Analysis of Santa Barbara Oxidant Study

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by

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ABSTRACT

An observational study was conducted in the Santa Barbara/Ventura area in September 1980 for the purpose of developing a data base for use in modeling the air quality environment in the area. The program consisted of six tracer releases together with a supporting network of surface wind stations, ozone monitors, pibal observations and aircraft measurements which supplemented the regular observational network in the area. Tracer releases were made from a number of offshore areas so that the resulting data would be of benefit in evaluating the potential impact of offshore drilling activities.

The 1980 study had as its principal purpose the generation of a data set and only cursory analyses were undertaken. The present study has utilized the data set to perform analyses related to the occurrence of high ozone concentrations in the area and the potential influence of offshore drilling.

The wind flow patterns in the channel are quite complex. Under the simplest regime in summer, the wind flow in the channel is predominantly from the west. Air parcels pass through the channel and exit up the slopes of the surrounding terrain.

At night, after the seabreeze has terminated, the air can no longer pass over the slopes due to the vertical stability gradients which develop after sunset. In this case the only routes for the eastward moving air parcel are to be deflected to the north or south. To the south, the air can escape offshore southward along the coast. To the north, the air is deflected into a counter-clockwise eddy which does not dissipate until mid-afternoon of the next day. Slope heating and the development of the sea-breeze lead to the dissipation of the eddy and a return to westerly flow.

Tracer trajectories were frequently subjected to wind shifts and light wind conditions. This led to significant dilution of the tracer material as well as uncertainties in the impact location on the coast. The maximum concentrations of the tracer as observed on the coast depended strongly on whether such wind shifts or light winds had occurred. Low dispersion (Pasquill Category E to G) was only observed when the tracer material had a direct impact on the coast under organized flow conditions. For most of the tracer tests, the maximum concentrations on the coast were reduced by the dilution associated with the light winds and wind shifts.

The impact of the tracer along the coast also depended on the time of arrival relative to the seabreeze cycle. Material arriving after the sea-breeze flow had ended was not carried into the inland valleys.

A shallow marine layer was frequently observed in mid-afternoon in the inland valleys. This layer originated over the water where surface cooling was dominant. The cool layer moved inland with the seabreeze, maintaining its identify often as far as Piru. Vertical mixing was restricted in this cool, undercutting layer and highest ozone concentrations frequently occurred after this layer had arrived at the inland location.

A build-up of ozone in the channel offshore was indicated during the period of September 29 to October 5 when warm temperatures aloft and offshore pressure gradients existed. This "reservoir" of ozone finally moved through Ventura County on October 4-5, producing high ozone concentrations. The primary source of the ozone for the reservoir is believed to be the terrain slopes to the east of Ventura. Ozone is delivered aloft due to slope heating. Easterly winds at that level move the pollution westward, often over the channel. Ozone concentrations at South Mt. reflect the effects of these ozone layers aloft.

There are indications that ozone or precursors are transported into southern Ventura County from offshore in the late afternoon or early evening. Evidence from one such event (October 2) suggests that the source of the ozone might have been the South Coast Air Basin.

Ozone layers were also observed aloft in the Simi Hills, imbedded in a layer of southeasterly winds. Presumably, this ozone originated in the San Fernando Valley or South Coast Air Basin. There was no evidence to suggest that this ozone affected surface concentrations in the South Central Coast Basin. No mechanisms for bringing the ozone to the surface have been described.

Some of the principal problems to be faced in the area are the definition of the offshore wind field, the transport route and fate of the layered ozone observed in the area and the importance of transport into the area from the South Coast Air Basin. Some of these problems can probably only be addressed through well-designed tracer studies.

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1. INTRODUCTION

During September and October 1980 a field program in the Santa Barbara/Ventura area was carried out by Meteorology Research, Inc. and the California Institute of Technology. The purpose of the program was to develop a data base for use in modeling the impact of offshore drilling operations on the coastal and inland valleys of the South Central Coast Air Basin. The work was conducted under contract to the Ventura County Air Pollution Control District. Final reports including project data were submitted by MRI (Lehrman et al, 1980) and by Caltech (Reible and Shair, 1981).

In view of the continuing degree of interest in the offshore environment, the present study was funded by the California Air Resources Board to carry out analyses of the data collected during the 1980 field program. The purpose of this study has been to:

1. Analyse the data.

2. Integrate the results with previous studies.

3. Interpret the results in terms of key issues related to offshore activities.

The study benefitted from a number of interactions with CARB personnel on existing problems in the offshore area.

2. BACKGROUND

A large number of studies have been carried out in the Santa Barbara/ Ventura area for the purpose of evaluating transport and dispersion conditions. The principal studies of significance to the present program are summarized below:

1. Edinger, J. (1963) - Detailed aircraft soundings were made in the Santa Clara Valley from the coast inland to the vicinity of Piru. Changes in mixing height and the modification of the marine layer due to heating were documented.

2. Edinger, J. and M. Wurtele (1971) - The study utilized aircraft measurements to determine the structure of the marine layer in the offshore zone from Palos Verdes and Catalina Island to Pt. Conception. Significant variations in the height of the marine layer were noted, particularly in the lee of the Santa Ynez Mts. (to the west of Santa Barbara) where the height of the marine layer was reduced by the action of wind flow over the mountains. Diurnal variations in the height of the layer were also observed with lower heights during the afternoon, offshore from Ventura.

3. Giroux et al (1974) - SF_6 was released into the stack of the Ormond Beach Generating Station continuously for several days. Ground sampling was carried out in Ventura County. The impact of the tracer plume was observed to the northwest of the Station during the morning, shifting to northeast and east by afternoon.

4. Kauper, E. and B. Niemann (1975) - A 10-day study was performed using aircraft observations of ozone and temperature profiles between Los Angeles and Ventura Counties. Ozone layers were frequently observed above the base of the sub-tropical subsidence inversion. These layers were attributed to transport from Los Angeles County.

5. Maas, S. and P. Harrison (1977) - A brief sampling study was made offshore to the west of Santa Barbara to investigate the characteristics of plumes from a natural oil seep. Cloud width data were taken as a function of distance from the source and indicated the low dispersion conditions existing offshore.

6. Lee, T. F. (1979) - A study of coastal stratus characateristics in Southern California was made by examining satellite photographs. Diurnal variations related to offshore clearing were of particular interest. Effects of terrain such as the Santa Ynez Mts. were also apparent.

7. Lehrman, D. et al. (1981) - An extensive air quality, tracer and meteorological observation program (Santa Barbara Oxidant Study) was carried out in the Santa Barbara/Ventura area in September/October 1980. This volume is an overview of the program, describing data acquisition and general meteorological characteristics.

8. Hayden, P. et al. (1981) - 121 aircraft temperature soundings were made in conjunction with the 1980 Santa Barbara oxidant study described in item 6. Inversion heights were estimated wherever possible.

9. Zannetti, P., D. Wilbur and R. Baxter (1981) - Tracer programs were conducted in the Santa Barbara Channel for BLM in conjunction with the U.S. Navy Post-Graduate School. Field programs took place in September 1980 and January 1981. Primary interest was in downwind distances of about 5 miles. Data obtained were used to determine the proper dispersion coefficients for use in over-water model calculations.

10. McRae, G. J. et al. (1981) - Two tracer releases were made from an El Segundo power plant during offshore wind conditions. In each case, the tracer material returned to the coast during the following day, once into Ventura County and once into the South Coast area. This article proposes a mechanism for the downward mixing of the elevated plume to the surface where it subsequently was transported onshore.

11. Shair, F. et al. (1982) - This article contains the observational details of the tracer tests described in item 9.

12. Schacher, G. et al. (1982) - This volume includes a comprehensive data set provided by the U.S. Naval Post-Graduate School for the experiments described in item 8 above. The meteorological measurements made provide the most comprehensive set of data yet obtained for over-water conditions in the channel.

13. Schacher, G. et al. (1982) - An analysis of the data included in item 11 was focussed on various techniques for estimating stability parameters appropriate for offshore modeling considerations.

14. Brodzinsky et al. (1982) - Two field studies were performed (December 1981 and June 1982) in the offshore area near Pismo Beach, California. Purpose of the program was to improve the input parameters for air quality simulation models in coastal zones. Meteorological and tracer measurements were made. The results of the study provide useful comparisons with similar studies in the Santa Barbara Channel (items 9, 12 and 13 above).

3.0 METEOROLOGICAL AND AIR QUALITY ENVIRONMENT

3.1 Topography

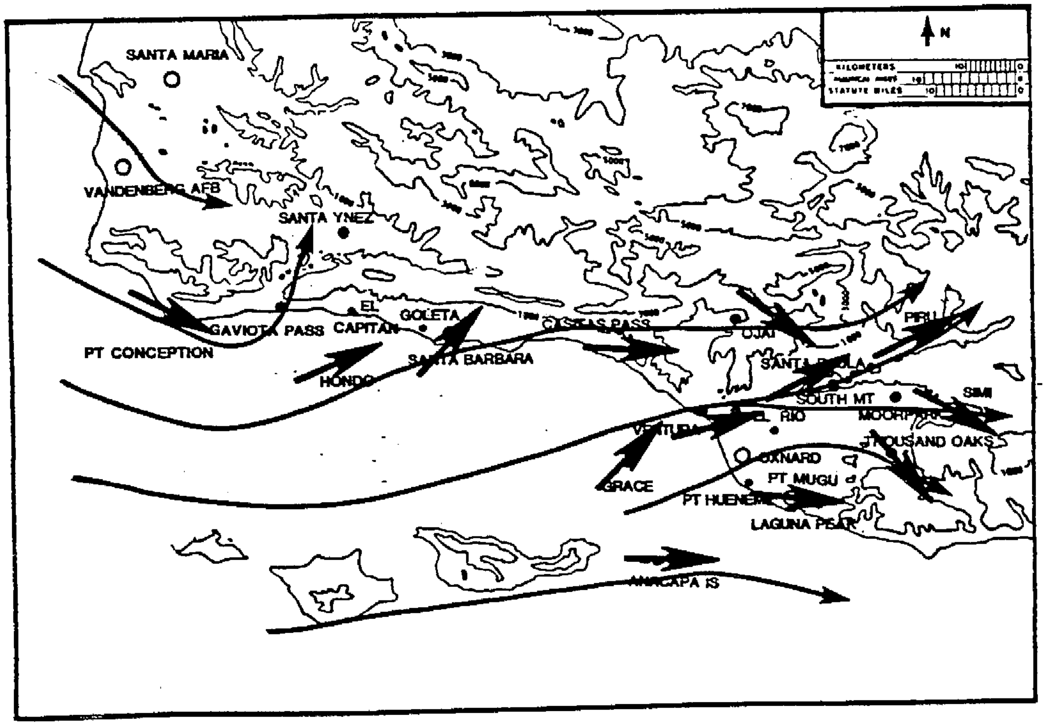
The Santa Barbara/Ventura area is dominated by narrow coastal plains bordered on the inland side by mountain ridges. Along the coast from Pt. Conception to Carpinteria the coastal plain is only a few miles wide at the foot of an east-west ridge to about 4000 ft. msl which lies some 5-10 miles inland. In the Ventura area the coastline turns to a northwest-southeast orientation and the coastal plain broadens, in places, to 10-20 miles. The principal low level route through the hills in this area is along the Santa Clara River Valley which extends east-northeast from Ventura through Fillmore and Piru. Other east-west valleys lead into Ojai to the north of the Santa Clara River Valley and Moorpark/Thousand Oaks to the south. These parallel valleys to the east of Ventura are separated by east-west ridges of 2000-3000 foot elevation.

3.2 Wind Flow Patterns

The flow patterns in the Santa Barbara/Ventura area are among the most complex to be found anywhere in California. This is primarily the result of the combination of the ocean and the high terrain which surrounds the area. Seabreeze and nocturnal drainage winds are pronounced along the inland slopes. The cool offshore waters provide considerable low-level stability during the summer and fall months which, at times, prevents the flow of air parcels from the coast to inland areas.

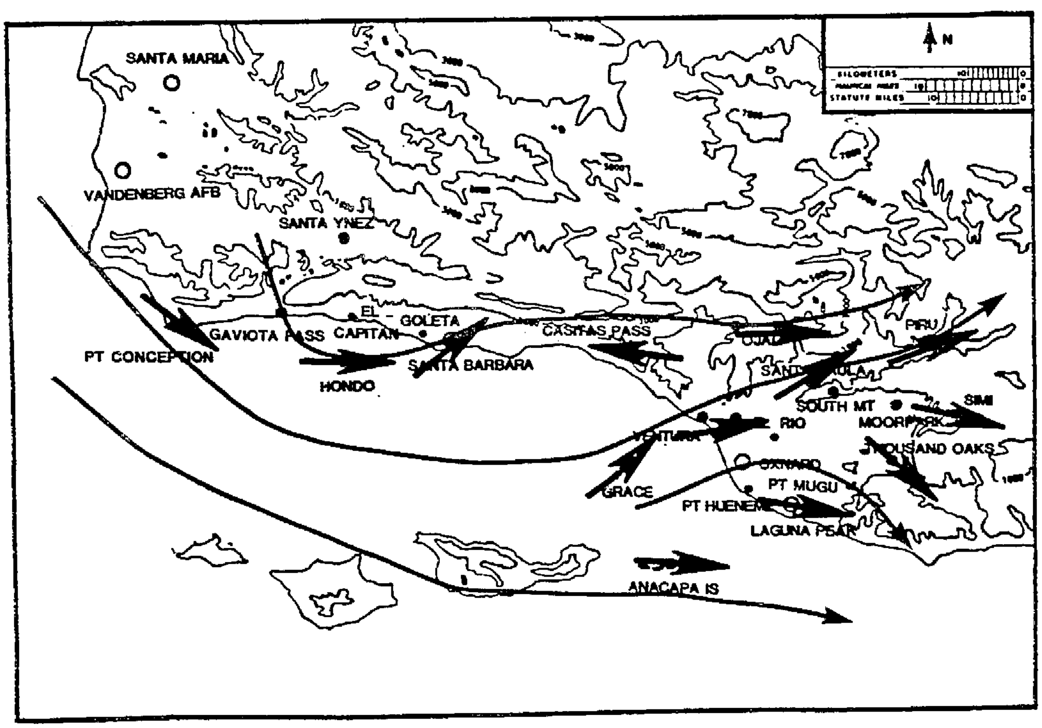
The regular surface wind network in the area was supplemented during the 1980 field program to provide a better description of the flow patterns. Most frequent wind directions have been determined for each of the available stations for the period of the observational program (September 6 to October 5). These directions are shown at two-hour intervals in Figs. 3.2.1 through 3.2.6.

It is convenient to start the diurnal description of the wind flow patterns with the 17 and 19 PDT charts (Fig. 3.2.1) when a relatively simple pattern exists. In the far western portion of the area surface winds are northwesterly, changing to west and southwest in the eastern part of the channel. There is evidence of a "Gaviota" eddy resulting from flow around Pt. Conception and slope heating. The remainder of the wind directions are controlled almost entirely by onshore, seabreeze flow and the effects of channeling in the inland valleys. The same pattern is apparent at 17 and 19 PDT with the exception of a wind shift to northerly at Gaviota. This represents the simplest flow pattern prevailing in the channel. Air parcels from the channel are carried inland readily and transported up the heated slopes surrounding the basin.



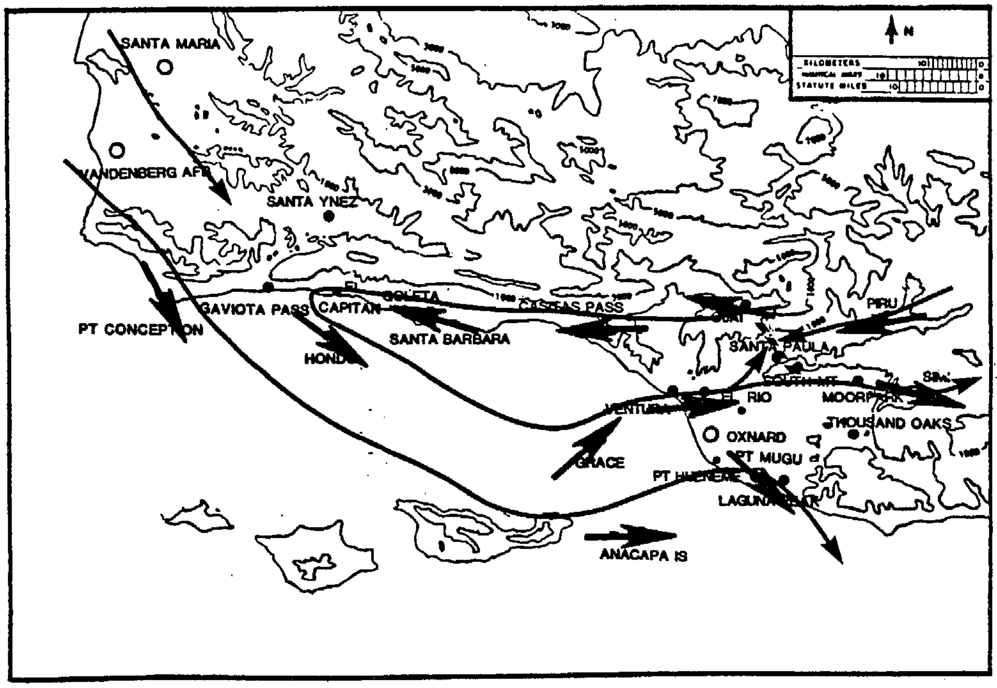
17 PDT

September 1980 Field Program



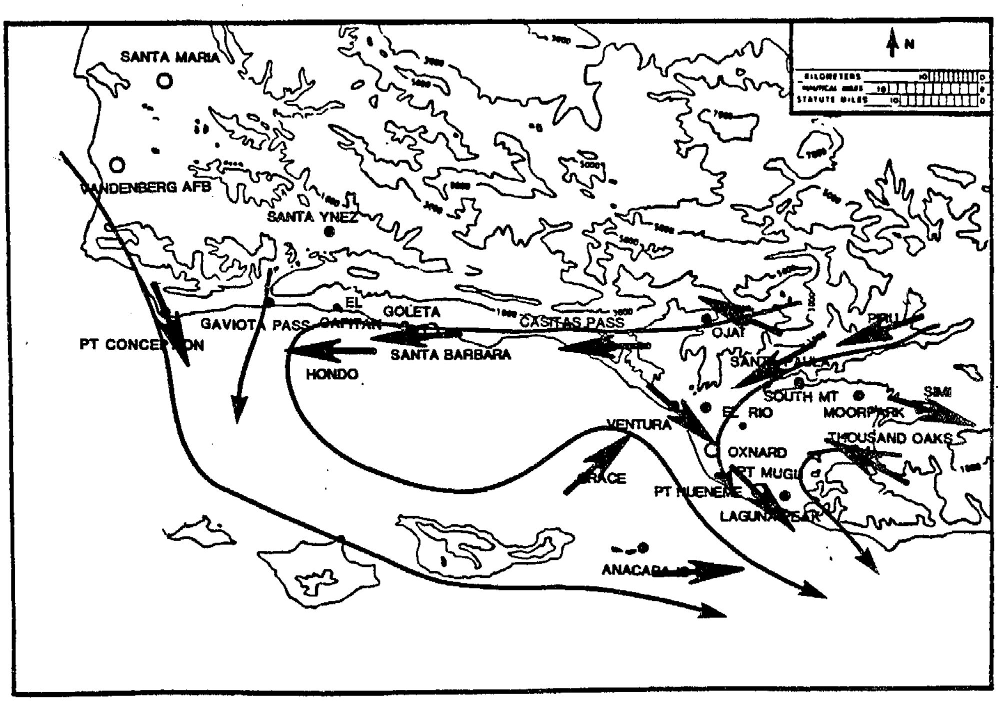
19 PDT

Fig. 3.2.1 MOST FREQUENT WIND DIRECTIONS



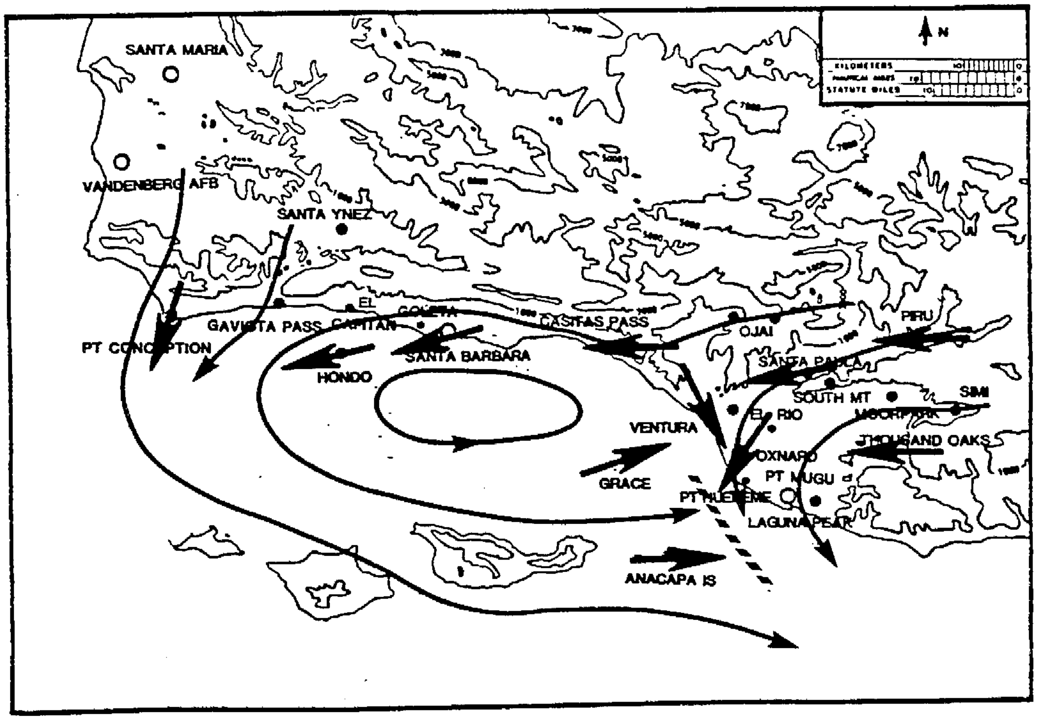
21 PDT

September 1980 Field Program



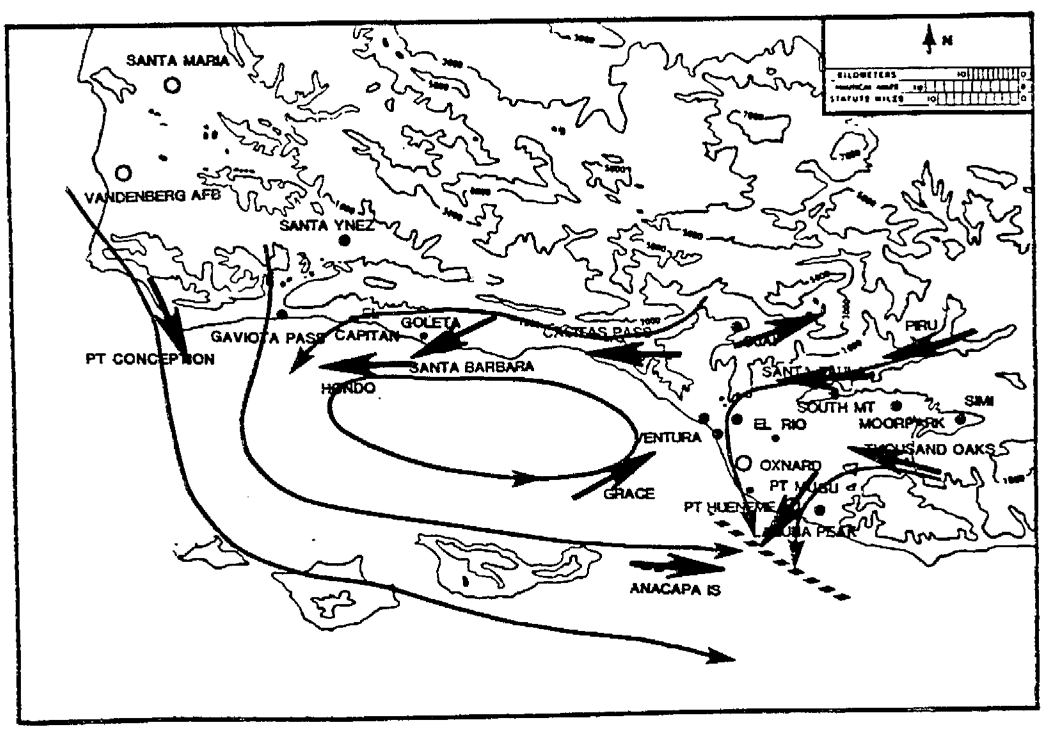
23 PDT

Fig. 3.2.2 MOST FREQUENT WIND DIRECTIONS



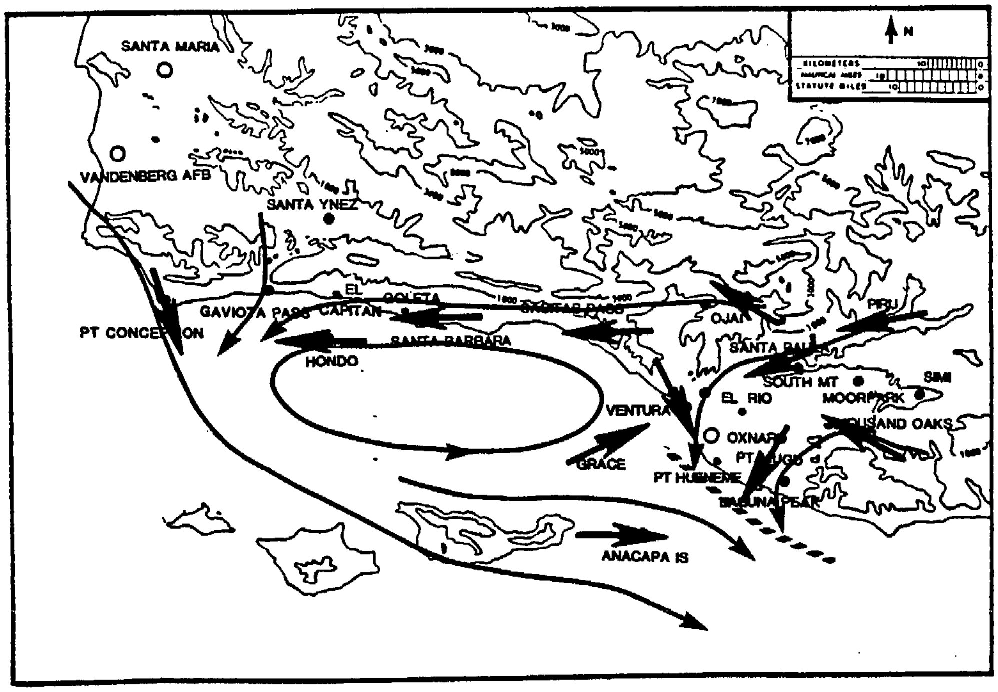
01 PDT

September 1980 Field Program



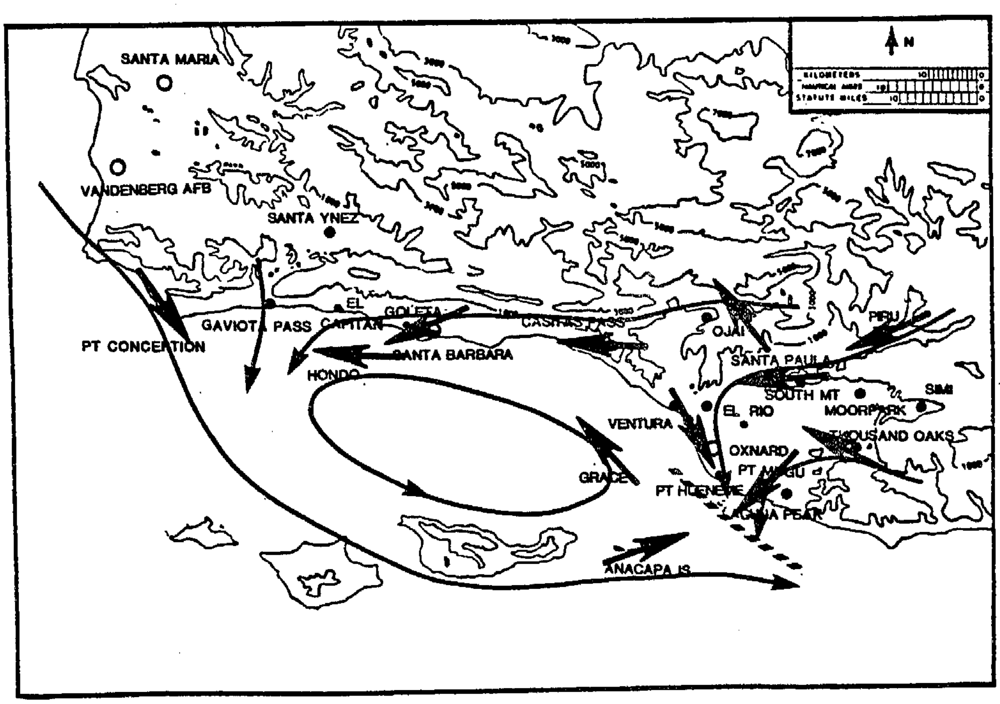
03 PDT

Fig. 3.2.3 MOST FREQUENT WIND DIRECTIONS



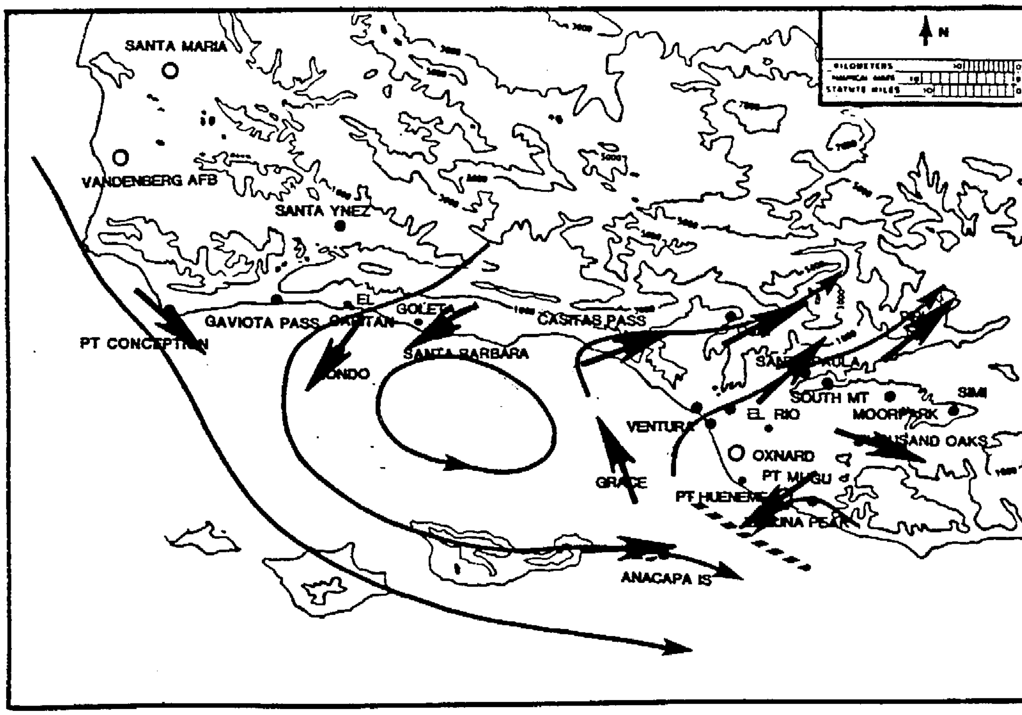
05 PDT

September 1980 Field Program



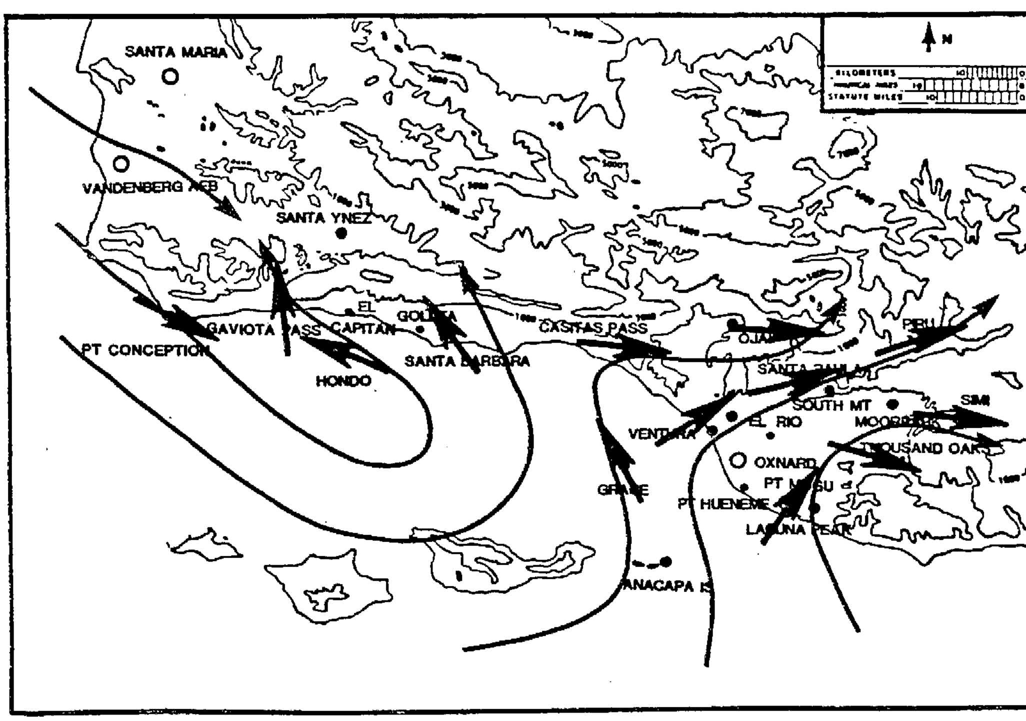
07 PDT

Fig. 3.2.4 MOST FREQUENT WIND DIRECTIONS



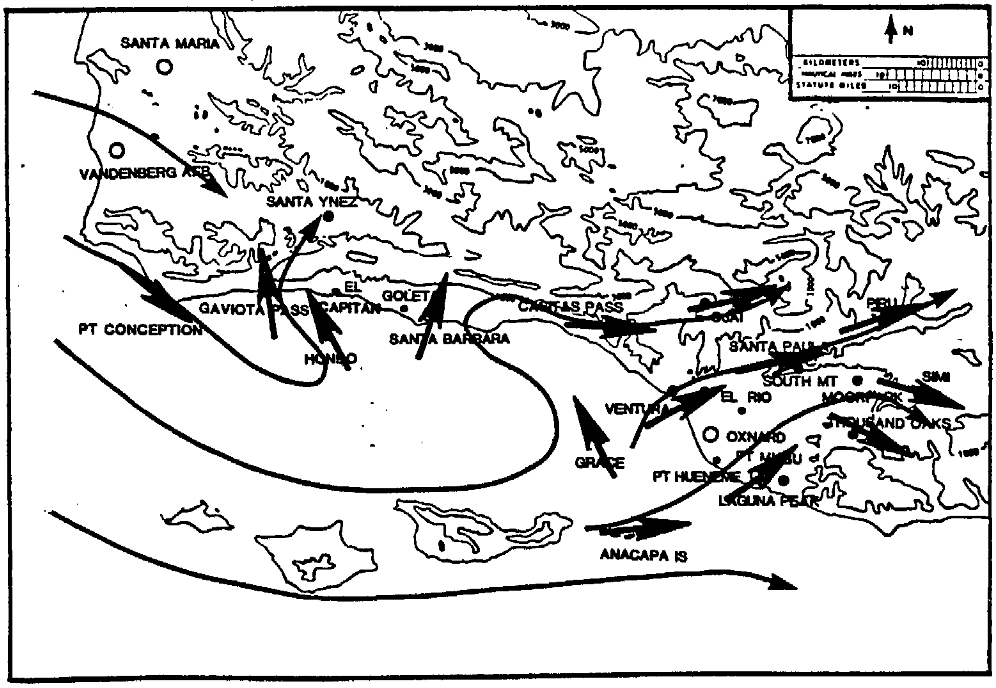
09 PDT

September 1980 Field Program



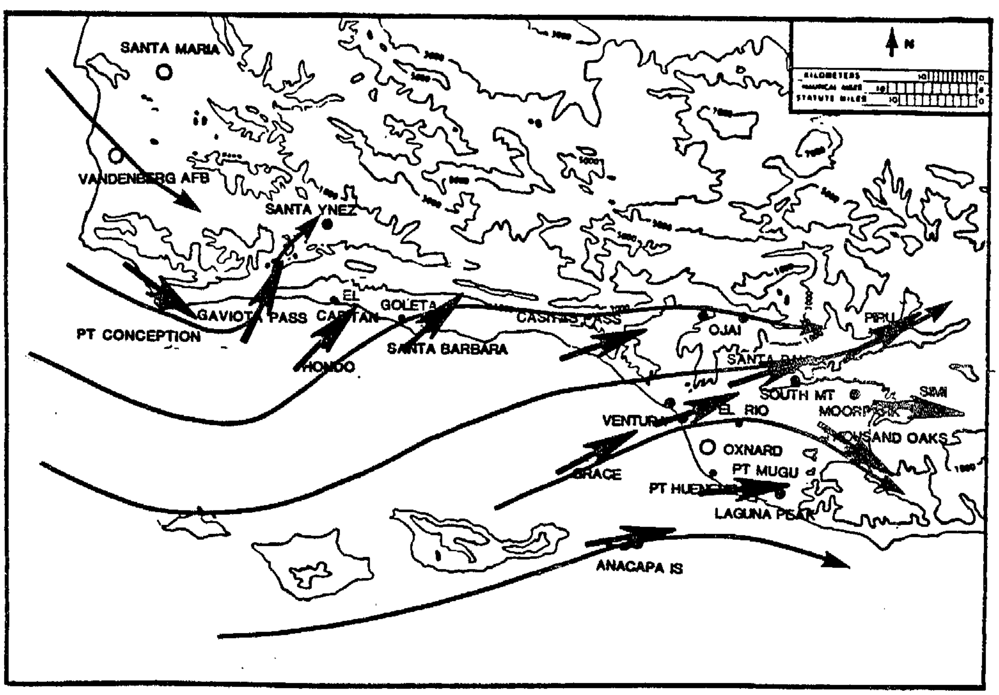
11 PDT

Fig. 3.2.5 MOST FREQUENT WIND DIRECTIONS



13 PDT

September 1980 Field Program



15 PDT

Fig. 3.2.6 MOST FREQUENT WIND DIRECTIONS

By 21 PDT (Fig. 3.2.2) the influence of the drainage winds can be seen along the northern coastal sections in the form of easterly winds from Ojai to Santa Barbara. The remainder of the Ventura coastal stations and the offshore areas continue to show westerly winds.

By 23 PDT (Fig. 3.2.2) the easterly flow along the northern coastal areas becomes more pronounced and includes Platform Hondo. Evidence also indicates a drainage flow down the Santa Clara Valley. It is apparent that this flow interacts with the westerly offshore winds and is deflected to the south, resulting in northerly winds along the immediate coastline (Ventura to Pt. Mugu). Surface westerly winds (e.g., Platform Grace) are unable to penetrate this drainage flow and are deflected toward the south offshore. The flow in the channel is indicated as a counter-clockwise eddy structure. In reality, the details of the interface between the easterly flow and the westerly flow in the channel are uncertain. The interface, in fact, might appear in the form of a shear zone instead of the continuous flow pattern indicated in the figure.

The flow patterns at 01 and 03 PDT (Fig. 3.2.3) continue in the same structure. The apparent eddy pattern in the channel is somewhat more pronounced. The flow along the Ventura coastline is a little more in the offshore direction and a convergence zone is indicated between the onshore westerly flow and the offshore drainage.

There is little change in this pattern through 07 PDT (Fig. 3.2.4) except that the eddy structure in the channel appears to shift somewhat toward the coast. This is shown primarily by the change in most frequent wind direction at Platform Grace from west-southwest to southeast.

The principal change at 09 PDT (Fig. 3.2.5) is the initiation of onshore winds from Carpinteria to Ventura and inland to Piru. The eddy structure offshore remains relatively unchanged and it is clear that the beginning of the seabreeze flow does not appreciably affect the channel flow pattern by 09 PDT. Santa Barbara and Platform Hondo winds continue from an east to northeast direction.

By 11 PDT (Fig. 3.2.5) the influence of the onshore (upslope) flow is much more apparent. The flow in the eastern part of the channel is directed toward the coast while the remnants of the eddy structure can be seen to the south and southwest of Platform Hondo.

