Long-EZ aircraft data and some hypotheses about drainage flow and turbulence[1]

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To complement the many vertically-looking instruments over the Salt Lake Valley, the Long-EZ airplane sampled horizontally. Wind, temperature, pressure, and turbulence were measured *in situ*. The airplane, based at Salt Lake City Municipal Airport #2 (SLC2), covered the Salt Lake Valley south of Interstate Highway 80 at the minimum safe altitude, 300 to 500 m above local ground. The three-dimensional position of the airplane is known each second within ±2 m, allowing coordination with terrain and with other instruments. Turbulence, determined by eddy correlation, used 50 samples per second, about one per meter of travel.

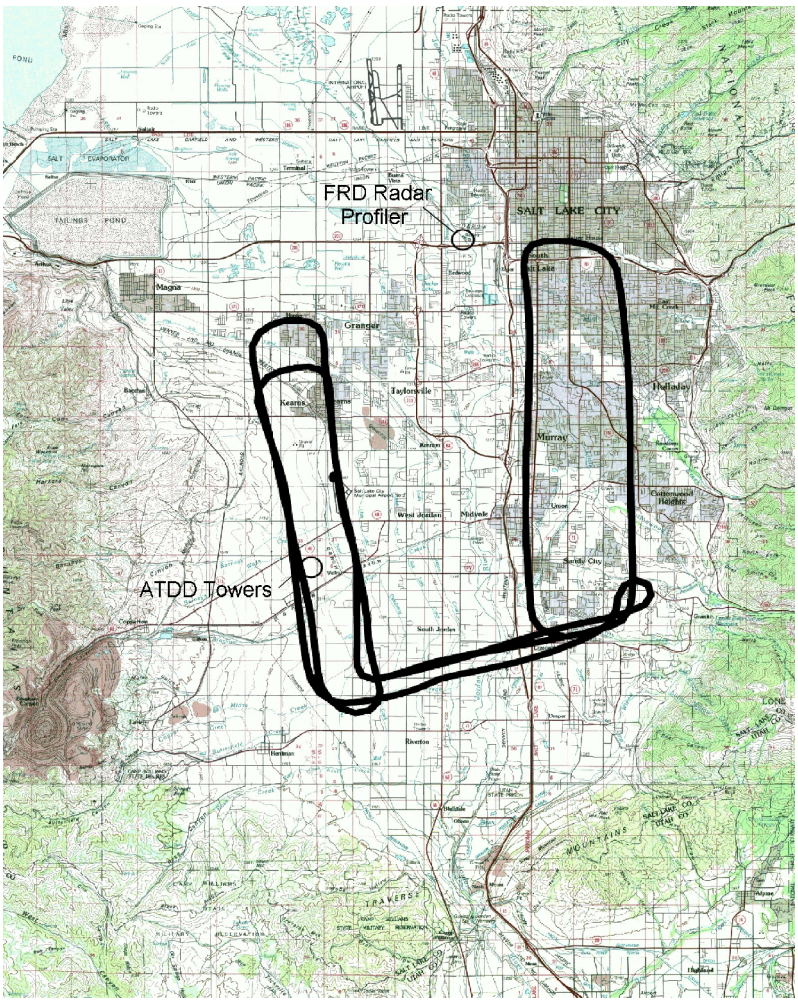

Figure 1: Long-EZ flight paths and surface sites

The flight path, shown in Fig. 1, had two race-track patterns, and an "L" over the west racetrack and the valley's south side. Flight were pre-dawn, nominally 0300 to 0700 Mountain Standard Time (MST: UTC - 7). Since ATDD also maintained a tower site within a few kilometers of SLC2, focus favored the western racetrack. The Field Research Division (FRD) of NOAA/ARL maintained radar and sodar profilers near the eastern racetrack as indicated in Fig.1. Each flight had three parts of roughly equal duration. Part one followed the west racetrack, of which the eastern leg passed over SLC2. Low passes over the runway on each circuit allowed low-altitude sampling near the ATDD tower site. Part two followed the east racetrack,

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sampling the influence of the Wasatch Mountains. Part three covered the “L” pattern on the valley’s western and southern sides, following paths depicted in Fig. 1. As in part one, there were low passes over SLC2.

Flights were made whenever possible, independent of Intensive Observation Periods (IOP), calendar time being more limited than flight time. Furthermore, catastrophic instrument disruptions occurred regularly until the cause was traced to a strong surface radio source near SLC2. We achieved five mornings of data, three during IOP’s: 18 October (IOP 7), 20 October (IOP 8), and 26 October (IOP 10). The remaining two were 19 and 25 October.

About 20 hours of measurements were obtained on 38 channels. The data were generally clean, except ambient pressure and surface temperature which were affected by radio-frequency (RF) interference. The strong surface source mentioned earlier left a prominent signature in both signals during the 30 s when the airplane was sufficiently close. More troublesome were the radio transmissions from the airplane itself, frequent in this urban area. Their detection, straightforward by eye, could not be automated, making their removal slow and tedious.

