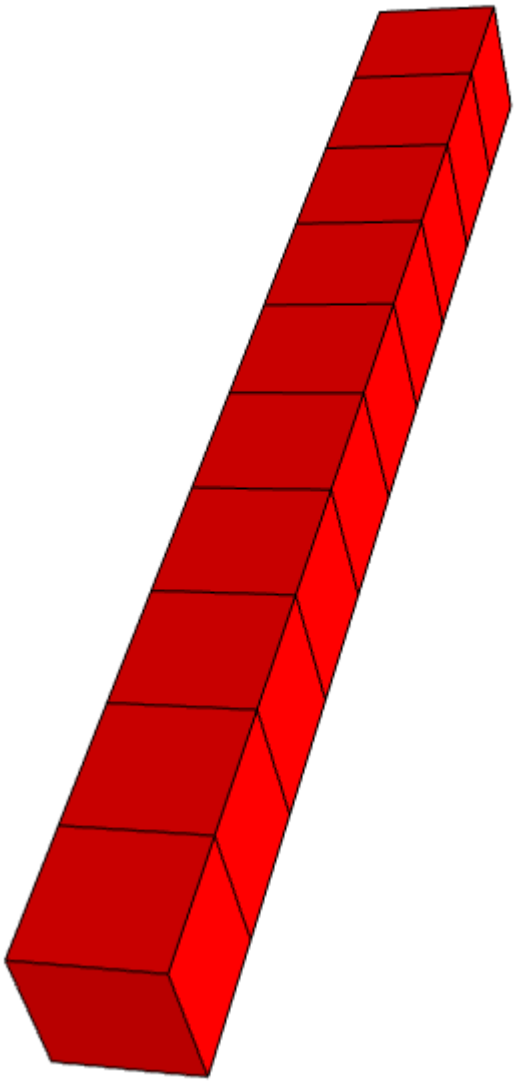
Gravity inversion in spherical coordinates using tesseroids

Leonardo Uieda

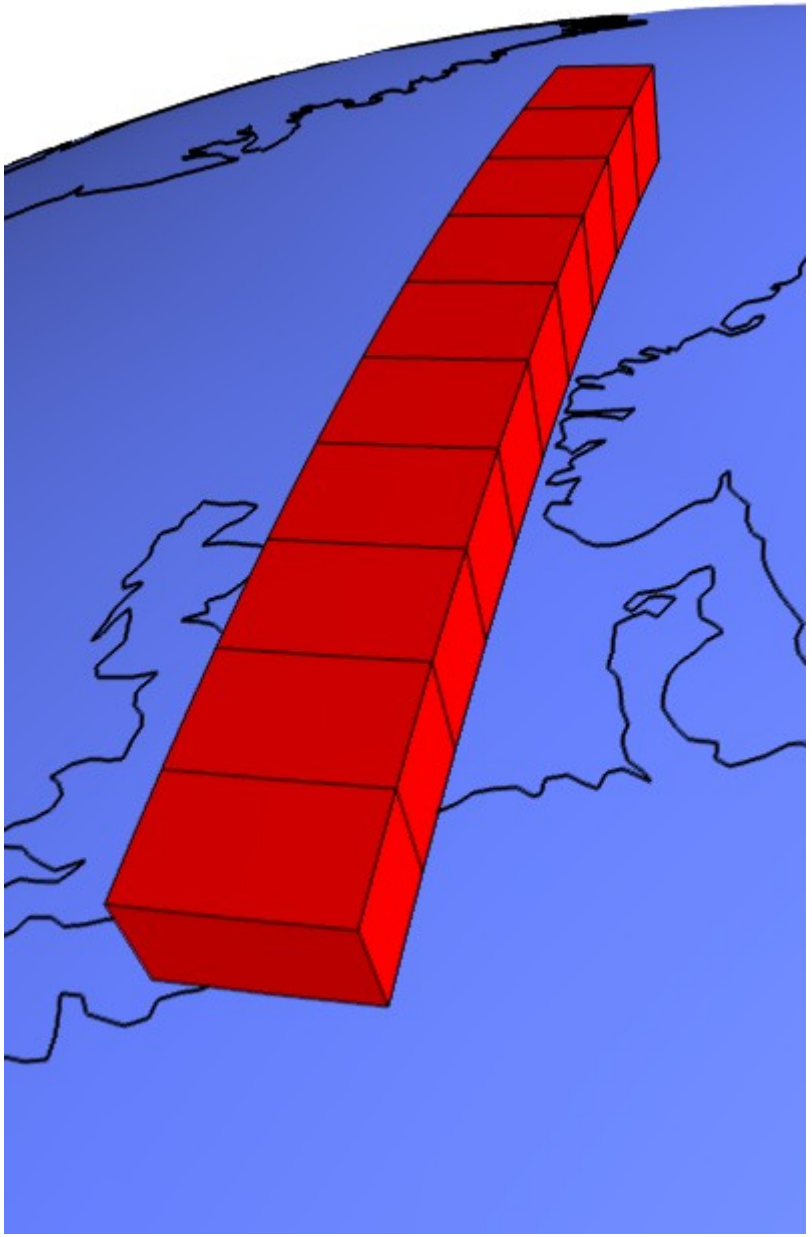
Valéria C. F. Barbosa

Cartesian



VS

Spherical



Existing inversion with tesseroids (Chaves and Ussami, 2013)

- Geoid height anomalies
- Space domain
- Regularization:
  - Depth-weighted Minimum Volume
  - Similarity to seismic tomography

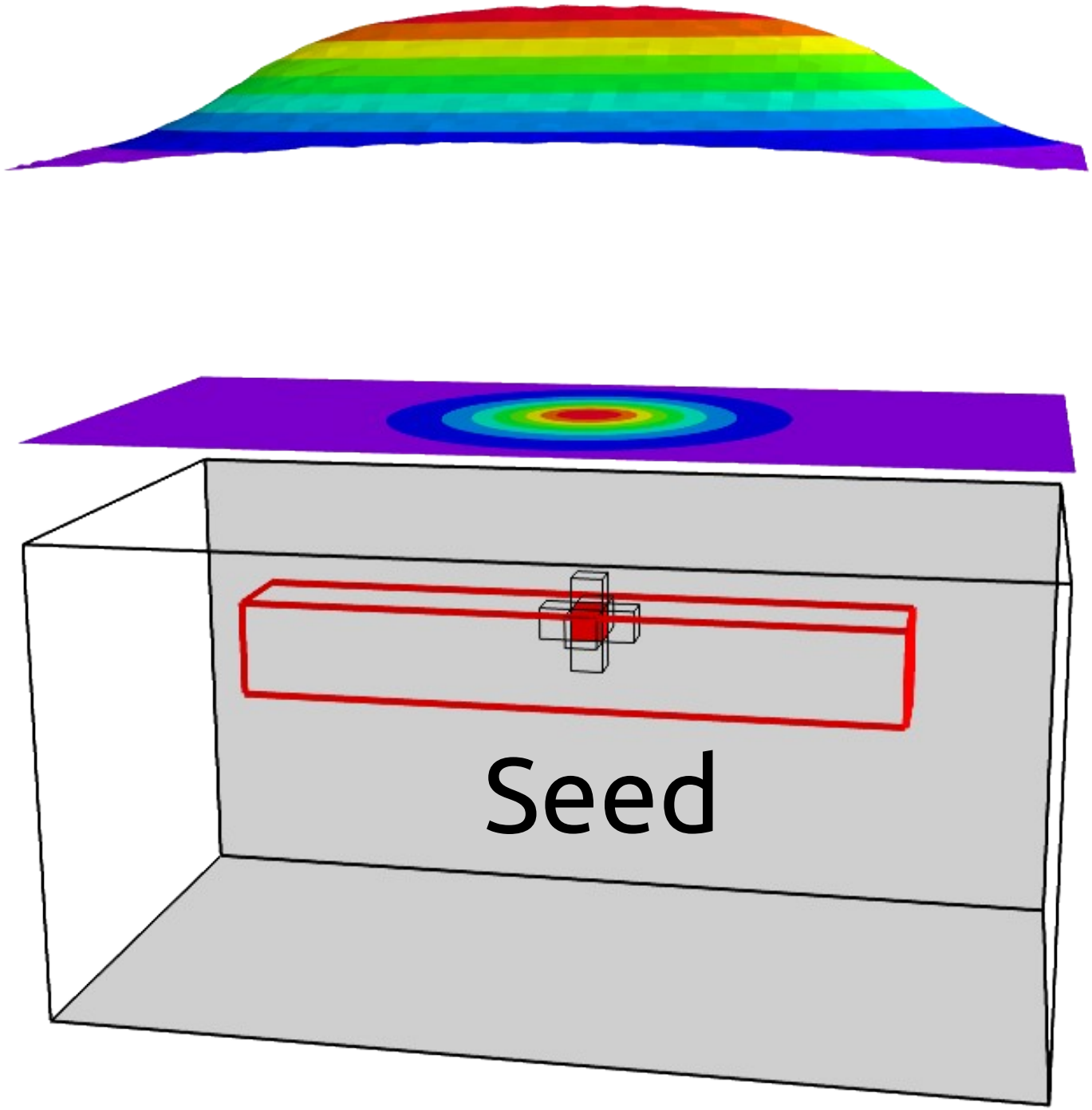
Adapt

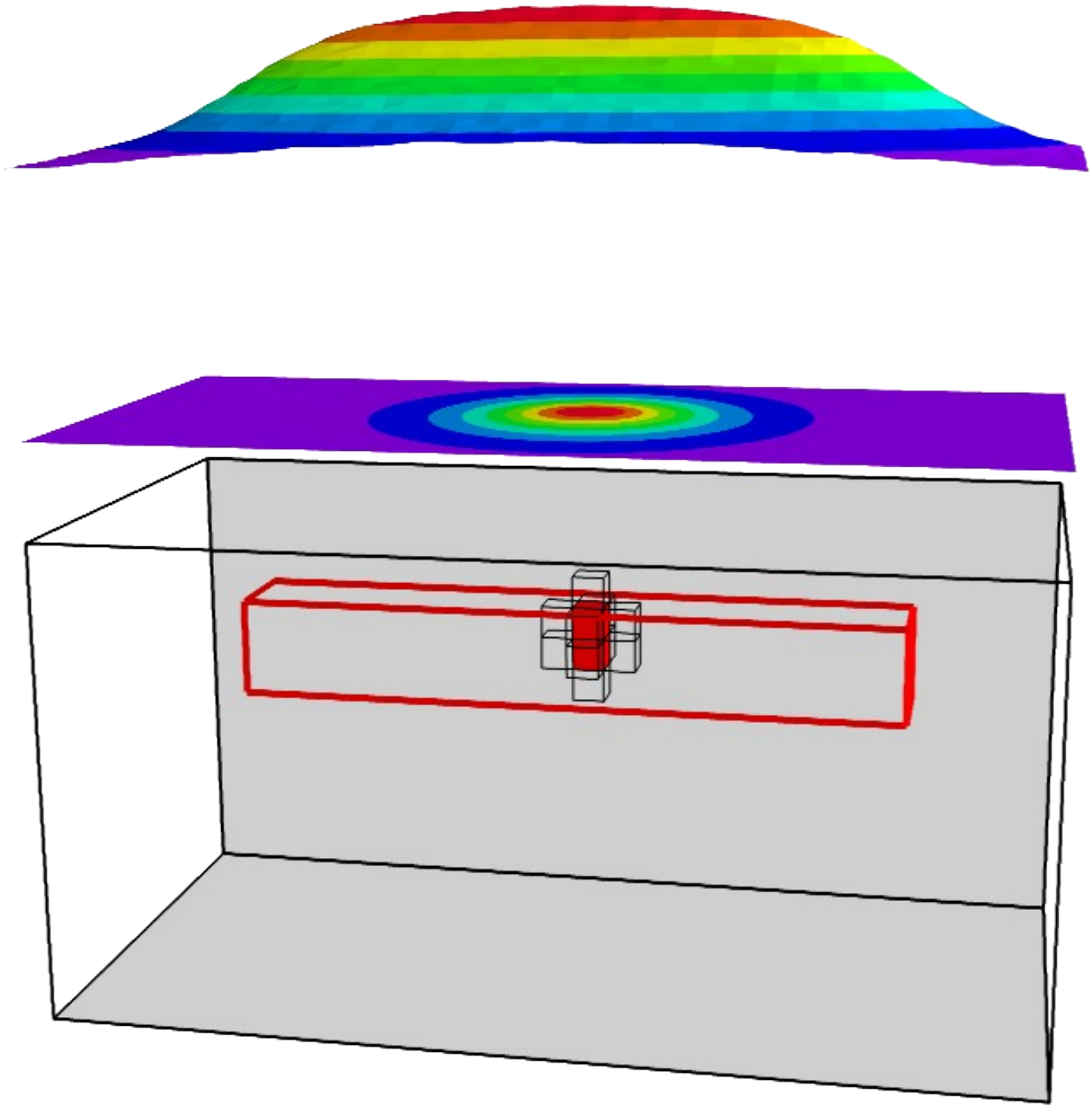
Planting anomalous densities

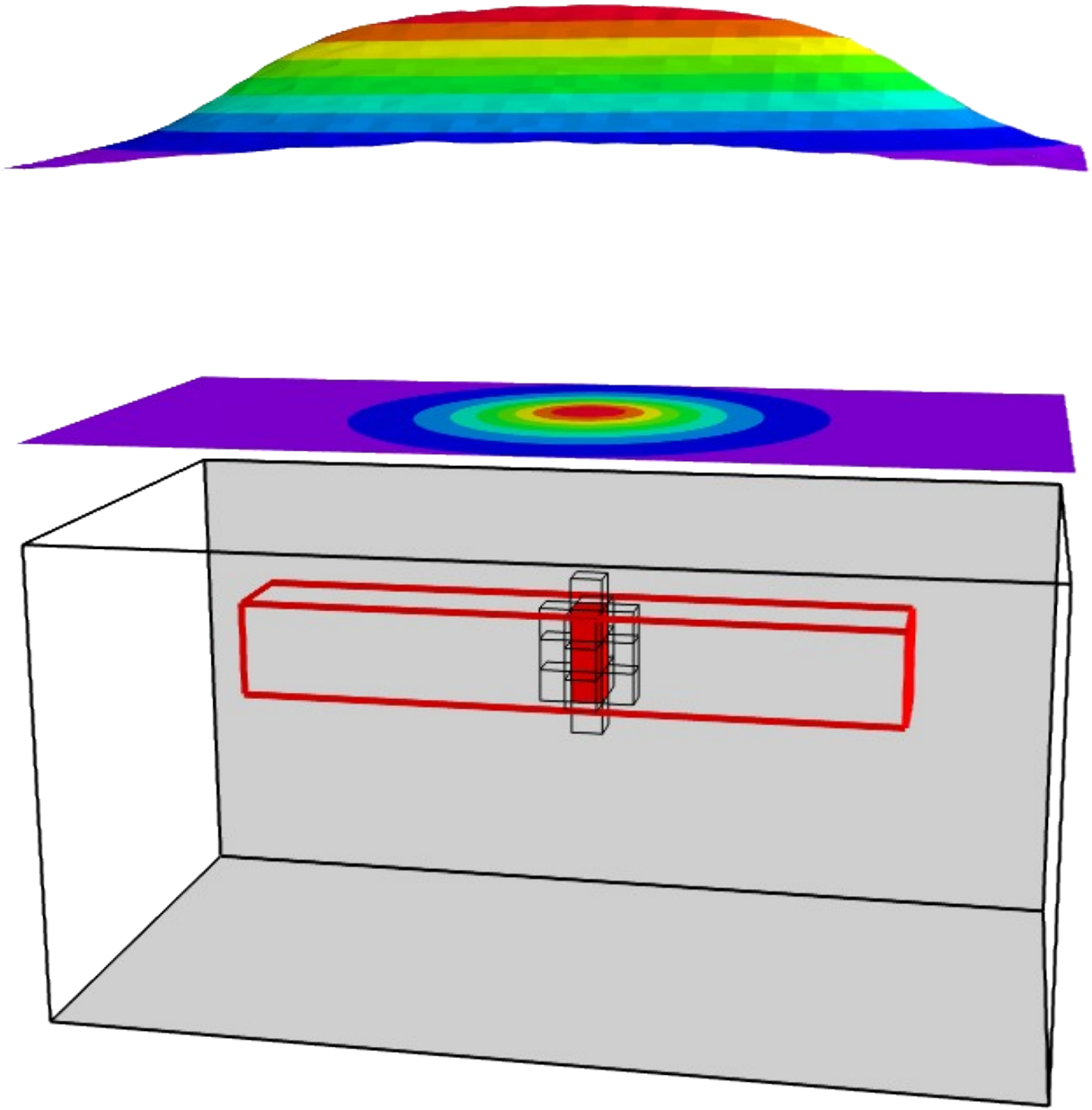
(Uieda and Barbosa, 2012)

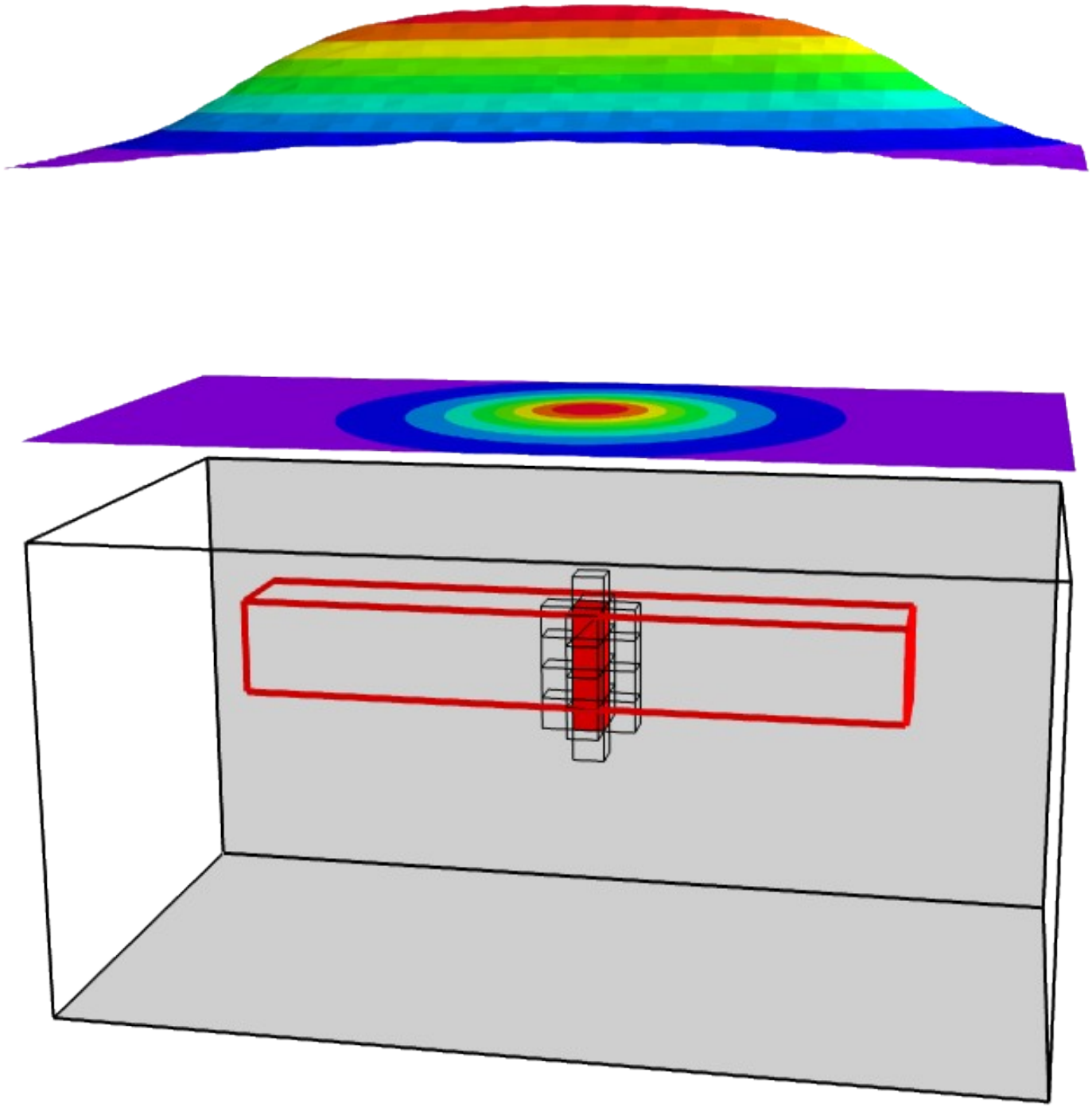
Planting anomalous densities

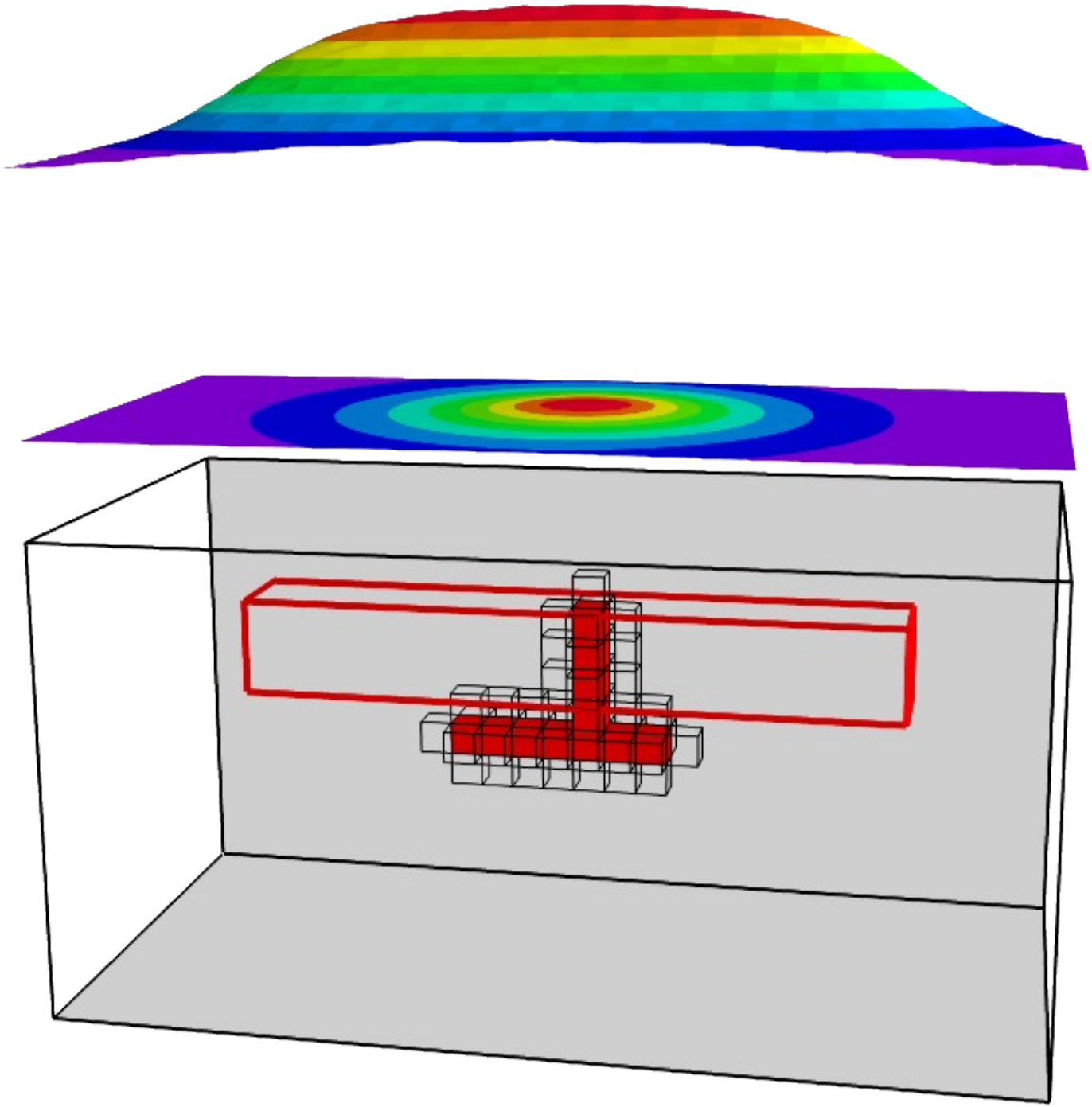
- Space domain
- Multicomponent: gravity + gradients
- Non-conventional inversion
  - Growth algorithm
  - No linear systems
  - Efficient sensitivity computations

