SBGf02599

Long-term variation of the lightning flash characteristics in the southeastern Brazil: 1988 – 1995

Osmar Pinto Jr. and Iara R. C. A. Pinto[(1)] , José H. Diniz, André M. Carvalho and Armando Cazetta Filho[(2)]

1-Instituto Nacional de Pesquisas Espaciais – INPE, Brazil
2-Companhia Energética de Minas Gerais – CEMIG, Brazil

ABSTRACT

The long-term variation of the cloud-to-ground lightning flash density in terms of its geographical, monthly and diurnal distribution is presented, based on the longest lightning data set ever obtained in the tropics. The results are based on 12.8 millions cloud-to-ground lightning flashes recorded in the southeastern Brazil from 1988 to 1995 with a lightning network consisting of four LPATS sensors located in Minas Gerais. They should be considered as reference for future studies in this region.

INTRODUCTION

The geographical distribution of cloud-to-ground lightning flashes has been studied by several authors. Orville (1991,1994) and Orville and Silver (1997) have published results for the contiguous United States from 1989 to 1995, using a network of over 100 wideband magnetic direction finders augmented by time-of-arrival sensors beginning in 1994. Hodanish et al. (1997) have published results for the state of Florida from 1986-1995. The monthly distribution of lightning activity has also been studied by several authors (Lopez and Holle, 1986; Orville, 1994; Reap, 1994; Watson et al., 1994; Pinto et al, 1996; Orville et al., 1997; Hodanish et al., 1997; Orville and Silver, 1997; Rocha et al., 1997; Pinto et al., 1997; Orville et al., 1997). In particular from summer to winter season, is also well documented: lightning activity over land has a maximum in the summer season and a minimum in the winter season. The hourly variability of the cloud-to-ground lightning activity, in turn, is well known to have a large peak associated with the maximum convective activity in the afternoon, even though variations of this pattern can also exist associated with local meteorological and orographic aspects. In Brazil, the first studies were published by Pinto et al. (1996) and Pinto et al. (1997). In this paper, the results of the first long-term study in Brazil of such distributions are presented.

LIGHTNING DATA

The data used in this paper were obtained by a lightning positioning and tracking system (LPATS), version III, located in the state of Minas Gerais, southeastern Brazil, during the years from 1988 to 1995. At that time, the system was composed of four sensors (for more details, see Pinto et al., 1996). Although the system was originally designed to cover a total area of 1,400,000 km^2, we have considered in this study only the region situated between 16° and 23° S and 42° and 48° W (about 420,000 km^2). This region corresponds approximately to the region for which the distance of any point to the geometric center of the sensors is below or equal to 350 km. The reason for this limitation was to guarantee high detection efficiency and high location accuracy. From the comparison of LPATS results with balloon electric-field data (Pinto et al., 1992 a,b) and CIGRÉ 10 kHz lightning flash counter data (Diniz et al., 1996) it was estimated that in this region the average detection efficiency is around 70 % and the location accuracy is better than 10 km. The flash density values in this paper were first calculated multiplying the measurements by an arbitrary factor of 1.4 to correct for the 70 % efficiency. In fact, the assumption of a uniform flash detection efficiency may be not real. It is possible that it may be lower than 70 % near the edges of the region considered. In order to take this fact into account the flash density was recalculated considering the efficiency values provided by manufacturer of system (Global Atmospheric, Inc). The lightning data were referenced to grid blocks that are approximately 55x55 km. This size was adopted so that the error in the flash location would not affect significantly the results, that is, misplacement of flashes by one grid block when the flash location is close to the grid block borders would not affect significantly the results. A similar procedure was adopted by Reap (1986). Here is worth mentioning that possible variations in the lightning parameters for distances less than 50 km would not be observed in this analysis.

