5.1 UPDATES TO THE NCAR AUTO-NOWCASTER FOR THE 2004 CONVECTIVE WEATHER SEASON

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1. INTRODUCTION

The NCAR Auto-nowcaster (ANC) runs as part of the FAA Aviation Weather Research Program's (AWRP) Convective Weather Product Development Team's (PDT) research demonstration on convective initiation in the Chicago area. This area has very congested air traffic routing, typically very large delays during thunderstorms, and exhibits a great deal of convective initiation by fronts, lake breezes, colliding outflows, and elevated forcing mechanisms. The region covered by the ANC system is a sub-section of this larger domain and consists of northeastern Illinois, most of Indiana, and western Ohio. The ANC has been running during the summer months over this region in 2002, 2003, and 2004. The NCAR ANC's unique human-computer interface allows forecasters to enter boundaries which are used along with predictors derived from Numerical Weather Prediction (NWP), observations, extrapolation, and feature-detection algorithms to provide detailed forecasts of convective initiation, growth and decay with 30 and 60 minute lead times to help improve aviation safety and efficiency.

Several updates were implemented for the 2004 operations in response to limitations identified in the previous year's operations. The primary goal of these updates was to increase the sensitivity to better capture convective initiation, minimize the number of obvious false alarm forecasts and improve the temporal continuity of the resulting forecasts. In order to accomplish this goal, improved methods for using more large-scale information were incorporated, allowing a more aggressive set of rules to be used in the forecast logic. The use of these large-scale data led to more consistent forecasts and helped capture storm initiation in a more timely manner, while limiting the number of false alarms. These modifications result in the initiation component of the forecasts being presented as likelihoods rather than deterministic forecasts. This is much more representative of the predictability of these initiation events.

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2. UPDATES FOR 2004 CONVECTIVE SEASON

The ANC system forecast generation algorithm is a fuzzy logic based expert system that applies membership functions to predictor fields derived from observations, NWP, and forecaster-input. The resultant interest fields have values that range from -1 to 1. These interest fields are weighted and summed to create a storm initiation forecast field and a storm growth and decay field. A complete description of the ANC system can be found in Mueller et al. (2003). Only the initiation part will be discussed here since that is where the significant changes from previous installations have been made.

The changes implemented for the 2004 convective season consisted of three primary areas: enhanced use of large-scale information, satellite information, and boundary information. Each of these areas will be discussed below.

2.1 *Enhanced use of large-scale information*

The enhanced useage of large-scale data was done so that it effectively acts to regulate the smaller scale information and put it into the correct context, much like a human forecaster would normally do in their forecast generation process. The primary sources of this additional information comes from the Rapid Update Cycle (RUC) model and surface-based (METAR) analyses. Some key characteristics of the RUC and surface fields that proved beneficial to the forecasts include the slower evolving nature of the input fields (which helps add more temporal consistency to the forecasts) and the use of these fields in both a positive and negative sense (which helps by eliminating areas where convection is not likely and enhancing areas where the large-scale environment is more conducive to convective development).

The RUC fields that are used include the maximum Convective Available Potential Energy (CAPE) found between 850 and 700 mb, the mean Relative Humidity (RH) between 875 and 625 mb, the frontal likelihood field (which is a unitless field based on low-level gradients in equivalent potential temperature and vorticity), and the vertical sum interest field (which is a count of the number of unstable layers in the vertical column).

Figure 1 shows a schematic of the forecast logic used for storm initiation. In previous years, only the information above the white dashed line were included in the forecast logic. Table 1 gives a listing of data sources, predictor fields, and weights that were used for the 60 minute initiation forecasts. There were 3 initiation thresholds at 0.7, 0.9, and 1.2 (with higher levels indicating higher likelihoods of initiation).

