Down-Canyon Afternoon Winds [1]

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ABSTRACT

In east-facing canyons in the coastal mountains of California, the daytime thermal up-canyon winds are frequently replaced, usually in early afternoon, by a moderately strong down-canyon wind. The same type of wind has also been noted in the western foothills of the Sierra Nevada. This shift in the wind to down canyon is important in wildland fire control and has been a factor in some fire-fighting fatalities. Results of a fire-climate survey conducted in northwestern San Diego County to study these winds show that, in the summer and early fall of 1959, winds switched to down canyon in the afternoon on about one-quarter of the days. From the surface records and a few double-theodolite and airplane observations, a diagrammatic model of this phenomenon has been constructed. The stability of the lower atmosphere along the coast was closely related to the occurrence of down-canyon winds in the area studied. The possibility of making short-range predictions exists by using this relationship along with other considerations.

1. Introduction

On 12 July 1959 on the Dry Fire in the southern Sierra Nevada in California, two fire fighters were burned — one fatally. The fire burned on the west side of the Kern River in an area with an easterly aspect. The preliminary investigation report read as follows: "Both men were sent after water for their crew. The Sector Boss instructed them on their route of travel to the source of water about ½ mile away. Wind was upslope and their route was below the fire. *At 1:30 P.M., about 45 minutes after they left the fire line, the wind started blowing downhill—a 180° change in direction* (italics added). The men on the fire line retreated into the burn. They noticed (the two men) on the opposite ridge returning with the water. The line boss decided the best place for them to go was to a pile of rocks on top of a small ridge. They had already been cut off from the stream where they had obtained water. The men were able to get to the rocks ahead of the fire after directions were shouted from the fire line. Flames surrounded the rocks—a borate drop from a TBM was unsuccessful—fire continued around the rocks for ten or fifteen minutes. Helicopters and ambulances rushed the men to the hospital in Kernville about one hour after they first were burned."

[1] Presented in part at 187th National Meeting of the American Meteorological Society, Eugene, Oregon, June 14–16, 1960.

Unfortunately, fire fighters can cite other tragedies related to the occurrence of down-canyon afternoon winds. Less than a month after the Dry Fire, the Decker Fire burned on the eastern slopes of the Santa Ana Mountains in southern California. The fire started on the afternoon of 8 August 1959, while winds were blowing down canyon. Early in the evening, the down-canyon winds suddenly stopped; the fire then responded to topographic influences and began running upslope. A firewhirl developed. It trapped and burned 25 men. Six were burned seriously, and all 6 later died.

The classical pattern of thermally-produced valley winds is one showing an up-valley wind during the daytime and a down-valley wind at night. Many observational and theoretical studies have been made of this wind system. Hawkes [1] has presented the principles of mountain and valley winds as described in papers, mostly German, that appeared before World War II. Gleeson [2; 3] and Fleagle [4] have developed and expanded theories of this wind system, or portions of it, while Defant [5] has constructed a schematic model which shows the relationship of the valley wind system to the slope wind. From this model, fire fighters have been taught that, in mountainous topography and in the absence of an overriding pressure gradient, they can expect winds to blow up the valleys and canyons from shortly after sunrise until shortly after sunset and to blow down valley and down canyon at night.

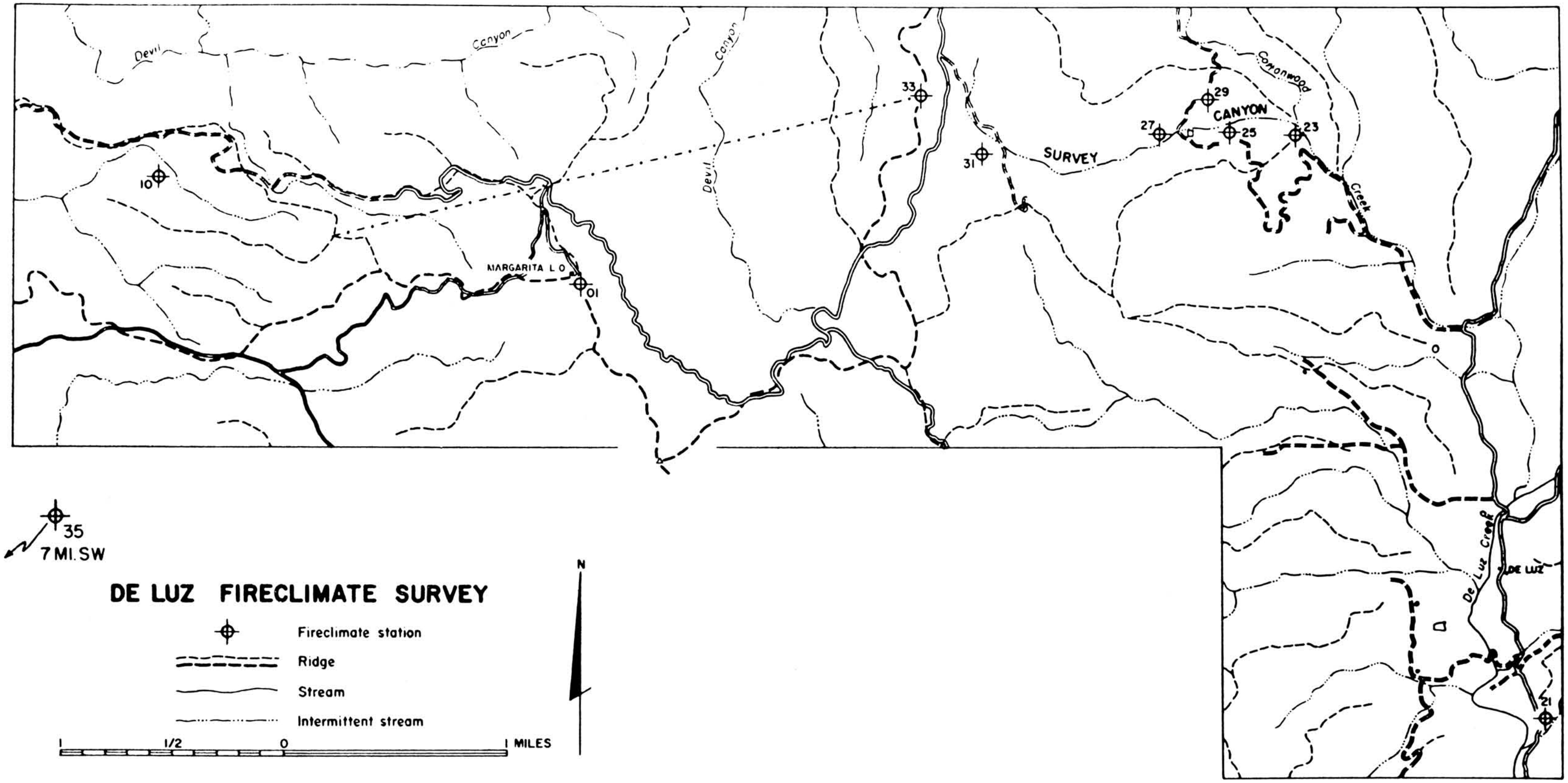

FIG. 1. Location of survey stations. Station 33 at the head of Survey Canyon is about 13 mi from the coast and about 50 mi north-northwest of San Diego. The cross section (fig. 2) runs along the bottom of the canyon in which station 10 is located, then along the straight dash-dot line to the head of Survey Canyon and along the bottom of Survey Canyon.

But there are times when winds shift to down canyon around noon or early afternoon in east-facing canyons. This shift has been observed during field surveys conducted by the Forest Fire Research Division of the Pacific Southwest Forest and Range Experiment Station in California, in the Coast Range [6] and in the western foothills of the Sierra Nevada [7]. Usually, a significant change in the synoptic weather pattern was not apparent. The down-canyon afternoon winds that have been observed were stronger than the normal up-canyon winds, and fires have burned erratically in the transition zone between up-canyon and down-canyon flow when the change is taking place.

2. The De Luz studies

To investigate this phenomenon, a small, east-facing canyon in northwestern San Diego County was selected for study. This canyon is on the east side of the Santa Margarita Mountains and opens eventually into the larger north-south De Luz Valley. De Luz Creek in turn joins Santa Margarita River which flows southwestward to the ocean.

