Using Analogs as Medium Range Guidance for a Heavy Snow Event

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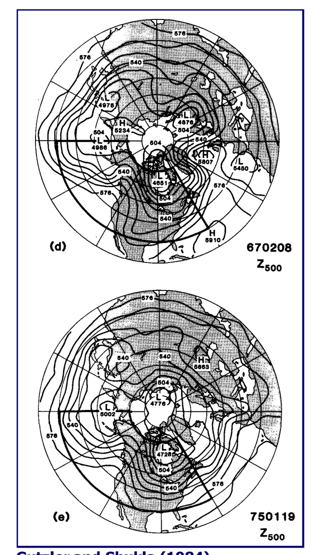
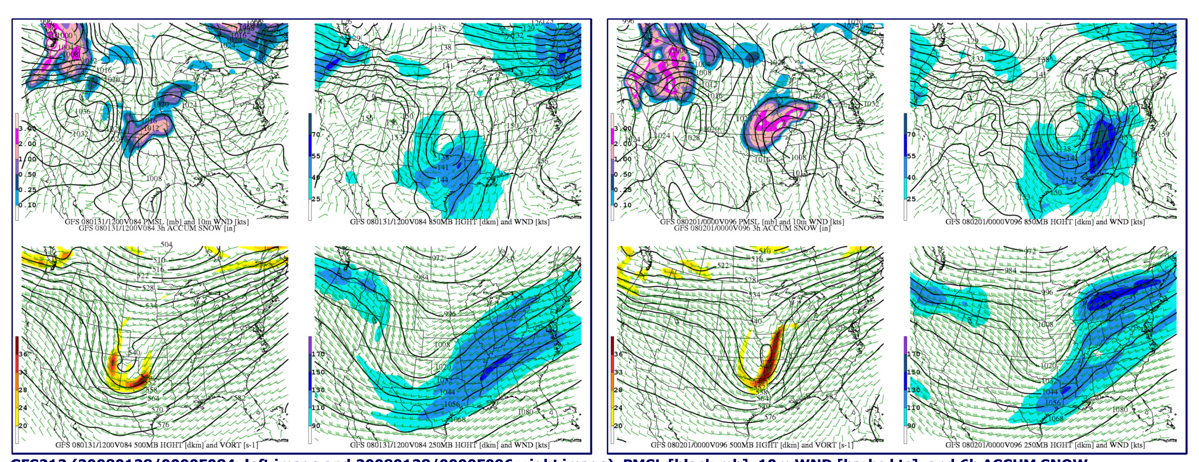
Introduction

- A blend of knowledge and experience is critical for effective interpretation of model output. Yet even seasoned forecasters sometimes fail to recognize significant weather events due to (over)reliance on model Quantitative Precipitation Forecast (QPF) values and less attention paid to the causative factors.
- Composite analysis and forecast analogs ("perfect prog" approach) can assist with this problem because weather events have quasi-repeatable atmospheric fields and results.
- Previous research such as Klein (1971), Gutzler and Shukla (1984), Vislocky and Young (1989), Roebber and Bosart (1998), and more recently Root et al. (2007) determined methods to identify analogs and found varying degrees of forecast applicability.
- The "perfect prog" approach, which is utilized in this research, has two weaknesses: the uncertainty that is inherent with NWP model forecasts (which this methodology depends on for pattern recognition skill) and the model biases that are coupled with deterministic NWP (Vislocky and Young 1989).
- Regardless, by utilizing forecast analogs in the medium range (HWO phase), a forecaster can gain historical experience and become familiar with the meteorological patterns associated with an event.