At 13 PDT (Fig. 3.2.6) the trend toward onshore flow continues but with slight indications of an eddy structure as evidenced by the southerly winds at Platforms Grace and Hondo. By 15 PDT (Fig. 3.2.6) the flow pattern becomes west to southwest in the channel and only a slight "Gaviota" eddy alters the basic pattern. During the September 1980 period the wind shift to west or southwest at Platform Hondo occurred by 11 PDT on 27% of the days and by 13 PDT on 43% of the days.

The principal driving forces which lead to this diurnal pattern are the development of the seabreeze and drainage flows. The ability of the air to pass up the slopes of the surrounding terrain leads to a westerly flow throughout the channel. The heated terrain slopes and the onshore seabreeze (from about 09 to 19 PDT during the summer) provide the mechanism for this ventilation to occur. At night, when the drainage flow develops, low-level stability prevents the passage of air up the slopes of the nearby terrain and a form of eddy structure occurs in the channel.

Although this is a typical sequence during the summer, larger scale synoptic weather patterns alter the flow to some extent. During the period of September 28 to October 2, 1980 a general offshore flow was superimposed on the normal diurnal pattern. The principal modifications to the diurnal pattern appeared to be:

1. Increased easterly flow at night along the coast from Carpinteria to Pt. Conception. This increased flow influenced areas as far offshore as Platform Hondo.

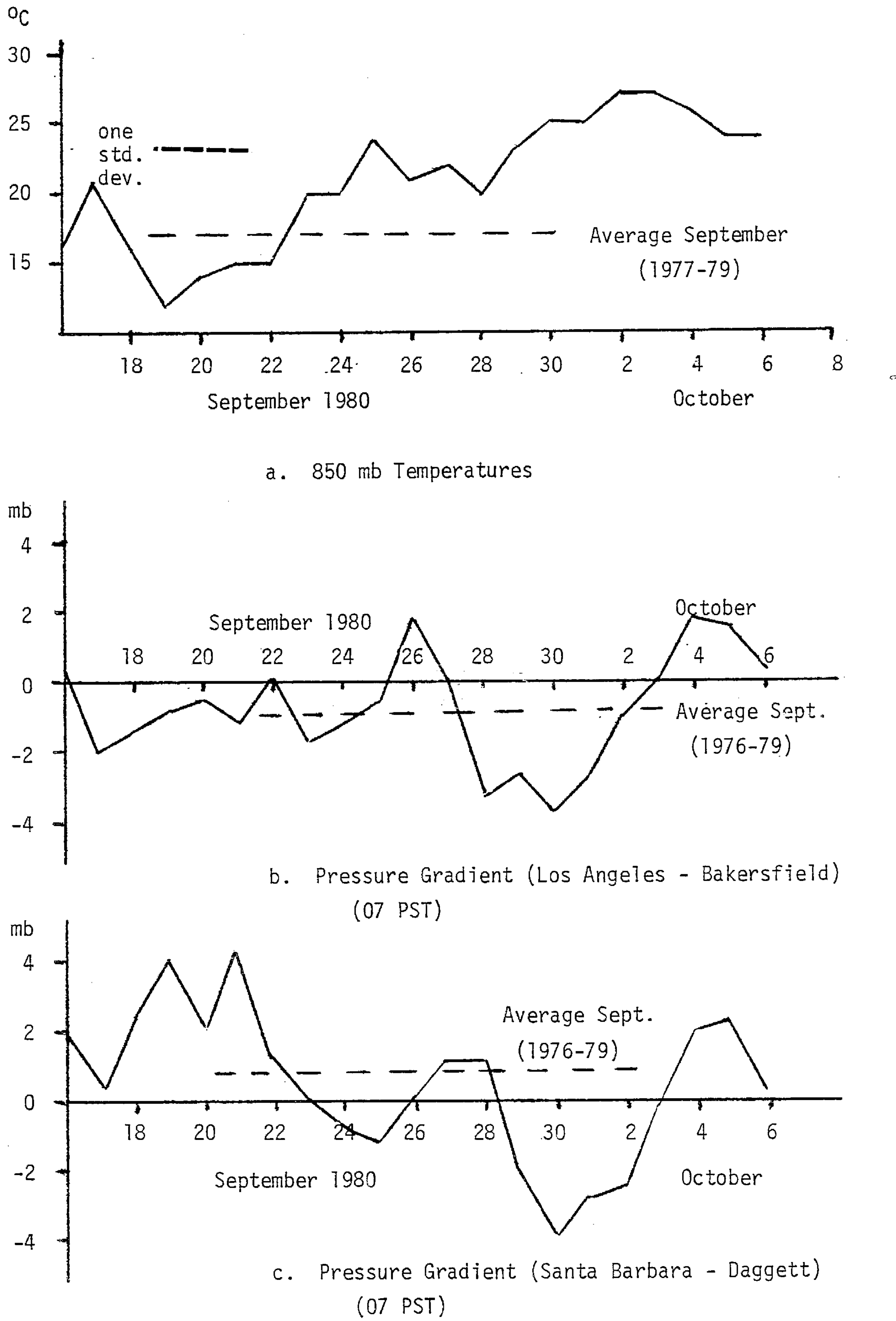
2. Surface winds in the southeastern part of the channel were predominantly from the southeast from the late evening through midday. These winds were followed by a few hours of the typical west to southwest flow. This period did not seem to last long enough for the transport of air parcels, for example, from Platform Grace to the coast. This limited period of westerly flow in the channel contributes to the concept of a "reservoir" build-up in the offshore area during episode conditions.

3.3 850 mb Temperatures

Temperatures at 850 mb (about 5000 ft. msl) provide an indication of the pollution potential in the region. This parameter is particularly useful in the coastal area where surface air temperatures are kept relatively uniform by ocean temperatures while the temperatures aloft may fluctuate considerably. The temperature aloft is then a measure of the low level stability and hence an indicator of the air pollution potential.

For the purposes of the present study, the 850 mb temperatures at Vandenberg AFB (04 PST) have been plotted in Fig. 3.3.1 for the direction of the 1980 field program. Normal 850 mb temperatures at Vandenberg are about 17°C as indicated in the figure. Dates of the tracer tests are shown in the figure by arrows.

Following normal or sub-normal 850 mb temperatures during the early part of the field program, the temperatures increased and were above normal for the last four tests. Tests 5 and 6 were carried out with 850 mb temperatures of 25°C or more. These high temperatures were reflected in high ozone values in the inland areas. The peak hourly ozone concentrations at Piru during 1980 was 21 pphm on October 2 when the 850 mb temperature was 27°C.



°C
30
25
20
15
one
std.
dev.
Average September
(1977-79)
18
20
22
24
26
28
30
2
4
6
8
September 1980
October
a. 850 mb Temperatures
mb
4
2
0
-2
-4
September 1980
October
18
20
22
24
26
28
30
2
4
6
Average Sept.
(1976-79)
b. Pressure Gradient (Los Angeles - Bakersfield)
(07 PST)
mb
4
2
0
-2
-4
Average Sept.
(1976-79)
18
20
22
24
26
28
30
2
4
6
September 1980
October
c. Pressure Gradient (Santa Barbara - Daggett)
(07 PST)

Fig. 3.3.1

3.4 Pressure Gradients

Surface pressure gradients between the coast and inland areas provide another indication of air pollution potential. Strong offshore gradients (inland pressures higher) tend to transport pollutants offshore and leave the coastal areas relatively warm and clean. Strong onshore gradients ventilate the coastal area rapidly and also lead to lower pollutant concentrations. Weak pressure gradients, particularly following offshore flow, appear to contribute significantly to air pollution potential.

Two pressure gradient parameters were chosen to represent the large scale pressure forces acting in the area. These are Los Angeles Airport (LAX) to Bakersfield and Santa Barbara to Daggett. These two parameters give a measure of the gradients in a north-south and east-west direction, respectively.

Plots of the two pressure gradients (measured at 07 PST) are shown in Fig. 3.3.1 for the period of the field program. Also shown are the 4-year average values for September (1976-79).

A period of near-normal gradients during the first half of the program was followed by a period of strong negative (offshore) gradients from September 28 through October 2. This was followed by a period of above normal (onshore) gradients. Note that the highest ozone concentration at Piru occurred as the pressure gradients were returning to near-normal after the period of offshore flow.

3.5 Ozone Characteristics

A summary of observed ozone concentrations in the Santa Barbara/Ventura area is given in Table 3.5.1 for the July-September period in 1979 and 1980.

As can be seen from the table, exceedances of the state ozone standard occur most frequently at Piru and Simi with Ojai and Thousand Oaks showing somewhat lower frequencies. Peak hourly ozone concentration usually occurs at Piru but a slightly higher concentration was observed in September 1979 at El Rio.

The last portion of the table shows the ozone experiences observed during the field program. The data in the table indicate that the field program was conducted during a period which was representative of high ozone occurrences.

Diurnal patterns of hourly concentrations for the period of the 1980 field program are shown in Figs. 3.5.1 to 3.5.3. Data for all available stations in the Santa Barbara/Ventura area are given as average hourly values for the field period.

Times of maximum concentration are summarized in Table 3.5.2.

Table 3.5.1

Peak Ozone Concentrations

1979

	No. hrs. >10 pphm			No. days >10 pphm			Peak July-Sept. Concentration
	July	Aug.	Sept.	July	Aug.	Sept.	
Santa Barbara - State	0	0	6	0	0	1	17 pphm
El Rio	0	7	42	0	2	8	23
Piru	102	43	80*	20	11	17*	22
Thousand Oaks	3	5	89	3	2	17	18
Simi	107	86	108	19	16	20	19
Ojai	61	52	55*	15	10	13*	18

1980

	July	Aug.	Sept.	July	Aug.	Sept.	
Santa Barbara - State	0	0	0	0	0	0	-
El Rio	1	3	4	1	2	2	12
Piru	99	65	73	21	13	16	16
Thousand Oaks	21	31	28	7	7	10	16
Simi	70*	1*	34	11*	1*	9	15
Ojai	55	65	36	11	12	9	16

* Incomplete data

Field Program (Sept. 16 to Oct. 5, 1980)

	No. hrs. >10 pphm	No. days >10 pphm	Peak Concentration
Santa Barbara - State	0	0	8
El Rio	20	5	13
Piru	65	14	21
Thousand Oaks	42	11	19
Simi	24	6	17
Ojai	36	7	16

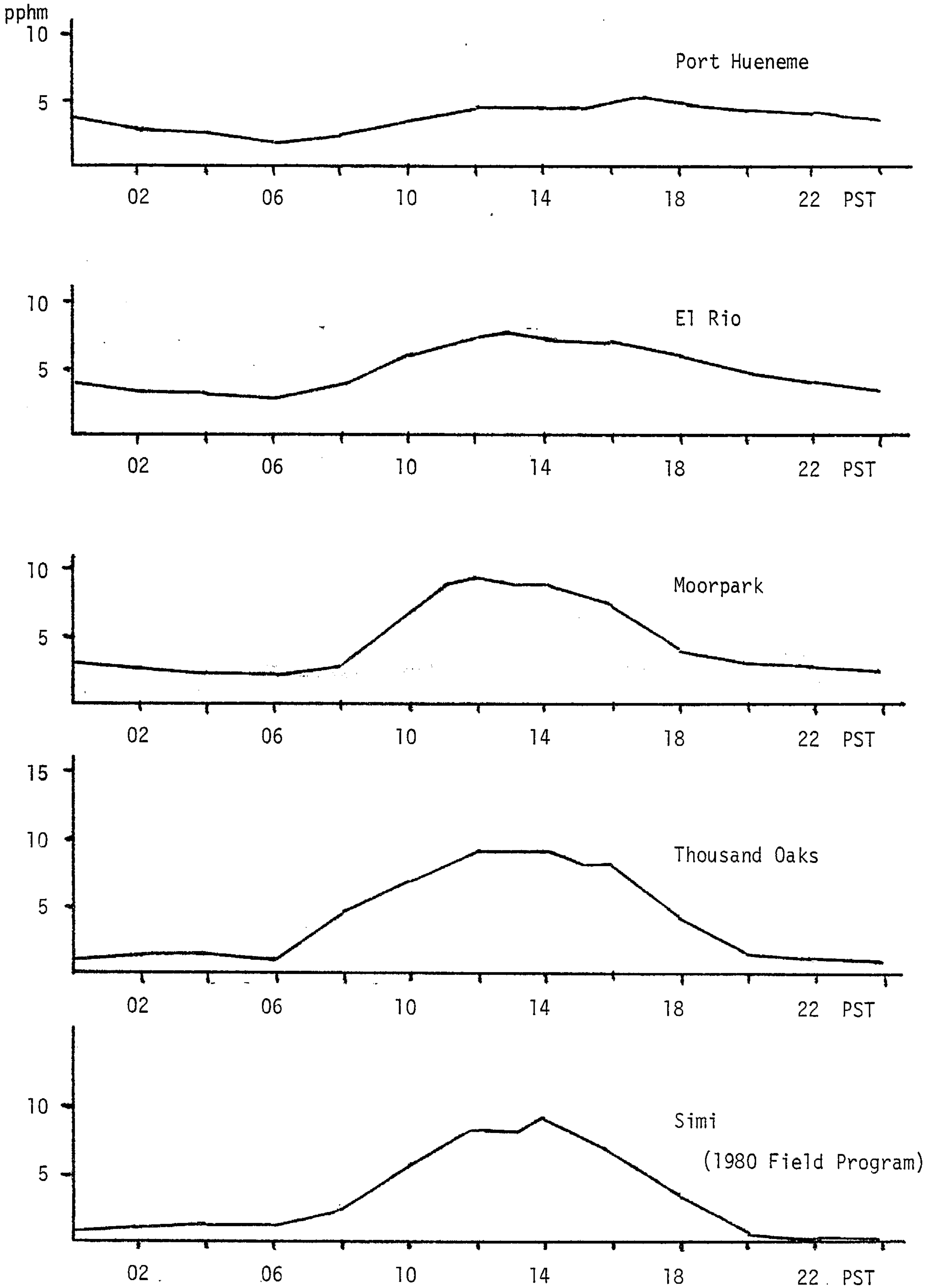


Fig. 3.5.1 AVERAGE HOURLY OZONE CONCENTRATIONS

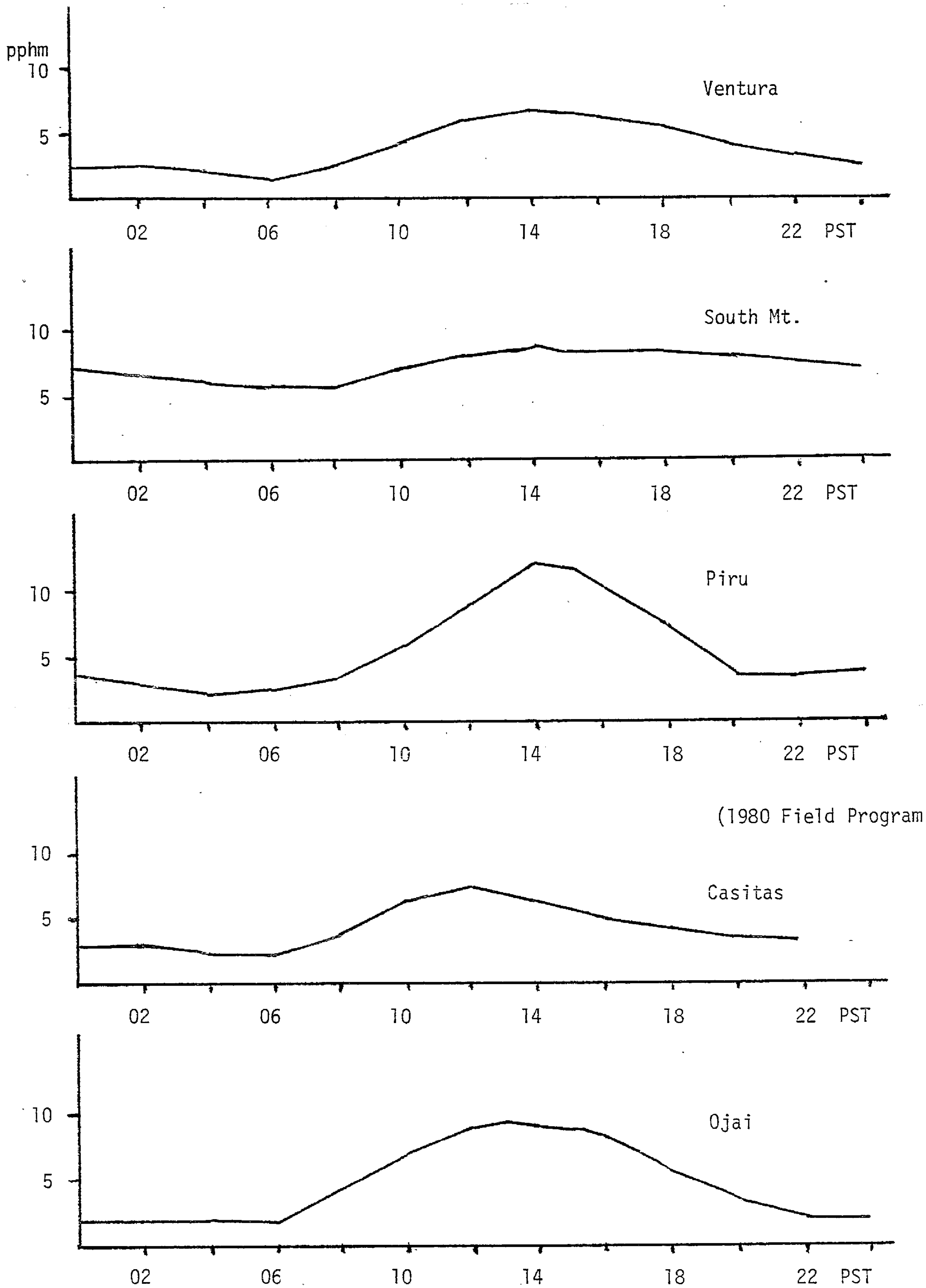


Fig. 3.5.2 AVERAGE HOURLY OZONE CONCENTRATIONS

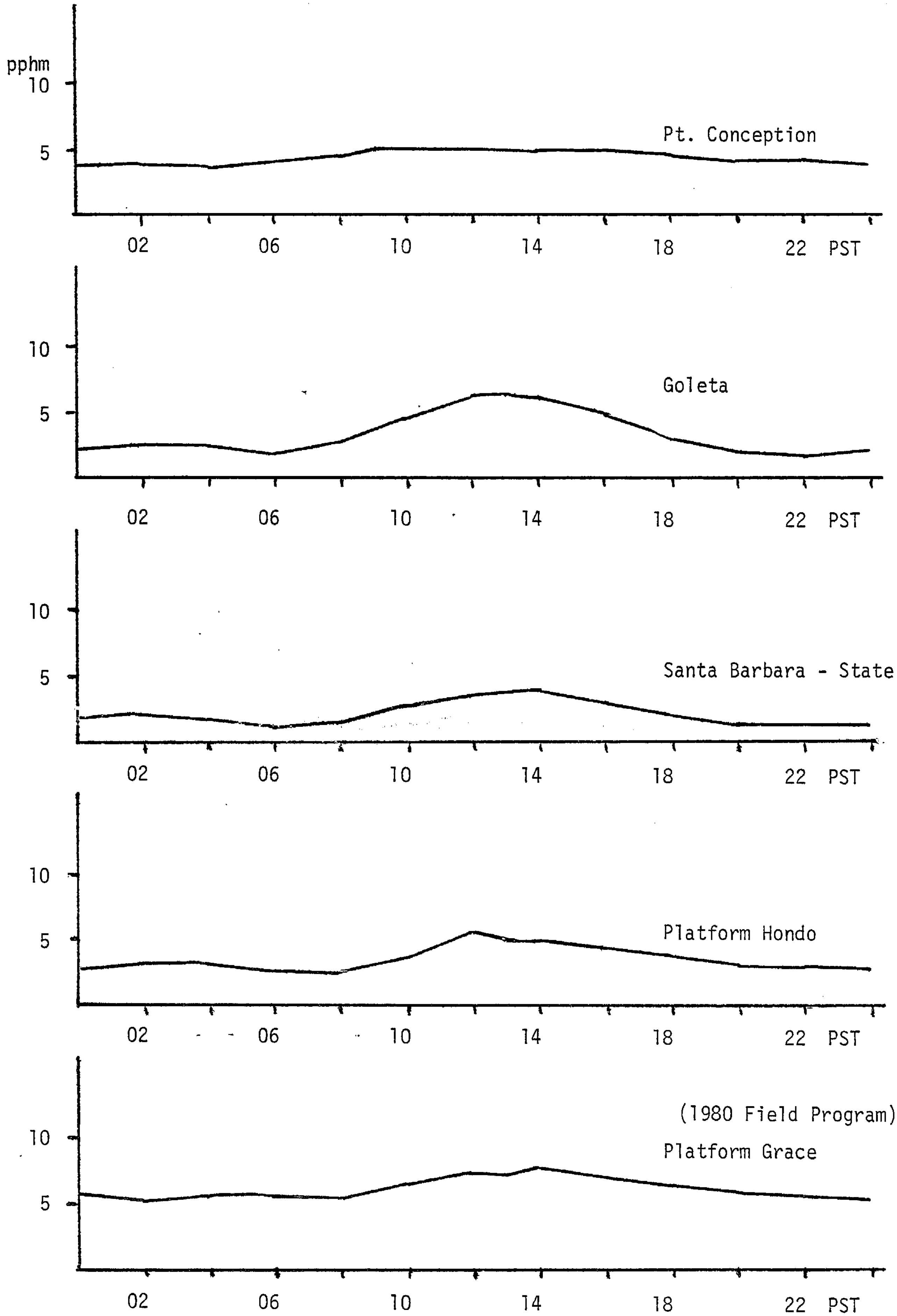


Fig. 3.5.3 AVERAGE HOURLY OZONE CONCENTRATIONS

Table 3.5.2

Times of Maximum Ozone Concentration
(September 16 - October 5, 1980)

Location	Time	Location	Time
Port Hueneme	17 PST	Piru	14 PST
El Rio	13	Casitas	12
Moorpark	12	Ojai	13
Thousand Oaks	13-14	Pt. Conception	12
Simi	14	Goleta	13
Ventura	14	Santa Barbara - State	14
South Mt.	14	Platform Hondo	12
		Platform Grace	14

Average concentrations for Ojai and Piru show relatively simple diurnal characteristics with peak values at 13 and 14 PST, respectively. Given a transport time of 2-3 hours from the coastal strip to the inland valleys, the air parcels containing the maximum ozone concnetrations probably left the coastal area at about 11 PST.

Average diurnal curves for Moorpark, Thousand Oaks and Simi show a more complex structure. An early peak or shoulder (about 12 PST) is followed by a second peak or shoulder at 14 PST on an average basis. Analogy with the Piru and Ojai data might suggest that the second peak was a result of transport from the coast while the earlier peak may result from less distant sources in the populated Oxnard Plain.

The time of the peak concentration at Port Hueneme is 17 PST which is quite late in comparison with the remaining locations. This peak appears to result from onshore transport on a late afternoon seabreeze and is discussed in greater detail in Section 5.

4.0 THE 1980 FIELD PROGRAM

4.1 Scope of the Program

From September 6 to October 5, 1980 a field study was carried out by Meteorology Research, Inc. (MRI) and the California Institute of Technology (Caltech) to develop a data base for use in modeling the impact of offshore drilling operations on the coastal and inland valley areas: The program consisted of the following:

1. Supplemental Ozone Monitoring Stations

   Moorpark
   Lake Casitas

2. Air Quality Measurements (ozone, NO, NO_x, CO and THC)

   Pt. Conception

3. Supplemental Surface Wind and Temperature Stations

   Pt. Conception
   Gaviota Pass
   Casitas Pass
   Ventura (Surfer's Point)
   Santa Paula
   Piru
   Upper Ojai
   Moorpark
   Thousand Oaks
   South Mountain

4. Upper Winds (pibals)

   Santa Ynez (twice daily but every 2 hours during tracer periods)
   Ojai (twice daily but every 2 hours during tracer periods)
   Simi (twice daily but every 2 hours during tracer periods)
   Pt. Conception (September 17)
   Ventura APCD (September 28)
   Ventura Marina (October 1)

5. Tethered Kite Wind Data

   Pt. Conception (September 17 and 22)
   Ventura APCD (September 28)

6. Aircraft Temperature Soundings

   Simi (twice daily)
   Ojai (twice daily)
   Santa Ynez (twice daily)

7. Air Quality Aircraft Sampling

   Regional sampling on tracer test days

8. Acoustic Sounder

   Santa Paula Airport

9. Six SF_6 Tracer Releases

   September 17
   September 22
   September 26
   September 28
   October 1
   October 3

Site locations referred to above are shown in Figure 4.1.1.

The Bureau of Land Management (BLM) also sponsored a field study (Zannetti, Wilbur and Baxter, 1981) in the Ventura area during September 1980. Four tracer releases were made from the R/V Acania during this program. The release of September 28 was a joint release for both programs. In addition to the tracer results, meteorological data were taken aboard the R/V Acania and onshore which supplemented the observational network established for the MRI/Caltech program.

Additional observational data on air quality and meteorology were provided to the program from the standard reporting networks of the Ventura and Santa Barbara Air Pollution Control Districts, NOAA, U.S. Navy - Pt. Mugu and the U.S. Air Force - Vandenberg AFB. Meteorological and air quality data from Platforms Grace (Chevron) and Hondo (Exxon) were of very great value in analyses of the offshore area.

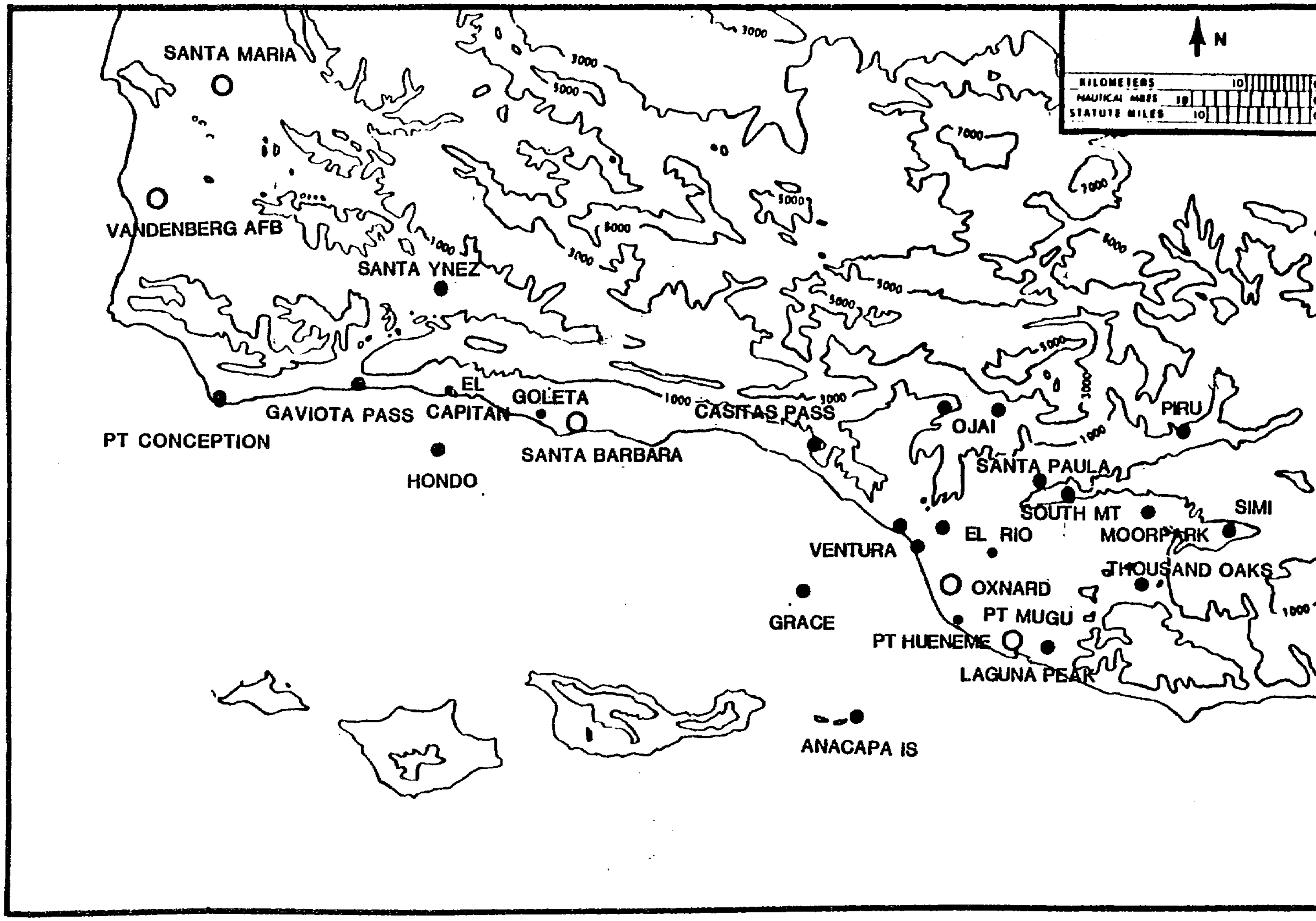


Fig. 4.1.1 MAP OF AREA

4.2 Test 1 17 September 1980 - Release from Pt. Conception (1100-1600 PDT)

4.2.1 General Meteorology

The weather of 17 September was dominated by a belt of high pressure extending accross California to the Great Plains (Figure 4.2.1). A closed low pressure system at 500 mb was located about 600 miles off the central California coast and was moving slowly eastward. Clear to scattered high cloud conditions prevailed in the Ventura/Santa Barbara area with unlimited ceilings.

Table 4.2.1 gives some of the significant meteorological parameters for September 17.

Table 4.2.1

Meteorological Parameters

September 17, 1980

850 mb Temp. (Vandenberg AFB)	21°C
Pressure Gradients (07 PST)	
LAX - Bakersfield	-2.0 mb
Santa Barbara - Daggett	0.3
Inversion Base (15 PST)	
Pt. Mugu	93 m
Maximum Surface Temperatures	
Thosand Oaks	92°F
Piru	93
Santa Barbara	85

In spite of relatively warm temperatures at 850 mb (compared to an average September value of 17°C) and rather small pressure gradients, ozone levels in the area were below the September average.

4.2.2 Transport Winds

Table 4.2.2 gives some examples of surface winds observed at several locations on September 17. Pt. Conception shows the prevalence of northwesterly winds throughout the day with moderate velocities. At the Santa Barbara Airport the south to southeasterly winds during the forenoon provide evidence of the presence of a Channel Eddy which disappears by 14 PST. Characteristically, wind directions at Santa Barbara veer from southeast to southwest during the process of dissipating the eddy. By 14 PST the wind direction was predominantly from the west throughout the channel.

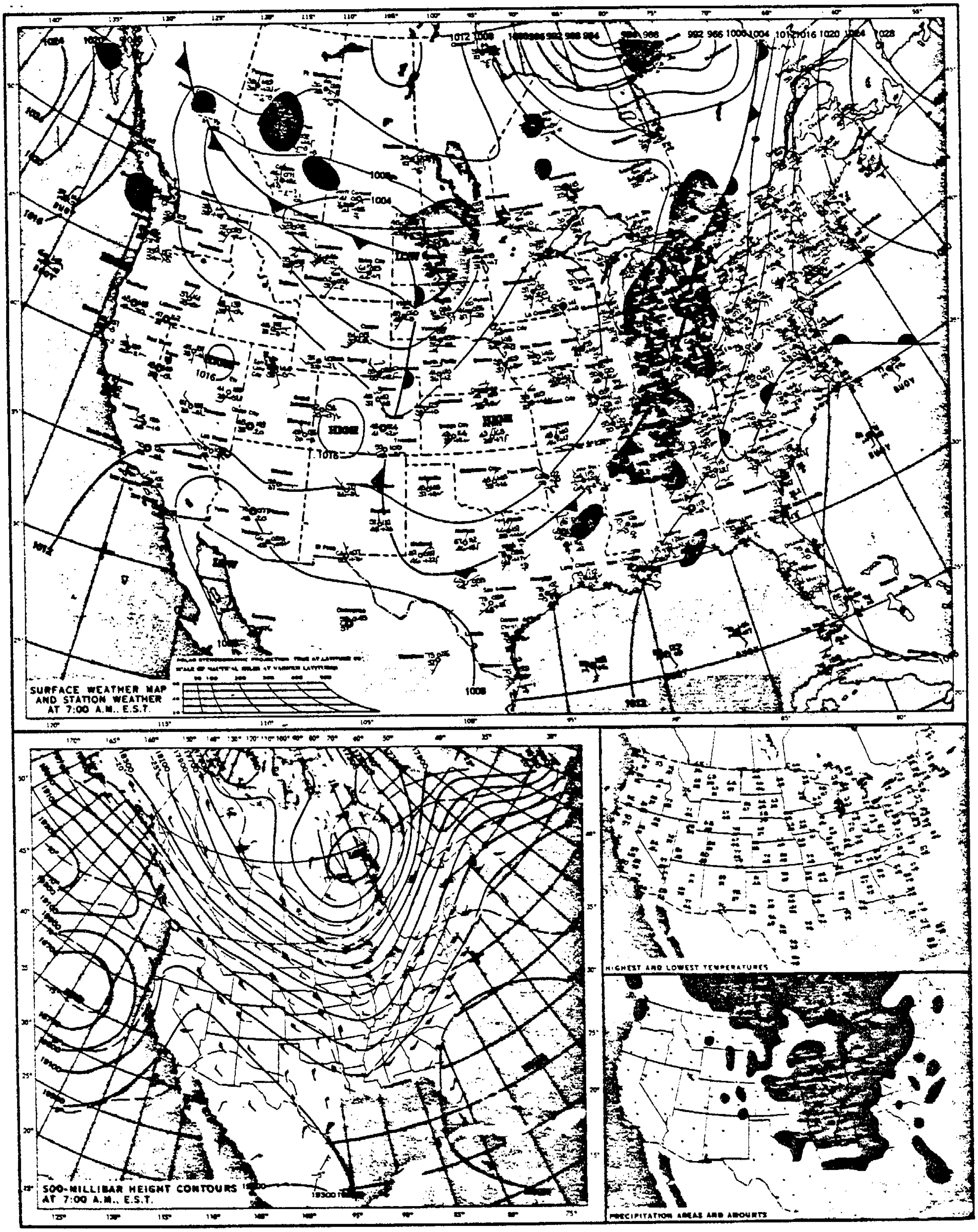


Fig. 4.2.1 WEATHER MAP - September 17,1980

Winds at Platform Grace were consistently from the southwest from 14 PST through the balance of the day. Unfortunately, winds were not available from Platform Hondo. The seabreeze flow at Ventura had started by 10 PST and continued until 20 PST.

Table 4.2.2

Transport Winds - Test 1

September 17, 1980

Time (PST)	Pt. Conception	Santa Barbara	Platform Grace	Ventura (Surfer's Point)
10	290°/8.0 m/s	140°/3 m/s	--	250°/3 m/s
12	278°/8.9	190°/1.5	--	265°/5.3
14	278°/11.7	250°/5.1	244°/6.8 m/s	265°/5.1
16	281°/7.2	230°/4.4	236°/4	270°/4.4
18	301°/5.6	350°/2.5	235°/7.1	260°/4.0
20	351°/4.4	190°/2	231°/8.9	175°/0.8
22	300°/3.6	100°/2.5	230°/7.8	240°/2.5
24	311°/3.8	Calm	225°/9.4	245°/0.4

4.2.3 Mixing Heights

Table 4.2.3 shows the mixing heights observed by several different methods on September 17. The most reliable indicator of mixing height comes from the soundings made by the air quality aircraft. Temperature, turbulence and air quality profiles can be used together to define a realistic mixing height.

Mixing heights over the water on September 17 were measured at 75 to 100 m. Inland the heights increased to 700-800 m as a result of surface heating. At all inland areas, there was evidence of two mixed layers by mid to late afternoon. The lower layer represents the intrusion of cool, marine air into the inland valleys. The upper layer represents the effects of surface heating and convective mixing prior to the arrival of the marine air. As indicated, the marine layer is relatively shallow (up to 300 m) which limits the upward dispersion of pollutants within that layer. Pibal mixing heights in the table generally reflect the deeper, convective layer since the wind directions in the two layers are similar. Strong directional wind shears frequently exist above the top of the convective layer and clearly mark the top of the onshore flow.

Table 4.2.3

Mixing Heights*

September 17, 1980

1. Measured by Sampling Aircraft

Time	Location	Height*
1353 PDT	Off Pt. Conception (upper layer to 700m)	150 m
1416	W end of Gaviota (upper layer to 800m)	100 m
1442	Santa Ynez Airport (upper layer to 750m)	120 m
1543	NW of Ojai	700 m
1601	Santa Paula Airport (upper layer to 800m)	300 m
1715	Oxnard Airport	250 m
1745	Santa Susana Airport (upper layer to 550m)	400 m
1834	Off Santa Barbara (upper layer to 900m)	100 m

2. Measured by Pibals

Time	Santa Ynez	Ojai	Simi
11 PDT	159 m	662 m	466 m
13	758	662	758
15	852	852	662
17	565	565	758
19	159(852)	263	159

3. Measured by MRI Acoustic Sounder

Santa Paula Airport	Height
11 PDT	100 m
13	150
15	No Top
17	No Top
19	80
21	160

* Heights are above surface

4.2.4 Regional Ozone Concentrations

Maximum ozone concentrations at a number of key locations in the area are given in Table 4.2.4. Peak hourly ozone recorded was 10 pphm at South Mt. The remainder of the locations showed values below the state ozone standard.

Background ozone concentration was 2-3 pphm, an unusually low value. This average concentration in the area was observed above the pollutant layer by aircraft soundings which are shown in the following section. A background ozone level of 4-5 pphm is more customary for areas relatively unaffected by urban sources. In view of the relatively warm temperature aloft, higher surface concentrations might have been expected.

Time of the maximum ozone concentration at each station is shown in the second column. All of the inland stations recorded peak ozone values near midday (except Ojai). Along the coast, El Rio, Ventura and Pt. Hueneme all had peak concentrations late in the day, after the normal solar radiation cycle had passed its peak. Platform Grace recorded a peak concentration at 14 PST, somewhat earlier than the coastal stations. In view of the west to southwest winds prevailing while the coastal maximum concentrations were recorded and the concentrations at Platform Grace, it is reasonable to suggest that the late afternoon concentrations along the coast were transported from offshore.

It is recognized that the late afternoon concentrations on September 17 were relatively small and of little impact significance. This time sequence, however, was observed in later tests with more significant concentrations.

The last column in Table 4.2.4 give the time of the peak temperature recorded at each of the locations. This parameter can be correlated with the time of the maximum ozone concentration to give an indication of the ozone source region. In most inland areas the ozone and temperature peaks very nearly coincided. This would suggest local or near upwind sources as a principal generator of ozone and precursors.

Pibal observations were made every two hours during the day at Simi and Upper Ojai. These can be used to estimate the total flow of air past these two stations prior to the time of the peak ozone concentration. This length of flow can, in turn, be used to estimate the upwind source of the air parcels in which the ozone was embedded.

Figure 4.2.2 shows the time sequence of ozone concentrations at Ojai, Piru and Simi. Ventura (Seaside Park) is also shown for comparison. Piru, Ojai and Simi all show ozone peaks between 11 and 12 PST. Ojai, however, has a somewhat larger peak at 16 PST, corresponding to a late afternoon increase at Ventura. From an examination of the wind characteristics associated with the bi-modal peaks, it is suggested that the early peak resulted from emissions in the coastal strip and transported inland. A separate source is needed to account for the second peak. All stations from Ojai to Port Hueneme and inland to Moorpark exhibited this late afternoon peak. Since the wind flow was consistently from the west to southwest, an offshore source is suggested.

