2015 *Canaan Valley & Environs* *Southeastern Naturalist* 13(Special Issue 7):18–32

Climate of Canaan Valley

Christoph A. Vogel[1,2,*] and Robert J. Leffler[3]

Abstract - In this paper, we present and examine climate data from 1944 to 2002 for Canaan Valley, WV, including average, extreme, and monthly and seasonal temperature, and precipitation and snowfall amounts. The data, collected over decades by several dedicated National Weather Service cooperative observers, indicate that Canaan Valley's "cash crop" may indeed be its climate. The Canaan Valley has summer temperatures similar to those found in northern New England, an average seasonal snowfall higher than any large city in the US, and a shorter growing season than that of Fairbanks, AK. We highlight the area's exceptional climate and compare it to other well known locations. We also present and assess climate trends, including some relationships to the El Niño Southern Oscillation state, in Canaan Valley's 57-year record.

Physical Geography of Canaan Valley

Canaan Valley (hereafter, the Valley) lies in north-central West Virginia in a physiographic region called the Allegheny Plateau. Canaan Valley is the highest valley of its size east of the Mississippi River in North America and has an average elevation of 3200 ft (974 m) above sea level. The oval-shaped valley resembles a huge bathtub with the axis orientated northeast–southwest. The Valley floor is about 5 mi (8 km) wide and 10 mi (16.1 km) long, covering about 50 mi^2 (80.5 km^2). The Valley and the erosion-softened slopes surrounding it are drained by the Blackwater River, a tributary of the Ohio and Mississippi river drainages.

The lowest elevation is 3100 ft (944.8 m) on the northwest side of the Valley in a notch between Canaan and Brown mountains where the Blackwater River exits Canaan Valley on its journey westward. The highest point is about 4450 ft (1356 m) at the summit of Weiss Knob on the southeast rim of the Valley.

The Valley's northeastern rim—the Eastern Continental Divide—forms an important weather, climate, and drainage boundary. Precipitation falling to the west of the Divide drains into the Gulf of Mexico. Precipitation falling to the east drains into the Atlantic Ocean.

Observation and Data Sources

In this study, we used weather and climate observations made by volunteer weather observers from the National Oceanic and Atmospheric Administration

---

[1] NOAA Liaison to Canaan Valley Institute, NOAA Atmospheric Turbulence and Diffusion Division, Oak Ridge Associated Universities, Oak Ridge, TN 37830. [2] Current address - C.A. Vogel Consulting, Mt. Pleasant, SC 29466. [3] NOAA National Weather Service, Office of Climate, Water, and Weather Services, Silver Spring, MD 20910 [now retired]. [*] Corresponding author - chascav100@gmail.com.

(NOAA)/National Weather Service (NWS) Cooperative Observer Program (COOP) in Canaan Valley, WV. We considered the period July 1944–July 2002. The Thompson Family gathered data from 1944 to 1995 at their farm located near the center of the Valley at an elevation of 3250 ft (990.6 m). After 1995, a new site about 1 mi (1.6 m) northwest of the Thompson's farm, near State Route 32, called Canaan Valley 2, was established. The two stations ran concurrently between 1993 and 1996; the Canaan Valley 2 station continues to operate today.

NWS COOP daily data are quality controlled, archived, and then published on a monthly basis by the National Climatic Data Center in the NOAA Climatological Data publication. Observations are taken using instrumentation installed and maintained by the NWS. COOP observers are trained and supervised by NWS field technicians, and site visitations occur at least once per year. Daily observations taken include 24-hour maximum and minimum temperatures, liquid-precipitation equivalent, snowfall and snow depth, and special phenomena (e.g., days with thunder, hail, damaging winds, fog, etc.). Thirty-year decadal averages are based on the 1961–1990 period. Extremes are based on the period July 1944–July 2002.

General Climatic Conditions

According to Thornthwaite's climate classifications (Thornthwaite 1948), the Valley has a cold, humid-type climate, just two steps warmer than the tundra classification. The Valley's climate is primarily influenced by three factors: location, high elevation (3200 ft/ 975 m), and topographic setting (bowl-like frost hollow).

Location

The Valley is in the mid-latitudes on the east side of a northern hemisphere continent, on the crest of the Allegheny Mountains, on the windward side of the eastern Continental Divide, and in close proximity to the Atlantic Ocean. This location has broad implications. Westerly winds dominate; thus, relatively warm, moist air masses from the Gulf of Mexico and cold, dry masses from Canada alternately affect the area, creating large day-to-day weather variability and unsettled conditions as the air masses mix.

Summer is characterized by light winds and moist air flowing northeastward from the southeast and Gulf of Mexico, and localized thundershowers are common. Winter is dominated by strong winds and alternating pulses of cold, dry air from Canada and warm, moist air from the Gulf of Mexico. Unsettled conditions are common during the colder months and can bring unrelenting days of blizzards or rain, depending on the temperature.

The Valley's location at the crest of the Alleghenies is a primary factor in enhancing the abundant precipitation—both rain and snow—that normally falls over much of the eastern US. Moisture-laden air moving into the Valley from the north, south, east, and west is moved by the prevailing westerlies and forced to rise and cool, enhancing cloud cover and precipitation. The high elevation also means that temperatures are frequently below freezing; thus, more of the precipitation falls as snow here than at lower-elevation sites.

