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Estimates of Lightning Occurrences by the satellite-mounted Optical Transient Detector Analysis for the Australian Region

An Australian lightning climatology was developed in the National Climate Centre, Bureau of Meteorology. The climatology is based on about five years of data from the satellite mounted Optical Transient Detector (OTD) instrument.

Thunderstorm occurrence at a particular location is traditionally expressed in terms of thunder days. A thunderstorm day (thunder day, T_d) 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 observing station (Glossary of Meteorology 1959). However for many scientific and practical purposes it is important to know the actual lightning activity rather than the fact that a thunderstorm occurred.

Lightning is defined as any and all of the various forms of visible electrical discharge produced by thunderstorms (Glossary of Meteorology 1959). It is caused by an electrical discharge between differently charged regions within the cloud (cloud flash, also referred to as intracloud flash) or between a charged region and earth (cloud-to-ground lightning flash, or simply ground flash).

Lightning is potentially hazardous to both people and property. For example, in the period 1803 to 1992, there have been 650 registered fatalities attributable to lightning in Australia (Coates 1996). In addition, bushfires, which result in damage to the natural environment, property and loss of life, are also associated with lightning. Given the potential hazards associated with lightning, knowledge about the spatial distribution of thunderstorms and lightning is important for, among other things, lightning protection design.

The installation of lightning flash counters around Australia in the late 1970s to early 1980s has provided the opportunity for more detailed regional estimates of lightning activity. The Bureau of Meteorology operates a network of the CIGRE-500 lightning flash counters. CIGRE-500 lightning counters were designed primarily to measure lighting strikes to ground (Prentice 1972). These counters were originally operated by the electricity supply authorities and the present dataset extends back more than 20 years. Long term records allow the estimation of lightning ground flash density (N_g) at the locations with counters installed. However, the sparse distribution of counters creates difficulties in generating a representative Australian lightning occurrence map.

The Optical Transient Detector (OTD) instrument, which is mounted on the NASA (National Aeronautics and Space Administration) Microlab satellite, offers a unique opportunity to estimate lightning occurrences across Australia. The OTD platform, which was launched in April 1995 into a near polar orbit (inclination of 70º with respect to the equator and altitude of approximately 710 km), provided observations of lightning activity over most parts of the globe for about 5 years. The combination of the wide field-of-view lens and the altitude of the orbit allows the OTD to observe an area of the earth equivalent to 1300x1300 km^2, with storm scale spatial resolution (~10 km) during both day and night (Christian et al 2003).

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The lightning ground flash density map presented here is based on data from the OTD for the Australian region (10ºS – 45ºS, 105ºE – 165ºE). It is important to note that the analysis is based on five years of OTD data. Additionally, Microlab is a polar orbiting satellite and consequently undersampling may influence the estimates of lightning activity in some areas (Christian et al. 2003). Finally, OTD estimates of lightning ground flash density ($N_{g)}$ were compared with, and evaluated against, estimates of N_g derived from a thunder day analysis.

N_g is conventionally estimated from T_d using an equation of the form $N_g = \mathbf{a}T_d^{\mathbf{b}}$, in which **a** and **b** are empirically derived constants that are influenced by the meteorological conditions at a given location. In this study, Eriksson's formula with derived values of **a** = 0.023 and **b** = 1.3 was used (Anderson and Eriksson 1980). Values of N_g derived from Eriksson's empirical formula using long-term average values (20 years) of T_d for some localities across Australia are compared with the N_g values derived from OTD data (table below).

State /Terr.	**Location**	**Lat**	**Long**	**T_d**	**N_{gE}**	**N_g OTD**
WA	Perth	31.9	116.0	15	0.8	0.5 - 1
NT	Darwin	12.3	131.0	97	8.8	4 - 6
QLD	Mount Isa	20.6	139.5	37	2.5	2 - 3
NSW	Coffs Harbour	30.3	153.1	36	2.4	2 – 3
VIC	Melbourne	37.7	144.8	13	0.6	0.5 – 1
SA	Ceduna	32.1	133.7	14	0.7	< 0.5
TAS	Hobart	42.8	147.5	5	0.2	< 0.5

In general, the table shows there is a good correspondence among N_g values. However, values for some localities are significantly different (e.g. Darwin), and clearly more work is needed to improve the results.

Development of a lightning ground flash density map for Australia is a collaborative project between the Bureau of Meteorology and the University of Queensland. The map presents N_g estimates based on currently available data. It is likely that it will be modified in the future as new data becomes available.

References

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