East Coast Cyclone of 31 March-1 April 2017

By
Richard H. Grumm
National Weather Service, State College, PA 16803

1. Introduction

A cyclone moved through the eastern United States 31 March to 2 April 2017 (Fig. 1). The storm system produced moderate to heavy rainfall in the Mid-Atlantic Region on 31 March and in southern New England on 1 April 2017l (Fig. 2). There was heavy wet snow in interior portions of New York and New England on 1 April 2017 (Fig. 3). Farther south there was severe weather southern Virginia and North Carolina. This late season storm produced quite a breadth of weather.

This paper will document the spring storm of 31 March to 2 April 2017. The focus is on the pattern, an overview of the key weather in the Mid-Atlantic region, and forecasts issues. The key forecast issues included the of track cyclone related to the areas where heavier precipitation. The snowfall north of the low center is not examined from a forecast perspective.

2. Methods and Data

The NCEP GFS and CFSR were used to reconstruct the pattern as the event developed.

The NCEP GEFS was used to show the cyclone forecast issues, the QPF issues, and the PH horizon issues.

Rainfall data was estimated using the Stage-IV data retrieved in 6-hour increments.

3. Pattern of the storms evolution

The 500 hPa wave that was associated with the storm was over the western United States on 28 March 2017. This wave moved eastward into a strong 500 hPa ridge. The 500 hPa wave weakened as it moved into the ridge (Figs. 4b-e) and was not well defined by 1200 UTC 2 April 2017.

Ahead of the 500 hPa short-wave there was above normally warm air at 850 hPa though 850 hPa temperatures were below 0C across northern New York and New England as the cyclone moved across the region (Fig. 5a-f). Along with the warm air there was a surge of deep moisture and high precipitable water (PW: Fig. 6). There was a surge of high PW was along the coast but the northern stream surface wave (Fig. 1a-c) pulled a second surge of high PW into the Ohio Valley and into western New York and Pennsylvania (Fig. 6a-c). The heaviest rain amounts each day were in close proximity to the high PW surges (Figs 2 & 6).

The 850 hPa cyclone had strong easterly winds north of the cyclone center and strong south-southeasterly flow south and east of the cyclone center (Fig. 7). The higher rainfall amounts were in close proximity to the strong 850 hPa winds. The 850 hPa v-wind anomalies over New Jersey and southern New England peaked at +3 to +5s above normal (Fig. 7c-f). Despite the weakening wave aloft, the storm produced 2 areas in excess of 72 mm or QPE, one over New Jersey and the other over southeastern New England (Fig. 8).

4. Forecasts

i) regional forecasts

NCEP GEFS QPFs for the key period of precipitation is shown in Figure 9. Nearly all GEFFS cycles depicted had 25 mm or more QPF from Maryland to southern New England. Nearly all GEFS cycles forecast the potential for 50 mm or more QPF over southeastern Pennsylvania and New Jersey. The ensemble mean had a closed 50 mm contour in close proximity to where 50 to 72 mm of QPF was observed (Fig. 8). In New England some members of the GEFS indicated the potential for 50 mm or more QPF.

The threat for over 50 mm or more QPF is better visualizing using the probability of exceedance (Fig. 10). These data imply a strong signal in southeastern Pennsylvania and New Jersey and weaker more uncertain signal in southern New England.

The QPF for the period ending at 0000 UTC 1 April (Fig 11) is used to illustrate that the GEFS did remarkably well the concept of two distinct 12-18 hour periods of QPF. The first significant period was farther to the south, over Pennsylvania, Maryland, and New Jersey and the second period was farther north over New York and New England.

The forecasts of the surface cyclone valid at 0000 UTC 01 April 2017 are shown in Figure 12. This time was closest to when most forecast cycles attempted to re-develop a cyclone along the coast. Interestingly the spread about the mean of all the forecasts for this cyclone was relatively low. Though not shown, the uncertainty was higher along the coast in the strong gradient in the cyclone that tracked south of Long Island New York.

ii) Predictability diagrams

The predictability horizon (PH) diagrams for select sites are shown in Figures 13-14. The PH diagram for Lancaster (Fig. 13), where about 32 mm of QPF was observed, was at time forecast to receive 30 to 70 mm of QPF. Many 24 hour forecasts focused on about 50 mm of QPF. The last forecast issued before the rain began showed a much lower mean value and spread closer to the observed QPE in and around Lancaster, PA.

State College, PA (Fig. 14) had a similar issue with relatively high confidence in a 20 mm or greater QPF event at ranges from about 48 to 84 hour in length then a dramatic decrease in the QPF potential on 31 March. The 24 hour QPE was around 12 mm and the event total was around 16 mm.

A point near Toms River, NJ (Fig. 15) was chosen as it was close to region of 50 to 72 mm of QPF. But it was located north of the area where the GEFS forecasts of 50 mm or more QPF were located. The PH diagram for all the intervening cycles consistently indicated a high threat for 30 mm of QPF with most forecast in the 24-108 hour ranges suggesting as much as 50 mm of QPF. Some longer ranges forecasts, with higher spread and thus more uncertainty suggested a maximum QPF of near 70 mm.

At a point near Boston, MA the GEFS QPF trends changed sharply toward a wetter solution just as the event began. In an area where 50 to 72 mm of QPF was observed, the shorter range forecasts favored a 30 to 60 mm event while longer forecasts had somewhat lower range.

5. Summary

A complex late season storm brought 1 to 3 inches of rainfall to portions of the Mid-Atlantic region and southern New England on 31 March to 1 April 2017. The heaviest rainfall was observed in New Jersey and southeastern New England. There was a 2-14 inch snowfall event across portions of central and northern New York and New England on 1 April 2017.

The higher QPF amounts were associated with a surge of high PW air with PW anomalies in the 1 to 2σ range. The heavier rainfall in New Jersey and southeastern New England was also in close proximity to the 3 to 5σ 850 hPa v-wind anomalies. Thus the deep moisture and strong low-level forcing were relatively well aligned with the areas of over 48 and 72 mm of QPE (Figs 6, 7, & 8). These patterns and the anomalies in the patterns still provide clues to potential for higher end QPF/QPE amounts.

The forecasts from the NCEP GEFS were presented. The plan view QPFs indicated a widespread area of 25 mm or more QPF from Maryland to southern New England and areas for the potential for over 50 mm of QPF. The highest probabilities for over 50 mm of QPF in the GEFS were in southeastern Pennsylvania and New Jersey. This was close but south and west of the observed areas of 50 to 72 mm of QPF. The GEFS hinted of 50 mm or more of QPF in New England but showed considerable uncertainty to the region where the higher QPF would occur. Thus the probabilities were lower and not one of the shown forecast cycles produced a 50 mm in the ensemble mean.

The predictability of the QPF was a critical issue in this event from a river and stream forecasts perspective. Due to the snow earlier in the month and a generally wet period flow on many streams was high. The PH diagrams for Lancaster and State College imply that the confidence a 25 to 50 mm QPF event diminished as forecast length decreased. At Toms River, NJ as similar issue arose, except at Toms River the GEFS under estimated the QPF. In Boston, MA the GEFS the GEFS showed a high confidence in a 30 to 40 mm QPF event but just before the event began the QPF increased and implied a 35 to 60 mm QPF event.

The PH diagrams show that in general the spread and uncertainty in QPF forecasts beyond about 108 hours in length is often quite large. The forecasts often begin to converge toward more confident solution in the 72 to 108 range. But these forecasts too can change and swing in different directions. This makes forecasting flooding and snow fall amounts difficult as they both rely heavily on accurate QPFs which are often quite elusive in the GEFS.

