SUNDOWNERS, DOWNSLOPE WIND EVENTS AROUND THE SANTA BARBARA CHANNEL

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ABSTRACT

Sundowners are downslope winds, occurring mainly in the late afternoon to early evening, that cause an irregular temperature increase in the Santa Barbara area. A study was made from September 1995 through August 1997, based upon a dense network of surface meteorological stations around the Santa Barbara Channel, as well as a radar profiler, and National Weather Service charts. Statistics were developed about the occurrence, wind strengths, and horizontal extent of events over the Santa Barbara Channel. A sundowner event on June 30, 1996, 0000 Greenwich Mean Time (GMT) was used to show that sundowners are mesoscale events influenced by the topography and strength of the marine layer. Although consistent with synoptic scale pressure gradients and maps indicating offshore flow, the events during this study showed offshore winds over a very limited aerial extent, with some coastal stations having onshore winds at all levels, and most offshore stations being unaffected. In general, the events during this study did not show good correlations to pressure differences between Santa Maria and buoy 54, or Bakersfield and buoy 54.

Keywords: Santa Barbara, sundowners, downslope winds.

INTRODUCTION

Downslope winds that commonly occur in the late afternoon to early evening are known as “sundowners” in the Santa Barbara area. These winds are heated adiabatically as they descend downslope from the north on the lee side of the east–west trending Santa Ynez Mountains, forming a lee side trough and a temperature increase outside of the diurnal norm. The Santa Barbara area is located just south of the Santa Ynez Mountains, along a one to five mile wide coastal plain (Ryan 1996). Fifteen surface stations and a radar profiler were used to determine the horizontal and vertical extent of sundowner winds (Figure 1). The events during this study, from September 1995 through August 1997, most frequently occurred at Gaviota West (godw), a surface station on the coast at the mouth of a canyon leading up

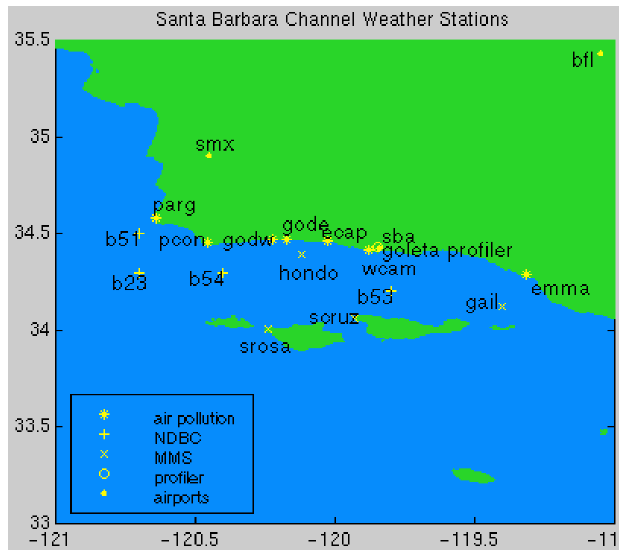

Figure 1. Location map of weather stations around the Santa Barbara Channel.

Nojoqui Pass. One possible reason for this is that Nojoqui Pass is the lowest gap in the Santa Ynez Mountains. Another is that godw is the furthest northwest of the stations studied, with the exception of buoy 51 and Point Conception (pcon), which are on the windward side of the mountains and are not affected by sundowner winds. National Weather Service charts were also used to determine the synoptic scale conditions during sundowner events.

