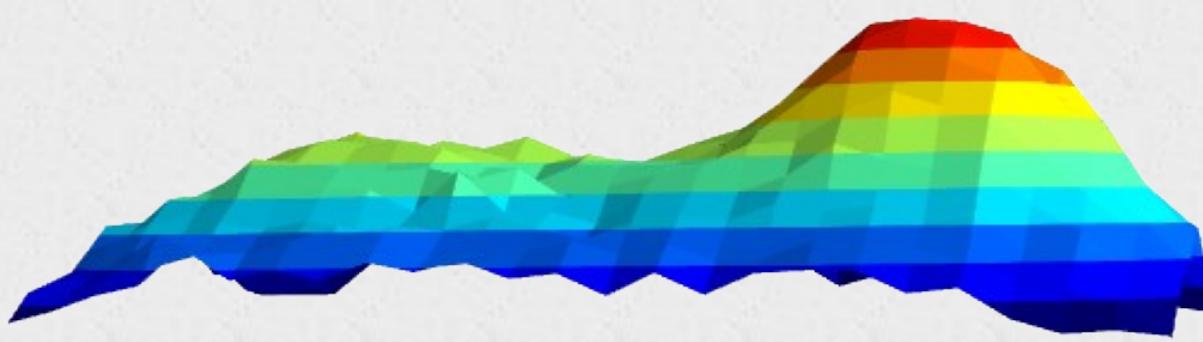


Observed data

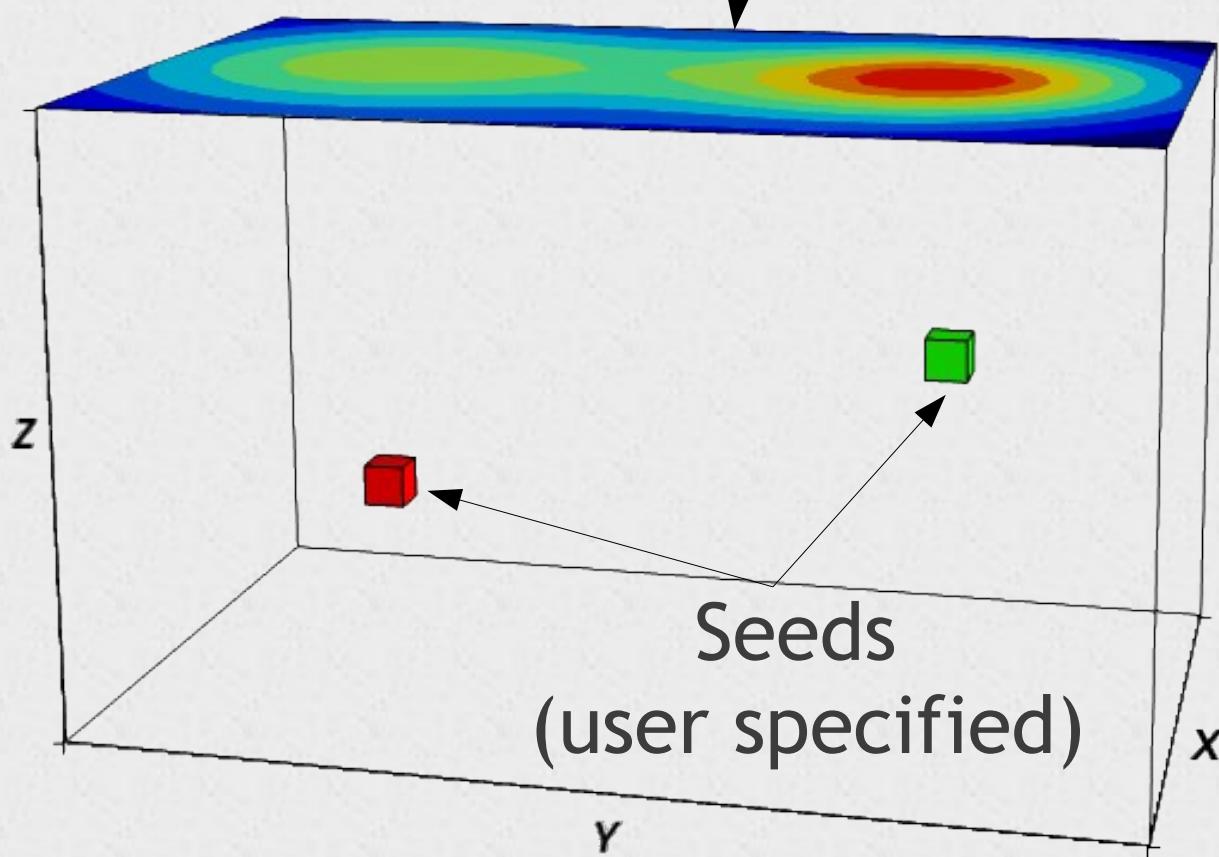
Mesh



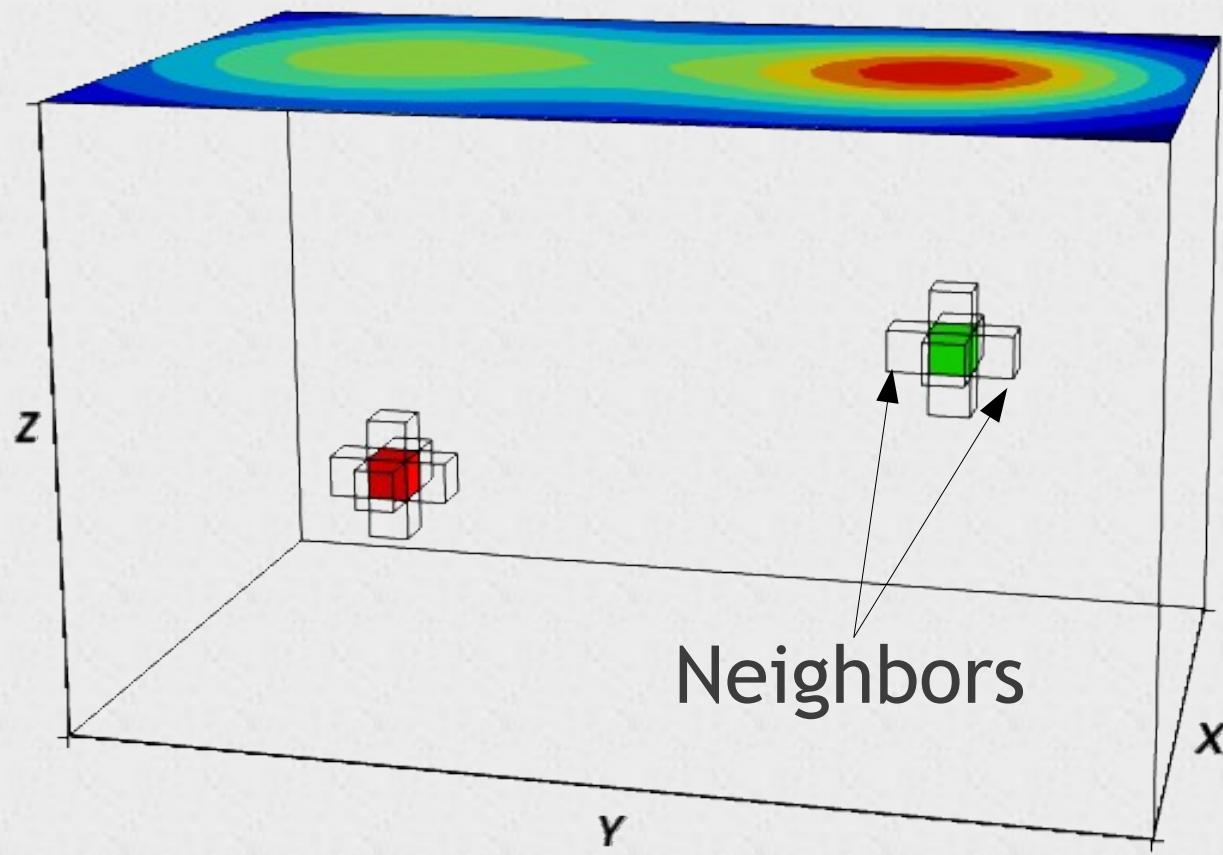
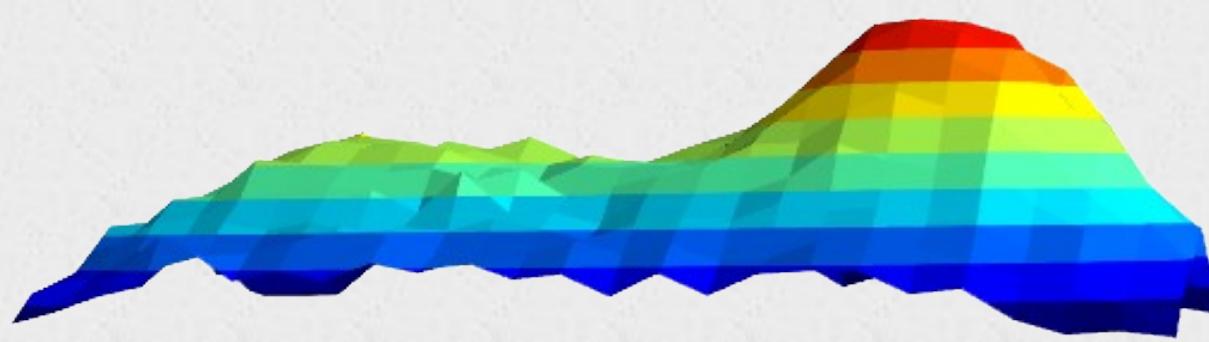




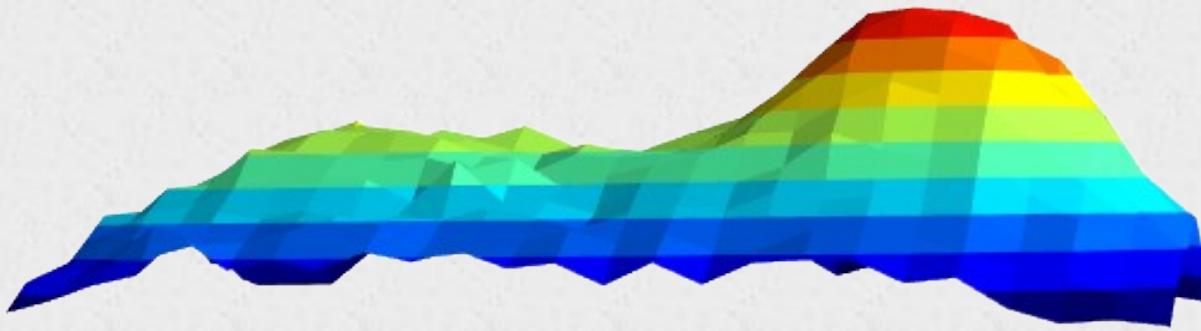
Predicted data



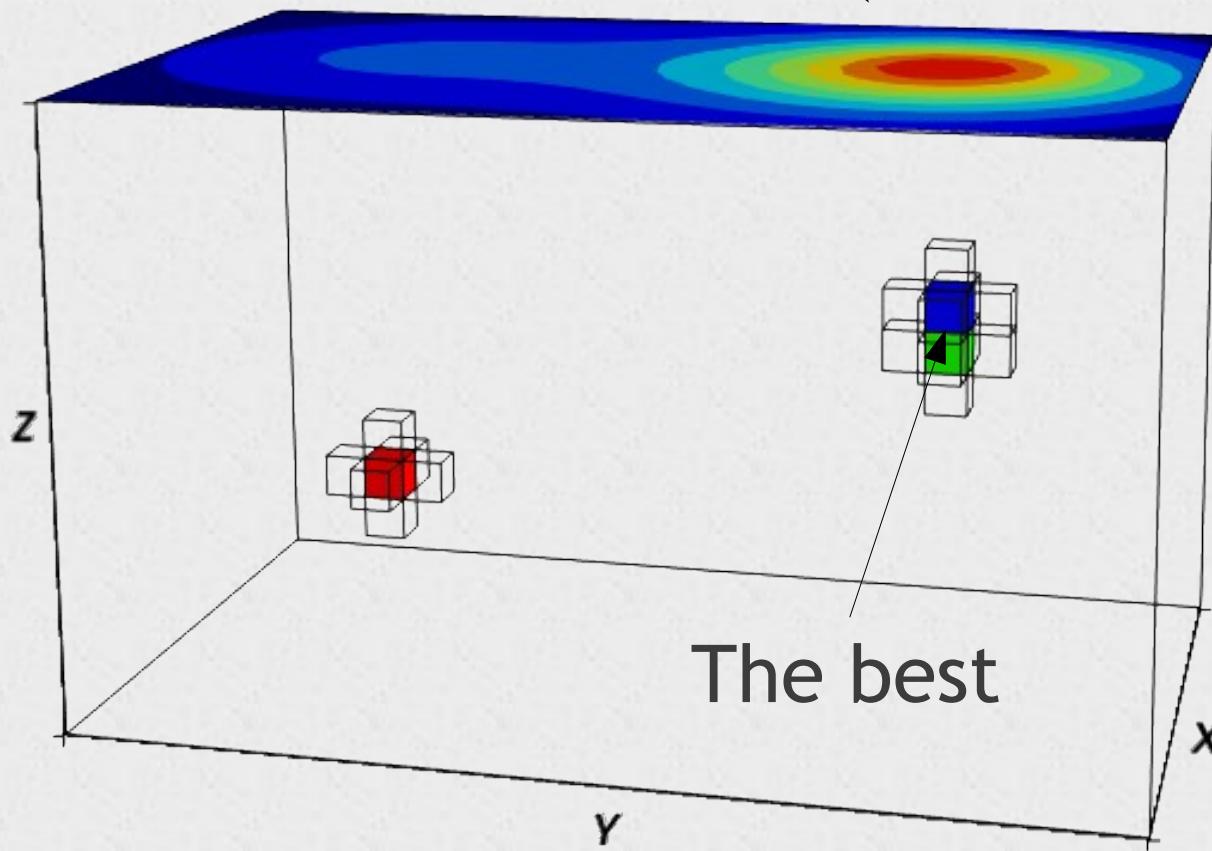
Seeds
(user specified)

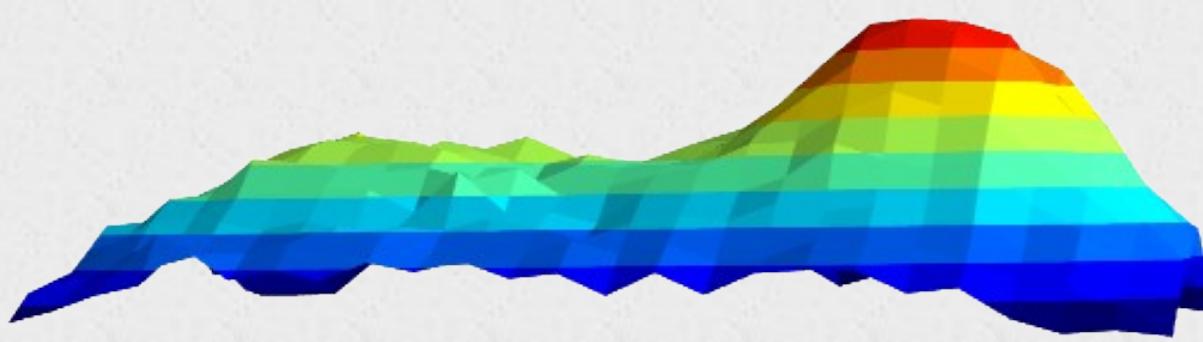


Neighbors

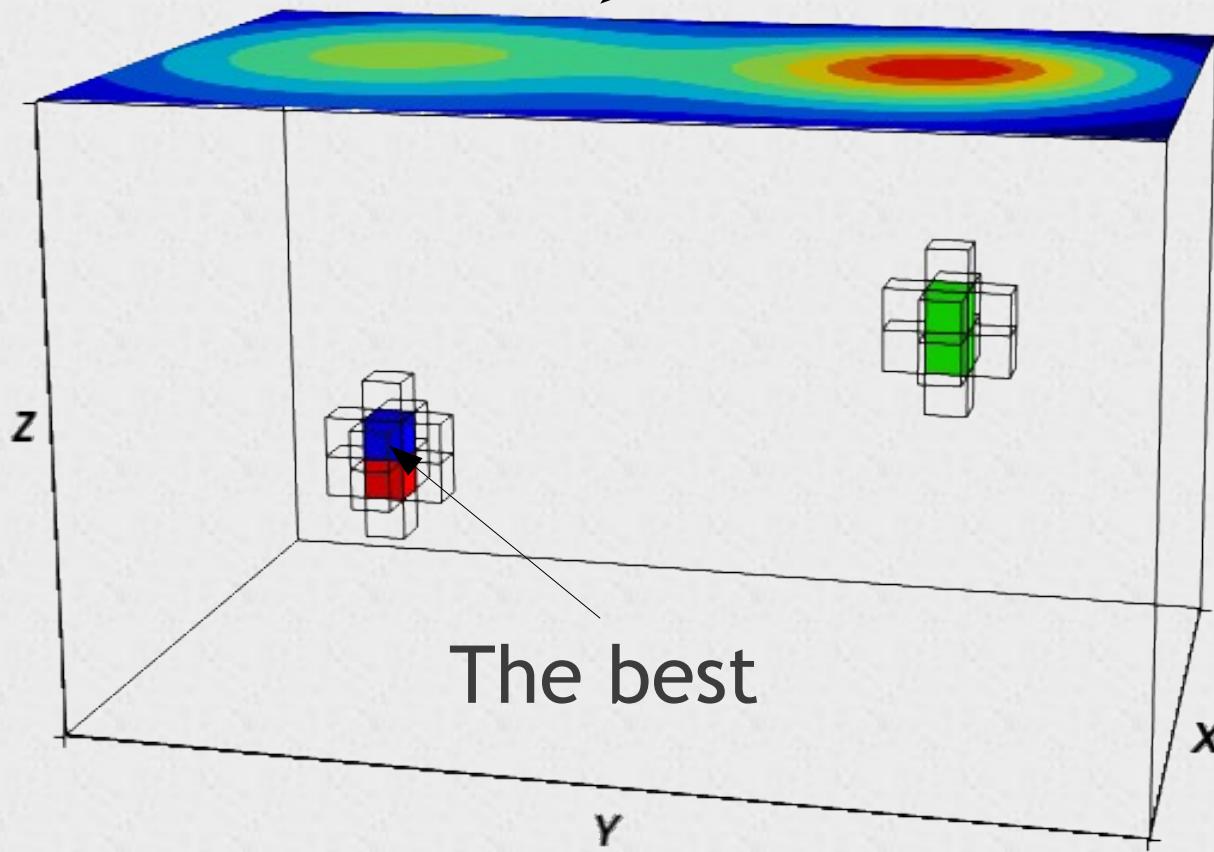


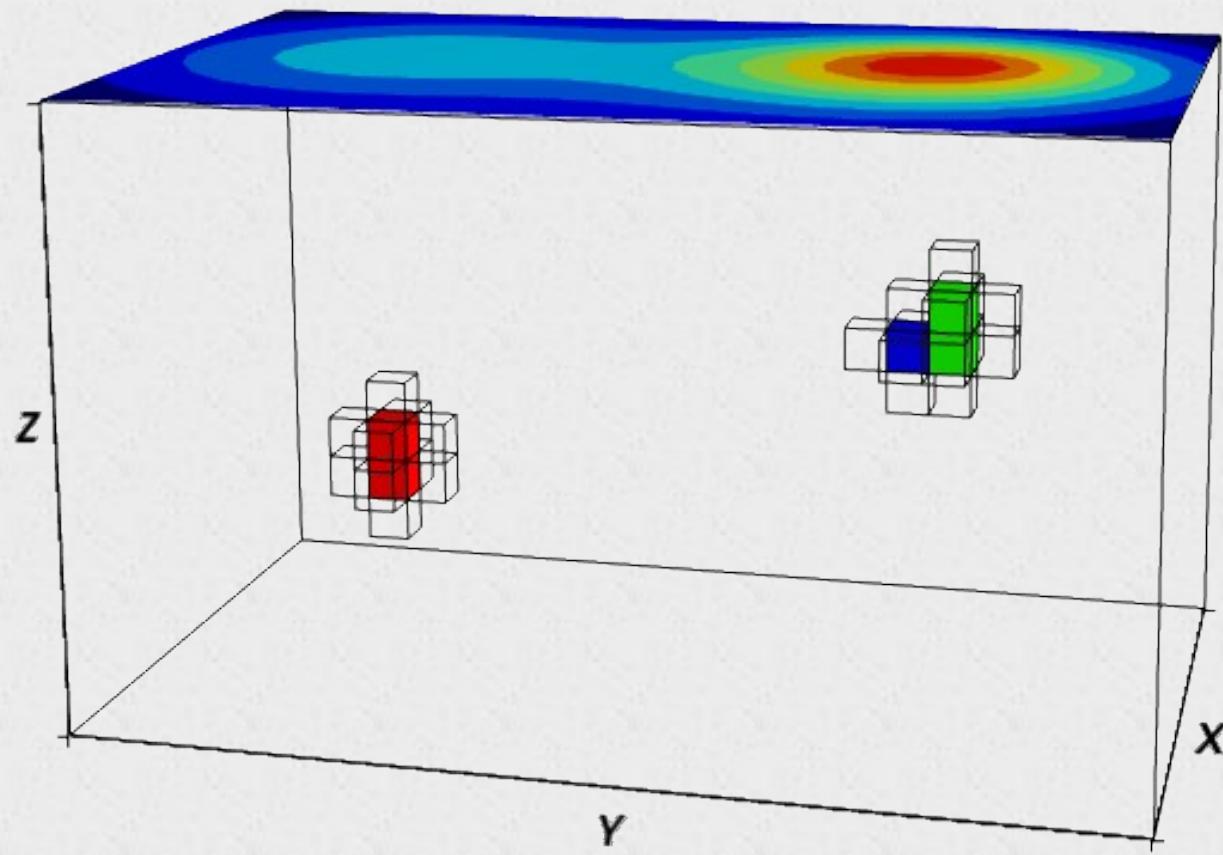
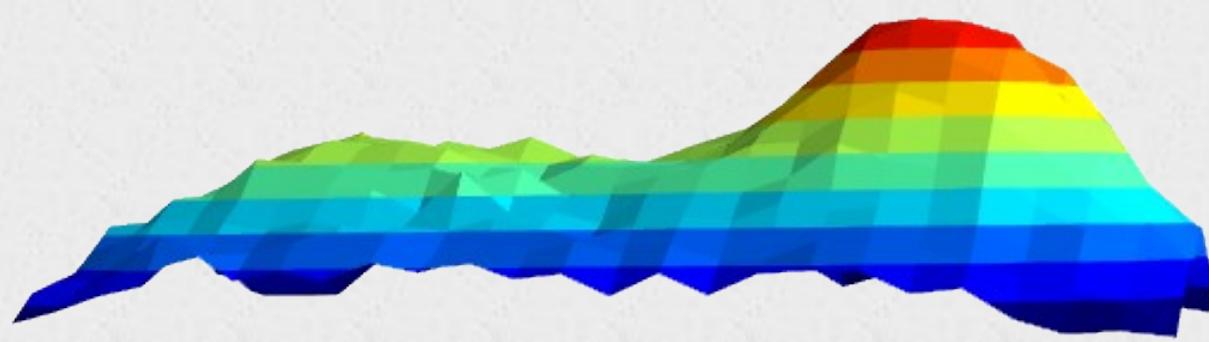
New predicted data

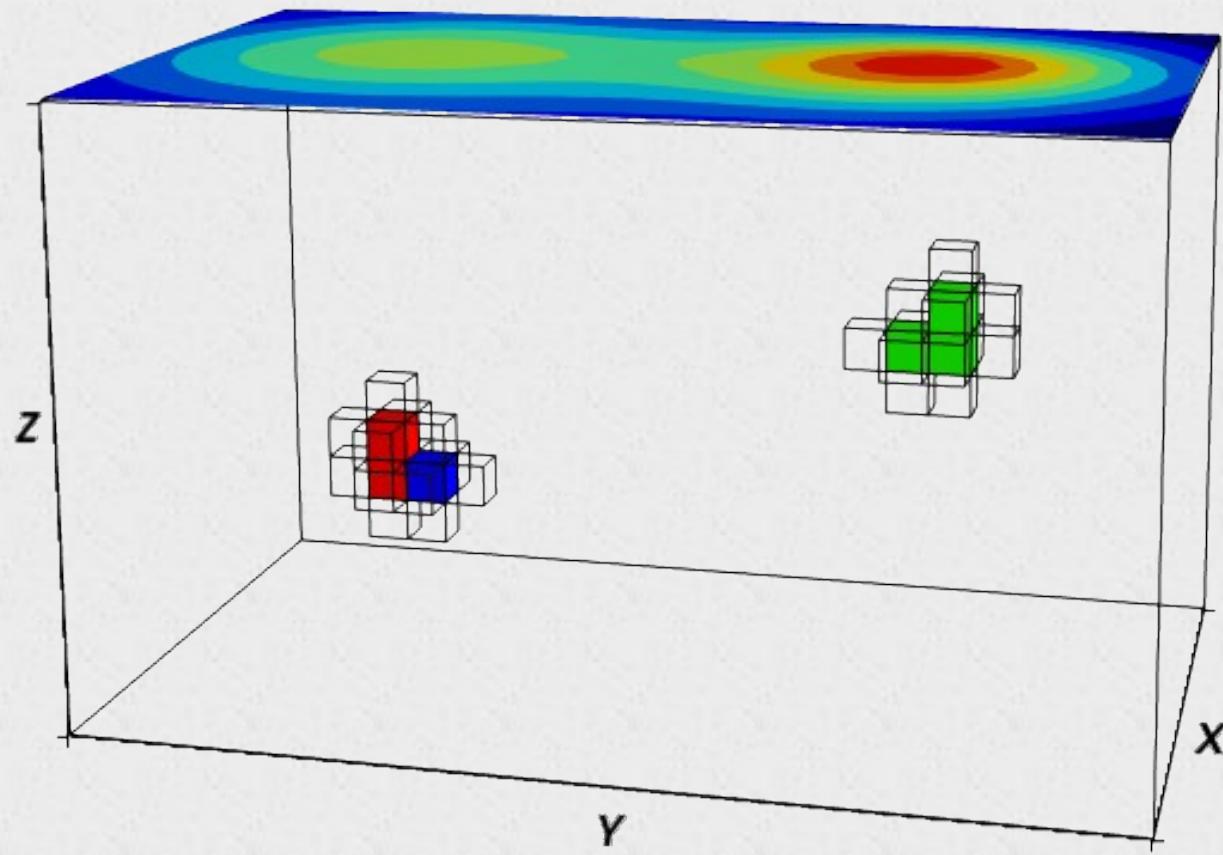
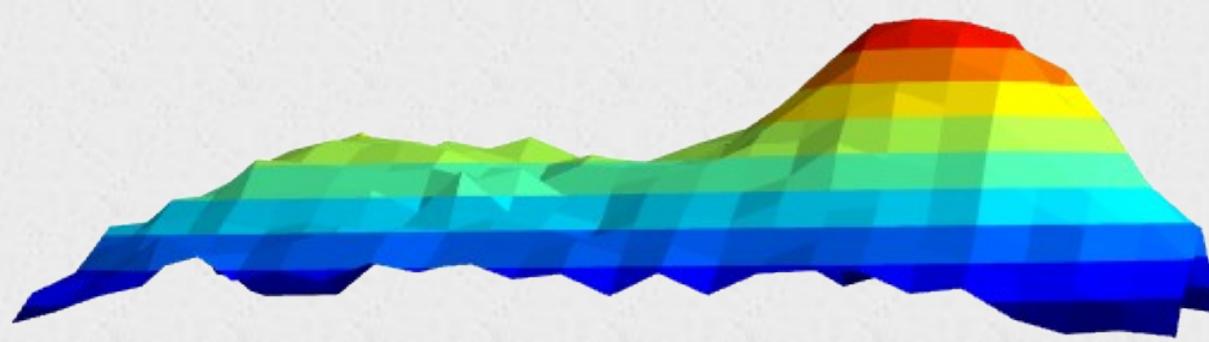


