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2.6 DEFINING OBSERVATION FIELDS FOR VERIFICATION OF SPATIAL FORECASTS OF CONVECTION

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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 Convective Significant Meteorological Advisories (C-SIGMET), describe convective activity at different spatial and temporal scales and differ slightly in the characteristics 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 the forecast's operational relevance. This process has been particularly difficult for evaluating forecasts from the CCFP and the C-SIGMETs where the CCFP and the C-SIGMETs are required to meet minimum size thresholds, as well as 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 en-route 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.

Therefore, new methods for defining the observation fields used for evaluating the CCFP and the C-SIGMET forecasts that take into account the impact of convection on the flow of air traffic (i.e., Convective Constraint Areas) and incorporates the observed coverage are presented in this paper.

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 Service of Canada. CCFP areas 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

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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 40dBZ composite reflectivity and also a coverage of at least 25% with echo tops of 25,000 ft. and greater (Weather Applications Workgroup, 2003).

Convective SIGMET: The C-SIGMET, generated by forecasters at the AWC, is a text forecast of convective activity that is issued hourly, but is valid for up to 2 h (NWS 1991). The forecasts are intended to capture severe or embedded thunderstorms and their hazards (*e.g.,* hail, high winds) that are either occurring or forecasted to occur within 30 minutes of the valid period and cover at least 40% of the 3,000 mi^2 or larger forecast area.

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 CCF that is a threat to aircraft. It is defined by VIP values of 3 or greater, and/or 3 or more stokes of lightning in 10 minutes 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 and the C-SIGMET are separated into parts: developing a definition for Convective Constrained Areas (CCA) and producing observed fields that reflect the attributes of the CCFP, particularly the size and coverage criteria.

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 how far the deviations typically were. 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 20nm away from intense convection in order minimize safety concerns that are due to convection. However, in practice, this distance if often too large when air space becomes congested. Therefore, to take this operational consideration into account, we defined the CCA here as an area of intense convection (identified by the 4-km NCWF-H grid) plus a 10nm radius surrounding the convection. The 10nm radius is measured from the center of each 4-km NCWF-H grid box.

Figure 1 shows the raw NCWF-H where the gray areas represent the grid boxes with intense convection. Once the 10nm radius criterion 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.

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 or C-SIGMET 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. 3. Increasing coverage represents a decrease in the flow of air traffic, although exactly how much of a decrease is yet to be determined and will be the focus of future work.

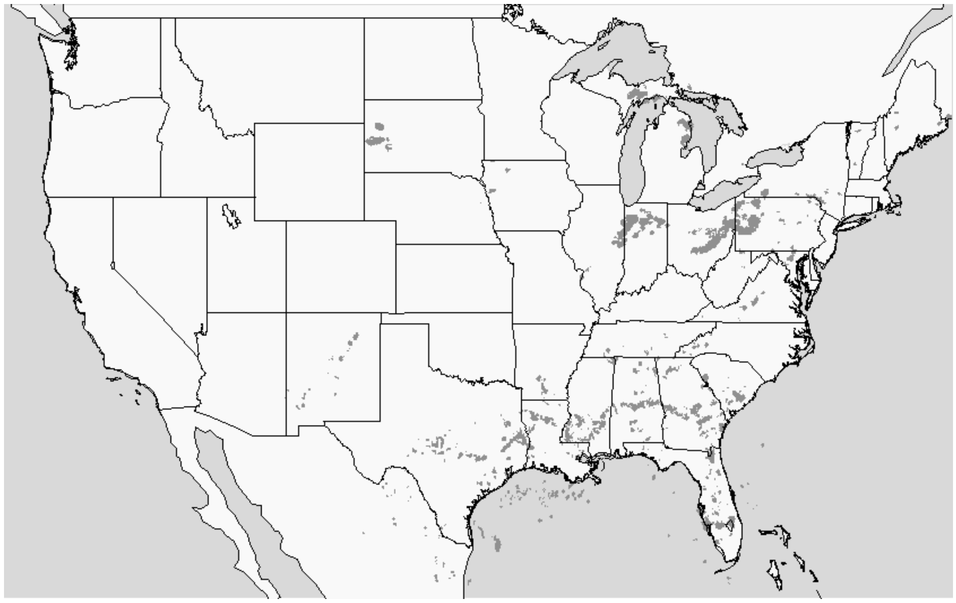


Figure 1. Raw NCWF Hazard Product at 4-km resolution, 4 July 2003, 1900 UTC. Gray areas indicate VIP values that are 3 and greater and cloud tops are assumed to be 20,000 ft and greater.

