Study of the equatorial electrojet starting from the electrodynamics parameters of the equatorial ionosphere.

F.O.GRODJI [1], *V.DOUMBIA* [2], *K. BOKA* [3]

1 Laboratoire de Physique de l'Atmosphère, Université de Cocody, 22 BP 582 Abidjan 22, COTE D'IVOIRE, franckgrodji@yahoo.fr

2 Laboratoire de Physique de l'Atmosphère, Université de Cocody, 22 BP 582 Abidjan 22, COTE D'IVOIRE,

3 Laboratoire de Physique de l'Atmosphère, Université de Cocody, 22 BP 582 Abidjan 22, COTE D'IVOIRE

Abstract

The determination of the physical parameters of the equatorial electrojet (EEJ) from Korhogo (Latitude +9.3; Longitude – 5.4; Dip -0.67) during the period of 1993 to 1994 was carried out by data of ionosonde IPS-42. The results made it possible to show that for a low average value of electron drift vertical approximately 5 m/s to the solstices and 6 m/s with the equinoxes in the morning, we obtained around midday a strong density of current of the EEJ (3.30A/km^2 in 1993 and 2.6A/km^2 in 1994). We determined during this study the values of the various electric fields intervening in the mechanism of formation of the EEJ. We showed the strong contribution of the polarization electric field in this phenomenon. The results gave the values of the zonal and polarization electric fields respectively 0.19mV/m and 3.5mV/m. The data of ionosonde IPS-42 made it possible to determine the density and intensity of current center of the EEJ (I_0 =231.11±53.7 A/km). We compared the intensity of the current in the center obtained with the ionosonde with that of the data on the ground. We obtained appreciably similar results.

1-Introduction

An early observation, at Huancayo in 1922, of the enhancement of the magnetic diurnal variation near the geomagnetic equator was attributed to a narrow ionospheric current which was later in 1951 named by Chapman the equatorial electrojet (EEJ). The EEJ thus makes part of a system of current of the ionosphere of the averages and low latitudes which results from the simultaneous action of two dynamos in the terrestrial environment (the ionosphere dynamo and the solar dynamo wind / magnetosphere).This phenomenon has been studied through different types of experiments: Its vertical structure has been investigated using instruments inside rockets [1]; its magnetic effects have been monitored with the help of meridian chains of magnetometers crossing the geomagnetic equator [2, 3, 4, 5]. Ionosphere soundings have allowed studies on the associated ionospheric electric fields as well as on electron densities and on ionospheric plasma instabilities [6]. Magnetic measurements onboard low altitude satellites have also been used to study the EEJ on a global scale [7, 8], and to isolate its magnetic contribution from core and lithospheric fields [9]. The data of radars HF and VHF made it possible to determine the zonal electric field in the equatorial ionosphere in F-region. [10, 11]. Speeds of vertical drifts $\vec{V_z} = \frac{\vec{E}\times\vec{B}}{B^2}$ of the equatorial ionosphere in F-region during the day were calculated starting from the observations of magnetometers [12]. We decided to study this current starting from a new approach. We decided to calculate the zonal electric field and the electric field of polarization in the area dynamo starting from the speed of vertical drift of the electrons at the magnetic equator, and deduce the density of current of the EEJ.

2 Study starting from the ionosonde IPS-42

Ionosonde IPS-42 is an experimental device made up of a sounder, 5 antennas, and a numerical apparatus which allows the data processing and of a computer which makes it possible to post the ionograms (figure1). This equipment was installed in Korhogo (Latitude +9.3; Longitude – 5.4; Dip -0.67) and functioned over two year's period of 1993 to 1994. It is noted that the E-region moved down the morning for minimal height h=105 km which represents the altitude of the maximum density current of the EEJ in the course of the day , then goes up after midday.

The examination of the data in magnetic quiet period with permit to obtain the daily movement of the E-region (figure2). The velocity of this region which boil consider at first approximation as being that of the electrons is calculated from the relation:

$$V_d = \frac{\Delta h}{\Delta t} \tag{1}$$

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Δh is the différence height of the layer E for the quarter-hour Δt. calculate allowed to deduce the speed of vertical drift from the electrons in E-region (figure3). Calculate allowed to determine the mean velocity of drift with 5m/s with the solstice and 6 m/s in equinox.

The relation $E_y = B.V_z.\cos(I)$ makes it possible to calculate the zonal field of surroundings 0.19 mV/m. The relation $\vec{E}_P = \frac{\sigma_H}{\sigma_P}\left(\vec{E}_y \times \frac{\vec{B}}{B}\right)$ makes it possible to determine the electric field of polarization to 3.5 mV/m. σ_H and σ_P are respectively conductivities of Hall and Pedersen.

