Creating a multipole dataset from a single dipole-spacing IP survey

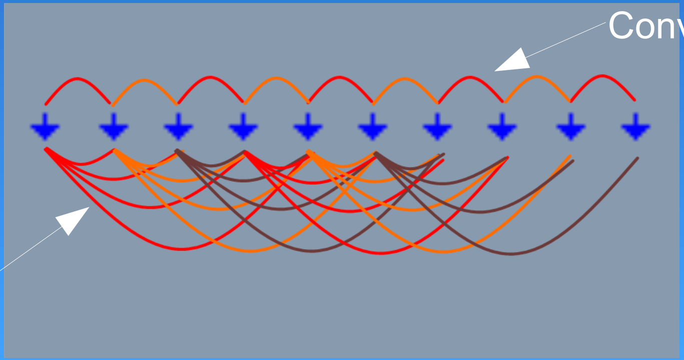
ExploreGeo Technical Note 10

Explanation – Pt 1

This technical note will investigate the possibility of creating a multipole dataset from a conventional single dipole-spacing induced polarisation survey.

In a conventional array, the same pair of current electrodes are associated with just one receiver dipole spacing. For example, transmitter dipole spacing (Tx) of 200m and receiver dipole spacing (Rx) of 100m. For the multipole design, all voltages are referenced to a common electrode and saved as full waveform data allowing any combination of of electrodes to be calculated post acquisition. For example, Tx of 200m and Rx of 100m, 200m, 300m and 400m.

A greater depth of investigation is expected for the multipole design. See Tech Note 5.



Explanation – Pt 2

For this exercise a real data set acquired with a transmitter dipole spacing of 400m and receiver electrode spacing of 200m was used. It had been acquired using the Search receiver and delivered as stacked and binned 200m, 400m, 600m and 800m multipoles. The section chosen for this test was from a conductive area with very high noise levels due to poor signal.

The 200m dipole database was cleaned and averaged and was then used as the basis to generate three new “pseudo-multipole” databases, to mimic the supplied data, by a series of processes discussed in detail on the next slide. These databases will be referred to as post-processed data.

In this note the post-processed data are compared to true multipole data supplied by the contractor.

Explanation – Pt 3

Each chargeability window was converted back to a voltage by multiplying by its respective primary voltage. Secondary voltages for adjacent electrodes were added and normalised by the average of the primary voltages;

$$\frac{M_n(j) \times Vp(j) + M_n(j+1) \times Vp(j+1)}{Vp(j) + Vp(j+1)}$$

M_n : nth chargeability window
Vp : primary voltage
j : dipole j
j+1 : adjacent dipole

It is good practice to include the current in the normalisation routine but it was not done in this case because the current for each repeat reading was exactly the same. This is because adjacent dipoles were acquired at the same time. If this is not the case, the following normalisation formula should be used, where I is the measured current;

$$\frac{I(j) + I(j+1)}{2} \left(\frac{M_n(j) \times Vp(j)}{I(j) \times (Vp(j) + Vp(j+1))} + \frac{M_n(j+1) \times Vp(j+1)}{I(j) \times (Vp(j) + Vp(j+1))} \right)$$

Electrode layout

In the following image, blue triangles represent potential electrodes and red triangles represent current electrodes. The potential electrodes are spaced at 200m and the current electrodes are spaced at 400m.

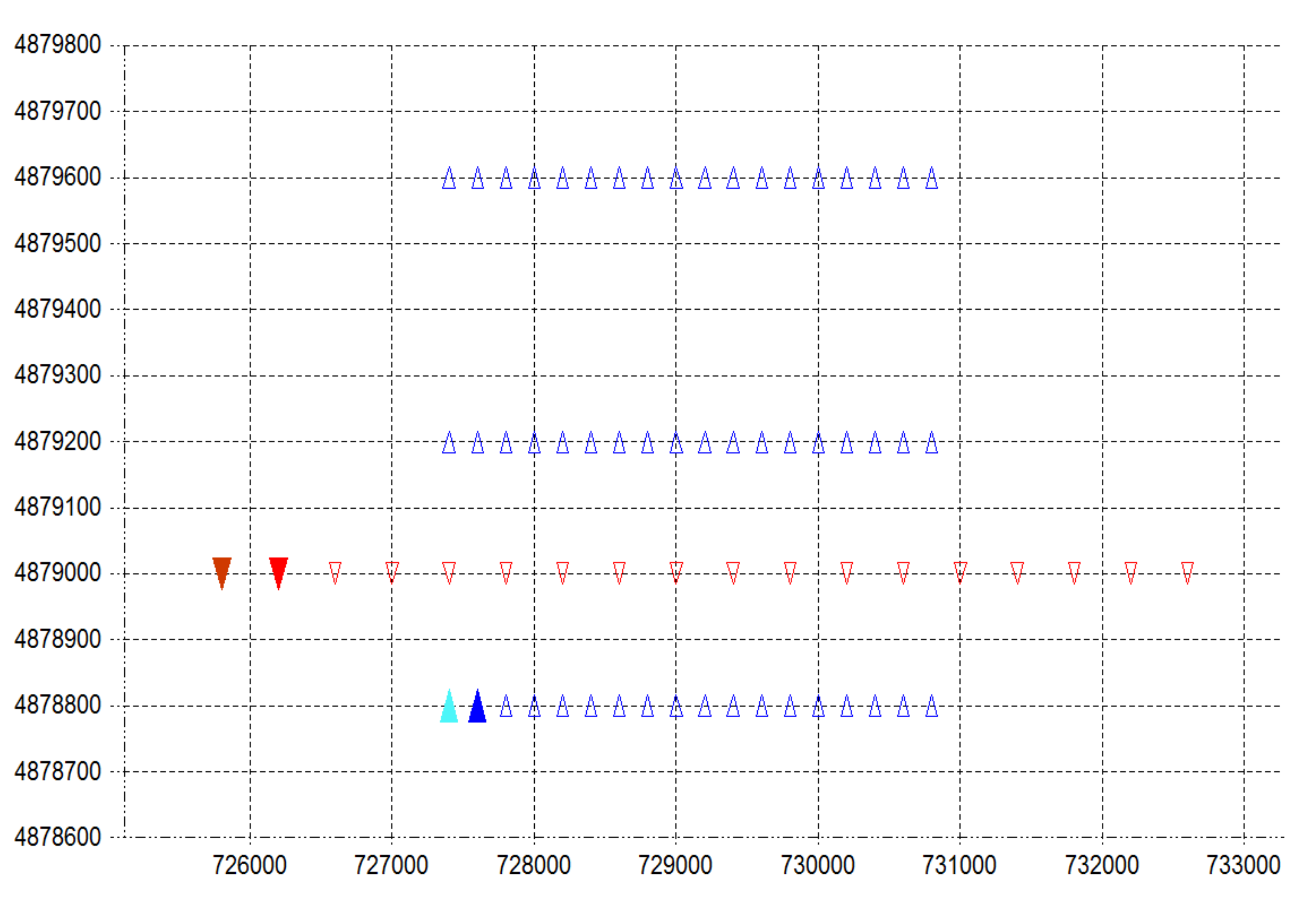


Figure Details – Pt 1

All of the figures presented are in the form of a spectral pseudo-section (SPS).

The plotting convention for the SPS is as follows;

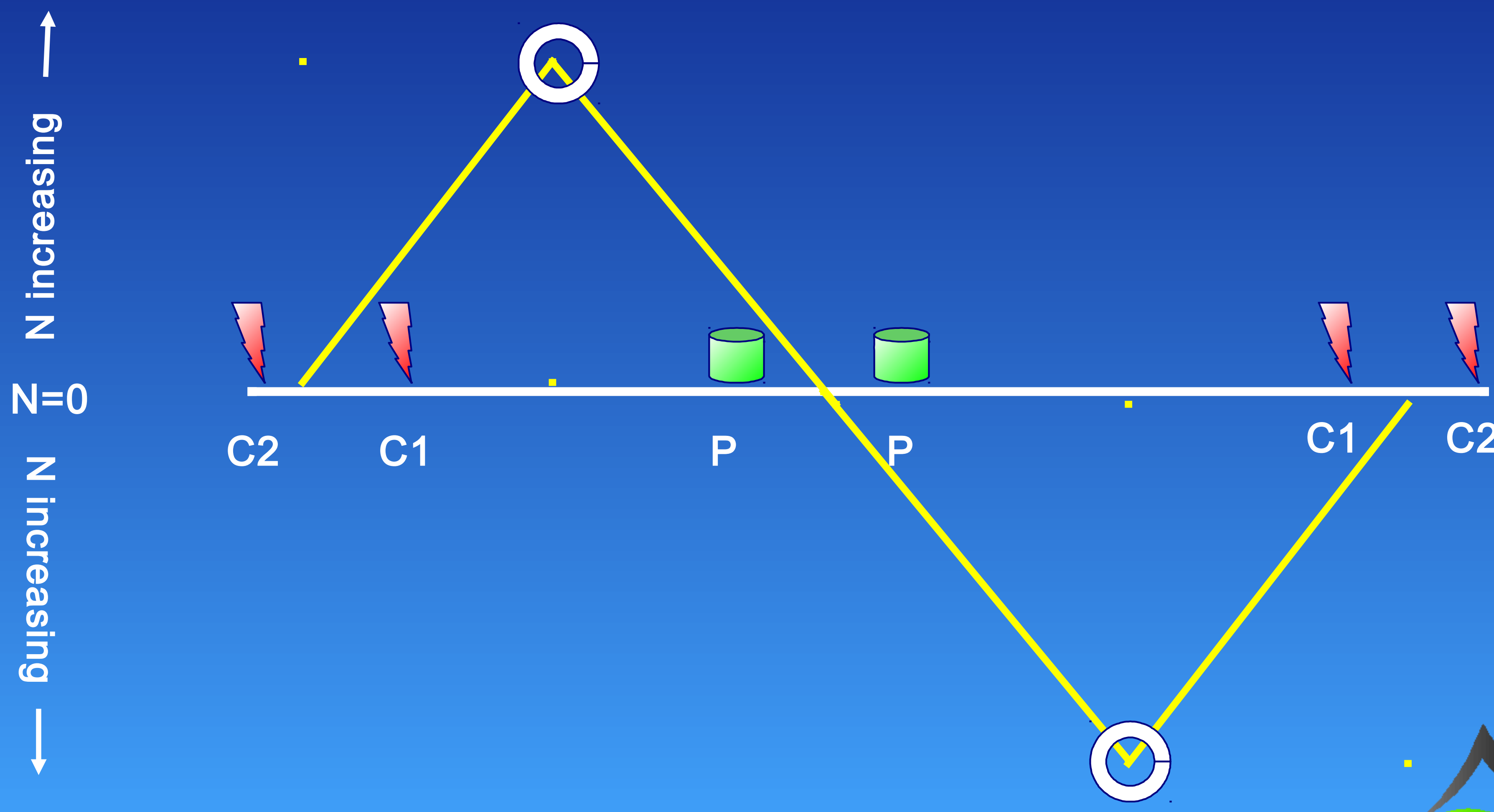


Figure details – Pt 2

Four comparisons have been made which outline the major differences and similarities between the true multipole and post-processed data.

The following slides will display a series of images which show the best match, worst match, the most missing decays, and late-time mismatch.

For each of the four comparisons, six slides are shown;

1. post-processed SPS decays in colour overlain on true multipole SPS decays in black
2. Detailed view of image 1 to highlight the feature of interest
3. Comparison of chargeability pseudosections for true multipole and post-processed data
4. Difference between post-processed data and true multipole chargeability pseudosections
5. Comparison of apparent resistivity pseudosections for true multipole and post-processed data
6. Difference between post-processed data and true multipole apparent resistivity pseudosections

Figure details – Pt 3

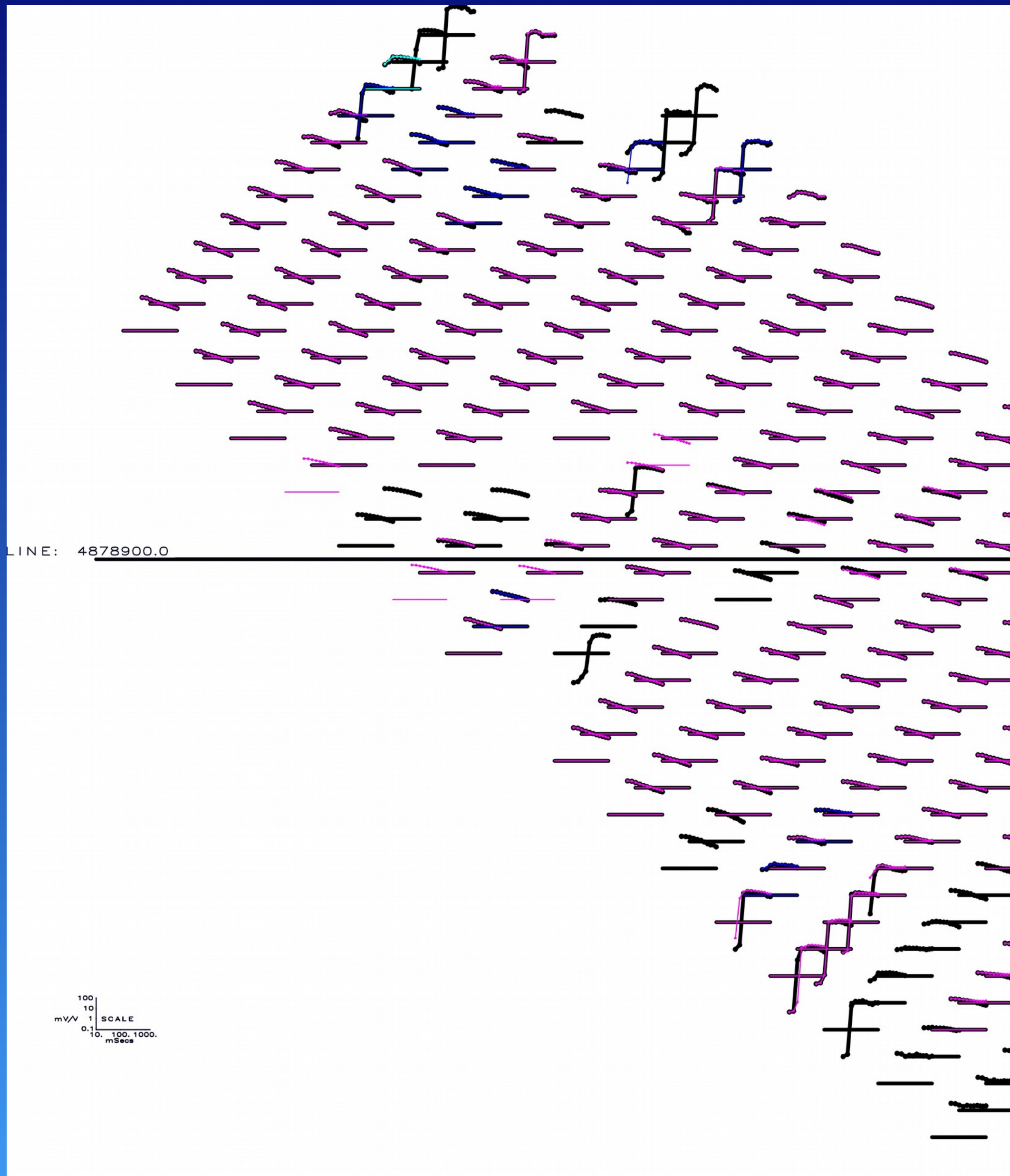
All resistivity contours are logarithmic at 10 levels per decade.

All chargeability contours are at an interval of 10 mV/V.

