1.4 AN EXAMINATION OF THE VARIABILITY OF SNOWFALL ASSOCIATED WITH TERRAIN-INDUCED CIRCULATIONS IN CENTRAL NEW MEXICO USING THE WORKSTATION ETA AND MM5 MODELS

Deirdre Kann*
National Weather Service, Albuquerque

Elizabeth Ritchie
EECE & HPCERC, University of New Mexico

1. INTRODUCTION

Research over the past decade has illustrated that mesoscale models can be successful in modeling the effects of terrain. Although numerical guidance from mesoscale models has not routinely been available to NWS forecast offices, forecasters have learned to consider the combination of synoptic scale regimes with local terrain-induced influences. Such “rules-of-thumb” can result in forecasts with improved verification much of the time, even when all the mechanisms associated with the pattern are not completely understood. The focus of this study is to determine if a mesoscale model can accurately depict variations in the snowfall associated with a common winter storm pattern and, if so, result in an improved understanding of the associated terrain-induced circulations.

2. BACKGROUND INFORMATION

Albuquerque is the largest population center of New Mexico and is situated in an area regularly influenced by nearby extreme terrain. Located along the Rio Grande, the Sandia and Manzano Mountains form a north-south barrier to the east and are separated by the Tijeras Pass, which has an elevation decrease of approximately 360 meters. East gap winds develop frequently in the Tijeras Pass, which is located 20 km east of the Albuquerque International airport. East winds are measured 13% of the time at the airport, and the strongest winds at the airport (>20 mph) are generally from the east.

Major snow events in New Mexico are frequently the result of a closed upper level low in a positively tilted trough with a surface high pressure surge into the state’s eastern plains (Fig 1). An upper level jet provides support for precipitation across western New Mexico. The strong east-to-west pressure gradient produces easterly flow, initially across the eastern half of the state. The resulting upslope flow can produce locally heavy snowfall along east facing slopes, particularly along the central mountain chain. The easterly gap wind through Tijeras Canyon has a downslope component (360 m from the canyon to Albuquerque), which can often inhibit precipitation across the Albuquerque metro area.

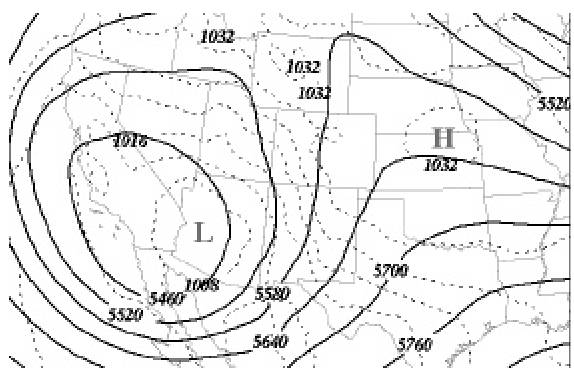

Figure 1. Synoptic pattern associated with major snow event in New Mexico, with 500 mb heights (solid lines) and mslp (dashed lines, H and L).

* *Corresponding author address*: Deirdre Kann, National Weather Service, 2341 Clark Carr Loop SE, Albuquerque, NM 87106;
e-mail: deirdre.kann@noaa.gov

