Western Region Technical Attachment
No. 94-37
December 20, 1994

"BIG VS SUPER" SNOWFALL EVENTS AT SALT LAKE CITY, UT A COMPOSITE COMPARISON

Frank M. Cooper - NWSFO Salt Lake City
Scott A. Weishaar - NWSFO Portland, Formerly NWSFO Salt Lake City
Alan S. Haynes - WFO Pueblo, Formerly NWSFO Salt Lake City
Lawrence B. Dunn - NWSFO Salt Lake City

Editor's Note: Composite analyses are useful in depicting meteorological patterns that have been associated with a particular weather phenomena or event when a significant number of cases are available for compositing. Composites cannot be used as forecast tools unless an analysis is conducted on the non-events associated with a particular composite pattern. These cases are considered the null cases, or non-events that are also associated with a particular pattern that may, in some cases, be associated with an event.

Unless a significant portion (over half) of patterns matching the composite are associated with an event, the composite cannot be useful as a forecast tool. This is not a trivial endeavor but is necessary for using composites as forecast tools. The reader must remember these points in reading this Technical Attachment.

Introduction

Over the years, analogues have been a useful forecast tool in analyzing unusual weather events. Recently, it has become feasible to easily generate composites based on historical NMC gridpoint weather data from 1948 to 1989, using software distributed with the data on the NMC Gridpoint Dataset CD-ROM. Composites can be used to identify significant weather events. Previous studies done at Bismarck, ND (Fors, Leblang and Turner 1993), Seattle, WA (Ferber 1993), and Phoenix, AZ (Haro 1994), have shown the usefulness of composites. Although the NMC gridded dataset lacks the resolution of a detailed analysis, it does allow the forecaster to develop a concept of the mean synoptic-scale atmospheric patterns associated with significant weather events.

In Utah, determining potential snowfall amounts for winter storms have always posed a challenge to forecasters. Lake and orographic effects are often significant factors for snowfall production at Salt Lake City (SLC) and the Wasatch Mountains east of the area. Often, the cold, unstable air associated with a northwest flow, following the passage of a trough and associated cold front, is more effective in producing snow at SLC than the dynamic forcing related to the trough itself. Although mesoscale factors (lake and orographic effects) play a leading role in producing snowfall at SLC in the majority of cases, they are less important when discussing the most significant snowfall events. The purpose of this study using composites is to differentiate the more frequent "BIG" storms (5.5 to 9.4 inches in 24 hrs) from the less frequent "SUPER" storms (9.5 inches or greater in 24 hrs).

Methodology

Thirty-nine cases were examined over a period of 27 years from 1963 to 1989. Cases prior to 1963 were not included since 700 mb heights and temperatures were not available for compositing charts. Of the 39 cases studied, 29 were classified as "BIG" storms while 10 were classified as "SUPER" storms. In other words, one "BIG" storm occurred about every year, while the less common "SUPER" storm occurred about every 2-3 years. Composites were developed from 500 mb heights, 700 mb heights and temperatures, and sea level pressure (SLP). The time nearest to the onset of snow is classified as T00, while T-12 and T+12 represent time frames 12 hours prior and 12 hours after the onset of the storm event.

Discussion

500 MB Analysis

At T-12, both the "BIG" and "SUPER" snowfall event composites (Figs. 1a and 1b) depict a trough off the west coast with a zonal flow across much of the U.S. The trough in the "SUPER" case, however, is broader and a little farther northwest with lower heights in its core. The compact height contours on the west side of the trough indicate a strong jet, which would slow the main trough and further develop the storm system. In the "BIG" case, Gulf of Alaska ridge axis is less amplified and the trough itself appears more progressive.

At T00, the onset of the snow event, the trough axis in the "BIG" case (Fig. 1c) is over central Nevada. A jet maxima appears to be rotating around the trough axis. The flow over Utah is southwest ahead of the approaching trough. In the "SUPER" storm (Fig. 1d), the trough axis is farther west and centered over the Sierra Mountains. A strong jet maxima on the west side of the trough continues to dig and develop the system as zonal flow continues over the state and downstream.

