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INTERNATIONAL EQUATORIAL ELECTROJET YEAR : THE AFRICAN SECTOR

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This paper presents the IEEY project in the African sector. The amount of our interpreted data is presently too short to allow proper scientific conclusions. Nevertheless, first typical results illustrate our network possibilities. Some preliminary observations are briefly presented for their interest towards immediate research goals.

O ANO INTERNACIONAL DO ELETROJATO EQUATORIAL: O SETOR AFRICANO. *Este relatório apresenta o projeto do IEEY no setor Africano. Não se trata ainda de uma apresentação científica porque nossos dados no momento são insuficientes para isto. No entanto, os primeiros resultados mais típicos ilustram a capacidade de nossa rede instrumentada. Apresentamos em resumo algumas observações preliminares pelo seu interesse relativo a objetivos de pesquisa imediatos.*

INTRODUCTION

paigns or by developing models and analytical studies

THE EQUATORIAL ELECTROJET

It was in 1922 that the first records of S_R, the regular magnetic field diurnal variation, at HUANCAYO (Peru) showed its amplitude to be two and a half times as large as the mid-latitude SR. In 1951, S. CHAPMAN gave the name "Equatorial Electrojet" to this S_R intensification, due to an electric current in the dynamo E region of the ionosphere (between 90 and 160 km altitudes). Fig. 1 shows the latitude ribbon centered on the geomagnetic dip equator along which the electrojet is flowing.

SCIENTIFIC OBJECTIVES

The electrojet as part of a global ionosphere magnetosphere study

Our contribution will include the mechanisms involving the earth's atmospheric dynamos; we will study the day-to-day variability of the equatorial jet in terms of the planetary geophysical conditions : solar activity, global-scale electrodynamic disturbances. We will analyze in particular the perturbations of ionospheric currents during magnetic storm periods.

One of these perturbations is the disturbance dynamo. The Joule energy dissipated in the auroral zones creates thermospheric neutral air motions (gravity waves, Hadley cells between polar and equatorial latitudes). These motions produce dynamo electric currents, which in turn produces modifications of the Earth's magnetic field.

Our contribution will include the following missions:

- Acquire a set of equatorial results during the IEEY (HF radars, ionosondes, magnetometers...) from which classes of typical behavior are defined.
- Analyze the equatorial results in relation with simultaneous observations from networks in other regions (ionosondes, magnetometers...) or with coordinated data from other programmes (LTCS, EITS, WITS, INTERMAGNET...)
- Build data bases for selected events.
- Bring up models of large-scale electric currents and validate these models through the IEEY data series.
- Study the effects of the equatorial electrojet on the global magnetic data of the internal fields.

Telluric currents and terrestrial conductivity

This study is based on spatial and temporal variations of the equatorial electrojet at a regional scale. The conductive structure of the crust and mantle can be deduced by joint use of magnetic and electric field measurements; it is the magnetotelluric method (still known as electromagnetic sounding). Attempts will be made to determine variations in lithosphere conductivity from the magnetic data alone. However,

