CONTRACT NO. 92-346
FINAL REPORT
MAY 1995

# Sierra Cooperative Ozone Impact Assessment Study: Year 4

## *Volume 1*

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD
Research Division

# Sierra Cooperative Ozone Impact Assessment Study: Year 4

Final Report

Contract No. 92-346

Volume 1

*Prepared for:*

California Air Resources Board
Research Division
2020 L Street
Sacramento, California 95814

*Prepared by:*

John J. Carroll and Alan J. Dixon

Department of Land, Air and Water Resources
University of California
Davis, California 95616

May 1995

ABSTRACT:

The purpose of the Sierra Cooperative Ozone Impact Assessment Study (SCOIAS) is to document the degree to which sensitive pine species in Sierran forests are exposed to ozone and the amount of injury the exposed trees exhibit. The major cooperators are the U.S. Forest Service (USFS), the California Air Resources Board (ARB) and the University of California, Davis (UCD). This document reports progress made by the UCD cooperators during the third and fourth years of the project (July 27, 1993 to May 18, 1995). The major tasks performed were the following: continued operation of the six sites established in the previous years' efforts; tree water potential measurements; data quality control, analysis and archiving; removal of instruments at the end of 1994; and relinquishing of the sites to the ARB. The six stations are Mountain Home within the Sequoia, Shaver Lake and Jerseydale in the Sierra, Five Mile Learning Center in the Stanislaus, Sly Park Learning Center in the Eldorado and White Cloud in the Tahoe National Forests. The ozone monitoring season is the warm part of the year, from about April 15 to October 15, although actual station operating dates depend on accessibility in the spring. In 1993 at all but the White Cloud site, the targeted 80% data coverage was attained or exceeded. At this site, a combination of computer system problems, A-C power supply problems, ozone monitor and wind speed sensor malfunctions caused data voids among all variables totaling almost 30% of the operational period. However, valid ozone data are available for about 83% of the season at this station. At the remainder of the sites, data coverage was better than 89%. For 1994, the 80% data coverage goal was attained or exceeded at four of the six sites. A combination of computer system and wind direction problems at Mountain Home and computer system and temperature sensor problems at Jerseydale led to data coverage of about 69% and 75%, respectively. However, ozone data are available for more than 80% of the time at both sites. The four remaining sites all had data coverage of greater than 90% with one site exceeding 99%. The problems occurred predominately in May, which is typically (and was in 1994, too) a month with lower ozone concentrations. Better than 80% data coverage was obtained at five of the six sites for the period from June 1 to September 30, 1994 and more than 98% at four of the sites during the same period. Measured ozone concentrations were typically highest in the afternoon hours, and tend to increase toward the southern end of the network. Stations located on well defined steep slopes show a very strong diurnal variation in ozone concentration and meteorological conditions. For both 1993 and 1994, peak ozone concentrations from June through September were greater than 60 ppbv at all sites nearly every day, in excess of 80 ppbv at most sites more than half the days and in excess of 100 ppbv at least a few days a month at all sites and more

than half the days at the most impacted site (Mountain Home). At several sites, ozone concentrations were frequently high several hours after sunset.

ACKNOWLEDGEMENTS:

We gratefully acknowledge the high level of cooperation and enthusiasm from the personnel at all the sites. The assistance of graduate students D. van Ooy, C. Pagliccia and D. Salardino are gratefully acknowledged. This report was submitted in fulfillment of ARB-UCD Interagency Agreement # 92-346, Sierra Cooperative Ozone Impact Assessment Study, by University of California, Davis under the partial sponsorship of the California Air Resources Board. Work was completed as of 5/18/95.

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SUMMARY AND CONCLUSIONS:

The purpose of the Sierra Cooperative Ozone Impact Assessment Study (SCOIAS) is to document the degree to which sensitive pine species in Sierran forests are exposed to ozone, the meteorological processes that coincide with high ozone concentrations and the amount of injury the exposed trees exhibit. The major cooperators are the U.S. Forest Service (USFS), the California Air Resources Board (ARB) and the University of California, Davis (UCD). This document reports progress made by the UCD cooperators during the third and fourth years of the project (July 27, 1993 to May 18, 1995). The primary tasks pursued were the continued operation of the six measurement sites established in the previous years, retrieval of the instrumentation in late fall, maintenance and recalibration of these over the winter, reinstallation of the stations as they became accessible in the spring and operation of the stations through the summer of 1994 and removal of all six sites by the end of 1994. The USFS cooperators have conducted training classes (June, 1993 and July, 1994) and continued scoring of ozone injury in plots of pine trees located near the monitoring sites.

The six sites were originally selected to satisfy both the needs of the biological effects researchers and meet the meteorological criteria necessary to characterize exposure of pine species to ozone in the immediate vicinity of the sites (Carroll, 1991; 1992; Carroll and Dixon, 1993). The sites range in elevation between 3550 and 6000 feet above mean sea level. Measurements of ozone concentration (differential UV absorption) and meteorological conditions (temperature, humidity, wind speed, wind direction and solar radiation) were recorded with a personal computer-based data acquisition system. The system also monitored several additional variables such as the A/D reference voltage and enclosure temperature. The stations were visited by project personnel approximately biweekly, at which time instrument maintenance was performed as necessary, and the recorded data retrieved via diskette. Two stations, located at learning centers, were operated year round except for a short period in winter used for maintenance and recalibration. Although this exceeds the contract requirements, these stations are used by the learning centers as part of their educational programs and this use is part of our agreements with them. The remaining four sites were deactivated in late fall, 1993, and were reinstalled between late April and early May, 1994, as the sites became physically accessible. All six sites were removed during November and December of 1994.

Tree water potential measurements were performed in order to calculate the available soil moisture at each of the sites. The testing was done at each of the six sites, approximately once every other month, for the latter half of the 1993 season and from June through October, 1994. Actual values for soil moisture have not been calculated yet, but the initial results indicate that available soil moisture decreased throughout the 1993 observation period and during most of the 1994 observation period. During October, 1994, soil moisture increased. This is likely due to the precipitation received at the sites in early October, before the last measurements were taken.

Quality assessment and quality control were performed both by UCD and a subcontractor from San Jose State University (SJSU). UCD maintains transfer standards for ozone, temperature and humidity and performs periodic checks of the wind sensors and radiation instruments. Based on these calibration checks and other data recorded in the monitoring systems and from field logs, data quality information is encoded into the archived records. In addition, the SJSU subcontractors perform two independent audits of each of the stations each year and have the ozone transfer standard checked yearly by the Standards Laboratory of the ARB. The calibration of the ozone transfer standard has changed less than 1.5% over the last 3.5 years.

All of the major objectives have been met -- with the exception of 80% data recovery at all sites. During the 1993 season (May 1 or station start-up, which ever comes later, to October 15), data at White Cloud were lost for intermittent periods totaling 29.7% of the season due to a series of problems with the computer systems, power supply (the power was accidentally shut off by local personnel), ozone monitor and anemometer. However, ozone data were obtained for 82.7% of the season. Problems with the computer systems at Jerseydale and Five Mile caused losses of up to 8% of the data. Power supply problems and ozone analyzer malfunctions at Shaver Lake combined for a 10.1% data loss; while at Sly Park, the 9.1% loss was primarily attributed to a wind direction sensor malfunction. During the 1994 season, data were lost for periods of 31.1% at Mountain Home and 24.6% at Jerseydale due to computer system problems and meteorological instrument malfunctions (wind speed and direction at Mountain Home and ambient temperature sensor at Jerseydale). Both of the meteorological instrument problems occurred early in the season and were solved by the last week of May. Taking this into account, during the period from June 1 to September 30, 1994, data loss at these two sites was almost entirely from computer problems and totalled 24.5% at Mountain Home and 19.9% at Jerseydale. At Shaver Lake, Sly Park and White Cloud, ozone analyzer malfunctions caused data losses of up to 9.7%. Again, all these problems were corrected by the end of May, so that data recovery equaled or exceeded 99% for the period from June 1 to September 30, 1994. Data recovery at Five Mile exceeded 99% for the entire season.

Available literature indicates that needle injury occurs from exposure to ozone concentrations of 60 ppbv, and is significant at and above 80 ppbv (e.g., Hogsett et al., 1985; Miller and Millecan, 1971; Skarby et al., 1987; Williams et al., 1977; Woodman, 1987). The recorded data suggest that serious to severe exposure (> 80 ppbv) of pines to ozone is likely. The data show that ozone concentrations were typically highest in the afternoon hours, and tended to increase toward the southern end of the network. Stations located on well defined steep slopes show a very strong diurnal variation in ozone concentrations and meteorological conditions. Hourly peak ozone concentrations from June through September were greater than 60 ppbv at all sites nearly every day, in excess of 80 ppbv at most sites more than half the days and in excess of 100 ppbv at least a few days a month at all sites and more than half the days at the most impacted site (Mountain Home). At the two sites in the middle of the network (Jerseydale and Five Mile Learning Center) and the northern-most site (White Cloud) the diurnal variations in ozone were not very well pronounced and nighttime values remained relatively high. The differences in the diurnal pattern among sites raises questions about spatial variability and the nature of three dimensional pollutant transport.

The stations at the southern end of the network appear to have higher peak ozone concentrations than those in the north. This latitudinal gradient may also be a result of altitude differences among the sites. The southernmost site, Mountain Home, is also the highest elevation site. It is also not clear whether these observations were due to the trapping of pollutants within or between inversion layers that intersect the slopes, the net accumulation of pollutants as the air traverses the San Joaquin Valley before turning upslope, or due to higher emission rates of primary pollutants in the southern part of the Valley.

RECOMMENDATIONS:

While the primary measurements described here are sufficient to document environmental conditions and ambient air quality, the actual exposures experienced by the trees may not be accurately defined. The literature suggests that injury to plant tissues is due to the flux of ozone into leaves (Coyne and Bingham, 1981; Yang et al., 1983). While ambient air quality can be documented by measurements of ozone concentration, a better indicator of tree exposure is the flux of ozone into the leaves (i.e., the product of ambient ozone concentration and stomatal conductance). Stomatal conductance is a function of air temperature, humidity, available sunlight, moisture status, age and other physiologic factors. Davis (1992) developed a method for estimating stomatal conductance in pine species using meteorological data such as those being collected at the SCOIAS sites.

Striking differences in the pattern of diurnal ozone concentration at White Cloud, Jerseydale and Five Mile compared to the other stations needs further study. Van Ooy and Carroll (1995) examined statistical patterns of the measured variables during 1992. As the data base expands to contain multiple observational periods, the repeatability and detailed nature of these differences can be examined more carefully. These differences in the diurnal pattern among sites raises questions about spatial variability and the nature of three dimensional pollutant transport. Observations over the Central Valley have frequently shown a strong vertical layering of ozone, with elevated layers of high ozone concentrations (> 80 ppbv) persisting through the night (Carroll and Dixon, 1989). These layers can impact the slopes of major topographic features. Given the complexity of the topography at and near the sites being studied, it is strongly recommended that portable ground unit(s) and aircraftborne systems be used to supplement the fixed site measurements and assess whether three dimensional spatial variability is significant in these areas. The airborne observations would also be needed to assess three dimensional transport issues.

## INTRODUCTION:

It has been established in laboratory conditions that ponderosa and Jeffrey pines are susceptible to injury when exposed to ozone (Coyne and Bingham, 1981). Ozone affects various parts of the plant adversely, including specific forms of needle injury observable at the end of a growing season. Chronic exposure and the accompanying injury and stress is believed to be a major threat to the viability of forests in California, including those along the western slopes of the Sierra. The United States Forest Service (USFS), National Parks Service (NPS), University of California, Davis (UCD) and the Air Resources Board (ARB) have established a cooperative study to document ozone exposure and any accompanying injury to selected stands of trees as a means of assessing the impact of ozone on naturally growing trees. The measurement of local concentrations of ozone and meteorological conditions near these stands of trees is the responsibility of the UCD group, and is the subject of this report.

During the summer and fall of 1990 a network of five stations was installed along the foothills of the Sierra Nevada. A sixth station was installed at Shaver Lake in July, 1991. The locations of the sites are shown in Figure 1. Additional information about the sites, including dates of operation, are listed in Table 1. The first five stations were operated in the fall of 1990 and were reinstalled in the spring of 1991 to begin the first full year's operation. Since the observable injury is cumulative, a key requirement of the measurement systems is that they be fully operational at least 80% of the duration of the growing season, which lasts from late April until the end of September. Beginning in late summer, USFS employees and other cooperators, not funded by this project, quantitatively score ozone specific needle injury, if any, and record other information on the health and vitality of the selected groups of trees located near each of the sites.

When the current funding began, all sites were in full operation. The instrumentation at the two learning centers (Five Mile and Sly Park) were operated through the winter of 1993-4 in support of educational programs given at those locations, in accordance with our agreements with the school districts. However, data recovery and quality control procedures are somewhat relaxed during winter periods. Instrumentation from all sites is withdrawn and refurbished prior to the start of the primary data acquisition season.

In addition to the operational tasks required to run the network, the principal investigator participated in the annual training meeting held in June, 1993 to familiarize cooperators with the injury assessment procedures. The principal investigator, project Staff Research Associate and one graduate student attended this meeting in July, 1994. The principal investigator and Staff Research Associate also attended the annual meetings for Project FOREST.

INSTRUMENTATION:

The list of currently recorded variables is contained in Table 2. The initial set of sensors were the wind systems mounted at the top of the towers and the temperature and relative humidity sensors mounted about two meters above the surface. The ozone monitors were located with the data acquisition equipment in weather protected environments. Input to the monitors was through 0.25 inch diameter teflon tubes mounted outdoors, two to three meters aboveground and at least 0.5 meters from extended surfaces such as roofs or walls. Photometric light sensors, sensitive to solar radiation, were installed at the top of the each instrument tower in 1991. These instruments were added to measure solar radiation reaching the trees. This, in addition to the air temperature and humidity data, can be used to estimate stomatal conductance and ozone uptake by the trees (Davis, 1992).

All instruments are calibrated in-house through the data acquisition systems used in the field. The wind speed sensors were calibrated using fixed RPM synchronous motor calibrators corresponding to two wind speeds and a torque watch to check the starting threshold. Starting thresholds and the accuracy of the wind direction sensors were checked. The temperature sensors were checked using a secondary standard, liquid in glass thermometer, and an electronic temperature sensor. The humidity sensors are calibrated in the laboratory with a high quality dew point hygrometer and a psychrometer. An electronic temperature and humidity transfer standard was used for in situ calibration checks during the monitoring season. The ozone monitors were calibrated in the laboratory and in situ using both their internal self-checks and by use of an ozone calibrator/transfer standard checked yearly by the ARB. These checks along with cleaning and filter changes are part of the routine maintenance procedures. The solar radiation instruments were calibrated at the laboratory using an Epply precision pyranometer.

SOFTWARE DEVELOPMENT AND DATA HANDLING:

Flexible, user friendly, data acquisition software have been developed at UCD. The program allows for listing recent data (the last 12 five minute averages or the last 16 hourly averages) to the screen with no interruption of the data acquisition function. This allows convenient access to the data by on-site personnel as well as by service technicians. The software has error trapping capabilities and restarts itself following power failures as well as miscues or unauthorized keyboard requests. The output of the data acquisition system consists of three types of files. The first contains five minute averages of the data sampled at one second intervals and the standard deviation of these data. The second contains a joint distribution table of the number of observations and the average of each variable by octant of wind direction. The third is a log file in which automatic and manual entries can be made describing significant events related to the data logging function such as restarts after power interruptions, use of user interactive features (hot keys) and the like. The format of these files is shown in Table 3. These data are copied onto diskettes for transfer to UCD. The last data copied to the diskette is also saved in a backup directory on the on-site system's hard disk and not deleted until the retrieved raw data has been successfully reduced. The data acquisition program also writes pertinent information to a log file which keeps track of various types of activities on the system.

Data acquired at the sites are processed at UCD using the procedures outlined in Figure 8. Data quality control was assessed from scanning the data themselves, log book entries, interpretation of the on-site log files and from periodic calibration checks. The raw data were transferred to a permanent archive which included a data quality word, as described below. The archive contains both the five minute data and the hourly, event-rose summaries. Each data record or set of records is marked by a data quality word. This word is set up so that each digit represents the data quality code for a particular instrument, as shown in Table 4. For example, if there were seven instruments, there would be seven digits in the quality control word (QCW). For the five minutes of data and its derivatives, there is one QCW per record. For the event data there is one QCW per grouped record. For the event data, if an instrument malfunctions for any part of the time, the whole period is flagged with the most critical code for that instrument. In addition to the data files themselves, summaries of the data quality assessments are kept as individual files at UCD. These are created as input files for programs that create archive files which include the appropriate quality control words.

High resolution digitized topographic data have been obtained from the United States Geological Survey (USGS) and three dimensional plots of the topography near each site, except Jerseydale for which there is no data, have been generated. These plots are shown in Figures 9 though 13. These plots will greatly aid the interpretation of data vis-a-vis local slope winds. When the Sierra topography is viewed at low resolution (e.g., Figure 1 in Appendix C), these sites appear to lie on a smooth surface generally tilting upward to the east-north-east. As such we would expect systematic, diurnal wind patterns like those found at Mountain Home and Sly Park at all sites. In fact (c.f., Appendix C), only these two show regular occurrence of westerlies in the day time and easterlies at night. These are also the only sites located on westward facing slopes above local valleys which extend westward to the Central Valley. Shaver Lake is in a basin with a steep walled valley extending to the northeast and its nocturnal winds are typically from the northeast (i.e., that valley). White Cloud is on a ridge near several intersecting valleys and has essentially no diurnal variation in wind directional frequency. It appears that local topographic details are strongly influencing local wind flow and the pollutant transport to these sites.

PRIMARY RECORD KEEPING:

Several written records of operating procedures, instrument use, and calibration histories are maintained. One is the TRAVELING LOG, in which information on site visits, problems encountered, maintenance performed, calibration data and other pertinent information is recorded. At each station, there is a STATION LOG in which UCD, the SJSU auditors and on-site personnel make entries. The STATION LOG contains a detailed operational history, records of instruments in use (by serial number), calibrations performed and repair and maintenance data. Finally, a MASTER BINDER is maintained at UCD which contains instrument calibration summaries and results, printouts of station on-line log files and QCW applicability files. These QCW files show when systematic corrections were made to the data and their corresponding application periods. This binder contains explanations of QCW non-zero values added to the archived data sets.

SUBCONTRACTOR ACTIVITY:

The primary functions of the subcontractor at SJSU were to provide independent quality assurance audits, to develop a separate data archive and tabulated summaries of hourly data, and to arrange for the certification of the transfer standard. A summary of their activities is contained in Appendix B.

The subcontractor conducted field audits between October 29 and November 1, 1993, between June 21 and 25 and between October 21 and 30 in 1994. The results of these audits were all generally positive. At Jerseydale and Five Mile in the first 1994 audit and at Jerseydale and Mountain Home in the second audit, the subcontractor reported errors between 50% and 150% at the 0 ppbv setting. While the percentage error was large, the absolute error was actually small. If the transfer standard and the ozone analyzer being calibrated are working properly, they will both indicate 9 ppbv when the transfer standard is set at 0 ppbv. This is due to an intentional offset of the instruments' outputs. The inherent noise in the instruments can produce a discrepancy of 3 ppbv and still be within the manufacturer's specifications (Dasibi, 1990). This will result in an error of 3/7, or 43%, at the zero point. At the sites mentioned, high percentage errors were caused by an average absolute error of 6 ppbv. These offsets were then applied to the data. During the first 1994 audit at Jerseydale, the absolute error at the 50 ppbv calibration range averaged 8 ppbv resulting in errors of up to 18%. The remainder of the sites were within 6% of the transfer standard. The second 1994 audit at Jerseydale indicated that the ozone analyzer varied from the transfer standard by up to 16%. A systematic correction for this offset was applied to the data. All of the remaining sites were within 10% of the transfer standard throughout the 50 to 250 ppbv calibration ranges.

A small disparity in the air temperature was found at Shaver Lake, Sly Park and White Cloud during the first 1994 audit, and at Five Mile and Sly Park during the second 1994 audit. Calibrations of all instruments have remained essentially constant except for the ozone monitors. These have shown small changes in the slope of their responses, but all remain near the calibrations established at the start of the season. The data processing programs apply small systematic corrections to the ozone data as well as removing the 9 ppbv offset deliberately set into the units' outputs.

INSTRUMENTATION PERFORMANCE:

The instrument performance is summarized in Table 5 for the 1993 and 1994 observation periods. Tables 5 (a) and (b) both show performance for the primary observation period of May 1 or station start-up, whichever occurs later, to October 15. Table 5 (c) shows the instrument performance for the period June 1 to September 30, 1994. The information is given in terms of the percent of the available hours during which data were lost. These statistics are subdivided in terms of which part of the system failed. At all but one station in 1993, we were able to achieve the targeted 80% data recovery and at all but two in 1994. The problems in 1993 at White Cloud were varied: the power was accidently turned off by local personnel unfamiliar with the equipment; the computer hung-up once; the wind speed problems were difficult to trouble shoot; and one of the internal boards of the ozone monitor needed to be replaced. In 1994, the primary problems at Mountain Home and Jerseydale were computer failures. These computer hang-ups were not repeatable in the laboratory. The meteorological instrument problems were solved before the end of May and did not reoccur. Preliminary analysis of the effect of lost data on seasonally averaged exposure suggest that even with 15 missing days, the seasonal averages vary less than 8% (Van Ooy, 1993).

The last column of the tables lists the percent of the time that the instrument enclosure temperature was greater than 30 °C or less than 20 °C, the values at which the United States Environmental Protection Agency (EPA) warns that the measured ozone concentrations no longer conform to EPA designation requirements (Dasibi, 1990). Tests of these systems in our laboratory to temperatures of 45 °C showed no dependence of the calibration slope or zero on the measuring unit's temperature.

MONITORING RESULTS:

The Sierran sites displayed pronounced differences in both ozone and meteorological patterns throughout the 1993 and 1994 seasons. Shaver Lake experienced the strongest diurnal ranges. Where strong diurnal ranges were observed (i.e., Shaver Lake, Mountain Home and Sly Park) the wind direction during the periods of increasing ozone concentration is predominately upslope, i.e., westerly or south-westerly, depending on the site. Jerseydale, Five Mile and White Cloud had weak diurnal variations in all variables. These last three sites experienced relatively warmer nighttime temperatures, lower nighttime humidities and small diurnal ozone concentration ranges.

Mountain Home and Sly Park both have well defined diurnal patterns in wind speed and direction. These patterns are typical of upslope-downslope mountain wind patterns. Jerseydale has a well defined diurnal pattern in wind direction while wind speed does not. Five Mile has a well defined diurnal pattern in wind speed, but the wind direction does not. White Cloud, located on a ridge, has the least amount of variability in wind direction. With the exception of Sly Park, wind speeds are low at night and increase during the day at the sites.

Ozone frequency distributions for May through October, 1993 and 1994, are shown in Table 6. In this table, the frequency distribution of hourly ozone concentrations is expressed in terms of percent of available data for each station by month. There are two trends discernable from this table. The first is that higher concentrations occurred more often at the southern end of the network than at the northern or central part. At most sites in 1993, the occurrence of higher concentrations was greatest in the months of July, August and September, but in 1994, the highest concentrations occurred in June, July and August. Since the air reaching the southern Sierra has a long fetch through the San Joaquin Valley (which contains a number of urban areas and transportation corridors), it is expected that latitudinal differences are representative and likely to occur every year. This has occurred each year from 1991 to 1994. Second, Mountain Home and Shaver Lake have the largest range of ozone concentrations including higher concentrations than are found at the remaining sites. This broad range of ozone concentrations is the result of greater diurnal variation at these two sites. Jerseydale and Five Mile had a high percentage of observations in a few ozone concentration intervals, indicative of the lack of a diurnal pattern. Sly Park and White Cloud had an intermediate level of variation in diurnal ozone pattern.

Hourly averaged data for each site, for the months of May through October, for 1993 and 1994, are plotted in Appendix A. Tabulated hourly data are contained in Volume 2. The typical diurnal pattern of upslope (westerly) winds during the daytime hours and downslope (easterly) winds at night is quite apparent at Mountain Home, Shaver Lake and Sly Park. Diurnal variations in the meteorological variables occur at Jerseydale and Five Mile but are not very apparent in the ozone data. At White Cloud, only air temperature shows a well defined diurnal pattern. While there are differences among stations, peak ozone concentrations usually occur in the afternoon hours when the upslope flows are well established, winds are strongest and temperatures are highest.

Nighttime minima in ozone concentrations were also different among the stations. Shaver Lake and Sly Park typically dropped the most at night, frequently reaching minima of 20 ppbv. Conversely, the other sites frequently had nighttime minima in excess of 60 ppbv. Some of the higher concentrations of ozone observed at White Cloud were found after sunset. This pattern appears regularly enough to suggest that the trajectory from the Sacramento valley is not directly from the Sacramento area to White Cloud. During travel ozone is formed, but not destroyed, indicating no nitric oxide (NO) emissions along the path and only limited contact with the ground occurs.

Clearly, several of the sites experienced ozone concentrations that can be injurious to vegetation. What is somewhat surprising is that in some cases, ozone concentrations remained high at night, while others did not, even with downslope flows. Given the distance these sites are from NO emission sources, the nocturnal ozone concentrations appear to be controlled by transport processes rather than by chemical processes (Lefohn and Pinkerton, 1988). These observations point to the need to examine fairly complex three dimensional transport hypotheses and appropriate three dimensional sampling to verify those selected.

COMPARISONS WITH OTHER DATA:

During the latter part of the 1993 season and throughout 1994, tree water potential measurements were performed. Trees were sampled at each site about every other month between June and November using the Scholander pressure-chamber technique (Koide et al., 1991). The pressure-chamber technique measures the tree's hydrostatic pressure which is approximately equal to the water potential when the tree is in equilibrium. The samples taken at each site were done during the two hours preceding sunrise since this is when the tree is in equilibrium. At individual sites, five trees were selected and one twig (about 1 cm in diameter) from each tree was used for measurement. Prior to removing the sample twig from the tree, the needles were enclosed in a plastic bag to prevent water loss during the measurement period. Once excised with a sharp razor blade, the sample was placed in the chamber with only the stem protruding from a rubber gasket which sealed the chamber. The chamber was then pressurized with nitrogen, and the exposed surface of the twig was examined with a dissecting microscope. The pressure was recorded when water first appeared on the cut surface. The results of these pressure-chamber measurements appear in Table 7 and Figure 14.

Actual values for soil moisture have not been calculated yet, but the initial results indicate that available soil moisture decreased throughout the 1993 observation period and during most of the 1994 observation period. During October, 1994, soil moisture increased at half of the measured sites. This is likely due to the precipitation received at the sites in early October, before the last measurements were taken. A comparison of the July/August 1993 and August 1994 results indicates the soil moisture at five sites in 1994 was less than at the same sites in 1993 with large differences occurring at Jerseydale and Sly Park. The winter preceding the 1993 season had substantially more precipitation than before the 1994 season, thus indicating a plausible reason for the soil moisture differences between years. Since transpiration is influenced by available soil moisture (Rundel and Jarrell, 1991) and ozone injury results from ozone uptake through stomata during transpiration, a more accurate estimate of ozone uptake could be obtained by using measured values of available soil moisture, instead of a fixed estimate, in stomatal conductance models (e.g., Davis, 1992).

With additional funding from the EPA in cooperation with Dr. P. Miller, USDA Forest Service at Riverside, we are examining relationships between ambient ozone concentrations and pine injury data collected by Project Forest cooperators. This is an on going effort but preliminary results indicate that chlorotic mottle increases with frequency of occurrence of ozone greater than 60 ppbv - especially on needles experiencing multiple year exposures. Similarly, it appears the fascicle retention declines with multiple year exposures to ozone greater than 100 ppbv. The continuing work seeks to determine the index that correlates best with measured injury.

## GENERAL CONCLUSIONS:

During the period of study (i.e., mid June to late September, 1991-1994), we have found occurrences of high ozone concentrations (greater than 90 ppbv) at all sites. Slopes east of the southern San Joaquin Valley frequently have high values of ozone. The diurnal patterns of air flow and ozone concentration are quite different among sites: three exhibit moderate to strong diurnal ozone variations with late afternoon peaks, three do not. The inter-annual variability of seasonal averages or histograms is small at each site and much smaller than the variability among sites. The effect of missing data on the seasonal statistics is small so long as less than 20% of the data are missing. The four years' data sets coupled with forest injury data should allow more precise delineation of exposure-response relationships for ozone and pines leading to more defensible ecological risk assessments.

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TABLE 1
SIERRA OZONE ASSESSMENT SITE CHARACTERISTICS

| NO. | NAME | NATIONAL FOREST | ELEV. (FEET) | COOPER-ATOR | WIND TOWER HEIGHT | OPERATING DATES |
|---|---|---|---|---|---|---|
| 1. | MOUNTAIN HOME | SEQUOIA | 6000 | CDF | 17m (56') | 10/10/90-11/12/90<br>5/25/91-11/07/91<br>5/14/92-11/12/92<br>5/10/93-10/16/93<br>5/05/94-10/30/94 |
| 2. | SHAVER LK. | SIERRA | 5650 | SCE | 12m (40') | 7/24/91-11/08/91<br>5/13/92-11/11/92<br>5/11/93-11/02/93<br>5/04/94-11/09/94 |
| 3. | JERSEYDALE | SIERRA | 3750 | USFS | 17m (56') | 9/21/90-12/18/90<br>5/09/91-11/08/91<br>4/23/92-11/11/92<br>4/28/93-12/02/93<br>4/27/94-11/09/94 |
| 4. | FIVE MILE LEARNING CENTER | STANIS-LAUS | 4000 | CLOVIS SCH. DISTRICT | 12m (40') | 12/05/90-11/21/91<br>1/07/92-12/22/92<br>1/26/93-11/28/93<br>1/11/94-12/20/94 |
| 5. | SLY PARK | ELDORADO | 3550 | SACRA. SCH. DISTRICT | 17m (56') | 10/30/90-12/22/92<br>1/15/93-12/14/93<br>3/23/94-12/21/94 |
| 6. | WHITE CLOUD | TAHOE | 4350 | USFS | 12m (40') | 9/26/90-11/28/90<br>4/23/91-11/14/91<br>4/27/92-11/19/92<br>4/27/93-11/18/93<br>4/28/94-11/21/94 |

TABLE 2
INSTRUMENT AND EQUIPMENT VENDORS:

| Vendor | Equipment | Model |
|---|---|---|
| Met-One | Temperature, Humidity | 083-1,1760TS-1760G |
| | Wind Speed | 014-1,1680-1812 |
| | Wind Direction | 024-1,1690-2106 |
| DASIBI | Ozone Monitor | 1008 AH |
| | Ozone Calibrator | 1008 PC |
| LI-COR | Solar Radiation | 200-SZ |
| DCL Computers | Data acquisition | DFID11XT |
| Tri-Ex Tower Corp, | 50' Telescoping Tower | W7-51 |
| | 33' Telescoping Tower | MW-33 |
| Keithly/Metrabyte | 8 channel MUX-A/D | STA-8PGA |

TABLE 3
DATA FILE STRUCTURES:

Definitions:

DD = Wind direction
RH = Relative humidity
$O_3$ = Ozone concentration
v = South to north wind component
S = Solar radiation
FF = Wind speed
Ta = Temperature
Tb = Enclosure temperature
u = West to east wind component
R = Reference 5 volts

LOG FILES:

- Date and time of program restarts (e.g. after operational maintenance, or power failures); of data acquisition interruptions due to use of "hot keys"; counts of instrument's error flag and manually entered notes.

ON-LINE FIVE MINUTE FILES

- Month, day, year, hour, minute, station number
- Number of obs., DD, FF, u, v, Ta, RH, $O_3$, Tb, S, R
  Rms (DD, FF, u, v, Ta, RH, $O_3$, Tb, S, R)

Twelve entries per hour, 24 hours per day. Data appended to these files every five minutes.

TABLE 3 (CONTINUED)

ON-LINE HOURLY SUMMARY WIND & EVENT FILES:

- Month, day, year, hour, minute, station number
- Event distribution by octants in the wind direction:

| Wind Dir. (Deg.) | Number of Obs. (count) | Average FF (m/s) | Average RH (%) | Average Ta (°C) | Average $O_3$ (ppbv) |
|---|---|---|---|---|---|
| CALM | 71 | 0.0 | 42 | 12.5 | 55 |
| 22.6 - 67.5 | 1647 | 1.9 | 38 | 13.6 | 59 |
| 67.5 - 112.5 | 1231 | 1.6 | 38 | 13.5 | 59 |
| . | . | . | . | . | . |
| . | . | . | . | . | . |
| . | . | . | . | . | . |
| 292.6 - 337.5 | 36 | 1.9 | 37 | 13.5 | 57 |
| 337.6 - 22.5 | 179 | 1.8 | 38 | 13.6 | 58 |

ARCHIVED FIVE MINUTE AVERAGE FILES:

-- Date (julian day), year, number of records, station
-- Time, Ave (DD,FF,u,v,Ta,RH,O,S), RMS (DD,FF,Ta,RH,O,S), QCW

UP TO 24 HOURS WORTH

ARCHIVED HOURLY EVENT DATA:

-- Julian day, year, number of data blocks, station.

-- Decimal hour, and QCW for the hour.
-- # of observations by wind direction.
-- Average wind speed "
-- Average humidity "
-- Average temperature "
-- Average ozone "

Repeat for each hour of the day for which data are available.

TABLE 4
SCOIAS DATA QUALITY CODES.

The values for the codes are as follows:

0 No known problems. Calibration corrections have been applied. Data should be fine.
1 No calibration corrections have been applied or no calibration correction available.
2 Systematic error adjustments applied or data corrected for noisy signal.
3 Data not representative, non-standard exposure (test).
4 Data not representative, cold start/warm up period.
5 Data questionable, malfunction suspected.
6 Data is no good, instrument malfunction.
7 Data is no good, instrument not connected or inoperative.
8 Used for TBOX only, means shelter temperature is outside EPA specified limits for the DASIBI monitors.
9 N/A

| Digit: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| QCW = | S | DD | FF | RH | TEMP. | OZONE | TBOX |

NOTE: Due to instrument warm up requirements, ozone data are flagged "4" for one-half hour following restarting after a power failure.

TABLE 5 (a)
Summary of operational performance for 1993 primary observing season.

| No. | Name | Dates of Operation | Percent of time data missed due to: I | II | III | IV | V | Total | % time T ≠ EP |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Mtn Home | 5/10 - 10/15 | 2.6 | 0.0 | 0.0 | 0.0 | 0.4 | 3.1 | <1 |
| 2 | Shaver Lk | 5/11 - 10/15 | 0.0 | 6.0 | 3.8 | 0.0 | 0.3 | 10.1 | 37 |
| 3 | Jerseydale | 5/01 - 10/15 | 5.9 | 0.1 | 1.5 | 0.0 | 0.4 | 7.9 | 52 |
| 4 | Five Mile | 5/01 - 10/15 | 4.5 | 0.2 | 0.1 | 0.0 | 0.3 | 5.2 | 11 |
| 5 | Sly Park | 5/01 - 10/15 | 0.5 | 0.3 | 0.1 | 7.7 | 0.5 | 9.1 | 9 |
| 6 | White Cld | 5/01 - 10/15 | 3.7 | 5.4 | 8.1 | 12.1 | 0.5 | 29.7 | 46 |

TABLE 5 (b)
Summary of operational performance for 1994 primary observing season.

| No. | Name | Dates of Operation | Percent of time data missed due to: I | II | III | IV | V | Total | % time T ≠ EP |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Mtn Home | 5/05 - 10/15 | 18.0 | 0.0 | 0.0 | 12.8 | 0.2 | 31.1 | 1 |
| 2 | Shaver Lk | 5/04 - 10/15 | 0.0 | 0.4 | 4.8 | 0.0 | 0.1 | 5.3 | NA |
| 3 | Jerseydale | 5/01 - 10/15 | 14.7 | 0.1 | 2.3 | 7.2 | 0.2 | 24.6 | 85 |
| 4 | Five Mile | 5/01 - 10/15 | 0.0 | 0.5 | 0.1 | 0.0 | 0.3 | 0.9 | 12 |
| 5 | Sly Park | 5/01 - 10/15 | 0.0 | 0.9 | 6.8 | 1.6 | 0.4 | 9.7 | 72 |
| 6 | White Cld | 5/01 - 10/15 | 0.0 | 0.1 | 8.1 | 0.0 | 0.2 | 8.4 | 55 |

TABLE 5 (c)
Summary of operational performance for 1994 alternate observing season.

| No. | Name | Dates of Operation | Percent of time data missed due to: I | II | III | IV | V | Total | % time T ≠ EP |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Mtn Home | 6/01 - 9/30 | 24.2 | 0.0 | 0.0 | 0.0 | 0.3 | 24.5 | <1 |
| 2 | Shaver Lk | 6/01 - 9/30 | 0.0 | 0.4 | 0.0 | 0.0 | 0.1 | 0.5 | NA |
| 3 | Jerseydale | 6/01 - 9/30 | 16.4 | 0.1 | 3.2 | 0.0 | 0.2 | 19.9 | 96 |
| 4 | Five Mile | 6/01 - 9/30 | 0.0 | 0.6 | 0.1 | 0.0 | 0.3 | 1.1 | 15 |
| 5 | Sly Park | 6/01 - 9/30 | 0.0 | 0.4 | 0.0 | 0.1 | 0.5 | 1.0 | 83 |
| 6 | White Cld | 6/01 - 9/30 | 0.0 | 0.2 | 0.3 | 0.0 | 0.3 | 0.8 | 65 |

I = Computer system failures.
II = AC power failures.
III = Ozone monitor problems.
IV = Meteorological instrument failures.
V = Operational maintenance.
EP = EPA temperature range of 20 to 30 °C.

TABLE 6 (a)
Percent of hourly average ozone concentrations by month (1993) and station for concentration ranges shown.

| | Ozone Concentrations (ppbv) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | < 50 | 50-59 | 60-69 | 70-79 | 80-89 | 90-99 | 100-109 | 110-119 | > 119 |
| MOUNTAIN HOME: | | | | | | | | | |
| May | 57.3 | 17.6 | 10.8 | 9.0 | 4.3 | 1.0 | 0.0 | 0.0 | 0.0 |
| June | 28.2 | 16.5 | 15.4 | 14.3 | 11.7 | 8.3 | 4.2 | 1.5 | 0.0 |
| July | 19.5 | 8.4 | 16.1 | 18.0 | 13.0 | 10.6 | 8.7 | 3.4 | 2.2 |
| August | 20.9 | 16.6 | 15.7 | 16.8 | 14.6 | 8.1 | 4.5 | 2.3 | 0.5 |
| September | 19.9 | 17.1 | 21.0 | 18.5 | 12.1 | 6.5 | 3.2 | 1.1 | 0.7 |
| October | 54.2 | 14.2 | 12.2 | 10.0 | 5.6 | 2.8 | 1.1 | 0.0 | 0.0 |
| SHAVER LAKE: | | | | | | | | | |
| May | 65.4 | 11.7 | 15.8 | 4.9 | 2.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| June | 54.5 | 11.2 | 11.8 | 10.0 | 6.7 | 4.5 | 1.0 | 0.4 | 0.0 |
| July | 50.6 | 6.9 | 10.4 | 10.9 | 11.4 | 5.9 | 2.9 | 1.0 | 0.0 |
| August | 55.1 | 9.4 | 9.7 | 11.6 | 7.7 | 3.1 | 1.9 | 0.5 | 0.9 |
| September | 52.9 | 10.2 | 11.6 | 12.3 | 9.9 | 2.1 | 0.8 | 0.1 | 0.0 |
| October | 72.2 | 12.8 | 8.5 | 3.4 | 1.2 | 0.9 | 0.8 | 0.1 | 0.0 |
| JERSEYDALE: | | | | | | | | | |
| May | 49.6 | 24.1 | 19.4 | 5.8 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| June | 37.9 | 21.6 | 26.0 | 10.9 | 3.0 | 0.6 | 0.0 | 0.0 | 0.0 |
| July | 4.3 | 15.2 | 25.9 | 33.3 | 16.4 | 4.0 | 0.6 | 0.1 | 0.1 |
| August | 10.0 | 18.0 | 39.3 | 23.6 | 7.2 | 1.4 | 0.6 | 0.0 | 0.0 |
| September | 11.2 | 14.7 | 25.0 | 32.5 | 12.7 | 3.6 | 0.3 | 0.0 | 0.0 |
| October | 33.5 | 20.2 | 19.4 | 14.4 | 7.5 | 4.4 | 0.5 | 0.0 | 0.0 |
| FIVE MILE: | | | | | | | | | |
| May | 53.1 | 24.8 | 16.3 | 5.2 | 0.5 | 0.1 | 0.0 | 0.0 | 0.0 |
| June | 41.6 | 24.1 | 22.7 | 7.0 | 4.0 | 0.7 | 0.0 | 0.0 | 0.0 |
| July | 7.2 | 7.7 | 27.3 | 28.0 | 21.4 | 7.4 | 1.1 | 0.0 | 0.0 |
| August | 15.3 | 23.0 | 26.9 | 22.6 | 10.9 | 1.4 | 0.0 | 0.0 | 0.0 |
| September | 10.9 | 14.4 | 35.1 | 24.1 | 12.5 | 2.8 | 0.1 | 0.0 | 0.0 |
| October | 45.5 | 24.1 | 16.5 | 8.0 | 5.7 | 0.3 | 0.0 | 0.0 | 0.0 |
| SLY PARK: | | | | | | | | | |
| May | 76.7 | 11.7 | 9.2 | 1.8 | 0.4 | 0.3 | 0.0 | 0.0 | 0.0 |
| June | 65.8 | 14.7 | 11.9 | 5.3 | 1.7 | 0.6 | 0.0 | 0.0 | 0.0 |
| July | 42.6 | 22.1 | 16.2 | 11.5 | 6.4 | 1.2 | 0.0 | 0.0 | 0.0 |
| August | 45.8 | 23.5 | 15.0 | 10.3 | 4.1 | 1.0 | 0.0 | 0.3 | 0.0 |
| September | 39.4 | 20.2 | 21.5 | 12.3 | 3.8 | 1.8 | 0.8 | 0.1 | 0.0 |
| October | 75.1 | 10.3 | 9.5 | 3.2 | 1.1 | 0.6 | 0.1 | 0.0 | 0.0 |
| WHITE CLOUD: | | | | | | | | | |
| May | 52.8 | 26.5 | 16.9 | 3.3 | 0.1 | 0.3 | 0.1 | 0.0 | 0.0 |
| June | 62.3 | 19.1 | 9.6 | 6.9 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| July | 34.1 | 29.9 | 19.1 | 10.2 | 5.6 | 0.4 | 0.4 | 0.2 | 0.0 |
| August | 24.4 | 23.8 | 21.6 | 18.0 | 9.5 | 1.5 | 1.0 | 0.2 | 0.0 |
| September | 22.1 | 28.2 | 30.5 | 16.1 | 2.0 | 0.3 | 0.8 | 0.0 | 0.0 |
| October | 66.3 | 20.4 | 8.8 | 3.9 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 |

TABLE 6 (b)
Percent of hourly average ozone concentrations by month (1994) and station for concentration ranges shown.

| Month | < 50 | 50-59 | 60-69 | 70-79 | 80-89 | 90-99 | 100-109 | 110-119 | > 119 |
|---|---|---|---|---|---|---|---|---|---|
| | Ozone Concentrations (ppbv) | | | | | | | | |
| MOUNTAIN HOME: | | | | | | | | | |
| May | 60.6 | 12.2 | 9.7 | 8.8 | 5.9 | 2.8 | 0.0 | 0.0 | 0.0 |
| June | 27.9 | 9.7 | 14.9 | 12.6 | 11.8 | 11.2 | 4.8 | 4.1 | 3.1 |
| July | 8.4 | 8.7 | 14.4 | 18.0 | 20.5 | 15.6 | 8.0 | 5.8 | 0.6 |
| August | 7.3 | 7.0 | 12.7 | 22.4 | 24.4 | 13.4 | 8.5 | 4.3 | 0.0 |
| September | 30.1 | 12.5 | 14.0 | 21.5 | 13.1 | 6.9 | 1.8 | 0.0 | 0.0 |
| October | 61.0 | 16.5 | 8.1 | 8.9 | 4.4 | 1.2 | 0.0 | 0.0 | 0.0 |
| SHAVER LAKE: | | | | | | | | | |
| May | 65.6 | 9.7 | 10.6 | 9.3 | 3.0 | 1.3 | 0.4 | 0.0 | 0.0 |
| June | 58.7 | 10.6 | 12.8 | 6.8 | 5.0 | 3.4 | 2.1 | 0.6 | 0.0 |
| July | 37.7 | 13.1 | 9.7 | 11.3 | 10.0 | 8.4 | 5.7 | 2.6 | 1.6 |
| August | 33.6 | 16.8 | 12.8 | 11.3 | 10.8 | 8.3 | 4.0 | 1.5 | 1.0 |
| September | 55.7 | 13.2 | 14.3 | 7.8 | 5.7 | 2.6 | 0.6 | 0.3 | 0.0 |
| October | 77.5 | 11.0 | 7.6 | 2.8 | 0.8 | 0.3 | 0.0 | 0.0 | 0.0 |
| JERSEYDALE: | | | | | | | | | |
| May | 67.5 | 18.6 | 9.7 | 4.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| June | 36.8 | 26.6 | 25.2 | 9.6 | 1.6 | 0.2 | 0.0 | 0.0 | 0.0 |
| July | 5.1 | 13.4 | 22.9 | 32.1 | 21.0 | 4.3 | 1.1 | 0.2 | 0.0 |
| August | 7.7 | 12.2 | 47.7 | 22.1 | 7.2 | 2.0 | 1.2 | 0.0 | 0.0 |
| September | 24.7 | 24.2 | 25.5 | 23.2 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| October | 54.9 | 19.8 | 17.8 | 7.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| FIVE MILE: | | | | | | | | | |
| May | 51.6 | 18.5 | 23.0 | 5.0 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| June | 27.9 | 19.9 | 23.8 | 18.5 | 8.6 | 1.4 | 0.0 | 0.0 | 0.0 |
| July | 5.7 | 12.9 | 21.9 | 33.4 | 18.7 | 4.9 | 2.0 | 0.5 | 0.0 |
| August | 4.5 | 10.9 | 28.9 | 37.1 | 14.9 | 3.2 | 0.6 | 0.0 | 0.0 |
| September | 14.7 | 20.2 | 24.6 | 26.9 | 13.0 | 0.6 | 0.0 | 0.0 | 0.0 |
| October | 42.7 | 21.5 | 16.8 | 16.6 | 2.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| SLY PARK: | | | | | | | | | |
| May | 74.4 | 15.3 | 6.5 | 3.2 | 0.4 | 0.2 | 0.0 | 0.0 | 0.0 |
| June | 60.7 | 18.4 | 11.4 | 6.9 | 2.0 | 0.6 | 0.1 | 0.0 | 0.0 |
| July | 40.8 | 21.0 | 19.9 | 10.5 | 5.2 | 2.0 | 0.5 | 0.0 | 0.0 |
| August | 43.5 | 23.8 | 19.8 | 9.3 | 3.0 | 0.7 | 0.0 | 0.0 | 0.0 |
| September | 62.2 | 18.3 | 13.8 | 4.3 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| October | 81.4 | 9.4 | 6.7 | 2.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| WHITE CLOUD: | | | | | | | | | |
| May | 27.1 | 34.6 | 28.7 | 8.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| June | 32.0 | 19.6 | 16.6 | 17.8 | 8.3 | 4.1 | 1.1 | 0.4 | 0.0 |
| July | 9.2 | 10.5 | 29.0 | 30.0 | 14.0 | 4.7 | 1.5 | 0.8 | 0.4 |
| August | 8.5 | 15.6 | 31.7 | 22.6 | 15.3 | 5.5 | 0.7 | 0.1 | 0.0 |
| September | 21.6 | 26.1 | 27.0 | 18.2 | 5.7 | 1.4 | 0.1 | 0.0 | 0.0 |
| October | 51.7 | 19.8 | 13.7 | 13.1 | 1.3 | 0.4 | 0.0 | 0.0 | 0.0 |

TABLE 7 (a)

Results of 1993 tree water potential measurements (bars).

| STATION | JUL-AUG mean | JUL-AUG rms | SEPTEMBER mean | SEPTEMBER rms | OCTOBER mean | OCTOBER rms |
|---|---|---|---|---|---|---|
| MOUNTAIN HOME | -5.08 | 0.54 | -5.56 | 0.51 | -5.30 | 0.80 |
| SHAVER LAKE | -4.16 | 0.55 | -6.00 | 2.08 | -5.50 | 1.62 |
| JERSEYDALE | -5.34 | 0.68 | -8.08 | 0.70 | -8.36 | 0.75 |
| FIVE MILE | -5.64 | 0.80 | -6.90 | 1.35 | -7.14 | 1.13 |
| SLY PARK | -6.78 | 0.82 | -8.18 | 1.27 | -7.58 | 0.78 |
| WHITE CLOUD | -5.54 | 0.67 | -6.84 | 0.81 | -6.14 | 0.65 |

TABLE 7 (b)

Results of 1994 tree water potential measurements (bars).
(Missing data = 99.99)

| STATION | JUNE mean | JUNE rms | JULY mean | JULY rms | AUGUST mean | AUGUST rms | OCT-NOV mean | OCT-NOV rms |
|---|---|---|---|---|---|---|---|---|
| MOUNTAIN HOME | -4.82 | 0.49 | -5.00 | 0.57 | -4.52 | 0.91 | 99.99 | 0.00 |
| SHAVER LAKE | -4.10 | 0.37 | 99.99 | 0.00 | -6.12 | 0.94 | 99.99 | 0.00 |
| JERSEYDALE | -7.10 | 1.10 | 99.99 | 0.00 | -13.94 | 1.10 | -5.36 | 0.54 |
| FIVE MILE | -5.46 | 0.74 | 99.99 | 0.00 | -6.82 | 2.33 | -7.08 | 2.17 |
| SLY PARK | -4.80 | 0.64 | -8.20 | 1.88 | -11.62 | 2.59 | -8.74 | 0.96 |
| WHITE CLOUD | -4.94 | 0.63 | -5.24 | 0.69 | -8.06 | 1.65 | -9.66 | 2.07 |

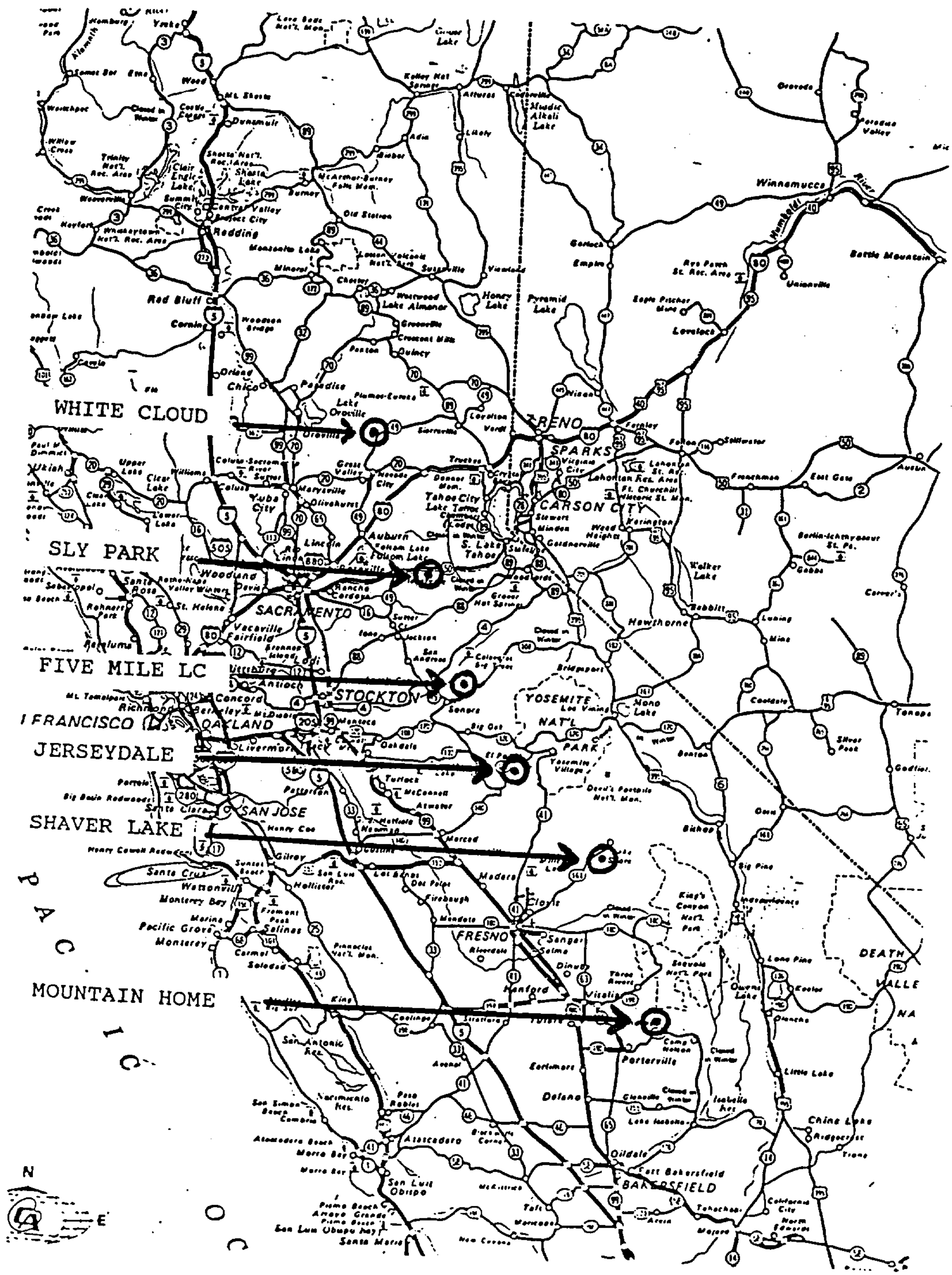



Figure 1. Map of central California showing the approximate locations of the ozone monitoring sites.

