Climate of California

Introduction

This publication consists of a narrative that describes some of the principal climatic features and a number of climatological summaries for stations in various geographic regions of the State. The detailed information presented should be sufficient for general use; however, some users may require additional information.

The National Climatic Data Center (NCDC) located in Asheville, North Carolina is authorized to perform special services for other government agencies and for private clients at the expense of the requester. The amount charged in all cases is intended to solely defray the expenses incurred by the government in satisfying such specific requests to the best of its ability. It is essential that requesters furnish the NCDC with a precise statement describing the problem so that a mutual understanding of the specifications is reached.

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The Means and Extremes of meteorological variables in the Climatography of the U.S. No.20 series are recorded by observers in the cooperative network. The Normals, Means and Extremes in the Local Climatological Data, annuals are computed from observations taken primarily at airports.

The editor of this publication expresses his thanks to those State Climatologists, who, over the years, have made significant and lasting contributions toward the development of this very useful series.

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Climate of California

Topographic Features- California extends along the shore of the Pacific Ocean between 32.5 and 42° North latitude. Its more than 1,340 miles of coastline constitutes nearly three-fourths of the Pacific coastline of the conterminous United States. Bounded on the north by Oregon, on the east by Nevada and Arizona, and on the south by Mexico, the total land area amounts to 158,693 square miles. With its major axis oriented in a northwest-southeast direction, the State is 800 miles in length. Its greatest east-west dimension is about 360 miles though its average width is 250 miles. However, it spreads over more than 10 degrees of longitude, a distance of 550 miles.

The Coast Range parallels the coastline from the Oregon border to just north of the Los Angeles Basin. It is generally no more than 50 miles from the coast to the crest of the range. The mountains rise abruptly from the ocean or from the narrow coastal plain to elevations of several thousand feet. Some peaks in the north are more than 8,000 feet above sea level.

The principal break in the Coast Range is at San Francisco Bay where an opening permits an abundant flow of marine air into the interior of the State under certain circulation patterns.

In the northern part of the State, the Coast Range merges with the Cascade Range, farther inland, to create an extensive area of rugged terrain more than 200 miles in width. The streams in the area work their way westward through deep canyons to the Pacific Ocean.

The Cascades then extend southeastward until they merge into the Sierra Nevada. In the north, the Cascades range generally from 5,000 to 10,000 feet in height, with Mt. Shasta rising to 14,162 feet. Farther south, the Sierra Nevada rise to over 10,000 feet in elevation. The Sierra Nevada, like the Coast Range, parallel the coast, but the crest over most of its length is about 150 miles inland. Thus, between the two ranges there is a broad, flat valley averaging 45 miles or more in width. At approximately 35° North latitude, the Sierra Nevada meet the Tehachapi Mountains. These then bend southwestward to join the Coast Range, closing off the southern end of the Central Valley.

From the point where the Tehachapi and the Coast Range join, a series of ranges extend southeastward to the southern border of the State. West of these ranges are basins that have a predominantly maritime climate, while to the east a continental desert regime prevails.

Both the extreme northeastern portion of California and the desert area of southern California east of the mountains lie within the Great Basin. The Great Basin extends from Utah to the Sierra Nevada and has no surface drainage to the ocean. It is an area of climatological extremes. In northeastern California, for example, Boca is one of the coldest reporting points in the State. Included in the deserts of the south, are Death Valley and the Mojave Desert. These are the hottest and driest parts of the State.

Streams in the southern part of California are small and intermittent. Draining the western slopes of the Sierra Nevada, however, is a series of streams of varying size. In the north, the Pit and Sacramento rivers combine to flow the length of the Sacramento Valley, through the Delta area, into San Francisco Bay. At intervals along the way, other streams join the Sacramento. Some of these are the: Feather, Yuba, Bear and American, all streams of considerable size, along with lesser creeks that drain small watersheds.

The San Joaquin Valley lies south of the Delta. Streams coming from the mountains into the northern two-thirds of the San Joaquin Valley empty into the San Joaquin River and drain northward to join the Sacramento River just before emptying into San Francisco Bay. In the southern one-third of the Valley, streams have no natural drainage to the ocean and much of the water is diverted away, however, occasionally water still empties into now usually dry Tulare Lake and Buena Vista Lake Bed.

