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The Effects of Extreme Precipitation Events on Climatology

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Introduction:

The National Climatic Data Center (NCDC) records and archives accumulated precipitation at 2,000 stations across the U.S. These precipitation records can be utilized to calculate the monthly average. However, this simple average does not account for the precipitation distribution. For example, during May 2007 in Albany, NY precipitation fell on 8 days, resulting in a cumulative rainfall total of 3.51 inches, near the monthly mean of 3.67 inches (Fig. 1). Three years later during September 2010, Albany only received 0.76 inches of rainfall during the first 29 days of the month. Then, on the final day of the month Albany received 2.68 inches of rain from a nearby quasi-stationary front. Despite this extremely disproportional distribution of precipitation, a 0.13-inch precipitation surplus resulted for September which on paper appears normal (Fig. 2). The purpose of this study is to examine "normal" precipitation months over a 30-year climatology at stations located across the U.S. to determine if "normal" precipitation is comprised of several days of little precipitation, a few days of extreme precipitation, or a hybrid of these two possibilities.

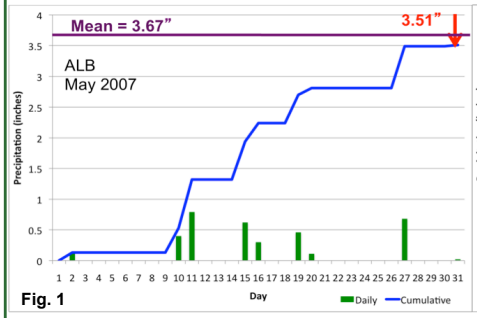


Fig. 1

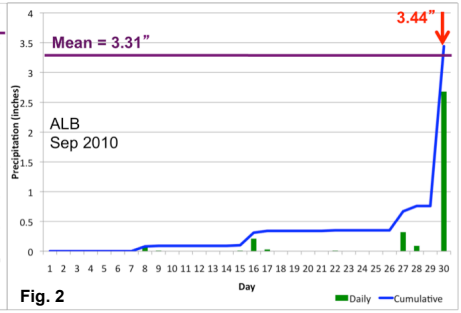


Fig. 2

Data and Methods:

Cities examined in this study include Geneva, NY, Denver, CO, Buffalo, NY, Tampa, FL, New Orleans, LA, Bismarck, ND, Seattle, WA, San Francisco, CA, Norfolk, VA, Louisville, KY, and Springfield, MO (Fig. 3). These locations were chosen based on climate, location, topography, and proximity to water. Thirty years (1981–2010) of data were collected from each city. Only the warm-seasons (April–September) were studied as convection preferentially contributes to precipitation during these months. All months that were ten years above or below the median monthly precipitation were considered "normal" and are considered here. In order to measure the impact of individual precipitation events on the cumulative monthly rainfall during these normal months, a percentage was calculated by dividing the month's largest precipitation event by the cumulative monthly rainfall.

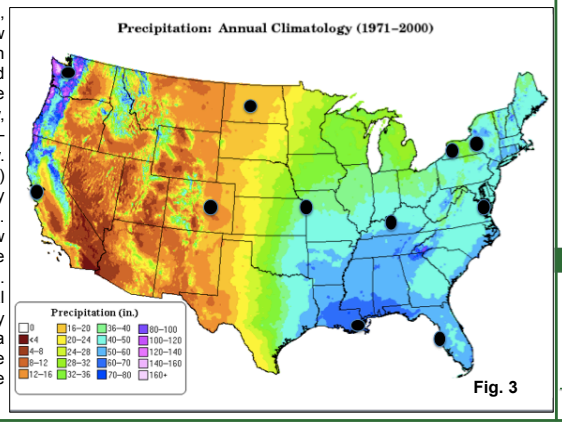


Fig. 3

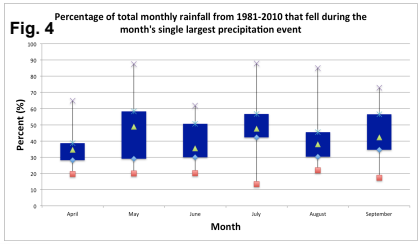
Climatological Results (Select Cities):

Denver, CO averaged precipitation on 8.78 days during normal months totaling an average of 1.70 inches of cumulative rain (Table 1). Excluding June, the maximum percentage of average monthly rainfall from a single event increased into July as temperatures rose, but decreased into September as temperatures began to drop. This pattern is logical given that thunderstorms, a major source for extreme precipitation events occur most frequently in the mid-summer. The inter-quartile (IQ) ranges spanned 28% to 58% of the total monthly precipitation across all months (Fig. 4). Thus, normal precipitation months in Denver typically had a single event that accounted for 1/3 to 1/2 of the monthly rainfall.