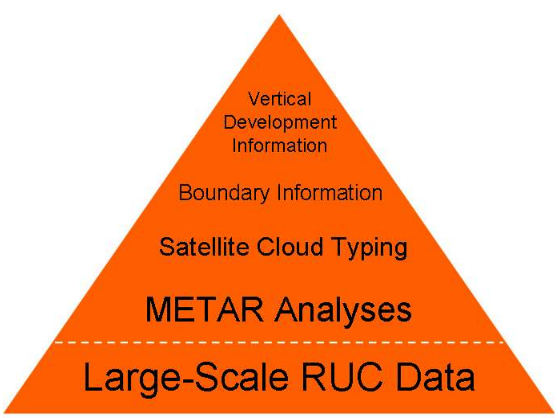


Figure 1 Schematic depicting the types of information utilized in the initiation forecast generation.

Table 1. Listing of data sources, predictor fields, and weights for the 60 minute initiation forecasts. Values in parenthesis are for times when satellite data is obscured and thus not utilized. VDRAS stands for Variational Doppler Radar Analysis System (Sun and Crook, 2001) and TITAN stands for Thunderstorm Identification, Tracking, Analysis, and Nowcasting (Dixon and Weiner, 1993)

Data Source	Predictor Field	Weight
RUC	CAPE (max. value between 850 and 700 mb)	0.17 (0.19)
RUC	RH (average between 875 and 625 mb)	0.17 (0.19)
RUC	RUC: Frontal Likelihood	0.16 (0.18)
RUC	RUC: Vert Sum Interest	0.1 (0.1)
METAR - RUC	Surface Lifted Index	0.2 (0.2)
METAR	Surface: Divergence	0.08 (0.08)
Boundary - VDRAS	Boundary: MaxW	0.2 (0.21)
Boundary - RUC	Boundary Relative Steering Flow	0.2 (0.21)
Boundary - TITAN	Boundary: StormInit Locations	0.25 (0.30)
Boundary	Boundary Collision	0.12 (0.14)
GOES Satellite	Clouds: Clear	0.4 (0.4)
GOES	Clouds: Cu/Cug	0.15 (NA)
GOES	IR Rate of Change	0.2 (NA)
Topography	Lake	0.1 (0.1)

2.2 *Enhanced use of satellite information*

In 2004 the satellite data was used to a larger degree also. This was done by having two separate sets of initiation logic (Note the two sets of weights in Table 1) which were switched to at the appropriate times. This was done via an algorithm that monitored high cloudiness over the domain and then switched to the appropriate setup (if not a significant fraction of high clouds then use the logic which includes all the satellite fields, if there was a significant fraction of high clouds then the IR Rate of Change and Satellite Cu/Cug fields were not used). This is important since the use of these fields during periods when there is a large amount of high cloudiness generally results in interest fields that are not really representative of the signals that they are meant to detect, especially the IR Rate of Change field which has been shown to be especially useful when used in appropriate conditions (Roberts and Rutledge, 2003).

2.3 *Enhanced use of boundary information*

The boundary information that was utilized was the combined boundaries from the automated detection algorithm (COLIDE) and those entered by the users in real-time. The users could enter boundaries with a simple interface via the data display. Once entered at two time periods, the system continued to extrapolate the entered boundaries until the user deleted them. The user could also modify existing boundaries by either re-entering them at any time or by modifying their speed.

The combination of the increased usage of large-scale information with the enhanced usage of the satellite data has allowed for the boundary information to be used more aggressively in the forecast logic. This has lead to much more timely forecast of convective initiation with reduced areas of false alarms. The initiation component of the forecast is depicted as regions of likelyhood whereas the growth and decay component is more deterministic. The reason for differentiating the forecasts is that there is much more uncertainty in the initiation component compared to the growth and decay component. Examples of how the final forecast field is presented can be seen in Figs. 2C and 4. Results using the above described updates will be discussed in the following section.

3. RESULTS

Several cases from 2003 were initially used to do some tuning prior to the 2004 convective season. One time period from these will be shown here along with an example and statistics from the 2004 real-time operations.

The first example, shown in Figure 2, is an example of a 60 minute initiation forecast from 04 July 2003. During this time period, the full suite of satellite data was being used and storms develop along the SW-NE oriented cold front. The forecast field shown in Fig. 2C shows the two components of the forecast, the gray-shades are the initiation component and the orange/yellow/red shades are the growth and decay component.

