9.8 DEFINING OBSERVATION FIELDS FOR VERIFICATION OF SPATIAL FORECASTS OF CONVECTION: Part 2

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1. INTRODUCTION

A variety of convective weather forecasts are produced operationally and used by the aviation community as decision-aides for re-routing air traffic around convective weather. These forecasts, which include the National Weather Service (NWS) Collaborative Convective Weather Forecast Product (CCFP) and National Convective Weather Forecast (NCWF), describe convective activity at different spatial and temporal scales, and differ in the characteristics of convection that are included in the forecast area.

A critical challenge in evaluating the quality of these forecasts is determining how to appropriately match the forecasts to the observations so that statistical results are representative of the forecast characteristics, the forecast spatial and temporal scales, and operational relevance. This process has been particularly difficult for evaluating forecasts from the CCFP. For instance, CCFP is required to meet minimum size thresholds, and specific criteria for coverage of convection, cloud top height, and cell movement.

Historically, observations used to evaluate the CCFP were expanded from a 4-km grid to a 40-km grid to approximately match the scale of the forecast (Mahoney et al. 2000). Matching the forecast scale was difficult to determine, since the impact of the convective activity on the operational flow of enroute air traffic was not well defined. Moreover, the coverage attribute was excluded from the verification approach, because the application of the attribute was not clearly understood.

The goal of this work is to establish a universal technique for defining a convective field that is built from raw observations, incorporates operational flight constraints, and can be used to evaluate convective forecasts on a variety of spatial scales. Therefore, following the Convective Constrained Area (CCA) definition that was developed by Mahoney et al. (2004), we alter the basic assumptions for the CCA and compare the results to the CCFP.

Data considered in this study are briefly described in Section 2, and the technique for defining the observations is considered in Section 3. The application of the technique is described in Section 4, and the overall conclusions and future work are discussed in Section 5.

2. DATA

The forecasts and the observations used in this study are described in this Section.

2.1. Forecasts

Collaborative Convective Forecast Product (CCFP): The CCFP forecasts are issued by the NWS Aviation Weather Center (AWC), but are produced through a collaborative process between AWC forecasters, airline and Center Weather Service Unit meteorologists and meteorologists from the Meteorological

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Service of Canada. CCFP forecasts are required for areas of intense convection and thunderstorms every two hours, with lead times of two, four, and six hours after the forecast delivery time. The CCFP is comprised of polygons that are at least 3,000 mi^2 in size and contains a coverage of at least 25% convection with echoes of at least 40 dBZ composite reflectivity and also a coverage of at least 25% with echo tops of 25,000 ft. and greater (Weather Applications Workgroup, 2003).

2.2. Observations

National Convective Weather Forecast Hazard Product (NCWF-H): The NCWF-H product (Mueller et al. 1999) is used to describe **intense** convection as it applies to the CCFP and the NCWF that is a threat to aircraft. It is defined by VIP values of 3 or greater, and/or 3 or more strokes of lightning in 10 min. within 8 km of a grid point, on a 4-km grid. Further information can be found at: *http://cdm.aviationweather.noaa.gov/ncwf/ncwf_wt/ncwf_wt_haz.htm*.

3. DEFINING THE OBSERVATIONS

The techniques for defining the observations for evaluating the CCFP are separated into parts: developing a definition for Convective Constrained Areas (CCA) and producing a convective coverage fields that reflect the attributes mainly of the CCFP.

The **Convective Constraint Area (CCA)** provides the basis for measuring the "scale" of convective activity that impacts the flow of enroute air traffic. Rhoda et al. (2002) determined that pilots do tend to deviate around strong precipitation until they get quite close to the arrival airport. However, they were unable to determine the typical distance of the deviations. Therefore, the CCA concept applied here follows guidance provided by the Aeronautical Information Manual (AIM 2003; *http://www1.faa.gov/ATPubs/AIM/index.htm*, which suggests that pilots should remain at least 20 nm away from intense convection in order to minimize safety concerns that are due to convection. However, in practice this 'safe' distance is quite variable and has not been directly measured. For this evaluation, we assume three distances: 0 nm (or no distance), 10 nm, and 20 nm. Therefore, the CCA is defined as an area of intense convection (identified by the 4-km NCWF-H grid) plus the radius (i.e., 0, 10, or 20 nm) surrounding the convection. The radius is measured from the center of each 4-km NCWF-H grid box.

