# 12.6 KATABATIC FLOW AND TURBULENCE AS SEEN FROM AIRBORNE IN-SITU MEASUREMENTS AND GROUND-BASED PROFILER MEASUREMENTS DURING VTMX

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## 1. INTRODUCTION

Our understanding of vertical transport and mixing processes in the lowest few kilometers of the atmosphere is very limited during periods of light winds and weak turbulence. The upward and downward movements of air parcels in stable and residual layers and the interactions between adjacent layers are difficult processes to characterize. A quantitative description of the atmosphere during morning and evening transition periods is also difficult to formulate. Heterogeneous land/water surfaces and complex terrain compromise our ability properly to characterize vertical transport and mixing.

The Vertical Turbulence and Mixing Experiment (VTMX) addresses these issues in the Salt Lake Valley of northern Utah. The Wasatch mountains to the east contribute to the development of cold pools trapped on the valley floor. Flows over the mountains and out of the canyons, as well as thermally driven winds between the Great Salt Lake and the valley floor generate wind shear and atmospheric waves. These winds can modify the vertical structure of the atmospheric boundary layer.

The case presented here exhibits an evolving drainage out of the Wasatch Mountains. Using data acquired by a small research airplane and a ground-based wind profiling system we describe some suggestive aspects of its structure.

## 2. DATA

The LongEZ (registration N3R) research aircraft flew several pre-dawn research missions during VTMX. The instrument suite and data acquisition system measure mean properties of the atmosphere as well as turbulent fluxes of heat and momentum. Measured meteorological quantities include the three-dimensional wind vector, air temperature, dew point, pressure, dry air density, and surface temperature. Aircraft information include latitude, longitude, altitude, pitch, roll, heading, and ground and air speed.

A 10-m tower, phased-array Doppler sodar, and radar wind profiler acquired surface and upper-air meteorological data during VTMX. These instruments were deployed in a dirt parking lot at the Raging Waters entertainment complex 5 km southwest of downtown Salt Lake City. A cup anemometer and vane measured 10-m wind speed and direction. Air temperature and relative humidity were measured at 2 m. These sensors were sampled once per second and averaged over 5-min intervals. A Radian phased-array Doppler sodar acquired 15-min wind profiles from 40 to 300 m with a 10-m resolution. A Radian 915-MHz phased-array radar wind profiler acquired one-hour wind profiles in a dual sampling mode. The first mode acquired high-resolution, low-range data from 124 to 2158 m with a resolution of 55 m. The second sampling mode acquired low-resolution, high-range data from 172 to 3732 m with a resolution of 96 m.

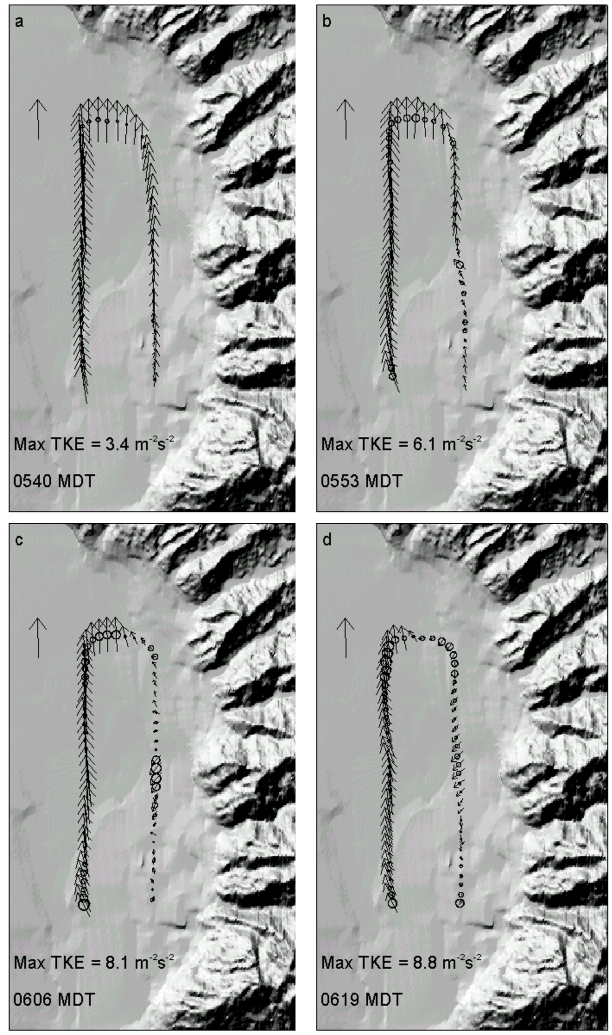


Fig. 1. LongEZ "racetrack"at 400 m AGL on 26 OCT 00.

