GEOPHYSICAL TRANSACTIONS 1991
Vol. 36. No. 3-4. pp. 271-288

THE STANDARD OF WINGST GEOMAGNETIC OBSERVATORY (ERDMAGNETISCHES OBSERVATORIUM WINGST) - ITS IMPROVEMENT AND PRESERVATION, DEMONSTRATED BY EXAMPLES

Günter SCHULZ*

The continuous measurement of the secular variation (SV) of the Earth's magnetic field is a task of highest priority at the Wingst Geomagnetic Observatory of the Bundesamt für Seeschiffahrt und Hydrographie (former Deutsches Hydrographisches Institut). As, by nature, SV progresses very slowly, the devices — i.e. the base-line instruments and, logically, those variometers the base-lines of which are determined by the measurements of the base-line instruments — have to keep their magnetic standards over several decades. Moreover, modern developments in the field of instrument construction have to be utilized in order to improve and/or ensure the standards. This paper describes by means of some examples, where priorities have been placed in the last few years. Problems which have arisen in this connection show where the limits of the measurement accuracy are set.

Keywords: observatory standards, pier tilt, secular variation, fluxgate magnetometer

1. Introduction

When Wingst Geomagnetic Observatory was inaugurated in 1938 it was possible to fall back upon a set of classic devices which had previously been procured for the predecessor station Wilhelmshaven in 1928: a magnetic station theodolite together with an oscillation box, an earth

---

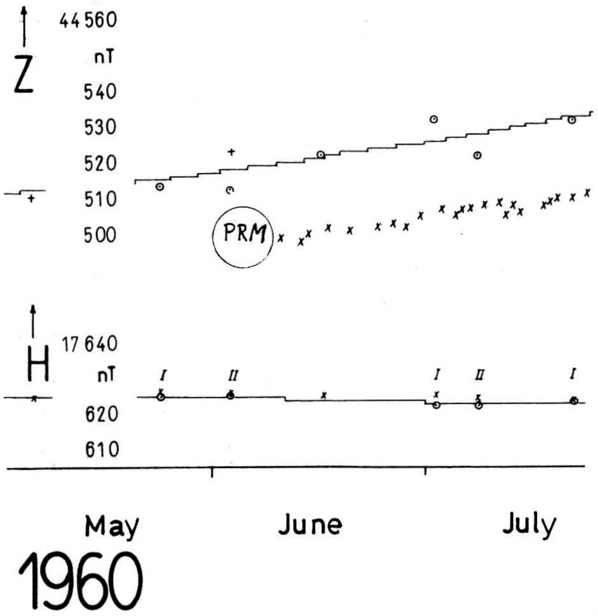
* Bundesamt für Seeschiffahrt und HydrographieErdmagnetisches Observatorium Am Olymp 13 D-2177 Wingst

Previously published in Dt. hydrogr. Z. 41, 1988. H. 3-6; this version contains measurement data obtained since then

inductor, as well as a photographic variometer system, all designed by G. Schulze, Potsdam [Voppel, 1988].

It is remarkable that the station theodolite has been operating as the main base-line instrument for the declination (*D*) until the present day; the photographic recorder — the variometer for the vertical component (*Z*) has been replaced in the meantime by a Lacour balance (which, contrary to the Schulze type, is completely sealed against humidity changes) — is no longer used as the main system for deriving hourly mean values, but renders an indispensable service as a reliable back-up. It is true for both devices — the base-line instrument as well as the variometer — that the accuracy of the readings or the stability of the recording, respectively, is hardly attained by modern instruments.

Similar statements are not true for the earth inductor. Its insufficiency becomes obvious when considering the results of measurements with the first proton magnetometer (PRM), procured in 1960. *Fig. 1* shows a detail of the Schulze system base-lines' original display and, therefore, supplies



documentation of the Observatory's instrument history. The upper part shows the Z base-line of the Schulze balance. Circles and vertical crosses mean base-line values calculated from the horizontal intensity (H) and the inclination (I), the latter measured by the earth inductor. The wide scatter of these values around the smoothed base-line catches the eye; deviations of some 10 nT are not exceptional. H is shown below; it runs extremely stably.

Starting from the middle of June, the first measurements with the PRM (diagonal crosses) impressively confirm that the scatter has to be entirely attributed to the earth inductor. (The step of some 20 nT between both time series is due to pier differences and deviations between the observatory standard and the International Magnetic Standard, IMS.) From then onwards, the PRM has operated as the primary standard, and the earth inductor has taken second place. That is a classic example for the exchange of standards making use of instrumental innovations.

