OPTIMIZING OUTPUT FROM QPF HELPER

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1. Introduction

QPF Helper is a GFE smart tool created by Ken Pomeroy at WR/SSD. It is designed to improve forecasts in complex terrain as it enables the forecaster to incorporate climatology into the QPF process. A monthly PRISM climatology grid is used as a base. QPF Helper samples point values from this input grid or the points can be preset with data from either a model grid or an inherited forecast grid. Once these editable values are set, the user has the option of using a Mountain Mapper algorithim or a Serpentine analysis to fit a surface to the changes. These changes are then added onto the existing base grid to create the QPF gridded forecast.

The goal was to optimize the output from the QPF Helper Smart Tool by utilizing the example of 3 wet storms that occurred in the Medford CWA in the winter of 07-08: January 4th, January 31st, and February 3rd. QPF grid verification was performed by comparing the forecast to a gridded estimate of precipitation, the QPE. The QPE creates an estimation of rainfall amounts by utilizing both remotely sensed data (radar, satellite) and 'ground truth' observations (rain gages). This data is quality controlled at the River Forecast Centers.

2. Potential weaknesses of QPE

An analysis of the QPE was performed for each event in order to determine if there are any means in which the NWRFC and CNRFC may enhance the representativeness of the QPE. Considering any weaknesses of the QPE should result in a more robust analysis of the accuracy of the QPF Helper generated QPF grids.

A few potential issues with the representativeness of the QPE file came to light. First, in the winter season, RAWS data can be contaminated by snowmelt. Care should be taken that contaminated and missing observations are stricken from the data set. Although quality control would be necessary, an additional consideration would be whether including data from CocoRaHs (the Community Collaborative Rain, Hail and Snow Network) volunteer observers would make the QPE more robust.

Most notably, there is a persistent discontinuity along the border between the NWRFC and CNRFC. This disparity is apparent when comparing Figure 1 (the QPE file for the 12-hour period ending at 00Z on Feb 01), with Figure 5 (a topographic map with cities and county names of the WFO Medford CWA -- the RFC border indicated by the red line). The effect is pronounced along the crest and on the east side of the Cascades where values from the CNRFC are much too low. The problem is similar at the border through the higher terrain of Eastern Klamath County and Western Lake County. A solution would be for offices to include data from beyond their area of responsibility.

3. QPF Helper Analysis

The extent to which QPF Helper results in an improvement over simply loading a model grid is quite clear. To demonstrate, Figure 2 is a graphic of the GFS40 QPF for the six-hour period ending at 06Z on February 3rd, 2008. It demonstrates the dearth of terrain effects in the GFS 40.

Figure 3, the NAM12 forecast for the same period, shows limited improvement. It shows the effects of terrain but in fact had excessive QPF at the higher elevations and QPF that was too low in valleys. In particular, the downslope effects in the Rogue Valley and Shasta Valley are exaggerated. While Figure 4, the actual QPF forecast created using QPF Helper with the PRISM climatology as the background field, markedly represents the presence of complex terrain. The actual topography is illustrated in Figure 5.

Post-event data from QPE grids was input into QPF Helper in order to compare the accuracy of forecast grids generated with QPF Helper. The data utilized came from the default sample set for QPF forecasts at WFO Medford: 'QPS Points.' These 13 points are: North Bend, Brookings, Illahe, Steamboat, Riddle, Sexton Summit, Williams, Crater Lake, Medford, Klamath Falls, Oak Knoll, Sawyers Bar, and Mt. Shasta City.

Figure 6 is a grid indicating the difference between the values in a QPF Helper created forecast grid and the QPE for the six-hour period ending at 06Z on February 3rd. A close inspection of Figure 6 indicates where the QPF field generated by inputting the QPE values into QPF Helper fails to closely reflect the QPE result. Excepting the previously mentioned discrepancy along RFC borders, the QPF Helper generated amounts are generally too high at valley locations including Southeast Siskiyou County, southern portions of the Rogue Valley, and much of the Illinois and Umpqua Valleys. It also tended to generate amounts that were too low at ridges including the coastal range near Brookings and east of North Bend, most of the Umpqua Divide, the Southern Oregon Cascades, much of the higher terrain of Siskiyou County, and Western Lake County. Two exceptions are that it forecast totals that are too high over the higher terrain of Northeast Douglas County and the most readily apparent error is a bulls-eye of low amounts around North Bend.

Additional cases were examined to check if this was typical behavior. The 12-hour period ending at 00Z on January 5th, 2008 was a case of strong southerly low and mid-level flow. As shown in Figure 7, the QPF Helper again generated QPF that was lower than the QPE for the Siskiyou County Mountains and the coastal range east of North Bend. Meanwhile, the strong downslope flow in southern Jackson and Douglas Counties was the likely culprit for QPF Helper over-forecasting QPF amounts. Amounts were also too high over much of the area east of the Cascades. However, this discrepancy likely results from the slow moving storm having not traveled far enough east to fully impact the entire area east of the Cascades.

4. Experimenting with the Sample Set

It was surmised that one way to reduce these differences between the QPE and the QPF Helper grids would be to add additional sample points. The number of sample points and their location should be selected with care. Utilizing a larger sample set would require more time to create the QPF gridded forecasts, which could eventually become a workload issue. In fact, utilizing more points does not automatically result in an improved QPF forecast. Adding the points of Powers and Elkton in Coos County to the Jan 4^{th} 12Z – Jan 5^{th} 00Z QPF grid increased precipitation amounts along the entire coast by 0.10 to 0.30 in. The greatest reduction in error was located along the higher terrain separating Northeast Coos County and Western Douglas County. However, this increase also impacted the QPF forecast for the Coquille Valley with an increase of 0.10 to 0.20 in. This improved results in much of the bulls-eye area around North Bend but over-corrected for central portions of the valley and noticeably worsened the results in the southern portion of the valley. The general effect was to reduce the gradient of QPF between the Coquille Valley and ridge locations. To avoid these errors, it is suggested that sample points should be evenly spaced and evenly distributed by elevation. Other important considerations are that it would likely be advantageous to show preference in selecting sample points, which have verifying observations and locations with which forecasters are already familiar.

The current set of QPS points represents the varied terrain of the forecast area, but it was surmised that they might be too greatly dispersed. The comparison of the QPE (Figure 8) and QPF Helper generated forecasts (Figure 9), and an analysis of the PRISM climatology grid for January 2008 (Figure 10) suggested the creation of six additional points: Burnt Ridge, Illinois Valley, Howard Prairie, Chemult, Tennant, and Alturas. These new points are indicated by hatched rectangles in Figure 10. The effect of adding these points into the QPS Points data set and re-running QPF Helper can be seen in Figure11.

Burnt Ridge is a RAWS site in the coastal range of Eastern Coos County. It will enable the forecaster to more precisely forecast for the higher elevations of the coastal range and has the advantage of being centrally located between the existing points at North Bend, Illahe, and Riddle. Adding Burnt Ridge had the greatest positive impact on the January 4^{th} case. The higher QPF at ridges in Northeast Coos and Western Douglas Counties was more representative and adding the point decreased the size of the bulls-eye over North Bend.

