5.2 NCAR INTEGRATED SOUNDING SYSTEM OBSERVATIONS FOR VTMX

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1. INTRODUCTION

The Department of Energy VTMX (Vertical Transport and Mixing) Program sponsored a month long campaign in the Salt Lake Valley during October of 2000. The campaign intensively studied stable layers, weak or intermittent turbulence and morning/evening transitions within an urban basin surrounded by complex terrain. The aim is to advance understanding of vertical transport and mixing processes and the development of measurement techniques in such an environment. Several organizations participated in the program operating a large range of sensors such as profilers, lidars, sodars, gas tracers, aircraft, tether-sondes and rawinsondes.

NCAR operated an enhanced Integrated Sounding System (ISS) near the southern end of the valley about 40km southeast of the Great Salt Lake. The valley closes in at this end to form a region known as the Jordan Narrows. Among the various phenomena being investigated with these instruments include the variability of airflow in and out of the valley and how the flow relates through the narrows is related to mixing and vertical transport processes.

2. INSTRUMENTATION

The basic NCAR ISS is described by Parsons et al (1994) and includes a wind profiler radar, a GPS radiosonde sounding system, and surface meteorology instruments. For the VTMX experiment, the system was enhanced by including a sodar, a backscatter lidar, an advanced wind profiler radar, and a tethered blimp supporting in situ instruments.

The sodar used was a Metek DSDPA.90-24 mini-sodar. Engelbart, et al (1999) describes the similar, but larger, DSDPA.90-64. For VTMX, the sodar was used with a frequency of 1674 Hz, 25m vertical resolution, and 15 minute time resolution.

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It was intended to fill in the region below the first range gate of the profiler (ground to about 300 meters) and it did this very well, providing winds to 300 m about 70% of the time.

The wind profiler used was MAPR (Multiple Antenna Profiler Radar), which is a based on a highly modified NOAA/AL Radian 915 MHz boundary layer wind profiler. It uses the spaced antenna technique, making it capable of making wind measurements at 1 – 5 minute intervals (much faster than the 30 minute sampling rate typical of the more common Doppler Beam Swinging or DBS wind profilers). The vertical resolution is 100 meters, however this is being improved to about 20 m (Yu et al, this volume). The radar is described in Cohn et al (2001).

The backscatter lidar is SABL (Scanning Aerosol Backscatter Lidar), operated for VTMX in the infrared (1064nm) band, pointing vertically, with a range resolution of 3.75m and 1s time resolution.

The tethered blimp, TAOS (Tethered Atmospheric Observing System), had 4 to 6 sensor packages measuring wind, temperature, relative humidity, and pressure suspended along a 600 m line.

2. EXAMPLES OF OBSERVATIONS

2.1 *Lidar*

The SABL lidar proved to particularly useful for observing stable layers during the project. An example is shown in figure 1, where a thin aerosol layer at about 900 meters and a deeper aerosol layer below are oscillating with a period of 7 or 8 minutes. Such wave-like perturbations were often seen as the gap flow developed in the late afternoon and early evening during first part of the campaign. Another interesting example is shown in figure 2, where a sudden rise in the height of backscatter is seen, which figure 5 below indicates is associated with a weak northerly surge.

2.2 Sodar

The sodar provided useful measurements of the low level flow through the area. Figure 3 shows wind measurements for 24 hours centered about the observations of figure 1. During the late afternoon and early evening there was often a period of northerlies which appear to have originated from a lake breeze effect over the Great Salt Lake, 40 km to the north. This was followed by a strong southerly gap flow.

2.3 *In-situ*

Figure 4 shows a radiosonde sounding at 22 UT on the same day. The cool lake breeze northerly can be seen at low levels, producing an inversion at about 300 – 400 m. This is about the level of a sharp gradient in backscatter seen by SABL (figure 1) and a reflectivity layer seen by MAPR (not shown). There is no obvious feature in the sounding at the level of the thin aerosol layer just below 1 km in figure 1, although the Richardson number does drop to around the critical level just above 1 km suggesting turbulence could be present. The Brunt-Vaisala period is 5 – 10 minutes around 1 km which is generally consistent with the period of the wave-like perturbations of the layer. The westerlies at 2 – 3 km are part of a predominant larger scale flow.