Fig. 1. Detail of SCHULZE system's H and Z base-line (lower or upper trace, respectively) of 1960, demonstrating the first measurements with the proton magnetometer (PRM) of the type VARIAN 4931 starting on June 09

H base-line:circles denote values measured with the magnetic theodolite according to Lamont's method, where I and II are the numbers of the deflection magnets used; diagonal crosses are values measured with three QHMs (Quartz Horizontal Magnetometer)

Z base-line: circles denote values derived from the smoothed H base-line and I values measured with the earth inductor; vertical crosses are values measured with a BMZ (Balance Magnetique Zero); diagonal crosses denote Z values derived from the smoothed H base-line and F values measured with the PRM

1. ábra. A Schulze rendszer 1960-as H (lent) és Z (fent) bázisvonalainak egy része a VARIAN 4931 típusú proton magnetométerrel (PRM) végzett június 9-én kezdődött első mérésekkel

H bázisvonal: a körök a Lamont módszer szerinti mágneses teodolittal végzett mérések eredményeit, I és II a mérésnél használt kitérítő mágneseket jelölik. Az ikszek 3 db kvarc horizontális magnetométerrel (QHM) végzett mérések értékeit jelölik

Z bázisvonal: a körök a simított H bázisvonalból és a föld-induktorral mért I értékekből számított Z bázisértékeket, a keresztek a BMZ-vel (Balance Magnetique Zero) mért értékeket, az ikszek a simított H bázisvonalból és a PRM-mel mért F értékekből levezetett Z értékeket jelölik

Рис. 1. Часть опорных линий H (внизу) и Z (вверху) 1960-го года системы Шульце с обозначением первых измерений выполненных протонным магнитометром (PRM) типа Вариан 4931 начиная с 9-го июня

Опорная линия H: кружками обозначены результаты измерений магнитными теодолитами по способу Ламонта, I и II обозначены магниты-уклонители применявшиеся при измерениях. Иксами обозначены результаты измерений выполненных тремя горизонтальными кварцевыми магнитометрами (QHM)

Опорная линия Z: кружками обозначены значения базисов Z рассчитанных по сглаженной опорной линии H и значениям I измеренным земным индуктором, крестиками - значения Z выведенные из сглаженной опорной линии H и значений F, измеренными PRM

The introduction of the digitally operating fluxgate magnetometer in 1980 [SCHULZ, 1983] means a complete change, not only from the standpoint of measuring technique but also from that of evaluation methodology. The new system renders improvements as far as linearity and certainty of the scale values, dynamic range, resolution, and cross-talk are concerned; in return for that, concessions have to be made to the stability of the fluxgates. Chapter 2 deals with this item.

As the fluxgates are mounted stationarily, they need not follow the SV — as is necessary with magnets of the classic type. What is more, statements with regard to technical disturbances of spontaneous (or statistical) type (outliers) or systematic type (drifts, cross-talk, and uncertainties of scale values) can be made by means of the simultaneous recording of the total intensity (F). The single components contribute to such a degree in so far as they contribute to the closing error (details are given in Chapter 3).

Whereas the quality of the recording system can be extensively controlled by internal observatory routines, the base-line instruments can only be checked by comparing them with those of other observatories: on the one hand, this can be accomplished by the momentary value comparison with nearby stations [SCHULZ and VOPPEL 1981]; on the other hand, if absolute standards are concerned, direct comparison measurements have to be carried out. Referring again to the station theodolite, it represents the Observatory's absolute D standard. Chapter 4 shows what kind of efforts have been made in order to track down the remaining permeable impurities and to meet the requirements for a connection measurement providing the check as to whether or not the IMS is fulfilled.

Chapter 5 gives an idea of how far pier differences can affect comparison measurements. Not only the instruments themselves have to be carefully preserved but also their environment has to be regularly checked so far as disturbing magnetic fields are concerned.

2. The base-line of the Z fluxgate

In the late 'seventies, the digital recording system was installed. Its main feature is a permanent over-determination, because F is recorded by means of a PRM as well. *Fig.* 2 shows the fluxgate magnetometer's Z

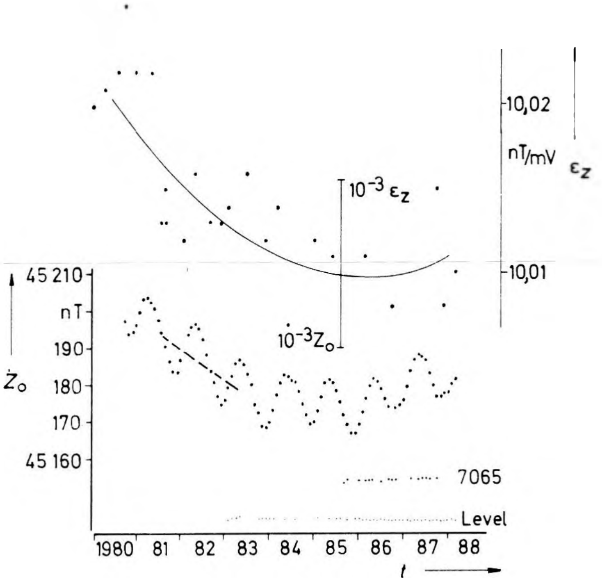


Fig.2. Lower part: monthly means of the fluxgate magnetometer's *Z* base-line values (left-hand scale) since 1980; upper part: the fluxgate magnetometer's *Z* scale values (right-hand scale), measured galvanically, for the same period.The scales are matched in such a way that equal relative fluctuations of either quantity give the same amount (see the scale in the middle). The small dashed line indicates the part previously shown in [SCHULZ 1983]. For the traces marked by '7065' and 'Level' see the text

