

PACIFIC SOUTHWEST Forest and Range Experiment Station

FOREST SERVICE
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LOW-LEVEL WIND MAXIMA in the 1969 San Mateo and Walker Fires

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A large void in the study of fire behavior is evident in the area of low-level wind maxima—sometimes called *low-level jets*. Byram (1954) studied the relationship of extreme fire behavior to wind profiles and established a classification of profile relation to fire behavior. That the presence of strong low-level wind maxima can greatly increase the rate of spread of forest fires is well known (Barad 1961). Most studies, however, have been prompted by interest in aircraft flight problems and in the relationship of low-level wind maxima to thunderstorm development: examples are papers by Means (1952), Curtis and Panofsky (1958), Pitchford and London (1962), and Bonner (1966). Much of the work has been focused on the low-level jet of the Great Plains, partly because this jet is both strong and prevalent east of the Rocky Mountains. Bonner (1968), in his evaluation of data from the U.S. Weather Bureau synoptic rawinsonde network for a 2-year period, suggested that the jet occurred much more often and was much stronger east of the Rockies than along the west coast. The west coast jet was considered different in other characteristics also. Data from Oakland and Santa Monica, California, show that speeds are much less and, unlike the condition east of the Rockies, northerly flow is more frequent than southerly flow. And although southerly jet flow was more prevalent at stations east of the Rockies, many of the stations also had a greater frequency of northerly jet flow than Oakland and Santa Monica. That low-level jet winds commonly occur in either direction is an important point to consider in determining possible mechanisms in their formation.

Although their occurrence is recorded at the observing stations relatively infrequently, the influence of low-level wind maxima on fire behavior is important. Also, statistics obtained from the few observing stations along the west coast may be somewhat misleading. Because the jet is characteristically small in vertical and horizontal extent, many

occurrences may not be observed in the large-scale grid of upper-air observations.

The occurrence of strong surface and low-level winds during the San Mateo and Walker Fires (*fig. 1*) of August 1969 reemphasizes the great need to understand how and why these winds occur. Data collected during this period also make a worthwhile basis for study. We had hoped that analogous situations could be found in records of unforecast strong surface winds in southern California since 1957, but none was found. Several instances of morning east-to-southeast winds over the Cleveland National Forest in southern California were recorded, some apparently associated with dying tropical disturbances in northwest Mexico. Instances of strong north-to-northeast winds were usually the result of fast-moving short-wave troughs. A record of similar situation on May 27, 1960 refers to a low-level northerly jet peaking at 3,000-ft. altitude, the result of a rapid ridging behind a weak front. Strong north-to-northeast winds of August 27-30, 1962 in the mountains north of Los Angeles appear to resemble the August 1969 situation in low-level behavior, but the causal mechanism, a synoptic-scale invasion of cold air at middle levels, was easier to determine. On the Liebre Fire in the northwest corner of the Angeles National Forest, the strong localized northerly winds observed for a short time on June 22, 1968 were almost certainly due to a weak, fast-moving short-wave trough.

This paper reports a study in which the San Mateo and Walker Fires served as a focus for examination of low-level wind maxima. Possible causes in general and probable influences in these fires were investigated and are discussed. Not enough data were available to determine accurately the relative contributions of wind-producing mechanisms in these fires. Nevertheless, a description of how various mechanisms contributed or might have contributed may be valuable in future forecasts of fire weather and fire behavior.

