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Short-Term (0-2hr) Automated Growth Forecast of Multi-cellular Convective Systems Associated with Large Scale, Daytime Forcing

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1.0 Introduction

This paper discusses current algorithm development towards a 1-2 hr national-scale nowcast of storms. It builds on the National Convective Weather Forecast (NCWF)[3] product. NCWF provides current convective hazards and 1-hour extrapolation forecasts of thunderstorm hazard locations.

Analysis of the NCWF shows that although the motion vectors are generally accurate, during rapid growth and dissipation of storm systems the forecast tend to be poor (Meganhardt et. al., 2000). Based on case-studies (Mueller et. al., 1999) and user-requirements studies (Wolfson, et. al, 1997), we determined that the best place to start algorithm development toward improved 1-2 hr forecast was to capture the growth associated with large-scale, day-time forced multi-cellular convection.

2.0 Storm climatology and diurnal cycle

The diurnal cycle of storm activity is evident in Fig 1. The percent coverage plots (Figs. 1b, 1c, and 1d) are based on WSI national composite reflectivity data collected between May and July of 1998, 1999, and 2000. Reflectivity values of >= 40dBZ are counted as a storm observation. At each grid the number of storm observations were summed and normalized to provide a percent coverage at each grid point (higher percentages have a darker color). These data are used to calculate the time series in Fig. 1a.

During the early morning hours (before sunrise) convection is concentrated in the mid-west (Fig 1b). These storms are likely associated with nocturnal meso-scale convective complexes. During the morning hours there is a steady decline in convection that reaches a minimum around 15:00Z (11:00 CDT, Fig 1c). This minima is followed by a steep increase in convective activity during afternoon heating with the majority of storms occurring at 21:00 Z (17:00 CDT). Review of Fig 1d suggests that much of the afternoon convection is associated with the sea breezes off the Gulf of Mexico and the Atlantic (increased convection in Alabama, Georgia, Florida, and South Carolina). However, the increase in afternoon convection was not limited to the south. There were significant increases throughout the eastern U.S. The only area that does not show significantly increased convective activity in the afternoon hours is the mid-western part of the U.S. The steep increase in storm activity occurs during a peak period for airline traffic and represents one of our primary forecast challenges.

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3.0 Forecast algorithm methodology

The growth algorithm builds on the NCWF storm extrapolation. It runs during the diurnal growth cycle (15 to 21Z). Figure 2 illustrates an automated forecast for May 12, 2000. Figure 2a shows a developing line of convection along a synoptic scale front. Since the cells are small and/or have a relatively short history, an extrapolation forecast has yet to be issued in this region. The primary goal of this technique is to differentiate small cells that are forming in air favorable for continued growth and those that are likely to die in 60 minutes.

The RUC data are used to determine locations of large-scale forcing. These data are processed using two different algorithms. The first utilizes fuzzy logic to determine the broad locations of large scale forcing based on the RUC surface equivalent potential temperature gradient, convergence, and vorticity fields. This area is outlined in white in Fig. 2b. The second algorithm tracks the movement of this area and provides motion vectors and the orientation of the line.

In the region of synoptic forcing, small storms are grown and clumped in the orientation of the front based on trending of radar and satellite data. Figure 2c shows small storms identified by the algorithm. These storms are grown and clumped based on their relative locations along the fronts (Fig. 2d). The satellite data are used to help identify where lines of developing cumulus are located to provide input into the extent of growth. The clumped regions are extrapolated based on the motion of the boundary (Fig. 2e). In areas outside the region of large-scale forcing the extrapolation forecast is used.

