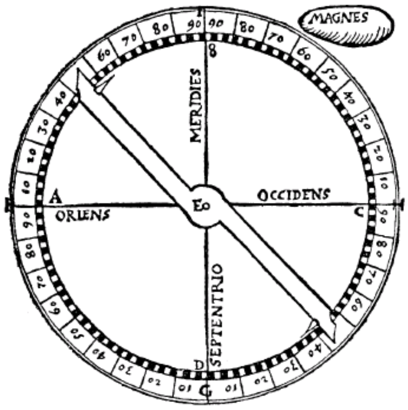
GeoForschungsZentrum Potsdam

Geomagnetic Results Wingst

2000

Yearbook No. 46



Potsdam 2004

Wingst Observatory: The Absolute House on the left and the Variometer House in the background

FGE double system at Wingst Observatory. One of the suspended triples is provided with a coil system constructed after Beblo at al. (1999)

Cover: Compass after Pierre de Maricourt, 1269 (SCHÜCK,1911)

Geomagnetic Results Wingst 2000 – Yearbook No 46

Günter Schulz

Contents

1 Introduction

This report (yearbook No 46) contains the results of Erdmagnetisches Observatorium Wingst (WNG) for 2000. Earlier reports were published by Bundesamt für Seeschiffahrt und Hydrographie[1]).

The enclosed CDrom contains recorded minute values as well as derived (hourly, daily, monthly) mean values and indices. It also provides recalculated epoch values from 1939.5 on and those of Marineobservatorium Wilhelmshaven (WLH) before then. Revised sets of monthly and daily mean values (since 1943) and K values (since 1944) are also included.

Using the visualisation software year.exe, the one-minute, hourly and daily values of the year under review can be displayed as graphs in the same manner as in the years before. High resolution magnetograms for each day are stored as post script files on the CDrom.

In the year under review, Wingst Observatory additionally published on a monthly basis:

a) Reports on geomagnetic indices and special geomagnetic events
b) Reports on preliminary daily and monthly means

Geomagnetic data have been provided on a regular basis to the following institutions:

a) International Space Environment Service (ISES): Geomagnetic indices and geomagnetic events (daily)

b) International Service of Geomagnetic Indices (ISGI): Geomagnetic indices and special geomagnetic events (monthly and annually)

c) World Data Centers for Geomagnetism: Microfiches of pulsation magnetogrammes, geomagnetic indices and one-minute values (annually)

d) INTERMAGNET (Global near-real-time magnetic observatory network): One-minute values (reported data via METEOSAT and Email, hourly; adjusted data via Email, on weekdays); Geomagnetic indices and one-minute values (CDrom, annually)

[1] The last one of these reports (SCHULZ, 2004) contains a complete digital set of all data that have been published since the establishment of Wingst Observatory in 1938.

Indices and information about special events were made available through a telephone service on weekdays.

Phone: +49 4778 812152

The preliminary variations and indices can be found on the Internet on a real time basis (10 min updates) in graphical form:

http://www.gfz-potsdam.de/pb2/pb23/GeoMag/Other/BothObs_e.html

or (update every hour):

http://www.bsh.de/en/Marine%20data/Observations/Geomagnetism/obs.jsp

and in numerical form (update every 10 minutes, pass word required):

ftp://wng@ftp.bsh.de/outgoing/boulder

Definitive (compressed) data from 1939 onwards (minute values since 1981) can be found at:

ftp://ftp.bsh.de/outgoing/wng

The following list shows some additional selected links providing Wingst data:

Intermagnet (variations):
http://www.intermagne.bgs.ac.uk/cgi-bin/imagform

RWC Brussels (indices):
http://sidc.oma.be/products/wng/index.php3

WDC Kyoto (pulsations):
http://swdcdb.kugi.kyoto-u.ac.jp:80/film

WDC Copenhagen (variations):
http://web.dmi.dk/fsweb/projects/wdcc1/obs.html

Address for data requests, data exchange and information:

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Am Olymp 13
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E-mail: guenter.schulz@bsh.de

Collaborators: W.D. Grube and A. Glodek.

2 General Remarks

Wingst Geomagnetic Observatory was established in 1938 as a successor to Wilhelmshaven. Since then, the station has been operated without interruption. The observatory's development is described by VOPPEL, 1988, and SCHULZ, 2001 (see also appendix 3). The development of the modern recording devices is given by SCHULZ, 1998. For the instrumentation since 1938, see also instr.txt on the Cdrom.

The observatory is located in the Lower Elbe area on top of a terminal moraine of the Saale glacial period (elevation 50 m). Its co-ordinates are:

	Latitude	Longitude
Geographic	53° 44.6'N	09° 04.4'E
Geomagnetic	54.2°	95.3°

Geomagnetic co-ordinates refer to DGRF (Definitive Geomagnetic Reference Field) 1980.

The following abbreviations are used throughout this report:

X North component
Y East component
Z Vertical component (downward positive)
H Horizontal intensity
D Declination (eastward positive)
I Inclination (downward positive)
F Total intensity
U North-west component
V North-east component

Times are related to UTC (Co-ordinated Universal Time).

2.1 Recording systems

The results of this edition were derived from the following recording systems:

a) Digital system for variations:

Suspended fluxgate magnetometer (FM) of type FGE(DMI) (*U*, V, Z): One-minute and hourly means as well as indices of activity
Proton precession magnetometer (PPM) of type V75(VARIAN) (F): One minute spot values for quality check only

b) Photographic system for variations of type SCHULZE/LA COUR (*D*, *H* and *Z*; 20 mm h^{-1}): Geomagnetic events (ssc, sfe, bay) and substitute hourly means

c) Photographic system for pulsations of type KIM762(KARMANN) (amplitude and phase characteristics see yearbook 1984): Geomagnetic events (pc, pi)

2.2 Levels, standards and constants

The results of this edition refer to the International Magnetic Standard (IMS). The results of the yearbooks up to and including 1980 referred to the Observatory Standard (OBS), which was represented by the classic type base line instruments bound to their original locations and surroundings.

H, *Z*, and *F* are referred to the proton vector magnetometer (PVM) of type ASKANIA/V4931(VARIAN) on pier NW (section 3.2), *D* to the fluxgate theodolite (DI-flux) of type 010B(ZEISS)/MAG01H(BARTINGTON) on pier NE (section 3.1) of the absolute house. Both instruments are assumed to represent IMS.

