SUNDOWNER WINDS

A Report on Significant Warming Events
Occurring in Santa Barbara, California.

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INTRODUCTION.

Along the Pacific coastline, beneath the ridges and canyons of the Santa Ynez Mountains, Santa Barbara, California enjoys some of the earth's most favorable weather. Mediterranean in classification, the climate is vintage southern California: an average high temperature of about 70 degrees year round, a predominately winter season rainfall of about 16 inches a year and, generally, a light and variable wind pattern.

The infamous Santa Ana winds which occasionally ravage the counties of Ventura, Los Angeles and Orange to the south leave the Santa Barbara area virtually untouched. The only disturbance to this idyllic picture comes when downslope winds pour across passes in the Santa Ynez Range, descending onto the Santa Barbara littoral.

These winds are "sundowners," Santa Barbara's special version of the Santa Ana regime. Sundowners frequently occur in the late afternoon or evening hours - hence the name. Light sundowners create irregular rises in temperature downtown with gentle offshore breezes. Stronger sundowners, occurring two or three times a year, can create sharp temperature rises, local gale force winds, and significant weather-related problems. Rarely, probably about a half dozen times in a century, an "explosive" sundowner occurs. These extremely strong and hot winds present a dangerous weather situation. In these events, super heated air from the Santa Ynez Valley bursts across the Santa Ynez Mountains and onto the coastal plain, reaching gale force or higher speeds within the city. Dust storms occur, fires can race down the mountain slopes, and great stress is felt by the human population, by animals, and by plants.

The most phenomenal of all known sundowners occurred on 17 June 1859. (Tomkins, undated publ.) It was recorded in historic texts from 19th century California as a frightening event without parallel in weather records in that part of the world. An engineering boat from the "US Coast Survey" fortuitously anchored near Santa Barbara monitored the weather that day and issued a report on its observations. The ship record states that temperatures reached into the mid 80sF by mid morning and no unusual weather was noted. At approximately 1pm, gusty northwest winds developed "from the direction of Santa Ynez Peak" accompanied by a sharp temperature rise and a severe dust storm. The storm "filled the inhabitants (of Goleta) with terror; they thought the end of the world had come." At 2 pm, the survey boat recorded a temperature of 133 degrees F (56 degrees C) in heavy blowing dust. Animals died in the fields, wild birds dropped from the air dead, and fruit and vegetables were "scorched on the windward side." The survey report stated that "no human being could withstand such heat." Contemporary accounts called the wind a "simoon," an Arabic word for a hot desert wind.

By 5 pm on that June day, the thermometer reading had dropped to 122 degrees. By 8 pm, it had cooled to 77 degrees. A North American high temperature record was established that day which would be eclipsed only years later by a 134 degree reading in Death Valley.

This paper examines 31 significant warming events of different types (including many sundowners) which occurred on the Santa Barbara coastal plain between 1985 and 1991. In addition, some guidance to the forecasting of such events is offered and public safety considerations are addressed.

PHYSICAL GEOGRAPHY

To the north of Santa Barbara County lies the broad, flat and (in summertime) hot San Joaquin Basin, which includes the cities of Bakersfield and Fresno. Within the county, which extends 43 miles north to south at Santa Barbara, the terrain is rugged and mountainous. Rising from the Cuyama River Valley on the northern boundary, there are three main east-to-west oriented mountain ranges:

(1) The Sierra Madre Range snakes in a long ridgeline with elevations to 5845 feet;

(2) the irregular San Rafael Range, with numerous peaks, rises to almost 7000 feet in the central part of the county;
(3) the Santa Ynez Mountain ridge, with elevations from less than 2500 feet to 4298 feet, extends to within six miles of the city of Santa Barbara.

Santa Barbara and Goleta are built on a narrow, one-to-five mile wide coastal plain, which rises precipitously to the Santa Ynez Mountain ridgeline. The ridge is notched with three significant openings: Nojoqui (pronounced nah-Ho-wee) Pass at 925 feet, Refugio Pass at 2254 feet, and San Marcos Pass, directly above the city of Santa Barbara, at 2224 feet. There is a fourth notch to the northeast of Santa Barbara, Romero Saddle at 3025 feet that can sometimes play a significant role in offshore wind episodes.

