

COMPLEX SEED SCENARIOS – DOES AGC WORK AS ASSUMED IN MULTISOURCE SETTINGS?

Case Study from Former Fort Huachuca

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M2S2

The Best of the SAGEEP/MRM: Lessons Learned, Case Studies, and Emerging Technologies in support of MMRP

Wednesday, June 28, 2023



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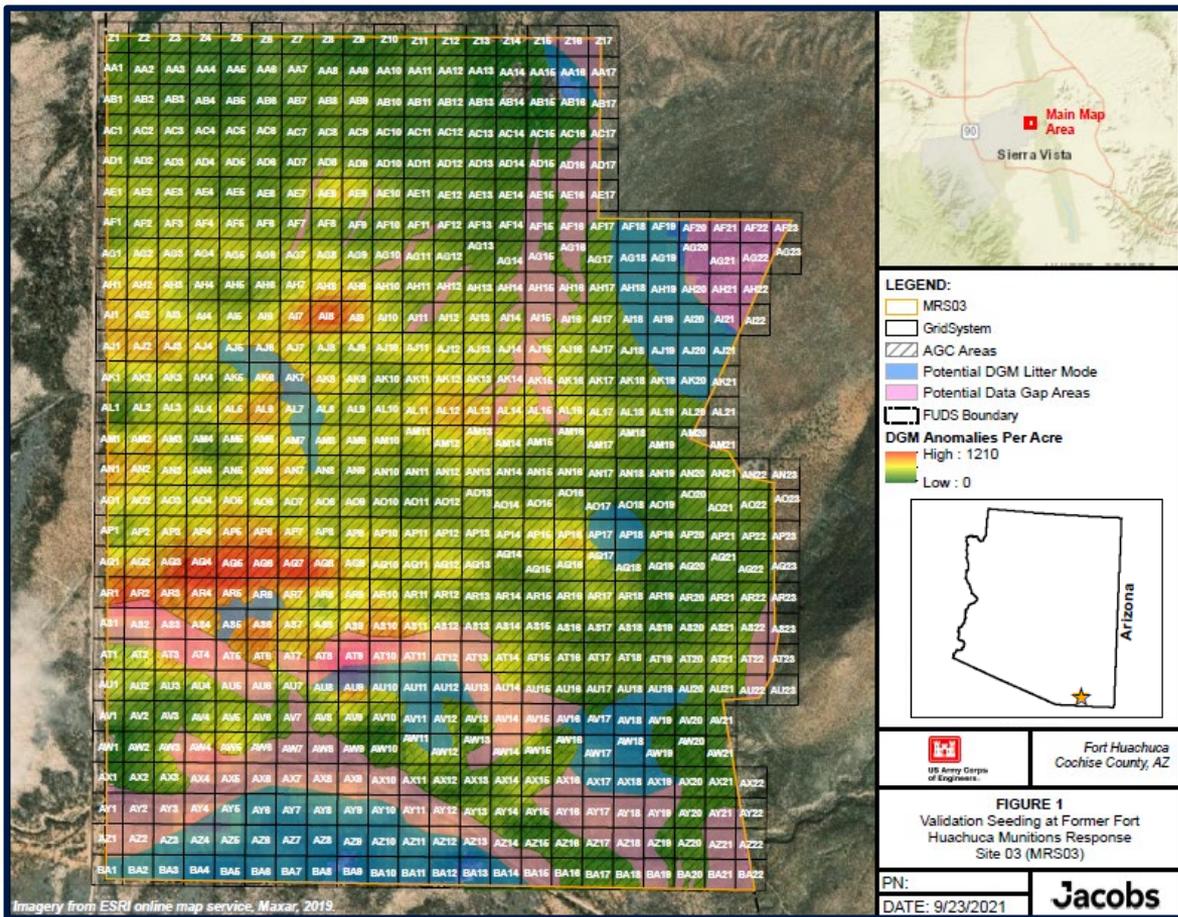
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Agenda

1. Overview of Fort Huachuca project
2. Summary of complex seeds
3. Complex seed classification challenges MM 2x2
4. Investigation and analysis
5. Results with other sensors
6. Conclusions, implications, USACE perspectives and final thoughts



Overview of Former Fort Huachuca Project



- RA over 548-acre MRS
- Jacobs contracted to perform third-party validation seeding, included:
 1. Emplacing over 1,000 seeds
 - Small ISO80s
 - Horizontal orientation
 - Two depths: 0.15 m (6 in) or 0.08 m (3 in) bgs
 2. Cued survey with MM 2x2 to ensure seeds detectable and classifiable
 - Measurements had to achieve standard cued metrics
 - Achieve decision statistic of ≥ 0.9000


 Fort Huachuca
 Cochise County, AZ

FIGURE 1
 Validation Seeding at Former Fort
 Huachuca Munitions Response
 Site 03 (MRS03)

PN:
 DATE: 9/23/2021





Imagery from ESRI online map service, Maxar, 2019.

