

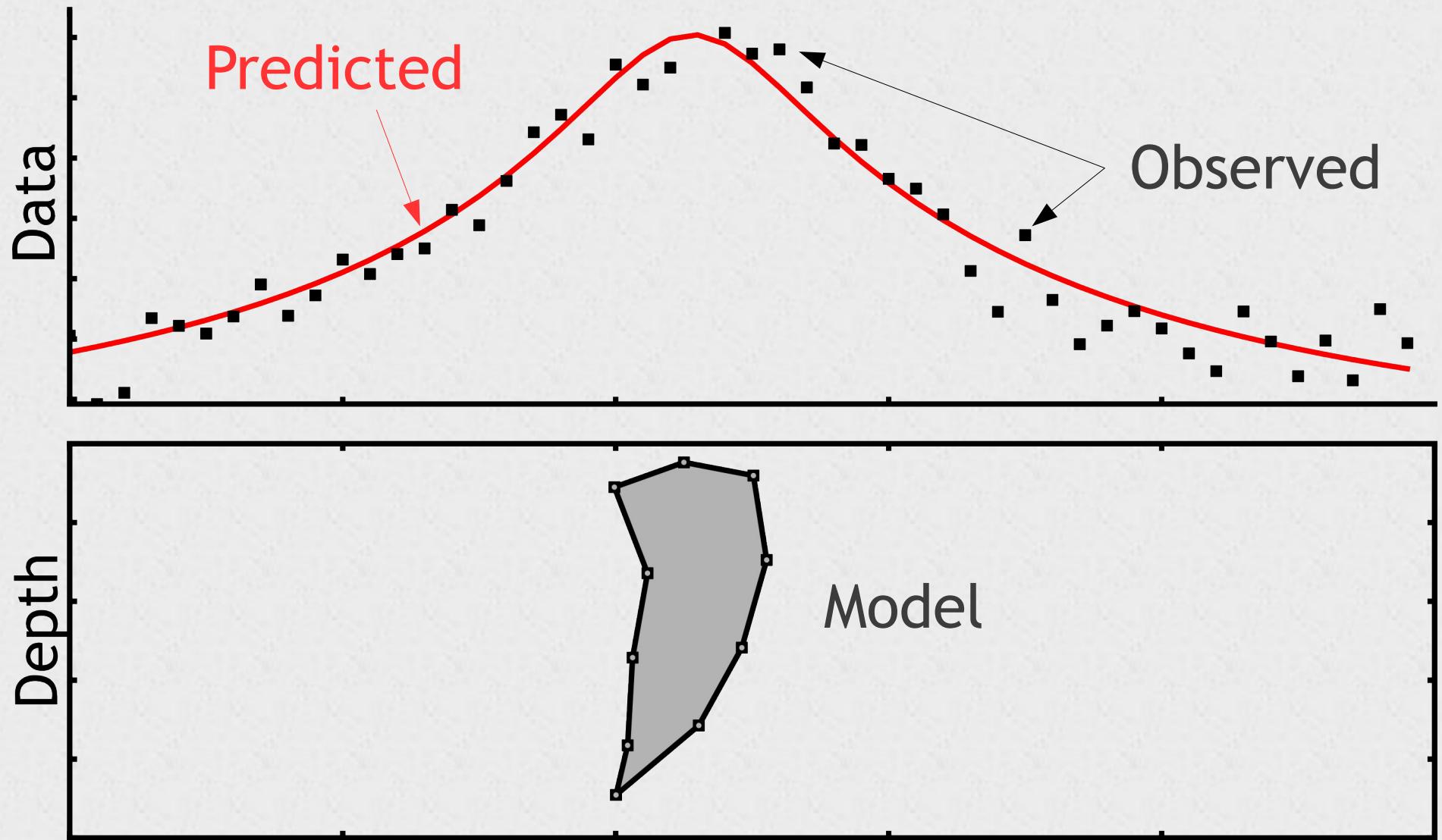
Rapid 3D inversion of gravity and gravity gradient data to test geologic hypotheses

Leonardo Uieda
Valéria C. F. Barbosa



Observatório Nacional
Rio de Janeiro, Brazil

Forward modeling

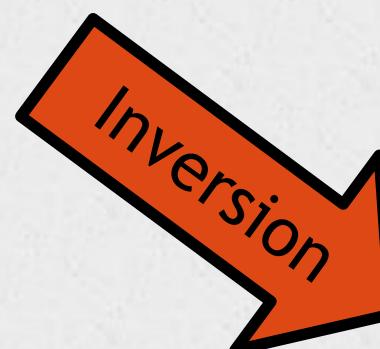
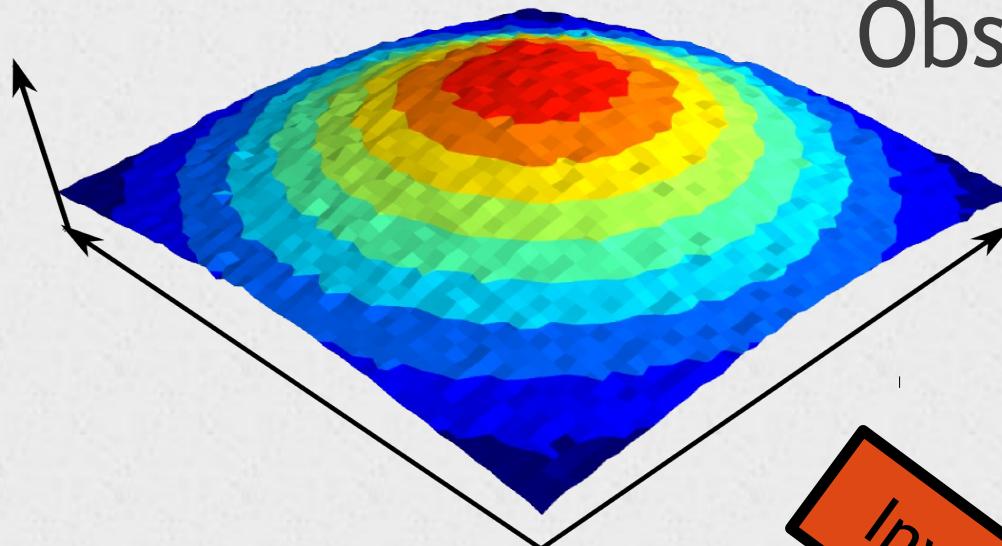


- ✓ Control
- ✓ Prior information
- ✓ Speed

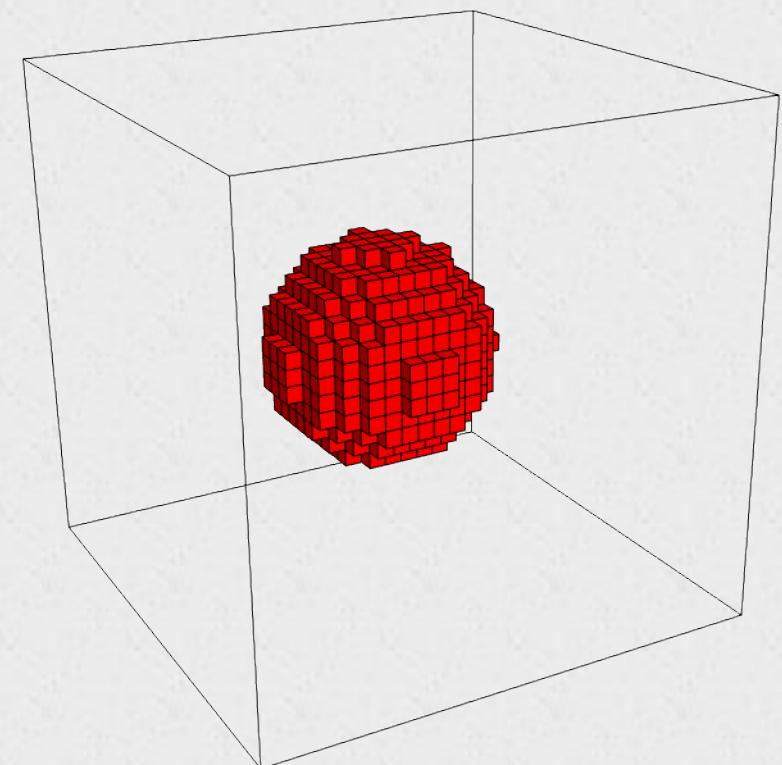
- ✗ Tedious
- ✗ Gravity + gradients
- ✗ 3D

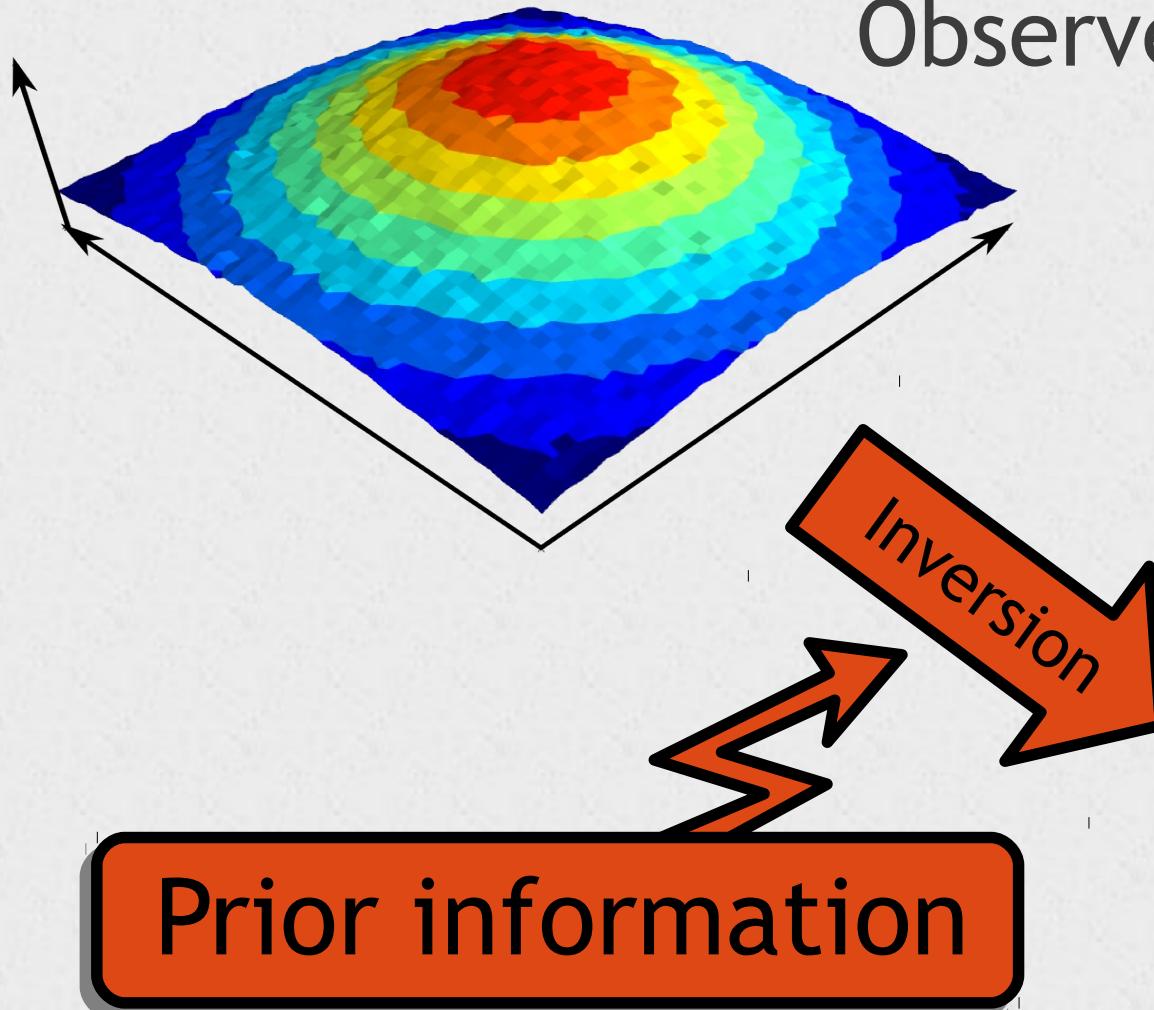
Geophysical inversion

Observed data



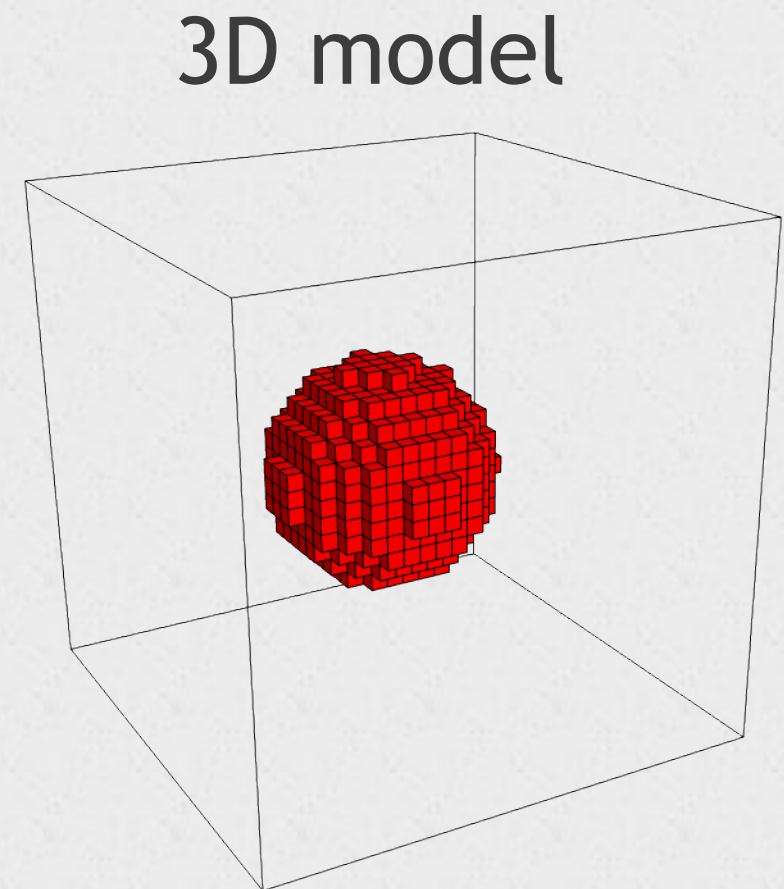
3D model





Regularization:

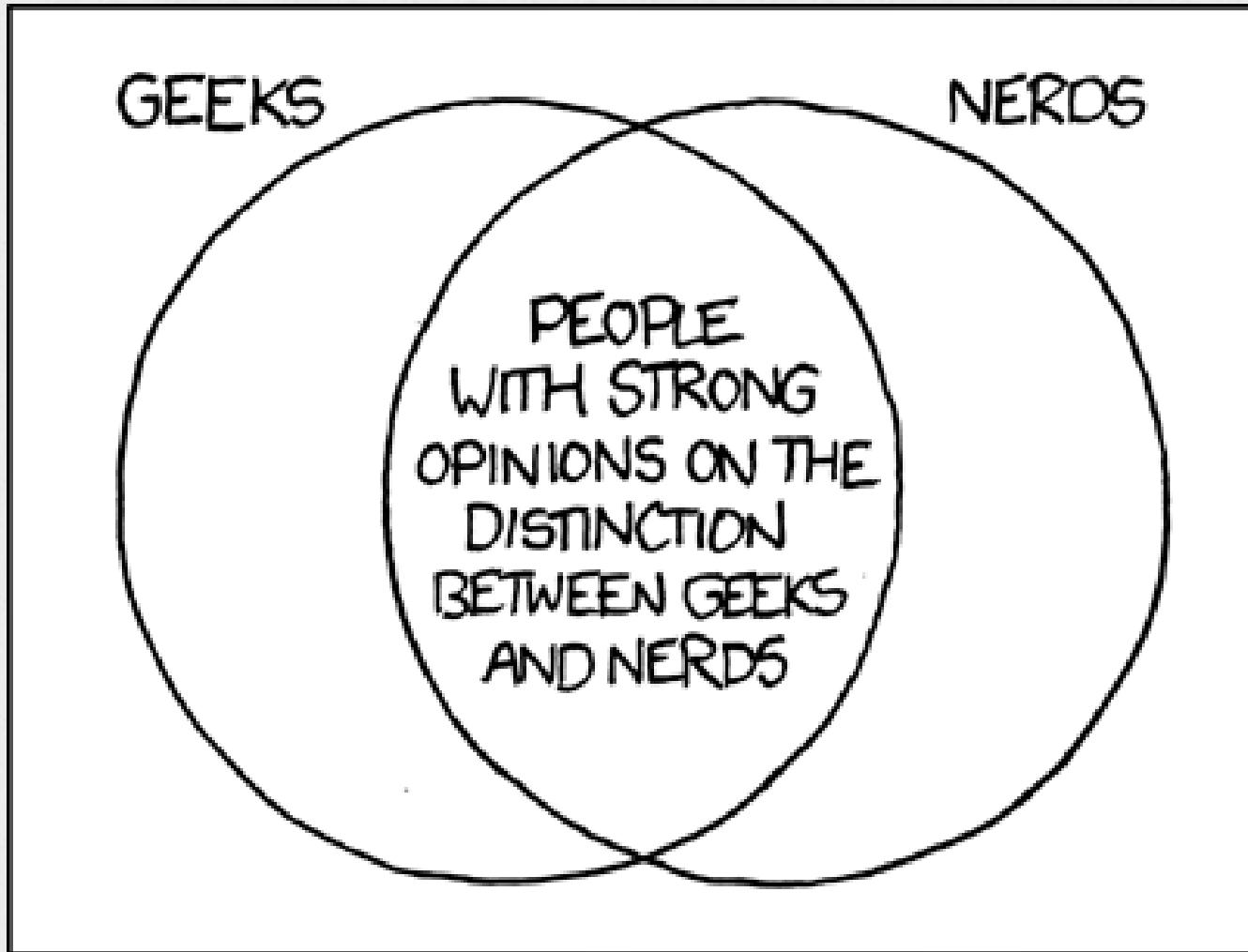
- Damping
- Smoothness



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

- ✗ Control
- ✗ Prior information
- ✗ Speed

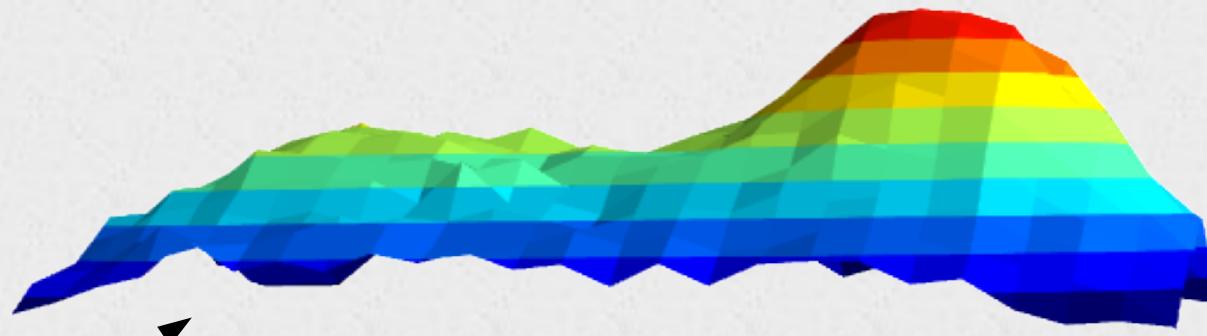
Something in the middle



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

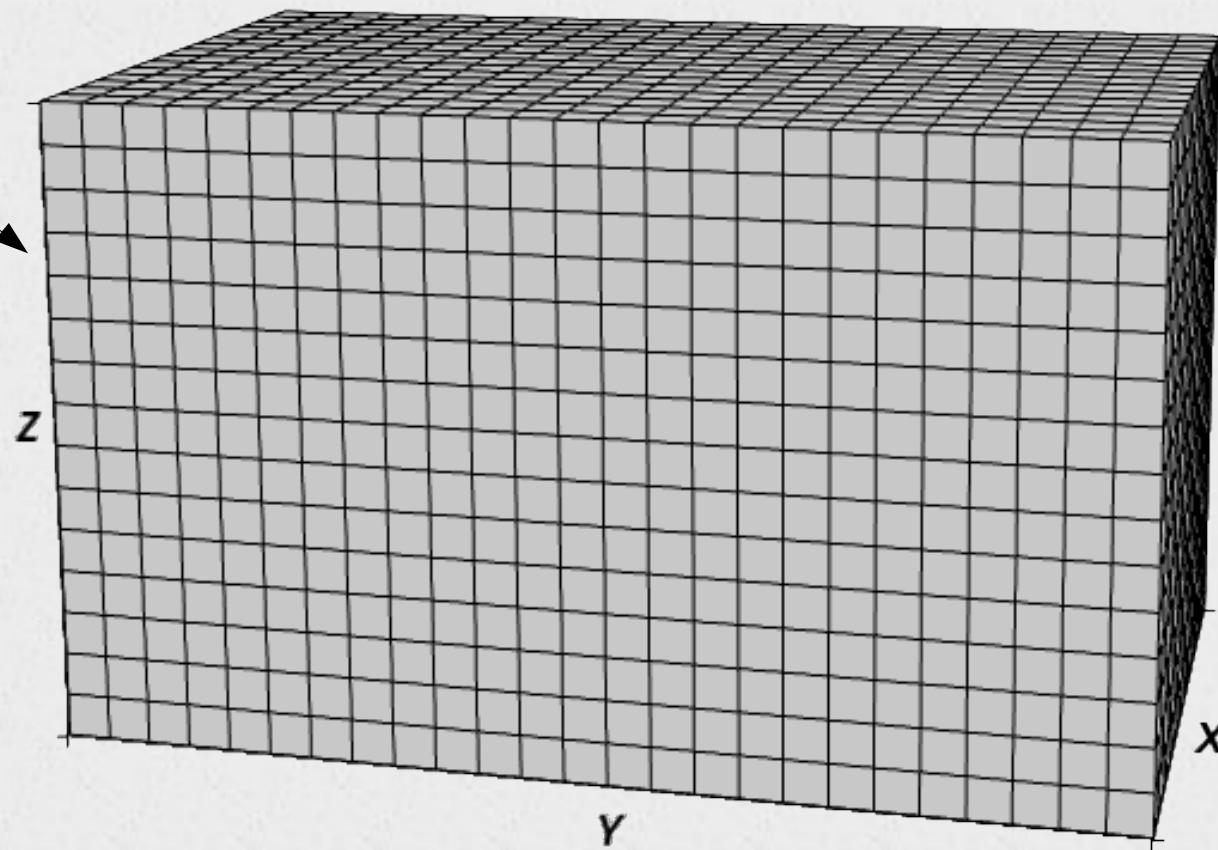
Planting anomalous densities

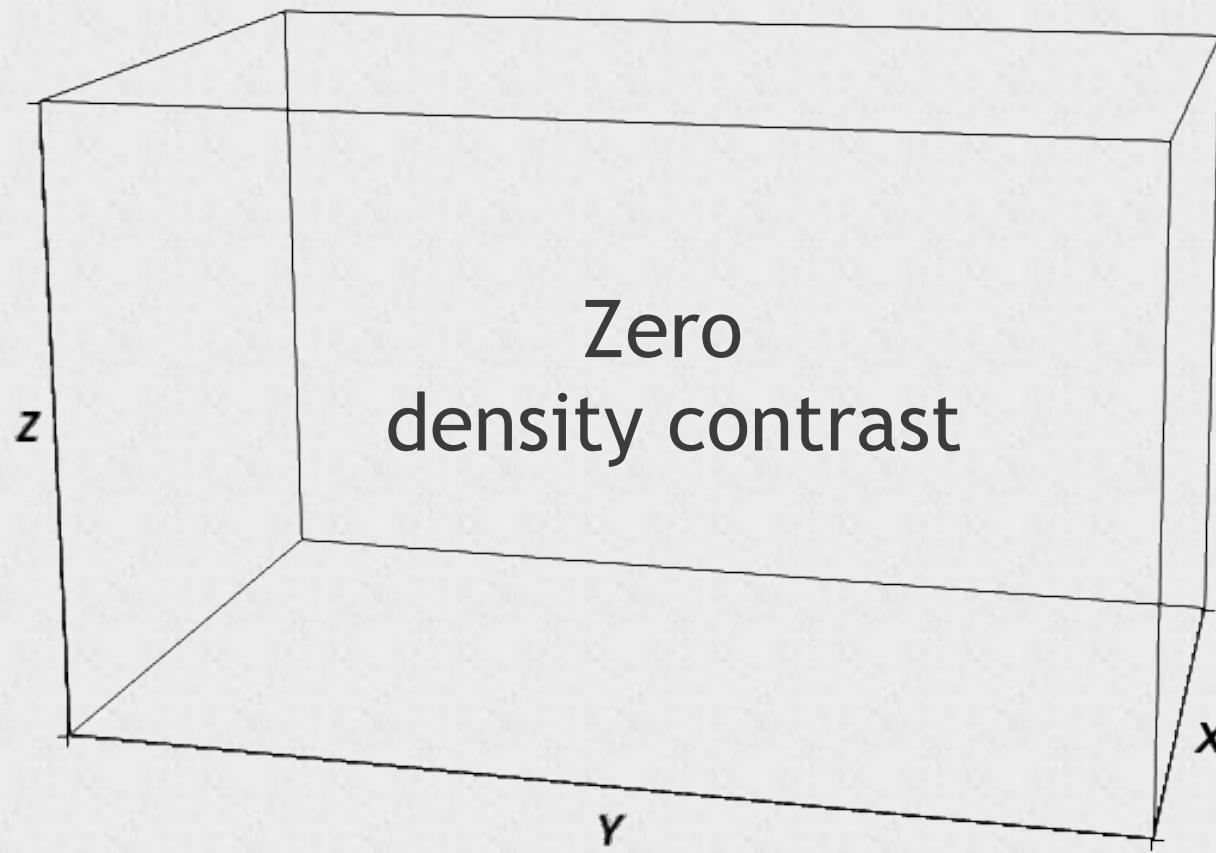
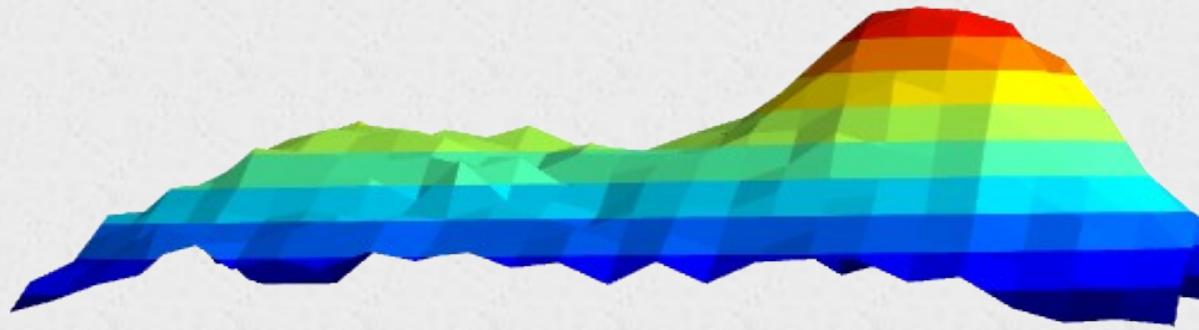
Uieda and Barbosa (2012), *Geophysics*

