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TILT-COMPENSATION OF FLUXGATE MAGNETOMETERS

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The disturbing effect of tilting of the piers on the recorded field components in the magnetic observatories is dealt with. In unfavourable conditions tilting may cause a change in the baseline of some 10 nT within a short time. The paper presents the results achieved by a suspended fluxgate magnetometer constructed for tilt compensation; the results approximate to the appointed 2 nT/year.

Keywords: magnetometer, observatories

1. Introduction

Even in the days when we ran the La Cour photographic recorders, we realized that the tilting of the instrument pier could be a serious problem. Of course we didn't have to worry about the two horizontal components since these were measured with suspended magnets and therefore almost unaffected by tilt. Only the La Cour *Z*-variometers suffered from tilting of the piers, which has been described by several authors.

Today it is different. When operating fluxgate sensors in northern Europe or at higher latitudes the two horizontal elements are the ones most sensitive to tilt, so that a tilt of only 5″ of the supporting pier will show up as a change of the baseline of approx. 1 nT.

I know that some observatories have avoided tilting by building their observatories deep in the ground, as is the case with some Japanese observatories. But for most other observatories I think that tilting can be

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observed as, for example, a seasonal variation of the baseline values or maybe as small fluctuations of the baselines.

At some observatories like the ones we are operating in the Arctic, tilting can be a real problem causing baseline drift of several tens of nT or more during a very short time in the summer when the permafrozen soil becomes soft.

Figure 1. shows an example of this kind of tilt. Here we have plotted baseline values for the two horizontal sensors together with the recorded tilt of the sensor pier. One can observe a very good correlation between tilt and baseline drift. The scale value of the H-level (LNS) is 0.64 min per full line (i.e.,2 divisions), corresponding to 10.5 nT at Thule. The scale value of the D-level (LEW) is 0.73 per full line (2 divisions), corresponding to 10.5 min at Thule.

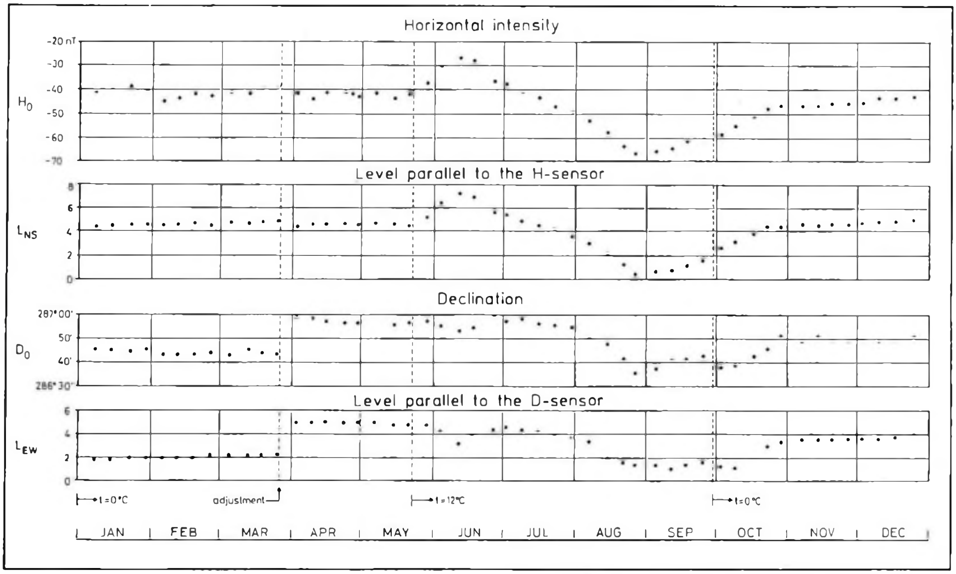

Fig.1. Baseline values and level readings. Thule 1985. Digital fluxgate magnetograph

1. ábra. Bázisvonal értéke és a pillérek dőlésének nagysága

Рис. 1. Значение опорной линии и величина наклонения столба

2. The suspended fluxgate magnetometer at Brorfelde

In an attempt to overcome the tilt problem some years ago we decided to build a suspended fluxgate magnetometer to compensate the tilt. I think it was one of the direct results of the discussions we had during the first instrument workshops in Ottawa. The principle of our suspended magnetometer is shown in *Fig. 2.* It consists of three fluxgate sensors mounted in grooves in a marble cube, the cube being suspended by two orthogonal Phosphor-bronze strips. Pictures of the instrument were published by Lauridsen [LAURIDSEN 1988].