On the north side of the Santa Ynez Range lies the Santa Ynez River Valley. The intermittent Santa Ynez River drains the valley from an elevation of 2000 feet at its source near the Ventura County line to 1326 feet at Gibraltar Reservoir to 751 feet at Bradbury Dam (Lake Cachuma) to the ocean near Lompoc.

SUNDOWNER DYNAMICS, SUMMARIZED.

The sundowner wind is a mesoscale phenomenon, which develops when north-to-south low level pressure gradients increase to a critical level across Santa Barbara County. Dynamical external forcing occurs in stably stratified air flowing below 10,000 feet in its cross-county trajectory, resulting in negative air mass buoyancy and a warming downslope wind directed toward the coastline. (Gedzelman 1985) The warming may be enhanced by thermal external forcing occurring over the Santa Ynez Valley immediately prior to the final downslope trajectory of the flow from the Santa Ynez Mountain ridgeline to the beaches. Strong and observable channeling of this gradient wind occurs in the vicinity of the major mountain passes and near the south-facing coastal canyons. The force of the gravity flow is modulated, generally, by fluctuations in the north-south low level pressure field.

Explosive sundowners result when super-heated air along the upper Santa Ynez Valley is forced into a down-valley flow by moderately strong and increasing north-south gradient wind at 1500 to 6000 feet. Eventually, thermal external forcing occurs through principal notches in the Santa Ynez Mountain ridgeline, and then along the general ridgeline east and west of Santa Ynez Peak.

The venting of hot air from the Santa Ynez Valley over the passes leads to the “explosive” nature of the event. Trapped internal gravity waves which are both orographically and thermally restricted (Atkinson 1981) create a virtual inferno along specific sections of the Santa Barbara Costal strip.

DATA COLLECTION AND REDUCTION

The Santa Barbara Airport FAA Flight Service Station complete weather record (MF 1-10 C) and daily temperature profile was analyzed for the 70 month period between April 1985 and January 1991 inclusive. During that time there were thirty-one significant warming events (SWE) covering a period of forty-six days.

Each of the SWE was analyzed and categorized based on the parameters outlined in the table on page 15. Of the 31 SWE, ten events showed no sign of sundowner activity (Category 0), five events were weak sundowners (Category 1), fourteen were moderate or strong sundowners (Category 2) and two were classified as (Category 3) explosive.

A representative example of an actual “observation day” fitting each SWE category is provided in the section following the text of this report, along with the associated macro surface and 500mb analyses. Mean statistical data and map types are then presented for each of the four SWE categories.

The following information is provided for interpretation of the observation data pages.

All times are Pacific Standard, except GMT where noted. Three hourly surface observations from Santa Barbara FSS in Goleta were utilized. Sea level pressure gradients were noted from Santa Maria Airport (SMX) to Santa Barbara, and from Bakersfield (BFL) to Santa Barbara. Bakersfield SLP data were not available for 2200 hours, therefore 2100 data were substituted for that station only. All SLP data are listed in tenths of millibars with the decimal point omitted. SLP data from surface observations are normally temperature-compensated, but may not be so adjusted in all cases. This may have a slight, but not significant, impact on values obtained.

It should be noted that SLP gradients used do not represent a true north-south orientation. Bakersfield lies 70 nm to the northeast of Santa Barbara; Santa Maria is 42 nm northwest of Santa Barbara.

Rawinsonde data was utilized for 1200 GMT soundings (unless otherwise noted) taken at Vandenberg AFB (VBG) and from NAS Pt. Mugu (NTD). The city of Santa Barbara lies almost exactly halfway between these upper air sounding points. Temperature and wind data were compared for the 850 and 700 mb levels; winds were plotted from 1000 to 9000 feet. The 500 millibar height was computed at Pt.Mugu.

Forest Service observation records were obtained from Los Prietos Ranger Station in the upper Santa Ynez Valley and were used, in combination with records from Bradbury Dam, to profile parameters in that critical area.

Other temperature and weather records were reviewed from Santa Maria Airport, Solvang, Santa Barbara County Fire Station Number 5 (FISTA5), Bradbury Dam (BRAD), and the downtown Santa Barbara Water Treatment Plant (WTRP). "HARBOR" refers to Santa Barbara Harbor and "EL CAP" refers to data from El Capitan State Park near Gaviota Pass.

