JP 4.13 DOWNSCALING THE NAM AND PROVIDING PRECIPITATION PROBABILITY FORECASTS USING "SMARTINIT" PROCESSING

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1. INTRODUCTION

In 2008, NCEP began "in house" processing of CONUS "smartinit" grids for the North American Mesoscale model (NAM). These grids serve as the first guess for the National Digital Forecast Database (NDFD) and contain many sensible weather forecast elements on a 5 km grid. (These grids are also generated for Alaska, Hawaii, and Puerto Rico – the latter two employ a horizontal resolution of 2.5 km.) Previous smartinit processing was performed by local National Weather Service offices using 40 km isobaric data. Running the code at NCEP allows the use of native 12 km grids with no interpolation of the data horizontally or vertically.

The surface (actually 2 or 10 meter) temperatures, dew points, and u and v wind components are downscaled from the native 12 km grid to a 5 km grid using unsmoothed 5 km topography and vegetation fraction fields and the method used by Benjamin et al. (2007). For the Alaska, Hawaii, and Puerto Rico domains, a 2.5 km topography and a 2.5 km land/sea mask field are used for the downscaling.

2. DOWNSCALED FIELDS

An example of downscaled temperatures is shown in figures 1 and 2. Fig. 1 shows a 12-km NAM 2-meter temperature forecast over the southwest. Fig. 2 shows the same forecast downscaled to the 5 km grid. Many terrain features are quite evident, with colder temperatures over the better-resolved mountains (such as the Sierra Nevada range of interior California) and warmer temperatures in many lower elevations.

Figures 3 and 4 show a similar comparison for 10-meter wind speeds over the Pacific Northwest. Faster speeds are shown where the 5 km topography field better resolves the taller peaks. In addition, the downscaling code is able to define the coastline more sharply, and a tighter coastal wind gradient is evident along the

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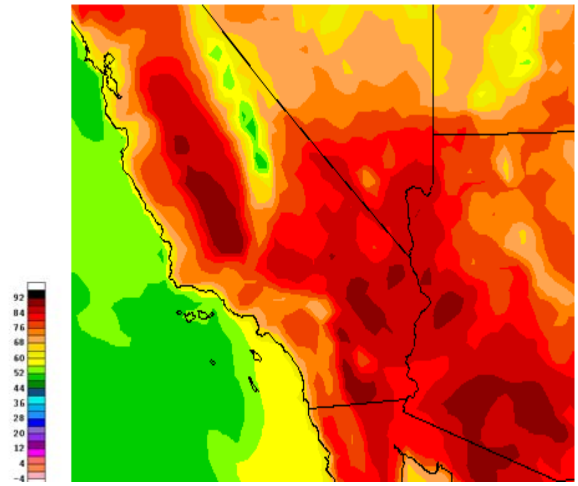

Fig. 1. NAM 2-m temperature forecast in degrees Fahrenheit, displayed on a 40 km grid, valid 1800 UTC 22 April 2009.

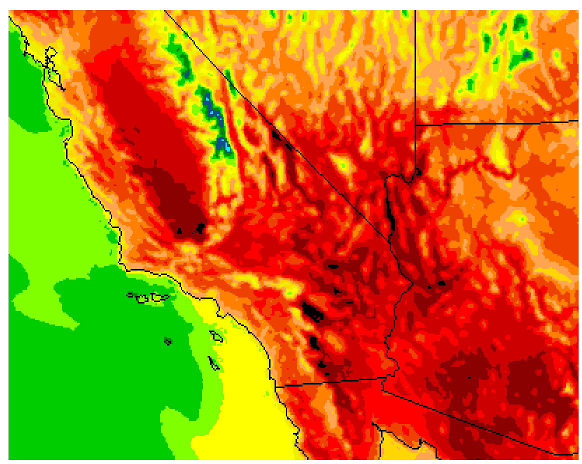

Fig. 2.. Same NAM temperature forecast as in Fig. 1, but downscaled onto a 5 km grid.

Washington and Oregon coasts and the Strait of Juan de Fuca.

