P11.2 THE MAN-IN-THE-LOOP (MITL) NOWCASTING DEMONSTRATION: FORECASTER INPUT INTO GRIDDED NOWCAST PRODUCTS

Rita Roberts[1], Steven Fano[2], Thomas Saxen[1], Cynthia Mueller[1], William Bunting[2], Kevin Johnston[3], Eric Nelson[1], David Albo[1], Huaqing Cai[1], Stephan Smith[3], Mamoudou Ba[3], and Thomas Amis[4]

[1]National Center for Atmospheric Research, Boulder, CO USA
[2]National Weather Service Forecast Office, Ft. Worth, TX USA
[3]National Weather Service, Silver Spring, MD USA
[4]National Weather Service Central Weather Service Unit, Ft. Worth TX USA

1. INTRODUCTION

The NCAR automated, short term (0-1 hr) thunderstorm nowcasting (Auto-nowcaster) system (Mueller et al. 2003) is currently being run at the U.S. National Weather Service (NWS) Weather Forecast Office (WFO) in Ft. Worth, Texas as part of the NWS Man-In-The-Loop) nowcasting demonstration. The MITL demonstration is a new endeavor in the NWS directed at emphasizing the increased role of the forecaster in 0-6 hr nowcasting applications, particularly in improving automated, short term nowcast products being generated for the aviation community and the public. The MITL concept was precipitated in part by results from a Federal Aviation Administration (FAA) Regional Convective Weather Forecast (RCWF) demonstration of the Auto-nowcaster in the NE United States in 2003. Results from the RCWF demonstration showed that boundaries entered into the Auto-nowcaster system by scientists during real-time operations led to significant improvement in thunderstorm initiation nowcasts (Roberts et al. 2003).

To operationally test the MITL concept, forecasters at the WFO are using the Auto-nowcaster interactive display tools to enter the locations of low-level convergence boundaries such as synoptic scale fronts, mesoscale outlow boundaries and boundaries between moist and dry boundary layer air (drylines). These boundaries are integrated into the feature detection algorithms running in the Auto-nowcaster system prior to the generation of thunderstorm nowcast products that are updated every 6 min. This task has been added to the regular list of duties ascribed to the NWS Short Term Forecaster postion.

In this paper we describe the role of the forecaster and enhancements he/she provides to the automated nowcasting system. Preliminary results of the performance of the forecaster-computer generated nowcast products are presented. Preliminary qualitative results of the MITL demonstration are also discussed based on forecaster surveys and real-time log files that register when Auto-nowcaster products were used in issuing NWS Short Term Forecasts, Area Weather Updates, Terminal Aerodome Forecasts (TAFs) and for briefing the severe weather spotter network.

2. MITL DEMONSTRATION

The NWS MITL mission is to provide timely and efficient transfer of FAA Aviation Weather Research Program (AWRP) capabilities that include automated detection and forecast digital products, into NWS operations to support NWS aviation-related forecasts. It is anticipated that inclusion of forecaster input early in the process of generating the digital aviation products will improve these products significantly. The success criteria for the MITL mission is to demonstrate that NWS MITL operations can be integrated with automated digital products to support aviation elements in the National Digital Forecast Database (see: http://www.weather.gov/forecasts/graphical/sectors).

The installation of the FAA funded Auto-nowcaster (hereafter referred to as the ANC) system at the Ft. Worth WFO is the first test of the MITL mission. The Ft. Worth demonstration is a 2 year program scheduled to run from March 2005 through March 2007. The role of the forecaster is to make use of an interactive ANC display tool (see Fig. 1) to examine operational datasets and enter the locations and movement of observed convergence boundaries. Identification of these boundaries and estimates of their motion are critical for producing accurate storm initiation, growth and decay nowcasts. Boundaries entered by the forecaster on the ANC dis-

