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A DRAMATIC EXAMPLE OF THE IMPORTANCE OF DETAILED MODEL TERRAIN IN PRODUCING ACCURATE QUANTITATIVE PRECIPITATION FORECASTS FOR SOUTHERN CALIFORNIA

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Introduction

January 1995 was a very wet month for southern California. Over 12 inches of rain were measured during the month in the city of Santa Barbara and at the Los Angeles Civic Center. For southern California, the strongest storm occurred on the 10th of January.

This Technical Attachment (TA) examines the rainfall patterns from this storm for the 24-hour period ending at 00Z on January 11. Model quantitative precipitation forecasts (QPF) from the NGM, Eta, and Meso-Eta are compared with actual observed precipitation for the period. As in other parts of the western United States (Bright and McCollum 1995), orographic enhancement plays the dominant role in the observed patterns of winter season rainfall over southern California. This TA illustrates the effect of improvements in model terrain and resulting QPF performance.

The Terrain of Southern California

Figure 1 is a map of the coastal terrain of Southern California. Mountains extend west to east from north of Santa Barbara (SBA) to northwest of Palm Springs (PSP), then southward to the Mexican border. These ranges form a vertical barrier of at least 2500 feet between the Pacific Ocean and the Mojave Desert. The highest peaks are almost 10,000 feet in the San Gabriel Mountains northeast of Mount Wilson (MWS) and over 11,500 feet in the San Bernardino Mountains southwest of Big Bear (L35). Figure 2 shows the change in elevation from Los Angeles International Airport (LAX) to Mount San Gorgonio (near L35). By comparison, this rise in terrain easily exceeds that for a similar 100 mile distance east from Pike's Peak, on the front range of the Rocky Mountains, to a point on the eastern plains of Colorado.

NGM Terrain and QPF

Figure 3 (color) depicts the NGM terrain contours for both California and Nevada. Although the actual terrain is very rugged with steep mountains and desert basins--containing both the highest and lowest points in the 48 states--the model terrain shows only a gradual, continuous slope from the Pacific coast to the Nevada border. The highest model terrain in California reaches a peak of only 6500 feet along the Nevada border, southeast of Reno. Along the central coast of California, the model is unable to resolve the coastal ranges. In southern California, the highest terrain for the east-west mountain ranges is only 2000 feet, which is below the minimum contour for these mountains and well over a mile below the highest peaks. Finally, the NGM model terrain also shows a 1000 foot contour extending miles off shore from Santa Barbara all the way to San Diego.

Figure 6 shows the NGM QPF output for this event. Not surprisingly, the QPF axis is aligned northwest-southeast, parallel to the model terrain contours, with forecast accumulations over one-half inch confined to central and northern California. The heaviest amounts, in excess of two inches, were over the central valley near Sacramento. This area corresponds to the greatest slope in the NGM's terrain.

Eta Terrain and QPF

Figure 4 (color) shows the effective Eta model terrain for the same area as depicted for the NGM. The Eta terrain is only a slight improvement over the NGM. It reaches a peak elevation in California of 7500 feet and, in southern California, the highest terrain in the east-west ranges is up to 3500 feet--both numbers still over a mile below the actual mountains. Like the NGM, the Eta's QPF (Fig. 5 - color) is also aligned along its terrain. The heaviest amounts, now in excess of three inches, are also located along the steepest model terrain, similar to the NGM.

Meso-Eta Terrain and QPF

Figure 7 shows the improved terrain resolution of the Meso-Eta model (Black 1994). The coastal range is now distinct from the Sierra Nevada Mountains with lower heights clearly depicting the central valley. Peak Meso-Eta terrain for the California mountains is now over 9000 feet--still 3000 to 4000 feet short of the actual terrain. In southern California, the east-west mountains of the Santa Ynez, San Gabriels, and San Bernardinos are also much more distinct, yet still 2000 to 4000 feet too low. As with the central valley, the deserts are also more accurately depicted.

Figure 8 (color) shows the Meso-Eta QPF for January 10. Directly reflecting this model's superior terrain definition, the Meso-Eta QPF shows much more detail than either the NGM or the Eta. In contrast to these models, the Meso-Eta QPF depicts distinct precipitation maxima oriented along the east-west ranges of southern California, along the coastal ranges, and along the Sierra Nevada. The highest Meso-Eta forecast accumulations are over 6 inches along the western slopes of the southern Sierra and over 5 inches in Santa Barbara County.

