

# Peak time of equatorial electrojet from different longitude sectors during fall solar minimum

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**Abstract.** Equatorial electrojet is an eastward flowing current at about  $\pm 3^\circ$  dip equator. This current intensity is always higher during noontime as it is greatly influenced by the ionization of Earth ionosphere. Apart from that, previous study had shown that EEJ current varies with longitude and latitude as well as solar cycle. The aim of this study is to investigate the peak time of EEJ current at different longitude sectors using simultaneous data in 2009. By eliminating Sq current contribution and normalizing ground-based data from MAGDAS/CPMN, IIG and WDC network, we managed to reach our purpose and gain reliable output. We found out that EEJ is strongest in South American sector. Our results show that the peak EEJ during fall solar minimum is observed at 11 LT for South American, Indian and Southeast Asian sector but it is 1 hr earlier in African sector.

## 1. Introduction

The equatorial electrojet current or EEJ has always been conceived as a phenomenon confined to narrow area around  $\pm 3^\circ$  of dip equator. It is affected by solar cycle [1, 2, 3, 4], seasons [5, 6, 7, 8] as well as varies with longitude [4, 5, 6, 8] and latitude [2, 9, 10]. At the dip-equator, this current overlaps with a part of global Sq current which consequently affect the reading of geomagnetic component measured at station near the dip equator. Thus, most of researchers will subtract the Sq contribution while studying the EEJ variability using geomagnetic data.

EEJ intensity is known to be greater during noontime due the highest rate of ionization at this period. Based on this, previous study of EEJ tends to choose the highest value of geomagnetic northward during 10 to 14 LT to represent this current component [11]. However, study by [1] had shown that the EEJ strength reached its maximum around 11 LT during solar minimum and around 12 LT during solar maximum. They conclude that the time for the peak EEJ is around local noon during solar maximum and shifts to earlier local times during solar minimum. This output is obtained using ground based data at three longitude sector which are east of South American, east of African, and Indian without considering the latitudinal variation of the observation stations. As EEJ is greatly known to vary with latitude, their result might contain uncertainties when a direct comparison is made using data in those three longitude sectors.

Apart from that, study by [8] has shown that the peak time of EEJ can be also affected by the existence of counter electrojet (CEJ) that happened during noontime. In their study, the peak off EEJ was observed 1 hr earlier which is at 10 LT time compare to the days without CEJ. This important feature of EEJ has recently been raised by [10] as the factor that causes the difference in EEJ peak time during two phases of solar cycle is still a remaining question.

## 2. Data and Analysis

This study utilizes two stations located along the same longitude, with one located near dip equator around  $\pm 3^\circ$  dip latitude while the other one is outside this region. The stations are grouped into six pairs, one in the South American sector, two in the South African sector (east and west), one in Indian sector and two in Southeast Asian sector (east and west). The data were obtained from various networks which are Magnetic Data Acquisition System/ Circum-pan Pacific Magnetometer Network

(MAGDAS/CPMN), Indian Institute of Geomagnetism (IIG) and International Real-time Magnetic Observatory Network (INTERMAGNET). Apart from that, we also requested data from one stand-alone station in South American sector. Table 1 shows the geomagnetic and geographic coordinate of the stations while and Figure 1 illustrates the geographic distribution.