All difference contours are at an interval of 0.2 mV/V and Ohm m

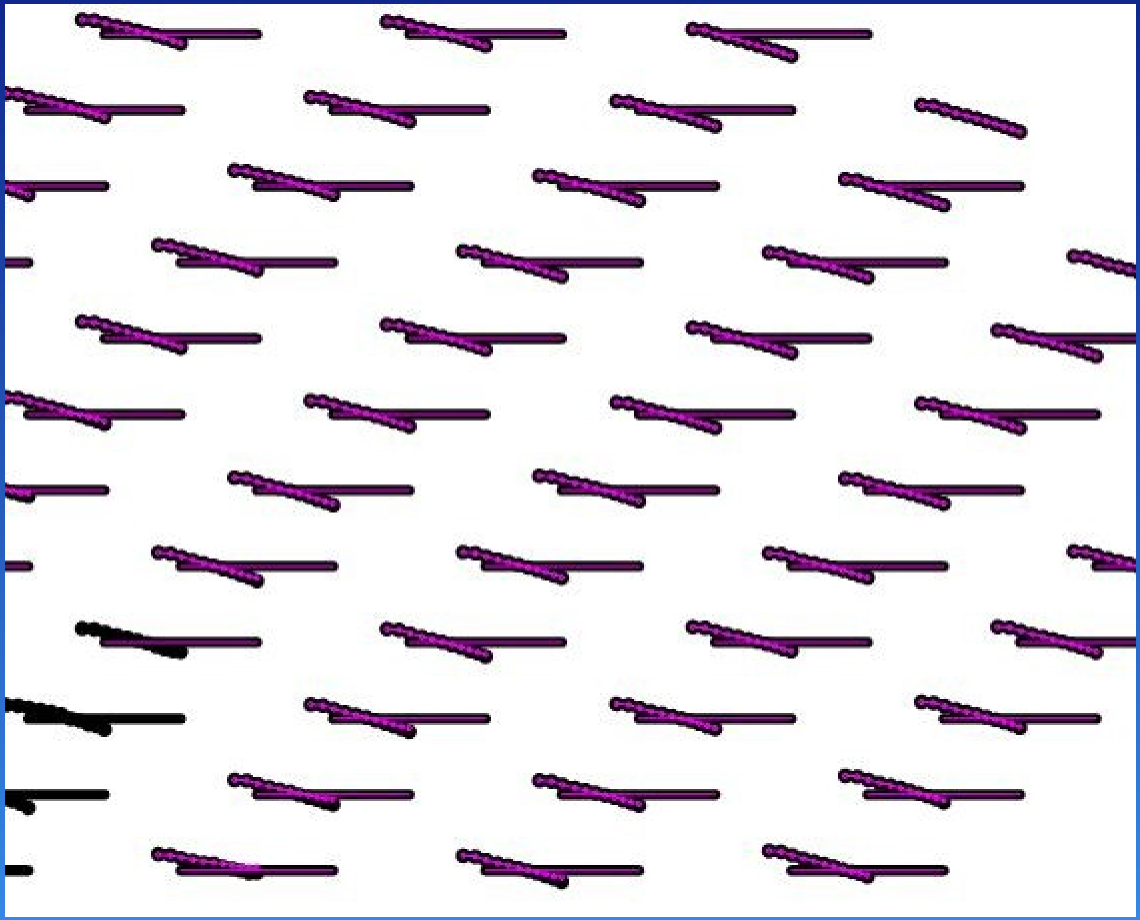
Best Match
600m Receiver Dipoles
Southern Receiver Line

Best Match SPS – 600m Rx



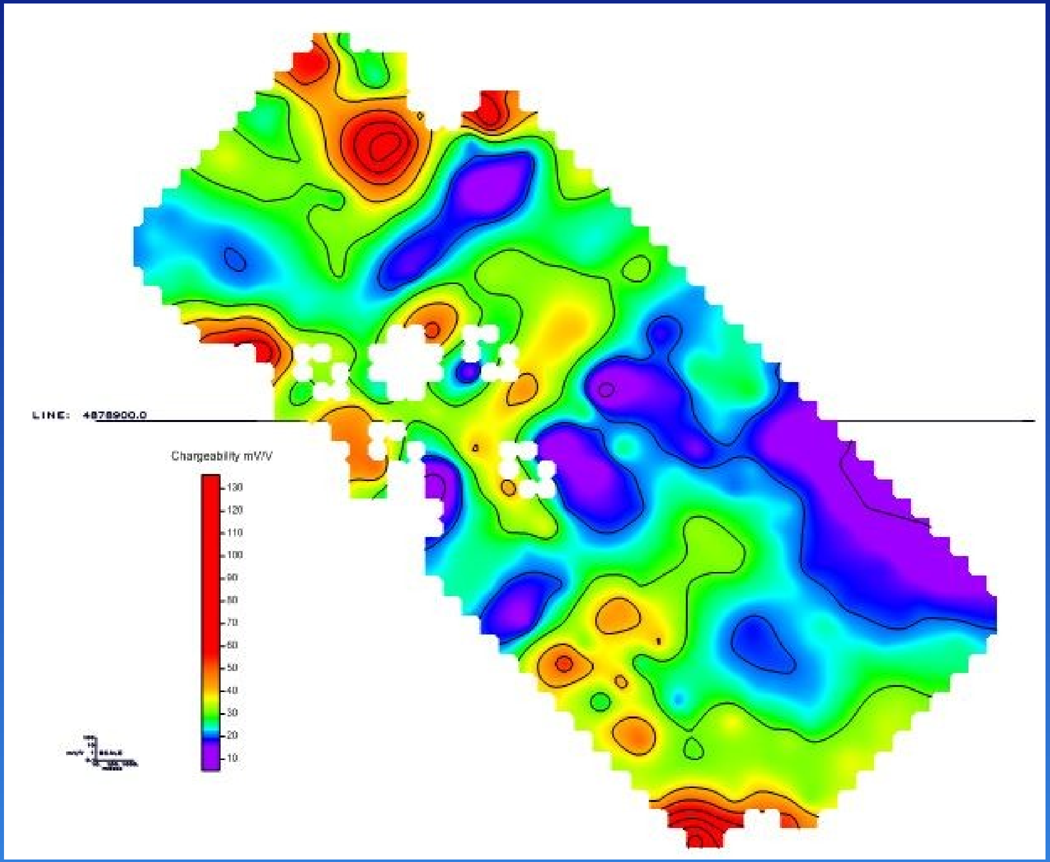
Colour post-processed decays overlain on black true multipole decays