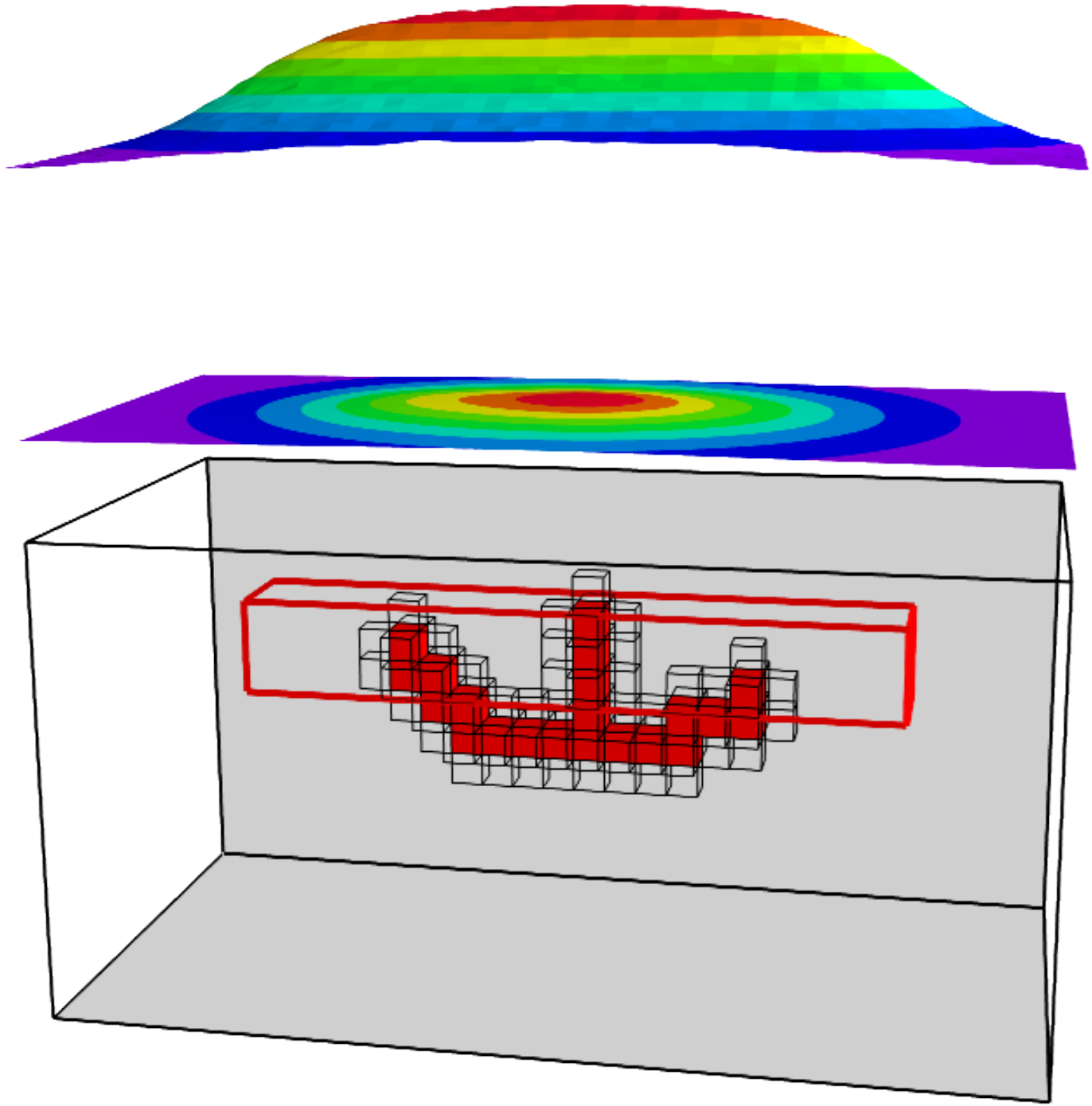

Seed

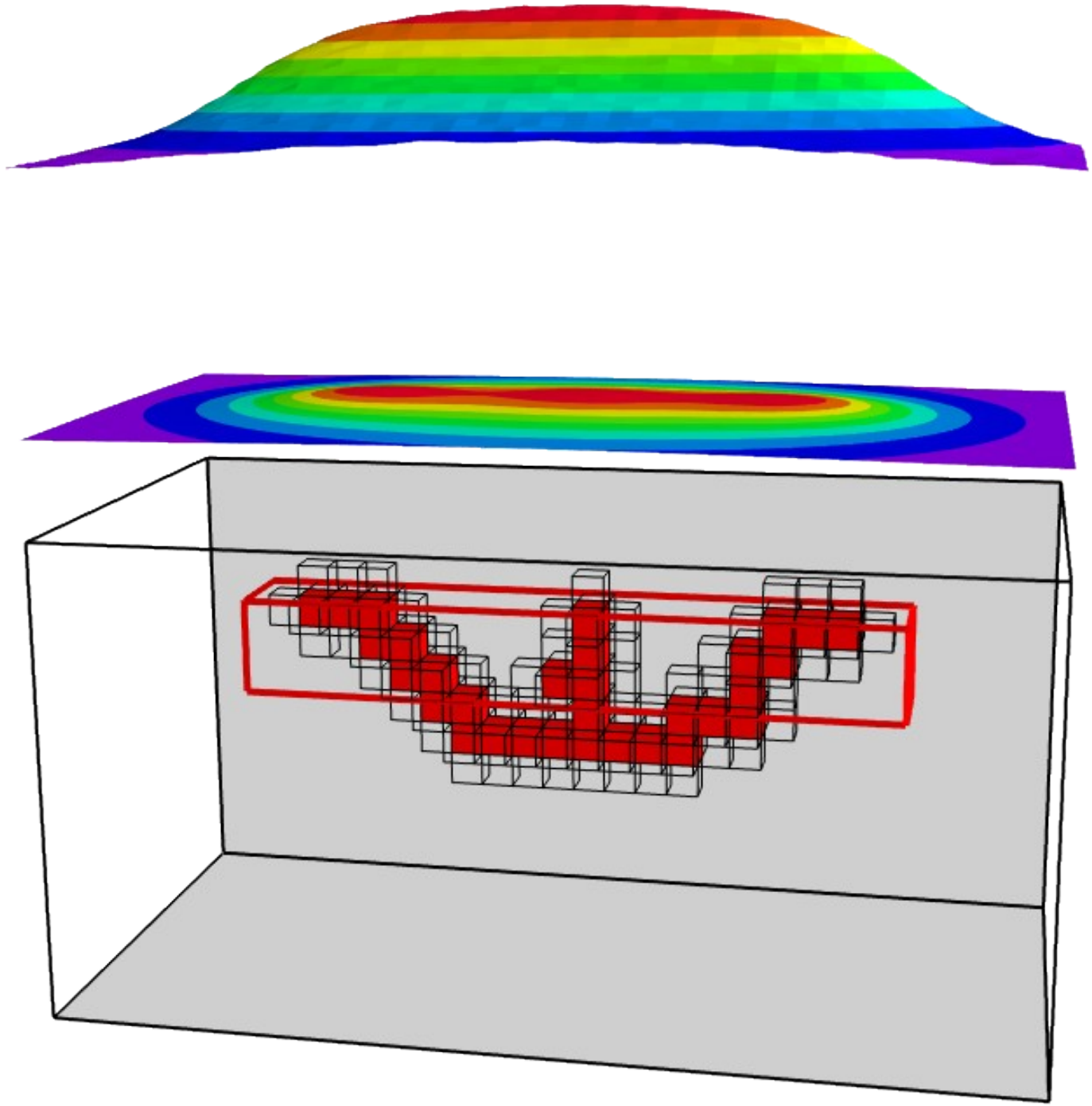


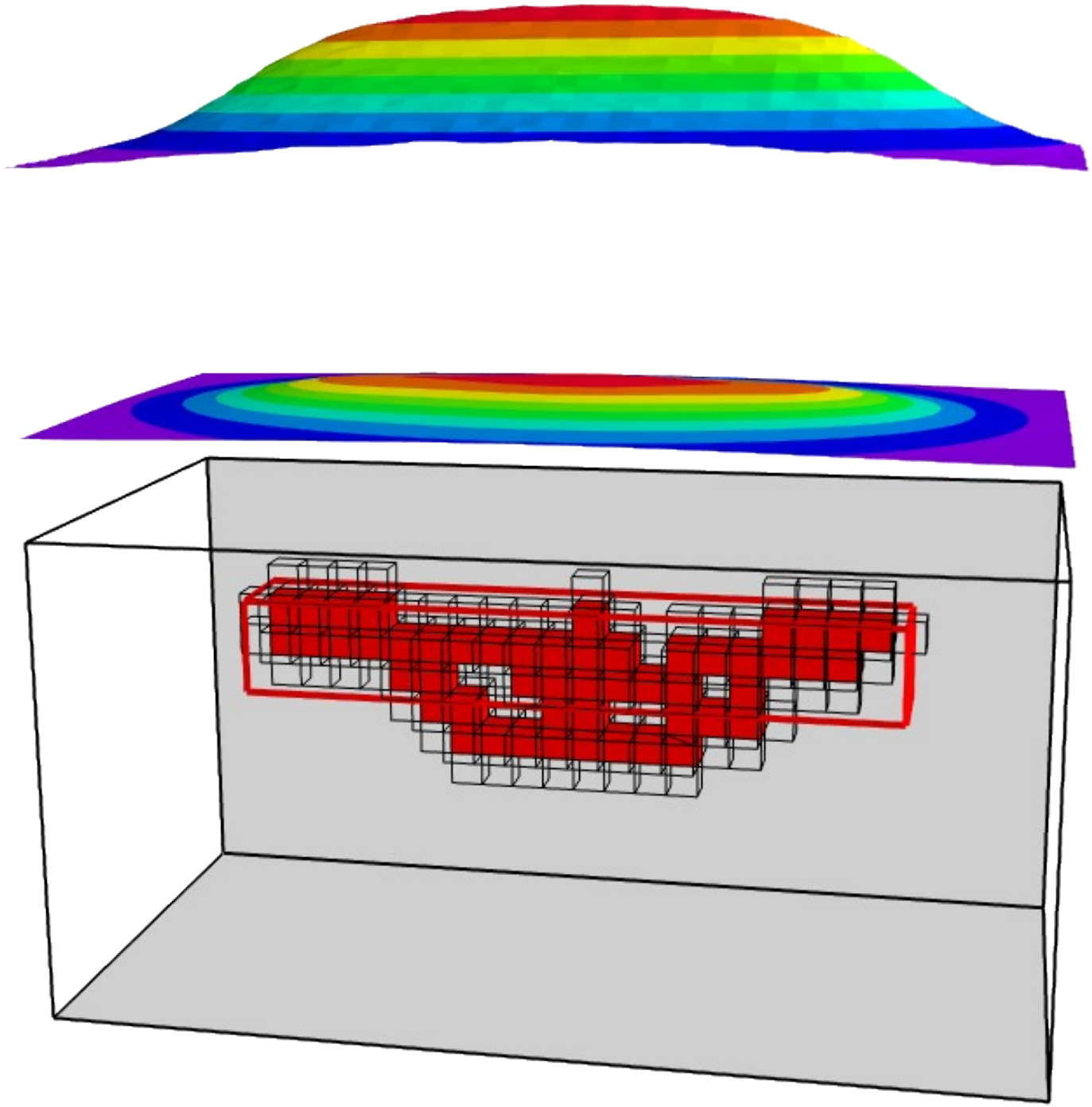


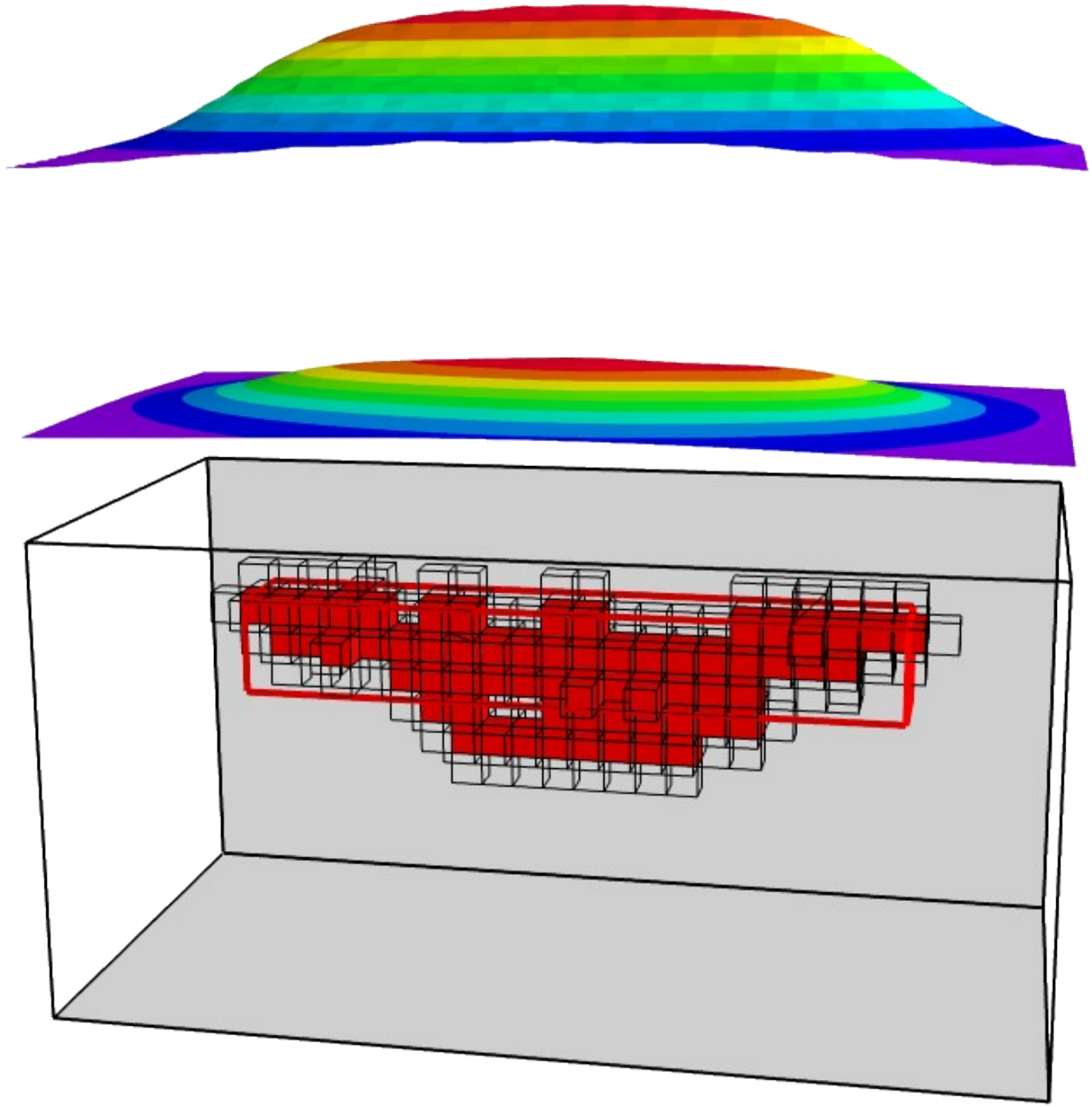


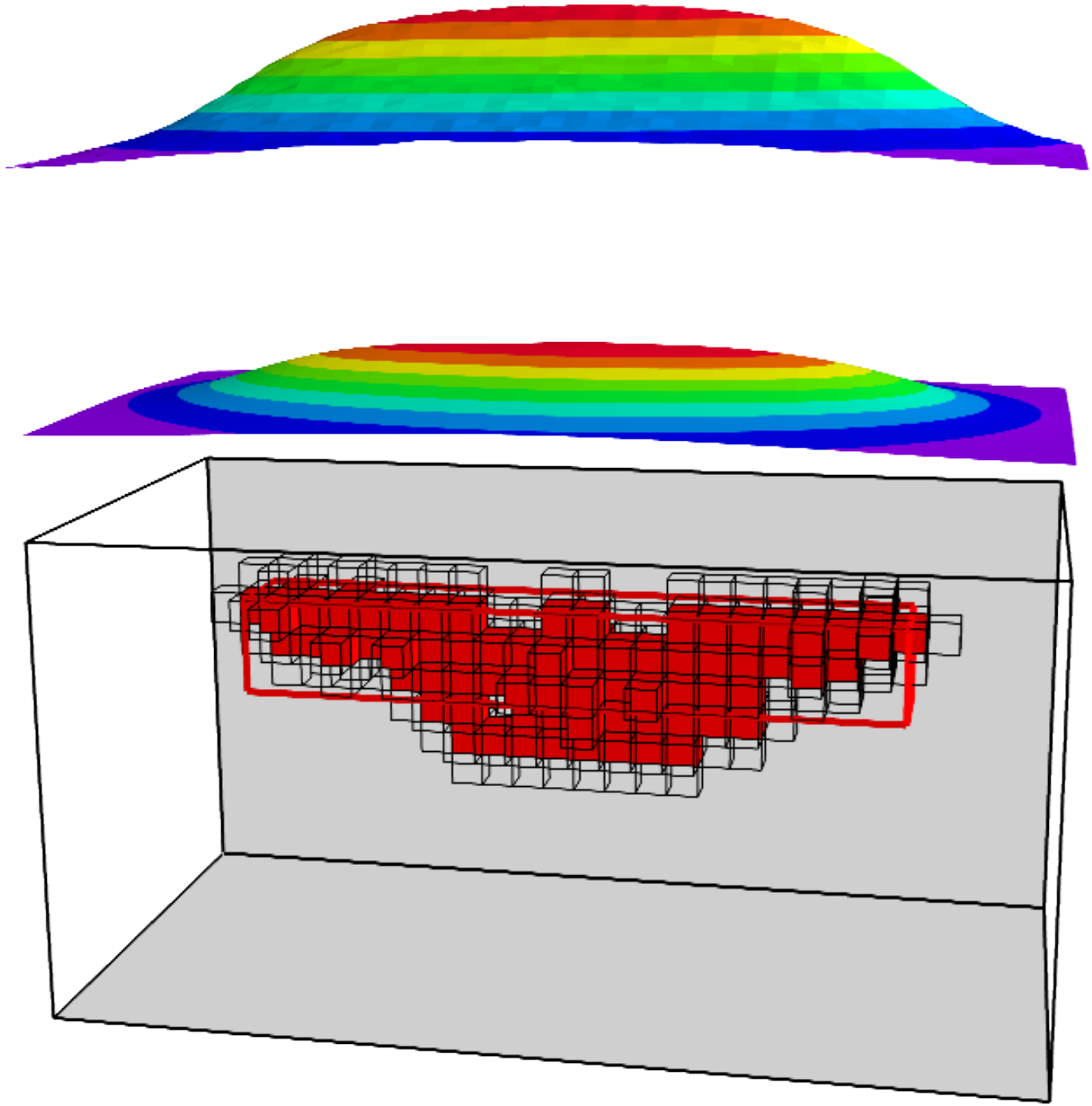


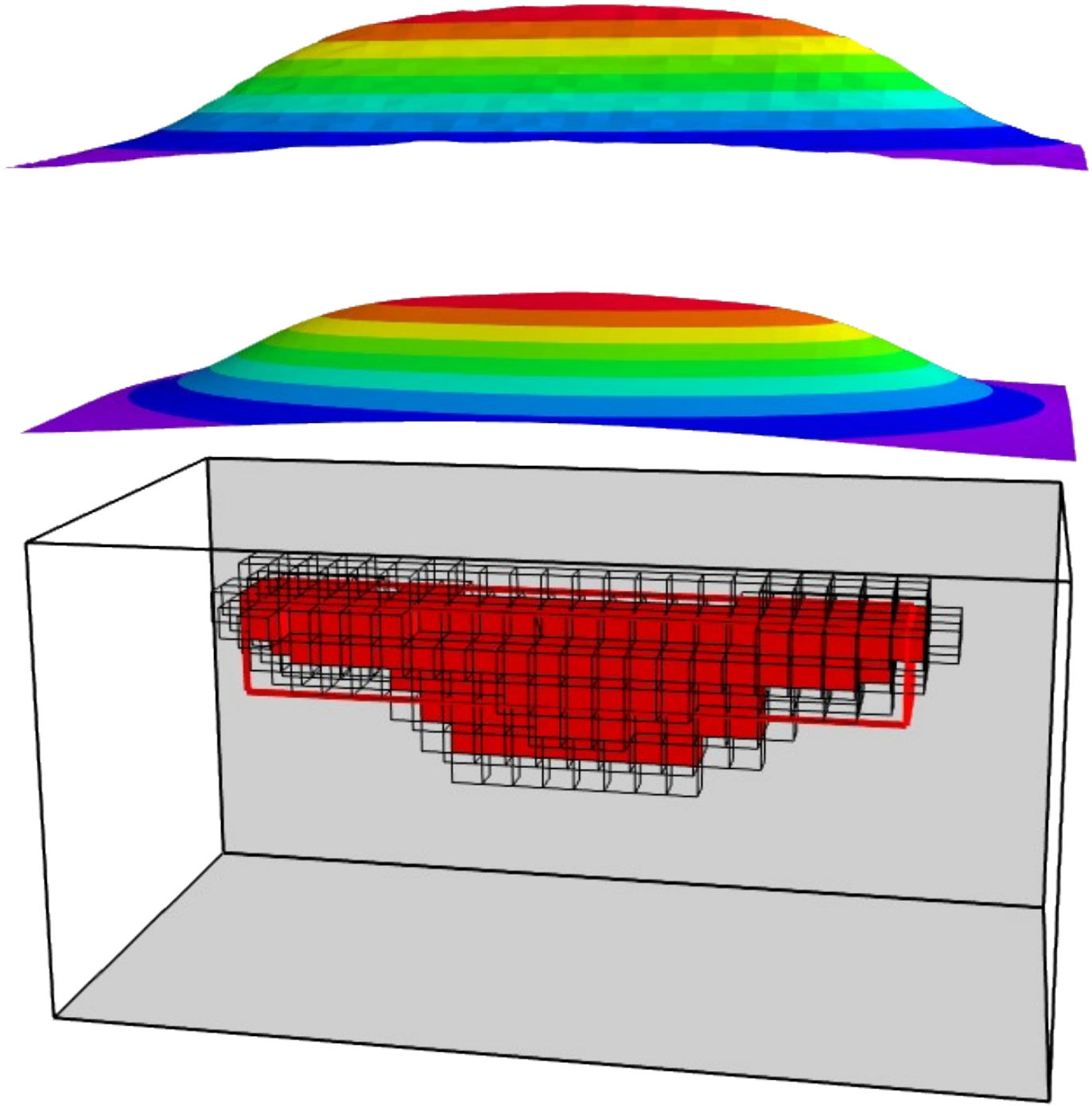


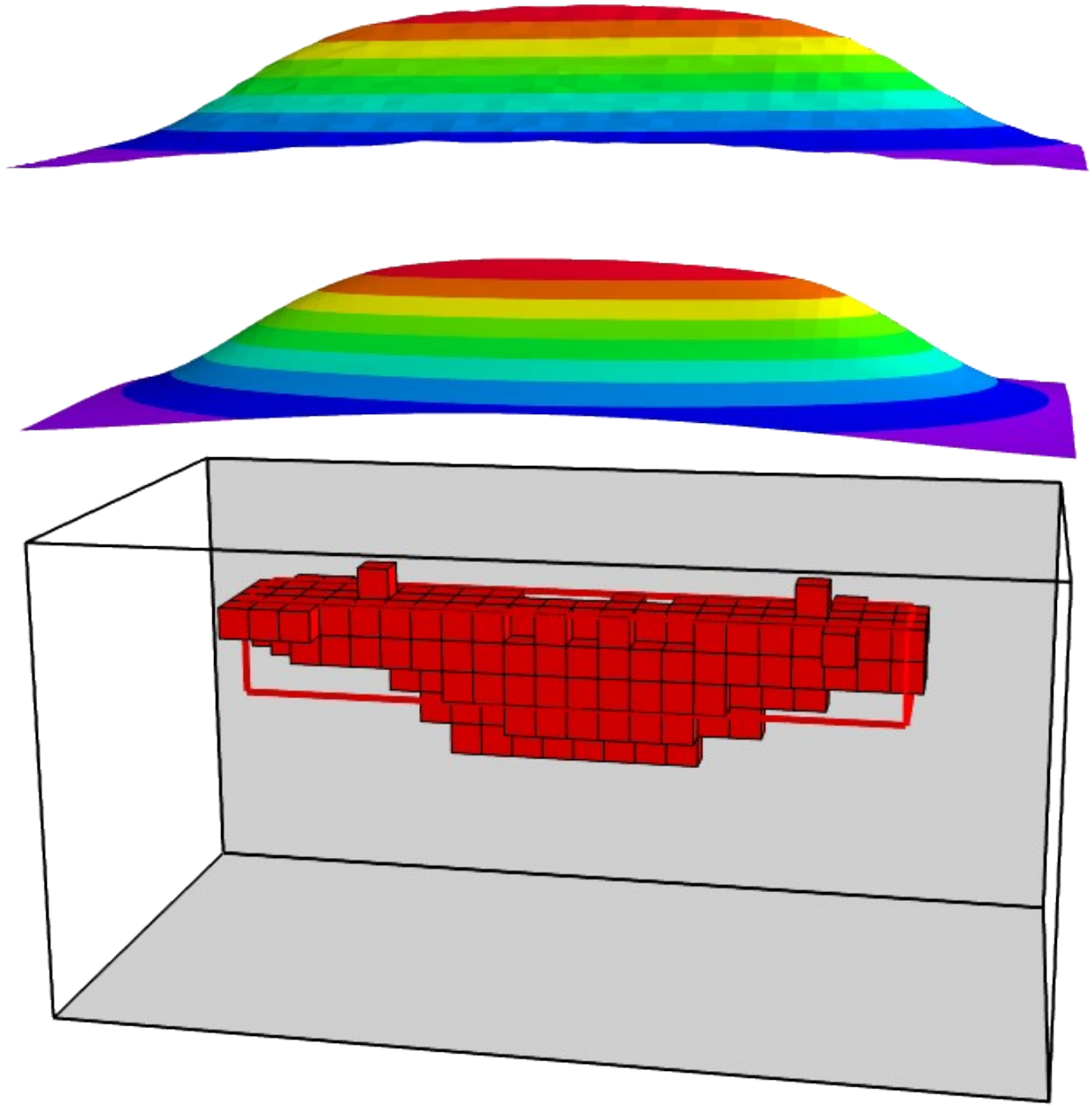










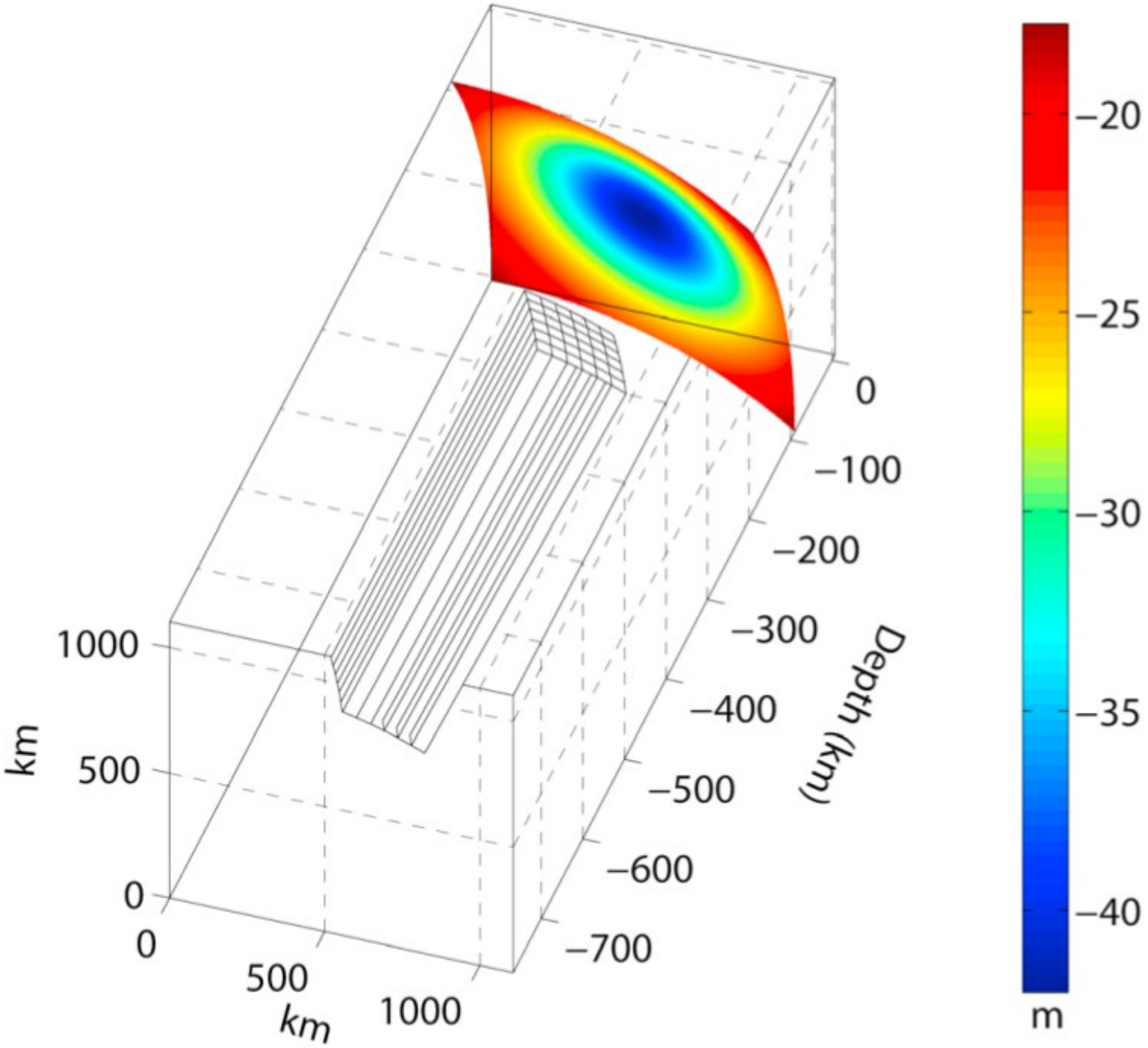


Synthetics

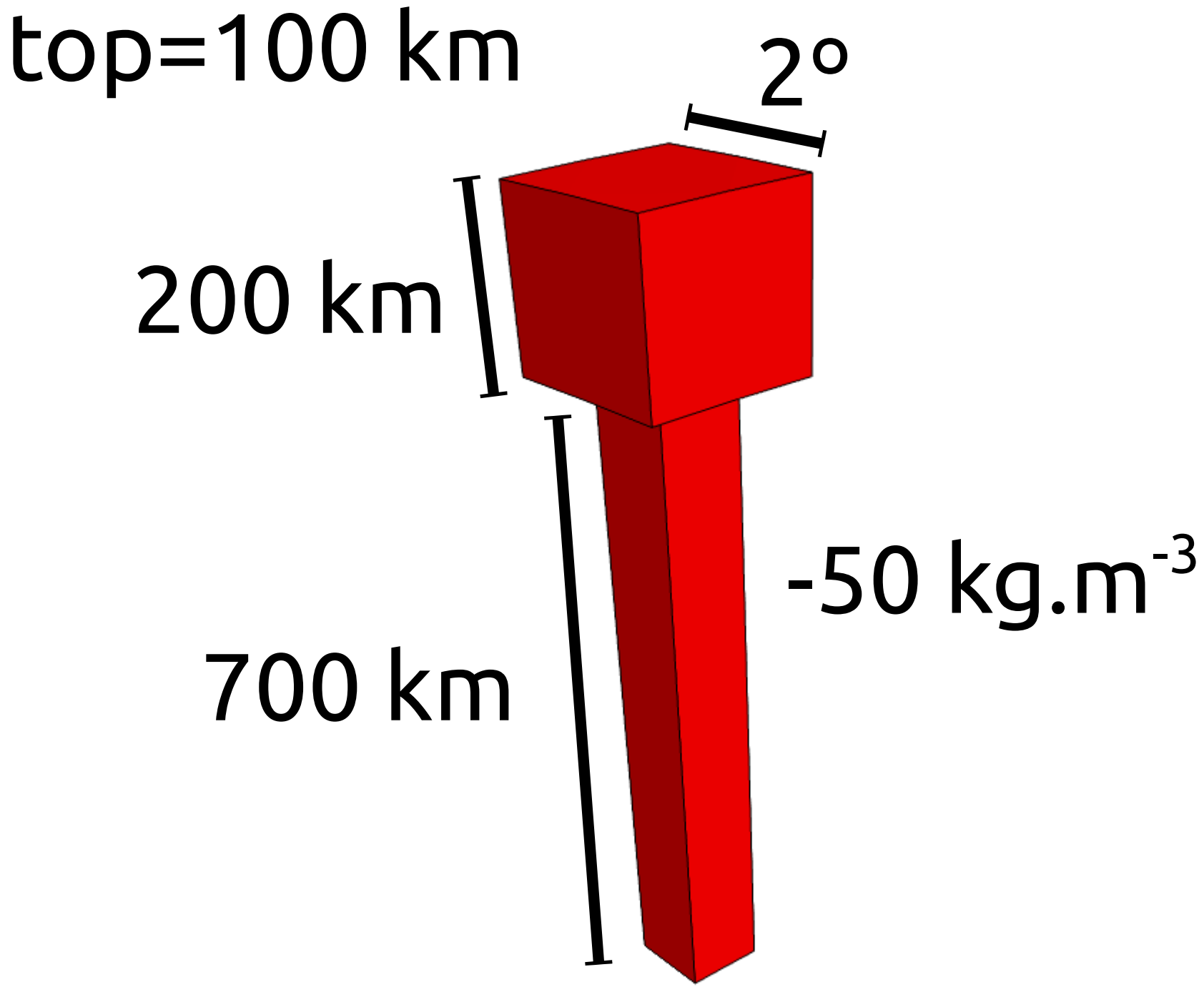
- Possible applications
- Advantages
- Shortcomings

