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A Climatological Investigation of the Diurnal Patterns of Precipitation over the Complex Terrain of Western Colorado

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Introduction

Hourly precipitation patterns in the highly complex terrain of western Colorado were analyzed for diurnal biases from 1948 to the present. To gain a regional perspective, the precipitation patterns for numerous locations across western Colorado were studied to determine, spatial, diurnal and seasonal patterns. This study will also discern differences based on actual quantitative precipitation amounts. To examine more significant events, comparisons between events greater than 2.5 mm (0.10 inches) and 6.4 mm (0.25 inches) were utilized.

Dinosaur, Colorado – 1804 meters *

Month	Observation Time (LST)							
	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24
JAN			2	1X	2	9	10	8
FEB		9-10	2	1X		8	9-10	3
MAR		8		1X	2	3	9-10	9-10
APR		10	3	1X	8	2	9	
MAY			9	2	3	1X	8	10
JUN	9	10			1-2	3	1-2	8
JUL	9	10		8	2	1X	3	
AUG	9	10	3	8	2X	1X		
SEP	9	10		1	2-3	2-3		8
OCT	2-3	10	8-9		1X	2-3	8-9	
NOV	3	8	2	1	10	3		9
DEC	2	3	3	1	8		10	9

Meeker, Colorado – 1902 meters *

Month	Observation Time (LST)							
	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24
JAN	8	9	2	1X	3		10	8
FEB	3	8	3	2	1X	3	10X	9
MAR	10	8-9		1	2	3		8-9
APR			8	1	9	1	1	10
MAY	8	9		2-3	1	2-3		10
JUN	9	10	8		1	3	2	
JUL	8	9-10	9-10	3	2X	1X		
AUG		10	8	3	1X	2X		9
SEP		9-10	9-10	8	3	1	2	
OCT	8	10	9	2	1			3
NOV	9	2-3			1	8	10	2-3
DEC	8	9	3	1X	3	10		2

Aspen, Colorado – 2438 meters *

Month	Observation Time (LST)							
	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24
JAN	9	2	1	8	10			3
FEB		3	1X	8	10	2	9	
MAR		3	1X		10	9	2	8
APR		2	1	3	10	8	9	
MAY	8	10	3			1	2	9
JUN	9	10		8	3	1X	2X	
JUL	9	10		8	3	1X	2X	
AUG	10	9			2	1X	3	8
SEP	9	8	1-2		3	1-2		10
OCT	8	2	1X		3	9	8	10
NOV		2X	1X	3	10		8-9	8-9
DEC	3	2	1		10	9	8	3

Site Climatology and Biases

The sites chosen for this study all reside in western Colorado west of the Continental Divide. Only locations with a significant climatological history of hourly precipitation data were selected, with all stations possessing at least 55 years worth of precipitation records.

These climatological sites were selected because they had strong datasets that extended back at least to 1948, when Cooperative Observer hourly precipitation data were first available. Most of the sites are found in valley locations and are associated with western Colorado population centers. The dataset elevations range from a low point of 1478 m at Grand Junction to 2707 m at Crested Butte. Annual precipitation amounts range from 221 mm at Grand Junction to 628 mm at Aspen.

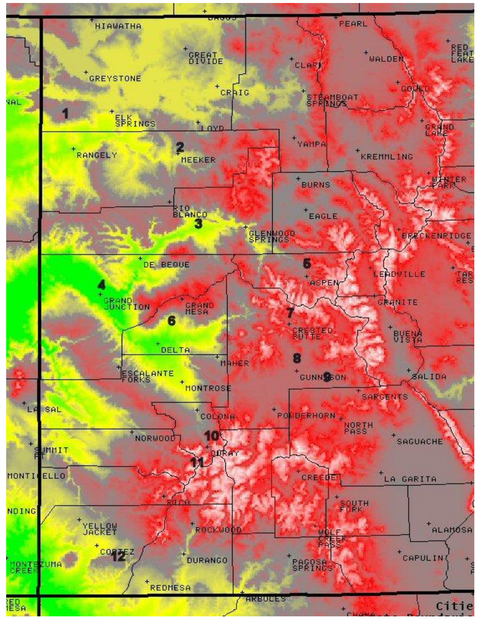
The chosen sites offer some interesting comparisons. Three sites, Crested Butte, Gunnison, and Cochetopa Creek all reside in one hydrologic basin in the north, center, and south respectively. Some sites have a favored orographic precipitation flow. Northwest-North flow produces increased precipitation for Aspen, Cochetopa Creek, Ouray, and Telluride. South-Southwest flow favors Cedaredge, Crested Butte, and Mesa Verde NP. See Figure 1 and Table 1 for a breakdown of locations, elevations and annual precipitation amounts at each location.

Observation Collection Methods

The hourly precipitation data were collected from the National Climatic Data Center in Asheville, North Carolina for a period of record consisting of 1948 through 2005. These data were then ingested into spreadsheets and analyzed to reveal data signatures.

To help eliminate noise from the data set and to make precipitation recording methods consistent, only events greater than 2.5 mm were analyzed, with a secondary cutoff at 6.4 mm, which was used to focus on more extreme precipitation events. In addition, the precipitation data was combined into 3 hour increments, with the study examining the diurnal trends during the eight 3 hour periods between midnight and midnight local standard time.

