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**A RECORD HEATWAVE ALONG THE
CENTRAL CALIFORNIA COAST - OCTOBER 7 - 8, 1996**

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Introduction

An offshore flow pattern resulted in a significant record breaking temperature event over Coastal California on October 7-8, 1996. Several daily high temperature records were broken in the San Francisco Bay Area and along the central California coast with the hottest temperatures in the Monterey Bay Area. On October 7, maximum temperatures climbed well into the upper 80s to the lower 100s over the Central Coast. The hottest record setting temperature on this day was at Salinas with 103° which beat the old calendar day record by 8 degrees. The climate station at Monterey reported 102°, smashing the old calendar day record by 15 degrees and just missing the all-time record high of 104°. On October 8, maximum temperatures once again climbed well into the 90s and lower 100s over the Central Coast with Monterey reaching 103°. It is interesting to note that only on two other occasions have temperatures risen above 100° for two consecutive days at the Monterey climate station in 44 years of records. These also occurred in October 1961 and Oct 1980. The purpose of this (TA) is to identify the synoptic and mesoscale patterns that led to this record breaking event using profiler data and Eta model forecast and surface analyses.

Climatology

September and October bring the return of the jet stream to lower latitudes after a summer migration to the north. The semi-permanent subtropical high of the Eastern Pacific weakens and the central valley cools, weakening the thermal trough inland. This weakens the dominant summer onshore flow. With the passage of midlatitude troughs aloft, high pressure at the surface quickly builds into the Pacific Northwest and sometimes into the Great Basin. When the surface high strengthens over the Great Basin, the likelihood for record breaking temperatures over coastal California becomes promising. Offshore flow develops when the surface thermal trough axis aligns itself along the coast or just west of it. Strong winds can result when the pressure gradient is particularly steep, but a strong wind is not a prerequisite for hot coastal temperatures. Offshore events can occur at any time of the year with the greatest frequency during September and October.

$$\Phi_1 - \Phi_0 = R \ln(p_0/p_1) \bar{T}$$

(1) hypsometric equation

Synoptic Pattern

At 00z Oct 7, a surface high pressure system was established from the Eastern Pacific to the Great Basin. By 12z, the semi-permanent thermal trough axis over the central valley migrated to about 60 nautical miles off the California coast (see Eta model Fig. 1). By 12z Oct 8, the thermal trough along the coast deepened due to the significant warming in that region (Eta model Fig. 2). The thermal nature of the trough is proven by the 12z 1000-850 mb thickness pattern (Eta model Fig. 3). Thickness is proportional to the mean temperature in a layer as defined by (1) the hypsometric equation (Holton 1979). In the core of the high, 850 mb temperatures at 12z were as warm as 23°C at Oakland, 25°C at Vandenberg AFB, and 27°C at Edwards AFB (see Fig. 3).

Meteograms

Meteograms for San Francisco and Monterey airports display the two day offshore event. The winds at Monterey airport were calm to light southeasterly each morning with sharp temperature rises into the early afternoon. The wind became northwesterly for a short period of time each afternoon temporarily offsetting the maximum temperature before another relative maximum temperature occurrence was reached later each afternoon (see Fig. 6). The winds at San Francisco airport were calm to light northeasterly each morning. The wind also became west to northwest each afternoon temporarily offsetting the maximum temperature on Oct 7 with another relative maximum occurring a few hours after 00z (see Fig. 7). On Oct 8 a sharp temperature rise was followed by a temperature fall in the afternoon as a stronger west to northwest wind came through the San Bruno Gap.

