Landmark Values of Equatorial Electrojet Current and Magnetic Field along a Meridian near Noon

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Landmark values of the equatorial electrojet: the minimum intensity $J_m \text{ A}\cdot\text{km}^{-1}$, its distance $x_m \text{ km}$ and ratio to maximum intensity J_m/J_0 ; the magnetic field constant $K \text{ nT}$; the maximum northward magnetic field $X_0 \text{ nT}$, and the distance of zero northward magnetic field $w_X \text{ km}$; the minimum northward magnetic field $X_m \text{ nT}$, its distance $u_m \text{ km}$ and ratio to maximum northward field X_m/X_0 ; the vertical magnetic field $Z_0 \text{ nT}$ at the dip equator and the distance of zero vertical field $w_Z \text{ km}$; the maximum vertical magnetic field $Z_M \text{ nT}$, its distance $u_M \text{ km}$ and ratio to maximum northward field Z_M/X_0 ; have all been derived from September equinox satellite data and they compare favourably with their values from ground-based data. Our J_m/J_0 agrees excellently with MUSMANN and SEILER (1978) and ANANDARAO and RAGHAVARAO (1979); while our x_m agrees excellently with the location of CAHILL's (1959) westward current, and the findings of MUSMANN and SEILER (1978). The landmark distances x_m , w_X , u_m , u_M , w_Z and the ratios J_m/J_0 , X_m/X_0 and Z_M/X_0 do not vary with longitude but the intensity J_m and magnetic fields, K , X_0 , X_m , Z_0 and Z_M have maxima around 90° E , 180° E and 270° E ; and minima around 155° E and 225° E .

1. Introduction

For a long time it has not been possible to determine from ground data all the parameters of a model of equatorial electrojet put forth as far back as 1965 (ONWUMECHILI, 1965, 1966, 1967). Consequently, its view of the equatorial electrojet (EEJ) could not be fully examined. With the help of satellite and rocket data we have now determined all the parameters, though naturally, some of them more reliably than others, because rocket data are much scarcer than satellite data.

It has therefore become possible for the first time to almost fully explore the model's view of the EEJ as well as its implications for the equatorial electrojet. In this paper we explore certain landmark values of the equatorial electrojet current and magnetic field along a meridian of longitude near local noon, that have so far not been reliably studied.

Recently, Onwumechili and Ozemena obtained some of the parameters from the analysis of 17 rocket flights into the EEJ. These are used in conjunction with other parameters determined from POGO satellite data of the September equinoxes

of 1967, 1968 and 1969 by ONWUMECHILI and AGU (1981). The resulting landmark values are then compared with their other observations, as well as determinations existing in scientific literature.

2. Minimum Current Intensity

The model can be reduced to a form suitable for the study of latitudinal variation of the eastward height-integrated current density (called intensity J), which is given by

$$J = J_0 \frac{a^2(a^2 + \alpha x^2)}{(a^2 + x^2)^2}. \quad (1)$$

J has a minimum value J_m at a distance x_m from the magnetic dip equator, where

$$J_m = J_0 \alpha^2 / 4(\alpha - 1) \quad \text{and} \quad x_m^2 = a^2(\alpha - 2) / \alpha. \quad (2)$$

For the POGO equinox data ONWUMECHILI and AGU (1981) have studied the peak eastward current intensity J_0 , at the axis of the EEJ above the magnetic dip equator at $x=0$, while ONWUMECHILI and OZOEMENA (1985) studied the meridional scale length a and the meridional distribution parameter α which controls the distribution of current along a meridian.

With values of J_0 , a and α determined by Onwumechili and Agu and given in ONWUMECHILI and AGU (1981) and ONWUMECHILI and OZOEMENA (1985), we have calculated J_m and x_m from Eq. (2) at 10° intervals of east longitude. The results are given in Table 1, and their means for 30° sectors are plotted in Fig. 1. The ratio of the minimum intensity J_m to the maximum intensity J_0 is also given in Table 1 in percentage.