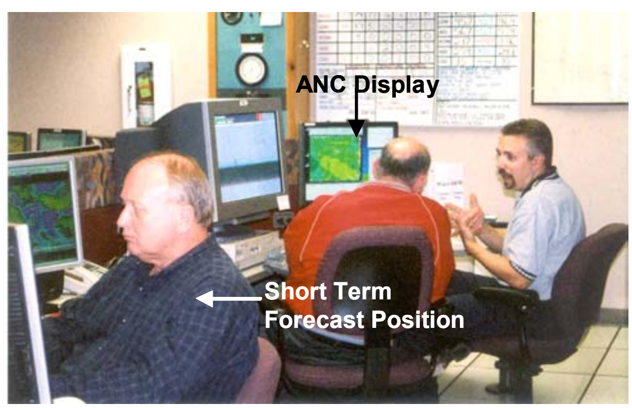

Figure 1. Forecaster being trained on the ANC System running at the Ft. Worth WFO. During daily operations the short term forecaster is responsible for entering boundaries on the ANC display.

Corresponding author address: Rita Roberts, NCAR, P.O. Box 3000, Boulder, CO 80307, email: rroberts@ucar.edu

[1]*NCAR is sponsored by the National Science Foundation*

play are immediately incorporated into downstream predictor algorithms within the ANC system and thunderstorm nowcast products are produced every 6 min. An additional objective of this demonstration is to disseminate these products to the NWS Central Weather Service Unit (CWSU) Ft. Worth office as guidance information for the CWSU meteorologists preparing aviation forecasts.

3. FORECASTER INTERACTION WITH ANC SYSTEM

Initial training on the Auto-nowcaster system was conducted in the Fall 2004 with a WFO lead forecaster chosen as the focal-point forecaster for the ANC system. In March, the ANC system was installed at the WFO and training of all the forecasters in the WFO was done by the focal-point forecaster (see Fig. 1). The interactive diagnostic tool used by the short term forecaster to enter boundaries has been designed to be fairly intuitive to use and require minimal impact on their time to insert the boundaries. Forecasters typically enter boundary locations once every 2-3 hours for large scale features and more frequently when thunderstorm outflows are present. Operational datasets including multiple radar mosaic images, mesonet, satellite and numerical model output fields (Mueller and Megenhardt, 2003; Trier et al., 2002) are available for use by the forecaster to locate surface convergence features.

3.1 Forecaster impact on final nowcast field

The ANC system produces thunderstorm nowcasts through the use of fuzzy logic (Mueller et al. 2003). All predictor fields in the system get converted to likelihood fields that can range in value from +1 (high interest for thunderstorms) to -1 (no interest or likelihood for thunderstorms) through the use of fuzzy logic. Each likelihood field is multiplied by a weight or confidence value and then all weighted, likelihood fields are summed together to produce a final thunderstorm initiation likelihood field. An example of this field is shown in Fig. 2a.
A pre-defined threshold value bounds the regions where thunderstorms are expected to occur in 60 min. For the ANC system at Ft. Worth, values greater than a threshold of 0.7 (pinks and reds in Fig.2a) represent the regions where new thunderstorms are forecast.

When a forecaster enters a convergence boundary location into the system, this acts to heighten the interest or likelihood for thunderstorms in the vicinity of the boundary. Figure 2b shows how the final likelihood field has changed once a boundary has been inserted into the ANC. The 60 min extrapolated boundary position (magenta polyline) is overlaid on Fig. 2b for reference. It is evident that there are areas of increased likelihood for thunderstorms located at specific regions along the 60 min extrapolated boundary postion. There is not a continuous heighten level of interest all along the boundary, as other factors such as the strength of convergence along the boundary, boundary-relative steering flow, and boundary-relative low-level shear all play a role in defining exactly where storms will form (see Mueller et al 2003 for more detailed discussion on the collection of boundary-related likelihood fields).