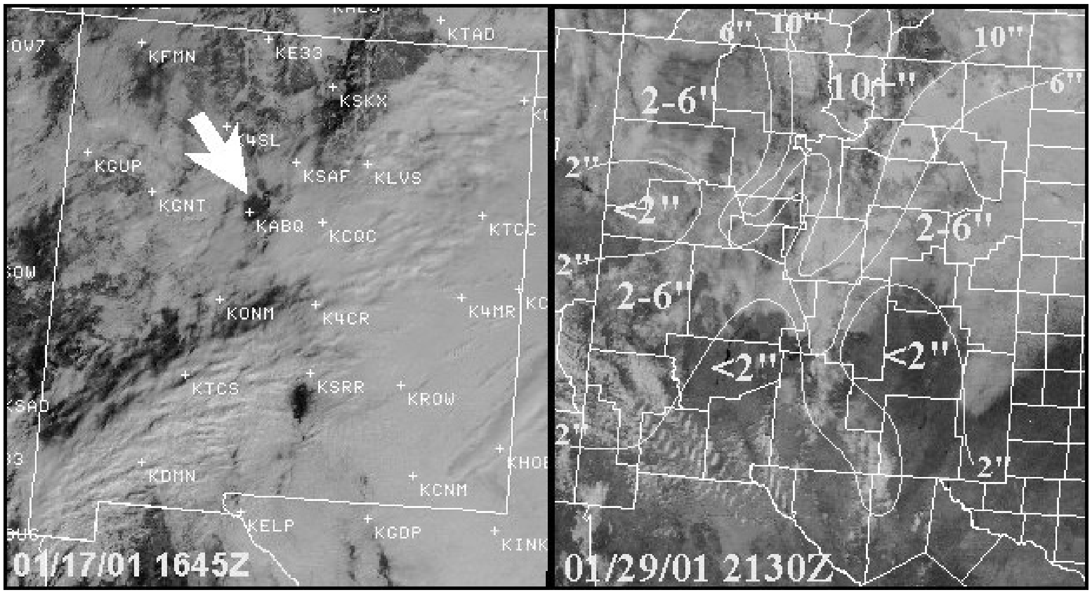

Figure 2. Visible satellite imagery depicting snow cover following two winter storms: 17 January 2001 at 1645 UTC (left, note snow void regions around KABQ) and 29 January 2001 at 2130 UTC (right, with contours of reported snow amounts).

In January 2001, two winter storms associated with the synoptic pattern shown in Fig.1 resulted in widespread snow across much of New Mexico. The first storm brought snow to much of the state on 16-17 January. Snow accumulations of over a foot in the north central mountains and 3 to 5 inches across the eastern plains were reported. The second storm examined in this study produced generally higher amounts of snow across much of the state, with some mixed precipitation across the southeast plains on 26-27 January. Gusty east canyon winds were recorded in Albuquerque with both storms. In Fig. 2, visible imagery illustrates the extent of the snow cover. During the first storm, Albuquerque received no snow and the void, as documented by visible imagery, was a near circular area of about 20 miles. A similar snow void area appears to the south of Ruidoso (KSRR) in south central New Mexico. Ten days later, when the second stronger system moved toward the state, east winds of greater than 20 mph were recorded at the airport for 24 continuous hours. In this case, however, two inches of snow was measured at the airport with amounts of 3 to 8 inches reported across the metro area. Determining the extent to which the downslope component associated with the east wind inhibits precipitation has proven to be challenge to forecasters.

3. PRELIMINARY MODELING RESULTS

At the time of the two winter storms examined in this study (January 2002), the workstation eta model was being run locally on a daily basis. The model was run at a 15 km resolution, and boundary conditions were obtained from the operational eta on grid type 104 (91 km resolution). In the previous five months (August through December 2000), daily runs of the workstation Eta at a 15 km resolution provided an improved spatial distribution of precipitation. Figure 3 illustrates an example of the difference between two 12-h precipitation forecasts, one from the operational eta model (left) and one from the workstation eta (right). While the lead times of the forecasts are different (12-h vs. 36-h) the difference in spatial detail of the precipitation forecast is readily apparent. However, the 15 km resolution of the workstation eta was still not sufficient to resolve the surface wind fields and associated patterns of vertical motions related to mesoscale terrain-induced circulations. In particular, the snow void areas of the 16-17 January storm were not resolved.