The following equations apply to *D* (see yearbook No 37, 1991), *H* and *Z* (see yearbook No 38, 1992):

$D_{OBS} = D_{IMS}$
$H_{OBS} = H_{IMS} + 6.7$ nT
$Z_{OBS} = Z_{IMS} + 11.1$ nT.

The differences for the derived elements depend on the components, i.e. for 2000:

$F_{OBS} = F_{IMS} + 12.8$ nT
$I_{OBS} = I_{IMS} - 0.15'$
$X_{OBS} = X_{IMS} + 6.7$ nT
$Y_{OBS} = Y_{IMS}$

The following physical standards are available at Wingst. They guarantee the quality of data:

SCHWILLE (frequency, DCF77, 10^{-8})
PATEK PHILIPPE and HOPF (UTC, DCF77)
CROPICO VS10 (Voltage, $5 \cdot 10^{-6}$)
GUILDLINE 100 Ohm (resistance, $5 \cdot 10^{-6}$)
Helmholtz coil of high precision (magnetic field strength, 10^{-4})

For the determination of the magnetic induction, the IAGA-recommended gyromagnetic constant (RASMUSSEN, 1991) was used:

$2\pi\tau^{-1} = 23.487203$ nT s

The azimuth marks were last checked by the German Geodetic Survey in 1995. Their values, related to the NE pier (R: 3504926.873, H: 5956702.028), and their deviations in the year under review are:

Azimuth mark	Azimuth	Deviation against
N	3811°.36’	N
NE	13° 23.19’	(-0.14 ±0.04)’
W	308° 42.94’	(-0.01 ±0.03’)

2.3 Special measurements

In the year under review, comparative measurements were carried out at Wingst and at the observatories Fürstenfeldbruck (FUR), Hurbanovo (HRB) and Wien-Kobenzl (WIK). The station differences are as follows:

at	WNG minus	D	I	F
FUR	FUR	-0.19’	-0.05’	0.0 nT
HRB	HRB	+0.01’	-0.06’	+0.1 nT
WIK	WIK	-0.25’	+0.07’	+1.5 nT
WNG	NGK	-0.07’	-0.12’	-1.0 nT

3 Absolute measurements

The absolute measurements were reduced according to the variations of the digital system (section 4).

3.1 Declination and Inclination

Absolute measurements of *D* were made with the *DI*-flux on an approximately monthly basis. Also the determination of *I* was included in the measurement routine. Each measurement is based on a set of four positions. *I* was corrected by the pier difference of -0.2’ in the sense of NW minus NE. The differences $E=I\text{-arctg}(Z/H)$ are shown in Table 1.

Additionally, relative measurements of *D* were carried out with the PVM according to the addition field method (Serson) on a weekly basis. The mean difference in the sense of PVM minus DI-flux of all pairs of measurements carried out on the same day was used as an instrument constant. Its value e is as follows:

e = -23.88’ (11 measurements).

3.2 Horizontal intensity, vertical component and total intensity

Absolute measurements of *H* and *Z* were carried out with the PVM according to the compensation field method (Nelson) after each relative determination of *D.*

The magnetic induction vector is over-determined due to the measurement of three elements within the meridian plane. The difference $c=F-(H^2+Z^2)^{1/2}$ represents the measurements' inherent accuracy. The annual mean of the error c amounted to:

+0.5 nT ± 0.4 nT value (52 measurements).

C is shown in Table 1.

As a rule, the PPM of type V75 was used. This instrument shows a long-term drift of some 0.1 nT depending on the components (SCHULZ AND CARSTENS, 1979).). Therefore, comparative measurements using the PPM of type V4931, which represents IMS (see section 2.2), were carried out on a monthly basis. All base line values as well as the recorded minute spot values of *F* (section 4) are referred to this instrument.

4 Digital recording system

Minute mean values of the orthogonal components *U*, *V*, and *Z* as well as spot values of *F* were acquired by the primary digital system (V75 and FGE (No 125), section 2.1). The PPM is not only part of the recording system but also serves as an indicator of the PVM (section 3).

Owing to over-determination, outliers, jumps and short-term base line instabilities between the dates of absolute measurements of all three components could be detected (section 4.1) and, under certain conditions, automatically eliminated. The following equation applies to Wingst:

$dF = 0.26\ dU + 0.26\ dV + 0.93\ dZ.$

Additionally, a forth fluxgate was operated, which had been aligned in such a way that its W orientation satisfies the following equation:

$dW = 0.578(dU + dV + dZ).$

In this way, jumps and outliers of the secondary system could be monitored independently.

A second suspended FM of type FGE (No 126), an FM of type EDA FM100B and a PPM of type PPM105(EDA) were operated as stand-by devices in case of failure of the primary system.

4.1 Base line values

Table 1 shows the base line values of the FGE125 referred to IMS. Fig 1 shows the results in graphical form. Absolute measurements of *D* and I (DI-flux) are marked by circles, those of *H* and *Z* (PVM) as well as relative measurements of D by dots. *I* (derived from H and Z) is also displayed (dots).

To obtain base line values, the dependence of the measured elements *D*, *H, I* and *F* on the recorded components *U*, *V*, and *Z* within the range of variations was developed up to terms of second order (section 6). Minute mean values of the magnetometer and the baseline instruments were processed, which had been synchronized within ±5 s.

For 2000, the base line values of the primary components refer to the following equivalent voltages *E* of the fluxgate compensation fields:

Component	*E* in mV (nominal)
U	12861
V	12613
Z	45463

4.2 Scale values, temperature coefficients and cross talk

Scale values and cross talk were traced back to the respective parameters of the old FM100C(EDA) system by employing stochastic methods, making use of strong variations during a substorm on April 7, 1995 (SCHULZ, 1998). The following values apply to the primary components (FGE125):

	Scale Values in nT/mV 1.000+	Cross Talk against FM100C in 10^{-3}	
U	$+10^{-3}(1.4 \pm 0.6)$	V: +0.2±1.0	Z: +0.9±0.6
V	$-10^{-3}(1.5 \pm 0.8)$	U: -0.7±0.6	Z: -0.5±0.4
Z	$+10^{-3}(0.8 \pm 0.6)$	U: -0.6±0.4	V: -1.2±0.8

Considering the respective values of the FM100C (see yearbook No 41, 1995), the absolute misalignments and errors of the scale values of the FGE125 fluxgates probably do not exceed the order of magnitude of 10^{-3}.

