Lessons Learned:

Difficult Cases Where it Works

2014 M2S2 Webinar Series – Munitions Classification

Black Tusk
GEOPHYSICS

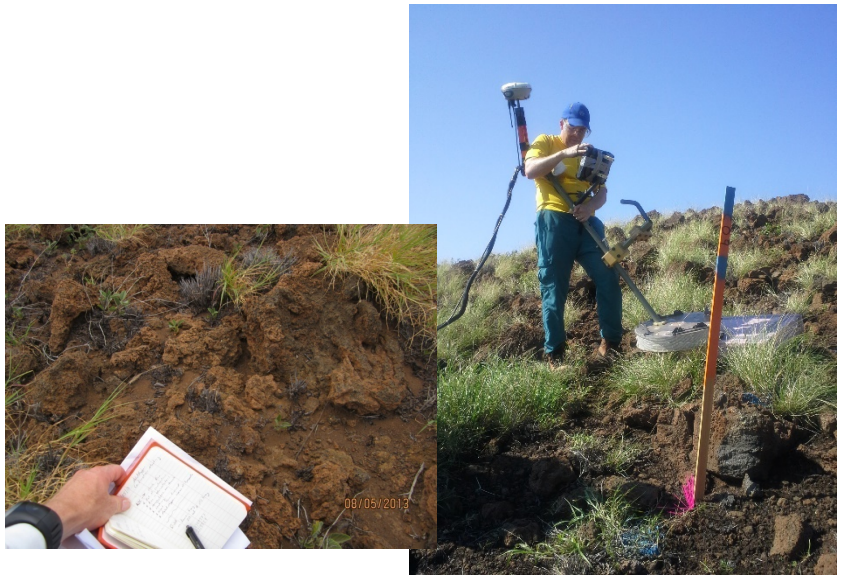
- The new generation of EMI systems are able to acquire higher spatial resolution, multi-static, multi-component, multi-time channel data
- With these new data, we are now able to apply advanced analysis and classification at increasingly difficult sites

Former Camp Ellis, Illinois

J-1. Area A: Rockets, rifle grenades, & hand grenades.

- Regions of with high density of clutter and targets

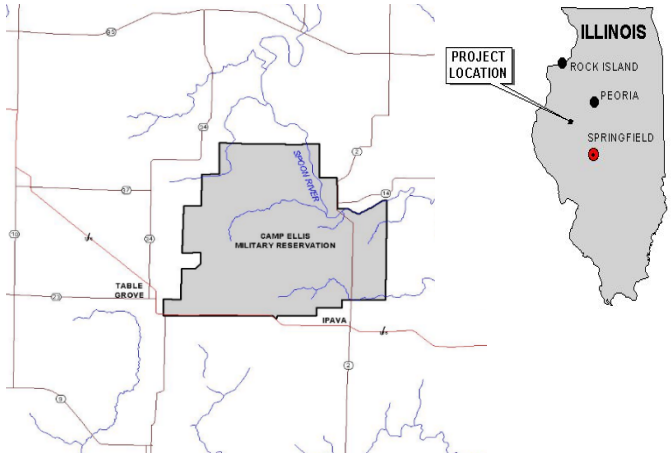
Former Waikoloa Maneuver Area, Hawaii



- Significant noise from magnetic soil
- Terrain and topography

Former Camp Ellis, Illinois

- Surface clearance of selected areas conducted in 1949
- Land sold in 1955 with no deed restrictions
- Archives Search Report 1996
- Land is currently wooded or used for farming



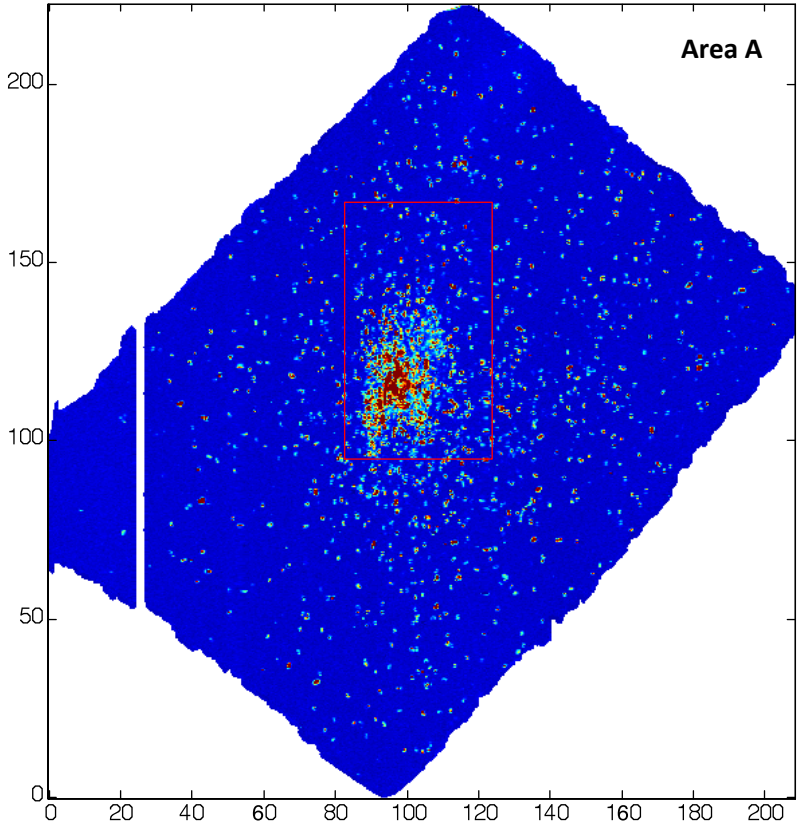
J-4. Area C: Rockets and rifle grenades.

J-2. Area B: Rockets, rifle grenades, & mortars.