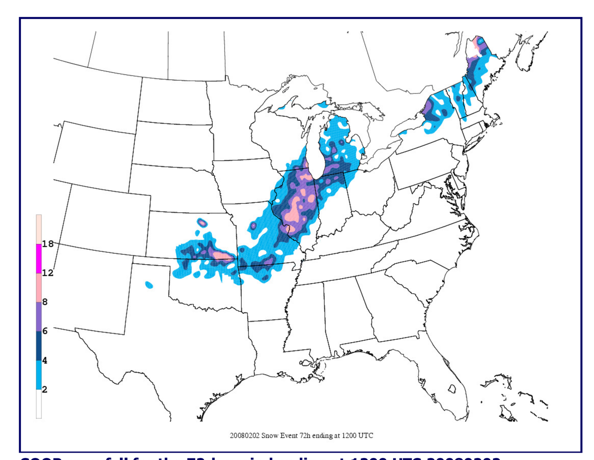


Gutzler and Shukla (1984)

The Baseline Case



GFS212 (20080128/0000F084: left image and 20080128/0000F096: right image) PMSL [black,mb], 10m WND [barbs,kts], and 6h ACCUM SNOW [shaded,in,13:1] (top left); 850-hPa HGHT [black,dm], ISOTACHS [shaded,kts], and WND [barbs,kts] (top right); 500-hPa HGHT [black,dm], WND [barbs,kts], and ABS VORTICITY [shaded,s-1] (bottom left); 250-hPa HGHT [black,dm], ISOTACHS [shaded,kts], and WND [barbs,kts] (bottom right).



COOP snowfall for the 72-h period ending at 1200 UTC 20080202.

- Winter storm affected the CONUS east of the Rocky Mountains from 31 January through 2 February 2008.
- Band of >2" snow fell from Kansas/Oklahoma east into the mid-Mississippi Valley and northeast into the Great Lakes region. An axis of >6" snow fell from STL (00Z-12Z 1 February 2008) northeastward into lower Michigan.
- Event was relatively well forecast 3-5 days out. Deterministic models had both good agreement in mass fields and considerable run-to-run consistency.

- The GFS212 20080128/0000F096 was compared against 20,160 potential analogs.
- After the thresholds were applied: 387 potential analogs
- After "duplicate" times were removed: 187 analogs
- 25 out of 30 SW/NE oriented STL heavy snow cases were included within the 187 analogs.

