ENHANCING MODEL RELIABILITY FROM TEM DATA
UTILIZING VARIOUS MULTIPLE DATA STRATEGIES

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TOPICS

- TEM inversion
  - what do we mean by TEM inversion
  - motivation
  - forward simulation criteria
  - inversion techniques
- Ground Example 1
  - well studied groundwater basin
  - multiple small loops, with multiple stations and multiple base frequencies
  - well data, other ground data, airborne data
- Ground Example 2
  - deep investigation of sedimentary basin
  - larger loops with multiple stations
  - vertical and horizontal components
- AEM Example
  - associated airborne data

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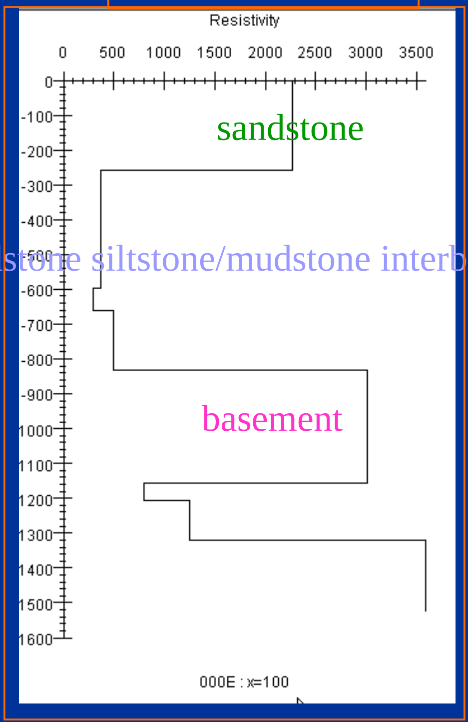
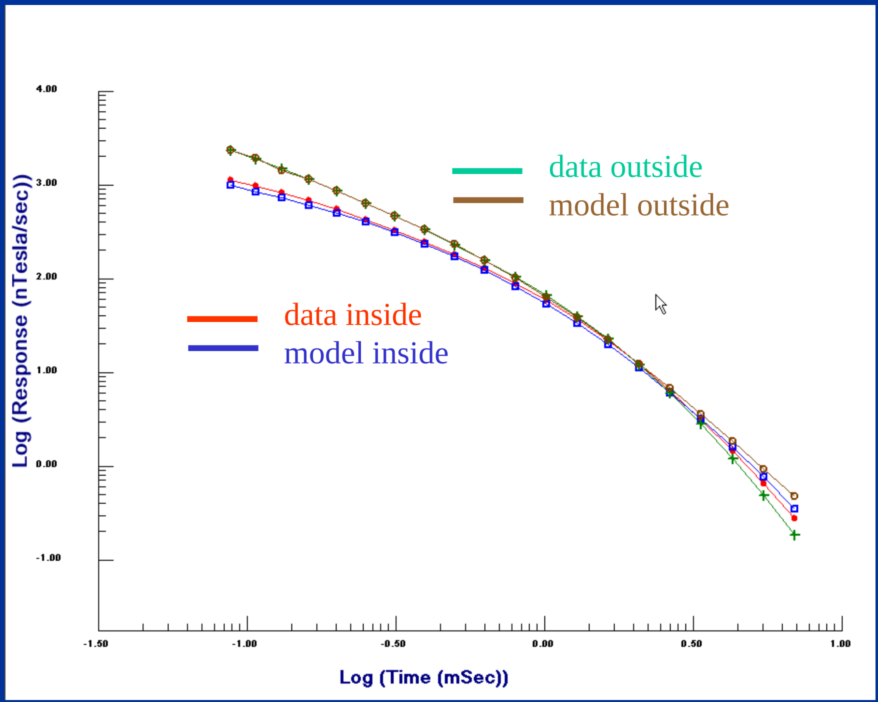
• what do we mean by TEM inversion?

determine by an automatic procedure of forward models at each datapoint (x,y) the resistivity as a function of depth - rho(z)

but with the objective to find as accurately as possible the depths where there are distinct variations in resistivity

Resistivity vs Depth

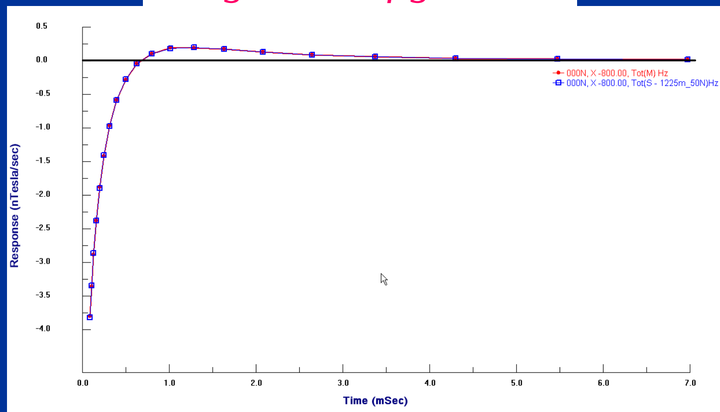




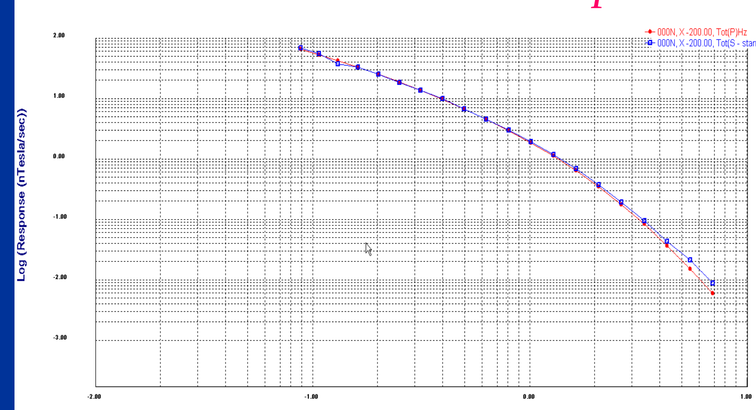
- **motivation?**

for several years, we have been “inverting”
-moving loop - in-loop and slingram style
-fixed loop - inside and outside loop
-airborne - inside and outside TX
with Z (vertical) and X (horizontal) coil orientations

slingram configuration



traditional inside loop



-inversion of one data element although
having multiple time windows is not reliable due to “noise”.