Figures 5 and 6 show a better example of the coastline sharpening performed by the downscaling code. The wind speed gradient in the smartinit field is much sharper than the initial NAM forecast along the New England and Long Island shores.

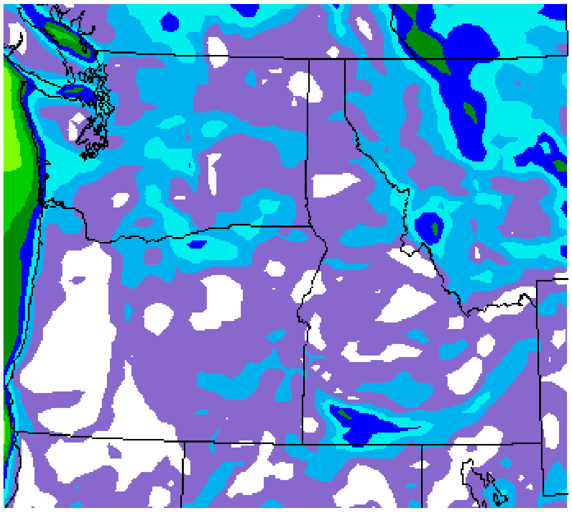

Fig. 3. NAM 10-m wind speed forecast in knots (valid 1200 UTC 22 April 2009) displayed on a 40 km grid.

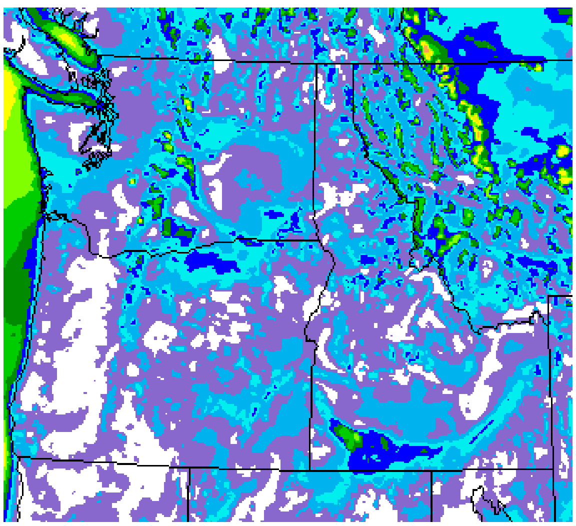

Fig. 4.. Same NAM wind speed forecast as in Fig. 3, but dowscaled onto a 5 km grid.

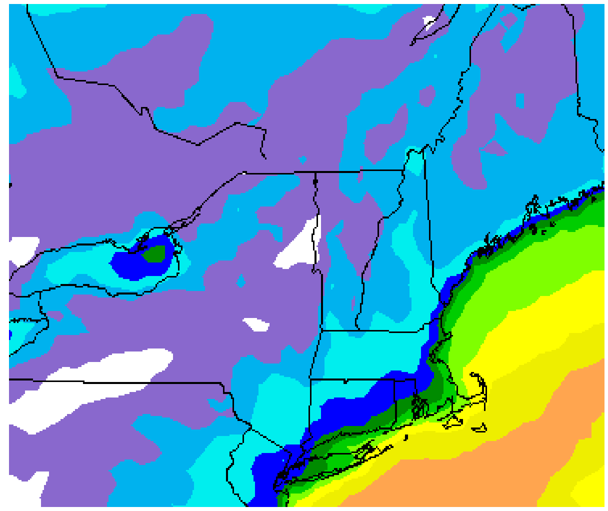

Fig. 5: Same as in Fig. 3, except for a forecast valid 1200 UTC 03 November 2007.