2. ábra. Lent: A fluxgate magnetométer Z bázisvonal-értékeinek havi átlagai (bal oldali skála) 1980-tól. Fent: A fluxgate magnetométer *Z*-re vonatkozó skála-értékei (jobb oldali skála), galvanikusan mérve, ugyanerre az időszakra. A skálák úgy vannak összehangolva, hogy mindkét mennyiség egyenlő relatív fluktuációi azonos nagyságúak (lásd a középső skálát). A pontozott vonal a korábban már [SCHULZ 1983]-ban bemutatott részt jelöli. A '7065'-tel és 'Level'-lel jelölt vonalak jelentését lásd a szövegben

Рис. 2. Внизу по-месячные средние (шкала слева из значений по опорной линии *Z* магнитометра флюксгейт начиная с 1980 г. Вверху значения шкал (шкала справа) магнитометра флюксгейт относящиеся к *Z* измеренные гальваническим способом, по тому же периоду. Шкалы увязаны между собой таким образом, что относительные флюктуации обеих величин равны между собой (см. шкалу на середине). Пунктирной линией обозначен участок уже представленный ранее (Шульц (SCHULZ 1983)) Смысл линий, обозначенных '7065' и 'Level', см. в тексте base-line. Monthly mean values of half-weekly measurements cover a period from 1980 to date. A long term trend is superimposed by an annual period, the amplitude of which attains almost 10 nT. As was shown earlier [SCHULZ 1983], the seasonal fluctuation runs with the variation of the humidity inside the variometer house. The point where the humidity penetrates into the system is not yet known.

Let us now have a look at the long term trend. It is the point in question: additionally, in the upper part of Fig. 2, the scale values were drawn in such a way that their relative scatter matches the relative fluctuations of the base-line. The scale values can be determined galvanically with an absolute accuracy of $5 \cdot 10^{-4}$ by means of the Observatory's magnetic field generating and electrical standards.The line smooths the individual values.

A parallel course of both quantities is quite obvious. This means that tilting and any deformation of the fluxgates can be ruled out as a cause of the base-line's trend, the former being confirmed by the level readings (marked 'Level'). Instability of the digital voltmeter within the feedback circuit does not play a role either, as can be seen below (marked '7065').

Two mechanisms are conceivable: fluctuations of the precision resistor and/or the compensation coil's factor, both parts within the feedback loop of the fluxgate.

3. Turning the horizontal fluxgates

Until May 1984, the horizontal fluxgates were aligned towards the geographic co-ordinates X (North component) and Y (East component), respectively. Then the fluxgates were turned counter-clockwise by 45° within the horizontal plain *(Fig. 3)*. As the orthogonal configuration was preserved, the base-line of F could be checked later on by the usual routine.

Y had not contributed to the closing error S until then, owing to the negligible coefficient of the linear term of the series expansion valid for Wingst:

$$S = F_m - F = \delta F_m - \delta F$$

$$\delta F = 0.37\, \delta X + 6.5 \cdot 10^{-3}\, \delta Y + 0.93\, \delta Z$$

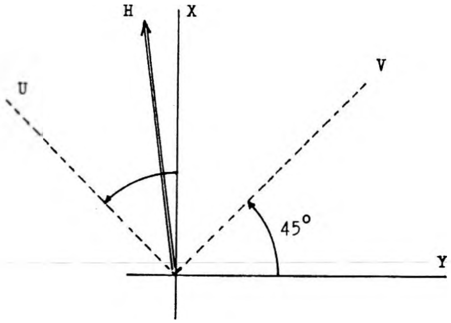


Fig.3. Turning of the horizontal fluxgates counter-clockwise by 45° from (X,Y) to (U,V) within the horizontal plane

3. ábra. A horizontális fluxgate-ek 45°-kal az óramutató járásával ellentétes irányba forgatva (X, Y)-tól (U, V) felé a horizontális síkban

Рис. 3. Горизонтальные флюксгейты повернутые на 45° ж против часовой стрелки от (X,Y) к (U,V) в горизонтальной плоскости

F means the readings of the PRM. Therefore, outliers and short term base-line fluctuations of Y had eluded the check. After the turning, the weight of X was allocated equally to both new components U and V:

$$\delta F = 0.27\ \delta U + 0.26\ \delta V + 0{,}93\ \delta Z$$

This is due to the fact that D almost vanishes at Wingst. From then onwards, D — calculated from U and V — has been included in the permanent check of the F base-line. The recording system has become more secure. *Fig. 4* shows the Z fluxgate in the foreground and those of the horizontal components in the background. One can recognize their directions easily by means of the Helmholtz coils with which the scale values are checked.

A recording sample of 1984, (4th September) from 10 to 20 UTC *(Fig.5)*, i.e., three months after turning the fluxgates, where H and D were computed from U and V, demonstrates the efficiency of the over-determined system. A fairly strong disturbance is shown — F and Z each increase by more than 200 nT within two hours. H fluctuates within comparable limits.