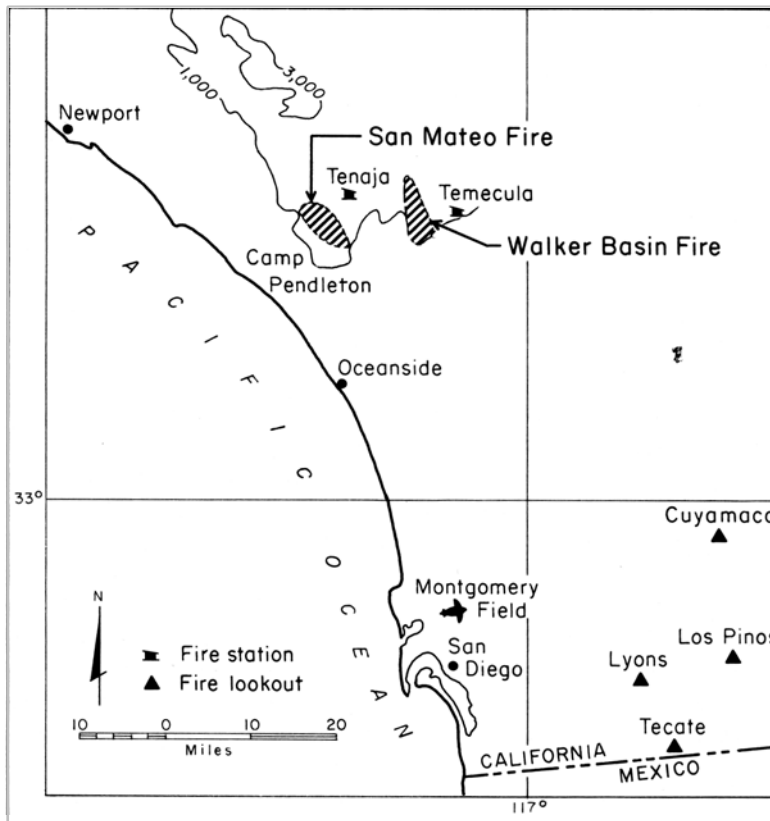


Figure 1—*San Mateo and Walker fire area.*

THE SAN MATEO AND WALKER FIRES

The San Mateo Fire started during the afternoon of August 22 on Camp Pendleton military reservation in lower San Mateo Canyon and spread rapidly upcanyon and southeastward under strong northwesterly winds. Most of the spread was during the first afternoon. By night, winds had died down and fire spread was stopped on the southwest at De Luz Creek by the decrease in wind and fuel and increase in humidity, and on the northeast by rocky ridges and good fuel-breaks. During the next day, under light wind conditions, the fire spread slightly to a

total of 16,849 acres.

The Walker Fire began south of Murietta in Walker Basin and burned rapidly southeastward during the afternoon and evening of August 22. Most of the acreage was burned during this time, but a few more acres on the west and southwest sectors burned on the 23rd. The 24th was quiet, and control was achieved on the morning of the 25th at a final area of 16,800 acres. There were also several other fires in the area during the period, including the Moosa Fire, which burned over 6,000 acres.

WEATHER SITUATION

The fires were preceded by a long period of above-normal temperatures in southern California, owing to the influence of a large pressure ridge aloft extending from the Pacific over the central and western part of the United States (Dickson 1969). Conditions were hot and dry with extreme fire danger in the fire areas. On the morning of Friday, August

22, before the fires started, several of the lookouts reported strong winds generally from the northwest on the coastal side of the mountains and the northeast on the desert side.

Tecate Lookout, at 3,887 ft. on the Mexican border, estimated winds of 39 knots with gusts to 48 knots at 0800 and northwest at 39 knots at 1007 (all

times given are Pacific daylight saving time). At the same time, Cuyamaca at 6,500 ft. reported northwest winds at 17 knots with gusts to 25 knots. Lyons Lookout at 3,755 ft. reported northeast winds at 26 knots while Los Pinos at 4,800 ft. had northeast winds at 22 knots. The winds over San Diego's Montgomery Field (MYF) were quite strong by 1700 on August 21 (fig. 2), with the low-level maximum from the northwest at 19 knots at 2,000 ft. The winds increased, however, to 36 knots at 2,000 ft. at 1700 on August 22. Winds were still 24 knots at 5,000 ft. at 0500 on August 23, but dropped off rapidly later that morning and by 1700 the strongest wind reported below 10,000 ft. was 16 knots. The winds determined by pilot balloon observations (fig. 3) near the fire at the California Division of Forestry Fire Station in Temecula were similar to the winds at Montgomery Field; however, they showed several differences in detail in the lower level from the first observation at 2100 August 22 until the last at 1700 August 23. The maximum, however, during the interval was 22 knots between 4,000 and 5,000 ft. m.s.l. near 0030 on August 23. The maximum at Temecula occurred about 7-1/2 hours later and 3,000 ft. higher than at Montgomery Field. The winds weakened significantly by the 0800 observation on August 23.

Available upper-air data from rawinsonde observations in the area indicate that the winds were not as strong to the north. At 1700 on the 21st, the winds at Montgomery Field were very different from those at Vandenberg Air Force Base (VBG) and Jackass Flats (UCC, near Las Vegas) as shown in figure 4. At Vandenberg Air Force Base and Jackass Flats they

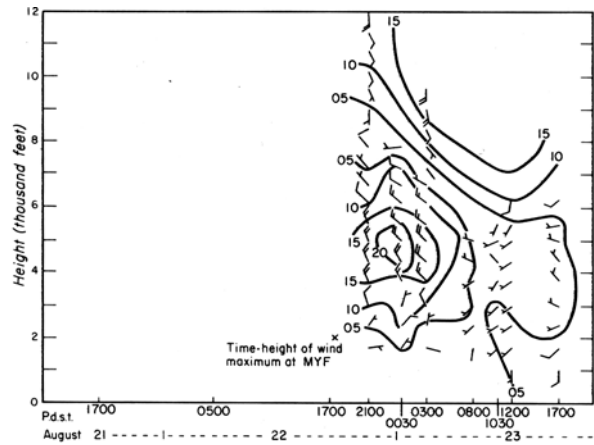


Figure 3—Winds (in knots) over Temecula, August 22-23, 1969. (Pacific daylight saving time.)

were weak and disorganized whereas at Montgomery Field they were strong and consistently northwesterly. Unfortunately, data from San Nicolas Island (NSI) and Yuma (YUM) were missing. The difference between winds at Montgomery Field and Vandenberg Air Force Base was less but still evident at 1700 the next day (fig. 5); the winds at Montgomery Field were much stronger. Strong winds were also evident at 1700 on August 22 at San Nicholas Island, west of the fire area. At 1700 on the 23rd (fig. 6) winds over Montgomery Field had decreased considerably. The wind at 3,000 ft. had decreased to 8 knots, and the maximum wind was only 16 knots at 1,000 ft. (fig. 2). Winds were still strong, however, over San Nicolas Island and had increased over Vandenberg Air Force Base.

