WESTERN REGION TECHNICAL ATTACHMENT
NO. 98-09
MARCH 10, 1998

# COMPOSITE MAPS OF SELECTED WARM EVENTS IN SAN DIEGO

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## Introduction

This study was done in an effort to help forecasters at the spin-up office in San Diego California, identify the synoptic conditions that result in much above normal maximum temperatures at Lindbergh Field. The study also shows the utility of composite mapping using gridpoint data.

## Local Geography of San Diego

San Diego is situated on the southwestern tip of southern California, bordered by the Pacific Ocean to the west. The elevation of Lindbergh Field is 13 feet. To the east, the terrain slopes gently upward for about 40 miles, then rises abruptly to above 6000 feet into the Laguna and Cuyamaca Mountains. The Pacific Ocean has a strong moderating effect on maximum temperatures at San Diego, but under certain meteorological conditions, maximum temperatures can climb to well above climatological normals. The meteorological conditions which characterize these events will become apparent in the results section of this Technical Attachment, immediately following a discussion on methodology.

## Methodology

The data used to generate the composites of this study were obtained from a CD-ROM entitled "NMC Grid Point Data Set", which was prepared by the University of Washington (Mass, 1987). Additional software used with the CD-ROM, NMCDraw, allows users to retrieve and view gridded data and produce composites. A recent study involving the use of composites in identifying significant rainfall events in San Diego, California (Atkin and Reynolds, 1995), has shown the usefulness of this technique. The NMC Grid Point Data Set contains data for several significant levels, covering different spans of time for each level.

Weather observations analyzed for San Diego were taken at Lindbergh Field, on San Diego Bay, for the duration of this study. WSF-51 forms were reviewed for the years 1971-1989, to identify days in which the maximum observed temperature was more than ten degrees above the monthly normal. Three-hundred-and-sixty such days met criteria and were available on the CD-ROM. The 1200 UTC surface, 850 MB, 700 MB, and 500 MB maps were selected and viewed using NMCDraw. Seasonal maps were then composited for surface pressure, 850 MB temperature, 700 MB heights, and 500 MB heights. Figure 1 shows the number of dates which were available for each seasonal composite map. The seasons were split as follows: Winter (January, February, March), Spring (April, May, June), Summer (July, August, September), Fall (October, November, December). This allowed seasonal variations in patterns to be more easily identified.

## Results

### Winter Events

For the period January-March (Fig. 2), the sea level pressure (SLP) pattern clearly points to an offshore wind event at the surface, with a mean 1028 MB surface high near the Great Salt Lake, and the surface trough offshore. At 850 MB, thermal gradients to the plateau are significant, providing additional support for strong offshore flow at the coast [*Offshore flow occurs when the surface pressure over Nevada and Utah becomes greater than the surface pressure over the coastal areas of southern California, resulting in north to northeast low level flow over the coastal areas and locally over the adjacent coastal waters. Strong offshore events are known locally as "Santa Ana" events (Small, 1995)*]. At 700 MB, the 315 dam height contour suggests easterly flow is occurring well through the troposphere. The 500 MB ridge axis is overhead, however heights remain below 580 dam. The greatest number of events occurred during this time period.

### Spring Events

For the period April-June (Fig. 3), surface gradients are weaker than during winter, but still offshore. Effects of a higher sun angle are reflected in higher 850 MB temperatures, and evidence of a thermal low appearing over northwest Mexico. At 700 MB, there still appears to be some support for offshore winds. At 500 MB, heights are now above 582 dam. These composite maps are the least definitive of the four seasons. It appears as though we are seeing the combined effects from both offshore flow and subsidence.

### Summer Events

For the period July-September (Fig. 4), strong high pressure aloft dominates, with the ridge well inland, and 500 MB heights now near 590 dam. At 850 MB, temperatures exceed 25 degrees centigrade. A thermal low is well developed at the surface, and the Plateau High is weaker, and displaced farther south, compared to the other seasons. These warm events, although fewest in number, clearly stand out from the others, suggesting another mechanism, such as subsidence, playing the major role in increasing temperatures at the coast, instead of foehn-type winds.

### Fall Events

For the period October-December (Fig. 5), surface high pressure (1027 MB) again appears near the Great Salt Lake, with strong offshore gradients in place. Temperatures at 850 MB are much lower than in summer, with the thermal gradient reappearing to the plateau. At

700 MB, easterly wind support is evident and at 500 MB, heights still exceed 582 dam. The combination of strong ridging aloft, and offshore flow, helps to explain the large number of events observed during this time of year.

