Forecasting

SIMILAR CASES OF COLD AIR CYCLOGENESIS AND HEAVY SNOWFALL JUST EAST OF THE ROCKIES AND APPALACHIANS

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ABSTRACT

Two synoptically similar situations are presented that involve strong surface Low development and heavy snow in response to strong 500-mb vorticity maxima crossing the mountains. LFM performance is evaluated and found to be reasonably accurate at 500 mb but inaccurate at the surface in each case. The poor surface pressure forecasts apparently contributed to poor precipitation forecasts. Common features of each system are discussed with the intentions of flagging the situation for future recognition and identifying a possible characteristic model error.

This study compares two synoptically similar situations that involve deep surface Low development and heavy snowfall in response to a strong 500-mb vorticity (vort) maximum crossing the mountains. In the February 6, 1984 case, the system was to the lee of the rockies. Each system was at about 35° North Latitude.

Figures 1 thru 4 show the 24-hour limited fine-mesh model (LFM) 500-mb hgt/vort progs and the verifying analyses for the two cases. In each case, the 500 mb prog was fairly accurate. Note that each case featured a strong (greater than or equal to 22 per sec) vorticity maximum rounding the bottom of a long-wave trough, with a slightly less intense vort max about 10° Latitude to the north. 500-mb temperatures in each cases were cold....Less than or equal to -30 C. Figures 5 and 7 show the 24-hr LFM surface pressure/1000-500 mb thickness progs. Figures 6 and 8 show the verifying surface analyses, overlayed with the observed snowfall for the preceeding 12 hours.

Despite the general accuracy of the LFM 500-mb forecasts, the LFM surface forecasts were fairly poor. In each case, the surface Low was forecast much too far east. Although only the 24-hour LFM progs are shown, a similar pattern of reasonably good 500-mb forecasts and correspondingly poor surface forecasts occurred in both earlier and later runs of the LFM and spectral models.

The impact of surface Low development so far west was significant, as seen in figures 6 and 8, heavy snow fell north and west of the surface Lows. In the eastern storm, heavy snow continued to fall across northern North Carolina and extreme southeast Virginia after 1200 GMT Feb. 6, with maximum storm accumulations of 7 inches. (2) The LFM had forecast much lighter precipitation amounts in this area. In the Colorado case, heavy snow was restricted to the mountains and adjacent high plains of central and northern Colorado. Maximum acculumations of 30 inches were reported in the foothills west of Denver (3). The LFM quantitative precipitation forecast implied heavy snows in southeast Colorado and western Kansas, too far southeast of the observed heavy snowfall. The questions therefore arise: why did these surface forecast errors occur, and more importantly, how can the synoptic situation be flagged for future recognition?

Each system was basically "cold air" cyclogenesis, with the main baroclinic zones both forecast and observed well to the east. In neither case was there a strong surface High to the north or northeast, so warm advection was minimal. Strong positive vorticity advection (PVA) therefore provided the bulk of the upward motion. Thus the surface Low development and heavy snowfalls occurred with this strong pva just east of the vorticity maxima. In each case, the surface Lows verified unusually close to the 500-mb vort max, considering that the upper systems were neither negatively tilted nor closed-off. So perhaps it is not too surprising that the models forecast the surface Lows in the main baroclinic zones well to the east.

In each case, considerable snow shower and squall activity had been occurring under the upper trough and cold pool the previous day, signalling strong instability. This was especially true in the February 1984 case, when a line of intense snow squalls swept across Tennessee and Kentucky on Feb. 5. This instability may have contributed to the strong surface Low developments as well as the heavy snowfalls.

