WEATHER MODIFICATION POTENTIAL DURING UTAH DROUGHT

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Abstract. An investigation of the meteorological characteristics of wintertime Utah drought has shown that drought periods are characterized more by a reduction in the number of precipitation episodes than by differences in the episodes. As a result, precipitation episodes during drought should be no more or less amenable to weather modification than their non- drought counterparts.

1. INTRODUCTION

As a part of the Bureau of Reclamation's Southwest Drought Research Program, North American Weather Consultants (NAWC) participated in a multi-disciplinary study of Utah drought. The study was administered by the Utah Division of Water Resources and other participants included the State Climatologist, the Utah Water Research Laboratory, and the Department of Economics at Utah State University. A final report describing all work performed during this study is in press (Bowles et al. 1982).

2. WEATHER MODIFICATION POTENTIAL DURING UTAH DROUGHT

One task assigned to NAWC was to determine the feasibility of applying weather modification during drought. Toward that goal, the meteorological characteristics of wintertime (Nov-Apr) Utah drought were investigated from the following three approaches: a 3-day weather typing scheme developed by Elliott (1949), daily precipitation data, and rawinsonde data from NWS stations in and surrounding Utah. A monthly Palmer Index (Palmer, 1965) of less than -2 (signifying moderate or worse drought) was used to identify winter drought periods objectively. A non-drought sample was also selected for comparison. The drought and non-drought samples were taken from a 49-year record (1931- 1980). There were approximately 50 winter months in the two samples.

Elliott provided a listing of three-day weather types for the period 1931-1980. The weather types were then grouped into four general types that influence Utah weather. The general types depict the surface and 500 mb conditions over the Western U.S. and include the western trough, which is typically wet; the western ridge, which is generally dry; zonal flow, wet or dry depending on the latitude of the jet stream; and split flow, which also can be wet or dry depending on the location of the southern jet stream. The drought and non-drought samples contained 581 and 476 three-day generalized weather types, respectively. Frequency distributions are shown in Table 1.

Not surprisingly, the western trough type occurred 40 percent less frequently during drought. The western ridge type was more frequent by 18 percent. However, of the four types, western ridges were the most frequent during both drought and non-drought periods. Zonal flow occurred 24 percent more frequently during drought, while the split flow types were 11 percent less frequent. These results suggest that winter drought in Utah is characterized not by the predominance of ridges (since ridges are almost as frequent during non-drought), but by a change in the circulation toward a higher index (or lower wave number). Western troughs tend to occur during high wave number conditions.

Table 1 Percent frequency of occurrence of generalized 3-day weather types of Utah.

General Type	Drought Months	Non-Drought Months	Relative Difference
Western Trough	17.2	28.8	-40
Western Ridge	45.8	38.9	+18
Zonal Flow	29.0	23.3	+24
Split Flow	8.0	9.0	-11
	100.0	100.0	

As expected from the decrease in the occurrence of western trough weather types, the percent of winter days having precipitation decreased during drought. However, in and west of the Wasatch Mountains, when precipitation did occur during drought, daily amounts were very similar to those during non-drought. Locations to the lee of the mountains were doubly affected during drought by both a reduction in the percent of days with precipitation and lower mean daily amounts. On the windward side, the drought deficit in precipitation was almost entirely related to the lower frequency of western trough weather types. To the lee, all weather types contributed to the drought deficit, especially the western trough and zonal flow types.

The analysis of rawinsonde data was restricted to stormy periods in order to address the potential for weather modification. That is, fair weather days were excluded. Rawinsonde data collected at Salt Lake City, Ely, Grand Junction, and Las Vegas between 1964 and 1979 were used in the analysis. When storms did occur during drought, rawinsonde-inferred parameters such as cloud base and top heights and temperatures were very similar to those during non-drought periods (Table 2). However, freezing levels and 500 mb heights were slightly higher, as were cloud base mixing ratios. In line with the trend to a higher index, more zonal circulation during drought, winds at 700 and 500 mb were more frequently from the west and averaged about 10 percent stronger. At Grand Junction, which could be considered to the lee of the Wasatch Mountains, the frequency of low-based, thick clouds (probably precipitating) was less during drought. This relative lack of low clouds, abetted by the stronger winds aloft which would enhance lee-side evaporation, could explain the reduction in mean daily amounts mentioned above.

3. SUMMARY

In summary, these studies have shown that winter drought in Utah is characterized more by a reduction in the number of precipitation events than by differences in the events themselves. Storms occurring during drought were very similar to their non-drought counterparts, particularly to the west of the mountains. Therefore, the storms that do occur during drought should be no more or no less seedable than any other storms.

Table 2 Selected rawinsonde-derived statistics for drought and non-drought periods (stormy winter days only).

	SLC		ELY		GJT		LAS	
Parameter	Drought	Non Drought	Drought	Non Drought	Drought	Non Drought	Drought	Non Drought
Percent with clouds based below 3 km	42	44	32	35	25	36	13	18
Mean base height[1] (km)	2.3	2.2	2.5	2.5	2.3	2.3	2.4	2.3
Mean cloud base mixing ratio[1] (g/kg)	3.4	3.4	3.5	3.2	3.8	3.6	4.2	4.0
Mean top height[1,2] (km)	5.7	5.7	5.1	5.1	5.5	5.5	4.6	4.8
Mean top temperature[1,2] (°C)	-25	-25	-21	-23	-24	-24	-17	-20
Mean freezing level (m)	1840	1820	2480	2250	2430	2140	2170	1980
Mean 500 mb height (m)	5550	5520	5560	5530	5570	5550	5600	5560

[1]: Statistics are for clouds based below 3 km. Sounding prior to 1964 were excluded due to humidity errors.

[2]: Cloud top based on saturation relative to ice.

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