ESTCP Live Site Data Collection at the Former Camp Ellis

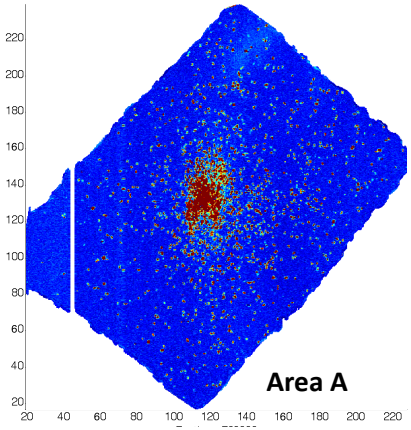
- Area A: Former rockets, rifle grenade and hand grenade range
- Area mapped with the MetalMapper

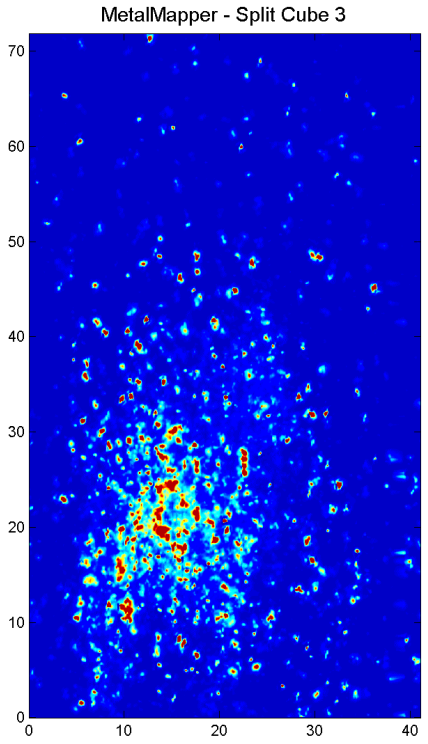
J-1. Area A: Rockets, rifle grenades, & hand grenades.

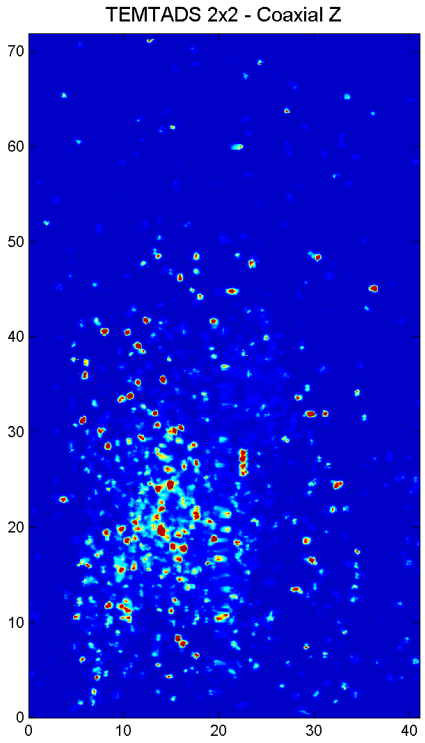


ESTCP Live Site Data Collection at the Former Camp Ellis

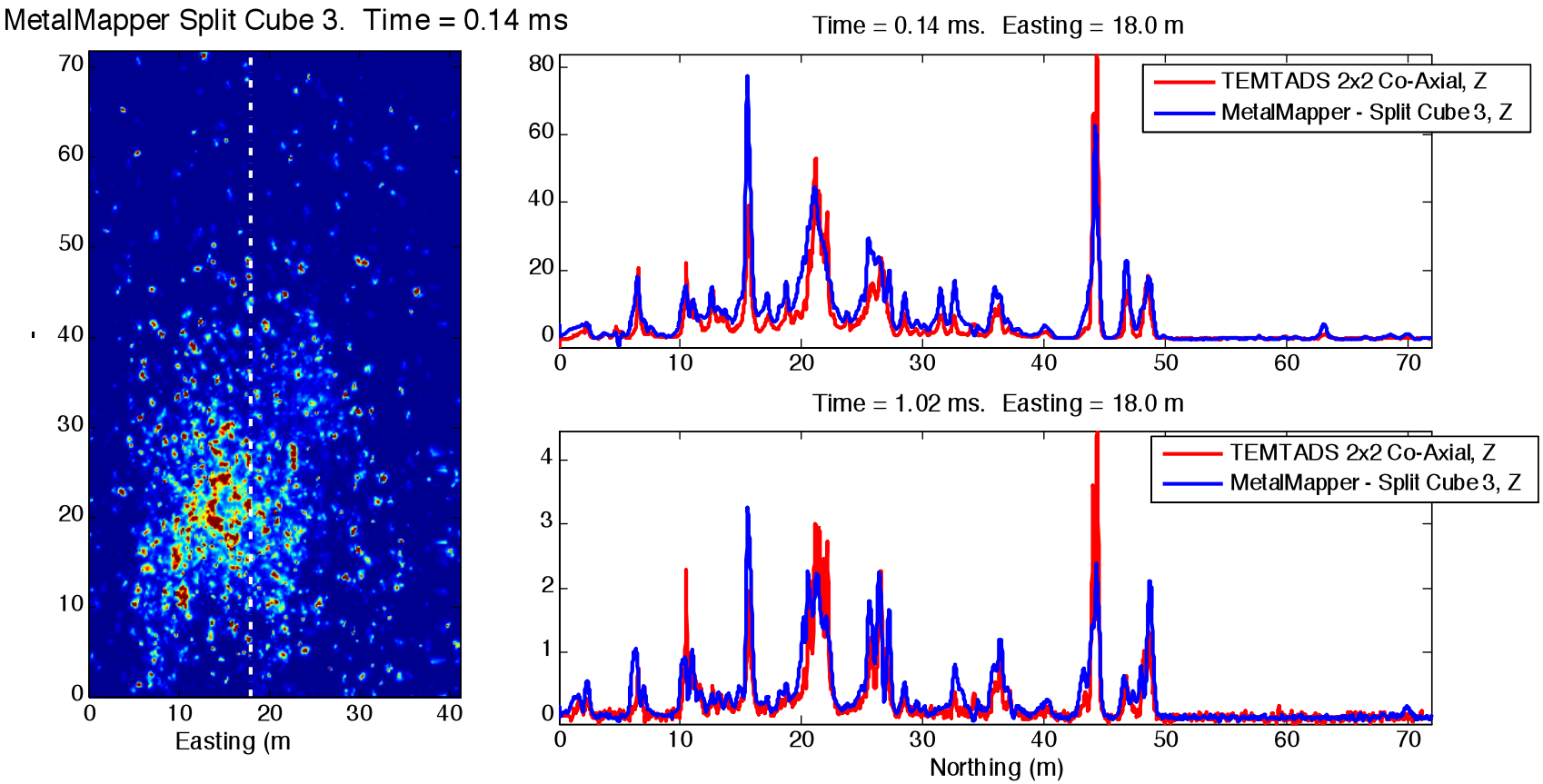
- Area A: Former rockets, rifle grenade and hand grenade range
- Subset of site mapped with a TEMTADS 2x2







