P 1.39 FLASH FLOODING DURING A SEVERE DROUGHT: A CASE STUDY OF THE 2002 OGALLALA, NE EVENT

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1. INTRODUCTION

During the overnight hours of 5-6 July 2002, a significant flash flood event occurred over portions of southwestern Nebraska. In particular, for more than nine hours localized heavy precipitation fell over Keith and Perkins counties, where some areas received more than 25 cm. By the time the event ended, the town of Ogallala (OGA), NE was flooded, Interstate 80 was washed out causing a major disruption to holiday travel, and one fatality resulted. A unique aspect of this case was the fact that it occurred during an extreme drought. Other cases of heavy rainfall and flash flooding events in Nebraska during the warm season have been studied (Zapotocny and Byrd 2002). However, the events of 6 July 2002 somewhat differed in that the weeks and months leading up to the flash flood had been extremely dry. Several stations in western Nebraska reported rainfall well below normal for the first six months of 2002 as compared to normal conditions over the past 50 years (Table 1).

TABLE 1. Southwest Nebraska precipitation.

Station	2002 Precip. to date (cm)	Normal Precip. to date (cm)	Percentage of normal (%)
Ogallala	9.75	25.63	38.06
Kingsley Dam	13.21	26.01	50.78
Big Springs	9.98	24.49	40.77
Madrid	8.81	27.03	32.61

Doswell et al. (1996) present an ingredients based methodology for the prediction of flash floods, whereby events share some common meteorological characteristics. In particular, the occurrence of high rainfall rates over a long period of time must coincide for flash flooding to occur. Moreover, high rainfall rates result from rapidly rising moisture laden air and long durations are due to the slow movment of the system. In the case of the Ogallala flash flood, many of these ingredients combined to produce heavy rainfall over a long period of time.

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Numerous studies have shown that the use of numerical models can improve the skill of forecasting meso and storm scale events. For example, Colle and Mass (2000) showed that using MM5 over the Pacific northwest improved precipitation forecasts when run at a small horizontal resolution during the winter months. In this study, we attempt to shed light on the question: Would a mesoscale model, centered over Ogallala, NE have provided additional useful information to forecasters for this event? This paper will discuss an overview of the conditions leading up to the event as well as some model comparisons between the 40 km ETA (grid 212) and 4 km PSU/NCAR MM5V3.

2. SYNOPTIC CONDITIONS

Several features associated with the Doswell et al. (1996) ingredients based methodology were in place for this flood event. A strong mid to upper level system that brought torrential rain to Texas lifted north into southeastern Colorado by 0000 UTC 6 July, with numerous shortwaves evident in the upstream flow. The upper level flow over western Nebraska was extremely weak between 0000 and 1200 UTC 6 July, with speeds ranging from 2 to 5 ms^{-1} (5-10 kts) just prior to the initiation of deep moist convection over western Nebraska (Fig. 1).

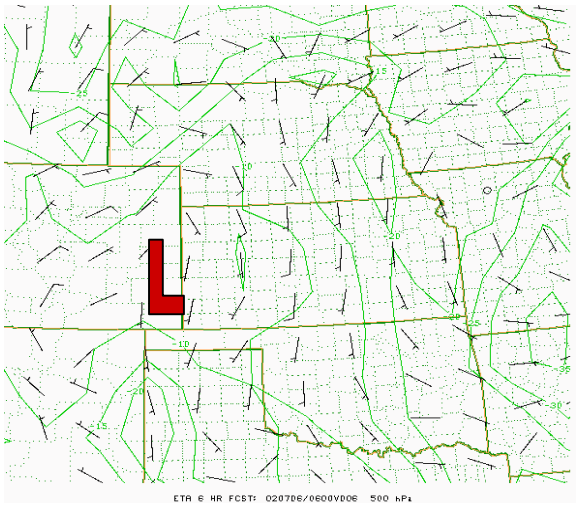

FIG. 1. 500 hPa winds (kts.) and isodrosotherms (°C) from the ETA 6 hour forecast valid 0600 UTC 6 July 2002. The approximate position of the upper level low is shown in red.

Weak flow between 500 hPa and 300 hPa allowed for extremely slow translational speeds of convection during the period. Also of note is a relatively moist layer at 500 hPa as seen in the isodrosotherm pattern over the OGA region (Fig. 1). Nearly saturated conditions existed from the surface to 400 hPa over the area of interest prior to and during the ongoing convection.