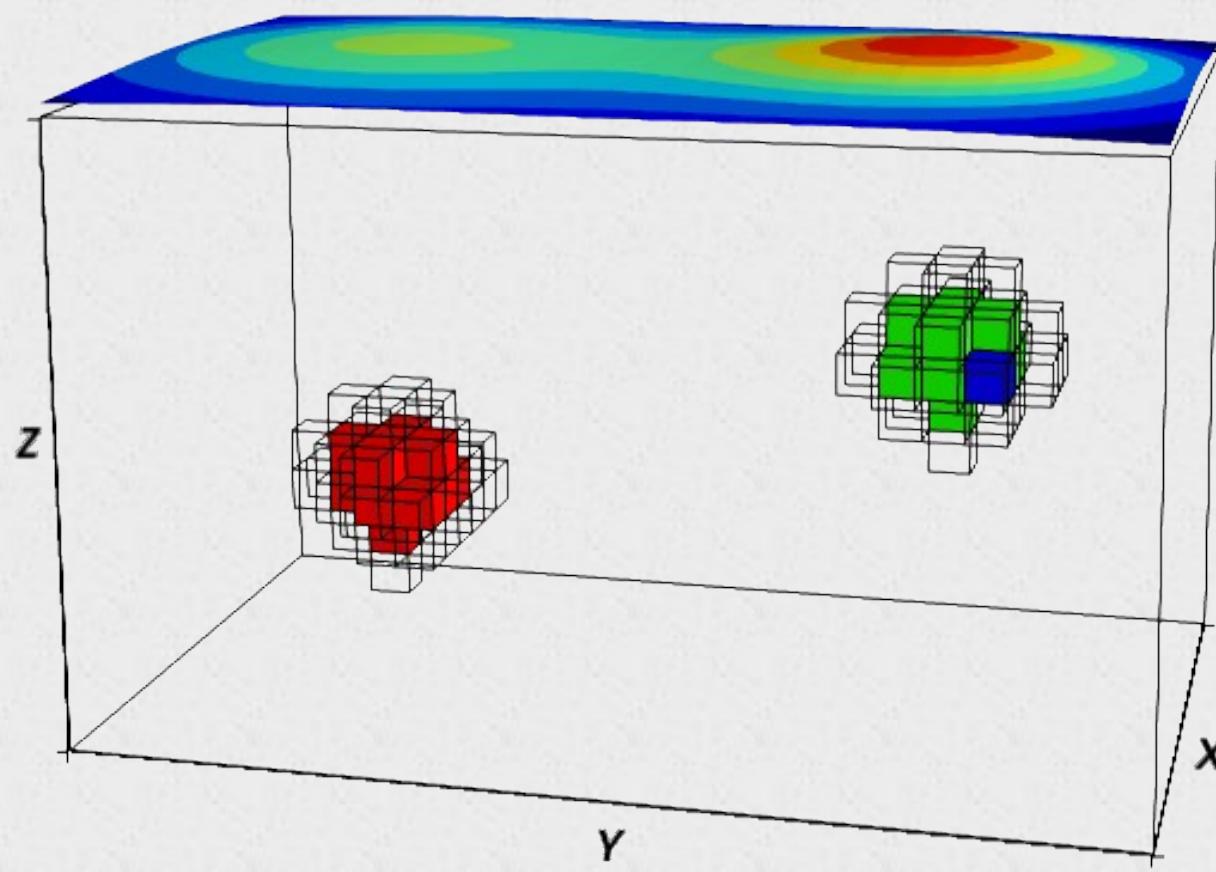
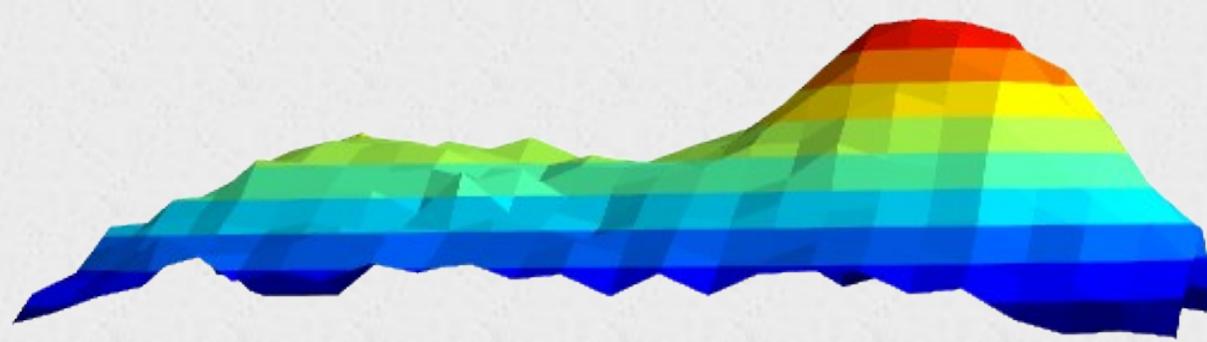


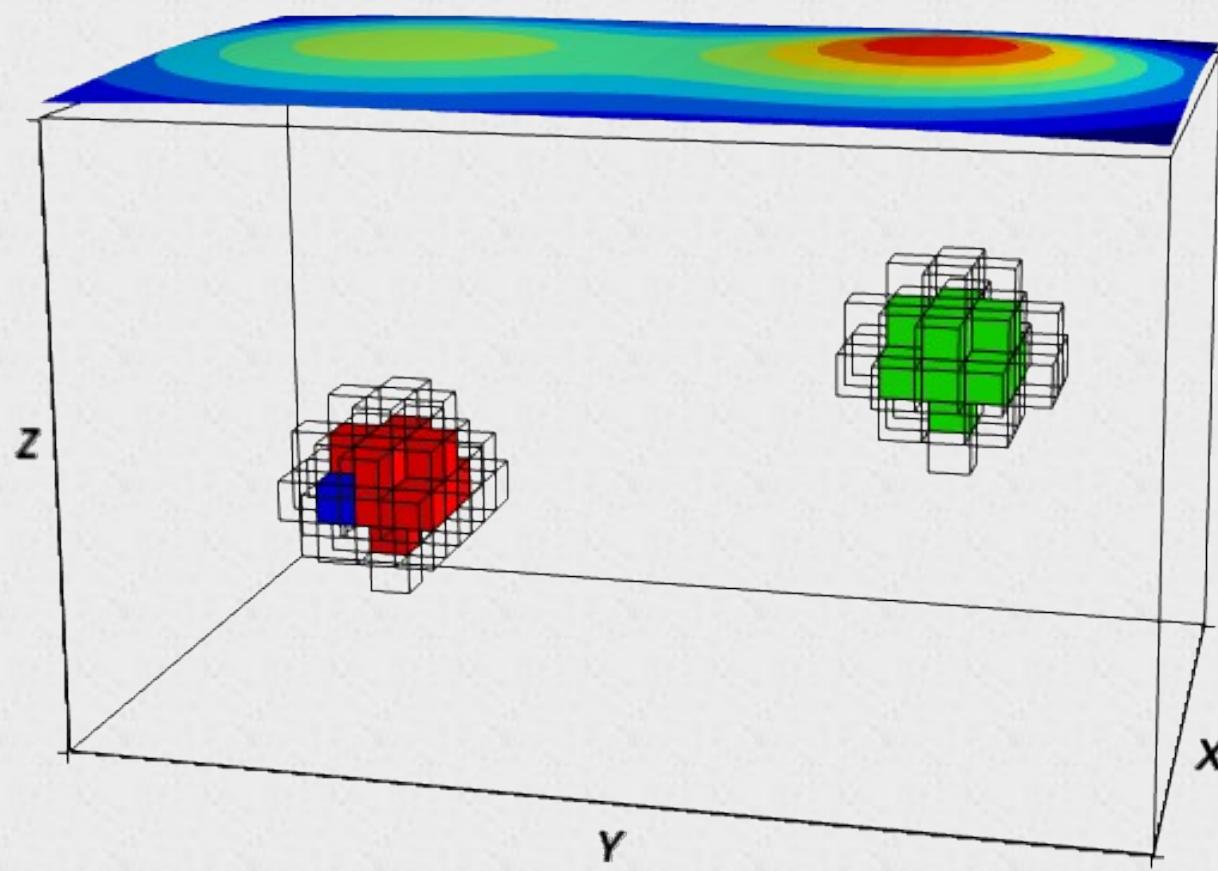
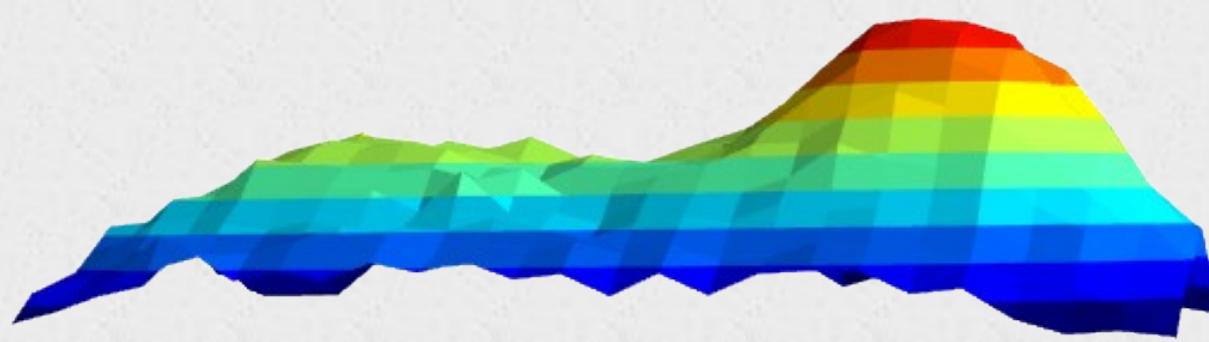
New predicted data

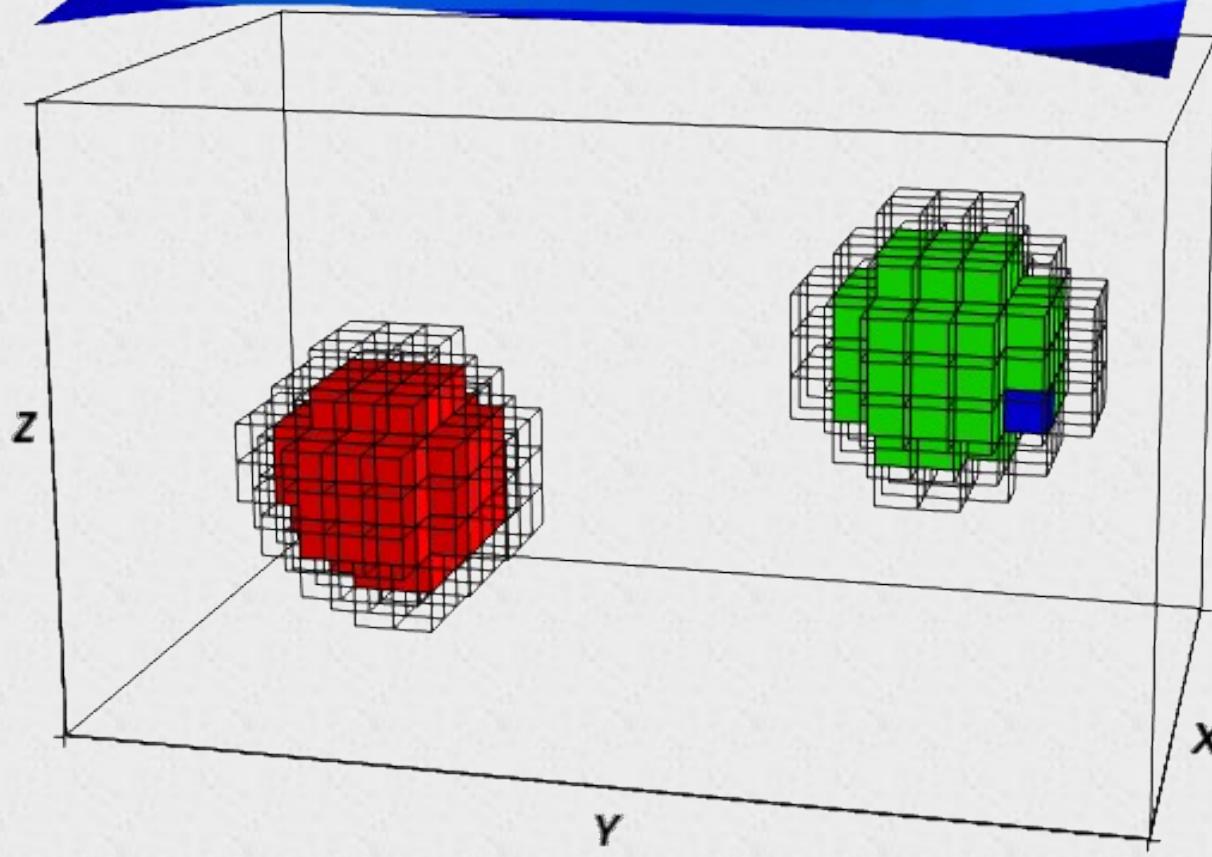
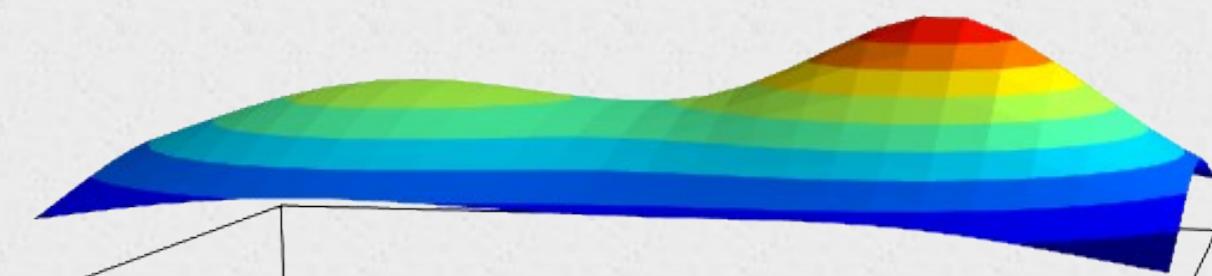
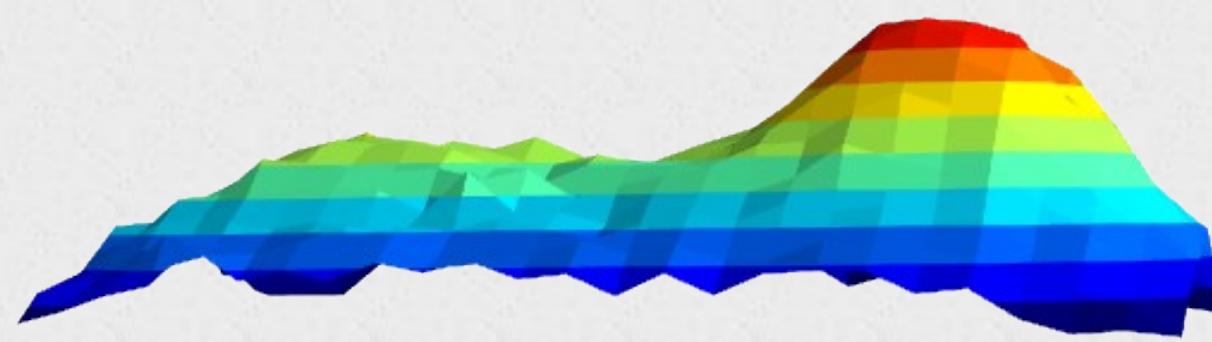


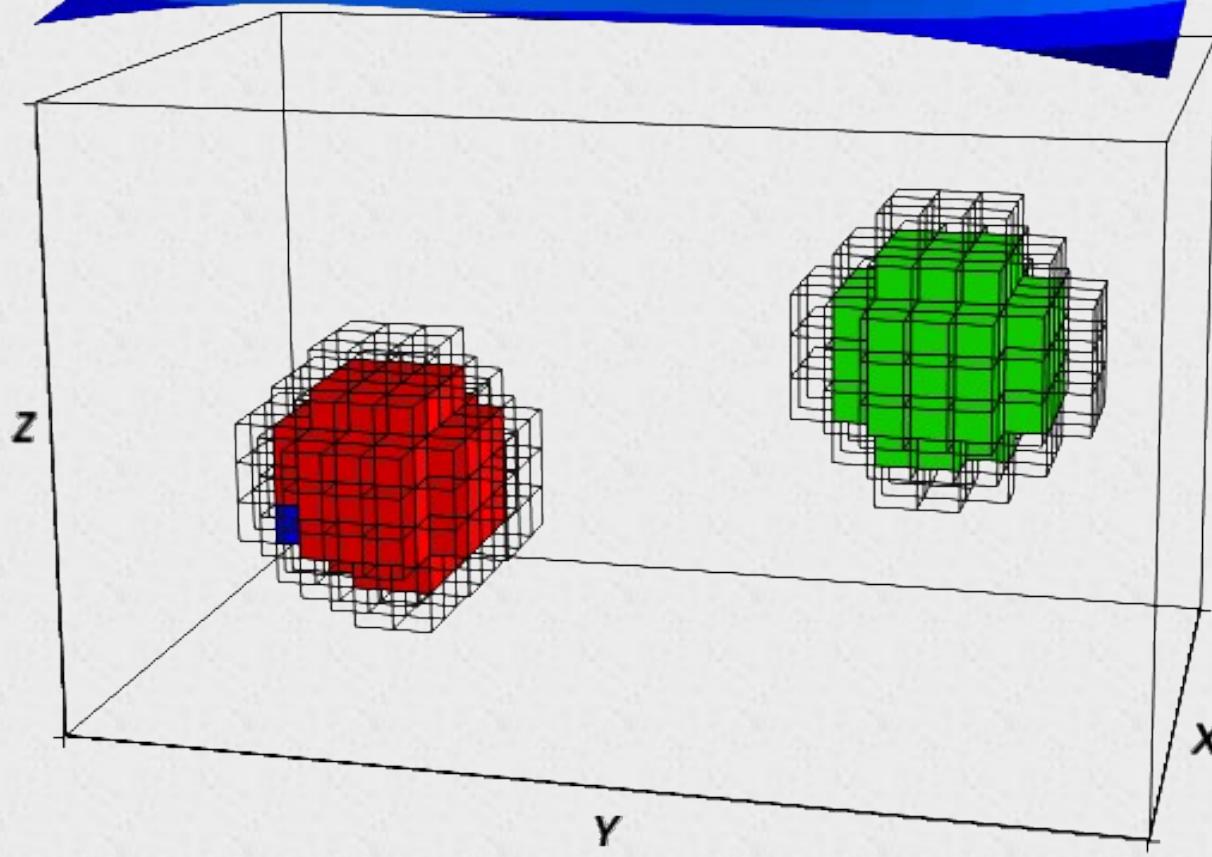
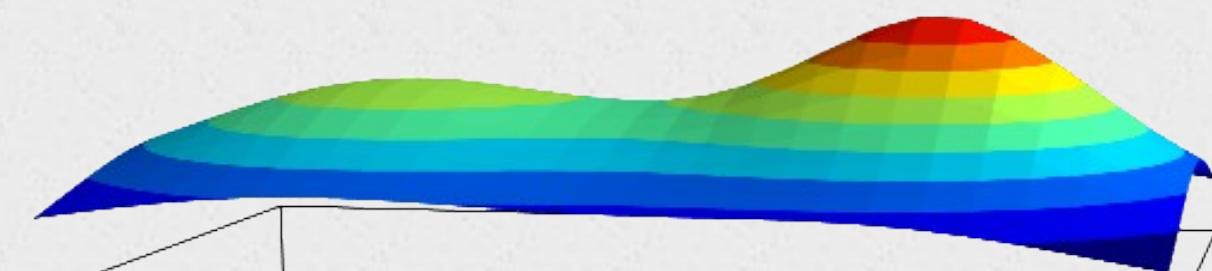
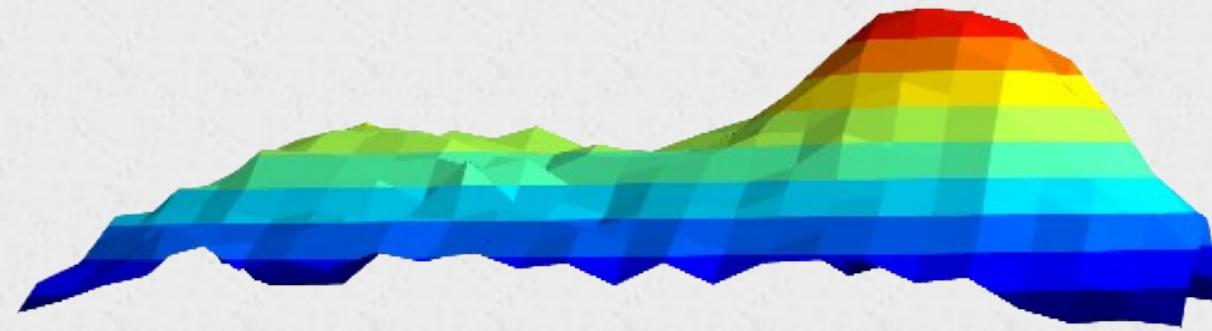


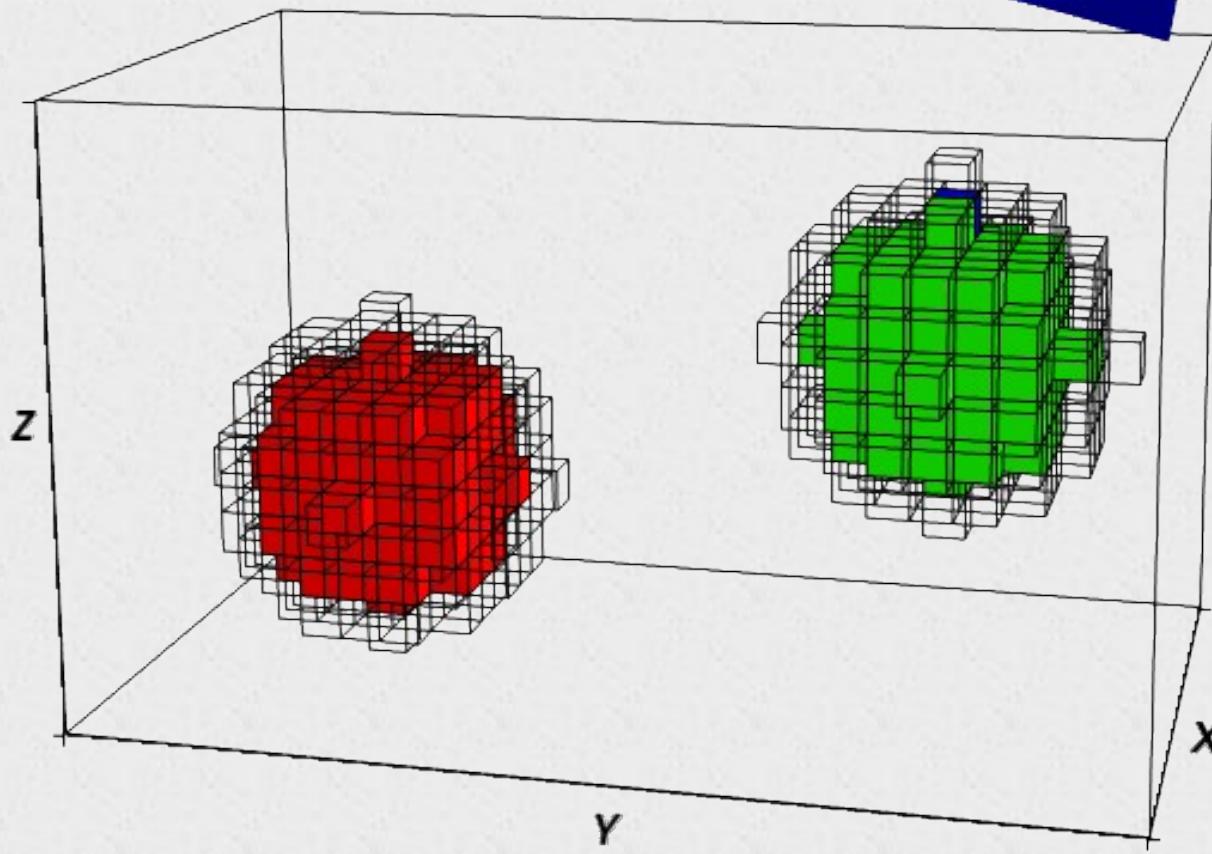
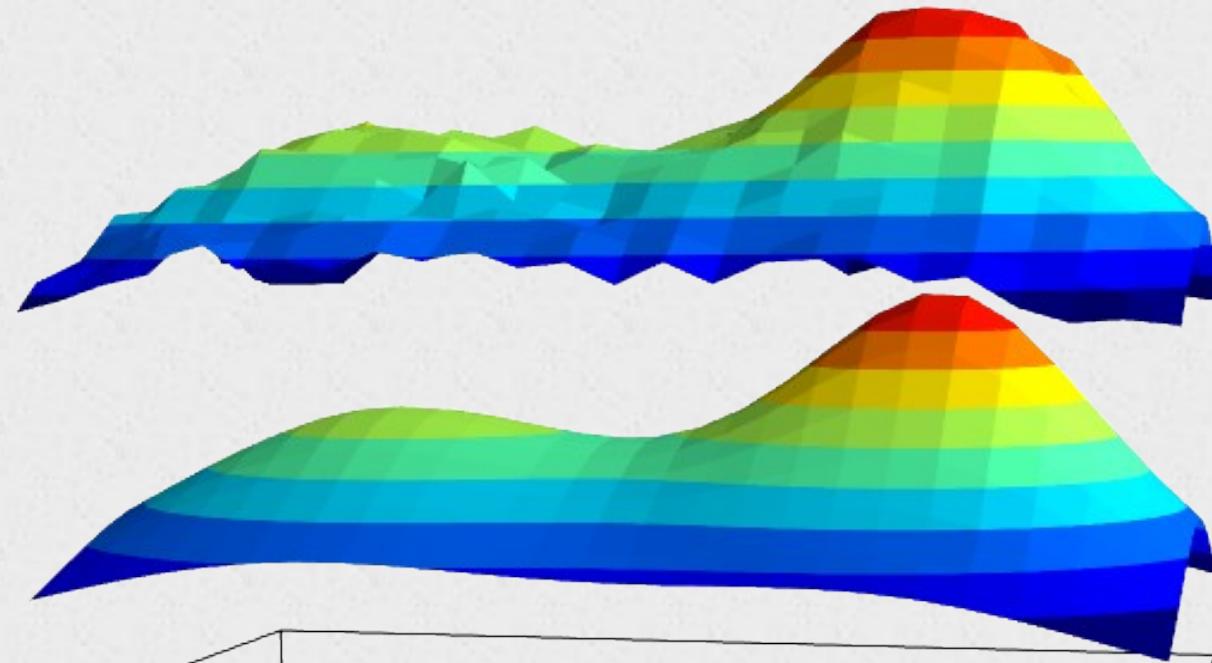