Table 4.2.4
Regional Maximum Ozone Concentrations (pphm)

September 17, 1980

Location	Max O_3	Time of Max O_3 (PST)	Wind Dirction at Time of Max	Time of Temp Max (PST)
Pt. Conception	6	11-12	280°	07
Goleta	7	12-13	210°	14-15
Platform Hondo	M	M	M	M
Ojai	9	16	300°	12-13
Piru	7	11-13	260°	12
Simi Valley	6	12-13	280°	12-15
South Mt.	10	11	195°	09-11
Thousand Oaks	7	10	315°	11
Moorpark	7	11-12,15	230°	12
El Rio	6	13-14,16-17	190°	12
Ventura	6	16-17	275°	11
Pt. Hueneme	4	15	290°*	12*
Platform Grace	7	14	M	M
Background	2-3			

*Pt. Mugu

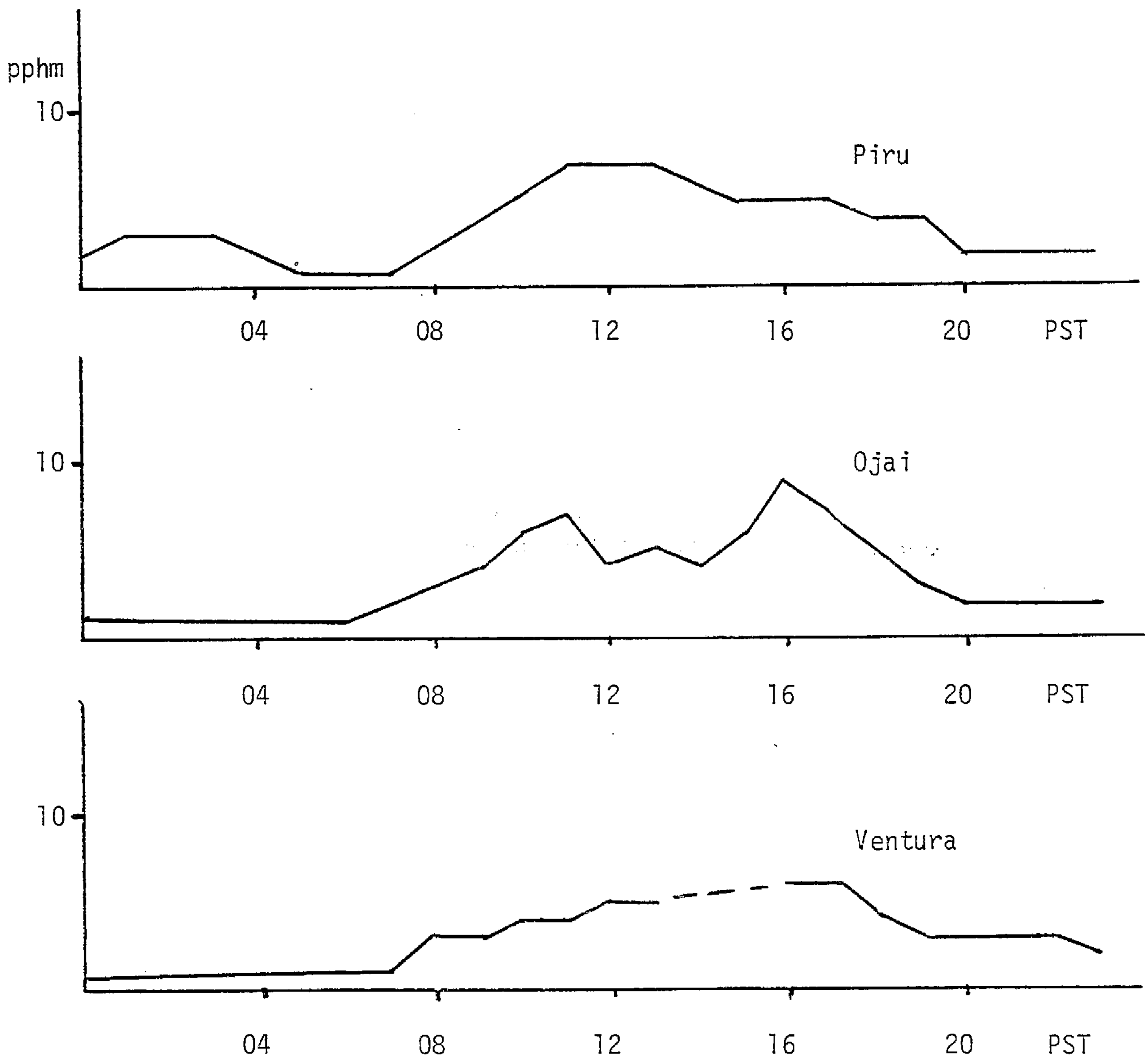


Fig. 4.2.2a HOURLY OZONE CONCENTRATIONS - September 17,1980

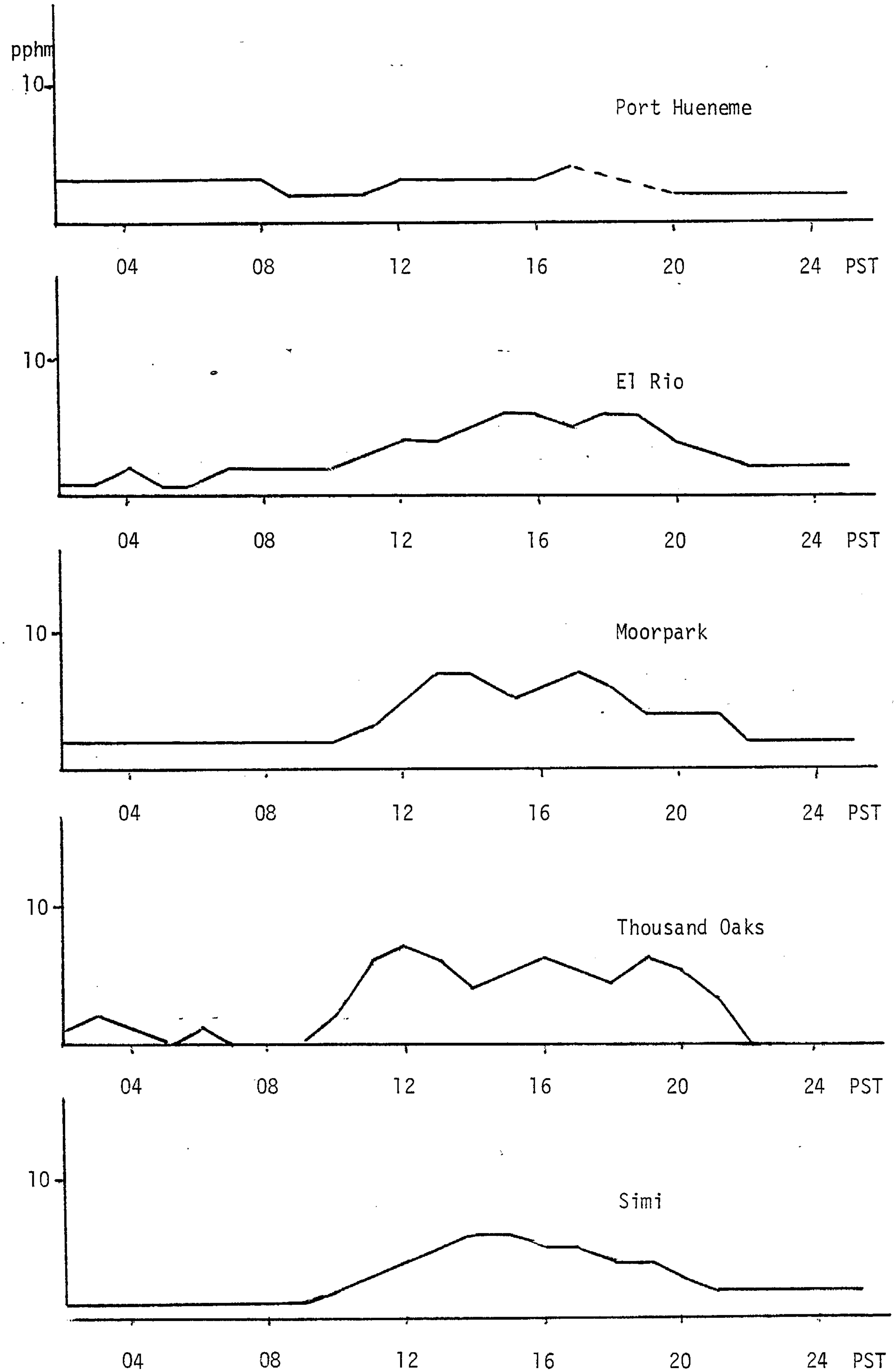


Fig. 4.2.2b HOURLY OZONE CONCENTRATIONS - September 17,1980

4.2.5 Aircraft Sampling

The MRI air quality aircraft carried out a series of spirals and traverses from 1333-1900 PDT. The area covered extended from Pt. Conception to Oxnard and included several of the inland valleys.

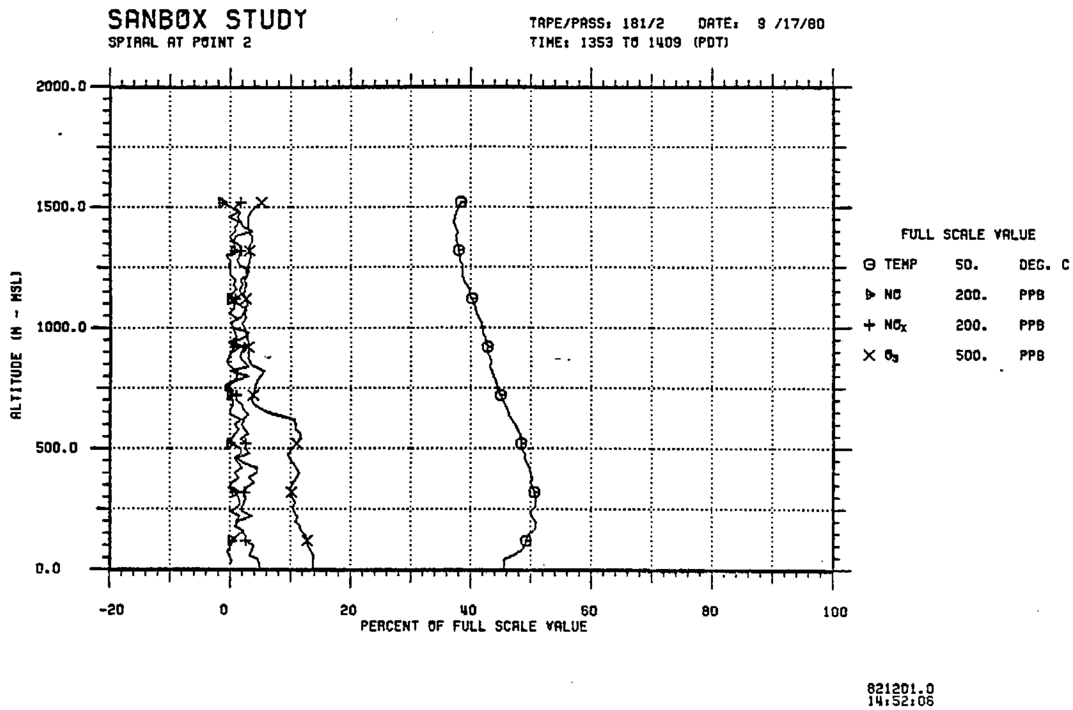
Figure 4.2.3 shows a sounding made over the water off Pt. Conception at 1353 PDT. A low-level inversion was present in the temperature sounding, resulting in a shallow, over-water mixing layer of about 100 m depth. This layer is distinctly shown by the turbulence levels which decrease rapidly through the layer.

The ozone trace in Figure 4.2.3 shows a deeper layer to about 650 m with low ozone concentrations at higher levels. Surface ozone values were about 7 pphm decreasing to 5 pphm at 650 m-msl. The dew-point trace verifies the layered structure with higher humidities evident above 650 m. Upper winds were from the northwest in the lowest 650 m and from the west-northwest at higher levels. The sounding gives a clear definition of the mixed-layer depth over the water superimposed on a 650 m deep layer being advected in from upwind.

The next sounding (Figure 4.2.4) was made over the ocean near the coast in the vicinity of Gaviota Pass. The 650 m - deep ozone layer is still clearly evident with average concentrations of about 6 pphm. The second panel in the figure shows that both turbulence and dewpoint values were strongly stratified into several layers, suggesting that extensive mixing was not present in the 650 m layer. The stratification did not appear in the pollutant parameters to any significant degree.

A sounding was made at Santa Ynez Airport at 1442 PDT (Figure 4.2.5). The pollutant parameters and the temperature structure indicate two layers, one from the surface to 350 m-msl and the other extending to about 1000 m-msl. Ozone concentrations of 5-7 pphm characterized both layers. SO_2 concentrations to 12 ppb were observed in the upper layer.

Upper wind measurements made at Santa Ynez at the time of the sounding indicate that the lower layer represented a shallow seabreeze flow from the west, undercutting the air aloft. The winds in the upper layer were from the west to northwest. A sharp wind shear existed at the 1000 m level.



AIRCRAFT SOUNDING OFF PT. CONCEPTION

(1353 PDT)

September 17,1980

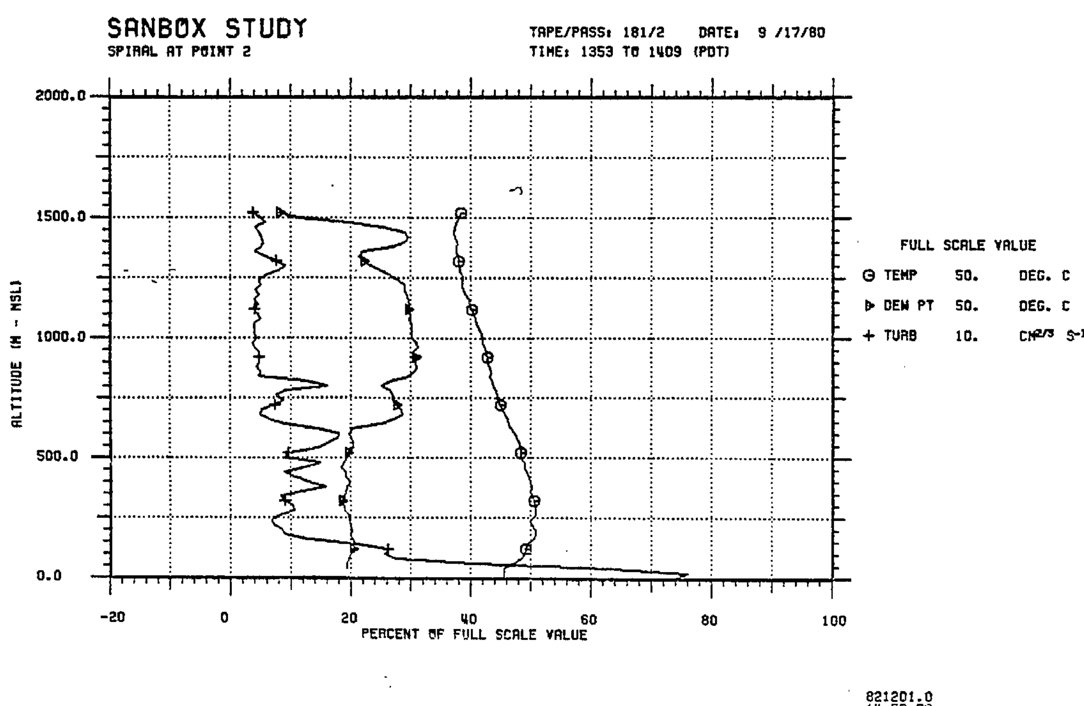
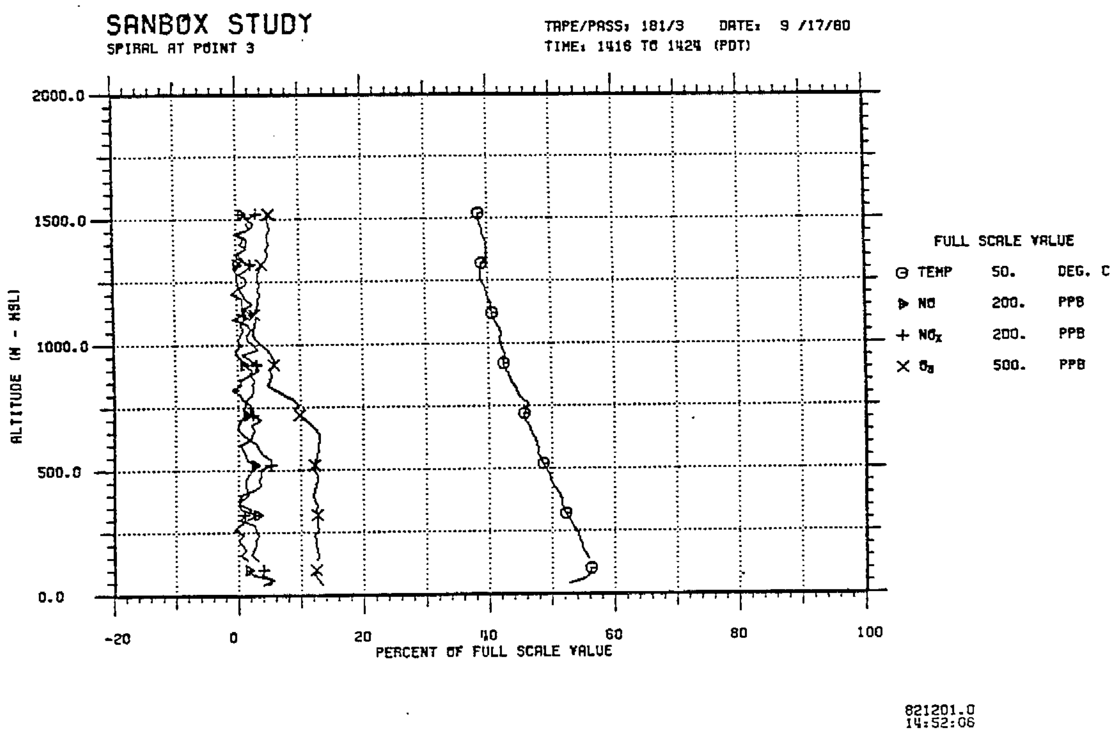


Fig. 4.2.3



AIRCRAFT SOUNDING OFF GAVIOTA

(1416 PDT)

September 17,1980

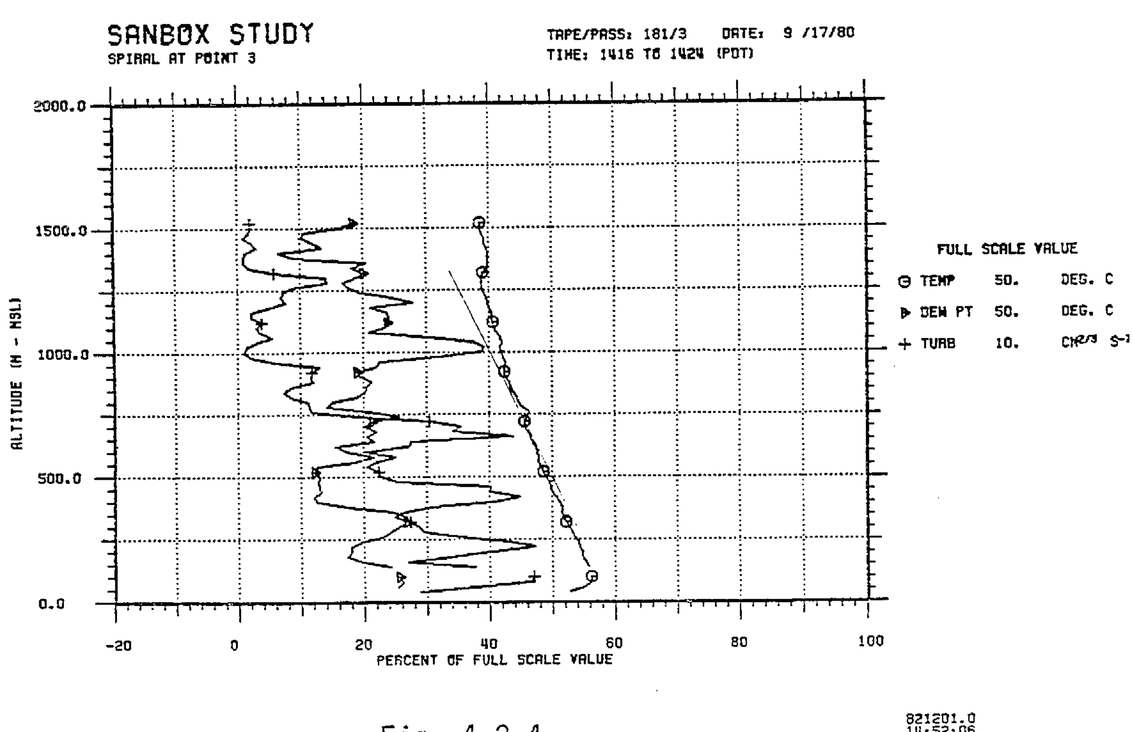
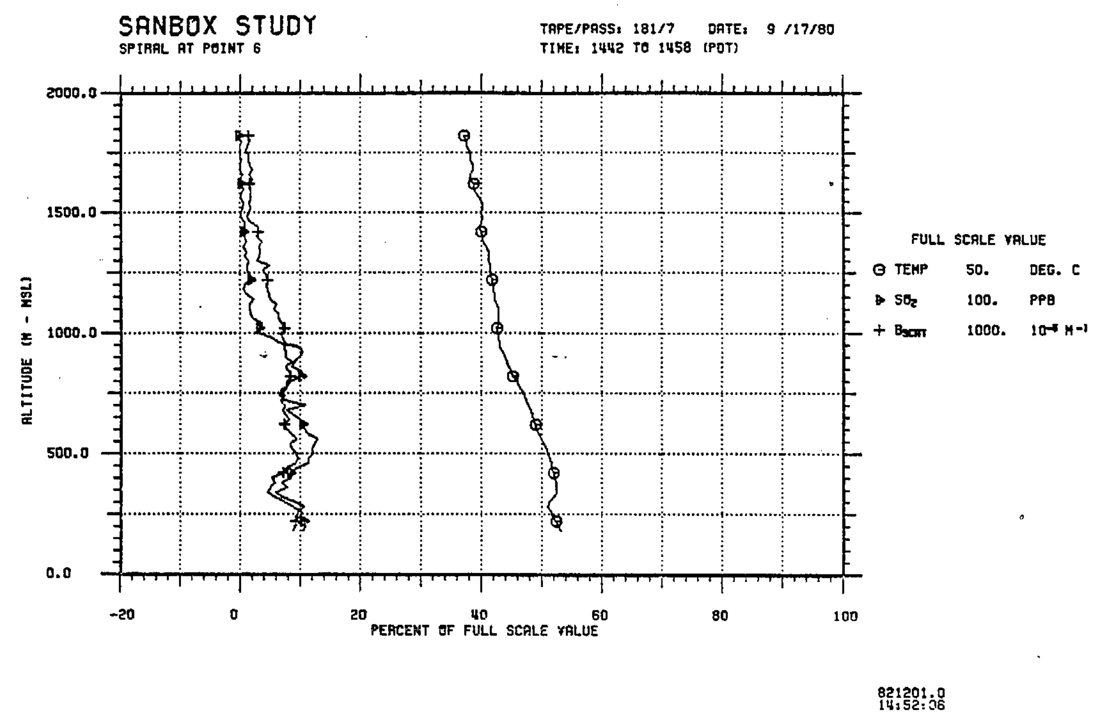


Fig. 4.2.4



AIRCRAFT SOUNDING AT SANTA YNEZ

(1442 PDT)

September 17,1980

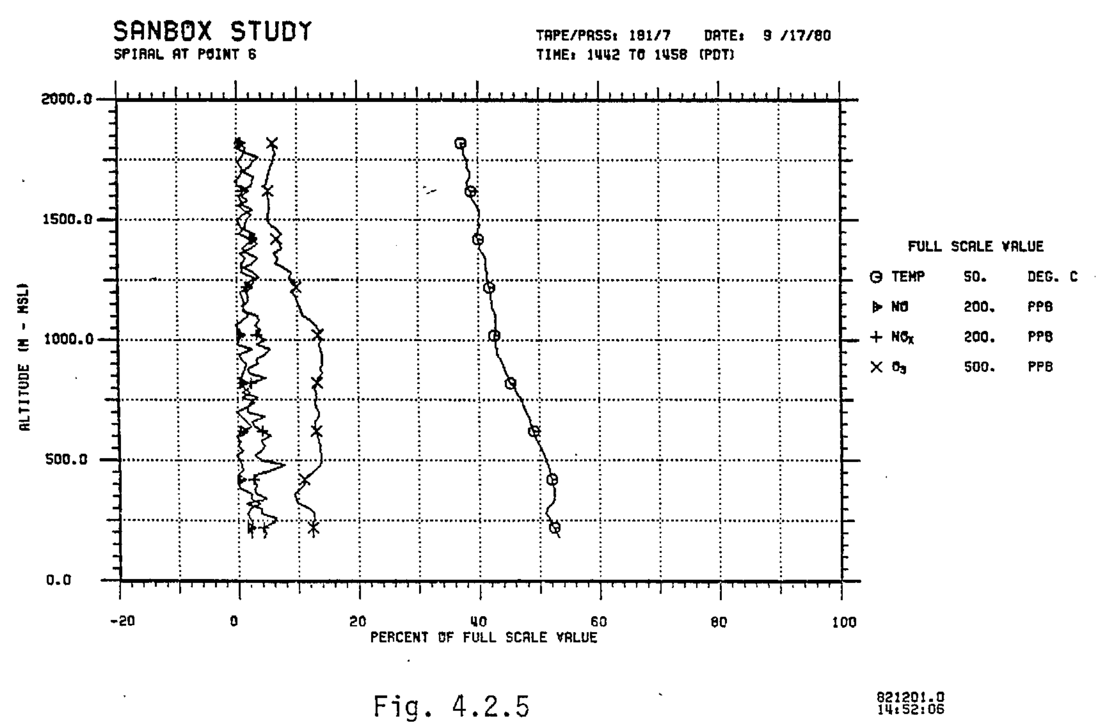


Fig. 4.2.5

The next aircraft sounding was made near Ojai at 1543 PDT (Figure 4.2.6). During the traverse from Santa Ynez to Ojai ozone concentrations as high as 15 pphm were observed west of Carpinteria at an elevation of 457 m-msl. These concentrations were well above any surface concentrations measured on September 17.

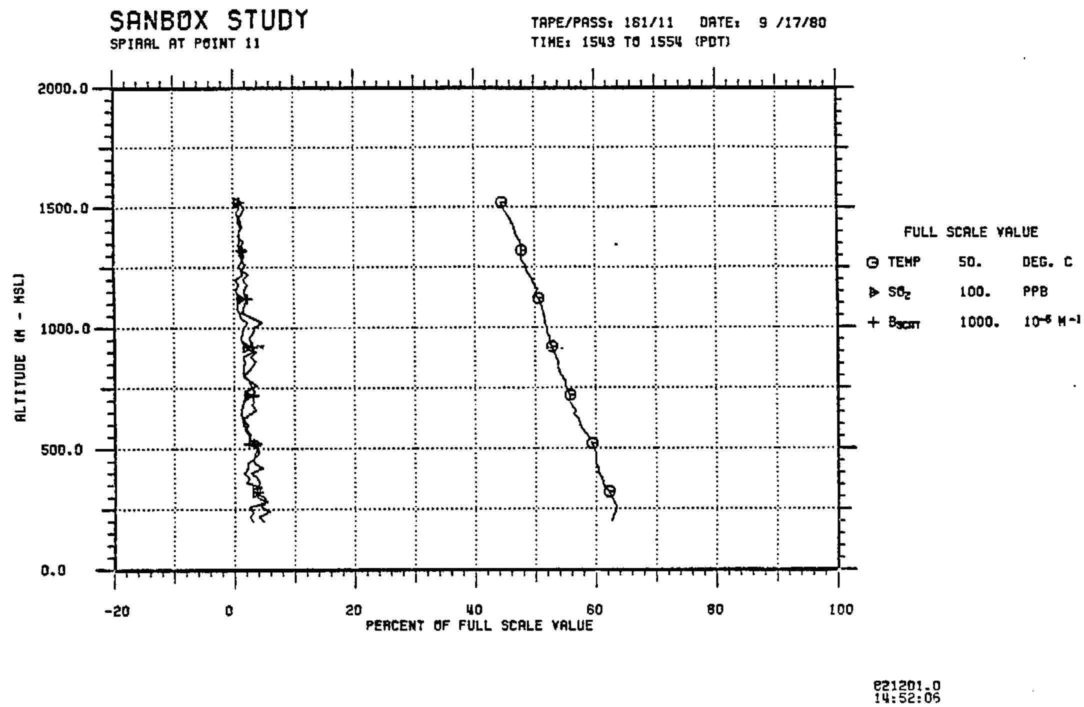
The sounding at Ojai shows a relatively well-mixed layer to about 1000 m-msl where a slight increase in the temperature stability was present. Pollutant parameters were well-mixed in the layer with ozone concentrations averaging about 4 pphm and comparably low values of the other pollutants. Upper winds at Ojai were from the west-southwest in the mixed layer with a sharp wind shear to southeasterly above 1000 m-msl.

Similar ozone concentrations were observed in a sounding at Santa Paula Airport (Figure 4.2.7) at 1601 PDT. Average values of about 4 pphm existed to a level of 1000 m-msl. At Santa Paula, however, a low level temperature inversion existed at about 350 m-msl, representing a shallow seabreeze flow. This layer is indicated more dramatically by the turbulence values in the lower panel of the figure.

The shallow seabreeze flow is also shown in the sounding at Oxnard Airport at 1715 PDT (Figure 4.2.8). Top of the seabreeze flow was 400 m-msl but a surface inversion led to an accumulation of NO_x in the surface layers. SO_2 values to 19 ppb also occurred in the surface layer.

A sounding was then made at the Santa Susana Airport (near Simi) at 1745 PDT (Figure 4.2.9). A mixed layer to 700 m-msl is shown by the temperature, SO_2 and b_{scat} traces. An elevated ozone layer existed within the inversion and above the mixed layer. Winds were westerly throughout both layers. Maximum observed ozone values were not more than 5 pphm.

A final sounding on September 17 was made at 1834 PDT offshore from Santa Barbara (Figure 4.2.10). An inversion existed over the water to a depth of 200 m. In the stable air above the inversion, three large b_{scat} plumes are shown in the figure. Each plume is supported by peaks in both NO_x and SO_2. An ozone layer of 7-8 pphm extended from the surface to 750 m-msl before the concentrations decreased to background levels aloft. This layer appears to be similar to that observed in soundings at Pt. Conception and Gaviota earlier in the day. Although no upper wind observations were taken near Santa Barbara, winds at Santa Ynez and Pt. Conception were northwesterly and westerly at Ojai.



AIRCRAFT SOUNDING AT LAKE CASITAS

(1543 PDT)

September 17,1980

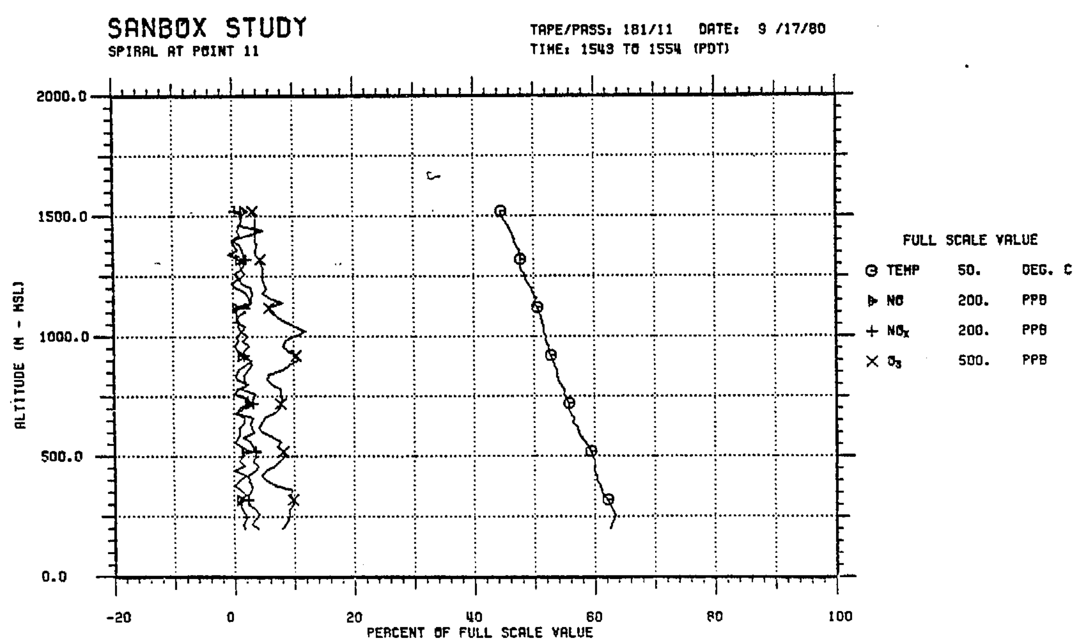
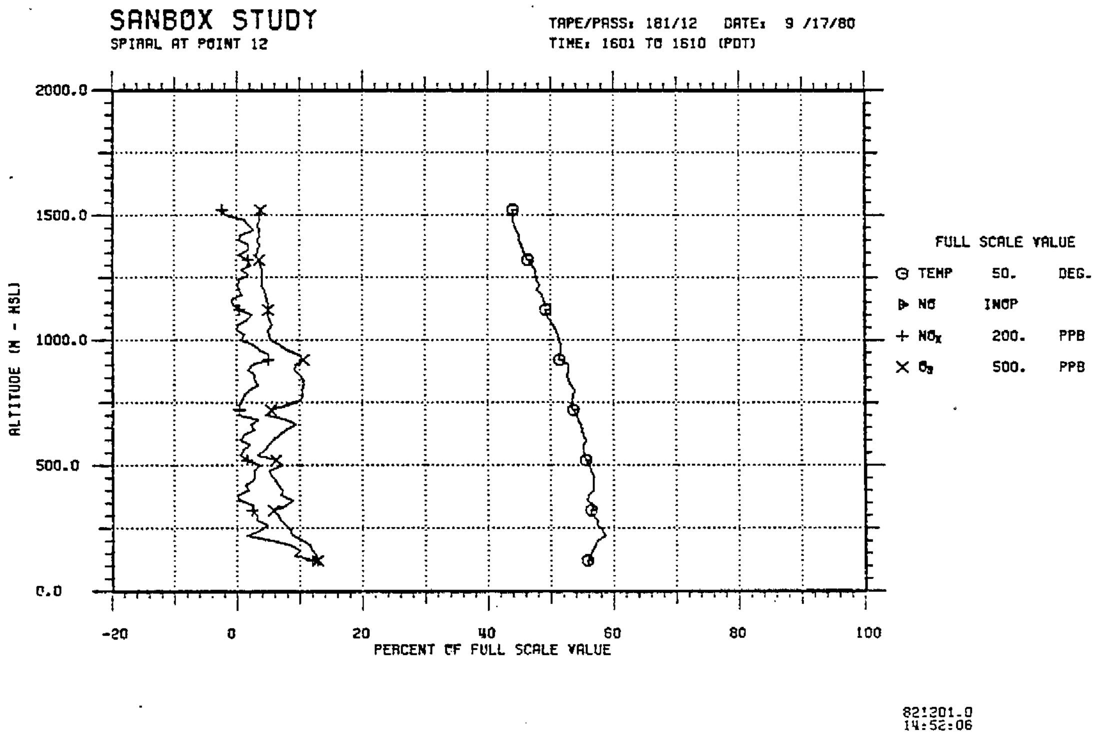


Fig. 4.2.6



AIRCRAFT SOUNDING AT SANTA PAULA

(1601 PDT)

September 17,1980

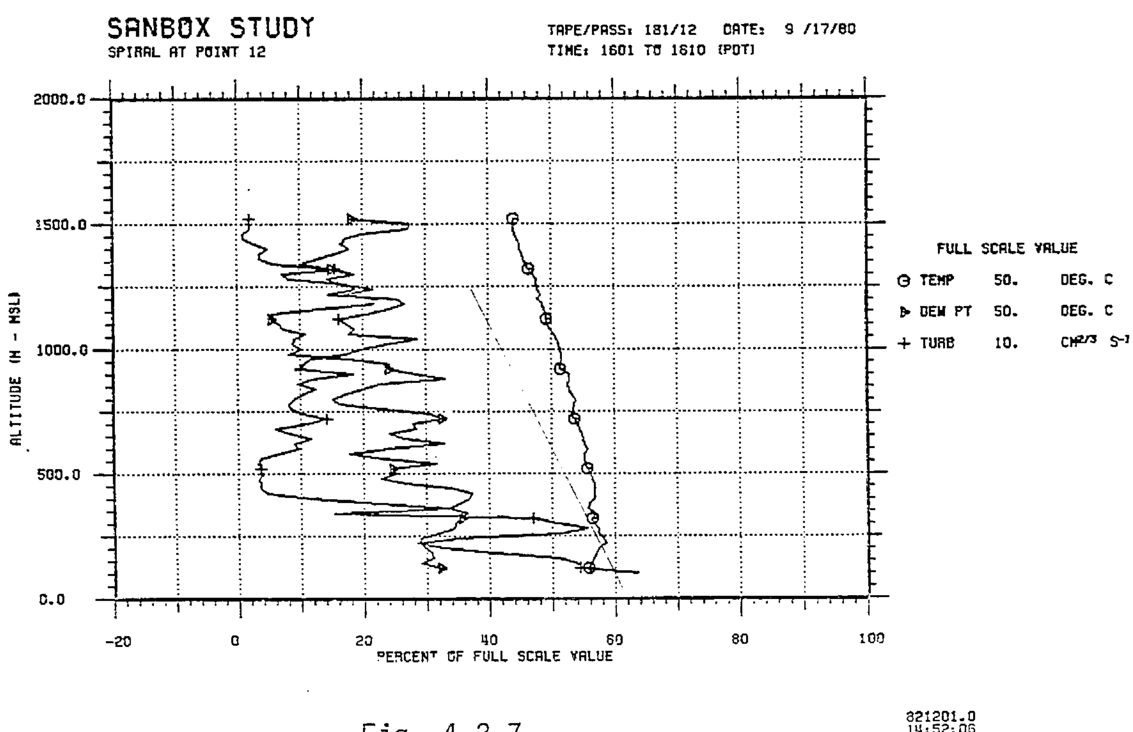
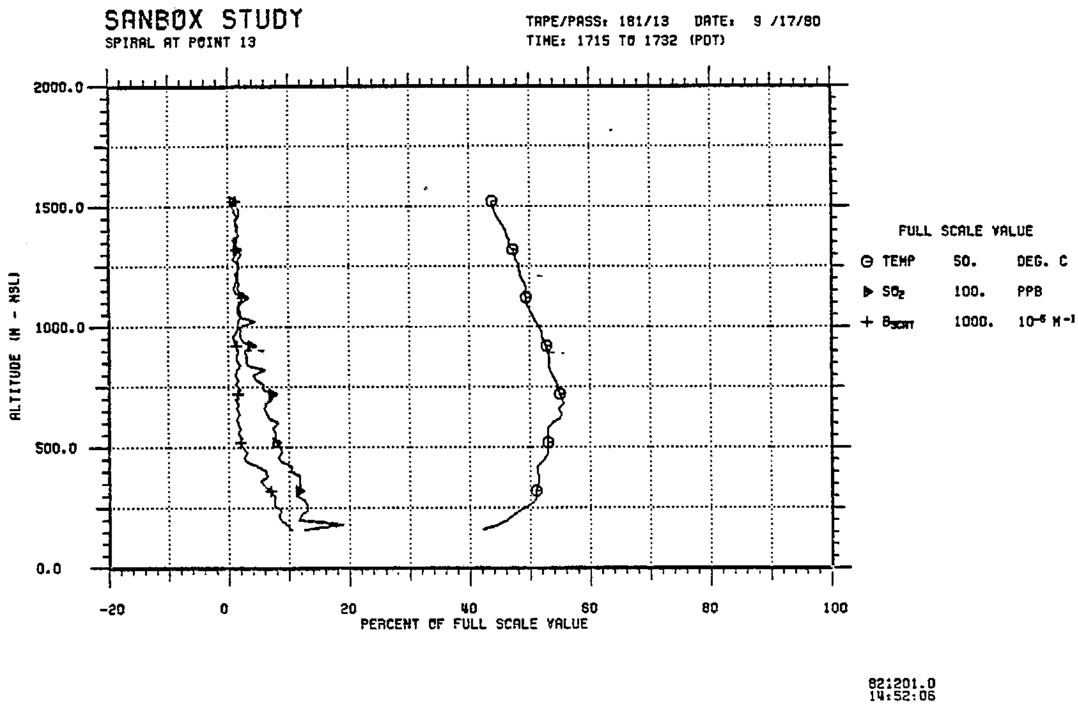


Fig. 4.2.7



AIRCRAFT SOUNDING AT OXNARD

(1715 PDT)