An example of TAOS observations are shown in figure 5. There were 5 sensors packages deployed in this example and the trace of the lowest package, at about 200 meters, is marked. At upper levels 400 – 600 m, the wind is northerly, however starts off southerly at the lower levels. At 300 m, the wind is gradually changing from northerly to southerly. At the time of the jump in the aerosol layer of figure 2, there is a sudden wind gust at the 200 m level as a northerly surge passed through. This episode is one of several examples observed where low level stable air is disturbed upwards by a shift in wind.

4. MAPR BIRD ALGOTHIRM

A major problem for MAPR in this project was bird echo contamination. Migrating small birds travel at night and can completely dominate profiler echoes. MAPR may be more susceptible than DBS profilers to bird echoes because of the wider antenna beam used. Also algorithms to deal with bird echoes on spaced antenna radar are relatively undeveloped. The NCAR site was near the convergence of two mountain ranges which appear to have funneled migrating birds into the region of the site.

Figure 6 illustrates preliminary efforts at removing the effects of bird echoes. The upper panel shows results with no bird algorithm applied. The strong highly variable northerly winds after 1UT are the result of birds flying south. The lower panel shows the same period after application of spectral filtering techniques, based partly on the work of Merritt (1995), and wavelet filtering techniques of Jordan et al (1997). There is improvement with many fewer variable northerlies and the westerly wind layer aloft is more apparent, although some bird effects do remain. Further development of bird filtering techniques is on-going and it is hoped that many of the remaining bird effects can be removed.

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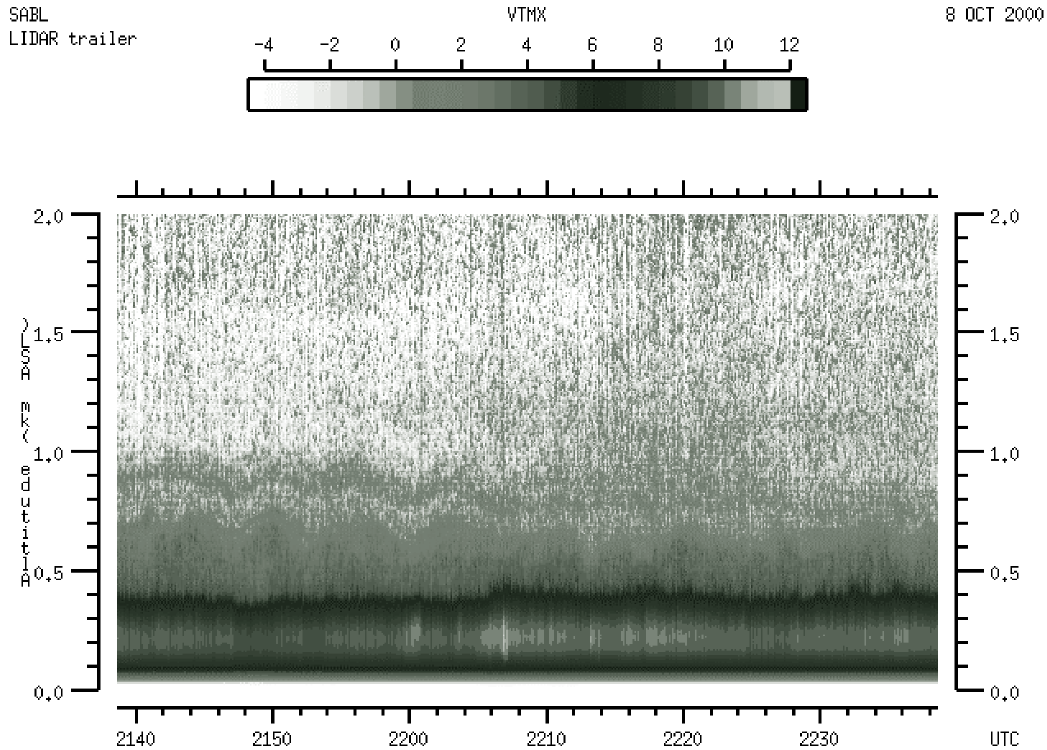

Figure 1 : One hour of SABL Lidar Observations, 8 October, 2000.

