P5.1

Case Study of 0-6h Experimental and Operational Aviation Thunderstorm Forecasts

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This paper provides a case-study analysis of the forecasts on July 14th 2004, shows the experimental NCWF-2 and E-NCWF probability forecasts that are under development at NCAR and FSL, and discusses our collaboration between NCAR, FSL, MIT/LL and AWC towards a combined 0-6h forecast.

The NCWF-2 should be available through Experimental ADDS late this summer and E-NCWF will be added to Experimental ADDS at the beginning of next summer.

We are excited about building a new 0-6 h convective forecast product that combines input from observations, NWP and forecasters. We believe that this case and others illustrate the need for forecasters to provide qualitative insight that cannot be realized by automated forecasts and for automation to provide spatially detailed information, help mitigate forecaster subjectivity, and allow frequent routine forecast updates.

We have compiled two sets of forecast panels for review;

- E-NCWF and NCWF-2

  These 6 panel plots show probability forecasts at the valid time indicated at the top of the page. The E-NCWF which is a probability forecast based on RUC convective precipitation is shown for 6h in the upper left, 4h in center left, and 2h in center right panels, the NCWF-2 which is a probability forecast based primarily on VIL data but also includes RUC and lightning data is shown for 1h in the lower left and for 2h in lower right panels, and the CIWS VIL field at the valid-time is shown in the upper right panel.

- CCFP and Convective SIGMETs

  These 6 panel plots show corresponding CCFP and Convective SIGMETs. The data were obtained through RTVS and include the CCA coverage observations. The CCFP 6h is shown in the upper left, 4h in the center left, and 2h in the center right, the Convective SIGMET extrapolated by RTVS for 1h is shown in the lower left, and 2h in the lower right panels, the CIWS VIL field at valid time is shown in the upper right panel.

Both sets of panels are provided for 11, 13, 15, 17, 19 and 21 Z valid times. A discussion of the weather and the forecast products is provided.

Synoptic Overview

There was a fair amount of weather on July 14th. A low pressure system was centered over south-eastern Ontario slowly moving to the east. A vigorous shortwave trough lifted northeastward out of the Great Lakes region toward the Northeast U.S. during the early morning hours. The positively tilted trough was characterized by a speed maximum on its western flank that approached the base of the trough. A surface cold front extended from southern Ontario southwestward into Ohio, Kentucky, and westward through the central Plains. A warm front extended from southern Ontario southeastward to the Virginia coastline. Within the warm sector, a surface pre-frontal trough provided additional low-level convergence in a moist, unstable airmass. These large-scale features were well detected and forecast. Through out the night, there were three regions of convection, a squall-line just east of Michigan, another in Southern Tennessee, and isolated storms in Southern Indiana. The later two systems dissipated before dawn, with the Michigan squall-line the only one to maintain itself through morning till around 16Z when it too dissipated. New development started relatively early in the day with storms forming in western New York and Pennsylvania by 15Z. A strong line of convection formed in the Tennessee in association with the cold front around 19Z.

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Valid - 11Z on July 14th

One of the forecast challenges was to predict whether the system in the NE was going to stay steady state. In this case, because the storm system stayed steady-state, the RCWF (not shown) and NCWF-2 forecasts were very good at 1 and 2h. In fact, they would have also been good at 4h and 6h because of the nature of the system (the line existed all night). The RUC forecast was also good, indicating the presence of a line in the 6h forecast although the forecast was west of the actual system. The CCFP forecaster provided valuable information in correctly forecasting that the line was not going to dissipate (which is often the case in the early morning hours). They also correctly forecast that the convection in S. Indiana and the squall-line in southern Tennessee were going to dissipate. A synoptic assessment is provided:

> By 11Z, the 85kt 300hPa speed maximum is beginning to round the base of the shortwave trough. Thus, the trough has taken on a neutral tilt. Strong upper-tropospheric divergence is noted spreading over the western NY/PA region and providing plenty of upward motion. A weak low-level jet and warm-air advection (WAA) at 850hPa in western NY/PA and southern Ontario provide additional forcing, which allows convection to persist overnight. 12Z Buffalo, NY and Pittsburg, PA soundings indicate a pre-frontal environment that is characterized by veering low-level winds (WAA) and a decoupled boundary layer with convection rooted above the inversion at about 850-800hPa. This elevated convection is likely to persist throughout the early morning hours, as is indicated by CCFP forecasters and slowly dissipate as the low-level jet weakens. A southeastward propagating MCS over KY/TN is forecast to dissipate, with a capped environment and less optimal upper dynamics likely being the limiting factors (12Z BNA sounding indicates a weak elevated mixed layer at ~750hPa).

This case shows a prime example of where automated and forecaster input together would provide a valuable forecast; the automation to provide specific information on extrapolated location, regions of favorable development as indicated by NWP, and the forecaster to modify or accept forecast regions.

13Z on July 14th

Once again, the forecast problem is whether the line will maintain itself. The CCFP forecaster does a good job, even at 6h predicting that the line will not dissipate. While the longer-range (4-h and 6-h) CCFP and RUC forecasts do accurately maintain the line, there is a time-lag issue, with the squall-line forecast too far west. The shorter range (2-h, 1-h) forecasts are better, especially with the extension of the convection south toward the Maryland border. Because, the line is a steady-state system the extrapolations do very well at positioning. From a forecaster standpoint:

> Convection begins to expand in areal coverage southward along the warm front to the MD border. While diurnal weakening of the low-level jet would suggest a weakening trend, increased upper dynamics was the cause of strengthening convection. Large-scale upward motion increased over western NY and PA as the upper tropospheric speed maximum began to round the base of the trough resulting in greater speed divergence and positive vorticity advection on the east flank. Also, the trough began to assume a negative tilt resulting in greater directional diffluence. Though there was an underestimation of the eastward propagation of the convection (particularly at 4-h and 6-h), all of these factors led CCFP forecasters to believe that it would not dissipate.

Again, automation along with forecaster input needs to be combined in order to forecast the continued existence of the line (CCFP forecaster and RUC) and to locate the line properly (extrapolation of observations).

15Z on July 14th

This forecast has to take into account the new growth in Western Pennsylvania. Although the 1hr NCWF-2 picks up on the new growth region, the 2h forecast only provides a hint of potential development. The RUC forecast is still doing a good job of predicting the area of coverage but gives little indication of whether to expect new development or the continuation of the line. The CCFP forecasts pick up on the growth region at all forecast periods (especially the 2 and 4h forecasts). The CCFP reasoning for this forecast was:

> Infrared satellite imagery suggests that initial elevated convection in central PA and western NY is beginning to weaken as cloud top temperatures warm. However, the CCFP forecasts (2-h, 4-h, and 6-h) anticipate convection to remain active in the western PA/NY area in the form of new development along the cold front and pre-frontal trough as increased warm-sector surface heating over western PA and enhanced synoptic-scale lift leads to initiation in the region of surface convergence. Additional development is expected along the cold front and decaying MCS outflow in the TN/mid-Atlantic region at 4-h and 6-h forecasts, but only dissipating convection associated with the MCS is realized. Due to convective inhibition and less-favorable upper divergence, more low-level destabilization is needed for development in this area.

Initiation and new growth regions are very difficult for automated products to forecast. The observation based systems (like NCWF-2) tend to miss new development. RUC does a nice job of capturing zones of storm initiation however there is a tendency to over-forecast. The forecaster's ability to assimilate various sets of information at different scales greatly contributes to the quality of the forecast.

17Z on July 14th,

The 1-h and 2-h NCWF-2 both accurately depict the leading squall-line (dissipating in eastern NY/PA) and the trailing convection (intensifying in north-central PA). The CCFP and RUC-based forecast also show good skill, but focus more on the trailing convection and extend the convection too far southwest. The forecast reasoning:

> Strong heating has resulted in a moderately unstable airmass in the pre-frontal environment. Within the warm sector, a thermal axis extends from the mid-Atlantic region northward to southern PA. The new development is focused along the warm front on the nose of the thermal ridge and extends southward along the pre-frontal trough. CCFP forecasts have keyed in on this development along the pre-frontal trough. CCFP forecasts have correctly represented the dissipation (to below CCFP criteria) of the elevated convection in east/central NY due to the weakening of the low-level jet and the propagation of the convection away from the best upper support.

19Z on July 14th

All forecasts have locked onto the strong north/south line across eastern PA. In particular, the consistency of forecasts at 2-h is quite strong, with high probability forecast by NCWF-2 and E-NCWF and medium coverage forecast by CCFP. A new initiation region in TN is forecast by the RUC-based E-NCWF (especially at 4- and 6-h) but missed by the other forecasts. The forecast reasoning:

> As upper speed maximum continues to round the base of the trough giving it an increased negative tilt, mid-level cold-air advection increases. Throughout the day, increased mid-level CAA over surface heating has induced a very unstable airmass in central PA southward into the mid-Atlantic region. Enhanced surface convergence and increasing upper divergence has led to continued growth of convection into an organized squall line along the pre-frontal trough from southern NY to far northern VA. Additional activity exists in western PA along the main cold front. Both areas were forecast well by the 2-h, 4-h, and 6-h CCFP forecasts. CCFP forecasts missed convective initiation in central TN at 19Z. This development along the surface cold front was just ahead of the upper trough axis and aided by a subtle upper disturbance within the northwest flow aloft. IR imagery detects this feature well as it shifted southeastward out of the central Plains. The subtle nature of this feature makes it difficult to detect and may have simply been overlooked by the forecaster.

21Z on July 14th,

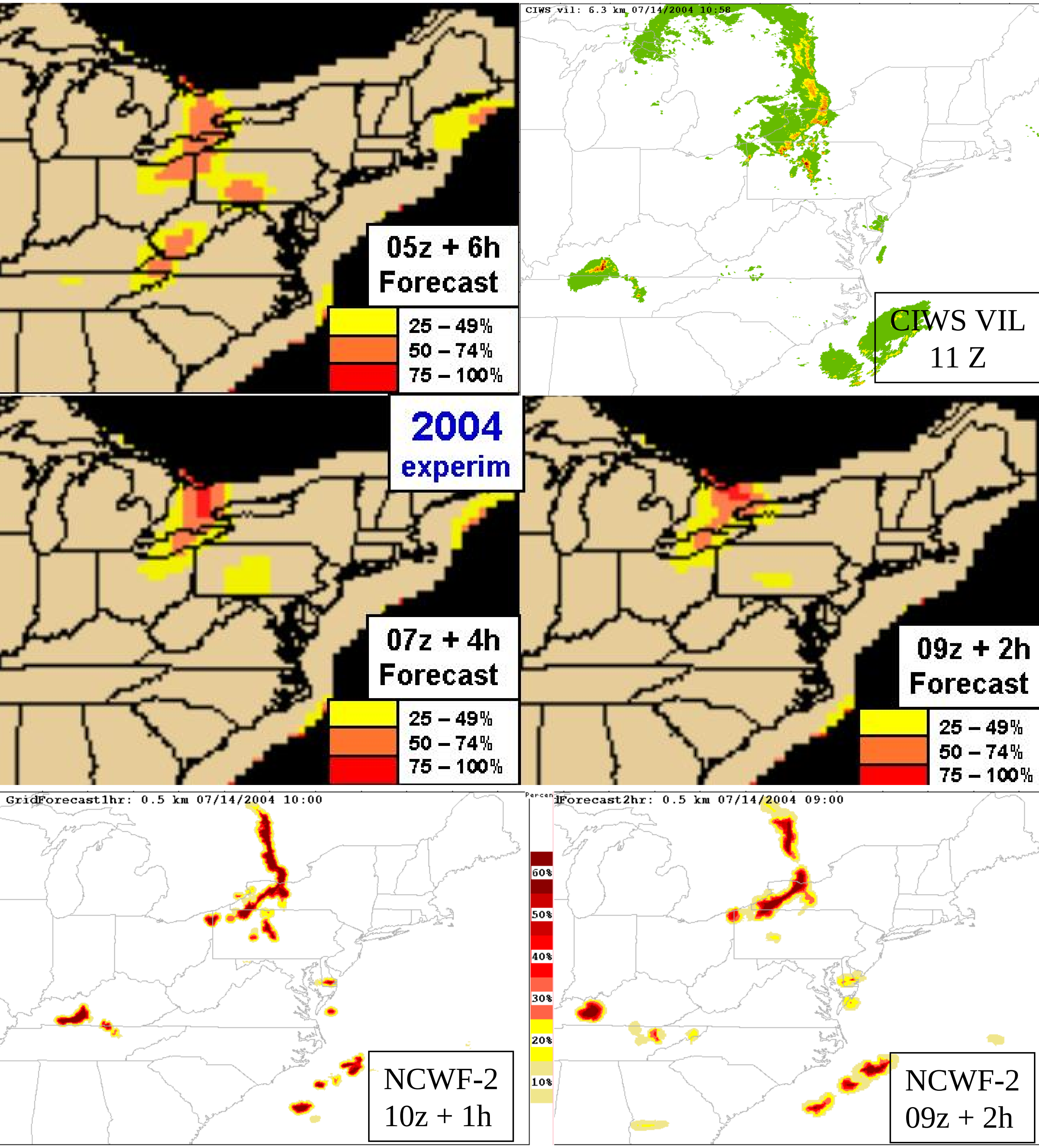
At this point, extrapolation forecasts are pretty good. The agreement between the 6-h CCFP medium coverage area and the 6-h E-NCWF high probability is very good, suggesting a combined automated – forecaster product could provide a superior forecast. At 2-h and 1-h lead-time, the NCWF-2 forecast does a very good job of capturing the convective details from southeastern PA through northeast VA. The forecast reasoning:

