Quite Time Longitudinal and UT Variation of the Equatorial Electrojet inferred from CHAMP Satellite.

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ABSTRACT

Analysis of the longitudinal and UT variations of the height integrated eastward current intensity of the equatorial electrojet in the solar maximum and solar minimum years (2002) and (2006) using CHAMP Satellite data is presented here. The low orbit of the CHAMP and its high precision instrumentation makes it suitable for the study. Data were selected from the hours of 10 to 13 around local noon and during magnetically quiet periods when the equatorial electrojet was expected to be highest.

The results obtained showed that the amplitudes of the longitudinal variation were higher in the solar maximum year than in the solar minimum year and the regularities and irregularities in the longitudinal variations were almost the same in both the solar maximum and solar minimum years. Similarly the regularities and irregularities in the Universal time (UT) variations were almost the same in both years. We observed that the systematic and unsystematic variations of the EEJ with longitudes and UT were not affected by the solar activity.

(Keywords: equatorial electrojet, equatorial ionosphere, height integrated current intensity)

INTRODUCTION

In the dayside ionosphere, the solar winds set up a polarization electric field which usually points to the eastward direction. At the magnetic dip equator, where the magnetic field is exactly horizontal, this electric field has an interesting effect: the resulting upward E x B drift of electrons generates a negative charge at the top and a positive charge at the bottom of the ionospheric E-region (about 90 to 130 km altitude).

The resulting electric field prevents the further upward drift of electrons. Instead, they are now propelled westward by the eastward electric field. This westward movement of the electrons constitutes an eastward electric current which is called the Equatorial Electrojet. The motion of the ions is largely inhibited at this altitude, due to their collisions with the neutral gas.Thus, the equatorial electrojet (EEJ) is a narrow ribbon of current flowing eastward in the day time equatorial region of the Earth's Ionosphere.

The abnormal large amplitude of variations in the horizontal components measured at equatorial geomagnetic observatories, as a result of EEJ, was noticed as early as 1920 from the Huancayo Geomagnetic Observatory. Observations by radar, rockets, satellites, and geomagnetic observatories are used nowadays to study EEJ. The equatorial electrojet has been extensively studied from ground observatories (e.g., Forbush, 1981, Rastogi, 1981), from sounding rockets (e.g., Onwumechili, 1997), from radar backscatter experiments (e.g., Coohen and Hooke, 1978), and from low earth orbiting satellites (e.g., Cain and Sweeney, 1973). These types of observations are complementary: ground observations track very closely to the temporal variations of the equatorial electrojet EEJ.

In this work we employed the CHAMP Satellite data to study the quiet time longitudinal and UT variation of the equatorial electrojet height integrated eastward current intensity because CHAMP satellite magnetic field measurements are ideal tools for investigating the Equatorial Electrojet (Okeke, 2005a).

MATERIALS AND METHOD

The data used for this study were obtained from the CHAMP Satellite data spanning a period of six years (2000-2006) making half of a solar cycle. We selected data for the solar maximum year (2002) and the solar minimum year (2006).

Since we are interested in the primary variations of the equatorial electrojet, we selected data from around local noon, 10 to 13 hour local time, when the current intensity reached the highest level. Furthermore, only magnetically quiet periods with Kp=0...2 were considered.

To study the longitudinal and Universal Time (UT) variations, five international quiet days (IQDs), which are the most quiet days in each month based on the magnetic disturbance index (Okeke, 2005b, Rabiu, 2007) were selected from the Equinox or E-months (March, April, September, October), June-solstice or J-months (May, June, July, August), and December or D-months (January, February, November, December). Appropriate polynomials were then fit to the data for the height integrated eastward current intensity against the longitude and UT, respectively.

Days with regular, fairly regular, and irregular variations in longitude and UT were obtained for each year. The ratio of solar maximum to the solar minimum in each category was obtained correspondingly. For comparison, the amplitudes of the EEJ on all the IQDs were obtained from the longitudinal variations. These were averaged over the seasons; the ratios of the values in the corresponding seasons were obtained for comparison.