3. Northward Magnetic Field Component of the Equatorial Electrojet

On evaluating the double integrals of the expressions for the current density of the EEJ over the altitude and latitude extents of the EEJ, the model gives complicated expressions for the northward component X and the vertical component Z of the magnetic field of the equatorial electrojet. On certain assumptions, the northward component may be approximated to

$$(\text{sg. } z)X = \frac{1}{2} Ka \frac{(v + \alpha v + 2\alpha a)(u + b)^2 + (v + \alpha v + 2a)(v + a)^2}{[(u + b)^2 + (v + a)^2]^2}, \quad (3)$$

where x is the northward distance from the axis of the EEJ and u is the magnitude of x , z is the vertically downward distance from the axis of the EEJ and v is the magnitude of z , b is the vertical scale length of the EEJ and (sg. z) is the sign of z .

Table 1. Showing equatorial electrojet J_m A·km⁻¹, minimum eastward current intensity (here westward); J_m/J_0 , percentage of peak westward to peak eastward intensity; K nT, magnetic field constant; X_0 nT, maximum northward magnetic field; and distances: x_m km, from dip equator to minimum intensity; w_x km, from dip equator to zero northward magnetic field; w km, from dip equator to zero current; all at 10° intervals of longitude in September equinox derived from satellite data.

Longitude E degrees	J_m A·km ⁻¹	x_m km	$J_m/J_0\%$	K nT	X_0 nT	w_x km	w km
0	-58	446	-29	124	59	265	228
10	-52	496	-30	109	55	289	253
20	-53	493	-31	108	54	285	250
30	-64	448	-28	145	70	271	231
40	-66	485	-29	143	72	286	248
50	-63	488	-30	134	67	286	249
60	-65	457	-30	133	64	267	233
70	-74	461	-31	151	73	268	234
80	-88	415	-27	203	93	256	215
90	-114	505	-33	218	110	283	253
100	-103	437	-29	224	105	261	224
110	-67	486	-31	138	69	281	247
120	-72	440	-29	157	74	263	226
130	-63	487	-31	129	65	282	247
140	-58	493	-30	122	62	286	251
150	-45	478	-30	94	47	278	243
160	-45	468	-31	92	45	272	238
170	-55	450	-31	112	53	261	228
180	-96	494	-32	190	96	281	249
190	-92	494	-31	186	94	284	250
200	-62	458	-31	127	61	267	233
210	-59	473	-29	126	62	279	242
220	-38	441	-28	84	40	264	226
230	-37	521	-33	70	36	291	261
240	-53	442	-30	111	52	260	225
250	-62	445	-29	133	63	264	228
260	-74	466	-32	148	72	268	236
270	-105	447	-31	214	101	260	227
280	-101	463	-31	204	99	267	234
290	-93	509	-33	177	90	285	255
300	-96	465	-30	199	97	271	236
310	-88	461	-30	187	91	271	236
320	-72	471	-30	151	74	277	241
330	-56	498	-31	112	57	285	252
340	-72	479	-31	146	72	276	242
350	-74	437	-31	151	70	255	222
Mean	-70	469	-30	146	71	273	239
SD σ	± 20	± 25	± 1	± 40	± 19	± 10	± 11

The parameter K which appears in all expressions for the magnetic field of the EEJ derived from the model stands for the magnetic field of an infinite current sheet with constant intensity J_0 . Onwumechili and Agu determined K from the POGO equinox data at 10° intervals of east longitude and these are given in Table 1. Their sectoral means are plotted in Fig. 1.

The highest northward magnetic component of the EEJ is X_0 , which occurs at the magnetic dip equator under the axis of the EEJ where $u=0$. To compute this from Eq. (3) we need values of b and v in addition to the other parameters already used above. Recently, Onwumechili and Ozoemena determined from the data of 17 rocket measurements of EEJ current density that $b=9.47\pm0.46$ km. Since we are interested in X_0 on the earth's surface, v represents the altitude of the peak density of the electrojet. SAMPATH and SASTRY (1979) determined this altitude as 106 ± 1.5 km in India while DAVIS *et al.* (1967) gave it as near 107 km off the coast of Peru. We therefore adopt $v=106$ km. With all these parameters we have computed X_0 at $u=0$ from Eq. (3) and the result is given in Table 1. The sectoral means are plotted in Fig. 2.

