Winter 2008 PoP Verification Study

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Introduction

In this study we utilized BoiVerify2.0 to assess our Official forecast, several models sources and in particular the Short-Range Ensemble Forecasts (SREF). We looked at the forecast reliability of the Official forecast and SREF for the period of January 1, 2008 through February 29, 2008 for the entire County and Warning Forecast Area (CWFA), elevations above 7000 feet, and the desert elevations below 3000 feet. We then analyzed the bias in the Official PoP forecast as well as for a variety of numerical guidance. We focused on three significant precipitation events during January and February of 2008. QPF statistics were not included due to problems in the QPE analysis. A brief synoptic overview for each of the precipitation events in included below.

Synoptic Situation for Three Precipitation Events

January 4-6, 2008

A widespread area of heavy precipitation moved into the southern Sierra Nevada on January 4th and spread across the CWFA on January 5th. At 00Z, on January 5th, 2008, two jet streaks at 300mb, one located over northern California (140 kt) and the second (125+ kt) impinging on the central California coast can be seen in Figure 1. Central California was ideally situated in the right entrance region of the first jet and the left exit region of the second jet, which substantially enhanced vertical motion and upper level divergence. The system had a significant tap of sub-tropical moisture with precipitable water values of 1.0-1.5 inches (not shown) and 700mb dewpoint temperatures of 4-6°C as depicted in Fig. 3. The overall system shifted slowly to the south across the CWFA over the course of the next 24 hours. Strong flow across the Sierra (Fig. 2 and Fig. 3) enabled heavy precipitation to occur in many of the normally "rain shadowed" locations, including Bishop, CA, which received 4.00 inches (the wettest day on record). The vast majority of the CWFA received precipitation from this event. Desert locations on average received less than 0.25 of an inch of precipitation with significantly higher amounts across Inyo (CA) , Esmeralda (NV), Nye (NV) and Mohave (AZ) counties (1.0-2.0+ inches of liquid equivalent).

January 26-28, 2008

The second event began on January 26th and continued into January 28th. At 00Z on the 28th the upper level jet max (120+ kts) at 250mb was located along the southern California coast (Fig. 4.) The system also had a significant tap of the sub-tropical moisture, tracked further south then the previous event and provided more of a significant

impact to the desert locations. Precipitable water values exceeded one inch (not shown) and 700mb dewpoint temperatures of 2-4°C reached into the southern portions of the CWFA (Fig. 5). Rainfall totals averaged 0.50-1.00 across much of the lower deserts with many of the higher elevations receiving 1.00-2.00 inches of liquid equivalent.

February 2-4, 2008

The third event took more of an inland trajectory, which does not typically allow for the injection of substantial moisture. This held true for this event. At 12Z on February 3rd, a vigorous 150+ knot jet (Fig. 6) was moving down the west coast and into central California with upper level divergence maximized across the northern portions of the CWFA. Locations received on average 0.25-0.50 inches of precipitation with the exception of the low desert regions where values were much lower and a few higher elevations sites which received in excess of 1.00 inch of precipitation.

Short-Range Ensemble Forecasts (SREF) and Official Forecast Reliability

Due to computer resource limitations, Probability of Precipitation (PoP) forecast reliability statistics were calculated for only the Official database and the SREF for the period of January 1st, 2008 through February 29th, 2008. These statistics were calculated for three regions: the entire forecast area, elevations above 7000 feet and elevations below 3000 feet.

Official Forecast

The forecast reliability statistics for the entire forecast area were quite uniform for each percentile throughout the forecast period, only varying by a few percent between 12-hr, 36-hr, 60-hr and 84-hr forecasts (Table 1). The difference in the reliability when 10% or 100% was forecast was negligible. When a PoP of 30% was forecast, precipitation was observed 45% (±1%) of the time. When 70% was forecast, precipitation was observed 97% (±2%) of the time. The largest difference between the forecast and observed PoP values occurred between PoP forecasts of 35% and 75%, where differences exceeded 20% (Fig. 7).

Forecast reliability statistics were also generated for elevations above 7000 feet and below 3000 feet. Differences between forecast and observed were reduced at both the higher elevations and the lower elevations for PoP forecasts of 70%. When a PoP of 70% was forecast for elevations above 7000 feet precipitation was observed 77% (±1%) of time and when a PoP of 70% was forecast below 3000 feet precipitation was observed 84% (±7%) of the time. Just prior to the start of 2008, the operational staff increased their use of climatological PoPs and transitioned to a continuous PoP field. It is conjectured that both of these changes provided an increase in the accuracy of the PoP forecasts for the higher elevations. The lowest reliability in the Official forecast of PoP occurs in the elevations below 3000 feet for a forecast PoP of 30%. The difference is largest at the shortest lead times (precipitation is observed 60% of the time with a PoP forecast of 30% at forecast hour 12).

SREF

The results of the forecast reliability for the SREF at 9-hr, 33-hr, 57-hr, and 81-hr forecasts indicated an overestimation of PoP in forecasts of 30% or higher for all lead times (Table 1). When the SREF predicted a PoP of 30%, precipitation was observed 22% (±4%) of the time. When the SREF indicated a PoP of 70%, precipitation was observed 43% (±3%) of the time. For those instances when the SREF predicted a PoP of 100%, precipitation was observed 83% (±6%) of the time. Although there were some differences in the statistics at elevations above 7000 feet and below 3000 feet, the overall high bias in PoP was consistent. Systemically, the SREF produces an overestimate in PoP by 15-20%.

Although in a quantitative sense, the SREF statistics had relatively large errors, the results can still be applied to forecast operations to aid in reducing forecasts errors in PoP.

PoP Bias in the Official Forecast and Several Model Sources

The methodology used to produce the Official PoP forecasts changed during the second half of December, 2007. The new methodology utilizes a grid-based climatological PoP, particularly in the extended portion of the forecast. A "continuous" PoP was also implemented as part of the new methodology, where gradients of PoP are in increments of one, rather than by increments of ten or higher, producing a smoother more meteorologically correct field. Bias statistics were calculated for five events, two precipitation events (Nov. 30-Dec. 1 and Dec. 7-8, 2007) prior to the change in methodology (Fig. 8) and three events (January 4-6, January 26-28 and February 2-4) following implementation of the new PoP methodology (Fig. 9). Statistics from the three events forecast with the new methodology indicated an overall reduction in bias at all lead times and the bias remained near zero through 84 hours. This significant reduction in the bias of the Official forecast of PoP is at least partially due to the changes in the PoP methodology.

