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USING A LOCALLY DEVELOPED SFERICS UNIT AS A COMPLEMENT FOR WEATHER RADAR TEST RESULTS SPRING/SUMMER 1985

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1. INTRODUCTION

The use of lightning (SFERICS) detection has long been dreamed of as a low cost supplement to radar for thunderstorm detection and tracking. Kohl and Miller (1963), Taylor (1973), Graff and O'Malley (1975) have shown a connection between surface severe weather and sferics responses. Kohl and Miller showed the relation between rapid sferics increases and the onset of severe weather. Taylor showed how sferics burst rates at 3 MHz increasing at an exponential rate signified the onset of a tornado. Graff and O'Malley tied together the periodicity of sferics increases and decreases to the periodicity of severe weather events.

A simple sferics device can be constructed using an A.M. radio and a strip chart recorder. **The primary use of this type of sferics unit would be to alert the radar operator to developing convection.** Weak electrification begins during the early transition phase from tower cumulus (TCU) to cumulonimbus (CB) (Kohl, 1962). An increase in sferics during a period of no echoes on the PPI could alert the radar operator to look for developing thunderstorms above the freezing level.

2. INSTRUMENTATION AND THEORY OF OPERATION

The study of sferics in relation to severe weather has covered most of the electromagnetic spectrum from 1 KHz up into the UHF range.

The sferics device used at WSO Fargo is an A.M. radio tuned to 500 KHz, and a Leeds/Northrup (L/N) Speedomax Model H Recorder, with a response time of one second full scale. Since it is within the range of most A.M. radios, 500 KHz was chosen. Due to atmospheric attenuation at that frequency the maximum range is limited to 175 nautical miles. The radio is set to 20 Mv at signal saturation, which corresponds to the saturation peak of the L/N recorder (Fig. 1).

The theory between sferics pulses per minute (PPM) rate change and severe weather occurrences has been studied by Kohl (1962); Taylor (1973); Brown and Hughes (1973); and operationally by Graff and O'Malley (1975). While the connection between PPM rate changes and severe weather **is somewhat nebulous**, research has shown that sferics is useful enough to **alert** the radar operator for potentially severe weather. However, since severe weather has been observed during the overall PPM rate change cycle, only subjective conclusions (in the operational environment) may be drawn.

The major drawback to this sferics unit is that it is omni-directional. It detects sferics from storms in all directions within 175 nautical miles (NM) and gives an **overall index** of storm activity. However, since most severe weather within Fargo's area of responsibility is usually due to one cluster of storms at a time, a sudden increase in the PPM rate would alert the operator to look for the causative storm; i.e., employing the WRIST technique (Lowden, 1984).

3. STORM INTENSITY

Sferics are produced during all phases of CB growth, thunderstorm maturity, and the rainout/dissipation stage. However, sferic count rates are usually the greatest during growing storms. The transition, however, from a thunderstorm to a severe thunderstorm often produces a nearly exponential increase in sferics PPM rates. Field data indicate that a greater percentage of severe weather occurs during this growth phase. By recording the cumulative PPM rate, a trend in the intensity change rate may be shown. As the PPM rate increases, a higher scale response is achieved.

While storms closer to the receiver would generally create a higher scale response than storms farther away, storms in the process of becoming severe would create a logarithmic increase in scale response. This should be true regardless of the distance from the receiver.

4. CASE STUDY

Numerous severe weather events occurred within Fargo's county area of responsibility during the spring/summer season 1985, and 10 were closely analyzed using the sferics recorder. The severe weather episode of May 10th is studied in some detail here as it is representative of all observed episodes.

Fig. 2 is a copy of the actual sferics amplitude versus time recorder; Fig. 3 is a hand-copied trace of the same data, designed to 'smooth out' the spurious noise.

