3.1 TRANSITIONING NCAR'S AUTONOWCAST SYSTEM CAPABILITY INTO NWS OPERATION

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1. Introduction

High quality nowcasts of thunderstorms have the potential to be a tremendous benefit to the general public. Properly integrated as a critical impact factor into management of the National Air Space, they could reduce the lengthy delays commonly experienced during the spring and summer in the United States.

Attempts to develop robust and accurate automated nowcasts of thunderstorms have been limited by the fact that it is extremely difficult to develop automated techniques which are able to detect consistently the boundary layer convergence lines and/or fronts which are critical to the initiation of the majority of thunderstorms. On the other hand, human forecasters, using a variety of remote and in-situ observations, are remarkably good at quickly identifying and tracking them. The human brain's ability to detect discontinuities in multiple spatial fields and recognize repeating patterns far exceeds the current state of the art of automated objective algorithms. A strategy for progress in improving thunderstorm nowcasts demands a hybrid approach, one that efficiently takes advantage of the human's ability to detect and track fronts and boundaries to calibrate an automated nowcasting system.

For the last 3 years, the National Weather Service (NWS), in collaboration with the National Center for Atmospheric Research (NCAR), has been attempting to demonstrate just such an approach at its Weather Forecast Office (WFO) in Dallas-Fort Worth, Texas (FWD). Labeled the Man-In-The-Loop (MITL) Demonstration, NCAR's Thunderstorm Autonowcast system, or Autonowcaster (ANC), has been installed in the office to provide guidance to WFO forecasters for severe weather operations and to meteorologists at the Center Weather Service Unit (CWSU) for support of aviation (Roberts et al., 2005). ANC is a suite of automated applications that produces 0-1 hour thunderstorm nowcasting predictor fields derived from from observation-based feature detections, numerical weather prediction model output, and human forecaster input.

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Data ingested by ANC include radar, satellite, sounding, and surface data. The software applications in the ANC environment include algorithms for boundary-storm interactions, cumulus cloud detection and growth, boundary-relative shear profile, boundary-relative updraft strength and storm trends and tracks. A fuzzy-logic application is used to combine the weighted outputs from the various analysis algorithms to produce time- and space-specific forecasts of thunderstorm initiation, growth and decay. A more comprehensive and detailed overview of ANC is described in Mueller et al. (2003).

2. Man-In-The-Loop Demonstration at FWD

The main objective of the MITL demonstration is to show that a human forecaster–automated system approach can produce a significant improvement in thunderstorm nowcast accuracy above and beyond that provided by a purely automated nowcast system. In addition, we wish to examine the feasibility of such an approach from an efficiency and workload perspective, test different operations concepts, assess the utility of the nowcasts to both NWS and FAA, and finally to better understand convection and its initiation.

The ANC system runs at NCAR in Boulder, Colorado and forecast products are sent in real time to FWD. After reviewing current observations, forecasters are required to identify and input surface boundaries on the ANC display system. These boundaries are then sent back Boulder and ingested by the ANC algorithms. The process has proved to be cumbersome and inconvenient for forecasters, as they are required to learn to use the native ANC display system, which many of them are unfamiliar with. To rectify this situation, the NWS' Meteorological Development Laboratory (MDL) has redeveloped the key ANC graphical user interfaces for the Advanced Weather Interactive Processing System (AWIPS) which is the core information technology system used in all NWS WFOs. This software was recently installed at FWD and will be used by forecasters for the 2008 convective season.

Over the course of the demonstration to date, forecasters have experimented with several different operations concepts using the ANC. The following is a scenario that has been shown to be viable.

1. Short Term Forecaster arrives on shift and receives shift briefing from outgoing Short Term Forecaster
2. Within first hour, decide which Regime Setting

(e.g. pulse storms, cold front, dry line, etc) is most appropriate for the day and put ANC in that regime.