The PoP forecast bias was calculated for several models sources for each of the three events in January and February and their cumulative results are depicted in Fig. 9 and Table 2. The cumulative results indicate biases that were found in each of the events individually. Additionally, bias statistics were calculated for elevations above 7000 feet (Fig. 10) and below 3000 feet (Fig. 11). A brief summary of these bias statistics are listed below:

- The ECMWF, GFS and the Official had the smallest bias
- The NAM had the largest bias (~20% too low), particularly at elevations above 7000 feet
- The SREF had a large bias (15-20% too high)
- The ADJMAV/ADJMEX had a large bias (10-20% too low), particularly at elevations above 7000 feet
- The Official forecast had a small low bias at all lead times and elevations

- The Official forecast had slightly higher bias at elevations above 7000 feet
- The bias in the GFS drifted to higher, positive values between forecast hours 84 and 120 hours.

The ECMWF and the GFS showed very minor differences when separating out elevations below 3000 feet and above 7000 feet, most likely due to their lower resolution and coarser topography.

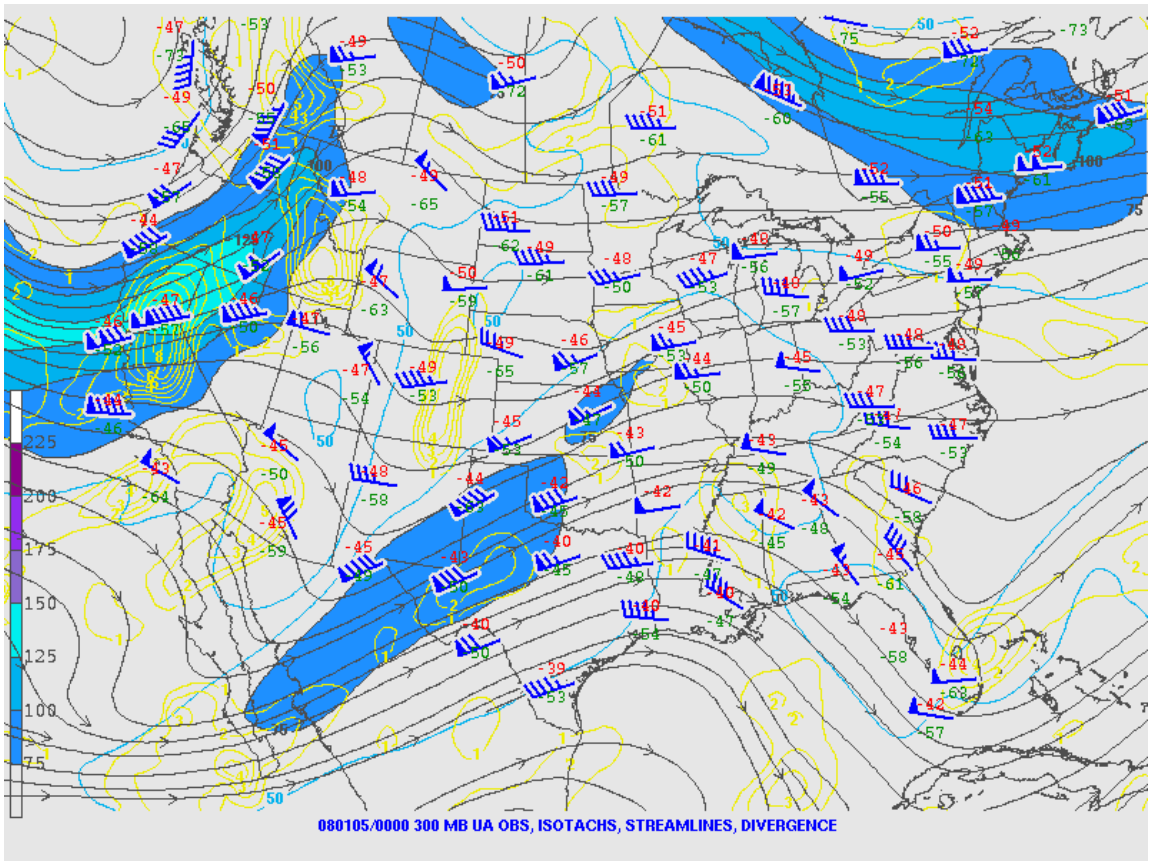

Figure 1. 300mb analysis of wind, streamlines, divergence (yellow lines) and temperature (blue lines) for 00Z January 5, 2008.