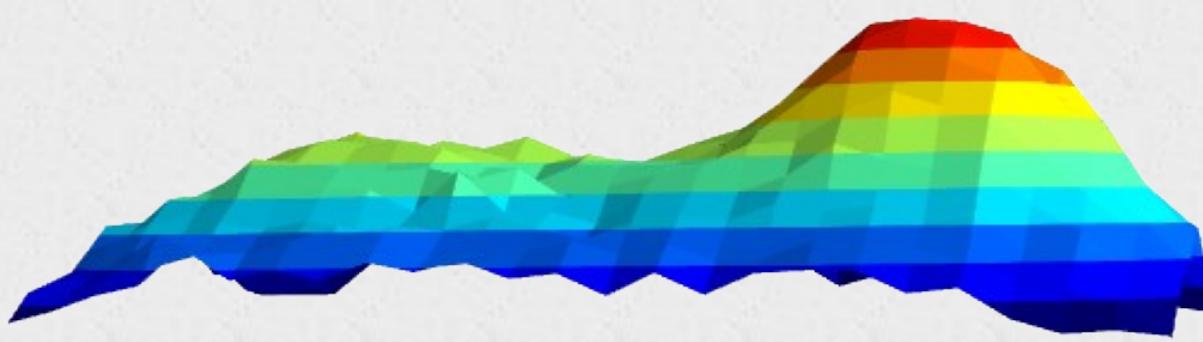


Observed data

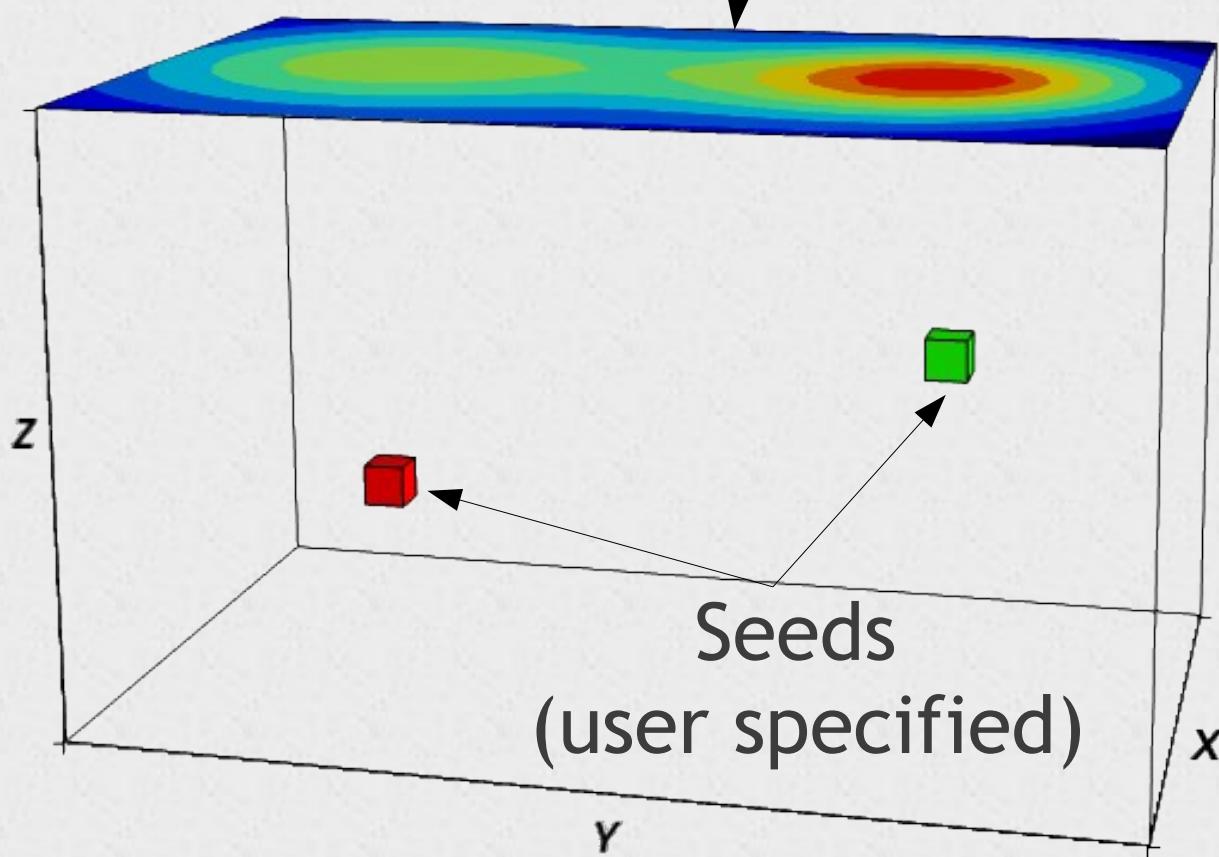
Mesh



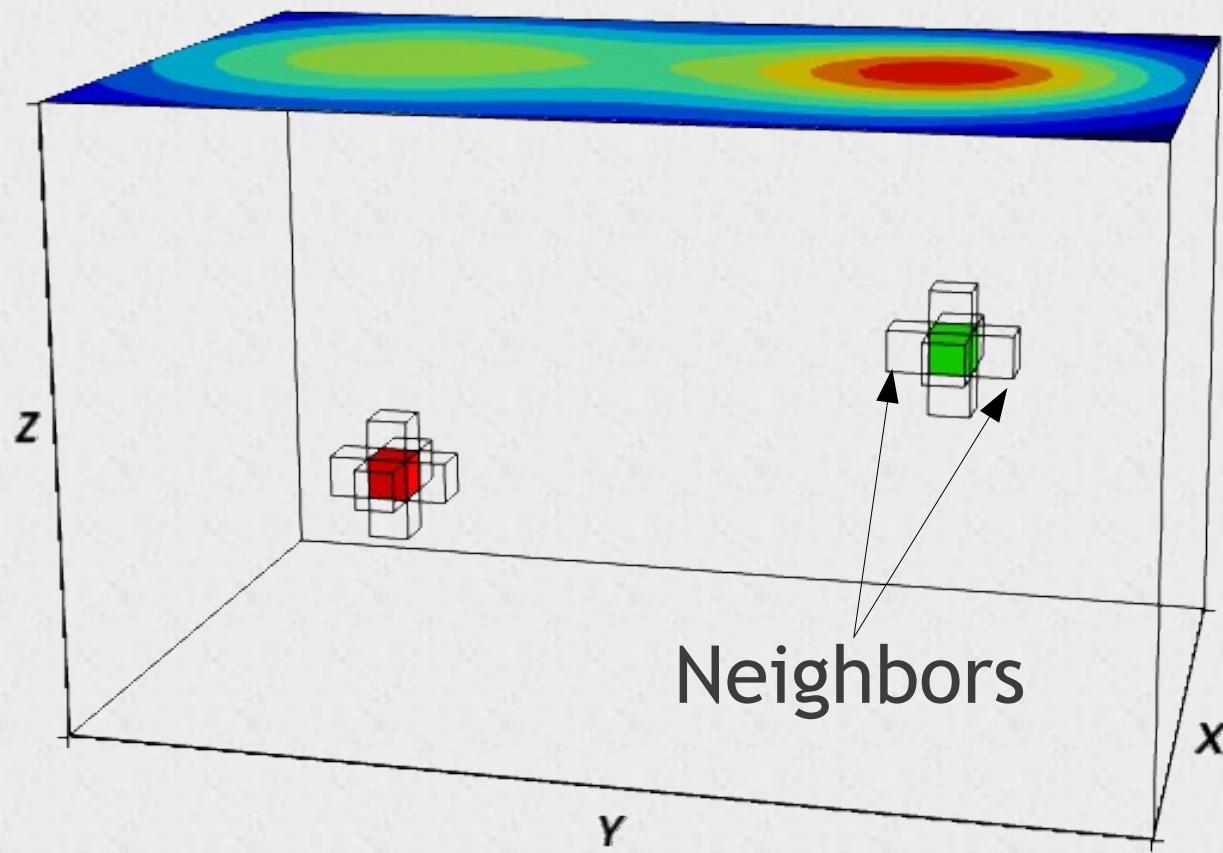
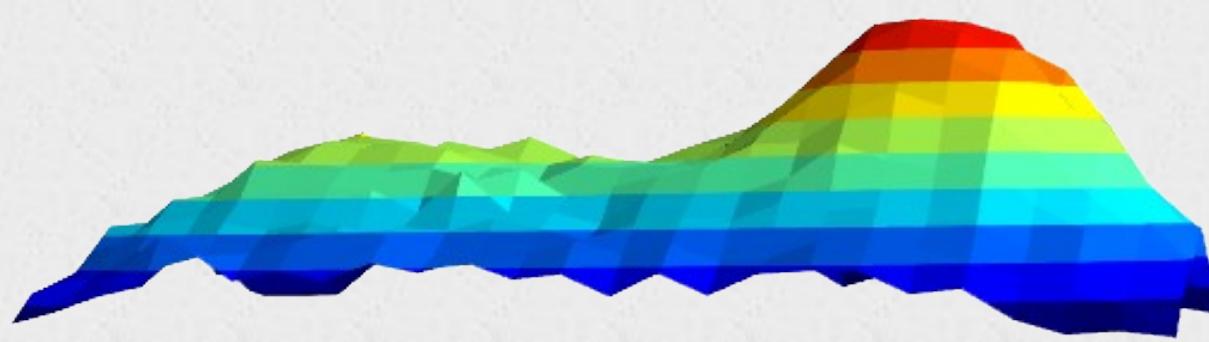


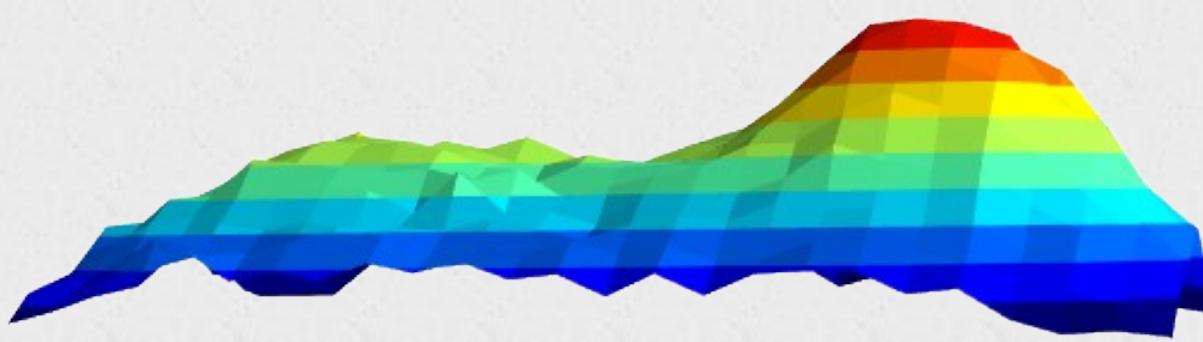


Predicted data

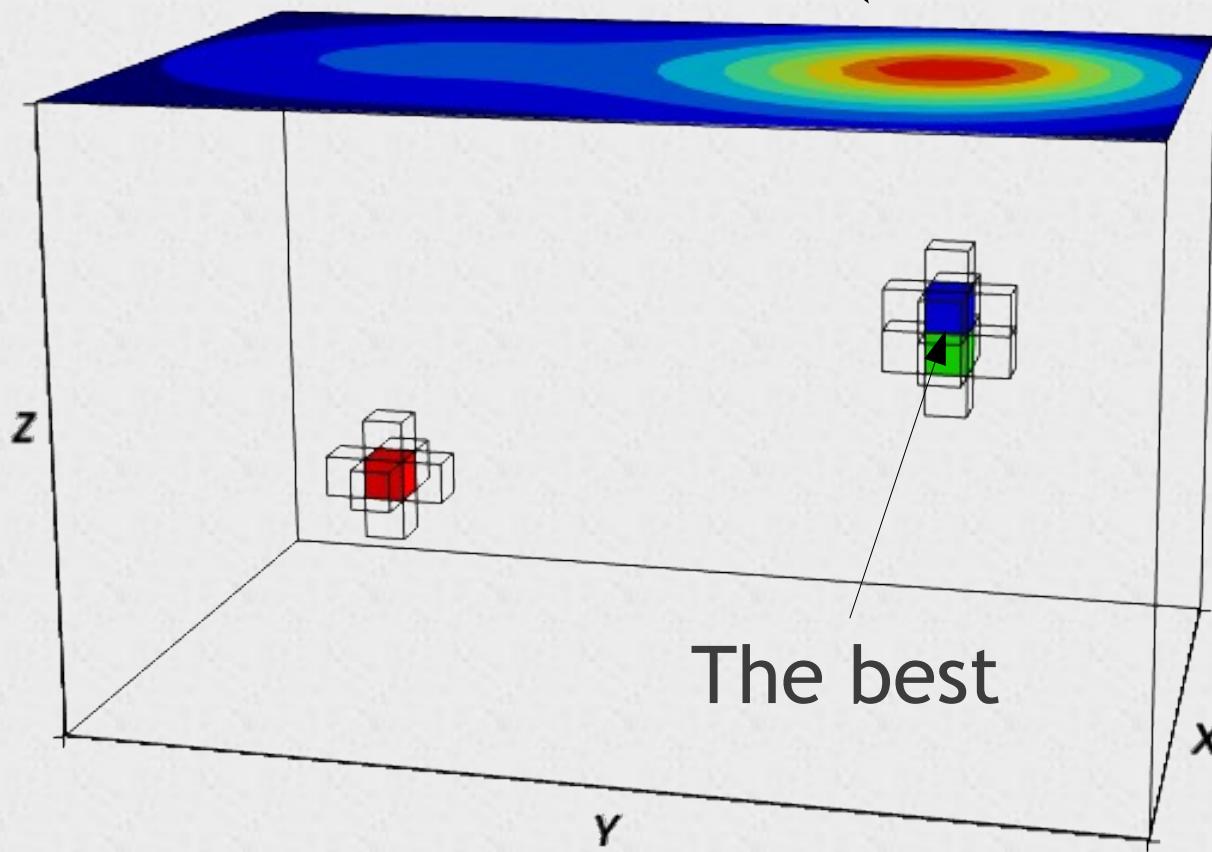


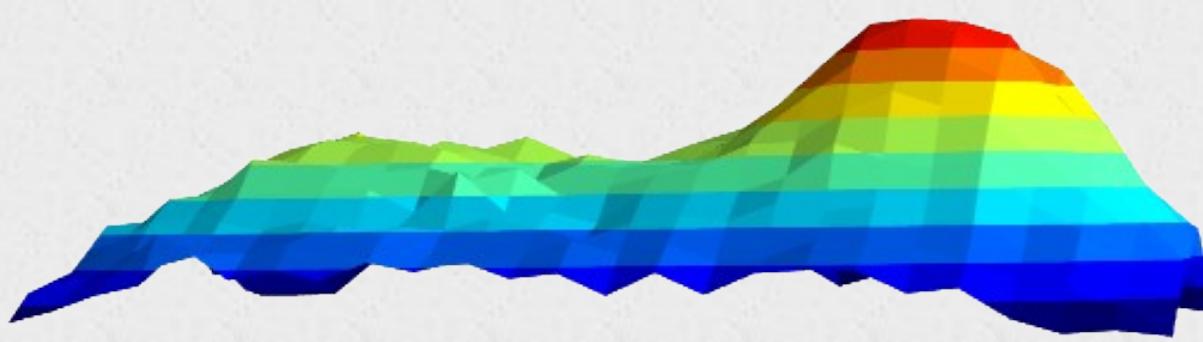
Seeds
(user specified)



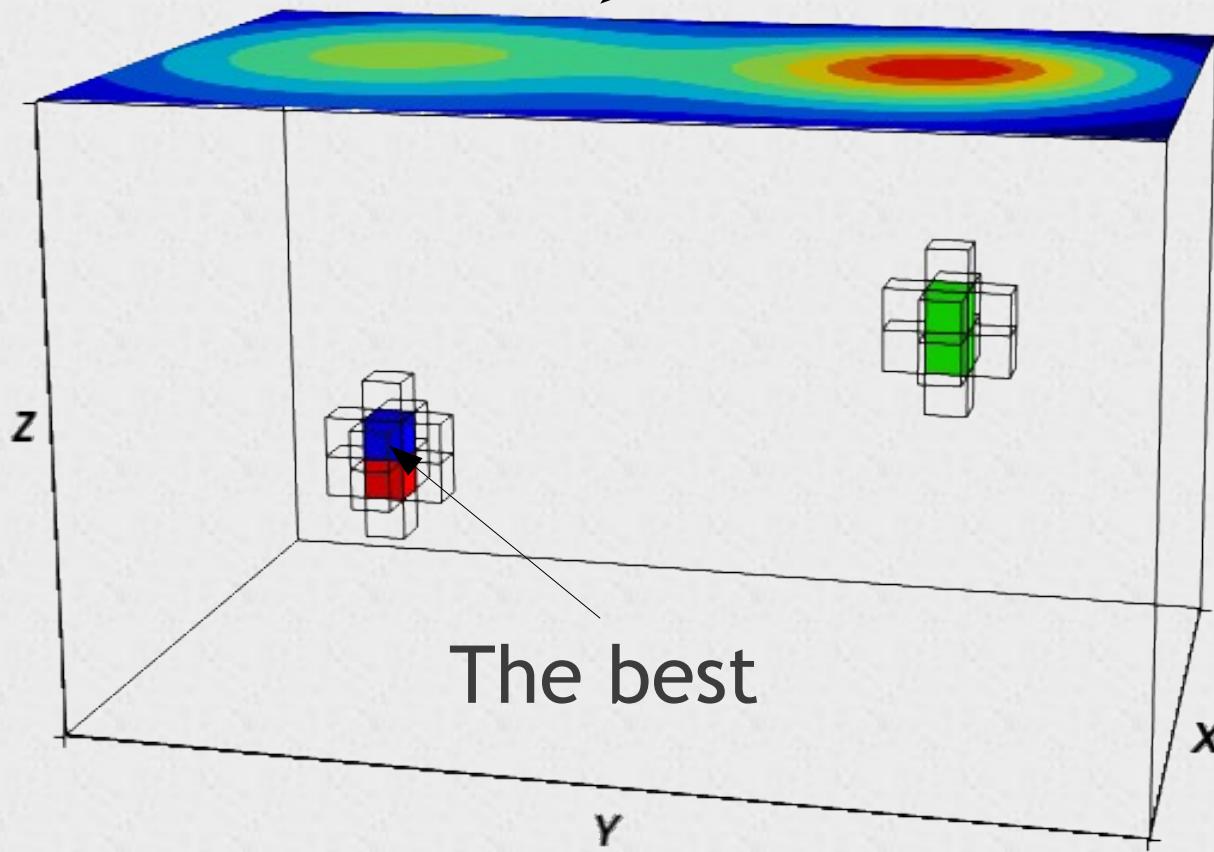


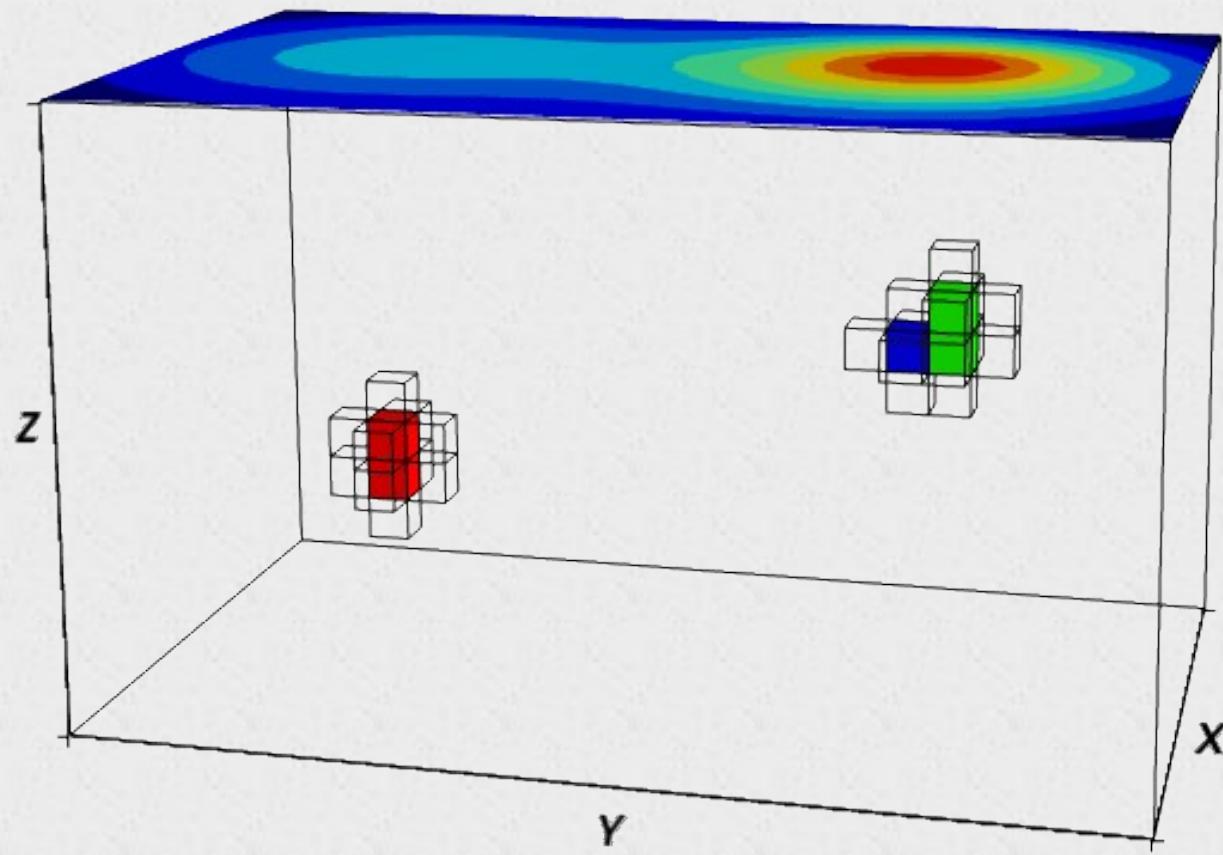
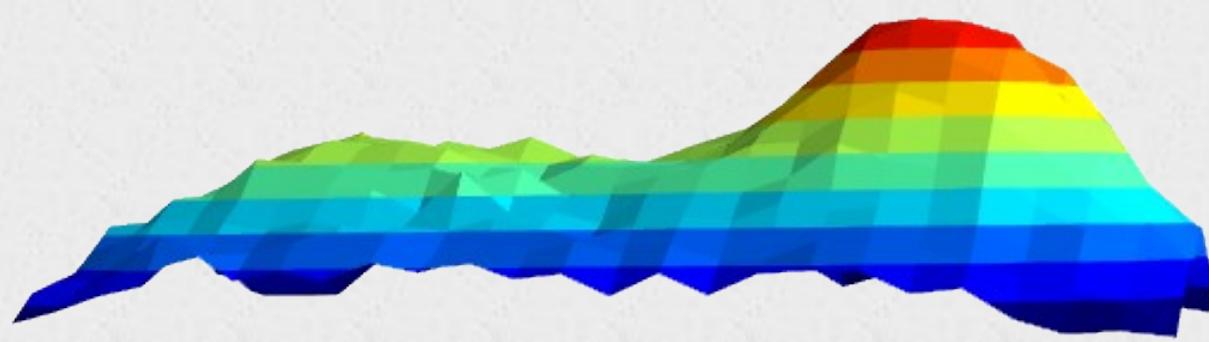
New predicted data

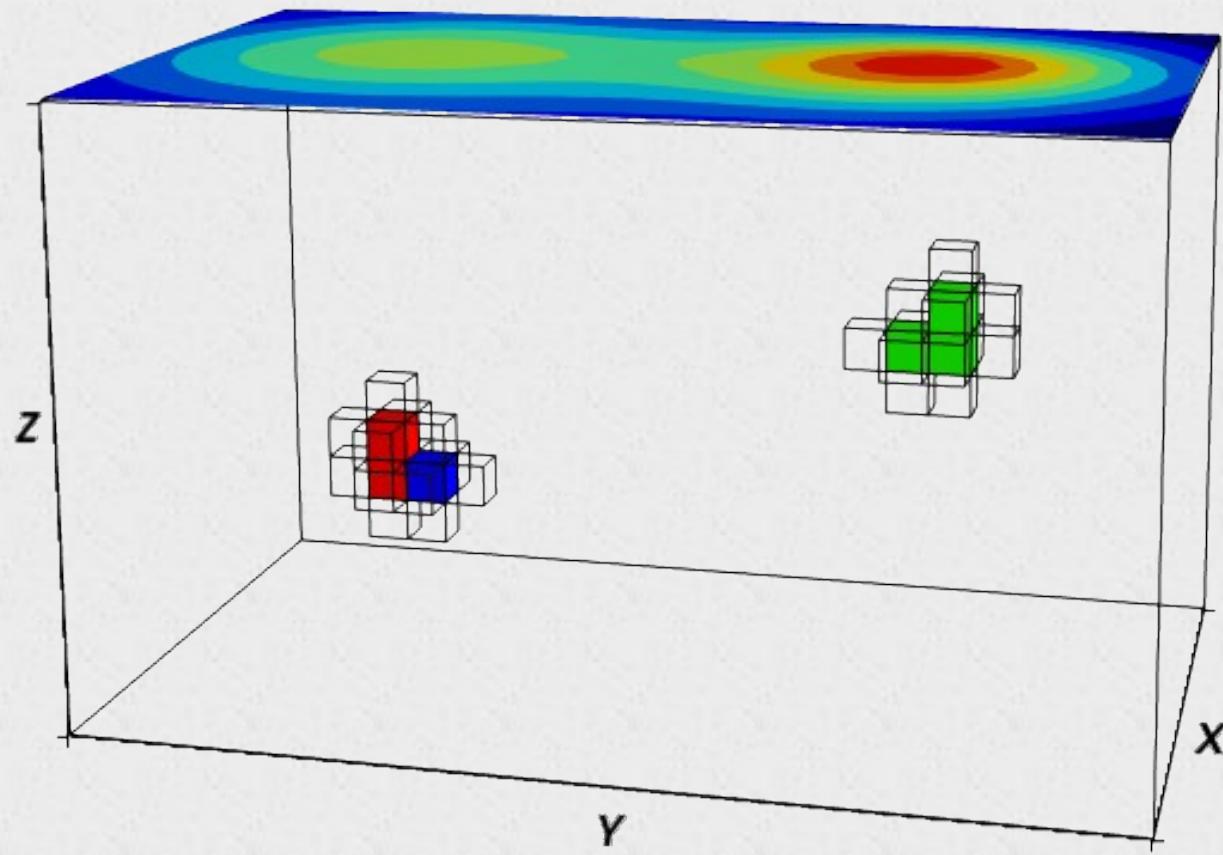
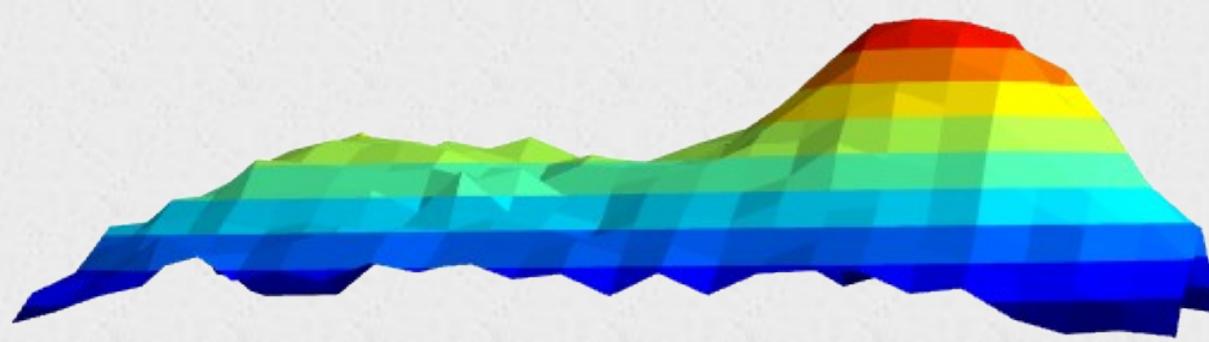


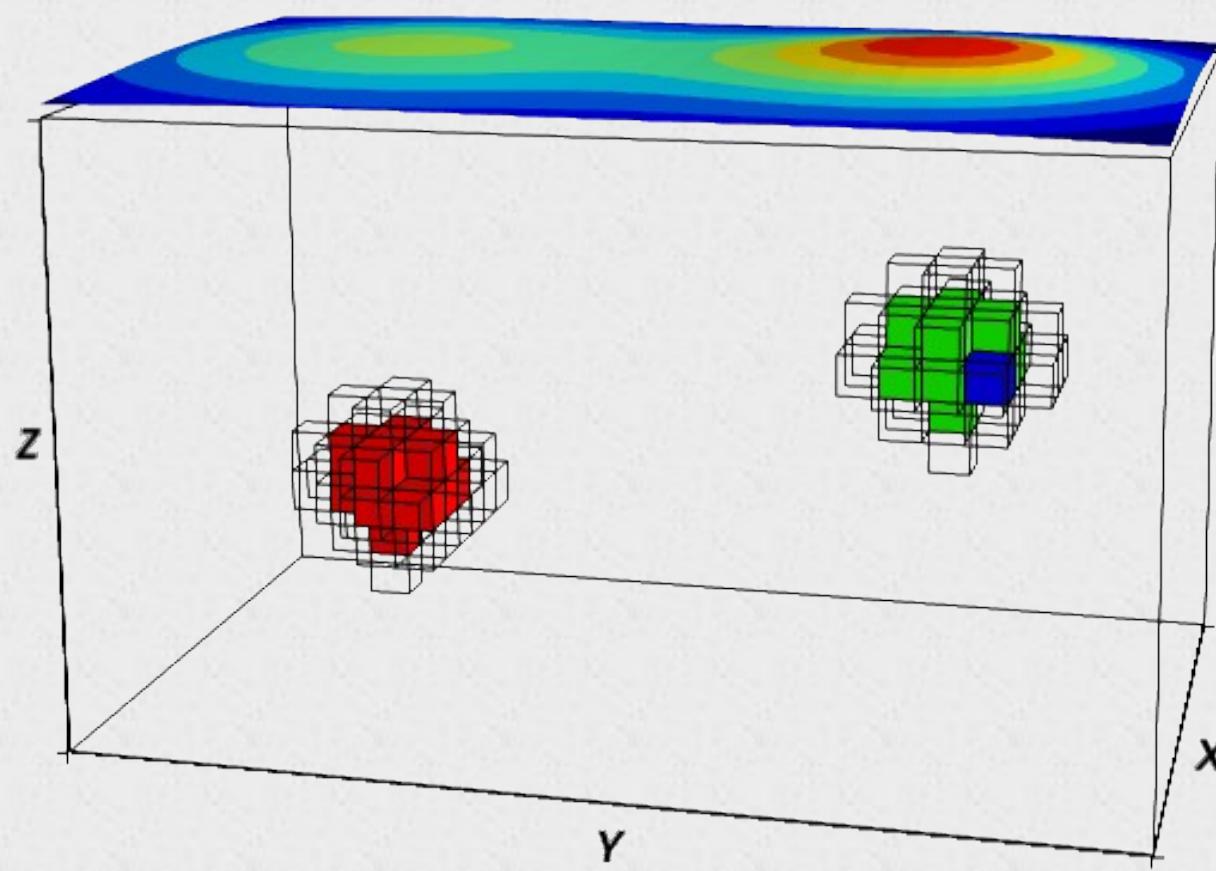
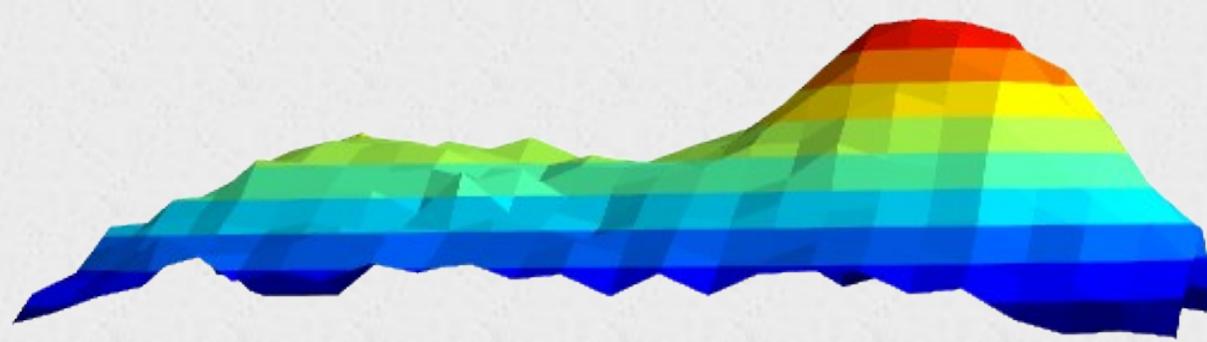