From this highest value, X_0 , at the dip equator, X decreases to zero at the field focus with a focal distance of w_X from the dip equator given by

$$(w_X + b)^2 = - \frac{(v + av + 2a)(v + a)^2}{(v + av + 2aa)}. \quad (4)$$

The values of w_X are given in Table 1 and plotted in Fig. 2.

The field X then becomes negative and proceeds to a minimum value of X_m at a distance u_m from the magnetic dip equator given by

$$(\text{sg. } z)X_m = - \frac{K(v + av + 2aa)^2}{16(1 - a)(v + a)^2} \quad (5)$$

and

$$(u_m + b)^2 = - \frac{(v + av + 4a - 2aa)(v + a)^2}{(v + av + 2aa)}. \quad (6)$$

The values of X_m and u_m are given in Table 2 at 10° intervals of east longitude, and their sectoral means in Fig. 2.

In the calculation of X_0 from Eq. (3) it was found that, to the nearest nT, there was no difference between the value of X_0 at $u=0$ obtained from the full expression and that obtained by neglecting the first term of the numerator and first term of the denominator of Eq. (3), which are much smaller than the terms following them. Neglecting these first terms simplifies the ratio of X_m to X_0 , as reflected in the expression

Fig. 1. Variation of 30° sectoral means of equatorial electrojet (a) J_m $A \cdot km^{-1}$, minimum eastward current intensity (here westward); (b) x_m km, distance from dip equator to minimum intensity; and (c) K nT, magnetic field constant; all derived from September equinox satellite data.

Fig. 2. Variation of 30° sectoral means of equatorial electrojet (a) X_0 nT, maximum northward magnetic field at dip equator; (b) w_x km, distance from dip equator to zero northward magnetic field; (c) X_m nT, minimum northward magnetic field; and (d) u_m km, distance from dip equator to minimum northward field; all derived from September equinox satellite data.

Table 2. Showing equatorial electrojet X_m nT, minimum northward magnetic field (here southward); X_m/X_0 , percentage of peak southward to peak northward magnetic field; Z_0 nT, vertical magnetic field at dip equator; Z_M nT, maximum vertical magnetic field; Z_M/X_0 , percentage of peak vertical to peak northward magnetic field; and distances: u_m km, from dip equator to minimum northward magnetic field; u_M km, from dip equator to maximum vertical magnetic field; w_z km, from dip equator to zero vertical magnetic field; all at 10° intervals of longitude in September equinox derived from satellite data.

Longitude E degrees	X_m nT	u_m km	$X_m/X_0\%$	Z_0 nT	Z_M nT	u_M km	$Z_M/X_0\%$	w_z km
0	-23	558	-39	4	47	205	80	831
10	-22	607	-40	3	44	224	80	906
20	-22	603	-41	3	44	222	81	889
30	-26	562	-37	4	54	206	77	860
40	-28	597	-39	4	58	219	81	899
50	-26	599	-39	4	54	220	81	897
60	-26	567	-41	4	51	209	80	833
70	-30	571	-41	4	59	211	81	837
80	-34	530	-37	6	72	193	77	813
90	-49	611	-45	6	91	227	83	876
100	-41	549	-39	6	83	202	79	821
110	-28	595	-41	4	55	220	80	877
120	-29	552	-39	5	59	203	80	827
130	-26	597	-40	4	52	220	78	880
140	-25	604	-40	3	49	222	79	898
150	-19	589	-40	3	37	217	79	871
160	-19	578	-42	3	36	213	80	848
170	-23	559	-43	3	43	206	81	813
180	-41	602	-43	5	77	223	80	875
190	-39	604	-41	5	78	223	83	886
200	-25	568	-41	4	49	210	80	832
210	-24	584	-39	4	49	215	79	877
220	-15	553	-38	2	31	203	78	834
230	-16	627	-44	2	30	233	83	900
240	-21	552	-40	3	42	203	81	812
250	-25	557	-40	4	50	206	79	831
260	-31	574	-43	4	58	213	81	835
270	-43	556	-43	6	82	205	81	811
280	-42	571	-42	6	80	211	81	831
290	-40	615	-44	5	74	229	82	884
300	-40	574	-41	6	78	212	80	845
310	-36	572	-40	5	72	211	79	851
320	-29	582	-39	4	59	214	80	868
330	-23	607	-40	3	46	224	81	888
340	-30	587	-42	4	58	217	81	859
350	-30	546	-43	4	57	202	81	797
Mean	-29	579	-41	4	57	214	80	855
SD σ	± 8	± 23	± 2	± 1	± 16	± 9	± 1	± 31