Illinois Valley is another RAWS site. It is located at the Illinois Valley Airport in Southwest Josephine County. It is centrally located between the existing points of Illahe and Sawyers Bar, and also between Brookings and Williams. Adding the point reduced the QPF error at Illinois Valley by more than 30%, but lowered amounts spread into the Siskiyou Mountains of Southeast Josephine County and Northwest Siskiyou County. Adding a point at Illinois Valley would only be beneficial if the area of impact or mountain influence could be reduced.

Howard Prairie only has daily data from a cooperative observer. But, it is a key location near two major passes over the southern Oregon Cascades and Siskiyou mountains. It has the advantage of being centrally located between the existing points at Crater Lake and Oak Knoll. In this case, there was little difference from adding the point. While the point was not necessary in this particular instance, there are frequent instances when the QPF in the vicinity of Howard Prairie could differ significantly from Crater Lake and Oak Knoll. It bodes well that adding the point in this case did not negatively impact the forecast.

Chemult in Northern Klamath County is another cooperative observer site. It is a high mountain valley located near the border between the NWRFC and CNRFC. Border issues negatively impacted the QPE. The QPE reported 0.08 inches while the observer reported 0.65 inches. This point is likely unnecessary as the relationship between Chemult and the QPF entered at Crater Lake and Klamath Falls is reflected well. However, the analysis shows the importance of repairing the QPE over Northern and Eastern Klamath County.

Tennant is located near the eastern slopes of the Northern California Cascades. It is centrally located between Mt Shasta City and Klamath Falls. Using the PRISM climatology, QPF Helper generated an amount over an inch less than actually occurred on January 4th. Another result was excessive QPF generated in the lower elevations of Southeast Siskiyou County in the vicinity of the Ash Creek RAWS. Improving the forecast in this area proved to be problematic. Adjusting the QPF at Tennant up or the QPF at Ash Creek down worsened other areas in Southern Siskiyou County.

Alturas is an ASOS site representing the valleys of Modoc County in Northeast California. The main benefit of Alturas is its impact on Modoc and Lake Counties. This is an area larger than the state of New Jersey in which there are no points utilized in QPF Helper. Climatologically, the rainfall at Alturas is very similar to Klamath Falls. But, adding a point will more easily allow forecasters to account for differences in duration of rainfall at the two points.

5. Other Suggestions for Improving QPF Forecasts

During strong westerly low-level flow, precipitation amounts are typically greatest along the coastal range and southern Oregon Cascades. Adjusting the PRISM influence higher will raise the QPF in mountain locations and lower it in valleys. This should work well for an instance of high-based thunderstorms. However, this would not be meteorologically sound given the extreme differences between the cases of westerly flow and southerly flow. Adjusting the PRISM influence would change values at all ridges and valleys rather than just those impacted by the low level winds.

One possible solution is to create edit areas comprising areas that will be affected by upslope or downslope conditions given a wind direction. Alternatively, an idea for further study would be to quantify an adjustment factor to climatology for these situations when conditions are known to deviate from normal. This special event climatology could be added as another QPF source.

6. Conclusions

Strict quality control of the QPE file is needed to keep it from being contaminated by missing data or snowmelt at RAWS stations.

The QPE file clearly indicates the border between the CNRFC and NWRFC. Each office including points across the border in their analysis would enhance the accuracy of the QPE. While the analysis from both offices would benefit, the data suggest it is more imperative that the CNRFC begin including data from the NWRFC.

QPF Helper generated forecasts for WFO Medford can likely be improved by placing additional points at: Burnt Ridge, Howard Prairie, and Alturas. Additional points at Illinois Valley, Chemult, and Tennant would likely be helpful if the areal impact could be lessened. In general, it is suggested that sample points should be evenly spaced and evenly distributed by elevation. This will reduce overlapping the influence of point data. Care should be given to determine any areas that are weakly influenced or not influenced at all by the current sample set. Another important consideration is that it would likely be advantageous to select sample points with verifying observations.

QPF Helper's terrain adjustments could likely be improved by creating an adjustment factor for low-level wind direction. In the southerly flow case of Jan 31st, the QPF Helper representation of the QPE grid underestimates precipitation amounts in Southern Siskiyou County. While QPF Helper representation of the QPE grid from the Feb 03rd case with low-level westerly flow overestimates precipitation amounts in the same area.

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Ken Pomeroy: QPF Helper Training for Focal Points. http://ww2.wrh.noaa.gov/SSD, Website accessed 3/06/08.