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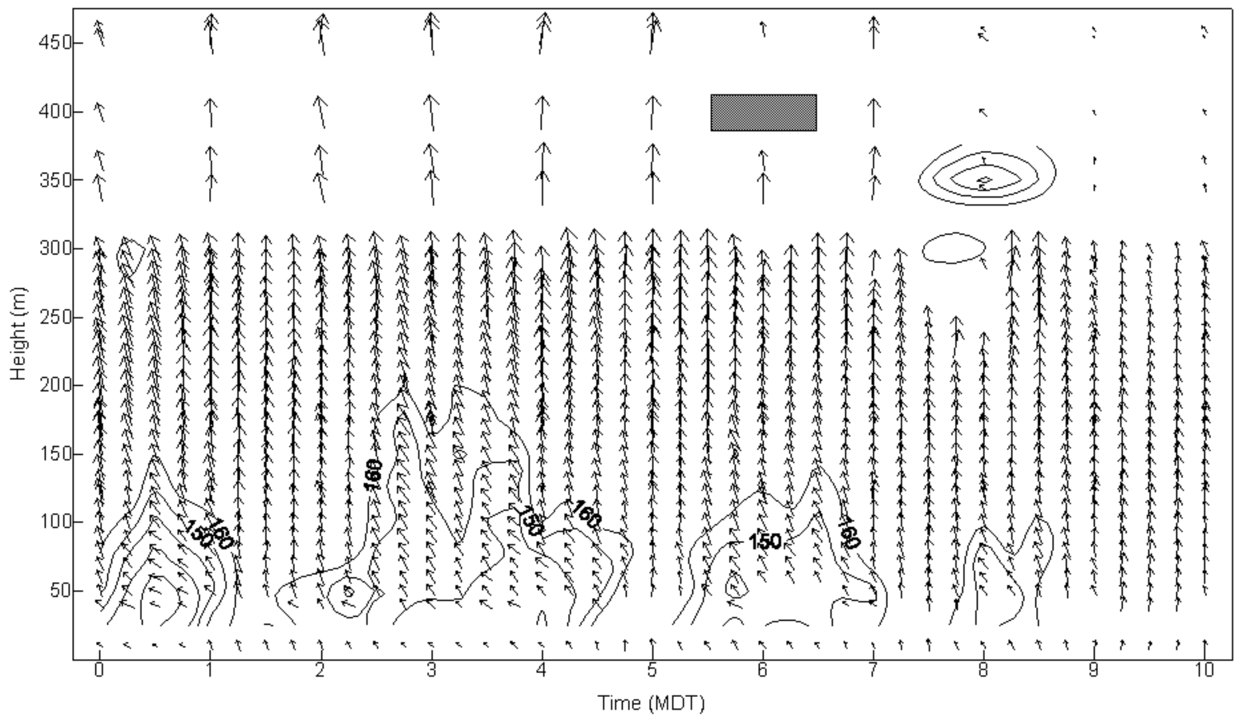


Fig. 2. Time-height plot of tower, sodar, and radar wind, 26 OCT 00 (IOP 10). Isogon contour interval of 10 deg help depict apparent southeasterly drainage flows. Shaded box at 400 m from 0534-0625 MDT represents LongEZ sampling interval.

## 3. ANALYSIS

The LongEZ flew a repeated thirteen-minute north-south "racetrack" pattern at 400 m AGL on the eastern side of the Salt Lake Valley during the predawn hours of 26 October 2000 (VTMX IOP-10). Fig. 1 shows wind vectors acquired by the LongEZ for four sequential flight tracks over a 50-min period. The two north-south legs of the race track are separated by about 5 km. Relative magnitude of the turbulent kinetic energy (TKE) is represented by open circles. The wind vector from the radar at 400 m is also included 4 km west of the northwest corner of the track.

Winds at flight level were from the south in the first period, centered at 0540 MDT. Winds were 12 m $s^{-1}$ on the west side of the track with weak turbulence everywhere. On the 0553 track a weak southeasterly flow appeared along the east leg, with increased turbulence on the northwest corner. By 0606, a moderate northeasterly flow and strong turbulence were encountered along the middle portion of the east leg. Turbulence also strengthened on the north end of the track. The turbulence increase is probably a combination of local generation and advection. The northeasterly drainage flow extended along most of the eastern leg by 0619 while turbulence intensity decreased. Strong turbulence appeared again on the northwest corner. The wind along the western leg remained at 10 m $s^{-1}$ during the sampling period with a slight backing from the south to southeast with time. The wind opposite the mouth of Little Cottonwood Canyon at the southeast corner of the racetrack remained light and only weakly turbulent. The integrated tower, sodar, and radar data (Fig. 2) show dominant southerly flow, 4 to 5 m $s^{-1}$, repeatedly interrupted by southeasterly flow in a surface-based layer which deepens beyond 100 m and then subsides. Such encroachments were centered on 0030 MDT, 0300 MDT, 0600 MDT, and 0800 MDT. Between these episodes, the southerly flow reestablished itself all the way to the surface at 0130 MDT, 0500 MDT, and 0700 MDT.

## 4. SUMMARY

These data suggest an oscillating drainage flow. The airplane sampled the event centered on 0600 MDT. The east flight leg passed first above the drainage flow, then through the turbulent entrainment layer at its top, and finally within the drainage itself, characterized by northeast wind. The west flight leg, farther into the valley shows only south winds, though there was drainage beneath, revealed in the now southeast flow reported by the tower, sodar, and radar. Having a longer record, these instruments reveal the oscillatory nature of the drainage. More surface and upper air data from the whole Salt Lake Valley will be needed to verify these hypotheses.

## 5. ACKNOWLEDGMENTS

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