Magnetic Variations in Ile-Ife, Nigeria,1999 - 2003

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Summary

From February 1999 to February 2003 the magnetic field in Ile-Ife, Nigeria, was registered with a three component fluxgate magnetometer, called MarsMag system. The instrument, a surplus engineering model of a satellite magnetometer, was destined for education purposes within a DAAD (German Academic Exchange Service) lectureship at the Department of Geology, Obafemi Awolowo University.

At the same time Sam Ogunade from the Department of Physics was running an Intermagnet observatory on campus. Due to the difficult conditions there, the instruments failed in 1998 and the MarsMag system was installed to fill the gap temporarily. At first, the main purpose was the recording of data for corrections in groundmagnetic surveys.

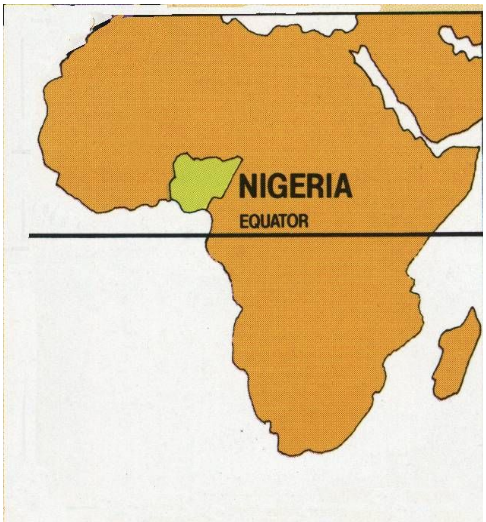
The observatory could not be repaired until now and so the auxiliary system registered a four year long timeseries. Although MarsMag is not an original observatory instrument, it was possible to process and correct the data to meet at least minimum quality standards.

As a first result the Sq- variations at the site were identified. They show strong, interesting seasonal effects. The stabilty of the instrument was good and therefore also long-term drifts over the four years of obser-vation were analyzed. There are significant differences to the actual IGRF model. The question should be discussed, whether this model is not biased due to the small number of observatories at low latitudes.

With the high data rate of 1 reading per second, a large number of shorter events like sfe, ssc, magnetic storm, etc. are also recorded in detail. The corrrelation with data from higher latitudes is possible and might be of interest for satellite data as well. Interested scientists are very welcome to get a copy of the data sets.

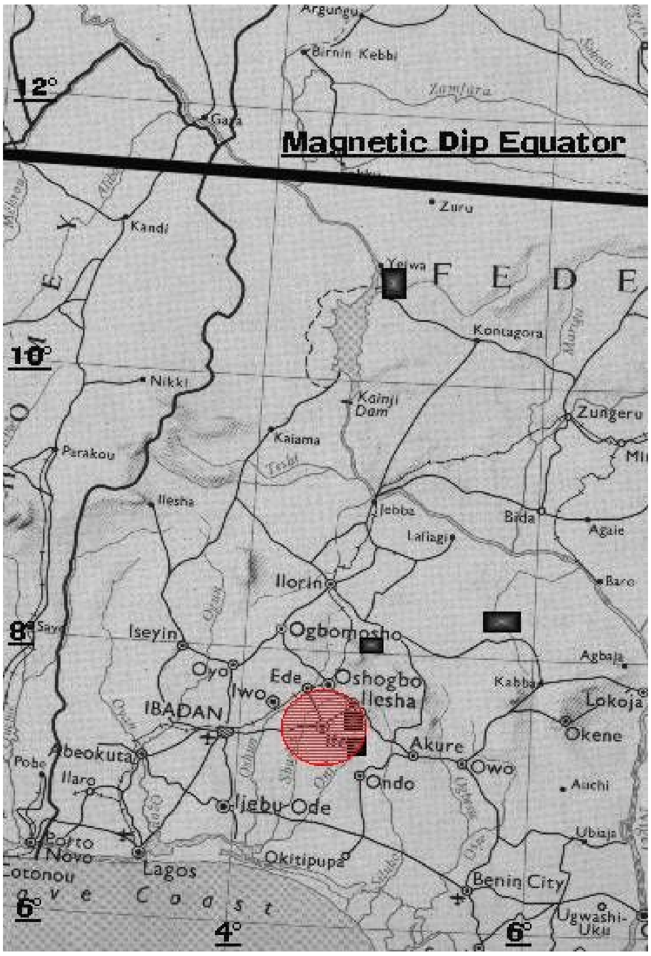
The geomagnetic observatory on the Campus of the Obafemi-Awolowo-University in Ile-Ife

In 1991, Sam Ogunade initated an INTER-MAGNET observatory on the ground of the Obafemi-Awolowo-University (OAU). The campus is close to the city of Ile-Ife in SW Nigeria.



The situation for the observatory was always difficult, first it was built in a remote place where it was burgeled. During the military regime the state authorities were not interested in the universities at all. It was the support from foreign countries (UK, Germany) that allowed the operation at a new place within the staff quaters of OAU.

In 1998 a civil war began in the area, flooding the save campus with refugees and cutting the links between the campus and the city.