The effect of the mountains must also be considered. It is interesting that each case occurred just east of some of the highest peaks in the Rockies and Appalachians. However, it is uncertain exactly what role the mountains played in influencing the all-important positioning of the strong surface Lows. it is also unclear whether or not terrain-smoothing in the LFM affected the model surface pressure forecasts. (4)

CONCLUSION

Based on the two examples presented, an indication exists for a possible systematic correction to numerical model surface and precipitation forecasts based on a certain type of upper air pattern. A strong (greater than or equal to 22 per sec) vorticity maximum bottoming out at the southern end of a long-wave trough accoumpanied by a core of very cold air aloft (less than or equal to -30 C), should be carefully watched for cold air cyclogenesis and associated heavy snow just east of the vort max, over and just east of the mountains. Vigorous snow shower or snow squall activity associated with the vort max before it crosses the mountains may be a precursor of such cyclogenesis. The LFM and spectral models apparently tend to forecast surface Low development much too far east in these situations, with resultant poor precipitation forecasts.

Further cases must be collected to determine how reliable this type of systematic model correction will be. The role of the mountains in this synoptic situation should also be studied. The nested grid model recently implemented by the National Weather Service's National Meteorological Center, will also be evaluated to see how it handles this type of situation in comparison to the other forecast models.

ACKNOWLEDGMENTS

Special thanks to Dave Mannarano of NMC's forecast branch for his many helpful suggestions offered in preparation of this study.

FOOTNOTES AND REFERENCES

1. *Frank Brody graduated with a B.S. degree in Meteorology from Penn State University in 1977. He began work with the National Weather Service during that same year after having worked part-time at Accu-Weather while attending school. He has worked at National Weather Service Offices in Washington, DC, Charleston, WV, and Raleigh, NC, before joining NMC's forecast branch in 1982.*

2. *Sabones, Michael E., 1984: "Snow Case Study 'A Sub Synoptic Scale Heavy Snowfall Event Over North Carolina'" Eastern Region Technical Attachment 84-5 (A), March 5.*

3. *Information supplied by National Weather Service forecast office, Denver, Colorado.*

4. *Personal communication, Dr. Norman Phillips and Dr. Dennis Deaven, National Weather Service, NMC, Development Division, Camp Springs, Md.*

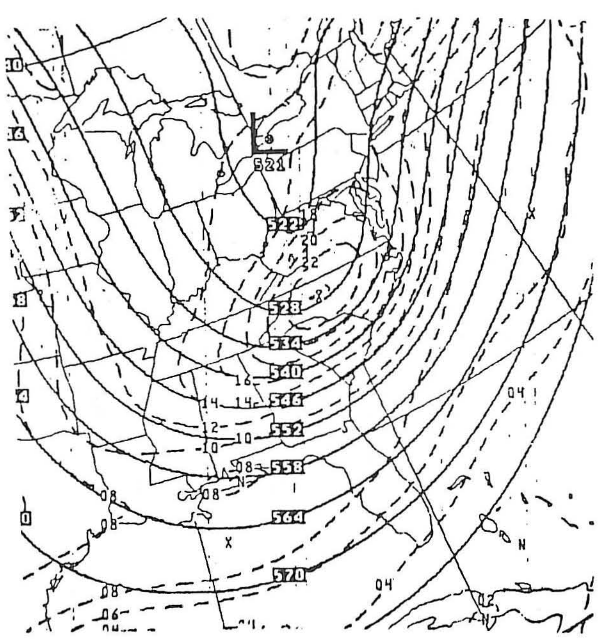


Figure 1. 24-hr LFM 500-mb hgt/vort forecast, VT 1200 GMT 6 Feb. 1984.