In past deployments of the ANC at military and international forecast offices, forecasters at those offices did not often view the final likelihood field and instead preferred to have only the polygons (see white polygons overlaid onto Figs. 2a,b) representing the thunderstorm nowcasts be displayed as an overlay on top of the current radar imagery. In contrast, forecasters at the Ft. Worth office find this final likelihood field to be more informative than just viewing a display of the nowcast polygons. Because this final field incorporates predictor information from both observational data and numerical

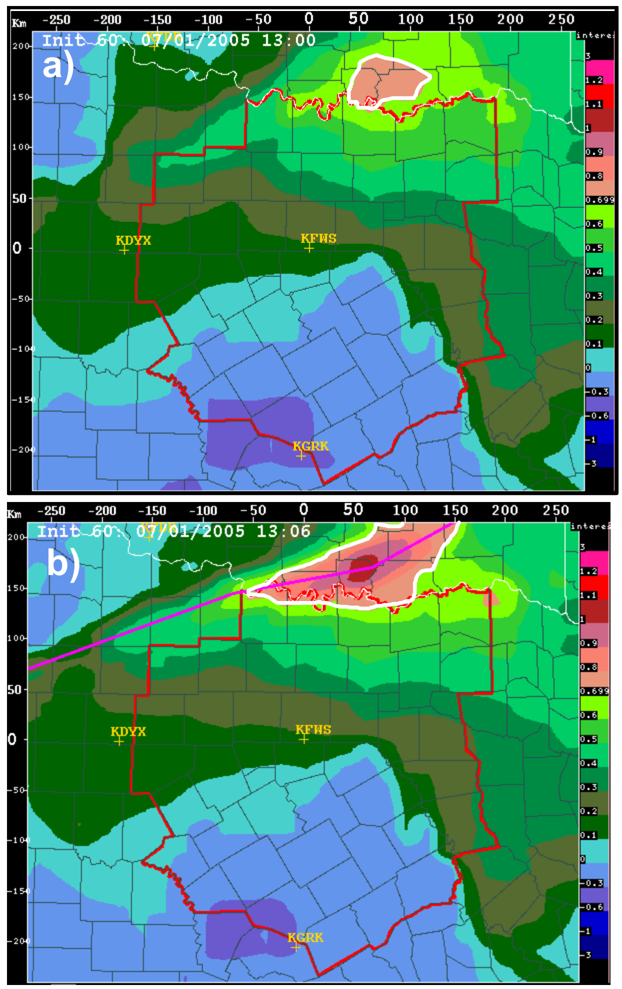

Figure 2. ANC final thunderstorm likelihood fields on 1 July 2005. Positive (negative) values represent regions more (less) likely for thunderstorms occur. Red overlay is the WFO County Warning Area. White polygon is the contour representing the area of 0.7 or greater likeklihood for thunderstorms. See text. a) 13:00 UTC; b) 13:06 UTC with 60 min boundary position (magenta) overlaid.

