SRH-SSD 2005-02
5/2005

Technical Attachment

MAV and FWC Ceiling and Visibility Verification Summaries
WFO Tulsa, OK
1 October 2004 through 15 February 2005

Steve Amburn
WFO Tulsa

1. Introduction

A question arose concerning the value and requirement of the FWC (NGM) MOS guidance in aviation forecasts of ceiling and visibility, given the availability of MAV (GFS) MOS guidance. Although subjective opinions were readily available, an objective analysis of the verification data was needed to determine the relative value of each MOS product.

Data were obtained for TUL, MLC, FSM and FYV, which are the only sites in the Tulsa CWA for which both FWC and MAV MOS guidance is produced. Forecast categories from the MAV MOS were combined to match those of the FWC MOS categories for this comparison.

2. Data

Data for this analysis were obtained from the TAFTrack real-time, aviation verification program developed by James Frederick of WFO Tulsa. The period of time for which verification is desired can be set for any length of time, up to the day and hour prior when the program is run. The time of interest for this study was October 1, 2004 through February 15, 2005. This verification data were processed in approximately 15 minutes.

3. Visibility Data and Results

Tables 1 and 2 show the summary counts of FWC and MAV MOS forecast categories for visibilities, respectively. The forecast categories are listed down the left side, while the observed categories are shown across from left to right. For example, the FWC MOS forecast a total of 73 hours of category 2 visibilities. It was observed as category 2 only two hours, but as category 3 a total of 19 hours.

Note on the far right of each table is a weighted average (Wtd Avg) for the forecast category. This number represents the average expected category given the forecast category. For category 1, the expected observed value from the FWC was a category 4.2. For the MAV the expected observed category was 4.0. The FWC actually did a somewhat better job with category 2 than the MAV. The MAV was slightly better with category 3. Categories 4 and 5 were ties.

ALL \ Vsby								
COUNT	**Contingency**		**Observed**					
	FWC Ctgry	**1**	**2**	**3**	**4**	**5**	**Tot Fcst**	**Wtd Avg**
	1	**0**	**5**	**5**	**7**	**22**	**39**	**4.2**
	2	**2**	**2**	**19**	**25**	**25**	**73**	**3.9**
	3	**18**	**19**	**102**	**184**	**463**	**786**	**4.3**
	4	**53**	**24**	**223**	**484**	**1881**	**2665**	**4.5**
	5	**26**	**15**	**61**	**278**	**8632**	**9017**	**4.9**

Table 1. FWC hours of forecast categories and observed hours by visibility category.

All \ Vsby								
COUNT	**Contingency**		**Observed**					
	MAV Ctgry	**1**	**2**	**3**	**4**	**5**	**Fcst**	**Wtd Avg**
	1	**18**	**18**	**38**	**82**	**139**	**295**	**4.0**
	2	**5**	**6**	**59**	**102**	**186**	**358**	**4.3**
	3	**9**	**8**	**59**	**93**	**188**	**357**	**4.2**
	4	**40**	**20**	**158**	**327**	**1098**	**1643**	**4.5**
	5	**27**	**13**	**100**	**377**	**9506**	**10023**	**4.9**

Table 2. MAV number of forecast hours and observed hours by visibility category.

In all forecast visibility categories from the FWC and the MAV, it is clear that categories 4 and 5 will be the most likely outcomes. For that reason, it would be advisable to not depend on either MOS for visibility forecasts.

4. Ceiling Data and Results

Tables 3 and 4 are similar to tables 1 and 2 except they represent ceiling data. It can be seen in the weighted averages in the right column of each table which MOS product performs the best for each category. For category 1, the MAV was best. For categories 2 and 3, the FWC was actually better. The MAV did best in categories 4 and 5, while the FWC is better at category 6. The MAV was better at category 7.

