SUSTech Southern University of Science and Technology

南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

地球与空间科学系 DEPARTMENT OF EARTH AND SPACE SCIENCES

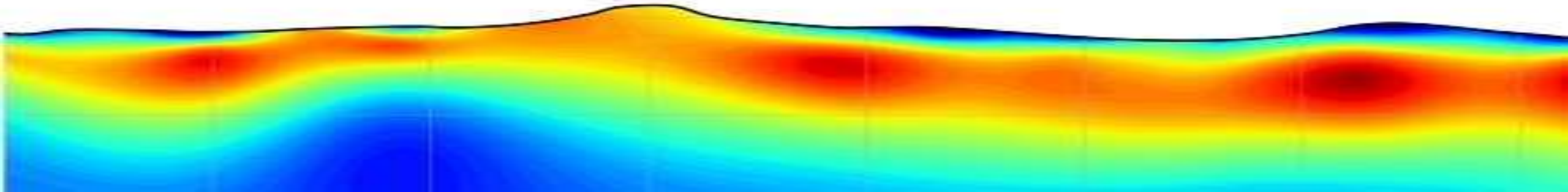
ESS302 Applied Geophysics II

Gravity, Magnetic, Electrical, Electromagnetic and Well Logging

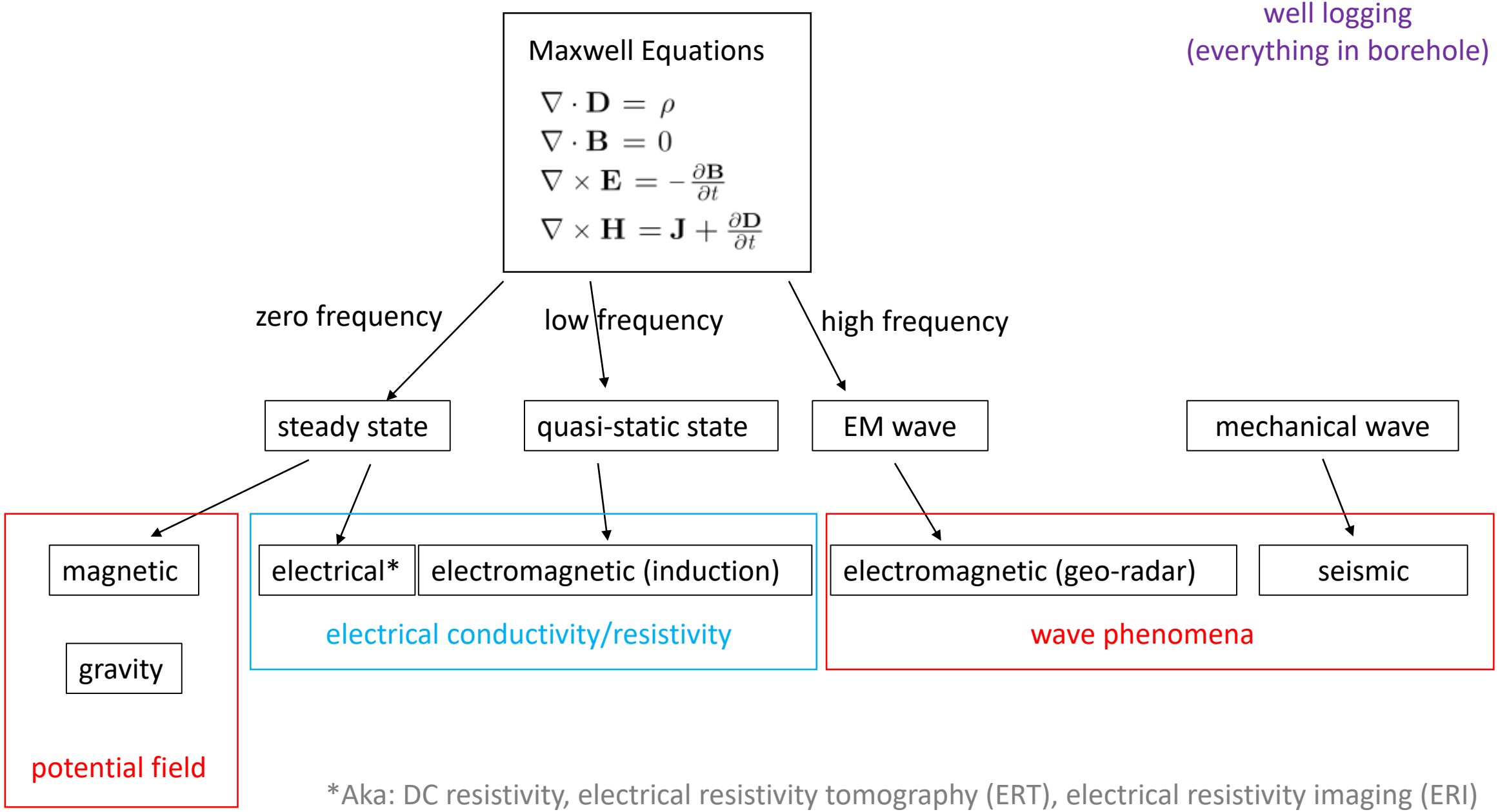
Electrical 2: Survey and Data

Instructor: Dikun Yang

Feb – May, 2019

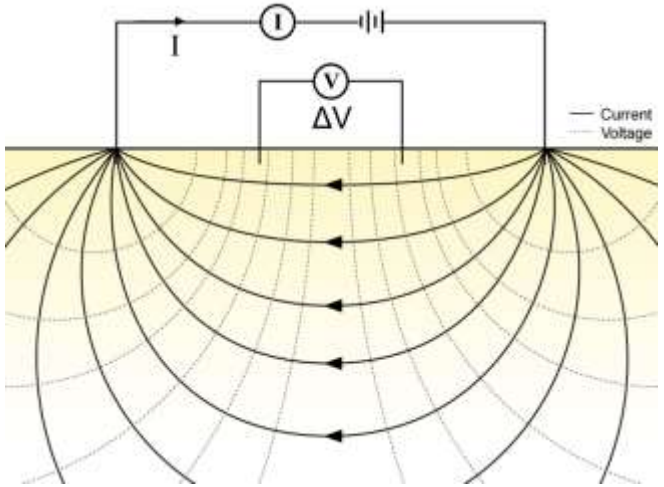


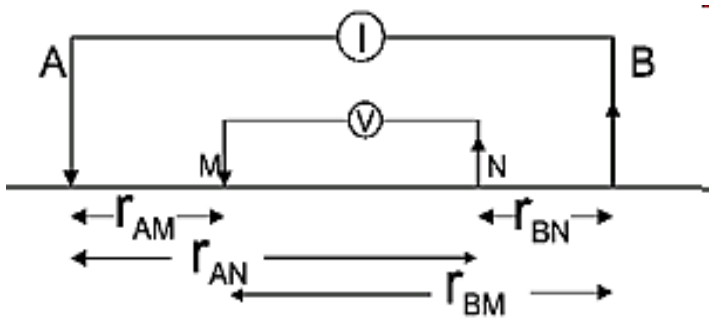
well logging
(everything in borehole)

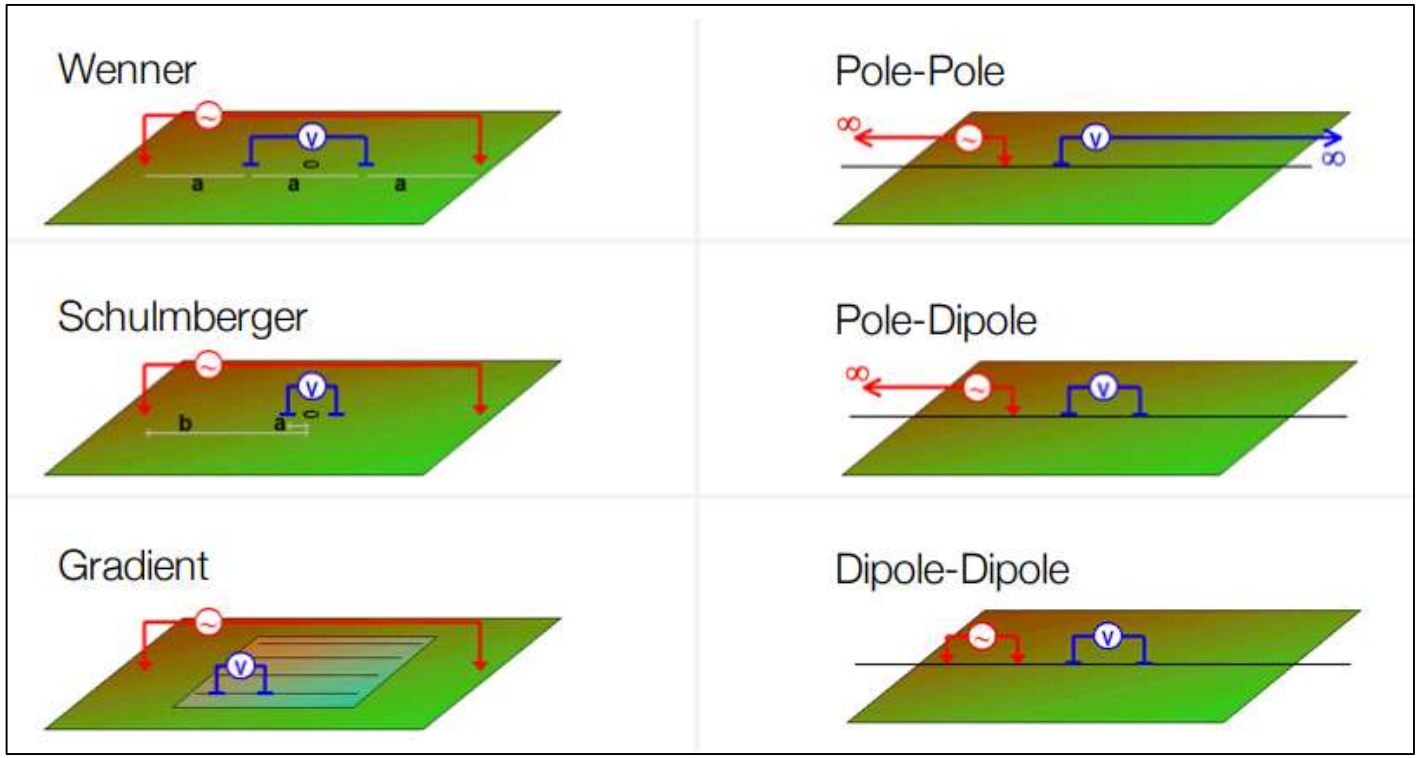


*Aka: DC resistivity, electrical resistivity tomography (ERT), electrical resistivity imaging (ERI)