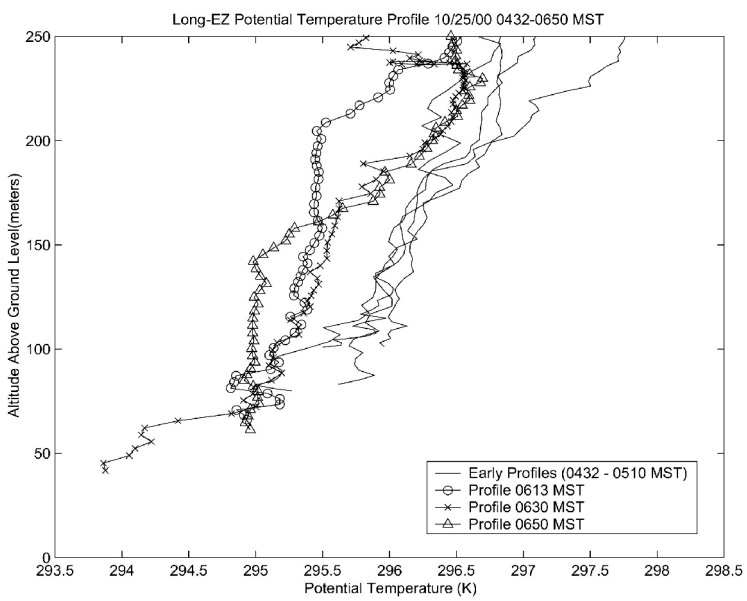
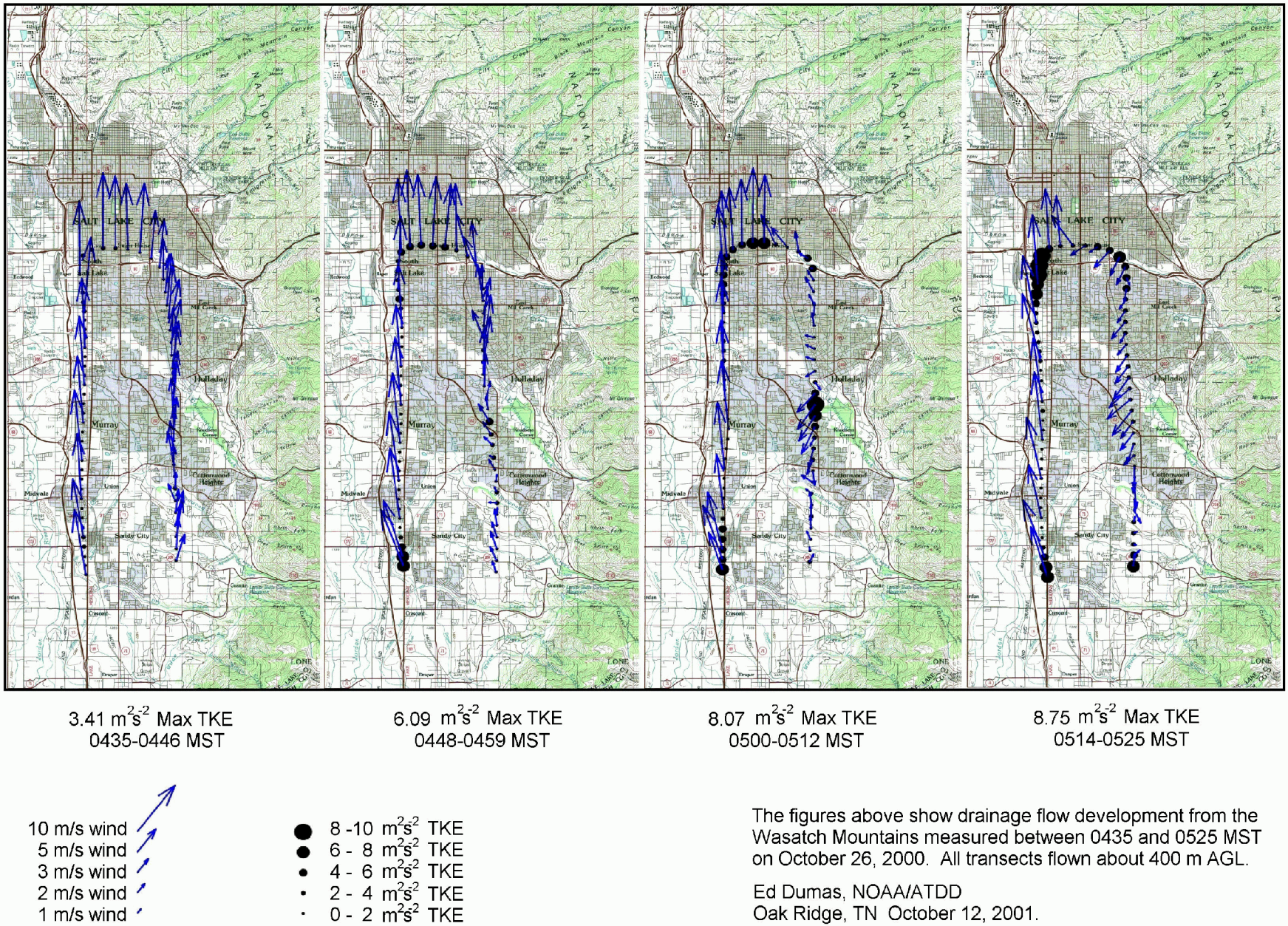