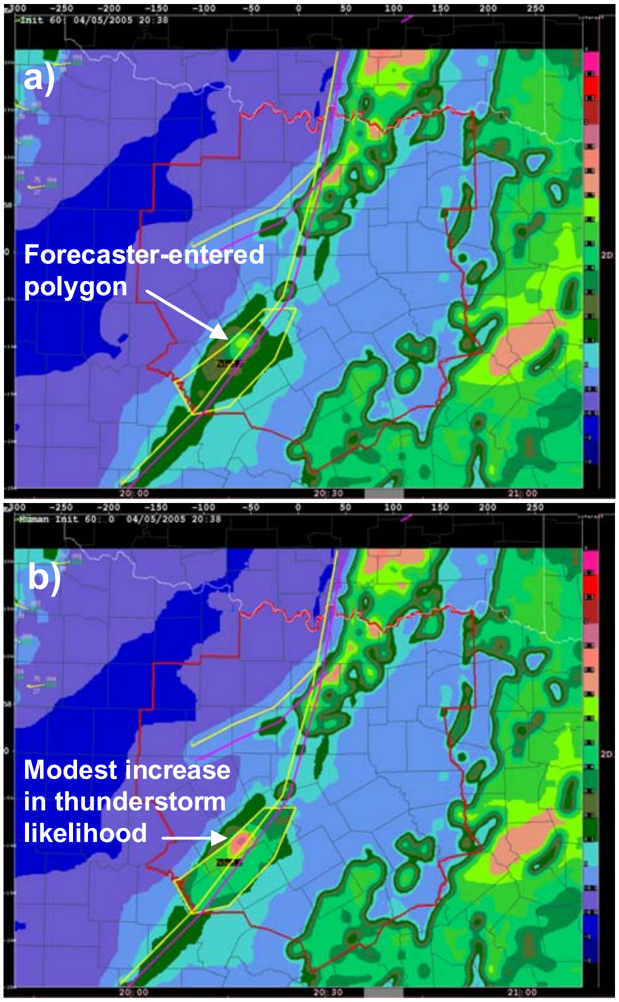

Figure 3. ANC final thunderstorm likelihood fields on 5 April 2005 at 20:38 UTC. Yellow polyline is the boundary location entered by the forecaster. The magenta polyline is the 60 min extrapolated position. The yellow polygon is the polygon entered by the forecaster. a) Likelihood field before forecaster increased likelihood values within the polygon; b) Likelihood field after values within the polygon have been increased using the polygon tool.

model derived fields and shows the effect on the forecast field when a boundary has been inserted, forecasters are often able to tell when the final forecast field looks good or is being affected by overly optimistic (for thunderstorm development) numerical model runs.

. It is well know that all surface convergence boundaries, including synoptic fronts, mesoscale outlow boundaries and gust fronts are not created equal, i.e., they do not exhibit the same characteristics and attributes from one feature to the next. For a single large scale convergence feature, one portion of the boundary may be more favorable to thunderstorm production than another portion due to differences in boundary layer moisture distribution or environmental stability (CAPE, CIN, and vertical shear)

A second (polygon) tool was developed for the forecasters at Ft. Worth to address situations when forecasters know that stability information from the numerical models is not representative and causing the ANC to falsely forecast thunderstorms, for example, along a section of a boundary that is significantly capped aloft.

Figure 3 shows an example of how the polygon tool was used by a Ft. Worth forecaster to conservatively increase the likelihood for thunderstorm initiation along the southern portion of the north-south boundary, based on his observation of the model output and current observational datasets. Forecasters have also explored using the polygon tool to heighten interest or likelihood in regions where elevated convection is expected to occur. The ANC system is not designed to nowcast elevated convection, but this was an interesting use of the tool by the WFO forecasters.

4. EVALUATION OF THE MITL DEMONSTRATION

4.1 Quantitative performance

Validation statistics for the ANC thunderstorm nowcasts are run at the end of each day of the MITL demonstration and can be viewed to get a sense of how the forecaster-computer system is performing in near real-time. Statistics on the overal performance of the system with and without forecaster input of convergence boundaries will be compiled and assessed at the end of the first year of the MITL demonstration. To get an idea of how the system has been performing, two different events are discussed here briefly.

On 10 April, a dryline developed within the Ft. Worth County Warning Area (CWA). The atmosphere was sufficiently unstable and isolated thunderstorms began to form in the area after 19:00 UTC. At 19:40 the location of the forecaster -entered boundary can be seen in Fig. 4a. The white polygons overlaid onto the reflectivity image represent the 60 min ANC nowcasts predicting the development of a line of storms by approximately 20:40 UTC. The verification of the nowcasts is shown in Fig. 4b where a line of storms have indeed developed along the dryline.

The nightly statistical summary for 10 April is shown in Fig. 5. In particular, the POD are quite good at the early time periods (during the initiation stage) because of the dryline boundary entered by the forecaster earlier in the afternoon.

