59 A CLIMATOLOGICAL GEOSPATIAL ANALYSIS OF STORM-BASED FLASH FLOOD WARNINGS ACROSS THE CONUS

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1. Introduction

Despite flash flooding being one of the deadliest weather-related hazards, it remains one of the most complex hazards to forecast as both the atmosphere and land components must be favorable for it to occur (Morss et al. 2015). Additionally, flash flooding is further complicated by the fact that it can occur on widely varying spatial and temporal scales. The complicated nature of this hazard has direct consequence on the way the National Weather Service (NWS), its partners, and the public prepare for and respond to flash flooding (Terti et al. 2017). The primary way of notifying the public of an impending event is through flash flood products issued by the NWS. In particular, flash flood warnings (FFWs) are issued over a given area when “flooding is imminent or likely…reserved for short-term events which require immediate action to protect life and property” (NWS Directive 10-922, 2019). In order to better understand the nature of this hazard and how the NWS handles flash flooding, it is advantageous to conduct a climatological geospatial analysis of flash flood warnings across the CONUS. To date, few studies exist in the scientific literature that document the nature of FFWs across the CONUS. As such, this study presents the first geospatial informational overview of FFWs across the CONUS.

2. Data and Methods

Archived flash flood warning polygon shapefiles were obtained from the Iowa Environmental Mesonet (IEM). Since storm-based polygons provide more insight on the size of the threat, data products were collected over the period spanning from 1 October 2007 to 31 May 2019. Only flash flood warnings classified as new warnings (NEW) were analyzed for this study. Flash flood statements and extensions were not included in this analysis. QGIS was used to categorize, query, and analyze shapefile data obtained from IEM. Shapefile data was projected in the North American Datum of 1983 (NAD 83). MATLAB was used for more strenuous analyses that were not possible to conduct in QGIS.

3. Results

Data was analyzed at several scales: CONUS, NWS Regions, and Weather Forecast Offices (WFOs). For the purpose of this discussion, only CONUS-wide results will be discussed.

3.1 CONUS-wide

From 1 October 2007 to 31 May 2019, 41784 FFWs were issued across the CONUS. Figure 1 shows the distribution of FFWs by year from 2008 to 2018.

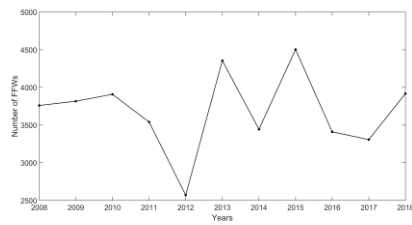

Figure 1: Yearly distribution of flash flood warnings across the CONUS from 2008 to 2018.

On average, 3685 FFWs were issued each year across the CONUS. The drastic reduction in FFWs in 2012 is attributable to the historic 2012 flash drought and subsequent drought that, at its peak, ravaged a large majority of the contiguous United States (Basara et al. 2019). Not surprisingly, 2015 exhibited the highest number of FFWs issued as 2015 was the third wettest year across the CONUS according to historical records (Crouch et al. 2016). A linear trendline was applied to the 10 years of data but there was little to no increase or decrease apparent in the number of FFWs issued from 2008 to 2018, suggesting that the overall number of FFWs issued has remained fairly consistent over the past decade.

In terms of a seasonal distribution, Figure 2 displays monthly FFWs totals from 2008 to 2018.

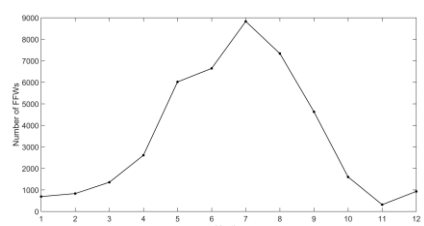

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Figure 2: Seasonal distribution of FFWs across the CONUS from 2008 to 2018.

As expected, a sudden increase in FFWs is apparent during the warm season months of April through July when deep moist convection (DMC) is most common. On average, July exhibited the greatest number of flash flood warnings (8827 FFWs) and November exhibited the fewest (315 FFWs).

As for the local time of FFW issuance, Figure 3 shows the diurnal distribution of FFW issuance.