The Allegheny Mountains crest in north–central West Virginia, forming a significant barrier about 100 mi (160.9 km) long and 15 mi (24.1 km), wide with elevations of 3000 ft (914 m) to nearly 5000 ft (1524 m). The elevated plateau surface averages about 3000 ft (914 m) above the lowlands to the west and east. This topographic barrier causes broad orographic uplift of air masses traveling across it. Being near the crest of the rise also results in easterly winds laden with Atlantic moisture having an upslope path. Upslope causes water vapor to cool and condense which produces increased clouds and precipitation (Leffler 1974, 1977)

High elevation

The Valley's 3200-ft (975-m) elevation means that temperatures are typically 10–15 °F (5.6–8.3 °C) cooler than in surrounding lowlands. Elevational differences in temperature are greater in the summer than in the winter. During winter in the Valley, temperatures are more frequently below freezing, causing more of the precipitation to fall as snow there than at nearby sites. During the winter months, temperatures occasionally increase with elevation. This phenomenon occurs when strong, high-level winds force warm air up and over the shallow, dense, cold air at lower elevations. Under these conditions, a temperature inversion occurs, with warmer conditions occurring in the Valley and the surrounding highlands than in the lowlands.

Topographic setting

The combination of the Valley's position on the crest of the Alleghenies and its high-elevation floor are an ideal configuration for creating low temperatures. This topography creates conditions which efficiently contain the build-up of cold air drainage under clear, calm weather conditions, resulting in low minimum temperatures during all months.

Topographic settings such as the Valley's are sometimes referred to as frost hollows. The term is usually reserved for low spots, which exhibit an increased frequency of frosts and are topographically ideal for trapping cold air under clear skies and windless conditions. The Valley is a textbook example of a large-scale elevated frost hollow.

Specific Climatic Conditions

The Valley has a high-altitude climate, a feature that translates into cool shade and warm sun on bright, sunny days. Another high-elevation feature is the potential for large day–night temperature fluctuations, especially when the air is dry.

The Valley's average annual temperature is 45 °F (7.2 ºC; Table 1). Summers (June–August) are cool—the average afternoon maximum is 75 ºF (23.9 °C) and the average morning minimum is 51 °F (10.5 °C). About half of summer mornings experience temperatures ~40 ºF (4.4 °C) or below. Summer temperatures average 5 degrees cooler than Burlington, VT, 400 mi (644 km) to the northeast, and about 15 °F (9.4 °C) cooler than big cities such as Baltimore, MD and Washington, DC, which are only 200 mi (322 km) and 150 mi (241 km) to the east, respectively. On average, days with a high temperature of 90 °F (32.2 °C) occur only once every 15 years in the Valley. For comparison, Washington, DC sizzles with an average of 38 days per year when the temperature reaches 90º F (32.2 °C).

Freezes can occur in the Valley during any month; on average, there is a freeze in July once every six years. A minimum temperature of 27 °F (-2.8 °C) or lower has been recorded in all summer months. The Valley's average summer growing season (consecutive days without freezing temperatures) is only 89 days, with the average last frost occurring 1 June and the first on 30 August, and a considerably shorter frost-free period in some years. The average growing season in the Valley is 99 days, 16 days shorter than the 115 day average for the Fairbanks International Airport, AK (NRCC 2015), which is located only 100 mi (160 km) south of the Arctic Circle.

Winters are considered moderate to severe; freezing or sub-freezing temperatures occur on about 160 days. Zero-degree (-17.8 °C) minimum temperatures occur about eight times a year. However, in most winters, northward incursions of mild Gulf of Mexico or Atlantic Ocean air provide frequent breaks in the cold weather. These breaks sometimes do not reach lower elevations to the east due to

Table 1. The climate of Blackwater Falls and Canaan Valley, WV, elevation = 3250 ft (991 m) above sea level. T = trace, less than 0.1 inch; means are for the period 1961–1990; temperatures adjusted to midnight–midnight observation time; extremes = all except rainfall 1945–1994; rainfall 1945–1964; mean number of days is estimated from published values for 1945–1964; data compiled from official National Weather Service cooperative station data from Thomas and Canaan Valley, WV. [Table is continued on next page.]

	Temperature (ºF)							
	Means			Extremes				
Month	Max	Min	Avg	Record max	Year	Record min	Year	Heating degree days
Jan	33.0	13.7	23.4	70	1950	-27	1984	1237
Feb	36.2	15.7	26.0	69	1985	-26	1963	1047
Mar	45.4	24.3	35.4	80	1954	-23	1960	877
Apr	55.9	32.2	44.0	85	1976	-1	1985	579
May	66.2	41.4	53.8	86	1979	14	1947	312
Jun	73.2	48.4	60.8	91	1952	23	1977	116
Jul	76.5	52.7	64.6	96	1988	27	1988	51
Aug	75.1	51.3	63.2	93	1948	25	1957	81
Sep	69.3	45.2	57.2	84	1953	18	1964	210
Oct	59.3	35.0	47.2	82	1951	5	1952	521
Nov	47.9	27.4	37.6	75	1958	-14	1956	780
Dec	37.9	18.9	28.4	76	1951	-20	1983	1101
Year	56.4	33.8	45.1	96	1988	-27	1984	6912

the shallow cold-air damming which occurs when northeast winds trap cold air in the lower elevations east of the Eastern Continental Divide.

Precipitation

Precipitation averages about 55 in (139.7 cm) per year and is evenly distributed throughout the seasons (Table 1). Drought conditions are seldom experienced

Table 1, continued.