3. Using satellite, surface observations, and other data sets, determine location of surface boundaries across the forecast area. Remove any invalid boundaries and enter new surface boundaries and send these data to the ANC system. The boundaries may be stationary or be assigned a movement.
4. Monitor ANC output, including Initiation Fields and Growth and Decay components.
5. Based on ANC output, make adjustments to ANC interest fields using Graphical Interface tools as needed. The tools used to control the sensitivity of the ANC "Initiation" fields and "Growth and Decay" fields include using a polygon editor to effectively increase or decrease ANC "Initiation" output values over a relatively small geographic region or using ANC "Nudging" to adjust the output for the entire ANC forecast domain.
6. Consider using ANC output for forecast products such as aviation forecasts (TAFs), short-term forecasts (NOWs), forecast discussions (AFDs), and mesoscale weather updates (AWUs).
7. If ANC is forecasting convective initiation near a major airport (e.g. DFW), coordinate with CWSU as needed to discuss the forecast and timing.
8. Continue monitoring mesoscale environment. Make appropriate adjustments to locations of ANC Boundaries and Polygon settings. Consider changing Regime Setting as necessary.

An important outcome of the MITL demonstration is that forecasters do not have to spend an inordinate amount of time entering in boundaries and monitoring them. They can generally locate and input the important ones during the morning pre-convective period and update them once convection is underway. Little “baby-sitting” of the ANC system is generally required.

3. Forecast impact on the final nowcast fields

It is hoped that forecasters using ANC, interact with it in a way to improve the forecasts where thunderstorms occur and to do no harm where they don’t. In other words, we would like to improve the probability of detection without generating a significant number of false alarms. In general, the MITL demonstration has shown this to be true in practice. Where forecasters place the boundaries is where they appear both in the nowcasts and in reality. Conversely, in areas where forecasters do not input boundaries nothing occurs either in the forecasts or nature. 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. 1a.

A pre-defined threshold value bounds the regions where thunderstorms are expected to occur in 60 minutes. The pre-defined threshold is region specific and is determined from a large number of thunderstorm events under a broad spectrum of synoptic modes for that region. For example, in the Ft. Worth County Warning Area (CWA), values greater than a threshold of 0.7 (pinks and reds in Fig.1) represent the regions where new thunderstorms are forecast.

After the forecaster analyzes and reviews satellite and radar imagery, surface observations, and other data sets, and determines the presence of a surface boundary, she/he uses the ANC system to enter that boundary and sends the information to ANC algorithms running in Boulder. In the next ANC forecast cycle, the inserted boundary acts to heighten the interest or likelihood for thunderstorms in the vicinity of the boundary. Figure 1b shows how the final likelihood field has changed once a boundary has been inserted into the ANC. The 60-min extrapolated boundary position (magenta line) is overlaid on Fig. 1b for reference. It is evident that there are areas of increased likelihood for thunderstorms located at specific regions along the 60-min extrapolated boundary position. The level of heightened interest is not uniform 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 influence exactly where storms will form (see Mueller et al., 2003 for a more detailed discussion on the collection of boundary-related likelihood fields).

4. ANC implementation plan for NWS operations within AWIPS

A regional implementation of the ANC system that could support a CWSU’s entire area of responsibility has been proposed for NWS operational implementation. The ANC nowcast products will be disseminated from the regional system to the corresponding CWSU and all neighboring WFOs.

Phase I of the transition is to use the current ANC demonstration at FWD to prove the current prototype and operations concepts within an AWIPS environment. Forecasters will use the AWIPS versions of the ANC interfaces to enter mesoscale and/or synoptic scale surface boundaries, creating polygons delimiting regions of interest, and displaying ANC forecast products on AWIPS.

During Phase-II, an MDL prototype will be developed whose domain covers the entire Ft. Worth CWSU area of responsibility. The development of this prototype is expected to be completed by July 2008. The software will be installed on MDL hardware and will be tested side by side with the NCAR version for 2008 and 2009. An assessment on the performance of this prototype will be done to correct any deficiencies of the prototype. MDL will subsequently perform an operational assessment of the benefits and performance impact of the ANC system on NWS WFO operations.

5. Summary

To date, the Man-In-The-Loop demonstration at FWD has shown that a hybrid human-automated system approach to thunderstorm nowcasting is feasible for NWS operations. Forecasters are generally able to input correctly the positions of key boundaries and fronts during the pre-convective phase of a thunderstorm event and need to only minimally monitor the system once convection is underway. These nowcasts have shown significantly improved skill compared to the automated nowcasts.

For the 2008 convective season, forecasters at FWD will for the first time use AWIPS versions of the ANC interfaces and be able to fully exercise their skill and expertise in interacting with the ANC system.

Over the next two years, MDL will work with NCAR to prototype a regional version of ANC targeted for eventual NWS operational implementation.