Table 1 contains the storm reports received at WSO Fargo between 8:00 AM CDT and 5:30 PM CDT, the time span sampled by the local sferics unit for this event. Some of the reported storm events are labelled on the left side of Fig. 2; the time (CDT) is on the right. Note that most of the hail events reported were preceded by marked sferics 'spikes' of 3 to 8 minutes duration, 5 to 10 minutes prior to the event. Note, however, that the 1 3/4" hail and confirmed funnel cloud (with radar hook echo) 50 miles east of Fargo at 10:20 AM occurred during a marked sferics lull.

Between 3:15 PM and 3:40 PM, a very strong PPM rate increase/decrease peak occurred prior to 1 3/4" hail reported 115 miles north of Fargo, at Grafton ND.

At 4:12 PM, explosive convection developed 35 to 60 miles southwest of Fargo. This development was heralded by a 20 minute PPM increase that was unmistakable. This cluster of storms passed 20 to 40 miles west of Fargo between 4:30 and 5:30 PM, producing 1 3/4" hail and several confirmed funnel clouds.

The PPM rates decreased between 5:00 PM and 5:10 PM; however, that trend reversed rapidly from 5:10 PM - 5:40 PM as a new cluster of intense thunderstorms developed 65 miles southeast of Fargo. The unit was shut down at 5:40 PM to conserve paper.

The various spikes on Fig. 3 marked with "MT" refer to the spikes that correspond to maximum top emergencies on radar (Graff and O'Malley, 1975). Other data labelled on Fig. 3 include the approximate time of occurrence of hail, strong winds (50 kts or more), and funnel clouds.

5. CONCLUSIONS

Studies over the last 30 years have shown a very good correlation between the rate of increase in lightning activity and the onset of severe weather. The faster the increase in sferics pulse per minute rates, the more likely the onset of severe weather, with exponential increases exhibiting the highest threat. Sferics cannot, however, help determine the type of severe weather. Sferics can act as an early warning to the radar operator to employ the WRIST technique for storm detection. Since a developing storm matures electrically before producing a radar echo, a rapid increase in the sferics rate under PPINE conditions could alert the operator to look above the freezing level.

Since the advent of Doppler radar to the field is still in the future, sferics can help the present day conventional radar operator/severe weather coordinator make critical decisions. Sferics will never replace radar, but it may continue to be a valuable tool in the short-fused severe weather warning environment.