MetalMapper and TEMTADS 2x2 data comparison



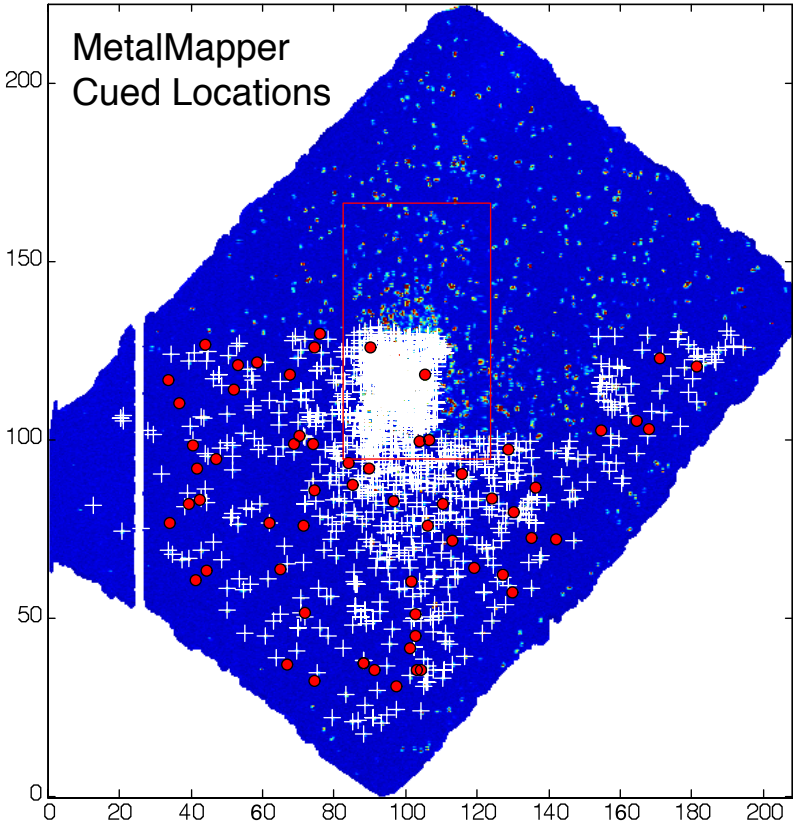
Cued Data Collection and Analysis

MetalMapper anomalies

- 1689 anomalies
- Number of TOI: 63
- Number of non-TOI: 1626

TEMTADS 2x2

- 1529 anomalies
- Number of TOI: 39
- Number of non-TOI: 1490



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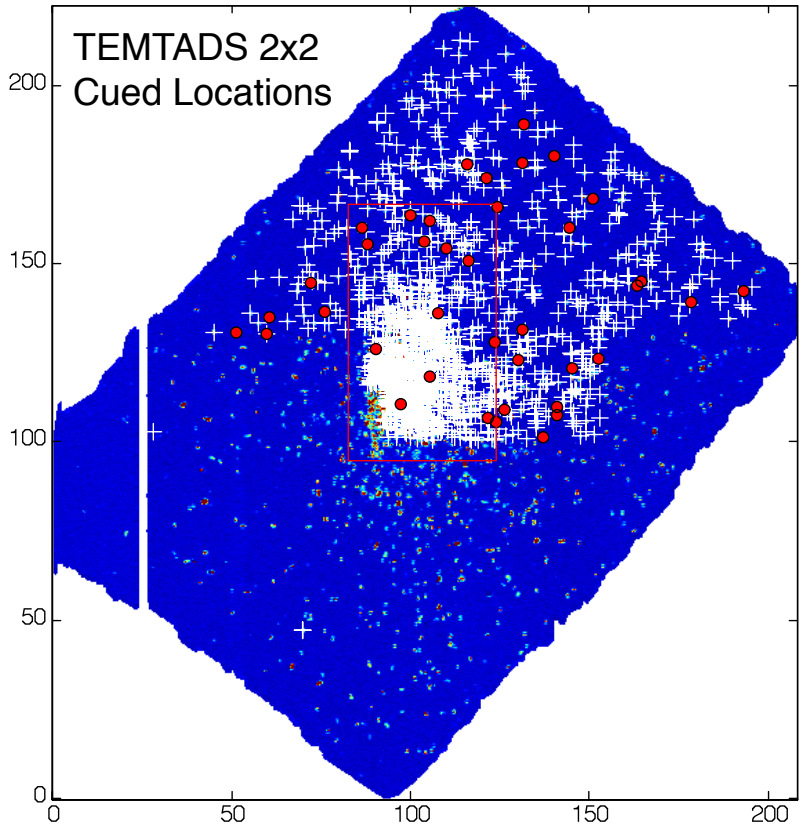
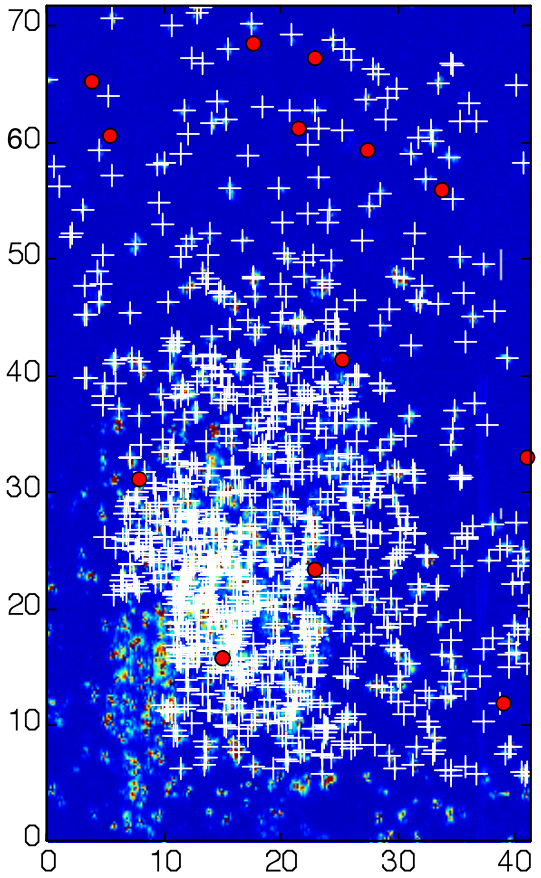