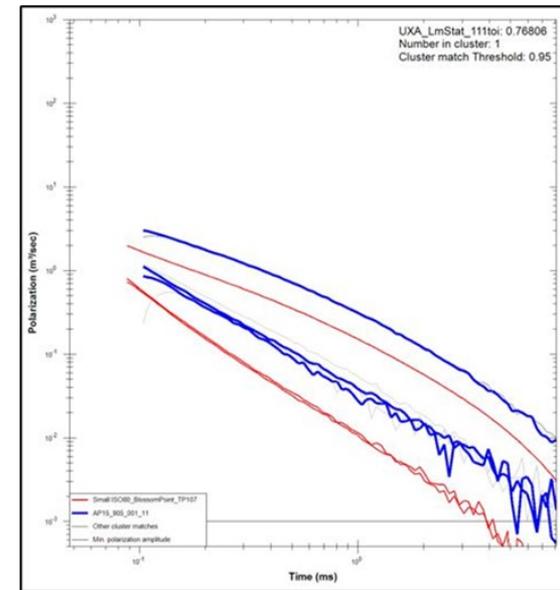
Complex Seed Summary

- 100 seeds (50 pairs) emplaced in a “complex” scenario
 - Complex = two ISOs placed as a pair near each other
- Goal - provide USACE data to monitor RA contractor’s performance in multi-source scenarios
- Constraints from Seed Plan and QAPP:
 - Seeds not placed one on top of other
 - Distances allowed: touching - 0.5 m (~20 in) apart
 - Cued measurement over each seed in the pair
- Ground truth details:
 - Actual seed distances: 0.10 m (3.9 in) - 0.41 m (16.1 in)
 - Orientation
 - 1 pair perpendicular
 - 22 pairs parallel side-by-side
 - 27 pairs parallel in-line
 - All complex seeds initially buried at 0.15 m (6 in) bgs



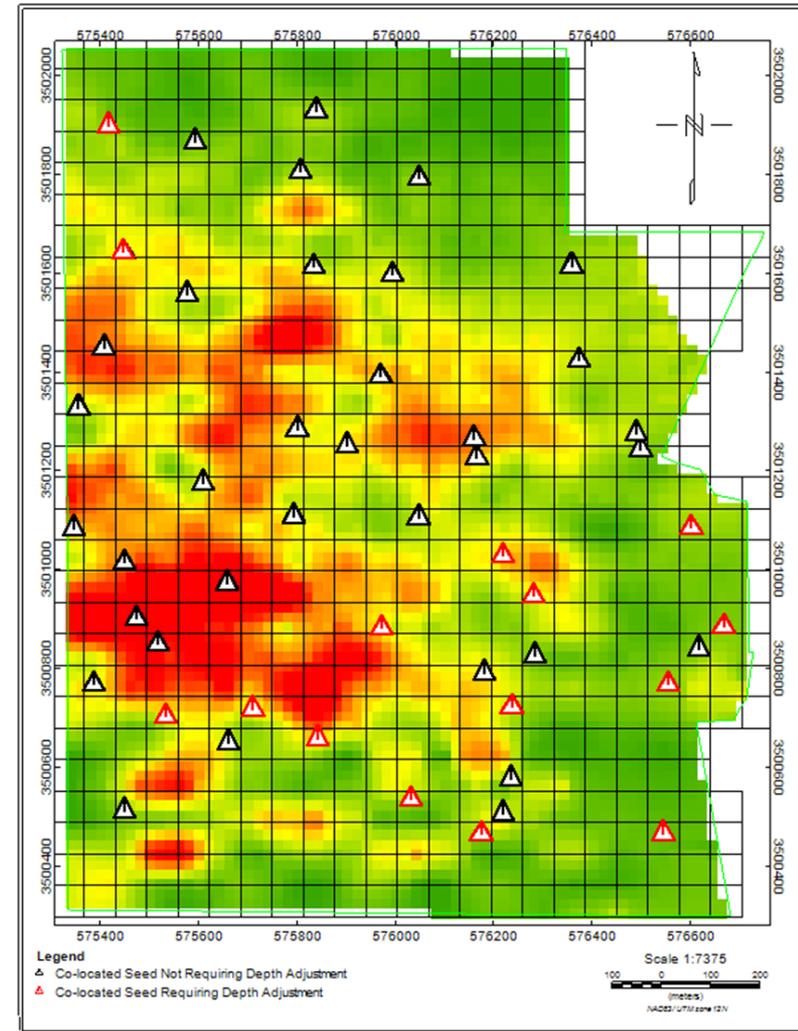
Complex Seed Classification Challenges

- 33% of complex seeds failed 0.9000 decision stat (significantly higher than single source seed failure rate)
- Following a second round of cued measurements, fail rate dropped to 19%, which was still considered high
- Failing decision statistics had an average 0.7839 and similar classification results
- Distance ranged between complex seed pairs that failed:
 - Minimum - 10.7 cm (4.2 in)
 - Maximum - 39.6 cm (15.6 in)
 - Average - 26.1 cm (10.3 in)
- Ultimately, all 19 failures required a depth adjustment from 0.15 m (6 in) bgs to 0.08 m (3 in) bgs to pass (QAPP specified CA)



