Extended Abstract for:

Detection Efficiencies and Range Accuracies of Three Portable Lightning Detectors Compared with the National Lightning Detection Network

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Overview

Three portable, hand-held lightning detectors are compared with the National Lightning Detection Network. The three detectors are the SkyScan[TM], the StrikeAlert[TM], and the Thunderbolt. The first two detectors use a series of LED readouts to indicate distance ranges to every cloud-to-ground lightning strike detected by the receivers. The third uses an LCD readout to give textual messages regarding lightning activity in the area. The portable detectors are found to have near-perfect efficiencies (96-100%) in detecting lightning strikes within 40 miles (64 km). However, the ability to determine the actual distance to the strike is far lower (36-76%).

Method

The portable lightning detectors (PLDs) used for this study indicate the distance from a cloud-to-ground (CG) lightning strike through either a series of light-emitting diodes (LEDs) corresponding to distance range bins (StrikeAlert[TM] and SkyScan[TM]), or through a liquid-crystal display (LCD) giving short, textual messages and warnings about general lightning activity in the area (Thunderbolt). These units do not have data ports whereby a data logger could be connected. In order to permanently record data the devices had to be videotaped and the videotaped images later manually transcribed to a spreadsheet. Simultaneous recording of all three detectors was accomplished by placing them side-by-side on a movable audio-visual (A/V) cart and setting up the digital video camera on a tripod positioned such that it could capture all three displays. For safety reasons, and to avoid water damage to the detectors and camera, data collection was ceased if rain began to fall or if lightning was within six miles (based on flash-to-bang calculations). Because the National Lightning Data Network (NLDN) data are recorded to one-hundredth of a second the videotape had to be calibrated as precisely as possible. The digital video camera features a built in clock that displays to the nearest second, and prior to recording an event the clock on the camera was synchronized with the atomic clock operated by the National Institute of Standards and Technology website (*www.time.gov*).

One important qualification on the methodology should be noted. The StrikeAlert[TM] detector is the size and shape of a garage door opener, with the LEDs located along the smaller edge of the unit (what the manufacturer calls the top of the unit.) The manufacturer's instructions for the StrikeAlert[TM] detector state that the unit is designed to be used in an upright position, and that its accuracy may be affected if not upright. However, in order to videotape all three units operating simultaneously, the StrikeAlert[TM] was tilted forward so that it was nearly horizontal. It is unclear how this impacts the results, although the resulting detection efficiency of this unit was comparable to the other units.

Once the location information was transcribed from the videotape to a spreadsheet a computer program was written to read the data and compare the ranges of any lightning strikes reported from the NLDN that were within 40 miles of the test site (Millersville University) with the information recorded by the three portable detectors. For the two detectors that indicate the range of the strike through LED displays (StrikeAlert^{TM} and SkyScan^{TM}) the NLDN data were converted to indicate which LED should have been lit on the detector if the detector accurately determined the range to the strike. The median position accuracy of the NLDN over the United States is reported by its operator, Vaisala, Inc., as 500 m (Cramer et al., 2004). To account for this uncertainty, if an NLDN reported strike was within one mile of a range-bin cutoff for the detector it was counted in both adjacent range bins. For example, if an NLDN strike was reported at a distance of 19 miles, and the 20 to 40 mile range bin LED was lit on the detector, then the strike was credited as a hit rather than a miss for that detector.

The clock on the video camera was synchronized with the National Institute of Standards and Technology atomic clock via their website interface. Because this was done manually it could only be synchronized to within approximately 1 second. To account for a possible one-second synchronization error when comparing the NLDN strikes to the portable lightning detectors, we used the detector information not only at the second when the NLDN recorded a strike, but at one second prior and one second after the NLDN strike was recorded. The most favorable data from the portable detector within this three-second window was then used to compare with the NLDN. For example, if the NLDN reported a strike at a distance of 24 miles at t seconds, and the 20 to 40 mile range LED of the detector was not lit at time t but was lit at time $t - 1$ second or $t + 1$ second, then the detector was credited with a hit.

The detectors were only compared with strikes recorded by the NLDN. Strikes recorded by the detectors, but not reported by the NLDN, were not studied. Thus, the false-alarm rate of the detectors was not a focus of this project, though there were numerous periods where at least one of the detectors reported significant lightning activity while the NLDN showed no lightning strikes within 40 miles. It is possible that these were due to cloud lightning.

Results

Tables 1 and 2 show the results for the SkyScan^{TM} and StrikeAlert^{TM} detectors on May 16 and July 11, 2007. The tables show the number of strikes recorded by the NLDN while the portable detector was operational. The tables also show the detection efficiency, which is defined as the percent of NLDN strikes within 40 miles of the

portable detector that were actually reported by the detector. The final column in the tables is the range efficiency, which is defined as the number of NLDN strikes within 40 miles of the portable detector that were classified in the correct range bin by the portable detector. Both detectors had near-perfect detection efficiencies, detecting all but a few strikes reported by the NLDN that were within 40 miles. However, their range efficiencies were much poorer and highly variable. The SkyScan had range efficiencies of 65% and 76% on the two days respectively, while the StrikeAlert had range efficiencies of 36% and 42% (note that the StrikeAlert was oriented horizontally, contrary to the manufacturer's recommendation).

Table 1. Results for SkyScan^{TM} Detector

Date	NLDN Strikes	Detection Efficiency	Range Efficiency
5/16/2007	126	96%	65%
7/11/2007	55	100%	76%

Table 2. Results for StrikeAlert^{TM} detector. This detector was not in the upright position during measurements, contrary to the manufacturer's recommendation.

