

P1.7 Predicting Lightning Potential on Different Time Scales—A Conceptual Model and First Results

Wiebke Deierling*, Cathy Kessinger and Eric Nelson
National Center for Atmospheric Research, Boulder, Colorado

1. INTRODUCTION

Range forecasters at the Army Test and Evaluation Command's (ATEC's) White Sands Missile Range (WSMR) are responsible for issuing forecasts and hazardous weather warnings in support of range tests and routine range activities. Lightning poses a serious hazard for workers and equipment. This work aims to develop a lightning prediction system for short (e.g. < 30 minutes) and longer (up to several hours) lead times. To predict lightning on very short time scales the National Center for Atmospheric Research (NCAR) Auto-Nowcaster (ANC) system (e.g. Mueller et al. 2003; Saxen et al. 2008) is used. For prediction of lightning on longer time scales, the skill of model forecasts is tested. From the model forecast, microphysical and dynamical cloud parameters are used to compute areas of lightning potential threats. First results will be presented in the following.

2. CONCEPTUAL MODEL

The lightning prediction system's first part is concerned with short lead times (e.g. < 30 minutes). At WSMR, a Lightning Mapping Array (LMA) (Thomas et al., 2004) is permanently installed and provides real-time information about total lightning activity. Furthermore, as part of the NCAR ANC at WSMR, Saxen et al. (2002, 2008) developed a short term (e.g. 0-15 minute) total lightning fuzzy logic forecast system that is based on WSR-88D radar reflectivity characteristics. It inputs boundary-relative steering flow and radar reflectivity characteristics above the -10° C level, including the reflectivity volume exceeding 30dBZ, maximum reflectivity, volume growth rate and echo top height. It outputs elliptical markers to highlight storms capable of producing cloud-

to-ground lightning in very near term (Saxen et al. 2002, 2008). Figure 1 shows an example of this reflectivity base cloud-to-ground lightning potential.

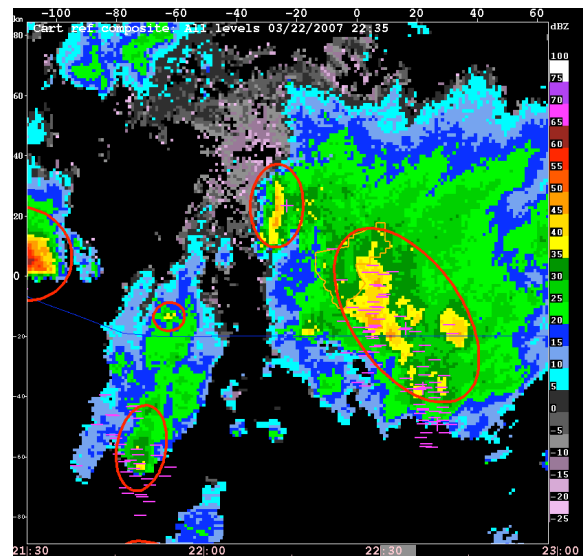


Figure 1. Reflectivity based CG lightning potential.

In the future it is planned to combine this algorithm tuned for total lightning activity with the NCAR ANC thunderstorm growth and decay algorithm that includes total lightning membership functions in order to produce 30-60 minute total lightning potential forecasts. Nelson et al. (2009) reports on first results from this effort.

The second part of the lightning prediction system focuses on longer lead time forecasts (several hours). A lightning potential forecast field is computed from microphysical and dynamical model output. Herein, NCAR's Real-Time Four-Dimensional Data Assimilation (RT-FDDA) model analysis and forecast output (Liu et al. 2008) from the inner most grid centered at WSMR with 3.3 km horizontal grid spacing and with the Lin et al.

*Corresponding author address: Wiebke Deierling, NCAR/RAL, P.O. Box 3000, Boulder, CO 80301; email: deierlin@ucar.edu

(1983) microphysics scheme is used. From the model output, lightning amounts are computed in each grid cell using an empirical relationship for lightning – ice water path from Petersen et al. (2005) and lightning – updraft volume based on Deierling and Petersen (2008). A fuzzy logic algorithm combines these two parameters to compute a single lightning potential.