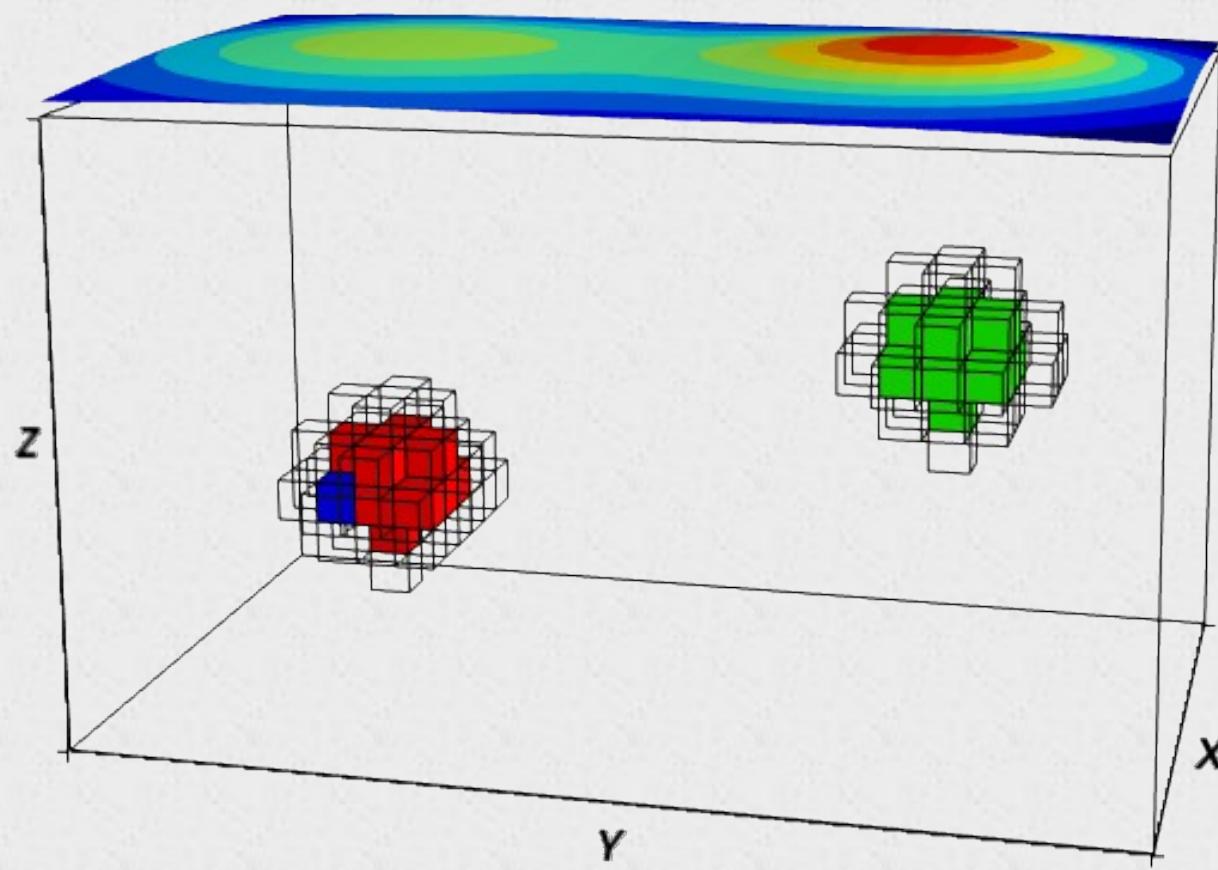
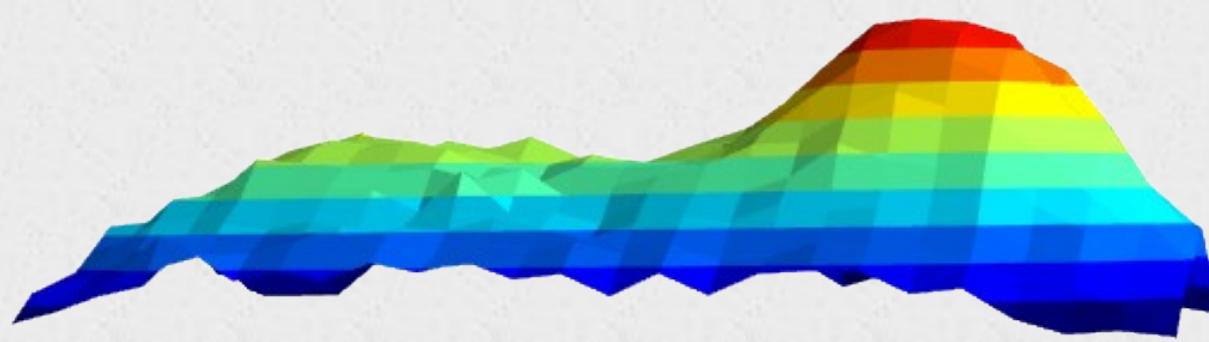
New predicted data

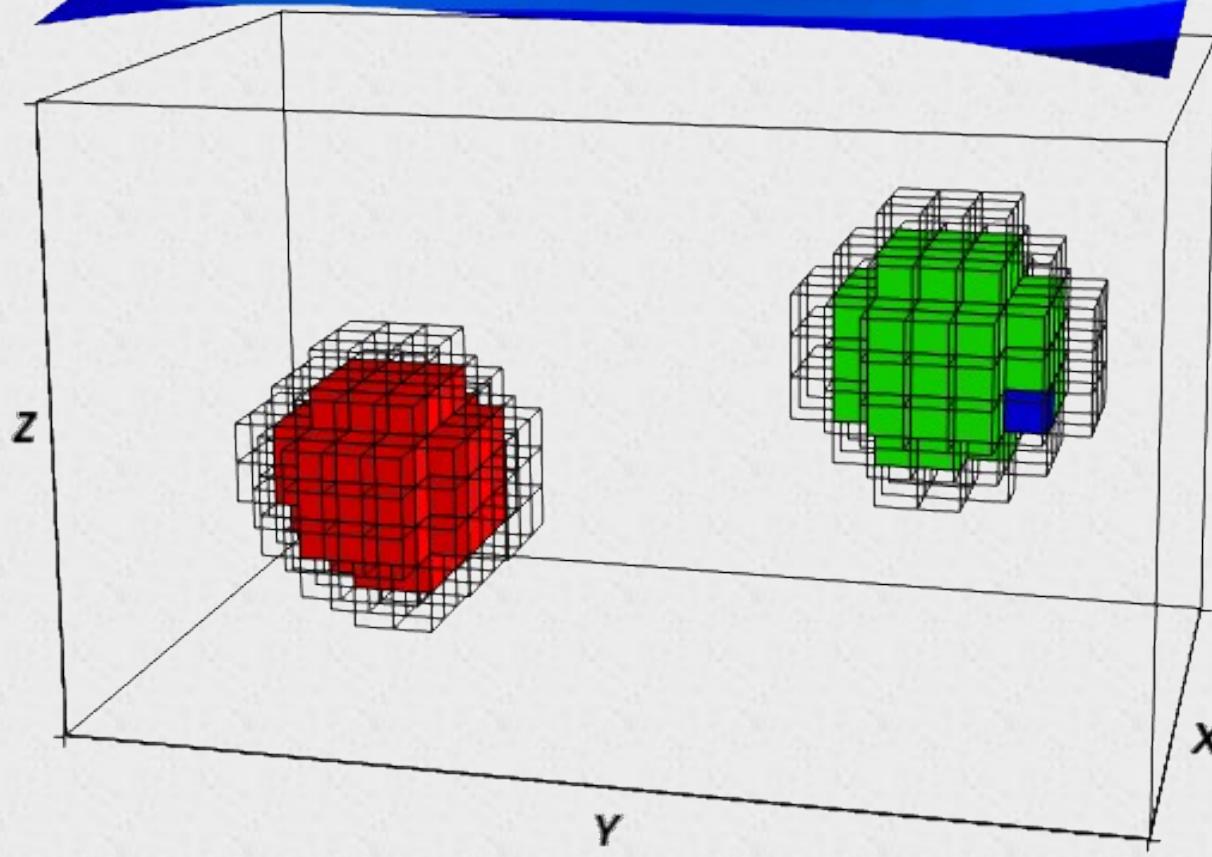
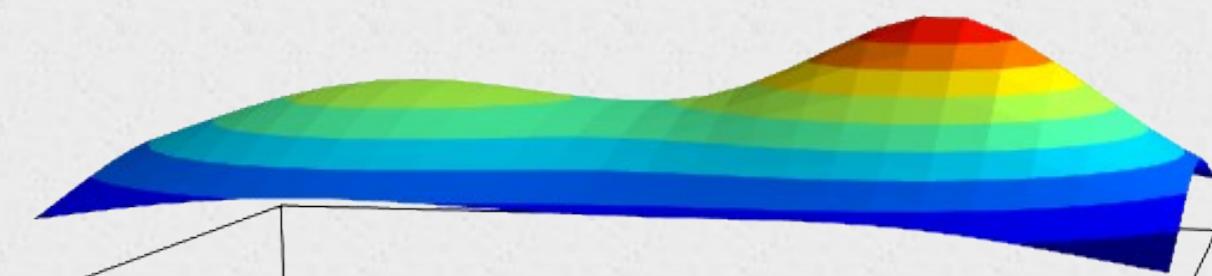
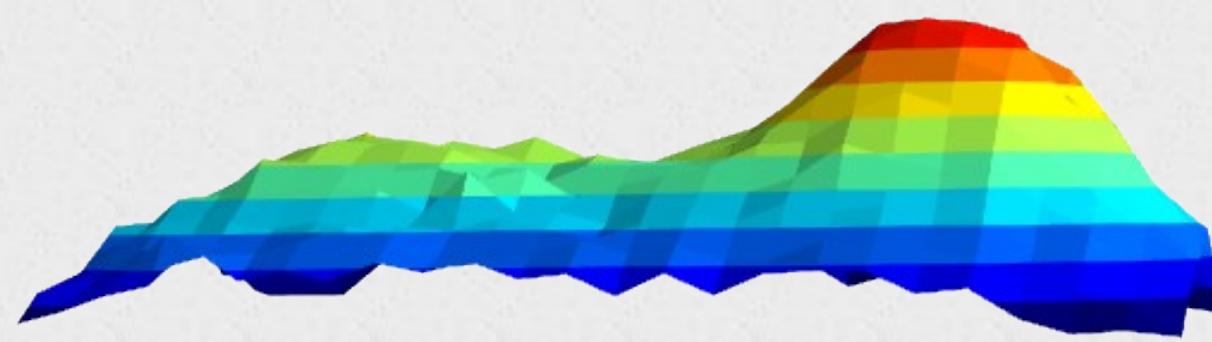


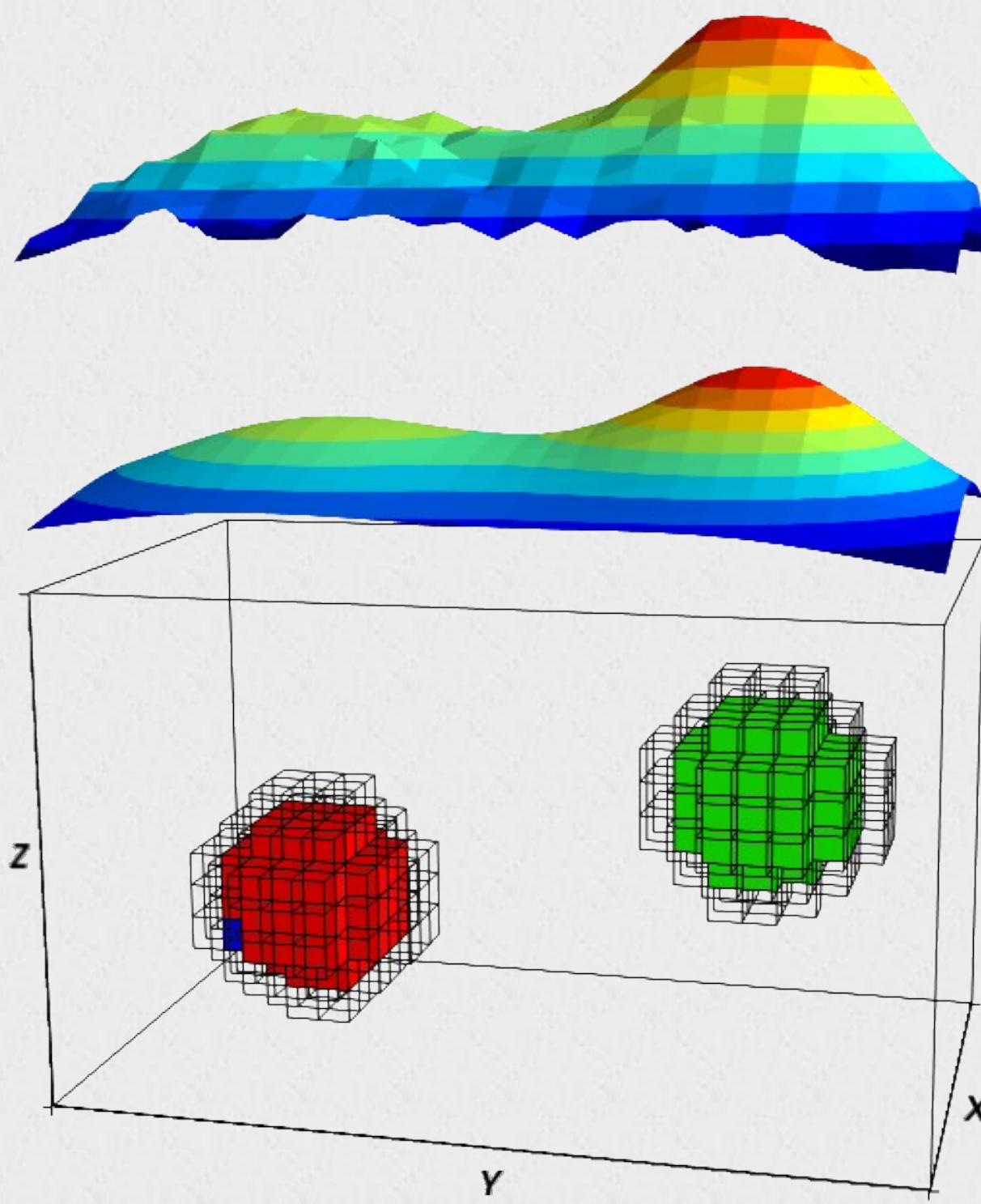


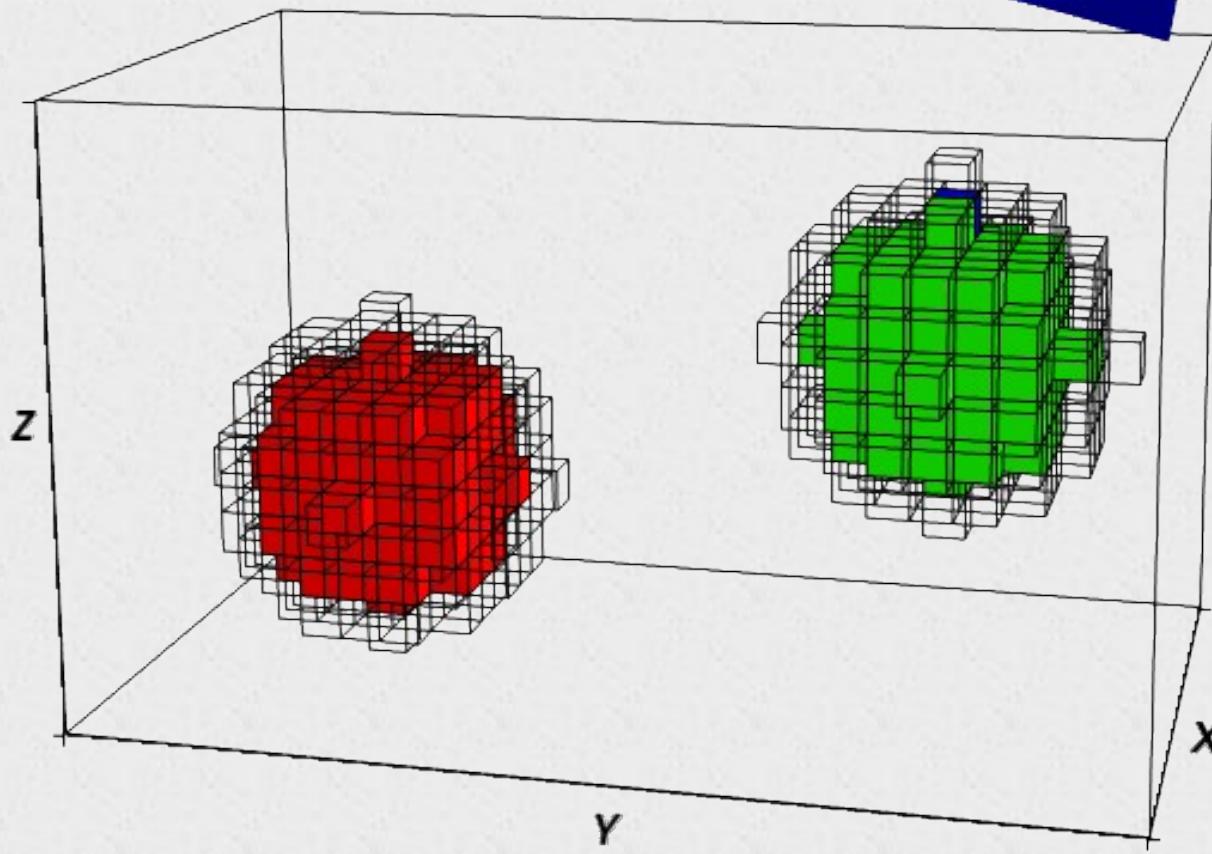
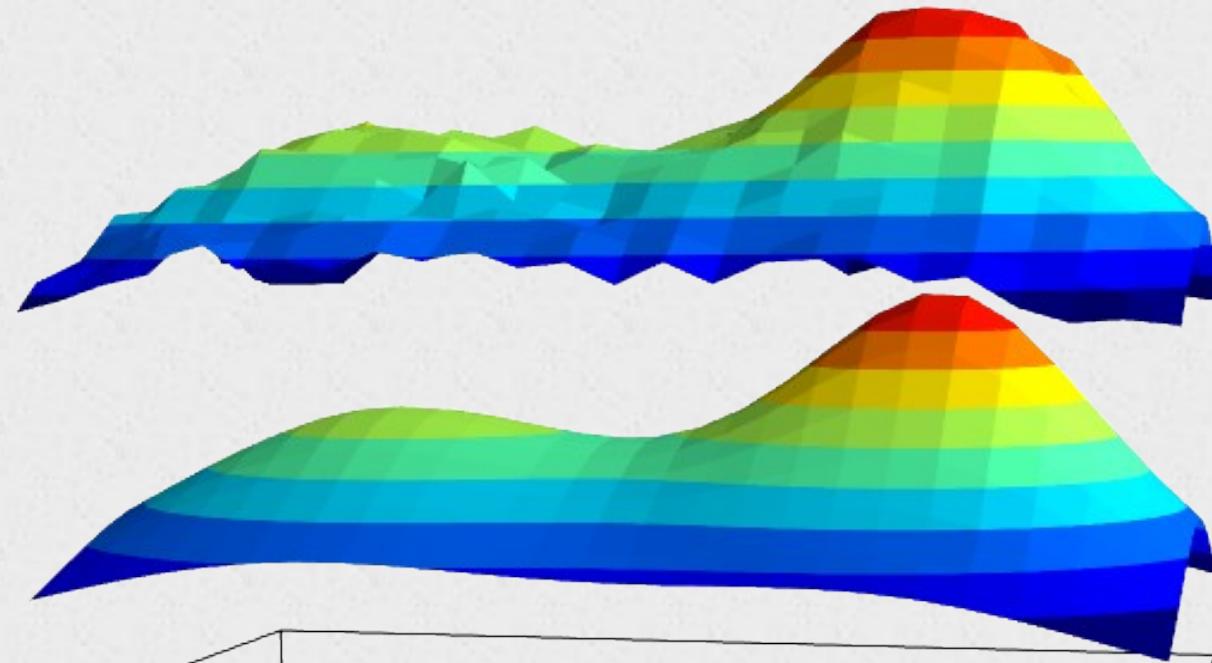


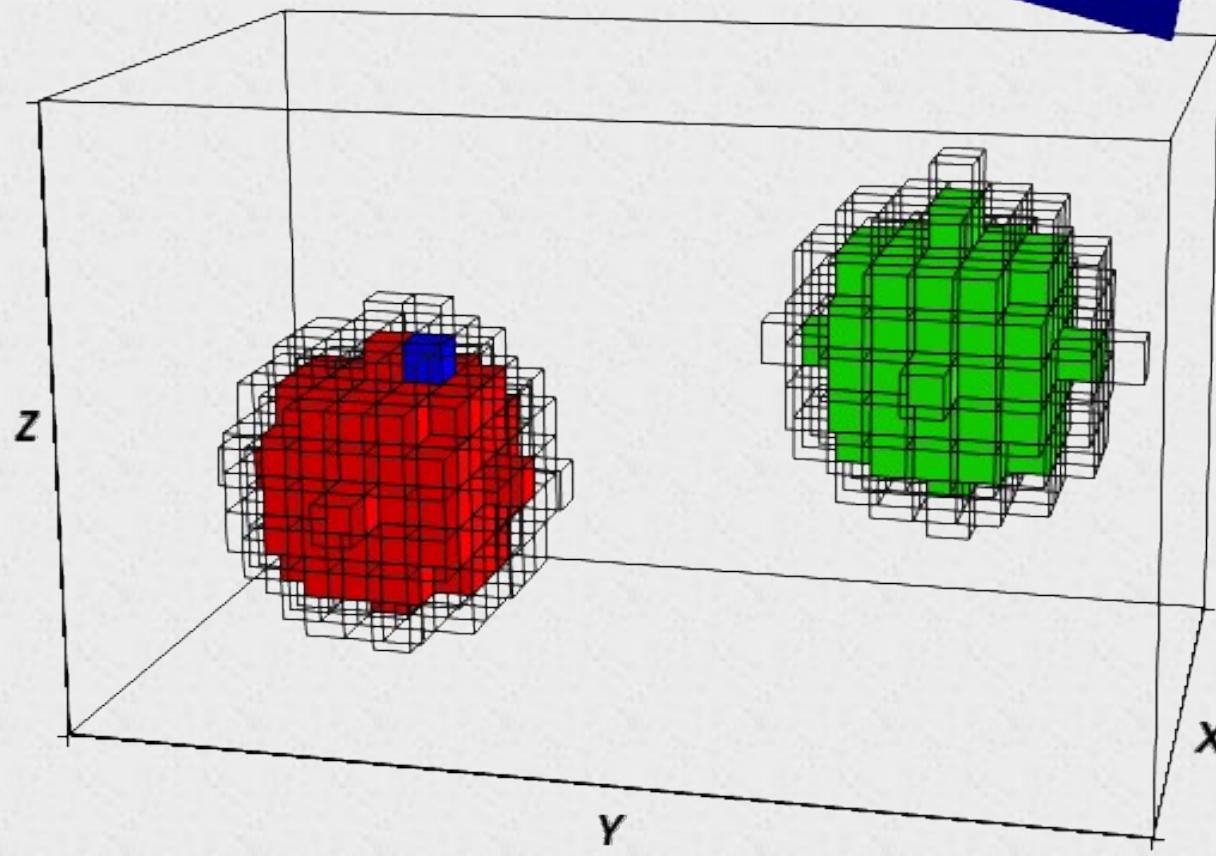
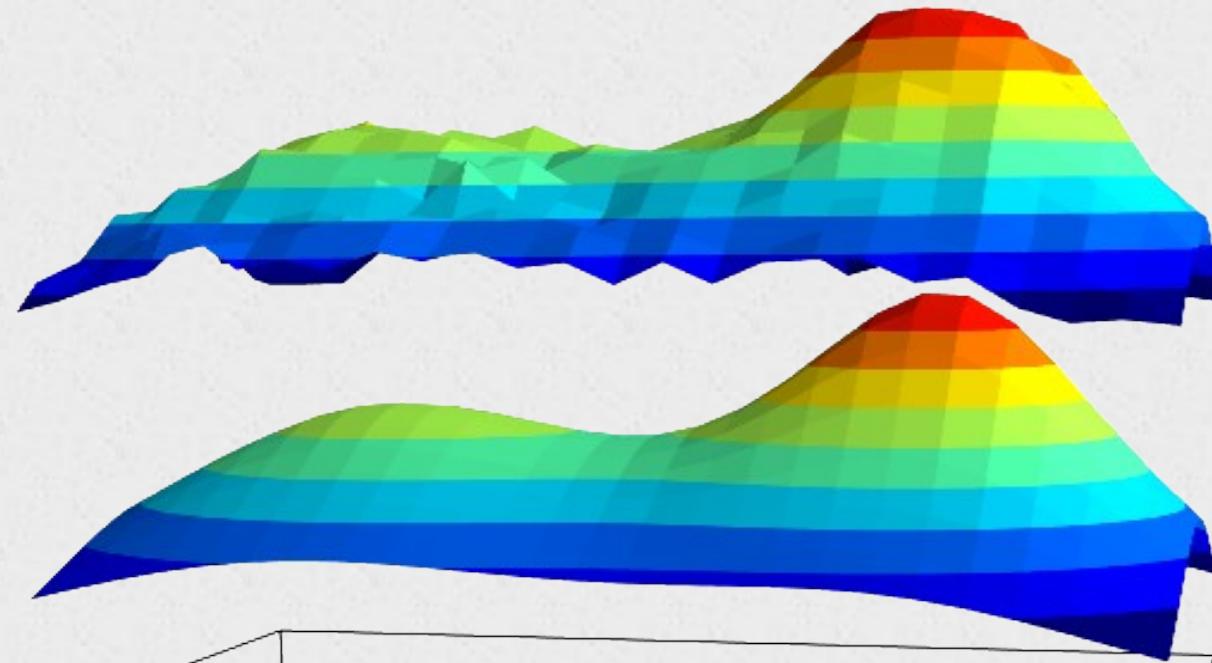




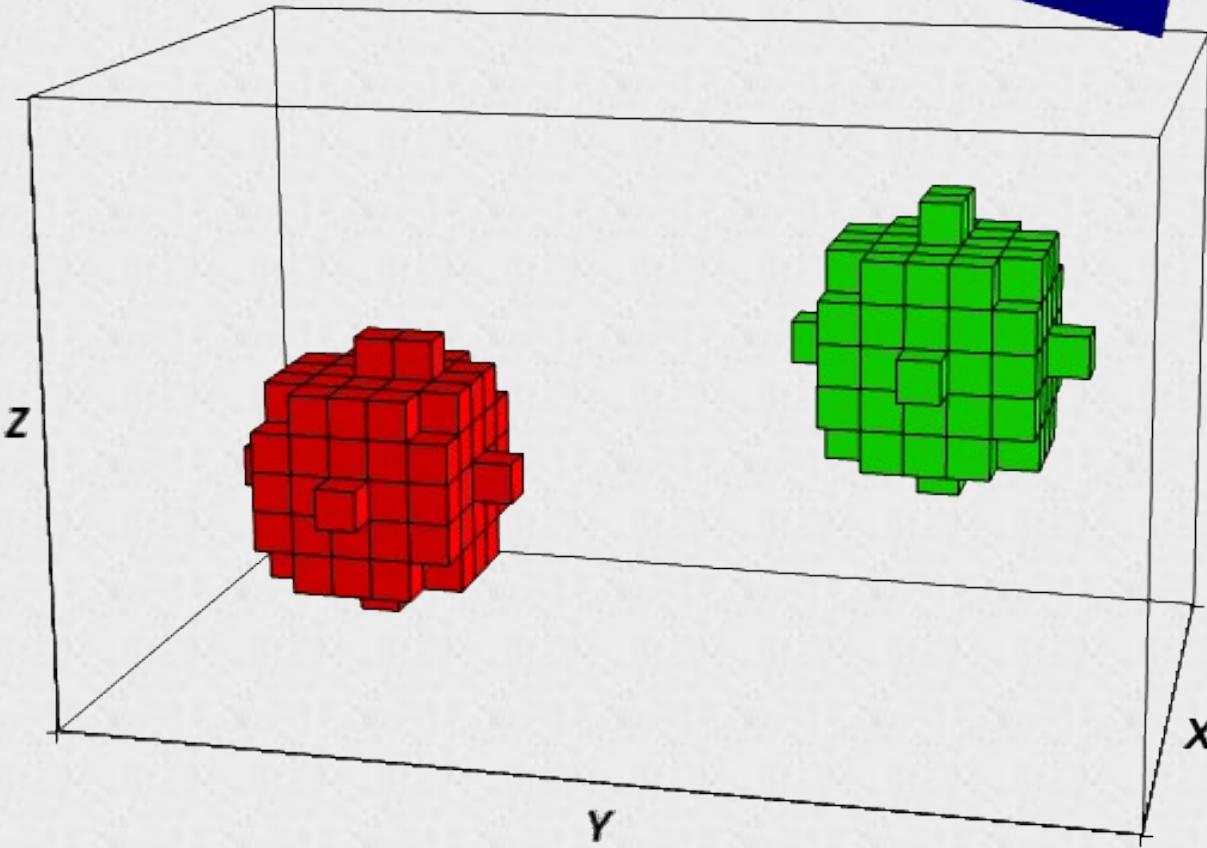








Fit!