Cued Data Collection and Analysis

- Classification performed by one production group and multiple “expert” analysts
- Ability to resolve multiple sources within the view of a target is critical

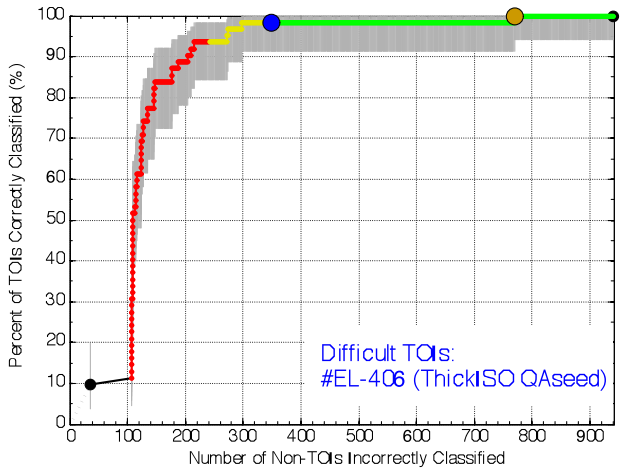
Advanced EMI instruments collect high quality data from which multiple targets can be resolved

TEMTADS 2x2 Cued Locations
N = 1069 (total = 1529)

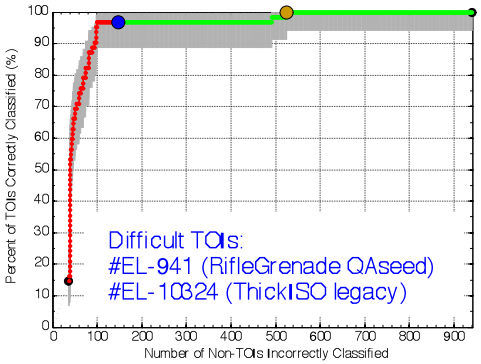


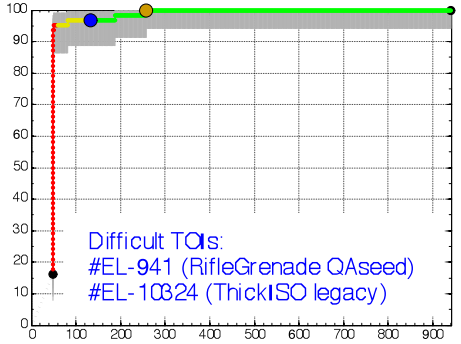
Cued Data Collection and Analysis: MetalMapper Cued Results

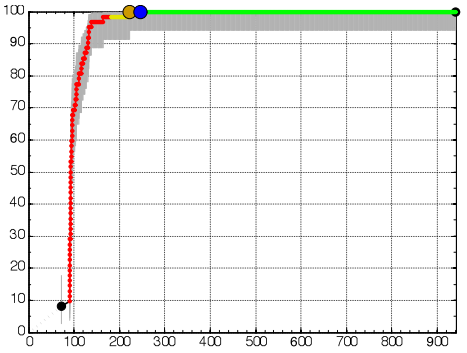
Industry/Production Analyst



Experienced, "Expert" Analysts



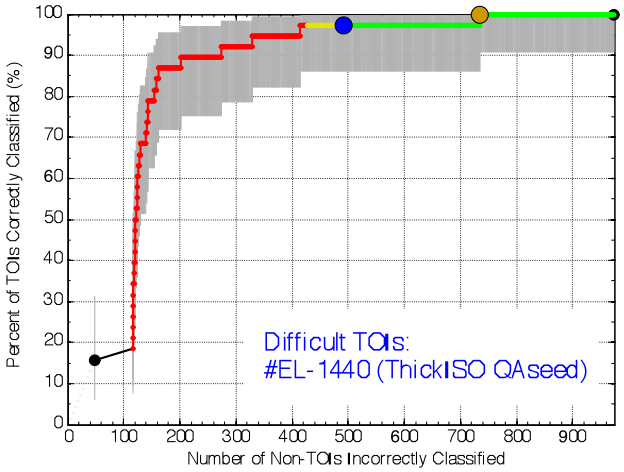




Note: 10324/324 removed from TOI list (ground truth error)

