Responds to the referee's comments

We thank the reviewer for his comments. Those comments are all valuable and very helpful for revising and improving our paper. Some corrections have been made in the paper and all of them have been also list in the responds. We thanks for the referee's comments and suggestions, and hope that the correction will meet with approval.

The responds to the referee's comments are as follows:

Review

General

The authors address a critical point in geomagnetic measurement. The data quality directly depends on the observations accuracy. The method presented here seems good for highlighting the human factor.

Comments

- The basic observatory concepts are explained here (variometer, scalar and vector absolute measurement, diflux, baselines, …). However, the descriptions are short so that they could remain nebulous for a reader that is not familiar with the observatory practices. Maybe another reviewer or the editor could give an opinion on it.

  Response: Special thanks for the referee's good comments. A paragraph has been added to explain the basic concept of the observatory. (P1 L26-P2 L5)

  "Usually, at least a set of three major instruments: a variometer, an absolute scalar magnetometer and a fluxgate theodolite are used to measure the geomagnetic field at most observatories (Gonsette et al., 2017). The variometer can record the continuous variations of the geomagnetic field components. As the variometer usually works as a near-zero sensor and the measuring range within ±3000 nT, may be as great as ±4000 nT at high latitudes (Jankowski et al., 1996), the recording is not the absolute value but the relative value. Therefore, to obtain the absolute geomagnetic field components in tens of thousands of nanotesla, a reference values or called baselines should be added to these relative values. The absolute scalar magnetometer can record the intensity of the geomagnetic field, but the direction of the geomagnetic field relative to the geographic north still cannot be determined by the two instruments. Therefore the fluxgate theodolite is introduced to measure the direction of geomagnetic field, including magnetic declination D and inclination I. Then the unique absolute vector geomagnetic field can be determined by F, D and I, and the baselines of each components of the variometer can be calculated. The process of measuring the absolute vector geomagnetic field is called 'absolute measurements'. "

- As already mentioned in the preliminary review, the intercomparison sessions organized during the biannual IAGA workshop on geomagnetic observatory instruments, methods and data systems follows a slightly similar method. The authors could refer to it and explain in a few words in what it is similar or different. The proceedings of these workshops are available at : http://www.iaga-aiga.org/publications/proceedings/

Response: As Reviewer suggested that some sentences were added to explain the similarities and differences with the intercomparison session.

(P3 L9-15)

"As known, to promote high quality data in geomagnetic observation, the IAGA Division V Working Group organizes the international comparison sessions every two years. The fluxgate theodolites from different countries were compared by make absolute measurements at an observatory during the session. The difference between these instruments (instrument difference) can be computed by comparing the baselines. If the absolute measurements were made on different pillars, the baseline can be corrected to the reference pillar for comparison by add a pillar difference. Therefore, the personal difference, the azimuth error caused by inexact positioning (position error), even the error of pillar difference (pillar error) are included in the instrument difference. "

(P3 L24-29)

"The measurement procedure of the observation experiment is similar to that of international comparison. What's different is that the observation experiment only concern on the differences between observers. Only the difference between the baselines, which are determined by the same instruments and different persons, is calculated. The difference between the baselines, which are determined by the different instruments and different (or identical) persons, is not used here (to eliminate pillar error and the systematic differences of instruments). Therefore, the instrument difference, including the position error and pillar error were not be involved in the personal difference."

- P4 L 15: The whole paragraph describes the processing but it is not clear. A few equations could help to understand easily.

Response: An equation was added to describe the processing clearly. (P5 L14-18)

"The general form of the equation for computing the personal difference for arbitrary component 'W' is shown below:

$$\Delta W_B(k) = | \overline{W}_B(k,i) - \overline{W}_B(k,j) |$$

Here, k is the instrument serial number, i and j represent different observers, W_B is the computed baseline value, $\overline{W}_B$ is the average of a set of baselines, ΔW_B is the personal difference."

- P5 L15: since the variometer baselines are used here the field variation should have (almost) no impact on the result. Another possible error can be due to the horizontality of the fluxgate sensor. For measuring the declination, the observer has to put the sensor in the horizontal plan (apart the alignment errors that are compensated by the

measurement protocol). The horizontality (i.e. the vertical circle at 90 °) should be controlled at each step otherwise, there is a projection of the Z component.

Response: Thanks for the referee's comments. It is really true as referee's suggested that the horizontality of the fluxgate sensor is one of possible reason which should be taken account. And the discussion of this reason has been added to this paper. (P6 L14-16)

"Another possible reason may be due to the horizontality of the fluxgate sensor. For measuring the declination, the observer has to put the sensor in the horizontal plan, and the horizontality (i.e. the vertical circle at 90 °) should be controlled at each step, otherwise there is a projection of the Z component."

- P5 L17: the error is not directly reported in the final result because a baseline adoption is performed (i.e. a curve fitting). Therefore, if the error is purely random and the amount of measurement sufficient, the errors are strongly attenuated.

Response: Thanks for the referee's comments. The geomagnetic field is varying during a set of absolute measurements, and the variometer has to keep track of this change. Since the variometer is rather stable and has a high precision, the baseline should be a constant value in a short period time. So the daily variation of the geomagnetic field nearly has no effect on the baseline. In addition, this work only concerns on the personal difference, and it was calculated by the average of a set of the baselines which determined by same DI-flux and same variometer. Therefore the error caused by geomagnetic field changes can be ignored in this observation experiment. And the error will not be discussed here as a possible reason. The sentences about this error in original paper were deleted.

Technical

Generally the English language could be improved.

P1L18 : ~~Intruduction~~ Introduction

Response: The word has been corrected. (P1 L18)

P1L23 : Actually there is no special recommendation. For instance, the BGS uses the HDZ configuration. That mainly depends on the variometer design.

Response: We have made correction according to the referee's comments. For precision expressing, the words "recommended as the three independent elements, and" were deleted. Now, the original sentence has been replaced by "Nowadays, D, I and F are extensively adopted in most geomagnetic observatories in the world (Bitterly et al., 1984; Jankowski et al., 1996)". (P1 L23)

P2L2: ~~This is meaning~~ That means

Response: The words have been corrected. (P2 L7)

P3L8: given in the Intermagnet reference manual (St Louis, 2011)

Response: Following the suggestion, this sentence has been corrected as "The baseline value computing methods are given in the INTERMAGNET reference manual (St Louis, 2011)". (P4 L3)

P3L14: I would suggest a reference: Gonsette, A., Rasson, J., and Humbled, F.: In situ vector calibration of magnetic observatories, Geosci. Instrum. Method. Data Syst., 6, 361-366, https://doi.org/10.5194/gi-6-361-2017, 2017.

Response: This reference has been added to this paper. It's very useful in explaining the geomagnetic observation at observatory for our paper. (P1 L27; P4 L8)