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Estimates of lightning ground flash density in Australia and its relationship to thunder-days

Y. Kuleshov
National Climate Centre, Bureau of Meteorology, Melbourne, Australia

and

E.R. Jayaratne
School of Physical and Chemical Sciences, Queensland University of Technology,
Brisbane, Australia

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A method of deriving lightning ground flash density from CIGRE lightning flash counter registrations based on the detection efficiency of the instrument, independent of the latitudinal variation of cloud flash-to-ground flash ratio is presented. Using this method, the annual mean ground flash densities, N_g, over a period of up to 22 years were recalculated from the counter registrations for 17 selected Australian sites. The results were compared with the corresponding thunder-day data, T_d, to obtain an empirical formula of the form $N_g = a\, T_d^b$. The best estimates of the empirical constants a and b derived using the proposed method were found to be 0.012 and 1.4 respectively. The derived N_g values were compared with the values obtained from three other established formulae developed by earlier workers in different countries. The N_g values were also compared with values derived using present methods of estimating lightning ground flash density which utilises the ratio of cloud flashes to ground flashes. Taking into account the improved method of calculation and the relatively long period of observation, we believe that the new empirical formula presented in this paper gives the best estimates of lightning ground flash density in Australia.

Introduction

Lightning is a phenomenon that is highly variable in space and time. The derivation of reliable estimates of its activity, therefore, requires statistical averaging over a large area and a considerable number of years of observation. The lightning flash density, defined as the number of flashes of a specific type occurring on or over unit area in unit time, is widely used as a statistical description of lightning activity. This parameter is commonly expressed as a number of flashes per square kilometer per year ($km^{-2}\ yr^{-1}$). Of greater interest for lightning protection purposes is the lightning ground flash density N_g – the number of flashes striking a unit area of the ground per unit time, preferably

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Corresponding author address: Y. Kuleshov, National Climate Centre, Bureau of Meteorology, GPO Box 1289K, Melbourne, Vic., 3001, Australia
Email: y.kuleshov@bom.gov.au

expressed as a long-term (more than 10 years) average value (Lightning Protection 2004). In this paper, we present a method of deriving lightning ground flash density from CIGRE lightning flash counter registrations based on the detection efficiency of the instrument, independent of the latitudinal variation of cloud flash-to-ground flash ratio.

The lightning ground flash density, N_g, may be obtained from direct measurements by lightning flash counters, lightning location systems or satellite-based detectors. Alternatively, it may be estimated from thunder-days (T_d) using empirically derived equations.

Lightning ground flash density: measurements and derivations

Lightning flash counters

Several different types of lightning flash counters (LFCs) have been developed for the registration of lightning occurrences. Two types of counters that have been used extensively around the world are the 500 Hz CIGRE (International Conference on Large Electric Systems) lightning flash counter developed at the University of Queensland (UQ) and initially referred to as RAB or UQ 500 Hz, and the CIGRE 10 kHz counter developed in South Africa by replacing the UQ 500 Hz filter with a 10 kHz filter and initially referred to as RSA 10 kHz (Anderson et al. 1979). Another counter which has been extensively used for research is the CGR3 (Cloud-Ground Ratio #3) instrument (Mackerras and Darveniza 1992; Baral and Mackerras 1992, 1993). The CGR3 counter has separate registers for negative ground flashes, positive ground flashes, and intracloud flashes; the effective ranges vary between 12 and 16 km depending on type of flash. These counters were installed in Brisbane and Darwin, and were used for the derivation of total, intracloud and ground flash density estimates at those localities.

Since 1973, the Bureau of Meteorology has been operating a network of about 40 lightning flash counters of the 500 Hz CIGRE design. These were originally installed and operated with the assistance of Australian electricity supply authorities. CIGRE-500 lightning counters were designed primarily to measure lighting strikes to ground. They have proved to be a useful and reliable tool for the measurement of lightning activity and have been used at many locations around the world to provide estimates of ground flash density (Barham 1965; Prentice 1972).