RESULTS AND DISCUSSION

Figure 1 shows the geographical distribution of the average cloud-to-ground lightning flash density during the period from 1988 to 1995, assuming a constant detection efficiency of 70 %. Figure 2 shows the same flash density, but at this time considering the detection efficiency values provided by the manufacturer of the lightning system. Although these

efficiency values are not necessarily real, they are supposed to be more representatives of the real values than the assumption of constant detection efficiency. Figure 3 shows the diurnal distribution of cloud-to-ground lightning flashes for the same period. The distribution has the typical pattern obtained in most parts of the world, with a peak around afternoon. This distribution is indicative that most lightning flashes in the southeastern part of Brazil originates from isolated thunderstorms with a minor contribution of large convective systems. Figure 4 shows the monthly distribution of cloud-to-ground lightning flashes for the same period. The distribution presents two peaks in the months of February and November. Such a behavior is typical for tropical regions and is in agreement with temperature data.

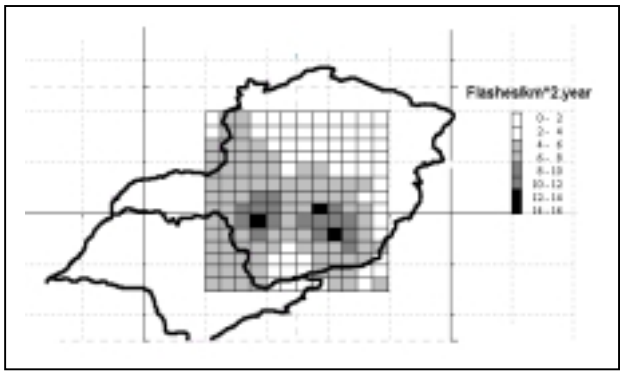

Fig. 1 – Geographical distribution of cloud-to-groud lightning flashes from 1988 to 1995

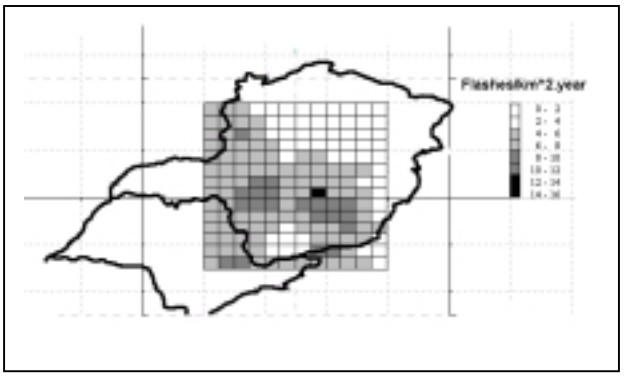

Fig. 2 – Geographical distribution of cloud-to-ground lightning flashes from 1988 to 1995 corrected by the detection effeciency of the system.

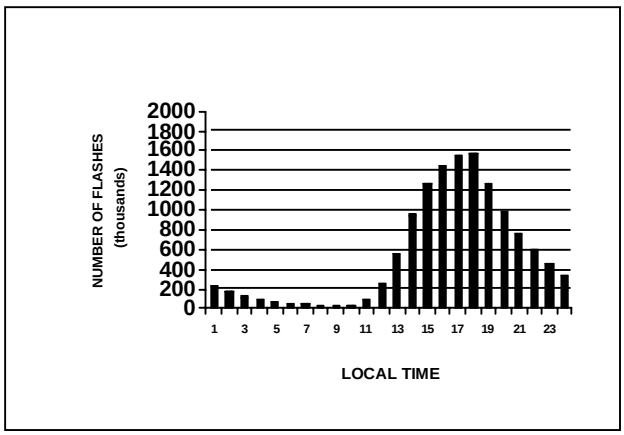

Fig. 3 – Diurnal distribution of cloud-to-ground lightning flashes in the southeastern Brazil from 1988 to 1995.

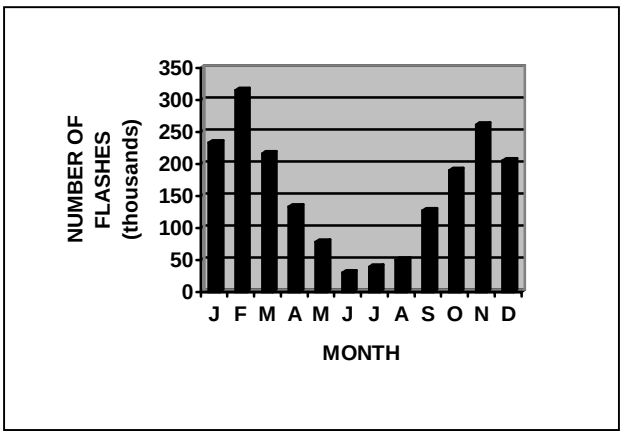

Fig. 4 – Monthly distribution of cloud-to-ground lightning flashes in the southeastern Brazil from 1988 to 1995.