Best Match SPS Detail – 600m Rx

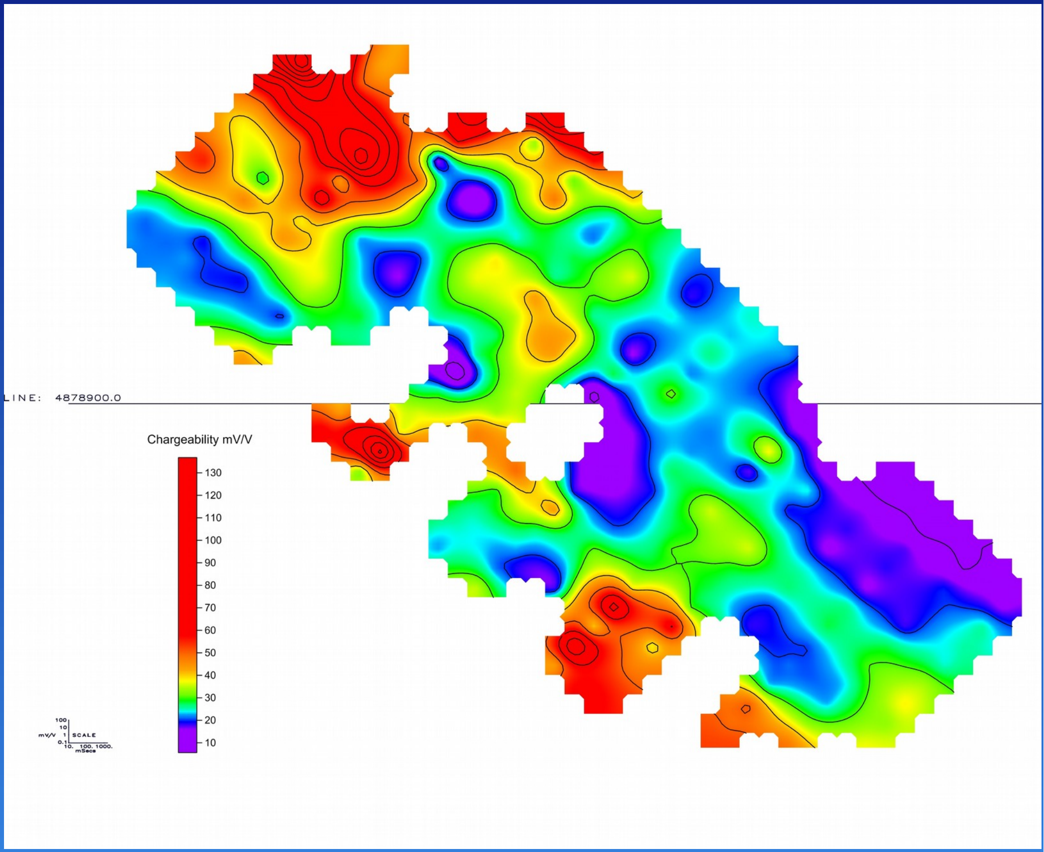


Excellent overlap

Best Match IP – 600m Rx

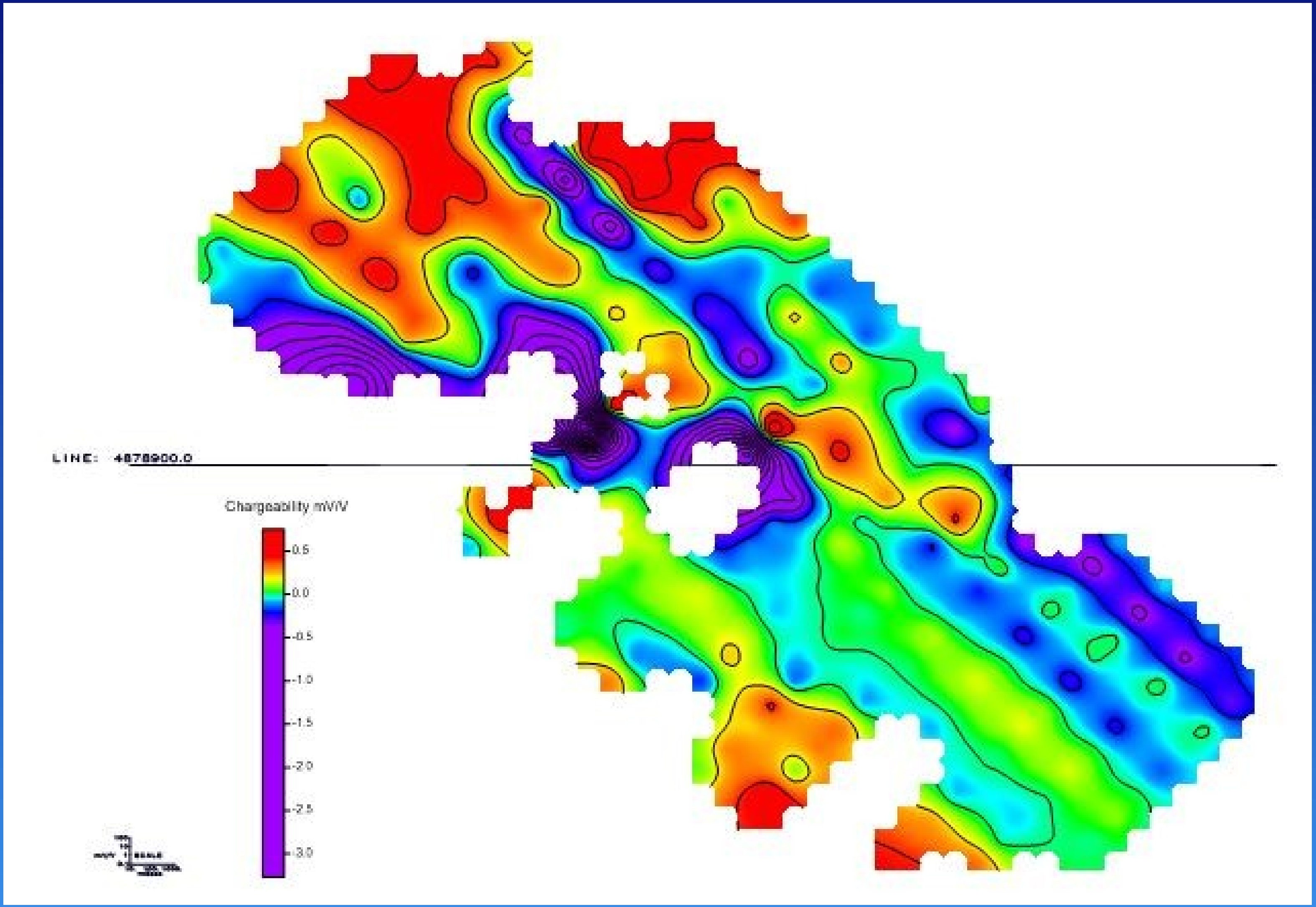


True multipoles



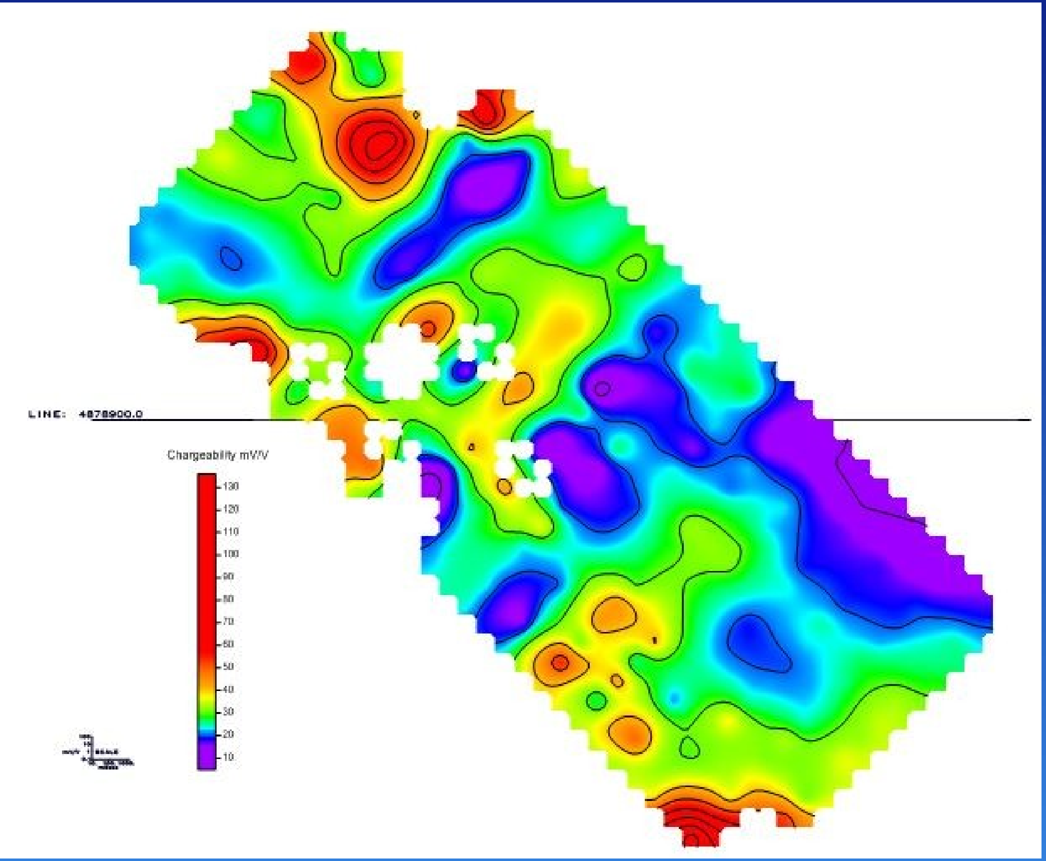
Post-processed data

Best Match IP Difference – 600m Rx

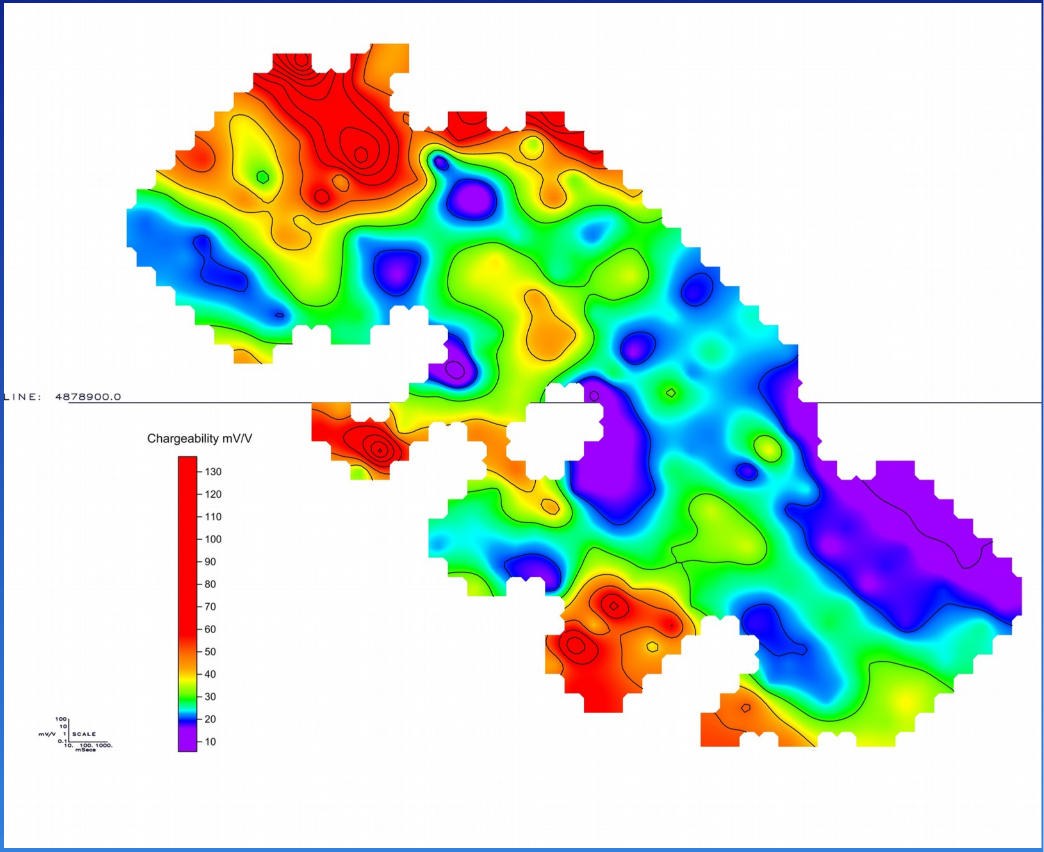


Post-processed data minus true multipole data

Best Match IP – 600m Rx

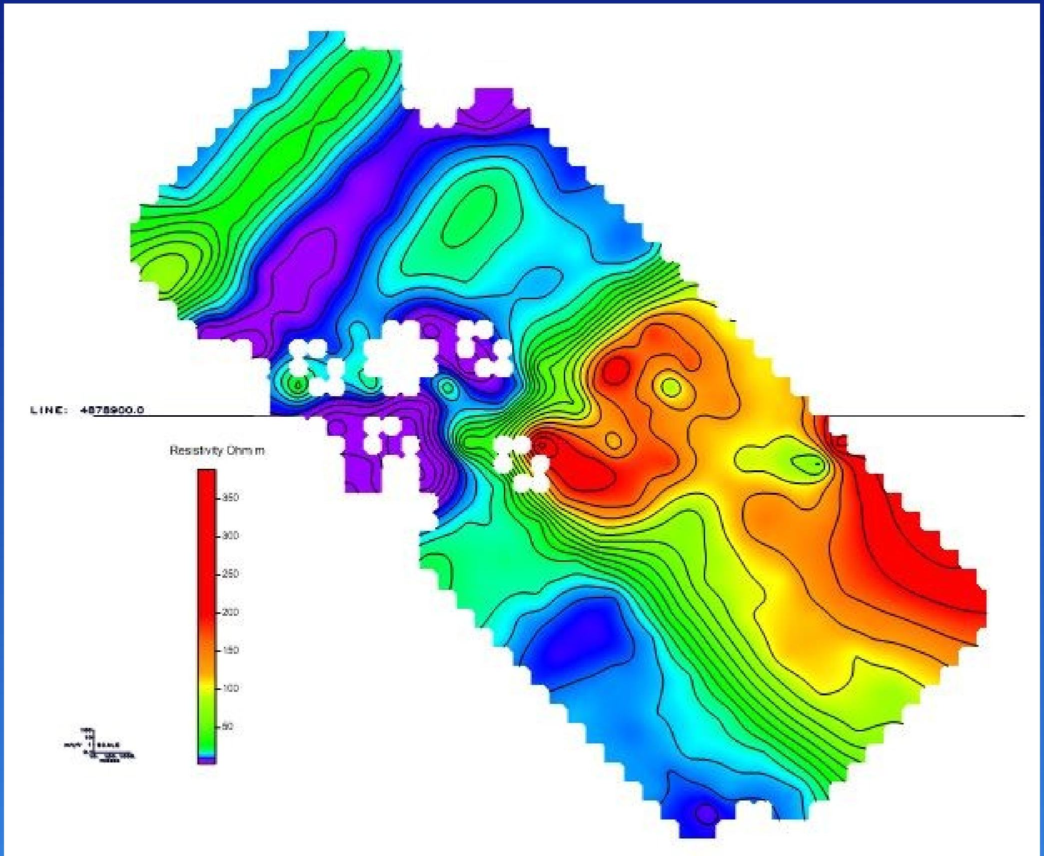


True multipoles

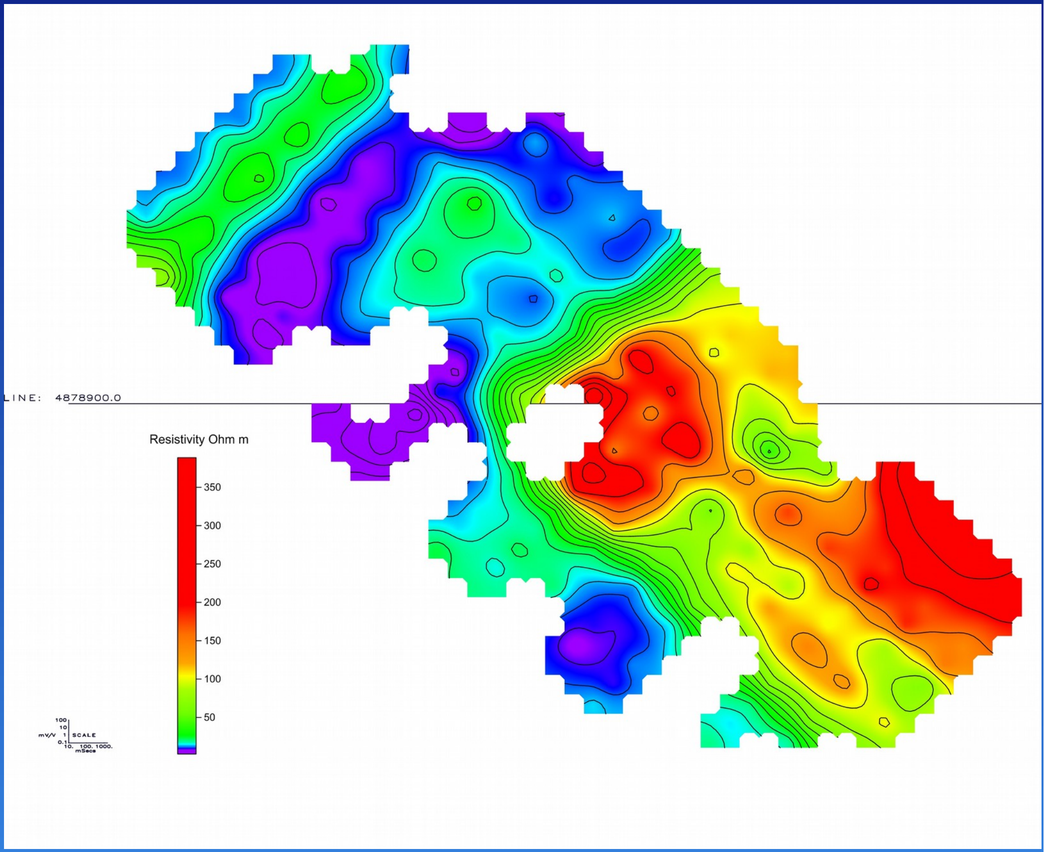


Post-processed data

Best Match Resistivity – 600m Rx

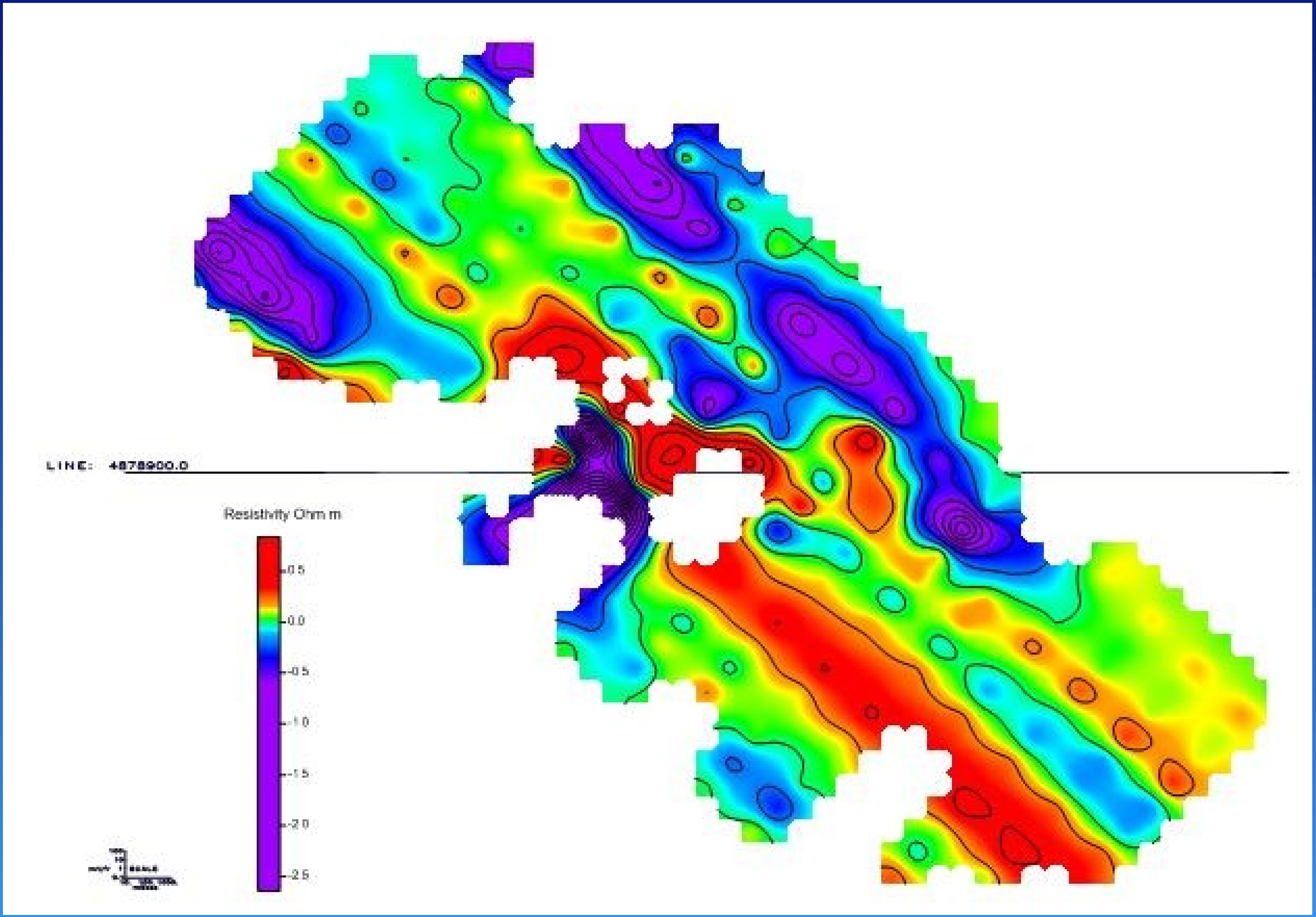


True multipoles



Post-processed data

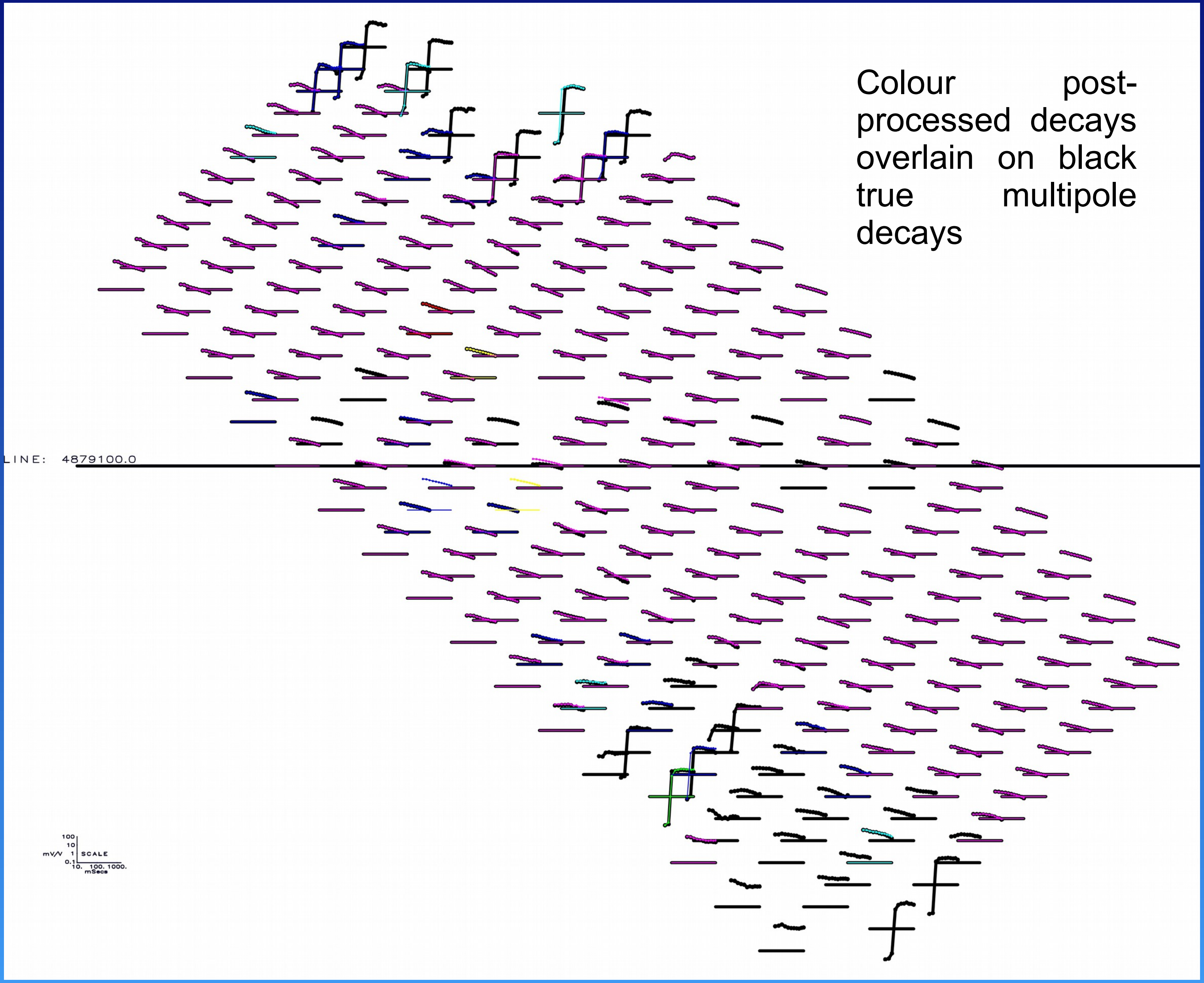
Best Match Resistivity Difference – 600m Rx