Date	NLDN Strikes	Detection Efficiency	Range Efficiency
5/16/2007	96	100%	42%
7/11/2007	55	98%	36%

The results for the Thunderbolt detector were much more complicated to tabulate and quantify since, instead of reporting a simple range to an individual strike, this detector gives detailed and varied text messages regarding more general lighting activity via an LCD readout. Table 3 shows sample results for a portion of the data gathered from the Thunderbolt on May 16, 2007. The table also shows the messages displayed on the Thunderbolt detector for the three second window centered on the strike time. Those instances where the Thunderbolt reported messages that were not consistent with the NLDN data are shown in bold, italic font.

In order to quantify these results we calculated a "consistency factor" by finding the total number of NLDN lightning strikes within 40 miles and dividing it into the number of times a message consistent with the NLDN data was displayed on the detector. These results for both the May 16 and July 11 events are shown in Table 4. For the May 16th event, out of 45 NLDN strikes recorded, the Thunderbolt indicated a consistent message for 31 of the strikes for a consistency factor of 69%. For the July 11th event, out of 123 NLDN strikes the Thunderbolt displayed a consistent message 79 times for a consistency factor of 64%.

Table 3. A portion of the results for theThunderbolt detector on May 16, 2007. Messages from the detector that are inconsistent with the NLDN data are shown in bold italics. The term 'local' as used by the manufacturer is defined as within 8 miles. Results for the entire data set are summarized in Table 4.

t (sec. GMT)	distance (miles)	Message ($t-1$ second)	Message (t)	Message (t+1 second)
63280	18	local activity possible	local activity possible	local activity possible
63288	17	local activity possible	*closest strike 1 mile*	*closest strike 1 mile*
63294	20	*closest strike 1 mile*	*closest strike 1 mile*	*closest strike 1 mile*
63321	17	*closest strike 1 mile*	*closest strike 1 mile*	*closest strike 1 mile*
63333	27	*closest strike 1 mile*	*closest strike 1 mile*	*closest strike 1 mile*
63335	20	*closest strike 1 mile*	*closest strike 1 mile*	*closest strike 1 mile*
63340	18	*closest strike 1 mile*	*closest strike 1 mile*	*closest strike 1 mile*
63357	20	local activity possible	local activity possible	local activity possible
63377	18	warning strikes detected	warning strikes detected	warning strikes detected
63488	18	warning strikes detected	warning strikes detected	warning strikes detected
63498	16	warning strikes detected	warning strikes detected	warning strikes detected
63516	18	warning strikes detected	warning strikes detected	warning strikes detected
63537	16	*storm activity 7 miles*	*storm activity 7 miles*	*storm activity 7 miles*
63550	15	*ground strikes 4 miles or less*	*ground strikes 4 miles or less*	*ground strikes 4 miles or less*
63577	17	*ground strikes 4 miles or less*	*ground strikes 4 miles or less*	time to < 15 minutes
63577	13	*ground strikes 4 miles or less*	*ground strikes 4 miles or less*	time to < 15 minutes
63583	17	time to < 15 minutes	*ground strikes 4 miles or less*	*ground strikes 4 miles or less*
63598	19	*warning storm is local*	*warning storm is local*	*warning storm is local*
63599	13	*warning storm is local*	*warning storm is local*	*warning storm is local*
63612	15	time to < 15 minutes	time to < 15 minutes	time to < 15 minutes
63614	16	time to < 15 minutes	time to < 15 minutes	time to < 15 minutes
63624	17	time to < 15 minutes	time to < 15 minutes	time to < 15 minutes
63656	15	time to < 15 minutes	time to < 15 minutes	time to < 15 minutes
63660	16	time to < 15 minutes	time to < 15 minutes	local strikes extend time
63664	15	*local strikes extend time*	*local strikes extend time*	*local strikes extend time*
63673	12	*warning storm is local*	*warning storm is local*	*warning storm is local*
63686	17	*warning storm is local*	*warning storm is local*	*warning storm is local*
63689	14	*warning storm is local*	*warning storm is local*	*warning storm is local*
63706	11	time to < 15 minutes	local strikes extend time	local strikes extend time
63729	12	time to < 15 minutes	local strikes extend time	local strikes extend time
63739	14	*local strikes extend time*	*local strikes extend time*	*local strikes extend time*
63742	14	*local strikes extend time*	*local strikes extend time*	*local strikes extend time*
63751	12	*local strikes extend time*	*local strikes extend time*	*local strikes extend time*
63764	10	*warning storm is local*	*warning storm is local*	time to < 15 minutes
63784	13	*warning storm is local*	*warning storm is local*	*warning storm is local*

Table 4. Consistency factors for May 16 and July 11 events for Thunderbolt detector.

Date	NLDN Strikes	Consistent Messages	Consistency Factor
5/16/2007	45	31	69%
7/11/2007	123	79	64%

Summary

Three hand-held, portable lightning detectors were evaluated against the NLDN, for two separate thunderstorm events on May 16 and July 11, 2007. Although the overall detection efficiencies of the PLD's for lightning strikes occurring within 40 miles were near 100%, the efficiency of accurately determining the range to the strike was far lower. For the SkyScan and StrikeAlert detectors, which indicate distance to every strike, the range efficiencies varied from 65-76% and 36-42% respectively. For the Thunderbolt, which indicates general lightning activity through textual messages, the displayed messages were consistent with the NLDN data for 64 – 69% of the NLDN-detected lightning strikes.

References

Cramer J. A., K. L. Cummins, A. Morris, R. Smith, and T. R. Turner, 2004: Recent upgrades to the U.S. National Lightning Detection Network. *18th Int. Lightning Detection Conf.*, Helsinki, Finland, Vaisala, Inc., Reference No. 48