P1.7 SIMULATIONS OF CANYON DRAINAGE FLOW AND ITS INTERACTION WITH THE STABLE AIR OF THE SALT LAKE BASIN

James R. Stalker*

Los Alamos National Laboratory
Los Alamos, New Mexico

1. INTRODUCTION

Simulations of several intensive observation periods (IOPs) are being performed using the Regional Atmospheric Modeling System (RAMS) with 2-km horizontal resolution. At this resolution, the northern Mill Creek and Parley's canyons are not fully resolved. However, the big and little Cottonwood canyons, situated to the Salt Lake city downtown area, that are of interest to this study, are resolved well (see Fig. 1b). Horizontal resolution of 1 km or less is required to adequately resolve all the major canyons of the Wasatch mountains (not shown). A single large grid (301X301X50) has been used in this study as opposed to traditional nested grids (see Fig. 1a). This is, in attempt, to reduce any inconsistencies and numerical instabilities that may arise at the nested boundaries. The grid center is collocated with the Argonne National Laboratory (ANL) observational site at the mouth of the big Cottonwood canyon (40.64 N & 111.80 W) during the vertical transport and mixing (VTMX) Salt Lake city October 2000 field experiment. These simulations have been initialized and nudged with the NCEP 6-hr reanalysis datasets that have horizontal resolution on the order of 250 km. Several surface and upper-air measurements (e.g., profiler and RASS) have been used in the characterization and validation of the model results. In this paper, results of only IOP 10 (25 October 2000) are presented. Results of all 5 IOP simulations with further refinements in horizontal resolution are being developed to be presented at the conference.

2. OBSERVATIONS

Data from eleven surface stations have been used to characterize the stages of cooling/heating of the surface temperature. The surface temperature data show that four distinct periods are evident (not shown). An early evening transition period, marked by drainage flow into the basin, exists between 6 PM and 9 PM local time. During this period, the surface temperature exhibits an oscillation. See Fig. 2 for the early evening transition period of 25 October 2000. In addition to drainage flow, there seems to be a well-mixed period indicated by rebounding surface temperatures late at night (between

* *Corresponding author address:* Dr. James R. Stallker, EES-8 Mailstop D401, Los Alamos National Laboratory, Los Alamos, NM 87545. Email: stalker@lanl.gov.

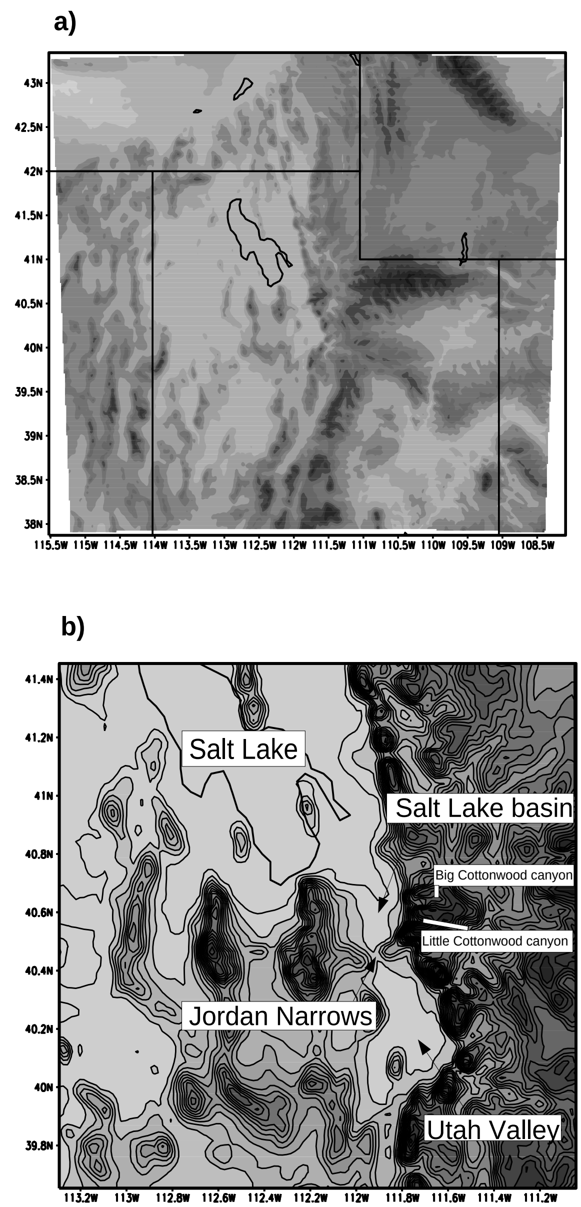

Fig. 1 a) RAMS topography within a large single grid at 2-km resolution. b) Same as a except shows a zoomed-in area centered over the Salt Lake Valley.