Typical Electrical Surveys along Lines



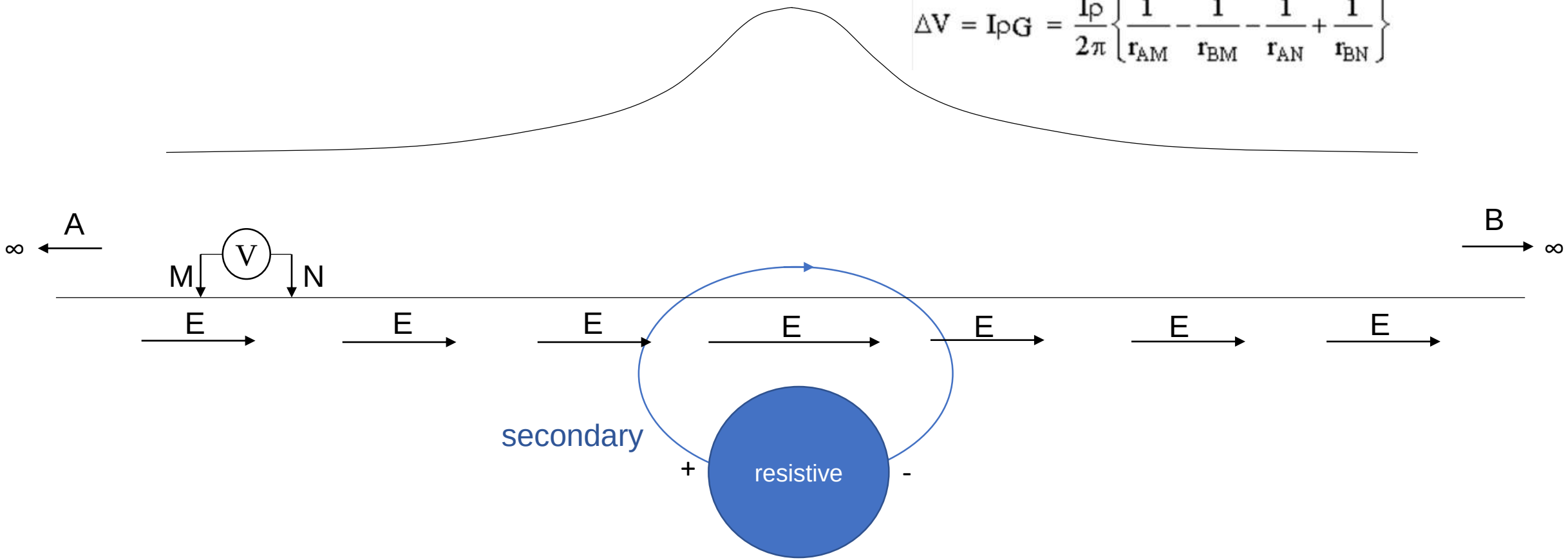




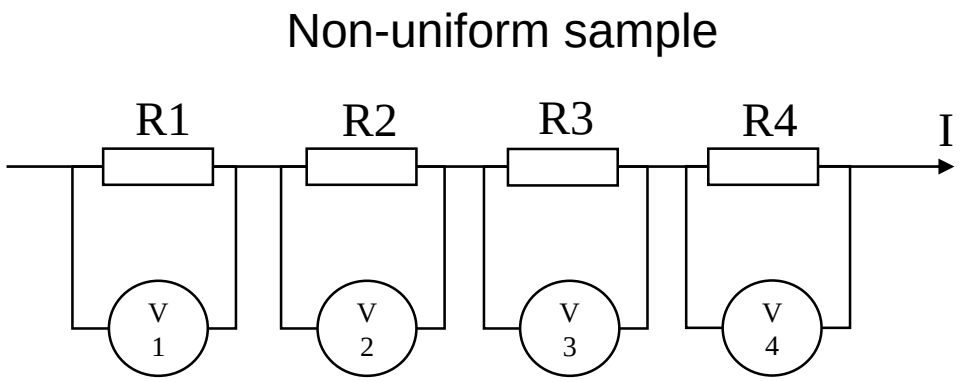
$$\Delta V = I\rho G = \frac{I\rho}{2\pi}\left\{\frac{1}{r_{AM}} - \frac{1}{r_{BM}} - \frac{1}{r_{AN}} + \frac{1}{r_{BN}}\right\} \qquad \rho = \frac{\Delta V}{IG}$$

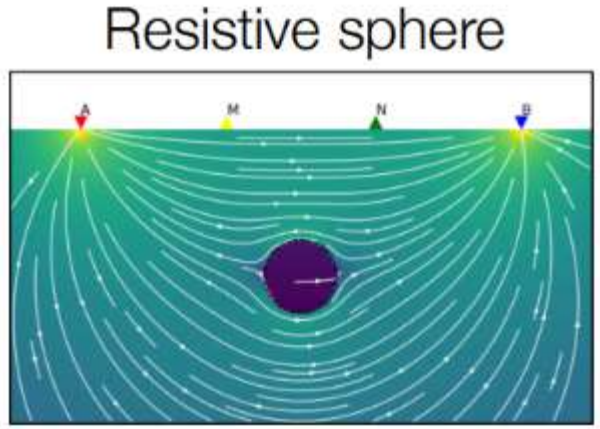
Physical Intuition of Electrical Anomaly (1)

$$\Delta V = I\rho G = \frac{I\rho}{2\pi}\left\{\frac{1}{r_{AM}} - \frac{1}{r_{BM}} - \frac{1}{r_{AN}} + \frac{1}{r_{BN}}\right\}$$



Physical Intuition of Electrical Anomaly (2)





$$\Delta V = I\rho G = \frac{I\rho}{2\pi}\left\{\frac{1}{r_{AM}} - \frac{1}{r_{BM}} - \frac{1}{r_{AN}} + \frac{1}{r_{BN}}\right\}$$