September 17,1980

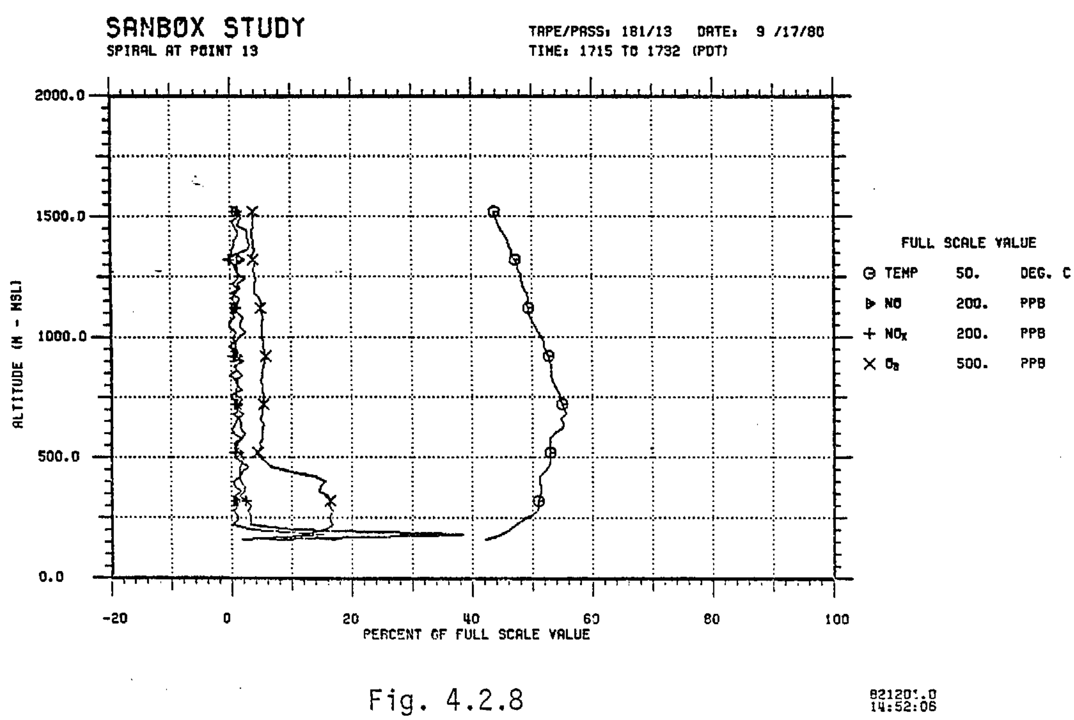
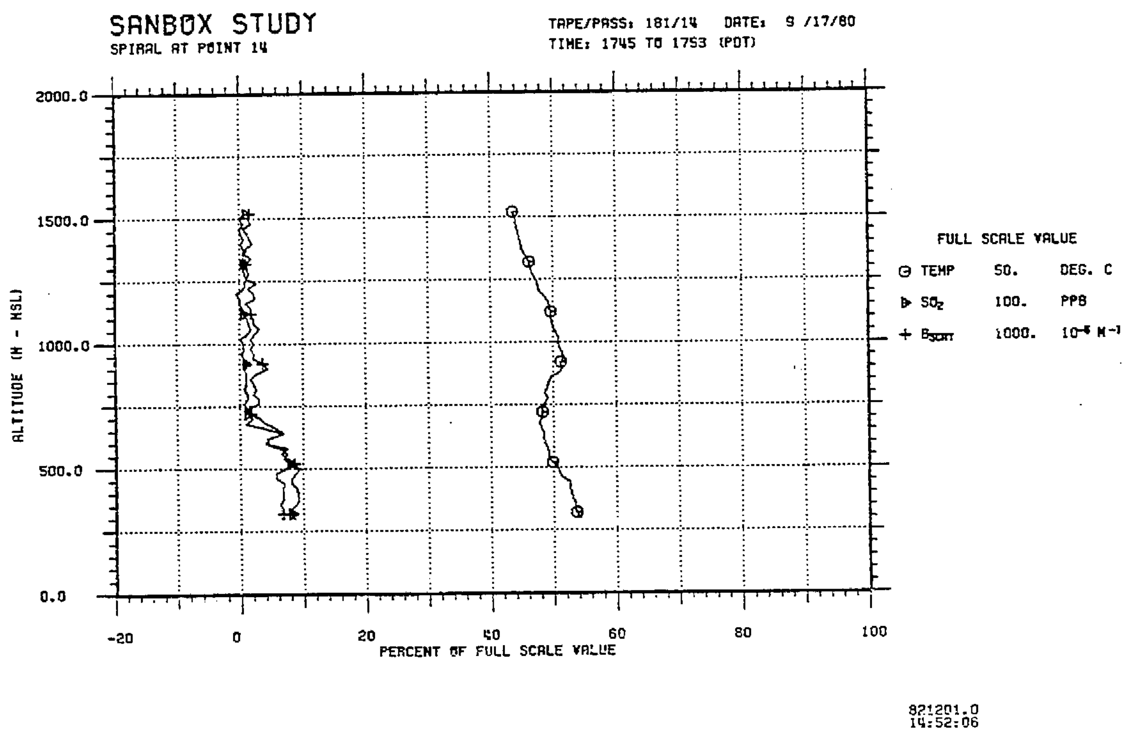


Fig. 4.2.8



AIRCRAFT SOUNDING AT SANTA SUSANA

(1745 PDT)

September 17,1980

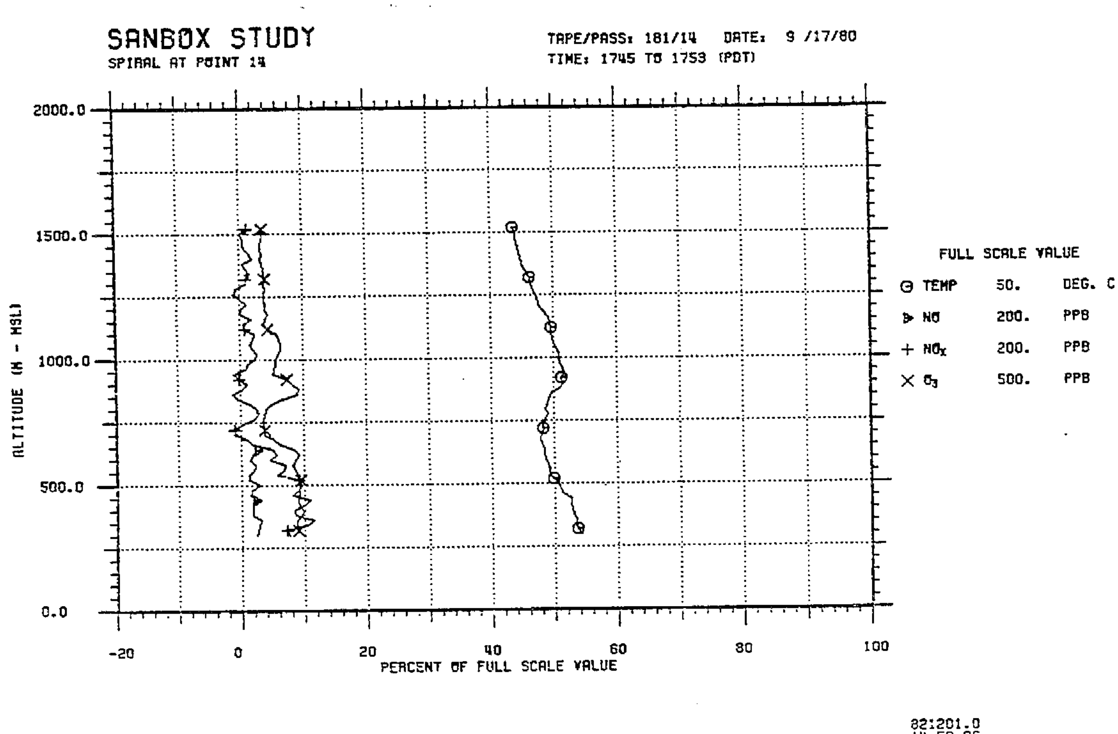
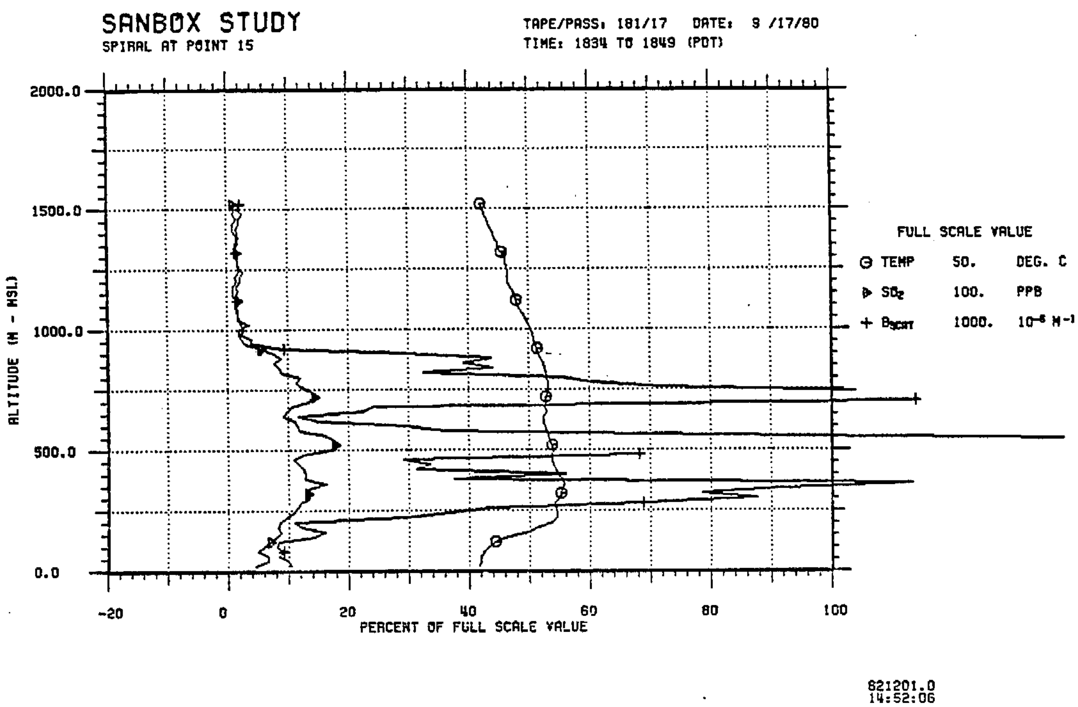


Fig. 4.2.9



AIRCRAFT SOUNDING OFF SANTA BARBARA

(1834 PDT)

September 17,1980

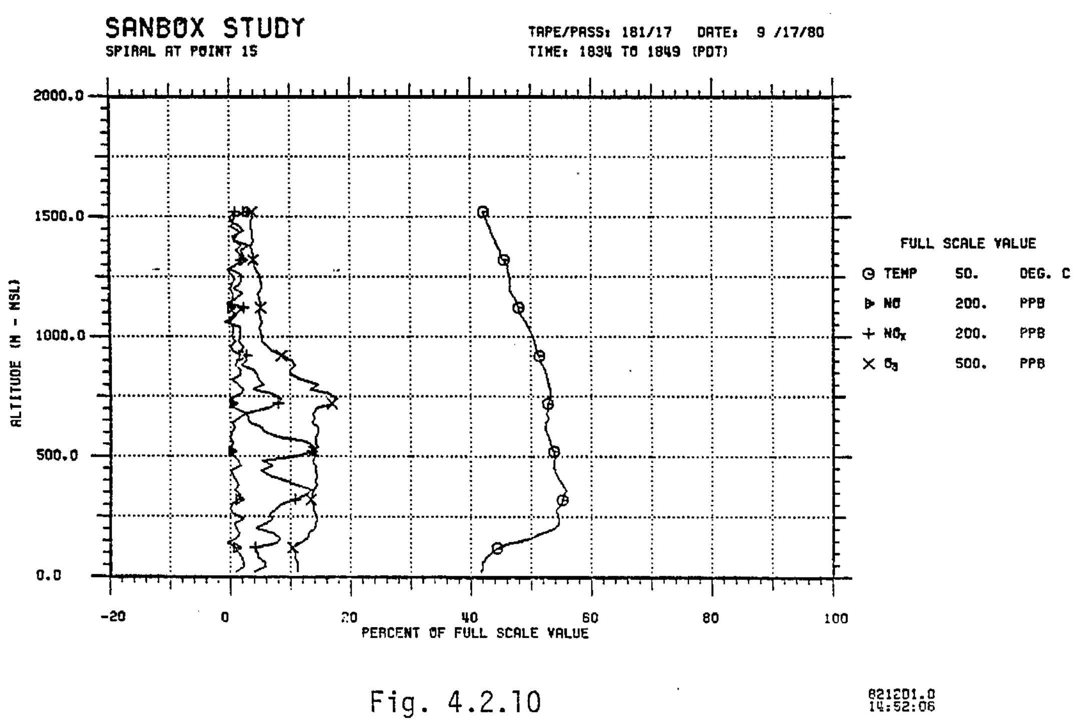


Fig. 4.2.10

4.2.6 Tracer Results - Test 1

Release Location: Pt. Conception
Date: September 17, 1980
Time: 11-16 PDT
Release Rate: 10.6 g SF_6 per sec

Surface winds at Pt. Conception during the release period are given in Table 4.2.5.

Table 4.2.5

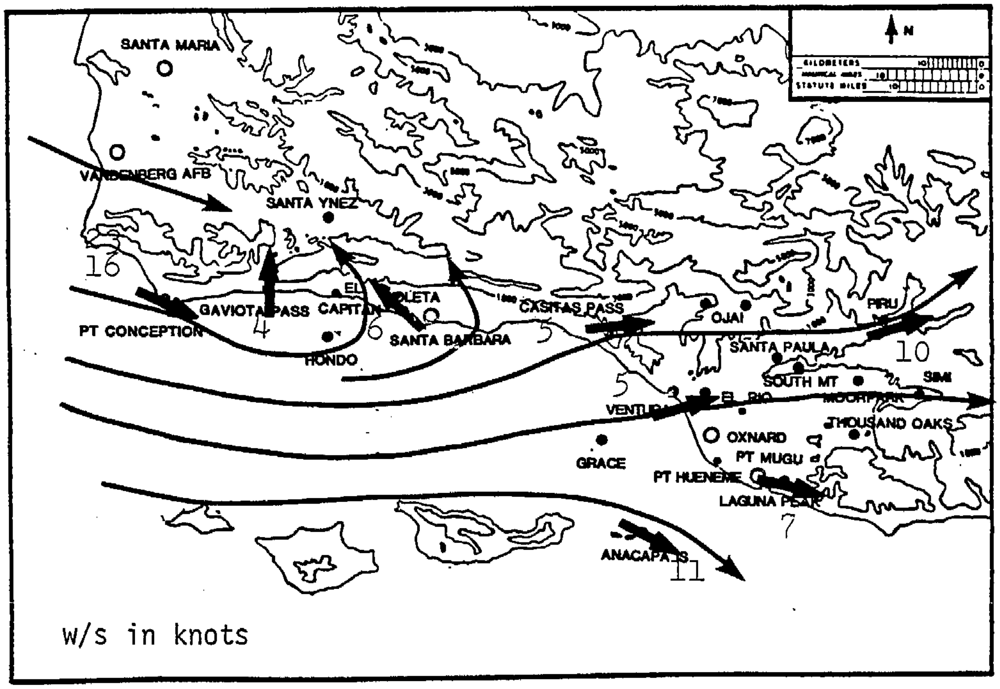
Surface Winds - Pt. Conception
September 17, 1980

Time	Wind Direction	Wind Speed
11 PDT	295°	7.2 m/s
12	290	8.0
13	286	10.2
14	278	8.9
15	285	9.6
16	278	11.7

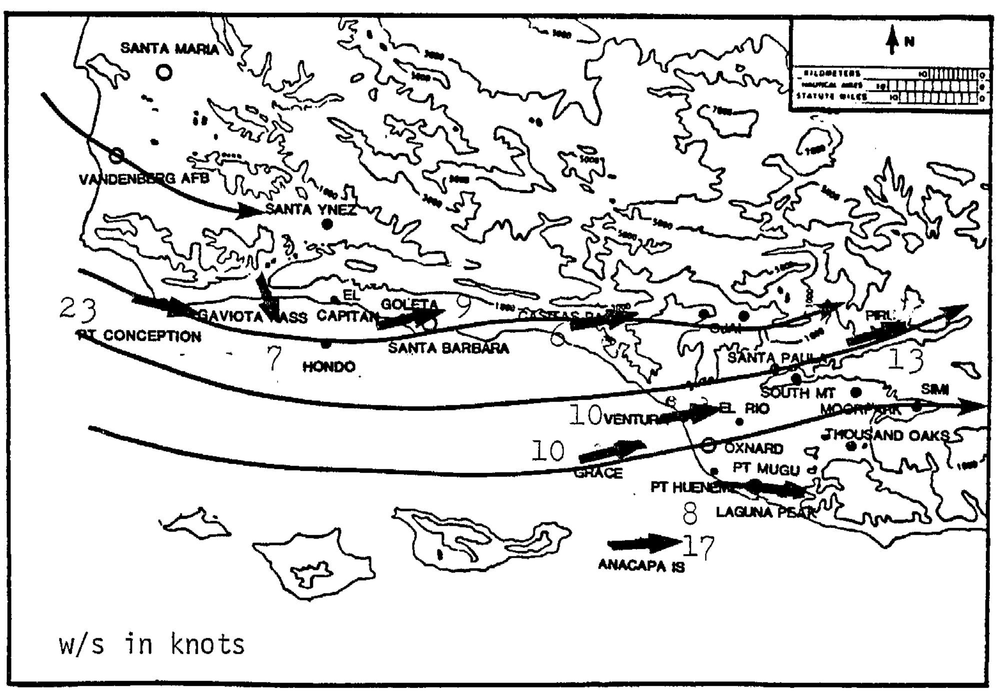
Wind directions were consistently from the northwest with relatively strong velocities.

Figures 4.2.11 and 4.2.12 show streamline charts for the period 10 to 22 PST on September 17. For the first few hours of the release surface winds at Santa Barbara and Gaviota were from the south to southeast, indicating the presence of a "Gaviota Eddy". Elsewhere in the channel a general westerly flow was established by 10 PST, continuing through 14 PST. By 18 PST the wind at Casitas Pass had turned to southeast, indicating the start of a nocturnal eddy in the northern portion of the channel. By 22 PST the influence of this eddy had spread westward to include the Santa Barbara area. A feature of the afternoon and evening was the relatively strong wind at Platform Grace from the southwest (Table 4.2.2).

Estimated tracer trajectories in September 17 are shown in Figure 4.2.13. Times when peak concentrations were observed at various locations are also given in the figure. Three principal trajectories are shown. One of these was indicated by very high concentrations observed at Platform Hondo between 14 and 16 PDT. The southernmost trajectory was indicated by aircraft tracer samples obtained about 16-17 PDT over the mid to southern part of the channel. The central trajectory was suggested by the tracer arrival times at Carpenteria, Ojai and Santa Paula. In keeping with the streamline charts (Figures 4.2.11 and 4.2.12) the tracer trajectories show dominant northwest to westerly wind directions. From the time of arrival of the SF_6 along the Ventura coast it is estimated that the travel velocity for the tracer within the channel was 6-8 m/s.



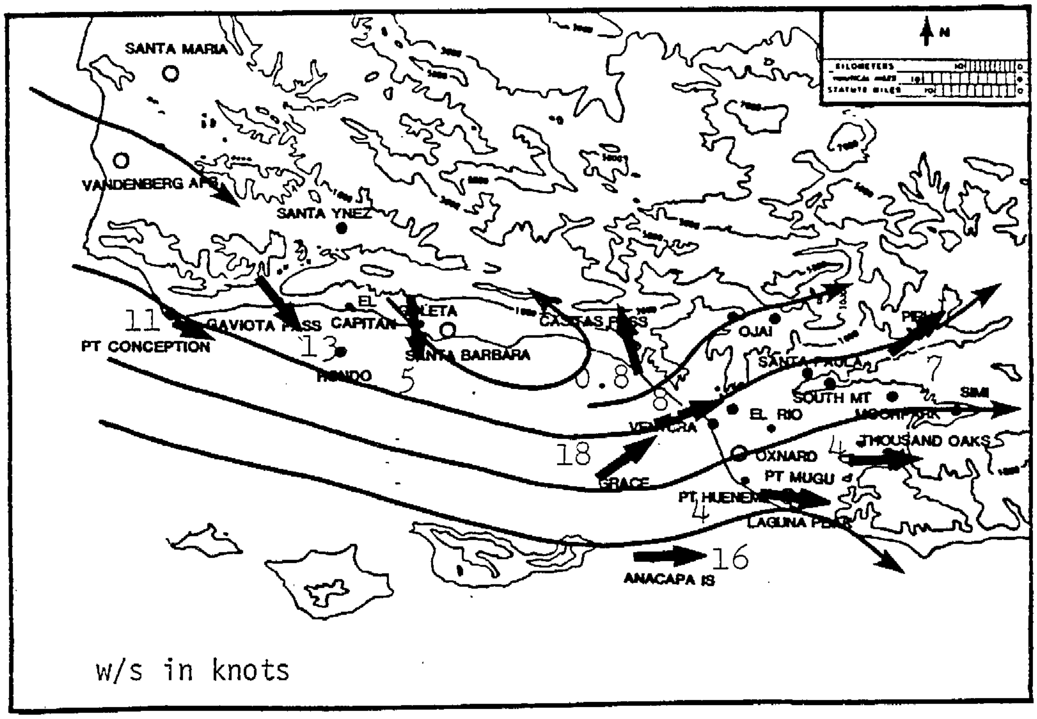
10 PST



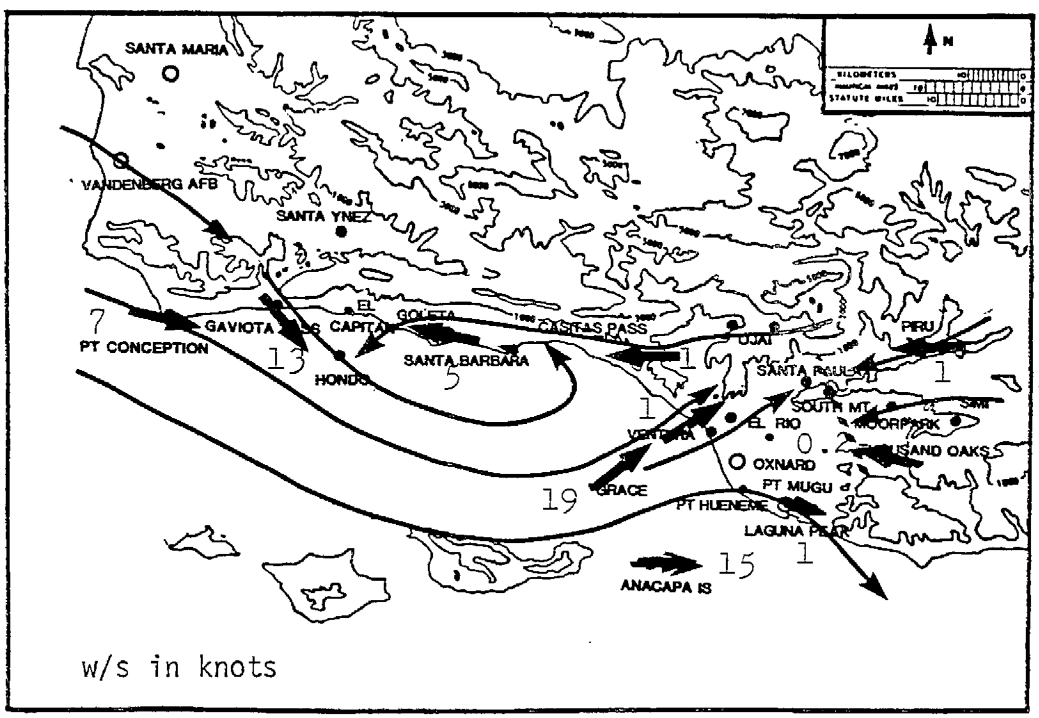
14 PST

September 17,1980

Fig. 4.2.11 STREAMLINE CHARTS



18 PST



22 PST September 17,1980

Fig. 4.2.12 STREAMLINE CHARTS

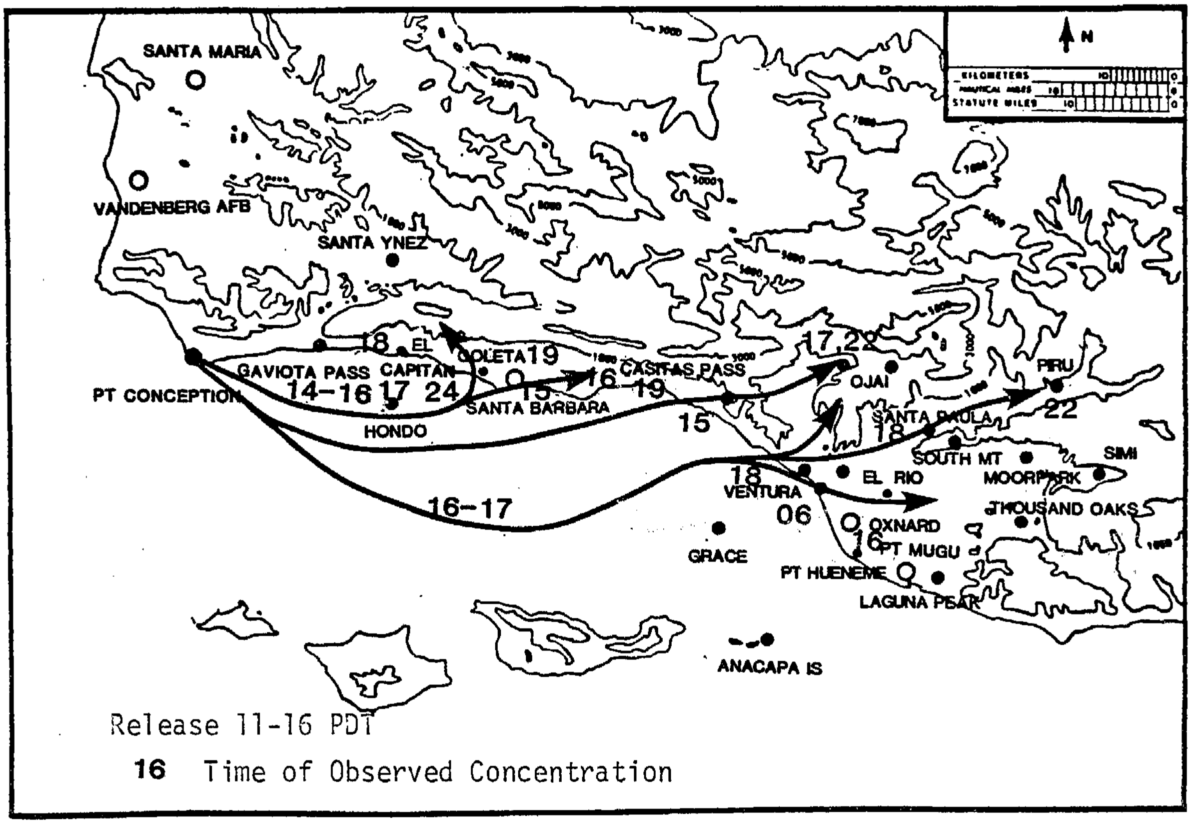


Fig. 4.2.13 ESTIMATED TRACER TRAJECTORIES

September 17,1980

The arrival of SF_6 tracer at Piru and Ojai on September 17 is shown in Figure 4.2.14 together with the comparative hourly ozone concentrations. Two SF_6 peaks are shown in the Ojai plot while only one major peak appears in the Piru data. Reference to Figure 4.2.13 suggests that the central trajectory indicated in the figure produced the early peak at Ojai which did not influence Piru. The southern trajectory resulted in a later SF_6 arrival at both Ojai and Piru.

Peak ozone concentrations on September 17 were recorded from 11 to 13 PST at Piru and at 16 PST at Ojai. The first SF_6 peak at Ojai occurred at the same time as the ozone peak. The later SF_6 peaks occurred well after the ozone peaks at Piru and Ojai. Based on the tracer data, the air parcel in which the ozone peak occurred at Ojai crossed the coast line about 14 PST.

Xu/Q values for September 17 have been computed for all maximum concentrations which appeared to be associated with a direct trajectory impact, As indicated in Figure 4.2.13, this included all concentrations measured on September 17 but excluded those observed during the following day. Peak concentration values were used in the computations since maximum impact is of primary interest and those locations influenced by plume edges have been excluded. Distances were measured along the trajectories indicated in Figure 4.2.13. Computed Xu/Q values are given in Table 4.2.6.

Table 4.2.6

Calculated Xu/Q Values
Test 1 - September 17, 1980

Wind Speed	Location	Time	Type of Sample	Distance	Xu/Q ($x10^{-6}$)
9.3 m/s	El Capitan	17 PDT	H	60 km	0.28m^{-2}
	El Capitan	17	A	60	10.1
	Ellwood	17	A	60	13.6
	Santa Barbara	16	H	80	3.99
	Camarillo	19	H	150	0.27
	Ojai	18	H	130	0.23
	Oxnard	16	H	135	0.26
	Carpinteria	15	H	100	4.11
	Piru	22	H	165	0.30
	Santa Barbara	15	A	75	9.36
	Goleta	16	A	70	9.54
	Hondo	14	H	38	23.4
	NW Ventura	18	A/C	75	5.3
	Santa Barbara	16	A/C	75	7.18
	Santa Barbara	19	A/C	75	3.07

H - Hourly sample
A - Automobile sample
A/C - Aircraft sample

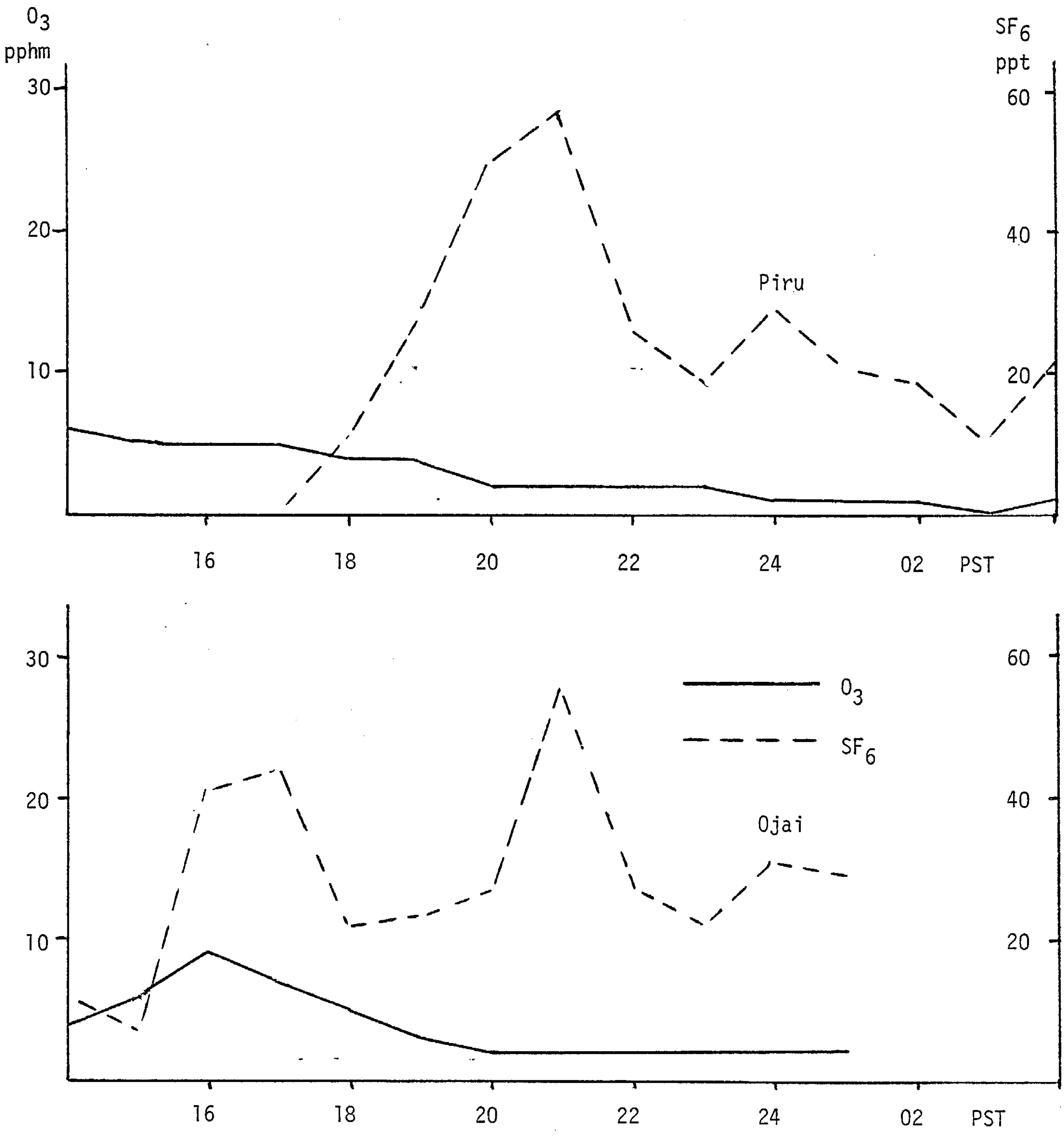


Fig. 4.2.14 HOURLY CONCENTRATIONS OF OZONE AND SF_6

September 17,1980

Maximum Xu/Q values occurred in the area of El Capitan Beach to Santa Barbara. Highest values were all grab samples taken in auto or aircraft traverses. The Xu/Q values are plotted in Figure 4.2.15 as a function of distance along the indicated trajectories. Maximum Xu/Q values in the El Capitan/Santa Barbara area corresponded to a G stability category. Hourly samples farther downwind corresponded to Category E in the Pasquill stability system.

Total tracer dosage was computed at each of the hourly sampling stations for a 24-hour period of maximum impact. These totals are shown in Table 4.2.7 together with the number of hours with hourly SF_6 concentrations of 10 ppt or more. The starting time of the 24-hour period varied from one station to another. Far downwind stations were usually started at a later time and sampled later than the near downwind stations.

Table 4.2.7

Total SF_6 Dosages
Test 1 - September 17, 1980

Location	Total Dosage	Number of hours $\geq$ 10 ppt
Santa Ynez	0 ppt	0
Gaviota	0	0
El Capitan	498	14
Santa Barbara	2032	7
Carpinteria	2027	17
Ojai	333	11
Ventura	302	8
Santa Paula	822	18
Piru	364	16
Oxnard	120	3
Camarillo	321	12
Simi	2	2

Although the peak short-term impact of the tracer was in the El Capitan/Santa Barbara area, the largest total dosages were observed slightly downwind at Santa Barbara and Carpinteria. The impact of the tracer in the Ojai and Santa Clara Valley is also shown. In view of the five hour release period the duration of the concentration greater than 10 ppt indicates extensive carry-over into the following day at El Capitan, Carpinteria, Santa Paula, Piru and Camarillo. It is to be noted that this carry-over is particularly characteristic of the inland valley areas of Ventura County.

Tracer concentrations were sampled by auto traverses on September 18, Figure 4.2.16. Traverse routes are shown together with shaded sections of the routes where tracer concentrations greater than 10 ppt were observed. These sections occurred primarily in the inland valleys and sporadically along the Coast Highway. Peak SF_6 concentration observed on September 18 was 35 ppt in the Ojai Valley. Although there were widespread concentrations of SF_6 on September 18, peak concentrations were relatively small.

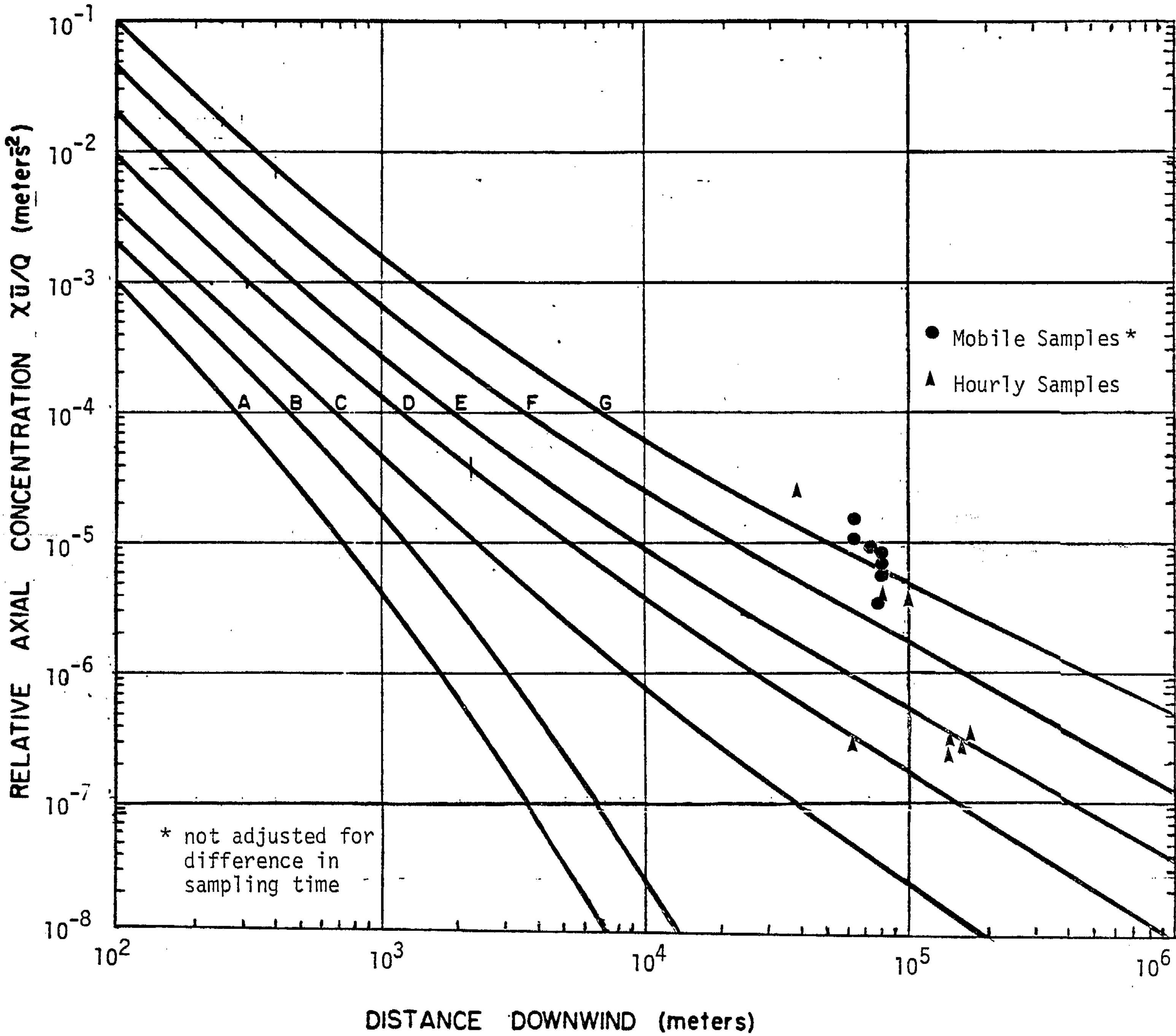


Fig. 4.2.15 XU/Q VALUES - Test 1
September 17,1980

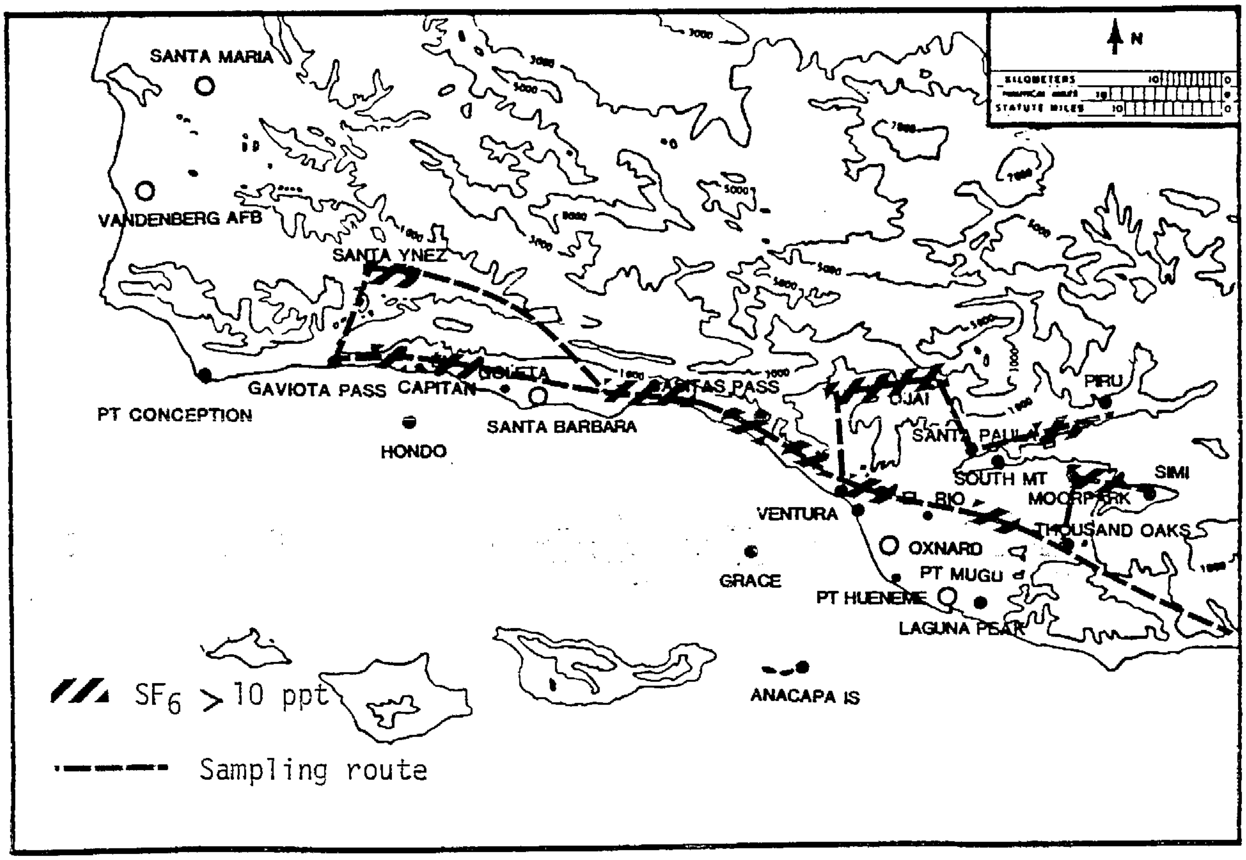


Fig. 4.2.16 LOCATIONS OF SF_6 CONCENTRATIONS ($>$ 10 ppt)

September 18,1984

4.3 Test 2 22 September 1980 - Release from 3 mi South of Pt. Conception (1100-1600 PDT)

4.3.1 General Meteorology

The surface pressure field was dominated by a thermal trough which extended from the Gulf of Lower California to northern California (Figure 4.3.1). At 500 mb a weak, short-wave trough moved across the state with a destabilizing effect and a consequent deepening of the mixed layer in the study area. Cloud conditions were broken to overcast throughout the day over the channel and immediate coastal area. Ceilings ranged in the area of 500 to 1500 ft with visibilities generally 3-5 miles in fog and haze.