Precipitation (inches)

	Total precipitation			Snow			
Month	Avg	Max day	Year	Avg	Max month	Year	Max on ground
Jan	4.23	1.55	1955	31.3	69.0	1985	68
Feb	3.80	2.00	1948	29.5	80.5	1958	83
Mar	5.06	2.18	1954	21.8	73.0	1960	60
Apr	5.18	1.54	1952	10.7	30.0	1961	16
May	5.27	2.25	1960	0.3	5.0	1960	2
Jun	5.38	2.33	1949	0.0	T	1945	T
Jul	5.46	2.44	1958	0.0	0.0	-	0
Aug	4.91	3.50	1955	0.0	0.0	-	0
Sep	4.17	2.08	1964	0.0	T	1990	T
Oct	3.87	4.00	1954	2.5	14.0	1979	8
Nov	4.32	1.98	1962	12.1	37.0	1976	24
Dec	4.74	2.11	1948	25.3	67.0	1969	52
Year	56.39	4.00	1954	133.5	80.5	1958	83

Mean number of days

			Temperatures			
			Max		Min	
Month	Snowfall >1"	Precip. ≥ 0.10"	≥90º	≤32º	≤32º	≤0º
Jan	12	11	0	14	28	5
Feb	11	12	0	8	25	3
Mar	6	13	0	5	25	1
Apr	2	12	0	1	17	0
May	<1	12	0	0	6	0
Jun	0	10	0	0	1	0
Jul	0	11	<1	0	<1	0
Aug	0	8	0	0	1	0
Sep	0	7	0	0	4	0
Oct	1	7	0	1	14	0
Nov	4	9	0	3	21	<1
Dec	8	10	0	9	28	3
Year	44	122	<1	41	170	12

but when drought occurs, the threat of forest fires increases, and stream flow and well levels are low. Precipitation records from the Thomas station may be more representative than the Canaan Valley Station because we believe the more protected exposure of the rain gauge at the Thomas station may result in a more accurate catch of both rain and snow. The Canaan Valley station, although protected somewhat from high winds in the immediate vicinity of the rain gauge, is located in the middle of the Valley where large open meadows allow the full force of the strong winds that frequent the Highlands to blow unimpeded and reduce the catch in the rain gauge.

Snowfall

The Valley is referred to by some as a snow bowl because it has long been noted for its exceptionally heavy snowfalls. Snowfall on the Valley's floor averages 11.2 ft (3.4 m) for the 30 years between 1961 and 1990. Snow has been observed as early as September and as late as June. The lowest seasonal snowfall total for that period was 5.5 ft (1.67 m) and the highest was 21.4 ft. (6.53 m) during the winters of 1948–1949 and 1995–1996, respectively. The average maximum snow depth reached is about 2.5 ft (0.76 m) in late February. However, due to the high variability of conditions, depth and times of maximum snow-cover vary considerably. Occasionally, a winter month occurs with a daily measurable snowfall of ≥0.1 in (0.25 cm).

Due to the frequent thaws that result from warm-air intrusions from the east and south, snow cover is usually intermittent. Occasionally, in cold winters that feature a persistent and strong northwest-wind flow, a snow pack up to 5 ft (1.5 m) deep can develop and persist. Under such conditions, north-facing slopes above 4000 ft (1219 m) in elevation can hold the pack into mid-April, and drifts in high, windblown meadows can persist well into May.

Significant snowfalls of 4–8 in (10.1–20.3 cm) or more resulting from northwest winds are common. These snowfalls, sometimes referred to by local residents as lake flakes, are commonly the result of upslope movement and cooling of air masses as they cross over the broad, elevated Allegheny Plateau. Sometimes the northwest snows are enhanced by shallow-level moisture inputs and streamers from the Great Lakes, but this is the exception rather than the rule.

With elevations on the Valley rim averaging about 4100 ft (1250 m), air is forced to rise 3500 ft (1067 m) from the western Ohio River Valley bottomlands 130 mi (209.2 km) to the west. The ascent forces expansion, cooling, and increased precipitation. Thus, when many areas at lower elevations have clearing skies after cold frontal passages in northwest-wind flow, the Valley, the immediate windward crest of the Alleghenies, and surrounding highlands can experience persistent and heavy snowfall and blizzard conditions (winds greater than 35 mph. [56.3 km/h] for 3 hours or more, combined with snow and blowing snow that reduces visibility to <1/4 mile [0.4 km]; Leffler 2005).

Heavy snows can also result from Atlantic coastal storms (nor'easters) passing along the coast. Under these conditions, moist easterly winds flowing off the ocean are further lifted by the Allegheny Front (Eastern Continental divide). With the forced ascent, the lift squeezes more precipitation from an already moisture-saturated air mass. Under this scenario, the heaviest snowfalls occur over and just to the east of the Allegheny Front (Dolly Sods, Roaring Plains, Spruce Mountain) and towns just east of the front—Petersburg and Keyser. Some of the enhanced snowfall from these northeasters spills over into the Valley on the stiff easterly winds. When coastal storms move to the north of the Valley, cold air usually begins flowing in and winds turn around to the northwest, adding more high-elevation upslope snow to the totals.

All of these factors combine to give the Valley an average snowfall of 134 inches (340 cm), over one-foot greater than Rangeley, ME (121 inches [307 cm]), the snowiest reporting station in Maine (Nexus 2015). The northwest wind flow and upslope-enhanced lift also combine to produce an unusually high number of snow days: 44 days with 1.0 in (2.54 cm) or more of snowfall (Table 1). By contrast, Washington, DC experiences only four snow days in an average winter.

Severe weather

Thunderstorms occur in the Valley on about 50 days per year. Violent localized winds from any direction may accompany intense summer thunderstorms. Damaging tornadoes have been recorded only twice—in June 1944 and May 1948—though damaging winds can occur in any month. The high elevation and preponderance of open meadows contribute to the increased frequency of damaging winds and howling blizzards in the winter. In general, the strongest winds precede the passage of low-pressure storms in the fall, winter, and spring, and come from the westerly quadrants.

Dense fog with near-zero visibility is a frequent occurrence in the Valley, especially during clear, calm conditions in the fall and during the moist summer months. Dense fog is also common on the ridgetops surrounding the Valley, when moist air is cooled to below the condensation point as it ascends the higher elevations.