$$8(1 - \alpha)a(v + av + 2a)X_m = -(v + av + 2aa)^2 X_0. \quad (7)$$

The ratio of the minimum field X_m to the highest field X_0 is given in 10° intervals of east longitude in percentage in Table 2.

4. Vertical Magnetic Field Component of the Equatorial Electrojet

When the complicated expression for the downward vertical magnetic field component of the equatorial electrojet, Z , is approximated in the same way as for X , then

$$-(\text{sg. } x)Z = \frac{1}{2} Ka \frac{(u + b)[(1 + \alpha)(u + b)^2 + (v + av + 3a - aa)(v + a)]}{[(u + b)^2 + (v + a)^2]^2}, \quad (8)$$

where (sg. x) is the sign of x .

From our values of the parameters the values of Z_0 , at the magnetic dip equator on the earth where $u=0$ in Eq. (8), are computed and given in Table 2.

Close to the dip equator the first terms of the numerator and denominator of Eq. (8) are very small compared with the terms following them. Neglecting them, Z in that region is given by

$$-(\text{sg. } x)Z = \frac{1}{2} \frac{Ka(v + av + 3a - aa)}{(v + a)^3} (u + b). \quad (9)$$

Therefore, in that neighbourhood the magnitude of Z grows linearly with the effective distance $(u + b)$, though the real distance is u from the dip equator, and with a gradient proportional to the intensity of the electrojet. Thus Z is not zero at the dip equator because the effective distance there is not zero but b .

From the small value at the dip equator, Z quickly proceeds to a minimum to the north and a maximum of equal magnitude to the south of the dip equator. With the usual approximations, the maximum Z_M and the minimum occur at equal distances u_M on opposite sides of the dip equator, and are given by

$$(u_M + b)^2 = \frac{(v + av + 3a - aa)(v + a)^2}{6(1 - \alpha)a}, \quad \text{and} \quad (10)$$

$$-(\text{sg. } x)Z_M = \frac{1}{2} Ka \frac{[6(1 - \alpha)a + (1 + \alpha)(v + a)](v + av + 3a - aa)^2}{(u_M + b)(v + a)[6(1 - \alpha)a + (v + av + 3a - aa)]^2}. \quad (11)$$

The values of Z_M and u_M are given in Table 2 at 10° intervals of east longitude, and their sectoral means are plotted in Fig. 3. The percentage of Z_M to X_0 is also given in Table 2.

From the maximum and minimum, respectively, the magnitude of Z slowly decreases to zero at a distance w_Z on both sides of the dip equator given by

Fig. 3. Variation of 30° sectoral means of equatorial electrojet (a) Z_M nT, maximum vertical magnetic field; (b) u_M km, distance from dip equator to maximum vertical field; and (c) w_Z km, distance from dip equator to zero vertical magnetic field; all derived from September equinox satellite data.

$$(w_z + b)^2 = - \frac{(v + \alpha v + 3a - \alpha a)(v + a)}{(1 + \alpha)}. \quad (12)$$

The values of w_z at 10° intervals of east longitude are given in Table 2 and their sectoral means are plotted in Fig. 3.

