Anomalous Day-to-Day Variability of Y Component During D-Months in Bangui

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Abstract The diurnal variation in the east-west component (Y) for Bangui during the d-months (January, February, November and December) of the years 1999 and 2000 was studied using the published monthly five international quiet days for the respective months. The study revealed the existence of certain degree of day-to-day variability pattern of the Y component during the d-months of the years studied. Several forms of Abnormal Quiet Days (AQDs) were also found in Sq(Y).There were more AQDs than Normal Quiet Days (NQDs), with 14(70%) and 6(30%) in 1999 and 13(65%) and 7(35%) in 2000 respectively. The high degree of day-to-day variability observed in the Y component in Bangui suggests that this is a peculiar feature of the individual days of the d-months observed in Bangui, as results from Mbour, shown to sustain those of Bangui, shows only one abnormal day in the d-months of 1999 and none in 2000.

Key words: Abnormal Quiet Day (AQD), Eastward field, Westward field, Day-to-day variation, Sq (Y).

Introduction

The concept of abnormal quiet days (AQDs)was first introduced by Brown and Williams (1969). They defined abnormal quiet days as those of the five international quiet days in each month on which the time of maximum diurnal variation of Sq (H) deviates or falls outside the specified time interval, which is generally around local noon at low latitudes. Days on which the diurnal maximum H component falls within the time interval 0830 – 1330 are termed as ''normal'' quiet days (NQDs). Days whose maximum occurred outside this range are termed ''abnormal'' quiet days (AQDs). However, Alex & Jadhav (2007), in their study of the day-to-day variability in the occurrence characteristics of Sq focus during d-months and its association with diurnal changes in the Declination component, defined abnormal quiet days in Sq (D) as days representing a dominant westward-directed field (negative Y) in the morning hours, when a dominant eastward field is expected at most of the low latitude stations. These AQDs are an aspect of the anomalous day-to-day characteristics of the Sq current system brought about by the ionosphere.

It is generally agreed that the ionospheric current system is widely/hugely responsible for daily variations in the magnetic field at the Earth's surface during geomagnetic quiet conditions; which is generated by solar heating and result in E-region conductivity at about 90 – 130km above the earth's surface. Various researchers have studied the day-to-day variability of Sq. Schlapp (1968) suggested that it is due to the variations in the dynamo driving force rather than the variation in conductivity. Alex et al. (1992) studied demonstrated complex day-to-day variations in patterns in D and the Horizontal component during d-months. Rastogi (1993), on his part reported remarkable changes in the summer – winter variation pattern in the eastward field.

In this paper attempt is made to show the abnormal day-to-day variations in Y component at Bangui an equatorial and low latitude station in Central Africa during the d-months of the pre-solar maximum and solar maximum years of 1999 and 2000.

Data Set and Method

The data set used to depict the anomalous day-to-day variability in the Y component is mainly restricted to the average hourly values of Y components for the years 1999 and 2000 in Bangui (BNG) and Mbour (MBO).The data set was obtained from the International Real-time magnetic observatory network site (www.intermagnet.org). The list of geomagnetic quiet days for the five quiet days of each of the d-months used was obtained from the International Service of Geomagnetic Indices (ISGI) site (http://*isgi.cetp.ipsl.fr/).*

The main focus of the study is on Bangui, but results from Mbour are also here presented to sustain the results reached in the case of Bangui. The respective station codes with their geographic and geomagnetic location are shown in Table 1.

Table 1: List of stations with their coordinates

Station	Code	Geographic Longitude (°)	Geographic Latitude(°)	Geomagnetic Longitude(°)	Geomagnetic Latitude(°)
Bangui	BNG	18.567	04.333	89.000	04.700
Mbour	MBO	343.020	14.400	56.800	20.680

The period of study falls in the pre-solar maximum year (1999) and the solar maximum year (2000). The data was carefully scrutinised. There was no need for conversion of the data from D to Y since the data obtained from INTERMAGNET was already in Y

component format. Times are in local time (LT) for the respective stations.

