THE ANALYSIS OF BASELINES FOR DIFFERENT FLUXGATE THEODOLITES OF GEOMAGNETIC OBSERVATORIES

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ABSTRACT

This paper analyzes the baselines of 8 geomagnetic observatories in the China Magnetic Observatory Network. The baselines of similar variometers were measured by two different fluxgate theodolites during the same time period. The results demonstrate that two baseline values measured by two independent absolute instruments did not completely coincide for the same components even though the differences between pillars and instruments had been corrected. The baseline values were still not smooth, and there existed obvious wave variations for the D, H, and Z components. The causes of this inconsistency might be the differences between the two pillars installed with two independent absolute instruments and instrument problems in some of the observatories. In other words, the difference in the geomagnetic field between two points in the same observational area is not a constant.

Keywords: Geomagnetic observatory, Fluxgate theodolite, Absolute measurement, Baseline value

1 INTRODUCTION

A good geomagnetic observational system should consist of two parts, relative recording and absolute measurement of the geomagnetic field, in order to get uninterrupted, reliable geomagnetic data and publish the observatory yearbook. There should be more than two sets of independent magnetometers to accurately measure the values of F, D, and I components and more than two sets of independent variometers to record the variations of three independent components of the geomagnetic field in real time at the observatory.

One of the main tasks at a geomagnetic observatory is to regularly perform parallel absolute measurements in order to monitor and calibrate the variation of baseline values of the variometer. Theoretically, the trend of baselines of different absolute instruments should be exactly the same for each specific geomagnetic element after the correction of pillar and instrument differences is done. The data and their variations provided from a geomagnetic observatory should be reliable even when they are measured by different absolute instruments.

If observatories get different baseline values for one component of the variometer with a different absolute instrument after the pillar and instrument differences have been applied, the observatory will produce different geomagnetic definitive data with different absolute instruments. This problem is fatal for measurement of the geomagnetic field. It will make absolute measurements lose intrinsic value. The problem must be seriously analyzed and studied.

The measurement of baseline values is very significant for data quality control at a geomagnetic observatory. On the one hand, the stability of baselines is one of the most important means to evaluate the operating quality of variometers. On the other hand, the baseline value of a variometer being measured by two sets of absolute instruments is an important index for evaluating the operational situation of instruments themselves. This paper deals with the issue of a baseline measured by two sets of absolute instruments.

2 DATA SELECTION

In this paper, data collected during 2009 from 8 geomagnetic observatories, LZH (Lanzhou), KSH (Kashi), QIX (Qianling), CNH (Changchun), CDP (Chengdu), WHN (Wuhan), WMQ (Urumchi), and DED (Dedu) of the China Geomagnetic Observatory Network, have been used. Absolute instruments used at the observatories include fluxgate theodolites MINGEO DIM, and MAG2KP made in Hungary, CTM-DI made in China, and GSM-19F Overhauser magnetometers made in Canada. In addition, the relative recording system, FHDZ-M15, consists of a FGE suspended fluxgate variometer made in Denmark and a GSM-19F to record real time variations of the D, H, Z, and F components of the geomagnetic field.

At each observatory different fluxgate theodolites and the GSM-19F Overhauser magnetometer are combined as two sets of absolute instruments to measure the F, D, I components for quality control of the baselines of the FHDZ-M15. The parameters for the instruments and variometer are listed in Table 1.

Table 1. The parameters for the instruments and variometer

Serial number	Name of Equipment	Model of equipment	Physical Component	Main parameter	Measurement ways
1	fluxgate theodolite	CTM-DI	Absolute Declination and inclination	Precision: 1′	manual
2	fluxgate theodolite	MINGEO DIM	Absolute Declination and inclination	Precision: 1″	manual
3	fluxgate theodolite	MAG2KP	Absolute Declination and inclination	Precision: 1″	manual
4	Overhauser magnetometer	GSM-19F	Absolute total field	Resolution: 0.01nT， Accuracy: 0.2nT，sampling rate:5times/s	Manual and automatic
5	relative recording system	FHDZ-M15	Relative recording of D, H, Z and Absolute total field F	sampling rate: 1s	automatic

3 DATA PROCESSING AND ANALYZING

Temporal changes of baselines denoted in terms of DB, HB, and ZB at the observatories mentioned above during 2009 are shown in Figures1 through 8. One can see the comparison of the baseline values from two sets of absolute instruments in each diagram and their difference. Different colors represent the data from different instruments denoted at the lower left corner of each diagram in the (a) sections of the figures, and the differences of the two baselines are shown in the (b) sections. The scales of the ordinates in the diagrams are 0.1′ for D and 1nT for H and Z, and the scale of the abscissa is one month. For each diagram the temperature curves are also shown at the bottom of the (a) section.