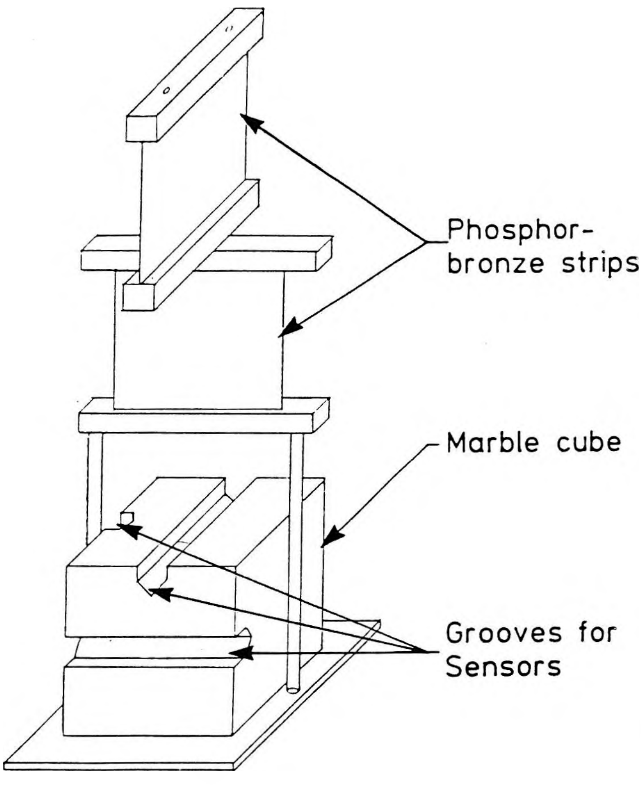

Fig.2. Principle of suspended magnetometer

2. ábra. Felfüggesztett magnetométer elvi rajza

Рис. 2. Принципиальная схема подвешенного магнитометра

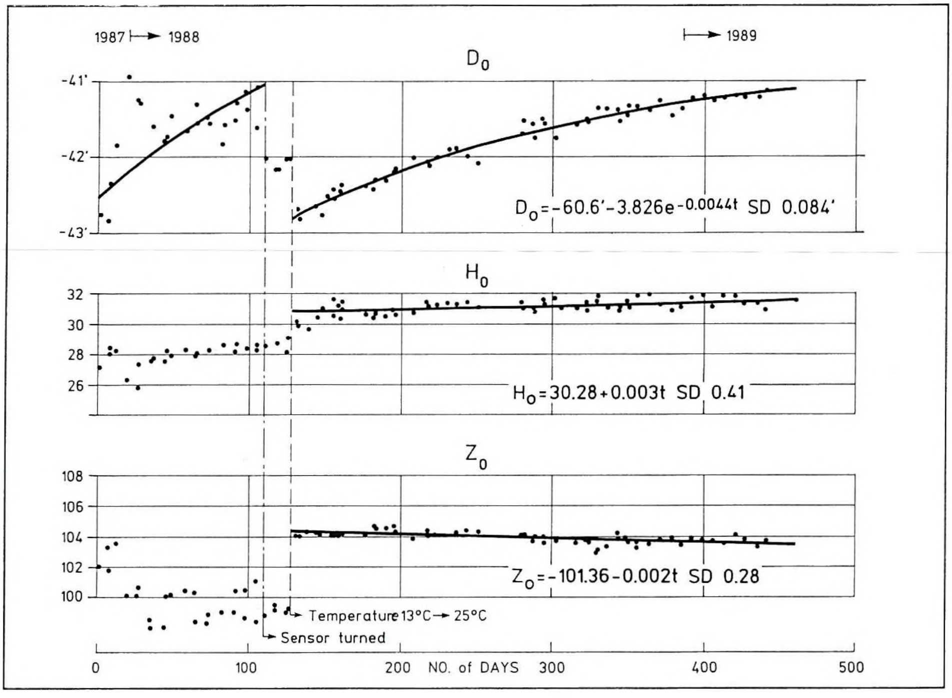

Fig. 3. Long-term stability of suspended system

3. ábra Felfüggesztéses rendszer hosszúidejű stabilitása

Рис. 3. Влияние изменения температуры на датчики

At the workshop in Nurmijärvi, we showed the results [RASMUSSEN 1990] of our first long-term test of the suspended system. It was tested for approximately one year and some of the results are shown in *Fig. 3*. During the first three months we had some problems which were associated with the data collecting system. After that we have had 11 months of undisturbed testing.

The main results are that the *H*- and *Z*-sensors show a drift of approx. 1 nT/year, while the *D*-sensor shows a drift which decays exponentially, so that after one year the drift is down to 3 nT/year.

We think that this rather large drift in the *D*-component may be caused by a too weak mechanical construction or may be due to improper annealing of the mechanical parts of the instruments.

The temperature drift of the sensors is also illustrated in Fig. 3. The values measured were somewhat higher than those measured before suspending the sensors and we therefore wondered if the higher temperature coefficient could be due to magnetic contamination of the mechanical parts of the magnetometers.