MATERIALS AND METHODS

There were two main criteria used to find sundowner events during this study. First, days with temperatures greater than 25°C correlated with north (offshore) winds were found from monthly time series plots at Gaviota West. Then these days were used to find when there was a temperature difference of 10°C or more between Gaviota West and buoy 54. These criteria were used because 25°C is much higher than the average summer temperature of about 18°C to 19°C in this area, and because buoy 54 is usually unaffected by events and represents the regional norm if there was no sundowner event (Dorman et al., in press). When days of possible events were determined from these criteria, time series plots of about one week around the event day were made for the temperature at Gaviota West, the pressure gradients between Bakersfield (BFL) and buoy 54, and Santa Maria (SMX) and buoy 54, and the north wind component at Gaviota West (Figure 2). These plots and scatter plots of the godw/buoy 54 temperature difference vs. BFL/buoy 54 pressure difference, godw/buoy 54 temperature difference vs. SMX/buoy 54 pressure difference, godw/buoy 54 temperature difference vs. godw north wind speed, BFL/buoy 54 pressure difference vs. godw north wind speed, SMX/buoy 54 pressure difference vs. godw north wind speed, and godw temperature vs. godw north wind speed were made to determine any correlations between these pressure gradients and sundowner events (Figure 3). Correlation coefficients for temperatures between stations and north wind speed components between stations were calculated for the time of maximum temperature at Gaviota West (Tables 1 and 2). The event that occurred on June 30, 1996, 0000 GMT was then chosen to further study the synoptic and mesoscale conditions for a sundowner event. For this date, a map of the winds at all stations and a table of their temperatures was made (Figure 4), the wind speeds and temperatures at various heights from the surface to 2295 m were determined from a radar profiler at Goleta (Figure 5), and National Weather Service surface and 850 mb charts were studied to determine the synoptic scale conditions during this event (Figures 6 and 7).

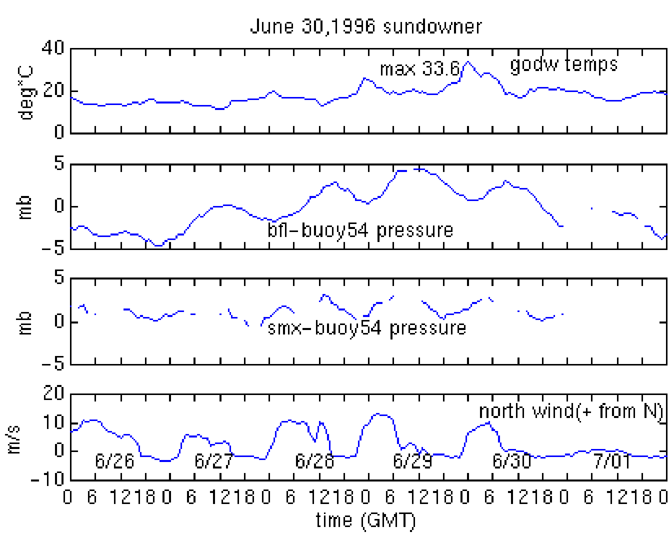

Figure 2. Time series plots of temperatures, pressure gradients, and north wind speed components.

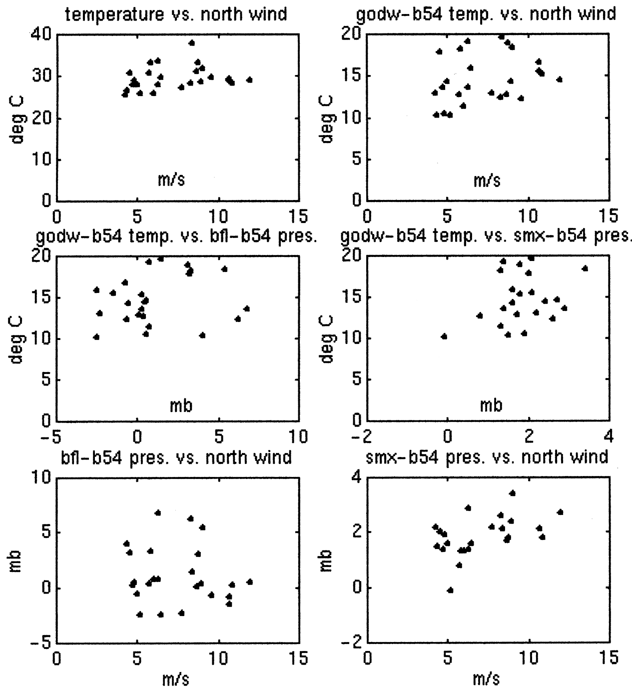

Figure 3. Scatter plots of godw temperature vs. north wind speed, godw-buoy54 temperature vs. north wind, godw-buoy 54 temperature vs. bfl-buoy 54 pressure, godw-buoy 54 temperature vs. smx-buoy 54 pressure, bfl-buoy 54 pressure vs. godw north wind, and smx-buoy 54 pressure vs. godw north wind for all sundowner events from September 1995 through August 1997.