Observed Precipitation and Model Performance

Observed precipitation maxima for the 24-hour period ending 00Z on January 11 are shown in Fig. 9 (color). The highest amounts, greater than 10 inches, fell on the east-west oriented mountains of Ventura and Santa Barbara Counties. In addition, there were secondary maxima of 5 to 6 inches along the coastal ranges of San Luis Obispo County and 4 to 5 inches on the western slopes of the Sierra Nevada Mountains, both northwest and south of Lake Tahoe.

Both the NGM and the Eta models seemed to do their best in handling the precipitation over the Sierra Nevada Mountains, however their maximum values were displaced over the central valley, too far to the west. The peak QPF values for the NGM (Eta) corresponded to 50 (60) percent of the maximum observed values. In contrast, the Meso-Eta forecast maximums for the Sierra were located along the western slopes of the mountains and amounts were in general agreement with the observed amounts, except for a slight overestimate in the southern Sierra.

Neither the NGM nor the Eta did well over the east-west ranges of southern California. While over 10 inches of rain was actually measured there, the NGM forecast was for less than half an inch. The Eta QPF was not much better. Although it forecast 2 inches of rain for this area, this was still less than 20 percent of what was actually observed. Both the Eta and the NGM forecast maximum precipitation along axes aligned north-south along their model terrain, rather than east-west along the actual ridge lines.

The alignment of the Meso-Eta QPF was much better. This model's forecast maxima was aligned east-west along the ridge lines, with a maximum over southeastern Santa Barbara County of more than 6 inches. However, this was still only 60 percent of what actually fell there.

Conclusions

Although this is only one example, it clearly illustrates the effect model terrain has on resulting QPFs. Simply stated, models which allow for advections through solid granite cannot hope to produce accurate QPFs, regardless of the sophistication of their physics.

Further, this example supports the conclusion that improved model terrain resolution will result in improved forecasts. As a direct result of its greater terrain resolution, the Meso-Eta shows the potential of being an important tool for forecasting winter season precipitation in southern California.

Finally, this example also illustrates the biases existing models have for distributing precipitation based on oversimplified model terrain. Clearly, it is just as important for forecasters to understand the model terrain for their forecast area as it is for them to know the actual terrain.

References

Black, T.L., 1994: The New NMC Mesoscale Eta Model: Description and Forecast Examples. *Wea. Forecasting*, **9**, 265-278.

Bright, D. and D. McCollum, 1995: A Case Study of Mesoscale Orographic Enhancement of Precipitation in the Santa Catalina Mountains of Arizona. Western Region Technical Attachment No. 95-35, 10 pp.

Horel, J., 1995, Unpublished. University of Utah. Figures 8 and 9.

