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Evaluation of the B.C. Lightning Location System at the Pacific Weather Centre

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INTRODUCTION

In the summer of 1980 the B.C. Ministry of Forests began installing an automatic lightning detection system in B.C. similar to those operating in the western United States and Alaska. In 1982 the network covered nearly all of the province. The system is designed to record cloud-to-ground lightning strikes to aid the Forest Service Protection Branch look for lightning caused fires which account for nearly half the forest fires in the province. The information is stored in the B.C. Systems Corporation IBM computer in Victoria. The Ministry of Forests has made this information available to A.E.S. and in August of this year the Pacific Weather Centre acquired a computer link to the IBM computer in Victoria and began accessing the data. The information was used at the Pacific Weather Centre to confirm lightning activity and correlate it with other weather parameters and satellite imagery.

LIGHTNING DETECTION

1. Theory of Lightning Detection

When a cloud-to-ground discharge occurs an electromagnetic wave is generated by the current in the discharge. This travels as a cylindrical wave through the atmosphere. About 95% of the discharges are from the bottom of the cloud. These discharges lower negative charge to the ground and are referred to as negative strokes. A small percentage of strokes (5%) lower positive charge to the ground from the top of the cloud and are called positive strokes (Fuquay). These are thought to be good fire starters as they generally are outside the rain shaft. Positive strokes are generally associated with the dissipating stages of large storms (Fuquay). Large distant negative strokes can become inverted through ionospheric reflection and appear as positive strokes (Krider). All discharges including inter-cloud discharges produce distinct electromagnetic wave signatures which the system uses to screen out noise and inter-cloud discharges. It is believed that inter-cloud discharges occur at least twice as frequently as cloud-to-ground strokes (Krider et al 1980).

2. Automatic Lightning Location System in B.C.

The Lightning Detection Network operated by the Ministry of Forests had eleven detectors in place in 1982 (Figure 1) to cover over 80% of the province. These are connected to a position analyzer in Victoria which determines the co-ordinates and intensity of each stroke. Positive and negative strokes are identified and stored. The system can record 8 strokes

per second. The detection efficiency of cloud-to-ground strokes at an optimum range of 330 km is 80 to 90%. The position analyzer is polled every five minutes by the B.C. Systems Corporation computer.

The system in place at the PWC is identical to that used at the six B.C. Ministry of Forests Regional offices across the province. This consists of an HP85 desk top computer connected to an eight pen plotter with a 2400 BAUD line to the IBM computer in Victoria. The latest information available to PWC can be from 5 seconds to 5 minutes old.

3. Errors in the System

The location of a lightning strike is subject to a number of errors. Most errors due to sighting are corrected by calibration at the site. The wave length of the signal is in the order of 100 km. so most objects (even mountains) are too small to cause errors, unless very close. The coordinates of any stroke is calculated using the bearing reported from two detectors. This gives rise to two main types of error: overrange and baseline.

a) If a strike occurs within 20 km. of a detector it does not compute a bearing and depends on other detectors to record the event.

b) If a strike occurs within eight degrees of a line joining two detectors this line is taken as the direction and the distance is the ratio of the signal strengths at the detectors. This can lead to some error in direction to distance.

4. Use of the System at PWC

The protocol to establish contact with the IBM computer was fairly straight forward and all forecasters quickly learned the routine. See example of lightning detection chart in Figure 2. The lightning data was used in three main ways at PWC:

a) "Nowcasting" to pinpoint onset of lightning activity and to confirm airways and fire weather forecasts.

b) Comparing satellite data and lightning data. See Pacific Region Technical Note 82-014.

c) Data was transferred to another chart and transmitted by facsimile to the AES field stations.

5. Some Observations

The system is able to report more lightning and earlier than from normal meteorological surface observations. It pinpoints the area of the most intense activity. On at least one occasion, it alerted forecasters to the onset of lightning in an area not expected. In a study by Rea and Fontana, it was noted that the lightning location system identified areas of lightning an hour before radar.

More positive lightning was recorded than expected. Fuquay found positive lightning on 16 of 48 storm days. We recorded positive strokes in 32 out of 33 days and on two days positive strokes predominated. On one such occasion from 1500 hrs. Oct. 23 to 1500 hrs. Oct. 24 the system recorded 181 positive strokes to 25 negative. Nearly all these occurred along the B.C. coast with cloud tops to about 24 thousand feet. Cloud-to-cloud lightning was reported from the weather stations at Prince Rupert and Port Hardy at the same time.

On at least two occasions lightning was reported cloud-to-ground from our AES reporting stations and not picked up by the lightning location system although lightning strikes were recorded further away (50 miles). On another one or two occasions lightning was recorded by the system in the Castlegar area but no evidence of such activity could be confirmed by other reports.

Two severe storm days were examined by a summer student in the Pacific Region Technical Note 82-014. It appeared to confirm that the most intense lightning occurred in an area which was clear early in the day and at the edge of moisture moving in from the south. A rapid increase in activity began after 1500 hours reaching a peak in three hours and subsiding after that. Highest counts occurred as cloud top temperatures as seen from satellite infra-red pictures reached -50°C and this isotherm was expanding rapidly. Rea and Fontana found maximum radar cell tops correlated well with maximum frequency of cloud to ground lightning.