Analysis is carried out using the *EUEL* index from September 16 to 30, 2009. In order to compare the result from all longitude sectors, we normalize the *EUEL* index observed at these stations to the dip equator with the aid of the CM4 model [12]. The method is introduced by [9] to overcome the latitudinal variation effect of EEJ current. In this technique, the latitudinal profile of Sq is obtained by applying fitting of polynomial of degree 2 to the CM4 model. This is done after the region of  $6^\circ$  across dip equator was masked in order to avoid the influence of the EEJ in the determination of Sq profile. Using this latitudinal profile, we normalize the observed *EUEL* at off-dip equator station ( $\theta^\circ$  dip latitude) to dip equator ( $0^\circ$  dip latitude) to obtain normalized Sq at dip equator,  $EUEL_{Sq(0^\circ)}$ . On the other hand, *EUEL* observed at station near dip equator ( $\theta^\circ$  dip latitude) is normalized to dip equator ( $0^\circ$  dip latitude) directly using CM4 model profile to give normalized total current at dip equator,  $EUEL_{total(0^\circ)}$ . We further calculate EEJ current by subtracting  $EUEL_{Sq(0^\circ)}$  from  $EUEL_{total(0^\circ)}$ . The details procedure of this technique can be found in [9]. We further apply the same steps to all stations pairs.

**Table 1.** Geomagnetic and geographic coordinates of stations used in this study

| Region         | Station     |      | Geographic |         | Geomagnetic |         |
|----------------|-------------|------|------------|---------|-------------|---------|
|                | Name        | Code | Lat.(°)    | Lon.(°) | Lat.(°)     | Lon.(°) |
| South America  | Ancon       | ANC  | -11.77     | -77.15  | 0.77        | 354.33  |
|                | Fuquene     | FUQ  | 5.40       | -73.73  | 15.72       | 357.99  |
| African        | Ilorin      | ILR  | 8.50       | 4.68    | -1.82       | 76.80   |
|                | Tamanrasset | TAM  | 22.8       | 5.5     | 25.4        | 80.6    |
|                | Adis Ababa  | AAB  | 9.04       | 38.77   | 0.18        | 110.47  |
|                | Nairobi     | NAB  | -1.16      | 36.48   | -10.65      | 108.18  |
| India          | Tirunelveli | TIR  | 8.70       | 77.80   | 0.21        | 149.30  |
|                | Alibag      | ABG  | 18.62      | 72.87   | 10.36       | 146.54  |
| Southeast Asia | Langkawi    | LKW  | 6.30       | 99.78   | -2.32       | 171.29  |
|                | Kototabang  | KTB  | -0.20      | 100.32  | -10.63      | 171.93  |
|                | Davao       | DAV  | 7.00       | 125.40  | -1.02       | 196.54  |
|                | Muntinlupa  | MUT  | 14.37      | 121.02  | 6.79        | 192.25  |

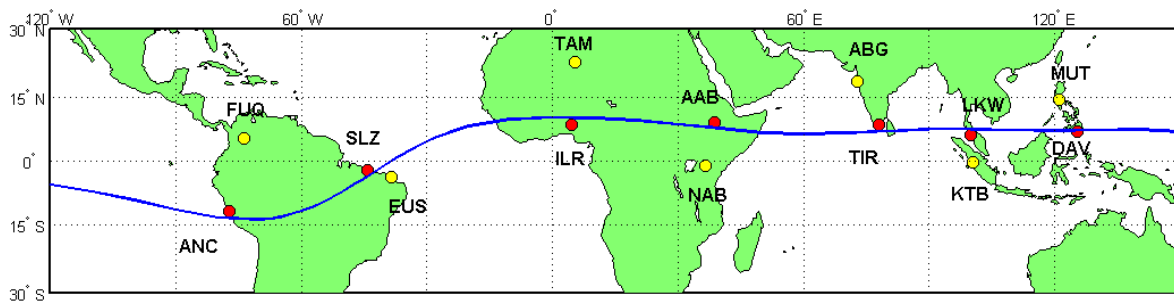


**Figure 1.** Map of stations used in this study

Figure 2(a) illustrates the original and normalized data of ILR-TAM pair in the west of African sector. The black thick lines indicate the mean of *EUEL* with the highest is at ILR station (near dip equator) while the lower is at TAM station (off-dip equator). The normalized *EUEL* from ILR which

is the total current is represented by the thick blue dashed line while the thick green dashed line is the Sq current obtained by the normalization of EUEL at TAM station.

