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MANUAL VIL ESTIMATES IN ARIZONA AND THEIR RELATIONSHIP TO SIGNIFICANT CONVECTIVE WEATHER

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Introduction

A manual method of computing vertically integrated liquid water content (VIL) from conventional radar was outlined in Eastern Region Technical Attachment 91-4A by Louis Giordano, WSFO Pittsburgh. To recap the Giordano Method, a range-height indicator scan is first performed on the selected cell. The height of the top and bottom of each VIP level of 3 or more is noted. These are then used to compute the thickness of the layer, to which a multiplicative factor is applied. These factors are 0.3, 0.6, 1.2, and 1.8 for VIPs 3, 4, 5, and 6, respectively. Finally, these numbers are summed together totalling the final value of the VIL. This method was used over the summer of 1992 in Phoenix, Arizona, using a WSR-74C radar. The effort was undertaken in order to determine if VILs could be used in the desert climate of the Southwest in locating significant convective weather.

Data

During the summer of 1992, a number of thunderstorms occurred within the radar's umbrella. Heavy rain, strong wind, and hail events were observed by spotters and/or ALERT gages: however, a few promising storms were located in unpopulated areas. The intensity and possible significant weather for these storms could not be verified. Adding to the database, several low VIL storms that did not produce significant weather were also observed which helped to set low-end thresholds. Verification of actual weather occurrences was obtained from warnings, statements, ALERT data, *Storm Data,* and other spotter reports. The total sample size for this study was rather small due to both the labor-intensive nature of this technique and the low priority it was given by on-shift radar operators. A summary of the data used is included in Table 3.

Results

From the data gathered, correlations between VIL and significant convective weather exist in Arizona. However, not all VILs indicative of significant weather events were associated with severe weather **reports** as many of these events occurred in sparsely populated areas and were unverifiable. Table 1 summarizes the results.

1. Precipitation - Rainfall
   VIL measurements of less than 30 did not relate to any significant events in this category. When the VIL for a storm did rise above 30 but remained less than 100, rainfalls of 0.25 to 1.00 inches occurred. Precipitation amounts of greater than 1.00 inch were reported when the storm VIL value rose above 100 and flash flooding was also often observed.

   When forecasting the potential for flash flooding, the rainfall rate is as important as the total amount expected. Unfortunately, only one heavy rain event, July 10, 1992, passed directly over the ALERT gages at the time of the VIL observations. The Mount Ord (depicted on Fig. 1) gage recorded 1.26 inches of rainfall in 27 minutes ending at 0119 UTC. At 0054 UTC, a VIL was calculated at 116 and rose to 140 by 0138 UTC. As a result of this storm, a section of State Route 188 north of Roosevelt Lake was closed due to rocks on the road, deposited by runoff. In another case earlier that day, a VIL of nearly 122 was associated with rainfall of 1.38 inches in two hours at Sunset Point and 0.99 inches in two hours at Crown King. Table 2 is a summary of the rainfall amounts for both of these cases.

2. Hail
   When hail is present in a thunderstorm, it is often coated with liquid water. This makes each hailstone highly reflective to radar energy, and, thus, the thunderstorms with hail all had exceptionally high VIL readings. Hail in excess of ½ inch in diameter was observed in two of the four cases when the VIL rose above 120. The one exception to this was the Prescott event of August 30, 1992, where the maximum calculated VIL was 95.7. Terrain blockage caused a truncation of the bottom of the storm, which lowered the VIL value by not allowing a complete measurement of the storm structure. In the other two cases, hail may have occurred but could not be confirmed since the storm was over an unpopulated area and documented only by the ALERT gages.

3. Wind
   Both the trend of the calculated VIL values and the magnitude are important when attempting to ascertain the potential for strong thunderstorm outflow winds. The lower threshold value of VIL for winds capable of causing damage (40+ mph) was found to be about 50. If the VIL is steady or increasing and above 50, the winds generally remain below severe thunderstorm levels (58 mph). However, if the VIL magnitude is greater than 50 and decreasing, winds in excess of 58 mph may be produced.

Summary and Future Considerations

The process of calculating the manual VIL estimate leads to errors, some of which are taken into account in the calculations. Beam spreading, terrain blockage, and equipment limitations all contribute to errors. Nevertheless, significant convective weather from storms already present shows some correlation to VIL in the Desert Southwest. This method provides a good first-guess as to the potential for individual storms to produce flash flooding or severe weather.

The findings produced from this small sample set have led the way for future work using the WSR-88D. Now that the 88D is operating in Phoenix, VIL readings can be compared to the manually generated VILs from the WSR-74C, and the threshold values presented here can be related to the values from the Doppler radar. Future work will also take into account differing meteorological conditions by using a larger sample set, further refining the threshold values.

Acknowledgements

I wish to thank Bill Abbey and the staff of WSO Phoenix for performing the tedious task of gathering the data used.

