4.13 VERIFICATION OF THE AVIATION WEATHER CENTER'S CONVECTIVE SIGMET OUTLOOKS USING RTVS

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1. INTRODUCTION

The National Weather Service (NWS) Aviation Weather Center (AWC) is responsible for issuing forecasts and warnings of weather hazards of interest to the aviation community. Forecasts include turbulence, icing, and low visibility conditions and may be issued as Airmen's Meteorological Advisories (AIRMETs) and convective and nonconvective Significant Weather Advisories (SIGMETs). Convective SIGMET forecasts are of particular importance during the summer convective season.

Through funds provided by the Federal Aviation Administration Weather Research Program, the Forecast Systems Laboratory (FSL) is developing a Real-Time Verification System (RTVS). This system provides an easy-to-use approach for tracking the quality of forecast products (Mahoney et al. 1997). The RTVS has been used to verify the AWC AIRMETs (Mahoney et al. 1998), and has provided valuable information to AWC planning and upgrades (Mahoney 1999).

A recent addition to the RTVS is the verification of the AWC convective SIGMET outlook. Convective SIGMET outlooks (hereafter referred to as "outlooks") are issued hourly, are valid from two to six hours after issuance time, and represent areas where convective SIGMETs are likely to be issued during the valid period.

In addition to an examination of its standard outlooks, the AWC was also tasked to determine the possible benefits of issuing outlooks at other intervals and with shorter valid times. In July and August 1998, the AWC conducted a six-week evaluation of experimental outlook forecasting; outlooks were valid for 2-h periods, as opposed to the standard 4-h forecast lengths, and valid times ranged from 2 to 6 h after the issuance time. For a detailed description of the exercise and its objectives, see Hudson and Mosher (1999).

In this paper, we describe the methods used to verify the AWC standard and experimental convective SIGMET outlooks using the RTVS and present verification results for the 1998 convection season.

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2. VERIFICATION METHODS

2.1 Data Collection

Outlooks are verified using all convective SIGMETs that are valid during any portion of the valid period of the outlook. Both the convective SIGMETs and outlooks are issued at 55 minutes after the hour, on an hourly basis. The valid period for standard outlooks is 4 h, beginning 2 h after the issuance time; convective SIGMETs are valid for a 2-h period beginning at the issuance time.

The experimental outlooks were valid at a specific time; however, for the purposes of this study they were considered to have a valid period +/-1 h from the valid times given. Experimental outlooks were only forecast on Monday through Friday. The issuance and valid times are shown in Table 1.

Table 1. Valid times for Aviation Weather Center (AWC) Experimental Outlooks

	2 HR	4 HR	6 HR
14 UTC	16 UTC	18 UTC	20 UTC
16 UTC	18 UTC	20 UTC	22 UTC
18 UTC	20 UTC	22 UTC	00 UTC
20 UTC	22 UTC	00 UTC	02 UTC

2.2 Verification Statistics

Statistics were computed for each outlook following previous work such as Mahoney et al. (1998) and Brown et al. (1997). One difference from previous statistical work using the RTVS was that the verifying "observations," i.e., the convective SIGMETs, are areas rather than point observations such as pilot reports or Meteorological Aviation Reports (METAR), or surface reports. The following method was used to generate pairs of outlook/SIGMET "observations". All convective SIGMETs valid during any part of the outlook valid period were used as verifying observations. Figure 1 shows the outlook for 0300 UTC on 22 July 1998, valid from 0300 UTC until 0700 UTC, and the corresponding SIGMETs that were subsequently issued and valid during some part of that period. The outlook and corresponding SIGMETs were placed on a 40-km grid, so that each grid point could be said to have been inside/outside of the outlook and inside/outside of any SIGMETs during the valid period. (Some convective SIGMETs are issued as isolated point locations or lines; these forecasts also report distances of influence from the point or line, so that a SIGMET "area" can always be determined.) From this grid, a contingency table of forecast-observation pairs was generated. Unlike pilot reports, which cannot generally be used as "No" observations unless specifically reported, areas without outlooks can be reliably considered as "No" forecasts; likewise, grid points outside of SIGMET area are considered reliable "No" observations. However, with the large areas generally outside of outlook and SIGMET coverage at any given time, "No/No" observations tend to be much larger than the other contingency values, so that statistical measures using No/No values are difficult to use objectively.