Lightning location systems

At present, there are several regional or local radio frequency surface lightning location networks in operation. These use detectors that locate individual lightning strokes with high accuracy using time-of-arrival and direction-finding methods. For example, the National Lightning Detection Network in the United States has been in continuous operation for about 20 years now (Bent and Lyons 1984; Orville and Huffines 1999). It is a robust network, with a stationary configuration and presently covers the entire continental land mass of the contiguous United States. Similar systems are also in use in other countries such as Sweden and South Africa. Lightning location systems (LLS) have been installed in some parts of Australia. The first LLS was installed in southeast Queensland in December 1980 and was operational continuously until relatively recently. Later, in December 1991, an LLS was installed in NSW and data are available from the commercial provider Kattron Pty Ltd. The GPATS Pty Ltd LLS network throughout Australia came into commercial service in 1998. While providing better space coverage in comparison to LFCs, LLS networks are capable of accurately positioning lightning strokes and might provide spot checks against other methods at selected sites. However, it is required to accumulate a sufficient number of years of LLS archived data to draw statistically reliable conclusions due to the high temporal variability of the phenomenon.

Satellite-based detectors

Satellite-based instruments offer an opportunity to observe lightning from space to estimate lightning activity on the global scale. Detailed reviews of early satellite-based measurements may be found in Mackerras et al. (1998). More recently, a considerable amount of information has been obtained from the Optical Transient Detector (OTD) aboard the Microlab satellite (Christian et al. 1996) and the Lightning Imaging Sensor (LIS), NASA Earth Observing System instrument on the Tropical Rainfall Measuring Mission satellite (Christian et al. 1999). The data archives for OTD and LIS consist of approximately five years of records each. Although these satellite-based instruments have proved to be useful for observation of global lightning activity (e.g. determining the average global flash rate and the annual variation of the global flash rate), for other applications (e.g. comparisons of spatially local or inter-annual variability) there may be considerable uncertainty arising from under-sampling (Christian et al. 2003). However, OTD and LIS data may be useful for filling in the gaps in the areas of Australia with little or no data from LFCs, LLS or thunder-day observations.

Relationship between ground flash density and thunder-days

A thunder-day is a standard meteorological parameter that is recorded at synoptic stations around the world.

Thunderstorm day (thunder-day) is defined as ‘an observational day (any 24-hour period selected as the basis for climatological or hydrological observations) during which thunder is heard at the station. Precipitation need not occur’ (Glossary of Meteorology 1959). Long-term meteorological records of thunder-days are available for many countries (World Meteorological Organization 1953). A lightning ground flash density, N_g, is conventionally estimated from T_d using an equation of the form $N_g = aT_d^b$, in which a and b are empirically derived constants that may depend on the meteorological conditions at a given location. The earliest estimates of the equation for Australia were by Mackerras (1978) who, using early CIGRE-500 observations, derived values of a = 0.01 and b = 1.4. This study was based on results from 26 sites for the period 1965 to 1977 and the Bureau of Meteorology thunder-day map based on data from 1954 to 1963 (Darveniza and Mackerras 2003, personal communication). Anderson and Eriksson (1980), based on 120 observations over two years in South Africa, derived values of a = 0.023 and b = 1.3. The corresponding equation has since become known as ‘Eriksson’s Formula’. A subsequent study using 62 stations over a longer period of five years from 1976 to 1980 yielded the values a = 0.04 and b = 1.25 (Anderson et al. 1984). The equation using these two values of the constants is generally known as the ‘CIGRE Formula’. Both the CIGRE and Eriksson’s equations are used in the literature, although they were both derived at the same location; and there are very few studies to compare their results with those from other parts of the world.

Therefore, the accuracy of estimating N_g from T_d using the formula depends on two main factors – the reliability of the recorded values of T_d and the choice of the empirically derived constants a and b.

The availability of a reasonably large and complete lightning flash dataset obtained at several Australian sites over a range of locations, together with long-term available records of thunder-days, provided a strong incentive to evaluate the empirical relationship between N_g and T_d, and to investigate the accuracy of the various methods of deriving N_g from lightning flash counter registrations.