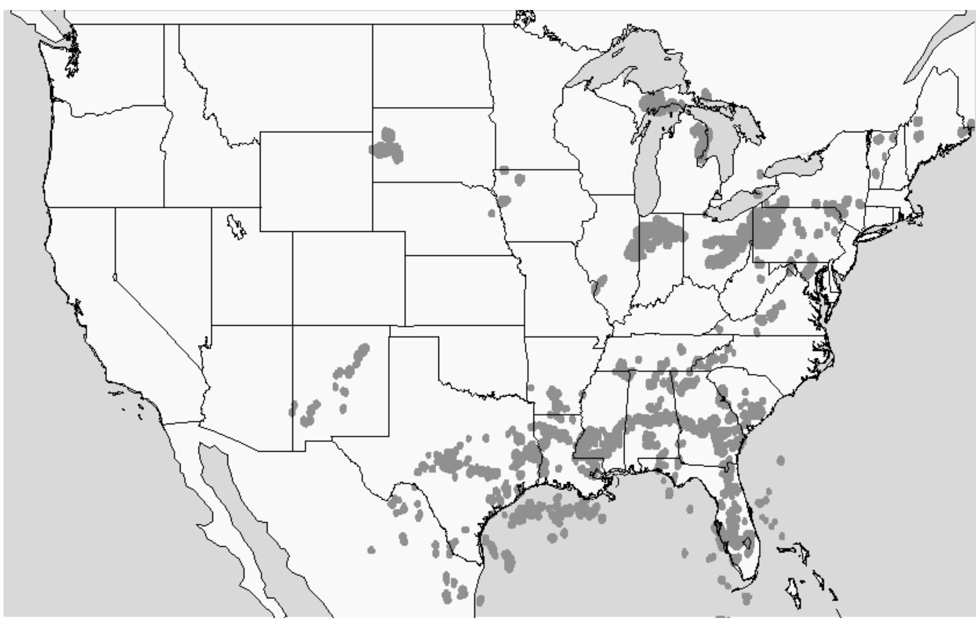


Figure 2. Map of convective activity that impacts enroute air traffic for 4 July 2003, 1900 UTC. Gray areas indicate 4-km NCWF Hazard + 10 nm radius.

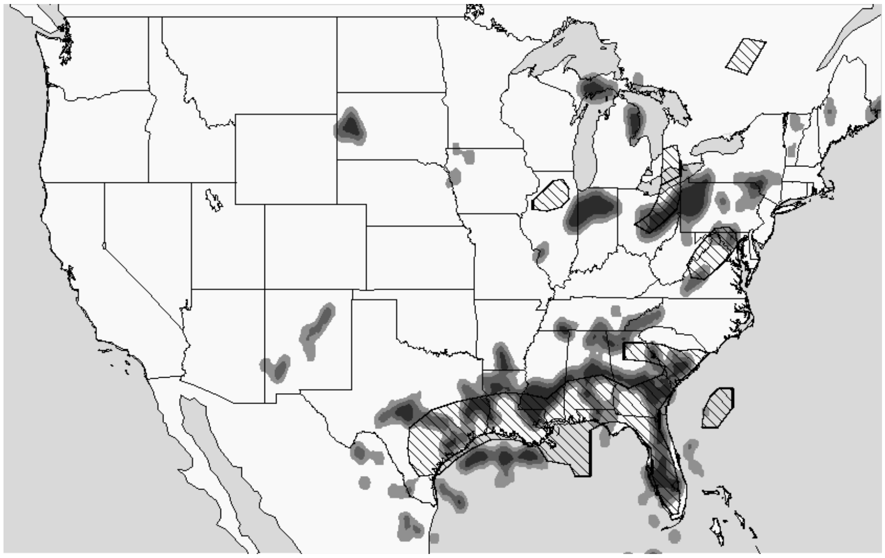


Figure 3. Map of convective constraint areas with coverage 3,000 mi^2 area that is 25-49% (light gray), 50-74% (medium gray) and 75% and greater (dark gray), 4 July 2003, 1900 UTC. Hatched areas indicate CCFP forecast.