During the winter months, the Valley's surrounding ridges are frequently cloaked with a frost line. This beautiful line, above which all trees are coated pure white, actually corresponds to the cloud base and is the result of rime icing. Rime ice forms when super-cooled water vapor in clouds freezes upon contact with below-freezing surfaces, forming a buildup of ice crystals.

Snowfall and Temperature Analyses

We examined the data presented above to determine long-term trends. The questions we examined were: (1) Are there any significant statistical trends in the climate records, or have they remained stable? and (2) Are there any low-frequency atmospheric phenomena which serve as predictors of seasonal climate variabililty, especially in the winter? Here we summarize the results of our brief analyses of temperature and precipitation records.

The Valley area has seen some population decline during the period of analyses with little anthropogenically induced change likely (Wikelopedia 2015). Population growth and land-use patterns are expected to remain stable as nearly 94 percent of the land is is now owned by the federal and state governments (70 percent of the Valley's lands are in national Canaan Valley Wildlife Refuge while the WV state government owns an additional 24 percent in the Canaan Valley Resort state park).Thus, the Valley is an excellent candidate for studying naturally driven long-term climate variability and trends at higher elevations of the eastern US.

One situation that introduces data discontinuities and resulting biases into long-term climate-variability/change studies is the relocation of measurement sites. Even changes of tens of feet can produce apparent changes in climate analyses. In the case of the Canaan Valley stations, a comparison of monthly averaged temperatures during a period of overlapping data (January 1993–March 1996) showed a systematic difference between the two sites. A linear regression fit through data representing COOP station 1 (S1) as a function of COOP station 2 (S2) gave the relation,

$$S1 = 5.63 + 0.933*S2,$$

with a correlation coefficient $R^2 = 0.997$. Thus, in order to establish a continuous temperature record through July of 2002, we used station 1 records through March 1996; after March 1996, we adjusted station 2 records according to the above linear relation to estimate their value as if they had been measured at station 1.

A similar analysis on snowfall data yielded a non-linear relationship. However, because we observed that a limited number of extraneous points significantly altered the correlation, and because one would not expect to see a bias (assuming the same observer) in precipitation values between two stations within 2 km of each other and at the same elevation, we derived a continuous data set by using station 2 data when station 1 data was missing.

Snowfall

Figure 1 shows seasonal (from 1 July to 30 June) snowfall totals for Canaan Valley, as measured at the NWS COOP station. Over the 54 winter seasons available from the digitized data record, the average snowfall was 133 in (338 cm) with a standard deviation of 39 in (99 cm), not unlike the 1961–1990 averages. However, snowfall amounts in this extended record show extremes of 69 in (175 cm) in the 1948–1949 season to 257 in (653 cm) during 1995–1996.

When observing time-series records such as these, it is useful to assess trends by fitting an average curve to the data, keeping in mind the relatively short period of record compared to the longer time intervals often associated with climate change. Figure 1 shows a 30-y running-average fit to the data. Any point indicated along the 30-y running-mean curve is an average of 15 years ahead and 15 years behind that point. The curve has a standard deviation of 2.4 in (6.1 cm; less than 2% of the mean) and a slope of only 0.15 in (0.38 cm) per year. These can be considered small deviations, and we found no significant trend in the snowfall time series over the measurement period.

A further question we evaluated was whether large-scale phenomena such as the El Niño Southern Oscillation (ENSO) correlate with climate variability in the Valley. ENSO is known to affect global weather and climate (NOAA 2015). The ENSO index is defined as a 3-month average of sea surface-temperature departures from normal for a critical region of the equatorial Pacific (Nino 3.4 region: 120°W–170°W longitude, 5°N–5°S latitude). Any case in which this region is characterized by a positive departure of >0.5 °C from normal is termed El Niño. A case with a negative departure of >0.5 °C is called La Niña. The index is termed neutral when sea surface temperature is within ± 0.5 °C of average. The particular state in which ENSO resides (La Niña, neutral, or El Niño) and its intensity have implications for seasonal climates across the globe, and can have significant impacts on weather and climate in particular regions of the US (Patton et al. 2003). This situation suggests the question: Can we use the phase of ENSO as a predictor for snowfall amounts in the Valley?

Researchers have found significant correlations between ENSO phases and seasonal snowfall amounts in some parts of the mid-Atlantic region. One consideration is the length of the time lag between the establishment of an ENSO state and the resulting effect (if any) on the Valley's climate. In this analysis, we