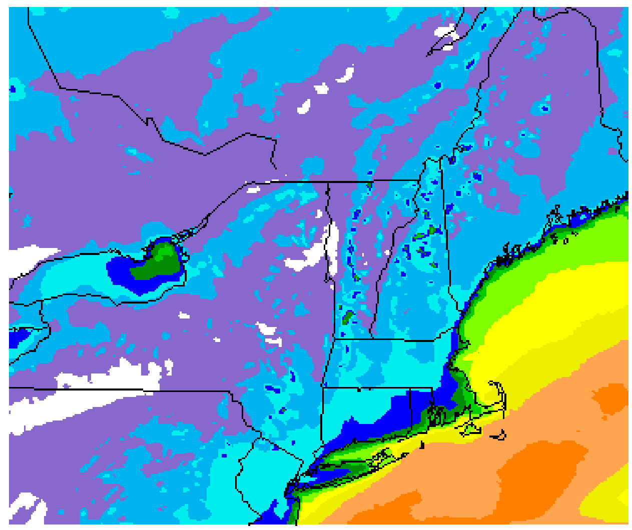

Fig. 6. Same NAM wind speed forecast as in Fig. 5, but downscaled onto a 5 km grid.

3. PROBABILITY OF PRECIPITATION

The original smartinit code generates probability of precipitation (PoP) fields using the model forecasts of precipitation amounts. Higher PoP values are predicted at grid points where the model generates heavy precipitation, and low PoP values are predicted at grd points where the model generates light amounts. In addition, the code uses the average boundary layer relative humidity to boost low PoP in situations in which the model has high low level relative humidity but is generating zero or light precipitation. This is an attempt to differentiate situations in which the model predicts an environment completely unfavorable to precipitation from situations which are "close" to generating precipitation.

This method was developed for the Eta model (no longer run deterministically by NCEP), and it is the author's belief that it did have merit, particularly in the days when the Eta was run at lower resolution. The model had a well-known dry bias, particularly during the convective season, and it look extreme events for the model to generate high amounts of precipitation. When the model was able to predict high amounts, they often verified, justifying the high PoP. More recent versions of the Eta and now the NAM, however, are more likely to generate high amounts, although they are often the result of interaction between non-convective and convective processes and are very localized. In addition, they often do not verify in the correct location or sometimes do not verify at all. This makes a PoP based simply on precipitation amount show poor skill. An example of a NAM precipitation forecast with localized maxima is shown in Fig. 7. Very intense, localized rainfall is predicted by the NAM over northeast Texas and part of eastern Arkansas, northern Mississippi and east-central Missouri. Fig. 8 shows the PoP predicted by the pure smartinit method. The field shows extreme discontinuity, with nearly 100 per cent likelihood of rain in northeast Texas with less than a 40 per cent chance in areas immediately surrounding it. The same is true over eastern Arkansas and northern Mississippi with a major gradient of 0 too 100 over a small distance over northern Mississippi. The overall relationship between forecasted precipitation and the resulting smartinit PoP is quite evident.

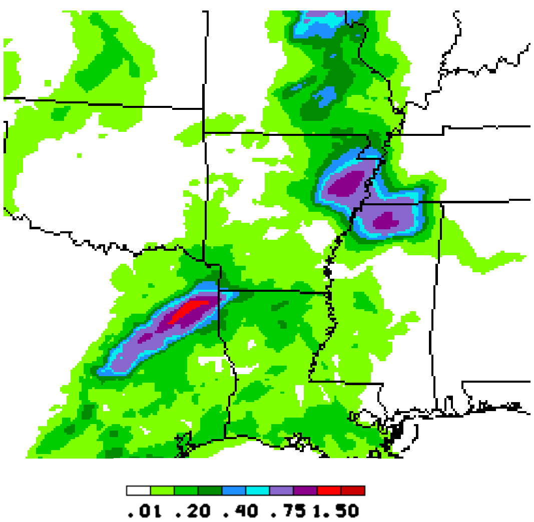

Fig. 7. NAM forecast of 3-hour precipitation amounts (inches) valid 2100 UTC 18 Apri 2009..

Another example is shown in Figures 9 and 10. The localized precipitation maxima in Fig. 9 show up dramatically in the PoP field in Fig. 10 which looks very discontinuous in eastern South Carolina and parts of the Virginias.

