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THE BENEFITS OF HIGHER RESOLUTION IN REPRESENTING TOPOGRAPHY

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INTRODUCTION

As computer resources continue to increase, the possibility of higher resolution operational numerical weather models become more of a certainty. In 1993, the Eta model replaced the LFM as the 'early' model run with 80 km resolution and 38 vertical layers (Eta-80). In 1996, the model's resolution was improved to 48 km while continuing to keep 38 layers in the vertical (Eta-48). Also in 1996, an even higher resolution version of this model was made operational and has proven to be a superior model in terms of low-level features and QPF (Staudenmaier, 1996, Burks and Staudenmaier, 1996). This model, the Eta-29 (commonly referred to as the Meso Eta model) has 29 km horizontal resolution and 50 vertical layers. In 1997, an even higher resolution model will become available for an evaluation period to forecasters in the Western Region. This model, the Eta-10 will have 10 km horizontal resolution and 60 vertical layers. This Technical Attachment (TA) will compare the three different resolutions of the models (Eta-48, Eta-29, and Eta-10) in how they resolve topographical features in the Western Region.

THE DERIVATION OF TOPOGRAPHY

In all three models, the derivation of topography is done nearly the same. The model topography is represented as discrete steps whose tops coincide exactly with one of the model's vertical layer interfaces (Black, 1994). In determining their elevations, each grid box is first divided into subboxes. Sixteen subboxes were used in the Eta-48 and the Eta-29, while 64 subboxes were used in the Eta-10. Mean elevations for each of these subboxes are calculated from official United States Geological Survey (USGS) topographical data. In the Eta-48 and Eta-29 models, 10 minute data were used, while in the Eta-10 model, 30 second data were used. Using these values, the maximum mean value from each of the rows and columns is determined, resulting in intermediate terrain values. The mean of these row/column mean values is taken to yield an intermediate value for the step height for that grid box. Having already determined the height of each model interface based on the standard atmosphere and the specified distribution of vertical resolution (38/50/60 vertical layers), the final step elevation is found by moving the mean either up or down to match the closest layer interface in the model domain. Additionally, the grid box is checked to make sure that it isn't in a hole (the surrounding grid points are higher than the grid box in question). If this is the case, the grid box is raised to the level of the closest surrounding grid box so that convergence can occur in the box, along with vertical motions. Along steep slopes of topography, a Laplacian is used to adjust the model topography to approximate the curvature of the real slope. This is done to avoid unwarranted horizontal spreading of regions of elevated topography.

THE ETA-48

Figure 1 shows the model terrain for the Eta-48 model. As one would expect, it is very smooth, with very little detail in the topographical features. Important aspects of this figure to note are that 1) the Sierra Nevada Mountains in California have a peak elevation of only around 7800 feet, 2) there is no Central Valley in California, and only a poorly defined Snake River Valley in Idaho, 3) the Cascade Mountains of Washington and Oregon are poorly defined, and 4) there are no indications of isolated mountains like Mount Olympus in Washington or deep valleys like Death Valley, in California.

THE ETA-29

Topography in the Eta-29 fairs much better as many more details begin to appear (Fig. 2). The Sierra Nevada Mountains now have a peak elevation of near 9500 feet, still below reality, but getting closer. The peaks of the Sierra Nevada Mountains are now located near reality as well, in California, as opposed to being located on the California/Nevada border in the Eta-48. There is now a well-defined Central Valley in California, although the Coastal Range Mountains separating it from the Pacific Ocean are still poorly defined. The Snake River Valley is well defined although both it and the Central Valley still suffer from the model surface being higher than reality. The Cascade Mountains of Washington and Oregon are much better defined with a Columbia River Gorge now becoming evident. Mount Olympus still is not resolvable; however Death Valley is now becoming noticeable, even though it is more than 3000 feet higher in the model than in reality. In the Great Basin, the series of southwest-northeast oriented mountain ranges are not resolvable, and due to the way topography is derived, contribute to some locations being some 2000-3000 feet higher in the model than in reality, leading to all surface data and some sounding data being lost during the assimilation process (Staudenmaier, 1996).

