Comparison of Total Lightning and Severe Weather Reports during the 2013 Convective Season

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ABSTRACT: Several commercial lightning detection networks have improved total lightning detection [i.e., cloud-to-ground (CG) and in- cloud (IC) lightning] over the contiguous U.S. (CONUS) in recent years.

The Storm Prediction Center (SPC) has real-time data feeds from two of these networks and is able to separate the data into CG and IC flashes. The SPC is responsible for forecasting both lightning and severe weather for the CONUS and therefore needs a relatively simple and timely total lightning display. The most common method for processing lightning data at the SPC involves converting the flash point data into gridded data for ease of interpretation and display with other data such as radar imagery. A 20 x 20 km grid is most commonly used with the data stored into 5 minute bins, which closely matches the frequency of national radar imagery.

Initial results from the summer of 2013 confirm previous studies showing that the number of total lightning flashes greatly exceeds the number of CG flashes. Several different display methods such as plots of absolute numbers of CG and IC flashes and the ratio of IC to CG have been explored. Testing is continuing and has highlighted the complexities of displaying total lightning for multiple, simultaneous events over the CONUS during the convective season.

Preliminary results from the 2013 convective season along with some examples from major severe weather events will be presented.

INTRODUCTION

The Storm Prediction Center (SPC) is responsible for a wide variety of severe weather forecast products, from multi-day outlooks, to mesoscale discussions, and ultimately severe thunderstorm and tornado watches over the lower 48 states. Lightning is one of the tools used by SPC forecasters for nearly three decades to monitor on-going convective systems. The location and time of the first strike is critical information for the forecaster. Until recently, this meant monitoring the Cloud-to-Ground (CG) lightning strikes. However, CG lightning strikes are often only a small part of total lightning which

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includes In-Cloud (IC) flashes. A complicating factor is that the forecasters on duty must monitor the weather for rapid changes over large sections of the country where many storms may be occurring at the same time. Total lightning has been available to the SPC since late 2012. Some initial issues with grouping of flashes as IC or CG flashes by the provider were resolved with the total lightning in June of 2013. Since that time, the IC and CG flashes have been available to the SPC. If total lightning flashes are related to updraft strength in the favored -10 to -20 degrees C region and storm severity as discussed in MacGorman and Rust (1998), then the question is how best to detect this and display total lightning products.

BACKGROUND

Initially, CG flashes were converted to a gridded data set and overlaid as contours on radar and satellite images. Further, it was found that 20 x 20 km gridded lightning flashes in 5 minute time intervals added value to the radar and satellite images for growth and decay of storms. Even for CG flashes, it is not uncommon to see many tens of flashes even in a 5 minute interval. For contour intervals to be useful across a wide range of lightning flash counts, a “pseudo-log” contouring scale of 1, 3, 10, 30, 100, 300, 1000 and 3000 has been used for over a decade at the SPC.

Gridded data allows for ease of interpretation for intense convection, rather than plotted data where many flashes are repeatedly plotted on top of each other. However, one drawback to the gridded lightning data remains. As storms move from one grid cell to another, lightning flashes assigned to a grid often produce the effect of splitting the storm cell between two adjacent grid cells until it translates completely to the next grid cell. This could be interpreted as either a decay or growth depending on which grid cell is monitored. This is a common problem that can affect the interpretation of the time rate of change of lightning flashes when dealing with convection covering large areas of the country. This is not as large a problem for local NWS offices that have much smaller domains to cover. Alternatively, sophisticated storm tracking methods that would follow an individual storm cell and assign flashes to it would be useful but have not yet been developed for gridded data at the SPC.

One of the functions of the SPC forecaster is to monitor on-going weather, including convective initiation, so one benefit of having total lightning is the critical lead time that it can provide for the initiation of convection where there are no CG flashes. Often, the only flashes are IC for the first several minutes (MacGorman and Rust 1998) after initiation and in some cases; the time delay between IC and CG can be much longer.

Several different data plots of gridded data have been tested on the National Center AWIPS (N-AWIPS) displays at the SPC. The first was to simply plot the total number of flashes (CG and IC) using the “pseudo-log” scale so that low-end events could easily be distinguished from high-end events (similar to the method of plotting CG flashes). The larger number of IC flashes to CG flashes became immediately apparent when plotting and comparing the two categories. Over 300 total lightning flashes per 5 minutes in a 20 x 20 km grid cell have been observed for intense convection.

Another plotting method that was tested was contouring the ratio of total flashes to CG flashes. In the most intense convection, IC lightning was much larger than CG lightning with the ratio often above 50. One drawback to this display method was that no data could be plotted for a grid cell if CG lightning was absent, as a 0 in the denominator would result in dividing by 0.