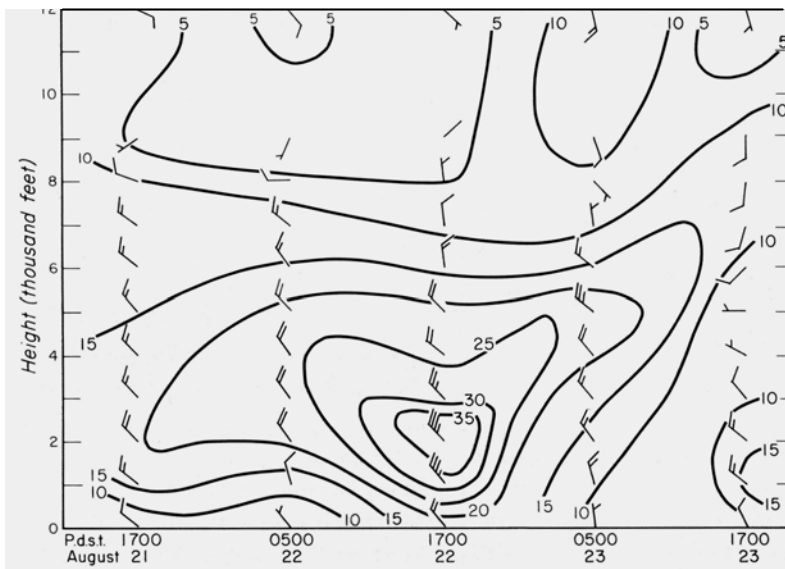


Figure 2— Winds (in knots) over Montgomery Field (MYF) San Diego for August 21-23, 1969. (Pacific daylight saving time.)

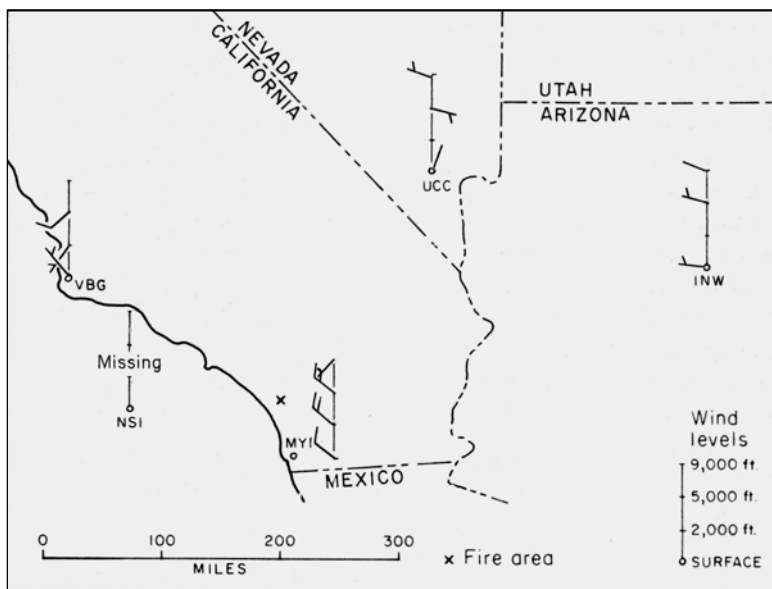


Figure 4—Winds (in knots) at 1700 August 21, 1969. (Pacific daylight saving time.)

Figure 5—Winds (in knots) at 1700 August 22, 1969. (Pacific daylight saving time.)