## Conclusion

Composite mapping has made it possible to identify synoptic characteristics of selected warm events in San Diego. Due to its location on San Diego Bay, with temperate ocean waters, and proximity to the Laguna Mountains, most warm episodes are the result of foehn-type, offshore flow, otherwise known as Santa Ana winds (Small, 1995). The composite maps identify this clearly during the fall and winter, and to a lesser extent during the spring. Figure 1 illustrates that the vast majority of warm episodes identified, occurred during these three seasons, which synoptically are the most dynamic. The "spring" months appear to be a combination of offshore events and subsidence events, which likely make these maps the most difficult to interpret. Summer warm events are much less frequent, and primarily the result of subsidence heating and a weaker than normal sea breeze.

The features noted in the composites were also seen in the individual maps, and were not a peculiarity of the compositing. These maps should only be considered as a method for giving forecasters a "heads-up" to potential warm events. To more effectively utilize composite maps as a forecasting tool, it would be necessary to determine the number of events, if any, with a similar pattern that did not produce much above normal temperatures at Lindbergh Field (so called "null" events).

While the gridded data on the CD-ROM is quite useful, it would have been advantageous to have mid-level winds included among the data. As it was, we estimated mid-level winds, based on the height contour pattern.

## Acknowledgments

Data retrieval from CD-ROM software and compositing software was developed by Mark Albright of the University of Washington. The graphical display and data retrieval software (NMCDraw) was developed by Richard LeBlang, WSFO Bismarck.

## References

Atkin, D. V. and J. A. Reynolds, 1995: Composite Maps of Selected Rainfall Events in San Diego. Western Region Technical Attachment No. 95-06

Fors, J. R. and R. S. LeBlang, 1993: Synoptic Composites of Three Significant Weather Types in North Dakota Using NMC Gridded Data on CD-ROM. American Meteorological Society Weather Analysis and Forecasting Conference, Vienna, VA.

Small, I. J., 1995: Santa Ana Winds and The Fire Outbreak of Fall 1993. NOAA Technical Memorandum NWS WR-230.

