

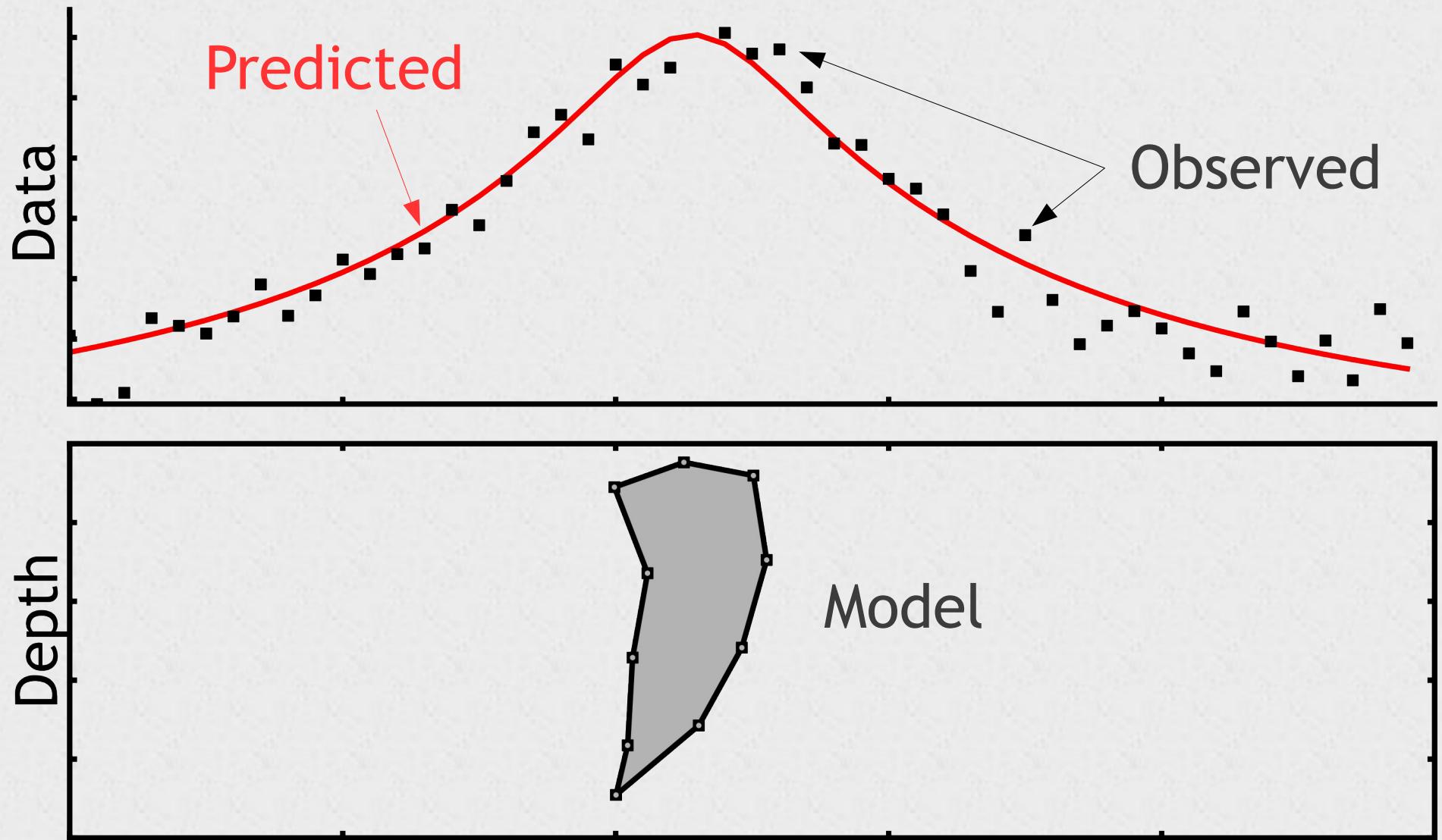
# Rapid 3D inversion of gravity and gravity gradient data to test geologic hypotheses

Leonardo Uieda  
Valéria C. F. Barbosa



Observatório Nacional  
Rio de Janeiro, Brazil

# Forward modeling

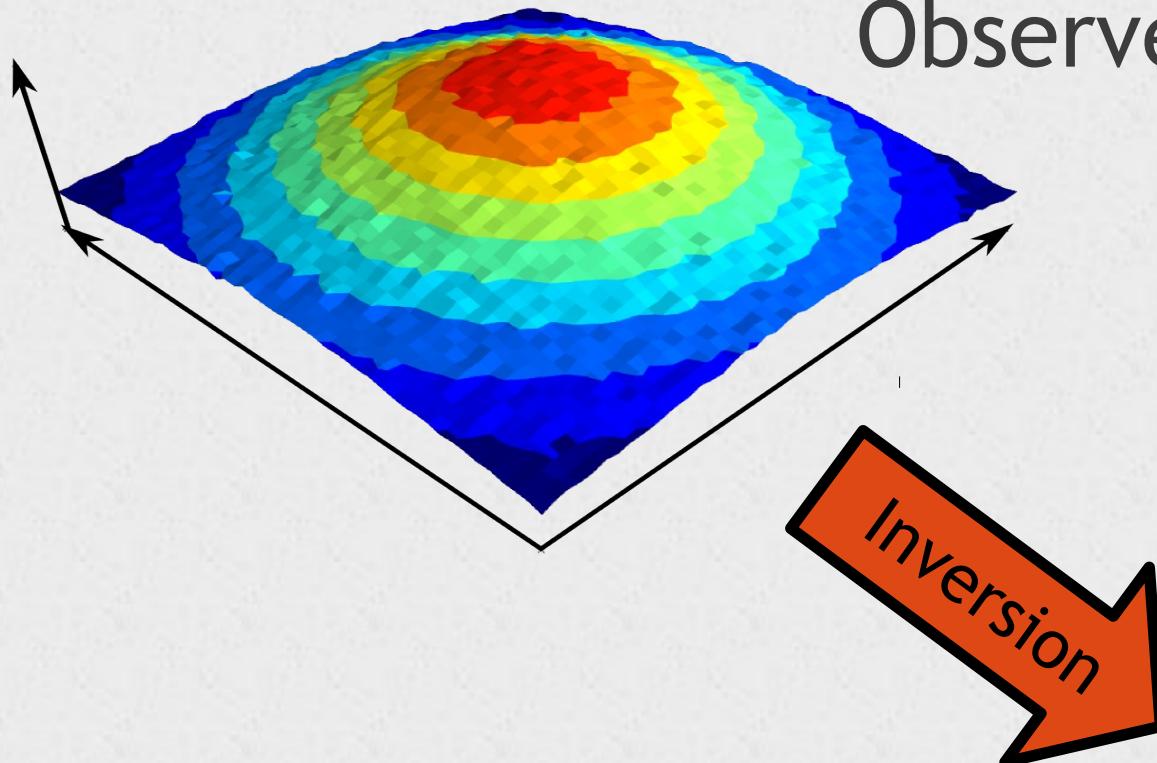


- ✓ Control
- ✓ Prior information
- ✓ Speed

- ✗ Tedious
- ✗ Gravity + gradients
- ✗ 3D

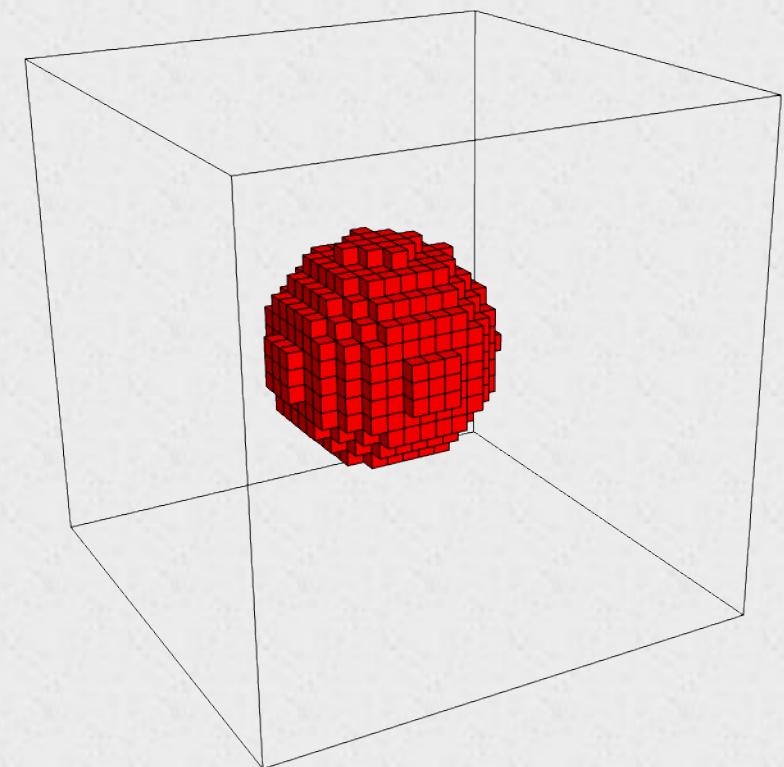
# Geophysical inversion

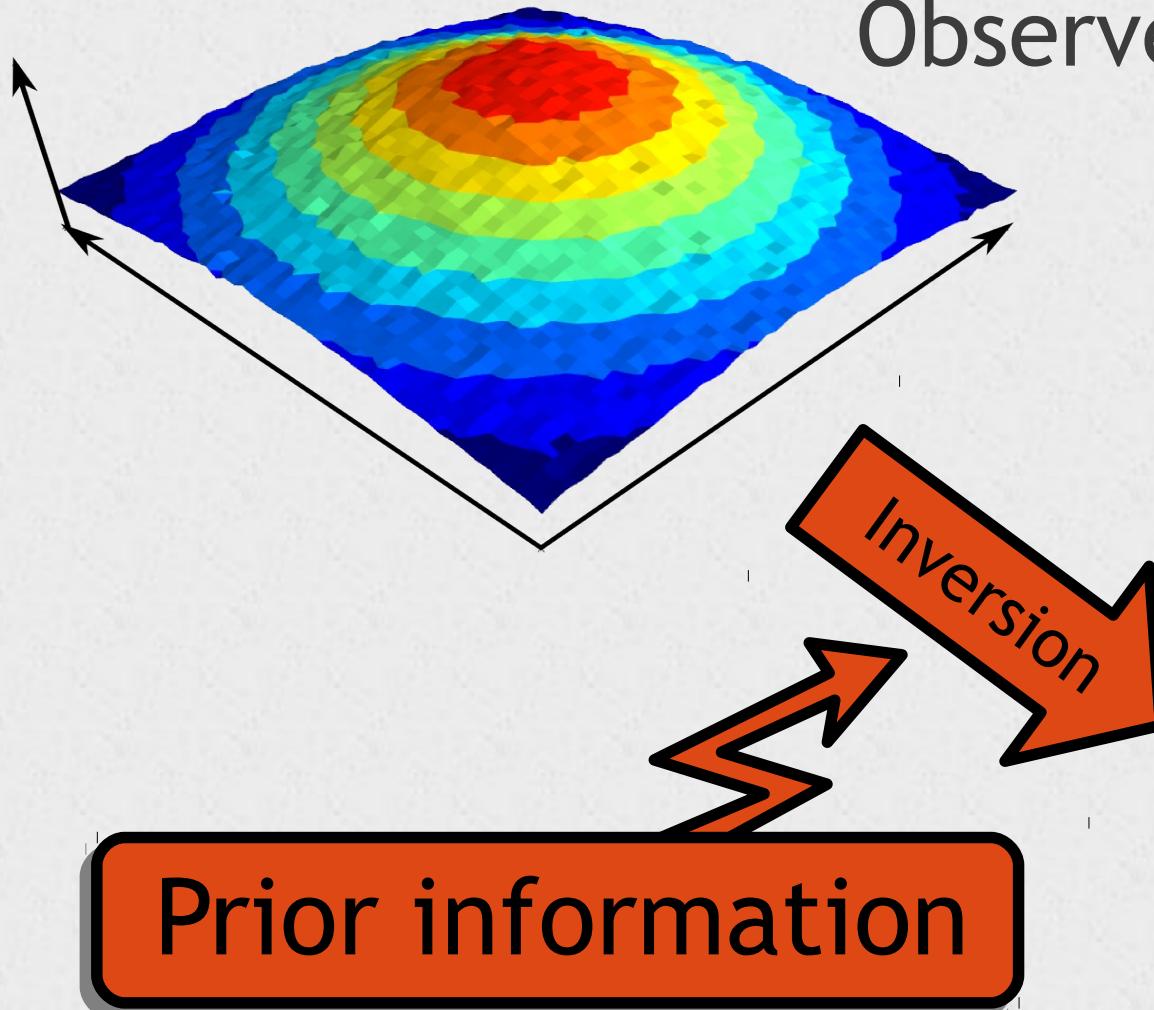
Observed data



Inversion

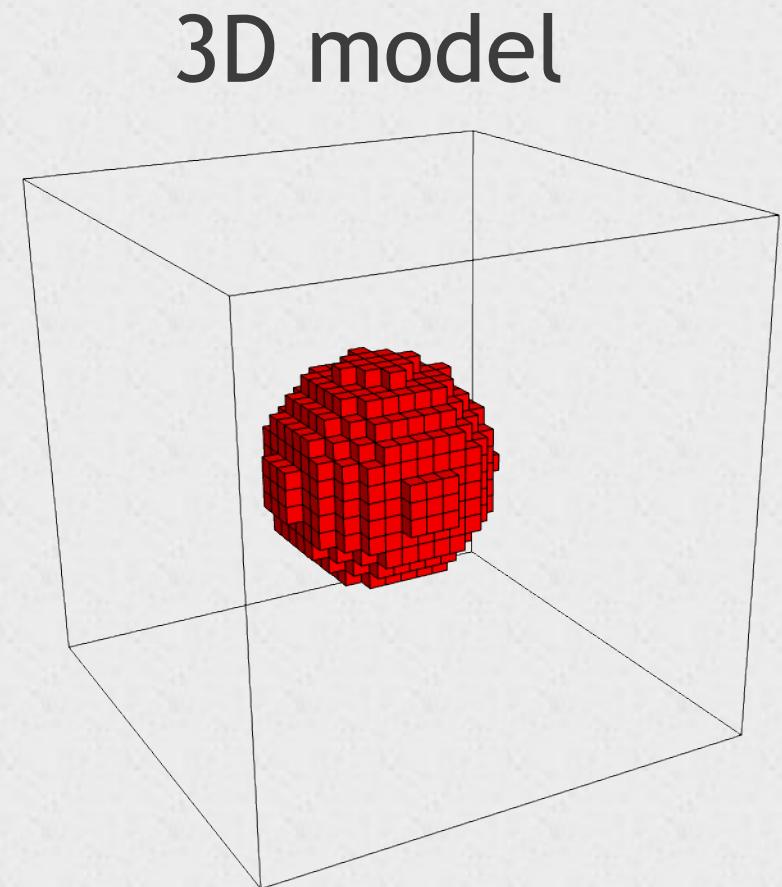
3D model





Regularization:

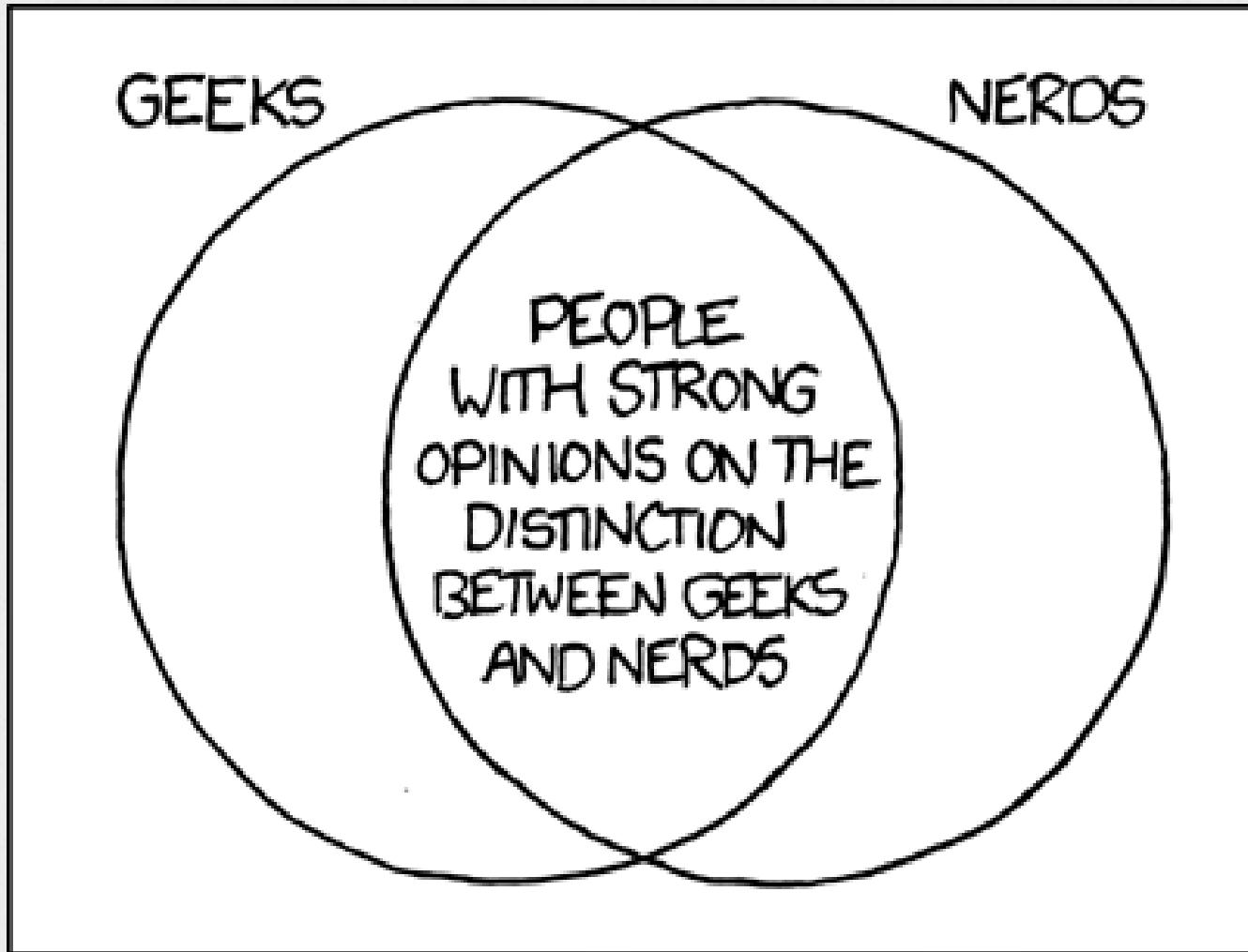
- Damping
- Smoothness



- ✓ Automatic fit
- ✓ Gravity + gradients
- ✓ 3D

- ✗ Control
- ✗ Prior information
- ✗ Speed

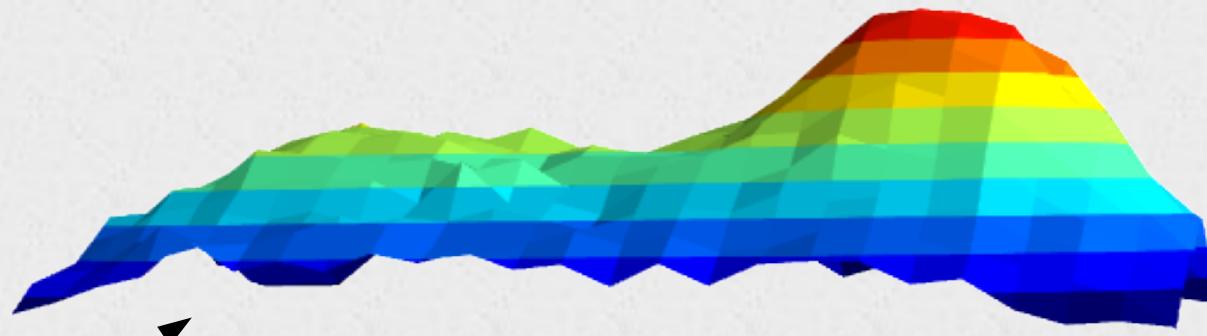
# Something in the middle



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

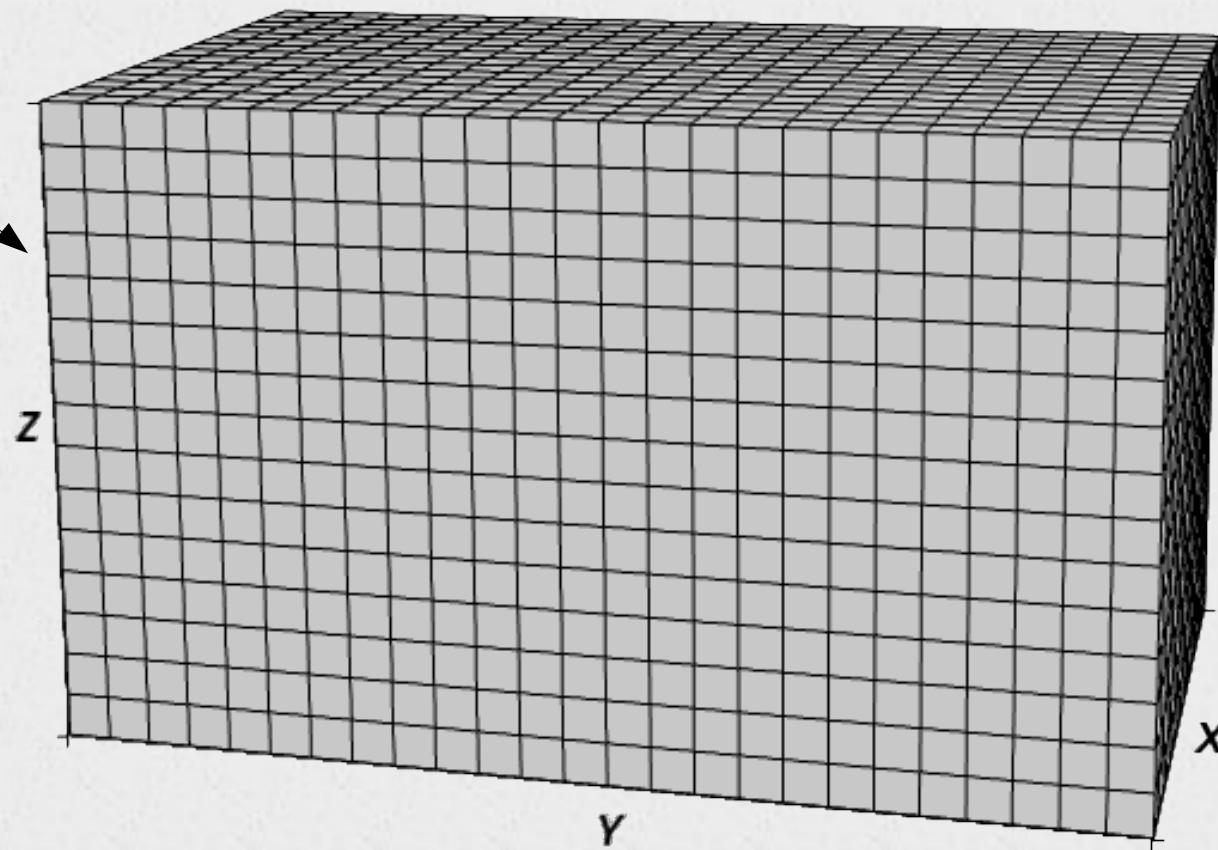
# Planting anomalous densities

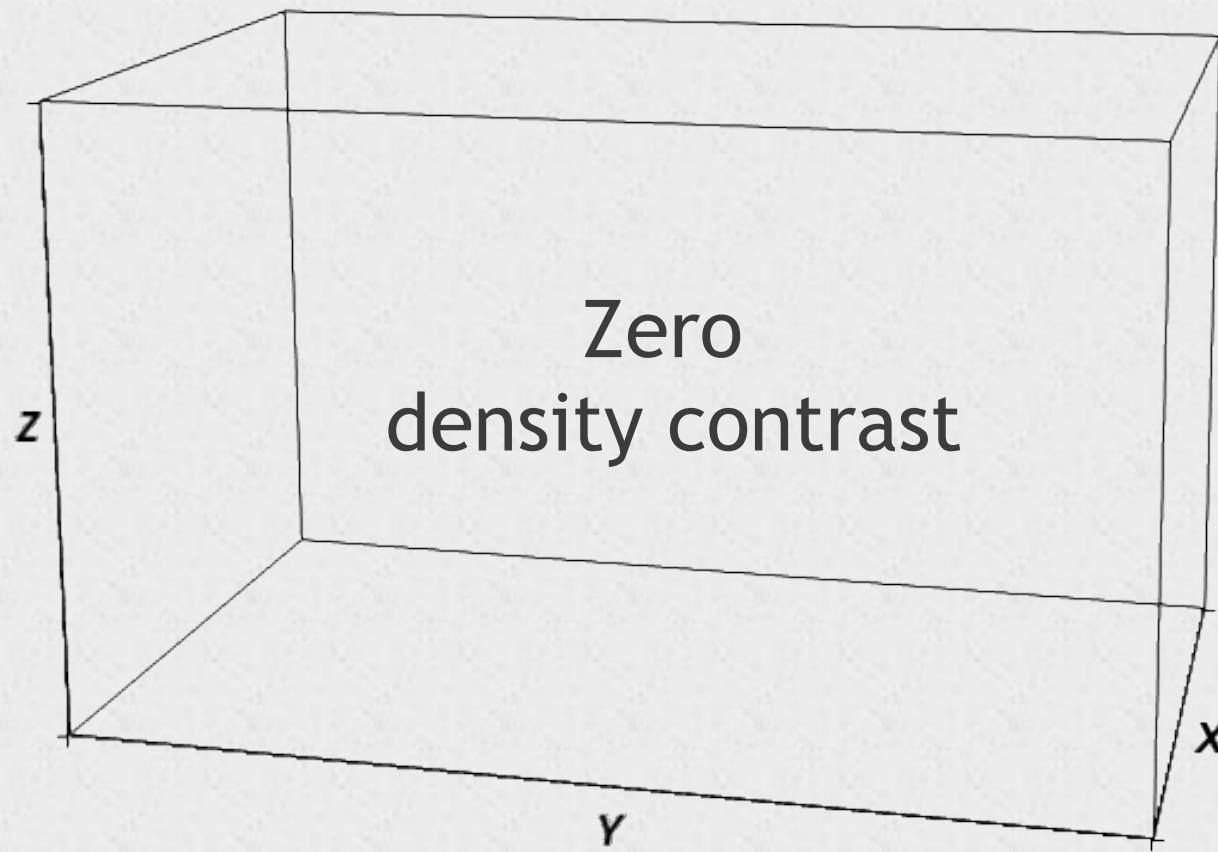
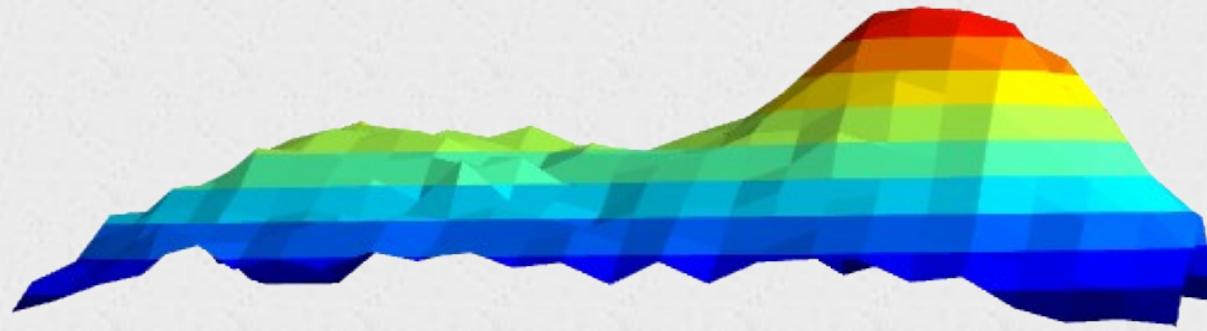
Uieda and Barbosa (2012)