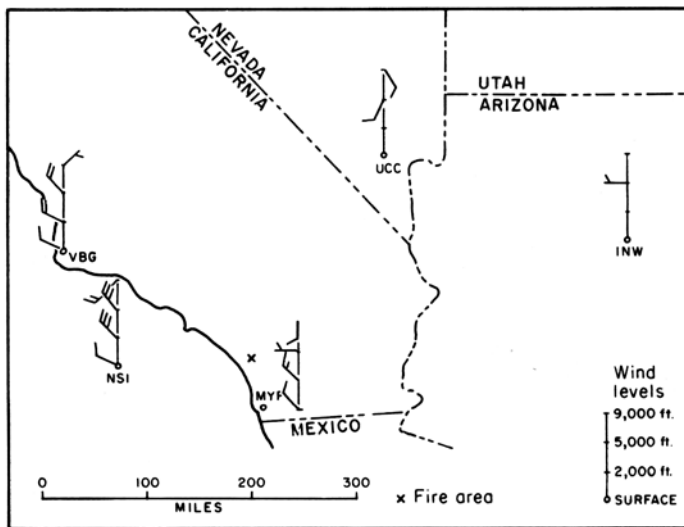
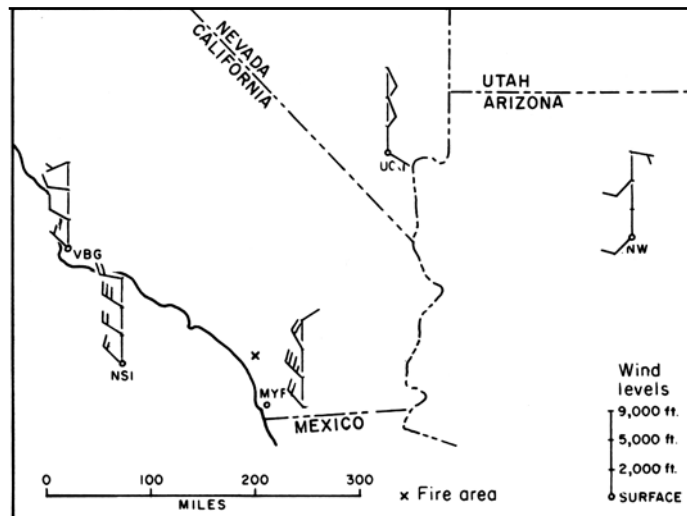


Figure 6—Winds (in knots) at 1700 August 23, 1969. (Pacific daylight saving time.)

A comparison of temperature and wind profiles for 1700 on August 21, 22, and 23 at Montgomery Field (*fig. 7*) showed the correspondence of inversion height and strength to maximum-wind height and strength. The temperatures as well as the windspeeds at the tops of the inversions on both August 21 and August 22 were very high. The temperatures were greater than 90° F. on August 22 and more than 95° F. on August 21 at heights of maximum temperature near 2,000 ft.

Changes of the wind profile from the afternoon of August 21 to the afternoon of August 23 at Montgomery Field are shown in *figure 8*. Winds were strong on August 21, and the jet-nose was at about

2,000 ft. There was a great increase in the maximum wind by the afternoon of the 22nd, and the maximum was still at about 2,000 ft. The height of the maximum wind increased to about 5,000 ft. by the morning of August 23. The pilot-balloon observations (*fig. 9*) show that the maximum winds were already at 5,000 ft. by 2100 on the 22nd at Temecula. There was a rapid decrease of the wind at Temecula on the morning of the 23rd and in the afternoon sounding at Montgomery Field. The strong winds were low-level phenomena. Winds at 700 mb. in the area remained light during the entire period. They remained light southeasterly at Montgomery Field, very light from the southwest to the southeast at Vandenberg Air Force Base and southwesterly at San Nicolas Island.

POSSIBLE WIND-PRODUCING MECHANISMS

The mechanisms that may have contributed to the low-level maxima observed in the San Mateo and Walker Fires vary in complexity and in probable degree of influence. We have included some mechanisms, and evaluations of their probable degrees of influence, in the discussion even though their influence may have been slight or only remotely possible. This was done in an attempt to include mechanisms that, although they seem to have little influence in this case, may be important in other similar situations.

Supergradient Wind

A fairly subjective estimate of the gradient in the area of the fires (*fig. 10*) indicates that at 850 mb. the geostrophic wind and gradient wind were within a few knots of the observed windspeed.

The geostrophic wind is defined by the relationship:

$$V_g = - \frac{g}{f} \frac{\partial z}{\partial n}$$

where V_g is the geostrophic wind, g is the acceleration of gravity, f is the coriolis parameter ($2\omega \sin\phi$)

which at 33°N. is $7.94 \times 10^{-5} \text{sec.}^{-1}$ and $\frac{\partial z}{\partial n}$ is the

pressure-height contour gradient. Thus at the latitude of the study area, geostrophic winds at 20 knots, for example, would correspond to a contour gradient of about 13.5 meters per 100 miles. The winds could have been gradient because of packing of contours. Whether or not packing did occur cannot be determined because upper-air data density is not great

enough. Curvature of flow is also not known accurately enough to determine how much the curvature would have made the gradient winds differ from the geostrophic. Comparison of successive streamline maps, however, indicates the trajectory of flow was anticyclonic in the fire area, and thus the gradient winds were greater than the geostrophic.

A comparison of winds from 5,000 ft. to 9,000 ft. over Montgomery Field with those over San Nicolas Island on August 22 at 1700 shows a great contrast in change of direction of windflow (*fig. 5*). The winds veered between 5,000 ft. and 9,000 ft. from 330/20 to 050/02 over Montgomery Field, but over San Nicolas Island the winds backed with height from 295/30 to 270/22. These changes with height affected the curvature of the windflow in the layer so that the winds changed from slightly anticyclonic at 5,000 ft. to greatly anticyclonic at 6,000 ft. and also caused the winds in the layer from 6,000 ft. to 9,000 ft. to converge near the southwestern corner of California. In this layer the anticyclonic curvature of the windflow is certainly significant and could indicate a gradient wind in the southwest corner of California that was stronger than geostrophic. The anticyclonic flow and the accompanying subsidence would have contributed to the strength of the inversion near the coast. Although the data are not sufficient to indicate definitely that supergradient winds occurred, this seems quite likely. Means (1952) writing of the low-level jet in the southern plains of the United States, says, "Wind speeds frequently appear to be greater than the expected geostrophic or gradient speeds." We know that this is not uncommon in the southern California mountains.