RESULTS AND DISCUSSIONS

VARIATION OF THE EASTWARD CURRENT INTENSITY WITH LONGITUDE

In this section we present our results and discussions of the longitudinal variation of the eastward current intensity which we have investigated. Tables 1 and 2 present the summary of the international quiet days (IQDs) we used for the investigation. Longitudinal variation of the equatorial electrojet was observed on all the IQDs in the solar maximum and solar minimum years. This is in line with the earlier findings of previous researchers in the field (e.g. Judav et al., 2002, Maus et al., 2007).

Table 1: Summary of Number of Regular, Fairly Regular, and Irregular Longitudinal Variations on the IQDs.

	2002	2006	solar max:solar min
Systematic variations	4	6	0.7
Fairly systematic variations	7	5	1.4
Unsystematic variations	4	4	1.0

Table 2: Summary of the IQDs used for the Analysis of the Longitudinal Variations of the EEJ Eastward Intensity in the Solar Maximum Year, 2002.

Days	Average Kp index	Mean EEJ Intensity (A/m)
17 Jan	0.33	0.01
23 Jan	0.33	0.03
24 Jan	0.30	0.05
29 Jan	0.30	0.06
30 Jan	0.32	0.04
4 Jun	1.21	0.02
5 Jun	1.2	0.02
6 Jun	0.33	0.06
14 Jun	0.64	0.04
16 Jun	1.43	0.02
11 Oct	1.33	0.02
12 Oct	1.33	0.28
15 Oct	1.30	0.08
22 Oct	1.63	0.10
23 Oct	1.67	0.05

Table 3: Summary of the IQDs used for the Analysis of the Longitudinal Variation of the Eastward Current Intensity in the Solar Minimum Year, 2002.

Days	Average Kp Index	Mean EEJ Intensity(A/m)
8 Jan	0.13	0.08
9 Jan	0.01	0.05
10 Jan	0.13	0.07
28 Jan	0.22	0.07
29 Jan	0.64	0.04
3 Jun	0.14	0.020
5 Jun	0.21	0.08
7 Jun	0.32	0.02
11 Jun	1.31	0.01
18 Jun	1.31	0.01
11 Oct	0.67	0.10
12 Oct	0.72	0.09
13 Oct	1.12	0.08
19 Oct	0.77	0.07
20 Oct	1.23	0.08

Table 4: Position of the Amplitude of the EEJ Eastward Current Intensity on the IQDs used in the Solar Maximum Year, 2002.

Days	Amplitude of Variation 2002 (A/m)	Position
17 Jan	0.29	60E
23 Jan	0.21	125W
24 Jan	0.18	30W
29 Jan	0.25	140W
30 Jan	0.23	40W
4 Jun	0.13	45W
5 Jun	0.14	120W
6 Jun	0.15	1E
14 Jun	0.13	95E
16 Jun	0.1	125E
11 Oct	0.18	95E
12 Oct	0.13	120W
15 Oct	0.14	90E
22 Oct	0.33	100W
23 Oct	0.18	120W

In the solar maximum year, systematic variations were observed for 4 days out of the IQDs and fairly systematic variations were observed for 7 days. No systematic variations were observed on the remaining 4 days.

In the solar minimum year, systematic variations were observed for 6 days of the IQDs and fairly systematic variations were observed for 5 days. No systematic variation was observed on the remaining 4 days.

The regularity or irregularity of the variation of the EEJ current intensity with longitude is not affected by the solar activity as shown in the Table 1. The results obtained from Figures 1-28, show that the amplitudes recorded in the solar maximum year are higher than the amplitudes recorded in the solar minimum year. This implies that solar activity is responsible for the solar radiations that produce the ions and the electrons that constitute the ionospheric currents. This solar activity is higher in the solar maximum year than in the solar minimum year. The systematic and unsystematic variations arise because the solar variations have periodic and non periodic components.

A number of possible causes of the longitudinal variation of the EEJ current intensity have been suggested (e.g. Forbush, 1981). The most plausible seems to be the dependence of the Cowling Conductivity on the ambient field strength.(Luhr et al., 2004). Another possible cause is the angle between the magnetic fields. It deviates in some regions by 12° from orthogonality. This means the EEJ current has a non varnishing component parallel to the lines of force. The parallel conductivity is known to be very high, thus currents can be more intense here, if we assume the same vertical electric field strength. Furthermore the EEJ current deviates from the geographic equator up to 12 ° latitude and the currents flow in some regions at angle 30° with respect to the west-east direction. This may change the influence of solar wind either in favor of or opposing the plasma motion.