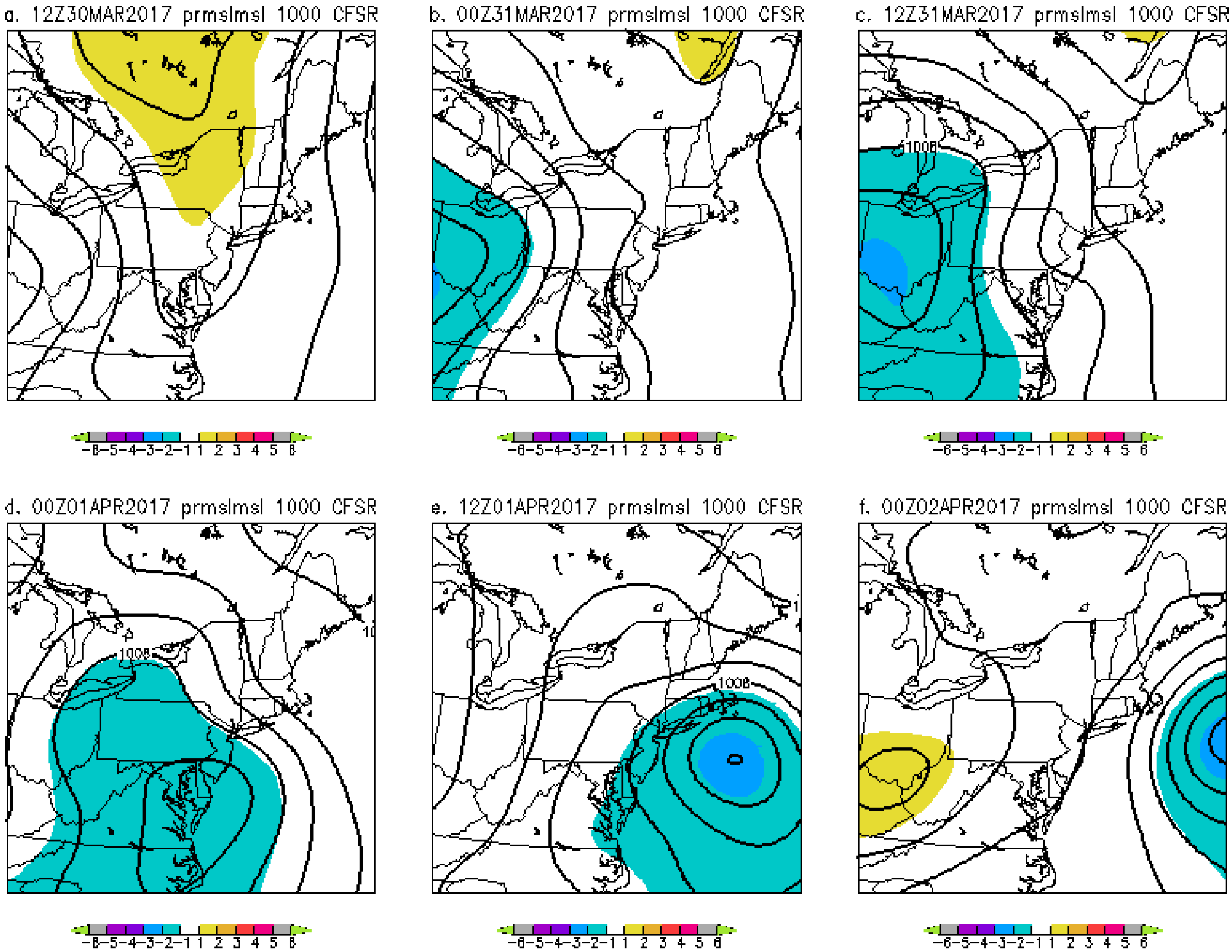

Figure 1, CFSR mean sea-level pressure and pressure anomalies in 12 hour periods from a) 1200 UTC 30 to f) 0000 UTC 2 April 2017. Contours every 4hPa and shading in standard deviations from normal as in the color bar. **Return to text.**

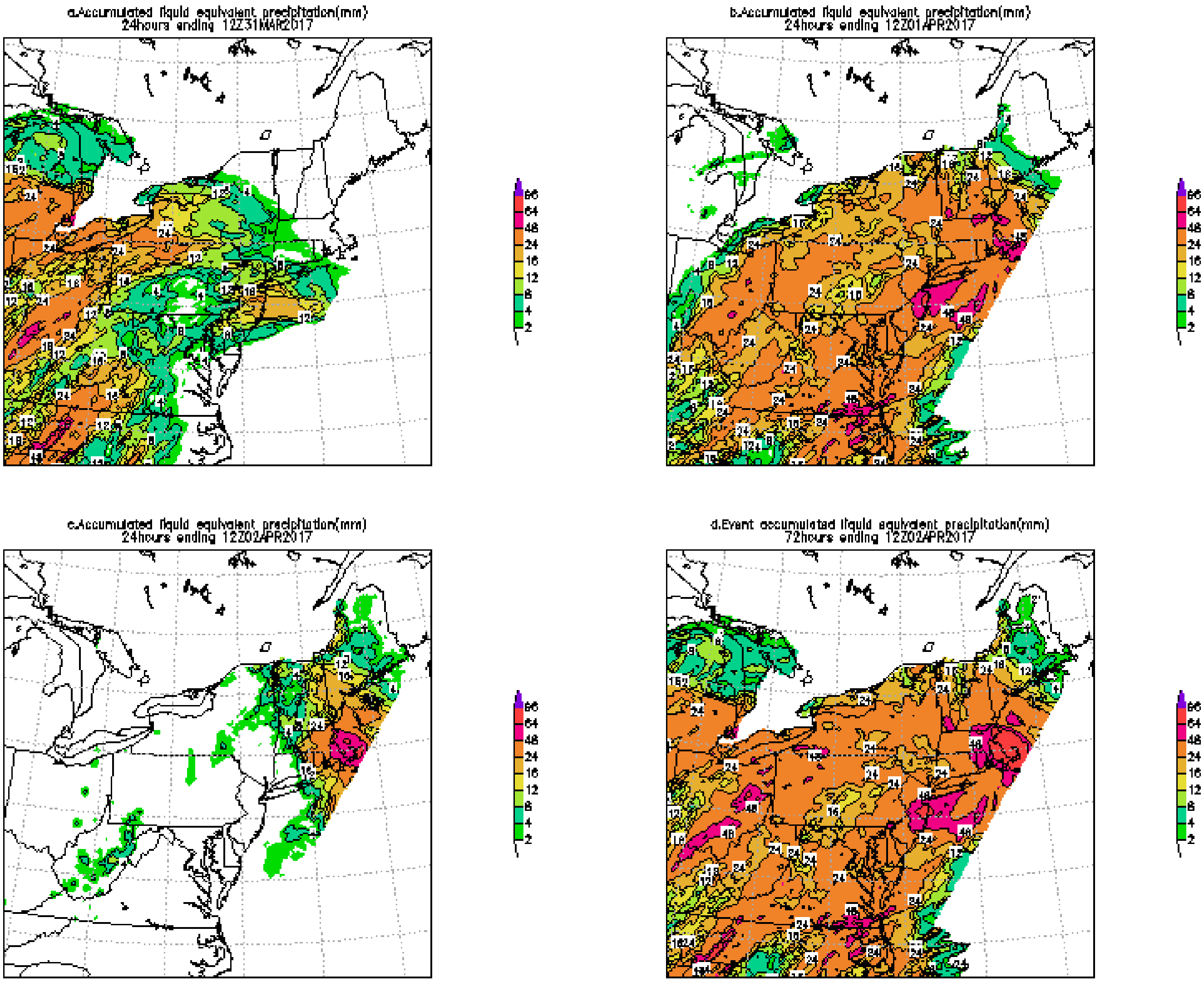

Figure 2, Stage-IV QPE showing the 24 hour total rainfall for the periods ending at a) 1200 UTC 31 March, b) 1200 UTC 1 April and c) 1200 UTC 2 April 2017 and the d) event total QPE. **[Return to text.](#)**