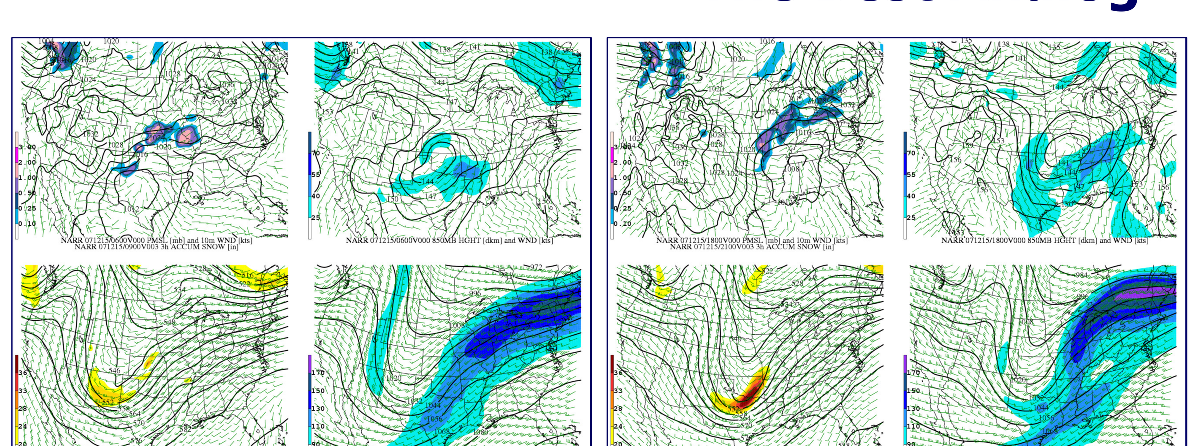
DATE	H300cor	H500cor	H850cor	T850cor	T850mae	F850cor	TA850cor	F700cor	T2cor	T2mae	PMSLcor	PWTRcor	f096TOTAL	f084TOTAL	f108TOTAL	AVG
20080201/0000	0.996	0.994	0.820	0.969	1.1	0.098	0.412	0.275	0.943	2.9	0.919	0.963	8.615	9.036	9.269	8.973
20071215/1800	0.954	0.951	0.865	0.938	2.0	0.359	0.594	0.011	0.943	3.2	0.946	0.865	8.369	7.411	5.923	7.234
20031214/0000	0.967	0.967	0.741	0.865	2.9	0.191	0.478	-0.038	0.937	1.9	0.754	0.934	7.432	7.397	6.381	7.070
20001214/0000	0.965	0.969	0.754	0.879	3.1	0.412	0.555	0.312	0.918	4.3	0.962	0.945	7.674	6.573	5.439	6.562
19871215/0600	0.920	0.891	0.879	0.900	3.4	0.112	0.409	0.459	0.920	2.3	0.867	0.903	7.985	5.488	5.587	6.353
19870119/0600	0.983	0.972	0.745	0.908	2.2	0.122	0.430	0.242	0.920	3.4	0.845	0.933	7.568	3.399	7.963	6.310
20021224/1800	0.917	0.905	0.709	0.967	1.3	0.000	0.544	0.083	0.949	1.6	0.856	0.935	8.172	4.033	6.438	6.215
19930226/0000	0.913	0.891	0.792	0.830	3.4	0.317	0.463	0.123	0.847	3.7	0.888	0.852	7.021	7.463	3.363	5.949
19990102/1200	0.969	0.949	0.893	0.862	4.2	-0.093	0.431	0.021	0.943	4.3	0.940	0.773	6.581	7.693	3.457	5.910
19970109/0600	0.948	0.949	0.872	0.888	2.5	-0.027	0.499	-0.023	0.839	3.7	0.812	0.932	7.178	4.775	5.722	5.892
19950107/0000	0.977	0.955	0.224	0.887	3.1	0.013	0.236	0.056	0.881	2.3	0.577	0.907	4.938	6.161	6.248	5.783
19911203/0000	0.949	0.963	0.483	0.934	3.5	0.075	0.276	-0.075	0.940	2.7	0.797	0.924	5.962	5.423	5.409	5.598
19890221/0000	0.979	0.964	0.458	0.834	4.3	0.112	0.082	0.169	0.894	4.6	0.769	0.839	4.818	7.169	4.711	5.566
20020119/1200	0.932	0.937	0.104	0.789	3.3	0.239	0.183	-0.054	0.911	2.3	0.673	0.742	4.470	6.715	5.337	5.507
19920114/0000	0.978	0.964	0.421	0.936	2.1	-0.086	0.436	-0.090	0.950	3.6	0.781	0.896	5.909	3.242	7.192	5.448
19860206/1800	0.950	0.934	0.895	0.903	3.3	0.107	0.413	-0.129	0.943	5.5	0.955	0.714	6.497	5.264	4.569	5.443
20071228/1200	0.933	0.888	0.371	0.899	2.7	0.017	0.231	-0.225	0.896	2.4	0.821	0.811	5.505	6.292	4.423	5.407
19820212/1800	0.942	0.923	0.019	0.826	3.0	0.003	0.257	0.046	0.921	2.6	0.757	0.753	4.375	5.870	5.720	5.322
19831204/0000	0.973	0.966	0.668	0.925	6.7	0.296	0.467	0.104	0.948	4.0	0.961	0.913	5.951	4.551	5.356	5.286
19971114/0000	0.912	0.876	0.716	0.863	2.9	0.129	0.379	0.126	0.889	4.3	0.776	0.834	6.308	6.400	3.088	5.265
20070122/0000	0.912	0.895	0.021	0.847	2.6	-0.183	0.122	-0.067	0.933	2.6	0.608	0.828	3.833	6.173	5.777	5.261
20000214/0000	0.964	0.965	0.380	0.806	4.3	0.355	0.221	0.148	0.916	6.4	0.867	0.885	4.567	5.885	5.294	5.249
19940309/1800	0.953	0.943	0.287	0.950	2.2	0.216	0.649	-0.118	0.742	4.0	0.726	0.913	5.494	4.260	5.899	5.218
19850110/1800	0.905	0.874	0.402	0.827	5.3	-0.104	0.346	-0.031	0.941	2.0	0.884	0.908	5.207	6.831	3.504	5.180
19960126/1800	0.964	0.951	0.307	0.788	4.4	0.008	0.367	-0.067	0.803	4.3	0.415	0.870	3.535	7.467	4.525	5.176
20021204/1800	0.940	0.893	0.361	0.784	3.9	0.196	0.239	-0.054	0.888	2.3	0.747	0.742	5.138	7.873	2.098	5.037
19831206/0600	0.968	0.970	0.180	0.913	3.5	0.104	0.389	0.063	0.907	3.4	0.565	0.930	4.614	2.562	7.621	4.932
19930216/1200	0.966	0.963	0.516	0.815	4.7	-0.169	0.177	0.061	0.948	3.7	0.702	0.926	4.839	6.042	3.778	4.886
20020302/1200	0.942	0.922	0.390	0.754	4.9	-0.131	0.308	-0.086	0.845	3.1	0.739	0.732	4.267	7.383	2.965	4.872
20000311/1200	0.953	0.941	0.481	0.952	1.5	-0.013	0.445	0.257	0.949	2.9	0.829	0.928	7.046	3.352	4.109	4.836
20070213/1800	0.964	0.929	0.653	0.881	3.6	0.030	0.354	0.077	0.965	3.1	0.899	0.798	6.522	6.238	1.704	4.821