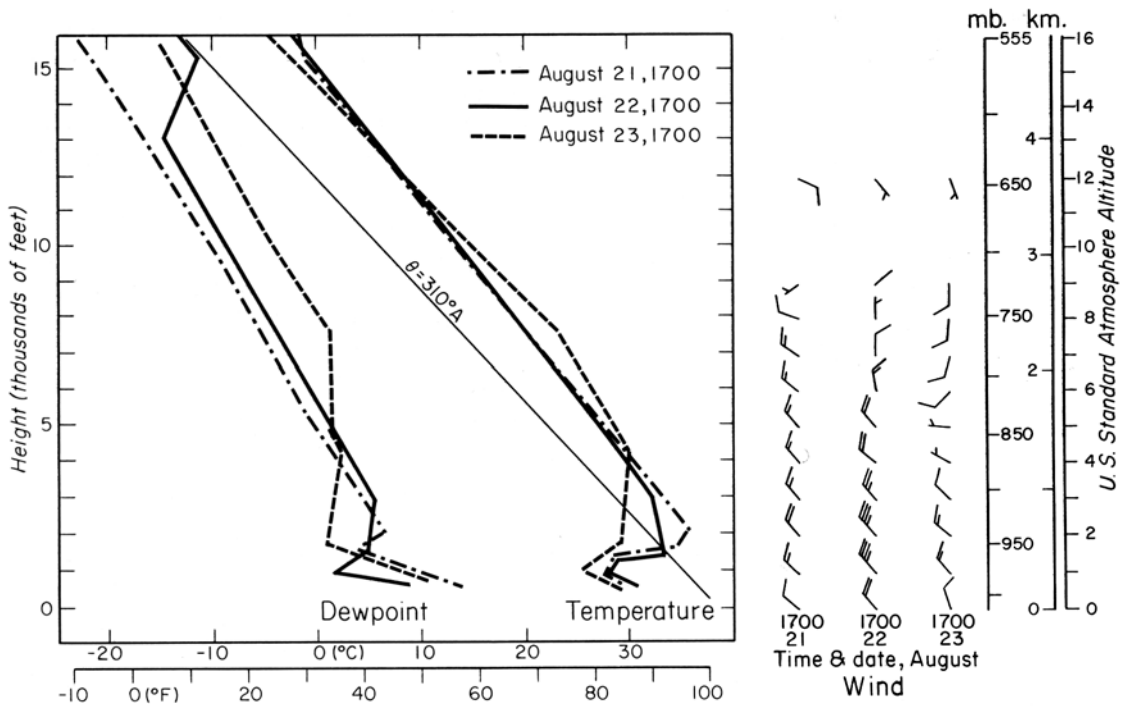


Figure 7—Dewpoint, temperature, and wind profiles (in knots) at Montgomery Field (MYF). (Pacific daylight saving time.)

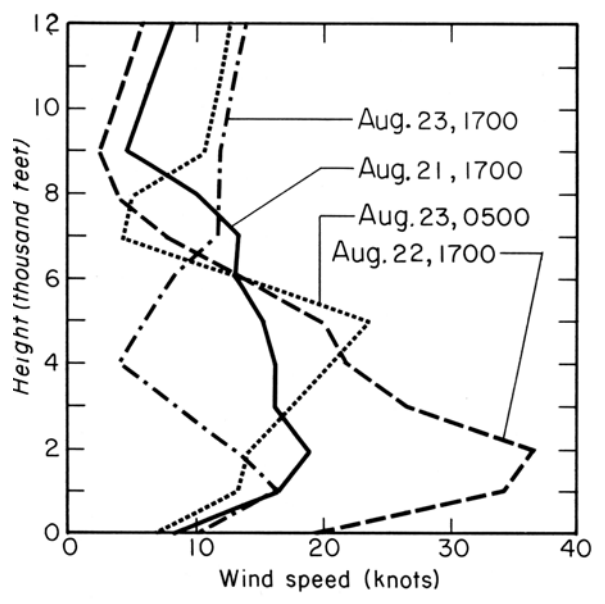


Figure 8—Wind profiles for Montgomery Field (MYF). (Pacific daylight saving time.)