Fig. 1

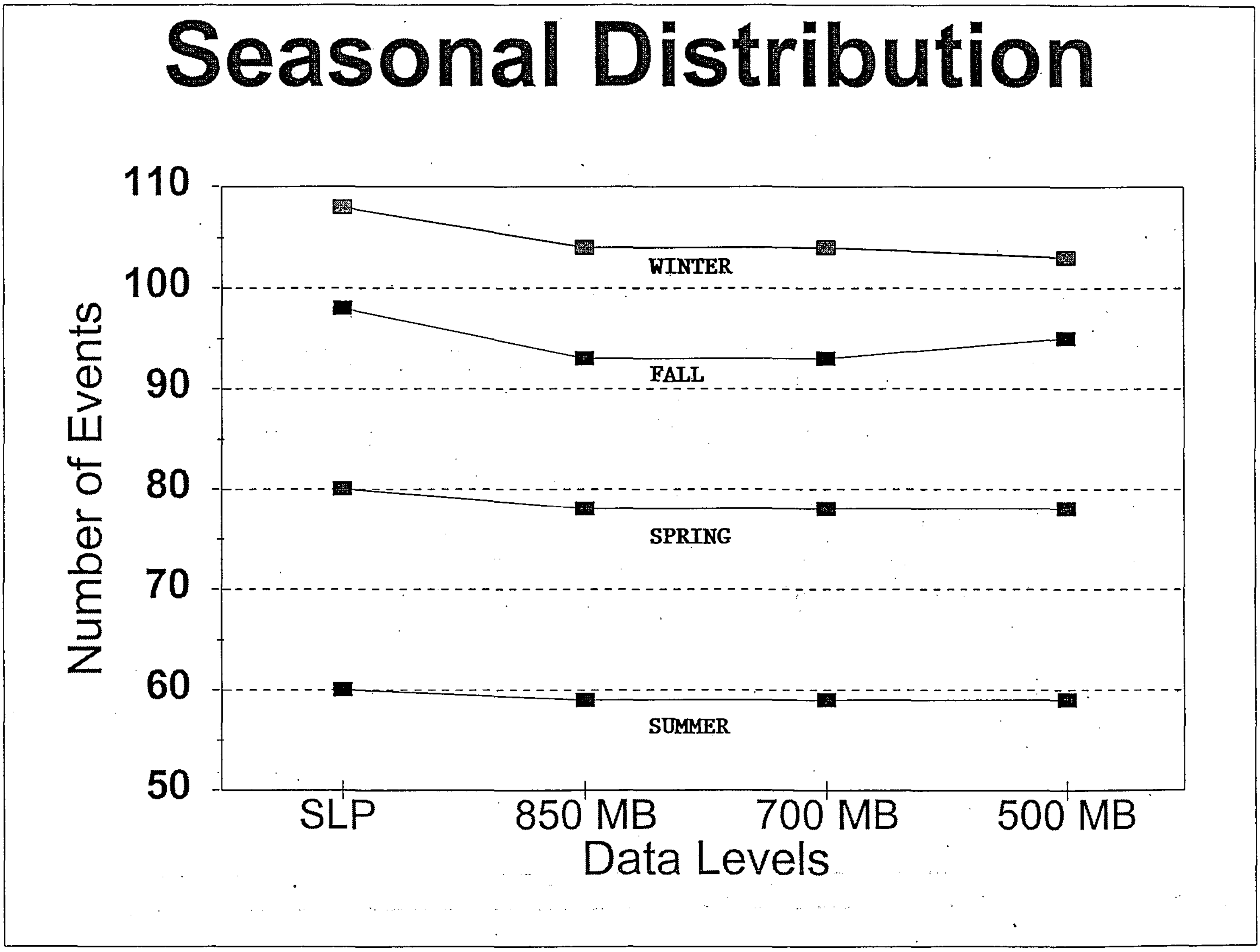


Fig. 1 The number and distribution of maps used to build each composite map.

Fig. 2 "Winter" (JFM)