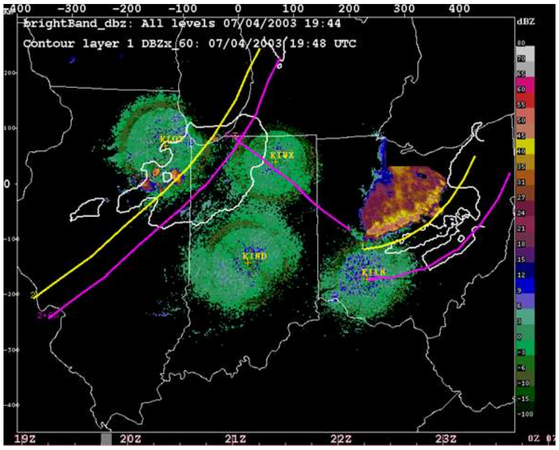
Figure 3 shows the individual interest fields that went into making this forecast. It can be seen that no one individual field or data source really controls the forecast, it is the combination of all the pieces of information. It can be seen though that for this case, the RUC average RH field and the satellite clear field do help eliminate potential false alarms, especially out ahead of the cold front.

The next case is from the summer 2004 real-time ANC system, specifically an example of a 60 minute initations forecast from 27 May 2004. The forecast field is shown in Fig. 4, with the blue contours indicating the 35 dBZ areas 60 minutes in the future (green contours are the current 35 dBZ areas). Not that in the SW corner of the domain, there is an initiation forecast that has been produced well in advance of any convective development.

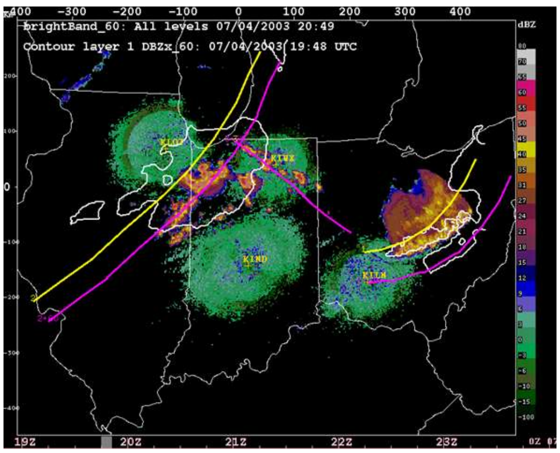
Figure 5 shows the time series plots for the statistics for this particular day. The statistics that are shown include the areal coverage at the forecast validation time, the Critical Success Index (CSI), the Probability of Detection (POD), and the False Alarm Ratio (FAR), where:

CSI = Successes/(False alarms + Failures + Successes)
POD = Successes/(Successes + Failures)
FAR = False Alarms/(False Alarms + Successes)

A.



B.



C.

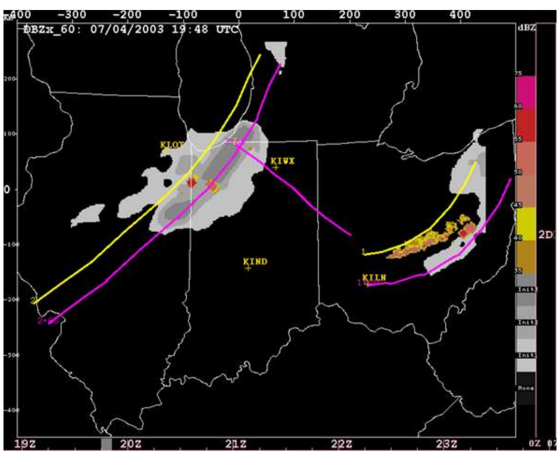


Figure 2 Depiction of a case from 04 July 2003. Fig. 2A shows the reflectivity at forecast time with boundary locations (yellow) and their 60 minute extrapolated positions (magenta) and the 60 minute forecast contour. Fig. 2B shows the reflectivity at forecast valid time and Fig. 2C shows the actual forecast field.