In STL Heavy Snow Climo

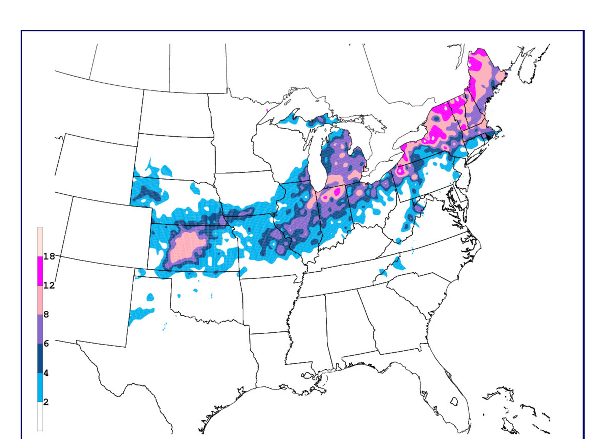
Heavy Snow Occurs

Heavy Snow Does Not Occur

The Best Analog



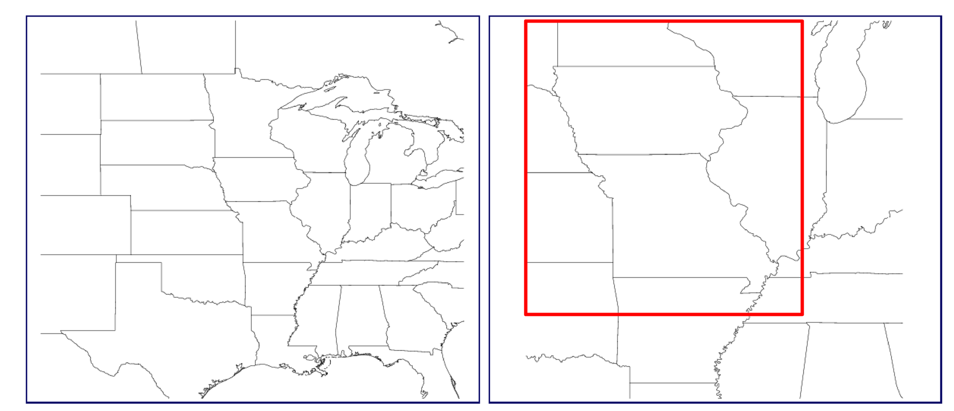
NARR (20071215/0600: left image and 20071215/1800: right image) PMSL [black,mb], 10m WND [barbs,kts], and 3h ACCUM SNOW [shaded,in,13:1] (top left); NARR 850-hPa HGHT [black,dm], ISOTACHS [shaded,kts], and WND [barbs,kts] (top right); NARR 500-hPa HGHT [black,dm], WND [barbs,kts], and ABS VORTICITY [shaded,s-1] (bottom left); NARR 250-hPa HGHT [black,dm], ISOTACHS [shaded,kts], and WND [barbs,kts] (bottom right).