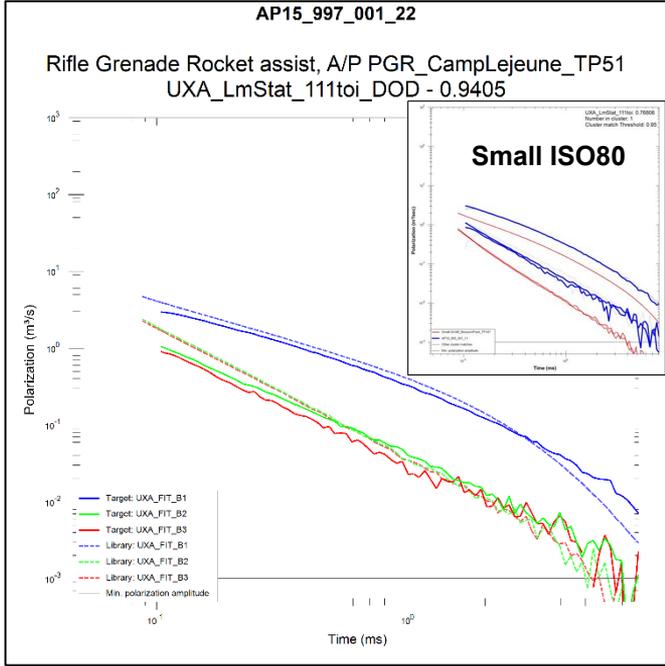
Investigation Findings

- Attempt to determine the root cause of the complex seed failures
- Map shows location of all complex seed pairs; red triangles required depth adjustment to pass
- Complex seed failures occur mostly in low - mid anomaly densities and are geographically distributed across site
- Seed pair orientation of failures:
 - 17 parallel and in-line
 - 1 parallel side-by-side
 - 1 perpendicular
- SBGs reviewed, all passed quantitative and qualitative analysis, no indication of drift issues



Investigation: What do the failed seeds match to?

- Ran failed complex seeds against entire DoD TOI library
- Failed seeds matched well to rifle grenade rocket
- Comparison made of size/decay for small ISO vs. rifle grenade vs. seed results
 - Equivalent wall thicknesses for all three
 - Rifle grenade ~63% larger than small ISO
 - Seed results ~53% larger than small ISO



TOI	Size	Decay
Small ISO	0.24	0.03
Rifle grenade	0.65	0.03
Seed results	0.51	0.04

In-Depth Analysis of Single Complex Seed Pair

Seeds AP15_905 and AP15_997

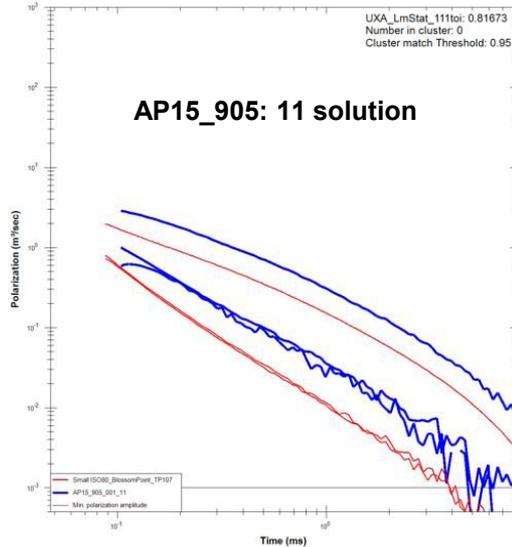
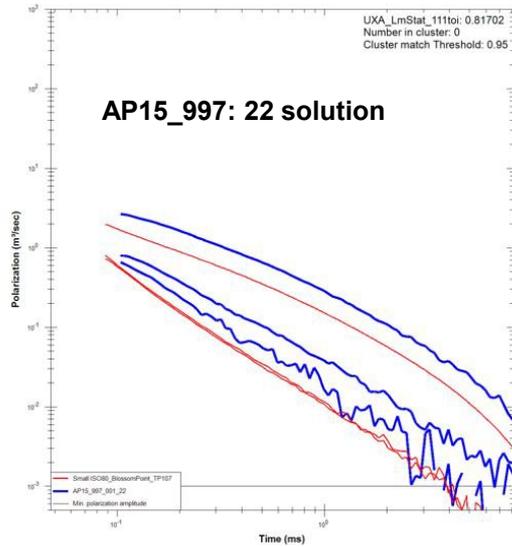