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- **forward simulation criteria**

Reproduce Instrument Response

Current waveforms are periodic:

✓Transmitting Waveform is repeated many times and data are stacked

✓A discrete spectrum at harmonics of the base-frequency

✓Finite bandwidth – electronic implementation, linearity of coils , high frequency noise

✓Correct loop geometry - no circular or square approximations

✓Utilization of variable current waveforms with different instruments

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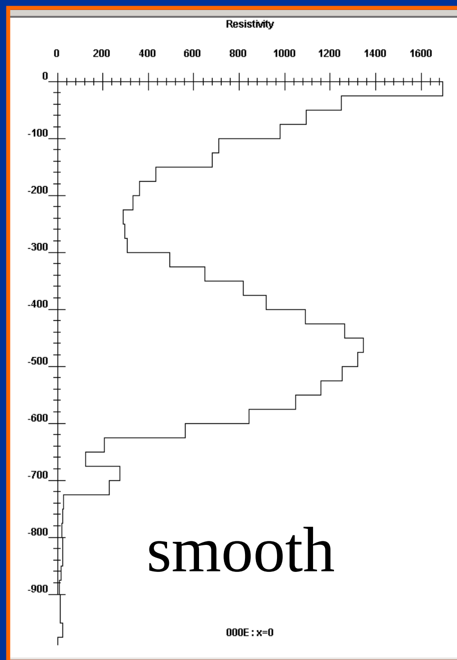
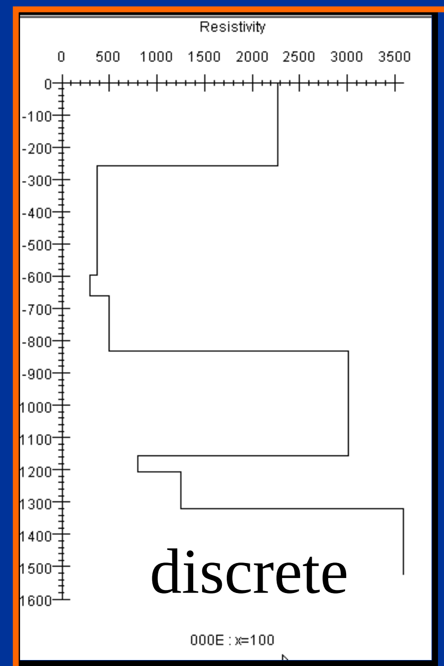
- **inversion techniques**

- overparametrized (occam) vs underparametrized (marquardt)
- unconstrained and constrained resistivities, thicknesses and depths

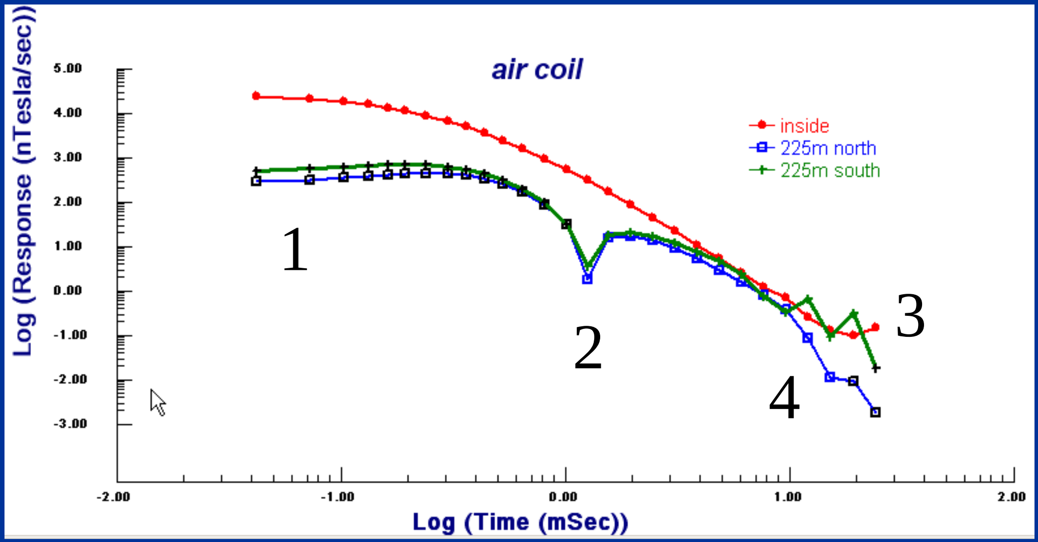




-although smooth models are useful qualitatively
for some purposes they do not give adequate precision

-additional data components allows more complexity
in the discrete models and more certainty with the model

- **Ground Example 1 – USGS WRD Tucson**
  - well studied groundwater basin
  - 2 outside and 1 inside loop measurement



1. difference in early-time outside loop response
   - instrument, cultural, natural, or geological noise
2. common crossover time of currents
3. odd late time inloop response
4. noisy but still useful late time outside loop response

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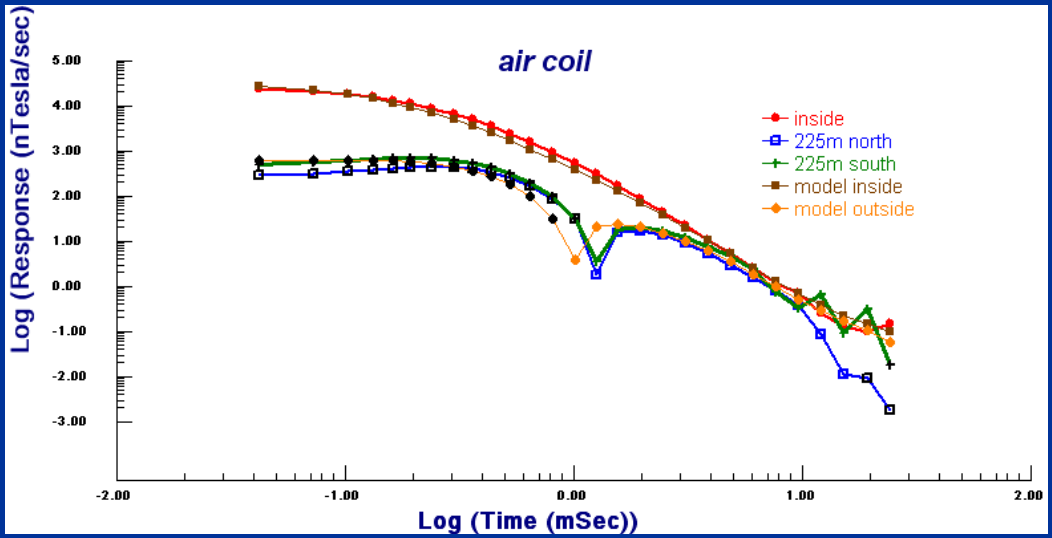
- **Ground Example 1**
  - **well studied groundwater basin**

without an inversion for multiple datapoints, a trial and error procedure must use single station inversions and multiple station forward results iteratively