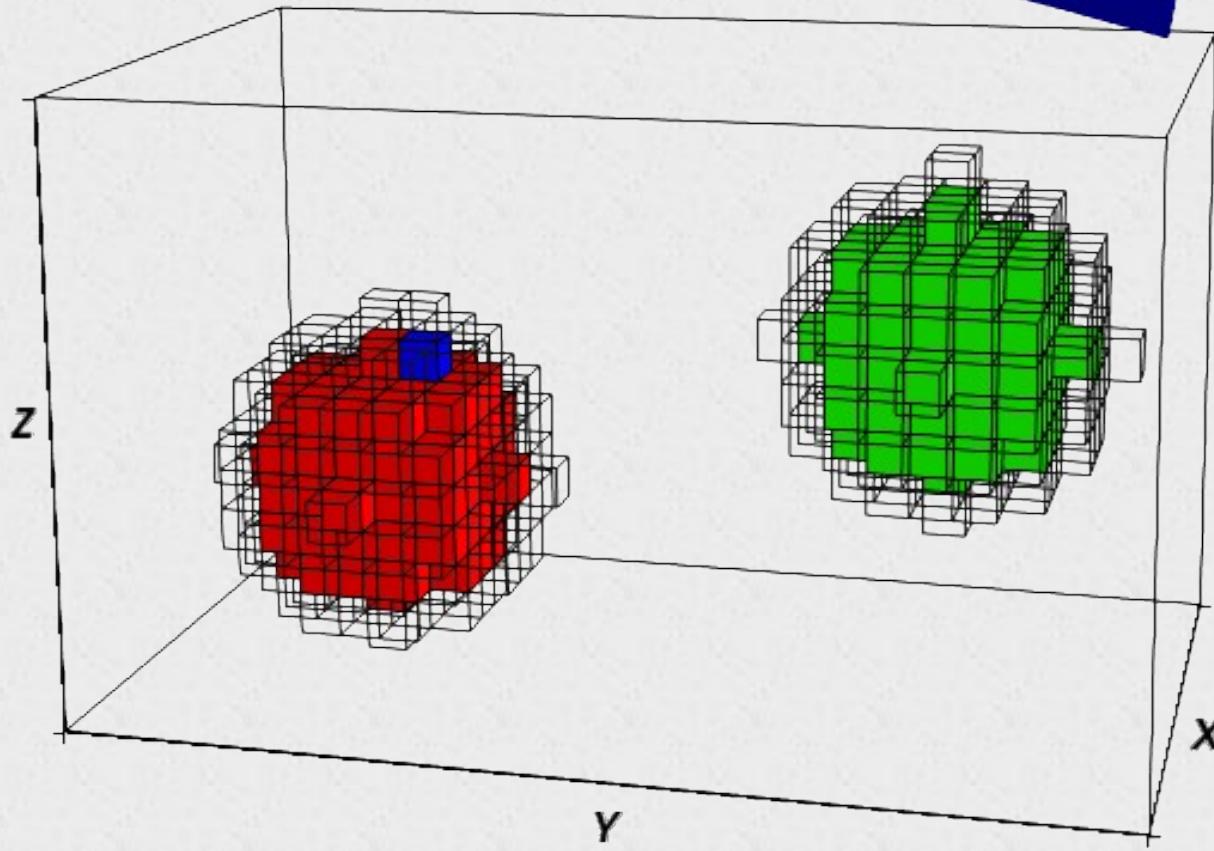
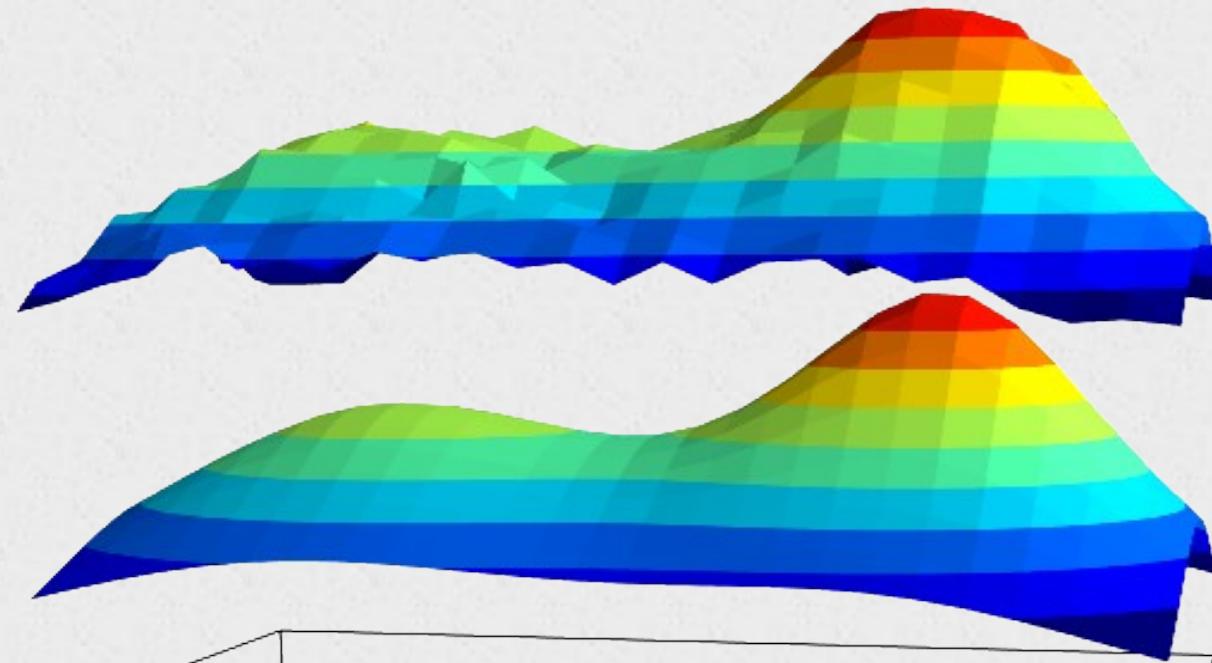




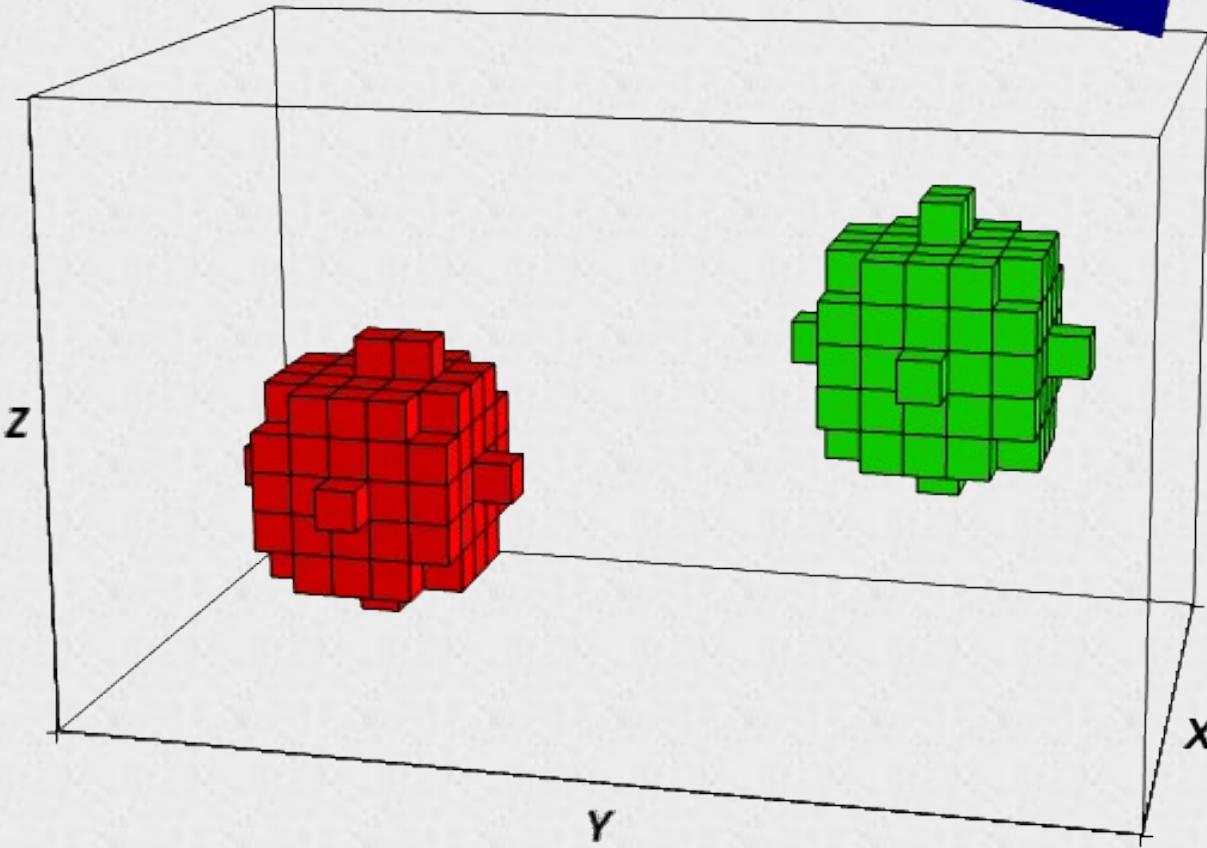








Fit!



Seeds = Skeleton



Inversion → Body



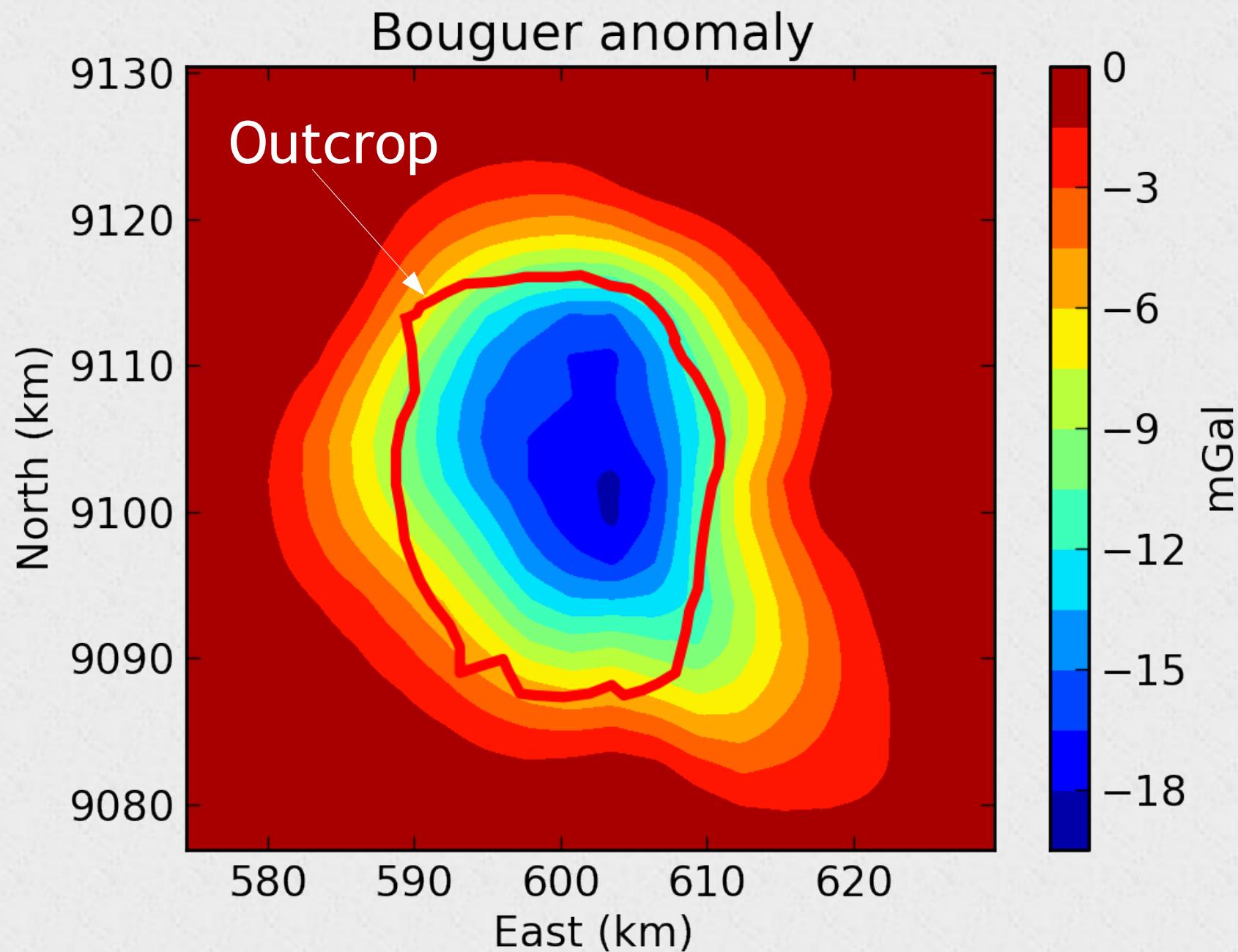
- ✓ Control
- ✓ Prior information
- ✓ Speed
- ✓ Automatic fit
- ✓ 3D (only need skeleton)
- ✓ Gravity + Gradients

Seeds

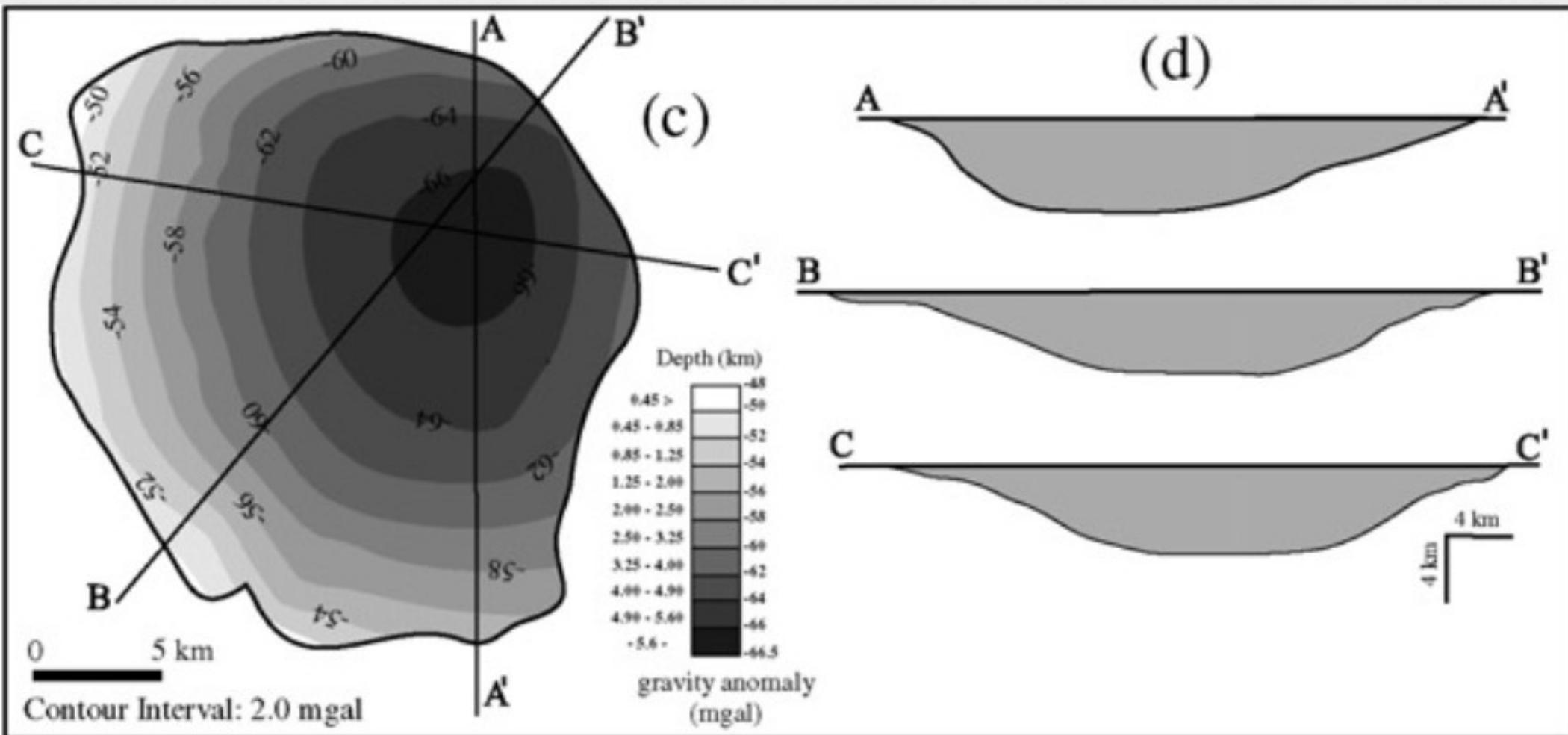


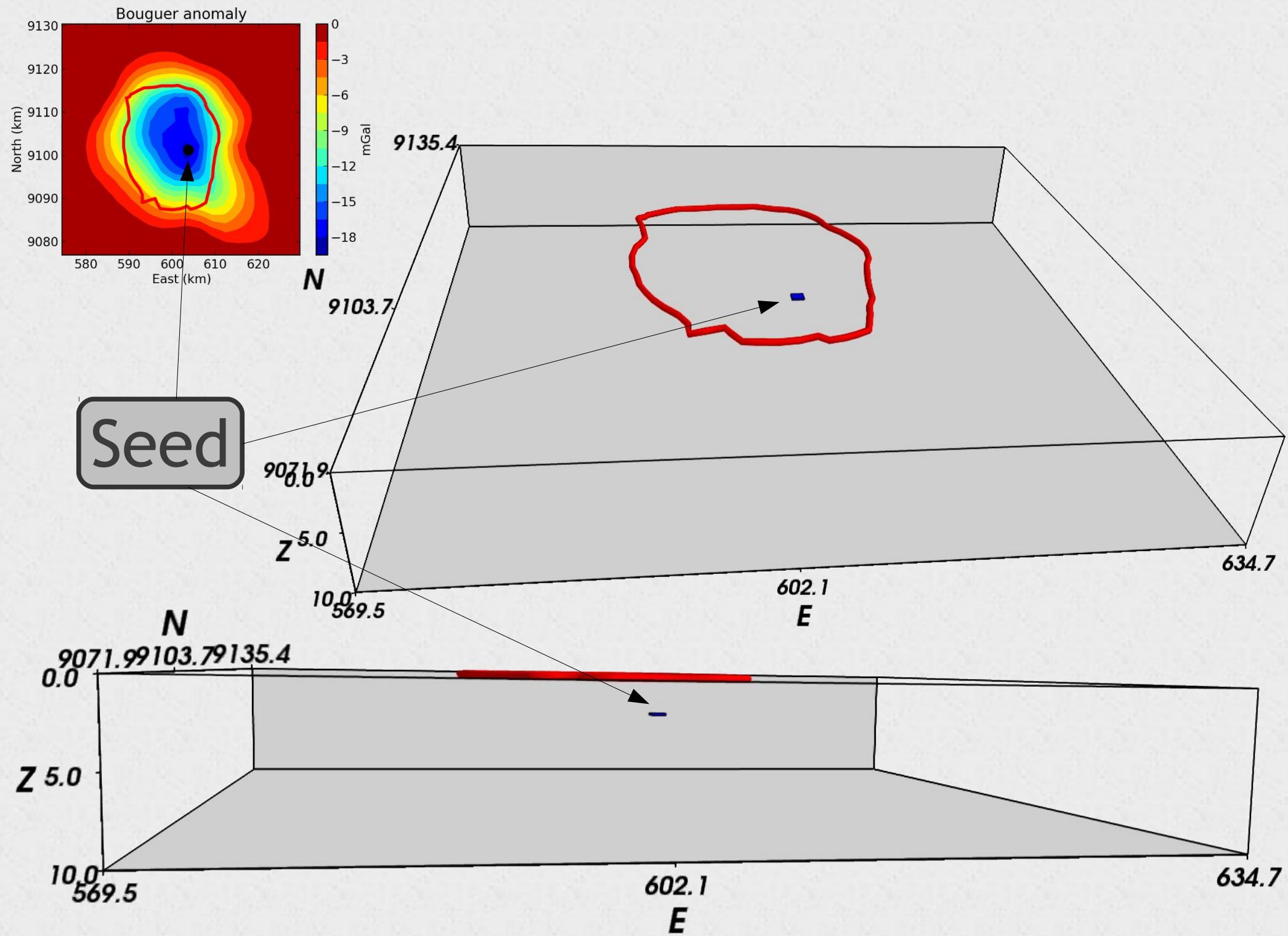
Example applications

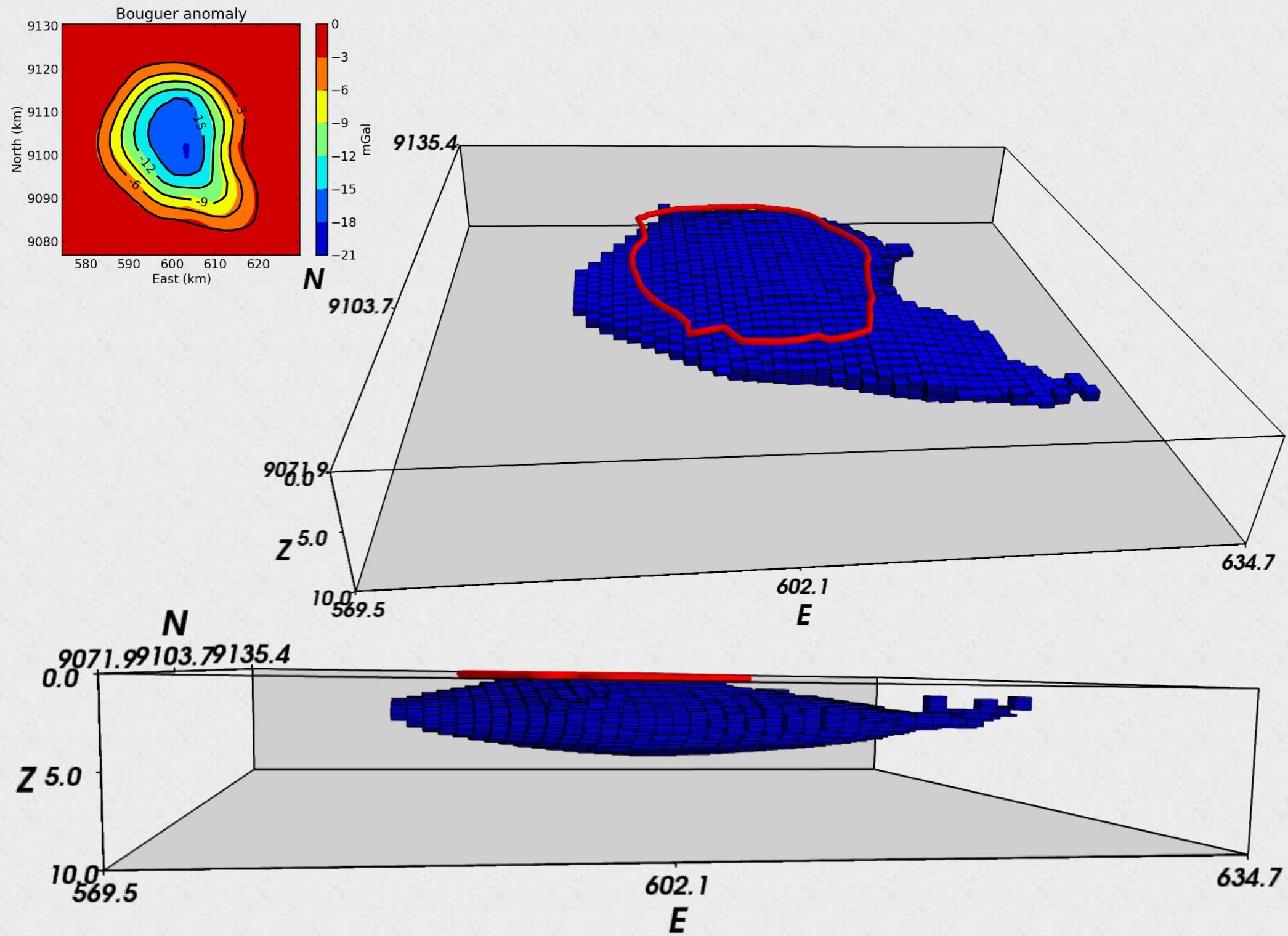
Redenção granite



Oliveira et al. (2008)