(Hypothetical) Mantle Plume

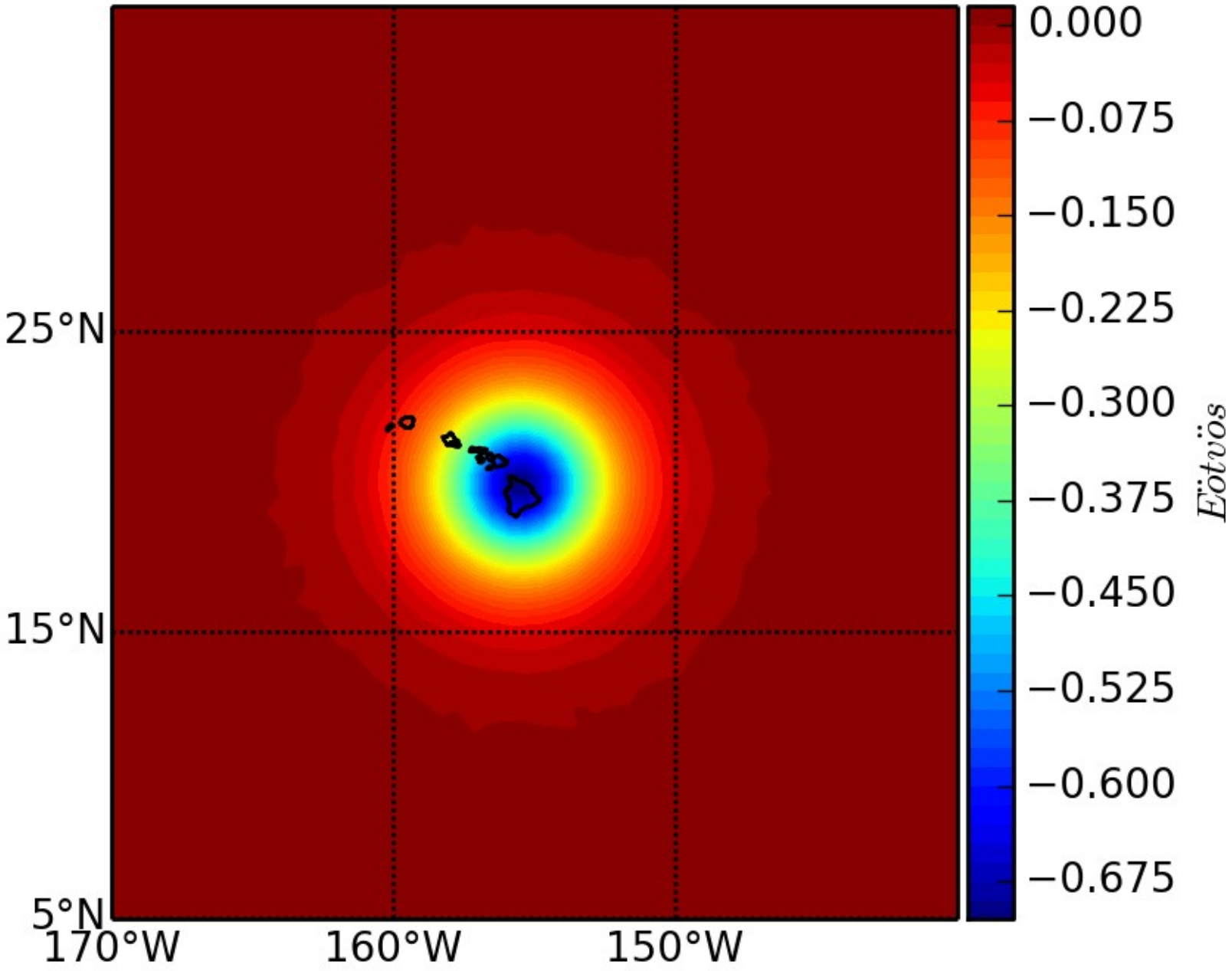
Inspired by synthetics in Chaves and Ussami (2013)



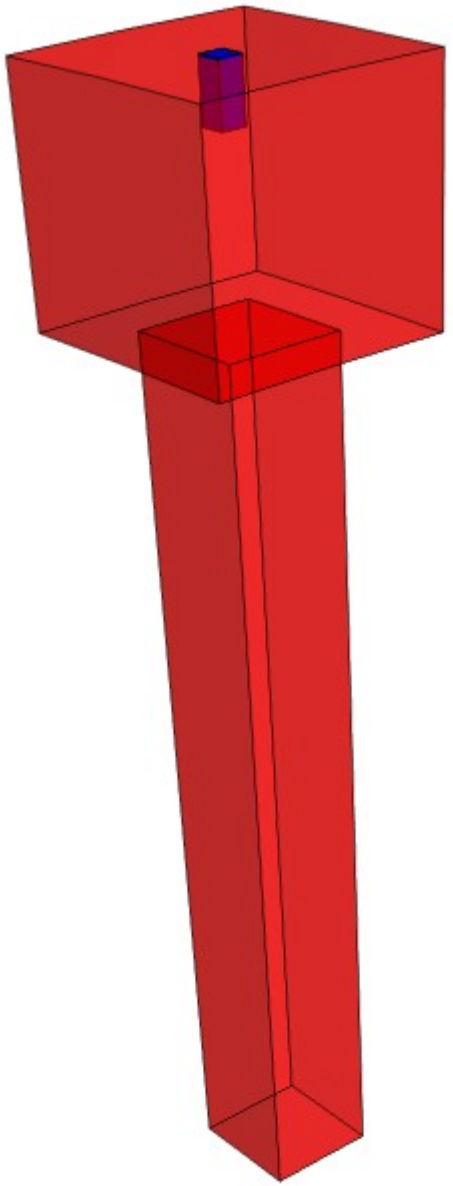
After Chaves and Ussami (2013)

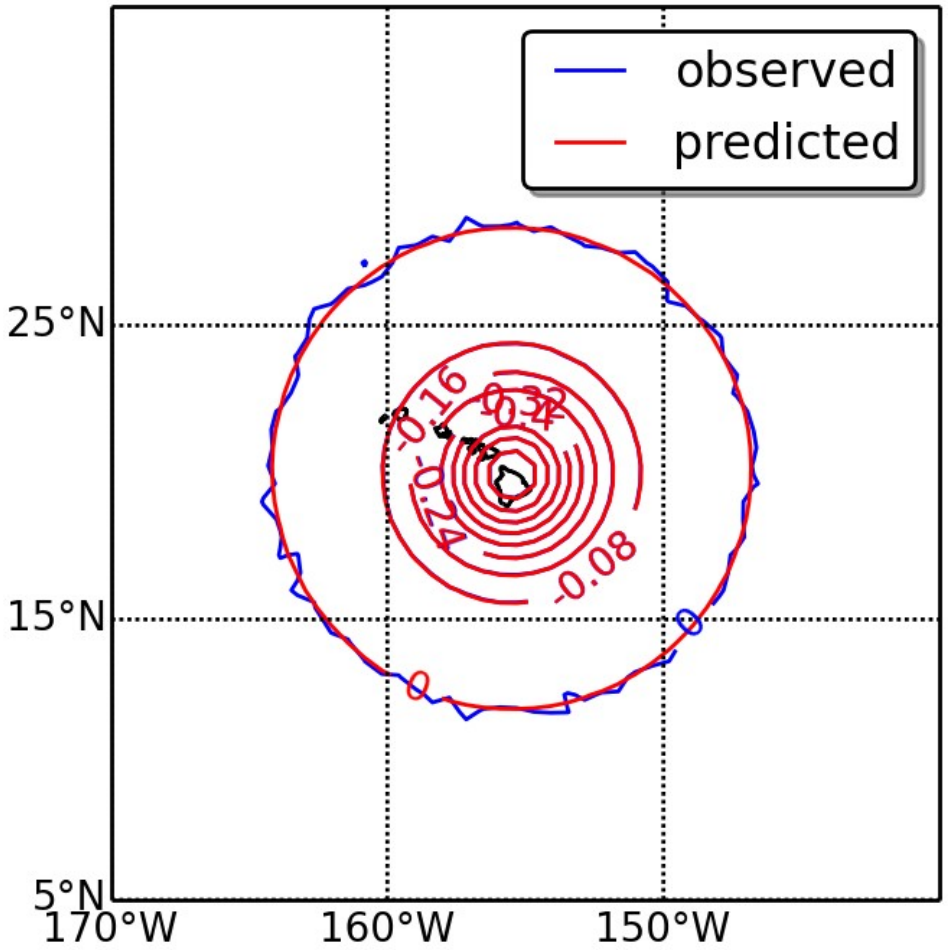

top=100 km
2°
200 km
700 km
-50 kg.m-3

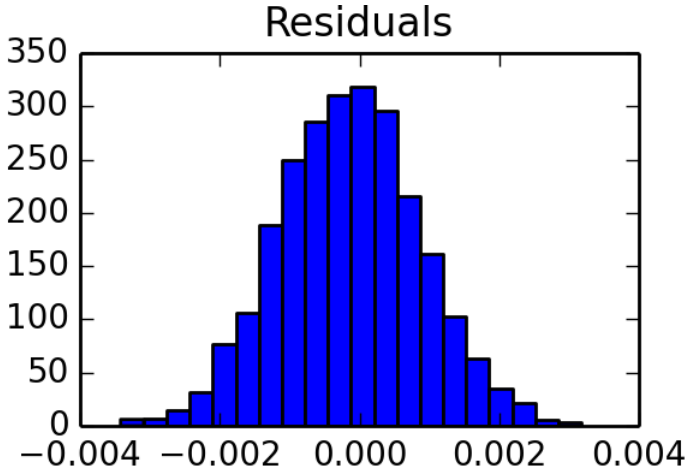
g_{zz} at 250 km

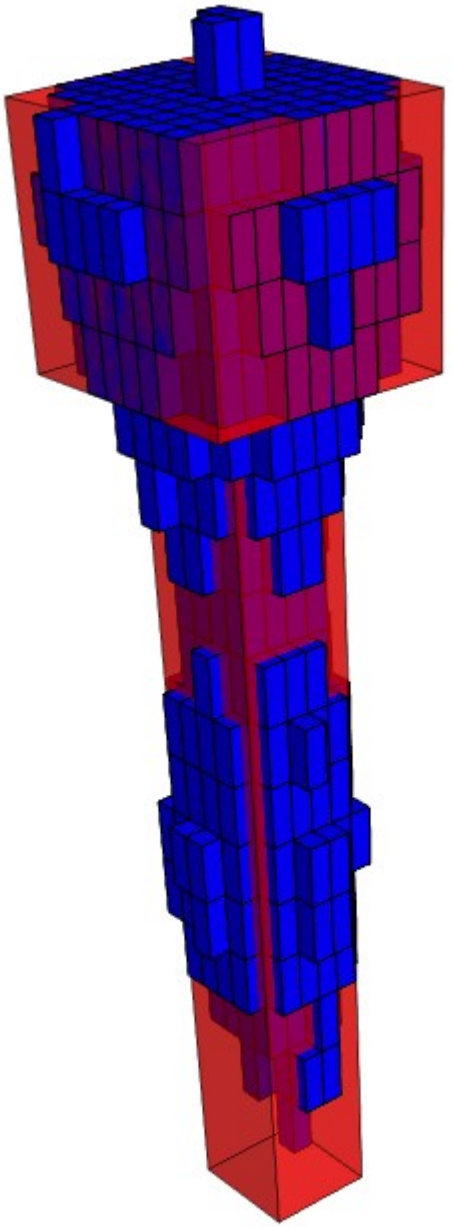

25°N
15°N
5°N
170°W
160°W
150°W
0.000
−0.075
−0.150
−0.225
−0.300
−0.375
−0.450
−0.525
−0.600
−0.675
Eötvös

