Monitoring methane gas migration in a near surface confined aquifer using electrical resistivity tomography

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Motivations

- Of 316,439 wells drilled in Alberta from 1910-2004, 4.6% have integrity failures (Davies et al., 2014)

- Integrity failures can release methane

- Poses explosion risk, emission of greenhouse gases to the atmosphere, and groundwater contamination

- Integrity failures 1.6-6 times more likely in unconventional wells (Ingraffea et al., 2014)

Site Location

- Peace River valley, British Columbia
- Fluvioglacial environment
- Flat site with minimal elevation changes

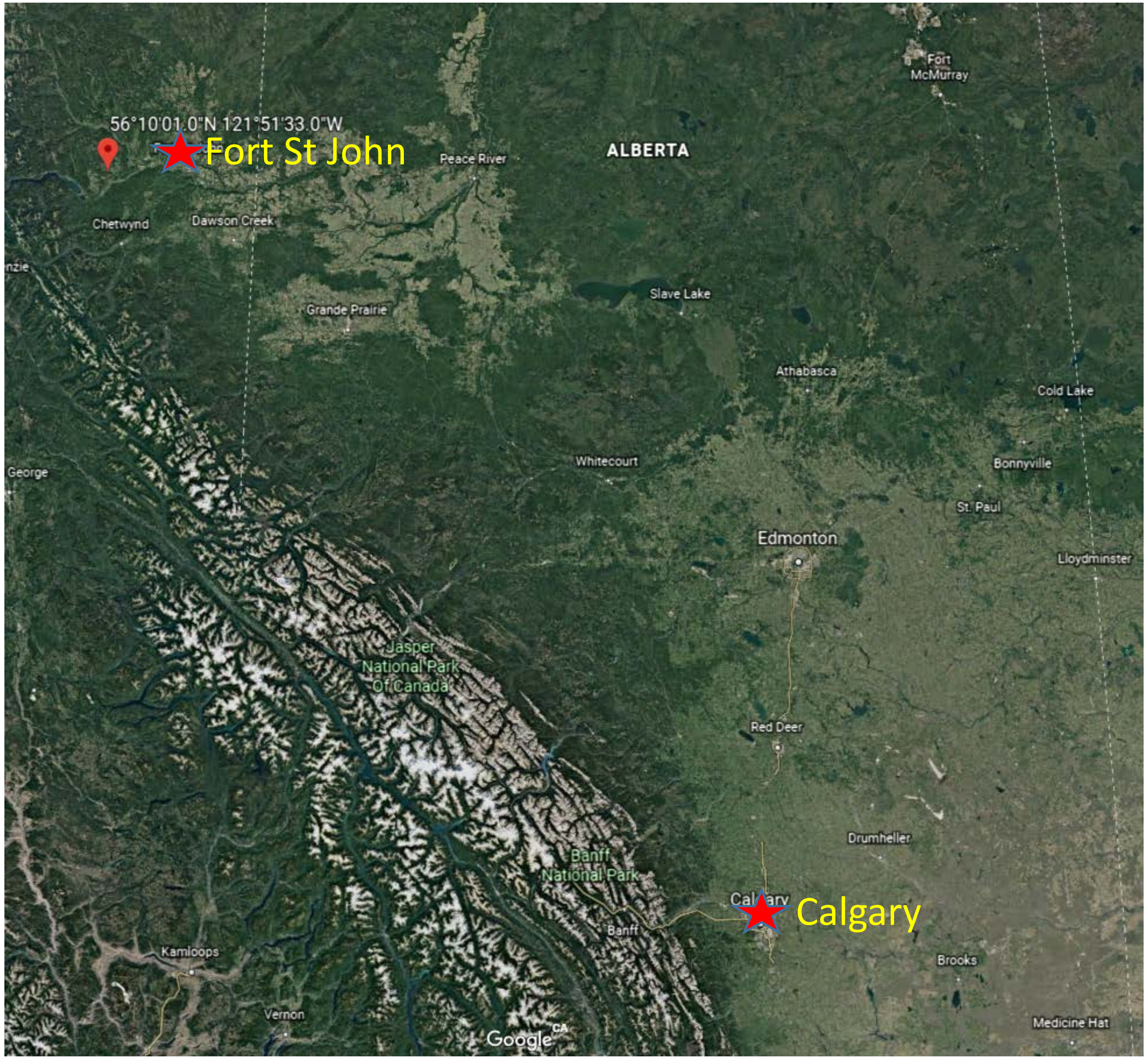
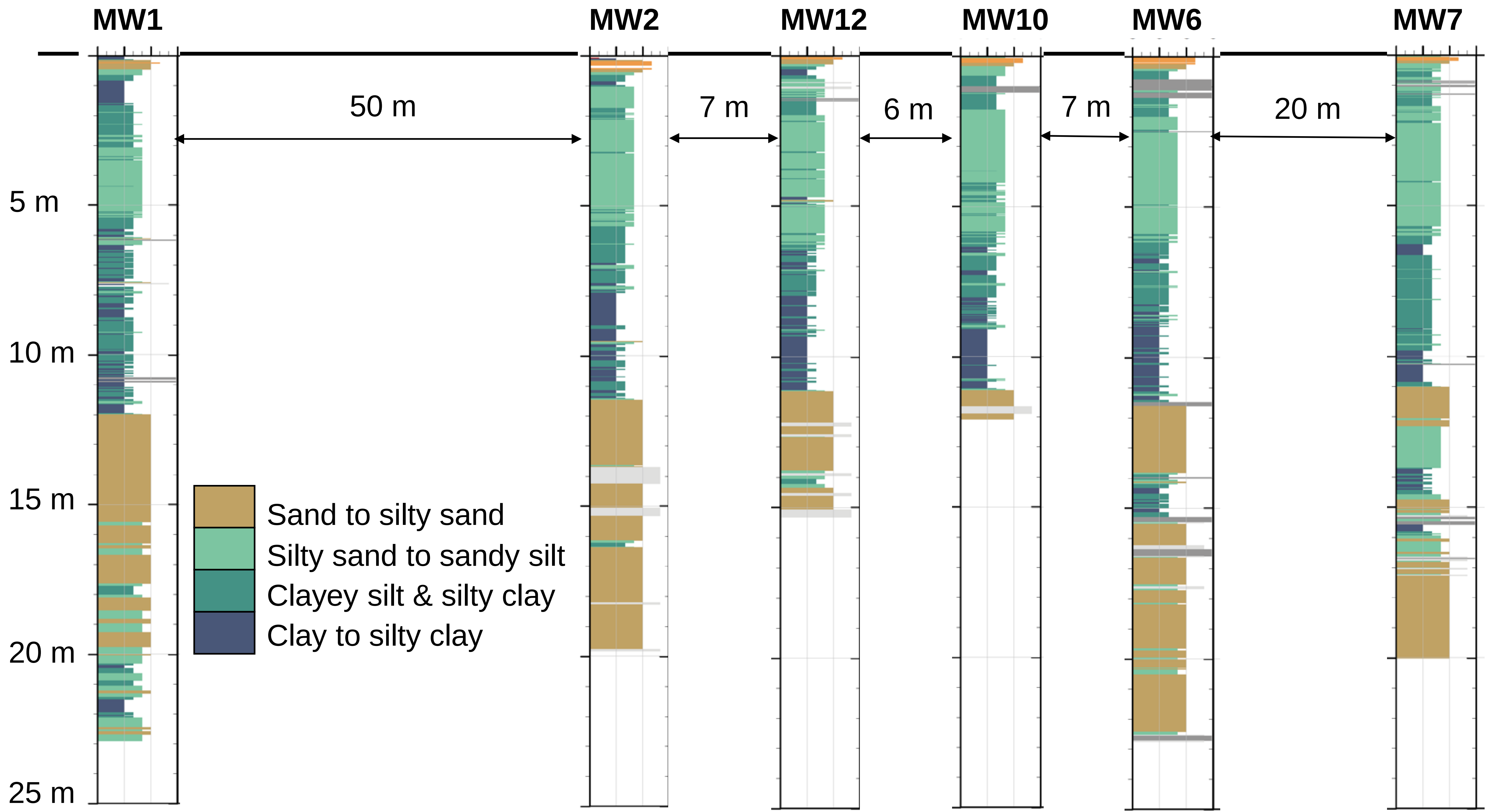
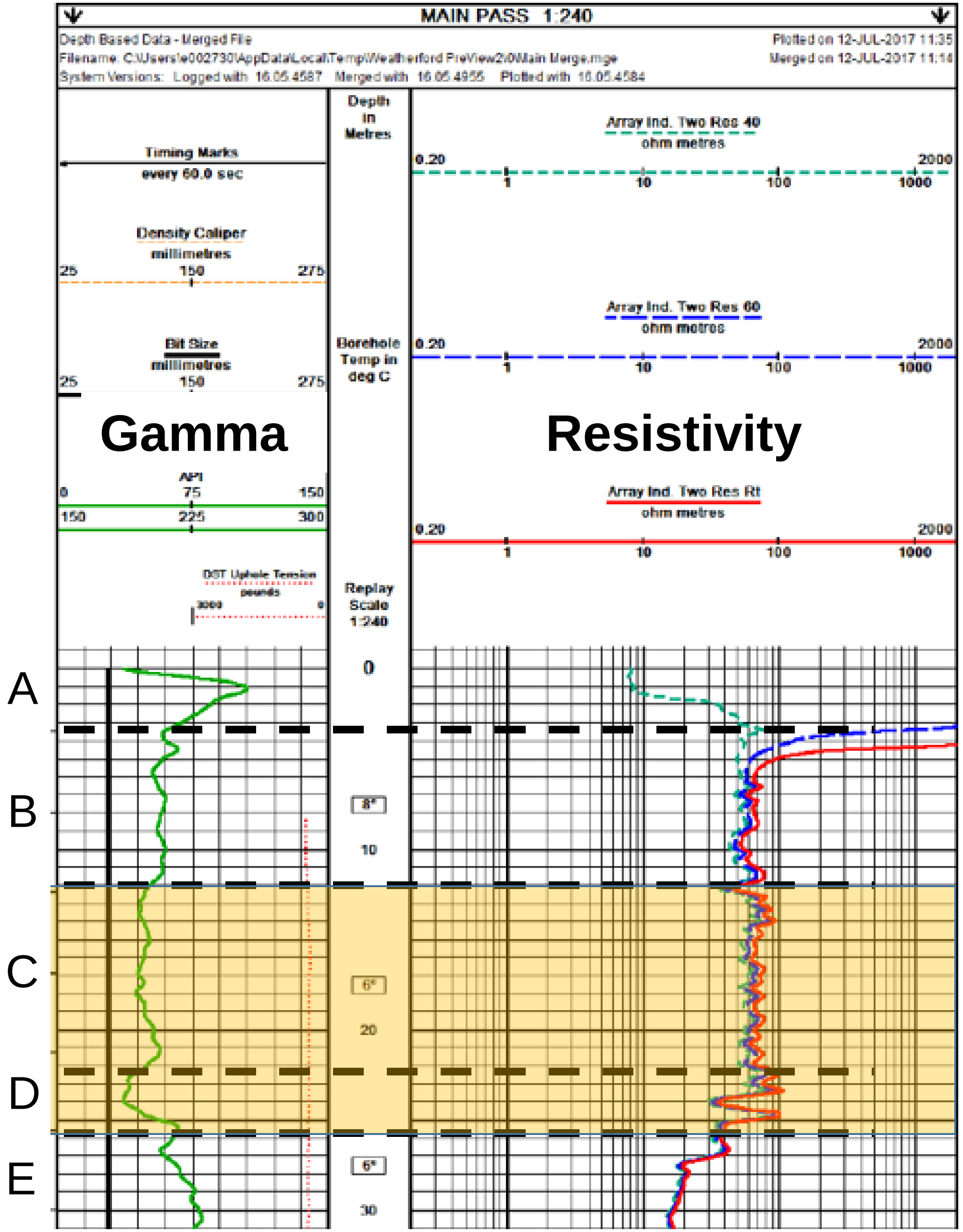