SUMMARY OF JULY 10, 1992 THUNDERSTORM NEAR MOUNT ORD

TIME UTC	RAINFALL TOTAL	
0052	0.04	
0052	0.08	
0053	0.11	
0053	0.15	
0054	0.19	VIL 116.1
0054	0.23	
0055	0.27	
0055	0.31	
0056	0.35	
0057	0.39	
0057	0.43	
0058	0.47	
0058	0.51	
0112	1.02	

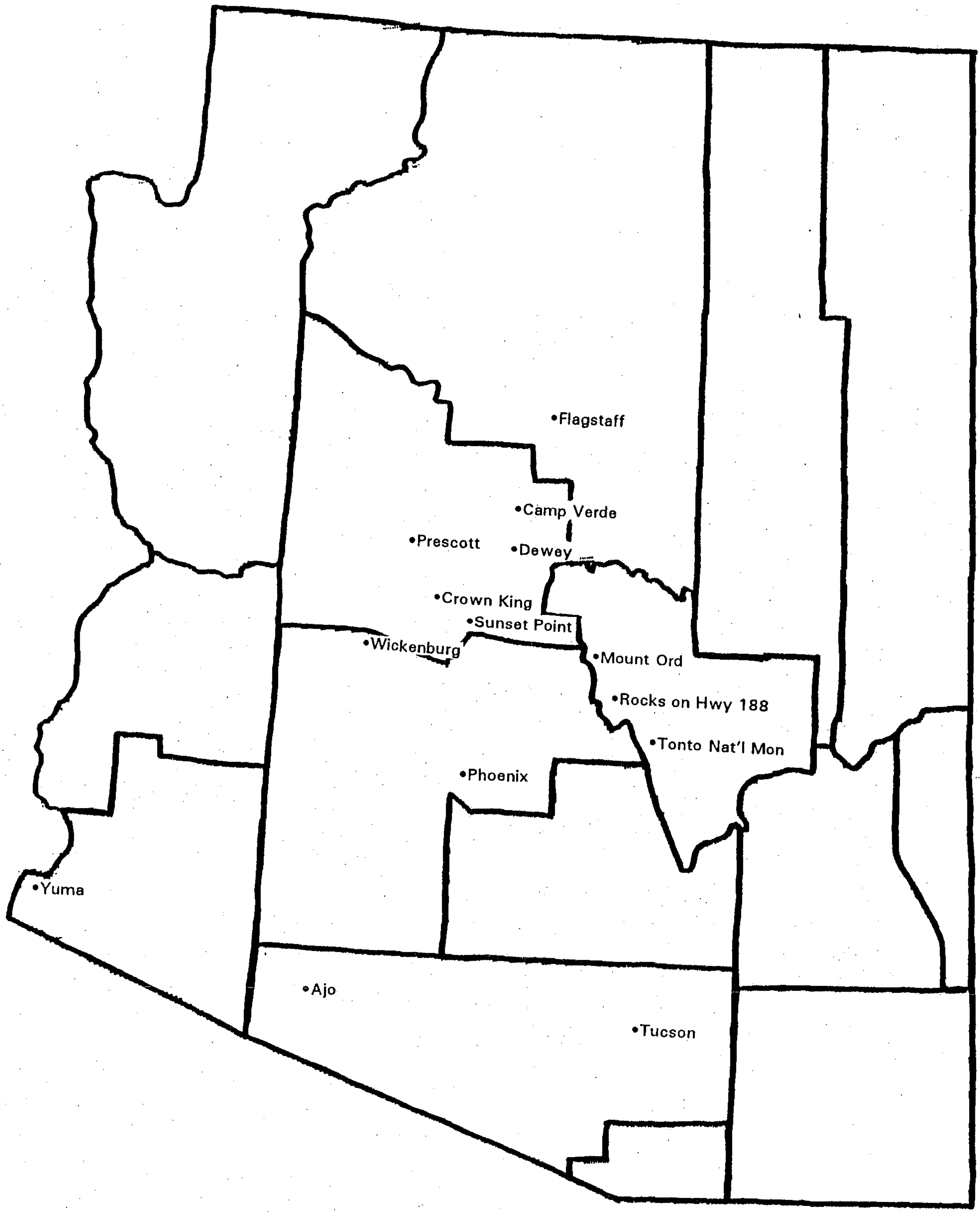
SUMMARY OF JULY 10, 1992 THUNDERSTORM NEAR SUNSET POINT

TIME UTC	RAINFALL TOTAL	
2227	0.04	
2230	0.08	
2234	0.12	
2235	0.16	
2237	0.20	
2238	0.24	
2239	0.28	
2240	0.31	
2243	0.35	VIL 121.8 at 2244 UTC
2245	0.43	
2247	0.47	
2249	0.51	
2251	0.55	
2257	0.69	

TABLE 2

CONVECTIVE ELEMENT	VIL VALUE
HEAVY RAIN (UP TO 1")	30 < VIL < 100
EXCESSIVE RAINFALL (>1")	> 100
RAINFALL RATE OF > 1/2" PER 1/2 HOUR	< 120
STRONG GUSTS - > 40 MPH	> 50 AND STEADY OR INCR
SEVERE GUSTS - > 57 MPH	> 50 AND FALLING
LARGE HAIL - 1/2" OR GREATER	> 120

TABLE 1. VIL correlation to convective elements.