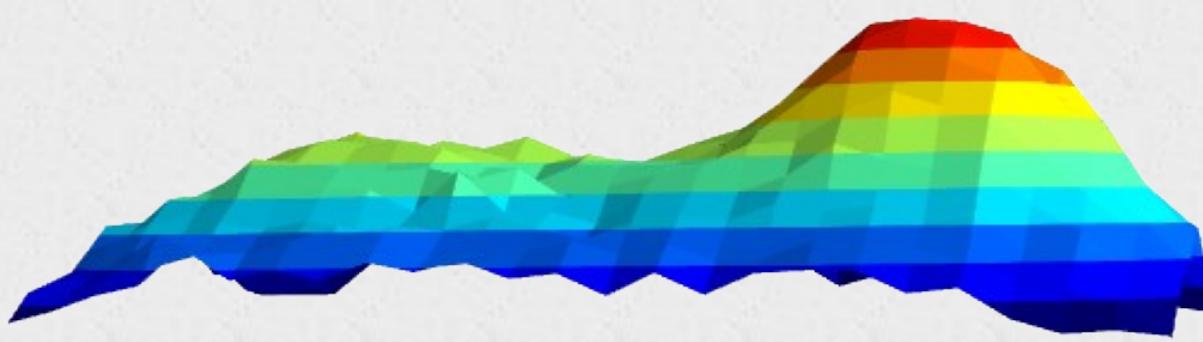


Observed data

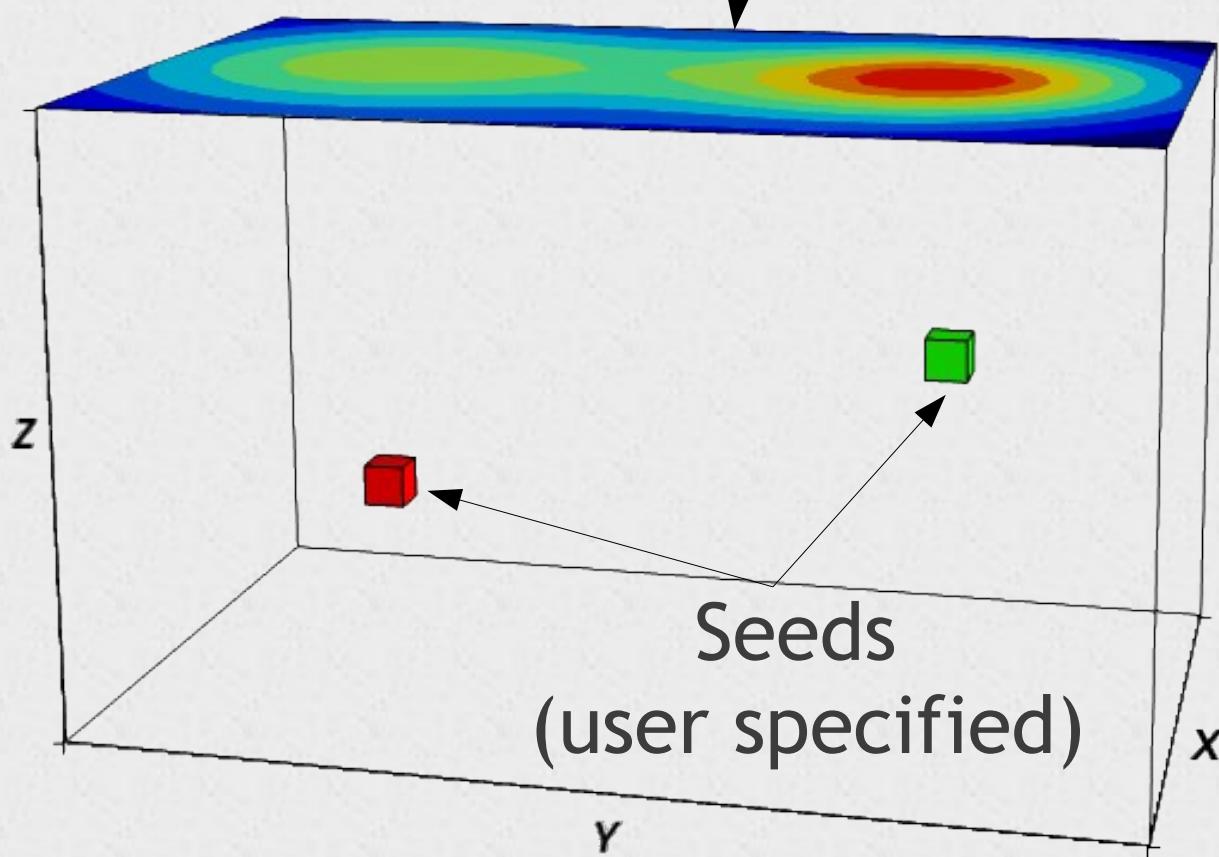
Mesh



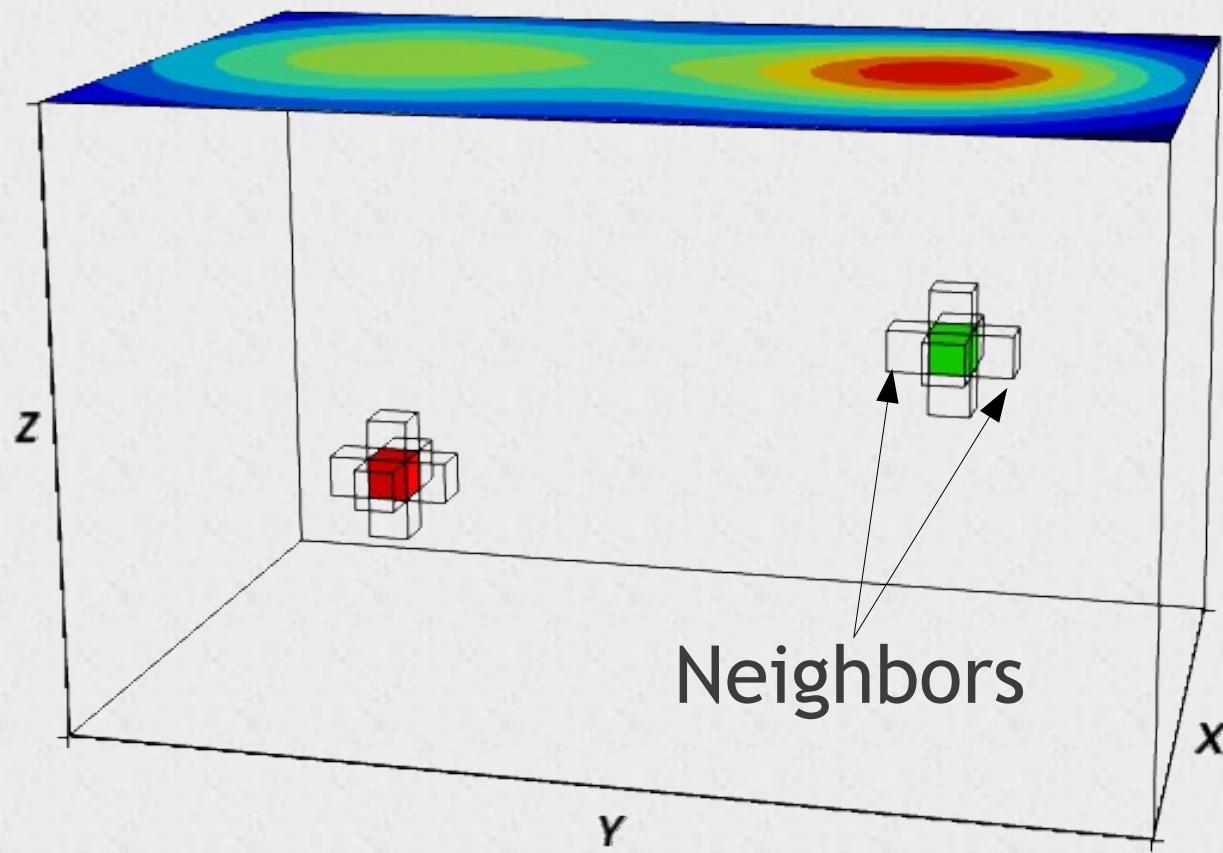
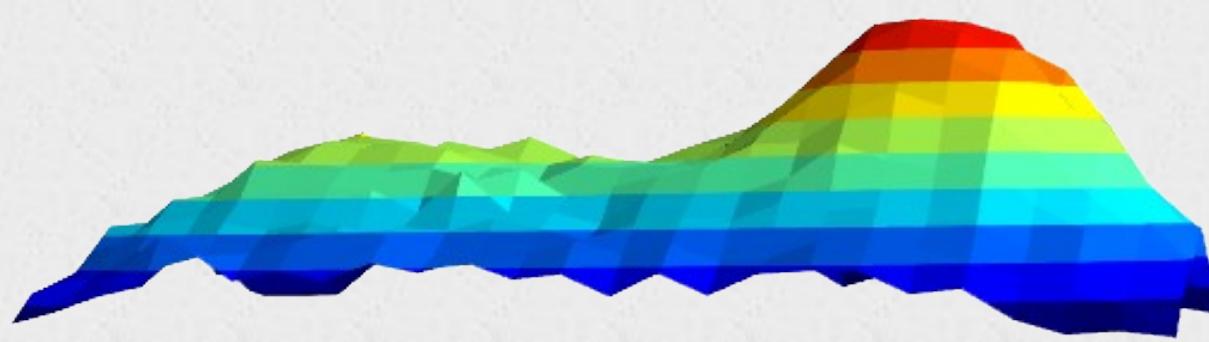




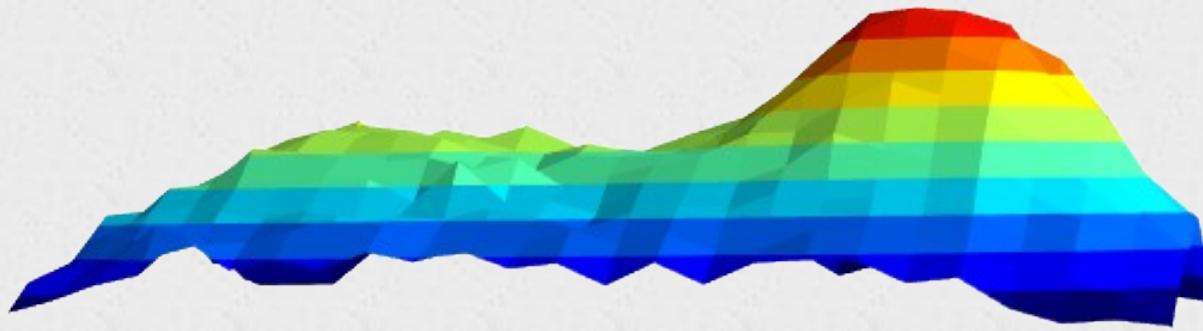
Predicted data



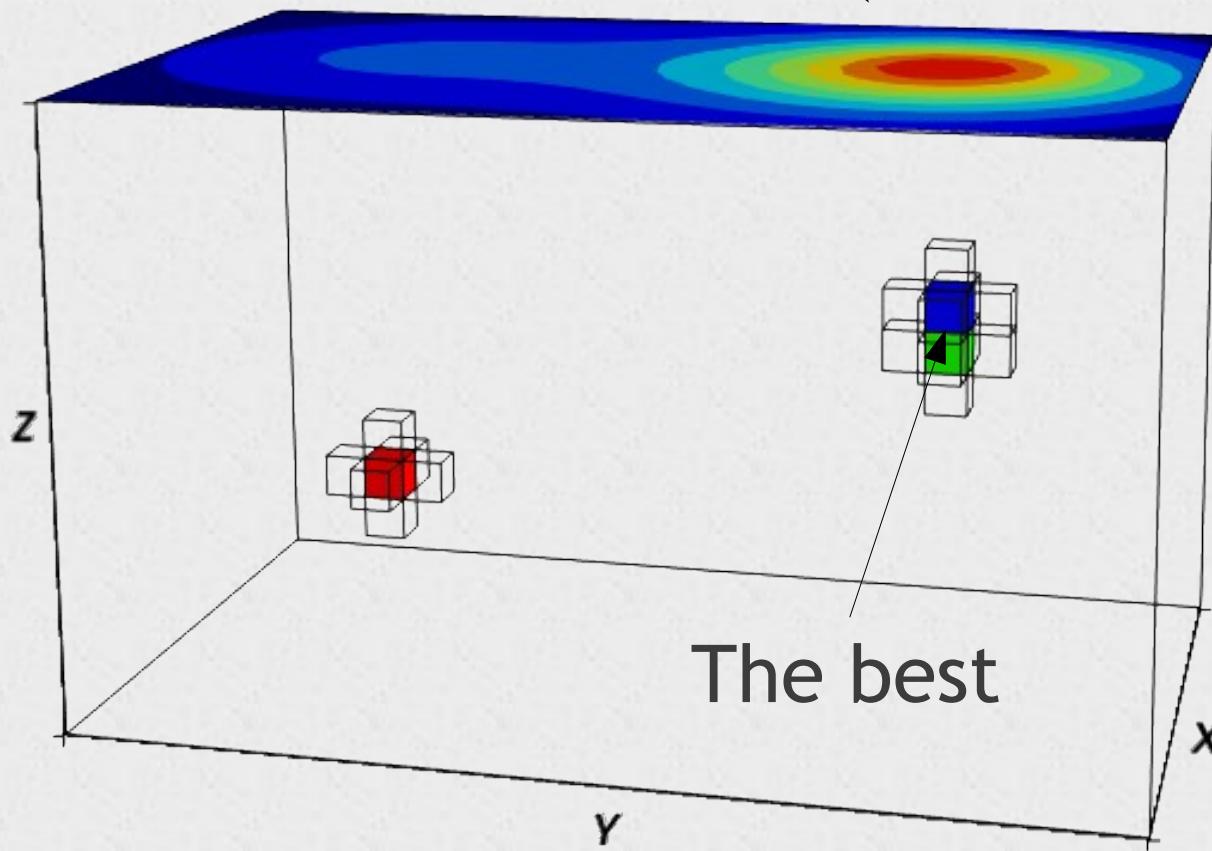
Seeds  
(user specified)



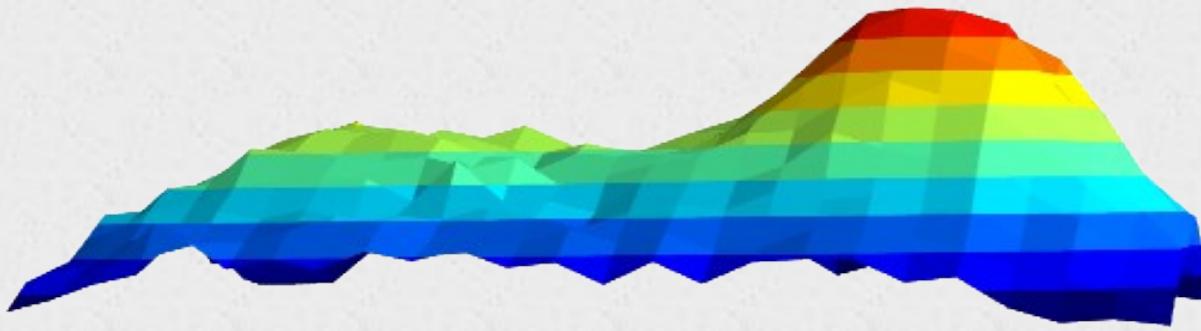
Neighbors



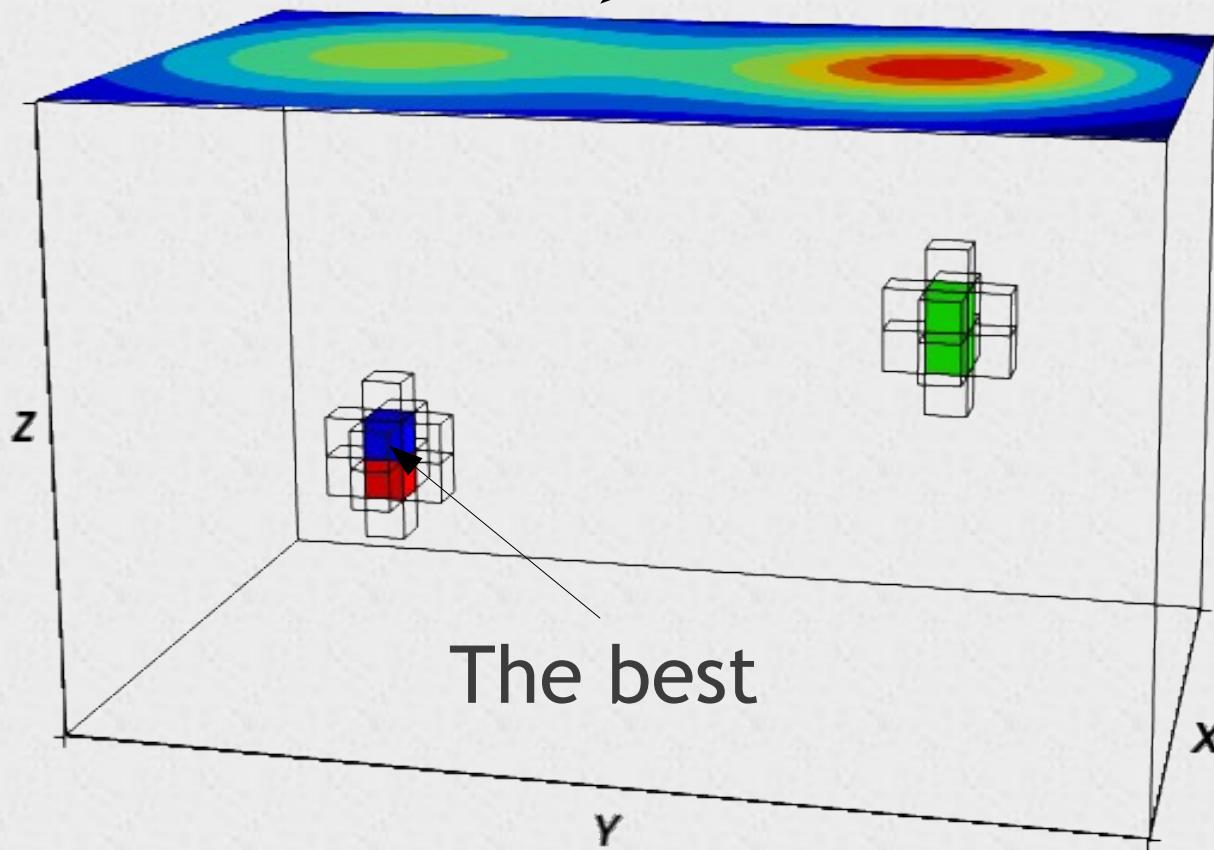
New predicted data

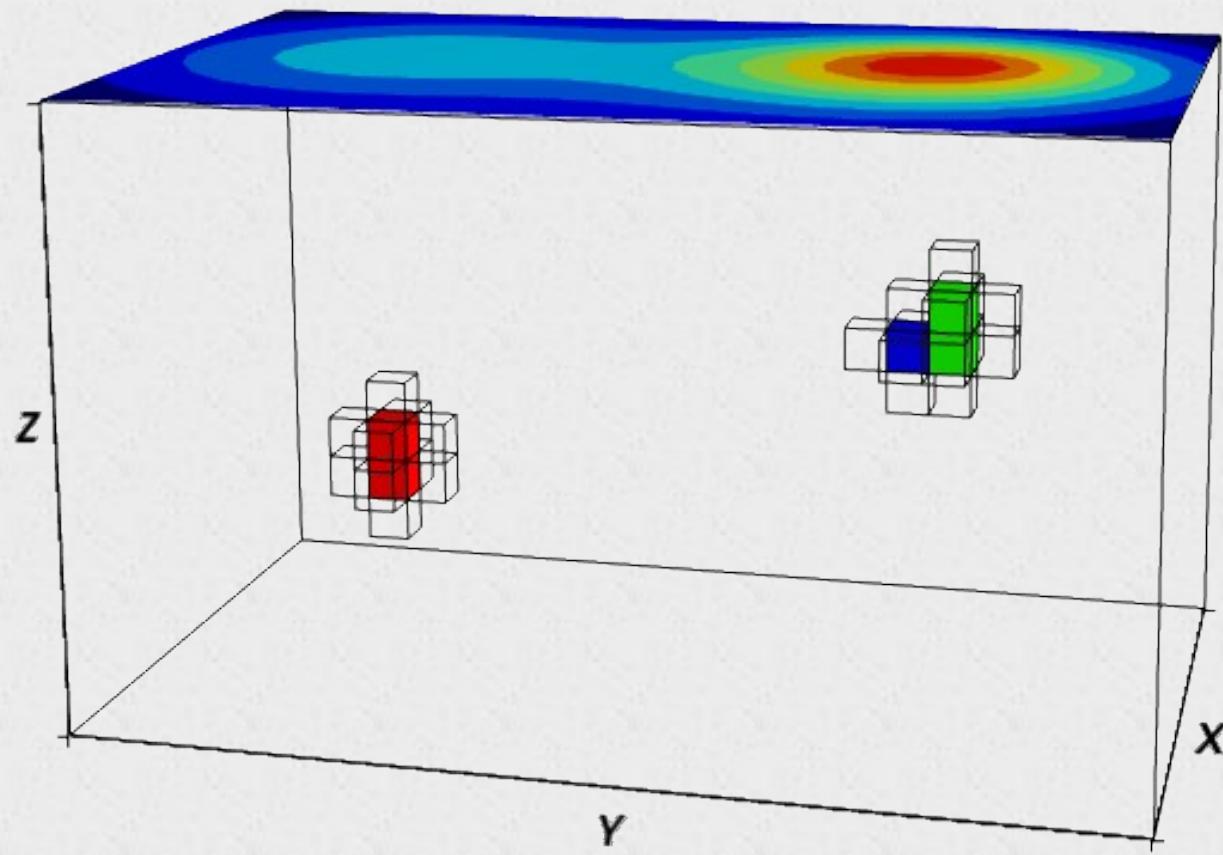
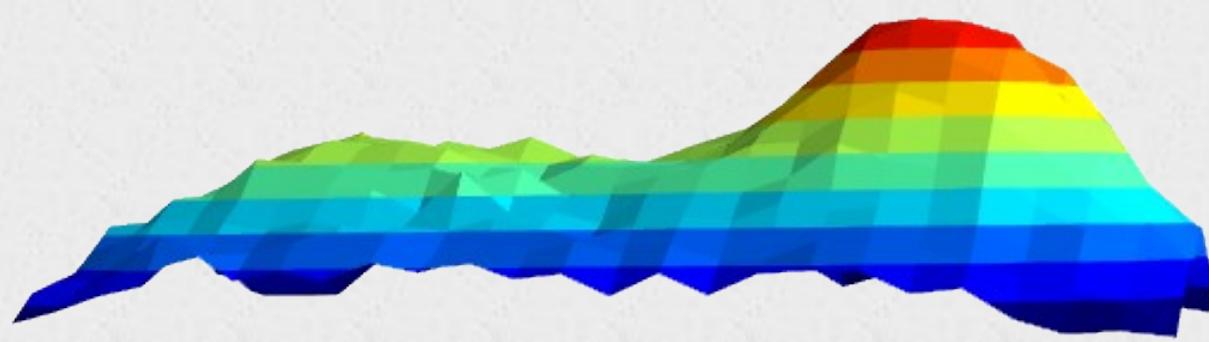


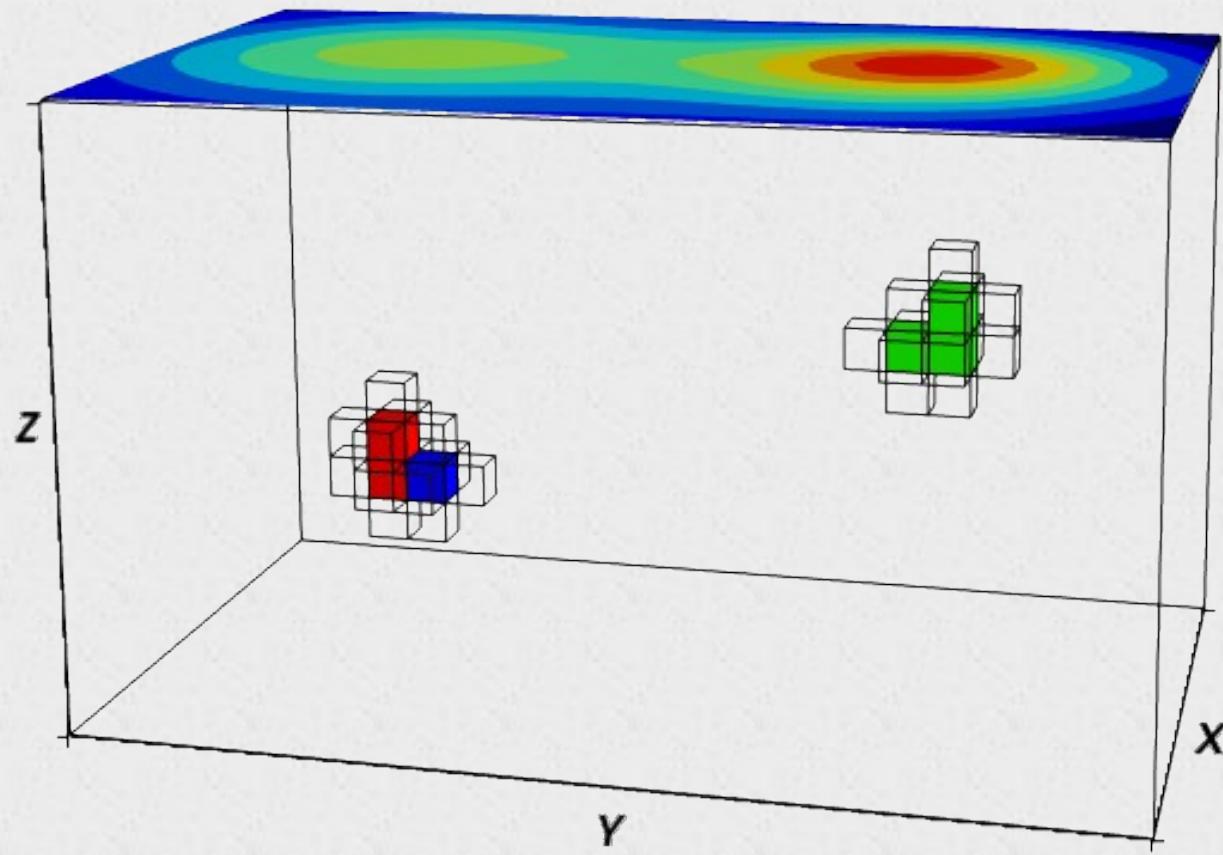
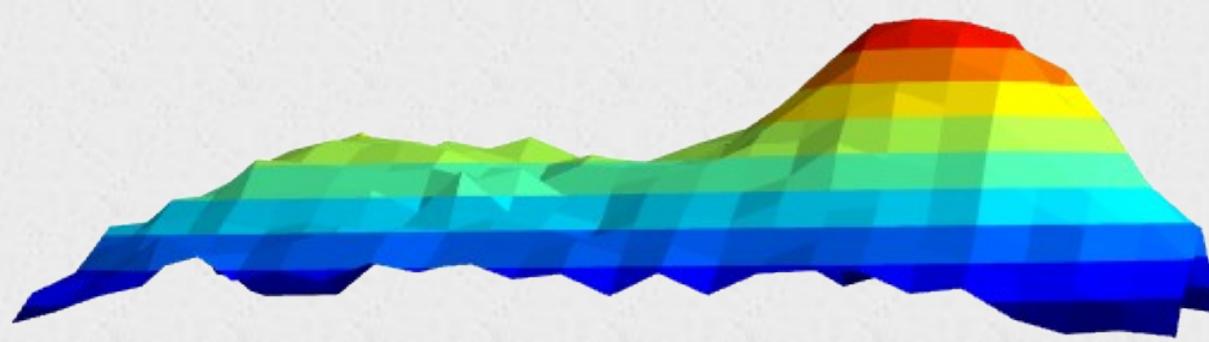
The best

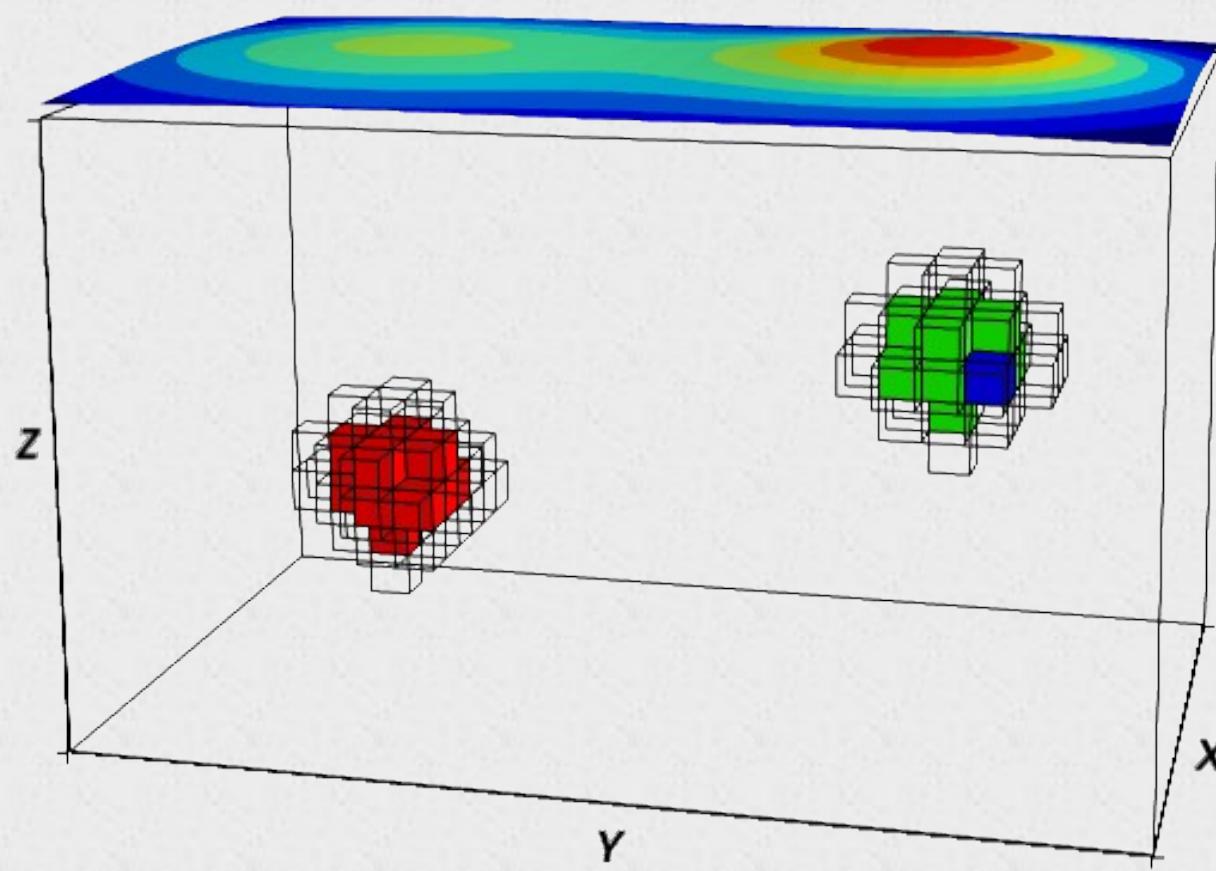
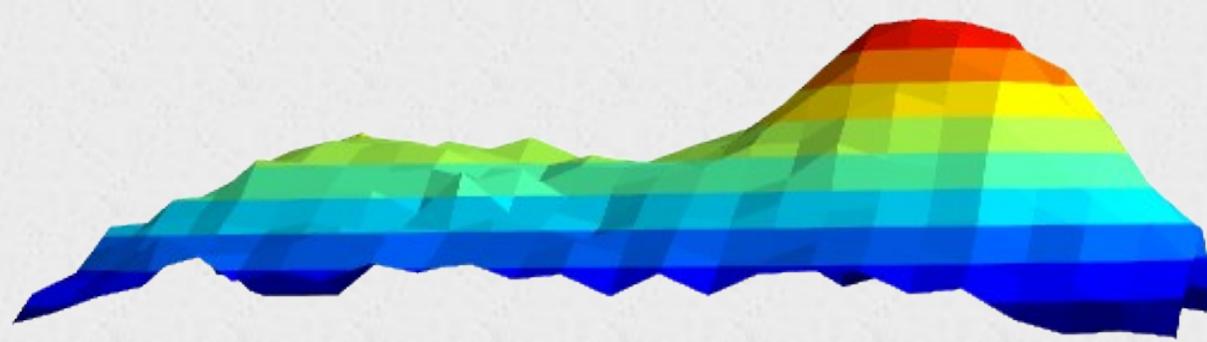