Image from Google Earth

Site Geology - Core Logs



Geophysics Logs



Clays and soil – High gamma, low resistivity

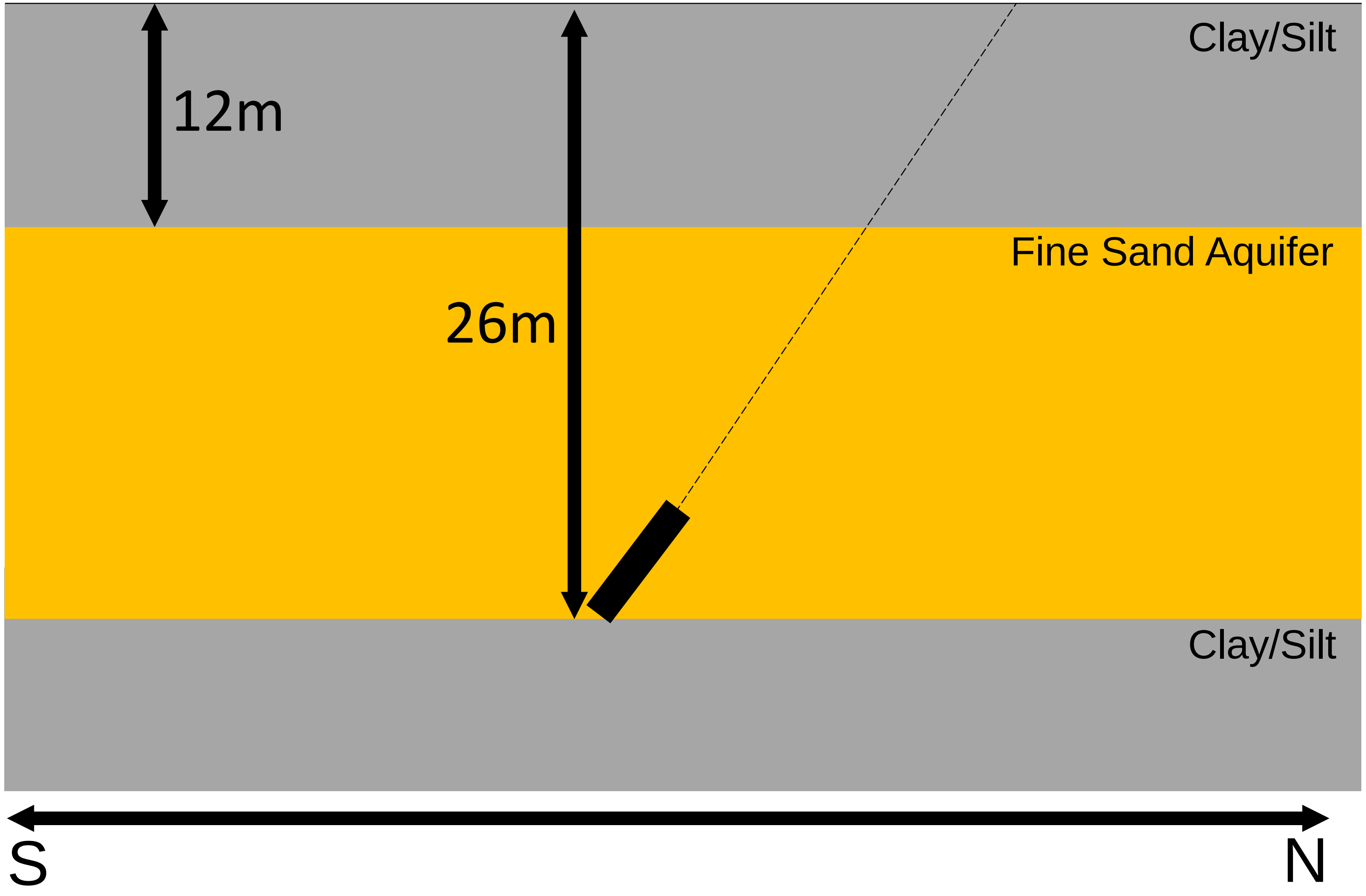
Clays and silt ~ 60 API, 60 Ωm resistivity

Fine sand to silt ~ 45 API, 80 Ωm resistivity

Clays ~ 75 API, 20 Ωm resistivity

Injection

- 1.5 m^3 per day
- 66 days
- 85% methane



Electrical Resistivity Tomography

- Current Injected into a pair of electrodes, another pair measures the potential difference resulting in apparent resistivity.

- Data are inverted to give a resistivity profile of the 2D line.

Dipole-Dipole

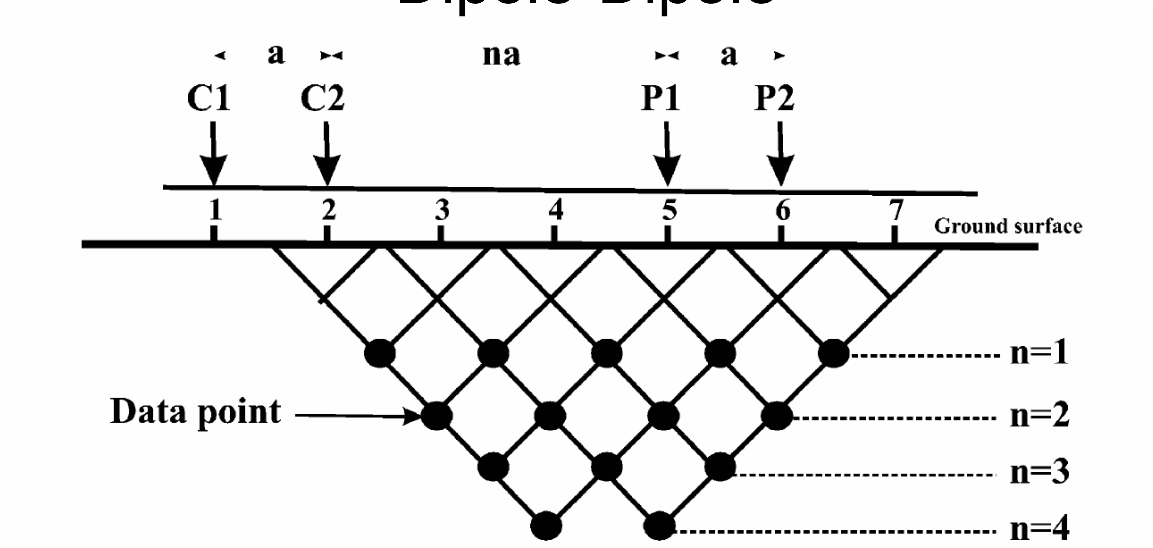
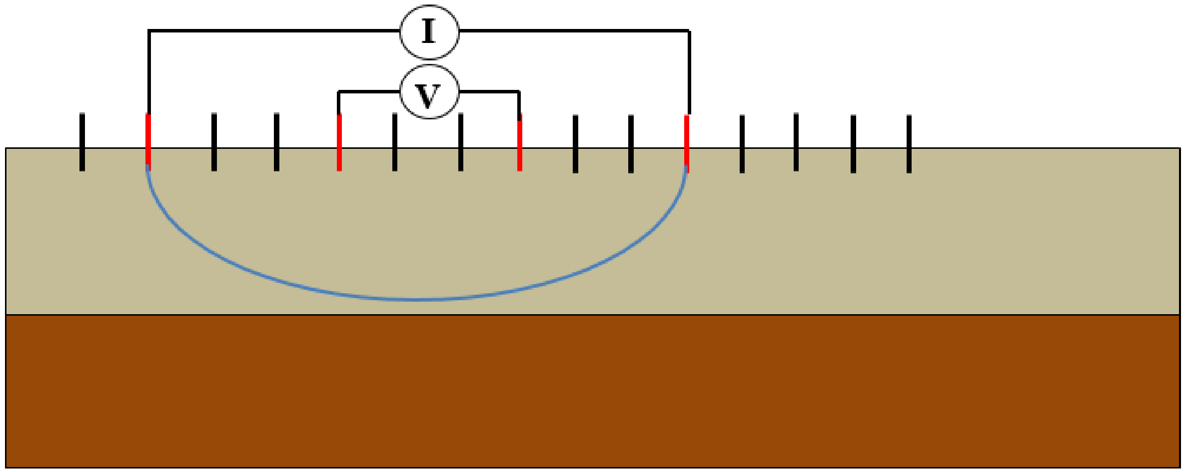
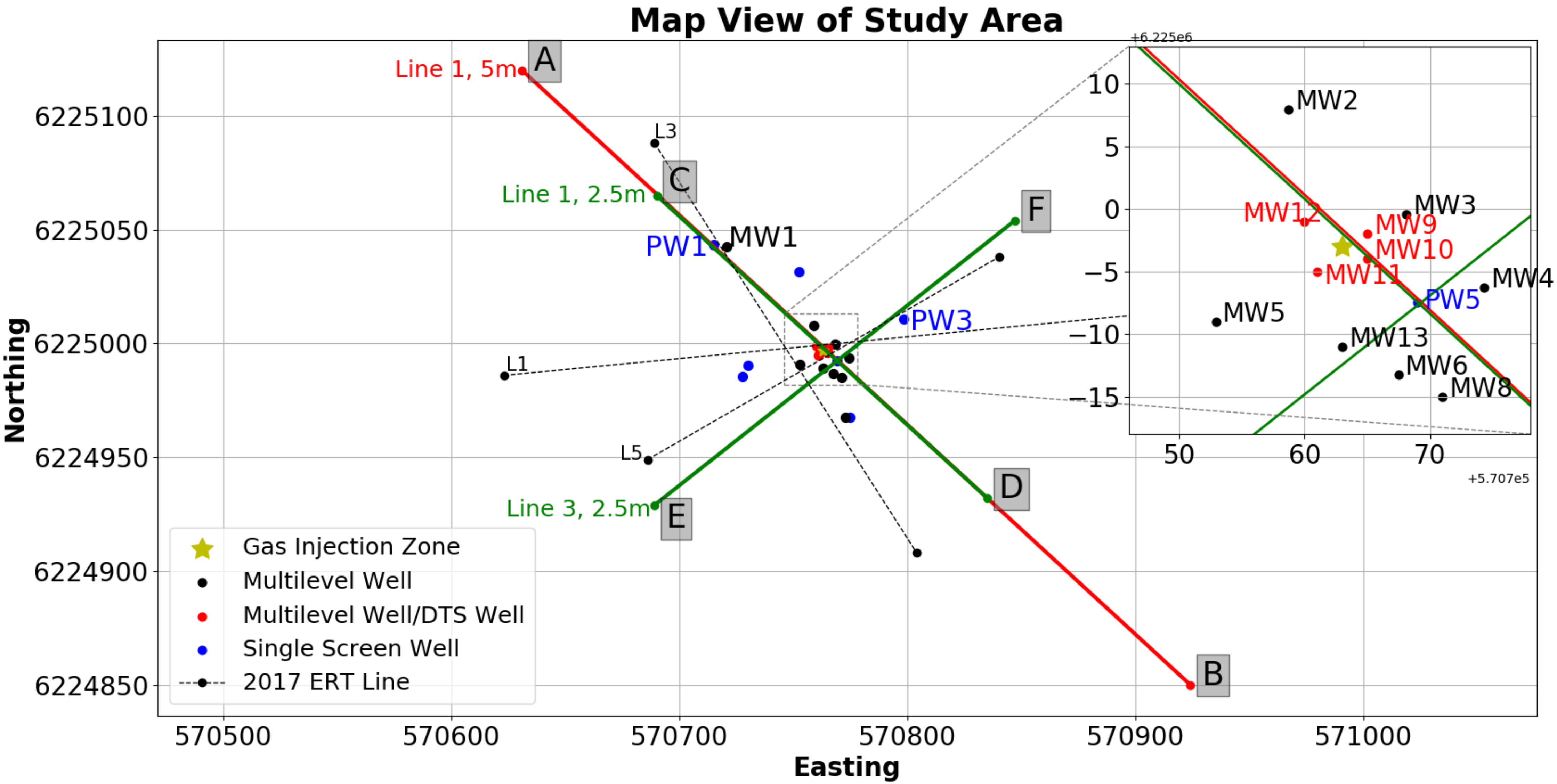