We further calculate the EEJ current from the difference between the total current and Sq obtained in Figure 2(a). The output is presented in Figure 2(b). At this stage, we only consider the reading between 09 LT to 15 LT. The EEJ current within this period is shown by the thick red line. The blue and green lines here are the same as the one in Figure 2(a).

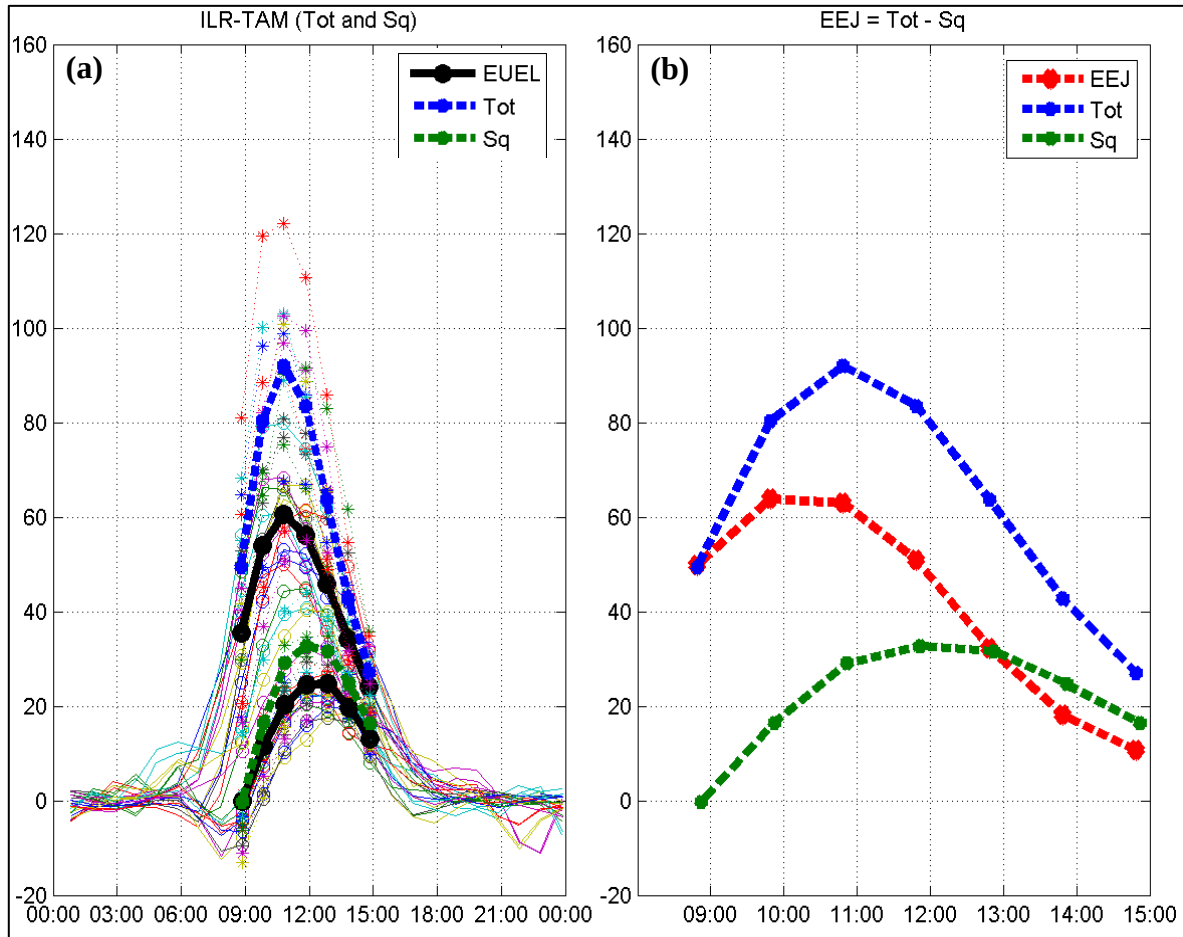


**Figure 2 a)** EUEL from dip equator station (ILR) and off-dip equator station (TAM) are indicate by thick black lines and their normalized values are indicate by thick blue line and thick green line respectively **b)** EEJ current (thick red line) is calculated from total current (normalized EUEL at ILR, thick blue line) minus Sq current (normalized EUEL at TAM, thick green line)

