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A Cost-Efficient Method for Detecting Unexploded 122mm 9M22U Rockets Using Remote Sensing

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INTRODUCTION

- The BM-21 Grad is a Soviet multiple rocket launcher with a high failure rate (over 4%) that may result in up to 1,640 explosive fragments in a 640m x 640m lethal area.¹



Figure 1: BM-21 Grad²

- Magnetometers are sensors that detect magnetic disturbances in the Earth's surface.³
- BM-21 Grad 122mm rockets (see figure 6) are composed of magnetic material such as aluminum, so they can be detected by mounting a magnetometer to a drone with a programmed flight path over an area.⁴



Figure 2: Cicada drone flying the UMT MFAM MagPike over a test-site in Ukraine

METHODS

- The UMT MFAM MagPike was mounted on a Cicada drone (see figure 2)
- Flew the MFAM over multiple sites that had simulated UXOs and live 9M22U rockets
- Parsed and de-striped Raw magnetics data to remove directional interference
- Removed the takeoff, landing, and line leveling errors from the data using Arc Map.
- Removed the total magnetic field from each data set
- Created Power Spectral Density (PSD) plots to analyze site-wide background noise
- Visualized each data set using Kriging interpolation, and a low-pass convolution filter was used to remove signal noise for data analysis

Tiny drone-based magnetic sensors can cost-effectively detect unexploded rockets

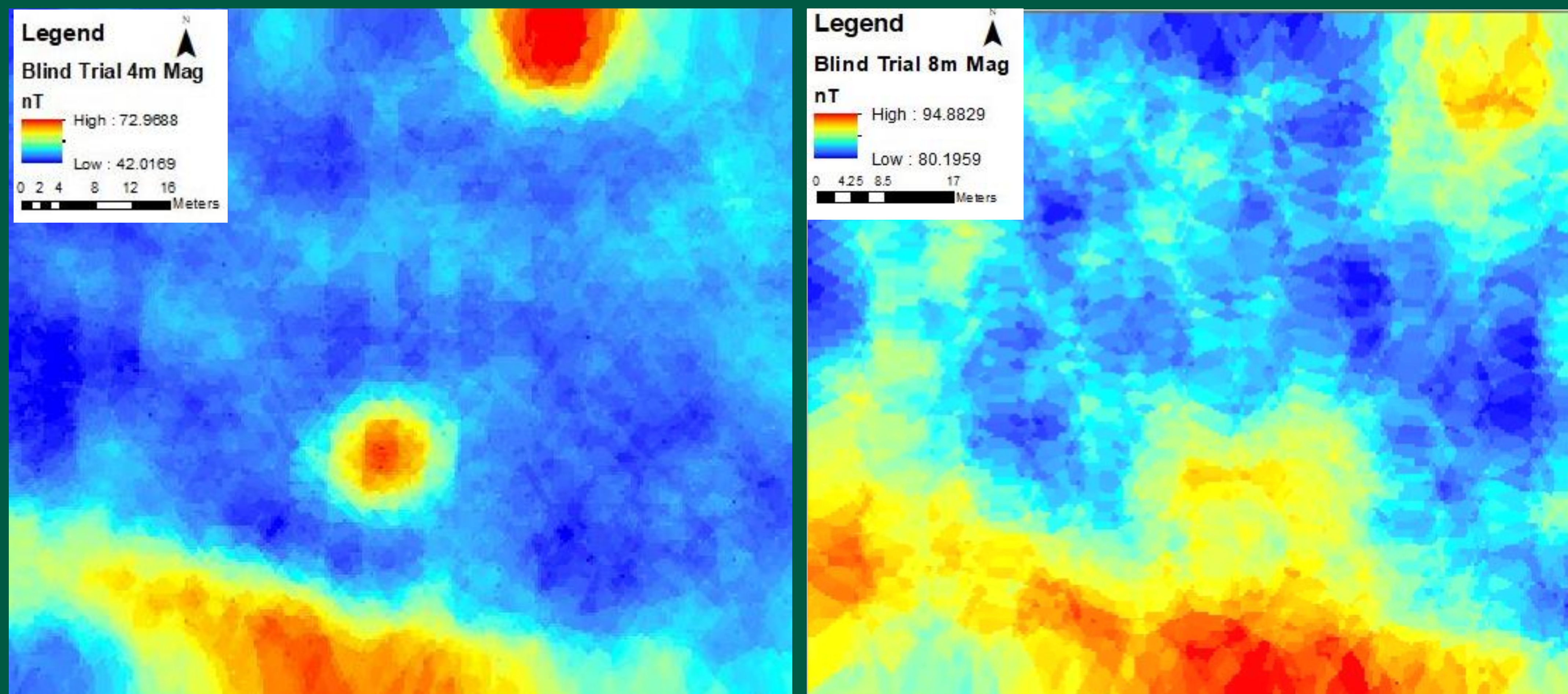


Figure 3: Aerial images of unexploded 122mm 9M22U rockets collected from Ukraine. In the left image, the magnetometer is collecting data from 4 meters above ground level, while the right image depicts data collected at 8 meters above ground level. The two buried rockets are identifiable by the circular red spots, with the elongated red spot on the bottom of the image being a road.

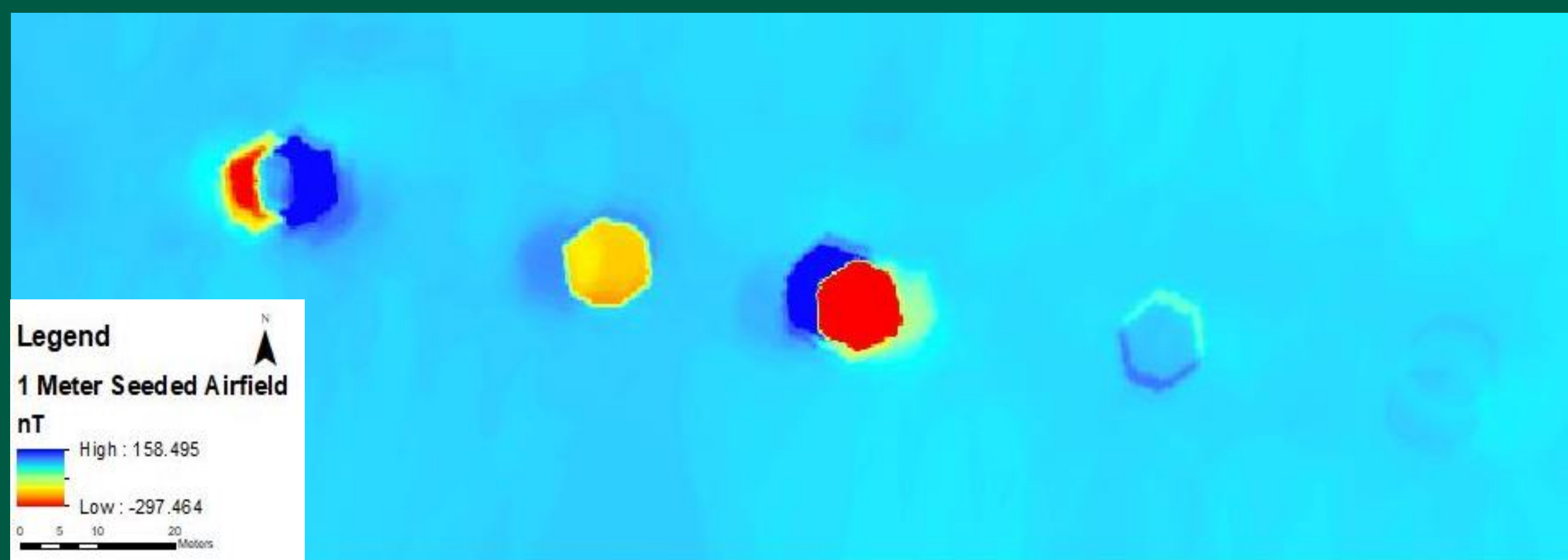


Figure 4: 1-meter magnetometer data collected over an airfield in Chernihiv, Ukraine. The trial was completed at ground level with a handheld magnetometer. Being closest to the surface resulted in the clearest imaging, indicating that there are six anomalies in the survey area.