In this paper the definition of AQDs for Sq (Y) is adopted as given by Alex and Jadhav (2007). Normal days are designated as the days in a particular month having a well-defined eastward field (where the Y component is positive) in the morning hours, and changing over to a westward directed field (where Y is negative) in the afternoon hours. The abnormal days represent days in a month having a dominant westward directed field in the morning hours (when a dominant eastward directed field is expected) and a somewhat eastward field in the afternoon hours. The anomalous behaviour in Y component for the different quiet days was studied and results obtained as presented in this paper.

Results and Observations

Table 2 and Table 3 show the number of abnormal and normal days for each of the d-month of 1999 and 2000. Some selected diurnal variation plots of the Y component for the normal and abnormal days for the individual d-months of 1999 for both Bangui (BNG) and Mbour (MBO) are shown in figures 1a, 1b, 2a and 2b.

Table 2: Number of normal and abnormal days in d-months of 1999 in Bangui (BNG)

d-month	Normal Days	Abnormal Days
January	-	5
February	1	4
November	3	2
December	2	3

Table 3: Number of normal and abnormal days in d-months of 2000 in Bangui (BNG)

d-month	Normal Days	Abnormal Days
January	3	2
February	1	4
November	1	4
December	2	3

Careful scrutiny of the individual days in Figure 1a in terms of the diurnal pattern for the normal days in Bangui shows a well-defined eastward directed field (positive Y) in the morning hours in all the curves, with a maximum occurring between the hours of 0900h – 1100h local time (LT), with a minimum occurring in the afternoon hours. Study of the Y component curves for the days designated as abnormal days (Figure 2a) show a dominant and well defined westward directed field (negative Y) in the morning hours, when a dominant eastward directed field should normally be expected. It is seen that there is a maximum negative excursion in the morning hours occurring before 0900h LT in most of the curves, and a maximum positive excursion in the afternoon hours occurring between 1400h LT-1600h LT. It is also observed in all the curves that this dominance of the westward directed field over the eastward directed field has also suppressed the morning maximum positive excursion usually observed on normal days. There is a great degree of unpredictability in the pattern of the diurnal variation of the Y component seen in the day-to-day study of the d-months. This unpredictability pattern can be seen by looking at particular days of the d-months.

Looking at the variations of the Y component in Bangui on the 26 February 1999, a normal day (Figure 1a), it shows less influence of the eastward directed field in the early morning hours, which changes just before noon with a maximum in the afternoon hours. Incidentally, this is the only day that recorded an abnormal variability condition in Mbour (Figure 1b) in the d-months of 1999. In Figure 2a, 1 February 1999, is an abnormal day, where variations in the Y components shows a significant negative excursion caused by eastward field during the early morning hours, with a minimum occurring just after 0600h LT, and changing over to a positive excursion, eastward field, in the afternoon hours, with maximum at about 1400h LT. Similar features can be seen on the 2 February 1999, another abnormal day, but with a suppressed westward field in the morning hours, with minimum occurring around 1000h LT, changing over to the eastward field with suppressed maximum at about 1500h LT. This abnormality in the diurnal variation of Y on these days in Bangui is absent in Mbour (Figure 2b). It can be seen that both days are normal days at Mbour, with positive excursion in Y in the morning hours, changing to the negative excursion in the afternoon hours. Except on the 26 February 1999, which recorded an abnormal condition, all the other five quiet days of the d-months in 1999 for Mbour are normal days (Figure 1b and 2b).