Cued Data Collection and Analysis: TEMTADS 2x2 Cued Results

Industry/Production Analyst



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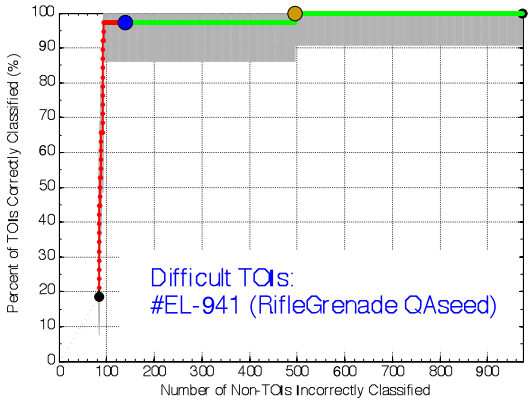
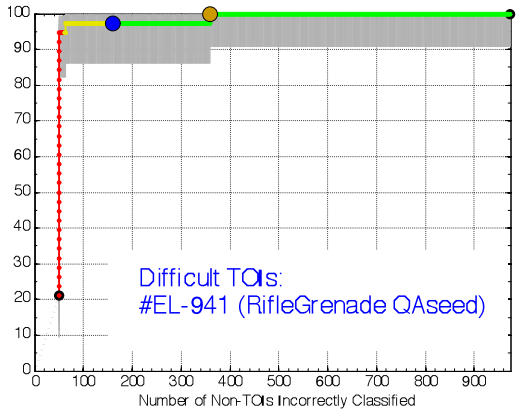
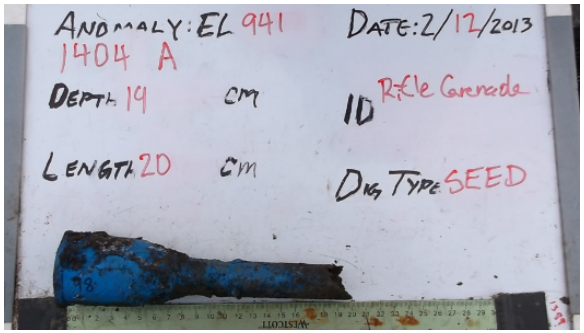






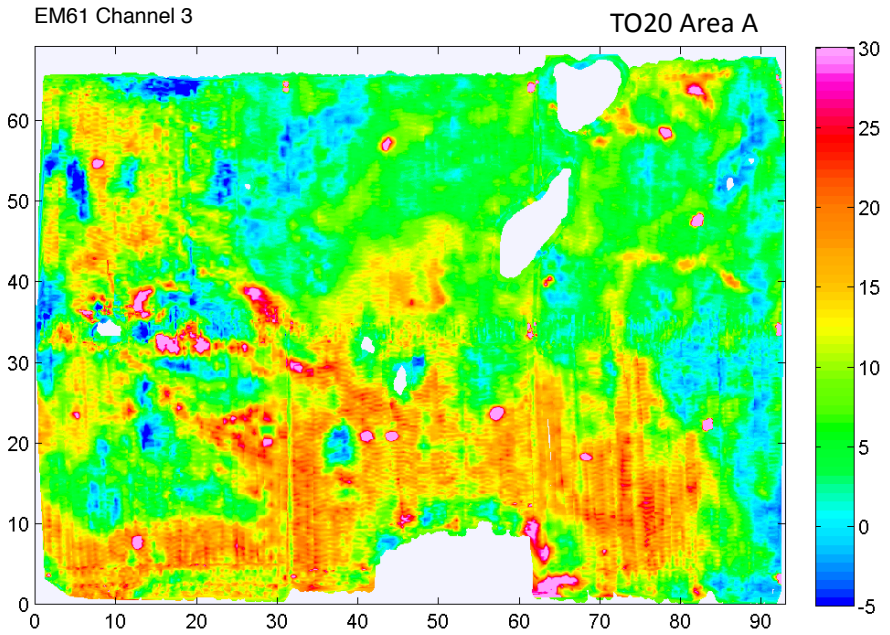
Former Waikoloa Maneuver Area, Hawaii

- Significant noise from magnetic soil
- Terrain and topography

Former Waikoloa Maneuver Area, Hawaii

Data Collection 1:

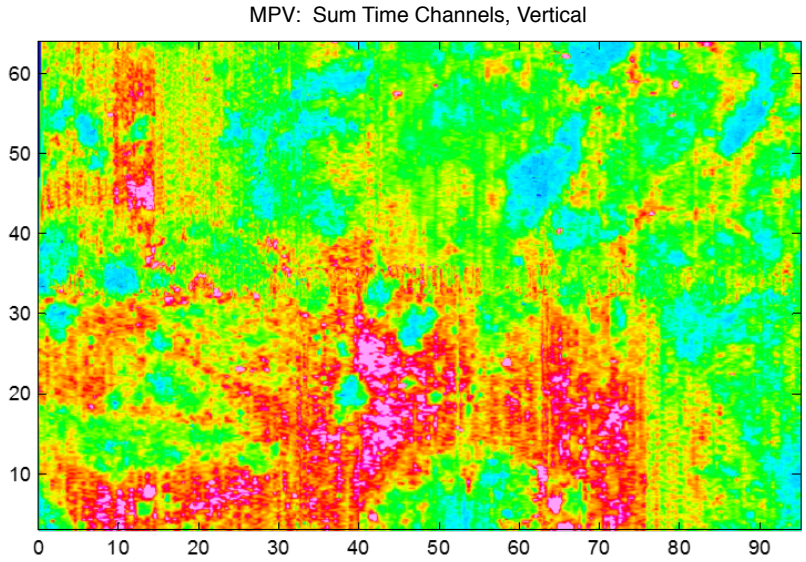
- *DGM*: Geonics EM61 Mark 2
- *Cued interrogation*: MetalMapper
- Three sites surveyed (TO17, TO20A, TO20B)