Temperature coefficients were neglected because the FGE double system had been installed in the old variometer room (SCHULZ 2001) with almost perfect temperature control (contact thermometers, ±0.03°C).

5 Data processing

The base line values (Tables 1) were smoothed by Bathspline approximation in steps of 0.01‘ for *D* or 0.1 nT for *H* and *Z*, respectively (SCHOTT, 1992).

Hourly mean values were formed using 60 minute mean values of U, V, and Z (taken at minutes 00 to 59 UTC and centred at second 30) as well as 60 F spot values (taken at second 05).

The international quiet (*Q*) and disturbed (*D*) days were taken from the Niemegk listings of ISGI. *A* denotes normal days. In the case of averaging, *A* means that all days of the month or the year, respectively, have been included.

The data were processed by a computer double system of type HP9000 330/360. Each workstation is connected to a data acquisition unit of type HP3852 and to the Internet. All necessary calculations including those for the yearbook were carried out by the workstation of type HP9000 360.

6 Indices

The indices presented in this edition (File wng00.k and Table 4) indicate the local disturbances of the geomagnetic field resulting from particle radiation. Their meaning in detail:

K: geomagnetic three-hourly index, quasi-logarithmic measure of the maximum disturbance in steps of 0 to 9; lower limit for *K* = 9: 500 nT

sum: Sum of the eight three-hourly indices of a day

Ak: Mean value of the equivalent amplitudes derived from the eight three-hourly indices. The mean value of the daily disturbance of the geomagnetic field is 2 *Ak* nT

Ck: daily character figure derived from *Ak* and scaled from 0.0 to 2.5.

C: estimated daily character figure; scale: 0, 1, 2

The indices were derived using the IAGA-recommended FMI-routine (Häkkinen, 1992).

7 Files on the CDrom

\wingst *Wingst root directory, containing the following subdirectories and files*

tree_00.txt: File structure

info.txt: Information on the operating system

yearb00\: *Directory containing this report (yearbook No 46), tables 5 and 6, magnetograms and a reprint*

yearb00\yearb00.pdf: This report

yearb00\tabs5_00\: Directory containing tables wngYYmmm.e of hourly and daily mean values for the month mmm of the element e data (*D* in 0.1', *H* and *Z* in nT).

yearb00\tabs6\tab6_00.txt: Tables of indices

yearb00\mags00\dhz2000mmdd.ps: Magnetograms (post script) of the day dd in the month mm

yearb00\instr.txt: Instruments used since 1938

yearb00\wng6dec.pdf: Reprint of SCHULZ, 2001

progs\: *Directory containing software*

progs\year.exe: Visualisation programme for hourly and daily mean values as well as one-minute values located in data\2000

progs\readme.txt: Notes concerning operation of the programme year.exe and the meaning of the parameters in year.ini

progs\setup.bat: Installs the programme year under the local directory c:\year and starts the visualisation software

data00\: *Directory containing the following data*

data00\wlh+wng.yr: Updated epoch values WLH and WNG (*D* and *I* in 0.1'; *F*, *H*, *X*, *Y*, and *Z* in nT)

data00\wng.mon: Updated monthly mean values WNG (since 1943; *D* and *I* in 0.1'; *F*, *H*, *X*, *Y*, and *Z* in nT) data00\wng.day: Updated daily mean values WNG (since 1944; *D* and *I* in 0.1'; *F*, *H*, *X*, *Y*, and *Z* in nT)

data00\wng.k: Updated activity figures *K*, *Ak*, *Ck*, and *C* as well as monthly and annual mean values of *Ak*, *Ck,* and *C* (since 1944)

yearb.exe input files:

data00\hour00\wng00mmm.wdc: Hourly mean values of the month mmm in the format WDC (ICSU, 1989); yearb.exe input files

data00\min00mm\wng00mmm.0nn: One-minute values of the days nn for the month mm or mmm, respectively, in the format WDC (ICSU, 1989); yearb.exe input files

data00\iaga00\: Directory containing the following data in the IAGA2000 format (http://www.ngdc.noaa.gov/IAGA/wg2)

data00\iaga00\YR.WNG: Epoch values WNG starting 1939 (from 1981 on: *D* and *I* in 0.01´; *X, Y, Z, H* and *F* in 0.1 nT; before then: 0.1' or 1 nT, respectively)

data00\iaga00\2000MT.WNG: Monthly means (*D* and *I* in 0.01'; *X, Y, Z, H* and *F* in 0.1 nT)

data00\iaga00\2000DY.WNG: Daily means (*D* and *I* in 0.01'; *X, Y, Z, H* and *F* in 0.1 nT)

data00\iaga900\2000mmHR.WNG: Hourly means (*F, X, Y* and *Z* in 0.1 nT) of the month mm

data00\iaga00\2000mmMN.WNG: Minute means (*F, X, Y* and *Z* in 0.1 nT) of the month mm

