Brief Climatology for Los Alamos, NM

Bowen (1990) published a comprehensive climatology of the Los Alamos area based on observations at several meteorological-observing stations within the Laboratory's boundary. This early work was followed by a summary document (Bowen, 1992) that used more recent observations. These documents should be consulted for detailed analyses and station-to-station comparisons.

The climate description presented here summarizes some of the Bowen analyses and discusses some recent observations of wind patterns in Los Alamos canyon and evapotranspiration. The material is organized in sections that discuss the meteorological variables related to (1) the state of the atmosphere (its temperature, pressure, and moisture), (2) precipitation, (3) wind conditions, and (4) the exchange of energy at the surface. Normal values are based on observations taken at the official Los Alamos meteorological-observing station from 1961 to 1990. When extremes are given, the entire record is used. Although the location of the "official" station has changed over the years, all locations are within 30 m (100 ft) of each other in elevation and 5 km (3 mi) in distance. The composite record from the official stations is used to describe the climate of Pajarito plateau, at an elevation of approximately 2250 m (7400 ft) above sea level.

In general terms, Los Alamos has a temperate mountain climate with four distinct seasons. Spring tends to be windy and dry. Summer begins with warm, often dry, conditions in June, followed by a 2-month rainy season. In the autumn there is a return to drier, cooler, and calmer weather. And in winter, mid-latitude storms drop far enough south to keep the ground covered with snow for about two months. Details of the climate are presented below.

Atmospheric State. In July, the warmest month of the year, the temperature ranges from an average daily high of 27.2° C (81° F) to an average daily low of 12.8° C (55° F). The extreme daily high temperature in the record is 35°C (95° F). In January, the coldest month, the temperature ranges from an average daily high of 4.4° C (40° F) to a low of -8.3° C (17° F). The extreme daily low temperature in the record is -27.8° C (-18° F). The large daily range in temperature results from the site's relatively dry, clear atmosphere, which allows strong solar heating during the daytime and rapid radiative cooling at night.

Although the dry atmosphere promotes rapid nighttime cooling near the ground, this cooling is somewhat counterbalanced by the flux of heat from above, generated by turbulence in the drainage flow. Therefore, the strong surface-based temperature inversions often observed in valleys are not observed on the Pajarito plateau. Inversions of 3° C (5.4° F) over 100 m (328 ft) are typical, and these are generally destroyed in less than 2 hours after sunrise.

Average atmospheric pressure at the official observing station is 776 mbar (22.92 in. of Hg), which is 76% of standard sea level pressure. The average near-surface air density for the site is 0.958 kg/m ^{3} ; this is based on a calculation using the mean pressure and temperature at the official observing station.

Although relative humidity can vary considerably over 24 hours, monthly average values vary little during the year. Relative humidity ranges from a low of 39% in June to a high of 56% in December, averaging 51% over the entire year. Absolute humidity, a better indicator of atmospheric moisture content, ranges from a low of 2.4 g of water/m^3 of air in January to a high of 8.7 g/m^3 in July and August, when moist, subtropical air invades the region during the rainy season. Fog in Los Alamos is very rare, occurring less than five times a year on average.

Precipitation. The average annual precipitation (rainfall plus the water-equivalent of frozen precipitation) is 47.6 cm (18.7 in.). However, the annual total fluctuates considerably from year to year; the standard deviation of these fluctuation is 12.2 cm (4.8 in.). The lowest recorded annual precipitation is 17.3 cm (6.8 in.) and the highest is 77.1 cm (30.3 in.). The maximum precipitation recorded for a 24-h period is 8.8 cm (3.5 in.). The maximum 15-min precipitation in the record is 2.3 cm (0.9 in.).

Because of the eastward slope of the terrain, there is a large east-to-west gradient in precipitation across the plateau. White Rock often receives 13 cm less annual precipitation than does the official observing station, and the eastern flanks of the Jemez often receive 13 cm more.

About 36% of the annual precipitation falls from convective storms during July and August. Most of these convective storms are of the single-cell type; local conditions do not support the development of supercells and the severe weather associated with them.

This summertime precipitation maximum is often referred to as the "monsoon" season. However, the signature of a true monsoon circulation, namely large and persistent changes in wind direction, is not observed. "Rainy season" is probably a more accurate characterization of the July-August period.

Lightning is very frequent in Los Alamos. In an average year Los Alamos experiences 61 thunderstorm days a year, about twice the national average. (A thunderstorm day is defined as a day on which thunder is heard or a thunderstorm occurs). Only in the southeastern part of the country is this frequency exceeded. In addition to lightning, hail often accompanies these summertime convective storms. Hailstones of 0.6 cm (0.25 in.) are common, but stones of 2.54 cm (1 in.) have been reported. Hail has caused significant damage to property and vegetation, and localized accumulations of 7.6 cm (3 in.) have been observed.

