The Complex, Multi-Scale Flow Interactions in a Portion of the Rio Grande Basin

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The Pajarito Plateau is located on the eastern flank of the Jemez Mountains and the west side of the Rio Grande Valley, in north-central New Mexico, where the river runs roughly north to south. On the Pajarito Plateau, a network of surface meteorological stations has been routinely maintained by Los Alamos National Laboratory. This network includes five instrumented towers, within an approximately 10 km by 15 km area. The towers stand from 23 m to 92 m tall, with multiple wind measurement heights. Investigation of the station records indicates that the wind fields can be quite complicated and may be the result of interactions of thermally and/or dynamically driven flows of many scales. Slope flows are often found on the plateau during the morning and evening transition times, but it is not unusual to find wind directions that are inconsistent with slope flows at some or all of the stations. It has been speculated that valley circulations, as well as synoptically driven winds, interact with the slope flows, but the mesonet measurements alone, with no measurements in the remainder of the valley, were not sufficient to investigate this hypothesis.

Thus, during October of 1995, supplemental meteorological instrumentation was placed in the Rio Grande basin to study the complex interaction of thermally and dynamically driven air flow in the area. A sodar was added near the 92 m tower and a radar wind profiler was placed in the Rio Grande Valley, just east of the plateau and near the river. Measurements were also added at the top of Pajarito Mountain, just west of the plateau, and across the valley, to the east, on top of Tesuque Peak (in the Sangre de Cristo Mountains). Two surface stations were also added to the north-facing slopes of Pajarito Mountain.

The workshop presentation includes observations from October 1995 and results of simulations of this area, with the RAMS model. This study addresses two science questions. 1) What is the nature of the interaction of terrain-induced flows with cold air in basins and with flows of different scales? and 2) How do large-scale weather patterns affect these interactions? By addressing these questions, we hope to better understand the vertical motions and transport processes in the basin.

Examination of wind observations reveals that, on relatively synoptically quiet nights, the winds on the slopes of Pajarito Mountain tend to flow down the slope, through the night. Likewise, in Los Alamos Canyon, one of a number of narrow canyons that cut through the plateau from west to east, winds were consistently downvalley, beginning just after sunset and lasting through the night.

The other stations on the plateau typically have downslope flows early in the evening, but these flows are not maintained until morning. Sometimes the winds on the plateau turn clockwise through the night. This is consistent with the conceptual interaction of slope and valley flows, where westerly slope flows, off of the Jemez mountains and the Pajarito Plateau, are found just after sunset. As the night progresses, the winds turn through northwesterly and northerly, as the slope flows merge with the downvalley flow in the Rio Grande basin. After sunrise, the flows on the plateau turn through northeasterly and then easterly, in the morning transition. However, on a significant number of nights, the wind directions at one or two of the mesonet towers can also be very different from the other towers, indicating circulation on the plateau other than what would be expected from the conceptual interaction of the slope and valley flows.

Data from the profiler, in the valley, indicate that the upvalley flows from the previous day, can remain in the basin well into the night. At the lowest profiler measurement heights (about 100 m AGL), winds switch to downvalley sometimes as late as a few hours before sunrise.

Wind directions at the stations on the two mountain peaks appear to align with the synoptic winds at night, but show some indications of influence by the local, thermally-driven flows during the day and the transition times, especially on Pajarito Mountain.

To add additional insight into the nature of the flows in this portion of the Rio Grande basin, we are simulating them with the RAMS model. Five nested grids are used, in order to simulate regional to local scale flows. The simulation begins at 0000 UTC 23 October 1995 and runs through 1800 UTC 25 October. Preliminary results from the simulations indicate that the model tends to recreate the downslope flows early in the evening, but the downvalley flow in the Los Alamos canyon is not as stable of a feature as found in the observations. Early evening westerly flows extend down the slope and up the other side of the Rio Grande basin. With time, downslope flows also develop on the east side of the basin. The model runs agree with the profiler observations, where downvalley winds in the Rio Grande basin develop later in the night.

The model captures the morning transition period relatively well, when easterly flow tends to dominate the stations on the plateau. However, the changing winds through the night were not as well simulated by RAMS.

Gravity waves are found to influence the model vertical motions in the basin, especially above the tops of the Jemez and Sangre de Cristo Mountains. Model wind fields also indicate that the synoptic winds sometimes flow around the Jemez Mountains. This is particularly evident early in the simulation, when northwest flow diverts around the Jemez, resulting in lower wind speeds and easterly wind directions over parts of the plateau.

These results are preliminary and work is continuing to better understand the complex flow interactions. Our plans include increasing the vertical resolution in RAMS in hopes of better simulating the valley flow in Los Alamos Canyon and to investigate the vertical structure measured by the towers. We plan to nest the HIGRAD model within the RAMS simulations to simulate the finer scale flows. We also plan to investigate similar flow interactions in the Salt Lake City basin.