5. Results and Discussions

In this paper every effort has been made to avoid republishing any data that had been published before. However, because of some errors in the distance of the position of zero current density and intensity from the magnetic dip equator, w km (called the half width of the electrojet), the corrected values of w have been listed in Table 1. Because of this effort, the values of certain parameters used in the computation of results or discussions presented here have been omitted. The means of their 36 values at 10° intervals of east longitude are: meridional scale length $a = 326 \pm 19$ km, meridional distribution parameter $\alpha = -1.863 \pm 0.059$, peak eastward current intensity $J_0 = 232 \pm 63$ amperes per km, total eastward current $I_+ = (54 \pm 11) \times 10^3$ amperes, and latitudinal extent of the EEJ $L_1 = 784 \pm 30$ km.

5.1 Minimum current intensity

When the model was proposed in 1965, it was recognized that the value of α was crucial. If α is positive, the extremal value J_m in Eq. (2) would exist only for $\alpha > 2$, and in that case J_m would be a maximum rather than a minimum and there would be no westward (or return) current on the flanks of the dip equator. If α is negative J_m would be a minimum, and there would be westward (or return) current on the flanks of the dip equator.

By fitting actual ground-based observations of the EEJ, α came out negative with the above implications. About 15 years later, it became possible to determine α from satellite data processed differently from ground data. Here α again came out negative, and in reasonable agreement with its value from ground data.

ONWUMECHILI and OZOEMENA (1985) applied the principle of continuity of current to the model, and found that for the current to be nondivergent, $\alpha \leq -1$.

Furthermore, CAHILL (1959) observed westward current between 102 km and 108 km altitude on his rocket flight 83 at the location (3.38° N, 158.68° W). Since the dip latitude of Jarvis (0.4° S, 160.0° W) was 1.1° , the flight location was 4.88° , or 539 km north of the magnetic dip equator. Also, ANANDARAO and RAGHAVARAO (1979) found that when observed winds were incorporated in their model of the EEJ, westward currents resulted on the flanks of the dip equator.

We have therefore reached the point of being reasonably confident that Eq. (2) and the attendant results presented here are referring to a real westward, and most likely the return current, of the EEJ. The longitudinal variation of the intensity of this westward current is like that of the intensity of the eastward current presented by ONWUMECHILI and AGU (1981). With an average of -70 ± 20 A·km⁻¹, the minimum intensity J_m has principal highest magnitudes of almost equal intensity

around 90°E and 270°E , and a subsidiary high magnitude around 180°E . The smallest magnitudes are around 155°E and 225°E .

From Table 1, the distance of the position of minimum current intensity, x_m km, from the dip equator is 469 ± 25 km and from Fig. 1, x_m does not vary systematically with longitude.

The ratio J_m/J_0 of the peak westward intensity to the peak eastward intensity is -30 ± 1 percent. This depends only on the meridional distribution parameter α and does not vary systematically with longitude. The ratio of the peak westward to the peak eastward intensity in the wind model of EEJ by Anandarao and Raghavarao is also -29% . MUSMANN and SEILER (1978) reported that westward current flowing at about 5° from the dip equator with intensity of about 30% of the peak eastward intensity at the dip equator is implied by their observations in Brazil. These are in excellent agreement with our results.

It is also interesting to compare the results here arising from POGO equinoctial data with results from POGO solstitial data. For this, we have provided in Fig. 4 the so far unpublished sectoral variation of half width w km, peak eastward intensity J_0 A·km $^{-1}$ and total eastward current I_+ amperes for June 1969. The sectoral variation of J_m in Fig. 1 is similar to those of J_0 and I_+ in Fig. 4. Also, both x_m in Fig. 1 and w in Fig. 4 show no systematic variation with longitude.

