6. Meteorological Monitoring

Background

Meteorological monitoring is necessary to characterize the speed, direction, and depth of transport in the region and for model initiation and validation. The existing National Weather Service (NWS) surface and upper air monitoring sites are insufficient to characterize the complex meteorological setting of the study area. In addition, NWS upper air measurements (rawinsondes) are taken only twice per day. Thus, they may not capture important small time scale meteorological changes and because they provide nearly instantaneous measurements, they may not be representative of average conditions.

The Wave Propagation Laboratory (WPL) of the National Atmospheric and Oceanic Administration (NOAA) will provide much of the meteorological measurements data for Project MOHAVE. Air Resource Specialists (ARS), the optical monitoring contractor, will provide surface meteorological data at the four receptor sites. WPL has a unique capability of providing continuous wind and temperature profiles in the atmospheric boundary layer (ABL) using wind profiling radars with Radio Acoustic Sounding Systems (RASS). The radars transmit 915 MHz signals and receive back-scattered signals from the atmosphere. With three antennas, usually two tilted and one vertical, the three components of the wind can be measured using the Doppler effect. The best results are obtained when the winds are averaged over about one hour. The RASS component uses the Bragg scatter of radar waves from vertical propagating acoustic waves to measure the sound speed. Because the sound speed depends upon air temperature, temperature profiles can be derived. Usually the instrument is configured to provide one 5-minute averaged temperature profile each hour. The backscattered intensities received by the wind profiler in the form of signal-to-noise ratios can also qualitatively indicate mixing depths. The advantage of the wind profiler/RASS instruments over rawinsondes is that they provide continuous profiles in time.

Objectives

The wind profiler/RASS data consist of wind profiles, nominally to 2.5 km, and temperature profiles to almost 600 m. These data are necessary to characterize the speed, direction, and depth of material transport in the region and also necessary for model initiation and validation. The primary objective is to measure the transport of material from the MPP to GCNP. Also, it is important to characterize the flow from major urban areas in the region (e.g., South Coast Basin, Las Vegas, Phoenix/Tucson) and to separate this flow from flow containing the MPP emissions. There are two other major power plants nearby, the Reid Gardner Plant near Overton, Nevada, to the northwest of the Grand Canyon and the NGS near Page, Arizona to the northeast. It is also desirable to

determine the frequency of transport from these sources.

There are several ancillary problems which relate to the potential transport paths which the MPP plume may take into the Grand Canyon region. An indirect path is along the Colorado River to the north and then over Lake Mead. Because the lake is lower in elevation than the surrounding terrain and the ABL over the lake is usually more stable than that over the surrounding land due to the relatively cool water, the pollution may pool and collect in the Lake Mead Basin. Also, material from other sources (e.g. Las Vegas/Henderson or Reid Gardner) may collect in the same basin. A change in wind may transport this material into the lower portion of the Grand Canyon near Meadview. It is therefore important to monitor the winds and stability in the Lake Mead area, both over the lake and near the western entrance to the Grand Canyon.

With southwesterly flow near the surface, the material from the MPP may be transported more directly toward the Grand Canyon region over the high plateaus to the northeast of the plant. This path also requires meteorological monitoring.

Surface meteorology will be monitored at all the wind profiler sites so that the lower gates of the profilers can be compared with surface parameters. Also, NOAA/WPL will provide at least four surface pressure sites. Gaynor *et al.* (1991) have shown that winds calculated from surface pressure gradients can be used as surrogates for transport winds. The pressure array will allow calculations of mesoscale transport winds which can be compared with and be adjunct to profiler winds.

Another contribution from NOAA/WPL will be the wind and temperature data from profiler/RASS operations performed as part of the South Coast Air Basin study beginning in July, 1992, and continuing through the summer intensive period. Among the tentative locations for these instruments are the Cajon, Banning and Tehachapi passes. These data will be useful adjuncts to Project MOHAVE by providing upstream information on potential transport from the Los Angeles Basin and San Joaquin Valley into the MPP region. Starting in February, 1992 wind profiler data from sites on the Mogollon Rim (central Arizona) will be available. These wind profiler sites will help characterize periods of flow from the southeast into the study area.

NOAA/WPL will also provide tethersonde and airsonde profiles for short periods and at critical locations during the winter and summer intensives. These profiles will be measured at transport, drainage, or pooling locations that will not have regular continuous measurements. Because of the limited height range of the tethersonde, the preferred locations for these profiles will be in regions with shallow boundary layers. One general area of this type is the Lake Mead basin where a relatively shallow ABL compared to the surrounding desert may persist well into the morning due to the cool water surface and to the nocturnal drainage of cool air into the basin.