AP15_905/AP15_997 Seed Pair Collection Summary

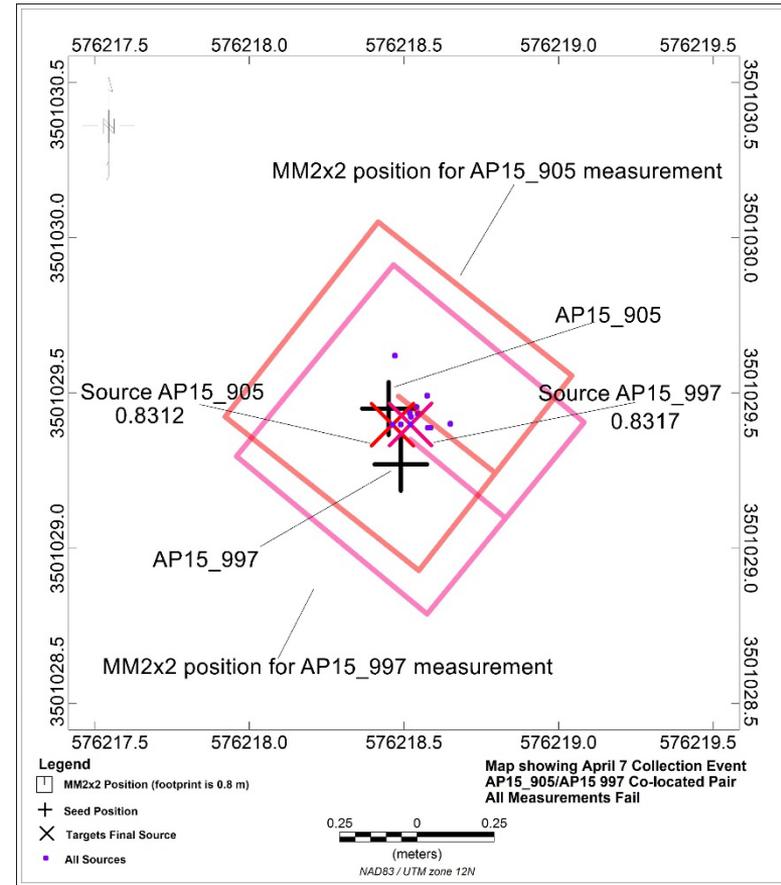
- 11 cued measurements taken over pair
 - 7 over AP15_905
 - 4 over AP15_997
- Data collected over ~40 days
- Three different background locations
 - SAM/SBG Distance: 303 m - 118 m
 - SAM/SBG Time: 20 mins - 7.5 mins
- Seeds in-line, 19 cm (7.5 in) apart

UXA Target ID	Collection Date	Collection Time	Background	SBG/SAM Dist (m)	SBG/SAM Time Offset	Seed to Array Dist (m)	Decision Stat	Pass/Fail	Seed Depth (in)
Seed AP15_905									
AP15_905_001_11	3/31/2022	18:40:48	AN15_2034	118.40	12:16	0.07	0.7783	Fail	6
AP15_905_001_11	4/7/2022	15:37:11	AN15_2065	118.49	08:48	0.05	0.8312	Fail	6
AP15_905_001_11	4/18/2022	17:44:23	AN15_2065	118.53	11:59	0.04	0.8376	Fail	6
AP15_905_002_32	4/22/2022	15:10:03	AR13_2043	195.76	19:57	0.14	0.8269	Fail	6
AP15_905_001_21	5/3/2022	18:01:21	AP20_2039	303.21	07:39	0.04	0.9057	Pass	3
AP15_905_001_21	5/10/2022	14:48:20	AR13_2043	195.74	07:58	0.01	0.9655	Pass	3
AP15_905_002_22	5/10/2022	14:48:54	AR13_2043	195.74	08:31	0.02	0.9859	Pass	3
Seed AP15_997									
AP15_997_001_33	3/31/2022	18:42:01	AN15_2034	118.57	13:29	0.04	0.8025	Fail	6
AP15_997_001_22	4/7/2022	15:38:22	AN15_2065	118.63	09:59	0.09	0.8317	Fail	6
AP15_997_002_22	4/18/2022	17:46:34	AN15_2065	118.61	10:41	0.02	0.8318	Fail	6
AP15_997_001_21	4/22/2022	15:29:31	AR13_2043	195.65	15:33	0.02	0.9224	Pass	3

AP15_905/AP15_997, April 7 Classification Results



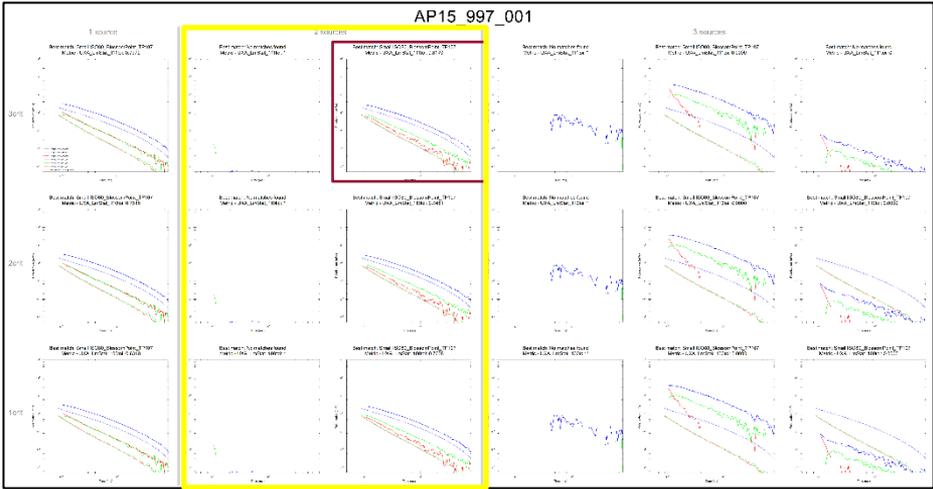
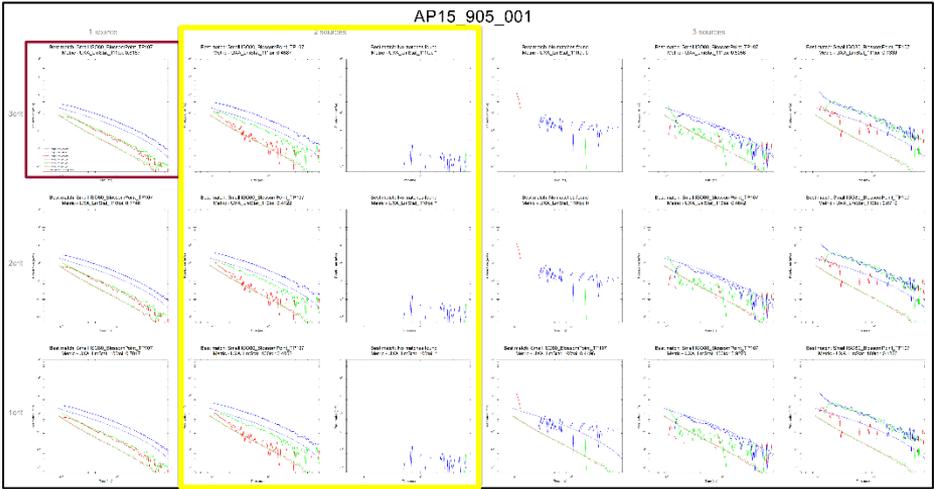
- SAMs taken less than 2 minutes apart
- Background: ~9 minutes and ~118 m between SAM/SBG
- Array to source offset and decision stat:
 - AP15_905: 5 cm (2.0 in); **0.8312**
 - AP15_997: 9 cm (13.5 in); **0.8317**