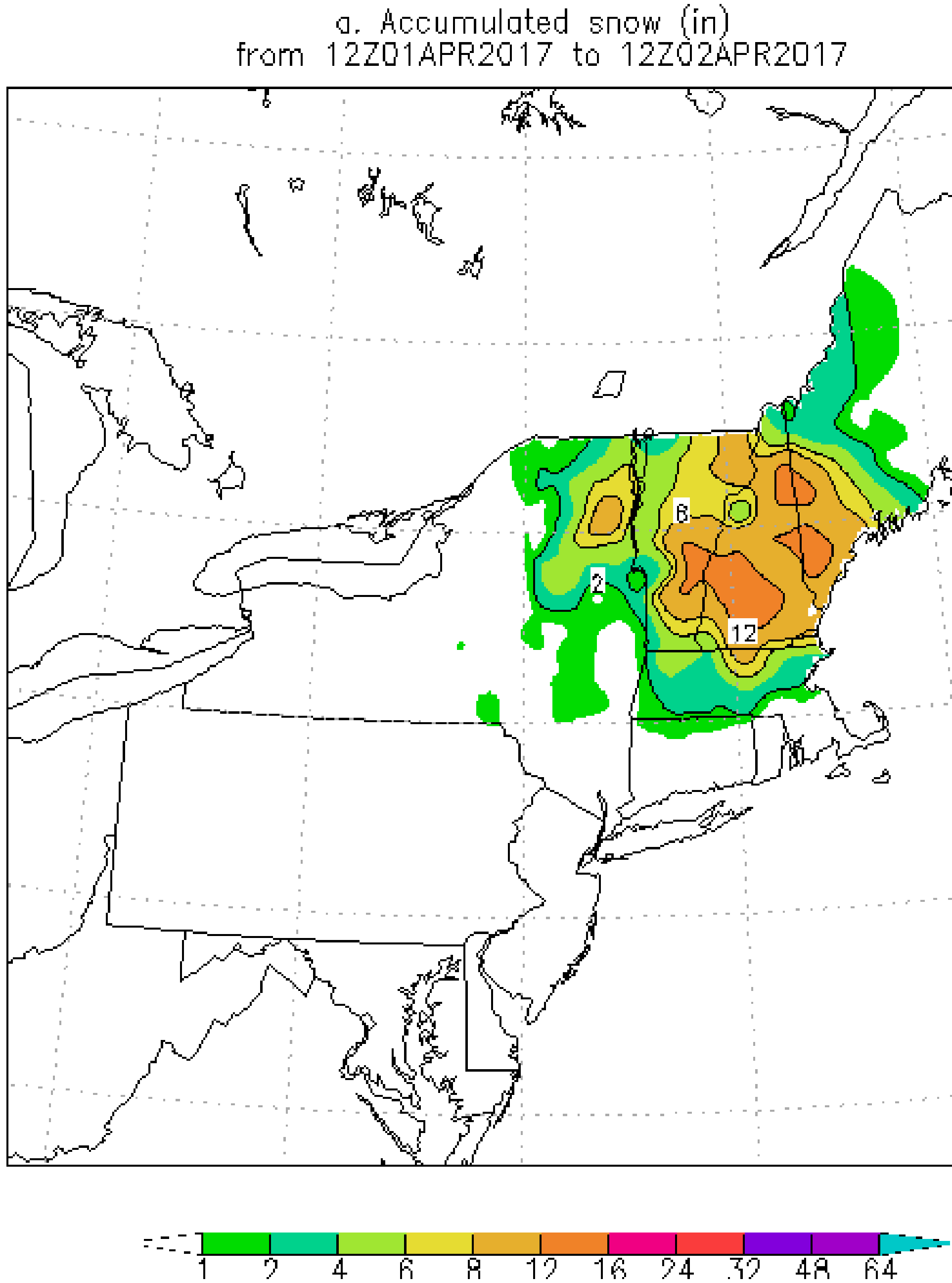

Figure 3. National snow site gridded 24 hour snowfall showing all snow reports for the 2-day period ending at 1200 UTC 2 April 2017. Values in inches. **Return to text.**

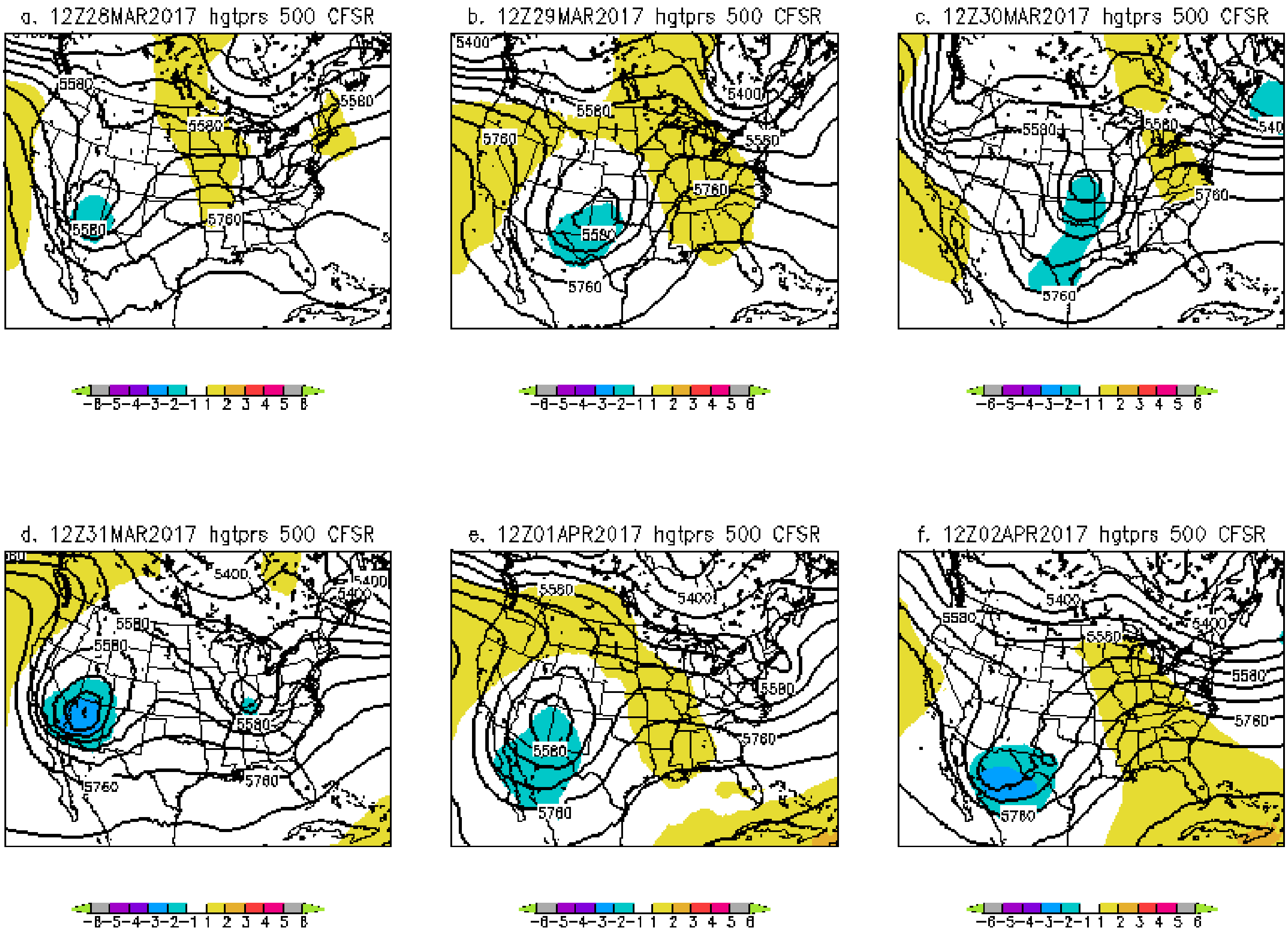

Figure 4. As in Figure 1 except for CFSR 500 hPa height and height anomalies in 24 hour intervals from a) 1200 UTC 28 March through f) 1200 UTC 2 April 2017. **[Return to text.]**

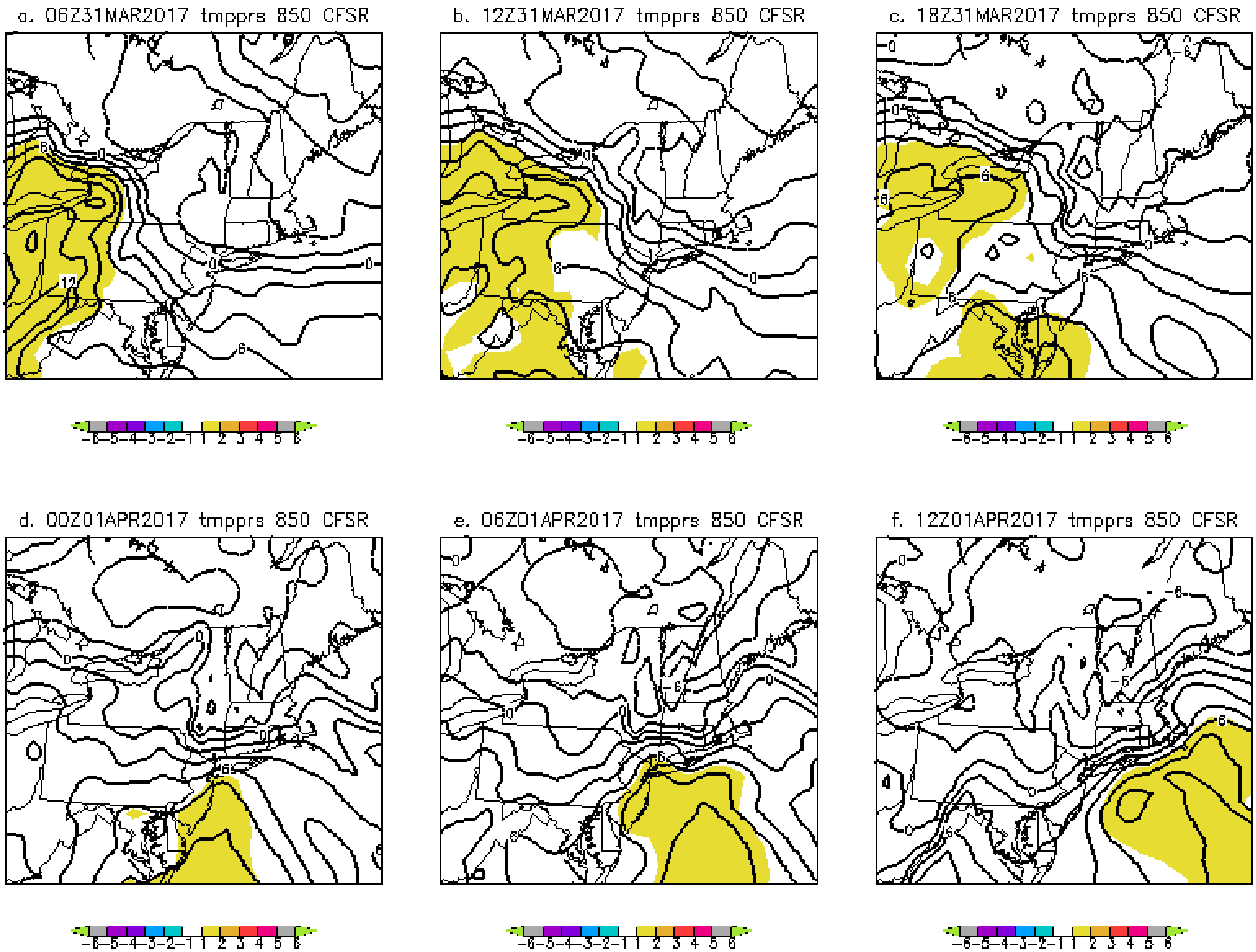

Figure 5. As in Figure 4 except for CFSR 850 hPa temperatures and temperature anomalies zoomed over the northeastern United States and whon in 6-hour increments from a) 0600 UTC 31 March through f) 1200 UTC 1 April 2017. **Return to text.**

