Comments on “Large Peak Current Cloud-to-Ground Lightning Flashes during the Summer Months in the Contiguous United States”

RICHARD E. ORVILLE

Department of Meteorology, Texas A&M University, College Station, Texas

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The recent paper by Lyons et al. (1998) reports on large peak current lightning flashes recorded by the National Lightning Detection Network (NLDN) during 14 summer months in four years, 1991–95. Lyons et al. examine, arbitrarily, only flashes with peak currents higher than 75 kA. It is an important contribution. High peak current flashes of positive polarity, for example, have been shown to be associated with sprites and elves in the stratosphere and mesosphere. The purpose of this note, however, is to emphasize that ground truth for negative return stroke peak currents exists only up to 60 kA and this is for triggered lightning (Idone et al. 1993, Table 1). No ground truth exists for return stroke positive peak currents. Despite this problem, we are still justified in making peak current estimates as long as the limitations are recognized. I quote from Lyons et al. (1998, p. 2227) and add explanatory comments:

The NLDN actually measures signal strength (in LLP units), which then must be converted into an estimate of $I_{\text{max}}$. Limited calibration of NLDN peak currents has been attempted using ground truth measurements obtained during rocket-triggered lightning studies (Orville 1991). That study suggested a conversion of $I_{\text{max}} = 2.3 \text{ kA} + 0.19 \cdot \text{LLP units}$, although the widely used conversion of $I_{\text{max}} = 0.2 \cdot \text{ LLP units}$ introduces errors of less than 5%. However, that study did not deal with any events known to have values $I_{\text{max}} > 60 \text{ kA}$.

It is true that the Orville (1991) study did not deal with values higher than 60 kA. There are none. There are no “events known to have values $I_{\text{max}} > 60 \text{ kA}$. “ This is true today. No ground truth exists for negative flashes with peak current greater than 60 kA. In addition, it should be noted that no ground truth exists for positive flashes of any current value. Lyons et al. (1998, p. 2228) continue:

A reexamination of the NLDN calibration by Idone et al. (1993) suggested a revised formulation, $I_{\text{max}} = 4.2 \text{ kA} + 0.17 \cdot \text{ LLP units}$. It was held to be accurate to better than 15% in the 15–60 kA range and should be valid for $I_{\text{max}} > 60 \text{ kA}$ to about the 15% level [provided the possible effect of DF nonlinear amplification is accounted for and minimized].

The italicized partial sentence is from Idone et al. (1993) and was omitted by Lyons et al. Idone worked with an expanded triggered lightning dataset, but unfortunately, there were still no measured peak current values greater than 60 kA. The Idone expression may be valid for values greater than 60 kA, but this is a guess involving the assumption of linearity beyond the calibration dataset maximum. Lyons et al. (1998, p. 2228) state further that:

For this study we converted the NLDN data using the relationship $I_{\text{max}} = 0.185 \text{ kA} \cdot \text{ LLP units}$ as suggested by the NLDN operator (Cummins et al. 1996), which for a 75-kA peak current results in computed values within 3% of the Idone et al. (1993) formulation.

Cummins et al. (1996, 1998) worked with the same dataset used by Idone, but forced the intercept to zero. The result is an expression that should be used today, but still suffers from a lack of experimental data above 60 kA for negative flashes and no experimental data for positive flashes.

An explanation is appropriate for the source of the “widely used conversion of $I_{\text{max}} = 0.2 \cdot \text{ LLP units}$ introduces errors of less than 5%.” What is the origin of the 0.2 factor? In the spring of 1982, we established a small lightning detection network in eastern New York. Our first summer of operation produced thousands of lightning recordings with peak signal strengths in terms of LLP units. We calculated the median value of the summer negative peak current distribution and found it to be 150 LLP units. Knowing that the lightning measurements by Berger (1967) had been done at a similar latitude in Switzerland, we equated the 150 LLP units to the median peak currents measured by Berger at the
Mount San Salvatore Observatory. The median of Berger’s measured negative peak currents to the instrumented towers was 30 kA. Thus, a factor of 0.2 applied to the LLP measurements would yield an estimate of the negative peak current in units of kA. It is surprising that 15 years later our approximation resulting in the 0.2 factor “introduces errors of less than 5%” and is still widely used and now supported by independent experiments.

REFERENCES