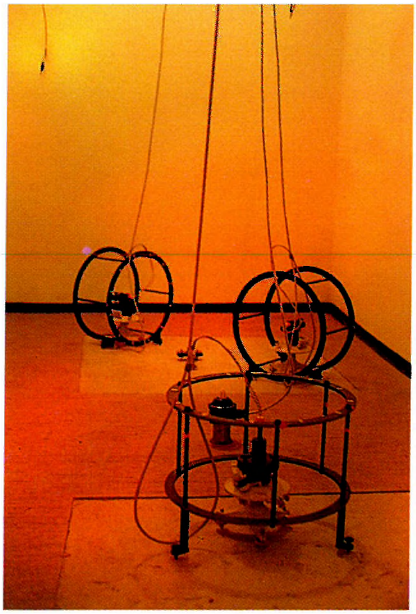


Fig. 4. View of the fluxgates mounted separately on levelled bases, after turning them by 45° (see Fig.3). The components to be recorded can be recognized by the orientations of the Helmholtz coils. *U* and *V* are positioned in the background. For the configuration before that, see Fig.3 in [SCHULZ 1983].

4. ábra. A *Z, U* és *V* műszerek külön-külön szintezett talpakon felállítva, a 45 °-os elfordítás után (ld. 3. ábra). A regisztrálandó komponenseket a Helmholtz tekercs helyzetéből lehet megállapítani. Az *U* és *V* komponenseket regisztráló műszerek a háttérben láthatók. Az ezt megelőző felállást ld. [SCHULZ 1983] 3. ábráján

Рис. 4. Приборы *Z, U* и *V*, установленные на отдельно нивелированных опорах после поворота на 45° (см. рис. 3). Компоненты подлежащие регистрации определяются по положению катушки Гельмгольца. Приборы по регистрации компонент *U* и *V* видны на заднем плане. Предшествовавшую ситуацию см. на рис. Шульц (SCHULZ 1983)

The essential point in this Figure is the run of the base-line *F*, the resolution of which is fifty times higher than that of the components. It can easily be seen that the fluctuation of *F* corresponds to that of *H*. This fact points clearly to cross-talk, because the scale values of *U* and *V* are certain within $5 \cdot 10^{-4}$.

A multiple regression of this recording proved the cross-talk — referred to *F* — to be relatively high for both *U* and *V*:

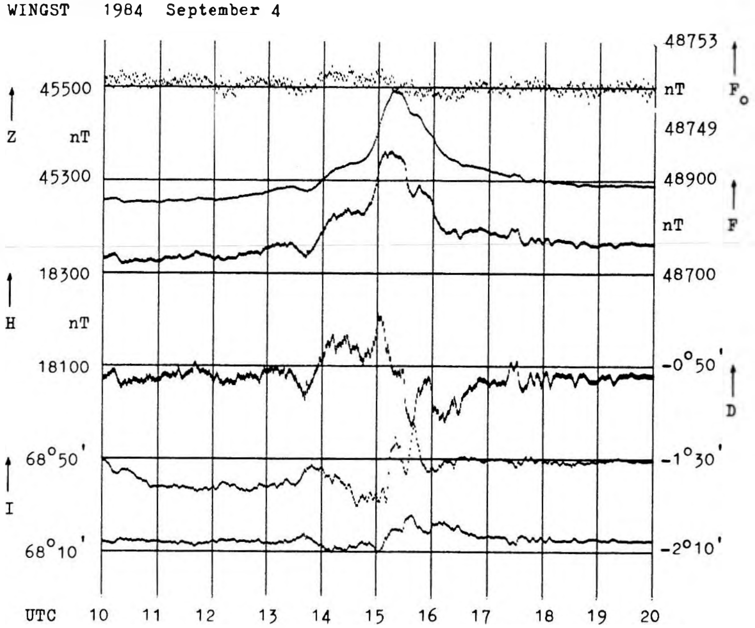


Fig.5. Plotted minute values as a function of UTC. The components *Z*, *H*, and *I* are scaled on the left, *F* and *D* on the right. Top: scatter of base-line *F* scaled on the right. A relationship between *H* and *F* can be recognized.

5. ábra. UTC függvényében ábrázolt perces értékek. A *Z, H* és *I* komponensek a bal oldali skálán, az *F* és *D* komponensek a jobb oldali skálán vannak. Fent: Az F alapvonal szórása. H és F között összefüggés figyelhető meg

Рис. 5. Минутные значения изображенные в зависимости от UTC. Компоненты *Z, H* и *I* находятся на левой, а компоненты *F* и *D* - на правой шкале. Вверху: разброс по опорной линии F. Наблюдется зависимость между *H* и *F*

$$F_0 = C + 10^{-3} (3.36\, U + 2.83\, V - 0.64\, Z),$$

where *C* denotes a constant value without any physical significance. 'Referred to *F*' means that only deviations from the orthogonality of the triple as a whole could have been picked up. That is why *F* does not contain any information about the triple's orientation within the reference coordinate system. The coefficients of *U* and *V* can be interpreted as follows: they are caused by a deviation from orthogonality either of the horizontal fluxgates to each other or of the vertical fluxgate against the perpendicular on the plane spanned by the horizontal fluxgates.