Table 4.3.1 gives the significant meteorological parameters on September 22.

Table 4.3.1

Meteorological Parameters

Setpember 22, 1980

850 mb Temperature (Vandenberg AFB)	15°C
Pressure Gradients (07 PST)	
LAX-Bakersfield	0.1 mb
Santa Barbara-Daggett	1.3
Inversion Base (15 PST)	
Pt. Mugu	535 m
Maximum Surface Temperatures	
Thousand Oaks	70°F
Piru	75°
Santa Barbara	69°

Compared to September 17 (Test 1), the temperature at 850 mb was considerably lower and inland pressure gradients were somewhat higher on September 22. Maximum temperatures inland were nearly 20°F cooler on the 22nd.

4.3.2 Transport Winds

Transport winds at a number of locations on September 22 are shown in Table 4.3.2. The principal difference in the winds on Tests 1 and 2 can be seen at Platform Grace where winds during the seabreeze cycle were considerably stronger on September 17. The characteristic diurnal cycle of wind directions at Santa Barbara was again apparent. Note the wind directions at Platform Hondo, shifting from easterly to southwest and back to easterly after sunset with moderate velocities.

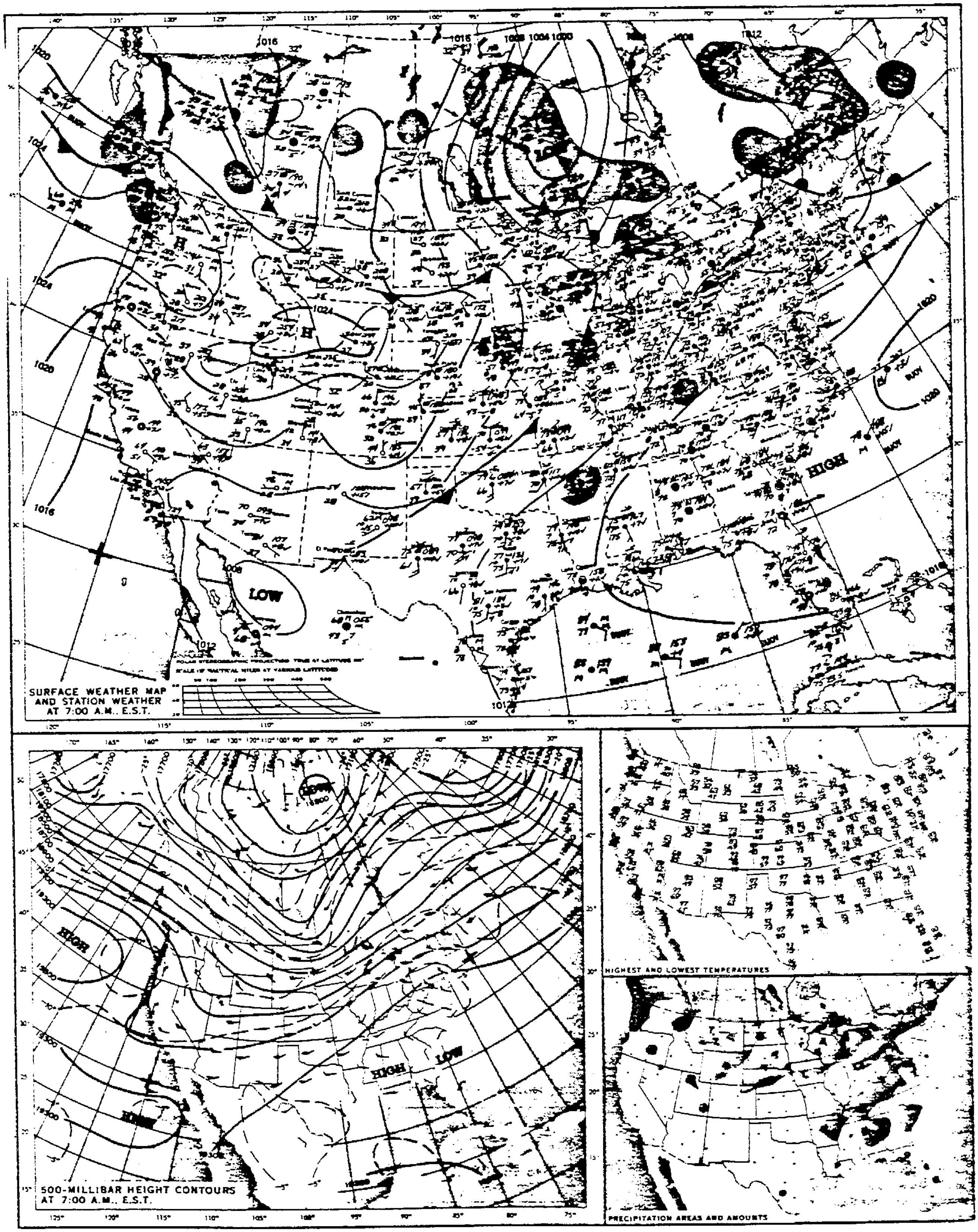


Fig. 4.3.1 WEATHER MAP - September 22,1980

4.3.3 Mixing Heights

Mixing height estimates from several sources are given in Table 4.3.3. Mixing heights over the water were substantially higher than in Test 1, reflecting the cooler temperatures aloft. In the inland areas the mixing layers as defined by the pibal measurements were lower on September 22. As indicated in Table 4.3.3 there was an elevated layer (extending to about 1000 m-msl) of pollutants which was embedded in an easterly wind flow. Tops of the lower layer as measured by the aircraft soundings agree well with the pibal mixing heights. The upper layers observed by the sampling aircraft are clearly in a separate air layer.

4.3.4 Regional Ozone Concentrations

Maximum ozone concentrations for September 22 are given in Table 4.3.4. Maximum hourly concentrations exceeded the state standard at Piru and South Mt. but only slightly.

The background ozone concentration was observed as 7 pphm by aircraft soundings (see Section 4.3.5). This is considerably higher than existed on September 17. Cooler temperatures aloft on September 22 should have reduced surface ozone concentrations compared to September 17. Apparently the effect of the cooler temperatures was overcome by the higher background levels of September 22.

Table 4.3.2

Transport Winds - Test 2

September 22, 1980

Time PST	Pt. Conception		Hondo		Santa Barbara		Grace		Ventura	
	w/d	w/s	w/d	w/s	w/d	w/s	w/d	w/s	w/d	w/s
10	137°	1.9m/s	072°	0.9m/s		calm	094°	0.8m/s	230°	2.6m/s
12	255	5.2	063	0.4	140°	3.6m/s	222	0.7	240	3.3
14	297	9.2	242	0.9	200	4.1	249	2.5	255	4.3
16	293	9.2	261	3.1	250	5.7	251	3.7	270	4.6
18	285	7.1	246	4.5	220	3.6	259	5.1	275	4.2
20	106	2.3	170	1.3	100	2.1	268	3.4	040	2.1
22	110	5.7	072	3.6	120	3.1	259	1.6	320	1.0
24	355	1.5	080	4.9	080	3.1	252	0.9	350	1.4

Table 4.3.3

Mixing Heights*

September 22, 1980

1. Measured by Sampling Aircraft

Time	Location	Height*
1318 PDT	off Pt. Conception	500 m
1344	off Gaviota Pass (upper layer to 900m)	250
1412	Santa Ynez Airport	800
1455	near Ojai (upper layer to 900m)	500
1512	Santa Paula Airport (upper layer to 800m)	250
1620	Oxnard Airport (upper layer to 1000m)	400
1652	Santa Susana Airport (upper layer to 600m)	400
1741	off Santa Barbara (upper layer to 700m)	400

2. Measured by Pibals

Time	Santa Ynez	Ojai	Simi
09 PDT	53m	365m	159m
11	758	365	263
13	565	263	565
15	758	466	365
17	662	466	365
19	365	159	365
21	---	159	---

3. Measured by MRI Acoustic Sounder

Santa Paula Airport	Height
11 PDT	380m
13	No Top
15	No Top
17	180
19	140
21	90

*Heights are above surface

Time histories of the ozone concentrations at several locations in the area are shown in Figure 4.3.2. Peak concentrations at Ojai, Piru and Simi occurred at or near the time of maximum temperature (Table 4.3.3). A significant surge of ozone attributable to the late arrival of the marine air was not present at these stations. Time histories at Ventura and Port Hueneme were similar to those shown previously for September 17. Peak concentrations occurred at 16-17 and 18 PST, respectively. Surface winds were westerly at the time of maximum concentration. As in the case of September 17, the ozone concentration at Platform Grace peaked at 14-16 PST with a WSW wind. These winds and those occurring simultaneously along the coast again suggest late afternoon transport of ozone from the offshore area into the coastal zone. The widespread nature of the offshore concentrations is apparent from the similarity in ozone histories at Ventura and Port Hueneme.

Inland, the early ozone peaks (12-13 PST) suggest that the air parcels originated in the coastal area and were transported to the inland stations. The extended nature of the peaks may have resulted from the relatively light winds on September 22. Note also (Sect. 4.3.5) the occurrence of high ozone values aloft in the late afternoon. These also may have contributed to the extended nature of the peaks.

Table 4.3.4

Regional Maximum Ozone Concentrations (pphm)

September 22, 1980

Location	Max O_3	Time of Max (PST)	Wind Direction at time of Max	Time of Max Temp (PST)
Pt. Conception	6	13	281°	09-11
Goleta	8	12-14	170	12
Platform Hondo	6	12-14	63-242	--
Ojai	10	12-15	325	12-13
Piru	11	13-16	265	12-14
Simi Valley	10	12-14	280	14-15
South Mt.	12	03	140	13-15
Thousand Oaks	9	14-15	285	13
Moorpark	7	14-17	M	M
El Rio	8	15-18	180	10-15
Ventura	8	16-17	270	10
Pt. Hueneme	7	18	280*	14*
Platform Grace	10	14-16	255	10
Background	7			

*Pt. Mugu

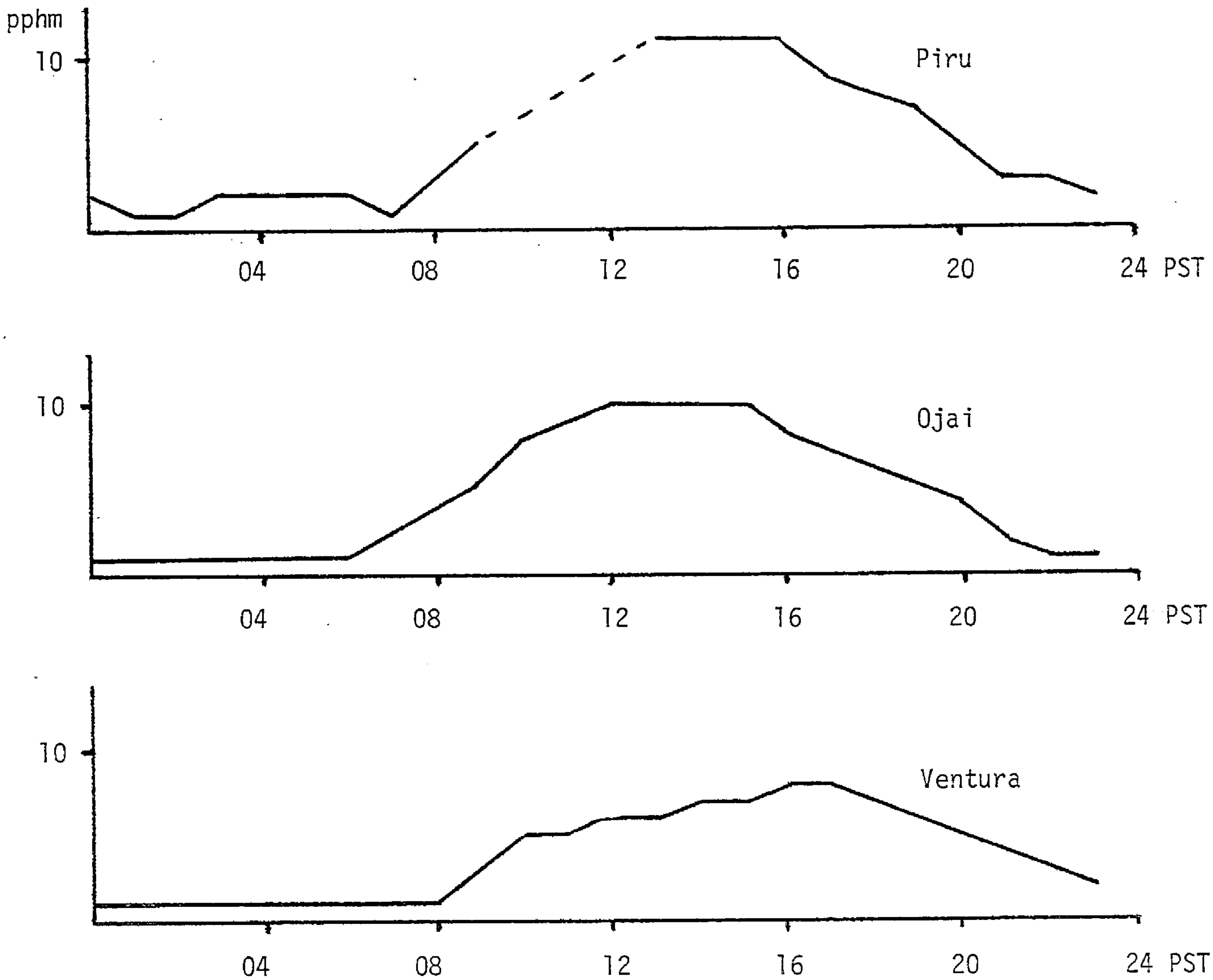


Fig. 4.3.2a HOURLY OZONE CONCENTRATIONS

September 22,1980

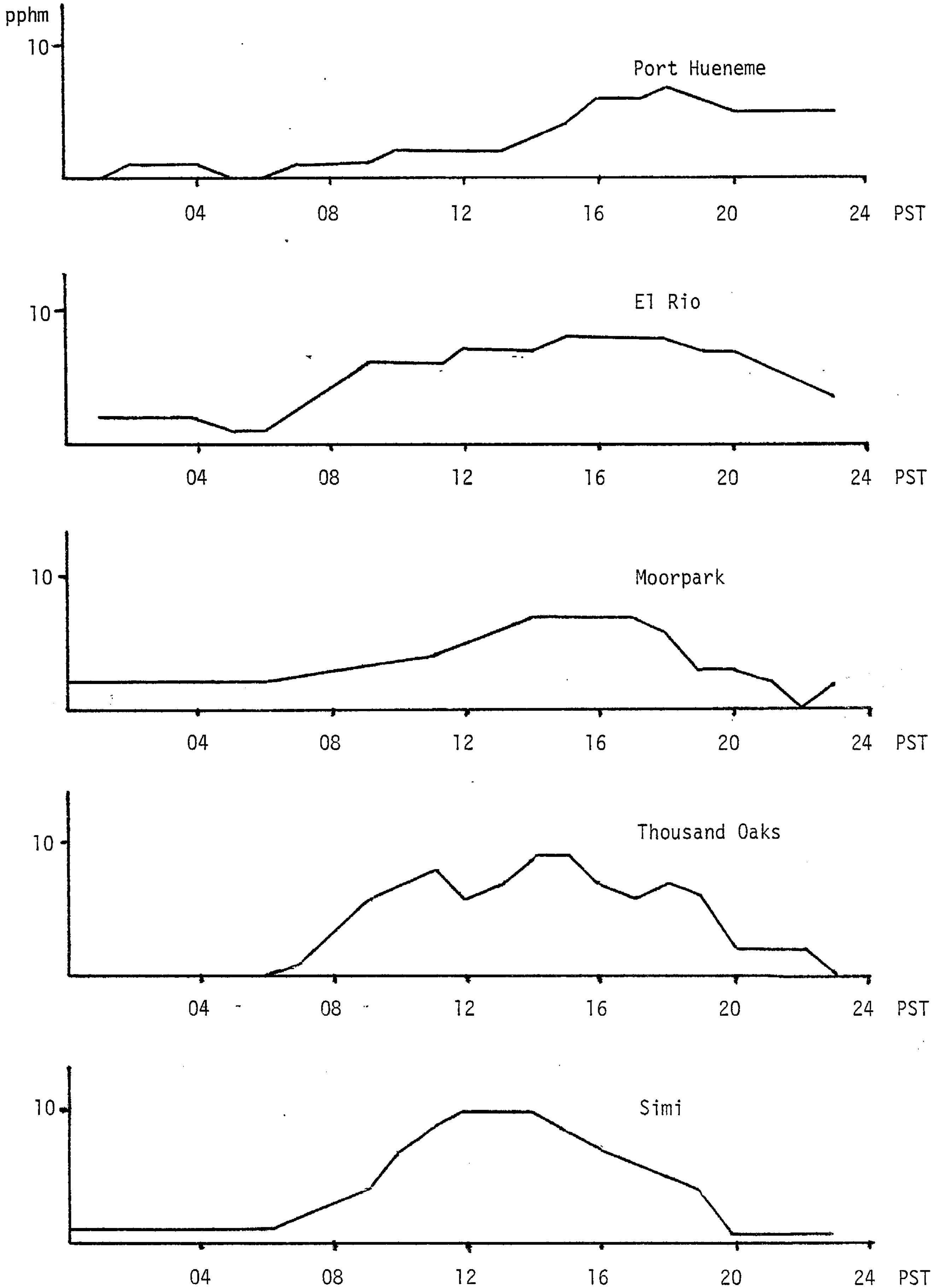


Fig. 4.3.2b HOURLY OZONE CONCENTRATIONS - September 22,1980

4.3.5 Aircraft Sampling

The aircraft sampling route on September 22 was quite similar to that described on September 17. Sampling took place primarily along the coast from Oxnard to Pt. Conception and in the coastal valleys near Santa Ynez, Ojai, Santa Paula and Simi. Ozone concentrations, however, were significantly greater than on September 17.

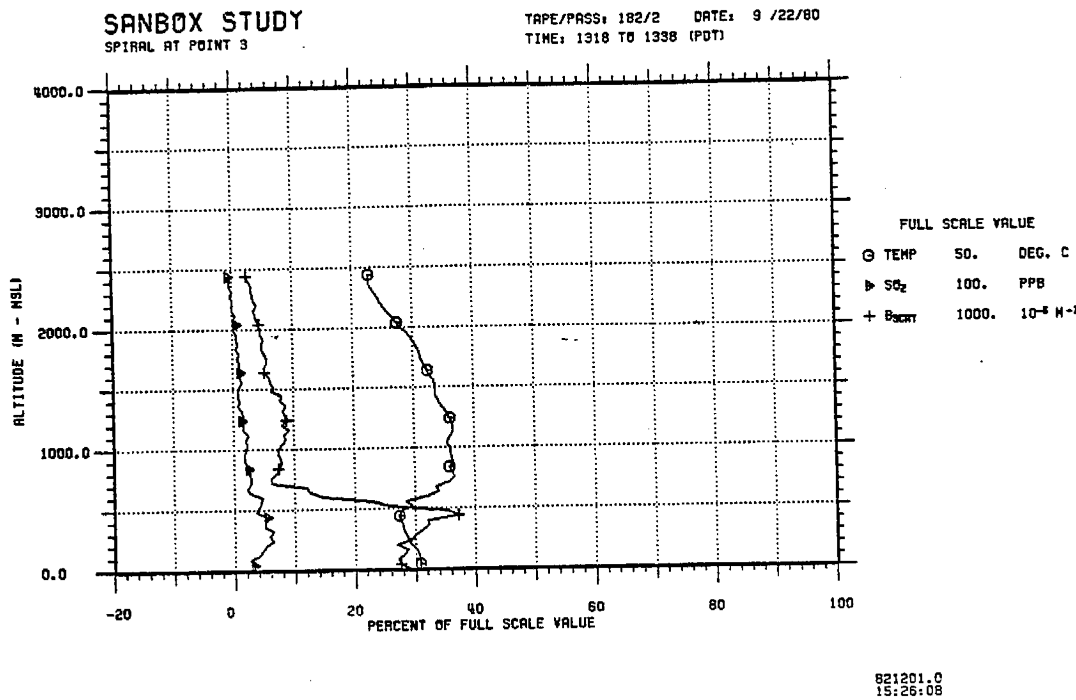
The first sounding on September 22 was made off Pt. Conception at 1318 PDT (Figure 4.3.3). There was a well-mixed layer in the lowest 500 m, characterized by a sharp temperature inversion and significant values of b_{scat}. Ozone concentrations, however, were only 6 pphm in the lower layer increasing to a peak of nearly 10 pphm above the inversion. At the top of the sounding ozone concentrations were 7 pphm, compared to 1-2 pphm at comparable levels on September 17. Upper winds offshore were light (estimated at 1 m/s) until 1430 PDT when westerly winds commenced.

Another sounding was made off Gaviota Pass at 1344 PDT (Figure 4.3.4). The sounding was quite similar to that observed at Pt. Conception but with a slightly shallower mixed layer. Ozone concentrations varied from 7-10 pphm throughout the sounding in a manner similar to the measurements made at Pt. Conception one-half hour earlier.

The aircraft sampled at Santa Ynez Airport beginning at 1412 PDT (Figure 4.3.5). A deep, mixed layer was present to about 1000 m-msl with a stable layer aloft. Ozone concentrations were slightly higher in the mixed layer but ranged from 7-8 pphm throughout the sounding.

The next sounding was made to the northeast of Lake Casitas, near Ojai at 1455 PDT (Figure 4.3.6). The temperature structure in the figure indicates a mixed layer to about 700 m-msl, an isothermal layer to 1100 m-msl with a strong inversion at higher levels. Ozone and b_{scat} values were slightly higher in the isothermal layer but ranged from 15-18 pphm to 1100 m-msl. Winds in the mixed layer were from the west-southwest but were from the east in the isothermal layer where highest ozone values were observed. Relative humidities to 1100 m-msl were considerably higher than on September 17.

A sounding was then made at Santa Paula Airport at 1512 PDT (Figure 4.3.7). The characteristics of the sounding were almost identical to those observed near Ojai. The height of the inversion was somewhat lower but highest ozone values (13 pphm) were present above the base of the inversion at 900 m-msl.



AIRCRAFT SOUNDING OFF PT. CONCEPTION

(1318 PDT)

September 22,1980

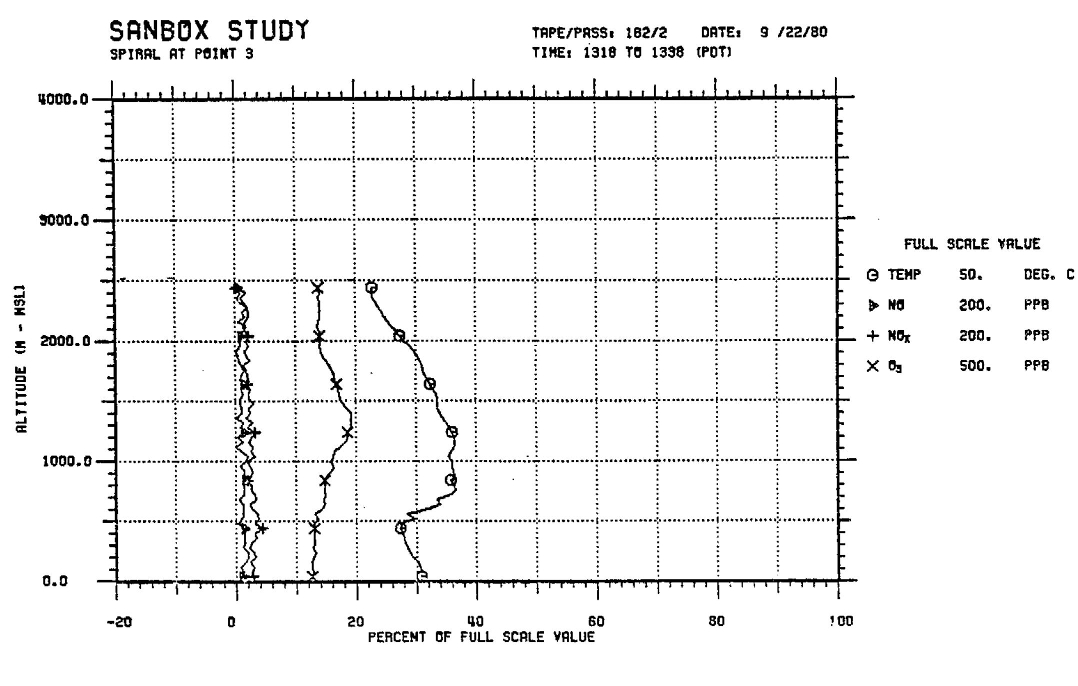
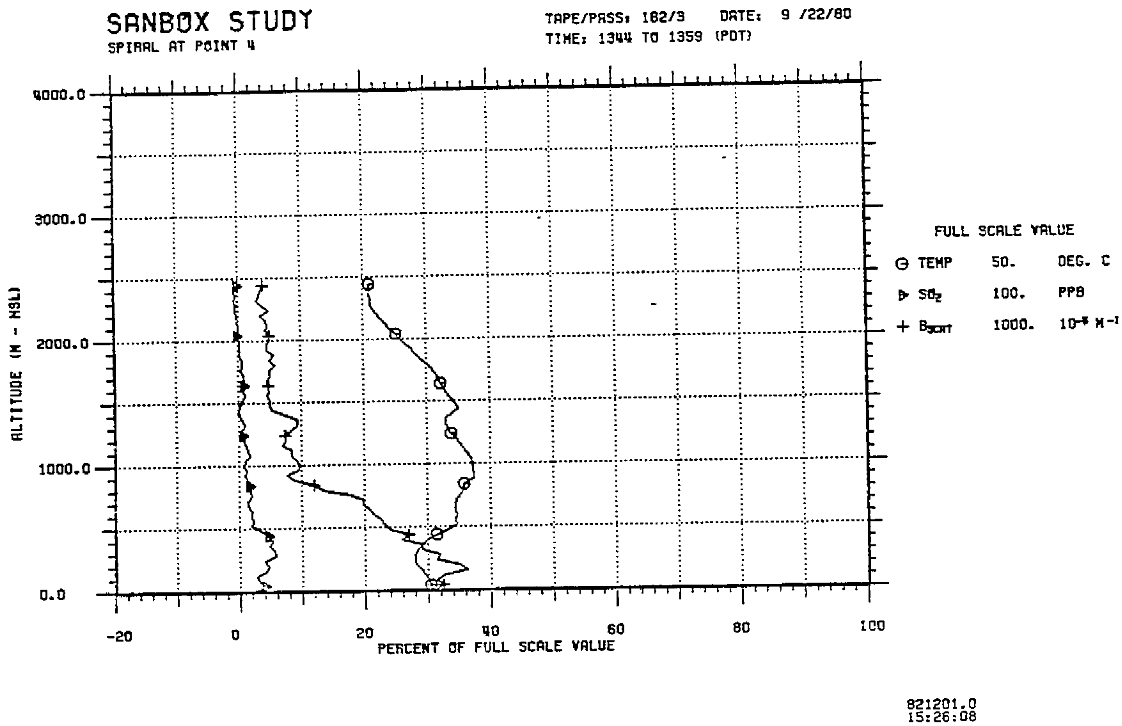


Fig. 4.3.3



AIRCRAFT SOUNDING OFF GAVIOTA

(1344 PDT)

September 22,1980

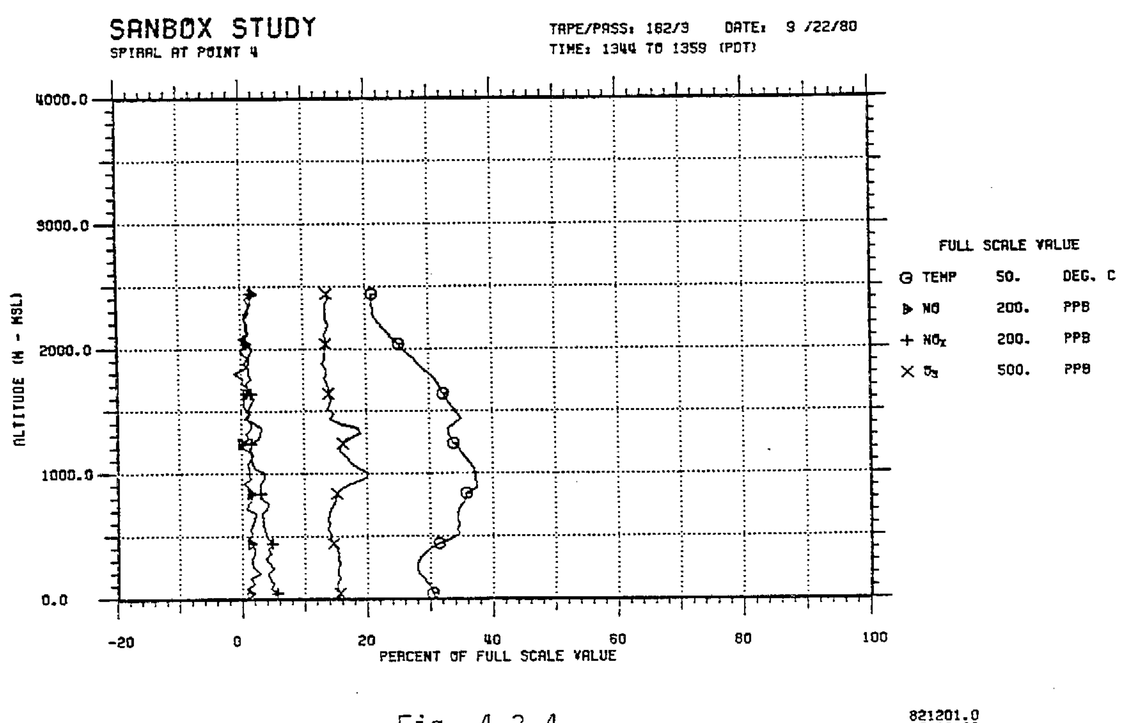
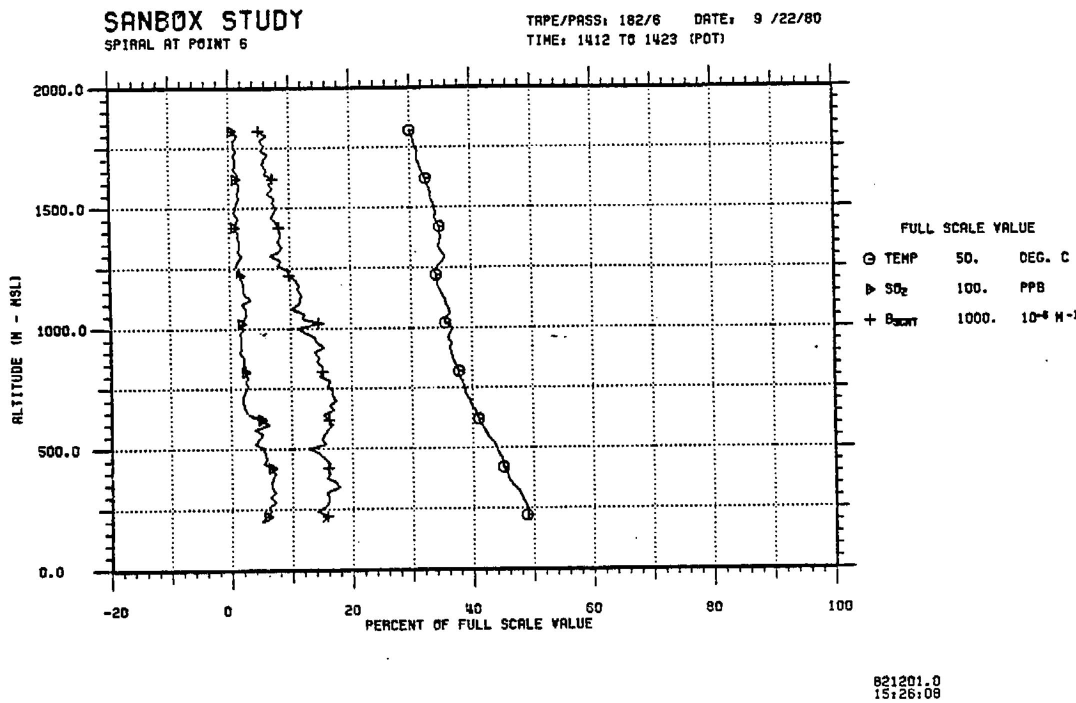


Fig. 4.3.4



AIRCRAFT SOUNDING AT SANTA YNEZ

(1412 PDT)

September 22,1980

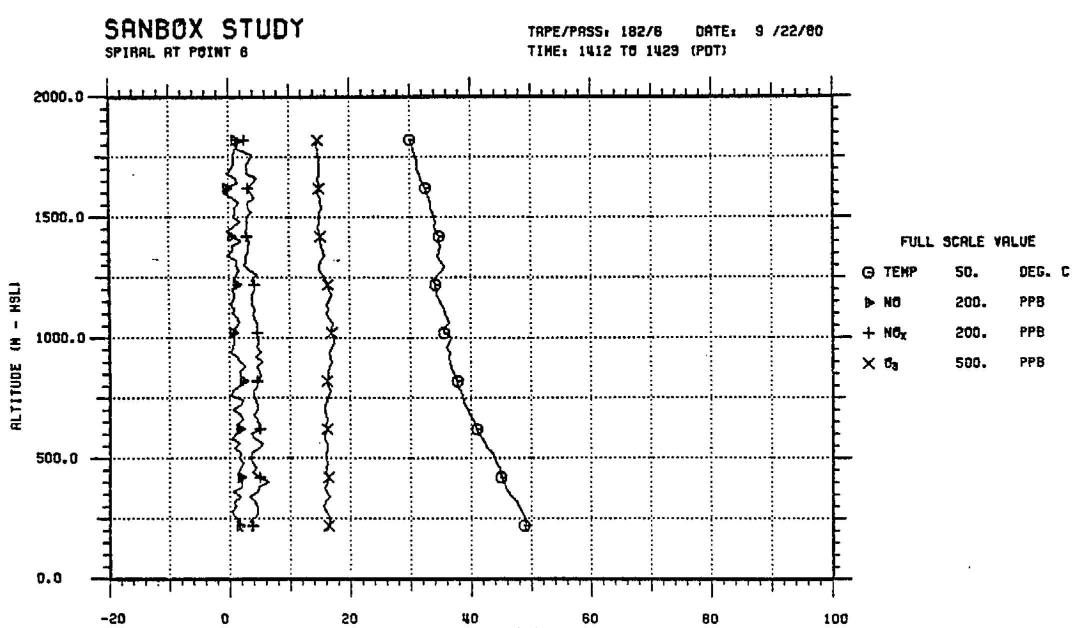


Fig. 4.3.5

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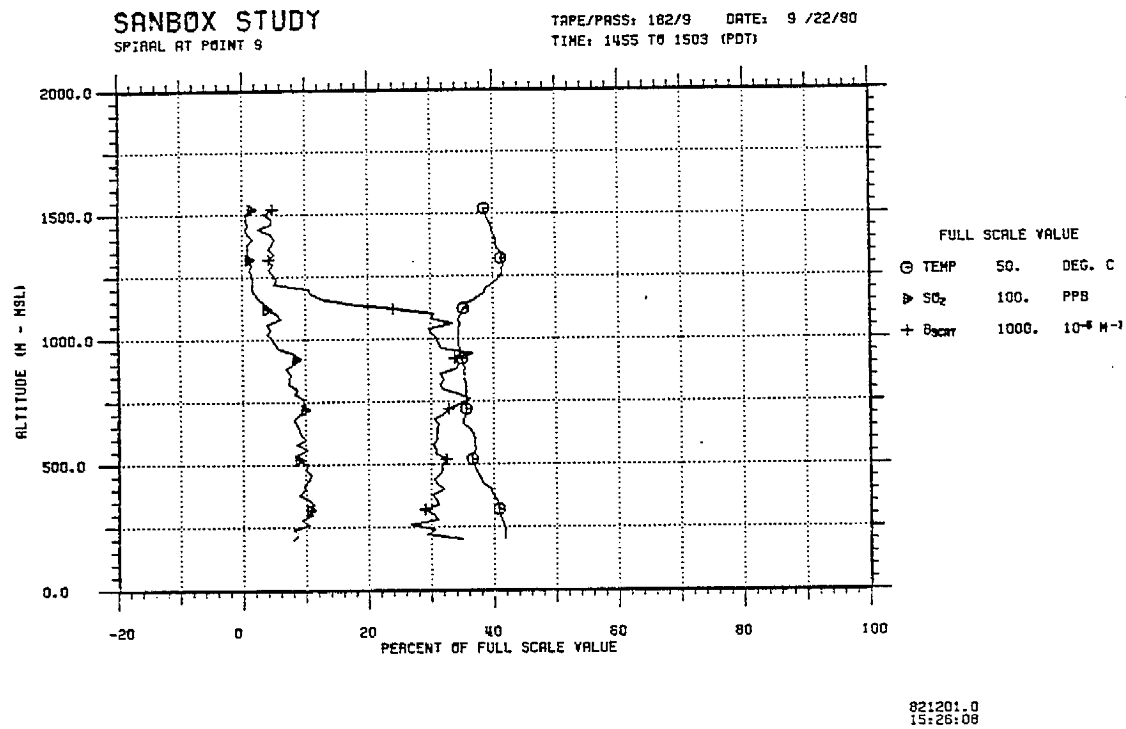
15:26:08



AIRCRAFT SOUNDING AT LAKE CASITAS

(1455 PDT)

