SORD Technical Memorandum: SORD-2006-01

Analysis of Thunderstorm Forecasts and Cloud-to-Ground Lightning in the Vicinity of the Nevada Test Site

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ABSTRACT

Summertime (June through September) cloud-to-ground (CG) lightning flash activity in the vicinity of the NTS was analyzed for 2003 and 2004. These data were melded with the SORD daily weather forecasts to permit evaluation of the reliability of forecasts of thunderstorm activity on the NTS. A total of 83% of the thunderstorm/CG predictions were correct. Based on the analysis of local upper-air soundings taken on thunderstorm days, a representative speed of movement of thunderstorm activity across the NTS is 20 mph. Additional analysis of the time of occurrence of thunderstorm and CG lightning data showed that if thunderstorms are forecast in the 0800 LT NTS weather forecast package, a two-hour window of safety exists prior to the occurrence of thunderstorms and CG lightning on the NTS.

ANALYSIS OF THUNDERSTORM FORECASTS AND CLOUD-TO-GROUND LIGHTNING IN THE VICINITY OF THE NEVADA TEST SITE

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I. Introduction

Thunderstorms and the lightning activity accompanying them can not only damage property and sensitive equipment, but are also a safety hazard for personnel working on and around the Nevada Test Site (NTS). In addition, these storms can be accompanied by strong surface winds and heavy precipitation that can cause flash flooding. Although thunderstorms can occur all year, Quiring (1983), Randerson (1997), and Skrbac (1999) have shown that 75-80% of the thunderstorms over southern Nevada occur during the summer months; June through September. Moreover, Randerson and Sanders (2002) have characterized cloud-to-ground (CG) lightning activity on the NTS. Their analysis shows a large inter-annual variation in CG lightning on the NTS, a peak in flash activity between 1300 and 1500 PDT, the effect of terrain, and a CG flash rate of 50 to 75 fl/hr in the most active thunderstorms.

Forecasting thunderstorm activity on the NTS is provided by National Oceanic and Atmospheric Administration (NOAA), Air Resources Laboratory (ARL) research meteorologists/forecasters working at the Special Operations and Research Division (SORD). Weather forecasts for the NTS are issued twice daily, Monday through Friday, at 0800 and 1500 LT. Hazardous weather advisories and lightning alerts are issued as required to a wide variety of programs conducted on the NTS. Lightning data are acquired from the NTS Lightning Detection System operated and maintained by ARL/SORD. This system and the Lightning Alert process have been described by Randerson and Sanders (1999) and updated by Randerson (2004).

II. Data

Summertime (June through September) cloud-to-ground (CG) lightning flash activity in the vicinity of the NTS was analyzed for 2003 and 2004. Data were tabulated for a total of 244 days. CG flash activity was stratified into two categories; namely, CG flashes that were detected within the 20-mi Lightning Alert Area and those that occurred on the NTS. A total of 33,024 CG flashes were detected within the Alert Area. Of these flashes, 7036 (or 21%) were detected on the NTS. Days on which the CG flashes occurred within the 20-mi Alert Area were identified as CG lightning or thunderstorm days. These data were melded with the SORD daily weather forecasts to permit evaluation of the reliability of forecasts of thunderstorm activity on the NTS. The NTS weather forecast package used was the one issued by the SORD Duty Forecast at 0800 PDT, Monday through Friday. All these forecasts were scanned to identify the days on which thunderstorms were forecast for the NTS. In addition, the dates on which Lightning Alerts were issued were also tabulated for the summers of 2003 and 2004. These days were identified as CG lightning, or, thunderstorm days.

Another data file was created to capture the estimated mean transport speed of thunderstorms near the NTS. This file was created by using the dates on which NTS thunderstorms occurred and the archive of atmospheric upper-air soundings taken twice daily at the Desert Rock Meteorological Observatory (DRA); at 0500 PDT and 1700 PDT. The results of all the analyses of these data are described next.

III. Results

NTS thunderstorms prediction and CG lightning:

Of the total number of 0800 PDT forecasts issued, there were 58 forecasts for thunderstorms on the NTS and 61 CG lightning days. Lightning Alerts were issued for all thunderstorm days, except for three days. On one day, the lightning occurred off the NTS and after hours so that no one was on duty at DRA. In the other two cases, the Duty Forecaster decided not to issue an Alert because the thunderstorms were not on the NTS, were dissipating, and were moving away from the NTS. In both cases a single CG flash was detected just inside the Alert Area.