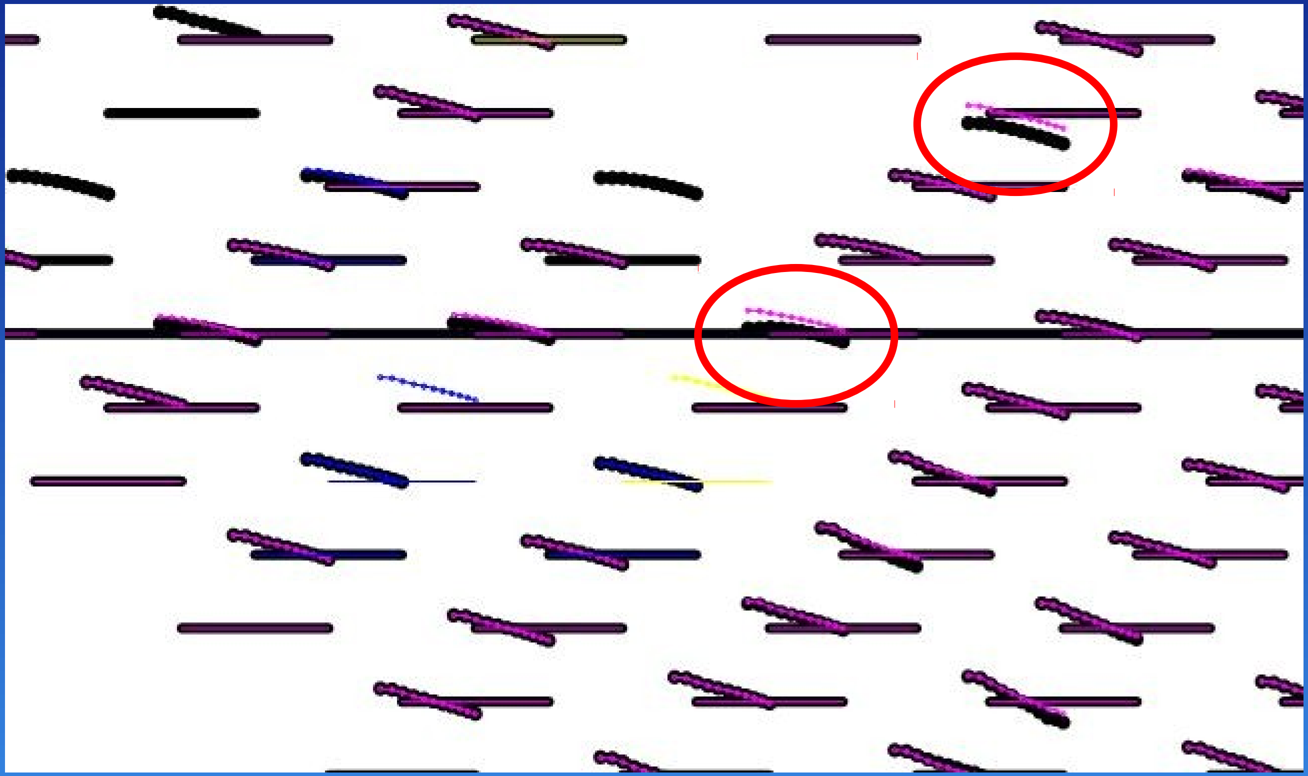
Post-processed data minus true multipole data