Field Study Plan

A wind profiler with RASS will operate in close proximity to the MPP from September 1991 through September 1992. This location will be supplemented with the DRI operation of an AeroVironment Doppler sodar for a quality control (QC) check of the profiler and to supplement the profiler with detailed low level winds. Another wind profiler with RASS will be located at Truxton to monitor the possibility of direct southwest to northeast transport from the plant. The Truxton site is in open terrain; this allows the data from this site to reflect the general flow patterns over the entire study area. It will also measure the south and southeast summer monsoonal flow from which directions material may be transported from Phoenix and Tucson or from smelters to the south and southeast. A doppler sodar will also operate most of the study period at Meadview.

In support of the winter intensive study, two additional wind profilers will be operated from mid-November 1991 through late-January 1992. The site locations will be the following:

1) South of MPP in the vicinity of Needles, which is usually downwind of MPP during the winter.

2) At Temple Bar, on the south shore of Lake Mead, about 30 km west of GCNP. This site will help characterize low level flow over Lake Mead, which may vary significantly from the flow at higher levels.

During the winter intensive period, NOAA/WPL will intermittently operate a tethersonde and/or radiosonde to supplement the upper air data. The locations may be at Cottonwood Cove to monitor wind and stability in the upper Mohave Valley, or near Lake Mead to monitor the meteorology in the Lake Mead Basin.

From July 1992 through September 1992, a supplemental profiler will operate at Cottonwood Cove (Lake Mohave) in support of the summer intensive experiment. The plume is typically transported past this site, especially during night and morning hours, and may exit the Colorado River valley near this site during the late morning and afternoon. An additional wind profiler will be located at Meadview. The sodar at Meadview will be moved to Temple Bar to measure low level flow above Lake Mead. The combination of doppler sodar at lake level, combined with a wind profiler at Meadview, 500 meters above lake level, will provide a vertical profile extending to about 3 km above lake level. NOAA/WPL will likely participate in the South Coast Air Basin Study which will occur during the same period as the MOHAVE summer intensive. WPL will have six profilers operating in the South Coast Basin. One or two of those will be on the east (desert) side of the Tehachapi, Cajon, or Banning Passes. Combining data from the South Coast profilers with data from the profilers

deployed for the MOHAVE summer intensive will provide a rare opportunity to continuously monitor the winds from Southern California to the Grand Canyon.

Data Collection

All the profilers will provide hourly consensus averaged winds in two modes -- a high range resolution mode, usually about 60 to 100 m and a low range resolution mode, usually 200 to 400 m. Minimum heights of around 150 m and maximum ranges of about 2.5 km are expected. During the more moist summer monsoon period, much higher ranges may be expected.

The RASS temperature profiles are measured once per hour representing 5 minute consensus averaged profiles. The minimum range is about 150 m; the maximum range expected under dry desert conditions is nominally 600 m. The Doppler sodar at Overton or Temple Bar will provide a minimum range of about 50 m and a maximum range of about 600 m with about a 50 m range resolution.

The surface meteorological data associated with the profilers will probably represent 5 minute averages of wind, temperature, and relative humidity measured about 3 m above the ground. The locations measuring surface pressure will also have temperature and relative humidity instrumentation.

Where phone lines are available, all profilers, including those with RASS, and the sodar will be interrogated by phone once per day and the ASCII files sent to a hub work station located at NOAA/WPL in Boulder, Colorado. This validation level zero data will also be available at each site from printer paper and on the hard disks of each controlling PC. The surface meteorological data collected at the profiler sites will also be sent over the same phone lines to the hub. The pressure sites, unless co-located with the profilers, may not have phone line capabilities depending on the feasibility of installing lines.

Data Quality Assurance

Wind profilers and Doppler sodars identical to those to be deployed for Project MOHAVE are periodically tested and compared at NOAA's Boulder Atmospheric Observatory which includes a 300 m meteorological tower. The RASS derived temperatures are also compared to thermometers on the tower. All instrumentation will have been previously tested in other field studies prior to deployment. The collocation of a Doppler sodar at the MPP with a wind profiler will provide a continuous field quality assurance check on both the profiler and the sodar.

All the data that is recorded and printed out at each site and sent over phone line to the hub in Boulder will be level zero. The field programs on each control computer for the radar/RASS and sodar provide consensus averaging which is equivalent to on-line, real-time sorting of data according to consistency criteria. The wind profiler/RASS and sodar data will be screened by an automated editor (Wuertz and Weber, 1989) after each 24 hour collection period.

This data will in turn be inspected by qualified staff and flagged if required. The resulting ASCII files of winds and temperatures, along with graphical displays, will then be available for quick dissemination by diskette or by electronic transfer.

The in situ surface meteorological data will require similar inspection and will be averaged into one hour blocks. These data will be available for similar dissemination.

Data Processing and Analysis

The senior scientific staff at NOAA/WPL will cooperate closely with the modelers to ensure that level one data are readily available to them in a useful form. NOAA/WPL scientific staff will take leadership in analyzing wind profiler/RASS, sodar, tethersonde, radiosonde, and surface meteorological data to gain insight into the often complex transport processes in the project region. This effort will require the use of various types of data from project collaborators outside of NOAA. The surface pressure array may be very critical in extending the understanding of material transport over a larger area than that covered by upper air wind measurements.