Position of the station

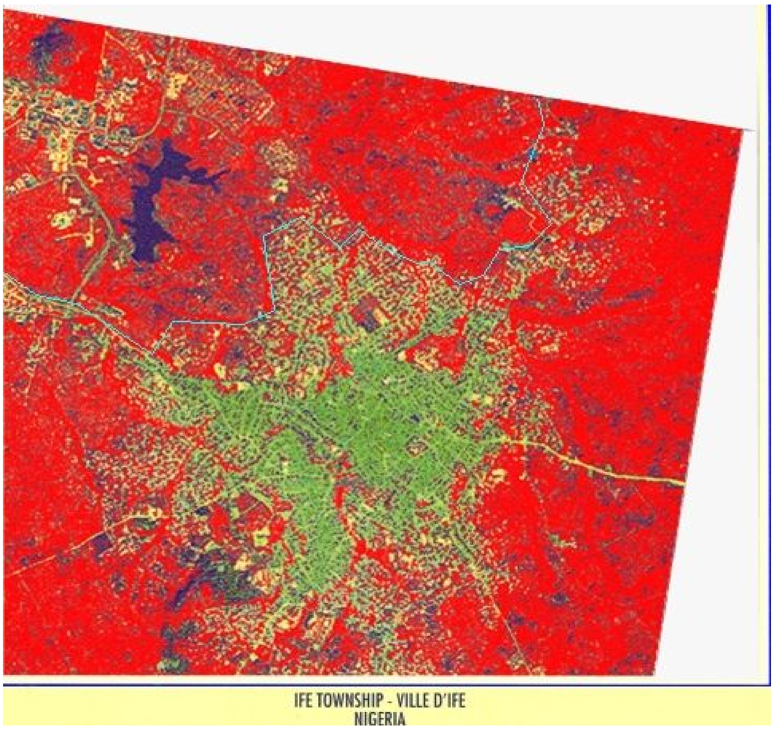
The site is north of the geographic equator, but south of the magnetic dip equator.

The coordinates of the magneto-meter are:

geographic:	Lat.: 7°31'41.3" N Long: 4°32'40.4" E
geomagnetic:	Lat.: 9°54' S Long: 3°56' E

Under these conditions the power supply detoriated and the equipment got damaged. Also the situation for the people becameworse, influencing the operation of the observatory badly: No personal, especially no qualified technician, was available.

Under these circumstances we decided to install MarsMag as an auxiliary fluxgate system at the observatory.



Satellite image of the city of Ile-Ife (250,000 people) and part of the University campus (49 km², top left, blue border).

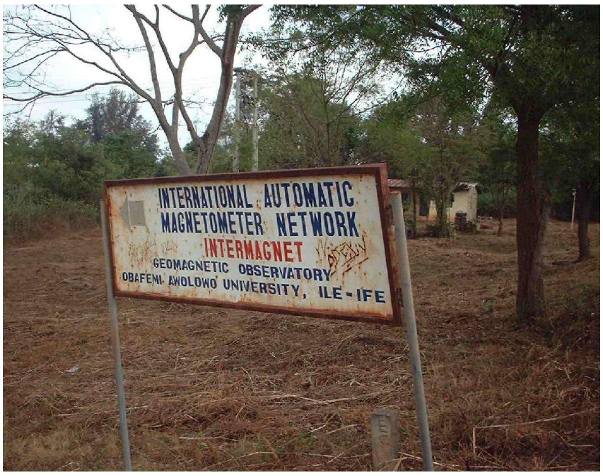
At the Obafemi-Awolowo-University over 25,000 students are registered.

The campus has its own dam and water supply (not always working). A 3 km long highway is leading from the campus gate to the university buildings (top left).

Image from RECTAS, Ile-Ife

The oservatory is close to a road in the staff quaters of OAU. Due to traffic, noise of up to 5nT is produced. Filter technics had to be used to eliminate these influences.

The major advantage of the site is the better security situation on the campus



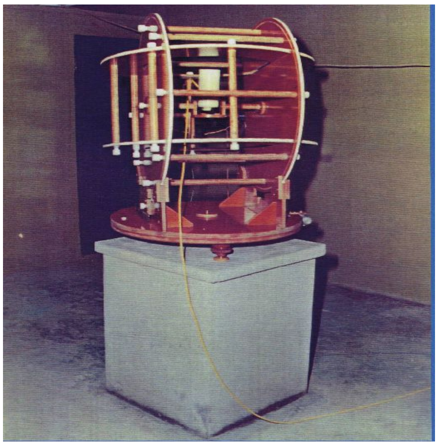
The building hosting the observatory has an iron roof. Repairs and other undocumented technical operations produced severe offsets, which had to be corrected.

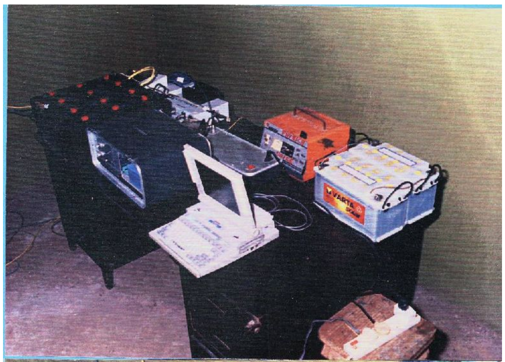
The main problem between 1999 and 2003 was the unstable power supply. Severe power failures happened dayly, partly lasting for weeks. Under- or overvoltages, spikes and humidity destroyed the computer equipment.