Most of the major streams are fed by melting snow from the high slopes of the Sierra Nevada. Streamflow continues well into or throughout the arid summer months. Nearly all of the streams have been dammed to hold the water supply in reservoirs for irrigation, industrial and domestic uses throughout the dry part of the year, and to provide flood control during the winter and spring. As a result, less and less water from these streams flows directly to the ocean. Most of it is being used at least once before being drained to the ocean or put into storage.

At the north end of the State, an extensive area is drained by the: Klamath, Salmon, Trinity, Eel and Van Duzen rivers.

The largest streams on the central coast are the Russian River, which empties into the ocean about 50 miles north of San Francisco, and the Salinas River, which discharges into Monterey Bay. Other streams along the coast are short and small.

The Central Valley lies between the Coast Range and the Sierra Nevada. At the point where the rivers empty through Carquinez Strait into San Francisco Bay, the valley floor is only about 10 feet above sea level. Indeed, some reclaimed farmland within the delta system lies at or below sea level. At the north end of the Central Valley, Red Bluff is approximately 300 feet in elevation, while Bakersfield, near the south end, is around 400 feet. In length the valley extends nearly 500 miles, while the width of the floor is about 45 miles; when the gently sloping foothill area is included it extends to about 120 miles.

Within the State are found a variety of climates and extremes. Temperatures have been recorded from -45 degrees Fahrenheit (° F) to 134. Annual precipitation has exceeded 150 inches at one measuring site, while other points have gone for more than a year with no measurable rain. This variation in climate results from a number of causes.

The topography of the State is varied and includes Death Valley, the lowest point in the western hemisphere, with an elevation of 282 feet below sea level and less than 85 miles away, Mt. Whitney, the highest peak in the conterminous states at 14,494 feet above sea level. These wide ranges of altitude are responsible in part for the variety of climates and vegetation found in the State. Another significant factor is the continuous interaction of maritime air masses with those

of continental origin. The combination of these influences results in pronounced climatic changes within short distances.

Over the northern three-fourths of the State, there are two primary mountain chains paralleling the coast, while in the southern one-fourth there is only one. Isotherms run mostly north-south, parallel to the contours of the mountains. Along the western side of the Coast Range, the climate is dominated by the Pacific Ocean. Warm winters, cool summers, small daily and seasonal temperature ranges and high relative humidities are characteristic of this area. With increasing distance from the ocean, the maritime influence decreases. Areas that are well protected from the ocean experience a more continental type of climate with warmer summers, colder winters, greater daily and seasonal temperature ranges and generally lower relative humidities. Many parts of the State lie within a transitional zone where conditions range between these two climatic extremes. The mixture depends upon local topography and its influence on circulation patterns.

Summer is dry over most of the State. With the northward migration of the semi-permanent Pacific high, most storm tracks are deflected far to the north. California seldom receives precipitation from Pacific storms during this time of year. Occasionally, however, moist air drifts northward during the warm months from the Gulf of Mexico or the Gulf of California. At such times, scattered, locally heavy showers occur, mostly over the desert and mountain portions of the State.

The Pacific high decreases in intensity in winter and moves further south, permitting storms to move into and across the State, producing widespread rain at low elevations and snow at high elevations. Occasionally the broad-scale circulation pattern permits a series of storms to move into California from the southwest. This type of storm pattern is responsible for occasional heavy rains that may cause serious flooding.

The easternmost mountain chains form a barrier that protects much of California from the extremely cold air of the Great Basin in winter. There are occasions when cold air from an extensive high pressure area spreads westward and southward over California. In these cases, the warming by compression as the air flows down the slopes of the mountains into the valleys results in considerable moderation of temperatures. The ranges of mountains to the west offer some protection to the interior from the strong flow of air off the Pacific Ocean. As a result, precipitation is heavy on the coastal or western side of both the Coast Range and the Sierra Nevada and lighter on the eastern slopes. Precipitation is also slightly reduced at the highest elevations of the Sierra Nevada because the range extends above the level of maximum transport of the moisture-laden winds from the Pacific.