A similar method to the previous was to contour the ratio of IC flashes to CG flashes. Owing to the larger numbers of IC flashes (but lower than total flashes) to CG flashes, the ratio was only slightly lower than for total to CG flashes but still often climbed above 50.

TOTAL LIGHTNING EXAMPLE

Several tornadoes were reported from Stanton county in extreme northeastern Nebraska to Cherokee county in northwestern Iowa during the late afternoon and early evening of October 4, 2013, as shown in Fig. 1. The total lightning count in Fig. 2 shows that the storm complex was producing over 100 total flashes per five minutes (IC plus CG), which continued from the beginning through the ending time of the tornadoes. As the storm complex moved into northwestern Iowa, it was producing over 300 total flashes per five minutes for a period of about 45 minutes. Figure 3 shows that the ratio of total flashes (IC and CG) to CG flashes was over 10, and it remained over 10 while the storms were producing tornadoes. Figure 4 shows the total flashes and the ratio of IC to CG flashes. The ratio of IC to CG generally remained above 5 and occasionally over 50 through the time of the tornadoes. Both of the ratios (total flashes to CG and IC to CG) varied substantially while the storms were producing tornadoes. The contoured values of each of the ratios after the tornadoes ended (but while hail and wind were still reported) continued to vary substantially. In this one case as the severe weather event was ending, the total flashes began to diminish.

SUMMARY

While only one case has been shown here, it does highlight that total lightning and the much higher numbers of IC flashes can provide some information about storm intensity. Total lightning seems to exhibit fairly good time continuity (over 5 minute intervals); however, at this early stage of investigation, the ratios of total flashes to CG flashes and IC to CG flashes can remain high, but vary significantly in magnitude over time. Total lightning should play a valuable role in severe weather detection as total lightning networks expand and improve detection efficiency, along with the future lightning products from GOES-R.

Efforts are continuing for the spring of 2014 to evaluate the total lightning and examples will be presented at the conference.

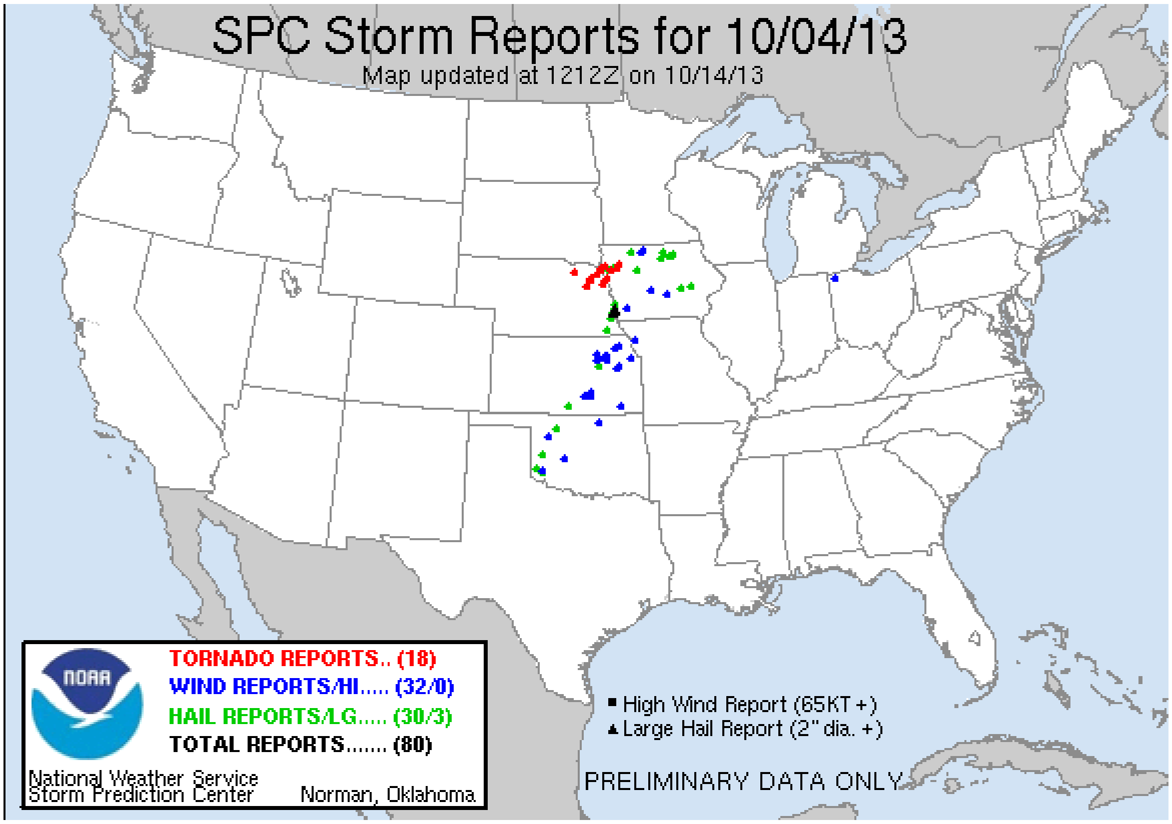

Figure 1. Preliminary severe reports for 12 to 12 UTC 10/04-05/2013.