Figure 1 shows the raw NCWF-H where the small gray (green) areas represent the grid boxes with intense convection. When a 10 nm radius is applied to the observations in Fig. 1, the areas grow slightly as shown in Fig. 2 to represent the CCAs. The CCAs in Fig. 2 should not be thought of as areas "closed" to enroute air traffic. Rather, they should be considered as areas where the flow of en-route air traffic is reduced because of the influences produced by the intense convection. Figure 3 shows the CCA with a 20 nm radius, representing the guidance to pilots described in the AIM.

Using the CCA as the area of interest, coverage is computed by evaluating the percentage of 4-km CCA boxes meeting the CCA criterion within a larger 92x92 km search box. This search box represents the 3,000 mi^2 minimum size required before a CCFP forecast polygon can be issued. The percent of observed coverage within the search box is assigned to the center 4-km box. The search box is moved one grid square and the coverage is recomputed and assigned to the center 4-km box. This procedure continues until each 4-km box within the forecast domain has an observed coverage value assigned to it. The coverage of the CCA, for the example shown in Fig. 1, is shown in Fig. 4a-c. Increasing coverage represents a decrease in the flow of air traffic, although exactly how much of a decrease is difficult to determine and will be the focus of future work.

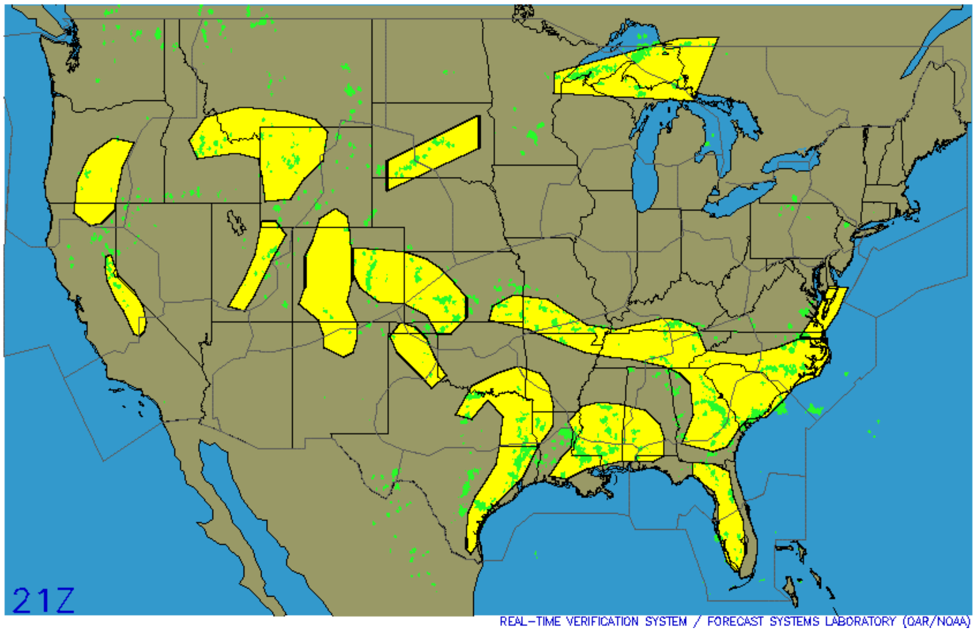


Figure 1. Raw NCWF Hazard Product at 4-km resolution, 2100 UTC on 30 June 2004. Small green areas indicate VIP values that are 3 and greater and cloud tops are assumed to be 20,000 ft and greater. Large yellow areas are CCFP forecast.