Instruments, methods and data

The Bureau of Meteorology lightning flash counter network

The CIGRE-500 instrument, used by the Bureau, incorporates a 500 Hz peak transmission filter circuit that causes the device to respond mainly to the positive-going step changes in electric field characteristic of negative ground flash return strokes. Higher frequencies are attenuated to avoid response to the radiation fields, thus ensuring that the effective range is determined mainly by the large electrostatic component of close ground flashes. However, many intracloud flashes exhibit field changes as low as 500 Hz, and are counted by the instrument. Negative ground flashes constitute the bulk of ground flashes. However, it has been shown that approximately four per cent of ground flashes may carry a net positive charge (Orville et al. 1987; Jayaratne and Ramachandran 1998). Bunn (1968) showed that these flashes show a truncated negative voltage ramp that may cause them to be recorded by the CIGRE-500 counter in a similar manner to intracloud flashes.

The antenna used is a vertical aluminium tube of dimensions and electrical characteristics conforming to CIGRE standards (Anderson et al. 1979). The number of flashes is registered by an electromechanical counter that is intended to increment one count for every flash detected. A one-second dead time interval after the instrument is triggered is intended to prevent multiple stroke flashes from causing multiple counts.

The counters are situated at about 40 locations scattered widely across Australia. The objective of maintaining a network is to determine regional values and a geographical distribution of N_g. These are estimated from the counter registrations, R. The counters are manually read each day and a cumulative record is sent to the Bureau at the end of each month. The estimation of N_g from R requires estimates of the detection efficiency and effective range of the instrument. In addition, the falsely registered intracloud flashes need to be estimated and eliminated from the count. This requires a knowledge of the, so-called, cloud flash-to-ground flash ratio, $Z = N_c/N_g$, at the monitoring sites.

Method 1

The method currently employed by the Bureau is after Prentice (1974), first described by Prentice and Mackerras (1969). The values of estimates of effective ranges of the counter to cloud flashes (L_c) and ground flashes (L_g) currently used in this method are 20 and 30 km respectively. The ratio Z is estimated to decrease with increasing latitude, ranging from a low of two in Victoria, Southern Australia and southern Western Australia to around three in New South Wales and southeastern Queensland to four in northern Queensland to a high of seven at the ‘top end’ near Darwin. These values are obtained from early worldwide estimates of the latitudinal variation of Z by Pierce (1970) and Prentice and Mackerras (1977). The average annual ground flash density is derived from the relationship $N_g = R/\pi(L_g^2+ZL_c^2)$ where R is the average annual registrations. Using this method, which we shall denote as Method 1, for Darwin with R=28,450 and Z=7 the derived ground flash density is 2.45 flashes km^{-2} yr^{-1}.

However, Mackerras and Darveniza (1994), using a worldwide network of fourteen CGR3 counters in eleven countries have shown that Z is largely independent of latitude. The mean value of Z measured at the fourteen sites was 1.9. Values at thirteen of the sites were within a factor of two of this mean.

Method 2

These findings provide a foundation for developing a method of deriving lightning ground flash density from counter registrations, which is based on the detection efficiency of the instrument and independent of latitudinal variation of the values of the Z ratio. The detection efficiency of the CIGRE-500 counter to ground flashes was evaluated using the values for effective ranges of the counter of 30 km for ground flashes as recommended by Prentice and Mackerras (1969) and 15 km for cloud flashes, which is a recently corrected estimation by Mackerras (personal communication 2003). Mackerras and Darveniza (1994) demonstrated that the mean value of Z measured at fourteen sites worldwide was 1.9, and that it was largely independent of latitude. We shall use the Z value of 1.9 as the most representative estimate currently available from the literature. Applying the above-mentioned values of Z and effective ranges for ground and cloud flashes, the detection efficiency of the CIGRE-500 counter to ground flashes was calculated as 0.68. This is the fraction of counter registrations that are ground flashes. The number of lightning ground flashes, N, may then be expressed in terms of the registered counts, R, as:

$$N = 0.68R \qquad \ldots 1$$

The effective horizontal range of 30 km gives a detection area for ground flashes of 2827 km^2. The ground flash density may then be calculated from

$$N_g = N/2827 \qquad \ldots 2$$

The above method assumes a constant value of Z and so avoids the need to estimate regional values for the Z ratio. We shall denote this as Method 2. Using Eqns 1 and 2, for Darwin with R=28450 we then compute the corresponding values N=19346 and N_g=6.84. The Ng value estimated using Method 2 is much higher than that derived using Method 1 currently employed by the Bureau. Possible causes for such differences between estimates are discussed in the section Results and discussion.

Thunder-day data archive

Lightning is a highly variably temporal and spatial phenomenon, and the best estimates of local N_g values are that derived from instrumental records. However, for many countries lightning flash counter data are not available. Therefore, and because of the availability of long-term records of thunder-days, estimation of lightning flash density from thunder-days is still widely used even in countries with well-established lightning flash counter networks. Recently, using the Australian thunder-day records, thunderstorm distribution across the country was analysed in detail and an updated Average Annual Thunder-Day Map of Australia was prepared at the National Climate Centre, the Bureau of Meteorology (Kuleshov et al. 2002). The map was included in the new Australian Standard, 'Lightning Protection' (2004). The Bureau's climate sites provide a reasonably good coverage of the country, except in sparsely populated areas, and have a sufficient length of thunder-day records that are largely complete. During the preparation of the map, thorough examination and quality control of T_d data from approximately 1400 sites across Australia were made and about 300 of the best sites were selected. In the present analysis, data from LFCs located at sites not on this list of 300 were excluded from our analysis.

Results and discussion

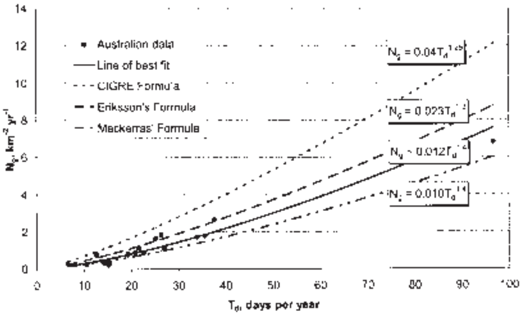
Of the 40 stations with LFCs, seventeen sites were selected for their reliability and availability of lightning count data and thunder-day records over sufficiently long periods of observation and to represent a wide geographical distribution across the continent. Table 1 gives the location, latitude and longitude of each site, and the respective number of years over which reliable lightning flash counter data were available (columns 1-4 respectively). Thunder-day records for selected sites were extracted from the National Climate Centre archive, and an annual number of thunder-days averaged over years of data, T_d, was derived for each station (column 5). The ground flash densities, N_g, were calculated from the counter registrations by applying Eqns 1 and 2 in Method 2 as described above. These values of average annual lightning ground flash density we denote as N_gA (column 6). Values of N_g calculated using Method 1 were taken from the summary of Lightning Flash Counter Registrations (2003) and we denote them as N_gB (column 7). Values of average annual lightning ground flash densities computed from T_d using the CIGRE, Eriksson's and Mackerras' Formulas we denote as N_gC, N_gE and N_gM and they are shown in columns 8, 9 and 10 respectively.