Wind data for Point Conception's "Harvest" Oil Platform, 38 nm west of Santa Barbara, were entered as "CNCP WIND" when available. Data from nearby Platform "Irene" was substituted when noted.

DISCUSSION OF SWE AND COLLECTED DATA.

Ten of the SWE observed between 1985 and 1991 gave no evidence of sundowner wind or temperature anomalies outside of normal diurnal ranging; these SWE were used as control data for this study. These abnormally warm days can be ascribed, in most cases, to mean ridging aloft across the district. Usually a matter of the "eastern Pacific high" shifting to the coast, the warming is sometimes a result of Santa Ana (offshore) conditions occurring further south.

This situation normally results in east to southeast winds aloft above 3000 feet at VBG and NTD. Temperatures in Santa Barbara can exceed 104 degrees F (40C) in these events but surface wind is usually light, from southeast to southwest.

The boundary between the hot air at Santa Barbara and marine air at the beaches can be sharp and active in these events, with local low level wind shear and striking air density shifts causing problems at Santa Barbara Airport, which is located immediately adjacent to the beach at Goleta.

The downslope and offshore mechanism that causes warming winds at Santa Barbara is essentially the same as that which causes the larger scale Santa Ana winds to the south and the small scale warming winds at Avila Beach in San Luis Obispo County to the north.

All categories of Santa Barbara's sundowner winds appear to develop in similar fashion. Standing eddy streaming (Figure 1, after Forchgott, 1949) seems best to approximate the mountain wind pattern existing near Santa Barbara just prior to the onset of sundowner winds. A north-south gradient flow develops over the county. The gradient is primarily enhanced by (1) packing behind a southward-moving trough or (2) an 850 mb high pressure ridge moving into central California near the Bay Area, often sandwiching between a "thermal" low over the lower Colorado River Valley and a synoptic scale short wave approaching northern California from the Gulf of Alaska. Early on, downslope tendencies within the gradient wind layers on the on the south side of the Santa Ynez Mountains are blocked by a relatively cool and stable marine inversion at Santa Barbara, where weak southerly surface wind is experienced. Temperatures within the gradient wind profile at 3000-6000 feet may range from approximately 50 to 77 degrees F, depending on the season. The dynamics of the gradient wind in this standing eddy regime further increases the surface pressure on the north side of the Santa Ynez Range and further decreases the SLP at Santa Barbara, resulting in a low pressure anomaly at Santa Barbara respective to the rest of southern California. (Clark and Dembek, 1990) Diurnal heating of the boundary layer along the Santa Barbara coastal strip temporarily increases the onshore/upslope wind as significant SLP falls develop around midday.

Then, usually during early or mid afternoon, the weakening of the Santa Barbara marine inversion (by isolation and/or warm advection) removes the resistance to downslope "wave streaming" effects. (Figure 2, after Atkinson, 1981)

As SLP differentials increase across the county, warm gradient winds begin their extrusion onto the littoral, funneling through Nojoqui Pass. Sundowner winds generally begin here, channeling downward to the coast, often meeting the marine layer head-on, then deflecting to the left (eastward) along the beaches toward Santa Barbara, where the boundary layer flow is still usually southerly. (See sundowner flow maps at the conclusion of this paper.) This ultimately creates a 250 to 280 degree modified sundowner wind, which can reach all the way to the downtown area. Occasionally, when the warm air does not breach the higher passes, the Nojoqui wind will be the only significant stream into the Santa Barbara area. A hot, gusty wind, it does not mix with the marine layer, and causes strong low-level turbulence along the beaches and at the airport. More frequently, however, the other major passes and canyons along the Santa Ynez ridgeline also become significant wind channels. Refugio Pass and Canyon direct strong north to northwest winds toward Refugio and El Capitan Beaches. Though winds near these beaches are strong, the outflow boundary from the Refugio stream normally lies only one to two miles east of El Capitan. (Greg White, personal communication, 1991) The boundary is extremely sharp; temperatures may change by 15 to 30 degrees F or more within one-quarter mile, or within two or three minutes along the oscillating front.