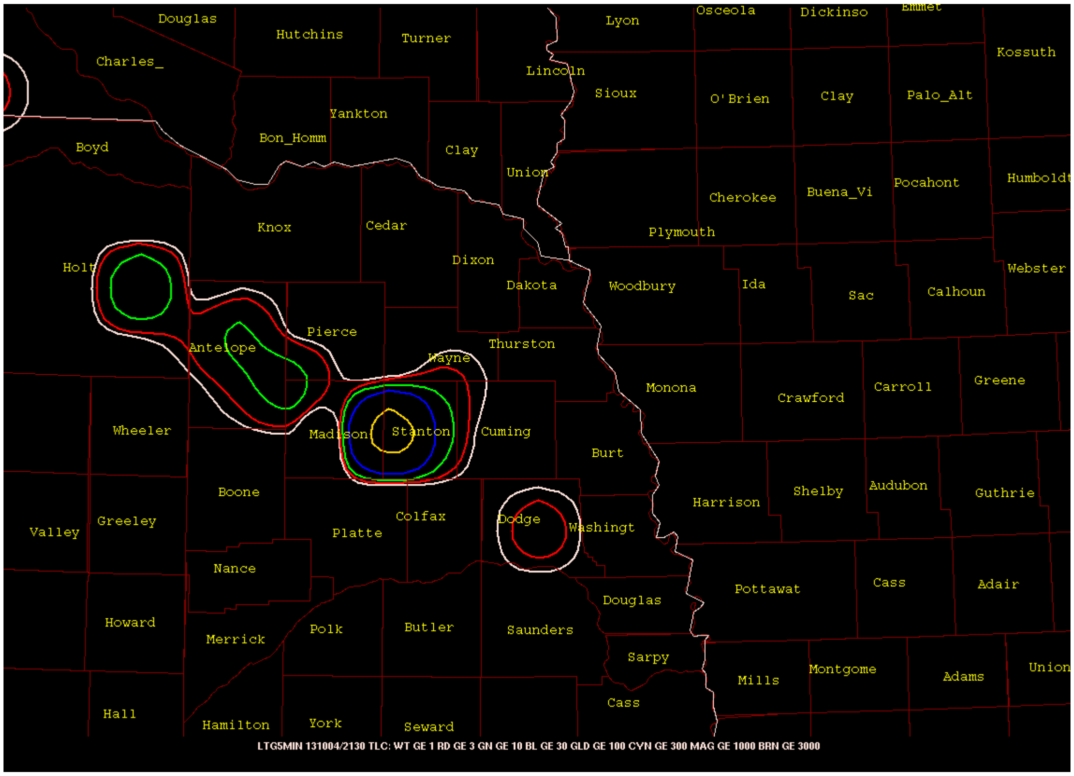

Figure 2. Total lightning flashes (IC plus CG) for 5 minutes ending at 2130 UTC. Contours are for 1, 3, 10, 30 and 100 flashes. Area of tornadoes extended from Stanton county NE to Cherokee county IA.