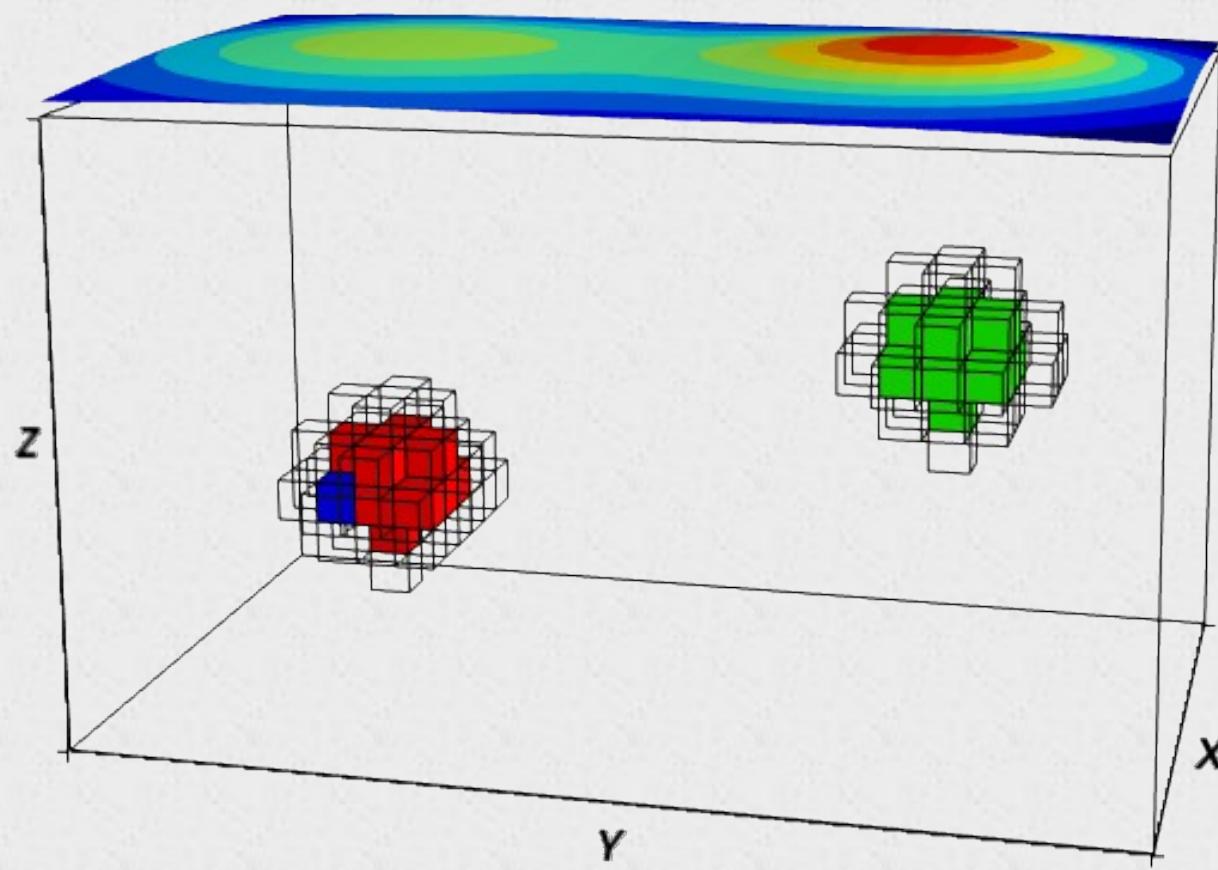
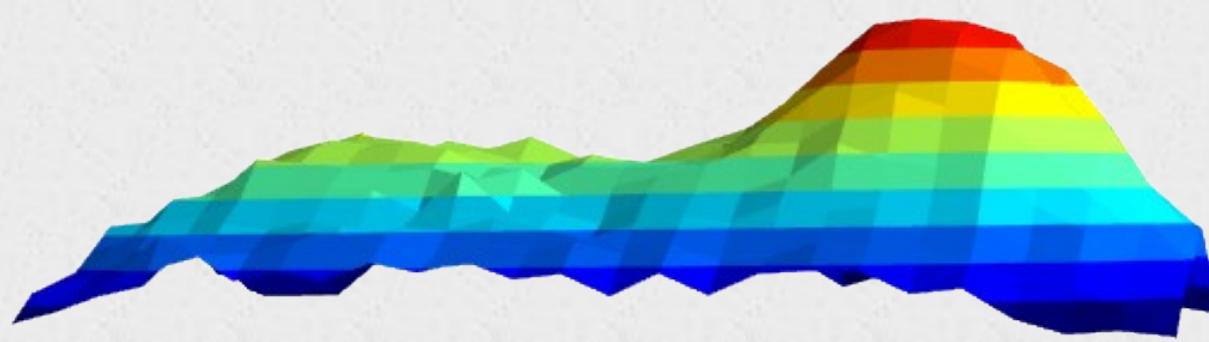
New predicted data

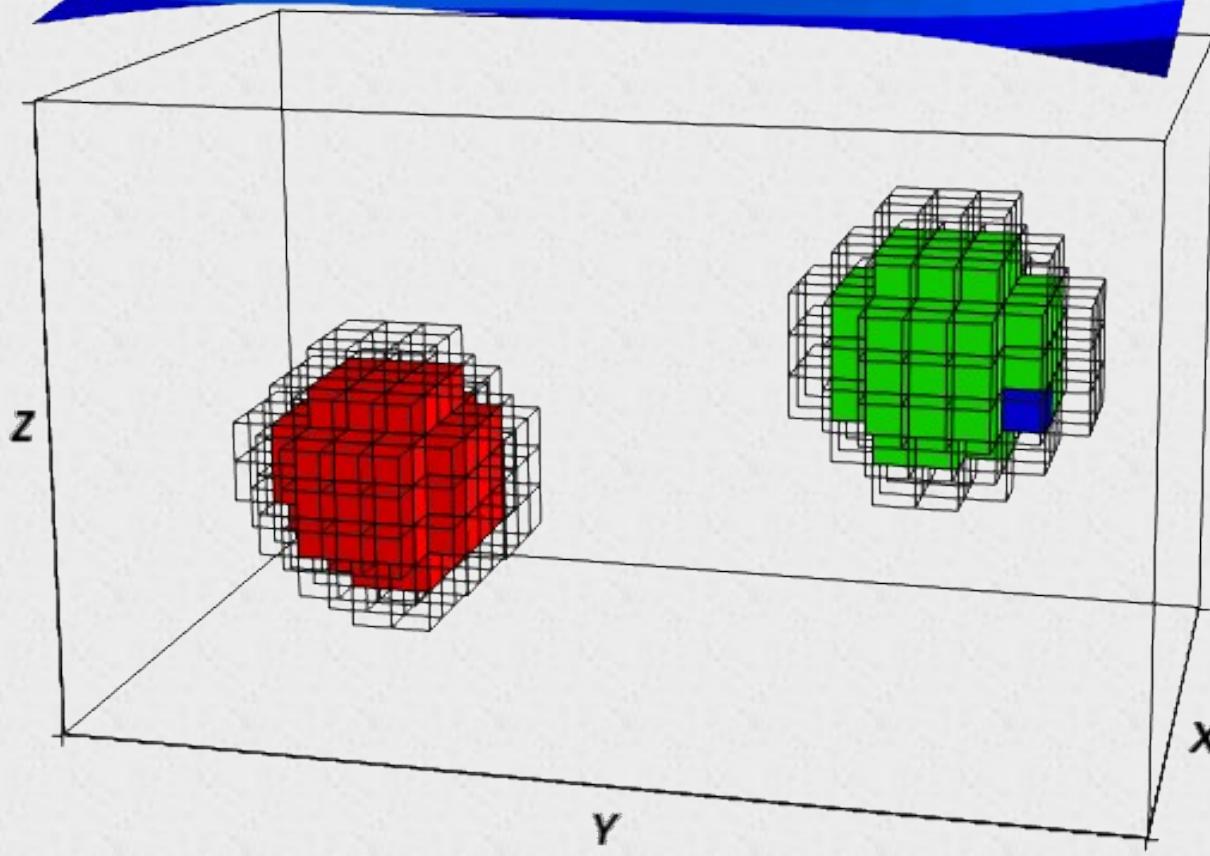
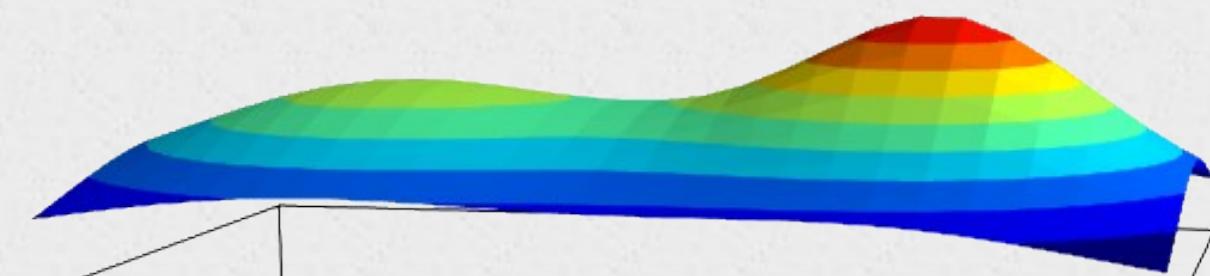
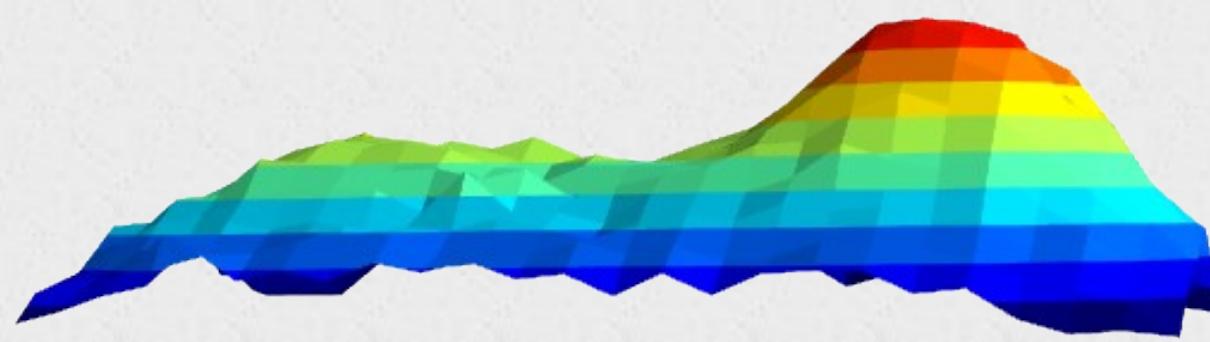


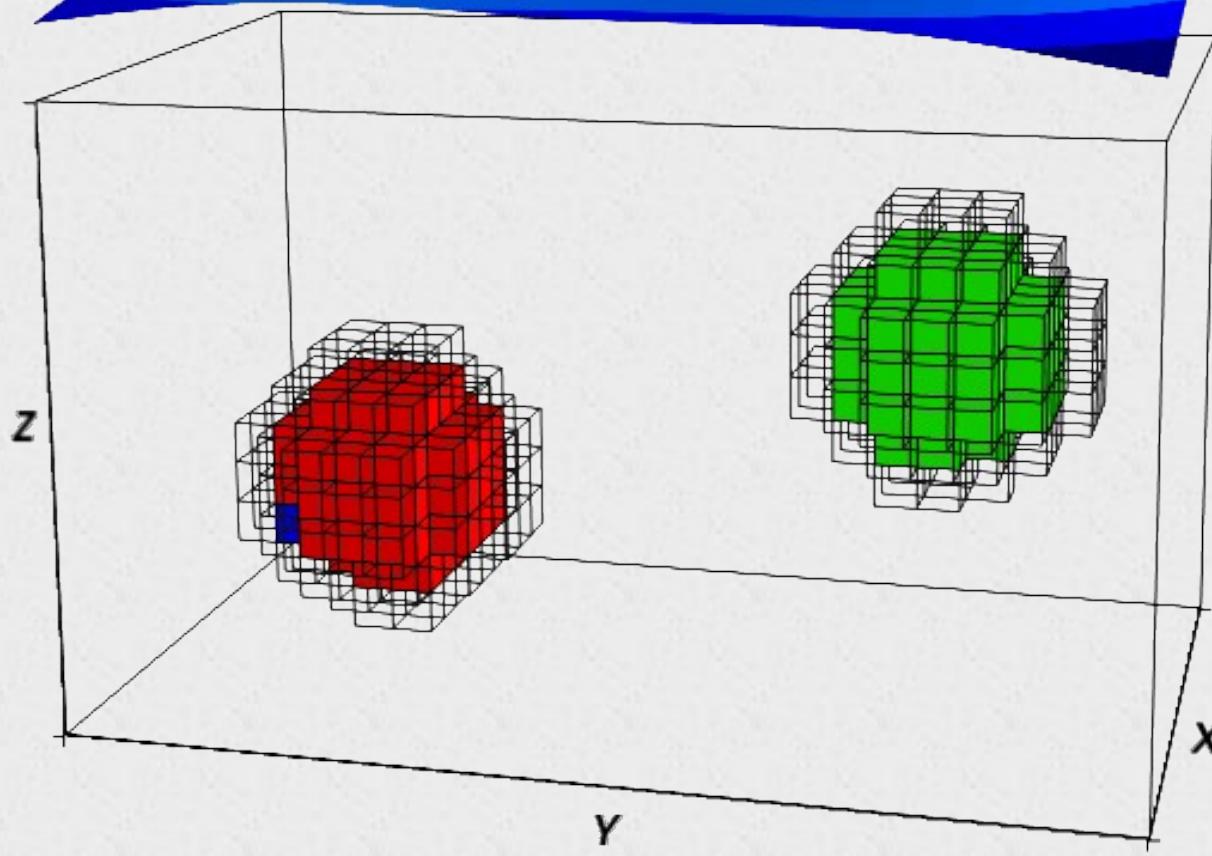
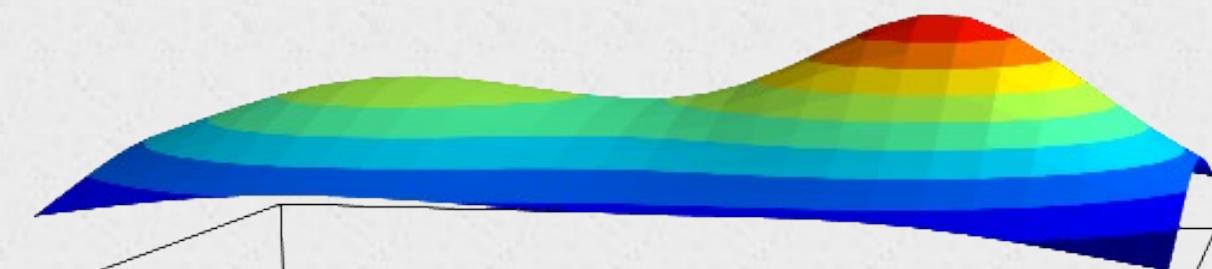
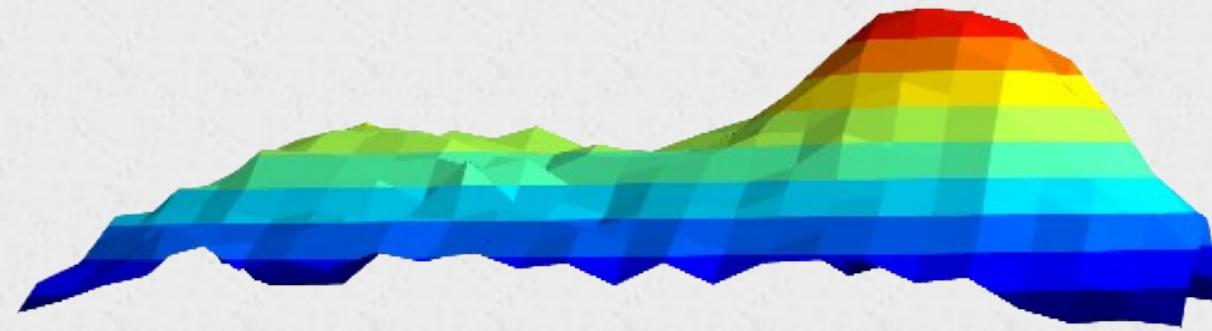


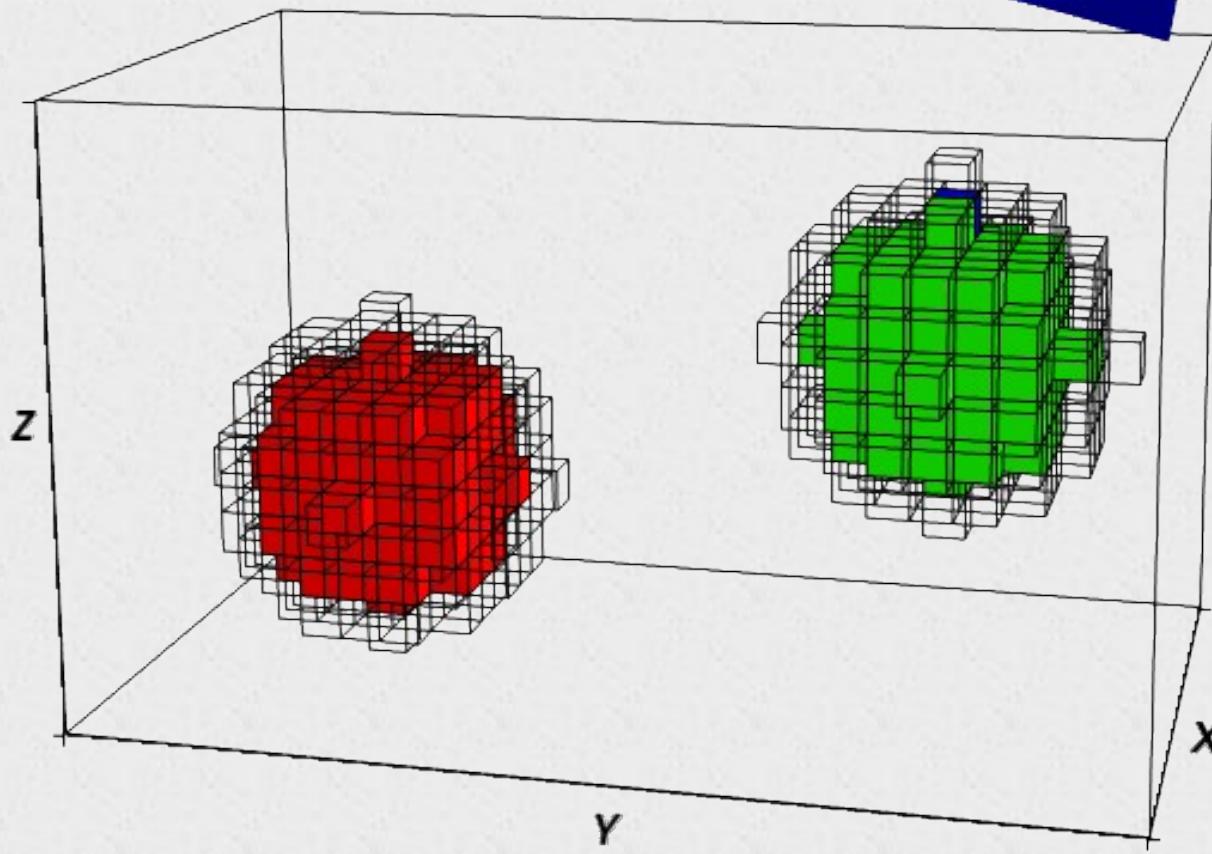
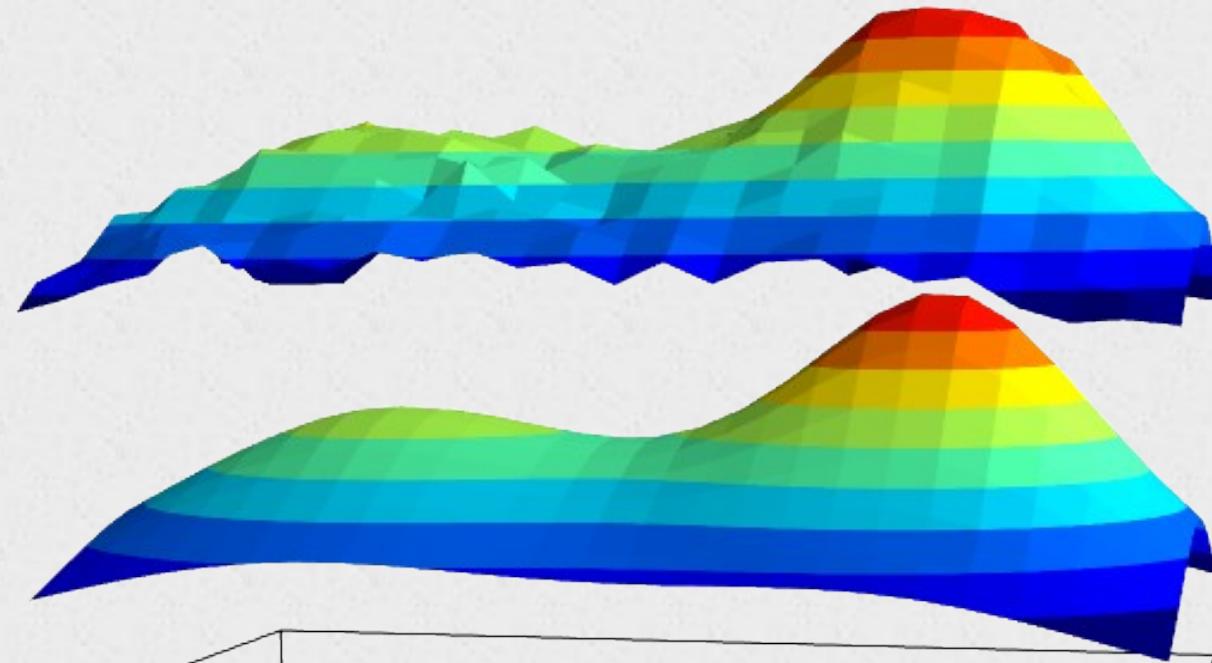


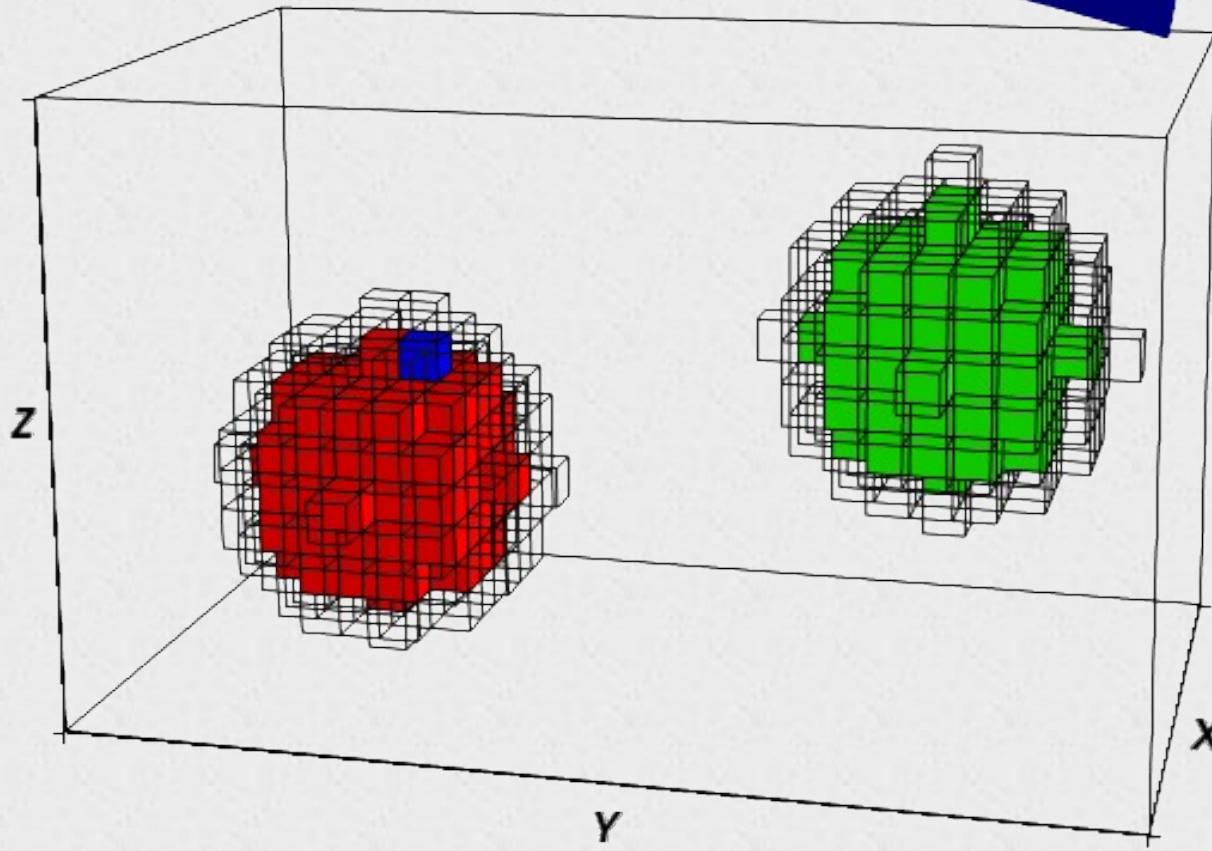
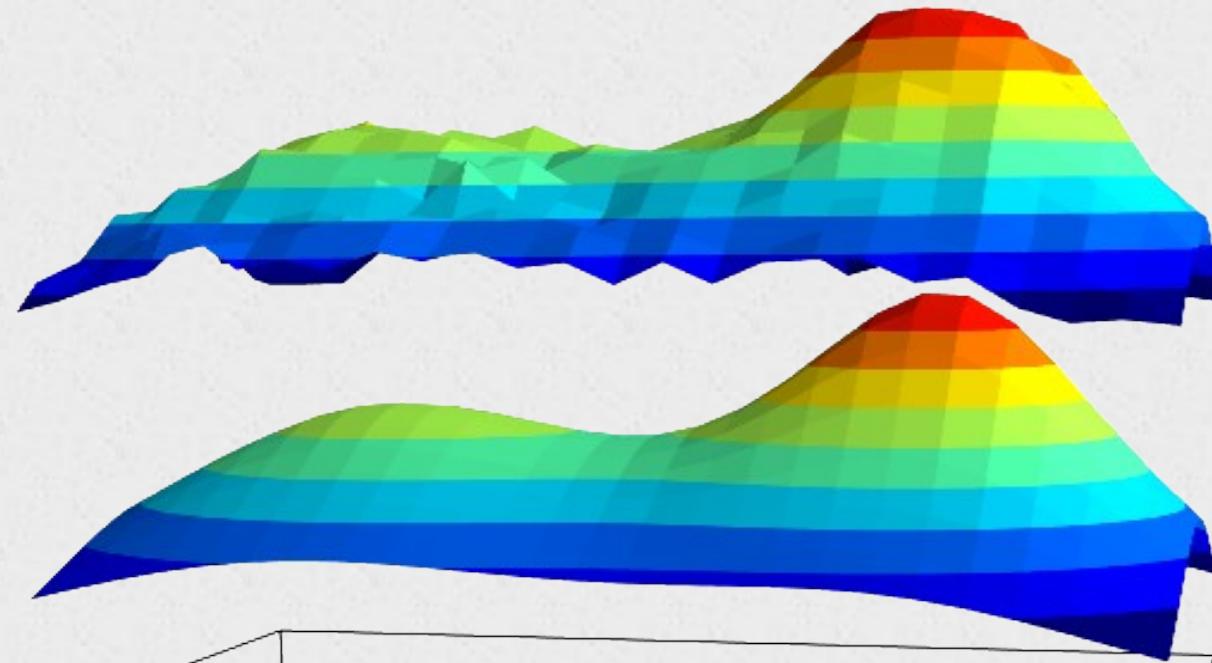