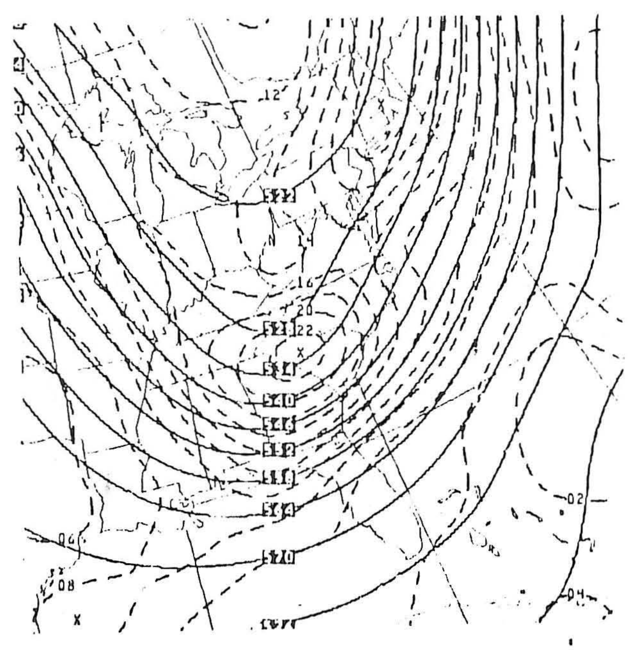


Figure 2. Init. analysis 500-mb hgt/vort, 1200 GMT 6 Feb. 1984.

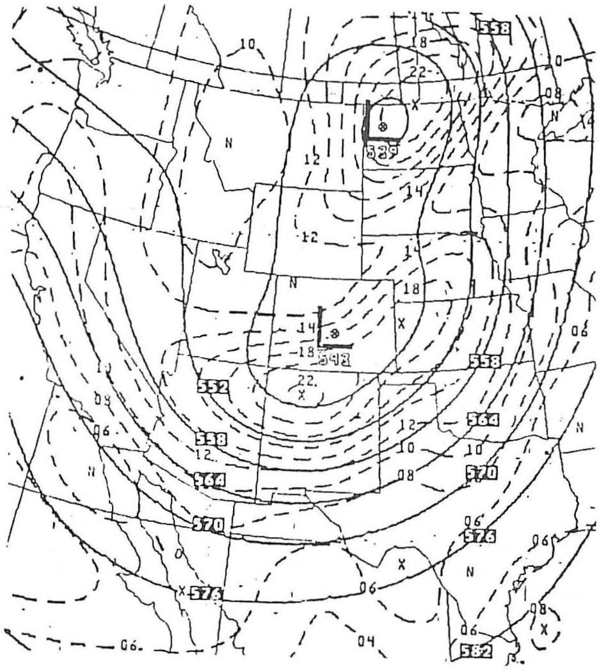


Figure 3. 24-hr LFM 500-mb hgt/vort forecast, VT 1200 GMT 16 Oct. 1984.

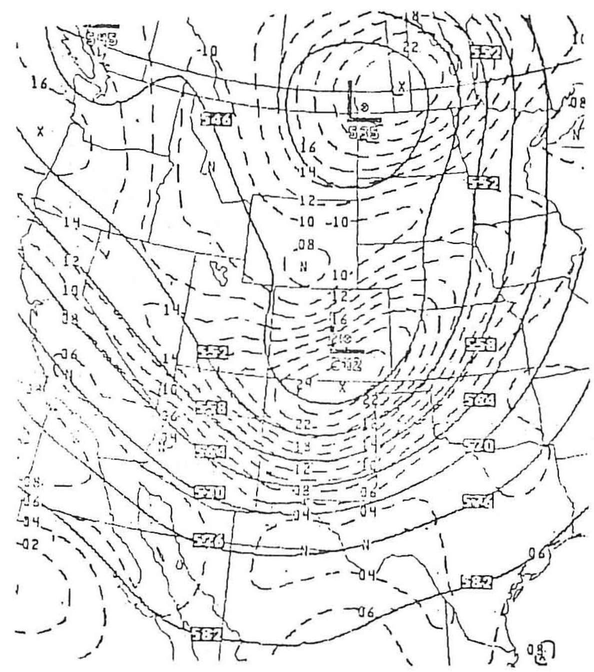


Figure 4. Init. analysis 500-mb hgt/vort, 1200 GMT 16 Oct. 1984.