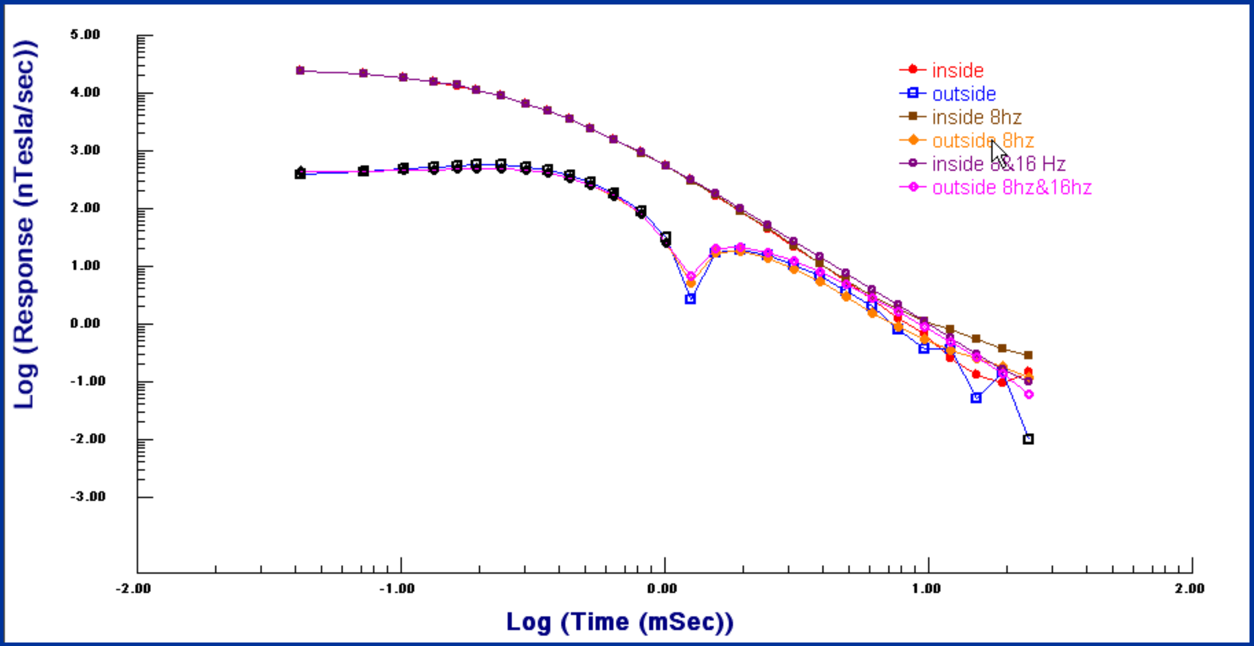


rho	dz
6.6	45
15	290
.8	

BUT, TOO TIME CONSUMING
and statistically uncertain

- **Ground Example 1**
  - **use of stacked data and multiple data point inversions**

single inversion for all data points

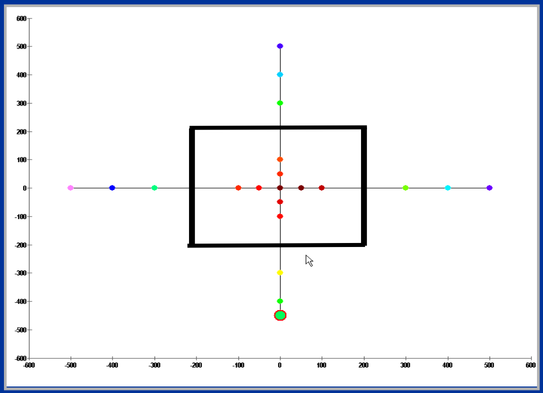


rho	Δz
4	3.6
5	36
15	

quicker and less labor oriented multiple data point inversions

Note: model consistent with ground FEM data, and well hole information to a limited depth

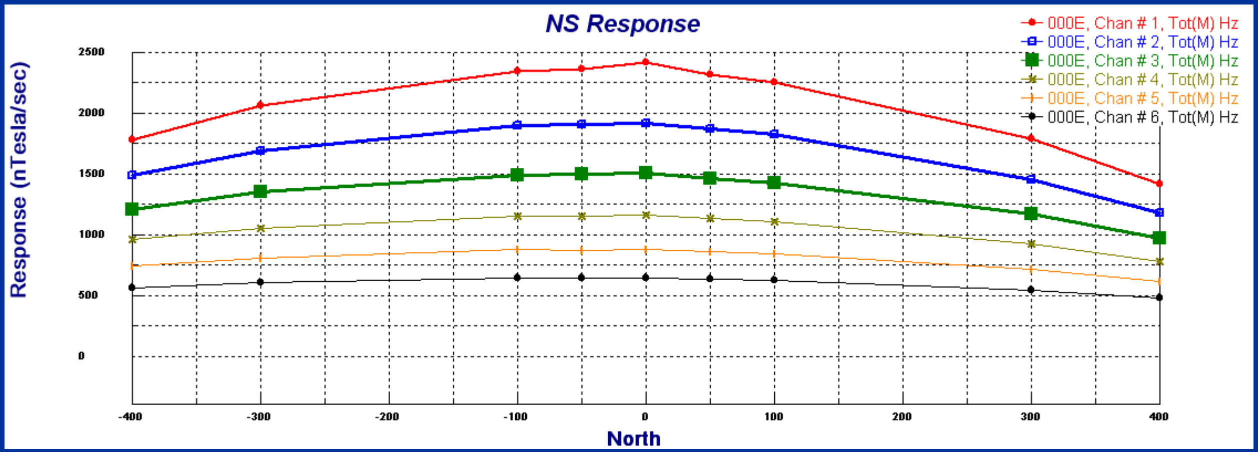
- **Ground Example 2 – deep sedimentary interpretation**
  - **relatively unknown sedimentary sequencing**
  - **400x400 loop**



22 measurements
11 NS, 11 EW

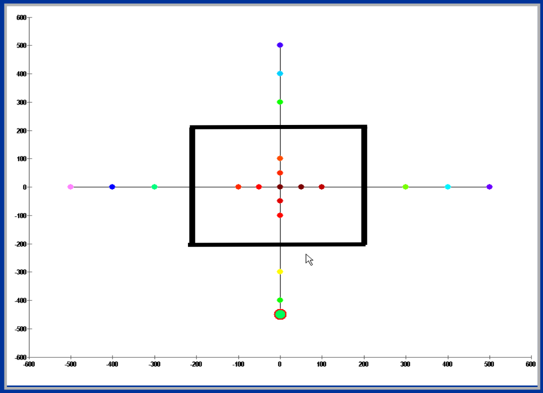
Survey Objective:

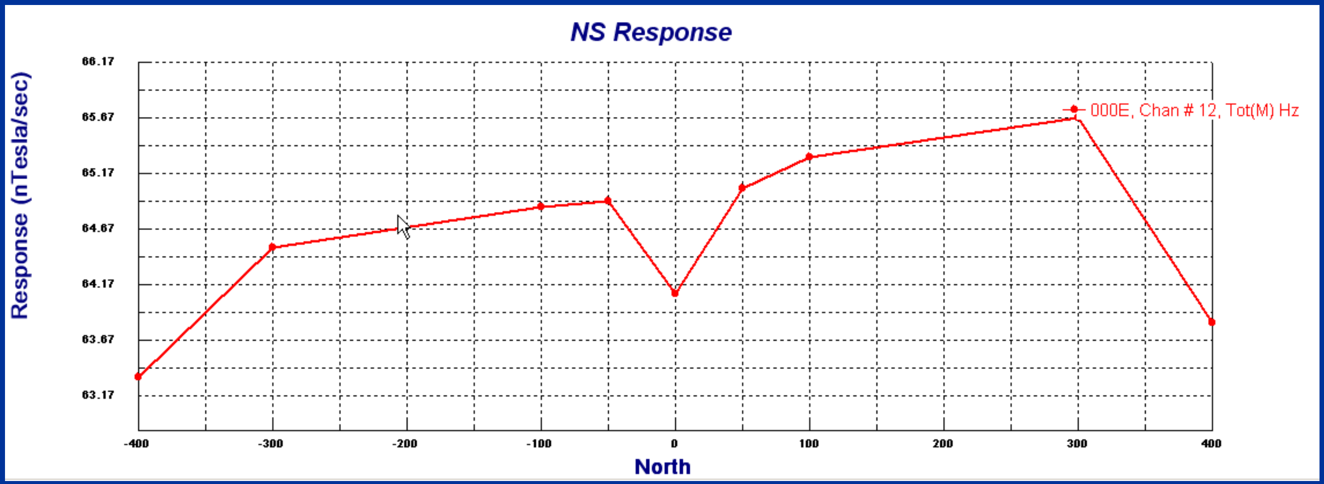
- depth to basement through sedimentary sequence
- bedding discrimination