September 22,1980

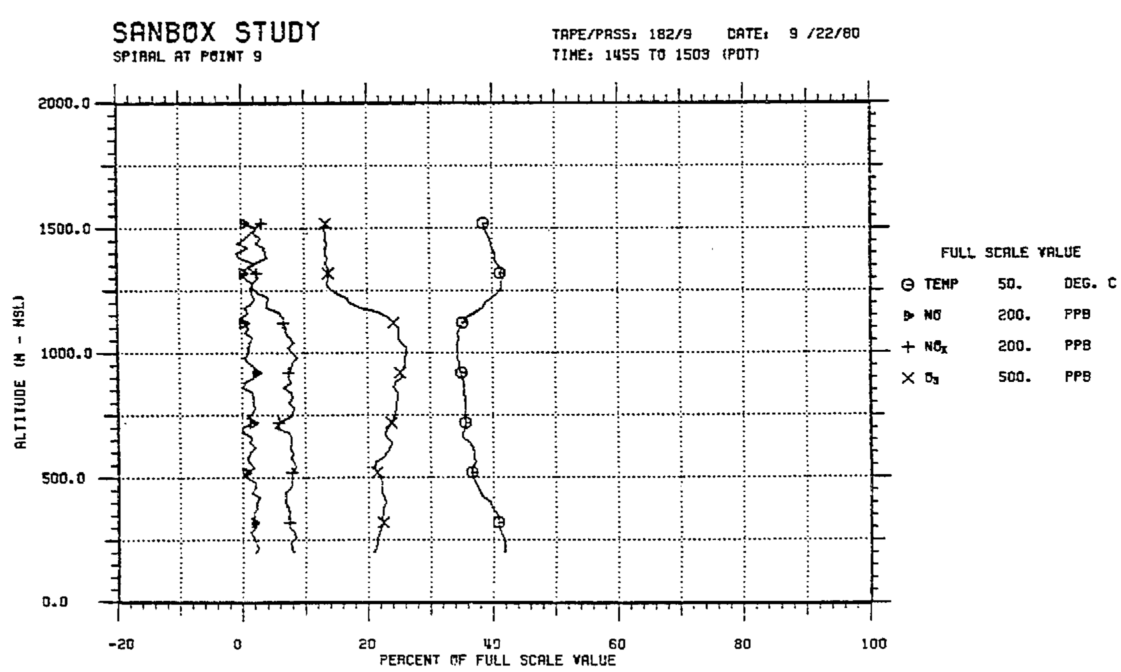


Fig. 4.3.6

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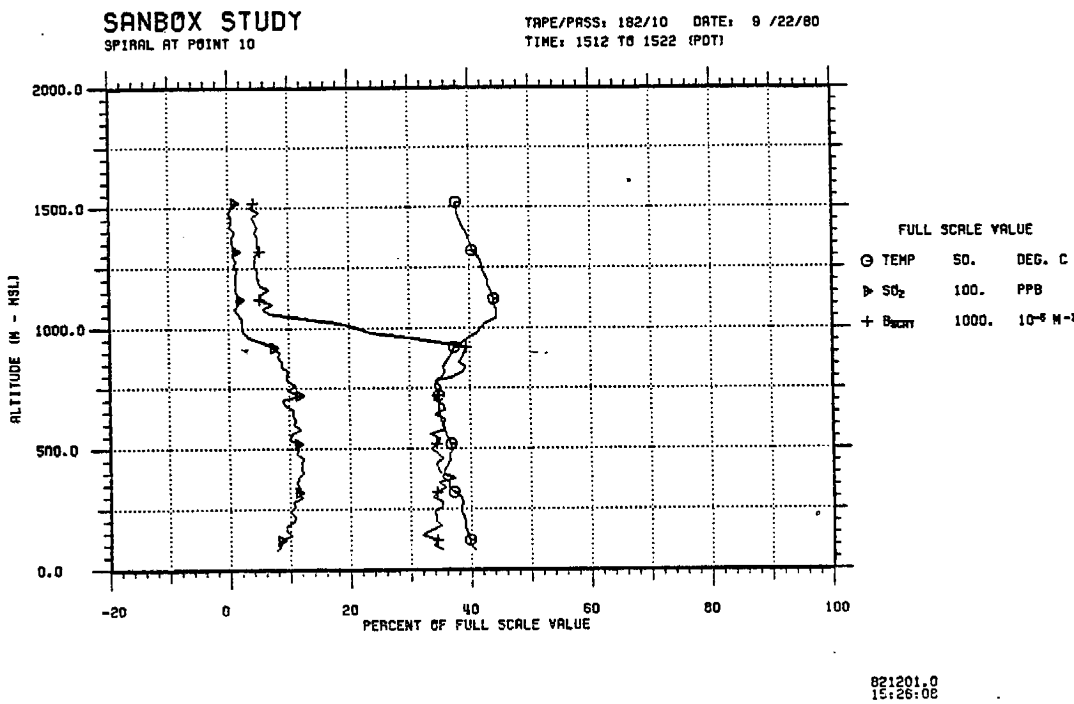


AIRCRAFT SOUNDING AT SANTA PAULA

(1512 PDT)

September 22,1980

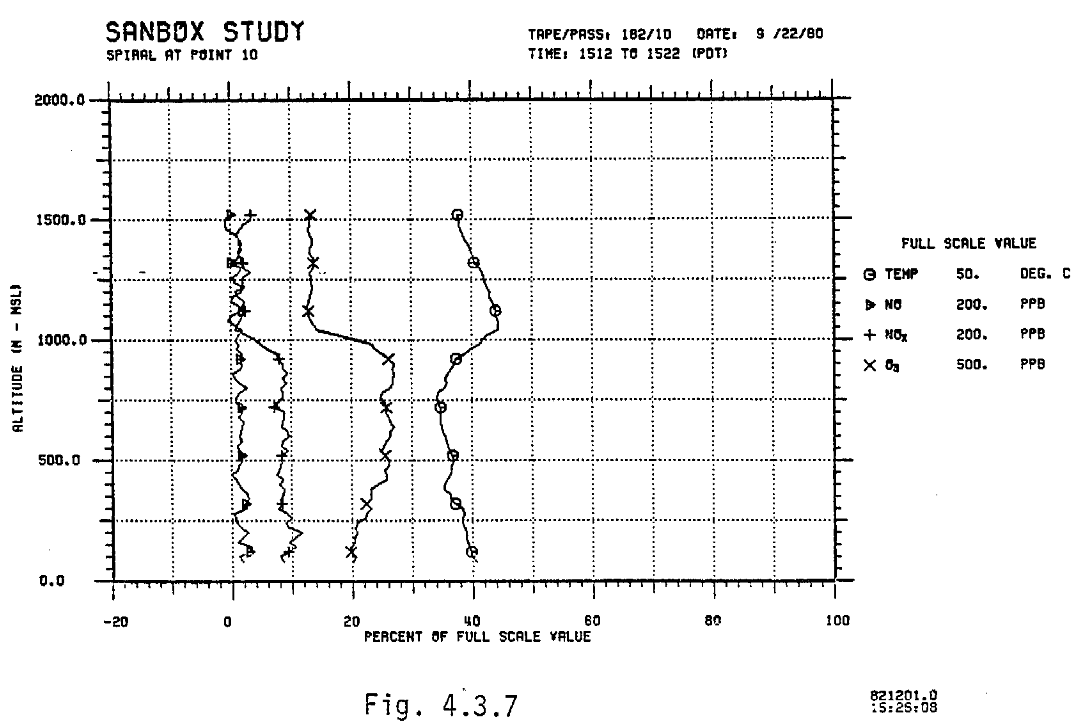
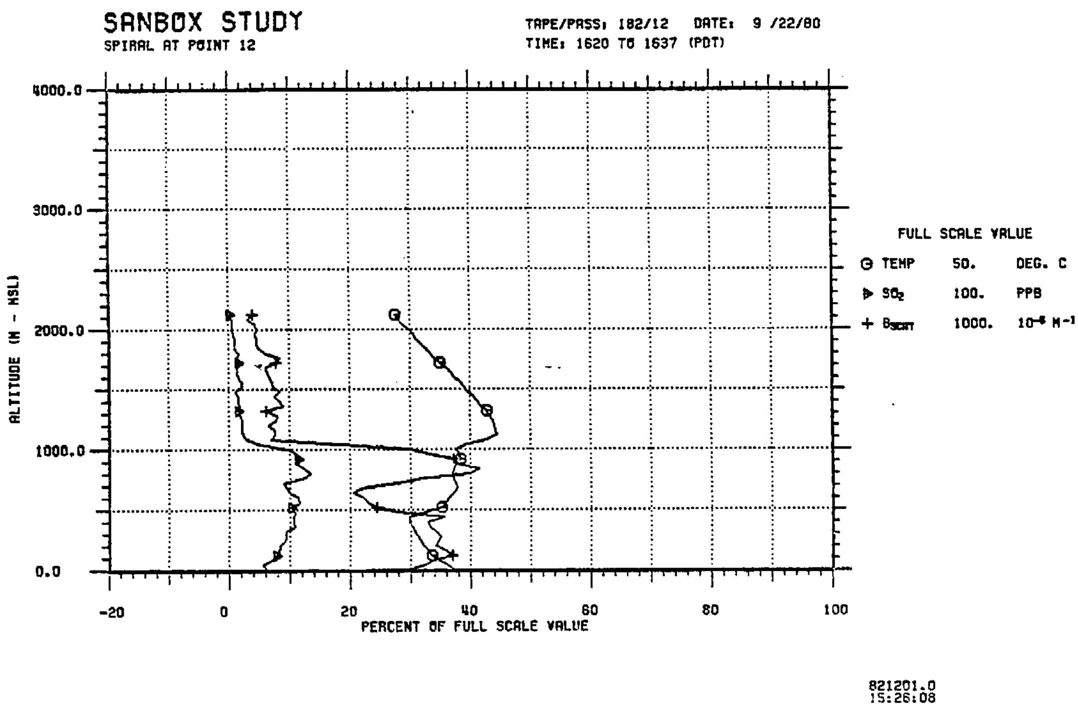


Fig. 4.3.7

A somewhat more complex temperature structure was present in the sounding at Oxnard Airport at 1620 PDT (Figure 4.3.8). The upper level inversion was observed at 1000 m-msl but a second strong inversion existed at 400 m-msl which represented the influx of sea air in the surface levels. Ozone values were 10 pphm in the low level, mixed layer but increased to 20 pphm near the base of the upper level inversion. Although there were no upper wind observations at Oxnard, winds at Simi and Ojai were from the east in this high ozone layer. The high ozone aloft was accompanied by substantial values of b_{scat}.

The sounding at Santa Susana Airport at 1652 PDT (Figure 4.3.9) was very similar to that observed at Oxnard. The upper level inversion was at 900 m-msl, somewhat lower than at Oxnard but the maximum ozone concentration (18 pphm) occurred within this inversion layer. Low-level ozone concentrations were reduced to about 10 pphm.

The final spiral on September 22 was made at 1741 PDT (Figure 4.3.10) over the water south of Santa Barbara. A temperature inversion was present at 400 m-msl with a much stronger inversion at 700 m-msl. Ozone values were 7 pphm for the lowest layer increasing to 9-11 pphm aloft.



AIRCRAFT SOUNDING AT OXNARD

(1620 PDT)

September 22,1980

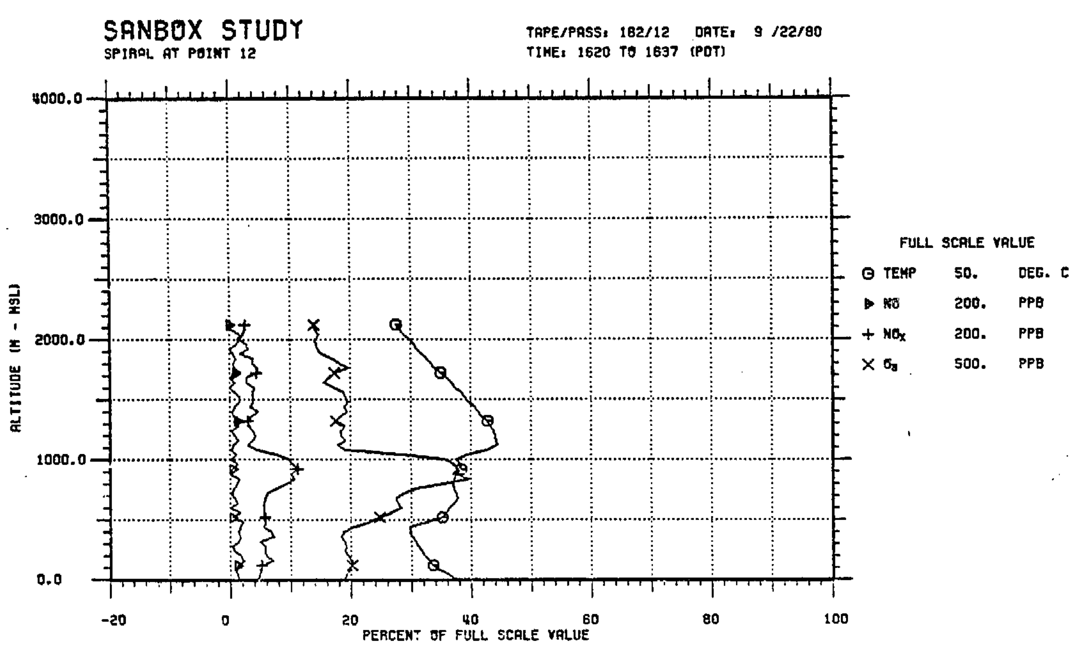
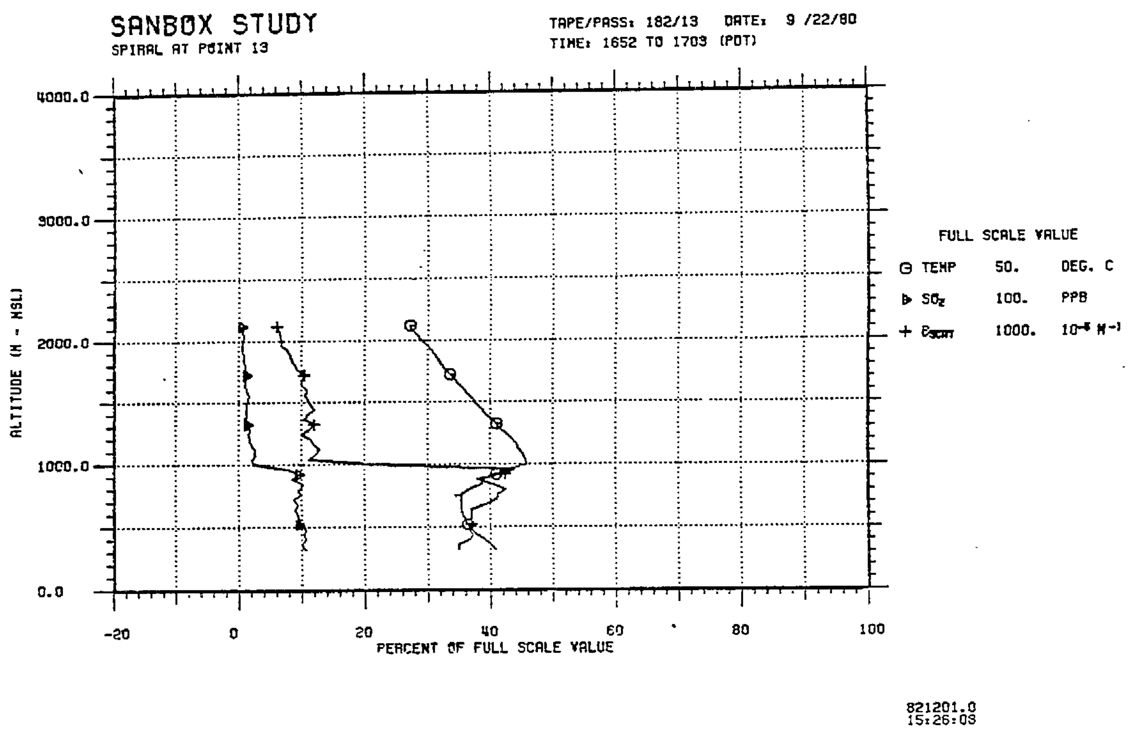


Fig. 4.3.8



AIRCRAFT SOUNDING AT SANTA SUSANA

(1652 PDT)

September 22,1980

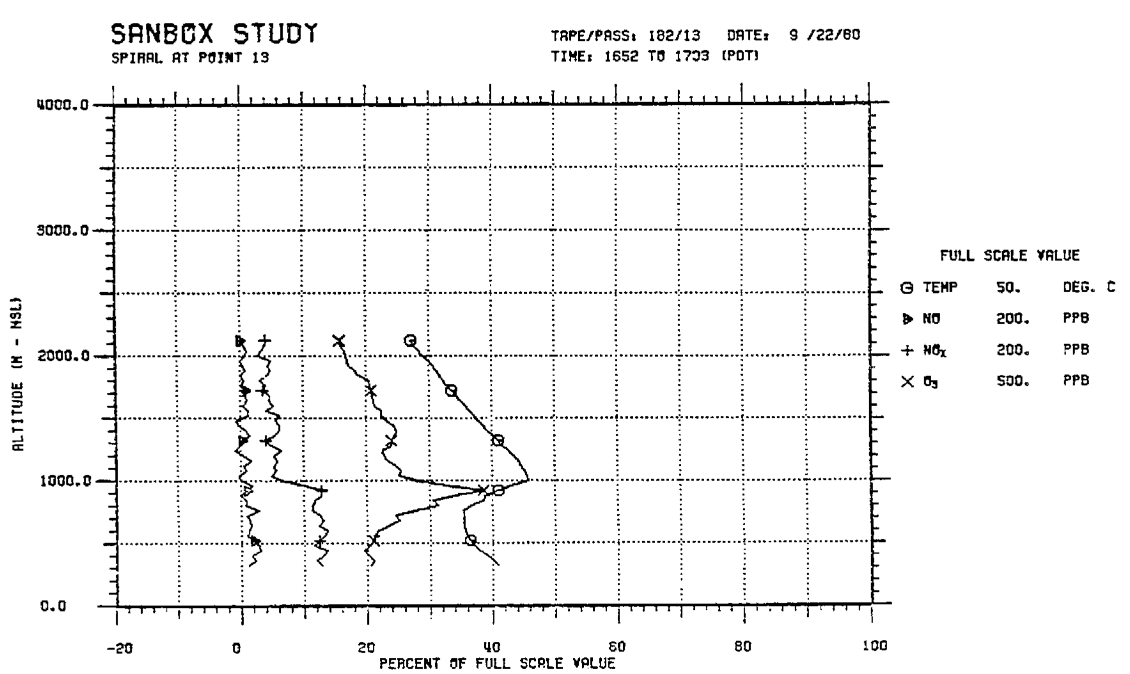
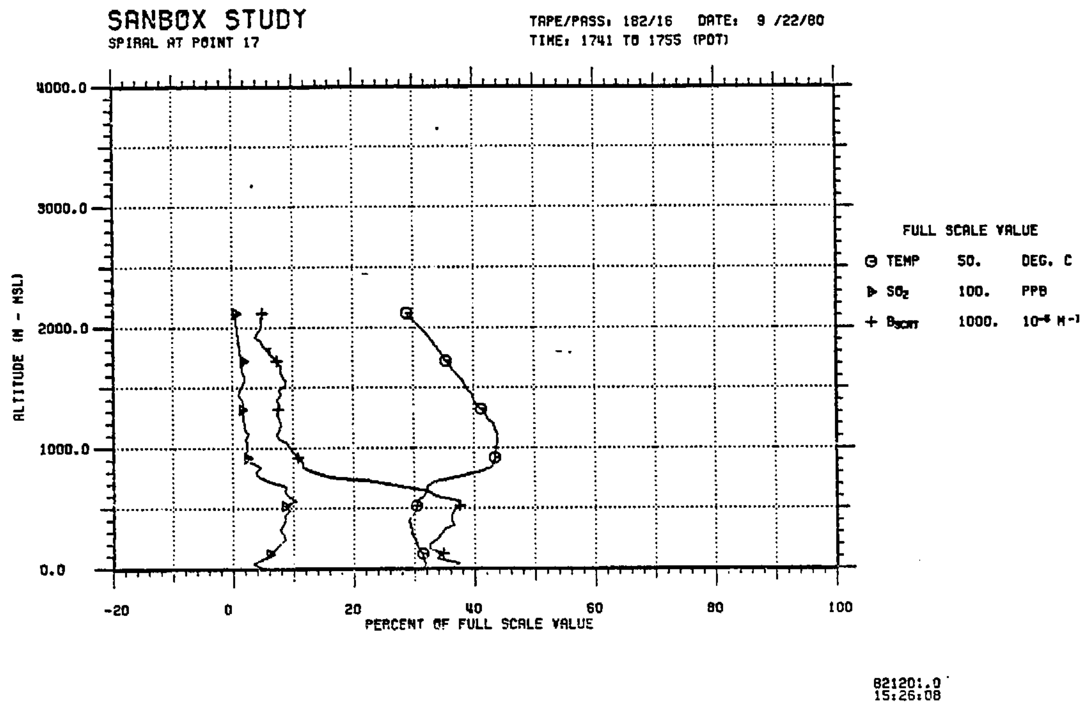


Fig. 4.3.9



AIRCRAFT SOUNDING OFF SANTA BARBARA

(1741 PDT)

September 22,1980

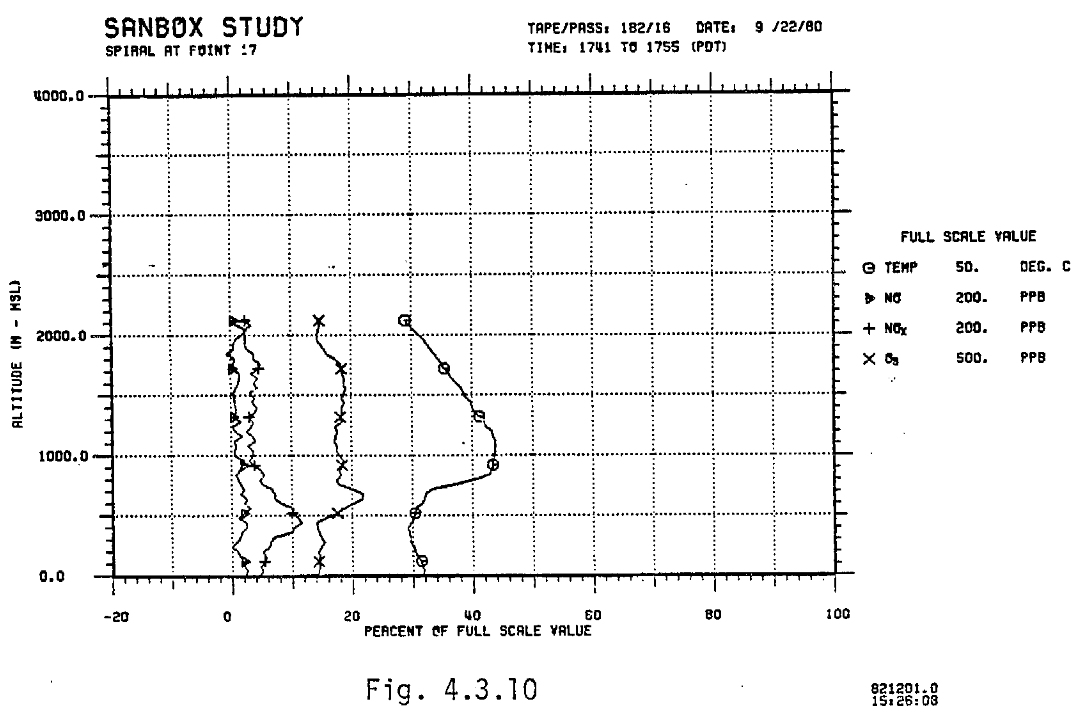


Fig. 4.3.10

4.3.6 Tracer Results - Test 2

Release Location: 3 mi South of Pt. Conception
Date: September 22, 1980
Time: 11-16 PDT
Release Rate: 8.83 g SF_6 per sec

The tracer material for Test 2 was released from a boat about 3 miles south of Pt. Conception. A kite system was used to measure the surface winds from the boat during the release. During the first three hours of the release the winds were light and variable, too light to support the kite and attached tether. During this period, surface winds at Platform Hondo were very light (less than 1 m/s) from the northeast. For the last two hours of the release, surface winds at the boat and at Platform Hondo shifted to a westerly direction and increased in velocity. Estimated winds, as observed on the boat, are given in Table 4.3.5.

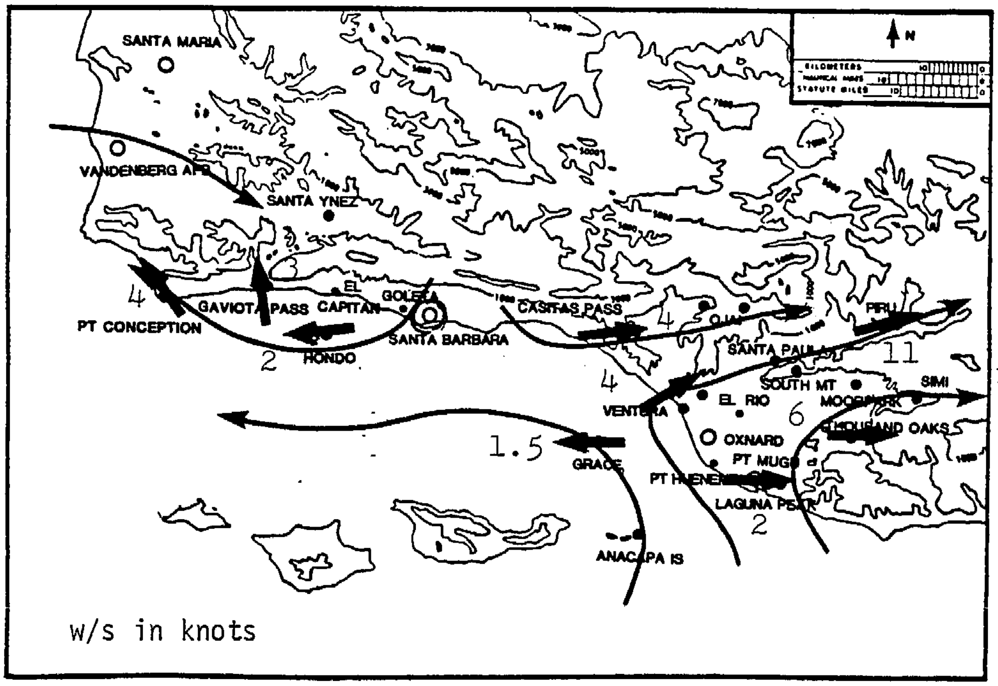
Table 4.3.5

Surface Winds - Release Boat
September 22, 1980

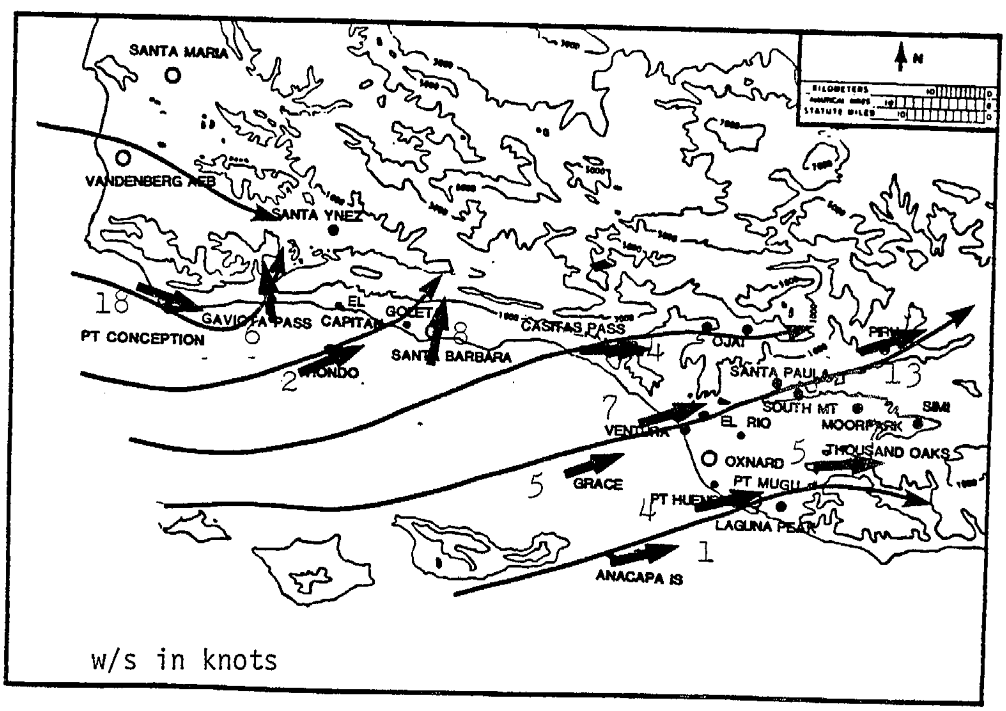
Time	Wind Direction	Wind Speed
11-14 PDT	---	est. 1 m/s
15	250°	4
16	295°	5.5

Streamline charts for September 22 are shown in Figures 4.3.11 and 4.3.12. At 10 PST surface winds throughout the channel were generally from the east including a southeast wind at Pt. Conception. By 14 PST the surface winds had shifted to westerly in the entire channel but with an indication of a small eddy between Pt. Conception and Gaviota. this pattern continued through 18 PST. By 22 PST, however, easterly winds prevailed along the coastline from Santa Barbara to Pt. Conception with onshore flow persisting in Ventura County.

The estimated tracer trajectories, based on these streamline charts and the observed tracer concentrations, are shown in Figure 4.3.13. One trajectory is estimated to have been associated with the lgiht easterly winds with tracer material moving slightly westward before being picked up in the westerly wind shift and carried eastward as far as Ventura County. From the times of observed SF_6 concentrations on the coast, the travel velocity of the tracer averaged about 2-3 m/s.

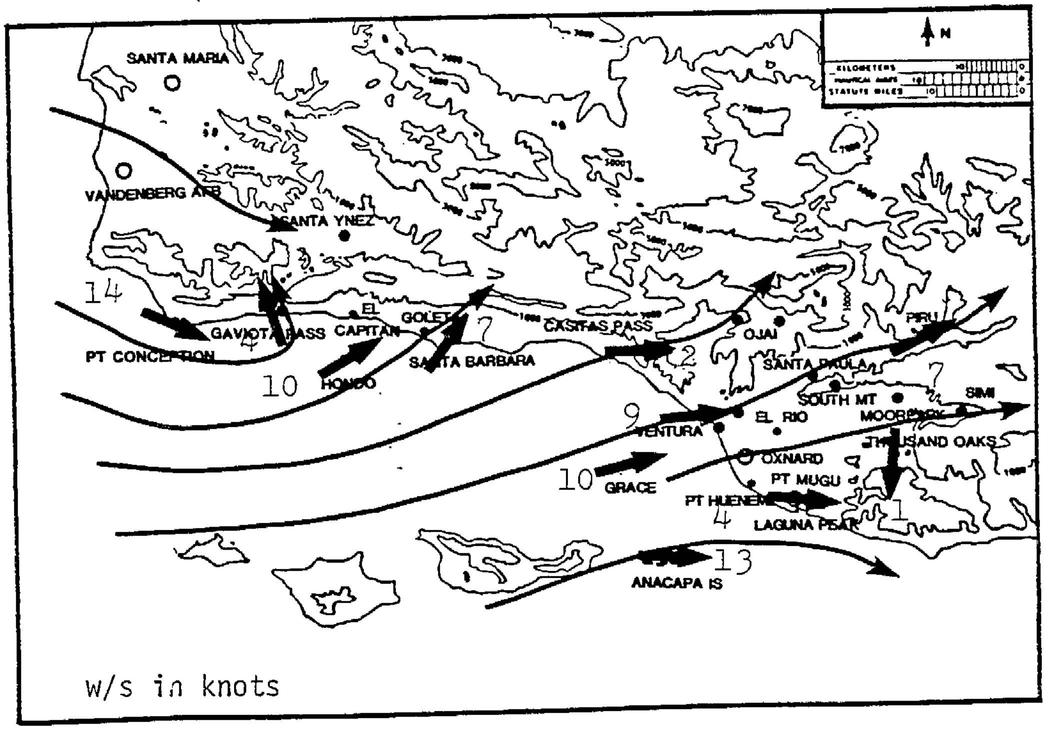


10 PST

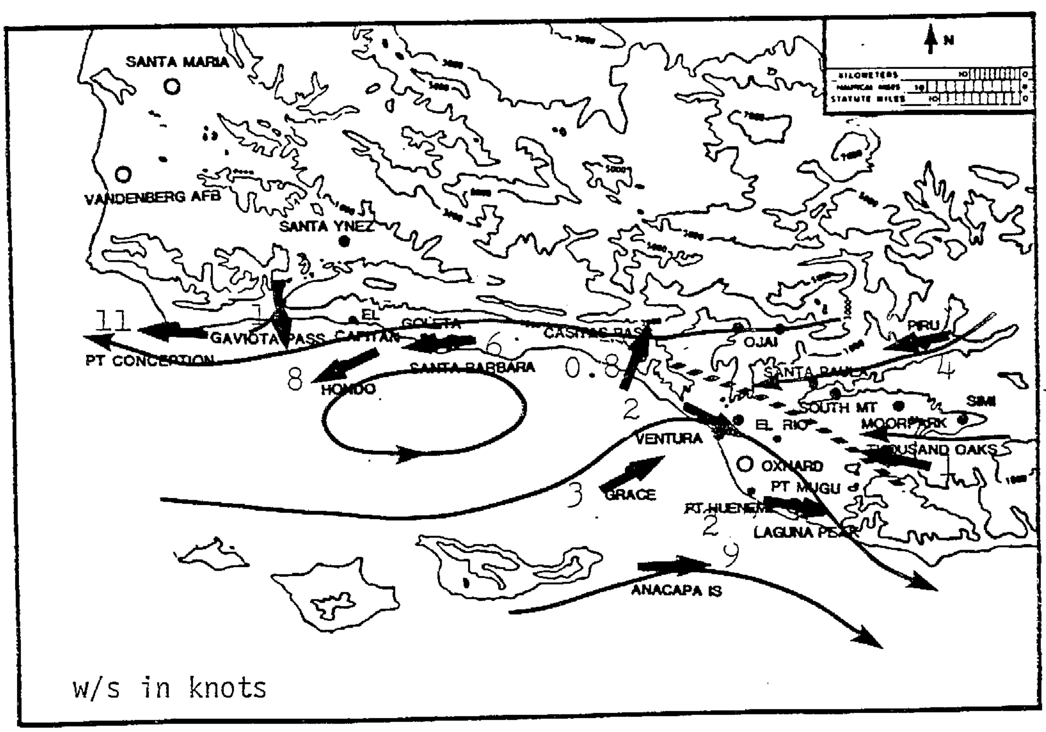


14 PST

Fig. 4.3.11 STREAMLINE CHARTS - September 22,1980



18 PST



22 PST

Fig. 4.3.12 STREAMLINE CHARTS - September 22,1980

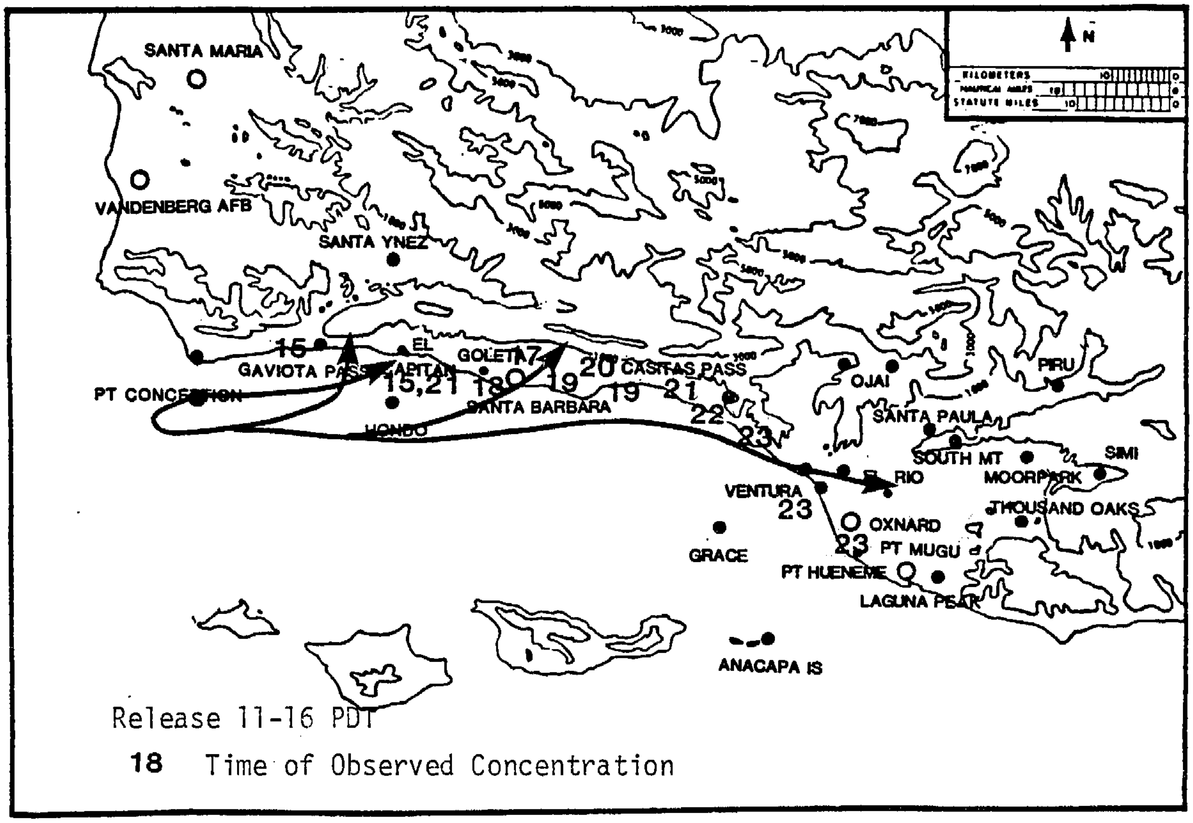


Fig. 4.3.13 ESTIMATED TRACER TRAJECTORIES

September 22,1980

The second tracer trajectory represents the material leaving the release point late in the release period after the wind shift to westerly had occurred. This material apparently impacted directly on the coast between Gaviota and Santa Barbara and moved eastward thereafter.

The tracer material arrived at the Ventura coast line about 23 PDT, much later than the peak ozone periods and too late to be carried into the inland valleys by the seabreeze flow. No tracer material was observed at Piru and peak concentrations in the inland areas of Ventura County were quite small.

Xu/Q values were computed for September 22 based on peak, observed concentrations and distances measured along the trajectories indicated in Figure 4.3.13. These Xu/Q values are given in Table 4.3.6.

Table 4.3.6
Calculated Xu/Q Values
Test 2 - September 22, 1980

Wind Speed	Location	Time	Type of Sample	Distance	Xu/Q ($x10^{-6}$)
2.5 m/s	Carpinteria	21 PDT	H	110 km	0.27 m^{-2}
	El Capitan	15	H	45	0.53
	El Capitan	21	H	60	0.33
	Gaviota	15	H	25	1.29
	Oxnard	23	H	140	0.05
	Santa Barbara	19	H	90	0.27
	Ventura	23	H	130	0.03
	W Santa Barbara	17	A	65	0.72
	Goleta	18	A	60	1.27
	Goleta	19	A	60	0.66
	Carpinteria	22	A	100	0.30
	Santa Barbara	20	A	90	0.42
	Santa Barbara	19	A	90	0.49

H - Hourly sample
A - Automobile sample

These values have been plotted in Figure 4.3.14 for comparison with the Pasquill stability categories. The highest Xu/Q values shown in the table correspond to those concentrations measured along the coast west of Santa Barbara between 15 and 18 PDT. As indicated in Figure 4.3.14 these corresponded to an E category. Xu/Q values for Ventura County locations were obtained from hourly observations only and might be expected to be lower relative to the automobile samples. As shown in the figure most of the hourly concentrations corresponded to Category D.