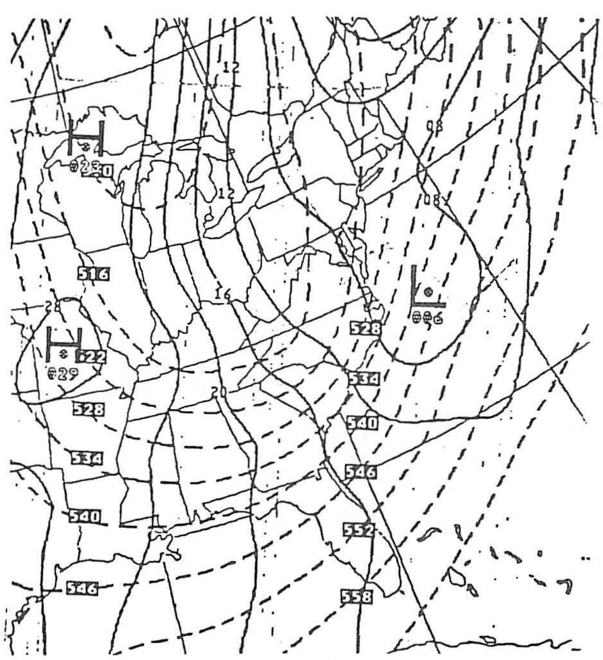


Figure 5. 24-hr LFM sfc pressure/1000-500 mb thickness forecast, VT 1200 GMT 6 Feb. 1984.

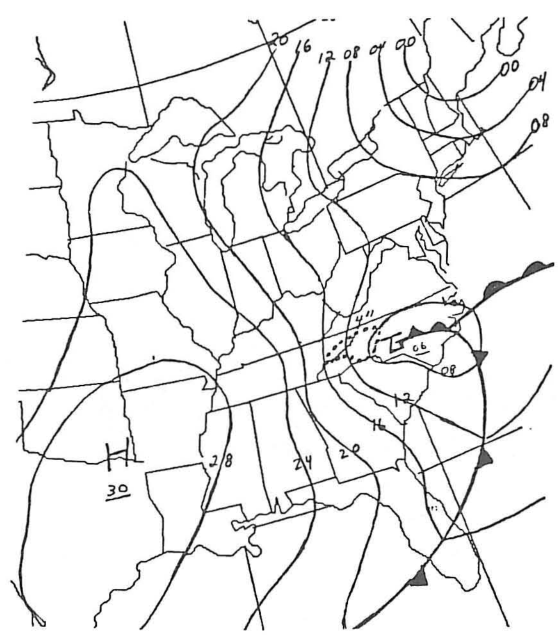


Figure 6. NMC sfc analysis, 1200 GMT 6 Feb. 1984, with total snowfall for previous 12 hr shaded.

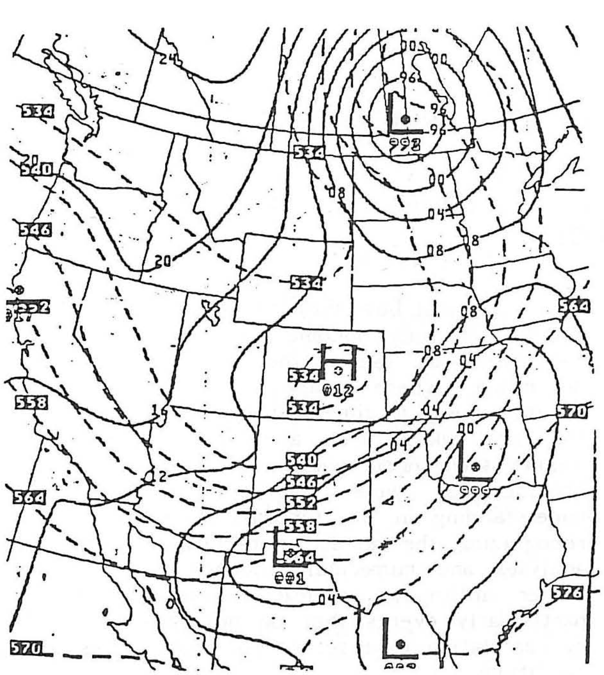


Figure 7. 24-hr LFM sfc pressure/1000-500 mb thickness forecast, VT 1200 GMT 16 Oct. 1984.