> By this time of the day, the main focus of forecasting convection shifts from anticipating initiation to assessing convective evolution. The CCFP forecasters have accurately determined that the NY/PA convection will remain confined to the pre-frontal trough in the maximum unstable airmass. They have extrapolated the speed and motion while accounting for thermodynamic and storm-scale factors (such as the development of a forward-propagating cold pool) that will affect storm velocity.

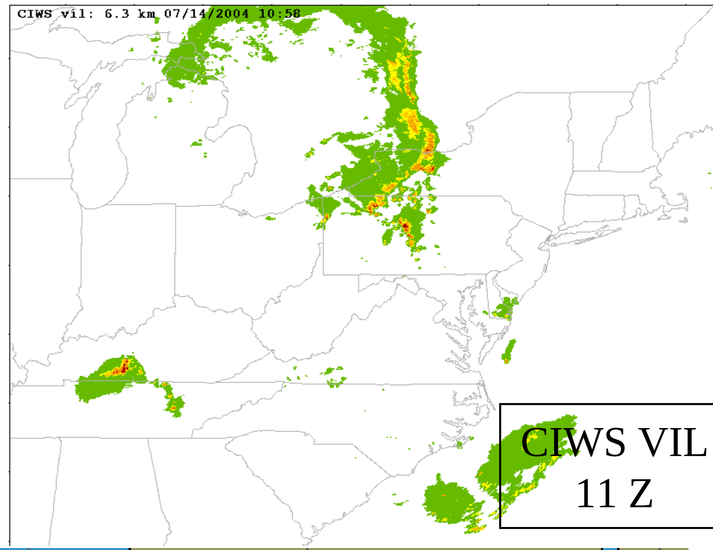
Summary

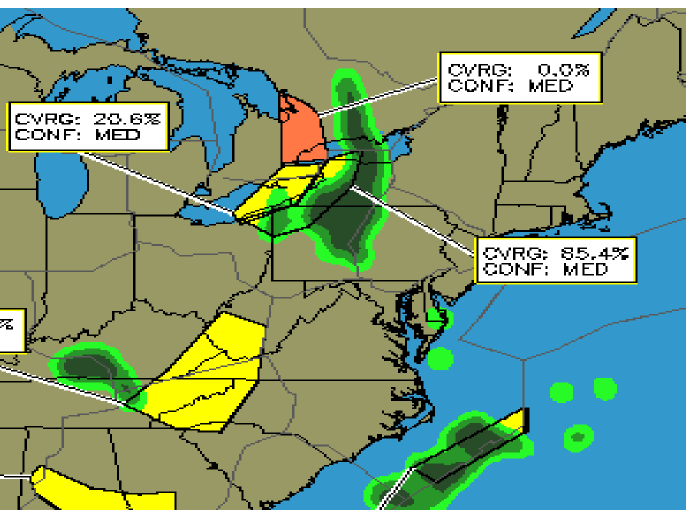
The National Research Council's report on Weather Forecasting Accuracy for FAA Traffic Flow Management states that, "*One approach for an operational system that will serve the aviation community's needs is to blend short-term observation-based forecast techniques with NWP output in a manner that provides a time continuum of reliable quantitative measures of uncertainty.*" Our collaboration hopes to follow this approach by making the best use of available information and forecasts. This case hopefully illustrates the role of each forecast element in the continuum and provides a starting point for our continued development.

