# Comments on the "Latitudinal Variation of Lightning Parameters"

STANLEY A. CHANGNON, JR.
Illinois State Water Survey, Urbana

23 April 1970

A general relationship between the frequency of ground stroke lightning and latitude has been suggested by Pierce (1970). His data indicate that the frequency of ground stroke lightning increases with increasing latitude, and this is explained as being related largely to the lower cloud bases and therefore lower negative charge centers in thunderstorms in more northerly latitudes. Pierce's inability to obtain a good relationship from the available limited global data is explained as being a result of inadequate spatial sampling, and physiographic and climatic differences between sites.

Long records of damaging lightning occurrences (Changnon, 1964) and thunderstorm frequencies (Changnon, 1957) for regions within Illinois offer an opportunity to examine the lightning-latitude relationship on a smaller scale. Illinois has a north-south extent of 385 mi (5°30′ of latitude); uniformly flat terrain with 94% of the area having elevations between 300 and 800 feet MSL; largely cash-grain farm lands that are almost totally devoid of forests; many small towns and occasional moderate sized urban areas, and one major urban complex; and one climate, humid continental. Thus, Illinois is an area with only small-scale physiographic and climatic differences which should have only a minor effect on ground stroke lightning frequencies. Therefore, if its north-south extent is sufficient to measure lightning-latitudinal changes, lightning data for the state should be useful in examining the Pierce results. Pierce's curve (Pierce, 1970, Fig. 1), which describes the proportion of all thunderstorm flashes that go to earth in the Illinois latitudes (37°0′N to 42°30′N), indicates a change from 0.24 in the south to 0.30 in the north. This 25% greater frequency in the north than the south would indicate that the north-south extent of Illinois is sufficient to reflect a significant latitudinal change, if such exists.

A detailed investigation of all damaging lightning occurrences in Illinois during the 1914–47 period (Changnon, 1964) provided frequencies of these events in each of the nine crop-reporting districts within Illinois. Although the number of cloud-to-ground strokes that produce damages is only a small percent of the total number of strokes, it was assumed that regional frequencies of these damage occurrences provided an indirect measure or index of the total regional frequencies of ground strokes. To help insure this, the regional frequencies of these damaging lightning occurrences were normalized by the amount of area in each region and the regional numbers of thunderstorms. The average thunderstorm distribution across the state is generally inversely related to latitude with average annual point frequencies ranging from 36 thunderstorm days in the north to 58 days in the extreme south.

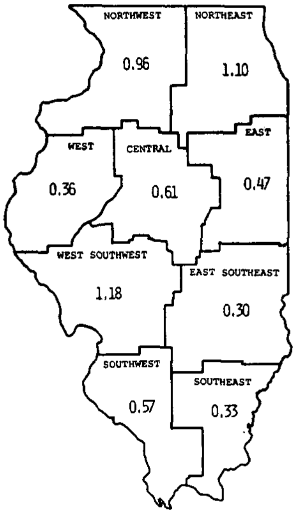


FIG. 1. Regional damaging lightning occurrences per 1000 $mi^2$ expressed as a percent of thunderstorm occurrences, 1914–47.

The 34-year regional frequencies of damaging lightning varied from a low of 26 occurrences in southeastern Illinois to a high of 150 in west-southwestern Illinois (Changnon, 1964). Normalization to account for differences in the areal extent of the regions expressed the frequency of damaging lightning strokes per 1000 $mi^2$. For instance, the 150 damaging lightning occurrences in the WSW region of 7500 $mi^2$ became a value of 20 per 1000 $mi^2$. Since the Illinois research indicated that 74% of the structures damaged by lightning were in rural locales (farms and small towns), further target normalization for the nine regions was not necessary because of the uniform distribution of small towns and farms across Illinois (Anonymous, 1964). However, the area-adjusted values were normalized further to adjust for regional differences in thunderstorm frequency and to allow simultaneous expression of the lightning occurrences as a percent of thunderstorm occurrences. The regional occurrences per 1000 $mi^2$ were divided by the product of the average annual number of regional thunderstorms and the number of years in the lightning sample. For example, in the WSW region this product was 1700 (50 thunderstorms per year $\times$34 years); divided into the 20 occurrences, the resulting value or index indicated that 1.18% of all thunderstorms in this region produced damaging lightning.

The resulting regional values which provide a relative measure of the ground-stroke lightning frequencies across Illinois are shown in Fig. 1. These indicate that the greatest frequency of ground-stroke lightning was in west-southwestern Illinois and the lowest frequency was at the same latitude, but in the east-southeastern region. Pierce indicates the possibility that nearby points at the same latitude may differ considerably in their ground-stroke frequencies, and the Illinois data certainly support this.

In general, the values in Fig. 1 support a conclusion for latitudinal variations in the distribution of cloud-to-ground lightning within Illinois, and also suggest that within the geophysical uniformity of Illinois there appear to be other important reasons for major localized increases and decreases in lightning. Available data indicate that thunderstorms in southwestern Illinois, where the cloud-to-ground lightning is shown to be most frequent, provide slightly more precipitation (Changnon, 1957) and occur somewhat more frequently at night than do thunderstorms elsewhere in Illinois (Changnon, 1968). Interestingly, the WSW region of maximization is also the region of greatest tornado activity (Changnon and Stout, 1957), hailstorm frequency (Huff and Changnon, 1959), and heavy rainstorm occurrences (Stout and Huff, 1962).

An underlying assumption in the regional pattern of Fig. 1 is that there are no areal variations in the overall electrical activity of thunderstorms anywhere in Illinois. However, one possible explanation for the greater frequency of ground strokes in the WSW region would relate to the noted greater frequency of severe weather which indicates relatively more vigorous thunderstorms in that region. More vigorous thunderstorms could mean more electrical activity per storm, and thus a greater frequency of ground strokes per storm. More vigorous thunderstorms could also indicate the more frequent existence of storms with greater vertical extent resulting in a greater distance between their positive and negative charge centers. This also would favor a greater frequency of ground strokes. Another possible explanation relates to more particulates and greater conductivity in the atmosphere between the cloud base and the surface, and such a condition is reasonable in this region because it is generally downwind of the effluent from the St. Louis urban-industrial complex. The high value in the northeast region, the second highest in Illinois (Fig. 1), also may partially relate to this explanation since the Chicago urban-industrial complex is in this region.

Importantly, the Illinois results indicate that in an area of apparently homogeneous climate and surface, the latitudinal lightning relationship exists although it is masked in certain regions by other equally important local effects.

*Acknowledgments.* The advice and suggestions of Dr. Eugene A. Mueller of the State Water Survey staff are appreciated.

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