Hz data is relatively symmetric for NS and EW implying suitability of 1D model

- **Ground Example 2**





by Ch12, start to see switch in curvature inside the loop
with characteristic dropout at centre
- "inside loop soundings can be dangerous"

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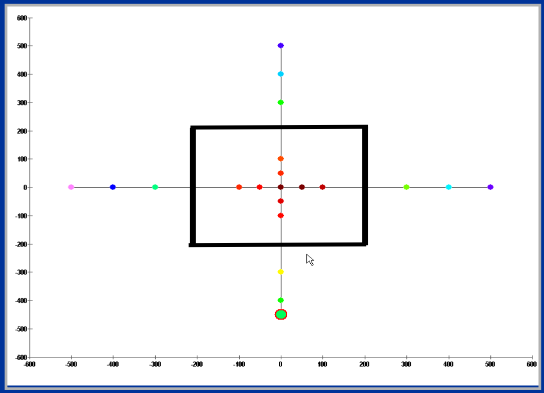
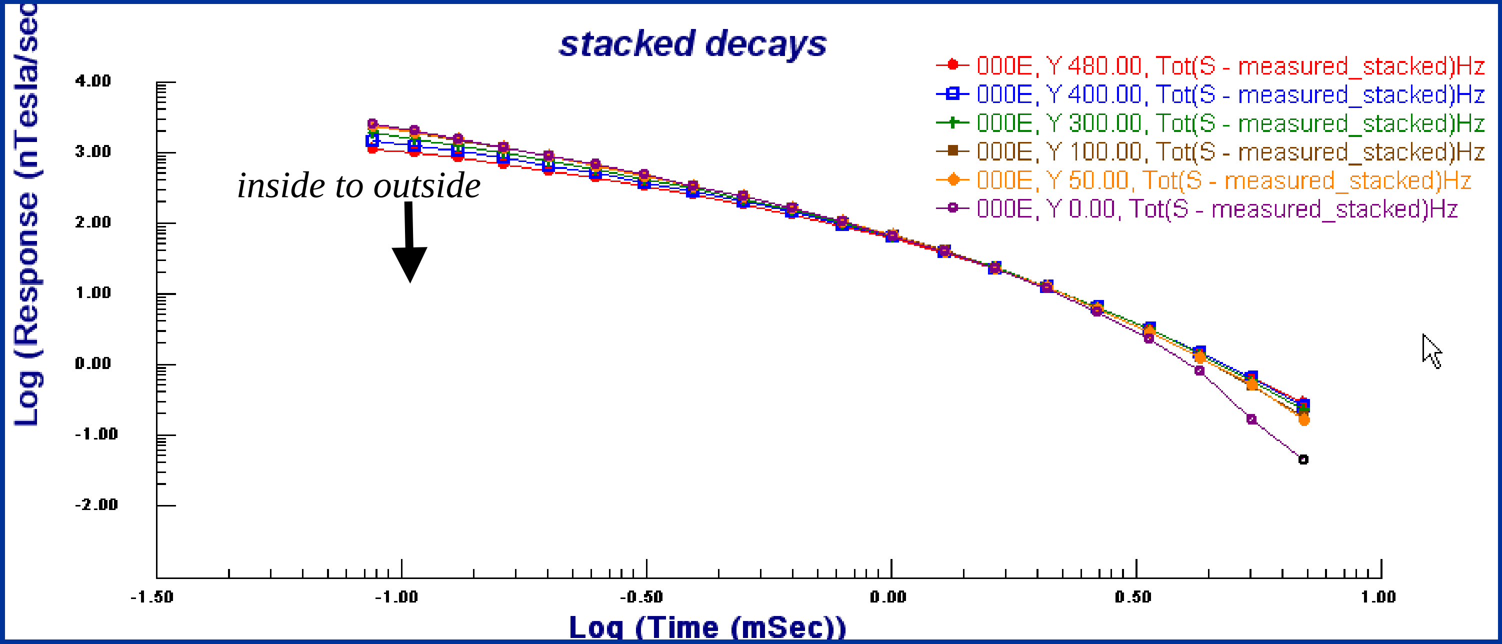
• Ground Example 2



Reduction of "Noise"
stack data at equivalent distances from centre
– 6 resulting data