6. REFERENCES

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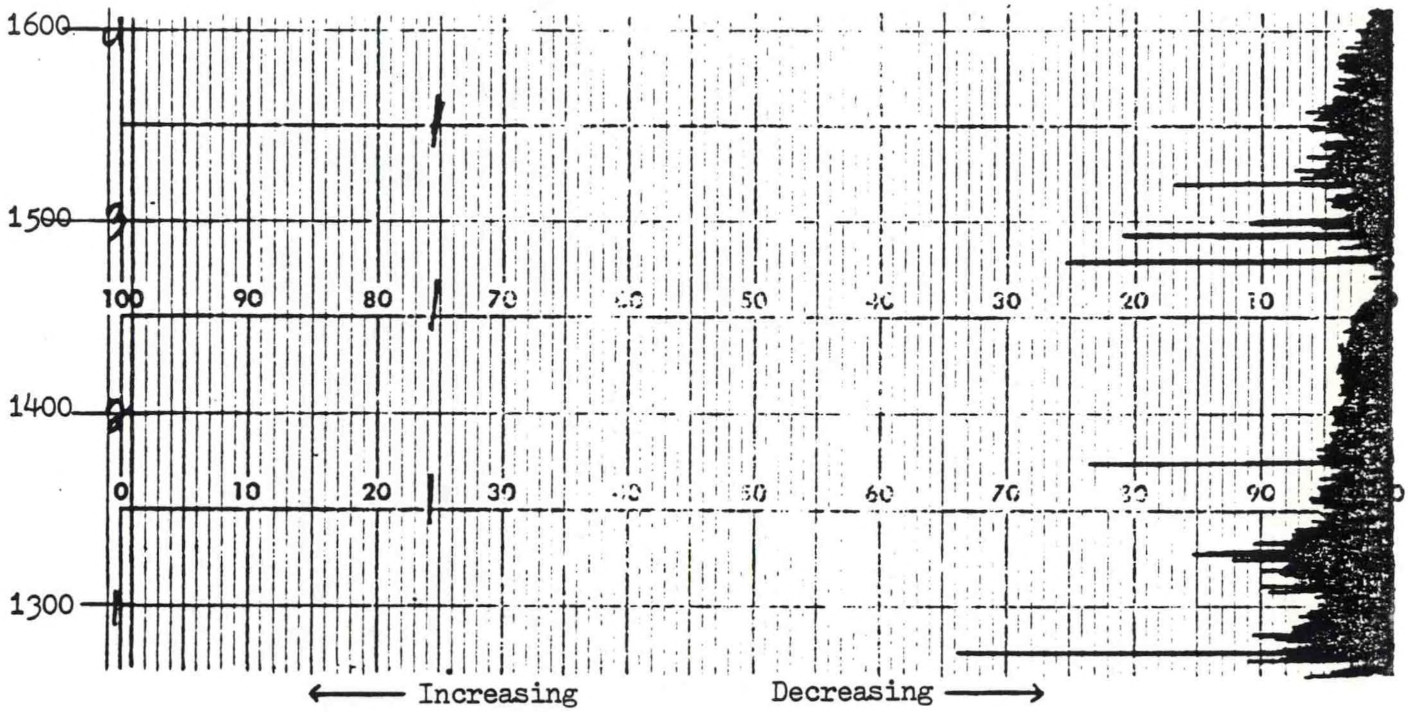

Figure 1. L/N recorder trace of normal background sferics noise. Spikes are light rain showers and CBs moving through the area, as well as local interference. Recorded June 12, 1985 between 1300 - 1600 CDT.