E-NCWF and NCWF-2
July 14, 2004 11Z

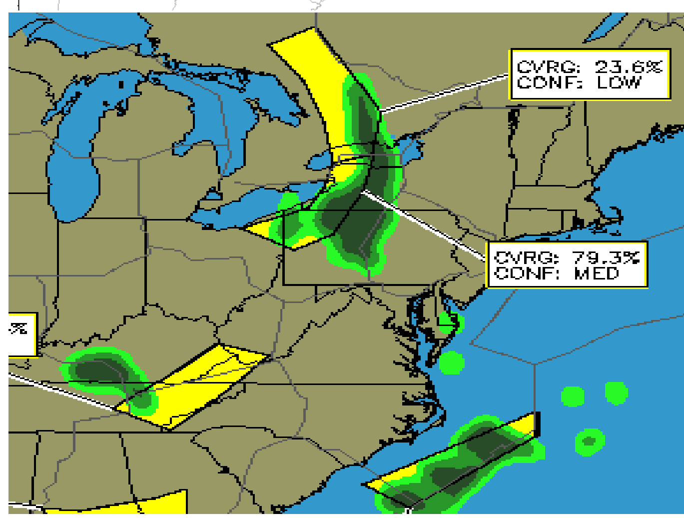


CCFP and Convective SIGMETs
July 14, 2004 11Z

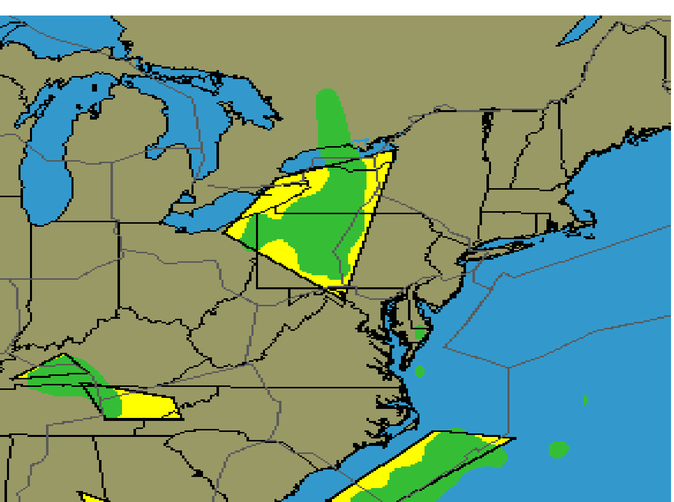




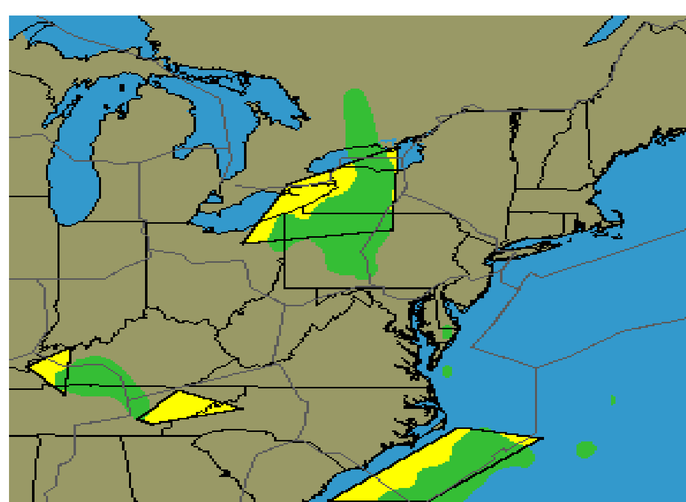
CCFP 07z + 4h



CCFP 09z + 2h



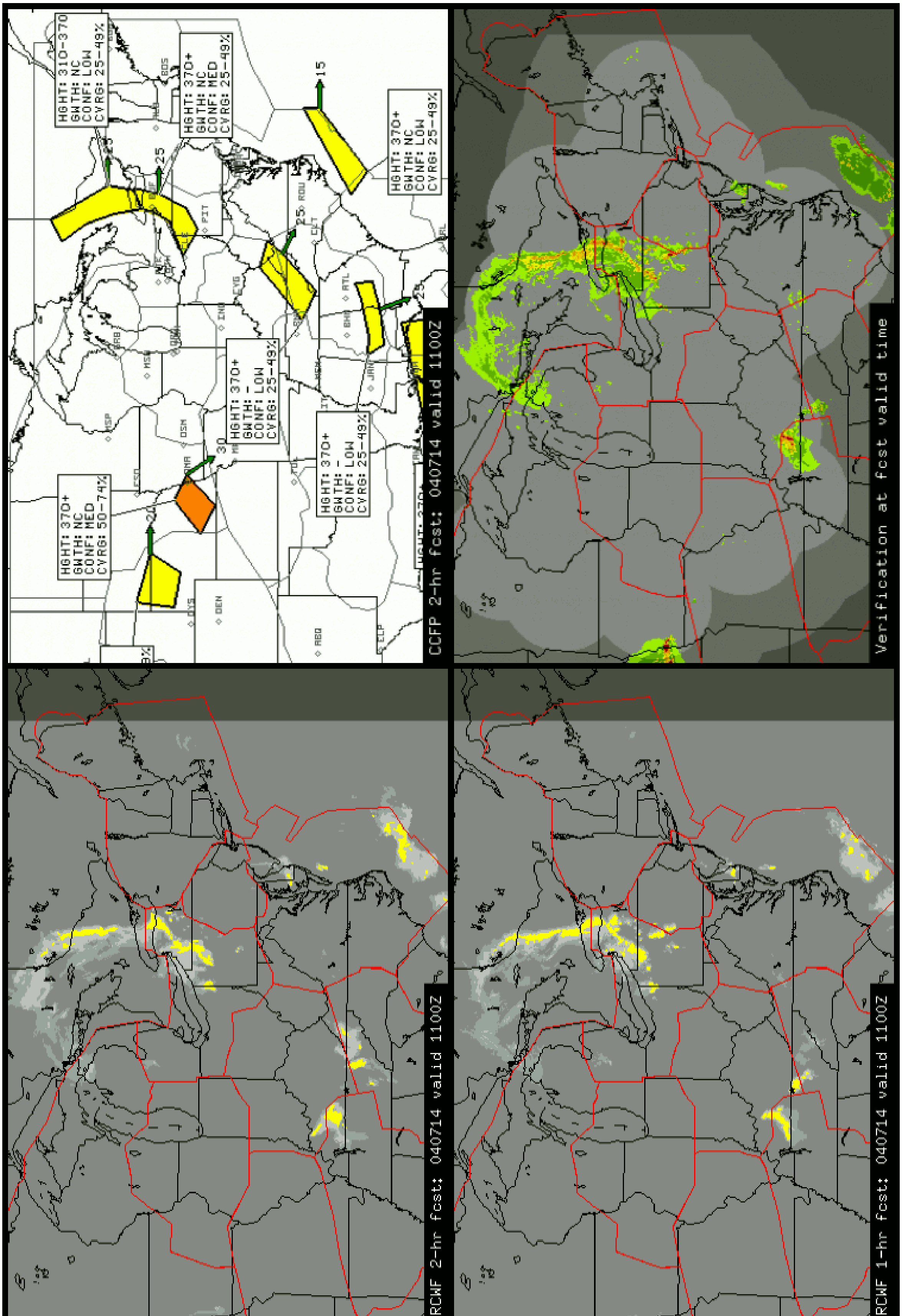
SIGMET 10z + 1h



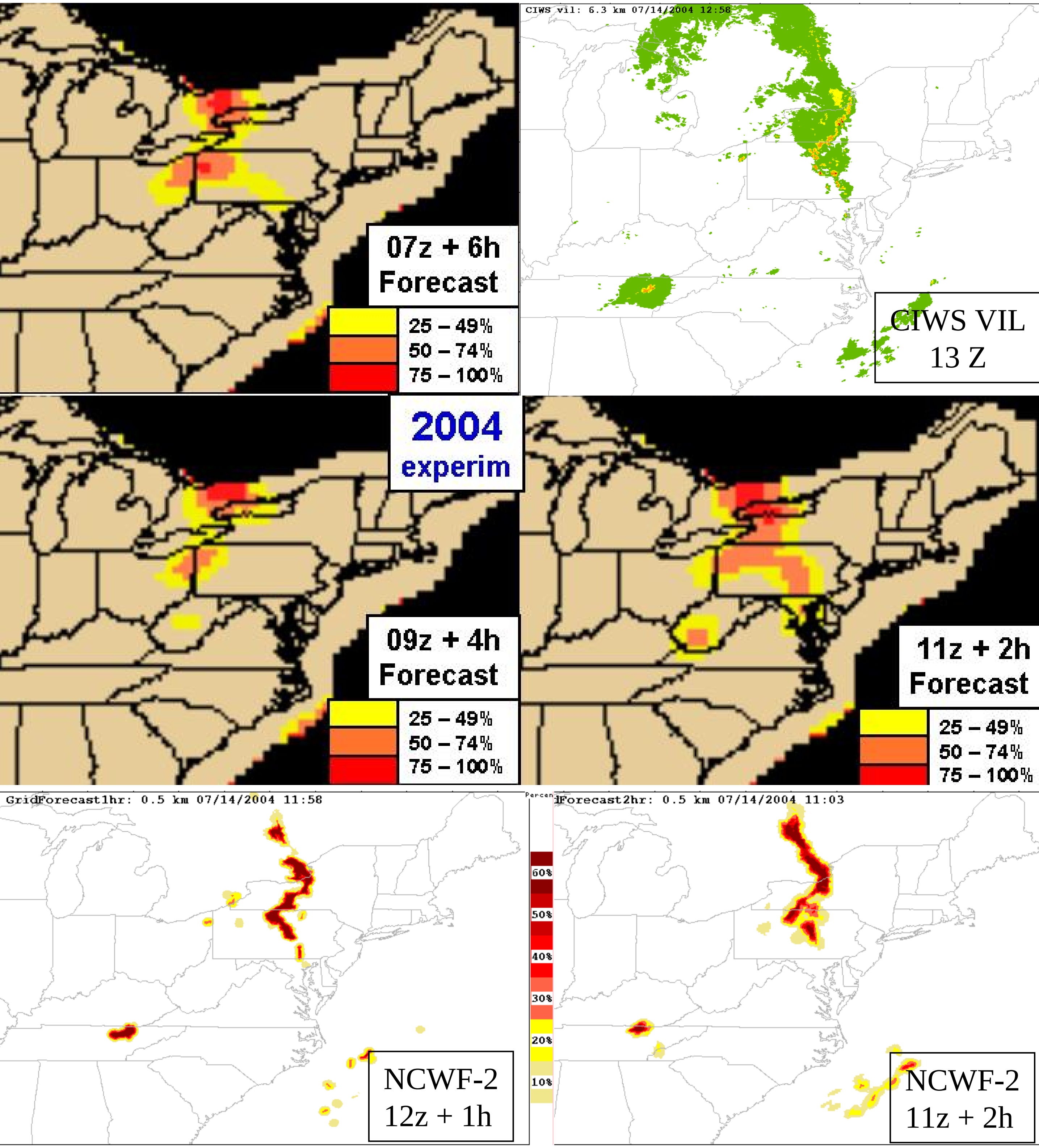
SIGMET 09z + 2h

CIWS-RCWF

July 14, 2004 11Z

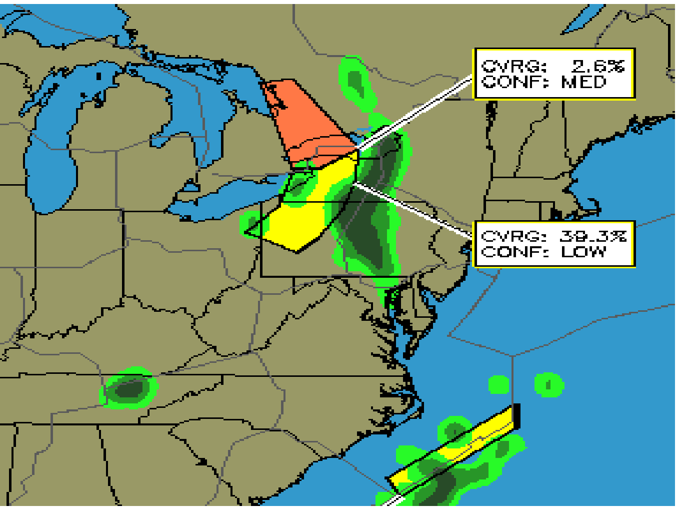


E-NCWF and NCWF-2
July 14, 2004 13Z

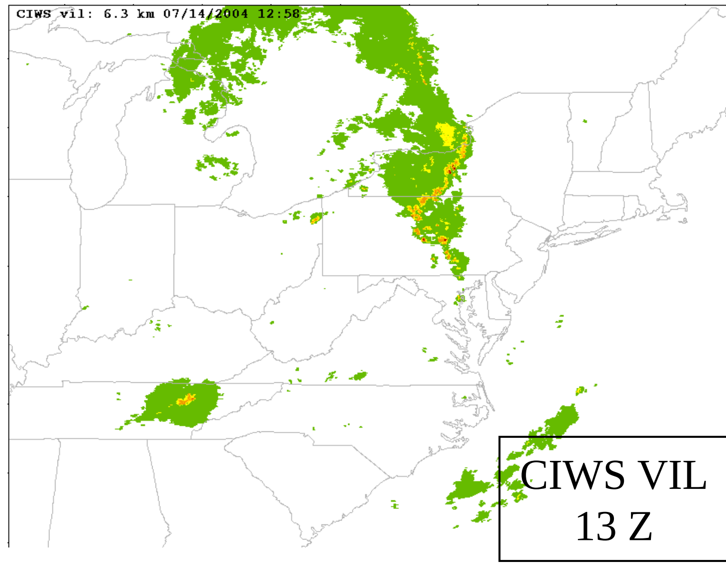


CCFP and Convective SIGMETs

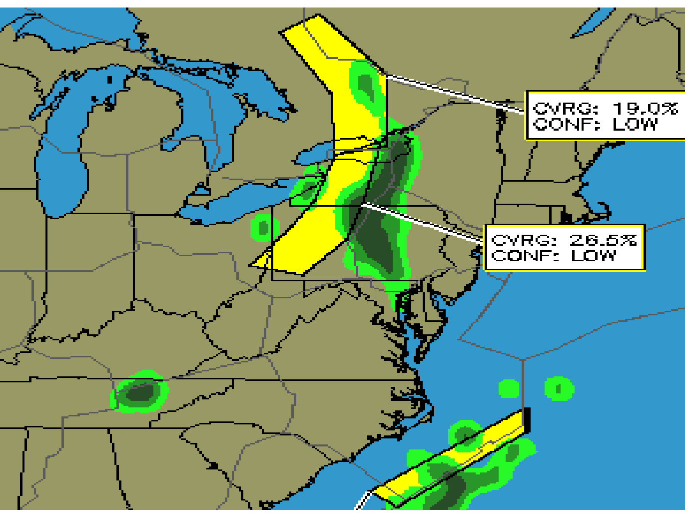
July 14, 2004 13Z



CCFP 07z + 6h



CIWS VIL
13 Z



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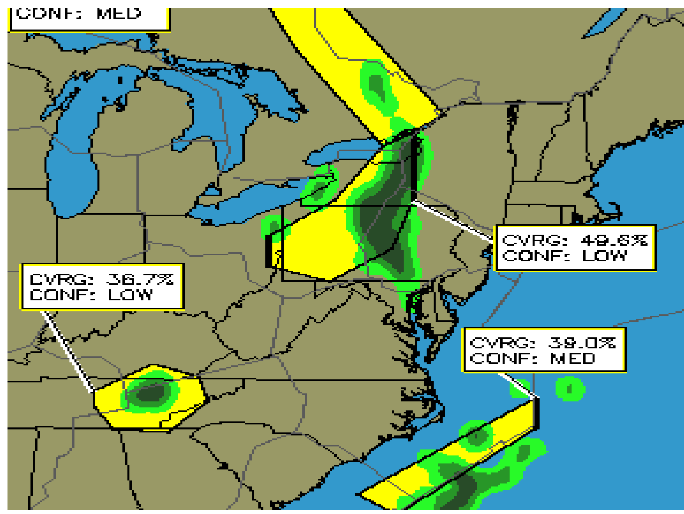