The main sundowner stream affecting Santa Barbara and Goleta directly is the one, which channels east of Santa Ynez Peak near San Marcos Pass. This wind is strongest directly below the pass. It gathers strength and squeezes through Windy Gap on Highway 154, then maintains much of its force and arrives with considerable velocity, sometimes gale strength, in the Hollister-Turnpike area along Modoc Road, and occasionally reaches the exclusive Hope Ranch section of Santa Barbara. Outflow from this sundowner stream affects Santa Barbara Airport as a north to northeast wind and Santa Barbara Harbor as a north to northwest wind. There appears to be a surface deflection of this flow, perhaps caused by marine air intrusion at the beaches and/or interaction with outflow streams from other canyons. The result of this deflection is a low level jet which intersects TV Hill and Pyramid Peak (elevation 459 feet), at times wreaking havoc in those exposed locations directly above Santa Barbara harbor.

Downslope wind is channeled through other canyons in the Santa Barbara area, including Glen Annie Canyon, for example, but those canyons do not generate the wind force exhibited below the main passes and saddles because they do not present significant openings in the ridgeline above. Some gaps in the Santa Ynez Range do exist to the east of Santa Barbara; Romero Saddle is a notable one. In some sundowner episodes, indicator winds are first observed in this area. Sundowner winds have been observed in some episodes along the coastal strip as far east as Carpenteria and Rincon Point.

There is a large variability in wind speed and direction and temperature along the immediate coast during sundowner events. The coast becomes a virtual battleground between competing canyon outflows and marine intrusions. Much less variability in meteorological parameters is apparent along the ridgeline and within the canyons themselves.

CATEGORY 3 SUNDOWNERS.

Historical data indicate that, about half a dozen times in a century, explosive sundowners occur in Santa Barbara. The latest events in 1985 and 1990 are well documented.

These most powerful windstorms seem to follow a specific developmental course. On the synoptic scale, a strong (5900m or greater) 500 millibbar eastward propagating ridge reaches the southern California coast within a few weeks on either side of the summer solstice. A surface “thermal” low pressure is centered near the Imperial Valley. A short wave trough approaches the Pacific Northwest coast, pushing an 850 millibar ridge over central California, thus forming a north-south pressure gradient over Santa Barbara County. A marine inversion may, or may not, push eastward toward Bradbury Dam from the Santa Maria and Lompoc Valleys.

Some comments about the Lompoc-Santa Maria Valley inversion are in order. A strong marine inversion was present in the Santa Maria Valley during the Category 3 sundowner event of 1990. But there was no inversion at Santa Maria during the

Category 3 vent of 1985. In fact, the 1985 event took place during the third warmest two-week period in Santa Maria since the turn of the century.

Category 2 and 3 events occur independently of inversions present in the Santa Maria area. Evidently, the inversion layer is usually absent from most west-county locations when winds at 850 millibars favor sundowner formation (i.e., are northerly or "quartering offshore"). Further, it should not be assumed that a deep inversion on the VBG sounding translates to an equally deep inversion through the Santa Ynez Valley. In the Bradbury-Los Prietos area, summertime inversions are invariably less than 900 feet thick and mix out early—before 0900 PST. Summer temperature sin this area are more akin to Las Vegas than to Santa Barbara or Santa Maria.

It seems plausible that the presence of a coastal inversion at Lompoc-Santa Maria could even create a stronger sundowner by blocking, then reversing, hot down-valley flow along the upper Santa Ynez Valley.

But, in any event, it is established that intense hating does occur in the upper valley. The hot air is established that intense heating does occur in the upper valley. The hot air is capped by the 3000 foot cross-ridge flow with its 340-025 degrees component. 850 millibar temperatures hold steady in the 70s F (low to mid 20s C).

After sunrise on sundowner day one, as strong surface-based super adiabatic lapse rate forms near Bradbury Dam and in the Los Prietos Ranger Station area. Temperatures here soar to 100 to 120 degrees F. Temperatures at Santa Barbara Airport, only ten miles away across the ridgeline, are around 70 F. The potential for energy release created by such differential heating is enormous.

