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HORIZONTAL VARIABILITY OF THE MARINE BOUNDARY LAYER STRUCTURE UPWIND OF SAN NICOLAS ISLAND DURING FIRE, 1987

Douglas R. Jensen
Code 543
Naval Ocean Systems Center
271 Catalina Blvd.
San Diego, CA 92152

INTRODUCTION

During the months of June and July 1987 the Marine Stratocumulus Intensive Field Observation Experiment of FIRE was conducted in the Southern California offshore area in the vicinity of San Nicolas Island. The Naval Ocean Systems Center (NOSC) airborne platform was utilized during FIRE to investigate the upwind low level horizontal variability of the marine boundary layer structure to determine the representativeness of SNI-based measurements to upwind open ocean conditions. The NOSC airborne meteorological platform made three flights during FIRE, two during clear sky conditions (19 & 23 July), and one during low stratus conditions (15 July). This paper addresses the boundary layer structure variations associated with the stratus clouds of 15 July 1987.

The prescribed flight pattern for the NOSC aircraft consisted of two upwind radial legs as shown in Figure 1. On each of the radials constant altitude flights were made at altitudes of 100ft and at 4000ft with spirals at each radial end point and midpoint. Parameters recorded by the NOSC aircraft included air temperature (AT), relative humidity (RH), sea surface temperatures (SST), cloud top temperatures (CTT), and aerosol extinction profiles. All flights were coordinated with the SNI ground based platforms and the NPS Research Vessel Point Sur to ensure simultaneous measurements.

MEASUREMENTS

Air temperature profiles taken at the four spirial locations (WP#1-4, Figure 1) are shown in Figure 2. The surface AT at SNI was lower than those measured upwind and did not increase linearly with upwind distance from SNI. Above 300m (within the haze/cloud layer) the AT at the island was bounded above and below by the upwind profiles. The inversion heights at all four locations were essentially the same. A sharper inversion did exist however at SNI.

Profiles of relative humidity are shown in Figure 3. The highest surface RH existed at SNI (97%) with the minimum (90%) at WP#2. These corresponded to the lowest and highest AT's respectively. Above 200m and below the stratus tops the SNI RH profile is bounded above and below by the upwind profiles. Just below the stratus tops the RH's at all spiral locations were within a few percent of each other.

Figure 4 shows the average weighted aerosol radius (RBAR) as a function of altitude for the aerosol profiles taken at each waypoint. At the surface the upwind RBAR values were between 0.3 and 0.4 m while at SNI RBAR was an order of magnitude higher. Above 300m and below the stratus tops the SNI RBAR profile is bounded by upwind profiles. The corresponding extinction coefficients calculated using MIE theory (0.53 m), Figure 5, shows a surface extinction coefficient at SNI to be one hundred times greater than that at the other upwind waypoints. This difference is strictly a SNI surface related phenomena since the RBAR versus altitude profiles show a rapid decrease in extinction with altitude. Within the stratus cloud deck (above 300m) the cloud aerosol extinction varied by as much as a factor of ten between waypoints. The variation was not necessarily in any wind related pattern.

The total integrated optical depth for 0.53 m as a function of altitude is shown in Figure 6 for each waypoint. The higher optical depths occurred upwind of SNI at waypoints 3 and 4. At SNI where the surface aerosol extinction was the highest, the total optical depth was next to the lowest. The major contribution to the optical depth occurred within the top 100 meters of the stratus deck. Aerosols below this height did contribute but not as significantly as did the stratus top. This is evidenced by the slight increase in the optical depth at the bottom of the SNI profile which resulted from a large increase in the number of surface based aerosols (Figures 5 and 6).

Horizontal profiles of sea surface temperatures, example in Figures 7, showed a general trend toward warmer water upwind of SNI. Large fluctuations of SST's were superimposed on this general warming trend with scale sizes in the order of 5 to 10 nmi. In general the sea surface temperatures were warmer than the air temperatures.