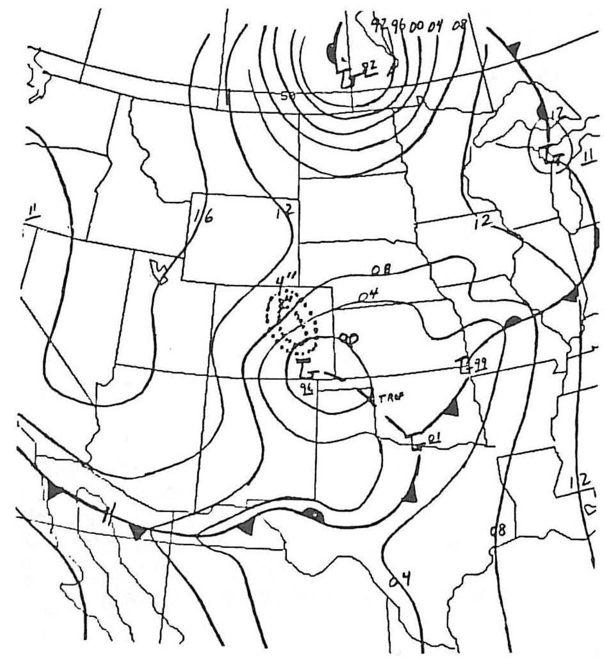
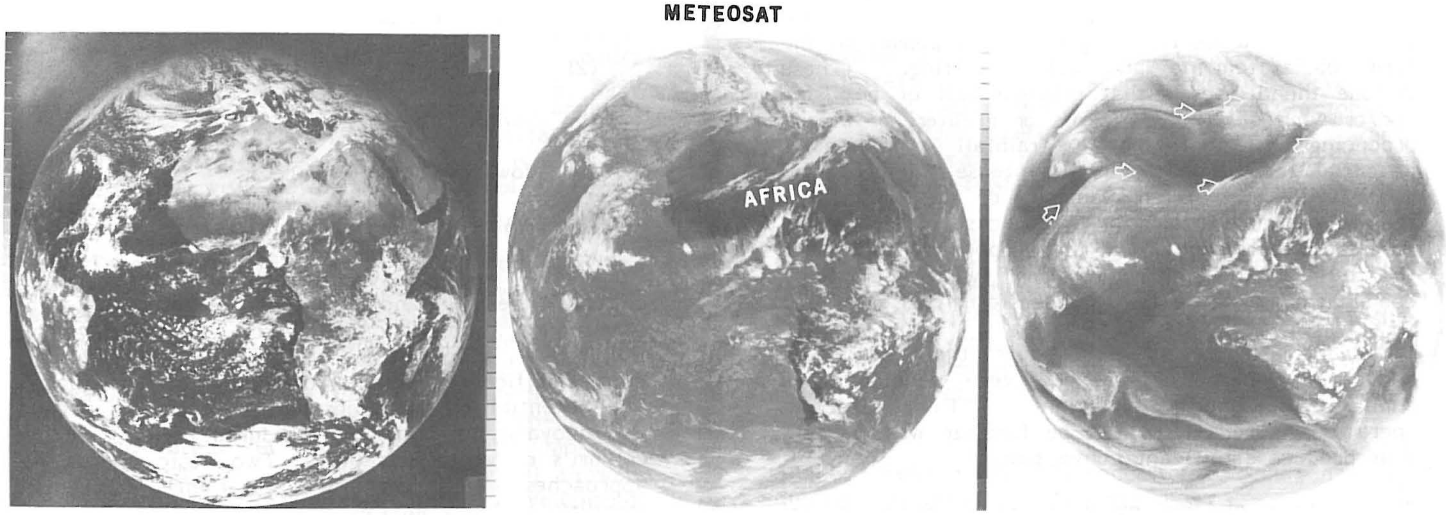


Figure 8. NMC sfc analysis, 1200 GMT 16 Oct. 1984, with total snowfall for previous 12 hr shaded.

GOES WATER VAPOR IMAGERY — continued from page 21

GOES WATER VAPOR IMAGERY

METEOSAT



VISUAL **INFRARED** **WATER VAPOR**

Figure 4. METEOSAT images, comparing visual, infrared and water vapor channels. (date unknown).