For most of the first day, the gradient wind traps the super heated air in the valley. Down-valley (east) winds occur along the Santa Ynez River. Then, in the late afternoon or evening, the downslope flow breaks through the decaying marine inversion at Santa Barbara, resulting in sharp temperature rises from Nojoqui to Gaviota. Warm air extrusions occur next at Refugio and San Marcos Passes causing evening temperatures at Santa Barbara to rise to 85 to 95 degrees F. The marine inversion and resistance to warm downslope flow has been eliminated and, with north-south pressure gradients continuing to increase, venting of very warm air from the Los Prietos area, and perhaps other valleys in eastern Santa Barbara County, can continue overnight. By sunrise on the second day, temperatures in Santa Barbara are already in the mid 80s F. Lee waves entraining warm valley air are already channeling through the passes and canyons. With maximum isolation, valley temperatures again heat rapidly to the 100 to 120 degree F range by midday. But now the gradient flow does not trap, but rather, directly transports the super heated air onto the Santa Barbara coastal plain. The hottest air, from Bradbury Dam eastward, extrudes over the ridgeline to the east of Santa Ynez Peak, especially near San Marcos Pass.

Strong internal gravity waves race down the canyons and reach the coast as gale force gusts, but become evanescent and dissipate quickly (Atkinson 1981) over Santa Barbara Channel. Temperatures in Santa Barbara, where the potential maximum temperature is 5 to 10 degrees F higher than in the Los Prietos area, reach easily to over 104 F by early afternoon. By late afternoon the cooling process usually begins and by 9 pm the sundowner is over. If the north-south gradient relaxes, the process for explosive sundowner activity outlined above will not repeat the next day, even though the SWE may still ensue.

The “Simoon of 1859” fits, albeit strongly, the pattern for Category 3 sundowers. Occurring almost on the summer solstice, the strong early afternoon heating probably resulted from the entrainment of the 120 degree F air from the Santa Ynez Valley into an established gradient flow. A 500 millibar value of more than 6000 m, with other synoptic conditions present for sundowner generation, would have been sufficient to produce this remarkable severe weather event.

Since 1950, explosive sundowners have occurred three times; in 1977, 1985 and 1990. All of these sundowners resulted in tragic and expensive firs and significant disruptions in the lives of county residents.

PUBLIC SAFETY.

SWE in general and sundowners in particular constitute a threat to public safety on two important fronts: Fire danger and danger to transportation. Other public safety concerns, such as human health and agricultural damage, are significant but beyond the scope of this report.

The fire danger associated with sundowner events is well documented. Fritz Cahill, USFS Fuels Officer, now retired, for the Los Padres National Forest, commented that the problem with sundowner-generated fires is that they run downhill—not uphill like normal fires—and they catch even veteran firefighters off guard.

A sundowner fire occurred in October 1971 below Romero Saddle and burned downward through Romero Canyon northeast of Santa Barbara. The next major sundowner fire was the Sycamore Canyon fire on 26 July 1977 which burned to within a few miles northwest of Montecito. The 1985 explosive sundowner spawned the Wheeler Fire, which burned to within four miles of Carpenteria.

The 27 June 1990 fire, called "Painted Cave," or just "Paint," after a prehistoric Indian landmark near the fire's origin, was the worst of all the sundowner blazes. This arson-caused fire was the subject of considerable national media attention. The forest Service had issued a "Red Flag Alert" on the day of the blaze, which was the third day of a major sundowner event. Fire prevention crews spotted the first smoke early after ignition (at 6:02 pm PDT) near Painted Cave Monument. But winds gusting at 40 to 60 miles per hour in the San Marcos Pass area overpowered the firefighters' early efforts. The burned areas was huge—from San Marcos Pass to across the 101 Freeway. Property losses were heavy, with over 500 structures, including some very expensive residences, destroyed. Videotape from the fire shows ash falling in Santa Barbara like some bizarre June snowfall. Transportation through the district was completely cut off. One human life was lost.

As bad as Painted Cave was in terms of destructiveness, it was very close at one point to becoming a human disaster with great loss of life. Stan Dumas, Assistant Fire Chief for the City of Santa Barbara, recounted that the fire raced to State Street, and in the 4200 block burned to within yards of a commercial chlorine supply tank containing 3000-5000 gallons of the chemical. Thirteen heroic firefighters, aided by one citizen, kept the tank from exploding. Dumas: "[the chlorine] would have gone through Hope Ranch. It would have been a real killer."