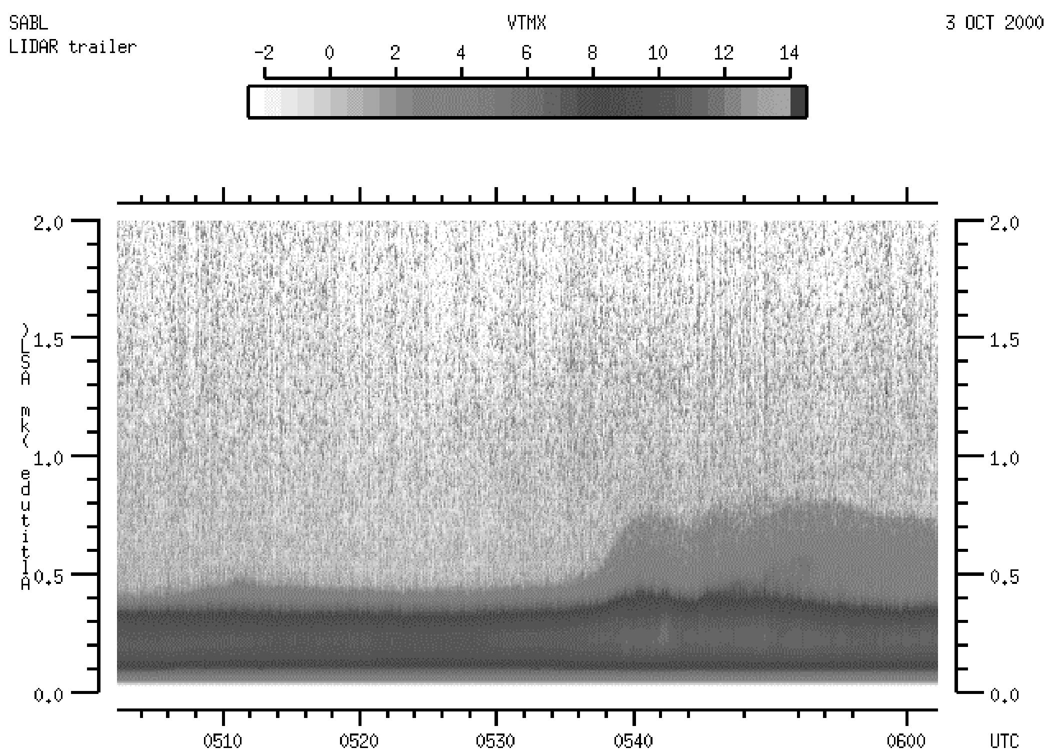

Figure 2 : One hour of SABL Lidar Observations, 3 October, 2000.