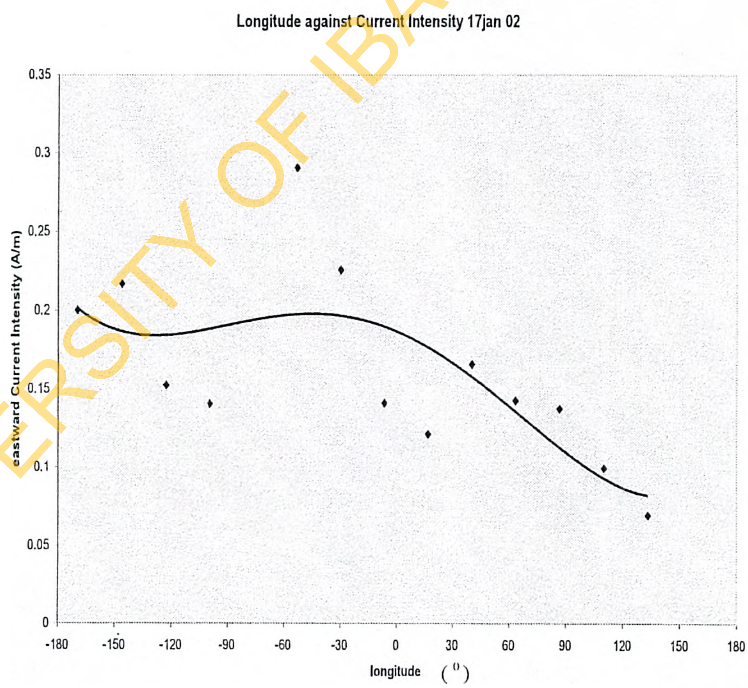

Figure 1: Unsystematic Longitudinal Variation of the Eastward Current Intensity on 17 January, 2002.

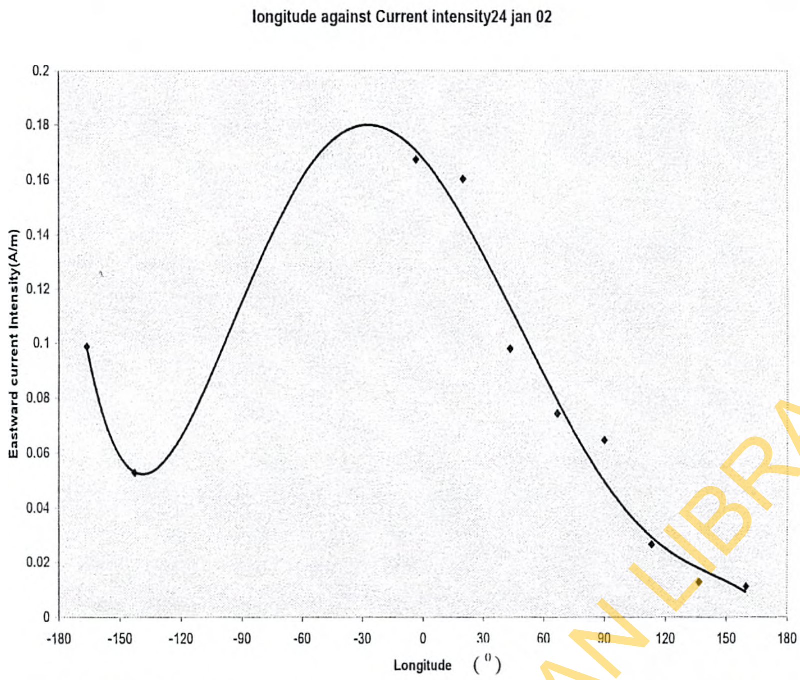

Figure 2: Systematic Longitudinal Variation on 24 January, 2002.