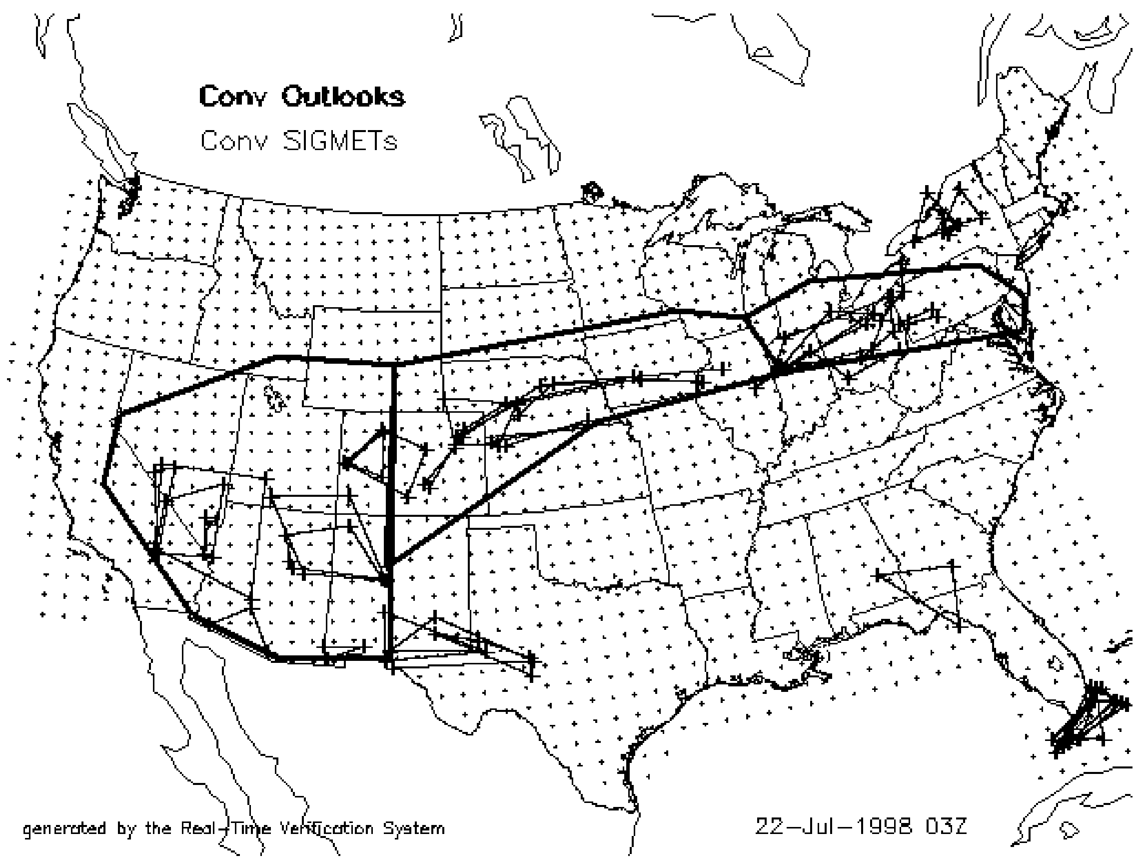

Figure 1. RTVS Display of Convective SIGMETs and Outlooks. Bold lines represent outlooks; thin lines with crosses represent SIGMETs. The outlooks displayed are valid 0300-0700 UTC 22 July 1998; SIGMETs are valid during some portion of the outlook valid period. Grid points used to determine counts and areas are also shown.

2.3 Statistical Calculations

Standard statistical measures such as probability of detection (POD), false alarm rate (FAR), and the Critical Success Index (CSI), or threat score, were computed from the contingency values. Also, the areas of each grid box were used to compute the total areas of coverage for the outlook and the SIGMETs. This allows the Area Efficiency to be calculated (Brown et al. 1997):

Area Eff. = PODy / Area of Outlooks

The Area Efficiency is a measure of how well the forecaster is able to capture the area of the SIGMETs without overforecasting. For example, a forecaster could use large areas in the outlook forecast, making it more likely to capture the SIGMETs; however, this may not provide the best overall forecast to the aviation users. Ideally, the forecaster desires a high POD with the smallest forecast area possible; area efficiency is one aspect of this ability.

3. VERIFICATION RESULTS

Statistical results from the six-week exercise are presented in Table 2. Due to two data ingest outages during the period, a total of about five days of convective SIGMET data were lost; since three days of this missing data fell on weekends, the experimental runs were not seriously affected.

The PODy for the standard outlooks was 0.65 for the six-week period. The experimental 2-h outlooks did nearly as well, with a general loss of accuracy over increased forecast lengths. The percent of the forecast area covered by outlooks (%-Area) averaged 17% for the standard outlooks, and was only 10% for the experimental 2-h outlooks. The experimental outlooks showed a general increase in % Area for longer forecast times—probably indicative of the increase in forecaster uncertainty for longer forecast times.

The Area Efficiency values show that the experimental 2-h outlooks were able to generate the best ratio of high PODy with small %-Area, with a value of 6.35 versus 3.75 for the standard outlooks. Also of note is that the experimental 2-h and 4-h outlooks both had slightly higher CSI scores than the standard outlooks.

A time series plot of the probability of detection of Yes values is shown in Figure 2. There is, as expected, a high variability from day to day in the PODy results during the period. The standard outlook forecasts ranged from roughly 0.50 to 0.80, possibly due to variability in weather conditions, although this is yet to be investigated. It is interesting to note that the experimental outlook forecasts began the period poorly, but showed improvement after the first two weeks of the exercise. The size of the outlook areas may also show improvements over time, and this aspect of the exercise will also be investigated.