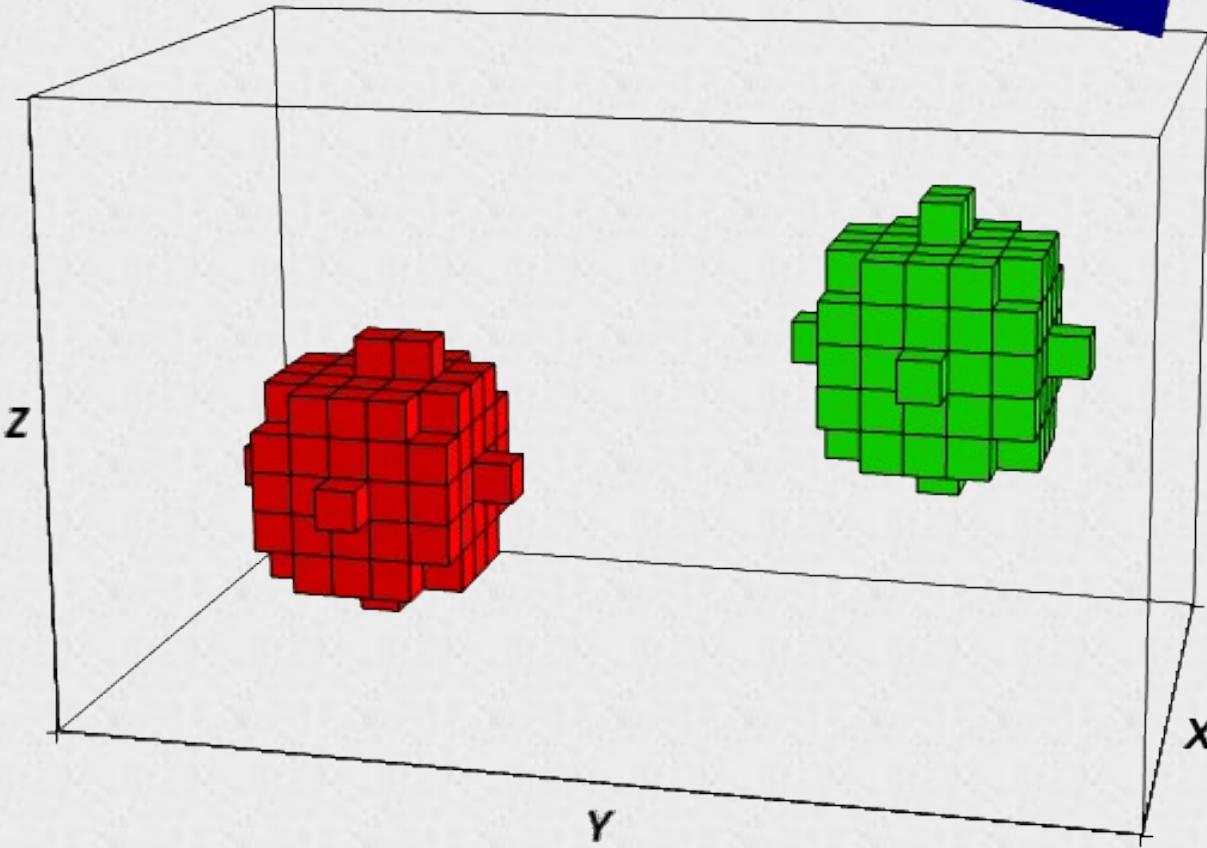








**Fit!**



# Seeds = Skeleton



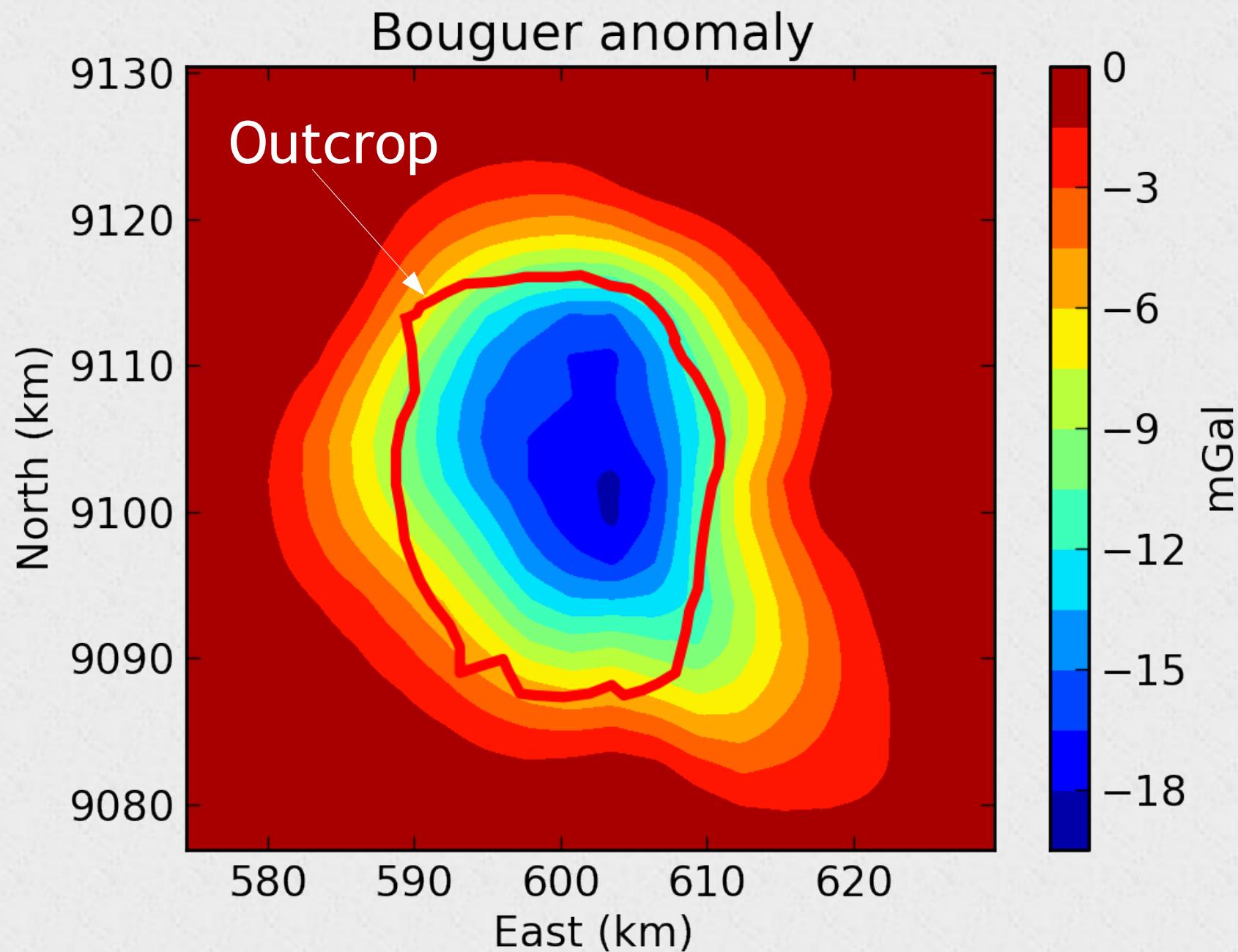
Inversion → Body



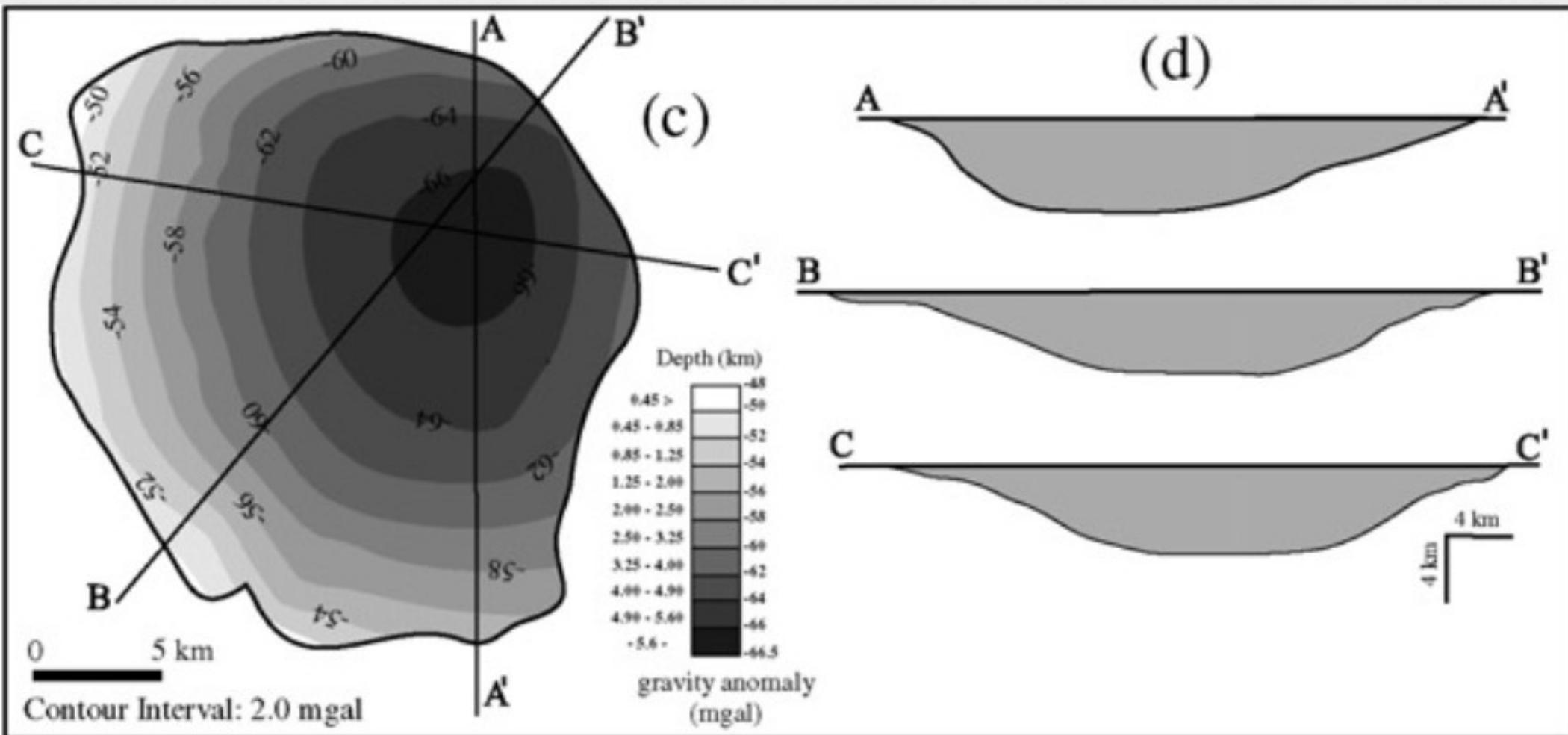
- ✓ Control
  - ✓ Prior information
  - ✓ Speed
  - ✓ Automatic fit
  - ✓ Gravity + Gradients
  - ✓ 3D (only need skeleton)
- 
- A diagram consisting of a vertical list of six items, each preceded by a green checkmark. To the right of the list, the word "Seeds" is written in a large, dark font. Three arrows originate from the right side of the word "Seeds": one points horizontally to the first checkmark, another points diagonally up and to the left to the second checkmark, and a third points vertically upwards to the third checkmark.

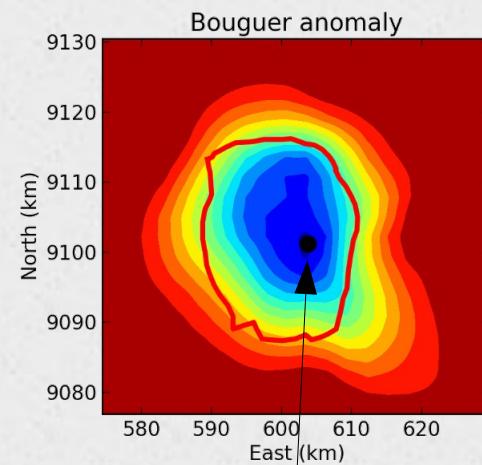
# Example applications

Redenção granite

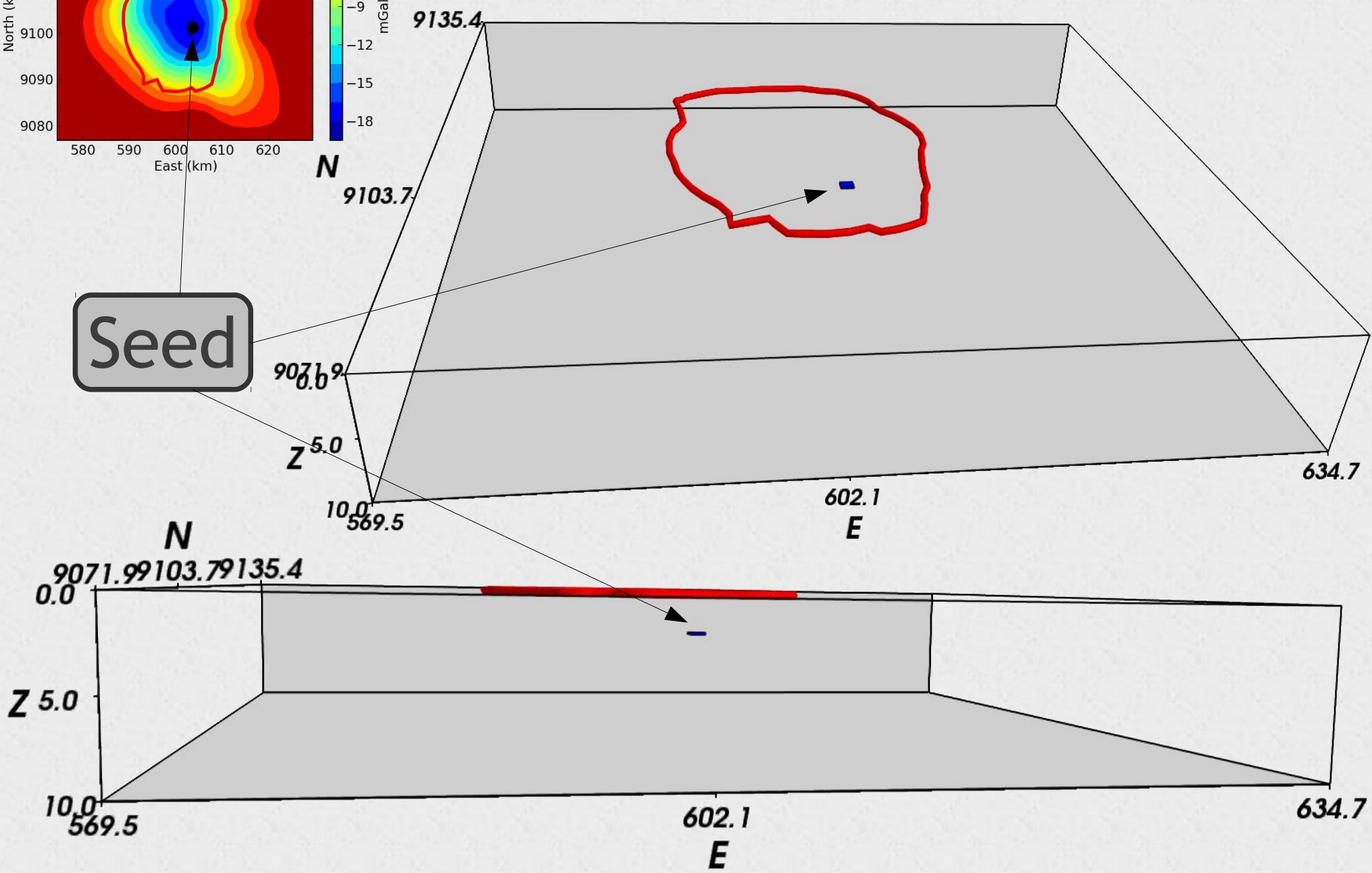


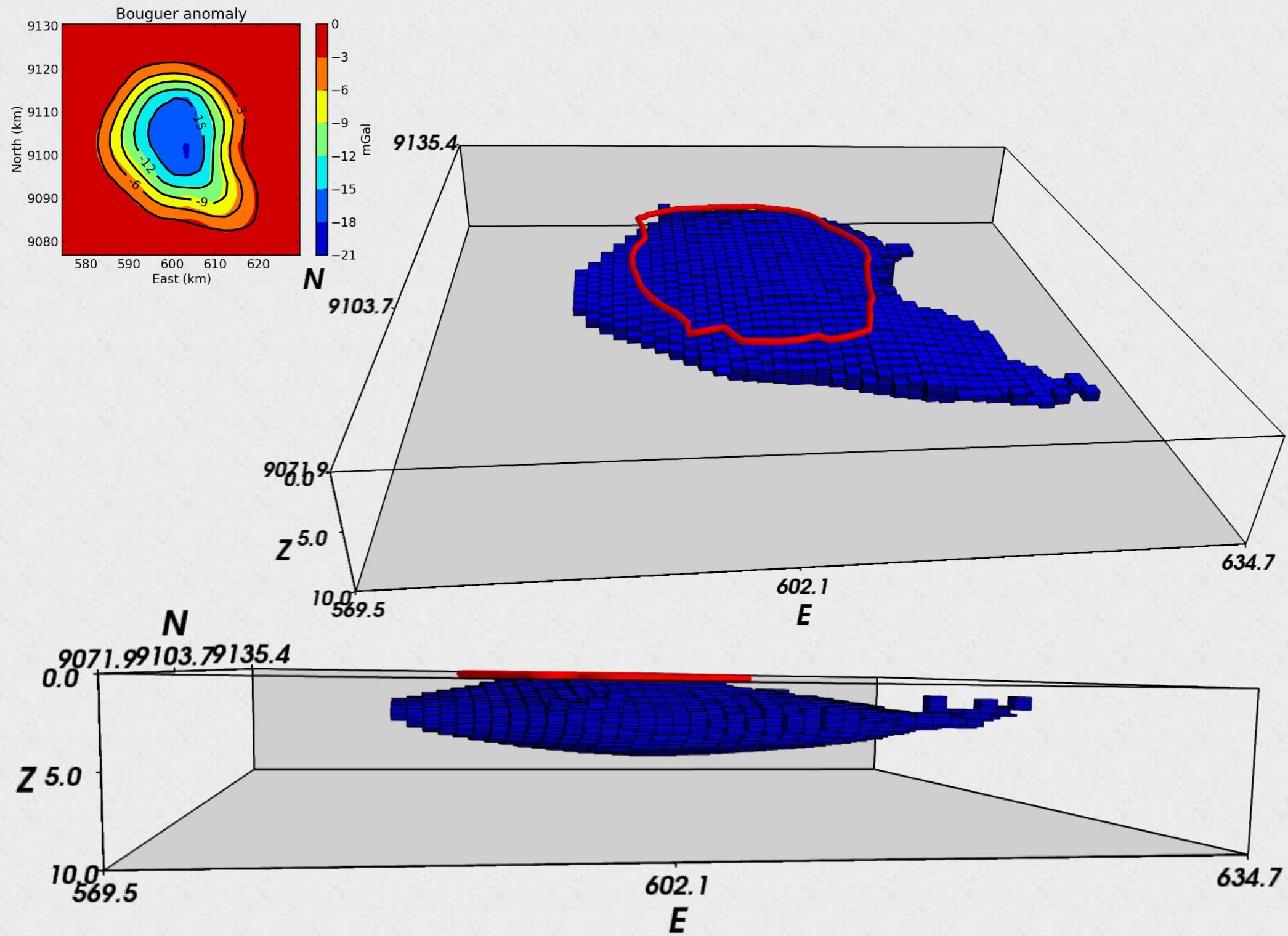
# Oliveira et al. (2008)





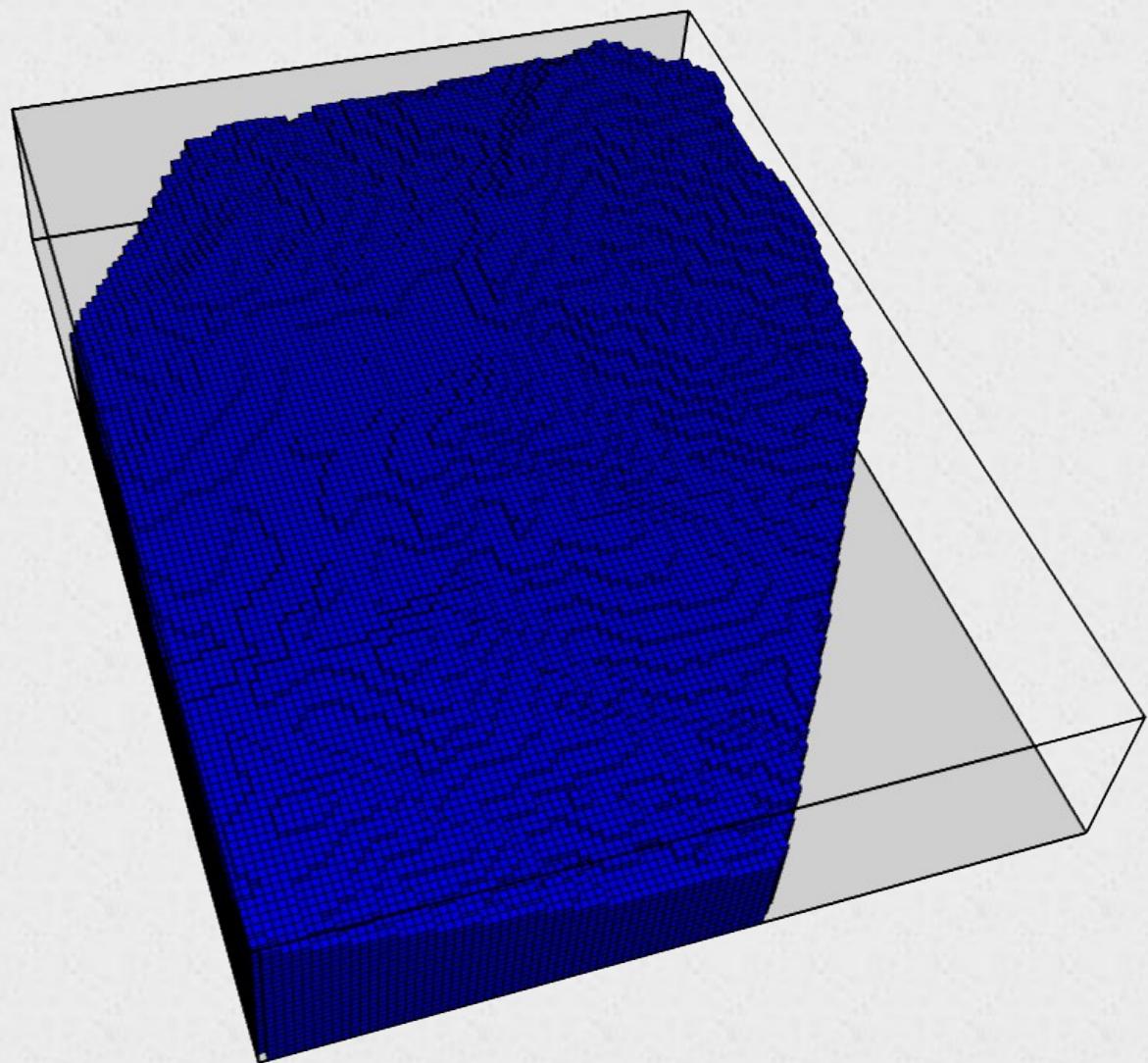
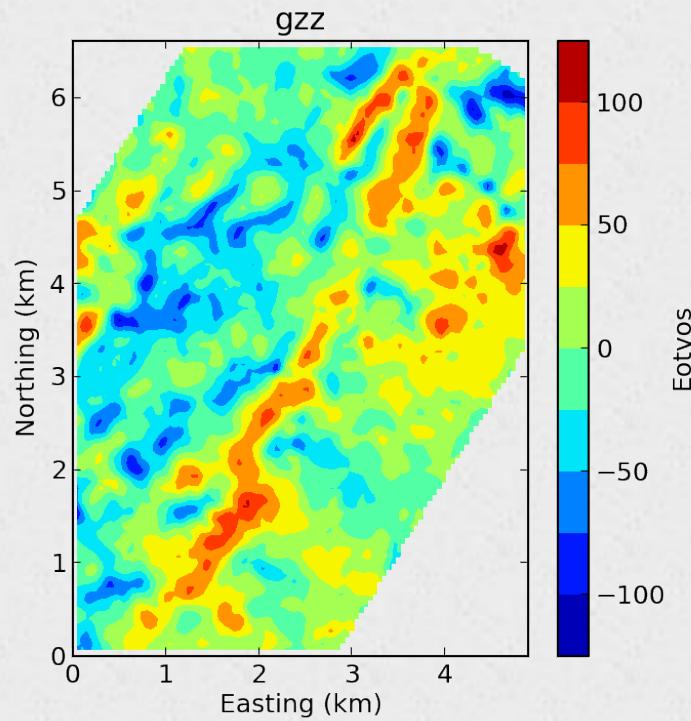
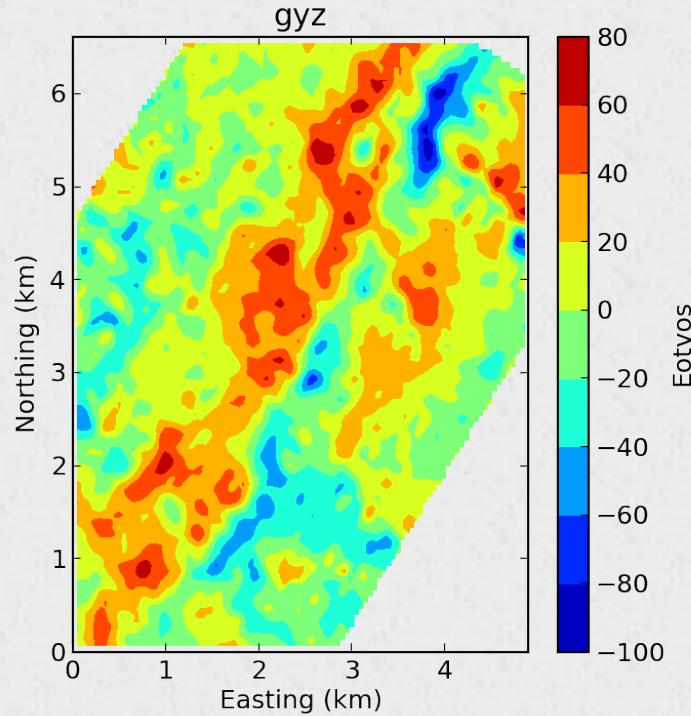
Density contrast = -0.09 g.cm<sup>-3</sup>



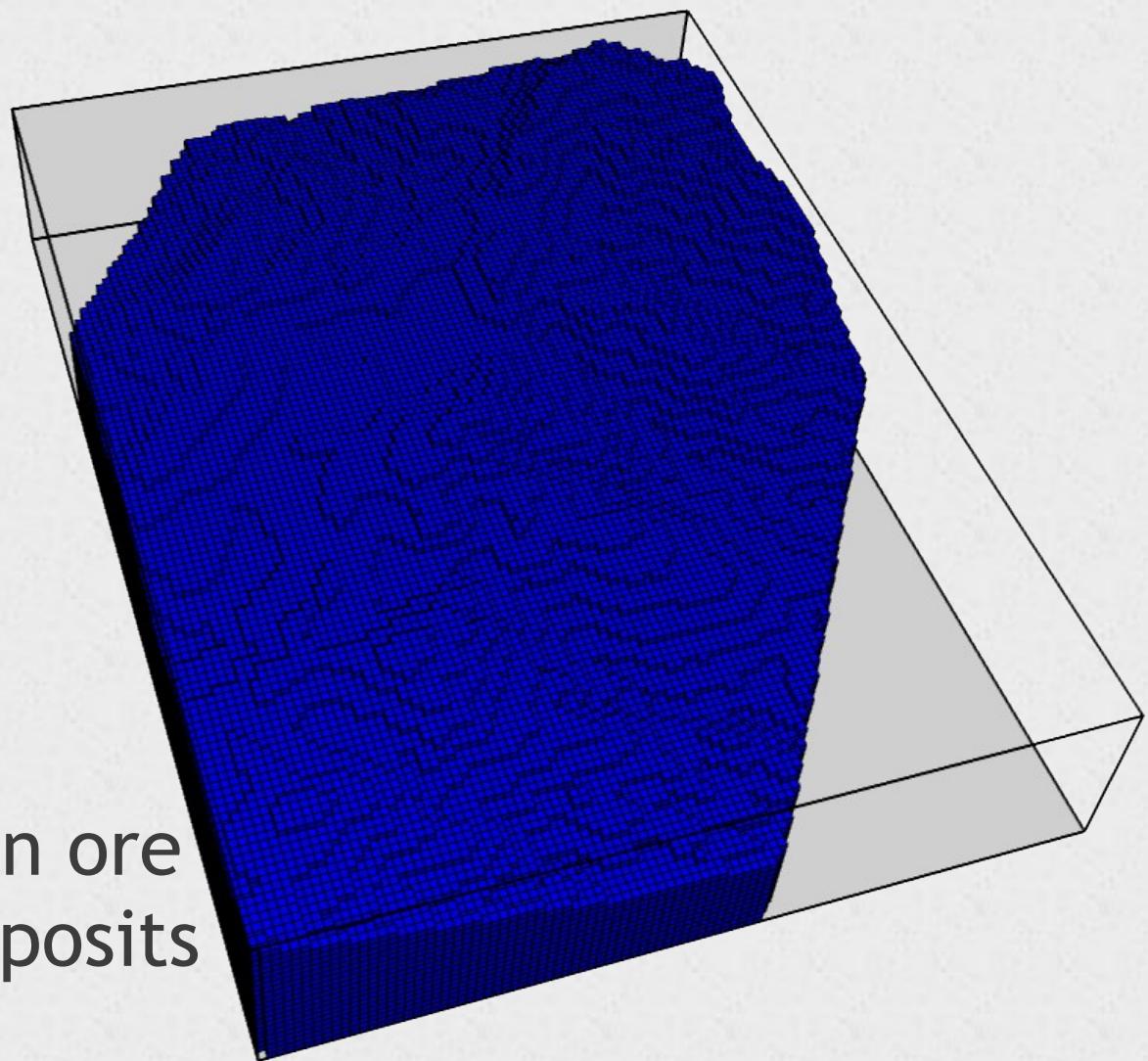
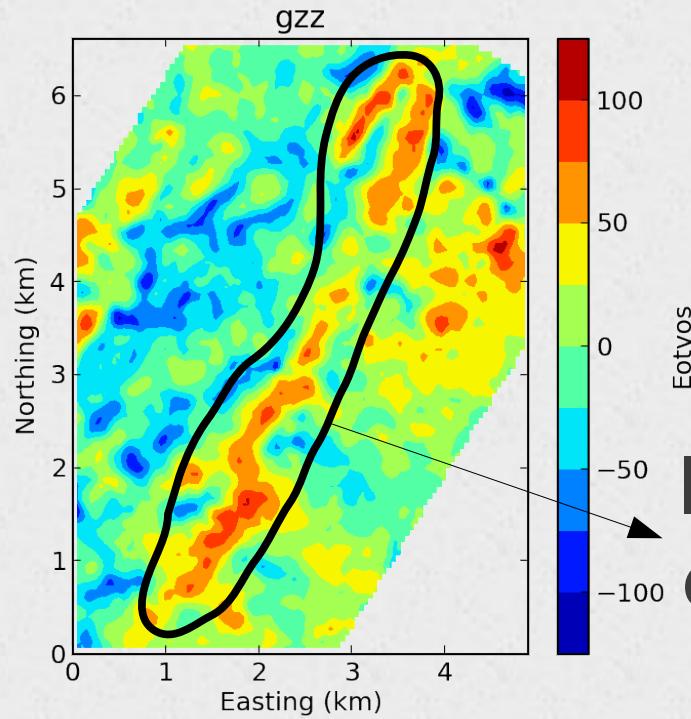
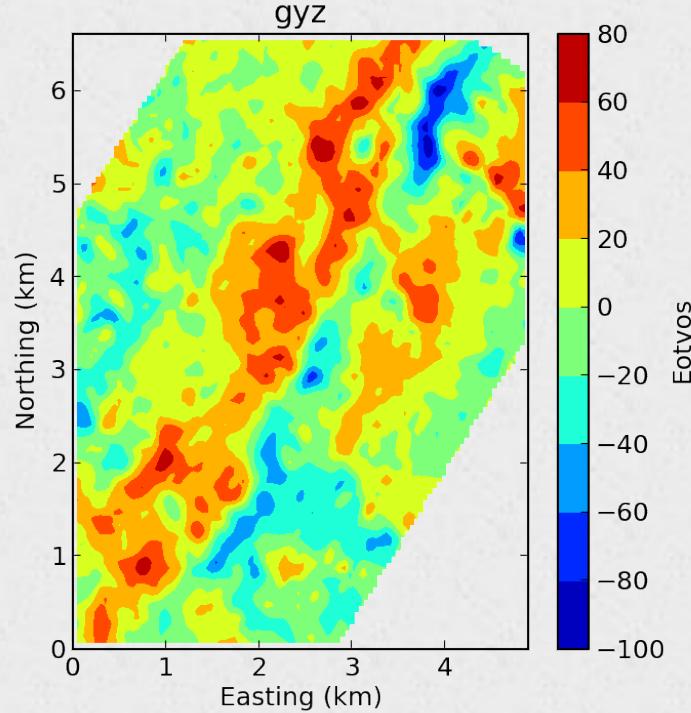