In 1958, eight wind recording stations (figs. 1 and 2) were established. Five of them were in the east-facing canyon, which will be referred to as Survey Canyon; one was on Margarita Lookout; one was in Wildcat Canyon, which opened to the west; and one was in north-south De Luz Valley. Temperatures and relative humidities were recorded at 4 of these stations (nos. 10, 21, 23 and 33) and at station 29 which did not have a wind recorder. This survey was continued for about 3½ weeks starting in mid-August. On several days, a tethered balloon was put up in Survey Canyon (see square, fig. 2).

In 1959, four wind-recording stations were established: one in Survey Canyon (no. 25), one in the saddle at the head of Survey Canyon (no. 33), one in Wildcat Canyon on the west side (no. 10), and one (no. 35) nearer the ocean about 7 mi southwest of station 10. Temperatures and relative humidities were recorded at the last 3 stations and at station 29. This survey was run from mid-July through October. On four days, double-theodolite pilot-balloon observations were made in Survey Canyon, and on one day temperatures were observed from an aircraft making a number of traverses in the plane of the cross section.

Each wind-recording station had a 3-cup Robinson-type anemometer and a wind vane on a 20-ft pole in a well-exposed location. The $\frac{1}{10}$- and 1-mi contacts made by the anemometer and

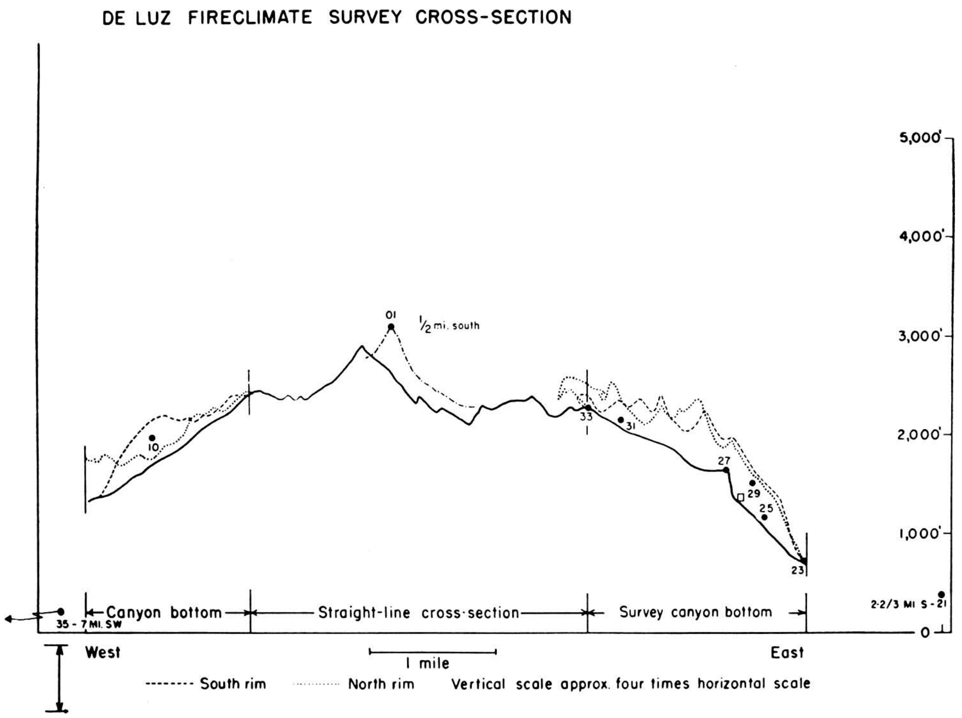

FIG. 2. East-west cross section through survey area.

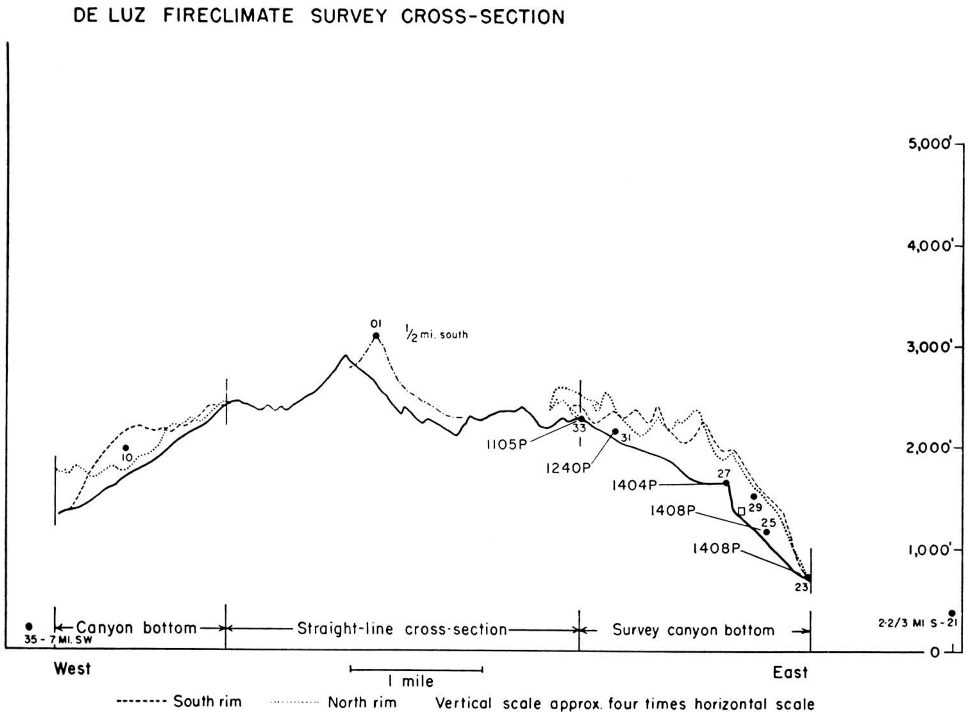

FIG. 3. Approximate time of wind shift to westerly at the stations in Survey Canyon on 8 September 1958.

the wind direction to 8 points of the compass were recorded on an Esterline-Angus operations recorder. Ten samples of wind direction were taken each hour.

Temperature and humidity were recorded on hygrothermographs exposed in shelters at standard height.

3. Down-canyon afternoon winds

Only a preliminary discussion of the phenomenon of down-canyon afternoon winds can be presented in this paper. Much is yet to be learned about the mechanism of these winds and their relationship to topography, to other toposcale patterns such as the sea breeze, and to the larger meso- and macroscale patterns. Further understanding will depend upon more extensive observations in a larger area and upon more intensive observations, including vertical soundings and the use of tracer techniques, in and near selected canyons.

Frequency. In 1958, during the 24 days of the survey, only one 3-day period of down-canyon afternoon winds was encountered. This was on the last 3 days, during a period of hot weather, which was somewhat surprising. It was expected that these winds would occur when the marine layer was deep and the coastal weather was cool.

In 1959, during the 3½-month survey, winds shifted to down-canyon during the daytime on about one quarter of the days, actually 28 out of 105 days. The down-canyon winds occurred during both hot and cool weather and with clear and cloudy skies.

Characteristics. Having 28 cases to work with for the 1959 season, we were able to examine some of the characteristics of these anomalous winds.

The average time of wind shift to down canyon at station 25 in Survey Canyon was about 1330 PST, although on some days the shift occurred as early as 1000 or 1100. If the shift did not take place before 1600 PST, the day was not classed as a down-canyon-wind day. The 1958 data, when 5 stations were in operation in Survey Canyon, showed that the shift takes place first in the saddle at the head of the canyon and then progresses steadily down the canyon (see fig. 3).

Fig. 4 shows that the speed of the winds that shifted to down canyon during the day (and

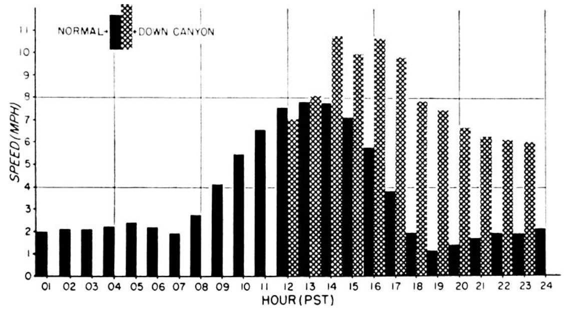

FIG. 4. Average hourly speeds of winds that shifted to down-canyon during the day compared with the speeds of the normal up-canyon daytime winds and nighttime drainage winds.

these occasionally continued into the evening hours) was higher than the speed of the normal up-canyon afternoon winds and the nighttime drainage winds. The greatest difference occurred during the late afternoon and early evening hours when winds usually became very light as they changed from up-canyon to down-canyon.