Image adapted from Adepelumi et al. (2006)

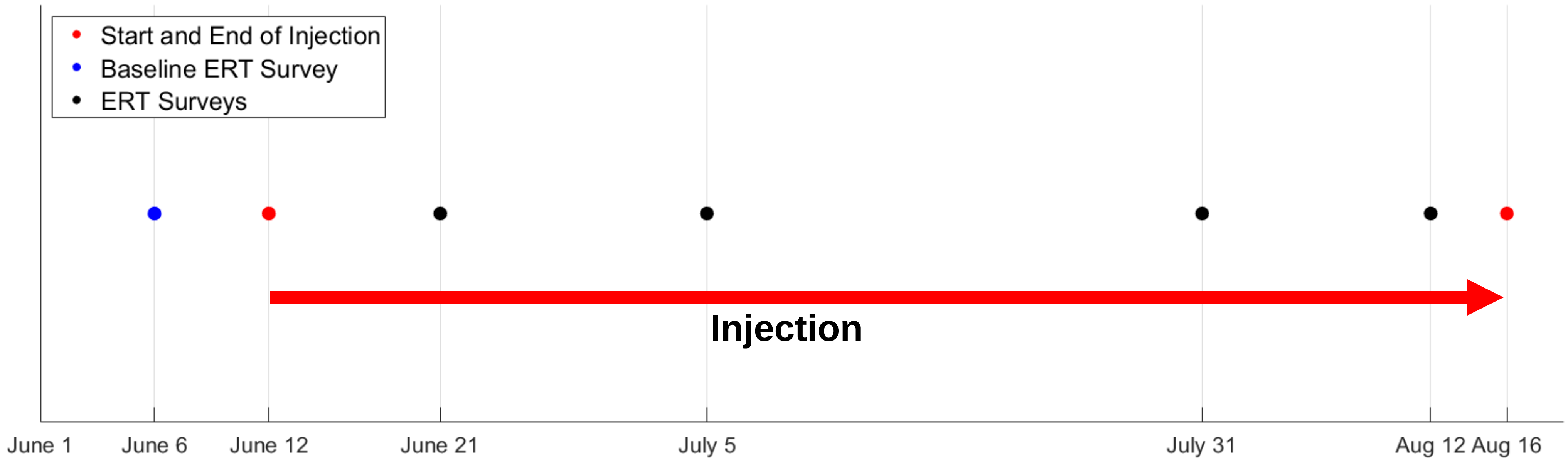
Gradient



Experimental Layout



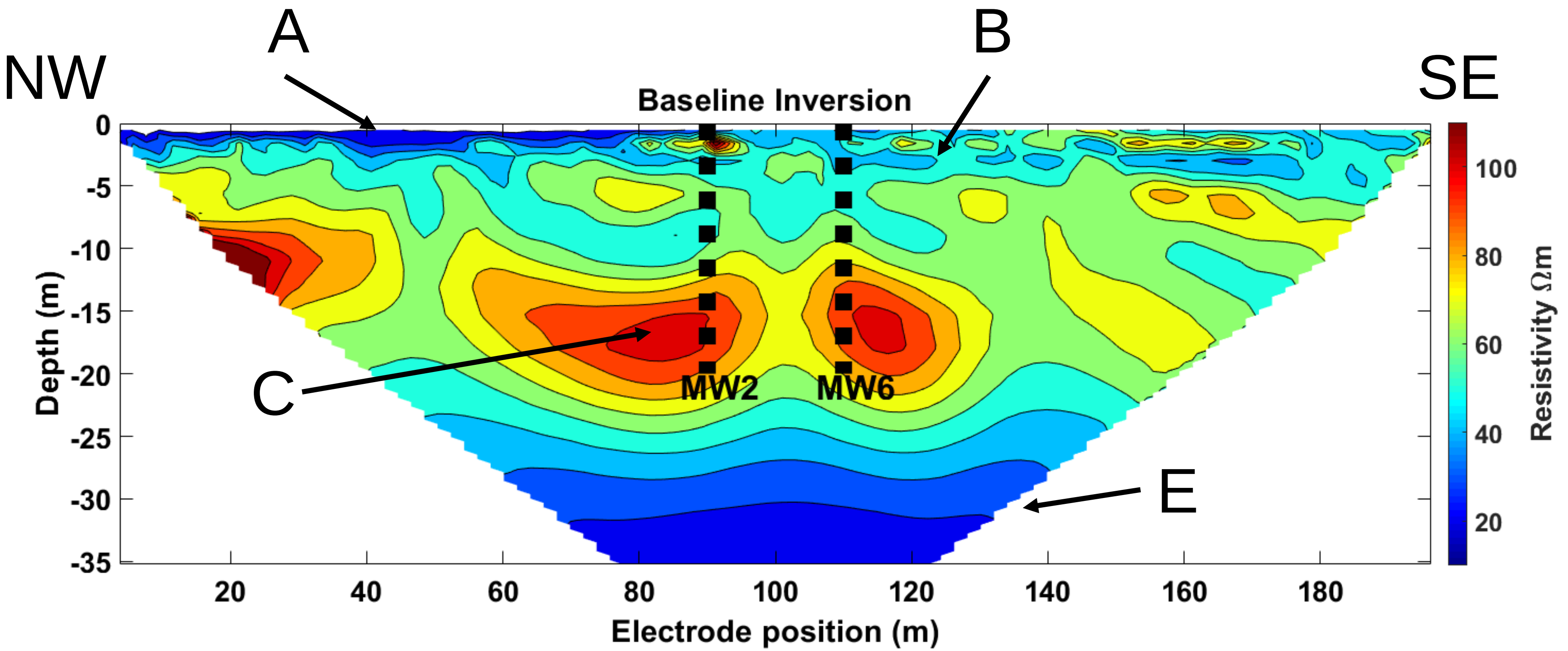
Data Collection

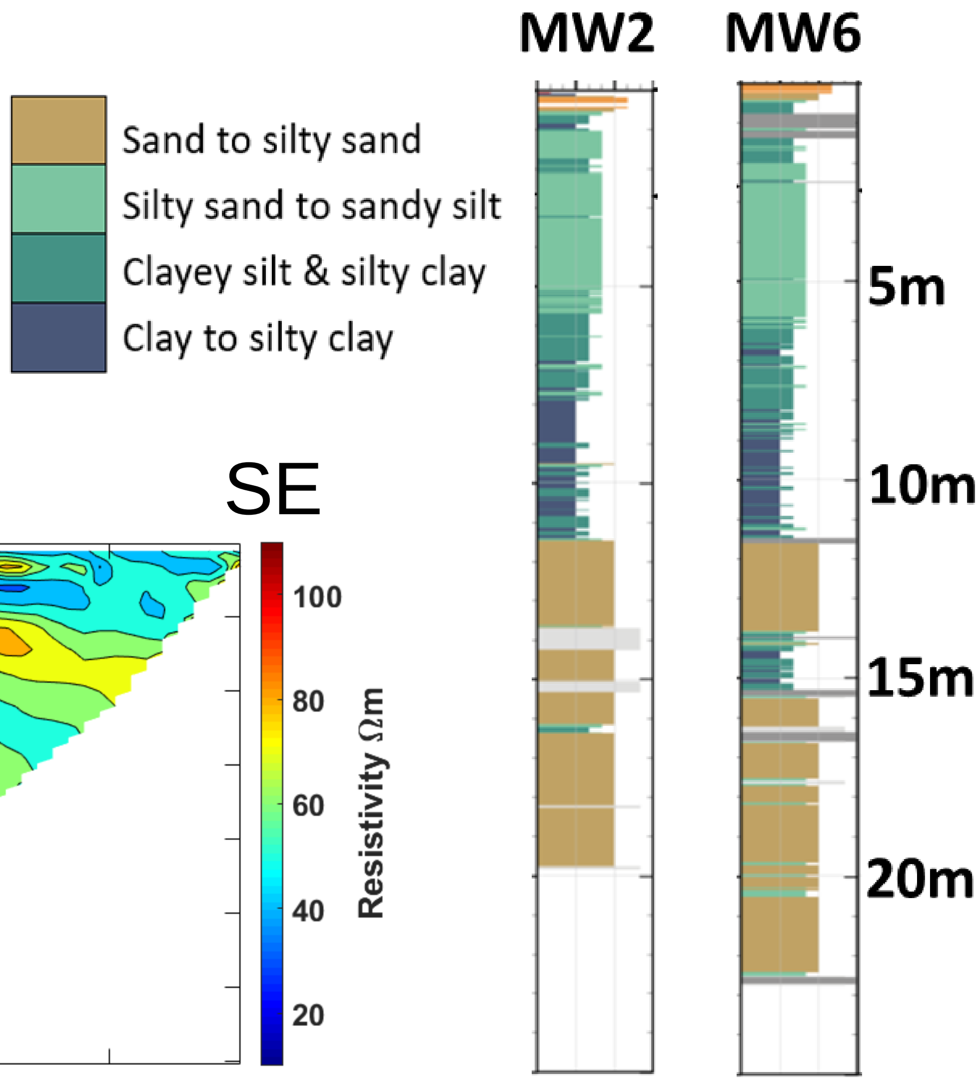


- Data differences calculated from the baseline model

Resistivity Model

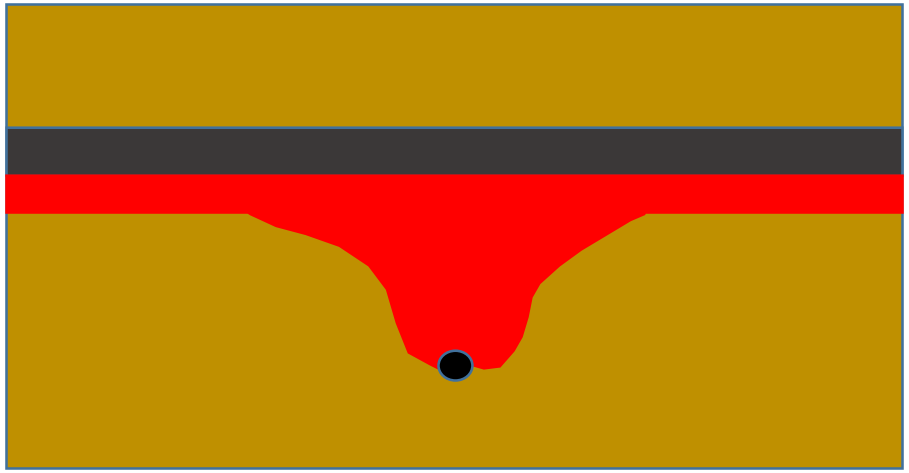
- Heterogeneity prevalent
- <2% RMS error