Table 2. Statistical Output for Six-week Period of Convective SIGMET Outlooks. YY, YN, NY, and NN are grid point counts; PODy, PODn, FAR, and CSI are fractions; % Area is percentage of Outlook area relative to the AWC national forecast area; Area Eff is the ratio of PODy (as a percentage) to % Area).

	STANDARD	**2 HOUR**	**4 HOUR**	**6 HOUR**
YY	182813	16503	21942	23589
YN	726127	50438	73091	85229
NY	97090	9934	16706	23421
NN	4260499	615928	587195	566695
PODy	0.65	0.62	0.57	0.50
PODn	0.85	0.92	0.89	0.87
FAR	0.80	0.75	0.77	0.78
CSI	0.18	0.21	0.20	0.18
% Area	17	10	14	16
Area Eff	3.75	6.35	4.11	3.18

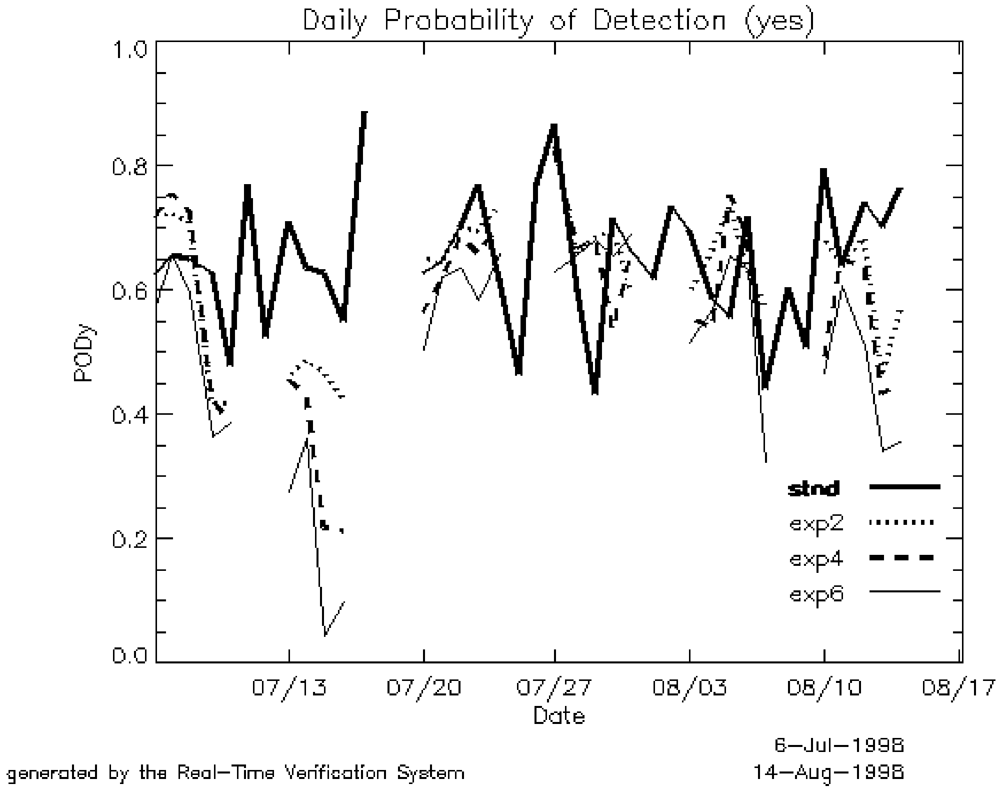

Figure 2. Daily time series plot of PODy for Standard and Experimental Outlooks.

4. CONCLUSIONS

The Real-Time Verification System was used to verify the Aviation Weather Center convective SIGMET outlooks using convective SIGMETs as verifying observations. Both "standard" outlooks and experimental outlooks were assessed. Based on the statistical results generated, several conclusions can be drawn:

- Probability of detection of "yes" for SIGMETs was highest for the "standard" outlooks, due to the larger area covered by the forecast. The experimental 2-h and 4-h outlooks were able to produce nearly as good PODy results with smaller areas as seen by their higher Area Efficiency. These results could be useful to the AWC in determining future forecasting methods such as the frequency and duration of convective SIGMET forecasts.
- PODy results for the experimental outlooks showed improvement over the course of the exercise, perhaps due to the forecasters becoming more accustomed to the forecast issues associated the experimental outlooks. This indicates that changes in forecasting procedures will take time to become comfortable to the forecasters, but over time the improvements should be noticeable.

5. FUTURE PLANS

Results from this study were made available through a temporary FSL Web site, to facilitate viewing of the results in real time. The convective SIGMET software is being implemented into the display interface, so that future examinations can be accessed through the RTVS displays.

The AWC continues to use the RTVS to examine the validity and usefulness of its in-flight aviation advisories. RTVS is currently being used to assess the method of creating the convective SIGMET itself. Lightning data are being used as a test verification observation dataset to determine its ability to locate possible SIGMET locations.

RTVS continues to expand its model verification capabilities. Several turbulence and icing algorithms are currently being verified in real time.

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