Model Simulations of the Influence of Synoptic Conditions on Vertical Motions in the Salt Lake City Region

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The Salt Lake City basin was the location of the Vertical Transport and Mixing (VTMX) program field experiment in October of 2000, and it is an area that has experienced urban air quality problems. During the experiment, air flow through the Jordan Narrows, the gap in the Traverse Range that divides the Salt Lake City basin from the Utah Lake basin to the south, was found to be significant, in addition to the known night time drainage from canyons that enter the valley from the east. Similar flow has been documented in earlier studies between the Tooele and Rush Valleys, just to the west, and through the series of passes that separate Rush Valley and Cedar Valley, to its east. This study addresses several science questions. What is the nature of the interactions of terrain induced flows with cold air in basins and with flows of different scales? How are circulations and vertical mixing within the Salt Lake City basin influenced by flows that enter or exit the basin from nearby basins and by drainage flows from the canyons that enter the valley from the east? How do synoptic scale weather patterns affect these interactions? Simulations of IOP's 7 and 8 of the field experiment with the Regional Atmospheric Modeling System (RAMS) have yielded results, which suggest that synoptic weather conditions influence the timing and location of the interaction of the flow through the Jordan Narrows with canyon drainage flows and thus the relative strength and locations of vertical motions that can lead to vertical transport and mixing.

Although the large scale weather is relatively weak during both IOP's, the rawinsonde soundings from the airport indicate that the low level vertical temperature gradient is more stable during IOP 7 and the winds above ridge top are light and from the east. In contrast, the ridge top winds during IOP 8 are somewhat stronger and from the west. Lidar and surface observations in the Salt Lake City basin indicate that the flow through the Jordan Narrows, from the south, starts earlier in the night and is stronger during IOP 7 that during IOP 8.

Both model simulations were started 24 hours before the start of each IOP, to allow local thermally driven flows to develop in the model. The model results agree qualitatively with the observations by producing stronger and earlier down valley (southerly) flow through the Jordan Narrows during IOP 7 than during IOP 8. However, the difference in the timing is much more dramatic in the model, which already shows down valley flow at the beginning of IOP 7. The flow through the Narrows is associated with a gravity wave that has higher amplitude and greater vertical motions during IOP 7. Also, the down valley flow converges with the canyon outflows earlier in the simulation of IOP 7, producing localized areas of vertical motion. The strength and the timing of the canyon outflows are also different during the two IOP's, indicating that they are also influenced by the synoptic conditions. Just before sunrise, both simulations show down valley flow in the basin, converging with the canyon outflows, but the locations of the associated vertical motions are somewhat different and the magnitudes are much larger for IOP 7.

The model simulations also produced easterly winds through Five Mile Pass, between the Rush and Cedar Valleys. This agrees with surface and kite observations from studies from the 1980's, which were unsure of the cause of the easterly flow at night. In the model results, the east winds appear to result from drainage off of the Wasatch and Lake Mountains, to the east of the pass. During IOP 7, the model produces the east winds earlier than during IOP 8 and they are reinforced by the easterly flow found above the ridge tops, early in the evening.

In summary, the simulations indicate that synoptic conditions influence the strength and onset times of canyon outflows and the flow through the Jordan Narrows and along the valley in the Salt Lake City basin. The interactions of the canyon outflows and valley flow determine the location and intensity of localized areas of vertical motion. The areas of vertical motion can change in their strength and their location under different synoptic conditions.