Worst Match
400m Receiver Dipoles
Central Receiver Line

Worst Match SPS – 400m Rx

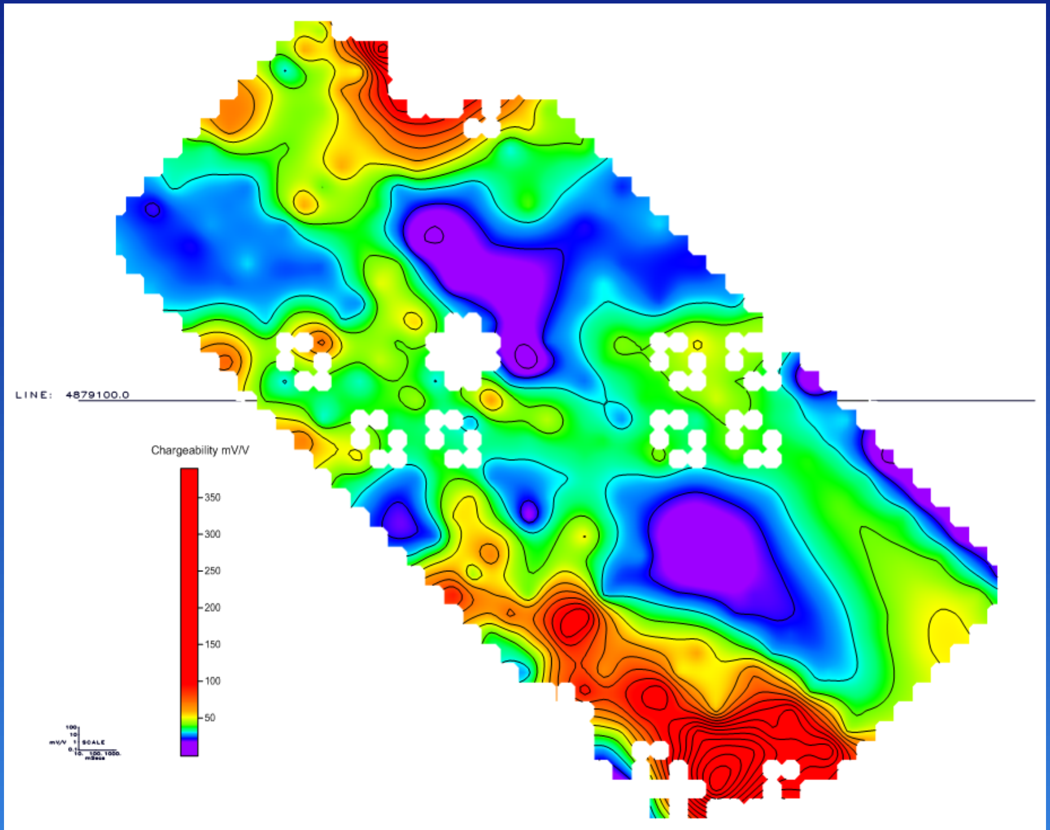


Worst Match SPS Detail – 400m Rx

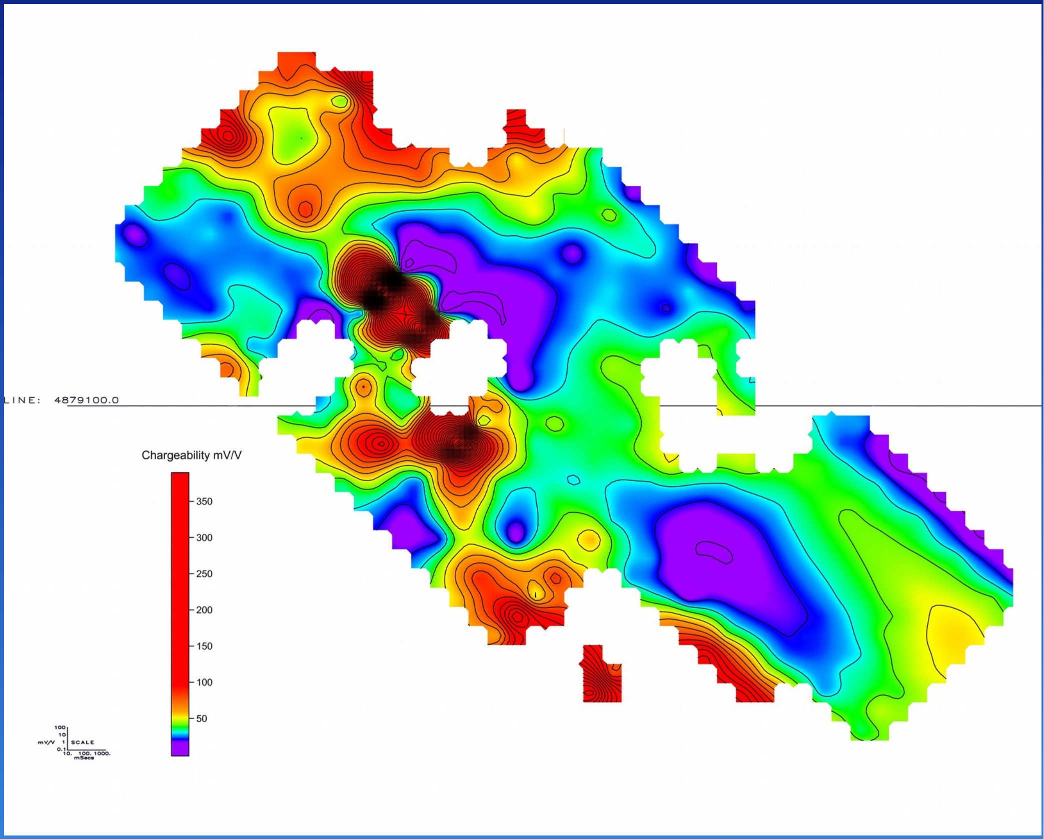


Poor overlap

Worst Match IP – 400m Rx

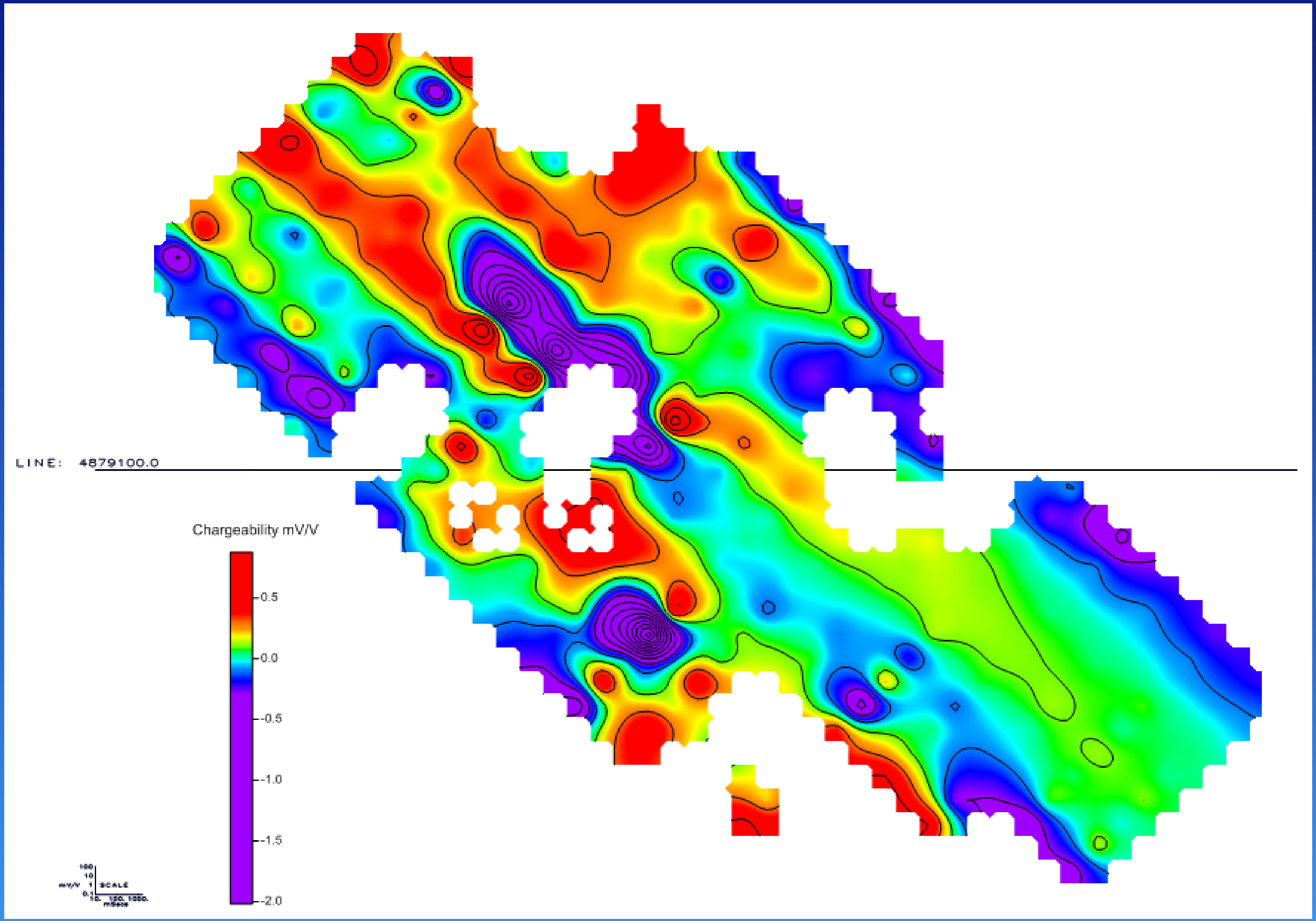


True multipoles



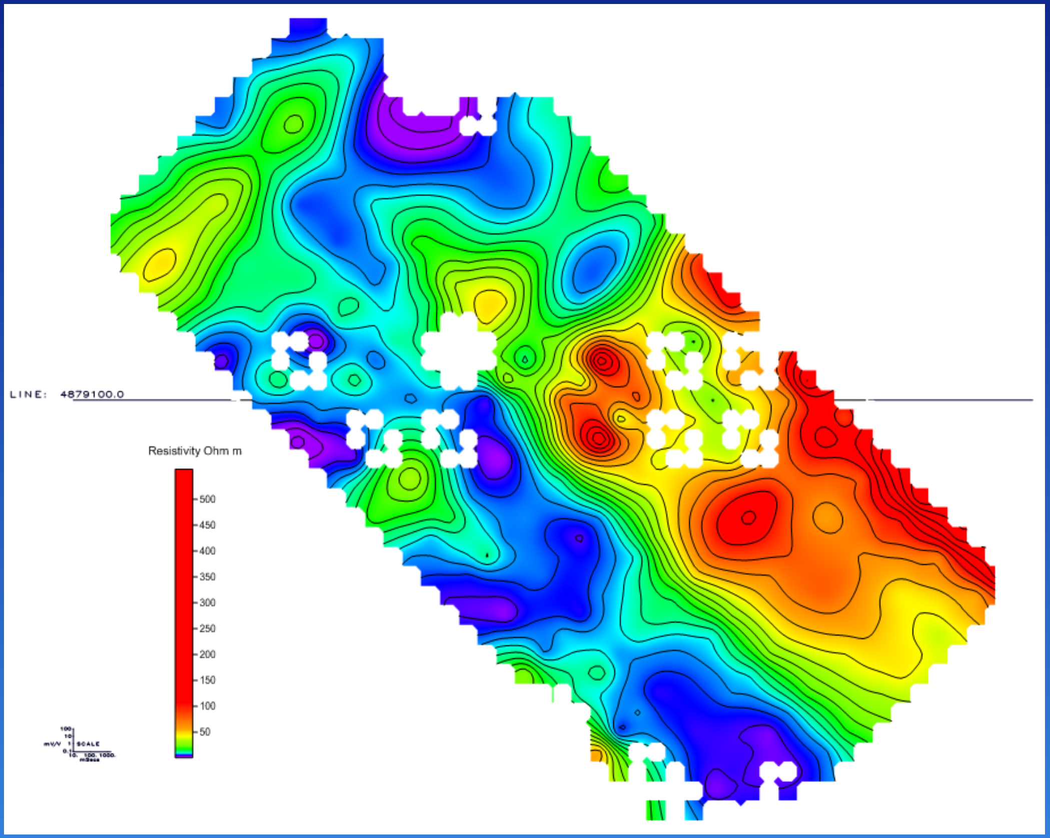
Post-processed data

Worst Match IP Difference – 400m Rx

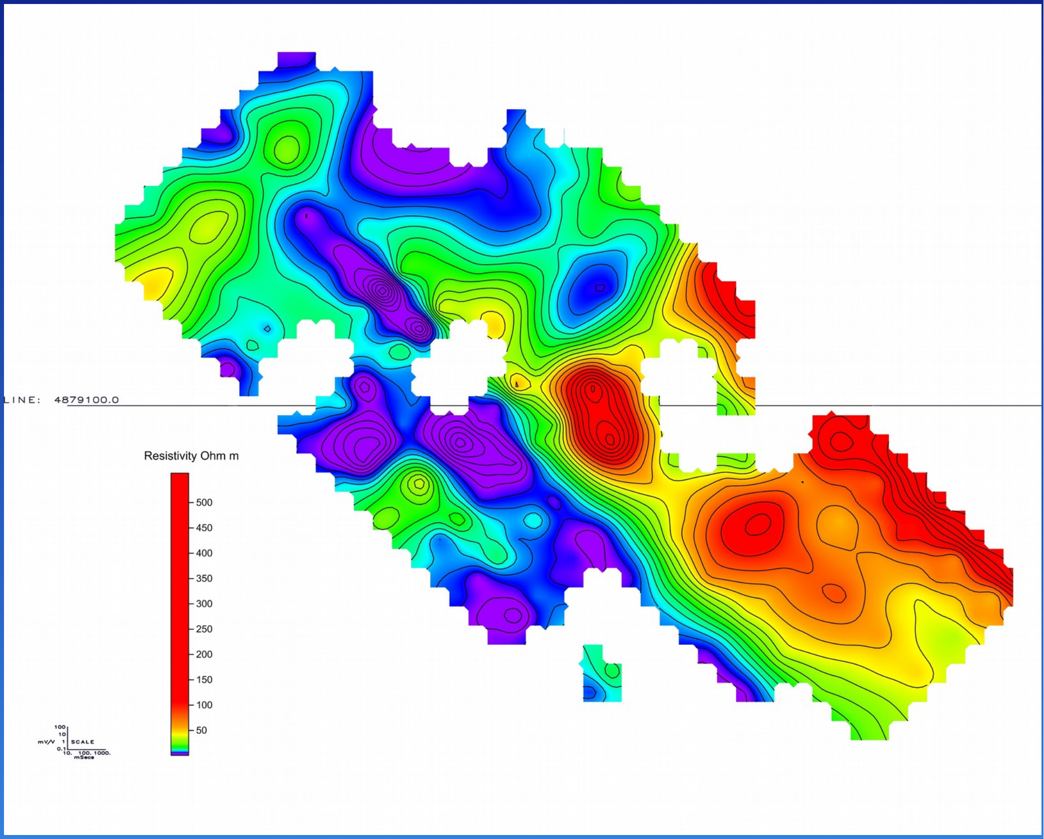


Post-processed data minus true multipole data

Worst Match Resistivity – 400m Rx

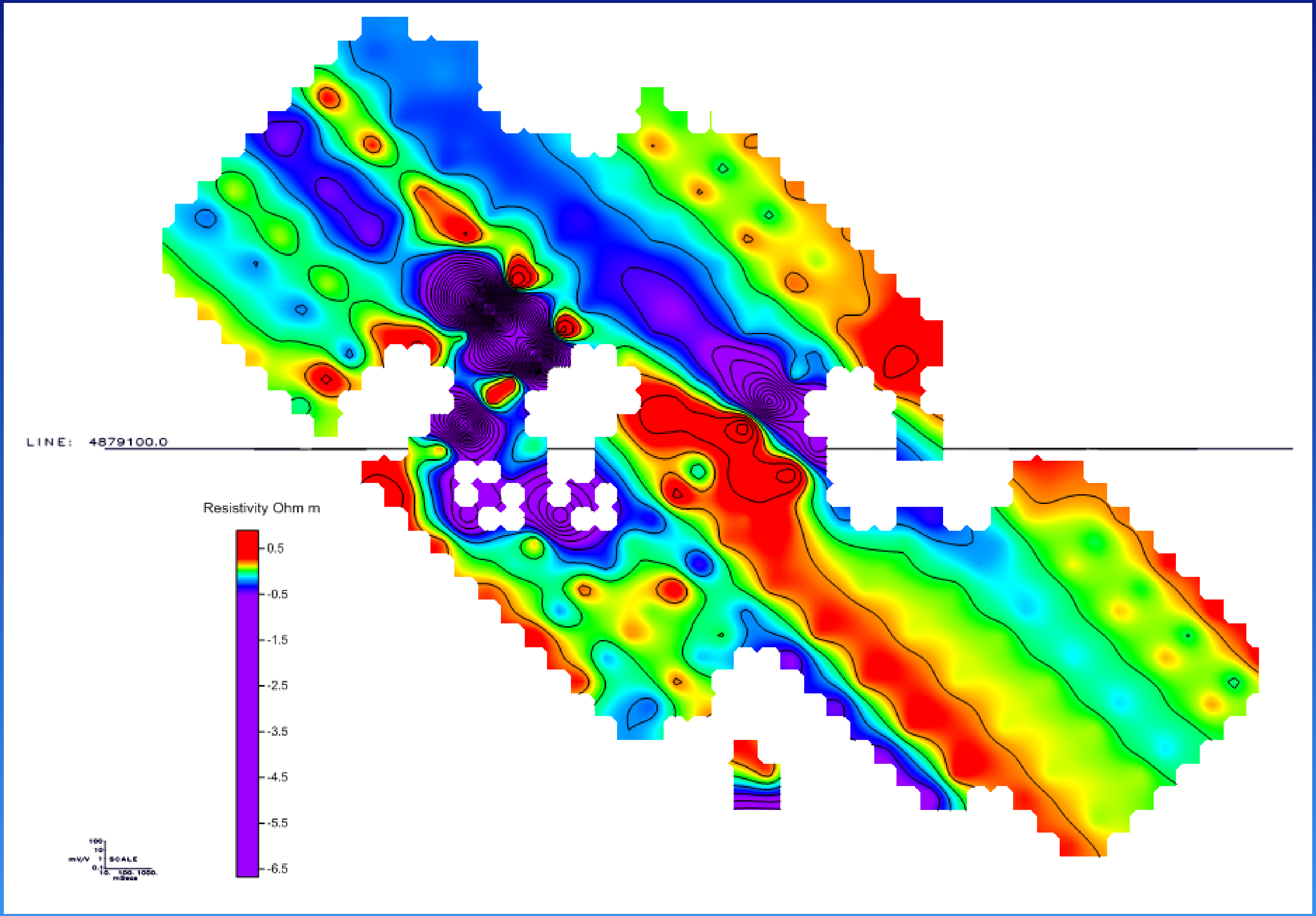


True multipoles



Post-processed data

Worst Match Resistivity Difference – 400m Rx



Post-processed data minus true multipole data

Late-time Mismatch
400m Receiver Dipoles
Southern Receiver Line

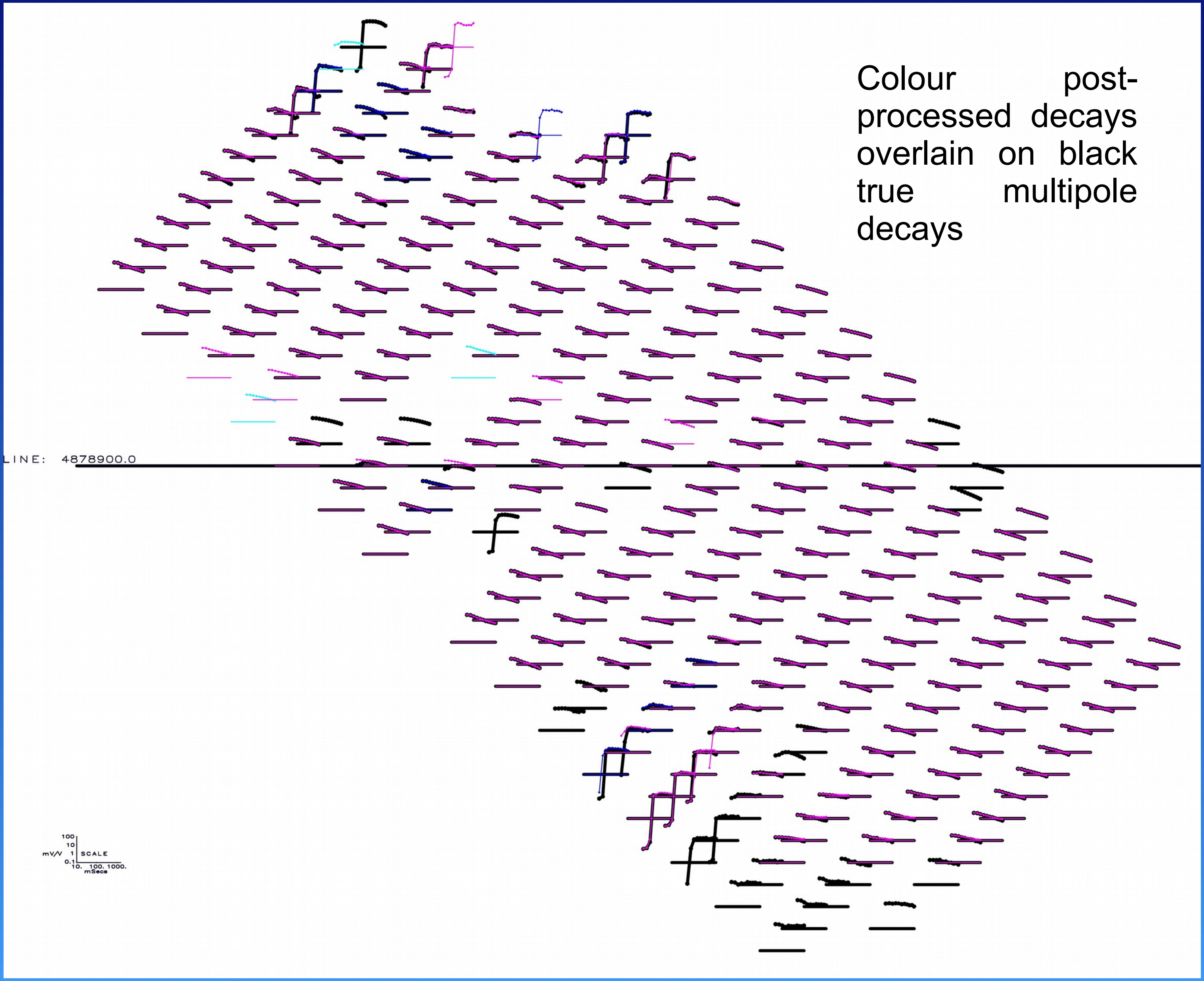
Late-time Mismatch – Explanation

This example demonstrates a good fit at early time but a poor fit at late time. The post-processed decays are consistently higher between windows 7 and 11. Since the chargeability integration window chosen for this dataset is between 5 and 11, this late-time mismatch is a significant factor in the comparison between the post-processed data and true multipole data.

As this mismatch is only a function of late-time chargeability, no resistivity comparisons will be shown in the following slides. The chargeability images will only cover windows 7 – 11.

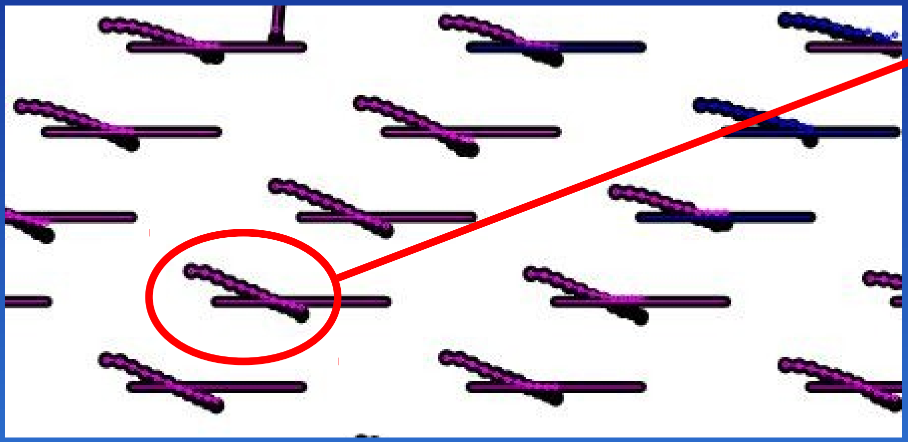
Due to the very large differences in the late time, the contour interval of the difference image has been increased to 5 mV/V.