Fort Ord Surface and Profiler Data

The Fort Ord profiler on Oct 6-7 clearly displays a deepening warm layer overhead that is several hundred meters deep with the warmest temperatures near 30°C (Fig. 4). In the lowest 400 meters the winds veered northeasterly to easterly by 07z Oct 7 with the greatest warming in this lowest layer occurring near 17z Oct 7. However, the layer from the surface to about 100 meters began to cool after 17z as the winds became westerly. This low layer cooling generally continued into Oct 8 and continued to deepen to almost 200 meters thick. The wind flow above 200 meters switched to northwesterly around 01z Oct 8 and continued until around 07z Oct 8 when it resumed northeasterly once again (Fig. 5). At Monterey NWSFO, mixing had continued for most of the night with easterly winds resuming well before sunrise the morning of Oct 8 as observed by the author (Canepa) who was on duty overnight.

Forecasting Maximum Temperatures

Temperature forecasting always poses a challenge to the forecaster particularly when forecasting for coastal communities. There is a simple and useful technique for forecasting maximum temperatures near sea level. This is done by bringing the 850 mb temperature

down a dry adiabat to sea level pressure on a Skew-T chart (Elliot 1988). This method works best when a synoptic scale high pressure system produces large scale subsidence over the forecast area anytime from late spring to early fall. Additionally, clear skies, a high sun angle, and light mixing with the air aloft are necessary. At a California coastal station, this would include a dominating offshore flow pattern in addition to the other criteria. Given that the 850 mb temperatures within the high were from 23°C to 27°C on the soundings, applying this to a Skew-T diagram one would find the expected temperature near 100°F in the forecast area. This technique, however, will not always work in every offshore flow event. It should be used along with forecast experience for predicting maximum temperatures. It is also important to note that forecasting experience has shown that even during the strongest offshore flow events, localized influxes of cool marine air will occur in irregular patterns along the coast further complicating the prediction problem. The 24 hour forecast 850 mb temperatures by the Eta model suggested a thermal trough along the coast. The 24 hr forecast verified well at 12z(see actual versus forecast Fig. 8). MOS guidance had forecast a high of 87° on Oct 8 at the Monterey Airport and this highly underestimated the actual high of 100°F.

Conclusion

Offshore flow patterns are not uncommon along the California coast. Climatologically, they are most frequent during the months of September and October when synoptic conditions become favorable for high pressure to build over the Great Basin. When they do occur, maximum temperature forecasting becomes extraordinarily challenging. The synoptic pattern that led to this record breaking event was characterized by a strong warm core high over the Great Basin with a thermal trough axis 60 nautical miles off the California coast. Additionally, the persistent offshore flow and subsidence over the coastal terrain helped compress and warm the air. What is unusual about this event is the persistence of the offshore flow resulting in two days of record breaking temperatures. On Oct 7, the Great Basin high pushed the thermal trough just off the coast creating the first day of offshore flow and coastal warming. The warming continued to deepen the coastal trough on Oct 8, thereby resulting in a continuation of coastal warming. On Oct 9, the thermal trough receded into the central valley and dissipated, and a marine layer reestablished itself along the coast. An onshore flow returned and resulted in a significant cooling along the immediate central coast as temperatures were as much as 10 to 30 degrees cooler.

In order to identify the onset of a coastal California offshore event, it is important to analyze the onset of a high positioning over the Great Basin, the orientation of the pressure gradient across California and the development of the thermal trough along the coast. Also important is the analysis of the profiler data for the strength and depth of the offshore flow. The Eta 850 mb temperature forecast is a useful forecasting tool if an offshore flow event becomes certain. As in this case, the 24 hour forecast verified well. Climatology also suggests that deep and persistent offshore flow events can lead to record breaking maximum temperatures over the coast for two, but rarely three consecutive days.

References

Elliott, George 1988: Weather Forecasting Rules, Techniques and Procedures. American Press, 101.

Holton, James R., 1979: An Introduction to Dynamic Meteorology. Academic Press Limited, 19, 70.