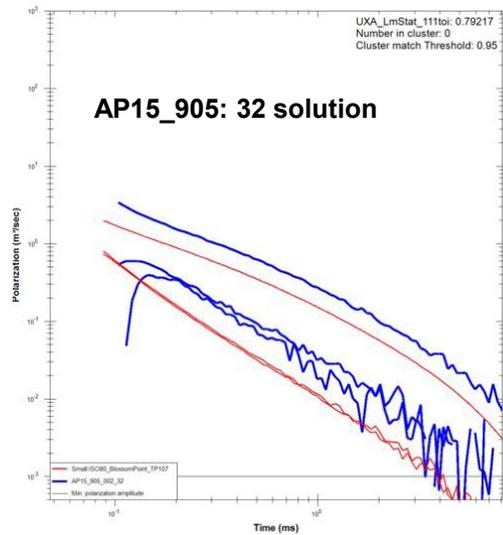
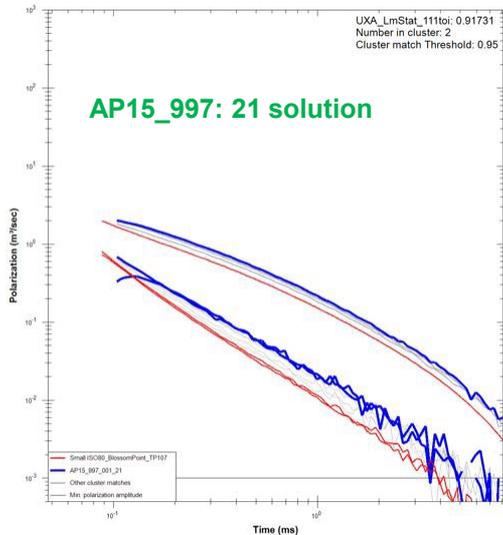
AP15_905/AP15_997, March 7 Multisource Polarizability Plots