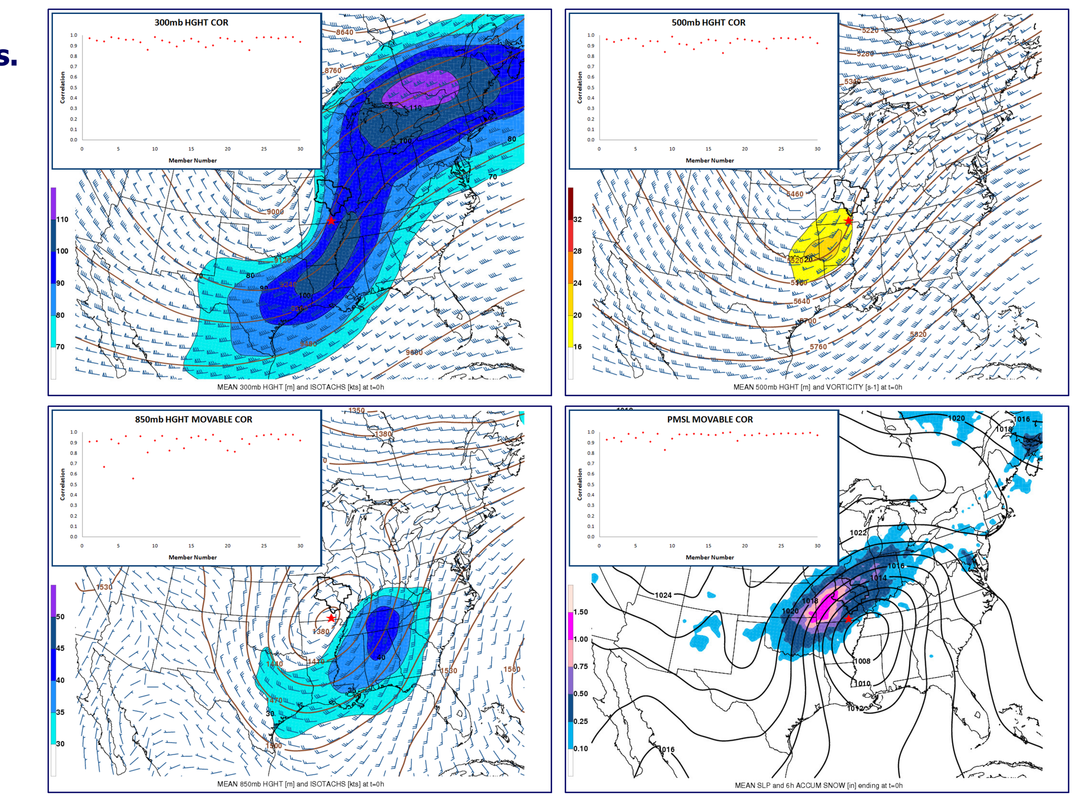
COOP snowfall for the 96-h period ending at 1200 UTC 20071217.

Methodology

- Search the 28-yr North American Regional Reanalysis (NARR) dataset against the model forecast (GFS212) for potential analogs.
  - ± 3 months from the date of the forecast
  - 6 h temporal resolution
  - 20,160 potential analogs
- During the first pass through the NARR dataset, statistics are computed on the following domains. If certain thresholds are exceeded, the date/time is considered a potential analog.