Flagstaff
Camp Verde
Prescott
Dewey
Crown King
Sunset Point
Wickenburg
Mount Ord
Rocks on Hwy 188
Tonto Nat'l Mon
Phoenix
Yuma
Ajo
Tucson

FIGURE 1

VIL Data - Summer 1992

Date	Time (Z)	VIL	Azimuth	Range	Comments	Max VIP
5/29	1820	36.9	357	124.8		5
	1910	16.8	354	92.8	0.20" pcpn Camp Verde	5
5/30	1945	3.9	341.8	96.6		3
	2330	12.6	351	126.0		4
	0025	3.9	352.6	98.9		3
6/3	1927	11.4	350.0	100.0		4
	2124	31.2	355.0	70.0		4
	2124	2.1	356.0	104.0		3
	2234	18.6	19.0	94.0		4
	2304	37.2	19.0	109.0		5
	2336	23.1	22.0	108.0		5
	2341	52.8	24.0	100.0		5
	0004	21.3	26.0	93.0		4
	0004	5.1	20.0	102.0		3
	0035	4.5	26.0	97.0		3
	0035	19.8	37.0	83.0		4
	0035	3.0	67.0	171.0		3
	0120	56.7	70.0	70.0	Tonto Nat'l Mon Wnd G35+	5
	0151	56.4	51.0	52.0		5
	0151	50.1	71.0	73.0		5
	0229	15.3	103.0	89.0	Downburst winds of 63 mph at 29th Ave and Union Hills with heavy rains around 0300Z	4
6/7	2054	12.0	144.0	127.0		4

Date	Time (Z)	VIL	Azimuth	Range	Comments	Max VIP
7/9	2253	90.3	15.0	85.0		6
7/10	2244	121.8	351.0	82.0	BWER Sunset Pt. 1.38" 327M to 522MST Crown King 5S .99" 248M to 453MST	6
	0012	68.7	58.0	70.0		6
	0054	116.1	66.0	64.0		6
	0138	140.1	67.0	67.0	Mt. Ord ALERT 1.26" in 27 mins. at about 0100Z - 0.51" in 6 mins.	6
	0220	105.0	62.0	62.0	Gust to 41 mph Apache Jct. 0220Z "High winds" east valley 0300Z	6
	0254	25.5	61.0	61.0		5
7/21	2239	32.7	110.0	174.0		5
7/22	2325	130.2	120.0	40.0	Pea sized hail & Gust 48 mph Unconfirmed Funnel cloud about 0030Z	6
	2350	107.7	130.0	51.0		6
7/25	0027	16.8	320.0	130.0		4
	0027	34.8	335.0	131.0		5
	0124	23.7	335.0	122.0		5
7/28	0040	54.6	25.0	80.0	Gust to 57 mph - 29th Ave and Union Hills. DVT G52 mph / vsby <1 blowing dust (0155Z)	5
	0115	18.3	35.0	75.0		4
8/2	0730 (1230am)	37.5	270.0	105.0		5
	0830 (130 am)	5.1	264.0	153.0		4
	0353 (853 pm)	8.7	107.0	134.0		4
	0540 (1040pm)	63.9	90.0	119.0		5
8/6	0055	111.3	127.0	145.8	0025Z...gust 61 mph TUS arpt 2.41" Dodge and Fort Lowell in TUS 1.25" in 30 mins at Prince Rd and Campbell (0200Z)	6
	0115	76.8	129.0	153.9		6
8/7	2359	13.8	95.0	125.0		4
	0016	12.0	98.0	125.0		4

Date	Time (Z)	VIL	Azimuth	Range	Comments	Max VIP
8/11	2225	52.8	105.5	166.2		5
	2259	31.8	109.0	178.0		5
8/12	2348	78.0	30.0	88.0	Gust 32 mph Apache Jct (0100Z)	6
8/13	2235	4.5	21.0	143.0		3
	0210	79.8	211.0	146.0		6
8/14	0135	30.9	334.0	96.0		5
	0234	45.3	40.0	136.0		5
8/15	0126	75.9	127.0	103.0		6
	0325	92.1	214.0	70.0	"High winds" Ajo area 0300Z	6
	0356	55.5	212.0	80.0	"Heavy rains" Gila Bend Gunnery range at 0505Z	6
8/19	0233	93.3	14.0	75.0	2.20" satellite pcpn est (2Z-6Z) East of Dewey 1.65" 0300Z-0445Z	6
8/30	2218	95.7	300.0	106.4		6
	2248	49.8	304.0	95.6		6
	2320	121.8	311.0	85.1	2326Z - Marble hail Wickenburg	6
	0020	70.8	322.0	151.4		6
	0155	86.4	305.0	166.5		6
	0225	46.8	309.0	155.8		5
	0225	95.7	342.0	133.7	1.75" hail Prescott (0236Z) Svrl other reports of large hail	6
9/13	1930	15.9	359.1	167.9		4
	2035	3.9	8.8	178.7		3