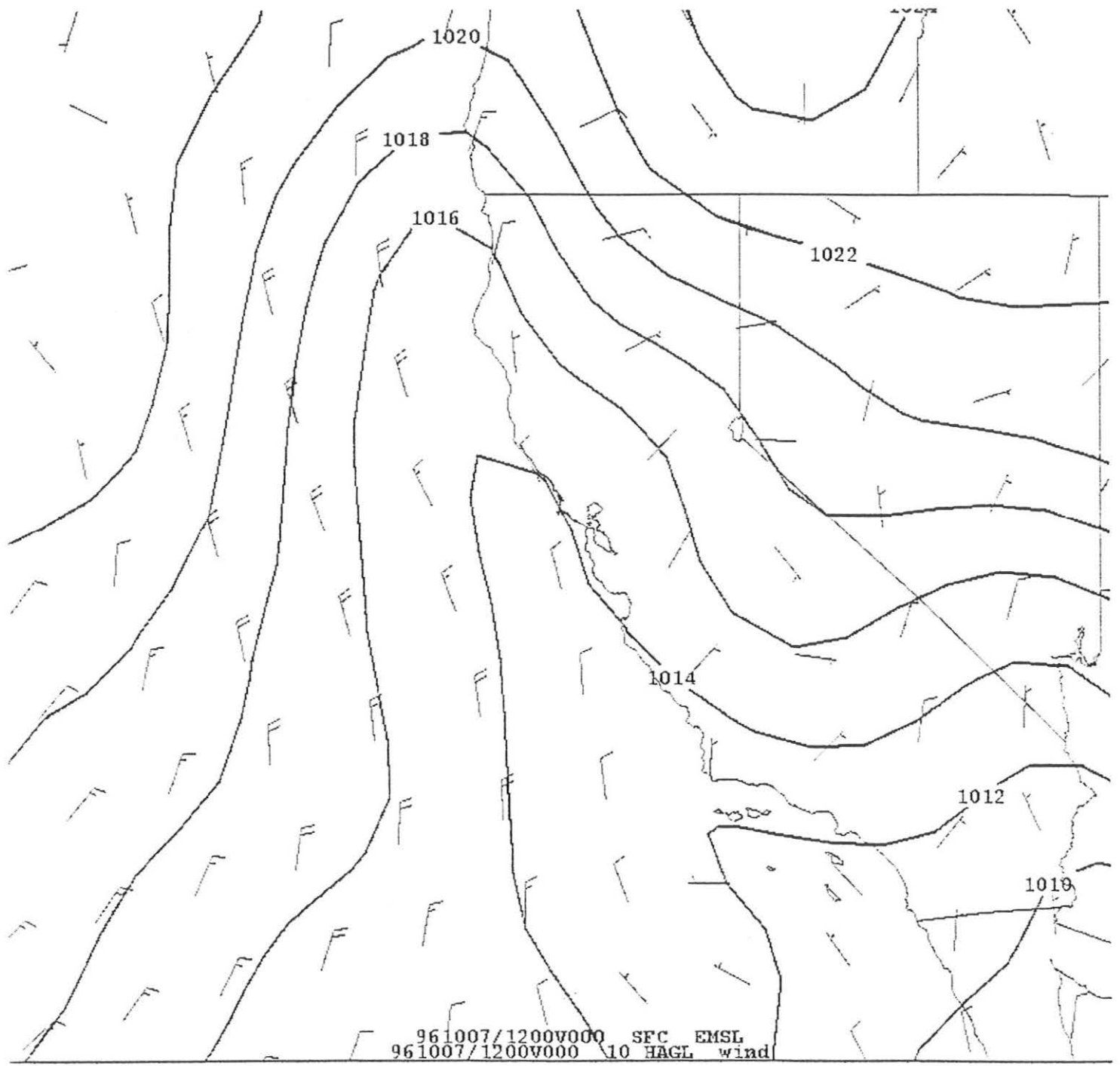


Fig. 1. 00 hr Eta model 12z Oct 7th 1996. Surface pressures and 10 meter winds.