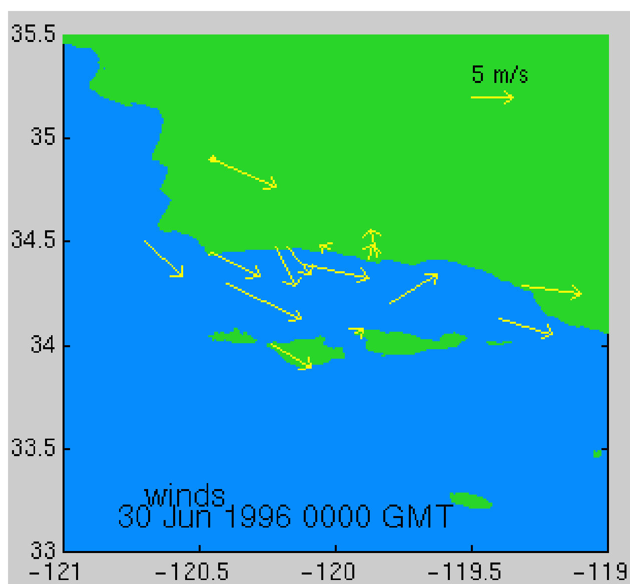

Figure 4. Map of winds on June 30, 1996, 0000 GMT and table of station temperatures.

station	temperature	station	temperature	station	temperature
pcon	21.5 C	ecap	28.3 C	srosa	18.8 C
godw	33.6 C	wcam	21.2 C	scruz	19.3 C
gode	34.1 C	buoy 54	14.4 C	gail	17.5 C
hondo	31.6 C	buoy 53	16.6 C		

Table 1. Correlation coefficients of temperatures between stations during sundowner events from September 1995 through August 1997.

station	godw	gode	ecap	wcam	buoy 54	hondo	gail	srosa	scruz
godw	1	0.7188	0.5644	0.5514	0.3275	0.7619	0.3089	0.3052	0.4417
gode	0.7188	1	0.7051	0.5263	0.0884	0.7545	0.2132	0.2094	0.3012
ecap	0.5644	0.7051	1	0.7207	0.2003	0.6867	0.3427	0.2032	0.3106
wcam	0.5514	0.5263	0.7207	1	0.3605	0.5857	0.5715	0.2724	0.4657
buoy 54	0.3275	0.0884	0.2003	0.3605	1	0.3722	0.6903	0.869	0.8807
hondo	0.7619	0.7545	0.6867	0.5857	0.3722	1	0.3793	0.4815	0.6015
gail	0.3089	0.2132	0.3427	0.5715	0.6903	0.3793	1	0.5568	0.7219
srosa	0.3052	0.2094	0.2032	0.2724	0.869	0.4815	0.5568	1	0.9096
scruz	0.4417	0.3012	0.3106	0.4657	0.8807	0.6015	0.7219	0.9096	1

Table 2. Correlation coefficients of north wind speed components between stations during sundowner events from September 1995 through August 1997.

station	godw	gode	ecap	wcam	buoy 54	hondo	gail	srosa	scruz
godw	1	0.4661	0.0727	NaN	0.3614	0.1988	NaN	-0.3124	-0.2039
gode	0.4661	1	0.4358	NaN	-0.0973	0.4021	NaN	-0.2134	0.059
ecap	0.0727	0.4358	1	NaN	-0.087	0.3747	NaN	-0.1821	0.0859
wcam	NaN	NaN	NaN	1	NaN	NaN	NaN	NaN	NaN
buoy 54	0.3614	-0.0973	-0.087	NaN	1	-0.0157	NaN	-0.0109	-0.0228
hondo	0.1988	0.4021	0.3747	NaN	-0.0157	1	NaN	-0.0516	0.3159
gail	NaN	NaN	NaN	NaN	NaN	NaN	1	NaN	NaN
srosa	-0.3124	-0.2134	-0.1821	NaN	-0.0109	-0.0516	NaN	1	0.2154
scruz	-0.2039	0.059	0.0859	NaN	0.0228	0.3159	NaN	0.2154	1

