Synthetic Study for Optimizing an Efficient Grid Size for MT and Long Period MT Measurements

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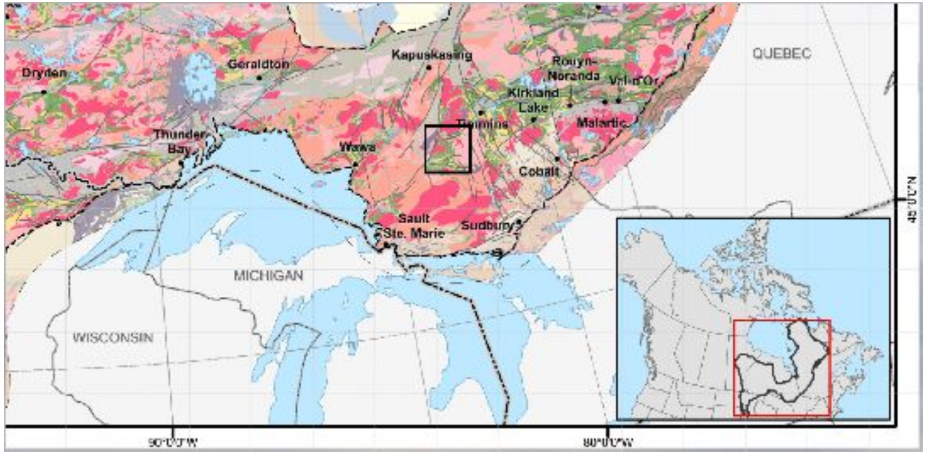
In our previous study of Long Period MT inversions, we observed an upward shift of anomalies for some models. We suspected that this effect depends on a MT stations grid layout.

The objective of this study is to find how the LP grid size reflects in 3D inversion data results.

Our 3D Model was inspired from the Ontario Canadian Shield (Abitibi Greenstone Belt), in the province of Ontario.

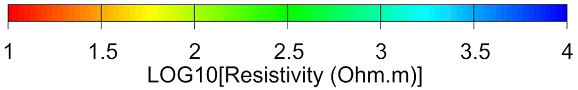


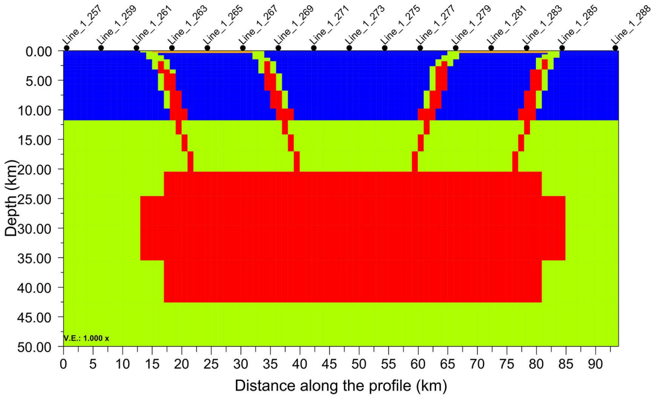
Img. 1 **Abitibi Province**

The model dimensions are 100 km long, 50 km wide. For the purpose of this study we display results down to 50 km.

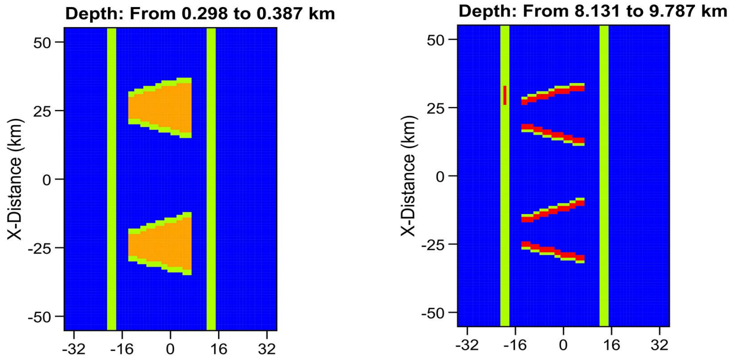
This very general model consists of

- a very resistive upper crust (10 000 Ωm)
- a middle to lower crust relatively conductive (100 Ωm)
- some localized conductive zone at the surface (30 Ωm)
- a large conductive zone in the lower crust (10 Ωm)
- several faults systems coming close to the surface