# Quadrilátero Ferrífero

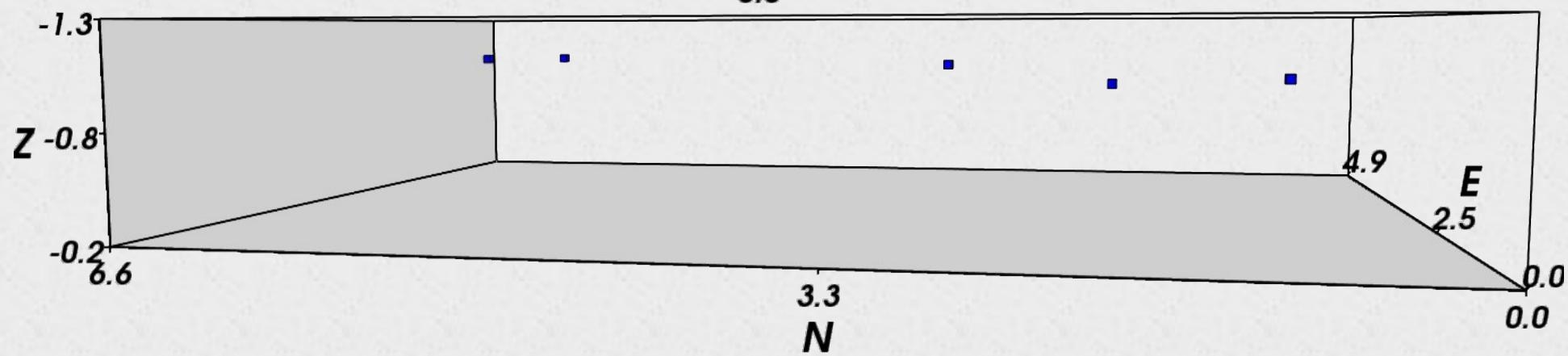
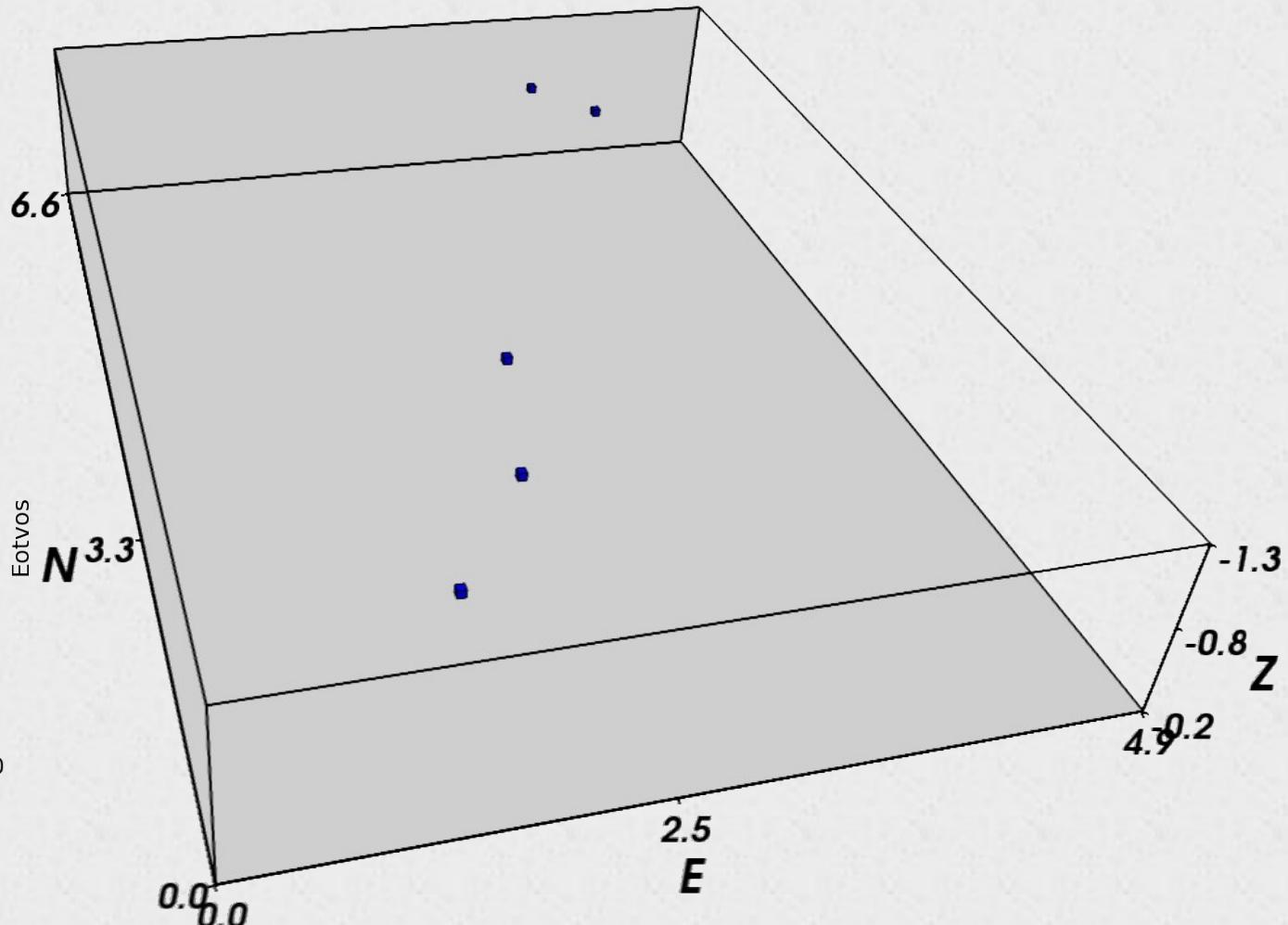
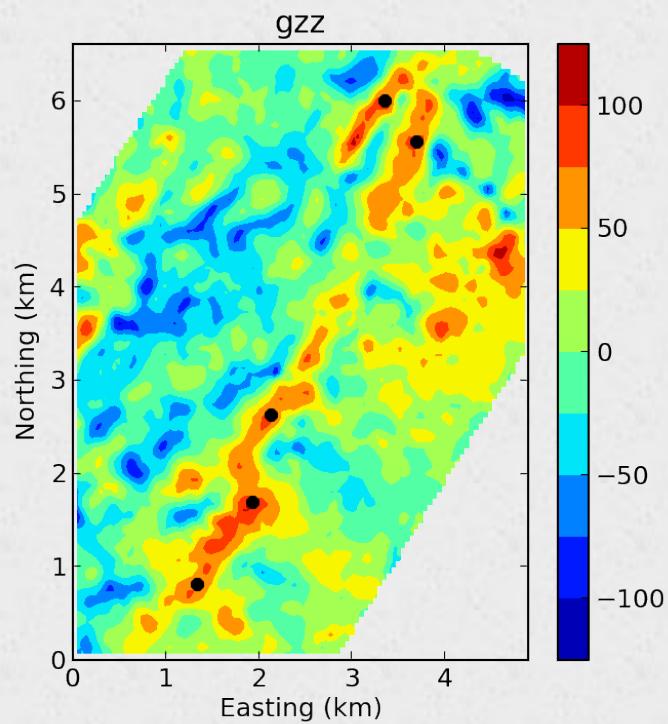
# Complex geology and topography

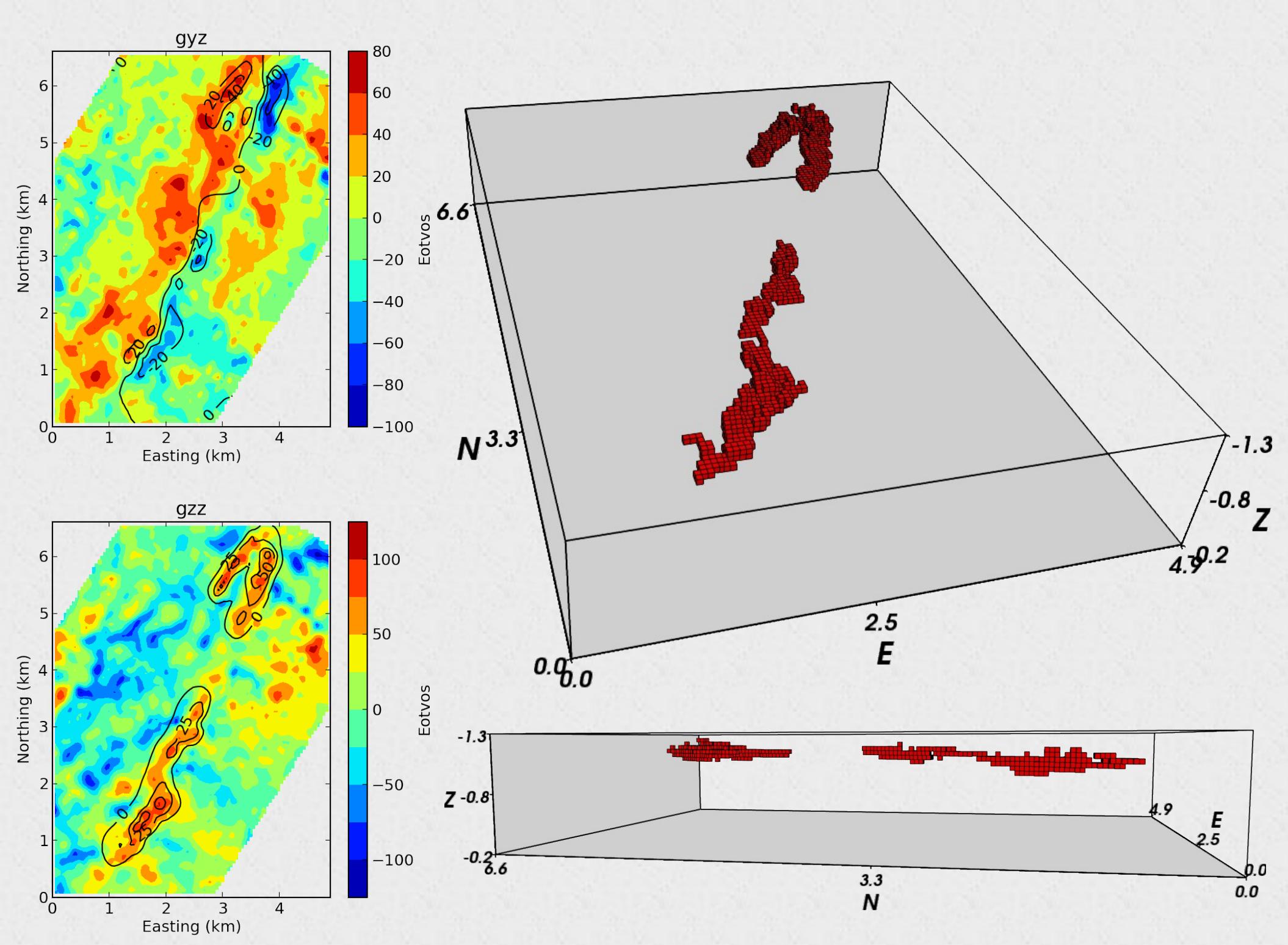


# Complex geology and topography



# Seeds





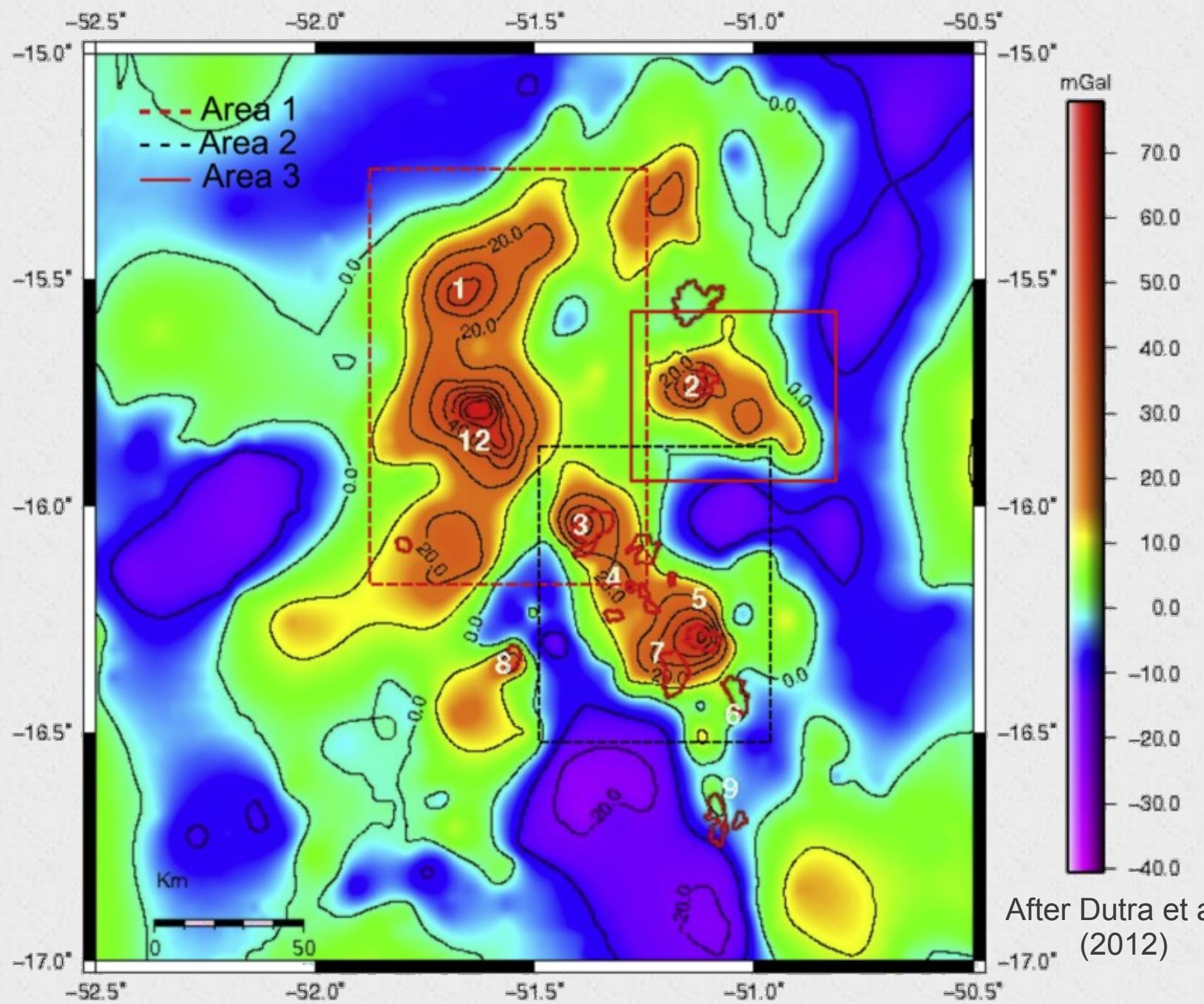
# Hypothesis testing

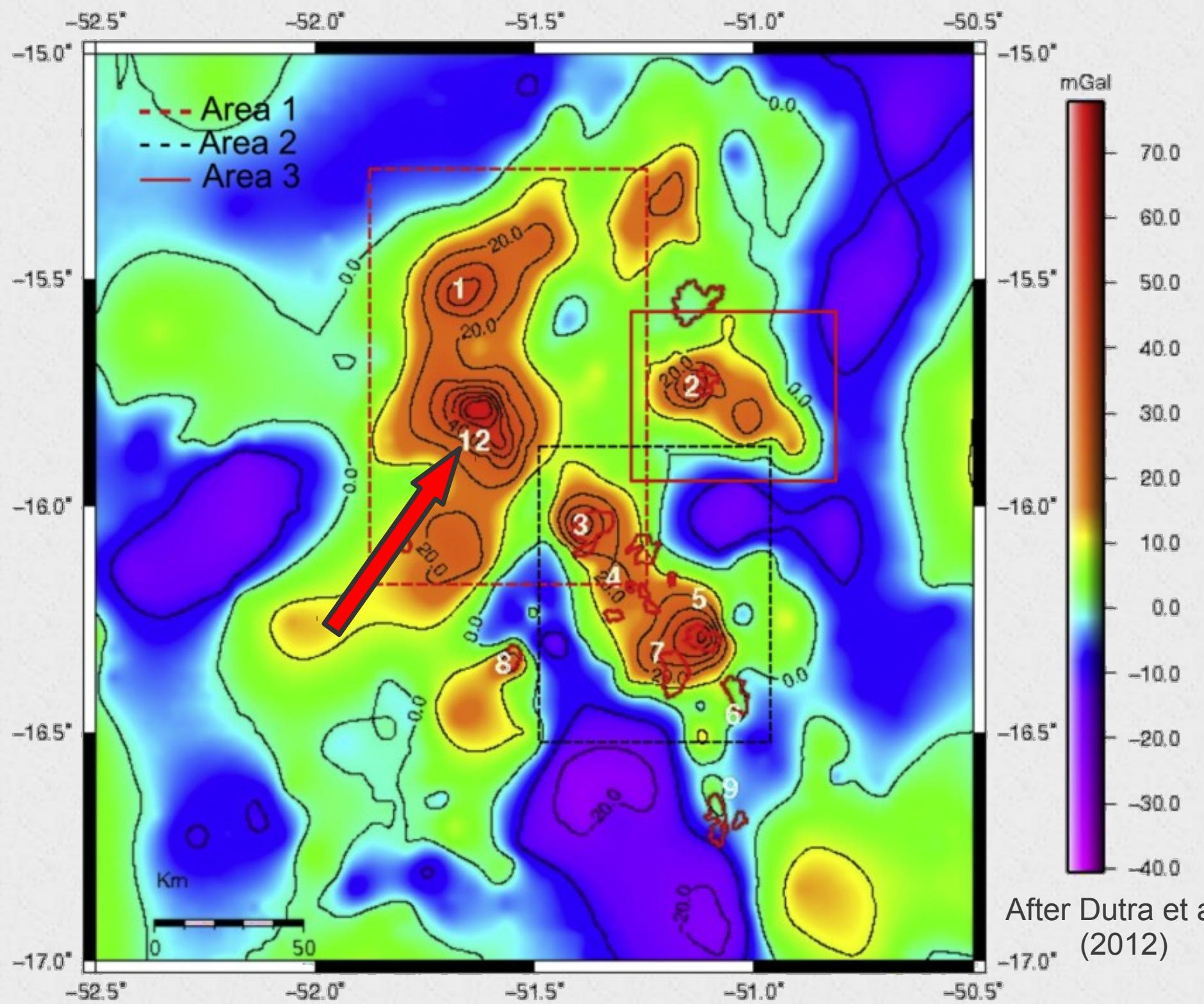
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Registro do Araguaia  
intrusion

# Registro do araguaia

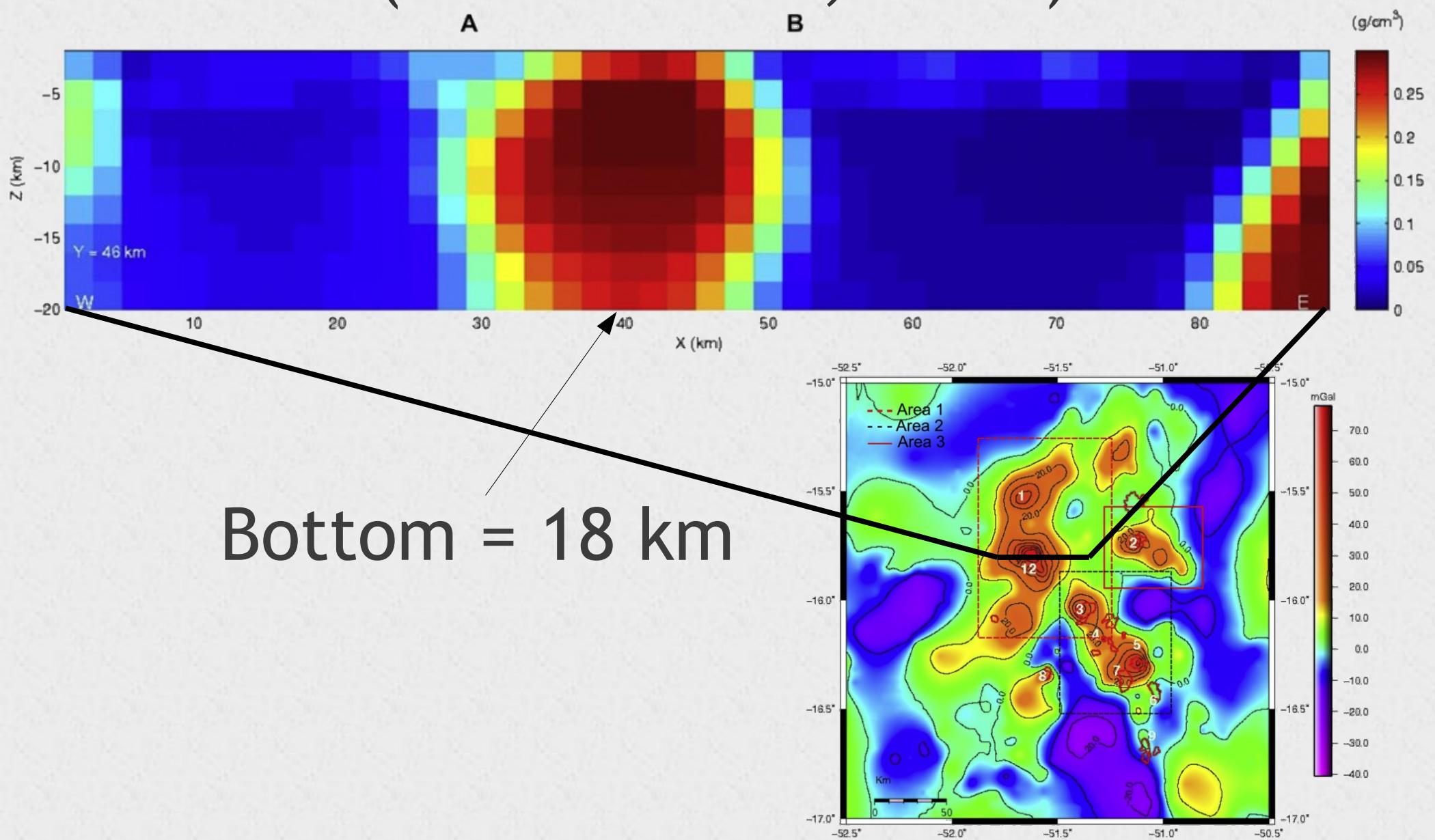
- Not outcropping
- Alkaline intrusion
- Density contrast  $\approx 0.3 \text{ g.cm}^{-3}$