One can see that during the rapid areal expansion phase (from about 19Z to 00Z when a line of storms develop along the E-W boundary across southern Illinois), the ANC forecasts showed significant skill over the extrapolation only forecast with 5 to 10% improvements in CSI and 30 to 40% improvements in POD.

This is also the time period when a user was available to enter boundaries and it can be seen that after about 00Z, the ANC forecast statistics match very closely the extrapolation forecasts (due to no human-entered boundaries being included). This illustrates the potential enhancements that can be achieved when a human is allowed to interact with the automated algorithms. Had the human not been present to enter the boundaries during the initiation/growth time period, the skill of the ANC forecasts would have been much closer to that of extrapolation since boundaries are a crucial part of the ANC logic.

4. SUMMARY

This paper summarized modifications made to the ANC to increase the timeliness of initiation forecasts, while still maintaining temporal continuity and minimizing the number of sporadic, obvious false alarms. For the most part, these objectives were met, but further enhancements based on the lessons learned from this season will be explored. Ideas include further use of additional large-scale fields to further refine both the initiation and growth and decay fields, adding the ability for users to enter polygons that can be used in the forecast logic, and further enhancements in the use of satellite products.

This year's operations also marked a change in the way the ANC system represented it's final forecast field where the initiation areas were generally much smoother and broader than they have been in the past and this part of the forecast should be thought of more like a likelihood (or probabilistic) forecast rather than a deterministic forecast. This sort of representation matches much more closely the predictability of these sort of phenomena compared to extrapolation (or growth/decay) forecasts which are much more predictable.

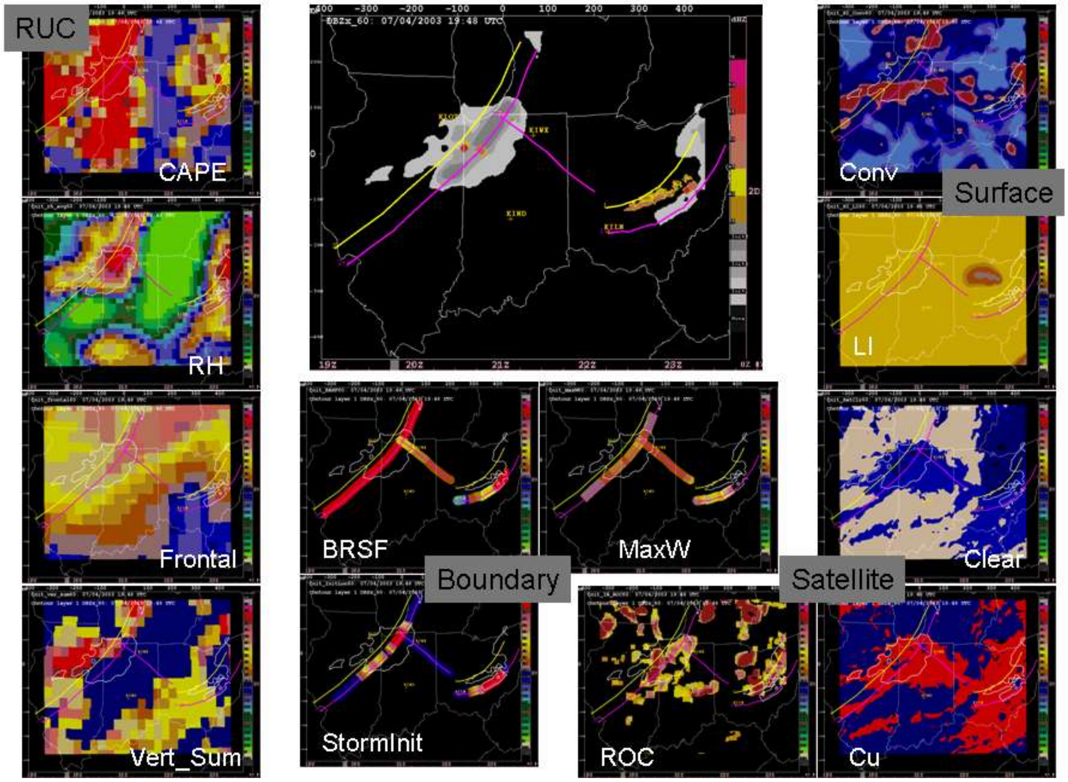


Figure 3 All the interest fields used to generate the forecast shown in Fig. 2 are dipicted. Warm colors represent positive values and cool colors represent negative values. The final forecast field is provided at the top center.