A strong anticyclone over the upper peninsula of Michigan slowly drifted to the south-southwest. Strong southeasterly flow occurred throughout much of the Central Plains by 0000 UTC on 6 July resulting in a saturated atmosphere over western Nebraska. A low level jet developed during the evening of 6 July, aiding moisture transport through the low levels into Nebraska, with precipitable water values between 4 and 5 cm (Fig. 2). CAPE values were relatively small over the period with virtually no convective inhibition. Moreover, visible satellite imagery depicts a weak low level trough oriented from northcentral Nebraska into northeastern Colorado (not shown). This feature remained nearly stationary for several hours, and serveed as the focal point for the continual upward motion and development of deep moist convection as storms moved into the OGA region.

The persistent mositure advection, a nearly stationary lifting mechanism and weak flow aloft combined to allow continual development of thunderstorm activity. Overall, the radar estimates match fairly well with the gauge totals, with peak amounts occurring in Keith and Perkins counties and exceeding 20 cm (Fig. 3). This was an extremely localized event, as regions just a few kilometers outside the town of Ogallala received less than 2.5 cm.

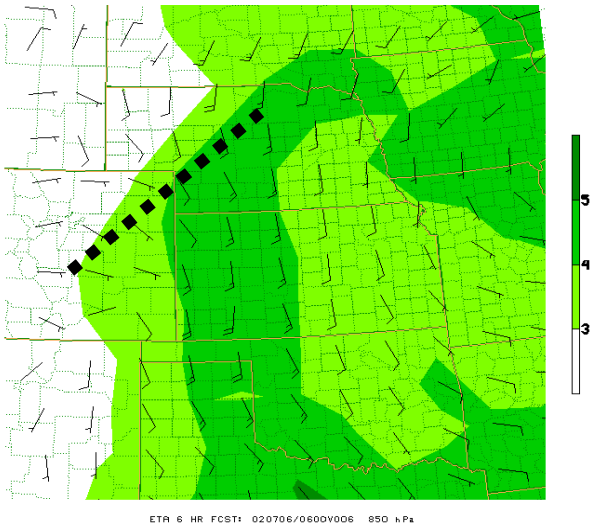

FIG. 2. 850 hPa winds (kts.) and precipitable water (cm) from the ETA 6 hour forecast valid 0600 UTC 6 July 2002. The approximate position of the satellite-depicted boundary is shown with dashed black lines.

3. MODEL COMPARISON

For a model comparison study, we employed the operational ETA (40 km) as well as the PSU/NCAR MM5V3. The MM5 was run in a “forecast” mode and initalized from the ETA, with the only boundary conditions used being the ETA forecasts. The horizontal