Instrumentation at the observatory

The observatory was originally equipped with mechanical, fluxgate and proton-precession magnetometers. Since there is no staff to operate and maintain the systems, none of the magnetometers was in continous operation.

The vector-proton-magnetometer (VPPM, sensor right)) is working, but the data logging system was out of order 1998–2000 and since 12.2002.





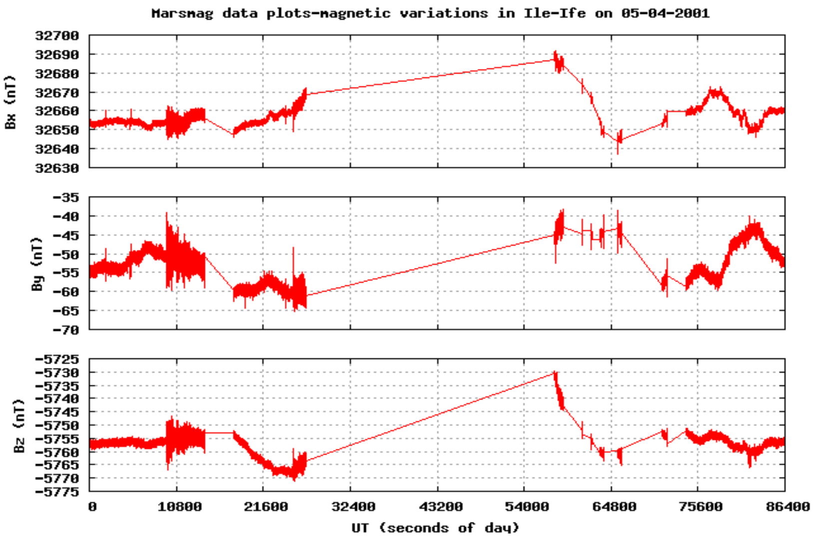
While for the VPPM hardware failures in the data logging systems (left picture, top) were the main problem, the FGM (data logger:left picture bottom) was out of operation because the faulty computer environment (hard- and software for storing the data). The magneto-meter itself is working.

In this situation with the original magneto-meters not running, an auxiliary fluxgate system was installed at the observatory. It was an engineering model for the ESA mission to Mars in 1994/96. The rocket exploded after launch, therefore the magnetometer was now obsolete and could be used for teaching purposes.

Because of reptiles, the sensor had to be covered.

Designed as a satellite instrument, the MarsMag system is very rugged and optimized for low power consumption.While the magnetometer needs only 4W, the computer system for the data-registration consumes 60W. This is the major disadvantage of the setup. The real advantage of the standard PC (386, Dos) is the ease in maintainance. The recording rate is one vector/sec.The internal clock of the computer is synchronized using GPS-receivers. At first, the system was used only as a base station for ground magnetic surveys. Therefore the 3-axis sensor was orientated to magnetic north. The data were reorientated using the IGRF2000 values for the site.

Data registration and processing

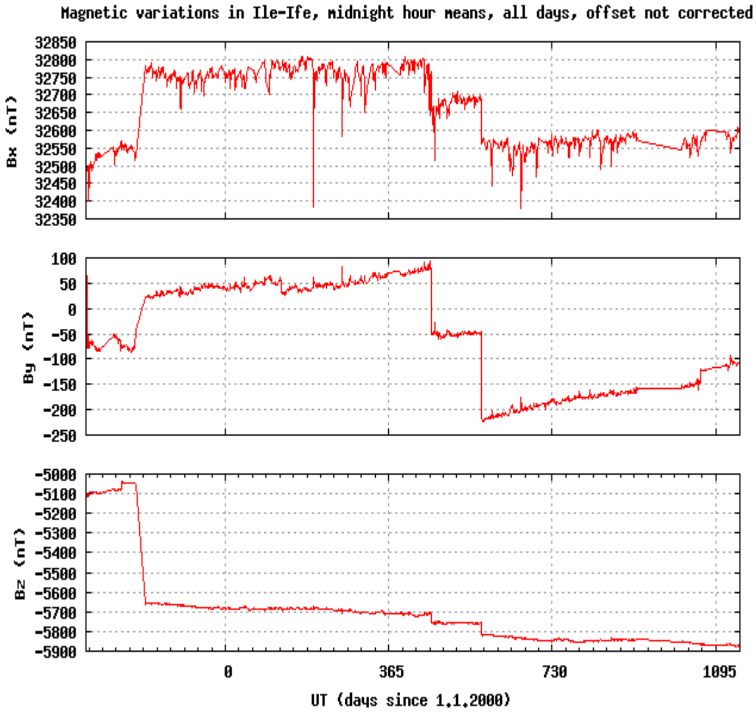


Because the standard PC depends on the 220V power supply, the frequent power failures led to very incomplete data sets (lef t: for 5.4.2001).