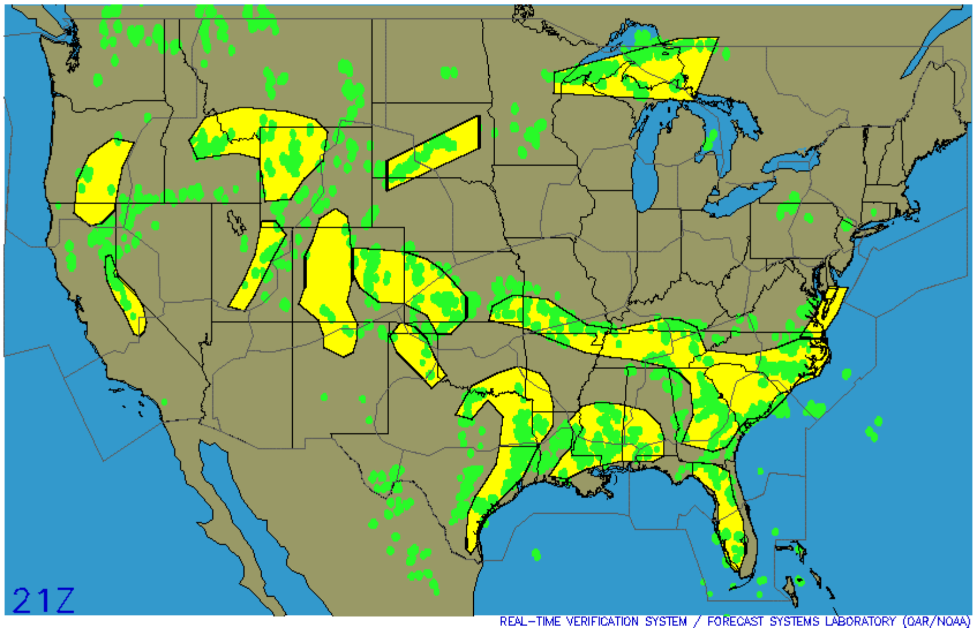


Figure 2. Map of convective activity that impacts enroute air traffic for 2100 UTC on 30 June 2004. Small gray areas indicate 4-km NCWF Hazard + 10 nm radius, large areas (yellow) are CCFP forecast.