Seed

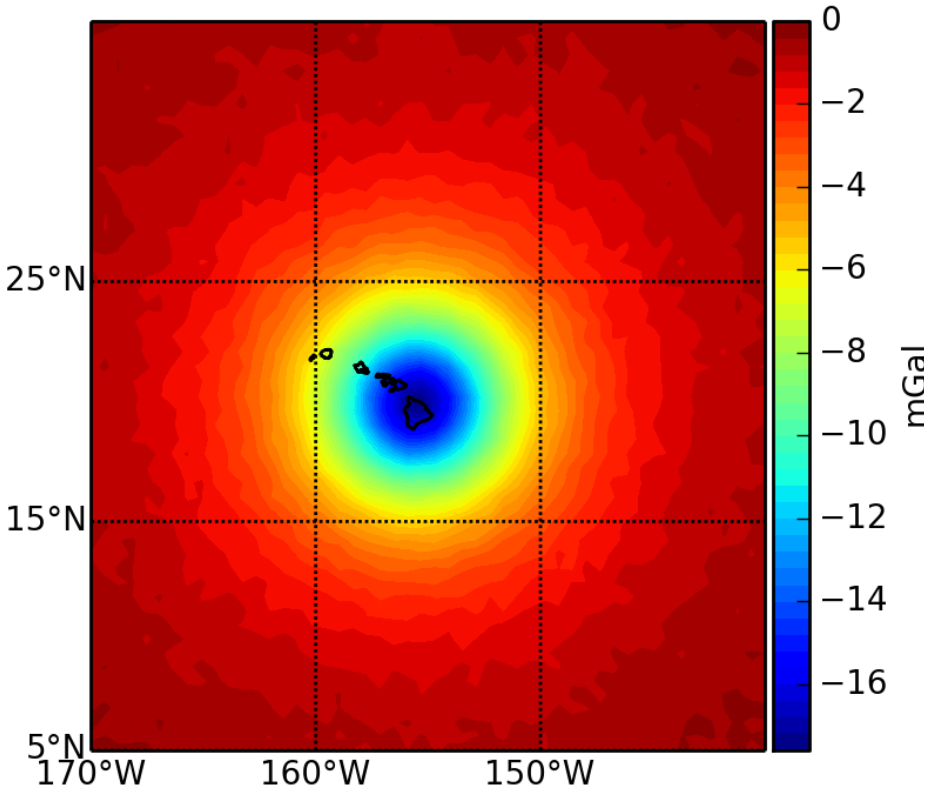


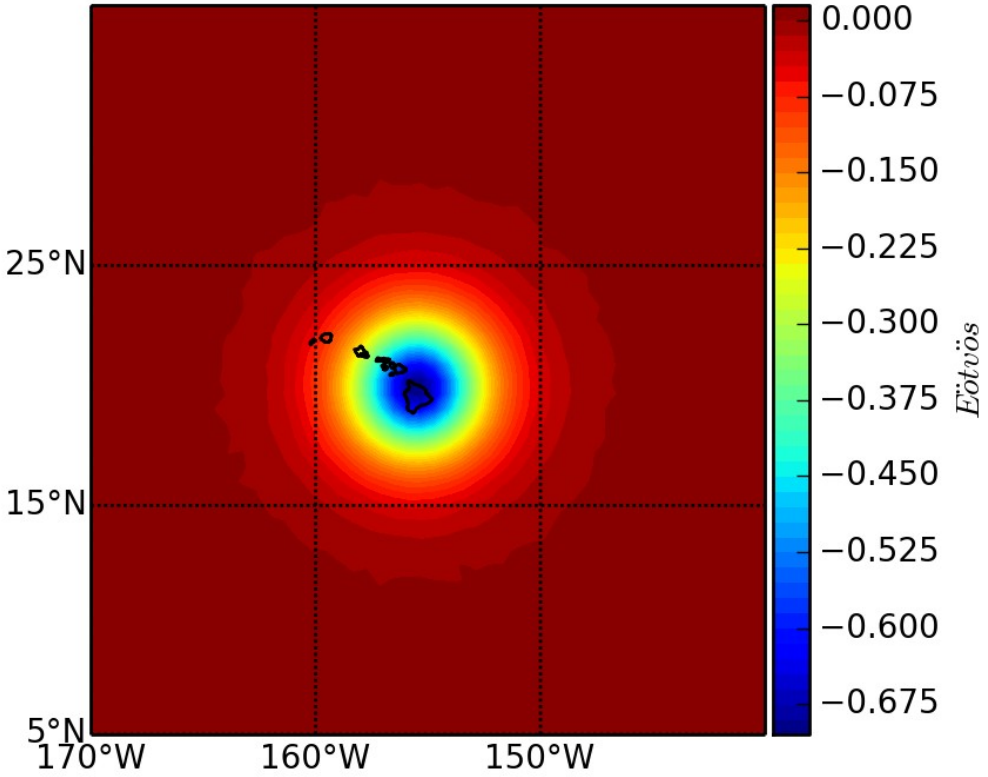

observed
predicted
25°N
15°N
5°N
170°W
160°W
150°W
-0.16
-0.32
-0.24
-0.08
0


Residuals
350
300
250
200
150
100
50
0
−0.004
−0.002
0.000
0.002
0.004

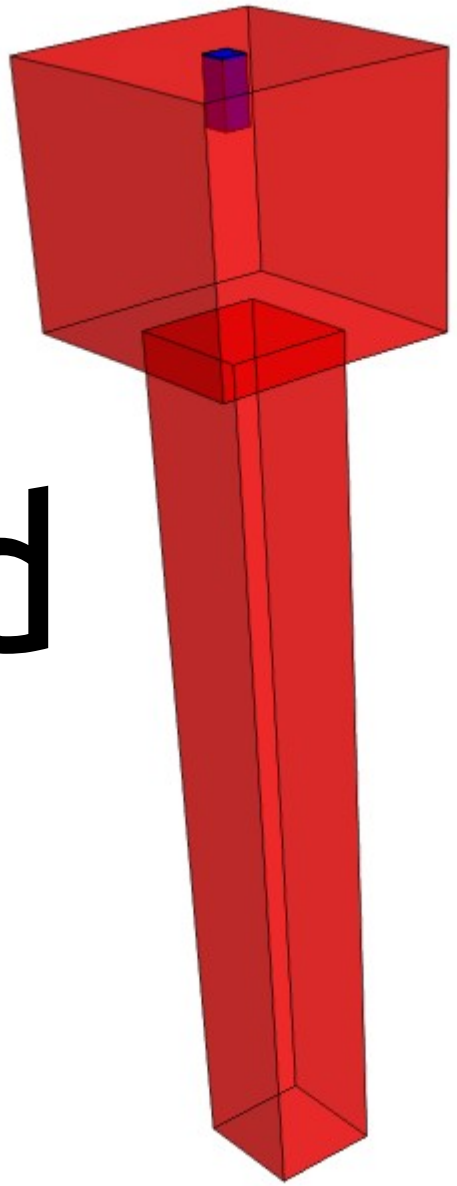


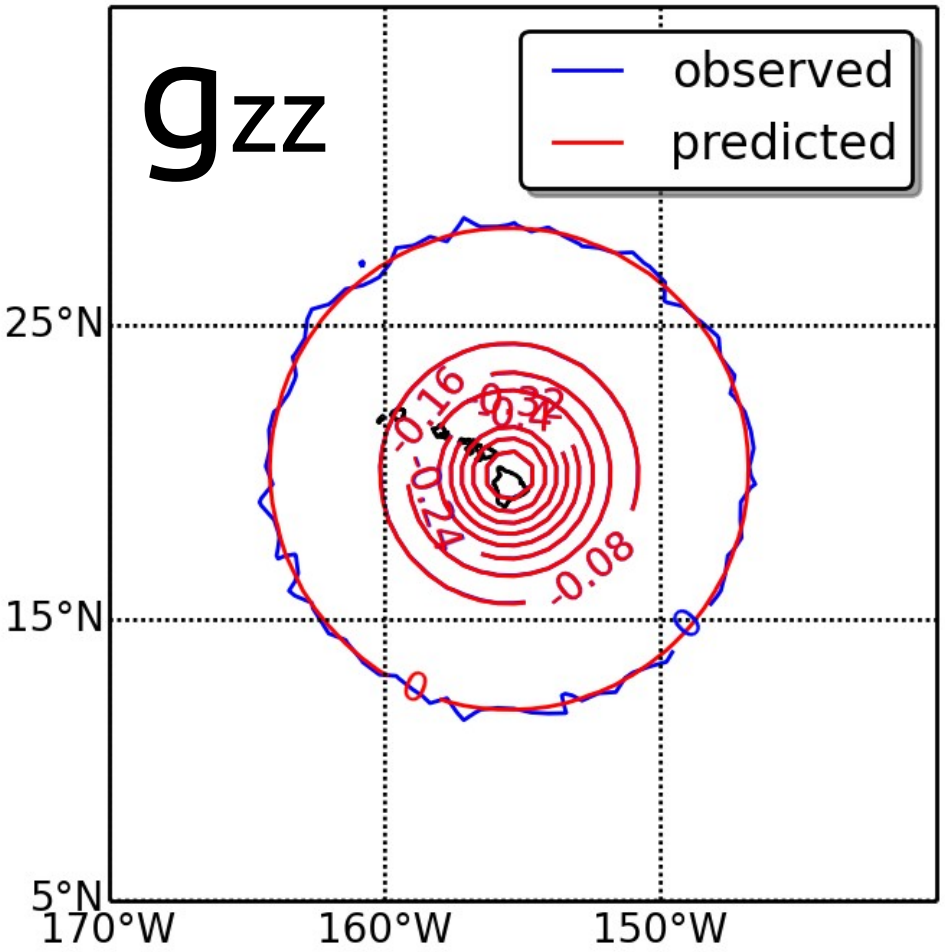
Joint $g_z + g_{zz}$?

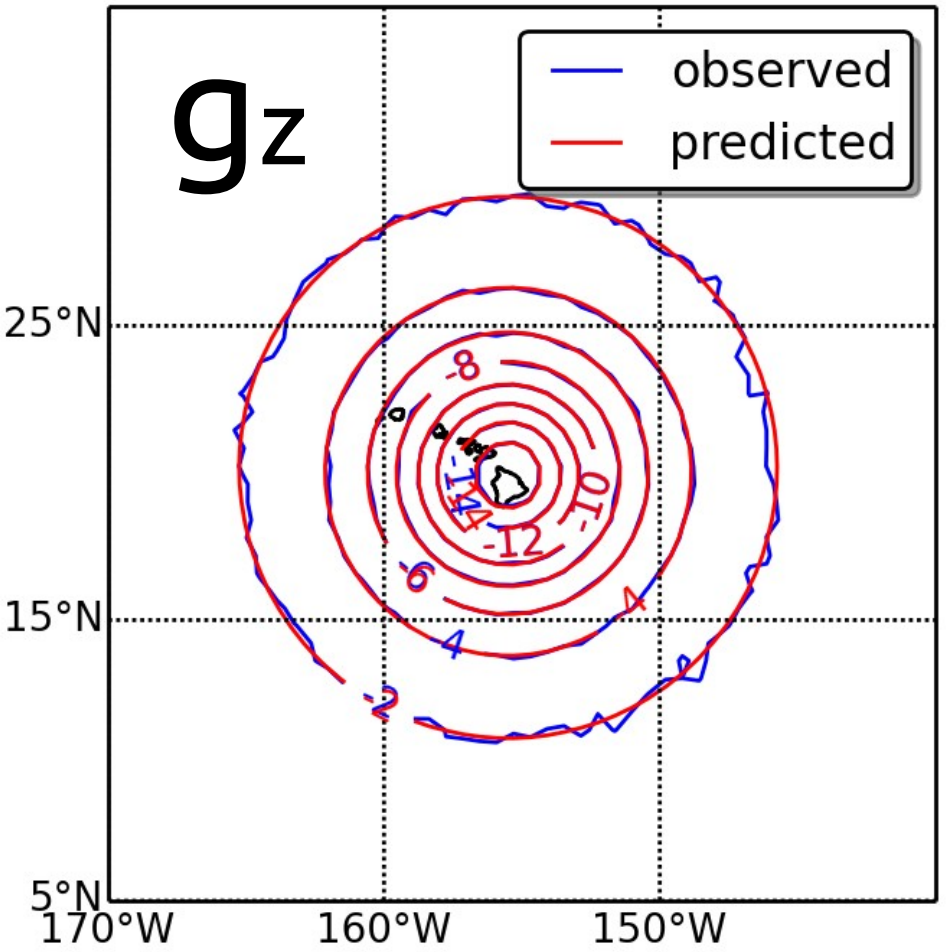

0
−2
−4
−6
−8
−10
−12
−14
−16
mGal
25°N
15°N
5°N
170°W
160°W
150°W

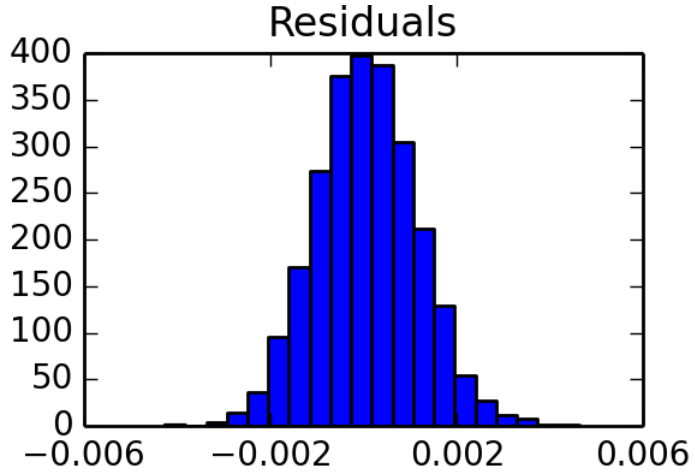

0.000
−0.075
−0.150
−0.225
−0.300
−0.375
−0.450
−0.525
−0.600
−0.675
Eötvös
25°N
15°N
5°N
170°W
160°W
150°W

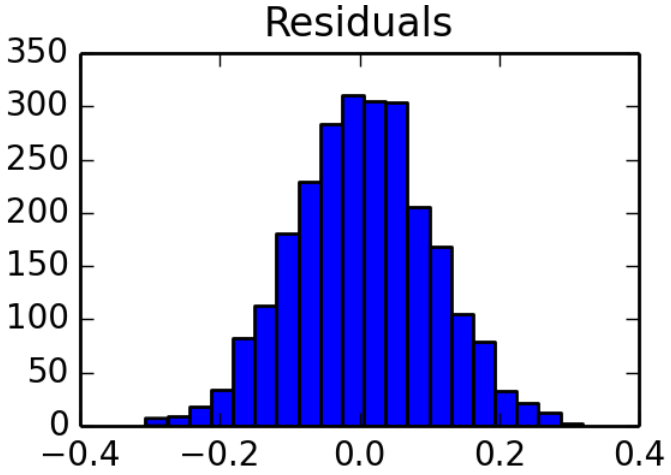
Same seed



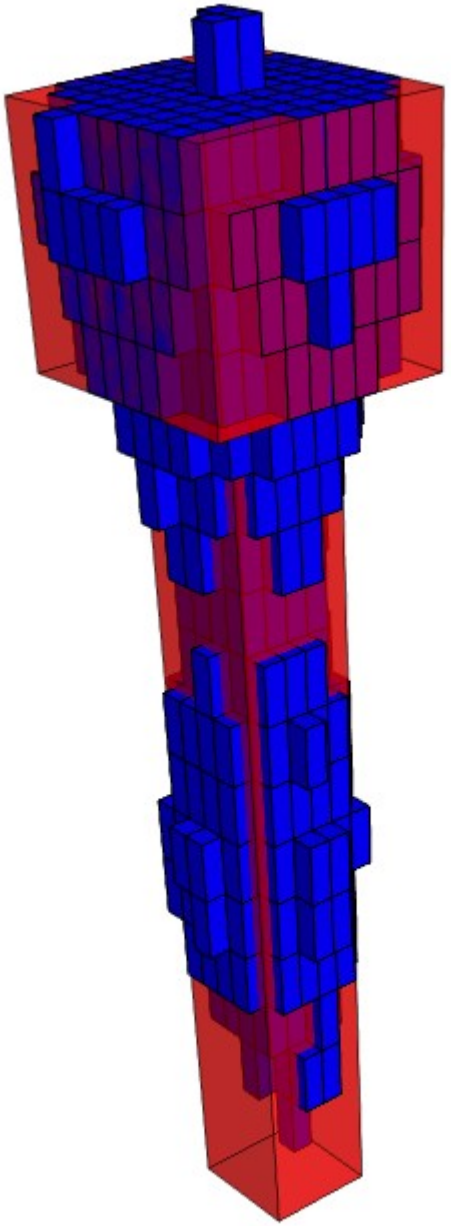

g_{zz}
observed
predicted
25°N
15°N
5°N
170°W
160°W
150°W
-0.16
-0.32
-0.24
-0.08
0


g_z
observed
predicted
25°N
15°N
5°N
170°W
160°W
150°W
-8
-14
-10
-12
-6
-4
-2
0

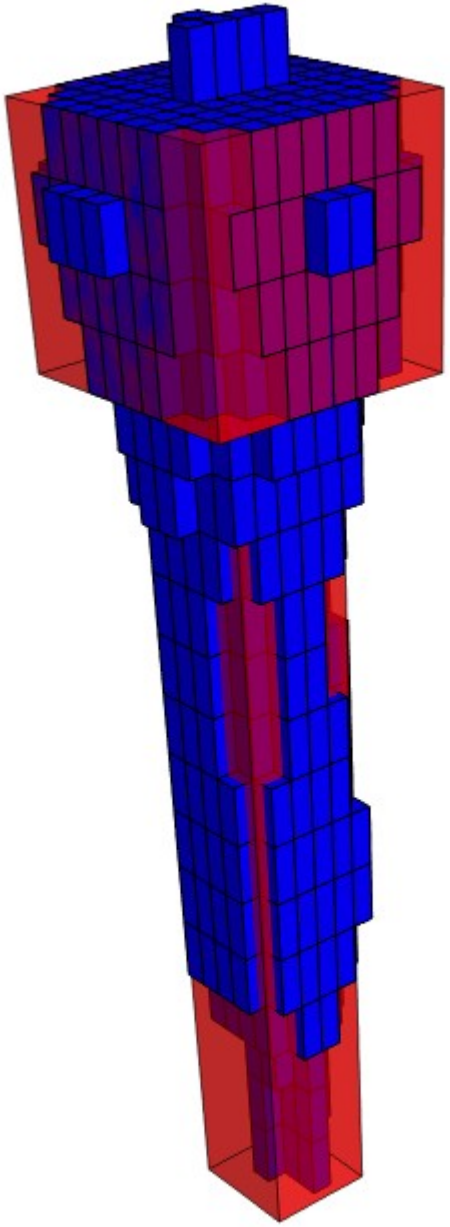

Residuals
400
350
300
250
200
150
100
50
0
−0.006
−0.002
0.002
0.006


Residuals
350
300
250
200
150
100
50
0
−0.4
−0.2
0.0
0.2
0.4

g_{zz}

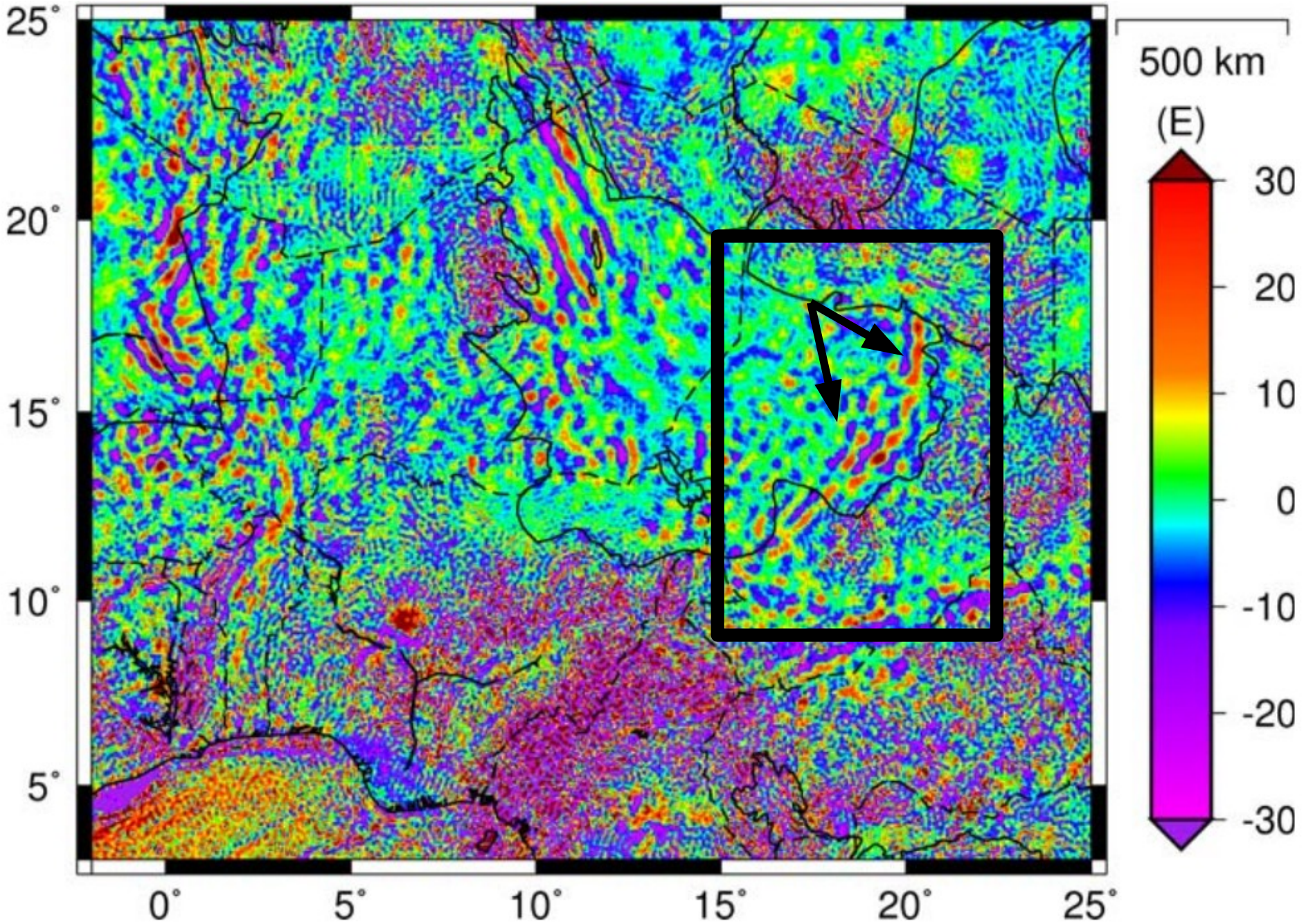


Joint

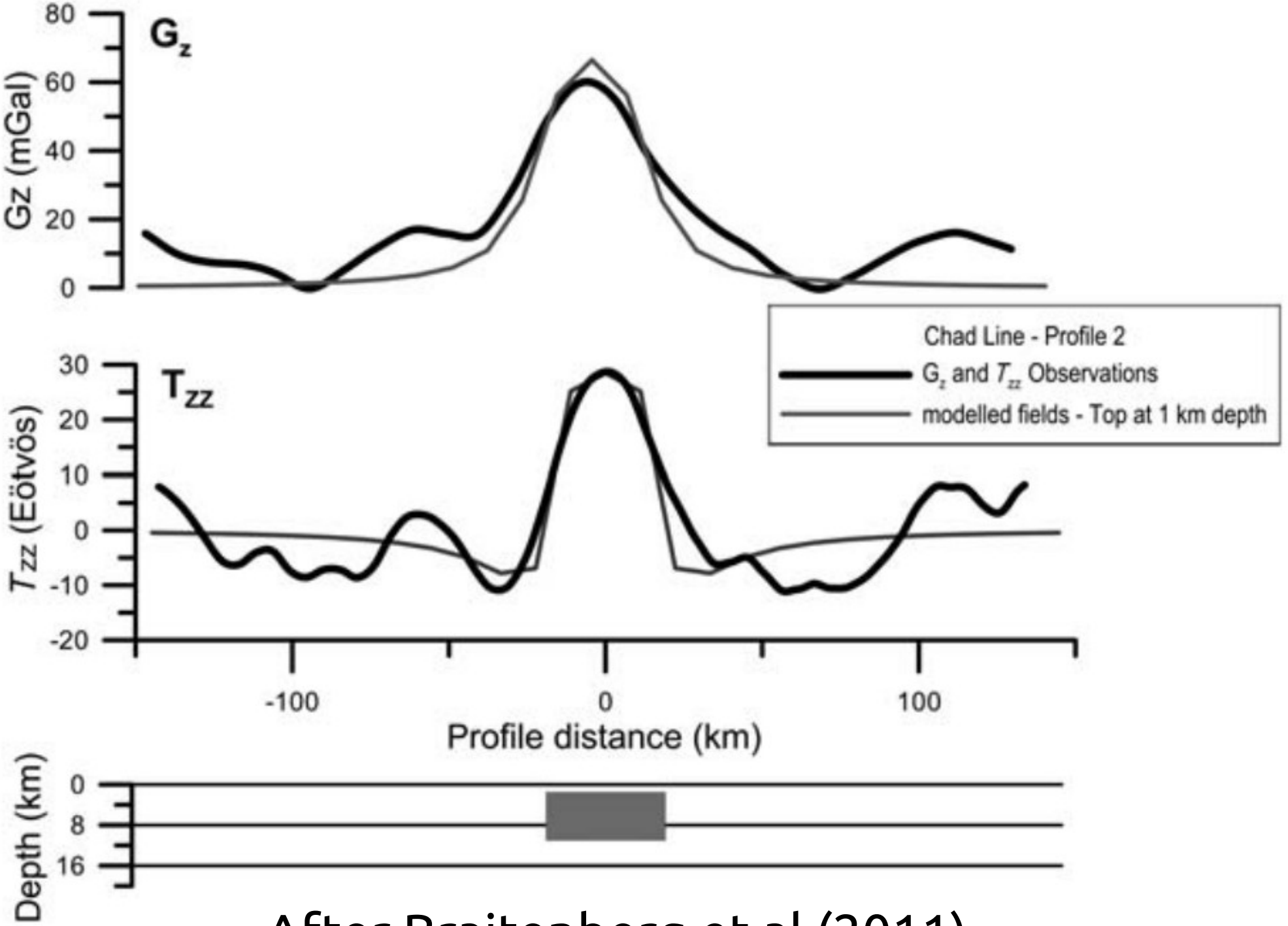


Lineament with dense rocks (magmatic)