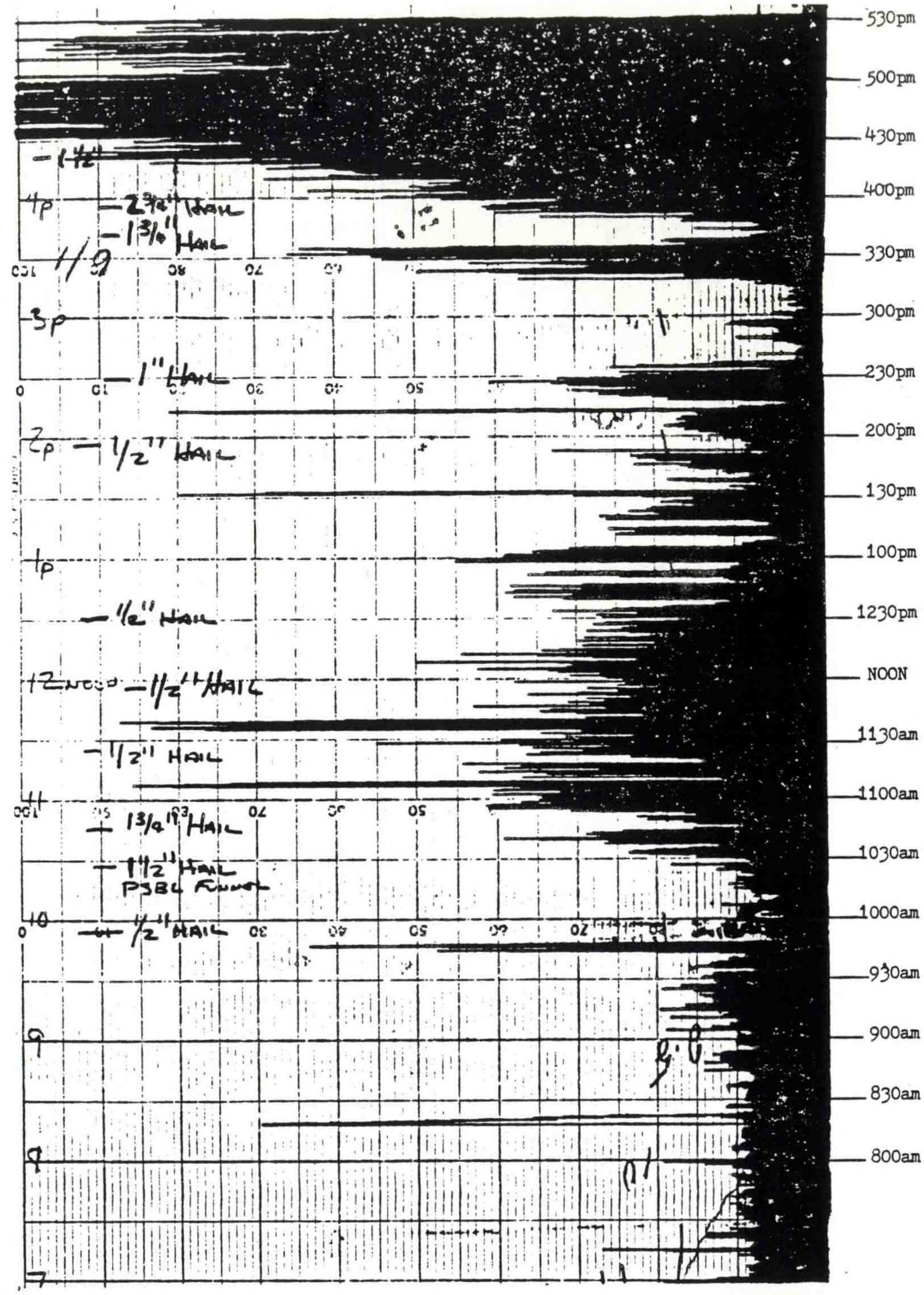

Figure 2. Strip chart record of 500 KHz signal amplitude vs. time interval. May 10. 1985 between 0700 - 1730 CDT.