The figure4 shows that the electric field of polarization in red contributes mainly to the mechanism of formation of the EEJ. The zonal electric field in blue is weak and practically constant.

From the two electric fields, one determines the densities of current of Pedersen and Hall thanks to the following relations:

$$\vec{j}_{P_1} = \sigma_P \vec{E}_y \quad (2)$$

$$\vec{j}_{H_2} = -\sigma_H \left(\frac{\vec{E}_p \times \vec{B}}{B}\right) \quad (3)$$

The total density of the current of the EEJ is then obtained through the relation:

$$\overrightarrow{j_{EEJ}} = \overrightarrow{j_{H2}} + \overrightarrow{j_{p1}} \quad (4)$$

The results showed that the current of Hall is largely higher than that of Pedersen.

The density of current of the EEJ obtained starting from ionosonde IPS-42 is approximately 3.30 A/km^2 in 1993 and 2.65 A/km^2 in 1994.

3- Discussions and conclusion

The study of the EEJ which we carried out made it possible to determine starting from the data of ionosonde IPS-42 installed with Korhogo of 1993 to 1994, the electrodynamics parameters of the current of the EEJ. The drift vertical velocity of the layer E which we supposed at first approximation with that of the electrons and whose value is relatively low, approximately 5m/s. we noticed that the vertical velocity of the electrons is very low in front of the drift horizontal velocity of the electrons around midday which is approximately of 300 m/s [6].

The data of the ionosonde IPS-42 allowed the determination of the zonal electric field and polarization electric field in the EEJ which is respectively of 1.5mV/m and 3.7mV/m. The value of the zonal field is close that obtained by Sow mamadou in 1999. After a morphological analysis of the fields we concluded that the polarization field enormously contributes at the formation of the EEJ in E-region [13].

The density of current of Hall being related to the field of polarization, we showed that the current of hall comes from the drift (E_PxB) is in fact the current of the EEJ to which the low density of current of Pedersen is added comes from the drift (E_yxB). This result was already shown by [14].

The density of current J_{EEJ} of the EEJ is then determine, we deduce the current in the centred from the EEJ (I_0 = 231.11 ± 53.7A/km) who is appreciably equal to DOUMBIA et al., 1998 which is of 232 ± 45 A/km for the data on the ground and of Fambitakoye 1976 (I_0= 250 A/km) for the profile of Tchad. The comparison of the profiles of intensity I_0 given from ionosonde IPS-42 (red) and those of measurements on the ground of DOUMBIA (green) shows a perfect resemblance (figure5). The study of the EEJ starting from ionosonde IPS-42 made it's possible to determine the characteristics of this current. This study made it possible to make a favorable projection in the study of this phenomenon.

References

1. Sampath S. and T. S. G. Sastry, (1979), Results from in situ Measurments of ionospheric current in the equatorial region I, J. Geomag. Geoelectr., 31, 373-379.

2. Chapman, S., (1951), The Equatorial Electrojet as Detected from the Abnormal Electric Current Distribution above Huancayo, Peru and Elsewhere, Arch. Meteorol. Geophys. Bioclimatol. A 44 P 368-390.

3. Forbush, S. E. and M. Casaverde (1961), The Equatorial Electrojet in Peru, Carnegie Institut. Washington., Publ. 620.

4. Fambitakoye, O. and P.N., Mayaud (1976), The Equatorial Electrojet and Regular Daily Variation S_R: A Determination of the Equatorial Electrojet Parameters, J. Atmos. Terr. Phys. 38, p. 1-17.

5. Hesse, D. (1982), An Investigation of the Equatorial Electrojet by Means of Ground-based Magnetic Measurements in Brazil, Ann. Géophys., t. 38, fasc. 3, p. 315-320.

6. Balsley. B, 1973 – Electri field in the equatorial ionosphere: a review techniques and measurements, J. Atmos. Terr. Phys. 35, p.1035-1044.

7. Cain, J. C. and R. E. Sweeney, (1973), The POGO data, J. Atmos. Terr. Phys. 35, p. 1231-1247,.

8. Onwumechili, C. A. and C.E. Agu (1980b), Longitudinal Variation of the Equatorial Electrojet Parameters Derived from POGO Satellite Observations, Planet. Space Sci., Vol. 29, p. 627-634.

9. Langel, R. A. M., M. Purucker and M. Rajaram (1993), The Equatorial Electrojet and Associated Currents as Seen in MAGSAT Data, J. Atmos. Terr. Phys., 55, p. 1233-1269

10. Woodman. R, 1970- vertical drift velocities and East-West electric field at the magnetic equator. J. Geophys. Res, 75, P.6249-6259.