Late-time Mismatch SPS – 400m Rx

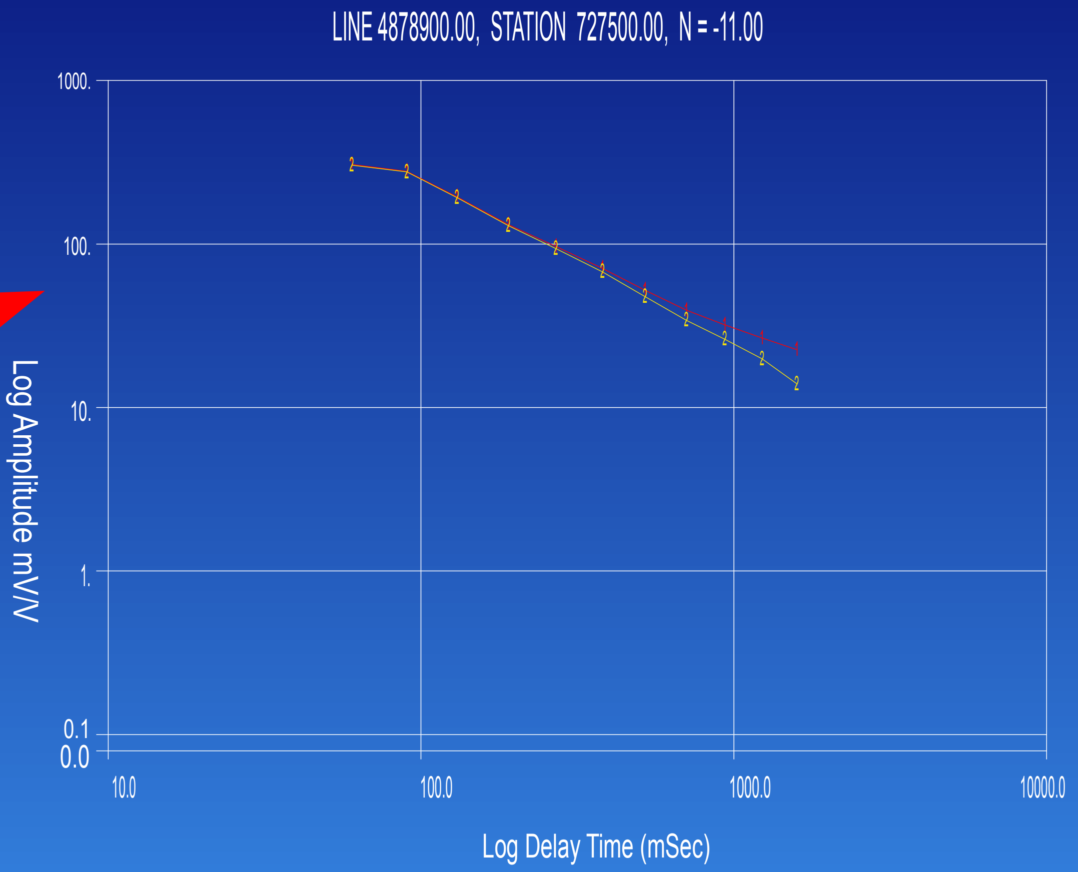


Colour post-processed decays overlain on black true multipole decays

Late-time Mismatch SPS Detail – 400m Rx

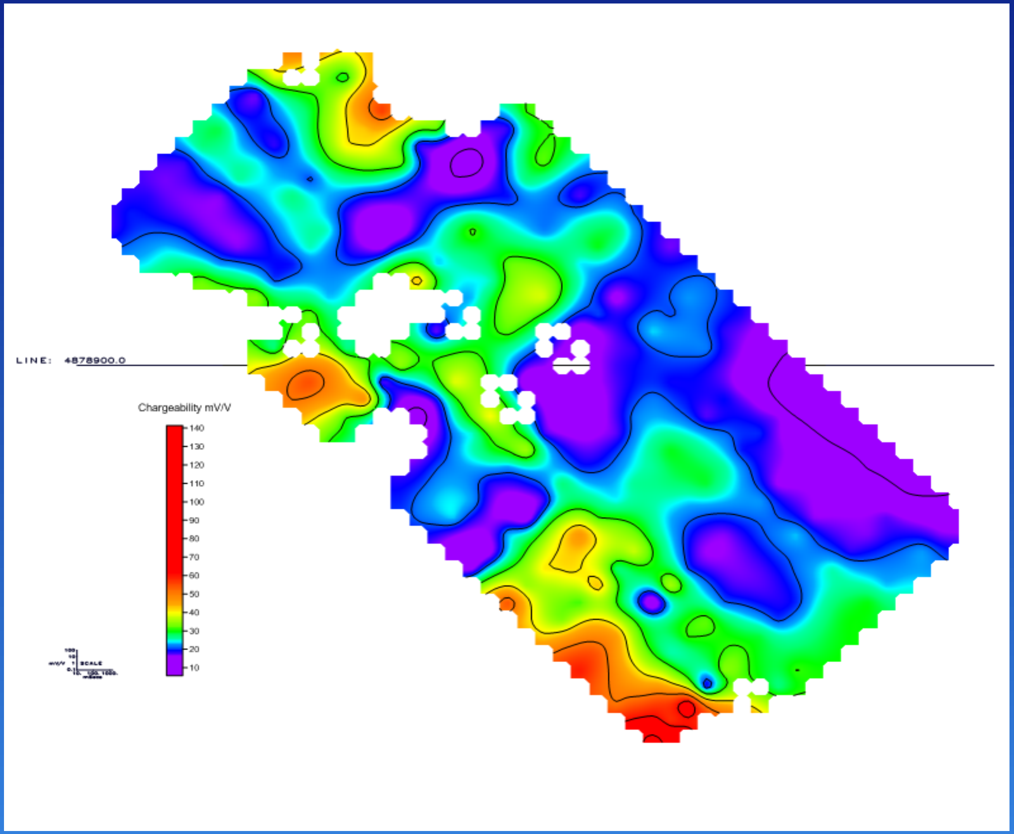


Poor overlap at chargeability windows 7 - 11

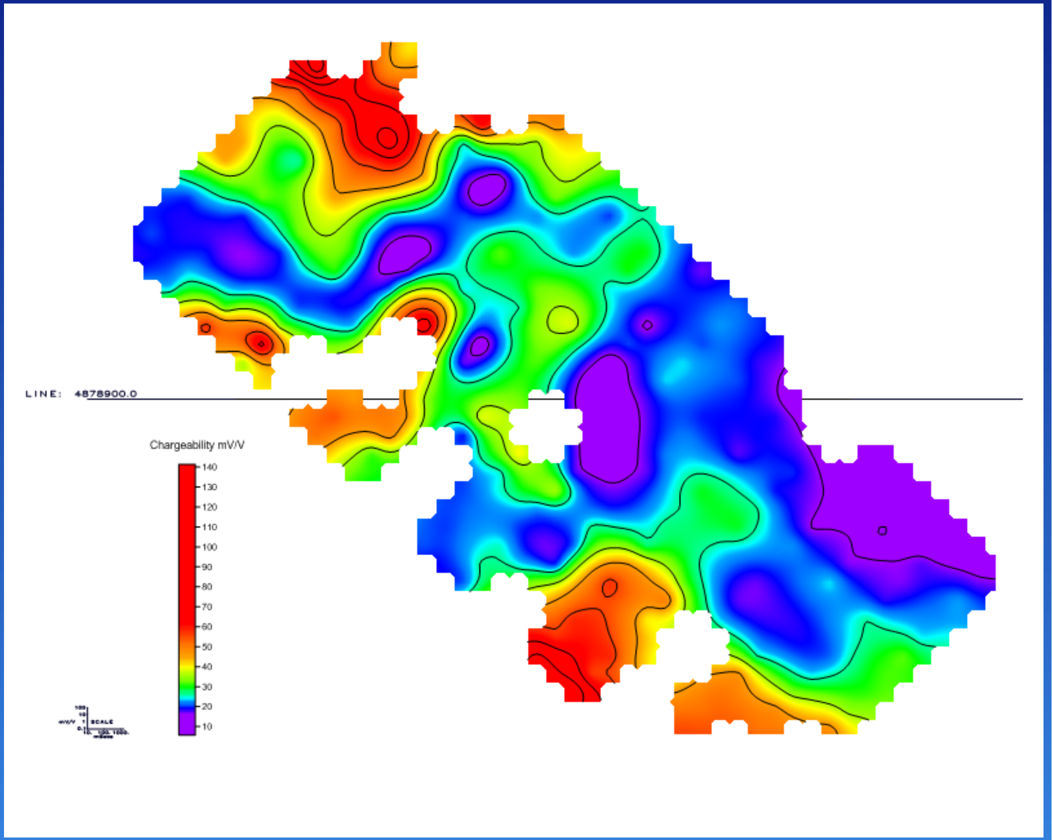


Decay plot of post-processed data (red) and true multipoles (yellow)

Late-time Mismatch IP – 400m Rx

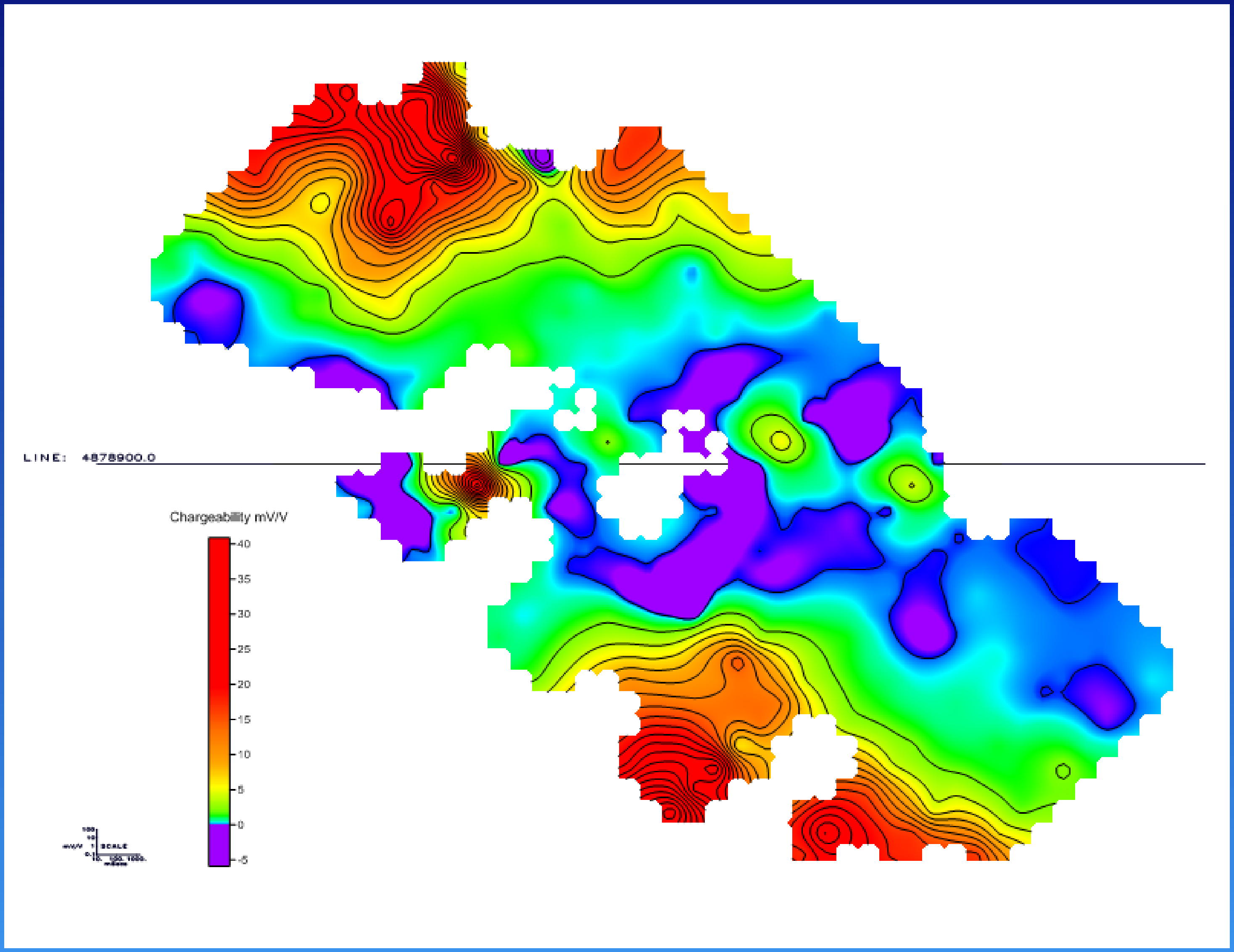


True multipole windows 7-11



Post-processed windows 7-11

Late-time Mismatch IP Difference – 400m Rx



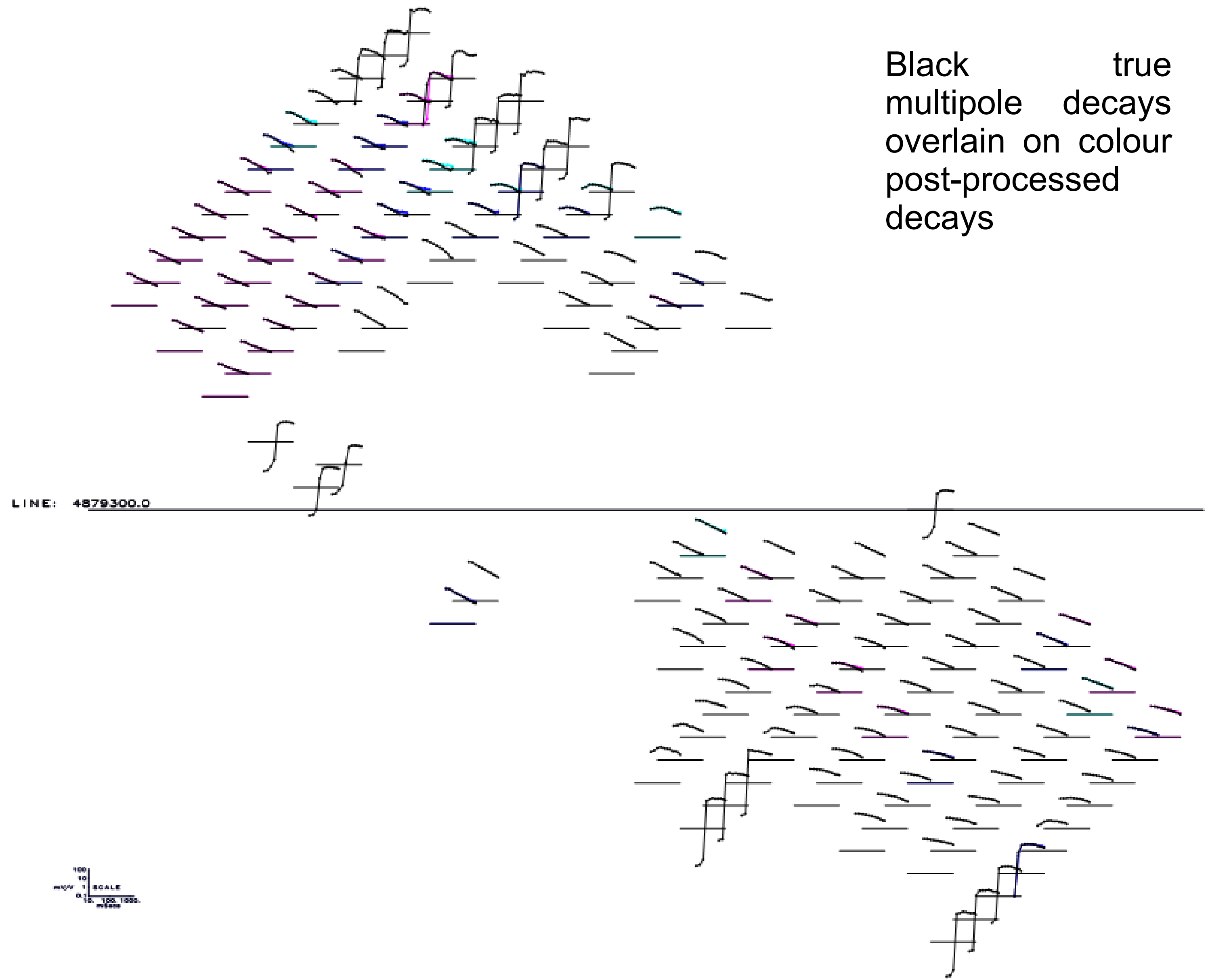
Post-processed windows 7-11 minus true multipole windows 7-11

Most Decays Missing
800m Receiver Dipoles
Northern Receiver Line

Most decays missing – Explanation

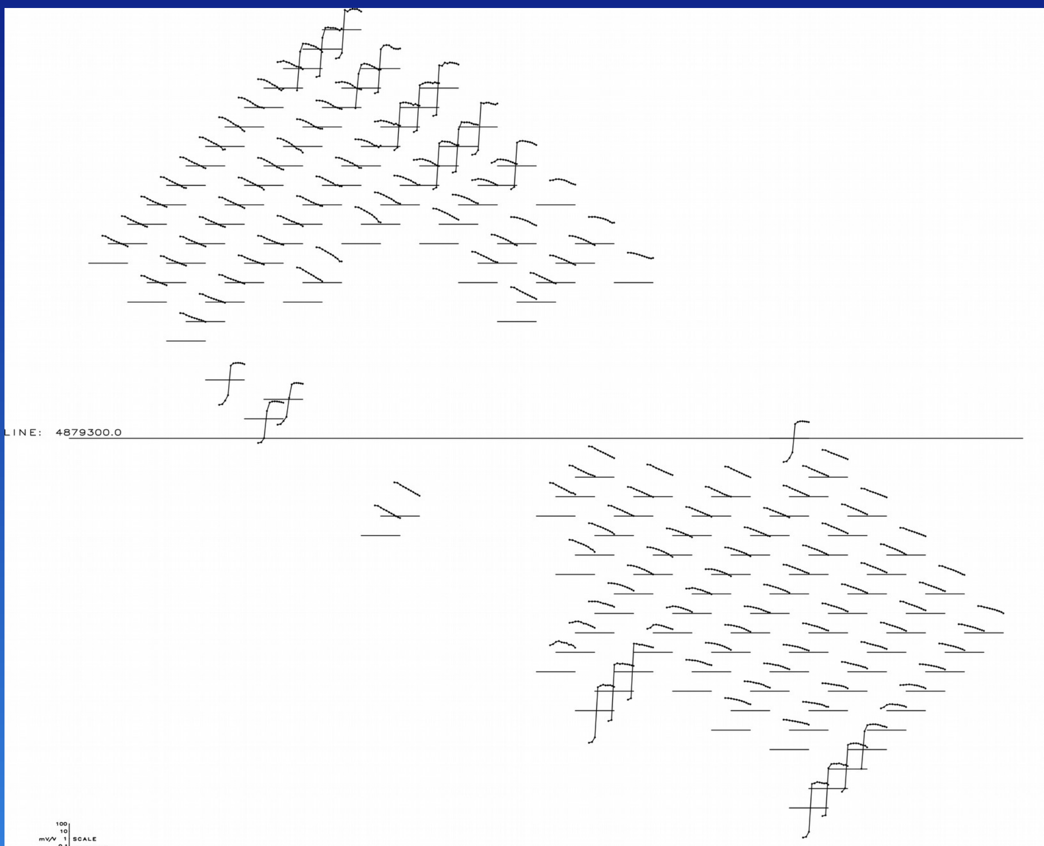
The original 200m Rx database was particularly noisy so many decays were deleted in the cleaning process. Since the post-processed data is calculated directly from this database, if a decay has been deleted from the original database any multipole derived from it cannot exist in the post-processed database.