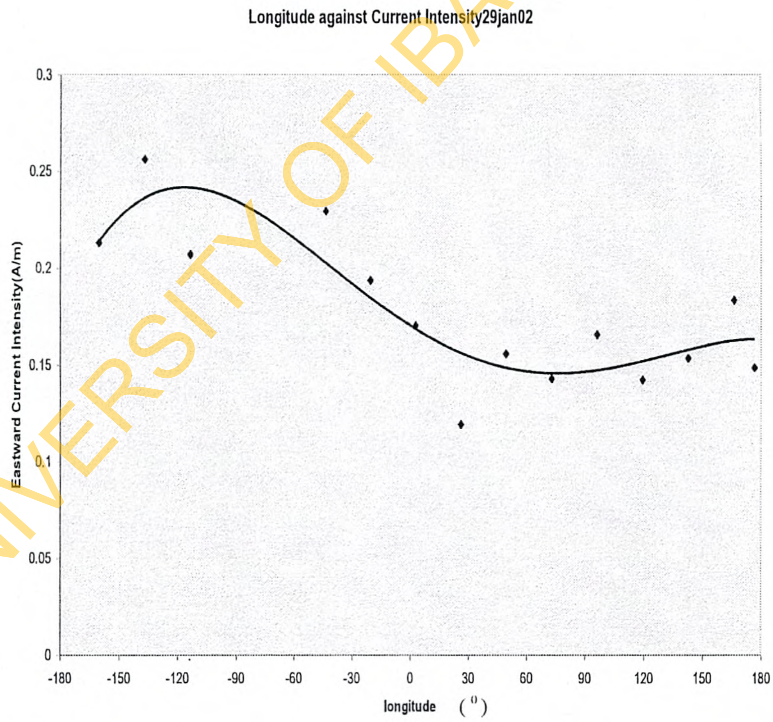

Figure 3: Systematic Longitudinal Variation on 29 January, 2002.

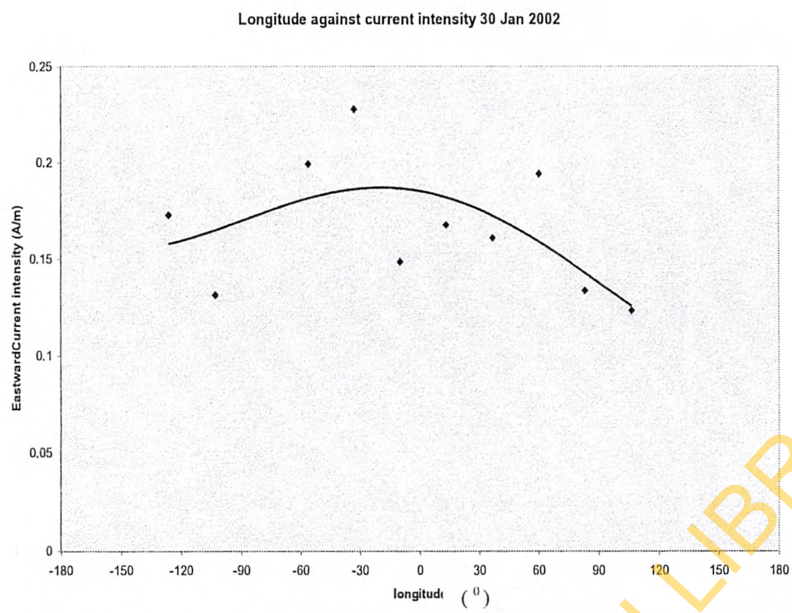

Figure 4: Unsystematic Longitudinal Variation of the EEJ Intensity on 30 January, 2002.