Instrument

Cases

Cables

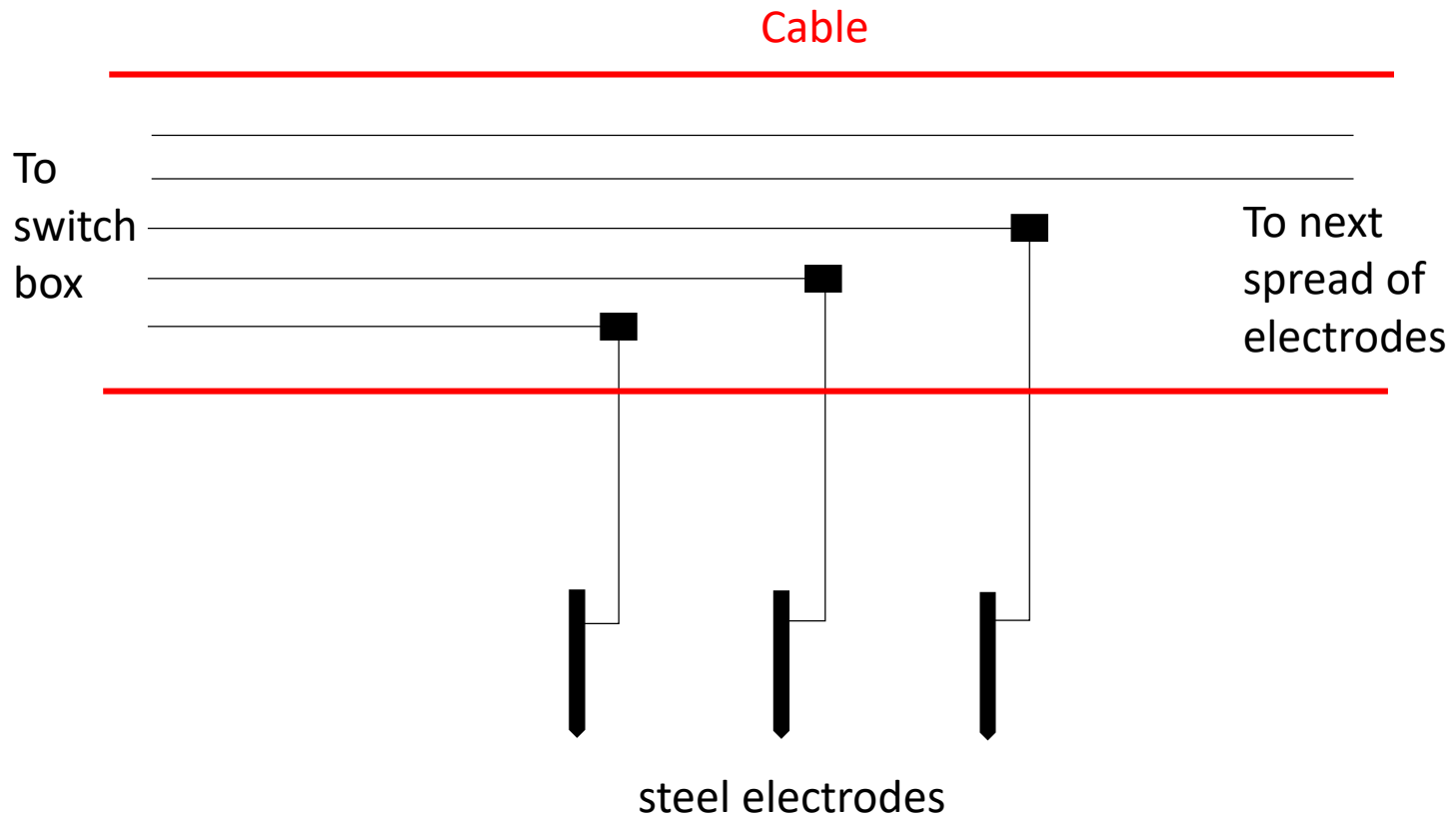
Battery

Console

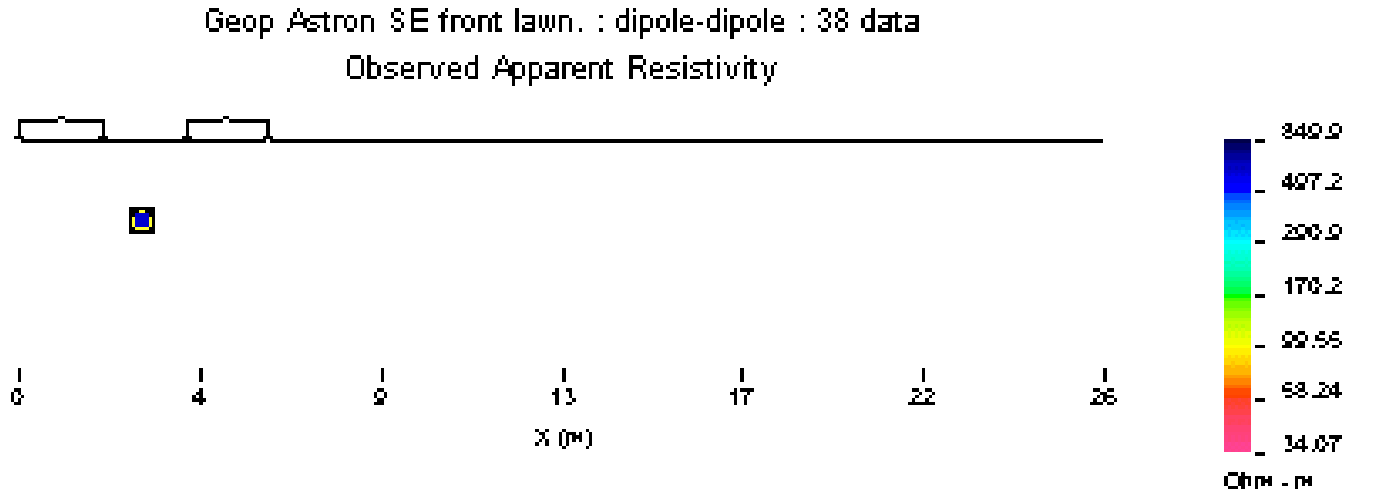
Connector

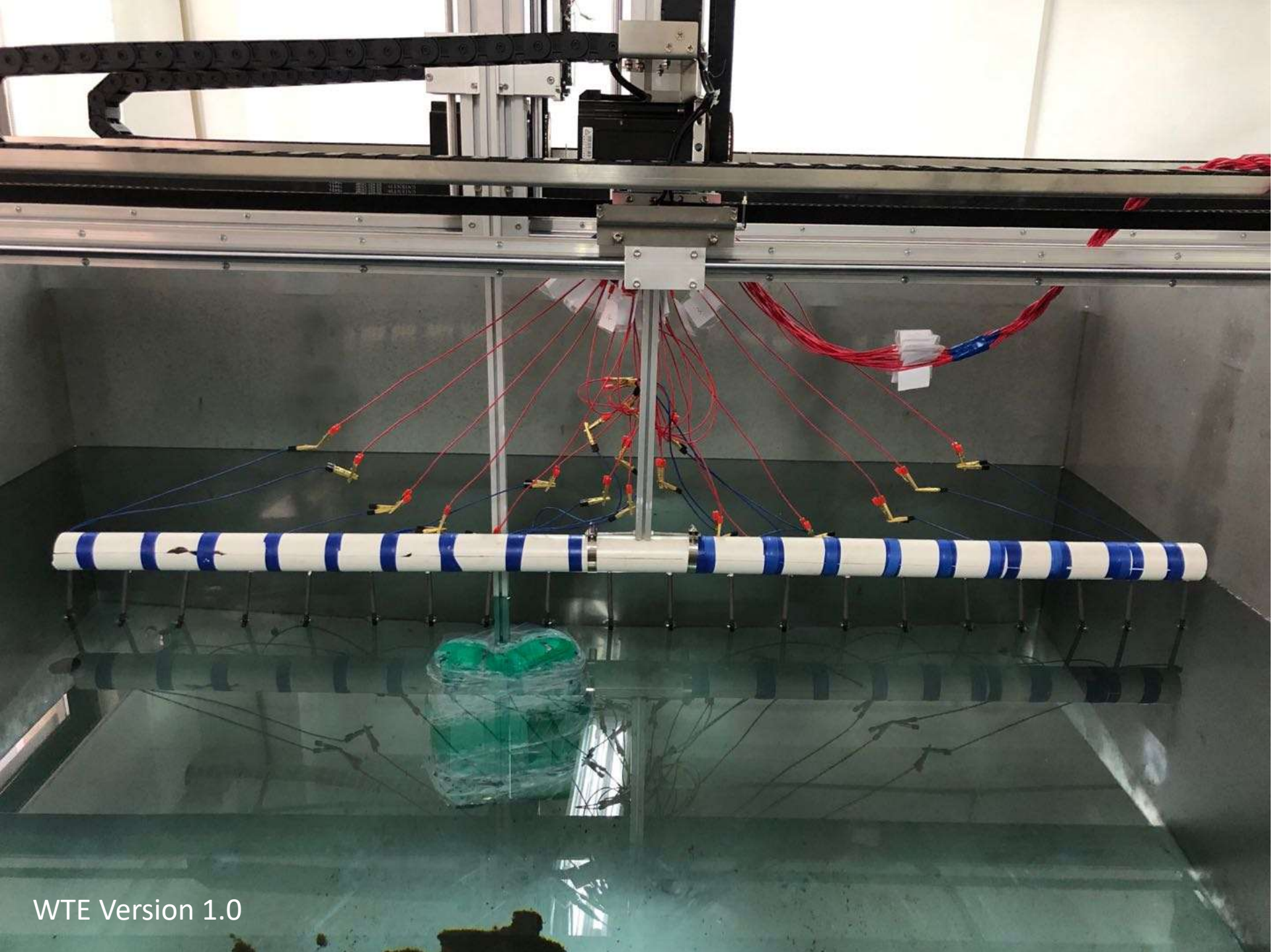
Electrodes

Switch box


Cable
To switch box
To next spread of electrodes
steel electrodes

- Computer-controlled switching
- Electrode status: Current, potential or null
- Real-time display of data (apparent resistivity)
- Pseudo-section of apparent resistivity





Water Tank Experiment

- Known targets
- Validation of numerical solutions
- Optimization of arrays

jupyter DC_Building_Pseudosections Last Checkpoint: 03/18/2019 (autosaved)

Logout

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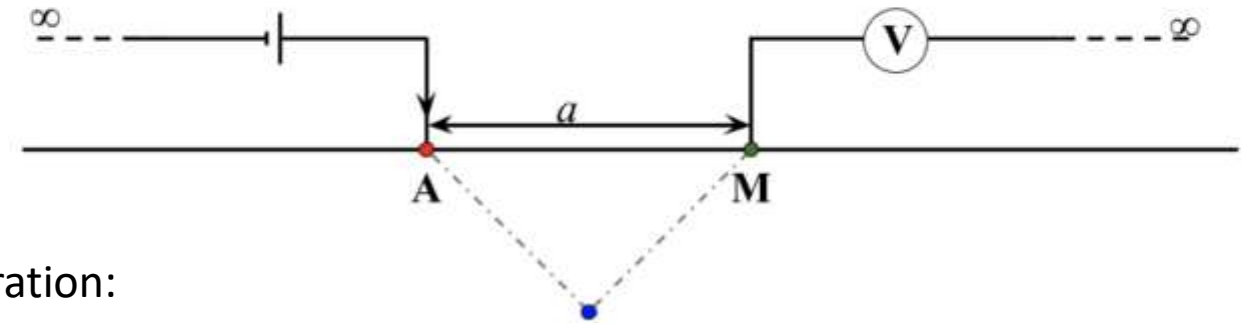
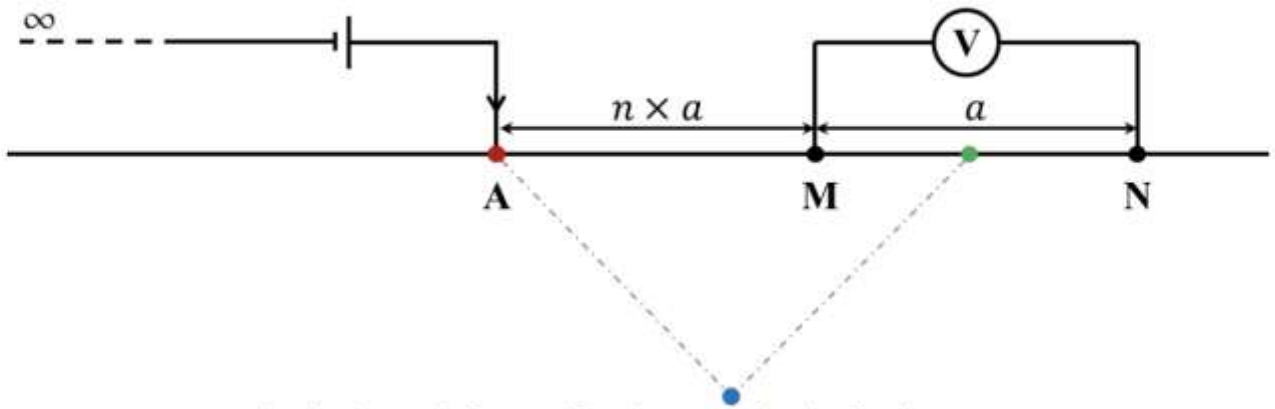
Trusted Python 3

Run Code



Basic skematic for a uniformly spaced pole-pole array.