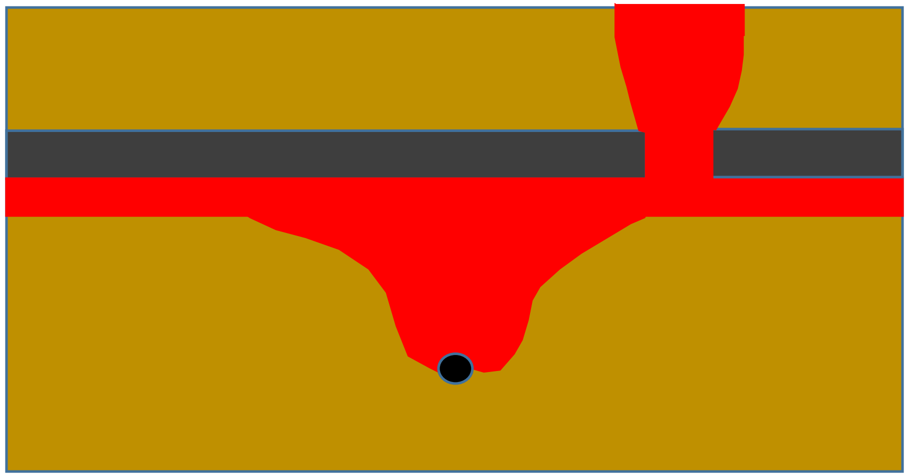




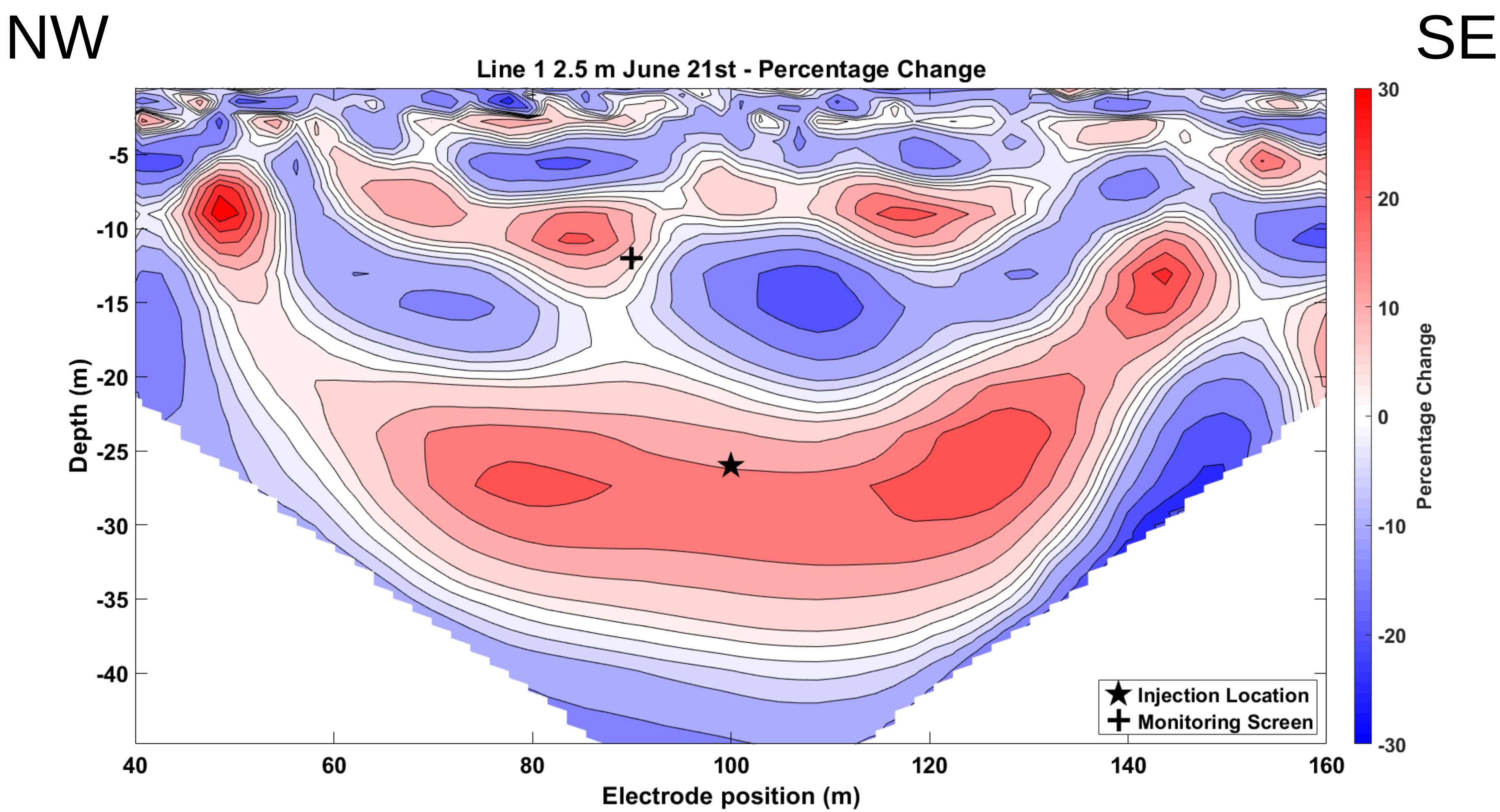
Expected gas behavior

- Buoyancy driven migration
- Impermeable layers are barriers to flow (Clay and silts)
- Gas is more resistive than groundwater
- ERT sensitive to temperature and saturation





Line 1 2.5 m Differences



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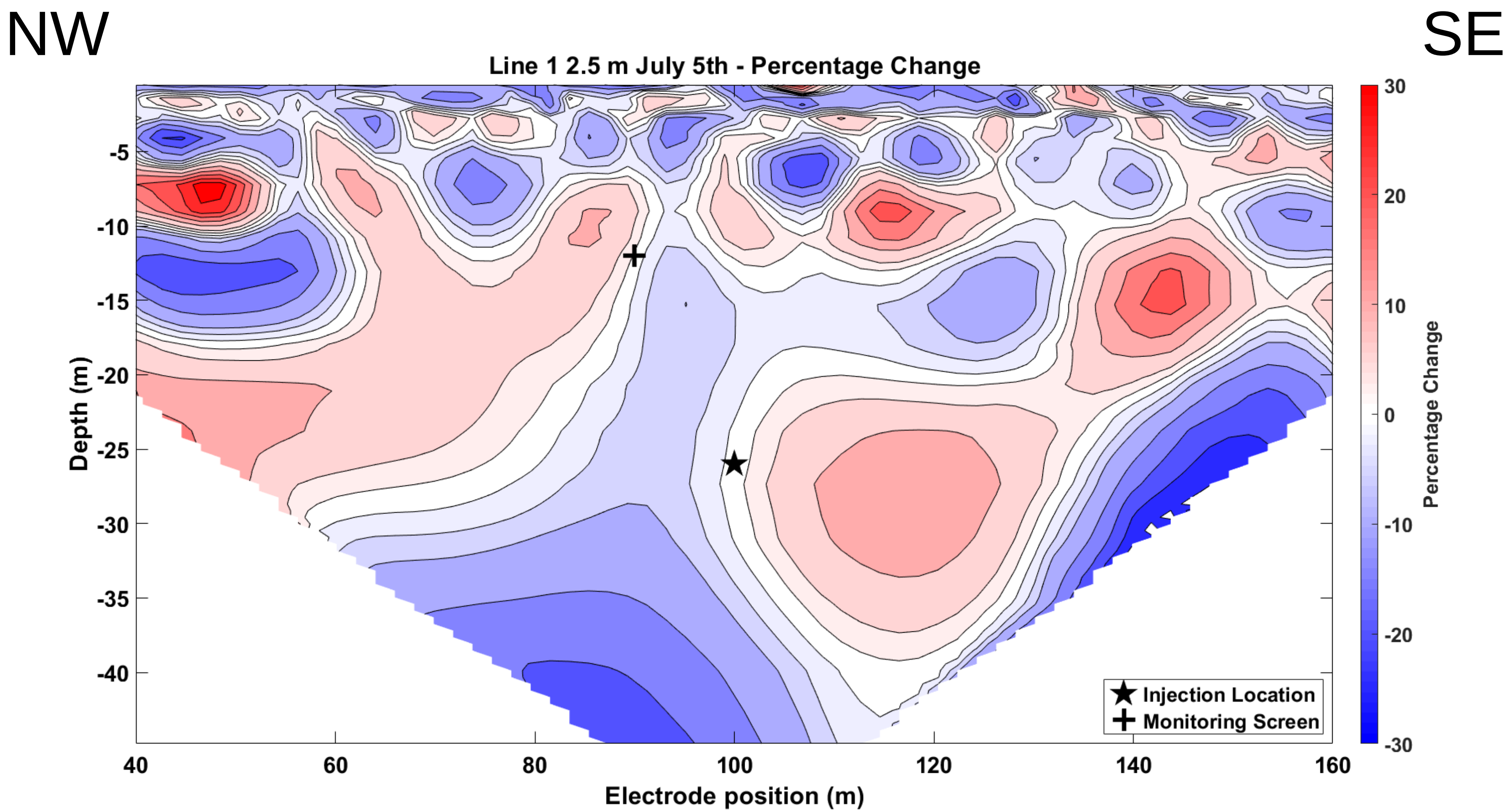
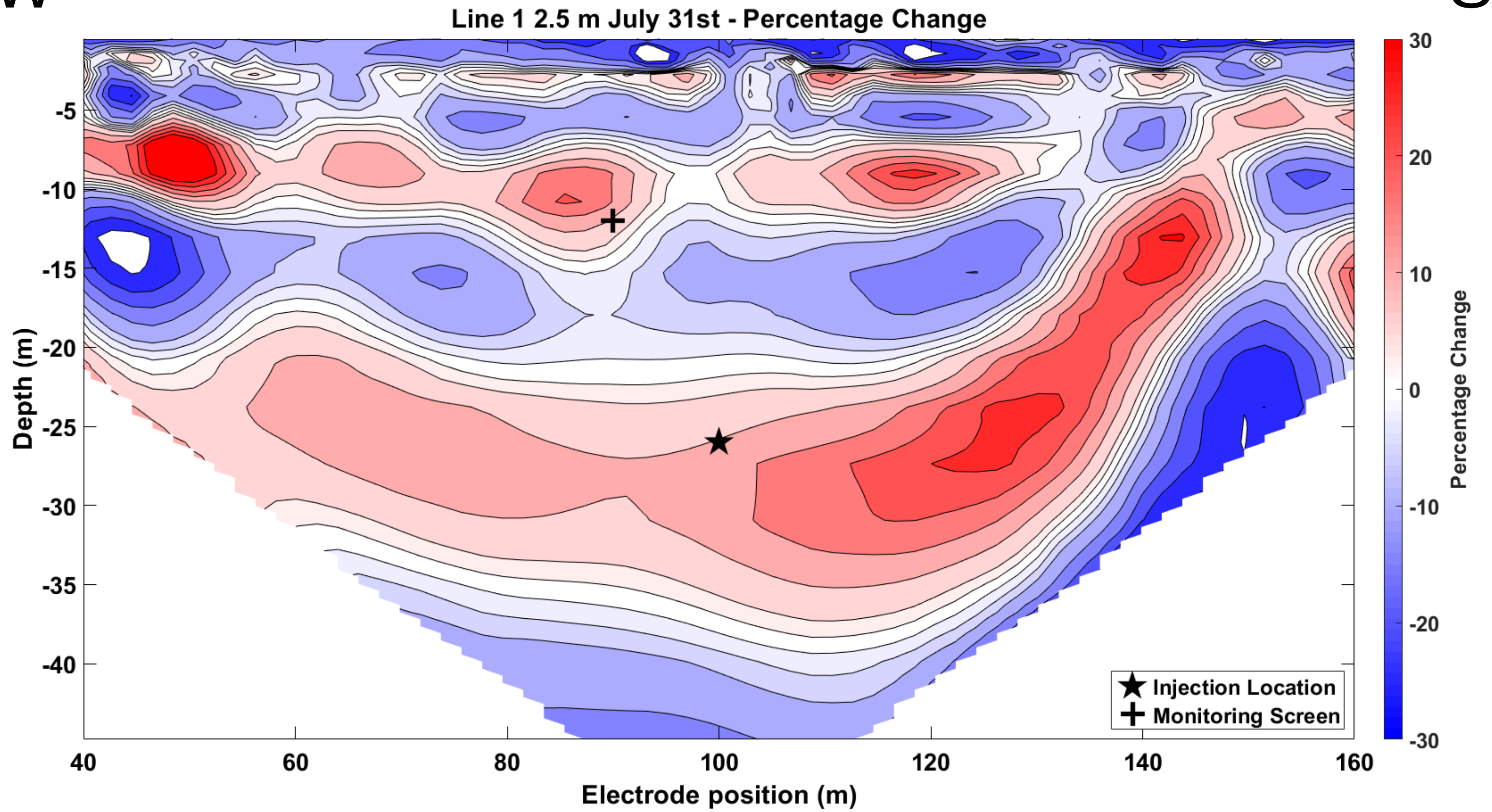