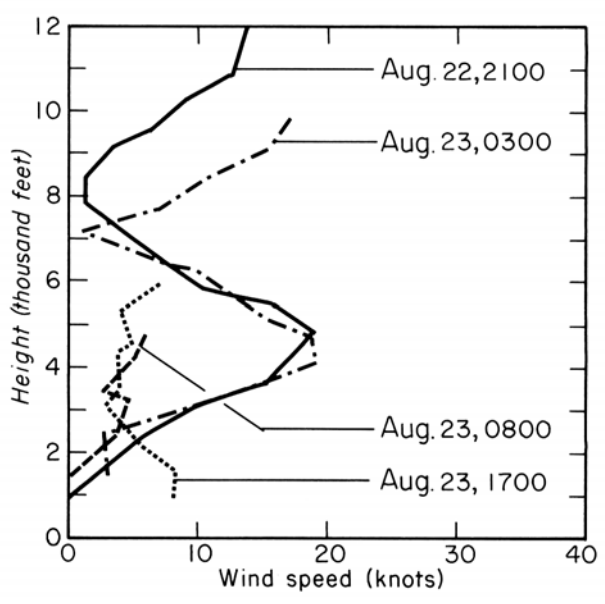


Figure 9—Wind profiles at Temecula. Surface winds at 2100, 0030, 0300, and 0900 were light and variable. (Pacific daylight saving time.)

Easterly Wave and Low-Level Ridge

A small-scale inverted trough (a weak easterly wave disturbance) was moving westward along the Mexican border over southern Arizona and southern California, as indicated by a weak vorticity maximum and by windflow in the 6,000- to 9,000-foot layer. A sharp ridge nosed-up northeastwardly just off the coast. The inverted trough to the east and the ridge to the west appeared to cause a zone of convergence between and could have been an important factor in producing the strong winds. The strong low-level ridge of high pressure off the coast which seems to be somewhat the antithesis of the Catalina "Cyclonic" eddy (Coffin 1959) may also, by itself, be an indicator of strong low-level winds in that area. Unfortunately, these disturbances were too far south and too weak to document and examine in any detail. The unusual characters of this convergence zone, the low-level ridge and the low-level winds suggest cause and effect relationships and should be watched for in future analyses.

Upper-Level Pressure Pattern

An examination of the pattern at 300 mb. indicates no jet stream near the area. There was, however, a weak low center that had apparently broken off earlier from a trough at that level and that remained for several days over extreme southeastern California. It is doubtful that this low pressure center could have had a significant effect on the low-level strong winds, considering that the 700-mb. and 500-mb. charts did not show such a feature.

Absolute Vorticity Conservation

One possible reason for development of this variation in windspeed is the principle of absolute vorticity conservation. The principle can be described in simple qualitative terms. If we assume that the

absolute vorticity, $\frac{\zeta+f}{D}$, is constant for individual

columns of the atmosphere moving southward, then as f , the coriolis parameter, decreases with decreasing latitude, the vorticity relative to the earth, ζ , must increase, and/or D , the column depth, must decrease. If D remains constant, the column must increase its relative vorticity as the column moves to the south. Relative vorticity can be defined in terms of natural coordinates:

$$\zeta = \frac{V}{r} + \frac{\partial V}{\partial n}$$

If the relative vorticity increases, owing mainly to an increase in shear, $\frac{\partial V}{\partial n}$, rather than curvature, $\frac{V}{r}$,

then a high-speed current at the western boundary of the flow along the coastal ranges must develop. For the fire area, this analysis is of course hypothetical, because of the many assumptions made, such as the change of column depth and change of shear and curvature along the air trajectory. It is difficult to obtain more than a quite conjectural indication of its contribution. All that can be said is that it may have contributed.

Inertial Oscillation

Another theory, advanced by Blackadar (1957) and applied to explain the formation of nocturnal

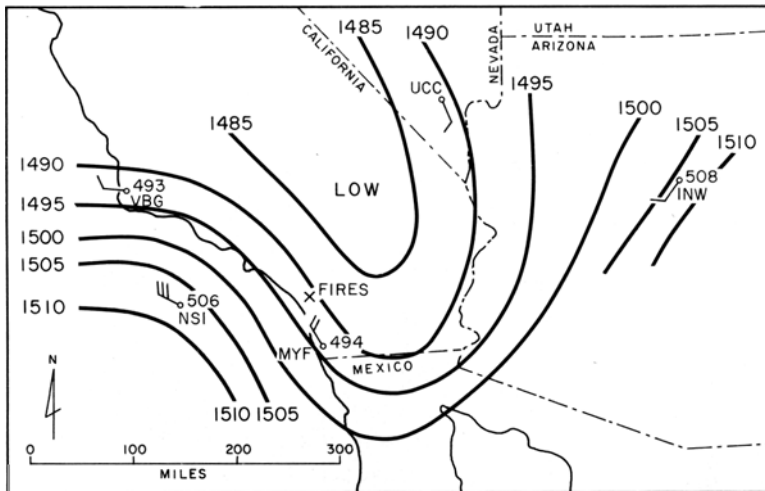


Figure 10-Winds at the level of 850 millibars and height contours (meters) at 1700 August 22, 1969. (Pacific daylight saving time.)