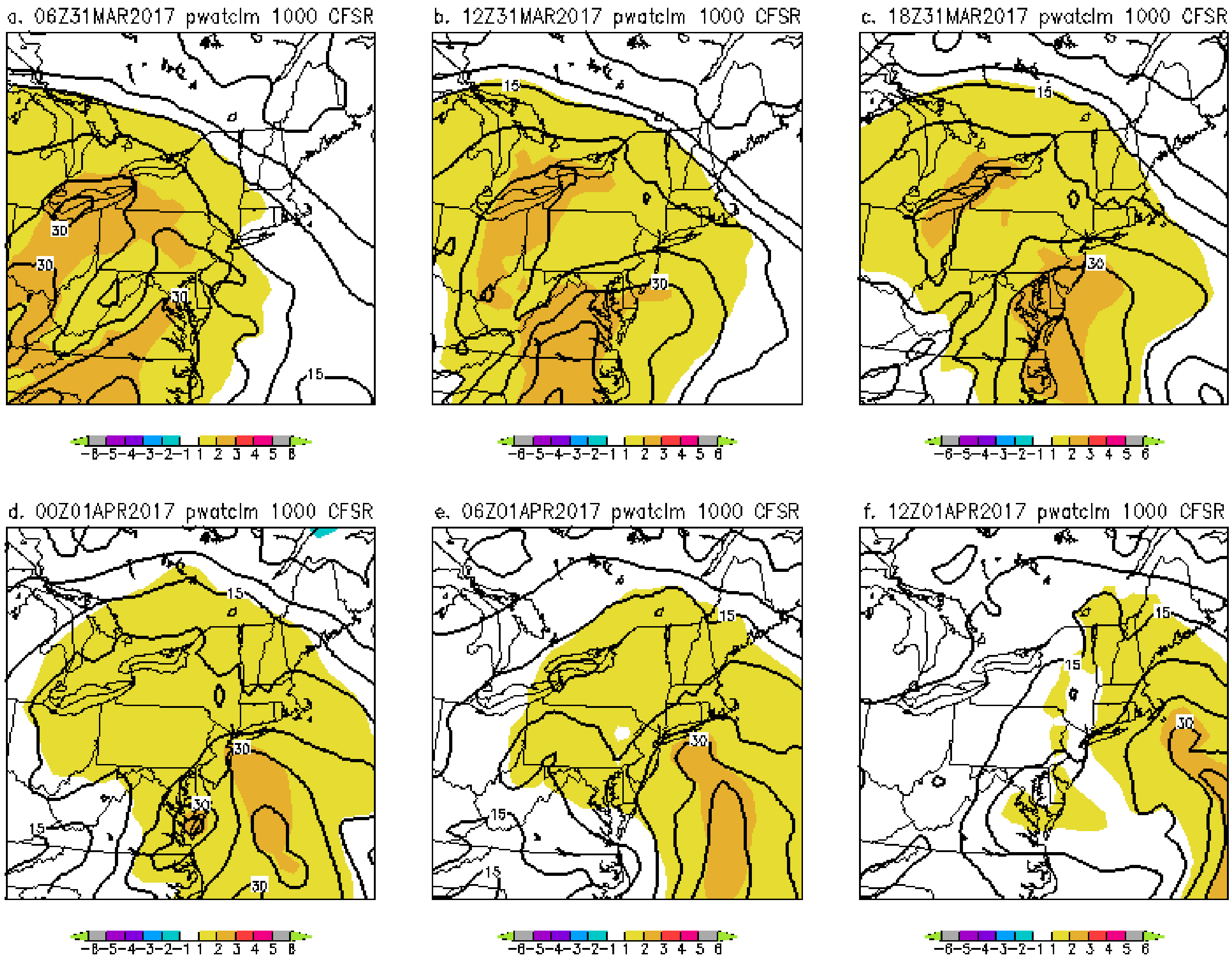

Figure 6. As in Figure 5 except for precipitable water and precipitable water anomalies. [Return to text.]

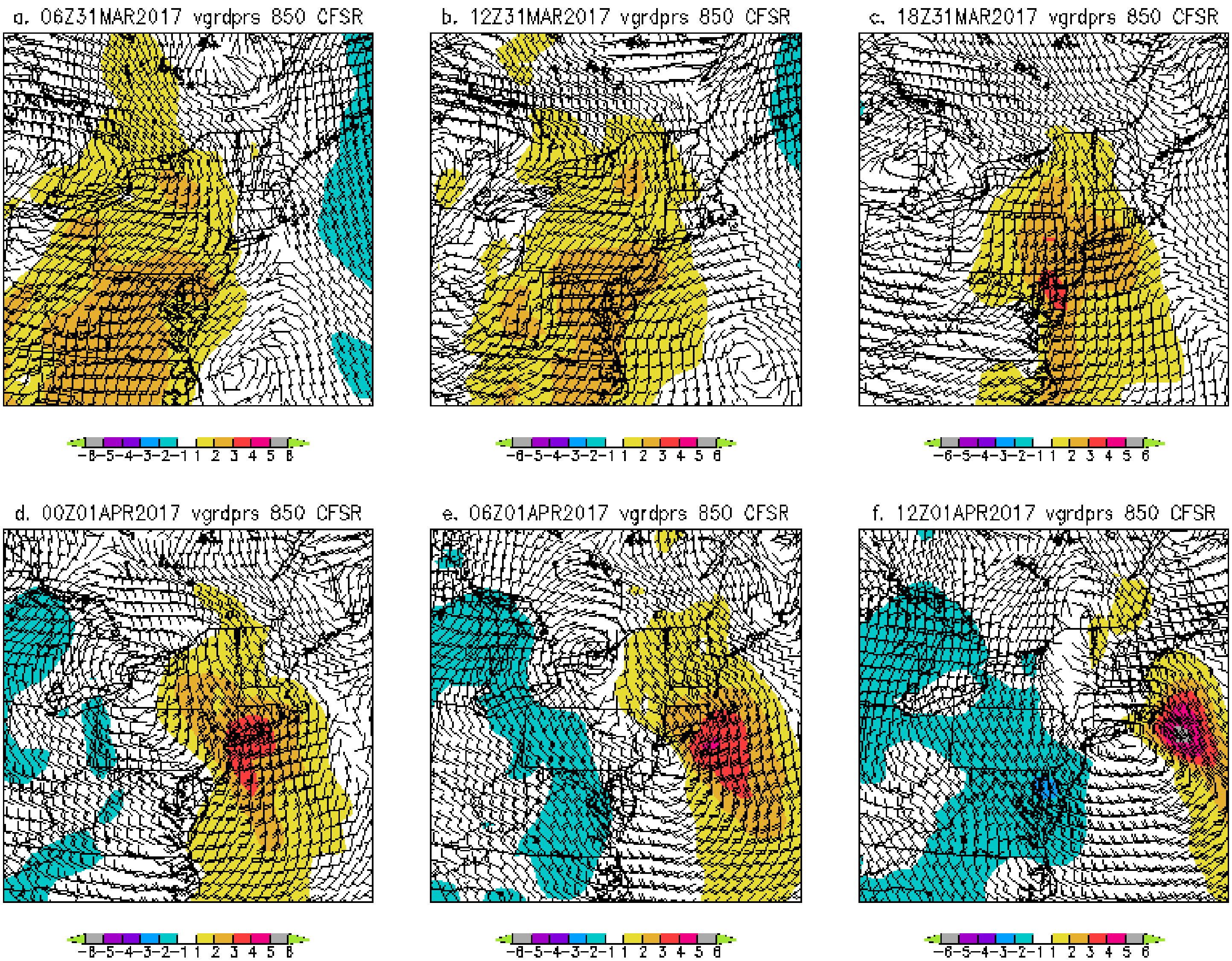

Figure 7. As in Figure 6 except for 850 hPa winds and 850 hPa v-wind anomalies. **Return to text.**