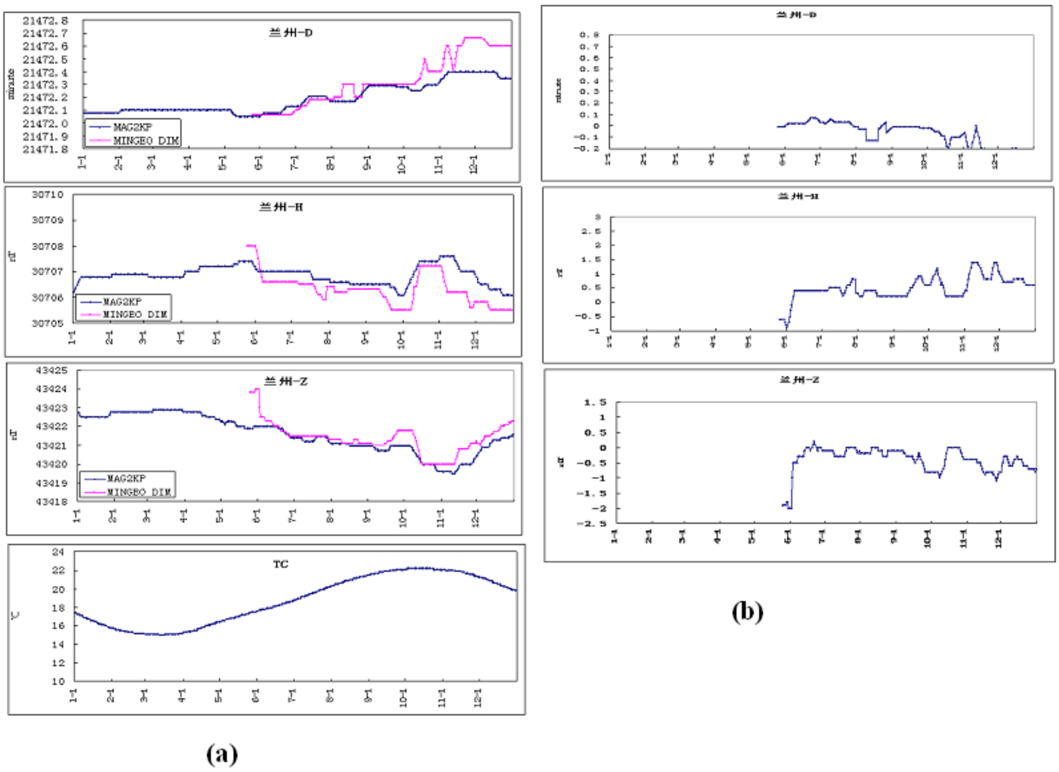


Figure 1. (a) Temporal variations of baselines for D, H, and Z and the room temperature for the Lanzhou Geomagnetic Observatory; (b) Difference of the baselines between two absolute instruments at the observatory.