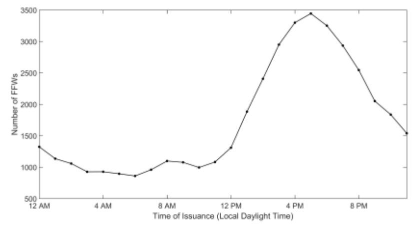

Figure 3: Temporal distribution of FFW issuance in local daylight time from October 2007 to May 2019.

As expected, a majority of FFWs are issued during the early afternoon to evening hours (1 pm – 8 pm local daylight time). Deep moist convection typically peaks during the afternoon to evening hours (Doswell and Bosart, 2001) and is the catalyst for producing heavy rainfall rates needed for flash flooding. The modest increase in FFWs at 8 am is likely attributable to NWS shift changes and the resulting outcome of obtaining a second perspective.

Figure 4 shows the distribution of FFW sizes over the entire period of analysis. 95% of FFWs are less than 3000 sq. mi. in area, with the remaining 5% (not shown) exceeding 3000 sq. mi.

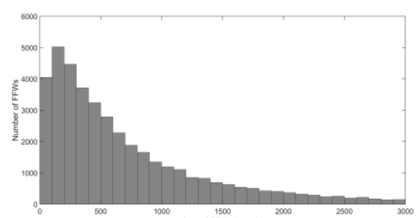

Figure 4: Size distribution of 95% of FFWs from October 2007 to May 2019.

FFW polygon sizes are characterized by a gamma distribution with smaller FFWs being significantly more common than larger FFWs (e.g. nearly half of all FFWs are less than 500 sq. mi.). The average area over the period of analysis is approximately 855 sq. mi. The largest FFW area observed was 24047 sq. mi. issued by the Springfield, Missouri WFO on March 18, 2008. Likewise, the smallest FFW area observed was 0.6528 sq. mi. issued by the Grand Forks, North Dakota WFO on March 27, 2009.

Figure 5 shows the distribution of FFW durations at the time of issuance (i.e. NEW FFWs).

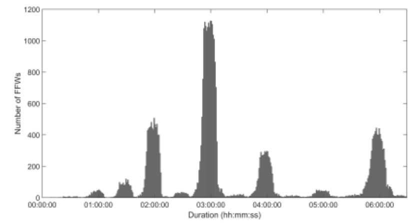

Figure 5: Distribution of FFW durations from October 2007 to May 2019.

It does not account for continuations (CONs), cancellations (CANs), extensions (EXTs), or expirations (EXPs). ~95% of NEW FFWs had a temporal duration less than 6 hours. The remaining 5% (not shown) had a temporal duration greater than 6 hours. FFWs lasting more than 6 hours were often found to be associated with dam or levee failures, as the impacts from such events are often long-lived. Figure 5 reveals that most FFWs are issued around hourly durations, with 3 hour warnings being the most common. This duration aligns with a common best practice in the NWS that NEW FFWs are issued for at least 3 hours. More surprisingly is the grouping of short-fused warnings, with 15% of all FFWs being less than 2 hours in length. Additional research is needed to determine the cause of these short-fused warnings, such as if they are associated with urban flash flood events, western slot canyon events, etc. Note that the bell curve around each hourly duration can be attributed to the NWS warning program (WarnGen) rounding the duration of the warning to the nearest 15 minute increment (e.g. a 3 hour FFW issued at 0256Z will have an end time of 0600Z, a duration of 03:04 hrs.).

4. Results

Results from this study provide the first CONUS-wide informational overview on storm-based FFWs. Yearly distributions revealed considerable variation in the number of FFWs issued from year-to-year. Over the past decade, however, the number of FFWs issued has remained consistent. Seasonal and temporal distributions revealed that the majority of FFWs are issued in the warm season months during the late afternoon to evening hours when deep moist convection is most prevalent. A majority of FFW areas are on the smaller side, with nearly half being less than 500 sq. mi. Lastly, nearly half of all NEW FFWs are typically 3 or fewer hours in duration. Results from this study are intended to inform best practices related to NWS training efforts.

5. References

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