Similar characteristics in the diurnal variation pattern can also be seen for Bangui in all the curves shown for both normal and abnormal days in the d-months of year 2000 as shown in Figures 3a and 4a. Referring to the variations in the curve of 4 February 2000 for Bangui, a normal day (Figure 3a), the Y component shows a marginal increase in the eastward field, with a maximum, somewhat suppressed, at about 1000h LT in the morning hours, and a significantly suppressed westward field in the afternoon hours, with a minimum at about 1600h LT. 30 December 2000, an abnormal day (Figure 4a), clearly shows the influence of a dominant westward field in the morning hours with maximum negative excursion at 0900h LT, changing over to eastward field with maximum at about 1300h LT. Almost similar to the case of 30 December 2000 is that of 31 December 2000, another abnormal day(Figure 4a). We can see, just as in the 30 December 2000, the westward directed field dominating most of the morning hours and exhibiting a negative excursion with minimum also occurring at about 0900h LT, subsequently changing over to a definite eastward directed field with positive excursion in the afternoon hours (though not as significant as the previous day) peaking at about 1400h LT. 20 December 2000, a normal day (Figure 3a), shows the presence of a strong eastward directed field in most of the morning hours, changing to a suppressed westward field dominating the afternoon hours. On these said days and all the selected quiet days shown in the d-months of 2000, the diurnal variation at Mbour reports normal days (Figure

3b and 4b), suggesting that there may be distortion in the Sq current system in the local ionospheric conductivity over Bangui on the abnormal days.

Discussion and Conclusion

The results presented in this paper suggest that on abnormal quiet days there is distortion in the Sq current system on a day-to-day basis during the d-months. It is also suggestive of additional fields present which are consistent with the presence of equivalent current system, such as that originally proposed by Butcher (1987). This additional current present on AQDs flows northward in the morning and southward in the afternoon, as a result the magnetic effects on AQDs are caused by a single current vortex (SCV) which flows clockwise extending over both hemispheres. But the driving forces for the proposed SCV have not yet been identified (Butcher,1989).According to Chapman & Bartels (1940), the day to day changes in the amplitude of Sq variations will be controlled by ionization changes, but variations in type of current system will be determined by irregularities in convection in the relevant ionosphere layers. However, with respect to explaining the distortions in the Sq current systems and its variability during the d-months, there exist different school of thoughts – Arora et al.(1980), Walker & Kannangara (1982), Takeda (1990),Mazaudier (1993), etc.

This study has mainly focussed on the day-to-day variability in the Sq diurnal variation as seen from the characteristics variation of the Y component at Bangui station in Central Africa Republic for the d-months of the years 1999 and 2000. The results shown here agree with that shown for the winter months of 1987 by Alex et al (1992). Signature of the formation of the northern Sq focus can be seen on all the normal days in the results following the expected diurnal variation pattern of the Y component. This is particularly evident on normal days, 21 December and 26 December 1999 (Figure 1a), and on 17 January, 18 January and 14 December 2000 (Figure 3a). Also, the presence of a dominant clockwise current system is obvious and active on abnormal days, which contrast, anticlockwise current system, which is active on normal days. This is clearly seen in the variation of Y component on the abnormal days of 30 January, 2 February, (Figure 2a) and 9 January, 30 December and 31 December 2000 (Figure 4a).

The results outlined in this paper shows that there is anomalous day-to-day variability in the Sq diurnal current pattern as seen in the diurnal variation in Y component during the d-months of the years 1999 and 2000 in Bangui. Several forms of AQDs were also observed as shown by the curves of 30 January, 31 January, 1 February, 2 February and 27 November 1999, and 8 January and 15 December 2000. Apart from the absence of the enhanced eastward directed field in the morning hours, there is only a marginal eastward directed field during the afternoon hours. This results in the decreasing of the amplitude variation in the afternoon hours. This decreasing maybe due to the effect of a reversed or counter electrojet. 27 November and 21 December 1999, and 2 November and 15 December 2000 shows pronounced secondary depression at approximately 1600h LT. Stening (1989), Rastogi (1974) and Onwumechili & Akasofu (1972) have explained that most pre-noon and afternoon depressions are effects due to counter electrojet.

In the d-months of both years there were more AQDs than NQDs, with 14 (70%) AQDs against 6 (30%) NQDs in 1999; and 13 (65%) AQDs against 7 (35%) NQDs in 2000. The high degree of day-to-day variability observed in the Y component suggests that this is a peculiar feature of the individual days of the d-months. This anomalous day-to-day variability in the pattern of the Sq diurnal variation current is evident from the variation in Y on the abnormal days, such as 1 February, 2 February, 27 November 1999, and 8 January, 9 January, 30 December 2000.