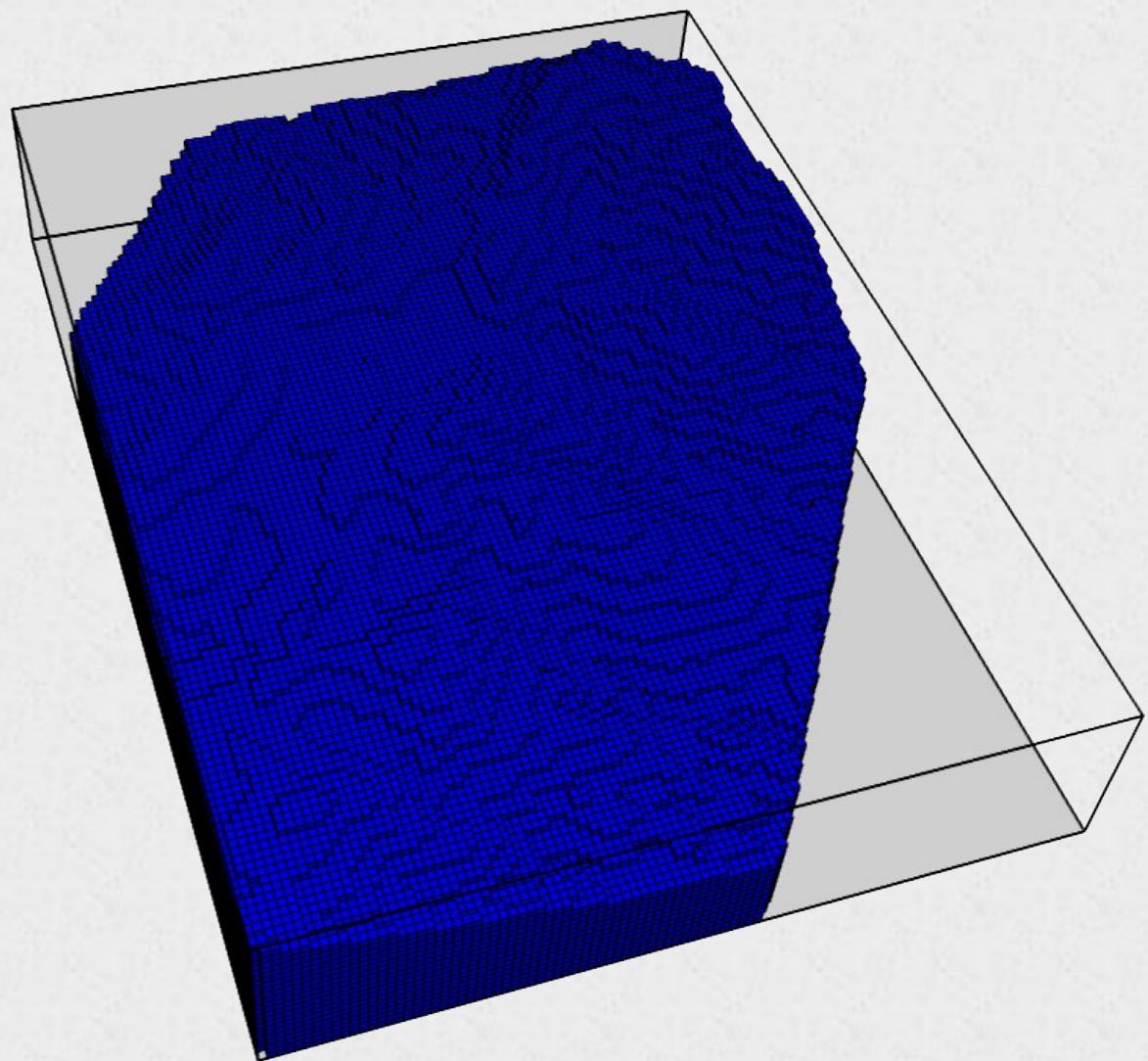
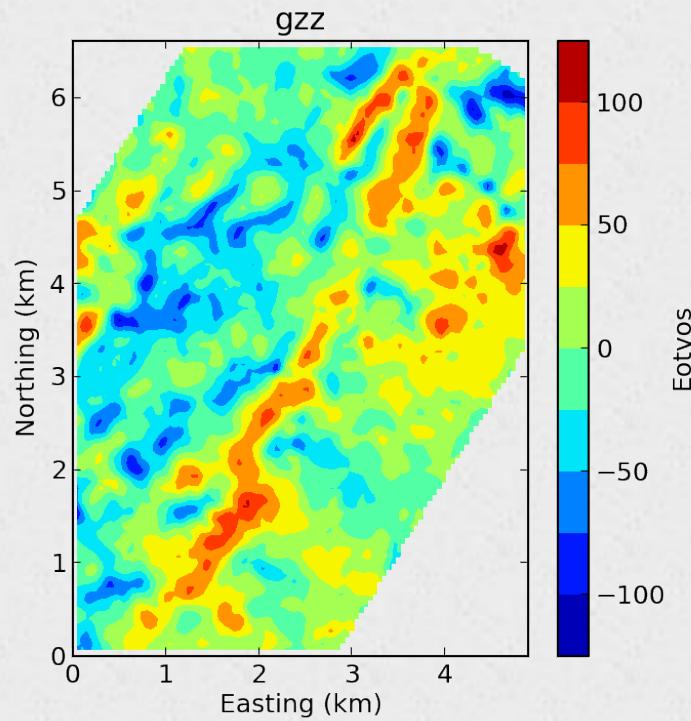
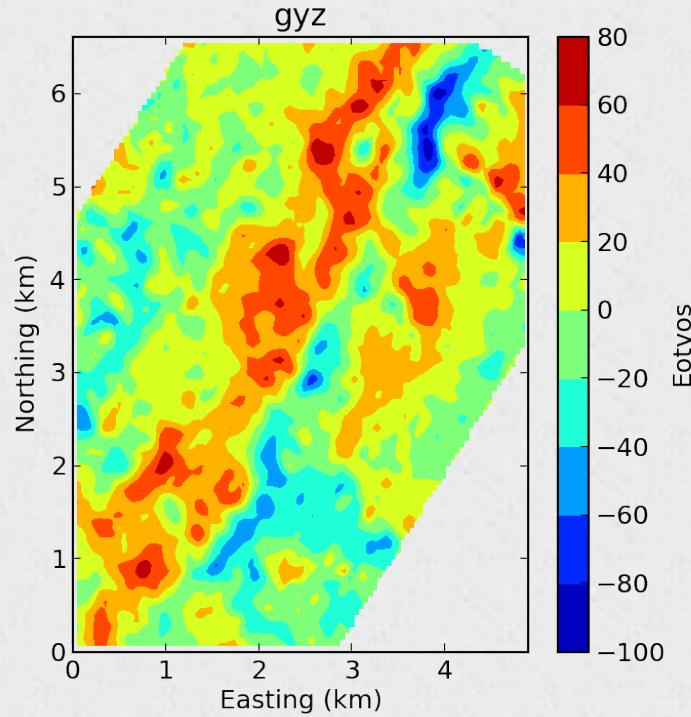




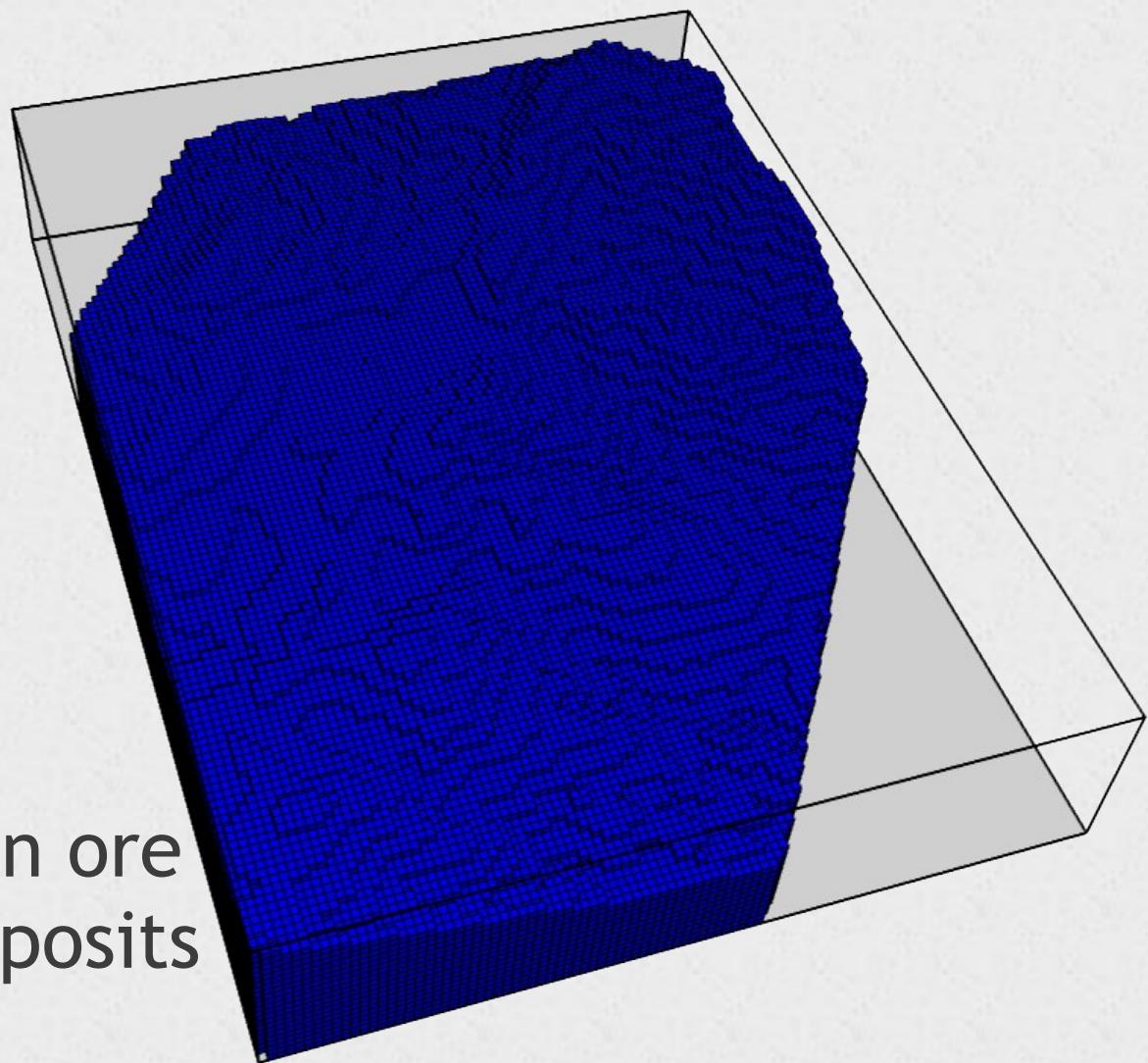
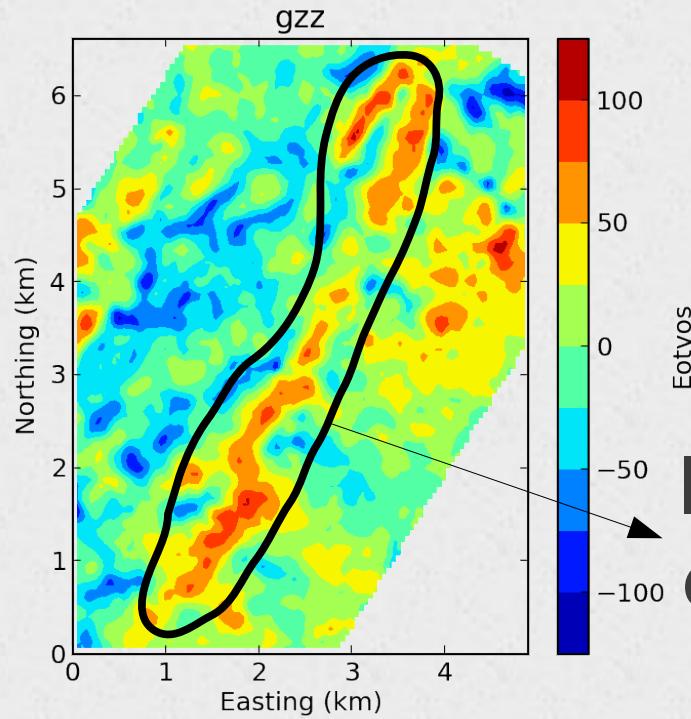
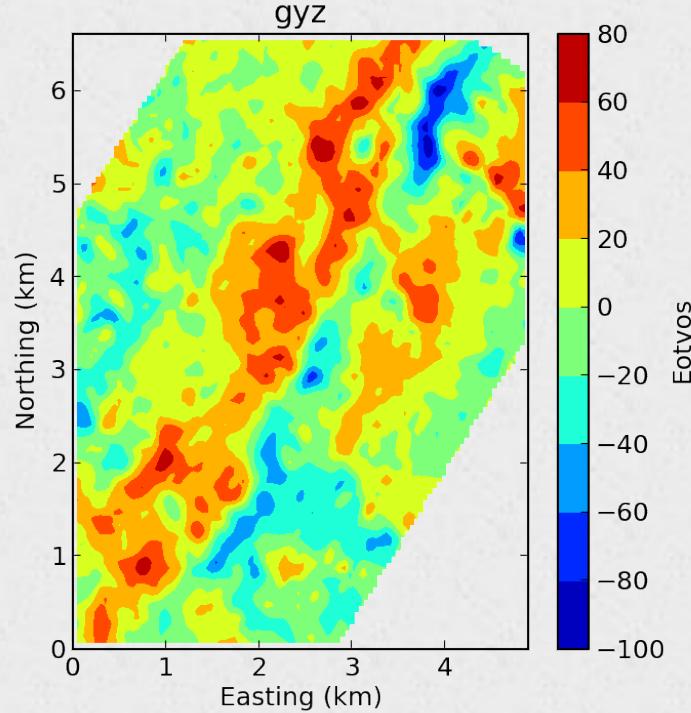


Quadrilátero Ferrífero

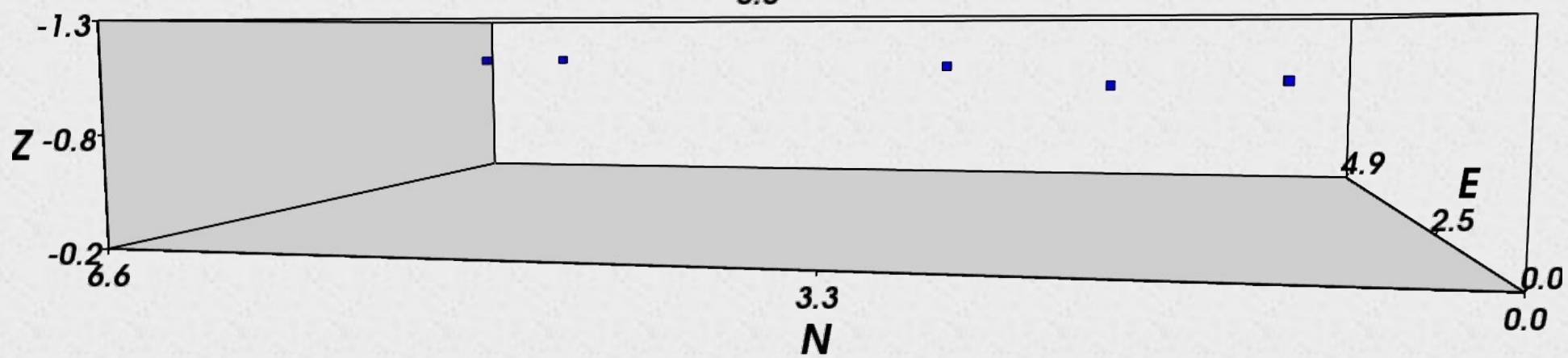
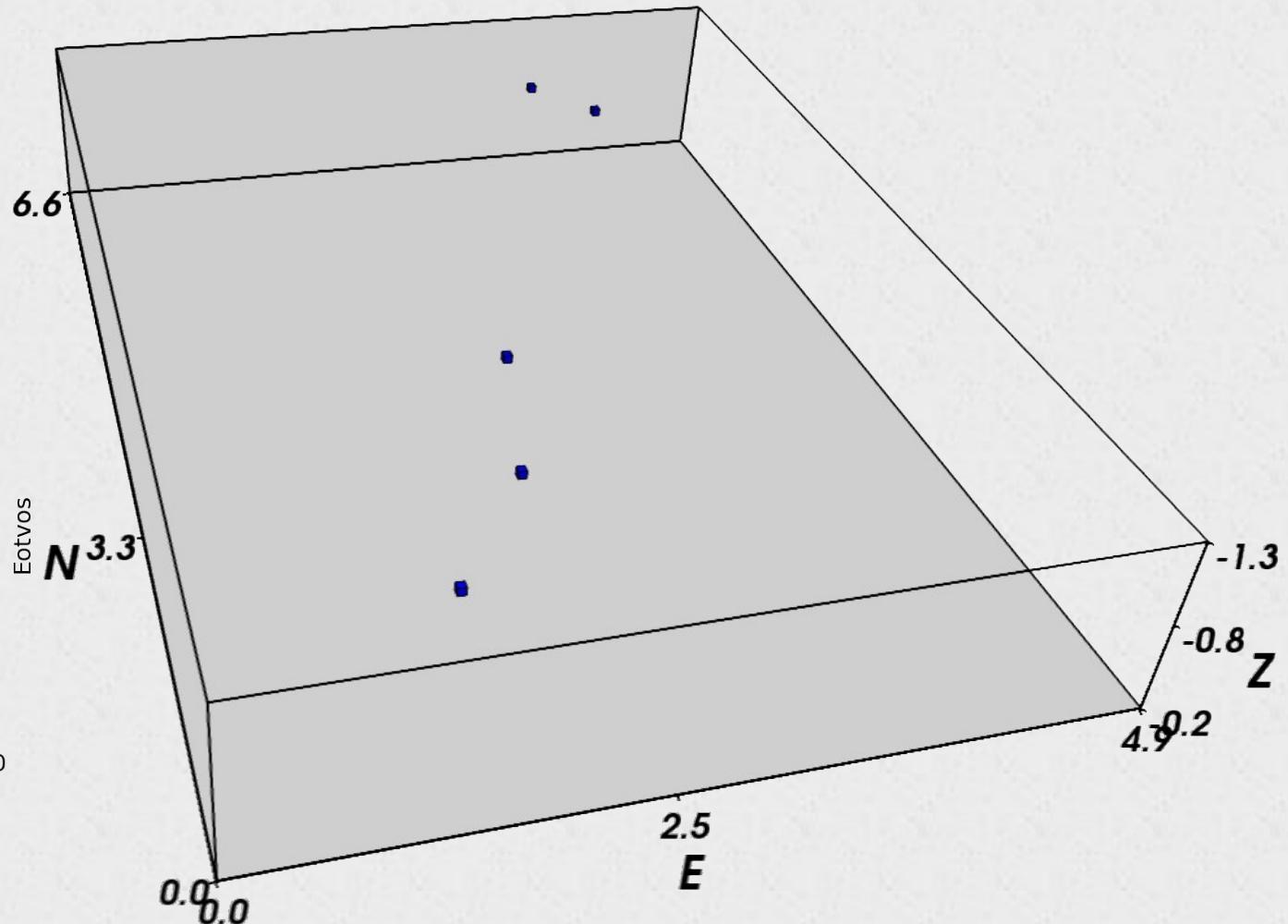
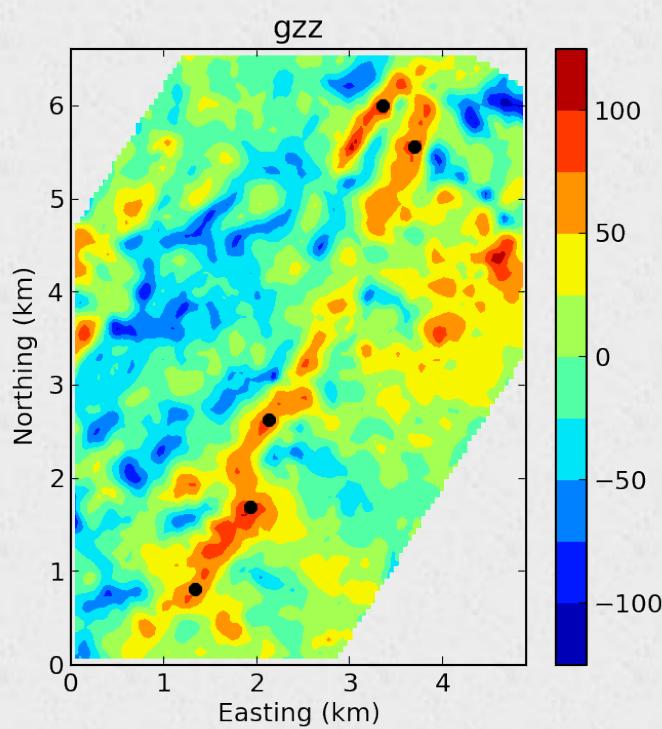
Complex geology and topography