***Figures*: Below**

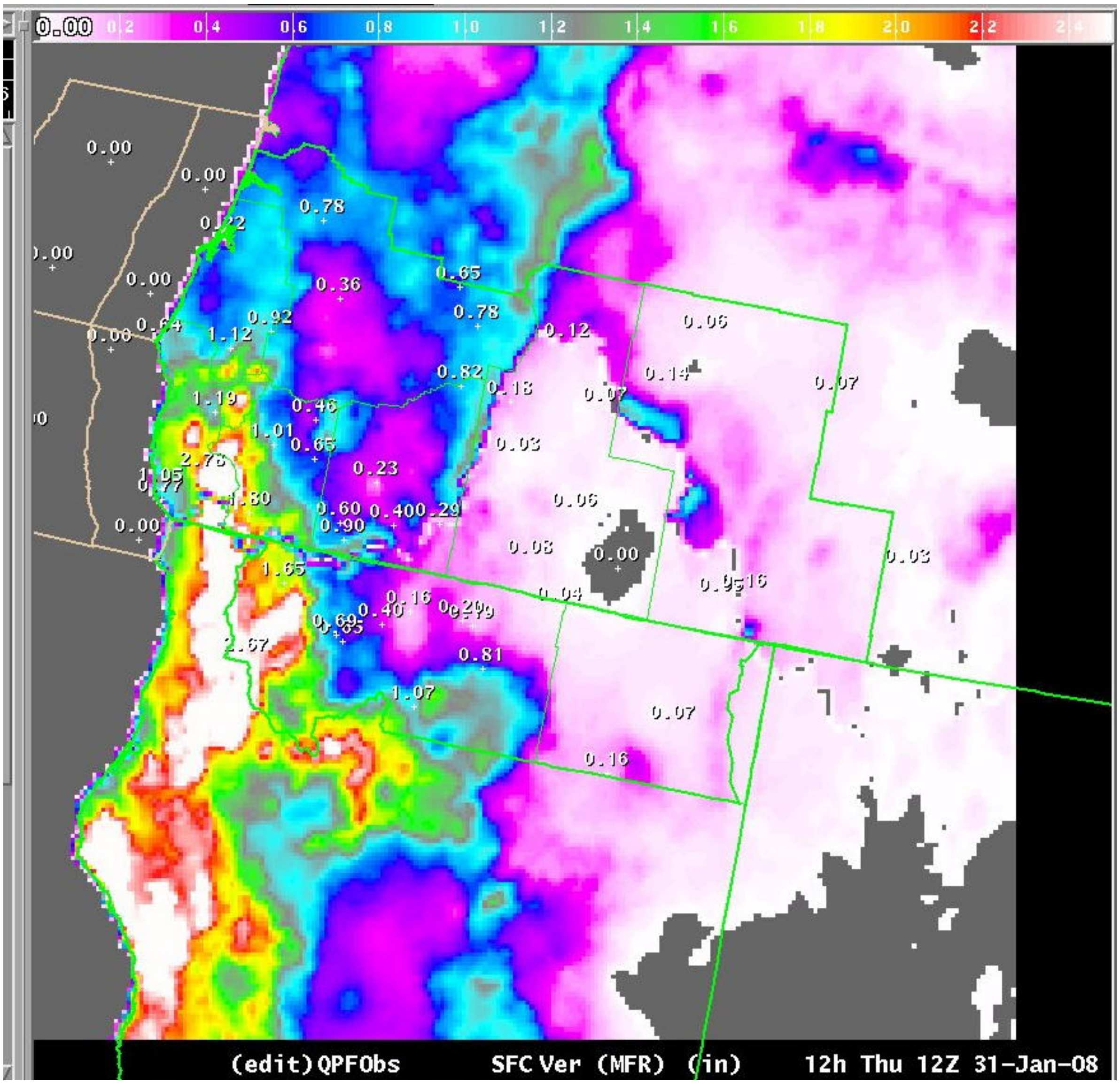

Figure 1. 12-hour QPE (in.) ending at 00Z February 1, 2008.

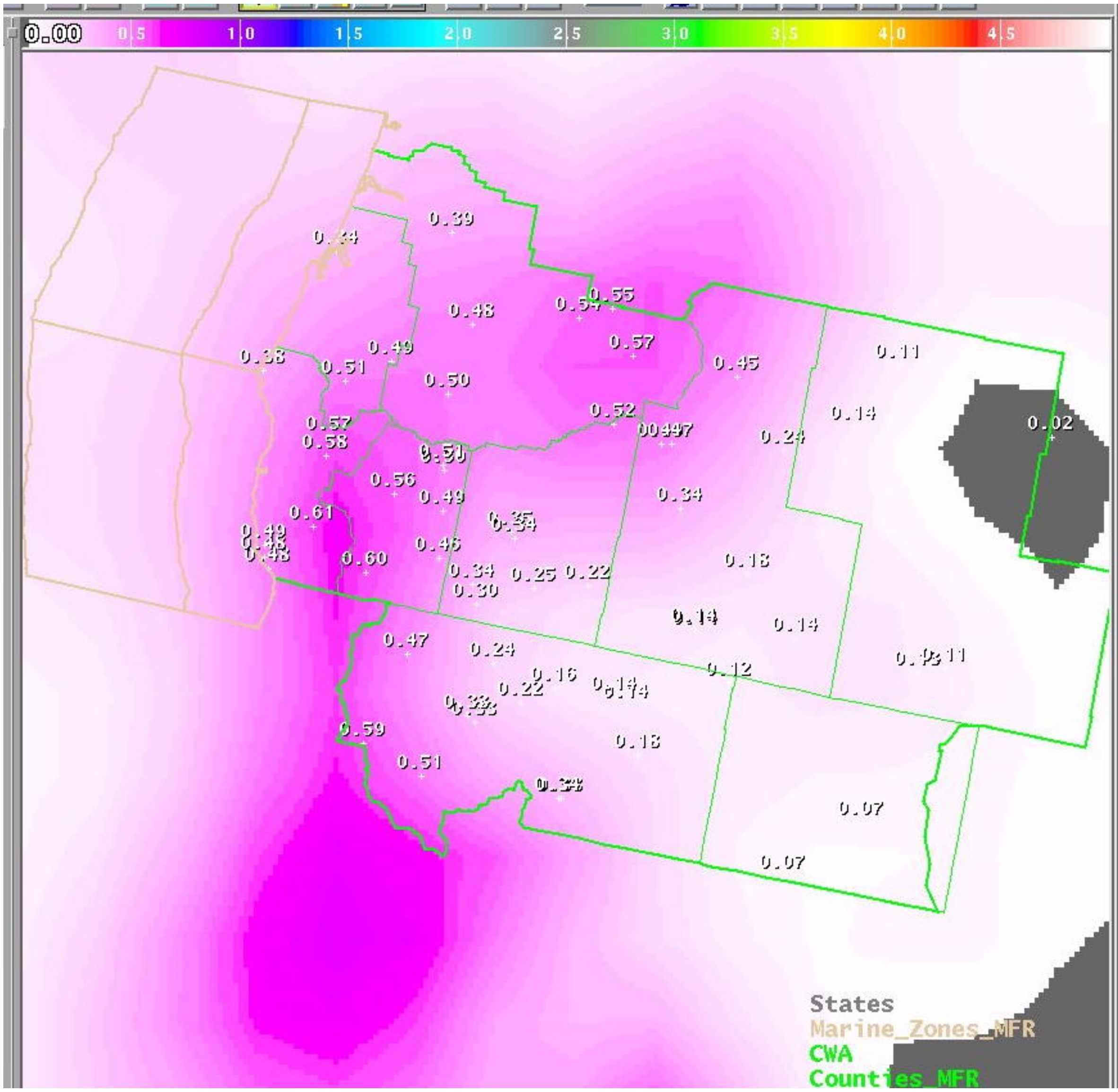

Figure 2. 6-hour GFS40 QPF (in.) ending at 06Z February 3, 2008.