- The values of the thresholds were determined by utilizing using a heavy snow climatology (≥6") that was developed in the LSXCWA (at this conference, see Gosselin et al. 2008).



- To reduce the 20,160 potential analogs, threshold values were determined based on the control run for the following fields:

300 HGHT COR on REGN: 0.85	850 TMPC MMAE on MESO: 3.8
500 HGHT COR on REGN: 0.83	PMSL MCOR on MESO: 0.83
850 TMPC MCOR on MESO: 0.88	850 HGHT MCOR on MESO: 0.60

- Once the 20,160 potential analogs are reduced, "duplicate" times are removed. "Duplicate" times occur due to the variability in system speed (e.g., a slow historical system may exhibit similar patterns to the forecast over a longer period of time).
- Therefore, the best analog is found over a 24-h period by using the following formula:

SUM(COR) - SUM(MAE/20)

- After the number of potential analogs are reduced, the analysis is rerun to find statistics on the following variables:

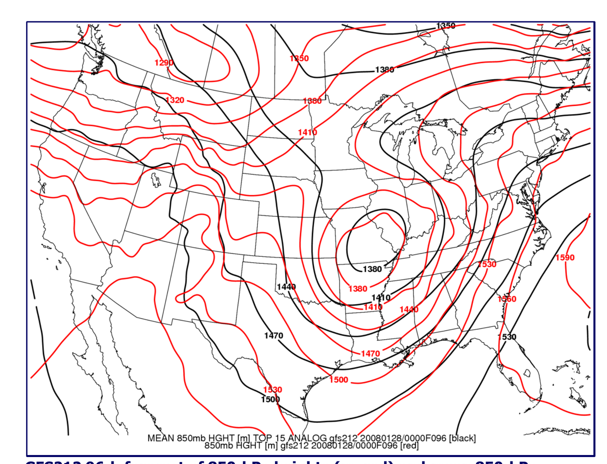
300 HGHT COR REGN	850 FRNT COR MESO
500 HGHT COR REGN	850 THTEADV COR MESO
700 FRNT COR REGN	2m TMPC MAE MESO
850 HGHT COR MESO	PMSL COR MESO
850 TMPC COR MESO	PWTR COR MESO
850 TMPC MAE MESO	

- After new statistics are determined, a score is computed using the following formula:

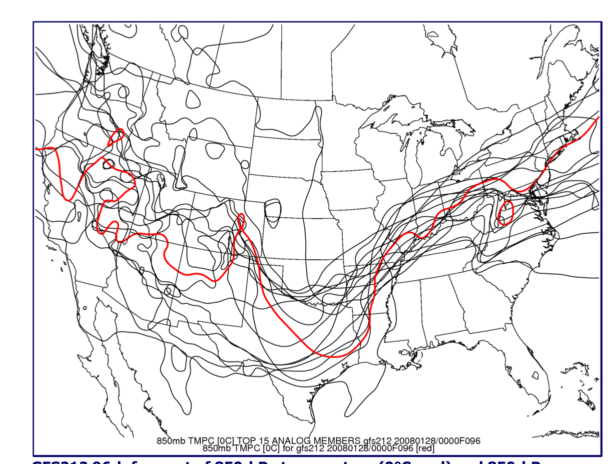
850HGHTCOR*3 + PMSLCOR*2 + SUM(COR) - SUM(MAE/3)

- Finally, in order to catch possible system direction, statistics are computed for ±12h from the time of the best analog using the matching forecast. The final analog rank is determined by averaging all three results scores (e.g., F084, F096, F108).