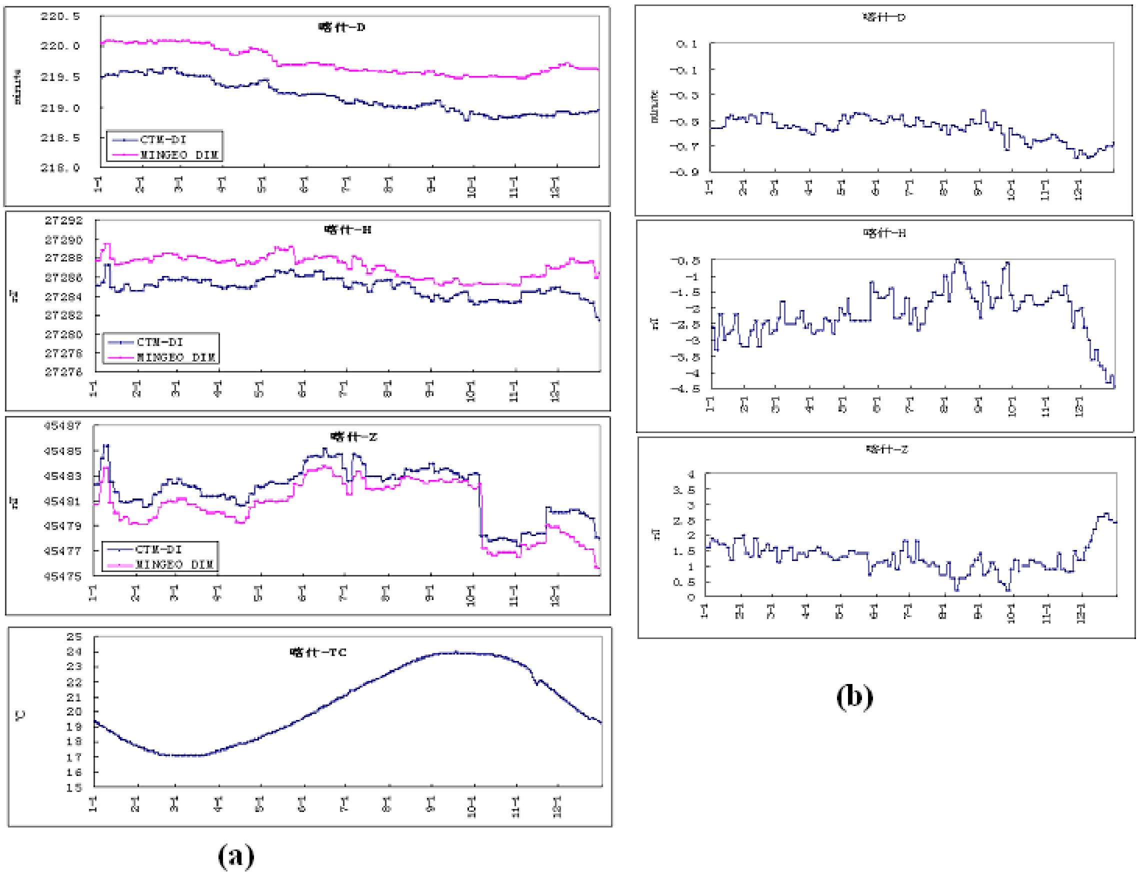


Figure 2. (a) Temporal variations of baselines for D, H, and Z and the room temperature for the Harshi Geomagnetic Observatory; (b) Difference of the baselines between two absolute instruments at the observatory.