Investigation of the frequency distribution of highest hourly temperatures and lowest hourly relative humidities showed that down-canyon afternoon winds tended to occur during both warm, dry weather and cool, humid weather and tended not to occur when the weather was more or less normal. At station 29 in Survey Canyon on days when the wind did not shift, the temperatures were most frequently in the high 80's and low 90's. On days when winds shifted to down canyon during the day, the temperatures showed a sort of bi-modal distribution — tending to be either below 85 or over 95. Relative humidities showed similar distributions.

Structure. In an attempt to investigate in more detail the phenomenon of down-canyon afternoon winds, cross sections of the lower atmosphere in the survey area were drawn with potential temperatures as the basis for analysis. Since pressure measurements were not made on the survey, actual temperature was converted to potential temperature by using the station elevation, the standard atmosphere and the interpolated sea-level pressure. Except for the one day on which temperatures were observed from an aircraft, upper-air temperatures were not measured on the survery. The 0400 PST and 1600 PST San Diego radiosonde observations were used as a guide for the coastal area, but even so the analysis above the ground surface involved a good deal of estimation.

Cross sections for two days, 17 and 20 August 1959, will illustrate differences in air structure. On August 17, the winds did not shift to down canyon during the day; on August 20, they did shift.

During the early morning of August 17 (fig. 5), the San Diego sounding and temperatures in the survey area showed a stable stratification. By 0800 PST (fig. 6), some heating had taken place at all stations and up-canyon winds were blowing in both canyons. Since the station in the saddle (no. 33) had an easterly wind, the highest surface potential temperatures were indicated west of that station.

Davidson and Rao [8; 9] did not find clear-cut evidence of the existence of up-valley winds in the Vermont valleys they studied in 1957. Since the De Luz cross sections show up-canyon daytime winds in both east-facing and west-facing canyons, there is no doubt that the wind in at least one canyon is a thermal wind regardless of the direction of the gradient wind.

By 1400 PST (fig. 7), the wind at the saddle station had shifted to westerly so the highest surface potential temperature was indicated east of that station. The pilot-balloon observation taken in Survey Canyon showed the layer of up-canyon winds and, above that, the southerly wind up De Luz Valley. From about 2500 to 4000 ft there was a layer of westerly winds; above that, there was the prevailing southerly flow. At 1600 PST (fig. 8), the pattern was very similar. The pilot-balloon observation, which was taken at 1500 PST, showed an increase in wind speed in the westerly wind layer and a shallow layer of east winds appearing above it.

On August 20 at 0400 PST (fig. 9), the lower atmosphere was much less stable than on the 17th. The marine inversion was just above 5000 ft. and is not shown on the cross section. Winds were down canyon in both the east and west canyons. By 0800 PST (fig. 10), up-canyon winds developed in both canyons, and superadiabatic conditions were indicated in Survey Canyon. The pilot-balloon observation showed the up-canyon and up-valley wind layers and southerly flow at cloud level. At 1000 PST (fig. 11), the pattern was similar but the wind speeds had increased. A shallow layer of westerly winds at about 5000 ft. was evident.

By 1200 PST (fig. 12), this layer of westerly winds lowered about 1000 ft. The wind in the saddle shifted to westerly, indicating that the highest potential temperatures were east of that

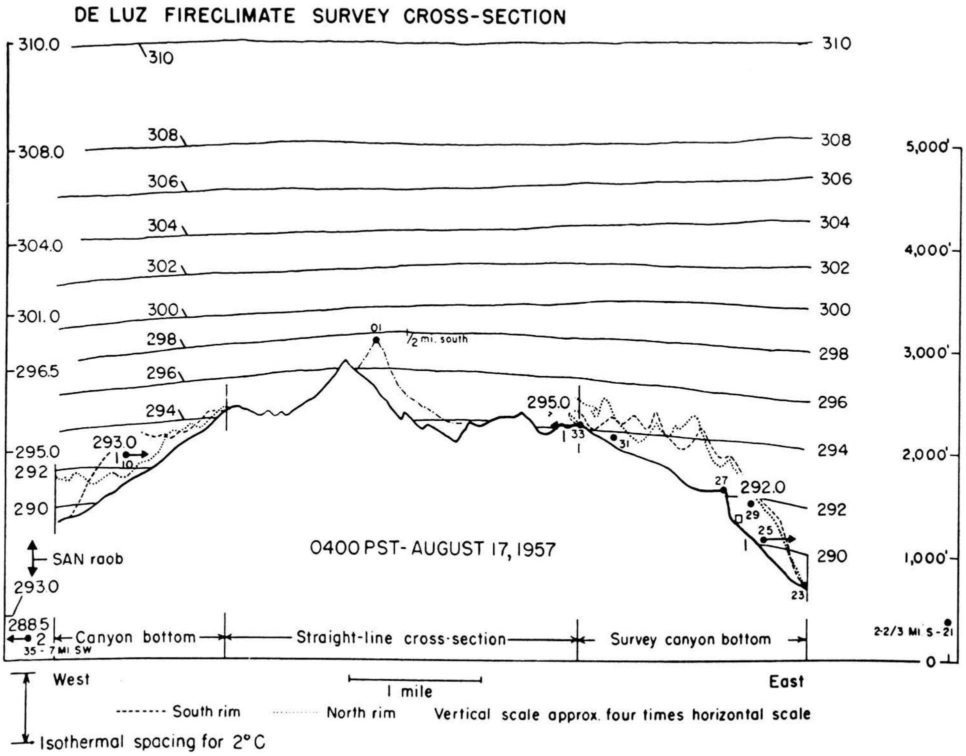

FIG. 5. Cross section through survey area, 0400 PST 17 August 1959. SAN raob is the San Diego radiosonde observation. In this and succeeding figures, the surface wind speeds plotted near the station dot are in miles per hour.

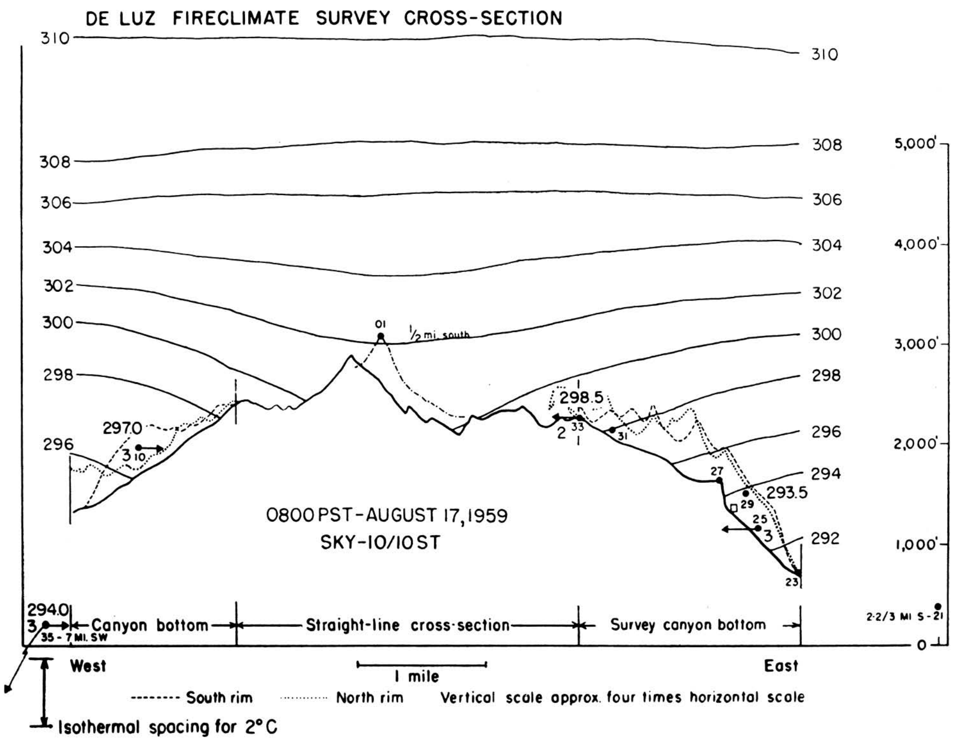

FIG. 6. Cross section through survey area, 0800 PST 17 August 1959.