The MITL demonstration of ANC represents the first fully-interactive, real-time nowcasting system used in NWS operations. The operations concepts proved to support thunderstorm nowcasting and aviation could be extended to cover NWS support of other critical mesoscale phenomena associated with winter storms and fire weather.

6. References

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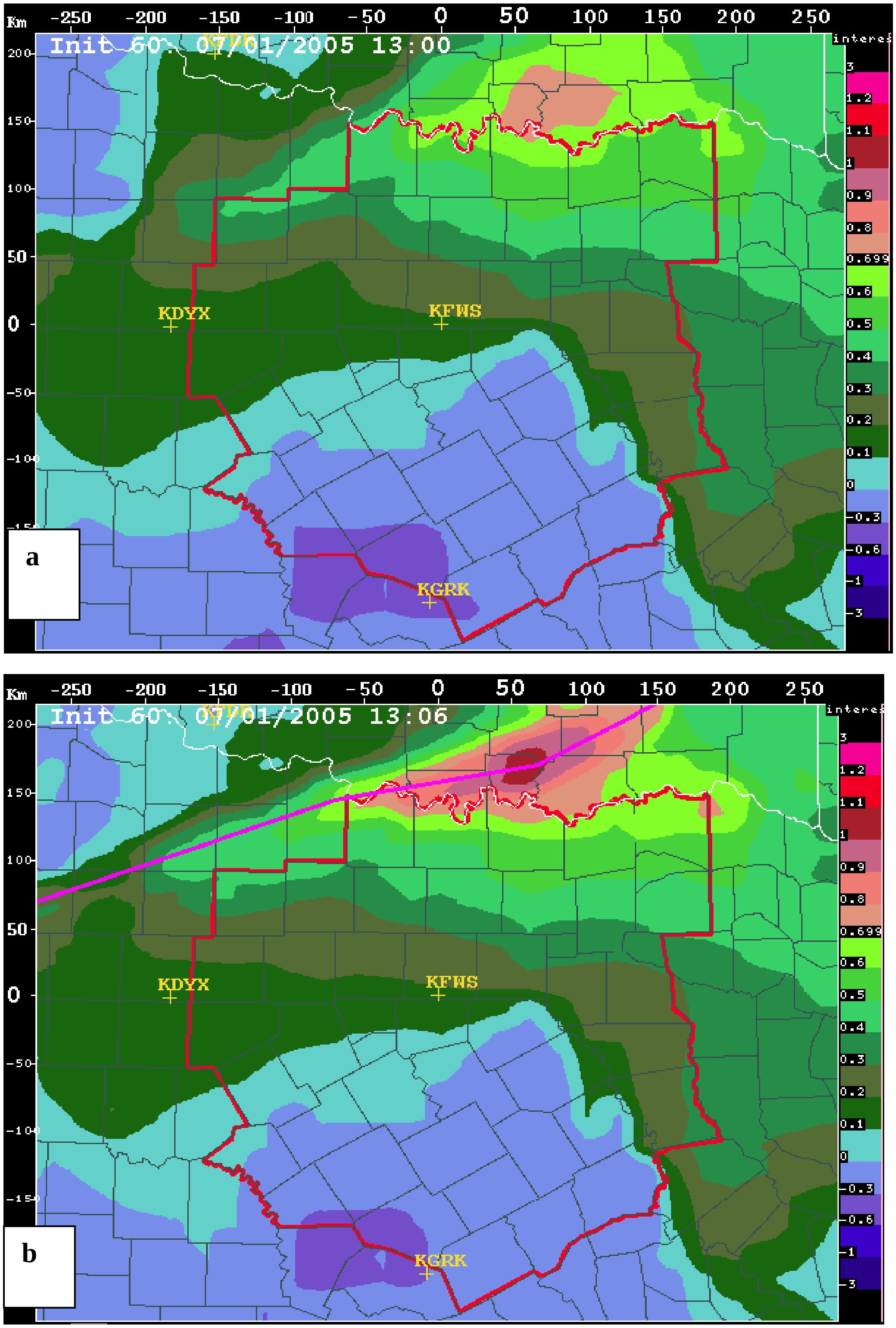

Figure 1: ANC final thunderstorm likelihood fields on 1 July 2005. Positive (negative) values represent regions more (less) likely for thunderstorms occur. Red overlay is the WFO County Warning Area. a) 13:00 UTC; b) 13:06 UTC with 60-min boundary position (magenta) overlaid. This case is taken from Roberts et al. 2005.