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Morel, P., Desbois, M. and G. Szejwach, 1978: A new insight into the troposphere with the water vapor channel of METEOSAT. Bull. Amer. Meteor. Soc., 59, pp. 5749-58.

Letters to the Editor

Dear Editor:

I have been reading with interest the discussion on the relevance of case studies. Many valid points were raised by McNulty's inquiry. Since the main objective of case studies is to learn from the past and better forecast the particular pattern in the future, we would benefit more from an analysis of many similar cases. One case may be anomalous, but many will tell us what weather to normally expect and what differences from the "average" a new case may provide. They can also tell us how well the progs verify and how to adjust them. For balance, weak cases — cases that failed to develop -- or those who track was diverted from the intended area of study should be included. Otherwise, an overforecasting bias likely would occur if only "hits" are analyzed. Thus we can take a further step and learn those subtle or minor synoptic or mesoscale features that enhance or diffuse a particular storm. A recent example was described by Schlatter and others in the July, 1985 issue of the Bulletin of the American Meteorological Society on forecasting convection at PROFS.

Every forecaster has learned that thunderstorm outflow boundaries cause new convection. However, forecasters need to know how reliable this indicator is and what other features make the difference. Schlatter and others observed: "On some days, numerous outflow boundaries propagated into potentially unstable air. Yet they neither triggered any new activity nor intensified convection already under way. On other apparently similar days, gust fronts were the important triggering mechanisms for convective development. Most forecasters revised downward their preconceived estimates of the percentage of gust fronts that spawn new convection." (1)

In conclusion, I believe a multiple case study can provide greater insight into a particular storm pattern, suggest more sophisticated objective aids and result in better forecasts.

(1) Schlater, T. W., P Schulz and J. M. Brown, 1985: Forecasting convection with the PROFS system: Comments on the Summer 1983 Experiment. Bulletin of the American Meteorological Society, 66, P. 806.

Mike Oard
Lead Forecaster
NWSFO, Great Falls, MT

Dear Editor:

Mr. Jerry LaRue's interview, in the February 1985 DIGEST was very thought provoking. I had hoped for constructive reaction among operational meteorologists.

Two of the LETTERS TO THE EDITOR in the May DIGEST concern Jerry's interview. I believe an additional comment is deserved.

A letter from a WSFO San Francisco LEAD FORECASTER challenged details on variation of precipitation around San Francisco. No help for the real problems was offered. If an experienced meteorologist has to "work for" personal weather information, what does the ordinary person have to do?

Another letter from Florida questioned how NWA has met the needs of operational meteorology. There is no question of the strength in unity idea, but unity must not be permitted to obscure any improvements that can be made from within. It is the general public who will determine the value of weather information. A forecast which is missunderstood, ignored or not available is worse than a "busted" forecast.

As technology improves, even an operational meteorologist must become more and more involved with communications and sales.

Sincerely,

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CORRECTIONS TO:

SIMILAR CASES OF COLD AIR CYCLOGENESIS AND HEAVY SNOWFALL JUST EAST OF THE ROCKIES AND APPALACHIANS

by Frank Brody
May 1985, pp 22-25

1. Pg 22, paragraph 1, should read:

   This study compares two synoptically similar situations that involve deep surface low development and heavy snowfall in response to a strong 500-mb vorticity maximum crossing the mountains. In the February 6, 1984 case, the system was to the lee of the Appalachians. In the October 16, 1984 case, the system was lee of the Rockies. Each system was at about 35 north latitude.

2. Pg 22, paragraph 4, lines 1 and 2 should read:

   The impact of surface low development so far west was significant. As seen in figures 6 and 8, heavy snow fell north and west of the surface lows.

3. Pg. 23, paragraph 1, lines 5 thru 11 should read:

   A strong (greater than or equal to 22 sec^{-1}) vorticity maximum bottoming out at the southern end of a long-wave trough, accompanied by a core of very cold air aloft (less than or equal to -30° C), should be carefully watched for cold air cyclogenesis and associated heavy snowfall just east of the vort max, over and just east of the mountains.