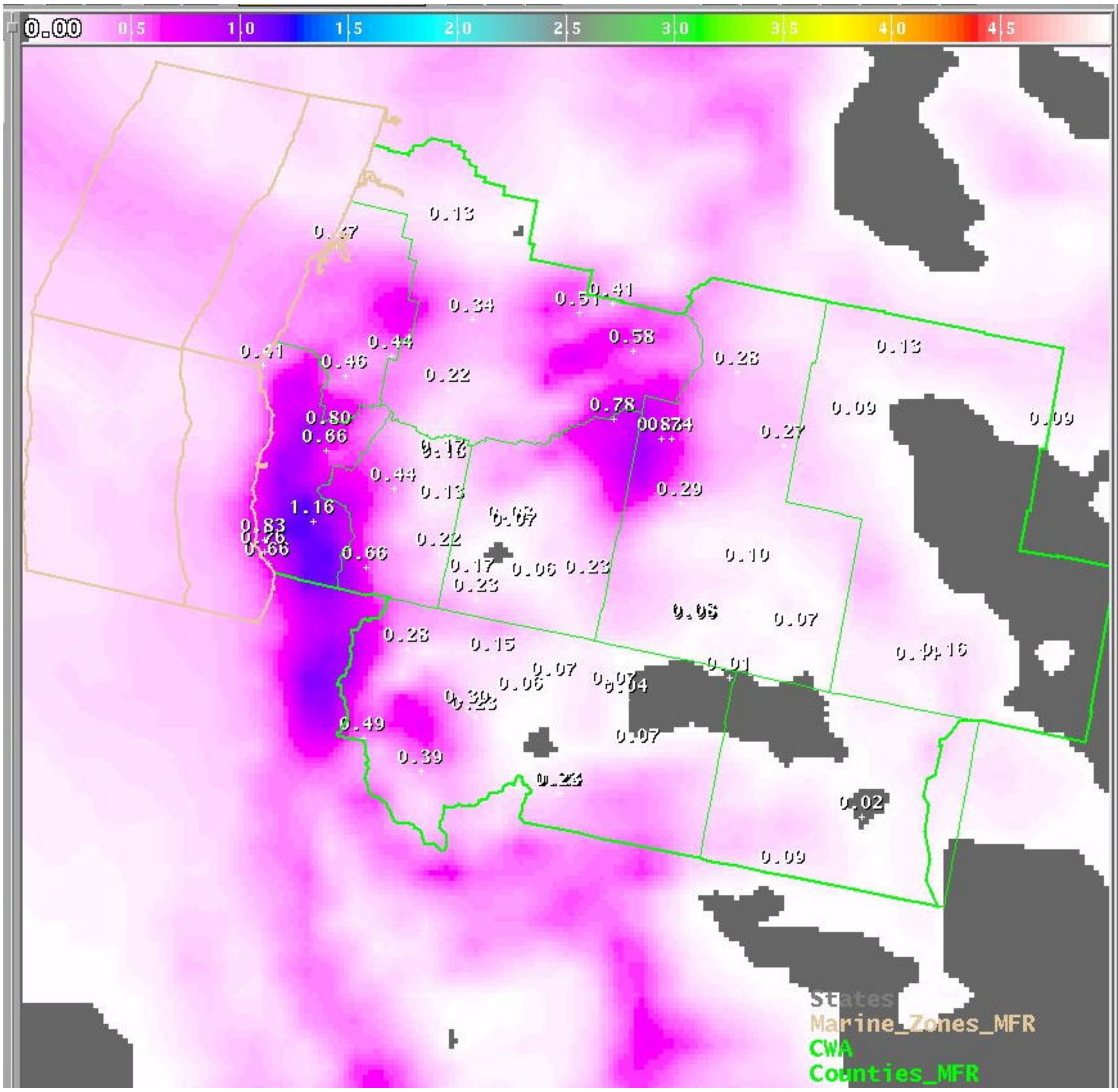

Figure 3. 6-hour NAM12 QPF (in.) ending at 06Z February 3, 2008.

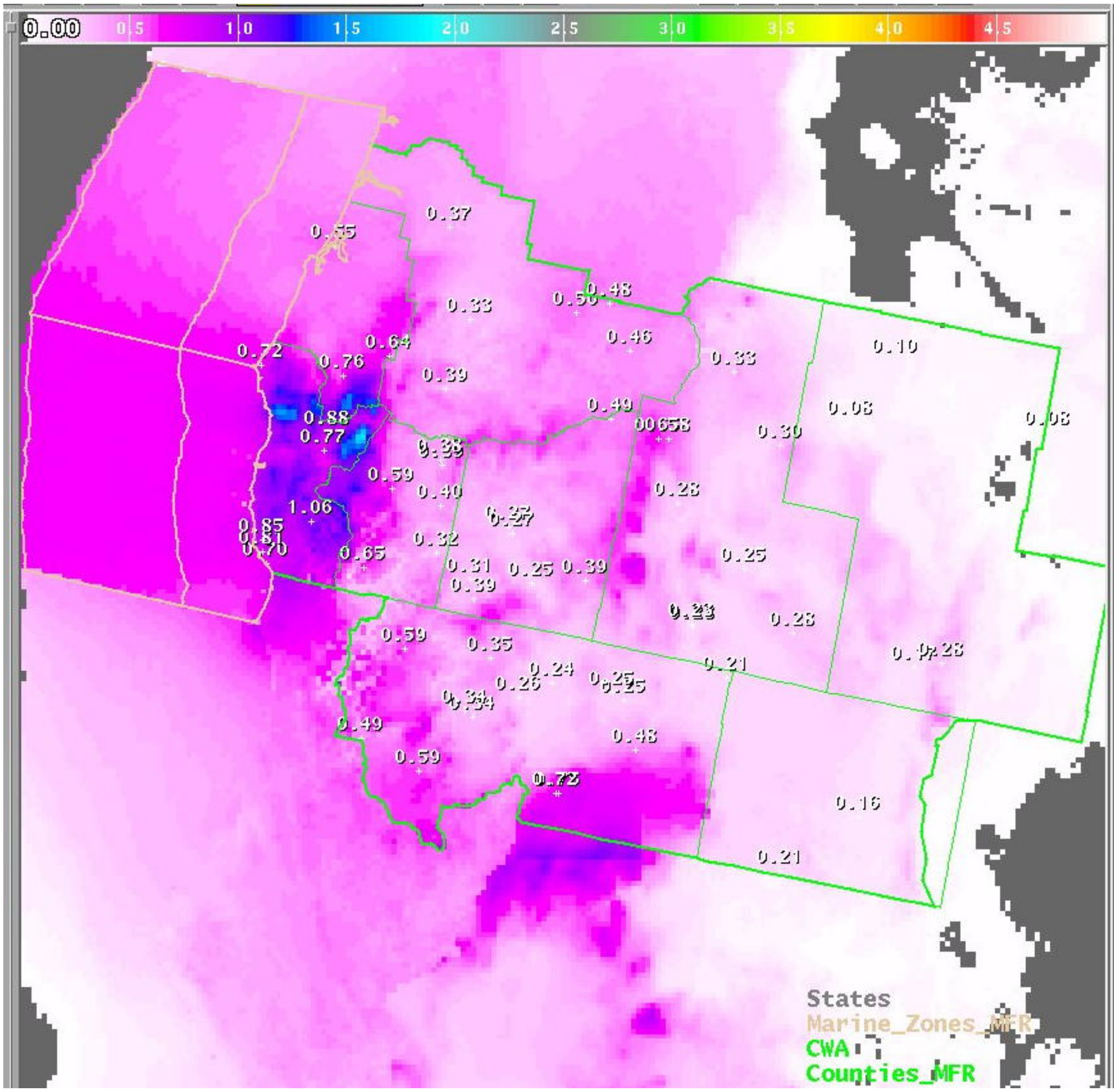

Figure 4. 6-hour QPF forecast (in.) created using QPF Helper ending at 06Z February 3, 2008.