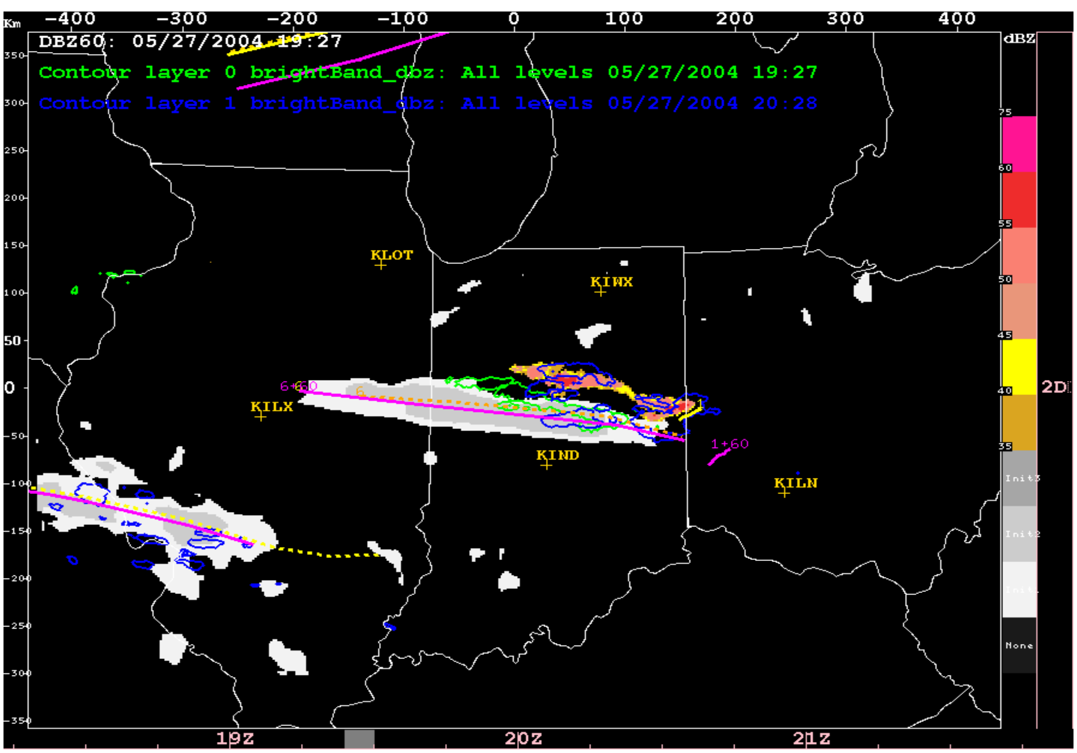


Figure 4 An example forecast from 27 May 2004. The blue contours are the 35 dBZ level 60 minutes into the future and the green countours are the same contour only at forecast time.

It also was evident that having a human user available to interact with the real-time system by entering boundaries that are diffucult for the automated algorithm to detect, can lead to beneficial results. There were numerous cases from 2004 that showed significant improvements over extrapolations forecasts during the early initiation phases. This was largely due to a human user entering boundaries that otherwise would not have been included in the system.