Based on cases like these which occurred every day in testing, it was decided that the original smartinit PoP method could not be used for the 12 km NAM. The Short-Range Ensemble Forecast (SREF) system (Du and Tracton, 2001) generates precipitation probability forecasts, and a blend of the smartinit method and SREF PoPs is used to generate final smartinit PoP products.

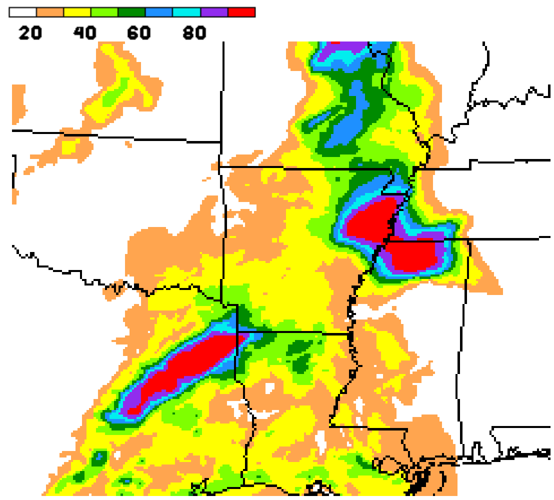

Fig. 8. NAM "pure smartinit" probability of precipitation for same valid time as in Fig. 7.

Specifically, the original smartinit PoP is computed for the desired 3, 6, or 12-hr period. The SREF probabilities for amounts of 0.01" and 0.10" covering the same time period are introduced; the SREF cycle used is the one 3 hours prior to the NAM cycle. If the original PoP is over 70, a bullseye feature liked those seen in Figs. 8 and 10 is feared, and the new PoP is computed by averaging the smartinit PoP, and the SREF probabilities of amounts greater than 0.01" and 0.10".

PoP = (smartpop + SREF .01 + SREF .1) /3

If the smartinit PoP is less than 30%, the SREF is given much more weight out of concern that the a maxima of NAM precipitation could be missing the grid point by a small distance.. The PoP is generated by adding twice the smartinit PoP, twice the SREF 0.01" probability, and the SREF 0.10" probability and dividing by 5.

PoP = (2*smartpcp + 2* SREF .01+ SREF 0.1) /5

Finally, if the smartinit PoP is between 30 and 70, it is equally weighted with the SREF 0.01" probability and averaged, with a minimum PoP of 20 specified.

PoP = MIN(20,(smartpop+SREF .01)/2)

An example of the blended field is seen in Fig. 11. Evidence of the original maxima exists, but the field is overall smoother, more continuous, and more realistic.

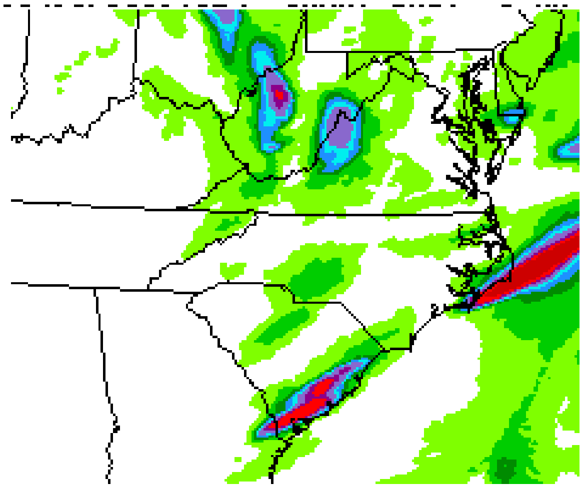

Fig. 9 Same as in Fig. 7 except for the 24-hour NAM forecast valid 00z 13 April 2009.