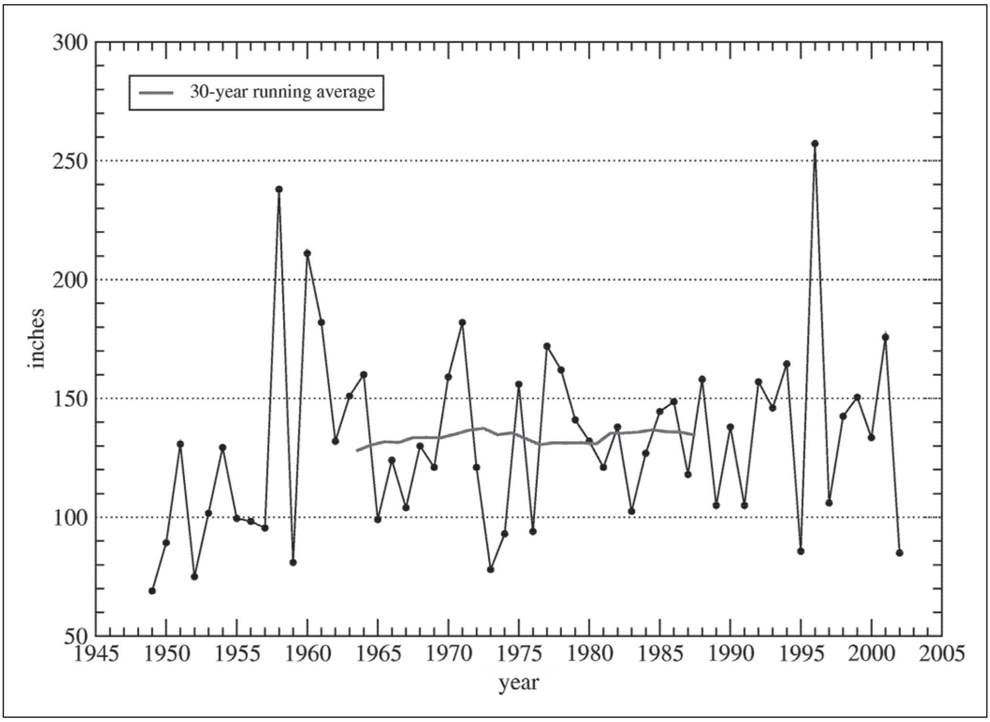

Figure 1. Annual snowfall totals for Canaan Valley, WV

decided to observe both the ENSO state during January–March of the observed winter season, and the ENSO state during the previous summer.

Figure 2 illustrates the Valley's snowfall record categorized according to the phase of ENSO during January–March. The results of our analysis indicate that when ENSO was in its neutral phase, the Valley experienced higher snowfall amounts, but during the El Niño phase, slightly less snow was recorded. During the La Niña phase, we would expect the least amount of snowfall with >10% below average amounts. However, there is considerable variation in the data. Some of the lowest snowfall amounts occurred during the neutral and El Niño phases, while high amounts occurred during La Niña events.

Figure 3 shows the same data categorized according to ENSO state during the previous summer; the differences in snowfall amounts are more pronounced, with the ranking of ENSO state as it relates to snowfall amounts. These plots seem to indicate that over the longer term, ENSO correlates with snowfall amount. However, the relatively large amount of scatter in the data suggests that other unidentified phenomena also influence climate variability.

Results of statistical tests (here P signifies a level of significance for a two-tailed Student's-t analysis for differences in mean values; the lower the value, the higher the significance) to determine whether the snowfall totals categorized according to ENSO state are statistically different showed that when we used the January–March ENSO state as a predictor (Fig. 2), only the difference between

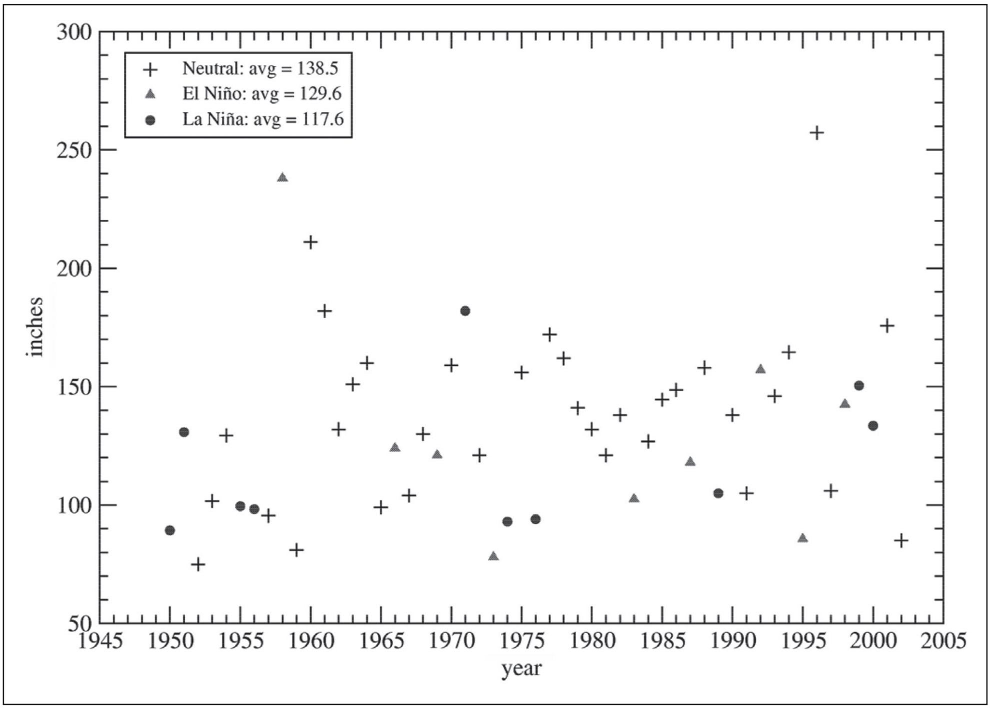

Figure 2. Seasonal snowfall amounts categorized according to the ENSO state during January, February, and March.

neutral and La Niña groups was significant ($P \leq 0.05$). When we used ENSO state during the previous summer as a predictor (Fig. 3), the difference between neutral and La Niña totals was significant ($P \leq 0.0125$), and the difference between El Niño and La Niña snowfall amounts was significant ($P \leq 0.05$). Although the correlations are relatively weak, these findings suggest that the ENSO state recorded during the summer prior to a winter season is a better predictor of snowfall amounts than the ENSO state of the current season, especially when considering differences between neutral and La Niña conditions. Differences between snowfall amounts categorized according to neutral and El Niño states were not significantly different for either method.

Temperature

We followed the same methodology used for snowfall to analyze temperature records. Figure 4 shows the average annual temperature over the 54-year period of record. The average is 46.5 °F (8.1 °C) with a standard deviation of 1.4 °F (0.8 °C). The highest average annual temperature was 49.5 °F (9.7 °C) in 1991, and the lowest was 43.4 °F (6.3 °C) in 1977. Unlike snowfall, which shows no significant trend in its 30-year running mean over the past 15 years, the 30-year running mean of temperature increases by almost a full degree over the same period.