Fig. 6 — a check of the *Z* fluxgate's alignment — indeed revealed a tilting towards the South by some 15'. The Figure shows the reception characteristic of the fluxgate projected into the horizontal plain. The characteristic was obtained by turning the fluxgate round the axis of the tripod, plotting the readings azimuthal against their mean. The outcome of the multiple regression resulted in portions for *U* and *V* according to the two circles. They fit well the coefficients of *Z* — indicated by dots.

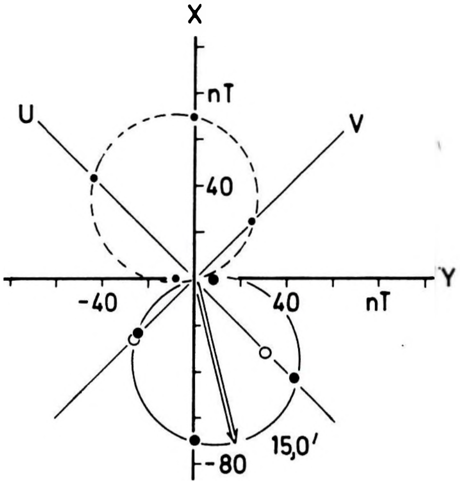


Fig.6. Reception characteristic of the *Z* fluxgate, projected into the horizontal plane, before adjustment. Dots: readings of *Z* referred to their mean value by turning the fluxgate around the tripod's axis; circles: values expected from the result of the multiple regression mentioned in the text. The arrow denotes the direction towards which the fluxgate was tilted.

6. ábra. A *Z* fluxgate vételi tulajdonsága a függőleges síkra vetítve, beállítás előtt. Pontok: A *Z* leolvasási értékei a fluxgate tripód tengely körüli elfordításakor az adatok középértékeire vonatkoztatva. Körök: a szövegben emlitett többszörös regresszió eredményéből várt értékek. A nyíl a fluxgate dőlési irányát jelzi.

Рис. 6. Приемные свойства флюксгейта *Z* в проекции на вертиакльную плоскость перед установкой. Точки: значения отсчета *Z* при повороте флюксгейта вокруг оси треноги, приведенные к средним значениям данных. Кружки: значения ожидаемые по многократной регрессии упомянутой в тексте. Стрелкой обозначено направление наклона флюксгейта

We came to the conclusion that the fluxgate must have been tilted by mistake while the horizontal ones were rotated in May of the same year. The coefficients for *Z* can be used as correction terms in order to cancel the effect of cross-talk when evaluating the recordings.

4. The station theodolite

It has been shown that the base-line stability of *Z* is far from being satisfactory. This problem can be overcome by carrying out base-line measurements more frequently. On the other hand, the variations are recorded with high accuracy due to the fact that the scale values are well known and the alignment of the fluxgates can be monitored and, if necessary, adjusted to within 3' [SCHULZ 1983].

What about the base-line instruments' accuracy? Do they represent IMS? *Table I* shows the result of absolute comparisons between Wingst (WNG) and the observatories Niemegk (NGK), Fürstenfeldbruck (FUR), Witteveen (WIT), Rude Skov (RSV), Brorfelde (BFE), Grocka (GCK), Nurmijärvi (NUR), Belsk (BEL), Hel (HEL) and Tihany (THY) carried out since 1980. It is noteworthy that the difference of *D* shows a systematic portion. The value of some 0.5' towards E (respectively 2 nT) is fairly high.

In November 1987, the difference between the connection measurement pier (SW) and the *D* pier (NE) was checked by the station theodolite itself. Previous results, attained by means of the same method (April 1981 and October 1984), were confirmed. That fact was sufficient motivation for subjecting the theodolite to a thorough investigation.

In the early 'sixties, iron impurities had already been found and were removed within the inserting and revolving device, i.e., rather close to the magnet (Deutsches Hydrographisches Institut, [1965]). In order to trace further possible impurities, a fluxgate was installed in a stationary manner very close to the magnet housing. Then the theodolite was turned around its vertical axis.

Fig. 7 shows the vertical component picked up by the fluxgate (diagonal crosses, left-hand scale). Drawn against the azimuth it clearly shows a double amplitude of some 7 nT.