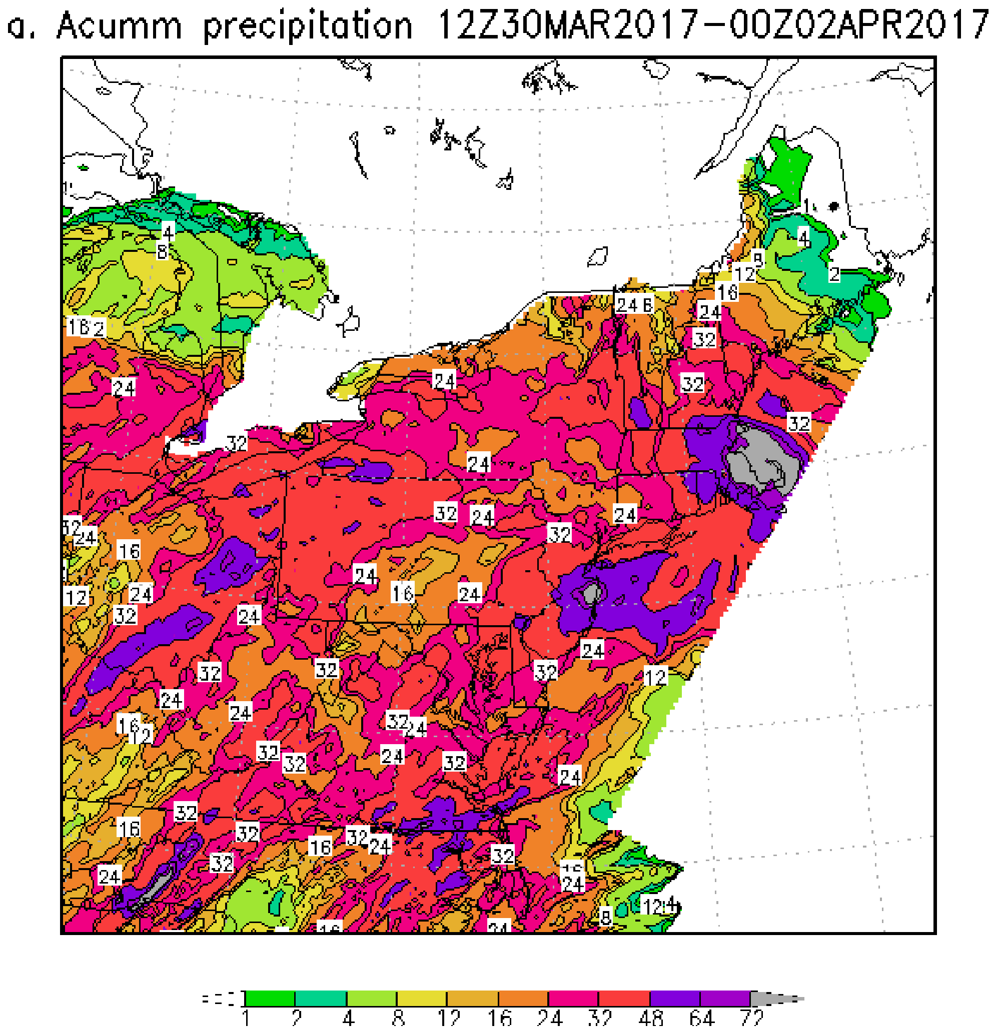

Figure 8. As in Figure 2 except focused over the period of highest QPF in the Mid-Atlantic region and southeastern New England. A 72 mm contour and shading color was added to show the maximum rainfall areas. **Return to text.**

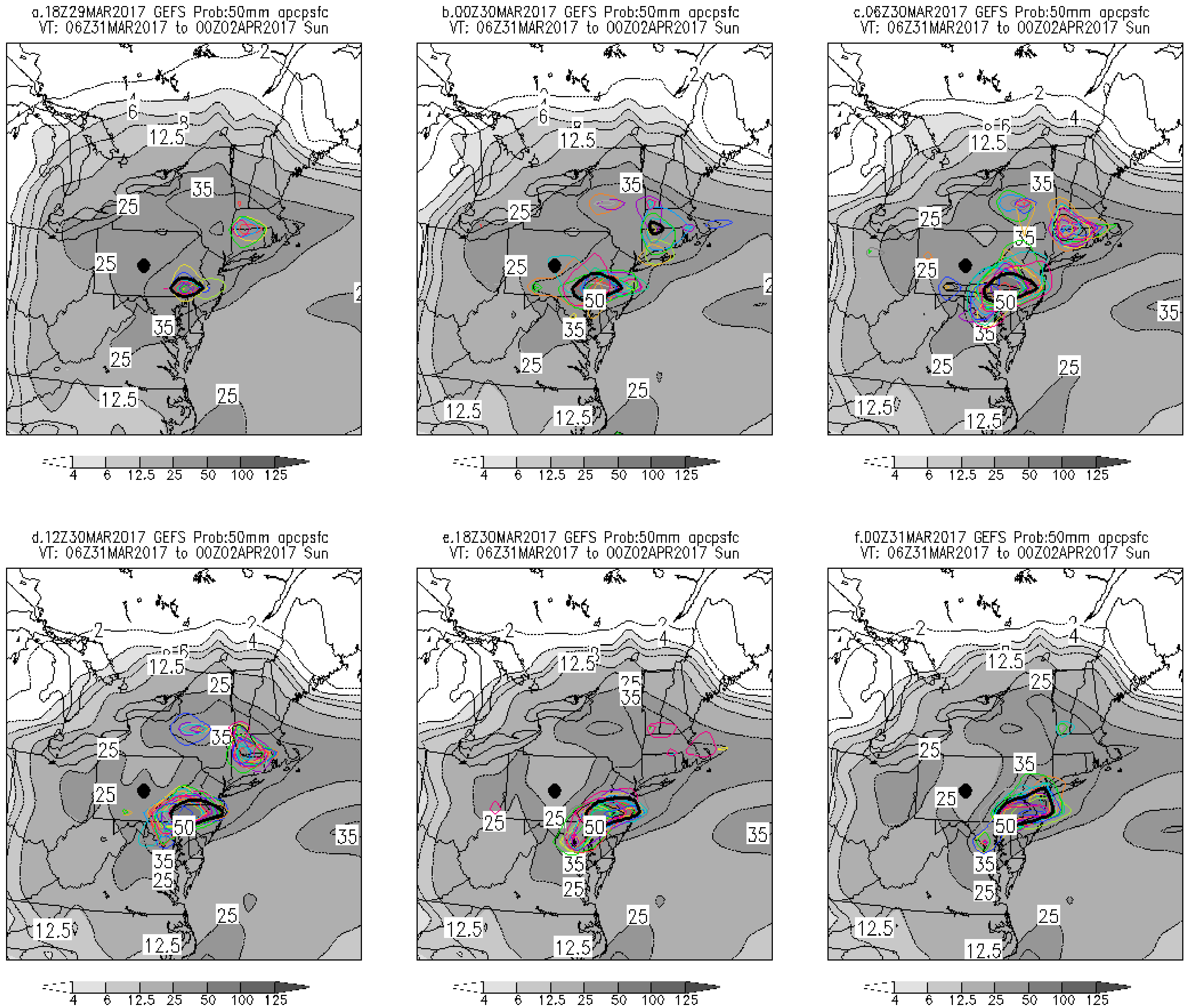

Figure 9. NCEP GEFS forecasts of the ensemble mean QPF (shaded) with highlighting contours and each members 50 mm contour if present for the period of 0600 UTC 31 March through 00000 UTC 2 April 2017. The thick black contour represents the 50 mm contour in the ensemble mean when present. GEFS initialized at a) 1800 UTC 29 March, b) 0000 UTC c) 30 March, d) 0600 UTC 30 March, e) 1200 UTC 30 March, f) 0000 UTC 31 March 2017. Note starting at 0600 UTC allowed summing the 31 March forecasts. . **Return to text.**