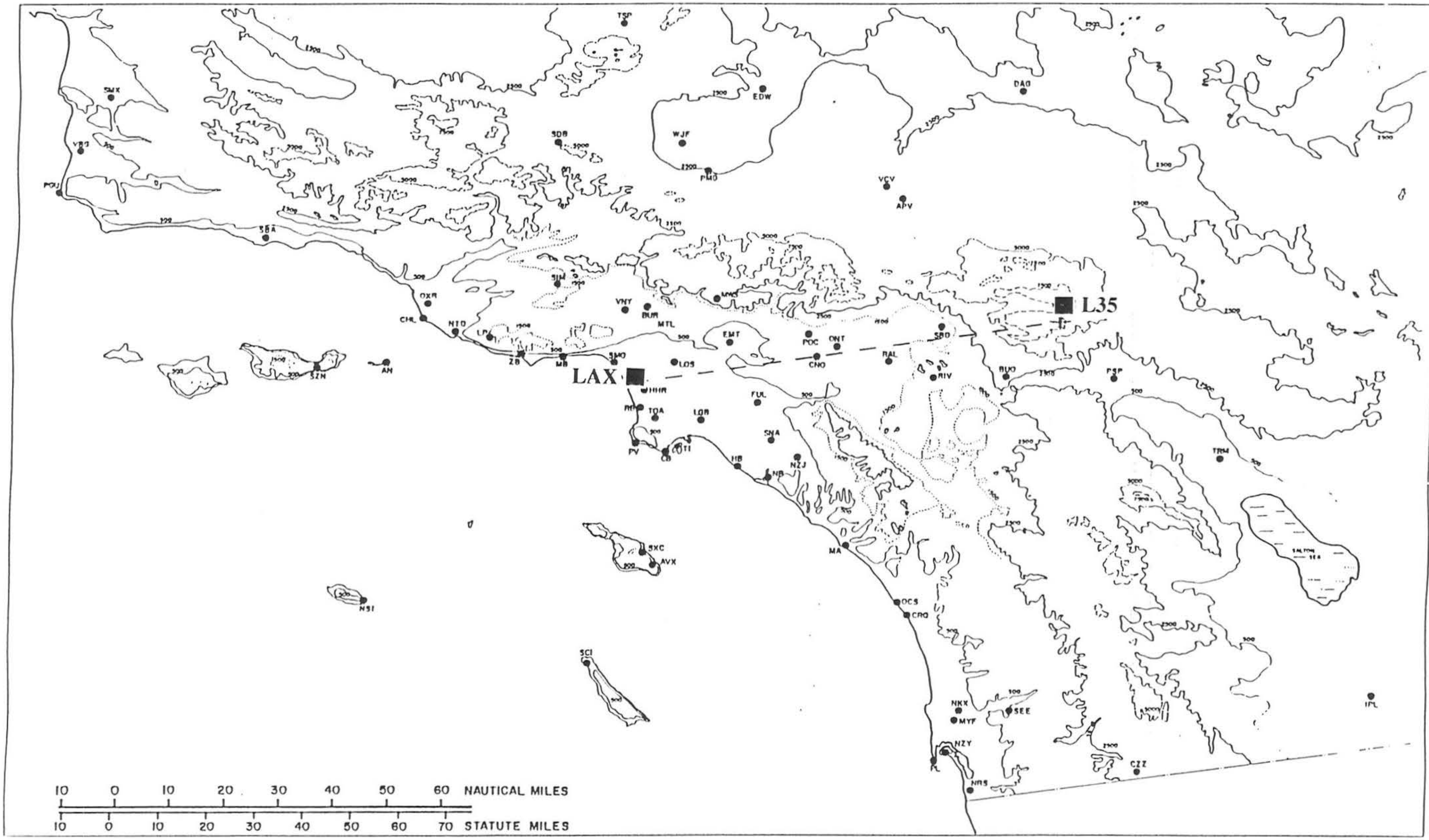

Figure 1 Southern California coastal terrain

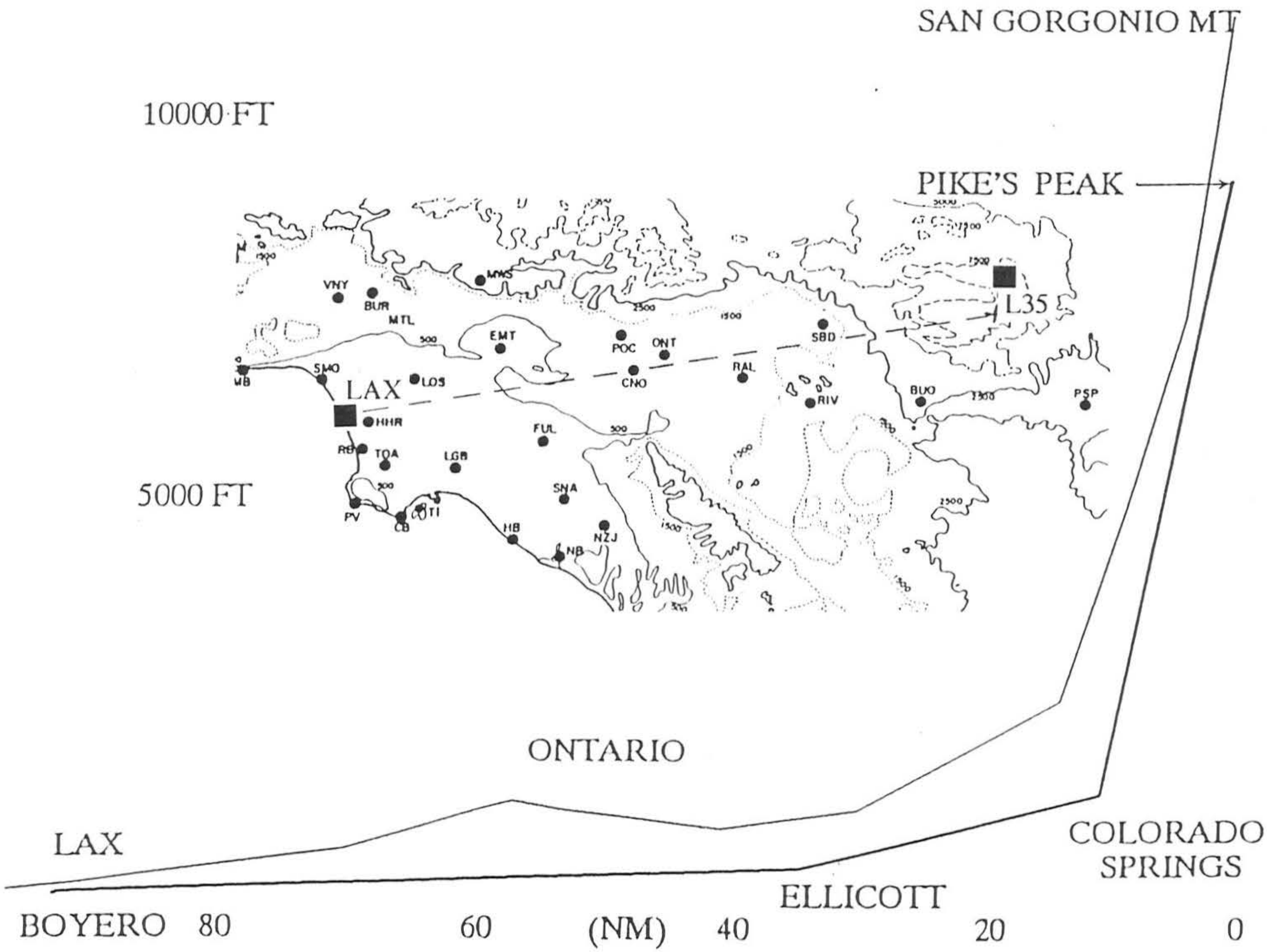

Figure 2 Comparison of southern California coastal terrain with the Colorado front range