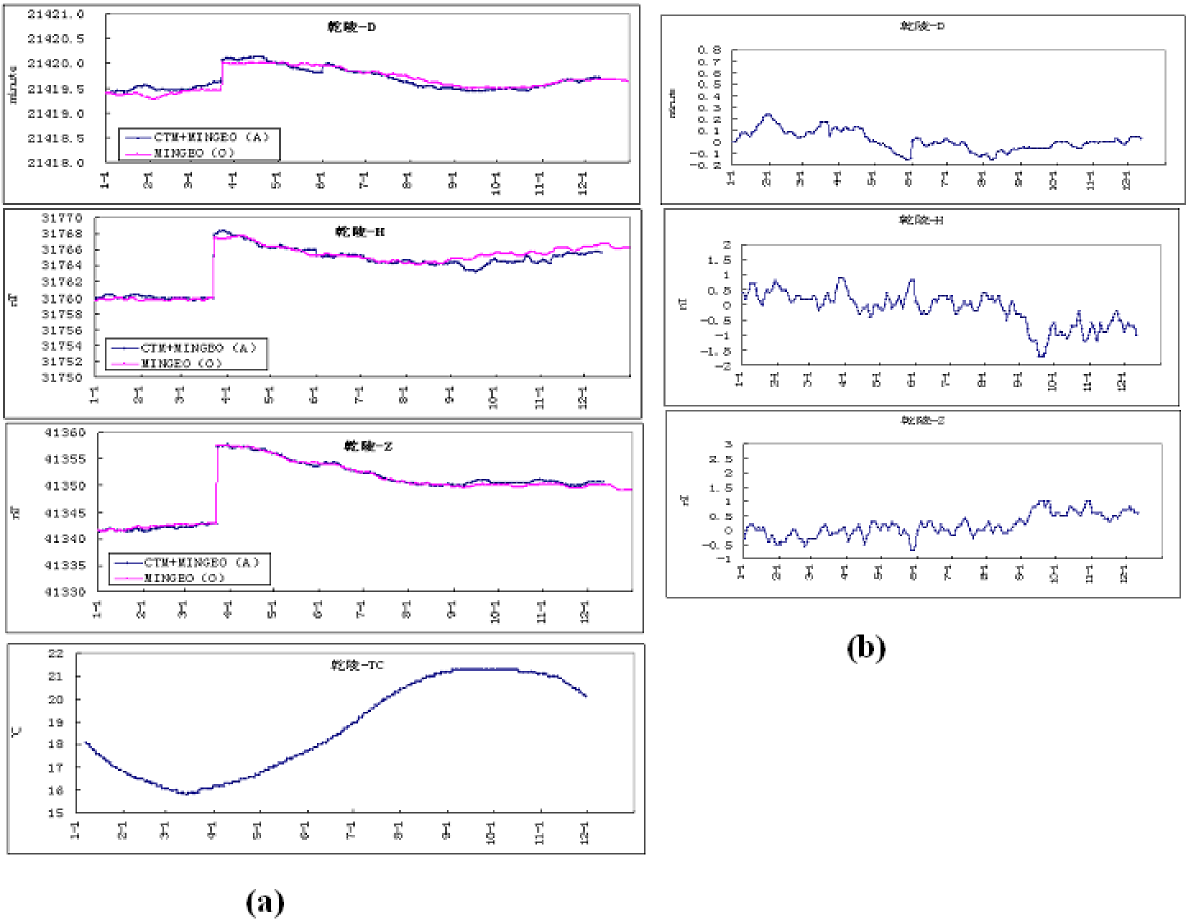
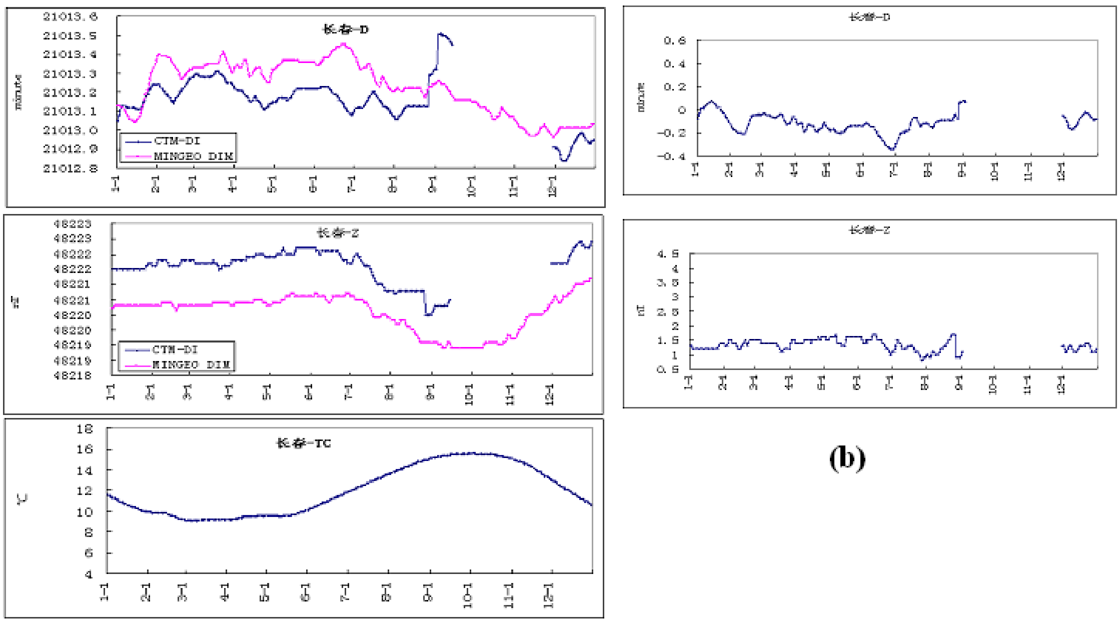


Figure 3. (a) Temporal variations of baselines for D,H, and Z and the room temperature for the Qianling Geomagnetic Observatory; (b) Difference of the baselines between two absolute instruments at the observatory.