Table 1. **List of Australian sites selected for the study and some associated parameters derived in the present study. T_d is the annual number of thunder-days averaged over the number of years of data collection at each site (days per year). N_gA, N_gB, N_gC, N_gE and N_gM are average annual lightning ground flash densities (km^{-2} yr^{-1}). N_gA values were derived from the Australian LFC data using the counter registrations by applying Eqns 1 and 2 in Method 2. N_gB values were taken from the annual summary of Lightning Flash Counter Registrations (2003). N_gC, N_gE and N_gM were computed from T_d using the CIGRE, Eriksson's and Mackerras' formulae respectively.**

1 *Location*	*2* *Lat. (°S)*	*3* *Long. (°E)*	*4* *Years of data*	*5* *Td*	*6* *NgA*	*7* *NgB*	*8* *NgC*	*9* *NgE*	*10* *NgM*
Albany	34.9	117.8	20	15	0.21	0.20	1.20	0.79	0.45
Geraldton	28.8	114.7	21	11	0.24	0.20	0.76	0.49	0.27
Kalgoorlie	30.8	121.5	22	21	0.89	0.70	1.77	1.19	0.70
Meekatharra	26.6	118.5	19	22	1.14	0.90	1.86	1.25	0.74
Moora	30.6	116.0	16	7	0.29	0.20	0.42	0.27	0.14
Perth	31.9	116.0	21	15	0.40	0.30	1.21	0.80	0.46
P. Hedland	20.4	118.6	22	23	0.90	0.50	1.97	1.32	0.79
Darwin	12.3	131.0	20	97	6.84	2.40	12.12	8.76	6.02
Ten. Creek	19.6	134.2	20	34	1.74	1.10	3.27	2.24	1.38
Ceduna	32.1	133.7	18	14	0.33	0.30	1.10	0.73	0.41
Mt Isa	20.6	139.5	19	37	2.66	1.40	3.71	2.57	1.60
St Lucia	27.5	153.0	15	25	1.67	1.00	2.25	1.52	0.91
Townsville	19.1	146.5	12	19	0.83	0.50	1.61	1.08	0.63
Cobar	31.5	145.8	18	27	1.10	0.70	2.47	1.67	1.01
Coffs Harb.	30.3	153.1	20	36	1.80	1.40	3.47	2.38	1.48
Lismore	28.8	152.3	16	26	1.86	1.10	2.38	1.61	0.97
Melbourne	37.7	144.8	21	13	0.80	0.60	0.95	0.62	0.35

In Fig. 1, we plot the derived values of N_g against T_d. The best-fit line through the Australian data has coefficients a = 0.012 and b = 1.4 (RMS error = 0.36). Clearly, the CIGRE Formula, as expected, always gives higher estimates of N_g (RMS error = 1.58). For example, N_gC for Melbourne is 18 per cent higher than N_gA (the smallest difference), and more than five times higher for Albany (the largest difference). According to the CIGRE Formula, N_gC in Darwin is more than 12 flashes km^{-2} yr^{-1}, which is 77 per cent higher than that derived by Method 2 (NgA = 6.84 flashes km^{-2} yr^{-1}). Comparison of our results with Eriksson's Formula (RMS error = 0.58), widely accepted as giving the most realistic Ng estimates, indicates a closer agreement. Of the seventeen sites examined, N_gE values were lower than N_gA values for five stations, with differences ranging from –4 per cent for Mt Isa to –23 per cent for Melbourne. N_gE values for the other twelve stations were higher than the corresponding N_gA values but there was a general overestimation factor of about one and a half, compared with a factor of about two and a half using the CIGRE Formula. In Darwin, for example, N_gE was higher than N_gA by 28 per cent. Evaluation of the earliest empirical formula from Mackerras (1978) shows that the Mackerras' Formula (RMS error = 0.48) in general gives lower N_g values in comparison with our results. N_gM values were higher than the corresponding N_gA values at four stations (with the range of errors from 11 per cent at Geraldton to 111 per cent at Albany), and they were lower than the N_gA values for thirteen sites, with errors ranging from –8 per cent for Cobar to –57 per cent for Melbourne.