Seeds = Skeleton



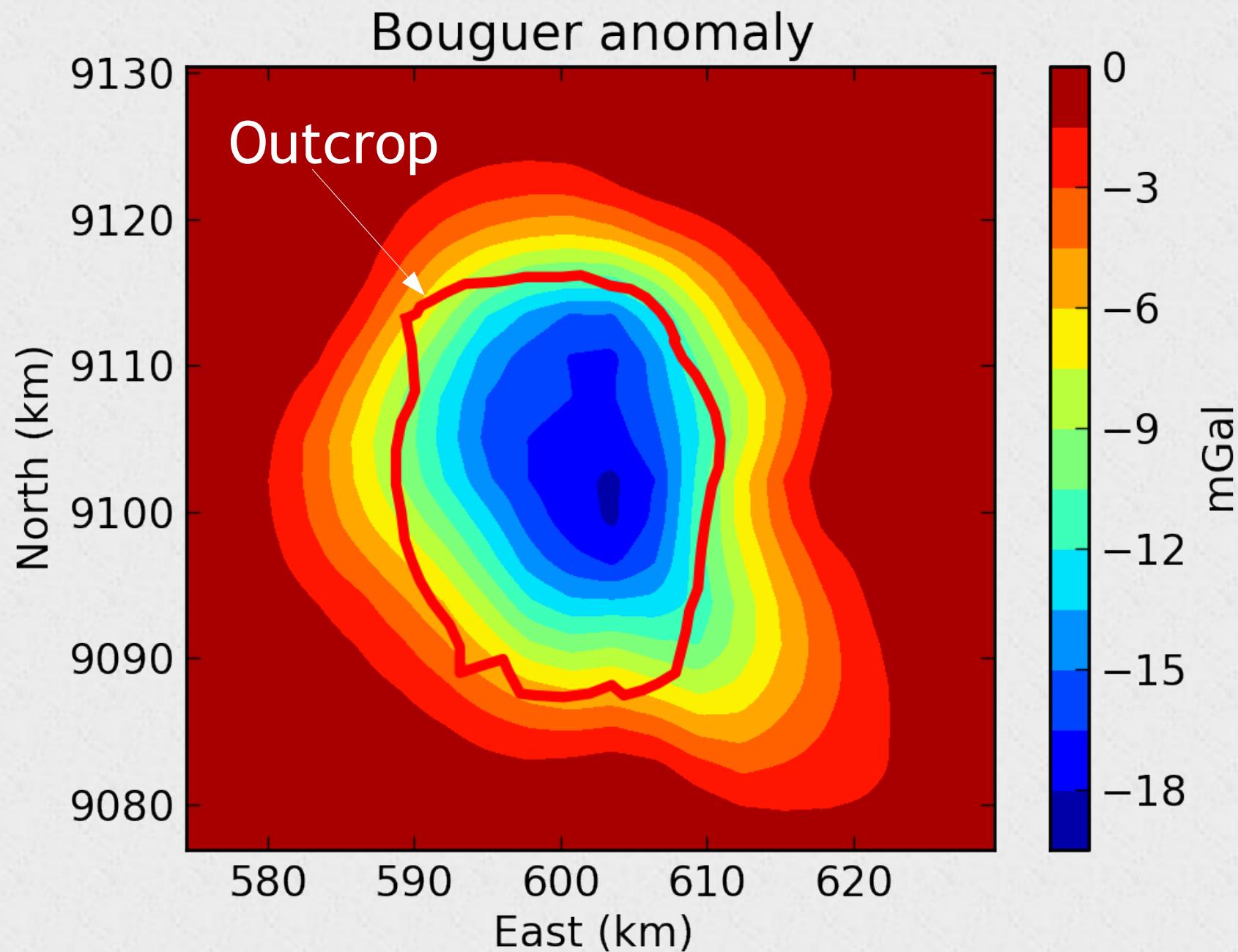
Inversion → Body



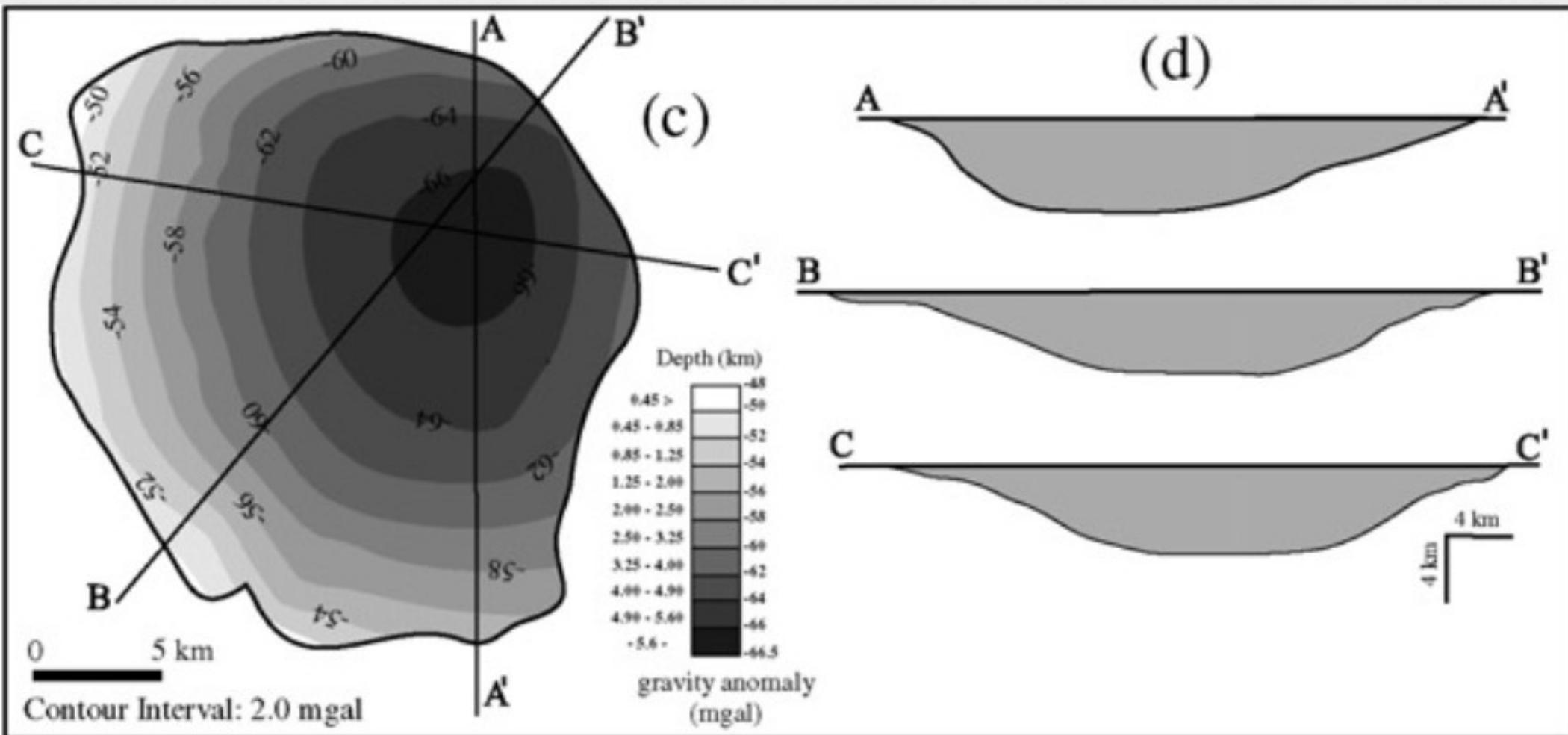
- ✓ Control
 - ✓ Prior information
 - ✓ Speed
 - ✓ Automatic fit
 - ✓ Gravity + Gradients
 - ✓ 3D (only need skeleton)
-
- ```
graph TD; Seeds[Seeds] --> Control[Control]; Seeds --> Prior[Prior information]; Seeds --> Speed[Speed]; Seeds --> Auto[Automatic fit]; Seeds --> Gravity[Gravity + Gradients]; Seeds --> 3D[3D (only need skeleton)];
```

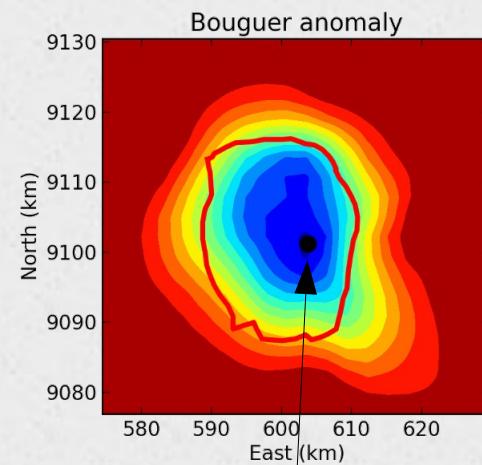
# Example applications

Redenção granite

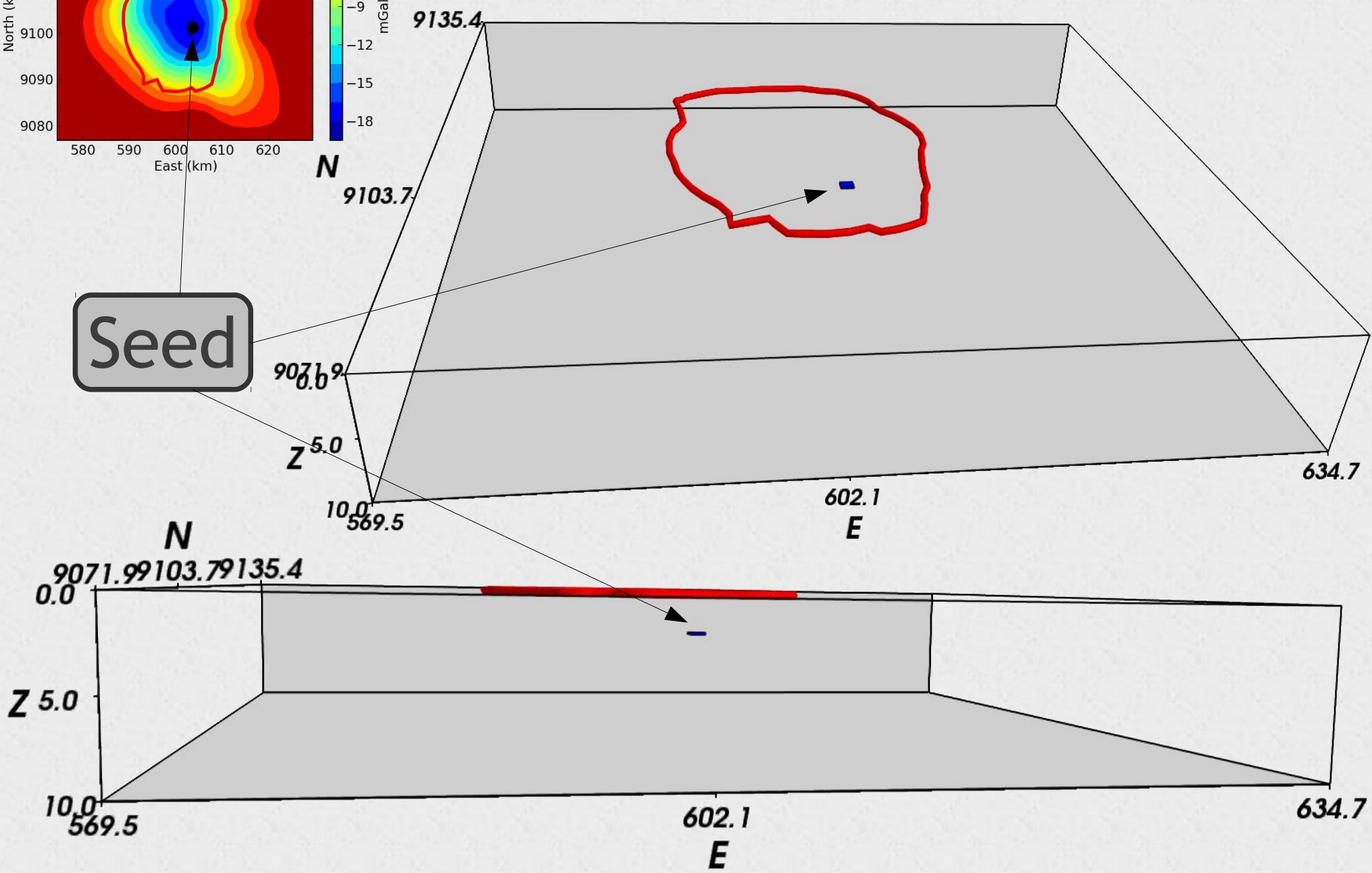


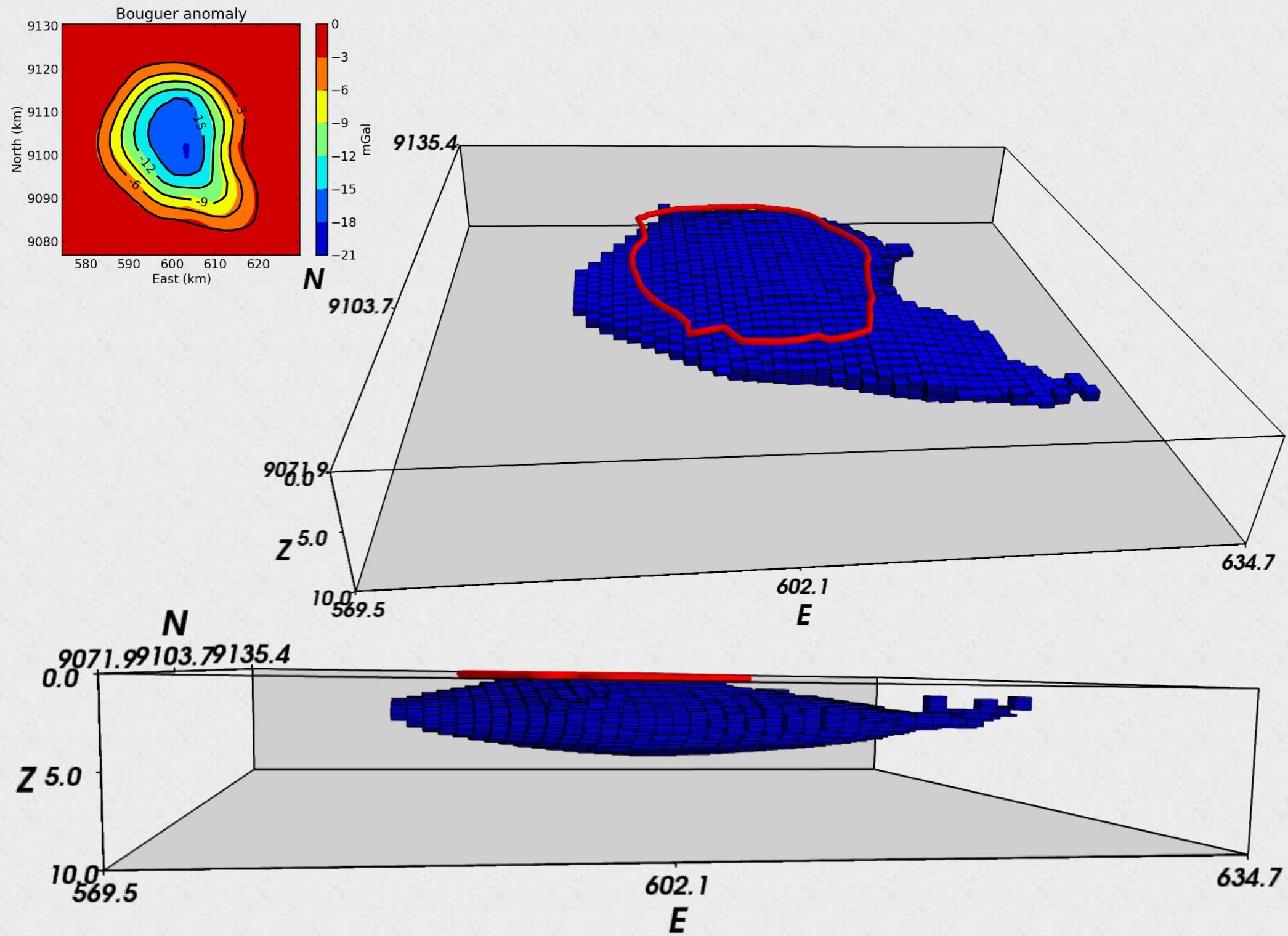
# Oliveira et al. (2008)





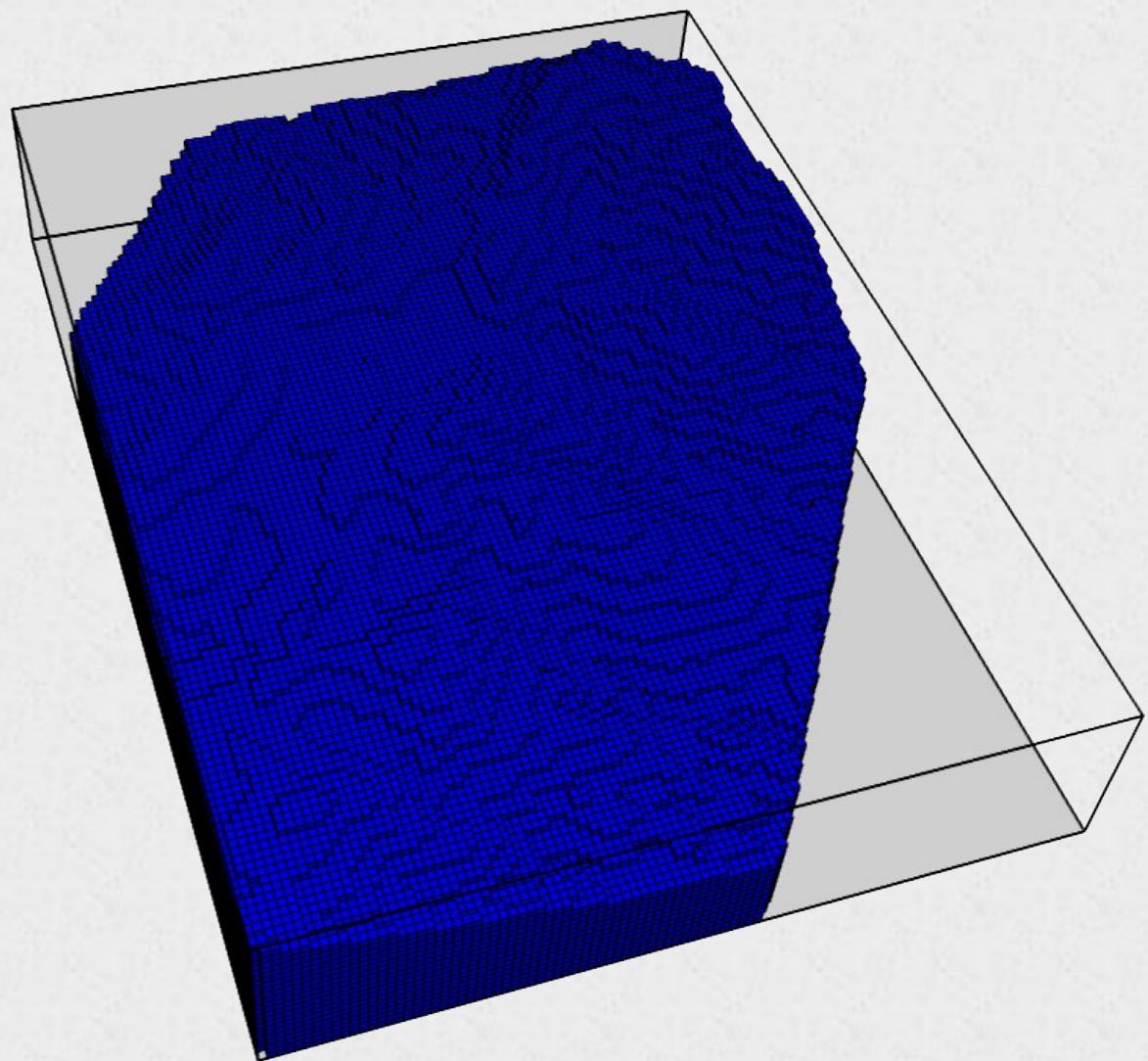
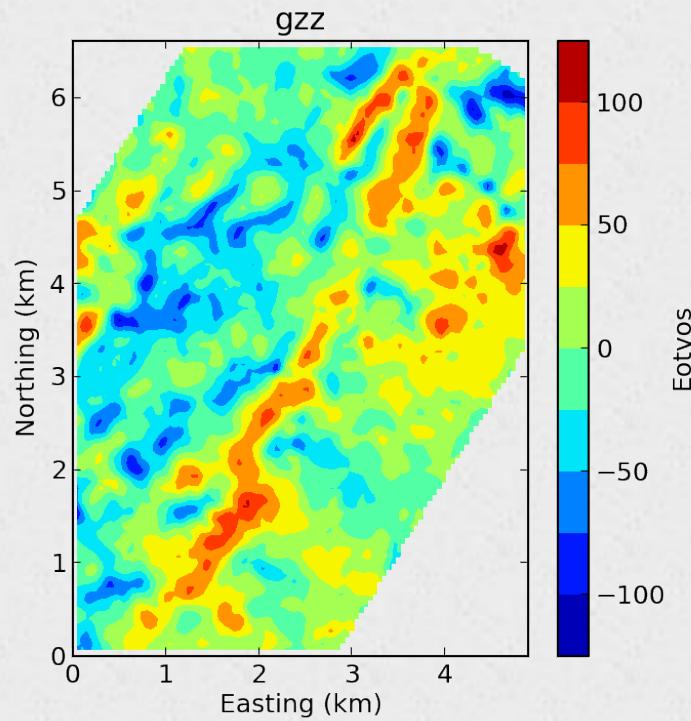
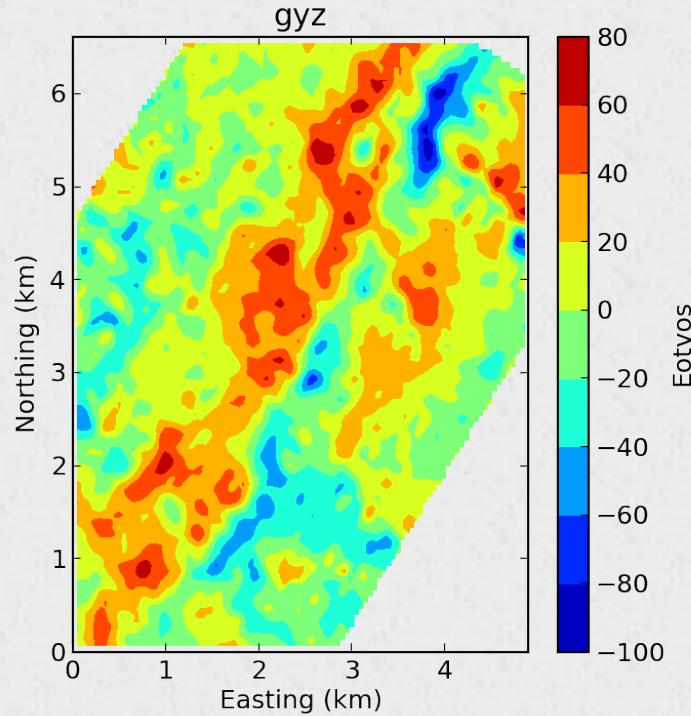
Density contrast = -0.09 g.cm<sup>-3</sup>



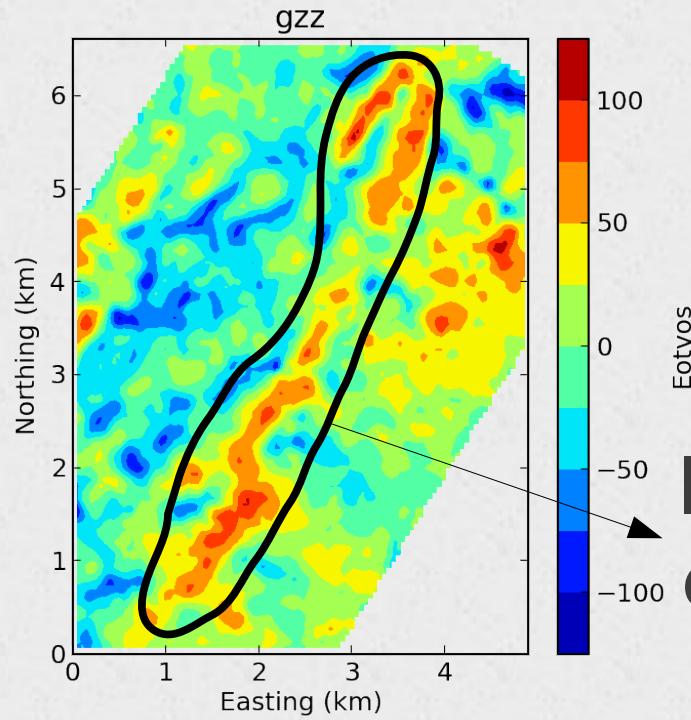
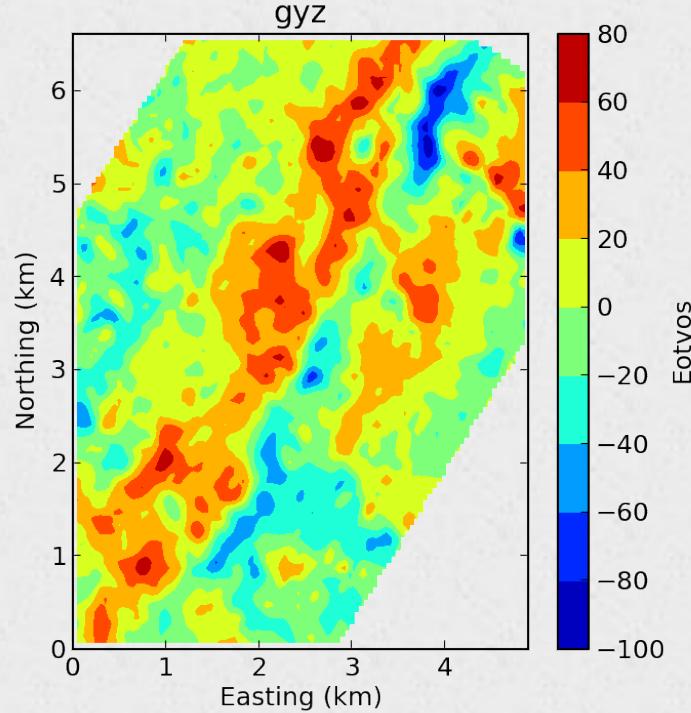