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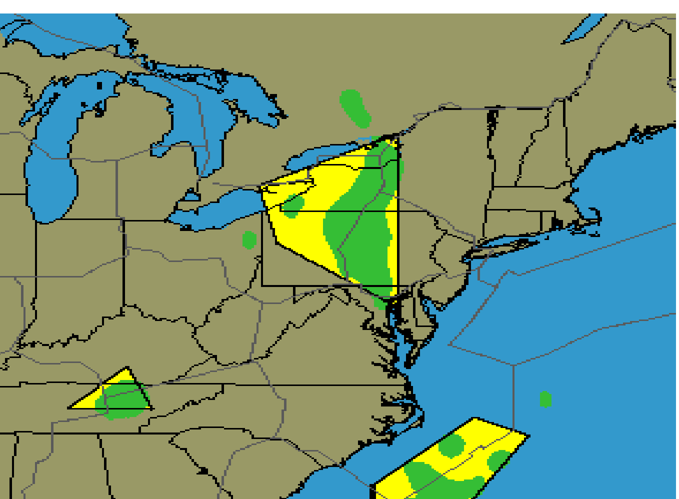
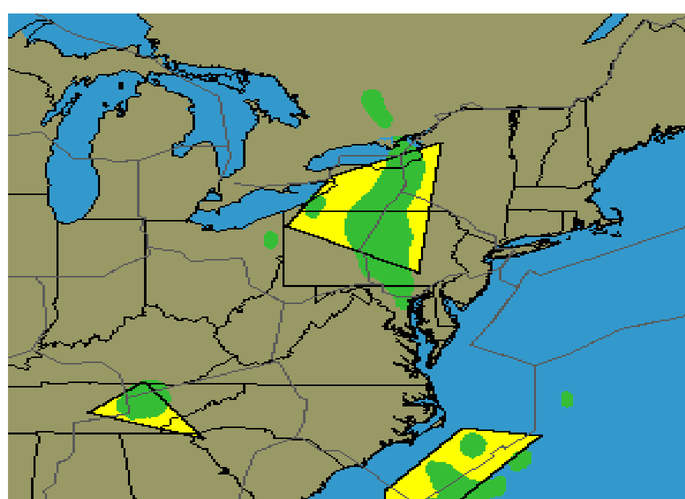
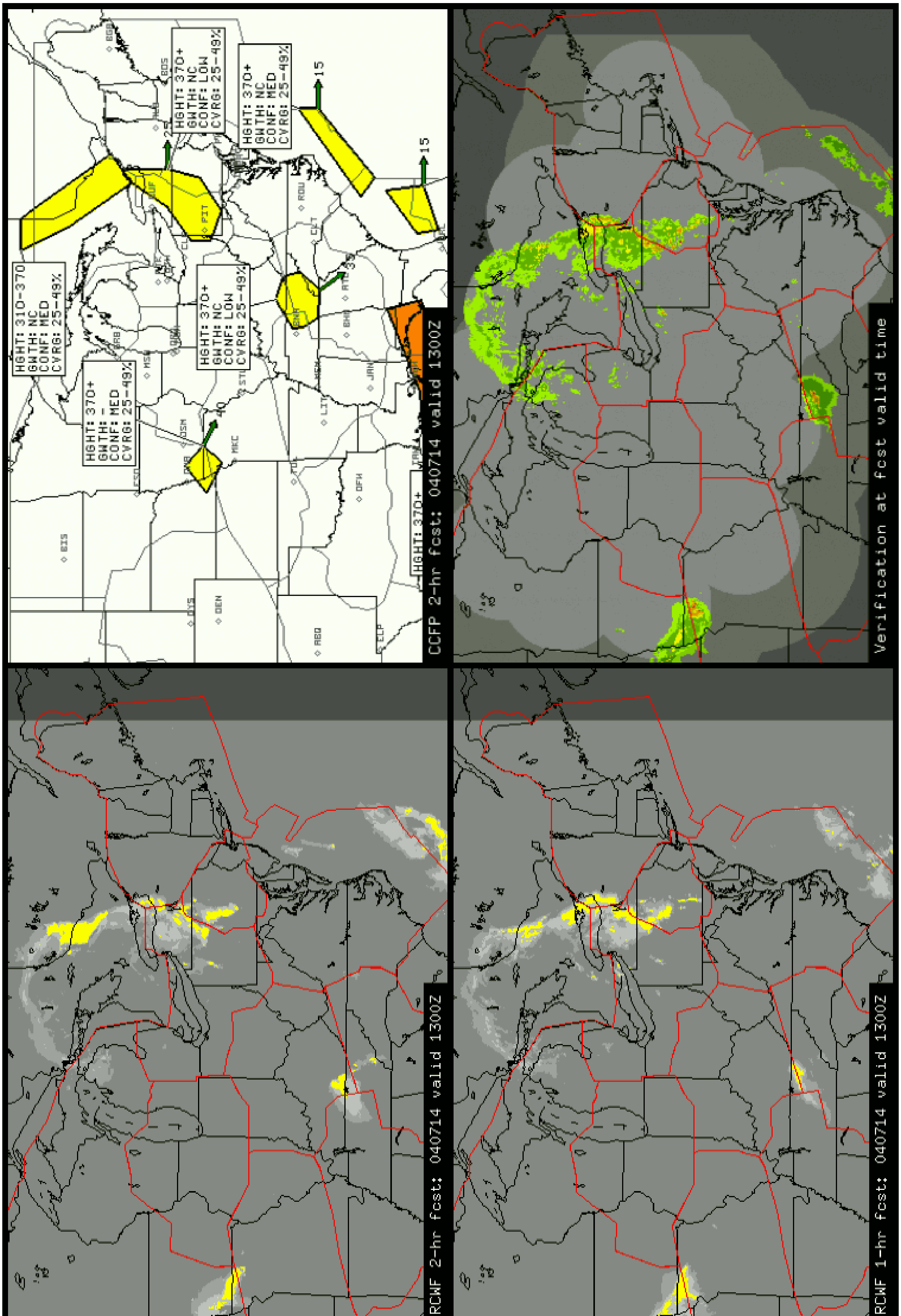