It was therefore decided to take down the instrument in order to test it for magnetic impurities. It did, in fact, show up to be quite magnetic, especially the bottom plate, which was made of brass.

After changing the magnetic parts and also building a new non-magnetic pier for the instrument, the magnetometer was once again set into operation, ready for a new long-term test.

The results for the first 7 months are shown in *Fig. 4*. During the first month some changes can be seen in the baselines, for which we have no good explanation, but some of the drift may have been caused by artificial disturbances as the sensor house was not completely undisturbed during

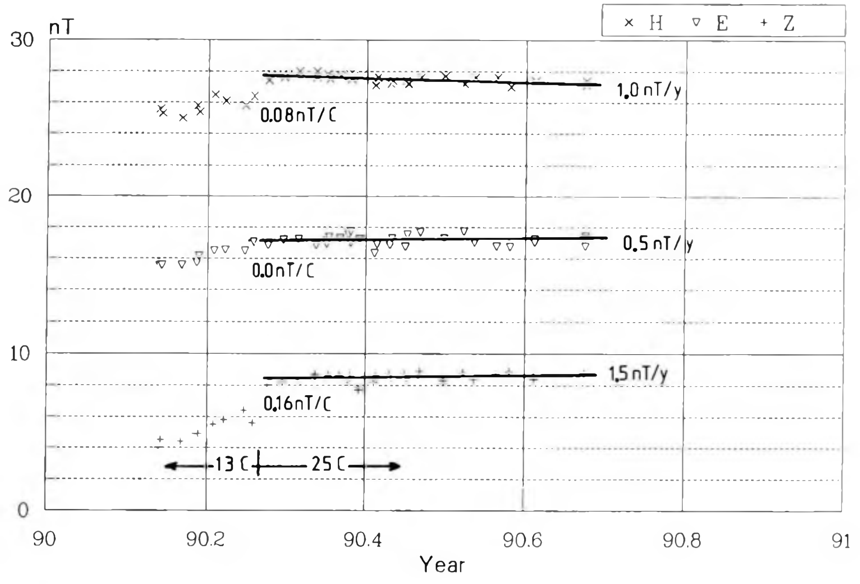

Fig.4. Baseline drift of suspended sensors. Brorfelde 1990

4. ábra. Felfüggesztett magnetométer bázisváltozása Brorfeldben 1990-ben

Рис. 4. Изменение базиса магнитометра в Брорфельде в 1990 г.

this period. The temperature was then raised by 12 °C and we found the temperature coefficients to be within the range expected (< 0.2 nT/°C).

The long-term stability is also very good now being less than 2 nT/year for all three components. I should maybe emphasize that the drift is the total drift of the instrument including, of course, the electronics.

3. Suspended magnetometers in the Arctic

During the last year we have also operated two suspended instruments at the observatory in Thule, where we have had the most serious tilt problems, as already indicated in the introduction. In the last 6 months these instruments were left completely undisturbed giving us an opportunity to measure long-term drift.

The baseline values for the supplementary magnetometer are shown in *Fig. 5.* As can be seen from the figure, we did have a small accident early

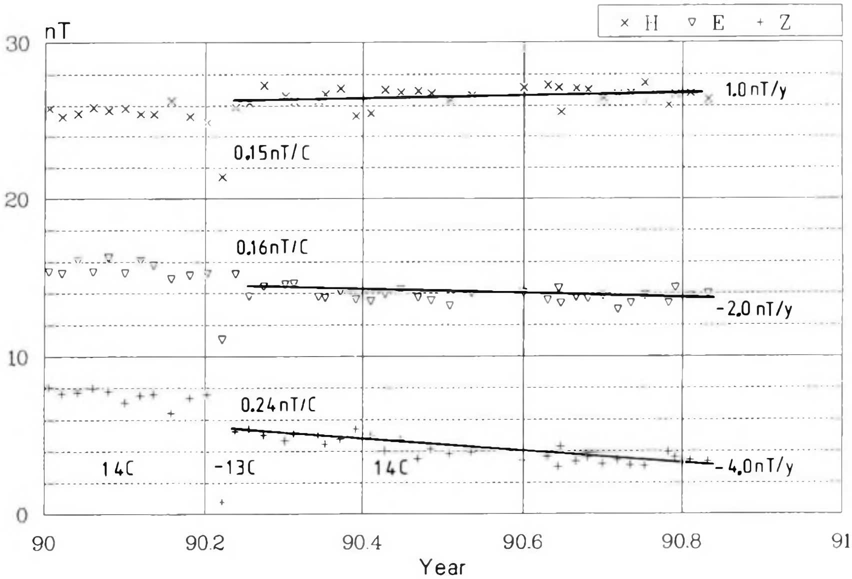

Fig. 5. Baseline drift of suspended sensors. Thule 1989-90. Supplementary magnetometer

5. ábra. Felfüggesztett magnetométer bázisváltozása Thule-ben 1989-90-ben (kisegítő műszer)

Рис. 5. Изменение базиса магнитометра в Туле в 1990 г. (вспомогательный прибор) in 1990, when the heating element in the variometer hut broke down so that the temperature for a few days went down to -13°C. This gave us the possibility to measure the temperature coefficients of the sensors. The temperature coefficients are approximately the same as for the sensors used in Brorfelde.