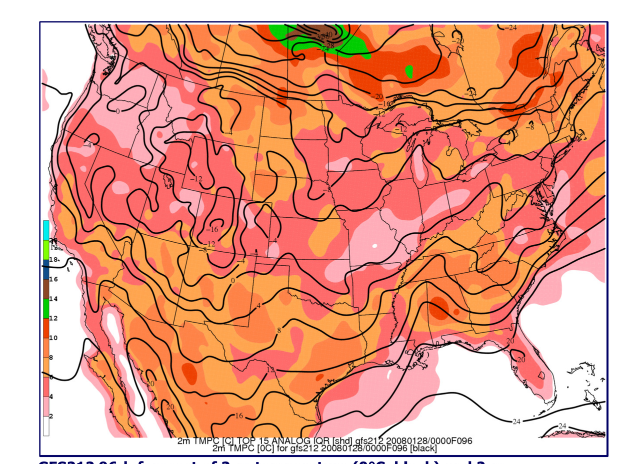
Samples of Measures of Center and Spread Guidance



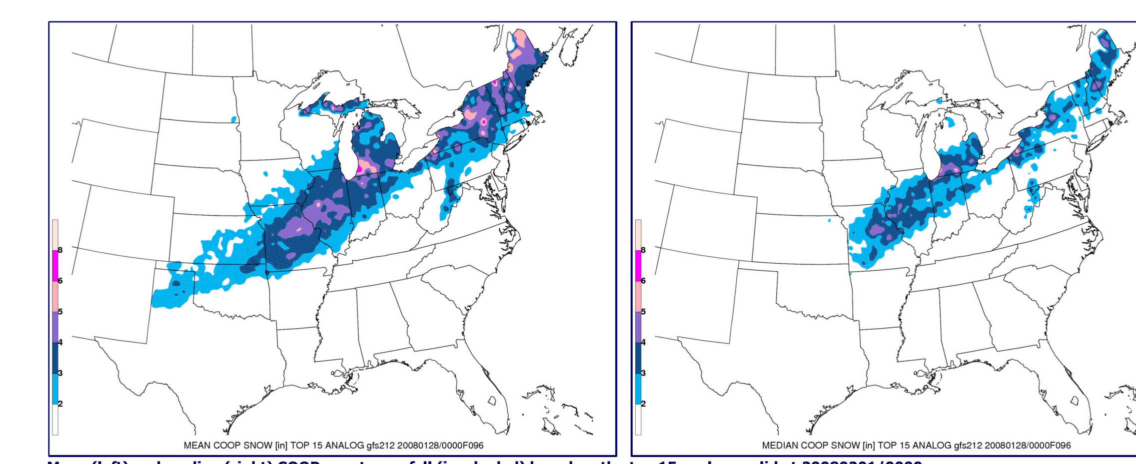
GFS212 96-h forecast of 850-hPa heights (m, red) and mean 850-hPa heights (m, black) based on the top 15 analogs valid at 20080201/0000 .



GFS212 96-h forecast of 850-hPa temperature (0°C, red) and 850-hPa temperature members (0°C, black) based on the top 15 analogs valid at 20080201/0000.