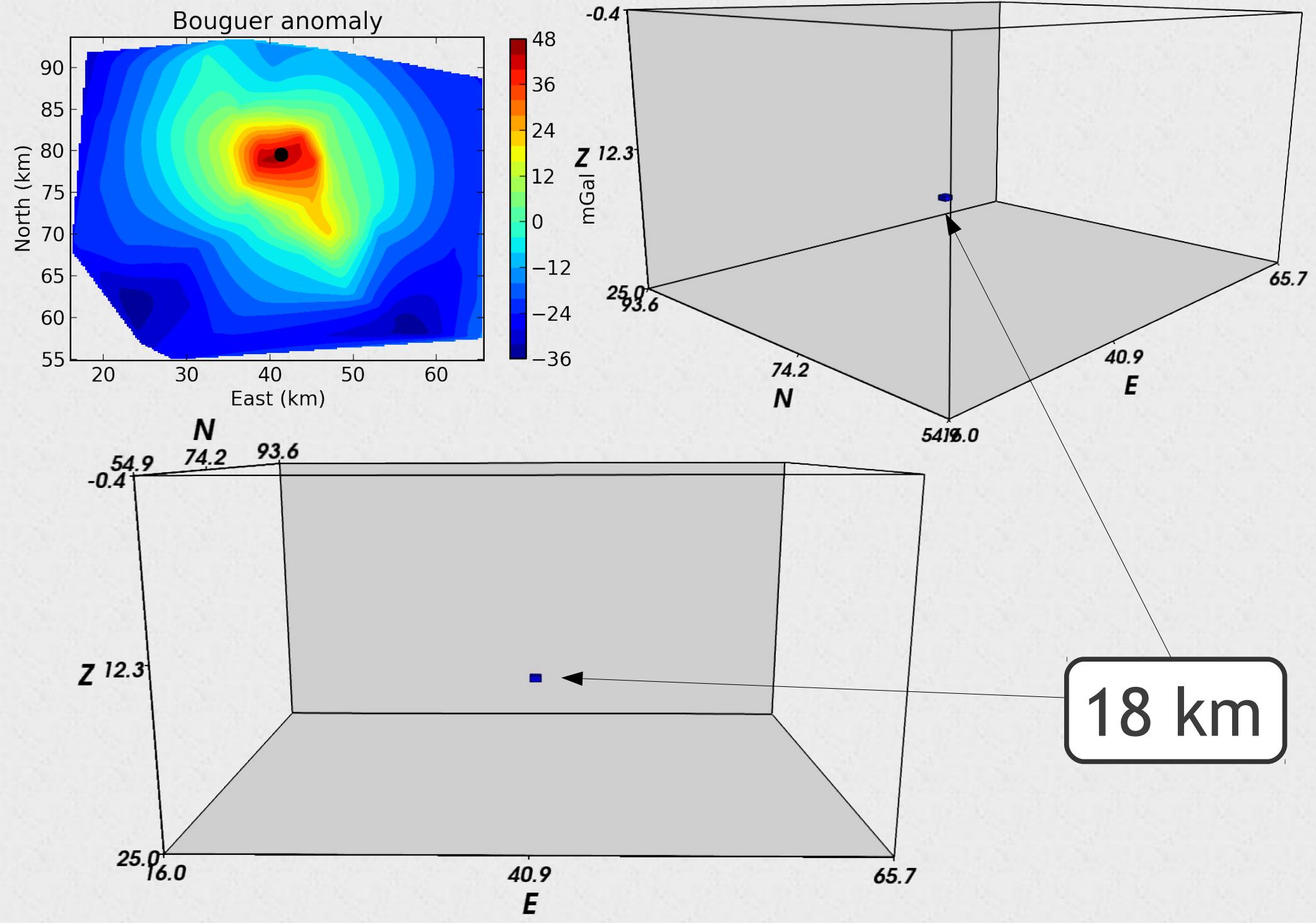


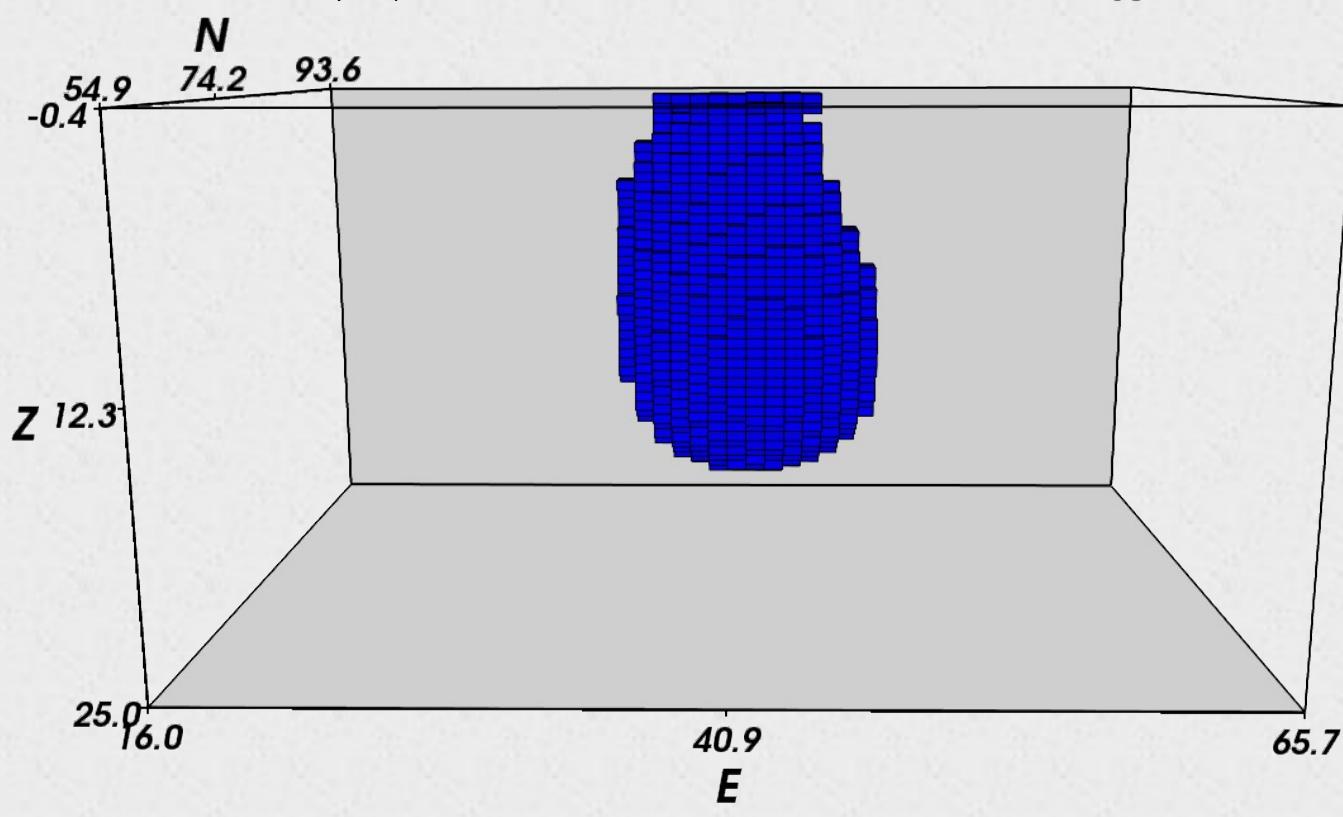
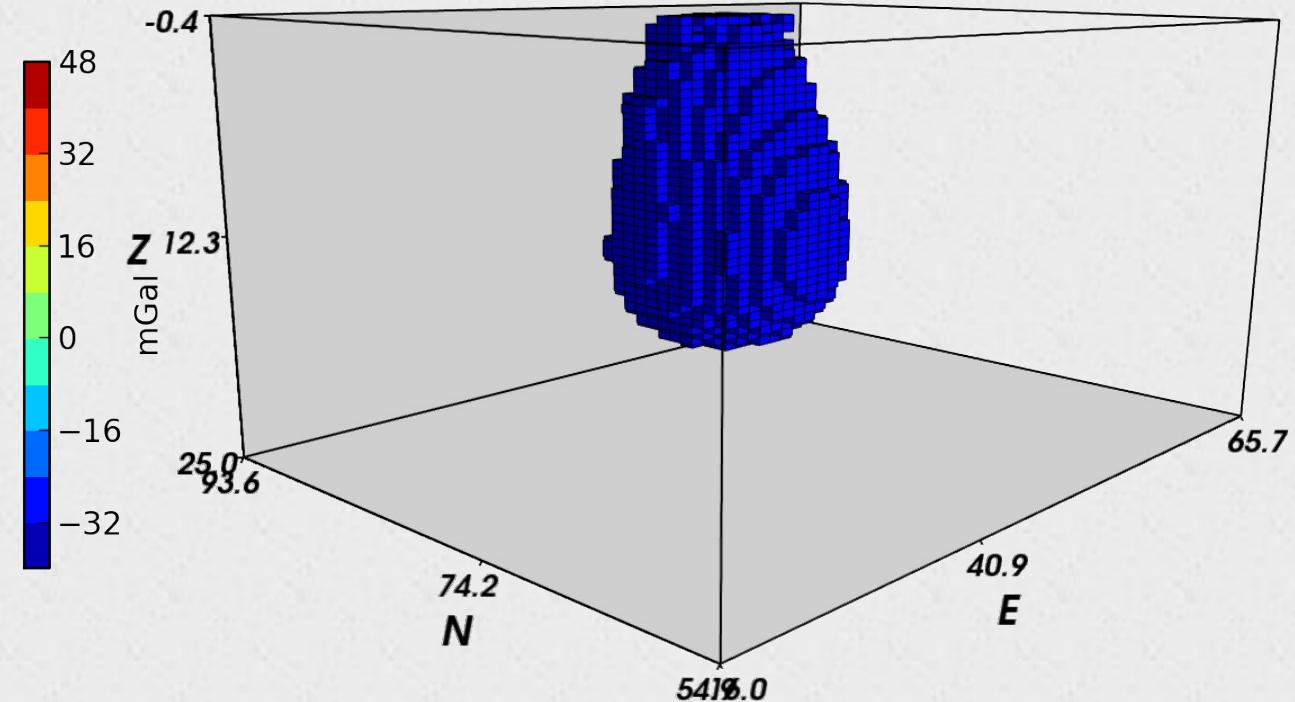
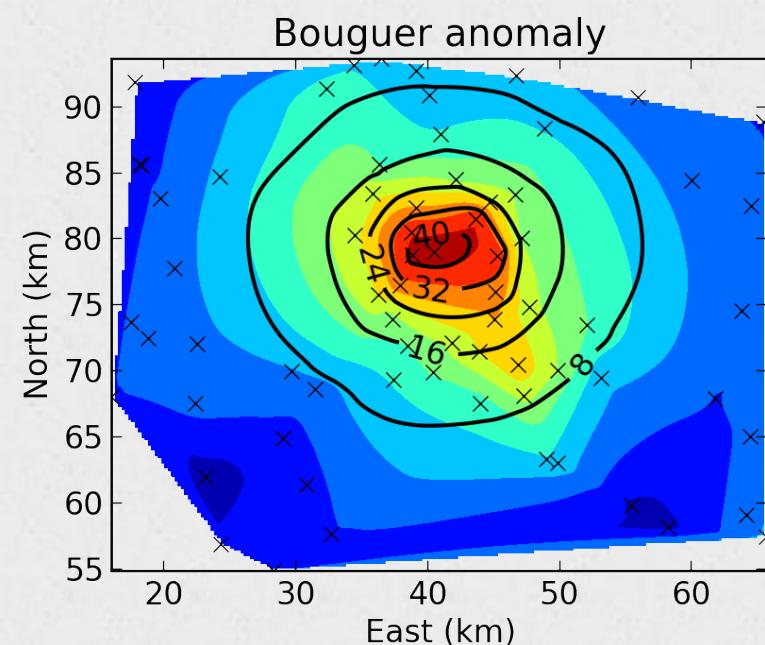
After Dutra et al.  
(2012)

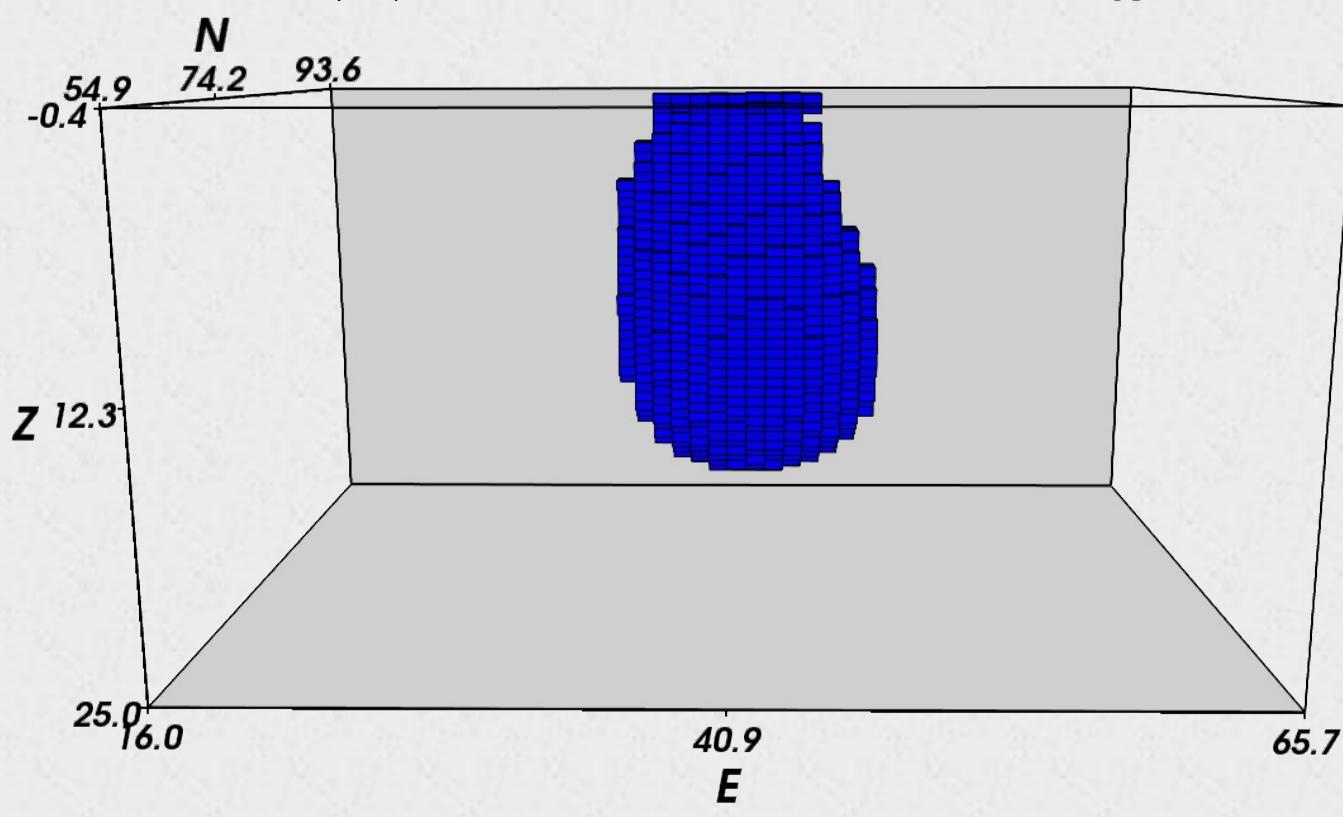
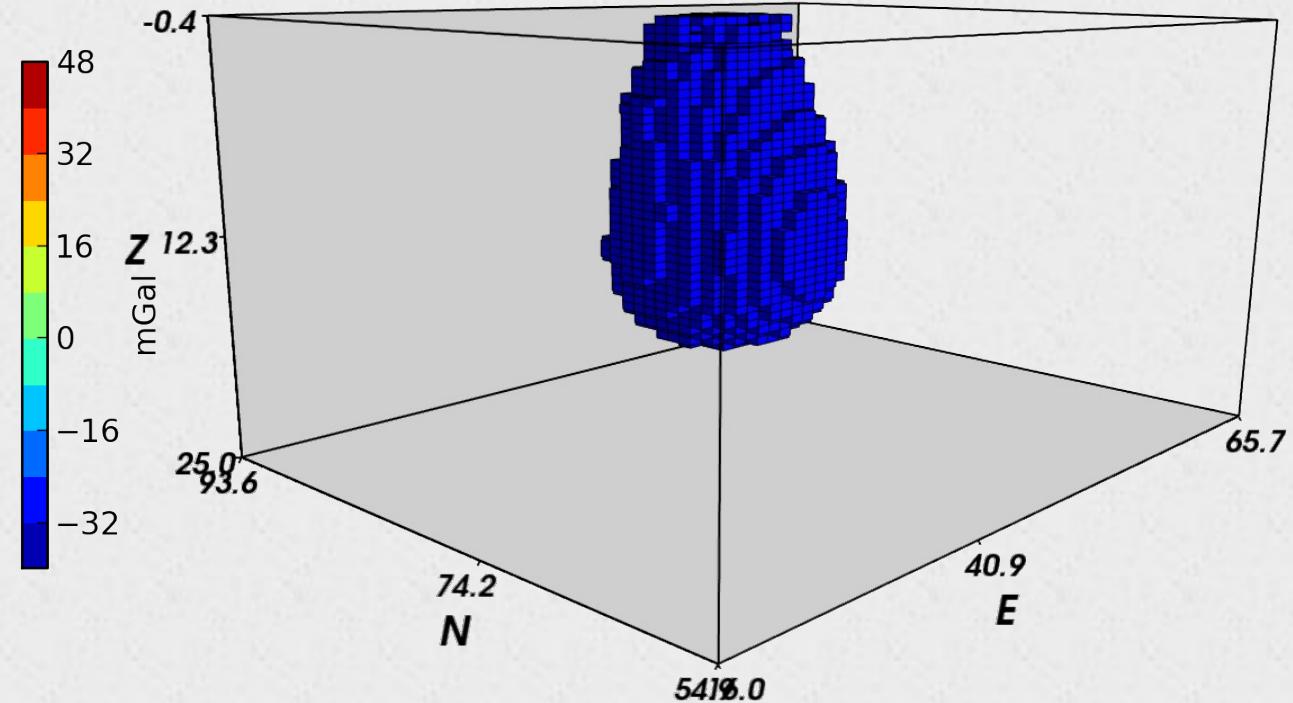
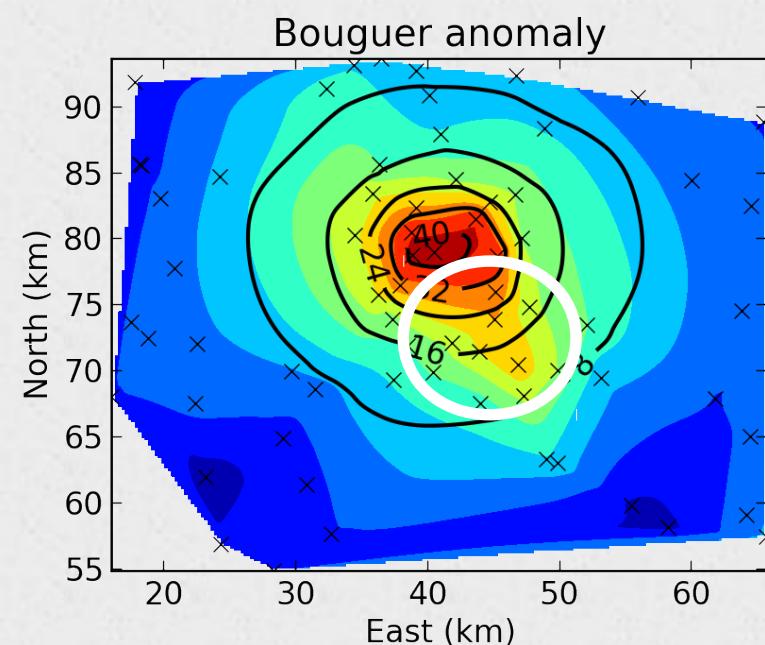
# 3D gravity inversion (Dutra et al., 2012)



# Hypothesis 1



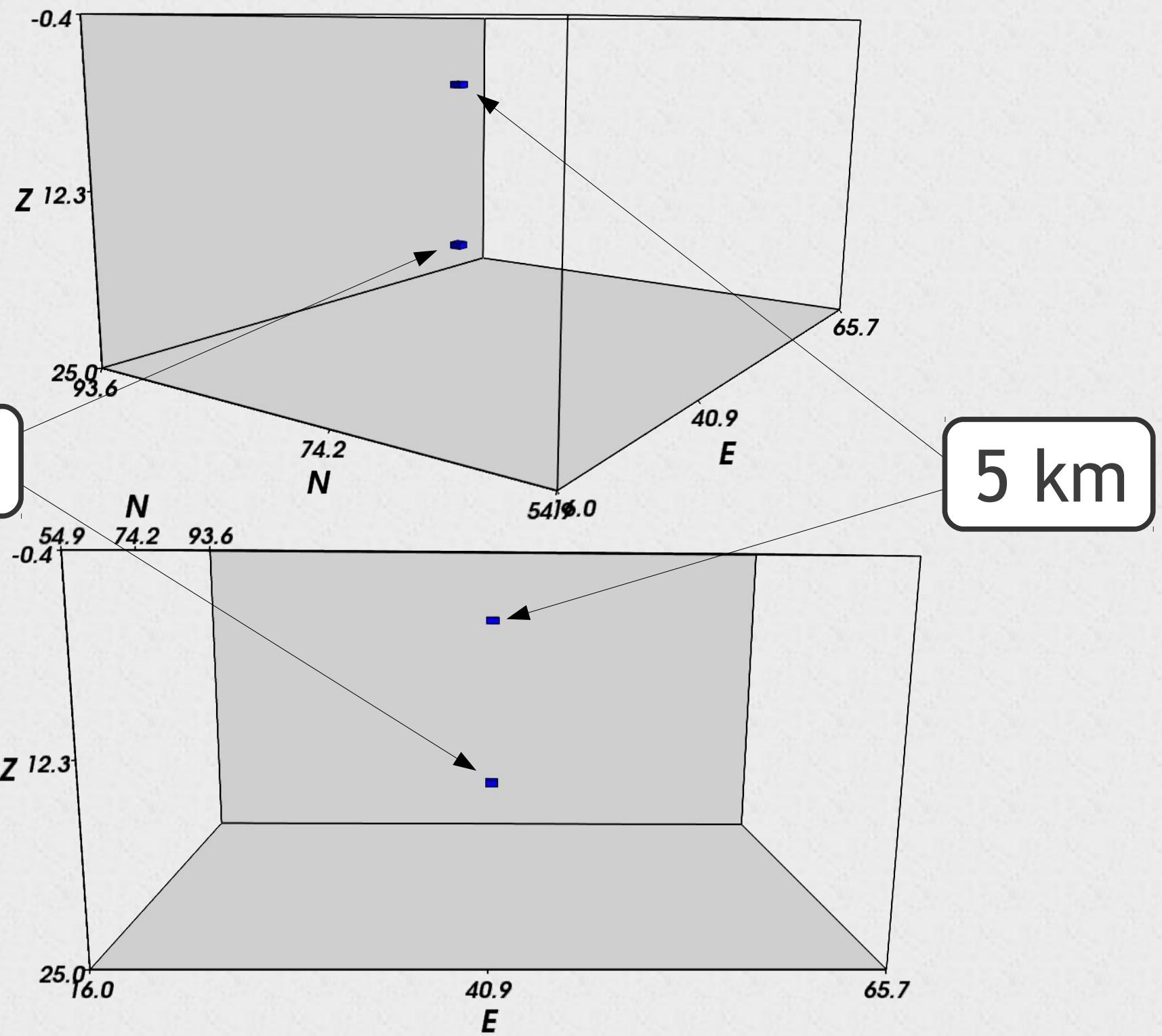


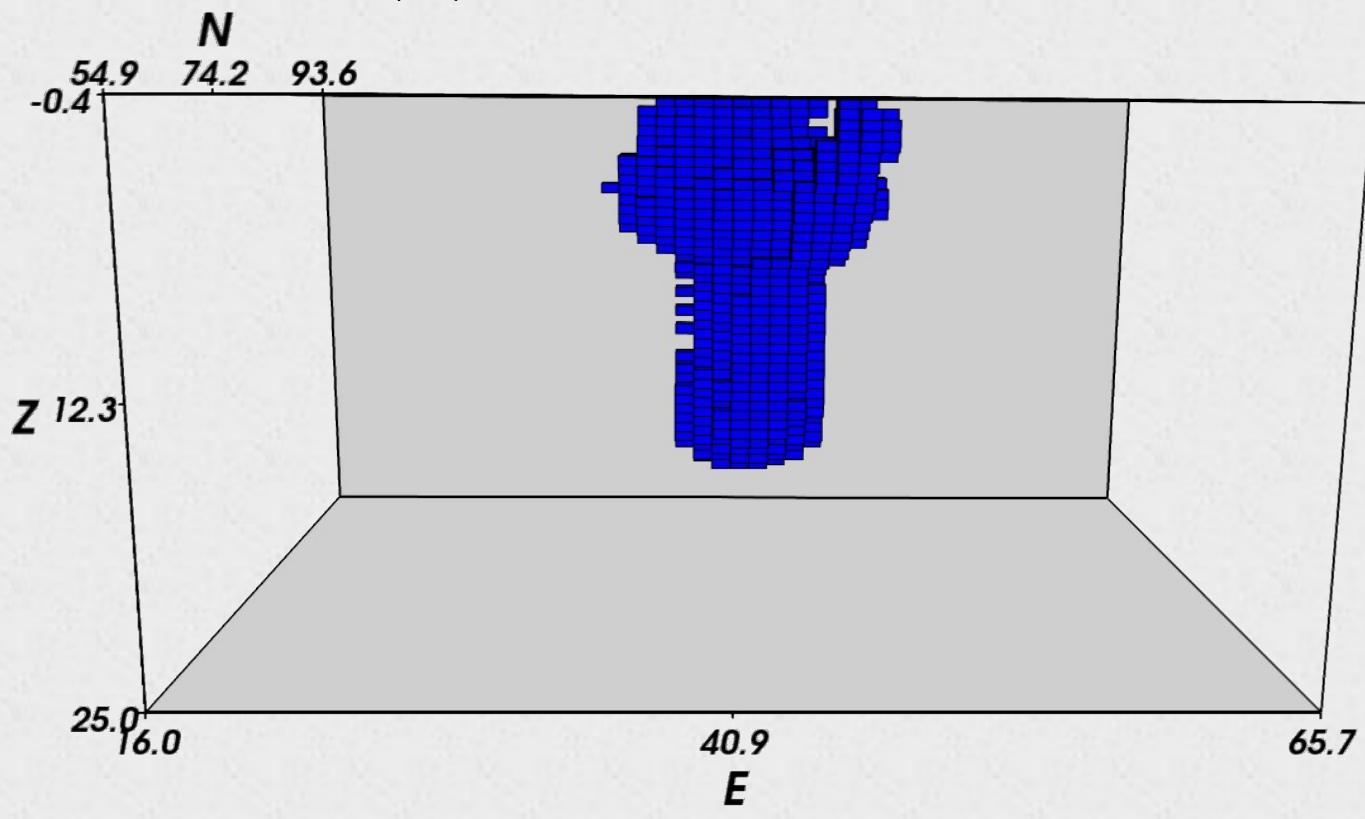
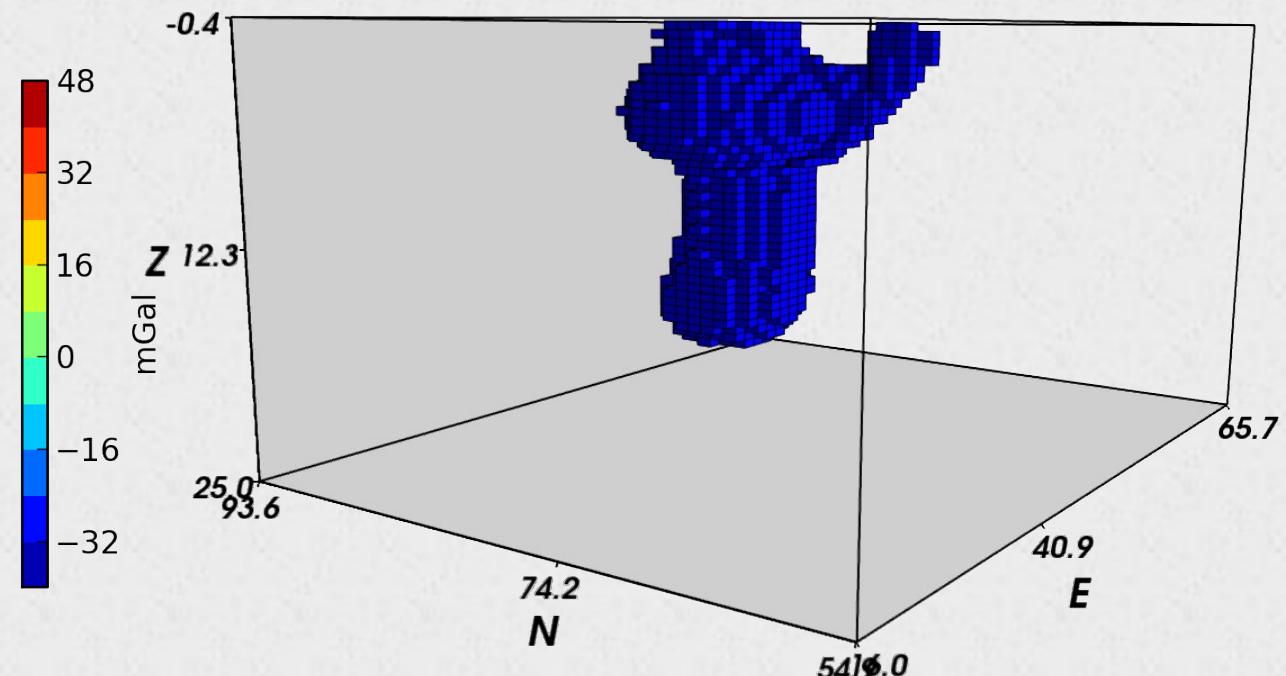
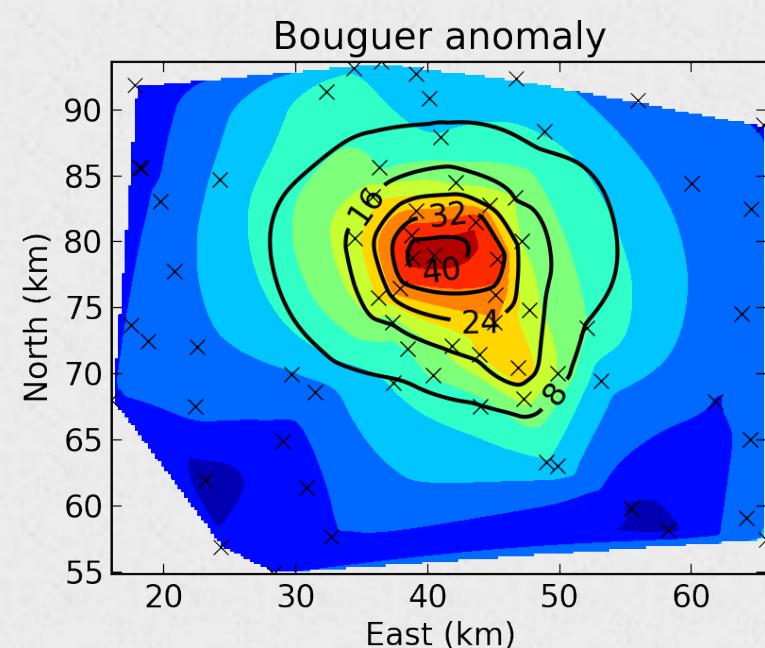