In 1999 ca. 40% of the time was covered. Until 2003 this ratio was improved to over 60%. In total 1148 days were recorded between 23.2.1999 and 22.2.2003, summing up to 4.59 Gbyte of raw data.

The procedures used for data recording and preprocessing are:

- System start, clock synchronisation PC-GPS, start of registration
- End of registration after several days, measuring the timeshift PC-GPS
- Storage of raw data, elemination of incomplete datasets (power failures)
- Cutting of raw data into complete sets between the power failures
- Correction of time shifts (PC-clock), cutting of data sets at 0h UT
- Pasting of all data for a single day, storing of the preprocessed dayly records



There are a number of factors not under control influencing the readings. Roof repairs and other works on the building and in the environment were the most serious, leading to the severe offset shown here.

For the correction of the data the following procedures were implemented:

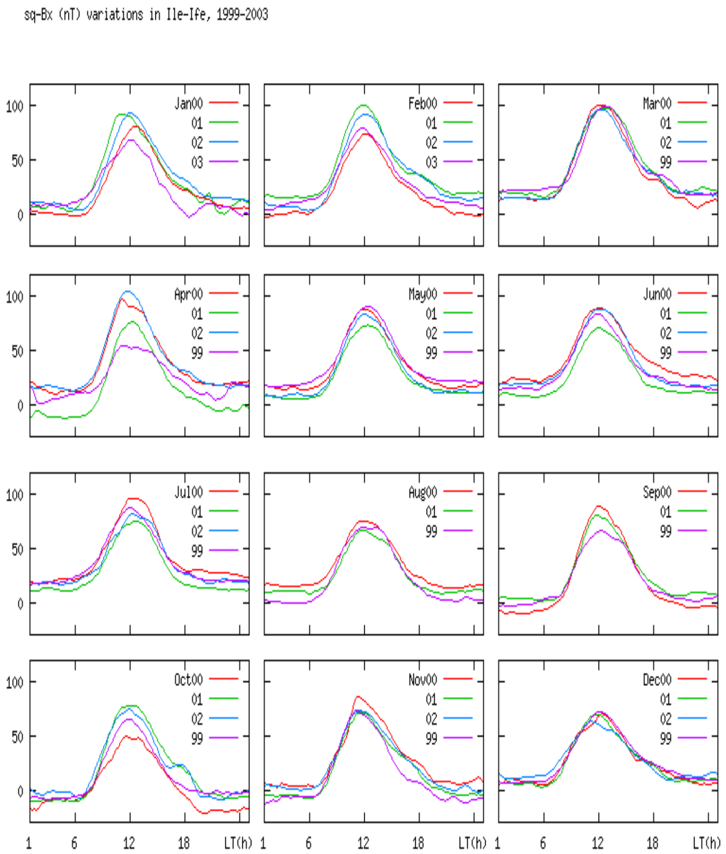
- Calculation of minute/hour means under elmination of spikes
- Identification of offsets in the time series
- Correction of offset in the dayly records
- Reorientation from magnetic to geodetic north (based on the IGRF model for 1.1.2000)

Sq-variations in Ile-Ife

The quietest days (if possible five or more) of each month were picked. Stacking these data, the Sq-variations for each component and month were calculated. The figures (Sq over local time) show the results for each component and 12 month, displaying four curves (1999 – 2003) in one plot.

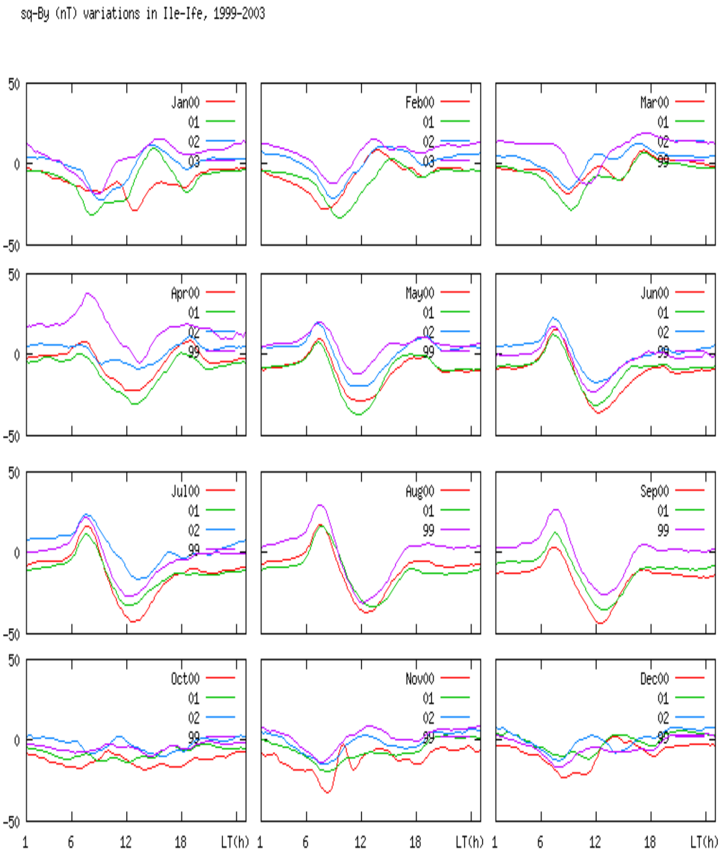
The monthly changes in Sq are usually classified into D-month (Nov.- Feb.), E-Month (Mar.,Apr. Sept., Oct.) and J-month (May-Aug.). The observations in Ile-Ife show, that for this site the classification has to be modified. Due to the special situation of the station south of the magnetic, but north of the geodetic equator, the three periods are better diveded into A (April – September), B (October – December) and C (January - March).