8 References

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

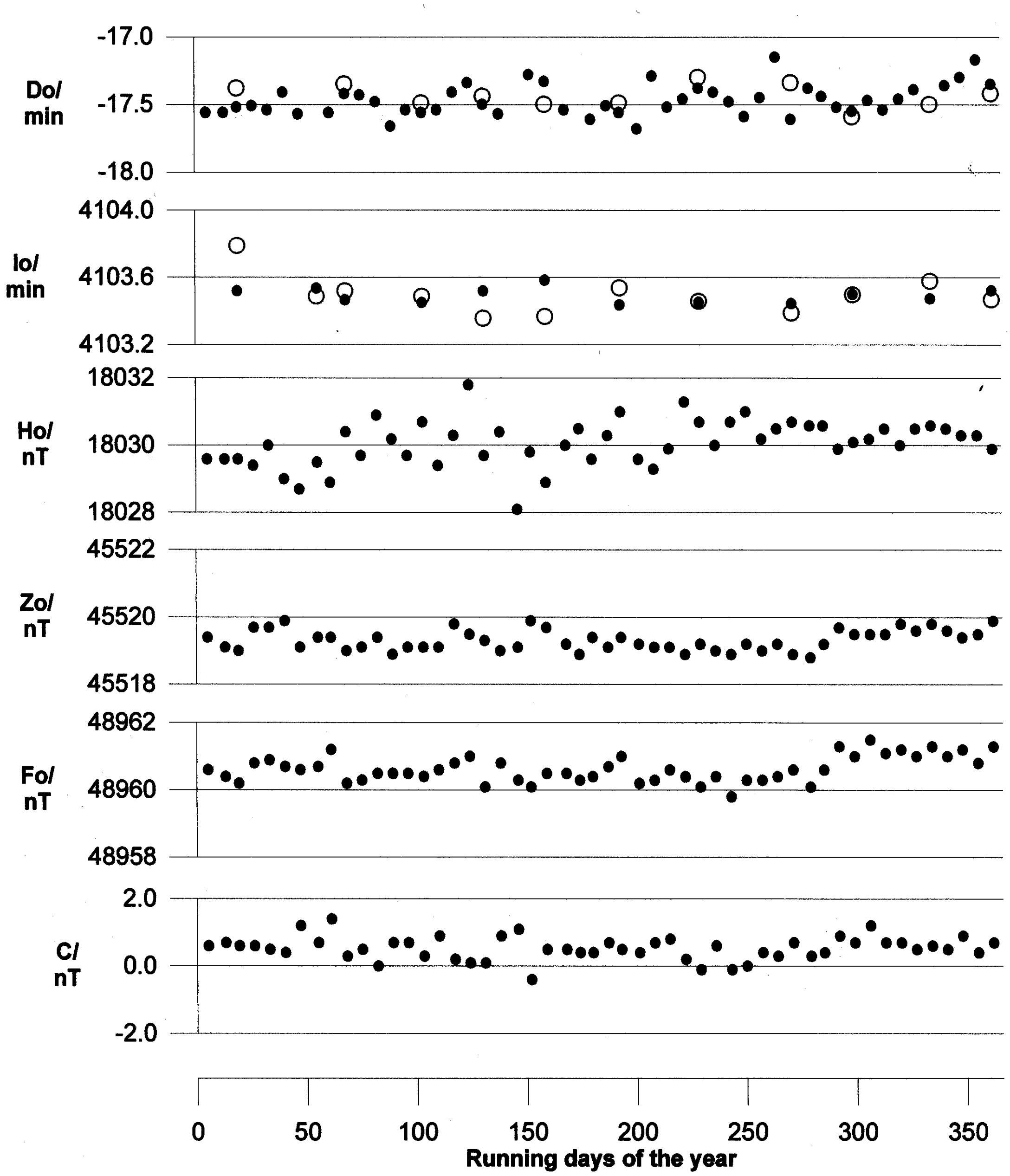

Fig. 1

Wingst 2000 Base line values of the fluxgate system FGE125, IMS

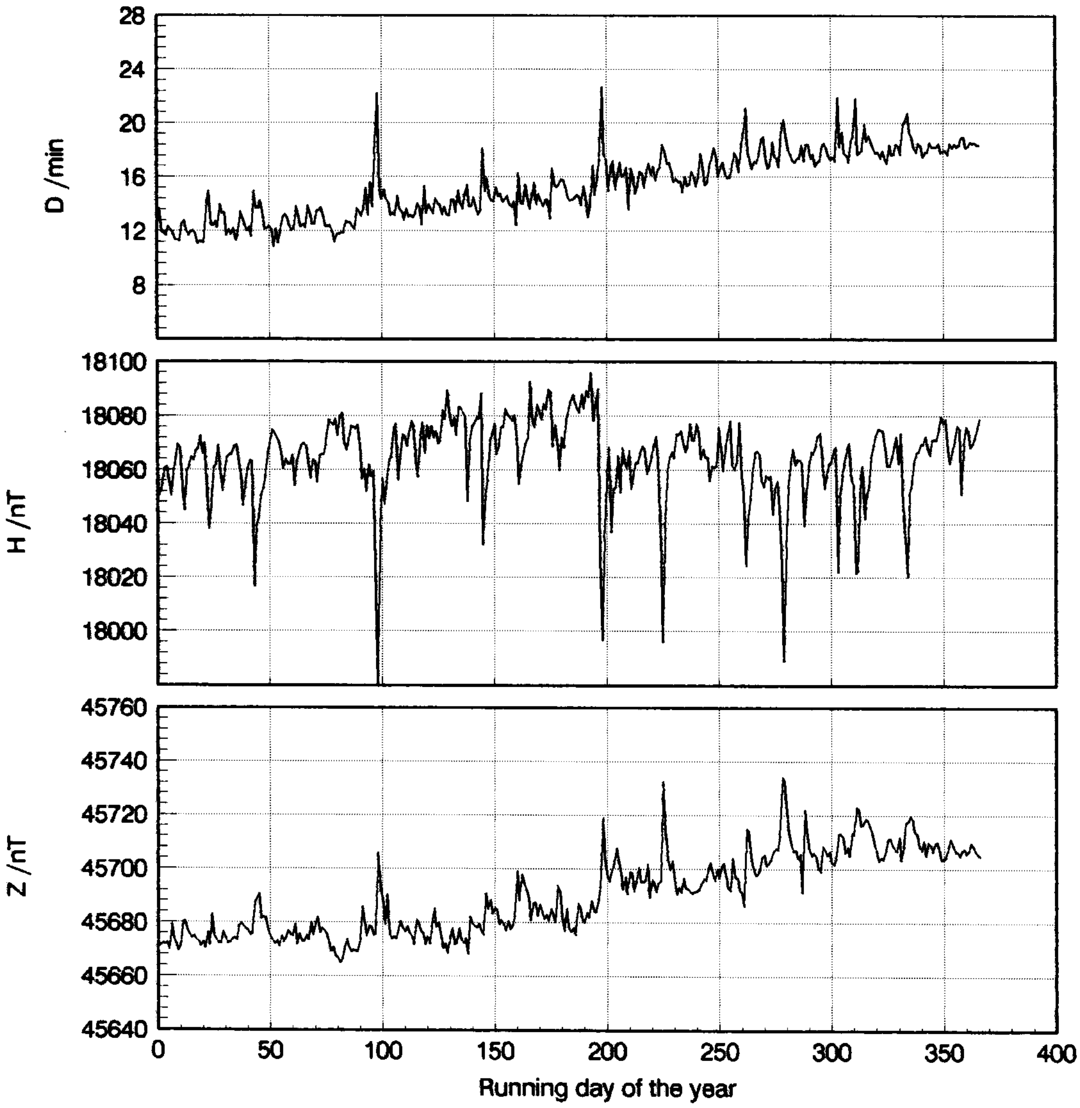

Fig. 2

Wingst 2000 Daily mean values D, H and Z

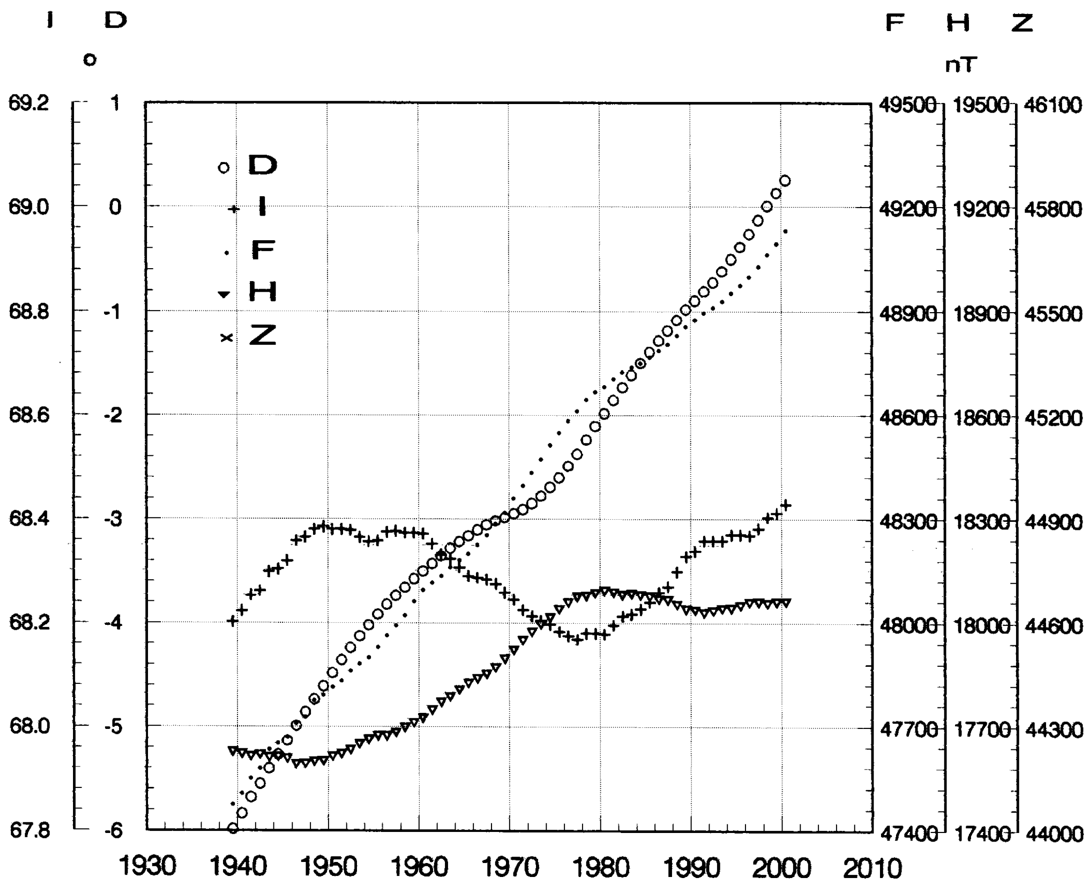

Fig. 3

Wingst Epoch values I, D, F, H and Z

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                yearb00.pdf
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                        wng00dec.h
                        wng00dec.z
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                mags00\dhz20001231.ps
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                wng6dec.pdf
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                year.ini
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                cga.bgi
                egavga.bgi
                herc.bgi
                vesa16.bgi
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                wng.day
                wng.k
                hour00\
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                        wng00dec.wdc
                min0001\
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                        200012HR.WNG
```

Fig. 4

Structure of the file set on CDrom

Wingst 2000

Base-line measurements, system FGE125, IMS

Month	day	Do(abs)	Do(rel)	Io	Fo nT	Ho nT	Zo nT	C	E
Jan.	5		-0°17.56'		48960.6	18029.6	45519.4	+0.6	
	13		-0 17.56		48960.4	18029.6	45519.1	+0.7	
	19	-0°17.38'	-0 17.52	+68°23.79'	48960.2	18029.6	45519.0	+0.6	+0.27'
	26		-0 17.51		48960.8	18029.4	45519.7	+0.6	
Feb.	2		-0 17.54		48960.9	18030.0	45519.7	+0.5	
	9		-0 17.41		48960.7	18029.0	45519.9	+0.5	
	16		-0 17.57		48960.6	18028.7	45519.1	+1.2	
	24		+* 39.99	+68 23.49	48960.7	18029.5	45519.4	+0.7	-0.05
March	1		-0 17.56		48961.2	18028.9	45519.4	+1.5	
	8	-0 17.35	-0 17.42	+68 23.52	48960.2	18030.4	45519.0	+0.3	+0.05
	15		-0 17.43		48960.3	18029.7	45519.1	+0.5	
	22		-0 17.48		48960.5	18030.9	45519.4	+0.0	
	29		-0 17.66		48960.5	18030.2	45518.9	+0.7	
April	5		-0 17.54		48960.5	18029.7	45519.1	+0.7	
	12	-0 17.49	-0 17.56	+68 23.49	48960.4	18030.7	45519.1	+0.3	+0.04
	19		-0 17.54		48960.6	18029.4	45519.1	+0.9	
	26		-0 17.41		48960.8	18030.3	45519.8	+0.2	
May	3		-0 17.34		48961.0	18031.8	45519.5	+0.1	
	10	-0 17.44	-0 17.50	+68 23.36	48960.1	18029.7	45519.3	+0.2	-0.16
	17		-0 17.57		48960.8	18030.4	45519.0	+0.9	
	25				48960.3	18028.1	45519.1	+1.1	
	31		-0 17.28		48960.1	18029.8	45519.9	-0.4	
June	7	-0 17.50	-0 17.33	+68 23.37	48960.5	18028.9	45519.7	+0.5	-0.21
	16		-0 17.54		48960.5	18030.0	45519.2	+0.5	
	22				48960.3	18030.5	45518.9	+0.4	
	28		-0 17.61		48960.4	18029.6	45519.4	+0.4	
July	5		-0 17.51		48960.7	18030.3	45519.1	+0.7	
	11	-0 17.49	-0 17.56	+68 23.54	48961.0	18031.0	45519.4	+0.5	+0.10
	19		-0 17.68		48960.2	18029.6	45519.2	+0.4	
	26		-0 17.29		48960.3	18029.3	45519.1	+0.7	
Aug.	2		-0 17.52		48960.6	18029.9	45519.1	+0.8	
	9		-0 17.46		48960.4	18031.3	45518.9	+0.2	
	16	-0 17.30	-0 17.38	+68 23.46	48960.1	18030.7	45519.2	-0.1	+0.01