Transportation is also negatively impacted by sundowner events. Highway traffic is affected, especially high-profile vehicle traffic, along the 101 Freeway from east of El Capitan through the Gaviota rest area and along Highway 154 from the top of San Marcos Pass through Windy Gap to the Hollister-Turnpike area of Santa Barbara. The California Highway patrol usually issues "high wind warnings" for the two highways based on an officer's subjective reports from the affected areas.

SWE, particularly sundowners, are of great concern to aviation interests. The Santa Barbara Flight Service Station has documented four aircraft mishaps at Santa Barbara during SWE occurring between 1985 and 1991. Pilots flying into Santa Barbara Airport during SWE should be aware of the dangers of low level wind shear and strong downdrafts on the lee side of the Santa Ynez Mountains.

One veteran Santa Maria pilot, who has flown the Santa Maria to Santa Barbara route during several sundowner events, calls the flights "scary." Flying over the Santa Ynez Mountain ridgeline and descending to around 3500 feet, the aircraft is forced downward within the gravity regime—losing up to 3000 feet of altitude and virtually out of control until stabilization can be regained, generally about 500 feet above the Santa Barbara runway complex. Near the runways, wind measuring equipment manifests extreme variability in speed and direction during sundowners as the main sundowner streams descending air which frequently attempts to make onshore incursions. During a recent Category 2 sundowner episode, Santa Barbara FSS initiated several "urgent pilot reports" when pilots radioed great difficulty in approaches and departures.

FORECASTING SUNDOWNERS.

It is important that forecasters be able to anticipate synoptic indicators and generate the north-south low level gradient responsible for sundowner development. Synoptic scale patterns, outlined earlier in this paper, are usually well reflected in 850/700 millibar NGM or AVN progs.

The Santa Maria to Santa Barbara SLP gradient is probably the most basic tool used in sundowner forecasting and evaluation. The Bakersfield to Santa Barbara gradient provides another aspect to the north-south pattern. But BFL is almost two times further from SBA than is SMX, and BFL is located in a different climate regime.

Based on the supporting data obtained within this study, the following rules apply for sundowner evaluation and forecasting:

(1) Sundowners will not occur if the BFL-SBA SLP gradient is negative, or if the SMX-SBA gradient is less than 1.8 mb.

(2) 3000 foot winds at VBG MUST flow from 335 to 025 degrees for sundowner development to occur. Winds above the 850 mb height may or may not show speed or direction variance compared with the 850 mb surface. 3000 foot wind speed at VBG is normally about 20 knots, but may be as little as 12 knots.

(3) SMX-SBA SLP gradients between approximately 2.0 and 4.0 mb can produce Category 2 sundowners.

(4) SMX-SBA SLP gradients between 3.5 and 6.5 mb can produce Category 2 sundowners.

(5) SMX-SBA SLP gradients between approximately 5.0 and 6.5 mb can produce Category 2 sundowners.

(6) Category 3 sundowners will occur within the SLP gradient parameters above, provided that (a) there has been an established sundowner event in progress and (b) SLP gradients are increasing and (c) maximum isolation is occurring, i.e., in the months of June or July.

(7) When sundowner events are forecast to occur or are occurring, aviation forecasts should ALWAYS use a LLWS caution in the Santa Barbara terminal forecast.

Einer Hovid, a Santa Barbara consulting meteorologist with many years of experience in sundowner forecasting has observed (personal communication, 1992) that SMX-SBA gradients of 2 to 3 millibars produce 20 to 30 knot winds through passes and canyons of the Santa Ynez Range. Gradients of 3 to 4 millibars yield 30 to 40 knot canyon winds, 4 to 5 millibars produce 40 to 50 knot winds, with over 50 knot winds expected if the gradient exceeds 5 millibars.

Maximum temperature forecasts for sundowner events at Santa Barbara Airport may have some success (1) by adding approximately 3 degrees F to the high temperature at Los Prietos or (2) by adding approximately 15 degrees to the mid-afternoon temperature at La Cumber Peak. These seem to provide a reasonable temperature forecast in what is invariably a highly irregular surface temperature profile on the Santa Barbara coastal strip.