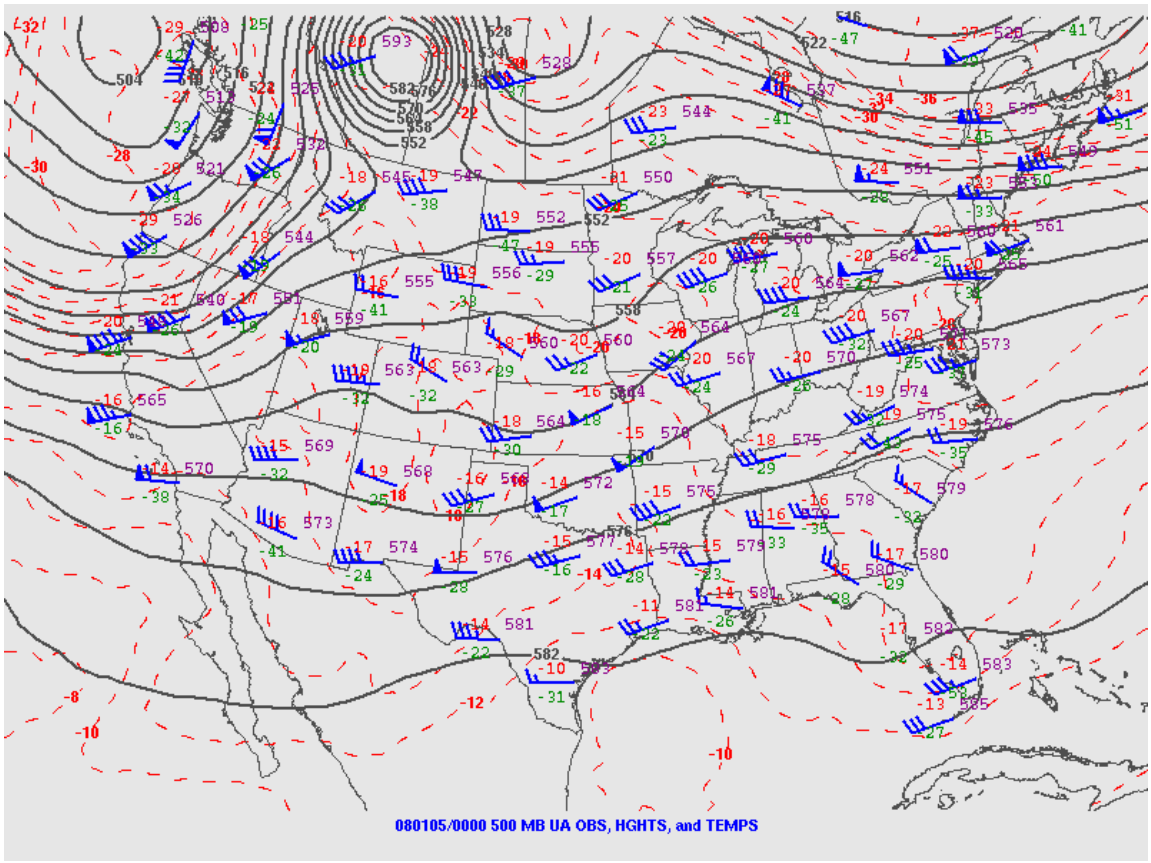

Figure 2. 500mb analysis of wind, heights and temperature (red dashed lines) for 00Z January 5, 2008.

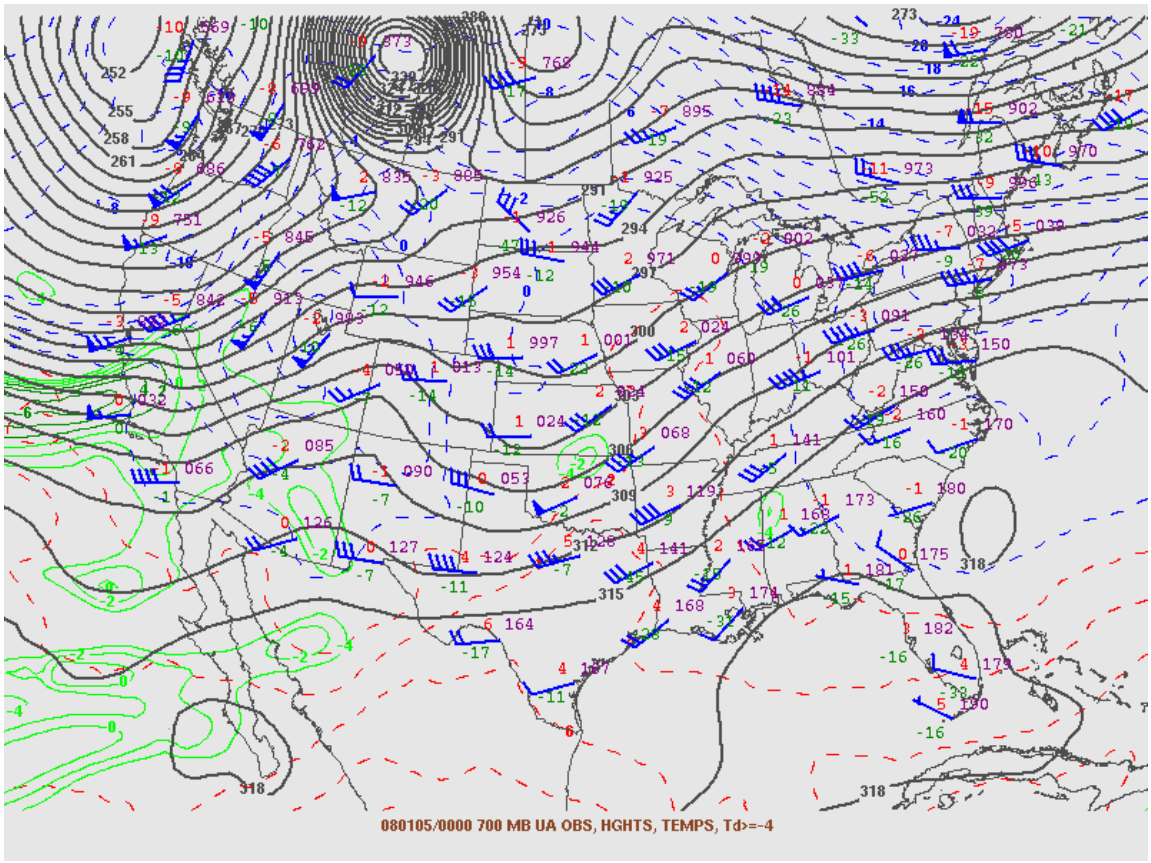

Figure 3. 700mb analysis of wind, heights, temperature (red and blue dashed lines) and dewpoint (green lines) for 00Z January 5, 2008.