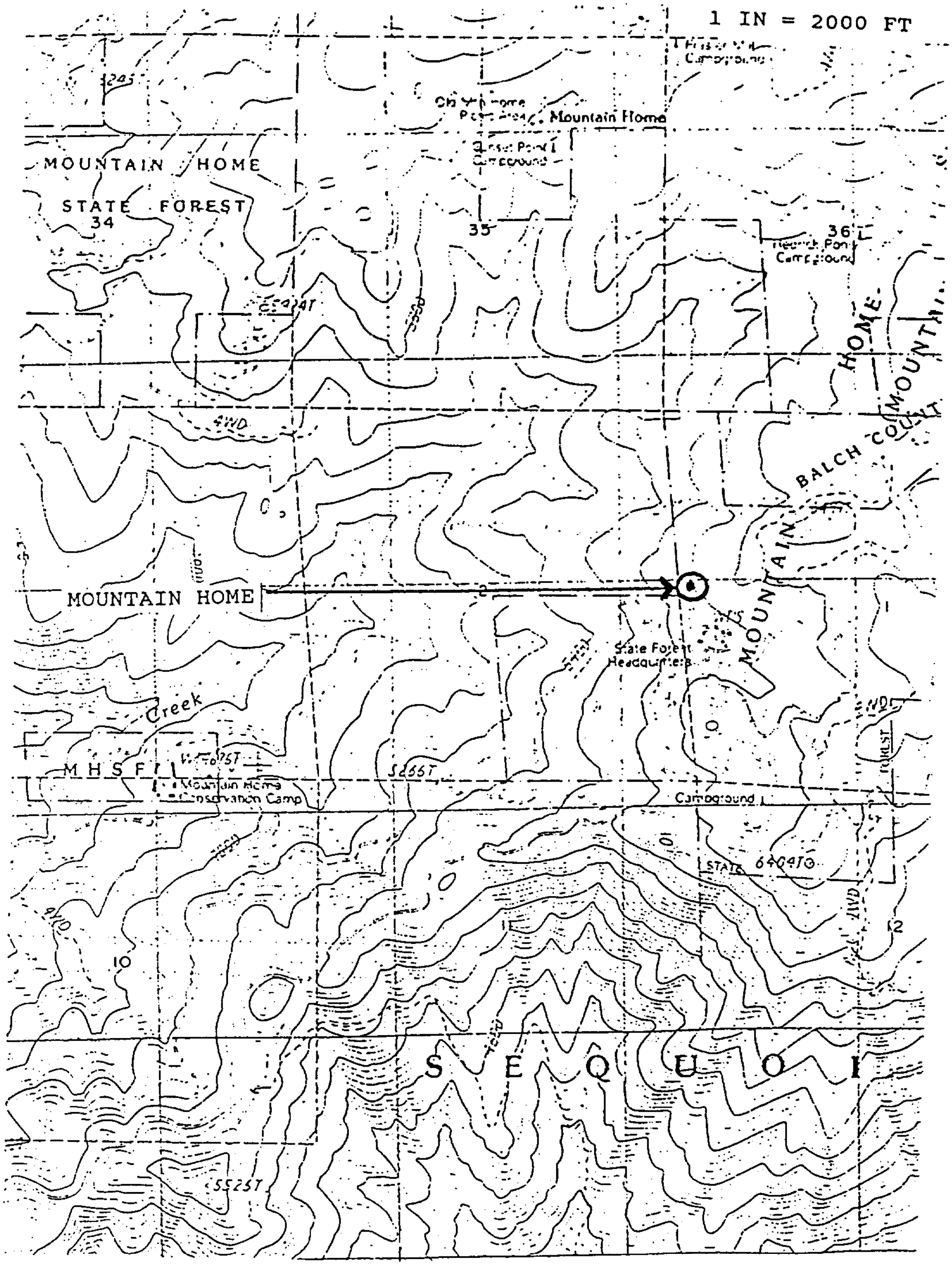



Figure 2. Detailed map of the Mountain Home area showing the location of the UCD - SCOIAS instrumentation.

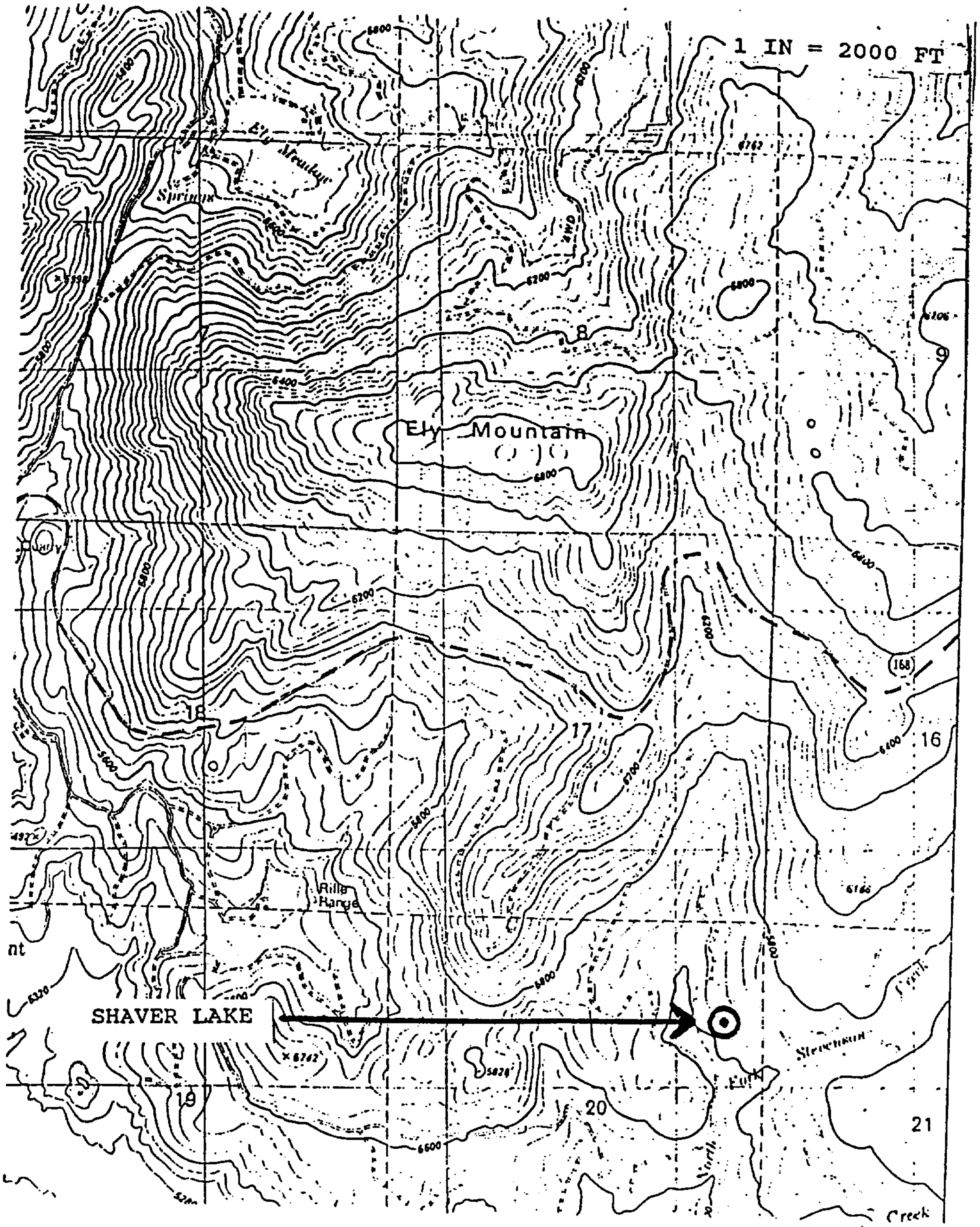



Figure 3. Detailed map of the Shaver Lake area showing the location of the UCD - SCOIAS instrumentation.

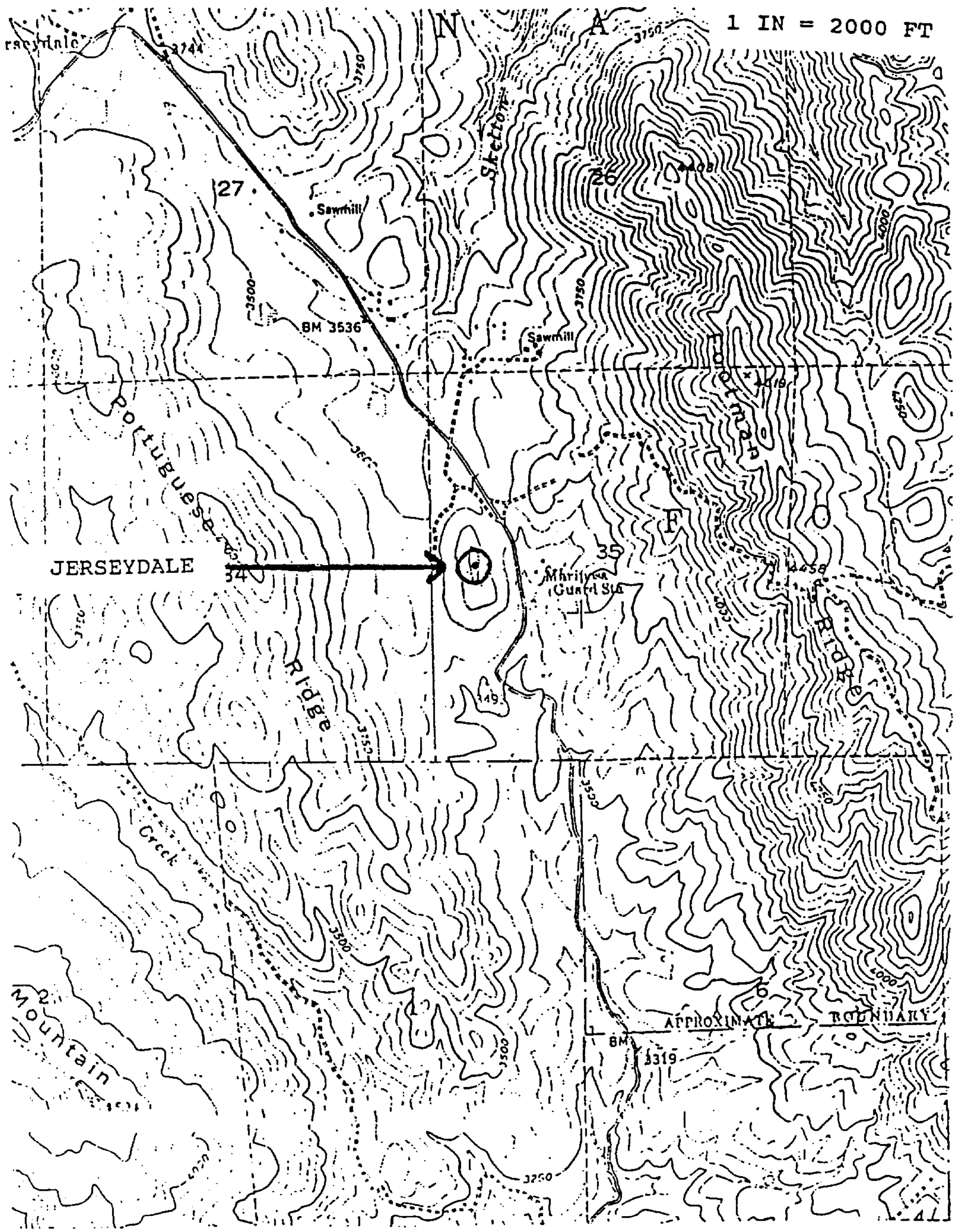



Figure 4. Detailed map of the Jerseydale area showing the location of the UCD - SCOIAS instrumentation.

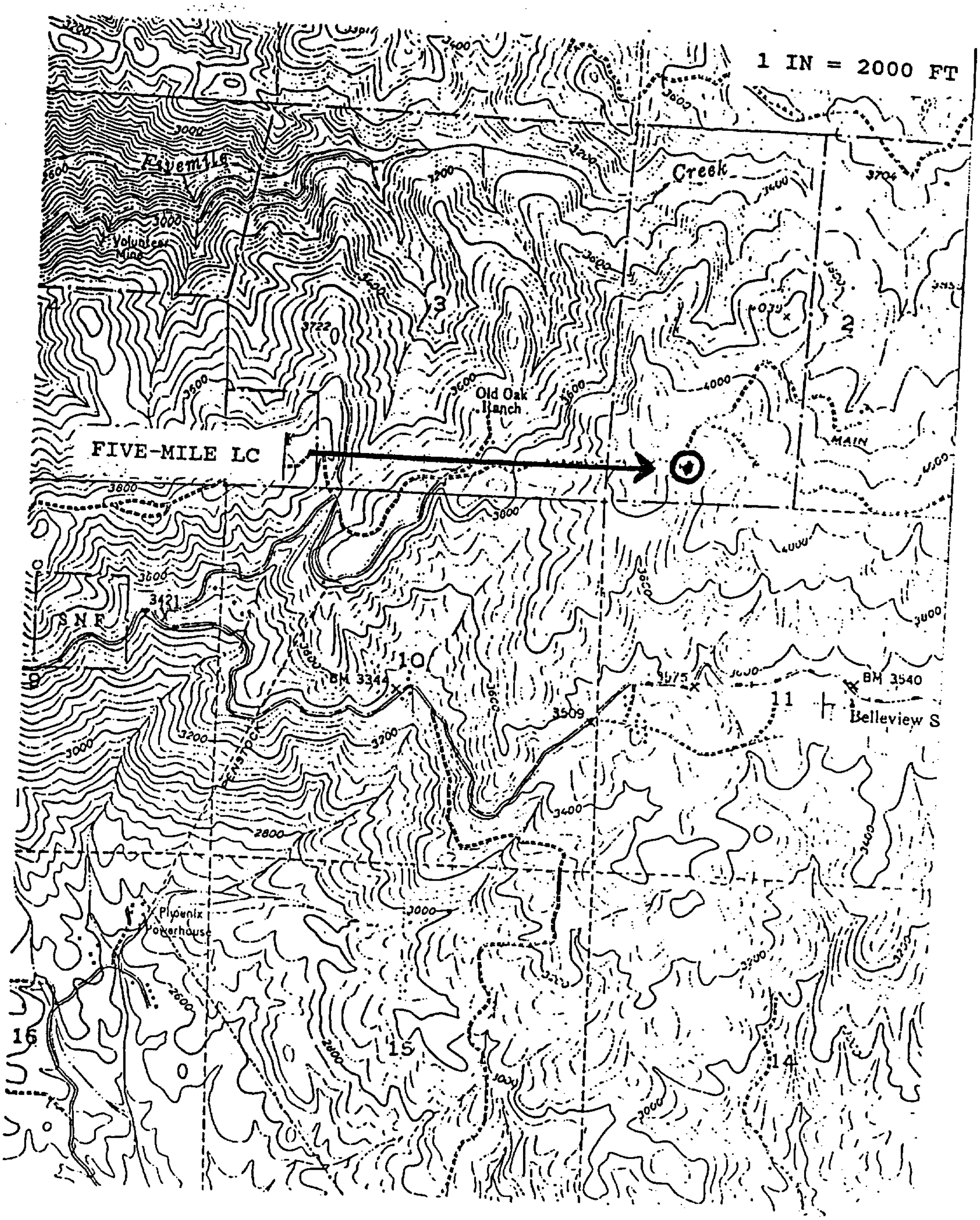



Figure 5. Detailed map of the Five Mile Learning Center area showing the location of the UCD - SCOIAS instrumentation.

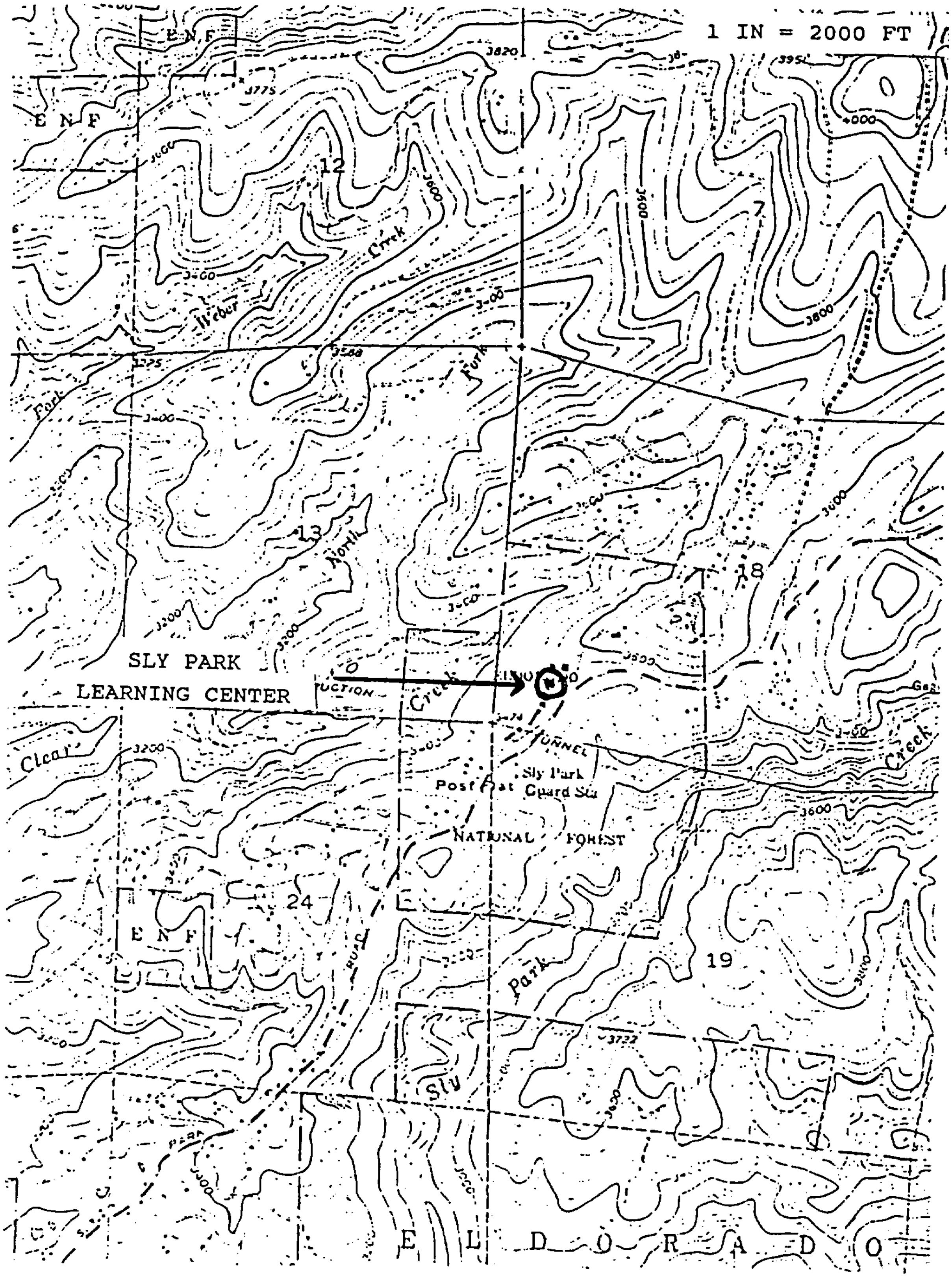



Figure 6. Detailed map of the Sly Park Learning Center area showing the location of the UCD - SCOIAS instrumentation.

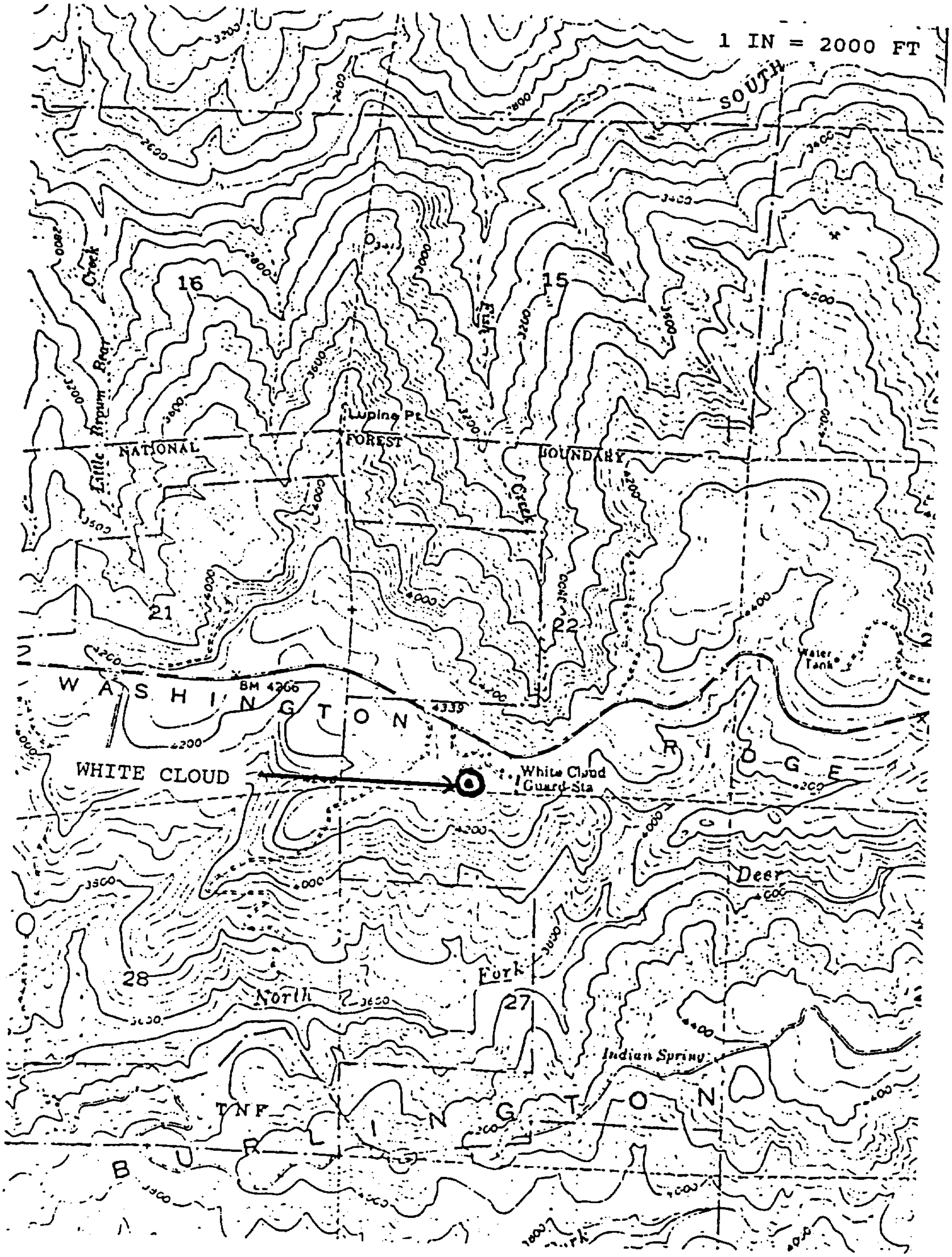



Figure 7. Detailed map of the White Cloud area showing the location of the UCD - SCOIAS instrumentation.

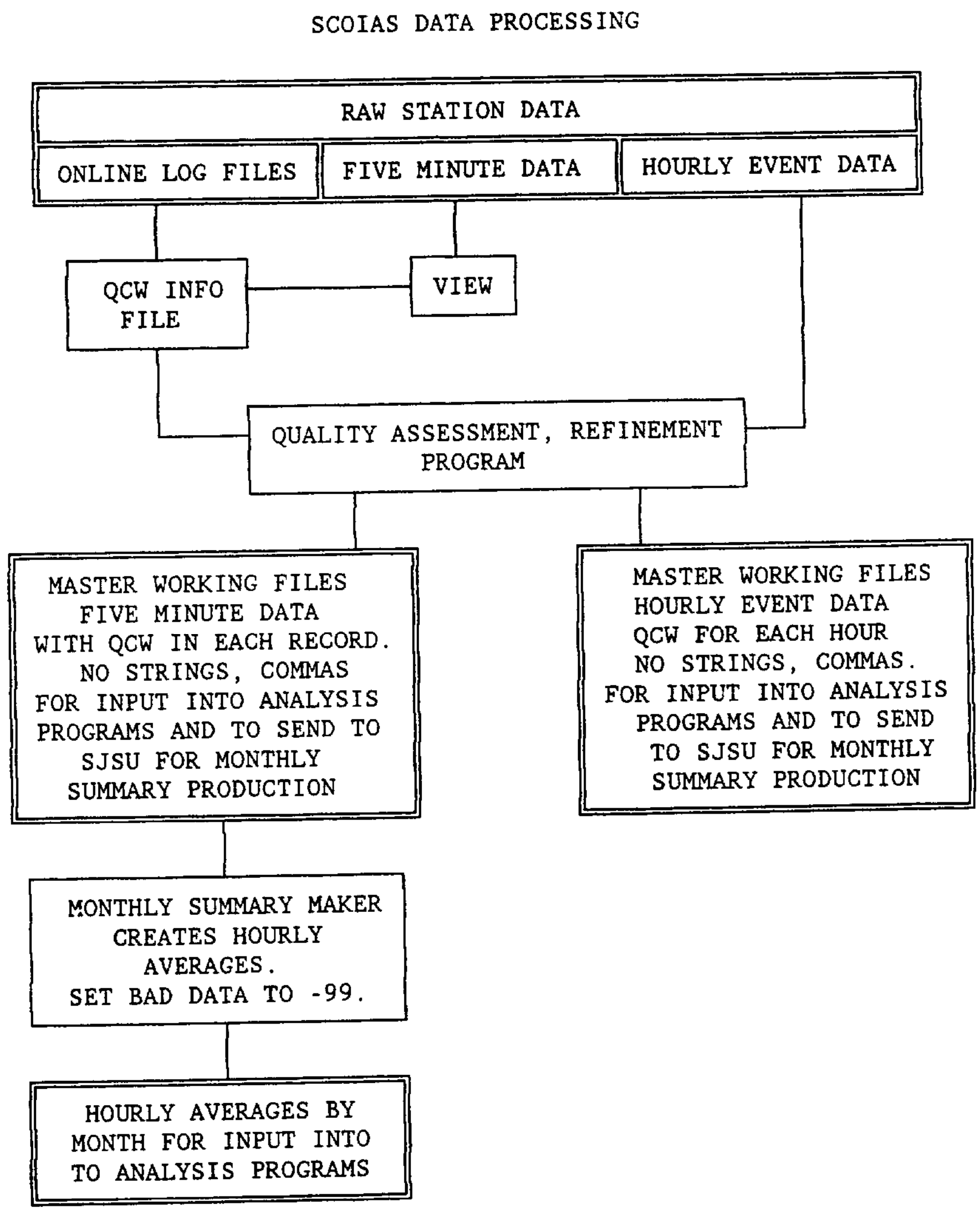



Figure 8. Summary of the SCOIAS data processing procedures. Boxes with double outline indicate data files. Boxes with single outlines represent data processing programs.

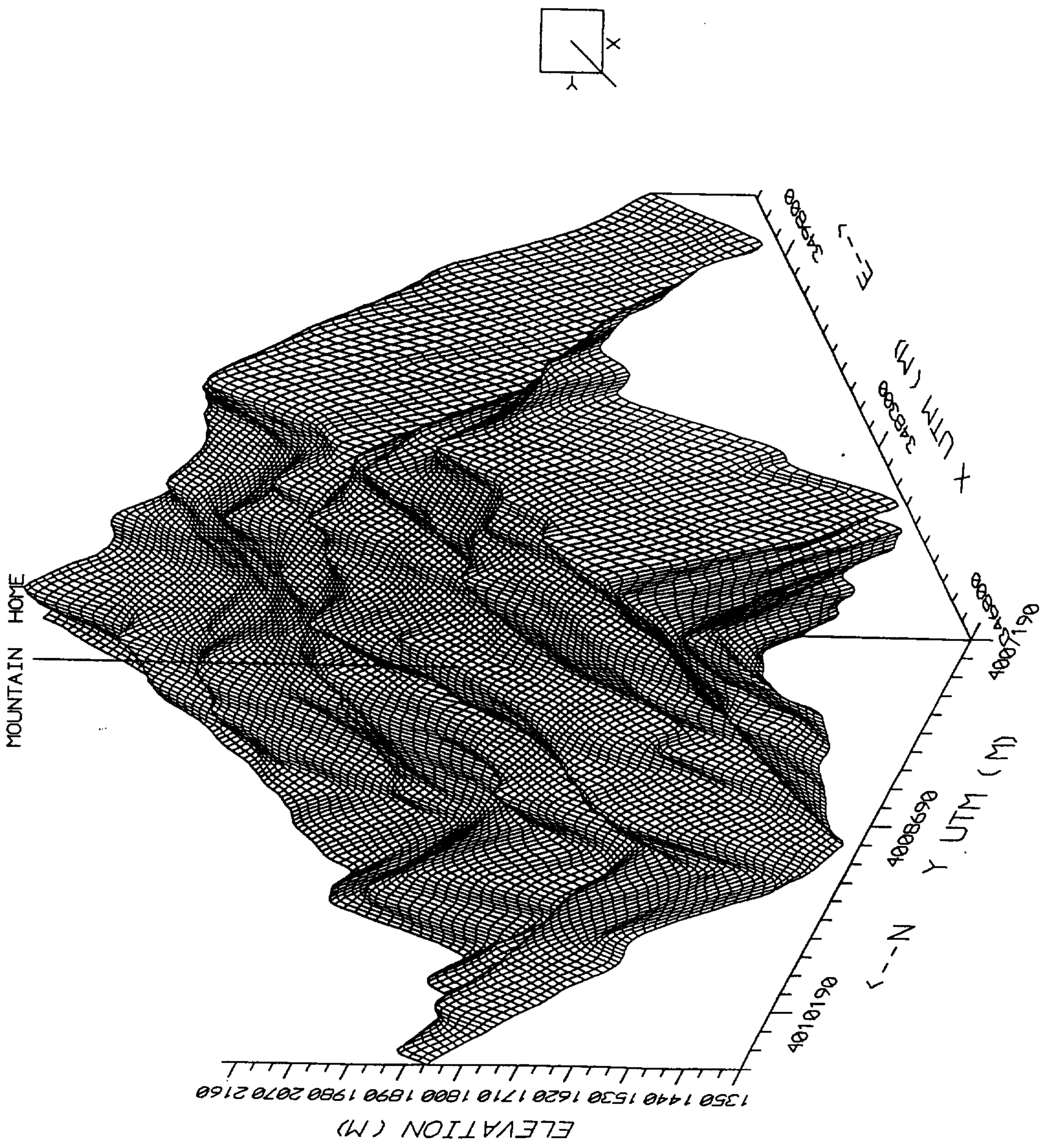



Figure 9. Three dimensional plot of the Mountain Home site.

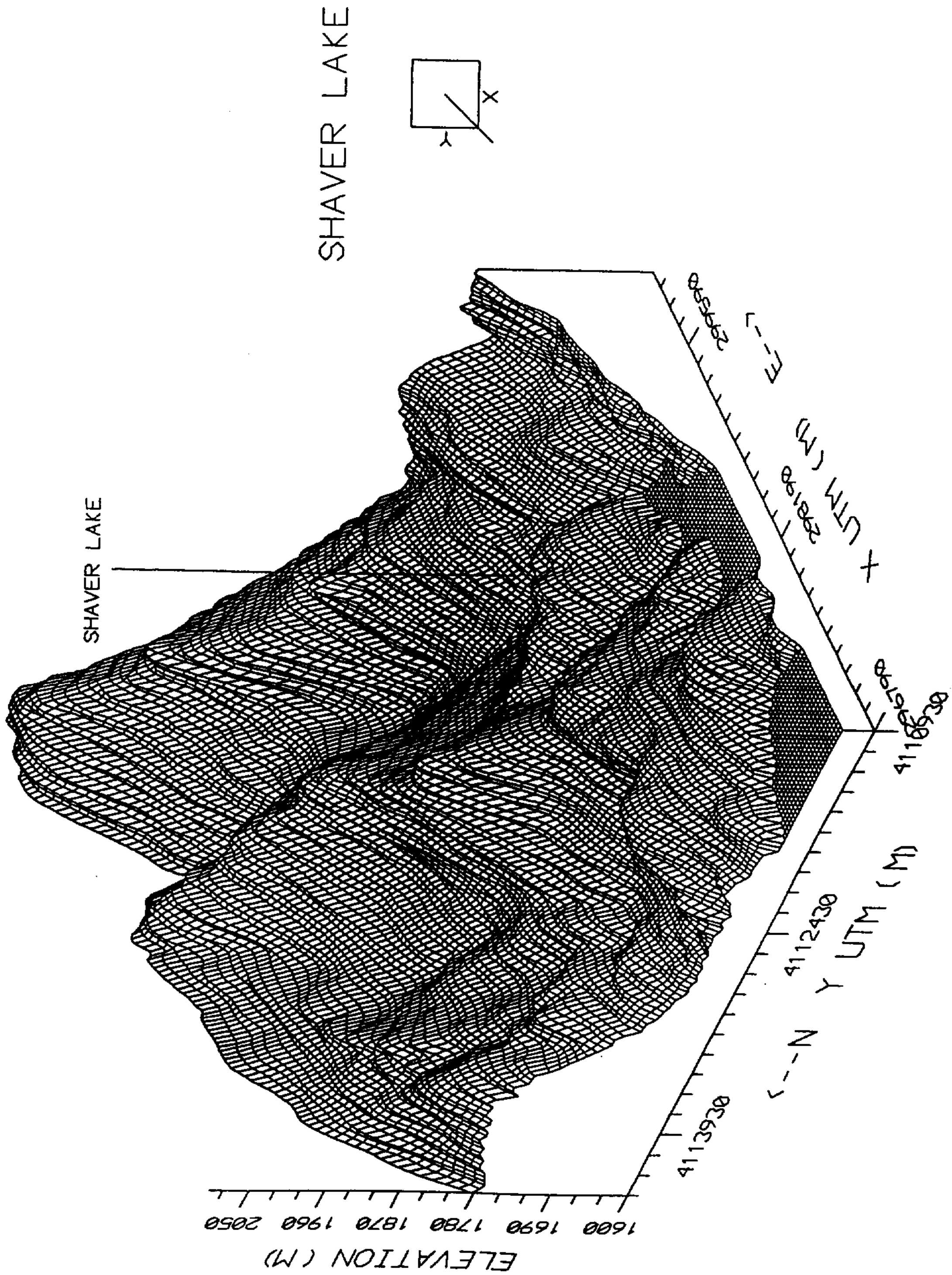



Figure 10. Three dimensional plot of the Shaver Lake site.

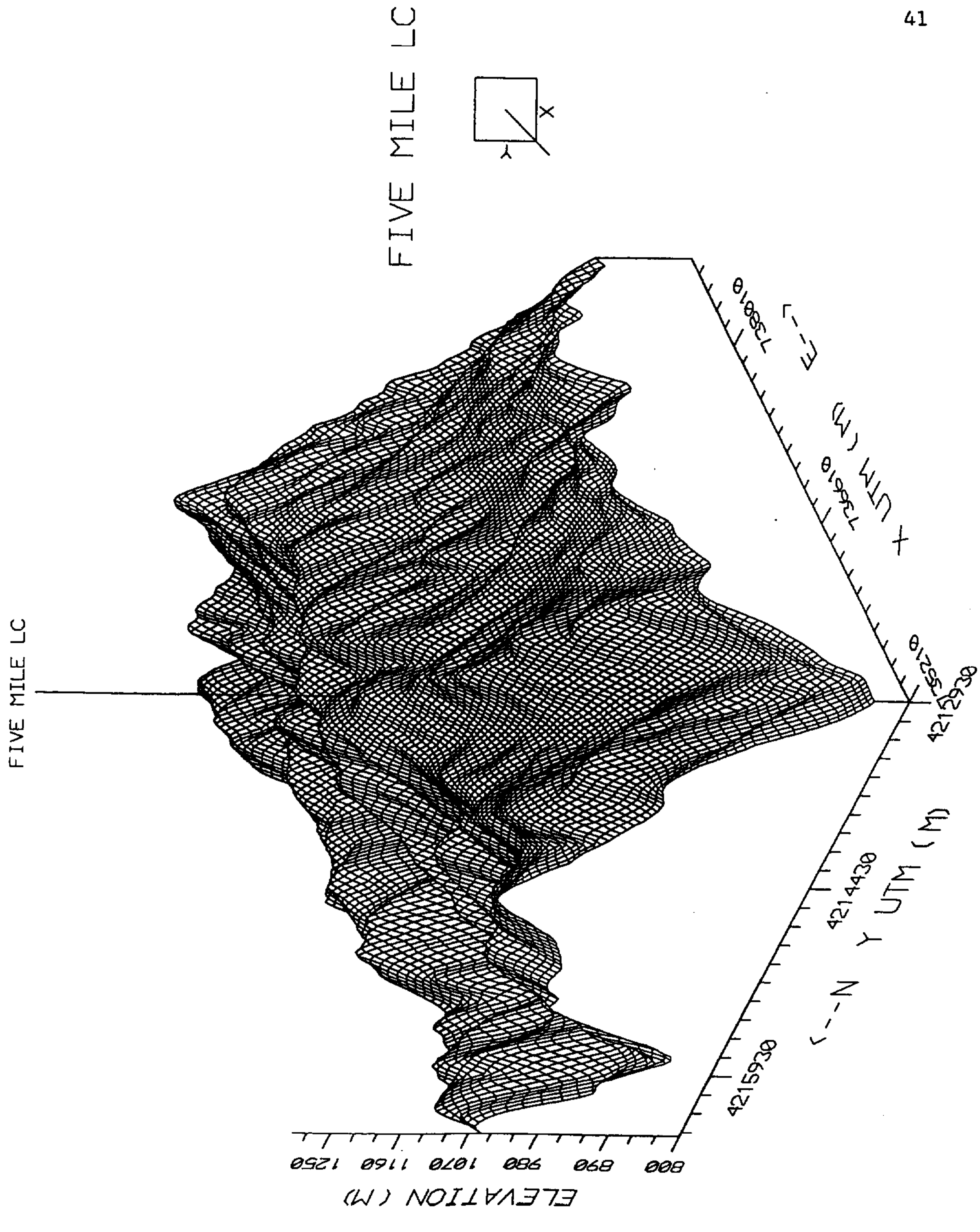



Figure 11. Three dimensional plot of the Five Mile site.

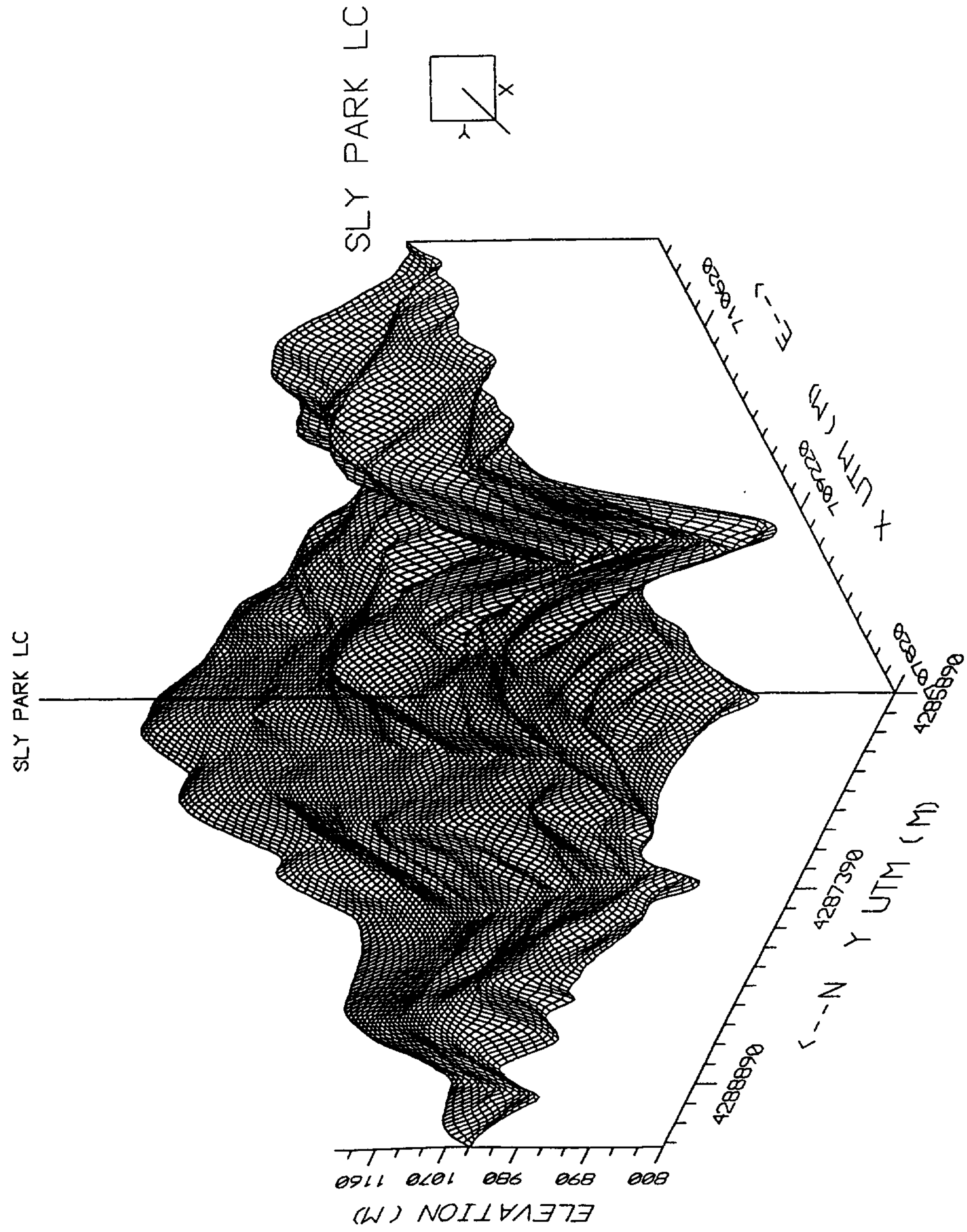



Figure 12. Three dimensional plot of the Sly Park site.

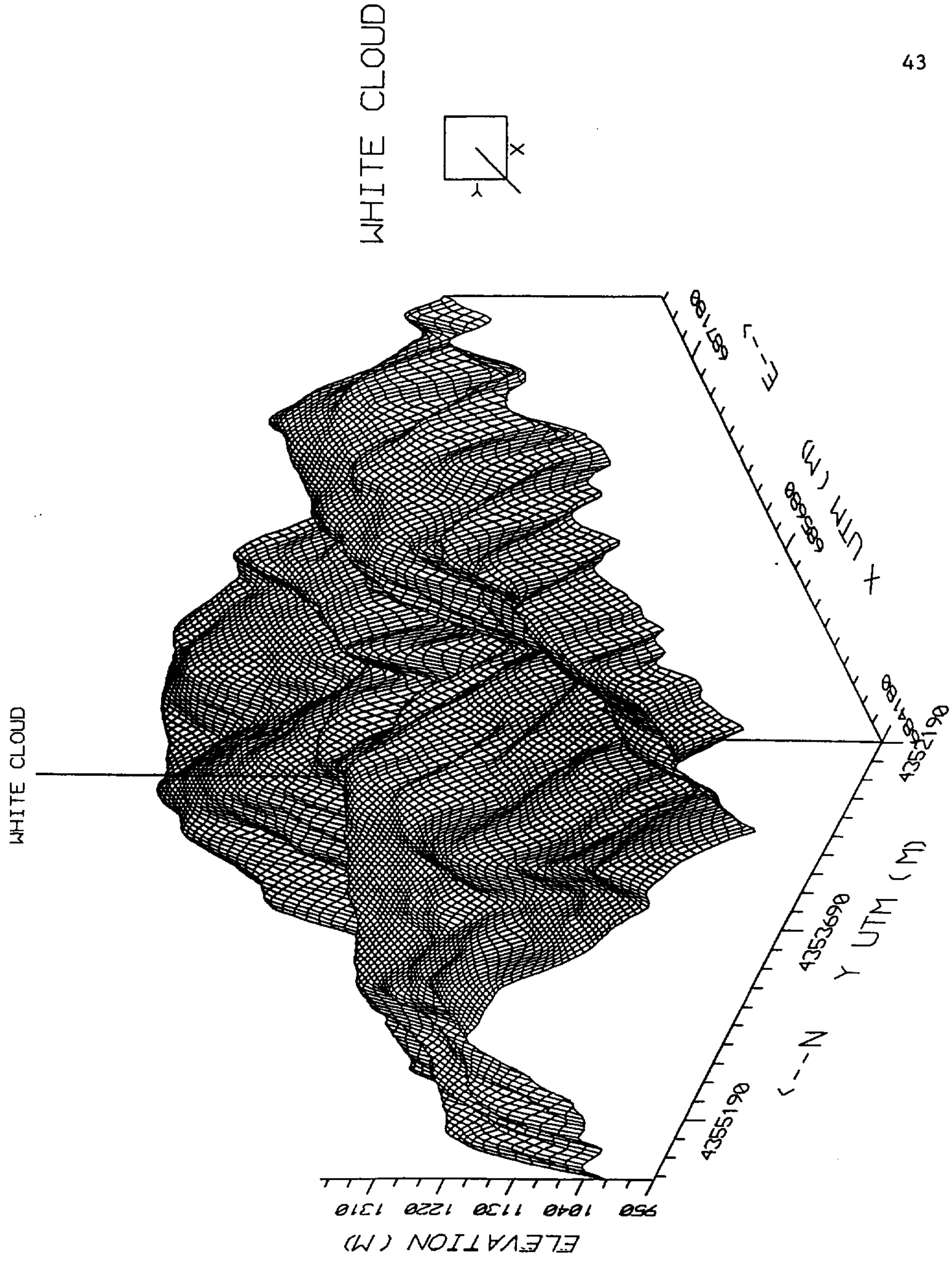



Figure 13. Three dimensional plot of the White Cloud site.

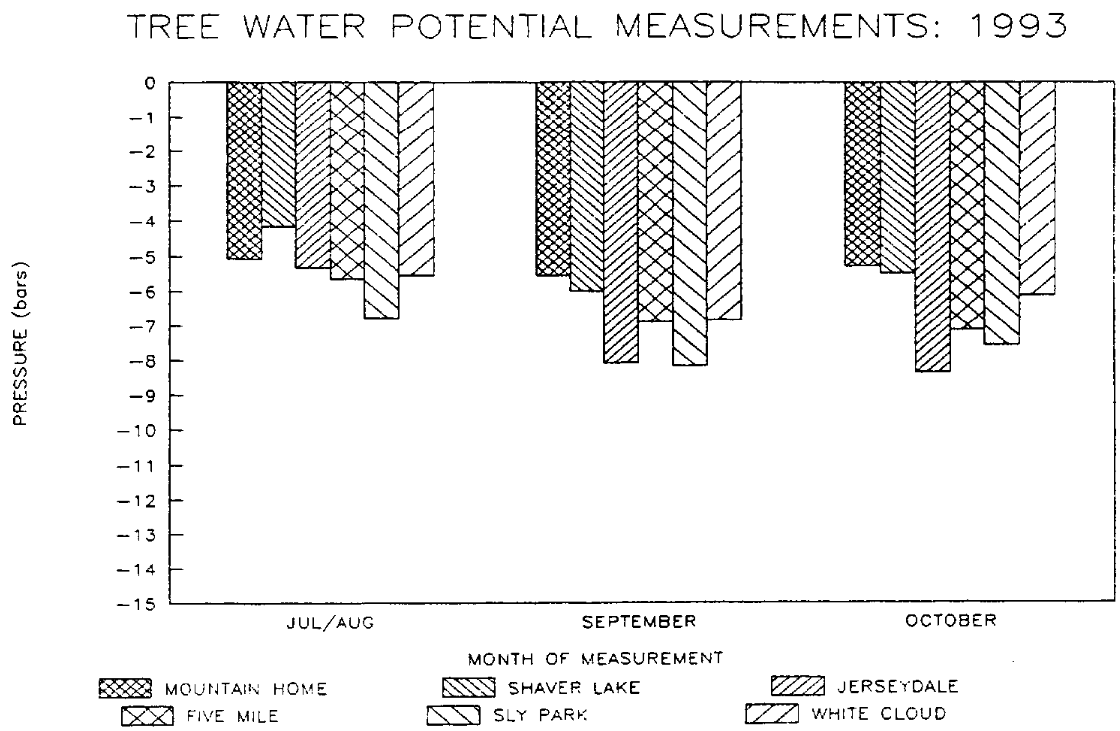



Figure 14 (a)

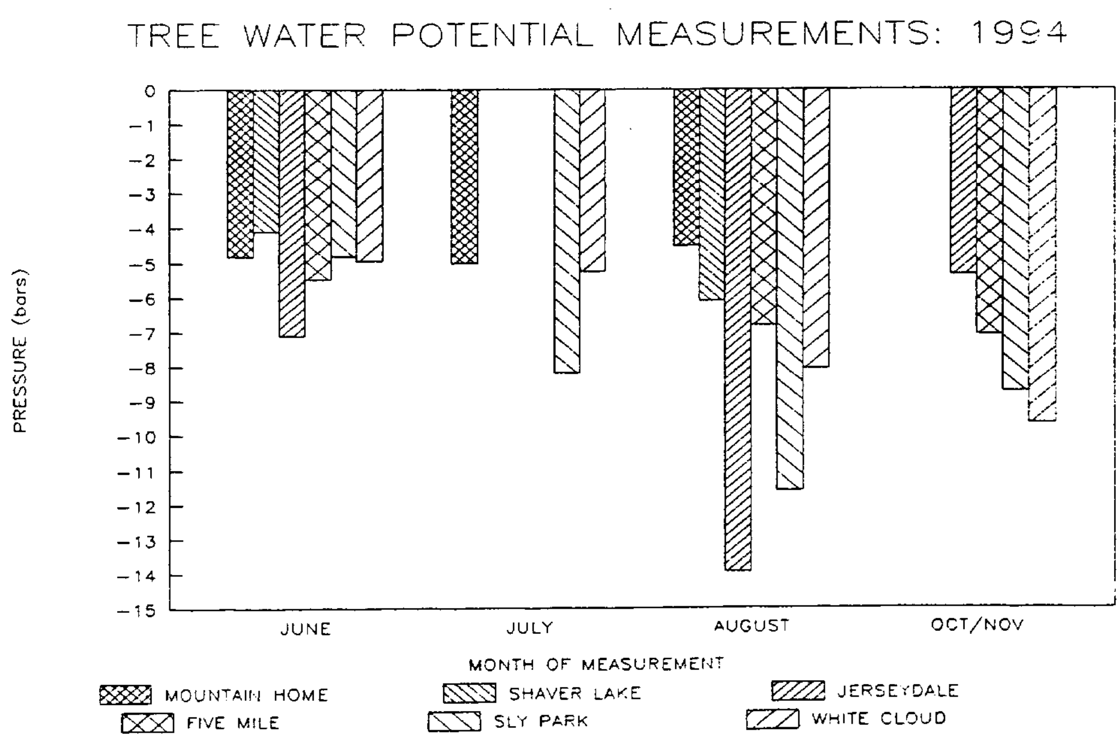
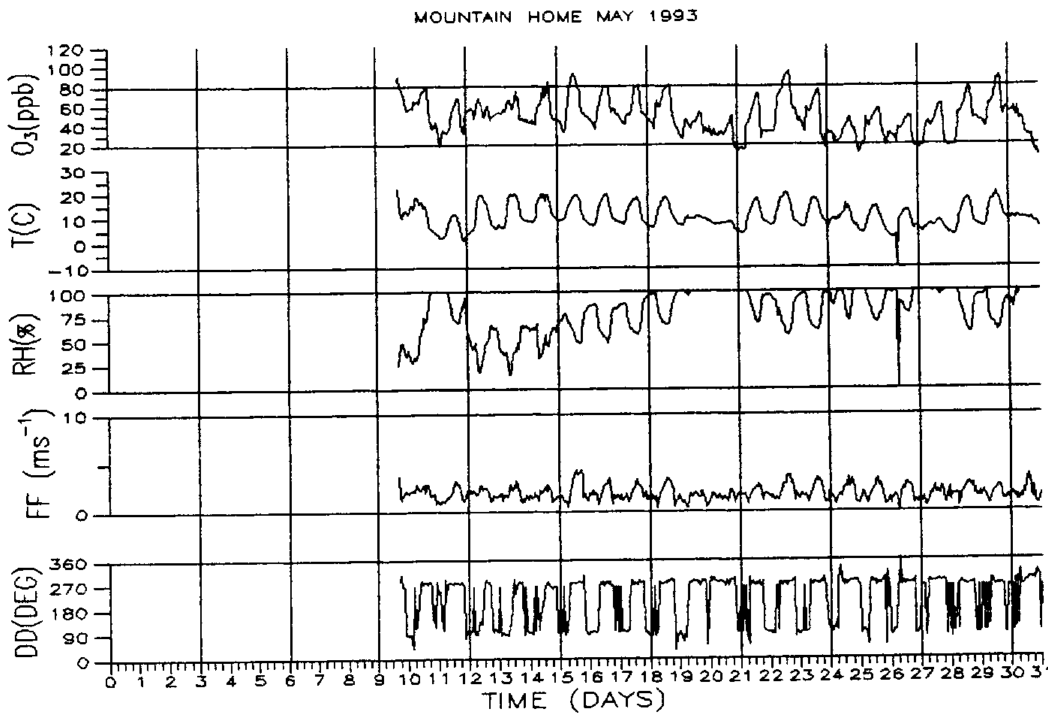


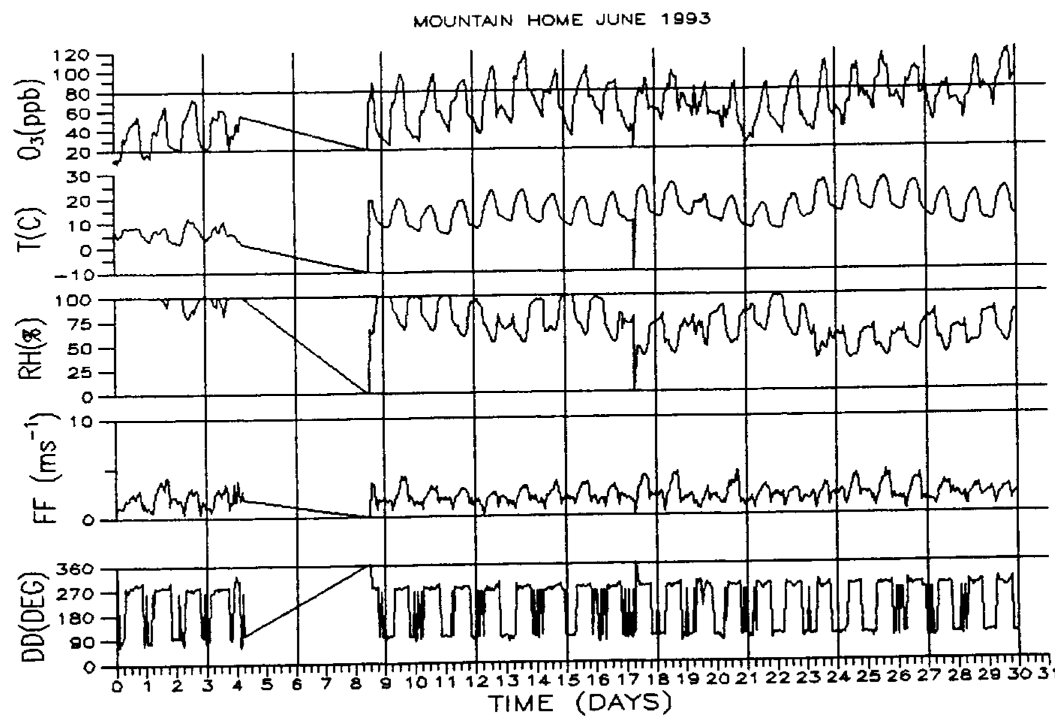

Figure 14 (b)

APPENDIX A:

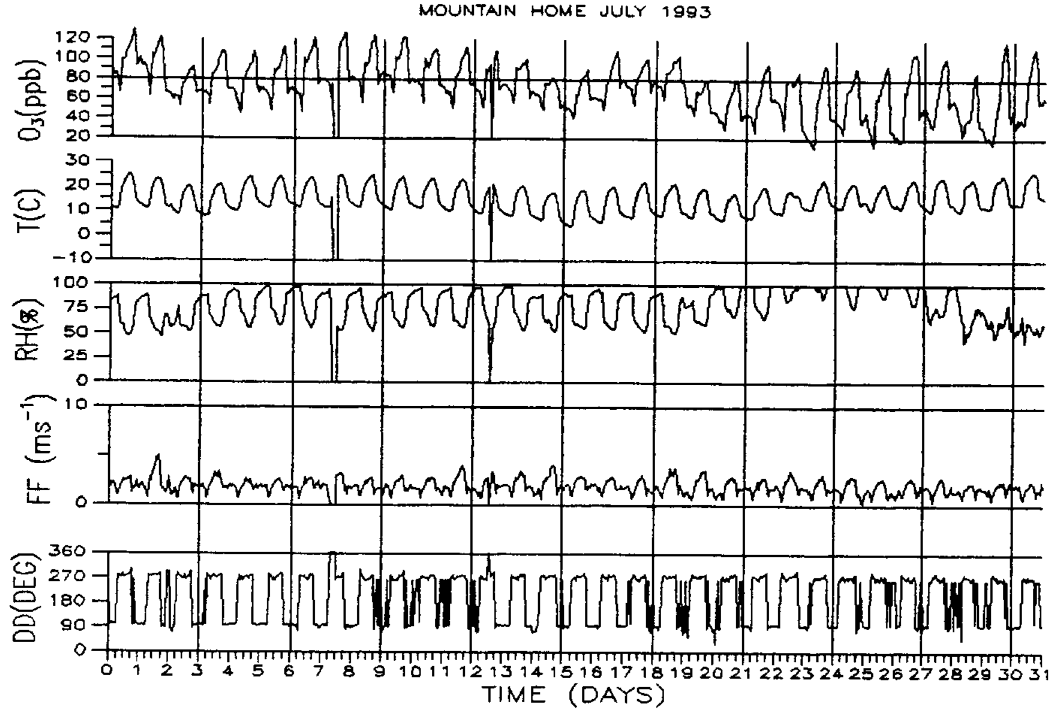
# TIME PLOTS

This appendix contains the time plots of the recorded variables for the 1993 and 1994 data. Time plots of hourly averaged wind direction (DD), wind speed (FF), relative humidity (RH), air temperature (T) and volumetric ozone concentration (O3) normalized to standard conditions of temperature and pressure at the sites for the months of May through October. Wind direction values greater than 360 indicate calm conditions. Values of any variable less than 0 indicate missing or bad data.