Most Decays Missing SPS – 800m Rx

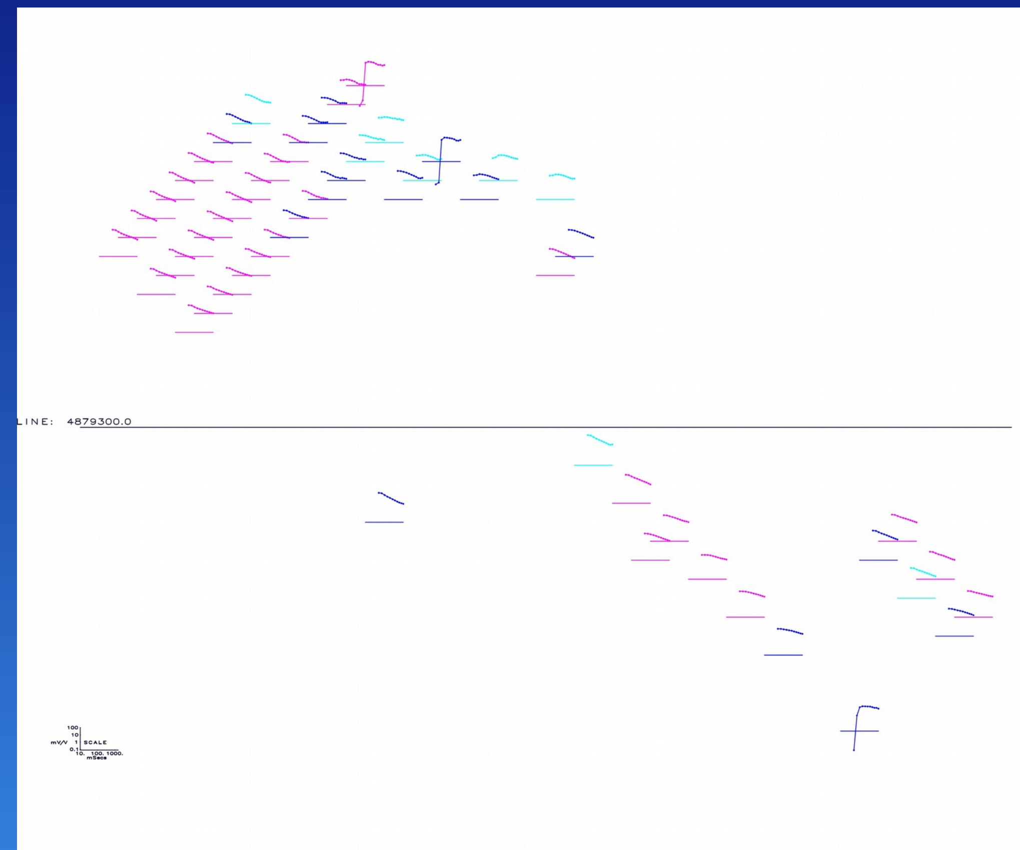


Black true multipole decays overlain on colour post-processed decays

Most Decays Missing SPS Detail – 800m Rx

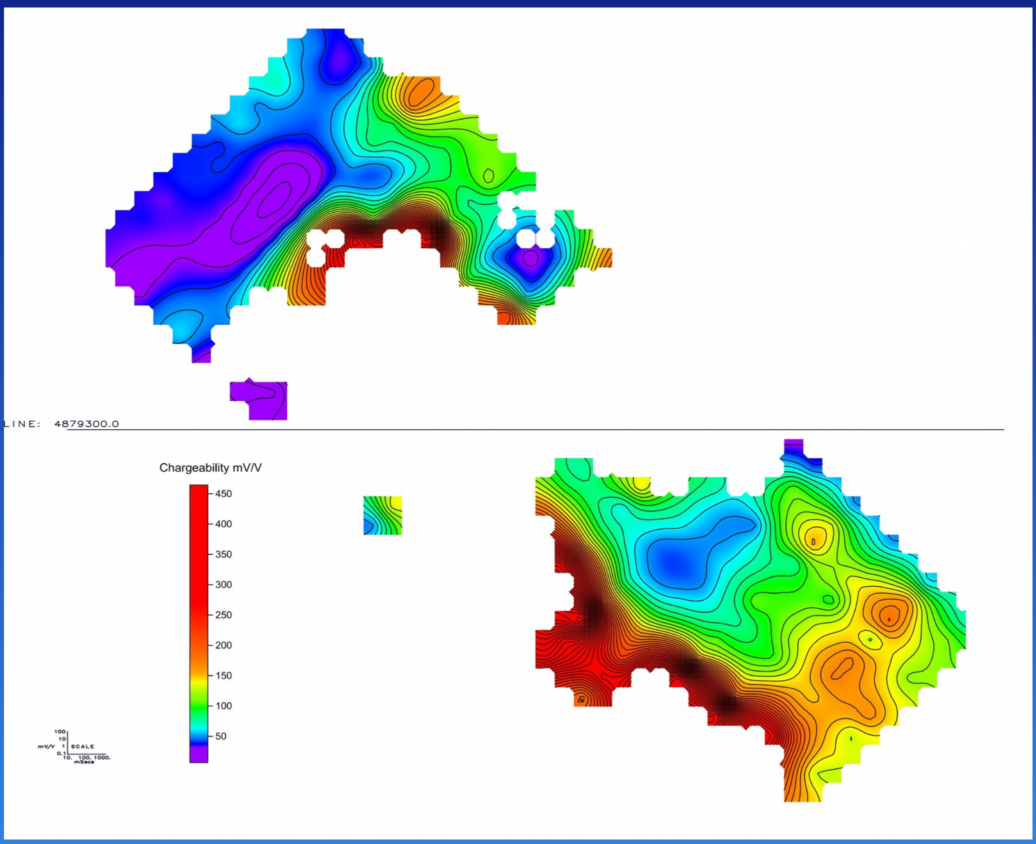


True multipoles

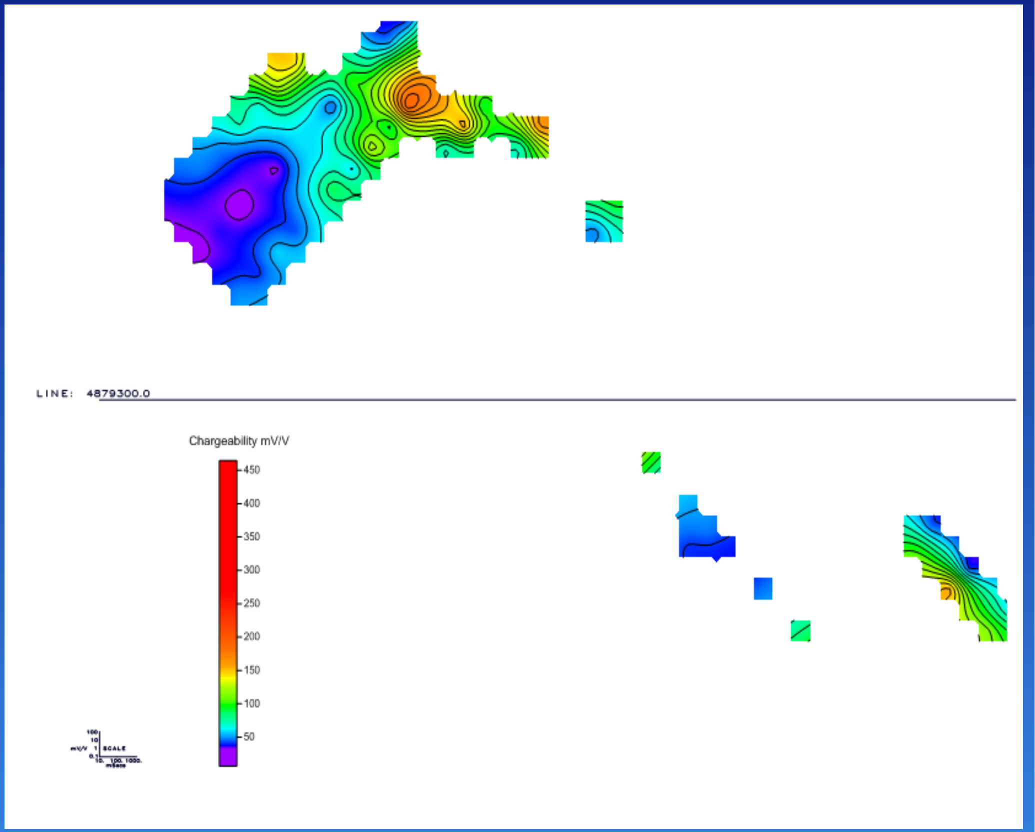


Post-processed data

Most Decays Missing IP – 800m Rx

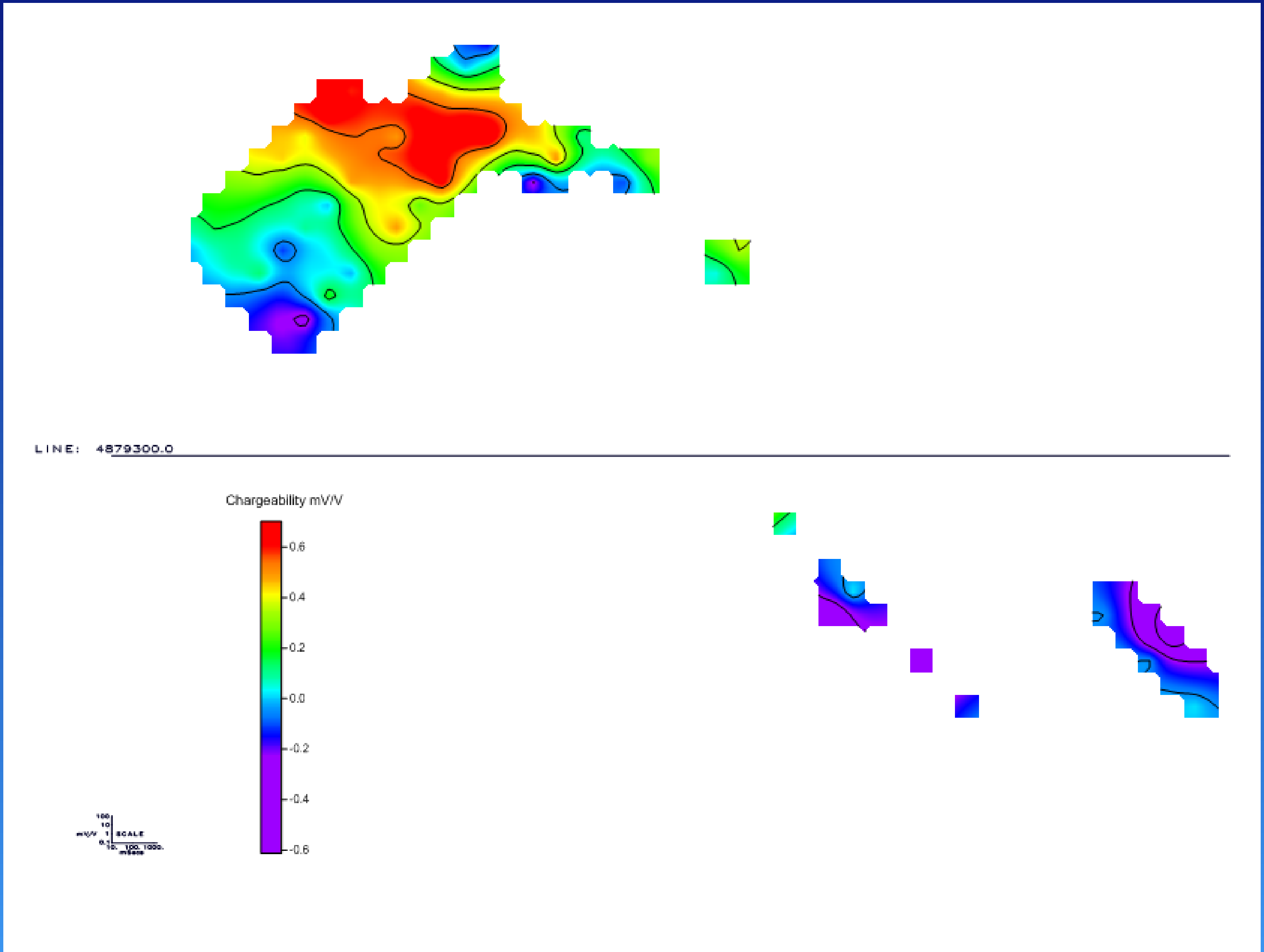


True multipoles



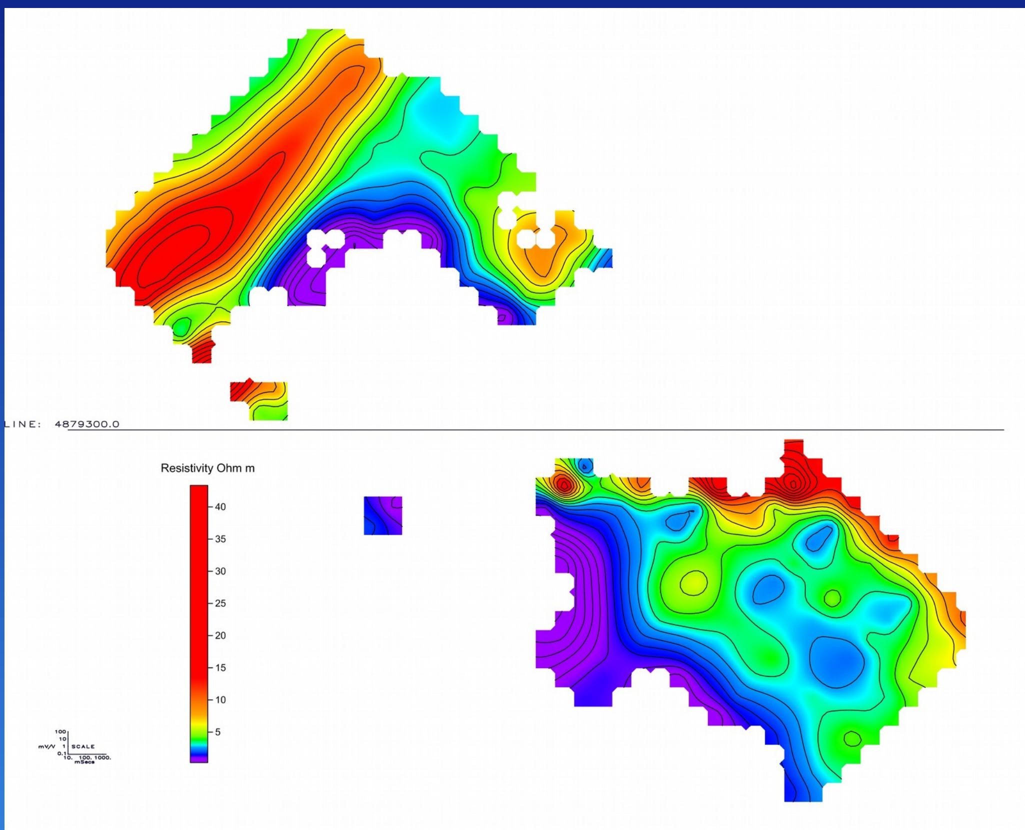
Post-processed data

Most Decays Missing IP Difference – 800m Rx

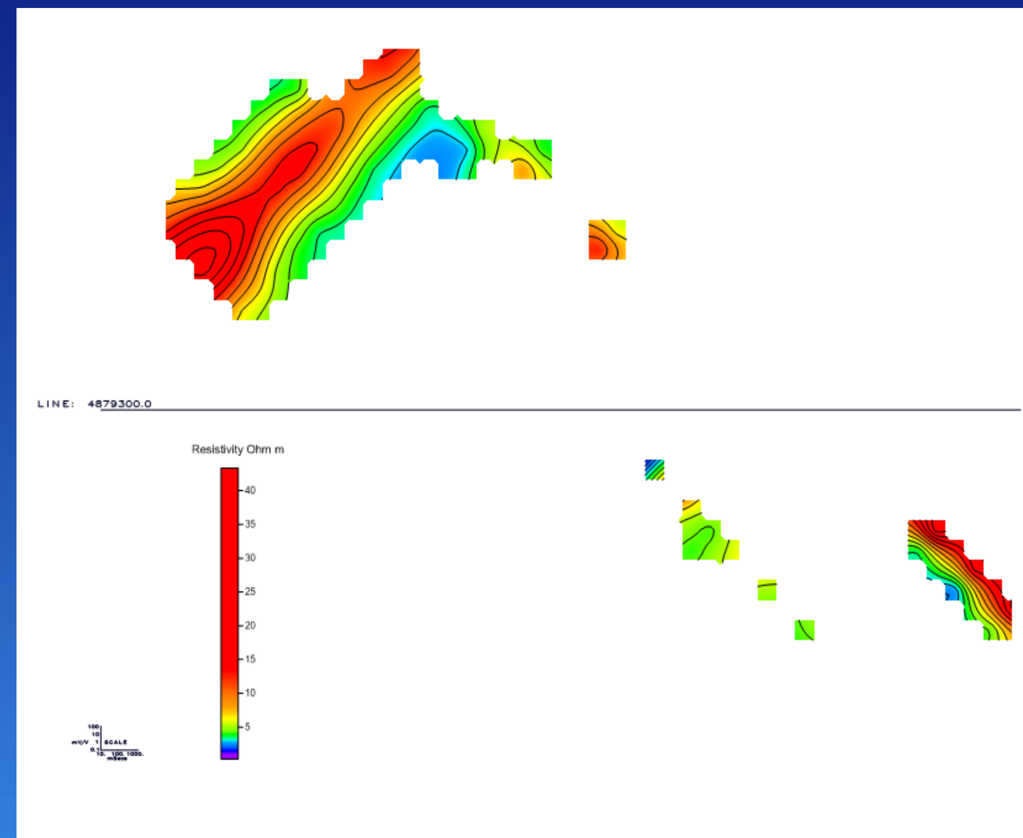


Post-processed data minus true multipoles

Most Decays Missing Resistivity – 800m Rx

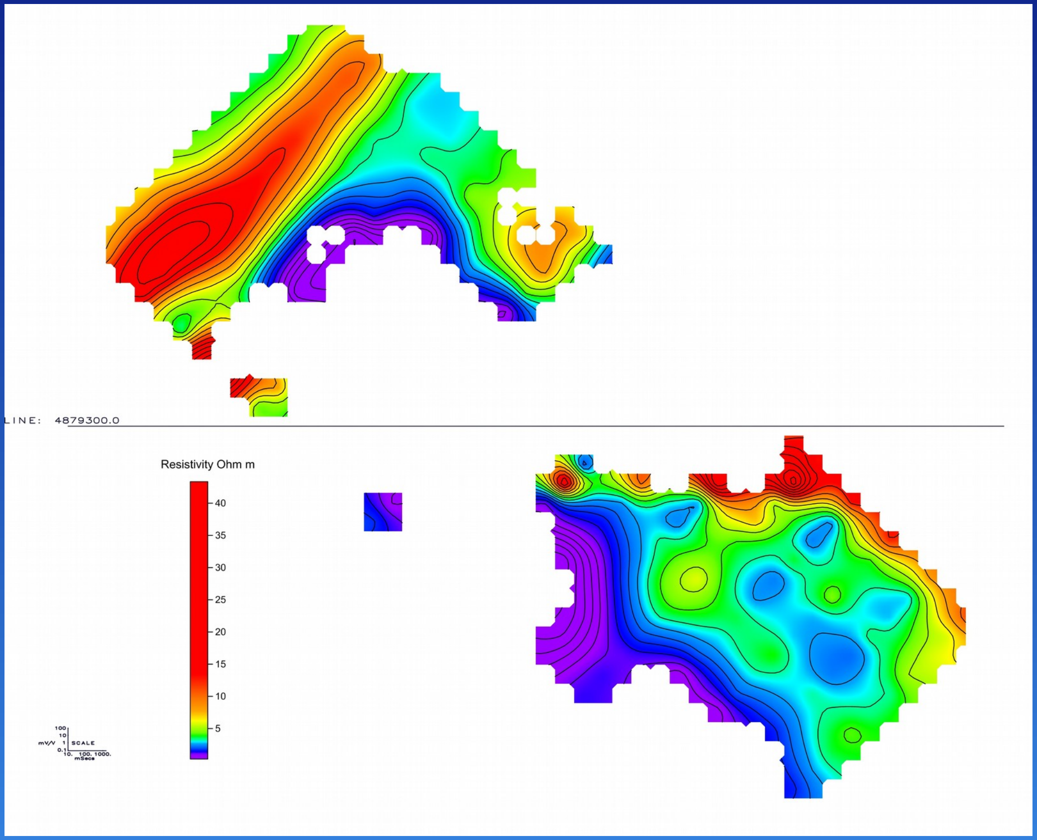


True multipoles

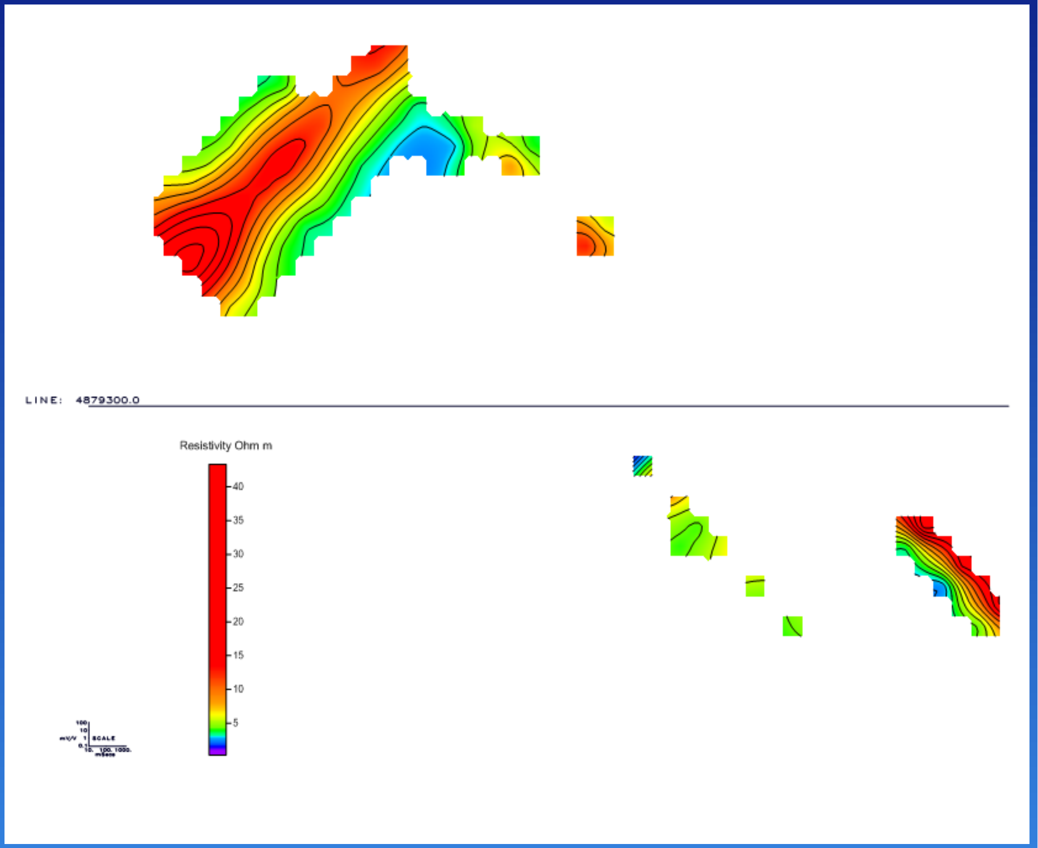


Post-processed data

Most Decays Missing Resistivity – 800m Rx

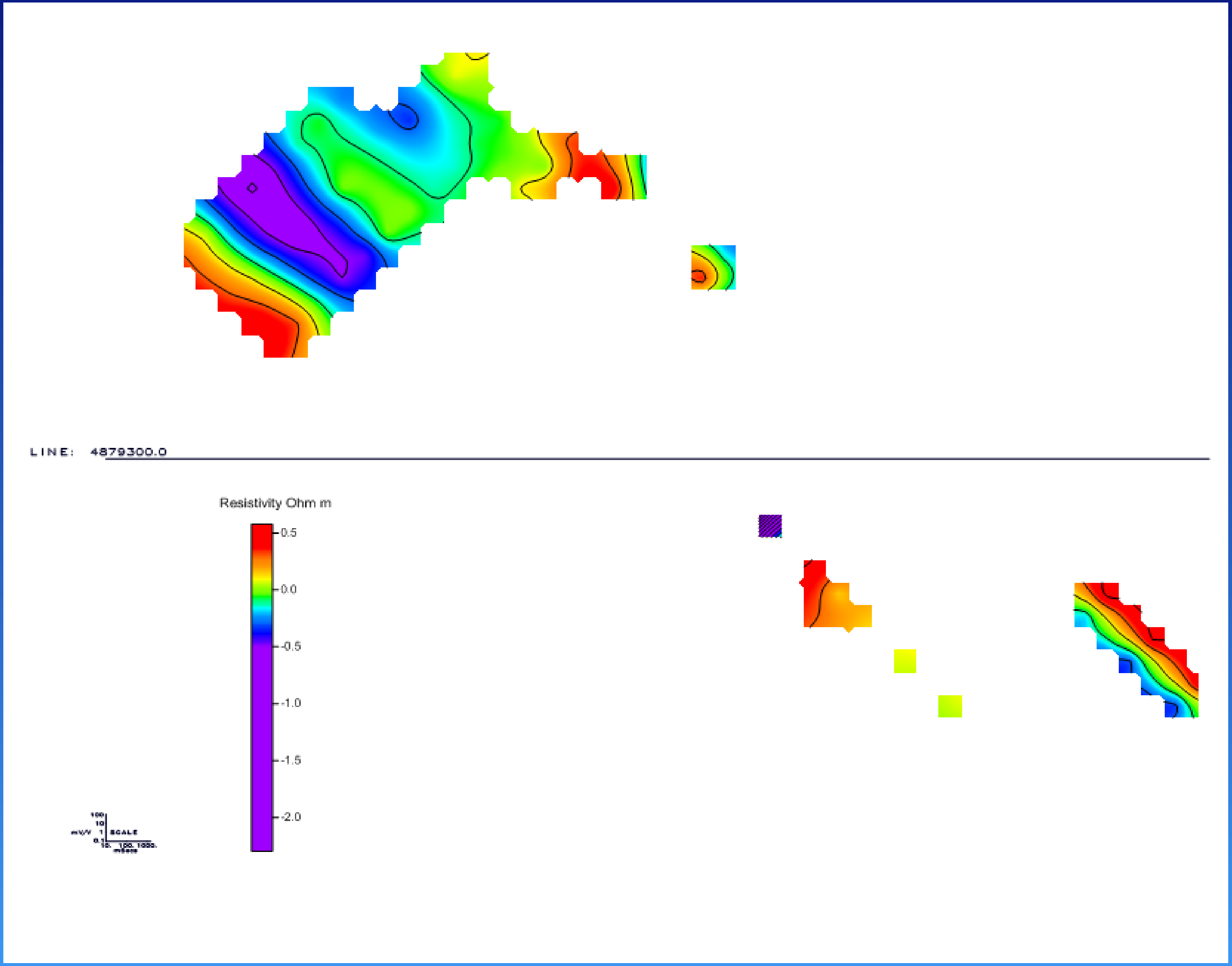


True multipoles



Post-processed data

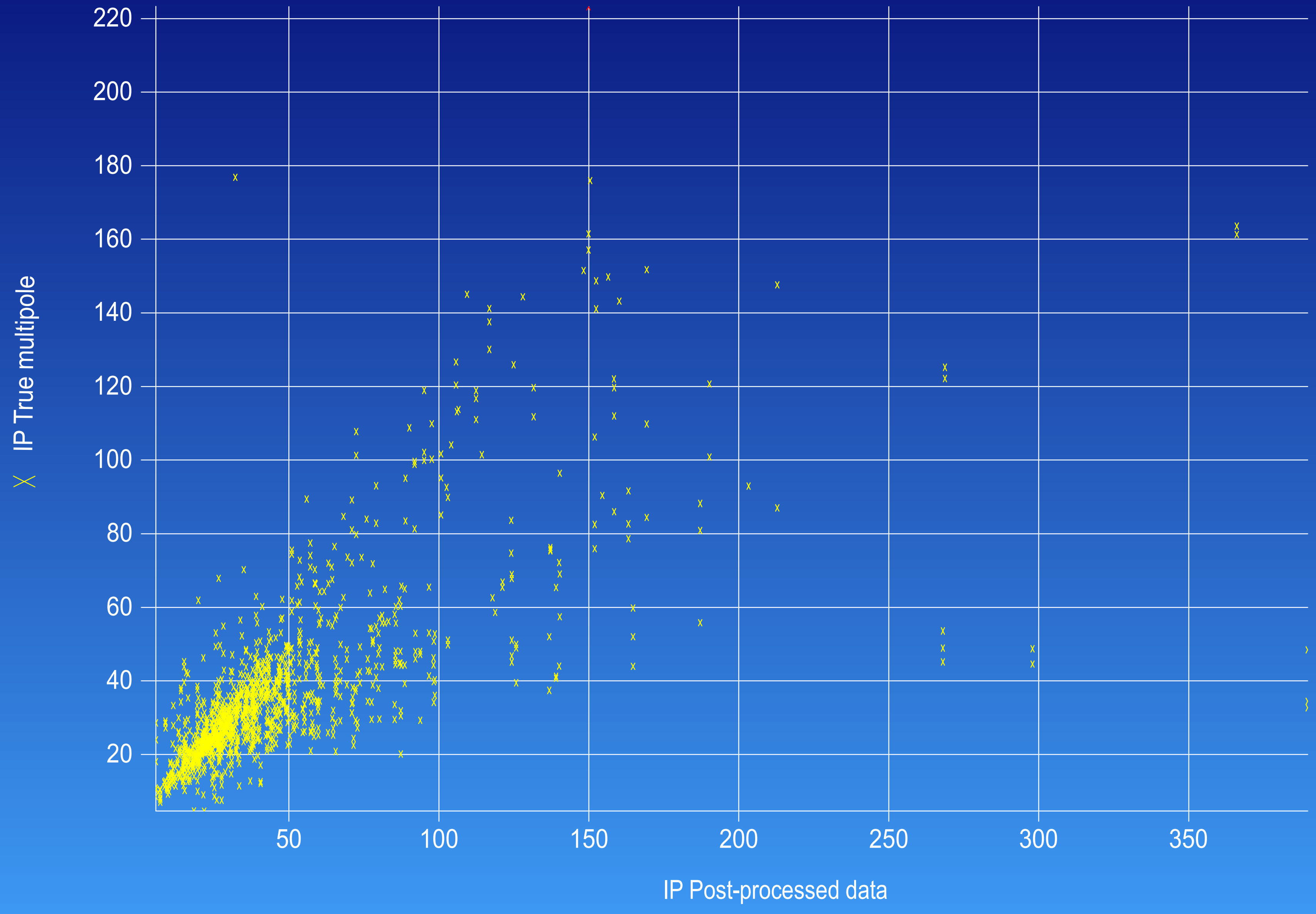