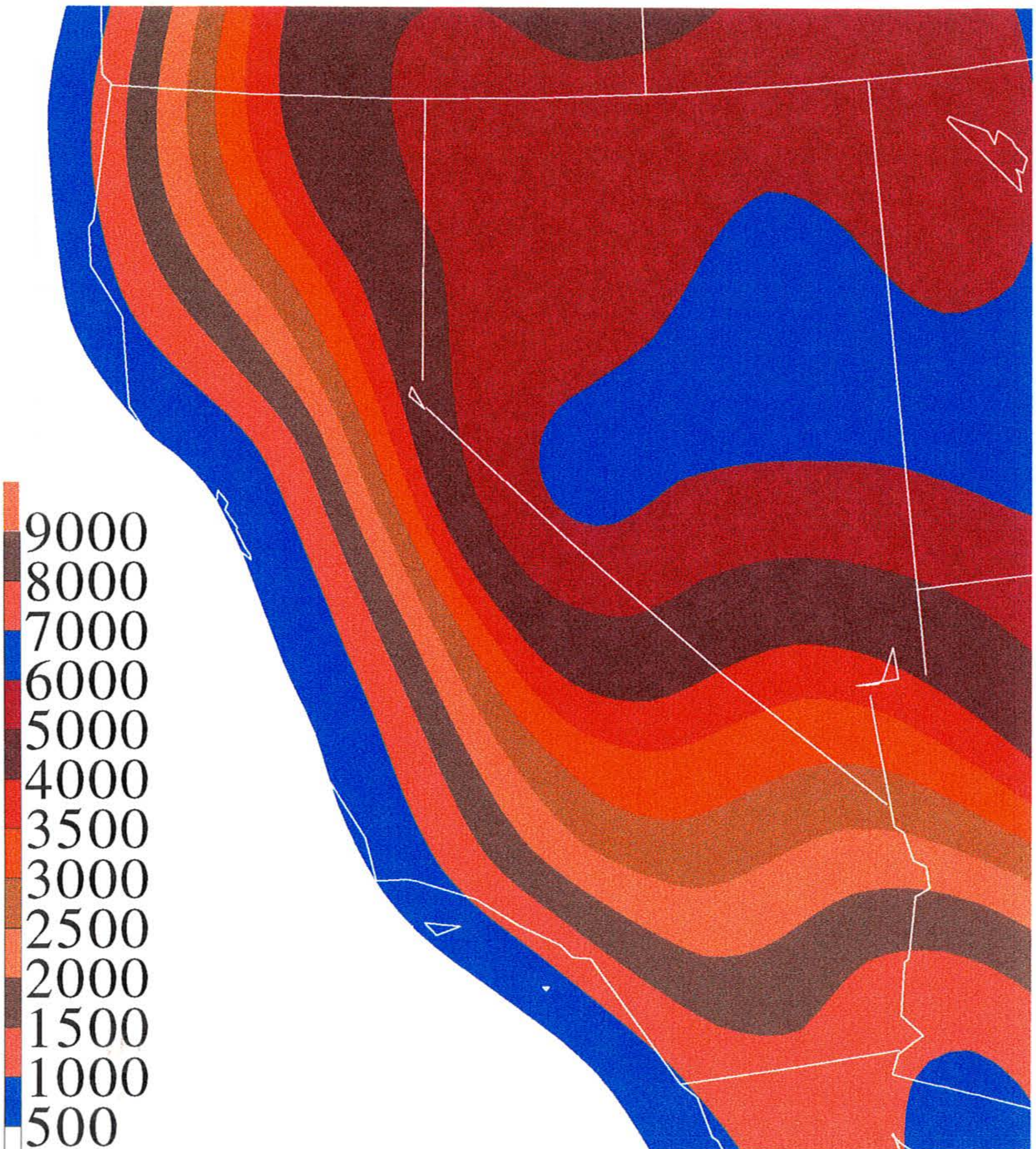

Figure 3 NGM Terrain (Feet)

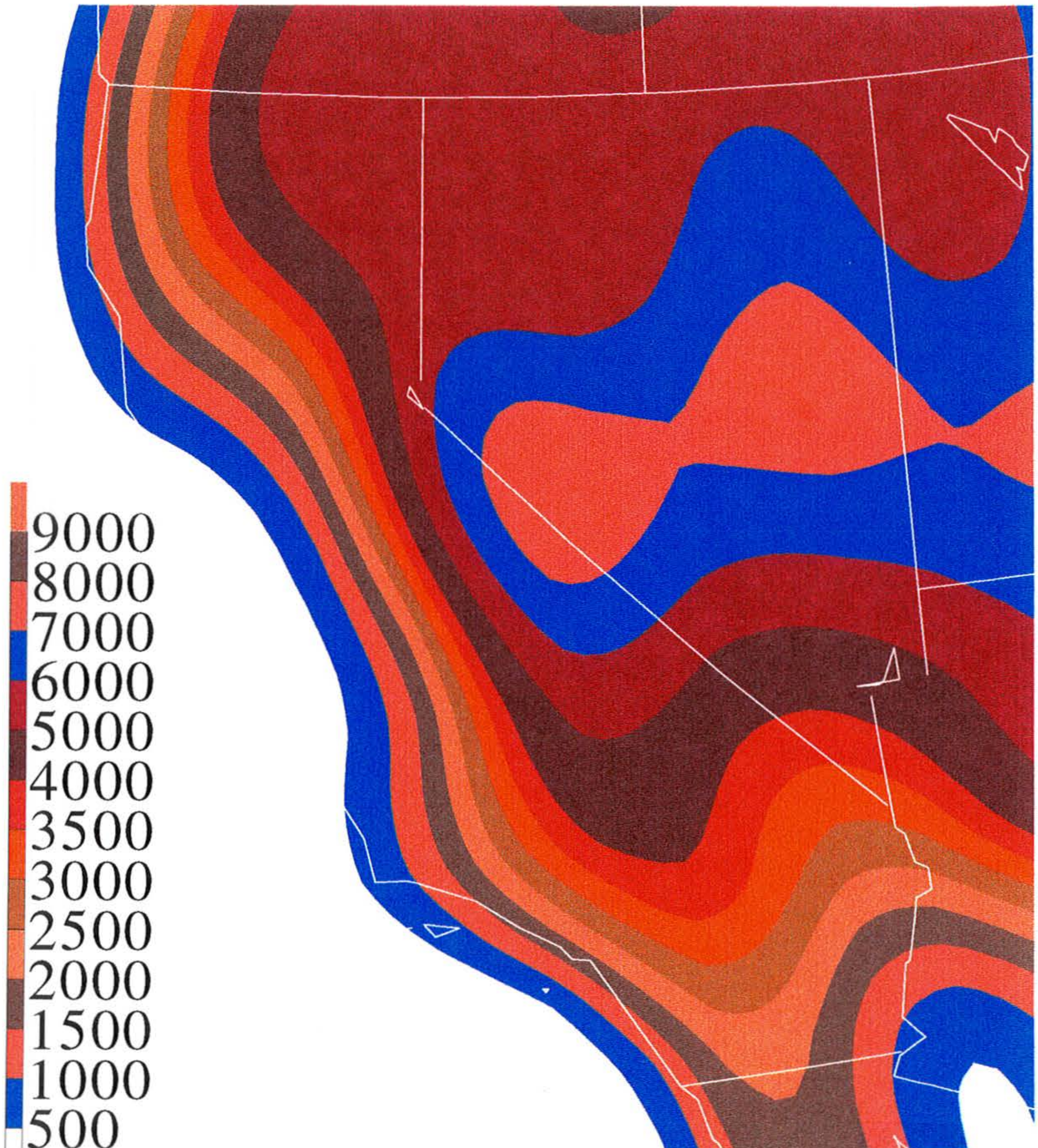

Figure 4 Eta Terrain (Feet)