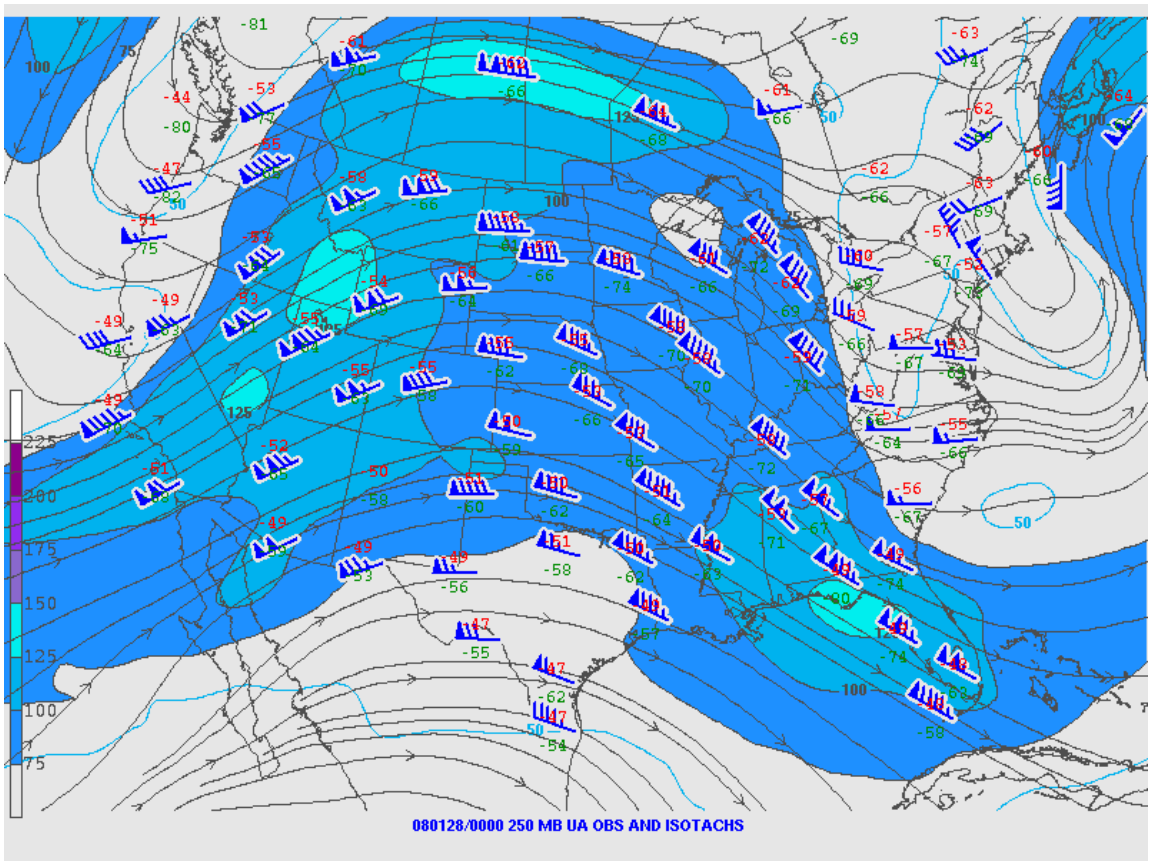

Figure 4. 250mb analysis of wind, streamlines and temperature (blue lines) 00Z January 28, 2008.

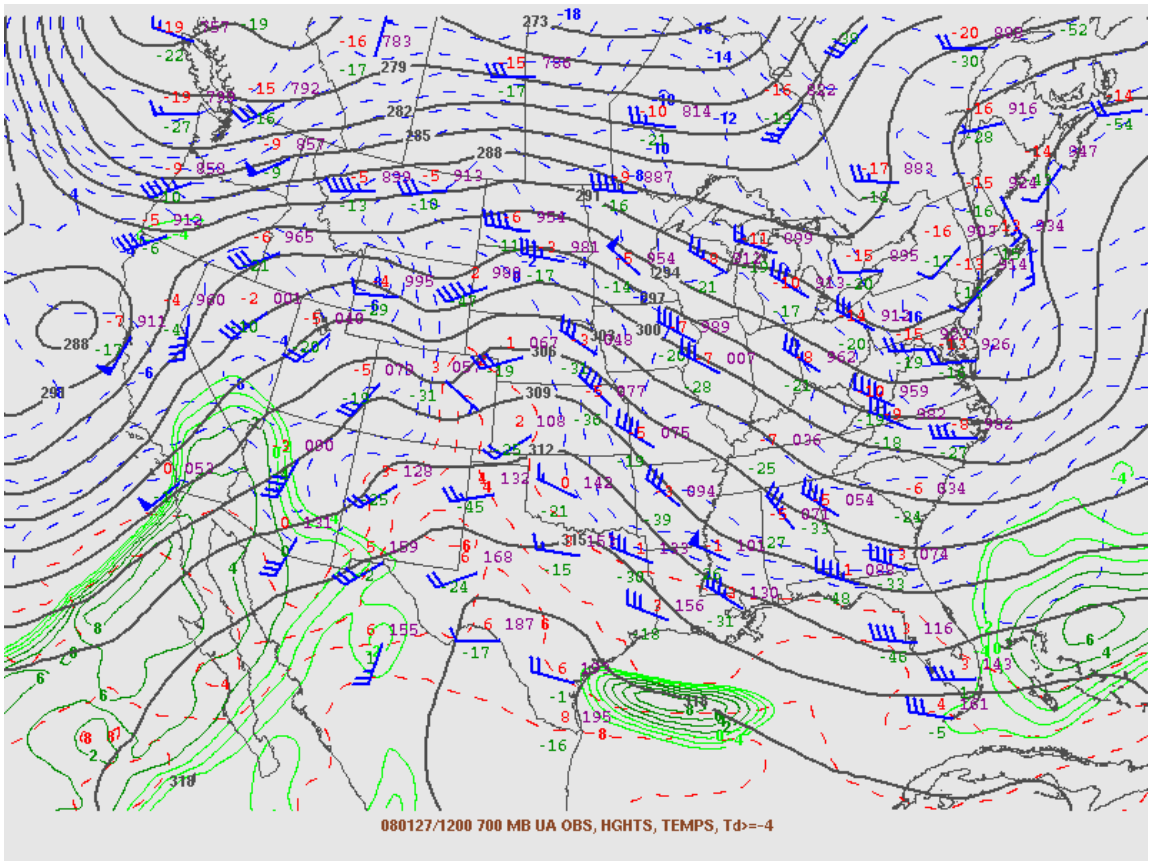

Figure 5. 700 mb analysis of wind, heights, temperature (red and blue dashed lines) and dewpoint (green lines) for 12Z January 27, 2008.