Acknowledgement

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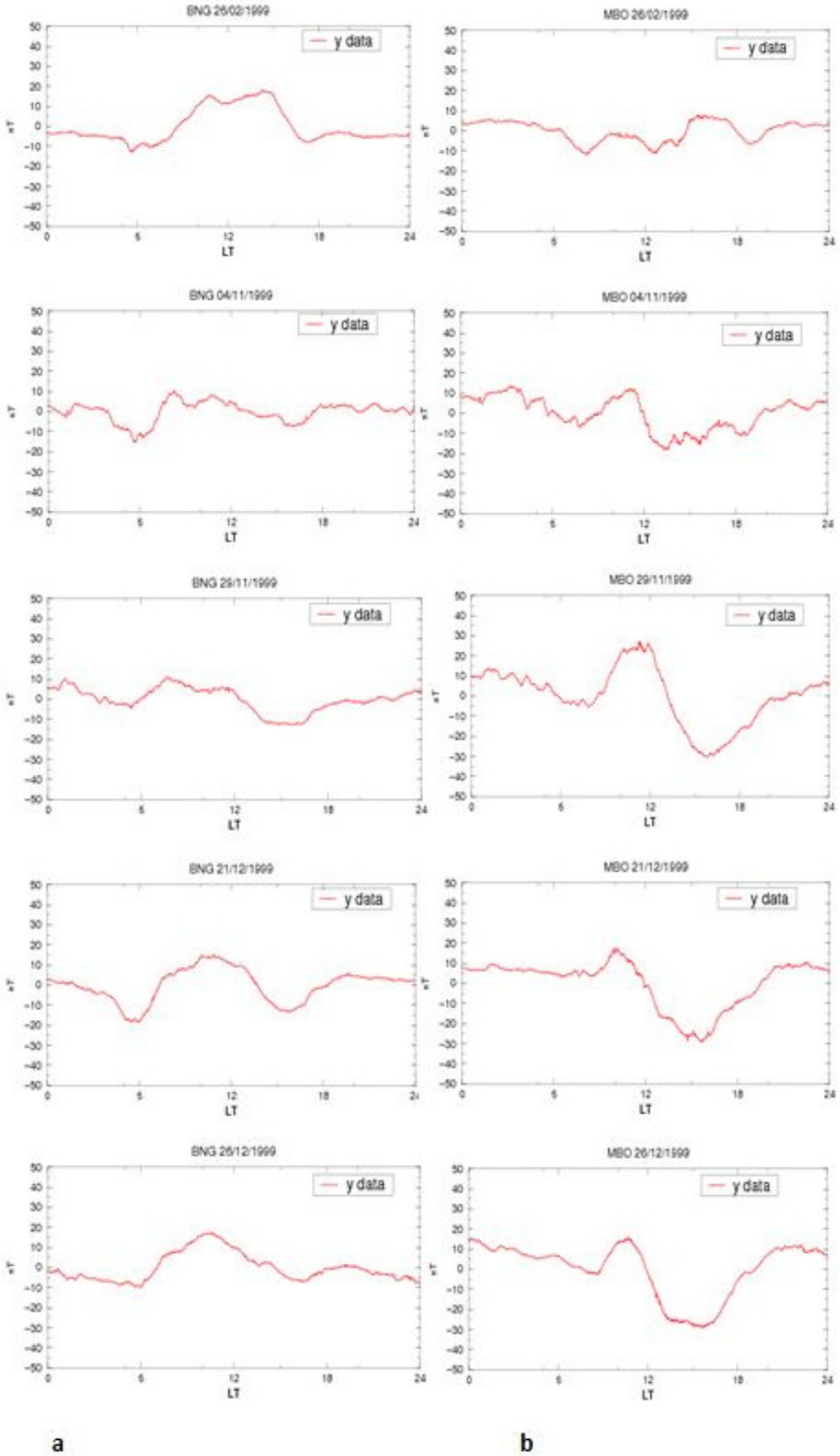

Figure 1. Diurnal variation of Y for (a) some 'Normal' days of d-months of 1999 in Bangui; (b) shows equivalent days in Mbour