On 1 July 2005, a mesoscale boundary produced by a severe storm in Oklahoma propagated from the north into the CWA bu 13:00 UTC (approximately 8am local time). At the same time, a stationary front was sagging down int the NE portion of the CWA. One of the forecasters just arriving to the WFO immediately entered the mesoscale boundary into the ANC system. Fig. 6a shows the location of the boundary (yellow line) and its extrapolated 60 min position by 14:34 UTC.

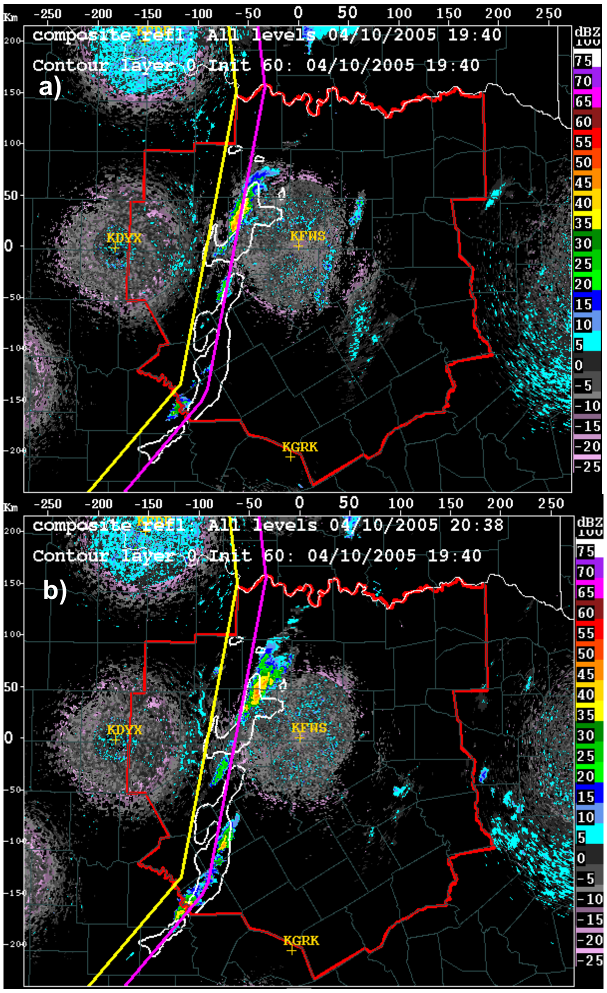

Figure 4. Forecaster-entered boundaries (yellow lines) and ANC nowcasts (white polygons) on 10 April 2005. a) At forecast time, 19:40 UTC; b) at validation time, 20:38 UTC.

It can be seen in Fig. 6a that the ANC is predicting additional thunderstorm development along the mesoscale outflow and further to the east ahead of the existing, intense thunderstorm in the NE section of the CWA. The validation image at 15:39 UTC is shown in Fig. 6b. The ANC did a reasonable job of capturing some of the new convection associated with the mesoscale boundary, but the movement of the boundaries appears to have been too fast at this particular time period which may account for the lack of nowcast polygons in some of the areas where thunderstorms did form. Better thunderstorm initiation performance is observed to the east of the CWA. However, the nightly validation statistics are only computed for nowcasts made within the CWA. Thus the statistics in Fig. 7 show only a modest improvement in POD and CSI skills compared to the persistence and extrapolation curves.