Measurement			WNG	D	I	F	H	Z		
when		where	minus			nT	nT	nT		
1980	Jun	NGK	NGK	+0.63		-0.1	+2.9		QHM,	PRM
		NGK	RSV	(+0.6)			(-0.6)			
1982	Mar	FUR	FUR	+0.2	+0.1	-1	(-1.7)	(-0.3)	DIF,	PRM
	Jul	WNG	BFE	+0.2			-0.6		QHM	
	Nov	WNG	FUR	+0.21	+0.05	-0.2	(-0.7)	(+0.1)	DIF	PRM
1983	Sep	WNG	FUR						DIF,	PRM
	Dec	WNG	GCK			+0.7			HTM,	PRM
1984	Oct	WNG	WIT	+0.56	+0.06	-1.5	(-1.3)	(-1.1)	DIF,	PRM
1987	Oct	FUR	FUR	+0.40	+0.05	-0.4	(-0.8)	(-0.1)	DIF, PRM	
1988	Apr	WNG	BFE	+0.74	-0.11	-1.0	+1.9	+0.7	DIF,	PRM
		WNG	NGK						PVM	
1989	Feb	FUR	FUR	+0.50	+0.05	+1.5	(0.0)	(+1.7)	DIF,	PRM
	May	NUR	NUR	+0.43	-0.03	+0.4	(+0.5)	(+0.3)	DIF,	PRM
1990	Apr	NGK	NGK	+0.14	-0.38	+1.8	(+5.6)	(-0.4)	DIF,	PRM
		BEL	BEL	+0.49	-0.01	+0.5	(+0.3)	(+0.4)	DIF,	PRM
	May	HEL	HEL	+2.20	+0.35	+3.4	(-3.3)	(+5.0)	DIF,	PRM
	Sep	THY	THY	+0.59	+0.14	-13.1	(-7.6)	(-10.8)	DIF,	PRM *
		FUR	FUR	+0.15	+0.28	-1.9	(-4.3)	(0.0)	DIF,	PRM
		NGK	NGK	+0.45	-0.41	+0.5	(+5.6)	(-1.6)	DIF,	PRM *
1991	Mar	FUR	FUR	+0.58					DIF	*
		BFE	BFE	+0.78					DIF	*
	Apr	BFE	BFE	+0.72					DIF	*

QHM: Quartz Horizontal Magnetometer, PRM: Proton Magnetometer, DIF: Probe Theodolite. Values in parentheses are derived.
Results of comaprison measurements (* preliminary)

Table I. Results of absolute comparison measurements between Wingst (WNG) and the observatories Niemegk (NGK), Rude Sjov (RSV), Brorfelde (BFE), Fürstenfeldbruck (FUR) Witteveen (WIT), Grocka (GCK), Nurmijärvi (NUR), Bels k (BEL), Hel (HEL) and Tihany (THY)

I.Táblázat. A Wingst (WNG), Niemegk (NGK), Rude Sjov (RSV), Brorfelde (BFE), Fürstenfeldbruck (FUR) Witteveen (WIT), Grocka (GCK), Nurmijärvi (NUR), Bels k (BEL), Hel (HEL) és Tihany (THY) obszervatóriumai közti abszolút összehasonlító mérések eredményei

*Таблица I.*_ Результаты абсолютных сравнительных измерений между обсерваториями Уингст (WNG) Нимегк (NGK) Руде Съов (RSV) Брорфельде (BFE) Фюрстенфельдбрук (FUR) Виттевен (WIT) Гроцка (GCK), Нурмиярви (NUR), Бельск (BEL), Гель (HEL) и Тихань (THY)

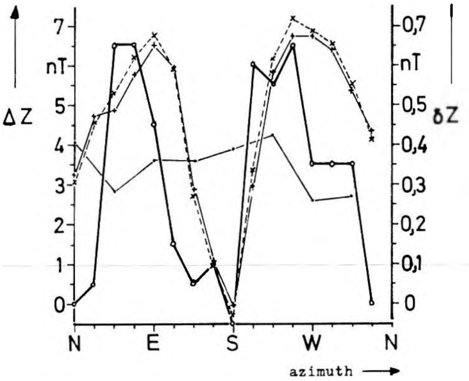


Fig. 7. Fluctuations of the Z component close to the station theodolite's magnet housing picked up while turning the instrument around its vertical axis (azimuth). Diagonal crosses (left-hand scale): without an additional field; vertical crosses (left-hand scale): the same procedure after having over-compensated the Z component by its own amount (-Z), via a Helmholtz coil; circles (right-hand scale): difference between both curves in the sense '-Z minus Z'; dots (left-hand scale): the same procedure as denoted in the first case after having removed permeable magnetic impurities (see text)

7. ábra. Az állomás mágneses teodolitja melletti Z komponens fluktuáció, melyet a műszer függőleges tengelye (azimuth) körüli elforgatásakor vettünk fel. Ikszek (bal oldali skála): kiegészítő mező nélkül; keresztek (bal oldali skála): ugyanaz az eljárás a Z komponens saját összegével való (-Z) kompenzálása után, Helmholtz tekercs segítségével; körök (jobb oldali skála): a két görbe közti különbség '-Z minus Z' irányban; pontok (bal oldali skála): ugyanaz az eljárás, mint az első esetben, a permeábilis mágneses szennyeződés eltávolítása után (lásd a szövegben)

Рис. 7. Флюктуация компоненты Z близ магнитного теодолита станции записанная во время поворота прибора вокруг вертикальной (азимутальной) оси. Иксы (шкала слева): без дополнительного поля. Крестики (шкала слева): то же, после компенсации компоненты Z собственной суммой (-Z) с помощью катушки Гельмгольца; кружки (шкала справа): разность между двумя кривыми в направлении '—Z минус Z'; точки (шкала слева): то же как и в первом случае после удаления проницаемого магнитного загрязнения (см. в тексте

When over-compensating the geomagnetic Z component by its own amount (-Z), the second curve was obtained (vertical crosses, left-hand scale). The field was generated by means of a Helmholtz coil connected to a highly stable DC source. The difference of both curves in the sense '-Z minus Z', indicated by the strong line (circles), is referred to the right-hand scale. Its peak-to-peak variation is just 0.7 nT and can be interpreted as the induced part of magnetism within the magnet housing. This is the only part that matters, because the permanent portion can be averaged away by observing in different positions of the telescope (Deutsches Hydrographisches Institut, [1965]).