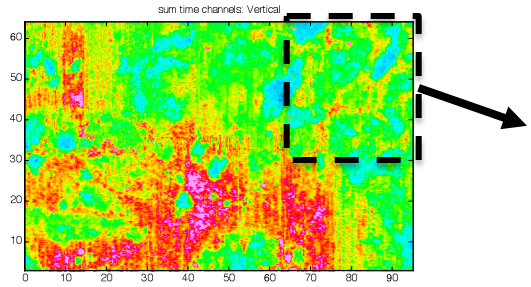
Former Waikoloa Maneuver Area, Hawaii

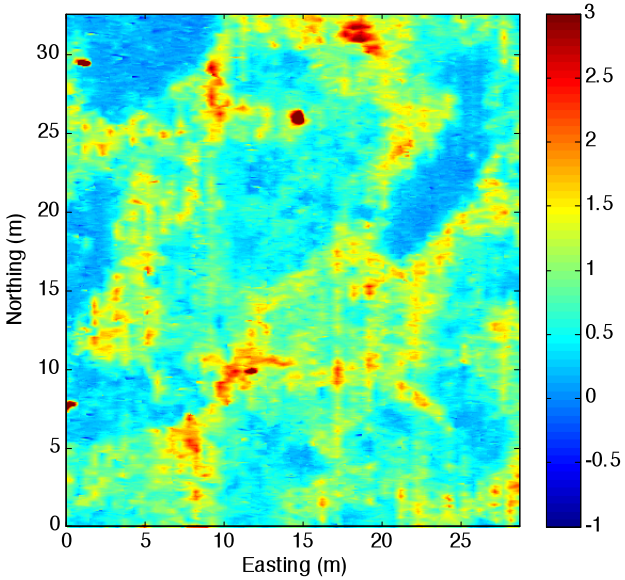
Data Collection 2:

- Man Portable Vector (MPV) instrument used for DGM and cued interrogation
- Only TO20A investigated
- MPV handheld form factor allows for more areas to be mapped

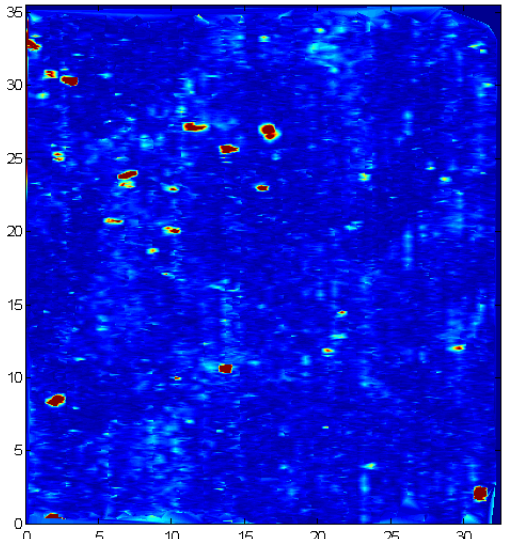


- Advanced EMI instruments are multi-static. For each transmitter pulse, the secondary field is measured at by receivers at multiple locations.
- The shape and symmetry of the soil response can be exploited

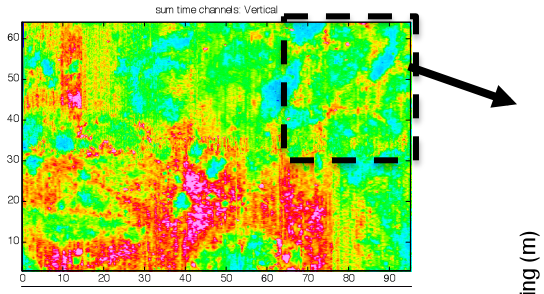


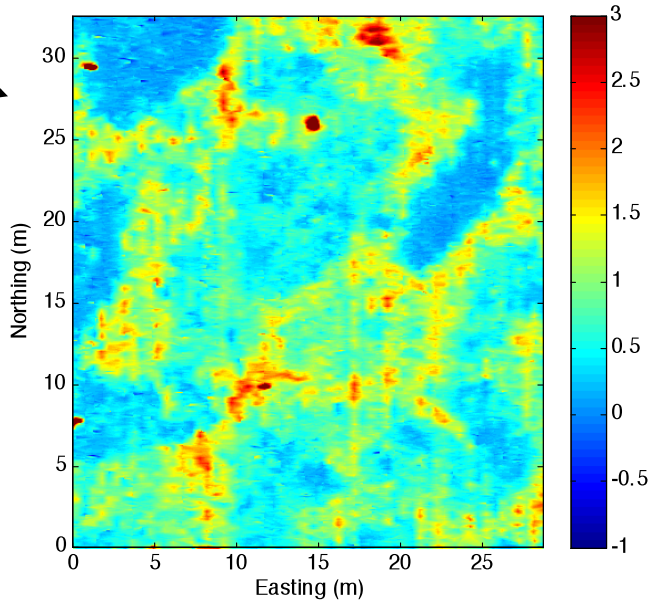


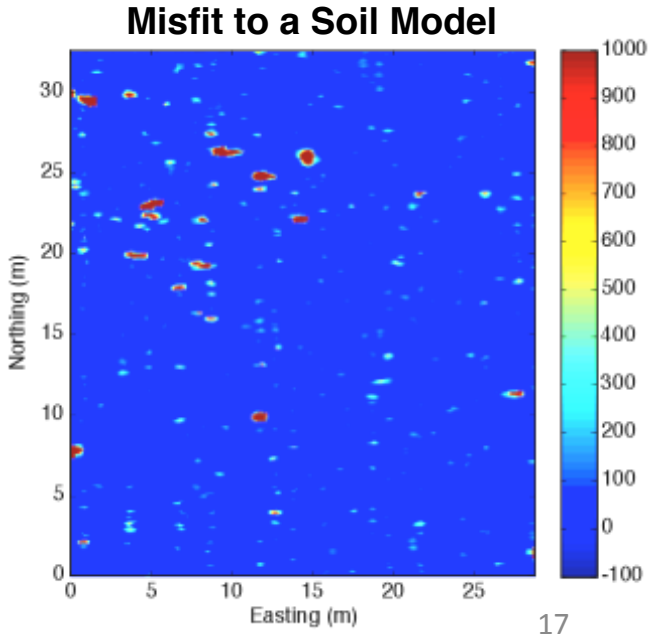
Soil Insensitive Components



- Advanced EMI instruments are multi-static, and have multiple time channels.
- The misfit to a soil model can identify soundings likely due to metal