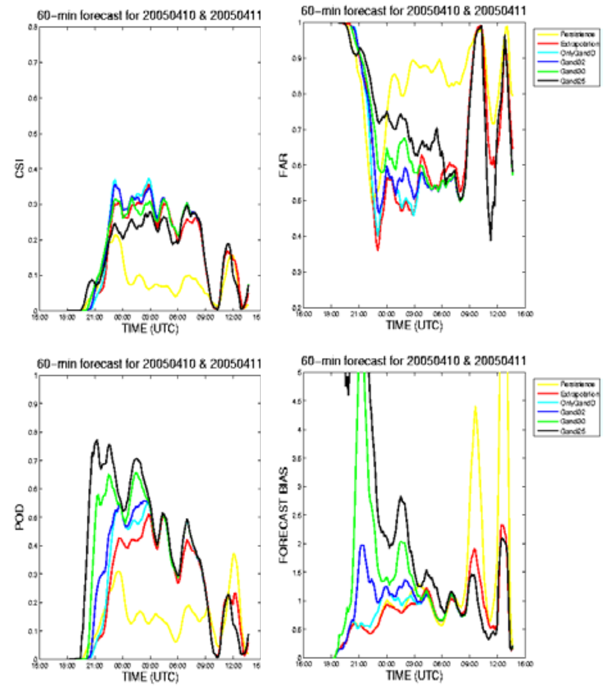

Figure 5. ANC validation statistics for 10 April 2005. ANC nowcast performance is compared grid for grid against the >35 dBZ echo locations at validation time and 2.5 km AGL.

4.2 Qualitative Performance

Forecaster feedback is important component in assessing the performance of the MITL demonstration. In additon to a web-based survey that the forecasters fill out at the end of the day, the forecaster also is asked to enter qualitative evaluation of the system during the day. He does this through the use of a GUI interface that is displayed constantly on the ANC display system (see Fig. 8). On 10 April, the short term forecaster on duty clicked on his forecaster ID number at the start of his shift. If the forecaster found the nowcasts produced by the MITL forecaster-ANC system to be helpful in producing his short term forecast discussion, or the area weather update, or for the terminal forecast or in briefing spotters about the location for potentially severe weather, then he would click on the appropriate button in the gui and these clicks getting immediately registered and time stamped in a daily log file. The short term forecast can also enter his opinion on the quality of the nowcasts many times during the day and these entries are also saved in the log file for later qualitative evaluation of the MITL system.

5. CONCLUDING COMMENTS

The MITL demonstration has shown that one of the biggest challenges for the forecasters is to find time in their daily routine to include their MITL tasks. This is particular true when the weather becomes severe.

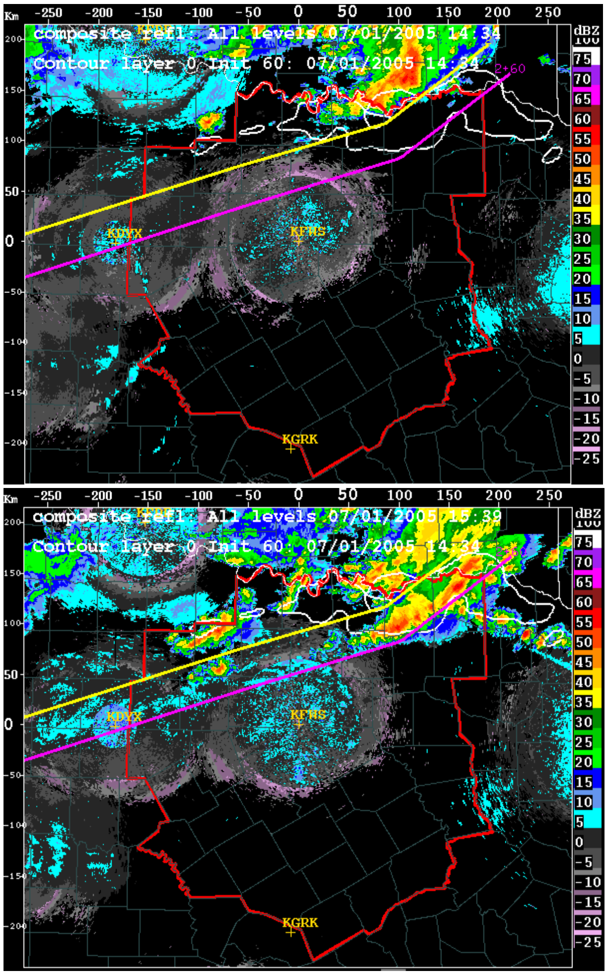

Figure 6. Forecaster-entered boundaries (yellow lines) and ANC nowcasts (white polygons) on 1 July 2005. a) At forecast time, 14:34 UTC; b) at validation time, 15:39 UTC.