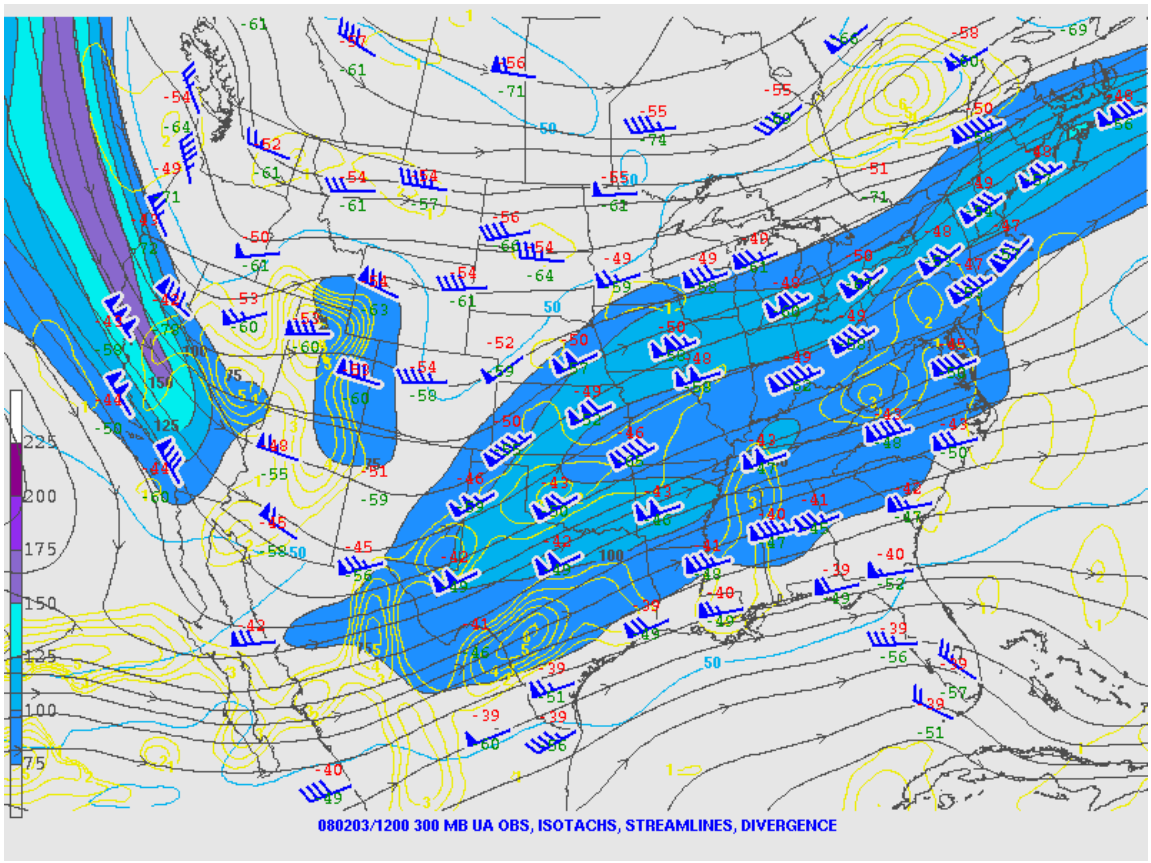

Figure 6. 300 mb analysis of wind, streamlines, divergence (yellow lines) and temperature (blue lines) for 12Z February 3, 2008

PoP Forecast Reliability

Jan 1 – Feb 29, 2007

Official

ALL

12-hr		36-hr		60-hr		84-hr	
F	O	F	O	F	O	F	O
100%	98	100%	##	100%	100	100%	100
70%	95	70%	97	70%	98	70%	96
30%	45	30%	44	30%	46	30%	45
10%	5	10%	8	10%	13	10%	13

> 7000 KFT AGL

12-hr		36-hr		60-hr		84-hr	
F	O	F	O	F	O	F	O
100%	98	100%	98	100%	100	100%	100
70%	78	70%	76	70%	77	70%	77
30%	40	30%	46	30%	52	30%	51
10%	10	10%	12	10%	16	10%	17

< 3000 KFT AGL

12-hr		36-hr		60-hr		84-hr	
F	O	F	O	F	O	F	O
100%	83	100%	83	100%	100	100%	n/a
70%	80	70%	77	70%	90	70%	88
30%	60	30%	58	30%	56	30%	53
10%	6	10%	9	10%	12	10%	12

SREF

ALL

9-hr		33-hr		57-hr		81-hr	
F	O	F	O	F	O	F	O
100%	83	100%	87	100%	86	100%	77
70%	44	70%	44	70%	43	70%	40
30%	20	30%	17	0%	26	30%	24
10%	7	10%	7	10%	8	10%	9

> 7000 KFT AGL

9-hr		33-hr		57-hr		81-hr	
F	O	F	O	F	O	F	O
100%	86	100%	88	100%	88	100%	78
70%	43	70%	45	70%	48	70%	50
30%	20	30%	20	30%	27	30%	32
10%	6	10%	7	10%	7	10%	12

< 3000 KFT AGL

9-hr		33-hr		57-hr		81-hr	
F	O	F	O	F	O	F	O
100%	84	100%	85	100%	89	100%	88
70%	55	70%	59	70%	48	70%	40
30%	28	30%	23	30%	37	30%	27
10%	7	10%	7	10%	14	10%	13

Table 1. Official Forecast and Short Range Ensemble Forecast (SREF) reliability statistics for the period Jan 1 – Feb. 29, 2008. Statistics were calculated for all grid boxes, elevations above 7000 feet, and elevations below 3000 feet.