An ENSO analysis similar to that performed with the temperature records is shown in Figure 5. Here, January–March average temperatures are associated

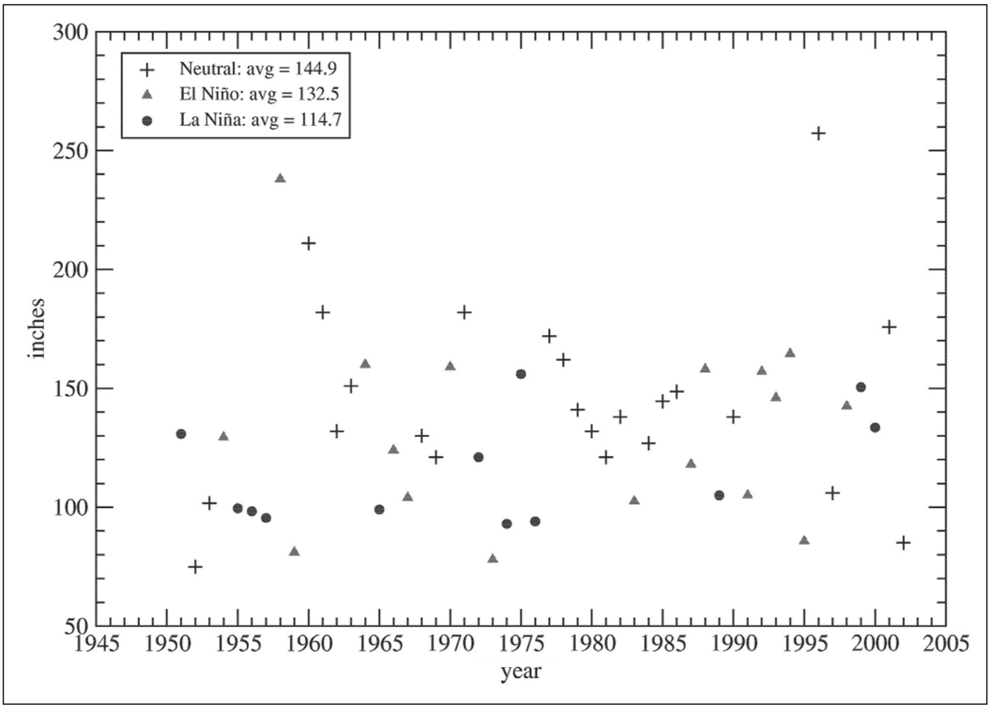

Figure 3. Snowfall amounts categorized according to the ENSO state during the previous summer.

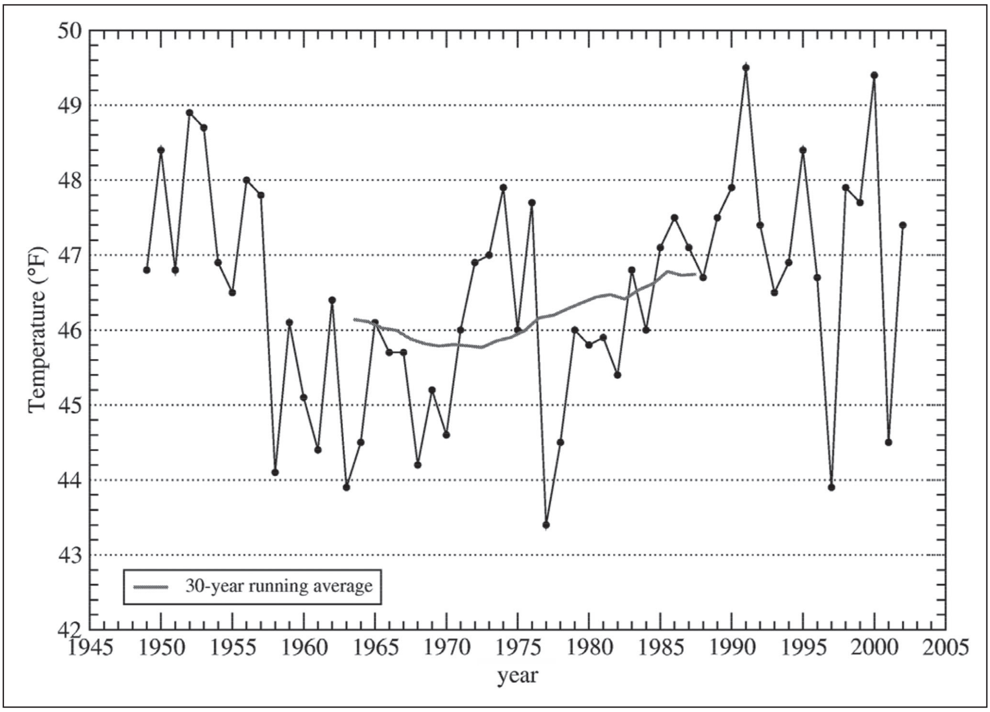

Figure 4. Average annual temperature for the Canaan Valley, WV.