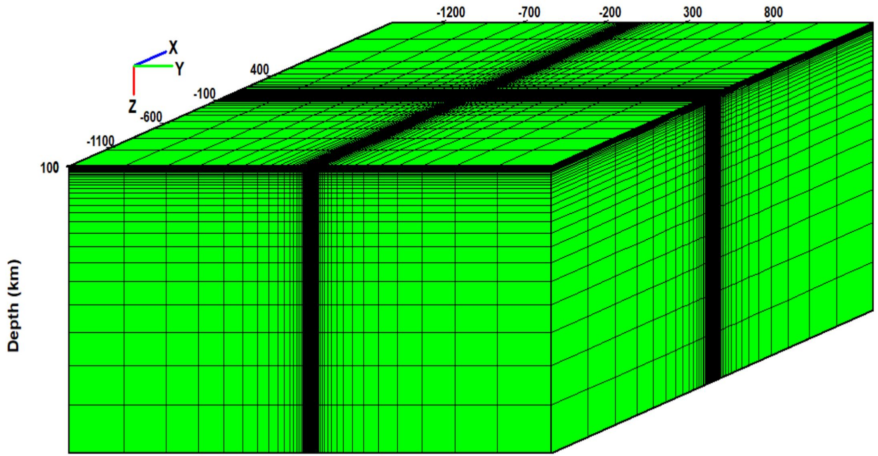


Img. 2 **Section of the model**

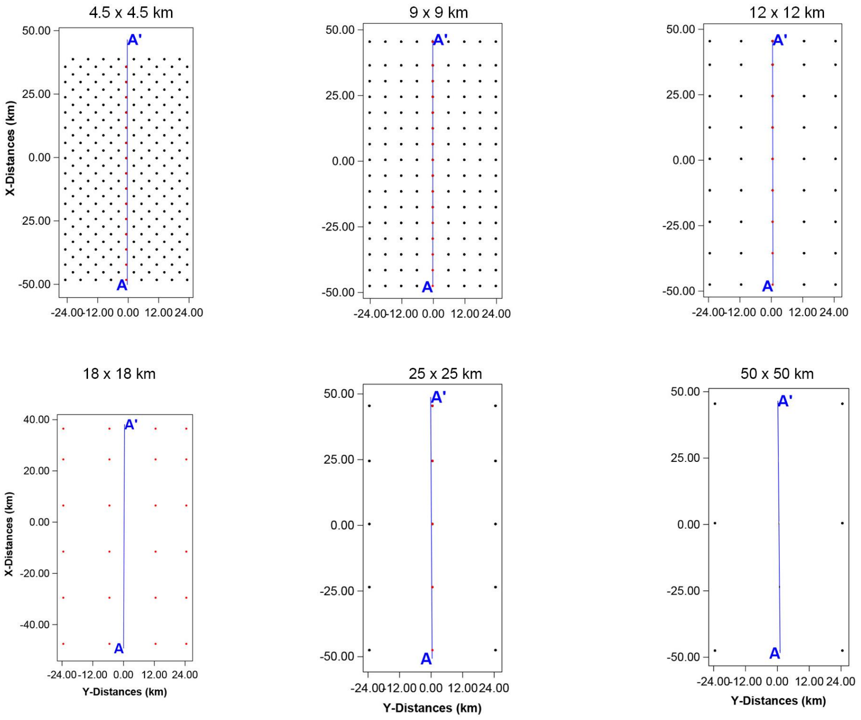


Img. 3 **Horizontal section of the model**

- ModEM was used to run 3D inversions
- Lateral mesh discretization we defined as ⅙ of the distance between the MT sites
- Minimum cell size in -z direction is 100m, increased logarithmically by factor 1.2
- 18 lateral padding cells added to all meshes
- 70 cells used in z direction
- 100 ohm-m homogenous starting model used for all inversions
- 4 component of impedance tensor used as an input with the tipper data
- 30% error floor used for diagonal elements and tipper while it is 5% for off-diagonal elements
- 5 frequency per decade for a total of 16 frequencies used for inversion
- Target RMS less than 1