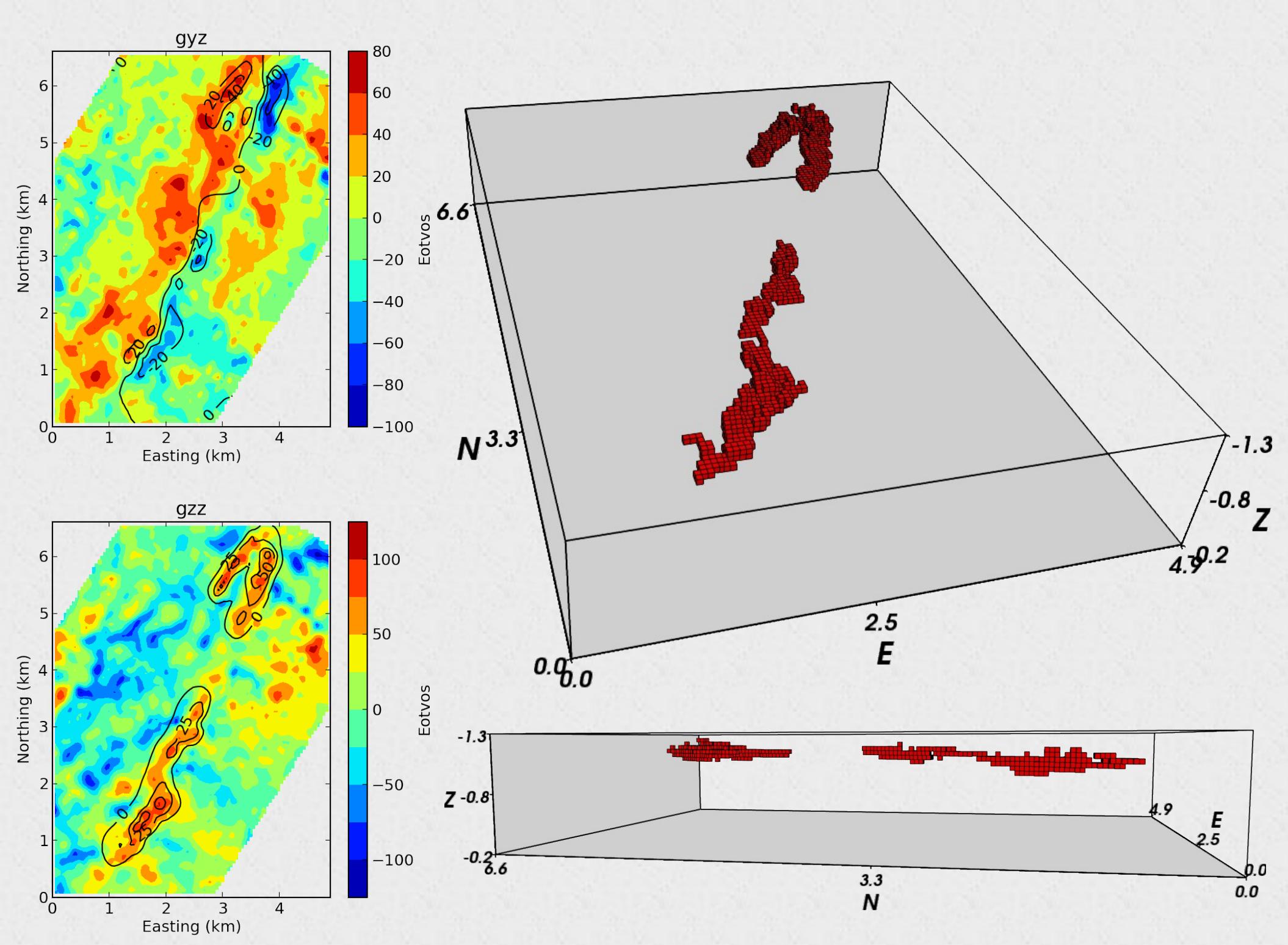


Complex geology and topography



Seeds



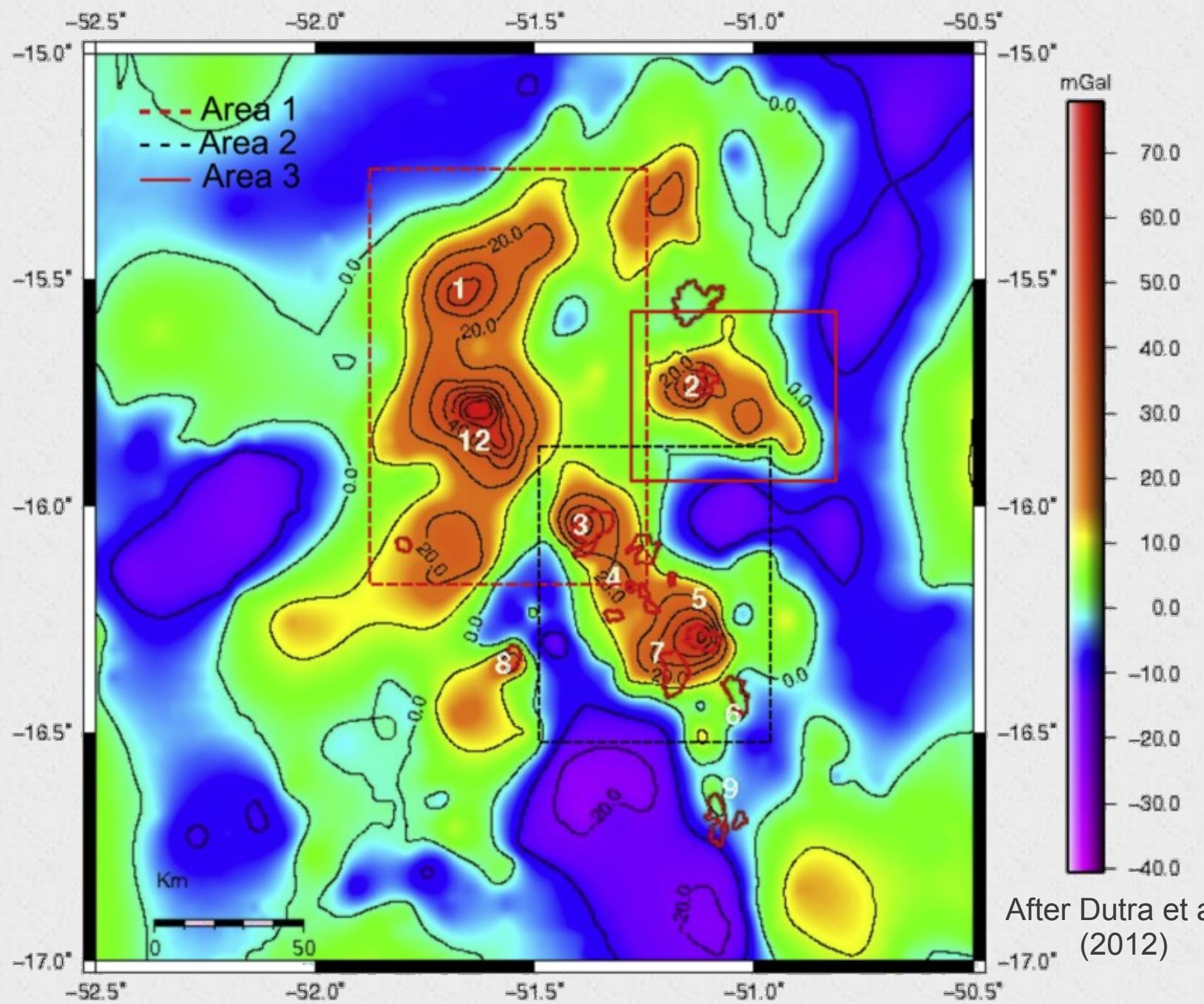


Hypothesis testing

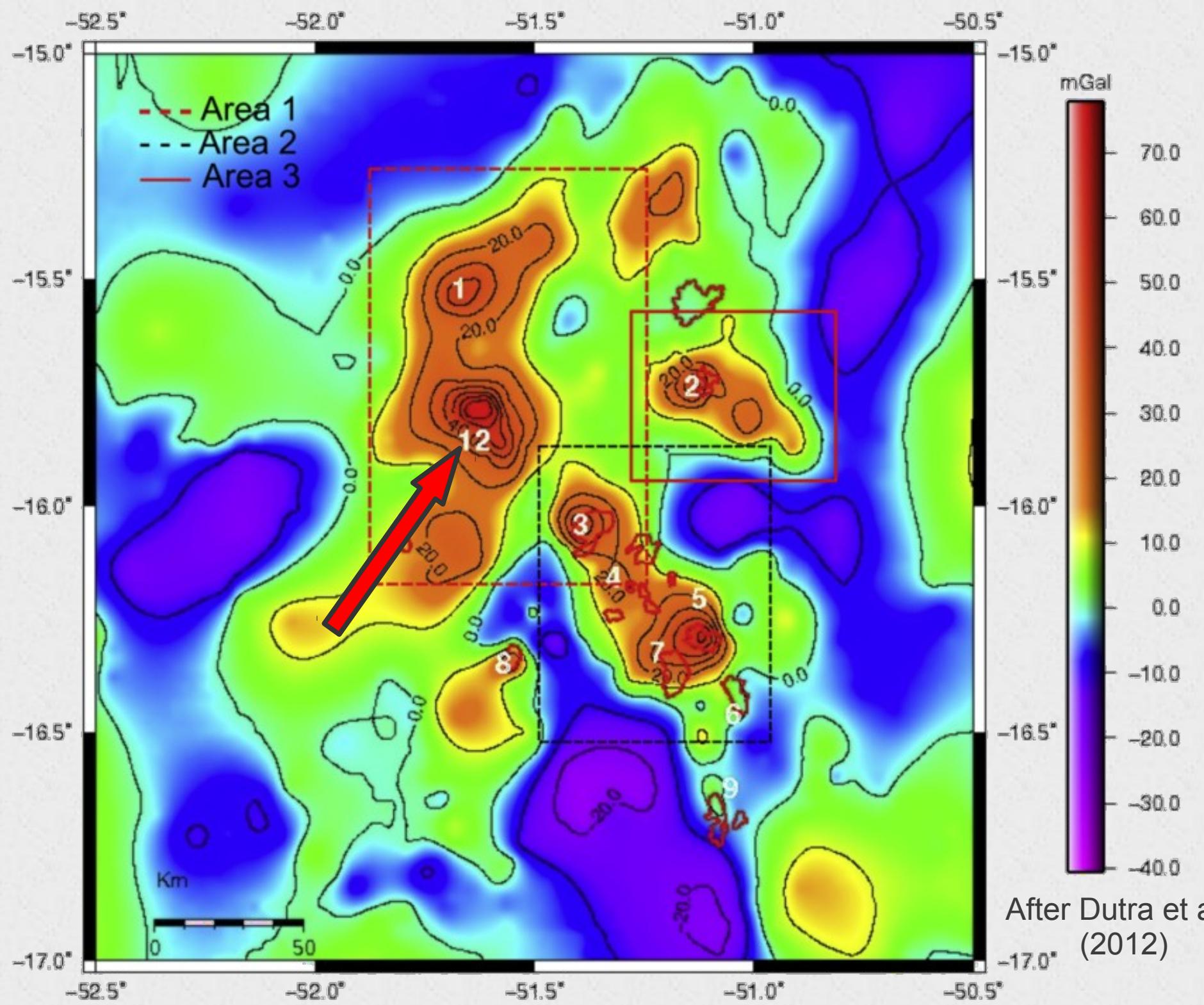
Registro do Araguaia
intrusion

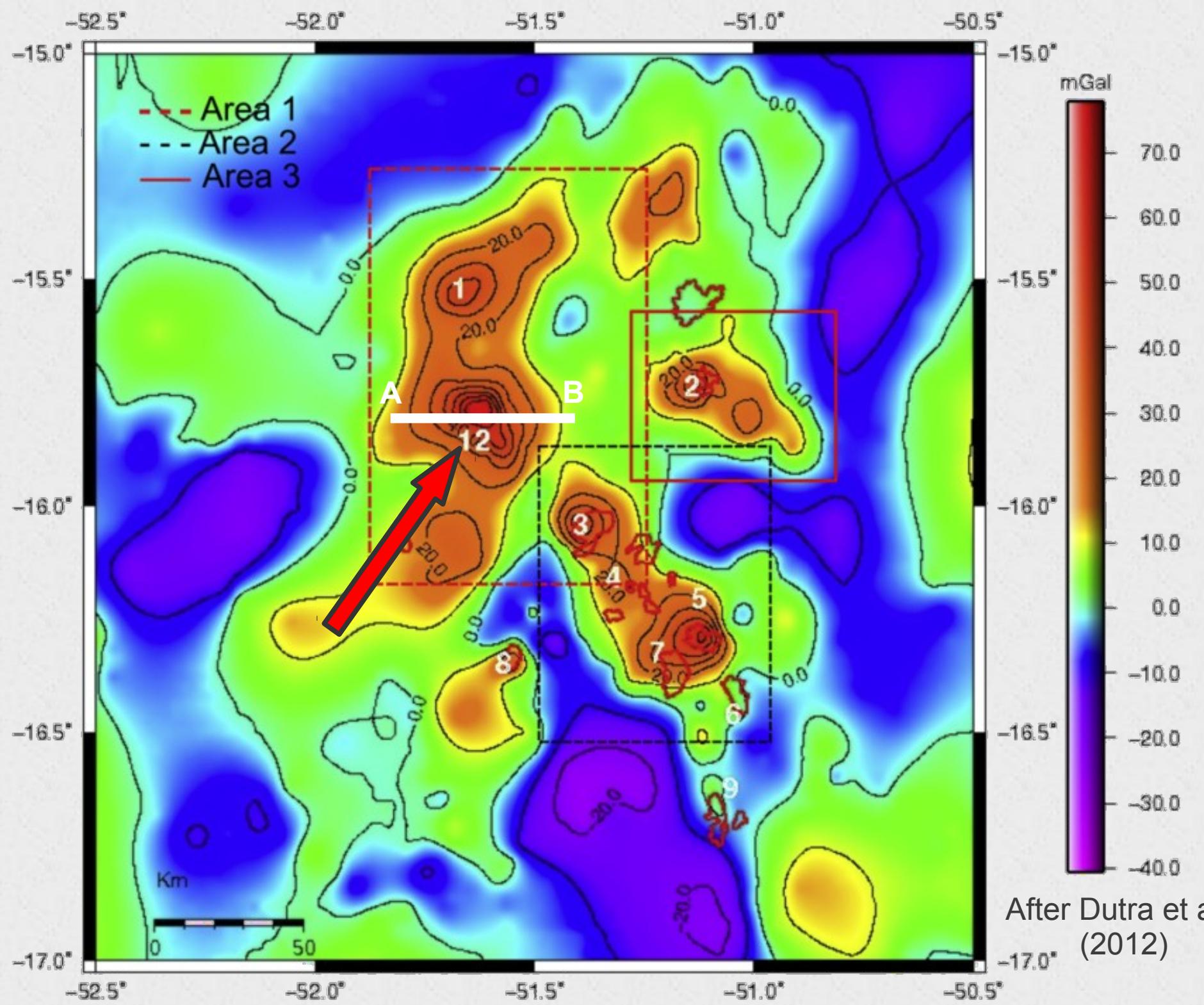
Registro do araguaia

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

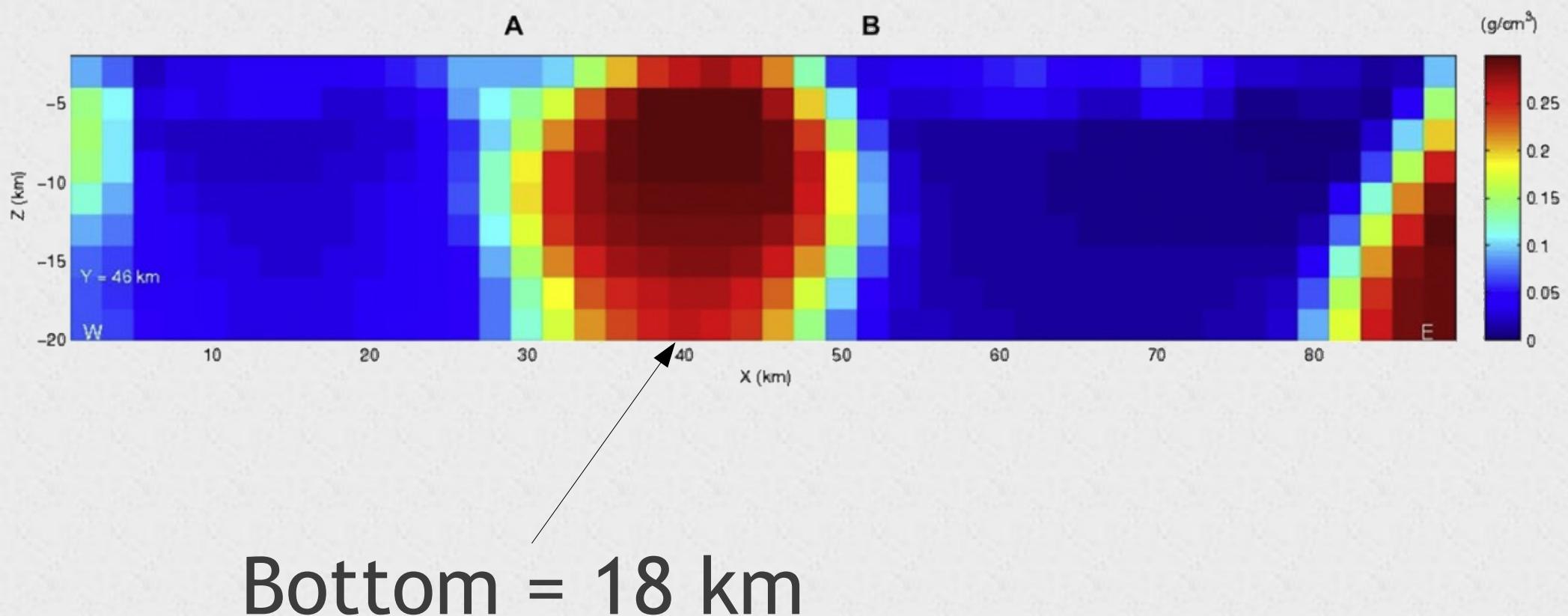


After Dutra et al.
(2012)

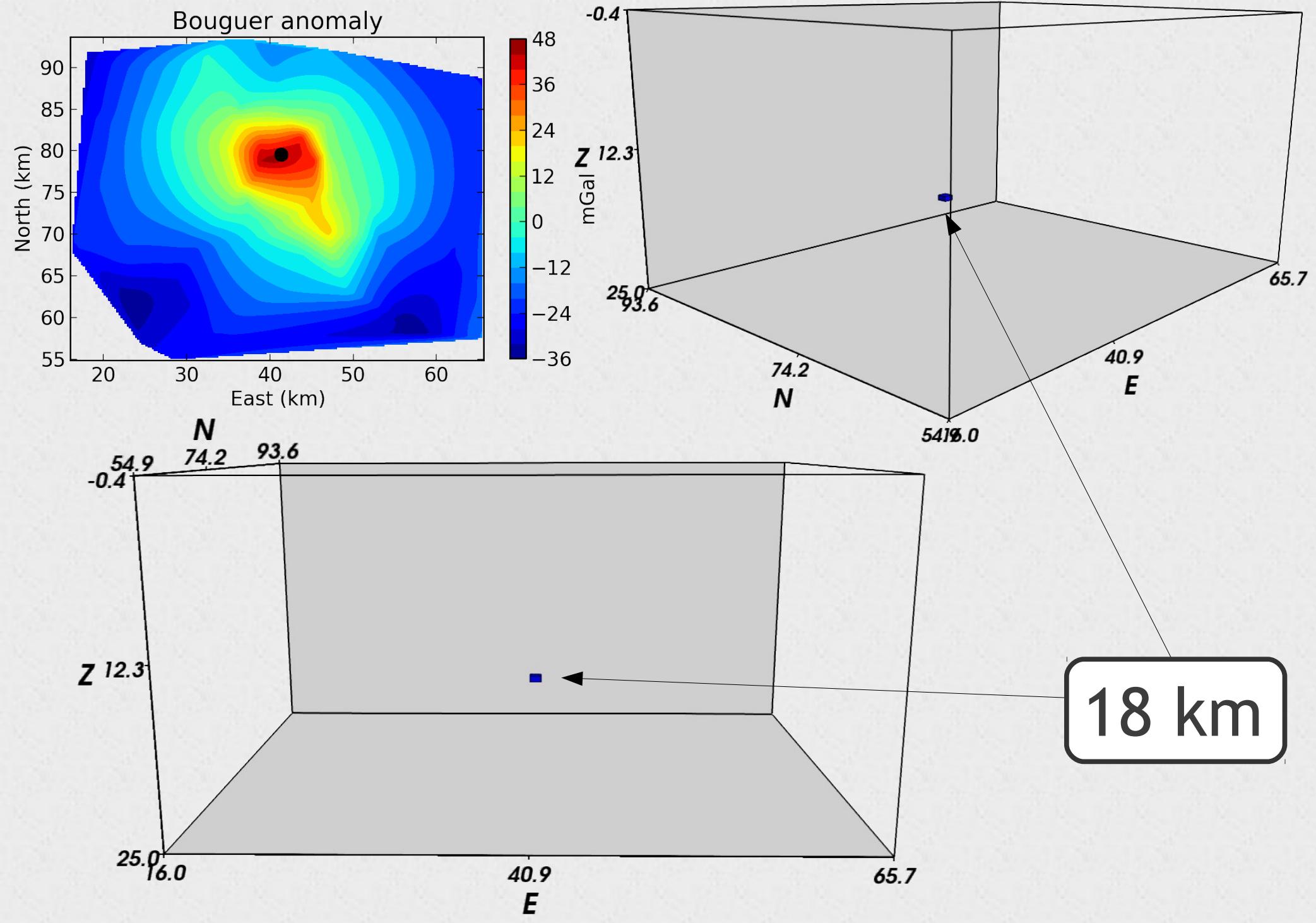


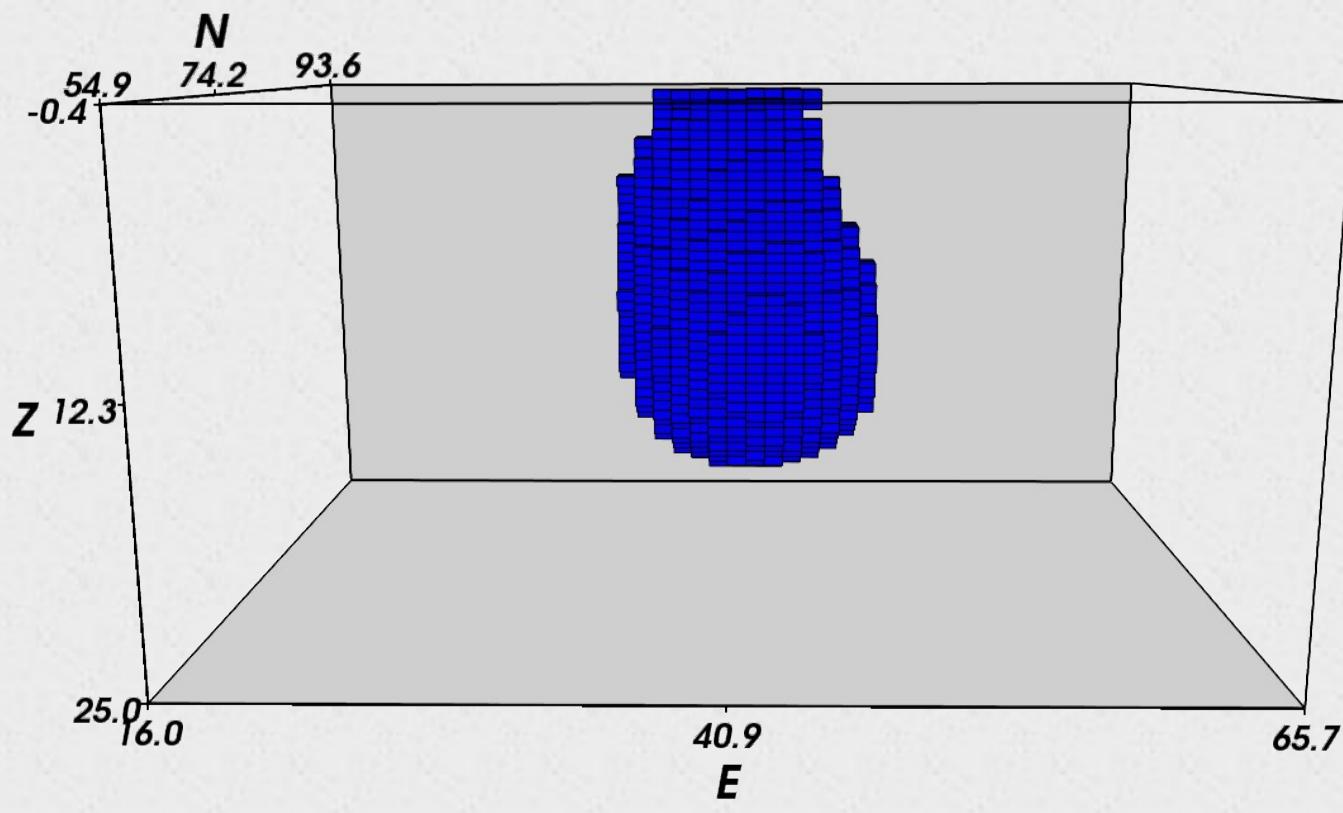
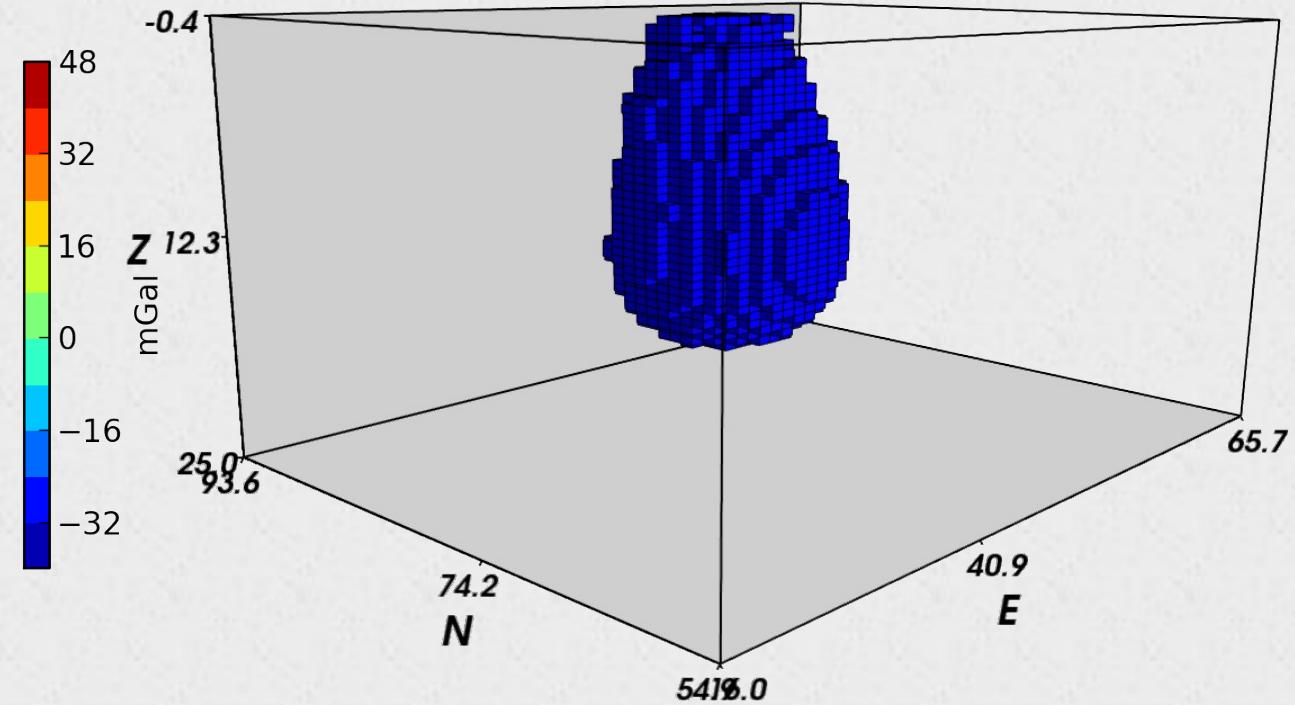
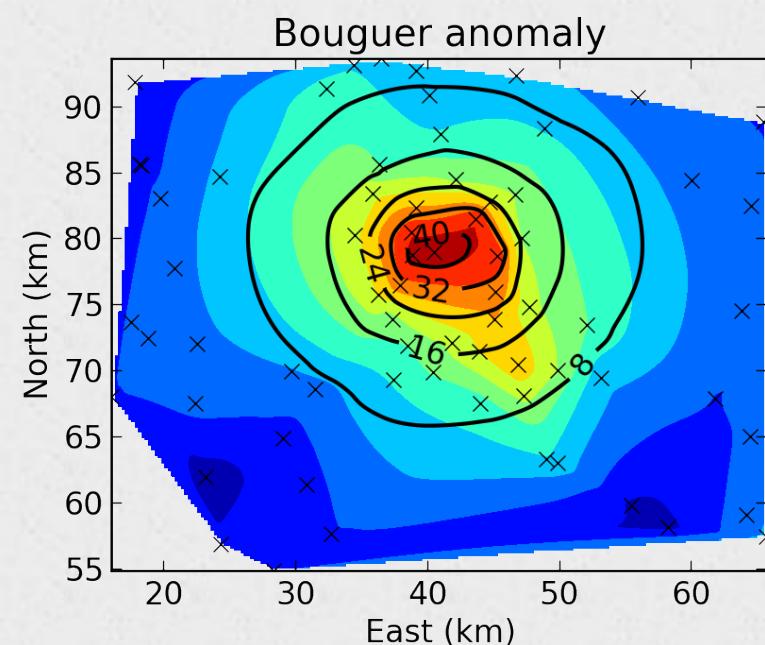