It can be seen from Figure 3(a) that the two curves of baselines at Qianling observatory are synchronous. The unsmooth baseline OF MINGEO (A) was due to the instability of the sensor after September; the bad sensor has been replaced.

It can be seen from Figure 3(b) that the difference values of the three components, DB, HB, and ZB, are unstable at Qianling Observatory with an annual range for DB of 0.4′, 3nT for HB, and 2nT for ZB.



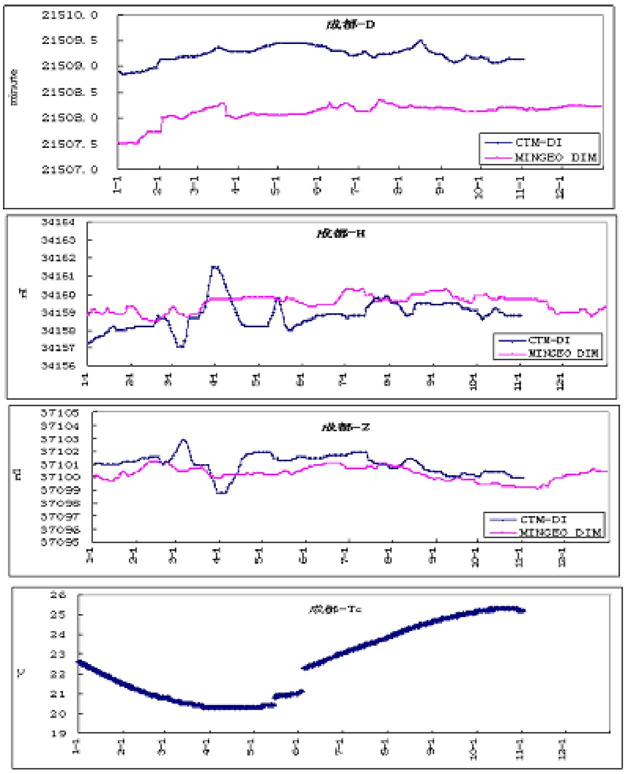
(b)

(a)

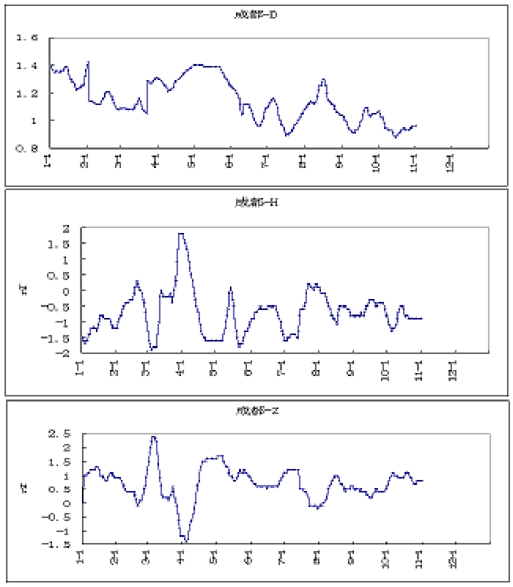
Figure 4. (a) Temporal variations of baselines for D,H, and Z and the room temperature for the Changchun Geomagnetic Observatory; (b) Difference of the baselines between two absolute instruments at the observatory.

It can be seen from Figure 4(a) that the DB values measured by two independent absolute instruments were not stable and also that the difference was large while the trends of HB and ZB were nearly the same at Changchun Observatory. It seems to the author that a systemic error exists between the two absolute instruments. The gap from September to November was caused by an incorrect AC-DC converter in the CTM-DI magnetometer. The elements HB and ZB followed the temperature.

It can be seen from Figure 4(b) that the annual range of DB is about 0.4′, 2nT for HB, and 1nT for ZB. This phenomenon might be caused by differences between pillars and observer differences.