Cloud top temperature profiles showed CTT's decreasing upwind of SNI in contrast to the SST observations. This decrease in upwind CTT's was thought to be caused by vertical mixing (SST warmer than the AT) thus resulting upwind stratus tops being at a higher elevation. However, stratus tops were within 100ft over the entire flight pattern.

CONCLUSIONS

Profiles of AT and RH taken "at" and "upwind" of SNI do show differences between the so called open ocean conditions and those taken near the island. However, the observed difference cannot be uniquely identified to island effects, especially since the upwind fluctuations of AT and RH bound the SNI measurements.

Total optical depths measured at SNI do not appear to be greatly effected by any surface based aerosol effects created by the island and could therefore realistically represent open ocean conditions. However, if one were to use the SNI aerosol measurements to predict ship to ship EO propagation conditions, significant errors could be introduced due to the increased number of surface aerosols observed near SNI which may not and were not characteristic of open ocean conditions.

Sea surface temperature measurements taken at the island will not in general represent those upwind open ocean conditions. Also, since CTT's varied appreciably along the upwind radials, measurements of CTT over the island may not be representative of actual open ocean CTT's.

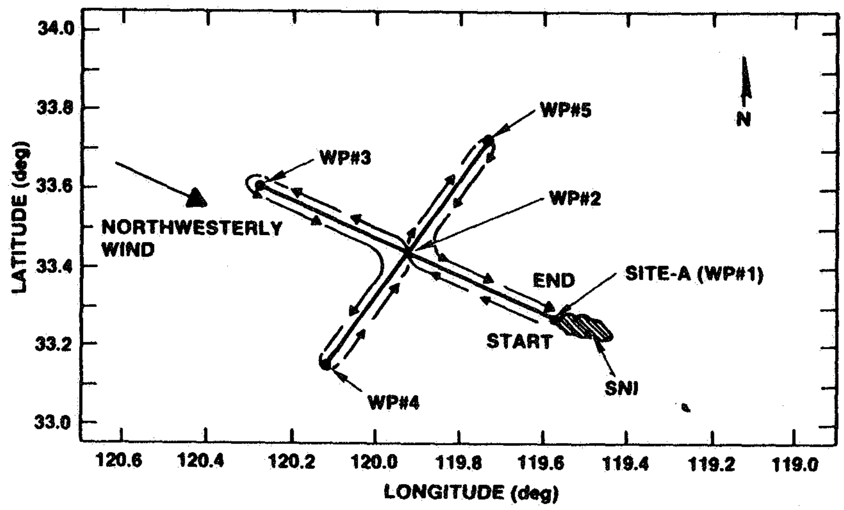

Figure 1. NOSC prescribed flight pattern.

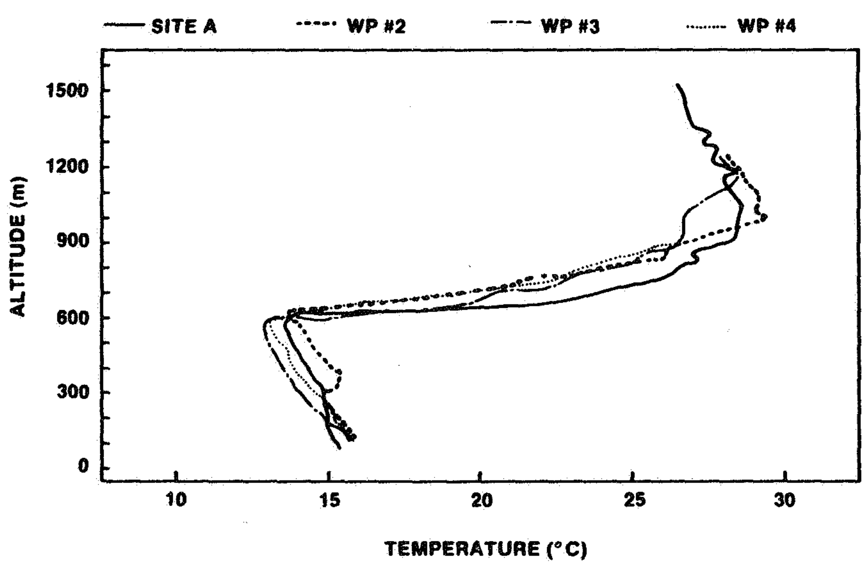

Figure 2. Air temperature profiles.