Fig. 1 **Comparison of N_g values derived from LFC data using Method 2 with N_g values calculated from T_d using the CIGRE, Eriksson's and Mackerras' formulae.**

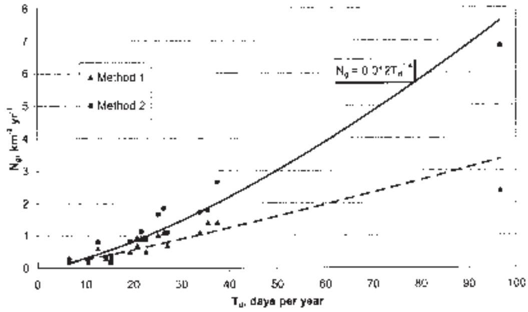


The line of best fit approach employed in Method 2 was also assessed using 'leave-one-out' cross-validation technique, i.e. each point was in turn left out, the model developed on the remainder and the error for the predicted point computed. The cross-validation demonstrated that errors for the predicted points for sixteen sites were in the range –53 per cent to 65 per cent, and the error for the last site (Albany) was 187 per cent; the RMS error for all sites examined was 0.54.

The values N_gB derived from the CIGRE-500 counter registrations using Method 1 were taken from the Bureau of Meteorology annual summary of the Lightning Flash Counter Registrations (2003). These values are compared with the values of N_gA derived using Method 2 in Fig. 2. Note that the values of N_gB are always less than N_gA . Underestimation is most evident for sites with high lightning activity (e.g. the values of N_gB for Darwin and Mt Isa are three times and twice less than the corresponding values of N_gA). A key difference between the two methods is in the use of the ratio of cloud flashes to ground flashes, Z, in calculating the number of ground flashes. Method 1 assumes that the Z values vary with latitude and are known at the various locations. Method 2 avoids the need to estimate regional values for the Z ratio by assuming a constant value at all locations.

It is pertinent to investigate further the values of Z used in Method 1. Early estimates of the variation of Z with latitude by Pierce (1970) and Prentice and Mackerras (1977) indicated that Z was high (about 6 to 9) in the tropics, was about 3 to 4 in the subtropics and temperate regions, and was about 1 to 1.5 at high latitudes. Mackerras and Darveniza (1994) used CGR3 counters to monitor lightning at fourteen sites in eleven countries covering latitudes from 60ºN to 27ºS between 1987 and 1991. They found tropical values of Z in the range 0.5 to 3.4 (weighted mean 2.3 for the latitude range 0º to 20º) and similar values in subtropical and temperate regions (range from 1.1 to 3.8 and weighted mean 2.2 for the latitude range 20º to 40º). Their values agreed with the earlier studies only at high latitudes (40º to 60º) where Z ranged from 1.0 to 1.5 with a weighted mean of 1.3. It was suggested that the disagreement was due to errors in the earlier studies which were conducted using simple lightning flash counters and visual observations and, so, the results obtained were not reliable in regions of high activity. They stated that it is only at higher latitudes, where the activity is generally lower, that there was reasonable agreement between the two sets of results. Mackerras et al. (1998) also reported lower values of Z at low latitudes than were reported by Pierce (1970) and Prentice and Mackerras (1977). Nevertheless, these relatively low Z values are in conflict with much larger tropical values of the cloud flash-to-ground flash ratio measured in Darwin as reported by Rutledge et al. (1992). During the Down Under Doppler and Electricity Experiment (DUNDEE) in the vicinity of Darwin during the wet seasons of November 1988 through February 1989, and November 1989 through February 1990, measurements of the mean ratio of intra-cloud to cloud-to-ground lightning flashes showed a systematic increase with total flash rate (Rutledge et al. 1992, Fig. 7). It was found that for total flash rates typical of midlatitude storms (1-3 min^{-1}), the Z values were 2 to 5, and when the total flash rate was 20-50 min^{-1} (typical for deep continental convection near Darwin) the Z values were as large as 30 to 40. Taking into consideration all available data, Mackerras et al. (1998) concluded that the question of tropical Z values must be considered unresolved at this stage.