Line 1 2.5 m Differences

NW SE



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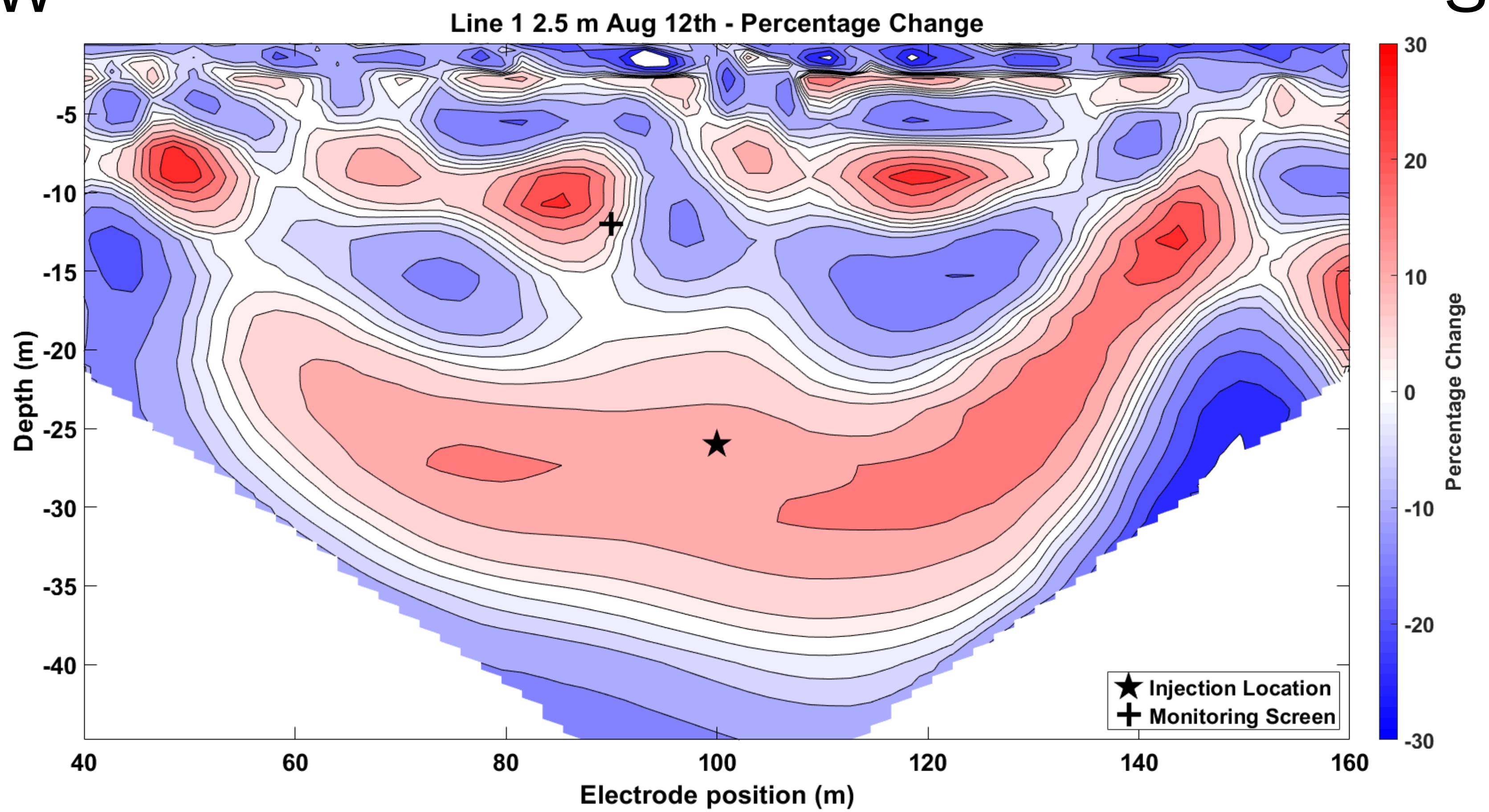
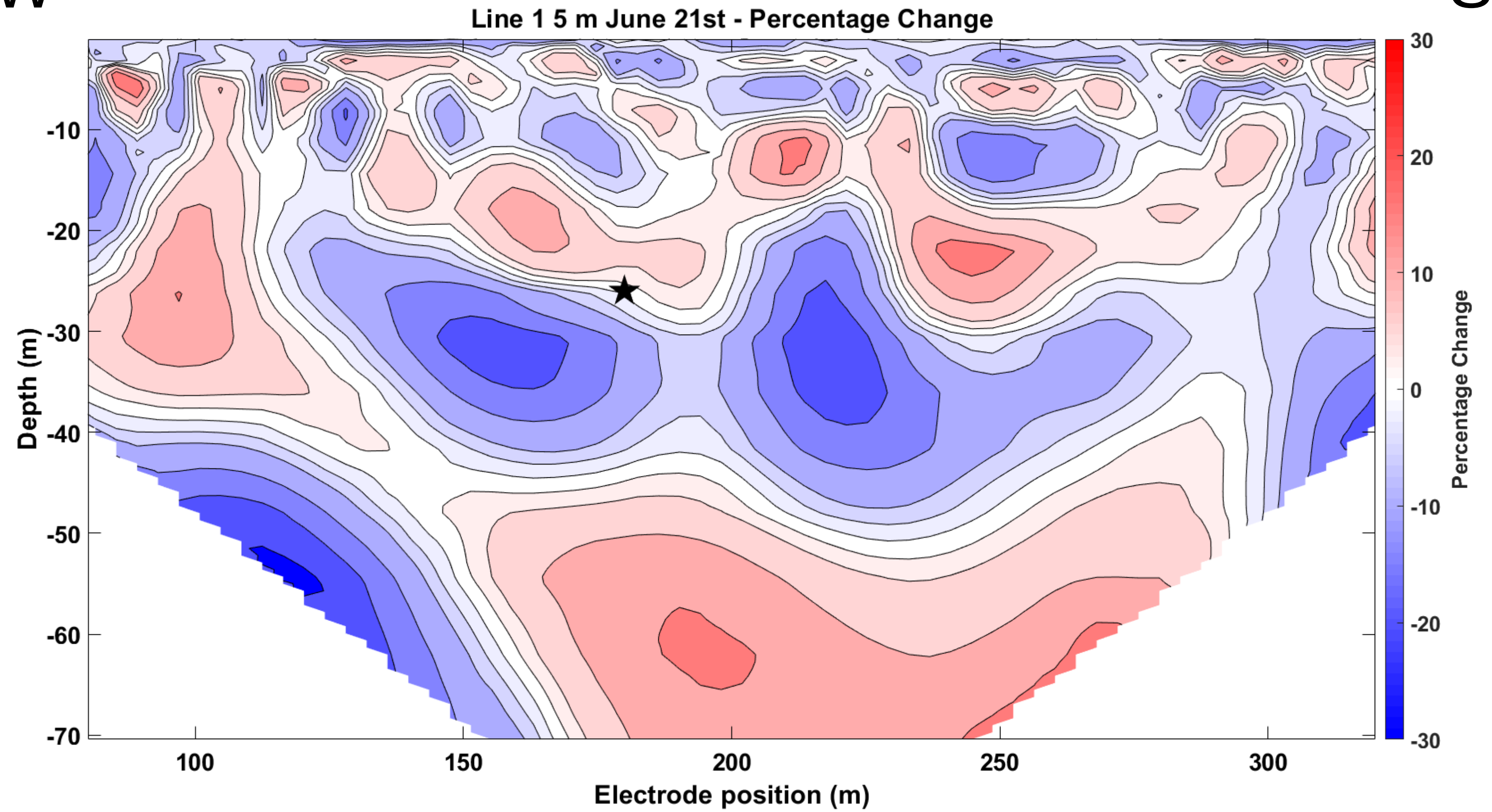
NW SE



Line 1 5 m Differences

NW SE



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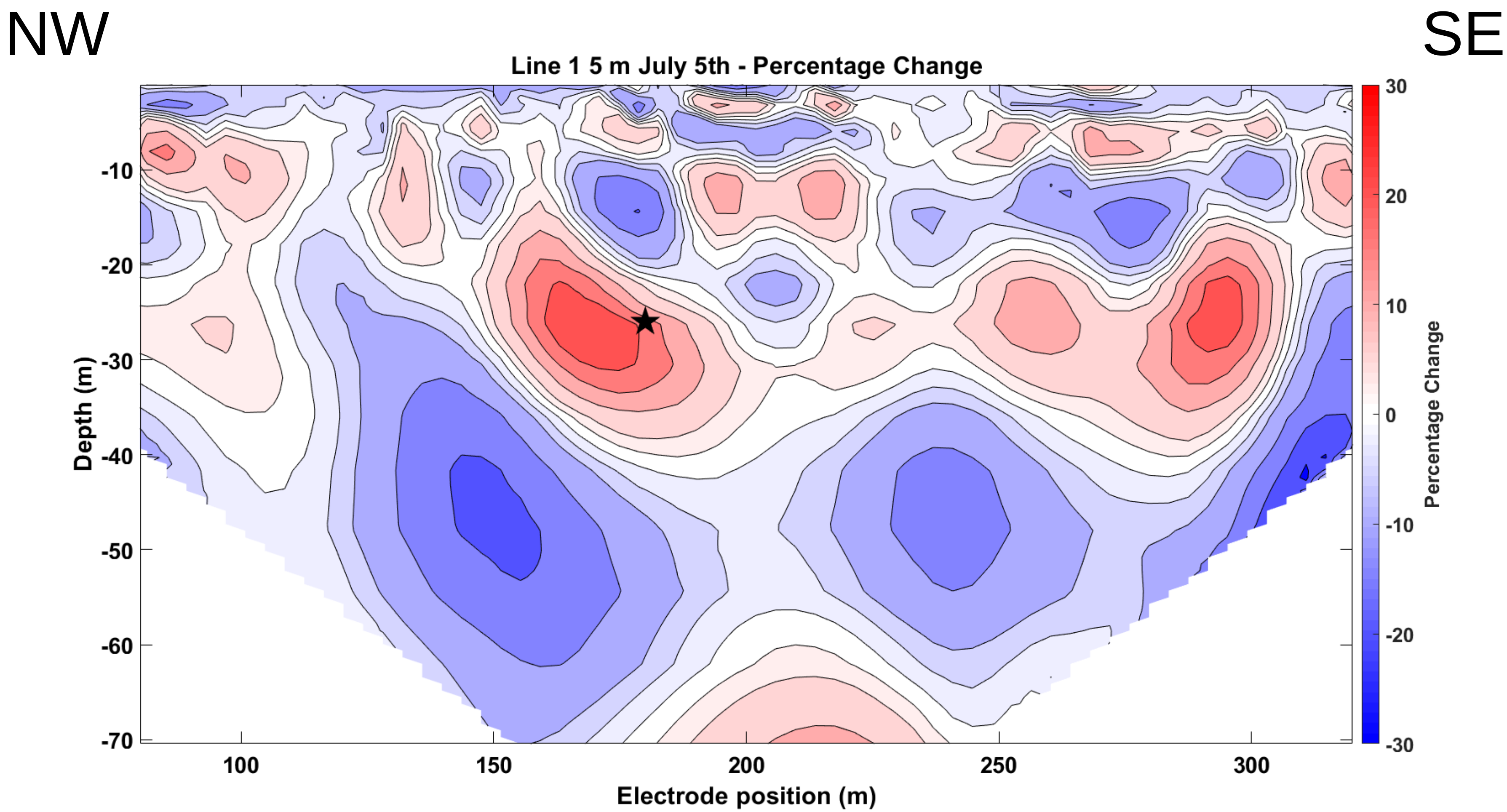