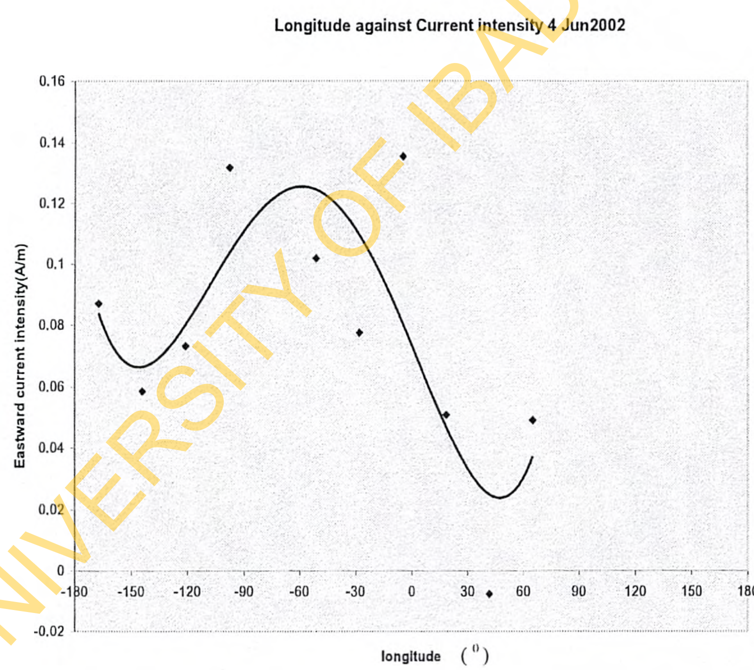

Figure 5: Fairly Systematic Longitudinal Variation on 4 June, 2002.

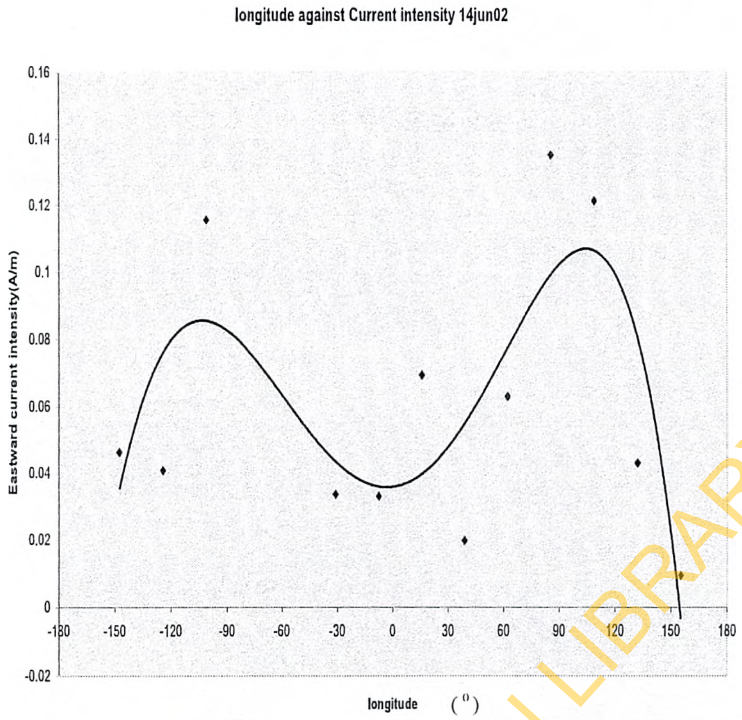

Figure 6: Unsystematic Longitudinal Variation on 14 June, 2002.

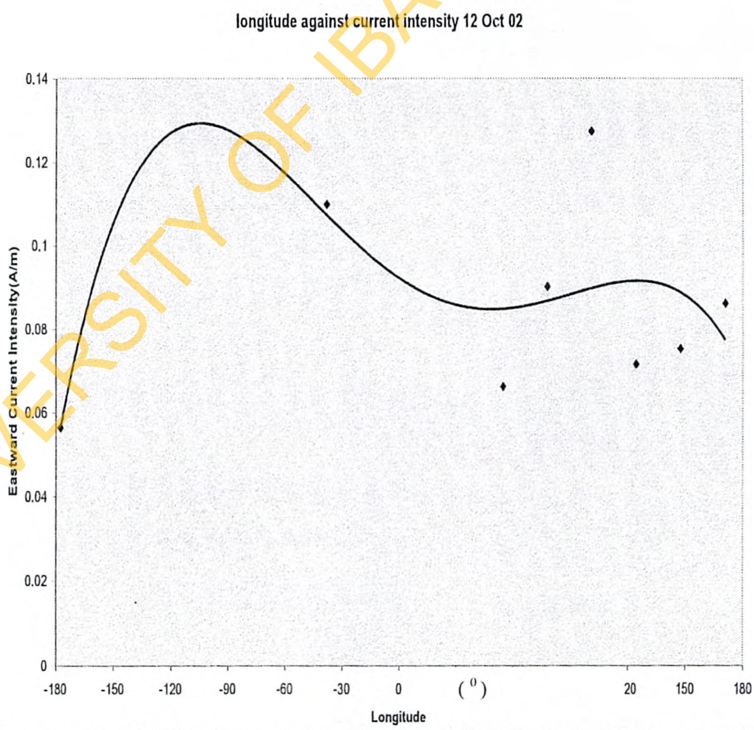

Figure 7: Fairly Systematic Longitudinal Variation on 12 October, 2002.

