Gi_2020-10 R2, Reaction to responses

“**PiCoG algorithm”:** Would you think that the following procedure is in line with what you did. Could this be a line out of an algorithm?

1. Define one of the N instruments as “reference instrument”.
2. Calculate the differences of all instruments and the reference instrument.
3. In all difference signals, identify the instrument j showing the strongest disturbance.
4. Use this difference to correct all instrument readings using Eg. 13
5. For the next iteration start over with 2. disregarding instrument j.

Remarks: The number of iterations is restricted to N-1 (N the number of instruments).

Instead of a statistical method, step 4. could also be done using the scalar product of the difference signal and the signal to be corrected (correlation).

The method reminds to the Gram-Schmidt process for orthogonalizing a set of vectors. These vectors being time series of magnetometer data. Their dimension is the number of samples.

The result of the algorithm is certainly not the same if different time periods of data are used. This depends on the intensity of disturbers switched on during the considered time span. Here PCA and factor analysis could be used to identify time series of disturbing signals.

PCA: You determine the main axes in the 3D distribution of magnetometer measurements and in the distribution of differences between two different magnetometers. Then you assume that your α can be calculated based on the quotient of variances along these main axes (Eq. 14). This is a very bold assumption and you named quite some requirement for this assumption. Asking for PCA, I meant to use PCA in the 3N dimensions of all available measured time series. If PCA is referred to in the title the reader will expect it to be used on the multivariate time series ($X_1(t)$, Y_1 (t), $Z_1(t)$, $\Delta X_{21}(t)$, ΔY_{21} (t), ΔZ_{21} (t), $\Delta X_{31}(t)$, ΔY_{31} (t), ΔZ_{31} (t),…). “1” being the reference magnetometer. This automatically produces what you call VPS-x directions (as components of the largest eigenvector). Mentioning PCA in this respect in the title, one would certainly also expect a factor analysis. That means an estimate of the time series of the disturbing signals by projection of the data vector to the eigenvector directions. My use of the term “spectral analysis” was perhaps misleading. I meant the spectrum of eigenvalues of the crosscovariance matrix of all measured data time series (https://en.wikipedia.org/wiki/Factor_analysis). This would also reveal the number of relevant disturbers as the number of eigenvelues essentially differing from zero. It also quantifies the content of disturbing signal in the reference magnetometer readings. Therefore it would be a straight forward method to calculate the α values.

Along that you get a measure for the correlations of differences and disturbance at sensor 1. Therefore my question: “In chapter 3.1. is assumed, that one of the magnetometers is very close to a disturber. Does the method also work, if that is not the case?” If a disturbing signal is present in the Deltas even with small intensities it can easily be identified by PCA and factor analysis for removal. Estimates of corrections of higher order (disturbers 2, 3, ...) result as projections on eigenvalues that are next smaller than the first.

Please judge for yourself whether the reference to PCA in the title is really justified.

But even PCA and factor analysis do not deliver unique results. In PCA geometry factors are completely ignored. Therefore exploitation of Eg. 3 and Eq. 6 would introduce a completely new idea going further than what can be done by PCA.

On page 6 between line 157 and line 180 you argue very intuitively. This lack of mathematical rigor should be mitigated using PCA in the way I proposed.

It is absolutely not clear how Eq. 10 follows from Eq. 9. I even doubt, that a linear relation between the correction value for B^i and the $\Delta B^{i,j}$ exists. This is only true if only one single disturber is on. I guess Eq.10 is the first order approach assuming that a certain disturber is very prominent (at a certain time span) in the difference $\Delta B^{i,j}$. Please clarify and explain that in the text.