However, when the forecasters do have the chance to intereact with the system, they have provided valuable insights in how to improve the performance of the ANC system, particularly by recommending important fields that should be added. Some of the recommended changes have already been added to the ANC system.

References

Mueller, C., and D. Megenhardt, 2003: Predictability of storm characteristics based on RUC environmental fields. Preprints, *31st Conf. on Radar Meteor.*, AMS,Seattle.

Mueller, C.K., T. Saxen, R. Roberts, J. Wilson, T. Betancourt, S. Dettling, N. Oien, and J. Yee, 2003: NCAR Convective Storm Nowcasting System. *Wea. Forecasting,* 18.

Roberts, R., T.Saxen, C. Mueller, and D. Albo, 2003: A forecaster-computer interactive capability of the NCAR Auto-nowcaster system for improved storm initiation nowcasts. *Preprints, 31st Conf. on Radar Meteorology,* AMS, Seattle.

Trier, S., D. Ahijevych, C. Davis, D. Megenhardt, C. Mueller, and N. Rehak, 2002: Enhancement of 0-3h forecasts of deep convection using mesoscale diagnostics derived from operational model analyses and forecasts. *International Conf. on Quantitative Precipitation Forecasting,* Reading, UK.

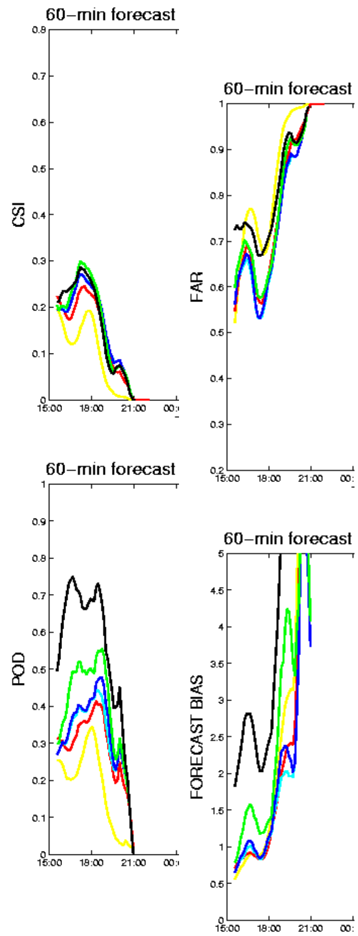

Figure 7. ANC validation statistics for 10 April 2005. ANC nowcast performance is compared grid for grid against the >35 dBZ echo locations at validation time and 2.5 km AGL.

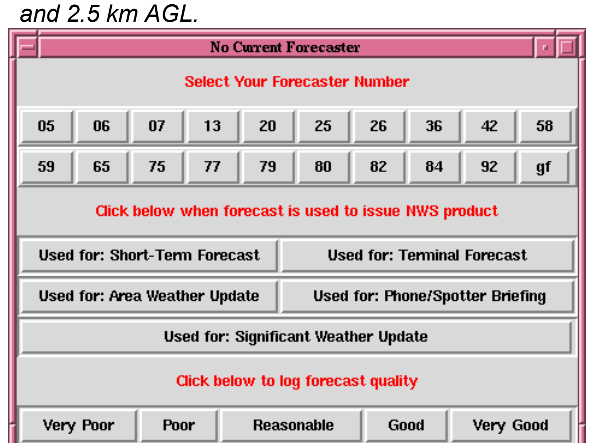

Figure 8. Gui interface for forecasters to enter qualitative evaluation of the MITL system performance.