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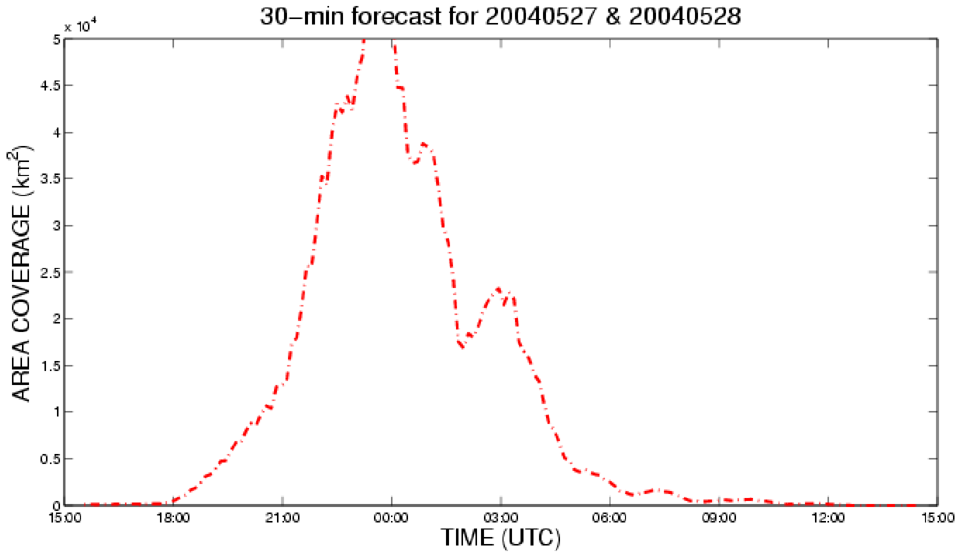