SIGMET 12z + 1h

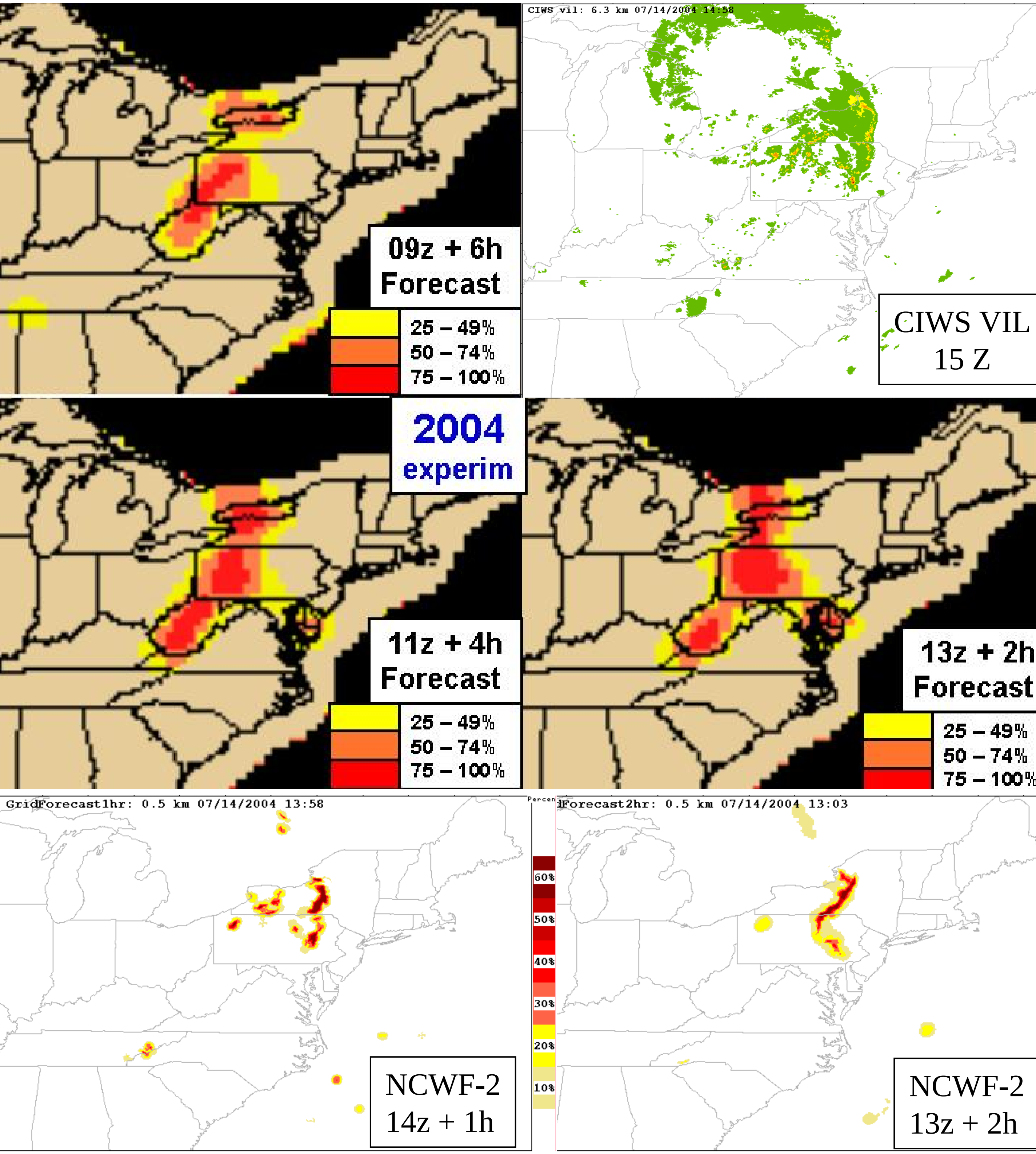


SIGMET 11z + 2h

CIWS-RCWF
July 14, 2004 13Z

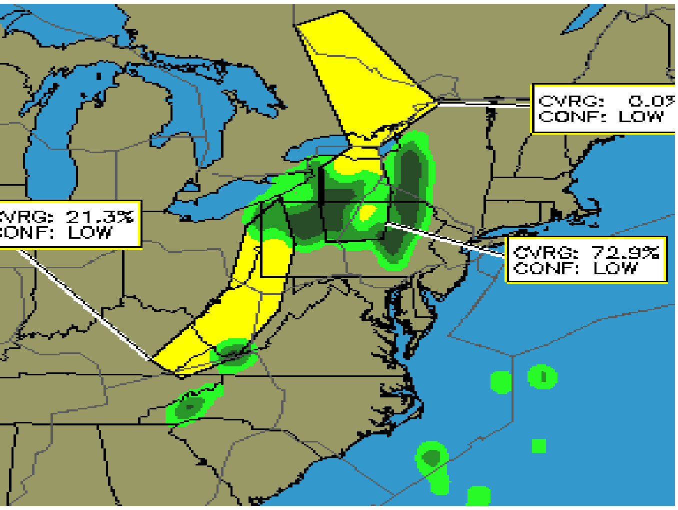


E-NCWF and NCWF-2
July 14, 2004 15Z

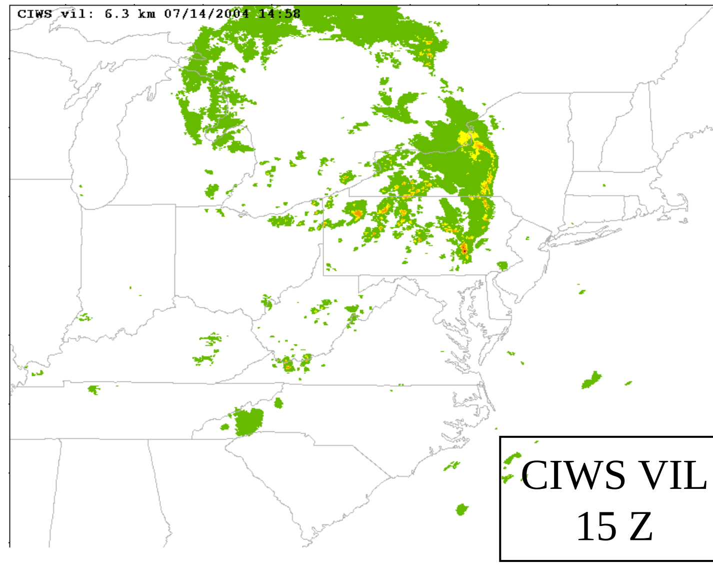


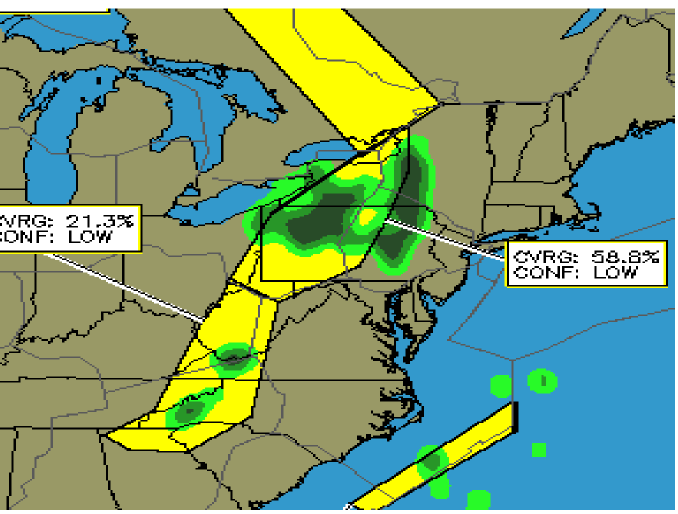
CCFP and Convective SIGMETs

July 14, 2004 15Z

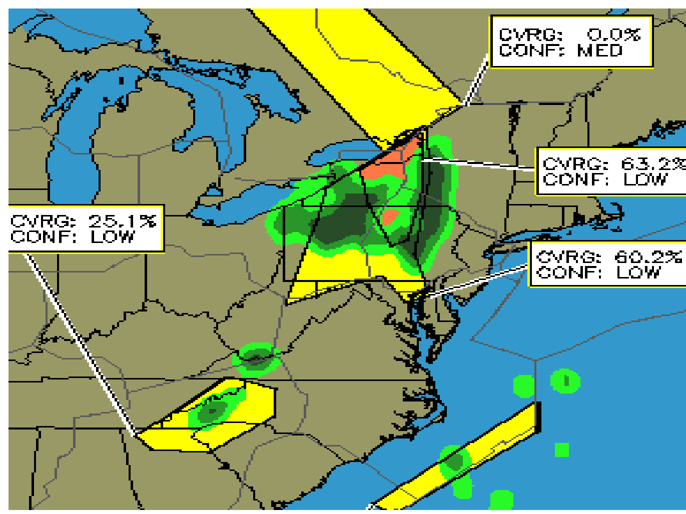


CCFP 09z + 6h

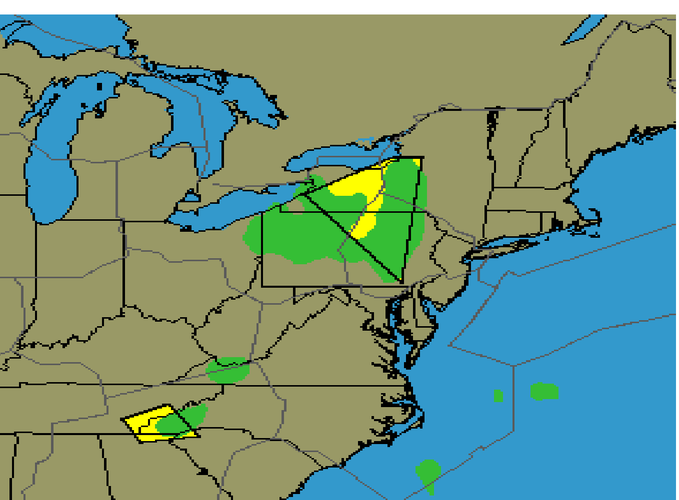




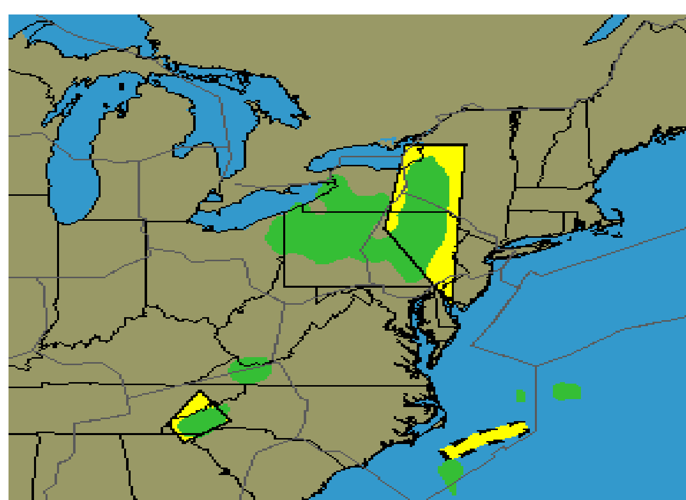
CCFP 11z + 4h



CCFP 13z + 2h



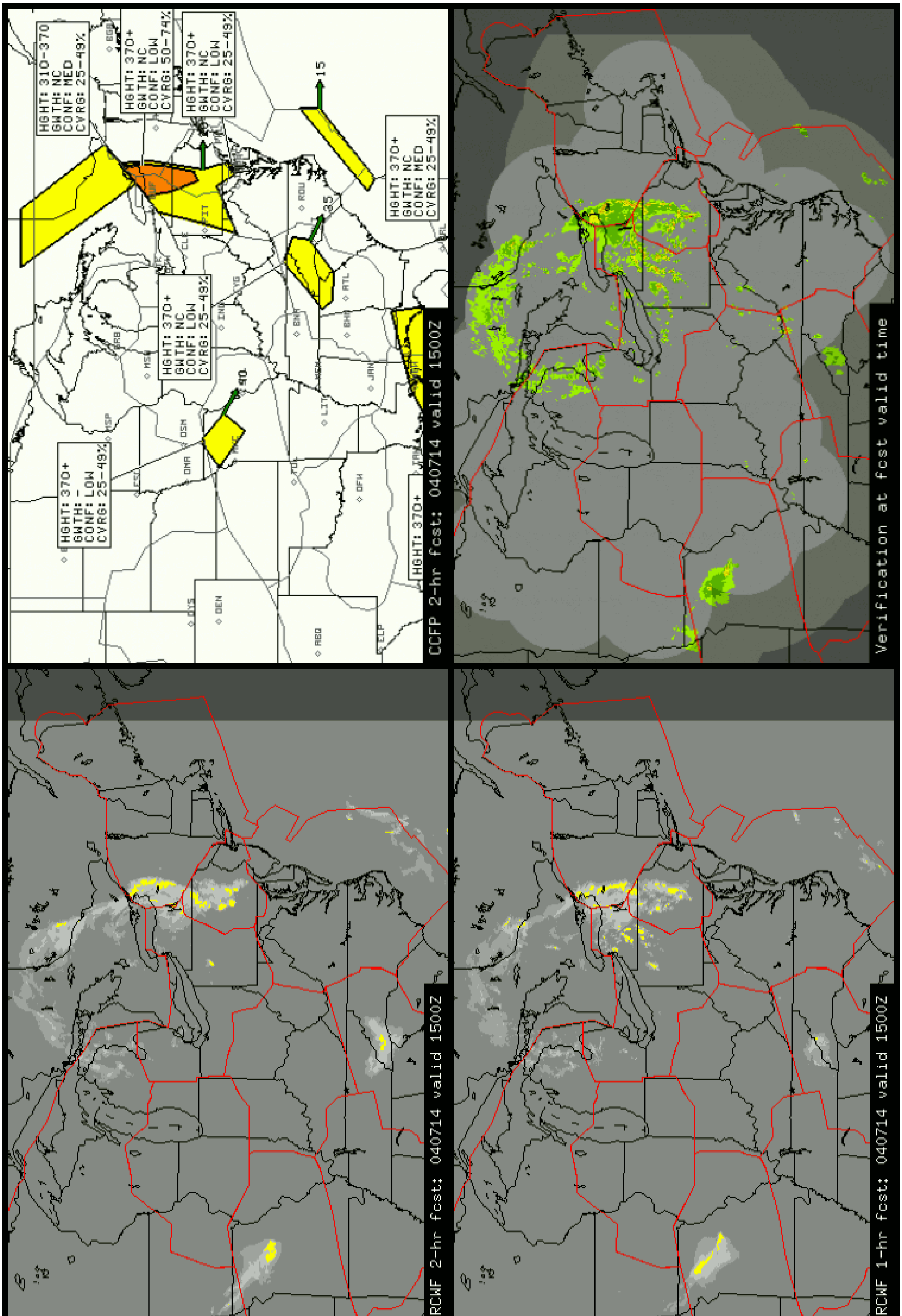
SIGMET 14z + 1h