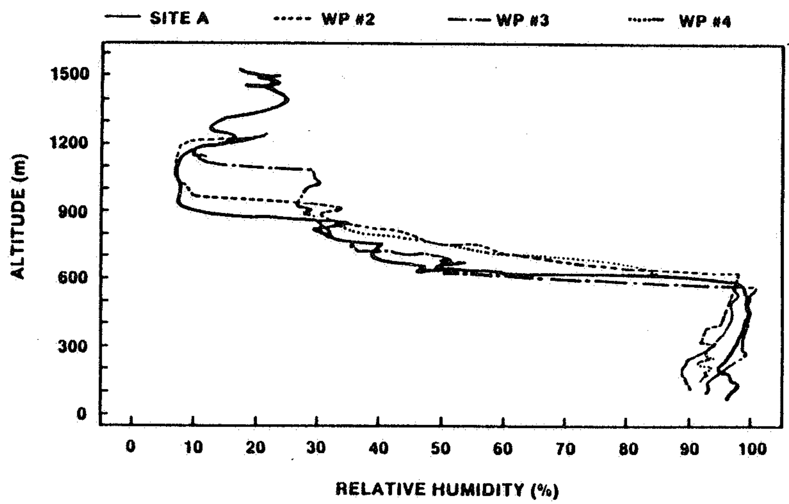

Figure 3. Relative Humidity profiles.

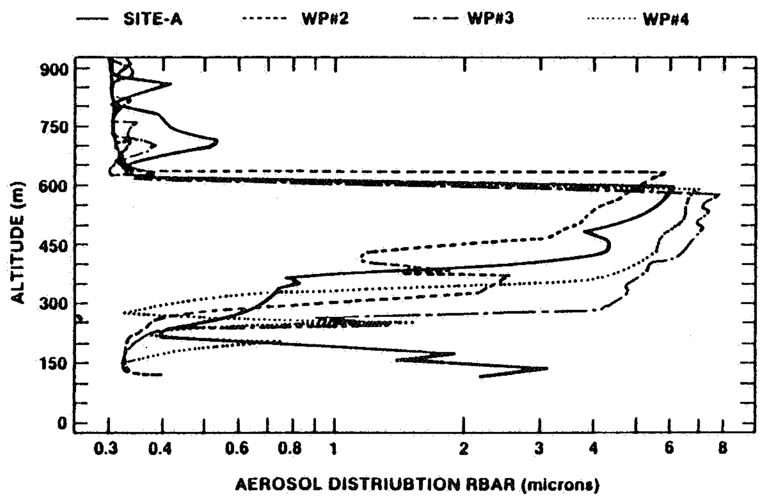

Figure 4. RBAR profiles.

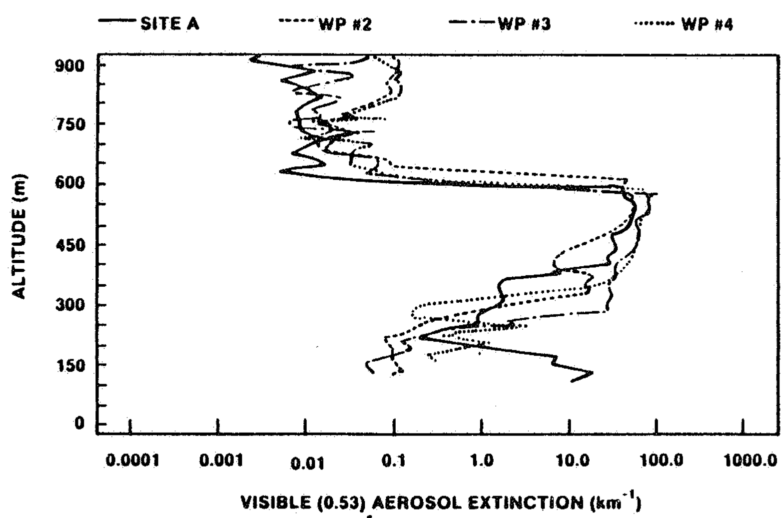

Figure 5. Aerosol extinction profiles.