# Quadrilátero Ferrífero

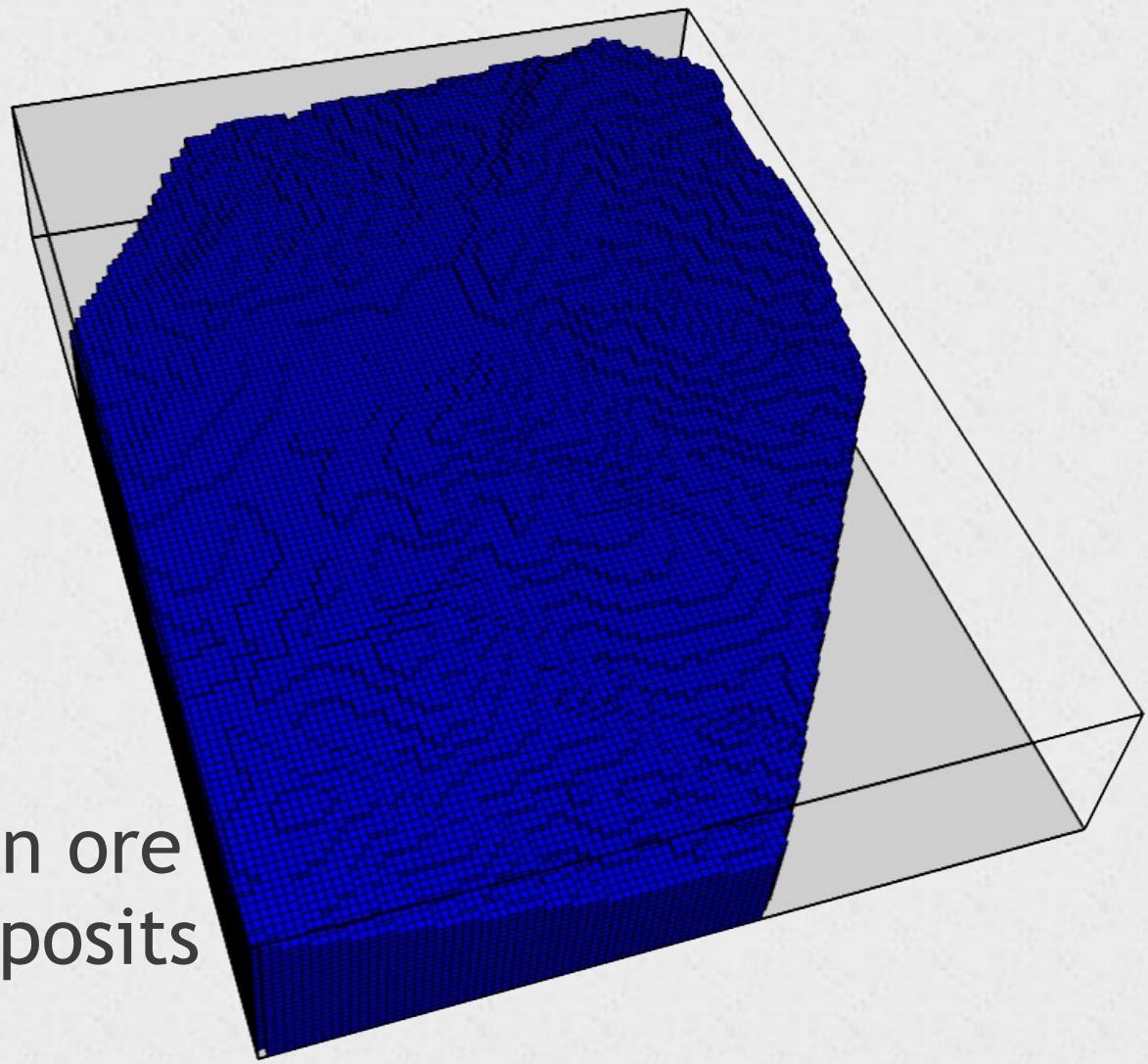
# Complex geology and topography



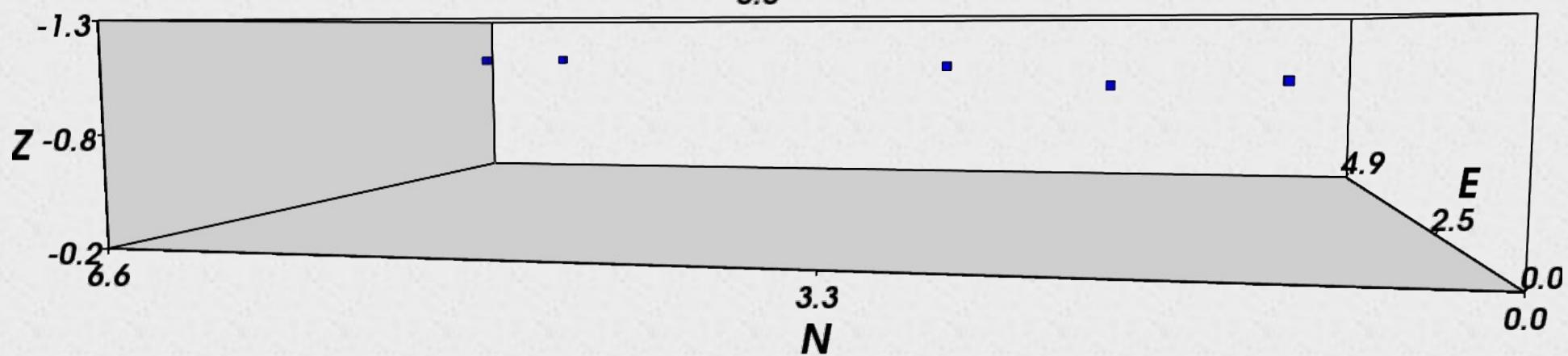
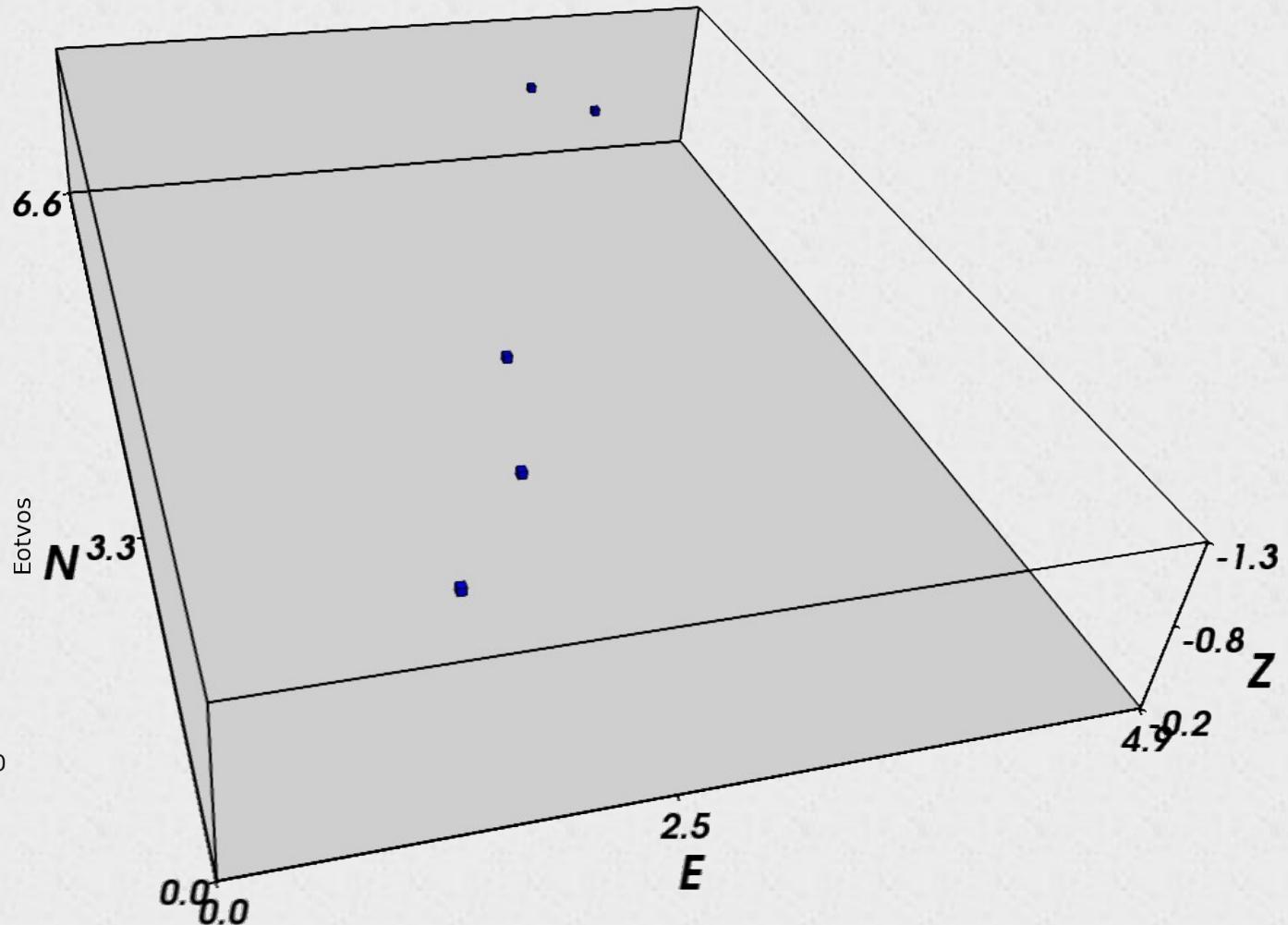
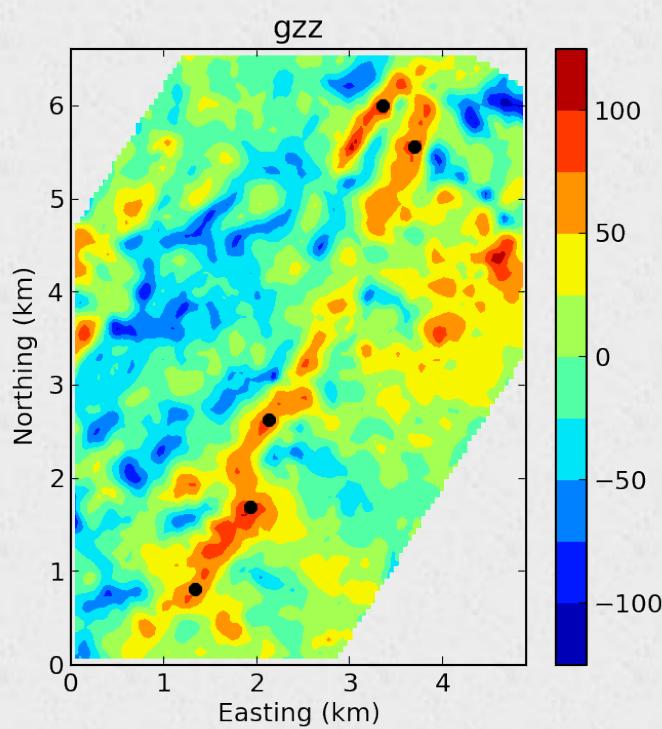
# Complex geology and topography

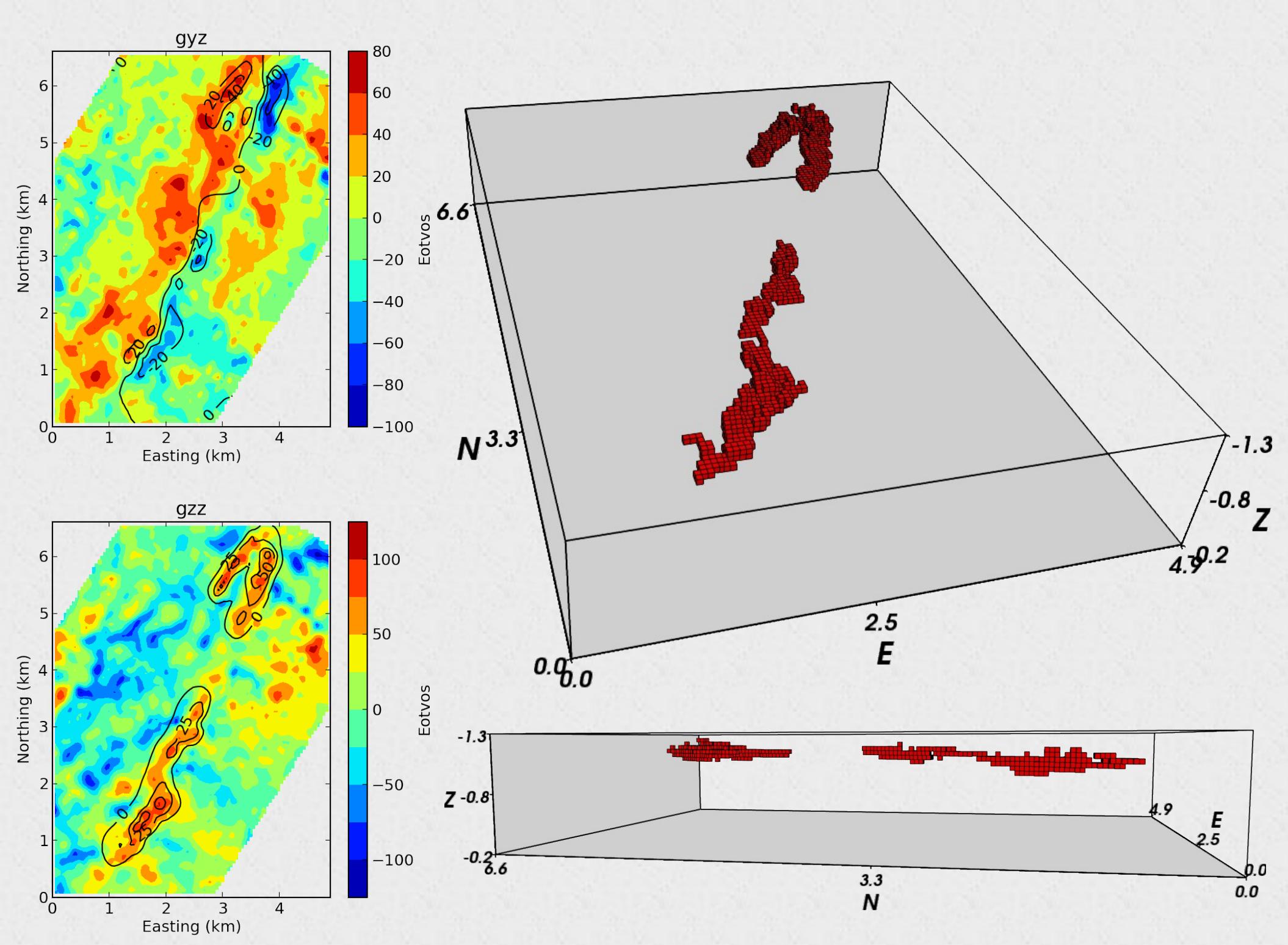


Iron ore  
deposits



# Seeds





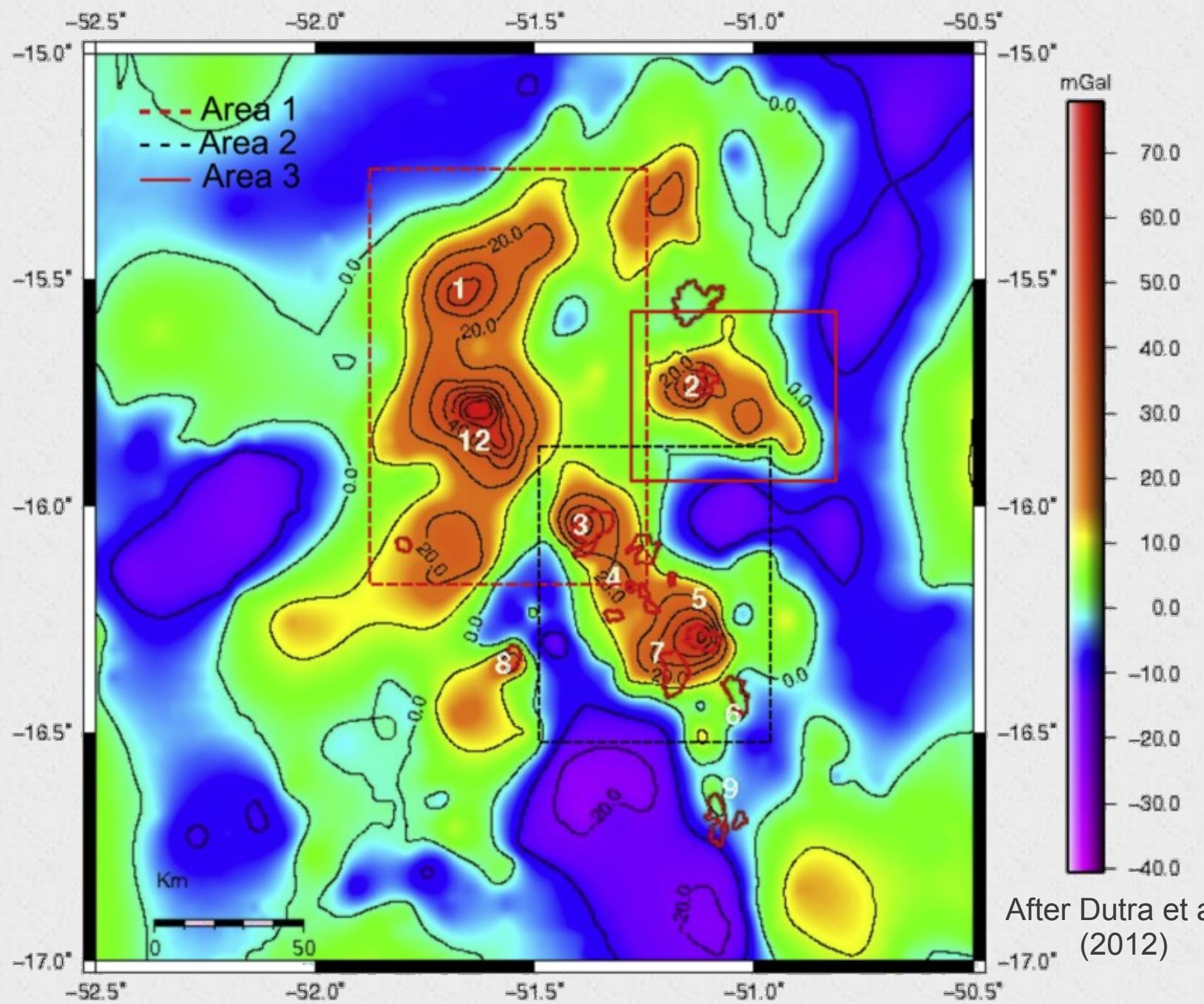
# Hypothesis testing

---

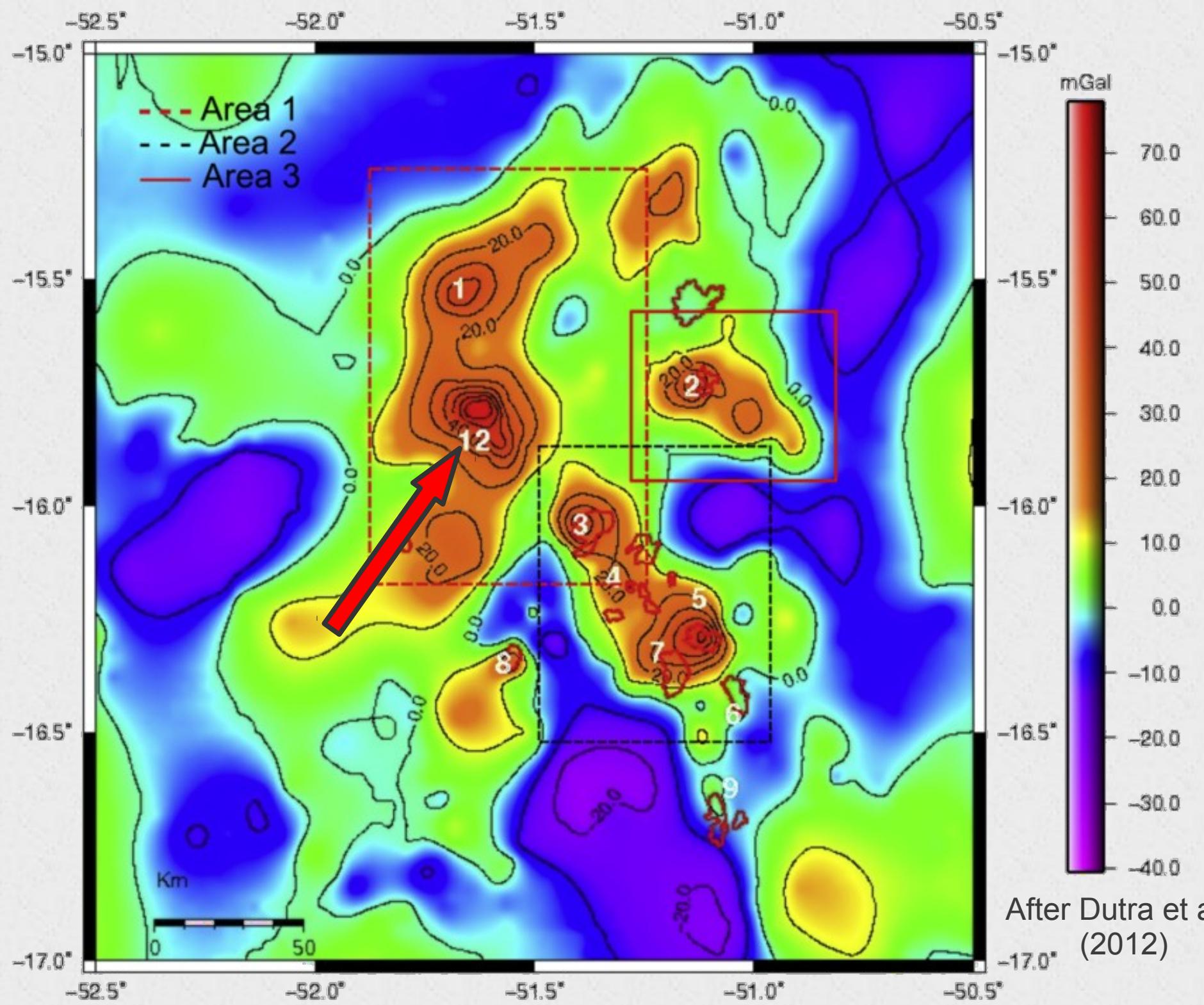
Registro do Araguaia  
intrusion

# Registro do araguaia

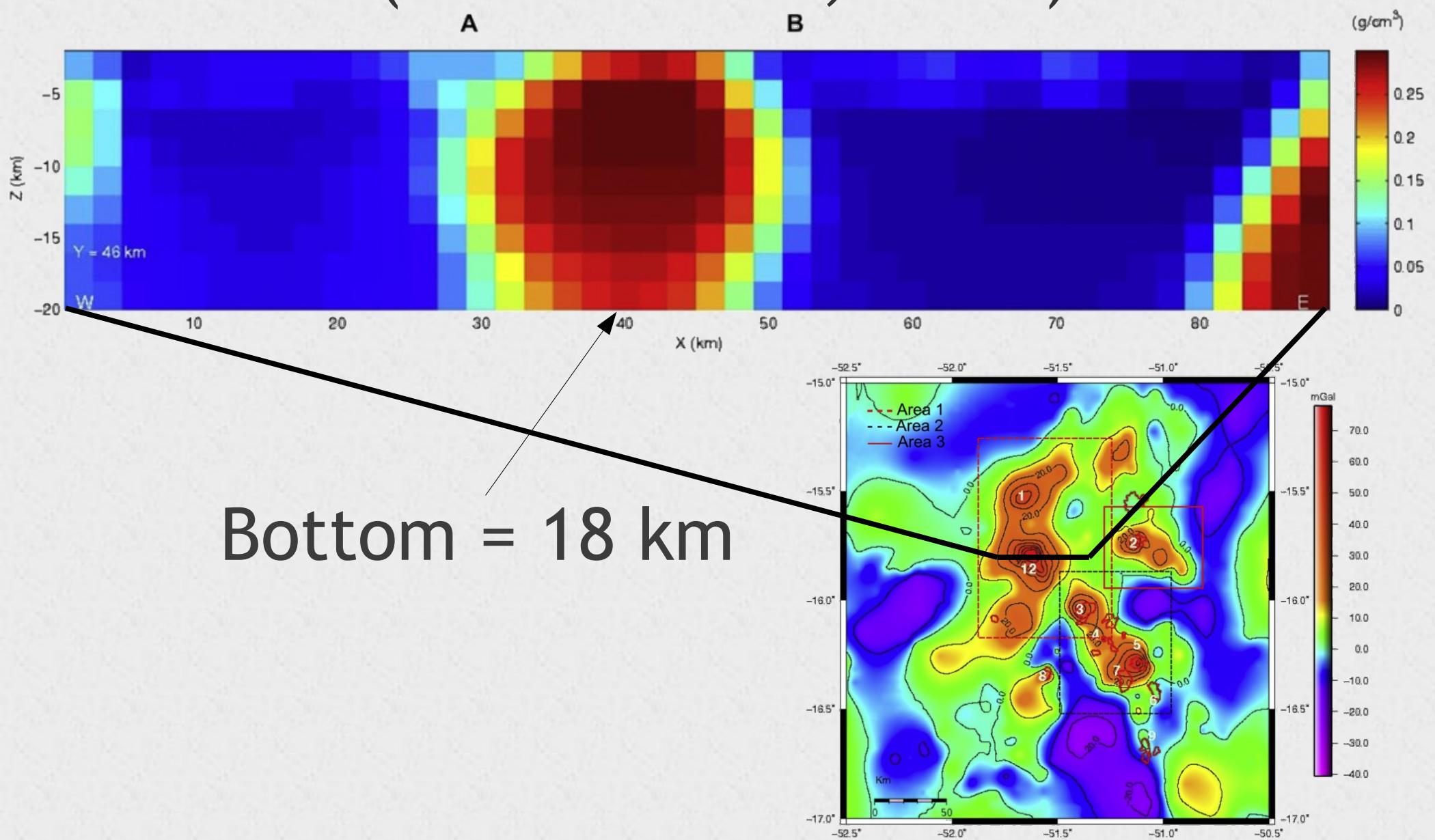
- Not outcropping
- Alkaline intrusion
- Density contrast  $\approx 0.3 \text{ g.cm}^{-3}$



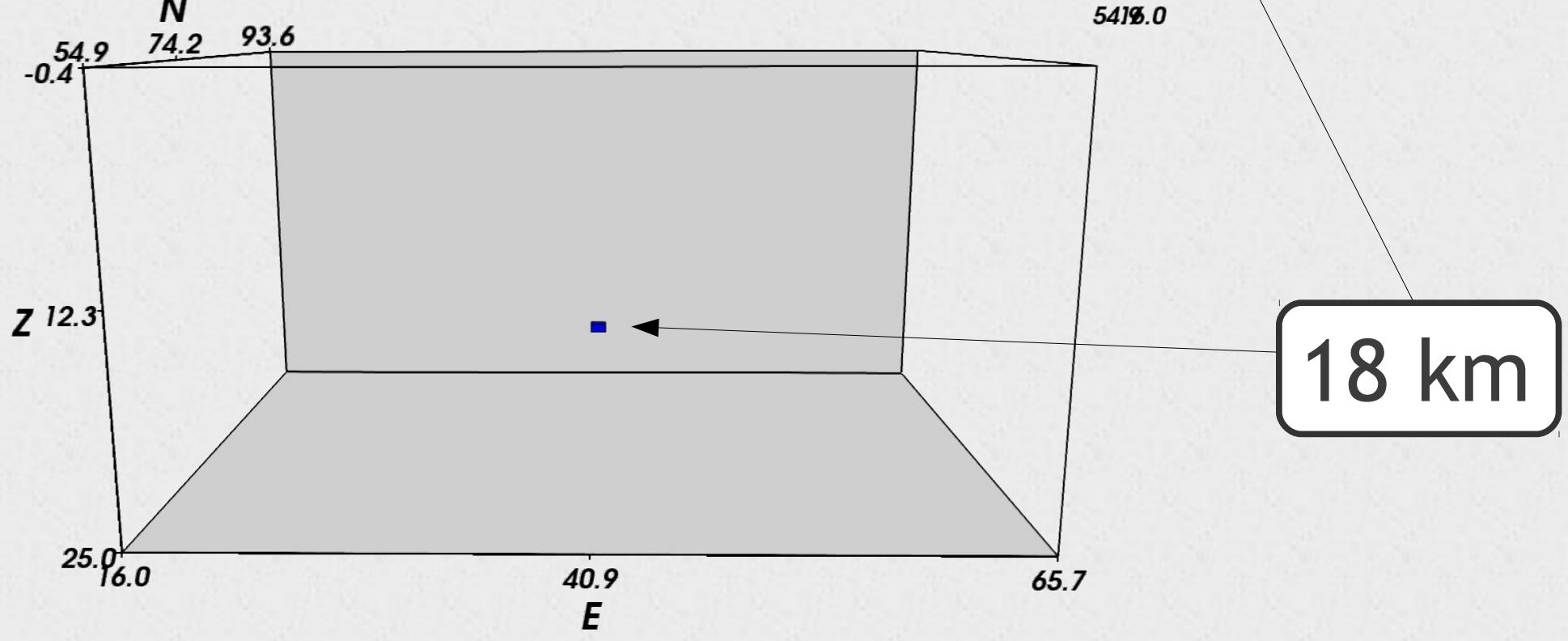
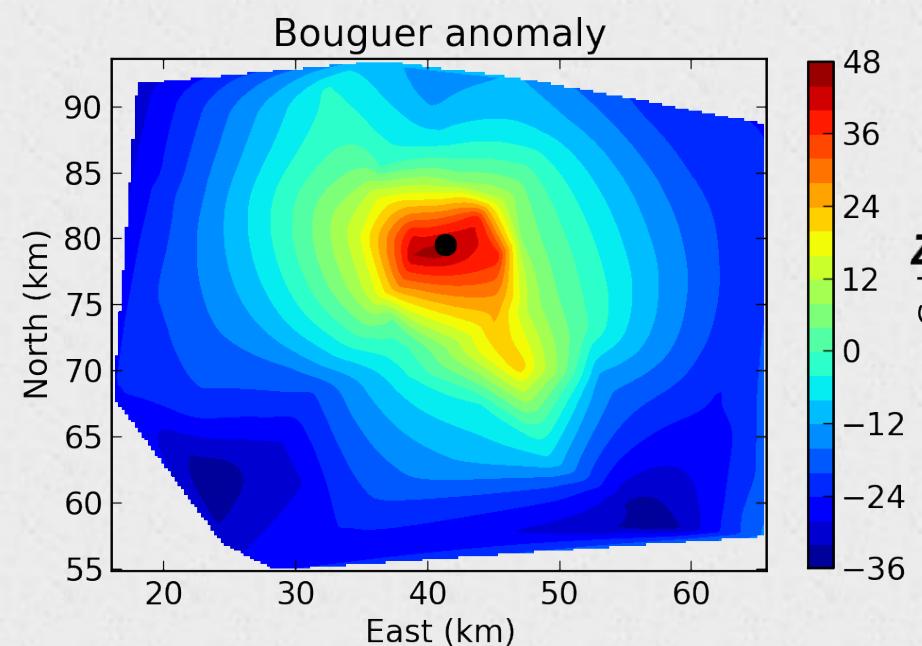
After Dutra et al.  
(2012)