5.2 Northward magnetic field component

The magnetic field constant K , with the average of 146 ± 40 nT, being the magnetic field of an infinite plane current sheet of constant intensity J_0 , is proportional of the peak eastward current intensity J_0 . From Fig. 1 it has equal maximum values in sectors 4 and 10 and a subsidiary maximum in sector 7. More specifically, the principal maxima occurred at 100°E and 270°E while the minima were at 160°E and 230°E . This longitudinal variation is similar to those of J_0 and I_+ found by ONWUMECHILI and AGU (1981) from equinoctial data and those in Fig. 4 from solstitial data.

The northward magnetic field component at the magnetic dip equator X_0 has maxima of 110 nT at 90°E , 96 nT at 180°E and 101 nT at 270°E in sectors 4, 7 and 10, respectively, minima of 45 nT and 36 nT at longitudes 160°E and 230°E in sectors 6 and 8, respectively, and a mean of 71 ± 19 nT. From the latitudinal profile electrojet survey of FORBUSH and CASAVARDE (1961), X_0 at 285°E in Peru was 90 nT. This compares very well with 90 nT at 290°E and 99 nT at 280°E in Table 1. From a similar profile of OGBUEHI and ONWUMECHILI (1965) across the equatorial electrojet at September Equinox in Nigeria, X_0 at 5°E was 59 nT. Again, this compares very well with our 59 nT at 0°E and 55 nT at 10°E in Table 1.

Like the other distances, w_x , the distance of the position of zero northward magnetic field component X , does not vary systematically with longitude and therefore its mean, 273 ± 10 km, may be used for any comparison. Unlike the presentations in the two profiles above, Hesse (private communication) has not presented the average profile from all the quiet days of his survey of the EEJ in Brazil. However, five of his profiles for October 17, 21 and 26, 1971, and November

Fig. 4. Variation of 30° sectoral means of equatorial electrojet (a) w km, distance from dip equator to zero current; (b) J_0 A·km⁻¹, peak eastward current intensity; and (c) I_+ in 10³ Amps, total eastward current; all derived from 1969 June solstice satellite data.

14 and 16, 1971 are available to us and we made rough estimates of distances and ratios. From these w_X has been estimated as 435 ± 60 km. The September equinox profile in Nigeria (ONWUMECHILI and OGBUEHI, 1967) gives w_X as 424 km. These ground-based values are higher than our value from satellite data. The difference may arise from underestimation of worldwide $Sq(X)$, on which the extraction of w_X from ground data depends.

The minimum northward magnetic field component of EEJ, X_m has major trough values of -49 nT at 90° E and -43 nT at 270° E, a minor trough value of -41 nT at 180° E, and crest values of -19 nT at 155° E and -16 nT at 225° E and a mean of -29 ± 8 nT. No available ground-based profile of the EEJ is suitable for the estimation of X_m .

The mean value of the ratio X_m/X_0 is $-41 \pm 2\%$. A rough estimate of X_m/X_0 from Hesse (private communication) gives $-32 \pm 6\%$. This is in reasonable agreement with our finding.

The position of the minimum northward magnetic field component is at a distance of u_m from the dip equator. This does not vary systematically with longitude and has a mean of 579 ± 23 km. The only profile from which an estimate is possible (Hesse, private communication) gives 662 ± 37 km. The agreement is reasonably good.

It should be noted that the northward magnetic field positions are more distant than the corresponding current positions. w_X exceeds w by 34 km and u_m exceeds x_m by 110 km. This is because the magnetic field of current at a point is inversely proportional to the distance of the point from the current. For example, reckoning from the position of zero current, the eastward (positive) current stretches from 0 to 478 km, while the westward (negative) current stretches from 0 to 545 km on the near side and from 478 km to 1023 km on the far side. Consequently, even though the total positive equals the total negative current, judging the distances of the positive and negative portions of the current from the position of zero current, the field at that position is still positive. A similar consideration explains why u_m is beyond x_m .