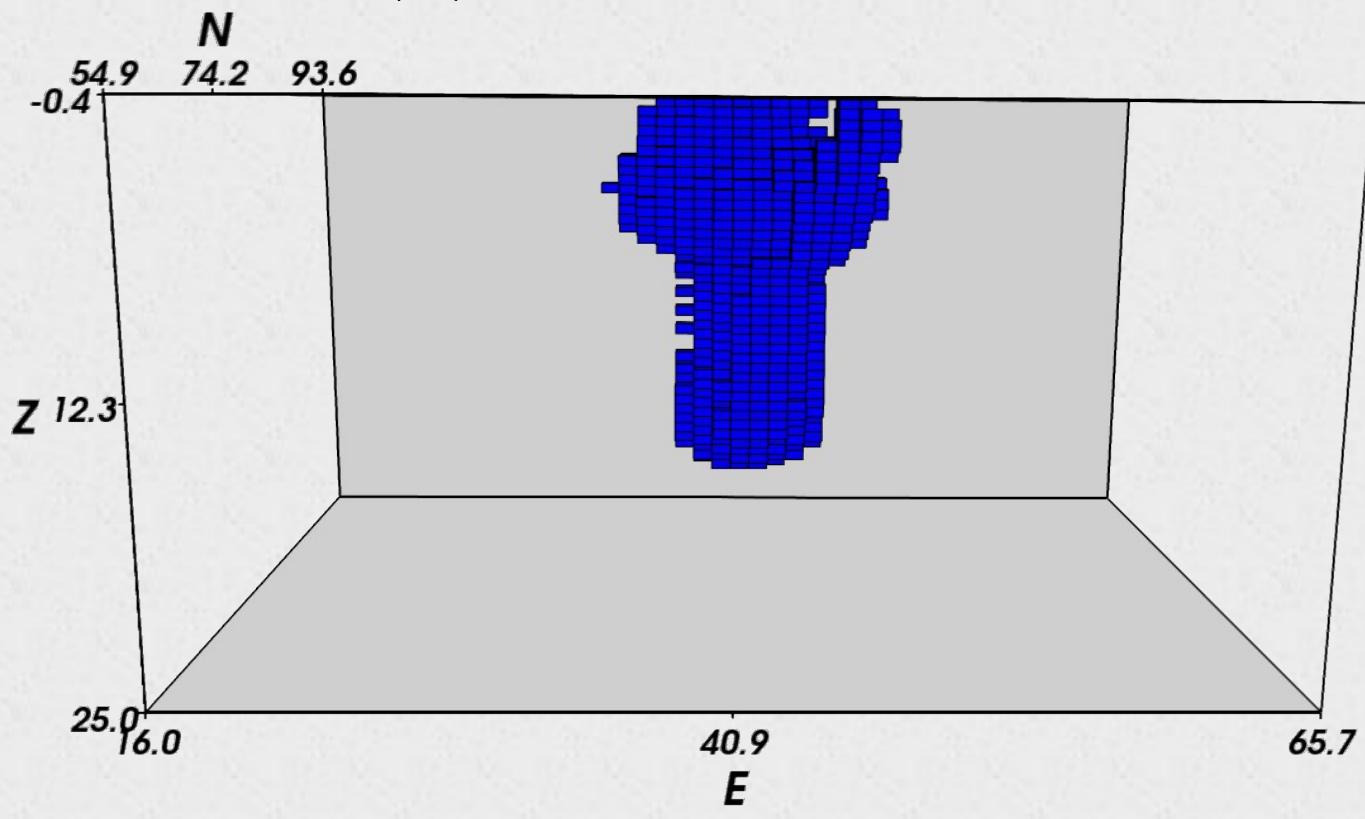
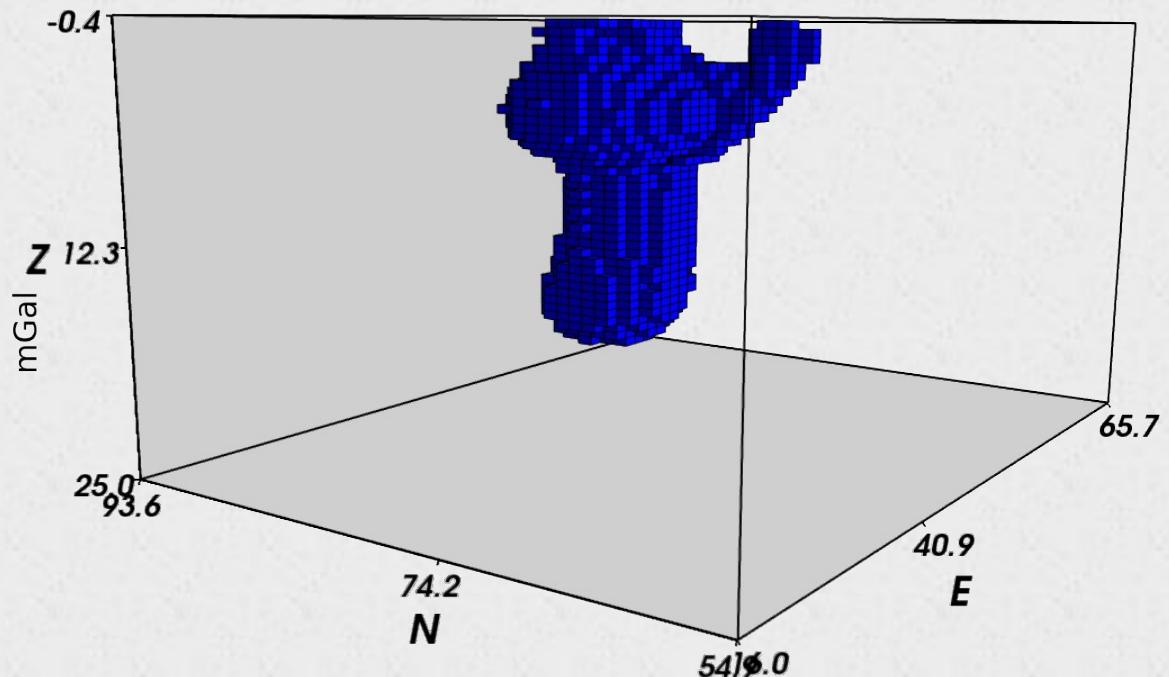
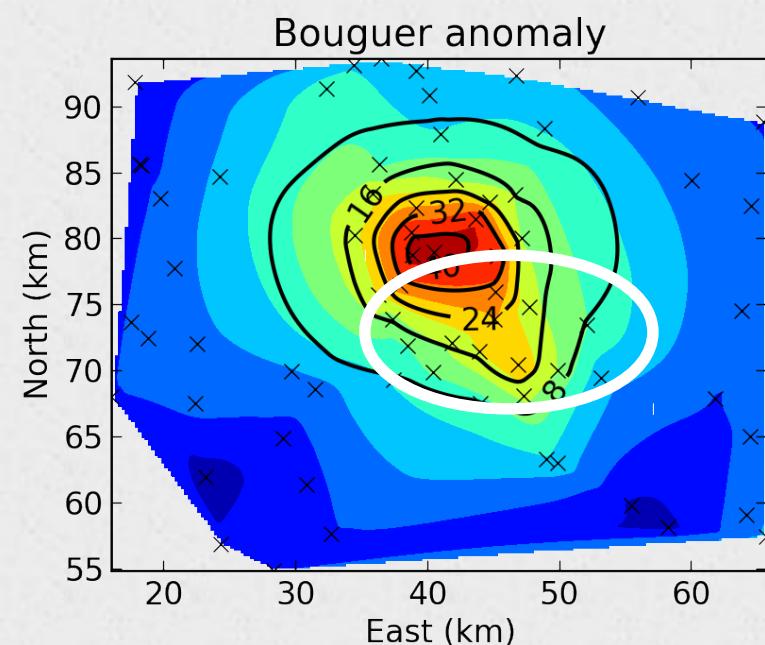
# Hypothesis 1

Hypothesis 1

# Hypothesis 2



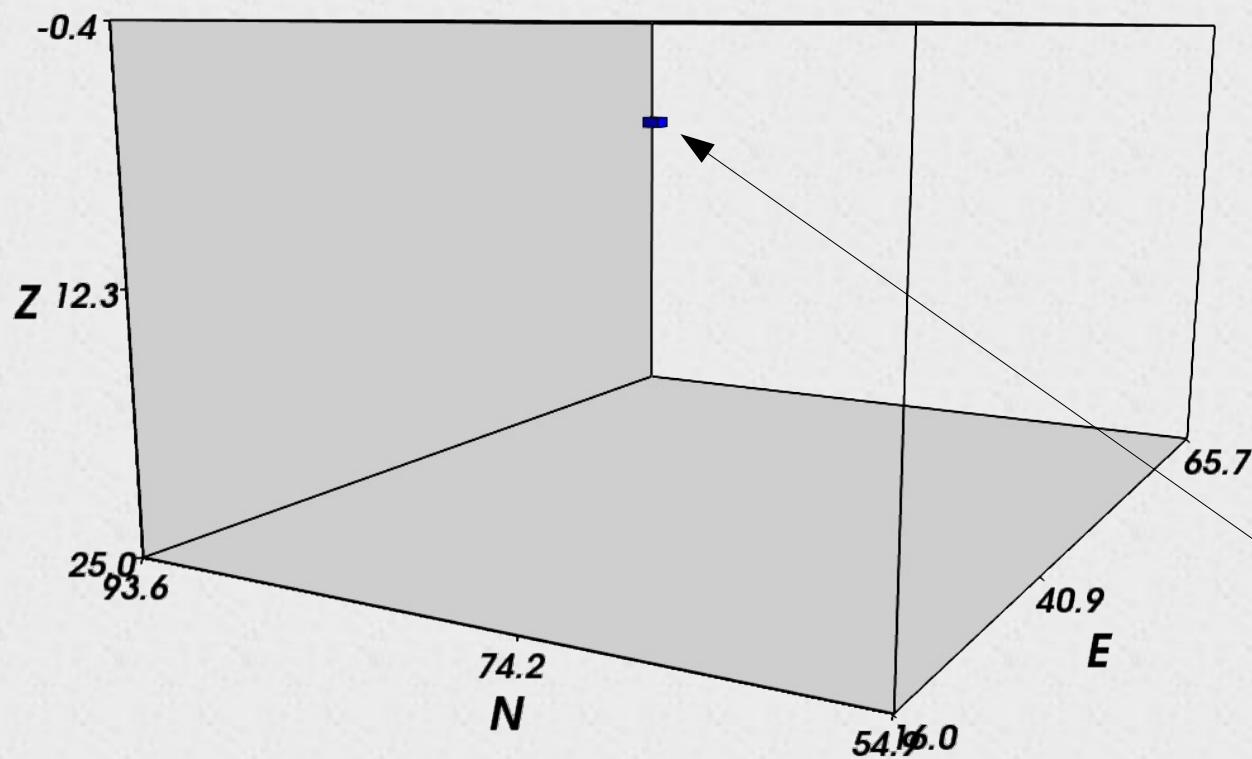




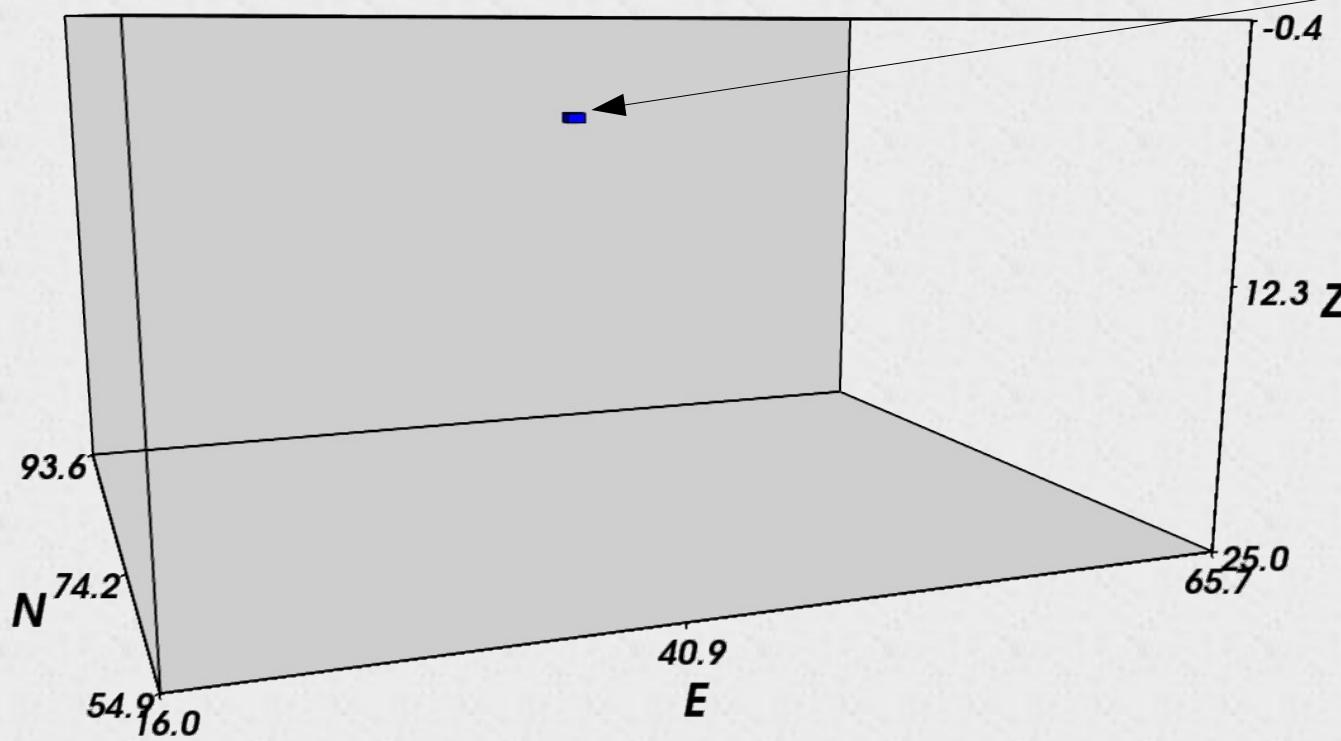
# Hypothesis 2

Hypothesis 2

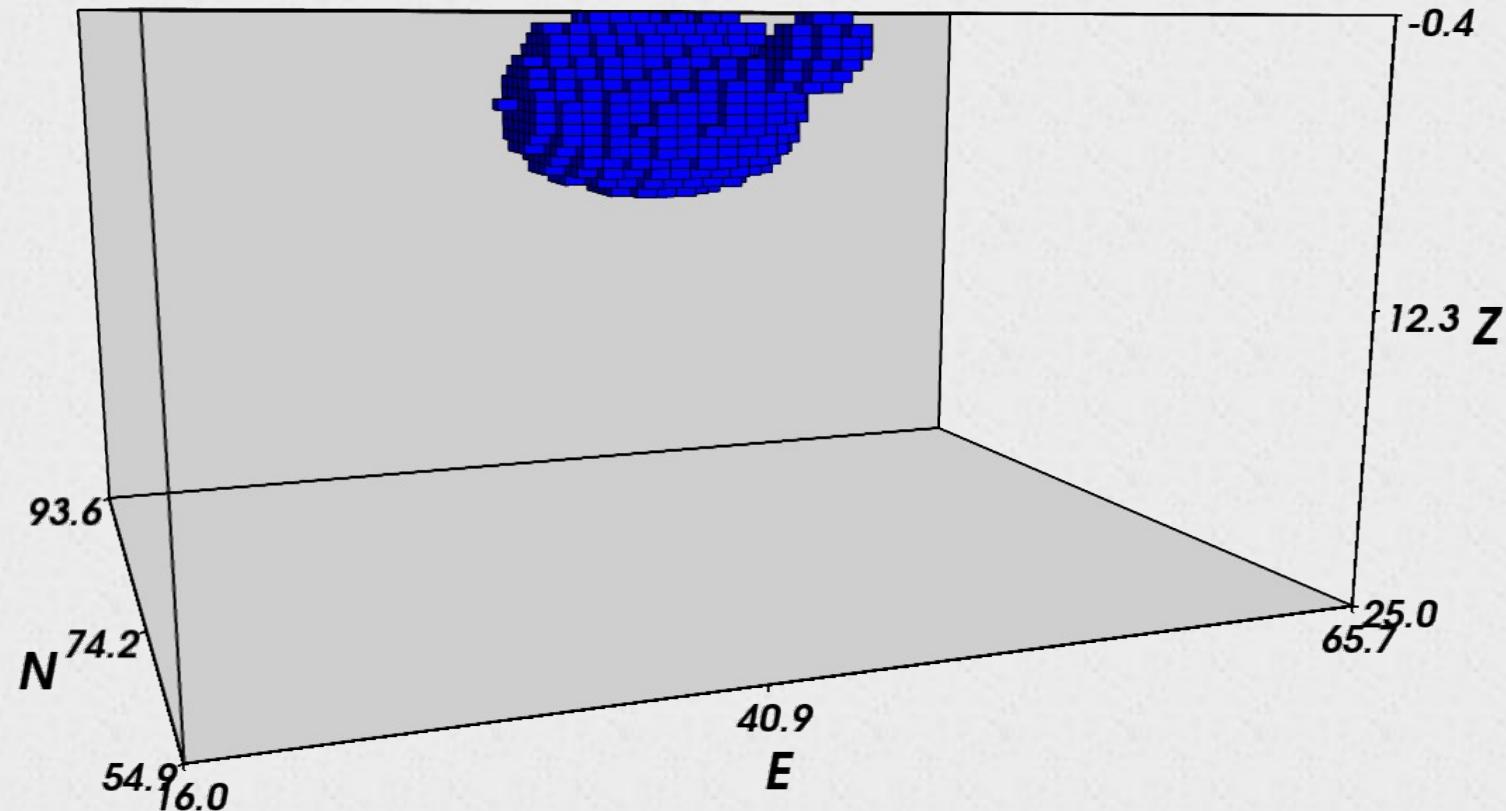
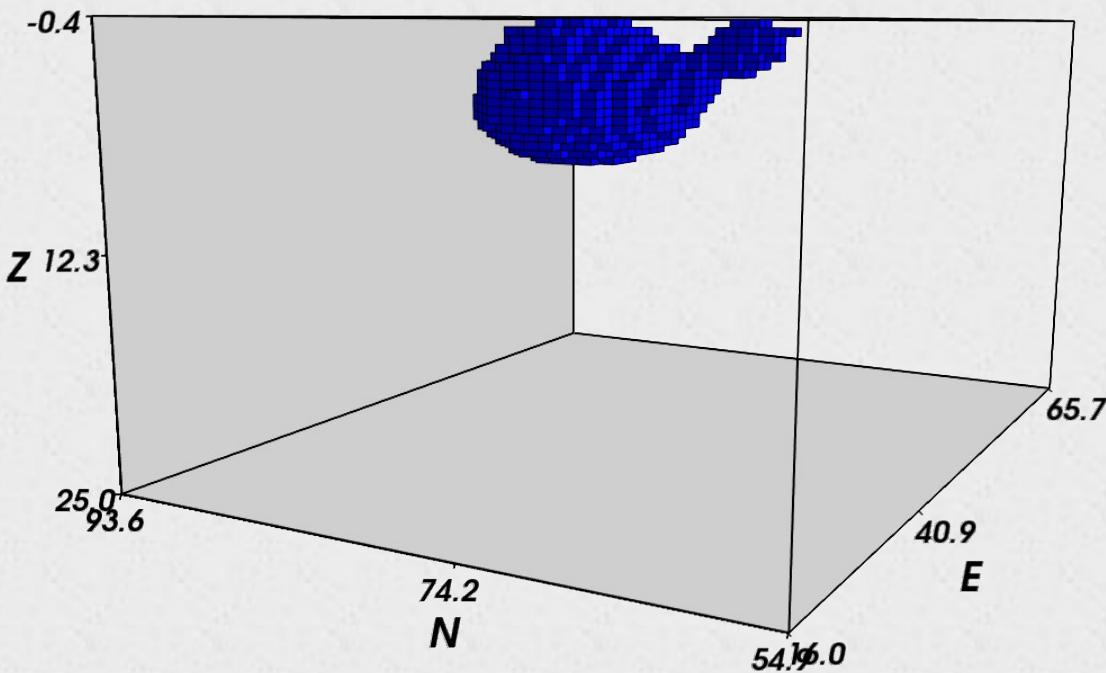
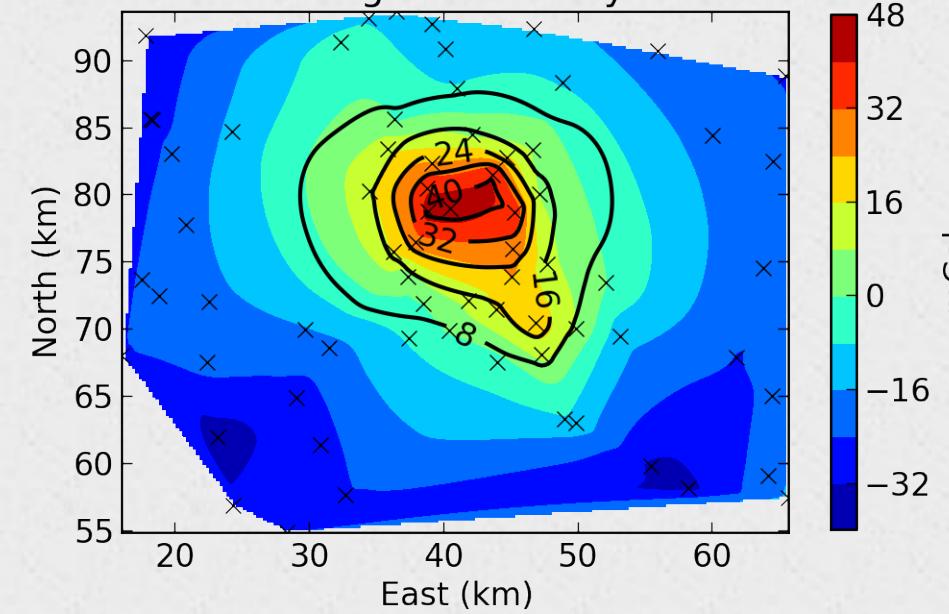
# Hypothesis 3



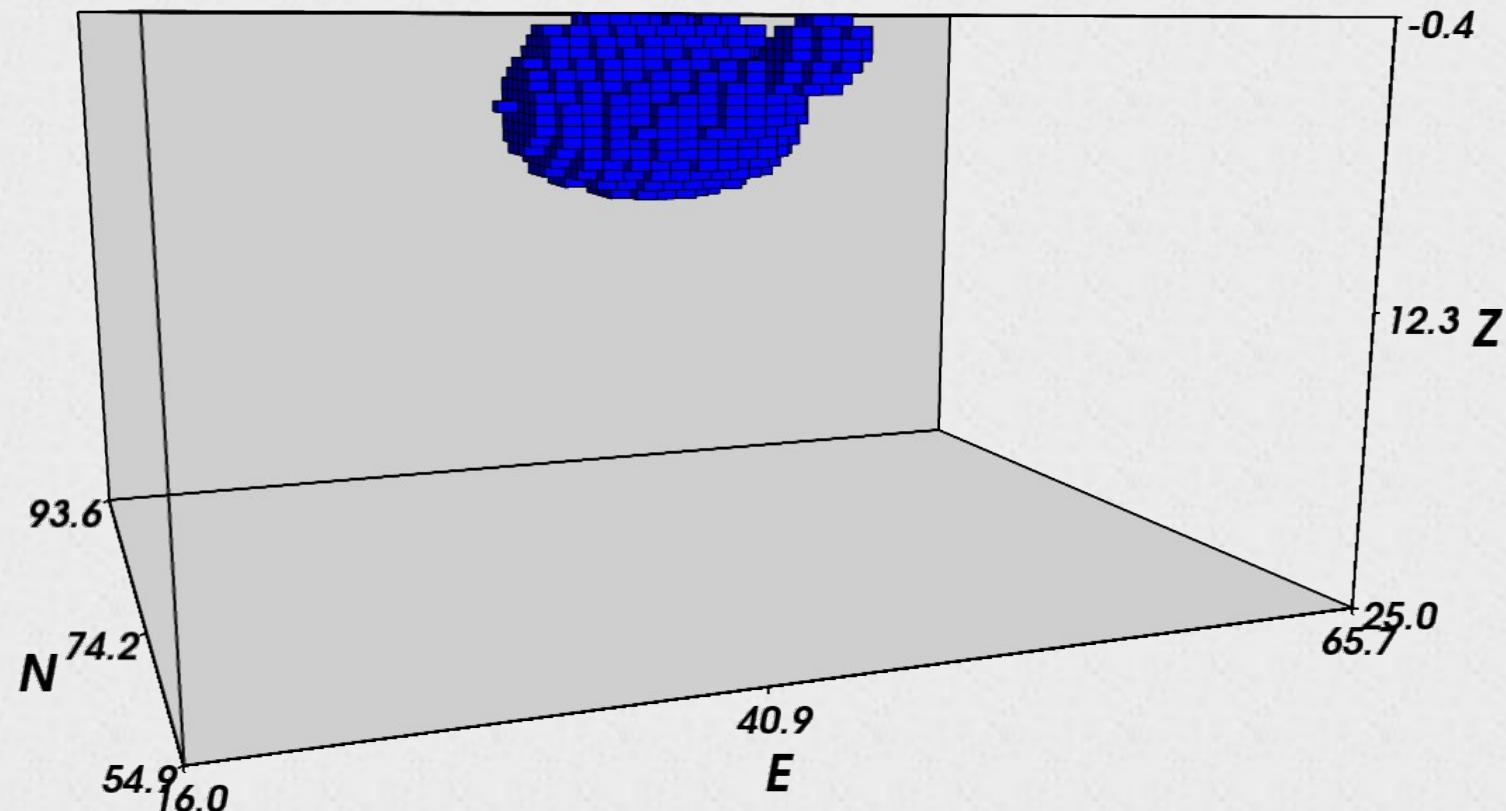
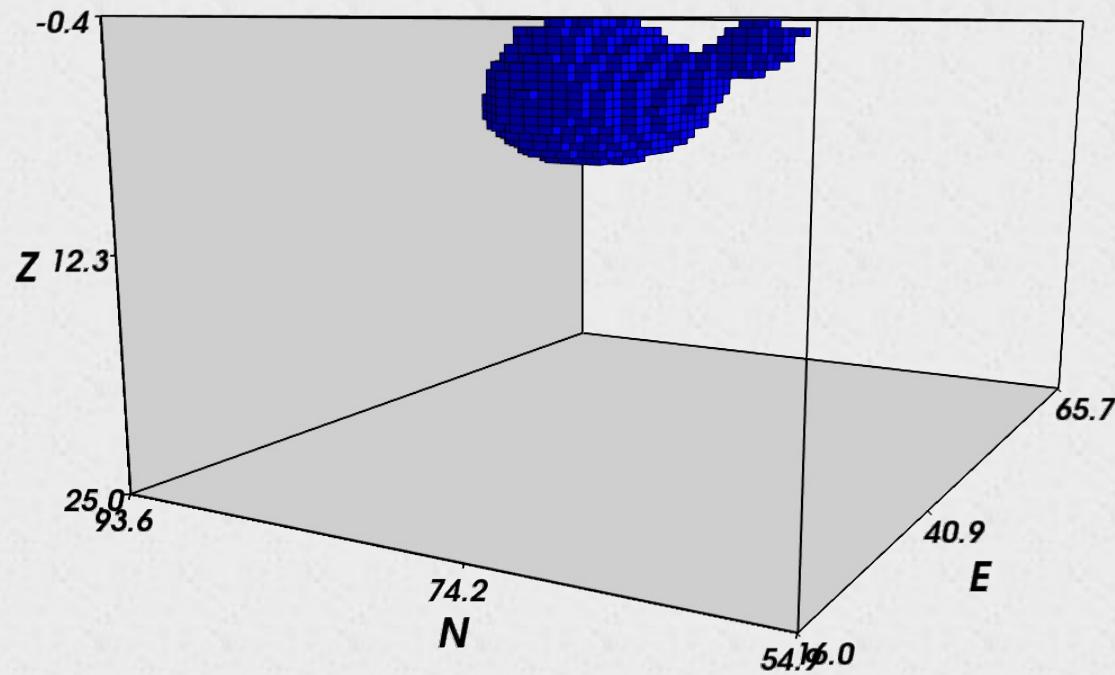
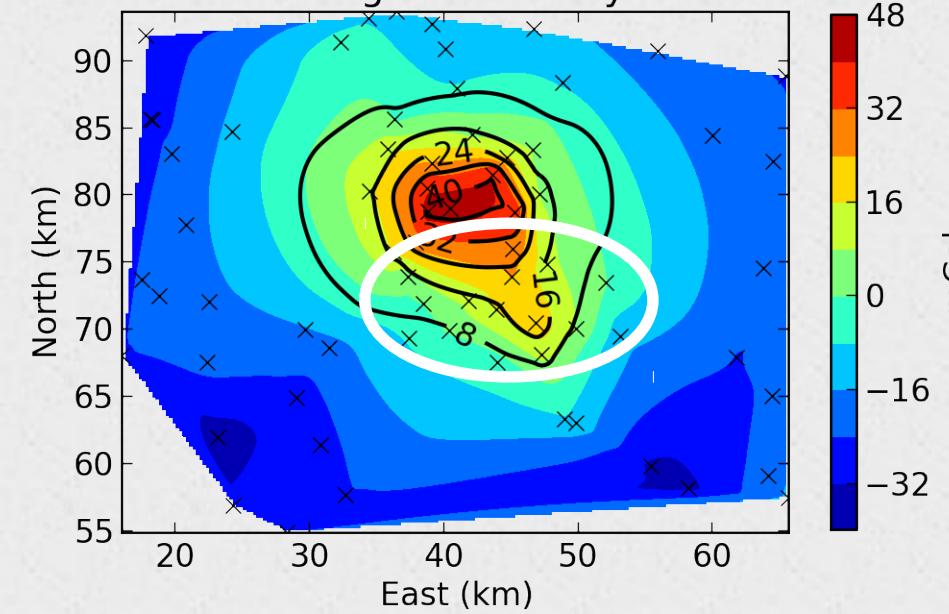
5 km