Since Santa Barbara Airport is normally one of the last places to manifest sundowner circulation effects, observations from SBA may fail to indicate a sundowner event already in progress. Lifeguard headquarters at El Capitan Beach, often one of the first coastal locations to feel the onset of the winds, may be directly contacted for early sundowner indications.

Sundowner events may be monitored in the earliest stages by polling the Santa Barbara County Flood Control "Alert" system and checking the following sensors: La Cumbre Peak Wind and Temperature (2500, 2505), San Antonio Creek Wind (2555), Sudden Peak Wind (2542), Refugio Wind (2537), Mount Calvary Monastery Wind and Temperature (2510, 2515), and Goleta Wind and Temperature (3090, 3096). The Los Prietos Ranger Station, east of Lake Cachuma, may be contacted directly for weather information. Also, Santa Barbara County Air Pollution Control District site data may be obtained from APCD personnel.

The US Forest Service, in the cooperation with NWS Fire Weather forecasters, plans to place automatic weather reporting stations at strategic points along the Santa Ynez Mountain ridgeline. These sites will be selected specifically to provide early warning of sundowner events. The first tow stations, at the top of the San Marcos Pass, are expected to be on line when funds become available. (Jim Schackelford, personal communication, 1992)

CONCLUSION.

A Significant meso-scale event like a sundowner, occurring over a heavily populated section of the California coast, clearly represents a threat to public safety.

Sundowners are predictable incidents. Perhaps, in the future, as sundowner events recur, lives and property can be saved as a result of further expansion of the observation network, refinements in forecast technique, and close inter-agency cooperation.

TABLE OF SIGNIFICANT WARMING EVENT (SWE) CATEGORIES	
CATEGORY	**DESCRIPTION**
0	**NON-SUNDOWNER ANOMALY.** Control data—no sundowner signals in this event. Warm advection with moderate or strong diurnal heating usually associated with mean ridging moving over the district. Normal diurnal temperature curve at surface observation points. Light surface winds, tending onshore in teh afternoon. Surface temperatures at Santa Barbara may reach 104 degrees F (40C).
1	**WEAK SUNDOWNER.** Maximum temperature occurs outside normal temperature curve. Surface winds tend offshore less than 15 knots at the coast. Strongest winds in passes and canyons with gusts to 30 knots.
2	**MODERATE TO STRONG SUNDOWNER.** Temperature maximum occurs outside normal diurnal temperature curve and manifests increase to 15 degrees F (8C) or more from normal curve. Gusty, usually offshore, winds more than 15 knots at the coast. Strongest winds in passes and canyons with gusts 30 to 50 knots.
3	**EXPLOSIVE SUNDOWNER.** Surface temperatures at Santa Barbara exceed 104 degrees F (40C) during early or mid afternoon. Gusty offshore surface winds reach 20 knots or more at the beaches. Winds in canyons and passes exceed 50 knot. Observed mainly during the months of June or July.

REFERENCES

Atkinson, B.W., 1981: Meso-Scale Atmospheric Circulations. Academic Press, San Francisco, 495pp.

Bosart, Lance F., 1983: Analysis of a California Eddy Event. Monthly Weather Review (AMS), 111, pp1619-1633.

Clark, John H.E. and Dembek, Scott R., 1990: the Catalina Eddy Event of July 1987: A Coastally Trapped Mesoscale Response to Synoptic Forcing. Monthly Weather Review (AMS), 119, pp1714-1735.

Finke, Brian W., 1990: Sundowner Winds and the June 25-28 Santa Barbara Fire. Western Region Technical Attachment No. 90-30.

Gedzelman, Stanley D., (Contrib. Ed.) 1985: Handbook of Applied Meteorology. John Wiley and Sons, New York.

Hooke, William H., (Contrib Ed.) 1986: Mesoscale Meteorology and Forecasting. American meteorological Society, Boston, 793pp.

Tomkins, Walker A., Undated: Santa Barbara's Incredible Hottest Day (based on historical text: Goleta: The Good Land, pp57-58) Santa Barbara National Bank.

Western Region Headquarters, 1990: Downslope Windstorms and Mountain Waves. Western Region Technical Attachment No. 90-31.

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