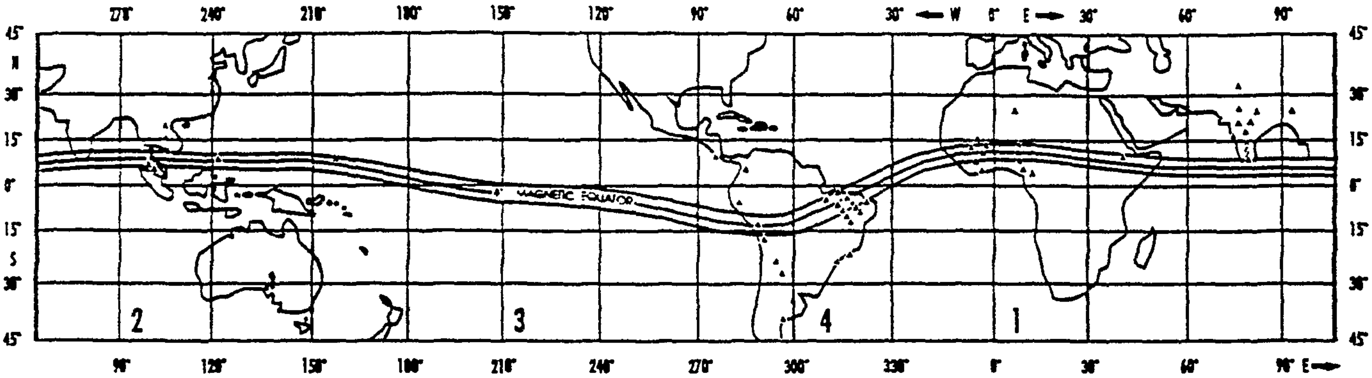

Figure 1. The International Equatorial Electrojet Year. The magnetic equator.
O Ano Internacional do Eletrojato Equatorial. O equador magnético.

Ionospheric prediction and electrojet models on regional scale

The ionosondes and HF radars will bring out better the dependence of E and F layer critical frequency changes on the mechanisms operating at the various spatial scales, hence the possibility of refined ionospheric HF predictions. We shall also use magnetic, interferometric and other data to provide a more complete 3D description of the electrojet (viz. the meridional current systems, which close the equatorial electric currents).

Instabilities in equatorial ionospheric plasmas

[redacted]

scale and continuous time contexts of the geophysical mechanisms.

The multiple ionosphere dynamic couplings

Although the low-latitude magnetic shells which confine the ionosphere equatorial plasmas should have the clearest and simplest electrodynamics and neutral drag effects in the world, the limited equatorial observations have not yet brought out complete latitude and longitude dependencies, as neither 11 - year (solar) nor seasonal and daily variations are sufficiently described yet.

From such incomplete morphologies it has been

Table 1. Instruments planned to be operating over the world during the IEEY project.

Instrumentos a serem operados no mundo durante o projeto IEEY.

	AFRICA		ASIA					AMERICA		
	West	Nigeria	India	China	Vietnam	Japan	Taiwan, Pacific	Brazil	Peru	Argentina

[redacted]

Table 2. Preliminary list of the IEEY Intensive Observational Phase (IOP)
Lista preliminar de Fase Observacional Intensiva do IEEY.

Geophysical calendar Regular world days		***instruments*** **scientific objectives (*)**
January	19, 20, 21	All instruments (*)
February	16, 17, 18	All instruments (*)
March	16, 17, 18	All instruments (*)
April	20, 21, 22	All instruments (*)
May	18, 19, 20	All instruments (*)
June	15, 16, 17	All instruments (*)
July	20, 21, 22	All instruments (*)
August	17, 18, 19	All instruments (*)
September	21, 22, 23	All instruments (*)
October	19, 20, 21	All instruments (*)
November	16, 17, 18	All instruments (*)
December	14, 15, 16	All instruments (*)
Long periods		***instruments*** **scientific objectives**
January	13th to 20th	All instruments Electromagnetic induction
March/April	March 16th to April 20th	All instruments Counter electrojet Solar-wind/Magnetosphere /Ionosphere interactions Electromagnetic induction
April	1st to 20 th	CEA HF radar at Korhogo Plasma Instabilities Electric field
June	1st to 21th	CEA HF radar at Korhogo Plasma instabilities Electric field
October	1st to 30th	All instruments coordination with CADRE Coupling atmosphere

The instruments are routinely operated 24 hours on 24 hours, but during selected periods (IOP) more intensive observations are made.
Ionosondes : Quarter-hourly routine ionograms
Magnetometers : routine time resolution of one minute
(*) : depending on the experimentator research field

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Laboratoire de Physique de la Terre et des Planètes, Univ. Paris Sud, **France.**

Ebre Observatory, Roquetes, Tarragona, Spain Institut für Geophysik der Universität Göttingen, Göttingen, **Germany.**