4. APPLICATION

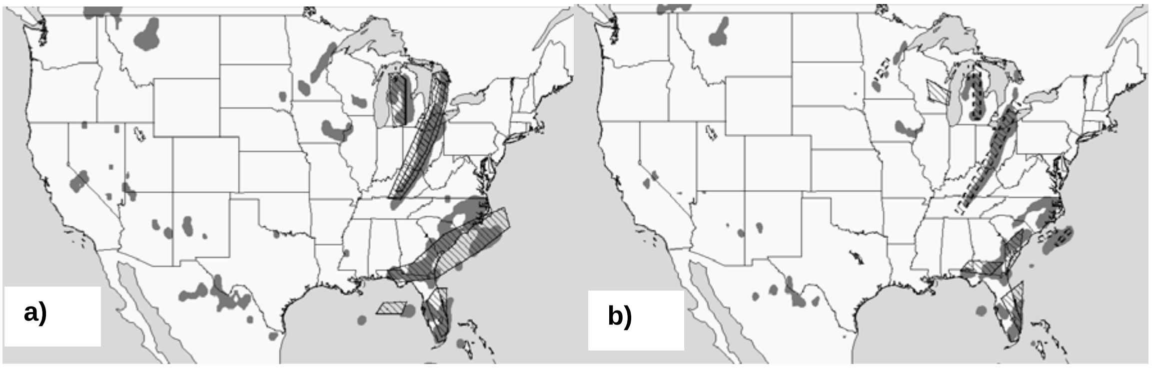
The application of the technique for defining observations is illustrated for two convective cases; a well-organized convective line (Fig. 4; 8 June 2003) and disorganized isolated convection (Fig. 5; 5 August 2003). The observed fields shown in the figures pictorially represent the "perfect" forecast where the sizes of the fields are greater than 3,000 mi^2 and the areas contain a coverage that is greater than the minimum threshold for the CCFP (25%; Figs. 4a and 4b) and the C-SIGMETs (40%; Figs. 4b and 5b).

For the 8 June 2003 case (Fig. 4), the forecasts nicely capture the main convective line over the Midwest and large convective area over the Southeast. Convection over the West and Southwest was left out of both forecasts, possibly because the impact on rerouting aircraft due to convection is generally less of a problem over the West than over the eastern half of the U.S.

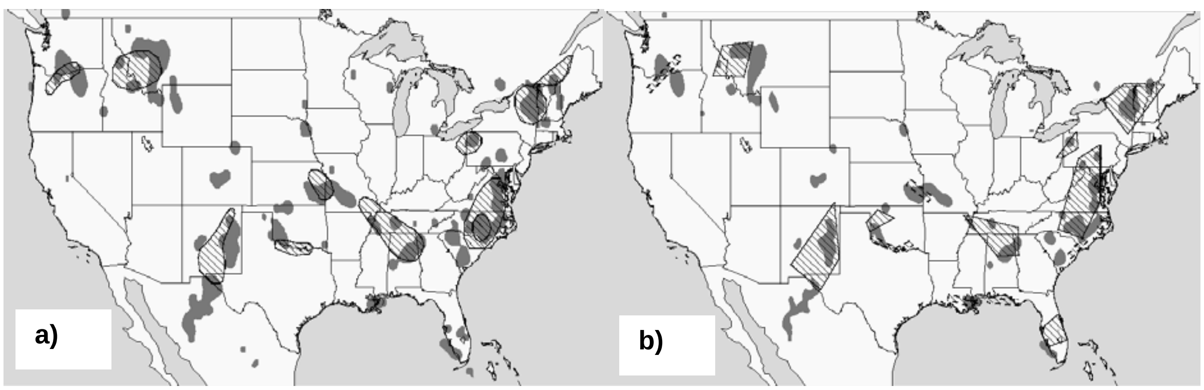
In the 5 August 2003 case (Fig. 5), the larger convective areas over the Northeast, Atlantic States, lower middle half of the U.S., and the upper Northwest were accurately captured by both the CCFP and the C-SIGMETs. However, the smaller convective areas were excluded from both forecasts. These results may suggest that the CCFP and the C-SIGMET forecasts are focused on main areas of convection that are typically much larger than 3,000 mi^2 and that the area requirement for the minimum forecast area should be reconsidered.

5. CONCLUSIONS AND FUTURE WORK

Defining the observed fields for verifying spatial forecasts for convection is key to developing approaches that meet the forecast and user requirements. In this paper, we build a definition for a Convective Constraint Area (i.e., CCA) that is consistent with operational guidelines and is used to characterize the airspace around intense convective weather where the flow of enroute air traffic may be obstructed or reduced. The CCA forms the basis for developing the coverage fields that are used to evaluate the quality of, and characterize the weather requirements for, the CCFP and the C-SIGMETs. Input from the user community is necessary to ensure that the size criterion of 10nm is operationally relevant. In addition, cloud top heights need to be added to the CCA techniques presented here to fully incorporate the CCFP weather attributes into the verification approach. Finally, the relationship between the observed coverage and the reduction in the flow of air traffic will be the focus of future work. Defining the observations in this manner sets the stage for the application of object-oriented verification approaches (Brown et al. 2002).



Figures 4 a and b. Organized convective line, 8 June 2003 2-h forecasts for CCFP (a) and C-SIGMET(b) issued 1900 UTC. Observed CCAs, coverage 25% (a) and 40% (b) in gray. Forecasts are indicated by hatched areas.



Figures 5 a and b. Disorganized convection, 5 August 2003, 2-h forecasts from the CCFP (a) and C-SIGMETs (b) issued at 2300 UTC. Observed CCAs, coverage 25% (a) and 40% (b) in gray. Forecasts are indicated hatched areas.

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