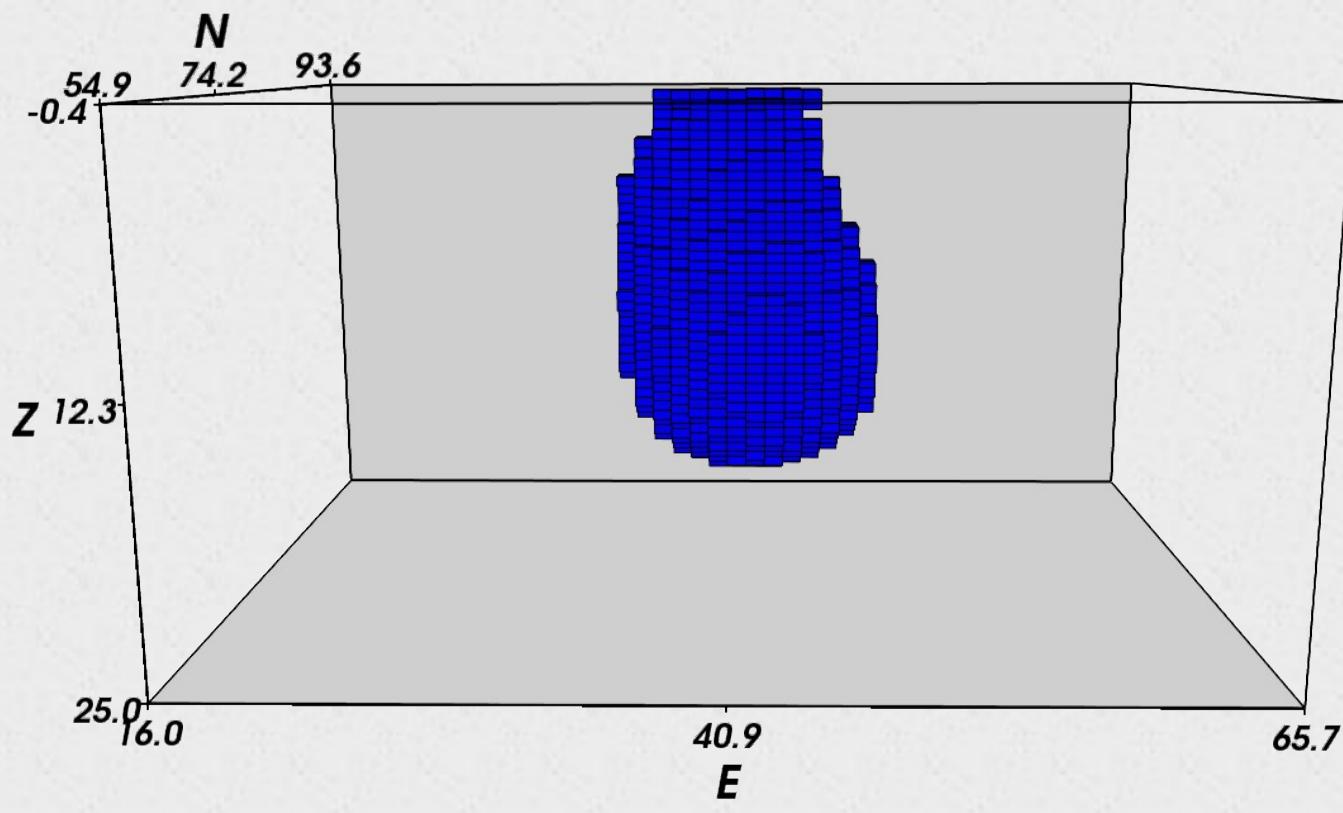
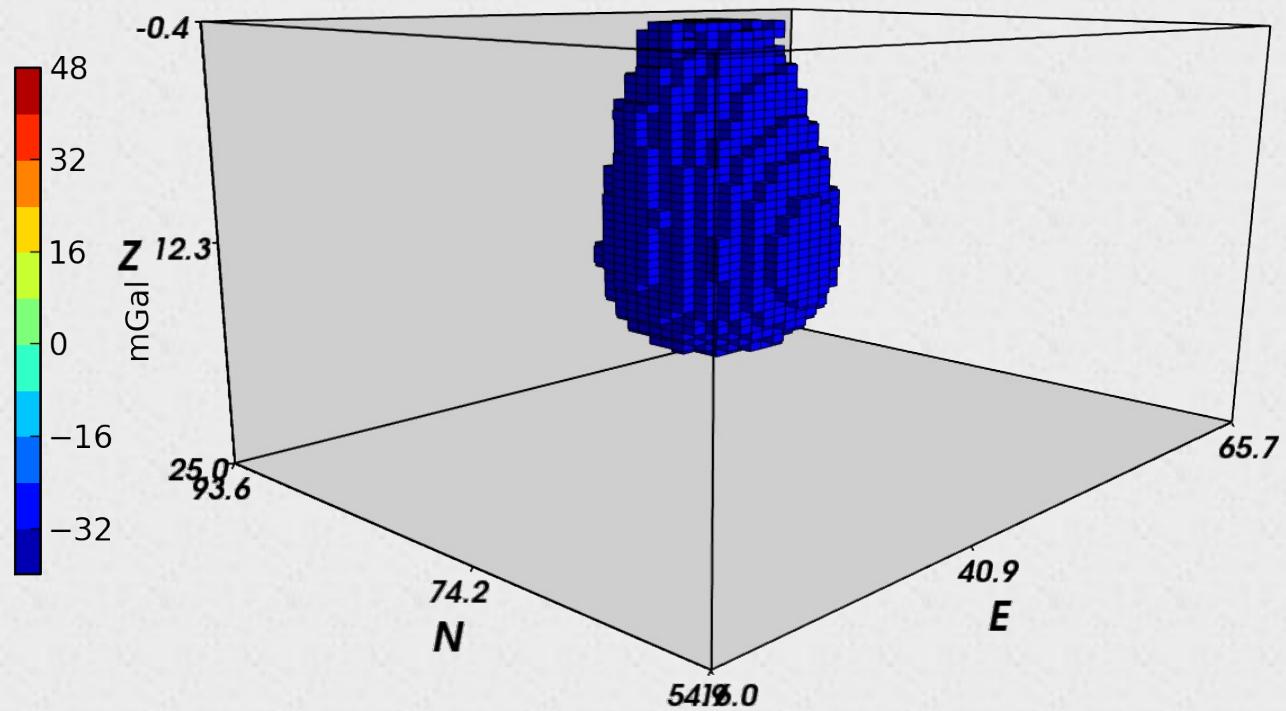
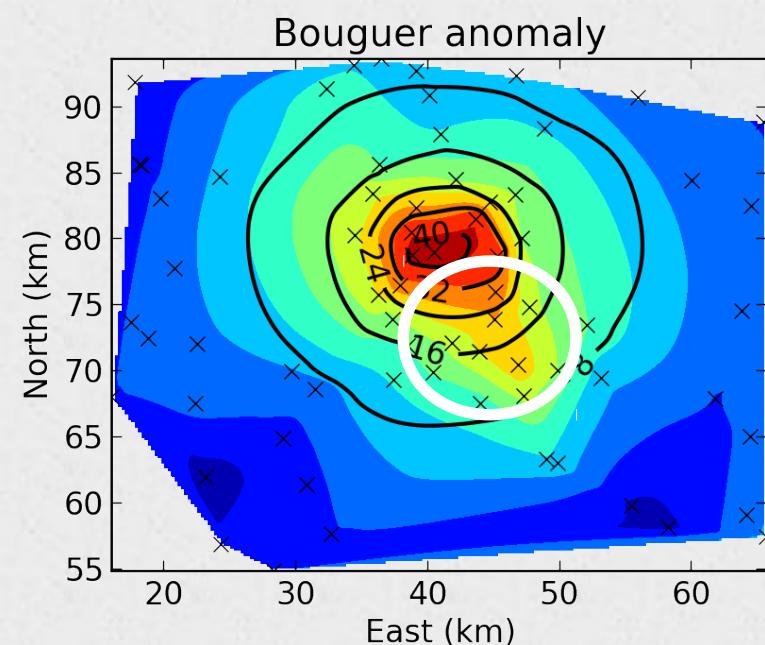
3D gravity inversion (Dutra et al., 2012)



Hypothesis 1



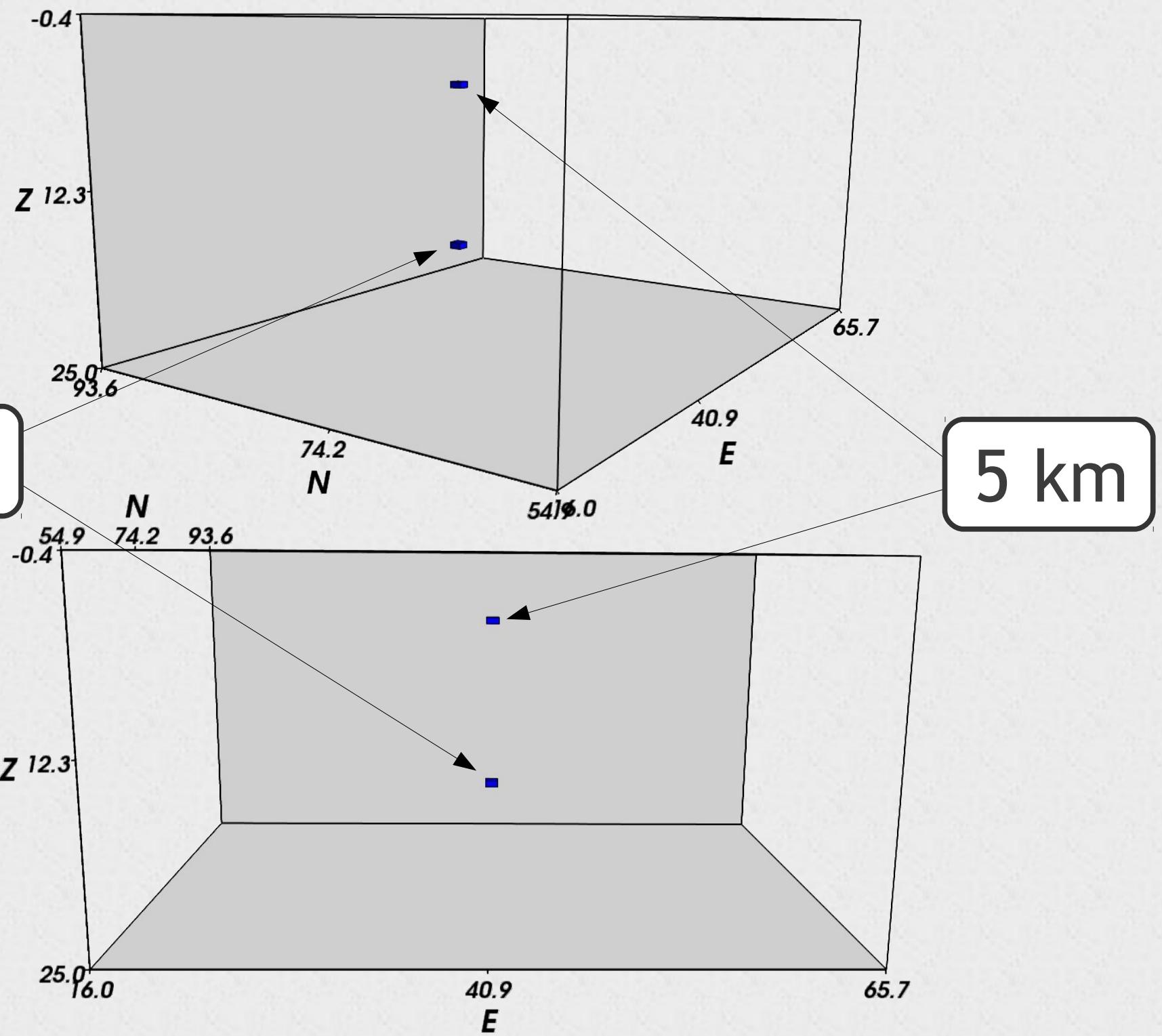


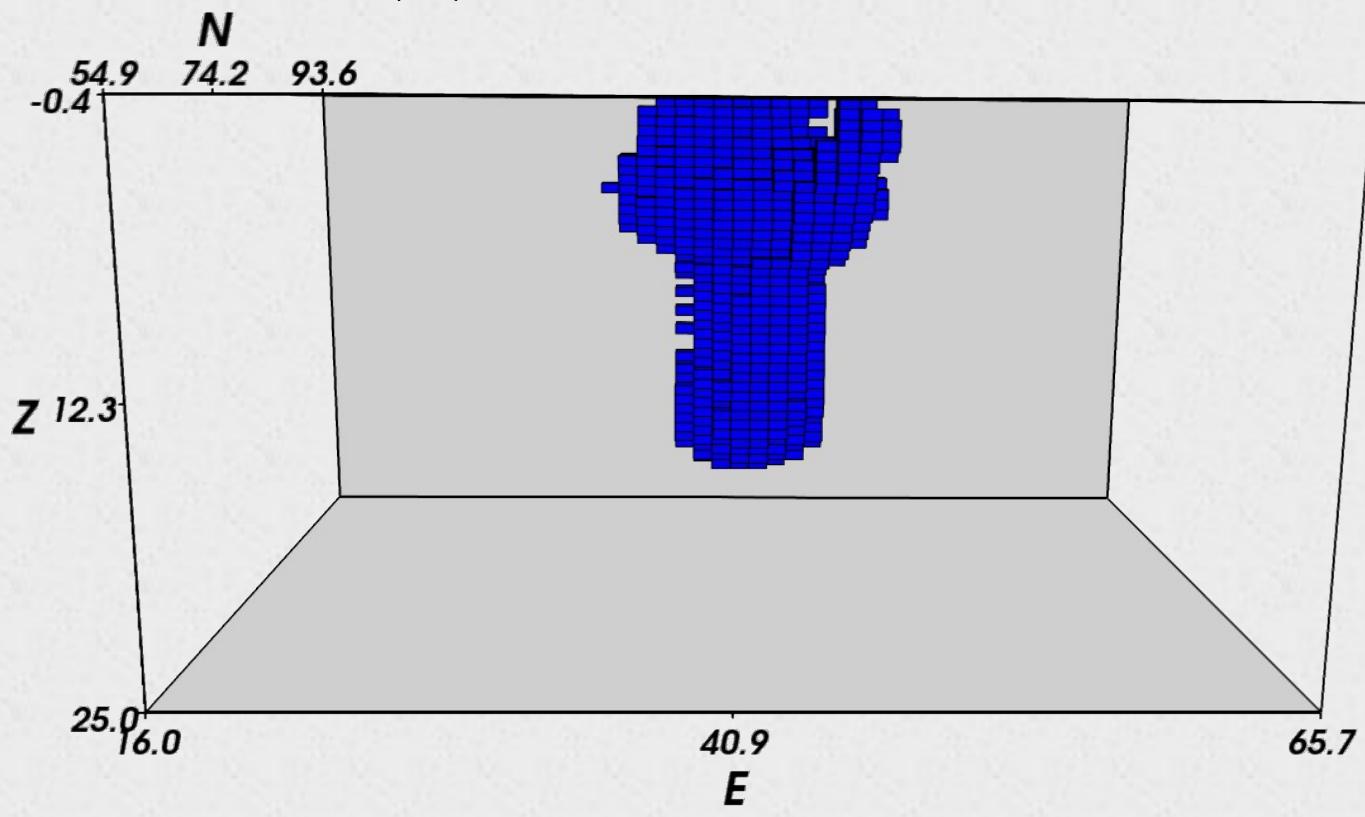
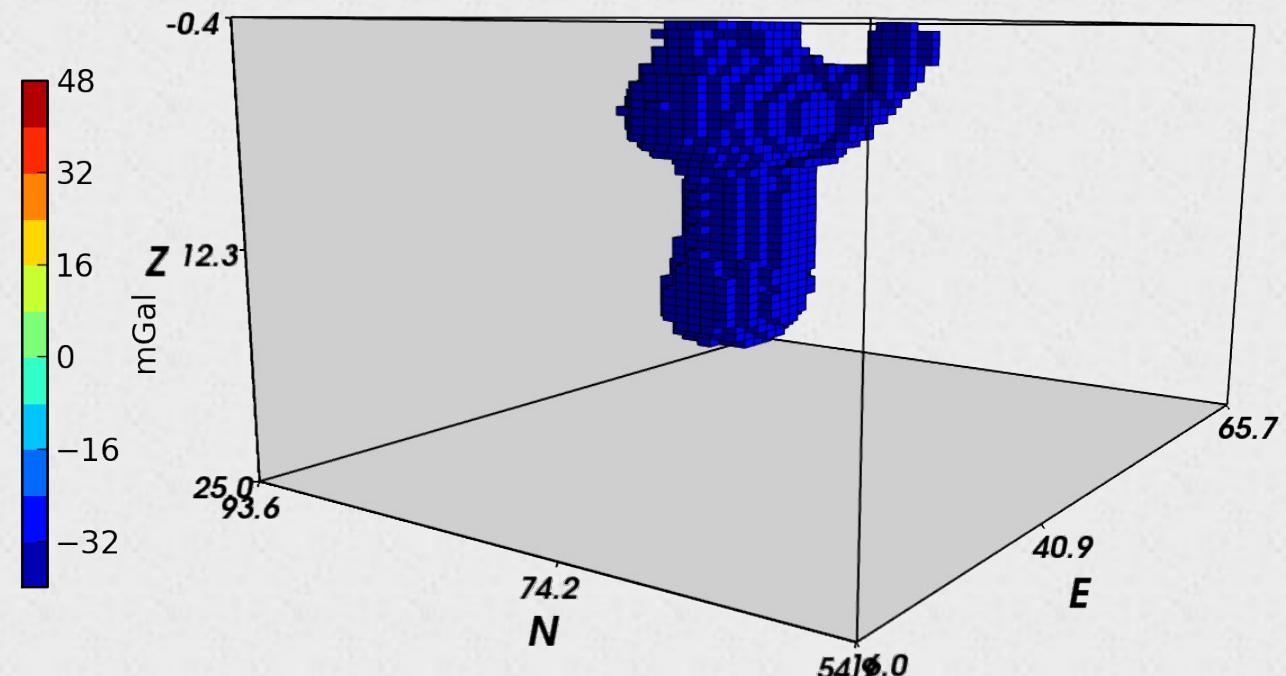
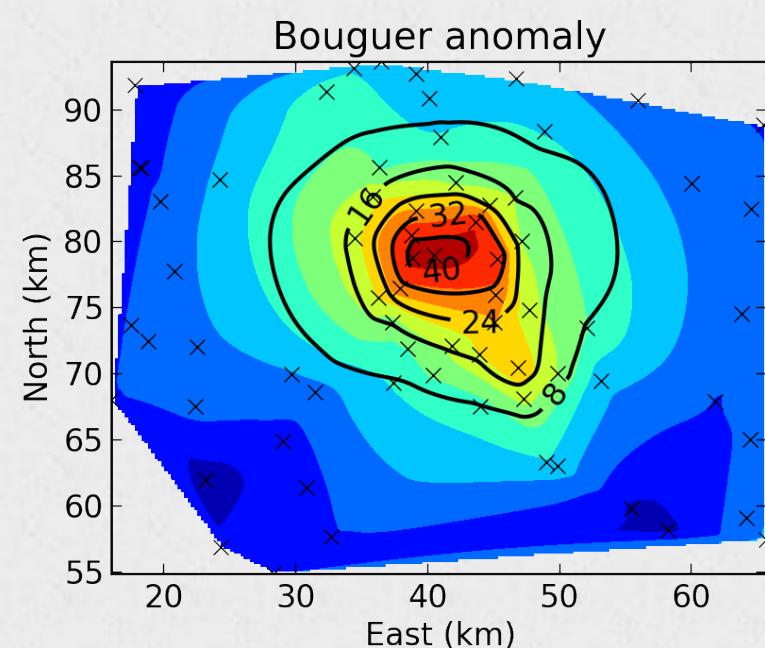


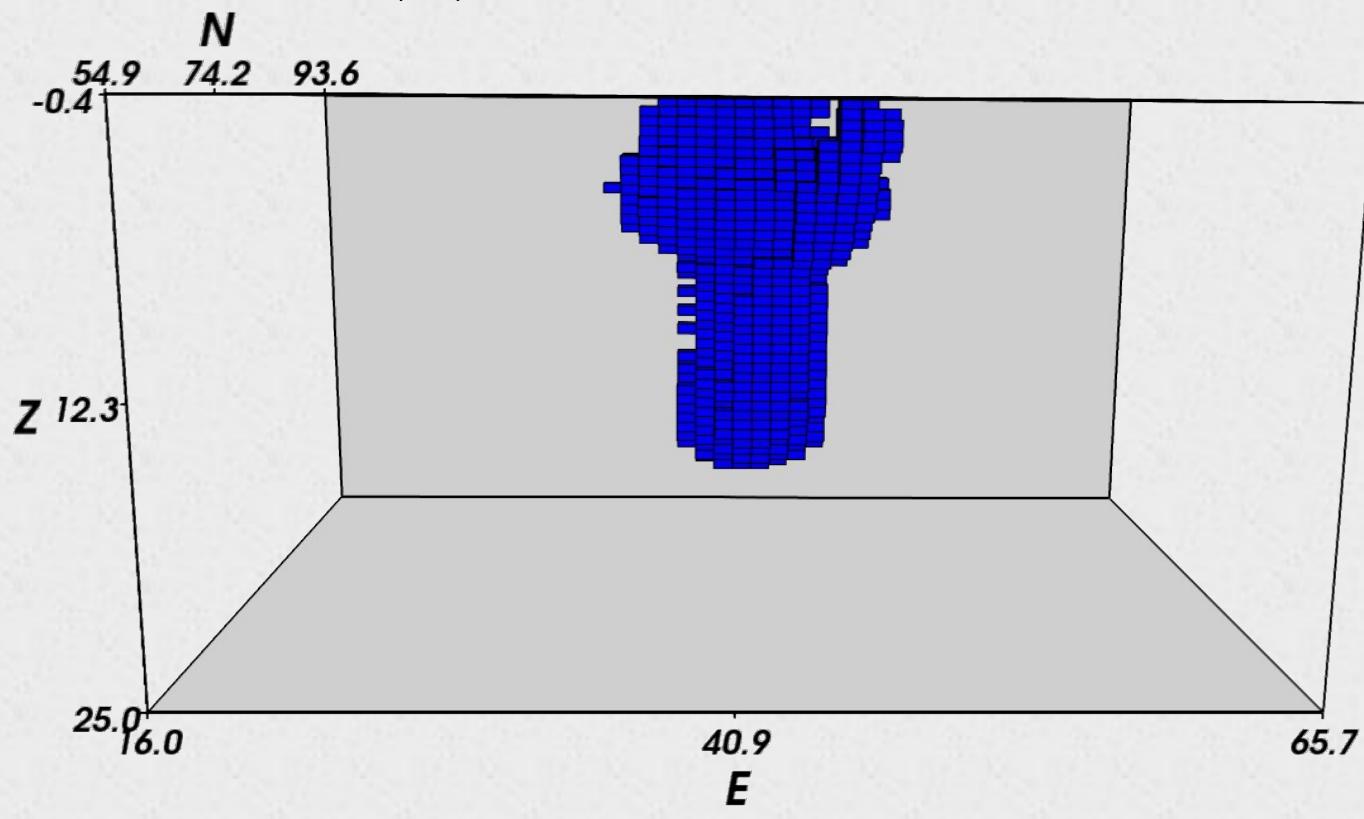
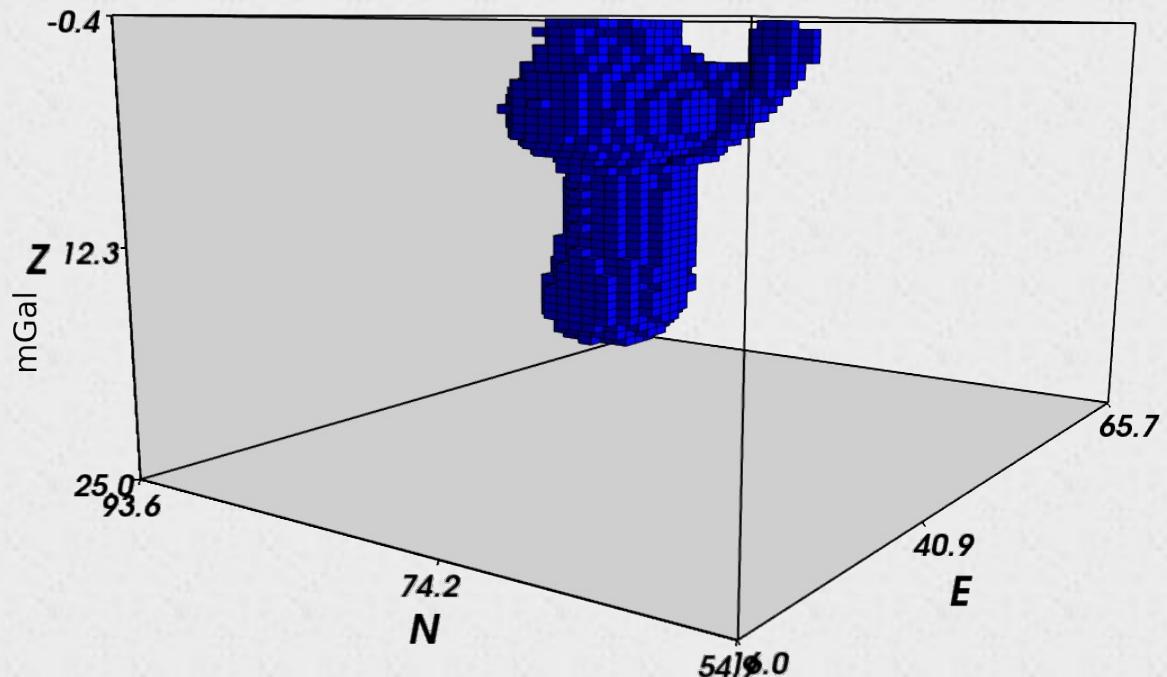
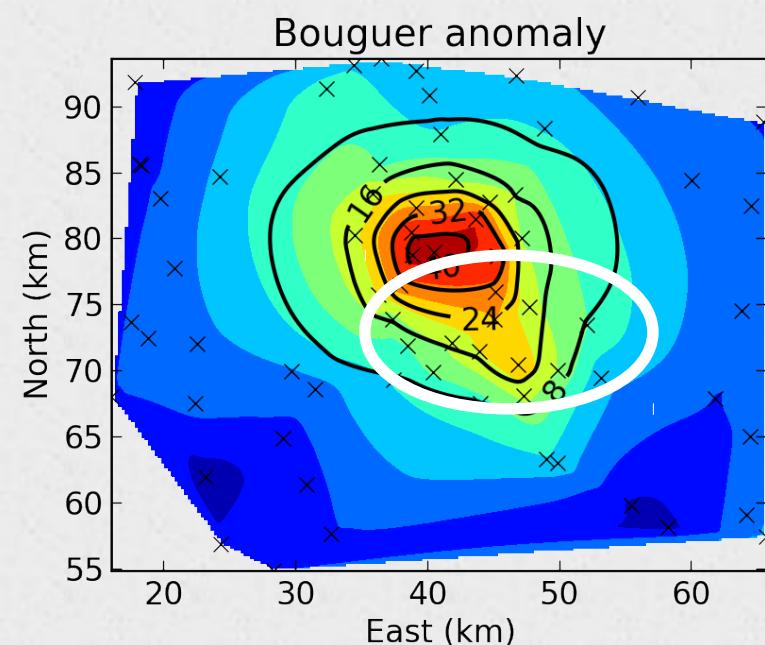
Hypothesis 1