It should be mentioned, that the observations were made during a maximum of the solar cycle. For a more detailed analysis of Sq, a longer timeseries, covering also the sunspot minimum, is needed.



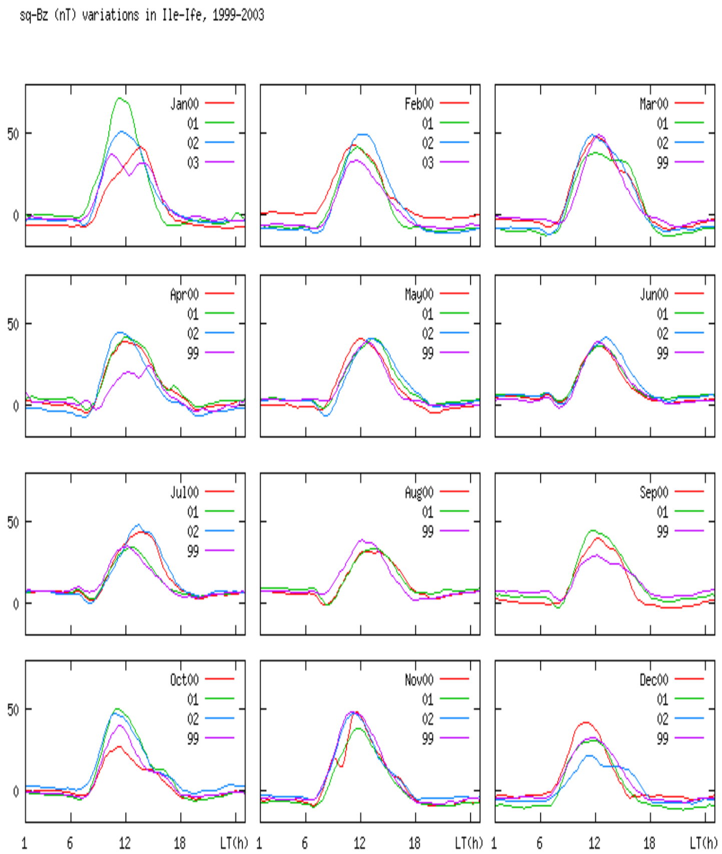
SqX variations in Ile-Ife, selected quiet days, 1999-2003. Displayed is the typical variation of the north component (in nT) over a day (local time in h) for each month.

SqX has maximum at noon with amplitudes between 60nT and 80nT, typical for the situation at low latitudes. The distance to the magnetic dip equator is approx. 400km, therefore the influences from the EEJ are already reduced.