Most Decays Missing Resistivity Difference – 800m Rx



Post-processed data minus true multipoles

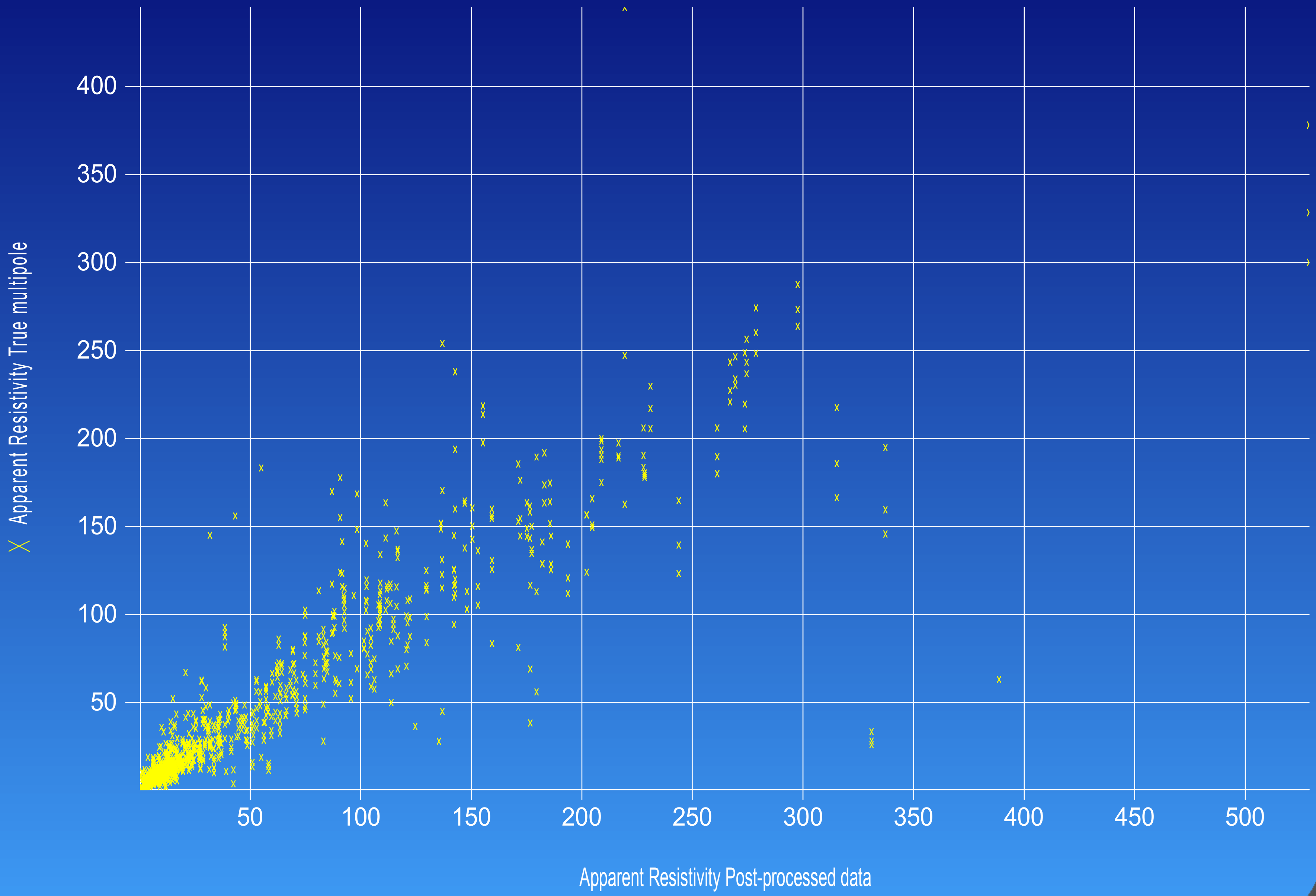
Chargeability Scatterplot

True multipoles vs post-processed data for all multipoles



Apparent Resistivity Scatterplot

True multipoles vs post-processed data



Conclusions

- The post-processed data is comparable to the true multipole data for this particular dataset, with a few small differences as outlined previously.
- Acquiring true multipole data does not cost extra but much more processing time is needed. The post-processed method saves some time at this stage of the job.
- The post-processed method can also be used on historical data for which true multipoles were not acquired during the survey.
- If it is an option then acquire multipole data, if not computing multipoles by summation of the stacked and binned data is a good compromise.