11 PM to ~3 AM). It is during this period that a well-developed southerly flow persists.

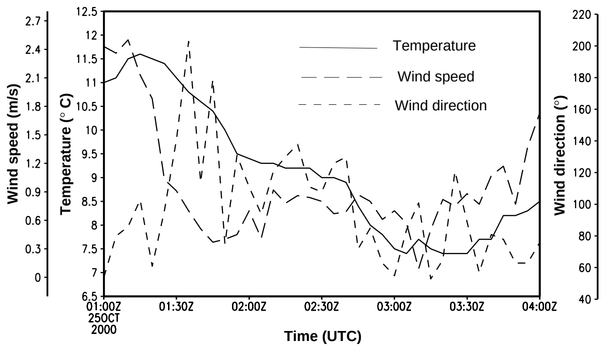

Fig. 2 Observed surface temperature, wind speed, and wind direction at Granite Elementary School.

This period is seemingly affected by long-wave surface upwelling into lower troposphere as well as possible compressional heating of the cold drainage. These well-mixed surface conditions may be pronounced in the downtown area due to the urban canopy. The southerly flow may also be enhanced from the urban heat island effects due, for example, to a reinforced meridional pressure gradient. The third transitional period (between 3AM and 7 AM) seems to be affected by long-wave radiative cooling of the shallow stable layer. The fourth period (starting from 7 AM) is the early morning transition in which short-wave radiative heating results in daytime boundary layer growth. In addition to surface station data, profiles of temperature (Fig. 3), wind speed (Fig. 4a), and wind direction (Fig. 4b) are used to illustrate the depth of cooling, low-level wind jet formation, and wind reversals for the early transition period. These observational data are proven critical, particularly, in the validation of interpolated initial conditions for the high resolution RAMS grid (see section 3 for details).

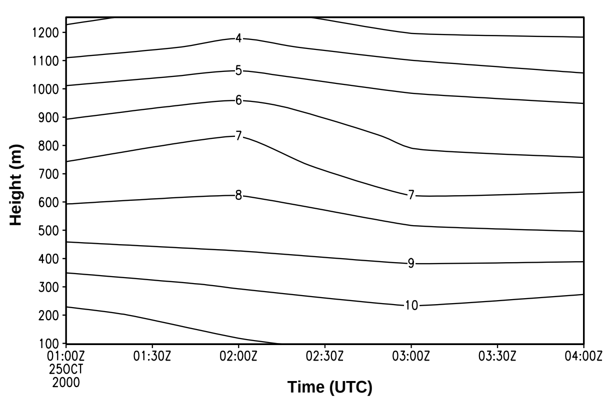

Fig. 3 ANL RASS temperature time-height section.

The goal of this paper and subsequent continuation of the VTMX research is to ascertain the effects of canyon drainage on the oscillatory behavior of temperature (in period 1) and the strength of the southerly flow (in period 2) described above and the resultant vertical mixing over the downtown area. An appreciable component of the gap flow dynamics near Jordan Narrows may also be present (not shown). Collaborations with other researchers will be sought in developing an understanding of the gap and drainage flow interaction. A collaborative effort has been initiated with the Chemical/Biological Nonproliferation (CBNP) research group at Los Alamos to develop a method to incorporate the urban canopy effects of downtown heating into the coarse resolution RAMS simulations on the VTMX processes.

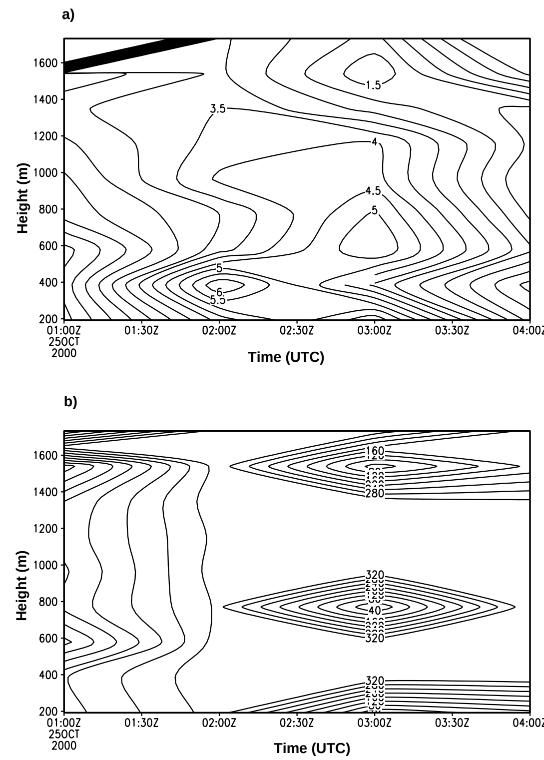

Fig. 4 a) ANL profiler wind speed time-height section.
b) ANL profiler wind direction time-height section.