(a)



(b)

Figure 5. (a) Temporal variations of baselines for D, H, and Z and the room temperature for the Chengdu Geomagnetic Observatory; (b) Difference of the baselines between two absolute instruments at the observatory.

It can be seen from Figure 5(a) that the trend of the curves is different at Chengdu observatory. The baseline from the CTM-DI fluxgate theodolite was very jumpy. The jump was confirmed by observatory staff as the CTM-DI has been out of order for a long time. The MINGEO-DI baseline, especially in DB, had abrupt changes before June, which were caused by improper procedures by new observers.

It can be seen from Figure 5(b) that the difference values of the baselines for all three components had a large range: The annual range for DB was about 2.3′ and 4nT for HB and ZB with the main cause being the variation of pillar difference, instrument problems, and improper measuring technique.

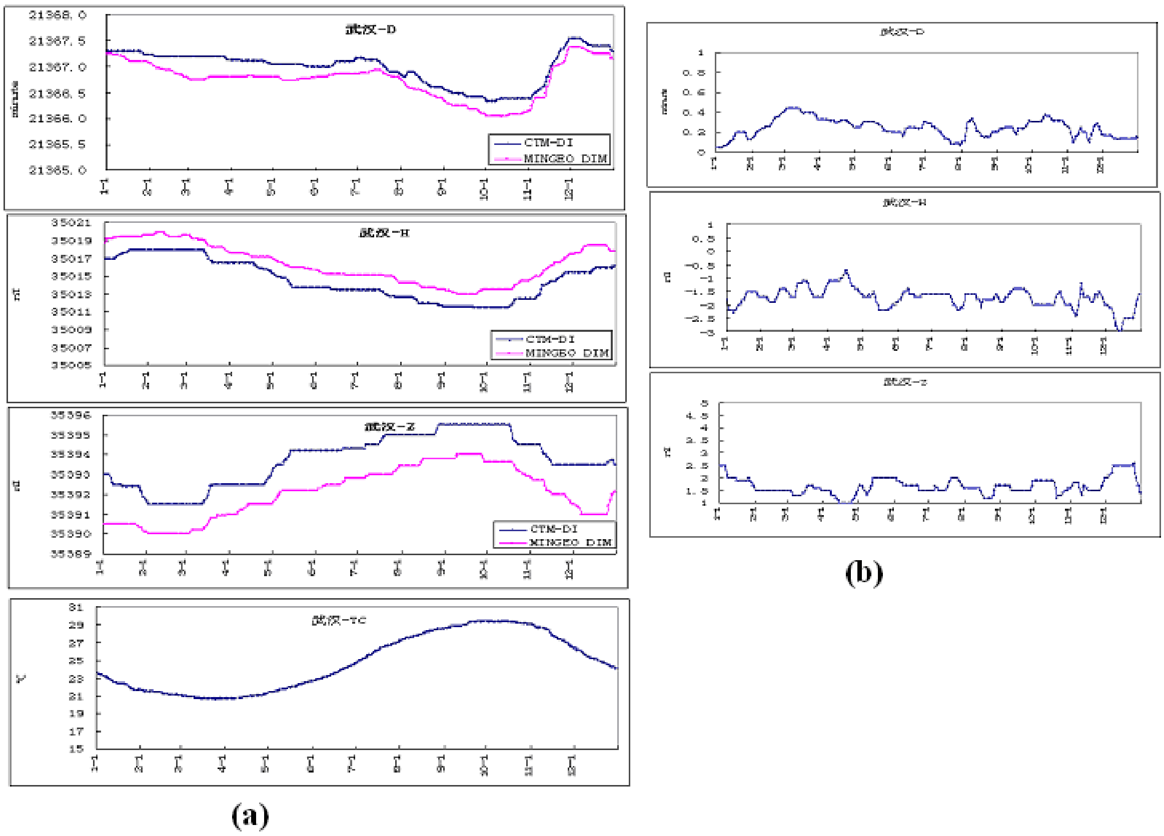


Figure 6. (a) Temporal variations of baselines for D,H and Z and the room temperature for the Wuhan Geomagnetic Observatory; (b) Difference of the baselines between two absolute instruments at the observatory.