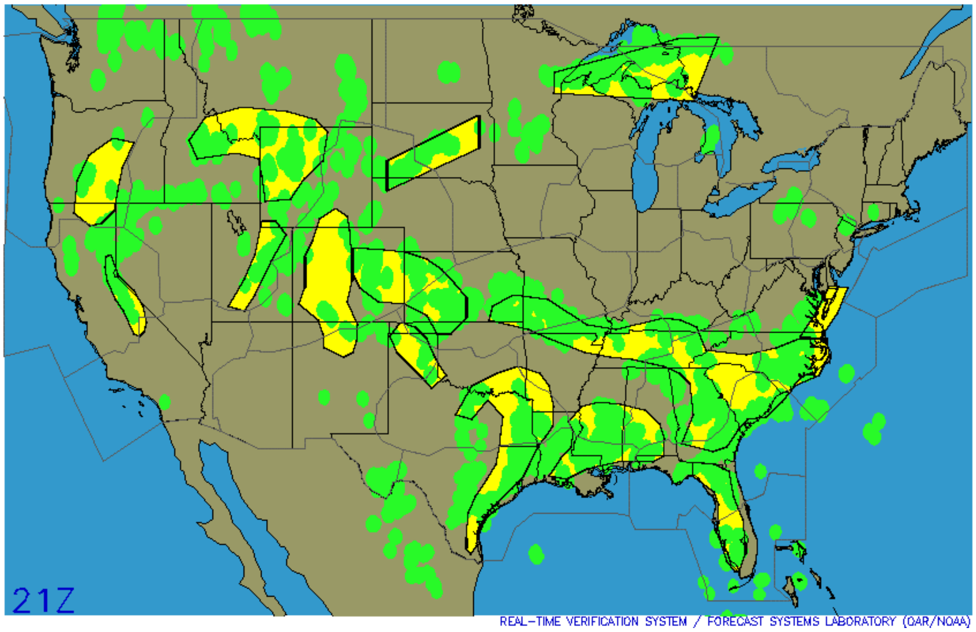


Figure 3. Same as Fig. 2, except for 20 nm radius

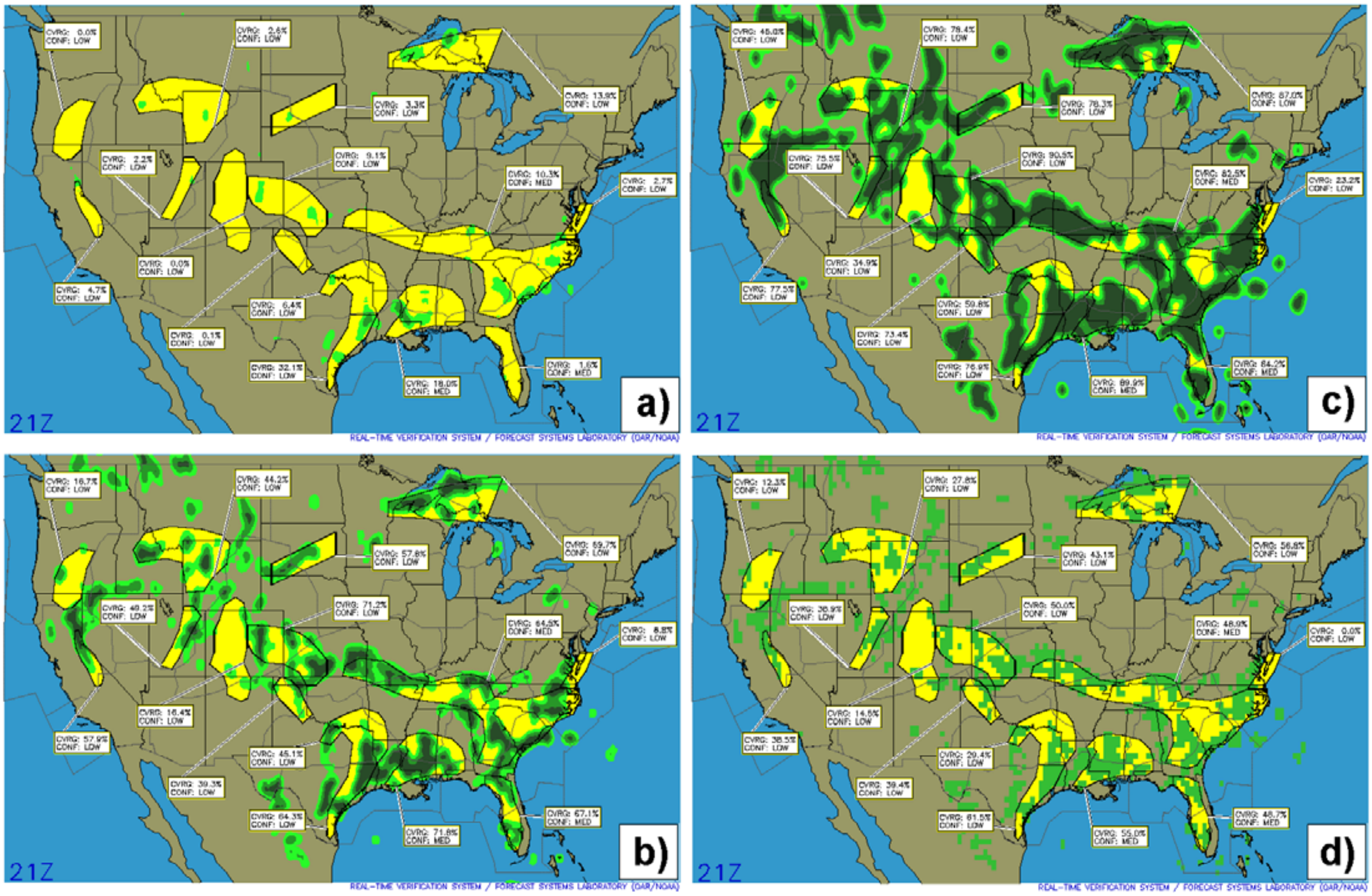
4. APPLICATION

The application of the technique for defining observations is illustrated for the 30 June 2004 convective case. The convection for this particular case could be classified as isolated scattered, often the most difficult to forecast. Figures 4 a-d show the derived coverage field for this case with: (a) 0 nm radius, (b) 10 nm radius, (c) 20 nm radius and (d) 40-km box technique. The CCFP areas are plotted along with the coverage.

