Simulations of Flow Interactions Near Los Alamos

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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, which stand from 23 m to 92 m tall and have 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.

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.

Analysis of the observations reveals that 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 more of the mesonet towers can also indicate circulations on the plateau other than what would be expected from the conceptual interaction of the slope and valley flows.

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. We use the RAMS model to simulate two consecutive nights in October 1995, when the synoptic weather pattern was changing. At the 500 mb level, a trough to the northeast of the region, moves farther to the north and east and the upper level flow becomes more zonal and weaker by the end of the second night. At the same time, the region is under the influence of the southeastern section of a surface high pressure system. The results of the simulation are compared to the observations on the two nights.

The the simulation, RAMS employs five nested grids, with horizontal grid spacing from 10.8 km to 75m, 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. Results from the simulation indicate that the model tends to recreate the observed downslope flows early in both of the evenings, with stronger winds on the first night. The model also qualitatively captures the morning transition period relatively well, when easterly flow tends to dominate the stations on the plateau. In both the observations and the simulation, the upslope flow is stronger, with a northerly component, on the first morning.

On the night of 23-24 October, the model produced northwest winds that diverted around the circular Jemez mountains and produced local areas of wind reversal on the leeward side of the range, on the Pajarito Plateau. Because the observations are concentrated on the plateau and just to the east and west of the plateau, the flow around the Jemez could not be confirmed by observations. The model runs agree with the profiler observations, where downvalley winds in the Rio Grande basin develop earlier on the first night, when the ambient northwest winds divert around the Jemez and flow down the valley. In contrast, the winds in both the model and the observations were much lighter on the plateau on the night of 24-25 October. This reflects the weaker upper level, synoptic flow on the second night. Gravity waves are also found to influence the model vertical motions in the basin, especially above the tops of the Jemez and Sangre de Cristo Mountains. The location of areas of upward motion associated with the gravity waves was different in the two simulated nights. Although the model does not correctly capture all of the details of the changing winds observed on the plateau during the night, it does suggest some mechanisms to explain the observations that would also be important for vertical transport and mixing.

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 details of the circulations, especially during the middle of the night, and to investigate the vertical structure measured by the towers. We plan to test the HIGRAD model in this area to simulate the finer scale flows.