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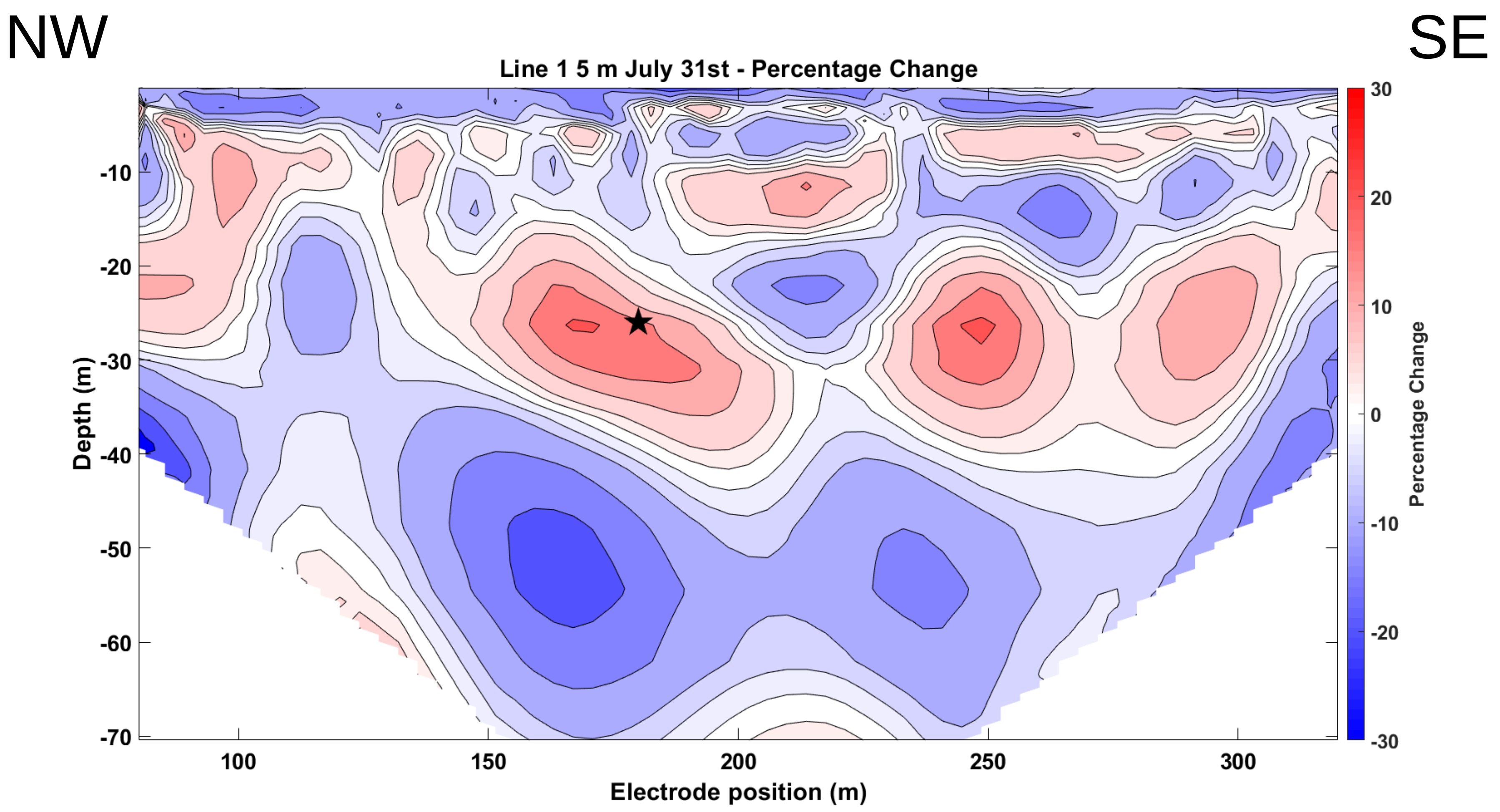

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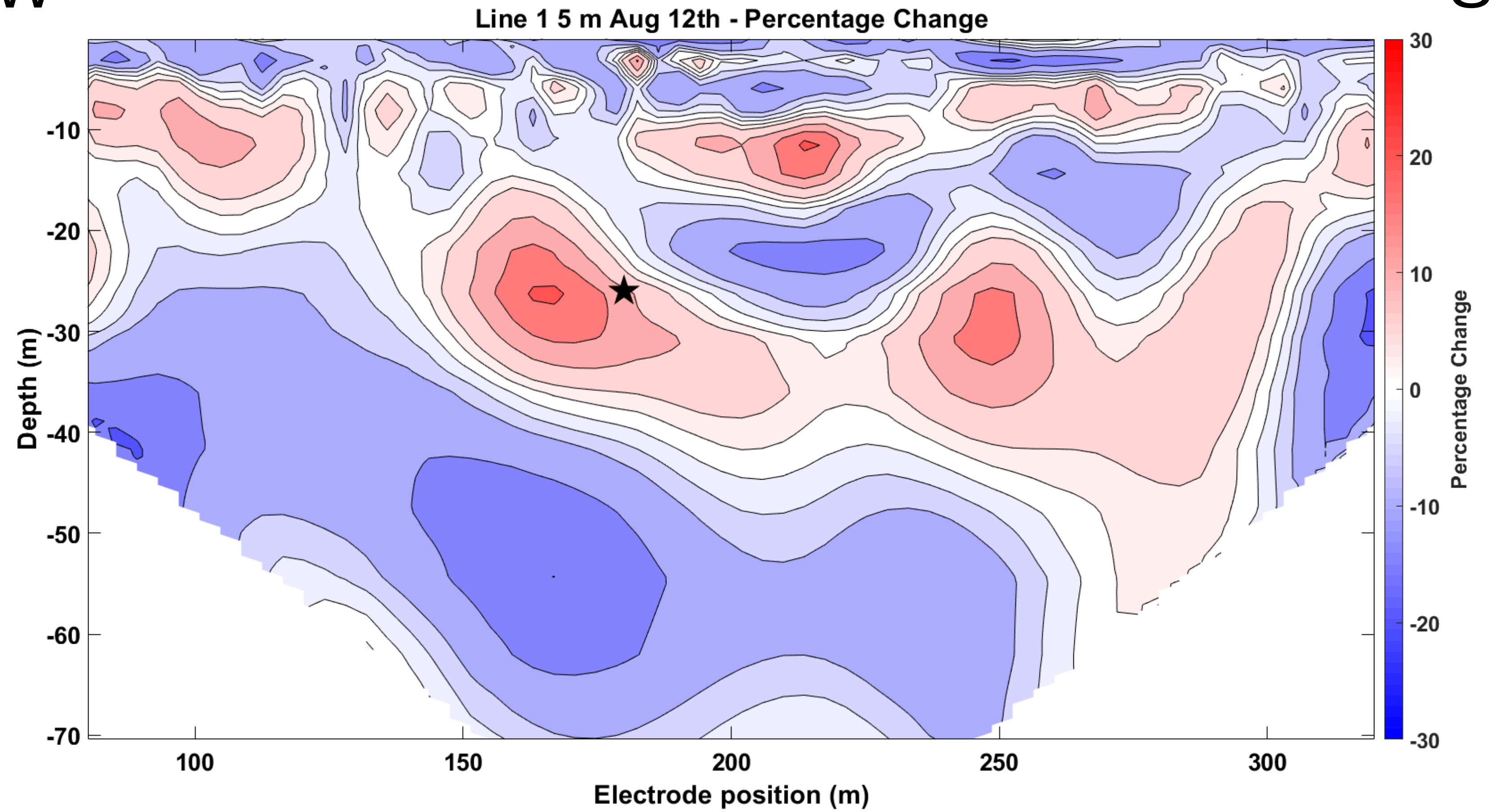
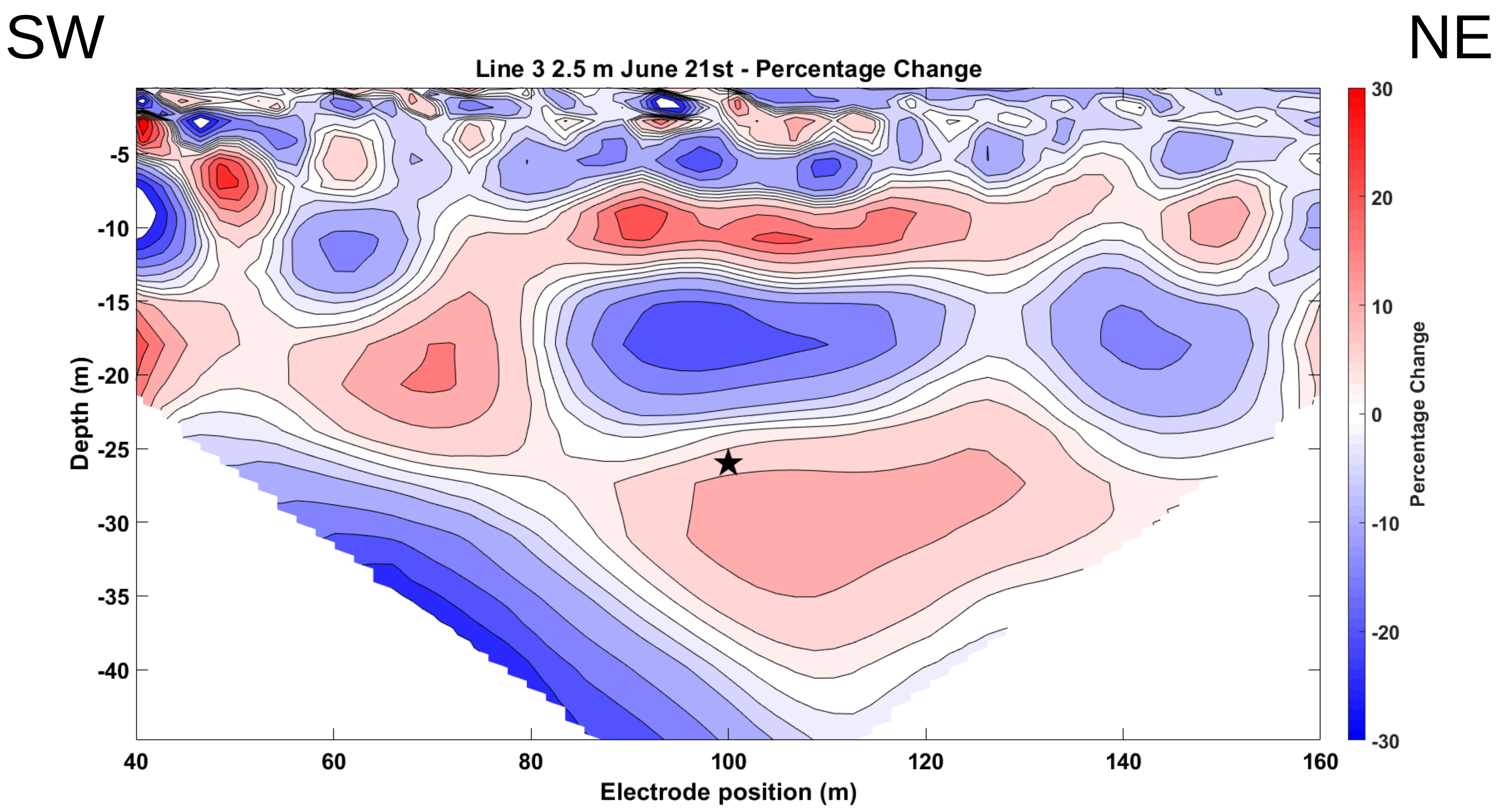


