# On the Occurrence of AQDs at Kodaikanal

J HANUMATH SASTRI & B SURYANARAYANA MURTHY
Indian Institute of Astrophysics, Kodaikanal 624 103

*Received* 28 *May* 1977; *accepted* 12 *September* 1977

A study is made of the occurrence of "abnormal quiet days" (AQDs) at Kodaikanal (10°14'N; 77°28'E; dip 3·5°N) using *H*-field data over a 26-yr period (1950-75). The results show distinctive differences in the morphological behaviour of AQDs at equatorial and midlatitudes.

The amplitude and the time of extremum in the diurnal variation of geomagnetic elements at any particular station exhibit variability on a day-to-day basis, even on quiet days. Several mechanisms have been proposed to account for this which include changes in position of *Sq* foci[1] and *Cp* current system in the polar region.[2] Brown and Williams[3] made a detailed study of the day-to-day variability in the phase of *Sq* on quiet days using *H*-data at Abinger (geogr. lat 51°11'N; geogr. long. 0°23'W) and two other stations near Greenwich, UK, and introduced the concept of "abnormal quiet days" (AQDs) defined as those of the five international quiet days in each month on which the extreme value in the diurnal variation of *H*-field falls outside a specified time interval, depending on the particular station concerned, centred at 1100 hrs LT. Using this approach they and Brown[4] found a marked solar control of the AQD phenomenon in that AQDs have been noticed to occur most frequently in years of sunspot minimum and during local winter months, i.e. when solar intensity is lowest. Subsequently, the method of Brown and Williams[3] has been applied to *H*-data at equatorial stations both inside and outside the electrojet region; for Alibag by Arora[5] and for Addis Ababa, Trivandrum and Alibag by Last *et al.*[6] The above recent investigations revealed significant differences in the characteristics of AQDs at middle and equatorial latitudes suggesting the need for further studies on the AQD phenomenon at other stations. To this end we have investigated the characteristics of AQDs at Kodaikanal (geogr. lat. 10°14'N; geogr. long. 77°28·E; dip 3·5°N), a station under the equatorial electrojet, for which uninterrupted magnetic data exists since 1950. The study is based on the hourly average

values of $H$-field for the five international quiet days of each month over the period 1950-75 (both inclusive).

Fig. 1 shows the distribution of the occurrence of the time of daily maximum in $H$ at Kodaikanal during international quiet days for each month over the 26-yr period mentioned above. The times of maximum have been summed up over half-hour intervals to give a count appropriate to 0000-0030, 0030-0100..... etc. hrs UT. It can be clearly seen from Fig. 1 that the distribution is essentially single peaked with the maximum of $H$ occurring mostly in the interval 0430-0730 hrs UT. (On 50% of the days the maximum occurred between 0530-0630 hrs UT.). There were, however, days for which the maximum of $H$ occurred outside the interval 0430-0730 hrs UT.

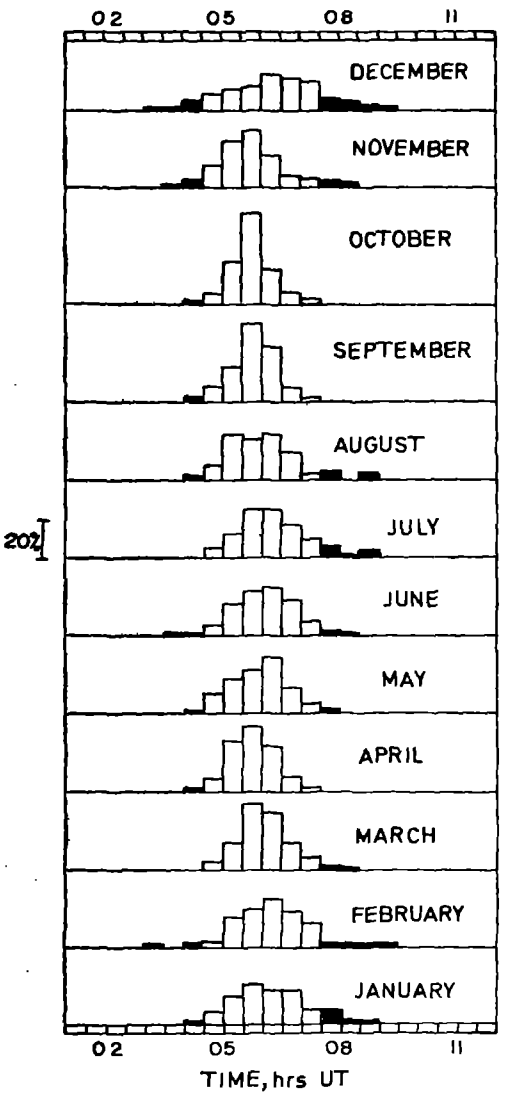


Fig. 1—Monthly histograms of percentage occurrence of international quiet days on which the diurnal maximum in $H$-component occurred during each half-hour interval at Kodaikanal over the period 1950-1975 (Black areas represent AQDs)