low-level wind maxima, is that windflow develops an inertial oscillation. As an inversion builds during the night, usually by radiational cooling of the earth's surface, the inversion insulates the windflow from the loss of energy by turbulence near the surface. As the loss of energy is decreased, the windspeed, as depicted by vector V_1 in *figure 11*, can increase to such a speed as that depicted by vector V_2 . As the inversion is destroyed, usually by solar heating, the airflow can again mix to the surface; more energy is again lost due to turbulence near the surface. The windspeed then tends to decrease. Thus, there is actually an oscillation from windspeed that is less than geostrophic to greater than geostrophic, because of inertia, as the coupling by eddy turbulence is decreased and increased by the formation and destruction of the inversion. The change of coupling causes a change in the ageostrophic vector, V_a , as shown in *figure 11*. The low-level windspeed maxima as shown in *figure 7* do show a correspondence to the strength of the inversion. There are two aspects, however, in which this mechanism seems inadequate to fully explain the phenomenon. First, the supergradient winds should occur primarily at night, when the surface inversion is most developed. In the fires studied here the winds continued well into the day. Second, Blackadar (1957) suggested that the diurnal oscillations should be greatest at inland stations where coefficients of eddy viscosity are larger than over the ocean. Here, strong winds occurred at sea and inland near the coast. Nevertheless, this mechanism, or an oscillation mechanism similar to it, could have been at least partially responsible for the low-level wind maxima.

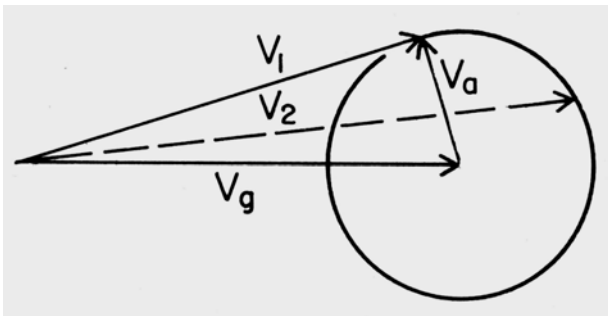


Figure 11—*Diagrammatic depiction of change of wind velocity from geostrophic, V_g , to less than geostrophic, V_1 , owing to the friction of the earth's surface; and to greater than geostrophic, V_2 , due to inertial oscillation. Here V_a is the ageostrophic vector.*

Channeling by Mountains

Channeling of flow by local mountains could be a factor in causing the strong winds. These winds were, in fact, nearly parallel to the Santa Ana Mountains, so that channeling may have been effective near the mountains, especially on the afternoons of August 21 and 22 when maximum winds were below mountain tops. This channeling is somewhat reflected in the convergence along the coast of the surface streamlines on Friday afternoon, *figure 12*. This could not be the entire reason for the winds because the jet is also seen over the ocean at San Nicolas Island. Also, at times, the strongest winds or nose of the profile occurred above the level of the mountains.

Temperature Perturbations in the Inversion Layer

Another factor that has been suggested as a contributor to strong low-level winds is the mesoscale horizontal temperature gradient within the inversion layer as described by Edinger (1960) and Miller (1968). Miller found that perturbations of the inversion layer induced by differential heating between land and sea, and partially by topography, were chiefly responsible for the low-level winds he studied in the San Francisco Bay area. Perturbations in the inversion layer could also have been a factor in producing the strong winds along the Santa Ana Mountains. We have too few temperature soundings in the area, however, to determine variation on a small-enough scale to evaluate the contribution, if any, of this mechanism.

Static Stability

The widespread thunderstorm and convective activity to the east and the strength of the inversion near the coast suggest that a well-developed wave or a vortex with a horizontal, north-south axis extended over the area. Either of these circulations, with upward motion to the southeast over eastern California and western Arizona, subsidence along the coast, and westerly flow at low levels, is in conformity with the synoptic situation and temperature distributions. The possible relation of the strong low-level winds to the thunderstorm and convective activity was considered. The winds, however, seemed to be too extensive, too anticyclonic, and too far from the convective activity to be very closely related to it.

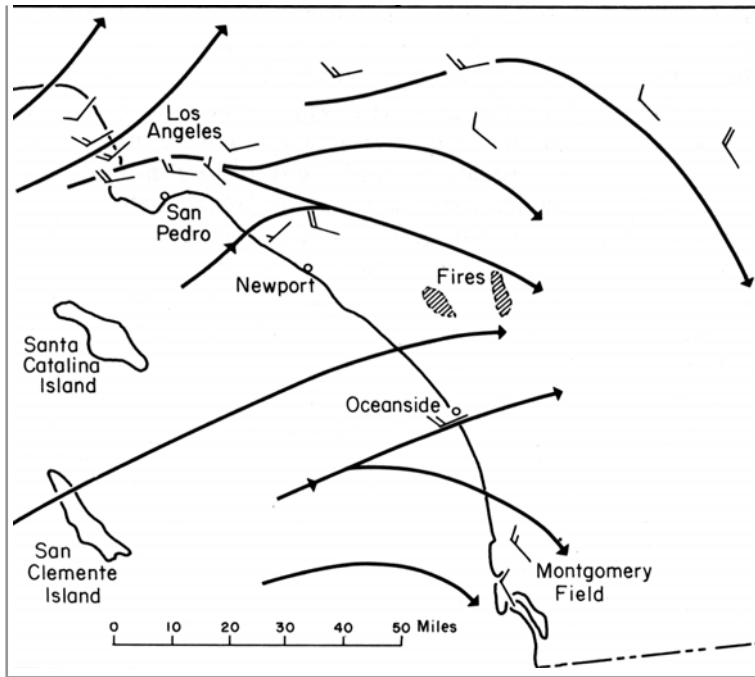


Figure 12—Surface winds and wind flow, 1700 August 22, 1969. (Pacific daylight saving time.)