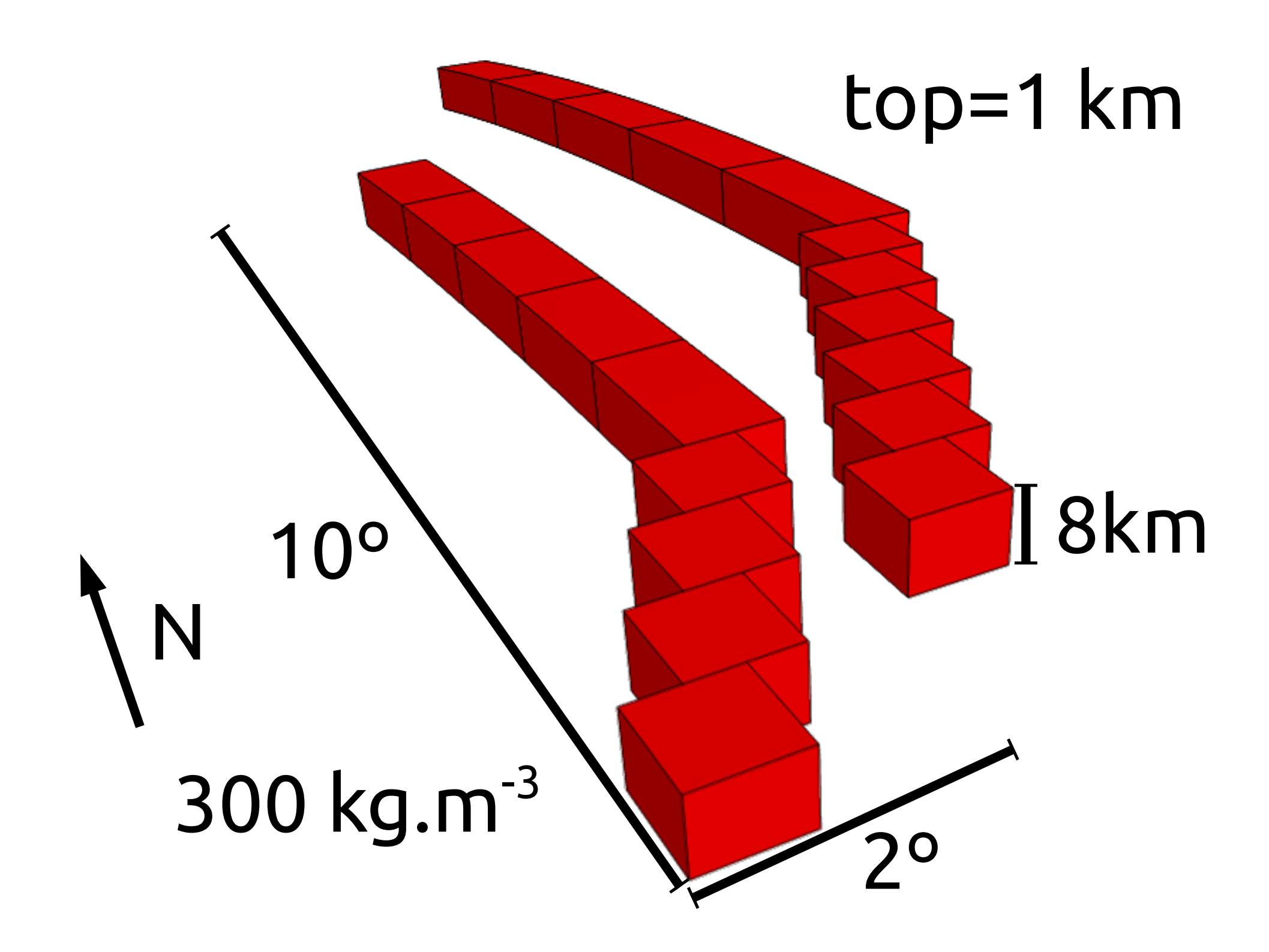
Inspired by Chad lineament model (Braitenberg et al, 2011)



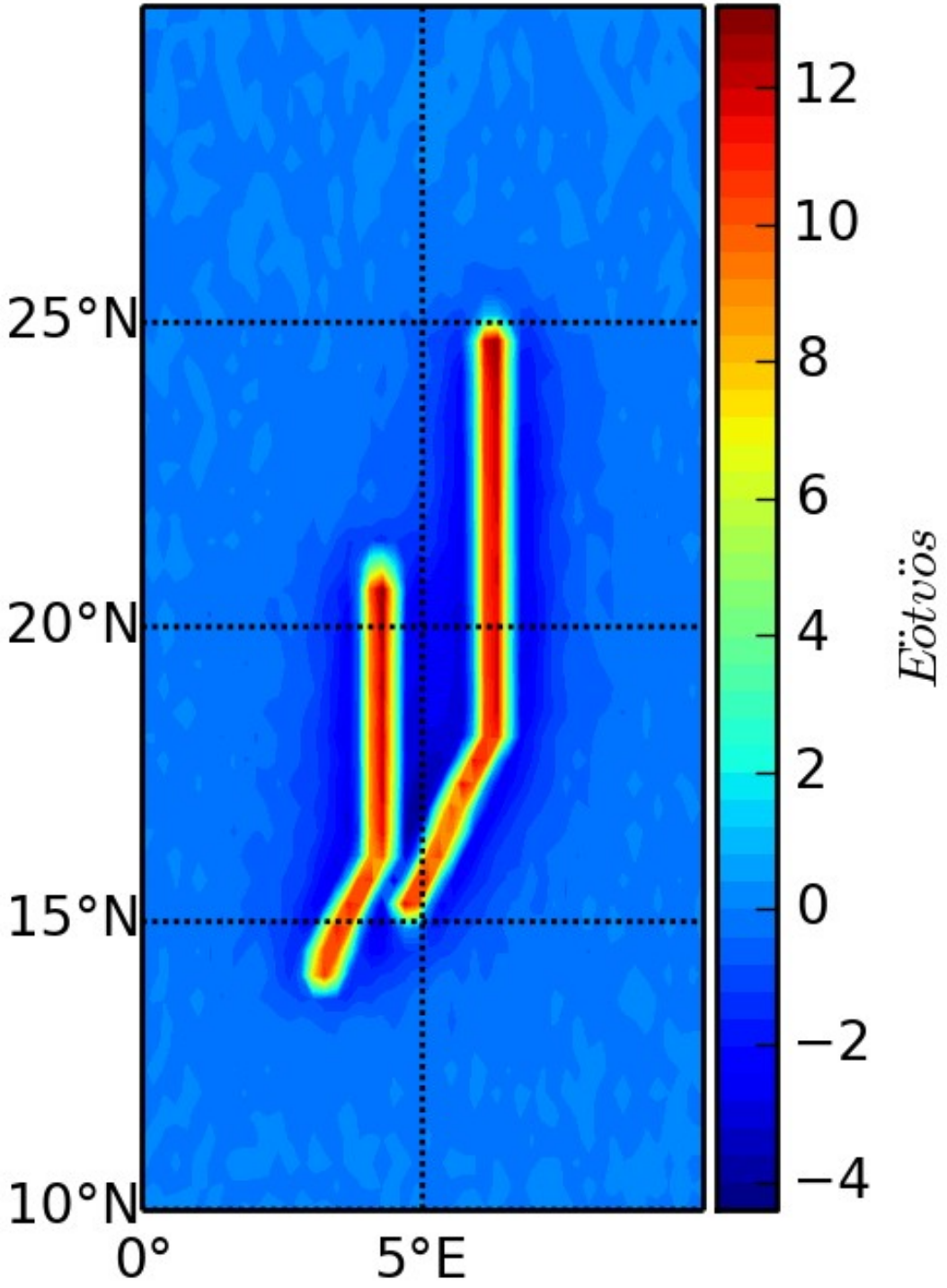
After Braitenberg et al (2011)



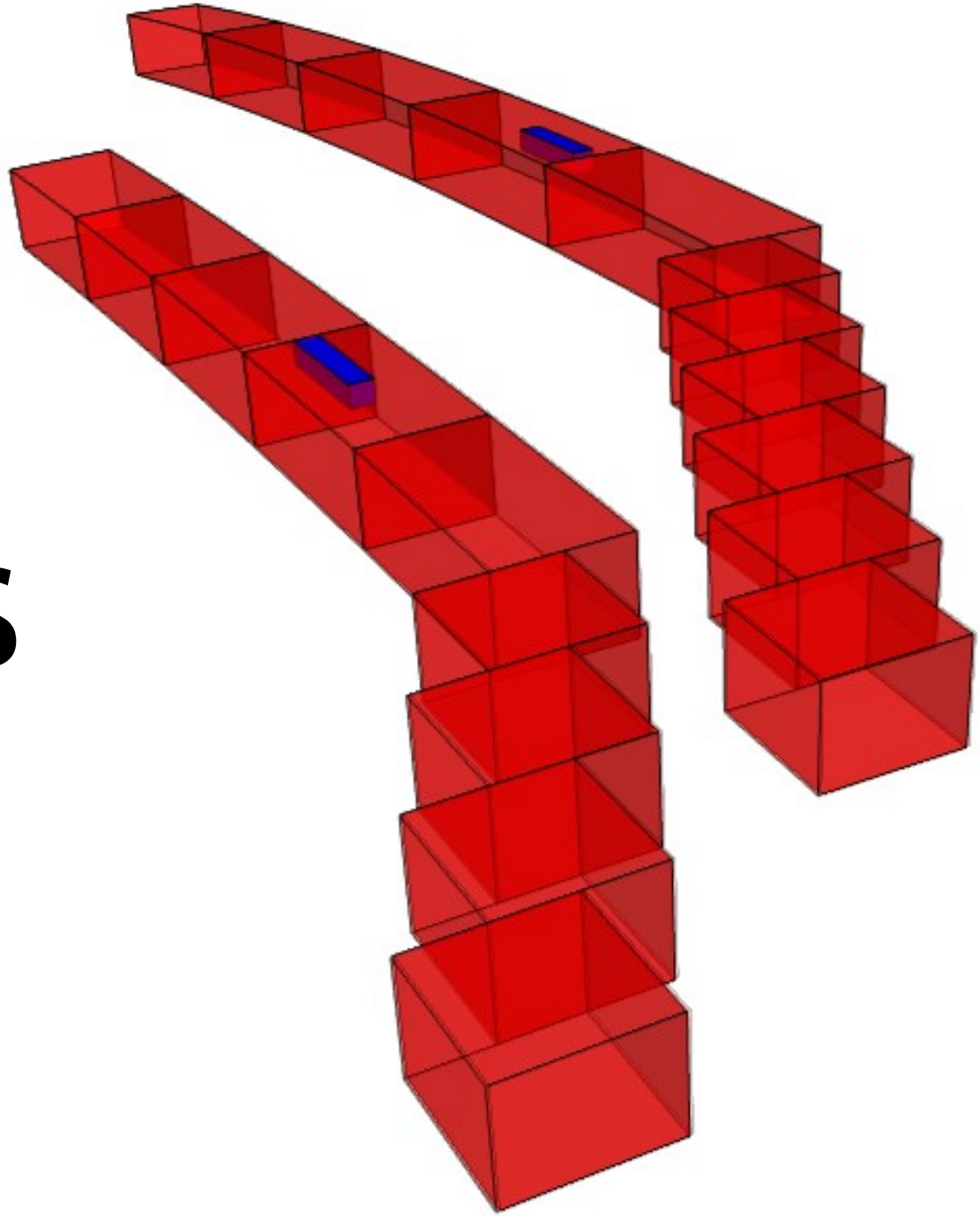
After Braitenberg et al (2011)

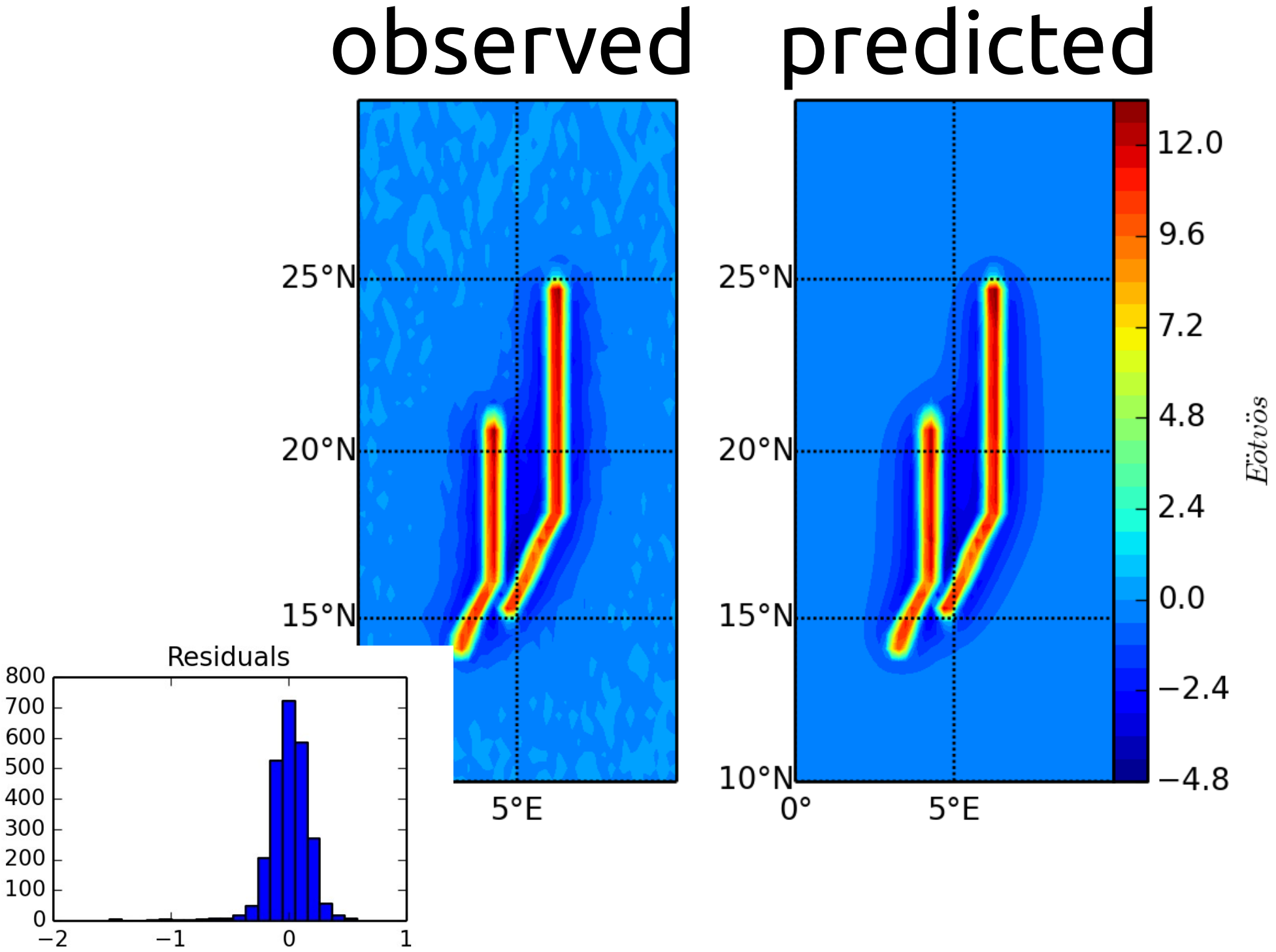

top=1 km
8km
10°
2°
N
300 kg.m-3

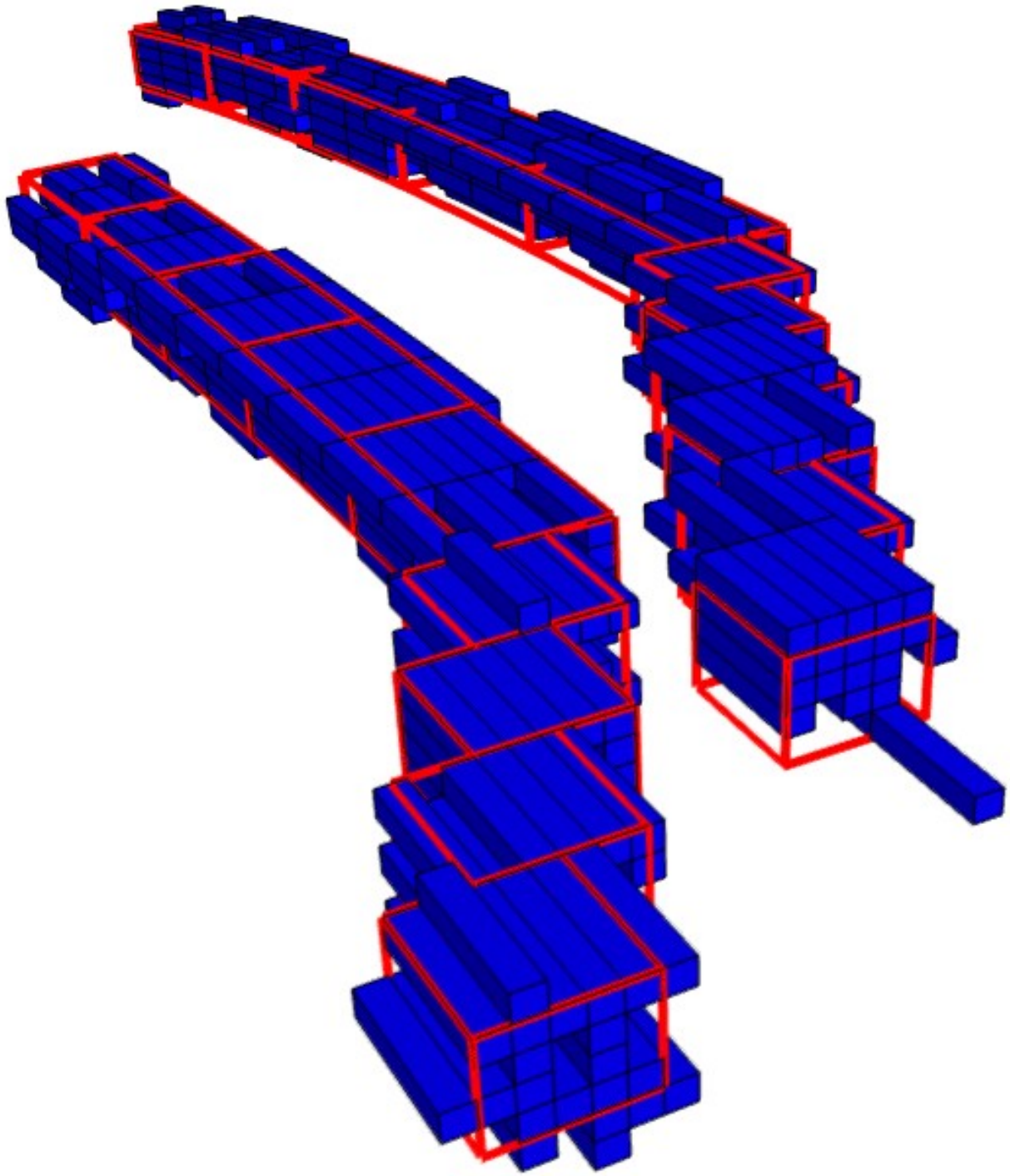
g_{zz}
At 20 km



Seeds

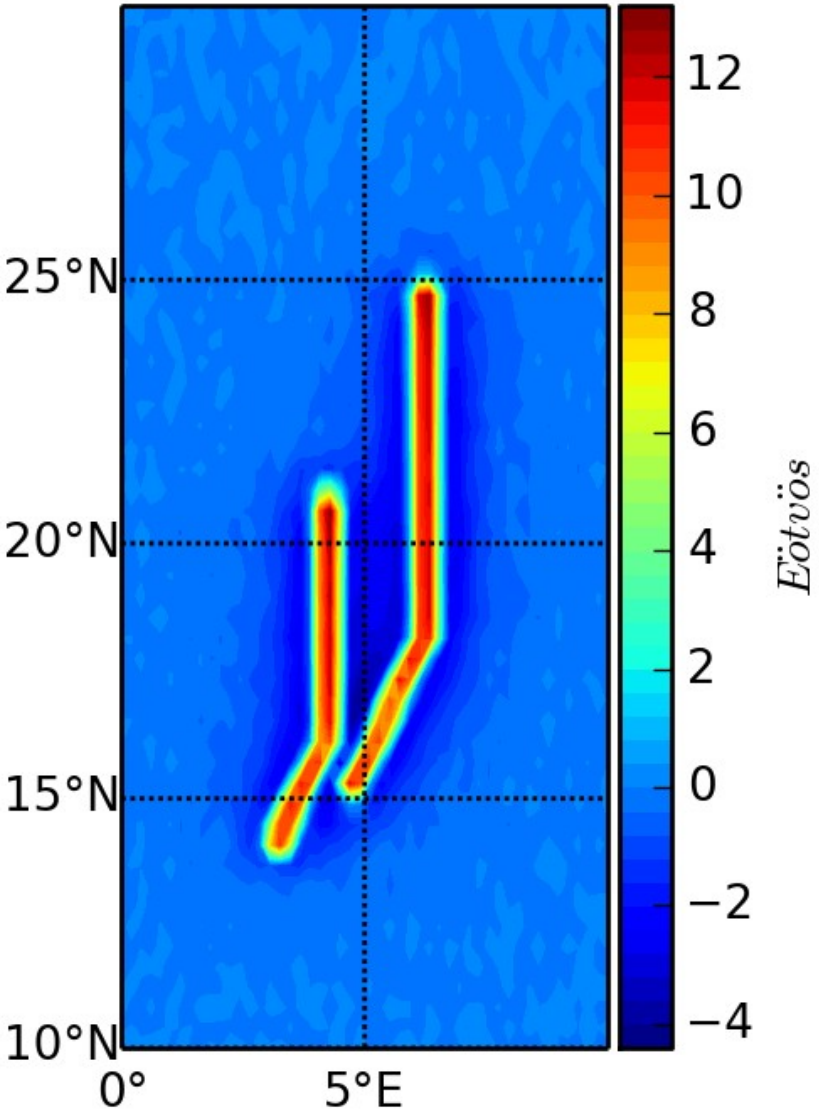



observed
predicted
25°N
20°N
15°N
10°N
0°
5°E
12.0
9.6
7.2
4.8
2.4
0.0
−2.4
−4.8
Eötvös
Residuals
800
700
600
500
400
300
200
100
0
−2
−1
0
1

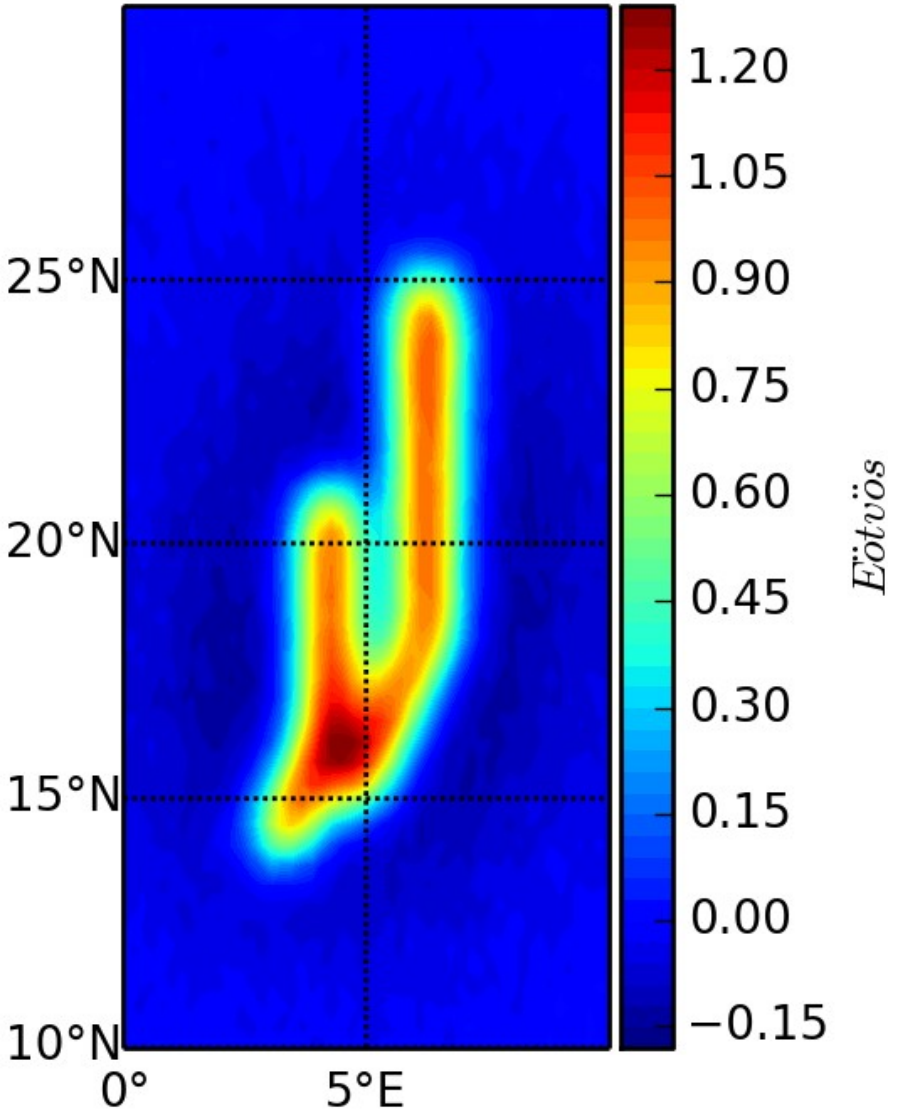


What if height=120 km?