Fig. 2 **Comparison of N_g values derived from LFC data using Method 1 (currently employed in the Bureau of Meteorology) and Method 2 (by applying Eqns 1 and 2).**



The most noteworthy feature of the study of Mackerras and Darveniza (1994) is the relatively small variation of Z with latitude over the entire latitude range 0º to 60º. This is in contrast with the strong latitudinal variation of Z found by Pierce (1970) and Prentice and Mackerras (1977) and used by the Bureau in their calculation of N_gB. Our results also give some support to lower values of Z for the range of Australian latitudes as it was found by Mackerras and Darveniza (1994). We believe that an overestimation of Z has contributed to abnormally low values of N_gB using Method 1. However, taking into consideration that the question of tropical Z values is considered as unresolved at this stage we suggest that the proposed Method 2 is preferable as it avoids the need to estimate latitudinal variation of the Z values and is based on the instrument detection efficiency. If the use of Method 1 is to be continued, it is strongly recommended that better estimates of Z should be derived using CGR3, or the recently upgraded CGR4 version, instruments at a wider distribution of sites covering the entire range of latitudes and climatic conditions across Australia.

Summary

We have used the lightning and thunder-day data obtained over a period of up to 22 years at seventeen widely distributed stations around Australia to derive an expression of the form $N_g = a\ T_d^b$ between the annual mean ground flash density, N_g, and thunder-days, T_d. The statistical best fit values of a and b were 0.012 and 1.4 respectively. These are in fair agreement with an empirical formula by Eriksson (Anderson and Eriksson 1980) who reported values of 0.023 and 1.3 respectively, based on data obtained over a period of two years in South Africa. A subsequent study over a five-year period in the same region found values of 0.04 and 1.25 respectively (Anderson et al. 1984). The corresponding relationship based on this more recent set of values came to be known as the CIGRE Formula and it gave much higher estimates of N_g. The earliest empirical formula developed by Mackerras (1978), based on Australian data, with values of a = 0.01 and b = 1.4 in general gives lower N_g values in comparison with our results. It is clear that the values of the two constants a and b vary with geographical location and climatological conditions. Based on the relatively large number of widely distributed stations and the long period of observation considered in the present study, we believe that our empirical formula, N_g=$0.012T_d^{1.4}$ gives the best estimate of ground flash density in Australia.

The Bureau of Meteorology presently estimates lightning ground flash densities from lightning flash counter data. We believe that there are two major flaws in Method 1 as used: (a) the calculation of ground flash density from counter registrations assumes overestimated values of the ratio of cloud flashes to ground flashes, Z, and its significant variation with latitude, and (b) it assumes that the instrument counts cloud flashes within the detection range of 20 km. The CIGRE-500 instrument is designed to count ground flashes in preference to cloud flashes, and we have estimated that 68 per cent of the registrations are due to ground flashes. The values of Z and effective detection ranges used by the Bureau are based on global observations made 30 years ago. Recent observations, including some in Australia, using more sophisticated instrumentation demonstrated that the Z value is largely independent of latitude, and a better estimate for the effective detection range of cloud flashes for the CIGRE-500 counter is 15 km. Each of the two assumptions used in Method 1 underestimates the calculated ground flash number.

We have suggested an alternative method of estimation of ground flash density from counter registrations. This method is based on the detection efficiency of the instrument, independent of the latitudinal variation of cloud flash-to-ground flash ratio. The calculated ground flash densities are in good agreement with the values derived from the empirical formulas.

Continuing work

Given the potential hazards associated with lightning, a sound knowledge of the spatial distribution of thunderstorms and lightning around Australia is of high importance. However, the sparse distribution of lightning counters creates a difficulty in generating a representative map of lightning incidence over the entire continent. The University of Queensland and the Bureau of Meteorology have combined their efforts in lightning research and are currently carrying out a collaborative project analysing the available LFC data corrected for site and counter errors and satellite-based detector data to fill in the areas with no LFC or thunder-day data. The project will culminate in the production of the first lightning ground flash density map for Australia, which we expect to be published and recommended to CIGRE in the near future. Estimates of ground flash density derived from LFC data and from thunder-day data is one of the major tasks within this project, and we believe that the method proposed in this study will make an important contribution to the project.

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