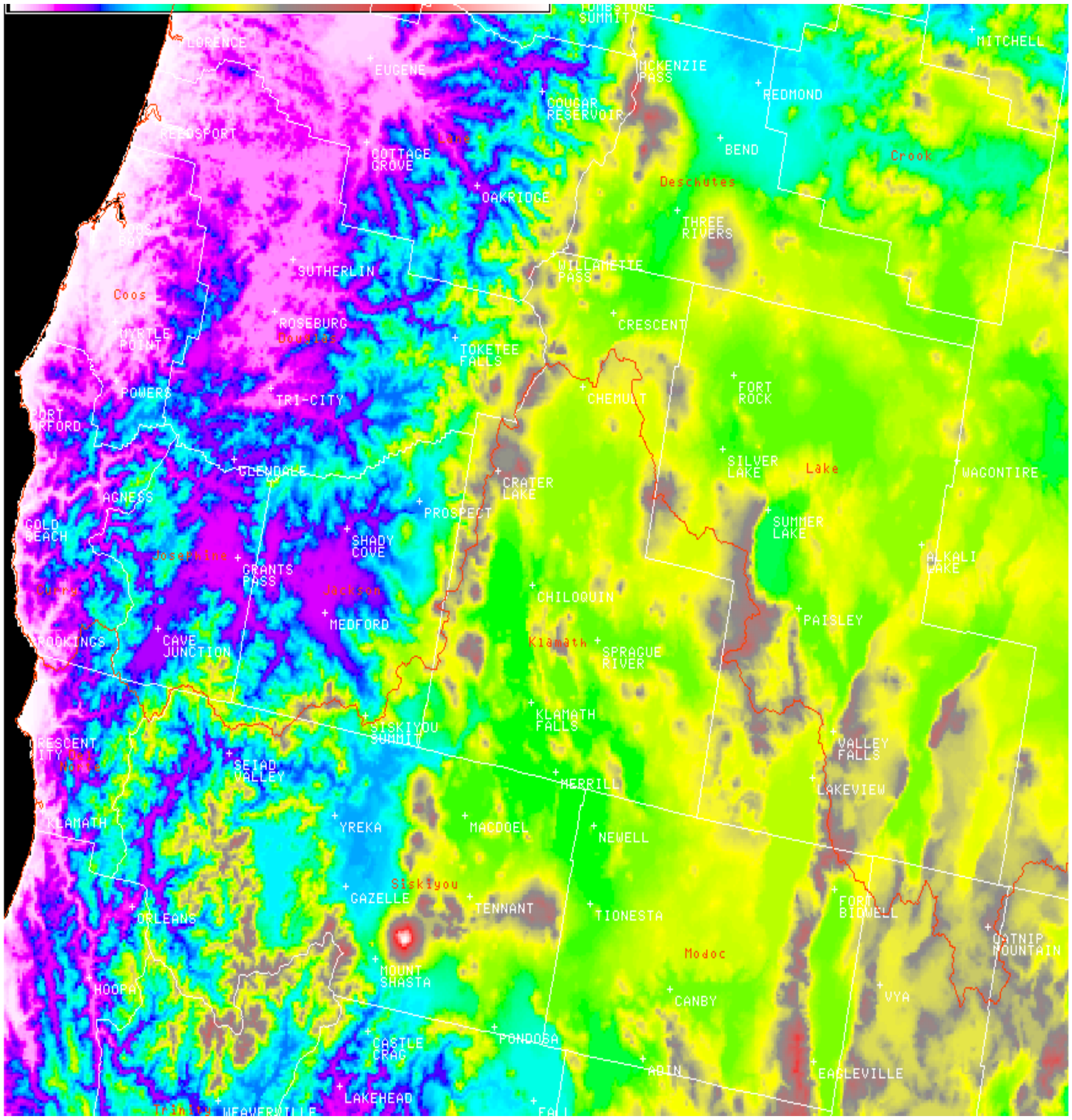

Figure 5. WFO Medford CWA topography (ft.) with NWRFC/CNRFC border in red.

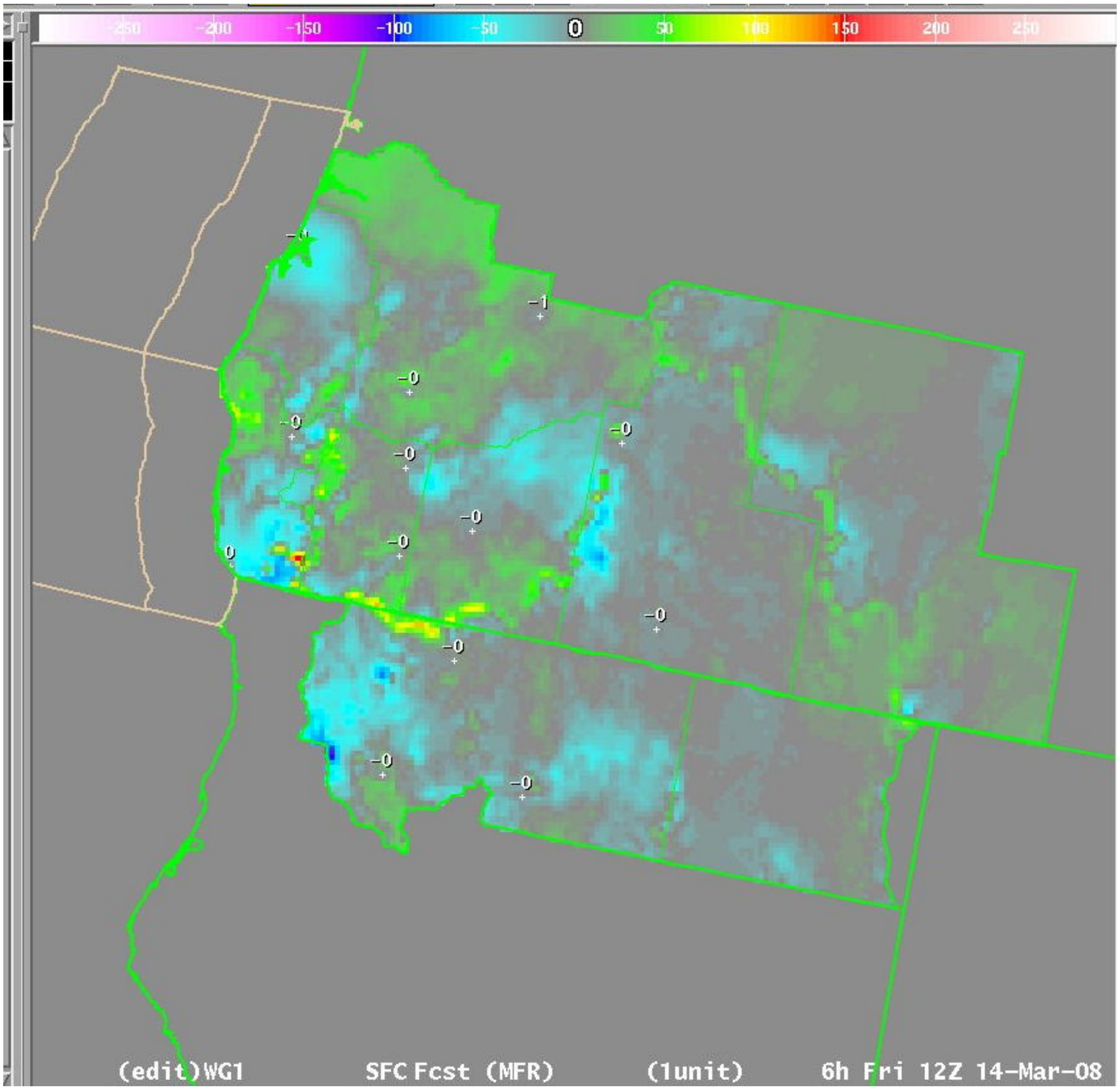

Figure 6. Difference between QPF Helper generated grid and QPE (in.) for the storm ending at 06Z February 3, 2008.