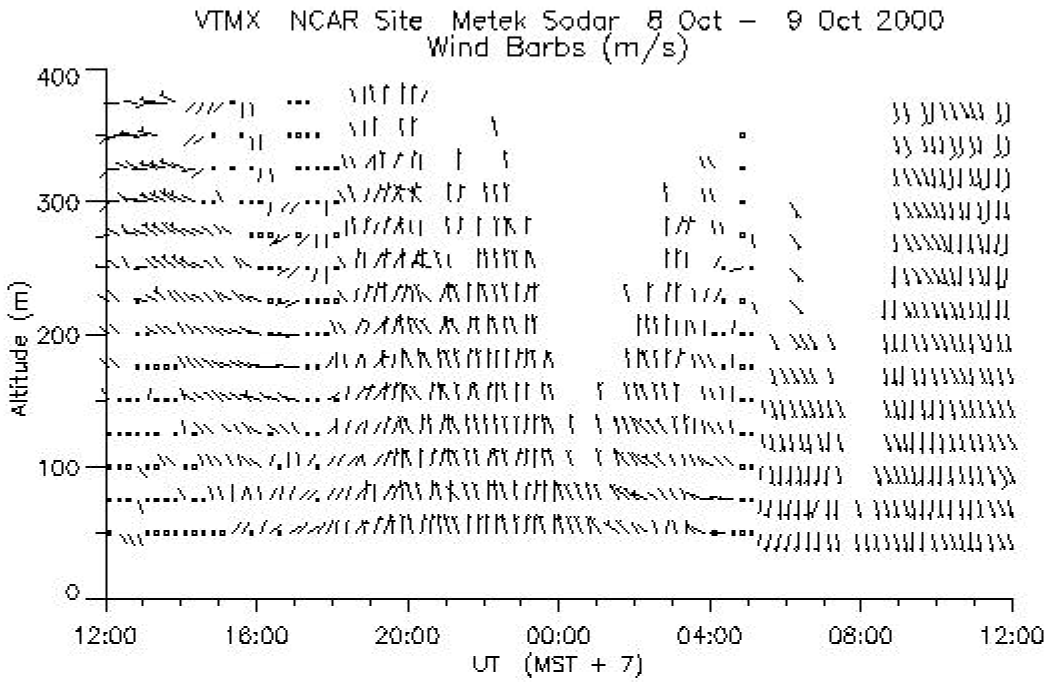

Figure 3: 24 hours of Sodar wind observations, 8 – 9 October, 2000.

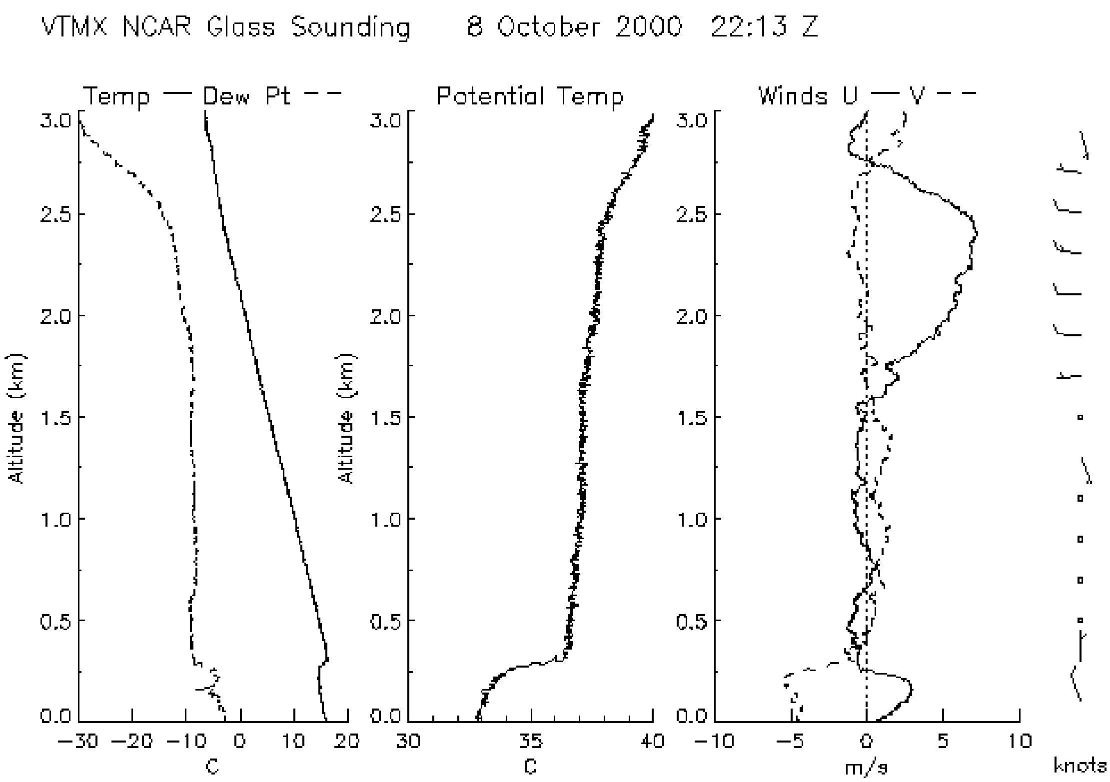

Figure 4 : Radiosonde sounding, 22Z on 8 October, 2000.