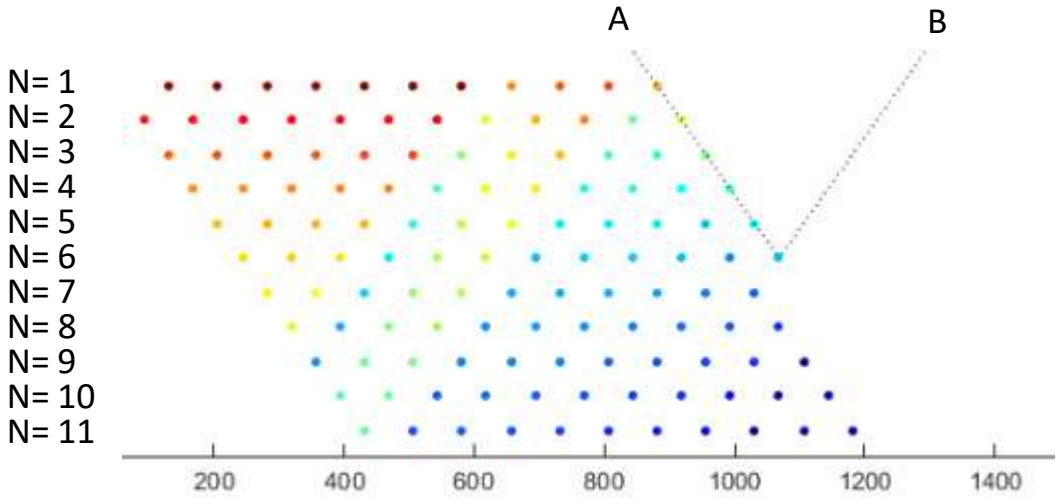
Pole or dipole array configuration:
a – basic spacing
n – multiplier

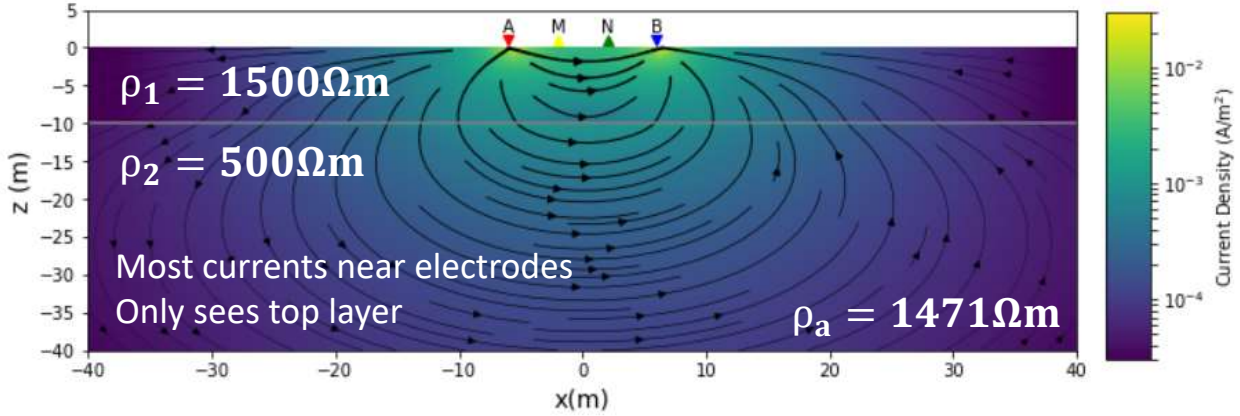


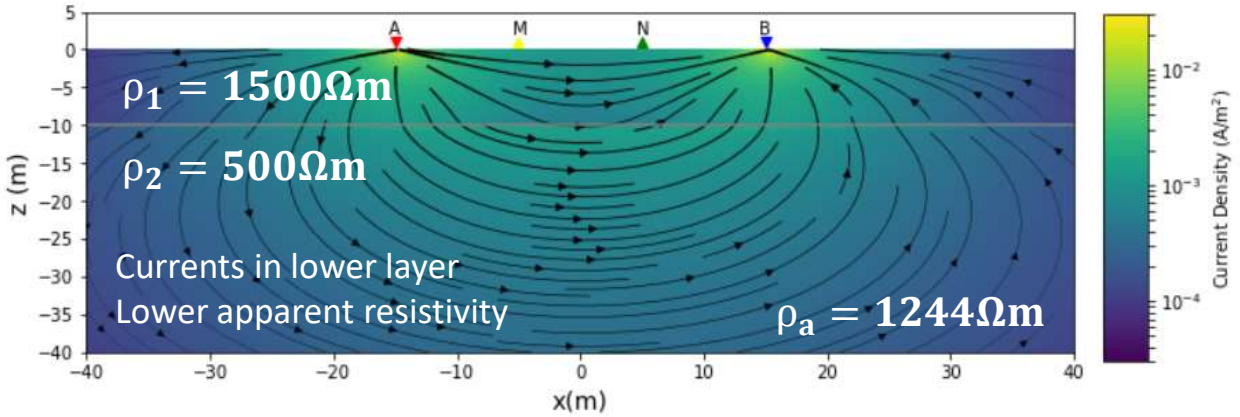
Basic skematic for a uniformly spaced pole-dipole array.

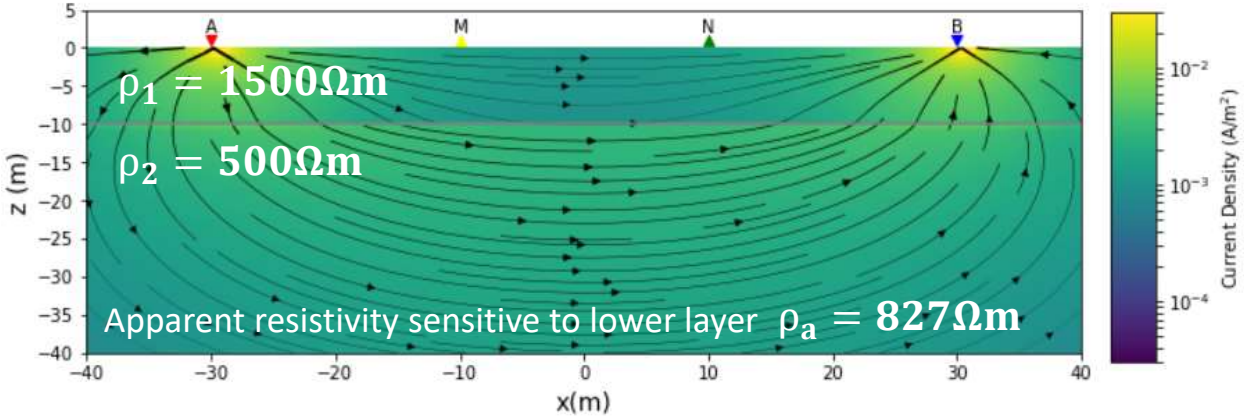
Geosci-labs/notebooks/dcip/DC_Building_Pseudosections.ipynb

Spacing and Depth









Apparent resistivity is a weighted average of the earth's resistivity as a distributed parameter (volume effect)

- Shallow always has higher weight
- Small spacing enhances weights for shallow
- Large spacing enhances weights for deep

jupyter DC_Building_Pseudosections Last Checkpoint: 03/18/2019 (autosaved)

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Run Code

```
In [7]: out = DC2DPseudoWidget()
        display(out)
```

