FINAL REPORT

An Examination of the Climatology and Environmental Characteristics of Flash Flooding in the Binghamton, NY County Warning Area

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Objectives:

1. Analyze a set of meteorological variables at the resolution of the regional NCEP/NCAR Reanalysis data and model BUFR soundings from relevant stations, to quantitatively identify combinations of variables that are associated with flash flooding. We will also examine the values of these variables in non-flood producing heavy rainfall events.

2. Examine, at a finer spatial and temporal resolution, those days that are misclassified by the above analysis, to identify features that operate at smaller and shorter scales.

Accomplishments/Findings:

This study used the publication *Storm Data* to compile a climatology of flash floods reported in the Binghamton, NY (BGM) County Warning Area (CWA) of the National Weather Service (NWS). This work revealed diurnal and seasonal trends in flash flood frequency across the CWA. Also evident was a spatial disparity in the number of flash flood reports in different portions of the CWA. In some cases, adjacent counties with similar topography reported a dissimilar number of flash floods. Because those counties reporting a strikingly smaller number of floods tended to be less populous than the neighboring counties reporting a larger number of events, a reporting bias may be to blame. Possible reporting biases aside, regional differences in the number flash flood reports across the CWA suggest that some areas are more prone to flash flooding than others. The tendencies discovered in the climatology can be applied to the activities of the BGM CWA, both in improving forecasts of flash flooding in flood-prone areas and in collecting data from counties found to possibly be under-reporting events.

The more significant component of the project was to analyze the environmental characteristics of flash flood events in the BGM CWA in order to refine flash flood forecasting procedures. BGM's flash flood forecasting checklist prior to this study was based on parameters and thresholds found to be significant at nearby NWS offices, rather than site-specific for BGM. Additionally, the study sought to identify any differences between flash flood and non-flooding heavy precipitation events so as to reduce the false

alarm rate. Quantitative (discriminant analysis) and qualitative (composite map) analysis was performed to discover parameters and combinations of parameters that differ between flood and non-flood events.

The results indicate that flash floods and non-floods differ most significantly in antecedent precipitation and antecedent soil moisture. Flash floods appear more likely to occur during periods of above-normal precipitation than non-floods. Winds at 850 mb and storm motion direction also showed differences between flood and non-flood events. In particular, an easterly to southeasterly 850-mb wind was almost always associated with flash flooding. The 850-mb wind tended to cluster into groups of generally easterly to southeasterly, southerly to west-southwesterly, and westerly-to northwesterly. Conditions of flood and non-flood events were compared for each of these groups. Within each group, certain parameters were found to differ between the flood and non-flood events. Lastly, some parameters that had been included on the Binghamton checklist were found to be unreliable. For these parameters, the threshold values on the checklist were infrequently exceeded during flash floods, or these thresholds were more likely to generate false alarms of non-events than to warn of a flash flood.

Benefits and Lessons Learned (Operational):

As a result of this research, the flash flood forecasting procedure at NWS BGM will be modified. Emphasis will be placed on antecedent precipitation, particularly the amount of precipitation that has fallen in the previous week. Atmospheric parameters found to differ between flood and non-flood events for a specific range of 850-mb wind directions will be included in a modified checklist.

Finally, the updated checklist will be supplemented by histograms and scatterplots illustrating the values of parameters for both flood and non-flood events. It is expected that this more integrated forecasting approach will improve NWS BGM's ability to accurately forecast flash floods.

Upon completion of a spin-off project (see below) the NWS Binghamton will also be supplied with a series of charts relating past flash flood occurrences to radar estimated precipitation amounts. These will be developed on a county by county basis.

The BWS Bingham forecasters will look more closely at the influence of the low level jet in forecasting flash floods. In many cases only a weak low level jet was identified in our research. This was counter to conventional features that the forecasters expected to be present during flash flood events.

Benefits and Lessons Learned (Academic):

The students in our undergraduate atmospheric science program have benefited greatly from the enhanced interaction with the Binghamton WSFO. This has included guest lectures in advanced forecasting and increase familiarity with the software package BUFKIT and the use of online radar products. This work has resulted in two offshoot research projects. A recent graduate, who worked on this partners project her senior year, will continue her studies of flash floods (using in part the data we compiled) at the University of Arizona.

Next semester an undergraduate (freshman) Cornell Presidential Research Scholar will extend the climatological aspect of this work. In particular he will rederive the flash flood precipitation climatology using radar versus gauge data. This will be done in

collaboration with NWS Binghamton forecasters.

We also hope to expand our empirical findings of the importance of antecedent precipitation, through a more physical modeling study. This may become the Ph.D. work of the graduate student supported by this project.

Publications/ Presentations:

An Examination of the Environmental Characteristics of Flash Flooding in the Binghamton, NY County Warning Area. Presented at the Northeast Regional Operational Workshop, Albany, NY, Nov. 2 2005:

An examination of flash flooding in the Binghamton, New York County warning area, poster presentation, AMS Conference on Severe Local Storms, January 2006 Atlanta, GA.

M.S. Thesis:
An Examination of the Climatology and Environmental Characteristics of Flash Flooding for the Binghamton, New York County Warning Area

We are currently drafting a manuscript for submission to the referred literature. We anticipate submission to *Weather and Forecasting*.

Summary of Roles:

WFO BGM provided the time of Michael Evans and to a lesser extent several other meteorologists from the WFO. The primary role of the meteorologists from WFO BGM was to advise the academic investigators in order to insure that results of the research were applicable to NWS flash flood forecasting operations. This was done through consultations on selecting and extracting the meteorological parameters used in the study. Sharing of the findings in these studies was accomplished at the university level with activities such as NWS personnel doing guest lectures at an advanced forecasting class at Cornell.

The WFO BGM played a crucial role in transitioning the research findings into a set of operational flash flood forecasting guidelines that will benefit not only WFO BGM, but surrounding offices as well. The WFO has the responsibility of updating the flash flood checklist and the WFO flash flood forecasting procedures, based on the results of the project. Michael Evans (the Science Operations Officer at BGM) had the responsibility of ensuring that the forecast staff at BGM receives proper training on the use of the checklist. Benefits from this study were spread to other WFO's in the area via presentations at conferences and workshops. In addition, other WFO's could use this study as a template for developing their own localized studies, in conjunction with the Northeast Regional Climate Center (NRCC).

Finally, the WFO provided the academic researchers with access to their AWIPS data archive and BUFKIT model sounding archive, and will assist in obtaining any necessary GEMPAK data from COMET.

The Cornell team was responsible for the majority of the statistical analyses and data computations. This work was primarily conducted by Stephen Jessup, under the direction of Assoc. Professor Art DeGaetano. The undergraduate student staff of the NOAA Northeast Regional Climate Center at Cornell was responsible for compiling the initial flash flood climatology.