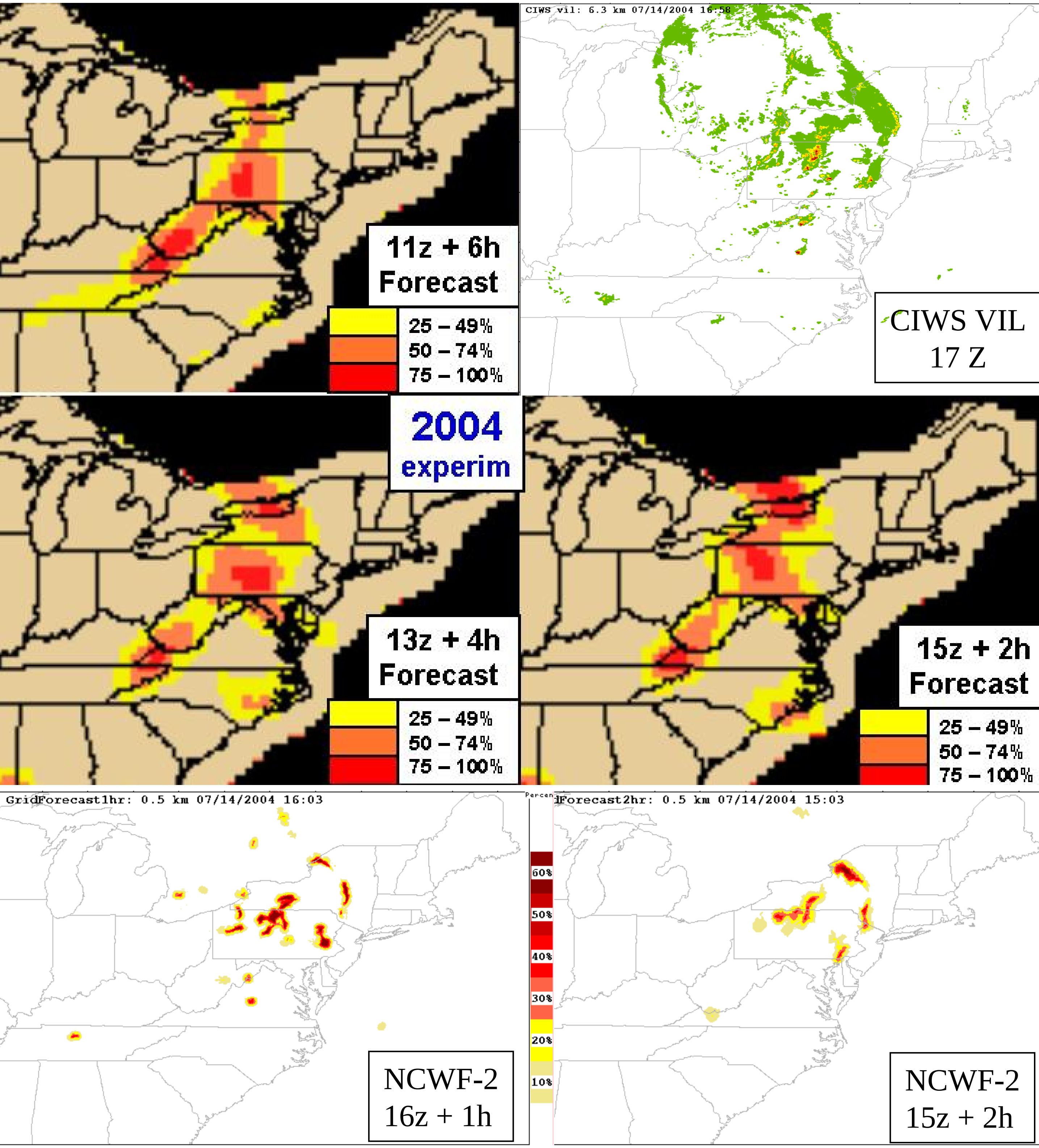
SIGMET 13z + 2h

CIWS-RCWF

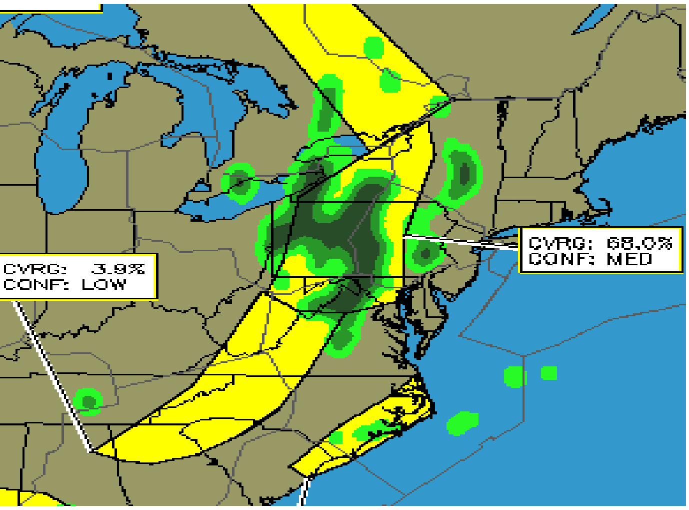
July 14, 2004 15Z



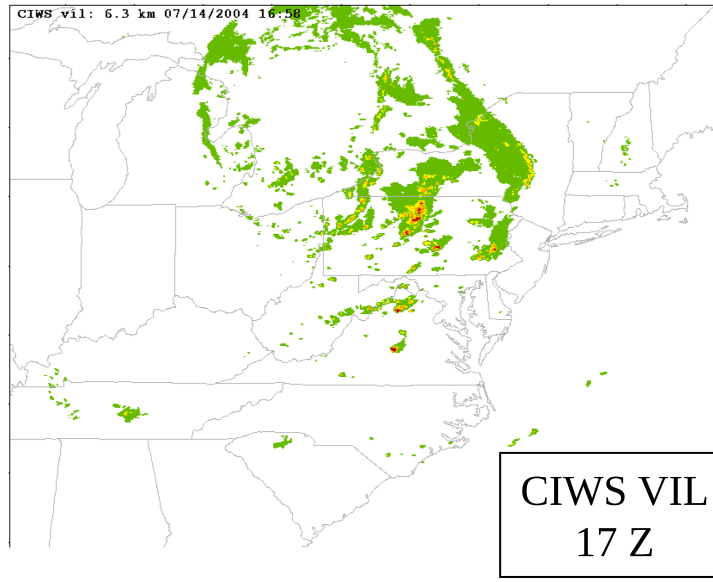
E-NCWF and NCWF-2
July 14, 2004 17Z

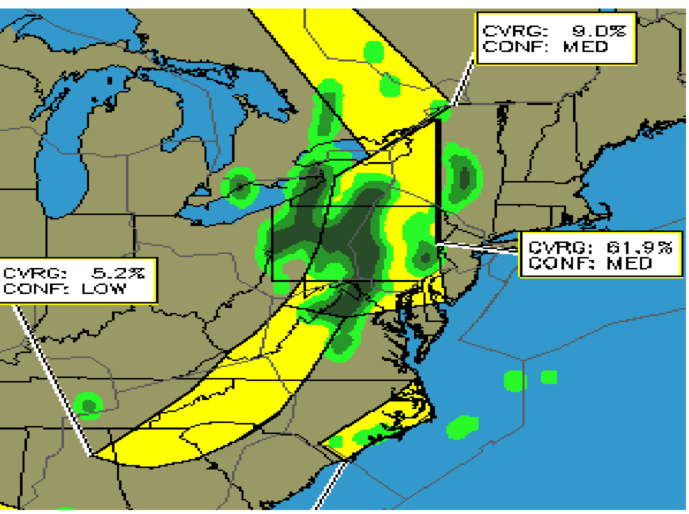


CCFP and Convective SIGMETs
July 14, 2004 17Z

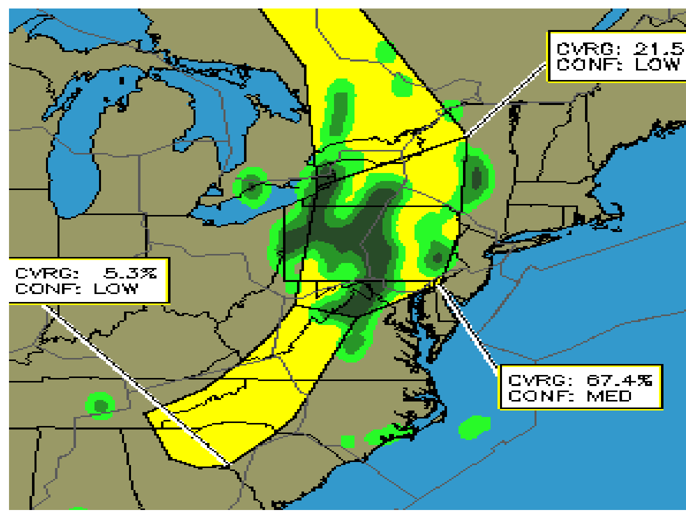


CCFP 11z + 6h

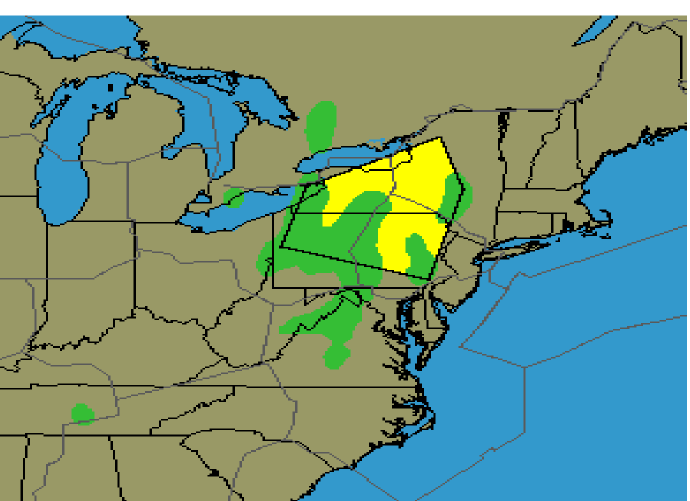




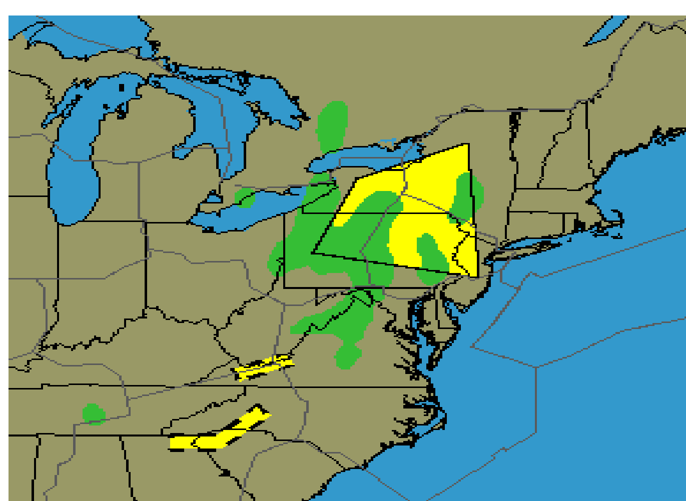
CCFP 13z + 4h



CCFP 15z + 2h



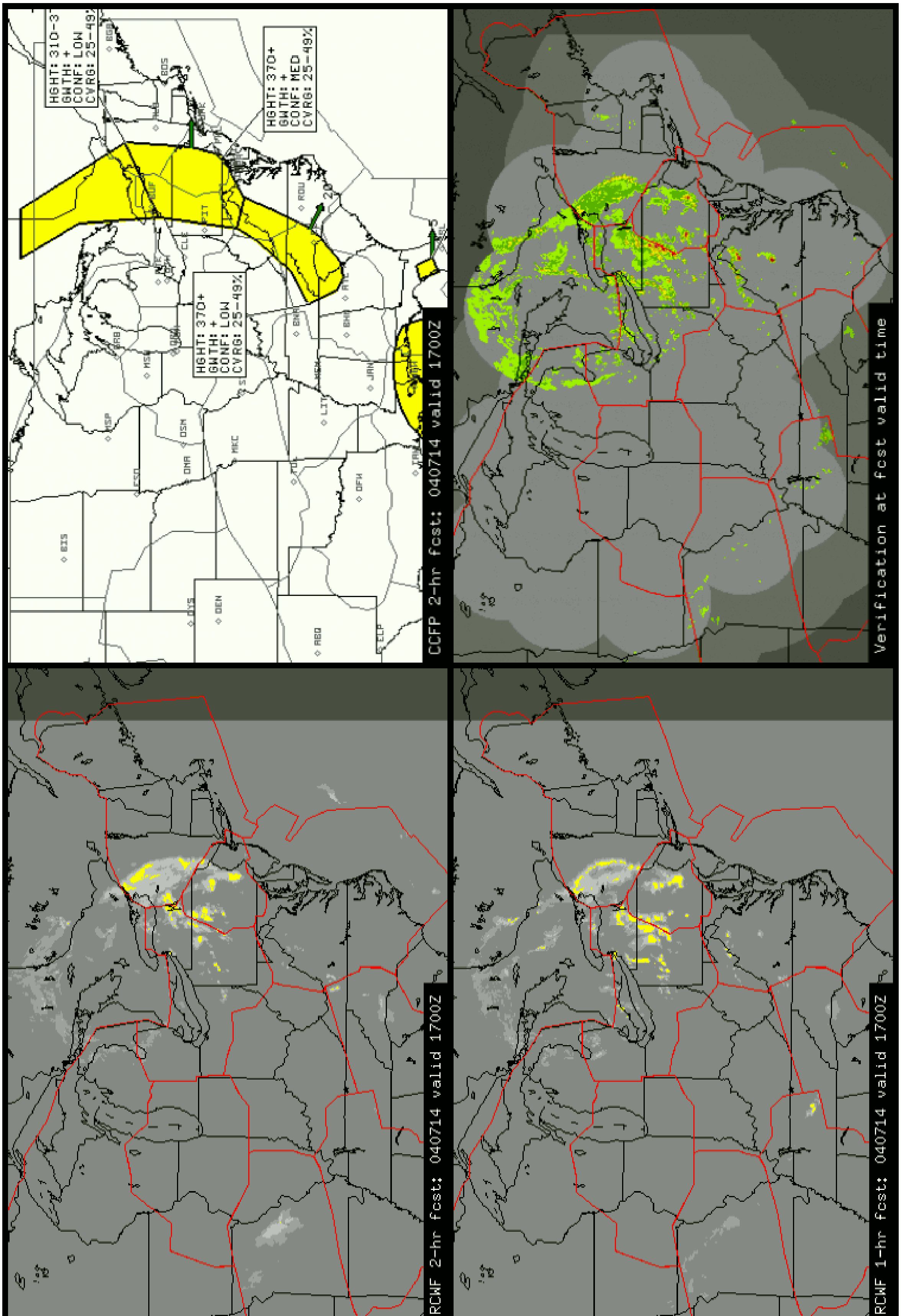
SIGMET 16z + 1h