Following Brown and Williams,[3] those days on which the maximum occurred during the interval 0430-0730 hrs UT have been designated as "normal quiet days" (NQDs) and those on which the maximum was outside this time interval as "abnormal quiet days" (AQDs). Out of the 1541 international quiet days examined, 110 days representing about 7% were AQDs. It may be seen from Fig. 1 that the AQD phenomenon at Kodaikanal is characterized by the presence of a slight phase shift in the normal diurnal variation of the $H$-component as the AQDs flank the NQD region and there is no secondary maximum in AQD occurrence around local midnight. The above behaviour is in good agreement with that at the two other electrojet stations, viz. Trivandrum and Addis Ababa recently reported by Last *et al.*[6] and establishes the distinctive difference in the occurrence pattern of AQDs at equatorial and midlatitudes.

Fig. 2 shows the monthly and seasonal variation of AQD occurrence at Kodaikanal. It may be seen that there is a semi-annual variation with maxima in local winter and summer (winter maximum is prominent) and a minimum during equinoxes. A similar trend is noticed even after the AQDs were separated into AM and PM types, i.e. for which the time of maximum of $H$-component was before 0430 hrs UT and after 0730 hrs UT, respectively. The sunspot cycle dependence of AQD occurrence is shown in Fig. 3 which depicts the 3-hr running means of Zurich sunspot number ($R_Z$) and the percentage annual occurrence of AQDs for (a) Greenwich Abinger/Hartland,[4] (b) Addis Ababa, Trivandrum and Alibag[6] and (c) Kodaikanal. It is evident from Fig. 3 that the relationship between the occurrence of AQDs at Kodaikanal and sunspot number is not quite apparent unlike at midlatitudes where there is

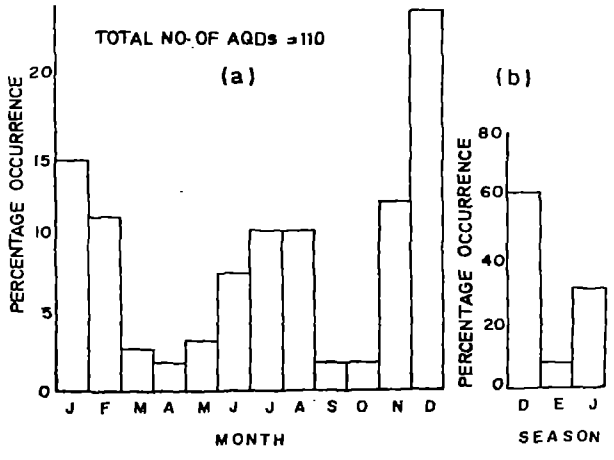


Fig. 2—Percentage occurrence of AQDs at Kodaikanal, (a) by month; and (b) by season (D—Nov. to Feb; E—Mar., Apr., Sept. and Oct.; J—May to Aug.)