UCL (University College London), **England.**

NCAR (National Center for Atmospheric Research), HAO (High Latitude Observatory), **USA.**

Beijing-University, **China.**

Instrumentation and schedule for the observational phase

Table 3 contains the description of the instrumentation over Africa. Figures 2a and 2b give the location of the different sites in West Africa and Nigeria. At the present time (March 1993) :

- The Korhogo ionosonde started observations in November 1st, 1992 and the West-Africa chain of magneto-tellurometers (except the Tombouctou station) in December 1st, 1992.
- The Tombouctou station is operating since February 1993.
- The HF radar of the CEA (Herbreteau, 1980) will be operated at Korhogo, from April 1993 to the end of June 1993, then it will move to Lamto.
- The UCL (University College of London) interferometer is at Korhogo and needs a setting up and start up mission in conjunction with the UCL group.
- The ionosondes of Tamanrasset and Ilorin need repairs. The Nigerian magnetometers chain is not yet operational.
- Financial support for the LETTI HF radar (Goutelard, 1992) is still in discussion.

Organization of the work.

The data reduction is presently being made in two steps, with firstly, acquisition on the ground and technical validation at the central bases, ORSTOM Dakar for magnetotellurics and CNET/SPI/Lannion with CRPE/ISSY for the ionosphere. A similar, more direct process is expected for the HF radars and the Optical Interferometer for which the part of building laboratories is more important.

The first objectives are to refine the geophysical concepts classically attached to some typical features, like evening electrojet cutoff, sunset electric currents and post-sunset spread F instability.

THE FIRST OBSERVATIONS

1) magnetometer observations (Figures 3 and 4)

Some H component latitude profiles of December 1992 revealed sunrise and sunset reverse currents which appear to confirm Onwumechili's previous results (1959). The Dakar ORSTOM groups are presently investigating the extent and occurrence of these phenomena.

Ionosonde observations: Spread F types and their differences on both sides of the Atlantic (Figure 5)

Previous results: Since the end of the seventies the classical distinction of equatorial spread F in two morphological types (range = Q and frequency = F) led to mutually incompatible interpretations.

i) R.G. Rastogi and R. Woodman (1978) saw kilometer-scale Q type traces derived from F meter single irregularities echoes on Huancayo ionograms.

ii) On the Chadian Sarh series (1969-1971), J.M.

Table 3. Location of the instruments in Africa

Localização dos instrumentos na África.

WEST AFRICA

Site	Geographic coordinates Latitude N / Longitude W	instrument
Tombouctou (Mali)	16°44'00" / 3° 00' 00"	1 magnetometer + Tell.
Mopti (Mali)	14°30'30" / 4°05'14"	1 magnetometer + Tell.
San (Mali)	13°14'00" / 4°52'00"	1 magnetometer + Tell.
Koutiala (Mali)	12°21'00" / 5°27'00"	1 magnetometer + Tell.
Sikasso (Mali)	11°21'/ 5°42'00"	1 magnetometer + Tell.
Nielle (Mali)	10°13'00" / 5°38'00"	1 magnetometer + Tell.
Korhogo (Ivory Coast)	9°20'00" / 5°26'00"	1 magnetometer + Tell.
Katiola (Ivory Coast)	8°11'00" / 5°03'00"	1 magnetometer + Tell.
Tiebessou (Ivory Coast)	7°13'00" / 5°14'30"	1 magnetometer + Tell.
Lamto (Ivory Coast)	6°14'00" / 5°01'30"	1 magnetometer + Tell.
M'Bour (Senegal)	14° 20' / 16° 55'	permanent magnetometer
Bangui (Rep. Cent. Afri.)	4° 24' / -18° 37'	permanent magnetometer
Dakar (Senegal)	14° 46' / 17° 25'	permanent ionosonde
Korhogo (Ivory Coast)	9° 27' / 5° 38'	permanent ionosonde CEA HF radar LETTI HF radar (*) UCL Interferometer (*)
Ouagadougou (Burk. Faso)	12° 22' / 1° 32'	permanent ionosonde
Tamanrasset (Algeria)	22° 56' / 5° 30'	permanent ionosonde (*) permanent magnetometer 2 magnetometers