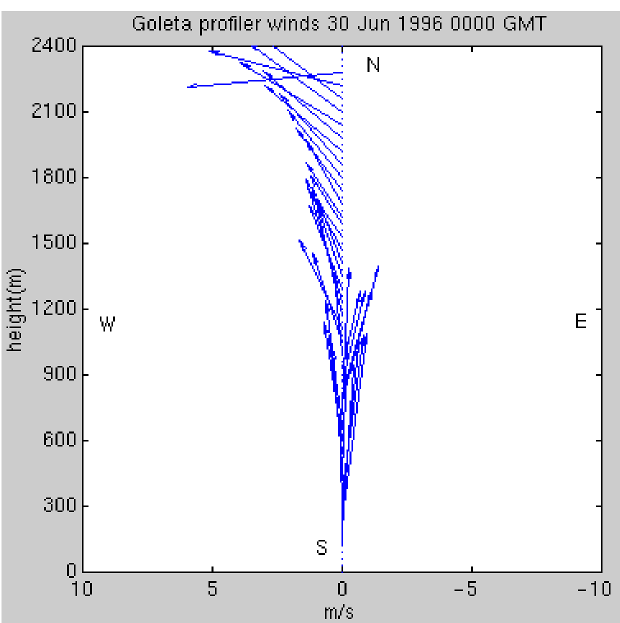

Figure 5. Wind speeds to 2295 m from the Goleta radar profiler for June 30, 1996, 0000 GMT.

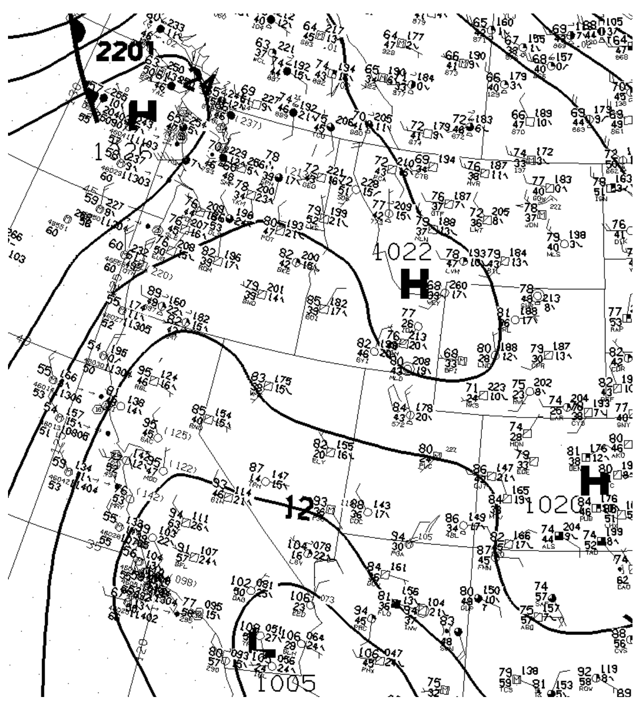

Figure 6. National Weather Service surface chart for June 30, 1996, 00Z.

