Geoscientific Instrumentation Methods and Data Systems Discussions

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Reply on RC1

M. Andy Kass et al.

Author comment on "A towed magnetic gradiometer array for rapid, detailed imaging of utility, geological, and archaeological targets" by M. Andy Kass et al., Geosci. Instrum. Method. Data Syst. Discuss., https://doi.org/10.5194/gi-2021-19-AC1, 2021

We thank the anonymous reviewer for the comments which will improve the clarity of the paper and address some of the issues. A comment-by-comment response is below. Generally, all comments were agreed with and changes have been made to the revised paper.

Line 43; You state that the system differs from other systems in two ways; towing design and fluxgate magnetometers.

I did find other systems using fluxgate; for example, Bartington instruments offer a solution (https://www.bartington.com/archaeology-forensics/), which also use the same magnetometers as you do.

Concerning the towing design, do you find your design superior to other system designs like the Bartington "Non-Magnetic Cart"?

This sentence has been slightly rewritten. It differs from *most* other systems in this way. Indeed there are a few systems (Bartington, Ferex) that utilize fluxgate and towing. However, these were not designed to be towed, but rather to be pushed by hand. The vehicle attachment is more ad hoc, and too close to the vehicle. It is the separation of the electronics from the sensors as well as the distance of the towing vehicle that results in superior performance with respect to towing. I would not make the blanket statement that this system is 'better,' but has some advantages in this sense over the others.

Line 46: Low noise compared to what?

Good point; that sentence isn't particularly meaningful. It has been removed. The sensor noise is low compared to electronic and motion noise.

Line 71: Cesium is only one kind of vapour used for optically pumped magnetimeters. You could use "alkali vapor" instead to include all types of optically pumped magnetometers using vapour.

Agreed. The change has been made.

Line 90: What is the argument for using the 1m fluxgate separation? I would expect archaeological structures to be relatively shallow targets.

The reason is two-fold: the availability and cost of 1m gradiometers and the desire to not create our own separation due to the required precision of mounting two separate vector sensors, and second is that the system was initially designed to look for drain pipes with a particular signal strength, for which 1m was completely adequate. There could potentially be some benefit to reducing the separation for weaker, shallower targets, but this study has not been done. I added a comment to this effect in the discussion.

Figure 1(a): both the IMU and the two antennas are relatively close to the magnetometers; this may cause some magnetic distribution. Furthermore, wires are passing close to the sensors. Since you don't mention it, I assume it's not an issue but have you tested/measured it?

This is an issue brought up by all reviewers. The sensor positions were tested quite extensively, and are placed in as close to a null position as possible. We made the decision to not put the sensors on poles due to engineering requirements, so their position is a tradeoff between noise suppression and construction limitations. The AC noise is aliased out and is essentially a non-issue. The DC noise due to DC currents and induced magnetic fields in the background are relatively small: less than 2 nT at our magnetic latitudes. This manifests as a DC signal in the sensors which is removed during the bias correction process. We note that even if the GPS units were mounted on poles, the power cable would still need to run up to the sensor, potentially producing a magnetic signature as well. A paragraph has been added in section 2.2.1.

Figure5(a); It is hard to differentiate between the colours. It would be more informative if you came with an estimate of how low a degree you need.

-and-

Line 328: What accuracy and resolution of an IMU would be sufficient for your application?

The precision of the IMU depends entirely on the requirements of the specific survey and which component you are looking at. However, we can generally say to get the contribution to the vector components of the magnetic field to be approximately 1 nT, the angle needs to be known to approximately 0.01 degrees (with a variety of assumptions)—this is in the discussion. However, this value is for computing the vector components of each sample independently; the requirement is less strict if more advanced signal processing is done to estimate the vector projections during data reduction.

Line 244: 2000nT at 6 degree.

I am afraid I am not sure what this comment is highlighting or requesting.