Table 1

Month (# of years)	average # of days it rained	average rainfall	average cumulative rainfall	average largest event
April (20)	8.85	0.19	1.69	0.60
May (19)	10.47	0.21	2.11	0.91
June (19)	8.63	0.20	1.55	0.61
July (20)	8.45	0.24	1.74	0.81
August (19)	9.16	0.22	1.94	0.81
September (20)	7.20	0.16	1.18	0.53
Cumulative Average	8.78	0.24	1.70	0.71

Fig. 4

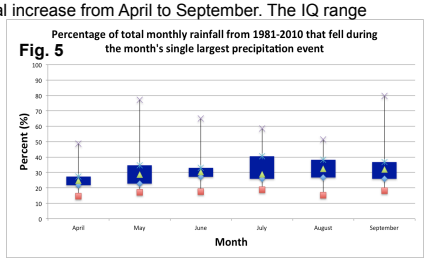


Buffalo, NY averaged precipitation on 11.78 days during normal months totaling an average of 3.25 inches of cumulative rain (Table 2). The maximum precipitation events in Buffalo declined from May through August, but spiked back up in September where one year had a single precipitation event that comprised 80% of the average precipitation. The IQ ranges hovered between 21% and 39% of the total precipitation and showed a general increase from April to September. The IQ range uniformity is consistent with a marine-modified environment. Thus, normal precipitation months in Buffalo typically had a single event that accounted for 1/5 to 2/5 of the monthly rainfall (Fig, 5).

Table 2

Month (# of years)	average # of days it rained	average rainfall	average cumulative rainfall	average largest event
April (20)	13.20	0.22	2.90	0.72
May (20)	12.55	0.27	3.32	1.06
June (20)	12.50	0.27	3.27	1.05
July (20)	10.90	0.29	2.99	1.01
August (20)	9.95	0.33	3.18	1.04
September (20)	11.55	0.38	3.83	1.32
Cumulative Average	11.78	0.29	3.25	1.03

Fig. 5

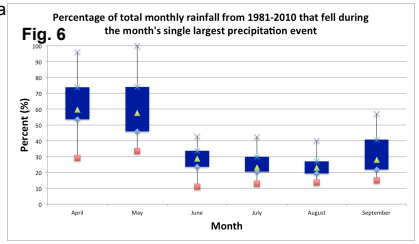


Tampa, FL averaged precipitation on 9.20 days during normal months totaling an average of 5.07 inches of rain (Table 3). Tampa's maritime tropical environment results in warm temperatures and robust atmospheric moisture. Sea breezes also contribute to precipitation totals. The percentages of total monthly rainfall during the largest precipitation event and IQ ranges peaked in April and May, dropped off in June, and rose again in September. Thus, in the early warm season when Tampa does not receive as much rain, normal precipitation months can have a single event that accounts for 1/2 to 3/4 of the total monthly rainfall, while in the later warm season months the largest events are reduced to 1/5 to 2/5 of the monthly rainfall (Fig. 6).

Table 3

Month (# of years)	average # of days it rained	average rainfall	average cumulative rainfall	average largest event
April (20)	5.15	0.34	1.68	1.03
May (20)	5.60	0.31	1.64	0.96
June (20)	12.40	0.54	6.50	1.88
July (20)	16.30	0.42	7.17	1.78
August (20)	15.75	0.48	7.49	1.75
September (20)	12.95	0.46	5.91	1.75
Cumulative Average	9.20	0.43	5.07	1.53

Fig. 6



Discussion and Summary:

Generally, months with smaller rainfall totals, and fewer precipitation events per month, had relatively large percentages of the total rainfall that fell during the month's largest precipitation. Conversely, months with larger rainfall totals and more precipitation events per month, had somewhat smaller percentages of the total rainfall that fell during the month's largest precipitation. This variety in the distribution of precipitation is likely tied closely to convection and modulated by geographic location, climate, and topography.

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