NIGERIA

Site	Geographic coordinates Latitude N / Longitude E	instrument
Ilorin	7° 58'/4° 55'	permanent ionosonde (*) 1 magnetometer (*)
Katsina	12° 55' / 7° 32'	1 magnetometer (*)
Kano	12° / 8° 44'	1 magnetometer (*)
Zaria	11° 28' / 8° 27'	1 magnetometer (*)
Kaduna	10° 39' / 8° 08'	1 magnetometer (*)
Minna	9° 21' / 6° 52'	1 magnetometer (*)
Ile-Ife	7° 17' / 5° 08'	1 magnetometer (*)
Ejirin	6° 28' / 4° 21'	1 magnetometer (*)

(*) : Not yet operating

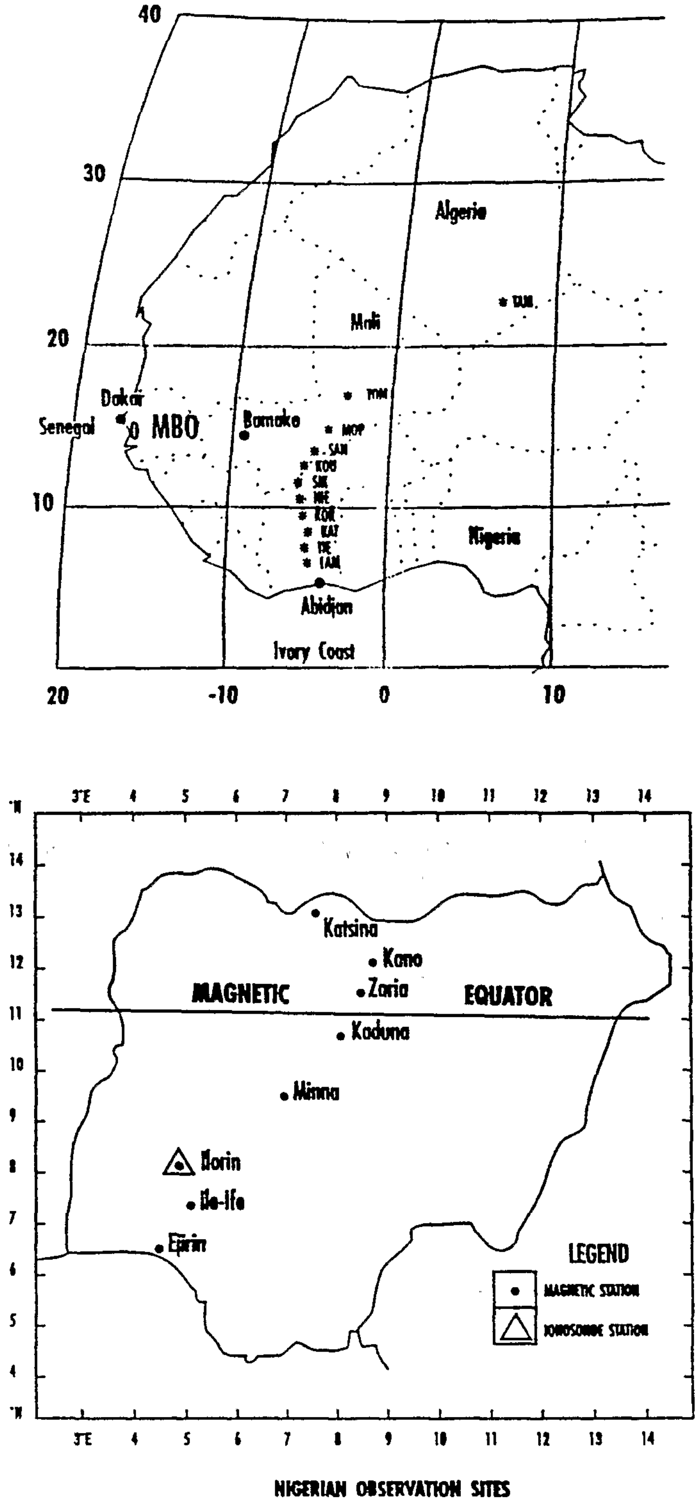

Figure 2. IEEY Experimentation: (a) over West-Africa and (b) over Nigeria.