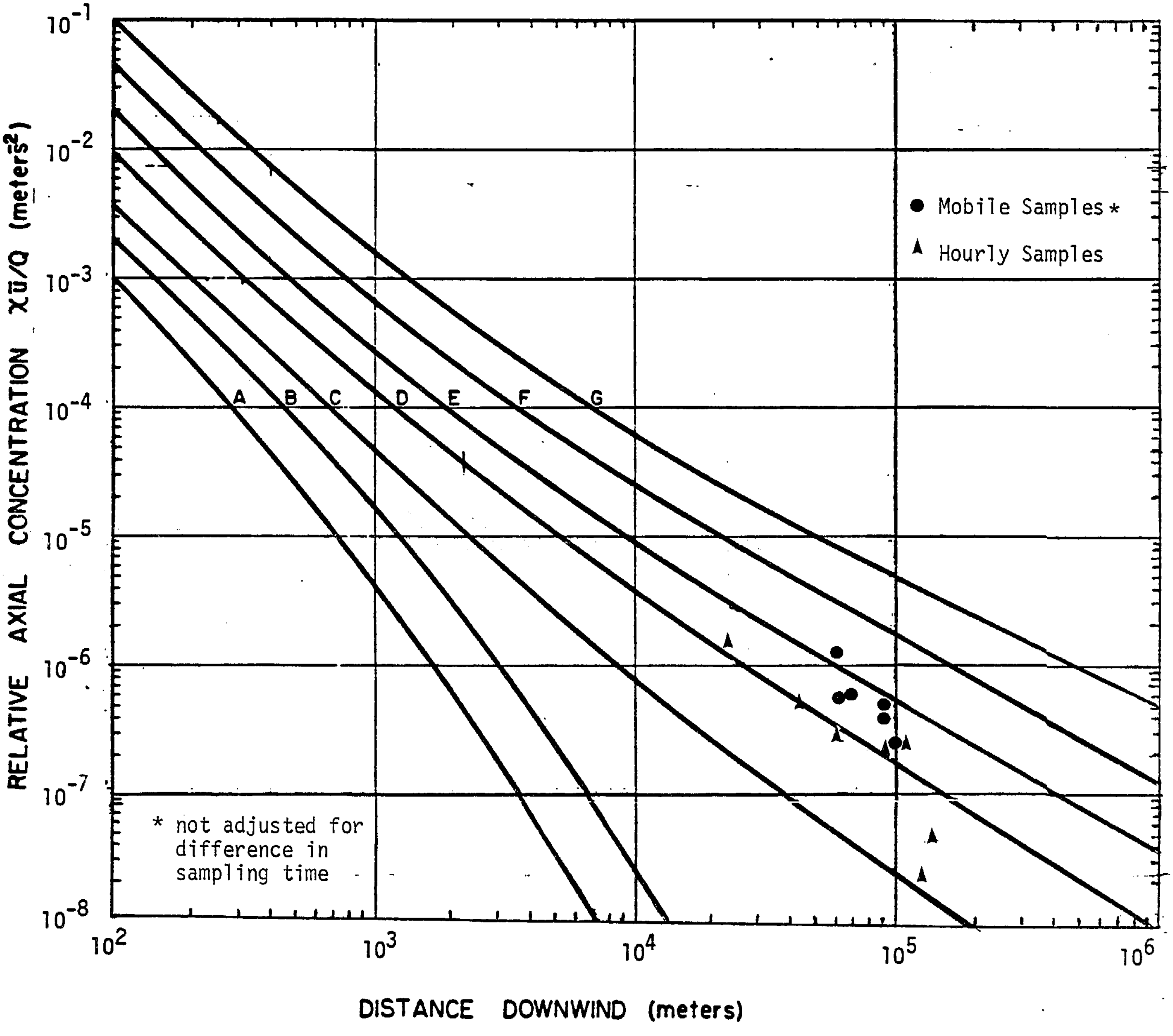


Fig. 4.3.14 XU/Q VALUES - Test 2
September 22,1980

Total SF_6 dosages were computed for the hourly observation stations and are given in Table 4.3.7.

Table 4.3.7

Total SF_6 Dosages
Test 2 - September 22, 1980

Location	Total Dosage	Number of hours $\geq$ 10 ppt
Santa Ynez	0	0
Gaviota	1438	15
El Capitan Beach	1805	18
Santa Barbara	596	5
Carpinteria	1069	15
Ventura	34	2
Santa Paula	20	1
Piru	0	0
Oxnard	89	5
Camarillo	11	1
Simi	11	1
Thousand Oaks	15	1

These dosages refer to the maximum 24-hour total observed at each station.

The principal short-term and long-term impacts were found in the Gaviota - El Capitan Beach area and as far east as Carpinteria. As discussed previously, the westerly flow which had prevailed during the afternoon along the Santa Barbara Coast, shifted to easterly by 20 PDT. Tracer material which had been carried eastward during the afternoon drifted westward again, resulting in long exposure times at several locations along the coast. At the same time, the flow reversal prevented substantial intrusions of material into the inland valleys of Ventura County as had occurred during Test 1 under substantially stronger wind conditions.

Figure 4.3.15 shows the locations of tracer material observed on the day after the release. Shaded areas represent observed concentrations of 10 ppt or more. Such concentrations were widespread on September 23, extending from the Santa Clara Valley northwestward along the Coast Highway to Gaviota. Highest SF_6 concentration measured on September 23 was 57 ppt near Carpinteria at about 10 PDT. Widespread occurrences of 15-25 ppt were noted. Since the BLM field program did not start until September 24, the carry-over observed on September 23 can be attributed primarily to the September 22 release.

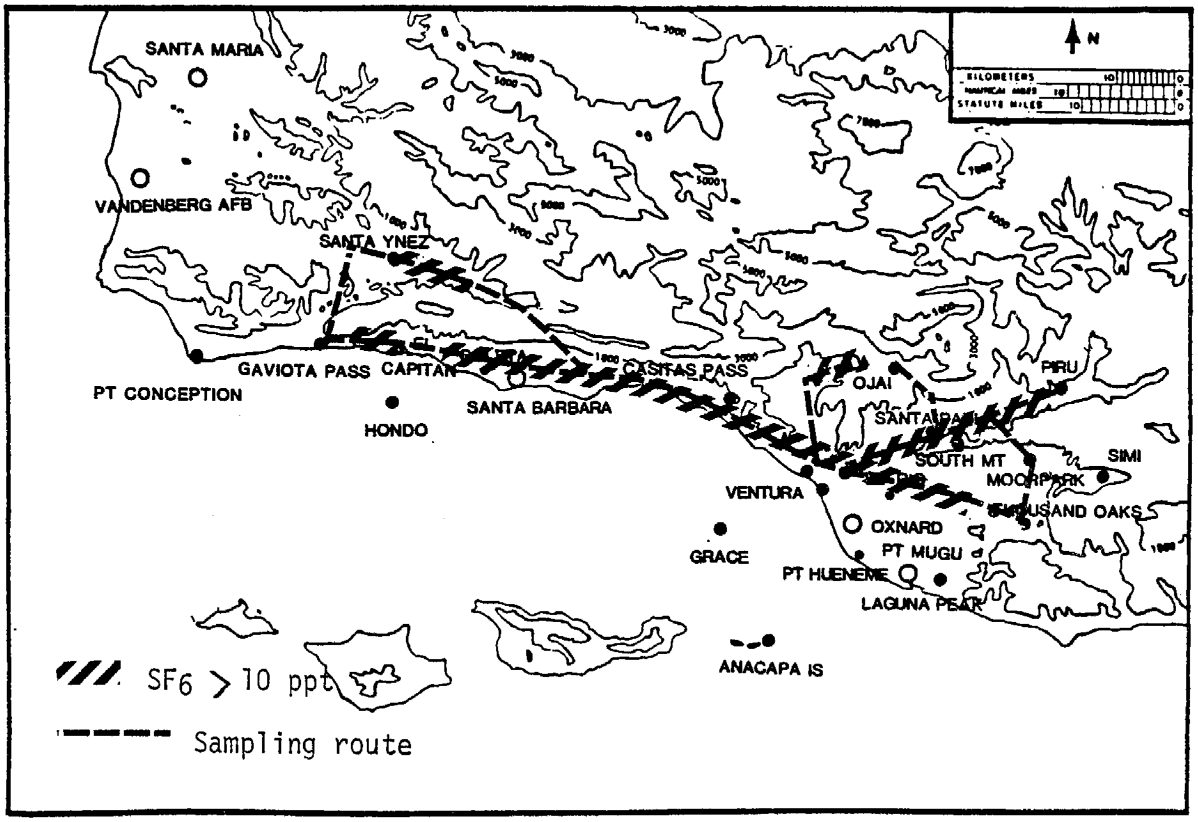


Fig. 4.3.15 LOCATIONS OF SF_6 CONCENTRATIONS - September 23,1980

(> 10 ppt)

4.4 Test 3 26 September 1980, Release from near Platform Hondo (0200-0700 PDT)

4.4.1 General Meteorology

The surface pressure field in the Southwest U.S. consisted of a weak thermal trough extending northward from Imperial Valley through central California (Figure 4.4.1). Relatively high pressure was present at 500 mb with the primary low pressure troughs well to the east and to the northwest. Cloud conditions over the channel and the coast were scattered to overcast throughout the day with ceilings of 300-900 ft. Visibilities were restricted to 1-5 miles in fog and haze.

Meteorological parameters for September 26 are given in Table 4.4.1.

Table 4.4.1

Meteorological Parameters

September 26, 1980

850 mb Temperature (Vandenberg AFB)	21°C
Pressure Gradients (07 PST)	
LAX-Bakersfield	1.8mb
Santa Barbara-Daggett	0.2
Inversion Base (15 PST)	
Pt. Mugu	262m
Maximum Surface Temperatures	
Thousand Oaks	75°F
Piru	83
Santa Barbara	66

By September 26 the temperature at 850 mb had warmed back to 21°C, the same as observed on September 17. Pressure gradients toward the inland areas, however, were slightly higher. Maximum surface temperatures inland were intermediate between September 17 and 22 and were somewhat cooler than might be expected in view of the temperatures aloft.

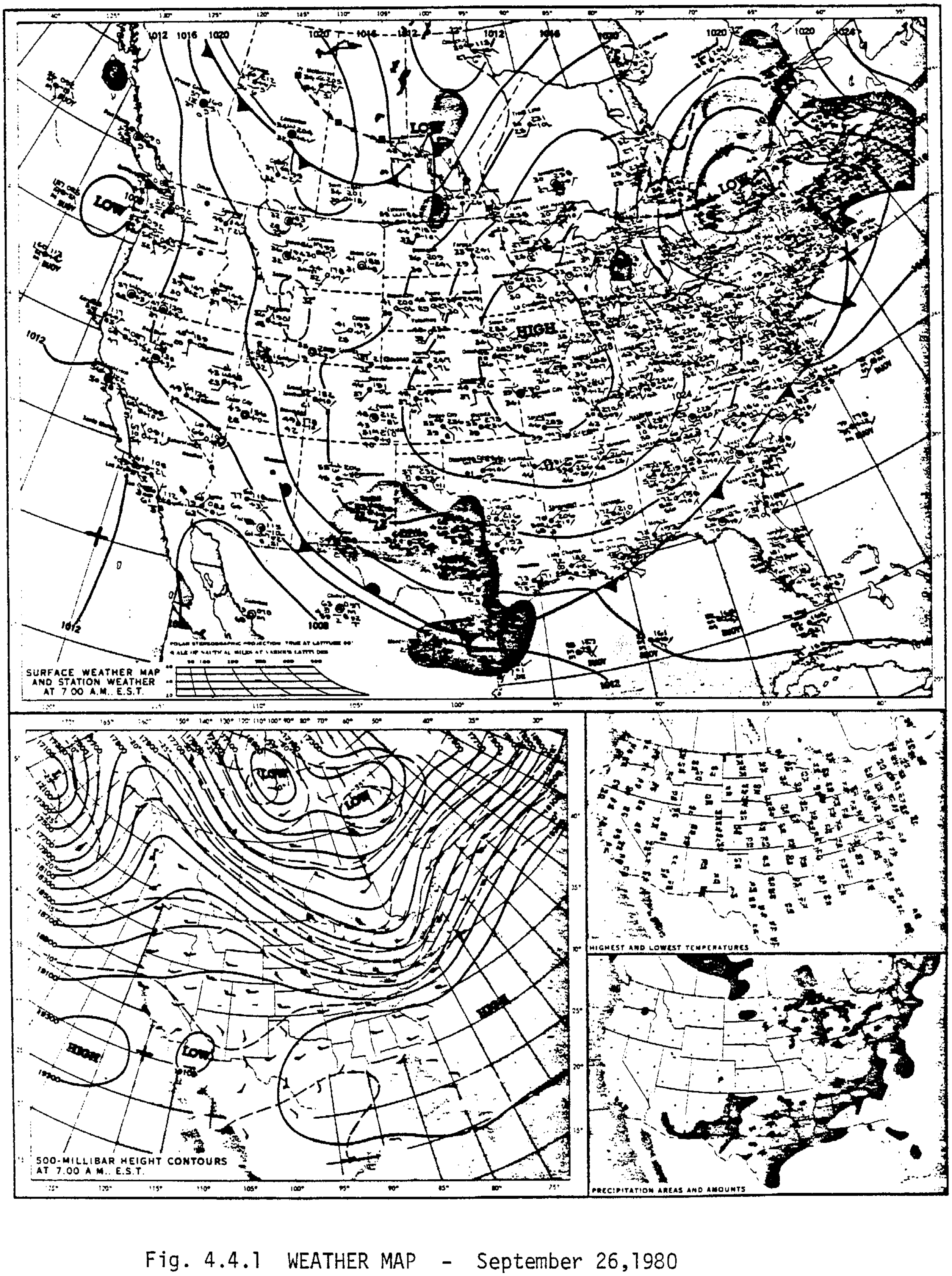


Fig. 4.4.1 WEATHER MAP - September 26,1980

4.4.2 Transport Winds

Transport winds in the area (Table 4.4.2) were characterized by several hours of moderately strong winds at Pt. Conception during midday. By 18 PST the wind at Pt. Conception had shifted to a northerly direction. At Hondo and Santa Barbara characteristic wind shifts from easterly to southwesterly occurred during the afternoon but with relatively light velocities during the evening. To the east, at Platform Grace and Ventura, the typical seabreeze flow was evident. Wind directions at Platform Grace were west to southwest except for a shift to a more southerly direction in the late forenoon.

4.4.3 Mixing Heights

Mixing heights, as defined by the pibals in Table 4.4.3 were relatively low in the inland areas and comparable to the heights of the low layers in Test 2. The aircraft flight was made in the early morning so that observed mixing heights reflect the presence of surface inversions.

Table 4.4.2

Transport Winds - Test 3

September 26, 1980

Time PST	Pt. Conception		Hondo		Santa Barbara		Grace		Ventura Surfers Point	
	w/d	w/s	w/d	w/s	w/d	w/s	w/d	w/s	w/d	w/s
02	026°	4.8 m/s	072°	1.8 m/s	060°	3.1 m/s	325°	1.3 m/s	035°	1.2 m/s
04	016	5.0	080	1.8	050	3.6	258	2.6	350	1.0
06	268	3.9	020	0.4	050	2.6	277	3.8	355	1.7
08	269	4.9	270	0.9		Calm	241	3.7	285	2.6
10	281	5.3	196	0.9	130	3.6	189	4.0	255	2.9
12	289	13.7	138	0.9	130	5.7	200	2.7	255	5.8
14	288	15.2	192	0.4	210	4.1	251	4.7	245	4.7
16	302	7.9	256	3.1	210	2.6	250	6.1	275	6.2
18	009	6.6	267	5.4		Calm	252	7.3	270	3.7
20	010	4.6	350	0.4		Calm	240	6.9	045	1.0
22	002	5.6	042	0.4		Calm	236	6.0	085	0.6
24	011	8.2	093	1.8		Calm	246	5.0	070	1.0

Table 4.4.3

Mixing Heights

September 26, 1980

1. Measured by Sampling Aircraft

Time	Location	Height*
0727 PDT	Santa Susana Airport	100m
0812	Near Ojai (upper layer to 600m)	100
0830	Fillmore (upper layer to 700m)	100

2. Measured by Pibals

Time	Santa Ynez	Ojai	Simi
09 PDT	---	159m	159m
11	263m	159	159
13	466	---	263
15	365	365	365
17	365	365	263
19	365	159	159

3. Measured by MRI Acounstic Sounder

Santa Paula Airport	Height
11 PDT	290m
13	180
15	170
17	180
19	100
21	70

* Heights are above surface

4.4.4 Regional Ozone Concentrations

Maximum ozone concentrations for September 26 are given in Table 4.4.4 for a number of locations in the area. In accordance with the increased temperatures aloft, maximum surface ozone concentrations in the area increased significantly. Peak hourly values at Ojai, Piru, Simi Valley, South Mt., Thousand Oaks and Moorpark all exceeded the state standard. Background ozone concentrations, as measured by the aircraft, were 5 pphm and near average for rural areas. Shallow, mixed layers in the inland areas also contributed to the increased peak ozone concentrations.

Time histories of the hourly ozone concentrations for several locations are shown in Figure 4.4.2. Peak concentrations occurred at 13 and 14 PST at Simi and Piru, respectively, but somewhat later at Ojai (15-16 PST). Maximum temperatures at Ojai and Piru occurred some two hours before the peak ozone arrived, suggesting the possible arrival of marine air. At Simi the maximum temperature occurred somewhat after the peak ozone.

As shown in Figure 4.4.2 the hourly ozone concentration at Ventura peaked at 16-17 PST, in agreement with the previous tests. Platform Grace recorded a peak at 15 PST. Winds at the two locations were southwest to west as in the previous tests. Onshore flow is again indicated as a probable source of the peak concentrations along the coast.

The stations in and to the east of the Oxnard Plain exhibited normal diurnal ozone patterns, suggesting the effects of sources in the coastal region. For Piru, Ojai and Ventura ozone transport from offshore had a significant effect

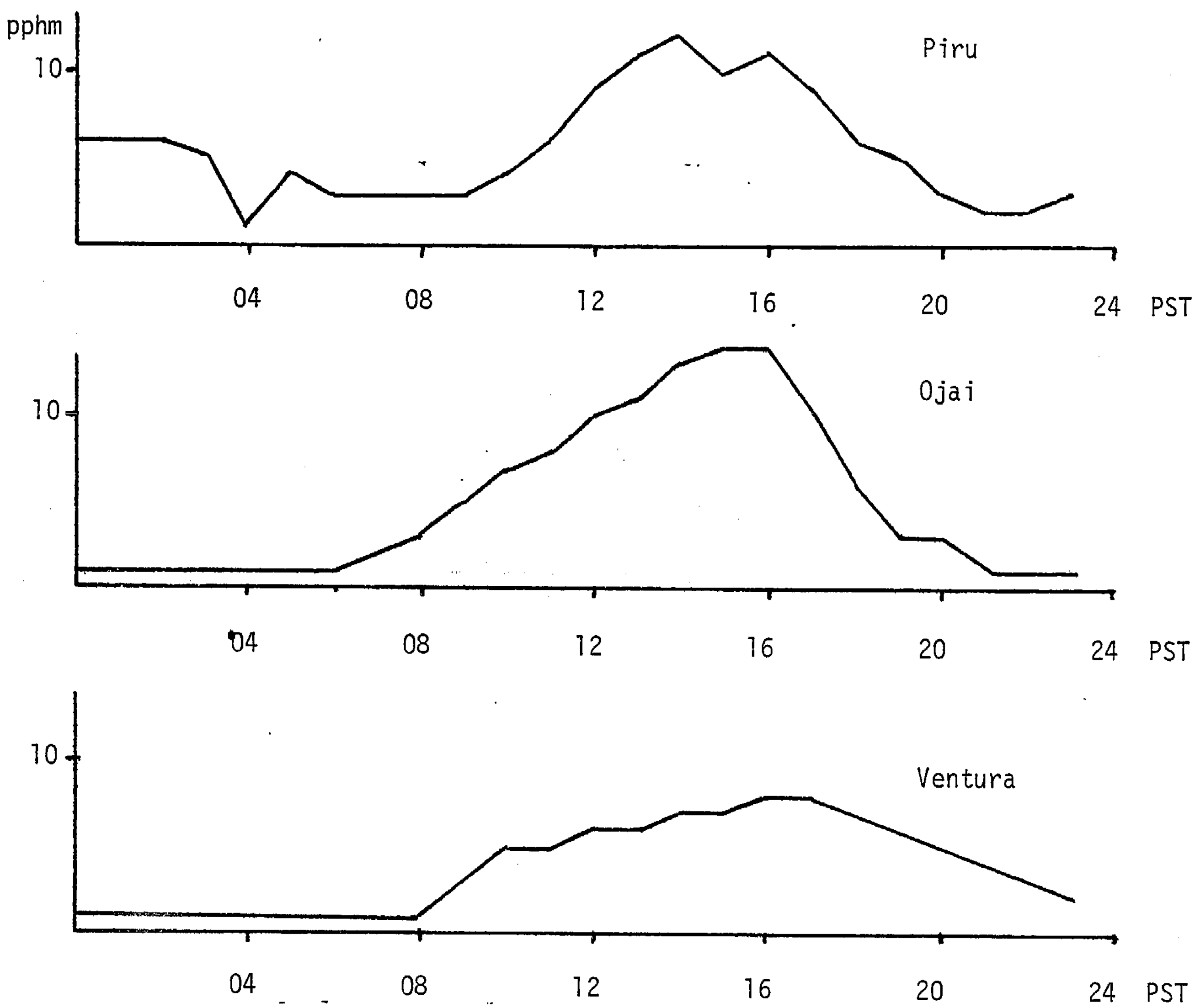
Table 4.4.4

Regional Maximum Ozone Concentrations (pphm)

September 26, 1980

Location	Max O_3	Time of Max (PST)	Wind Direction at Time of Max	Time of Max Temp (PST)
Pt. Conception	4	05-23	280°	20
Goleta	6	14-15	235	14
Platform Hondo	6	13	161	
Ojai	14	15-16	110,300	13
Piru	16	15	225	13
Simi Valley	15	13	280	16
South Mt.	14	11	180	08-09
Thousand Oaks	11	12-13	310	14
Moorpark	12	12	M	M
El Rio	6	10-14,17	M	M
Ventura	6	17	270	11-13
Pt. Hueneme	6	16-17	300*	12*
Platform Grace	7	15	244	23
Background	5			

*Pt. Mugu



HOURLY OZONE CONCENTRATIONS - September 26,1980

Fig. 4.4.2a

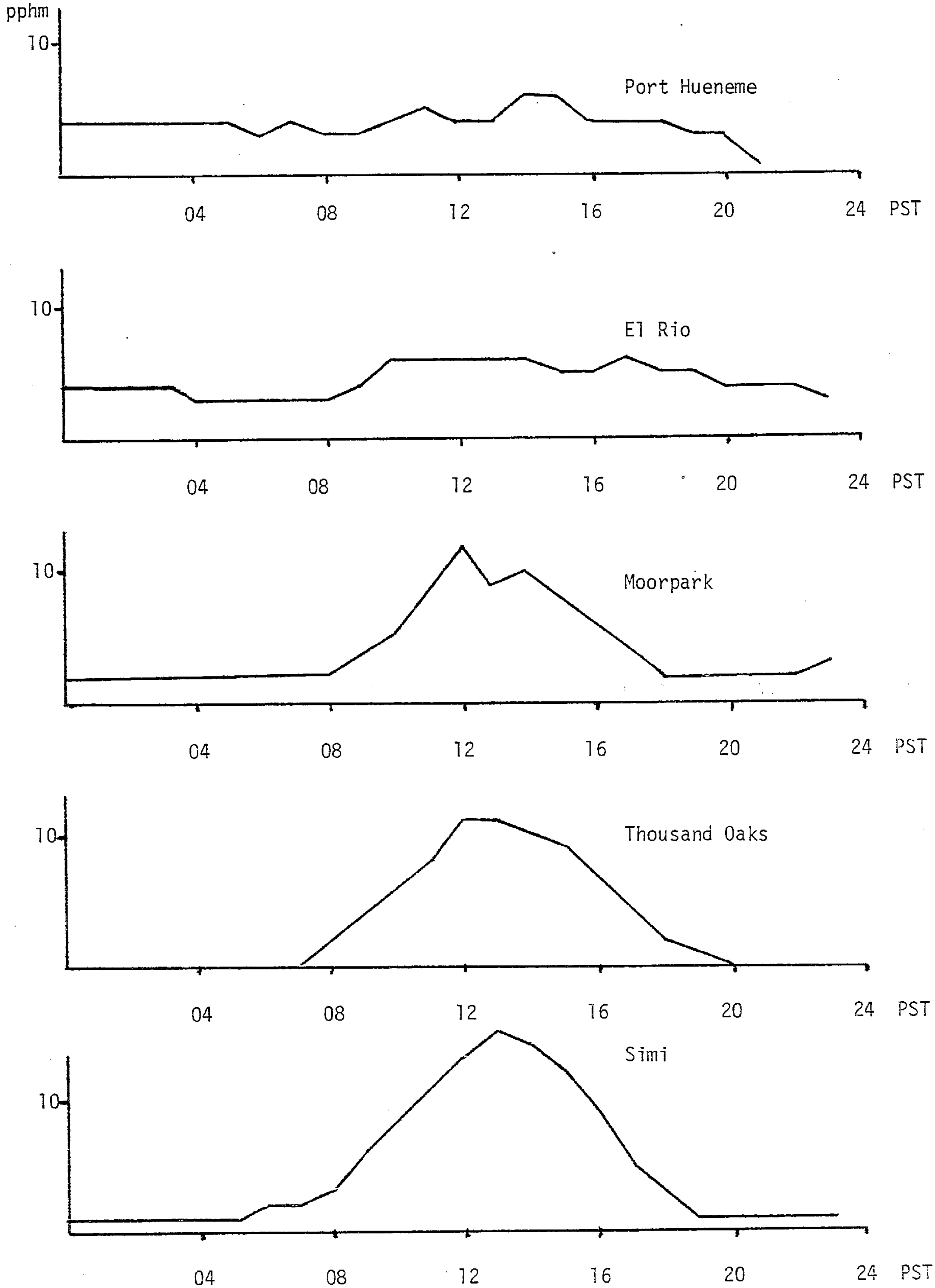


Fig. 4.4.2b HOURLY OZONE CONCENTRATIONS - September 26,1980

4.4.5 Aircraft Sampling

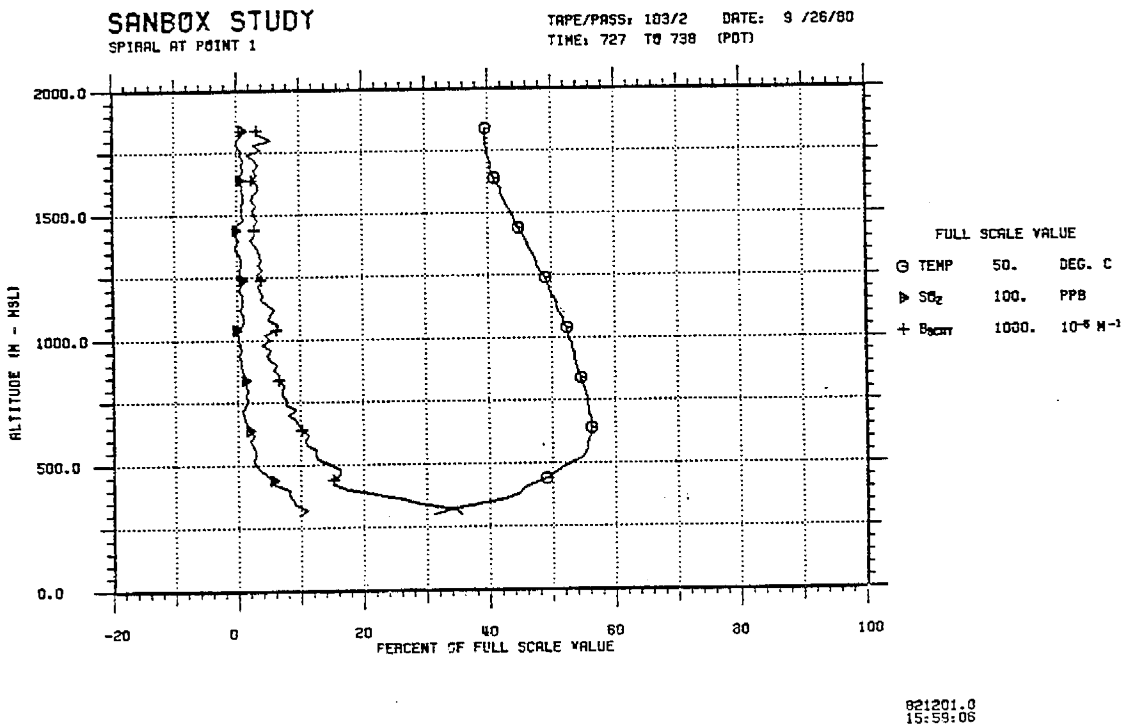
The MRI air quality aircraft sampled during the morning of September 26 in support of the early morning release near Platform Hondo. The sampling took place along the coast from Ventura to Gaviota and in the inland valleys to Santa Ynez, Ojai, Piru and Simi.

The first sounding was made at Santa Susana Airport near Simi at 0727 PDT (Figure 4.4.3). There was a strong surface inversion present to a level of 600 m-msl. Relatively high values of b_{scat} were observed within the surface layer, decreasing aloft. SO_2 concentrations to 10 ppb were also present in the layer. The ozone instrument was inoperative during this sounding. During a traverse from Santa Susana Airport to Oxnard (0744 PDT) ozone levels of 9-11 pphm were observed at a height of 610 m-msl. Winds in the inversion layer were from an east to east-northeast direction. Above the inversion the winds shifted abruptly to northwest to west.

The next sounding was made near Ojai at 0812 PDT (Figure 4.4.4). A strong surface temperature inversion was present to a height of 750 m-msl. High values of b_{scat} were confined to the surface layer under the strong inversion conditions. The same layer also exhibited an ozone deficit due to low-level scavenging by NO_x. Aloft the ozone concentrations were 8 pphm in the inversion layer decreasing to 5 pphm aloft.

A sounding was then made near Fillmore at 0830 PDT (Figure 4.4.5). A strong surface inversion was also present to a level of 750 m-msl. Reduced values of ozone were observed in the lower layers of the inversion increasing to 9 pphm at 750 m-msl. Further aloft the ozone concentrations decreaed to 5 pphm.

The balance of the flight was carried out in a traverse mode from Fillmore to Ventura and thence to Santa Barbara, Santa Ynez, Gaviota Pass and thence back to Santa Barbara. All of the traverses were flown at an altitude of about 700 m-msl. Ozone concentrations as high as 10 pphm were observed near Fillmore decreasing to a uniform 6-8 pphm throughout the balance of the flight.

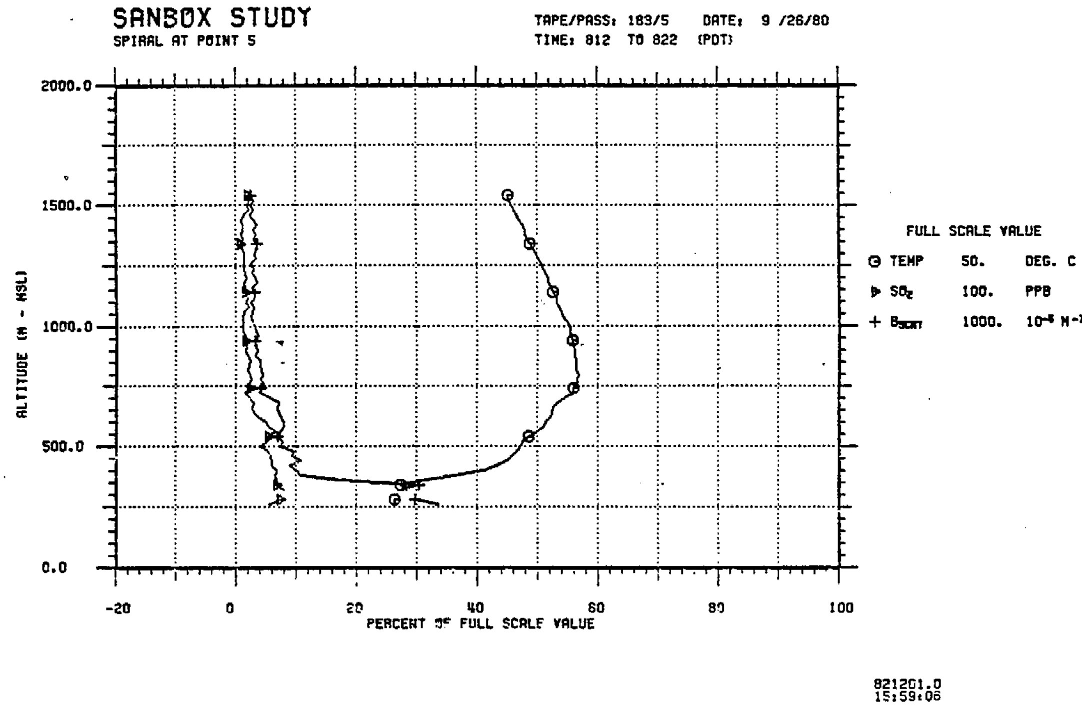


AIRCRAFT SOUNDING AT SANTA SUSANA

(0727 PDT)

September 26,1980

Fig. 4.4.3



AIRCRAFT SOUNDING NEAR OJAI

(0812 PDT)

September 26,1980

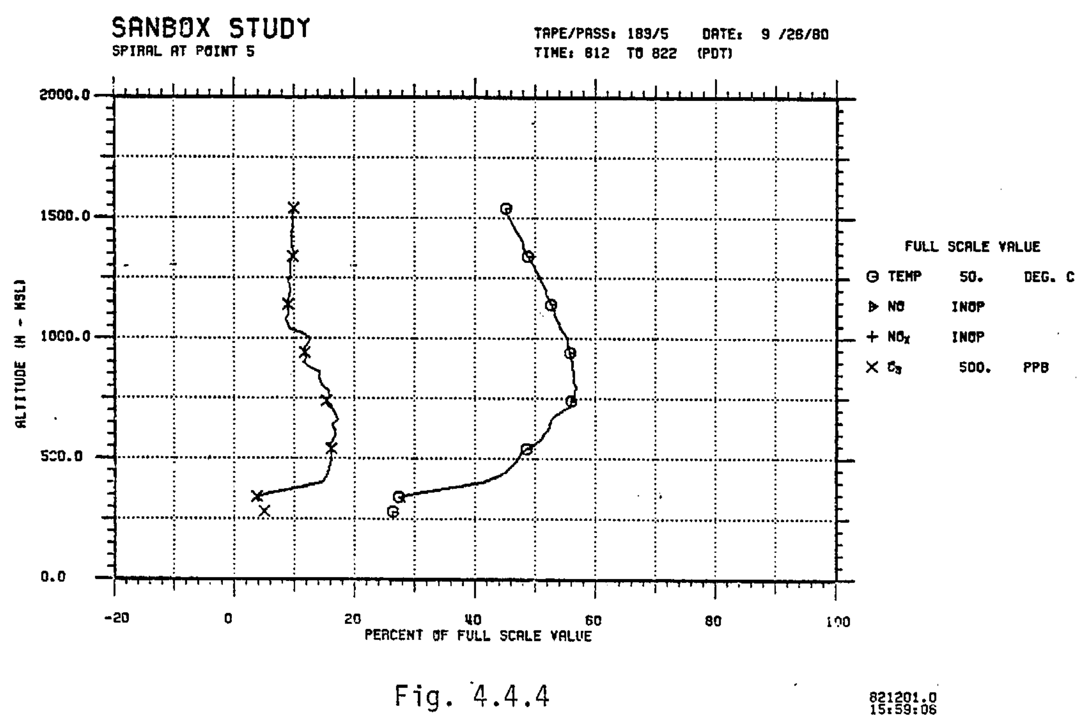
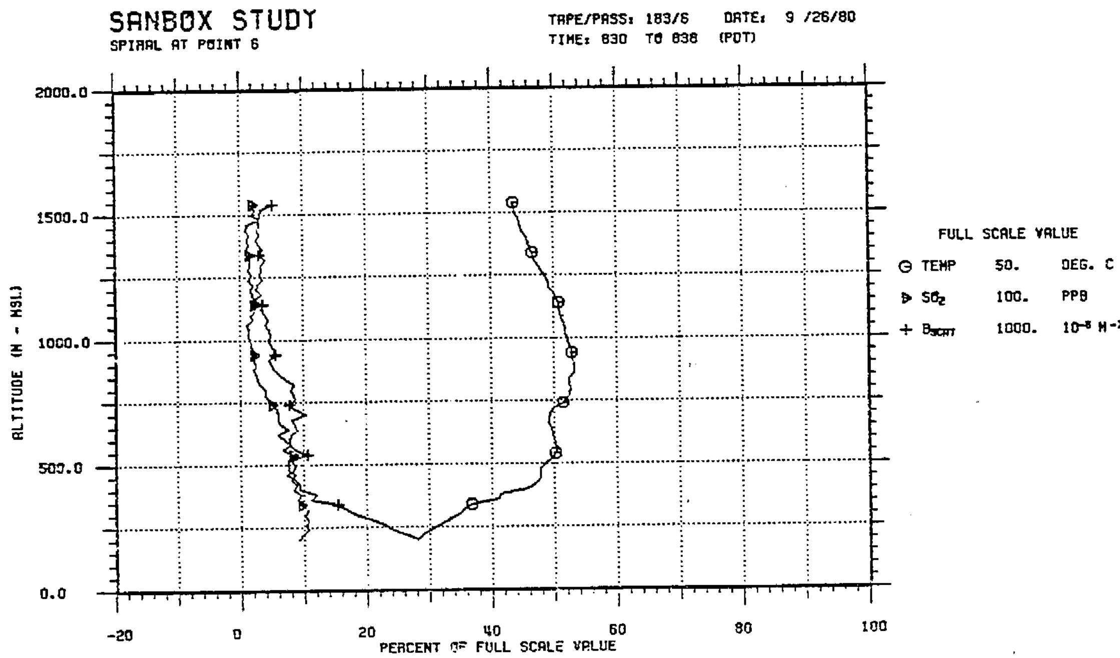


Fig. 4.4.4



AIRCRAFT SOUNDING NEAR FILLMORE

(0830 PDT)

September 26,1980

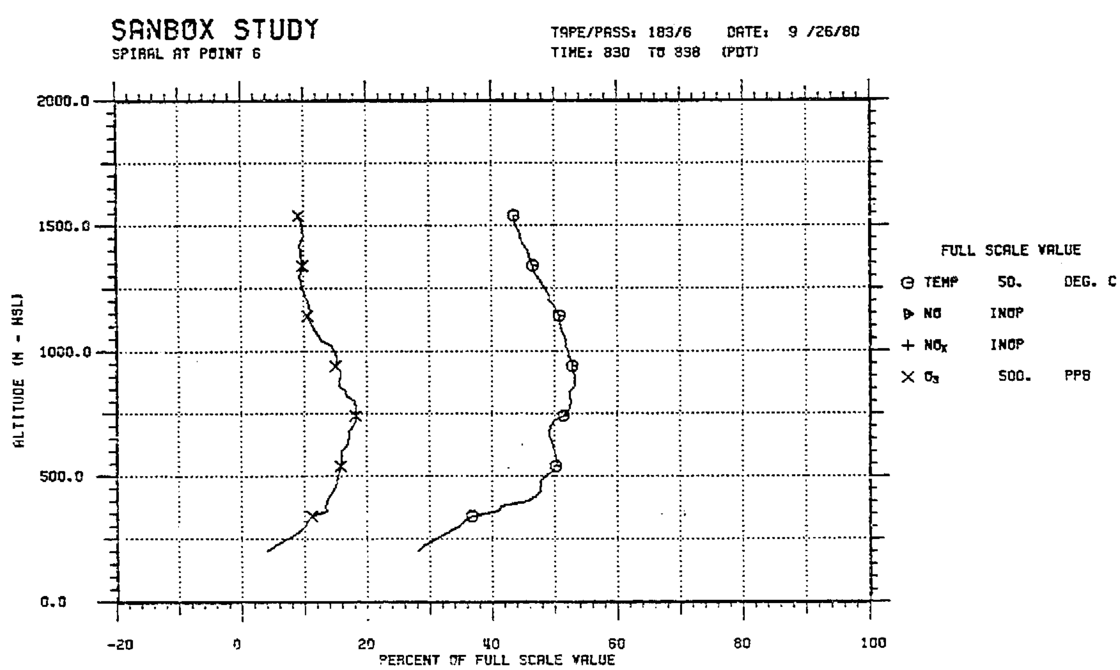


Fig. 4.4.5

821201.0
15:59:06

4.4.6 Tracer Results - Test 3

Release Location: Platform Hondo
Date: September 26, 1980
Time: 02-07 PDT
Release Rate: 7.96 g SF_6 per sec

An early morning release was planned at Platform Hondo with the expectation that surface winds would be light and a potential build-up of tracer material might occur in the area during the five hour release period.

Surface winds at Platform Hondo during the release period are given in Table 4.4.5.