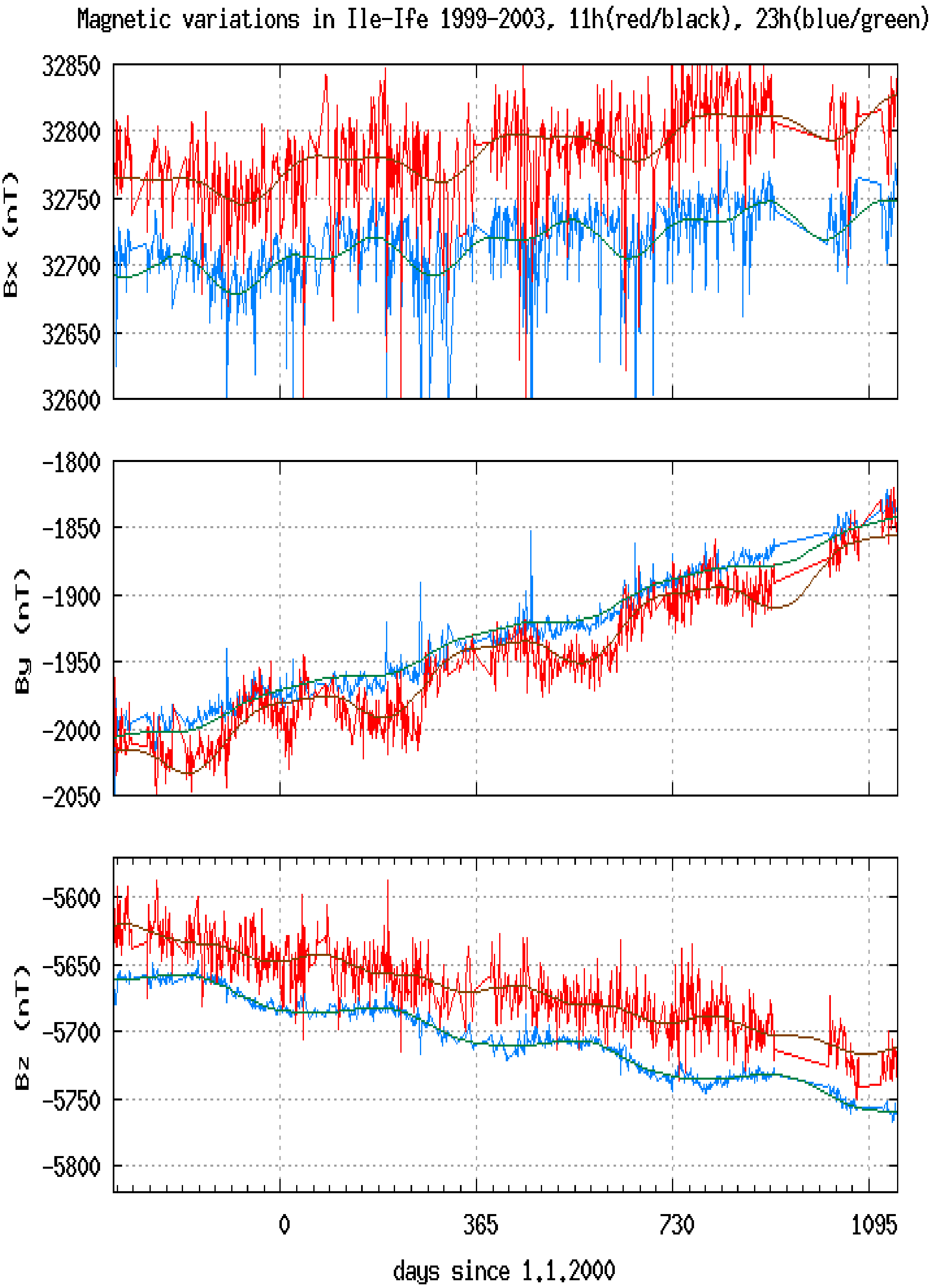
SqY variations in Ile-Ife, selected quiet days, 1999-2003. Displayed is the typical variation of the east component (in nT) over a day (local time in h) for each month.

SqY shows strong seasonal influences: between April and September there is a maximum (up to +20nT) in the morning and a minimum (to -40nT) in the noon/afternoon. The sun is then north of the station and the ionospheric current system of the southern hemisphere is dominant. Between October and December SqY is mostly flat. From Januar to March there is a minimum (-20nT) in the morning and a maximum (+10nT) in the afternoon.



SqZ variations in Ile-Ife, selected quiet days, 1999-2003. Displayed is the typical variation of the vertical component (in nT) over a day (local time in h) for each month.

SqZ also shows a maximum around noon with amplitudes of 30nT to 50nT. This indicates that the station is south of the ma-gnetic equator. The smaller amplitudes are from June to August.



Midnight (blue) and midday (red) hourly means of the magnetic field components in Ile-Ife, 1999 – 2003. Also shown is the best fit for long-term drift, annual and semiannual variations.

Long-term and seasonal variations in Ile-Ife, 1999-2003

Seasonal and longer variations (drifts) can be analyzed if all corrections, esp. for offsets, are made. The figure shows the midnight hour means for all days registered. Although the exact procedure for magnetic observatories was not implemented, the fluxgate data seem to be good enough for a first interpretation: The results are mostly consistent with the IGRF values.

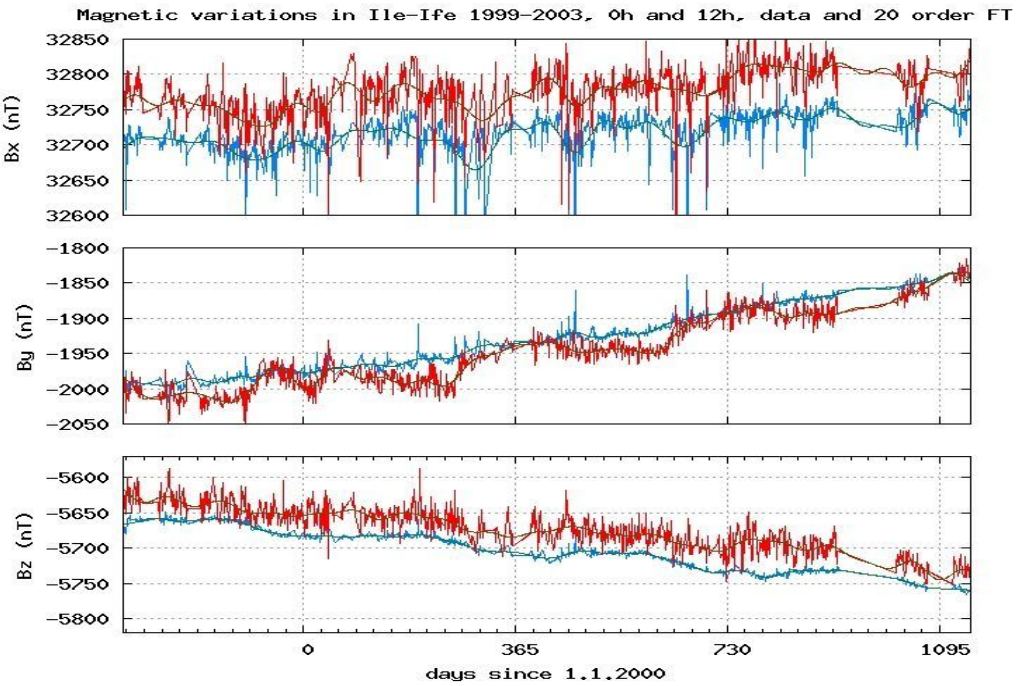
A least square fit up to semiannual signals and a complete Fourieranalysis were used on the midnight hourly means:

	Drift measured(nT/a)	Drift IGRF2000 (nT/a)	Annual wave (nT)	Semiannual wave(nT
Bx	13.5+-0.9	14.3	12.1+-1.3	8.4+-1.4
By	41.3+-0.3	56	5.3+-0.4	1.7+-0.4
Bz	-24.8+-0.1	-26.6	7.3+-0.2	0.9+-021

While Bx, H and Bz are confirming the IGRF predictions, the By component shows a significantly different result: It seems, that the IGRF overestimates the drift in By by a factor of 1.4.

The same analysis was done also for the midday hourly means. While the drifts are similar, seasonal variations in By are amplified during daytime:

	Drift measured (nT/a)	Annual wave (nT)	Semiannual wave (nT)
Bx	15.8+-1	13.1 +-1.5	5.3+-1.5
By	40.8+-0.4	16.1+-0.7	4.8+-0.7
Bz	-22.9+-0.5	3.4+-0.8	3.1+-0.8



Midnight (blue) and midday (red) hourly means of the magnetic field components in Ile-Ife, 1999 – 2003. Also shown is a Fourier fit (up to 20 order, approx 2 month). The seasonal variations in By are clearly seen in the midday data.

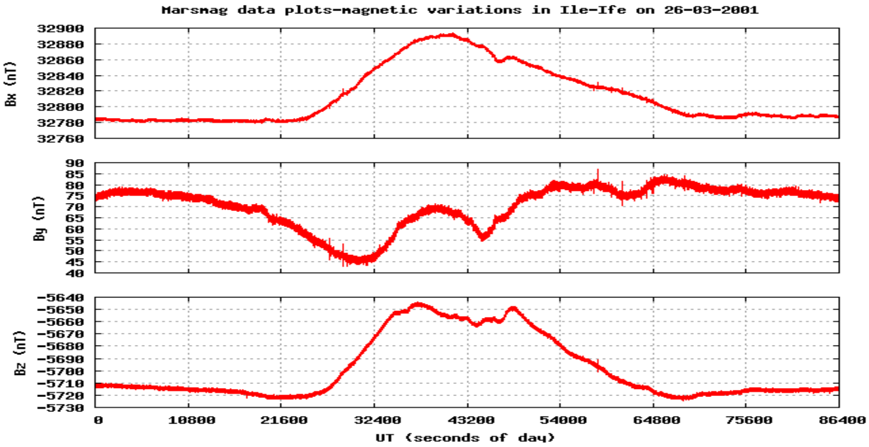
Magnetic storms and short period disturbances

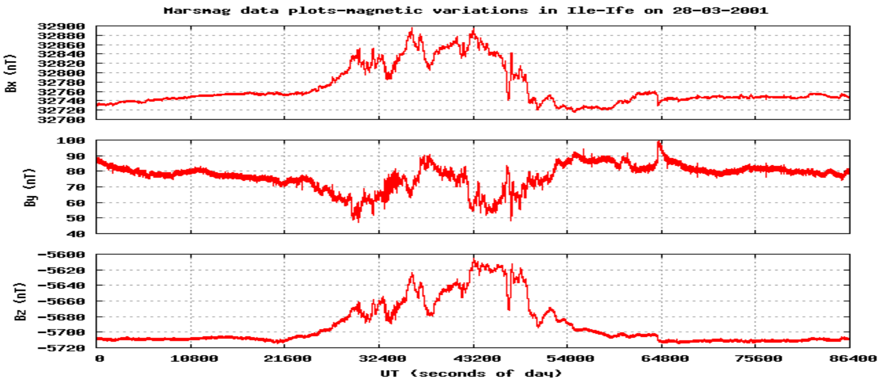
A large number of faster variations like sfe, ssc, pulsations or magnetic storms were also registered.

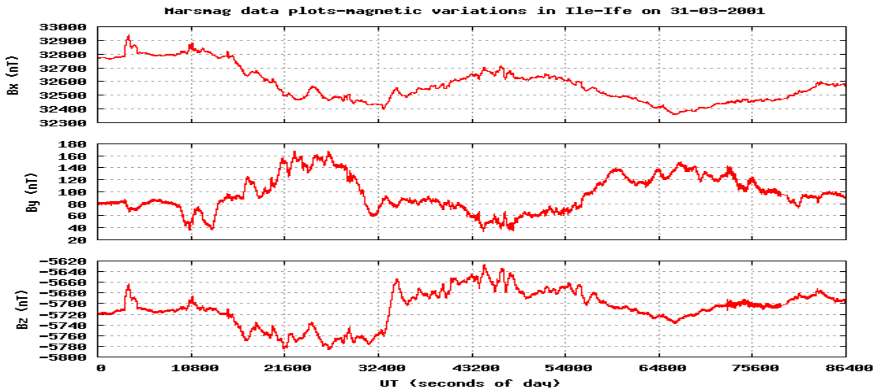
A first interpretation of special events has just started. Correlation analysis of the data sets and joint interpretation of records from different observatories seem to be interesting because of the fast data rate used for records in Ile-Ife.