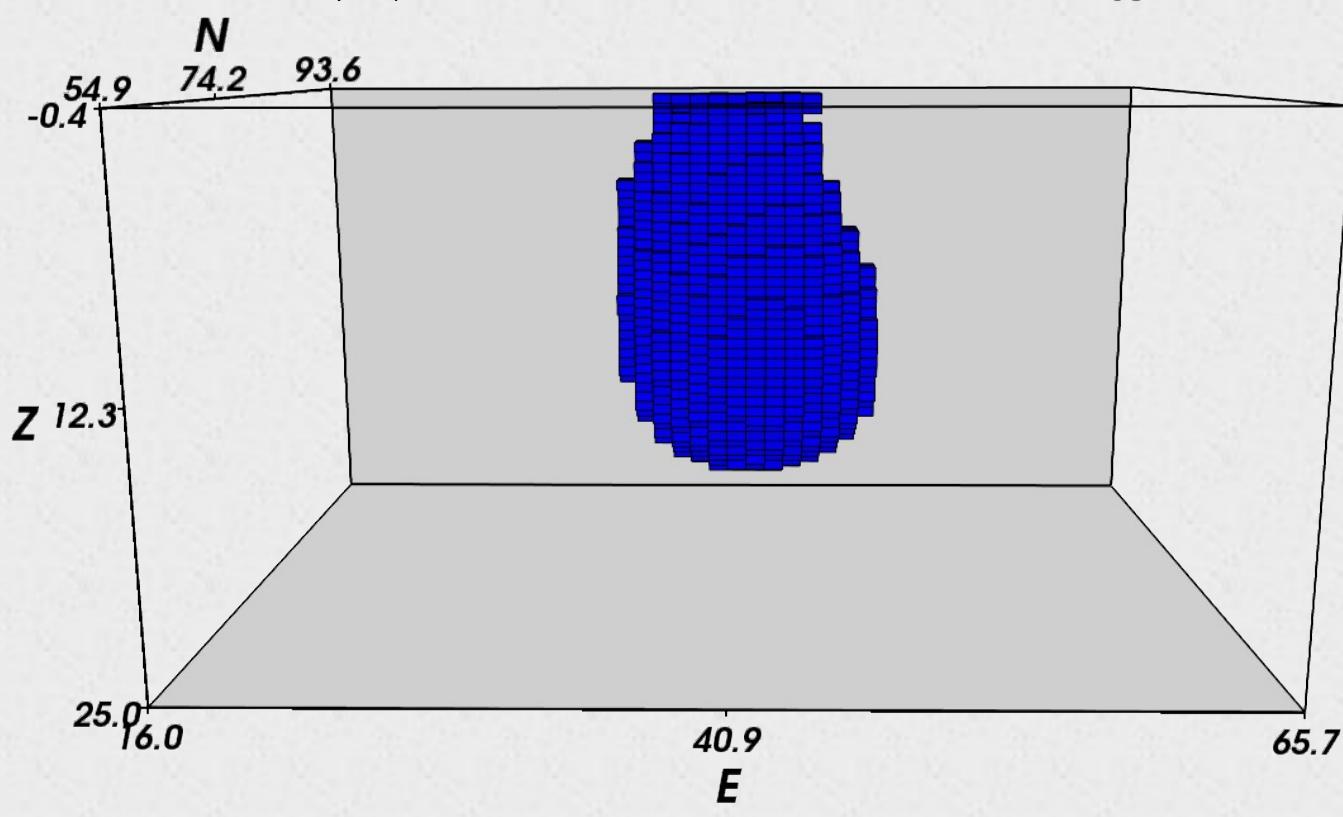
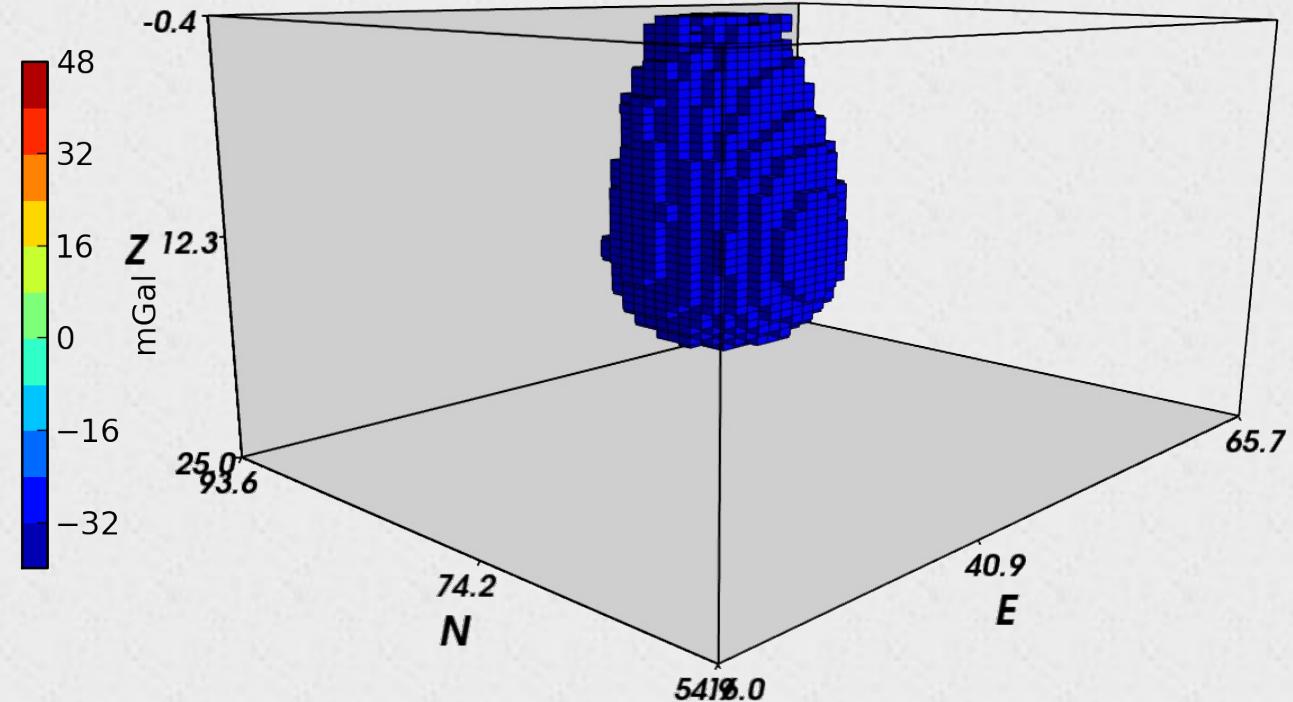
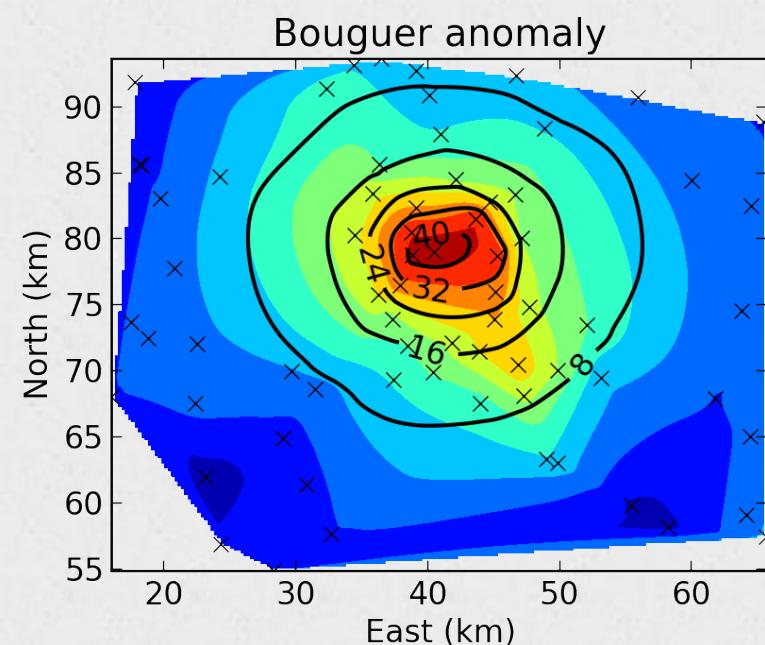


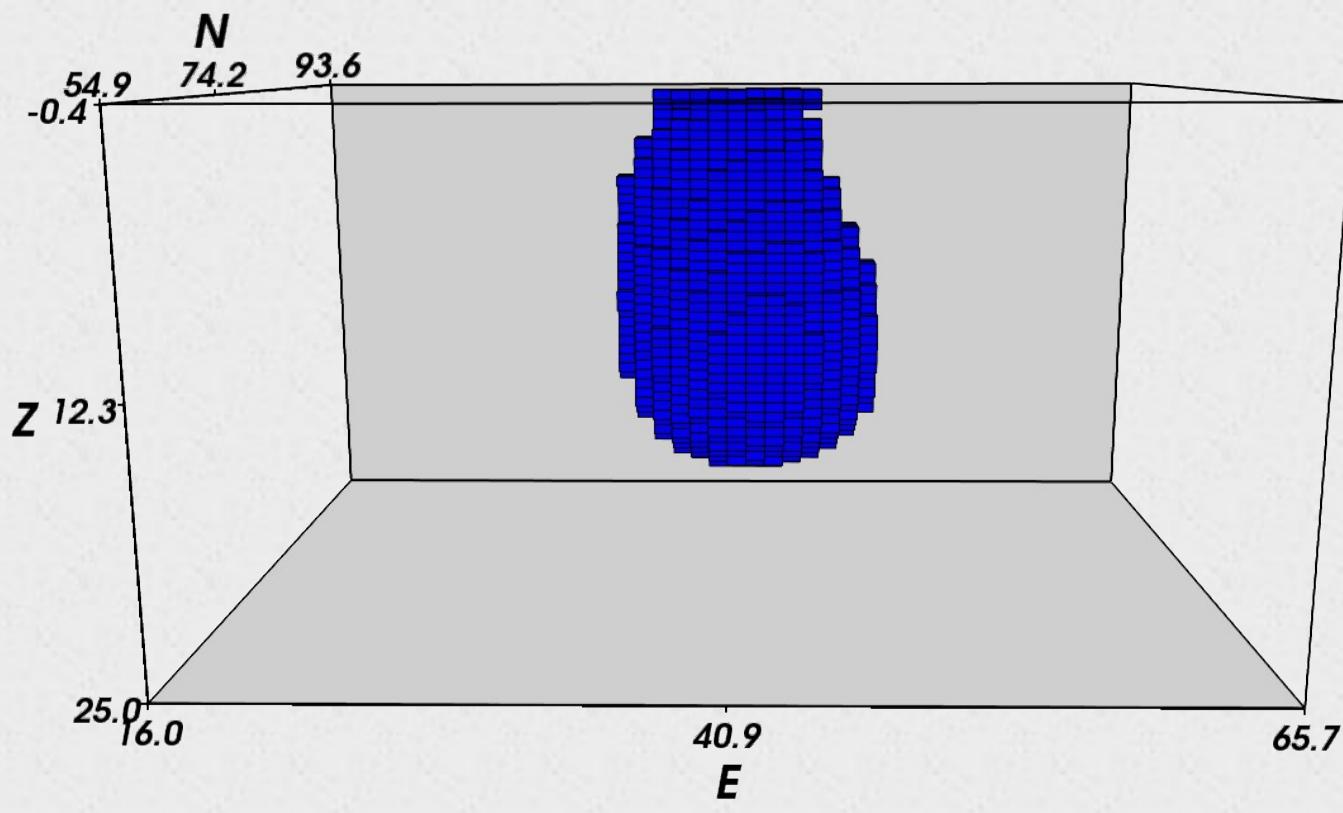
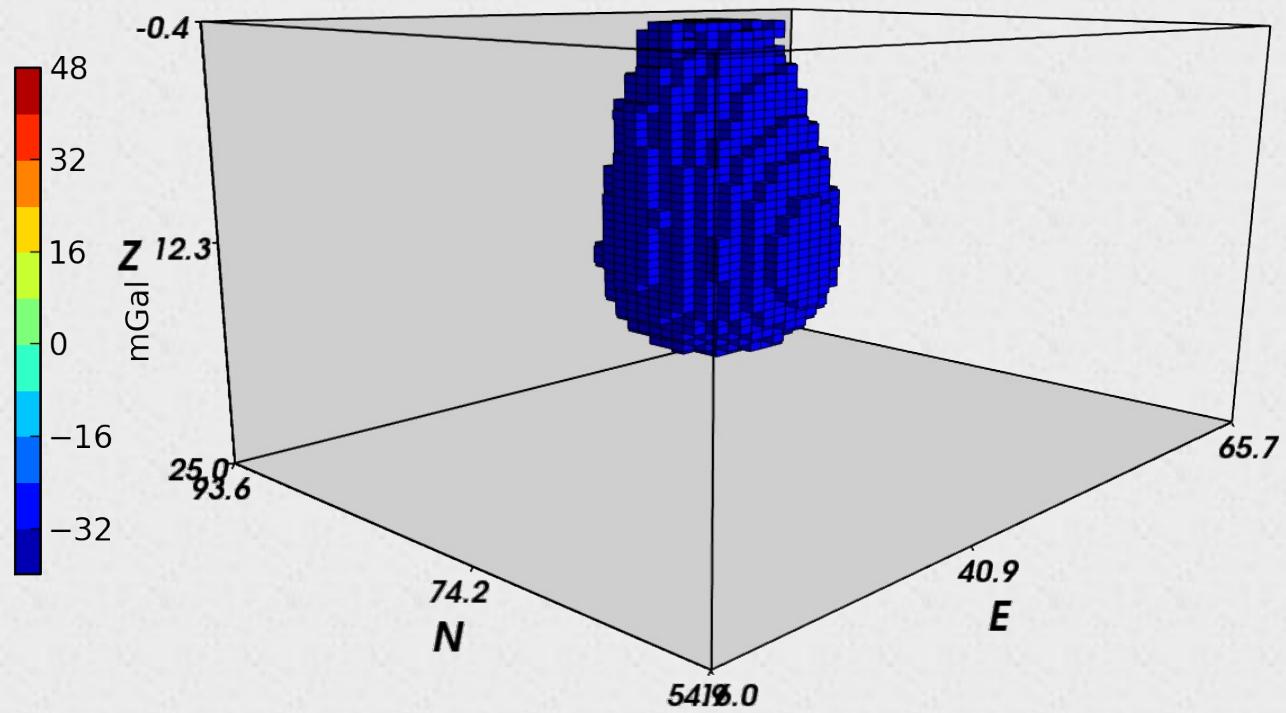
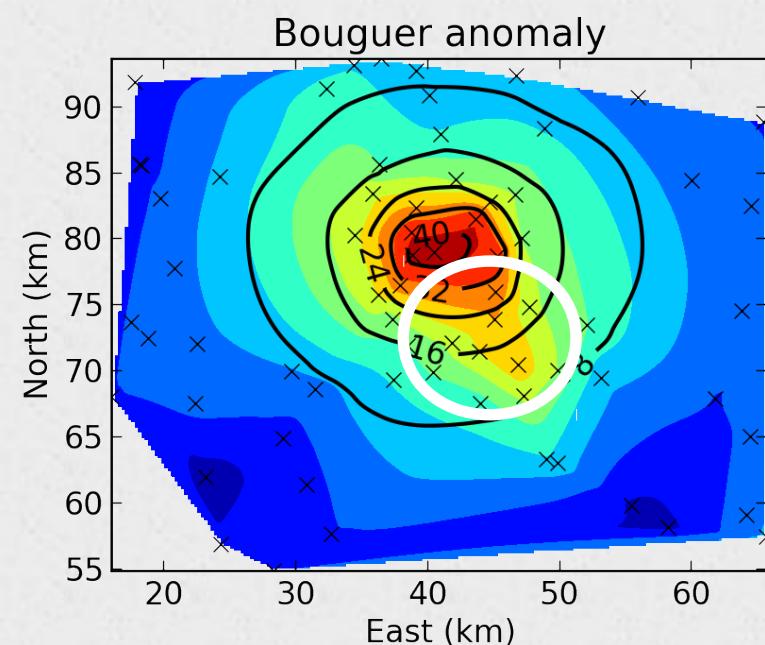
# 3D gravity inversion (Dutra et al., 2012)



# Hypothesis 1



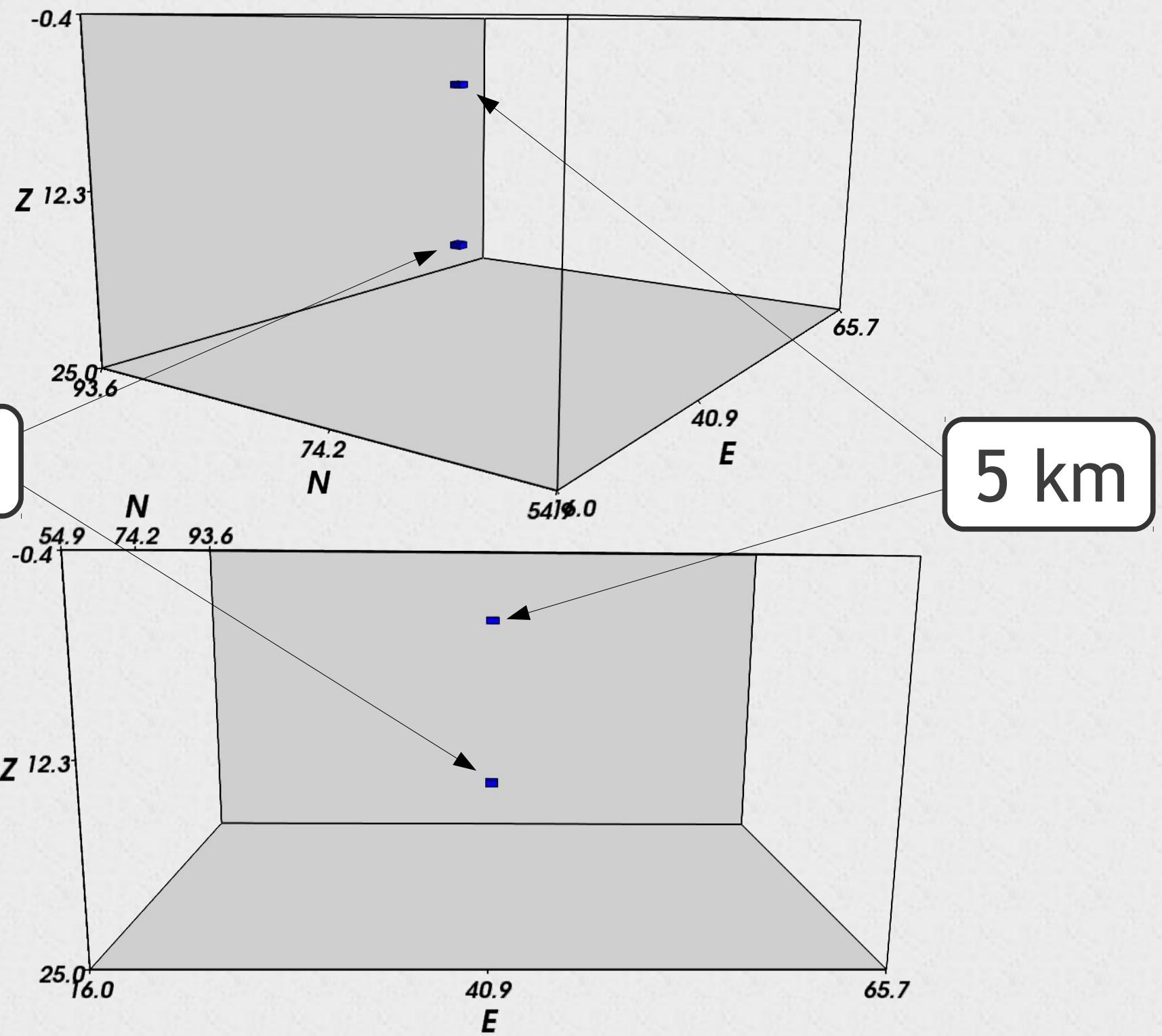


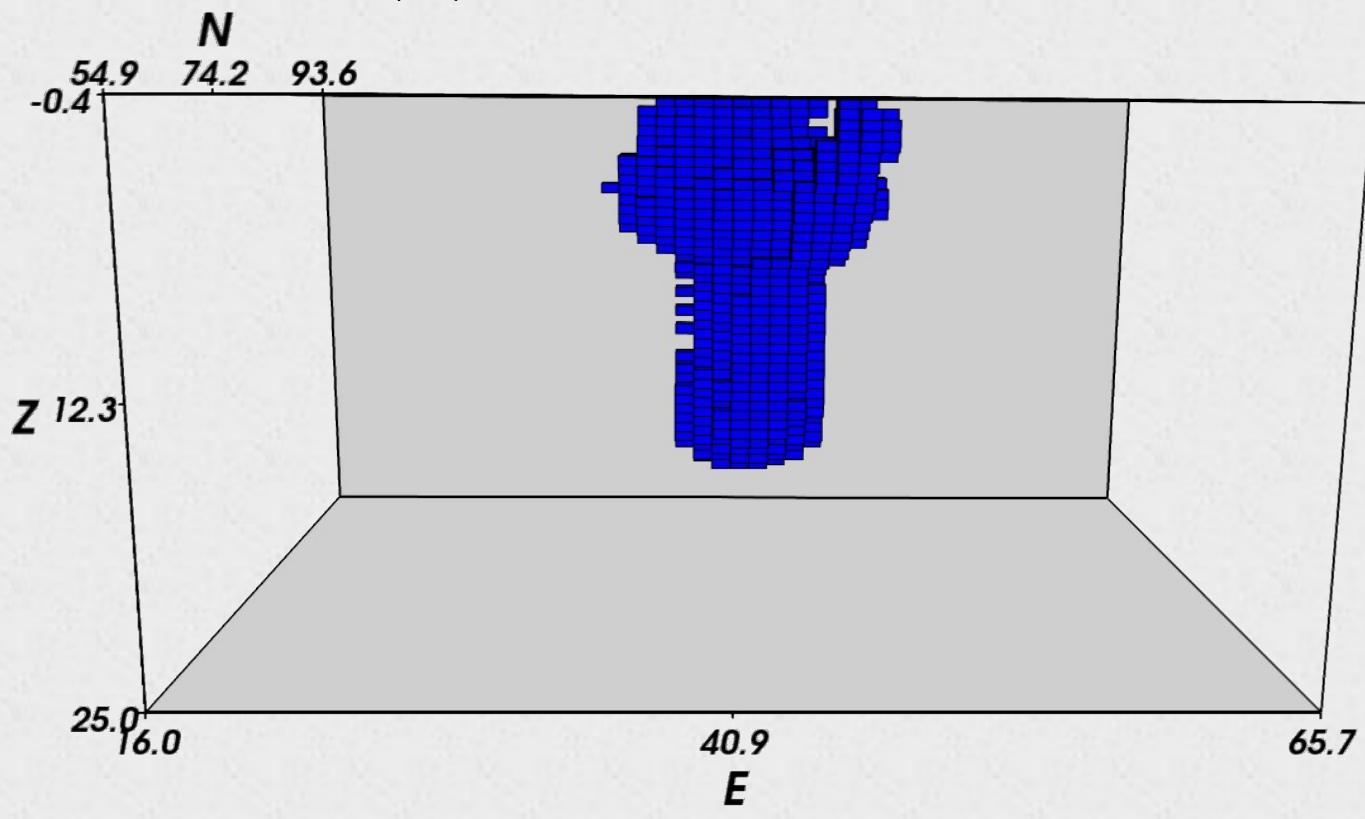
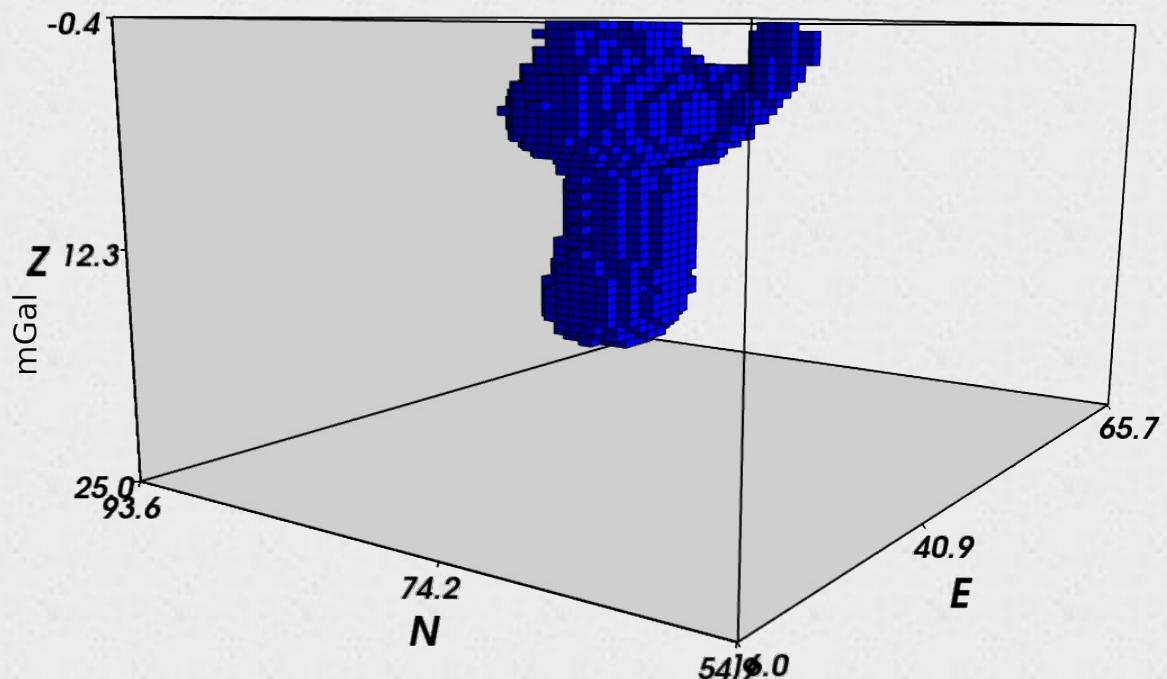
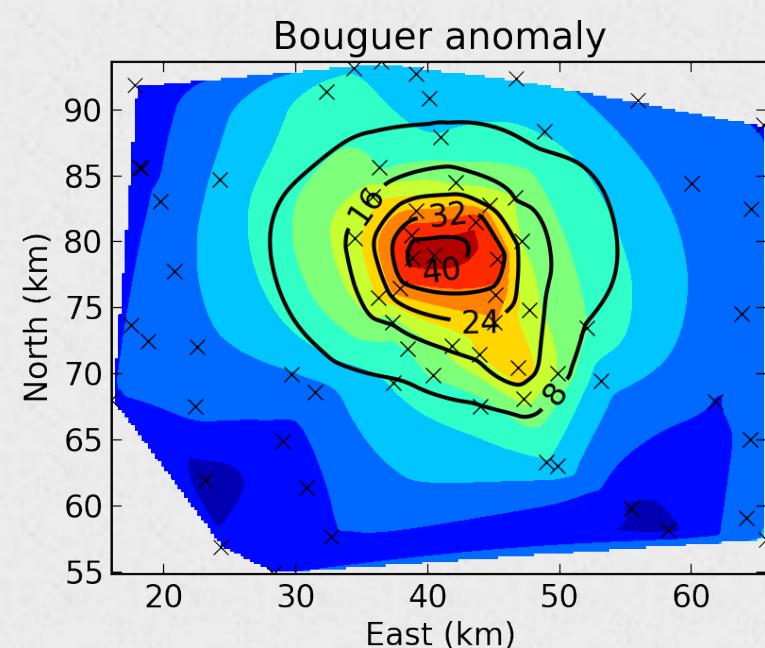


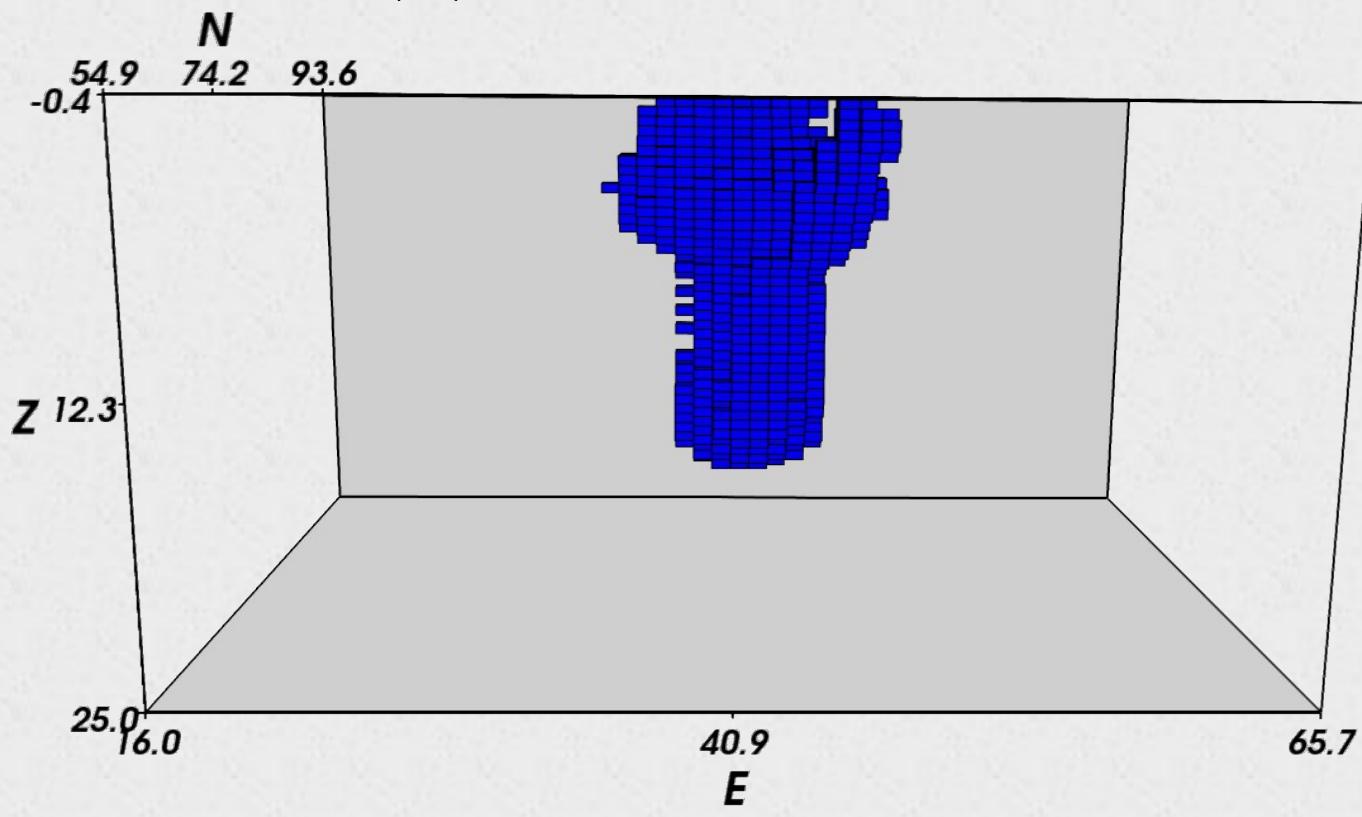
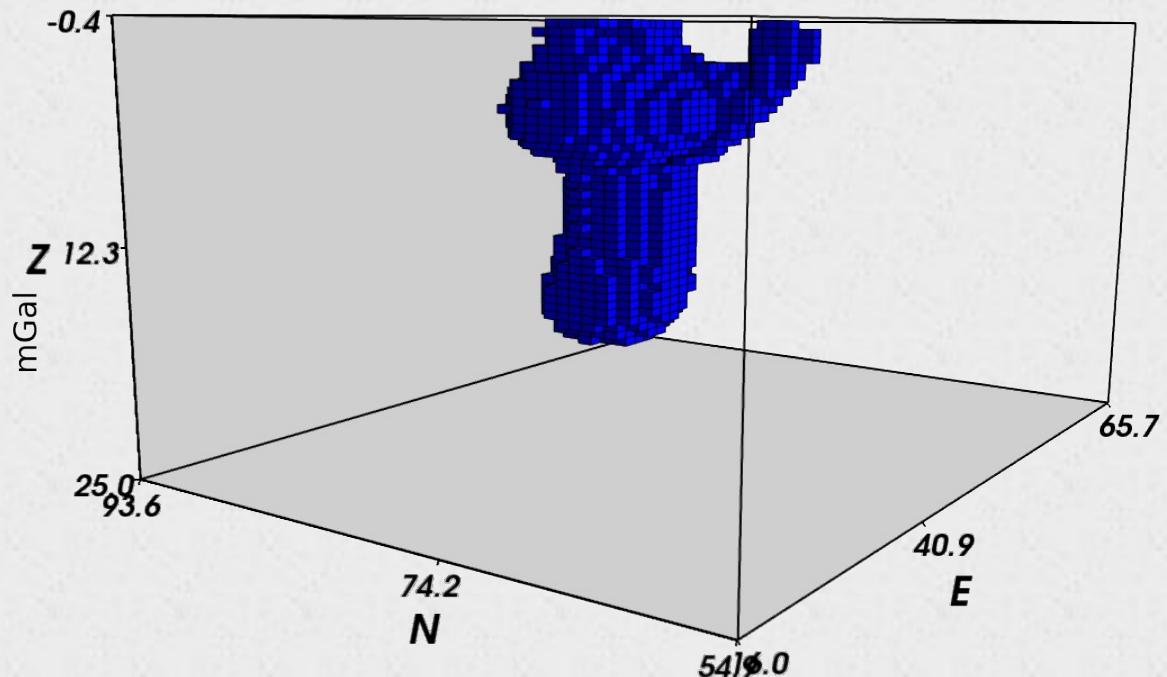
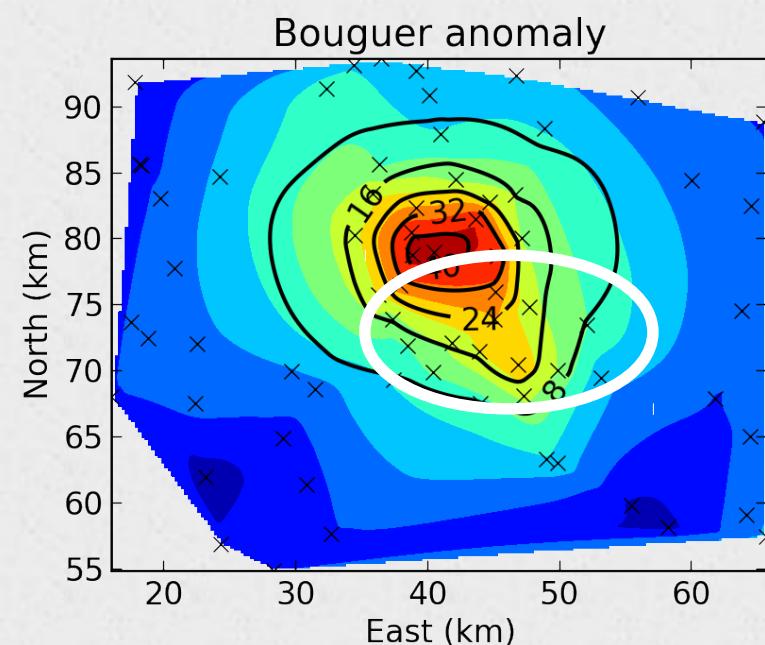
# Hypothesis 1