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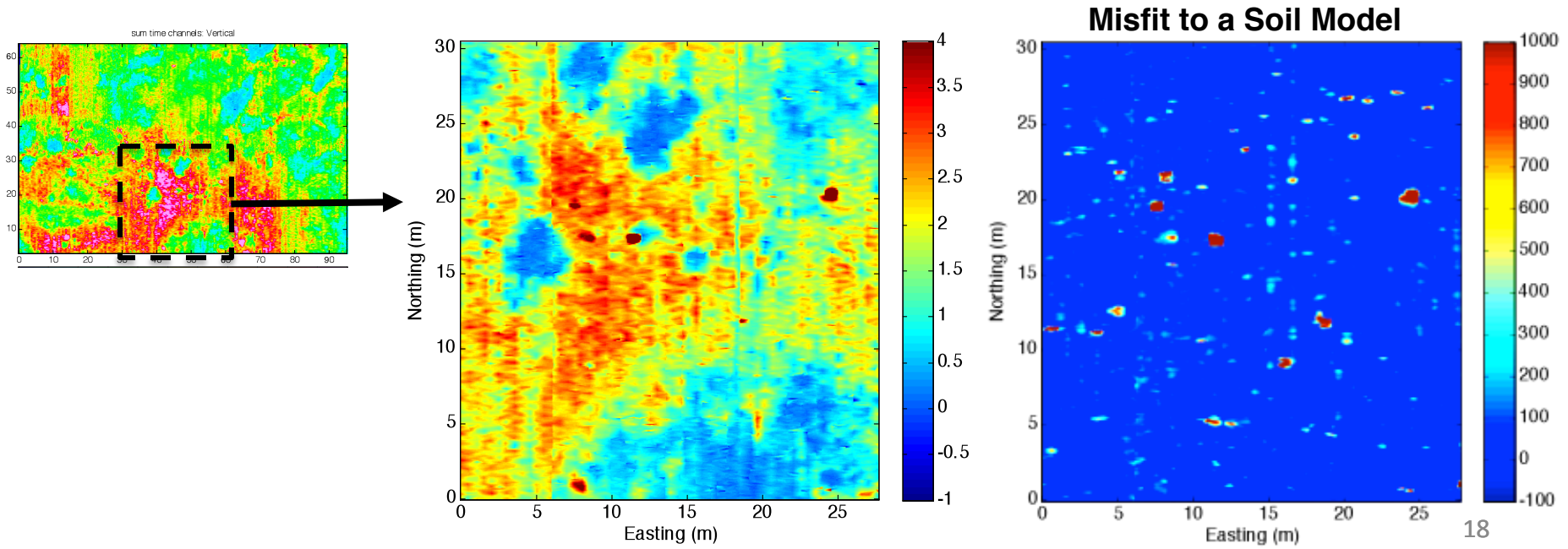
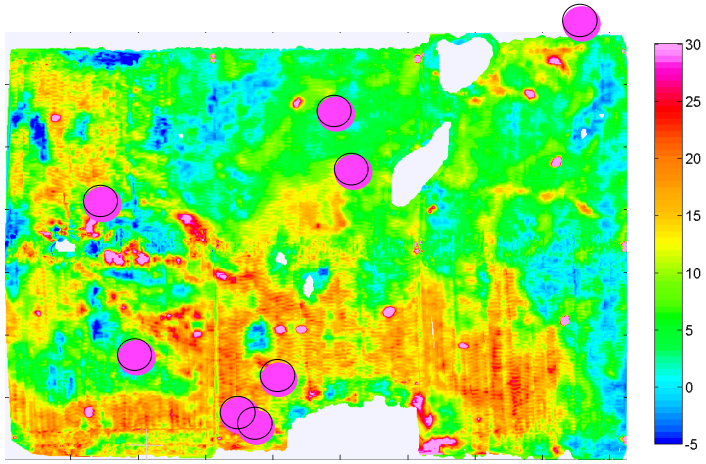


Processing Cued Measurements: MetalMapper

Standard procedure is to take background measurements to subtract from data

- *Not reliable at sites with high levels of magnetic soil response*

1. Spatial variability of the viscous remnant magnetization.
2. Variations in sensor/soil geometry (i.e. ground clearance and sensor orientation).

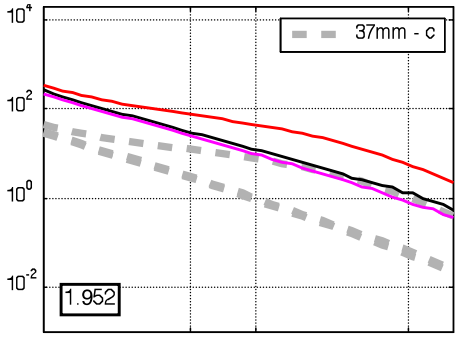


Background Measurements

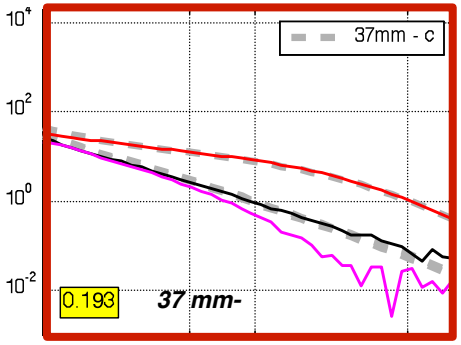
Processing Cued Measurements: MetalMapper

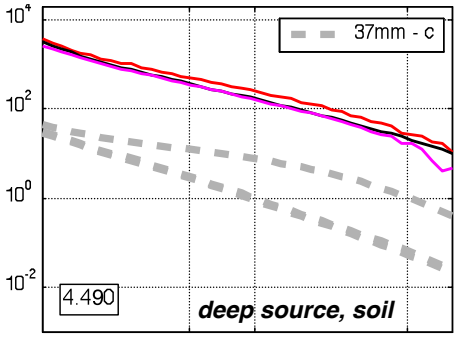
- Without accurate background measurements, the background response needs to be modeled.
- A deep source centered beneath the MetalMapper can accurately model the soil response.
- Simultaneously solve for target parameters and soil source strength