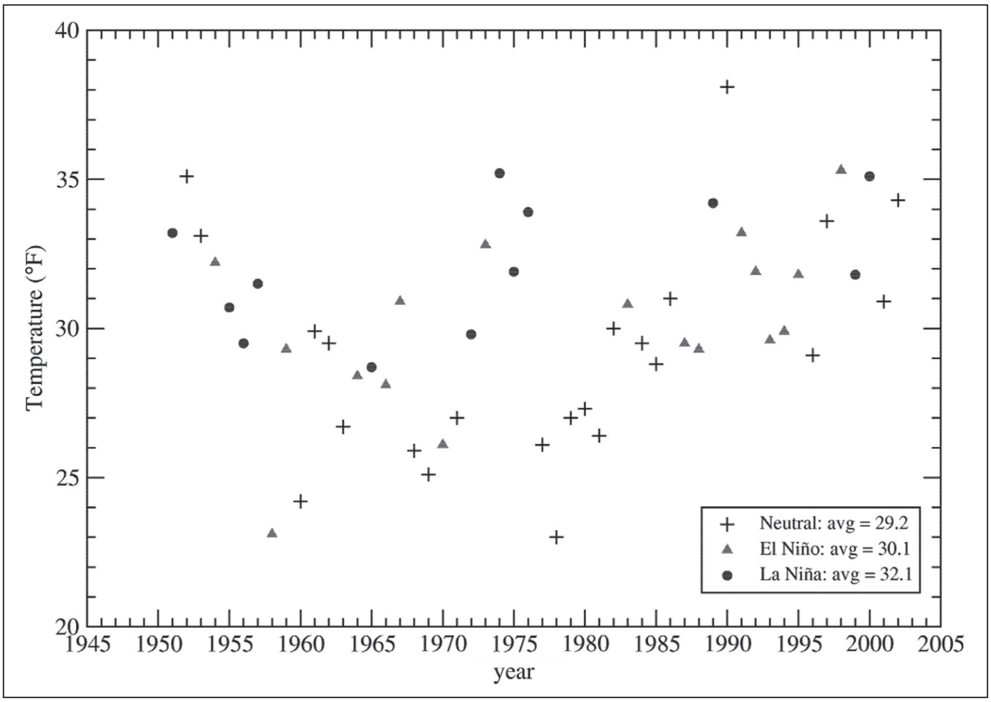

Figure 5. Average 3-month daily temperature during January, February, and March categorized according to the ENSO state during the previous summer.

with ENSO states of the previous summer. Although variability is similar to what we observed in our analyses of snowfall amounts, there is a weak dependence on the ENSO state. Neutral phases correlate with the coldest periods, El Niño phases with warmer periods, and La Niña phases with the warmest winters.

We conducted statistical tests similar to those performed for snowfall amounts. The results for temperature using the ENSO state of the previous summer as a predictor were similar to those found for snowfall using the same states, albeit at a significantly higher level of confidence. The differences between neutral and La Niña-grouped temperatures were significant with $P \leq 0.005$, while the differences between El Niño and La Niña were significant with $P \leq 0.025$. We found no significant difference between neutral and El Niño cases ($P \geq 0.05$).

It is also useful to compare summer and winter average temperatures. Figure 6 shows average temperatures during the January–March periods smoothed with a 30-year running mean. The average 3-month temperature for the 54-year record was 29.8 °F (-1.2 °C) with a standard deviation of 3.3 °F (1.8 °C). Figure 7 depicts average 3-month temperatures for June–August with a 30-year running mean. The average temperature over the entire record was 63.9 °F (17.7 °C) with a standard deviation of 1.5 °F (0.8 °C). As expected, variability in average temperatures was greater in the winter months than in the summer. Both plots show increases in 30-year mean temperatures over the last 15 years, although it is more pronounced in the summer data. Also, notable in these data are the warm summer of 1952 and the cold winter of 1978.

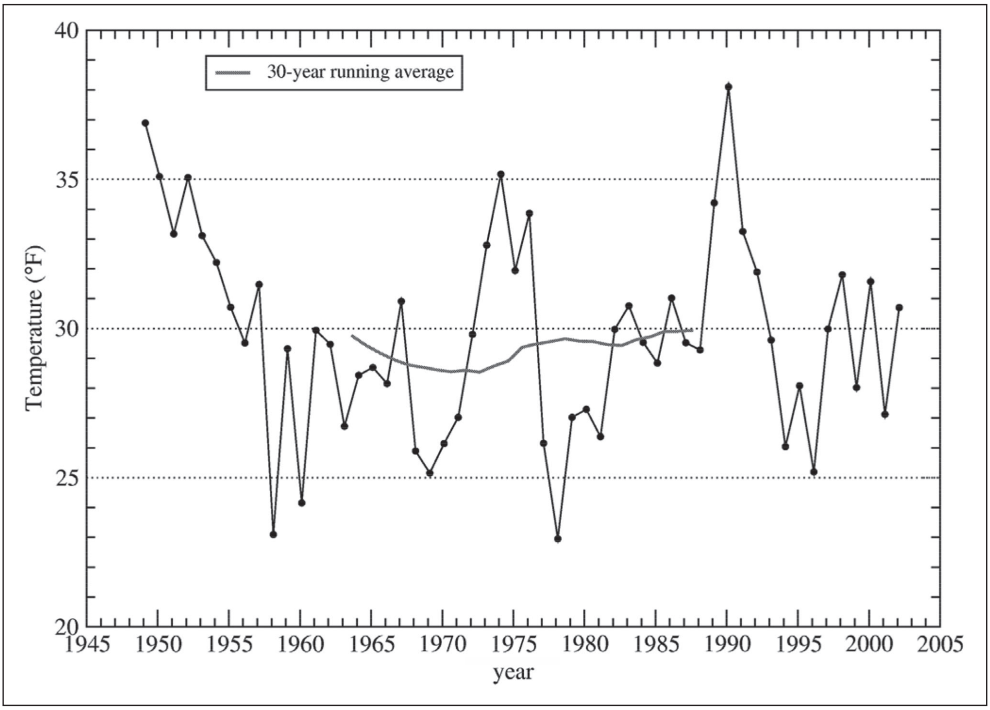

Figure 6. Average 3-month daily temperature during January, February, and March.