The long-term stability is also very good, less than 2 nT/year for *H*- and *E(D)*, while the drift for the *Z*-sensor is as high as -4 nT/year. *Figure 6* shows the baselines for the other magnetometer at Thule. The temperature coefficients are approximately the same as for the other suspended magnetometers. And the long-term drift is very good too. Only the *D*-sensor shows a somewhat larger drift.

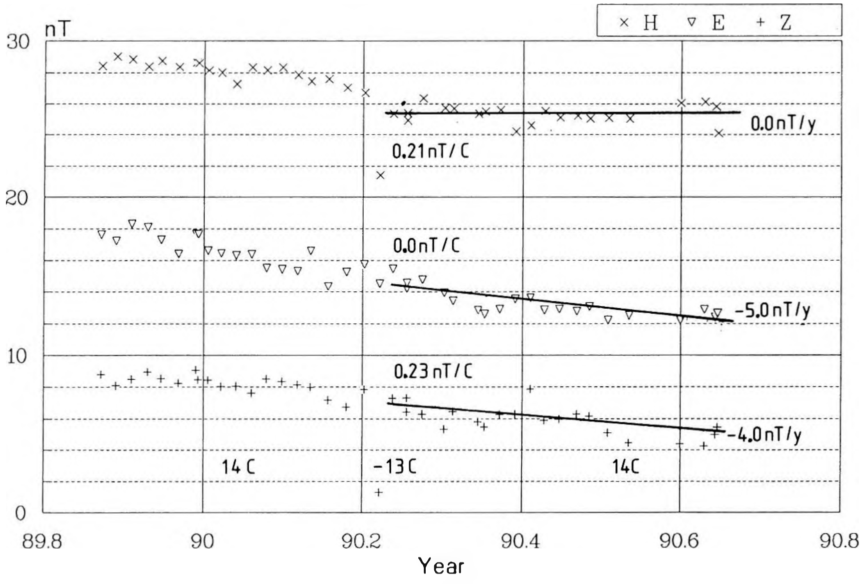

Fig. 6. Baseline drift of suspended sensors. Thule 1989-90. Primary magnetometer

6. ábra. Felfüggesztett magnetométer bázisváltozása Thule-ben 1989-90-ben (főműszer)

Рис. 6. Изменение базиса магнитометра в Туле в 1989 г. (основной прибор)

4. Summary

In summary I must say that it was our aim to build an instrument with drifts of no more than 2 nT/year in all elements. Unfortunately this was not completely achieved as, for example, the two Z-sensors in Thule show a drift of -4 nT/year. As the Z-component in Thule is almost parallel to the main field F, we have the possibility to investigate this 'large' drift in detail by comparing the protonmagnetometer output with the Z-sensor output. I hope such an investigation will give us an idea of what can be the cause of the drift so that the drift can be reduced in future instruments.

Finally I would mention that this year we are installing two more suspended fluxgate magnetometers at variometer stations where we have very serious tilt problems. We are also constructing a portable version of the suspended magnetometer to be used in repeat station work.

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FLUXGATE MAGNETOMÉTER DŐLÉSKOMPENZÁCIÓJA

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A cikk ismerteti az obszervatóriumokban a regisztrálásra használt pillérek elmozdulásának zavaró hatását a mérési eredményekre. Ennek nagysága kedvezőtlen esetben néhányszor tíz nT bázisvonalváltozást is okozhat rövid idő alatt. Bemutatja azokat az eredményeket, melyeket a dőlés kompenzálására konstruált felfüggesztett fluxgate magnetométerrel lehet elérni, és amely megközelíti a kitűzött 2 nT/év értéket.

КОМПЕНСАЦИЯ НАКЛОНЕНИЯ МАГНИТОМЕТРА ФЛЮКСГЕЙТ

Оле РАСМУССЕН

В статье рассматриваются помехи в результатах измерений, возникающие от смещения столба, применяемого в обсерваториях при записях. Величина этих помех в неблагоприятном случае может обусловить изменения в несколько десятков нт по опорной линии. Представлены результаты, достигаемые подвешенным магнитометром флюксгейт, сконструированным для компенсации наклона, и приближающиеся к желаемому значению в 2 нт/год.