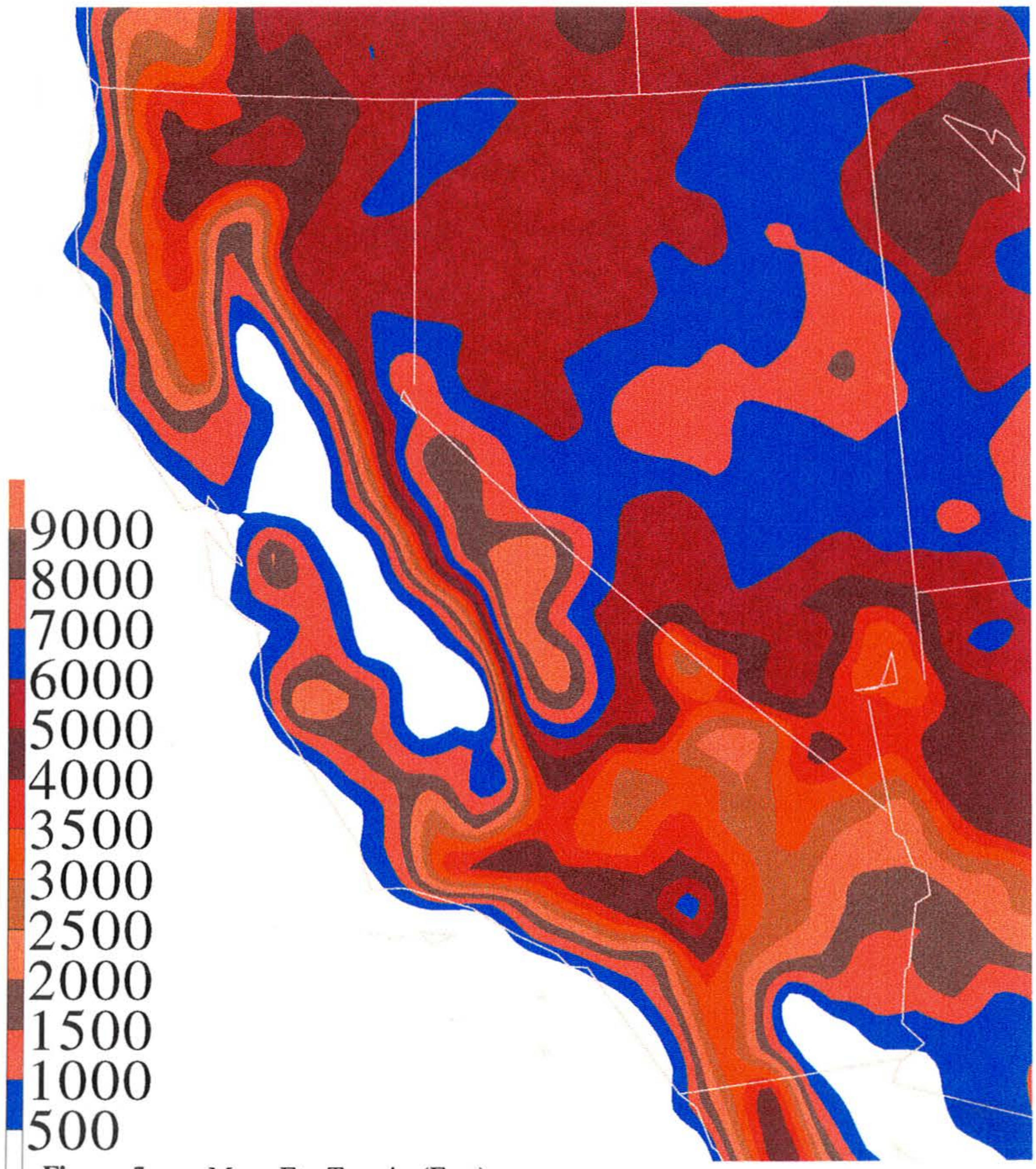

Figure 5 Meso-Eta Terrain (Feet)

