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AN EARLY ALERT SYSTEM FOR FLOODING IN THE MIDDLE ATLANTIC RIVER FORECAST DOMAIN

Richard H. Grumm & David J. Ondrejik
CTP Weather Forecast Office
National Weather Service, State College, PA 16801

Paul G. Knight & Justin M. Brolley *
Pennsylvania State Climate Office
Penn State University, University Park, PA 16802

INTRODUCTION

The challenge of flash flood forecasts continues to perplex forecasters across the nation during every season. Despite a host of research initiatives, the issues of timing, location and intensity of flood events continues to elude even the best predictors. To date, the main focus of advances in assessing the possibility of flash floods has been on fine tuning operational mesoscale models and improved quantitative precipitation forecasts, despite the fact that some studies indicate the serious shortcomings of their convective parameterization schemes (Gallus, 1999). Even with rapid advances in processing speeds and the testing of non-hydrostatic models, the forecast community has reached a plateau in flash flood prediction which will likely not be changed until cumulus scale models are quasi-operational, within 5 or 10 years. While cumulus scale models may hold high hopes, many areas will still be at risk of flash flooding during the next decade of development. This early alert system offers a paradigm shift in our thinking about flash flood forecasts. It offers a bold initiative to increase advanced watches and warnings of flash flooding, specifically for the Middle Atlantic River region, but with applications elsewhere in the nation. It is based on pattern recognition and uses a comprehensive database of both atmospheric analyses and tiered flood occurrences.

METHODOLOGY

The data for this project were acquired from both Storm Data from the National Climatic Data Center and the NCEP reanalysis data. Storm Data has records of historic storms, including flash floods and river floods, from 1950 to the present. NCEP reanalysis data was used to determine climatic anomalies for temperature, height, specific humidity, and wind from 1000 hPa to 200 hPa. Initially, the storm data was entered into a database.

The Storm Data archives contain descriptive data of flash floods. It records specific parameters including the start date and time of the storm, the end time of the storm, economic impact, type of storm, amount of precipitation and a brief description of the event. The flood data that was entered into the database began in 1980 since the archivist started distinguishing flood type beginning that year. Floods were then classified by type, river basin and economic damage. The date and time of each flood was matched with the closest date and time of upper air observations used in the reanalysis data.

The foundation of this early alert system was the research by Grumm and Hart (2001) establishing a real-time operational assessment of climatological anomalies of various model forecast fields based on derived monthly means from the NCEP reanalysis work (1948-2000). Since October 1999, the National Weather Service Office in State College has been producing graphical displays of model forecast anomaly fields for the Eta, Aviation, and the locally run MM5 computer models. Anomaly fields consist of the vertical mass-weighted mean anomaly for height, temperature, wind, and moisture. These parameters are compared to the climatological mean to determine the anomaly. This anomaly program, developed by Hart and Grumm (2001), was used to create anomaly fields for historically significant rainfall events over the MARFC domain dating back to 1948. These significant rainfall events were chosen based on the observed and estimated rainfall values. Once anomaly fields were created, a pattern recognition exercise was conducted to classify these events by time of year and significant types after Maddox (1979) with several examples including narrow cold frontal rain bands, mesoscale convective systems and the like.

The flood dates and type, obtained from the database, and the reanalysis of climatological anomalies were combined to find relationships between flash floods and anomalies of temperature,

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* *Corresponding authors address:* Paul G. Knight and Justin M. Brolley, Pennsylvania State University, Department of Meteorology, University Park, PA 16802; e-mail: psc@mail.meteo.psu.edu

height, moisture, and wind at all levels. Maximum temperature anomalies (especially during the winter) were higher near the surface and weaker above 500 hPa. Minimum temperature anomalies were weak indicating no potent cold air masses in the neighborhood during winter floods. Along with above average temperatures, maximum height anomalies were strong in the upper levels and V-wind maximums were large, indicating strong southerly winds. Specific humidity maximums were higher in floods than non-floods because moisture is obviously needed to produce the rainfall required for flooding. Also, specific humidity minimums were low, indicating that no dry air was present in the vicinity of flooding. The anomalies tended to be more robust during the winter than summer.

After ascertaining the means and standard deviations of the anomalies at each pressure level, the top five parameters for each season were chosen. These five parameters are listed in Table 1.

Winter	***Spring***	***Summer***	***Fall***
1000 hPa Temperature Maximum Anomaly	925 hPa Temperature Maximum Anomaly	1000 hPa Temperature Minimum Anomaly	1000 hPa Temperature Maximum Anomaly
1000 hPa Temperature Minimum Anomaly	200 hPa Height Maximum Anomaly	200 hPa Height Minimum Anomaly	1000 hPa Height Minimum Anomaly
250 hPa Height Maximum Anomaly	1000 hPa Height Minimum Anomaly	700 hPa Specific Humidity Minimum Anomaly	1000 hPa Specific Humidity Maximum Anomaly
925 hPa Specific Humidity Maximum Anomaly	850 hPa Specific Humidity Maximum Anomaly	850 hPa V-Wind Maximum Anomaly	700 hPa Specific Humidity Minimum Anomaly
1000 hPa V-Wind Maximum Anomaly	850 hPa V-Wind Maximum Anomaly	500 hPa V-Wind Minimum Anomaly	850 hPa V-Wind Maximum Anomaly

Table 1. Seasonal parameters ranked according to their maximum contribution to flooding events

For the top five parameters, the values of one standard deviation above (below) the mean for days without floods was set as the threshold for flooding. The number of flood observations that occurred above (below) the threshold of up to 32 combinations of the five top parameters were calculated and divided by the total number of observations. The probability of floods generally increased with the number of parameters reaching these thresholds.