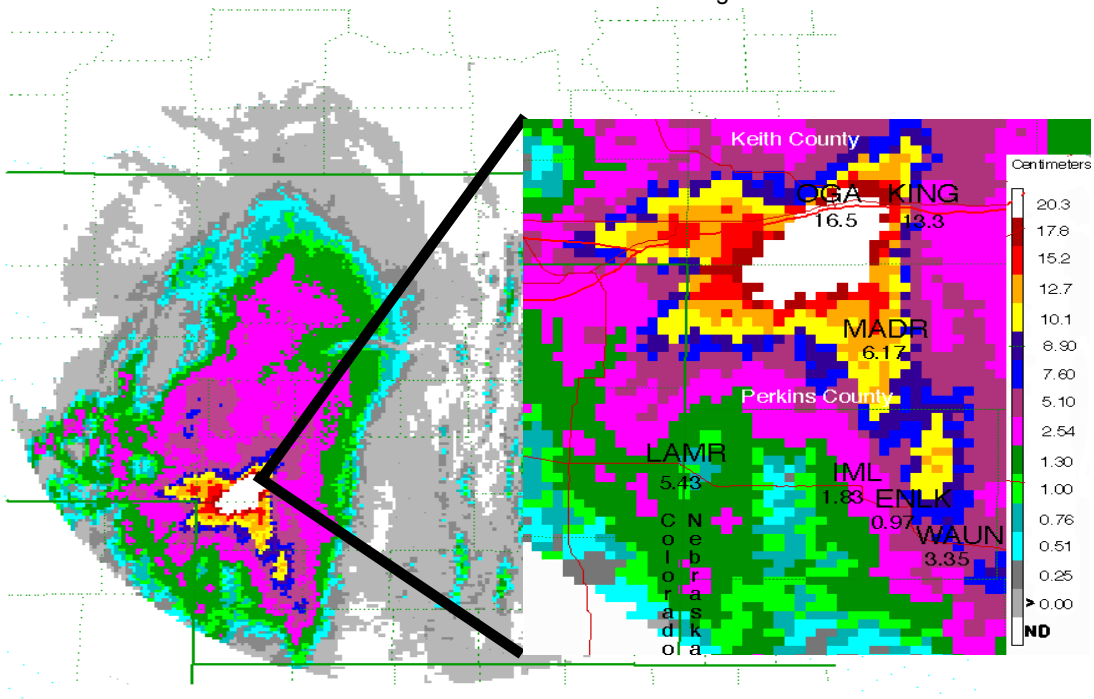

FIG. 3. North Platte, NE (KLNX) radar derived estimated storm precipitation totals (in cm) and COOP/ASOS rain gauge reports over the 24 hour period ending 7 July 2002.

resolutions for the MM5 domains 1,2 and 3 are 36 km, 12 km and 4 km, respectively with 139 x 208 grid points in the horizontal. There were 23 levels in the vertical in terrain-following (σ) coordinates. The Resiner 2 (graupel) explicit moisture scheme, RRTM raidation option and OSU land surface, and MRF boundary layer are chosen for all three domains. Several fields were examined between the model runs to assess their "handling" of the state of the atmosphere for the event.

The operational ETA successfully resolved the timing and structure of the warm core system, upper level flow and significant moisture advection originating to the south with the 24 hour forecast. To account for slight discrepancies in the timing of precipitation that existed between the two models, a 24 hour precipitation total was used.

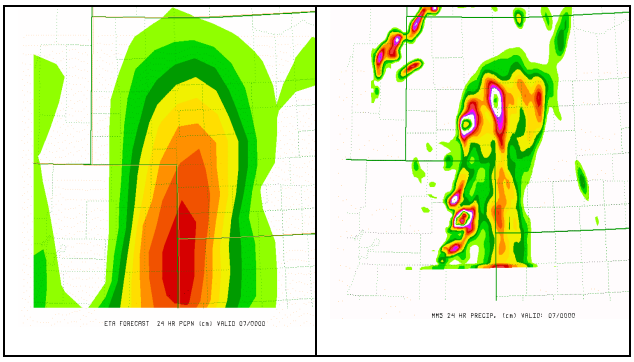

FIG. 4. ETA (left panel) and MM5 (right panel) forecasted 24 hour precipitation totals (in cm) valid 0000 UTC 6-7 July 2002.

Though both models underestimate peak precipitation amounts, they do capture well the overall pattern, namely that cells originated in eastern Colorado and northwestern Kansas and northward. Moreover, the MM5 precipitation exhibits a more convective "look", in that discrete cells can be inferred from the resulting precipitation while the ETA displays a more regional pattern as one expects with coarser horizontal resolution. The MM5 also resolves the intensity of precipitation of the precipitation much better than the ETA. Maximum amounts within the MM5 of 9-10 cm, placed to the north of Keith County, while a broad region of 4-4.5 cm is resolved to the south of OGA in the ETA. Other plots (not shown) indicate that MM5 better handled the precipitable water amounts than the ETA and even placed the low level boundary across southwest Nebraska several hours prior to the convection moving into the area. For this case, the MM5 was a better overall predictor of the ingredients leading up to the flash flood event.

4. SUMMARY

Several ingredients coincided during the overnight hours of 6 July 2002 over southwest Nebraska producing flash flooding conditions during an extreme drought. Deep and persistent mositure advection, weak upper level flow and the existence of a low level trough combined to produce heavy precipitation over several hours. When compared to the operational ETA, the MM5 more accurately placed the position and amount of forecasted precipitation from the event. Further work is underway to examine and compare an ensemble of ETA and MM5 forecasts to assess their respective change in predictability over time for this unique event.

5. ACKNOWLEDGEMENTS

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