There is a trend toward temperature uniformity from day to day and from season to season on the ocean side of the Coast Range and in coastal valleys. East of the Sierra Nevada, temperature patterns are continental in character with wide excursions from high readings to low. Between the two mountain chains and over much of the desert area, the temperature regime is intermediate between maritime and continental air masses. Hot summers are the rule while winters are moderate to cold.

In the basins and valleys adjoining the coast, climate is subject to wide variations within short distances as a result of the influence of topography on the circulation of marine air. The Los Angeles Basin and the San Francisco Bay area offer many varieties of climate within a few miles. In the Bay area, for example, the average maximum temperature in July is about 65° F at Half Moon Bay on the coast, 87 at Walnut Creek 25 miles inland, and 93 at Tracy, another 25 miles inland. Santa Monica Pier, in the Los Angeles area, enjoys a normal July maximum of around 69° F, while the average increases to 95° F at Canoga Park in the San Fernando Valley just 15 miles to the north.

The steady flow of air from the northwest during the summer helps to drive the California Current southward almost parallel to the California coastline. However, since the mean drift is slightly offshore, there is a band of upwelling immediately off the coast as water from deeper layers is drawn into the surface circulation. The water from below the surface is colder than the semi-permanent band of cold water just offshore, which ranges from 25 to 50 miles in width.

The temperature of water reaching the surface from deeper levels varies from about 49 in winter to 55° F in late summer along the northern California coast, and from 57 to 65 on the southern California coast. At a distance of 200 to 300 miles offshore, surface water temperatures range from 51 to 65° F in the north and from 60 to 67 in the south. Thus, the water near the coastline is as much as 10° F colder during the summer than is the water farther west.

Comparatively warm, moist Pacific air masses drifting over this band of cold water form a fog bank which is often carried inland by the prevailing northwest winds. In general, heat is added to the air as it moves inland during the summer months, and the fog quickly lifts to form a deck of low clouds that extend inland only a short distance before evaporating completely. Characteristically, this deck of clouds extends inland further during the night and then recedes to the vicinity of the coast during the day. This layer of maritime air is usually from 1,500 to 2,000 feet deep, while above this layer the air is relatively warm, dry and cloudless.

Temperature- On the coast, the small range in temperature from day to night and from winter to summer produces an unusually equable regime. With increasing distance from the coast, depending to some extent upon the amount of marine influence experienced, temperature ranges become wider. Higher elevations in the mountains also experience large temperature variation.

The lowest temperature recorded in the State was at Boca, 5,532 feet in Nevada County, when a reading of -45° F was observed on January 20, 1937. At Boca, where temperatures of 21° F or colder have been recorded in every month of the year, the long-term average minimum for January is 11. Greenland Ranch, on the other hand, at an elevation of 168 feet below sea level, has reported a maximum temperature of 134° F. This is the highest temperature observed anywhere in the United States, and occurred on July 10, 1913. This is an area where temperatures are persistently high throughout the summer. In the summer of 1917, there were 43 consecutive days with maximum readings of 120° F or higher at Greenland Ranch.

The average length of the growing season, as limited by occurrences of 32° F temperatures, ranges from 365 days on the south coast to less than 50 days at high elevations of the Sierras. Most coastal valleys and the Central Valley have a freeze-free season of 225 to 300 days. The

agricultural area within the southeastern desert basin experiences a growing season ranging from 225 to 325 days long. The season is limited to 100 to 125 days in the northeastern interior.

Precipitation- Annual precipitation totals in excess of 50 inches per year are characteristic of the west slope of the Sierra Nevada north of Stockton, the west slope of the Coast Range from Monterey County northward and parts of the Cascades. Exceptions to this are totals that decrease to about 20 inches in the vicinity of Monterey Bay and parts of the San Francisco Bay area. In the lee of the Coast Range, average yearly amounts drop off to 15 inches in parts of the Sacramento Valley and to less than eight inches over most of the San Joaquin Valley. The northeast interior portion of the State receives from 15 to 18 inches of precipitation a year.