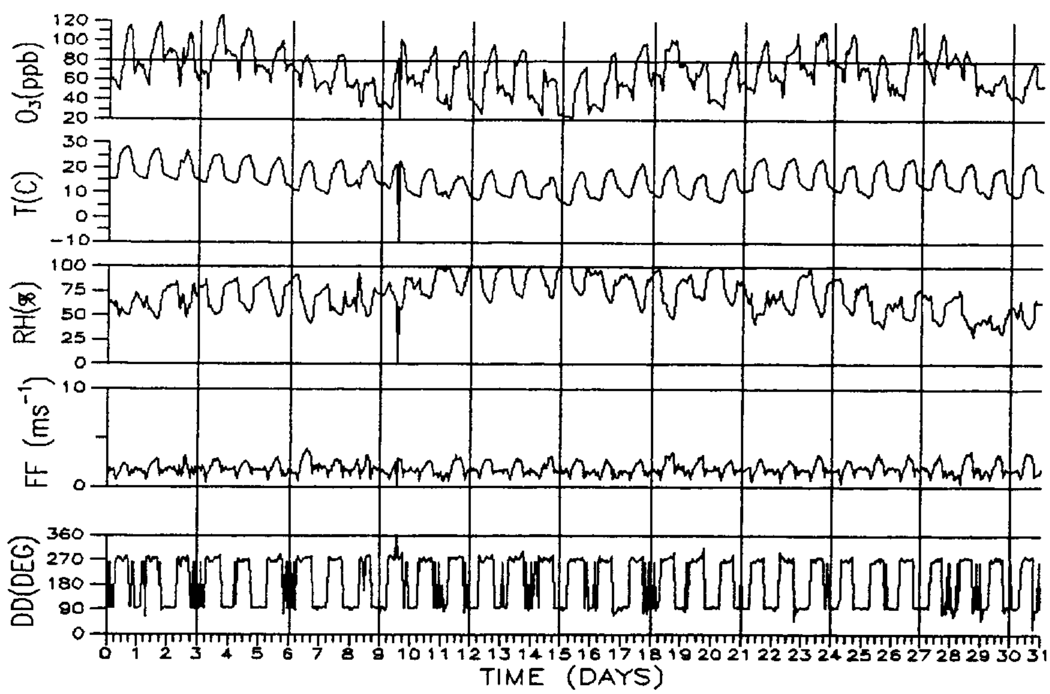

MOUNTAIN HOME MAY 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


MOUNTAIN HOME JUNE 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

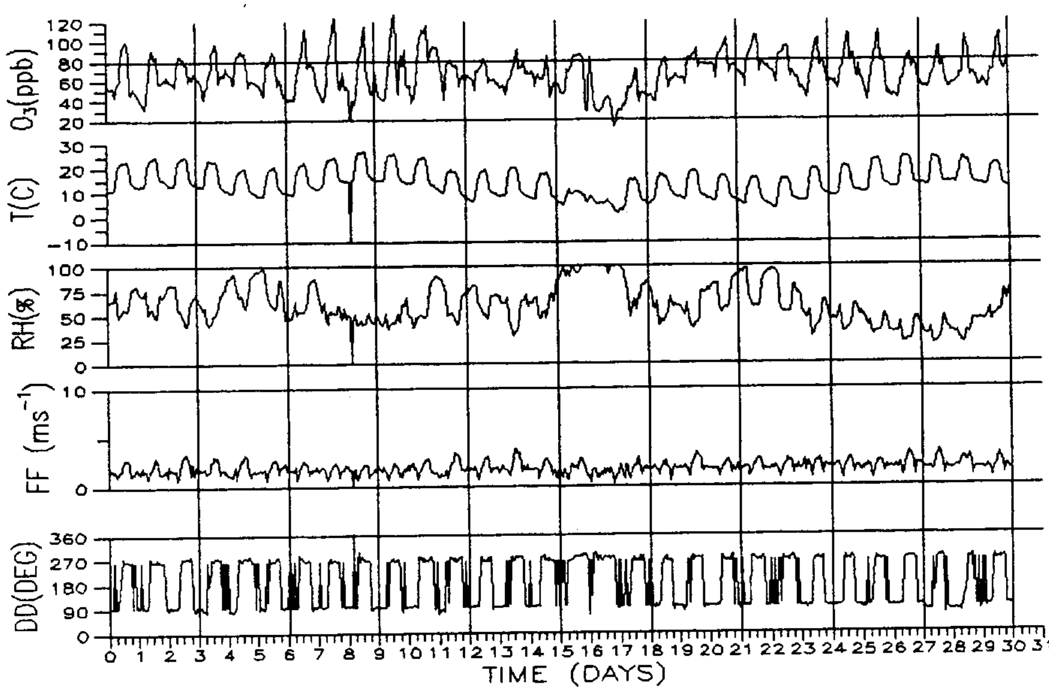
MOUNTAIN HOME JULY 1993



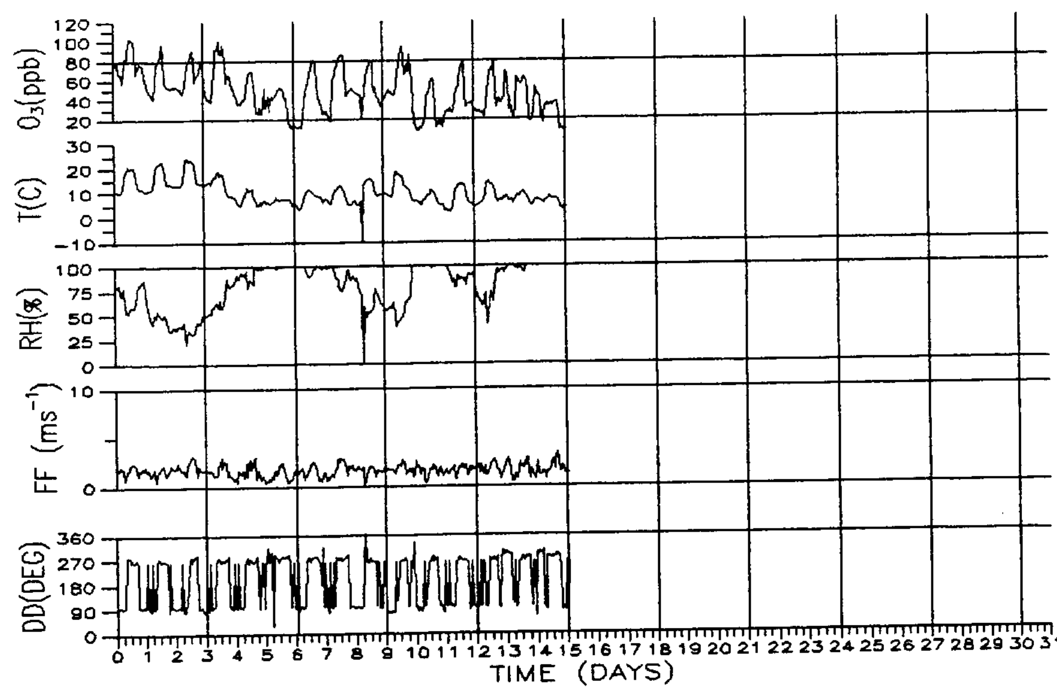

MOUNTAIN HOME AUGUST 1993

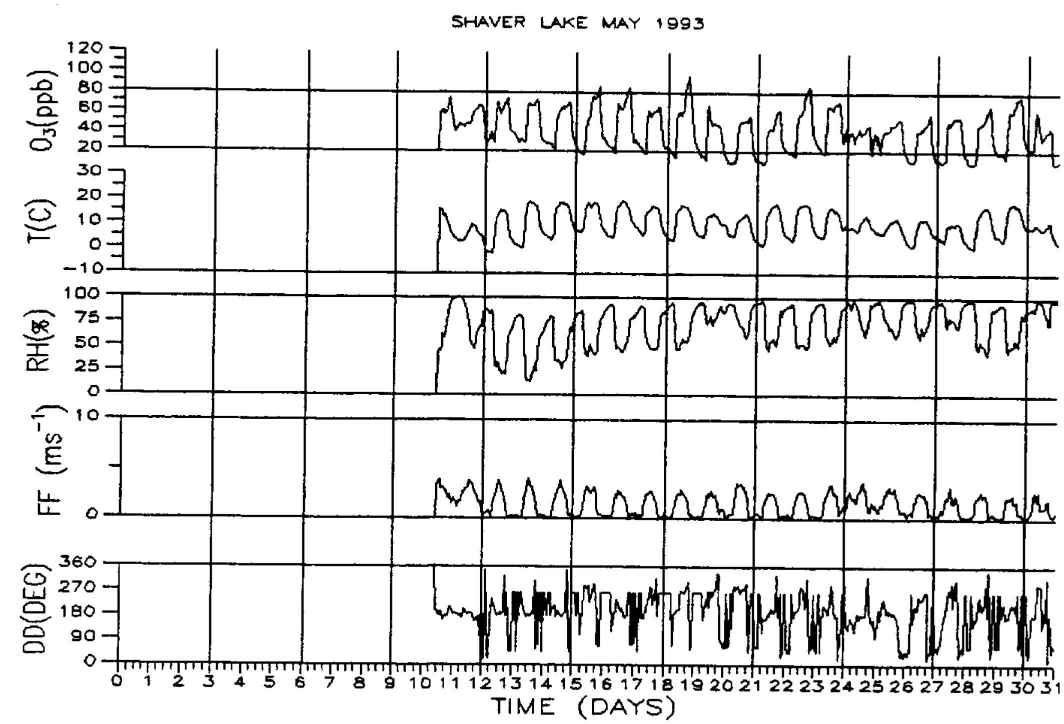


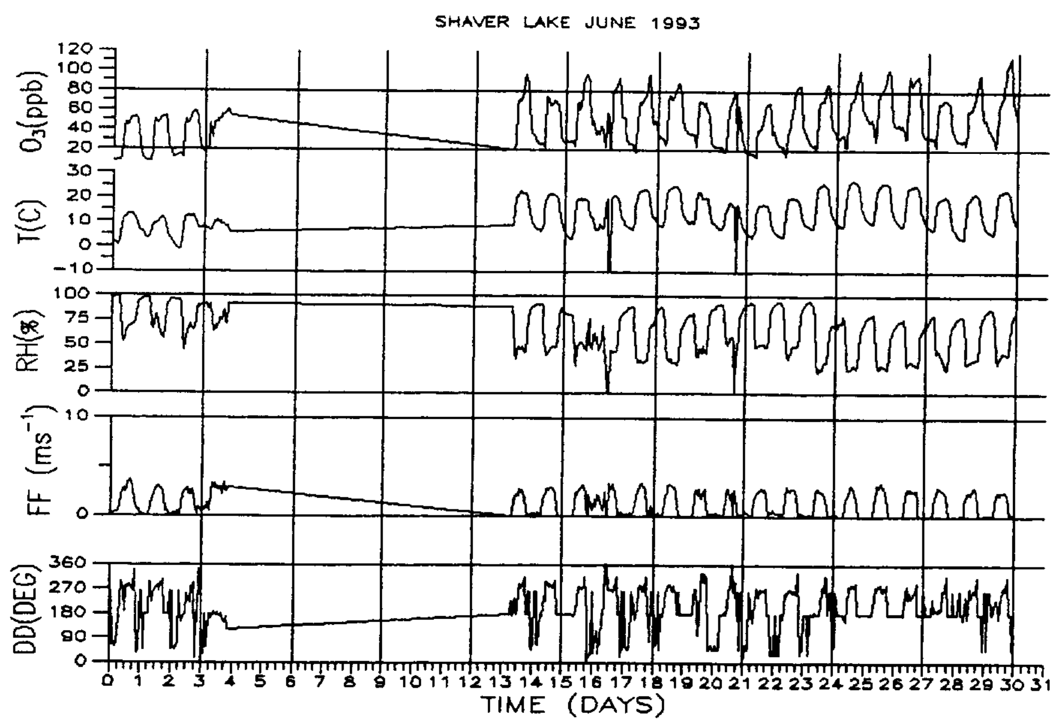
MOUNTAIN HOME SEPTEMBER 1993

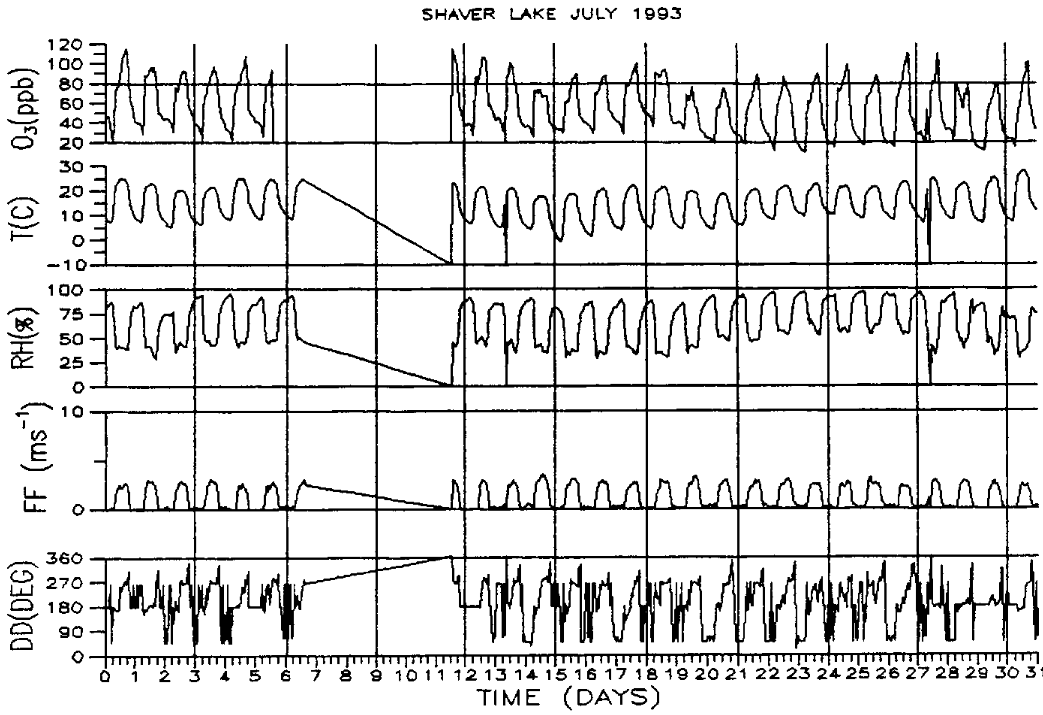


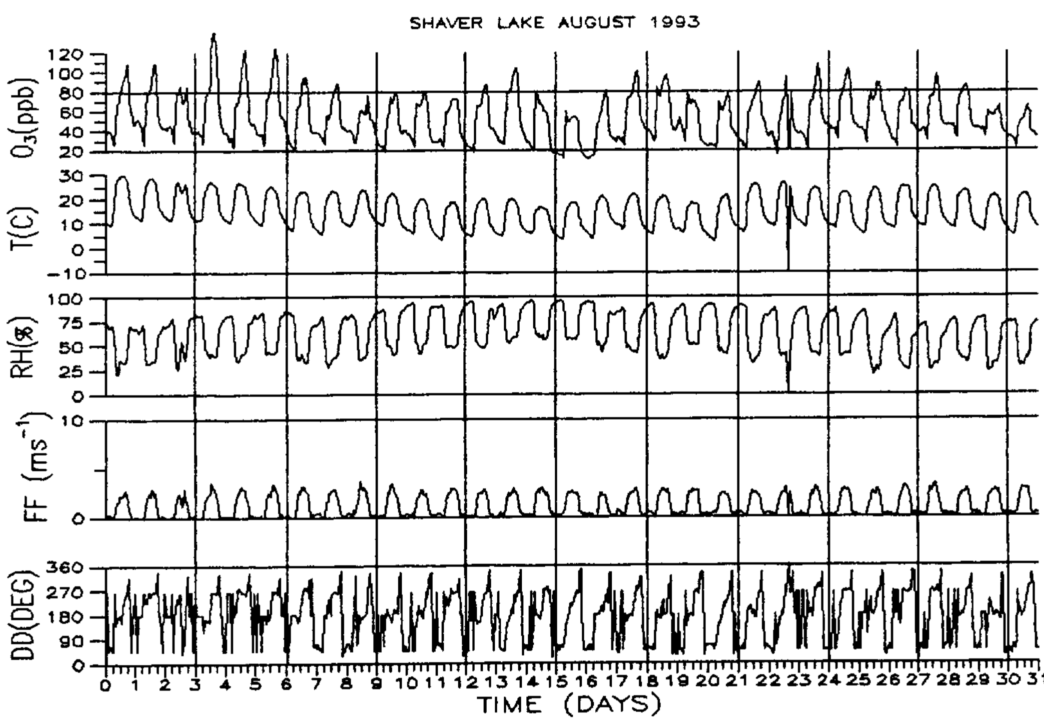

MOUNTAIN HOME OCTOBER 1993

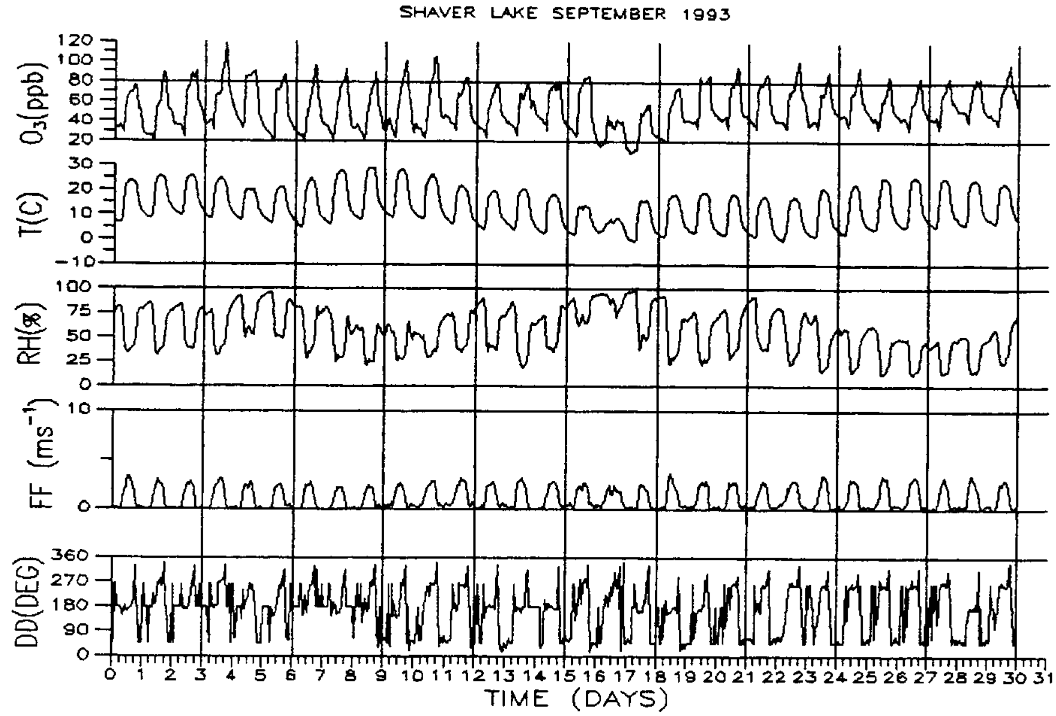


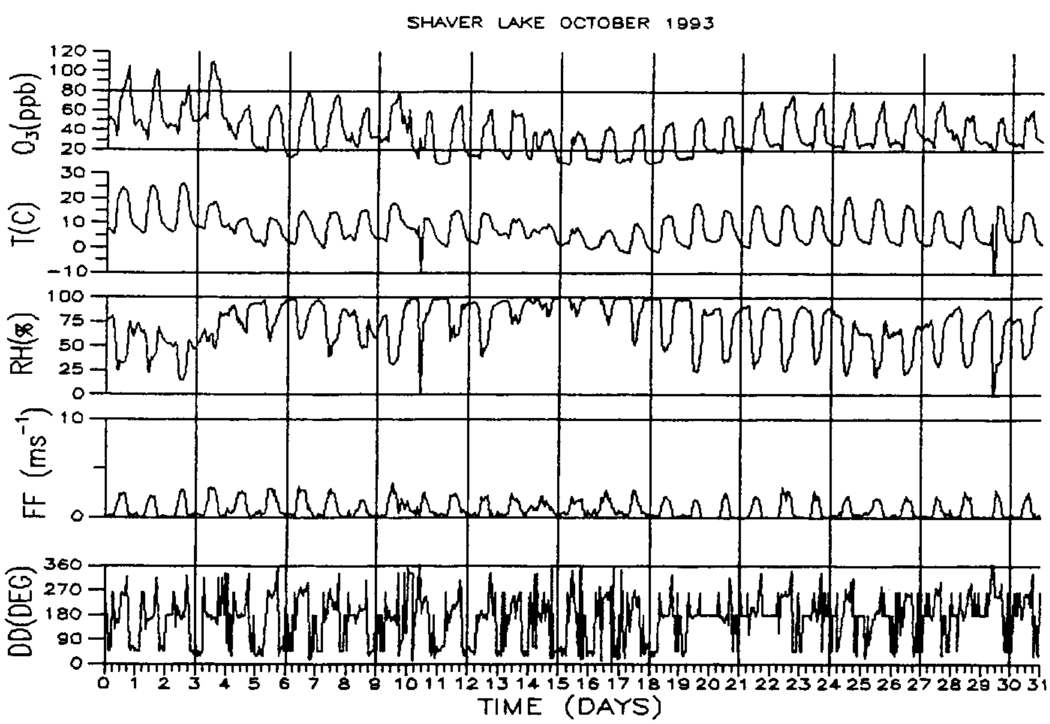

SHAVER LAKE MAY 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

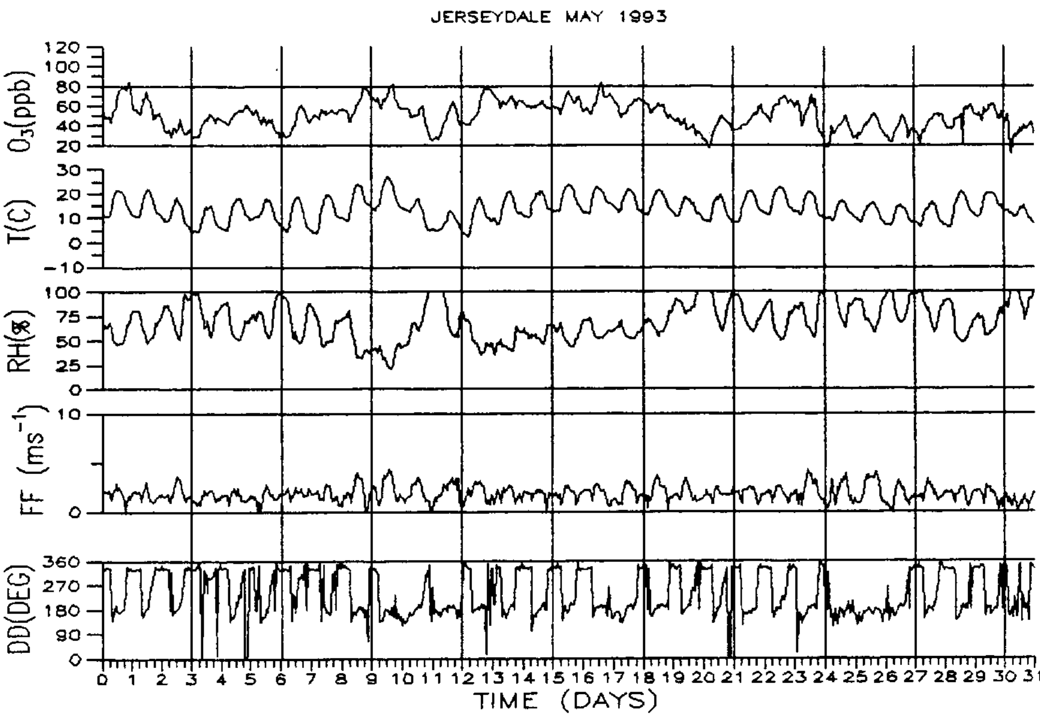

SHAVER LAKE JUNE 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

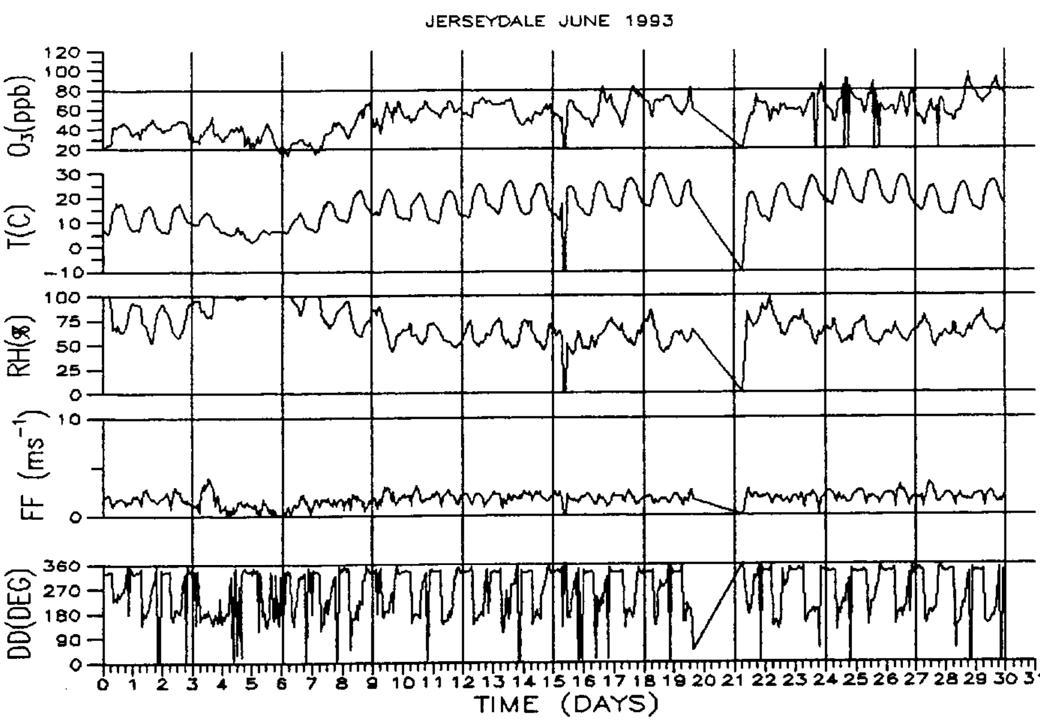

SHAVER LAKE JULY 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

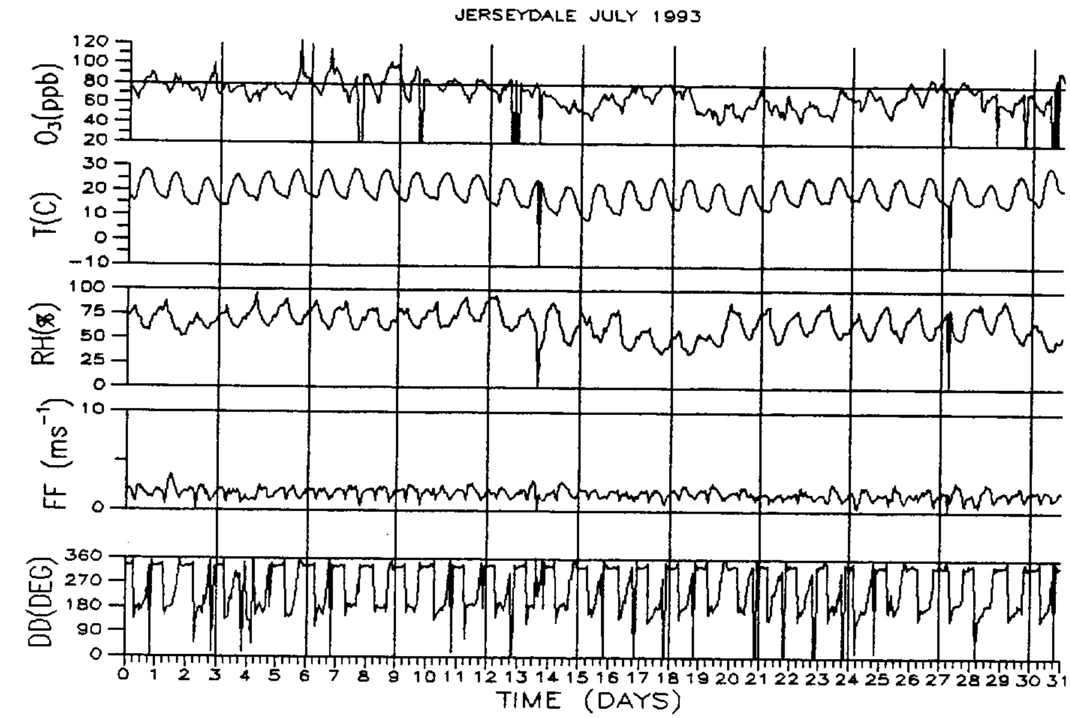

SHAVER LAKE AUGUST 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

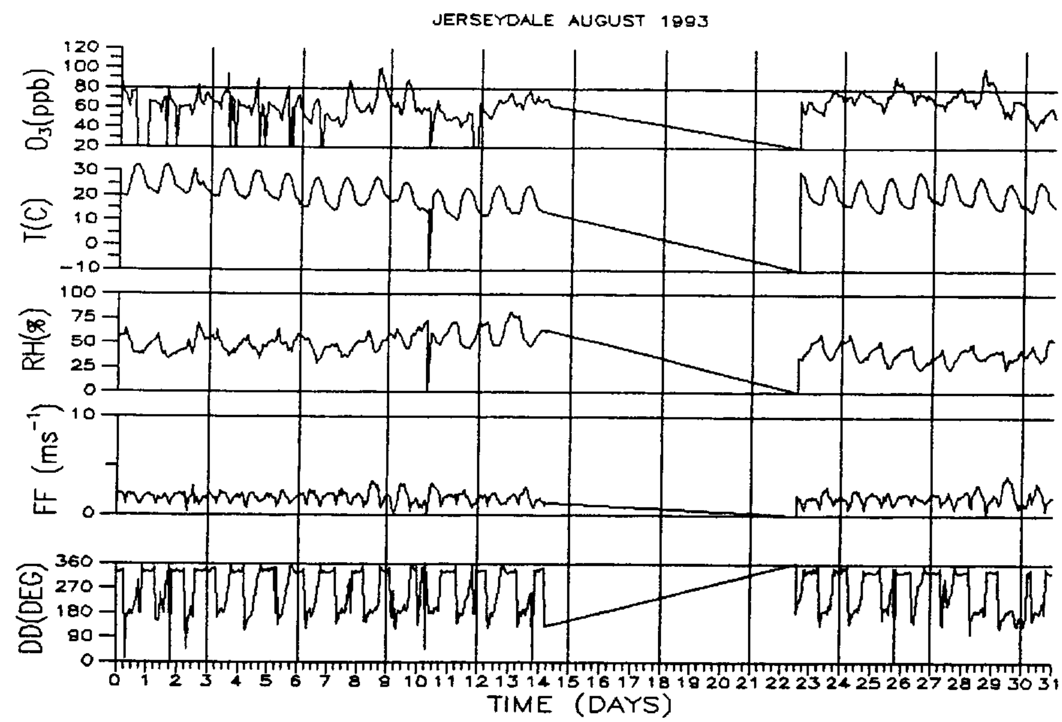

SHAVER LAKE SEPTEMBER 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

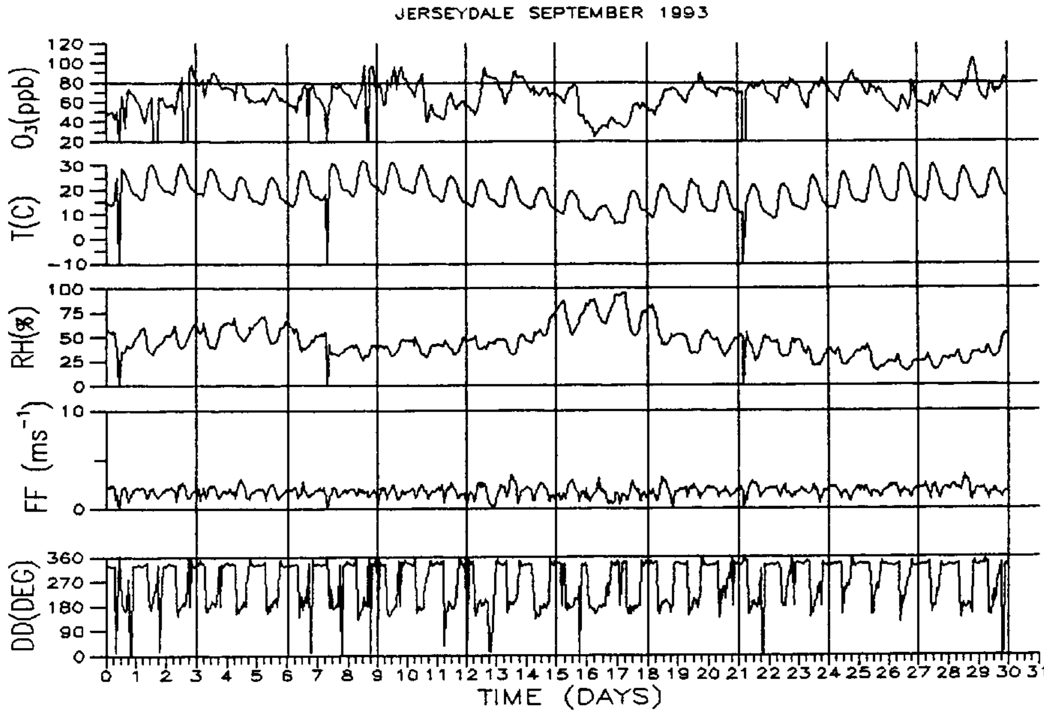

SHAVER LAKE OCTOBER 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

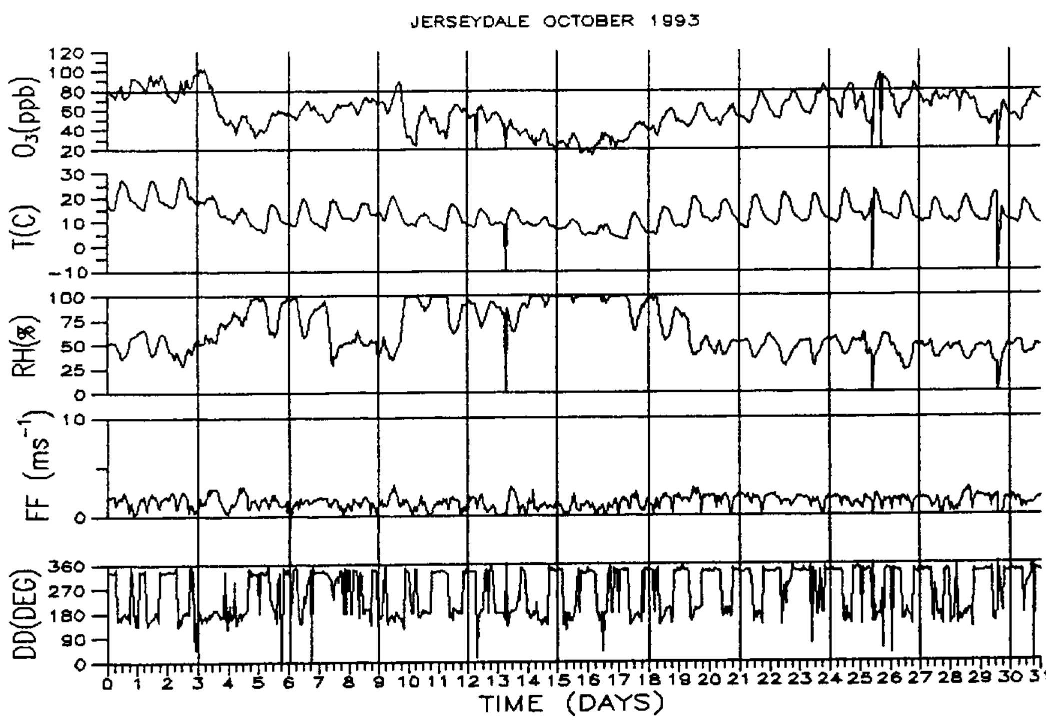

JERSEYDALE MAY 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

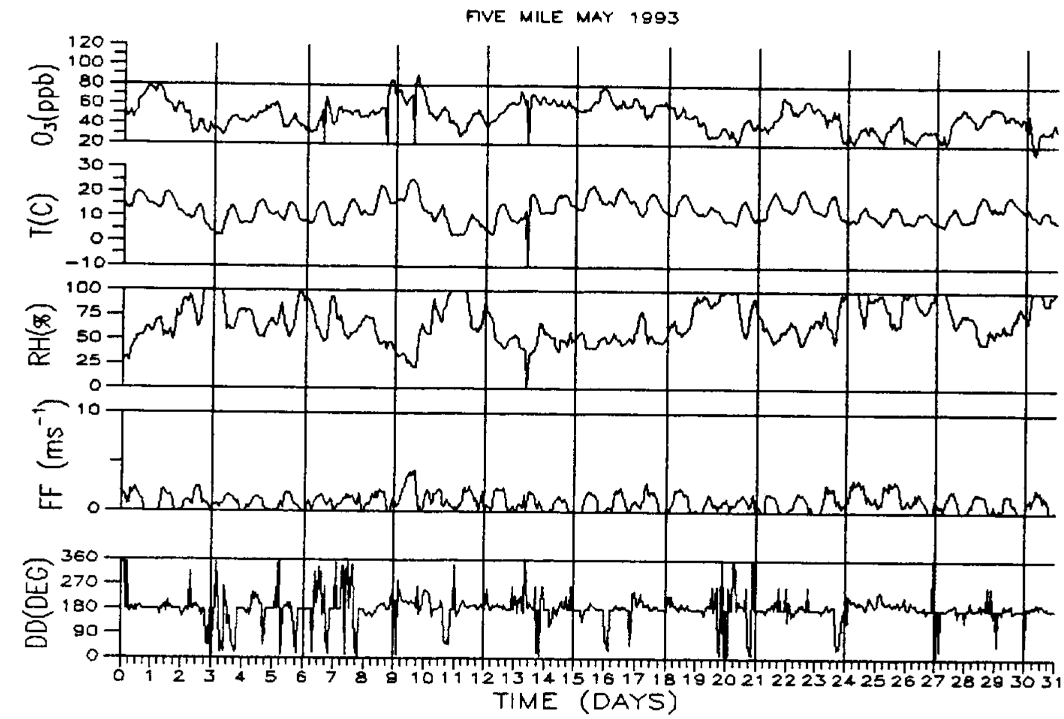

JERSEYDALE JUNE 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

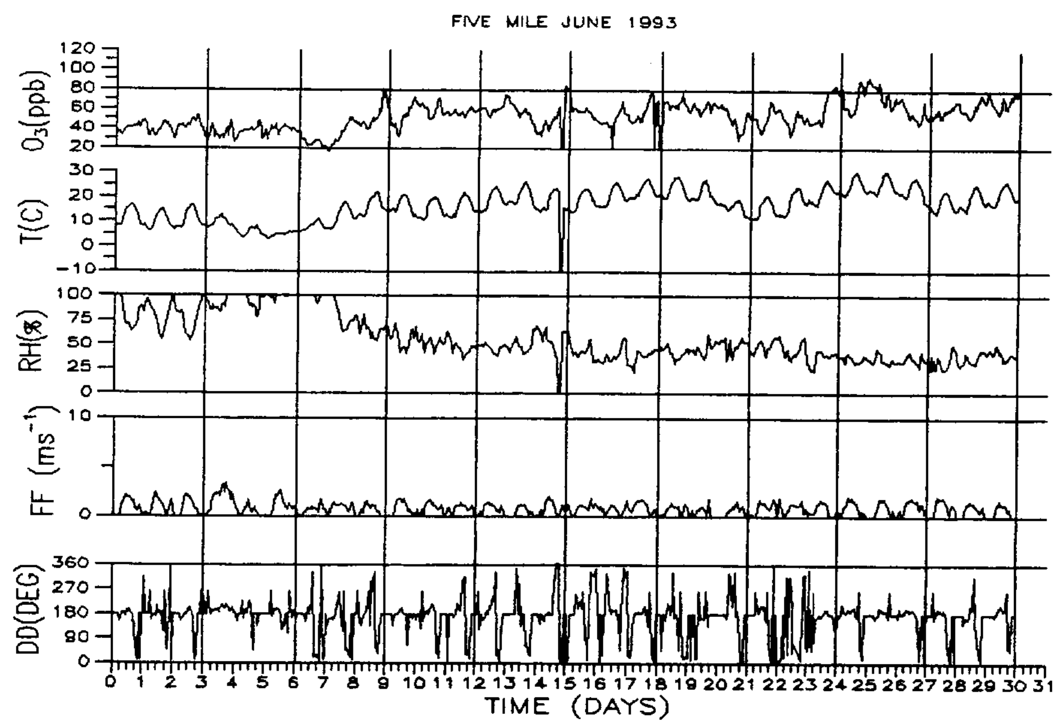

JERSEYDALE JULY 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

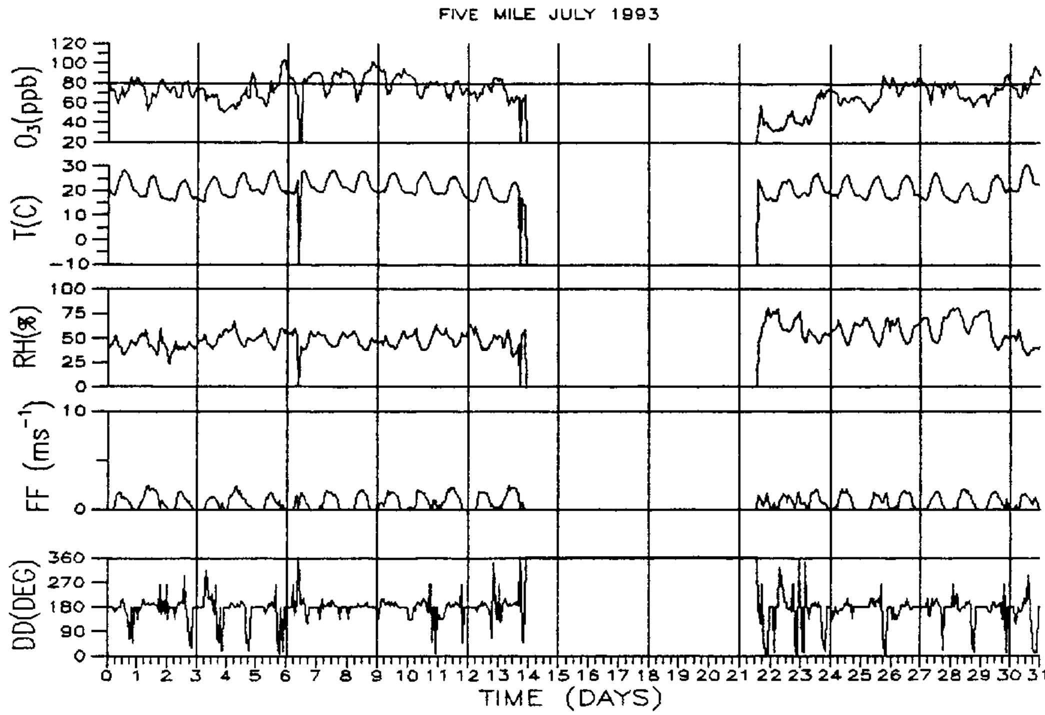

JERSEYDALE AUGUST 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

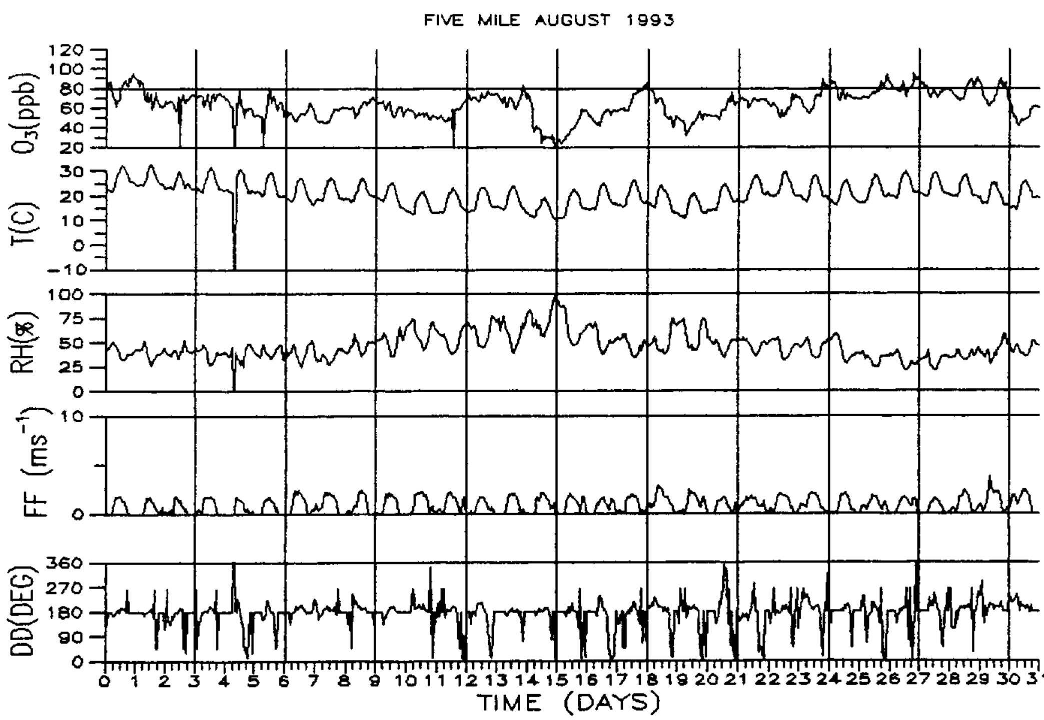

JERSEYDALE SEPTEMBER 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