CONCLUSION

The results presented in this paper represent the first long-term results obtained in the southeastern Brazil regarding density, and monthly and diurnal distribution of cloud-to-ground lightning flashes and should be consider as reference for future studies in this region.

REFERENCES

Diniz, J.H., A.M. Carvalho, L.C.L. Cherchiglia, J.J.S. Filho, and G.E.S. Amorim, 1996, Lightning research carried out by Companhia Energetica de Minas Gerais – Brazil, Proc. Int. Conf. Lightning Prot., 23, 24-29.

Hodanish, S., D. Sharp, W. Collins, C. Paxton, and R. E. Orville, 1997, A 10-yr monthly lightning climatology of Florida:

1986-95, Wea. Forecasting, 12, 439-448.
Lopez, R.E., and R.L. Holle, 1986, Diurnal and spatial variability of lightning activity in northeastern Colorado and central Florida during the summer, Mon. Weather Rev., 114, 1288-1312.
Orville, R.E., Lightning ground flash density in the contiguous United States – 1989, 1991, Mon. Wea. Rev., 119, 573-577.
Orville, R.E., 1994, Cloud-to-ground lightning flash characteristics in the contiguous United States: 1989-1991, J. Geophys. Res., 99(D5), 10,833-10,841.
Orville, R.E., and A.C. Silver, 1997, Lightning ground flash density in the contiguous United States: 1992-95, Mon. Wea. Rev., 125, 631-638.
Orville, R.E., E.J. Zipser, M. Brook, C. Weidman, G. Aulich, E.P. Krider, H. Christian, S. Goodman, R. Blakeslee, and K. Cummins, 1997, Lightning in the region of the TOGA COARE, Bull. Amer. Meteor. Soc., 73. 3-16.
Pinto, O., Jr., I.R.C.A. Pinto, R.B.B. Gin, and O. Mendes, Jr., 1992a, A coordinated study of a storm system over the South American continent 1. Weather information and quasi-DC stratospheric electric field data, J. Geophys. Res., 97(D16), 18,195-18,204.
Pinto, I. R. C. A., O. Pinto Jr., R.B.B. Gin, J.H. Diniz, R.L. de Araujo, and A.M. Carvalho, 1992b, A coordinated study of a storm system over the South American continent 2. Lightning-related data, J. Geophys. Res., 97(D16), 18,205-18,213.
Pinto, O., Jr., 1997, Lightning in Brazil, Proc. 5th International Congress of the Brazilian Geophysical Society, p. 1132-1133, São Paulo, Brazil.
Pinto, O., Jr., R.B.B. Gin, I.R.C.A. Pinto, O. Mendes Jr., J.H. Diniz, and A.M. Carvalho, 1996, Cloud-to-ground lightning flash characteristics in the southeastern Brazil for the 1992-1993 summer season, J. Geophys. Res., 101(D23), 29,627-29,635.
Reap, R.M., 1994, Analysis and prediction of lightning strike distributions associated with synoptic map types over Florida, Mon. Weather Rev., 122, 1698-1715.
Reap, R.M., 1986, Evaluation of cloud-to-ground lightning data from the western United States for the 1983-84 summer seasons, J. Climate Appl. Meteor., 25, 785-799.
Rocha, R.M.L., I.R.C.A. Pinto, and O. Pinto Jr., 1997, Cloud-to-ground lightning flash characteristics in the southeastern Brazil in the winter season, Proc. 5th International Congress of the Brazilian Geophysical Society, p. 1167-1169, São Paulo, Brazil.
Watson, A.I., R.E. Lopez, and R.L. Holle, 1994, Diurnal cloud-to-ground lightning patterns in Arizona during the southwest monsoon, Mon. Weather Rev., 122, 1716-1725.

ACKNOWLEDGMENTS

The authors would like to thank the Fundação de Amparo à Pesquisa do Estado de São paulo (FAPESP) for providing support to this research.