Summary

In this limited analysis, the Valley's snowfall and temperature records exhibit a weak correlation to the ENSO phenomenon. The fact that extremes in snowfall and temperature simultaneously run counter to the expected effects of the ENSO state suggests other unknown factors play a dominant role.

In conclusion, we summarize the unique climate of the Valley. In more populated, urban areas, hourly updates of wind speed, temperature, and humidity are available and the general public has a greater awareness of weather events. In the Valley, there are relatively few available real-time displays of local weather data; only those who have witnessed first-hand the large, rapid swings in weather and climate have a true appreciation for the uniqueness of the area. One can often travel less than 5 mi (8 km) in any direction and experience a climate very different from the Valley's. From a climate perspective, the Valley remains a particularly distinctive location, with its climate considered its "cash crop" (Weedfall and Dickerson 1965) and its location indeed a "bit of Canada gone astray" (Fortney 1977).

Acknowledgments

Grateful acknowledgement is made to the Thompson family for their decades of dedicated volunteer service in all kinds of weather, some not fit for man nor beast. Thanks are also extended to Ken Sturm for his recent years of service. This study could not have

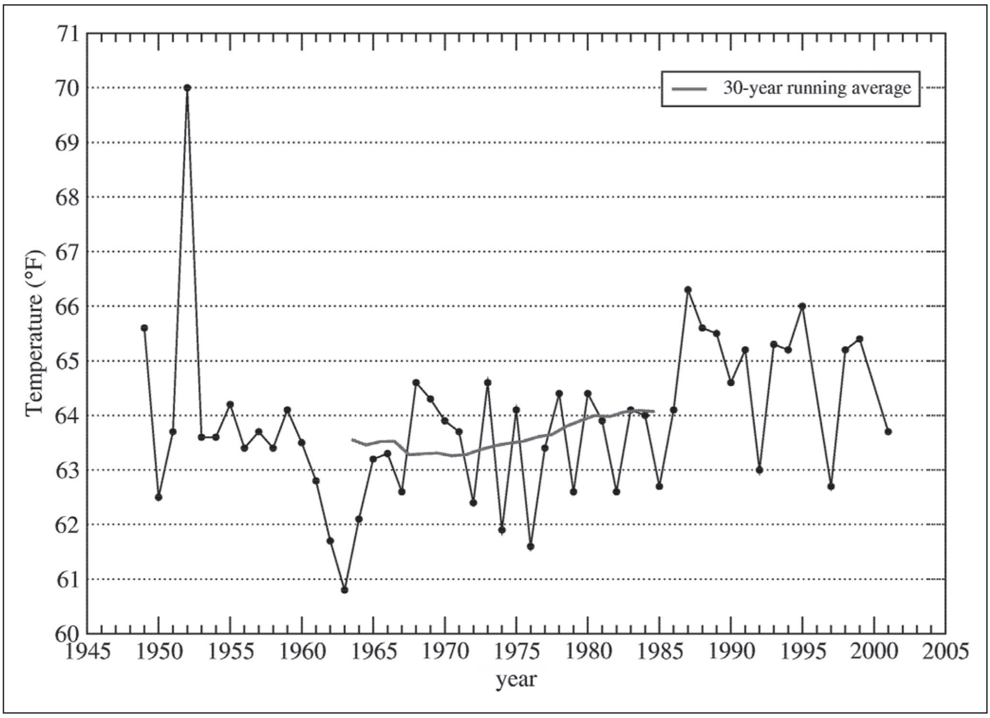

Figure 7. Average 3-month daily temperature during June, July, and August.

been conducted without their outstanding volunteer public service in the field of weather observation. We also acknowledge the National Climactic Data Center in Asheville, NC, for providing the edited, published data used in our analyses. We extend thanks to Robert O. Weedfall and W.H. Dickerson, authors of *The Climate of the Canaan Valley and Blackwater Falls State Park*, *West Virginia* (1965). Their report provided a critical, rich source of historical information on the Thompson family observations in the Valley. Finally, thanks to Jocelyn Smith, Laura Brake, and Denise Webb of the Canaan Valley Institute for their assistance in preparing the manuscript.

Literature Cited

Fortney, R.H., 1977. A bit of Canada gone astray. Wonderful West Virginia 41:24–31.

Leffler, R.J. 1974. Snowfall on the Allegheny Plateau of Maryland and West Virginia. Weatherwise 10/1974; 27:199–201. DOI:10.1080/00431672.1974.9931708.

Leffler, R.J. 1977. A distinct precipitation shadow in the valley of the South Branch of the Potomac River, West Virginia, National Weather Digest 2(4):21–24.

Leffler, R.J. 2005. Snowfall on the Allegheny Plateau of Maryland, Virginia, and West Virginia. NWS Baltimore/Washington Forecast Office Winter Weather Workshop Seminar.

National Oceanic and Atmospheric Administration (NOAA). 2015. NOAA's El Niño portal. Available online at http://www.elnino.noaa.gov.

Nexus. 2015. Current results: Average annual snowfall in Maine. Available online at http://www.currentresults.com/Weather/Maine/annual-snowfall.php.

Northeast Regional Climate Center (NRCC). 2015. CLIMOD dataset. Available online at http://climod.nrcc.cornell.edu/climod/frost/.

Patton, J.M., S.R. Smith, and J.J. O'Brien, 2003. Impacts of ENSO on snowfall frequencies in the United States. Monthly Weather Review 18:965–980.

Thornthwaite, C.W. 1948. An approach toward a rational classification of climate. Geographical Review 38:55–94.

Weedfall, R.O., and W.H. Dickerson 1965. The climate of the Canaan Valley and Blackwater Falls State Park, West Virginia, WV University Agricultural Experiment Station Current Report 43.

Wikipedia. 2015. Davis, West Virginia. Available online at https://en.wikipedia.org/wiki/Davis,_West_Virginia.