3. RESULTS OF LIGHTNING POTENTIAL FROM MODEL OUTPUT

First, a lightning potential was computed from model analysis output as well as 1-hr and 2-hr model forecasts over a two week period. As an example, Figure 2 shows the computed lightning potential based on the RT-FDDA analysis (i.e., 0-hr forecast) from July 17 2008 at 22 UTC. The lightning potential output is scaled between zero and one, where zero indicates a low lightning potential and one indicates a strong lightning potential. It can be seen that the model predicts some storms in the forecast domain with a strong lightning potential. The total lightning activity detected by the WSMR LMA indeed indicates several stronger storms (Figure 3) where the number of source densities exceeds 80/km². However the model prediction of the location, number and also intensity of the storms is not exactly right. It has to be kept in mind that the skill of the lightning potential forecast depends on how well the model predicts the location and intensity of storms in the region.

Next, the lightning potential for 1-hr and 2-hr model forecasts were computed yielding similar results. As an example, Figures 4 and 5 show the lightning potential for a 2-hr model forecast and the LMA measured total lightning activity for the same time (00 UTC on 18 July 2008)

Furthermore the CSI, POD, FAR and Bias (Wilks, 1995) of the lightning potential forecast were computed considering the entire forecast area for a two week period. The cells of a 2x2 contingency table were filled as follows. For the entire domain, if one grid point within the model-based lightning product indicated lightning, *lightning was predicted*; likewise if no grid points from the model-based lightning product indicated lightning, then *lightning was not predicted*. The validation for the LMA was handled in a similar manner and

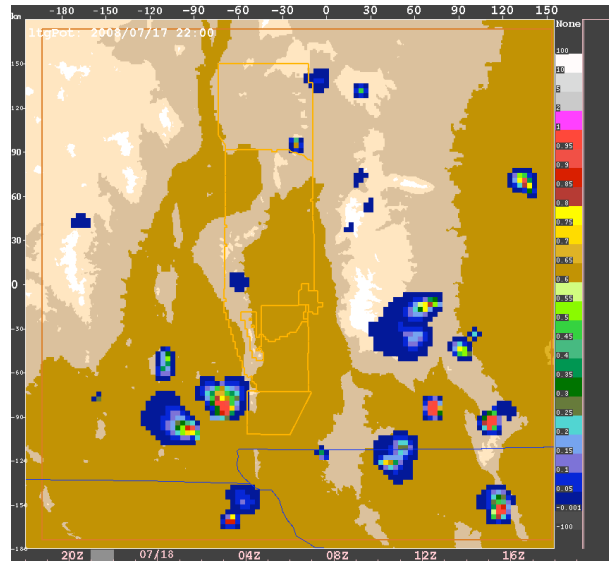


Figure 2. RT-FDDA model analysis output based lightning potential for 17 July 2008 at 22 UTC.

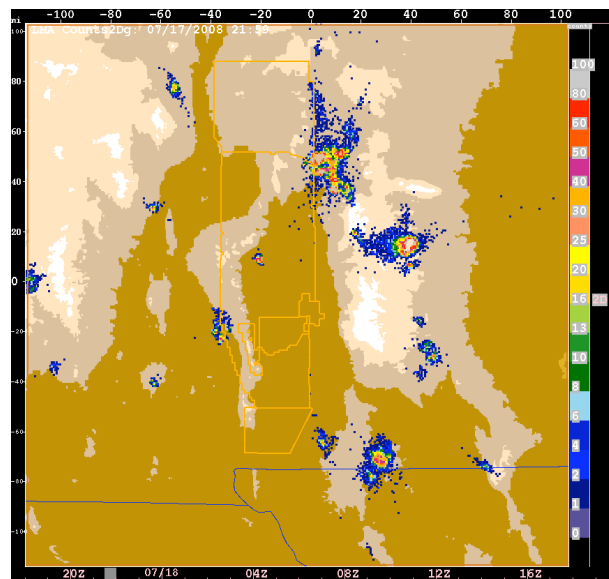


Figure 3. LMA measured total lightning activity at WSMR on 17 July 2008 at 22 UTC.

over the entire domain such that the presence of even one source density observation indicated that lightning was present. Statistics include the model analysis, 1-hr and 2-hr hour model forecasts over a two week period during July-August 2008.

