CLIMATE OF CALIFORNIA

TOPOGRAPHIC FEATURES – The State of California extends along the shore of the Pacific Ocean between latitudes 32.5° and 42° North. 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 thought its average width is only 250 miles. However, it spreads over more than 10° 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 spectacular Mt. Shasta rising to 14,161 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. In the vicinity of latitude 35 degrees North the Sierra Nevada meets the Tehachapi Mountains, which 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 Grerat 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 the coldest reporting point in the State. Included in the deserts of the south are Death Valley and the Mojave Desert which 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 River and the Sacramento River combine to flow the length of the Sacramento Valley, through the Delta area, into San Francisco Bay. At intervals along the way other streams empty their waters into the Sacramento. Some of these are the Feather, Yuba, Bead, and American—streams of considerable size—along with a host of lesser creeks that drain small watersheds.

South of the Delta lies the San Joaquin Valley. 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 just before emptying into San Francisco Bay. In the southern one-third of the Valley, streams have no natural drainage to the ocean, but empty into Tulare and Buena Vista Lakes.

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. Many of the streams have been dammed to hold the water supply in reservoirs for irrigation, industrial, and domestic uses thoughout 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 sea or percolated into underground storage.

At the north end of the State an extensive area is drained by the Klamath, Salmon, Trinity, Eel, and Van Duzen Rivers. These streams are not yet controlled as much as those on the slopes of the Sierra Nevada. Plans are being developed for the eventual use of these waters to meet requirements of this immediate area, or of areas to which the water might be transported.

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 Slainas River, which discharges into Monterey Bay. Other streams along the coast are short and small.

The Central Valley, sometimes called the Great 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 actually 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 only about 45 miles; when the gently sloping foothill area is included it extends to about 120 miles.

A large number of people come to California in order to enjoy the benefits of the celebrated climate. It comes as a surprise, therefore, to many newcomers to learn that within the State are to be found a variety of climates, ranging from one extreme to the other. Temperatures have been recorded from minus 45° to 134° F. Annual precipitation at one measuring station has exceeded 161 inches, while other points have gone for more than a year with no measureable rain. A Californian, if he is free to select his living site, may choose almost any kind of climate. 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 U.S., with an elevation of 276 feet below sea level and less than 85 miles away, Mt. Whitney, the highest peak in the conterminous states at 14,495 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 countours of the mountains, instead of east-west as is common in most parts of the temperate zone. 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 a dry period over most of the State. With the northward migration of the semi-permanent Pacific high during summer, 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 broadscale circulation pattern permits a series of storm centers to move into California from the southwest. This type of storm pattern is responsible for occasional heavy rains that may cause serious flooding.

EFFECTS OF TOPOGRAPHY ON CLIMATE – 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. Even 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.

Temperature trends toward 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 the maritime and the continental models. 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 64° F. at Half Moon Bay on the coast, 87° F. at Walnut Creeek only 25 miles inland, and 95° F. at Tracy, just 50 miles inland. Santa Monica Pier, in the Los Angeles area enjoys a normal July maximum of around 75° F., while the average increases to 95° F. at Canoga Park in the San Fernando Valley just 15 miles to the north.

EFFECT OF GENERAL CIRCULATION ON CLIMATE – A dominating factor in the weather of California is the semi-

permanent high pressure area of the north Pacific Ocean. This pressure center moves northward in summer, holding storm tracks well to the north, and as a result California receives little or no precipitation from this source during that period. In winter, the Pacific high retreats southward permitting storm centers to swing into and across California. These storms bring widespread, moderate precipitation to the State. Some of them travel far enough to the south to spread moisture beyond the Mexican border. When changes in the circulation pattern permit storm centers to approach the California coast from a southwesterly direction, copious amounts of moisture are carried by the northeastward streaming air. This results in heavy rains and often produces widespread flooding during the winter months.

There is another California weather characteristic that results from the location of the Pacific high. The steady flow of air from the northwest during the summer helps to drive the California Current of the Pacific Ocean as it sweeps 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° F. in winter to 55° F. in late summer along the northern California coast, and from 57° to 65° F. 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° F. in the south. Thus, the water near the coastline is as much as 10° 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 bank of fog which is often swept inland by the prevailing northwest winds out of the high pressure center. In general, heat is added to the air as it moves inland during these 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.

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. Exception to this are totals that decrease to about 20 inches in the Monterey Bay area and parts of the San Francisco Bay area. In the lee of the Coast Range yearly 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 moisture in a year.

The maximum intensity of precipitation for periods of 12 hours or longer which might be expected at intervals of 10 to 100 years is greater in portions of the San Gabriel and San Bernardino Mountains in southern California than anywhere else in the continental United States.

THUNDERSTORMS – 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 at intermediate and high elevations of the Sierra Nevada. In these mountain areas, thunderstorms, observed by radar at one point of another, average 50 to 60 days per year. They usually occur when cool, moist air moves in to break a prolonged hot spell.

SNOWFALL – Snow has been reported at one time or another 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, snow in moderate amounts is 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. Highways are closed for periods of a few hours to two or three days at a time by blowing and drifting snow. East of the Sierra Nevada at elevations of 4,000 feet, or higher, most winter precipitation is in the form of snow, but amounts are usually quite light.

TEMPERATURE – Within the boundaries of the State are to be found areas of moderate temperatures and other places where temperatures reach extreme values of either heat or cold. On the coast the small range in temperture 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 recorded in the State was at Boca, 5,532 feet in Nevada County, when a reading of minus -45° F. was observed on January 20, 1937. Here at Boca where sub-freezing temperatures have been recorded in every month of the year, the long-term average minimum for January is only 8° F. 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 though they are comfortably cool in winter. In the summer of 1917 there were 43 consecutive days with maximum readings of 120° F. or higher at Greenland Ranch.