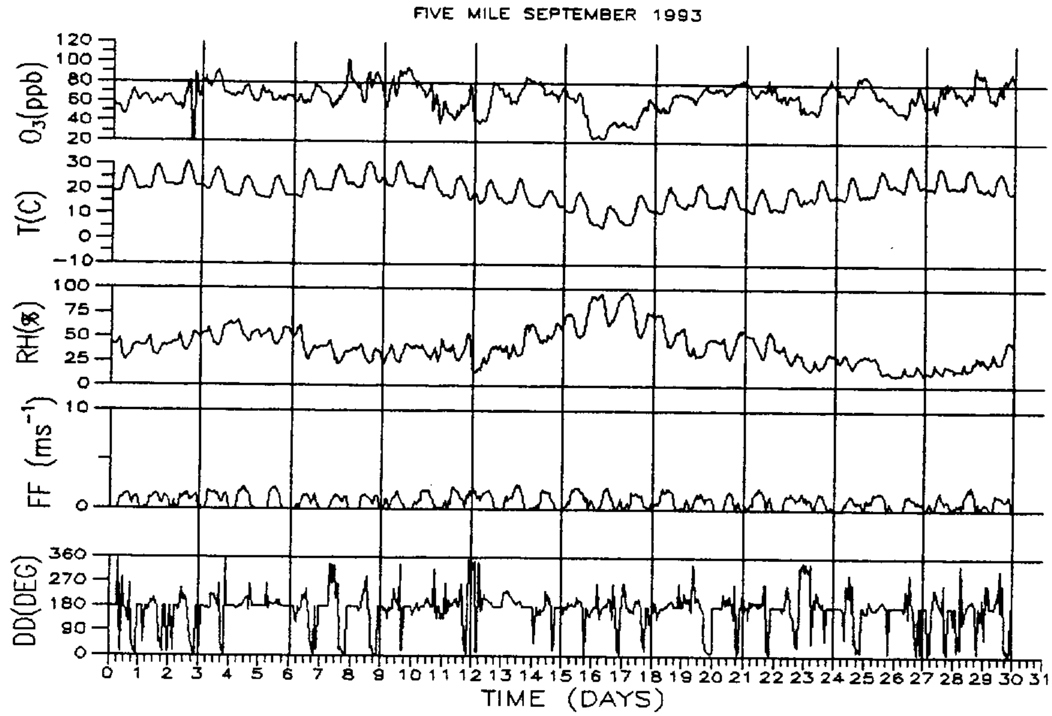

JERSEYDALE OCTOBER 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

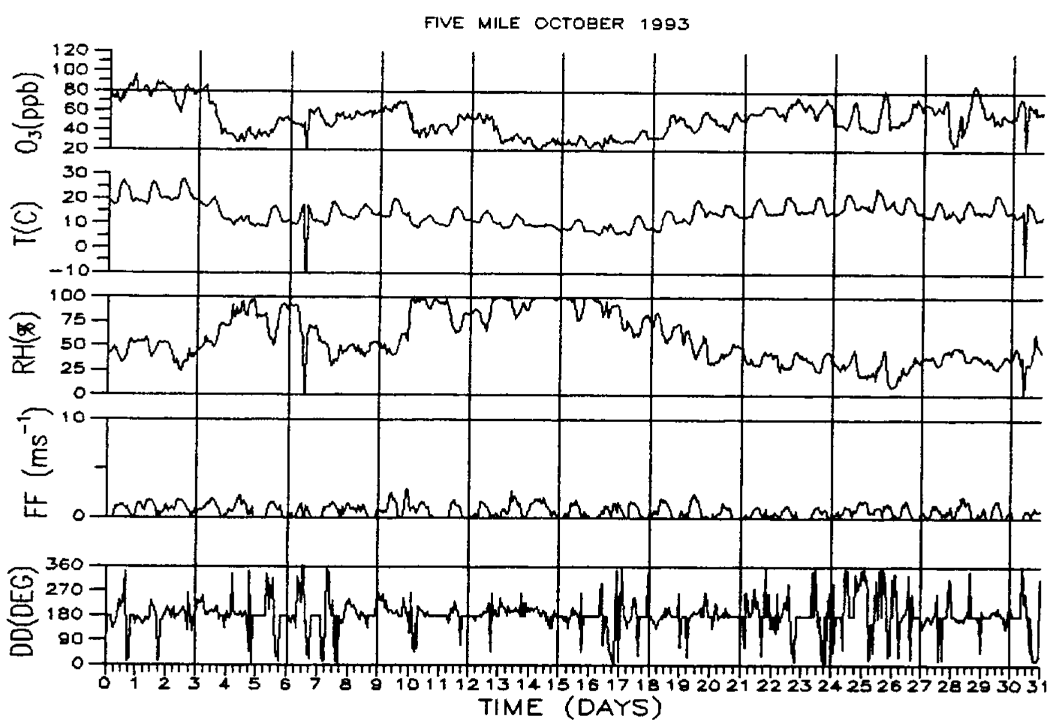

FIVE MILE MAY 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

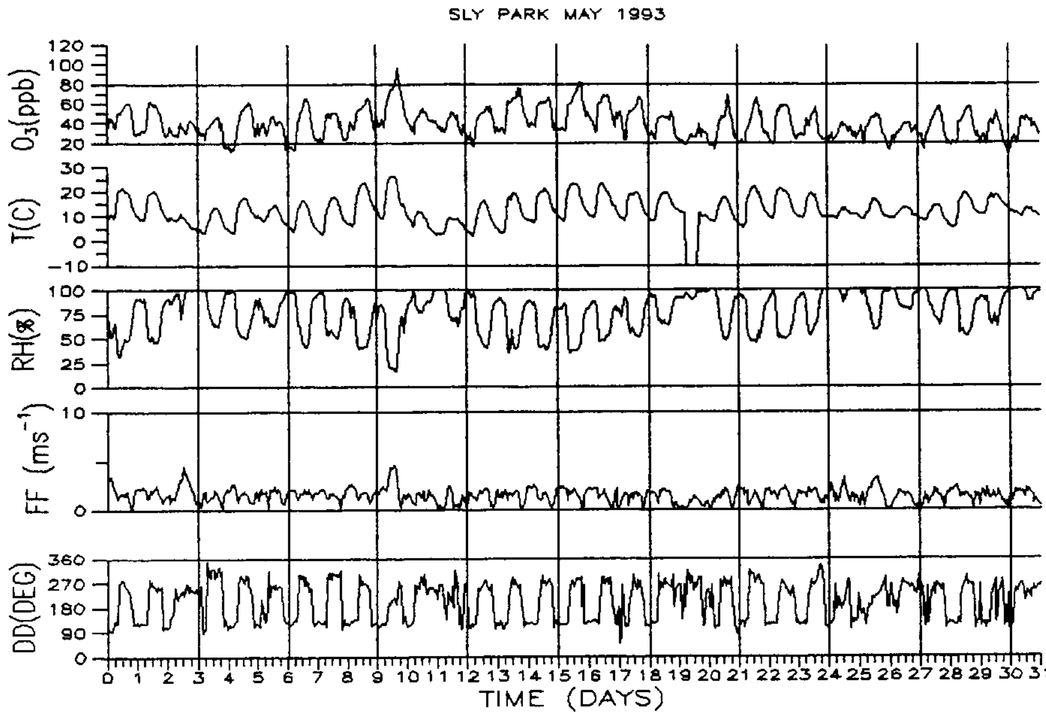

FIVE MILE JUNE 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

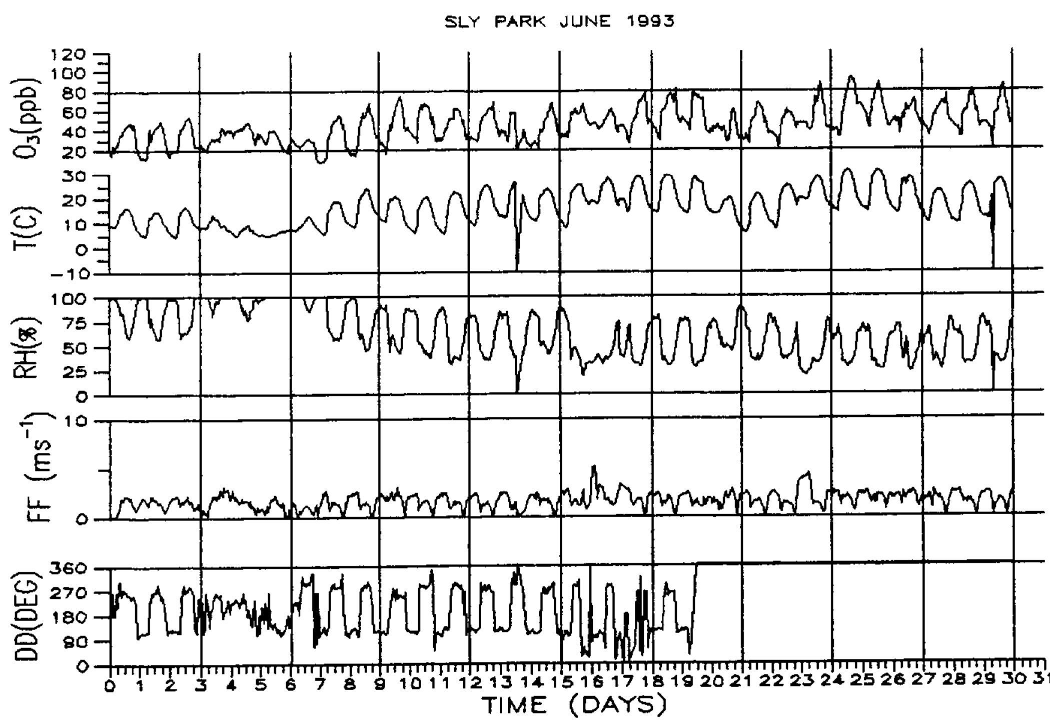

FIVE MILE JULY 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

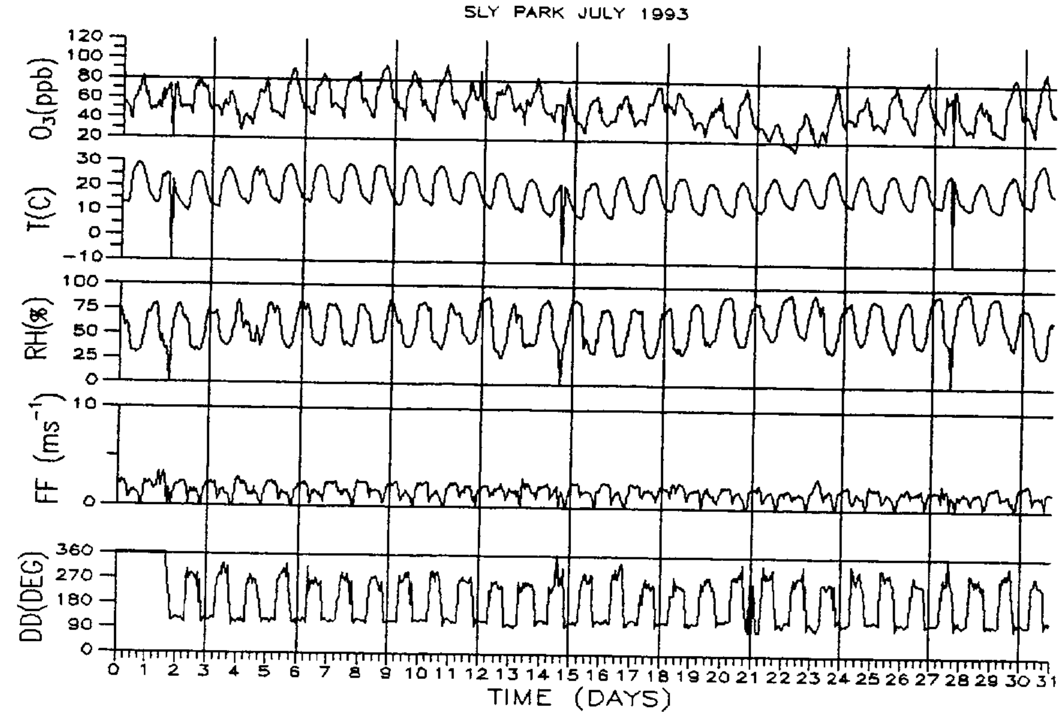

FIVE MILE AUGUST 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

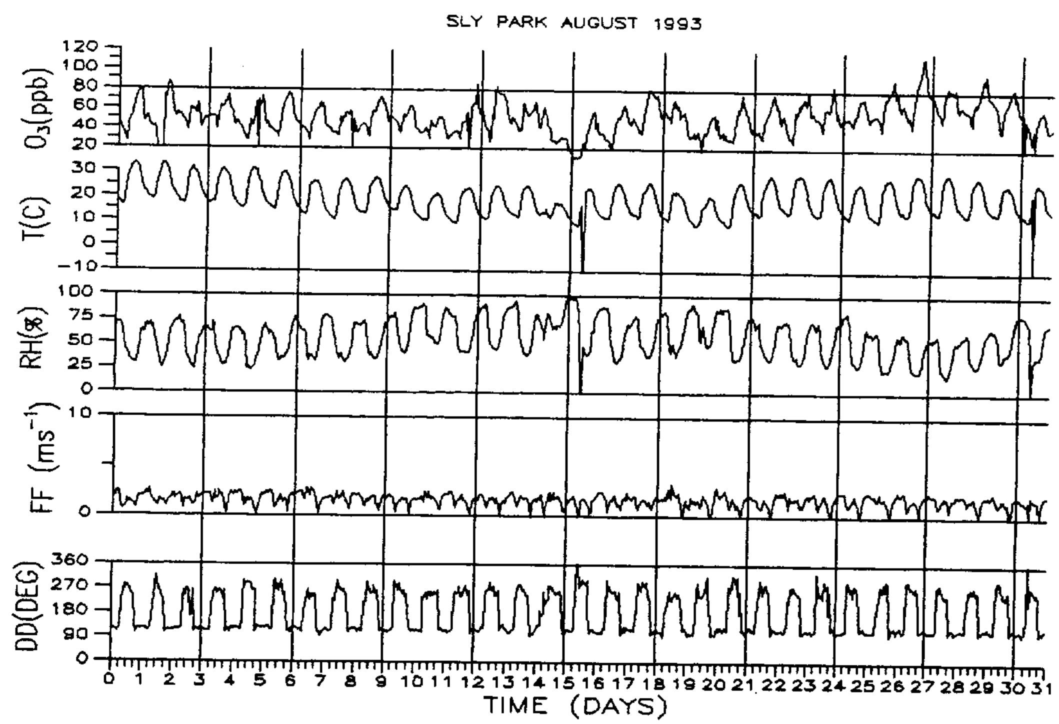

FIVE MILE SEPTEMBER 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


FIVE MILE OCTOBER 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

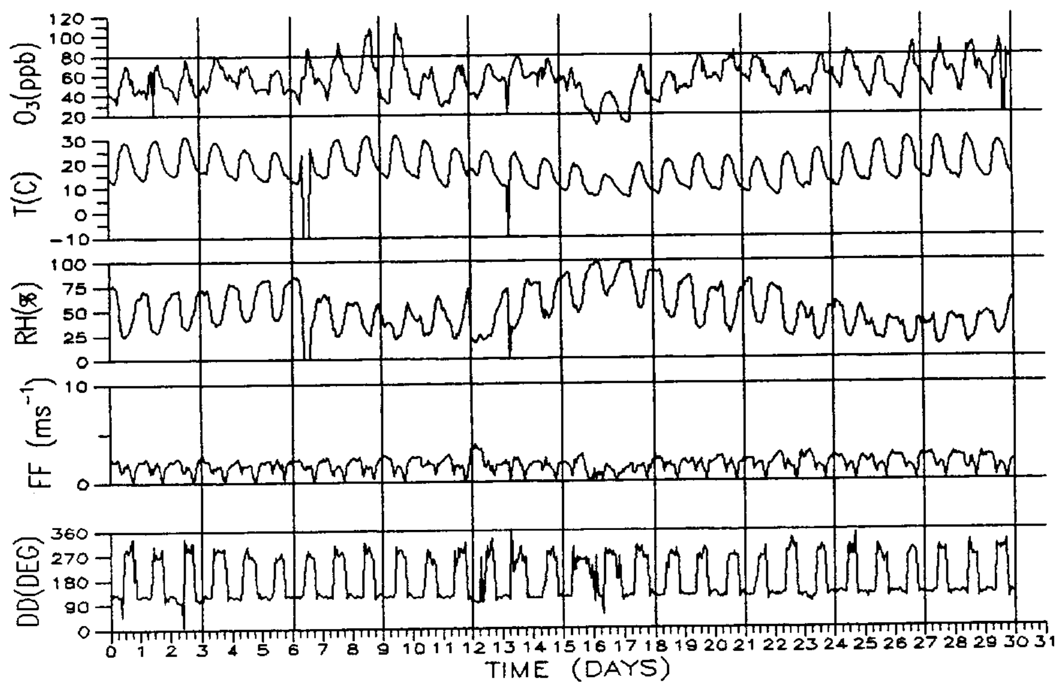

SLY PARK MAY 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


SLY PARK JUNE 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

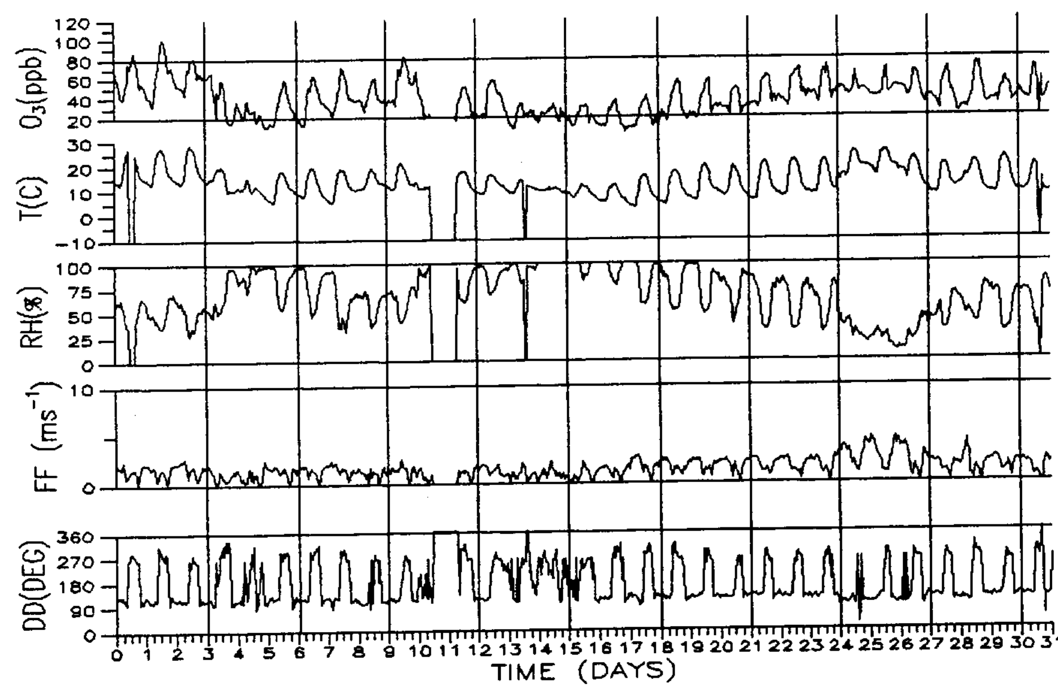

SLY PARK JULY 1993
$O_3$(ppb)
T(C)
RH(%)
FF (ms$^{-1}$)
DD(DEG)
TIME (DAYS)

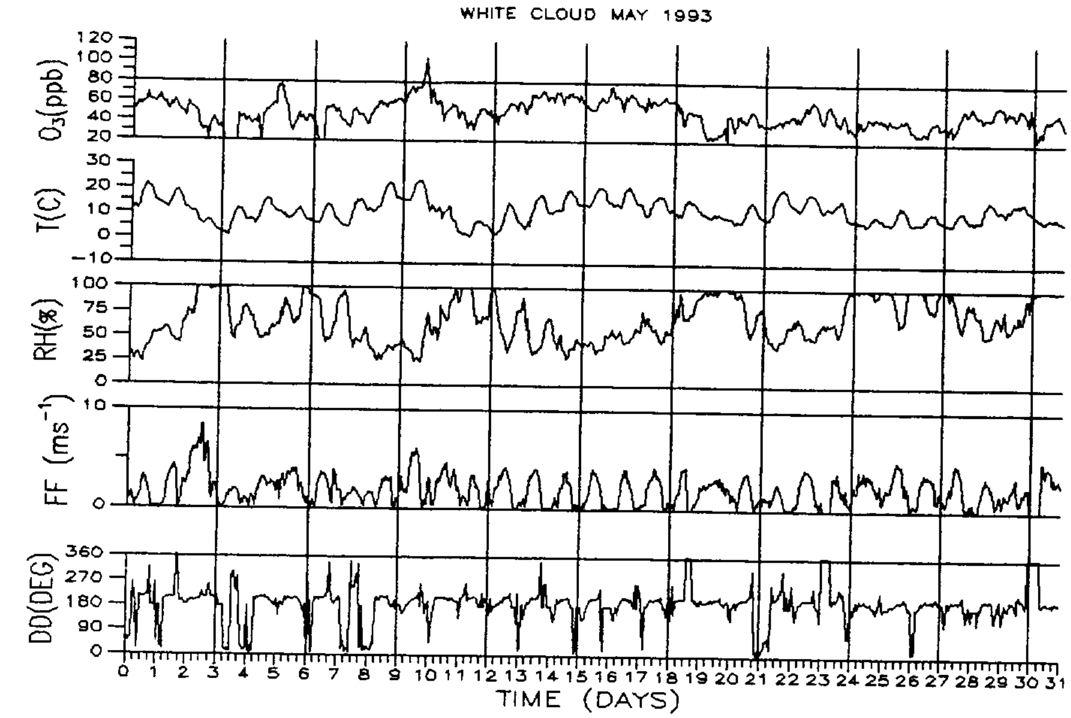

SLY PARK AUGUST 1993
$O_3$(ppb)
T(C)
RH(%)
FF (ms$^{-1}$)
DD(DEG)
TIME (DAYS)

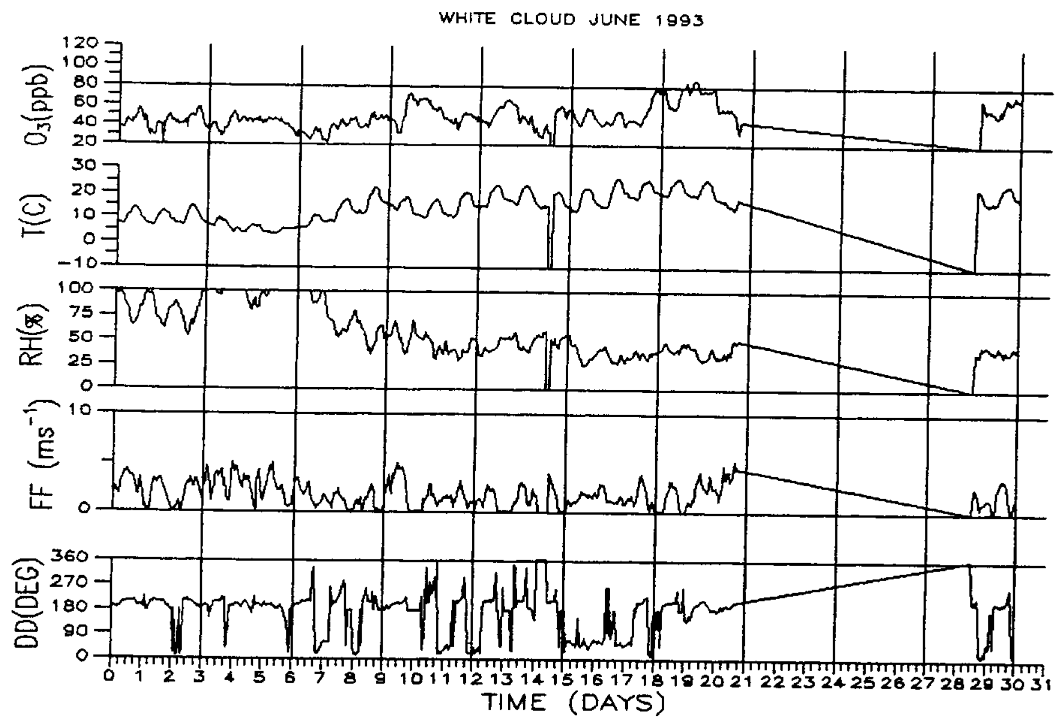
SLY PARK SEPTEMBER 1993

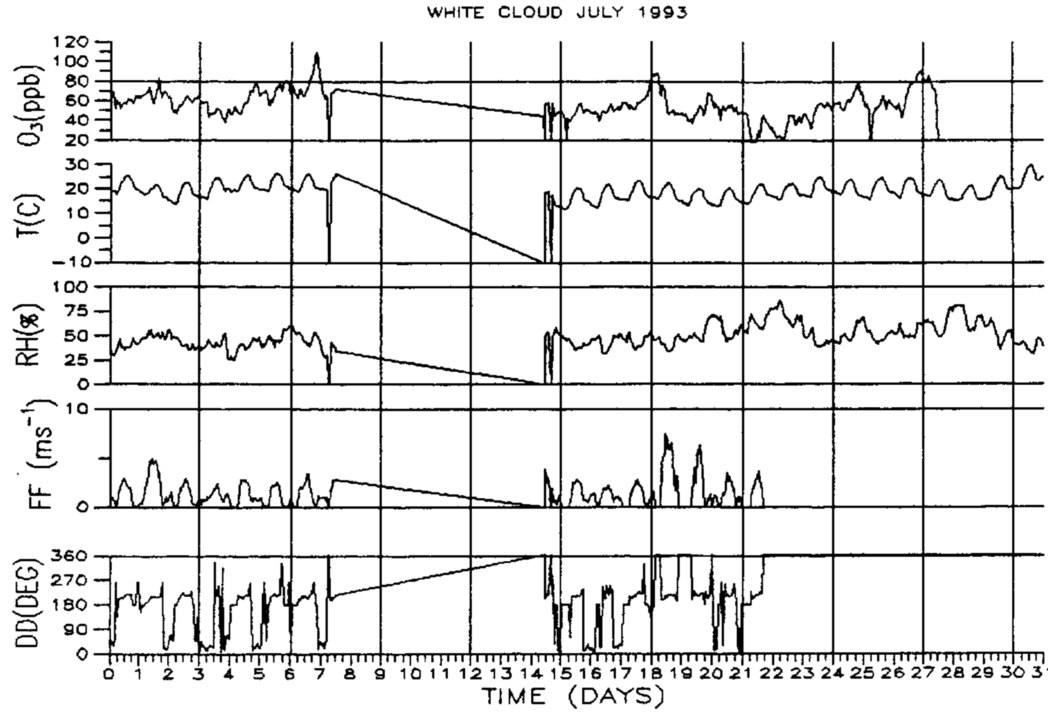


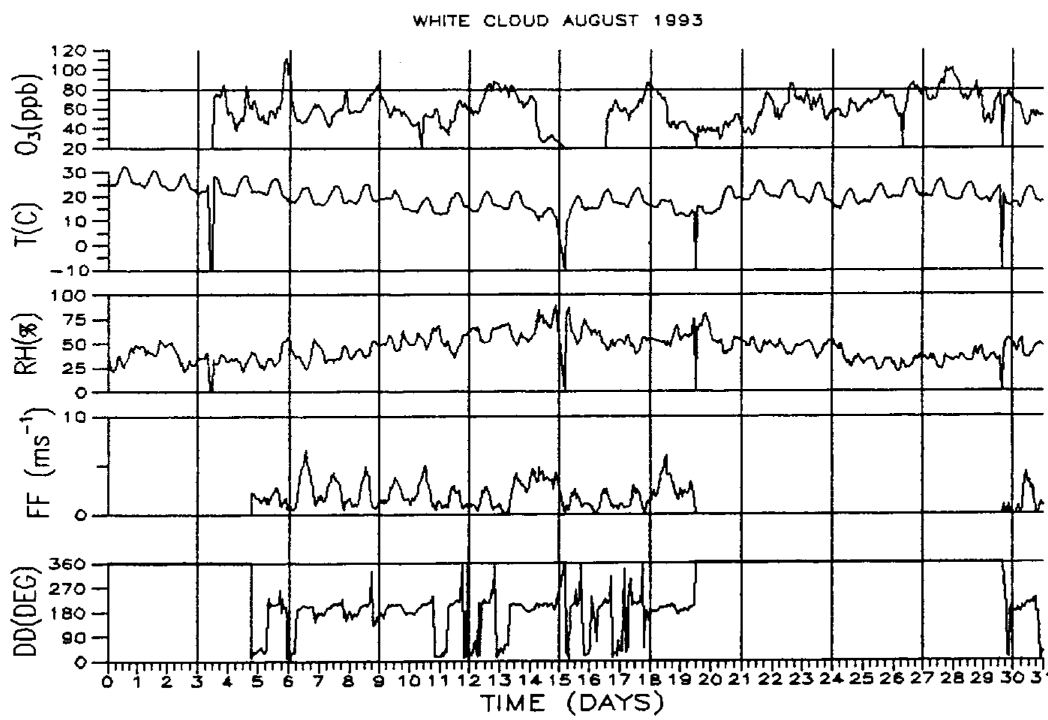

SLY PARK OCTOBER 1993

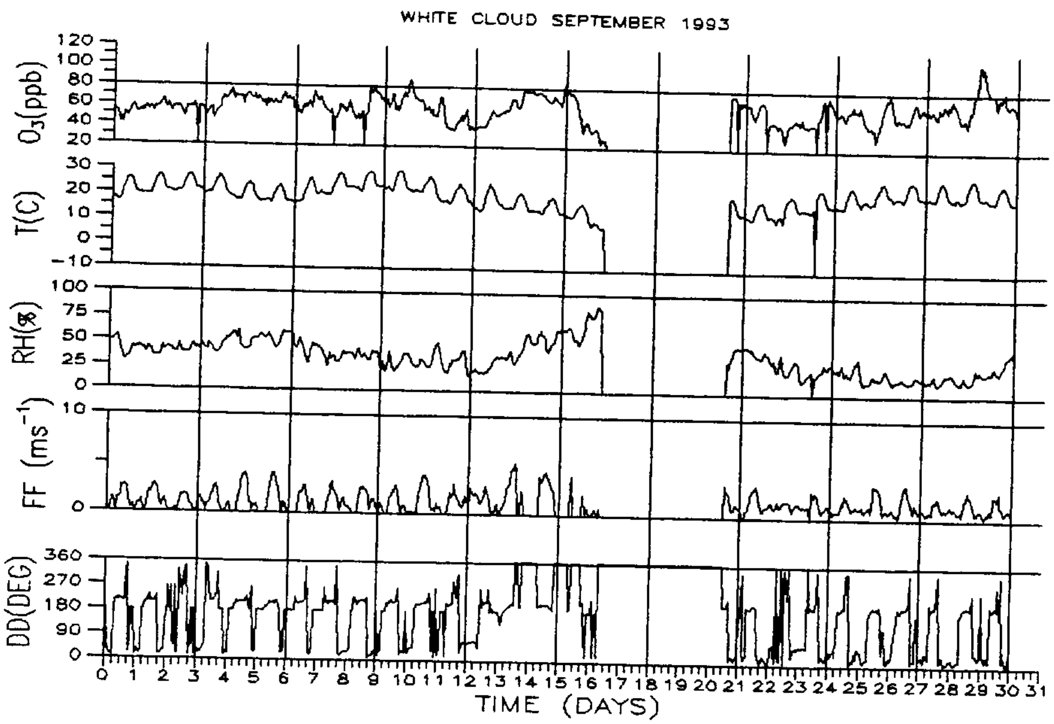


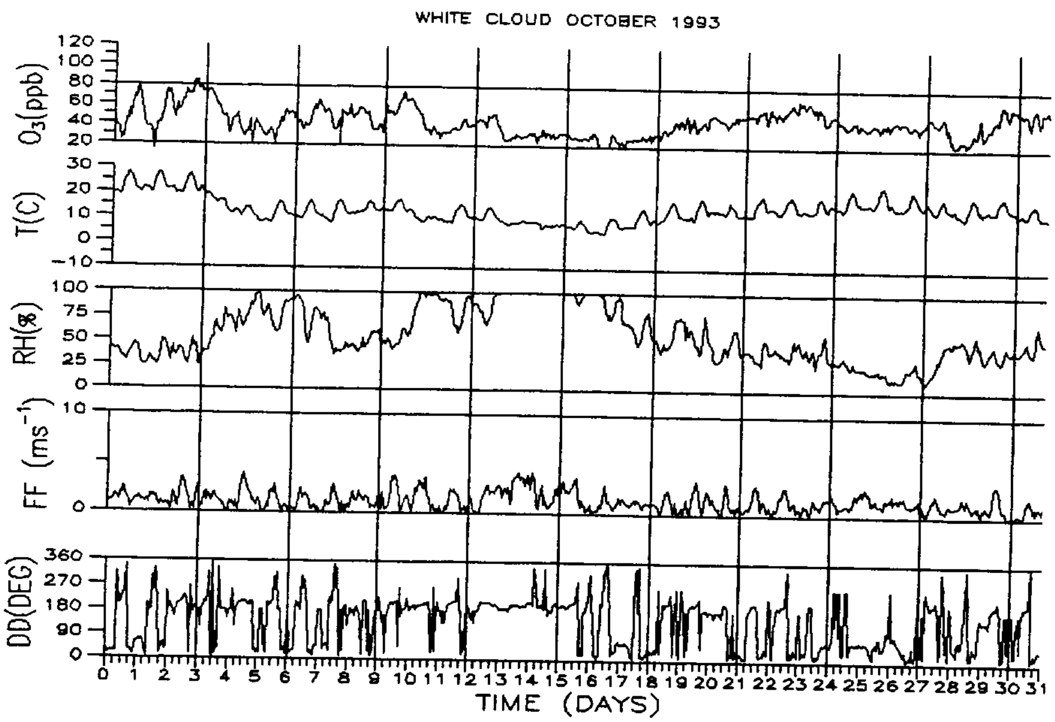

WHITE CLOUD MAY 1993
$O_3$(ppb)
T(C)
RH(%)
FF ($ms^{-1}$)
DD(DEG)
TIME (DAYS)

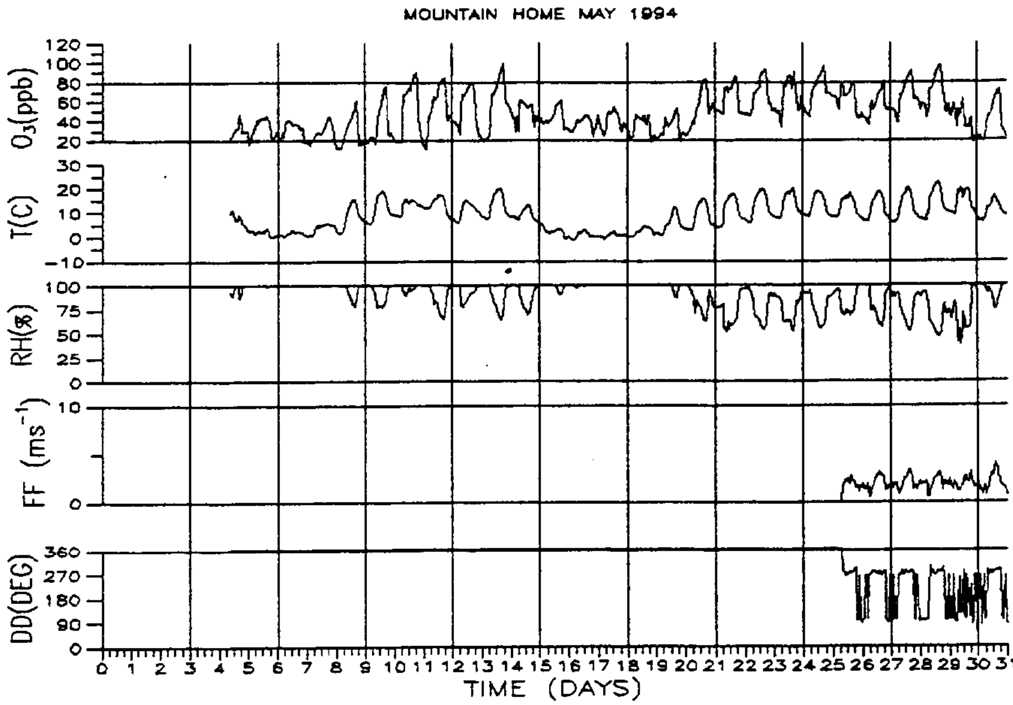

WHITE CLOUD JUNE 1993
$O_3$(ppb)
T(C)
RH(%)
FF ($ms^{-1}$)
DD(DEG)
TIME (DAYS)

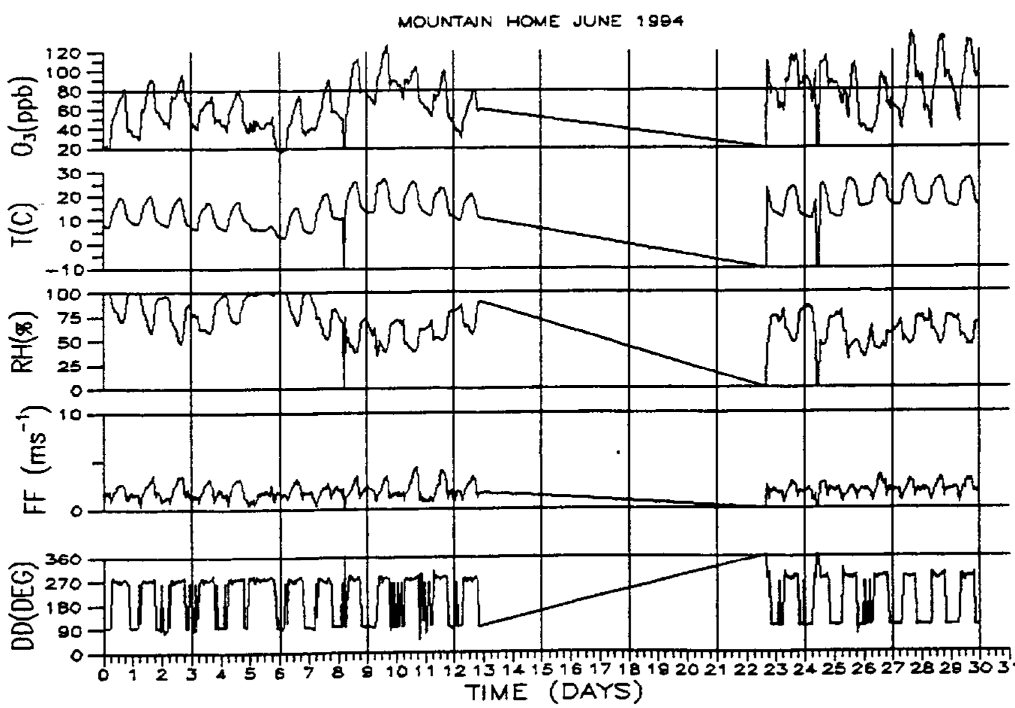

WHITE CLOUD JULY 1993
$O_3$(ppb)
T(C)
RH(%)
FF (ms$^{-1}$)
DD(DEG)
TIME (DAYS)


WHITE CLOUD AUGUST 1993
$O_3$(ppb)
T(C)
RH(%)
FF (ms$^{-1}$)
DD(DEG)
TIME (DAYS)