Hypothesis 1

# Hypothesis 2



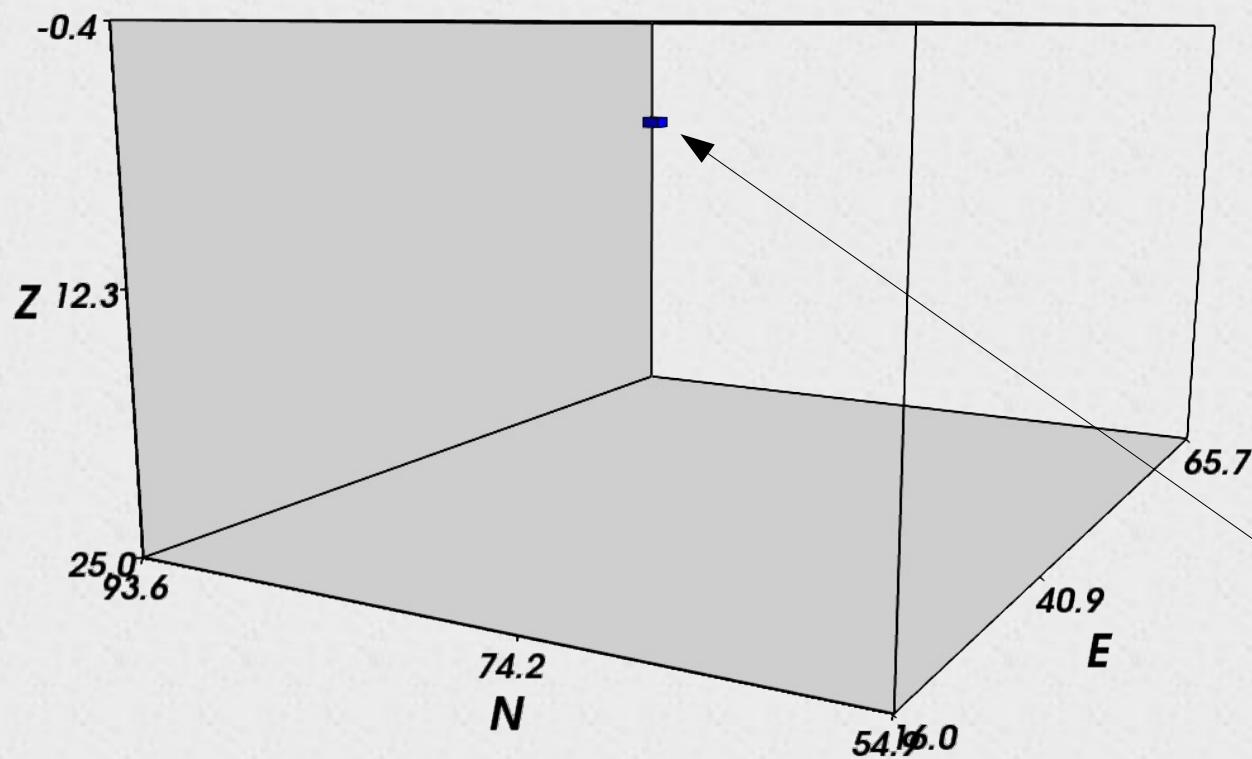




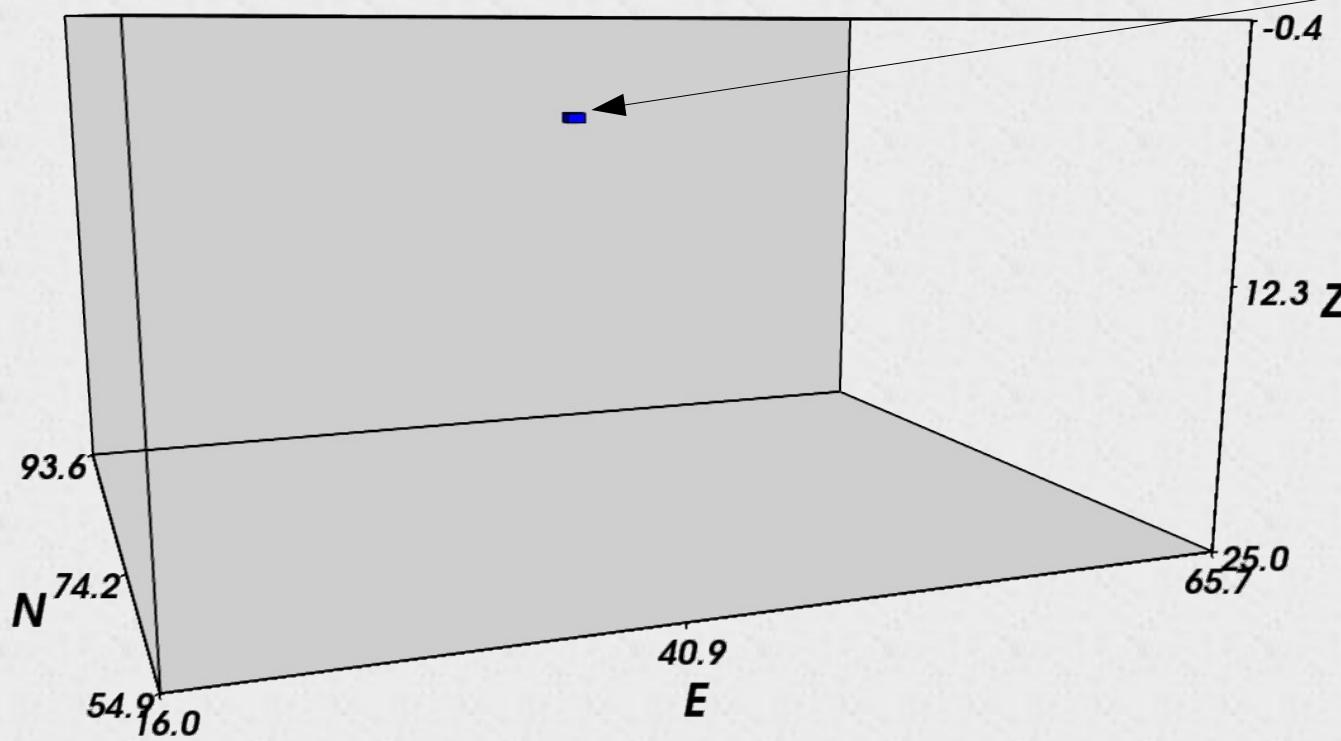
# Hypothesis 2

Hypothesis 2

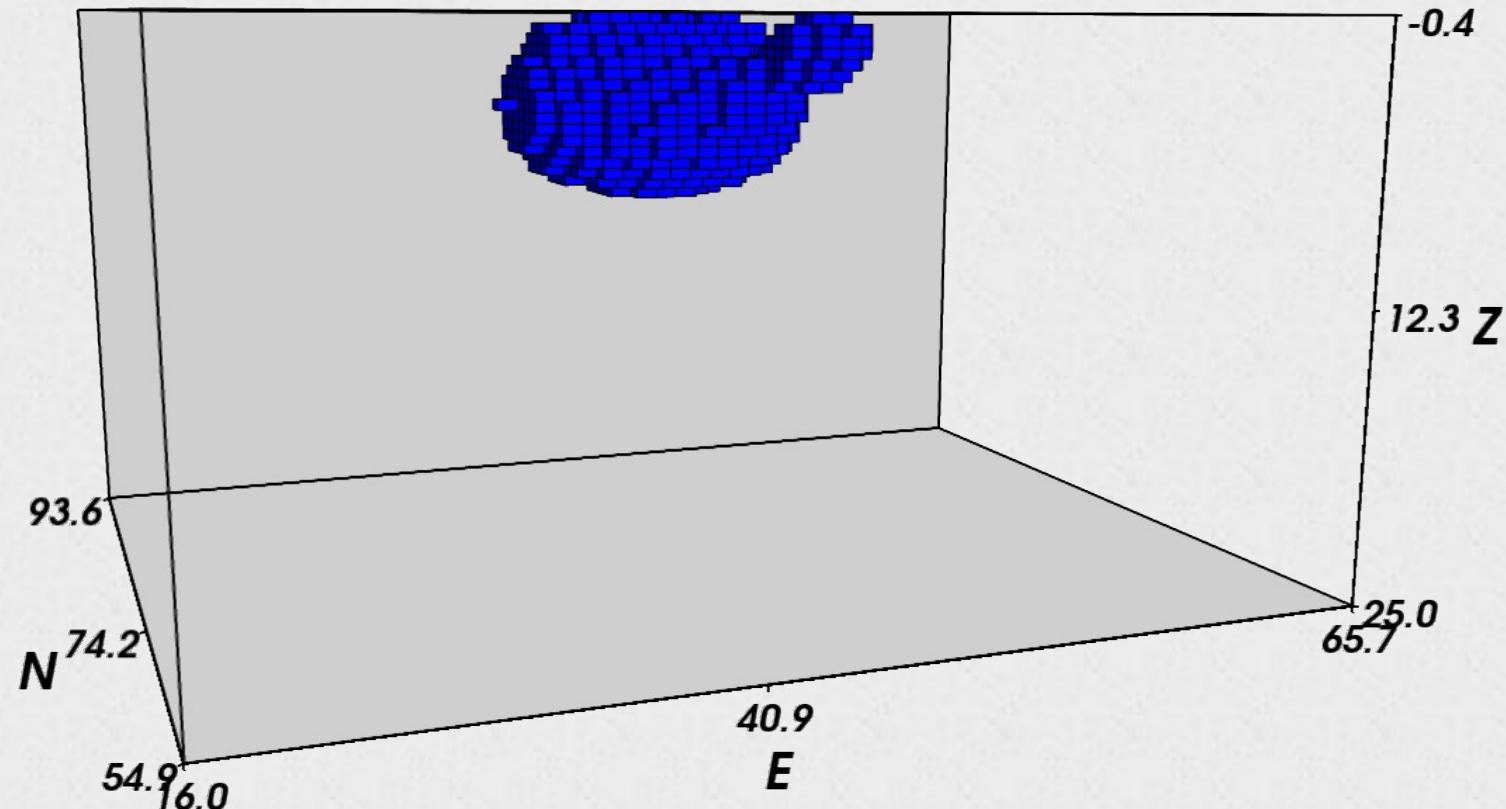
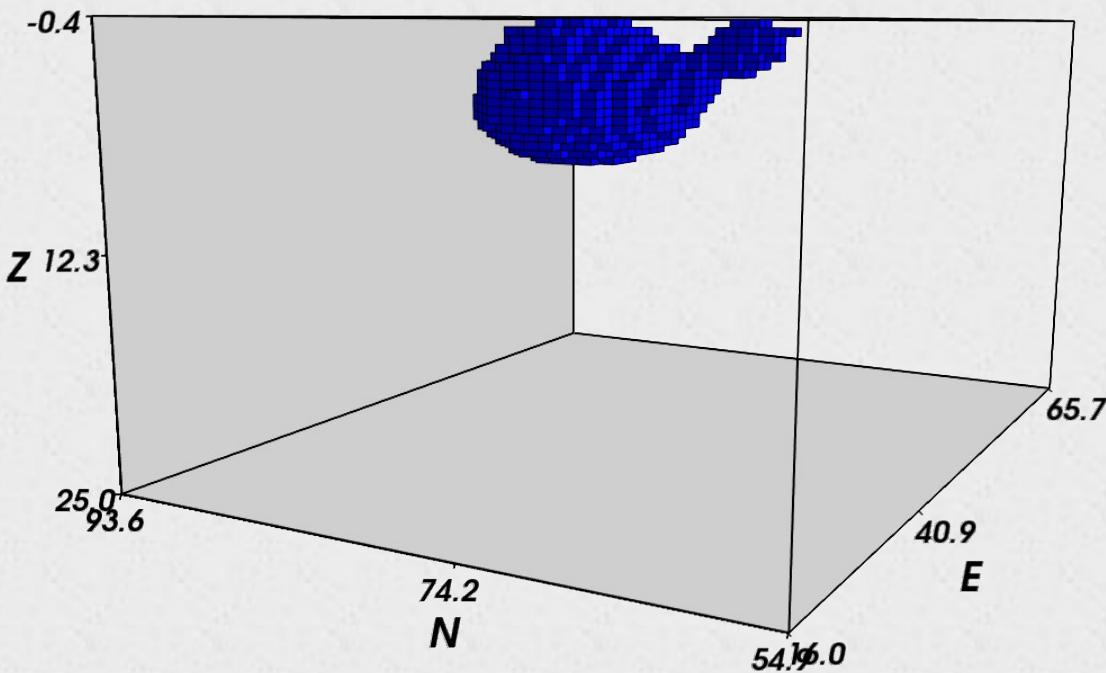
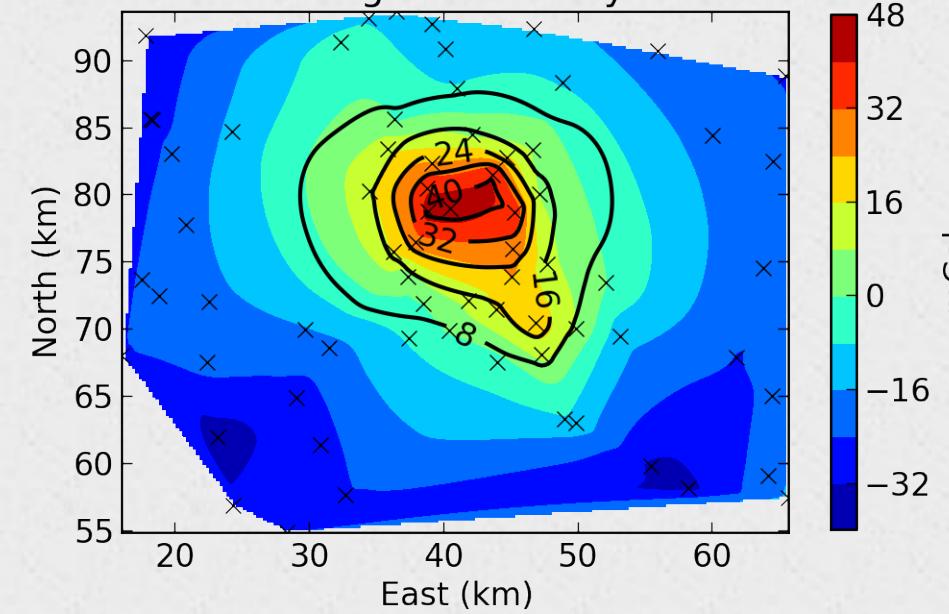
# Hypothesis 3



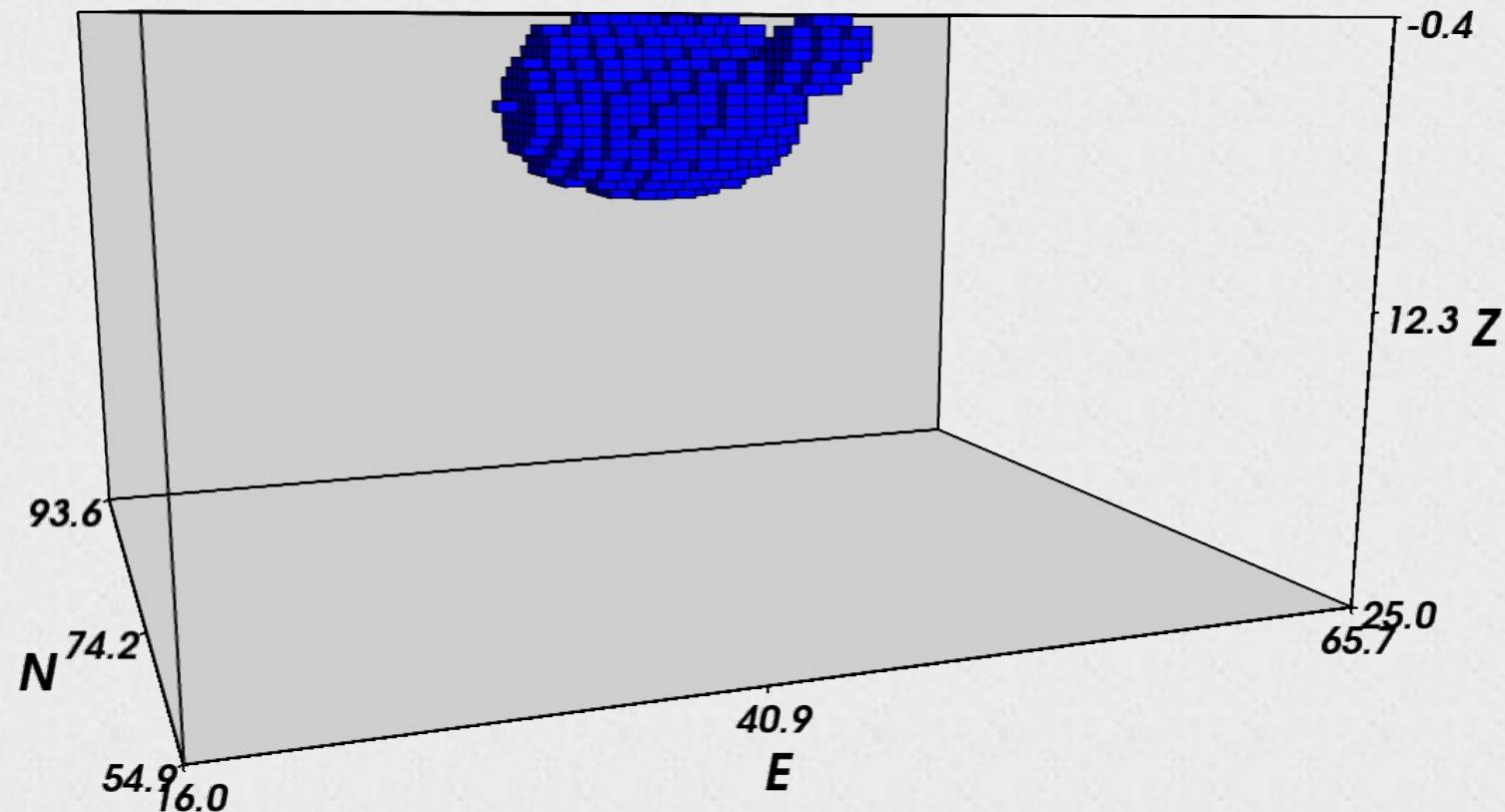
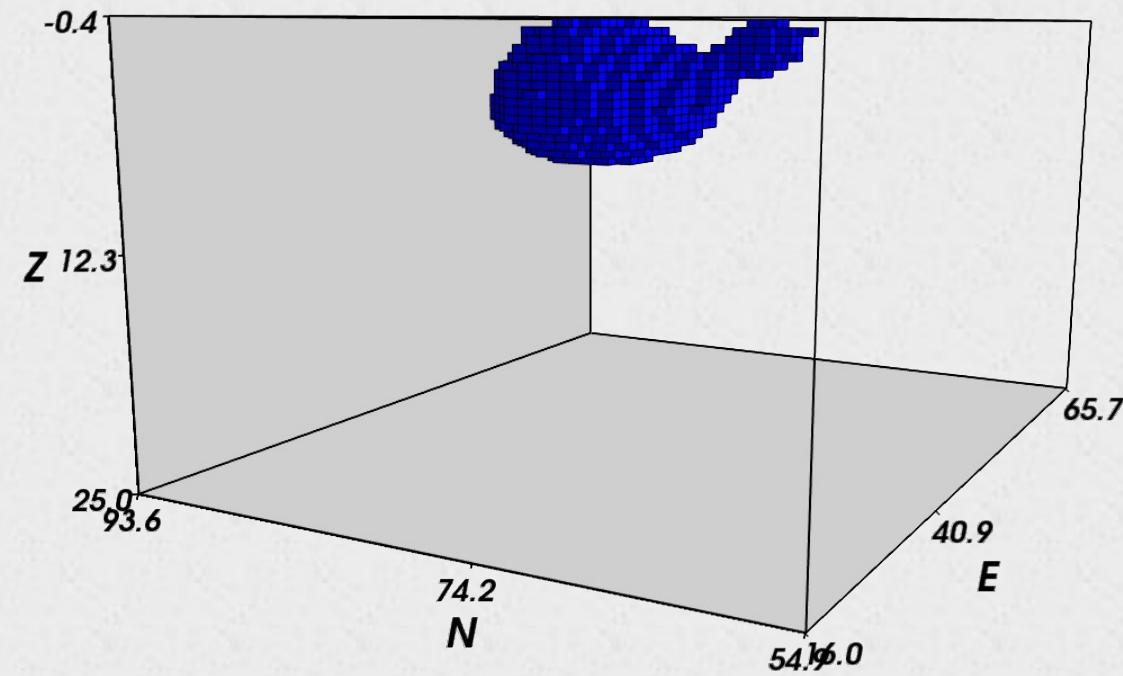
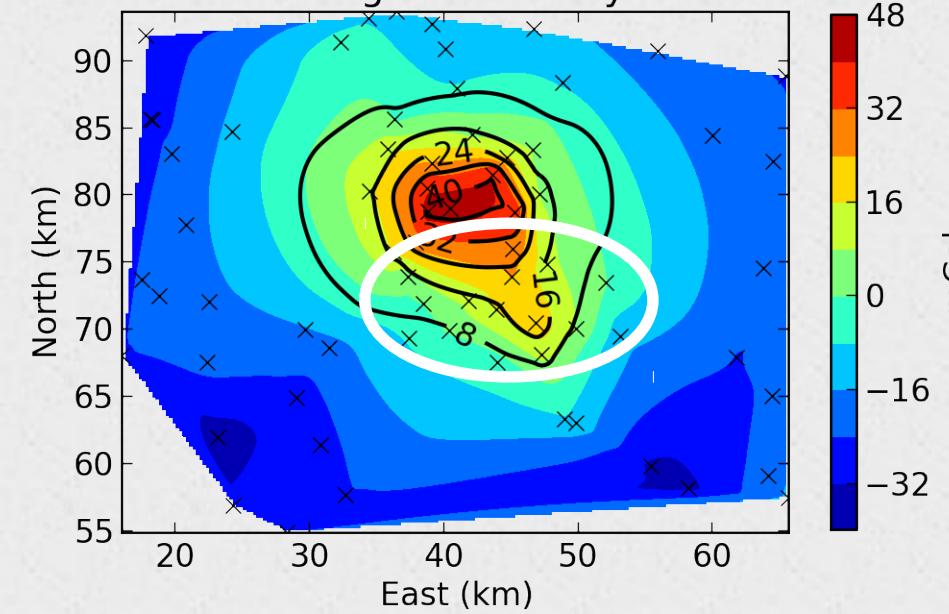
5 km



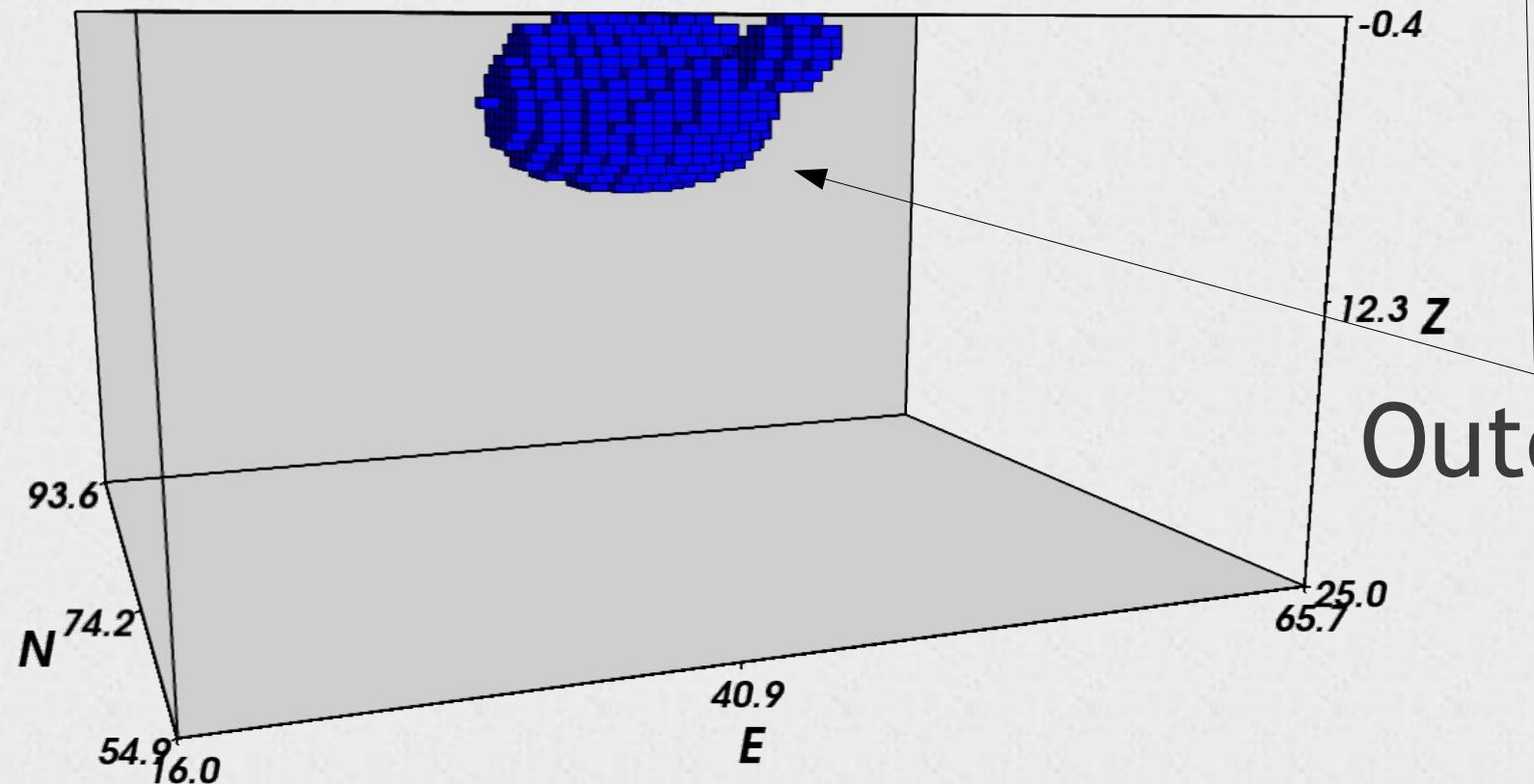
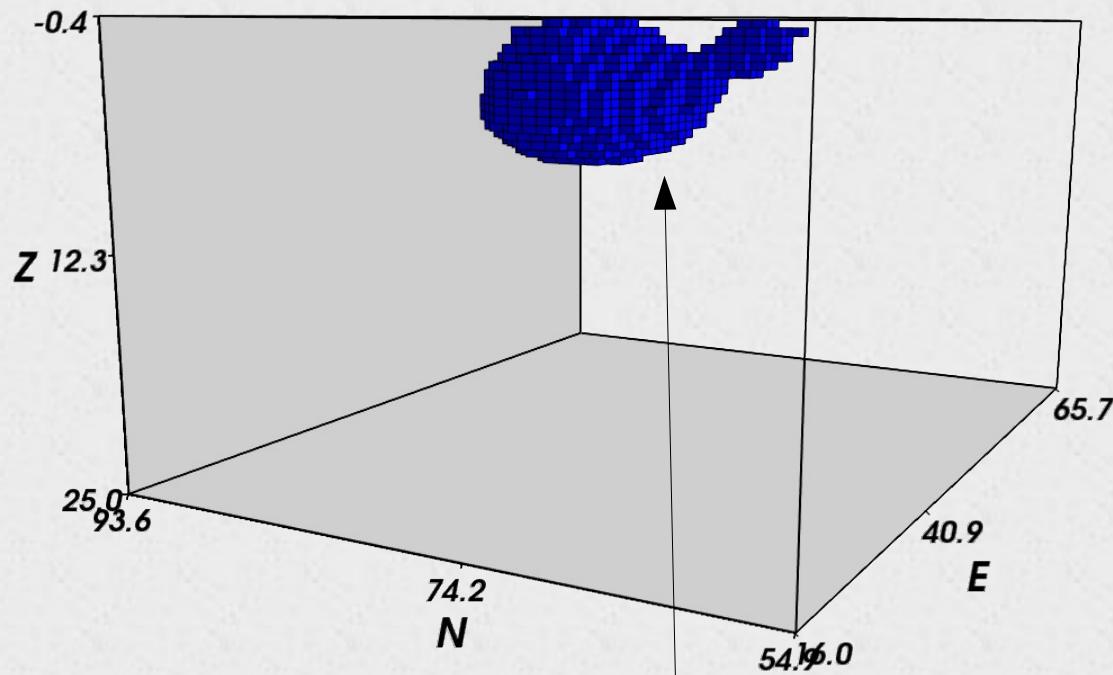
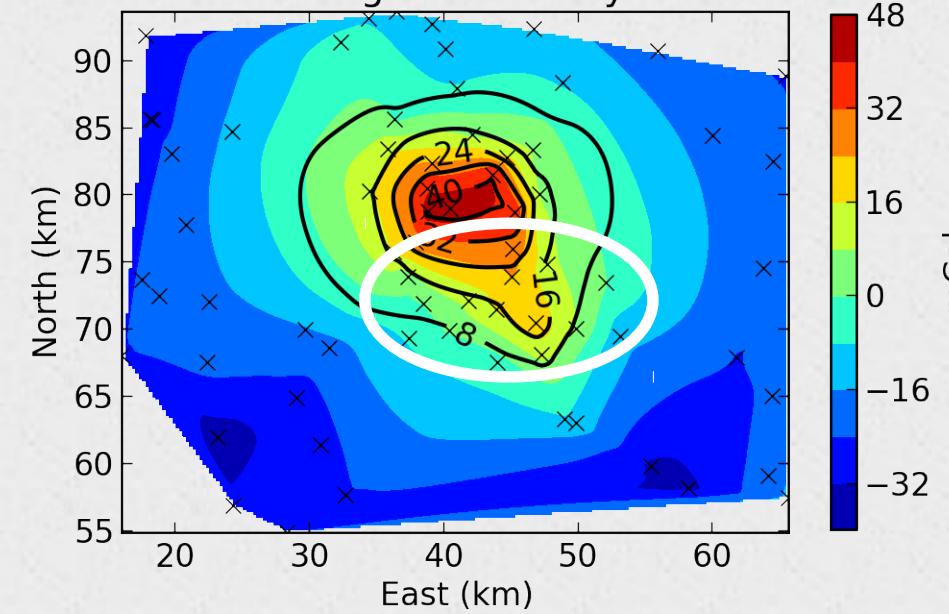
Bouguer anomaly