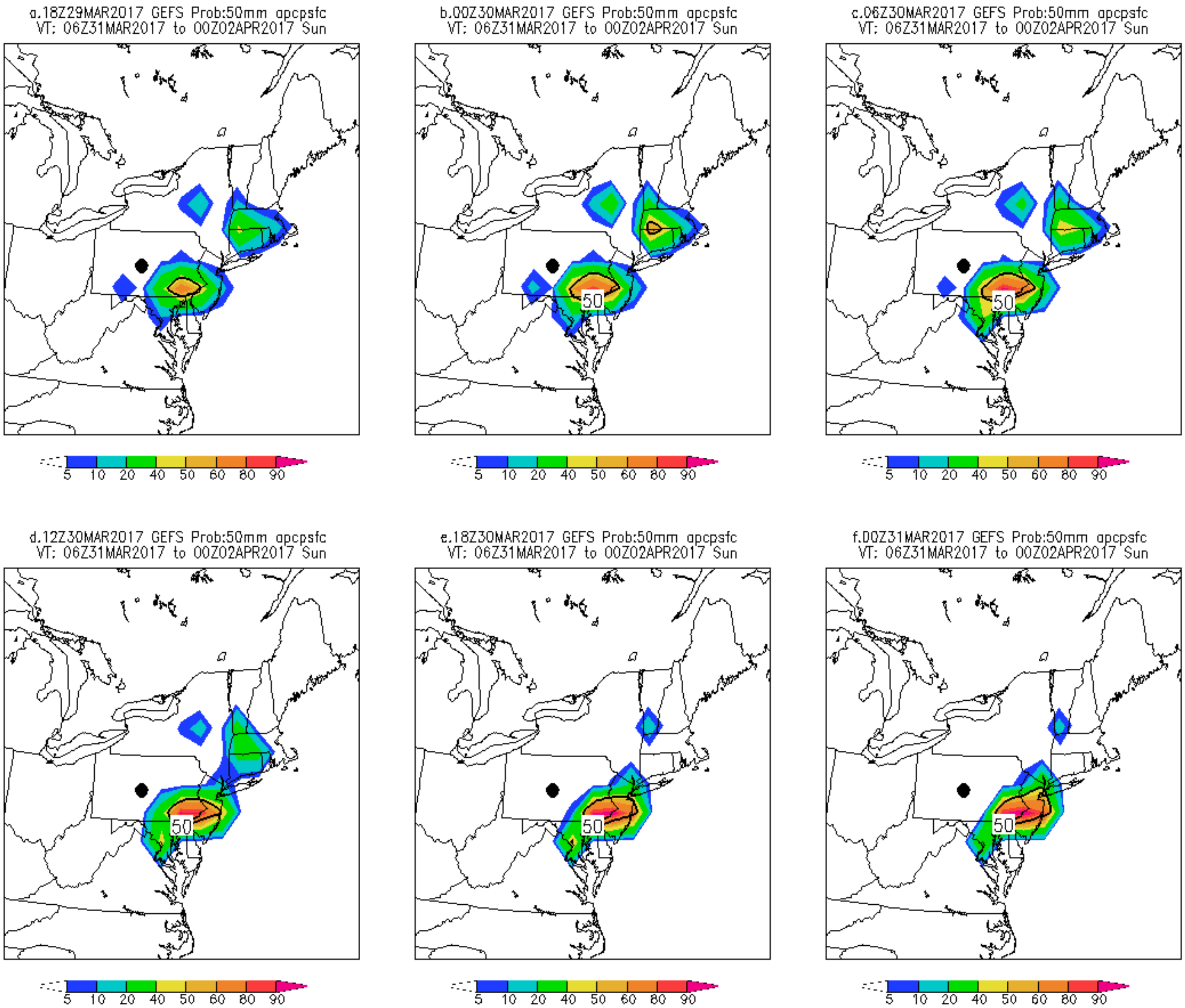

Figure 10. As in Figure 9 except for the GEFS QPF to exceed 50 mm or more QPF. . **Return to text.**

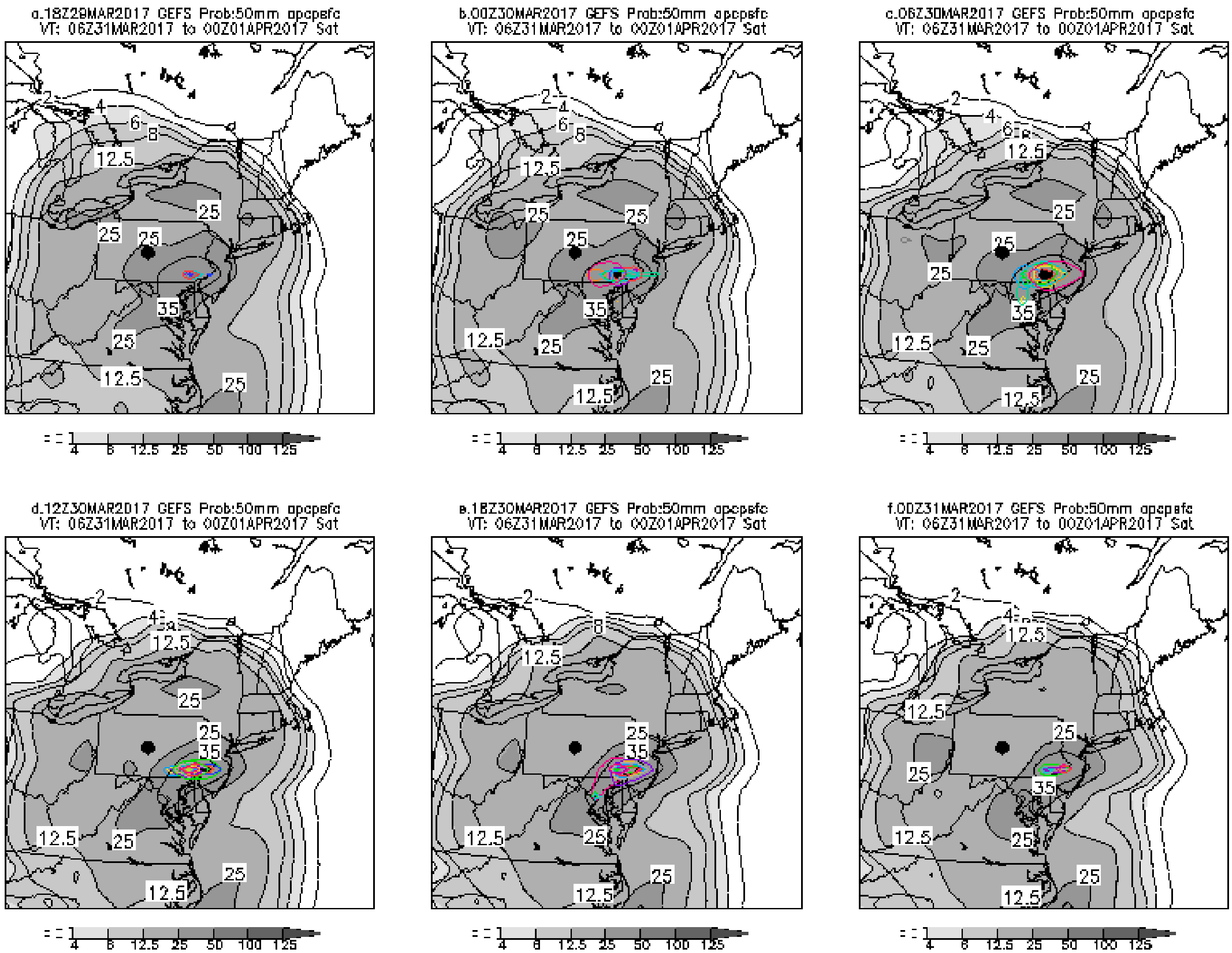

Figure 11.As in Figure 9 except for the QPF ending at 0000 UTC 1 April 2017. **Return to text.**