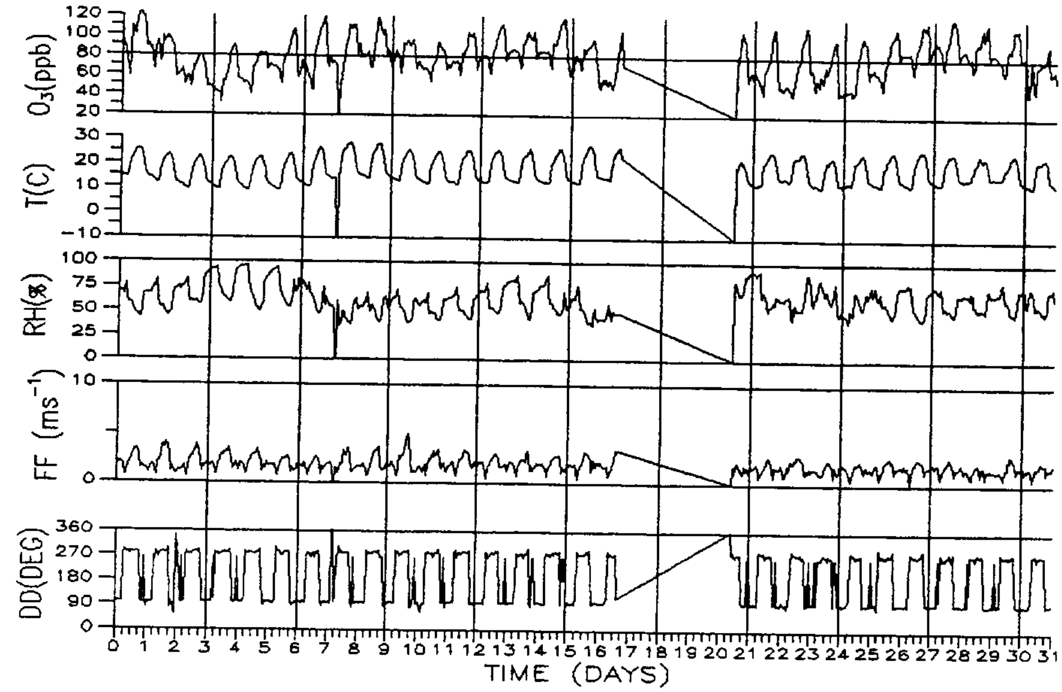

WHITE CLOUD SEPTEMBER 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


WHITE CLOUD OCTOBER 1993
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

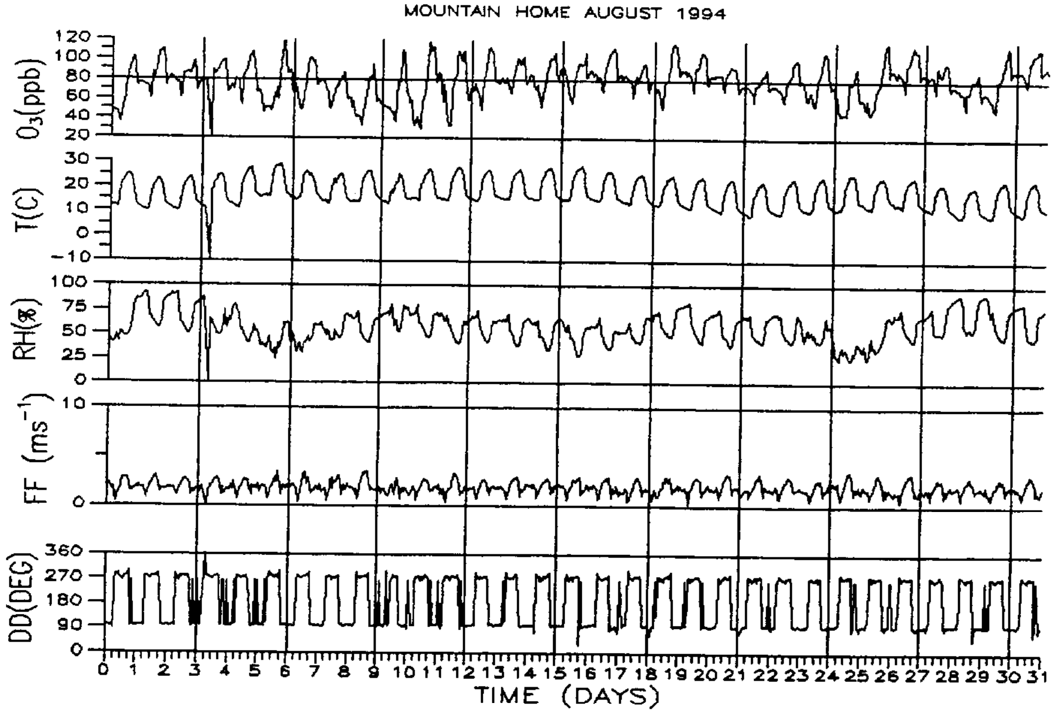

MOUNTAIN HOME MAY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

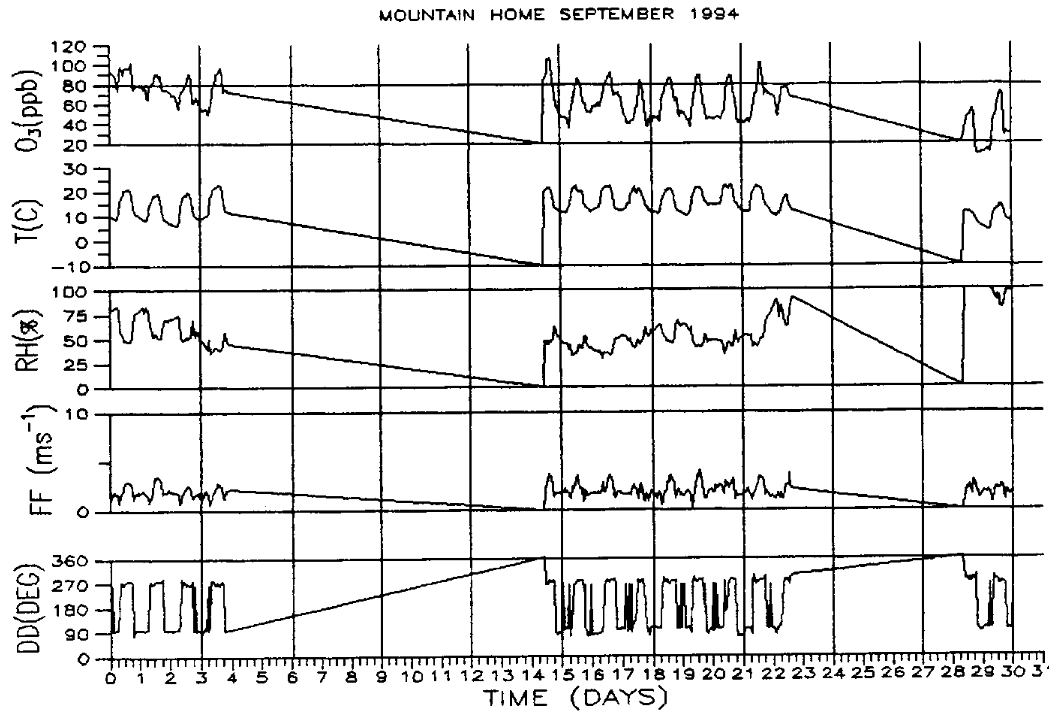

MOUNTAIN HOME JUNE 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

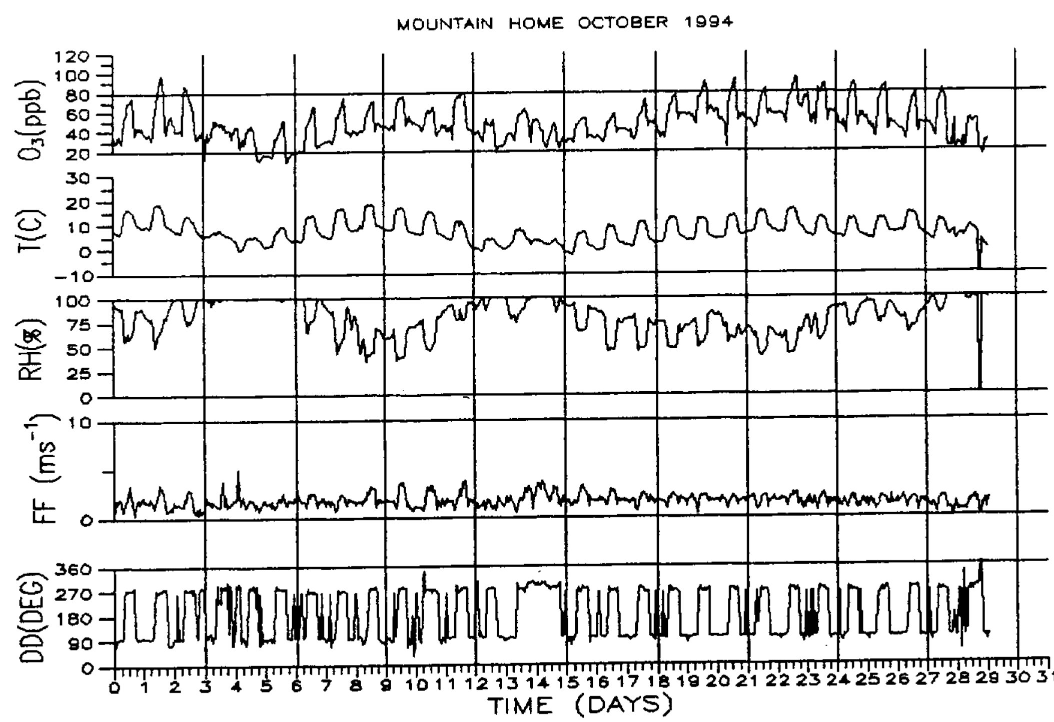
MOUNTAIN HOME JULY 1994

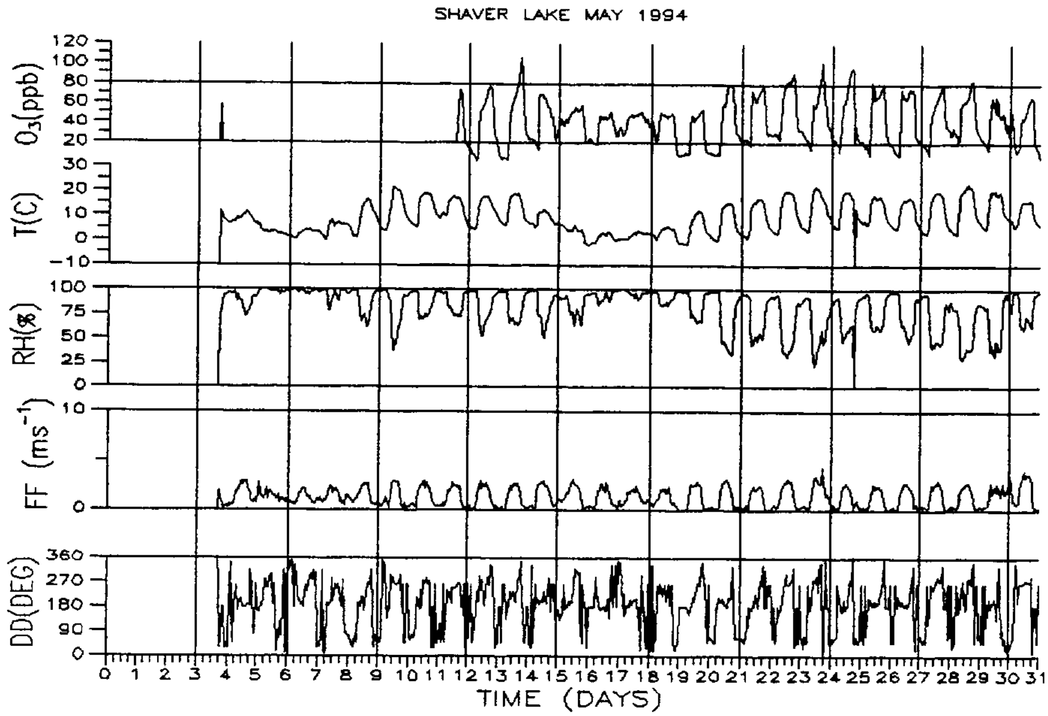


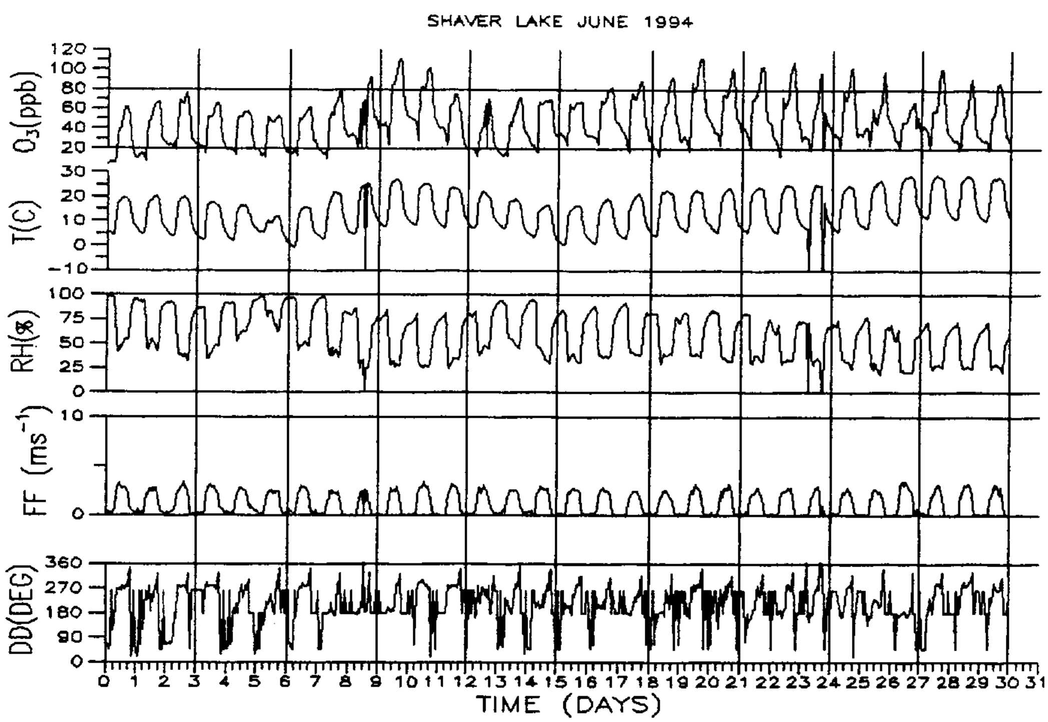

MOUNTAIN HOME AUGUST 1994

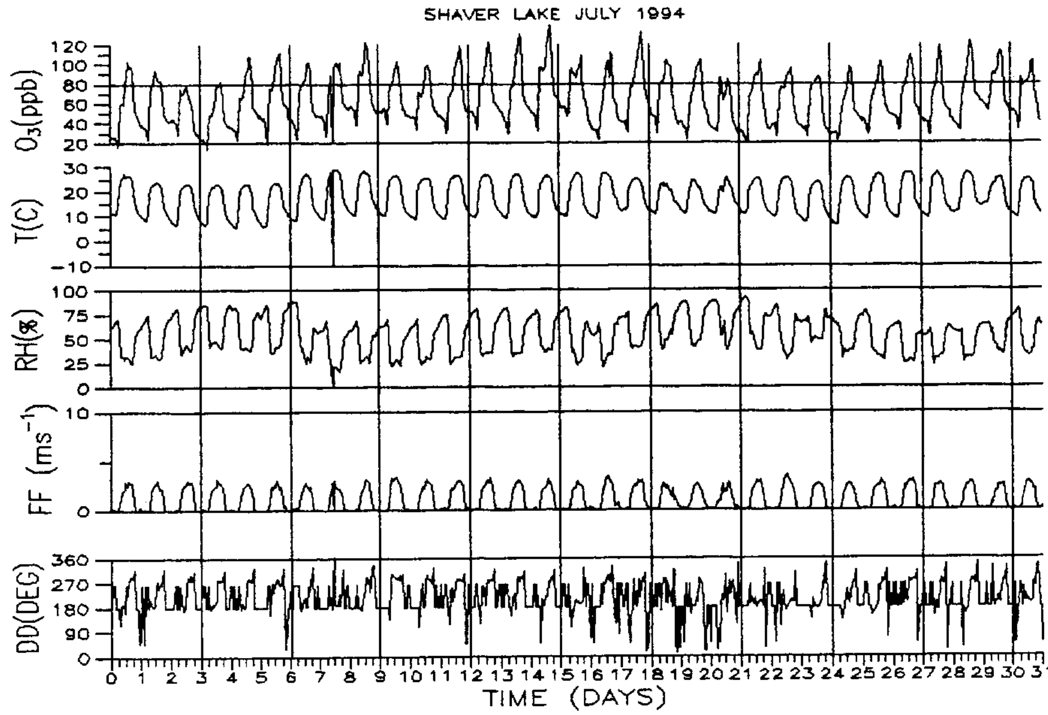


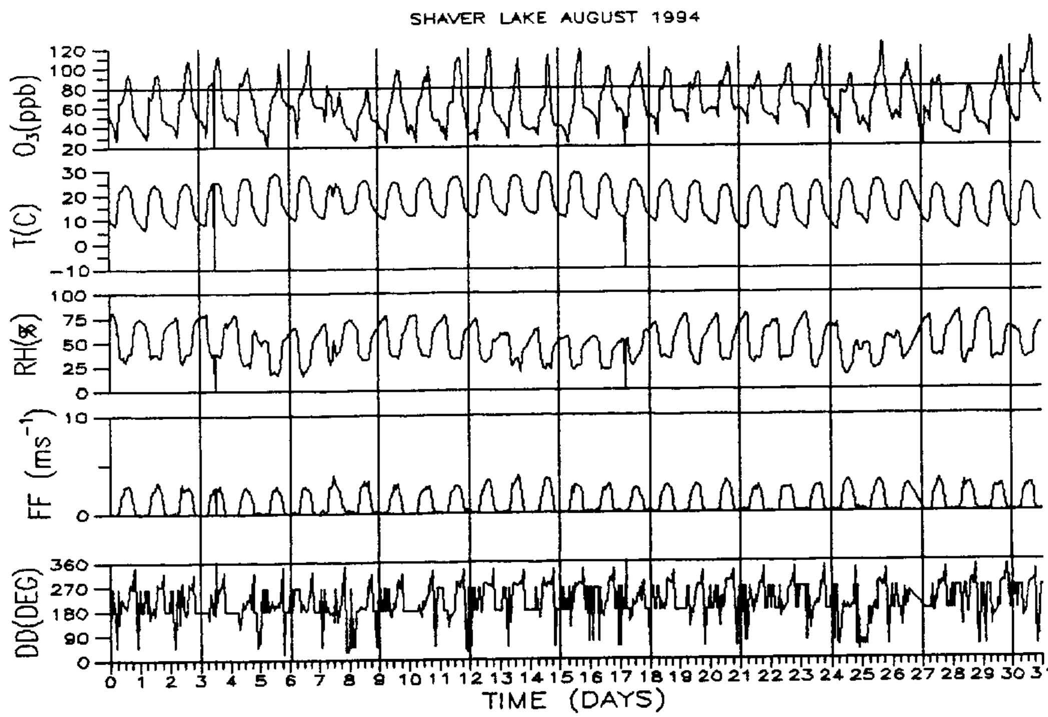

MOUNTAIN HOME SEPTEMBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

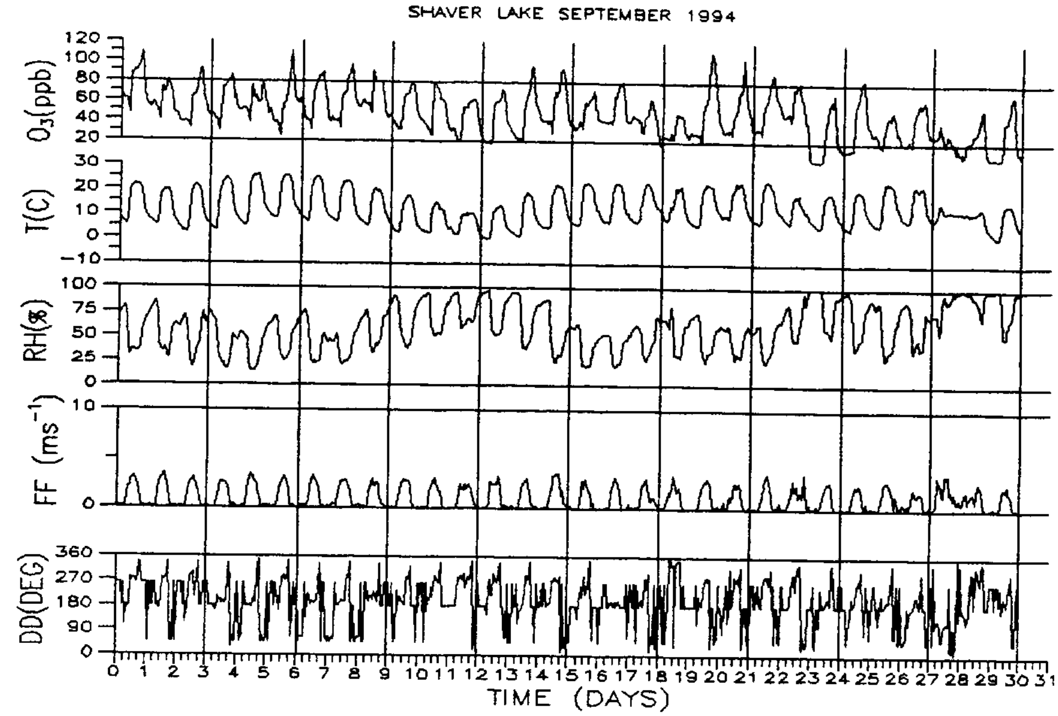

MOUNTAIN HOME OCTOBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

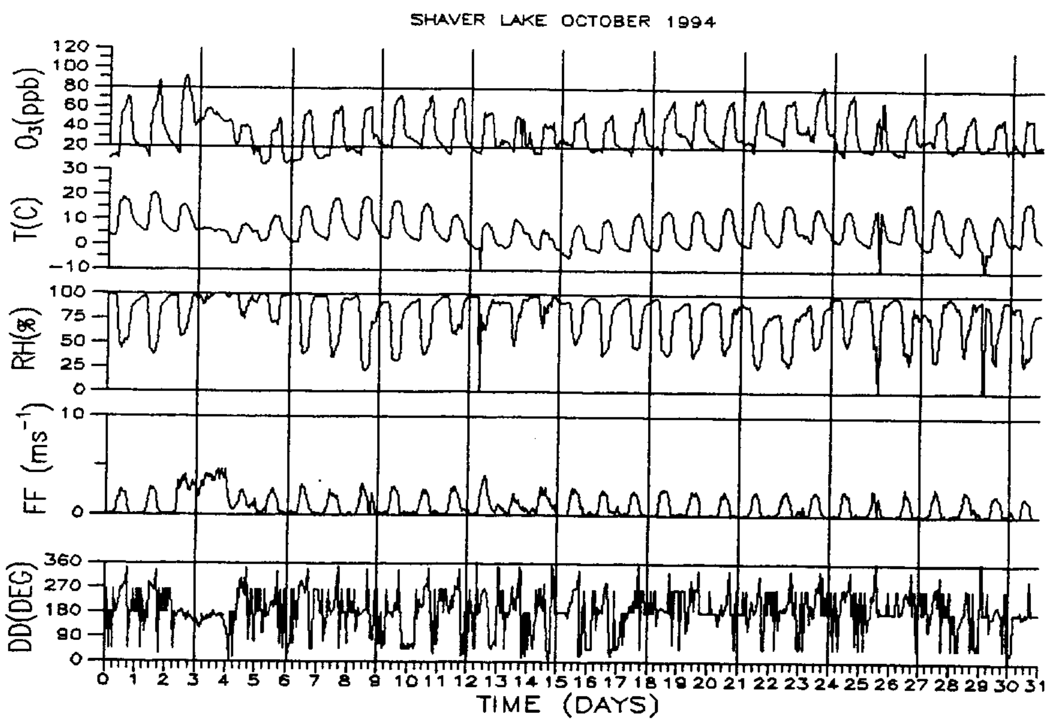

SHAVER LAKE MAY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

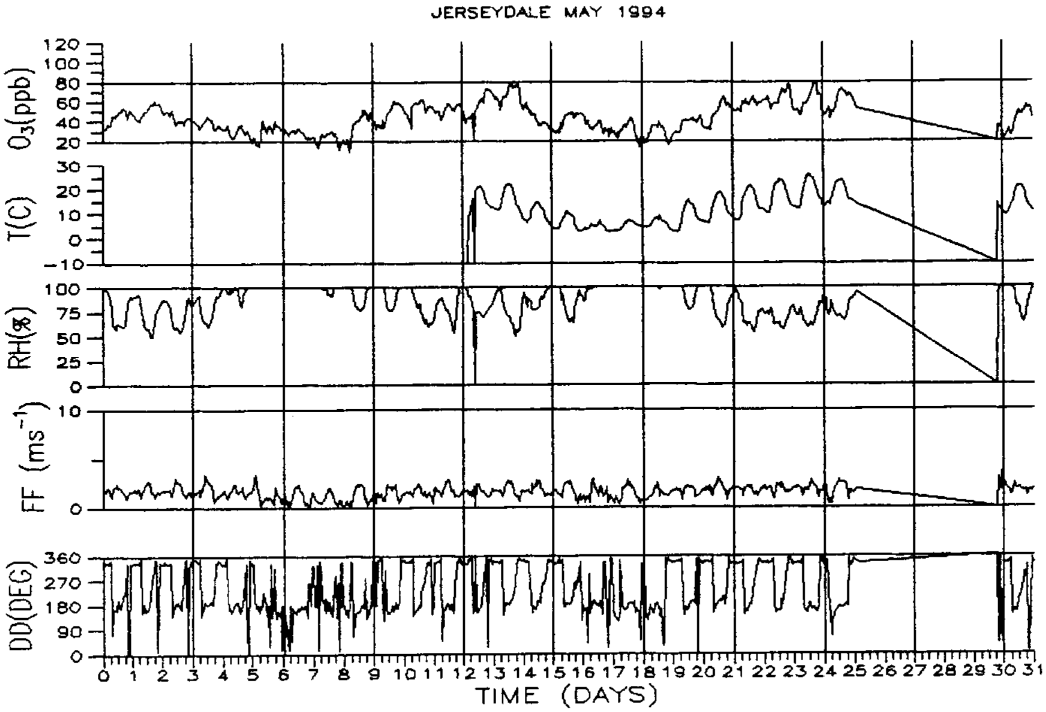

SHAVER LAKE JUNE 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

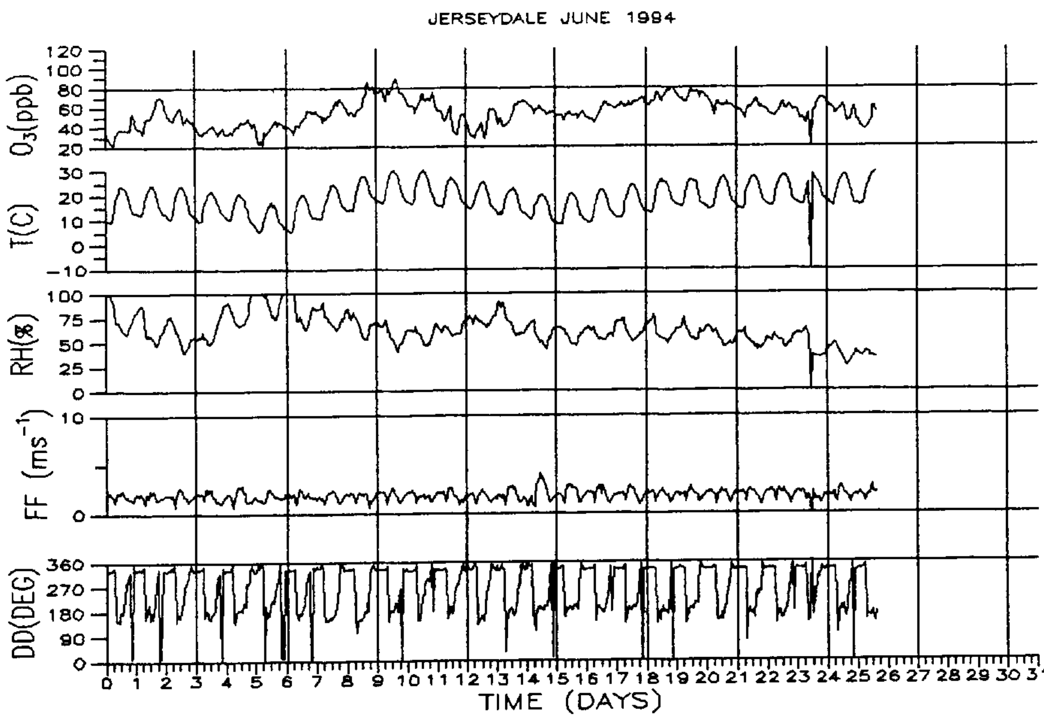

SHAVER LAKE JULY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

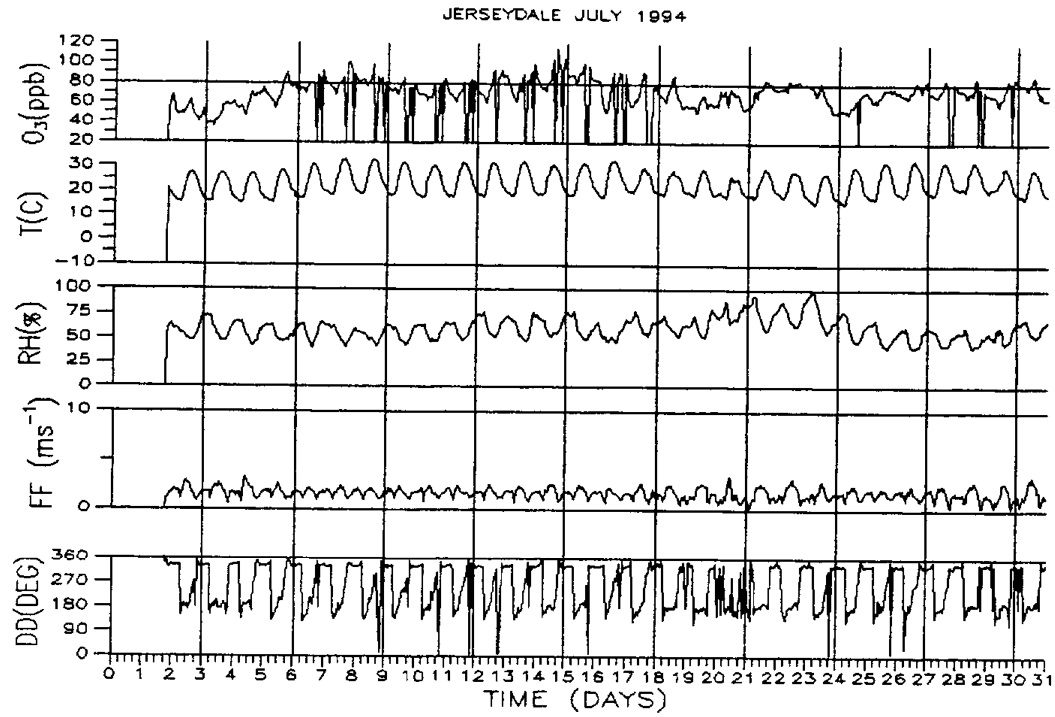

SHAVER LAKE AUGUST 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

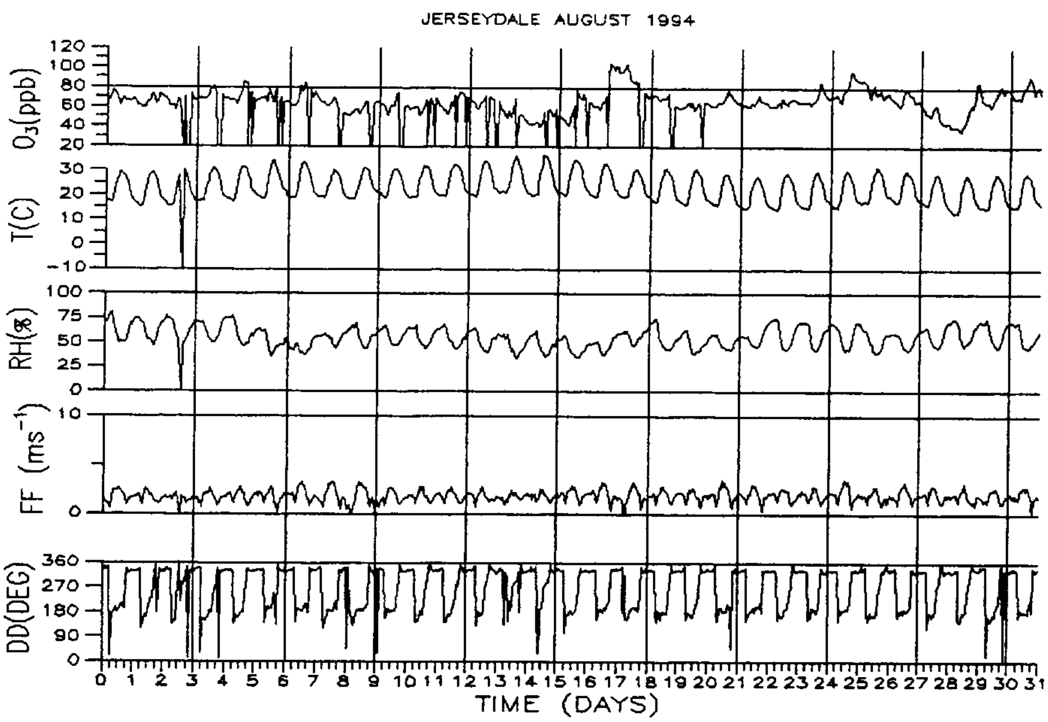

SHAVER LAKE SEPTEMBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


SHAVER LAKE OCTOBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

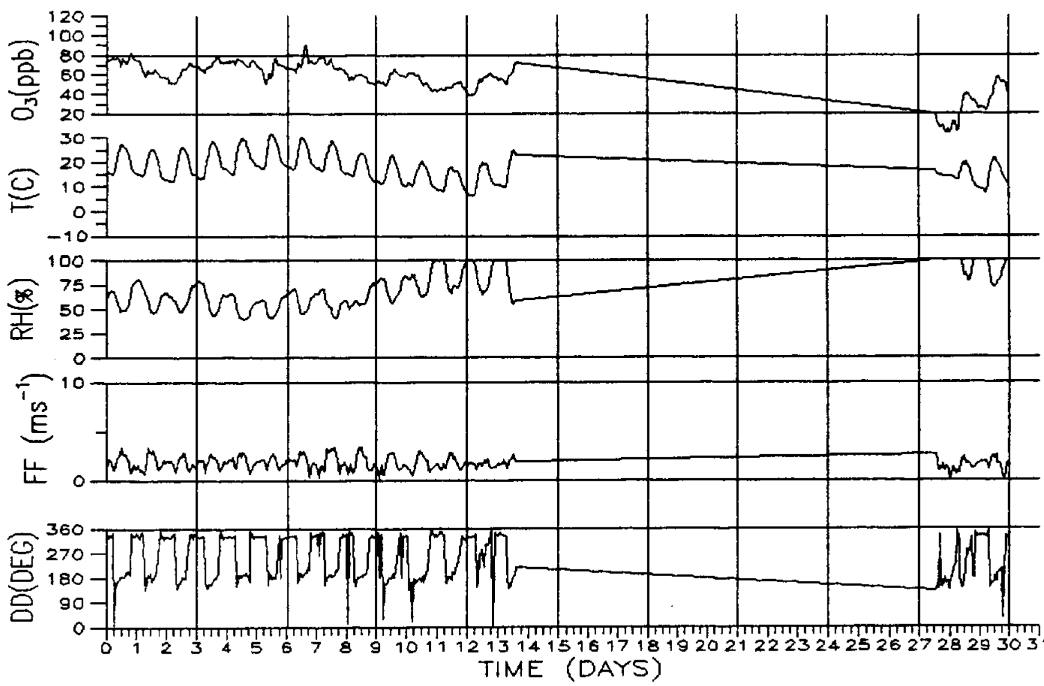

JERSEYDALE MAY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


JERSEYDALE JUNE 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

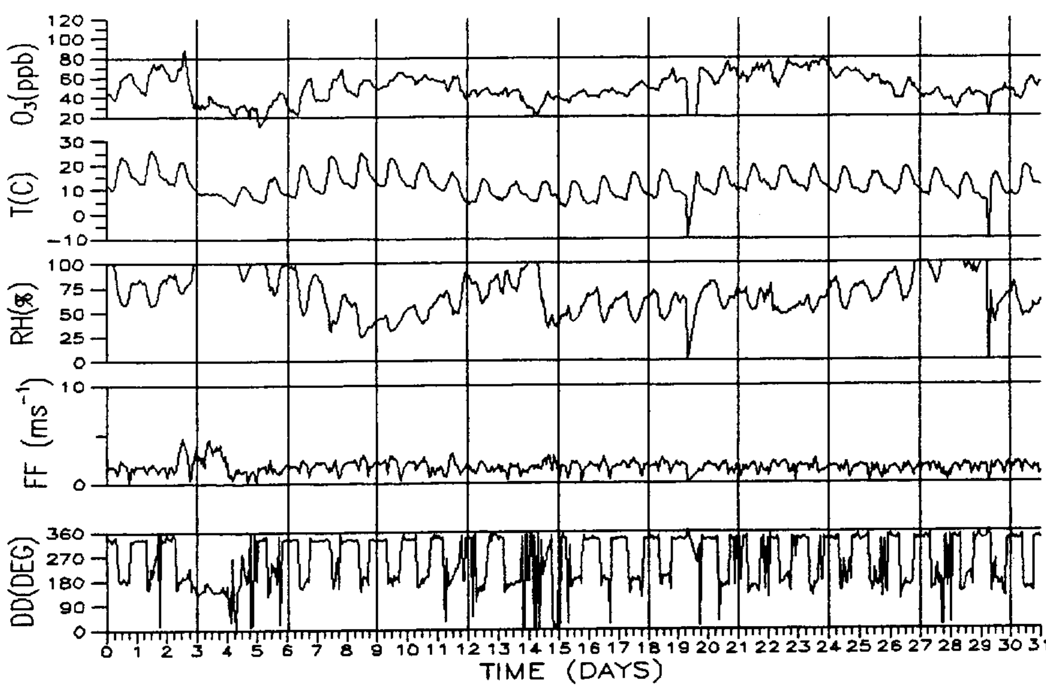

JERSEYDALE JULY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


JERSEYDALE AUGUST 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

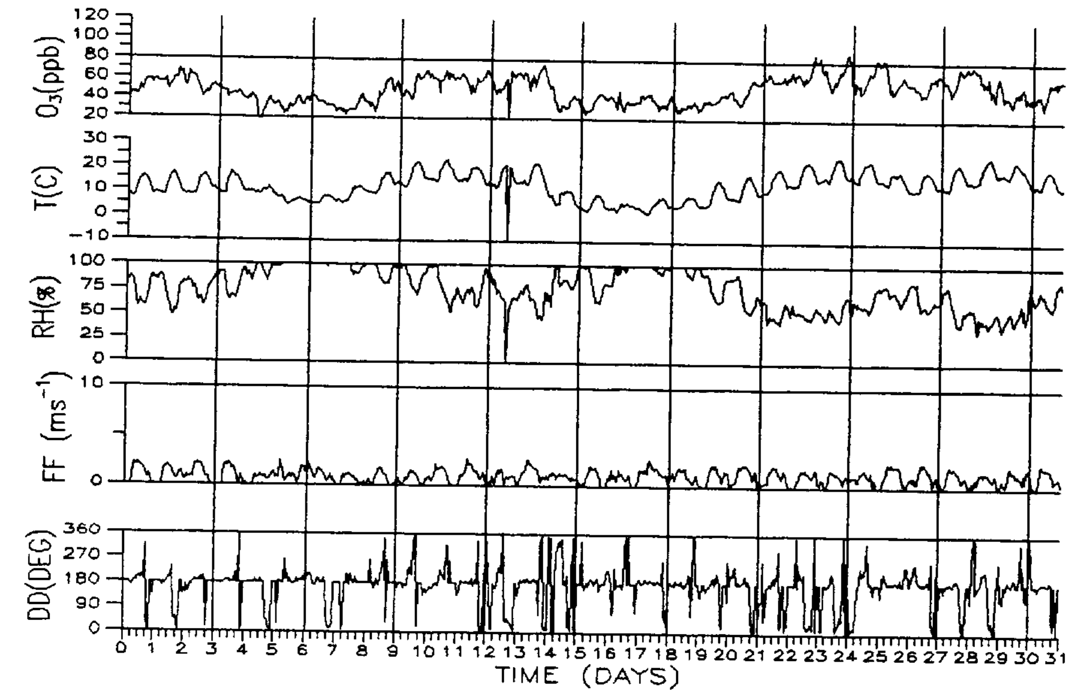
JERSEYDALE SEPTEMBER 1994



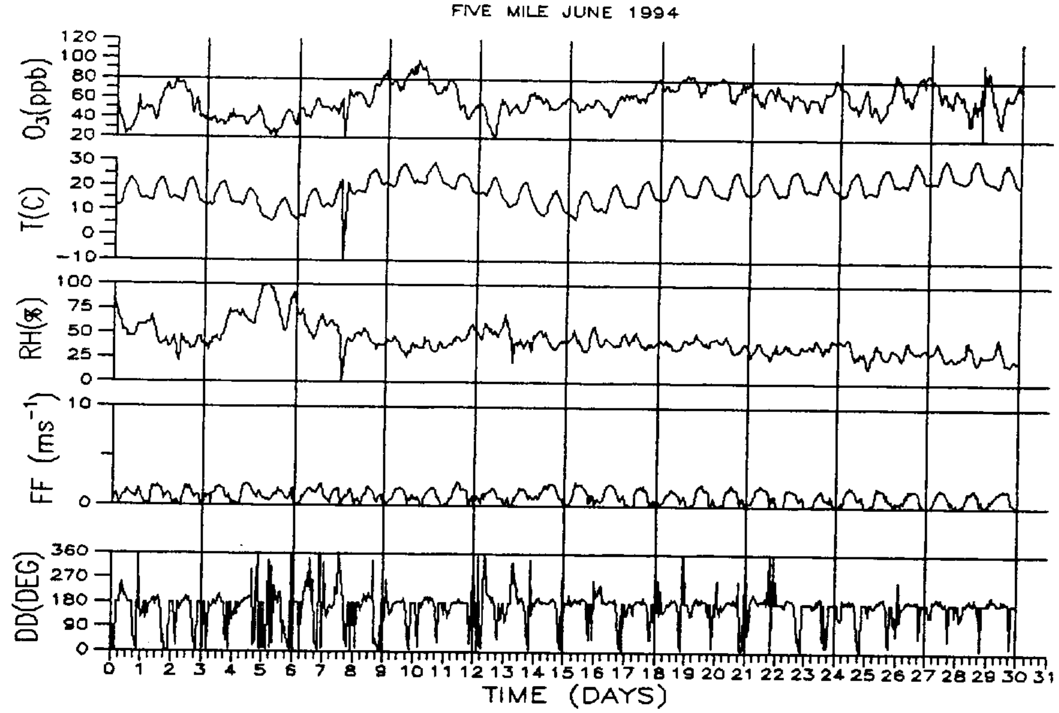

JERSEYDALE OCTOBER 1994

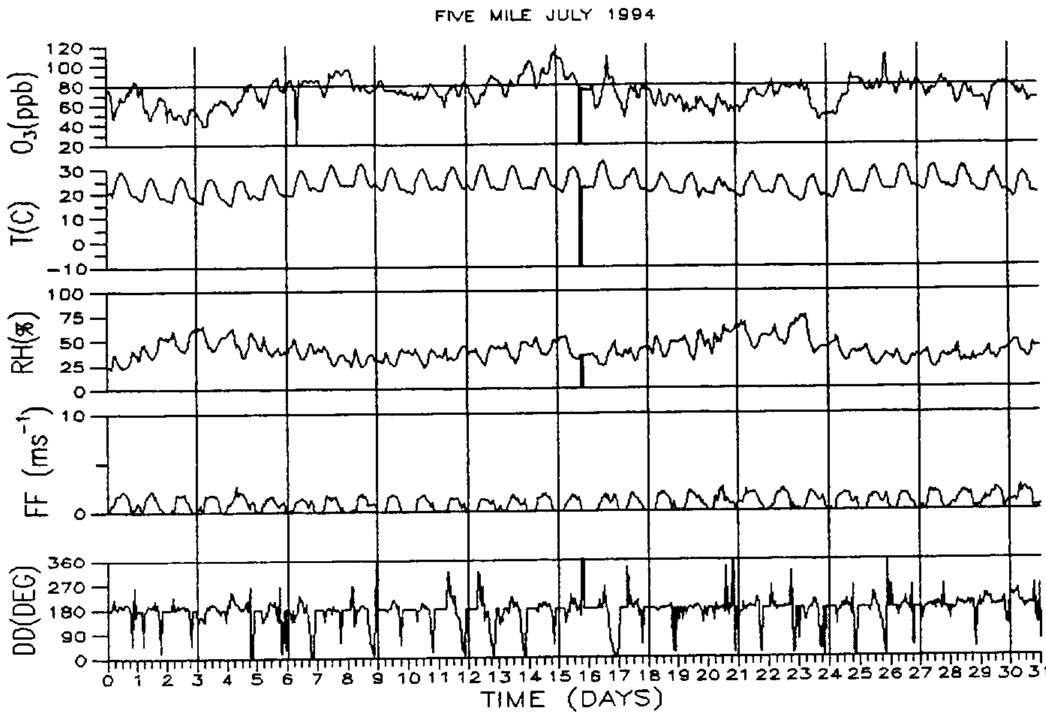


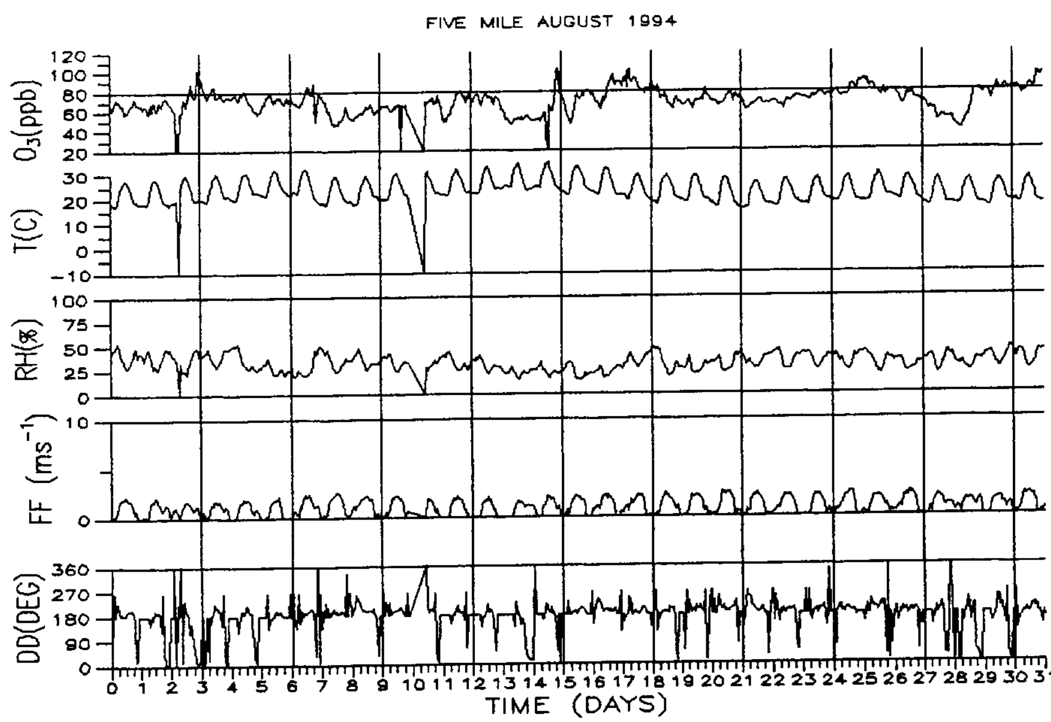
FIVE MILE MAY 1994

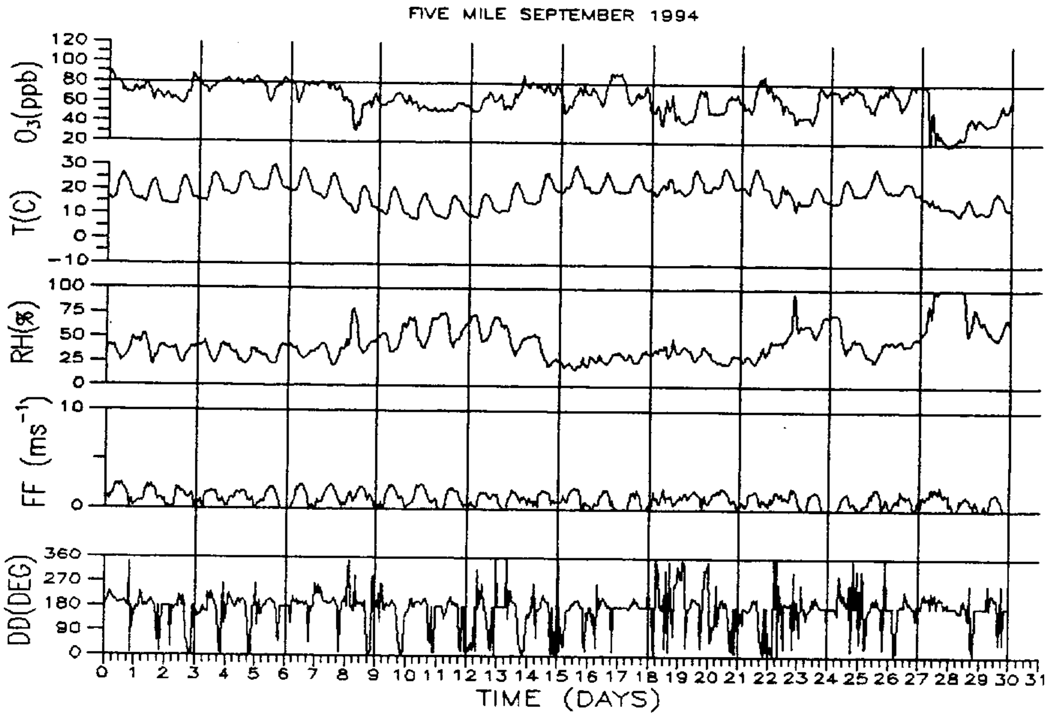


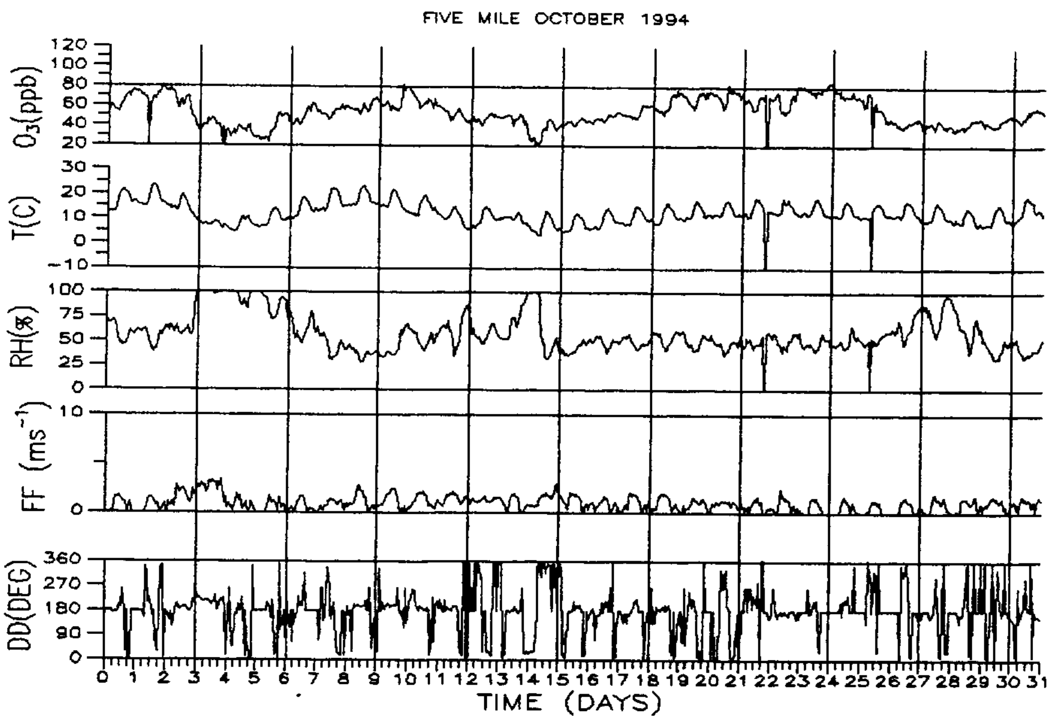

FIVE MILE JUNE 1994

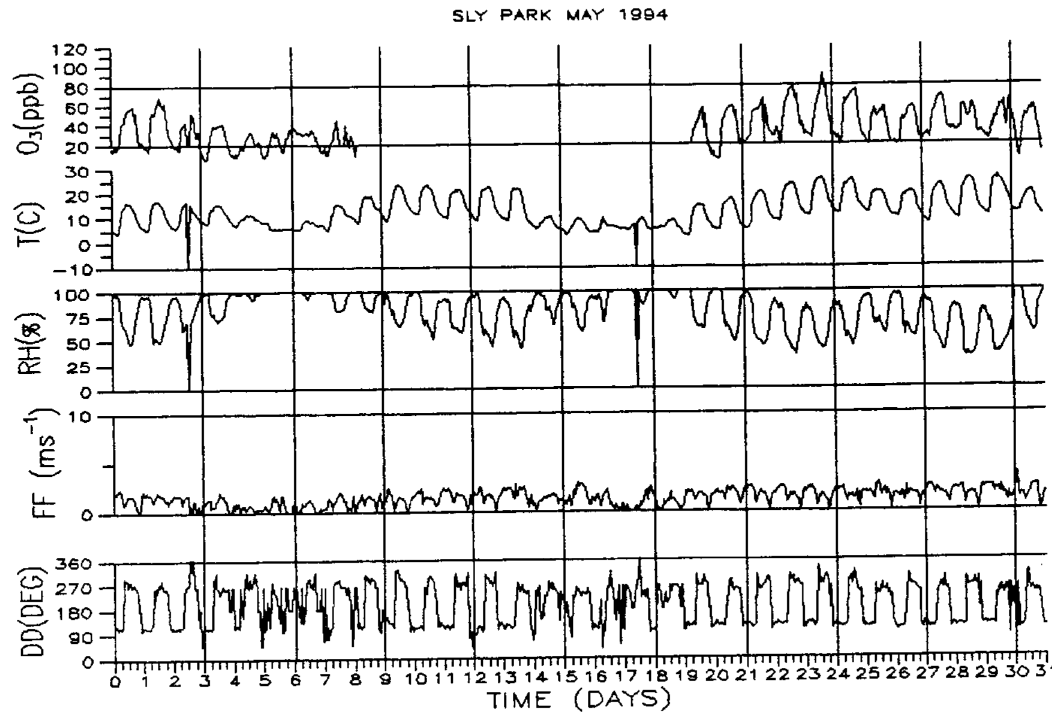


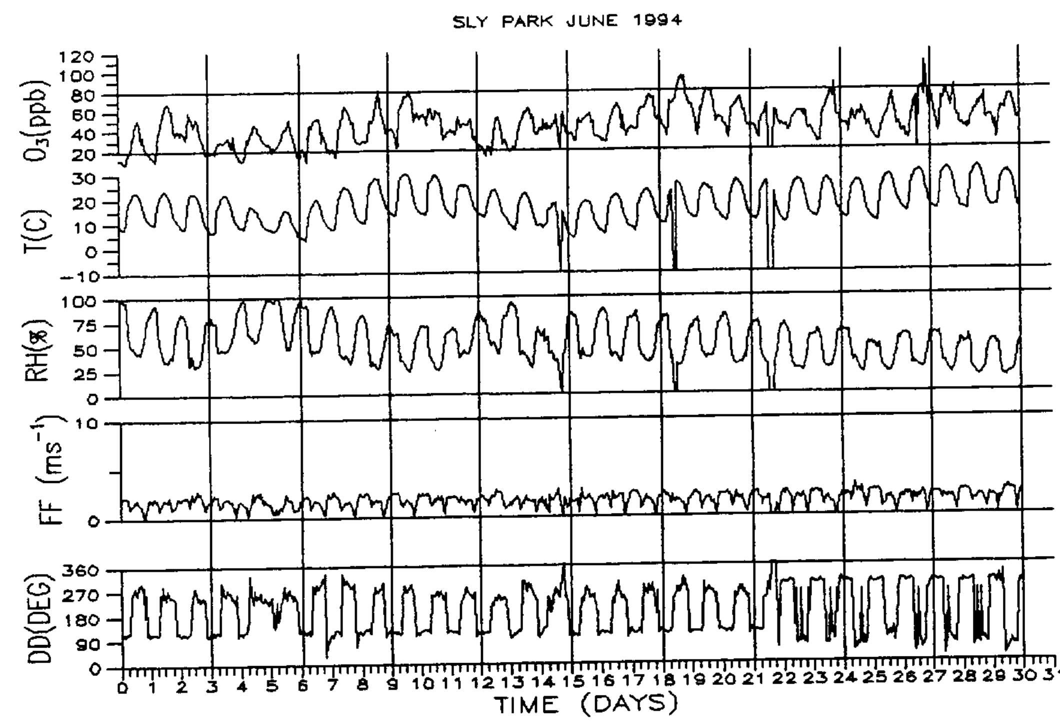

FIVE MILE JULY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

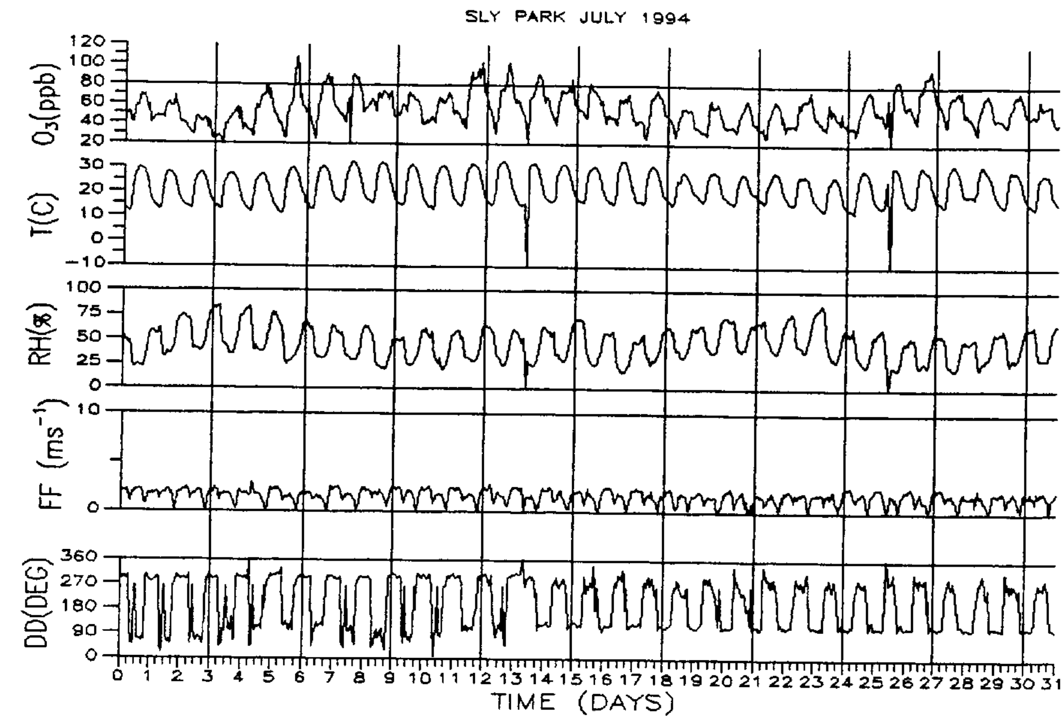

FIVE MILE AUGUST 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

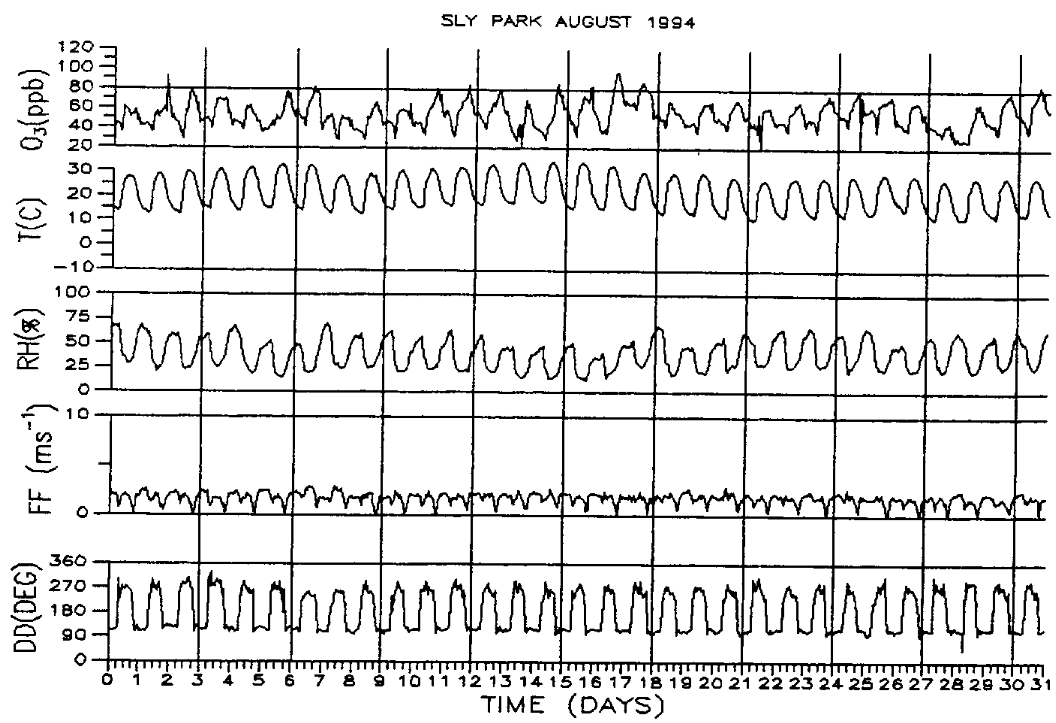

FIVE MILE SEPTEMBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

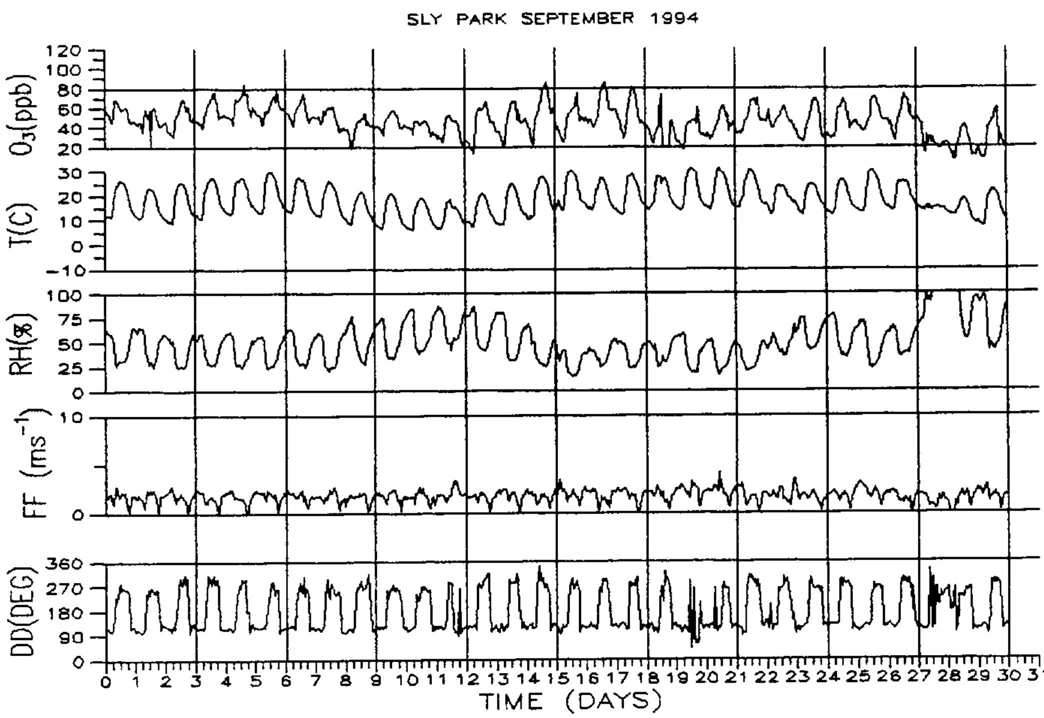

FIVE MILE OCTOBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

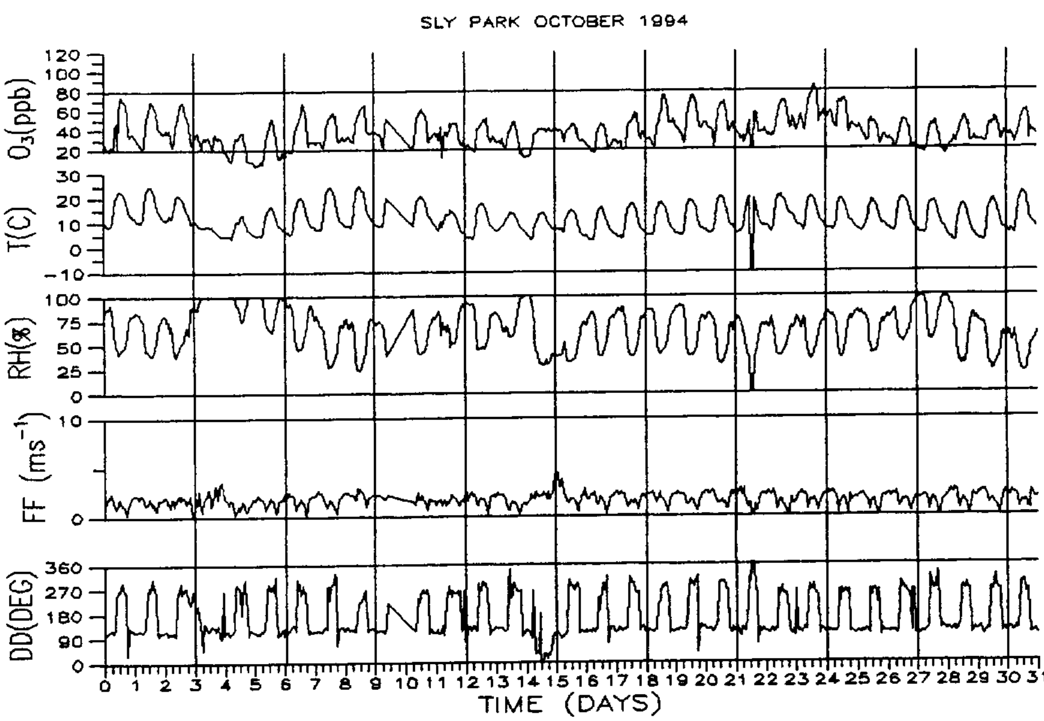

SLY PARK MAY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

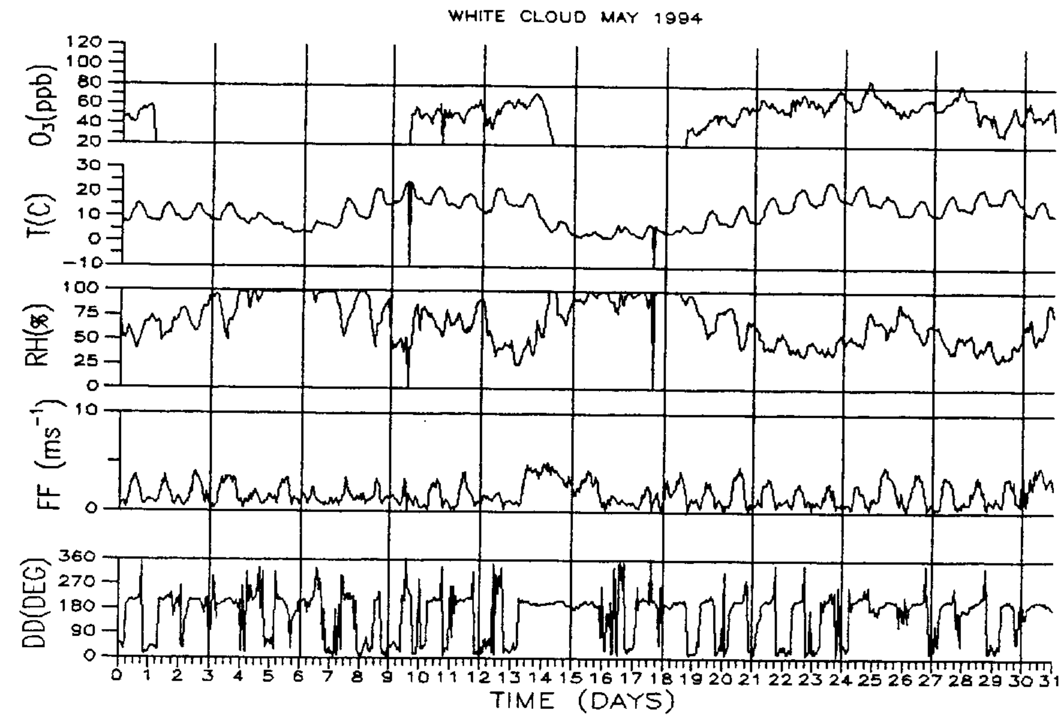

SLY PARK JUNE 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

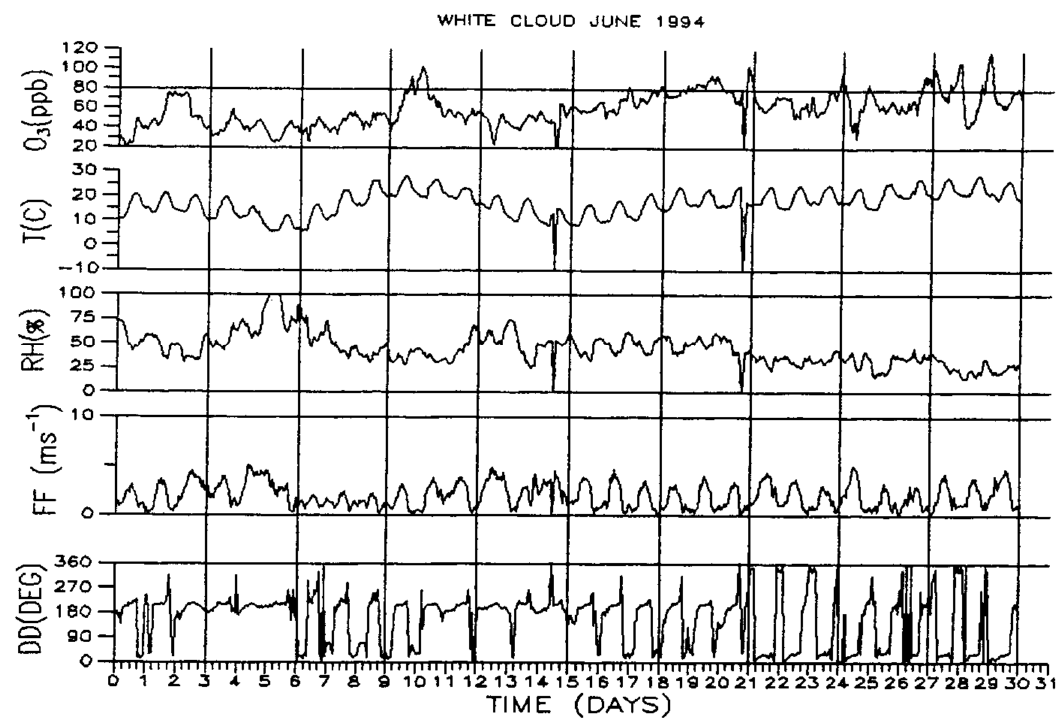

SLY PARK JULY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

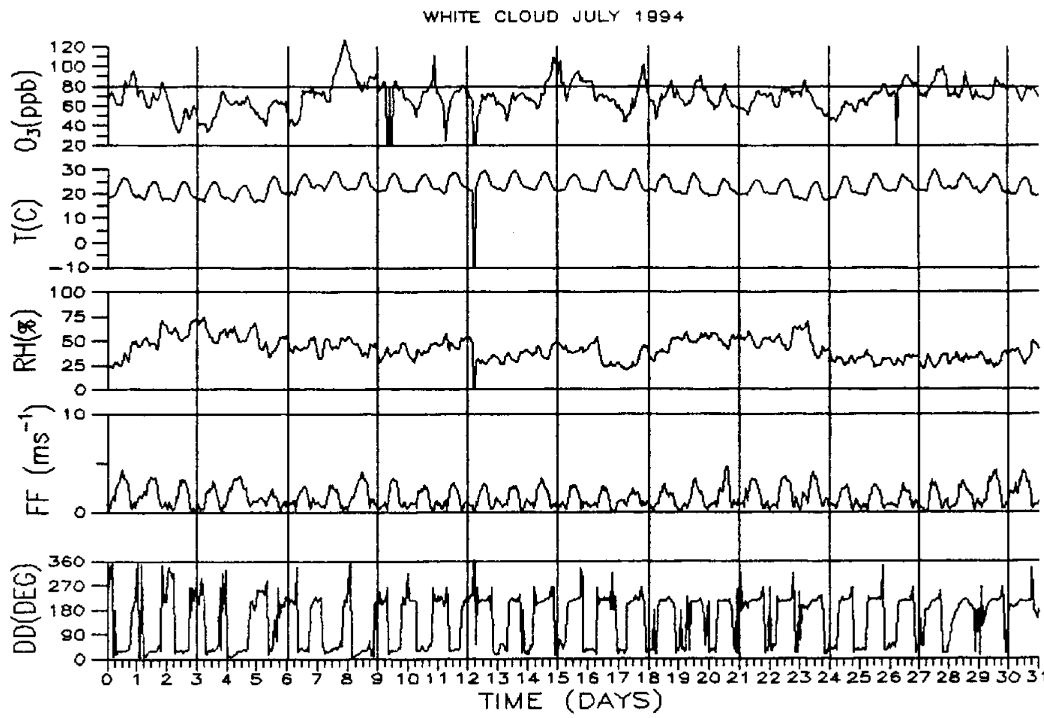

SLY PARK AUGUST 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

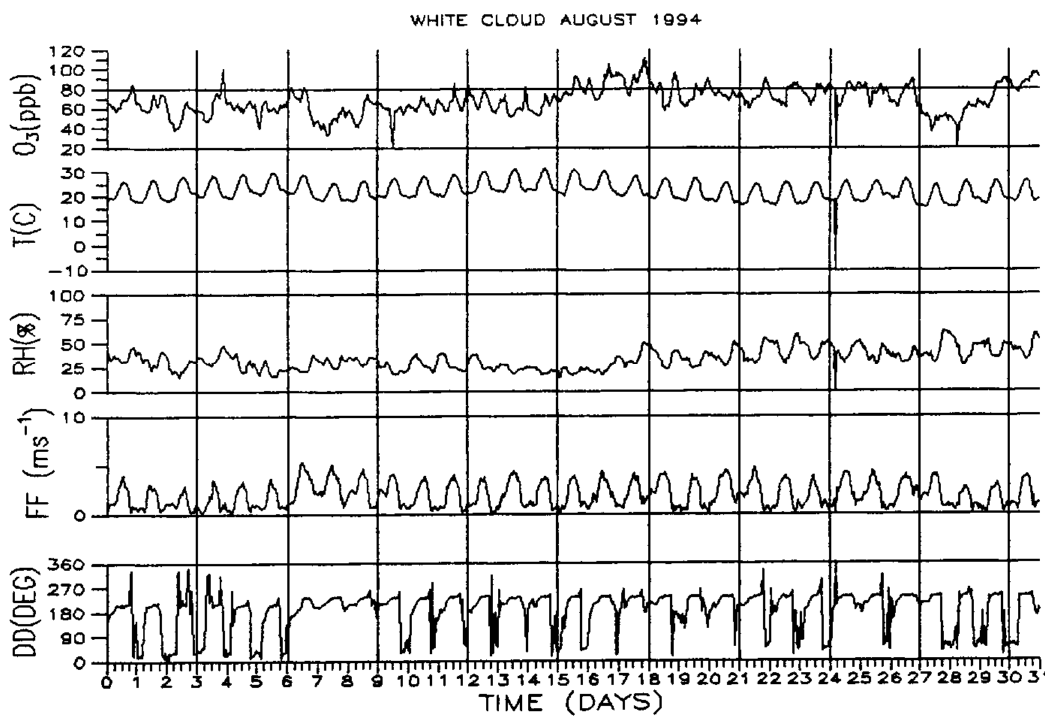

SLY PARK SEPTEMBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

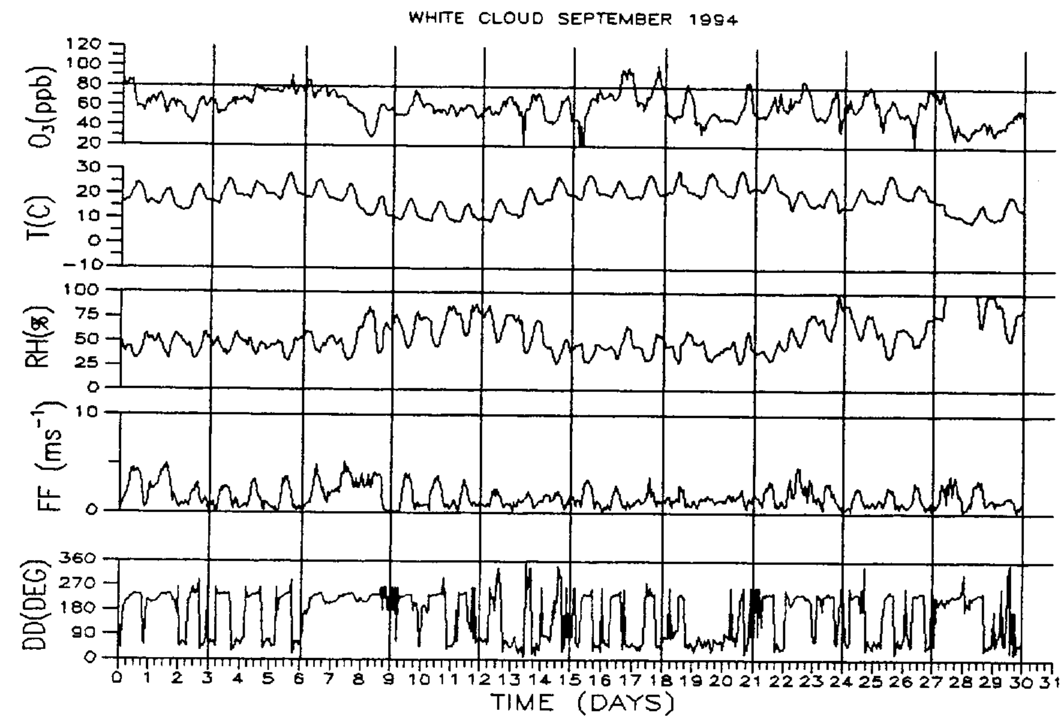

SLY PARK OCTOBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

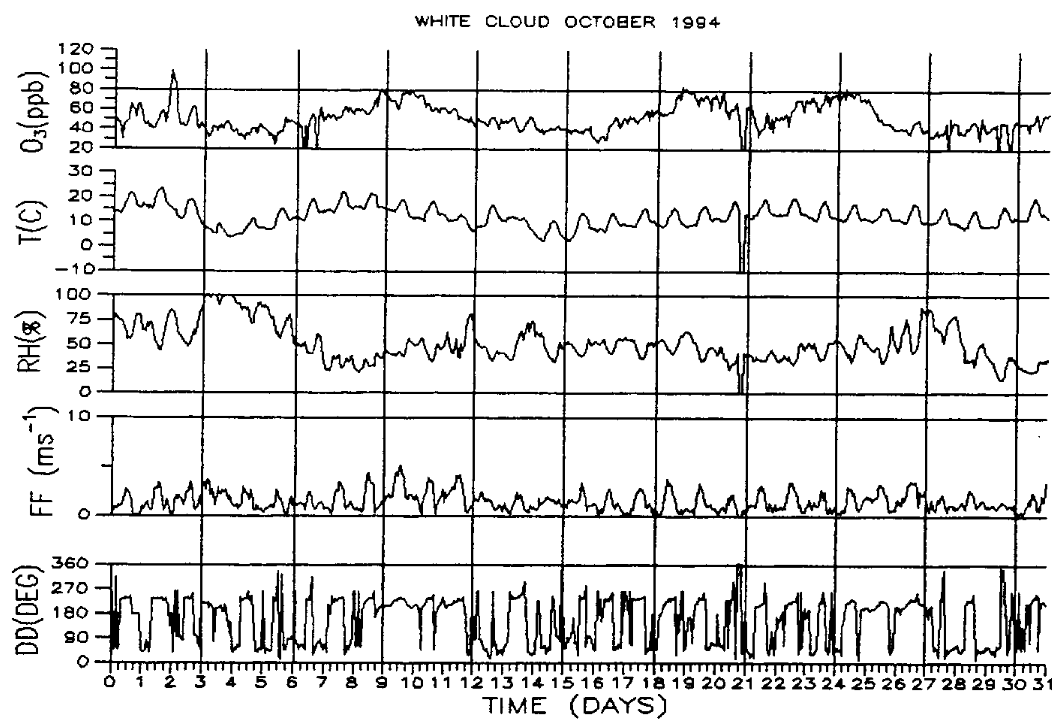

WHITE CLOUD MAY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


WHITE CLOUD JUNE 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


WHITE CLOUD JULY 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


WHITE CLOUD AUGUST 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


WHITE CLOUD SEPTEMBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)


WHITE CLOUD OCTOBER 1994
O3(ppb)
T(C)
RH(%)
FF (ms-1)
DD(DEG)
TIME (DAYS)

APPENDIX B:

# FIELD QUALITY ASSURANCE AUDITS

# AND

# DATA BASE DEVELOPMENT

# FOR

# THE SIERRA COOPERATIVE OZONE IMPACT ASSESSMENT STUDY: YEAR 4

FINAL REPORT, 1993/94

SUBMITTED TO

DEPARTMENT OF LAND, AIR AND WATER RESOURCES

UNIVERSITY OF CALIFORNIA, DAVIS

BY

GORDON STEWART, JR.

AND

KENNETH P. MacKAY

DEPARTMENT OF METEOROLOGY

SAN JOSE STATE UNIVERSITY

SAN JOSE, CA 95192

(408) 924-5203

MAY 1995

ACKNOWLEDGEMENTS: Greg Hunt and Brian Kahn assisted with the 1994 field audits. Alex Kotsiopulos transferred all data bases to Microsoft Access and wrote program modifications to facilitate data analysis and report generation. Bill Peculis produced the computer generated reports. We thank all of you for your assistance.

## 1. INTRODUCTION

The University of California, Davis, Department of Land, Air and Water Resources (UCD) has installed a network of six stations to measure meteorological parameters and ozone along the western slopes of the Sierra Nevada mountains. The San Jose State University, Department of Meteorology (SJSU) has contracted with UCD to (1) conduct a field quality assurance audit of network instrumentation to help assure the reliability of the data gathered, (2) develop the software for a user-friendly data base of the measurements collected from this network, and (3) identify a suitable case study and conduct meteorological analysis of the case. This report summarizes the progress made on the proposed tasks.

## 2. AIR QUALITY ASSURANCE AUDITS

The final field audits were performed for UCD in October 1993, June 1994 and October 1994. Reports of audit results for June and October 1994 have been submitted to UCD (MacKay and Stewart, 1994).

### 2.1 Audit One

The first audit for 1994 was performed for UCD on June 21-25. Ozone instruments were in agreement at all sites to within 3% except for the 0 and 50 ppbv levels at Five Mile and Jerseydale. The 0 ppbv level readings were up to 150% above the transfer standard and the 50 ppbv level readings were 6% and 18% above the transfer standard, respectively. The remainder of the sites were around 10% high at the 0 and 50 ppbv levels. Sly Park and White Cloud anemometer values were in error by > 35% at the low speed settings. This can be attributed to inadequate set-up procedures. At subsequent sites, a more careful alignment of the drive coupling gave consistent readings of -17% error at the highest speed and within + or - 4% at the lowest speed. Wind direction readings were unremarkable. Temperature readings were as much as 11.6F (Shaver Lake) below the standard and humidity readings were as much as 16.5% (Mountain Home) higher than standard.

## 2.2 Audit Two

The second audit for 1994 was performed for UCD on October 21 at White Cloud, October 22 at Sly Park and Five Mile, and on October 29 at Mountain home, Shaver Lake and Jerseydale. Ozone values were typically within 10% except at the 150 to 250 ppbv ranges at Jerseydale where the readings were about 15% lower than the transfer standard and the 0 ppbv range where the readings were 50% higher than the transfer standard at Jerseydale and Mountain Home. The other four sites' data logger values were from 20 to 30% higher than the ozone transfer standard's at the 0 ppbv setting. Anemometer readings ranged from 17.5% lower than the standard at 400 rpm (high speed) to 6% lower than the standard at 100 rpm (low speed). Wind direction readings were all within one degree except at Five Mile (1.2°) and Mountain Home (1.7°). Temperature readings ranged from 4.0F lower than standard at White Cloud, to 12.1F higher than standard at Five Mile and 8.1F higher than standard at Sly Park. The other three sites' temperatures were within 1.5F of the standard. Relative humidity values were within approximately + or - 10% or better at all sites.

# 3. DATA PROCESSING

During the year 1994, SJSU copied data base files to Microsoft Access. This off-the-shelf readily available software was modified to provide a more user-friendly data base and records reporting system than the previous software had allowed. The Access system has been tested, debugged and used exclusively to import all data files, analyze the data, set up spreadsheets and print reports for the entire 1990-1994 study period. No changes were required in the data gathering protocols and monthly summaries are similar to those reports generated from the old software with the exception that they are more readable. Printed copies of each years' (1990-1991, 1992, 1993, 1994) data summaries are divided into two volumes. Volume 1 contains monthly summaries for Mountain Home, Shaver Lake and Jerseydale. Volume 2 contains monthly summaries for Five Mile Learning Center, Sly Park and White Cloud. The first page of each volume is an introductory note that explains the format of the printed monthly report sheets (see Figures 1-10).

# 4.0 TASKS IN PROCESS

Final evaluation and episode analysis are currently being completed. An additional appendix (User's Manual) for producing reports from Access will also be included in the finalized version of this report.

## 5.0 SUMMARY

Three field audits of the Sierra Cooperative Ozone Impact Assessment Study network of meteorological and ozone concentration measuring stations were completed between October 1993 and October 1994. Reports summarizing the results for 1994 were submitted to UCD, thereafter. During 1994, the data management application program was changed to Microsoft Access and has been completely tested by producing all of the data for the study period into monthly reports. All known bugs have been corrected and the software is operating quickly and efficiently.

## 6.0 REFERENCE

MacKay, K.P., 1992. Field Quality Assurance Audits and Data Base Development. San Jose State University, San Jose, CA. 30 June 1992.

# INTRODUCTORY NOTE

The forms that are contained in this volume have a standard layout which is described as follows:

- The header appears as follows:

| | | |
|---|---|---|
| Month - Year | Type of Report | Date/Time of Printing |
| Station Name | | |

- The title row appears as follows:

| | | | |
|---|---|---|---|
| <---------------- Hours ----------------> | Peak value of the day *[1] | Time of Occurrence | Number of Peaks |

- The first column indicates the date that the measurements were recorded.
- The last three rows indicate the Monthly Average of the given hour, the number of days listed and the Monthly Max. for the given hour respectively.
- An occurance of the value "-99" means invalid data for that given date/hour. However, it can also mean no data in the case where data collection began after 00:00 hours of the start day or before 24:00 hours of the end day.

*[1] The Wind Direction and U, V components do not include peak values.

Figure 1: Example Introductory Note

September-1991
Jerseydale

## Wind Direction (Degrees)

*Calculated From U-V Components*

*PRINTED ON:* 3/6/95 22:25

| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/91 | 333 | 334 | 336 | 336 | 337 | 96 | 61 | 346 | 145 | 148 | 171 | 162 | 186 | 185 | 175 | 177 | 186 | 189 | 139 | 346 | 329 | 334 | 335 | 338 |
| 9/2/91 | 340 | 335 | 335 | 332 | 351 | 336 | 353 | 350 | 311 | 170 | 194 | 183 | 199 | 207 | 200 | 190 | 211 | 206 | 291 | 341 | 338 | 337 | 334 | 330 |
| 9/3/91 | 332 | 332 | 331 | 330 | 332 | 330 | 334 | 352 | 152 | 211 | 229 | 211 | 207 | 192 | 255 | 214 | 293 | 295 | 351 | 9 | 348 | 333 | 328 | 334 |
| 9/4/91 | 334 | 332 | 338 | 337 | 331 | 334 | 330 | 333 | 283 | 150 | 164 | 239 | 222 | 236 | 265 | 232 | 283 | 287 | 119 | 334 | 335 | 333 | 330 | 327 |
| 9/5/91 | 330 | 334 | 337 | 332 | 340 | 341 | 334 | 340 | 193 | 148 | 183 | 207 | 186 | 224 | 232 | 172 | 177 | 316 | 1 | 12 | 16 | 340 | 333 | 332 |
| 9/6/91 | 330 | 333 | 333 | 333 | 337 | 338 | 351 | 344 | 158 | 168 | 161 | 192 | 182 | 177 | 204 | 187 | 188 | 269 | 350 | 27 | 51 | 42 | 25 | 323 |
| 9/7/91 | 336 | 332 | 338 | 349 | 337 | 336 | 338 | 332 | 165 | 173 | 191 | 185 | 210 | 243 | 267 | 281 | 285 | 299 | 347 | 2 | 331 | 329 | 333 | 332 |
| 9/8/91 | 333 | 332 | 335 | 334 | 332 | 340 | 351 | 145 | 151 | 167 | 184 | 171 | 197 | 180 | 181 | 205 | 231 | 252 | 233 | 336 | 360 | 151 | 169 | 179 |
| 9/9/91 | 152 | 175 | 168 | 170 | 142 | 135 | 156 | 140 | 145 | 169 | 187 | 183 | 191 | 194 | 192 | 193 | 202 | 159 | 336 | 352 | 327 | 340 | 327 | 331 |
| 9/10/91 | 166 | 9 | 346 | 333 | 333 | 152 | 132 | 192 | 160 | 150 | 169 | 179 | 177 | 177 | 163 | 164 | 313 | 317 | 339 | 344 | 8 | 358 | 335 | 341 |
| 9/11/91 | 150 | 150 | 338 | 334 | 77 | 5 | 339 | 144 | 152 | 151 | 153 | 157 | 163 | 160 | 180 | 179 | 172 | 239 | 146 | 177 | 233 | 180 | 340 | 328 |
| 9/12/91 | 334 | 333 | 341 | 346 | 336 | 338 | 338 | 0 | 154 | 140 | 152 | 173 | 160 | 179 | 169 | 205 | 237 | 264 | 5 | 340 | 336 | 331 | 336 | 346 |
| 9/13/91 | 330 | 335 | 338 | 335 | 332 | 332 | 333 | 335 | 138 | 144 | 199 | 257 | 211 | 211 | 247 | 259 | 287 | 320 | 10 | 9 | 340 | 329 | 331 | 330 |
| 9/14/91 | 333 | 334 | 339 | 334 | 331 | 330 | 333 | 344 | 146 | 141 | 150 | 177 | 175 | 211 | 168 | 205 | 237 | 289 | 331 | 347 | 331 | 332 | 337 | 334 |
| 9/15/91 | 340 | 332 | 334 | 336 | 333 | 335 | 337 | 337 | 152 | 140 | 165 | 172 | 191 | 184 | 191 | 183 | 192 | 184 | 157 | 340 | 327 | 333 | 332 | 331 |
| 9/16/91 | 332 | 331 | 344 | 338 | 333 | 332 | 331 | 331 | 152 | 153 | 149 | 167 | 153 | 197 | 221 | 240 | 278 | 319 | 2 | 344 | 333 | 331 | 336 | 336 |
| 9/17/91 | 334 | 336 | 336 | 342 | 337 | 332 | 335 | 336 | 118 | 148 | 162 | 163 | 169 | 183 | 229 | 286 | 287 | 340 | 343 | 341 | 332 | 341 | 333 | 333 |
| 9/18/91 | 331 | 332 | 333 | 337 | 334 | 334 | 330 | 332 | 155 | 140 | 172 | 173 | 175 | 165 | 176 | 172 | 202 | 319 | 347 | 338 | 329 | 333 | 338 | 336 |
| 9/19/91 | 336 | 333 | 331 | 333 | 334 | 333 | 340 | 338 | 148 | 132 | 165 | 178 | 161 | 204 | 215 | 237 | 286 | 295 | 342 | 340 | 331 | 335 | 342 | 354 |
| 9/20/91 | 336 | 332 | 331 | 330 | 335 | 339 | 334 | 346 | 147 | 147 | 151 | 168 | 169 | 174 | 168 | 175 | 194 | 175 | 135 | 355 | 346 | 338 | 339 | 336 |
| 9/21/91 | 338 | 336 | 335 | 333 | 337 | 335 | 334 | 298 | 153 | 155 | 157 | 169 | 166 | 175 | 178 | 197 | 199 | 179 | 139 | 348 | 331 | 336 | 333 | 332 |
| 9/22/91 | 333 | 332 | 331 | 335 | 336 | 335 | 333 | 330 | 156 | 138 | 161 | 163 | 180 | 169 | 180 | 252 | 288 | 324 | 5 | 11 | 347 | 329 | 333 | 341 |
| 9/23/91 | 336 | 334 | 334 | 334 | 335 | 335 | 339 | 337 | 140 | 147 | 165 | 217 | 198 | 182 | 163 | 184 | 183 | 180 | 150 | 2 | 108 | 351 | 345 | 334 |
| 9/24/91 | 337 | 335 | 336 | 335 | 336 | 338 | 334 | 336 | 331 | 148 | 173 | 173 | 168 | 163 | 181 | 177 | 205 | 18 | 336 | 332 | 328 | 328 | 335 | 194 |
| 9/25/91 | 339 | 328 | 329 | 328 | 331 | 332 | 337 | 343 | 168 | 157 | 175 | 199 | 194 | 183 | 193 | 36 | 28 | 93 | 88 | 342 | 149 | 331 | 357 | 331 |
| 9/26/91 | 332 | 353 | 337 | 340 | 56 | 57 | 12 | 156 | 169 | 186 | 185 | 195 | 195 | 193 | 197 | 196 | 206 | 223 | 348 | 342 | 329 | 333 | 333 | 344 |
| 9/27/91 | 335 | 339 | 334 | 337 | 338 | 344 | 338 | 350 | 159 | 165 | 182 | 171 | 172 | 179 | 205 | 245 | 252 | 308 | 354 | 336 | 328 | 328 | 343 | 332 |
| 9/28/91 | 334 | 333 | 335 | 334 | 336 | 337 | 337 | 358 | 150 | 155 | 148 | 188 | 179 | 167 | 193 | 187 | 195 | 185 | 345 | 326 | 327 | 335 | 333 | 343 |
| 9/29/91 | 339 | 334 | 341 | 344 | 333 | 333 | 331 | 329 | 328 | 155 | 170 | 194 | 174 | 175 | 182 | 191 | 240 | 246 | 2 | 332 | 328 | 334 | 330 | 331 |
| 9/30/91 | 331 | 330 | 330 | 334 | 337 | 340 | 333 | 331 | 330 | 213 | 209 | 193 | 200 | 195 | 202 | 228 | 261 | 290 | 11 | 344 | 327 | 328 | 328 | 331 |

Figure 2: Example Wind Direction calculated from U-V components

September-1991
Jerseydale

## Wind Direction (Degrees)

PRINTED ON: 3/6/95 22:29

| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/91 | 333 | 334 | 337 | 337 | 338 | 185 | 86 | 253 | 176 | 147 | 167 | 156 | 184 | 187 | 172 | 171 | 183 | 190 | 122 | 241 | 330 | 335 | 335 | 338 |
| 9/2/91 | 342 | 335 | 336 | 332 | 320 | 338 | 185 | 234 | 256 | 172 | 194 | 180 | 203 | 210 | 204 | 194 | 217 | 214 | 237 | 227 | 338 | 339 | 334 | 331 |
| 9/3/91 | 333 | 333 | 332 | 330 | 333 | 330 | 335 | 253 | 153 | 216 | 227 | 212 | 215 | 197 | 244 | 216 | 234 | 294 | 156 | 68 | 287 | 306 | 329 | 336 |
| 9/4/91 | 335 | 332 | 340 | 338 | 332 | 334 | 330 | 334 | 265 | 152 | 170 | 239 | 226 | 240 | 264 | 271 | 283 | 296 | 99 | 281 | 336 | 333 | 330 | 328 |