The curve in the middle of Fig. 7 (dots) again refers to the left-hand scale and demonstrates the result after removing several parts of the housing and replacing them by new ones, where necessary.

Surprisingly, check measurements with the old parts and the new ones, do not show any significant difference, i.e., the alteration did not cause any shift of the *D* level (*Table II*). The differences in the sense 'telescope South minus North' do not differ significantly from each other either.

1985 July 9			D_0	telescope South minus North
with	new	parts	-1 ° 29.08'	-0.06'
	old		29.03'	-0.11'
	new		28.96'	-0.12'
new	minus	old	+0.01'	+0.02'

Table. II. Magnetic Theodolite Schulze 75, comparison of measurements with old and new parts, respectively (see text).

II. Táblázat. Schulze 75 mágneses teodolit a mérések összehasonlítása régi és új részekkel (ld. szöveg.)

Таблица II. Сопоставление измерений магнитным теодолитом Шульце 75 с прежними и новыми частями (см. в тексте)

The results are interpreted as follows: the impurities discovered within the housing — in their combined effect — had been negligible in such a way that they had not falsified the *D* measurements at any time. That means that the instrument is now virtually free of iron and may — at least in this sense — represent IMS. The reason for the deviation towards the East when comparing with neighbouring observatories is to be considered elsewhere.

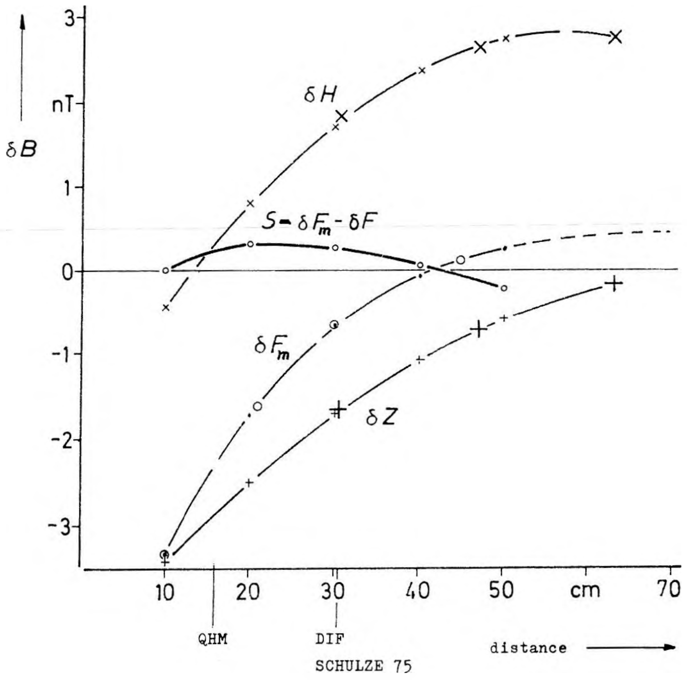


Fig.8. Gradients of pier differences above the connection pier SW in the sense 'NW minus SW'. Enlarged symbols: measured values; small symbols: calculated values. *S* (bold line) denotes the closing error within the magnetic meridian (see text); QHM and SCHULZE 75 mark the positions of the comparison instrument's magnets (quartz horizontal magnetometer or station theodolite, respectively); DIF marks the position of the probe theodolite's fluxgate

8. ábra. Pillérkülönbségek gradiensei a DNy-i kapcsoló pillér fölött 'ÉNy minusz DNy' irányban. Nagy jelek: mért értékek. Kis jelek: számított értékek *S* (vastag vonal) a mágneses meridiánon belüli zárási hibát jelöli (ld. szöveg). QHM (quartz horizontális magnetométer) és Schulze 75 (állomás-teodolit) az összehasonlító műszerek mágneseinek, DIF a próba teodolit fluxgate-jének elhelyezkedését mutatja

Рис. 8. Градиенты разностей между столбами в направлении 'СЗ минус ЮЗ' над юго-западным соединительным столбом. Крупные значки: измеренные значения. Малые значки: расчетные значения. *S* (жирная линия): ошибка при замыкании контура в пределах магнитного меридиана (см. в тексте) 'QHM' (кварцевый горизонтальный магнитометр и 'Schulze 75' (станционный теодолит отмечают положение магнитов сопоставляемых приборов а 'DIF' - флюксгейта пробного теодолита

5. Pier differences

Vertical gradients in *D* above the connection measurement pier can be ruled out as a cause of the deviation discussed in Chapter 4 because the magnet of the station theodolite and the fluxgate of the probe theodolite, i.e., the instrument the standard was transported with, are positioned at the same distance above the pier. On the other hand, gradients are quite possible, as *Fig. 8* shows. The diagram shows the correction for *H*, *Z*, and *F* as functions of the distance above the pier's cover plate, obtained from a set of different measurements. They were carried out by means of a PRM and a probe theodolite.

