Revision of the manuscript "In-situ vectorial calibration of magnetic observatory" (gi-2017- 21)

The manuscript describes the new aspect of in-situ calibration of geomagnetic observatory variometers, which uses as a reference records the absolute values of the Earth magnetic field components measured in the automatic mode. The recently developed equipment performs the automatic absolute measurements with a sample rate much higher (20-40 times) than that of manually operated instruments. This enhancement of the sample rate opens new possibilities of the absolute measurements, traditionally exploited for baselines estimation, for calibration of the scale factors, the orthogonality and orientation errors of magnetometers. This application of the absolute measurements is particularly important for deploying and operating unmanned geomagnetic observatories. So, the manuscript addresses the relevant topic within the scope of GI.

Authors show (both theoretically and experimentally), that the baselines are sensitive to the errors in scale factors and the variometer components misalignment in respect to the geographic frame axes. Applying some data processing procedure to the record of the arbitrary oriented variometer and the set of the absolute values of the magnetic field the transformation matrix is estimated. As a result, the corrected variometer data coincide well with that of the properly installed reference instrument. Unfortunately, authors had not provided the details of the data processing procedure. Further developing this calibration method it would be useful also to answer the following questions:

What is theoretical backgrounds of the selected data processing procedure?

What is the calibration uncertainty of the proposed method?

What factors are most important for achieving better accuracy?

Is it possible, for instance, to achieve the scale factors and the orientation errors accuracy, which is sufficient to meet the requirements to INTERMAGNET one-second data?

If the records of the badly calibrated variometer are used in the absolute measurements protocol, how accurate will be the results of this instrument calibration?

In my opinion, the manuscript could be published after correcting some drawbacks and unclear points, the list of which are given below.

p. 3, l. 3-4.

A comparison of two records for variometer calibration purposes was used by different authors. Please, add more references on this topic. I suggest to mention the book J. Jankowski and C. Sucksdorff, *IAGA guide for magnetic measurements and observatory practice*. Warsaw: IAGA, 1996, where a reference record obtained from absolute measurements was proposed to use for the variometers calibration (subsection 8.2, p. 160, 161):

"The method is easily used if there is a standard recording station with well known characteristics nearby. It will be more elaborate to collect the needed data from absolute measurements made during a magnetically active day. The method is based on a comparison of recorded natural variations of the magnetic field with simultaneously measured or recorded data which have no systematic errors.

...

The necessary data for the computation of quantities Δx_1, ... , Δx_n can be obtained from absolute measurements made during a disturbed day or disturbed days. It is a rather laborious and time consuming way, but has the advantage that it can be accomplished after the installation of the variometer. And every observatory has the facilities for these measurements."

p. 3 Eq. (4) and (5)

What is $\delta X_{voltage}$? If this is a voltage proportional to a measured signal δX_{real}, as it follows from the text in the lines 13-14, then $\delta X_{digital}$ is proportional to δX_{real} squared. From other side, $\delta X_{voltage}$ should not depend on δX_{real}, in order to keep k_X close to 1, if other terms in Eq. (5) are also constant. What are units of the terms in Eq. (4) and (5)?

p. 3 Eq. (6) and (7)

Probably, the vectors in these equations should be multiplied by element-wise manner, yielding the Hadamard product (also known as the Schur product or the entry-wise product). However, in the given notation it looks like an attempt to obtain a matrix product of two column vectors, which is not defined. I suggest to rewrite Eq. (6) and (7) using a special symbol for the entry-wise product or representing the column vector of the scale factors in the form of a square matrix (similarly to Eq. (3)).

Meaning of the symbol "*" is not described in the text. This symbol often denotes a complex conjugate of a matrix, so it would be better to explain directly its meaning in these equations.

p. 4, Eq. (8)

In my opinion, this equation is valid only for perfectly orthogonal components.

p. 5, Eq. (11) and (12)

Random components of measurement uncertainty, which are inevitably appeared in absolute values as well as variometer data due to instrumental noises or magnetic interferences, do not included in Eq. (11), (12). Does it mean that the method used for solving these equations is not influenced by this kind of disturbances? Please, provide some basic description of the data processing procedure used to estimate the calibration coefficients.

As it follows from the text (p. 5, l. 2-4), the variables *X, Y, Z, U, V, W* represent series of values. Then, in Eq. (11) these variables should be in the form of row vectors, but in Eq. (12) the same variables have to be in the form of column vectors. Is it correct?

Are the variables X_0, Y_0, Z_0 scalars or vectors?

What is the reason of using the two notations for matrices and vectors: “[]” in Eq. (3), (11), (12) and “()” in other equations?

In accordance with the journal rules vectors are identified in bold italic font and matrices — in bold roman font. Please, correct all equations in order to meet these requirements.

There is Intermagnet Technical Reference Manual, version 4.6 (2012). Is it necessary to refer to the previous version of the document?