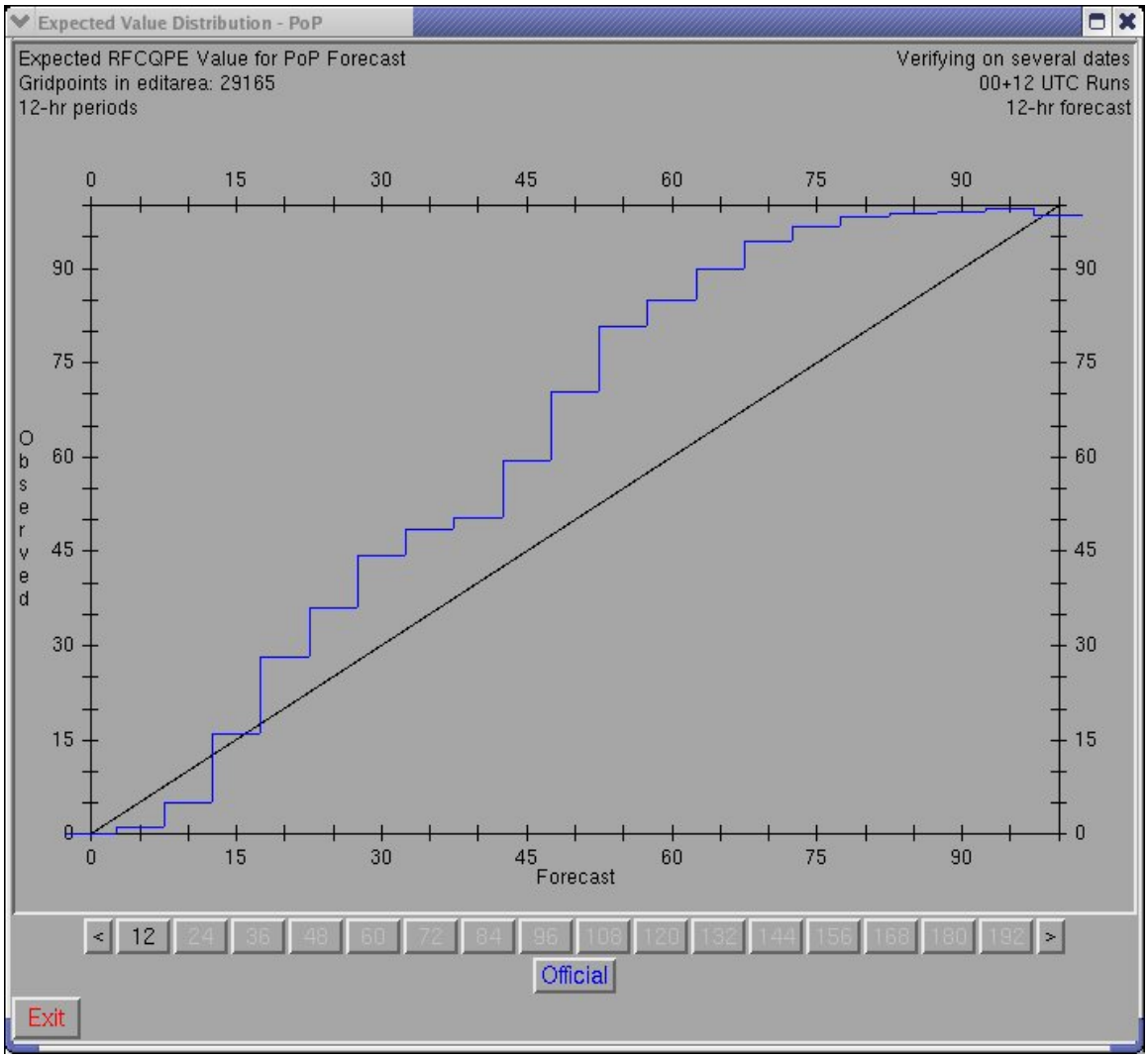

Figure 7. Forecast reliability plot of the Official forecast database for January 1, 2008 through February 29, 2008.

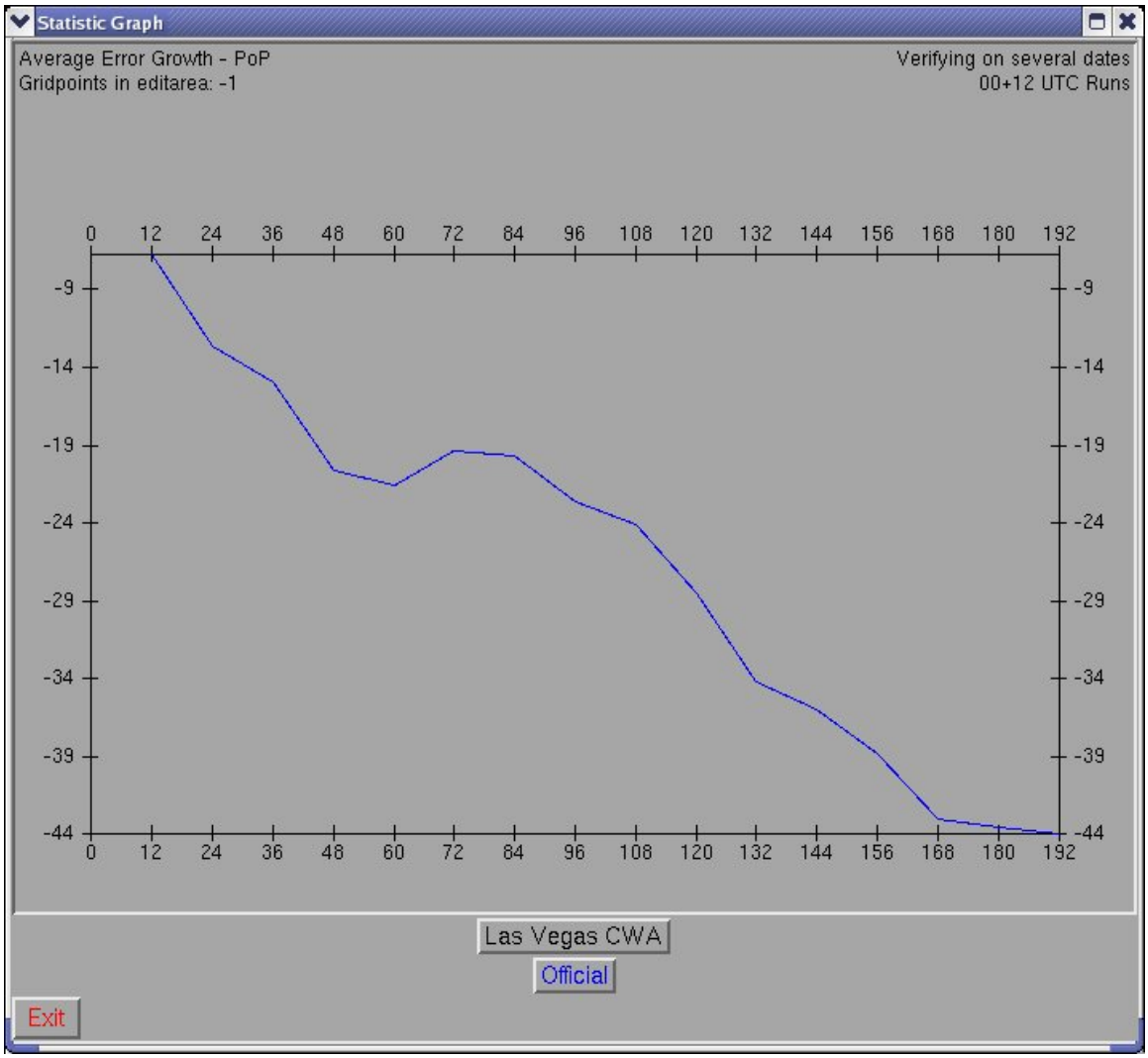

Figure 8. Bias (y-axis) in the Official forecast of PoP for two precipitation events (Nov. 30-Dec. 1 and Dec. 7-8, 2007) via forecast hours (x-axis).