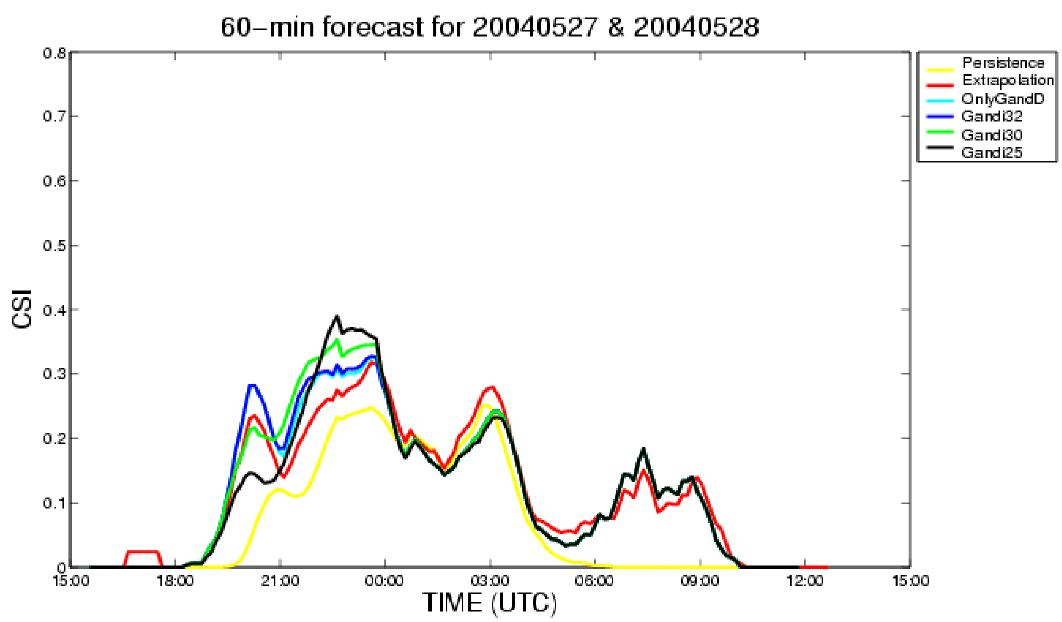

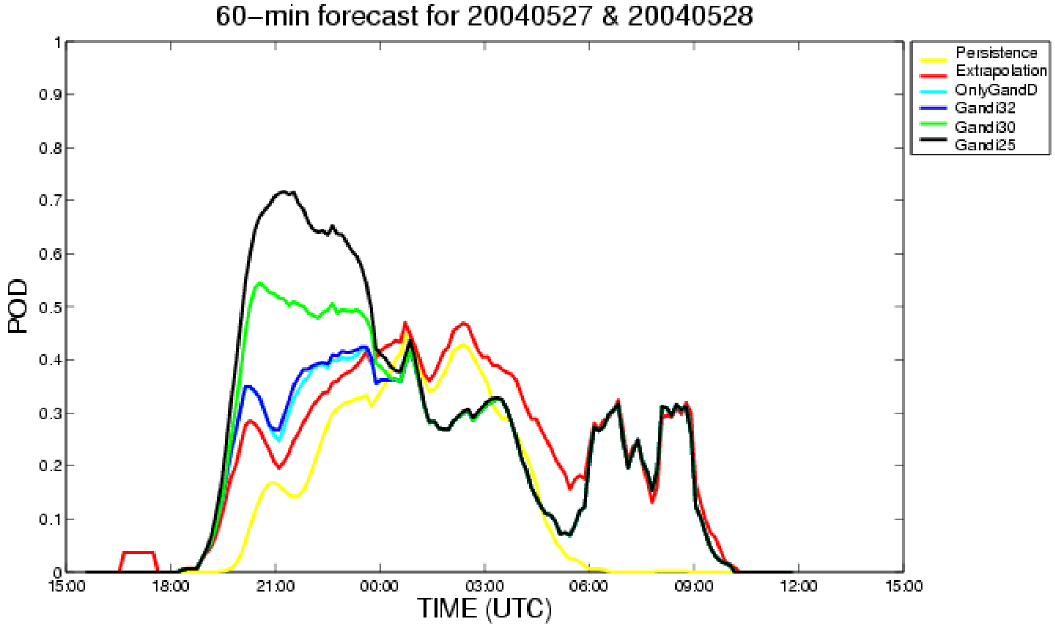

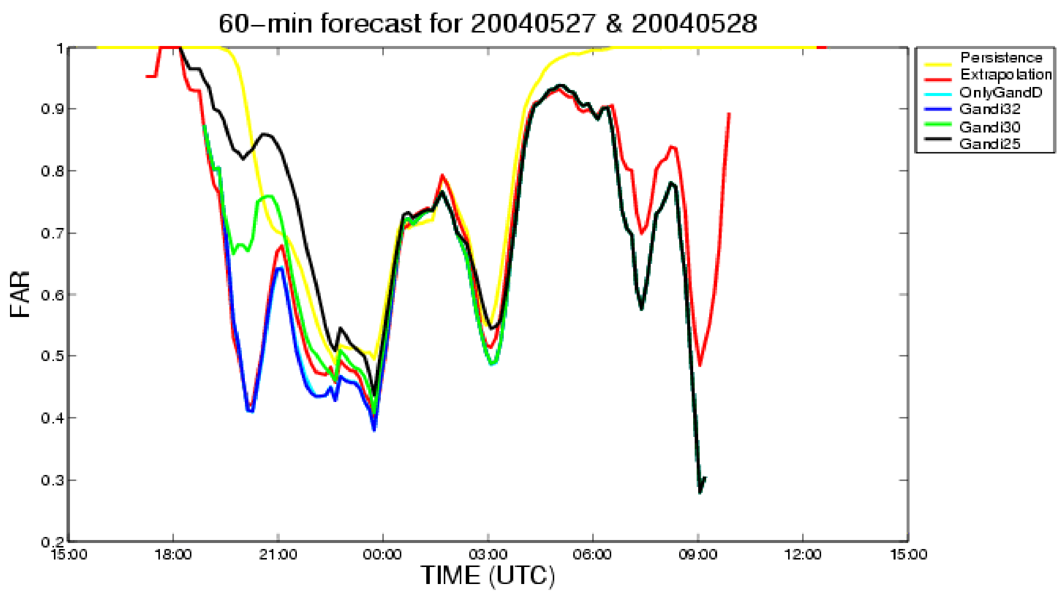

Figure 5 Time series plots of statistics for the 27 May 2004 event. The areal coverage (A), CSI (B), POD (C), and FAR (D) are shown. The yellow line represents the persistence forecasts, the red line the extrapolation forecasts, the cyan line in the ANC Growth and Decay forecasts, the blue, green, and black lines are the ANC forecasts including the Growth and Decay component and the three successive levels of initiation.

5. REFERENCES

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