| 9/5/91 | 331 | 334 | 337 | 333 | 342 | 342 | 335 | 282 | 254 | 149 | 195 | 209 | 187 | 227 | 229 | 169 | 167 | 274 | 176 | 90 | 44 | 283 | 334 | 332 |
| 9/6/91 | 331 | 334 | 335 | 333 | 338 | 310 | 194 | 257 | 160 | 167 | 162 | 193 | 184 | 168 | 208 | 187 | 190 | 268 | 258 | 60 | 52 | 97 | 25 | 273 |
| 9/7/91 | 338 | 285 | 209 | 278 | 310 | 338 | 339 | 333 | 208 | 174 | 197 | 181 | 217 | 242 | 263 | 279 | 286 | 297 | 319 | 150 | 332 | 329 | 335 | 333 |
| 9/8/91 | 333 | 332 | 336 | 334 | 332 | 341 | 318 | 140 | 151 | 165 | 181 | 172 | 202 | 180 | 182 | 207 | 241 | 256 | 193 | 250 | 190 | 177 | 166 | 174 |
| 9/9/91 | 152 | 175 | 168 | 167 | 142 | 137 | 155 | 144 | 148 | 168 | 187 | 181 | 192 | 195 | 193 | 193 | 218 | 184 | 287 | 230 | 328 | 282 | 328 | 308 |
| 9/10/91 | 159 | 220 | 229 | 334 | 249 | 156 | 140 | 138 | 163 | 151 | 165 | 186 | 180 | 181 | 162 | 153 | 244 | 305 | 310 | 259 | 127 | 117 | 337 | 255 |
| 9/11/91 | 171 | 144 | 327 | 336 | 158 | 173 | 312 | 142 | 151 | 151 | 150 | 157 | 168 | 159 | 186 | 175 | 170 | 204 | 139 | 172 | 193 | 148 | 300 | 329 |
| 9/12/91 | 335 | 334 | 342 | 316 | 336 | 338 | 339 | 158 | 156 | 138 | 152 | 174 | 164 | 175 | 170 | 214 | 242 | 270 | 178 | 341 | 307 | 332 | 338 | 317 |
| 9/13/91 | 331 | 335 | 339 | 334 | 332 | 332 | 334 | 337 | 176 | 146 | 208 | 250 | 219 | 214 | 246 | 262 | 285 | 259 | 99 | 97 | 342 | 330 | 332 | 330 |
| 9/14/91 | 333 | 334 | 339 | 334 | 332 | 331 | 333 | 281 | 182 | 143 | 155 | 176 | 180 | 217 | 167 | 199 | 244 | 290 | 300 | 316 | 330 | 332 | 338 | 335 |
| 9/15/91 | 340 | 333 | 335 | 337 | 333 | 336 | 338 | 335 | 174 | 141 | 167 | 170 | 195 | 189 | 194 | 184 | 195 | 177 | 141 | 257 | 328 | 334 | 333 | 331 |
| 9/16/91 | 332 | 332 | 314 | 340 | 333 | 332 | 331 | 332 | 208 | 152 | 150 | 166 | 151 | 204 | 225 | 243 | 279 | 320 | 150 | 255 | 334 | 332 | 337 | 337 |
| 9/17/91 | 335 | 336 | 337 | 343 | 338 | 333 | 336 | 338 | 161 | 148 | 160 | 164 | 170 | 188 | 232 | 248 | 287 | 221 | 312 | 313 | 332 | 342 | 334 | 333 |
| 9/18/91 | 331 | 332 | 333 | 337 | 334 | 334 | 331 | 333 | 211 | 139 | 169 | 176 | 176 | 162 | 178 | 174 | 206 | 253 | 216 | 340 | 331 | 333 | 339 | 336 |
| 9/19/91 | 337 | 333 | 332 | 333 | 334 | 332 | 341 | 339 | 171 | 133 | 166 | 182 | 161 | 204 | 225 | 237 | 284 | 291 | 343 | 282 | 333 | 336 | 343 | 294 |
| 9/20/91 | 337 | 331 | 332 | 330 | 335 | 340 | 334 | 287 | 187 | 152 | 150 | 167 | 169 | 172 | 167 | 174 | 197 | 170 | 135 | 257 | 317 | 339 | 340 | 335 |
| 9/21/91 | 338 | 336 | 336 | 334 | 338 | 335 | 334 | 218 | 155 | 153 | 157 | 169 | 167 | 175 | 181 | 202 | 207 | 177 | 157 | 177 | 332 | 336 | 334 | 332 |
| 9/22/91 | 333 | 332 | 332 | 336 | 336 | 335 | 333 | 301 | 155 | 141 | 161 | 160 | 178 | 167 | 191 | 255 | 286 | 321 | 155 | 69 | 168 | 329 | 333 | 343 |
| 9/23/91 | 336 | 334 | 333 | 334 | 335 | 336 | 281 | 340 | 217 | 149 | 164 | 222 | 203 | 181 | 168 | 189 | 181 | 178 | 147 | 113 | 113 | 184 | 288 | 335 |
| 9/24/91 | 337 | 335 | 336 | 335 | 337 | 338 | 334 | 337 | 330 | 227 | 172 | 173 | 168 | 164 | 193 | 177 | 215 | 144 | 283 | 332 | 329 | 328 | 299 | 186 |
| 9/25/91 | 280 | 329 | 329 | 329 | 331 | 333 | 337 | 256 | 195 | 156 | 174 | 202 | 195 | 184 | 184 | 68 | 99 | 101 | 118 | 244 | 180 | 302 | 176 | 166 |
| 9/26/91 | 334 | 204 | 338 | 341 | 191 | 221 | 148 | 149 | 169 | 186 | 189 | 198 | 195 | 194 | 197 | 201 | 211 | 235 | 211 | 312 | 329 | 334 | 333 | 286 |
| 9/27/91 | 336 | 340 | 334 | 338 | 339 | 345 | 310 | 287 | 213 | 164 | 183 | 168 | 169 | 178 | 212 | 245 | 256 | 253 | 204 | 278 | 329 | 328 | 343 | 333 |
| 9/28/91 | 334 | 333 | 335 | 335 | 336 | 338 | 309 | 176 | 171 | 157 | 147 | 188 | 178 | 172 | 199 | 186 | 196 | 164 | 155 | 328 | 299 | 335 | 333 | 311 |
| 9/29/91 | 340 | 334 | 342 | 344 | 333 | 333 | 332 | 329 | 247 | 157 | 179 | 196 | 169 | 178 | 184 | 195 | 245 | 239 | 184 | 332 | 328 | 335 | 331 | 331 |
| 9/30/91 | 331 | 330 | 331 | 335 | 338 | 341 | 333 | 332 | 330 | 206 | 216 | 206 | 206 | 199 | 206 | 227 | 260 | 288 | 129 | 255 | 328 | 328 | 329 | 332 |

Figure 3: Example Wind Direction (degrees)

September-1991 **Wind Speed (m/s)** *PRINTED ON: 3/6/95 22:31*

Jerseydale

| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Peak | Time | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/91 | 1.80 | 1.87 | 2.13 | 1.70 | 1.96 | 0.83 | 0.14 | 0.91 | 1.33 | 2.14 | 2.00 | 2.29 | 2.56 | 2.12 | 2.51 | 2.25 | 1.76 | 1.81 | 0.54 | 0.76 | 1.52 | 1.52 | 1.98 | 1.88 | 3.80 | 12.50 | |
| 9/2/91 | 1.58 | 1.95 | 1.85 | 1.84 | 1.05 | 1.57 | 0.59 | 0.53 | 1.01 | 2.04 | 2.81 | 3.07 | 2.80 | 2.58 | 2.52 | 2.60 | 1.78 | 1.40 | 0.35 | 0.71 | 1.27 | 1.54 | 1.77 | 1.80 | 4.50 | 11.75 | |
| 9/3/91 | 1.87 | 2.01 | 1.98 | 2.00 | 2.08 | 2.22 | 2.08 | 1.08 | 1.18 | 1.68 | 1.43 | 1.85 | 2.08 | 2.53 | 1.62 | 1.84 | 1.54 | 1.19 | 0.86 | 1.38 | 1.53 | 1.88 | 1.96 | 1.83 | 3.80 | 13.25 | |
| 9/4/91 | 2.14 | 2.13 | 1.82 | 1.98 | 2.20 | 1.98 | 2.20 | 1.85 | 1.42 | 2.12 | 1.82 | 1.56 | 2.40 | 2.34 | 2.06 | 1.53 | 1.30 | 0.94 | 0.80 | 1.18 | 1.58 | 1.83 | 2.02 | 1.95 | 3.10 | 14.00 | |
| 9/5/91 | 2.16 | 2.08 | 2.13 | 1.98 | 1.77 | 1.65 | 1.84 | 1.29 | 0.89 | 2.11 | 1.86 | 2.18 | 3.13 | 2.28 | 1.77 | 2.85 | 1.92 | 1.58 | 2.70 | 3.04 | 2.26 | 1.75 | 1.40 | 1.60 | 4.40 | 12.92 | 2 |
| 9/6/91 | 2.06 | 1.94 | 1.75 | 1.69 | 1.78 | 1.63 | 1.02 | 0.75 | 1.28 | 2.28 | 2.75 | 2.90 | 2.89 | 3.13 | 2.40 | 2.73 | 1.94 | 0.71 | 1.80 | 1.73 | 4.52 | 2.98 | 1.93 | 1.71 | 5.70 | 20.92 | 2 |
| 9/7/91 | 1.53 | 0.97 | 0.19 | 0.67 | 1.97 | 1.95 | 1.70 | 1.44 | 1.03 | 2.38 | 1.97 | 2.03 | 2.28 | 1.86 | 1.73 | 1.63 | 1.38 | 1.10 | 1.07 | 1.29 | 1.48 | 1.78 | 1.71 | 1.82 | 3.40 | 12.83 | |
| 9/8/91 | 1.92 | 2.00 | 1.84 | 1.87 | 1.98 | 1.73 | 0.81 | 0.99 | 1.64 | 2.04 | 2.36 | 2.72 | 2.68 | 3.21 | 2.79 | 2.08 | 1.73 | 0.91 | 0.35 | 0.47 | 0.03 | 0.34 | 0.80 | 0.63 | 4.60 | 13.42 | |
| 9/9/91 | 0.83 | 0.94 | 1.15 | 1.32 | 1.83 | 1.62 | 1.32 | 1.63 | 2.15 | 3.67 | 3.92 | 4.10 | 4.23 | 4.71 | 4.19 | 3.73 | 2.73 | 1.07 | 0.82 | 1.14 | 1.55 | 1.57 | 1.81 | 1.30 | 5.60 | 12.00 | 2 |
| 9/10/91 | 1.18 | 0.61 | 1.44 | 1.58 | 0.70 | 1.03 | 0.94 | 0.42 | 1.78 | 2.13 | 2.03 | 2.64 | 2.57 | 2.38 | 2.24 | 1.74 | 1.54 | 1.13 | 1.05 | 0.83 | 1.24 | 1.13 | 1.35 | 1.44 | 3.90 | 12.00 | |
| 9/11/91 | 0.72 | 0.71 | 1.58 | 1.78 | 0.39 | 0.76 | 0.87 | 1.46 | 1.77 | 1.90 | 2.21 | 2.74 | 2.48 | 2.25 | 1.99 | 2.30 | 2.23 | 0.71 | 0.83 | 0.95 | 0.38 | 0.18 | 1.33 | 1.70 | 3.30 | 15.50 | |
| 9/12/91 | 1.78 | 2.01 | 1.55 | 1.59 | 1.68 | 1.50 | 1.43 | 0.88 | 1.73 | 1.57 | 2.07 | 2.36 | 2.10 | 2.45 | 2.58 | 1.66 | 1.10 | 0.68 | 0.37 | 1.29 | 1.35 | 1.60 | 1.54 | 1.47 | 3.30 | 14.17 | |
| 9/13/91 | 1.80 | 2.02 | 1.83 | 2.04 | 1.93 | 1.93 | 1.73 | 1.39 | 1.36 | 2.13 | 1.73 | 1.48 | 1.95 | 2.23 | 1.69 | 1.68 | 1.49 | 1.47 | 1.26 | 1.39 | 1.13 | 1.62 | 1.67 | 2.02 | 3.10 | 13.92 | |
| 9/14/91 | 2.20 | 2.15 | 1.91 | 2.16 | 2.03 | 2.14 | 2.10 | 1.08 | 1.24 | 2.14 | 2.20 | 2.35 | 2.24 | 1.93 | 1.78 | 1.58 | 1.33 | 0.79 | 0.94 | 1.14 | 1.68 | 1.72 | 1.83 | 2.02 | 3.50 | 11.25 | |
| 9/15/91 | 1.68 | 2.07 | 2.12 | 1.89 | 2.12 | 2.05 | 1.93 | 1.12 | 1.65 | 1.86 | 2.15 | 2.21 | 2.41 | 2.34 | 2.25 | 2.26 | 1.90 | 1.53 | 0.96 | 1.28 | 1.88 | 1.75 | 2.03 | 2.06 | 3.00 | 11.33 | 6 |
| 9/16/91 | 2.08 | 2.22 | 1.54 | 1.85 | 2.06 | 2.13 | 2.15 | 1.82 | 1.15 | 1.93 | 2.13 | 2.61 | 2.40 | 2.13 | 2.14 | 1.78 | 1.43 | 1.08 | 1.41 | 1.37 | 1.66 | 1.76 | 1.73 | 1.91 | 3.50 | 11.50 | |
| 9/17/91 | 2.01 | 2.05 | 1.86 | 1.65 | 1.73 | 2.22 | 1.96 | 1.33 | 1.04 | 2.29 | 2.33 | 2.34 | 2.40 | 2.27 | 1.66 | 1.24 | 1.29 | 1.13 | 1.33 | 1.36 | 1.53 | 1.42 | 2.13 | 2.13 | 3.30 | 12.92 | |
| 9/18/91 | 2.24 | 2.26 | 2.43 | 2.15 | 2.05 | 2.16 | 2.22 | 1.59 | 1.22 | 1.77 | 2.09 | 2.23 | 2.66 | 2.47 | 2.20 | 2.01 | 1.48 | 0.52 | 0.64 | 1.32 | 1.60 | 1.88 | 1.78 | 1.83 | 3.50 | 12.42 | 2 |
| 9/19/91 | 1.75 | 2.21 | 2.03 | 1.90 | 1.93 | 1.98 | 1.63 | 1.28 | 1.27 | 1.68 | 2.05 | 2.21 | 2.66 | 2.46 | 1.58 | 1.52 | 1.12 | 0.62 | 1.04 | 1.48 | 1.76 | 1.68 | 1.45 | 1.20 | 3.50 | 13.17 | |
| 9/20/91 | 2.04 | 2.12 | 2.18 | 2.17 | 1.93 | 1.56 | 2.24 | 0.96 | 1.09 | 1.98 | 2.31 | 2.39 | 2.69 | 3.05 | 2.46 | 2.33 | 1.84 | 1.57 | 1.18 | 0.57 | 1.13 | 1.03 | 1.48 | 1.74 | 3.80 | 13.42 | |
| 9/21/91 | 1.90 | 1.92 | 1.90 | 2.13 | 1.86 | 2.19 | 2.15 | 1.17 | 2.04 | 1.56 | 2.27 | 2.40 | 2.48 | 2.65 | 2.70 | 2.16 | 1.99 | 1.28 | 0.52 | 0.73 | 1.64 | 1.79 | 2.02 | 2.03 | 3.40 | 14.67 | |
| 9/22/91 | 1.89 | 2.03 | 1.91 | 2.03 | 1.96 | 2.10 | 1.77 | 1.08 | 1.69 | 1.72 | 2.28 | 2.73 | 2.59 | 2.69 | 1.98 | 1.42 | 0.77 | 0.88 | 1.11 | 1.03 | 1.73 | 1.70 | 1.93 | 1.66 | 3.80 | 12.00 | |
| 9/23/91 | 1.93 | 2.21 | 2.03 | 1.78 | 1.90 | 2.00 | 1.78 | 1.36 | 1.05 | 1.63 | 2.01 | 1.67 | 2.48 | 2.61 | 2.11 | 2.10 | 2.04 | 1.48 | 0.35 | 0.42 | 0.11 | 0.39 | 1.53 | 1.83 | 3.40 | 13.17 | |
| 9/24/91 | 2.04 | 2.29 | 1.93 | 2.16 | 1.84 | 1.93 | 2.00 | 1.62 | 1.31 | 1.51 | 2.26 | 2.88 | 2.91 | 2.42 | 1.86 | 1.73 | 1.18 | 0.17 | 1.53 | 2.00 | 1.94 | 2.08 | 1.83 | 0.40 | 3.90 | 12.67 | |
| 9/25/91 | 1.67 | 2.23 | 2.40 | 2.61 | 2.31 | 2.20 | 1.99 | 1.63 | 1.63 | 2.34 | 2.58 | 3.04 | 3.36 | 3.48 | 2.35 | 0.98 | 1.74 | 2.40 | 1.36 | 0.96 | 1.20 | 1.42 | 0.82 | 0.53 | 4.90 | 13.18 | |
| 9/26/91 | 1.94 | 1.38 | 1.25 | 1.48 | 0.47 | 0.86 | 0.39 | 0.98 | 2.12 | 2.41 | 2.36 | 3.64 | 3.41 | 3.72 | 3.47 | 2.89 | 2.02 | 0.86 | 0.63 | 1.32 | 1.56 | 1.76 | 1.88 | 1.59 | 5.60 | 12.00 | |
| 9/27/91 | 2.11 | 1.86 | 1.93 | 1.87 | 1.63 | 1.43 | 1.55 | 0.84 | 0.96 | 1.96 | 2.34 | 2.37 | 2.65 | 2.50 | 2.36 | 1.63 | 1.32 | 0.68 | 1.14 | 1.47 | 1.59 | 1.63 | 1.72 | 2.11 | 3.40 | 11.50 | |
| 9/28/91 | 2.02 | 2.13 | 1.98 | 2.05 | 2.15 | 1.97 | 1.81 | 0.89 | 1.23 | 1.80 | 2.30 | 2.40 | 2.54 | 2.37 | 2.63 | 2.04 | 1.73 | 0.86 | 0.45 | 1.49 | 1.49 | 1.60 | 1.98 | 1.50 | 3.80 | 14.17 | |
| 9/29/91 | 1.65 | 2.03 | 1.72 | 1.58 | 2.05 | 1.87 | 1.84 | 1.83 | 1.06 | 1.38 | 1.49 | 2.02 | 2.61 | 2.58 | 2.53 | 2.53 | 1.32 | 0.72 | 0.97 | 1.65 | 1.65 | 1.60 | 1.93 | 1.95 | 3.90 | 15.92 | |
| 9/30/91 | 2.09 | 2.06 | 2.13 | 2.10 | 2.30 | 2.03 | 2.18 | 2.14 | 1.91 | 1.69 | 2.33 | 2.21 | 1.98 | 2.76 | 2.33 | 1.49 | 1.04 | 0.78 | 0.94 | 1.30 | 1.65 | 1.74 | 1.78 | 1.73 | 4.10 | 13.75 | |
| Av | 1.82 | 1.88 | 1.82 | 1.85 | 1.79 | 1.77 | 1.61 | 1.24 | 1.41 | 1.99 | 2.21 | 2.45 | 2.62 | 2.62 | 2.28 | 2.01 | 1.60 | 1.07 | 0.98 | 1.23 | 1.52 | 1.56 | 1.70 | 1.64 | | | |
| N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | | | |
| Mx | 2.24 | 2.29 | 2.43 | 2.61 | 2.31 | 2.22 | 2.24 | 2.14 | 2.15 | 3.67 | 3.92 | 4.1 | 4.23 | 4.71 | 4.19 | 3.73 | 2.73 | 2.4 | 2.7 | 3.04 | 4.52 | 2.98 | 2.13 | 2.13 | | | |

Figure 4: Example Wind Speed (meters per second)

September-1991
Jerseydale

## West to East Wind Component (m/s)

*PRINTED ON:* *3/6/95 22:33*

| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/91 | 0.82 | 0.82 | 0.85 | 0.68 | 0.76 | -0.23 | -0.09 | 0.21 | -0.64 | -0.97 | -0.23 | -0.56 | 0.22 | 0.15 | -0.17 | -0.11 | 0.15 | 0.28 | -0.31 | 0.18 | 0.77 | 0.63 | 0.83 | 0.71 |
| 9/2/91 | 0.53 | 0.83 | 0.77 | 0.86 | 0.15 | 0.61 | 0.07 | 0.08 | 0.07 | -0.29 | 0.54 | 0.12 | 0.73 | 0.92 | 0.70 | 0.35 | 0.71 | 0.54 | 0.23 | 0.20 | 0.46 | 0.58 | 0.77 | 0.88 |
| 9/3/91 | 0.86 | 0.92 | 0.95 | 1.00 | 0.94 | 1.10 | 0.88 | 0.14 | -0.48 | 0.52 | 0.59 | 0.71 | 0.65 | 0.41 | 1.06 | 0.80 | 0.81 | 0.96 | 0.11 | -0.21 | 0.31 | 0.79 | 1.01 | 0.77 |
| 9/4/91 | 0.92 | 0.98 | 0.67 | 0.78 | 1.04 | 0.87 | 1.09 | 0.82 | 0.25 | -0.91 | -0.37 | 0.97 | 1.24 | 1.65 | 1.46 | 1.28 | 1.11 | 0.77 | -0.53 | 0.43 | 0.65 | 0.82 | 1.00 | 1.05 |
| 9/5/91 | 1.06 | 0.91 | 0.83 | 0.90 | 0.58 | 0.54 | 0.79 | 0.43 | 0.06 | -0.95 | 0.07 | 0.73 | 0.26 | 1.18 | 1.00 | -0.36 | -0.08 | 0.77 | -0.02 | -0.61 | -0.59 | 0.54 | 0.61 | 0.73 |
| 9/6/91 | 1.01 | 0.86 | 0.78 | 0.74 | 0.67 | 0.58 | 0.14 | 0.19 | -0.33 | -0.42 | -0.68 | 0.48 | 0.10 | -0.14 | 0.81 | 0.31 | 0.25 | 0.40 | 0.27 | -0.70 | -3.41 | -1.76 | -0.76 | 0.91 |
| 9/7/91 | 0.59 | 0.46 | 0.07 | 0.13 | 0.73 | 0.77 | 0.63 | 0.64 | -0.20 | -0.24 | 0.28 | 0.13 | 0.88 | 1.10 | 1.28 | 1.31 | 1.16 | 0.89 | 0.23 | -0.05 | 0.72 | 0.92 | 0.76 | 0.82 |
| 9/8/91 | 0.87 | 0.92 | 0.77 | 0.82 | 0.93 | 0.58 | 0.12 | -0.48 | -0.67 | -0.39 | 0.14 | -0.37 | 0.64 | 0.01 | 0.04 | 0.70 | 1.05 | 0.81 | 0.13 | 0.16 | 0.00 | -0.16 | -0.14 | -0.01 |
| 9/9/91 | -0.38 | -0.08 | -0.23 | -0.18 | -0.98 | -1.10 | -0.50 | -0.88 | -1.03 | -0.55 | 0.43 | 0.17 | 0.71 | 1.00 | 0.76 | 0.74 | 0.81 | -0.28 | 0.28 | 0.14 | 0.82 | 0.52 | 0.96 | 0.62 |
| 9/10/91 | -0.26 | -0.02 | 0.33 | 0.70 | 0.26 | -0.44 | -0.63 | 0.04 | -0.52 | -0.89 | -0.24 | -0.03 | -0.10 | -0.08 | -0.57 | -0.28 | 0.92 | 0.68 | 0.35 | 0.22 | -0.17 | 0.04 | 0.53 | 0.42 |
| 9/11/91 | -0.18 | -0.33 | 0.58 | 0.75 | -0.18 | -0.05 | 0.31 | -0.76 | -0.69 | -0.72 | -0.83 | -0.92 | -0.55 | -0.61 | 0.01 | -0.02 | -0.27 | 0.36 | -0.41 | -0.05 | 0.28 | 0.00 | 0.45 | 0.88 |
| 9/12/91 | 0.76 | 0.89 | 0.49 | 0.38 | 0.68 | 0.57 | 0.52 | 0.00 | -0.68 | -0.77 | -0.78 | -0.23 | -0.51 | -0.03 | -0.41 | 0.52 | 0.58 | 0.60 | -0.02 | 0.43 | 0.53 | 0.76 | 0.60 | 0.35 |
| 9/13/91 | 0.88 | 0.83 | 0.67 | 0.87 | 0.91 | 0.88 | 0.78 | 0.58 | -0.82 | -1.06 | 0.38 | 0.97 | 0.73 | 0.89 | 0.88 | 1.14 | 1.20 | 0.77 | -0.20 | -0.20 | 0.38 | 0.83 | 0.80 | 1.00 |
| 9/14/91 | 1.00 | 0.93 | 0.67 | 0.93 | 0.98 | 1.05 | 0.96 | 0.28 | -0.54 | -1.18 | -0.89 | -0.09 | -0.13 | 0.80 | -0.30 | 0.44 | 0.80 | 0.67 | 0.43 | 0.26 | 0.80 | 0.80 | 0.71 | 0.85 |
| 9/15/91 | 0.58 | 0.96 | 0.90 | 0.78 | 0.97 | 0.85 | 0.73 | 0.41 | -0.66 | -0.94 | -0.43 | -0.23 | 0.36 | 0.13 | 0.34 | 0.09 | 0.32 | 0.10 | -0.35 | 0.42 | 1.01 | 0.78 | 0.93 | 0.98 |
| 9/16/91 | 0.97 | 1.04 | 0.41 | 0.67 | 0.93 | 0.99 | 1.03 | 0.87 | -0.25 | -0.73 | -0.91 | -0.53 | -0.89 | 0.52 | 1.15 | 1.31 | 1.26 | 0.62 | -0.05 | 0.35 | 0.73 | 0.84 | 0.68 | 0.78 |
| 9/17/91 | 0.86 | 0.83 | 0.76 | 0.51 | 0.67 | 1.01 | 0.80 | 0.52 | -0.41 | -1.03 | -0.58 | -0.54 | -0.36 | 0.09 | 0.93 | 0.90 | 1.08 | 0.32 | 0.36 | 0.43 | 0.70 | 0.46 | 0.95 | 0.97 |
| 9/18/91 | 1.08 | 1.04 | 1.09 | 0.85 | 0.88 | 0.93 | 1.08 | 0.73 | -0.23 | -0.96 | -0.23 | -0.22 | -0.18 | -0.54 | -0.12 | -0.23 | 0.44 | 0.21 | 0.13 | 0.47 | 0.80 | 0.83 | 0.66 | 0.74 |
| 9/19/91 | 0.70 | 1.00 | 0.99 | 0.85 | 0.85 | 0.89 | 0.53 | 0.46 | -0.38 | -1.01 | -0.44 | -0.07 | -0.70 | 0.83 | 0.63 | 0.98 | 0.94 | 0.48 | 0.30 | 0.48 | 0.83 | 0.70 | 0.44 | 0.13 |
| 9/20/91 | 0.83 | 1.00 | 1.04 | 1.06 | 0.82 | 0.54 | 0.98 | 0.21 | -0.50 | -0.90 | -0.92 | -0.41 | -0.43 | -0.27 | -0.41 | -0.18 | 0.37 | -0.13 | -0.82 | 0.04 | 0.27 | 0.39 | 0.53 | 0.72 |
| 9/21/91 | 0.72 | 0.77 | 0.78 | 0.95 | 0.73 | 0.92 | 0.94 | 0.16 | -0.78 | -0.53 | -0.73 | -0.38 | -0.50 | -0.18 | -0.08 | 0.53 | 0.58 | -0.02 | -0.32 | 0.14 | 0.80 | 0.74 | 0.91 | 0.92 |
| 9/22/91 | 0.85 | 0.92 | 0.92 | 0.83 | 0.78 | 0.86 | 0.78 | 0.21 | -0.57 | -0.96 | -0.59 | -0.66 | -0.02 | -0.42 | 0.01 | 1.02 | 0.67 | 0.47 | -0.09 | -0.18 | 0.36 | 0.85 | 0.87 | 0.53 |
| 9/23/91 | 0.78 | 0.96 | 0.90 | 0.77 | 0.79 | 0.83 | 0.61 | 0.51 | -0.24 | -0.74 | -0.43 | 0.67 | 0.58 | 0.07 | -0.47 | 0.13 | 0.09 | -0.01 | -0.17 | -0.02 | -0.08 | 0.03 | 0.38 | 0.79 |
| 9/24/91 | 0.80 | 0.98 | 0.78 | 0.90 | 0.73 | 0.71 | 0.86 | 0.63 | 0.58 | -0.29 | -0.22 | -0.29 | -0.52 | -0.56 | 0.03 | -0.08 | 0.39 | -0.04 | 0.59 | 0.92 | 1.01 | 1.09 | 0.62 | 0.01 |
| 9/25/91 | 0.57 | 1.16 | 1.23 | 1.36 | 1.11 | 1.00 | 0.76 | 0.45 | -0.29 | -0.78 | -0.18 | 0.84 | 0.68 | 0.18 | 0.39 | -0.43 | -0.64 | -1.57 | -0.77 | 0.27 | -0.24 | 0.63 | 0.04 | 0.14 |
| 9/26/91 | 0.89 | 0.16 | 0.48 | 0.49 | -0.03 | -0.12 | -0.07 | -0.35 | -0.35 | 0.19 | 0.15 | 0.81 | 0.74 | 0.70 | 0.92 | 0.71 | 0.73 | 0.49 | 0.09 | 0.38 | 0.79 | 0.79 | 0.84 | 0.43 |
| 9/27/91 | 0.88 | 0.63 | 0.84 | 0.72 | 0.60 | 0.38 | 0.58 | 0.14 | -0.21 | -0.41 | 0.05 | -0.27 | -0.28 | -0.05 | 0.79 | 1.18 | 0.90 | 0.43 | 0.11 | 0.56 | 0.82 | 0.85 | 0.51 | 0.98 |
| 9/28/91 | 0.88 | 0.97 | 0.82 | 0.88 | 0.88 | 0.75 | 0.68 | 0.03 | -0.50 | -0.58 | -0.99 | 0.25 | -0.05 | -0.39 | 0.51 | 0.19 | 0.40 | 0.06 | 0.12 | 0.81 | 0.77 | 0.67 | 0.90 | 0.43 |
| 9/29/91 | 0.58 | 0.89 | 0.55 | 0.44 | 0.92 | 0.85 | 0.88 | 0.93 | 0.18 | -0.36 | -0.17 | 0.33 | -0.23 | -0.17 | 0.08 | 0.42 | 0.88 | 0.48 | -0.03 | 0.78 | 0.86 | 0.68 | 0.96 | 0.94 |
| 9/30/91 | 0.99 | 1.02 | 1.05 | 0.92 | 0.88 | 0.67 | 0.98 | 1.01 | 0.92 | 0.44 | 0.83 | 0.32 | 0.44 | 0.57 | 0.69 | 0.82 | 0.82 | 0.59 | -0.16 | 0.35 | 0.88 | 0.91 | 0.93 | 0.83 |