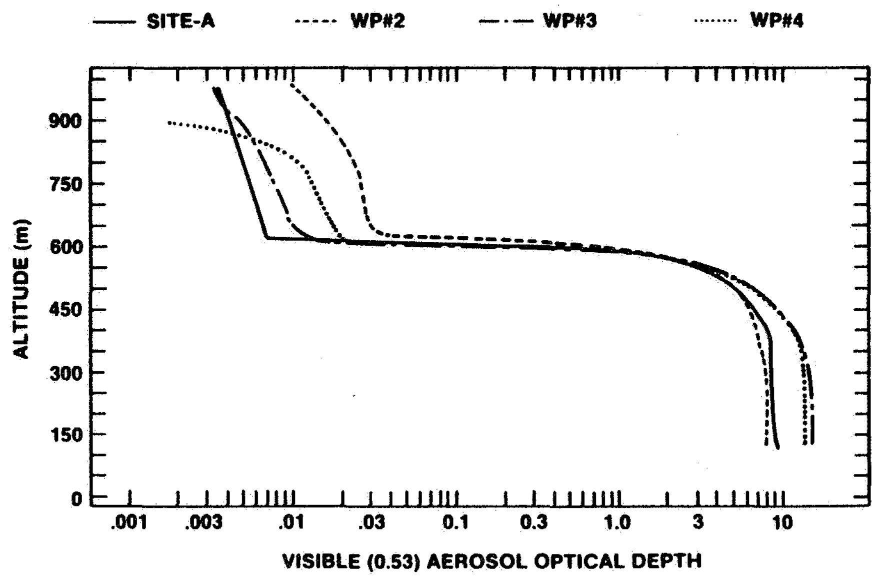

Figure 6. Optical depth profiles.

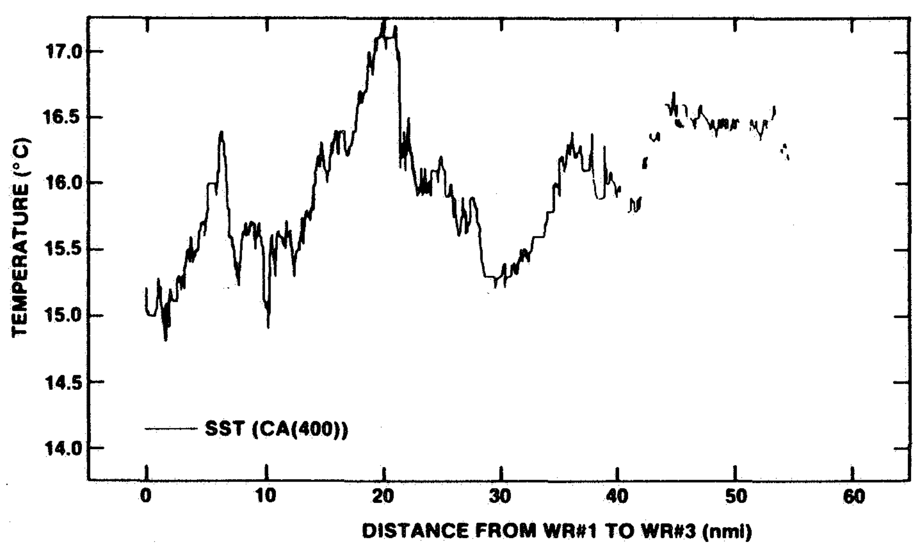

Figure 7. Sea surface temperature profiles.

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