Bouguer anomaly



Bouguer anomaly

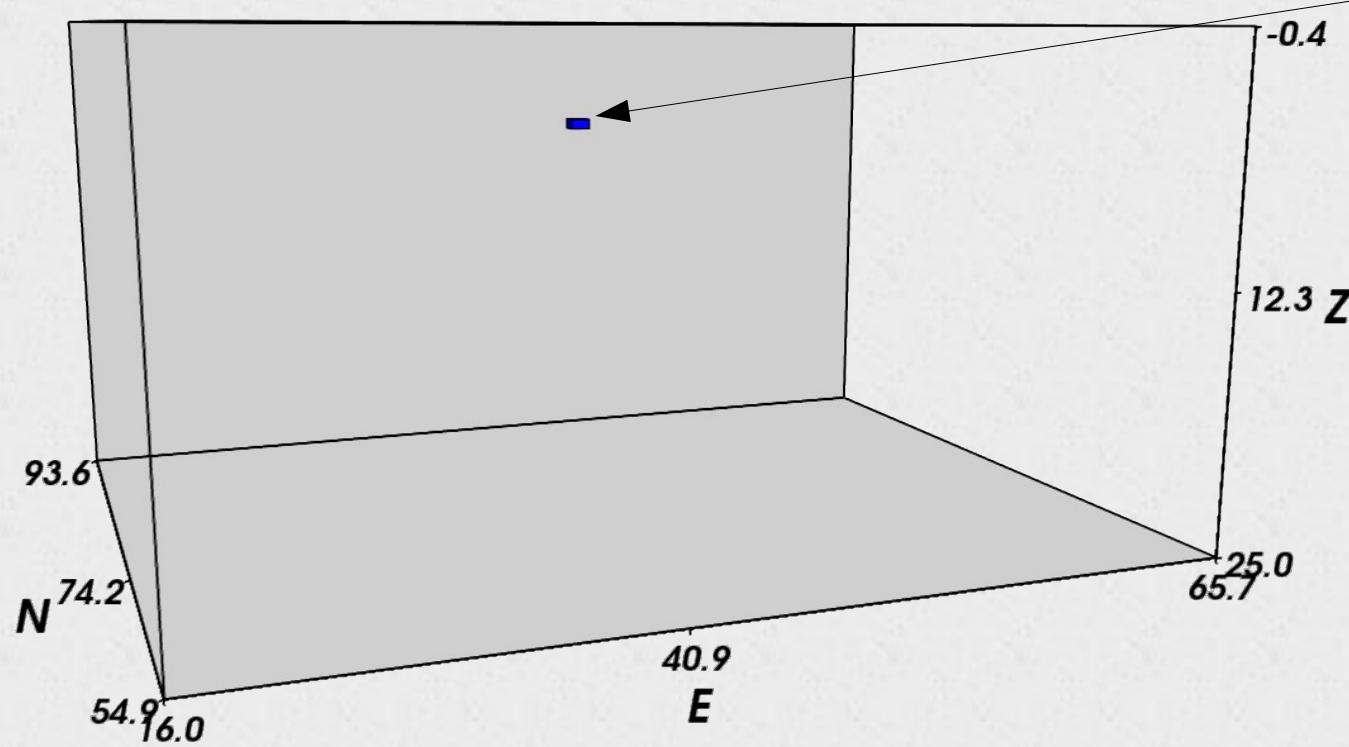
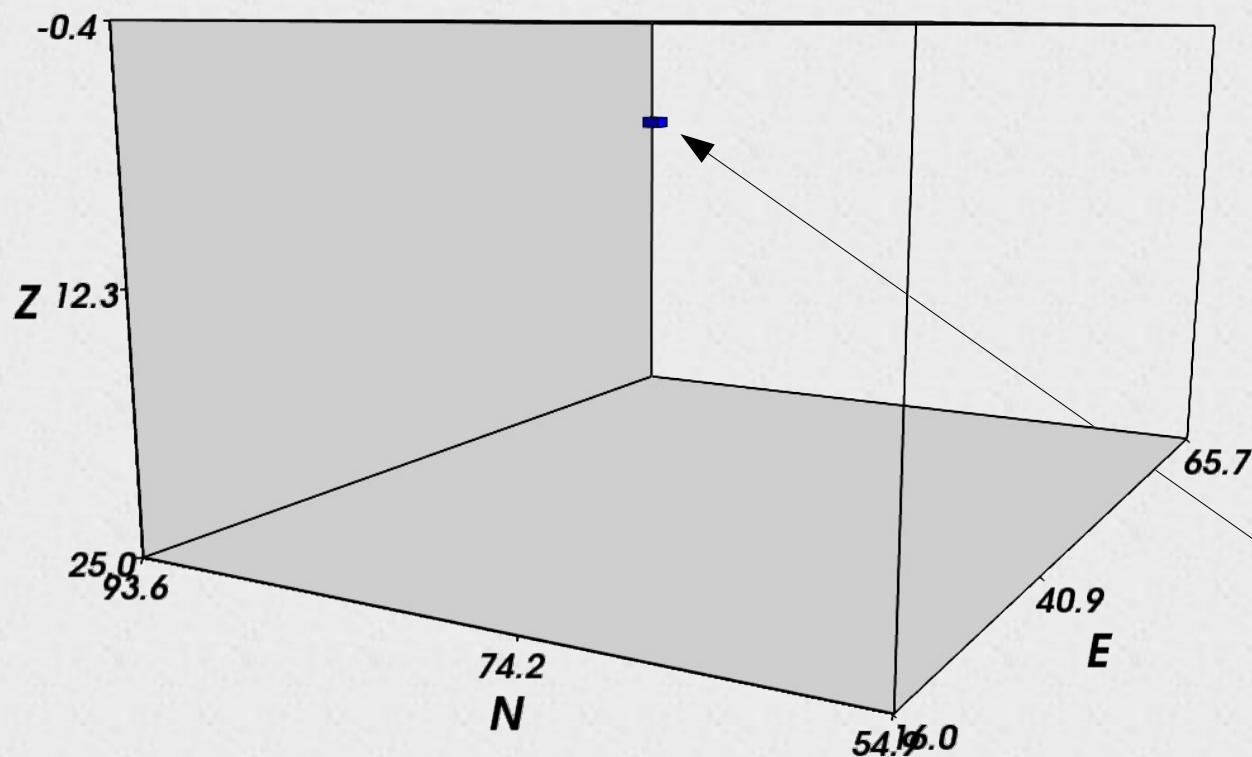


# Hypothesis 3

Hypothesis 3



# Hypothesis 4

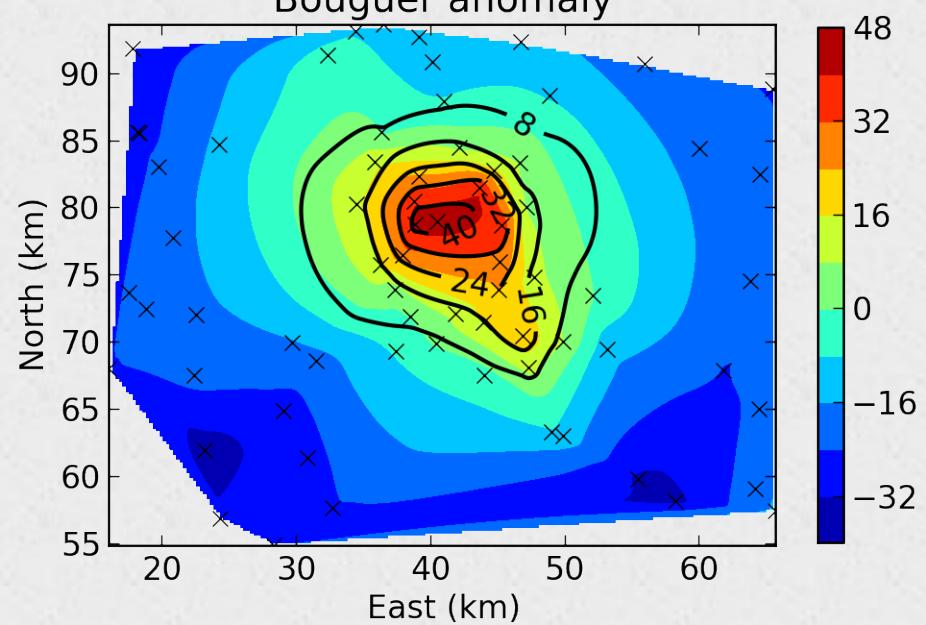


Density



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

Bouguer anomaly



-0.4

mGal  
Z 12.3

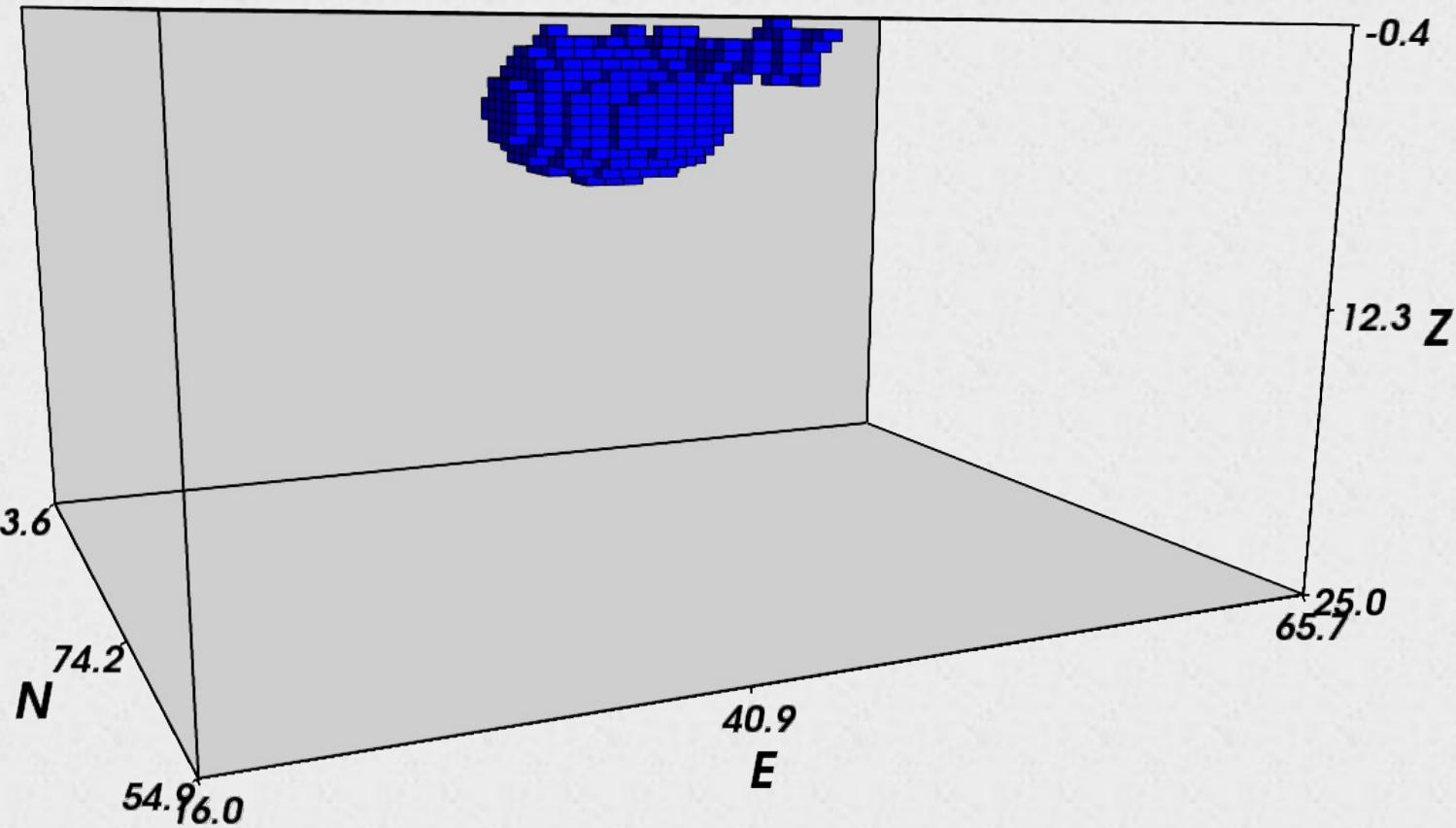
25.0  
93.6

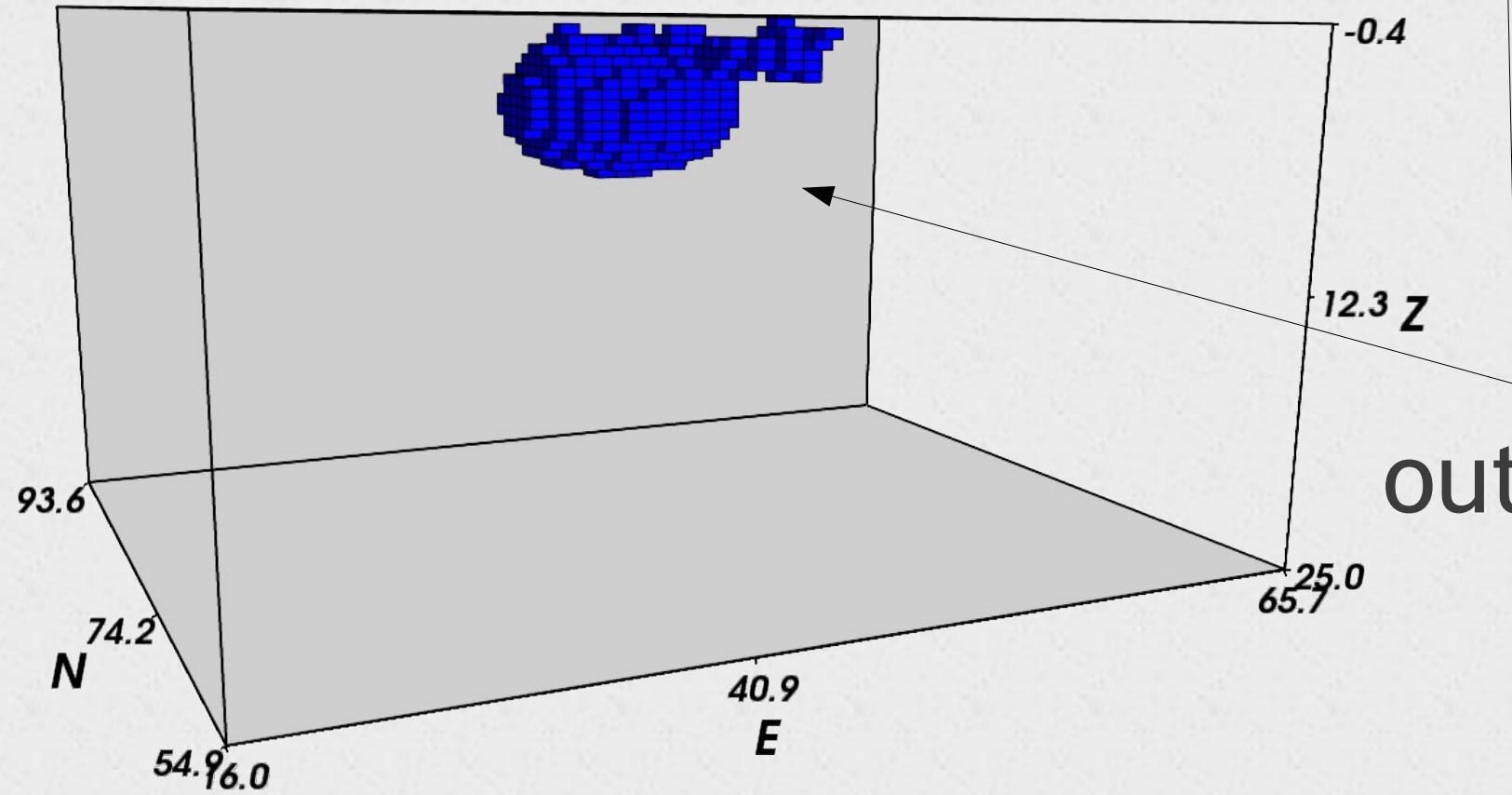
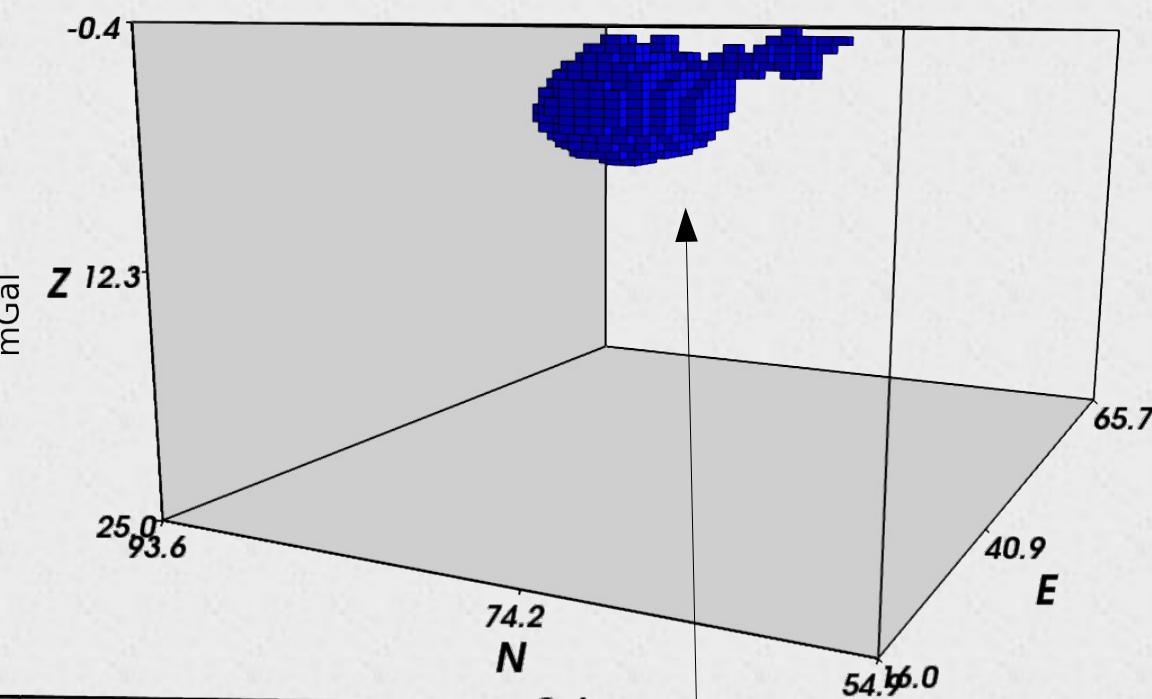
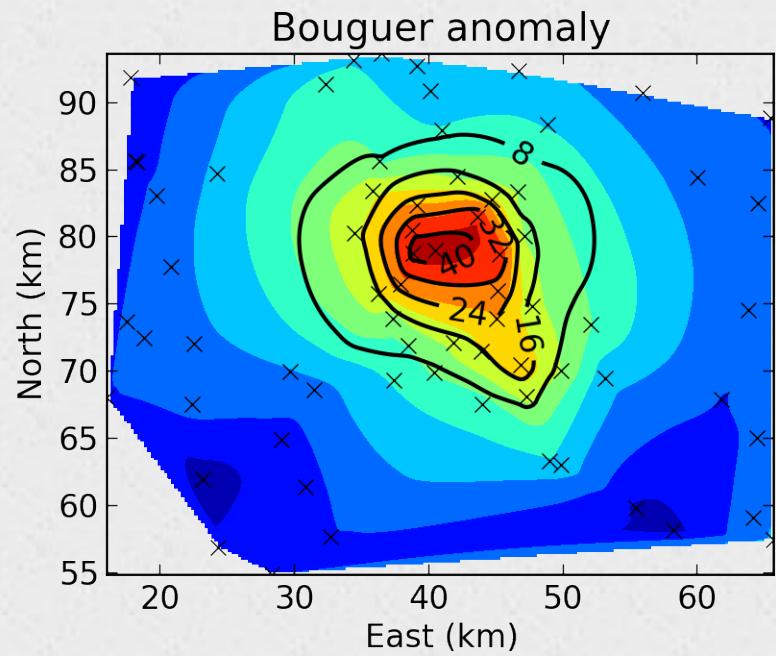
74.2  
N

54.9  
6.0

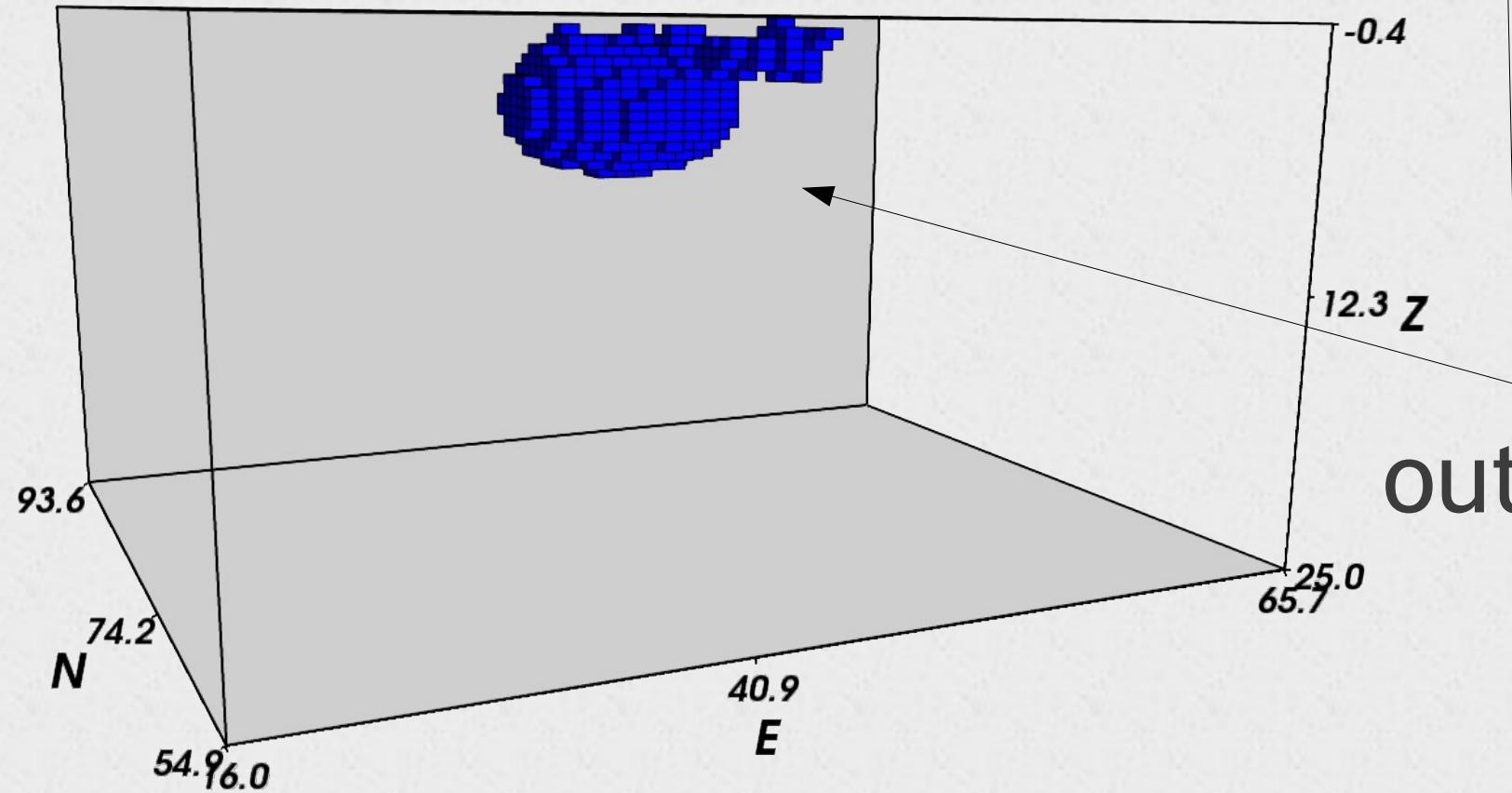
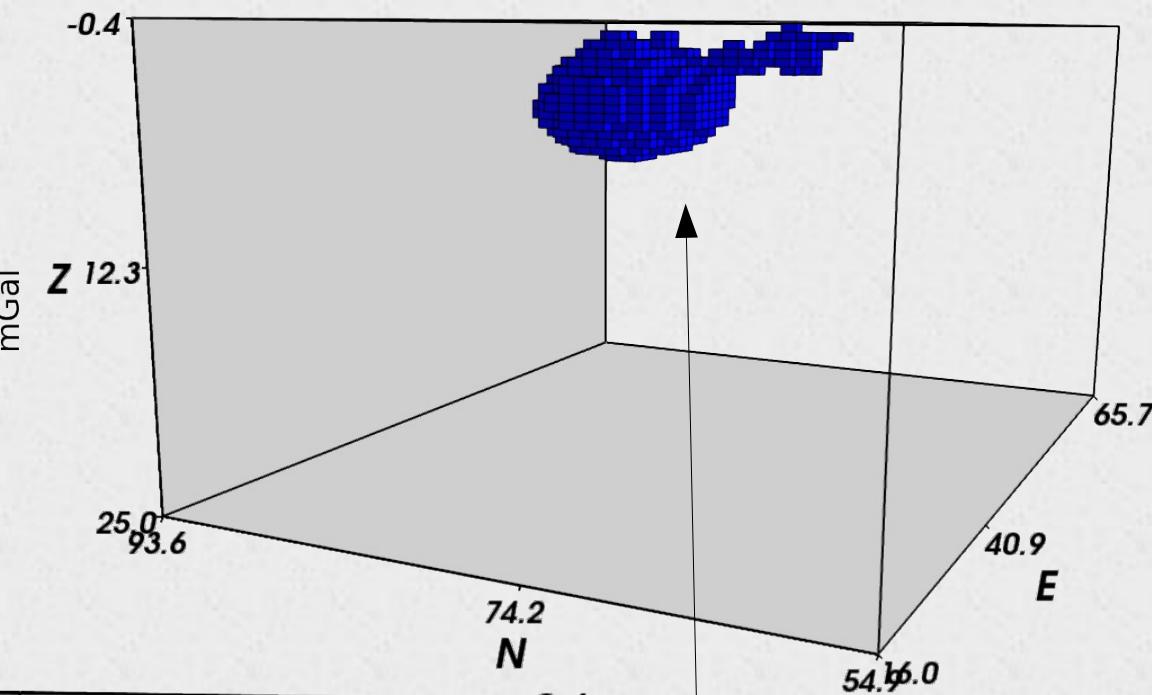
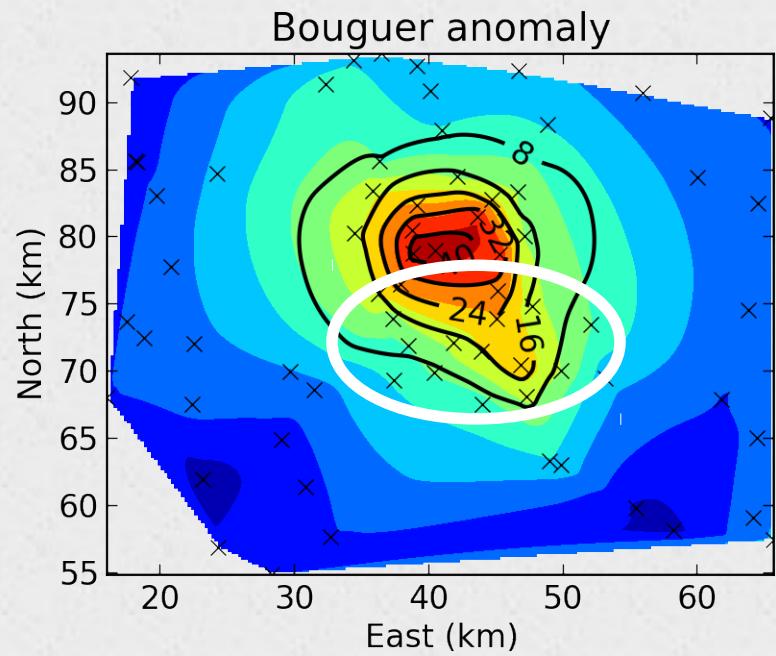
40.9  
E

65.7





Not  
outcropping



Not  
outcropping

# Hypothesis 4

Hypothesis 4

# Conclusion

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