Hypothesis 1

Hypothesis 2



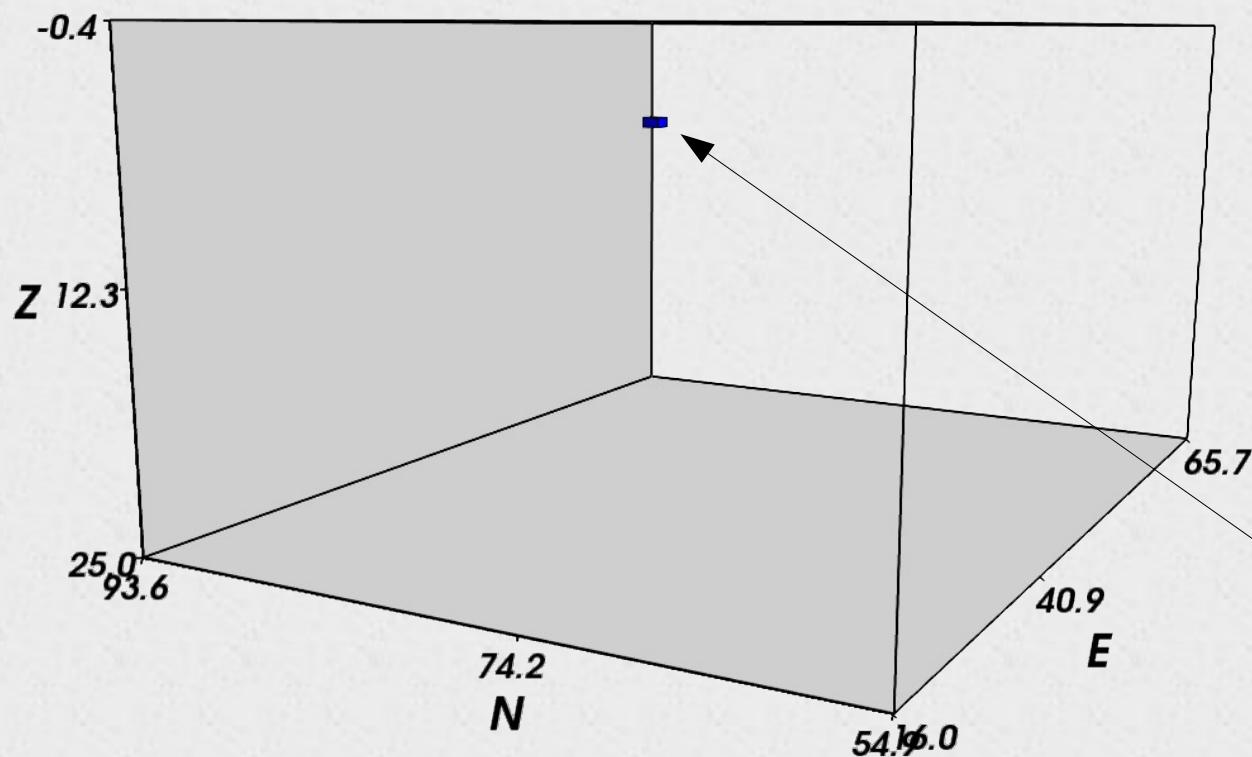




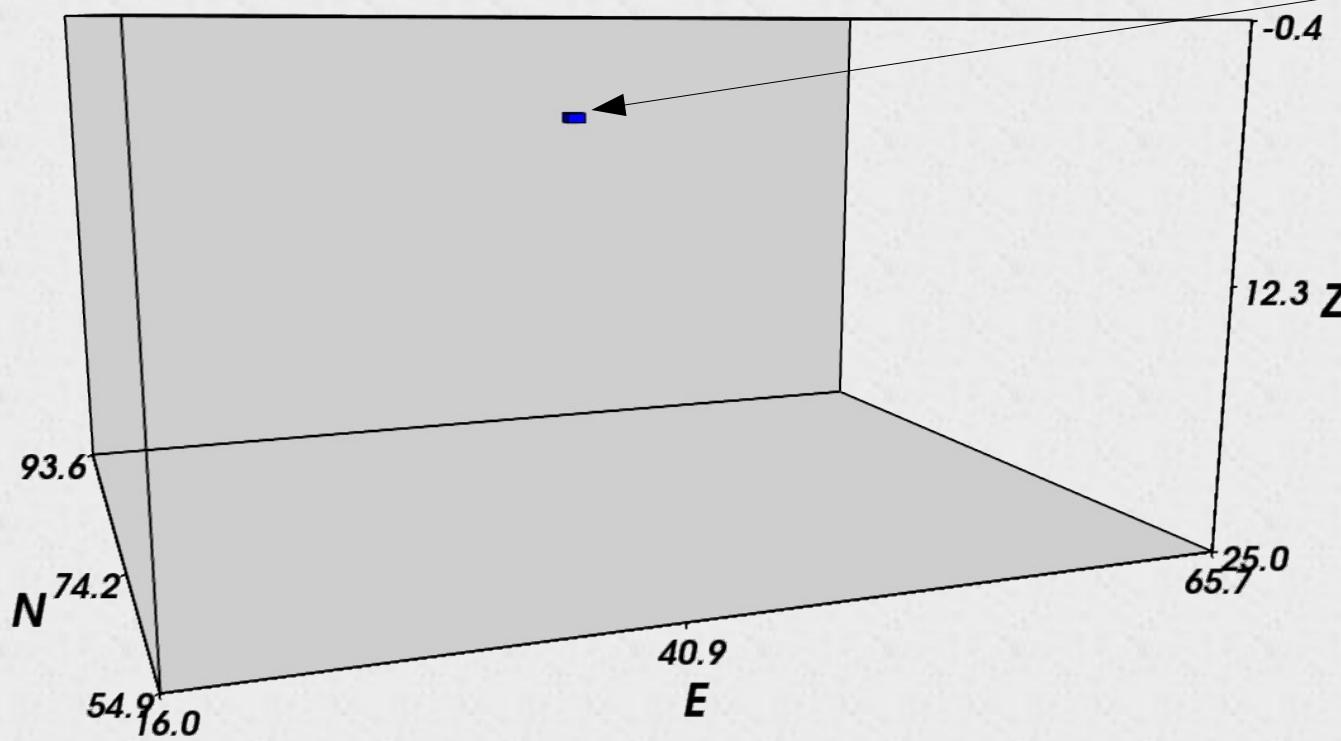
Hypothesis 2

Hypothesis 2

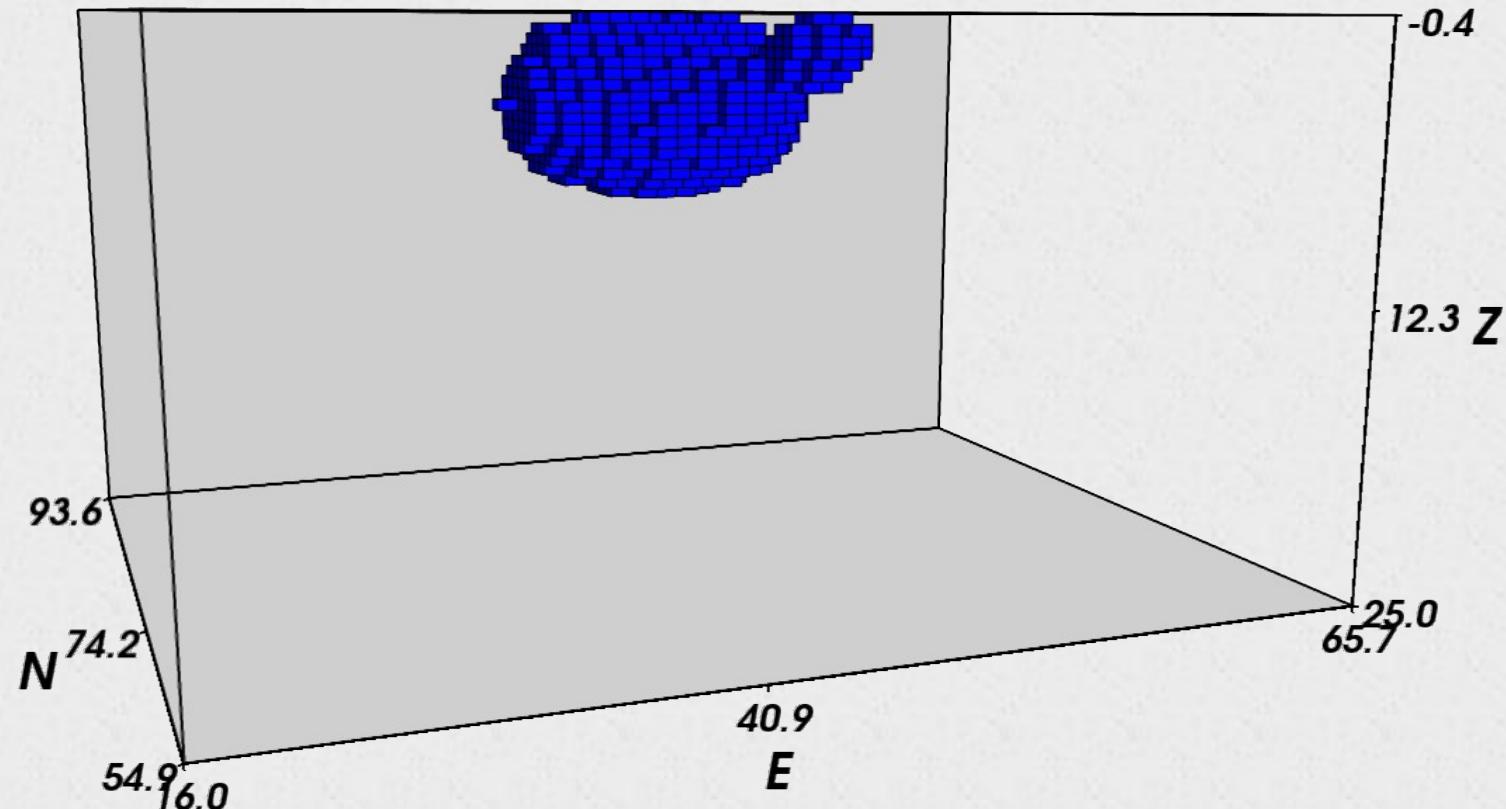
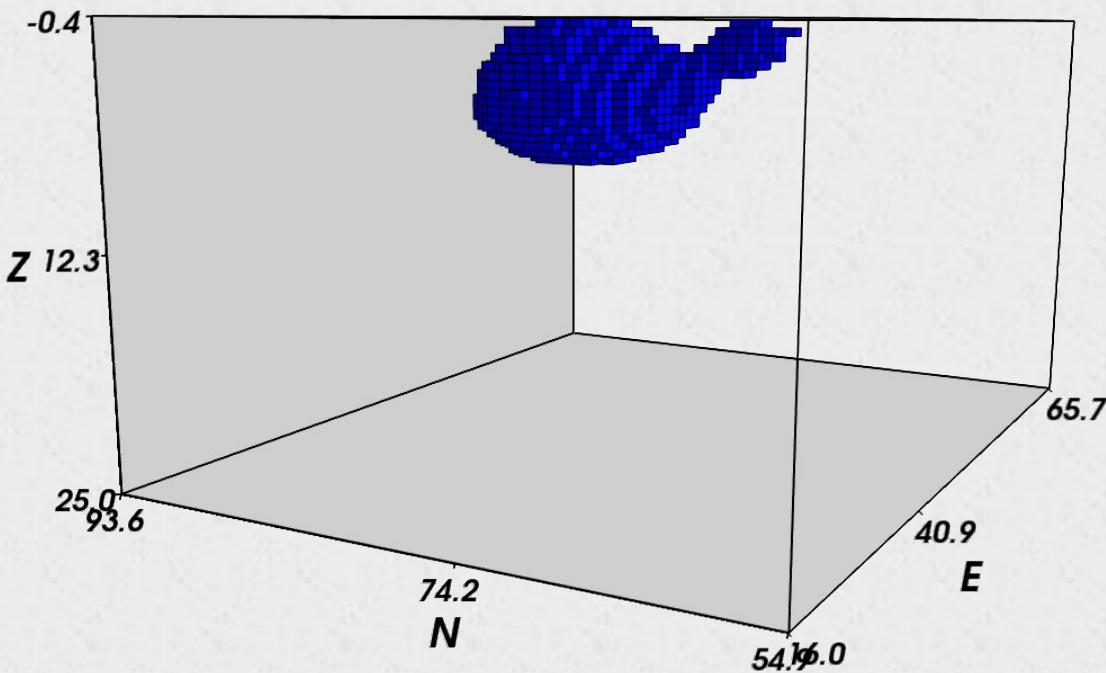
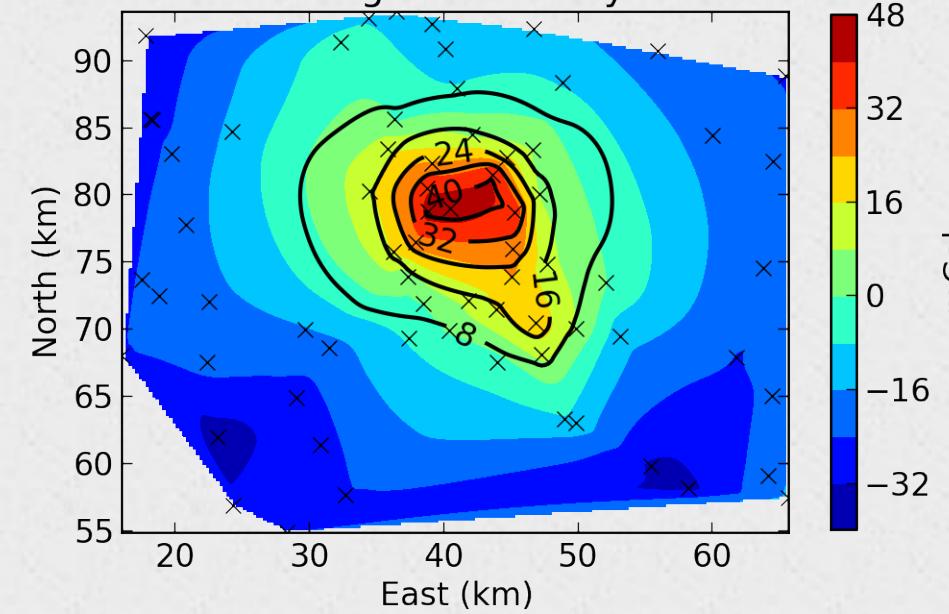
Hypothesis 3



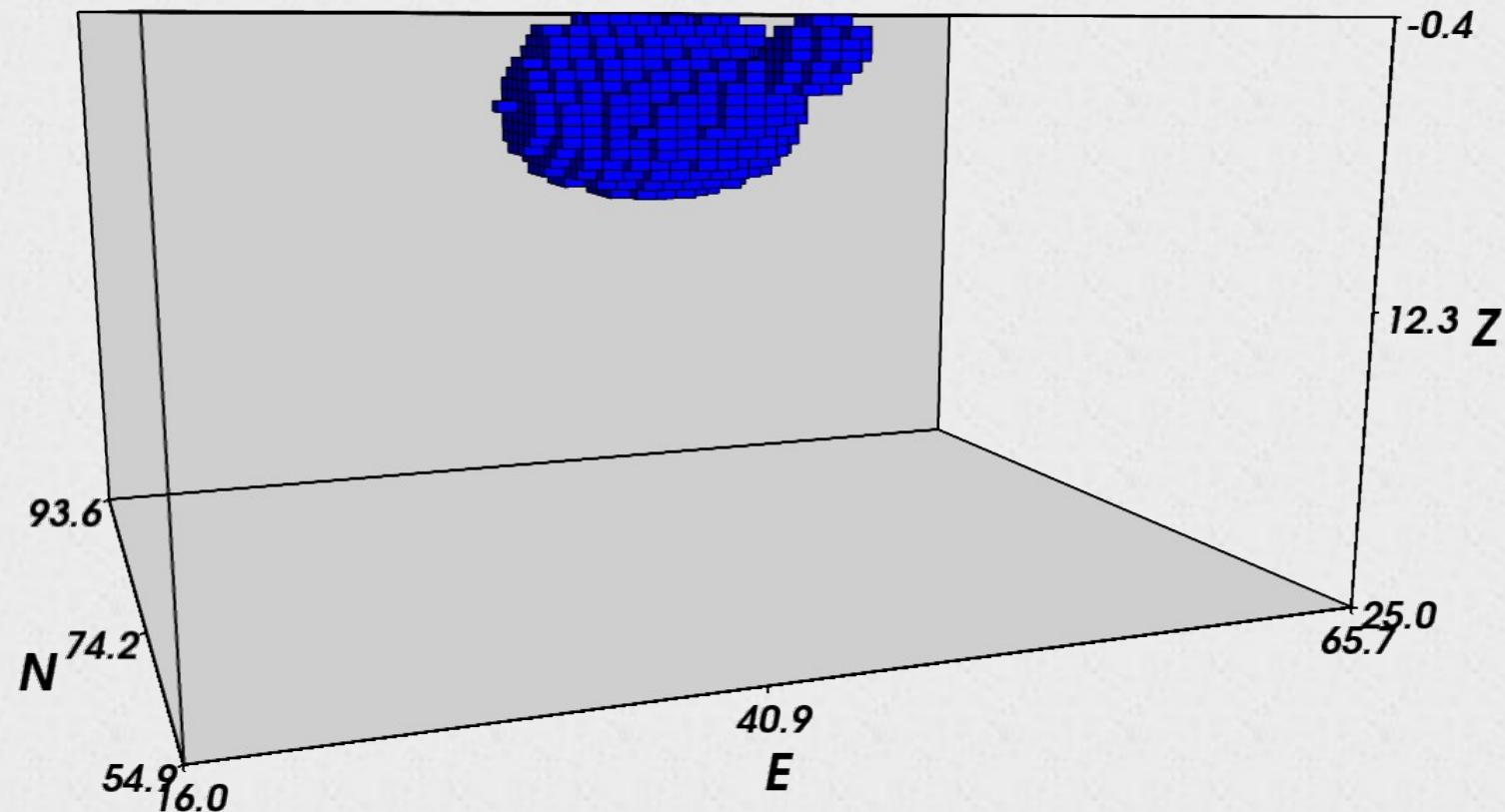
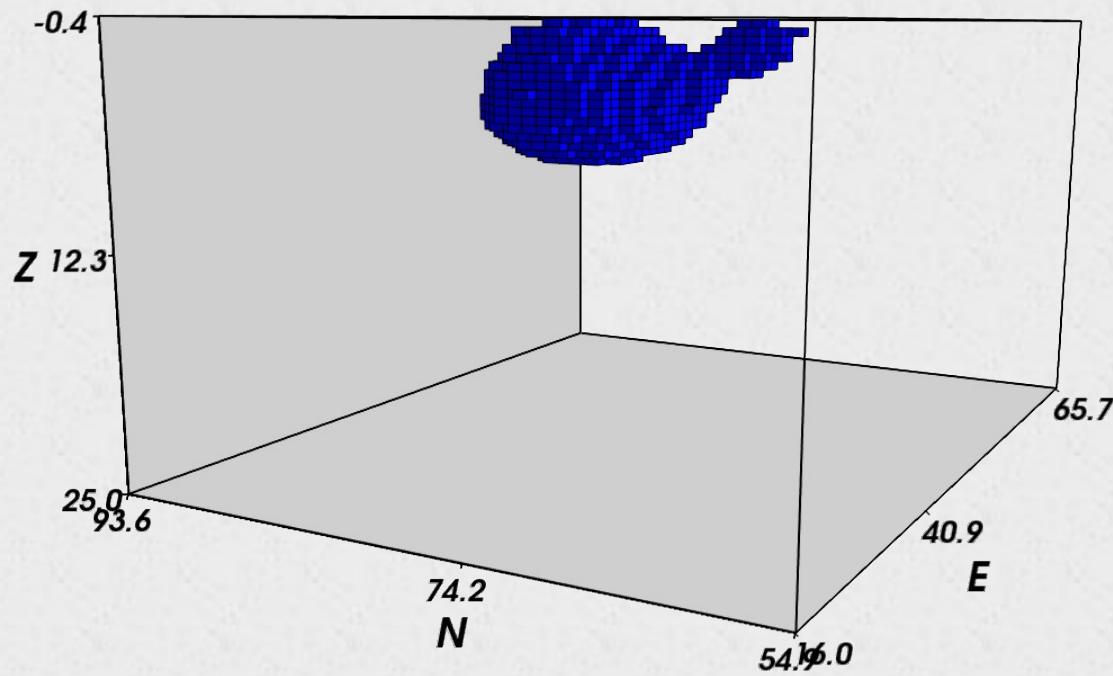
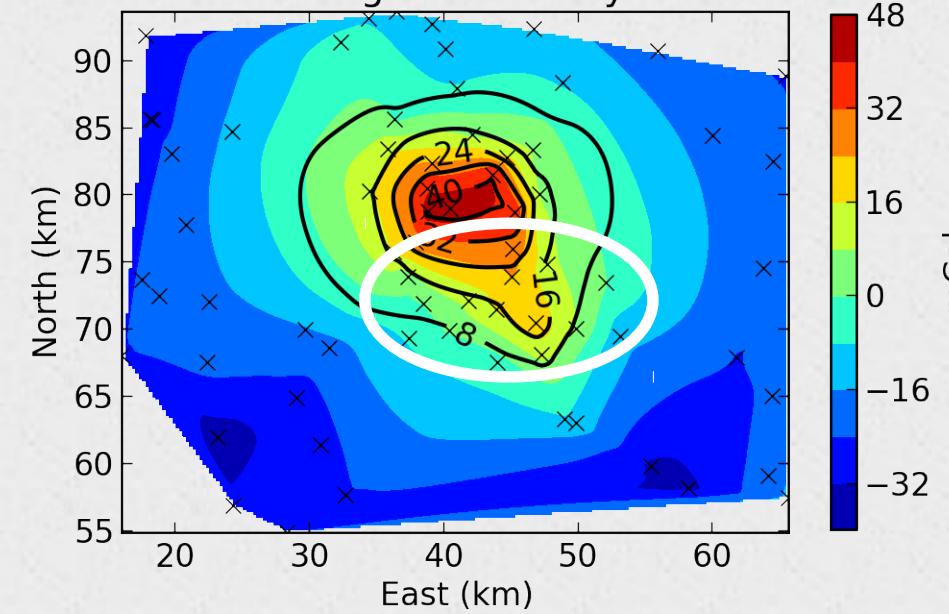
5 km