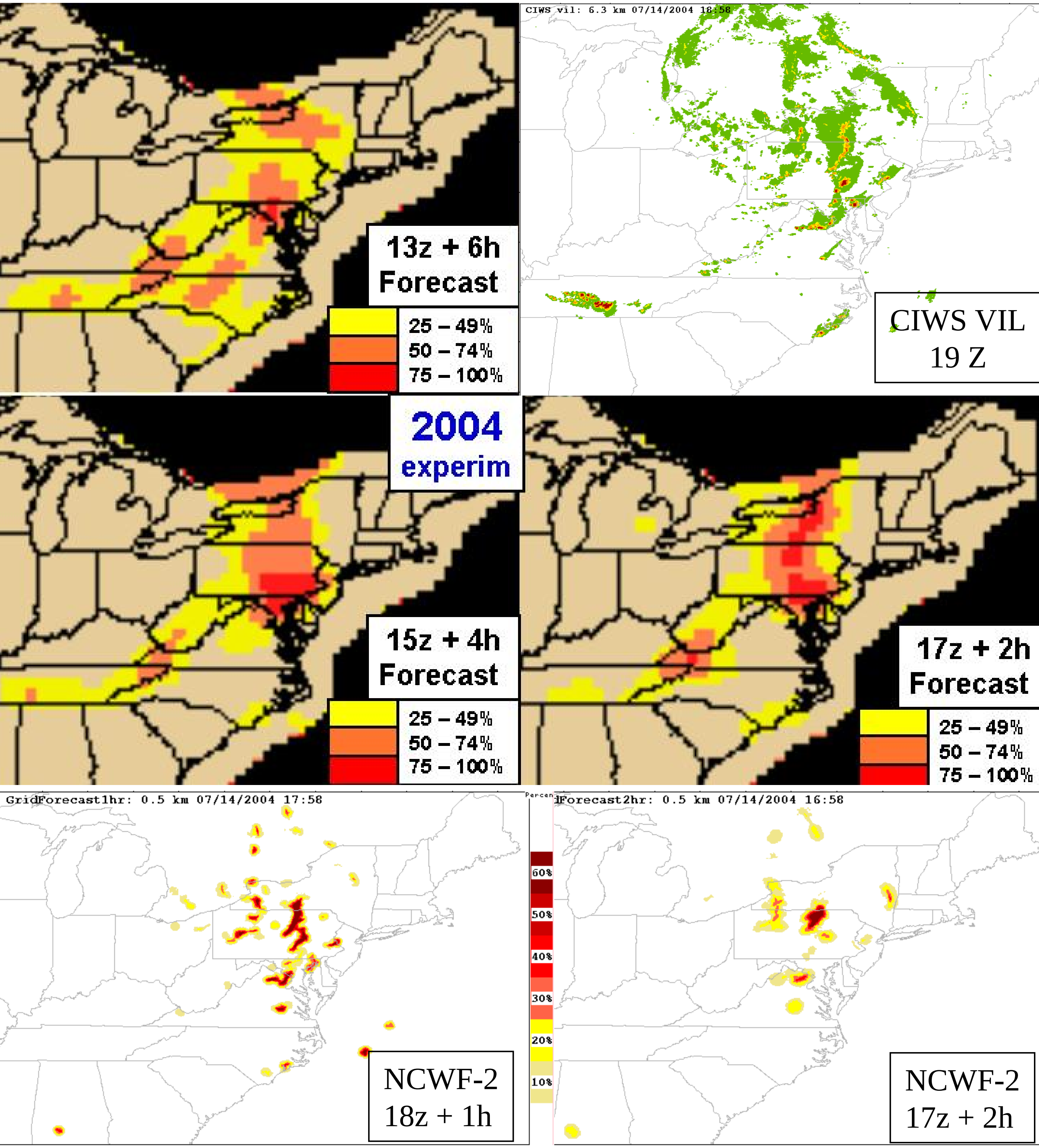
SIGMET 15z + 2h

CIWS-RCWF

July 14, 2004 17Z

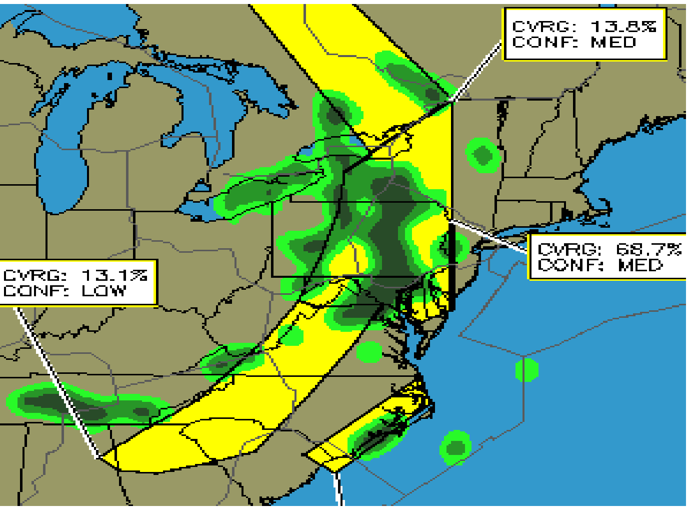


E-NCWF and NCWF-2
July 14, 2004 19Z

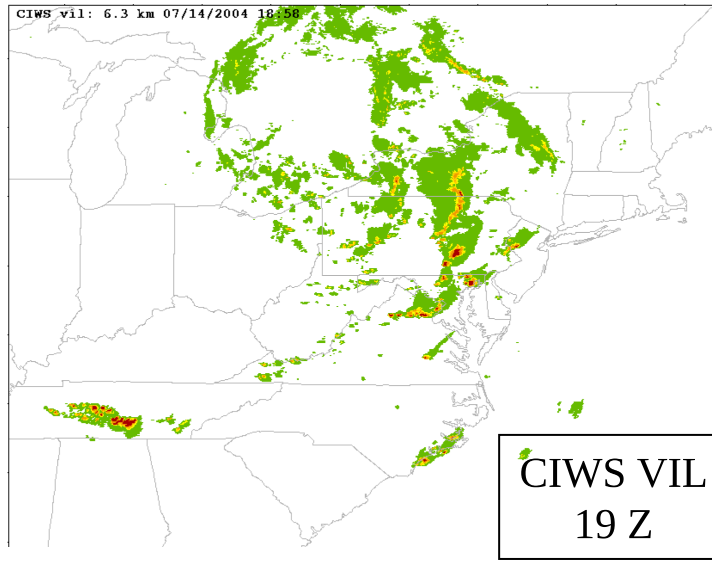


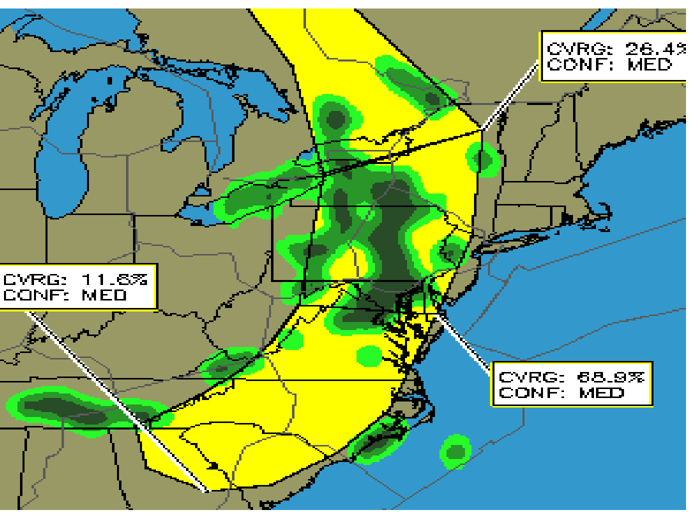
CCFP and Convective SIGMETs

July 14, 2004 19Z

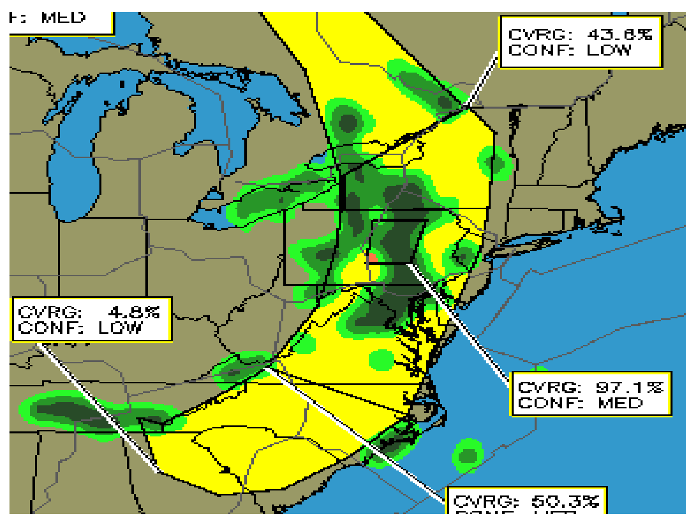


CCFP 13z + 6h

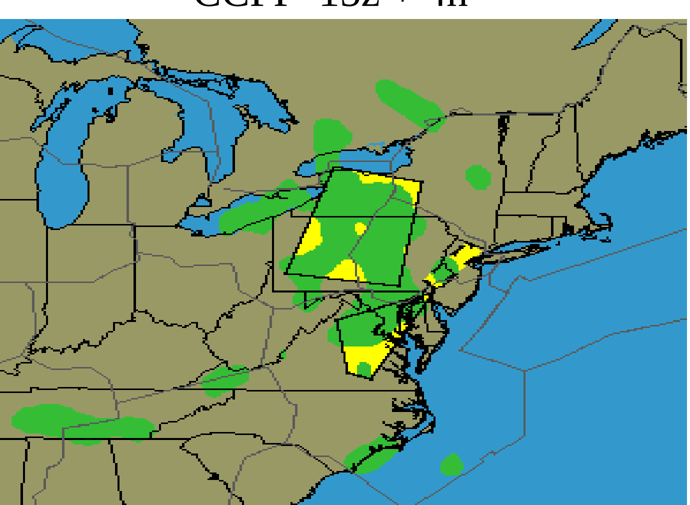




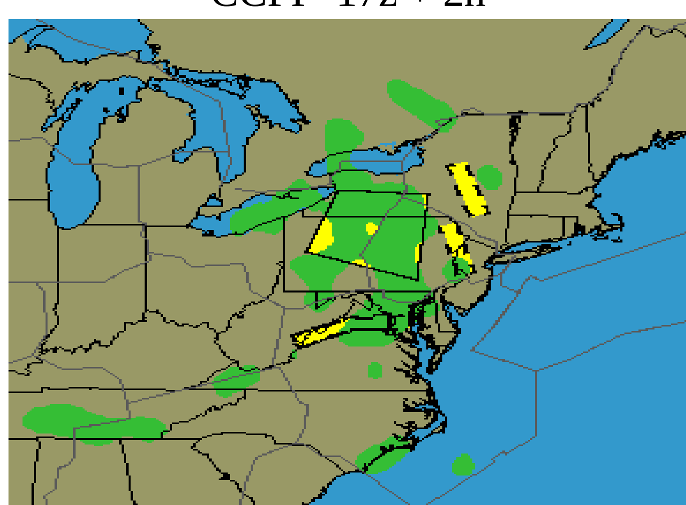
CCFP 15z + 4h



CCFP 17z + 2h



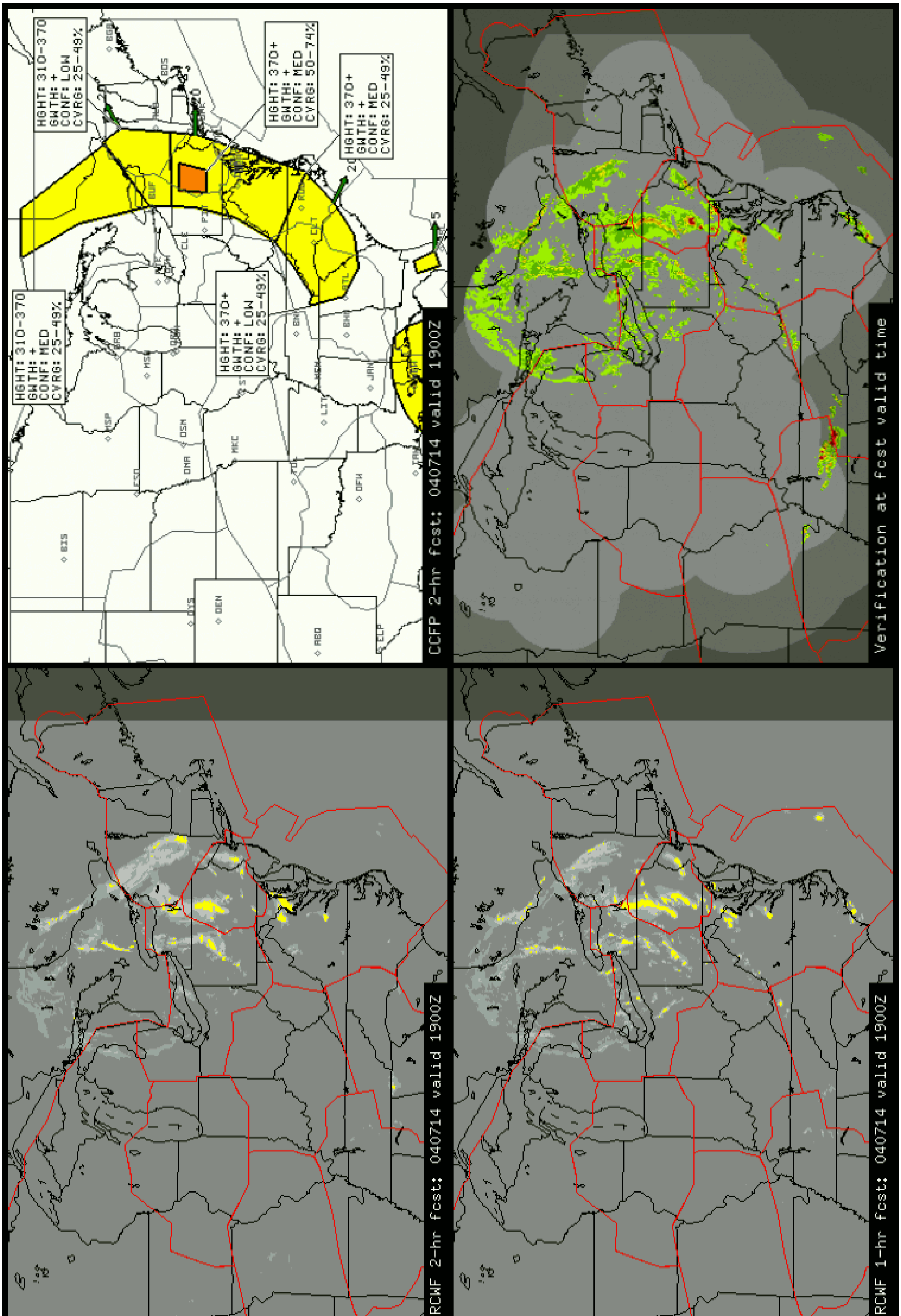
SIGMET 18z + 1h