Figure 5: Example West to East Wind Component

September-1991

Jerseydale

## South to North Wind Component (m/s)

*PRINTED ON:* *3/6/95 22:35*

| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/91 | -1.61 | -1.67 | -1.92 | -1.54 | -1.79 | 0.02 | -0.05 | -0.81 | 0.92 | 1.53 | 1.48 | 1.73 | 2.08 | 1.62 | 2.11 | 1.96 | 1.45 | 1.70 | 0.35 | -0.71 | -1.28 | -1.33 | -1.76 | -1.73 |
| 9/2/91 | -1.47 | -1.73 | -1.67 | -1.61 | -1.00 | -1.39 | -0.56 | -0.49 | -0.06 | 1.60 | 2.17 | 2.40 | 2.09 | 1.85 | 1.93 | 2.03 | 1.18 | 1.12 | -0.09 | -0.59 | -1.15 | -1.36 | -1.56 | -1.53 |
| 9/3/91 | -1.63 | -1.76 | -1.72 | -1.71 | -1.81 | -1.90 | -1.83 | -0.95 | 0.88 | 0.86 | 0.52 | 1.16 | 1.29 | 1.96 | 0.28 | 1.19 | -0.34 | -0.45 | -0.72 | -1.33 | -1.43 | -1.58 | -1.63 | -1.60 |
| 9/4/91 | -1.90 | -1.88 | -1.68 | -1.82 | -1.92 | -1.75 | -1.87 | -1.58 | -0.06 | 1.59 | 1.28 | 0.58 | 1.38 | 1.13 | 0.13 | 0.00 | -0.26 | -0.23 | 0.29 | -0.88 | -1.39 | -1.58 | -1.72 | -1.62 |
| 9/5/91 | -1.83 | -1.86 | -1.93 | -1.73 | -1.63 | -1.54 | -1.65 | -1.16 | 0.26 | 1.53 | 1.15 | 1.44 | 2.51 | 1.23 | 0.79 | 2.43 | 1.61 | -0.81 | -2.38 | -2.77 | -2.04 | -1.52 | -1.18 | -1.38 |
| 9/6/91 | -1.77 | -1.70 | -1.54 | -1.48 | -1.58 | -1.45 | -0.93 | -0.68 | 0.81 | 1.93 | 2.00 | 2.37 | 2.33 | 2.43 | 1.85 | 2.38 | 1.69 | 0.01 | -1.53 | -1.40 | -2.74 | -1.95 | -1.64 | -1.23 |
| 9/7/91 | -1.35 | -0.85 | -0.17 | -0.63 | -1.73 | -1.76 | -1.53 | -1.23 | 0.73 | 1.97 | 1.43 | 1.45 | 1.53 | 0.56 | 0.07 | -0.25 | -0.31 | -0.50 | -0.98 | -1.26 | -1.29 | -1.50 | -1.52 | -1.58 |
| 9/8/91 | -1.68 | -1.75 | -1.63 | -1.67 | -1.73 | -1.58 | -0.76 | 0.68 | 1.23 | 1.64 | 1.92 | 2.28 | 2.10 | 2.74 | 2.34 | 1.52 | 0.85 | 0.26 | 0.10 | -0.35 | -0.02 | 0.28 | 0.75 | 0.55 |
| 9/9/91 | 0.70 | 0.87 | 1.08 | 1.09 | 1.27 | 1.09 | 1.11 | 1.07 | 1.45 | 2.93 | 3.43 | 3.59 | 3.67 | 4.09 | 3.68 | 3.25 | 2.01 | 0.70 | -0.62 | -1.05 | -1.27 | -1.41 | -1.48 | -1.12 |
| 9/10/91 | 1.03 | -0.10 | -1.34 | -1.35 | -0.52 | 0.82 | 0.58 | 0.19 | 1.40 | 1.58 | 1.19 | 1.97 | 1.93 | 1.72 | 1.80 | 0.98 | -0.85 | -0.73 | -0.90 | -0.73 | -1.13 | -1.07 | -1.17 | -1.22 |
| 9/11/91 | 0.32 | 0.57 | -1.41 | -1.57 | -0.04 | -0.56 | -0.80 | 1.03 | 1.30 | 1.32 | 1.61 | 2.15 | 1.77 | 1.64 | 1.37 | 1.78 | 1.92 | 0.22 | 0.60 | 0.90 | 0.21 | 0.14 | -1.24 | -1.43 |
| 9/12/91 | -1.57 | -1.78 | -1.43 | -1.49 | -1.52 | -1.38 | -1.32 | -0.53 | 1.38 | 0.90 | 1.45 | 1.78 | 1.43 | 1.82 | 2.03 | 1.12 | 0.37 | 0.07 | -0.18 | -1.18 | -1.18 | -1.37 | -1.37 | -1.37 |
| 9/13/91 | -1.56 | -1.81 | -1.66 | -1.83 | -1.69 | -1.68 | -1.52 | -1.21 | 0.92 | 1.48 | 1.13 | 0.23 | 1.18 | 1.47 | 0.37 | 0.22 | -0.38 | -0.91 | -1.18 | -1.32 | -1.04 | -1.38 | -1.42 | -1.72 |
| 9/14/91 | -1.94 | -1.89 | -1.78 | -1.93 | -1.77 | -1.84 | -1.84 | -0.96 | 0.79 | 1.47 | 1.54 | 1.88 | 1.68 | 1.33 | 1.43 | 0.95 | 0.52 | -0.23 | -0.77 | -1.08 | -1.43 | -1.51 | -1.67 | -1.78 |
| 9/15/91 | -1.55 | -1.82 | -1.88 | -1.72 | -1.87 | -1.83 | -1.76 | -0.98 | 1.22 | 1.14 | 1.63 | 1.75 | 1.86 | 1.83 | 1.68 | 1.80 | 1.48 | 1.33 | 0.82 | -1.14 | -1.57 | -1.53 | -1.78 | -1.78 |
| 9/16/91 | -1.82 | -1.90 | -1.44 | -1.68 | -1.83 | -1.83 | -1.87 | -1.56 | 0.47 | 1.43 | 1.50 | 2.20 | 1.77 | 1.64 | 1.34 | 0.76 | -0.17 | -0.70 | -1.33 | -1.25 | -1.44 | -1.53 | -1.53 | -1.74 |
| 9/17/91 | -1.78 | -1.85 | -1.67 | -1.54 | -1.57 | -1.93 | -1.75 | -1.18 | 0.22 | 1.63 | 1.75 | 1.80 | 1.88 | 1.53 | 0.80 | -0.25 | -0.33 | -0.88 | -1.19 | -1.23 | -1.31 | -1.30 | -1.89 | -1.88 |
| 9/18/91 | -1.93 | -1.99 | -2.13 | -1.96 | -1.83 | -1.93 | -1.90 | -1.36 | 0.51 | 1.14 | 1.58 | 1.71 | 2.18 | 1.99 | 1.68 | 1.61 | 1.07 | -0.24 | -0.57 | -1.18 | -1.35 | -1.65 | -1.63 | -1.65 |
| 9/19/91 | -1.58 | -1.95 | -1.78 | -1.66 | -1.71 | -1.73 | -1.50 | -1.16 | 0.62 | 0.90 | 1.63 | 1.72 | 2.07 | 1.83 | 0.90 | 0.64 | -0.27 | -0.23 | -0.94 | -1.35 | -1.53 | -1.53 | -1.35 | -1.18 |
| 9/20/91 | -1.82 | -1.85 | -1.90 | -1.86 | -1.72 | -1.43 | -1.98 | -0.87 | 0.77 | 1.39 | 1.67 | 1.90 | 2.18 | 2.66 | 1.95 | 1.98 | 1.49 | 1.43 | 0.81 | -0.53 | -1.07 | -0.95 | -1.37 | -1.58 |
| 9/21/91 | -1.75 | -1.73 | -1.69 | -1.89 | -1.68 | -1.96 | -1.90 | -0.08 | 1.55 | 1.11 | 1.70 | 1.90 | 1.94 | 2.18 | 2.21 | 1.75 | 1.70 | 1.16 | 0.37 | -0.67 | -1.43 | -1.63 | -1.78 | -1.76 |
| 9/22/91 | -1.69 | -1.77 | -1.66 | -1.79 | -1.78 | -1.88 | -1.55 | -0.36 | 1.30 | 1.06 | 1.71 | 2.16 | 2.13 | 2.19 | 1.48 | 0.33 | -0.22 | -0.63 | -0.96 | -0.97 | -1.60 | -1.44 | -1.71 | -1.55 |
| 9/23/91 | -1.75 | -1.98 | -1.81 | -1.58 | -1.71 | -1.78 | -1.62 | -1.21 | 0.28 | 1.16 | 1.63 | 0.89 | 1.78 | 2.16 | 1.56 | 1.70 | 1.86 | 1.37 | 0.29 | -0.42 | 0.03 | -0.15 | -1.43 | -1.63 |
| 9/24/91 | -1.87 | -2.05 | -1.74 | -1.93 | -1.67 | -1.75 | -1.78 | -1.41 | -1.03 | 0.46 | 1.83 | 2.41 | 2.38 | 1.88 | 1.28 | 1.37 | 0.85 | -0.13 | -1.34 | -1.76 | -1.63 | -1.73 | -1.34 | 0.03 |
| 9/25/91 | -1.50 | -1.85 | -2.01 | -2.20 | -1.98 | -1.92 | -1.79 | -1.48 | 1.37 | 1.83 | 2.02 | 2.43 | 2.73 | 3.07 | 1.73 | -0.58 | -1.19 | 0.08 | -0.02 | -0.82 | 0.40 | -1.16 | -0.71 | -0.26 |
| 9/26/91 | -1.70 | -1.32 | -1.13 | -1.34 | -0.02 | -0.08 | -0.32 | 0.79 | 1.84 | 1.93 | 1.82 | 3.06 | 2.79 | 3.15 | 2.95 | 2.42 | 1.50 | 0.53 | -0.44 | -1.18 | -1.31 | -1.57 | -1.64 | -1.49 |
| 9/27/91 | -1.92 | -1.68 | -1.71 | -1.70 | -1.49 | -1.33 | -1.42 | -0.77 | 0.53 | 1.57 | 1.87 | 1.74 | 2.09 | 1.96 | 1.69 | 0.54 | 0.30 | -0.33 | -1.08 | -1.28 | -1.34 | -1.34 | -1.62 | -1.84 |
| 9/28/91 | -1.79 | -1.86 | -1.77 | -1.82 | -1.97 | -1.79 | -1.62 | -0.85 | 0.85 | 1.25 | 1.60 | 1.83 | 2.03 | 1.74 | 2.18 | 1.61 | 1.49 | 0.73 | -0.43 | -1.21 | -1.19 | -1.42 | -1.73 | -1.41 |
| 9/29/91 | -1.52 | -1.79 | -1.58 | -1.49 | -1.82 | -1.65 | -1.58 | -1.55 | -0.29 | 0.77 | 0.94 | 1.33 | 1.98 | 1.92 | 1.99 | 2.06 | 0.52 | 0.21 | -0.89 | -1.44 | -1.39 | -1.41 | -1.67 | -1.69 |
| 9/30/91 | -1.81 | -1.74 | -1.83 | -1.85 | -2.07 | -1.87 | -1.91 | -1.83 | -1.58 | 0.69 | 1.48 | 1.39 | 1.23 | 2.14 | 1.71 | 0.74 | 0.13 | -0.22 | -0.85 | -1.19 | -1.38 | -1.44 | -1.48 | -1.49 |

Figure 6: Example South to North Wind Component

September-1991

**Jerseydale**

## Relative Humidity (%)

*PRINTED ON:* 3/6/95 22:38

| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Peak | Time | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/91 | 53 | 51 | 50 | 49 | 51 | 49 | 52 | 50 | 42 | 38 | 35 | 30 | 31 | 30 | 30 | 30 | 31 | 33 | 38 | 44 | 45 | 47 | 45 | 44 | 54 | 0.42 | |
| 9/2/91 | 44 | 45 | 46 | 48 | 44 | 43 | 42 | 45 | 40 | 31 | 27 | 25 | 24 | 25 | 25 | 26 | 28 | 29 | 33 | 37 | 39 | 41 | 43 | 44 | 50 | 3.75 | |
| 9/3/91 | 45 | 47 | 47 | 46 | 46 | 47 | 47 | 42 | 36 | 31 | 27 | 26 | 27 | 28 | 27 | 27 | 28 | 33 | 36 | 42 | 43 | 43 | 45 | 46 | 48 | 1.67 | 7 |
| 9/4/91 | 45 | 44 | 43 | 41 | 42 | 43 | 45 | 42 | 35 | 32 | 29 | 26 | 26 | 26 | 24 | 24 | 26 | 30 | 32 | 32 | 34 | 34 | 36 | 38 | 46 | 0.17 | 10 |
| 9/5/91 | 38 | 38 | 37 | 38 | 37 | 37 | 40 | 39 | 35 | 31. | 29 | 26 | 26 | 28 | 31 | 35 | 36 | 66 | 51 | 42 | 41 | 40 | 41 | 42 | 79 | 17.67 | |
| 9/6/91 | 44 | 44 | 45 | 46 | 45 | 46 | 45 | 48 | 44 | 41 | 39 | 39 | 40 | 35 | 36 | 37 | 38 | 42 | 55 | 56 | 78 | 82 | 84 | 63 | 95 | 21.83 | |
| 9/7/91 | 54 | 52 | 50 | 52 | 87 | 87 | 73 | 69 | 56 | 47 | 45 | 39 | 37 | 38 | 39 | 38 | 35 | 40 | 40 | 46 | 45 | 47 | 50 | 53 | 93 | 4.58 | 4 |
| 9/8/91 | 55 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 49 | 44 | 41 | 39 | 41 | 41 | 39 | 37 | 37 | 37 | 37 | 39 | 40 | 41 | 42 | 43 | 57 | 1.25 | 15 |
| 9/9/91 | 42 | 40 | 42 | 43 | 48 | 59 | 53 | 46 | 39 | 34 | 27 | 26 | 30 | 31 | 33 | 35 | 45 | 56 | 66 | 73 | 78 | 81 | 84 | 84 | 85 | 23.25 | 3 |
| 9/10/91 | 69 | 66 | 72 | 76 | 71 | 69 | 82 | 79 | 69 | 63 | 56 | 51 | 50 | 48 | 49 | 48 | 50 | 54 | 62 | 64 | 65 | 65 | 67 | 70 | 85 | 6.92 | 2 |
| 9/11/91 | 69 | 70 | 75 | 77 | 73 | 75 | 74 | 65 | 58 | 52 | 47 | 43 | 41 | 39 | 38 | 40 | 44 | 47 | 53 | 55 | 58 | 60 | 65 | 69 | 78 | 3.00 | 2 |
| 9/12/91 | 68 | 69 | 69 | 70 | 70 | 68 | 67 | 63 | 53 | 44 | 42 | 39 | 37 | 35 | 35 | 35 | 39 | 42 | 46 | 48 | 49 | 50 | 52 | 54 | 71 | 0.08 | 4 |
| 9/13/91 | 56 | 57 | 57 | 59 | 60 | 60 | 57 | 55 | 46 | 39 | 34 | 31 | 30 | 31 | 32 | 32 | 31 | 34 | 36 | 41 | 44 | 45 | 47 | 48 | 61 | 5.67 | 2 |
| 9/14/91 | 48 | 48 | 48 | 50 | 52 | 52 | 52 | 48 | 40 | 34 | 30 | 29 | 28 | 28 | 27 | 25 | 28 | 33 | 37 | 40 | 41 | 42 | 44 | 44 | 53 | 5.83 | 6 |
| 9/15/91 | 44 | 45 | 46 | 46 | 48 | 47 | 47 | 46 | 36 | 31 | 28 | 25 | 25 | 25 | 25 | 24 | 25 | 28 | 32 | 37 | 40 | 39 | 39 | 39 | 49 | 4.92 | 4 |
| 9/16/91 | 38 | 36 | 35 | 36 | 38 | 38 | 38 | 37 | 30 | 26 | 24 | 22 | 21 | 21 | 23 | 22 | 20 | 23 | 29 | 33 | 37 | 39 | 36 | 37 | 40 | 4.83 | 6 |
| 9/17/91 | 38 | 39 | 39 | 39 | 39 | 41 | 41 | 39 | 33 | 29 | 27 | 24 | 23 | 24 | 24 | 24 | 25 | 28 | 33 | 38 | 40 | 40 | 41 | 41 | 42 | 6.42 | 5 |
| 9/18/91 | 42 | 43 | 42 | 43 | 44 | 42 | 43 | 41 | 36 | 30 | 25 | 23 | 22 | 21 | 22 | 22 | 24 | 30 | 33 | 35 | 36 | 38 | 38 | 38 | 46 | 4.42 | |
| 9/19/91 | 39 | 39 | 40 | 39 | 39 | 37 | 37 | 38 | 34 | 28 | 23 | 21 | 21 | 22 | 23 | 23 | 24 | 29 | 33 | 35 | 37 | 37 | 38 | 39 | 42 | 2.42 | 2 |
| 9/20/91 | 41 | 42 | 42 | 42 | 40 | 38 | 41 | 39 | 34 | 29 | 25 | 23 | 26 | 27 | 28 | 26 | 28 | 32 | 35 | 38 | 39 | 40 | 42 | 43 | 44 | 23.75 | |
| 9/21/91 | 43 | 44 | 44 | 44 | 44 | 45 | 45 | 41 | 35 | 31 | 29 | 26 | 26 | 27 | 28 | 29 | 30 | 33 | 36 | 39 | 39 | 40 | 43 | 44 | 47 | 6.17 | 2 |
| 9/22/91 | 45 | 47 | 50 | 49 | 48 | 49 | 49 | 44 | 39 | 36 | 32 | 30 | 30 | 30 | 31 | 32 | 34 | 35 | 39 | 41 | 43 | 42 | 44 | 46 | 51 | 2.58 | 5 |
| 9/23/91 | 46 | 47 | 48 | 47 | 47 | 48 | 47 | 48 | 41 | 34 | 30 | 25 | 26 | 28 | 28 | 27 | 30 | 32 | 37 | 39 | 39 | 40 | 42 | 43 | 51 | 7.33 | |
| 9/24/91 | 40 | 39 | 38 | 38 | 38 | 36 | 35 | 34 | 30 | 22 | 19 | 19 | 22 | 22 | 23 | 25 | 26 | 27 | 31 | 31 | 34 | 36 | 37 | 33 | 42 | 0.58 | |
| 9/25/91 | 35 | 36 | 35 | 33 | 33 | 30 | 29 | 29 | 26 | 22 | 19 | 18 | 20 | 26 | 26 | 28 | 27 | 29 | 26 | 30 | 33 | 35 | 36 | 37 | 38 | 22.58 | 5 |
| 9/26/91 | 37 | 36 | 37 | 38 | 39 | 43 | 43 | 42 | 37 | 35 | 32 | 31 | 32 | 32 | 32 | 32 | 32 | 35 | 41 | 43 | 43 | 44 | 45 | 47 | 49 | 23.92 | 2 |
| 9/27/91 | 49 | 49 | 50 | 49 | 48 | 47 | 46 | 43 | 40 | 34 | 30 | 27 | 28 | 26 | 30 | 32 | 34 | 40 | 43 | 47 | 48 | 51 | 51 | 52 | 53 | 21.58 | 5 |
| 9/28/91 | 52 | 51 | 51 | 52 | 52 | 51 | 51 | 47 | 39 | 30 | 30 | 27 | 27 | 26 | 27 | 28 | 30 | 33 | 37 | 41 | 42 | 43 | 43 | 41 | 53 | 3.17 | 4 |
| 9/29/91 | 40 | 42 | 41 | 41 | 42 | 43 | 46 | 45 | 38 | 30 | 27 | 24 | 22 | 23 | 24 | 25 | 28 | 32 | 36 | 38 | 39 | 42 | 43 | 44 | 47 | 6.33 | 5 |
| 9/30/91 | 46 | 47 | 47 | 47 | 45 | 44 | 45 | 44 | 40 | 32 | 27 | 25 | 24 | 24 | 26 | 28 | 30 | 33 | 36 | 39 | 41 | 42 | 45 | 47 | 48 | 2.58 | 8 |
| Av | 47 | 47 | 47 | 48 | 49 | 49 | 49 | 47 | 40 | 35 | 31 | 29 | 29 | 29 | 29 | 30 | 31 | 36 | 39 | 42 | 44 | 45 | 47 | 47 | | | |
| N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | | | |
| Mx | 69 | 70 | 75 | 77 | 87 | 87 | 82 | 79 | 69 | 63 | 56 | 51 | 50 | 48 | 49 | 48 | 50 | 66 | 66 | 73 | 78 | 82 | 84 | 84 | | | |

Figure 7: Example Relative Humidity (percent)

September-1991 **Ozone Concentration (ppbv)** PRINTED ON: 3/6/95 22:40

**Jerseydale**

| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Peak | Time | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/91 | 52 | 51 | 52 | 52 | 54 | 54 | 51 | 48 | 49 | 55 | 59 | 62 | 69 | 71 | 75 | 75 | 74 | 73 | 73 | 72 | 73 | 70 | 64 | 63 | 77 | 14.75 | 2 |
| 9/2/91 | 63 | 60 | 57 | 56 | 56 | 55 | 54 | 53 | 54 | 60 | 55 | 52 | 56 | 63 | 65 | 69 | 68 | 68 | 68 | 68 | 69 | 70 | 65 | 61 | 72 | 21.00 | 3 |
| 9/3/91 | 58 | 55 | 53 | 48 | 44 | 43 | 42 | 40 | 44 | 51 | 57 | 60 | 71 | 80 | 79 | 79 | 80 | 86 | 93 | 86 | 95 | 96 | 88 | 82 | 101 | 21.00 | 2 |
| 9/4/91 | 75 | 71 | 65 | 60 | 57 | 50 | 44 | 38 | 42 | 58 | 59 | 67 | 80 | 86 | 83 | 75 | 74 | 79 | 78 | 52 | 50 | 40 | 39 | 40 | 89 | 14.17 | 2 |
| 9/5/91 | 40 | 42 | 43 | 45 | 42 | 41 | 39 | 37 | 39 | 54 | 66 | 71 | 76 | 85 | 91 | 100 | 90 | 72 | 57 | 54 | 46 | 42 | 41 | 40 | 103 | 15.25 | 4 |
| 9/6/91 | 39 | 35 | 33 | 33 | 34 | 36 | 37 | 35 | 45 | 51 | 67 | 74 | 82 | 82 | 94 | 91 | 80 | 77 | 83 | 74 | 54 | 42 | 30 | 36 | 100 | 14.00 | 2 |
| 9/7/91 | 35 | 34 | 35 | 38 | 37 | 32 | 33 | 29 | 36 | 51 | 56 | 59 | 68 | 76 | 75 | 68 | 60 | 59 | 58 | 54 | 57 | 52 | 45 | 43 | 82 | 14.42 | |
| 9/8/91 | 42 | 41 | 41 | 41 | 42 | 43 | 43 | 43 | 47 | 50 | 54 | 59 | 66 | 70 | 67 | 61 | 52 | 44 | 44 | 42 | 40 | 38 | 36 | 34 | 74 | 13.08 | |
| 9/9/91 | 33 | 30 | 31 | 30 | 32 | 33 | 35 | 41 | 45 | 49 | 49 | 50 | 51 | 51 | 55 | 60 | 53 | 43 | 36 | 32 | 31 | 30 | 30 | 31 | 64 | 16.00 | |
| 9/10/91 | 37 | 38 | 36 | 34 | 36 | 36 | 27 | 25 | 28 | 32 | 35 | 39 | 42 | 44 | 49 | 53 | 55 | 55 | 54 | 55 | 55 | 55 | 56 | 56 | 58 | 17.58 | 2 |
| 9/11/91 | 55 | 53 | 52 | 52 | 53 | 53 | 53 | 50 | 54 | 55 | 58 | 61 | 63 | 65 | 70 | 73 | 71 | 65 | 62 | 63 | 64 | 66 | 66 | 65 | 76 | 15.58 | |
| 9/12/91 | 59 | 58 | 60 | 58 | 55 | 56 | 54 | 53 | 66 | -99 | 78 | 84 | 84 | 82 | 84 | 87 | 90 | 88 | 86 | 82 | 84 | 85 | 83 | 81 | 92 | 16.75 | |
| 9/13/91 | 79 | 78 | 77 | 76 | 74 | 73 | 69 | 67 | 75 | 81 | 78 | 80 | 82 | 85 | 93 | 91 | 78 | 75 | 80 | 80 | 82 | 82 | 76 | 72 | 97 | 14.92 | 2 |
| 9/14/91 | 72 | 74 | 74 | 72 | 71 | 70 | 69 | 66 | 72 | 76 | 78 | 79 | 80 | 82 | 82 | 81 | 79 | 73 | 72 | 70 | 67 | 66 | 68 | 68 | 84 | 13.75 | 2 |
| 9/15/91 | 69 | 68 | 68 | 69 | 68 | 69 | 68 | 65 | 73 | 75 | 71 | 69 | 72 | 76 | 83 | 84 | 82 | 83 | 80 | 78 | 77 | 74 | 74 | 73 | 86 | 14.75 | 2 |
| 9/16/91 | 72 | 72 | 71 | 73 | 72 | 70 | 69 | 67 | 70 | 76 | 78 | 79 | 78 | 81 | 91 | 86 | 73 | 73 | 78 | 85 | 87 | 81 | 73 | 71 | 94 | 14.75 | 4 |
| 9/17/91 | 70 | 69 | 70 | 72 | 73 | 72 | 71 | 68 | 75 | 80 | 83 | 84 | 87 | 93 | 99 | 94 | 91 | 96 | 96 | 107 | 111 | 105 | 97 | 93 | 113 | 20.33 | 2 |
| 9/18/91 | 89 | 85 | 81 | 84 | 82 | 78 | 77 | 75 | 84 | 93 | 91 | 95 | 93 | 93 | 96 | 99 | 102 | 114 | 114 | 107 | 100 | 98 | 98 | 97 | 120 | 17.75 | |
| 9/19/91 | 96 | 91 | 88 | 81 | 76 | 76 | 78 | 77 | 90 | 102 | 101 | 95 | 95 | 101 | 106 | 106 | 99 | 98 | 101 | 105 | 106 | 103 | 100 | 98 | 109 | 15.17 | |
| 9/20/91 | 97 | 93 | 88 | 86 | 86 | 84 | 85 | 80 | 93 | 97 | 95 | 93 | 102 | 112 | 111 | 101 | 99 | 99 | 95 | 93 | 93 | 94 | 92 | 91 | 114 | 13.67 | 2 |
| 9/21/91 | 89 | 87 | 84 | 83 | 84 | 85 | 84 | 81 | 88 | 88 | 91 | 92 | 95 | 97 | 99 | 100 | 99 | 94 | 92 | 89 | 87 | 85 | 87 | 85 | 102 | 14.83 | 2 |
| 9/22/91 | 85 | 84 | 84 | 88 | 90 | 94 | 94 | 96 | 106 | 108 | 107 | 108 | 106 | 110 | 114 | 112 | 105 | 102 | 100 | 100 | 98 | 96 | 96 | 96 | 116 | 14.58 | 3 |
| 9/23/91 | 94 | 93 | 92 | 89 | 89 | 89 | 86 | 84 | 89 | 95 | 94 | 90 | 94 | 97 | 98 | 94 | 95 | 97 | 96 | 97 | 98 | 99 | 97 | 96 | 100 | 14.25 | 5 |
| 9/24/91 | 89 | 82 | 80 | 77 | 74 | 73 | 68 | 64 | 63 | 67 | 78 | 82 | 92 | 96 | 100 | 103 | 94 | 97 | 92 | 89 | 88 | 86 | 82 | 81 | 106 | 15.08 | |
| 9/25/91 | 78 | 72 | 61 | 58 | 57 | 57 | 57 | 55 | 64 | 71 | 69 | 68 | 75 | 101 | 101 | 91 | 78 | 60 | 51 | 49 | 48 | 47 | 46 | 43 | 107 | 13.92 | |
| 9/26/91 | 42 | 42 | 43 | 42 | 42 | 44 | 41 | 36 | 40 | 44 | 50 | 57 | 69 | 75 | 79 | 80 | 82 | 82 | 83 | 78 | 75 | 71 | 73 | 74 | 85 | 16.92 | 5 |
| 9/27/91 | 74 | 75 | 75 | 72 | 72 | 68 | 65 | 58 | 64 | 72 | 68 | 67 | 69 | 65 | 72 | 72 | 70 | 69 | 71 | 70 | 71 | 69 | 66 | 66 | 76 | 1.33 | 8 |
| 9/28/91 | 66 | 64 | 63 | 62 | 62 | 61 | 60 | 59 | 63 | 60 | 62 | 61 | 65 | 67 | 69 | 71 | 73 | 70 | 70 | 71 | 71 | 68 | 66 | 65 | 74 | 16.08 | 4 |
| 9/29/91 | 62 | 61 | 56 | 52 | 50 | 50 | 45 | 41 | 44 | 60 | 60 | 59 | 59 | 62 | 66 | 67 | 69 | 77 | 80 | 81 | 80 | 75 | 71 | 67 | 83 | 18.25 | 4 |
| 9/30/91 | 62 | 56 | 52 | 52 | 49 | 47 | 46 | 44 | 43 | 46 | 50 | 53 | 53 | 54 | 60 | 59 | 61 | 64 | 66 | 67 | 67 | 64 | 61 | 59 | 68 | 19.67 | 9 |
| Av | 66 | 64 | 62 | 61 | 60 | 60 | 58 | 56 | 61 | 67 | 70 | 72 | 76 | 80 | 84 | 83 | 79 | 78 | 77 | 75 | 74 | 71 | 69 | 68 | | | |
| N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | | | |
| Mx | 97 | 93 | 92 | 89 | 90 | 94 | 94 | 96 | 106 | 108 | 107 | 108 | 106 | 112 | 114 | 112 | 105 | 114 | 114 | 107 | 111 | 105 | 100 | 98 | | | |

...tration (parts per billion by volume)

September-1991
Jerseydale

## Temperature (Degrees C°)

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| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Peak | Time | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/91 | 16.7 | 16.7 | 16.6 | 16.8 | 16.6 | 17.2 | 17.3 | 19.4 | 22.4 | 24.6 | 26.6 | 28.2 | 28.9 | 29.5 | 29.2 | 28.4 | 27.5 | 26.3 | 24.0 | 21.9 | 21.0 | 20.2 | 20.1 | 19.9 | 30.0 | 13.67 | |
| 9/2/91 | 19.8 | 19.4 | 19.1 | 18.2 | 18.8 | 18.8 | 19.7 | 21.6 | 24.8 | 28.5 | 30.7 | 31.6 | 32.2 | 32.2 | 31.5 | 30.4 | 29.3 | 28.2 | 26.1 | 24.3 | 23.3 | 22.4 | 21.4 | 20.8 | 33.0 | 13.17 | |
| 9/3/91 | 20.1 | 19.2 | 18.7 | 18.5 | 18.4 | 18.2 | 18.7 | 22.1 | 25.9 | 29.1 | 31.1 | 32.7 | 32.7 | 32.5 | 31.9 | 30.9 | 30.1 | 28.0 | 26.1 | 23.5 | 22.9 | 22.4 | 21.5 | 21.2 | 33.4 | 13.17 | |
| 9/4/91 | 20.9 | 20.8 | 20.8 | 20.3 | 19.7 | 19.3 | 18.8 | 21.3 | 25.7 | 28.4 | 30.0 | 32.1 | 33.1 | 32.6 | 31.9 | 30.9 | 30.0 | 28.5 | 26.5 | 24.6 | 23.0 | 22.2 | 21.2 | 20.4 | 33.6 | 12.67 | |
| 9/5/91 | 20.0 | 20.1 | 20.2 | 19.6 | 19.8 | 19.6 | 19.4 | 21.1 | 24.9 | 27.9 | 29.5 | 31.3 | 31.8 | 31.3 | 30.4 | 28.3 | 27.0 | 21.8 | 21.5 | 22.0 | 21.2 | 20.6 | 20.4 | 19.9 | 32.4 | 11.75 | |
| 9/6/91 | 19.2 | 18.9 | 18.5 | 18.3 | 18.7 | 18.5 | 19.0 | 20.0 | 23.4 | 24.9 | 26.6 | 28.0 | 27.4 | 27.6 | 26.3 | 25.4 | 23.7 | 22.2 | 20.9 | 20.5 | 16.4 | 15.6 | 15.2 | 17.1 | 29.5 | 13.08 | |
| 9/7/91 | 17.9 | 18.0 | 18.0 | 17.7 | 14.3 | 14.0 | 15.2 | 17.1 | 20.2 | 23.2 | 24.8 | 25.5 | 26.6 | 27.0 | 26.2 | 25.4 | 24.6 | 22.8 | 20.8 | 18.5 | 18.1 | 17.2 | 16.7 | 16.3 | 27.8 | 13.33 | |
| 9/8/91 | 15.8 | 15.1 | 15.1 | 15.3 | 15.5 | 15.9 | 16.5 | 18.4 | 20.4 | 22.8 | 24.6 | 25.5 | 26.2 | 25.7 | 25.2 | 24.6 | 23.2 | 21.6 | 20.1 | 18.4 | 17.7 | 17.1 | 16.8 | 16.3 | 26.6 | 12.67 | 3 |
| 9/9/91 | 16.9 | 17.2 | 16.8 | 15.9 | 14.3 | 11.1 | 12.3 | 14.8 | 16.8 | 18.6 | 18.4 | 19.2 | 19.5 | 19.5 | 18.7 | 17.3 | 15.2 | 13.7 | 11.7 | 10.0 | 9.1 | 8.4 | 8.2 | 8.4 | 20.0 | 11.42 | 3 |
| 9/10/91 | 9.3 | 8.7 | 8.0 | 7.7 | 8.3 | 8.5 | 7.9 | 9.6 | 12.3 | 14.1 | 16.4 | 17.7 | 18.3 | 18.8 | 18.0 | 18.1 | 17.9 | 16.2 | 13.9 | 12.8 | 12.1 | 11.6 | 11.2 | 10.6 | 19.5 | 13.83 | |
| 9/11/91 | 11.1 | 11.1 | 10.0 | 9.8 | 10.7 | 10.3 | 10.6 | 13.3 | 15.2 | 17.6 | 19.7 | 21.1 | 22.1 | 22.4 | 22.5 | 21.6 | 20.3 | 19.0 | 17.0 | 16.0 | 15.0 | 14.7 | 13.7 | 12.9 | 22.9 | 13.17 | 3 |
| 9/12/91 | 13.1 | 13.0 | 13.1 | 12.8 | 12.6 | 12.6 | 13.2 | 15.3 | 17.6 | 21.8 | 22.9 | 24.3 | 24.8 | 25.0 | 24.5 | 23.8 | 23.0 | 21.4 | 19.3 | 17.6 | 16.7 | 16.4 | 16.0 | 15.7 | 25.7 | 13.17 | |
| 9/13/91 | 15.0 | 14.9 | 14.9 | 14.5 | 14.0 | 13.8 | 14.5 | 16.4 | 20.2 | 22.6 | 24.9 | 25.9 | 26.6 | 26.6 | 26.0 | 25.1 | 24.2 | 22.2 | 20.1 | 18.2 | 17.1 | 16.5 | 15.6 | 15.3 | 27.7 | 13.17 | |
| 9/14/91 | 15.7 | 15.5 | 15.3 | 14.8 | 14.4 | 14.1 | 14.5 | 17.0 | 20.7 | 23.4 | 25.2 | 26.3 | 26.5 | 25.8 | 25.6 | 25.4 | 24.6 | 22.3 | 19.8 | 17.9 | 17.2 | 16.9 | 16.6 | 16.4 | 27.3 | 12.42 | |
| 9/15/91 | 16.3 | 15.9 | 15.6 | 15.5 | 15.0 | 15.1 | 15.4 | 17.2 | 21.6 | 24.3 | 26.3 | 27.5 | 28.4 | 28.5 | 28.1 | 27.5 | 26.6 | 25.3 | 23.1 | 21.0 | 19.8 | 19.4 | 18.8 | 18.4 | 29.1 | 13.50 | |
| 9/16/91 | 18.4 | 18.1 | 18.2 | 17.7 | 17.3 | 17.3 | 17.3 | 19.5 | 23.5 | 26.5 | 28.4 | 29.8 | 30.5 | 30.6 | 29.7 | 29.0 | 28.0 | 25.6 | 22.9 | 21.3 | 20.3 | 19.0 | 19.2 | 19.1 | 30.9 | 12.83 | 4 |
| 9/17/91 | 18.7 | 18.5 | 18.5 | 18.3 | 18.1 | 17.6 | 17.9 | 20.0 | 23.9 | 26.7 | 28.1 | 29.3 | 30.4 | 30.1 | 29.8 | 29.1 | 28.2 | 26.1 | 23.3 | 21.7 | 21.1 | 20.8 | 20.0 | 19.6 | 30.7 | 12.33 | 2 |
| 9/18/91 | 19.2 | 18.8 | 18.5 | 18.4 | 17.7 | 17.7 | 17.7 | 20.0 | 24.0 | 27.4 | 29.6 | 31.7 | 31.9 | 31.7 | 31.1 | 29.8 | 28.8 | 26.9 | 24.4 | 22.7 | 21.7 | 21.3 | 21.2 | 20.7 | 32.4 | 11.75 | 2 |
| 9/19/91 | 20.4 | 20.0 | 19.2 | 19.0 | 18.6 | 18.8 | 19.2 | 20.6 | 24.6 | 27.8 | 29.8 | 31.7 | 32.0 | 31.3 | 30.7 | 29.8 | 28.4 | 26.0 | 23.7 | 22.2 | 21.6 | 21.3 | 20.7 | 20.3 | 32.4 | 12.00 | |
| 9/20/91 | 19.5 | 19.0 | 18.6 | 18.2 | 18.4 | 18.4 | 18.2 | 20.5 | 24.1 | 26.7 | 28.5 | 30.1 | 30.4 | 29.5 | 28.9 | 28.0 | 26.8 | 24.6 | 22.3 | 20.6 | 20.2 | 19.7 | 18.9 | 18.4 | 31.0 | 12.25 | |
| 9/21/91 | 18.0 | 17.6 | 17.3 | 17.0 | 16.9 | 16.6 | 16.8 | 19.8 | 23.3 | 25.2 | 27.5 | 29.0 | 29.3 | 29.1 | 28.0 | 27.0 | 25.9 | 24.0 | 22.0 | 20.1 | 19.5 | 19.1 | 18.4 | 17.9 | 29.8 | 12.33 | 2 |
| 9/22/91 | 17.7 | 17.3 | 16.5 | 17.0 | 17.3 | 17.1 | 17.2 | 20.1 | 23.3 | 25.9 | 27.5 | 28.7 | 28.9 | 28.7 | 28.1 | 27.3 | 26.2 | 24.1 | 21.7 | 20.4 | 19.0 | 19.2 | 19.1 | 18.7 | 29.5 | 12.92 | |
| 9/23/91 | 18.5 | 18.3 | 18.0 | 18.1 | 17.9 | 17.3 | 18.0 | 19.1 | 23.0 | 26.0 | 27.9 | 29.9 | 30.3 | 29.4 | 28.9 | 27.9 | 26.4 | 24.4 | 22.4 | 21.1 | 20.6 | 20.0 | 19.0 | 18.5 | 30.9 | 12.50 | |
| 9/24/91 | 18.5 | 18.3 | 18.4 | 18.1 | 17.9 | 18.1 | 18.1 | 20.2 | 24.1 | 28.9 | 31.4 | 32.4 | 31.9 | 31.7 | 30.8 | 29.2 | 27.7 | 25.8 | 23.4 | 22.3 | 21.0 | 20.3 | 19.4 | 20.3 | 33.1 | 11.17 | |
| 9/25/91 | 19.2 | 18.3 | 17.9 | 17.8 | 17.5 | 18.3 | 18.7 | 21.0 | 25.1 | 27.9 | 30.2 | 31.1 | 30.5 | 28.2 | 27.4 | 26.4 | 26.1 | 25.0 | 24.5 | 22.8 | 21.0 | 20.1 | 19.8 | 19.2 | 31.4 | 11.50 | 2 |
| 9/26/91 | 19.1 | 19.0 | 18.8 | 18.1 | 18.2 | 17.4 | 17.7 | 19.8 | 22.3 | 24.4 | 26.3 | 27.4 | 27.2 | 27.1 | 26.3 | 25.2 | 24.0 | 22.1 | 20.0 | 18.5 | 18.0 | 17.3 | 17.0 | 16.5 | 28.0 | 11.83 | |
| 9/27/91 | 15.9 | 15.8 | 15.5 | 15.5 | 15.6 | 15.7 | 15.9 | 17.3 | 20.4 | 23.4 | 25.0 | 26.2 | 26.5 | 26.3 | 25.1 | 24.1 | 22.9 | 20.6 | 18.9 | 17.1 | 16.5 | 15.6 | 15.6 | 15.0 | 26.9 | 11.83 | 4 |
| 9/28/91 | 15.1 | 14.8 | 14.5 | 14.4 | 14.2 | 14.2 | 14.5 | 16.7 | 20.3 | 22.2 | 24.1 | 25.3 | 26.4 | 25.8 | 24.6 | 23.8 | 22.8 | 20.9 | 18.8 | 17.4 | 17.0 | 16.6 | 16.7 | 17.3 | 27.0 | 12.25 | |
| 9/29/91 | 17.1 | 16.2 | 16.3 | 16.4 | 16.0 | 15.7 | 15.6 | 17.3 | 21.3 | 24.5 | 26.6 | 27.9 | 28.5 | 28.3 | 27.6 | 26.6 | 25.3 | 23.3 | 21.2 | 20.1 | 19.7 | 18.4 | 18.0 | 17.3 | 29.1 | 12.83 | |
| 9/30/91 | 16.6 | 16.1 | 15.9 | 15.8 | 16.5 | 16.6 | 16.8 | 18.4 | 22.0 | 26.6 | 28.9 | 29.8 | 30.0 | 29.6 | 28.5 | 27.6 | 26.5 | 24.4 | 22.7 | 21.4 | 20.8 | 20.0 | 18.7 | 18.0 | 30.8 | 11.67 | |
| Av | 17.3 | 17.0 | 16.7 | 16.5 | 16.3 | 16.1 | 16.4 | 18.5 | 21.9 | 24.7 | 26.6 | 27.9 | 28.3 | 28.1 | 27.4 | 26.5 | 25.4 | 23.4 | 21.4 | 19.9 | 18.9 | 18.3 | 17.8 | 17.6 | | | |
| N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | | | |
| Mx | 20.9 | 20.8 | 20.8 | 20.3 | 19.8 | 19.6 | 19.7 | 22.1 | 25.9 | 29.1 | 31.4 | 32.7 | 33.1 | 32.6 | 31.9 | 30.9 | 30.1 | 28.5 | 26.5 | 24.6 | 23.3 | 22.4 | 21.5 | 21.2 | | | |

Figure 9: Temperature (degrees C)

September-1991
Jerseydale

# Solar Radiation (w/m^2)

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| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Peak | Time | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/91 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 251 | 527 | 698 | 820 | 881 | 875 | 802 | 685 | 526 | 337 | 122 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 10.92 | 26 |
| 9/2/91 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 196 | 483 | 698 | 808 | 875 | 881 | 796 | 698 | 526 | 337 | 116 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 11.00 | 24 |
| 9/3/91 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 177 | 489 | 685 | 796 | 869 | 851 | 783 | 679 | 514 | 318 | 98 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 11.25 | 17 |
| 9/4/91 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 159 | 496 | 661 | 704 | 881 | 832 | 777 | 667 | 520 | 318 | 86 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 11.08 | 16 |
| 9/5/91 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 135 | 471 | 691 | 790 | 869 | 832 | 722 | 520 | 294 | 129 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 11.17 | 17 |
| 9/6/91 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 147 | 459 | 526 | 667 | 893 | 746 | 698 | 490 | 404 | 141 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 1028 | 13.00 | 2 |
| 9/7/91 | 0 | 0 | 0 | 0 | 0 | 0 | 61 | 153 | 459 | 673 | 783 | 796 | 784 | 746 | 642 | 496 | 300 | 98 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 10.33 | 32 |
| 9/8/91 | 0 | 0 | 0 | 0 | 0 | 0 | 61 | 165 | 300 | 630 | 673 | 832 | 808 | 771 | 642 | 416 | 202 | 79 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 10.92 | 8 |
| 9/9/91 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 165 | 330 | 649 | 796 | 869 | 857 | 783 | 551 | 318 | 116 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 11.25 | 18 |
| 9/10/91 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 116 | 484 | 655 | 710 | 765 | 777 | 673 | 373 | 465 | 275 | 73 | 0 | 0 | 0 | 0 | 0 | 0 | 954 | 12.42 | 2 |
| 9/11/91 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 92 | 465 | 655 | 771 | 808 | 808 | 740 | 618 | 447 | 257 | 73 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 10.58 | 32 |
| 9/12/91 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 98 | 349 | 685 | 759 | 808 | 808 | 740 | 612 | 441 | 245 | 67 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 10.75 | 30 |
| 9/13/91 | 0 | 0 | 0 | 0 | 0 | 0 | 61 | 92 | 453 | 649 | 765 | 808 | 808 | 728 | 612 | 447 | 257 | 73 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 10.67 | 30 |
| 9/14/91 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 79 | 483 | 655 | 759 | 802 | 618 | 630 | 465 | 465 | 263 | 67 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 11.75 | 2 |
| 9/15/91 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 79 | 484 | 642 | 759 | 808 | 808 | 728 | 612 | 447 | 251 | 61 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 10.75 | 29 |
| 9/16/91 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 79 | 490 | 642 | 759 | 808 | 808 | 734 | 593 | 429 | 239 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 10.75 | 30 |
| 9/17/91 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 98 | 508 | 655 | 771 | 808 | 808 | 728 | 600 | 435 | 233 | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 10.58 | 31 |
| 9/18/91 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 110 | 496 | 655 | 759 | 808 | 802 | 722 | 600 | 429 | 226 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 10.75 | 27 |
| 9/19/91 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 110 | 477 | 630 | 740 | 808 | 790 | 704 | 569 | 398 | 220 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 11.00 | 22 |
| 9/20/91 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 122 | 477 | 630 | 728 | 802 | 746 | 691 | 563 | 398 | 214 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 11.17 | 13 |
| 9/21/91 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 128 | 477 | 636 | 734 | 808 | 771 | 704 | 569 | 404 | 214 | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 11.08 | 18 |
| 9/22/91 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 134 | 447 | 599 | 710 | 734 | 734 | 667 | 551 | 380 | 165 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 734 | 10.42 | 35 |
| 9/23/91 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 141 | 459 | 624 | 722 | 765 | 734 | 673 | 520 | 361 | 177 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 11.42 | 5 |
| 9/24/91 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 153 | 477 | 630 | 734 | 808 | 759 | 685 | 557 | 294 | 122 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 11.08 | 16 |
| 9/25/91 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 165 | 459 | 624 | 722 | 820 | 685 | 496 | 496 | 233 | 159 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 954 | 11.67 | |
| 9/26/91 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 128 | 441 | 606 | 710 | 710 | 661 | 698 | 526 | 361 | 196 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 11.42 | 3 |
| 9/27/91 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 153 | 447 | 606 | 710 | 740 | 734 | 685 | 544 | 386 | 208 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 808 | 11.67 | |
| 9/28/91 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 165 | 459 | 618 | 716 | 746 | 820 | 685 | 551 | 386 | 190 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 12.08 | 4 |
| 9/29/91 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 153 | 435 | 593 | 698 | 765 | 716 | 673 | 532 | 355 | 173 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 881 | 12.83 | |
| 9/30/91 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 153 | 441 | 593 | 698 | 734 | 734 | 643 | 526 | 361 | 171 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 734 | 10.58 | 30 |
| Av | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 136 | 457 | 640 | 742 | 808 | 780 | 710 | 572 | 411 | 222 | 53 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | | | |
| Mx | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 251 | 527 | 698 | 820 | 893 | 881 | 802 | 698 | 526 | 337 | 122 | 0 | 0 | 0 | 0 | 0 | 0 | | | |

APPENDIX C:

# The Spatial Variation of Ozone Climatology on the Western Slope of the Sierra Nevada

by:

Daphne J. Van Ooy[1] and John J. Carroll

Department of Land, Air and Water Resources
University of California
Davis, California 95616

[1]Current affiliation: CH2M Hill, Sacramento, California

# THE SPATIAL VARIATION OF OZONE CLIMATOLOGY ON THE WESTERN SLOPE OF THE SIERRA NEVADA

**Daphne J. Van Ooy[1] and John J. Carroll**
**Department of Land, Air and Water Resources**
**University of California, Davis**

## ABSTRACT

The spatial variability of ozone climatology is described for six remote sites on the western slope of the Sierra Nevada. A statistical analysis was applied to determine relationships between ozone concentrations and atmospheric variables, as well as relationships among sites. The sites, whose locations vary in latitude, elevation, and topography, show considerable variability in climatological patterns and statistics. However, the stations fall into two general groups: those with a distinct diurnal ozone pattern and those with a flat diurnal ozone pattern. Diurnal variations among sites appear to depend primarily on topographic setting rather than on remoteness from urban sources.

**Key word index: Ozone, climatology, coniferous forest, spatial variability.**

## INTRODUCTION

Ozone injury to the mixed conifer forest ecosystem of the Sierra Nevada has become a significant concern. At concentrations often measured in the Sierra Nevada, ozone is known to be toxic to plants (Heck and Brandt, 1977; Peterson et al., 1987; Woodman, 1987).

Tropospheric ozone is a secondary pollutant produced through a series of photochemical reactions. The precursors are oxides of nitrogen, primarily from automobile emissions, and hydrocarbons. Ozone can be transported up to hundreds of miles downstream from urban sources and persist on the order of hours to days (US EPA, 1984). The observance of ozone in remote regions of the Sierra Nevada has been attributed to atmospheric transport from sources in the Central Valley (Carroll and Baskett, 1977; Duckworth and Crowe, 1979; Miller et al., 1972; Pedersen and Cahill, 1989).

Because ozone formation is dependent on radiant energy, most natural exposure regimes will follow a sinusoidal pattern with the highest concentrations in the afternoon hours, just past the time of greatest solar radiation. Many remote locations exhibit a weaker diurnal variation than urban sites, with concentrations remaining high throughout the 24 hour day (Evans et at, 1983; Lefohn and Jones, 1986). The Landesanstalt fur Immissionsschutz des Landes Nordrhein-Westfalen has attributed this lack of diurnal variation observed in remote regions to reduced ozone scavenging by nitric oxide causing high concentrations to persist through the evening hours (Lefohn and Jones, 1986).

The six stations documented in this study are all considered geographically remote but display two types of diurnal ozone signatures. Three of the sites display weak diurnal variations, expected of remote sites, with ozone concentrations remaining high throughout the evening. The other three sites exhibit diurnal

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[1]Current affiliation: CH2M Hill, Sacramento, California

ozone patterns with pronounced afternoon peaks more characteristic of urban locations. Topographic effects on local transport appear to be more of a determining factor for ozone exposure patterns than is geographical distance from urban sources.

Ozone exposure patterns are not the sole criteria for ecosystem damage. Because ozone injury depends on the amount of ozone uptake by vegetation, the need to distinguish between ambient concentration, dosage, and flux is important (Munn, 1970; Runeckles, 1974; Fowler and Cape, 1982; Taylor et al., 1982). The flux of ozone into the plant tissue, i.e. the cause of injury, is dependent upon both ambient ozone concentration and stomatal conductance. The latter depends in part on local atmospheric conditions. Local microclimatology may be significant to the amount of ozone injury incurred.

## METHODS

This study describes relationships between local climatology and patterns of ozone concentration for the period June through September, 1992. High ozone concentrations generally occur in the summer months when temperatures are high, relative humidities are low, and greater radiant energy drives the photochemical reactions necessary for ozone production. In the cooler months monitoring was discontinued because ozone episodes are rare and the sites are not accessible.