COUNT	Contingency		Observed							
	FWC Ctgry	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Fcst**	**Wtd Avg**
	1	**19**	**20**	**21**	**34**	**3**	**0**	**59**	**156**	**4.4**
	2	**16**	**97**	**148**	**97**	**24**	**15**	**4**	**401**	**3.2**
	3	**39**	**143**	**202**	**290**	**116**	**52**	**105**	**947**	**3.9**
	4	**38**	**120**	**433**	**1331**	**552**	**281**	**634**	**3389**	**4.7**
	5	**9**	**2**	**25**	**141**	**135**	**126**	**340**	**778**	**5.7**
	6	**6**	**0**	**6**	**30**	**47**	**94**	**285**	**468**	**6.3**
	7	**37**	**20**	**69**	**224**	**108**	**80**	**5898**	**6436**	**6.8**

Table 3. FWC number of forecast and observed hours by ceiling category.

COUNT	Contingency		Observed							
	MAV Ctgry	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Fcst**	**Wtd Avg**
	1	**35**	**78**	**87**	**93**	**19**	**8**	**26**	**346**	**3.3**
	2	**12**	**76**	**123**	**135**	**38**	**29**	**9**	**422**	**3.6**
	3	**21**	**93**	**183**	**415**	**187**	**64**	**70**	**1033**	**4.1**
	4	**26**	**99**	**335**	**856**	**285**	**141**	**289**	**2031**	**4.4**
	5	**3**	**8**	**42**	**213**	**226**	**170**	**345**	**1007**	**5.5**
	6	**33**	**8**	**19**	**109**	**111**	**133**	**1770**	**2183**	**6.5**
	7	**30**	**25**	**94**	**313**	**120**	**108**	**4873**	**5563**	**6.6**

Table 4. MAV number of forecast and observed hours by ceiling category.

5. Category Errors for FWC and MAV

Table 5 shows the average visibility category errors for the FWC and MAV MOS guidance and the TAF based on the 5 FWC MOS categories. The forecast period was divided into four 6-hour periods, where the first period covers hours 1 through 6, period 2 covers hours 7 through 12, etc. The table also shows the biases of the different MOS forecasts.

Generally, the MAV MOS outperformed the FWC MOS. However, the FWC did have a lower average absolute error in two periods at FYV (Fayetteville, AR) and in one period at TUL (Tulsa, OK). The TAF average absolute error was included and can be seen to outperform both of the MAV and FWC MOS products in all periods and all TAF sites for visibility.

10/1/2004	through	2/15/2005					
			Abs Errs			**Bias**	
TUL Vsby	**Period**	**FWC**	**MAV**	**TAF**	**FWC**	**MAV**	**TAF**
	1	**0.29**	**0.28**	**0.17**	**-0.14**	**-0.12**	**0.07**
	2	**0.34**	**0.33**	**0.23**	**-0.15**	**-0.13**	**0.02**
	3	**0.35**	**0.36**	**0.26**	**-0.14**	**-0.12**	**0.04**
	4	**0.36**	**0.36**	**0.25**	**-0.11**	**-0.08**	**0.07**
FSM Vsby	**Period**						
	1	**0.34**	**0.32**	**0.18**	**-0.16**	**-0.12**	**0.03**
	2	**0.37**	**0.35**	**0.25**	**-0.19**	**-0.16**	**-0.02**
	3	**0.38**	**0.37**	**0.25**	**-0.19**	**-0.18**	**0.00**
	4	**0.39**	**0.39**	**0.26**	**-0.18**	**-0.17**	**0.02**
MLC Vsby	**Period**						
	Pd 1	**0.28**	**0.24**	**0.16**	**-0.13**	**-0.08**	**0.02**
	2	**0.28**	**0.25**	**0.23**	**-0.15**	**-0.10**	**-0.04**
	3	**0.30**	**0.27**	**0.22**	**-0.14**	**-0.10**	**-0.03**
	4	**0.33**	**0.29**	**0.22**	**-0.14**	**-0.09**	**0.00**
FYV Vsby	**Period**						
	1	**0.31**	**0.29**	**0.17**	**-0.19**	**-0.15**	**0.00**
	2	**0.34**	**0.34**	**0.24**	**-0.21**	**-0.21**	**-0.08**
	3	**0.37**	**0.40**	**0.26**	**-0.21**	**-0.24**	**-0.07**
	4	**0.38**	**0.46**	**0.24**	**-0.20**	**-0.27**	**-0.02**

Table 5. FWC, MAV and TAF average category errors by 6-hour periods for visibility. Period 1 covers the first 6-hours; Period 2 covers hours 7 through 12, etc.