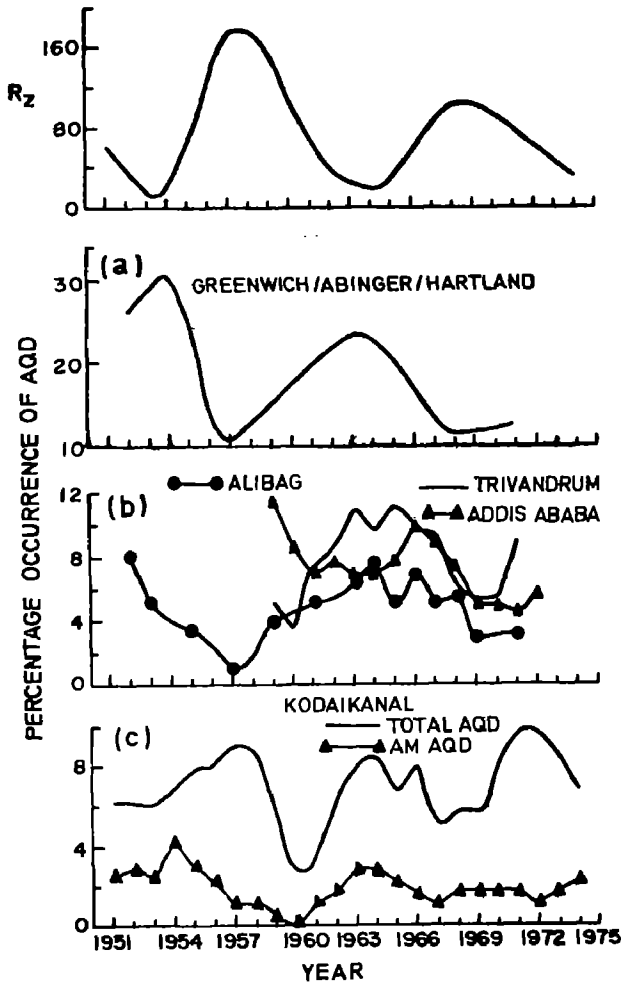


Fig. 3—3-yr running average of sunspot number ($R_Z$) and percentage annual occurrence of AQDs for: (a) Greenwich/Abinger/Hartland;[4] (b) Addis Ababa, Trivandrum and Alibag;[6] and (c) Kodaikanal (present study)

a clear-cut antiphase relationship between the occurrence of AQDs and sunspot number. To investigate this rather anomalous behaviour, the phase relationship between sunspot number and AQD occurrence is studied in a quantitative way by cross-correlating the curves of $R_Z$ and AQDs (total, AM and PM) using incremental lags of 1 yr. Maximum correlation is noticed when the curve of total AQDs and PM AQDs lead $Rz$ curve by 4 yr (correlation coefficient 0·47 and −0·56, respectively). In contrast to this, the sunspot cycle dependence of AM AQDs is less vague [see Fig. 3(c)] as maximum correlation is noticed when AM AQD curve leads $R_Z$ curve by 1 yr (correlation coefficient = −0·77, significant at $P>0·01$). The above observations suggest that the PM AQDs which are about 2·5 times as many as AM AQDs (see Fig. 1) are responsible for the lack of a clear-cut antiphase relationship between AQD occurrence at Kodaikanal and sunspot cycle. A similar influence of PM AQDs has also been inferred by Last *et al.*[6] in the sunspot cycle variation of AQD occurrence at Addis Ababa.

Brown and Williams[3] reported that the variability in the phase of $Sq(H)$ when it occurs most (i.e. local winter and sunspot minimum) represents a regional or planetary phenomenon as they found that 80% of AQDs are common to Abinger and Wingst, 1000 km apart. The figure fell to 35% in summer and sunspot maximum. Although a similar seasonal trend is noticed in the behaviour of common AQDs at Alibag, Trivandrum and Addis Ababa by Last *et al.*, the percentages of common AQDs were noticed to be small compared to those at midlatitudes. We have examined this aspect by working out the common AQDs with respect to Kodaikanal at the three stations Alibag, Annamalainagar and Trivandrum, all in the same longitude zone. It is to be noted that Annamalainagar and Trivandrum are situated north and south of Kodaikanal, respectively, in the electrojet region while Alibag is outside the influence of electrojet. It is found that 84% of AQDs of Kodaikanal are common to Trivandrum, 55% to Annamalianagar and 17% to Alibag. And, 51% of the AQDs at Kodaikanal are common to both Annamalainagar and Trivandrum. The finding that there is lack of close association in the occurrence of AQDs at Kodaiknanal and Alibag which are separated by about the same distance as Abinger and Wingst, coupled with the fact that the occurrence pattern of AQDs is different at middle and equatorial latitudes indicates that the AQD phenomenon may not be the same in these two latitude regions. Further, even in the electrojet region there are differences in the characteristics of AQDs at closeby stations brought to light by the present study. At Kodaikanal 72% of the AQDs are of PM type and the solar cycle control is not so obvious. On the other hand, at Trivandrum 59% of the AQDs are of AM type and there is an antiphase relationship between sunspot number and AQD occurrence.[6]

**References**

1. Hasegawa M, *J. geophys. Res.*, **65** (1960), 1437.
2. Mayaud P N, *Annls. Géophys.*, **21** (1965), 514.
3. Brown G M & Williams W R, *Planet. Space. Sci.*, **17** (1969), 455
4. Brown G M, *Nature, Lond.*, **251** (1974), 592.
5. Arora B R, *Indian J. Met. Geophys.*, **23** (1972), 195.
6. Last B J, Emilia D A & Outhred A K, *Planet Space-Sci.*, **24** (1976), 567.