### 3. Results and Discussion

Simultaneous observations from September 16 to 20, 2009 were recorded from 12 magnetometer stations located in six different longitude sectors. Figure 3 (a) shows the magnitude of total current obtained from CM4 model while Figure 3 (b) shows the one observed from ground based magnetometer data for the period between 09 LT and 15 LT. Their values are presented in Table 2. It can be seen that CM4 model result for peak EEJ current is at 11LT or 12LT. Nevertheless, analysis of total current from observations demonstrate every station pairs have the same result for peak EEJ current which is at 11 LT. These results indicate that the agreement between CM4 model and observation is only can be observed at east of African and west of Southeast Asian sector which both shows the peak time of EEJ is at 11 LT. The discrepancies between the model and observation data might be caused by the controlling parameter used in the model. In this model, only F10.7 and Dst were considered whereas the total current (i.e. EEJ and Sq) is known to be influenced by several other

factors such as the local wind and gravity waves. This difference however will not be discussed in this current paper.

We further analyze the magnitude of EEJ which is shown in Figure 4. Here we can compare the mean of EEJ from all station pair for each noontime from 09 LT to 15LT. We found that the magnitude of EEJ is strongest in South American sector regardless of local time and weakest in Indian sector during 09 and 10 LT but shifted to African sector during 11 to 14 LT.

In addition, we also examine the peak time of EEJ current as indicate by the circle symbols with the values are listed in Table 3. The results obtained show that the EEJ peak time is observed at 11 LT for South American, Indian and Southeast Asian sector while at African sector, it is observed at 10 LT. The peak time of 11b LT is in agreement with previous study by [1] for east of South American and Indian sector. Our EEJ peak time at African sector is however 1 hr early than the one obtained in their study. This discrepancy might cause by the latitudinal variation of EEJ which is neglected in their study.