At T+12, the most significant feature in the "BIG" snow event is the closed low development over southwest Montana (Fig. 1e). The ridge axis has already reached the Pacific Northwest coast and the trough axis has nearly passed SLC. By this time, lake and orographic effects associated with the northwest flow may be significant factors at SLC. In the "SUPER" case (Fig. 1f), a strong jet maxima remains on the west side of the trough axis. The trough axis is now over central Nevada with northern Utah on the cyclonic side of the jet in southwest flow.

700 MB Analysis

The same general trends noted at 500 mb are present at 700 mb. The "BIG" case is more progressive while the "SUPER" case is slower and developmental. At T-12, a split flow is evident over the Yukon (Fig. 2a) in the "BIG" snow event with a southwesterly flow over Utah. In the "SUPER" case (Fig. 2b), the flow over northwest Canada is more consolidated with a zonal flow over the state.

At T00, strong cold air advection (CAA) is evident over Utah in the "BIG" case (Fig. 2c), with the trough axis just west of the state and a ridge building into the Pacific Northwest. In the "SUPER" case (Fig. 2d), CAA is just beginning with the main trough axis near Vancouver Island.

By T+12, the coldest air has already reached northwest Utah in the "BIG" case (Fig. 2e). A ridge axis exists along the west coast. Mesoscale features (mainly lake effect and orographic lift) associated with northwest flow may be important at this time. Strong jet dynamics continue to dominate the "SUPER" case (Fig. 2f). CAA is just beginning over Utah. A significant trough is still upstream over the Pacific Northwest even 12 hours after snow began at SLC.

Sea Level Pressure

At T-12 there is a surface low over Nevada in both the "BIG" and "SUPER" storms (not shown). Similarly, there is still a surface low over the Great Basin at T00. In the "SUPER" storms, however, another surface low is found along the Washington coast, while in the "BIG" events, a surface ridge of high pressure is present over the Washington coast (Figs. 3a and 3b). At T+12, a surface low persists upstream from Utah in the "SUPER" storms, but high pressure builds in from the west in the "BIG" storms (not shown).

Conclusion

In conclusion, the duration of the snowfall event is the key factor in differentiating the "BIG" from the "SUPER" snow storms. The "BIG" case is characterized by a single progressive trough and a less amplified ridge in the Gulf of Alaska. The "SUPER" case is characterized by a long-wave planetary-scale trough over North America with weaker embedded systems moving through the trough, as well as a more amplified Gulf of Alaska ridge. The trough itself is slower and more developmental. By T+12, short-wave energy continues upstream in the Pacific Northwest allowing snowfall to continue over Utah while in the "BIG" event, the upper-level trough has almost passed SLC and the snow event has nearly ended.

Acknowledgements: The authors would like to thank Ed Carle (Lead Forecaster NWSFO Salt Lake City) for his contribution in analyzing the many cases involved in this study.