Line 3 2.5 m Differences



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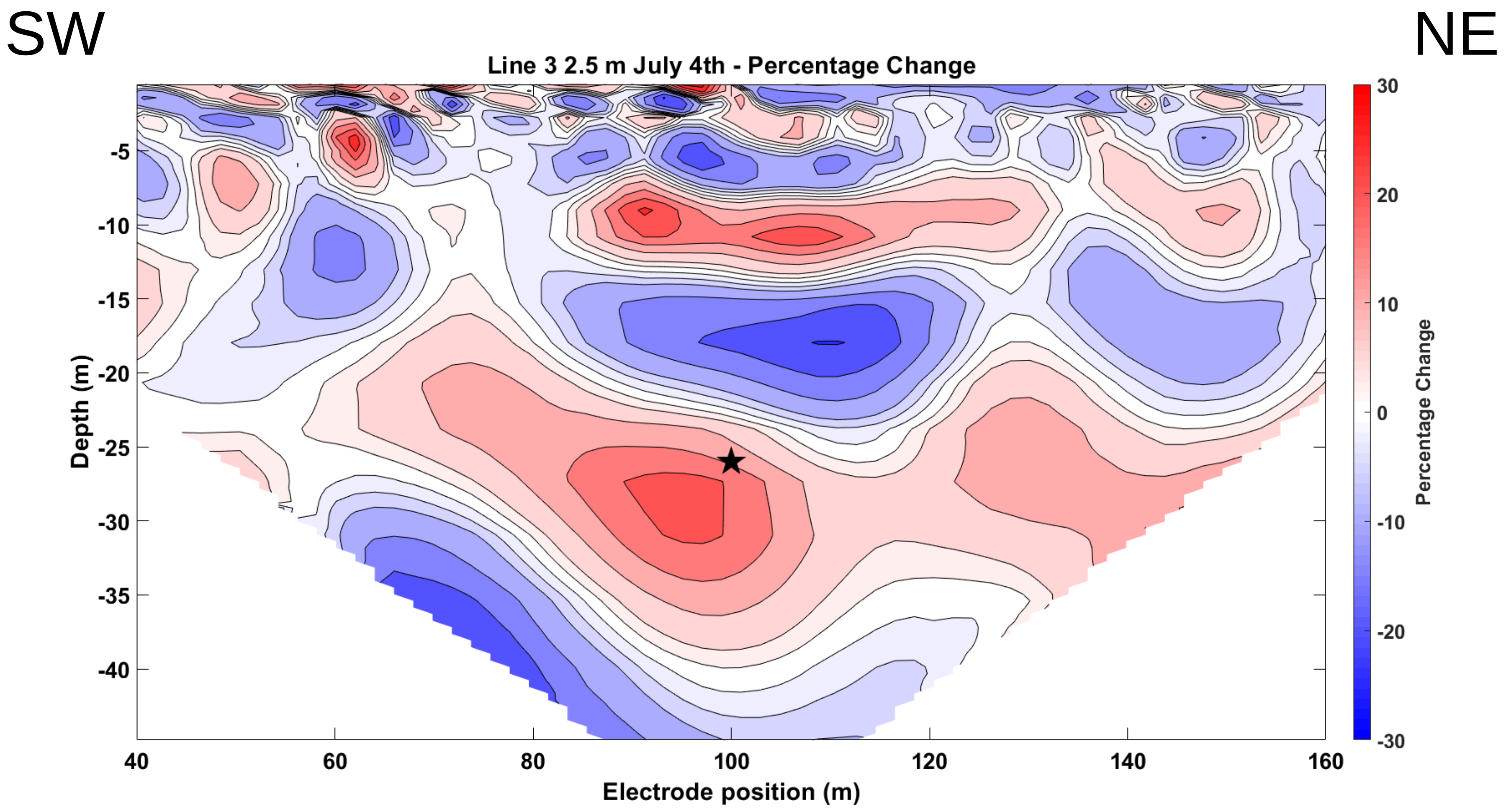

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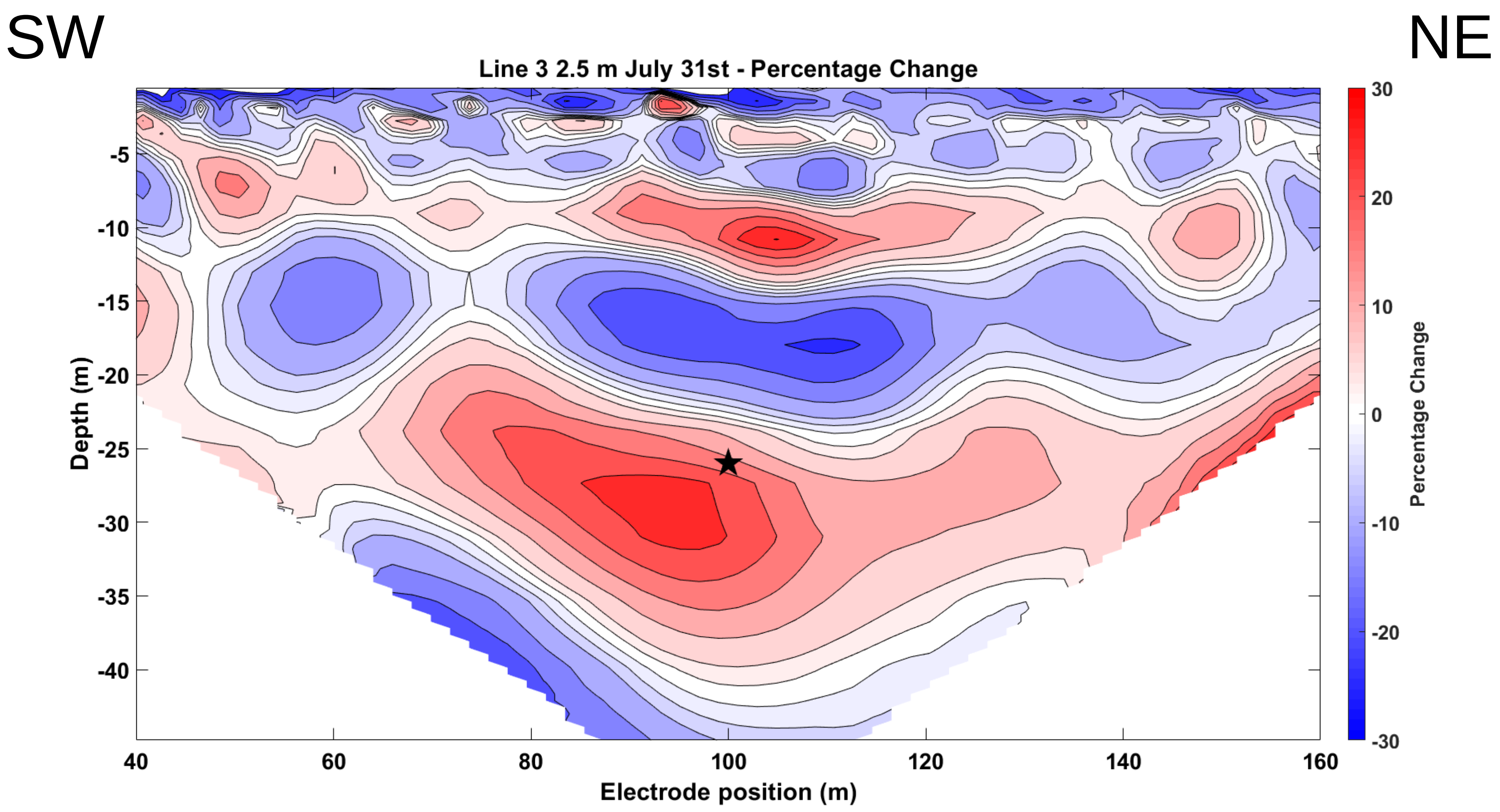

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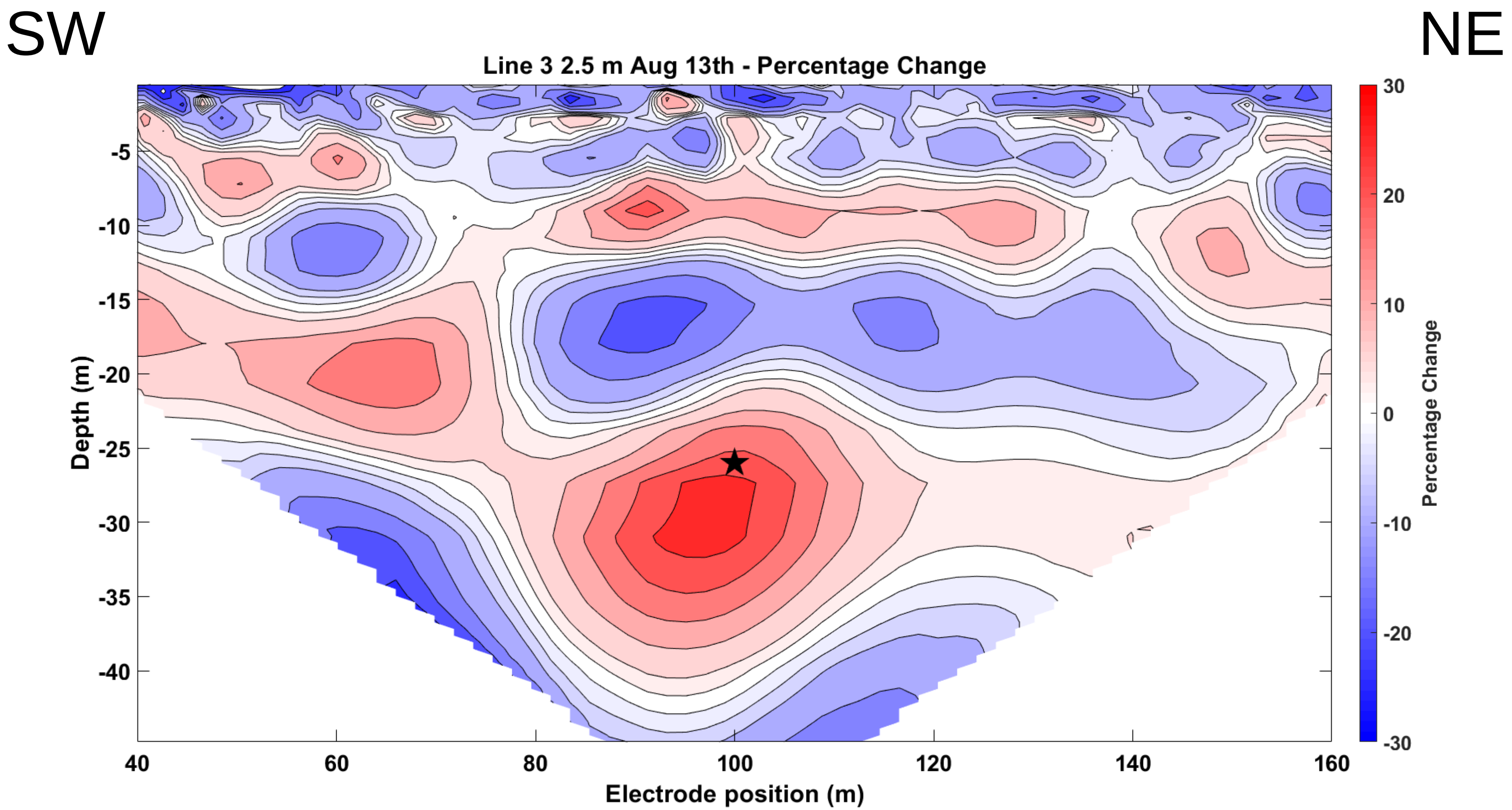
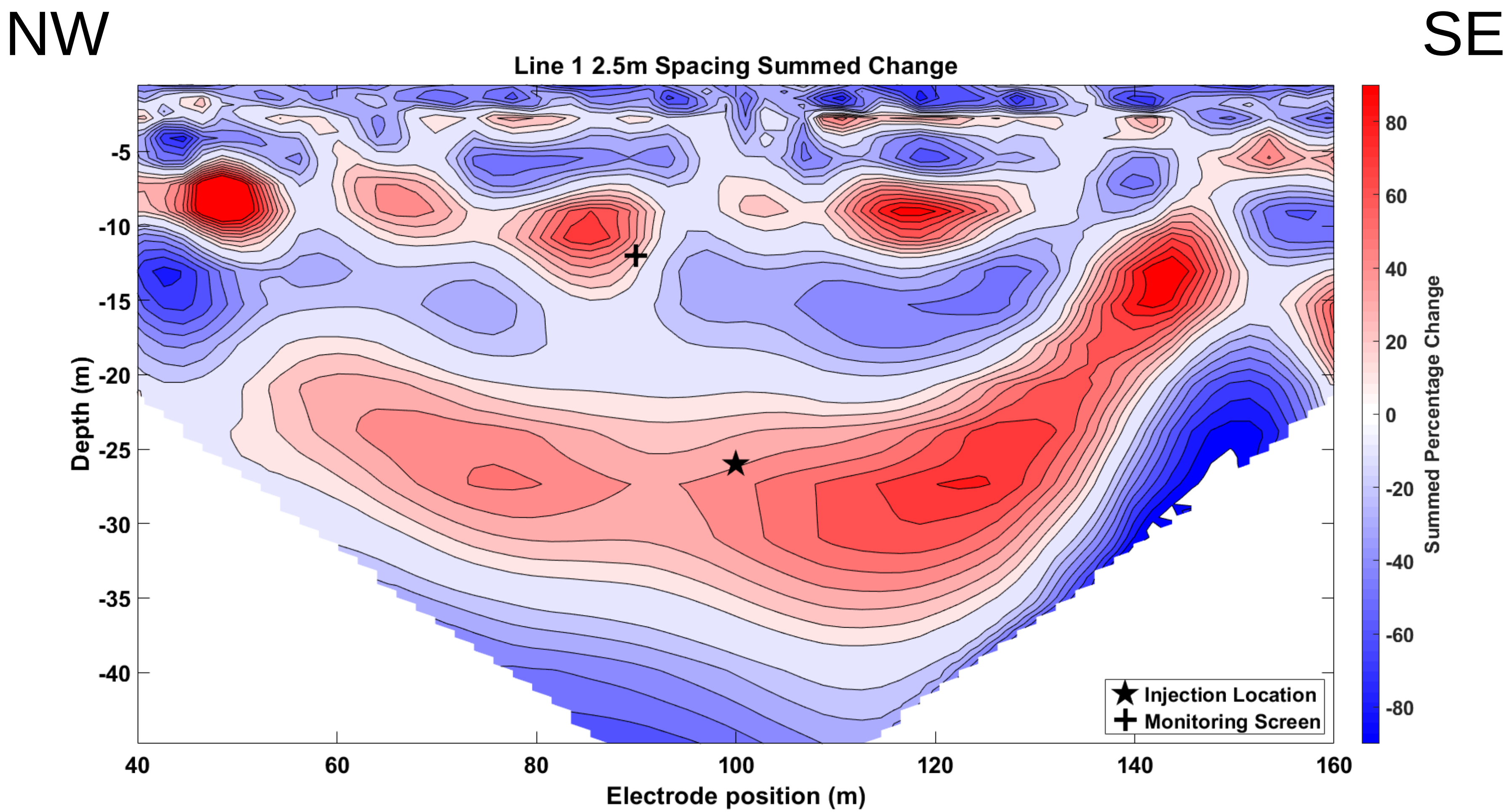