**Seed AP15_905
Fails**

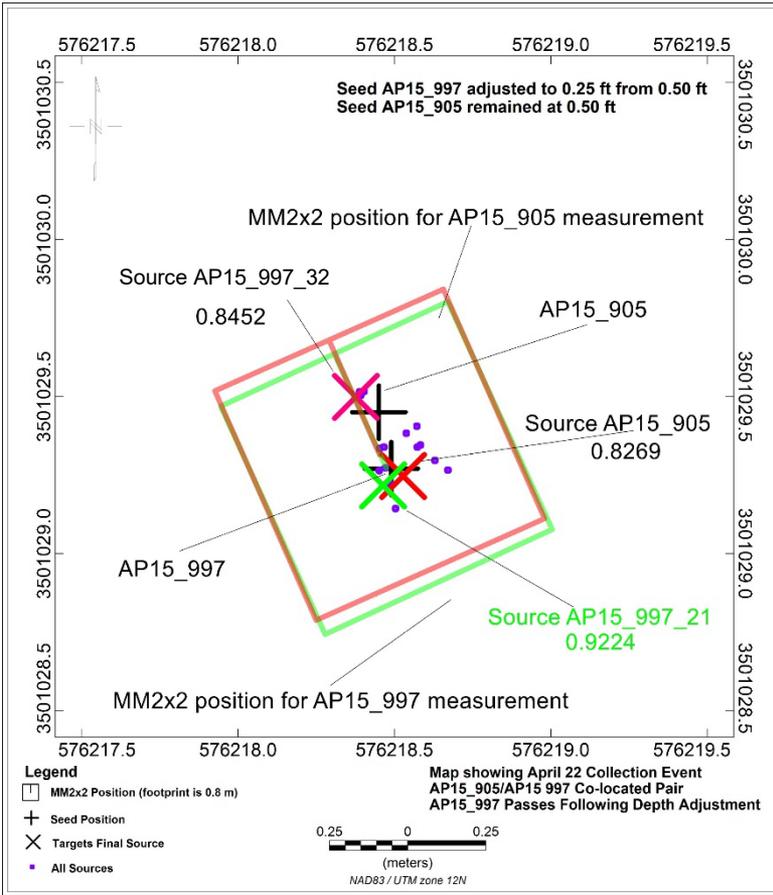
**Seed AP15_997
Fails**



AP15_905/AP15_997, April 22 Classification Results



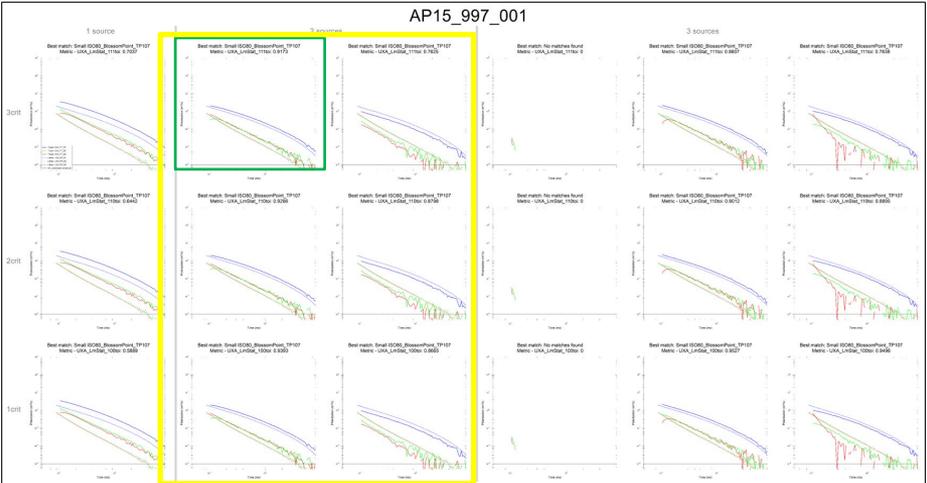
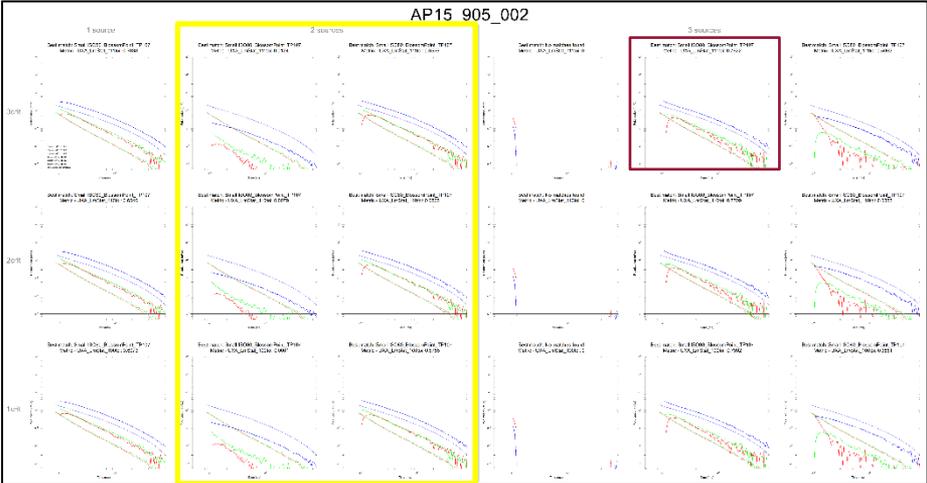
- SAMs taken ~6 minutes apart
- AP15_997 depth adjusted to 0.08 m (3 in) bgs, AP15_905 remained at 0.15 m (6 in) bgs
- Background: ~17 minutes and ~195 m between SAM/SBG
- Array to source offset and decision stat:
 - AP15_905: 14 cm (5.5 in); **0.8269**
 - AP15_997: 2 cm (0.8 in); **0.9224**



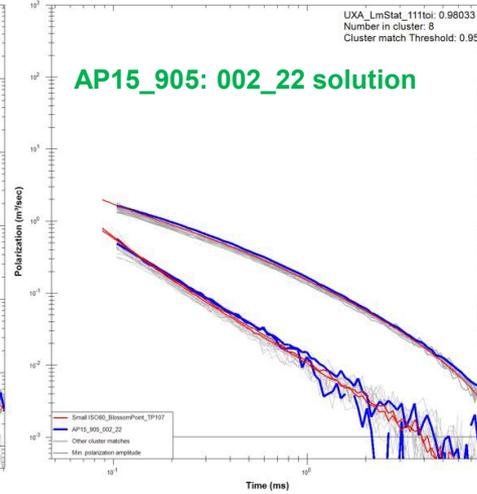
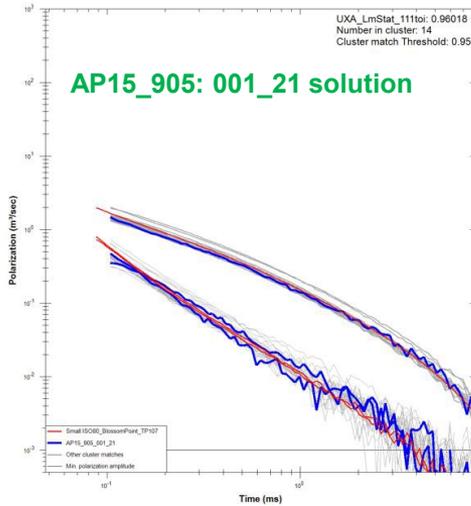
AP15_905/AP15_997, April 22 Multisource Polarizability Plots

