Winter Weather Guidance from Regional Historical Analogs

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Introduction

- A blend of knowledge and experience is critical for effective interpretation of model output. However, even experienced forecasters can fail to identify significant weather events.
- Failure to recognize these and similar events may be due to a variety of meteorological reasons, but an overreliance on deterministic Quantitative Precipitation Forecast (QPF) values and placement may be the primary cause.
- Conceptual models, composite analyses, and forecast analogs can all be utilized to support in the identification and analysis of these weather events. These techniques have been proven successful because their underlying foundation is based on the quasi-repeatability of atmospheric fields and their resultant sensible weather outcomes.
- The focus of the CIPS analog guidance is not to provide a deterministic forecast, but to give the scale and intensity of historical events that are similar to the current forecast.

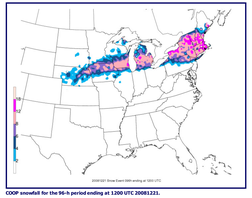
Methodology - The Big Picture

- Search the 28-yr North American Regional Reanalysis (NARR) dataset against the model forecast (GFS212-40km) for potential analogs.
  - 6 months over the winter season (OCT - MAR) with a 6-h temporal resolution
  - 20,384 potential analogs (28 winters, 6 months, 4 per day)
- Remove "duplicate" times by choosing the best analog over a 24-h period. 1984011512, 1984011518, 1984011600, 1984011606
- Refine and rank the resulting analogs using statistics from the following fields:
  - 300 HGHT COR, 500 HGHT COR, 700 FRNT COR, 850 HGHT COR, 850 TMPC COR, 850 TMPC MAE, 850 FRNT COR, 850 THTEADV COR, 2m TMPC COR, 2m TMPC MAE, PMSL COR, and PWTR COR
- Create products that are useful for winter storm guidance.
- For a detailed overview of the methodology, please see the corresponding preprint manuscript.

Midwest Case - 19 December 2008

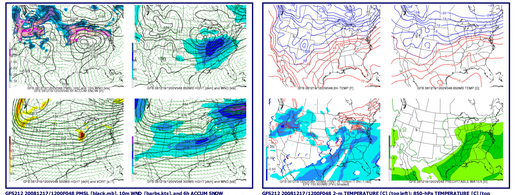
Event Overview

- Colorado Low produced a winter storm as it moved across the upper-Mississippi Valley and into the Great Lakes on 18 and 19 December 2009.
- Strong mid-level short wave and upper-level jet streak interaction helped to enhance synoptic-scale lift and northward transport of moisture ahead of the surface low.
- Band of heavy snow (>6") fell from northeast Nebraska through southern Wisconsin and into southern Lower Michigan.
- Major ice storm (~3/4" FZRA/glaze) across northeast Missouri, southeast Iowa, western and central Illinois, and into northern Indiana.



COOP snowfall for the 96-h period ending at 1200 UTC 20081221.

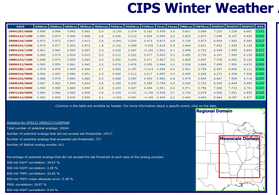
GFS212 Forecast



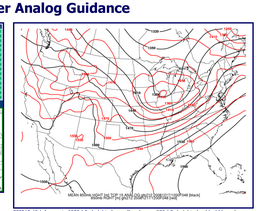
GFS212 20081217/1200F048 PMSL (black,mb), 10m WND (barbs,kts),and 6h ACCUM SNOW (shaded,in,12/1) (top left): 850-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (top-right); 500-hPa HGHT (black,dm), WND (barbs,kts), and ABS VORTICITY (shaded,s^-2) (bottom left); 300-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (bottom right).

GFS212 20081217/1200F048 2-m TEMPERATURE (C) (top left); 850-hPa TEMPERATURE (C) (top right); 700-hPa FRNT (red,K 100km^-1hr^-1 and 700-500-hPa EPV (shaded,PVU) (bottom left); PRECIPITABLE WATER (in) (bottom right).

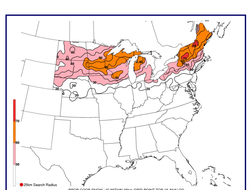
CIPS Winter Weather Analog Guidance



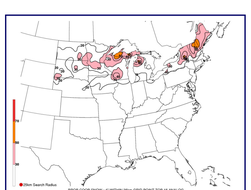
Top 15 analogs based on the GFS 48-h forecast valid at 20081219/1200. Inset figure shows the domains used to find the top 15 analogs.



GFS212 48-h forecast of 850-hPa heights (m, red) and mean 850-hPa heights (m, black) based on the top 15 analogs valid at 20081219/1200.