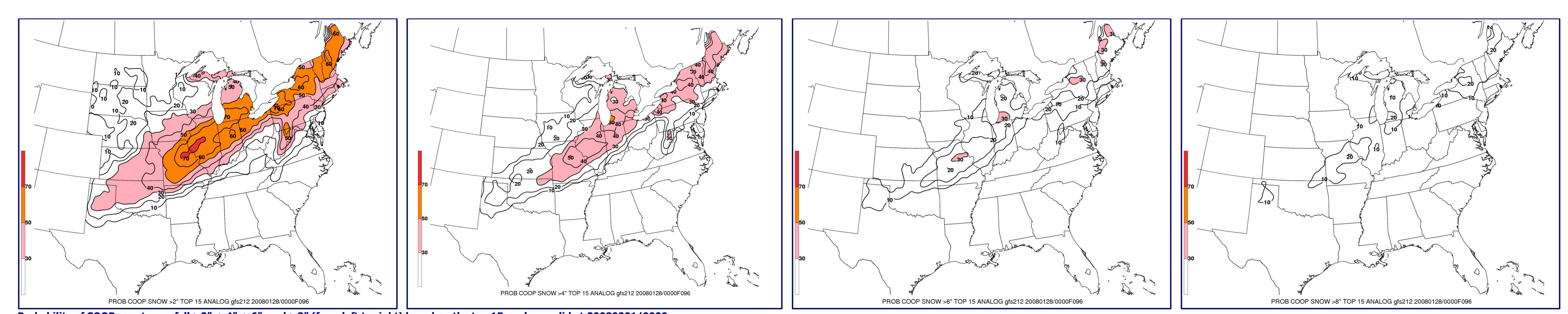


GFS212 96-h forecast of 2-m temperature (0°C, black) and 2-m temperature inner-quartile range (0°C, shaded) based on the top 15 analogs valid at 20080201/0000.

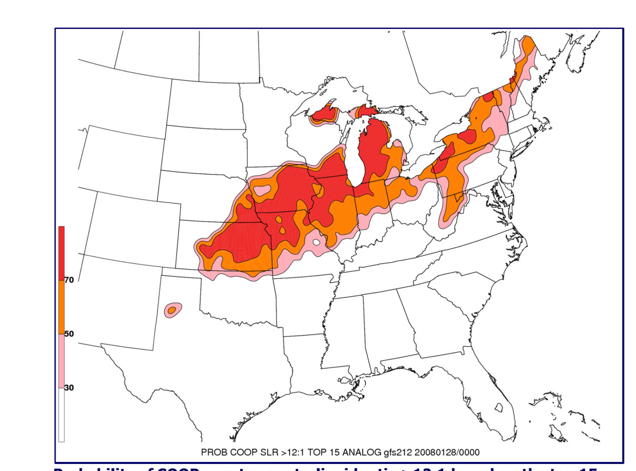


Mean (left) and median (right) COOP event snowfall (in, shaded) based on the top 15 analogs valid at 20080201/0000.

Samples of Probabilistic Guidance



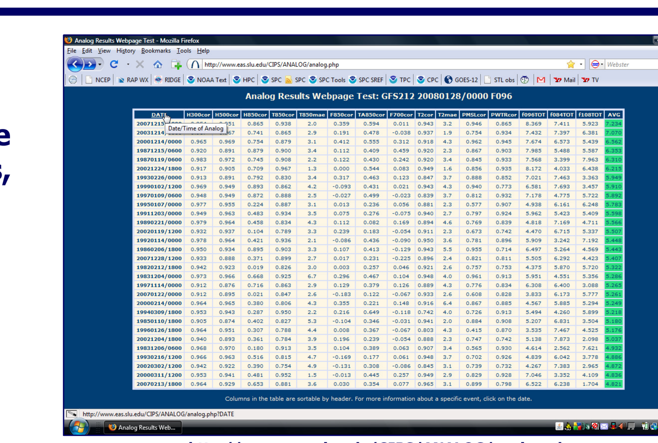
Probability of COOP event snowfall >2", >4", >6", and >8" (from left to right) based on the top 15 analogs valid at 20080201/0000.



Probability of COOP event snow-to-liquid ratio >12:1 based on the top 15 analogs valid at 20080201/0000.

Conclusions

- The goal of our analog system is NOT to make a forecast; but to provide medium-range guidance for heavy snow events by using a historical dataset.
- In addition, a forecaster can quickly gain historical experience and become familiar with the meteorological patterns associated with past similar events.
- The current approach is independent of QPF yet can still provide precipitation amounts (i.e., we already have the answers).
- Initially (~1 November 2008), the analog system will be run twice a day using the 00z and 12z GFS212 runs. Early in 2009, the goal is to expand this to also use the GFS Ensemble product. Presented here is only a sample of potential products, a complete suite can be found at the analog web site.
- The analog forecast approach can be applied to any meteorological event as long as a control run can be created. Future research has the methodology being expanded to heavy rain potential in the same HWO time frame.



http://www.eas.slu.edu/CIPS/ANALOG/analog.php