Img. 4 **Typical mesh used for inversions**

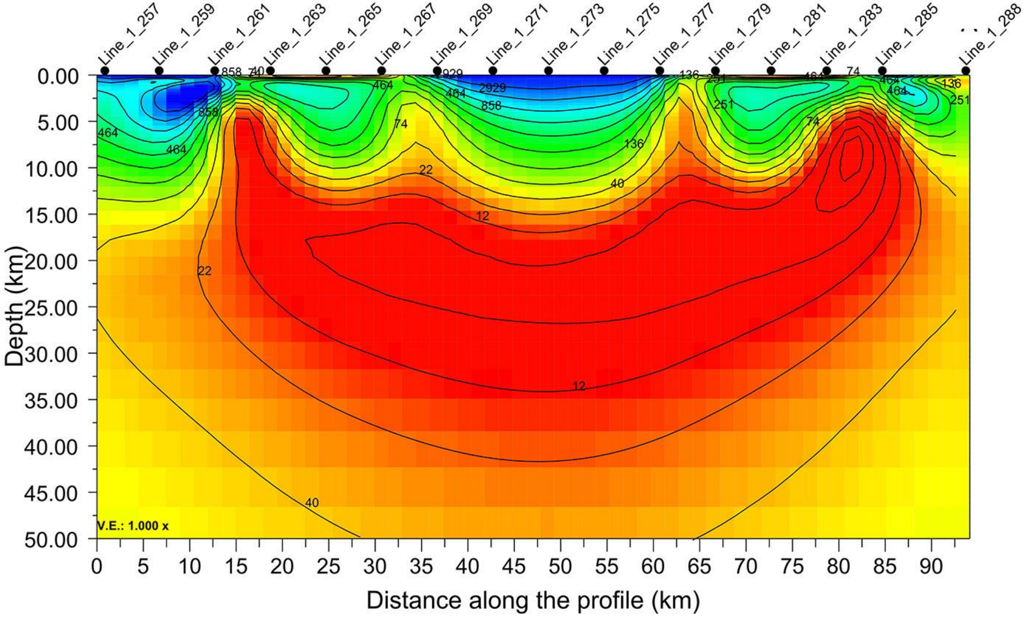


Img. 5 **Grid layouts**

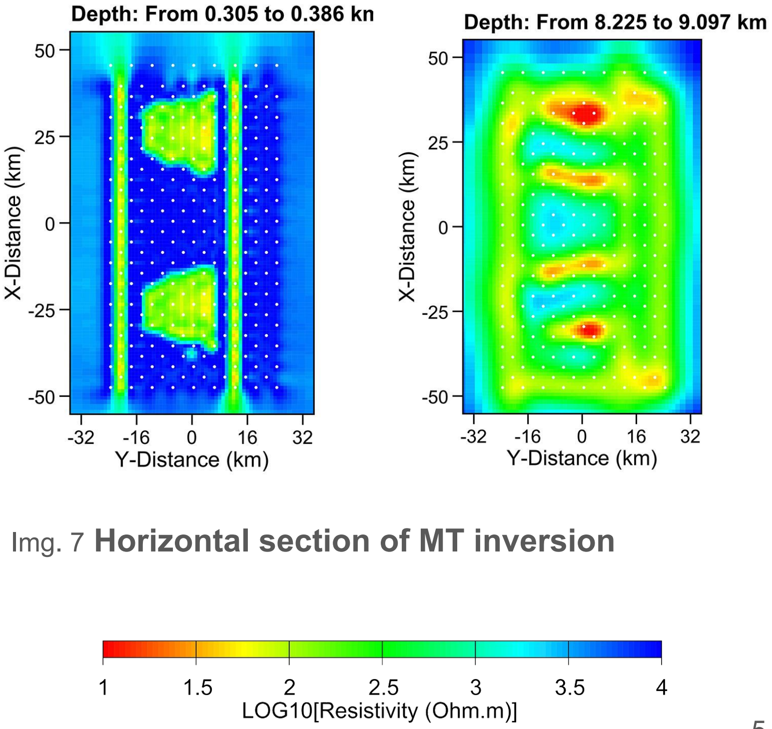
Note: *electrical sections for 18 x 18 km and 50 x 50 km inversions are not aligned with sounding stations.*

- Model 4.5 x 4.5 km
  - 255 Stations
  - 526,600 parameters
  - ~ 42 hours
- Model 9 x 9 km
  - 144 Stations
  - 390,600 parameters
  - ~ 29 hours
- Model 12 x 12 km
  - 45 Stations
  - 358,400 parameters
  - ~ 23 hours
- Model 18 x 18 km
  - 24 Stations
  - 302,400 parameters
  - ~ 18 hours
- Model 25 x 25 km
  - 15 Stations
  - 241,920 parameters
  - ~ 14 hours
- Model 50 x 50 km
  - 6 Stations
  - 181,440 parameters
  - ~ 5 hours

Reference model: wideband MT (10kHz - 10,000 seconds) synthetic model with 4.5 km grid spacing.