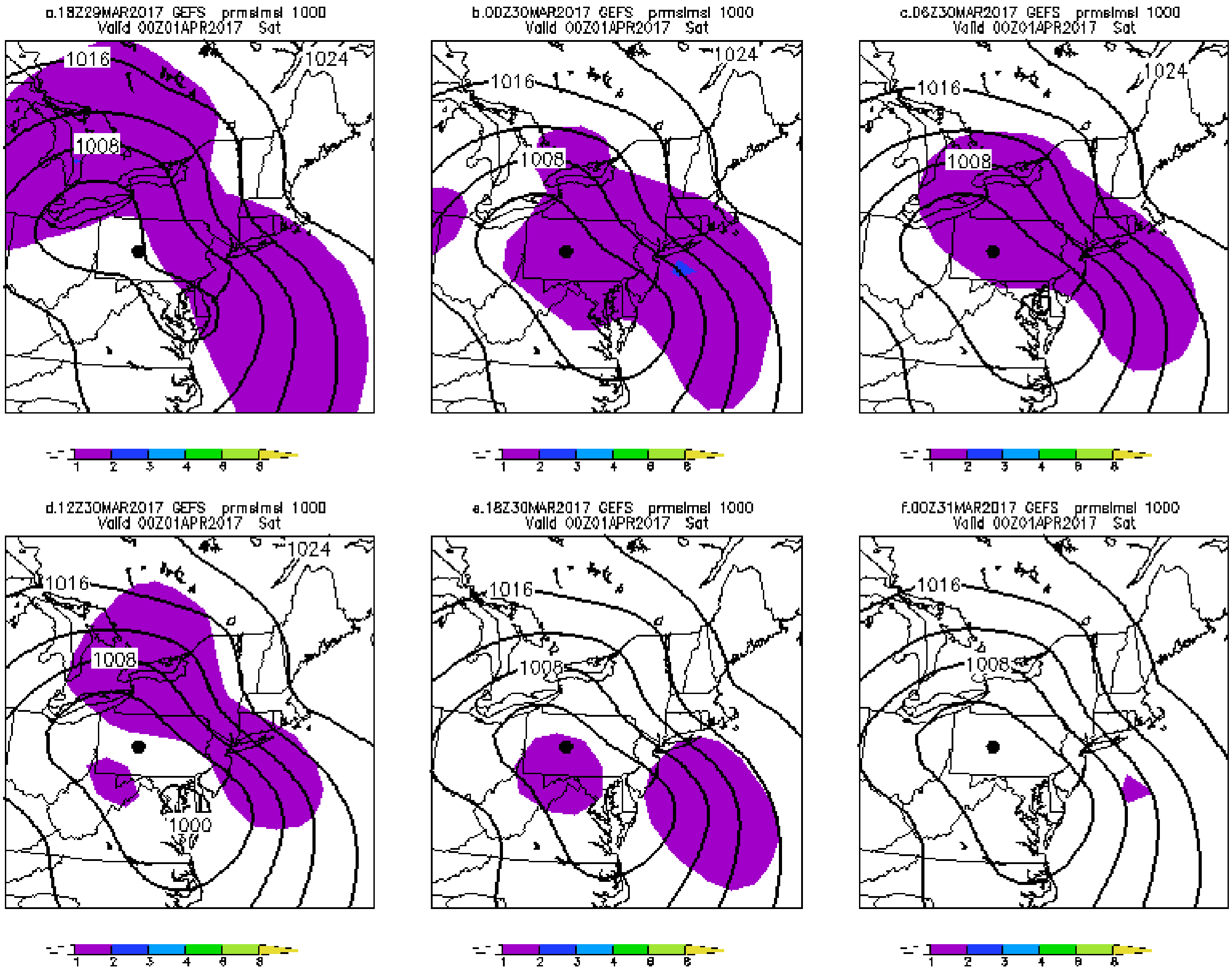

Figure 12. As in Figure 9 except for the GEFS ensemble mean, mean sea level pressure and the spread about the mean valid at 0000 UTC 1 April 2017. **[Return to text.](#)**

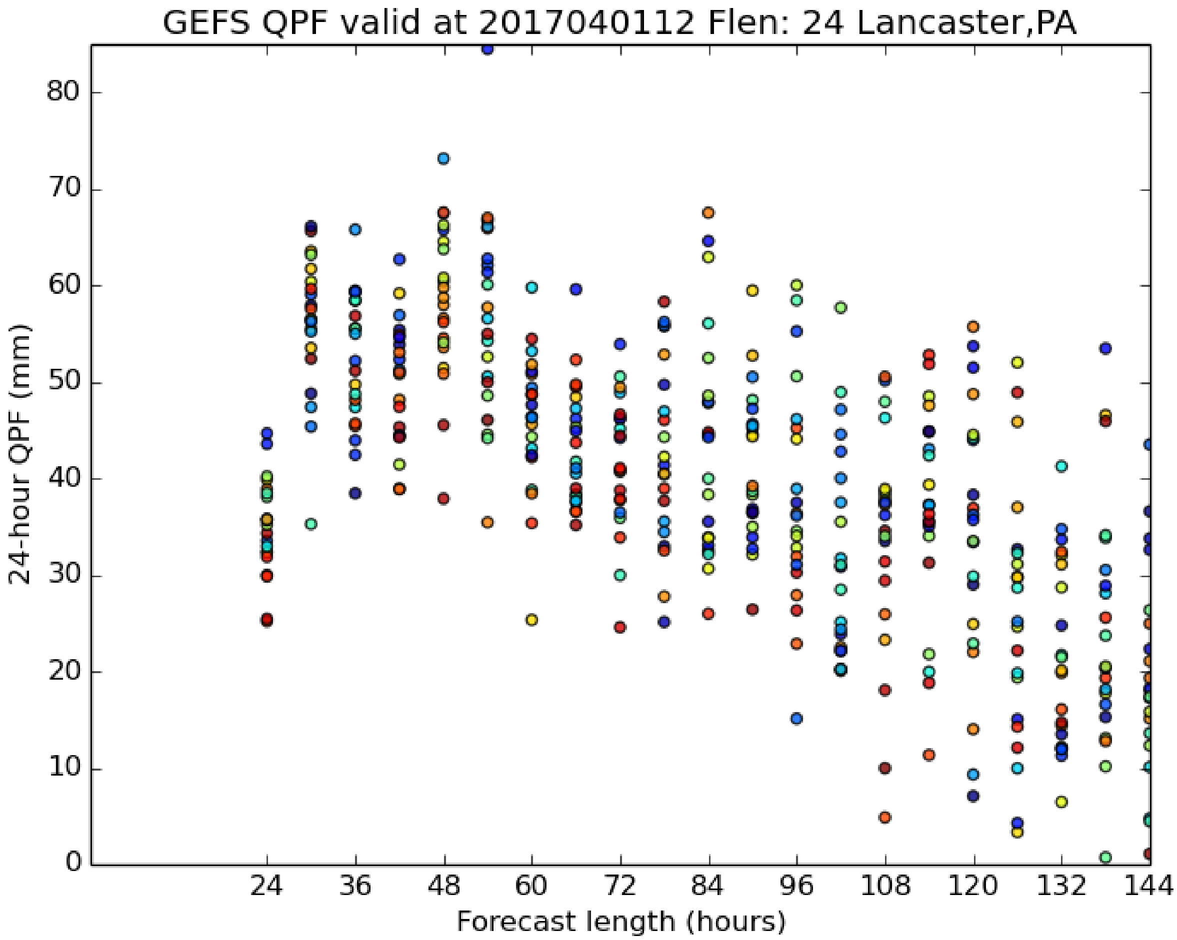

Figure 13. Predictability horizon diagram for a point near Lancaster, PA. The forecast shows accumulated rainfall for each GEFS cycle for the 24 hour period ending at 1200 UTC 1 April 2017. Each members accumulated QPF is shown for each 6-hour initialized GEFS cycle. Forecasts range in length from 144 to 24 hours prior to the onset of the accumulation window end time. **Return to text.**

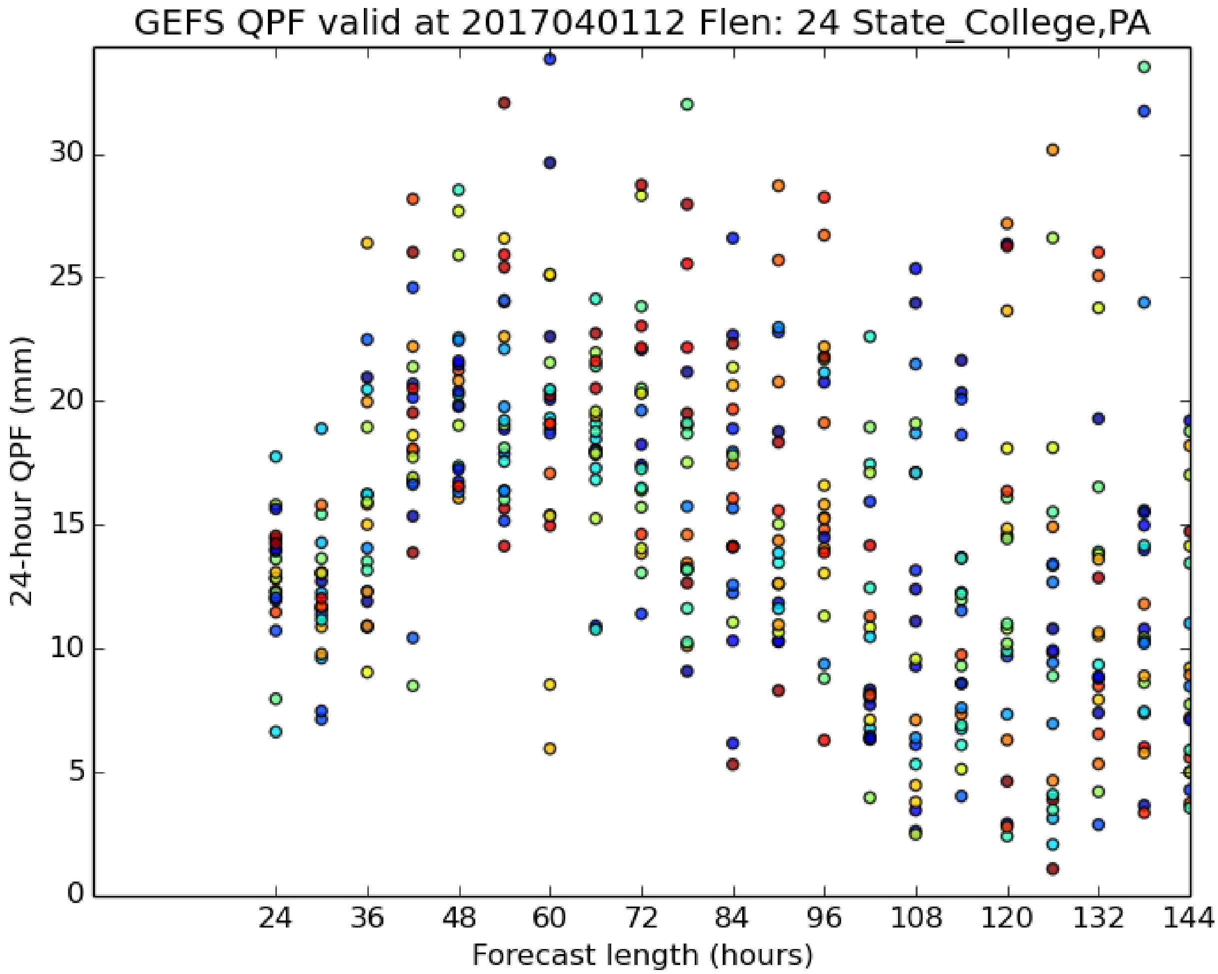

Figure 14. As in Figure 13 except for a point near State College, PA. [Return to text.]