It can be seen from Figure 6(a) that the general trends of all three components, DB, HB, and ZB, are similar. This is related to the temperature variations during the year at Wuhan observatory.

It can be seen from Figure 6(b) that the differences of baselines between the two instruments are stable, with an annual range of about 0.4′for DB, 2nT for HB, and 1.5nT for ZB. It was confirmed that both sets of instruments worked well, and the pillar difference has been corrected. The systemic error might be a pillar difference error made earlier when the pillar difference was not constant.

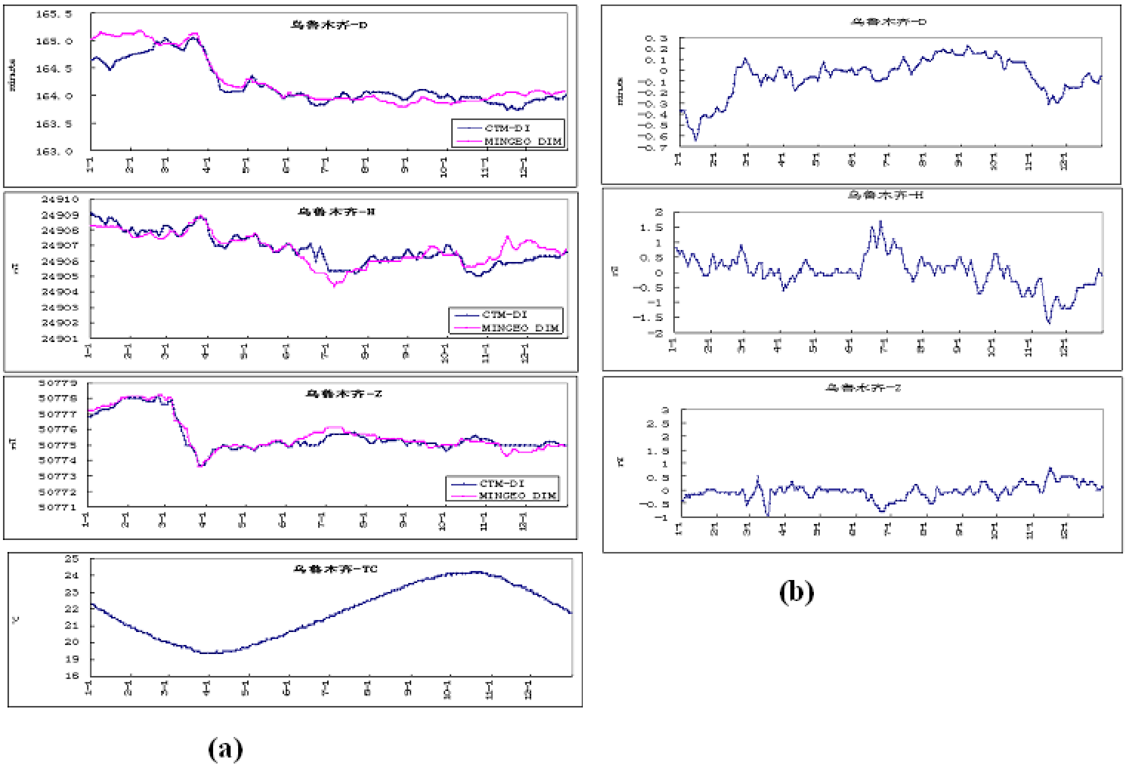
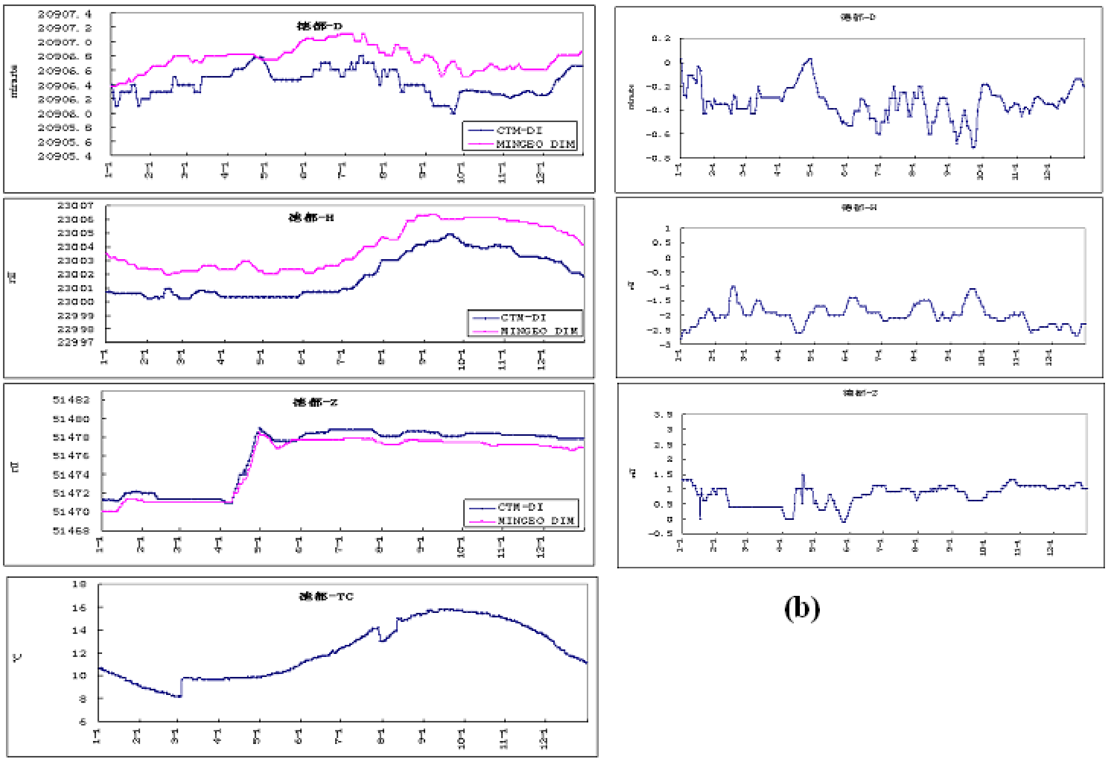