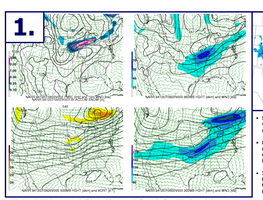
Probability of COOP event snowfall >2" within 25 km of a grid point based on the top 15 analogs valid at 20081219/1200.



Probability of COOP event snowfall >4" within 25 km of a grid point based on the top 15 analogs valid at 20081219/1200.

Top 4 Analogs

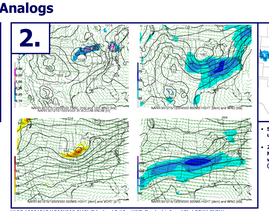
1.



- Strong mid-level short wave with coupled upper-level jet streak.
- Heavy snow (>6") fell from northeast Nebraska/north-central Iowa to southern Lower Michigan.
- Ice storm (~1.0" FZRA/glaze) from northeastern Kansas through northern Missouri and into northern Illinois.

NARR 19941207/0600V000 PMSL (black,mb), 10m WND (barbs,kts), and 3h ACCUM SNOW (shaded,in,1/2) (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^-2) (bottom left); 300-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (bottom right).

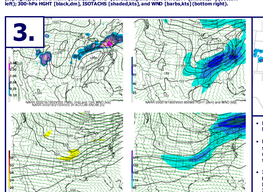
2.



- Strong mid-level short wave and upper-level jet streak support.
- 2-4" snow fell from southwestern Minnesota into central Wisconsin with embedded heavier amounts (>6").

NARR 19991215/1800V000 PMSL (black,mb), 10m WND (barbs,kts),and 3h ACCUM SNOW (shaded,in,1/2) (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^-2) (bottom left); 300-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (bottom right).

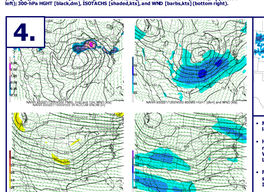
3.



- Mid-level short wave with upper-level jet streak interaction.
- Heavy snow (>6") band from south-central Nebraska through northern Illinois and into southern Lower Michigan.
- Ice storm (~0.5" FZRA/glaze) from southern Iowa/northern Missouri into north-central Illinois.

NARR 20000218/1800V000 PMSL (black,mb), 10m WND (barbs,kts),and 3h ACCUM SNOW (shaded,in,1/2) (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^-2) (bottom left); 300-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (bottom right).

4.



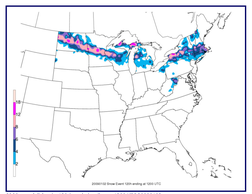
- Mid-level short wave with upper-level jet streak support.
- Heavy snow (>6") fell from northeast Nebraska into southern Wisconsin and into southern Lower Michigan.
- FZRA/glaze (~0.25") from southern Iowa and into northern Illinois.

NARR 19930201/1200V000 PMSL (black,mb), 10m WND (barbs,kts),and 3h ACCUM SNOW (shaded,in,1/2) (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^-2) (bottom left); 300-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (bottom right).

East Coast Case - 31 December 2008

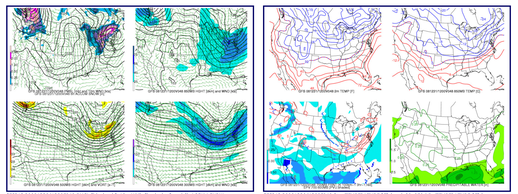
Event Overview

- A fast moving area of low pressure tracked from the northern Rocky Mountains across the upper-Mississippi Valley and into the Northeast on 30 and 31 December 2008.
- Strong mid-level short wave and upper-level jet streak accompanied the surface low pressure.
- Band of heavy snow (>6") fell from western and central New York into interior New England.



COOP snowfall for the 120-h period ending at 1200 UTC 20090102.

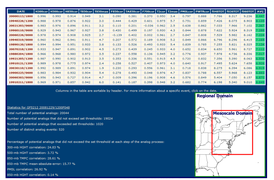
GFS212 Forecast



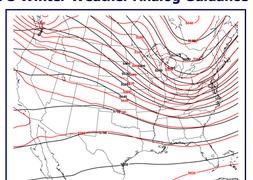
GFS212 20081220/1200F048 PMSL (black,mb), 10m WND (barbs,kts),and 6h ACCUM SNOW (shaded,in,12/1) (top left): 850-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (top-right); 500-hPa HGHT (black,dm), WND (barbs,kts), and ABS VORTICITY (shaded,s^-2) (bottom left); 300-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (bottom right).

GFS212 20081229/1200F048 2-m TEMPERATURE (C) (top left); 850-hPa TEMPERATURE (C) (top right); 700-hPa FRNT (red,K 100km^-1hr^-1 and 700-500-hPa EPV (shaded,PVU) (bottom left); PRECIPITABLE WATER (in) (bottom right).