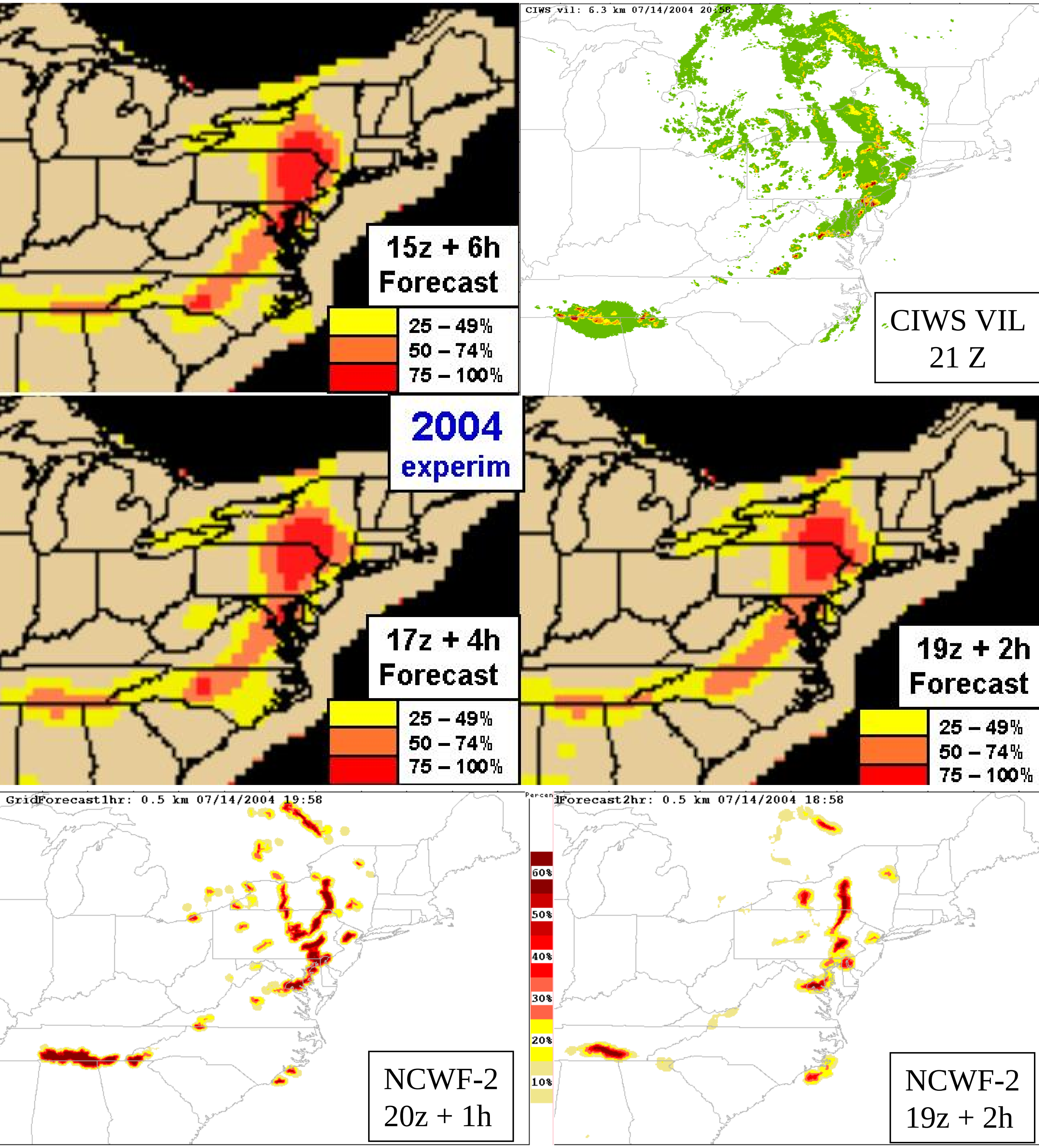
SIGMET 17z + 2h

CIWS-RCWF

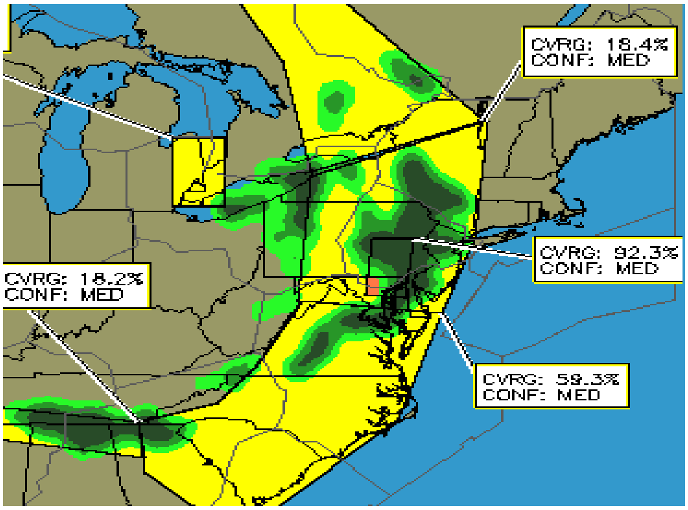
July 14, 2004 19Z



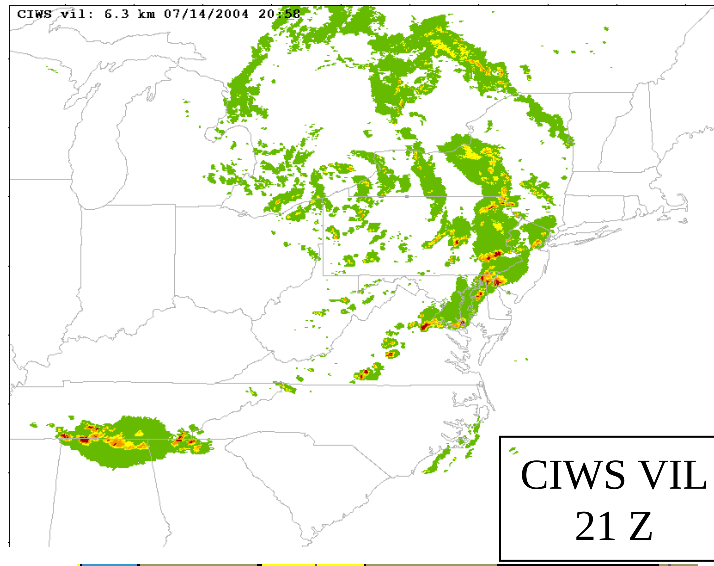
E-NCWF and NCWF-2
July 14, 2004 21Z

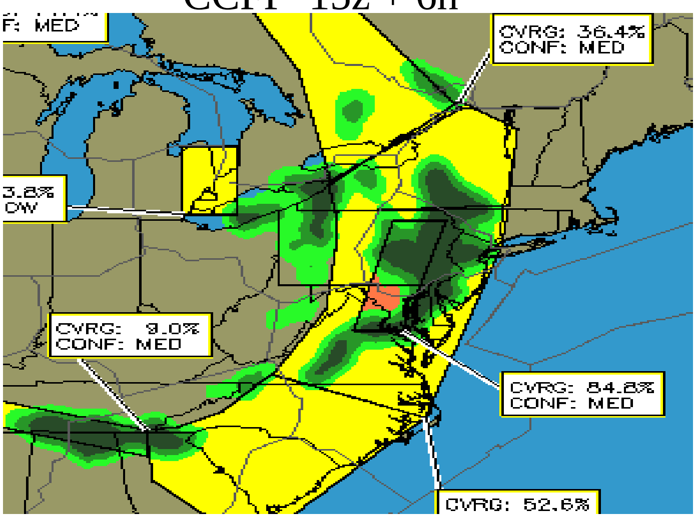


CCFP and Convective SIGMETs
July 14, 2004 21Z

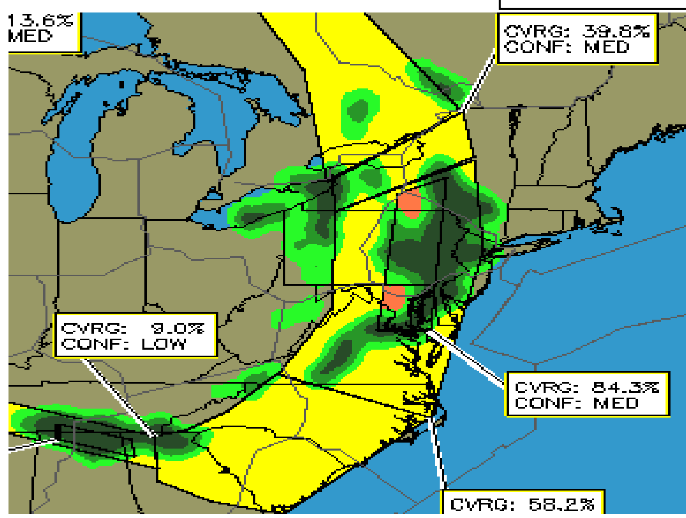


CCFP 15z + 6h

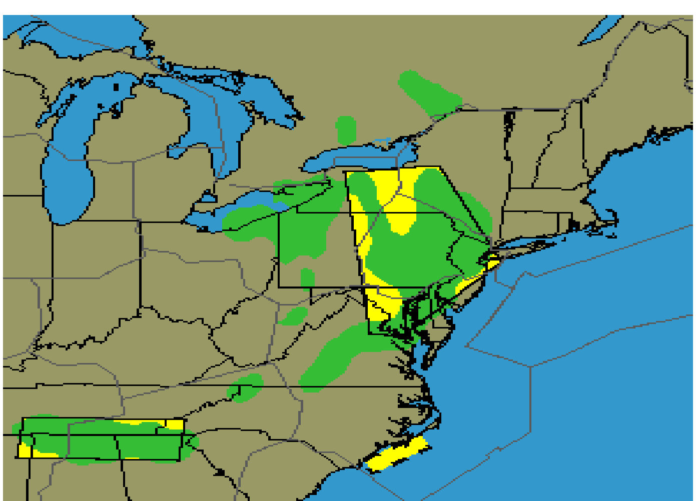




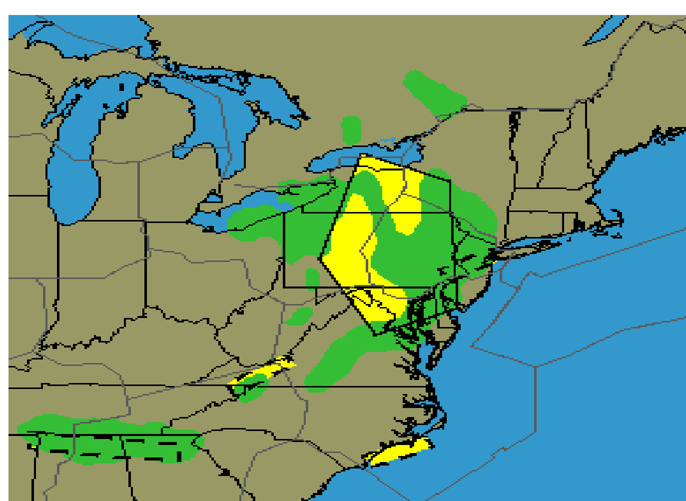
CCFP 17z + 4h



CCFP 19z + 2h



SIGMET 20z + 1h



SIGMET 19z + 2h

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