Box plots of 2-hr validation statistics for persistence, extrapolation (NCWF) and our preliminary growth algorithm are shown in Fig. 3. Box plots provide distributions with the mean shown as a line going through the center of the box, +/- 1 standard deviation within the box, +/- 2 standard deviations indicated by cross-lines and crosses indicating outliers. The statistics were calculated over a period that extended from Jun 9, 2001 to Aug 15, 2001. Only periods when the convection across the country covered 50,000 km^2 or greater are shown. The "preliminary growth" forecast does not clump the storms based on orientation of the front. Also, frontal motions were not available. This simplified version shows significant increase in POD over the NCWF (.246 and .158 respectively) with only a slight degradation in the FAR (.881 and .854

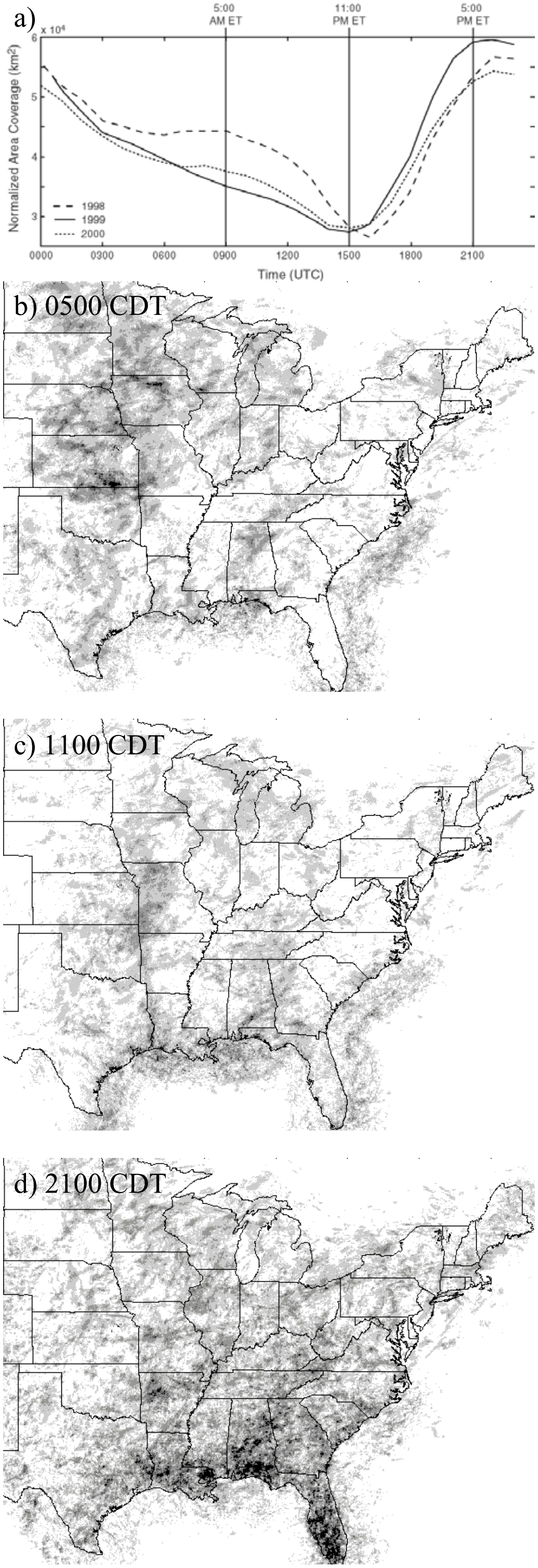

Figure 1. Figures 1b, c, and d show storm density plots calculated between May, June and July of 1998 for 0500, 1100, and 1600 CDT respectively. The darker colors indicate a higher frequency of convection. The time series, Fig 1a, uses these data averaged over the U.S.