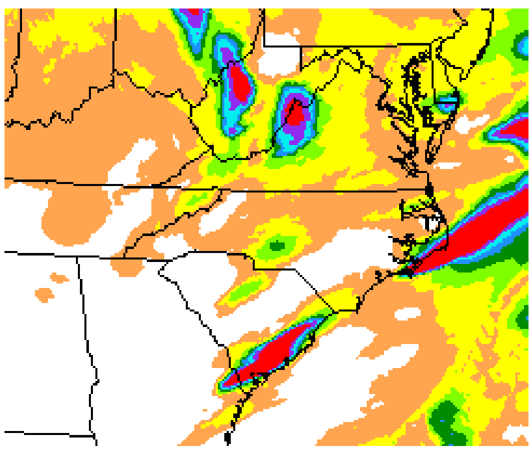

Fig. 10. Same as in Fig.9 except for the "pure smartinit" probability of precipitation

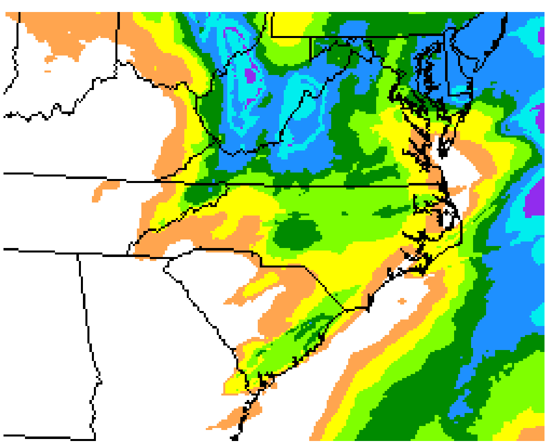

Fig. 11. Same as in Fig. 9, except for the blended probability of precipitation

A case on 20 April 2008 showed a nice example of the new PoP computation not just making a more realistic, continuous field but also leading to a much more skillful product. Fig. 12 shows a NAM 3-hour precipitation forecast with Fig. 13 showing the resulting pure smartinit PoP. Just about all of southeastern Virginia and most of northeastern North Carolina is shown to have less than a 30 per cent chance of precipitation. Again, the relationship between predicted NAM precipitation and smartinit PoP is painfully clear.

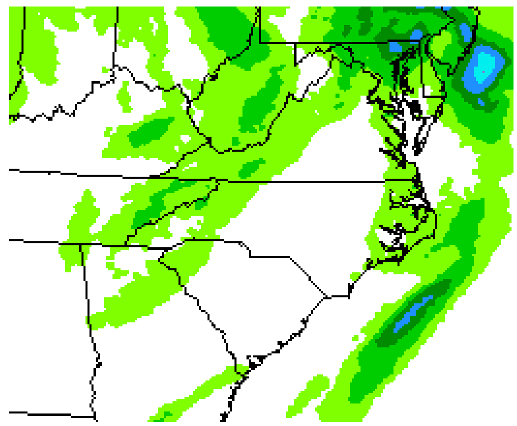

Fig. 12. NAM 21-hour forecast of 3-hour precipitation amounts (inches) valid 2100 UTC 20 April 2009.

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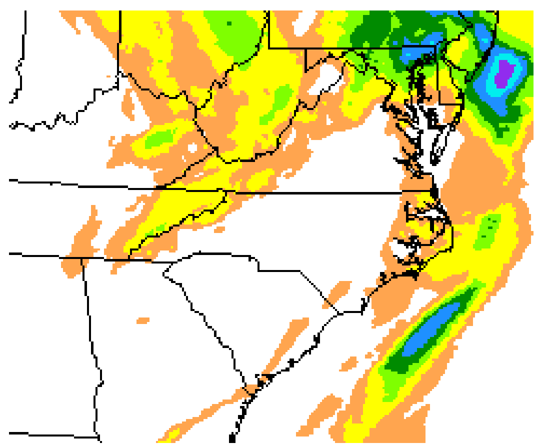

Fig. 13. Same as in Fig.11,except for the "pure smartinit" probability of precipitation.

Fig, 14 shows the SREF probability of at least 0.01" of precipitation in that three hour period, with large areas likely to have precipitation. The blended PoP is shown in Fig. 15, and the field shows the expected greater coverage and more realistic distribution of probabilities. In particular, the area of southern Virginia and northeastern North Carolina is predicted to have at least moderate chances of precipitation. The radar picture, valid at the middle of the time period, shown in Fig. 16 indicates a number of intense convective cells across that region, consistent with the higher PoP values. Widespread severe hail and even two tornadoes were reported in this region during this period.