3. RESULTS AND DISCUSSION

The results of two simulations, one started at 5 PM local time (run one) and the other started at 11 PM local time (run two) on 25 October 2000, are discussed. The second run has been successfully integrated for 3 hours. On the other hand, the first run (for period 1) exhibits extreme difficulty in the model integration compared to the second run. So far, run one has been successfully completed for only 25 minutes. However, the warming trend in the observed surface temperature (see Fig. 2) and the reduced wind conditions (see Fig. 2) are simulated fairly well as shown in Fig. 5. The reason for this

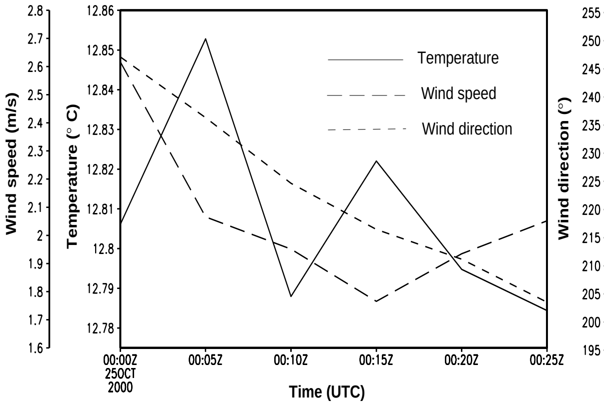

Fig. 5 RAMS simulated temperature, wind speed, and wind direction for the first 25 minutes at a location near Granite Elementary School.

difficulty is believed to be resulting from the unstable initial state of late afternoon conditions. Thus the time step required will be even smaller compared to an already small time step of 1 second used for this run.

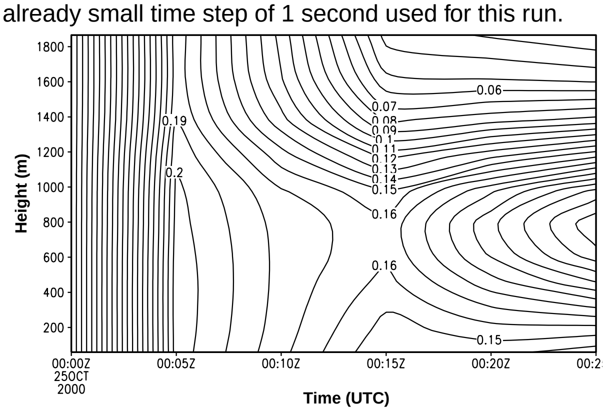

Fig. 6 Time-height section of RAMS simulated vertical motion for the first 25 minutes at a location near Granite Elementary School.

In addition to the interpolation errors in the initial conditions alluded to above, realistic low-level jets tend to form and induce directionally sheared flow instabilities, as shown in Fig. 6, that would enhance vertical motion (mixing). Also see Fig. 4 for the locations of low-level jets observed by the ANL profiler. Similar low-level jets are also simulated in run two (not shown).

The simulations of the two noted transition periods need to be extended in time and possibly refined further. For example, the large-scale data must contain adequate resolution to minimize interpolation errors in the initial and boundary conditions. This may alleviate the difficulty recognized in run one. The NCEP Eta model output with ~40-km resolution will be used for the future simulations. Five IOPs will be simulated with the intent to verify the following findings of an idealized set of simulations on the drainage flow interaction with the stable air of the basin:

a) an existing weakly-stable layer facilitates more vertical mixing between the canyon drainage flow and itself than for strongly-stable layers,

b) for the same stability and degree of cooling, a deeper existing stable layer tends to produce more vertical mixing than shallow layers,

and finally

c) increased degree of cooling tends to produce increased vertical mixing for a given set of stability and depth (Stalker et al. 2000).

4. ACKNOWLEDGMENTS

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5. REFERENCES

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