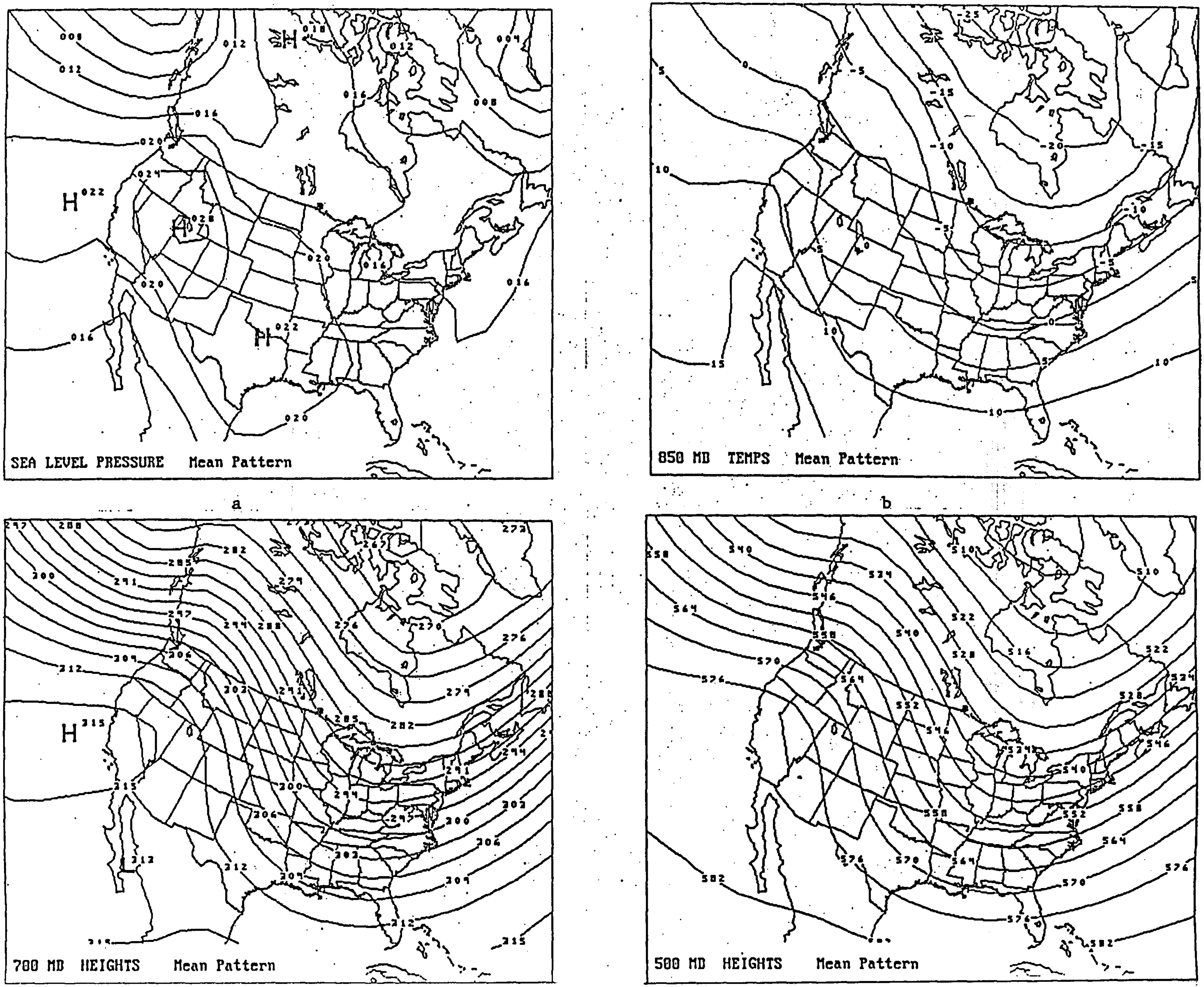

Fig. 3 "Spring" (AMJ)

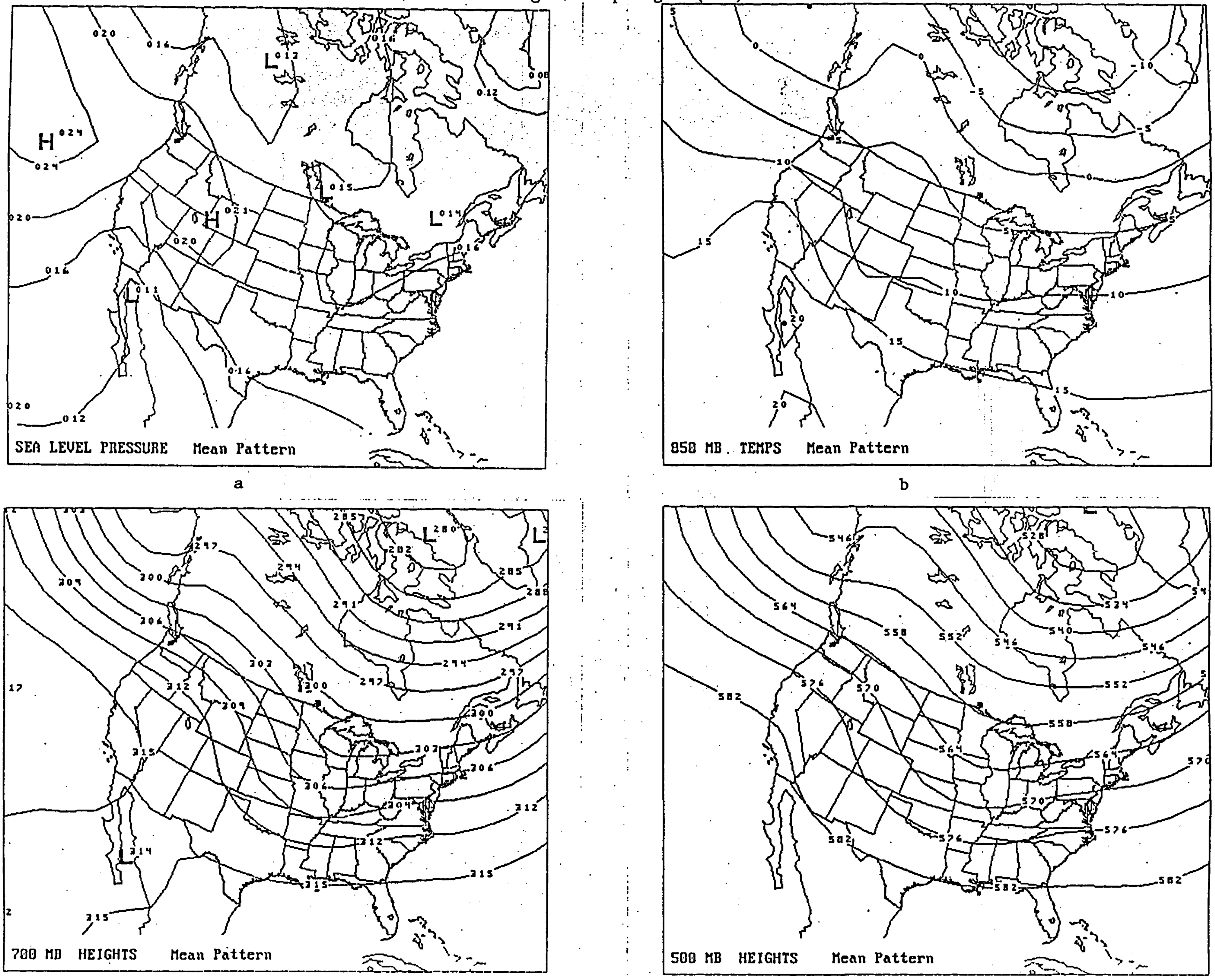

Fig. 4 "Summer" (JAS)