	23		-0 17.41		48960.4	18030.0	45519.0	+0.6	
	30		-0 17.48		48959.8	18030.7	45518.9	-0.1	
Sep.	6		-0 17.59		48960.3	18031.0	45519.2	+0.0	
	13		-0 17.45		48960.3	18030.2	45519.0	+0.4	
	20		-0 17.15		48960.4	18030.5	45519.2	+0.2	
	27	-0 17.34	-0 17.61	+68 23.39	48960.6	18030.7	45518.9	+0.7	-0.06
Oct.	5		-0 17.38		48960.1	18030.6	45518.8	+0.3	
	11		-0 17.44		48960.6	18030.6	45519.2	+0.4	
	18		-0 17.52		48961.3	18029.9	45519.7	+0.9	
	25	-0 17.59	-0 17.55	+68 23.50	48961.0	18030.1	45519.5	+0.7	+0.00
Nov.	1		-0 17.47		48961.5	18030.2	45519.5	+1.2	
	8		-0 17.54		48961.1	18030.5	45519.5	+0.7	
	15		-0 17.46		48961.2	18030.0	45519.8	+0.7	
	22		-0 17.39		48961.0	18030.5	45519.6	+0.5	
	29	-0 17.50	-0 17.03	+68 23.58	48961.3	18030.6	45519.8	+0.6	+0.10
Dec.	6		-0 17.36		48961.0	18030.5	45519.6	+0.5	
	13		-0 17.30		48961.2	18030.3	45519.4	+0.9	
	20		-0 17.17		48960.8	18030.3	45519.5	+0.4	
	27	-0 17.42	-0 17.35	+68 23.47	48961.3	18029.9	45519.9	+0.7	-0.05

Table 1 Wingst 2000 base line values of the fluxgate system FGE125

Wingst (WNG)
Geographic Coordinates: 53.743° N 9.073° E

2000

Monthly mean values, IMS

D: disturbed, Q: quiet, A: all days

Month		D	F nT	H nT	I	X nT	Y nT	Z nT
Jan	A	12.3'	49115	18060	68°25.6'	18060	64	45674
Feb	A	12.5	49118	18060	68 25.6	18060	66	45677
Mar	A	12.7	49118	18069	68 24.9	18069	67	45673
Apr	A	14.3	49120	18061	68 25.6	18061	75	45679
May	A	14.3	49123	18073	68 24.8	18073	75	45678
Jun	A	14.6	49131	18076	68 24.8	18076	77	45685
Jul	A	15.7	49134	18067	68 25.5	18067	82	45692
Aug	A	16.2	49138	18064	68 25.9	18064	85	45697
Sep	A	17.4	49139	18060	68 26.2	18060	91	45700
Oct	A	18.0	49146	18055	68 26.8	18055	94	45709
Nov	A	18.4	49149	18058	68 26.6	18058	97	45712
Dec	A	18.3	49150	18070	68 25.8	18070	96	45708
Mean	A	15.4	49132	18064	68 25.7	18064	81	45690
Jan	Q	11.4	49116	18068	68 25.0	18068	60	45672
Feb	Q	12.0	49119	18068	68 25.1	18068	63	45676
Mar	Q	12.4	49118	18074	68 24.6	18074	65	45672
Apr	Q	13.5	49122	18071	68 24.9	18071	71	45677
May	Q	13.9	49123	18081	68 24.2	18081	73	45674
Jun	Q	15.3	49130	18074	68 24.9	18074	80	45685
Jul	Q	15.2	49133	18075	68 24.9	18075	80	45687
Aug	Q	16.0	49136	18071	68 25.3	18071	84	45692
Sep	Q	16.5	49138	18070	68 25.4	18070	87	45695
Oct	Q	17.6	49147	18062	68 26.3	18062	93	45708
Nov	Q	17.5	49149	18072	68 25.6	18072	92	45705
Dec	Q	18.2	49149	18077	68 25.3	18077	96	45705
Mean	Q	15.0	49132	18072	68 25.1	18072	79	45687
Jan	D	13.7	49112	18050	68 26.2	18050	72	45675
Feb	D	13.4	49117	18046	68 26.7	18046	70	45682
Mar	D	13.2	49119	18059	68 25.7	18059	70	45679
Apr	D	16.7	49115	18036	68 27.3	18036	88	45684
May	D	15.2	49120	18059	68 25.7	18059	80	45679
Jun	D	13.7	49135	18081	68 24.5	18081	72	45687
Jul	D	17.3	49133	18049	68 26.9	18049	91	45698
Aug	D	17.1	49137	18046	68 27.2	18046	89	45704
Sep	D	19.0	49135	18044	68 27.3	18044	100	45703
Oct	D	19.5	49144	18027	68 28.8	18027	102	45719
Nov	D	20.0	49145	18031	68 28.6	18031	105	45718
Dec	D	18.3	49148	18065	68 26.0	18065	96	45708
Mean	D	16.4	49130	18049	68 26.7	18049	86	45695

Table 2 Monthly and annual mean values 2000
Wingst (WNG)

Geographic Coordinates: 53.743°N 9.073°E

Annual mean values (IMS)