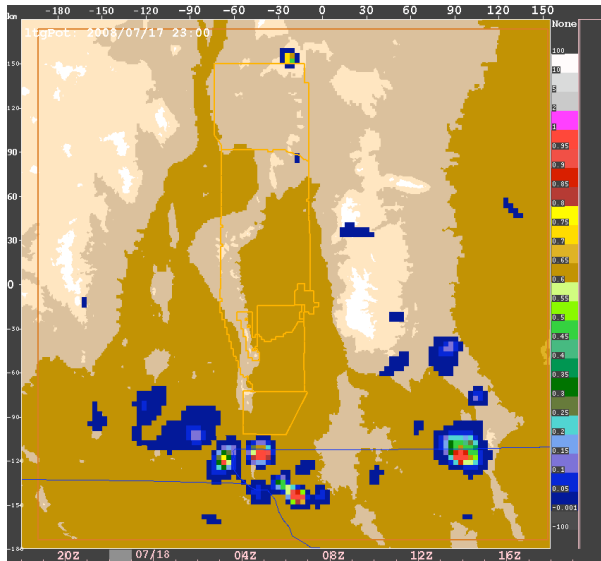


Figure 4. RT-FDDA 2-hr forecast based lightning potential for 18 July 2008 at 00 UTC.

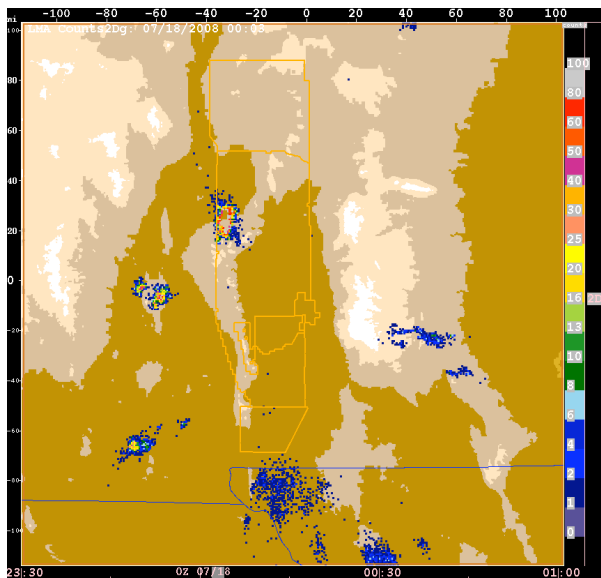


Figure 5. LMA measured total lightning activity at WSMR on 18 July 2008 around 00 UTC.

Figure 6 shows the lightning potential model statistics versus CSI, POD, FAR and Bias respectively. It can be seen that for a lower lightning potential the POD and CSI are around 0.7-0.8 and the Bias is around 0.8-1.0. The FAR is around 0.15-0.2 for the analysis and the 1-hr

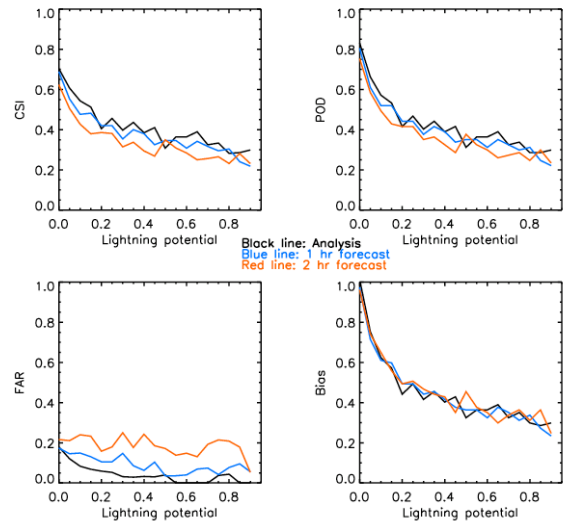


Figure 6. CSI, POD, FAR and Bias of the lightning potential forecast for the model analysis, 1-hr and 2-hr model forecasts over a two week period.

forecast data and slightly higher for the 2-hr forecast data.

These types of plots will be useful for tuning and calibration of the model-based algorithm once a sufficient number of cases have been examined.

4. SUMMARY AND OUTLOOK

In this paper we examined whether RT-FDDA model based lightning forecasts may have skill for longer lead times. Initial results show, that the model based lightning potential forecasts show skill at predicting a lightning threat. However, the location, timing and intensity of the predicted lightning potential depend crucially on how well the model predicts the small scale convection.

In the future, we will expand our analysis to a larger data set and examine the feasibility of extending these forecasts out to longer lead times – potentially out to 48 hours.

5. ACKNOWLEDGEMENTS

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