Thunderstorms may occur in California at any time of the year. Near the coast and over the Central Valley there appears to be no definite season. The storms are usually light and infrequent. Over the interior mountain areas storms are more intense, and they may become unusually severe on occasion in the Sierra Nevada. In these mountain areas, thunderstorms occur 50 to 60 days per year.

Snow has been reported in nearly every part of California, but it is very infrequent west of the Sierra Nevada except at high elevations of the Coast Range and the Cascades. In the Sierra Nevada, moderate amounts of snow are reported nearly every winter at elevations as low as 2,000 feet. Amounts and intensities increase with elevation to around 7,000 or 8,000 feet. Above 4,000 feet elevation snow remains on the ground for appreciable lengths of time each winter. Occasionally, highways are closed due to blowing and drifting snow. East of the Sierra Nevada at elevations of 4,000 feet and higher, most winter precipitation is in the form of snow, but amounts are usually quite light.

California lies within the zone of prevailing westerlies and on the east side of the semi-permanent high pressure area of the northeast Pacific Ocean. The basic flow is from the west or northwest during most of the year. Mountain chains within the State, however, are responsible for deflecting these winds and, except for the immediate coast, wind direction is likely to be more a product of local terrain than it is of prevailing circulation.

During the winter, wind direction and speed are modified by migratory pressure centers. With a strong high pressure area over the Great Basin and an intense low pressure area approaching from the west, strong and sometimes damaging winds occur, usually from an easterly or southeasterly direction, especially along the coast and in the coastal mountains. As the storms move inland, the winds veer to southerly and southwesterly directions, and high wind speeds may occur anywhere within the State with the greatest velocities at high elevations.

Under a slightly different configuration of these pressure systems, winds tend to flow out of the Great Basin into the Central Valley, the Southeastern Desert Basin, and the South Coast. Such wind situations are known in southern California as “Santa Ana” winds. The air is typically very dry. The winds are strong and gusty, sometimes exceed 100 mph, particularly near the mouth of canyons oriented along the direction of airflow. It is a situation that leads to serious fire suppression problems and often results in the temporary closing of sections of highways.

A similar circulation pattern creates the "northers" of the Sacramento and San Joaquin Valleys. As a result of compressional heating of air flowing out of the Great Basin, this situation results in pronounced summer heat waves. In winter, the result is usually a rather mild temperature accompanied by a dry, persistent wind.

The typical northwest wind of summer is reinforced by the dynamics of the thermal low pressure area located over the Central Valley and the Southeastern Desert area. In the San Francisco Bay area there is a marked diurnal pattern in the strength of the wind even though an onshore circulation tends to continue throughout the 24-hour period.

The Los Angeles Basin is almost completely enclosed by mountains on the north and east. The Pacific Ocean lies to the west. A temperature inversion tends to prevent vertical mixing of the air through more than a shallow layer. The geographical configuration and the southerly location of the Basin permit a fairly regular daily reversal of wind direction—offshore at night and onshore during the day. Pollution products tend to accumulate and remain within this circulation pattern.

Another local characteristic of the northwest wind along the shore is the creation of a jet effect in the vicinity of some of the more prominent headlands. The most outstanding of these currents of air is found off of and to the south of Point Arguello. Here a strong jet of air is projected southward past San Miguel and San Nicholas Islands, driving a huge eddy as much as 200 miles in diameter. The air swings eastward near San Diego then northward and westward along the coast to rejoin the southward flowing air at the west end of the Santa Barbara Channel. Similar but smaller eddies form in the vicinity of the Golden Gate, just south of Point Reyes and south of Monterey Bay around Point Sur. Wind speeds in the immediate vicinity of these major headlands can be two or three times as great as the wind flow at nearby points.

During periods of moderate to strong upper level, westerly flow over central parts of the State, particularly during the winter and spring, a "Sierra Wave" is created near Bishop.
On annual average, five tornadoes are reported in the State. They are generally not severe, in many cases amounting to little more than damage to trees or light buildings. In addition, pilots occasionally report funnel clouds aloft.
With the broad expanse of water to the west of California, the fetch of wind over hundreds of miles permits the buildup of seas and surf during much of the year. Seas of five feet or higher are observed most frequently off the California coast during spring with a 30 to 40 percent occurrence. Seas of eight feet or more occur 10 to 20 percent of the time, and seas of 12 feet or more are observed between five and 10 percent of the time during the spring. Such seas result in good surfing conditions at many beaches.