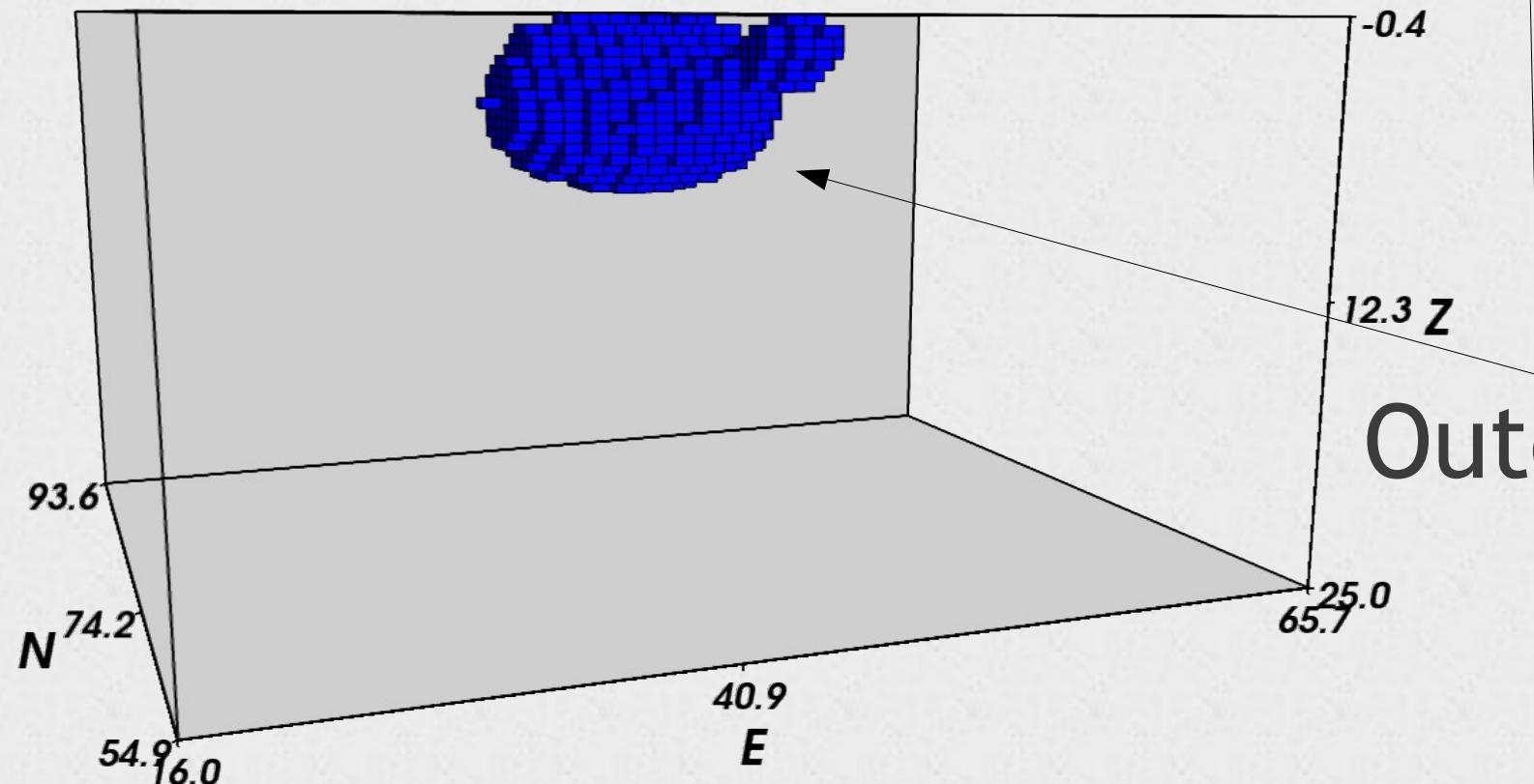
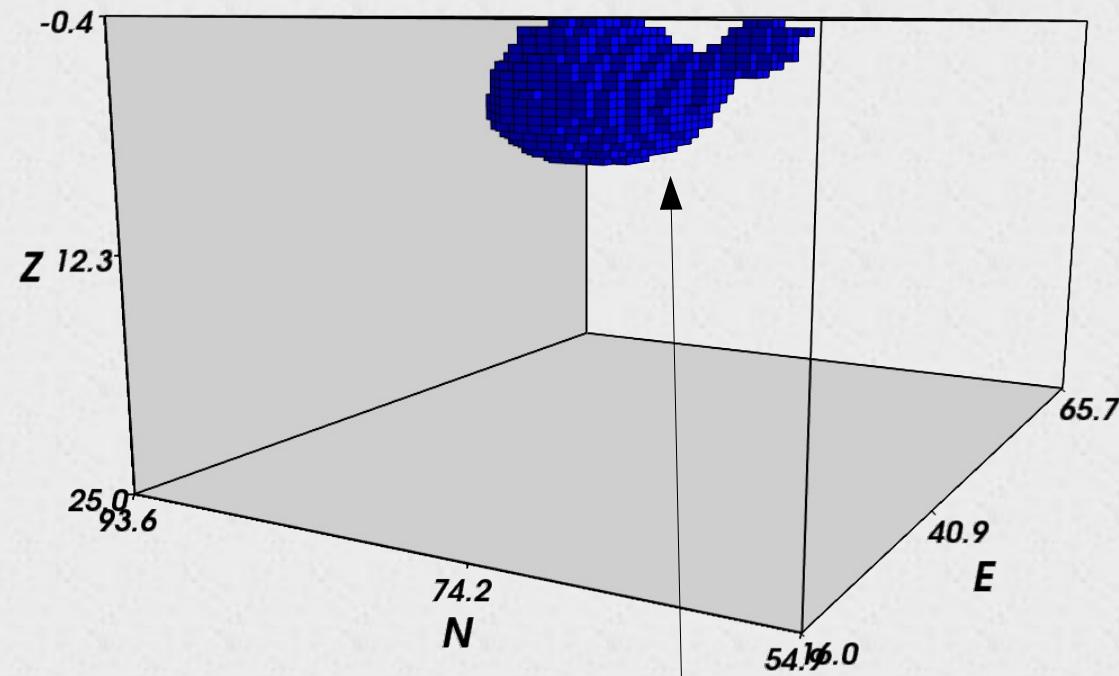
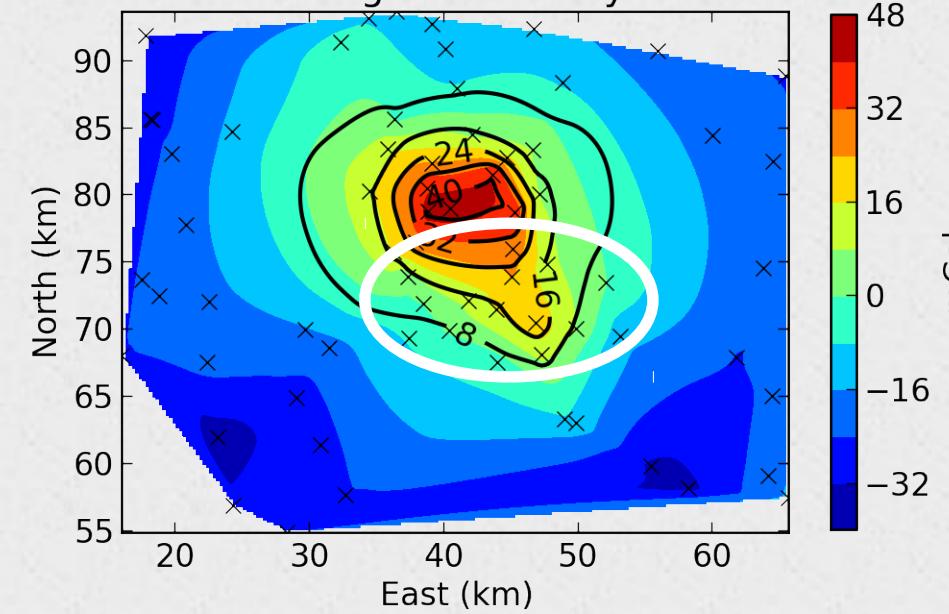
Bouguer anomaly



Bouguer anomaly



Bouguer anomaly

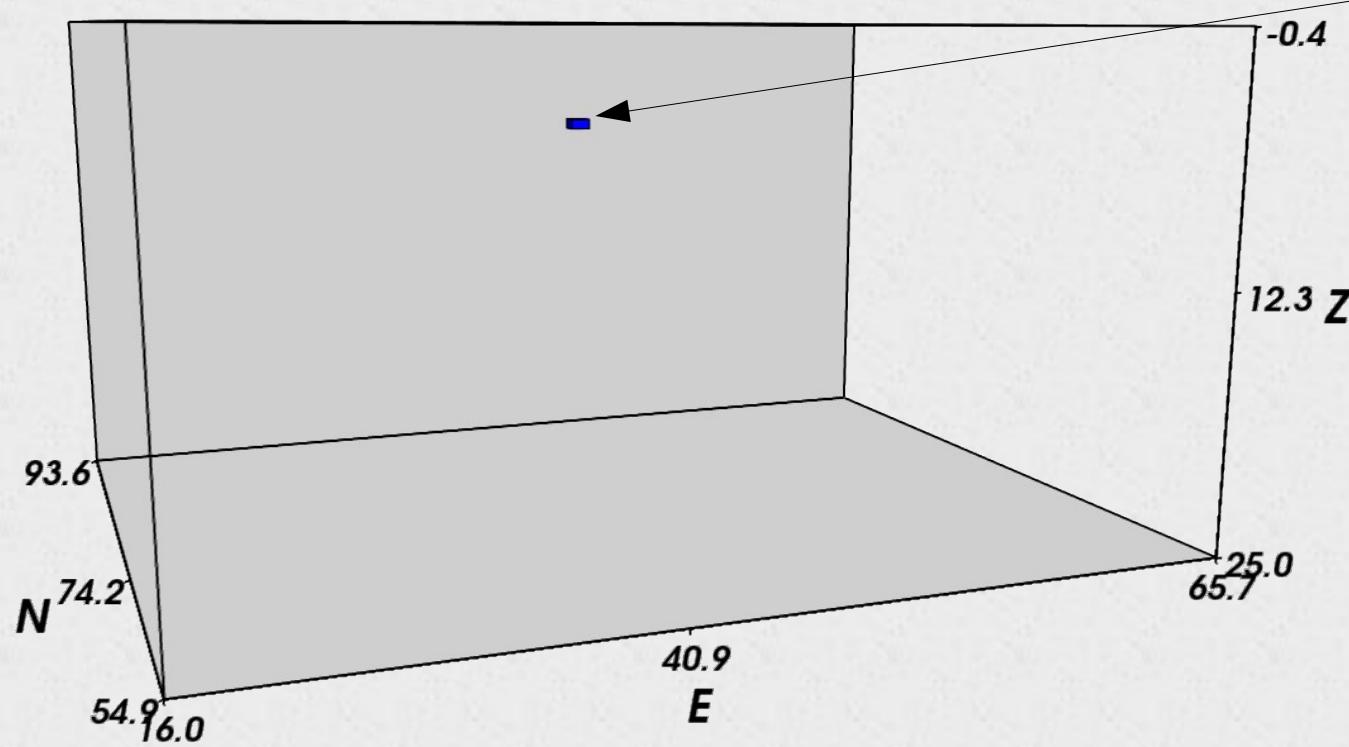
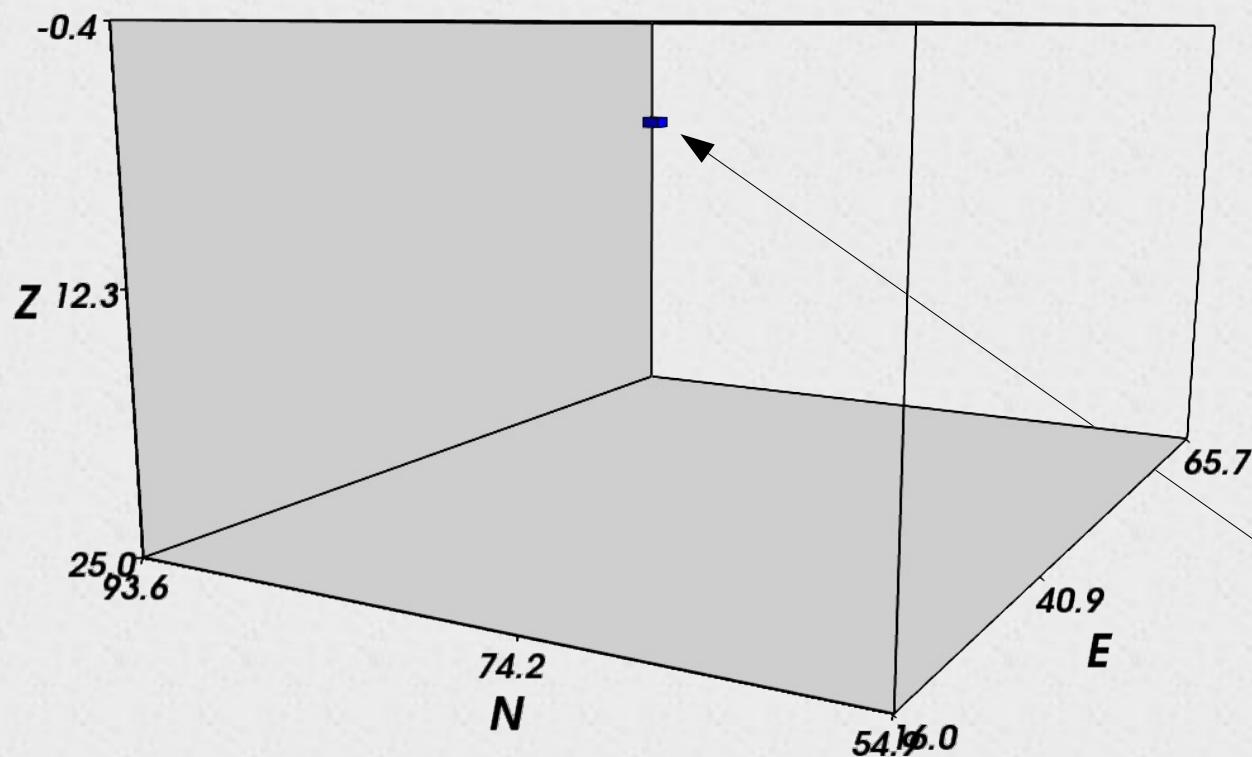


Outcropping

Hypothesis 3

Hypothesis 3

Hypothesis 4

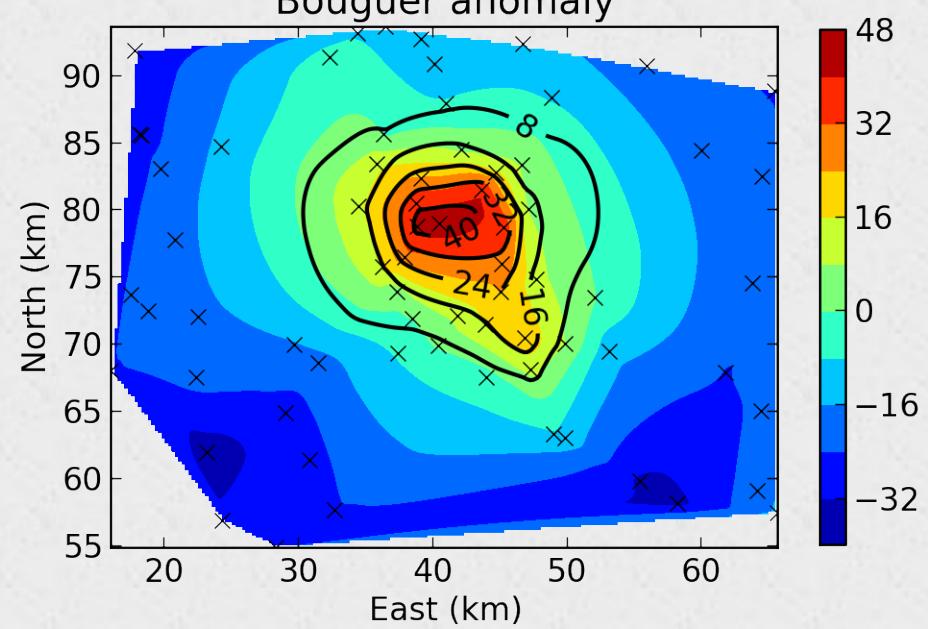


Density



500 g.cm⁻³

Bouguer anomaly



-0.4

mGal

Z 12.3

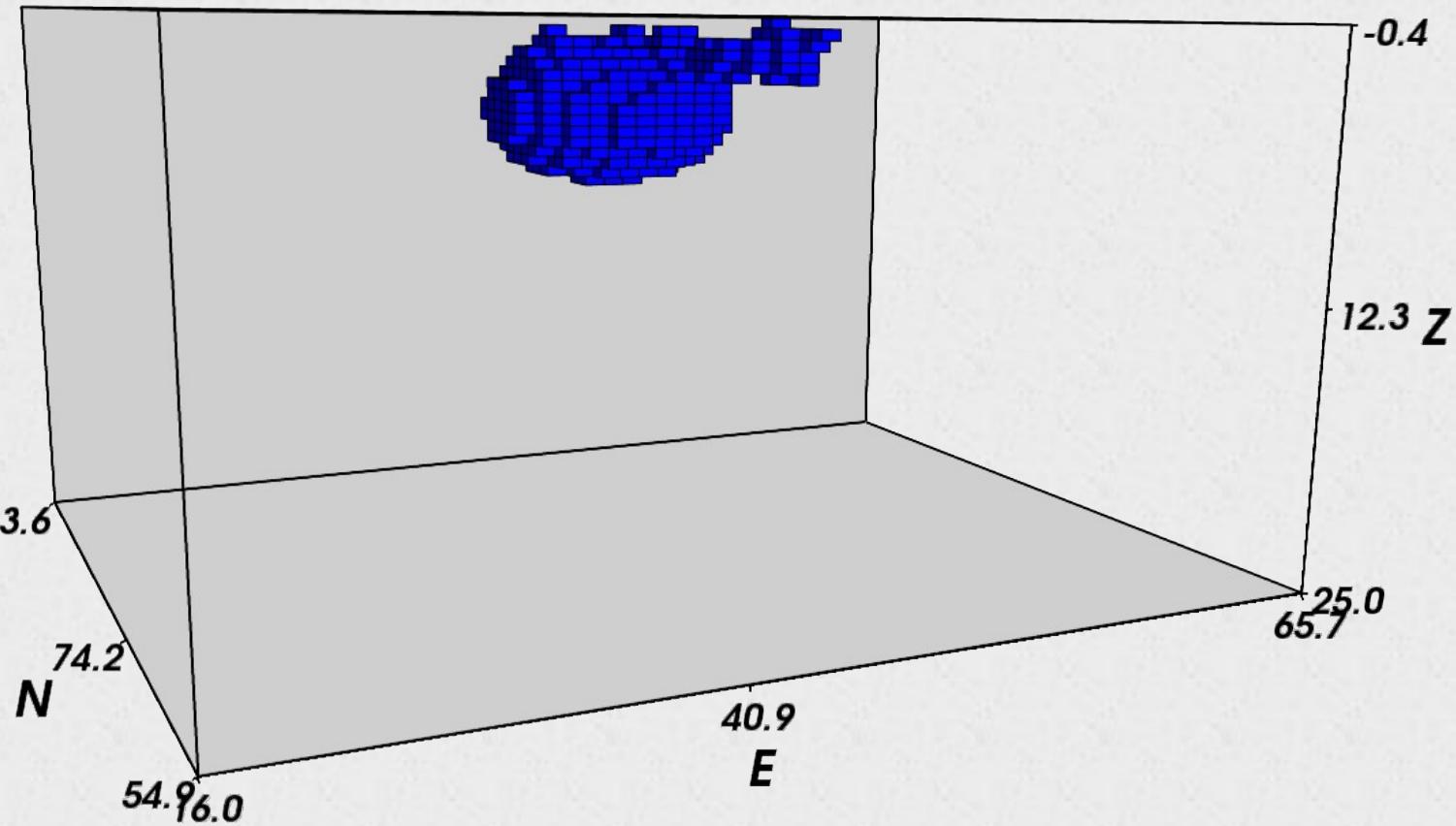
25.0
93.6

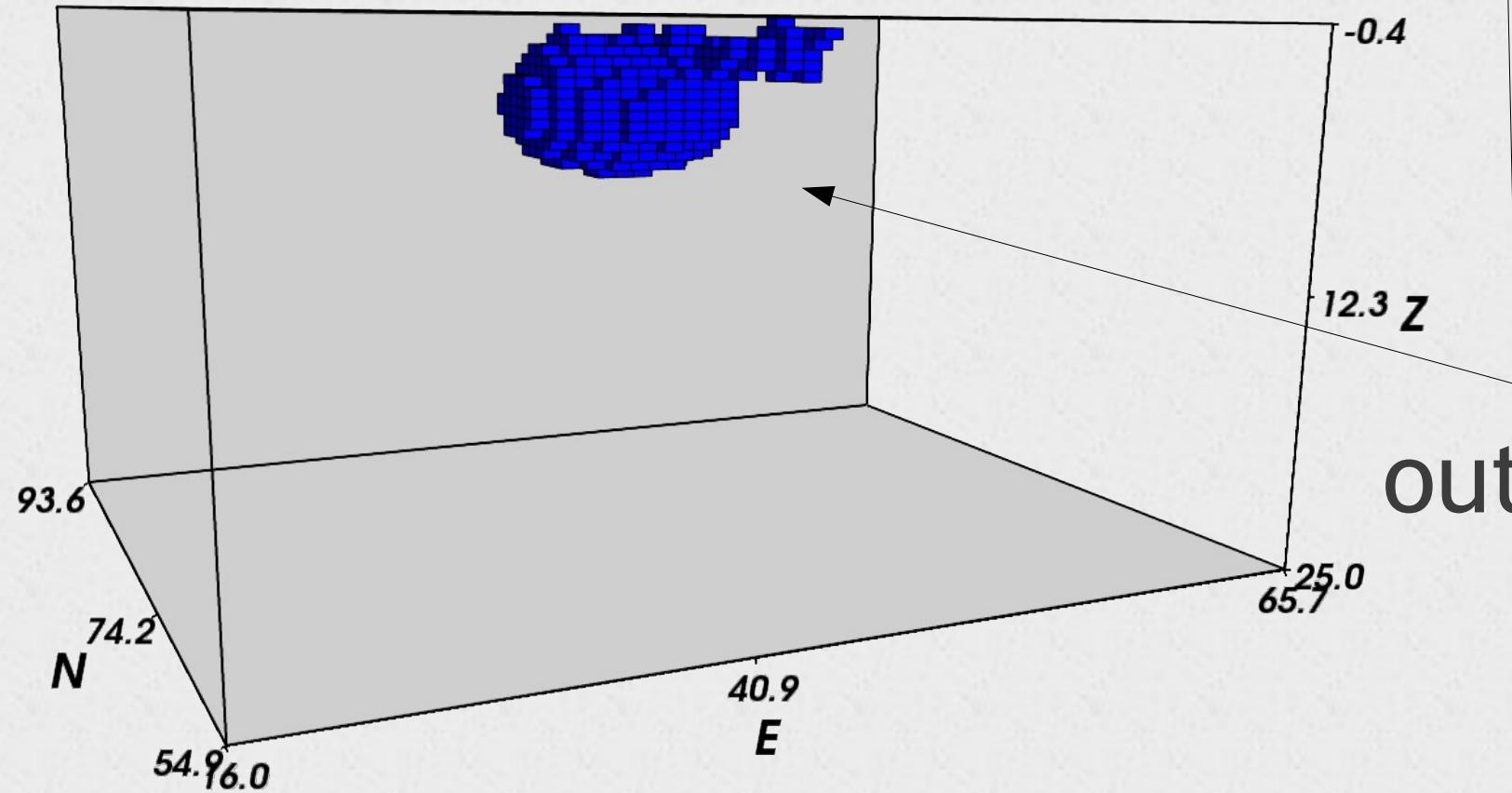
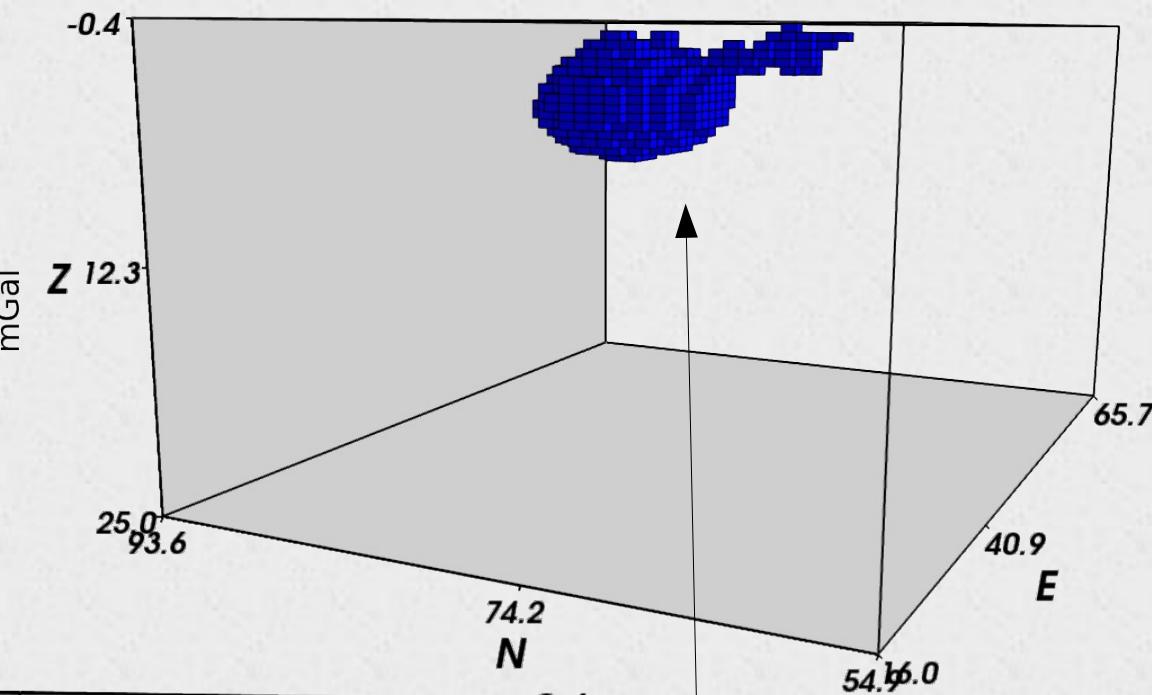
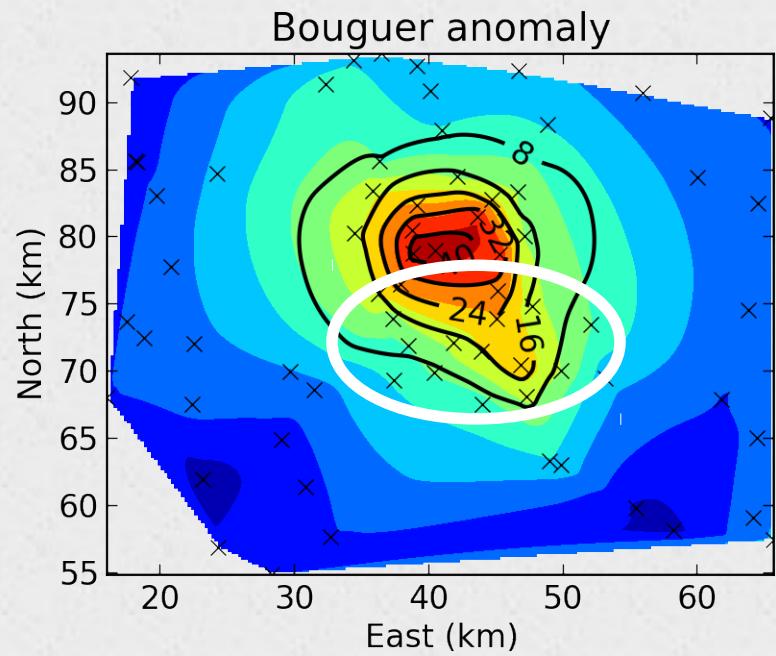
74.2
N

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

Synthetic data