Experimentos do IEEY na (a) África Ocidental e (b) Nigéria.

Faynot and P. Vila (1979) observed Q traces to precede F type echoes, especially near local sunset; later Q and F types appeared generally mixed on ionograms. These two results suggest the formation of primary Rayleigh-Taylor plasma bubble Q type whose wall gradients produce F type gradient-drift instabilities of decametric size.

iii) Using simultaneous VHF radar signatures, the Brazilian authors M.A. Abdu, I.S. Batista and J.A. Bittencourt (1981) separated the two types on Fortaleza (38°N, 4°S geographic) 1978-1979 ionograms; they deduced the occurrence of the two types to be anticorrelated from one night to another and in seasonal phase.

The opposition between range-type echoes (Q) and "f-type" diffuse trace (F) became again controversial and a reason for detailed comparisons.

Korhogo 1992 results:

Isolated comparisons during disturbed time over the Atlantic are rendered difficult by instrumental receiver and antenna characteristics, as well as by geophysical discrepancies between the two sectors.

The IPS42 ionograms obtained in November 1992 at Korhogo are not a good seasonal sample for comparison. We will need to analyze carefully both African and Brazilian full ionograms series from March-April and September-October, i.e., when the global thermosphere bulge is not causing asymmetries in the dynamo and tidal circulation moments; the vicinity of the two ionosondes making them 128 LT minutes only apart should allow very interesting joint studies.

Contrary to the results of Abdu et al (1981), the November 92 series at Korhogo show frequent intermixing of Q and F types making their distinction sometimes difficult. On the other hand, two physically significant features appear as Q subtypes at similar F region local sunset times : - "Satellites traces" with M reflections of the same character as those described at Fortaleza, that may be associated with gradients inside the large scale bubble walls. "F sporadic" more diffuse traces, which appear at the bottomside as consequence (Hanson, 1986) of the same electrodynamic upward thrust after sunset, and may merge upwards into the main F2 layer bubble (or sometimes remain at separate lower level). The multi-mode (M,N) echoes between these two Q-types do not develop exactly similar F types.

We wish to be able to rapidly interpret these data by HF radar "in situ" measurements of velocities, echo power spectra and group-path at constant evolutive phase. We hope that our Working Group session will bring some light on these interesting comparisons.

CONCLUSION

This paper only presents the first stage of the IEEY project over Africa : - the scientific motivations, - the organization, - the first observations. Several communications on the first results will be presented during the next session 7.1 of IAGA meeting devoted to the IEEY.

In a second stage of the work after IAGA August 1993 meeting, we will try to compare the results of our different instruments and discuss key parameter variations. This should eventually dictate new work plans for all participants of the IEEY community. We hope to get concerted experimental schedules, for optimal outputs of our networks until the end of the IEEY, and for building the data base.