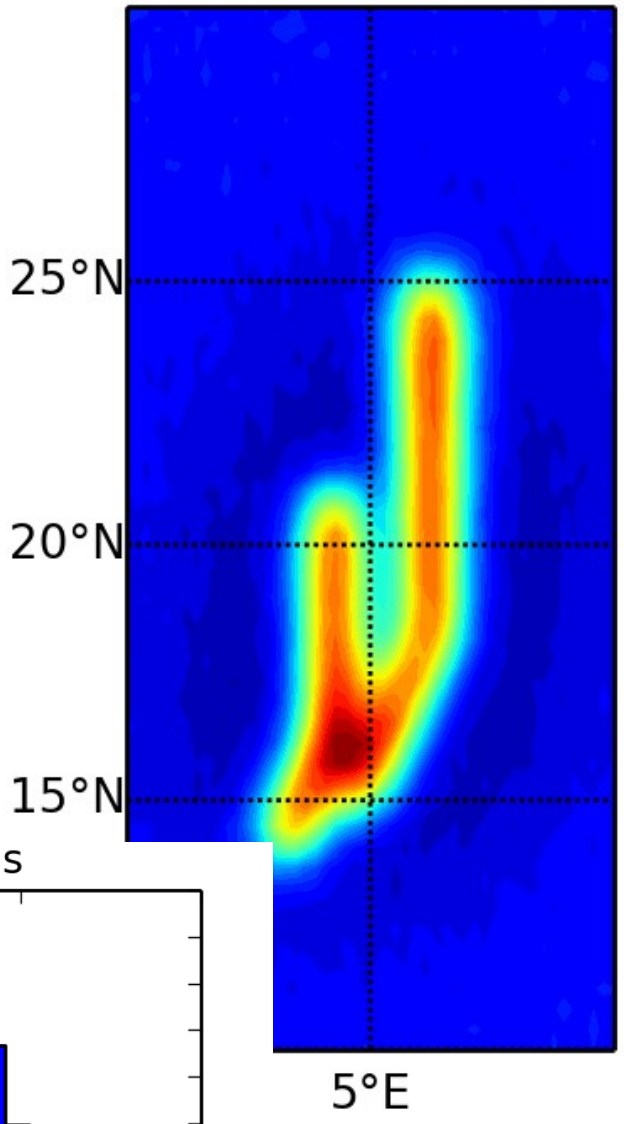
at 20 km

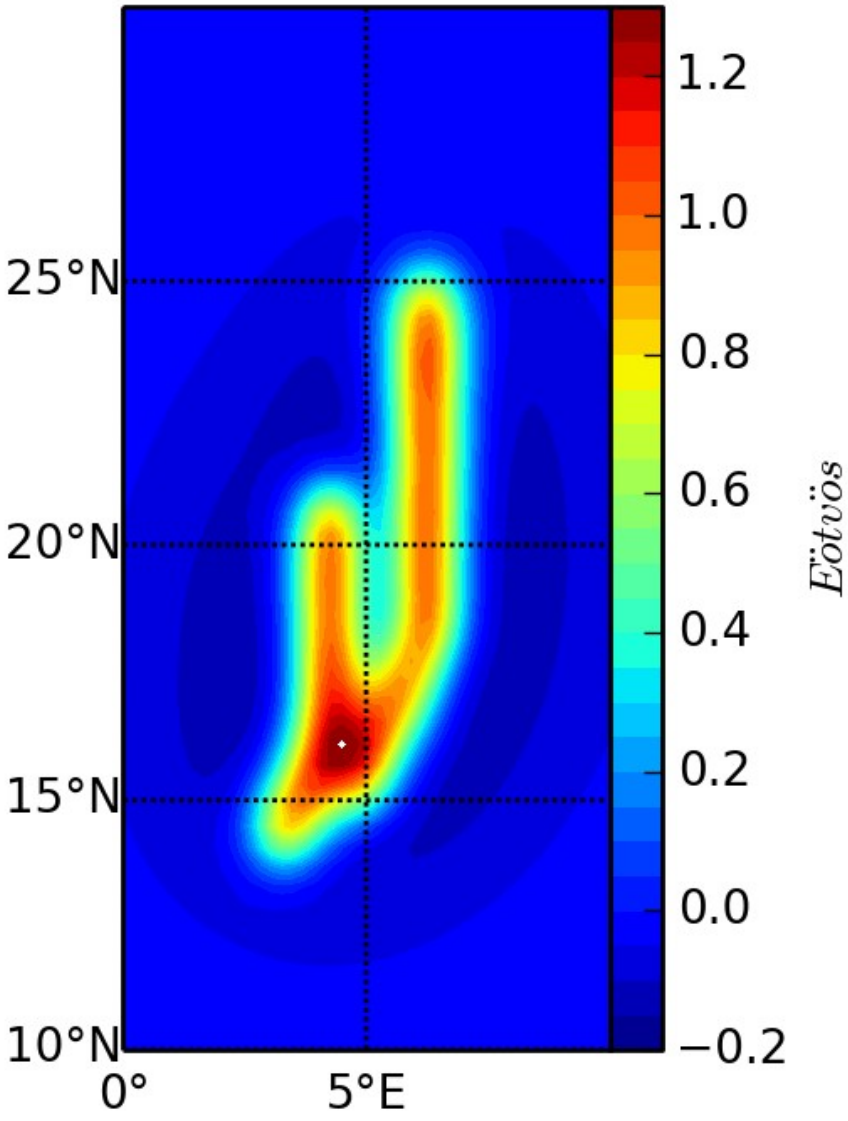


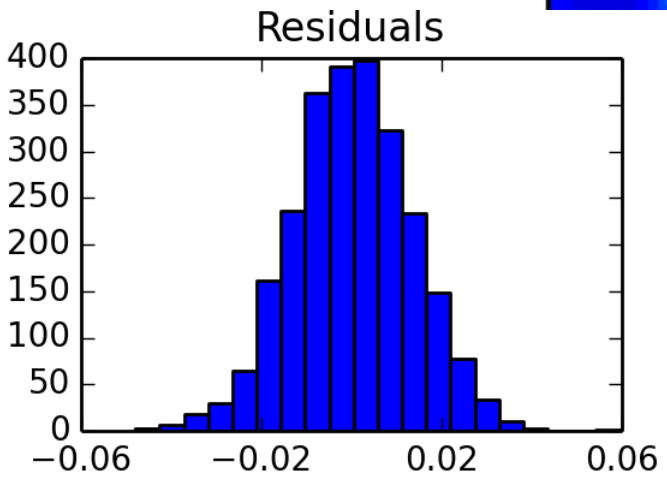
at 120 km



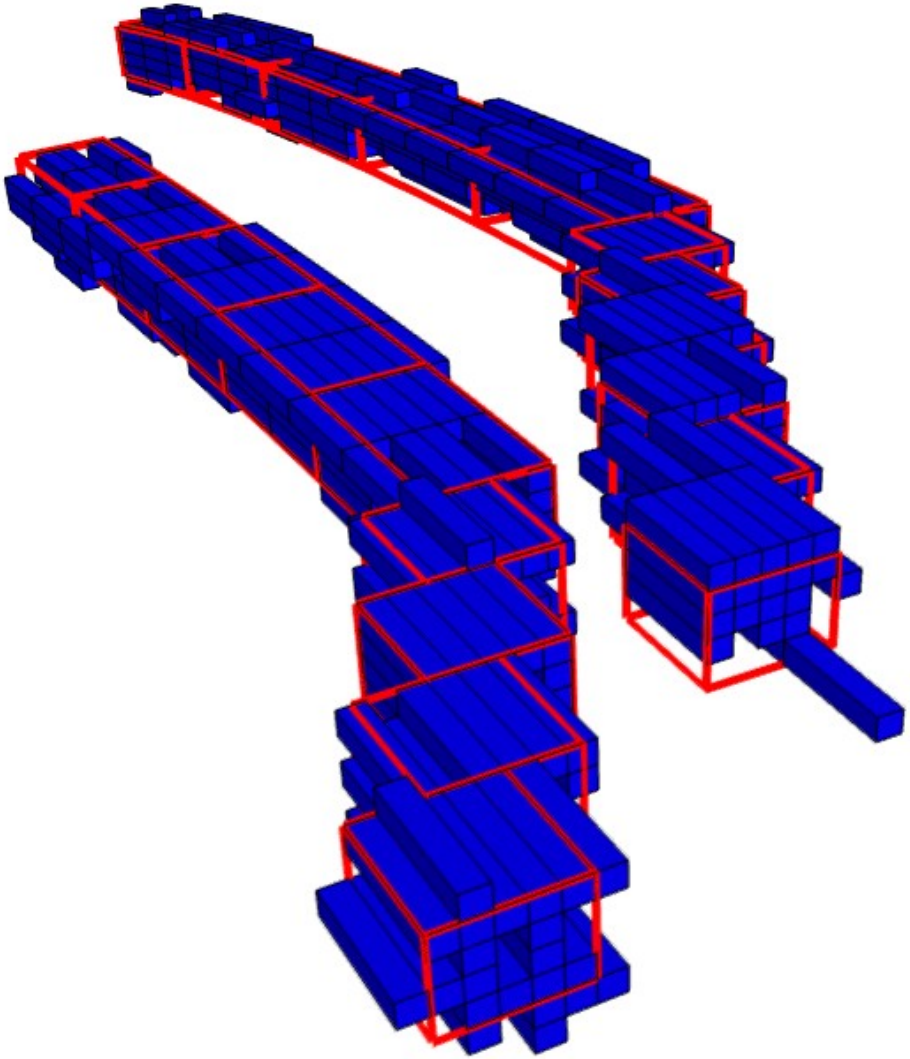
observed predicted



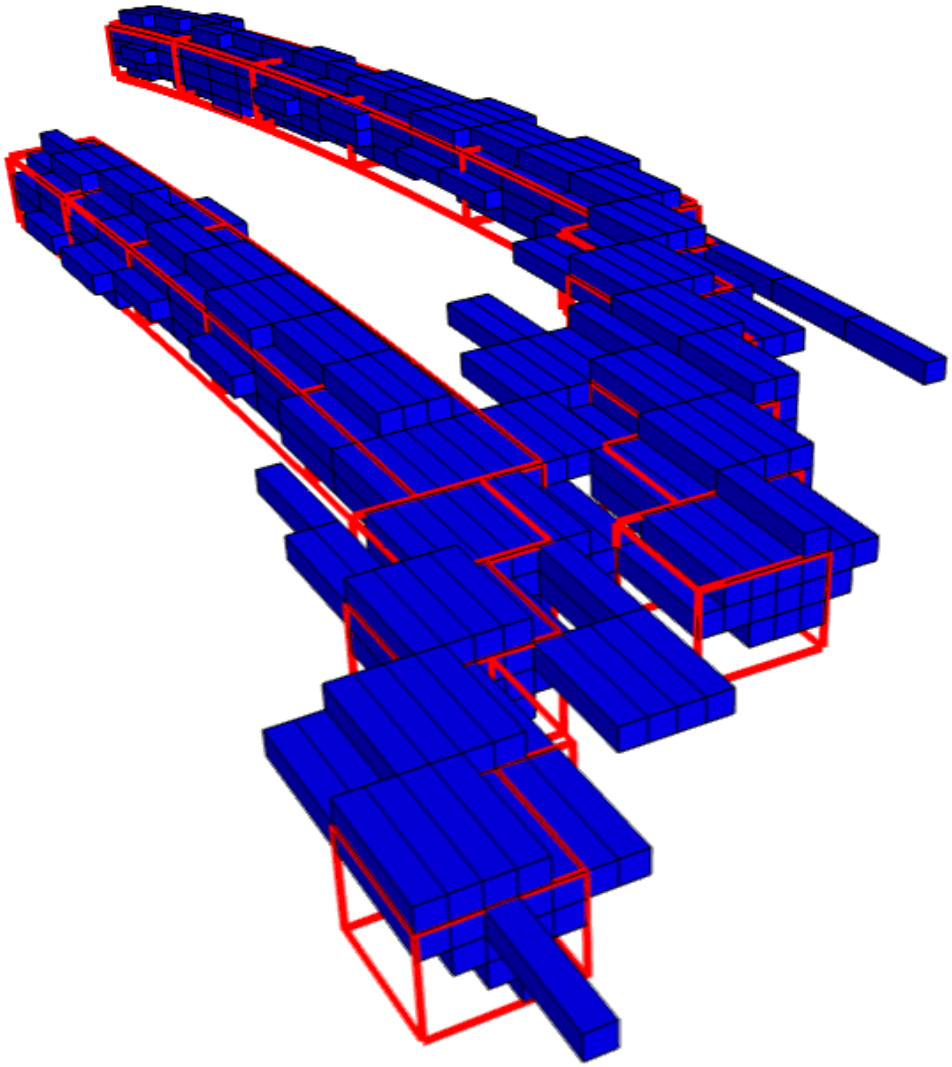




at 20 km



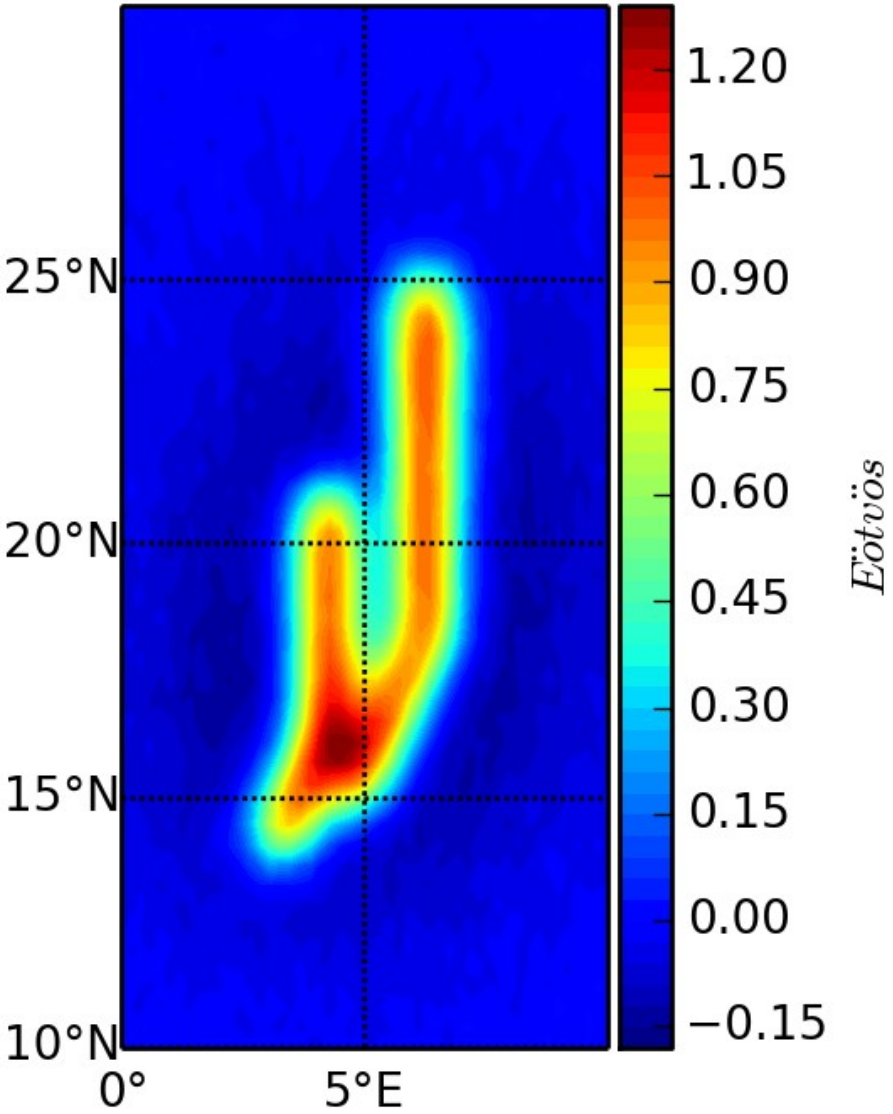
at 120 km



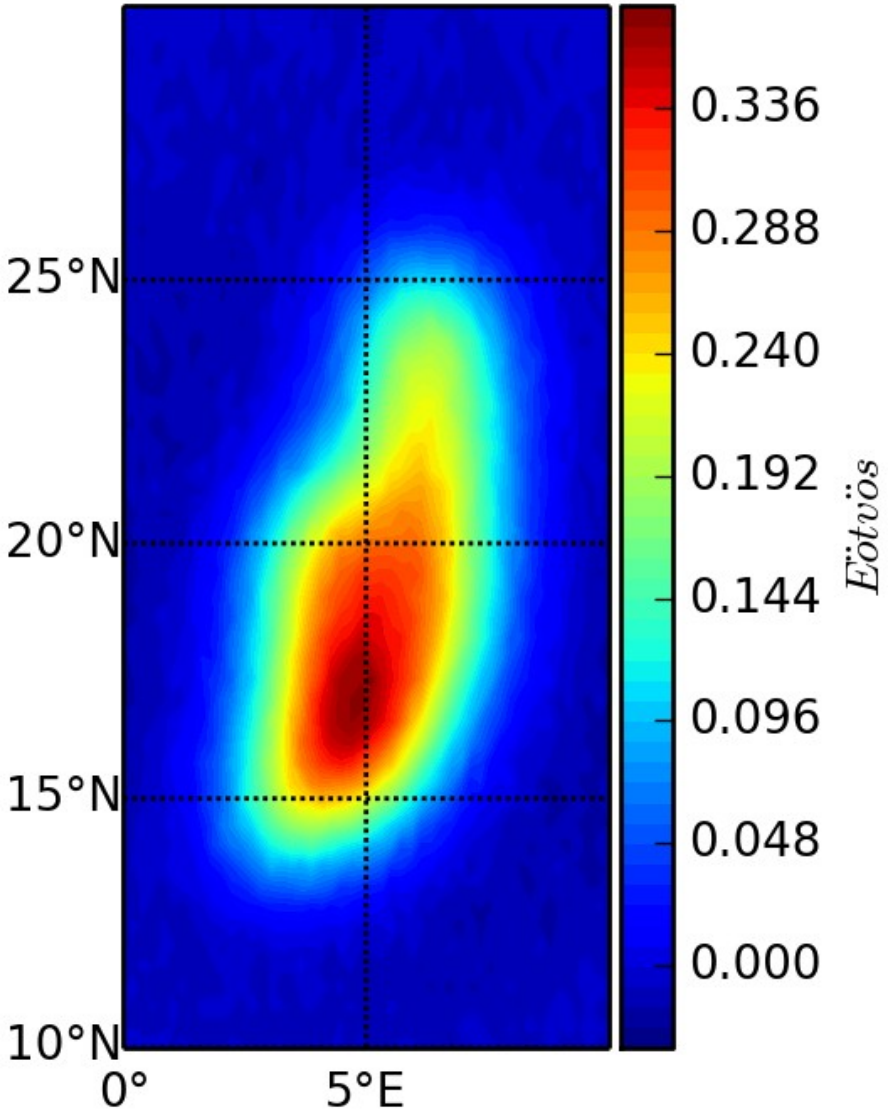
Even higher

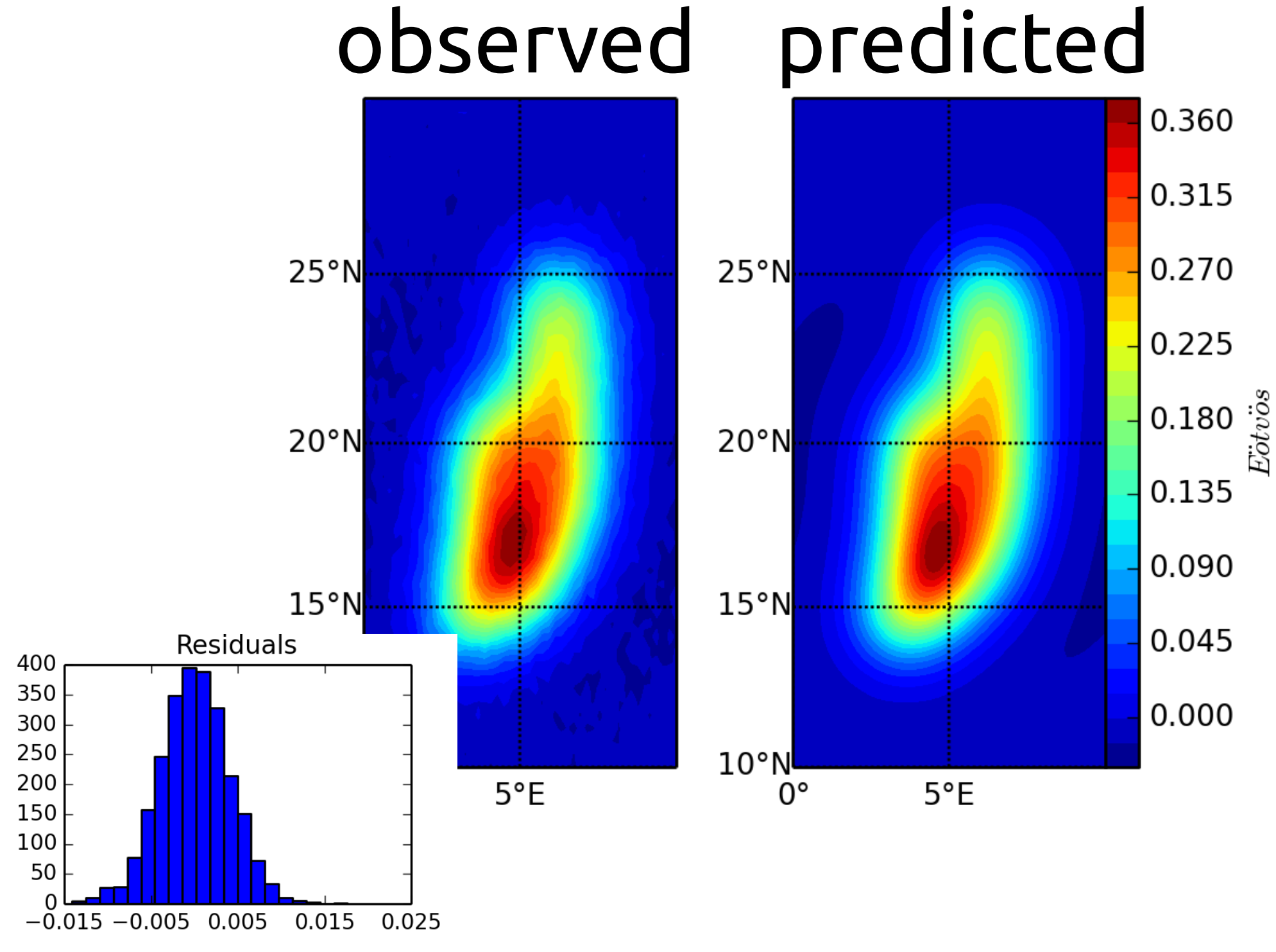
height=270 km

at 120 km

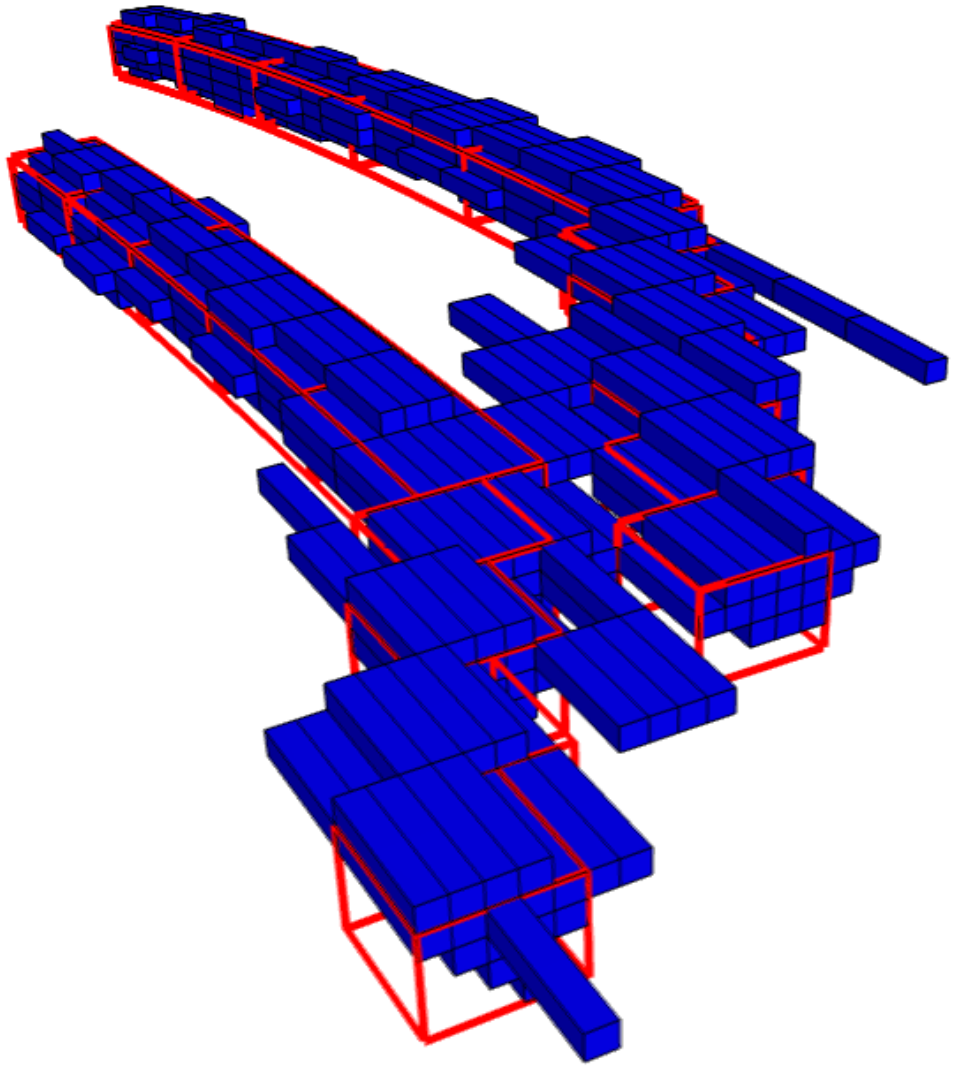


at 270 km

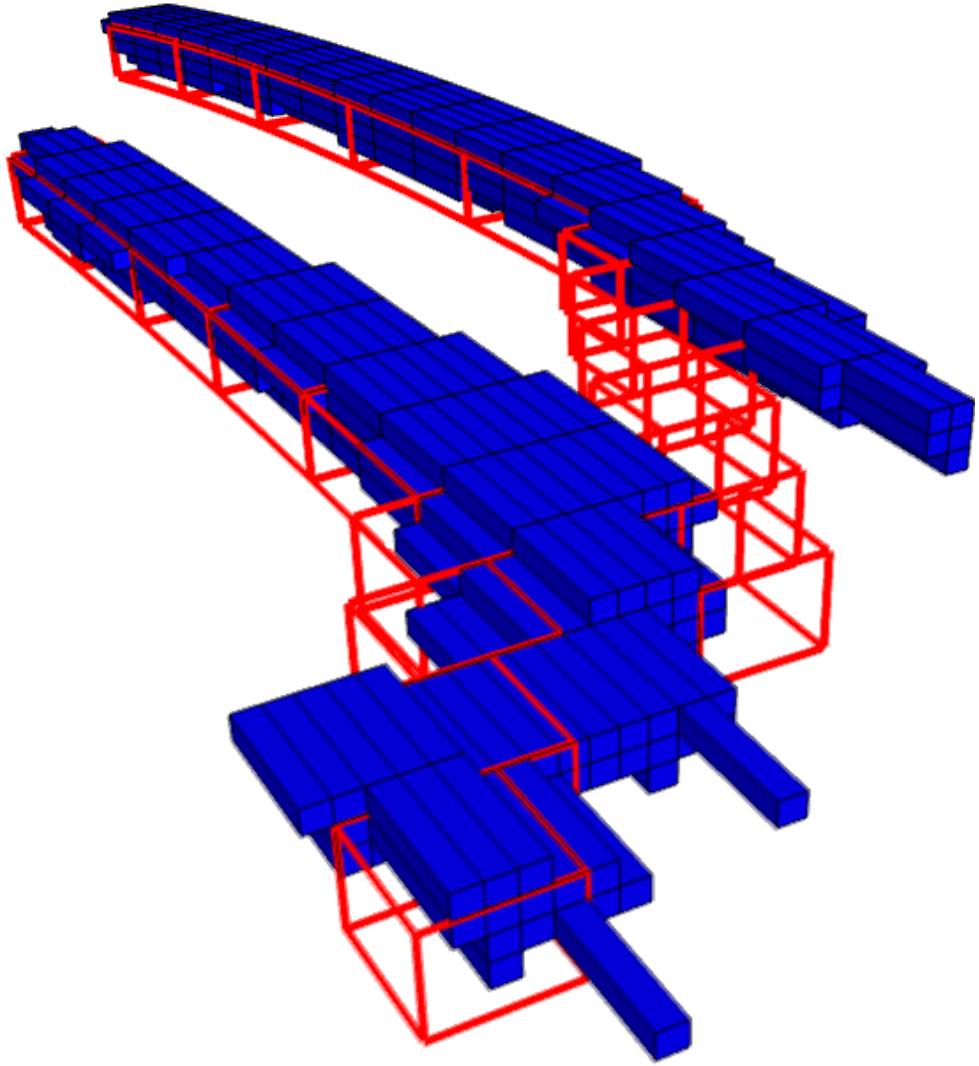



observed