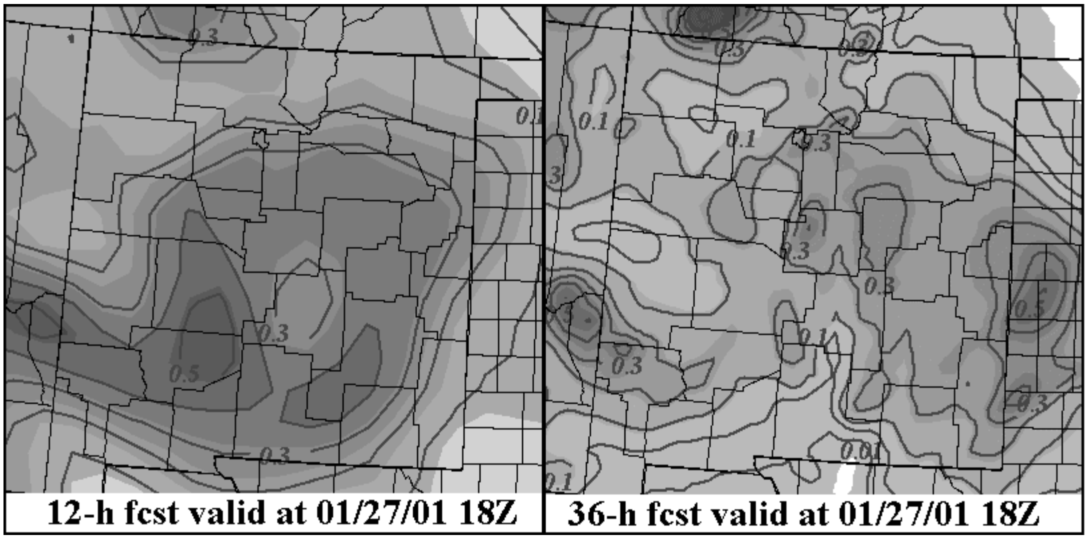

Figure 3. Precipitation forecasts for 12-h periods ending at 1800 UTC on 27 January 2001. On the left, 12-h lead time from the operational eta model and on the right, 36-h lead time from the workstation eta model.

Forecasts are now being produced using the workstation eta with a 10 km resolution using eta forecasts on grid type 212 (40 km) for boundary conditions. Additionally, forecasts have been generated for both storms using the PSU/NCAR nonhydrostatic model (MM5) using five nested domains with resolutions of 81 km, 27 km, 9 km, 3 km and 1km. The three smallest domains are illustrated in Fig. 4. Domain 4, with a resolution of 3 km, covers most of the state and virtually all of the major terrain features. Domain 5, with a resolution of 1 km, has an areal extent of 62 km by 51 km. It covers the Albuquerque metro area, the Sandia Mountains, Tijeras Canyon and the northern extend of the Manzano Mountains. Boundary conditions are also obtained from the eta forecasts on grid type 212. For both models, model precipitation is verified using NWS station observations as well as cooperative station measurements, snotel data and radar estimates.

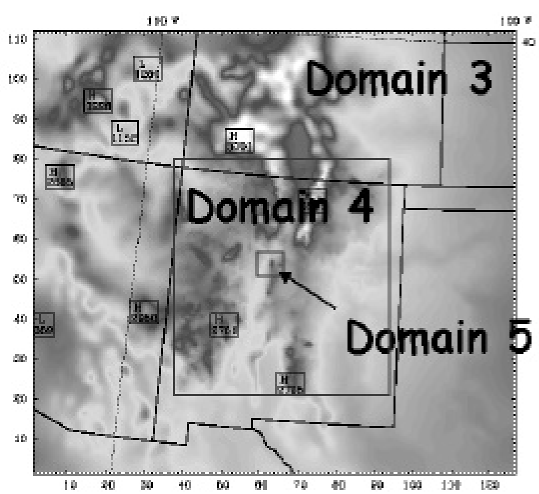

Figure 4. The innermost three domains used with the MM5 model.

A cursory examination of the forecasts produced by the MM5 model was promising. Forecasts of surface wind and precipitation for Domain 5 have captured the onset of the easterly gap winds recorded at the Albuquerque airport. For the second storm, the east winds persisted for a longer period and had greater strength. These differences in the surface wind field were also generated by the MM5. More important, the precipitation forecasts appear to reflect some of the major differences between the two storms.

Examples of precipitation forecasts for both storms over Domain 5 are shown in Fig. 5. The gray shading depicts precipitation, and the terrain is shown as solid contour lines at intervals of 200m. Two 12-h forecasts (00-12 UTC and 12-24 UTC) for 16 January 2001 are shown on the left, while similar forecasts starting 27 January 2001 appear on the right.