GROWING SEASON – 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 Sierra Nevada. 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 reports a growing season ranging from 225 to 325 days long, but the season is limited to 100 to 125 days in the northeastern interior.

WINDS – 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 in the free air above the State, therefore, is from the west or northwest during most of the year. The several 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, storm tracks move further south. 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 the coast 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 identified in southern California by the name "Santa Ana Wind." 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 occasionally leads to serious fire suppression problems and often results in the temporary closing of sections of main highways to campers, trucks, and light cars.

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 heat waves in summer. In winter the result is usually a rather mild temperature accompanied by a dry, persistent wind that many persons find unpleasant.

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. This helps to carry locally produced air pollution products away from the Bay area, but creates problems for the regions immediately south and east of the source area.

In the Los Angeles area, however, the Basin is almost completely enclosed by mountains on the north and east. Coupled with this is a characteristic of the air along most of the coastal area of California. The vertical temperature structure (inversion) tends to prevent vertical mixing of the air through more than a shallow layer (1,000 to 2,000 feet deep). 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. With the concentrated population and industry, pollution products tend to accumulate and remain within this circulation pattern.

Another local characteristic of the northwest wind alongshore 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 Pt. 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 Pt. Reyes, and south of Monterey Bay around Pt. 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 westerly flow at upper levels over the central part of the State, particularly during the winter and spring, the well-known "Sierra Wave" is created in the Bishop area. Although this phenomenon is particularly useful to sail plane enthusiasts, it can also be a hazard to the unwary pilot.

TORNADOES – Tornadoes have been reported in California, but with a frequency of only one or two per year. They are generally not severe, in many cases amounting to little more than damage to trees or light buildings. In addition, pilots occasionally report seeing funnel clouds aloft, particularly off the southern California coast.

WAVES AND SURF – 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. The "Climatological and Oceanographic Atlas" for the North Pacific Ocean suggests that seas of five feet or higher are observed most frequently off the California coast during the spring season. During these months they occur 30 percent to 40 percent of the time. Seas of eight feet or more occur 10 percent to 20 percent of the time, and seas of 12 feet or more are observed between five percent and 10 percent of the time during the spring.

Such seas result in good surfing conditions at many of the beaches along the coast. Water temperatures in the 50's in the San Francisco area, however, discourage all but the most hardy. Water temperatures in the 60's during much of the year on the southern California beaches makes the sport more enjoyable there.

RELATIVE HUMIDITY – 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. Since the ocean is the source of the cool, humid, maritime air of summer, it follows that with increasing distance from the ocean, relative humidity tends to decrease. Where mountain barriers prevent the free flow of marine air inland, humidities decrease rapidly. Where openings in these barriers permit a significant influx of cool, moist air it mixes with the drier inland air, resulting in a more gradual decrease of moisture. This pattern is characteristic of most coastal valleys.

The Mojave and Colorado Deserts experience very low humidities with the high temperatures of summer. Winter readings are 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 area, 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 so little precipitation that range and forest fires often result from the lightning strikes, although heavy precipitation occasionally results. Some flash flooding has been reported as a result of thunderstorms. Hail up to one-half inch in diameter is sometimes reported, but serious hail damage is infrequent.

FLOODS – In southern California most flooding is the result of heavy precipitation over periods of one or two 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 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 only a few 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. With the construction of more dams and reservoirs on these streams the frequency of damaging floods decreases. Most of the streams are still capable, however, of causing occasional major damage along their downstream reaches.

The extreme southern portion of the San Joaquin Valley has no direct drainage to the sea. Excessive runoff from the southern Sierra Nevada into this area can result in the temporary enlargement of Buena Vista Lake and Tulare Lake.

CLIMATE AND THE ECONOMY – Drought, as applied to agricultural practices in California, must be evaluated on a different basis than in other parts of the country. Typically there are extended periods every summer with little or no precipitation. This is the normal and expected condition. A deficiency of the precipitation 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.

Approximately 90 percent of California's water supply is used for agriculture. A shortage of irrigation water stored at the beginning of the season in numerous reservoirs is serious, since normal summer precipitation does not provide a sufficient amount of agriculture's requirements. California has about 37 million acres of farmland, but more than one-half of this is

open range and less then one-third is cropland. Approximately 8.5 million acres are under irrigation and this figure is increasing. At the present time agricultureal, domestic, and industrial demands for water amount to 30 million acre-feet per year. A requirement for 50 million acre-feet is anticipated within a few years.

Most of the water supply for crops comes from the mountains of the State. Falling as rain or snow during the winter, it is held in reservoirs and as snowpack until needed during the growing season. A smaller part of the State's water requirement is met by the importation of water from the Rockies via the Colorado River. This water is used in the southeastern Desert and the south coastal area. Within the State more than 70 percent of the streamflow is generated in the area north of the latitude of Sacramento, while about 80 percent of the water requirements lie south of this line. Thus, distribution of water is a major concern within 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 off-season truck crops and vegetables. Today's transportation networks carry these crops to all parts of the country and overseas. Some crops are grown that require a long freeze-free season. Others require the very high temperatures found only in some parts of the desert. The long dry spell of the summer period 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. Drying winds occasionally cause damage to developing crops. Splitting of ripening fruit sometimes results from unseasonable showers at an inappropriate time. In general, however, the distrubution of temperature and precipitation is highly favorable for most agricultural enterprises.