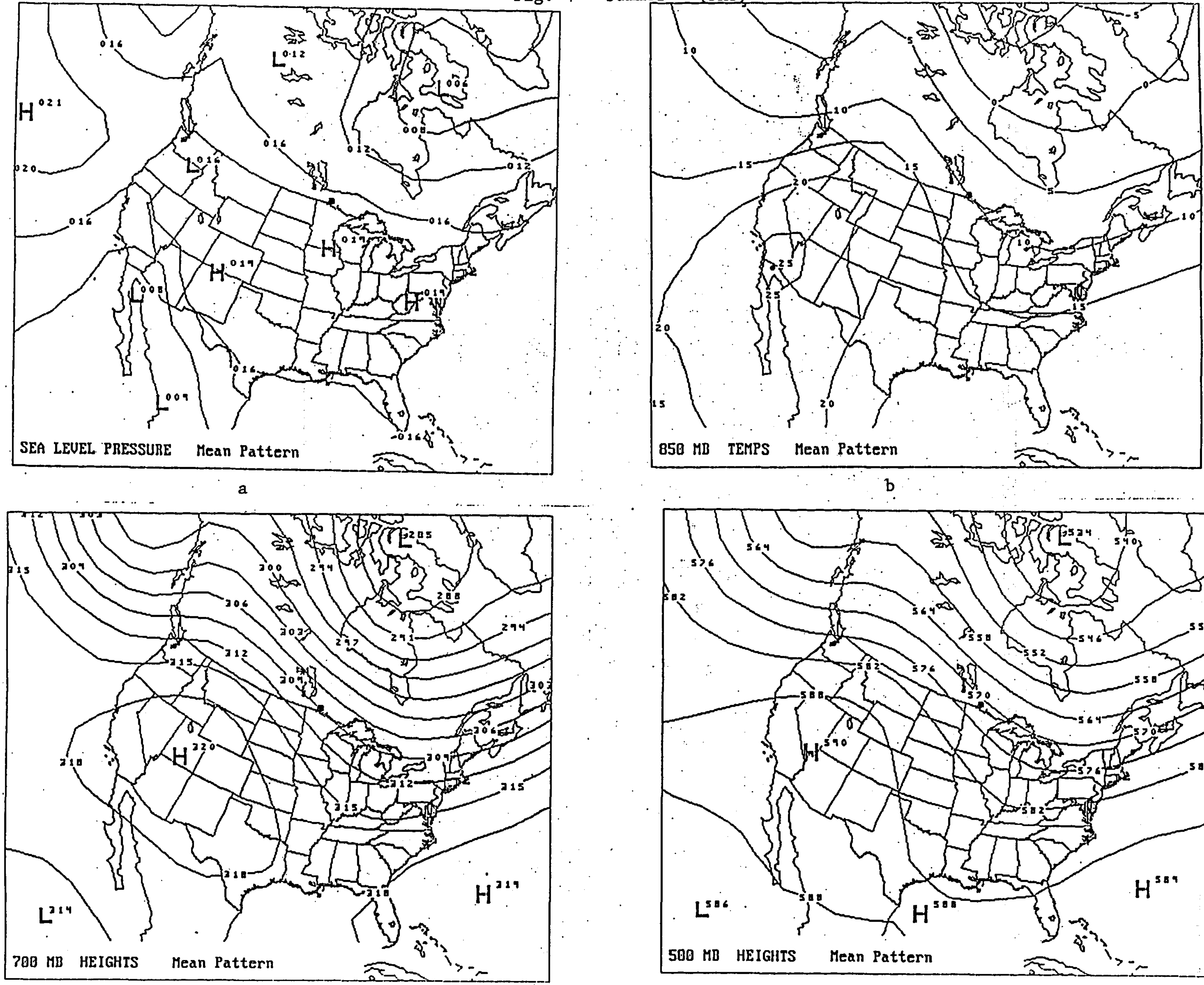

Fig. 5 "Fall" (OND)