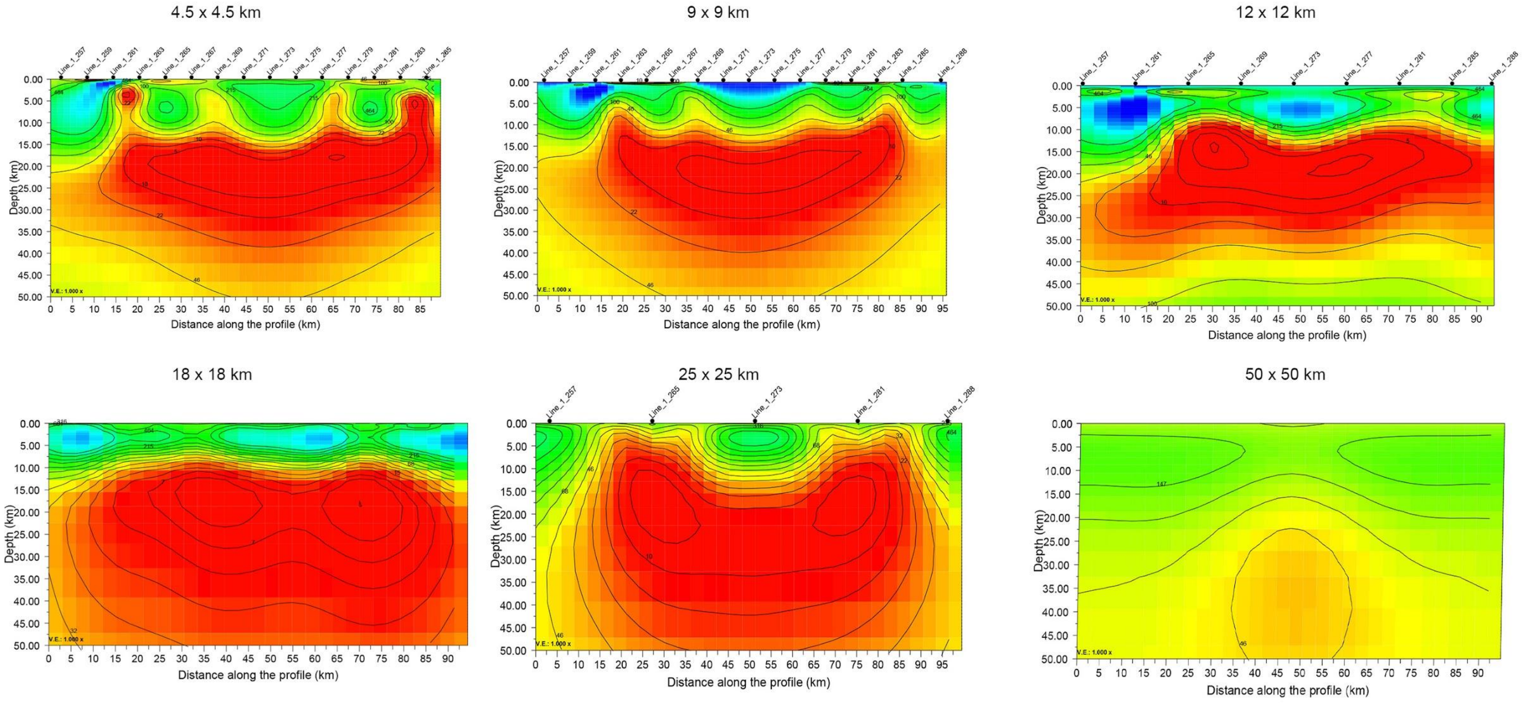


Img. 6 **Wideband MT inversion section**

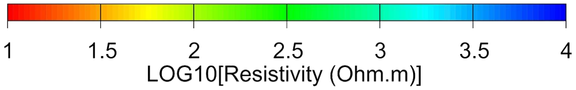


Img. 7 **Horizontal section of MT inversion**