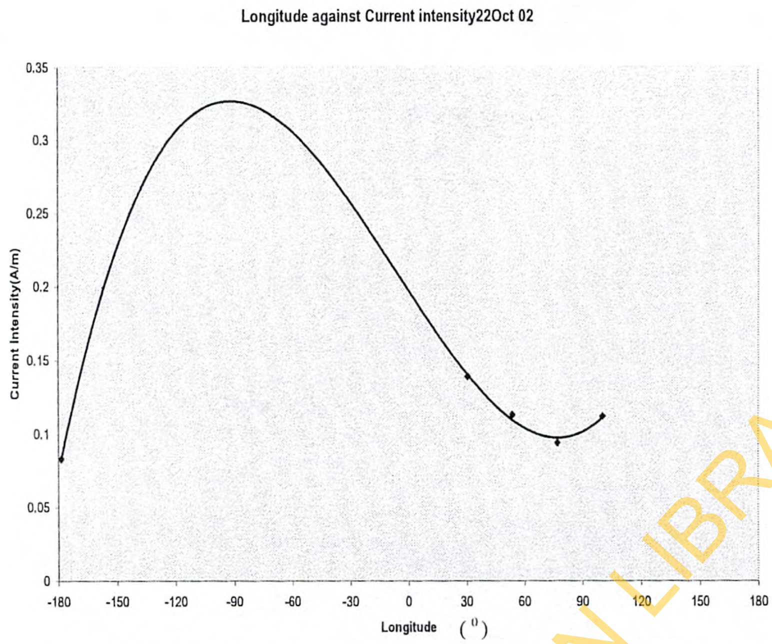

Figure 8: Systematic Variation of the EEJ Intensity on 22 October, 2002.

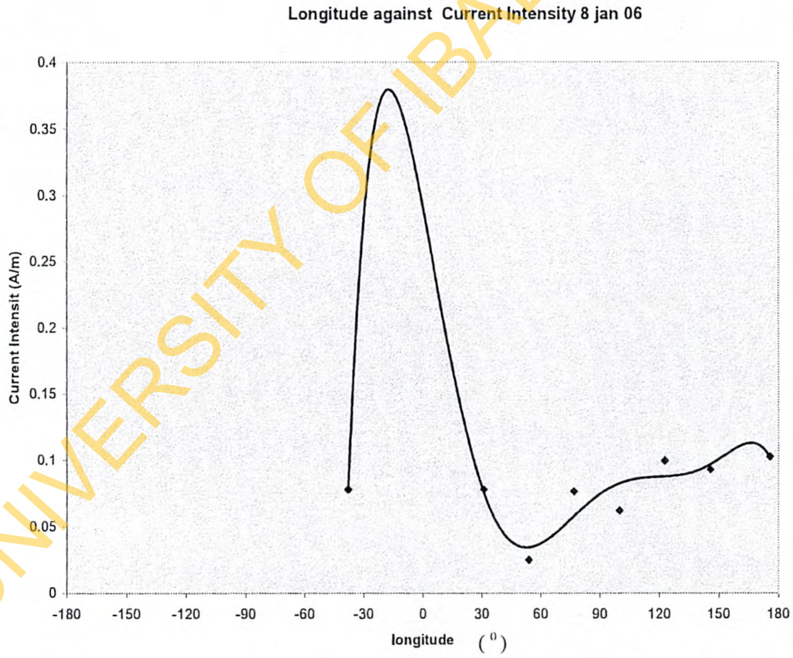

Figure 9: Systematic Variation of the EEJ Intensity on 8 January, 2006.