The six monitoring sites are located on the western slope of the Sierra Nevada, ranging from just east of Nevada City, in the north, to northeast of Porterville in the south (Figure 1 and Table 1). The sites vary in elevation, latitude, and topography. Detailed local topography for each of the sites, except Jerseydale, is shown in Figure 2. Digital topographical information is missing from the USGS database for Jerseydale. White Cloud, Five Mile, and Jerseydale (not shown) are situated on knolls or ridges. Sly Park, Shaver Lake, and Mountain Home lie on slopes tilting upward toward the east to northeast.

Instrumentation for the measurement of ozone concentrations and meteorological variables (temperature, relative humidity, global solar radiation, wind speed and wind direction) were installed at each site. The Dasibi model 1008AH ozone monitor that was used measured the mass of ozone and internally measured temperature and pressure to convert to ppbv (parts per billion by volume). Concentrations expressed as volumetric mixing ratios, being independent of pressure, allow measurements to be independent of the elevation of each site.

Data were sampled once per second and stored as five minute averages and standard deviations. Hourly average files were created when at least 75% of an hour's data was "present". Data recovery rates are listed in Table 1. Note that Shaver Lake had 35% of hours missing. If many high concentration episodes occurred during these periods, the seasonally averaged data may not be representative, particularly the histogram of ozone concentrations. However, nearly each day's data display a distinct diurnal variation, hence we are confident that the diurnal pattern in the seasonally averaged data is representative, although the magnitude may not be representative at this site.

A statistical analysis was conducted for each site to examine the correlation between high ozone concentrations and local atmospheric variables. Correlations between adjacent sites were also investigated. Correlation coefficients used in this study are Pearson's $r$.

## SEASONAL CLIMATOLOGY: OZONE

Means and standard deviations were calculated for ozone concentrations and atmospheric variables at each site (Table 2). Mountain Home, the southernmost and highest site, has a significantly higher mean ozone compared to the other sites, as well as a large standard deviation. Shaver Lake, adjacent to Mountain Home and second highest in elevation, has the lowest mean ozone and the largest standard deviation. Five Mile, Jerseydale, and White Cloud have similar intermediate means and standard deviations while Sly Park, at the lowest elevation, has a lower mean, comparable to Shaver Lake.

Frequency distributions of ozone concentrations for the sites are depicted in Figure 3. Shown are the percent of all hours at each site which fall into concentration ranges running 10 ppb wide and labeled by the upper end of each range; i.e., the interval from 0 to 10 ppb is the label 10. Mountain Home and Shaver Lake have distribution patterns which include a large percentage of hours with high concentrations. Mountain Home, in particular, experienced a significant percentage of hours exceeding the California state standard of 90 ppbv. Since the southern San Joaquin Valley is known to experience high ozone concentrations, the higher concentrations observed at these sites might be expected based on a transport hypothesis. The frequency distributions for Mountain Home and Shaver Lake are relatively broad, consistent with their larger standard deviations. White Cloud has the narrowest distribution and, accordingly, the smallest standard deviation. All six sites exhibit a lack of very low ozone concentrations, consistent with observations at non-urban sites reported in other studies.

Seasonally averaged (June-September) ozone concentrations, by hour of the day, are shown in Figure 4. Three sites, Mountain Home, Shaver Lake, and Sly Park, exhibit distinct diurnal variations. These sites experience a marked drop in hourly averaged concentrations in the late afternoon hours, with concentrations continuing to decrease until early morning. After sunrise a gradual rise in averaged concentrations occurs at these sites. While the largest average diurnal variation occurs at Shaver Lake, Mountain Home has the highest averaged concentrations during the daytime hours. The distinct diurnal variations observed at these sites are similar to diurnal ozone patterns typical of urban locations. The remaining three sites, Jerseydale, Five Mile, and White Cloud, have weak diurnal variations in ozone concentrations with only a slightly detectable early morning minimum. No pronounced evening drop in concentrations is detected. As expected, these sites which experience weaker diurnal variations also experience fewer occurrences of concentrations below 40 ppb. The flat diurnal patterns of these sites is often described as characteristic of sites remote from urban sources.

A data set with strong diurnal variations should show a strong decrease in autocorrelation with increasing lag time. Table 3 provides autocorrelations of the variables at each site with time lags up to five hours and a 24-hour lag. Consistent with its diurnal curve, Shaver Lake shows the least coherency for ozone concentrations in the first five hours. The autocorrelation coefficient drops considerably in a short period; However, the 24 hour lag is strong compared with the other sites. Shaver Lake experiences the widest diurnal range, but the greatest day to day constancy. For Five Mile, Jerseydale, and White Cloud, the sites with weak diurnal curves, the reverse is true. Ozone autocorrelations are relatively strong for lags of one to five hours but weak for the 24 hour autocorrelations.

To investigate the relationship between a weak diurnal pattern and the occurrence of high nighttime ozone concentrations, the seasonal occurrences of ozone concentrations >60 ppb and >90 ppb were computed and expressed as the percent of each hours' observations (Figure 5). The California standard for ozone is 90 ppb, while 60 ppb was chosen as the concentration above which sensitive species may incur injury. High concentration occurrences follow the same diurnal patterns as observed for seasonal average ozone concentrations. Mountain Home, Shaver Lake, and Sly Park exhibit moderate to strong diurnal variation in the number of occurrences above both thresholds, while Jerseydale, Five Mile, and White Cloud display weak diurnal variations. A significant percent of concentrations >60 ppb occurred at all the sites during daylight hours, but also through the night at Mountain Home, Jerseydale, Five Mile, and White Cloud. Although Mountain Home experienced numerous concentrations >60 ppb, during both day and night, the diurnal variation is pronounced compared to the three other sites with high nighttime concentrations. Most of the episodes above 90 ppb at Mountain Home occurred in the daytime, with a sharp drop in the number of exceedances at hour 19 or 20. In contrast, Jerseydale, Five Mile, and White Cloud experienced concentrations >90 ppb throughout the evening with no distinct drop in the late afternoon. All of these sites are non-urban and non-suburban in character. The strongly diurnal sites have no obvious nearby sources of nitric oxide. Hence it does not appear that nighttime scavenging is the cause of the nocturnal ozone minima at these locations.

## SEASONAL CLIMATOLOGY: WIND

Seasonal resultant wind directions were calculated by hour of the day, shown superimposed with the event distributions in Figure 5, to determine if average local winds have a bearing on the occurrence of high ozone concentrations. Both Mountain Home and Sly Park have well defined diurnal wind patterns typical of mountain slope locations, with upslope winds from the west during the day, and downslope winds from the east at night. Winds at Shaver Lake, Jerseydale, and Five Mile also exhibit diurnal patterns, but with more gradual shifts in direction. White Cloud has the least defined diurnal wind pattern. Both Mountain Home and Sly Park show evidence to support the hypothesis that ozone is transported to remote regions. The winds are upslope, from the San Joaquin Valley, from approximately 8 AM through 7 PM, corresponding (with a slight lead) with the period of the greatest number of high ozone events. Most of the peak concentrations occur well past noon. Shaver Lake also shows, although less distinctly, that high concentration events coincide with westerly (upslope) winds. The three sites which experience high ozone concentrations through the evening do not show any noticeable relationship between wind direction and the timing of events. Note also that at the least diurnal sites, the wind favors southerly directions during the warm part of the day.

To examine the constancy of the wind direction for the monitoring period June through October, 1992, resultant wind speeds and averaged wind speeds for each hour are depicted in Figure 6. Winds which are constant in direction have resultant wind speeds similar in magnitude to the average wind speeds, whereas for highly variable wind directions, resultant wind speeds are significantly smaller than the average speeds. Except for Sly Park, wind speeds tend to increase during the day, reaching a peak in the early afternoon, then become lighter during the night. Mountain Home winds appear to be directionally constant for all but the hours when the upslope-downslope shifts occur. The remaining sites have more daily variation in the constancy of the wind direction, with Shaver Lake winds displaying the most daytime variability and White Cloud the most nighttime variability. These two sites have the largest standard deviation for wind speed (cf. Table 2).

Due to the distinct wind-shift patterns at Mountain Home and Sly Park, the standard deviation for the east-west (u) wind component is large. The sites with flat diurnal ozone patterns and high nighttime concentrations have a larger standard deviation for the north-south (v) wind component than the u component. This indicates that most of the diurnal wind variation for the three sites with flat diurnal patterns occurred within the north-south direction, while for the sites with distinct diurnal regimes, most of the diurnal wind variation occurred within the east-west direction, as seen in the wind direction plots. This suggests that with alternating east-west wind components, upslope pollutant transport is followed by downslope transport of cleaner air, yielding the observed diurnal ozone patterns at these sites. Conversely, the sites at which the wind directions are more strongly north-south and the diurnal variability much weaker, polluted air appears to move along the slope contours, perpendicular to the horizontal pollutant gradient.

The autocorrelations of wind components (cf. Table 3) are highly variable among the sites. Sites which are situated on well defined slopes tilting upward to the east (Mountain Home and Sly Park) show high, short term constancy in u. The u component dominates, while the v component is weaker and probably responds to small changes in the synoptic situation. Wind speed autocorrelations are small, dropping rapidly with time lags, signifying that wind speed varies over short time scales. At Shaver Lake the 24 hour autocorrelation is significantly higher than any other site (as is the 24 hour ozone autocorrelation), indicating strong day-to-day constancy.

Studies have shown an association between high ozone concentrations aloft and synoptic scale meteorological patterns (Aneja et al., 1991; Evans et al., 1983); i.e., if wind direction is constant, long-range transport can account for high ozone concentrations observed at remote high elevation sites. Strong vertical layering of ozone, including persistent elevated layers of high concentrations, has frequently been observed (Carroll and Baskett, 1977; Carroll, 1991). Because ozone can be isolated aloft and transported downwind with minimal scavenging or deposition (Böhm, et al., 1991), these elevated layers may impact prominent slopes. At night, sinking motion associated with downslope winds, coupled with elevated layers of ozone, may cause the high ozone concentrations observed at those sites located on local terrain maxima, such as knolls and ridges, while the air near the valley floor can remain relatively clean.

## SEASONAL CLIMATOLOGY: TEMPERATURE AND RELATIVE HUMIDITY

Seasonal diurnal patterns of temperature and relative humidity are shown in Figures 8 and 9. Daytime average temperature maxima decrease with increasing elevation (cf. Table 1), while average relative humidity minima increase. The nighttime average temperature minima and relative humidity maxima, however, do not follow these daytime elevational gradients. At night, the variability among sites is also greater during the day. Shaver Lake again experiences the strongest diurnal ranges (as with ozone concentrations), with nighttime temperatures cooler and humidities higher than Mountain Home. The standard deviations (cf. Table 2) for both temperature and humidity are expectedly largest at Shaver Lake, followed by Sly Park. Jerseydale, Five Mile, and White Cloud have the weakest diurnal variations in temperature and relative humidity Therefore, the sites which experience flat diurnal patterns with high nighttime ozone concentrations, also experience relatively warmer nighttime temperatures and lower nighttime humidities.

Autocorrelations (cf. Table 3) for relative humidity, although stronger in general than those for ozone, follow the same pattern as those seen for ozone at each of the sites. Temperature autocorrelations are the strongest of all the variables. The autocorrelations for temperature and relative humidity do not show any pronounced differences among the sites. As expected for typical diurnal patterns of temperature and relative humidity, the coherency is strong for the first two to three hours of time lag, and the 24 hour coefficient is large.

## RELATION OF OZONE TO ATMOSPHERIC VARIABLES

Correlation coefficients between atmospheric variables and ozone are shown in Table 4. Correlations between ozone and temperature are generally strongest, followed closely by a high negative correlation with relative humidity. High concentrations of ozone are therefore likely to occur with high temperatures and low humidities. Correlations between ozone and wind speed are very low, with the exception of Shaver Lake and Mountain Home where high ozone concentrations are more likely to occur with stronger than average wind speeds. Local ozone transport, therefore, may be more significant at these two sites (which also have the greatest diurnal ozone variability). At Mountain Home the high ozone concentrations are most likely to occur with a westerly wind component, at Shaver Lake with westerly and southerly components, and at Sly Park with westerly and northerly components. Again, these are the sites with a diurnal ozone pattern. The remaining three sites have an insignificant correlation between wind component and ozone concentration, indicating again the lack of relationship between wind and ozone for the sites with flat diurnal patterns.

Correlation coefficients between sites for each of the variables are given in Table 5. Ozone shows the strongest correlation between Jerseydale and Five Mile. In general, adjacent sites have the strongest ozone correlations, although Five Mile and White Cloud have a strong relationship, while Shaver Lake and Jerseydale have a relatively weak one. Strong correlations are seen for temperature. Relative humidity is also strongly correlated between sites, although with greater variability than temperature. Wind relationships are much more erratic, showing both positive and negative correlations with a wide range in magnitude. Although the sites have a similarity in temperature and relative humidity patterns, wind and ozone patterns are much more diverse among sites.

## DISCUSSION AND CONCLUSIONS

The analysis of data from six Sierra Nevada sites for the 1992 summer season revealed several significant patterns. Mountain Home and Shaver Lake, at altitudes of 1890 and 1829 meters respectively, experienced the highest frequency of hourly ozone concentrations exceeding the state standard. The remaining sites, at lower elevations ranging from 1128 to 1326 meters, experienced significantly fewer exceedances of 90 ppb. The six station's data fall into two general groups: three where diurnal variations of ozone are weak, and three where these variations are strong. Those sites with high daytime and low nighttime concentrations (Mountain Home, Shaver Lake, and Sly Park) mimic to some degree an urban pattern, except that the nighttime minima do not decrease to typical urban minima. These sites also show a very strong diurnal variation in wind direction, with opposite wind directions between day and night. The nighttime minima of ozone concentrations are associated with easterly, downslope flows, which are free from emissions of oxides of nitrogen. The westerly, upslope winds from the valley, experienced during the day, correspond with the timing of high ozone concentration events. Temperature and relative humidity at these sites also show strong diurnal patterns.

The three sites exhibiting a "remote" diurnal ozone signature, with flat seasonally averaged diurnal ozone patterns, (Jerseydale, Five Mile, and White Cloud) experienced high ozone concentrations persisting through the nighttime. These sites show little relationship between the seasonal resultant wind direction and the timing of high ozone concentration events. The wind directional patterns do not show the east-west oscillating wind distribution described above; rather they are more broadly distributed, with stronger north-south components. Hence nocturnal flows are more perpendicular to the regional topographical fall lines than at the more diurnal sites, where the flows are parallel to the fall lines. These sites also have the weakest seasonal diurnal variations in temperature and relative humidity, with relatively warmer nighttime temperatures and lower nighttime humidities when compared to the other sites.

Complex topography produces complex three dimensional wind fields. We believe that the local topographical characteristics and their effect on local three dimensional transport of polluted air is a more significant influence on the diurnal ozone signature at a given site than is its "remoteness" from urban sources. All six sites are remote from such sources and are impacted by pollutants transported from these sources. The high nighttime ozone concentrations observed at Jerseydale, Five Mile, and White Cloud appear to be due to cross-slope transport, coupled with the fact that these sites are near local elevation maxima and may be more exposed to elevated layers of high ozone concentration. Geographically, White Cloud and Shaver Lake appear to be the farthest removed from Central Valley sources, yet the two represent the extremes in diurnal patterns: White Cloud exhibits the flat diurnal pattern expected of "remote" sites, while Shaver Lake exhibits the greatest diurnal variation. The major difference is their topographic setting: ridgetop for White Cloud, basin-valley floor for Shaver Lake. Measurements using Doppler wind finding techniques are needed to test these hypotheses.

Although significant, ozone exposure patterns alone may not be a representative gage of ozone injury to vegetation. Local climatology is likely a significant factor controlling the amount of ozone injury to sensitive species. High ozone concentrations primarily occur coincident with high temperatures and low humidities, conditions which may decrease plant stomata openings, thus reducing ozone uptake. The high ozone concentrations observed during the evening hours at some sites, when temperatures are cool, humidities high, and solar radiation absent, would be conducive to injury only to the extent the stomata are open. Since photosynthesis does not occur at night, it is generally presumed that the stomata of most plant species close during the nighttime, and ozone injury would be negligible. Conversely, high ozone concentrations occurring in cooler conditions, such as occurs at higher elevation or during late spring and early fall, would be conducive to high ozone uptake. Therefore, the amount of injury incurred by forest ecosystems may not be solely predictable by ambient ozone concentrations since local climatology is likely a significant factor controlling dosage for plant species.

## ACKNOWLEDGMENTS

We thank Mr. Alan Dixon for his dedicated attention to maintaining the instruments and evaluating data quality, and Mr. David Salardino for assisting with data processing. Support for this work was provided in part by the California Air Resources Board under agreement no. A132-188, by the Ecotoxicology Program of the University of California Toxic Substances Research and Training Program, and by the U.S. EPA (R814709) Center for Ecological Health Research at U.C. Davis. This support is gratefully acknowledged. Although the information in this document has been funded in part by the United States Environmental Protection Agency, it may not necessarily reflect the views of the Agency and no official endorsement should be inferred.

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| Site | Altitude (meters) | Latitude | Longitude | Wind Tower Height | Ozone Data Recovery |
|---|---|---|---|---|---|
| Mountain Home | 1890 | 36 12.9'N | 118 41.1'W | 17 m | 99.6% |
| Shaver Lake | 1829 | 37 8.4'N | 119 15.2'W | 12 m | 75.3% |
| Jerseydale | 1143 | 37 32.6'N | 120 17.9'W | 17 m | 87.5% |
| Five Mile | 1220 | 38 3.2'N | 120 17.9'W | 12 m | 87.0% |
| Sly Park | 1128 | 38 42.3N | 120 37.5'W | 17 m | 99.6% |
| White Cloud | 1326 | 39 19.o'N | 120 50.5'W | 12 m | 99.4% |

Table 1 Sierra Nevada site locations and characteristics.

| | | O3 | TA | RH | FF | UU | VV |
|---|---|---|---|---|---|---|---|
| MOUNTAIN HOME | MEAN | 71.4 | 15.1 | 64.8 | 1.7 | 0.31 | -0.013 |
| | SD | 24.0 | 5.6 | 20.6 | 0.9 | 1.75 | 0.19 |
| SHAVER LAKE | MEAN | 55.0 | 15.2 | 59.4 | 1.2 | 0.33 | 0.17 |
| | SD | 25.6 | 7.0 | 22.5 | 1.0 | 0.93 | 0.76 |
| JERSEYDALE | MEAN | 65.8 | 20.7 | 46.8 | 1.7 | 0.36 | -0.17 |
| | SD | 17.2 | 5.4 | 17.8 | 0.6 | 0.53 | 1.44 |
| FIVE MILE | MEAN | 64.1 | 19.4 | 47.2 | 1.0 | -0.024 | 0.32 |
| | SD | 18.2 | 5.1 | 19.8 | 0.7 | 0.28 | 0.85 |
| SLY PARK | MEAN | 55.4 | 19.4 | 51.1 | 1.6 | -0.39 | 0.36 |
| | SD | 18.3 | 6.5 | 21.7 | 0.6 | 1.27 | 0.43 |
| WHITE CLOUD | MEAN | 64.0 | 19.7 | 44.0 | 1.7 | 0.41 | 0.89 |
| | SD | 16.4 | 5.2 | 20.0 | 1.2 | 0.78 | 1.41 |

O3 = ozone concentration (ppbv)
TA = temperature (degrees C)
RH = relative humidity (%)
FF = wind speed (m/sec)
UU = east-west wind component (m/sec)
VV = north-south wind component (m/sec)

Table 2 Seasonal means and standard deviations of ozone and atmospheric variables.

| SITE | TIME LAG | O3 | TA | RH | FF | UU | VV |
|---|---|---|---|---|---|---|---|
| **Mountain Home** | 0.0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | 1.0 | 0.95 | 0.97 | 0.97 | 0.78 | 0.91 | 0.55 |
| | 2.0 | 0.86 | 0.90 | 0.92 | 0.56 | 0.75 | 0.33 |
| | 3.0 | 0.77 | 0.80 | 0.87 | 0.38 | 0.58 | 0.24 |
| | 4.0 | 0.69 | 0.67 | 0.81 | 0.20 | 0.40 | 0.19 |
| | 5.0 | 0.58 | 0.54 | 0.76 | 0.05 | 0.20 | 0.17 |
| | 24.0 | 0.75 | 0.91 | 0.78 | 0.66 | 0.87 | 0.33 |
| **Shaver Lake** | 0.0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | 1.0 | 0.94 | 0.96 | 0.94 | 0.91 | 0.81 | 0.77 |
| | 2.0 | 0.83 | 0.86 | 0.83 | 0.75 | 0.64 | 0.58 |
| | 3.0 | 0.70 | 0.72 | 0.71 | 0.56 | 0.45 | 0.40 |
| | 4.0 | 0.57 | 0.56 | 0.58 | 0.35 | 0.28 | 0.25 |
| | 5.0 | 0.43 | 0.38 | 0.46 | 0.14 | 0.12 | 0.11 |
| | 24.0 | 0.84 | 0.99 | 0.89 | 0.90 | 0.69 | 0.48 |
| **Jerseydale** | 0.0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | 1.0 | 0.98 | 0.97 | 0.98 | 0.74 | 0.68 | 0.92 |
| | 2.0 | 0.94 | 0.89 | 0.94 | 0.46 | 0.37 | 0.78 |
| | 3.0 | 0.89 | 0.77 | 0.89 | 0.23 | 0.17 | 0.62 |
| | 4.0 | 0.85 | 0.63 | 0.84 | 0.05 | 0.07 | 0.44 |
| | 5.0 | 0.80 | 0.47 | 0.79 | -0.10 | 0.00 | 0.25 |
| | 24.0 | 0.56 | 0.91 | 0.80 | 0.61 | 0.47 | 0.80 |
| **Five Mile** | 0.0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | 1.0 | 0.97 | 0.98 | 0.98 | 0.86 | 0.62 | 0.89 |
| | 2.0 | 0.93 | 0.92 | 0.96 | 0.68 | 0.38 | 0.72 |
| | 3.0 | 0.90 | 0.83 | 0.93 | 0.50 | 0.20 | 0.56 |
| | 4.0 | 0.87 | 0.73 | 0.89 | 0.33 | 0.06 | 0.40 |
| | 5.0 | 0.85 | 0.63 | 0.86 | 0.17 | 0.00 | 0.24 |
| | 24.0 | 0.61 | 0.88 | 0.79 | 0.67 | 0.26 | 0.66 |
| **Sly Park** | 0.0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | 1.0 | 0.96 | 0.97 | 0.97 | 0.76 | 0.92 | 0.70 |
| | 2.0 | 0.87 | 0.89 | 0.90 | 0.50 | 0.78 | 0.49 |
| | 3.0 | 0.79 | 0.78 | 0.82 | 0.29 | 0.62 | 0.37 |
| | 4.0 | 0.69 | 0.65 | 0.73 | 0.12 | 0.43 | 0.27 |
| | 5.0 | 0.59 | 0.50 | 0.64 | 0.01 | 0.24 | 0.17 |
| | 24.0 | 0.71 | 0.93 | 0.88 | 0.54 | 0.87 | 0.41 |
| **White Cloud** | 0.0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | 1.0 | 0.96 | 0.99 | 0.98 | 0.91 | 0.91 | 0.91 |
| | 2.0 | 0.91 | 0.95 | 0.95 | 0.77 | 0.78 | 0.79 |
| | 3.0 | 0.86 | 0.90 | 0.93 | 0.62 | 0.64 | 0.67 |
| | 4.0 | 0.81 | 0.83 | 0.90 | 0.47 | 0.48 | 0.55 |
| | 5.0 | 0.77 | 0.76 | 0.87 | 0.32 | 0.32 | 0.43 |
| | 24.0 | 0.52 | 0.89 | 0.77 | 0.65 | 0.70 | 0.58 |

Table 3 Autocorrelations for each variable with time lags up to 5 hours and a 24-hour lag.

| | TA | RH | FF | UU | VV |
|---|---|---|---|---|---|
| MOUNTAIN HOME | 0.65 | -0.52 | 0.48 | 0.46 | -0.08 |
| SHAVER LAKE | 0.72 | -0.64 | 0.67 | 0.58 | 0.28 |
| JERSEYDALE | 0.42 | -0.58 | 0.15 | 0.04 | 0.12 |
| FIVE MILE | 0.50 | -0.58 | -0.05 | -0.004 | 0.02 |
| SLY PARK | 0.68 | -0.66 | -0.12 | 0.39 | -0.30 |
| WHITE CLOUD | 0.52 | -0.41 | -0.13 | -0.02 | -0.09 |

Table 4 Correlations of atmospheric variables to ozone concentrations.

**OZONE**

| | Shaver Lake | Jerseydale | Five Mile | Sly Park | White Cloud |
|---|---|---|---|---|---|
| Mountain Home | 0.75 | 0.56 | 0.56 | 0.64 | 0.48 |
| Shaver Lake | | 0.49 | 0.38 | 0.62 | 0.35 |
| Jerseydale | | | 0.88 | 0.67 | 0.67 |
| Five Mile | | | | 0.70 | 0.76 |
| Sly Park | | | | | 0.67 |

**TEMPERATURE**

| | Shaver Lake | Jerseydale | Five Mile | Sly Park | White Cloud |
|---|---|---|---|---|---|
| Mountain Home | 0.95 | 0.94 | 0.90 | 0.93 | 0.87 |
| Shaver Lake | | 0.92 | 0.85 | 0.96 | 0.82 |
| Jerseydale | | | 0.91 | 0.94 | 0.89 |
| Five Mile | | | | 0.91 | 0.96 |
| Sly Park | | | | | 0.89 |

**RELATIVE HUMIDITY**

| | Shaver Lake | Jerseydale | Five Mile | Sly Park | White Cloud |
|---|---|---|---|---|---|
| Mountain Home | 0.82 | 0.80 | 0.79 | 0.78 | 0.74 |
| Shaver Lake | | 0.76 | 0.69 | 0.86 | 0.61 |
| Jerseydale | | | 0.90 | 0.82 | 0.81 |
| Five Mile | | | | 0.85 | 0.90 |
| Sly Park | | | | | 0.82 |

**WIND SPEED**

| | Shaver Lake | Jerseydale | Five Mile | Sly Park | White Cloud |
|---|---|---|---|---|---|
| Mountain Home | 0.68 | 0.41 | 0.46 | 0.14 | 0.44 |
| Shaver Lake | | 0.40 | 0.69 | -0.09 | 0.66 |
| Jerseydale | | | 0.38 | 0.40 | 0.35 |
| Five Mile | | | | -0.02 | 0.61 |
| Sly Park | | | | | 0.09 |

Table 5 Correlations between sites.

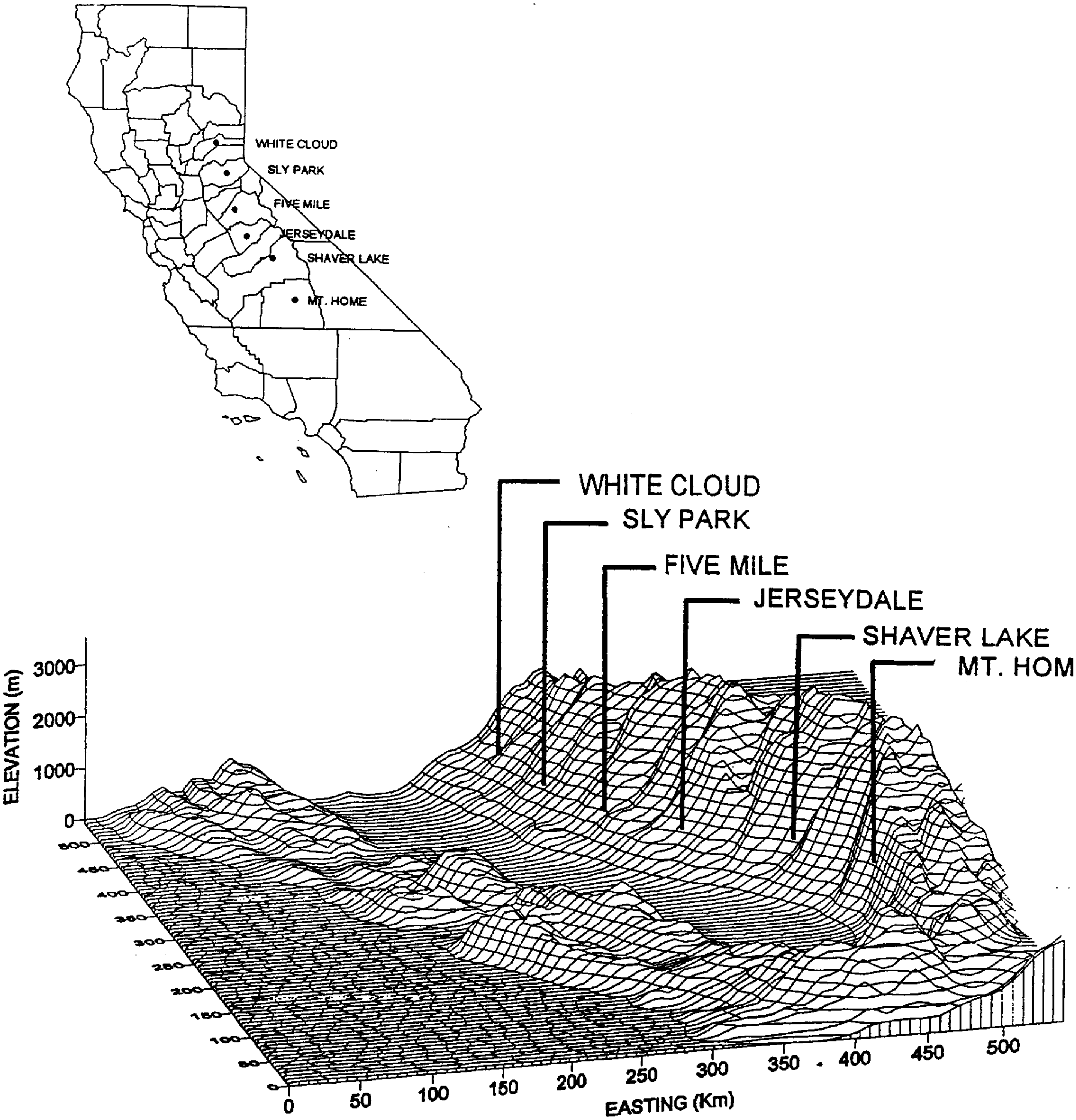


Figure 1. Perspective view of central California, showing approximate site locations. Horizontal area shown is 480 km on a side. Vertical exaggeration is factor of three.

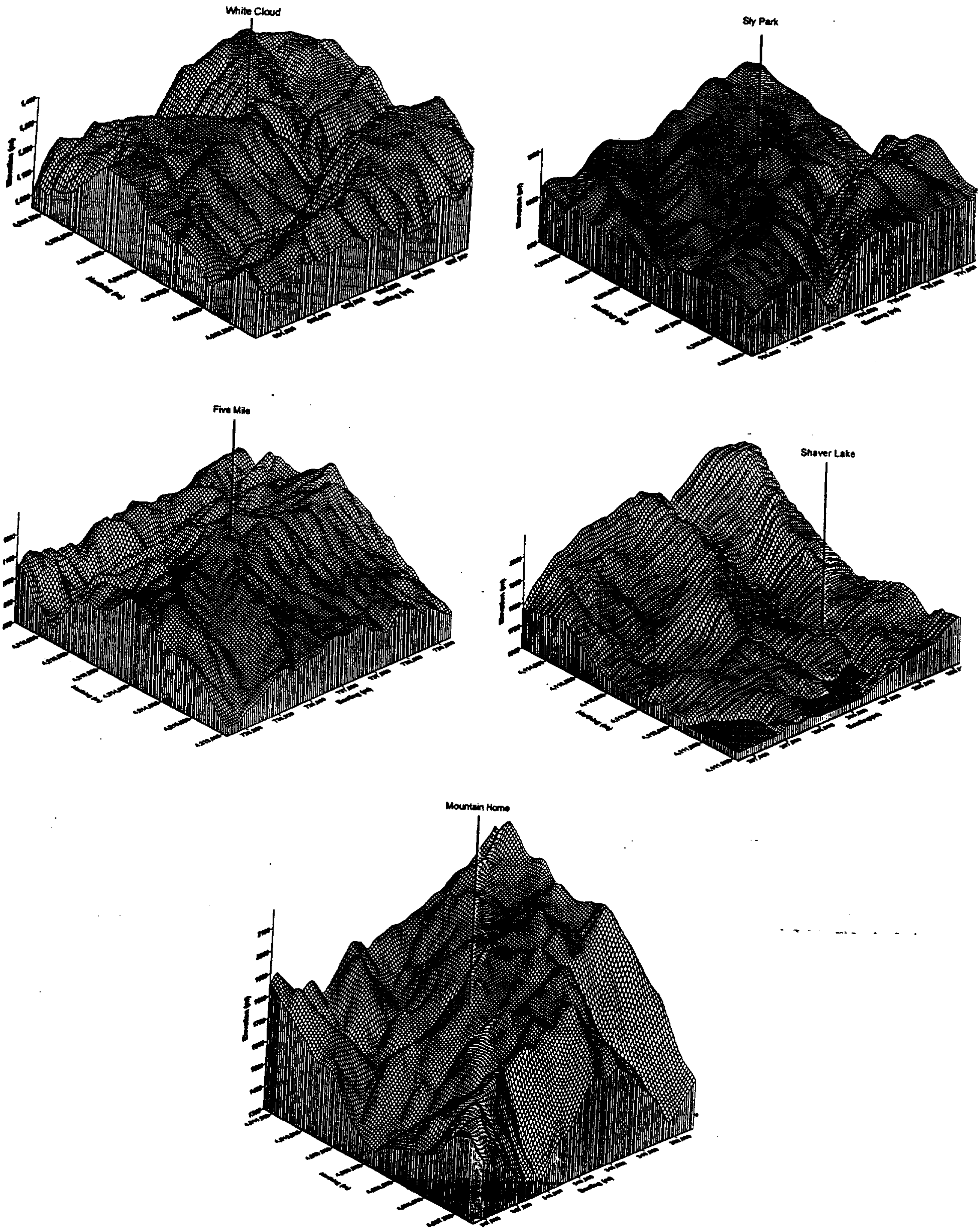


Figure 2. Site topography. All scales in meters. Vertical scale exaggerated by a factor of three.

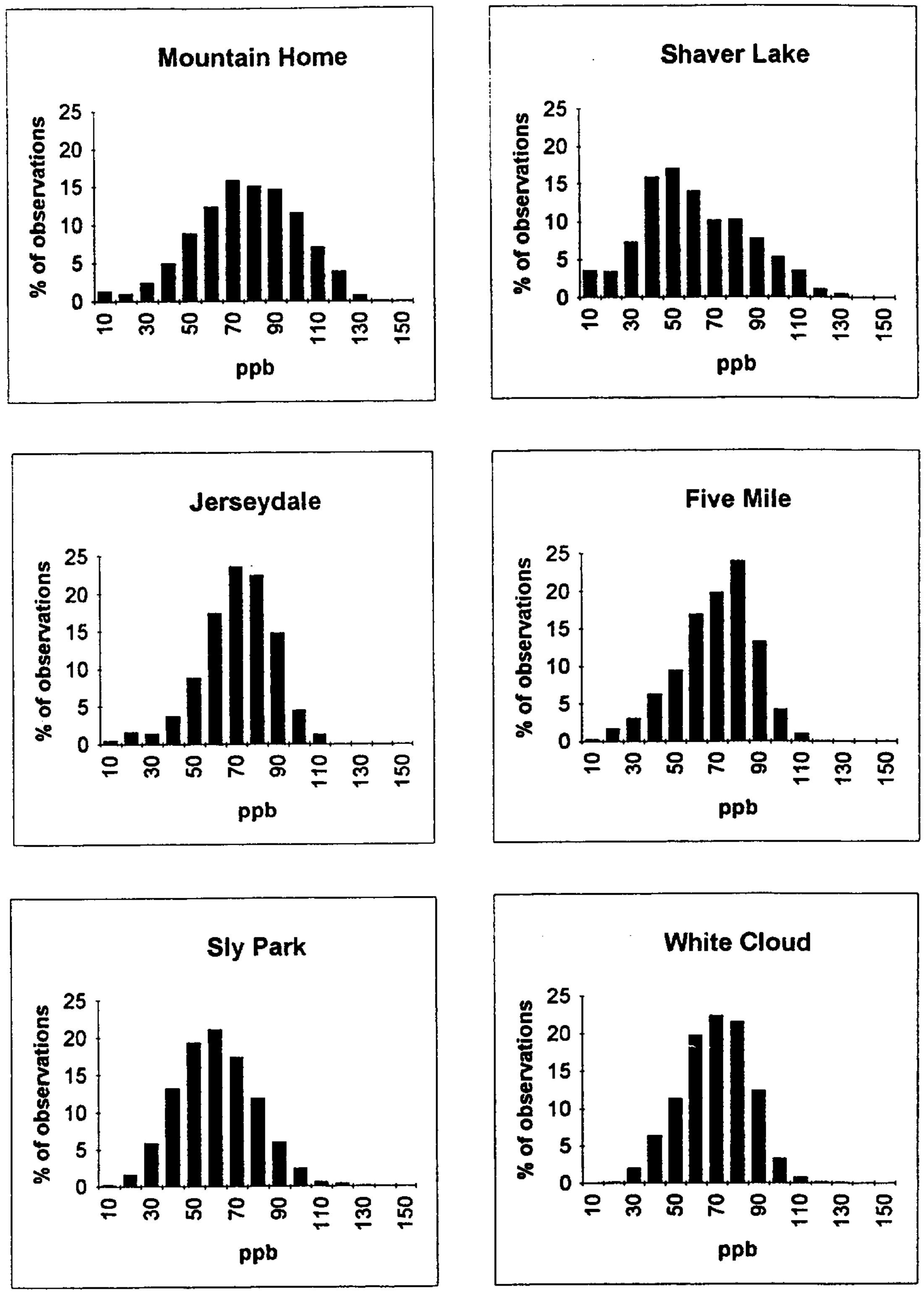


Figure 3 Ozone frequency distributions.

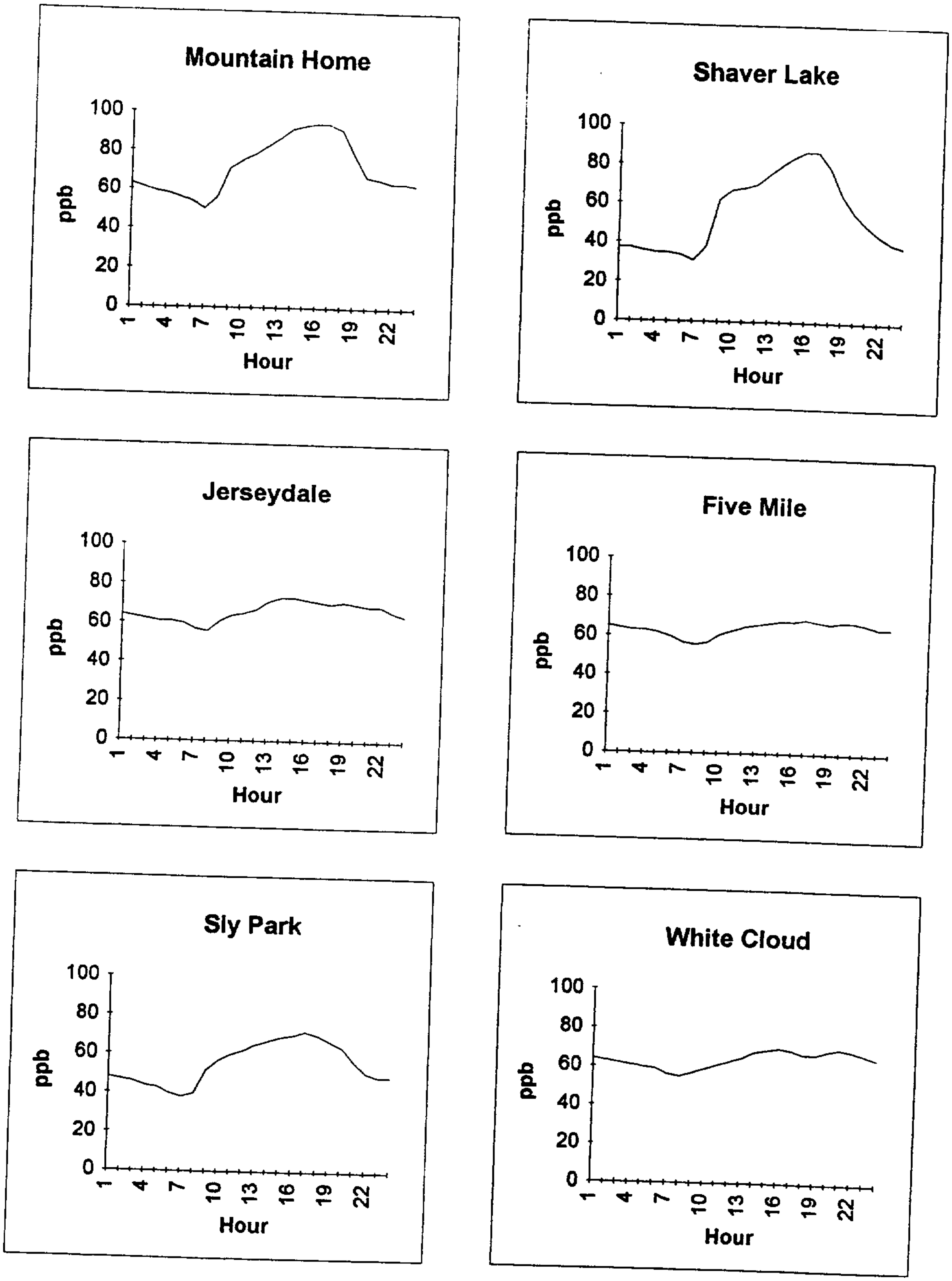


Figure 4 Seasonally averaged ozone concentrations by hour.

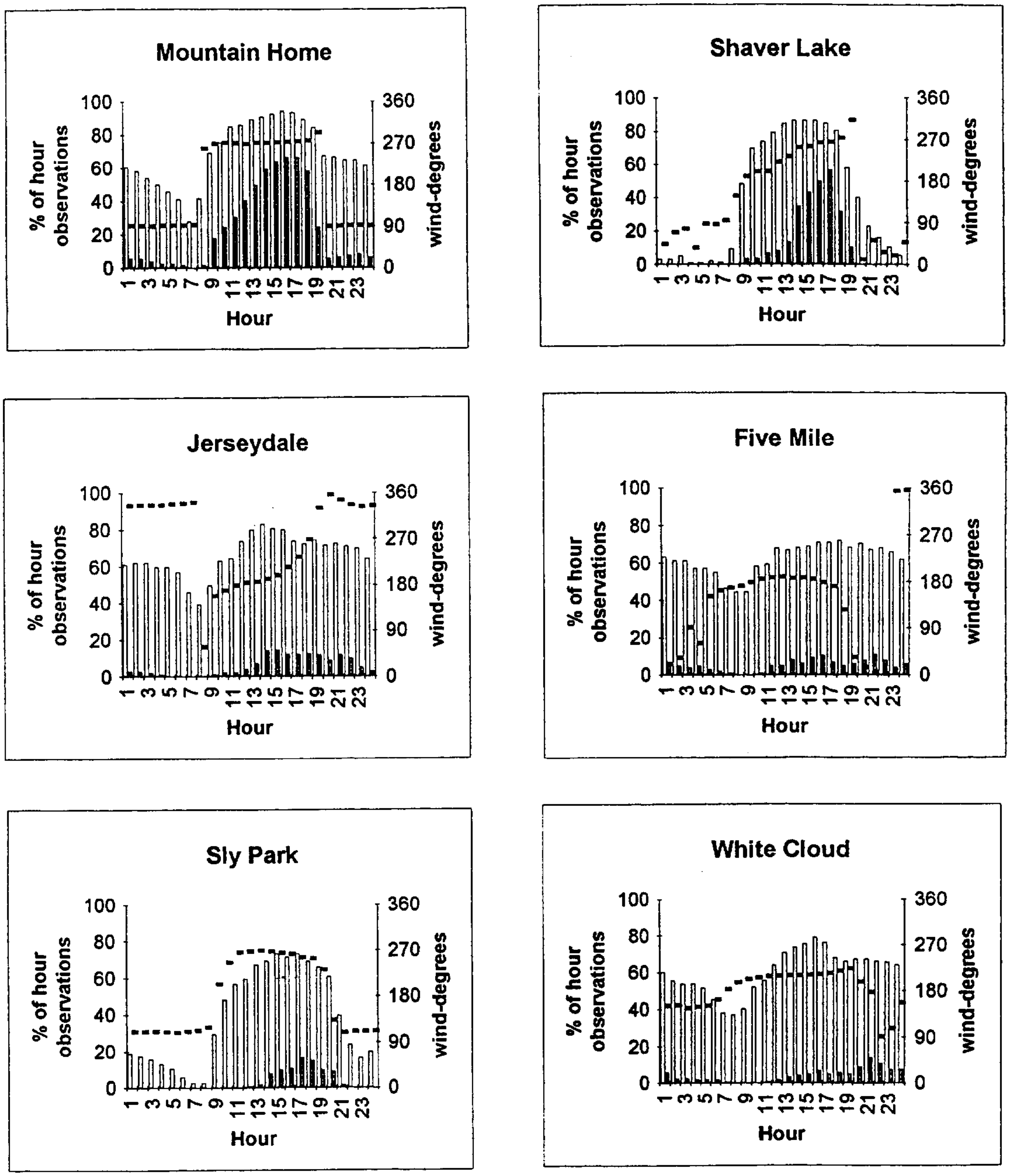


Figure 5 Distribution of ozone concentration events by hour: > 60 ppb (open bar), > 90 ppb (solid bar) shown in relation to the seasonal resultant wind direction (dashes).

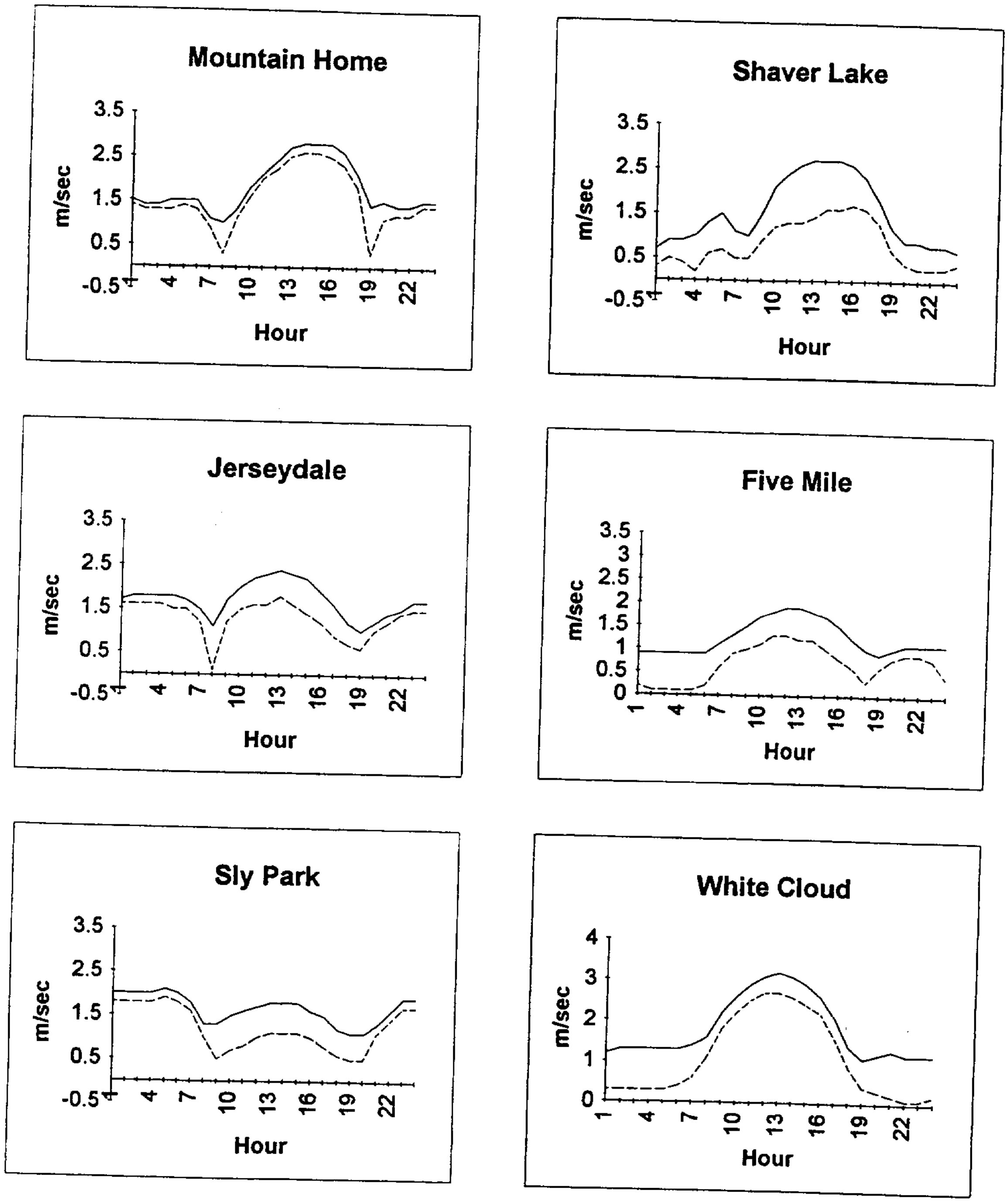


Figure 6   Average (solid lines) and resultant (dashed lines) wind speeds by hour.

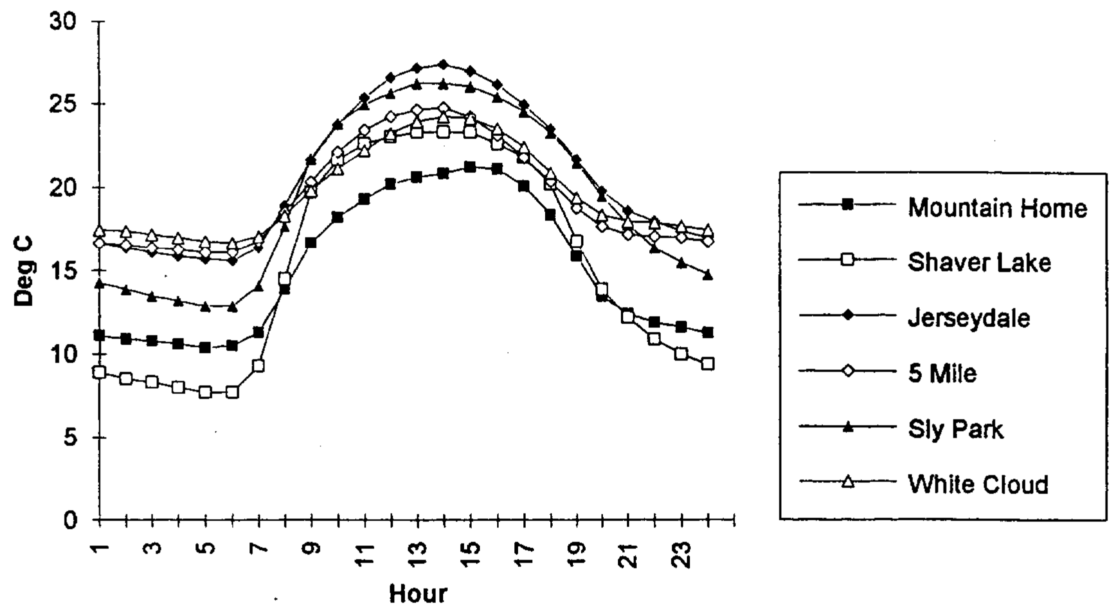


Figure 7 Seasonally averaged temperature by hour.

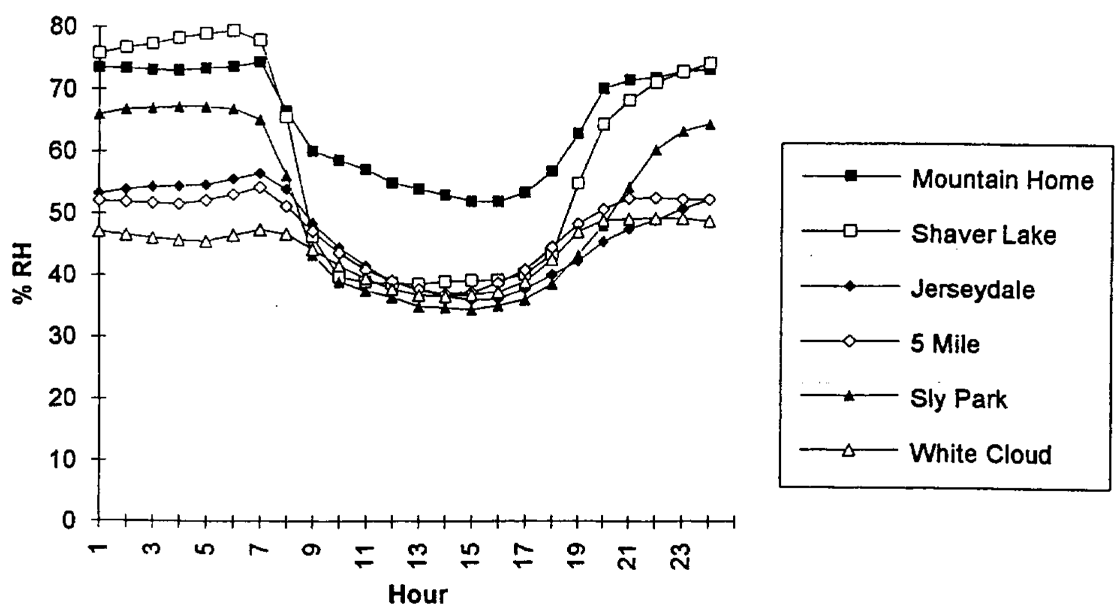


Figure 8 Seasonally averaged relative humitity by hour.