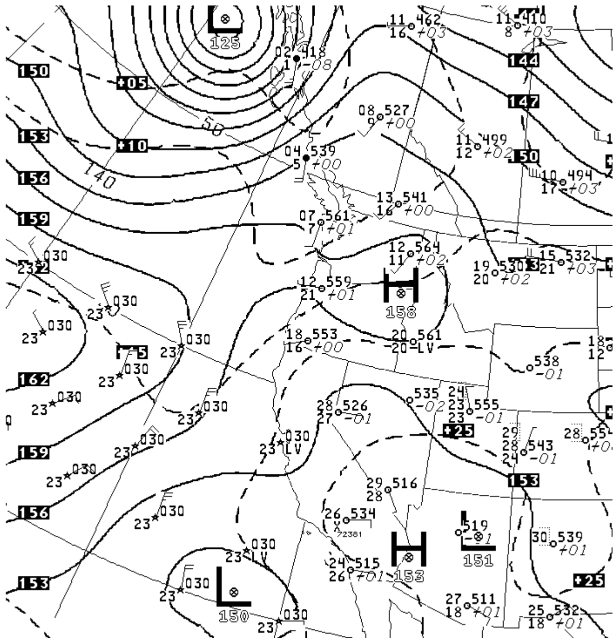

Figure 7. National Weather Service 850mb chart June 30, 1996, 00Z.

RESULTS

The sundowner events during this study occurred mainly between 2100 GMT and 0000 GMT. Figure 4 is a map of the winds and a table of the temperatures at all stations on June 30, 1996, 0000 GMT (June 29, 1996, 1700 PDT). Gaviota West and Gaviota East (gode) were most affected by sundowner winds from the north-northwest with temperatures of 33.6°C and 34.1°C, respectively. Hondo platform, the closest offshore station, was also affected by sundowner winds with a temperature of 31.6°C and winds from the west. Sundowner winds did not extend to the offshore stations buoy 51, buoy 54, Santa Rosa Island, or GAIL platform, where west-northwest winds prevailed with cool temperatures. These winds also did not affect Santa Cruz Island or buoy 53, where there were cool temperatures and winds from the southwest. El Capitan had onshore winds from the southeast and a temperature of 28.3°C. Finally, the surface station at West Campus (wcam) also had onshore winds, but from the southwest with a temperature of 21.2°C. The pressure gradient from BFL to buoy 54 was 0.7 mb, and from SMX to buoy 54 was 1.4 mb. There were very poor correlations of both north wind speed and temperatures between all coastal and nearshore stations during sundowner events, while the two island stations had a good temperature correlation (Tables 1 and 2). Winds were plotted from the surface to 2295 m using data from a radar profiler at Goleta. Profiler winds were variable and did not appear to increase from the north at height as expected (Figure 5). In fact, the winds were onshore (from southerly directions) at all levels from the surface to 2295 m.

DISCUSSION

Surface and upper air charts show that the sundowner event on June 30, 1996, 0000 GMT was associated with synoptic scale trough passage through central and southern California (Figures 6 and 7). Surface charts show a thermal low in the southeastern California desert and highs in southeast Idaho, and the Pacific Northwest. The 850 mb charts also show low pressure in the desert Southwest with higher pressure to the north. These charts are consistent with offshore flow in the Santa Barbara area, but as Figure 4 shows, this is not the case at all surface stations or the profiler in Goleta. Sundowners then must be mesoscale events, with some dependence on synoptic scale conditions. It appears that sundowners go offshore, mainly over godw, and meet the marine layer, where they then deflect off of it and veer to the east, in this case, a little further offshore than Hondo platform. Also, some coastal stations such as wcam and goleta did not experience these winds, possibly because they were bathed in marine air sheltering them. However, these stations may also be affected by sundowner events on a mesoscale in that onshore winds there are going in to fill the low created by heated downslope winds at godw.

Some events showed considerable north to south pressure gradients between SMX and buoy 54, and BFL and buoy 54. However, there does not appear to be a direct correlation between the events studied and pressure gradients, as evident by the scatter plots and statistics. Some events even had a negative gradient between BFL and buoy 54. This is in conflict with the hypothesis that sundowners are associated with synoptic scale, north to south, offshore pressure gradients between SMX and Santa Barbara, and BFL and Santa Barbara. As expected there is a closer relationship between the closer SMX station and buoy 54 pressure gradient though, and there is consistency in synoptic scale conditions when studying the surface and upper air charts for sundowner events.

Finally, an interesting observation for most events was that the winds at godw continued to increase from the north, often to speeds greater than 10 m/s, even after the time of maximum temperature. One possibility for this is that cooler marine air is brought over the Nojoqui Pass from the Santa Maria Basin after the sundowner event occurs.

LITERATURE CITED

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