Visually, it appears as though the amount of convection produced for the derived-coverage with a 10 nm radius seems to best fit the scale of the CCFP. However, with a 0 nm radius, nearly all CCAs meeting the CCFP 25% coverage criteria are removed. While on the other hand, for the 20nm radius, a large portion of the map is covered by CCAs with coverage values that are 25% or greater. The 10nm radius CCA seems to be similar in appearance to the historically used 40-km box technique (Fig. 4d).

Statistics were generated for the CCFP using the coverage field derived from the (a) 0 nm radius, (b) 10 nm radius, and (c) 20 nm radius and are shown in Table 1. The verification scores for the 40-km box method are shown as well and represent the statistical baseline of CCFP performance for this case.

The largest PODy value was computed for the CCA-0 nm case with nearly 75% of the convection being contained within a CCFP forecast area. However, all other scores suggest low overall skill. For instance, the CSI is small with a value of 0.08, the HSS is 0.12 and the Bias is large with a value of nearly 9.0. The scores for the CCA-20 nm case indicate good skill as represented by CSI and HSS with values reaching 0.40, an improvement over the 40-km box method. However, the PODy for the CCA-20 nm case was reduced to nearly 0.42 and the Bias was nearly half the Bias of the 40-km box method. For the CCA-10 nm case, all skill scores either remained the same as the 40-km box method or improved. For instance, the CSI, HSS, and the Bias values all improved over the 40-km box method indicating better forecast skill using with the CCA-10 nm method for evaluation of the CCFP. Therefore, these results suggest that the CCA-10 nm method is best for evaluating the CCFP, although further testing is needed and additional cases should be evaluated.



Figures 4 a-d. Coverage maps for 30 June 2004, valid 2100 UTC for the 2-h CCFP and observed CCAs for (a) 0 nm radius (b) 10 nm radius, (c) 20 nm radius, (d) 40-km boxes. Coverage 25-49% (light green; gray), 50-74% (medium green; gray), and 75-100% (dark green; gray). Coverage not computed for 40-km box case (Fig. 4d). Forecasts are indicated by large yellow (gray) areas that are consistent in each picture.

Table 1. RTVS verification statistics computed for the case of 30 June 2004 (2100 UTC valid time) for the derived-coverage using a 0, 10, and 20 nm radius. The statistics using the 40-km box method are included as a baseline.

CCFP (2-h forecast)				
Statistic	***0 nm***	***10 nm***	***20 nm***	***40-km box method***
PODy	*0.74*	*0.49*	*0.42*	*0.49*
CSI	*0.08*	*0.35*	*0.37*	*0.29*
Heidke	*0.12*	*0.40*	*0.40*	*0.34*
% Area	*18.09*	*18.09*	*18.09*	*18.10*
Bias	*8.63*	*0.90*	*0.56*	*1.21*

5. CONCLUSIONS AND FUTURE WORK

Defining the observed fields for verifying spatial forecasts for convection is key to developing verification approaches that meet the forecast and user requirements. In this paper, we test the definition of the Convective Constraint Area (CCA) by using a variety of radii to define intense convective weather that impacts the flow of air traffic. These results suggest that the CCA-10 nm method is best for evaluating the CCFP, although further testing is needed and additional cases should be evaluated. Moreover, this result does not confirm that the 10 nm radius used to develop the CCA is the optimal size as it relates to the flow of air traffic. Understanding this relationship will be the focus of future work.

Future work includes applying the CCA technique to other forecasts, such as the National Convective Weather Forecast (NCWF), testing the CCA radius against flight track observations, and expanding the approach to other convective cases.

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