5.3 Vertical magnetic field component

Although the vertical magnetic field component at the dip equator, Z_0 , is very small, it still indicates maxima in sectors 4, 7 and 10 in its longitudinal variation, and has a mean of 4 ± 1 nT. From the Peruvian profile of FORBUSH and CASAVARDE (1961), Z_0 was 8 nT at 285° E, in comparison with our finding of 6 nT at 280° E and 5 nT at 290° E. The Nigerian profile of OGBUEHI and ONWUMECHILI (1965) gave a Z_0 of 2 nT and 5° E as compared to 4 nT at 0° E and 3 nT at 10° E. Thus our findings of Z_0 are comparable to the values from ground-based profiles.

The longitudinal variation of the maximum vertical magnetic field component, Z_M , is like that of the peak intensities and the other magnetic field values. It has principal maxima of 91 nT at 90° E in sector 4 and 82 nT at 270° E in sector 10, with a subsidiary maximum of 78 nT at 190° E in sector 7. The minima are 36 nT at 160° E in sector 6 and 30 nT at 230° E in sector 8, and the mean is 57 ± 16 nT. Z_M was 36 nT

in the Nigerian profile (OGBUEHI and ONWUMECHILI, 1965) at 5°E , compared to our 47 nT at 0°E and 44 nT at 10°E . In Peru, Z_M was 50 nT to the North and 77 nT to the South at 285°E because of the strong asymmetry there (ONWUMECHILI, 1967). Their mean of 64 nT may be compared to our 80 nT at 280°E and 74 nT at 290°E . Although still comparable, the profile values are lower than our values by about 10 nT, probably because they have been more affected by earth induction than our values, derived from satellite data.

The average of the ratio Z_M/X_0 is $80\pm 1\%$, to be compared with 61% in the Nigerian profile, and 56% to the North and 86% to the South in the Peruvian profile; and $73\pm 3\%$ from the Brazilian profiles of Hesse (private communication). The mean profile ratio of $68\pm 6\%$ (from the three areas) is in reasonable agreement with ours, but is probably lower than ours for the same reason given in the preceeding paragraph.

The distance of maximum vertical magnetic field component, u_M , does not vary systematically with longitude and has a mean of 214 ± 9 km. u_M was 275 km in the Nigerian profile (OGBUEHI and ONWUMECHILI, 1965) and 327 km to the north but 325 km to the south in the Peruvian profile (FORBUSH and CASAVERDE, 1961); and 333 ± 5 km in Brazil. The profile mean of 311 ± 32 km is comparable with our mean.

In general, the magnetic field values from ground-based profiles are in good agreement with our results, but the distances from the profiles tend to be greater than the distances derived from satellite data. ONWUMECHILI and OZOEMENA (1985) had also noted the same situation with regard to the half width w and the latitudinal extent L_1 of the EEJ. CAIN and SWEENEY (1972) pointed out that latitudinal profiles of the EEJ are wider at greater altitudes and this has been reflected in all our expressions of the distances by v , the altitude of EEJ. In the first place, the rough estimates of the distances scaled from the profiles of investigators primarily interested in the magnetic field of the EEJ are far from being accurate. However, the general tendency suggests some basic difference, probably arising from the processing of the ground or the satellite data. One possibility is that the general background level of the worldwide Sq is underestimated in the ground profiles, while the general background of the ambient magnetic field B is overestimated in the satellite profiles by measuring the magnitude of electrojet signature from the high shoulders of the profile.

All the intensities and magnetic fields share the same longitudinal variation, namely, principal maxima of about equal magnitude around longitudes 90°E and 270°E with a subsidiary maximum around longitude 180°E , and minima around longitudes 155°E and 225°E . These confirm the findings of J_0 and total eastward current I_+ in ONWUMECHILI and AGU (1981) and OZOEMENA and ONWUMECHILI (1987), where possible explanations as well as the unexpected maximum around 90°E have been discussed. The subsidiary maximum is narrow and consequently looks isolated in a sectoral presentation.