ρ_1 1000

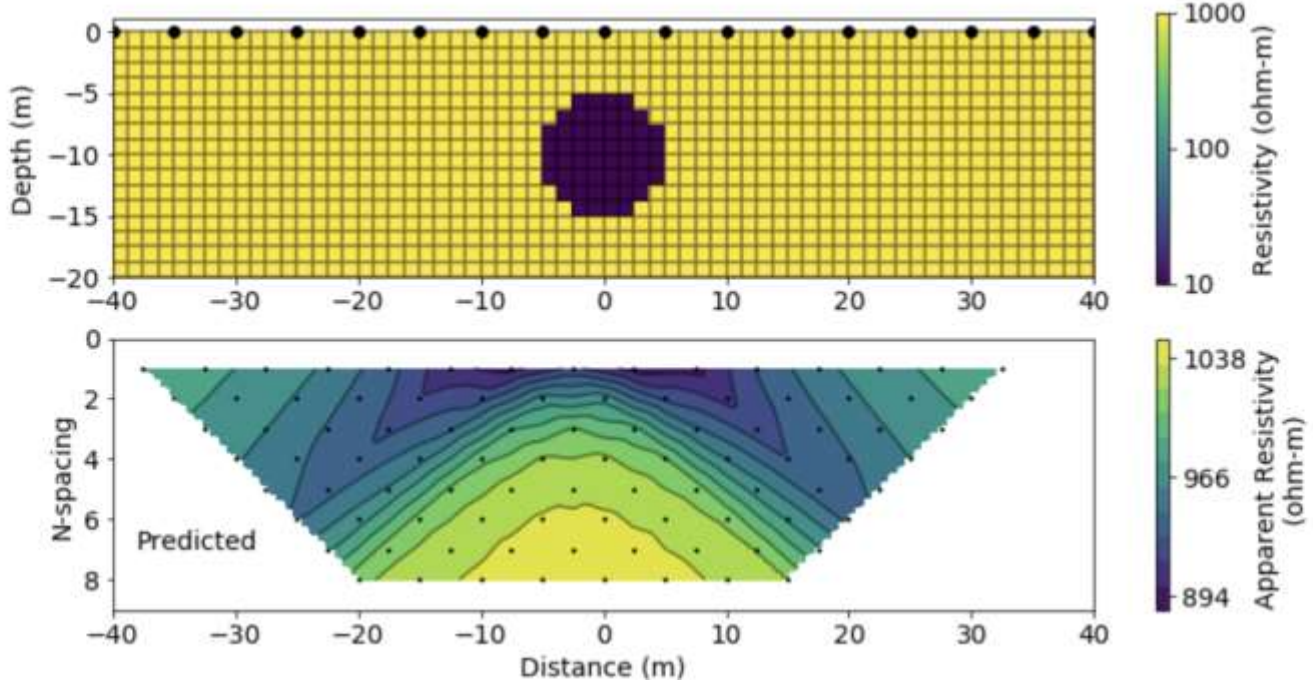
ρ_2 10

xc 0

zc -10

r 5

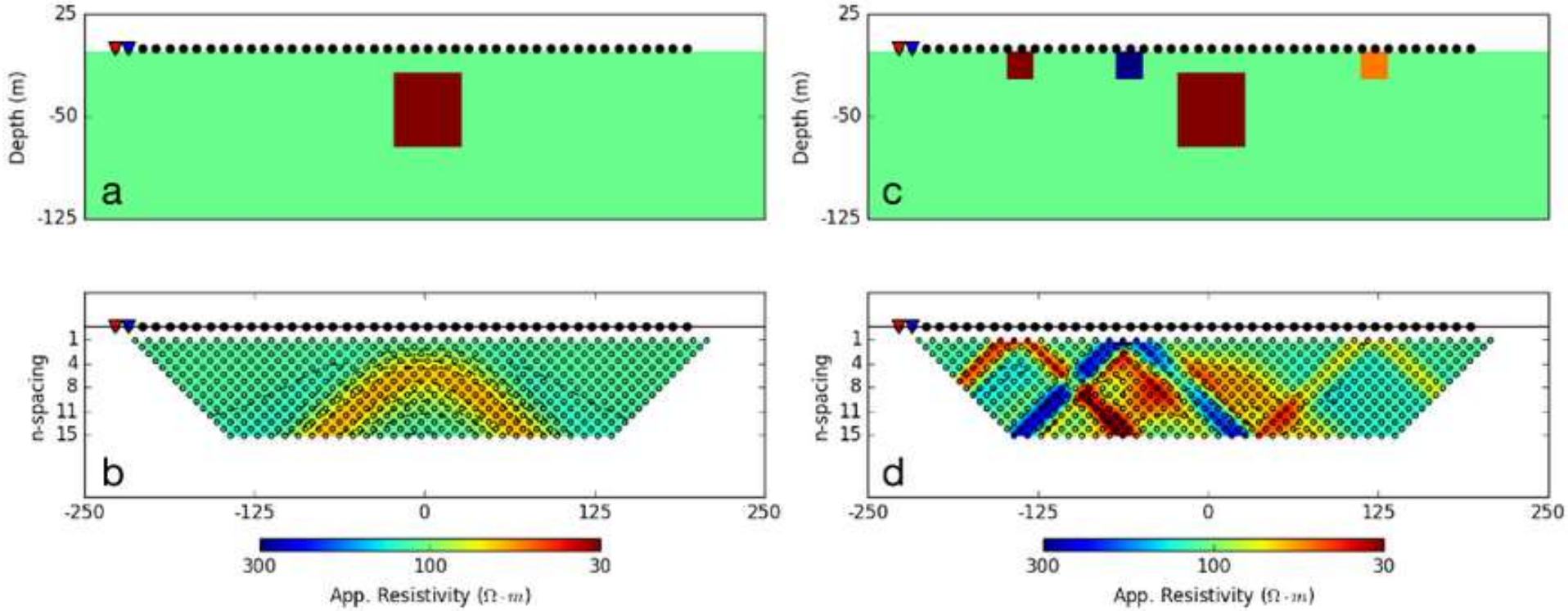
surveyType PolePole PoleDipole DipolePole DipoleDipole



Explore the following:

- How does a sphere manifest its anomaly on a pseudo-section?
- Which configuration has deeper depth of penetration? Why? (hint: adjust zc)
- Discussion: Use dipole or pole?

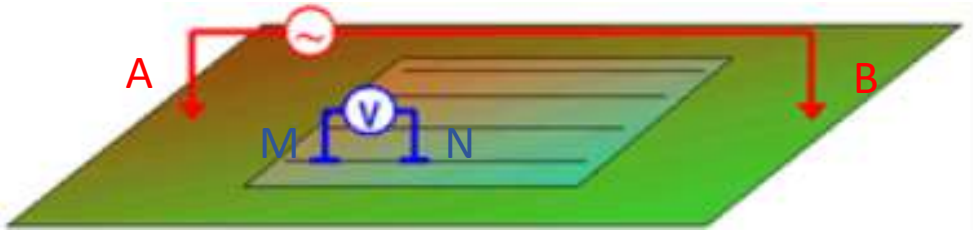
Anomaly of Compact Targets

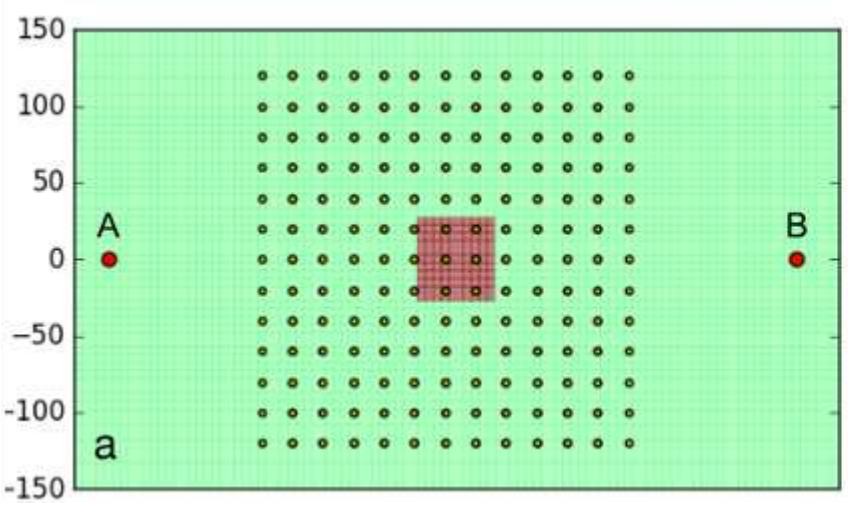


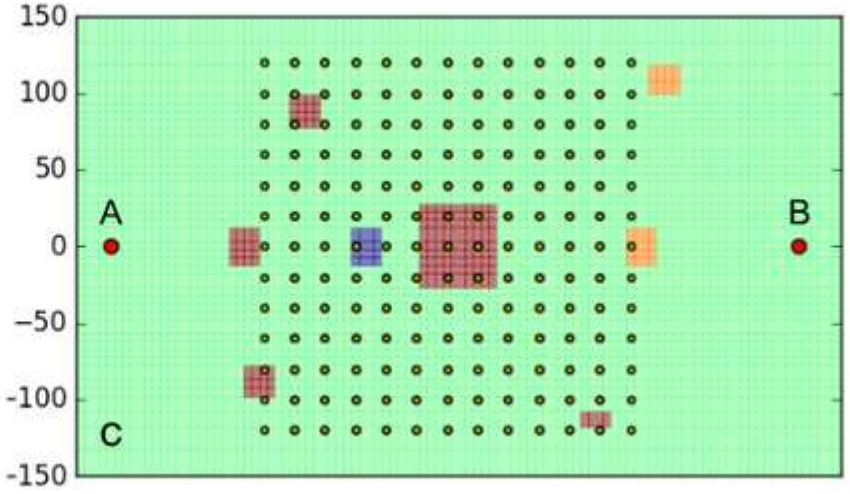
- Compact bodies: arc signature
- Depth of arc signature: depth of target
- Thickness of arc: size of target
- One block (left): easy to interpret
- Shallow blocks (right): geologic noises mask large buried conductor; hard to interpret

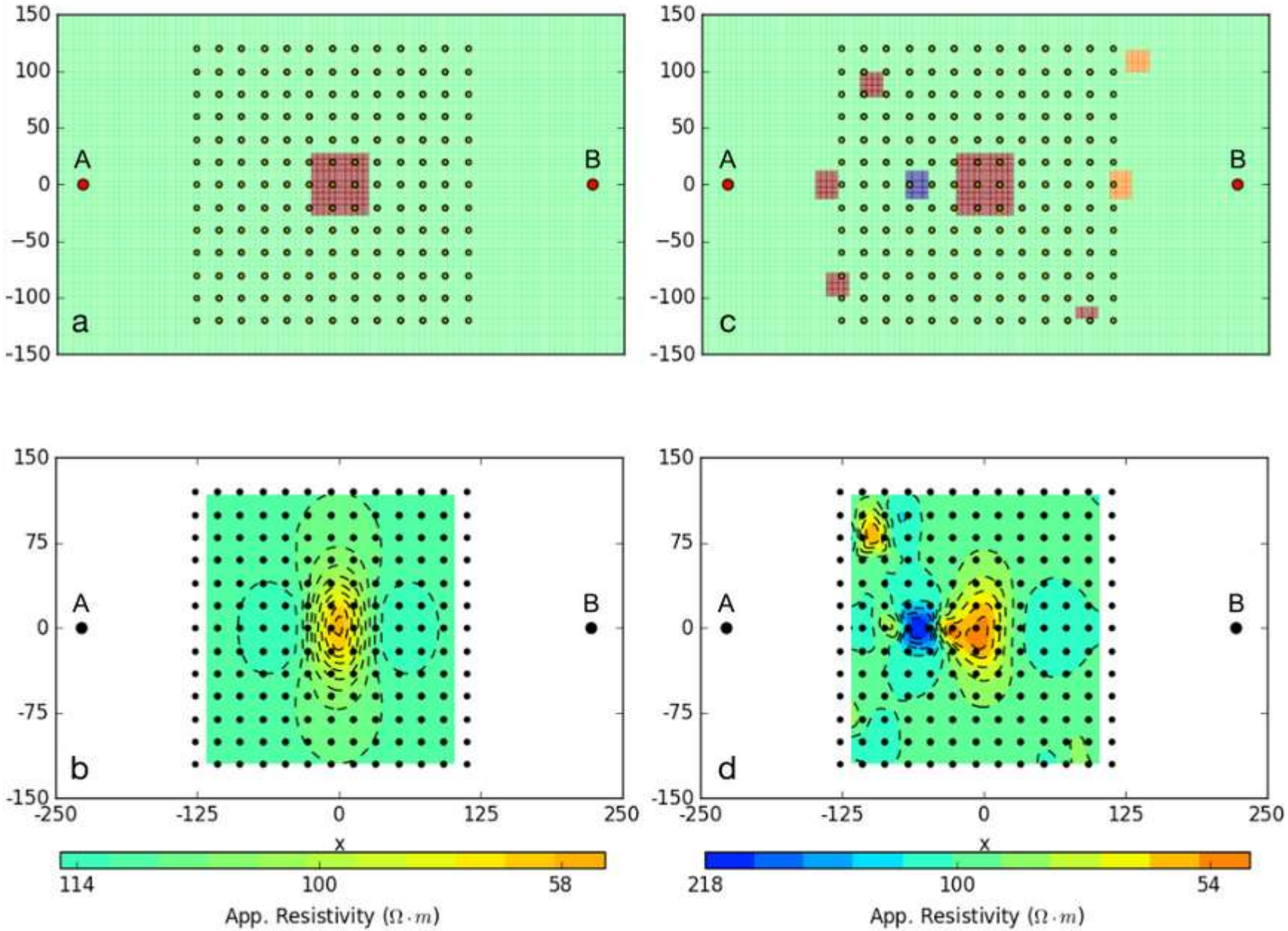
Gradient Array (A and B at infinity)