Line 1 2.5m Stacked Differences



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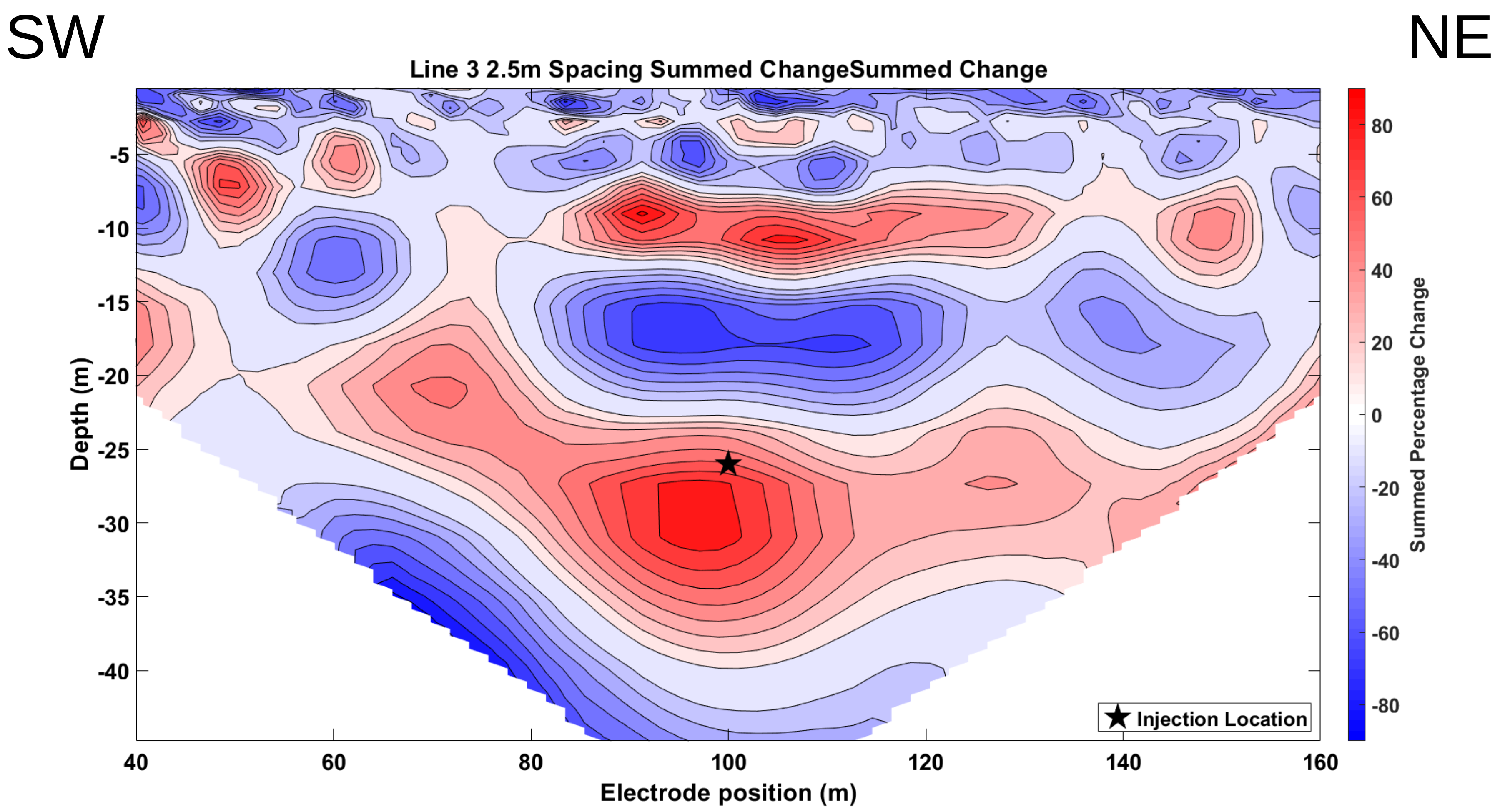

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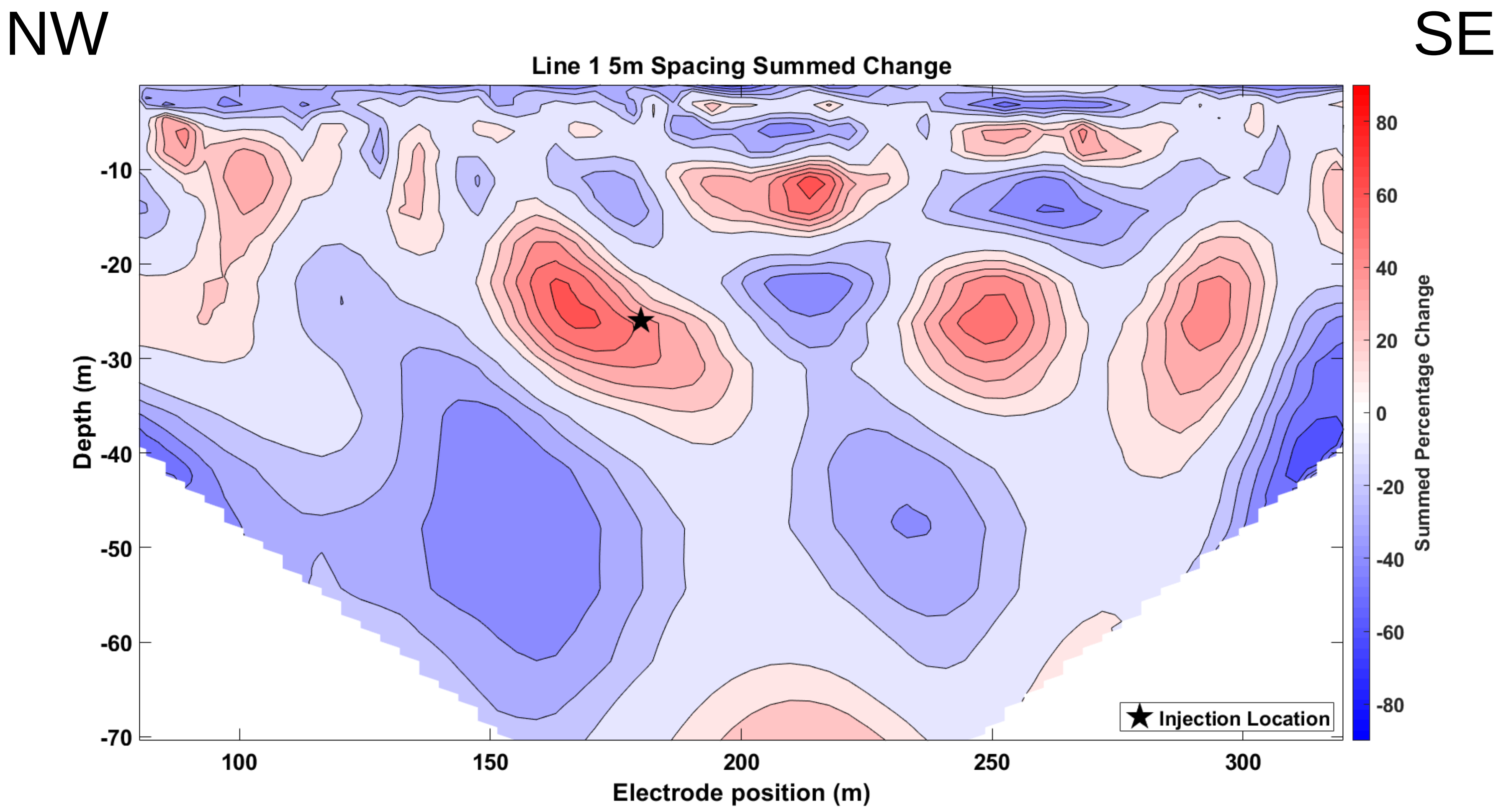

Conclusions and Future Work

Conclusions

- ERT viable method for monitoring gas migration
  - Increases in resistivity up to 27%
  - Increases seen around injection point and monitoring screen
- Heterogeneous nature of a fluvioglacial environment leads to significant lateral migration

Future Work

- Implement more accurate temperature corrections to increase confidence in changes.