THE ETA-10

Examination of the Eta-10 model topography (Fig. 3) clearly indicates the vast improvement in model resolution over the Eta-29 model. Many topographical features, which were only hinting at before, are now clearly defined. The Sierra Nevada Mountains now resolve peaks more than 11000 feet, with the orientation and location of the crest of the mountains in the correct location. In fact, the double structure of the mountains separating California and Nevada can now be shown with the White Mountains now resolvable east of Bishop. The Central Valley of California and the Snake River Valley of Idaho both show up clearly in the figure, with most elevations very close to reality. The Coastal Range Mountains of California are now well defined, with the Trinity Alps now visible. The Cascade Mountains have clearly defined peaks, even though many of them are still not high enough, as compared to reality. Mount Olympus is now clearly visible, although about 1000 feet shorter than reality. Other mountain peaks like Mount Shasta and Mount Lassen in California are now resolvable, but also are not tall enough. Death Valley is also visible, and is now only about 1000 feet too high.

CONCLUSIONS

The increase in resolution from 80 km to 48 km to 29 km has led to increasingly more accurate numerical forecasts especially in terms of low-level temperature and wind fields and QPF forecasts. The higher resolution of the Eta-10 should only continue this trend of more accurate forecasts. Now that specific mountain ranges and valleys are now being resolved, surface parameters like temperature and wind should be more accurate and useful to forecasters. The impact of better resolution on precipitation patterns has been shown to be very important to the Western Region, and with the higher resolution model, it appears that QPF forecasting will experience the greatest impact with this model, as specific precipitation maxima over specific river basins will now become resolvable. The model will still suffer from bias and from parameterization schemes that do not work perfectly as in the Eta-29 but, clearly, this model should improve the forecaster's ability to create a more specific and accurate forecast for the public, emergency managers, and other customers.

REFERENCES

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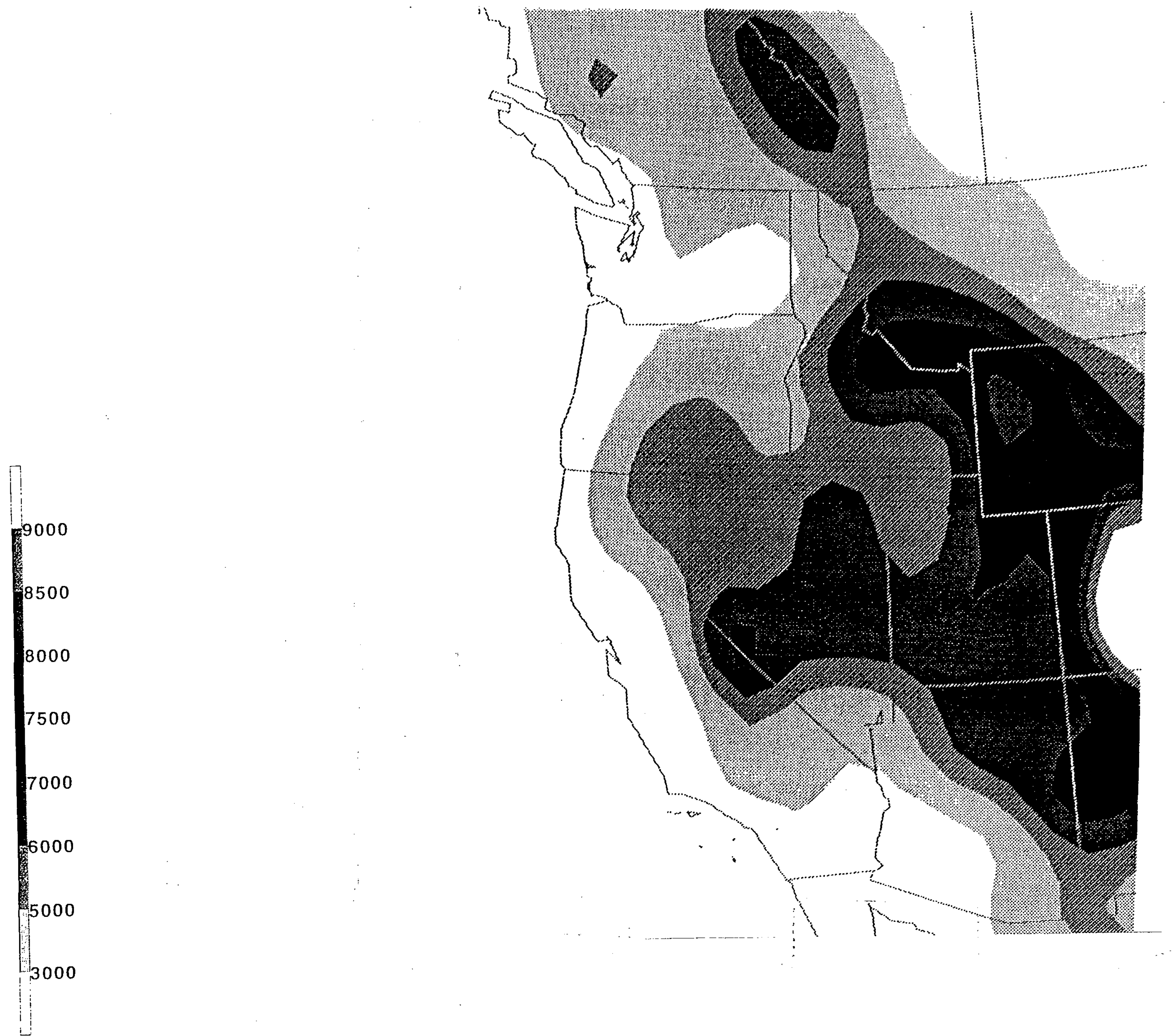