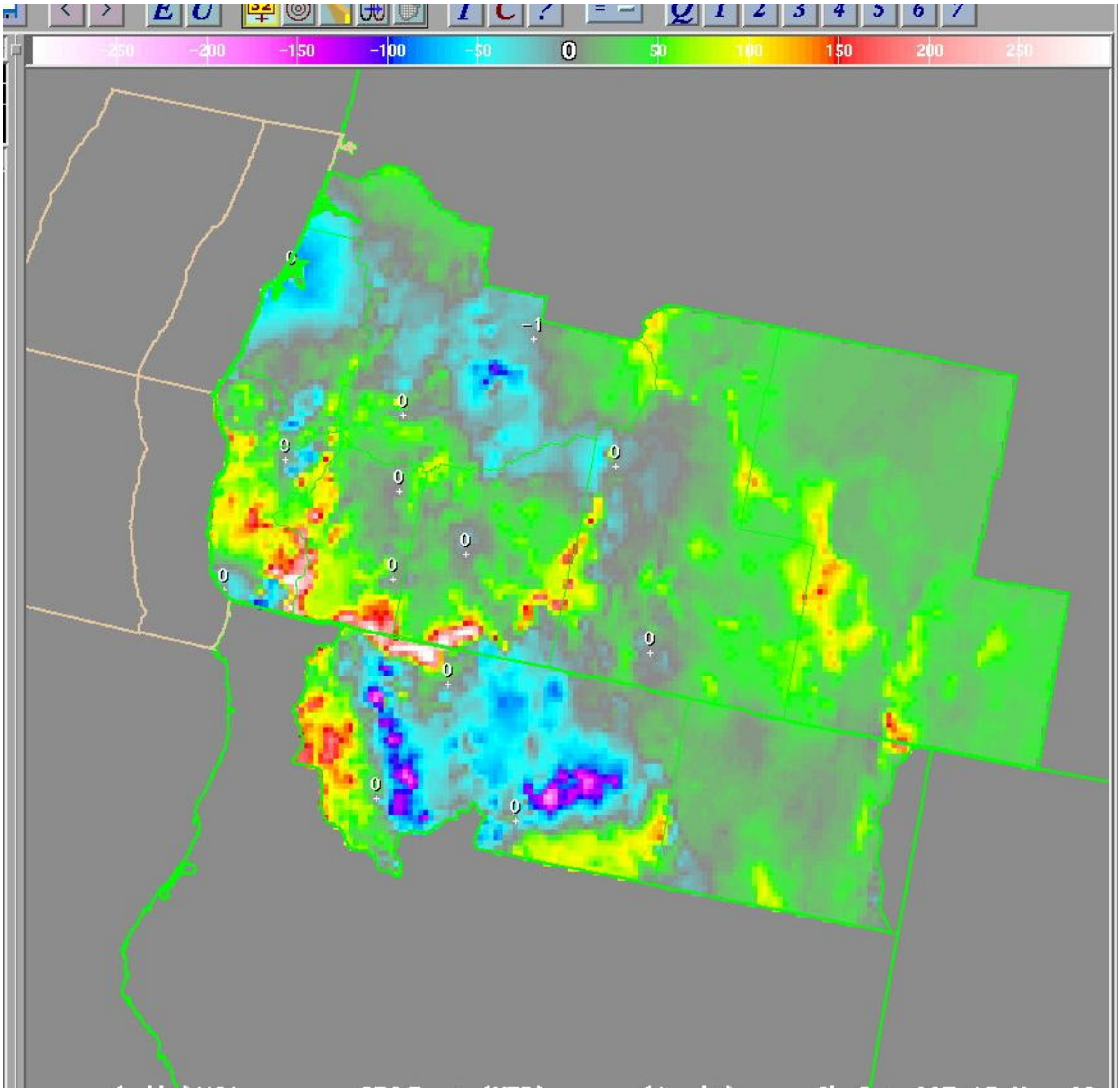

Figure 7. Difference (in.) between QPF Helper generated grid and QPE for the storm ending at 00Z January 5, 2008