The contingency table shown in Table 1 summarizes these data. For the thunderstorm or CG lightning days, 78% were predicted correctly and 21 % were not. If one deletes the three anomalies above; the correct score rises to 83%. Of the other "no" forecasts, NTS Lightning Alerts were issued immediately, as required. Thunderstorms did not occur on 10 days (4%) for which they were forecast. Overall, 91% of the forecasts were correct.

Table 1. NTS thunderstorm predictions versus observations of CG lightning; number of events.

		CG Lightning Observed	
		Yes	No
NTS Thunderstorm Predicted	Yes	48	10
	No	13	173

CG Lightning Days and Issued Lightning Alerts:

Lightning Alerts were issued on all days during which thunderstorms occurred within the 20-mi Lightning Alert Area. On a few days more than one lightning alert was issued; either to extend the alert to a later time or to issue a new alert late in the day after one issued early in the morning

had expired. Days with one or more Alerts were classified a lightning alert day. Table 2 presents the data on this comparison. The three anomalies are explained in the previous section. Skill in issuing Lightning Alerts is obvious.

Table 2. CG flashes detected within the Alert Area versus Lightning Alert Days; number of events.

		Lightning Alert Issued	
		Yes	No
CG Lightning Observed in Alert Area	Yes	58	3
	No	0	180

Thunderstorm Translation Speed:

A solid technical basis for establishing a representative speed of movement for thunderstorms lies in the DRA atmospheric sounding data collected twice daily, at 0500 and 1700 PDT, to altitudes near 30 km. To create the required data base, first, all summer days with CG lightning within the 20-mi Alert Area were tabulated and identified as NTS lightning or thunderstorm days. A day with one or more Lightning Alerts and, or, with early morning thunderstorms followed by afternoon thunderstorms and late evening storms is a lightning or thunderstorm day. As shown in the above tables, there were a total of 61 lightning days.

Second, archived upper-air sounding data for DRA were accessed for each lightning day. Mean thunderstorm speed of movement was determined by estimating the average wind speed between the 700-mb and 300-mb levels, or, approximately, between the 10,000-ft and 30,000-ft levels above mean sea level. The speed data were then separated into 5 mph categories ranging from 0-5 mph to 46-50 mph. These data are summarized in Figure 1. The data show that on 56% of the lightning days, thunderstorm translational speeds were ≤ 20 mph. Of the days with faster speeds, 15% occurred in late spring or late summer.

Operationally, SORD Duty Weather Forecasters can accurately determine thunderstorm translational speeds from the twice-daily upper-air soundings taken at DRA. If speeds greater than 20 mph are measured, the forecaster can easily factor this information into the Lightning Alert process, providing ample time for response by safety personnel. Moreover, the forecaster has access to high resolution NOAA satellite imagery of southern Nevada, to NOAA weather radar data, and to 15-min meso-scale meteorological data from the NTS. All these data sources are monitored by the Duty Forecaster and used to track weather conditions and to make the best possible thunderstorm/lightning forecasts for the NTS.

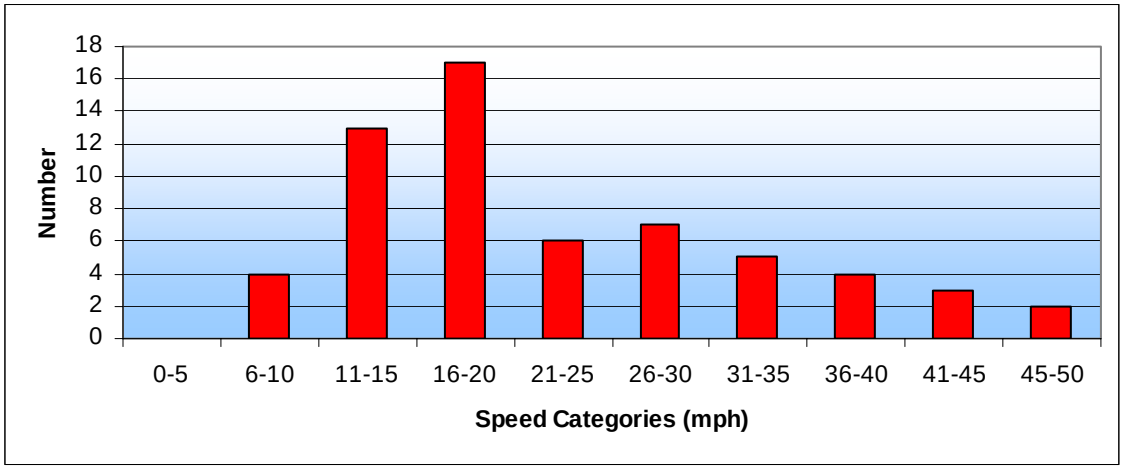

Figure 1. Distribution of Thunderstorm Mean Transport Speeds for 61 NTS Thunderstorm Days, June through September, 2003 and 2004.