Winter precipitation occurs mostly as snow; freezing rain is rare. The snow is generally dry; on average 20 units of snow is equivalent to 1 unit of water. Annual snowfall averages 150 cm (59 in.) but is quite variable. The standard deviation of fluctuations in the annual value is 71 cm (28 in.). The highest recorded snowfall for one season is 389 cm (153 in.), and the highest recorded snowfall for a 24-h period is 56 cm (22 in.). In a typical winter season, snowfalls equal to or exceeding 2.6 cm (1 in.) occur on 14 days, and snowfalls equal to or exceeding 10.2 cm (4 in.) occur on four days. The extreme single-storm snowfall in the record is 122 cm (4 ft).

Wind Conditions. Los Alamos winds are generally light, having an annual average (at the TA-6 station) of 2.5 m/s (5.5 mi/h). However, the period from mid-March to early June is apt to be windy. During this windy period, sustained wind speeds exceeding 4 m/s (8.8 mi/h) occur 20% of the time during the daytime, and the daily maximum wind gust exceeds 14 m/s (31 mi/h) about 20% of the time. The highest wind gust in the record is 34.4 m/s (77 mi/h). High winds are associated with frontal passages, thunderstorms, and mid-latitude storm systems. No tornadoes are known to have touched ground in the Los Alamos area; however, funnel clouds have been observed in Los Alamos and Santa Fe counties.

Winds over the plateau show considerable spatial structure and temporal variability. The relatively dry climate promotes strong solar heating during the daytime and radiative cooling by night. And because the topography is very complex, the heating and cooling rates are uneven over the area. When the large-scale pressure gradient is weak, thermally generated local flows develop and respond to the heating/cooling cycle. During sunny, light-wind days, an upslope flow often develops over the plateau in the morning hours. This flow is more pronounced along the western edge of the plateau, where it is 200 to 500 m (650 to 1650 ft) deep. By noon, southerly flow usually prevails over the entire plateau. Click here for daytime wind roses.

The prevailing nighttime flow over the western portion of the site is west-southwesterly to northwesterly. These nighttime westerlies result from cold air drainage off the Jemez Mountains and the Pajarito plateau; the drainage layer is typically 50 m (165 ft) deep in the vicinity of TA-6. At stations farther from the mountains, the nighttime direction is more variable but usually has a relatively strong westerly component. Just above the drainage layer, the prevailing nighttime flow is southwesterly. Click here for nighttime wind roses.

Observations made at TA-41 in Los Alamos canyon show that atmospheric flow in canyons is quite different from flow over the plateau. During the nighttime, cold air drainage flow is observed about 75% of the time. This gravity flow is steady and continues for an hour or two after sunrise when it abruptly ceases and is followed by an unsteady up-canyon flow for a couple of hours. The up-canyon flow usually gives way to the development of what appears to be a rotor that fills the canyon when the wind over the plateau has a strong cross-canyon component. When the rotor occurs, southwesterly (or southeasterly) flow over the plateau results in northwesterly (or northeasterly) flow at the canyon bottom. Down-canyon flow begins again around sunset, but the onset time appears to be more variable than cessation time in the morning. Rotors have been observed at night, but they are very rare.

Turbulence intensity, when expressed as the standard deviation of fluctuations in the horizontal wind direction has a median value of 22° during the day. Other things being equal, this value is larger than would be observed over flatter, smoother sites. At night, when the atmosphere is stable, the median value of the standard deviation of wind direction fluctuations drops to 15° .

Atmospheric dispersion potential is often related to a stability parameter that ranges from A to F (good to poor mixing potential). When this parameter is based on sigma phi measured at the TA-6 station, the frequency of occurrence of different stability parameter values is A: 10.6%, B: 8.0%, C: 15.9%, D:

38.6%, E: 13.9, and F: 13.1%. Statistics vary from station to station.

Energy Exchange at the Surface. Solar irradiance measurements show that Los Alamos receives more than 75% of possible sunshine annually. (Possible sunshine is defined as the amount received when the sky is cloud-free.) During most of the year, when there is no snow on the ground, about 80% of this incoming solar energy is absorbed at the surface. About half of this absorbed shortwave energy is offset by longwave radiation to space. The remainder of the radiant energy, called the net all-wave radiation, is dissipated by heating the soil, heating the lower layer of the atmosphere, and evaporating water from the soil and plants (called evapotranspiration). Preliminary analyses suggest that monthly total evapotranspiration reaches a maximum value of 7.4 cm (2.9 in.) in July. Monthly totals during January and February are about 0.8 cm (0.3 in.). Over the entire year, it appears that evapotranspiration totals approximately 90% of the annual precipitation.

References:

Bowen 1992: B.M. Bowen, *Los Alamos Climatology Summary*, Los Alamos National Laboratory Report LA-12232-MS, 42 pp.
Bowen 1990: B.M. Bowen, *Los Alamos Climatology*, Los Alamos National Laboratory report LA-11735-MS (May 1990).

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