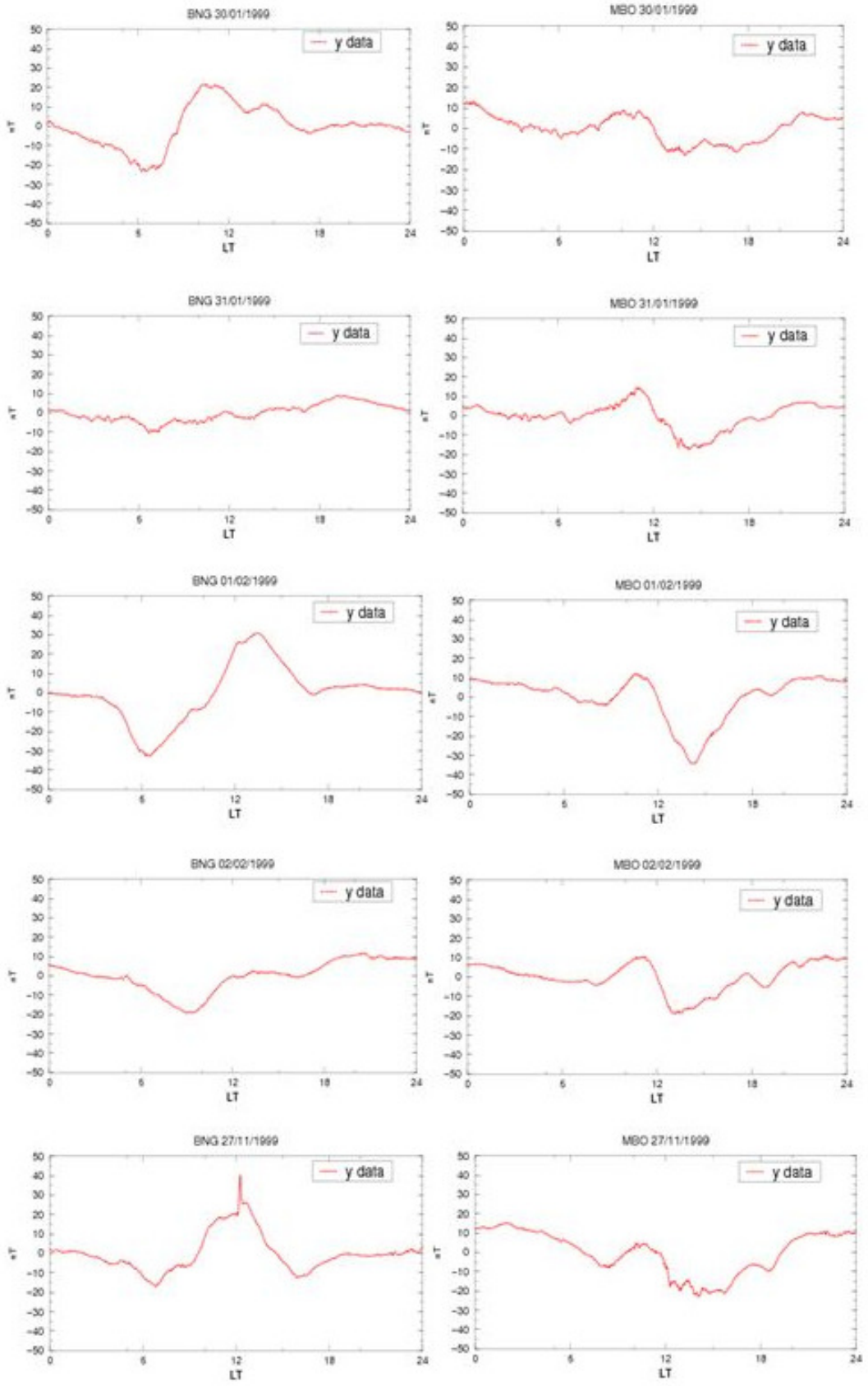

Figure 2. Diurnal variation of Y for (a) some 'Abnormal' days for d-months of 1999 in Bangui; (b) shows equivalent days in Mbour.