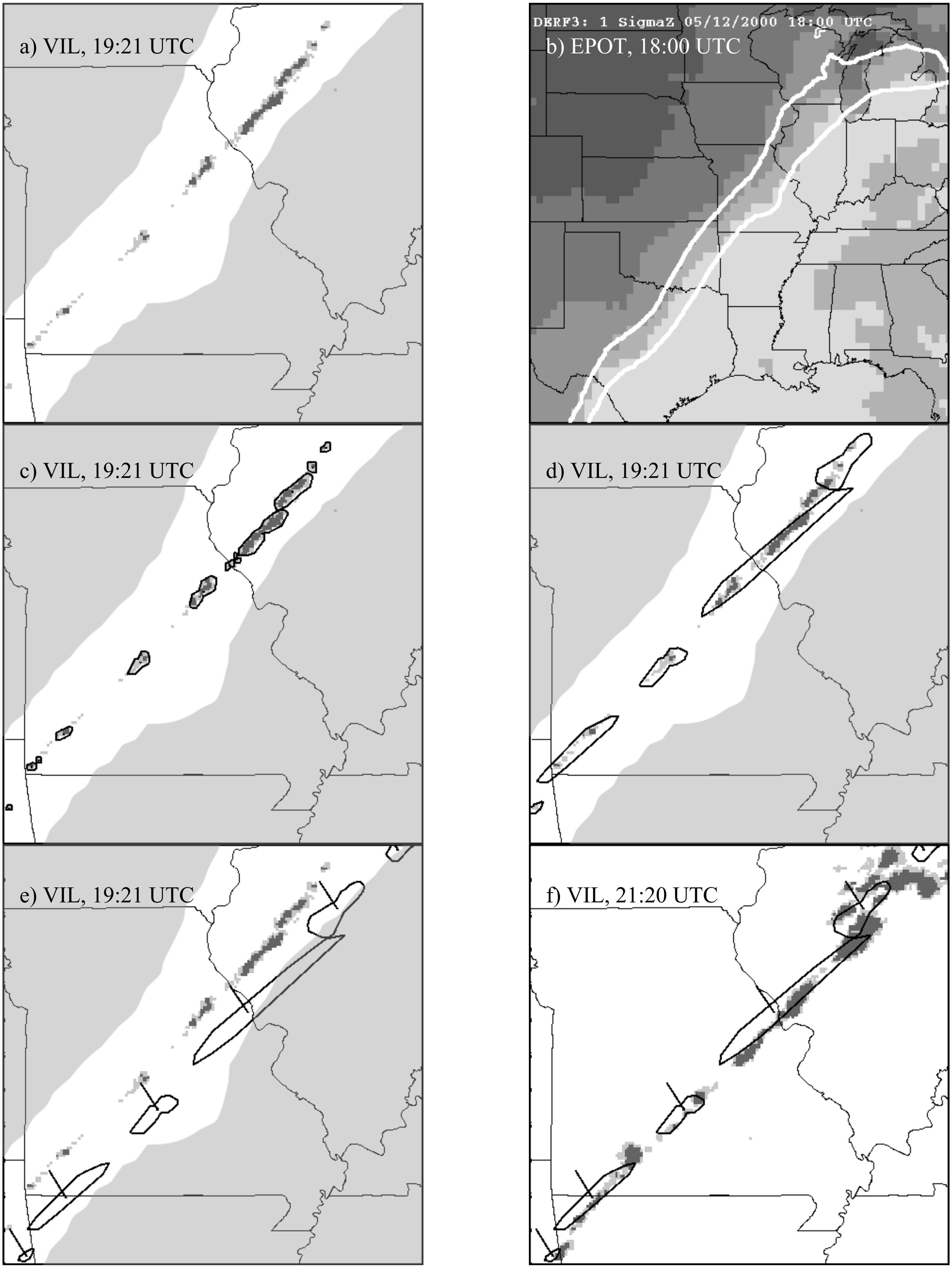

Figure 2. Radar data, Figs. 1a, c, d, e, and f, and RUC data, Fig.1b, from May 12, 2000 are shown. Figure 1a shows a developing line of storms. Figure 1f, shows validation of 2 hr forecast that uses the convective growth forecast algorithm discussed in this paper. The extrapolation forecast had not put out a forecast on this line at this early stage of development. Details of the figure and algorithm are given in the text.

respectively). It should be possible to reduce the bias with the new algorithm because growth will only be in the orientation of the front.