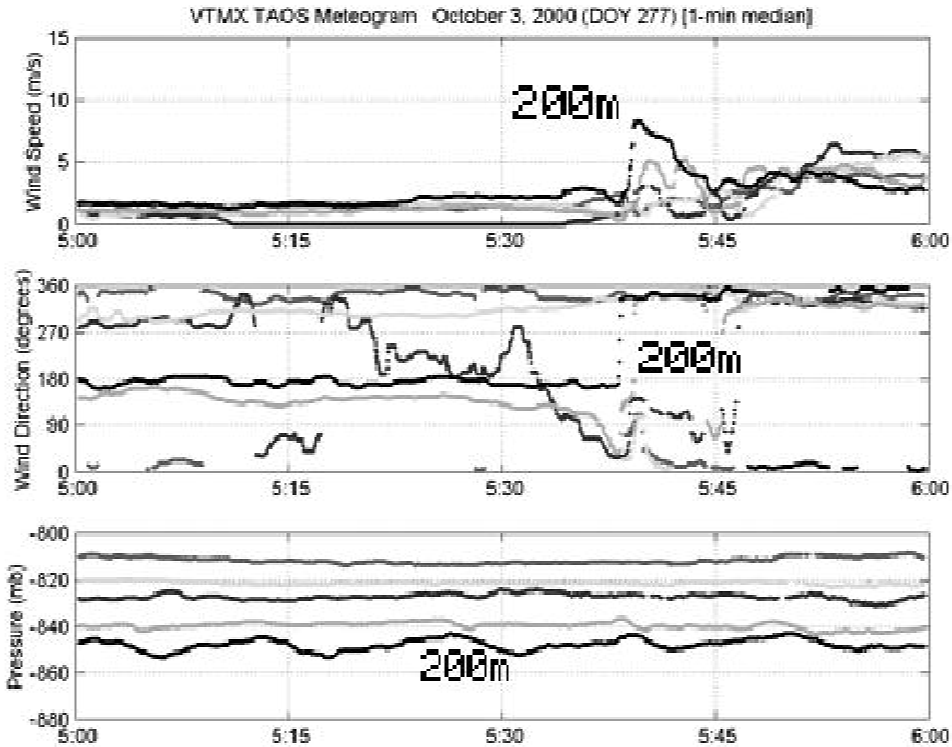

Figure 5: TAOS tether blimp observations at 5 levels from 200 to 600 m, 3 Oct.

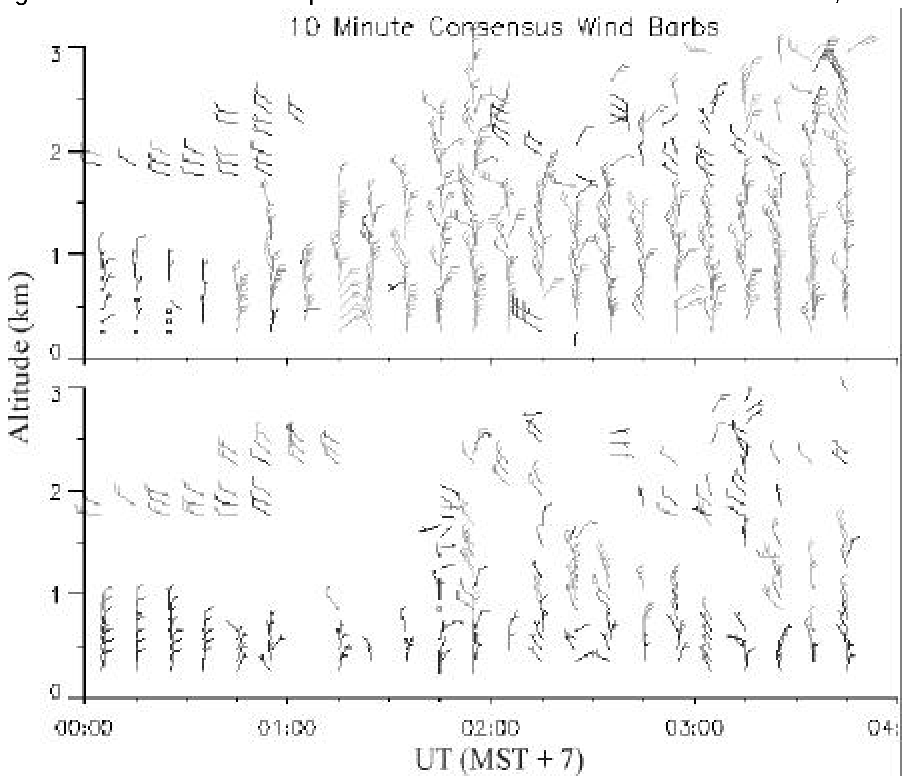

Figure 6: MAPR Winds before and after bird removal, 20 Oct.