Table 4.4.5

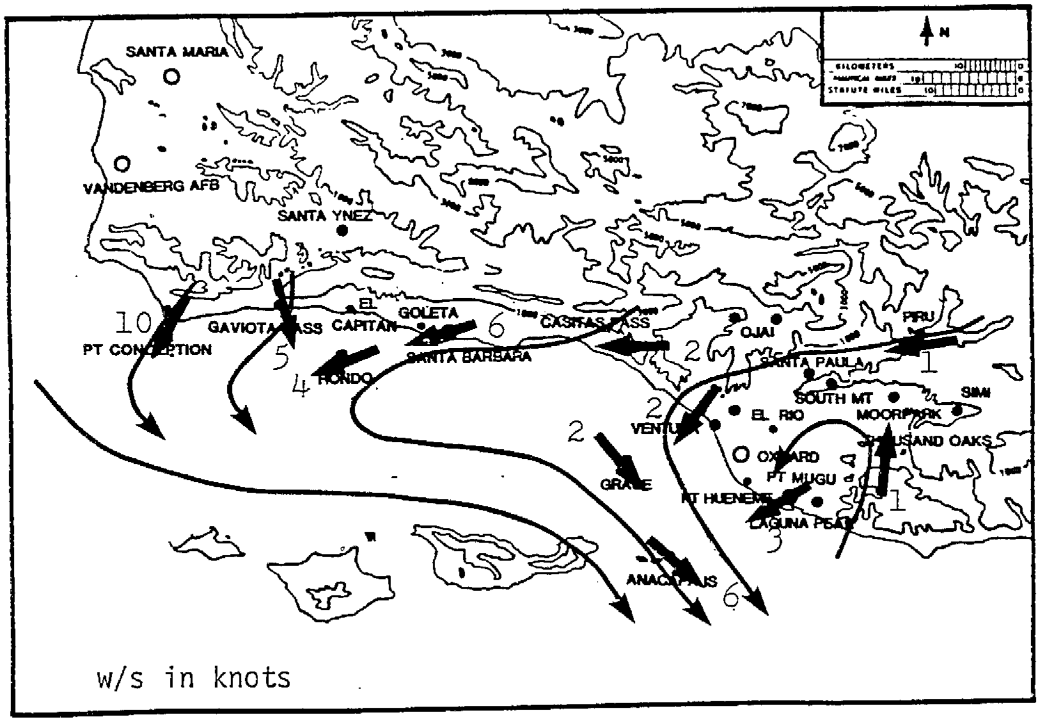
Surface Winds - Platform Hondo
September 26, 1980

Time	Wind Direction	Wind Speed
02 PDT	072°	2.7 m/s
03	072	1.8
04	072	0.4
05	080	1.8
06	042	1.3
07	020	0.4

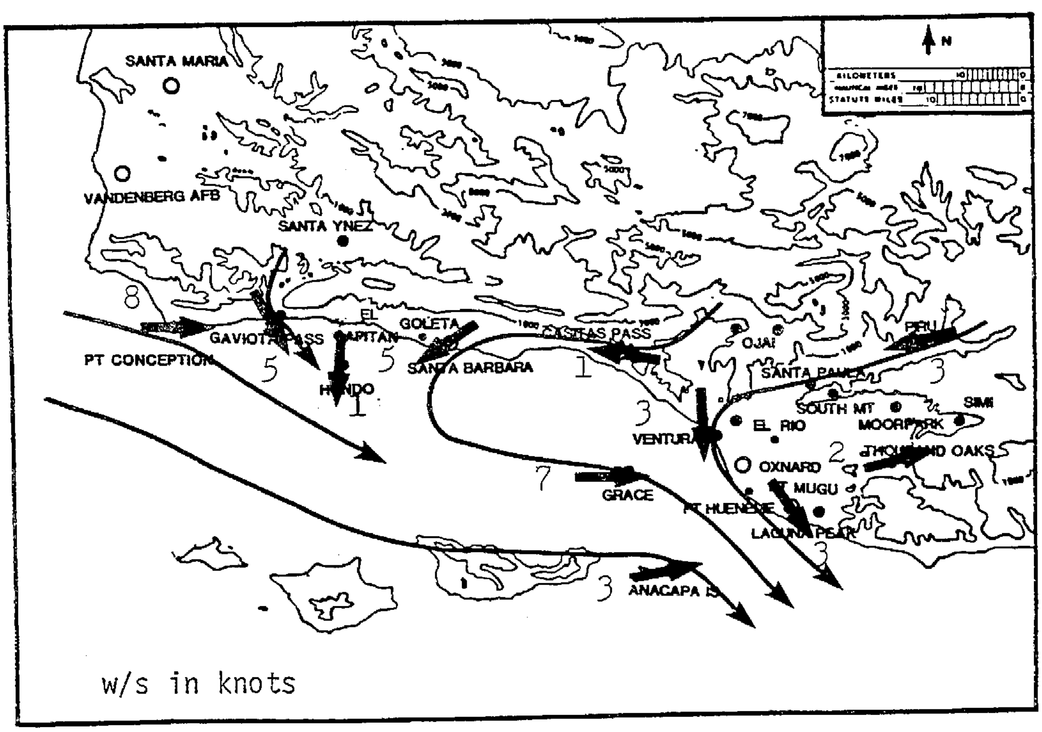
Surface wind directions were east to northeast throughout the release period with light wind velocities.

Streamline charts for September 26 are shown in Figures 4.4.6 to 4.4.8. North to northeasterly winds were present in the northwest portion of the channel through 06 PST. By 10 PST winds in the southern portion of the channel were westerly with southerly winds along the Santa Barbara coast. The flow gradually became more westerly through 18 PST, shifting into an eddy structure at 22 PST.

The estimated trajectories of the tracer material are given in Figure 4.4.9. It appears that material released in the early portion of the release period moved toward the south before being caught in the westerly flow after 08 PST. This material then moved rapidly eastward into Ventura County. A late portion of the tracer release was transported northward by the southerly and southeasterly flow, arriving at El Capitan Beach and Gaviota by 12-13 PDT. An average travel velocity of about 4 m/s was estimated for the tracer material arriving at the Ventura Coast.

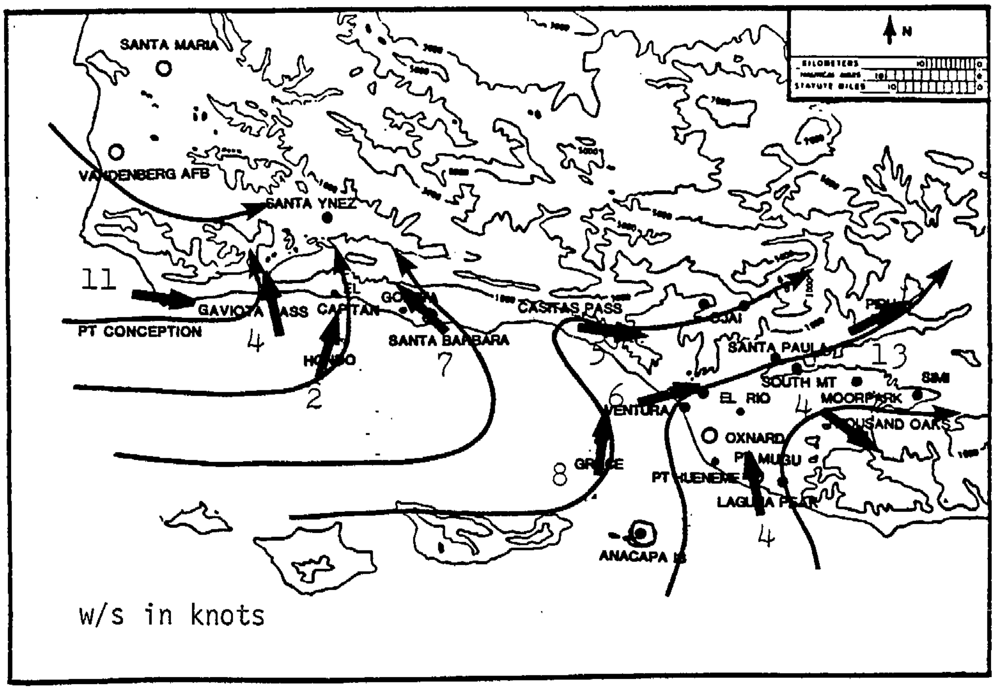


02 PST

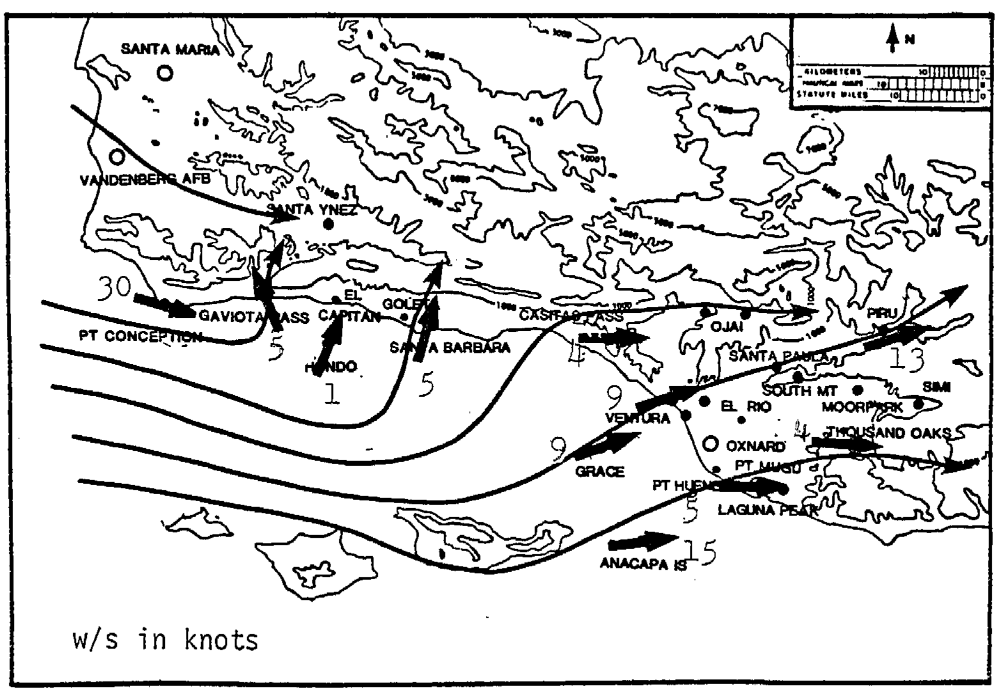


06 PST

Fig. 4.4.6 STREAMLINE CHARTS - September 26,1980

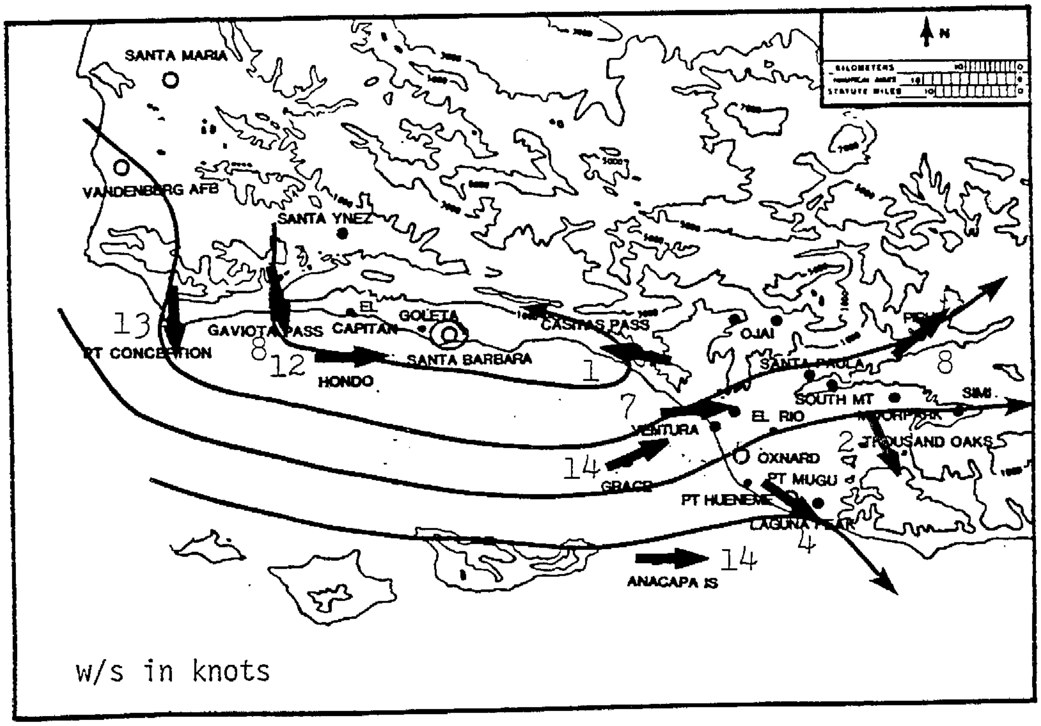


10 PST

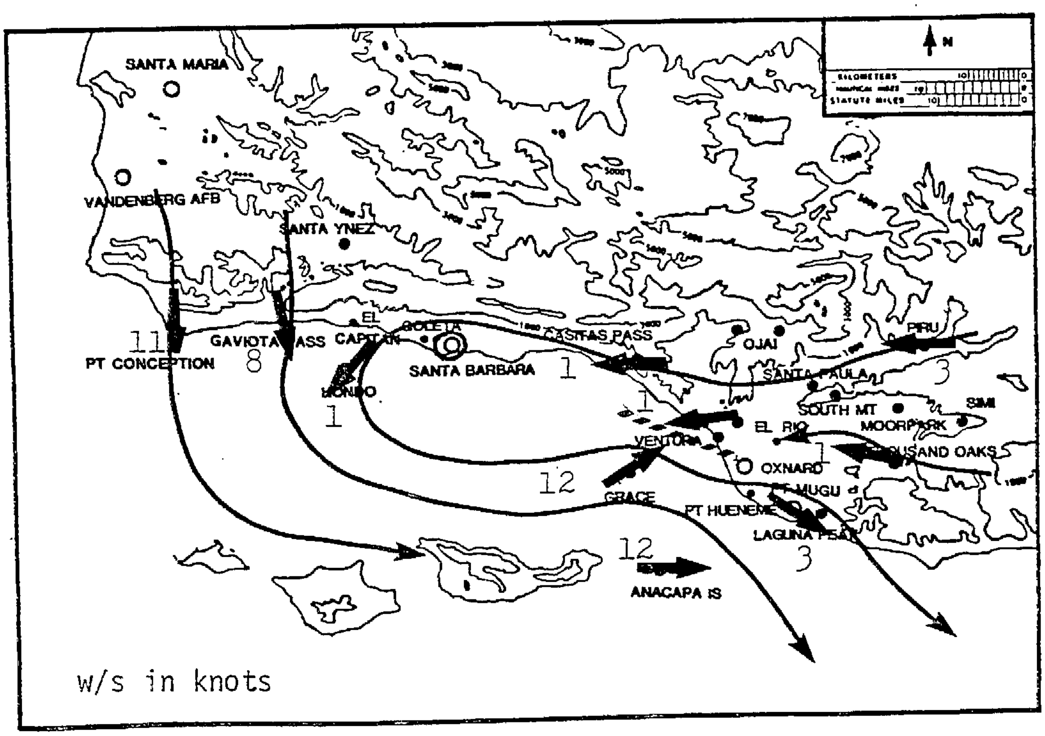


14 PST

Fig. 4.4.7 STREAMLINE CHARTS - September 26,1980



18 PST



22 PST

Fig. 4.4.8 STREAMLINE CHARTS - September 26,1980

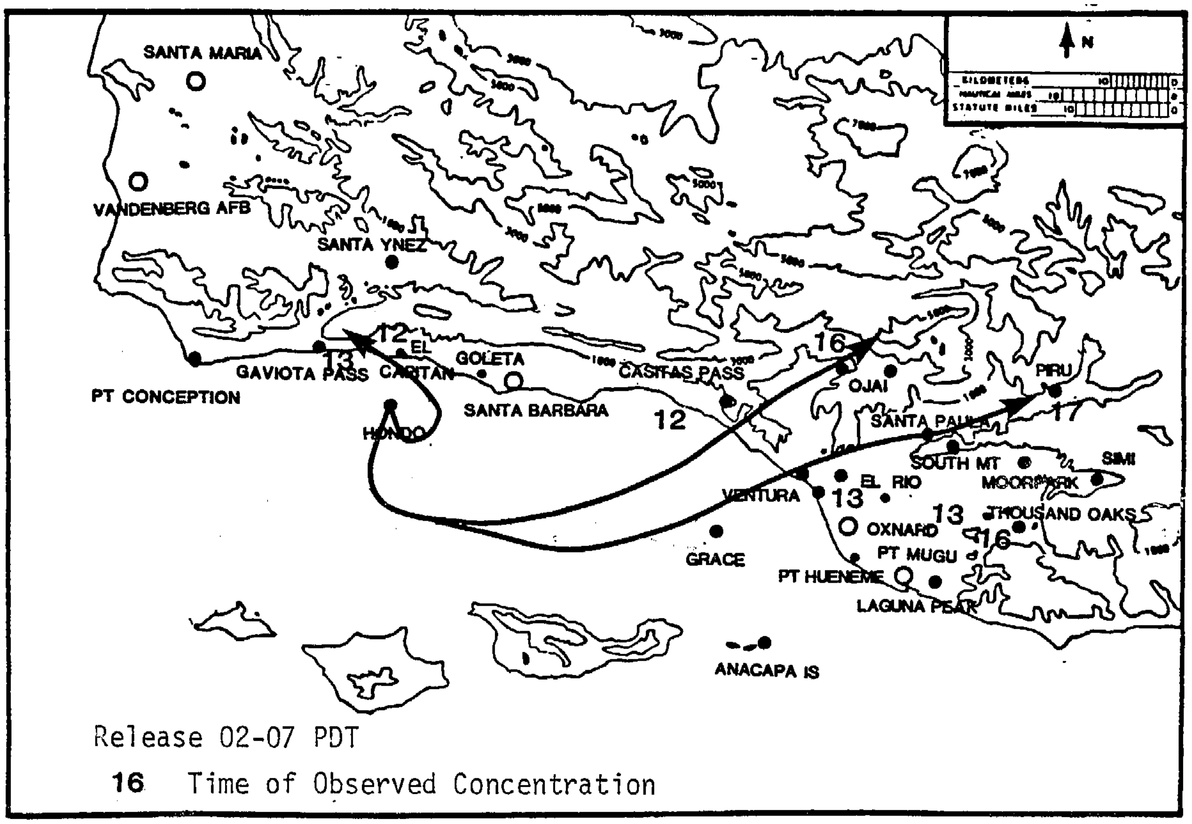


Fig. 4.4.9 ESTIMATED TRACER TRAJECTORIES - September 26,1980

Figure 4.4.10 gives the hourly concentrations of tracer and ozone at Piru and Ojai for September 26. Peak ozone and SF_6 concentrations at Ojai and Piru occurred simultaneously at 15 PST with a secondary SF_6 peak in the evening at both locations. As indicated in a previous section, the ozone peak (15 PST) occurred within the marine air intrusion after the maximum temperature had been reached in the inland valleys. The tracer data further substantiate the marine source for these air parcels and indicate that the parcels passed the shoreline about 11-12 PST.

The secondary peaks in the tracer material at Piru and Ojai are likely to be associated with a flow reversal and the onset of a nocturnal drainage wind. The occurrence of these higher SF_6 values suggests that ozone (or precursors) also may have been transported down valley by the drainage wind and thus be available for irradiation on the followng day. However, the early occurrence of the SF_6 peak (15 PST) suggests that most of the SF_6 may have escaped from the valley in the upslope flow with only small amounts returning to the valley during the night.

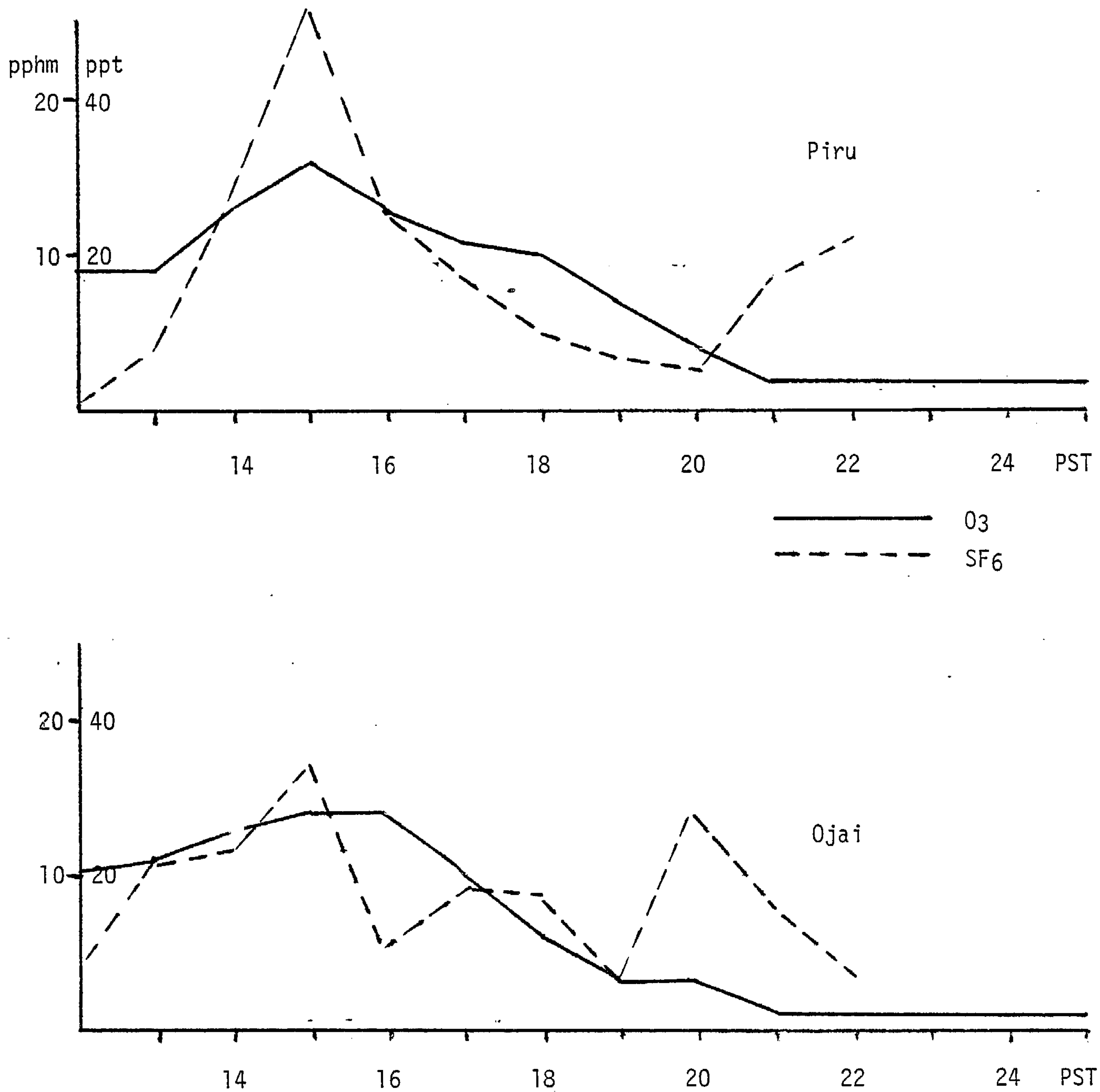
Xu/Q values were computed for September 26 and are shown in Table 4.4.6.

Table 4.4.6

Calculated Xu/Q Values
Test 3 - September 26, 1980

Wind Speed	Location	Time	Type of Sample	Distance	Xu/Q (x 10^{-6})
1.4 m/s	Camarillo	13 PDT	H	125 km	.06 m^{-2}
	Carpinteria	12	H	65	.04
	El Capitan	12	H	18	.09
	Ojai	16	H	100	.04
	Oxnard	13	H	110	.07
	Piru	16	H	145	.05
	Santa Susana	17	H	150	.04
	Thousand Oaks	16	H	135	.06
	Ventura	11	H	110	.15
	El Capitan	13	A	18	.05
	El Capitan	14	A	18	.04
	E El Capitan	15	A	15	.05
	Santa Paula	15	A/C	125	.04

H - Hourly sample
A - Automobile sample
A/C - Aircraft sample



HOURLY CONCENTRATIONS OF OZONE AND SF_6 - September 26,1980

Fig. 4.4.10

The Xu/Q values in the table have been plotted in Figure 4.4.11. The far downwind samples obtained in Ventura County consistently fall in the C-D Pasquill stability category. Concentrations from the trajectory associated with the latter part of the release (El Capitan/Gaviota) show even lower relative concentrations. Winds near the release site were quite light during the release period. This apparently led to a considerable initial dilution of the tracer cloud.

Total tracer dosages for the September 26 release are given in Table 4.4.7.

Table 4.4.7

Total SF_6 Dosages
Test 3 - September 26, 1980

Location	Total Dosage	Number of Hours $\geq$ 10 ppt
Santa Ynez	0	0
Gaviota	0	0
El Capitan	162	4
Santa Barbara	16	1
Carpinteria	250	11
Ojai	168	8
Ventura	409	12
Piru	201	10
Oxnard	146	6
Camarillo	71	2
Thousand Oaks	232	10
Simi	201	9

The maximum hourly impact was observed at Ventura (Table 4.4.6). The maximum total dosage was also observed at Ventura where 12 hours of concentrations $\geq$ 10 ppt were recorded. Carpinteria, Piru, Thousand Oaks and Simi all observed relatively high total dosages.

The first BLM tracer release took place on September 24. Background SF_6 concentrations on the morning of September 26 were small. The highest observed hourly concentration was 17 ppt at Camarillo. It is likely, therefore, that the BLM test did not contribute significantly to the concentration values shown in Table 4.4.7.

Figure 4.4.12 shows the automobile sampling routes on September 27, the day after the Test 3 release. Shaded areas represent observed SF_6 samples of at least 10 ppt. The second BLM release was made during the day on September 27 and clearly influenced two of the automobile sampling routes. Excluding these large SF_6 concentrations the highest SF_6 concentration observed was 17 ppt at Ventura. Areas where at least 10 ppt were observed were confined to the inland and coastal valleys of Ventura County. Carry-over from the previous day was not very widespread as indicated in the figure.

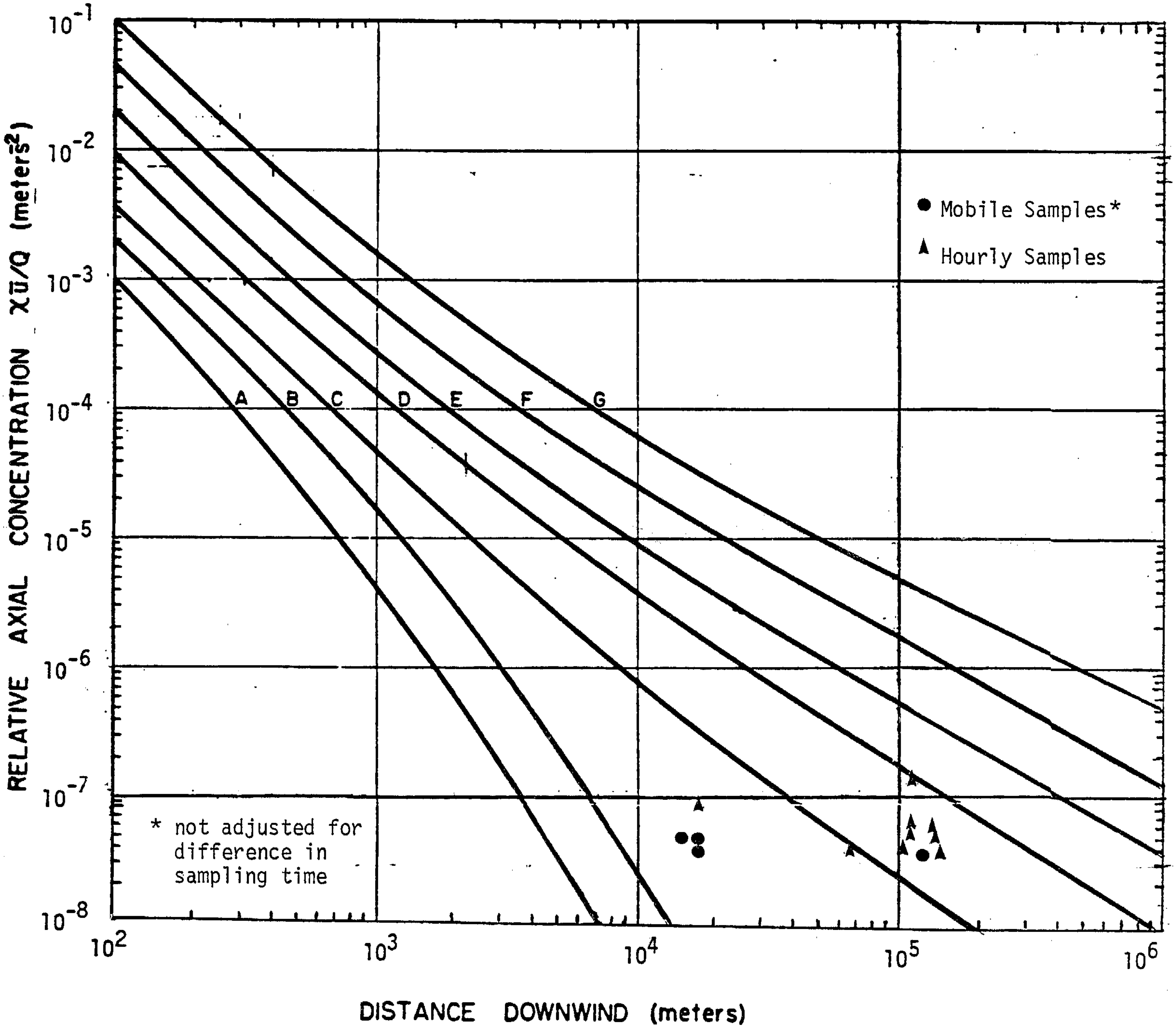


Fig. 4.4.11 XU/Q VALUES - Test 3
September 26,1980

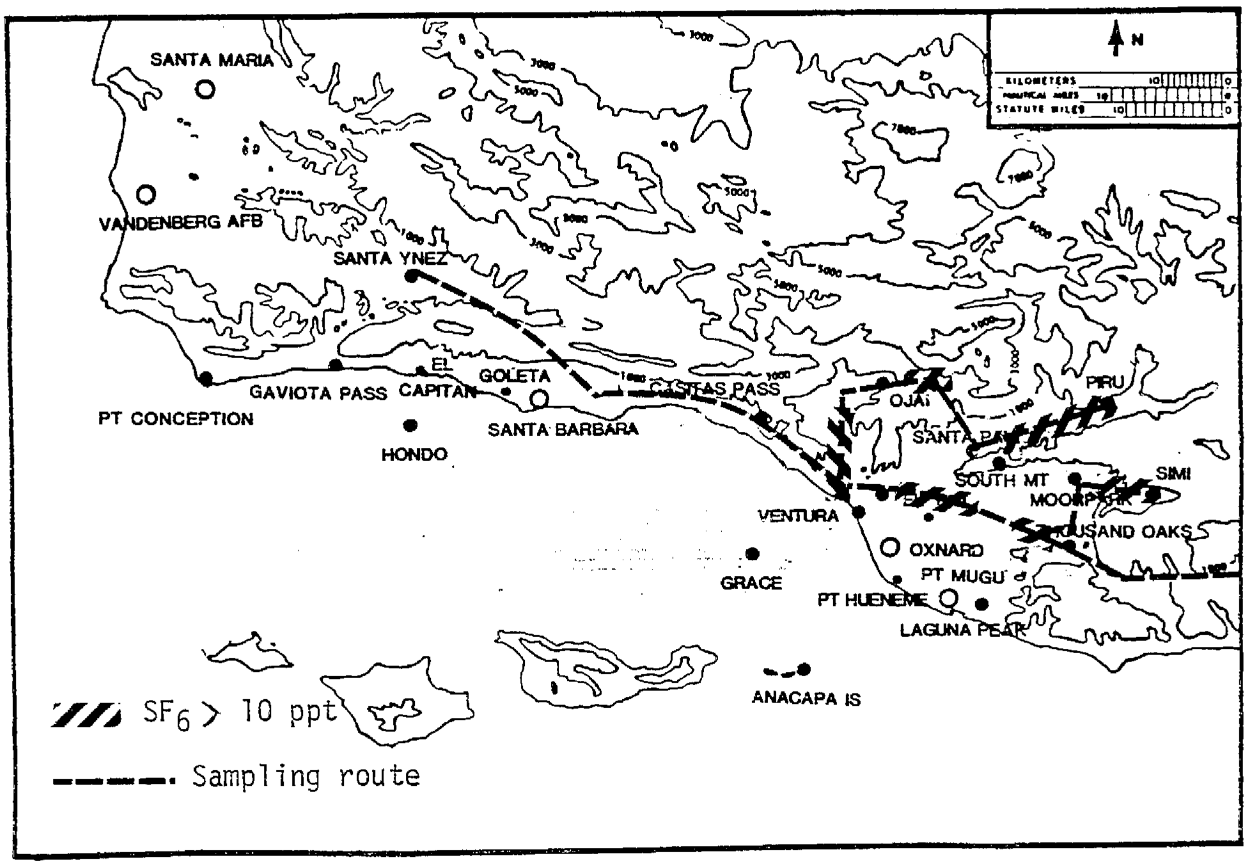


Fig. 4.4.12 LOCATIONS OF SF_6 CONCENTRATIONS - September 27,1980

(> 10 ppt)

4.5 Test 4 28 September 1980 - Release from R/V Acania, 4 mi West of Ventura Marina (1240-1900 PDT)

4.5.1 General Meteorology

A weak surface trough passed through the Southern California area early in the day, leading to a pressure trough at the surface and at 500 mb along the Colorado River and southern Nevada (Figure 4.5.1). During the balance of the day the study area came under the influence of a pressure ridge which was building into the western states following passage of the trough. The Santa Barbara area was clear all day except for a few scattered, low couds in the early morning. Visibility was restricted to 1 mile in fog and haze at 1030 PDT but improved rapidly thereafter. Pt. Mugu reported a few scattered clouds in the morning but restricted visibility until near noon.

Significant meteorological parameters for Setpember 28 are given in Table 4.5.1.

Table 4.5.1

Meteorological Parameters

September 28, 1980

850mb Temperature (Vandenberg AFB)	20°C
Pressure Gradients	
LAX-Bakersfield	-3.2mb
Santa Barbara-Daggett	1.1
Inversion Base (15 PST)	
Pt. Mugu	---
Maximum Surface Temperatures	
Thousand Oaks	76°C
Piru	83
Santa Barbara	70

Temperatures at 850 mb remained about the same as observed in Test 3 as did the maximum surface temperatures. Pressure grdients, however, changed to marked negative gradients (higher pressure inland) from San Francisco and Bakersfield toward Los Angeles. As a result, 5000-foot winds at Vandenberg AFB (03 PST) were northerly at 13 kts. Under these conditions some lee slope effect on the marine layer south of the Santa Ynez Mts. could be expected

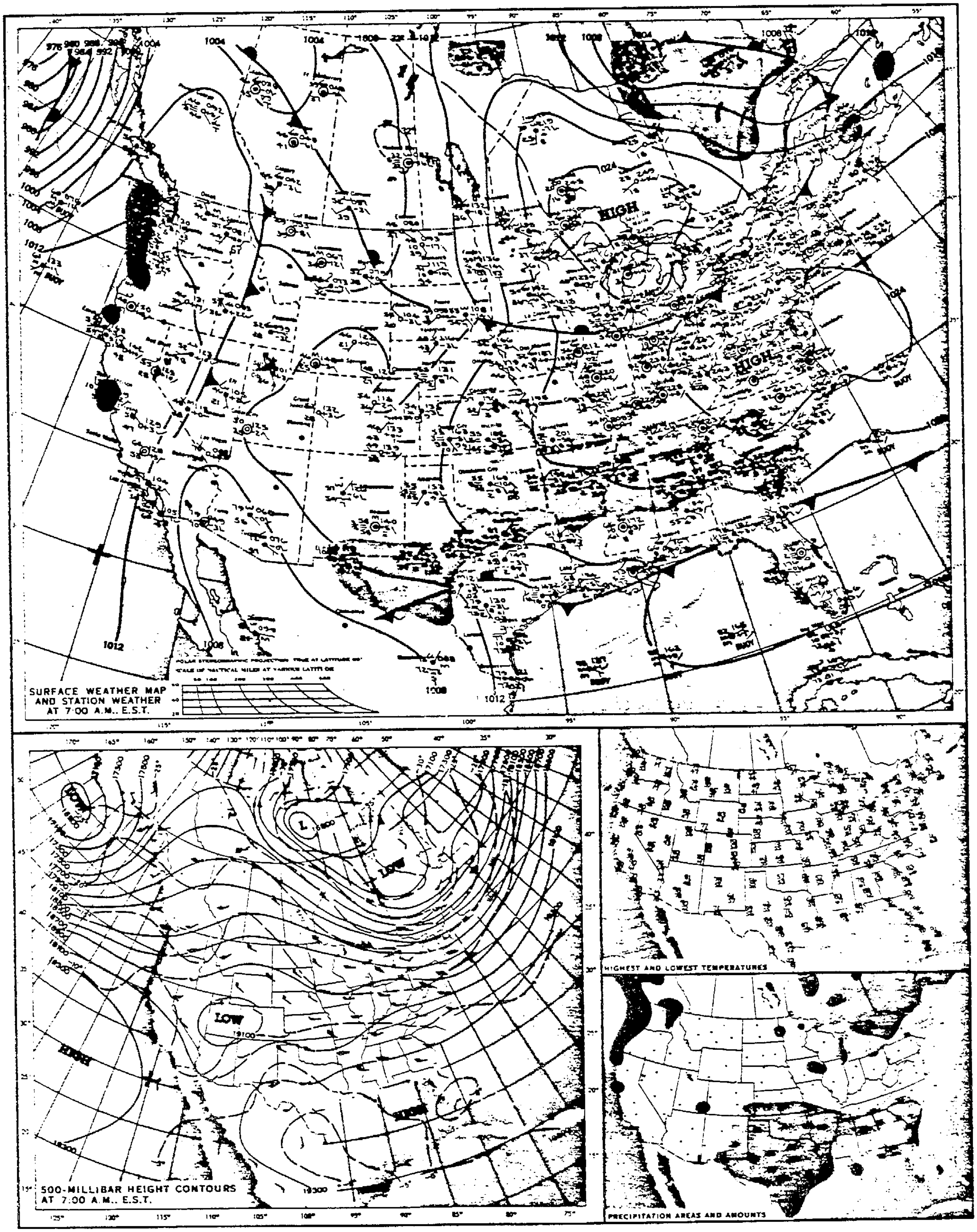


Fig. 4.5.1 WEATHER MAP - September 28,1980

4.5.2 Transport Winds

Table 4.5.2 shows the transport winds at a number of locations in the area on September 28. Pt. Conception winds were northwesterly until 22 PST when the wind direction shifted to northeast and east. Winds at both Hondo and Santa Barbara were east to southeast through the day and evening with velocities from light to near calm. The wind at Platform Grace was southeasterly through 12 PST shifting to a more normal southwesterly through the balance of the day but with reduced velocities compared to the earlier tests. At Ventura the seabreeze flow continued through 18 PST, becoming light northwesterly in the late evening.

Table 4.5.2

Transport Winds - Test 4

September 28, 1980

Time PST	Pt. Conception		Hondo		Santa Barbara		Grace		Ventura Surfers Point	
	w/s	w/d	w/d	w/s	w/d	w/s	w/d	w/s	w/d	w/s
10	302°	6.3m/s	156°	0.4m/s	130°	4.6m/s	153°	0.3m/s	210°	2.1m/s
12	300	10.8	117	1.3	140	3.6	176	0.8	220	2.9
14	296	12.1		Calm	150	4.6	222	1.9	225	3.3
16	305	6.7	117	1.3	130	2.6	226	3.0	235	3.3
18	358	2.3	089	0.4	140	2.6	255	2.8	210	0.7
20	336	3.4	093	0.4		Calm	237	3.6	110	0.6
22	045	2.1	091	1.3		Calm	240	2.7	330	0.6
24	112	3.0	080	0.9		Calm	255	1.0	355	1.2

As indicated in the Hondo and Santa Barbara data, the eddy continued in the channel all day without dissipating into the normal southwesterly winds along the Santa Barbara coast. Evidence of the eddy was also indicated at Platform Grace. The southeast to south winds indicated in the table were preceded by east to northeast winds in the early morning.

4.5.3 Mixing Heights

Mixing height data for September 28 are given in Table 4.5.3. Afternoon mixing heights in the inland valleys showed the presence of a low, marine layer together with additional pollutant layers aloft. Pibal heights reflect the depth of the convective layer and the vertical extent of the onshore flow. The top of the pollutant layer at Piru and Santa Susana Airport was above the height of the onshore flow and was characterized by easterly winds. Pollutant layers aloft (1000 m-msl) at Santa Susana Airport and at the west edge of the San Fernando Valley were quite similar and it is suggested that this material came from the San Fernando Valley.

It is to be noted that the surface mixing layer at Platform Grace was considered to be 100 m at 1410 PDT but a deeper pollutant layer existed to 500 m.

Table 4.5.3

Mixing Heights*

September 28, 1980

1. Measured by Sampling Aircraft

Time	Location	Height
1336 PDT	Near Ojai (Upper layer to 400m)	150m
1410	Platform Grace (Upper layer to 500m)	100
1458	Piru (Upper layer to 950m)	150
1517	Santa Paula Airport (Upper layer to 550m)	150
1556	Santa Susana Airport (Upper layer to 800m)	250
1610	W end of San Fernando Valley	800

2. Measured by Pibals

Time	Santa Ynez	Ojai	Simi	Ventura
11 PDT	263m	662m	263m	365m
13	263	365	466	662
15	263	662	365	758
17	263	365	565	565
19	159	263	263	53

3. Measured by MRI Acoustic Sounder

Santa Paula Airport	Height
11 PDT	200m
13	240
15	160
17	170
19	190
21	---

* Heights are above surface