Timeliness of NTS Thunderstorm Forecasts

To evaluate the beginning of CG lightning within the 20-mi Lightning Alert Area relative to the forecast of thunderstorm (and lightning) activity, the CG lightning data base was accessed to identify the time of occurrence (PDT) of the first CG flash. These data were matched with the days during which thunderstorms were forecast for the NTS in the 0800 PDT forecast package. Figure 2 portrays the results of this analysis. The figure shows that 85% of the thunderstorms and CG lightning detected within the 20-mile Alert Area occurred after 1000 PDT, or at least, 2 hrs after the 0800 PDT forecast for NTS thunderstorms was issued. Consequently, NTS personnel had at least a two-hour advisory of the potential for thunderstorms and CG lightning on the NTS. For the 15% of the events occurring prior to 0800 PDT, Lightning Alerts were issued by SORD Physical Science Technicians working at DRA in all cases except the one that occurred between 0000 and 0100 PDT when DRA was unmanned.

IV. Summary

- A solid technical basis for establishing a representative speed of movement for thunderstorms is given based on meteorological data collected on the NTS.
- When thunderstorm activity is included in the 0800 PDT NTS forecast package, personnel working on the NTS normally have, at least, a two-hour window in which to prepare to implement safety actions should a Lightning Alert be issued by SORD personnel.

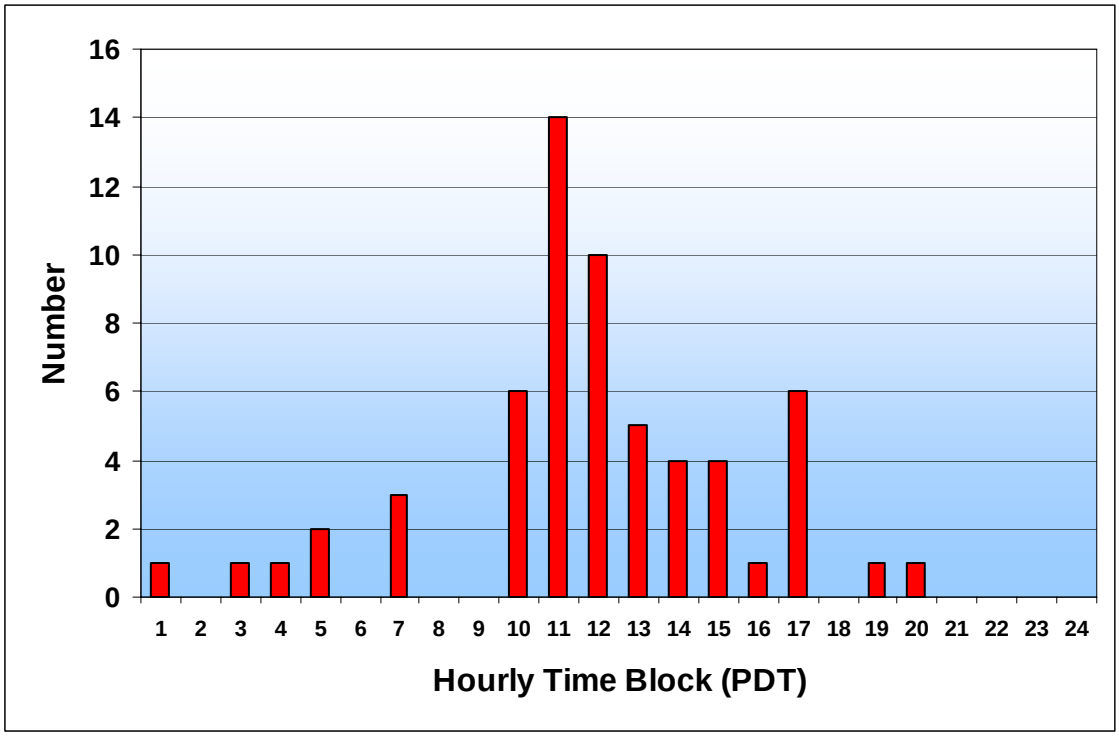

Figure 2. Distribution of the time of detection of the first CG flash within the 20-mile Lightning Alert Area on days when thunderstorms were forecast for the NTS in the 0800 PDT forecast package.

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