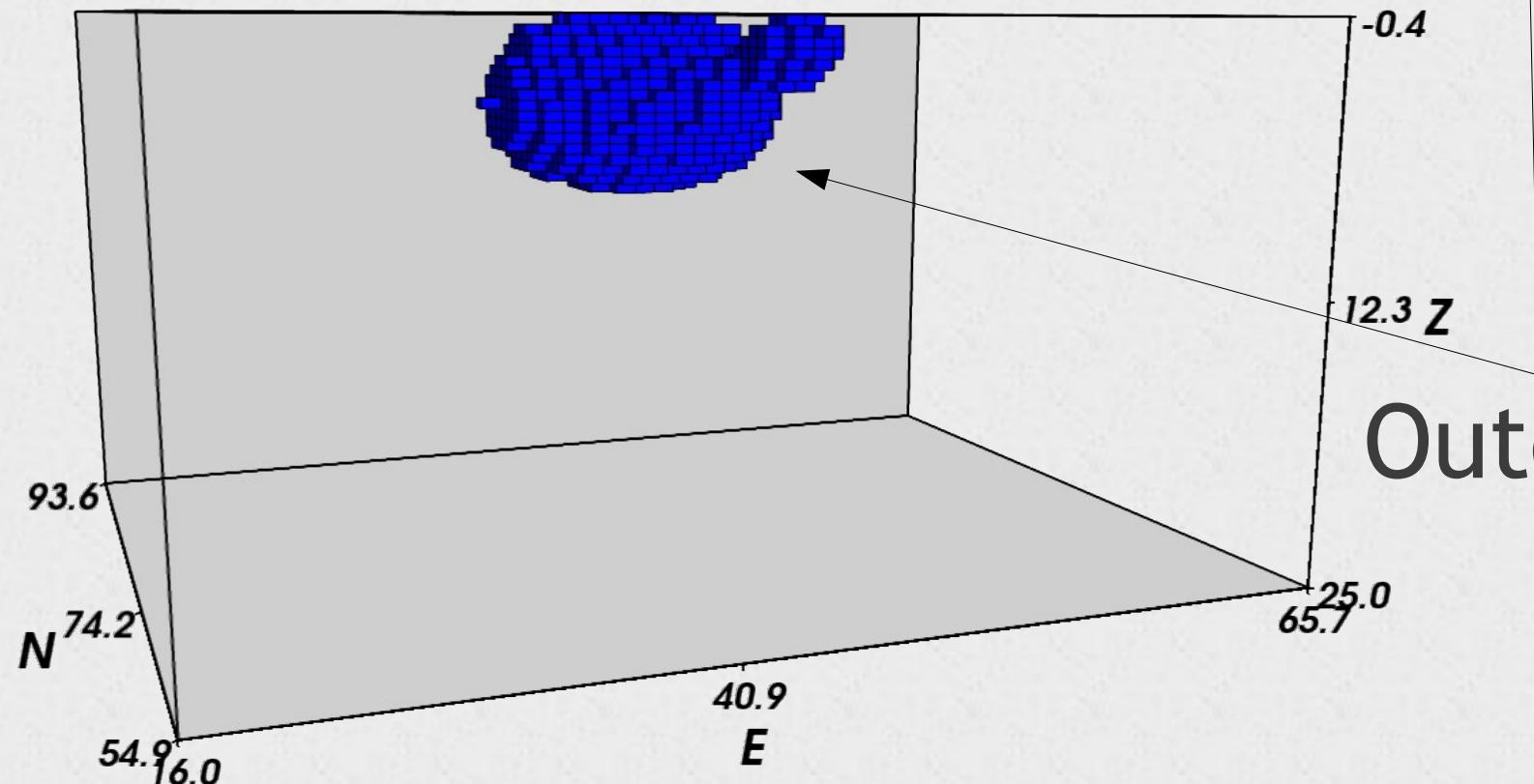
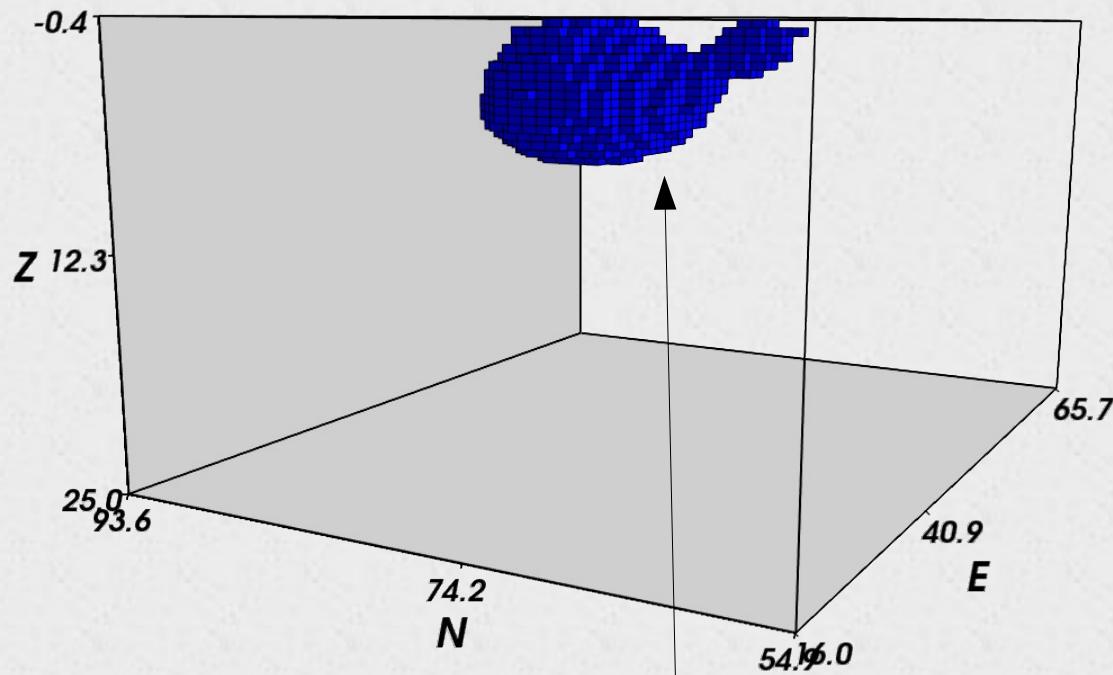
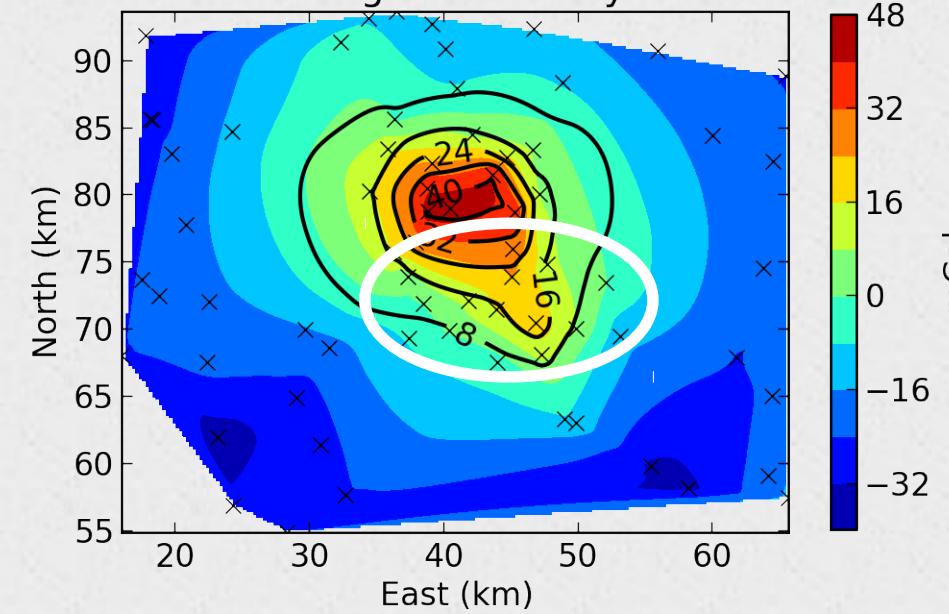
Bouguer anomaly



Bouguer anomaly



Bouguer anomaly

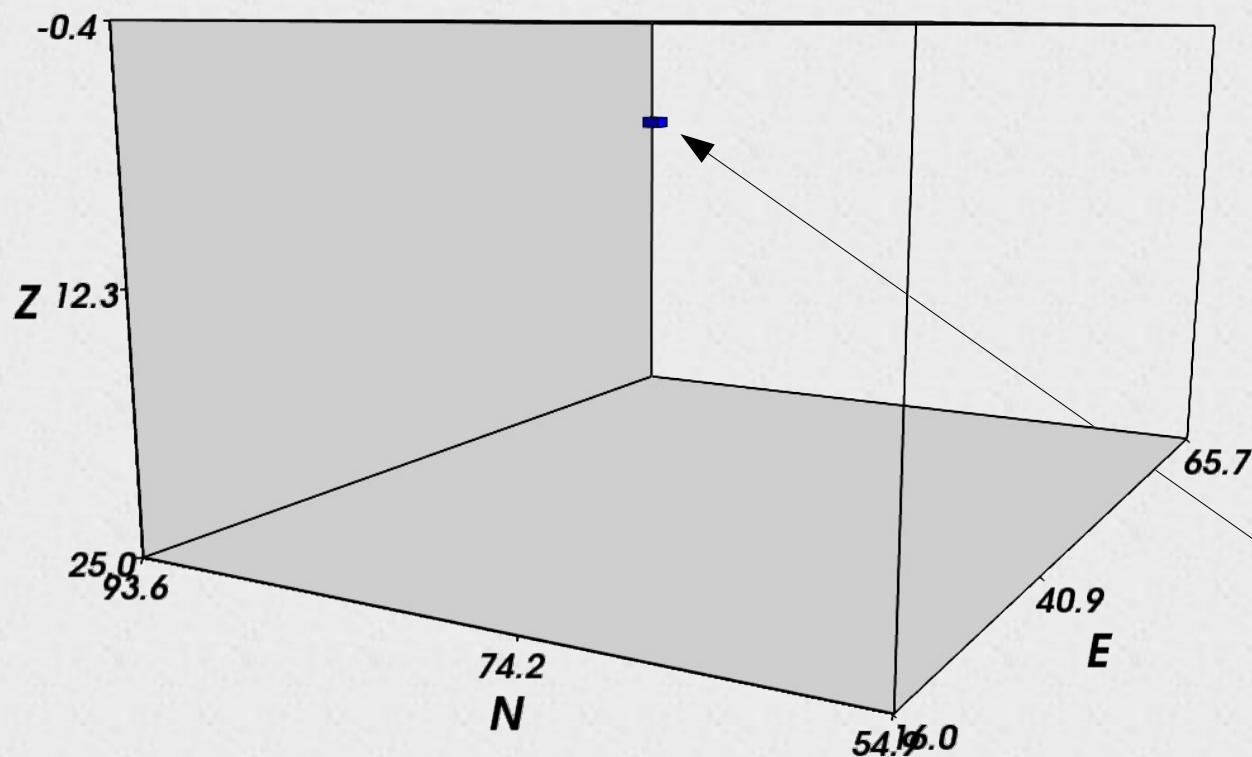


Outcropping

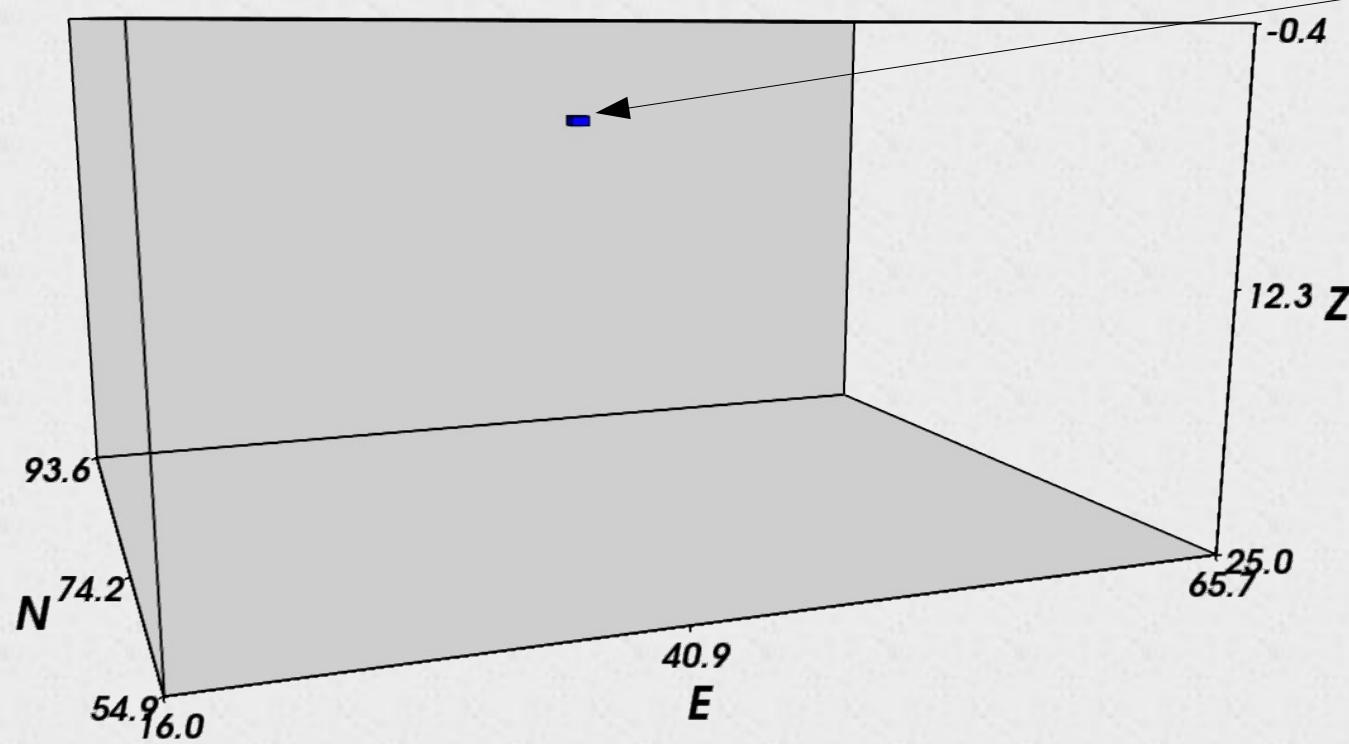
# Hypothesis 3

Hypothesis 3

# Hypothesis 4



5 km

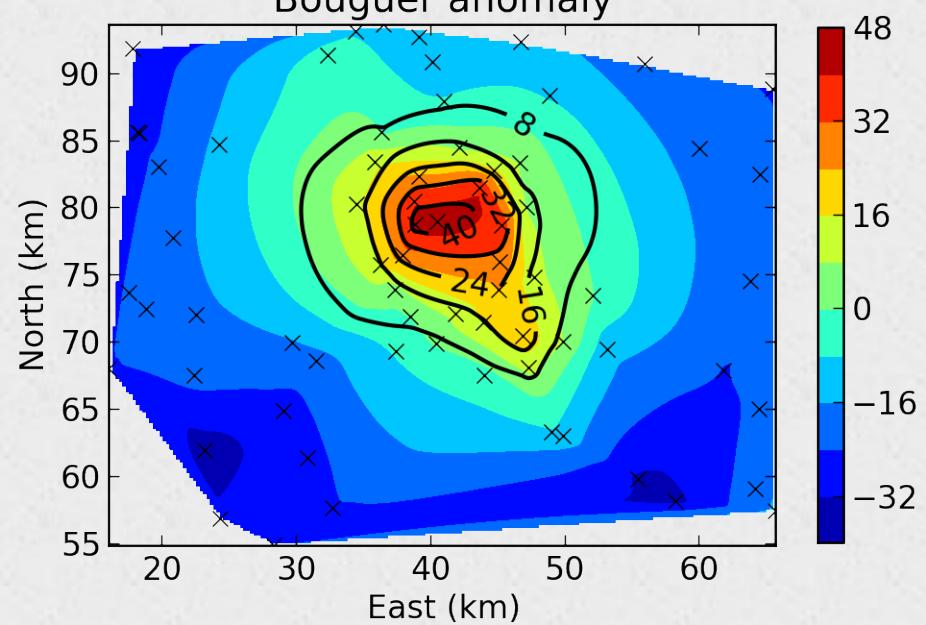


Density



0.5 g.cm<sup>-3</sup>

Bouguer anomaly



-0.4

mGal  
Z 12.3

25.0  
93.6

74.2  
N

54.9  
6.0

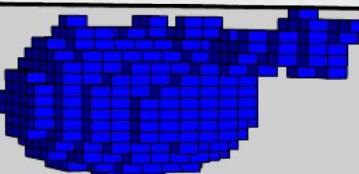
40.9  
E

65.7

40.9  
E

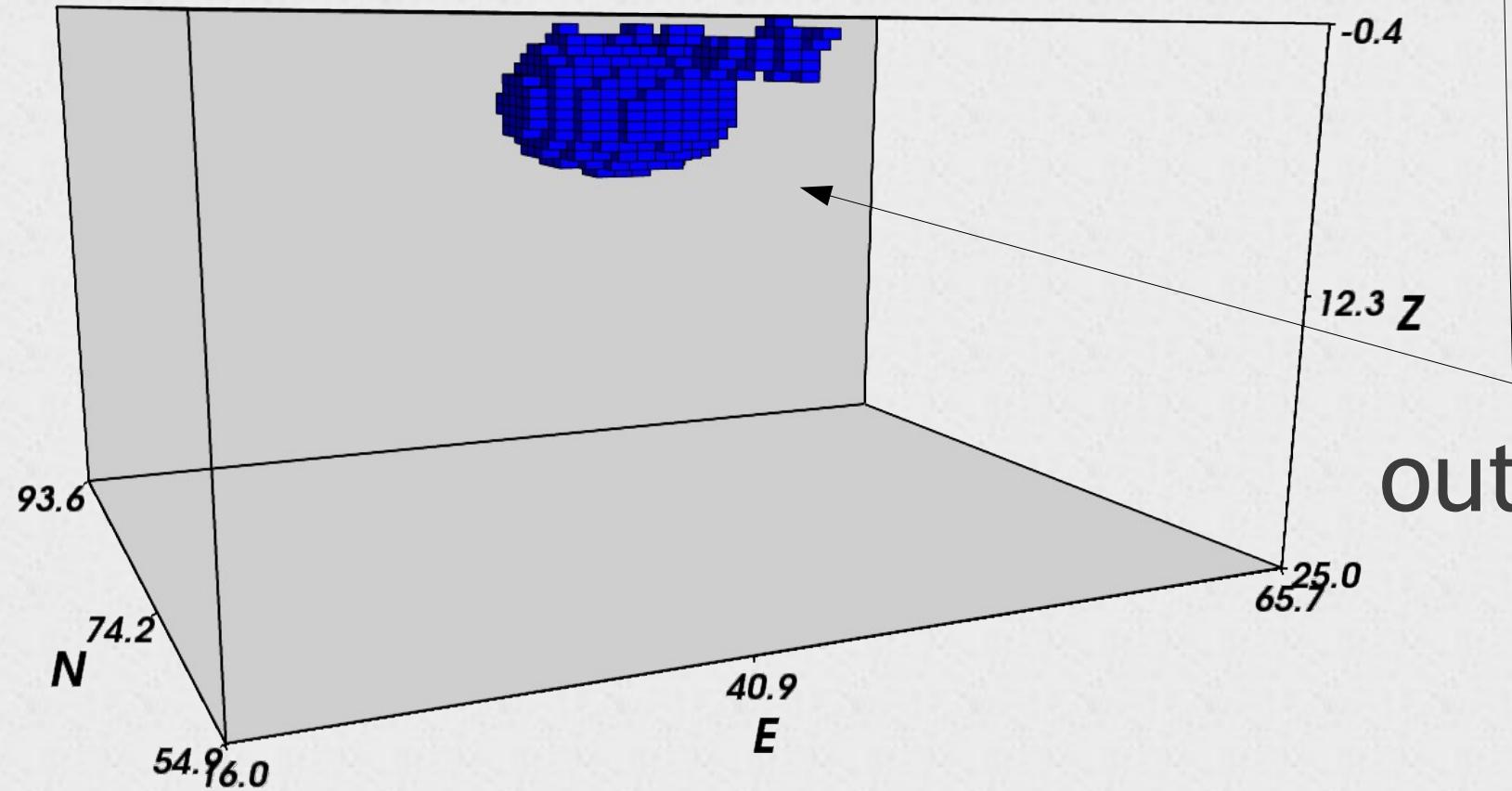
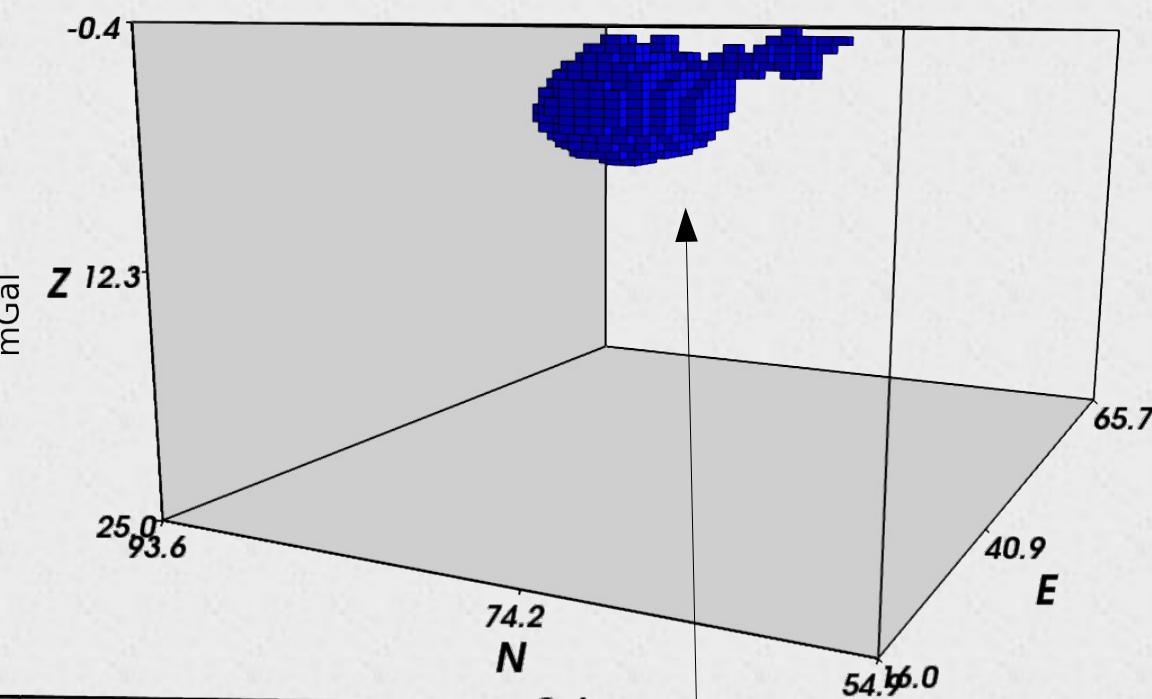
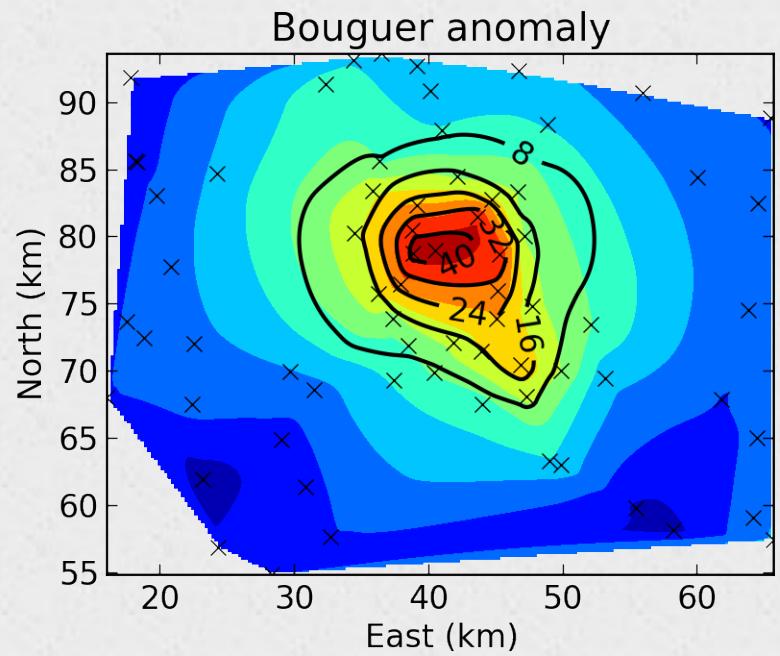
25.0  
65.7

12.3 Z

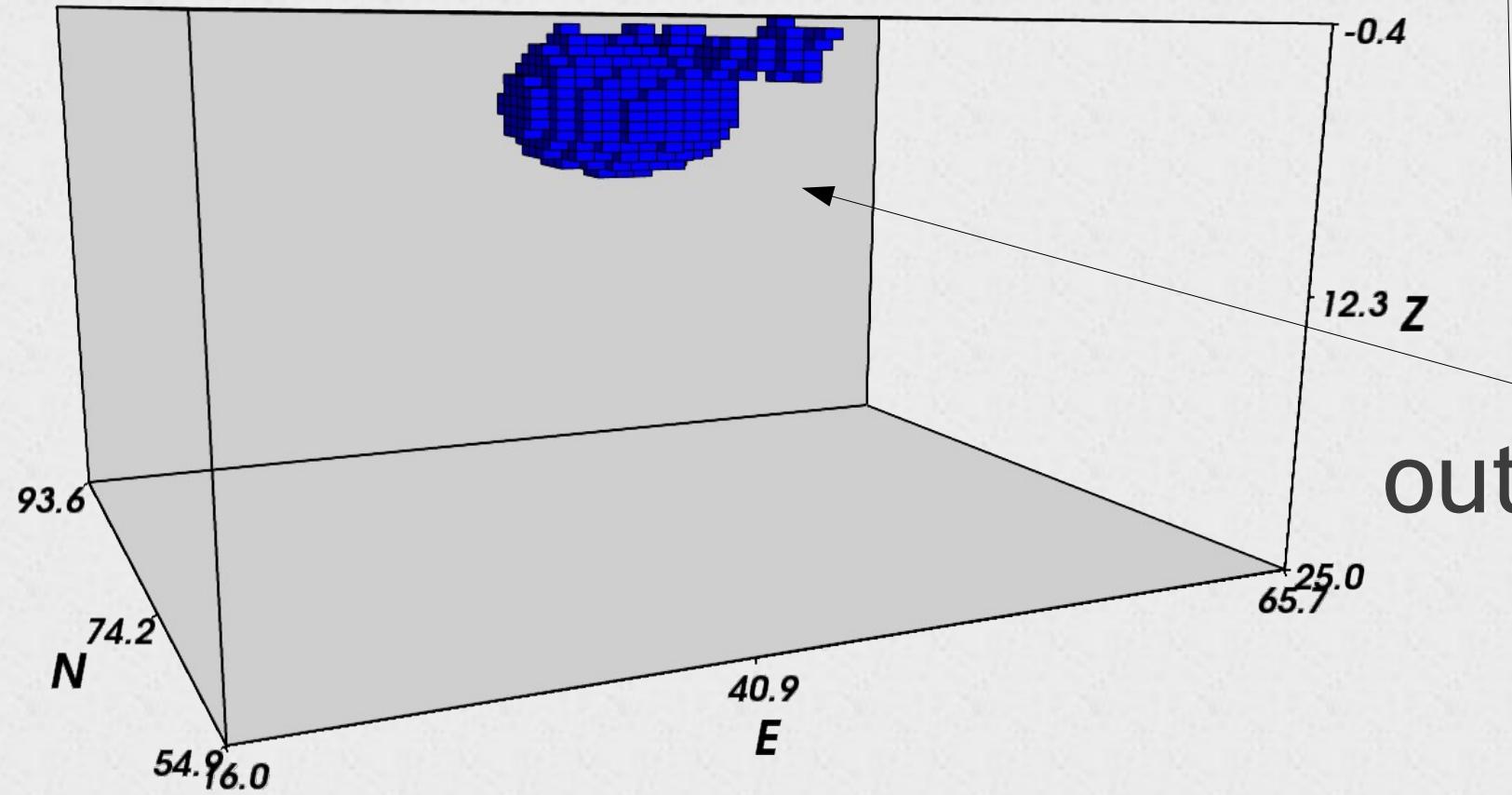
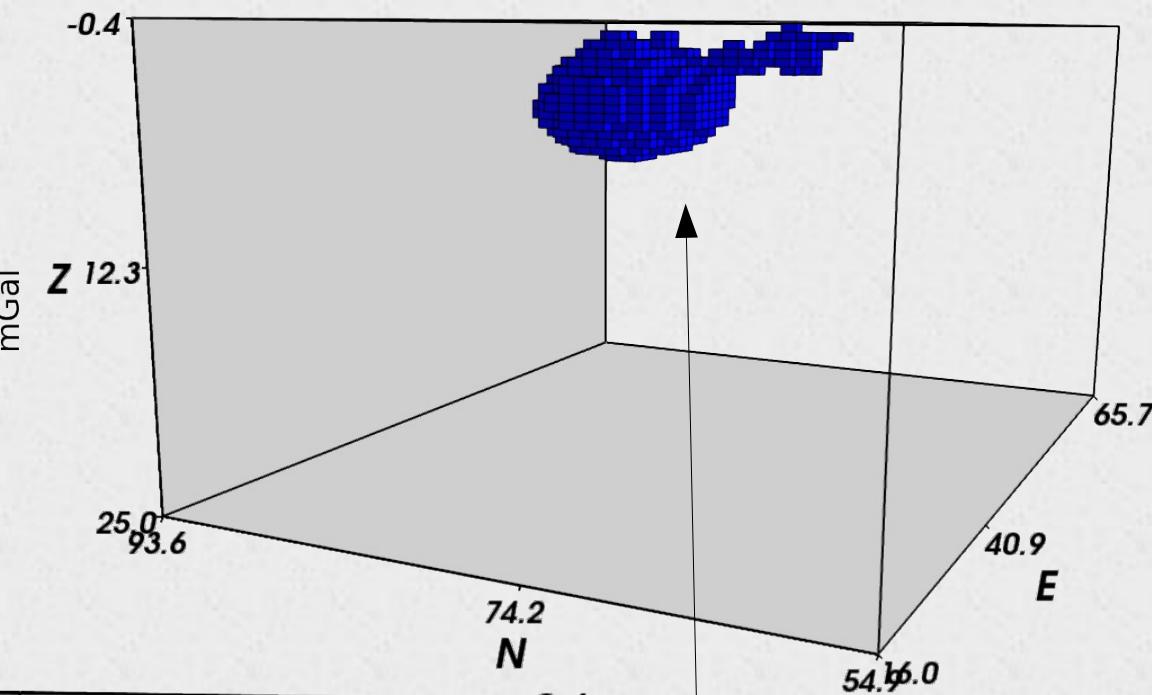
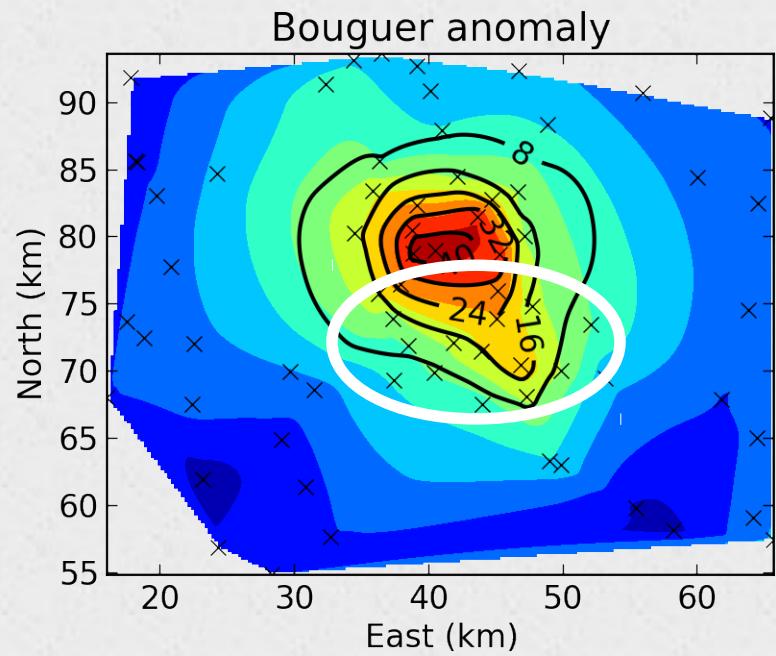


93.6  
74.2  
N

54.9  
6.0



Not  
outcropping



Not  
outcropping

# Hypothesis 4

Hypothesis 4

# Conclusion

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