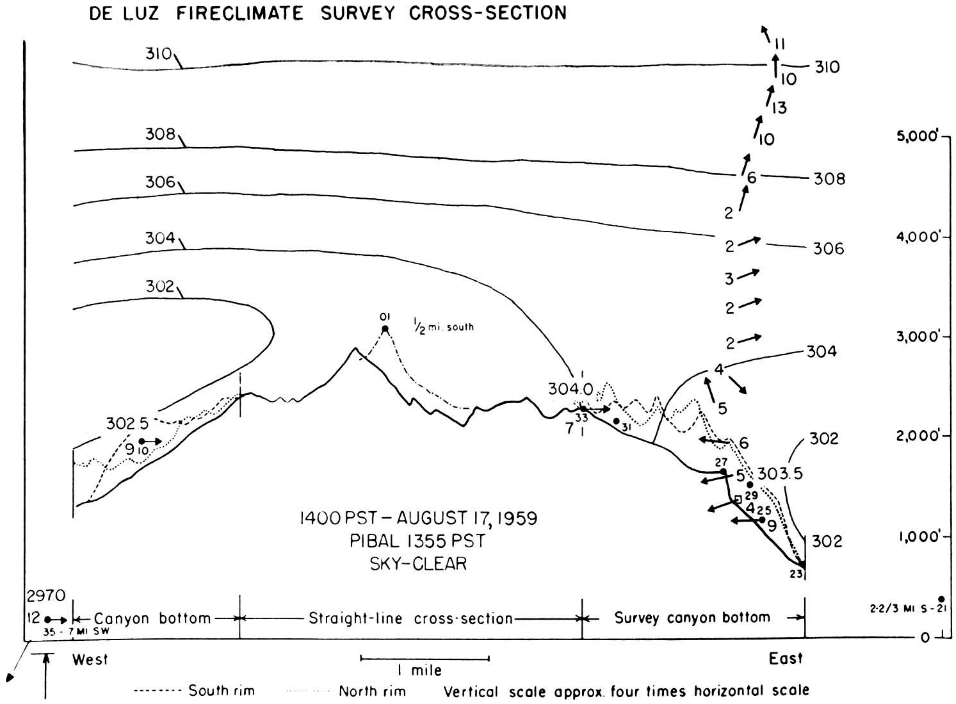

Fig. 7. Cross section through survey area, 1400 PST 17 August 1959. Wind speeds aloft, like the surface reports, are plotted in miles per hour.

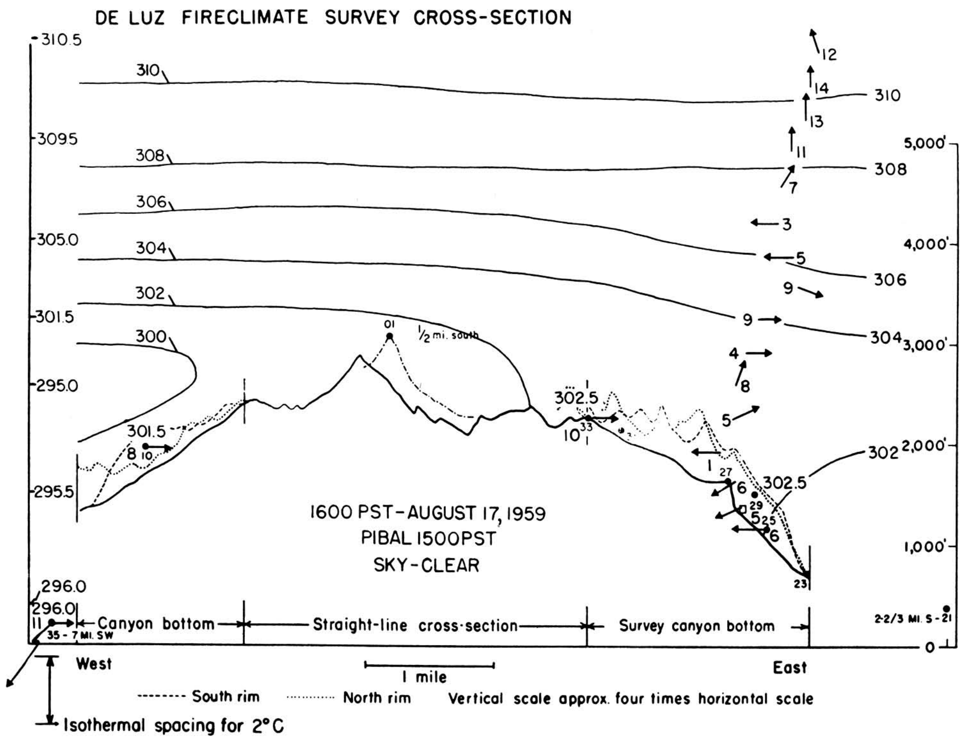

Fig. 8. Cross section through survey area, 1600 PST 17 August 1959.

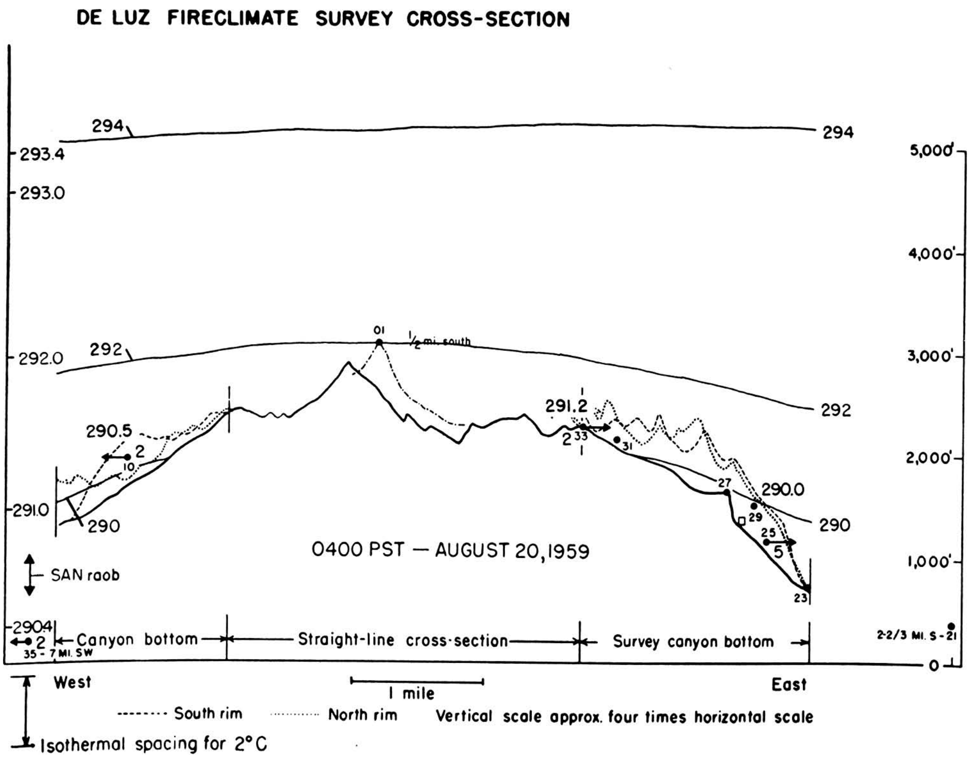

FIG. 9. Cross section through survey area, 0400 PST 20 August 1959.