References

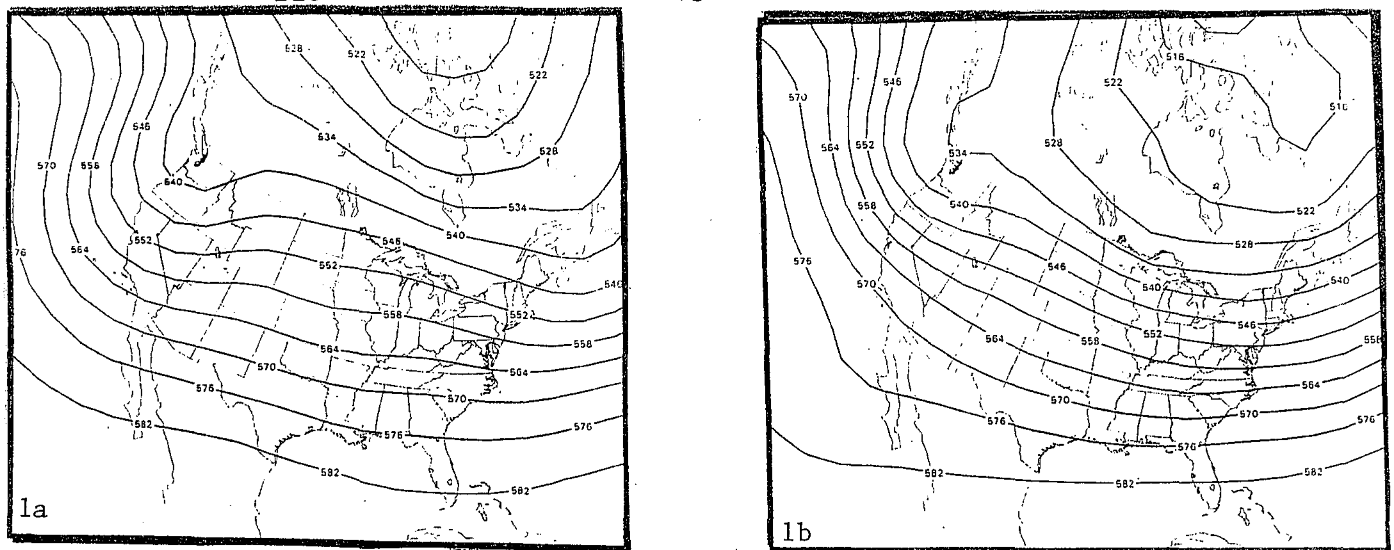
Ferber, Garth K., 1993: Snowstorms over the Puget Sound Lowlands. *Wea. Forecasting*, **8**, 481-503.

Fors, J.R., Leblang, Richard S., Turner, Robert G., 1993: Synoptic Composites of Three Significant Weather Types in North Dakota Using NMC Gridded Data on CDROM. *American Meteorological Society Preprint,* 13th Conference on Weather Analysis and Forecasting, 66-69.

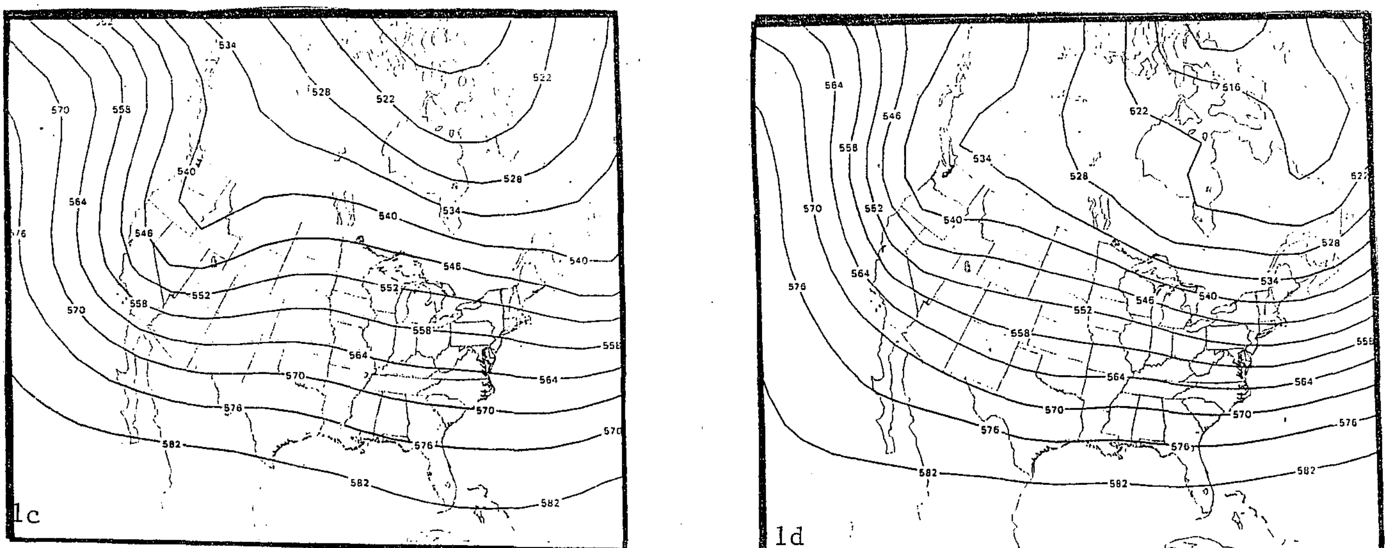
Haro, Jesus A., 1994: Agricultural Hard-Freeze Events in the Greater Phoenix Area: Some Associated Mean Atmospheric Patterns. Western Region Technical Attachment No. 94-30.