Figure 7. (a) Temporal variations of baselines for D,H, and Z and the room temperature for the Ulumuqi Geomagnetic Observatory; (b) Difference of the baselines between two absolute instruments at the observatory.

It can be seen from Figure 7(a) that the trends of temporal changes of baselines from the two instruments for each component in the Ulumuqi Observatory were almost the same, which shows that both sets of absolute instruments are well operated. The trends of the baselines, however, in all three components were coincident at the observatory, which might be caused by room temperature changes and may show the fluxgate theodolites have a bigger temperature coefficient.

It can be seen from Figure 7(b) that the component DB shows an annual range of nearly 1′, which might be due to a problem with fluxgate theodolite CTM-DI. The annual range is about 4nT for HB and 2nT for ZB.



(b)

(a)

Figure 8. (a) Temporal variations of baselines for D,H, and Z and the room temperature for the Chengdu Geomagnetic Observatory; (b) Difference of the baselines between two absolute instruments at the observatory.

It can be seen from Figure 8(a) that, generally speaking, the baselines of DB, HB, and ZB of both sets of instruments have a similar trend but in opposite directions on some days. The baseline values closely follow the temperature changes as seen in the other observations mentioned above. The jumps in ZB during April and May were due to high humidity, which may have made the Variometer, FHDZ-15, record distorted beginning in February.

It can be seen from Figure 8(b) that the differences of the baselines of both sets of absolute instruments were stable with ranges of 0.8′ for DB and 2nT for HB and ZB.

Theoretically, the baseline should be the indicator for monitoring the operational state of the variometer at the observatory. A straight baseline shows that the variometer and the absolute instrument are operating very well and that the operation of the observatory was good. In practice, however, when the variations of the baseline are too large, one needs to take many factors into account, such as the effect of room temperature changes, humidity changes, pillar difference changes on the absolute instrument, the quality of the instruments, and even the observers skill and so on. The case where two sets of absolute instruments are installed at an observatory for comparison of baseline variations is better than having only one instrument, especially when the baselines are consistent. We still need to be careful that room temperature is kept within reasonable limits, that pillar differences are checked, and that people working at the observatory are well trained.

4 REFERENCES

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