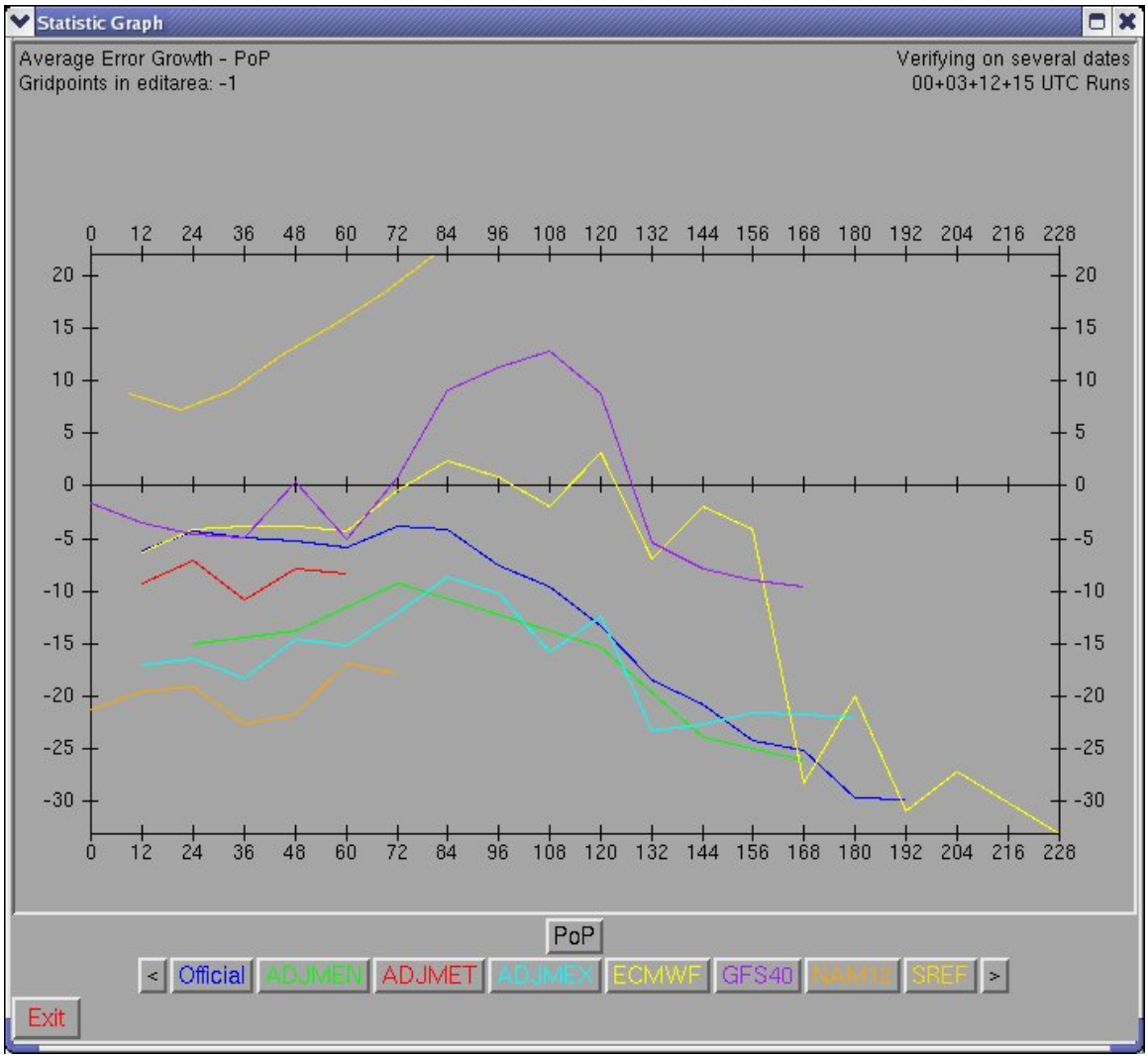

Figure 9. Bias in the Official, ADJMEN, ADJMET, ADJMEX, ECMWF, GFS40, NAM12 and SREF PoP forecast for three precipitation events (Jan. 4-6, Jan 26-28, and Feb. 2-4, 2008).

SREF	ALL	> 7 KFT	< 3 KFT
9-hr	8	9	7
33-hr	10	11	9
57-hr	16	13	16
81-hr	22	17	20

Official	ALL	> 7 KFT	< 3 KFT
12-hr	-6	-5	-6
36-hr	-5	-6	-4
60-hr	-5	-6	-5
84-hr	-4	-5	-3
108-hr	-7	-12	-9
132-hr	-18	-25	-15
156-hr	-24	-34	-20

NAM12	ALL	> 7 KFT	< 3 KFT
12-hr	-20	-25	-18
36-hr	-23	-27	-21
60-hr	-17	-22	-17

GFS	ALL	> 7 KFT	< 3 KFT
12-hr	-4	-5	-6
36-hr	-4	1	-8
60-hr	-4	0	-10
84-hr	10	8	2
108-hr	13	8	7
132-hr	-5	-8	-8
156-hr	-7	-17	-15

ECMWF	ALL	> 7 KFT	< 3 KFT
12-hr	-6	-3	-3
36-hr	-4	-1	0
60-hr	-4	0	-2
84-hr	2	7	5
108-hr	-2	0	1
132-hr	-6	-7	-3
156-hr	-11	-2	-1

ADJMEX	ALL	> 7 KFT	< 3 KFT
12-hr	-17	-21	-15
36-hr	-18	-22	-15
60-hr	-15	-15	-14
84-hr	-9	-13	-9
108-hr	-15	-23	-14
132-hr	-23	-32	-21
156-hr	-22	-32	-20

Table 2. PoP forecast Bias from Official forecast, SREF, NAM12, ECMWF, GFS and ADJMEX for three precipitation events (Jan. 4-6, Jan. 26-28 and Feb. 2-4, 2008).