Example: Target 1074



Single Source





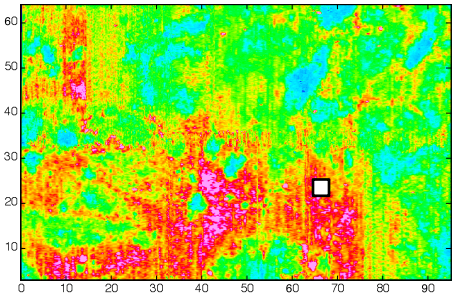
Two Source

Processing Cued Measurements: MPV

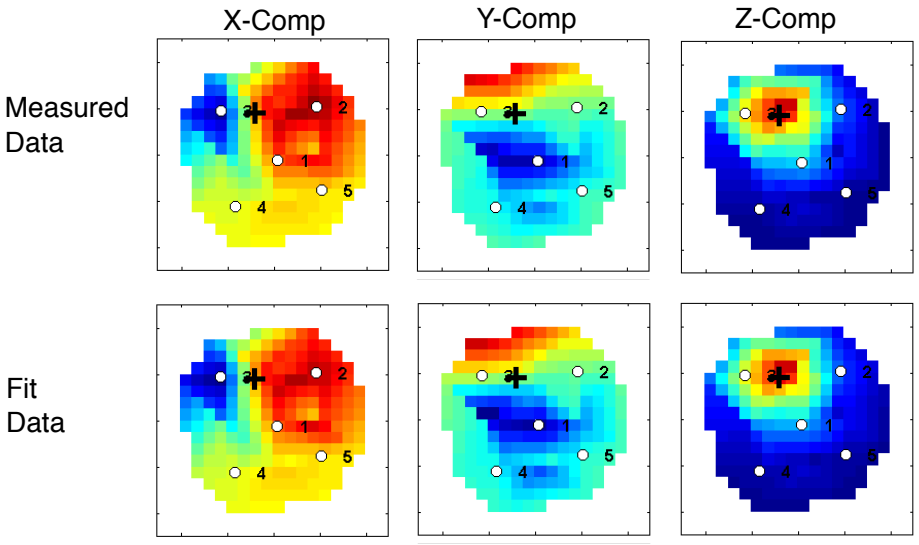
- 459 cued 5 point measurements made over approximately 3.5 days, averaging a production rate of 20 targets per hour
- Styrofoam used the elevate the sensor 10cm above the ground surface in order to reduce the soil response.
- Numerous background measurements acquired.

Processing Cued Measurements: MPV

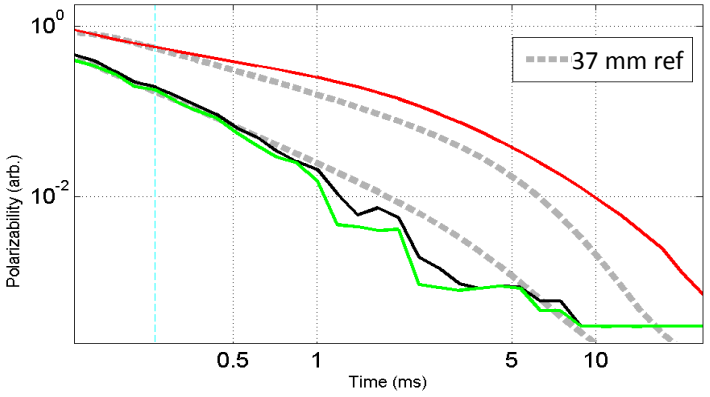
- Example: MPV Target 1
- Background measurements scaled



Data Fit



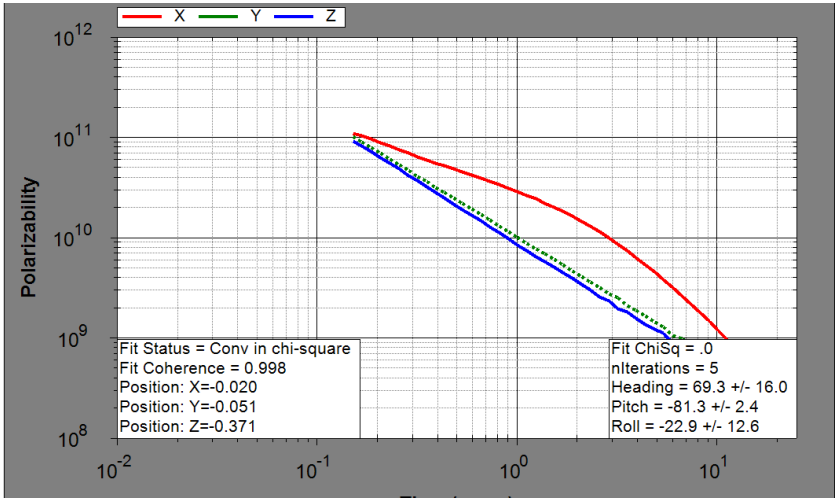
Recovered Polarizabilities



Processing Cued Measurements: MPV3D

- 3D Measurements involve a single sounding
- Collected data over 124 targets
- Production rate of 40 targets per hour
- In-field inversion guides sensor to source location for target picks not centered over anomaly

In-field inversion result for target 1



Conclusions

- Advanced EMI sensors allows for the application of advanced analysis and classification at increasingly more difficult sites
- Classification was successfully applied at a site with a high density of targets
- At sites with high levels of magnetic soil response, multi-static and multi-time channel EMI data can be used to reduce selection of anomalies due to soil, and to improve the accuracy with which target parameters are estimated

Acknowledgements

- SERDP and ESTCP
- Greg Van and John Baptiste (Parsons)
- Elise Goggin and Amy Walker (USACE)