In general, relative humidities are moderate to high along the coast throughout the year. Inland hunidities are high during the winter and low during the summer. With increasing distance from the ocean, relative humidity tends to decrease. Where mountain barriers prevent the flow of marine air inland, humidities rapidly decrease. Openings in these barriers permit a significant influx of cool, moist air and as it mixes with the drier inland air, a more gradual decrease of moisture results. This pattern is characteristic of most coastal valleys. Meanwhile, the State's deserts experience very low humidities with the high temperatures of summer. Winter humidity

is usually moderate to low and only occasionally do moist air and cool temperatures combine to produce high relative humidity readings.

The Sacramento and San Joaquin Valleys are areas of variable relative humidity. During the warm season, humidities are characteristically low and occasionally, under the influence of the "norther", readings may drop to below 10 percent. In the Delta, at the confluence of the Sacramento and San Joaquin Rivers, a strong inflow of marine air during the summer creates a transition zone between the high humidities of the coast and the low readings of the interior. Winter values are usually moderate to high. A shallow layer of ground fog, known locally as "tule fog", frequently forms at night and can persist for as long as two or three weeks.

Many California thunderstorms produce little to no precipitation. Range and forest fires often result from the lightning strikes. However, each year, some flash flooding is reported as a result of thunderstorms dropping heavy rain especially on steep slopes. Hail, up to one-half inch in diameter is sometimes reported, but serious damage is infrequent.

In southern California most flooding is the result of heavy precipitation over a period of days. The short streams and steep watersheds emptying onto lowlands that may be heavily populated produce large volumes of water within short periods and damage is often severe. The problem is sometimes compounded by the denuding of large areas of the watershed by fire during the previous season.

The west slopes of the coastal ranges in the central and northern parts of the State also experience flooding as a result of heavy precipitation over a period of days. These streams are usually longer than those of southern California and require a longer time to build up a flood potential. The Eel and Klamath rivers, as well as others in the northwestern part of California, are larger streams. The Klamath drains a basin of more than 12,000 square miles. In these streams, a flood buildup may extend over a period of a week or longer.
The streams of the Sierra Nevada and Cascades overflow either as a result of rainfall or snowmelt, or from a combination of these. Dams and reservoirs on these streams help decrease the flood potential. Most of the streams are still capable, however, of causing occasional major damage along their downstream reaches.

Climate and the Economy- There are extended periods every summer with little or no precipitation. This is the normal and expected condition. A precipitation deficiency becomes significant in the State when the normal winter water supply fails to materialize. Winter range is important in the livestock industry. An abnormally dry winter can be disastrous to cattle raising.

Most of California's water supply is used for agriculture. A shortage of irrigation water stored at the beginning of the season is serious, since normal summer precipitation does not provide a sufficient amount of agriculture's requirements. California has millions of acres of farm land under irrigation.

Most of the water supply for crops comes from the mountains of the State. Falling as rain or snow, it is held in reservoirs and as snow pack. A smaller part of the State's water requirement is met by water from the Rockies via the Colorado River. This water is used in the southeastern

Desert and the south coastal area. Within the State, approximately three-quarters of the stream flow is generated in the area north of the latitude of Sacramento, while more than four-fifths of the water requirements lie south of this line. Thus, water distribution is a major concern in the State.

The long growing season characteristic of most of the valley areas where agriculture is concentrated is an important factor in the production picture. Some parts of the State are able to produce winter truck crops. The long dry spell of the summer facilitates the planting, cultivation, and harvest of many crops, and isolated late spring, summer or early fall rains can possibly cause more damage than good. Splitting of ripening fruit sometimes results from unseasonable showers at an inappropriate time. Drying winds occasionally cause damage to developing crops. In general, however, the distribution of temperature and precipitation is highly favorable for most agricultural enterprises.