Seed AP15_905 Fails

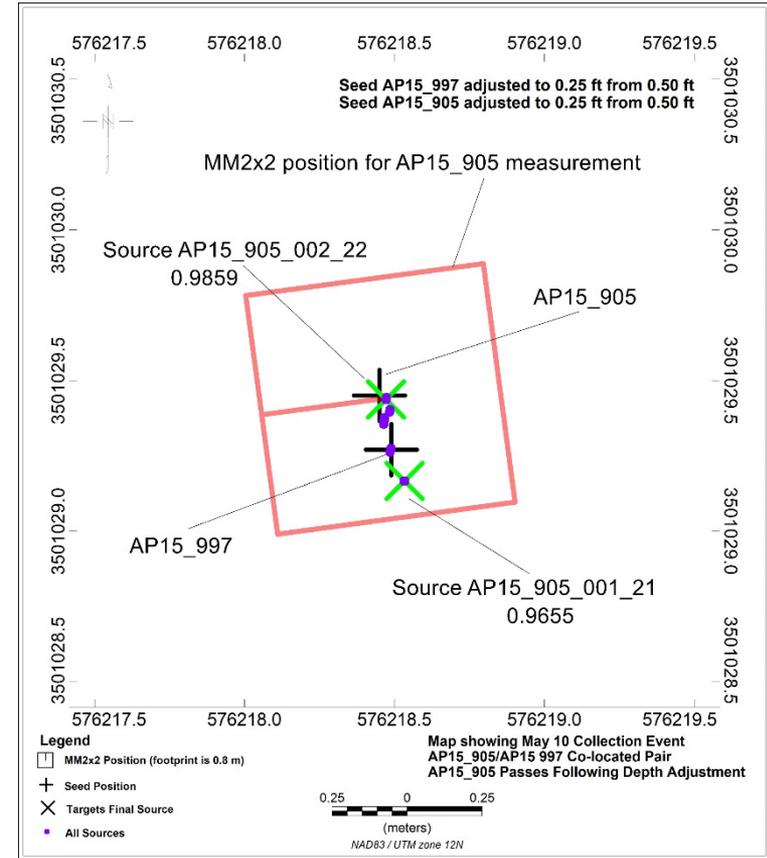
Seed AP15_997 Passes



AP15_905, May 10 Classification Results

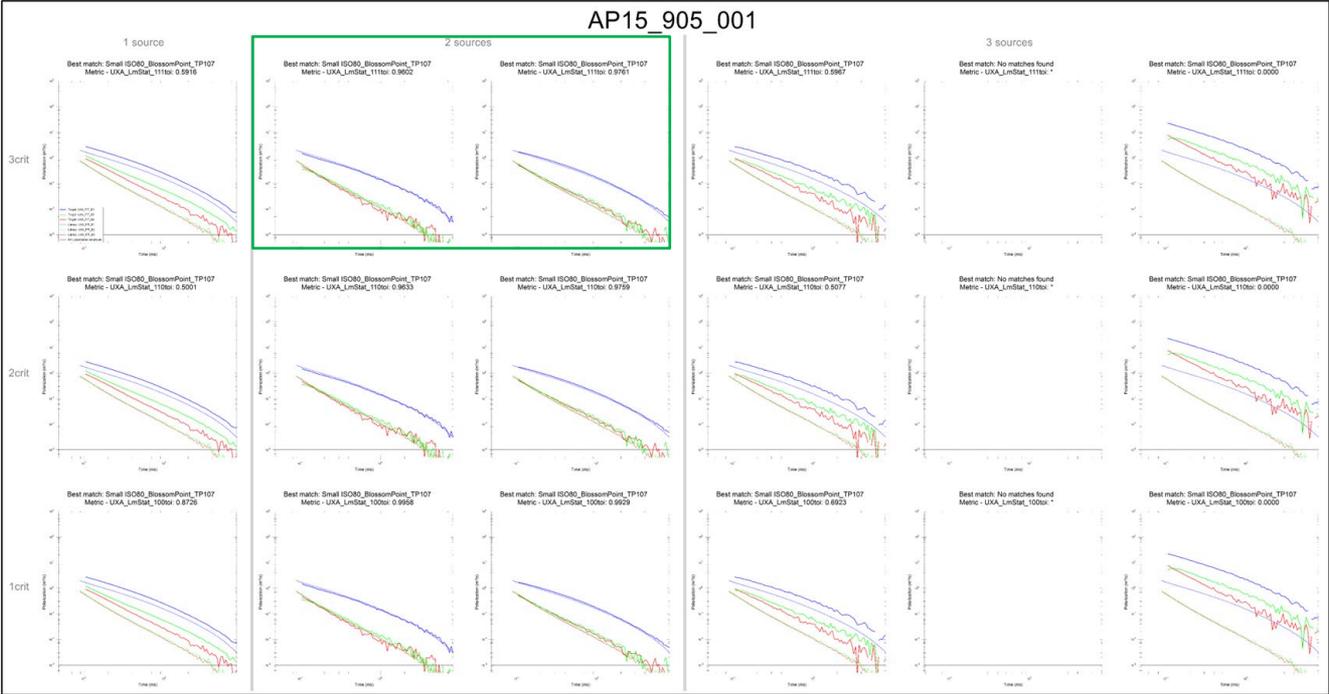


- Data collected over AP15_905 only (AP15_997 passed April 22)
- AP15_997 and AP15_905 adjusted to 0.08 m (3 in) bgs
- Background: ~8 minutes and ~195 m between SAM/SBG
- Array to source offset and decision stat:
 - AP15_905: 1 cm (0.4 in)
 - **Both seeds classified with decision stats above 0.9500**