4.0 Discussion

The growth algorithm provides a nice framework for issuing automated 2-hour forecasts. It has been designed to incorporate new information as new techniques are developed. Further work into tuning the algorithm to determine when to transition from forecast based on boundary motion to a forecast based on storm tracking is required. Similarly, tuning is required to determine the extent to grow and clump storms. Work is in progress to use the RUC derived stability and shear fields to improve the trending forecasts. Better use of satellite data in the forecast is also needed.

The extrapolation speeds in this example are quite good but many times the calculated front speed is too slow. Statistically, the forecast will look worse if the cell motions are incorrect, even though visually the forecast are improved by detecting the line earlier in its development. Algorithm tuning and enhancements will help improve these motions.

Plans are to run this algorithm in the northeast corridor during the summer of 2002 in order to test it on a variety of cases and provide statistical evaluation.

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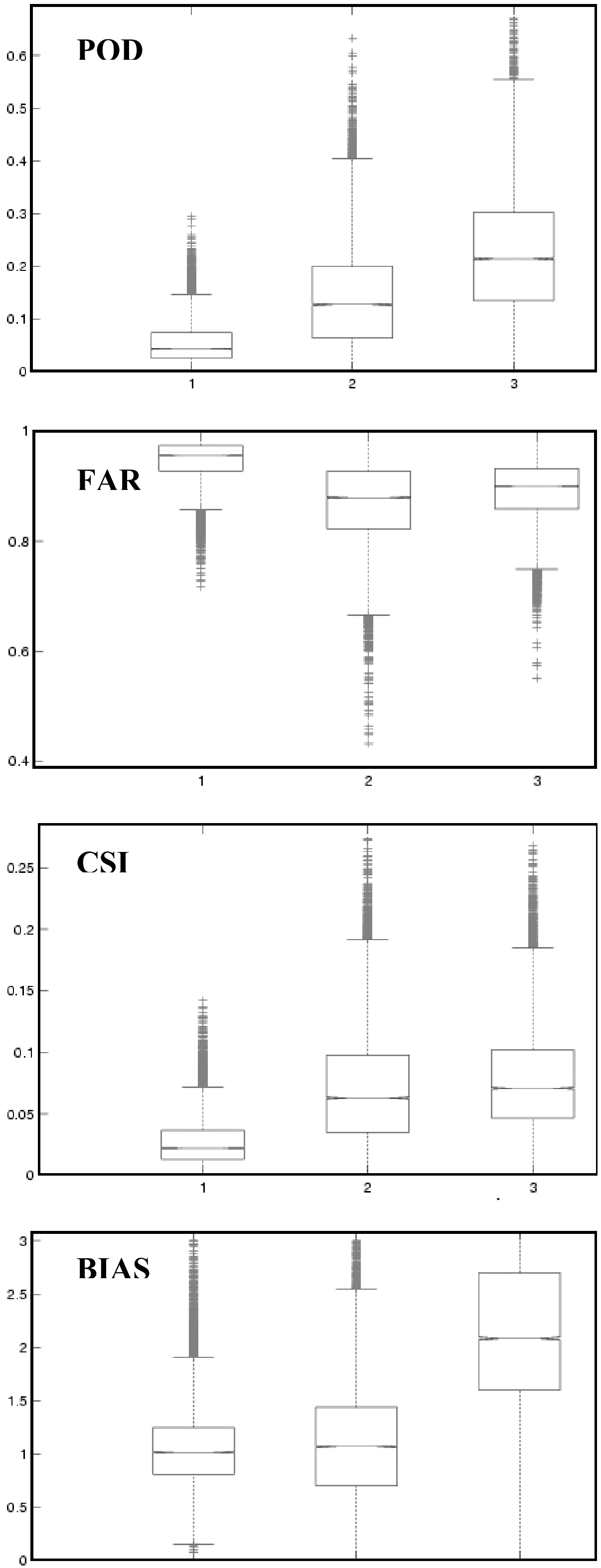

Figure 3. Box plots of 2 hr validation statistics for persistence (labeled 1), NCWF (labeled 2), and preliminary growth nowcast (labeled 3) for summer 2001.