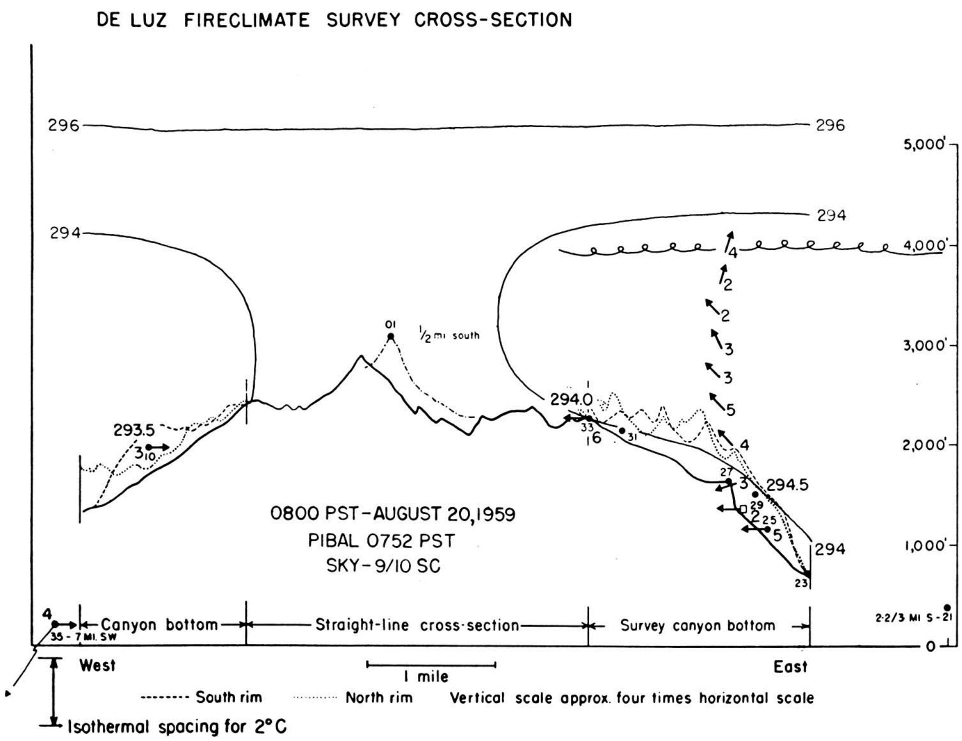

FIG. 10. Cross section through survey area, 0800 PST 20 August 1959. The base of the layer of coastal stratus is indicated at 4000 ft.

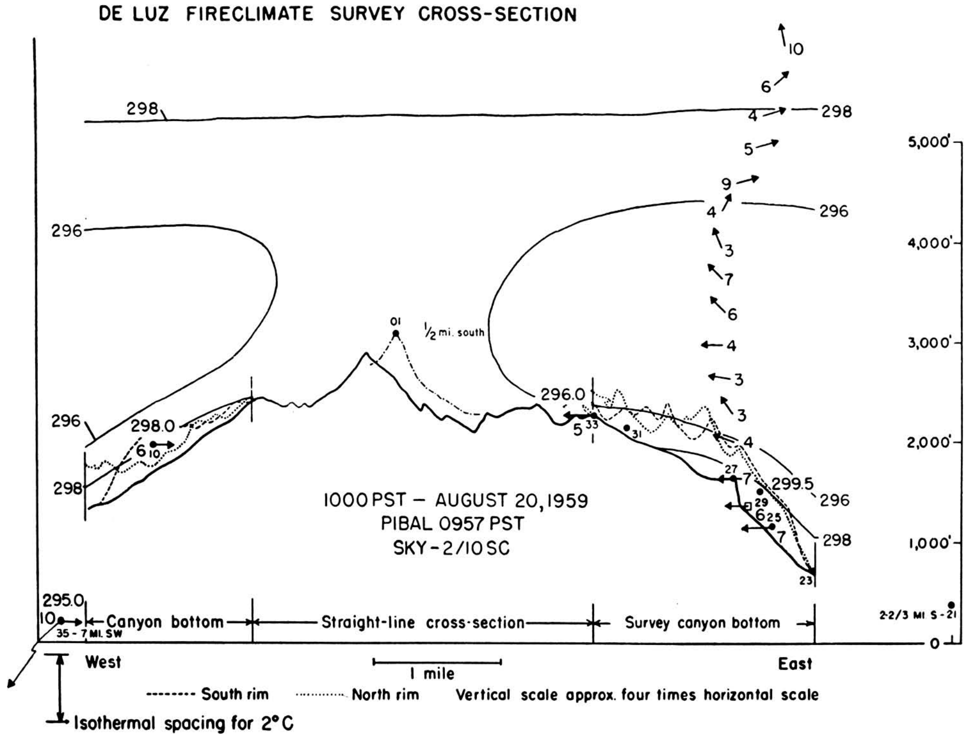

FIG. 11. Cross section through survey area, 1000 PST 20 August, 1959.

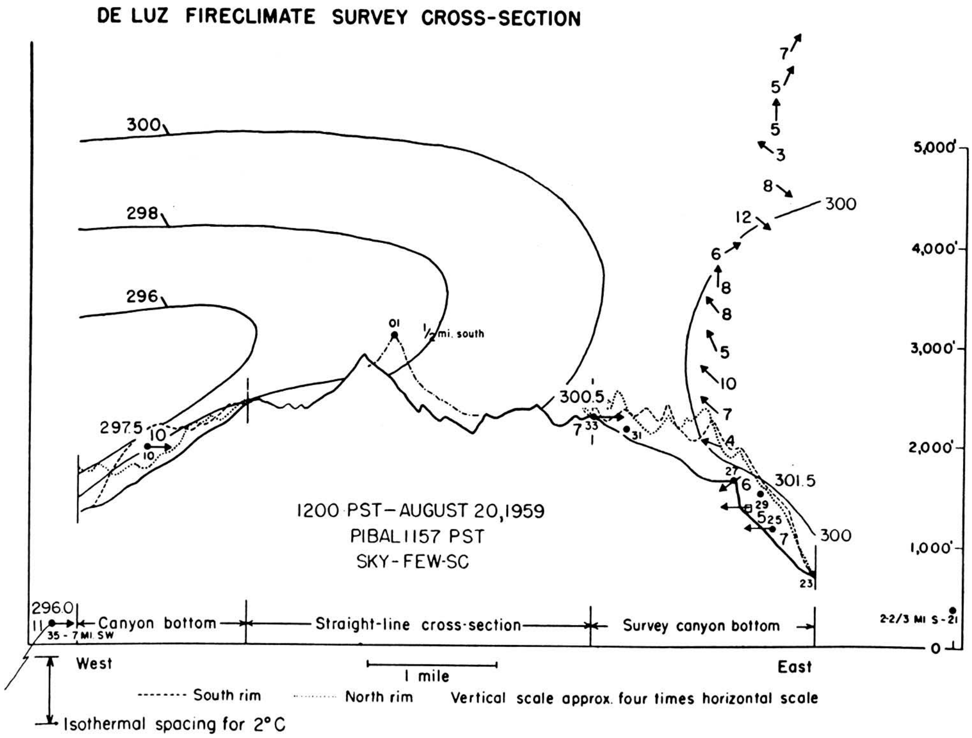

FIG. 12. Cross section through survey area, 1200 PST 20 August

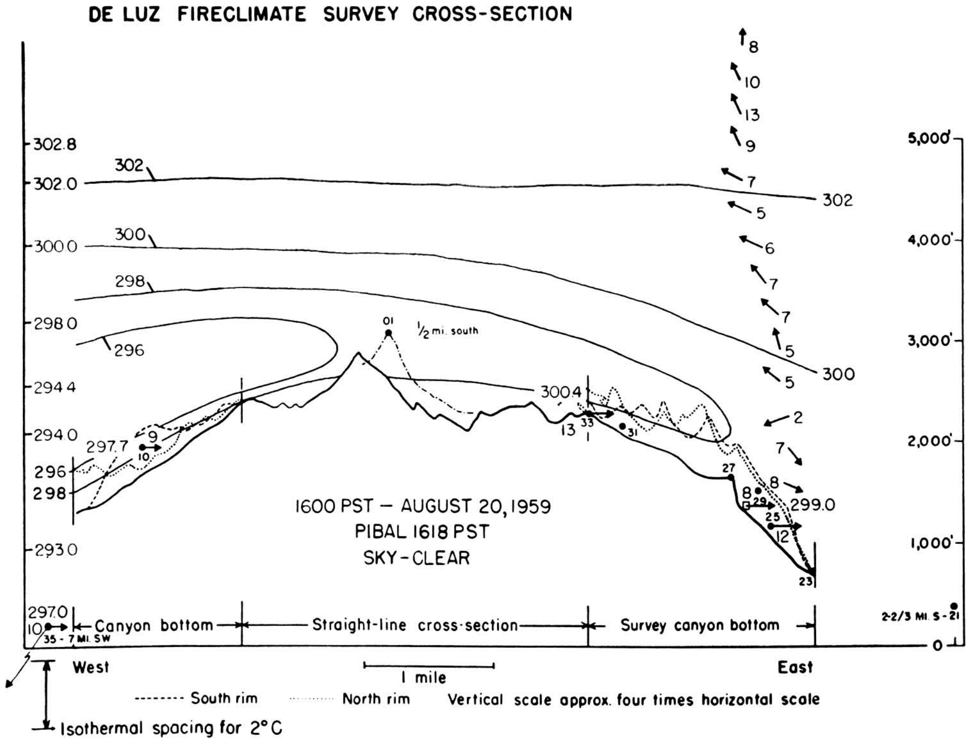

FIG. 13. Cross section through survey area, 1600 PST 20 August 1959.