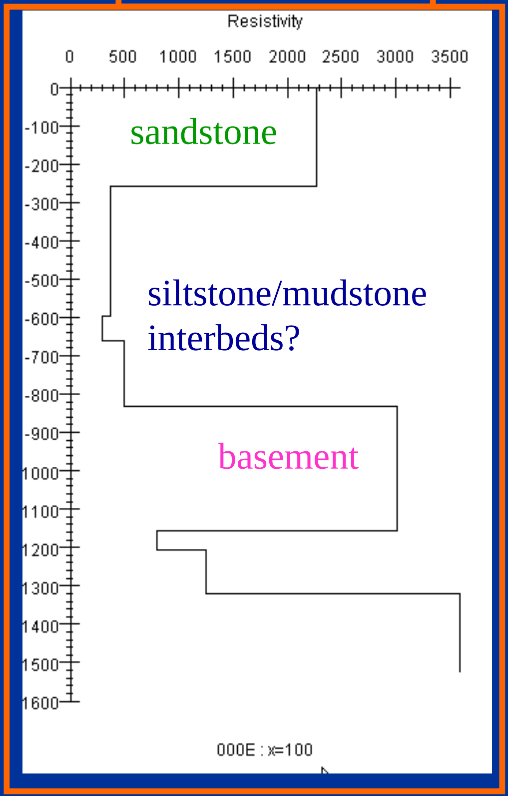


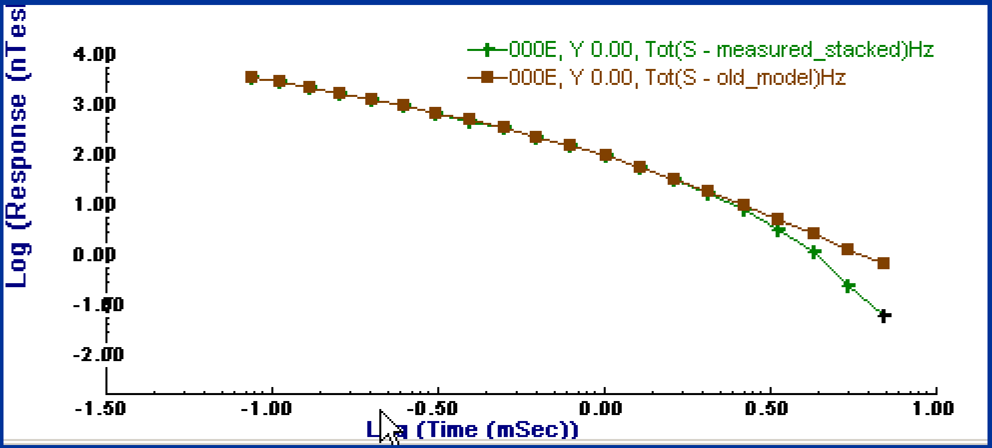
- **Ground Example 2**

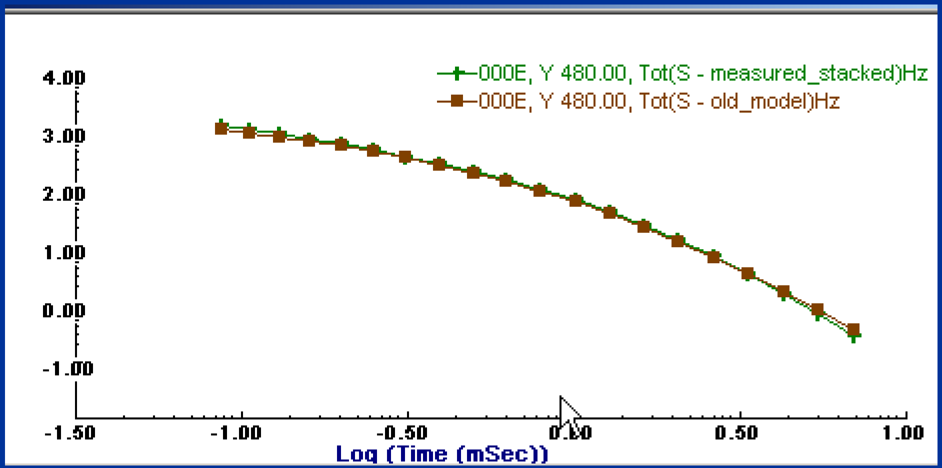
initial model fits

via repeated manual iteration

Resistivity vs Depth







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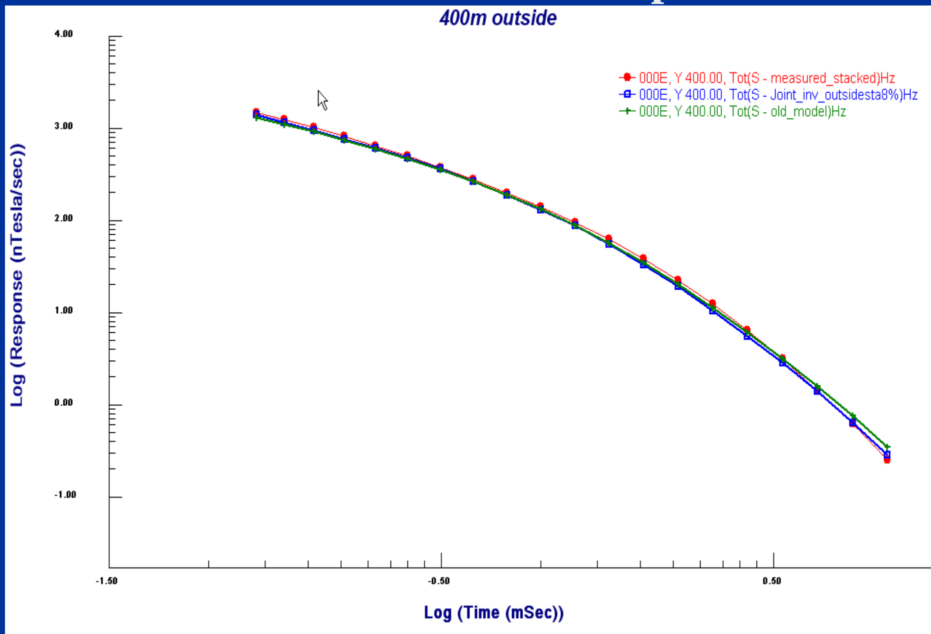
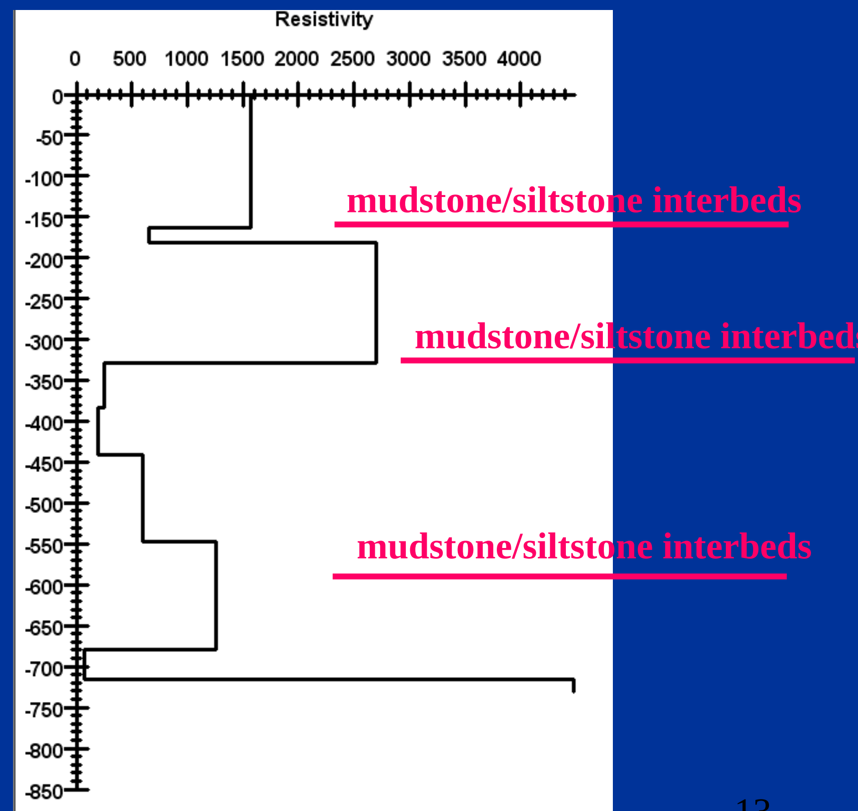
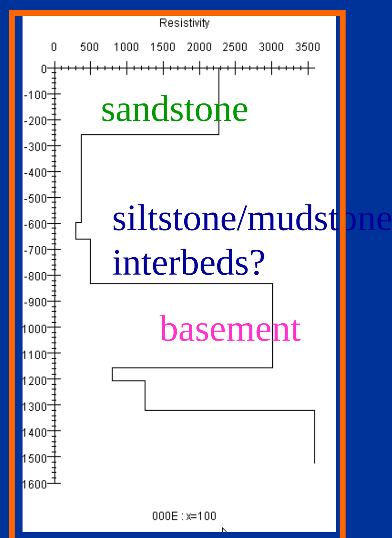