11. Balsley, B. B., and R.F. Woodman, (1971), Ionospheric drift velocity measurements at Jicamarca, Peru (July 1967- March 1970). Upper Atmosph. geophys. rep. UAG-17, NOAA Word data Center A. Boulder, Colo. Oct. 1971.

12. Anderson. D, Anghel. A, Yumoto. K, Ishitsuka. M and Kudeki. E, 2002 – Estimating day-time vertical ExB drift velocities in the equatorial F-region using ground-based magnetometer observations, Geophysi. Res. Let, vol. 29, no. 12, p. 31(1)-37(4).

13. Richmond. A, 1995- Ionospheric electrodynamics using magnetic apex coordinates, J. Geomag. Geoelec, 47, P. 191-212

Sastry, J. S. G, (1970), Diurnal Change in the Parameters of the Equatorial Electrojet as Observed by Rocket-born Magnetometers, Space Res. X, p. 778-785.

14. Doumouya. V, Vassal. J, cohen. Y Fambitakoye. O and Menvielle. M, 1998- The equatorial électrojet: First result from magnetic measurement , Ann. Geophys, 16, P. 658-676.

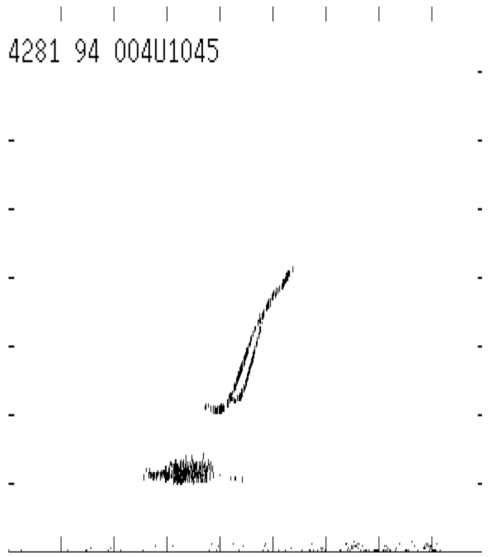

Figure 1 : ionograms of 01-06-93 of ionosonde IPS-42 Station of Korhogo

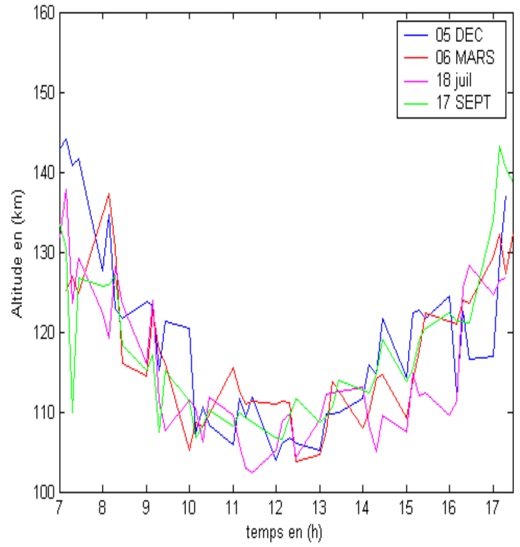

Figure 2: seasonal variation of the movement of the E-region

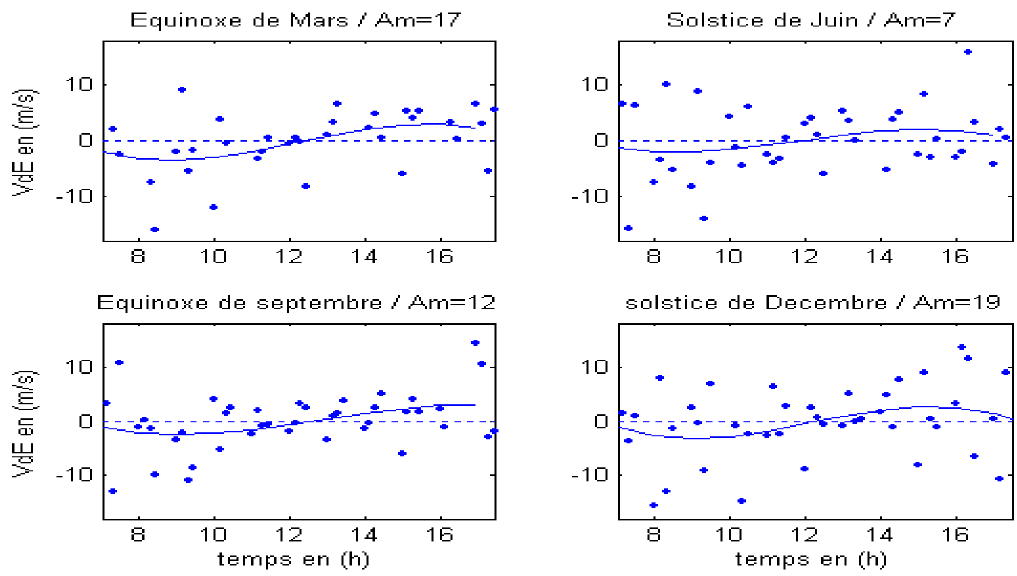

Figure 3 : seasonal variation of velocity drift of electron

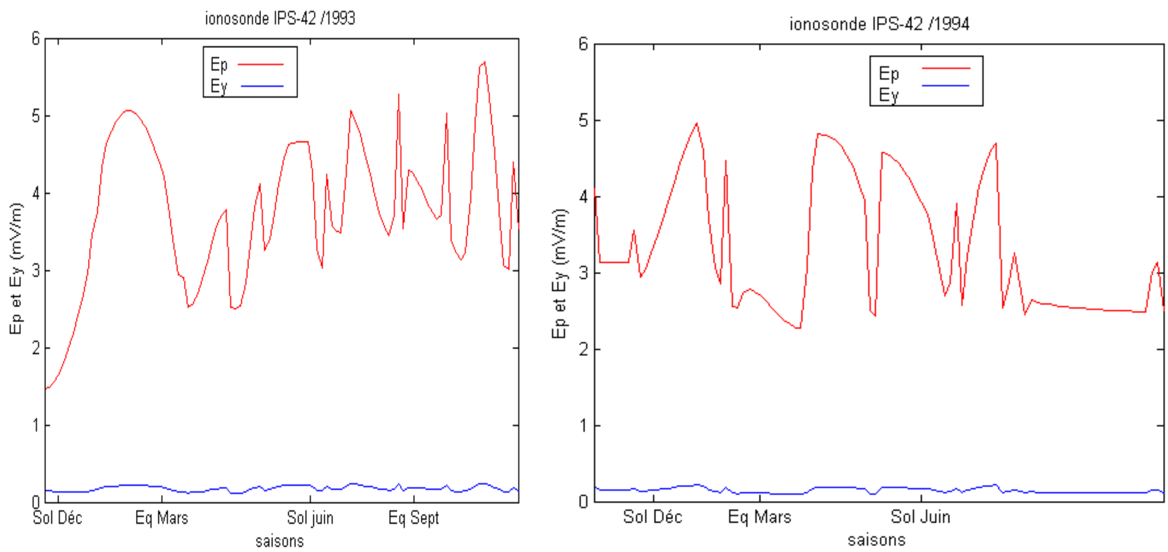

Figure 4: zonal electric field (blue) and electric field of polarization (red) obtained starting from the data of ionosonde IPS-42

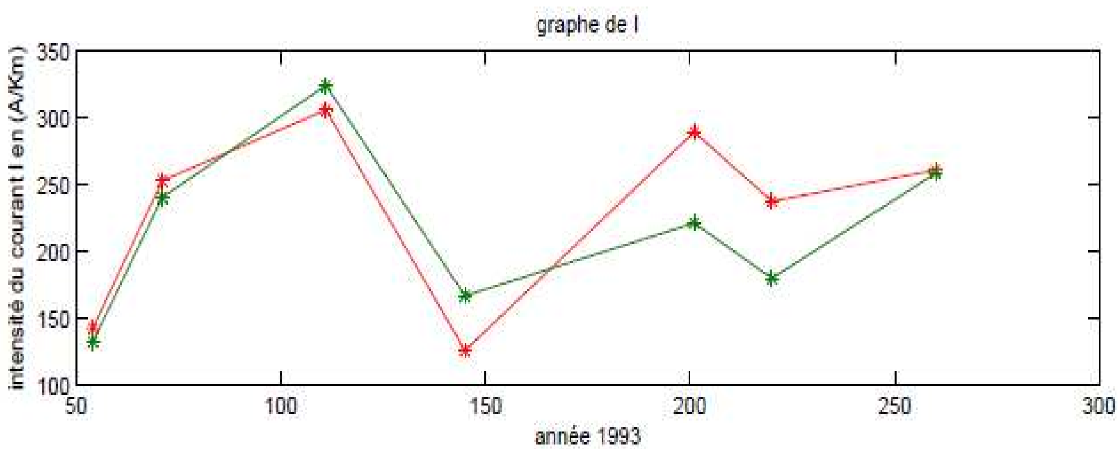

Figure 5: intensities of currents of measurements on the ground (green) and of ionosonde IPS-42 (red).