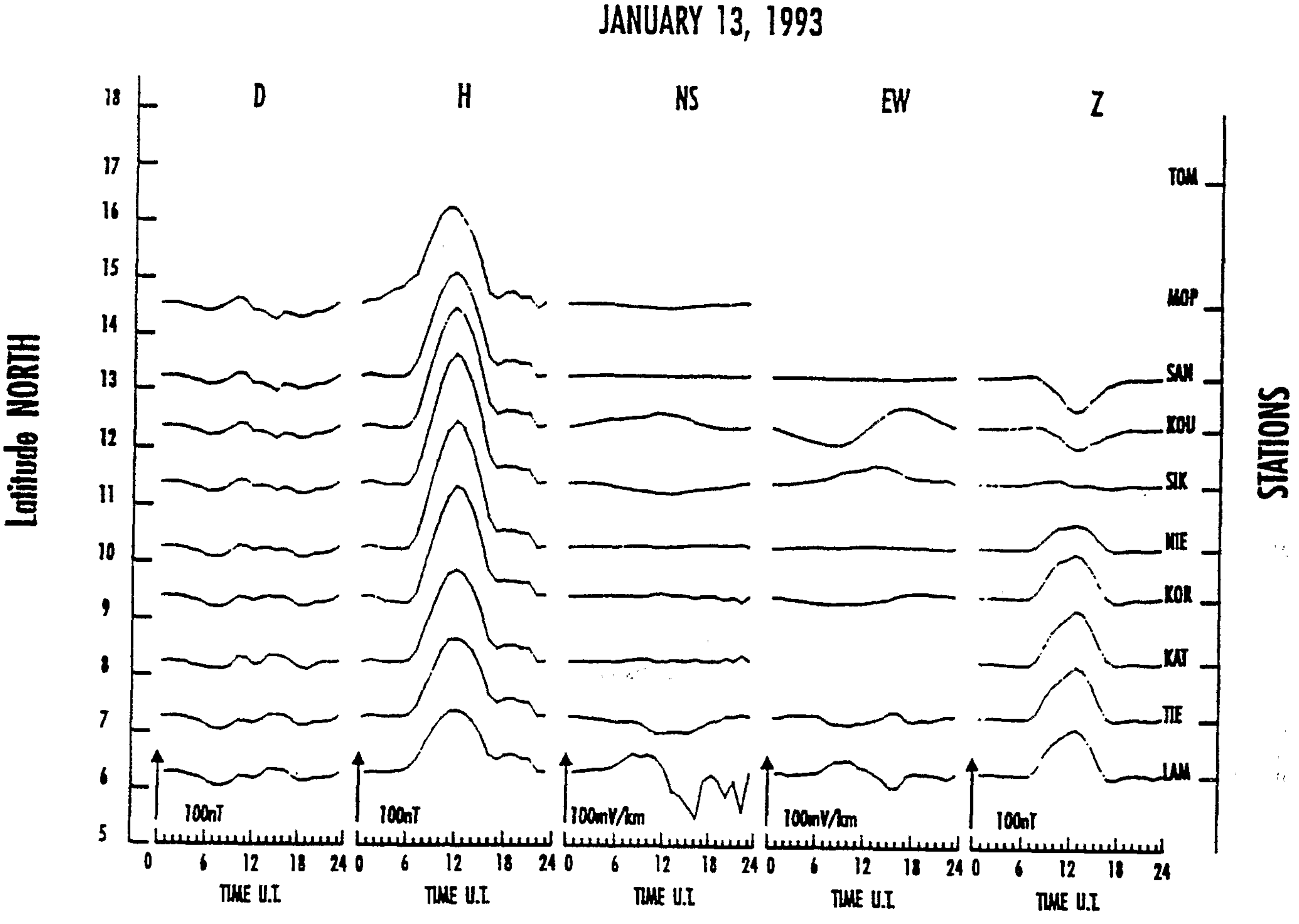

Figure 3. Diurnal variations of the 5 components (D, H, E_{NS}, E_{EW}, Z) measured by the magnetotelluric network. H, D, Z are the three components of the Earth's magnetic field; E_{NS}, E_{EW} are the two components of the telluric field.

Variação diurna das 5 componentes (D, H, E_{NS}, E_{EW}, Z) medidas pela rede magnetotelúrica. H,D e Z são as três componentes do campo magnético terrestre; E_{NS} e E_{EW} são as duas componentes do campo telúrico.