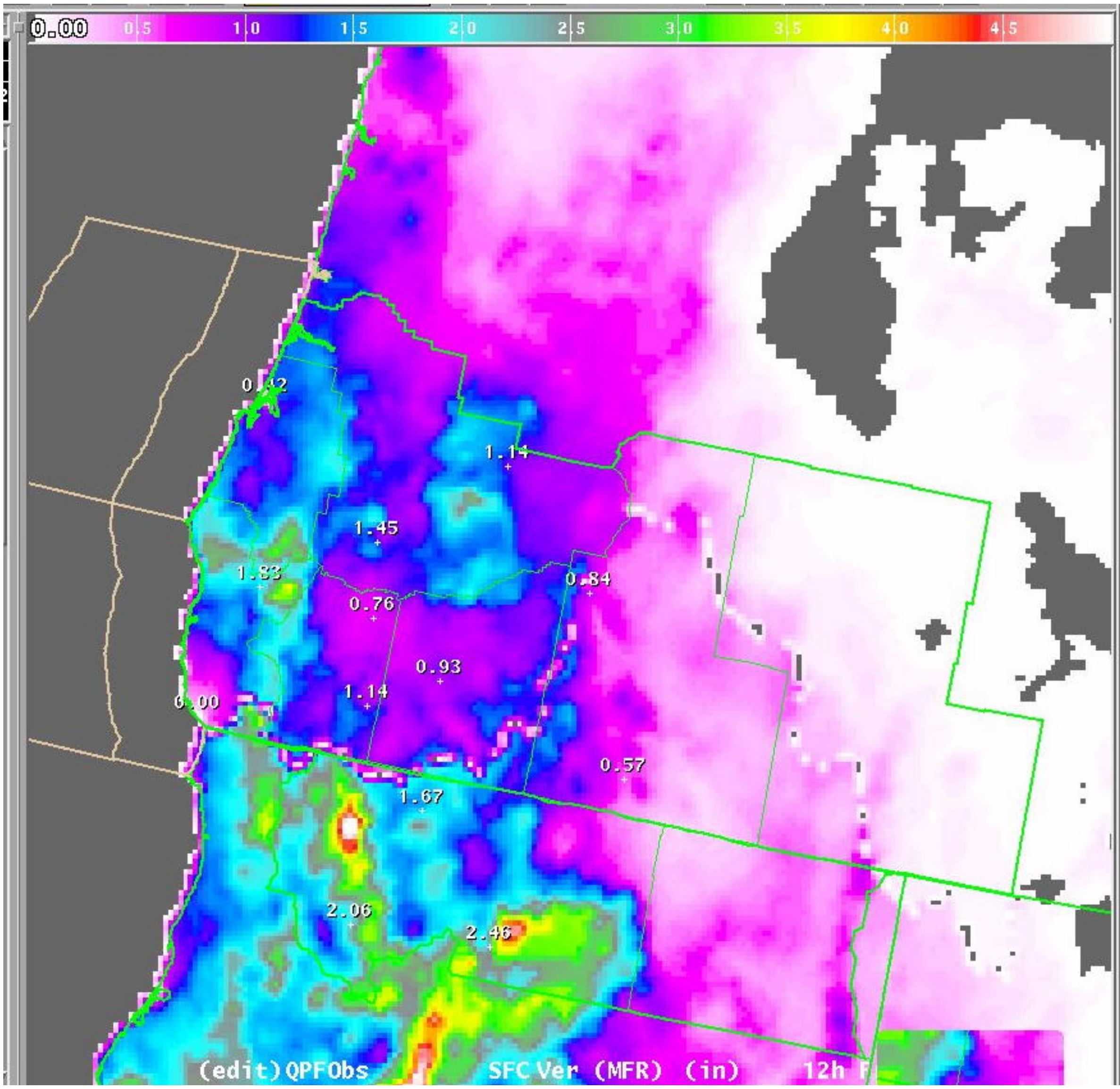

Figure 8. QPE (in.) for the 12 hour period ending at 00Z January 5, 2008.

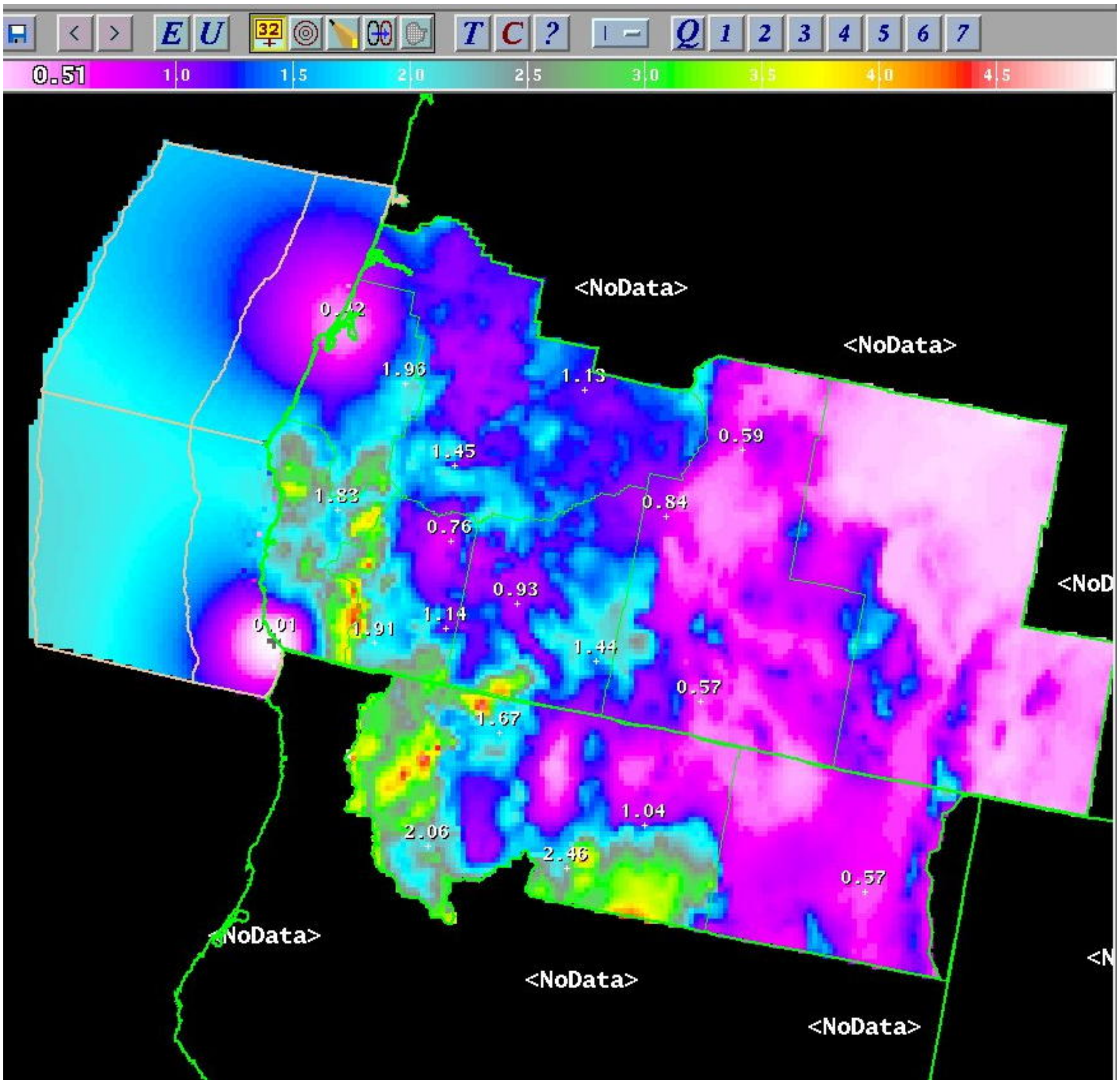

Figure 9. QPF Helper generated grid (in.) using ‘QPS Points’ and QPE values at those points for the 12 hour period ending at 00Z January 5, 2008.