predicted
25°N
20°N
15°N
10°N
0°
5°E
0.360
0.315
0.270
0.225
0.180
0.135
0.090
0.045
0.000
Eötvös
Residuals
400
350
300
250
200
150
100
50
0
−0.015
−0.005
0.005
0.015
0.025

at 120 km

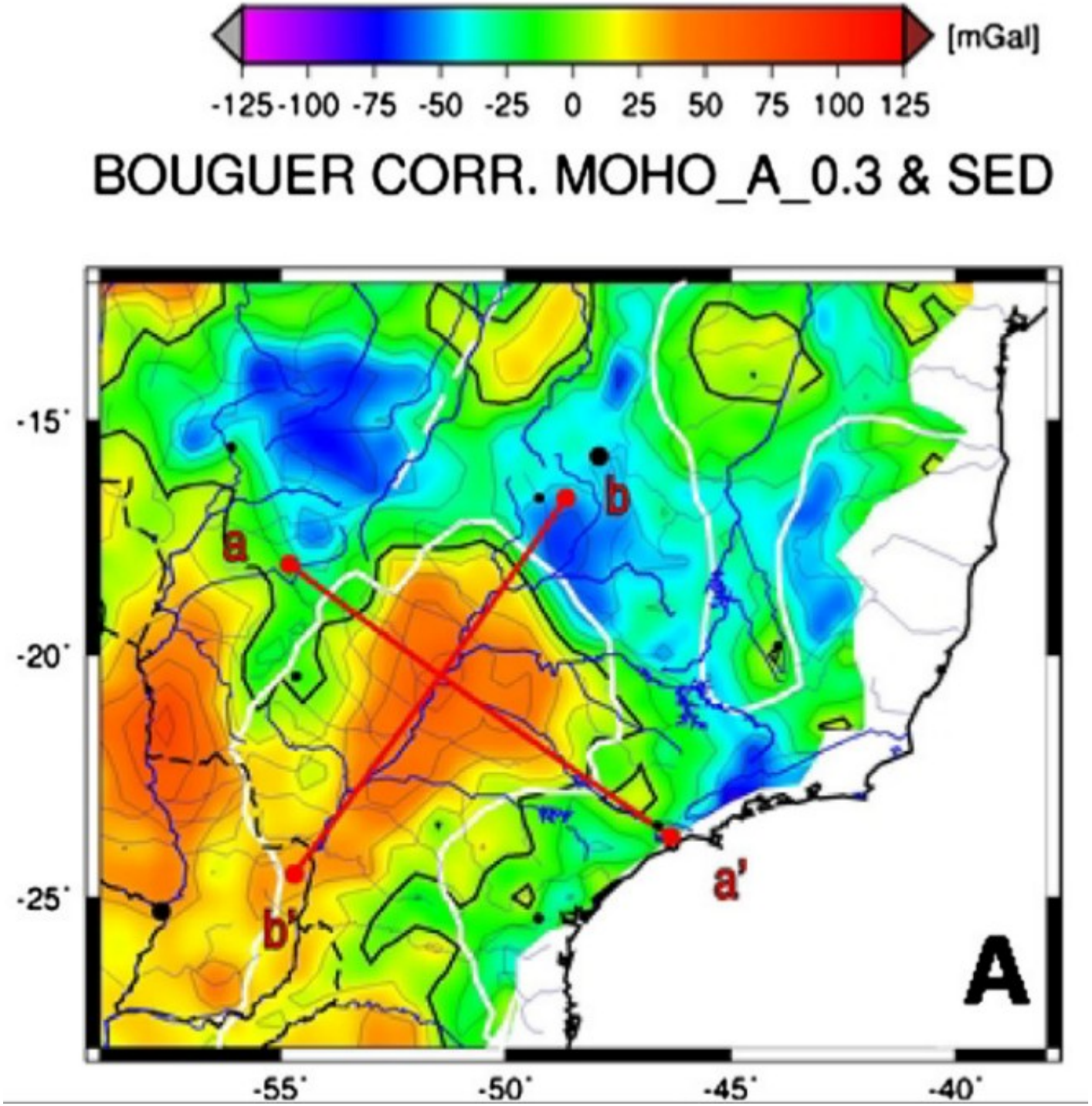


at 270 km

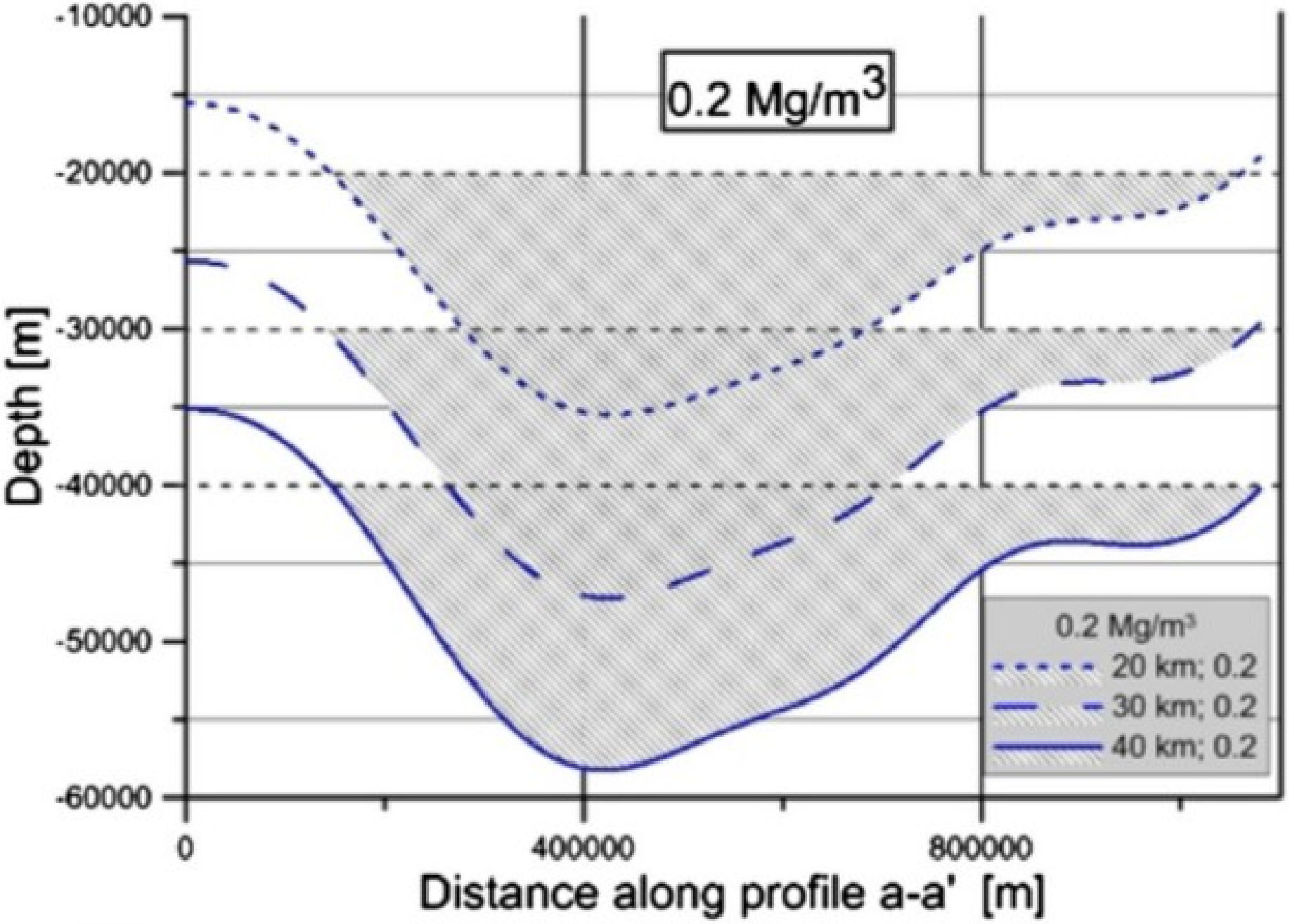


Magmatic underplating

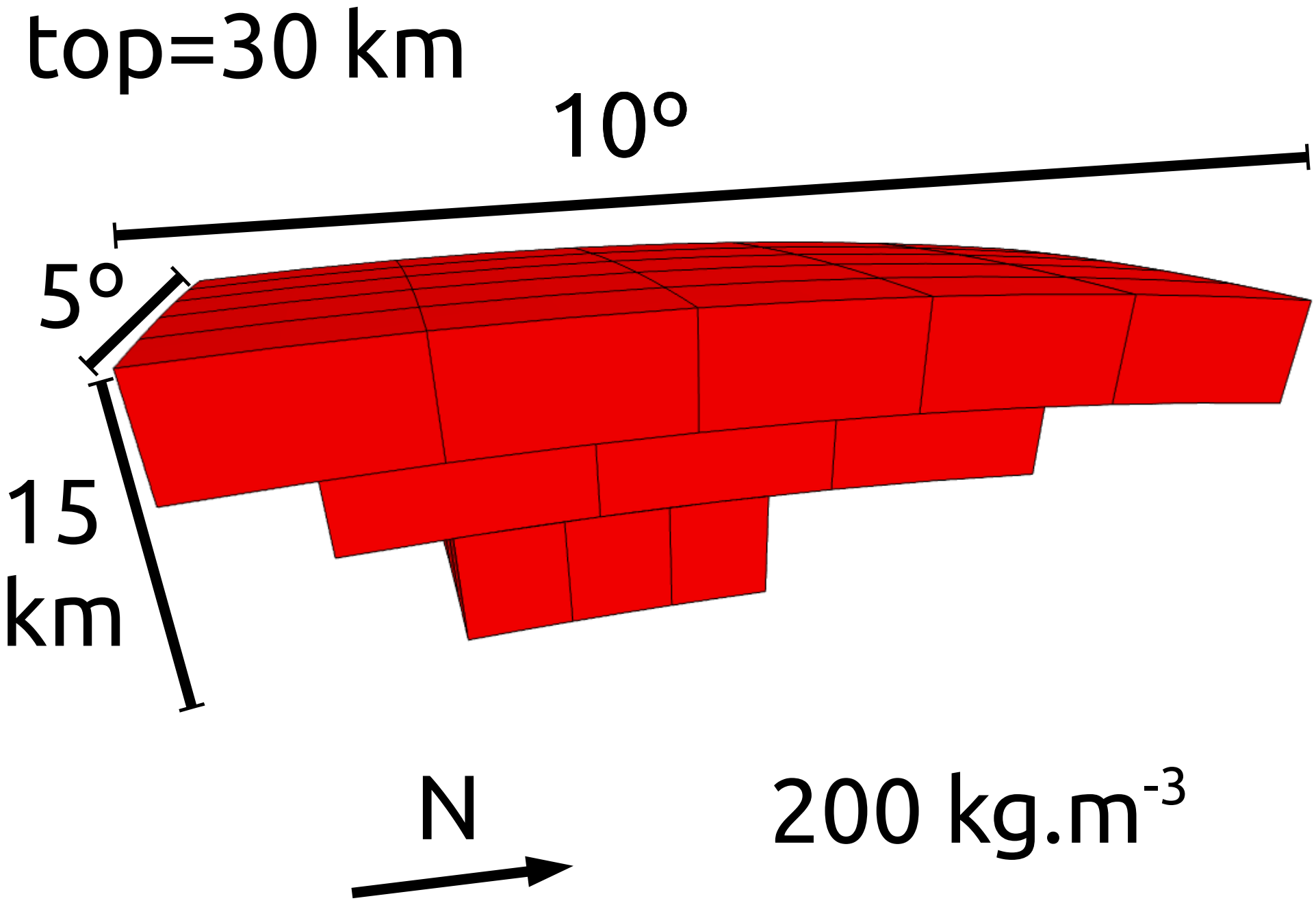
Inspired by model of the Paraná basin
by Mariani et al (2013)



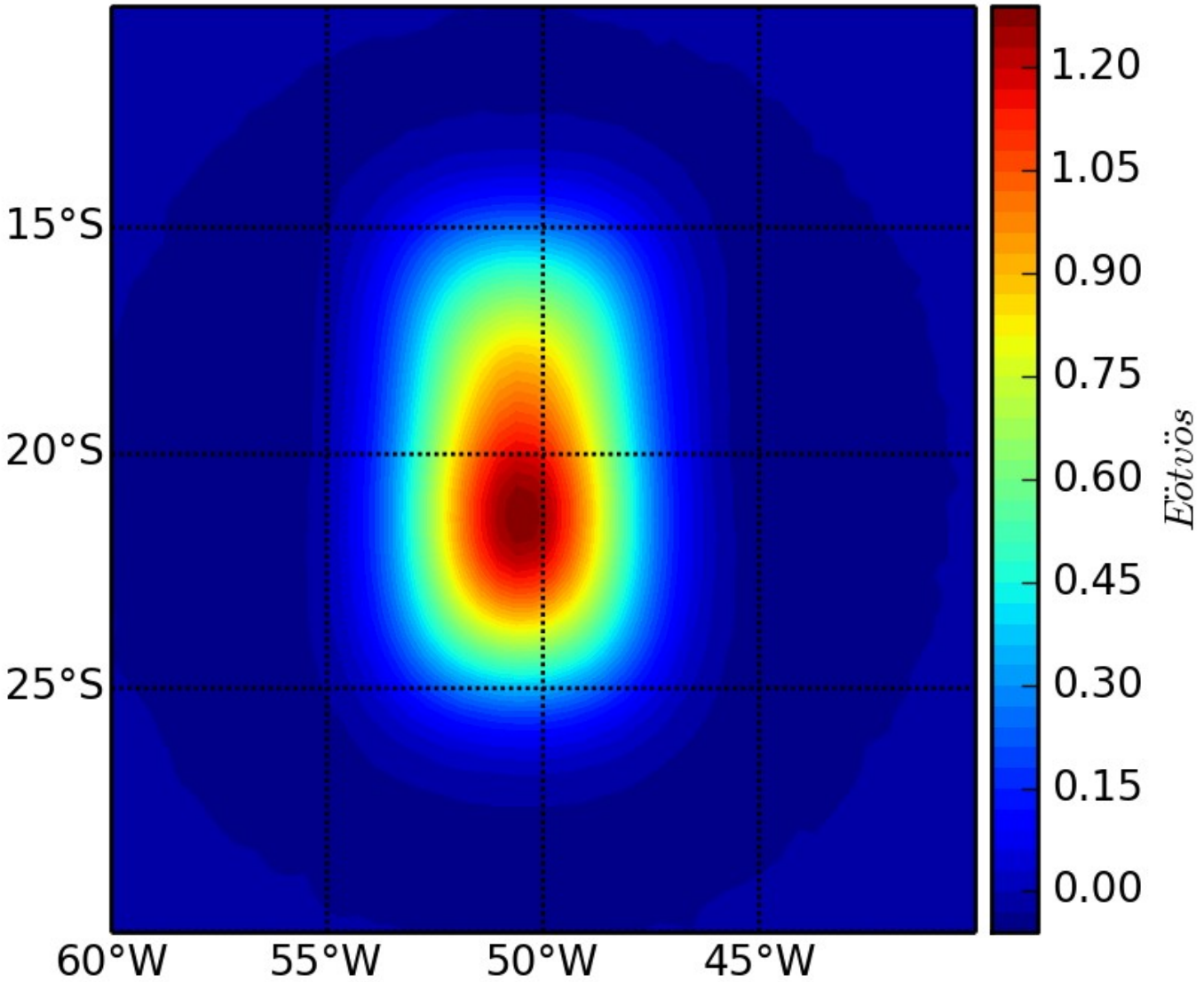
After Mariani et al (2013)



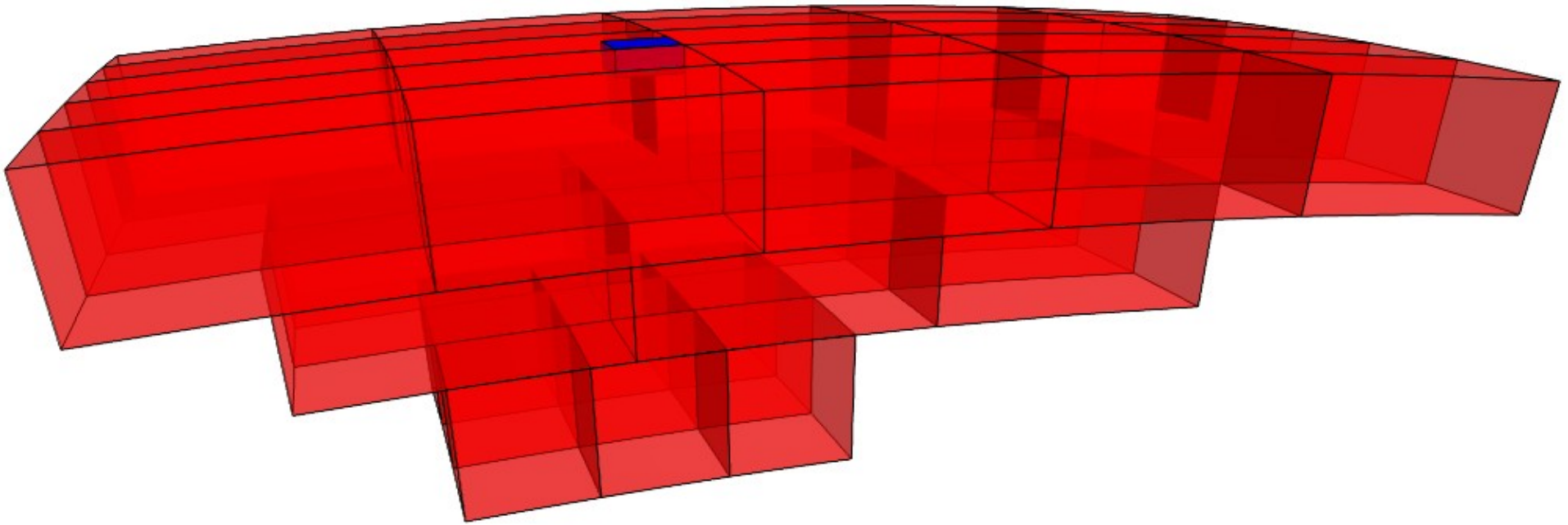
After Mariani et al (2013)