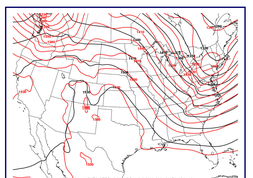
CIPS Winter Weather Analog Guidance



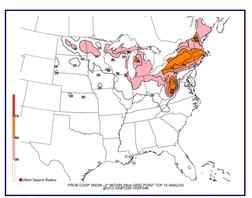
Top 15 analogs based on the GFS 48-h forecast valid at 20081231/1200. Inset figure shows the domains used to find the top 15 analogs.



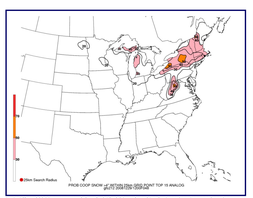
GFS212 48-h forecast of 500-hPa heights (m, red) and mean 500-hPa heights (m, black) based on the top 15 analogs valid at 20081231/1200.



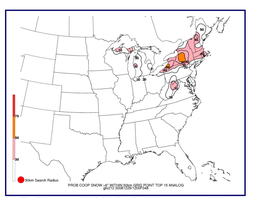
GFS212 48-h forecast of 850-hPa heights (m, red) and mean 850-hPa heights (m, black) based on the top 15 analogs valid at 20081231/1200.



Probability of COOP event snowfall >2" within 25 km of a grid point based on the top 15 analogs valid at 20081231/1200.



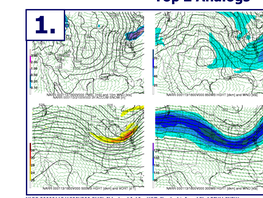
Probability of COOP event snowfall >4" within 25 km of a grid point based on the top 15 analogs valid at 20081231/1200.



Probability of COOP event snowfall >6" within 50 km of a grid point based on the top 15 analogs valid at 20081231/1200.

Top 2 Analogs

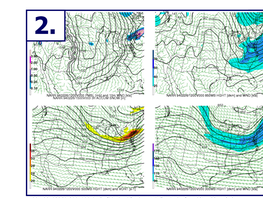
1.



- Strong mid-level short wave accompanied by weak surface low pressure developed in the lee of the Rockies and quickly moved eastward.
- Narrow band of heavy snow (>6") extended from the Upper Mississippi Valley through the lower Great Lakes and into interior New England.

NARR 20000113/1800V000 PMSL (black,mb), 10m WND (barbs,kts),and 3h ACCUM SNOW (shaded,in,1/2) (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^-2) (bottom left); 300-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (bottom right).

2.



- Low pressure developed over the northern Rockies and moved east southeastward through the southern Great Lakes and off the Mid-Atlantic.
- Band of heavy snow (6-8") extended from southern Wisconsin and northern Illinois eastward across southern New York.

NARR 19940220/1200V000 PMSL (black,mb), 10m WND (barbs,kts),and 3h ACCUM SNOW (shaded,in,1/2) (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^-2) (bottom left); 300-hPa HGHT (black,dm), ISOTACHS (shaded,kts), and WND (barbs,kts) (bottom right).

Using the Analog Guidance

- The analog system does not provide a deterministic forecast, but rather forecaster confidence by examining outcomes of events with similar environments to the forecast.
- Comparing mass fields of the GFS212 forecast and the mean of the top 15 analogs can assess the overall viability of the analogs to provide guidance for the forecast.
- Utilizing COOP-based event snowfall probabilities derived from the top analogs can give the location and accumulation potential for an upcoming snowfall event. These probabilities should be used in conjunction with an assessment of individual cases for best results.
- In the Midwest case, solely using the COOP-based event snowfall probabilities as guidance would place the snowfall potential too far north. The top four analogs suggest that the snowfall potential is further to the south.
- NCDC storm data from the individual analogs can be used to quickly gather more information on impacts for each event. In the Midwest case, there was a significant ice storm to the south of the heavy snow band. Three of the top four analogs also experienced significant ice storms to the south of the heavy snow band.

Conclusions

- The goal of our analog system is NOT to make a forecast; but to provide guidance for heavy snow events by using a historical dataset.
- In addition, a forecaster can quickly gain historical experience while becoming familiar with the meteorological patterns associated with past similar events. In turn, this information can provide a range of scales and intensities of sensible weather that are potential outcomes of the current forecast.
- The current approach is independent of QPF yet can still provide precipitation guidance (i.e., we already have the answers).
- Ensemble-like and probabilistic products based on the top 15 analogs can provide a quick overview of the historical events. However, to fully determine the range of historical events a short analysis of the top analogs is recommended.