Western Region Technical Attachment
No. 92-22
June 9, 1992

LLP and LPATS
TWO DIFFERENT LIGHTNING MAPPING TECHNOLOGIES

[Editor's Note: In addition to the listed references, information in this Technical Attachment was also obtained from personal communication with Dr. Fred Mosher, Chief, Techniques Development Unit, NSSFC.]

Introduction

Since the early 1980s, the Western Region has been generating near-real time lightning products and transmitting them on AFOS to the Western, Central, and Southern Regions (Rasch and Mathewson, 1984), (Mathewson, 1986), (Mielke, 1990). The source of these data is the Bureau of Land Management's (BLM) Automatic Lightning Detection System (ALDS) which covers the western one-third of the U.S. Forecasters are most familiar with the routine AFOS product CCCGPHWLS which is generated every 30 minutes.

Because of the growing interest in lightning data as an operational forecast tool, a federally funded Demonstration National Lightning Network was established in April 1987. This network was comprised of several smaller lightning detection networks, including the BLM's ALDS, but all used the same detection technology which was introduced by Lightning Location and Protection (LLP) in the 1970s. The lightning data from all the networks was collected by the State University of New York-Albany (SUNYA), and then transmitted to the NSSFC in Kansas City where an AFOS lightning product CCCGPHLDS was generated.

There were several developments in 1991, which we will not detail here, that led to a change in the national lightning data network. The upshot was that in December 1991, the NSSFC began receiving data from the Atmospheric Research Systems, Inc. (ARSI) network. This is a nationwide network that employs an entirely different lightning detection technology called Lightning Position and Tracking System (LPATS). The purpose of this Technical Attachment is to briefly review the LLP and LPATS technologies, now that they are both available to Western Region forecasters (under AFOS graphics WLS and LDS, respectively).

LLP

The basic sensor consists of two orthogonal loops, one oriented east-west, the other north-south. Very simply, the electromagnetic energy generated by lightning induces a signal in each loop which is dependent on the angle between the plane of the loop and the bearing to the lightning source. By using the ratio of signals induced in the two perpendicular loops, the bearing (azimuth) of the lightning source can be determined. If the bearing is determined by two or more direction finders, the location of the lightning source can be determined by triangulation (Figure 1). LLP developed methods to identify and filter the wave forms of various lightning signals so that only cloud-to-ground flashes were accepted. LLP also has the capability to distinguished between cloud-to-ground positive and negative flashes. A central processor at the BLM has the capability to identify redundant flashes so the same one is not counted twice.

LPATS

LPATS uses the time-of-arrival lightning mapping system, first developed by ARSI in the early 1980s. This system detects lightning with a simple whip antenna using a time-of-arrival technique. Each station identifies the time of a peak lightning signal that it receives and a central processor determines the differences in the times the lightning signal arrives at 4-6 stations. For a given time difference between two stations, the lightning signal can be located anywhere along a loci of points (hyperbola) that passes between the two stations (Figure 2). The location of the lightning is found by solving for the intersection of two hyperbolas, each determined by a separate pair of stations. LPATS does not use a strict waveform identification to filter different types of lightning, although it can distinguish between cloud-to-ground and other types of lightning. It is important to note that <u>all</u> types of lightning (cloud-to-ground, in-cloud, cloud-to-cloud, and cloud-to-air) are all accepted and plotted on the national AFOS lightning graphic LDS. However, cloud-to-ground flashes are much stronger; other types of flashes are weaker and their signals do not travel as far. Therefore, if the distance between stations is at least 125-150 miles, the lightning flashes mapped by LPATS have a high probability of being cloud-to-ground. The NSSFC estimates that only about 10 percent of the LPATS plotted flashes are other than cloud-to-ground.

The critical task of the time-of-arrival system is to accurately time the arrival of the lightning signal at four or more stations. ARSI has developed two techniques for synchronizing stations, one using the signal from a single LORAN-C navigational transmitter and the other using synchronization pulses from television broadcasts.

Operational Comparisons

Lightning data from these two different technologies is available to Western Region forecasters in near real-time. The 30-minute WLS AFOS graphic, generated at WSFO Boise, uses the LLP direction finder data from the BLM ALDS network. Beginning in December 1991, the 15-minute national AFOS graphic LDS, generated at the NSSFC, has used data from the LPATS time-of-arrival system. Since the beginning of the convection season, we've noticed some occasional differences in the two graphics and, of course, that's related to the two different technologies. A few of the characteristics and differences are summarized below.

- The LLP system accepts only cloud-to-ground <u>flashes</u>. The LPATS system accepts all types of lightning flashes and counts the <u>strokes</u>.

  Note: A <u>flash</u> may be comprised of several lightning return <u>strokes</u> -- each is counted separately on the LDS chart. Therefore, since the LPATS accepts all lightning flashes and counts individual strokes, the amount of lightning data plotted on the LDS graphic may be greater than that on the WLS graphic for a given period.