FIGURE 1
500 MB HEIGHTS

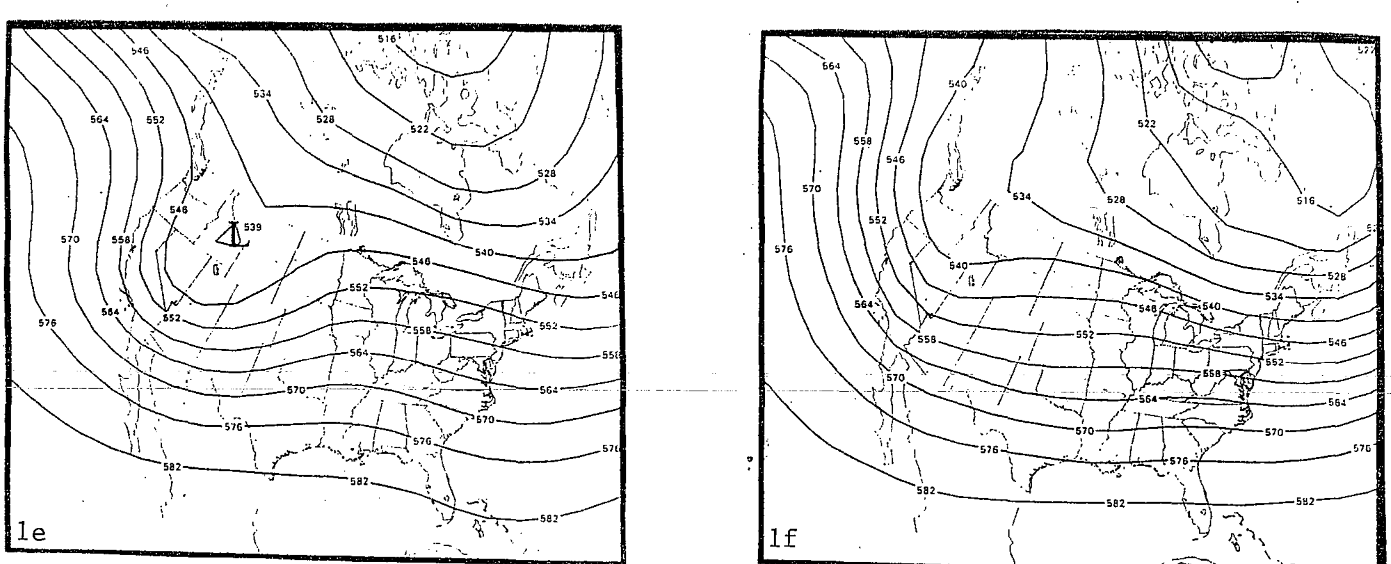
"BIG" VS "SUPER"