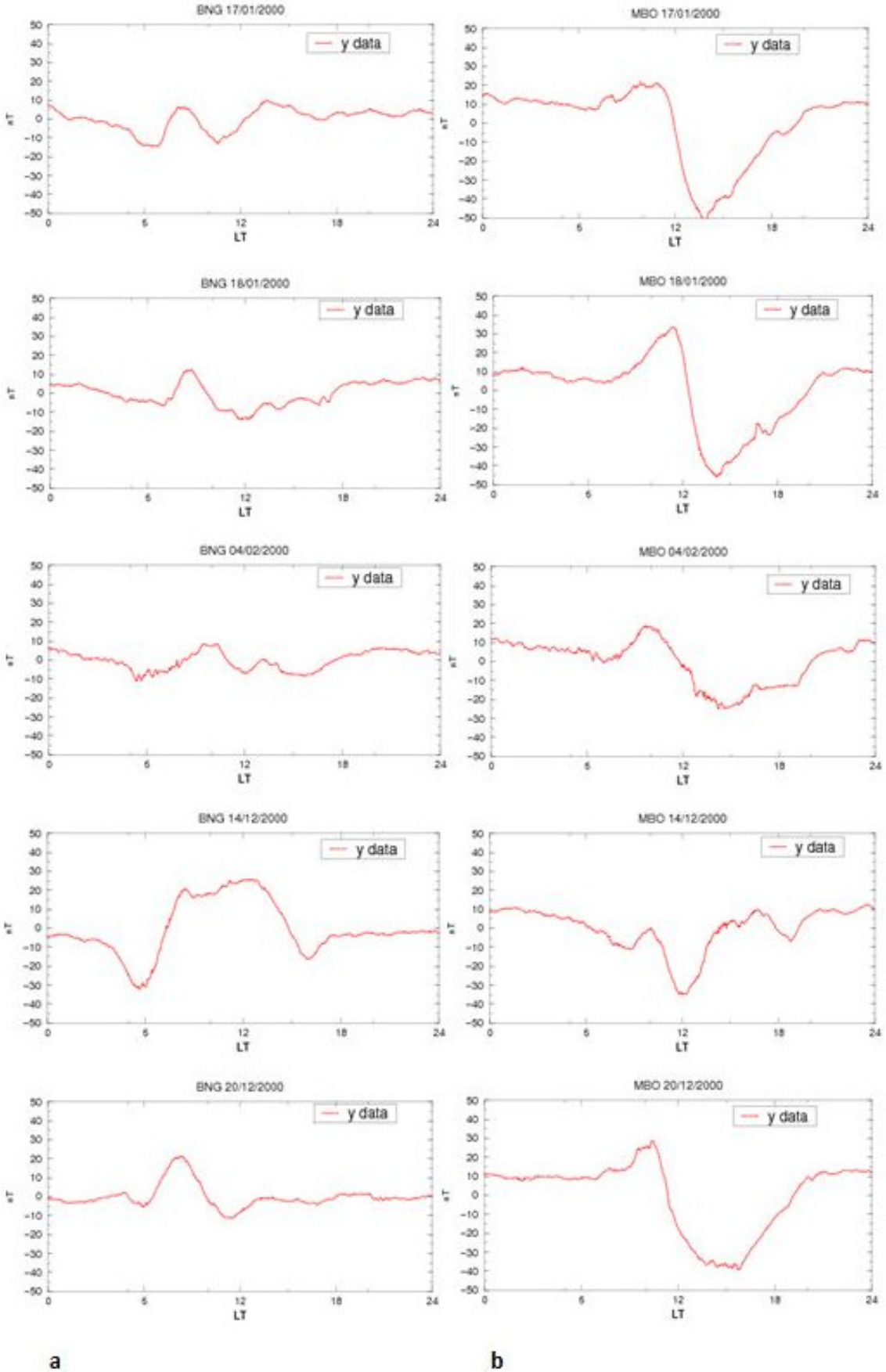

Figure 3. Diurnal variation of Y for (a) some 'Normal' days of d-months of 2000 in Bangui; (b) shows equivalent days in Mbour.