6 pt inversion – inside/outside

somewhat better late and early time

but quicker from a manpower perspective





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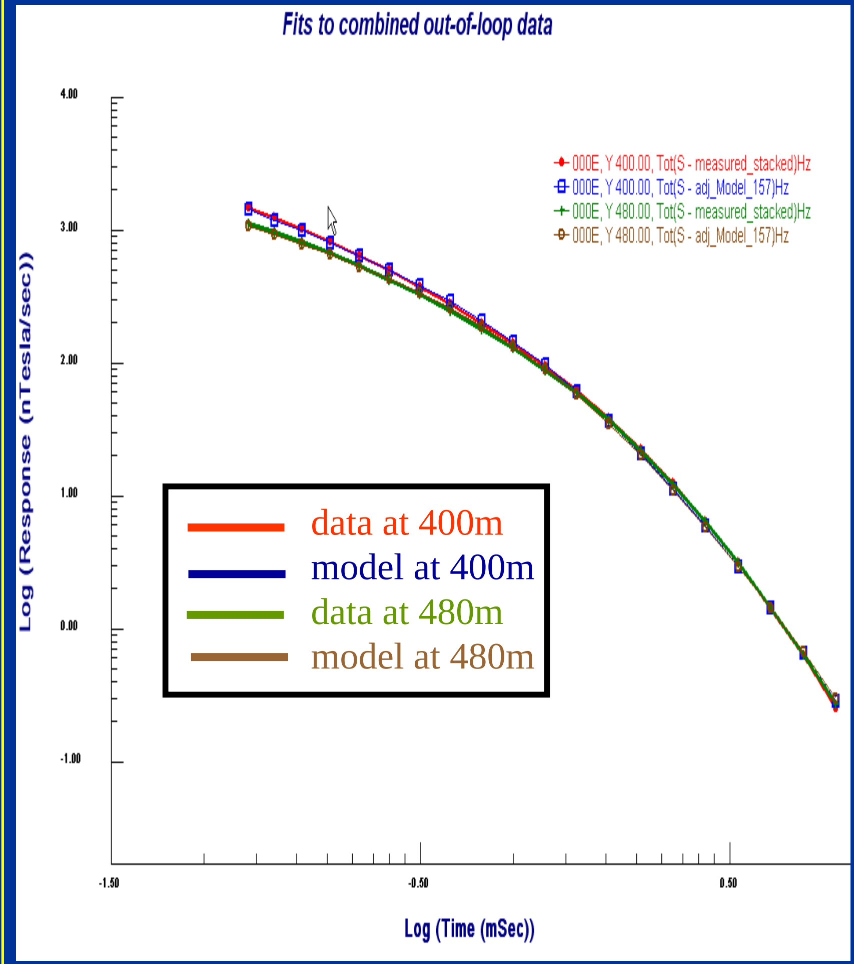
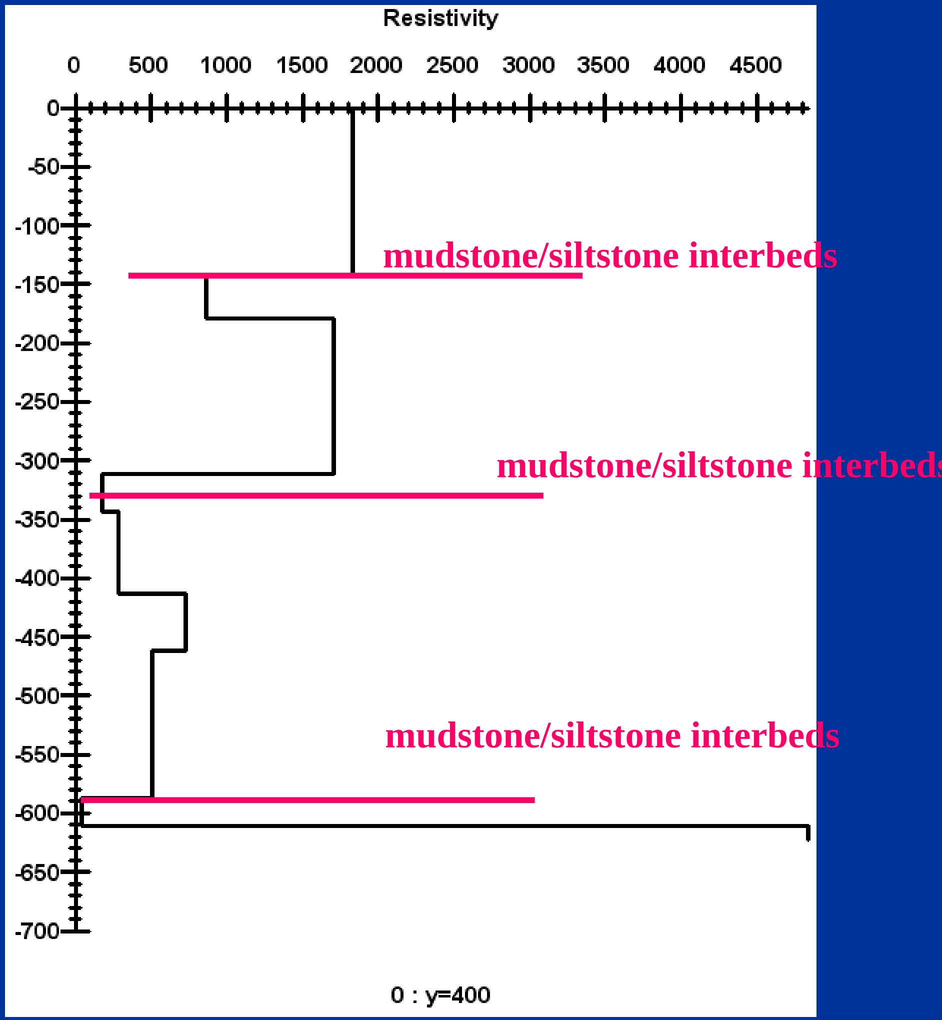
- **Ground Example 2**