station. The layer of westerly winds continued to lower during the afternoon, and, at 1440 PST, winds shifted to down-canyon at station 25. At 1600 PST (fig. 13), moderately strong winds blew down the east-facing canyon while a layer of east winds had developed aloft.

All of the pilot-balloon observations for 20 August 1959 are shown in fig. 14. Since the sky was overcast in the early forenoon, one could not be sure if the layer of west winds at about 5000 ft. was present earlier or developed during the forenoon. This time series shows (1) the progressive lowering of the west-wind layer until it filled the canyon at the 1456 PST observation, and (2) its replacement aloft by a layer of easterly winds. No attempt is made to explain this east-wind layer at this time.

The aircraft temperature measurements taken on 4 October 1959 between 1320 and 1420 PST were used, along with surface data, to construct a cross section from the coast through the survey area (fig. 15) Down-canyon winds were occurring in Survey Canyon at the time. These data helped to estimate what the vertical structure was like in the previous cross sections. The cross section shows a tongue of cool air flowing over the mountain range, while the lapse rate is super-adiabatic just above the surface. A second point of interest is the region of higher potential temperatures just east of Survey Canyon. The existence of higher potential temperatures in this region supports what was suggested earlier by the 1958 De Luz data.[2] The mountain range acts as a high-level heat source during the daytime, as has been suggested also by Braham and Dragnis [10]. A warm belt of higher potential temperatures is formed over the mountain range during the forenoon. This warm belt moves progressively eastward during the day, apparently in response to the sea breeze or some other more dominant circulation, and in the afternoon it is found east of the mountain range when winds are blowing down the east-facing canyon.

Diagrammatic model. When one pieces together the information obtained on the surveys and bits of information gleaned from field personnel who have observed these winds, the following sequence of events appears to take place (fig. 16).

During the early forenoon, up-canyon winds develop in both the east-facing and west-facing canyons. Winds in the saddle are easterly, prob-

[2] Schroeder, Mark J.: Prog. rep. on De Luz fireclimate survey. Div. Forest Fire Res., Pacific Southwest Forest and Range Exper. Sta., 31 July 1959. (Unpubl.)

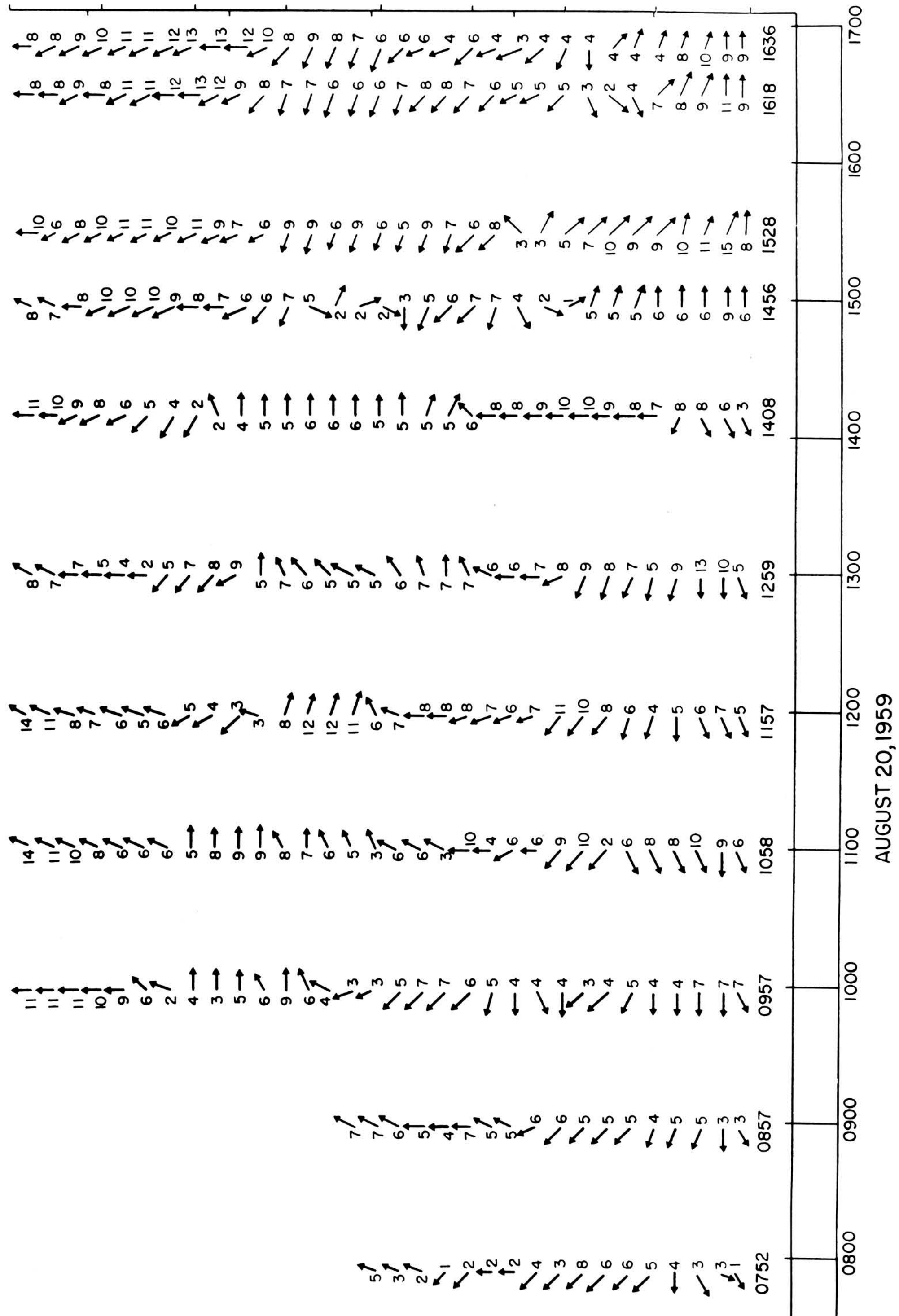

Fig. 14. Pilot balloon observations taken in Survey Canyon, 20 August 1959.