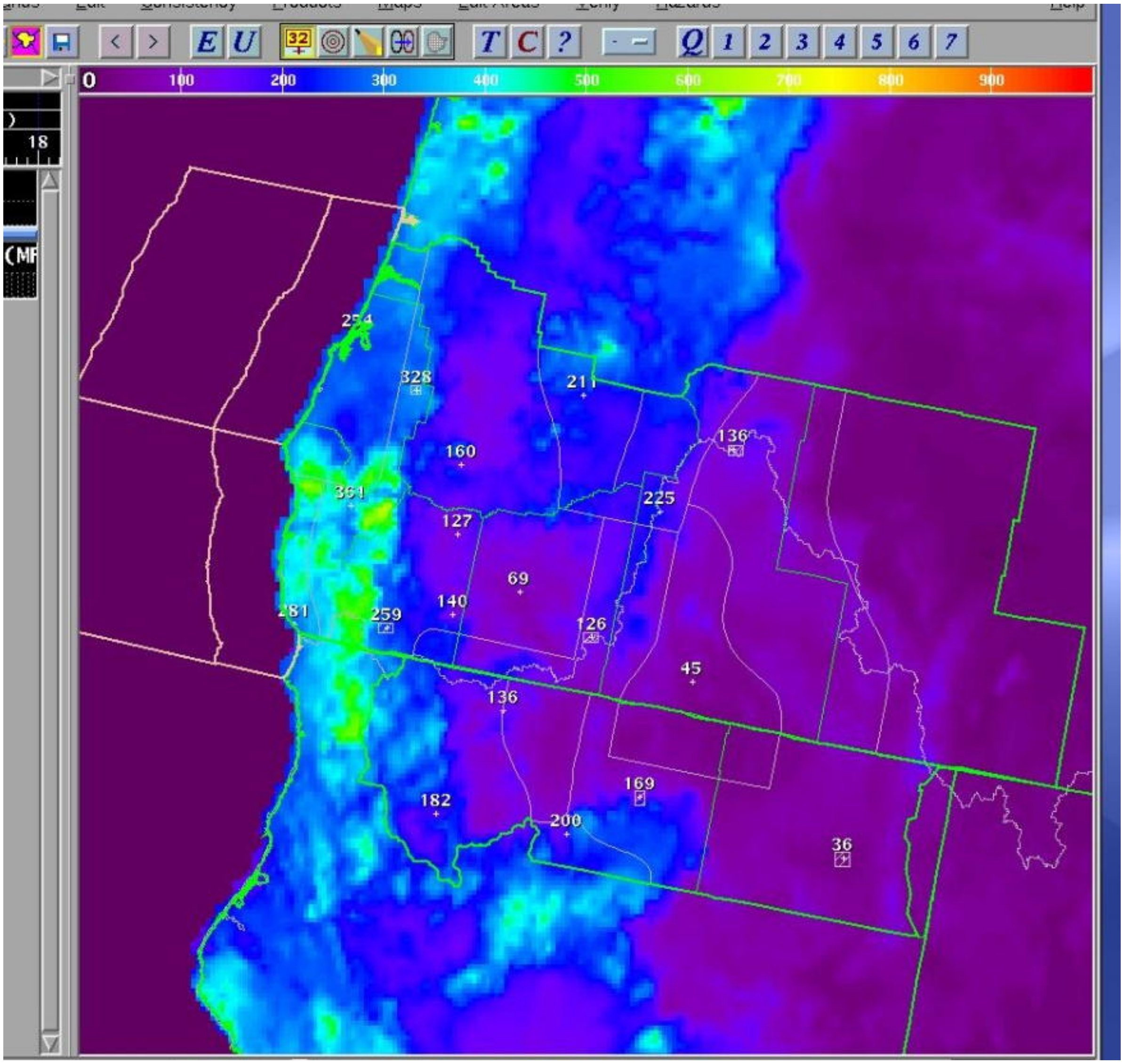

Figure 10. PRISM climatology values (mm.) for the month of January 2008.

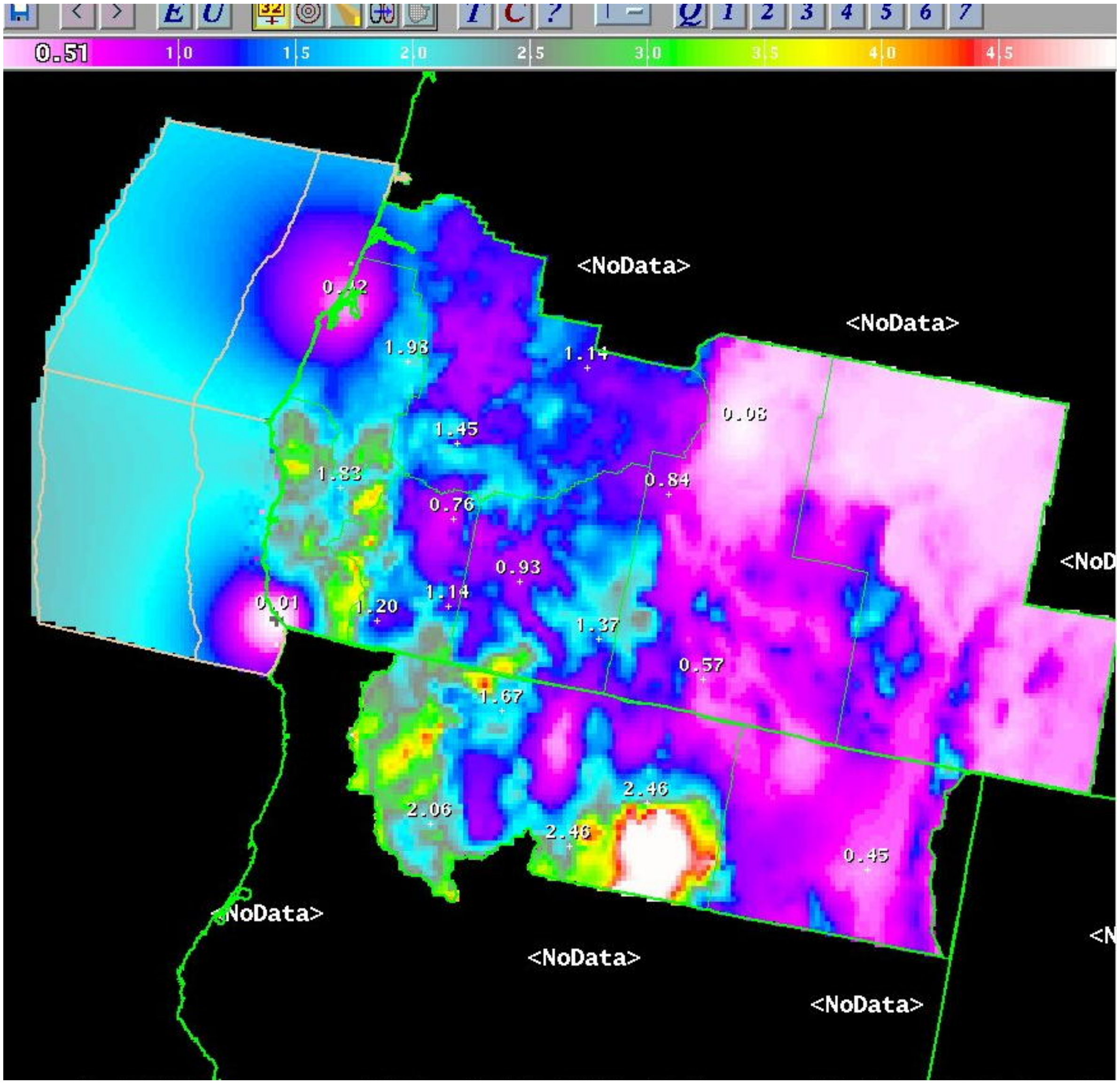

Figure 11. QPF Helper generated forecast grid (in.) for the 12 hour period ending at 00Z January 5, 2008 with 'QPS Points' and 6 additional points as the sample set and using the QPE values at those points.