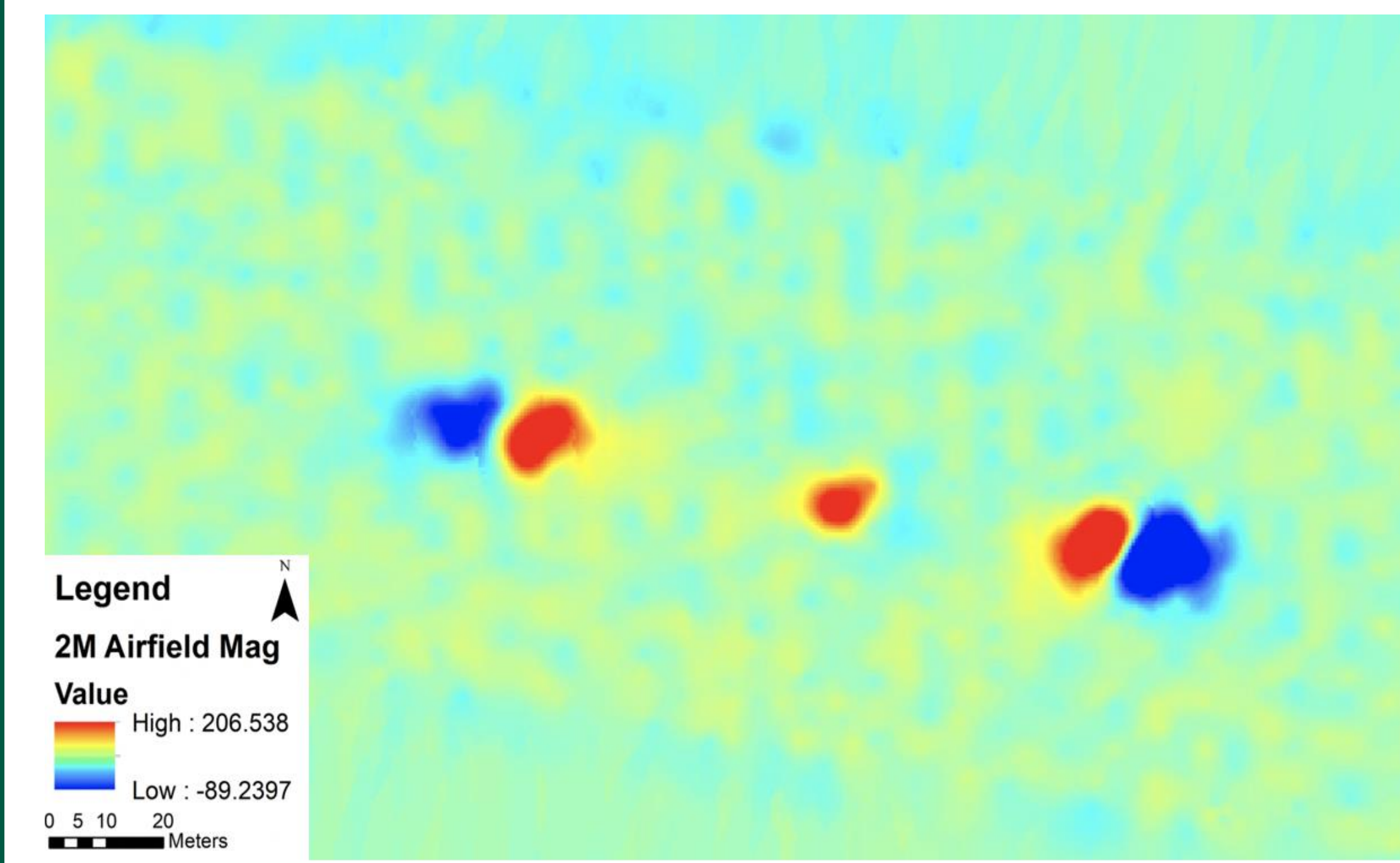


Figure 5: Aerial magnetometer data taken over an airfield in Chernihiv, Ukraine. The magnetometer was oriented 2-meters above the ground. The airfield contained three large unexploded rockets, which are identifiable compared to the background magnetic signature of the site.

RESULTS/CONCLUSIONS

- Magnetometry is an effective method for visualizing large unexploded ordnances.
- The methodology is less effective for detecting small munitions.
- Magnetometry reduces false positive rates by being highly accurate.
- The effectiveness of MFAM tapers off as the distance of the drone increases from the target (see figure 3).



Figure 6: BM-21 Grad 122-millimeter rocket

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