APPLICATIONS

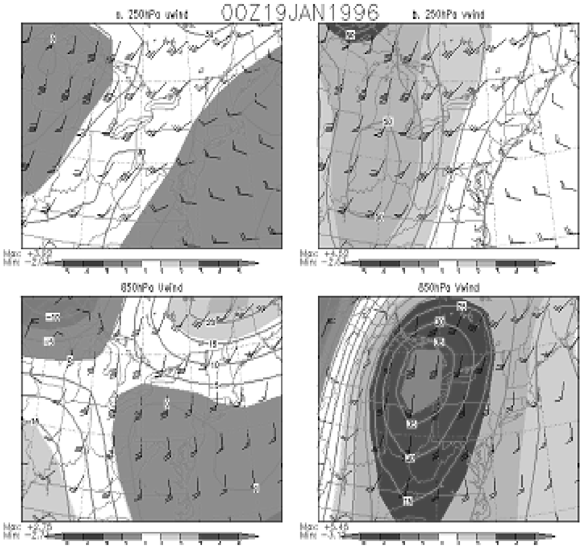

Figure 1 250 (upper) and 850 hPa u and v winds barbs and departures from the 30-year climatology.

One outcome of this project was to determine if there were distinct atmosphere anomalies associated with flash flooding. An examination was made of most flash flood cases over the Mid-Atlantic region.

The maximum and minimum height, temperature, moisture, and u and v wind components were loaded into a database for comparison with non-events. Visually, the results suggested that some distinct anomaly patterns were associated with heavy precipitation events across the region.

The events appeared to stratify into unidirectional shear cases, associated with strong southerly flow and a surge of anomalously high precipitable water (PWAT). Another event type was characterized by strong low-level easterly flow.

An example of a unidirectional shear case is shown Figure 1. Note the +5SD anomalous southerly 850 hPa jet beneath the anomalous 250 hPa jet. This strong low-level southerly component is capable of transporting highly anomalous PWAT values into the region as shown in Figure 2.

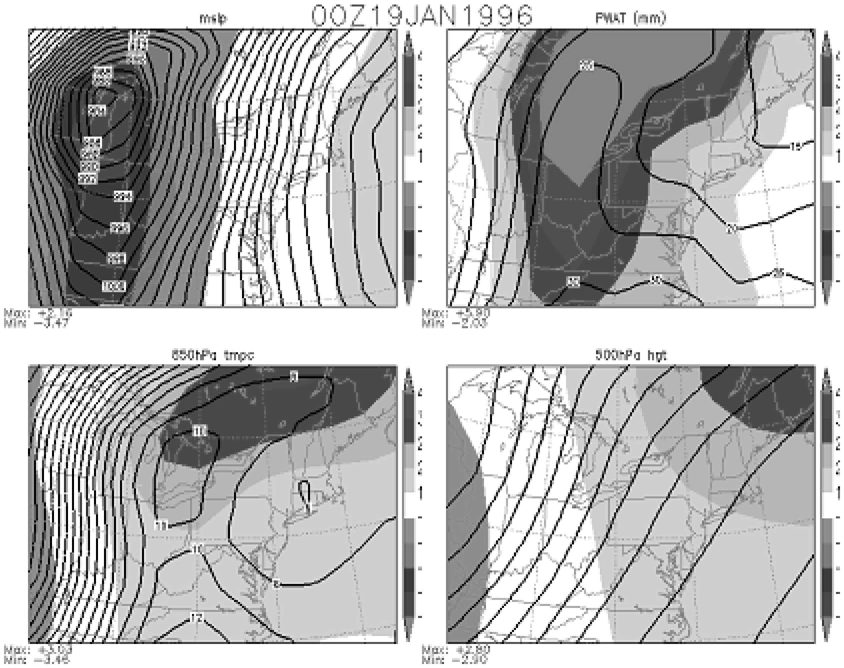

Figure 2. As in Figure 1 except a) mean-sea level pressure, b) pwat, c) 850 hpa temperatures, and d) 500 hPa heights.

Figure 2 shows how the strong low-level jet was able to transport unseasonably high temperatures and PWAT values into the region. This resulted in rapid snow melt and heavy rainfall which contributed to the record flooding on 19-20 January 1996.

Dozens of significant flooding cases have been assessed and the investigation continues in discovering the appropriate use of real-time anomalies in alerting operational forecasters to the risk of significant flood events. Once these thresholds are fine-tuned, a direct alert to the operational staff can be accomplished. This alert can contain specific information about past events and the likelihood that this event will produce a similar outcome. The results of this system should also produce a secondary benefit such as providing additional planning time for emergency managers whose interests lie along and near rivers and streams.

CONCLUSIONS

The outcome of this project will offer the operational forecasters another quantified method of assessing the risk of flooding in their county warning area. The implementation of the pattern recognition program should lead to a better ability to discern flood events with a high probability of occurrence and, in time, may lead to distinguishing specific regions which are most likely to be affected.

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