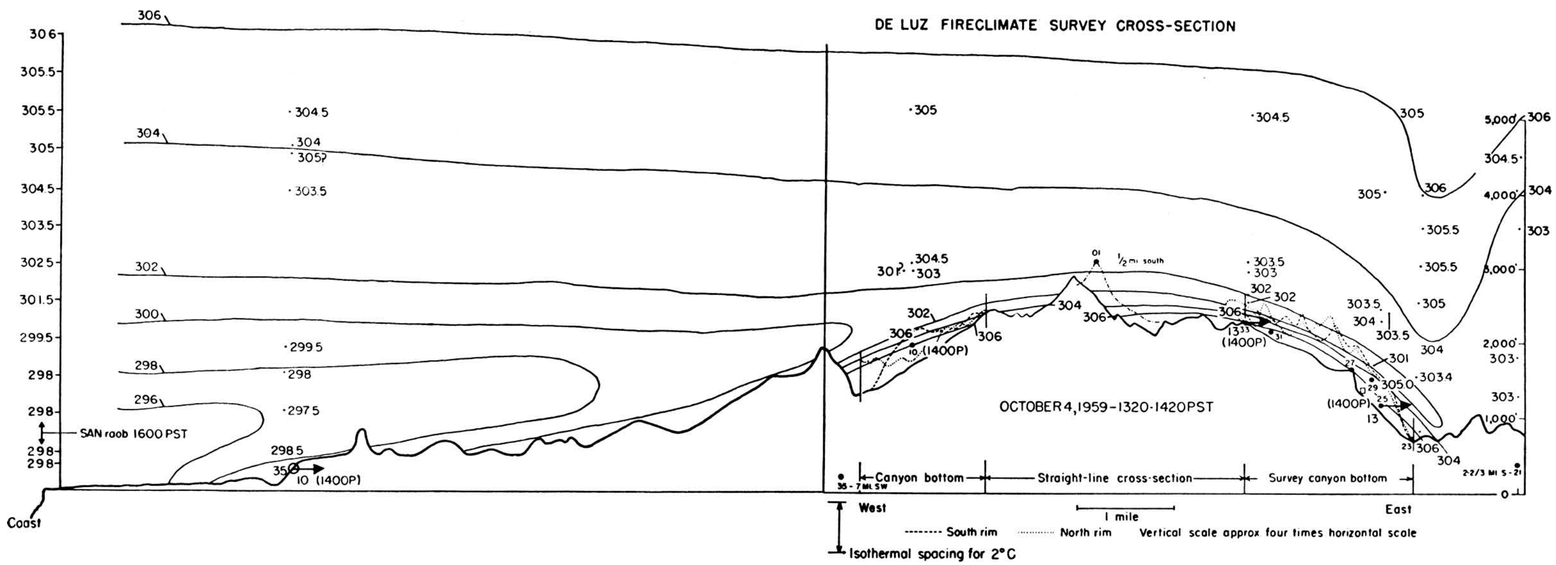

Fig. 15. Cross section from coast through survey area for 4 October 1959 using aircraft temperatures taken between 1320 and 1420 PST and surface observations at 1400 PST.

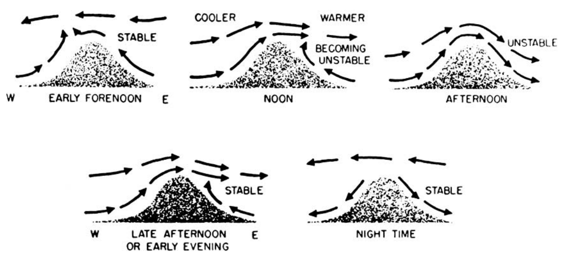

Fig. 16. Sequence of events during occurrence of down-canyon afternoon winds.

ably because of the inertia of the stronger air flow up the east-facing canyon where heating is greater at this time of day. The lower atmosphere is stable. Just above the ridge, winds are likely to be (but not necessarily) easterly.

With a horizontal temperature gradient in the lower atmosphere, cooler air to the west and warmer air to the east, a westerly wind develops. It flows over the range and remains aloft on the east side. This may be thought of as a separation of the boundary layer from the surface — a separation that is aided by the up-canyon thermal wind on the east side [11]. The westerly wind may be caused by the sea breeze, it may be a larger-scale circulation caused by the pressure difference between the east Pacific high and the thermal trough in the interior, or it may be caused by the heat source of higher mountains farther to the east. The later process could explain this type of wind in the western Sierra Nevada. Edinger [12] has indicated that this type of high-level heat source in the San Gabriel Mountains may be responsible for a diurnal wind oscillation above the marine inversion in the Los Angeles basin.

The first air that flows over the mountain range may well be air that has been over land, as Edinger [13] found in his study of the sea breeze in the Los Angeles basin. As the day goes on, cooler and cooler air is brought in from the west. This flow, combined with continued daytime heating, eventually causes the lower layers east of the ridge to become unstable. The cooler, heavier air then flows down the east-facing canyon.

During late afternoon, the westerly wind diminishes and cooling makes the lower layers more stable. Up-canyon thermal winds may develop temporarily and again cause the westerly wind layer to remain aloft.

At night, the normal down-canyon drainage winds develop in each canyon.

On some days, the late afternoon–early evening stage as indicated here does not materialize, and the afternoon pattern changes directly into the nighttime pattern.

Relation to weather patterns. Since, as has been noted earlier, down-canyon afternoon winds tended to occur on both warm and cool days, and tended not to occur on days with moderate temperatures, it was logical to look at the macro- and mesoscale weather patterns to see if occurrences favored any types of patterns.

In the macroscale, both upper-air and surface patterns were investigated. The 700-mb patterns were classified by the longitudinal position of the 700-mb ridge in the eastern Pacific or western United States and by the latitudinal position of the belt of westerlies through the ridge. No clear-cut relationship was found. The occurrence of down-canyon afternoon winds showed greatest preference for days when the ridge was at 125°W to 140W and least preference for days when the ridge was either over the western United States at 110W to 125W or farther out over the Pacific at 155W to 170W. It was noted, however, that, on most of the days when a moderate or strong 700-mb trough was near southern California, down-canyon afternoon winds occurred. This happened on 15 of 18 days when the trough was within 5 deg long of the survey area.

The surface weather patterns for the period of the survey in 1959 were classified by using, as a basis, the position and general shape of the east Pacific high. No decided preference for any type was found. The least-favorable pattern was one in which the Pacific high is located over the Aleutians.

To investigate the mesoscale patterns for the 1959 period of the survey, a pressure analysis was made each day for the southern California coastal areas by using the available hourly and 6-hourly reporting stations. Isobars for one-millibar intervals were drawn. This analysis was less than satisfactory because of the lack of a dense network of reporting stations in the general area of the survey and the apparent lack of agreement in pressures between several of the stations. As near as could be determined, the isobars were oriented parallel to the coast in the survey area and the thermal trough was to the east on most days. Though the pressure gradient across the coastal ranges varied, no relationship to the occurrence of down-canyon afternoon winds was found. This does not mean that a relationship to the mesoscale pattern does not exist — only that the available data did not reveal one. Two other mesoscale patterns appeared to be favorable and one appeared to be unfavorable. A deep Catalina eddy, such as is associated with a trough at 850 mb or the trailing end of a cold front that passes to the north and east, and a pattern with a thermal trough located over the coast ranges were the two favorable ones. The unfavorable pattern was one in which the thermal trough has been moved off the coast and an easterly pressure gradient existed over the coast range.

Relation to other parameters. A number of parameters have been investigated to determine if any showed a good relationship to the occurrence of down-canyon afternoon winds. Most of them showed a poor relationship, so only a few will be discussed.

a. Stability of the lower atmosphere. Since stability of the lower atmosphere appeared to be a significant factor in the occurrence of these winds, an attempt was made to relate the occurrence to the stability indicated by the San Diego radiosonde observation. One measure of the stability of a layer is the difference between the mean temperature of the layer and the temperature at the top of the layer. For this survey area, the layer from the surface to 860 mb was most significant. The 0400 PST radiosonde observation was selected because of its forecast value for the afternoon. This stability factor had the advantage of placing soundings which showed a high marine inversion and those which showed a low inversion or no inversion on one end of the scale and those which showed a strong marine inversion at an average height on the other end of the scale. The high marine inversion is a cool-weather type and the surface inversion and no inversion are usually warm-weather types along the California coast, and it had been noted that down-canyon afternoon winds tended to occur during both cool and warm weather. The point-biserial correlation coefficient [14] computed for this parameter was 0.62 and the 95% confidence interval was 0.49 to 0.71. Perfect correlation would be 1.0. This parameter showed a higher correlation than any other investigated, and its use in forecasting will be discussed below.

b. Departure of 700-mb height from monthly normal. This parameter was investigated because, from inspection of upper-air charts, it appeared that a trough near the survey area was favorable for occurrence. Again, the 0400 PST San Diego radiosonde observation was used. The point-biserial correlation coefficient computed was –0.43. This does show some correlation, and the negative sign means that lower heights are favorable.

c. Departure of 700-mb temperature from monthly normal. This parameter was investigated for the same reason as the one above. The point-biserial correlation coefficient was –0.33. This is not as high a correlation as above, but again it is in the direction one would expect — *i.e.,* lower temperatures, which are usually found in a trough aloft, being favorable.