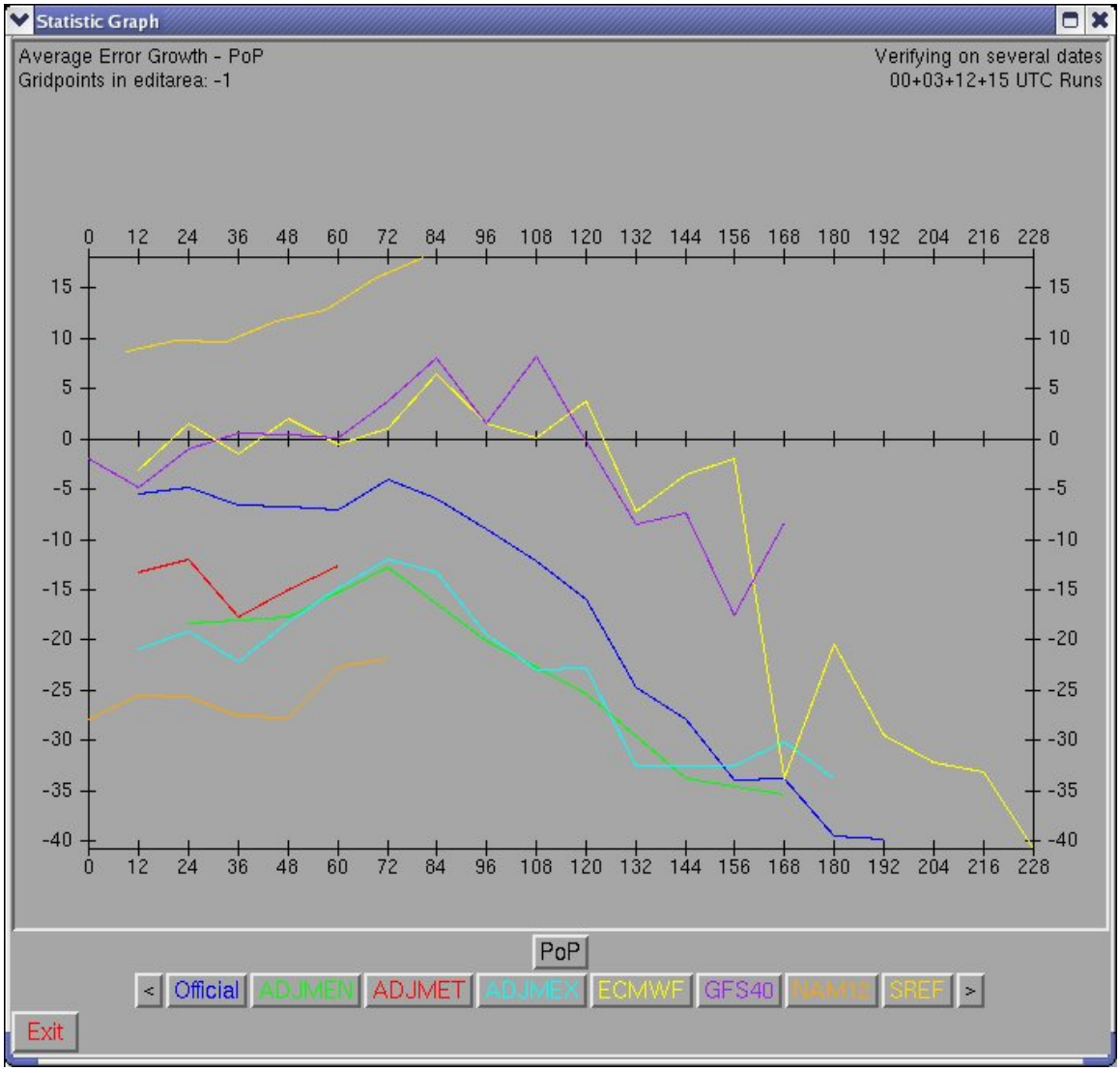

Figure 10. Bias in the Official, ADJMEN, ADJMET, ADJMEX, ECMWF, GFS40, NAM12 and SREF PoP forecast for elevations above 7000 feet for three precipitation events (Jan. 4-6, Jan 26-28, and Feb. 2-4, 2008).

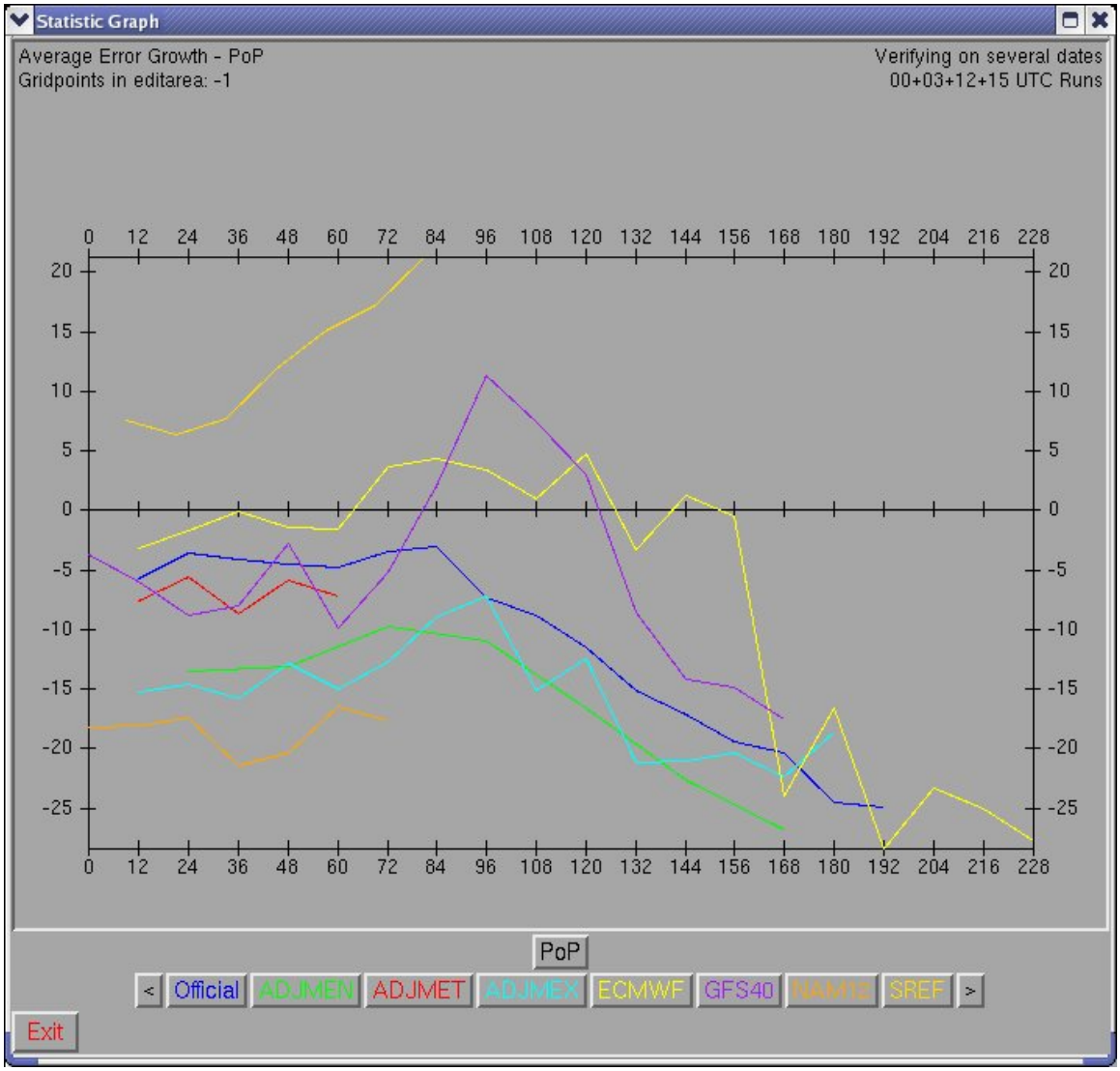

Figure 11. Bias in the Official, ADJMEN, ADJMET, ADJMEX, ECMWF, GFS40, NAM12 and SREF PoP forecast fore elevations below 3000 feet for three precipitation events (Jan. 4-6, Jan 26-28, and Feb. 2-4, 2008).