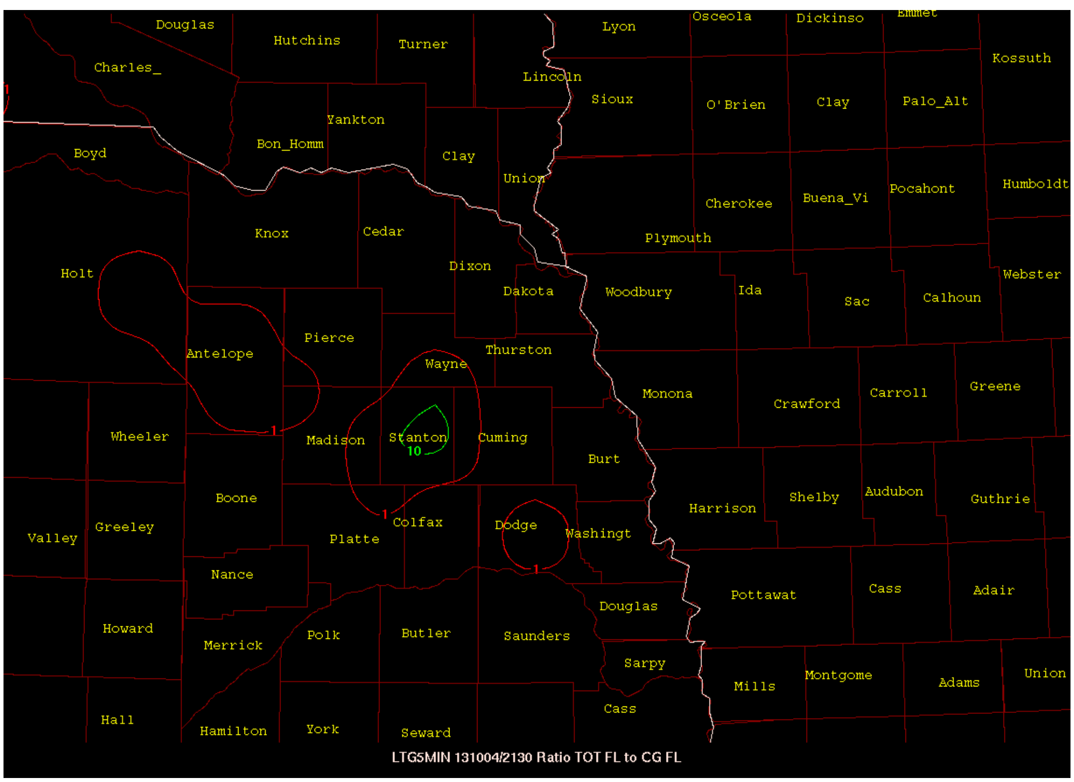

Figure 3. Ratio of total flashes to CG flashes (same time period as Fig. 2). Contours are 1 and 10.

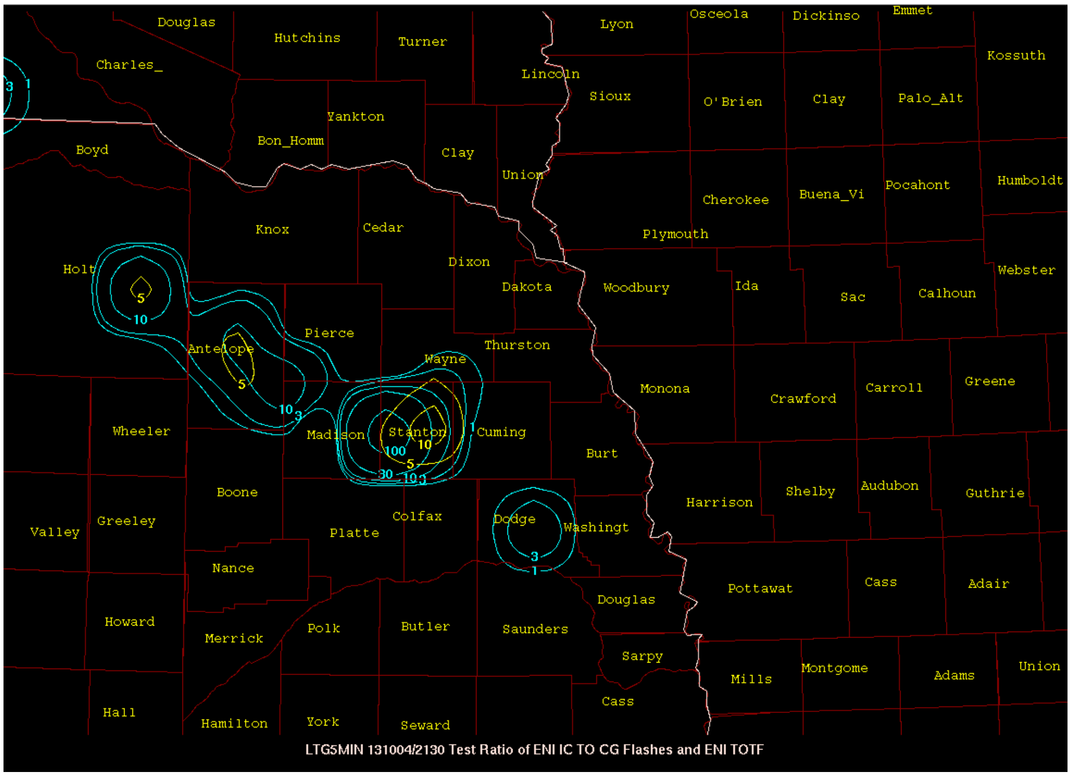

Figure 4. Total flashes in cyan contours (1, 3, 10, 30 and 100 flashes) and ratio of IC to CG flashes in yellow contours (5 and 10; same time period as Figs. 1 and 2)

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REFERENCES

MacGorman, D. R., and W. D. Rust, 1998: *The Electrical Nature of Storms*. Oxford University Press, 422 pp.