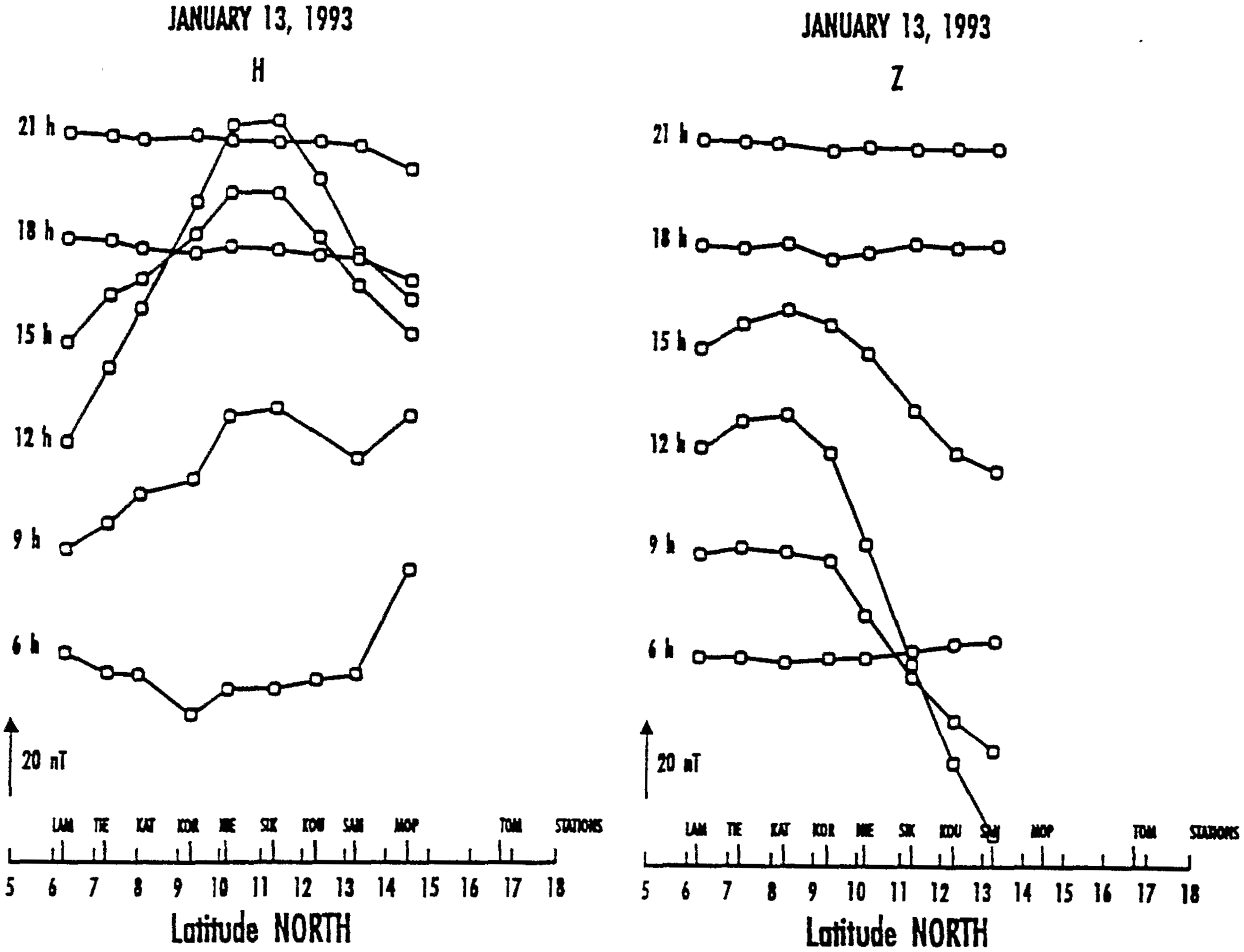

Figure 4. Latitudinal profiles of the H and Z components of the Earth's magnetic field

Perfis latitudinais das componentes H e Z do campo magnético terrestre.