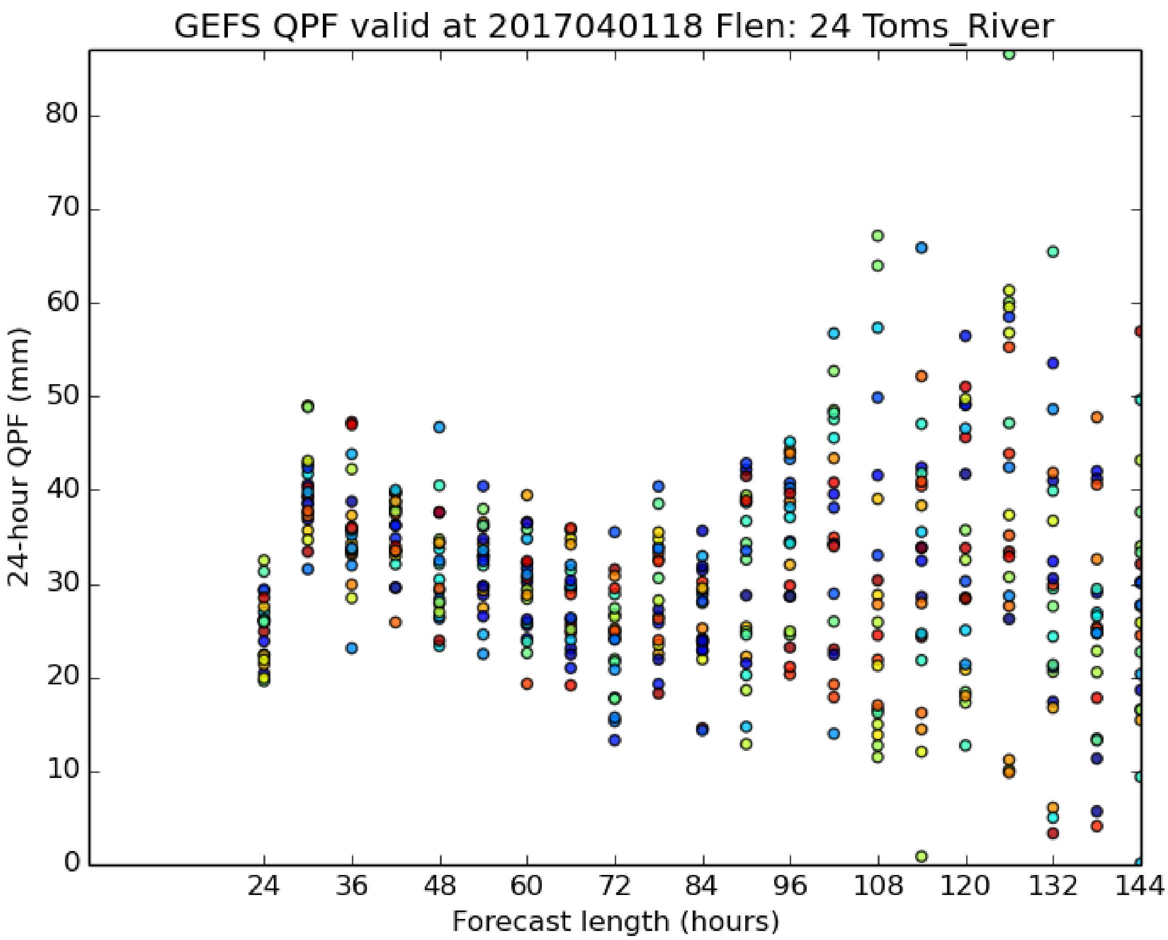

Figure 15. As in Figure 13 except for a point near Toms River, NJ. Note that the 24 hour period here ends at 1800 UTC 1 April to encompass the key period of observed rainfall. **Return to text.**

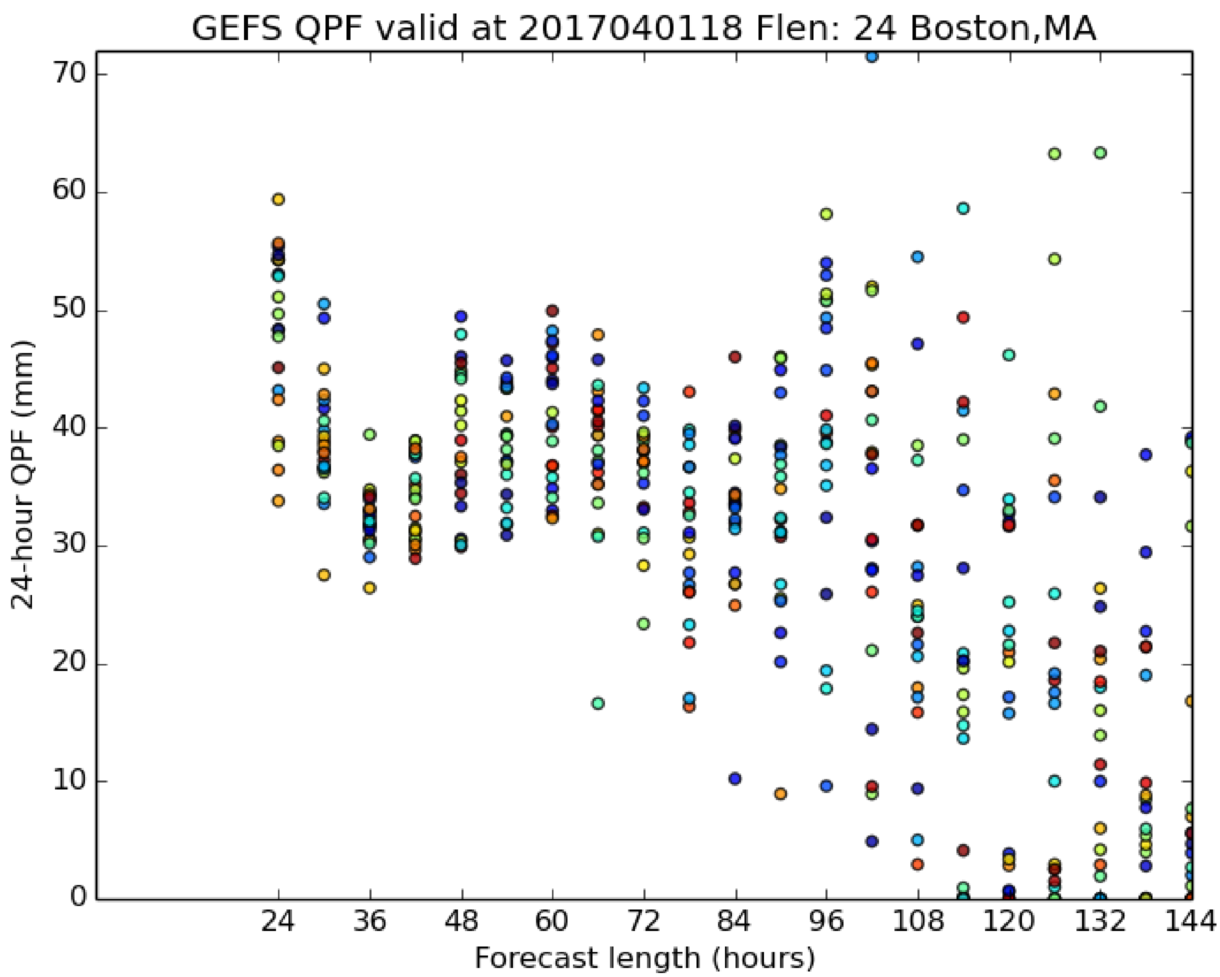

Figure 16. As in Figure 13 except for a point near Boston, MA and the accumulation window ending at 1800 UTC 1 April 2017. **Return to text.**