- Detects lateral variations in resistivity
- Fixed A and B: rapid acquisition of large areas
- Potential field problem





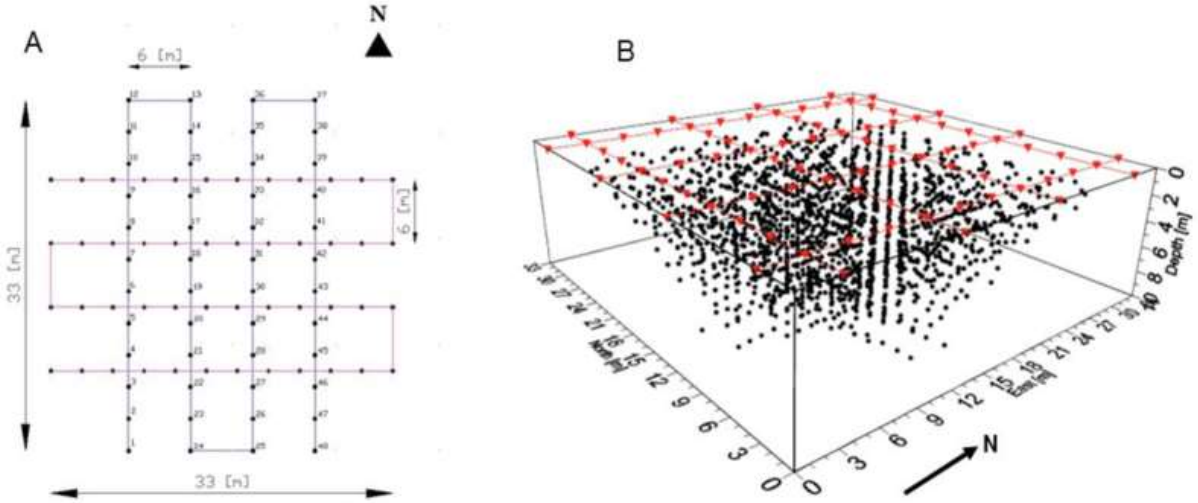


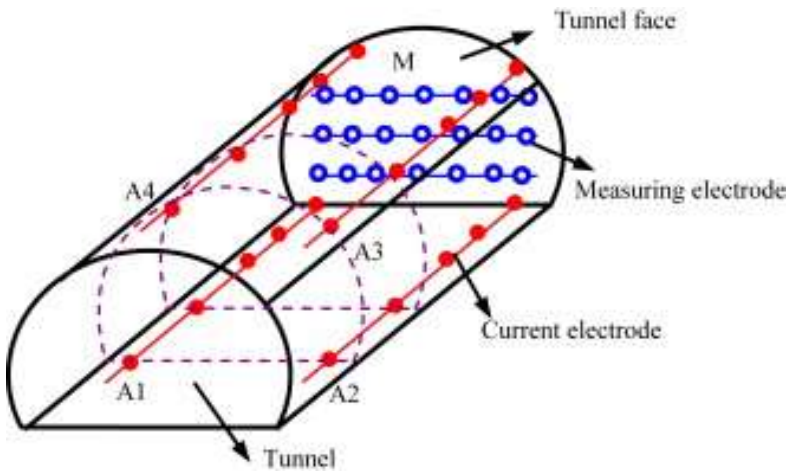


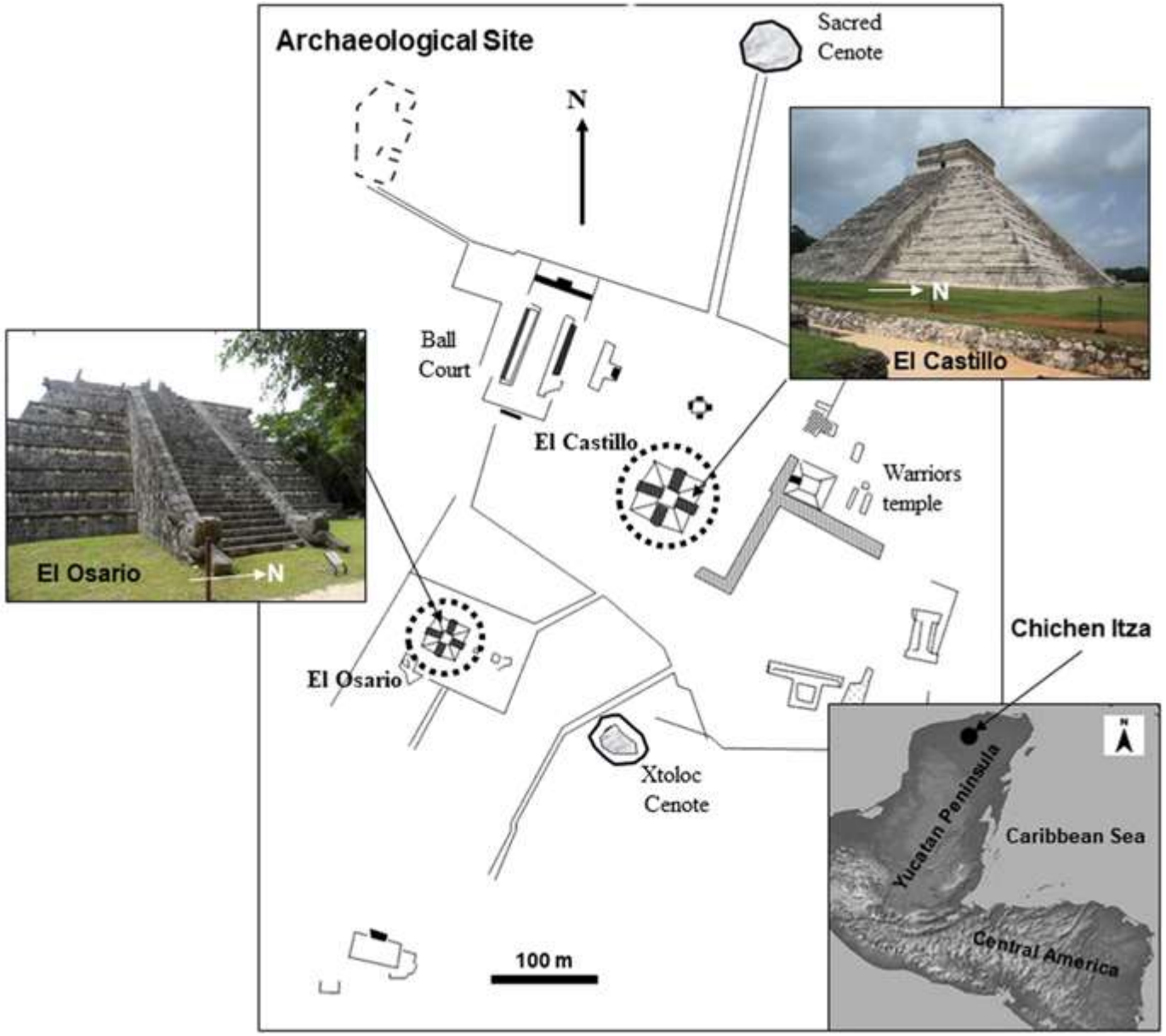
Recall induced magnetic anomaly at equator and discuss:

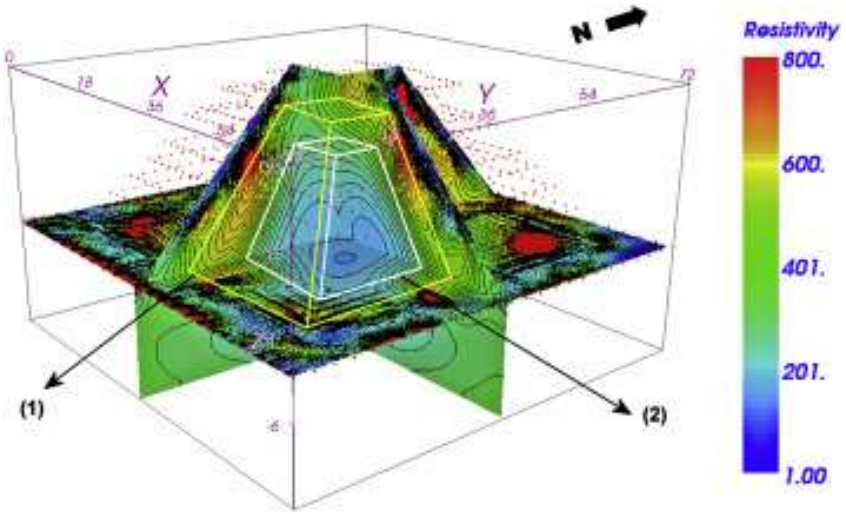
- Data are the most sensitive to the edges in ____ direction.
- The anomaly from a single block has the pattern of ___ anomaly.