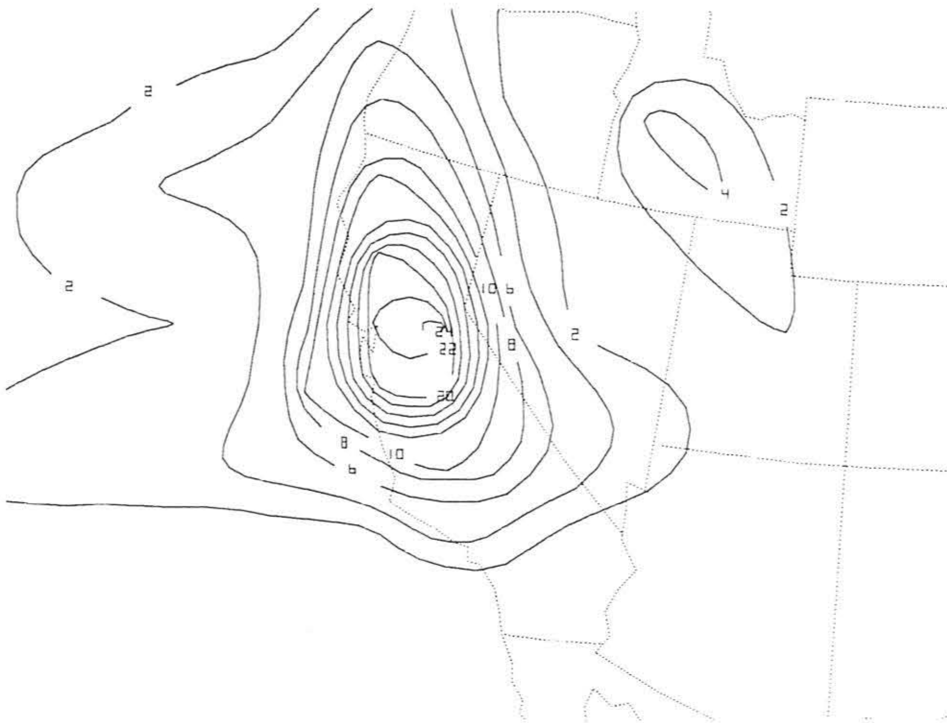

Figure 6 NGM QPF for the 24-Hour Period Ending 00Z, 11 January 1995 (Tenths of Inches)

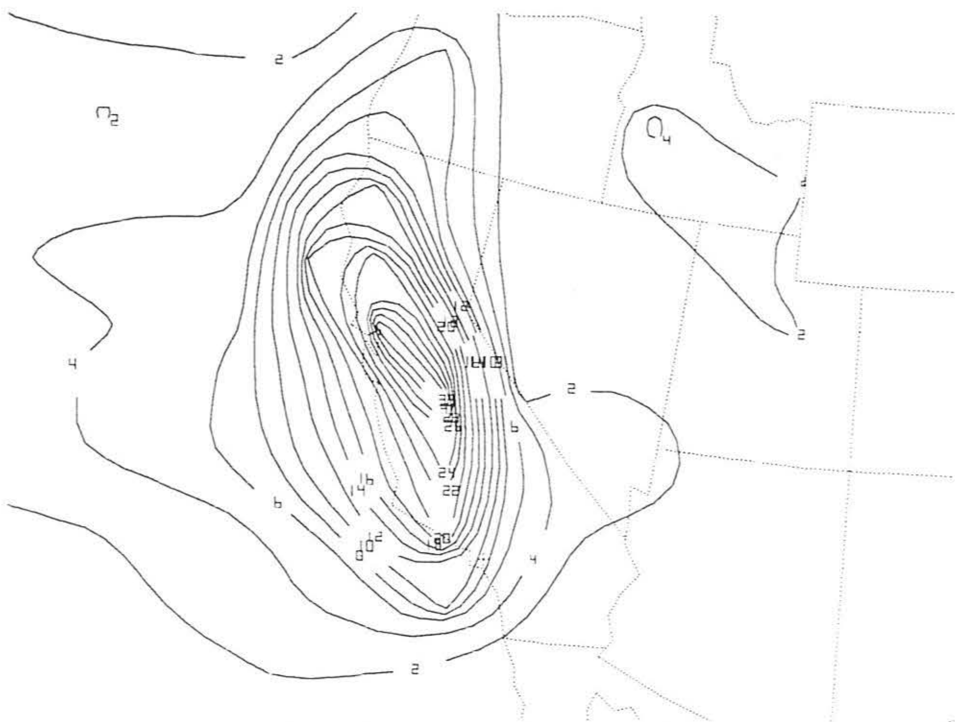

Figure 7 Eta QPF for the 24-Hour Period Ending 00Z, 11 January 1995 (Tenths of Inches)