Figure 1: Eta-48 topography

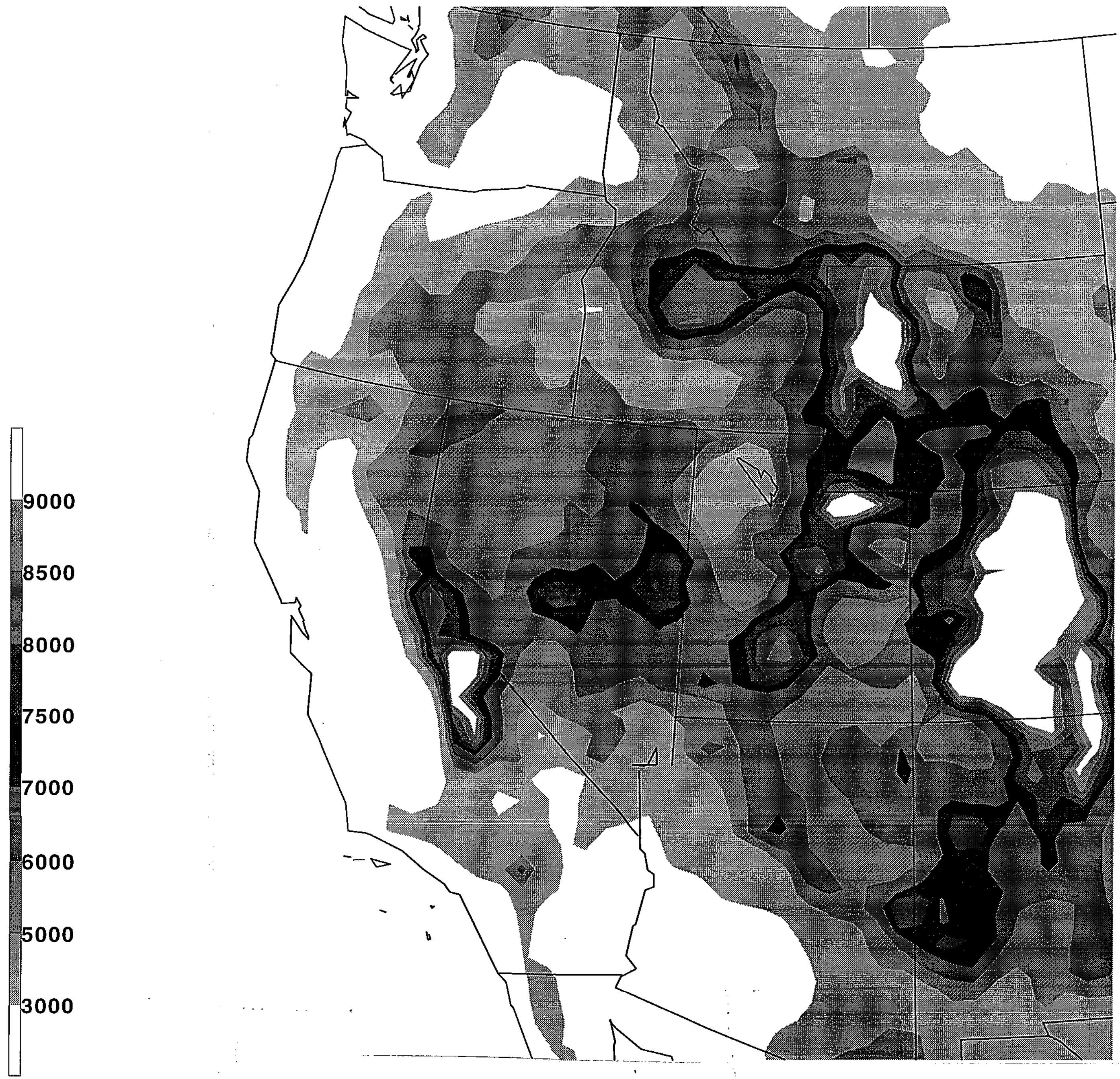

Figure 2: Eta-29 topography

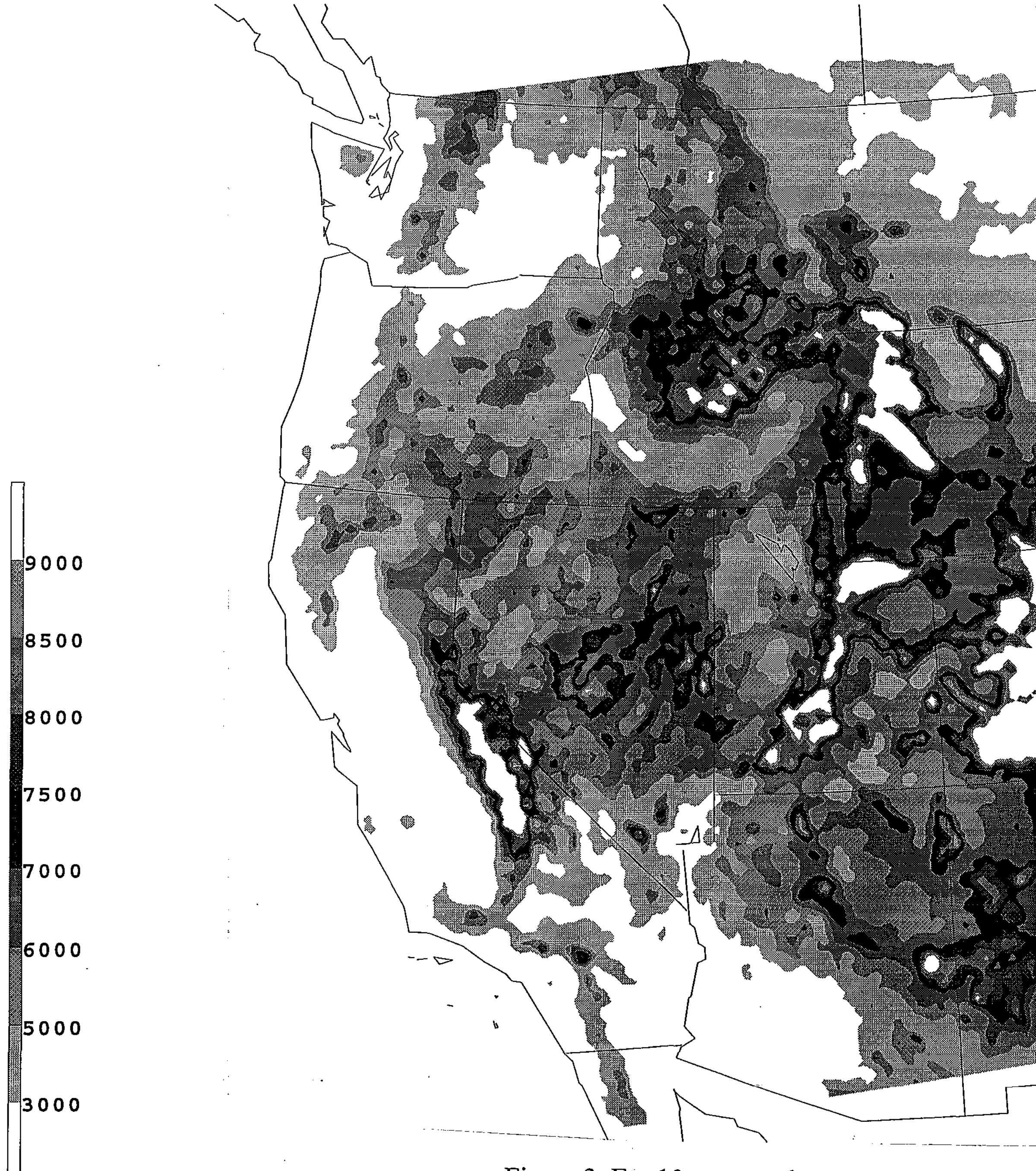

Figure 3: Eta-10 topography