AP15_905, May 5 Multisource Polarizability Plots

Seed AP15_905 Passes



Validation Seeding Complex Seed Analysis Conclusions

- Good news! All passed at depth of 0.08 m (3 in) bgs. Complex sources the size of small ISO **can be reliably** classified at 0.08 m (3 in) bgs or shallower!
- Bad news! Complex sources the size of small ISOs (37-mm) **cannot be reliably** classified at 0.15 m (6 in) bgs and deeper!
 - Failure rate of ~20%
 - ~90% of failures occur when items are oriented parallel and in-line with each other
 - Two items resolve into a single, larger source



RA Complex Seed Results - APEX

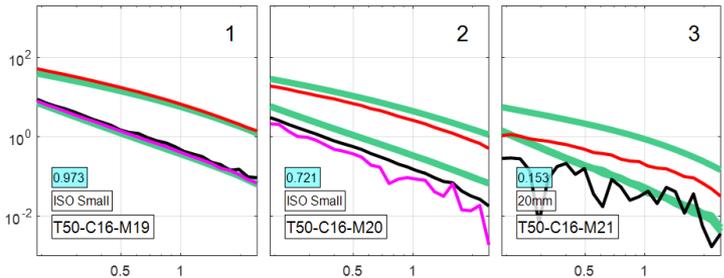


- 44 pairs surveyed using APEX one-pass classification
- **12 pairs (27%) pass:** Two Category 1 sources meet MQOs
 - 7 pairs - both seeds at 15 cm (6 in)
 - 5 pairs - either one or both seeds at 8 cm (3 in)
- **28 pairs (64%) pass/complicated:** Single Category 1 source meets MQOs for both seeds
 - Most have second source that would pass, but was identified as a “duplicate” by the data analyst
- **4 pairs (9%) fail:** single Category 1 source meets MQOs, other seed fails horizontal offset MQO (25 cm)
 - 2 pairs - both seeds at 15 cm (6 in)
 - 1 pair - both seeds at 8 cm (3 in)
 - 1 pair - a seed at 15 cm (6 in) and 8 cm (3 in)
- 98% of complex seeds predicted as larger, deeper item (60-mm mortar or 2.36-inch Bazooka Warhead)

UltraTEM Testing and Planned Data Review

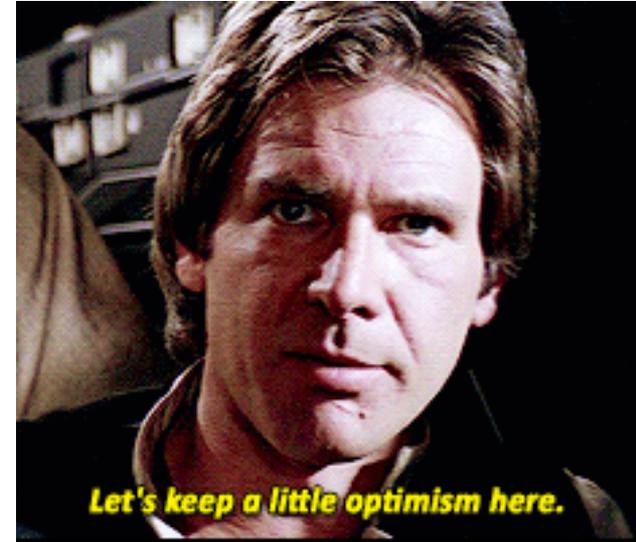


- Testing done with UltraTEM Portable Classifier by BTG
 - Depth 20 cm (8 in), seed separation of 16 cm (6 in)
 - Seeds placed parallel, perpendicular, and in-line
 - 11 of the 12 complex seed scenarios surveyed produced excellent polarizabilities, one did not
 - Additional testing using synthetic seeding
 - Conclusion: system does an accurate job estimating polarizabilities most, but not all the time
- MM2x2 data seed data sent to BTG for additional analysis



USACE Perspectives and Final Thoughts

- Collectively results challenge industry assumptions
 - Individual items cannot always be reliably classified in multi-source scenarios, even at shallow depths
 - Intrusive MQO “100% of recovered item positions ≤ 25 cm from predicted position” -- failures up to 39 cm and average 26.1 cm
- More research is being done to
 1. Understand implications of these findings
 2. Fully understand the failure in terms of depths, orientation of sources, and size of TOI
- Optimistic a successful solution will be achieved!
- USACE will not be emplacing complex validation seeds
- Function is QC, not QA, in accordance with upcoming 200-1-15 guidance revision



Thank you



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