Figure 2: Potential temperature 25 October 2000 from low passes

Data from 25 and 26 October have been cleaned of RF interference and given preliminary examination. Temperature profiles from the descents to SLC2 found the layer to be statically stable, consistent with the radiosonde profiles and with each other. The potential temperature profiles from 25 October in Fig. 2 illustrate some of the features. Early profiles, from the first segment of the flight, are depicted with plain lines since they corresponded closely with each other. More structure appeared in the profiles from the later passes. The air had further cooled by this time, still before dawn. The first profile (circles) had a nearly neutral layer, the upper part of which became more stable before the next two passes. But below 1550 m another neutral layer formed before the



The figures above show drainage flow development from the Wasatch Mountains measured between 0435 and 0525 MST on October 26, 2000. All transects flown about 400 m AGL.

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Figure 3: East-side wind pattern

third pass. These neutral layers implicate intermittent turbulent mixing. Wind measured during the low passes over SLC2 was generally from the south on 25 and 26 October, the same as at the normal flight level. Wind speed was about (10 ± 1) m s^{S1} on 25 October. The low passes on 26 October encountered greater variability, less amenable to simple description. Wind speed was (8 ± 2.5) m s^{S1} on 26 October with temperature profiles suggesting intermittent mixing, both early and late.

The wind on the east side of the valley follows a suggestive progression through the one-hour period sampled by the Long-EZ on 26 October (0435 - 0525 MST). In the first panel of Fig. 3 the wind came from the south nearly everywhere. Its speed was 12 m s^{S1} over the Interstate Highway (I15) though lighter to the east. Turbulence was initially weak everywhere. Disturbances appeared in the wind on the east side by the second panel, along with increased turbulence on the northwest corner of the racetrack. The third panel shows strong turbulence in newly evident northeast flow near the middle of the eastern leg. Turbulence had also further strengthened on the north end of the racetrack. In the final panel, the northeast flow had extended along most of the eastern leg, though turbulence had subsided. Strong turbulence appeared again on the northwest corner of the racetrack, though now on the western leg. Wind along the west leg of the racetrack remained about 10 m s^{S1} throughout the period. For comparison, the observations from the FRD's profiler are shown in Fig 4. The Long-EZ's height and time are marked by the gray rectangle. Though the profiler's wind data were missing there, adjacent data indicate persistent winds on the order of 10 m s^{S1} from the south, similar to that observed from the airplane.

This case shows a strong horizontal spatial pattern in turbulence, probably associated with an even stronger vertical structure. A hypothesis of drainage flow deepening over time appears plausible. In the second and third panels of Fig. 3 the wind direction backed toward northeast, as appropriate for drainage. At the same time the turbulence increased, not only by generation but also, probably, by advection. The entraining turbulence at the top of the deepening drainage layer pushed upward through the flight level as the flow deepened. As the drainage flow engulfed the flight path, turbulence subsided as in the fourth panel.

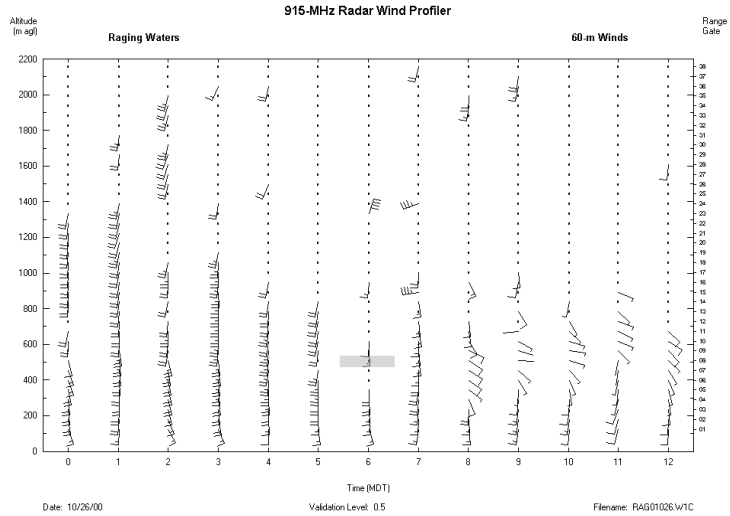

Figure 4: Wind from FRD profiler. Note times in MDT (UTC - 6). Gray rectangle indicates Long-EZ's time and height.

The profiler in Fig. 4 showed the wind beneath the northwest corner of the racetrack to back over time

toward southeast. Periodically, however, the south flow reestablished itself all the way to the ground as at 0100, 0400, and 0700 MDT (0000, 0300, and 0600 MST). Hypothetically, the drainage flow may be invading this site at ground level to be replaced periodically by south wind mixed downward from aloft.

The wind opposite the mouth of Little Cottonwood Canyon at the southeast corner of the racetrack unexpectedly remained light and only weakly turbulent. Probably this drainage was beneath the flight level. Testing these hypotheses will require additional information from sensors sampling the vertical structure of the flow and turbulence.