- Positive and negative cloud-to-ground flashes are distinguished by the LLP technology. The AFOS graphic 30-minute WLS includes both; the 30-minute WLR graphic plots only positive cloud-to-ground flashes. The national graphic LDS plots all types of lightning, including those that lower positive change to the ground.

- The ARSI network has a longer range than the BLM network. Therefore, it is not unusual to see lightning plotted over parts of Canada, Mexico, or coastal areas on the national LDS graphic.

- According to an NSSL study (MacGorman and Rust, 1988), the detection efficiency of the LLP technology is from 60-90 percent (depending on geographical region), while the LPATS detection efficiency was found to vary from 40-55 percent. Here in the West, where the distances between the BLM LLP direction finders are relatively large, it is estimated that detection efficiency is about 60 percent, still a little better than the LPATS technology.

  Results from this same study found lightning location errors of 3-6 miles with the LLP technology and errors of 6-13 miles with the LPATS system. However, for distances greater than 125 miles, the LPATS location errors improved to less than 6 miles.

Conclusion

Although there are some major differences between the systems, both provide useful and timely lightning information to Western Region forecasters. The NSSFC has contracted for lightning data from ARSI on a month-to-month basis, until a decision is made on a vendor for a national lightning data collection network. This decision is expected sometime this summer. In the meantime, the Western Region plans to continue generating lightning graphics using data from the BLM network. In any case, we very definitely plan to continue to furnish lightning data to our field stations.

References

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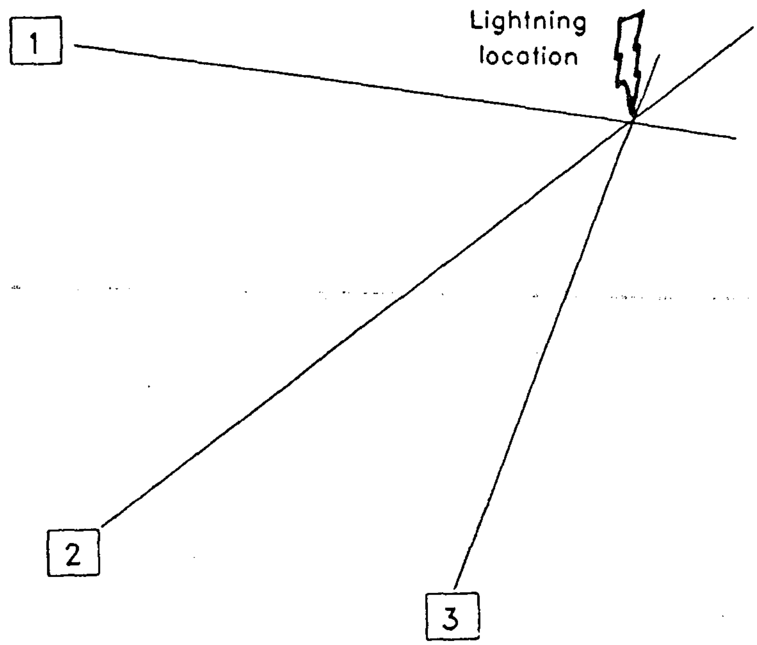

Figure 1 Locating lightning by triangulation. The bearings from the stations (numbered squares) intersect at the location of the lightning channel.

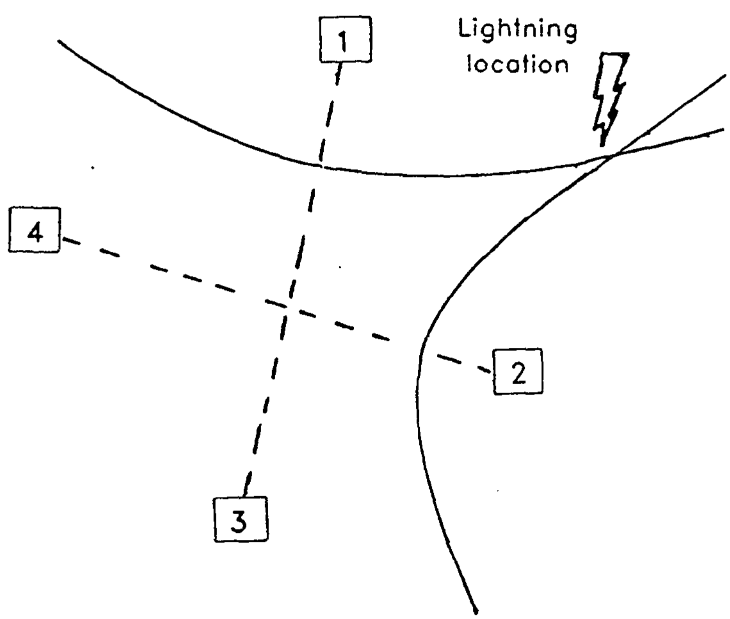

Figure 2 Locating lightning by the time-of-arrival technique. The difference in times that a lightning signal arrives at two stations (numbered squares) defines a hyperbola on which the lightning channel is located. The hyperbolas from different pairs of stations intersect at the location of the lightning channel.