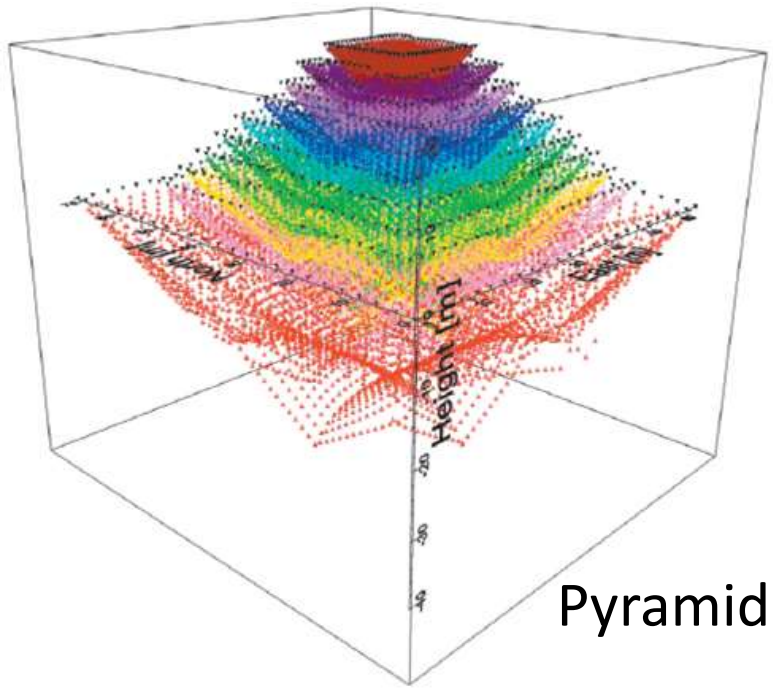
Non-2D Arrays







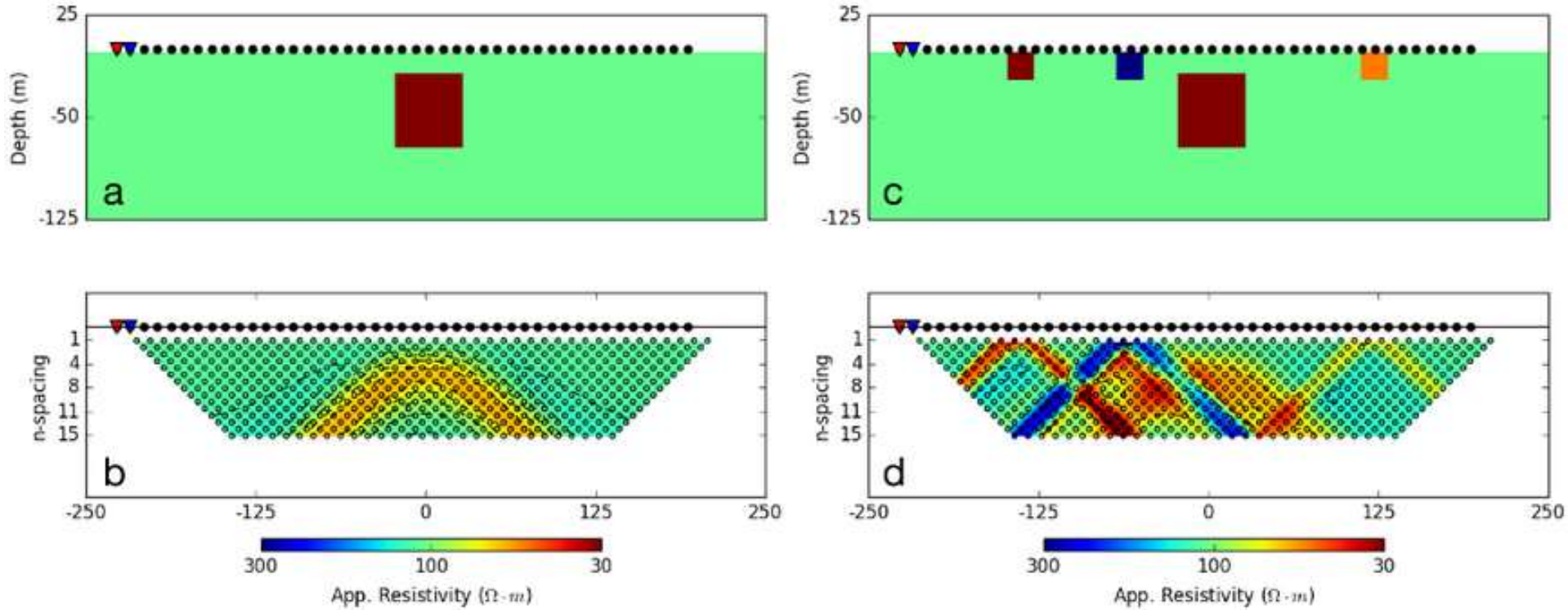




Pyramid array

Rethink Pseudo-sections

- Advantage: Why use apparent resistivity instead of raw voltage?
- Disadvantage: Can horizontal/vertical position of buried conductors/resistors be inferred directly from pseudo-section?

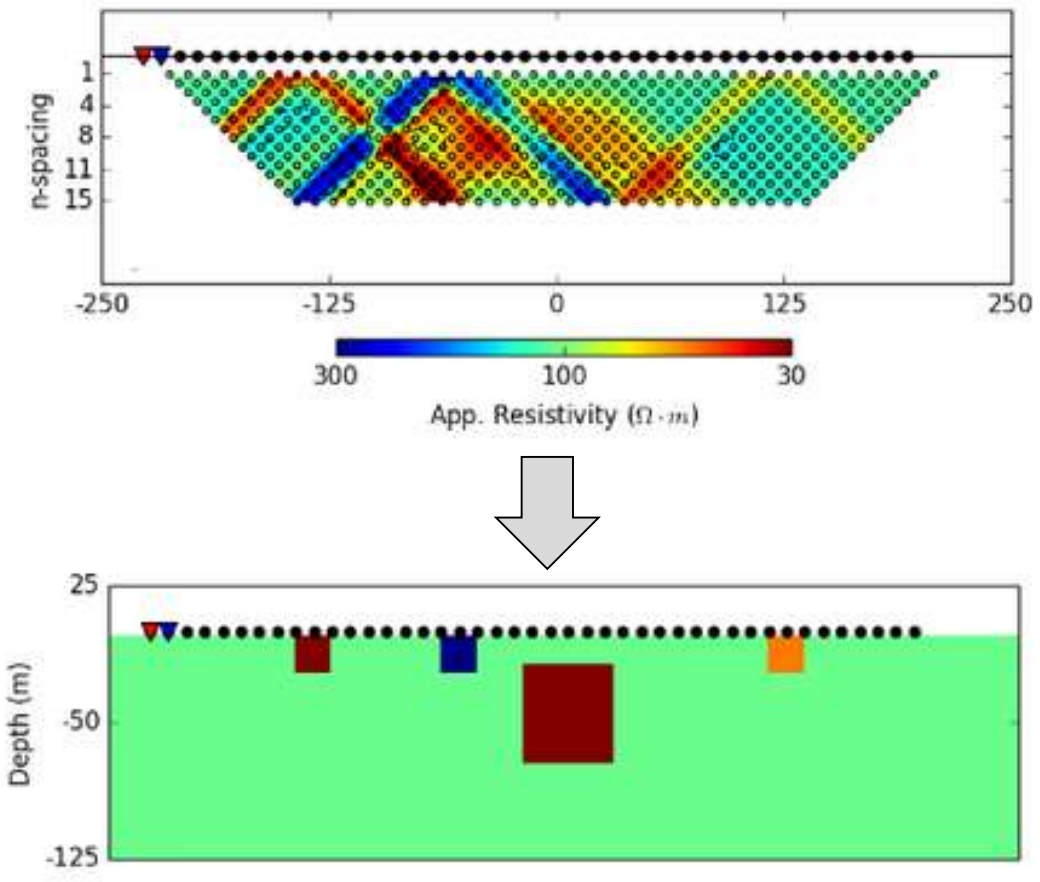


Quantitative Interpretation – Inversion

Goal of **Inversion**:

Find a resistivity (conductivity) model which:

- Explains all the data
- Is representative of the true geology



jupyter DC_Inversions (autosaved) geosci-labs/notebooks/dcip/DC_Inversions.ipynb

File Edit View Insert Cell Kernel Widgets Help

Run Code

ρ_1 1000

ρ_2 100

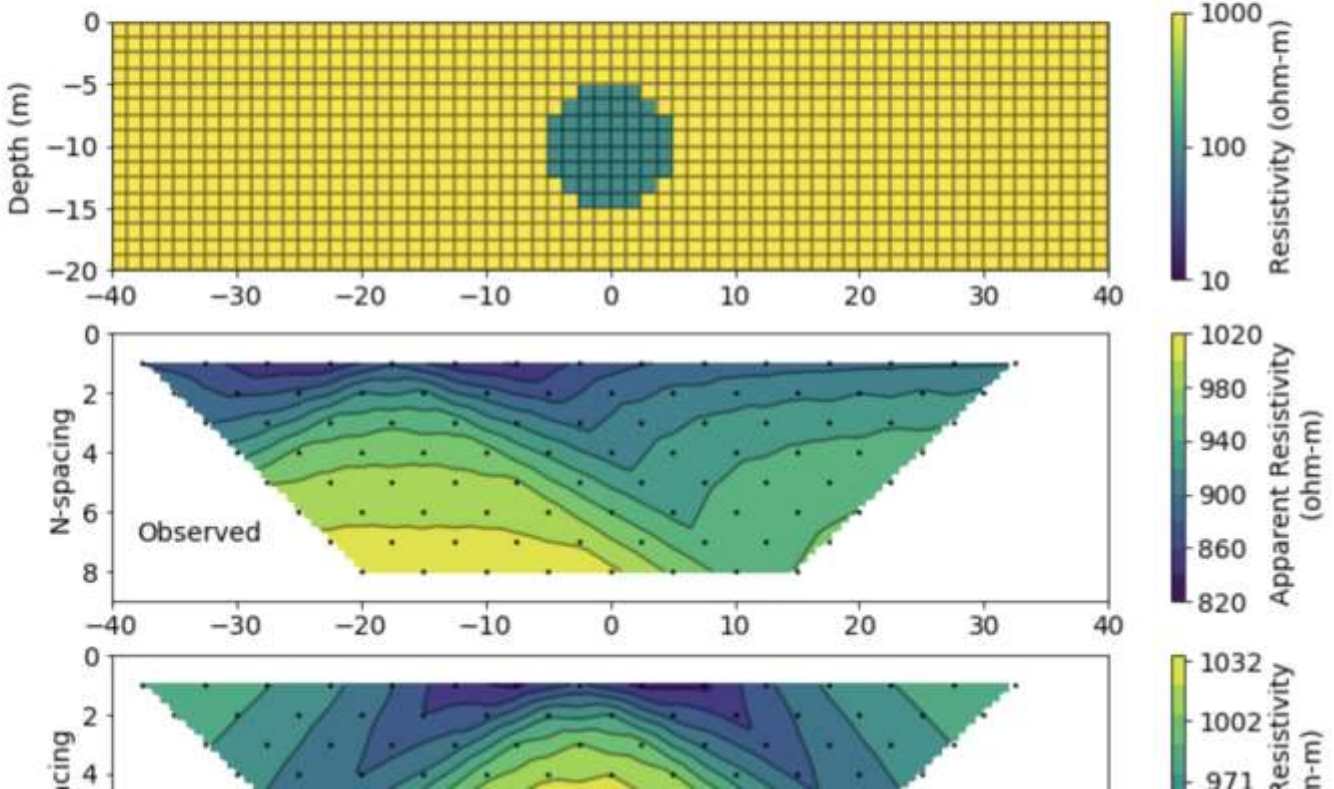
xc 0.00

zc -10.00

r 5.00

predmis pred mis

surveyType PolePole PoleDipole DipolePole DipoleDipole



Exercise:

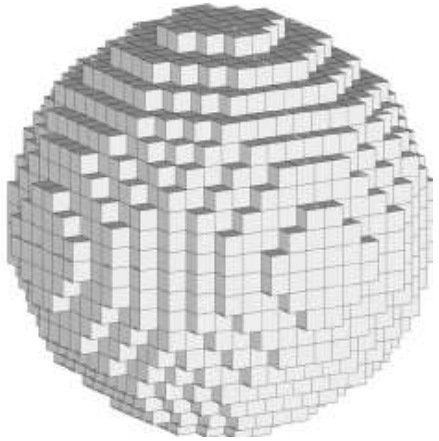
- Parameterize the model as a sphere (cylinder) in a uniform half-space
- Find a model that fits the observed data by interactive manual inversion (trial-and-error method)

Model section

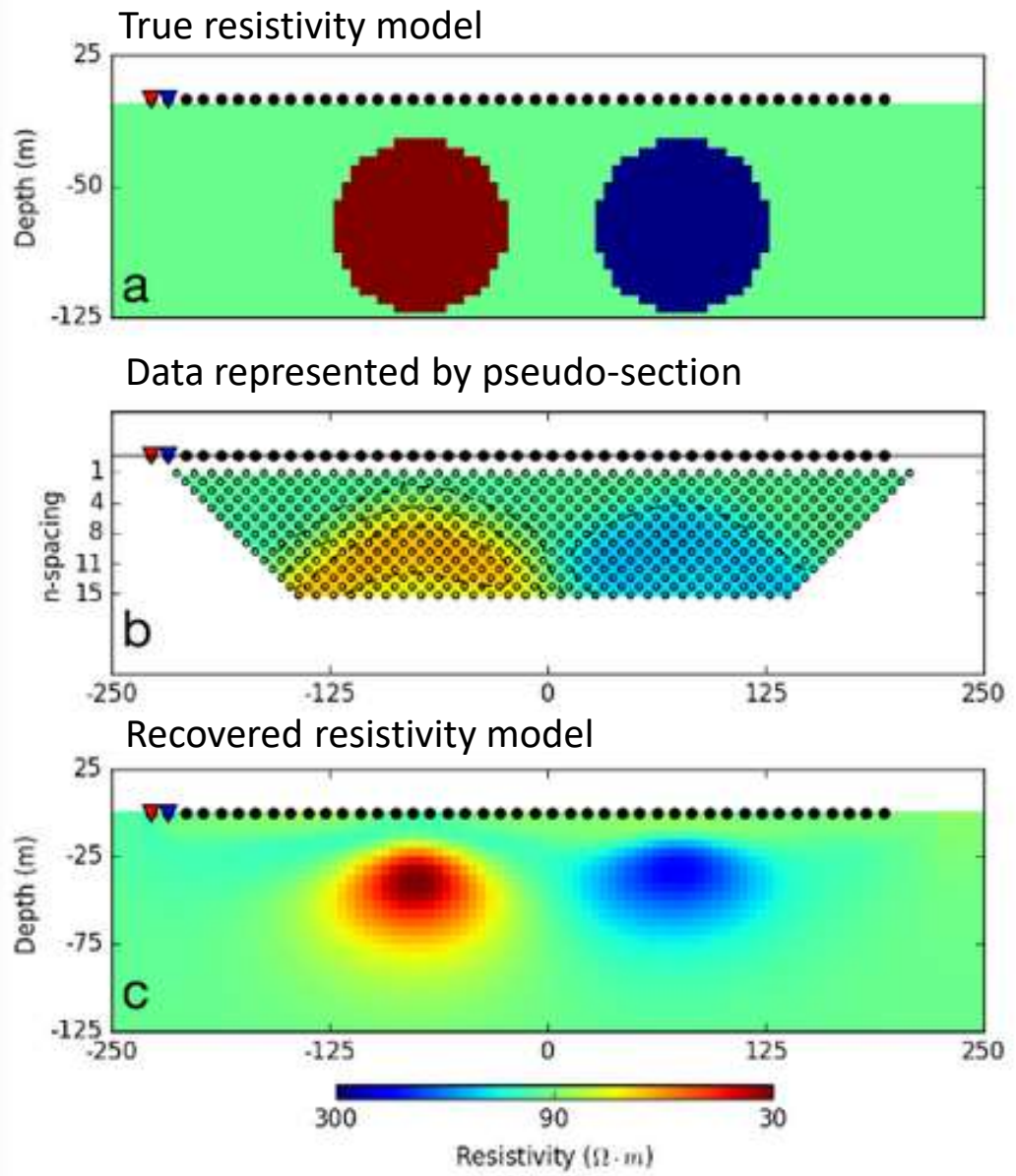
Observed data

Predicted or simulated data

Pixel/Voxel Inversion



- The earth consists of many small uniform elements
- Resistivity in cells allowed to vary
- Versatile but high ambiguity (volume effect)
  - Does not recover the true model
  - Recovers a geologically approximate model
  - Recovers structures represented in the data

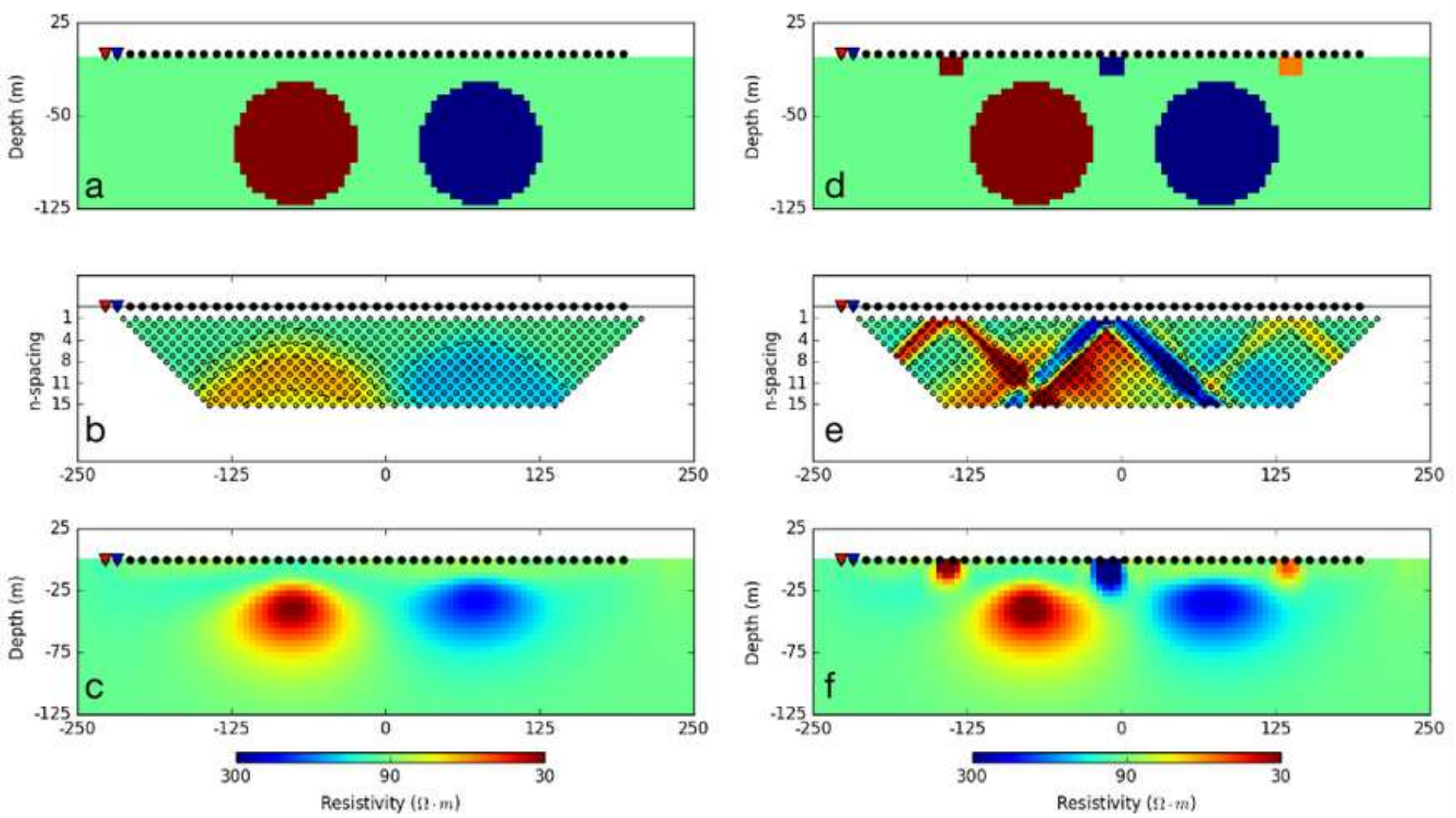


Pseudo-section vs. Inversion

True model

Pseudo-section

Inversion model



Summary

- Electrical survey instruments
- Data represented as apparent resistivity on pseudo-sections
- Electrode arrays: Spacing and depth
  - Pole, dipole, “gradient”
- Electrical data inversion