Fire Interaction With the Atmosphere

Another effect that is noteworthy is the contribution of the fire itself and its interaction with the atmosphere in bringing the strong winds to the surface. Clive M. Countryman, the fire behavior officer at the fires, observed: “On the Walker Fire

during the evening of August 22, the winds around the fire area, including points at the same elevation as the fire, were very light. The fire itself was obviously being influenced by strong winds. It was also obvious that subsidence was taking place near the fire area; humidity was very low and temperatures high, particularly at the higher elevations.”

SUMMARY AND CONCLUSIONS

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Oxford: 431.1:111.5:(794).

Retrieval Terms: fire weather; windflow; San Mateo Canyon Fire; Walker Basin Fire.

Strong low-level winds are not only important elements in fire behavior, but are significant in other problems. Therefore, the need to forecast the occurrence of such winds is great. In a case study in southern California, low-level wind jets that affected the severity of the San Mateo and Walker Basin Fires in August 1969 were studied. Because of the effects of a large pressure ridge aloft extending from the

Pacific over the Western United States, the two fires were preceded by a long period of above-normal temperatures in southern California.

In the two fires, it appears that the low-level wind maxima generally developed on a scale too small to be easily forecast. Furthermore, there was a lack of data and experience to determine the cause of these winds or to develop forecast techniques necessary to

foresee their development or advection over an area of concern. Investigators have pointed out mechanisms that may result in strong winds under various conditions. In the fire studied here, it is probable that the strong winds were a result of a combination of mechanisms.

The mechanism most likely to have contributed to the occurrence of strong winds was a strong pressure gradient that seems to have been related to the existence of a low-level ridge to the west and an easterly wave to the east. Channeling of flow by mountain ranges or other topographic features is another quite obvious mechanism to be considered as a major contributor in this situation and probably in many others. The other potential factors discussed in this paper are not as obviously influential. Inertial

oscillation, or an effect related to the tendency of airflow to conserve its absolute vorticity may also have operated. Other possible contributory mechanisms that have been suggested as causes in other cases and that may have contributed to the strong winds in this situation include perturbations in the height of the inversion layer and atmospheric static instability.

The list of effects that have been suggested as contributors to low-level wind maxima is quite long but very probably incomplete. An upper-air station network of greater density is needed to study and understand this phenomenon, but the experienced forecaster with knowledge of the relative probabilities under different circumstances can evaluate the chances of strong low-level maxima in each particular situation.

LITERATURE CITED

- Barad, M. L.
1961. **Low-altitude jet streams.** *Sci. Amer.* 205(2): 120-131.
- Blackadar, A. K.
1957. **Boundary of layer wind maxima and their significance for the growth of nocturnal inversions.** *Bull. Amer. Meteorol. Soc.* 38(5): 283-290.
- Bonner, W.
1966. **Case study of thunderstorm activity in relation to the low-level jet.** *Monthly Weather Rev.* 94(3): 167-178.
- Bonner, W.
1968. **Climatology of the low-level jet.** *Monthly Weather Rev.* 96(12): 833-850.
- Byram, George M.
1954. **Atmospheric conditions related to blowup fires.** U.S. Forest Serv. Southeastern Forest Exp. Sta. Paper 35, 34 p., illus.
- Coffin, Harry C.
1959. **Effect of marine air on fire climate in the mountains of southern California.** U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta. Tech. Paper 39, 30 p., illus.
- Curtis, R. C., and H. A. Panofsky
1958. **The relation between large-scale vertical motion and weather in summer.** *Bull. Amer. Meteorol. Soc.* 39(10): 521-531.
- Dickson, Robert R.
1969. **The weather and circulation of August 1969.** *Monthly Weather Rev.* 97(11): 830-834.
- Edinger, James G.
1960. **The influence of terrain and thermal stratification of flow across the California coastline.** Final report. Univ. Calif. at Los Angeles, Dep. Meteorol, 62 p.
- Means, L. L.
1952. **On thunderstorm forecasting in the central United States.** *Monthly Weather Rev.* 80(10): 165-180.
- Miller, Albert
1968. **Wind profiles in west coast temperature inversions.** San Jose State College Rep. 4, 57 p.
- Pitchford, R. L. and J. London
1962. **The low-level jet as related to nocturnal thunderstorms over midwest United States.** *J. Applied Meteorol.* 1(1): 43-47.

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