T-12 HRS



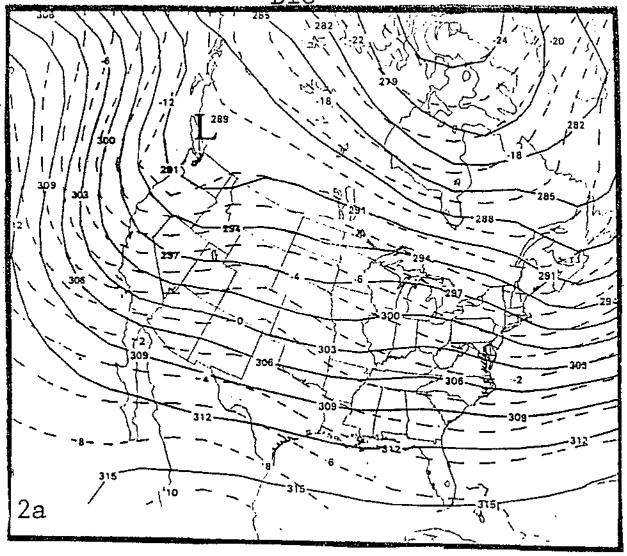
T00 HRS

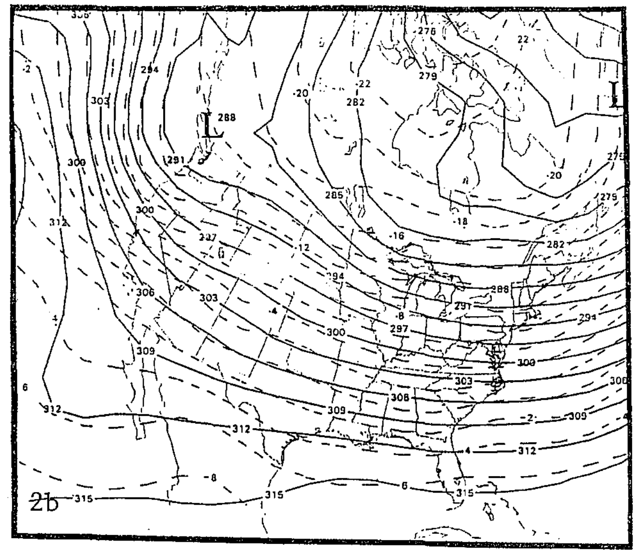


T+12 HRS

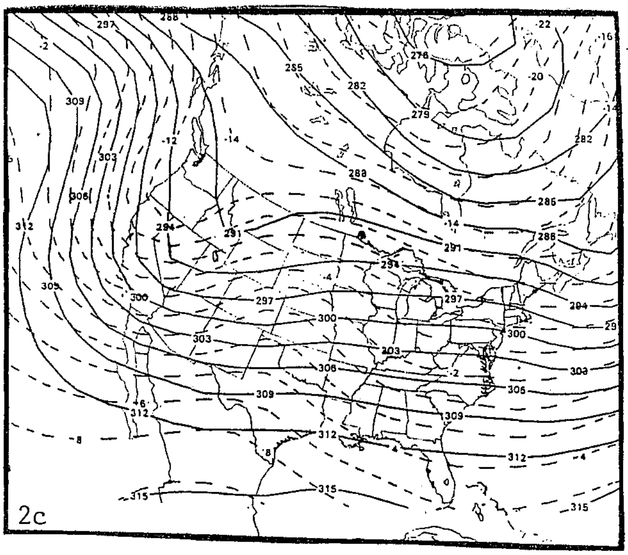
FIGURE 2
700 MB HEIGHTS AND TEMPERATURES

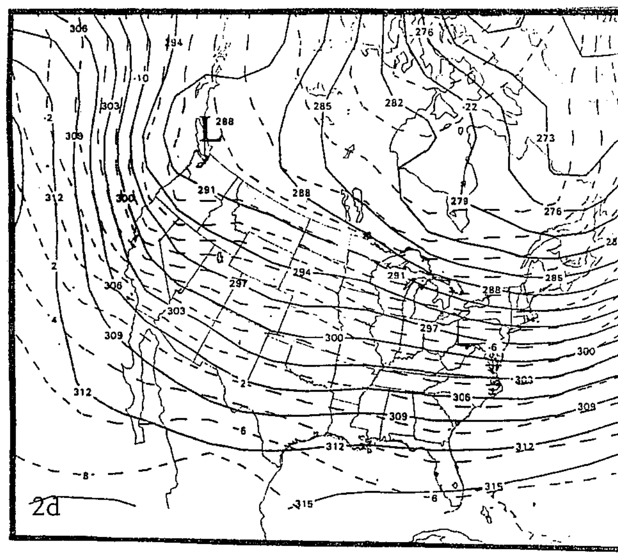
"BIG" VS "SUPER"