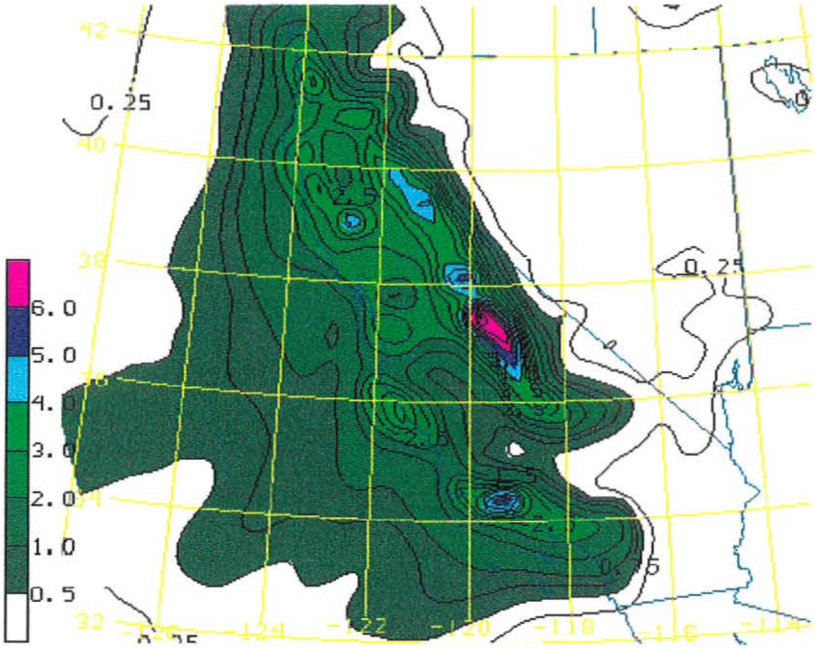

Figure 8 Meso-Eta QPF in Inches for the 24-Hour Period Ending 00Z, 11 January 1995 (University of Utah)

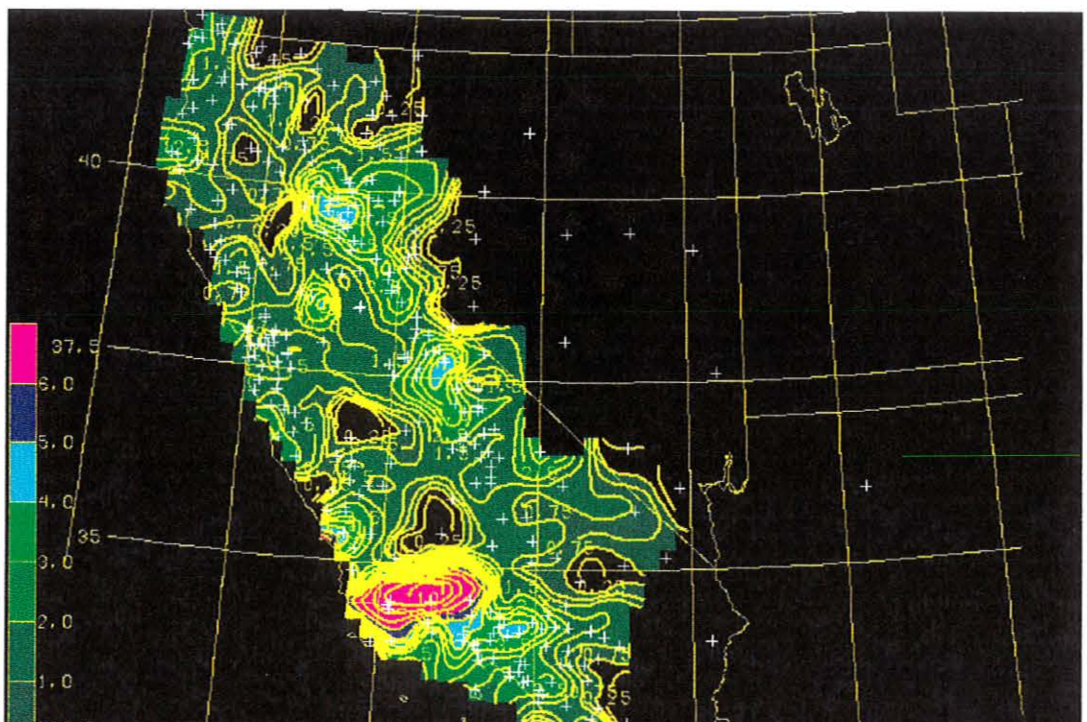

Figure 9 Observed Precipitation in Inches for the 24-Hour Period Ending 00Z, 11 January 1995 (University of Utah)