Epoch	D	F nT	H nT	I	X nT	Y nT	Z nT
1939.5	-5°59.1'	47476	17630	68°12.1'	17534	-1838	44081
1940.5	-5 50.2	47506	17624	68 13.4	17533	-1792	44116
1941.5	-5 40.8	47550	17617	68 15.2	17530	-1744	44166
1942.5	-5 33.1	47579	17622	68 15.7	17540	-1705	44196
1943.5	-5 24.2	47634	17614	68 18.0	17535	-1659	44259
1944.5	-5 16.2	47652	17616	68 18.3	17541	-1618	44276
1945.5	-5 8.2	47671	17611	68 19.2	17540	-1577	44299
1946.5	-4 59.6	47708	17595	68 21.5	17528	-1532	44346
1947.5	-4 51.7	47726	17596	68 22.0	17532	-1491	44365
1948.5	-4 44.4	47775	17602	68 22.9	17541	-1454	44415
1949.5	-4 36.6	47791	17604	68 23.2	17547	-1415	44431
1950.5	-4 29.1	47814	17617	68 22.9	17562	-1378	44451
1951.5	-4 21.5	47832	17624	68 22.8	17573	-1339	44468
1952.5	-4 14.5	47861	17636	68 22.7	17587	-1304	44494
1953.5	-4 7.6	47882	17653	68 22.0	17607	-1270	44510
1954.5	-4 1.3	47899	17666	68 21.5	17623	-1239	44523
1955.5	-3 55.1	47930	17676	68 21.6	17634	-1208	44552
1956.5	-3 49.3	47964	17676	68 22.6	17636	-1178	44589
1957.5	-3 44.2	47993	17686	68 22.6	17648	-1152	44616
1958.5	-3 39.5	48023	17700	68 22.4	17663	-1129	44643
1959.5	-3 34.6	48062	17714	68 22.4	17679	-1105	44679
1960.5	-3 30.1	48095	17727	68 22.4	17693	-1082	44710
1961.5	-3 25.7	48117	17751	68 21.1	17719	-1061	44723
1962.5	-3 21.3	48136	17773	68 20.0	17742	-1040	44735
1963.5	-3 16.9	48160	17789	68 19.4	17760	-1018	44755
1964.5	-3 13.1	48183	17810	68 18.4	17782	-1000	44771
1965.5	-3 9.6	48201	17829	68 17.5	17802	-983	44783
1966.5	-3 6.3	48226	17842	68 17.3	17815	-966	44805
1967.5	-3 3.4	48254	17855	68 17.1	17829	-952	44830
1968.5	-3 1.0	48286	17874	68 16.5	17849	-941	44857
1969.5	-2 59.2	48320	17899	68 15.5	17874	-932	44883
1970.5	-2 56.9	48359	17924	68 14.7	17900	-922	44915
1971.5	-2 54.5	48397	17953	68 13.6	17930	-911	44944
1972.5	-2 51.0	48434	17977	68 12.9	17954	-894	44975
1973.5	-2 46.6	48473	17999	68 12.2	17978	-872	45008
1974.5	-2 41.4	48513	18018	68 11.9	17998	-846	45043
1975.5	-2 36.0	48549	18043	68 11.0	18024	-818	45073
1976.5	-2 29.3	48583	18062	68 10.5	18045	-784	45101
1977.5	-2 22.4	48612	18078	68 10.1	18062	-748	45126
1978.5	-2 14.1	48646	18081	68 10.9	18066	-705	45161
1979.5	-2 6.3	48668	18089	68 10.9	18076	-664	45181
1980.5	-1 59.0	48682	18096	68 10.7	18085	-626	45194
1981.5	-1 51.4	48704	18091	68 11.7	18082	-586	45220
1982.5	-1 43.9	48724	18084	68 12.8	18076	-546	45244
1983.5	-1 36.9	48738	18087	68 13.0	18080	-510	45257
1984.5	-1 29.9	48752	18083	68 13.7	18077	-473	45274
1985.5	-1 23.5	48768	18080	68 14.4	18075	-439	45292
1986.5	-1 17.0	48787	18071	68 15.5	18067	-404	45316
1987.5	-1 11.1	48804	18069	68 16.2	18065	-374	45336
1988.5	-1 5.0	48829	18056	68 17.9	18053	-341	45368
1989.5	-59.0	48856	18042	68 19.7	18039	-309	45402
1990.5	-53.9	48875	18041	68 20.3	18038	-283	45423
1991.5	-48.5	48895	18032	68 21.5	18031	-255	45448
1992.5	-43.4	48911	18038	68 21.5	18037	-228	45463
1993.5	-37.1	48928	18044	68 21.6	18043	-195	45479
1994.5	-30.0	48952	18045	68 22.2	18044	-158	45505
1995.5	-23.0	48975	18053	68 22.2	18053	-121	45526
1996.5	-15.6	48998	18062	68 22.1	18062	-82	45547
1997.5	-7.6	49028	18063	68 22.9	18063	-40	45579
1998.5	0.5	49062	18059	68 24.2	18059	3	45618