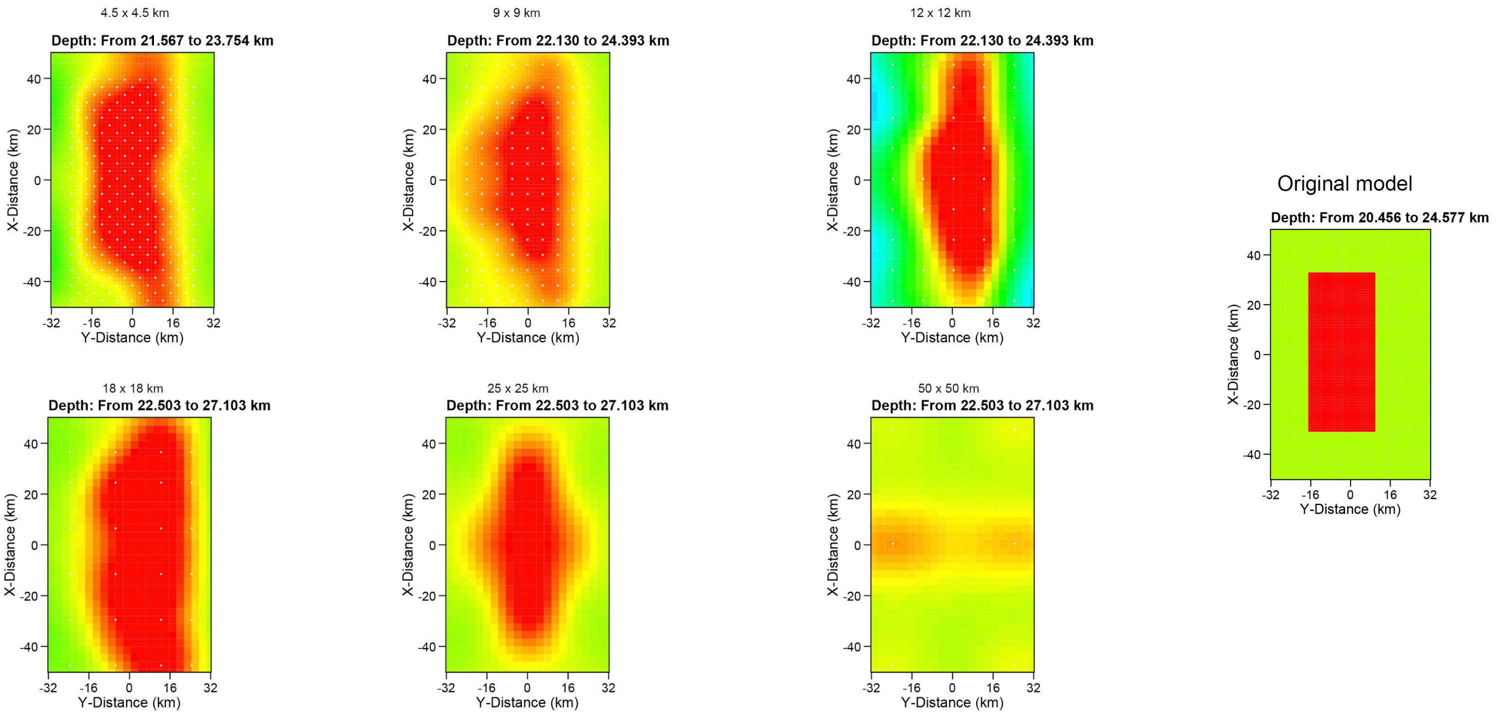
Long Period (LP: 30 s - 50,000 s) MT inversion results



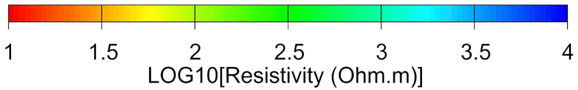
Img. 8 **LP inversion section with observation grids**