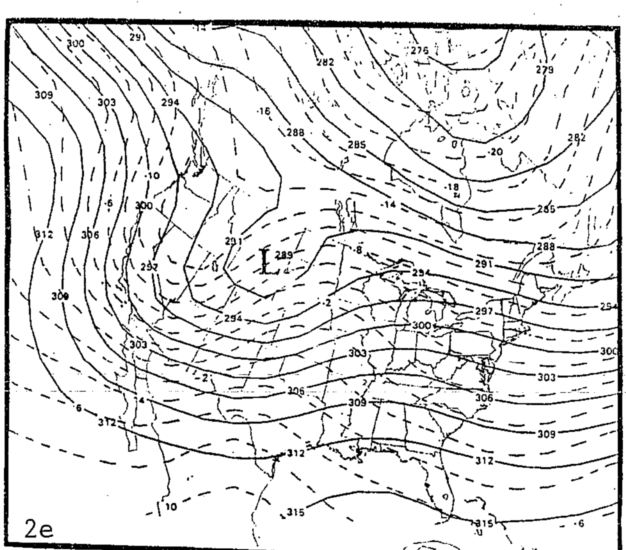


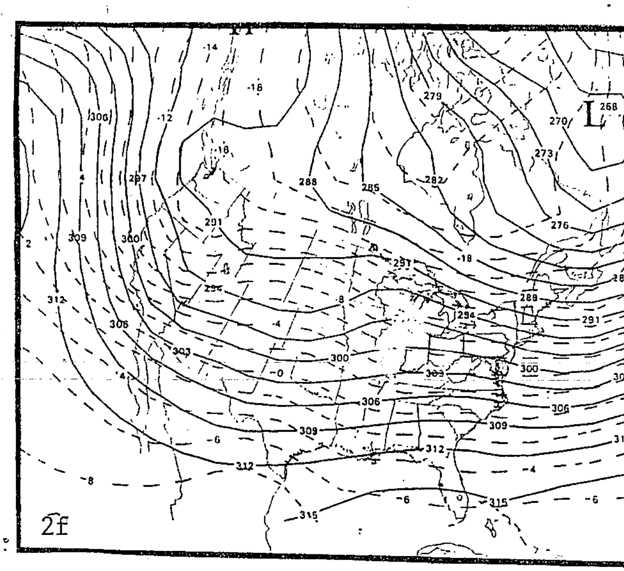
T-12 HRS





T00 HRS

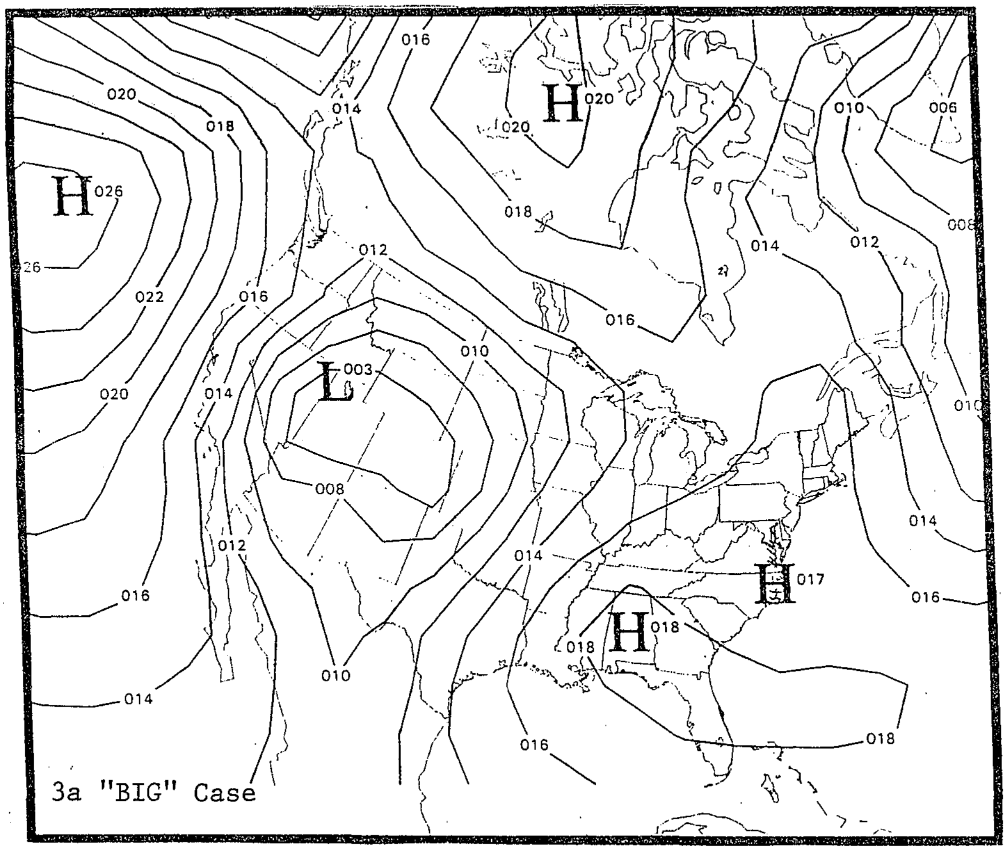