On a test basis two charts a day were prepared and transmitted by facsimile to other weather offices of lightning activity recorded by the system. It is intended to repeat this again in 1983.

CONCLUSION

The lightning location data is a valuable tool which gives forecasters access to the onset and location of lightning away from AES reporting stations. The activity can be correlated to satellite imagery and used for nowcasting. It is hoped that more research with satellite imagery and lightning data will aid in forecasting the location and intensity of lightning. We found the equipment reliable and easy to use. For our purposes a year round system would be desirable.

ACKNOWLEDGMENT

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Rea, J.A., and Fontana, C.E.; An Automatic Lightning Detection System in Northern California; NOAA Technical Memorandum NWS WR-153, 1980.

Pacific Region Technical Notes 82-014; P. Jackson; 1982; Satellite Imagery and Lightning Location - A Case Study.

MAP OF	MINISTRY OF FORESTS LIGHTNING LOCATION MAP	SYMBOLS		MAP #
PROVINCIAL MAP SCALE 1: 5 000 000	LIGHTNING DETECTORS IN B.C - AUG 20 1982	A MONDAY + TUESDAY X WEDNESDAY	T THURSDAY > FRIDAY Y SATURDAY * SUNDAY	1

FIGURE 1

Location of B.C. Ministry of Forests Lightning Detection Finders as of 1982

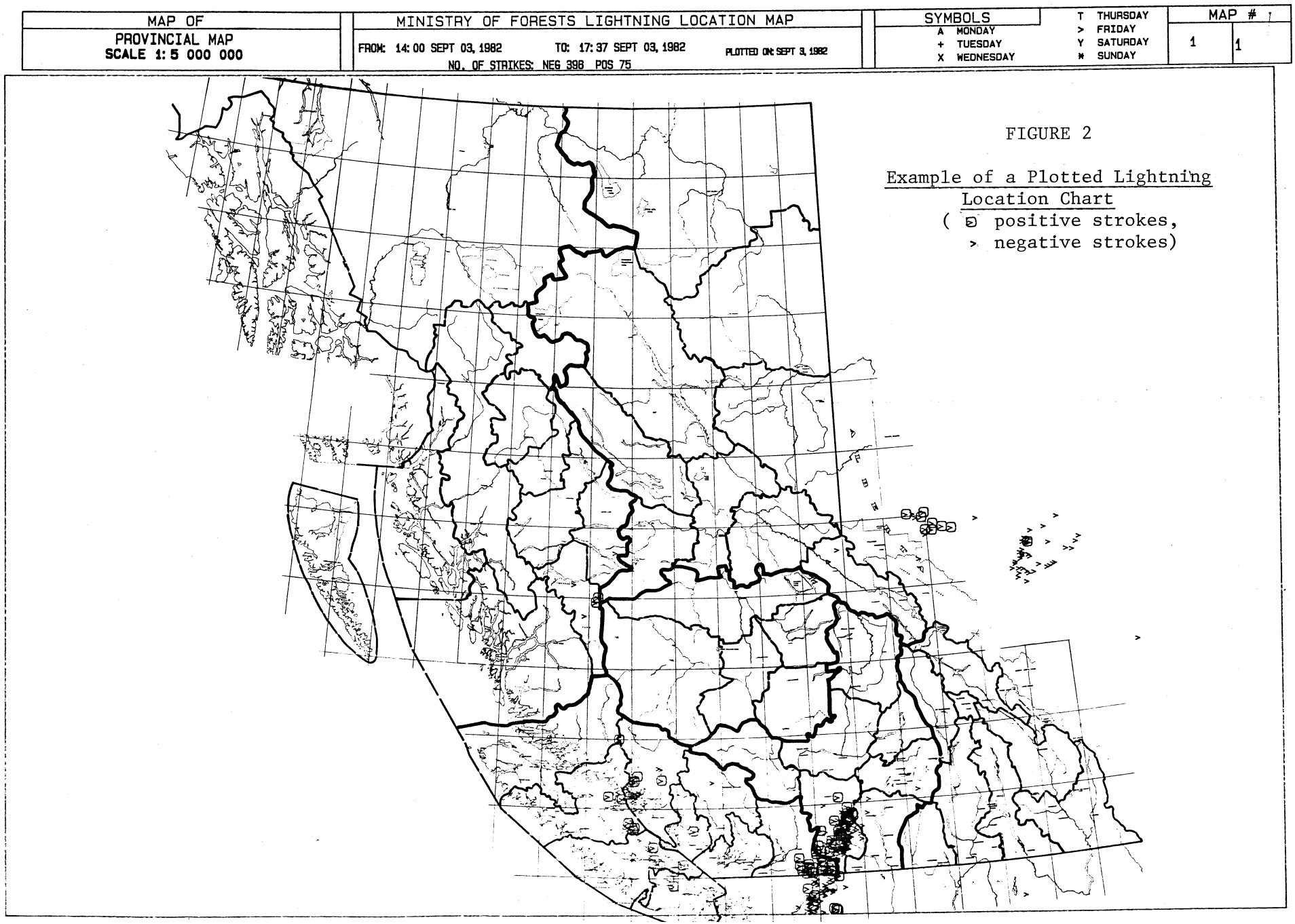

FIGURE 2

Example of a Plotted Lightning Location Chart
(positive strokes,
negative strokes)