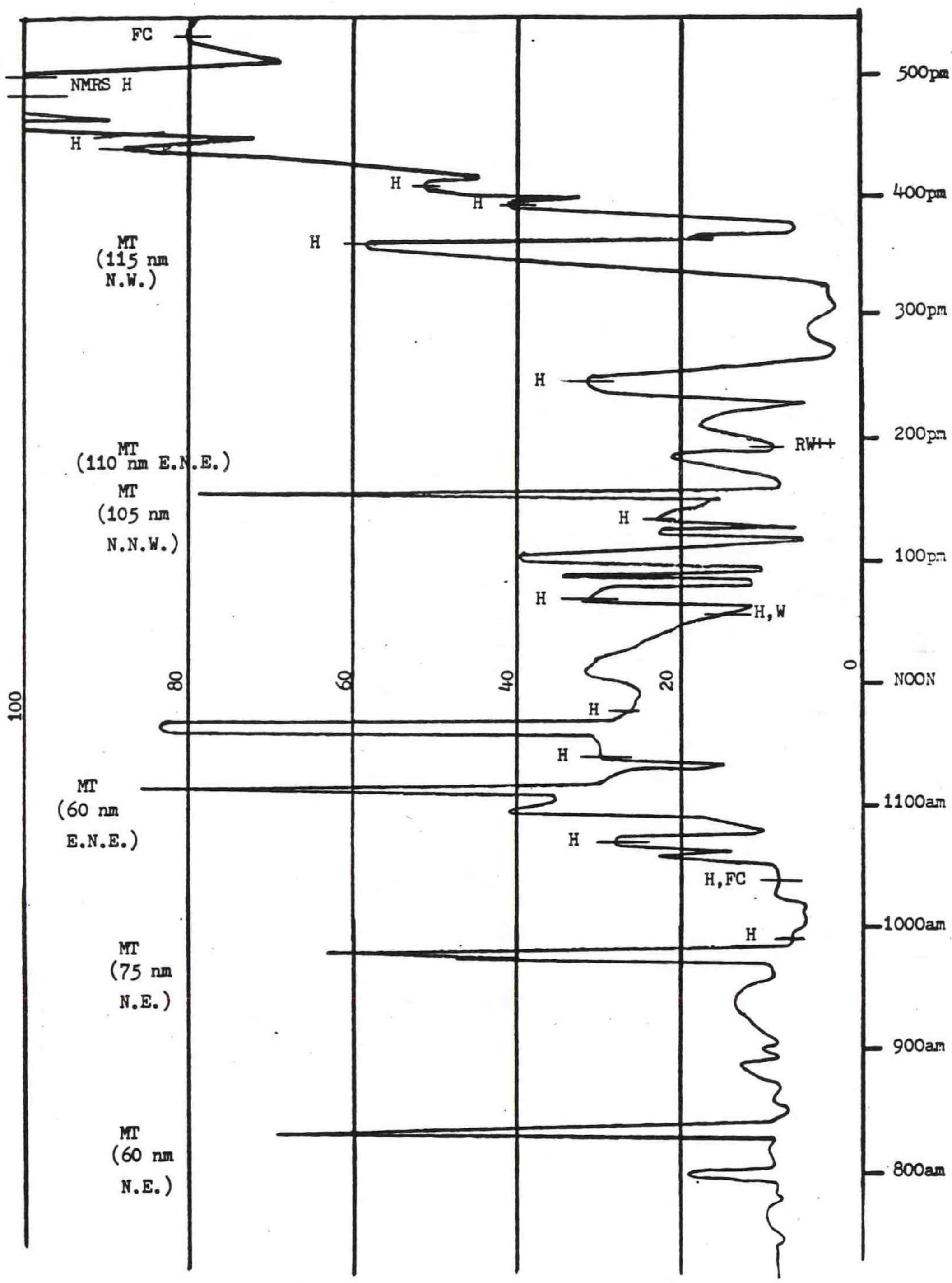

Figure 3. Same as Figure 2, except hand copies to 'smooth out' noise. "MT" denotes approximate time of radar indications of emerging maximum tops. Parenthetical data includes distance of max top from radar, and direction on 16-point compass. Hash marks on trace denote approximate time of occurrence of hail (H), wind damage (W), tornado (T) or funnel cloud (FC).

TABLE 1

TIME	EVENT	AZ/RAN
955AM	1/2 IN HAIL	97/70
1020AM	13/4 IN HAIL FUNNEL CLOUD	93/50
1040AM	13/4 IN HAIL	82/55
1125AM	1/2 IN HAIL	67/45
1152AM	3/4 IN HAIL	47/30
1232PM	1/2 IN HAIL	54/40
1242PM	1 IN HAIL	74/68
235PM	1 IN HAIL	54/62
340PM	13/4 IN HAIL	346/110
350PM	23/4 IN HAIL	345/105
353PM	13/4 IN HAIL	341/95
422PM	3/4 IN HAIL	352/100
423PM	1/2IN HAIL	94/20
425PM	11/2IN HAIL	237/45
435PM	3/4IN HAIL	210/25
443PM	3/4IN HAIL	240/8
445PM	3/4IN HAIL	267/15
448PM	1IN HAIL	52/40
454PM	13/4 IN HAIL	267/25
515PM	FUNNEL CLOUDS	258/37
537PM	FUNNEL CLOUD	296/55

Table 1. The storm reports received at WSO Fargo between 8:00 AM CDT and 5:30 PM CDT May 10th, 1985 - the time span sampled by the local sferics unit for this event. AZ/RANs are taken with WSO Fargo as the center point.