The first 12-h forecasts for 16 January indicates two areas of precipitation (snow), one associated with upslope along the eastern slopes of the Sandia Mountains and a second area to the west of the Albuquerque metro area. In the second 12-hour period, the upslope precipitation increases both in amounts and in its southward extent along the central mountains. In both 12-h forecast periods, a precipitation free area is maintained to the west of Tijeras Canyon.

The forecasts for 27 January depict a different pattern of precipitation. In the initial 12-h period, precipitation is limited to the east slopes of the Sandia Mountains. In the second 12-h period, precipitation increases in both intensity and areal extent. While amounts are lighter along the valley, a “bulge” of somewhat greater amounts is located to the west of Tijeras canyon.

4. CONCLUDING COMMENTS

Initial results indicate that forecasts from the MM5 have captured some mesoscale features observed during the two winter storms but not captured by the operational or workstation versions of the eta model. Additional model diagnostics are presently being conducted, particularly those related to vertical motions produced by the interaction of the low-level wind field with terrain and supportive dynamics. It is anticipated that if an improved precipitation field can be produced in the Albuquerque metro area, the model output will lead to an improved understanding of the mesoscale precipitation processes and thus improved forecasts of future events.

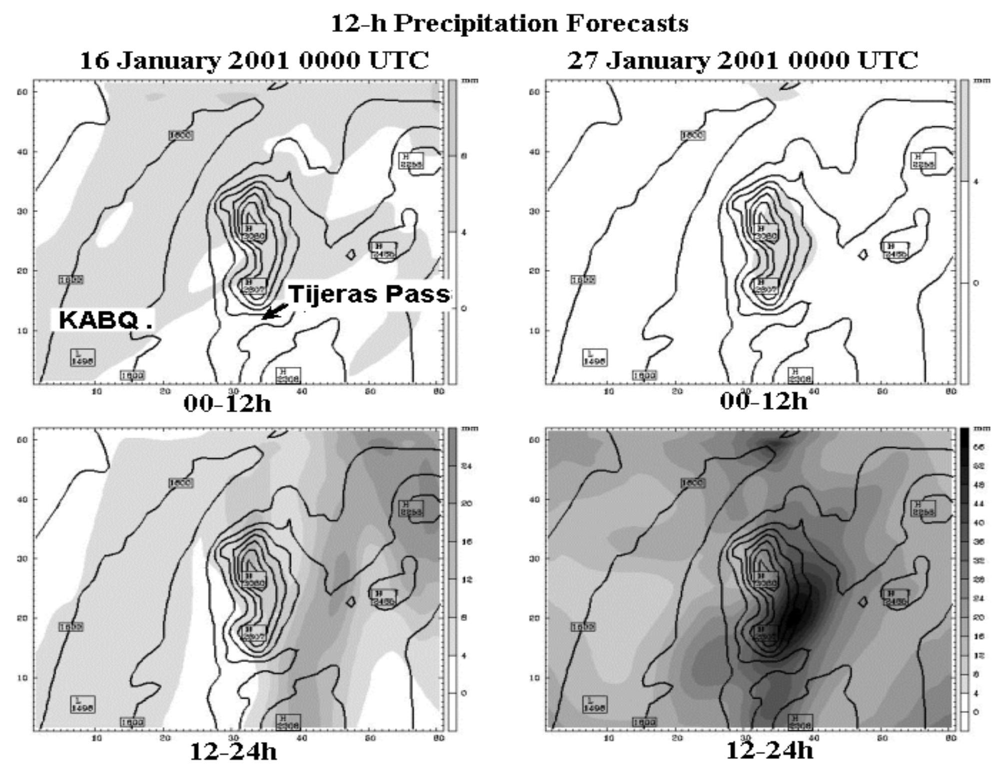

Figure 5. Two 12-h precipitation forecasts (00-12h and 12-24h) from the MM5 model for Domain 5 (1 km) in central New Mexico. On the left model start time is 0000 UTC 16 January 2001, and on the right start time is 0000 UTC 27 Janaury 2001. Contours of terrain are shown in 200 m intervals. KABQ and Tijeras Pass are indicated on the upper left panel.