Within the range of interest, the closing error

$$S = \delta F_m - \delta F$$

$$\text{with} \quad \delta F = 0.37\,\delta H + 0.93\,\delta Z$$

does not become greater than 0.3 nT. As the difference in *F* was measured very accurately, the error must be attributed to *H* and/or *Z*.

6. Conclusion

The examples make it clear that - besides the routine work — considerable effort is necessary in order to preserve the Observatory's standard and, if possible, to improve it. This means that, apart from any considerations, one has to keep pace with the rapid instrumental development.

At Wingst Geomagnetic Observatory (and, of course, at other observatories as well) the introduction of the PRM and its improvements [SCHULZ, CARSTENS 1979] and its development to the proton vector magnetometer [VOPPEL 1969], [VOPPEL 1972] and [SCHULZ 1981] represents an important milestone.

On the other hand, the declination standard, i.e. the station theodolite, was already put into operation in 1928 — four years before the Second International Polar Year — and has not been replaced since. A non-magnetic theodolite of the Zeiss type (DI-flux) may be an alternative.

The introduction of the digital technique in connection with the fluxgate principle resulted in a change of the recording system. However, the base-lines of the modern system do not reach the stability of those of the old photographic apparatus. This is an example showing the need for compromises within the interplay of priorities.

REFERENCES

SCHULZ G. and U. CARSTENS 1979: A period measuring proton magnetometer with a direct readout. Dt.hydrogr. Z. **32**, pp. 119-125.

SCHULZ G., 1981: Base-line measurements of the declination, by means of a proton vector magnetometer, at the Wingst Geomagnetic Observatory (Erdmagnetisches Observatorium Wingst) Dt.hydrogr. Z.**34**, pp. 26-37

SCHULZ G. and D. VOPPEL 1981: A comparison of momentary values between 22 European geomagnetic observatories continued over many years. Manuscript presented at the 4th IAGA Scientific Assembly, Edinburgh, Aug.3-15, 1981

SCHULZ G.1983: Experience with a digital recording magnetometer system at Wingst Geomagnetic Observatory (Erdmagnetisches Observatorium Wingst). Dt.hydrogr.Z.**36**, pp. 173-190

Deutsches Hydrographisches Institut, 1965: Preface in: Ergebnisse der erdmagnetischen Beobachtungen im Observatorium Wingst in den Jahren 1961 und 1962. Deutsches Hydrographisches Institut. Erdmagn.Jahrb. **13**, Hamburg

VOPPEL D. 1969: Ein Spulentheodolit zur Messung der erdmagnetischen Komponenten mit dem Protonenmagnetometer. Z. Geophys. **35**, pp. 151-159.

VOPPEL D.1972: The proton vector magnetometer at Wingst Observatory. Deutsches Hydrographisches Institut. Erdmagn.Jahrb. **17**, pp. 133-149, Hamburg

VOPPEL D. 1988: Some remarks on the history of Wingst Geomagnetic Observatory during the first 50 years. Dt.hydrogr.Z.**41**, pp. 109-117

A WINGSTI MÁGNESES OBSZERVATÓRIUM ÁLLANDÓI - TÖKÉLETESÍTÉSÜK ÉS MEGŐRZÉSÜK NÉHÁNY PÉLDÁN BEMUTATVA

Günter SCHULZ

A földi mágneses tér szekuláris variációjának folyamatos mérése a Bundesamt für Seeschiffahrt und Hydrographie (korábban Deutsches Hydrographisches Institut) wingst-i geomágneses obszervatóriumának legfontosabb feladata. Mivel természeténél fogva a szekuláris mágneses variáció igen lassú folyamat, a mérőeszközöknek - nevezetesen az abszolút-műszereknek és természetesen azoknak a variométereknek, melyeknek bázisait ezen műszerek mérései alapján határozzák meg - több évtizeden keresztül meg kell

őrizniük minőségüket. Másfelől, a műszerfejlesztés eredményeit fel kell használni a minőség megtartásának ill. javításának érdekében. Jelen dolgozat néhány példán keresztül bemutatja, mely területek kaptak jelentőséget az elmúlt években. Az ezzel kapcsolatban felmerült problémák jelzik, hova helyeződtek a mérési pontosság határai.

ПАРАМЕТРЫ МАГНИТНОЙ ОБСЕРВАТОРИИ В УИНГСТЕ ИХ УСОВЕРШЕНСТВОВАНИЕ И СОХРАНЕНИЕ ИЛЛЮСТРИРОВАННОЕ НА НЕКОТОРЫХ ПРИМЕРАХ

Г. ШУЛЬЦ

Задача Магнитной обсерватории в Уингсте заключается в наблюдении вековых изменений магнитного поля. Фундаментальным требованием обсерватории является постоянство (или хотя бы известность) аппаратурных параметров в течении нескольких десятилетий. Наряду с этим имеются значительные достижения в разработке новых видов магнитной аппаратуры. Автором дается характеристика процесса введения новых видов аппаратуры в Обсерватории Уингст с иллюстрациями на примерах.