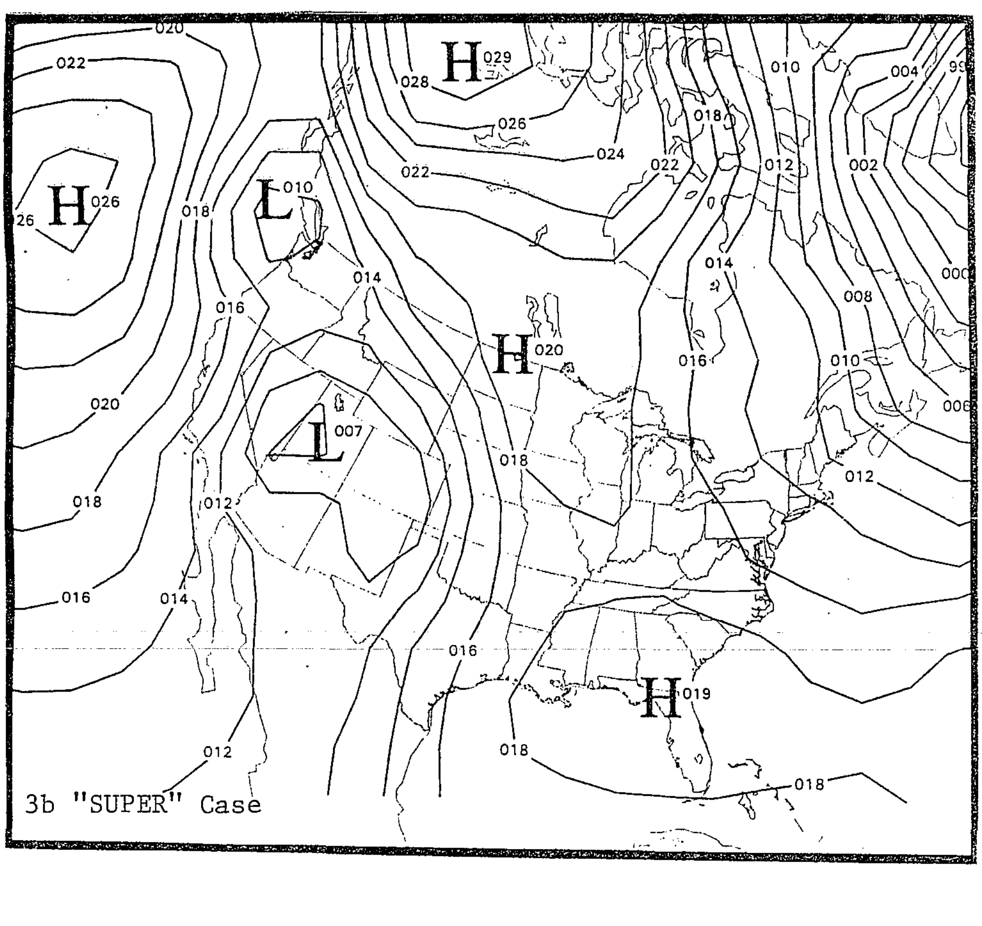
T+12 HRS

FIGURE 3

SEA LEVEL PRESSURE (SLP) at T00 HRS



3a "BIG" Case



3b "SUPER" Case