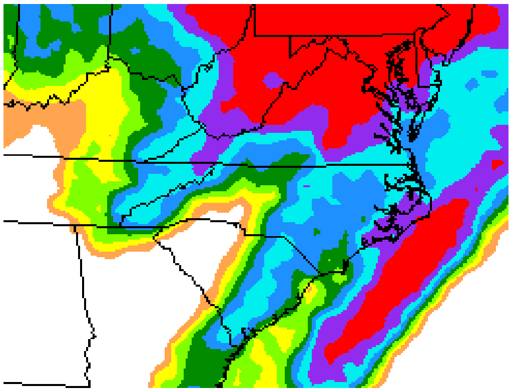

Fig. 14. SREF 24-hour probability of precipitation exceeding 0.01" valid at 2100 UTC 20 April 2009.

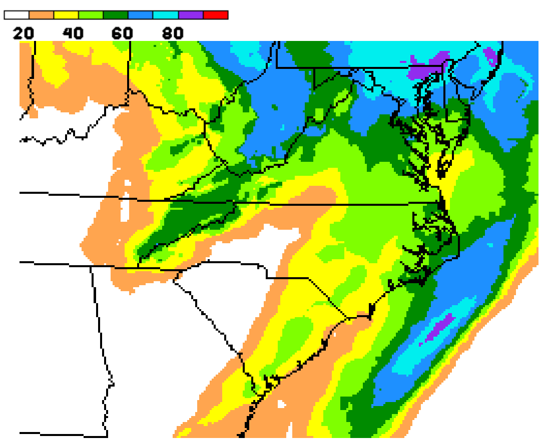

Fig. 15. Same as in Fig.12 except for the blended NAM/SREF probability of precipitation.

While the new method, is a clear improvement over the original smartinit code, there is still much potential to make the output even better. While the field shown in Fig.11 is a major improvement over the original field in Fig. 10, there are still some continuity issues. For example, the maximum area over West Virginia and southeastern Ohio has a sort of inner ring feature. In addition, there is an odd "break" in the higher values just west of Washington, DC, and the higher value area in eastern South Carolina has some "streaks" which add an element of discontinuity to the field.

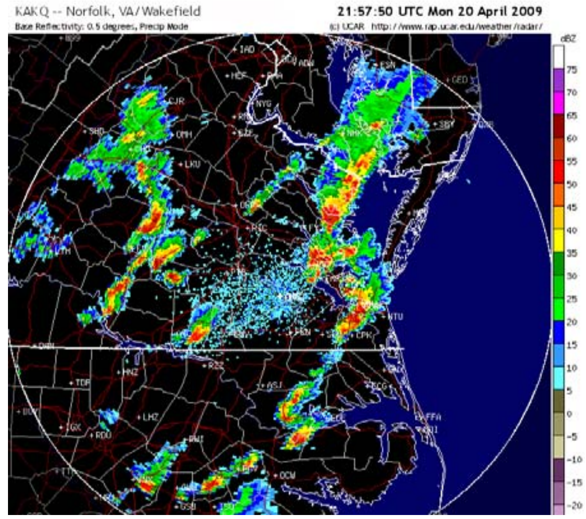

Fig. 16. Wakefield, Virginia radar reflectivity valid 2200 UTC 20 April 2009.

Finding a better blend has been a tough process. A new trial method attempts to weight the original PoP higher if the precipitation is part of a non-convective event, since those are less prone to bullseye features. The liftex index is used to do this, and the SREF PoP is given more weight if the lifted index is below zero at the end of the forecast period. The forecast shown in Fig. 11, but computed with the alternate PoP formulation is shown in Fig. 17. The field is clearly more continuous and a little smoother, but there are also a few speckles over North Carolina, and one can question whether the high-end PoP values that align with the NAM maxima are reasonable.