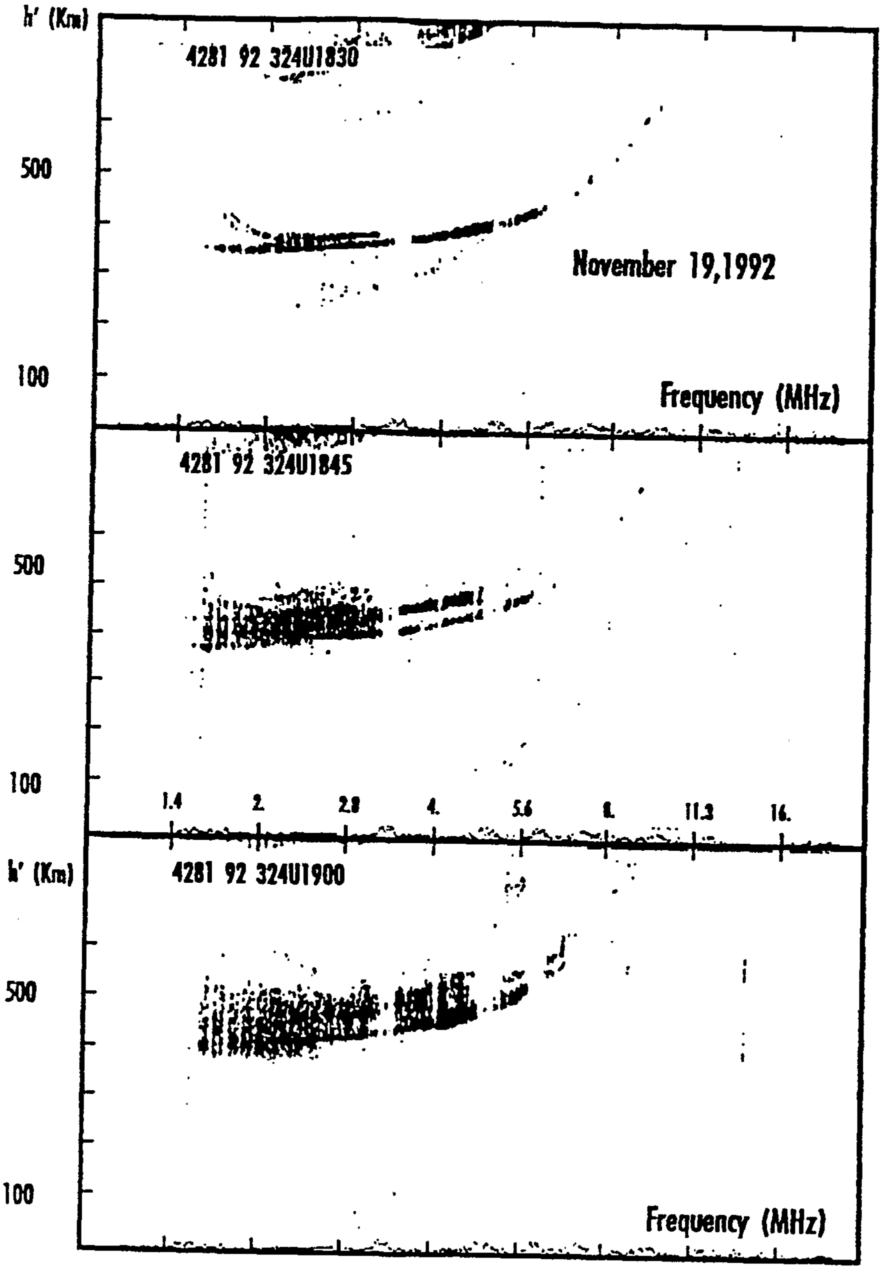

Figure 5. Ionograms obtained at Korhogo, in November 19, 1992, at 18h30, 18h45 and 19h00 UT.
Ionogramas obtidos em Korhogo, em 19 novembro de 1992 às 18:30, 18:45 e 19:00 horas UT.

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