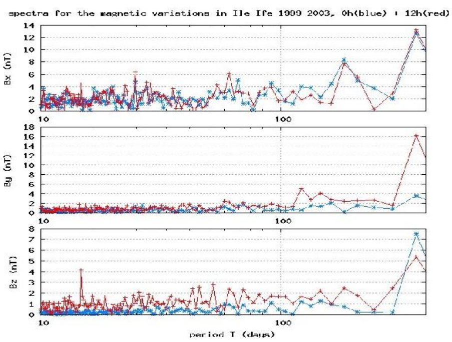
On the right, three days in March 2001 are shown, displaying the development of a magnetic storm:

- •Magnetic quiet day 26.3
- •Magnetic disturbed day 28.3
- •Magnetic storm 31.3







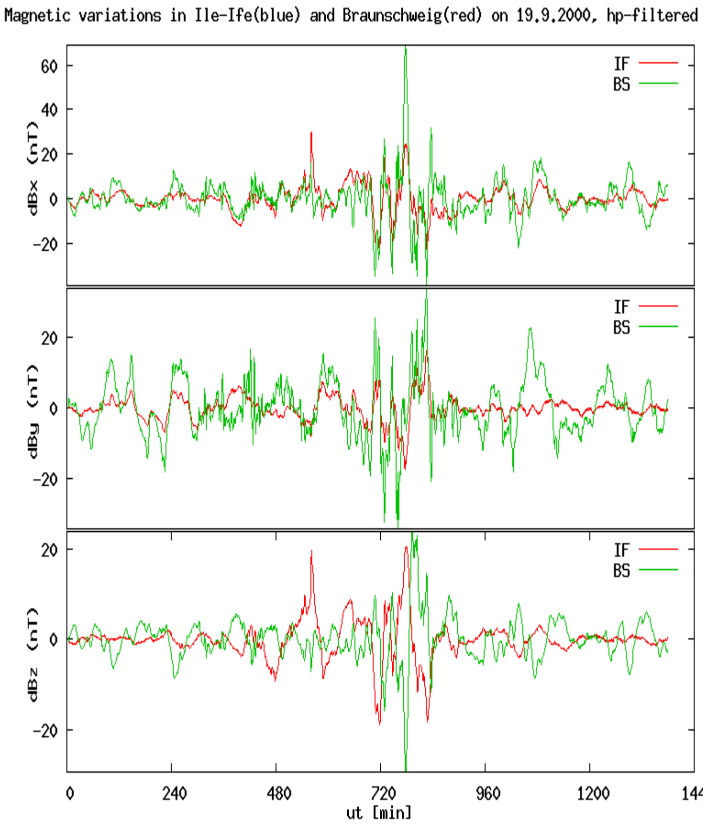


The Fourieranalysis shows, that shorter period disturbances (e.g. magnetic storms) are significantly reduced in the By- and Bz-components during night time. In Bx, the same signals are much more daytime independent.

Short period variations are best detected in the high pass filtered data. The figure shows data from Ile-Ife (Nigeria) and Braunschweig (Germany) for the 19.9.2000. The cross-correlations are:

	Bx BS	By BS	Bz BS
Bx IFE	+0.8	-0.6	+0.8
By IFE	-0.7	+0.6	-0.6
Bz IFE	-0.7	+0.5	-0.7

An autocorrelation analysis shows also, that the signals in Ile-Ife and Braunschweig have a similar structure.



Outlook

The data presented here are far from beeing completely analyzed. For instance, there is a great number of events, from pulsations to magnetic storms, still to be worked on. This can only be done in cooperation with other observatories or satellite data. Interested scientists are welcome to ask for a copy of the Ile-Ife-data (at one second rate or minute/hour- means).

The observatory in Ile-Ife is presently not running, but the Departments of Physics and Geology are looking for young scientists to take over responsibilities. For a succesful and continuous operation the group in Ile-Ife needs a strong link to the international geoscientific community.

Prof. Sam Ogunade, the founding director of the observatory, was operating the observatory with great enthusiasm and also own financial contributions. With his death he left a gap that will not easily be filled in Nigeria. The new scientist for the observatory will need not only the financial support from the university in Ile-Ife, but also the moral support of our community.

In times when most of the interests ar focused on satellite methods, there is a danger, that other, classical methods are more or less neglected. Apart from the question, whether the new methods can really substitute the ground based observations completely – for instance in terms of continuous long term registrations / stability – it should also be mentioned, that the observatories are places where young scientists are trained. It is here, where they have a chance to make a contribution from a developing country to a global problem.

I hope, this poster has created some interest not only for the data presented, but also for the situation of our colleagues in Nigeria.