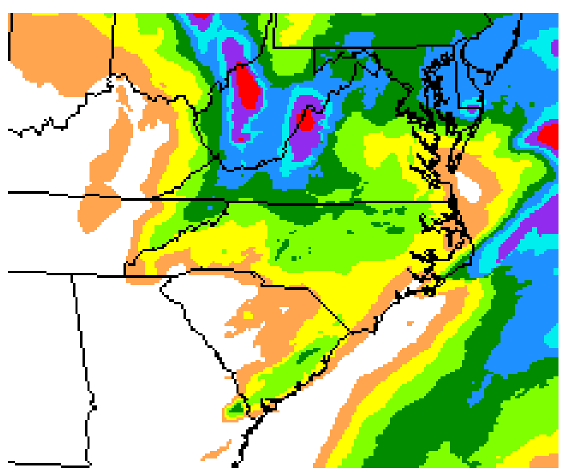

Fig. 17. Same as in Fig.11, except computed using the alternate probability of precipitation computation discussed above.

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Another example using the trial PoP computation is shown in Figs. 18 and 19. Fig. 18 shows a PoP field generated using the current formulation, and Fig. 19 shows the experimental method computation. The odd ring feature over southern Kansas is eliminated by the new method, and its field looks a bit more continuous, particularly northwest of Kansas City, Missouri. On the other hand, the enhanced maximum along the Illinois-Iowa border reduces smoothness to some extent. There is clearly no ideal way to set this up, and more trial and error is required. One shortcoming of the lifted index method is that the values are read in as instantaneous values; it is therefore possible that the value may have been negative at the start of period but have gone positive after the precipitation has fallen and the atmosphere has stabilized. The code would therefore be "fooled" into thinking that the precipitation was non-convective. This is especially likely for 6 and 12-hour periods (these plots have dealt with only 3-hour periods), using a precipitation accumulation covering many hours but an instantaneous value of lifted index. The SREF unfortunately does not have probabilities of convective precipitation.

In the grand scheme, a more skillful PoP product would likely be generated by using only the SREF data. The intent here, however, is to maintain some continuity between the NAM precipitation forecasts and the accompanying probabilities. An overall higher weighting of the SREF, though, is being considered.

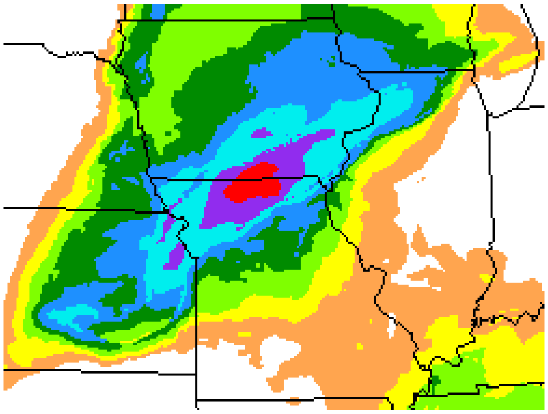

Fig.18. 21-hour forecast of 3-hour probability of precipitation using the current smartinit forumulation, valid 0000 UTC 16 May 2009.

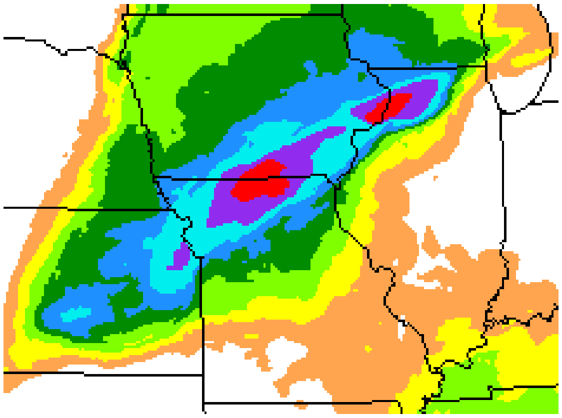

Fig. 19. Same as in Fig. 18, except computed using the alternate probability of precipitation formulation.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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Du, J., and M.S. Tracton, 2001: Implementation of a real-time short-range ensemble forecasting system at NCEP: an update. Preprints, *9th Conf. on Mesoscale Processes*, Fort Lauderdale, FL, Amer. Meteo. Soc., 355-356.