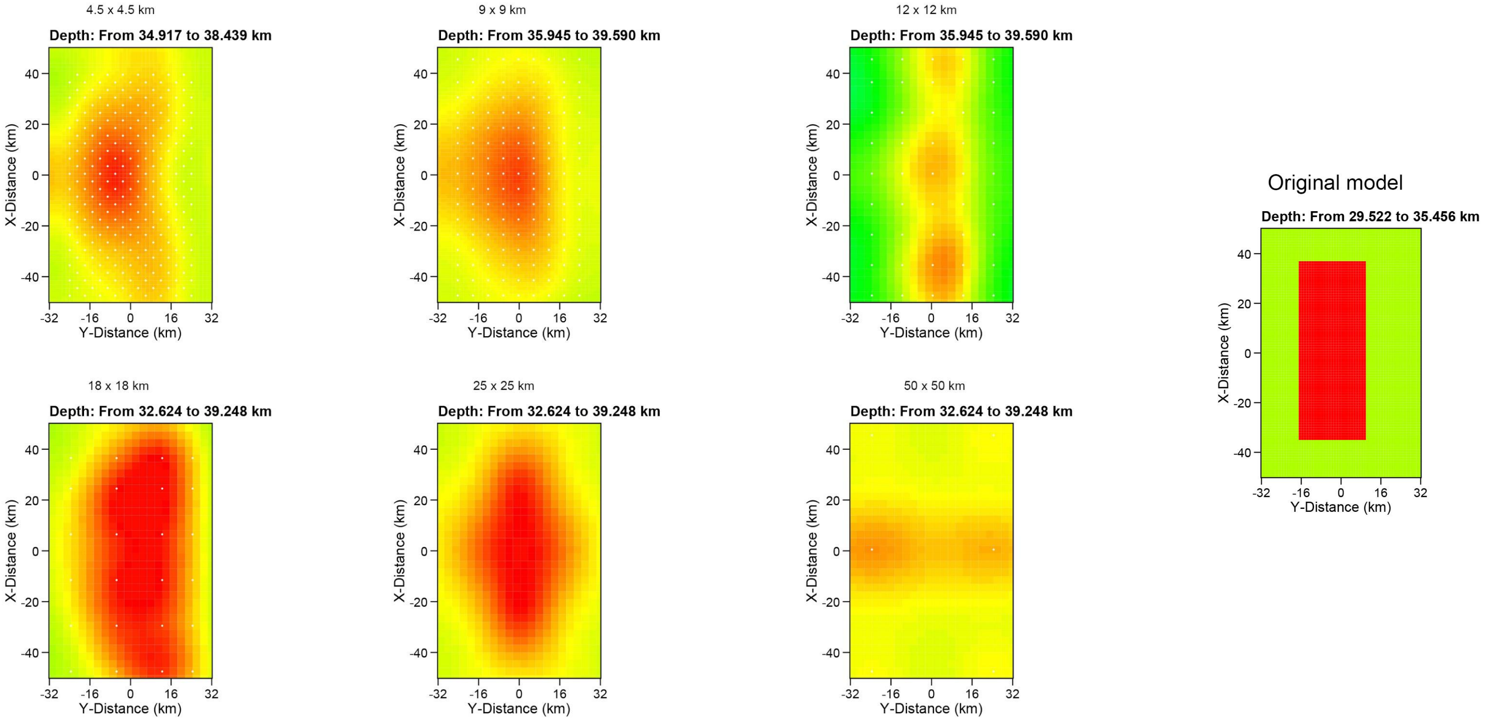
Long Period (LP) MT inversion results



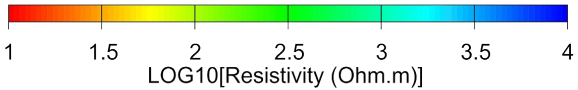
Img. 9 **Horizontal section of LP inversion on a depth ~23 km (depending on model cell size)**



Long Period (LP) MT inversion results



Img. 10 **Horizontal section of LP inversion on a depth ~35 km (depending on model cell size)**



Discussion:

Surface anomalies (up to 2-5 km) formed by conductive mineral bodies or fault systems are considered to be less important and are often completely ignored during deep lithospheric studies. The upper layers conductivity is being estimated and averaged over the whole survey area.

The Magnetotelluric sounding signal measured on the surface represents an apparent resistivity at a depth dependent on frequency and conductivity of averaged ground thickness above. This assumption works generally well in smoothly layered geology, but might integrate an error in estimations and inversions in more complicated situations.

The Long Period Magnetotelluric measurements below 10 seconds are not sensitive to the upper geology; that does not necessarily mean that the technique is insensitive to it. The models show poor resolution of near surface conductive features. By forcing calculated models to converge to the data, the inverted results show some sensitivity to the near surface conductive features. This sensitivity is discussable. It seems that by increasing the density of synthetic stations , we start getting better results just above the high resistive layer.

During our study, we observed inconsistent variations of the upper conductive features from the LP inversions. This suggest that mesh size and grid layout are critical parameters to overcome near surface challenges.

This new study gave us better control on the inversion results created by a given grid size.

These new regulated grids seem to better mitigate our calculated depth estimations. These tendency of shifting all of our results upwards is now minimized. Although it is still quite visible on the tight grids .

The 25 x 25 km grid recovers pretty well the structural information as well as the conductive formation, while the 50 x 50 km shows only some evidence of a deep, massive conductor.

Conclusions

- The near surface 3D conductivity creates an uncertainty in the deep conductor depth estimations.
- Tighter grid size tends to shift results upward.
- Loose grid size tends to decrease the resolution of the recovered conductive features.
- For this particular study, best results are observed when the grid size is the range of 25 x 25 km.