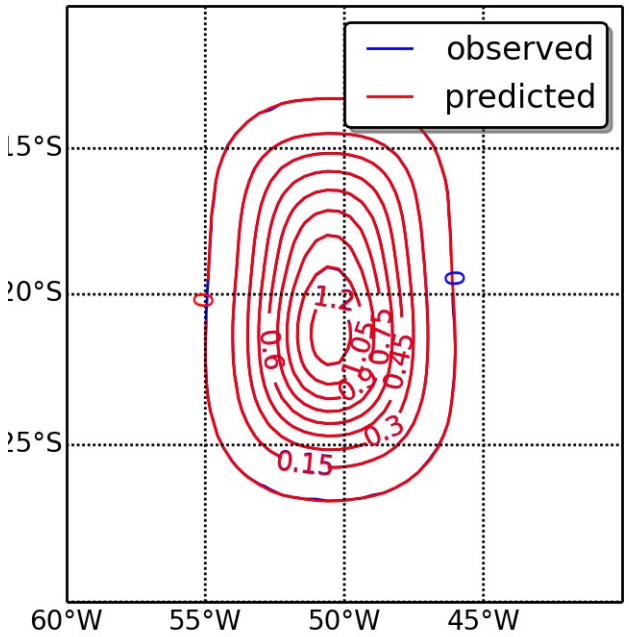

top=30 km
10°
5°
15
km
N
200 kg.m-3

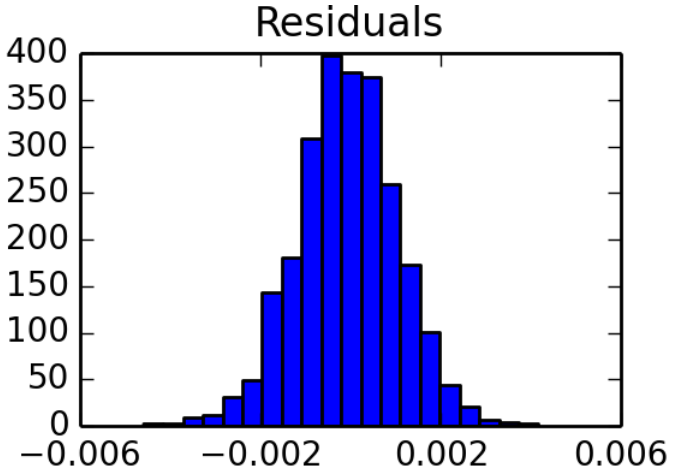
g_{zz} at 250 km

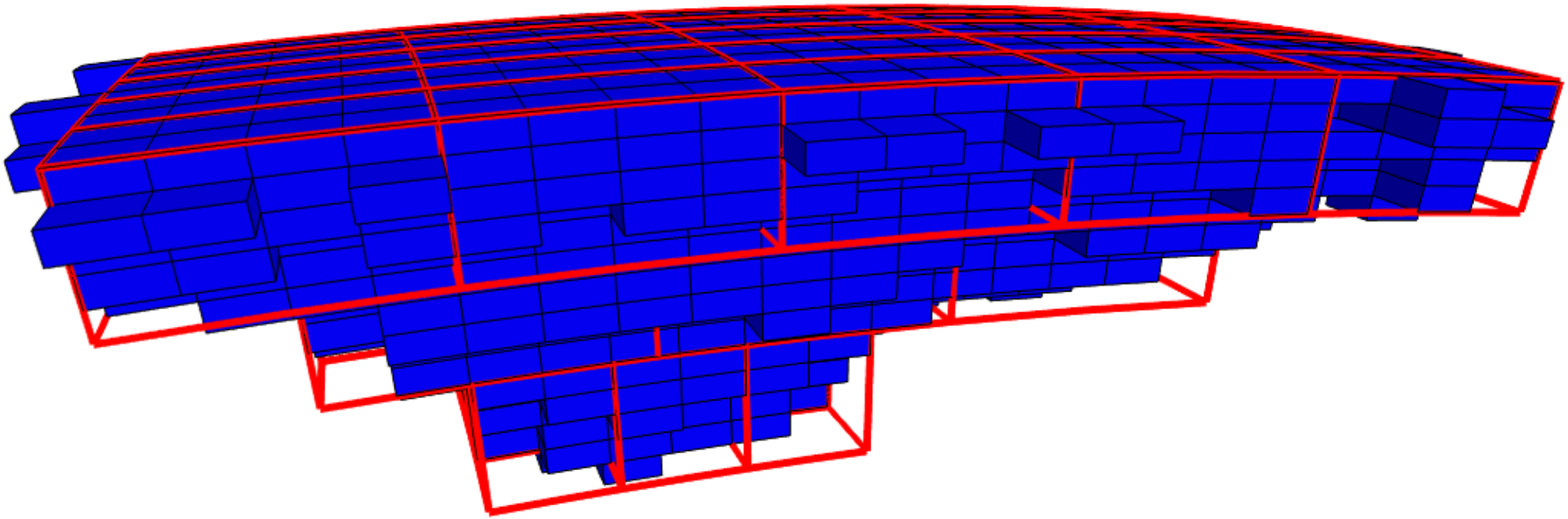

15°S
20°S
25°S
60°W
55°W
50°W
45°W
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
Eötvös

Seed

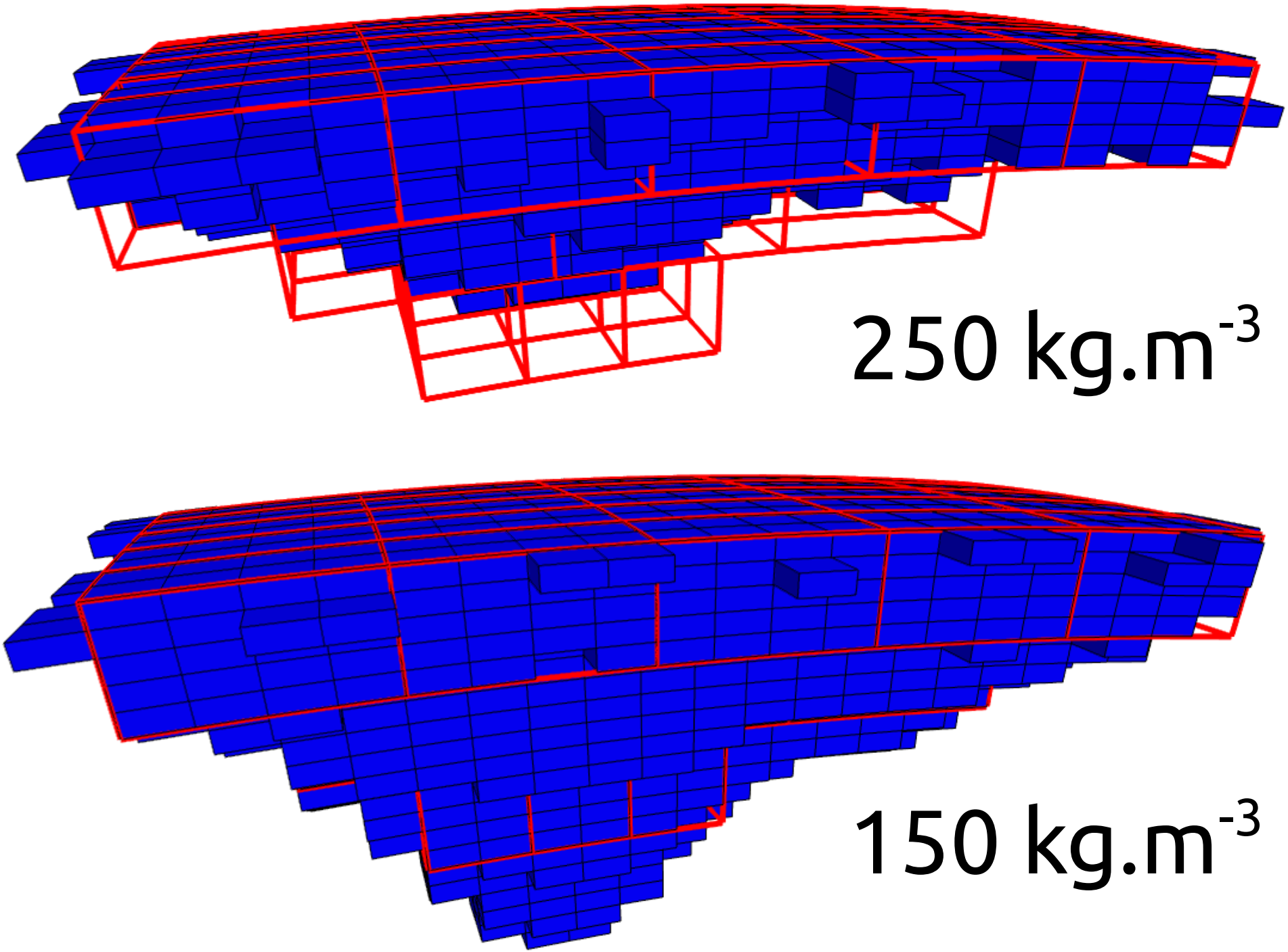



observed
predicted
15°S
20°S
25°S
60°W
55°W
50°W
45°W
1.2
0.9
0.6
0.45
0.3
0.15

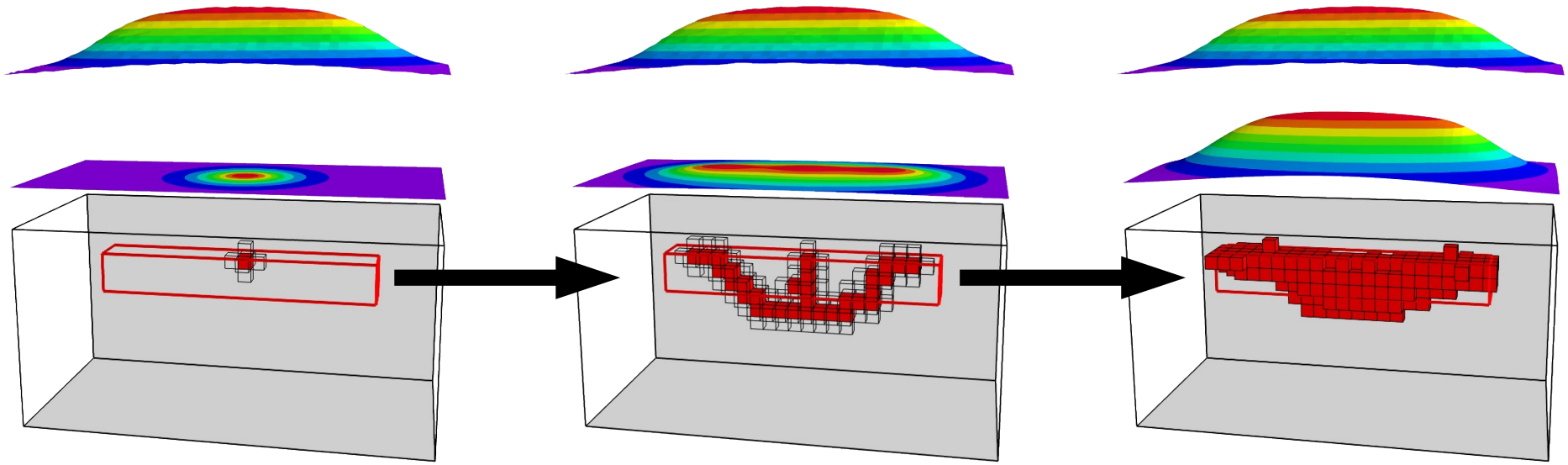

Residuals
400
350
300
250
200
150
100
50
0
−0.006
−0.002
0.002
0.006

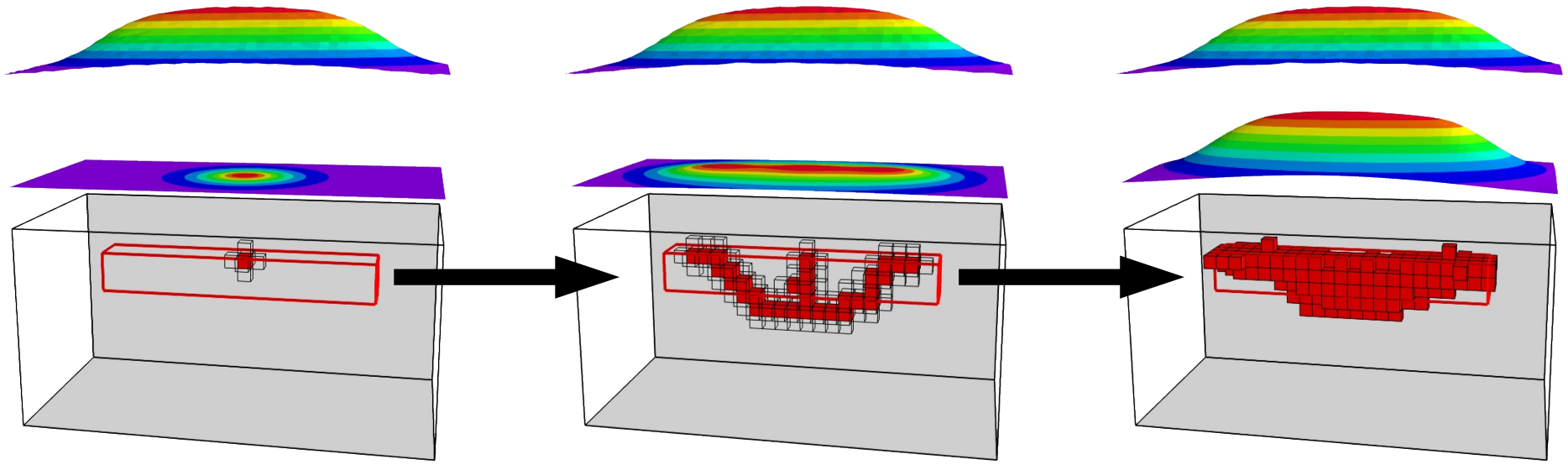


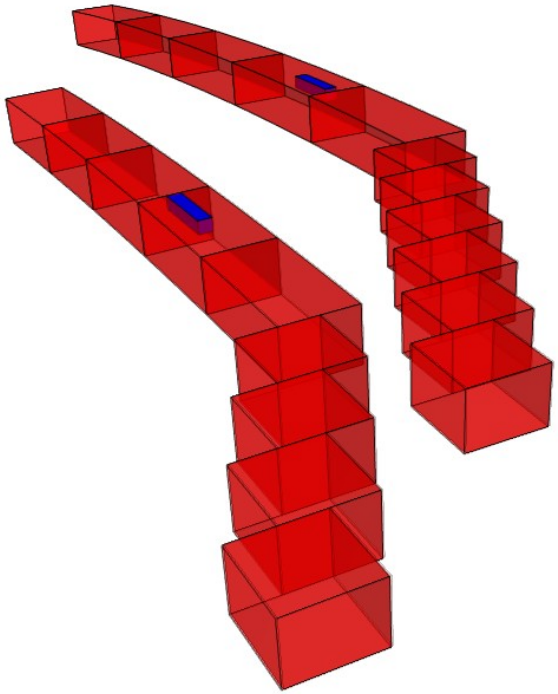
What if I use wrong density?


250 kg.m-3
150 kg.m-3

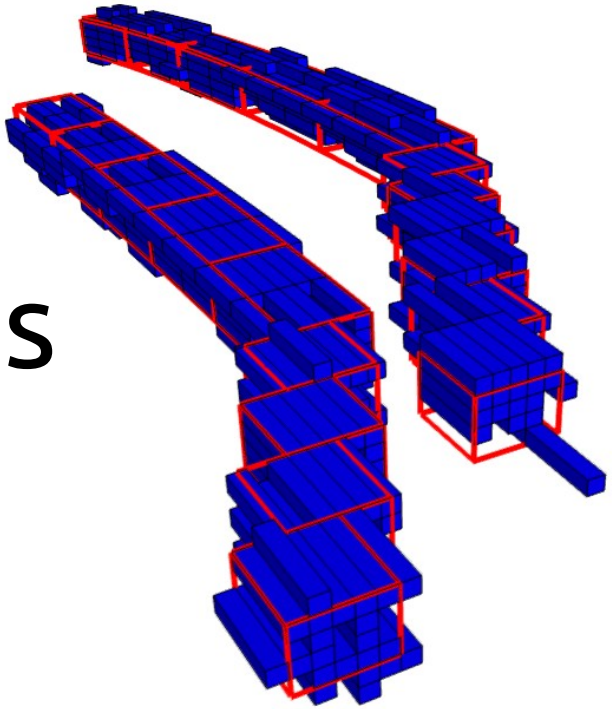
In conclusion



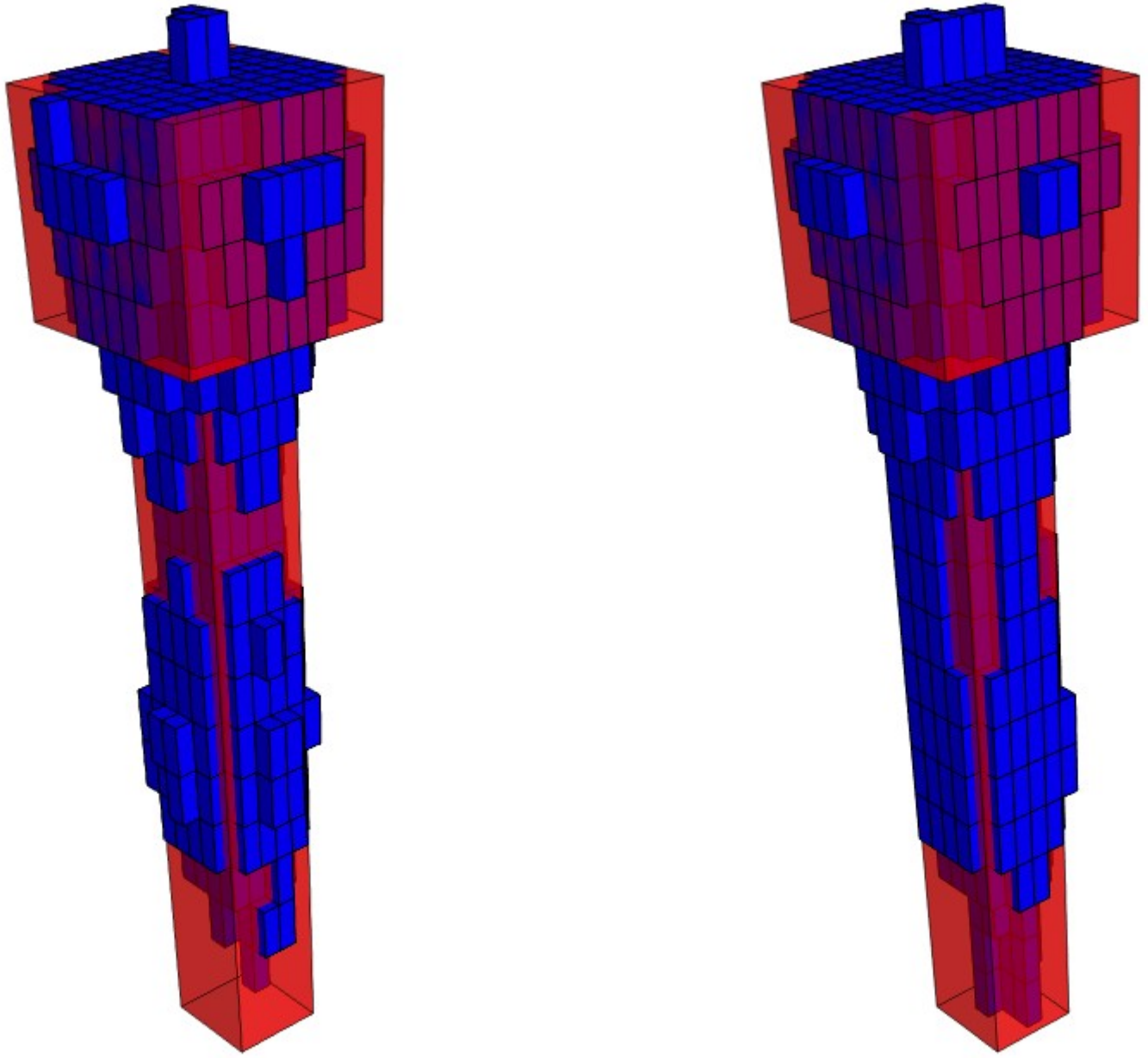




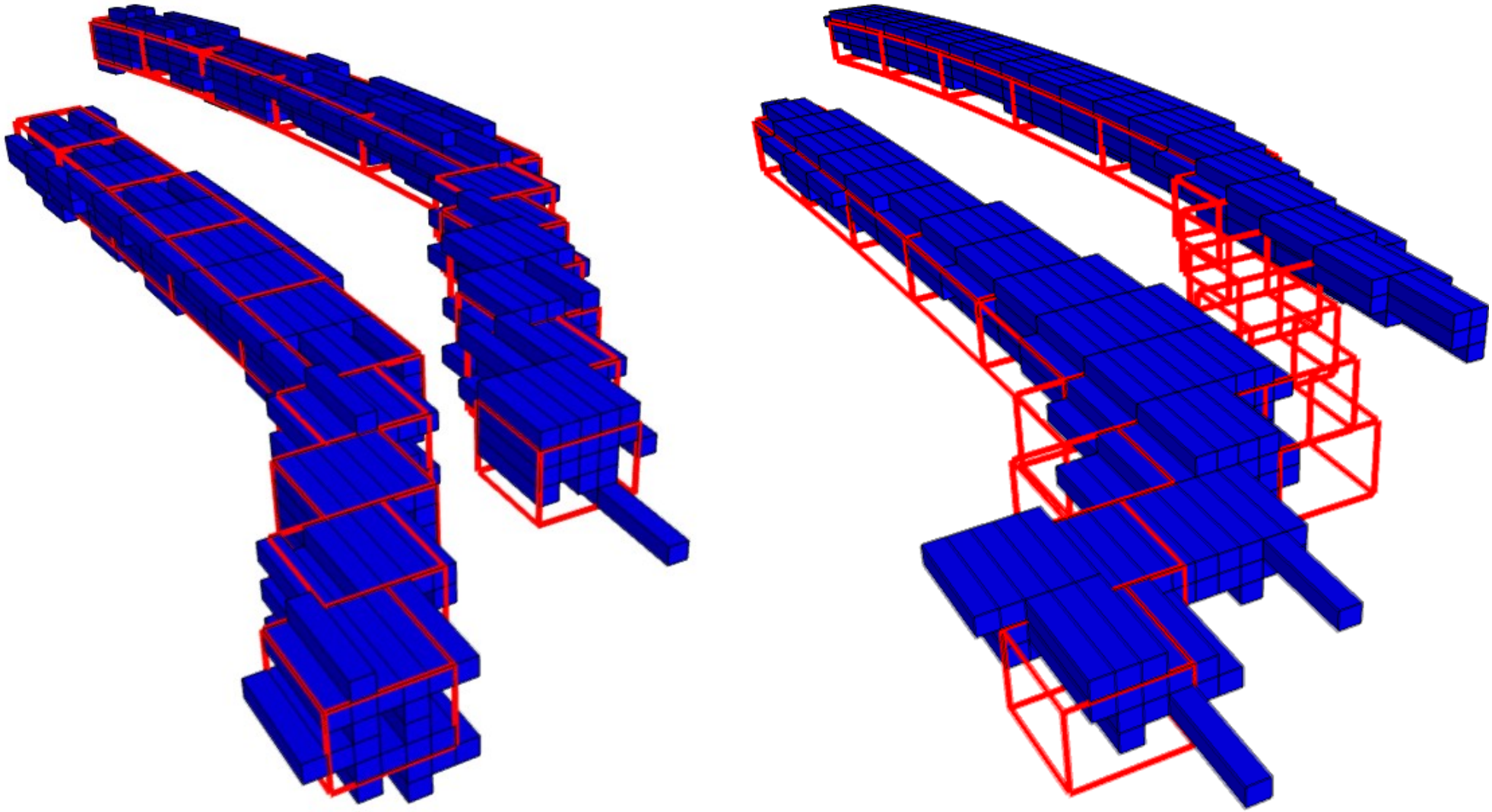
for tesseroids



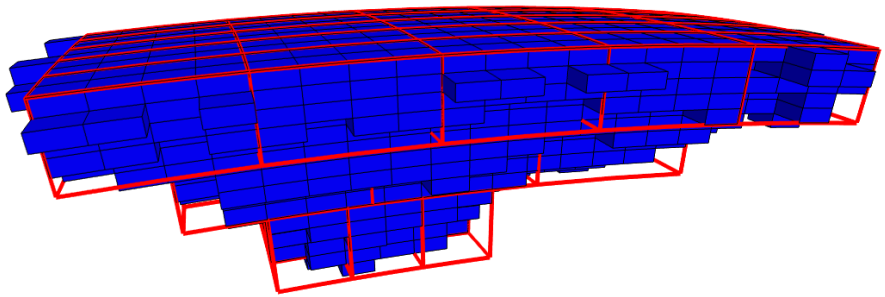
single vs joint



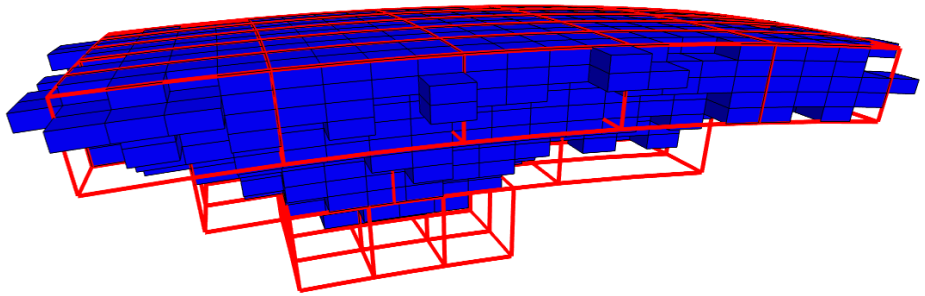
height matters



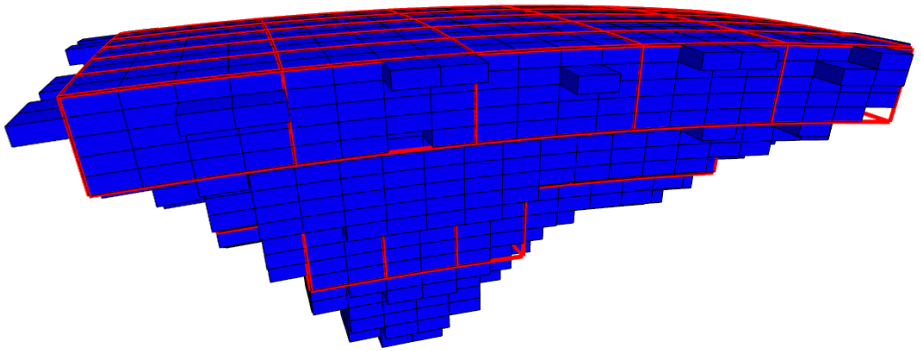
correct



↑ dense



↓ dense



Future

- Multicomponent data
- Real data
- Dipping models (subduction)

OPEN SOURCE

Fatiando a Terra

Geophysical modeling and inversion

fatiando.org

github.com/leouieda/egu2014