6. Conclusions

This study is important for two main reasons. First, it is the first study since all the parameters of the model have been estimated, and therefore certain approximations in its application have been dispensed with. Second, the only previous comprehensive comparisons of electrojet parameters from satellite and ground-based data were all for X_0 (reviewed in AGU and ONWUMECHILI (1981) and ONWUMECHILI (1985)) and w and L_1 in ONWUMECHILI and OZEMENA (1985). This study makes a comprehensive comparison of nine additional parameters derived from satellite and ground-based data. Even if order of magnitude or no agreement exist, it would still be of interest. The following are among the conclusions from this study.

1) The minimum current intensity J_m is westwards, about -70 ± 20 A/km, and occurs at a distance of x_m , about 469 ± 25 km from the magnetic dip equator and on both sides of it. The percentage of the minimum to the maximum current intensity at the dip equator J_m/J_0 is about $-30 \pm 1\%$.

2) The maximum northward magnetic field component at the dip equator X_0 is about 71 ± 19 nT, and this field decreases to zero at a distance of w_X from the dip equator, about 273 ± 10 km.

3) The minimum northward magnetic field component X_m is negative (southwards) about -29 ± 8 nT, and occurs at a distance of u_m , about 579 ± 23 km from the dip equator. The percentage of the minimum to the maximum northward field X_m/X_0 is about $-41 \pm 2\%$.

4) At the dip equator, the vertical magnetic field component Z_0 is about 4 ± 1 nT, and after growing to a maximum this field component eventually becomes zero at a distance of w_Z from the dip equator, about 855 ± 31 km.

5) The maximum vertical magnetic field Z_M is about 57 ± 16 nT, and occurs at a distance of u_M from the dip equator, u_M being about 214 ± 9 km. The percentage of the maximum vertical field to the maximum northward field Z_M/X_0 is about $80 \pm 1\%$.

6) Variations of an eastward current are usually regarded as closely related to variations of its northward magnetic field component. We find, however, that the distance of zero northward field w_X exceeds the distance of zero current w by about 34 km, and the distance of minimum northward field u_m exceeds the distance of minimum current x_m by about 110 km, the difference in each case being more than three times the sample standard deviation. Given the westward (return) currents on the flanks of the dip equator, this has been explained as the consequence of the inverse distance law of the magnetic field of current.

7) There is excellent agreement between our ratio J_m/J_0 and the findings of MUSMANN and SEILER (1978), and ANANDARAO and RAGHAVARAO (1979); and also excellent agreement between our x_m and the location of the westward current measured by CAHILL (1959), and the findings of MUSMANN and SEILER (1978).

8) There is good agreement between the magnetic fields, X_0 , Z_0 and Z_M , derived from satellite and ground-based data.

9) There is reasonable agreement between the ratios of the magnetic fields, X_m/X_0 and Z_M/X_0 , derived from satellite and ground-based data.

10) Considering that the satellite and ground-based magnetic data are not contemporaneous, and the rough estimates of distances from ground-based profiles, the agreements between the landmark distances w_X , u_m and u_M and w_Z derived from satellite and ground-based data are not disappointing. However, in view of the consistent tendency for the ground profile distances to exceed the distances derived from satellite data, the matter needs further investigation, such as paying particular attention to careful determination of all the landmark distances from ground-based data.

11) The intensities and magnetic fields, J_m , K , X_0 , X_m , Z_0 and Z_M , have the same longitudinal variation, characterized by principal maxima of about equal magnitude around longitudes 90° E and 270° E with a subsidiary maximum around 180° E, and minima around longitudes 155° E and 225° E.

12) The intensity and magnetic field ratios, J_m/J_0 , X_m/X_0 and Z_M/X_0 , do not vary systematically with longitude. In each case the actual variation is small, the sample standard deviation being less than 5% of the mean.

13) The landmark distances, x_m , w_X , u_m , u_M and w_Z do not vary systematically with longitude. The actual variation is also small, and in no case does the sample standard deviation exceed 5% of the mean.

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