1999.5	8.0	49094	18063	68 24.7	18063	42	45651
2000.5	15.4	49132	18064	68 25.7	18064	81	45690

Table 3 Wingst Epoch values from 1939 to 2000

Wingst (WNG)
Geographic Coordinates: 53.743°N 9.073°E

2000

Absolute and relative Frequencies of the Three-hourly Index K

K	UTC 0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
0	24	24	7	7	2	12	10	14
1	59	63	103	76	61	59	51	38
2	100	117	135	123	128	105	95	104
3	100	107	81	116	102	93	106	95
4	53	34	28	33	49	58	48	78
5	19	16	9	7	14	25	42	27
6	7	5	2	4	9	10	8	7
7	3	0	1	0	1	3	4	0
8	0	0	0	0	0	0	1	0
9	1	0	0	0	0	1	1	3

Absolute Number of Days during the Year for a given K

K	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0	13	8	19	7	1	1	0	7	7	7	10	20	100
1	41	38	62	38	19	30	27	34	25	55	56	85	510
2	81	63	78	81	100	71	76	77	77	68	56	79	907
3	62	57	70	71	71	74	79	74	67	67	60	48	800
4	33	40	16	33	37	41	34	33	40	28	34	12	381
5	14	23	3	6	16	16	20	17	14	9	17	4	159
6	4	3	0	0	3	7	5	5	8	11	6	0	52
7	0	0	0	1	1	0	4	1	1	3	1	0	12
8	0	0	0	1	0	0	0	0	0	0	0	0	1
9	0	0	0	2	0	0	3	0	1	0	0	0	6

Absolute Number of Three-hour-intervals for a given K

Table 4 Statistics of indices 2000

Appendix 3: On the calculation of base-line values using definitive variations

1. Co-ordinate systems

At Wingst Observatory, the elements *D*, *I*, *F*, *Z*, Nelson's H and Serson's *D* are measured using a DI-flux and a PVM (VOPPEL, 1972; SCHULZ, 1981), respectively. On the other hand, variations of the geomagnetic components are recorded by fluxgates aligned towards the co-ordinates *U*, *V* and *Z*, which differ from the geographic co-ordinates *X*, *Y* and *Z*. This system, which is also Cartesian, is derived from the geographic system by 45° counter-clockwise rotation on the horizontal plane (from N to NE). Advantage: due to the small declination at Wingst, both horizontal components *U* and *V* are equally included in the difference between the recorded and calculated *F*.

X (N) and *Y* (E) can be calculated from the recorded components *U* (NW) and *V* (NE) as follows:

(1) $X = a(U+V)$ and $Y = a(V-U)$, with a = sqrt(2)/2

They are analytically connected with the polar co-ordinates D and H:

(2) D = atan(Y/X) and $H = \mathrm{sqrt}(X^2+Y^2)$

Generally, the following applies to the base-line values B_0:

(3) $B_0 = B-b$, with

B = *X*, *Y*, *Z*, *H*, *D*, *I* or *F*	for the elements, and
b = *x*, *y*, *z*, *h*, *d*, *i* or *f*	for the corresponding variations.

Relation (1) applies also to the variations:

$x = a(u+v)$ and $y = a(v-u)$.

2. Determination of definitive variations:

There are two major advantages to having definitive variations available:

Base-line measurements of different elements can be carried out consecutively – and , if appropriate, independently at the same location. In the latter case, the determination of differences between two locations is not necessary.

The readings can be reduced individually according to the variations of the element measured. Freed from external parts, the quality of the readings can be easily checked and outliers detected by assessing their scattering at a given coil/sensor position.

a) D, I, F and Nelson's H:

The elements *D*, *I*, *F*, *Z* and *H* are measured using a DI-flux and a PVM (compensation field method), respectively. The corresponding variations *d*, *i*, *f* and *h* have to be calculated from these elements and from the variations *x*, *y* and *z*. In order to obtain definitive values, this can be done by developing relation (2) according to Taylor's rule within the range of variations up to terms of second order. The results of the latest base-line measurements can be inserted for the coefficients according to (3).The following applies to the elements on the horizontal plane (*d* and *i in radians*):

$$h = 1/H[Xx+Yy+0.5(1-X^2/H^2)x^2+0.5(1-Y^2/H^2)y^2-(XY/H^2)xy)]$$

(4a)

$$d = 1/H^2\ [Xy-Yx-XY/\mathrm{H}^2(x^2-y^2)-((Y^2-X^2)/H^2)xy]$$

Correspondingly, the following applies to the magnetic meridian:

$$f = 1/F[Hh+Zz+0.5(1-H^2/F^2)h^2+0.5(1-Z^2/F^2)z^2-(HZ/\mathrm{F}^2)hz)]$$

(4b)

$$i = 1/F^2[Hz-Zh-HZ/F^2(h^2-z^2)-((Z^2-H^2)/F^2)hz]$$

Even for strong variations (storm), higher terms do not have to be added. They seldom exceed the relative order of magnitude of 10^{-3}.

B-b

are the readings of the elements referred to the respective coil/sensor position, freed from external parts.

b) Serson's D:

The readings S of Serson's *D* (*PVM, addition field method*) can be developed in the same manner. They are given by

$$S^2{}_1 = Z^2+H^2+A^2-2HA\sin(d) \text{ and}$$

(5)

$$S^2{}_2 = Z^2+H^2+A^2+2HA\sin(\mathrm{d}).$$

The horizontal bias field A is either directed eastward (index 1) or westward (index 2), respectively. Applying Taylor's rule, the following expressions can be used to reduce the readings (5)

$$s_1 = 1/S\{Zz+Hh-HAd–0.5/S^2[(S^2-Z^2)z^2+(S^2-H^2)h^2-H^2A^2d^2]+HZhz-HAZzd-H^2Ahd\}$$

and

$$s_2 = 1/S\{Zz+Hh+HAd–0.5/S^2[(S^2-Z^2)\mathrm{z}^2+(S^2-H^2)h^2-H^2A^2d^2]+HZhz+HAZzd+H^2Ahd\},$$

respectively.

Half the difference α in the sense 1 minus 2 is the small correction which has to be applied to the fixed nominal position on the horizontal circle to get the base-line of Serson's *D* referred to the respective coil position:

$$\alpha = S/(2HA)[S_{01}-S_{02}]$$

c) A more simple routine for D, I, F and H:

Going back to the elements *D*, *I*, *F* and *H*, the following simplification provides an faster method from the programmer's point of view. It corresponds to the quadratic solutions (4), but only linear terms are taken into account. Index 1 denotes the terms developed at the positions of the base-line values B_0 most recently calculated, index 2 those at the measured elements :

$$d_1 = 1/H_0^2(X_0y-Y_0x) \qquad d_2 = 1/H^2(-Xy+ Yx)$$

$$i_1 = 1/F_0^2(H_0z-Z_0h) \qquad i_2 = 1/F^2(-Hz+Zh)$$

$$f_1 = 1/F_0(H_0h+Z_0z) \qquad f_2 = 1/F(-Hh-Zz)$$

$$h_1 = 1/H_0(X_0x+Y_0y) \qquad h_2 = 1/H(-Xx-Yy)$$

In this way, half the differences in the sense 1 minus 2

$$b = 1/2(b_1-b_2)$$

are sufficiently accurate and can also be considered definitive.

References:

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

VOPPEL, D. 1972: The proton vector magnetometer at Wingst Observatory – technical data and application. Erdmagn. Jahrb. Nr 17, 133-149