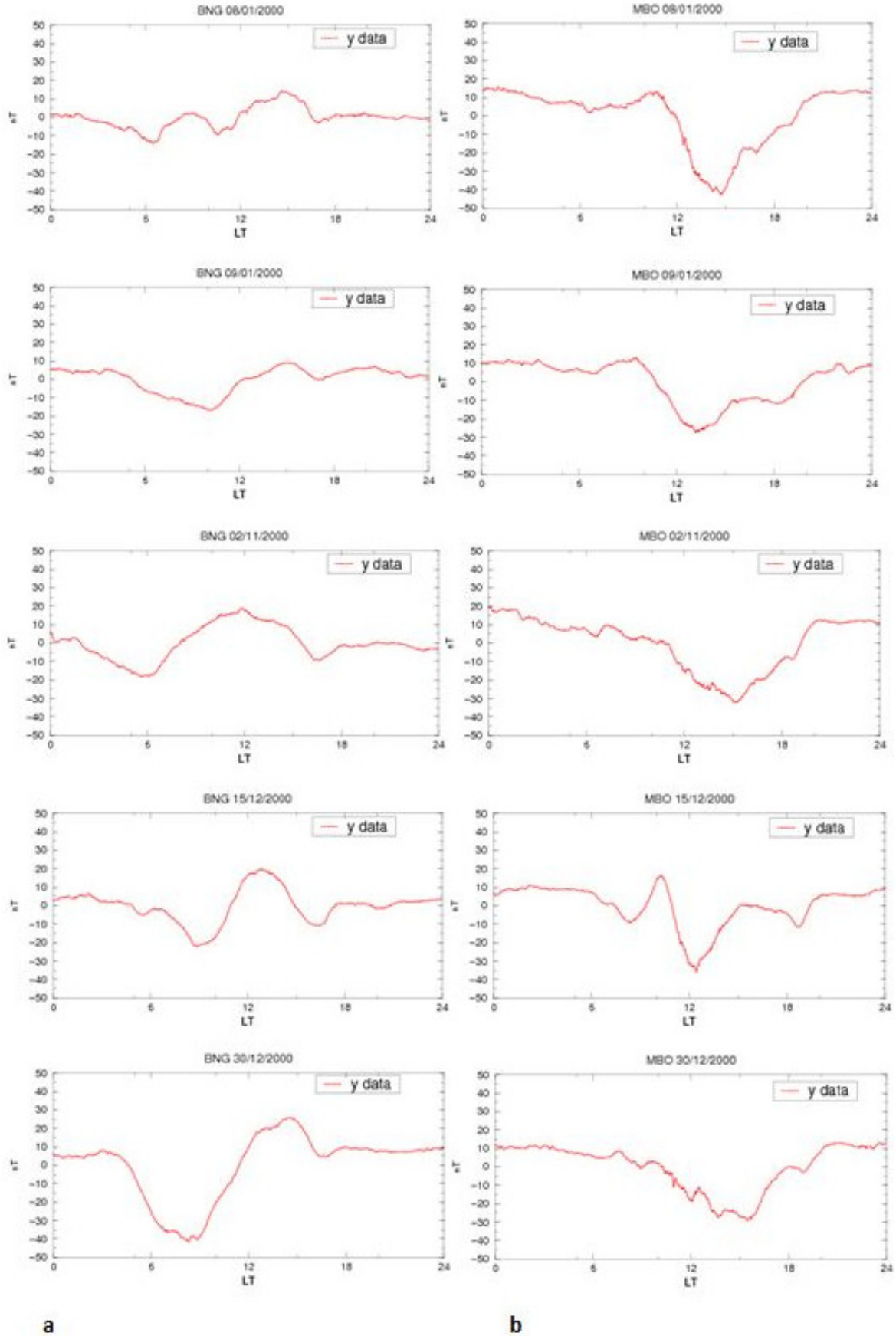

Figure 4. Diurnal variation of Y for (a) some 'Abnormal' days of d-months of 2000 in Bangui; (b) shows equivalent days in Mbour.