* For this presentation, data graphs are presented showing the 2.5 mm events per month per 3 hour period. One, 2, and 3 in the graphs represent the 3 hour periods with the highest number of events. Eight, 9, and 10 represent the 3 hour periods with the lowest number of events. An “X” represents a subjectively strong signal.



Site	Location	Elevation	Annual Precipitation
1	Dinosaur NM	1804 m	296 mm
2	Meeker	1902 m	417 mm
3	Rifle	1615 m	295 mm
4	Grand Junction	1481 m	221 mm
5	Aspen	2438 m	628 mm
6	Cedaredge	1902 m	318 mm
7	Crested Butte	2707 m	599 mm
8	Gunnison	2338 m	265 mm
9	Cochetopa Cr.	2438 m	281 mm
10	Ouray	2390 m	582 mm
11	Telluride	2682 m	589 mm
12	Mesa Verde NP	2167 m	453 mm

Figure1/Table 1 Map of western Colorado study locations with location identifier and elevation.

Preliminary Results

Preliminary findings of the precipitation data show that several sites exhibited consistent diurnal patterns during the warm season, defined as the period of May through September, including Crested Butte, Gunnison, Telluride and Grand Junction. Precipitation maxima for events greater than 2.5 mm tended to peak during the afternoon and evening hours (1200 to 2100 MST), with Grand Junction (a low valley location) typically peaking up to 3 hours later than the higher valleys and mountain locations.

Significant precipitation across western Colorado is normally received from two sources, the winter snows (November through March) and monsoonal thunderstorms (July through September).

The winter season diurnal tendencies exhibited a shift from the monsoon season tendency with an afternoon and evening pattern to a primarily nocturnal tendency. The strongest shifts were noted at Mesa Verde, Telluride, Crested Butte, Grand Junction and Aspen.

The transitional months of autumn (namely October) and spring (April through June) data was particularly noisy and showed no significant trends.

Winter Season

- Defined as November through March for this study.
- Majority of precipitation events greater than 2.5 mm occur between 0300 and 1200 MST.
- Nocturnal events peaked in the month of January with strong signals noted at several sites between 0600 and 1200 MST.
- By March, pattern starts to shift to more daytime driven events.

Monsoonal Season

- Defined as July through September for this study.
- Majority of precipitation events greater than 2.5 mm occur between 1500 and 1800 MST.
- Two exceptions at Grand Junction and Rifle where events shifted to between 1800 and 2100 MST.
- September tended to show more variability in timing of events.

Spatial Bias

- Northern sites exhibited less seasonal variability than sites located in southwest Colorado.
- Northern sites also exhibited timing shifts of only +/- 3 hours from season to season.
- Southern sites exhibited strong timing shifts, most notable between the winter and monsoonal seasons.

Conclusion

This ongoing study examines diurnal precipitation trends in western Colorado. Preliminary findings show the diurnal precipitation maxima tends to peak during the warm-season late afternoon and evening hours.

During the cool season, the patterns shifted to more nocturnal events with the majority of all the lower valleys seeing more significant precipitation events ending before mid-morning. Mountain locales showed a slightly longer duration, with events last through midday, before tapering off during the afternoon hours.

Gunnison, Colorado – 2338 meters *

Month	Observation Time (LST)							
	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24
JAN	10	10	1-2	3		10	1-2	
FEB	2-3	2-3		1	10	8	9	
MAR		1	2	3	9	10	8	8
APR	3	8	1		10	2		9
MAY	8	10	1	1	1			9
JUN	10	9		3	2	1	8	
JUL	8-9	10		8-9	3X	1X	2X	
AUG	8-9	10		8-9	1X	2X	3	
SEP	10	8	9		3	2	1	8
OCT	1		3	2	9	10	8	
NOV	3		1	2	8	9	10	
DEC	3	8	2	1	9-10		9-10	

Telluride, Colorado – 2682 meters *

Month	Observation Time (LST)							
	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24
JAN		9	2	1	3	8		10
FEB	3	3	9	1	8	2	10	
MAR		1	10	2	8-9	3		8-9
APR	10	9		1	3	2		8
MAY	9	10			2	1	3	8
JUN	9-10	9-10			1	2	3	8
JUL	9	8	10		2X	1X	3	
AUG	9	8	10		1X	2X	3	
SEP		10	8	3	1X	2X		9
OCT		8		1	2	3	9	10
NOV		1	8	2		9	10	3
DEC	10	2-3		1	2-3	8-9		8-9

Mesa Verde NP, Colorado – 2167 meters *

Month	Observation Time (LST)							
	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24
JAN	9		3	1	2		8	10
FEB	9		2	1X		3	10	8
MAR			1x	2x	3	10	8	9
APR	8		3	1	2		9	10
MAY	9	10	8	3	1	2		
JUN	10	9		3	1-2	1-2		8
JUL	9	10		8	2-3x	1X	2-3X	
AUG		10	9	8	2	1X	3	
SEP	10	8	8	2	3	1		9
OCT	10	8		2		1	9	3
NOV			1	2	3	10	8	9
DEC		8	3	2	1	8	10	9