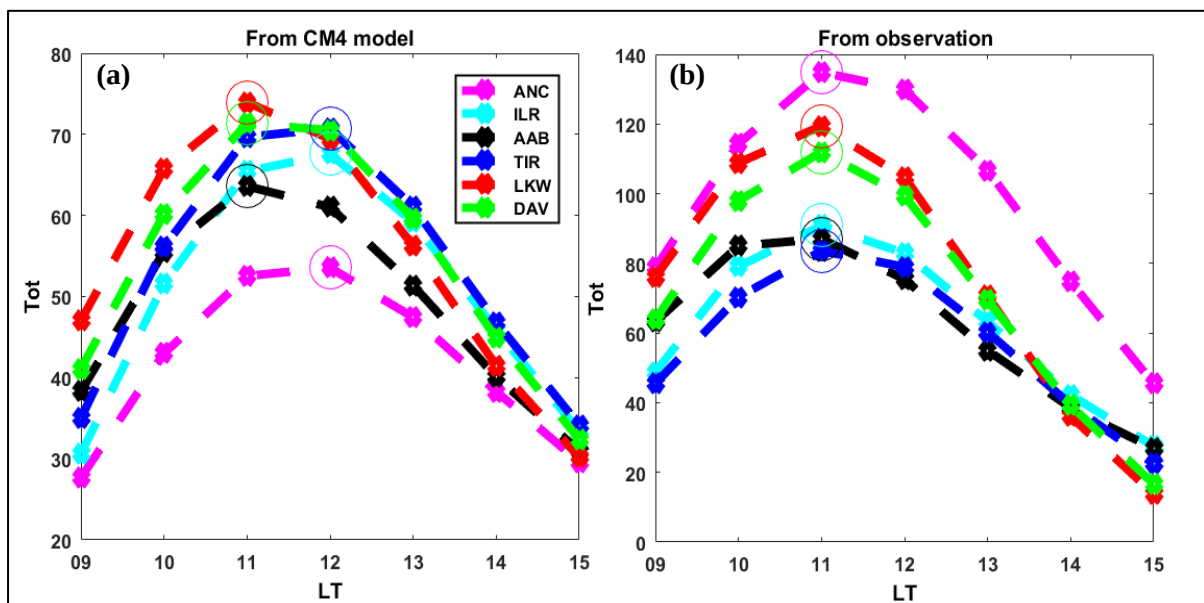


**Figure 3.** Magnitude of total current from a) CM4 model and b) observation between 09LT and 1500 LT from six longitude sectors (stations)

**Table 2.** Peak time of total current from CM4 model and observation

| Station | CM4 Model | Observation |
|---------|-----------|-------------|
| ANC     | 12        | 11          |
| ILR     | 12        | 11          |
| AAB     | 11        | 11          |
| TIR     | 12        | 11          |
| LKW     | 11        | 11          |
| DAV     | 11        | 11          |

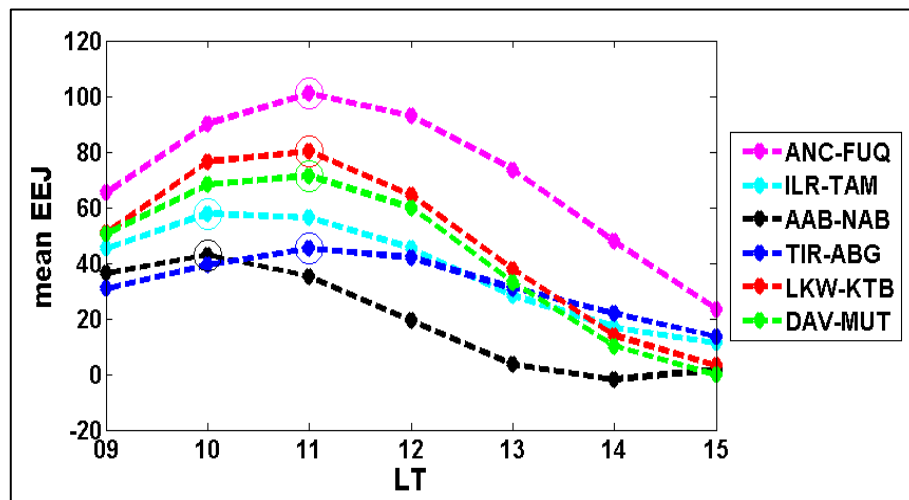


**Figure 4.** Mean EEJ from 09 LT to 15 LT calculated from all station pairs. Circle symbol indicate the maximum mean value which represents the peak time of EEJ

**Table 3.** Maximum local time (LT) where mean EEJ amplitude is the highest (see Figure 4)

| Pair(region)                        | Local time (LT) |
|-------------------------------------|-----------------|
| ANC-FUQ(South America)              | 11              |
| ILR-TAM(west African)               | 10              |
| AAB-NAB(east African)               | 10              |
| TIR-ABG(India)                      | 11              |
| LKW-KTB(west Southeast Asia)        | 11              |
| <b>DAV-MUT(east Southeast Asia)</b> | <b>11</b>       |

## 5. Conclusions

In this study, the total current from CM4 model and observation are found to be different where our analysis shows that the peak time of total current measured from ground based magnetometer is observed at 11 LT for all six longitude sectors. Other than that, we found out that EEJ peak time at most longitude sector is at 11 LT except for African sector which EEJ there is observed to be maximum at 10 LT in the solar minimum phase. Further research on this phenomenon should be conducted using solar maximum data in order to understand the factor that causes the longitudinal variation of EEJ peak time.

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