better mid-time fits
with only outside loop



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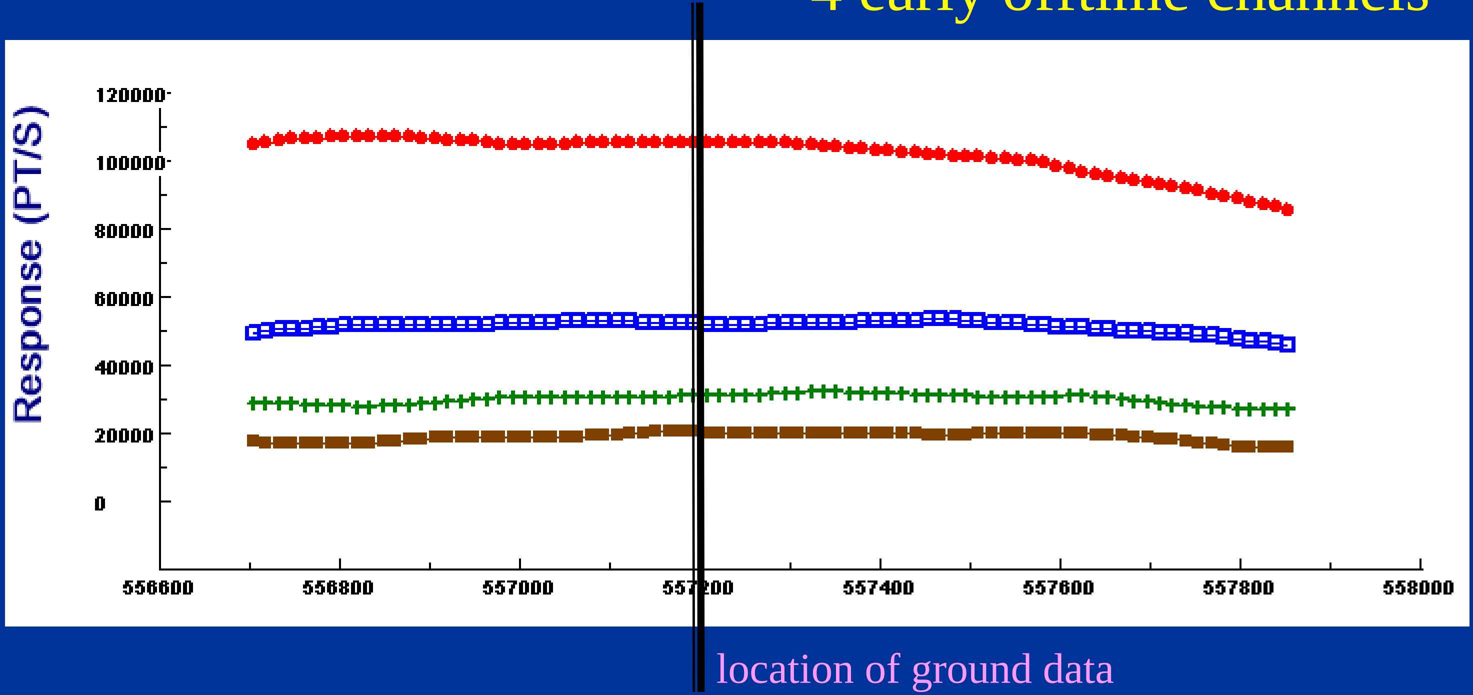
- **Airborne Time Domain Example**
  - **associated airborne data example 1**