Table 5 also shows the average biases of the FWC, MAV and TAF. Both the FWC and MAV had negative biases for visibility (visibility forecasts too low) in all periods at all TAF sites. However, the MAV negative bias was less than that of the FWC except in periods 2, 3 and 4 at FYV. The TAF bias showed very little bias, with most values between -0.05 and +0.05.

Table 6 shows ceiling verification by category and biases for the FWC and MOS, and includes TAF verification. In this comparison, the MAV MOS outperformed the FWC MOS in all periods at all TAF sites in the Tulsa CWFA. The MAV average absolute error was actually lower than the TAF in 5 of the 16 periods.
Table 6 also shows the average ceiling biases of the FWC. MAV and TAF. The FWC had a negative bias in all periods (ceilings forecast too low), while the MAV generally had very small negative and positive biases. The TAF biases were also generally small and both positive and negative.

10/1/2004	through	2/15/2005					
			Abs Errs			**Bias**	
TUL Ceiling	**Period**	**FWC**	**MAV**	**TAF**	**FWC**	**MAV**	**TAF**
	1	**0.57**	**0.53**	**0.42**	**-0.19**	**-0.02**	**0.03**
	2	**0.62**	**0.59**	**0.58**	**-0.15**	**0.05**	**-0.02**
	3	**0.66**	**0.63**	**0.63**	**-0.13**	**0.09**	**0.00**
	4	**0.70**	**0.67**	**0.67**	**-0.07**	**0.15**	**0.05**
FSM Ceiling	**Period**						
	1	**0.67**	**0.56**	**0.48**	**-0.32**	**-0.08**	**-0.01**
	2	**0.72**	**0.61**	**0.62**	**-0.33**	**-0.07**	**-0.09**
	3	**0.75**	**0.69**	**0.69**	**-0.34**	**-0.08**	**-0.13**
	4	**0.77**	**0.70**	**0.74**	**-0.29**	**-0.02**	**-0.09**
MLC Ceiling	**Period**						
	1	**0.69**	**0.61**	**0.47**	**-0.24**	**-0.02**	**0.02**
	2	**0.69**	**0.61**	**0.63**	**-0.21**	**0.07**	**-0.05**
	3	**0.73**	**0.66**	**0.65**	**-0.20**	**0.09**	**-0.04**
	4	**0.78**	**0.70**	**0.72**	**-0.16**	**0.12**	**0.00**
FYV Ceiling	**Period**						
	1	**0.69**	**0.59**	**0.47**	**-0.34**	**-0.12**	**-0.03**
	2	**0.72**	**0.63**	**0.63**	**-0.35**	**-0.07**	**-0.14**
	3	**0.75**	**0.69**	**0.66**	**-0.35**	**-0.07**	**-0.14**
	4	**0.81**	**0.70**	**0.71**	**-0.31**	**-0.02**	**-0.09**

Table 6. FWC, MAV TAF average category errors by 6-hour periods for ceilings. Period 1 covers the first 6-hours, Period 2 covers hours 7 through 12, etc

6. Conclusion

This objective analysis of ceiling and visibility guidance indicates that the FWC MOS rarely beat the MAV MOS in a direct comparison of average category errors by period. Additionally, the FWC generally had a larger negative bias for both ceiling and visibility forecasts. Based on this data, it appears the FWC MOS provides little or no significant guidance of value that is not available from the MAV MOS.

Similar studies can be conducted for different time periods or seasons to test the seasonality of the FWC and/or MAV MOS guidances. Also, the TAFTrack verification program can be used to help forecasters identify any individual biases they might have.