d. 850-mb height difference between San Diego and Point Arguello at 0400 PST. It was thought that a height gradient which would produce onshore winds at this high level might be favorable. The height at Point Arguello was subtracted from the height at San Diego so that a positive difference would indicate an onshore wind component. The point-biserial correlation cofficient turned out to be only 0.18, and the 95 per cent confidence interval was –0.03 to 0.36.

e. 850-mb temperature difference between Santa Monica and Las Vegas at 1600 PST. A horizontal temperature gradient in the lower atmosphere should be favorable. However, the point-biserial correlation coefficient turned out to be only 0.07. It is felt that, for this survey area, temperature measurements were not available in the places that would indicate the temperature gradient affecting the area. With upper-air stations as far apart as they are, there was little choice. The temperature gradient at 4000 or 5000 ft from a point a short distance off the coast to a point just east of the coastal mountains may be quite different.

f. Sea-level pressure from the coast inland at 1600 PST. It was mentioned above that no relationship between sea-level pressure gradient along the coast and the occurrence of down-canyon afternoon winds was found. Here again, it is likely that pressure measurements were not available from the places that might show a relationship. The pressure gradient from El Toro to San Bernardino was selected for the short distance from the coast inland. El Toro is about 20 mi northwest of the survey area and about 8 mi from the coast. San Bernardino is about 48 mi from the coast. The point-biserial correlation coefficient was only –0.10. For the gradient from the coast to the desert region, Los Angeles and Needles were selected. Needles is on the California-Arizona border. The point-biserial correlation coefficient for this gradient was –0.22. The negative sign in each case indicates that a weaker onshore gradient was more favorable. As with the 850-mb temperature gradient, it is felt that the pressure gradient from a point a short distance offshore to a point just east of the coastal mountains may show different results.

g. Radiation. No solar-radiation measurements were made on the survey and, therefore, it is not possible to determine if there was a relationship between radiation received locally and the occurrence of down-canyon afternoon winds. The only available solar-radiation data were those published by the U. S. Weather Bureau for Riverside and Los Angeles. The point-biserial correlation coefficients were –0.22 for Riverside and –0.10 for Los Angeles. The negative sign indicates that lower radiation values were favorable, but, since the coefficients are so low, the relationships are not considered significant.

Forecasting. Since the stability factor showed a much better correlation than any of the other parameters investigated, this should be the first one considered in forecasting. The stability factor was computed from the 0400 PST San Diego radiosonde observation for each day of the 1959 survey and is plotted in fig. 17. A dot or circle

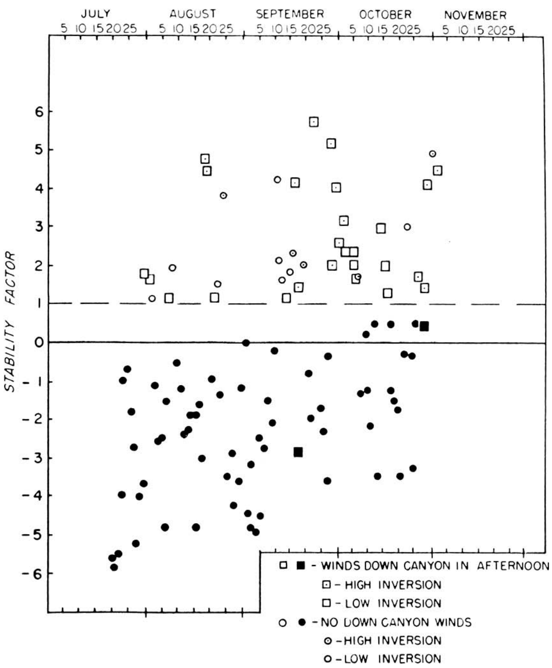

Fig. 17. Stability factor from the San Diego radiosonde observation at 0400 PST each day of the 1959 survey. The stability factor is the difference in °C between the mean temperature of the layer from the surface to 860 mb and the temperature at the top of that layer. Higher values indicate less stability.

indicates that down-canyon afternoon winds did not occur, and a square indicates that they did occur. A stability-factor value of plus 1 appeared to be the best dividing line. Only 2 occurrences were noted with smaller values of the stability factor. Two-thirds of the days with higher values of the factor had down-canyon afternoon winds. A forecaster using just this one parameter could have predicted these winds with 85 per cent accuracy. Dots and open squares are "hits," and circles and solid squares are "misses." Stability factors calculated from radiosonde observations showing either high or low inversions had higher values, while lower values were obtained when inversions were at middle elevations. The high and low inversions had been indicated separately to show that both occurred with "hits" and with "misses."

Applying this parameter to the 24 days of the 1958 survey, a poor sample indeed, would have resulted in forecasting down-canyon winds on 4 days, whereas they actually occurred on 3 of these days.

One would expect that, with less daytime heating in the fall than in summer, the value of the stability factor used as the dividing line should be varied with the season. With the 1959 data, however, no improvement would have resulted.

In actual practice, one would want to consider other parameters before making a forecast. These investigations show that the presence of an upper-air trough near the area should be considered a favorable factor. On the other hand, down-canyon afternoon winds should not be forecast if an easterly sea-level pressure gradient, strong enough to produce at least moderate easterly winds, is expected to be over the area. During the 1959 survey, this gradient was evident on 2 occasions when tropical storms moved up from the south and caused east winds in the survey area and on 2 other occasions when a buildup of pressure in the Great Basin forced the thermal trough off the coast of southern California.

4. Indications and conclusions

Although many parts of the mechanism of down-canyon afternoon winds are not fully understood, some indications and conclusions can be obtained from the studies so far.

(1) Down-canyon afternoon winds appear to be generally stronger than the normal up-canyon winds.

(2) They can occur when the marine layer is deep. In this case the marine air simply spills over the coastal ranges.

(3) They can also occur when the marine layer is very shallow or absent. It is this case that can produce very critical fire weather. The weather is generally warm, and humidities are low over the entire area. A sudden, unexpected wind shift and increase in speed can make a bad fire situation critical.

(4) Some degree of instability in the lower atmosphere, the presence of a trough aloft near the area, and a weak sea-level pressure gradient over the area are favorable factors.

(5) An easterly sea-level pressure gradient over the area is unfavorable.

5. Future work

Future work will need to be both more intensive and more extensive.

(1) To fully understand the mechanism of these winds, it will be necessary to take frequent upper-air measurements of not only wind, but also temperature, humidity and pressure. These measurements should be taken on both sides of the ridge and above the ridge as well.

(2) To apply forecast parameters to other areas, it will be necessary to study the occurrence in a number of areas so that the effect of the ridge height and the distance from the ocean may be determined. If the measure of stability of the lower layer proves to be a valuable forecast parameter, it is likely that the depth of the layer and the value of the stability factor will vary with the ridge height and distance from the ocean.

(3) The search for other forecast parameters must continue, not only for those that may be useful in forecasting whether or not down-canyon afternoon winds will occur but also for those that will be useful in foretelling the time that they will begin and the time that they will end.

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NEWS AND NOTES

Change in Air Force Organization

The Air Force Systems Command (AFSC), which was established on 1 April 1961, is made up of elements of two former Air Force organizations, the Air Research and Development Command and the Air Material Command. The AFSC is concerned with delivery of complete, timely, and operable AEROSPACE systems to its consumers, the Strategic Air Command, Tactical Air Command, and the Air Defense Command.

Director Appointed for U. S. Share in Indian Ocean Expedition

The National Academy of Sciences' Committee on Atmospheric Sciences has announced the appointment of Dr. Colin S. Ramage, chairman, Department of Meteorology and Oceanography, University of Hawaii, as Director of the U. S. Meteorology Program of the International Indian Ocean Expedition.

Dr. Ramage has also recently accepted appointment by the Special Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions (ICSU) as representative to the Committee on Air-Sea Interaction of the International Association of Meteorology and Atmospheric Physics (IAMAP), and as the international coordinator of the meteorology program of the Indian Ocean Expedition.

The deep interest which Dr. Ramage has in the meteorology program of the Indian Ocean Expedition is well founded upon a considerable experience with and knowledege of the scientific and technical problems of the area to be studied.

Dr. Ramage has been associated with the University of Hawaii since 1956, becoming professor of meteorology in 1958, and assuming the chairmanship of the

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