4 early offtime channels

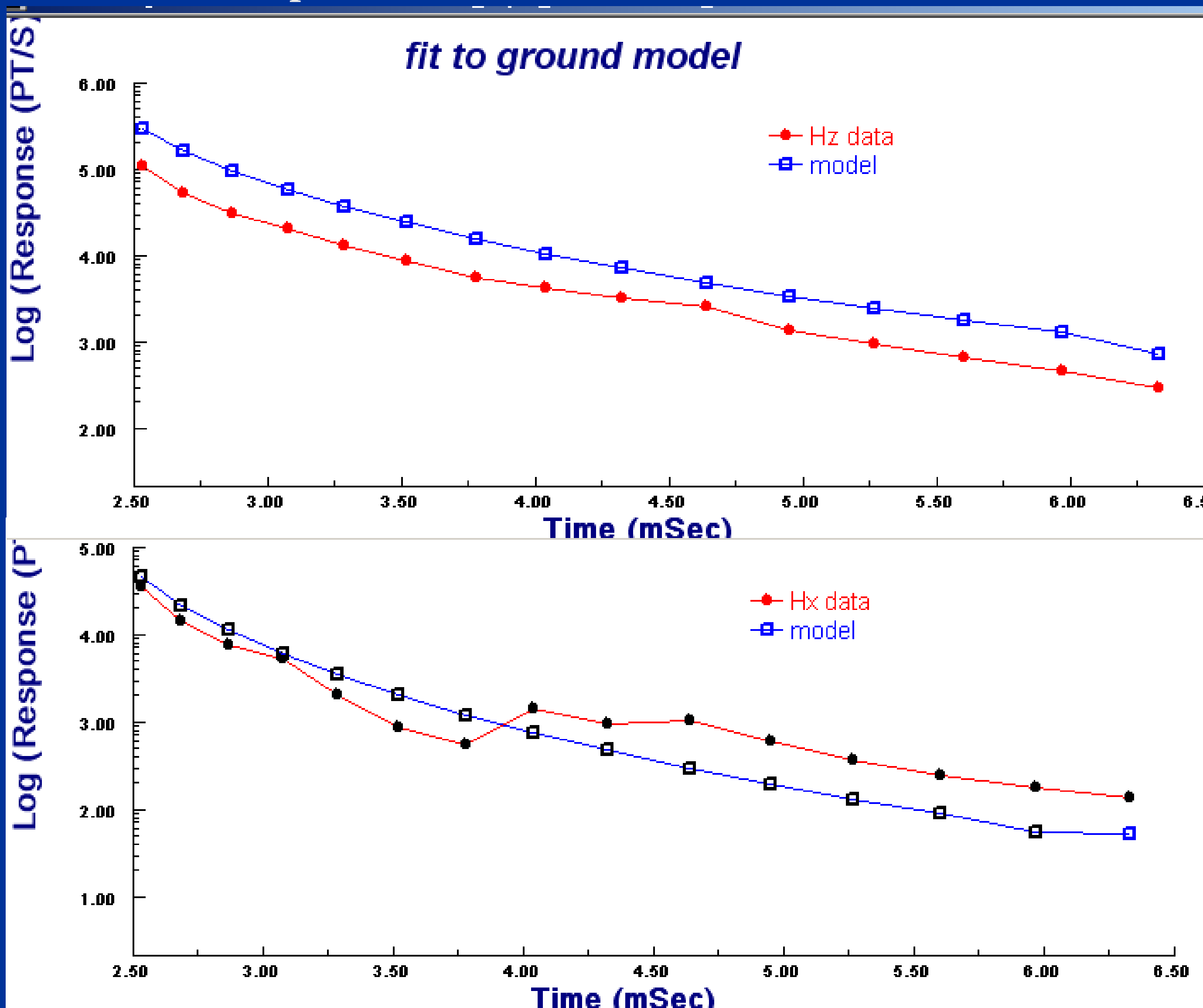


location of ground data

<u>smooth spatial response</u>

thus we would expect a slowly varying 1D model to be reasonably appropriate

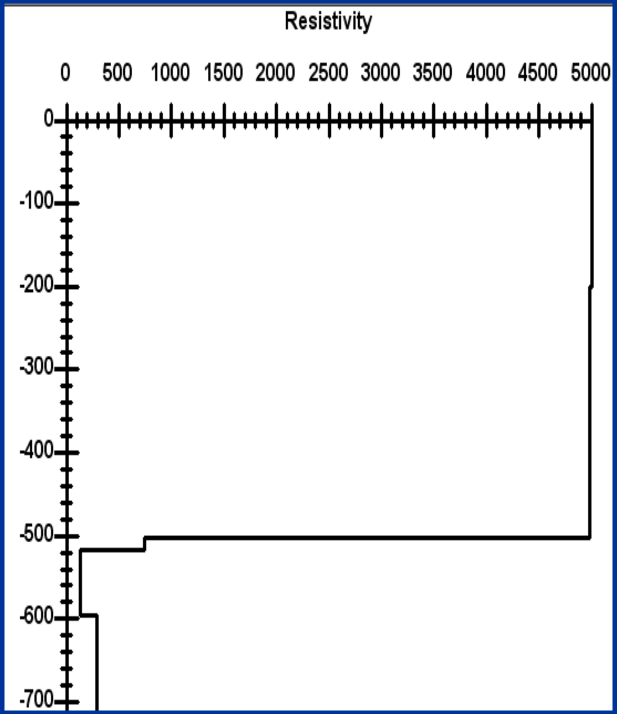
- **AEM Example**



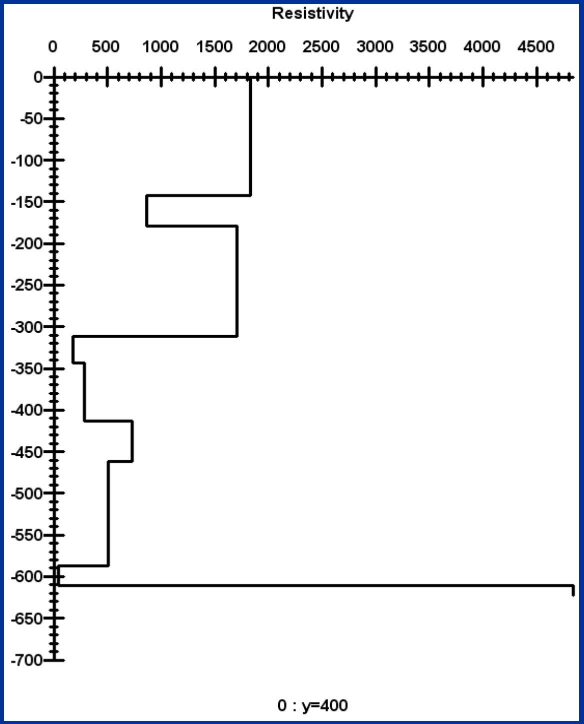
Hz decays correctly but amplitude shift of "3"
Hx approximately correct within data limits

- **AEM Example**

Joint Hz (15 chn) and Hx (5) chns



airborne data model



ground data model

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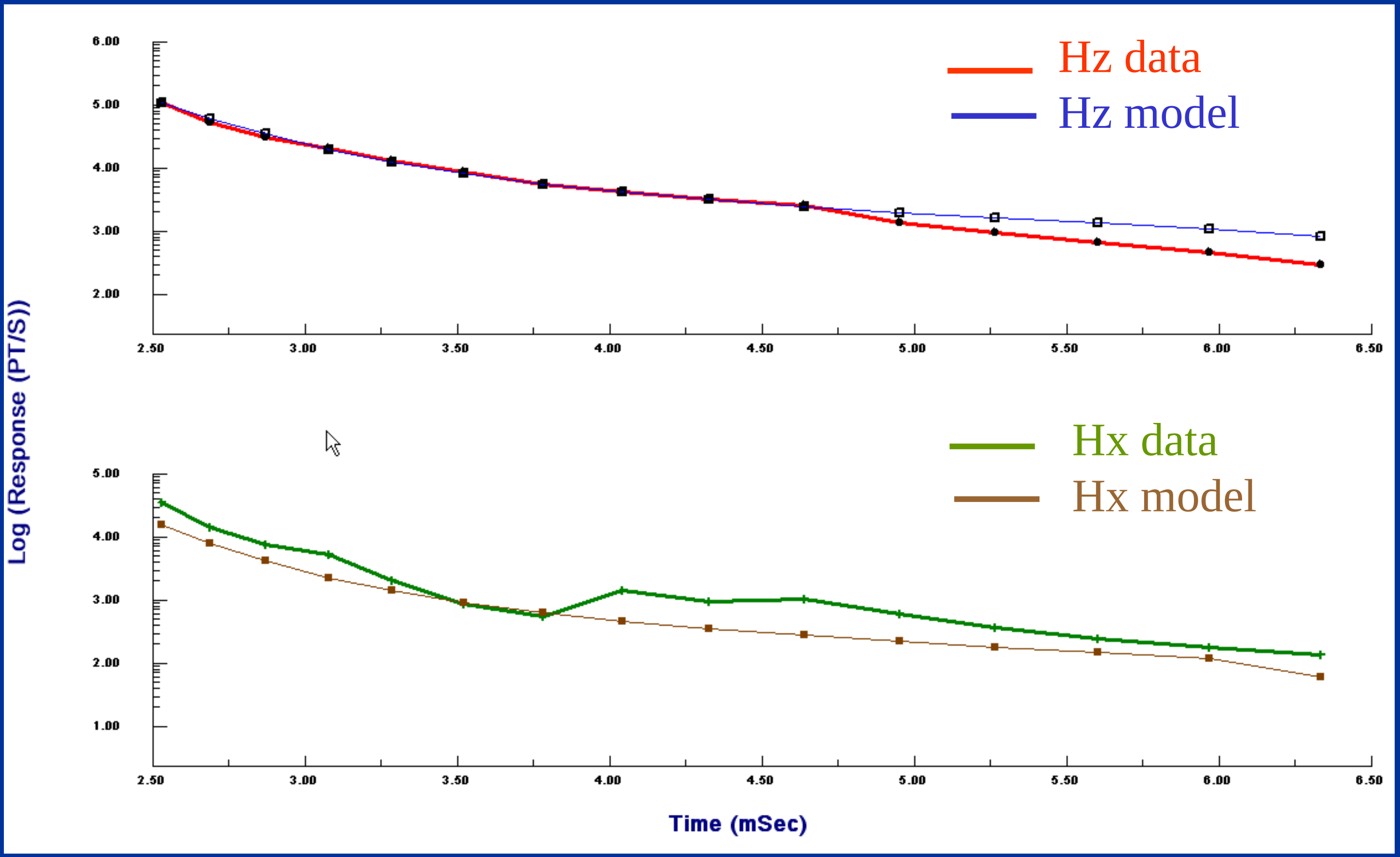
- **AEM Example**

Joint Hz (10 chn) and Hx (5) chns



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Comments

- **multiple common distance outside loop measurements allow:**

a) checking of geology from 1D inversion interpretation
b) allows checking of data accuracy and system effects
c) stacking of stations to help minimize lateral effects
and improve signal to noise
d) multiple station inversions to provide more reliable models

Recommendation:

calibration of airborne data with ground data for more reliable inversion results