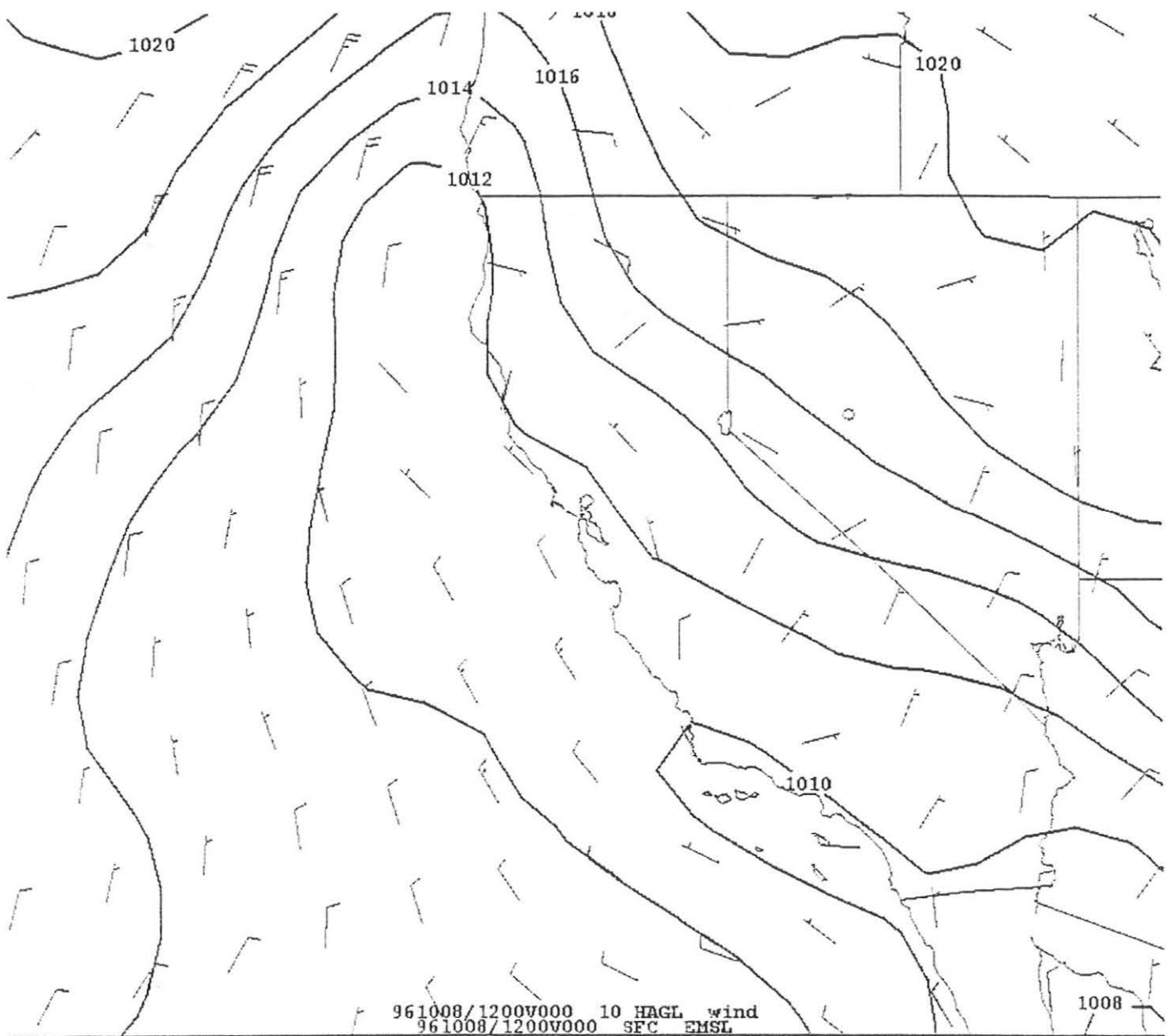


Fig. 2. 00 hr Eta model 12z Oct 8th 1996. Surface pressures and 10 meter winds.

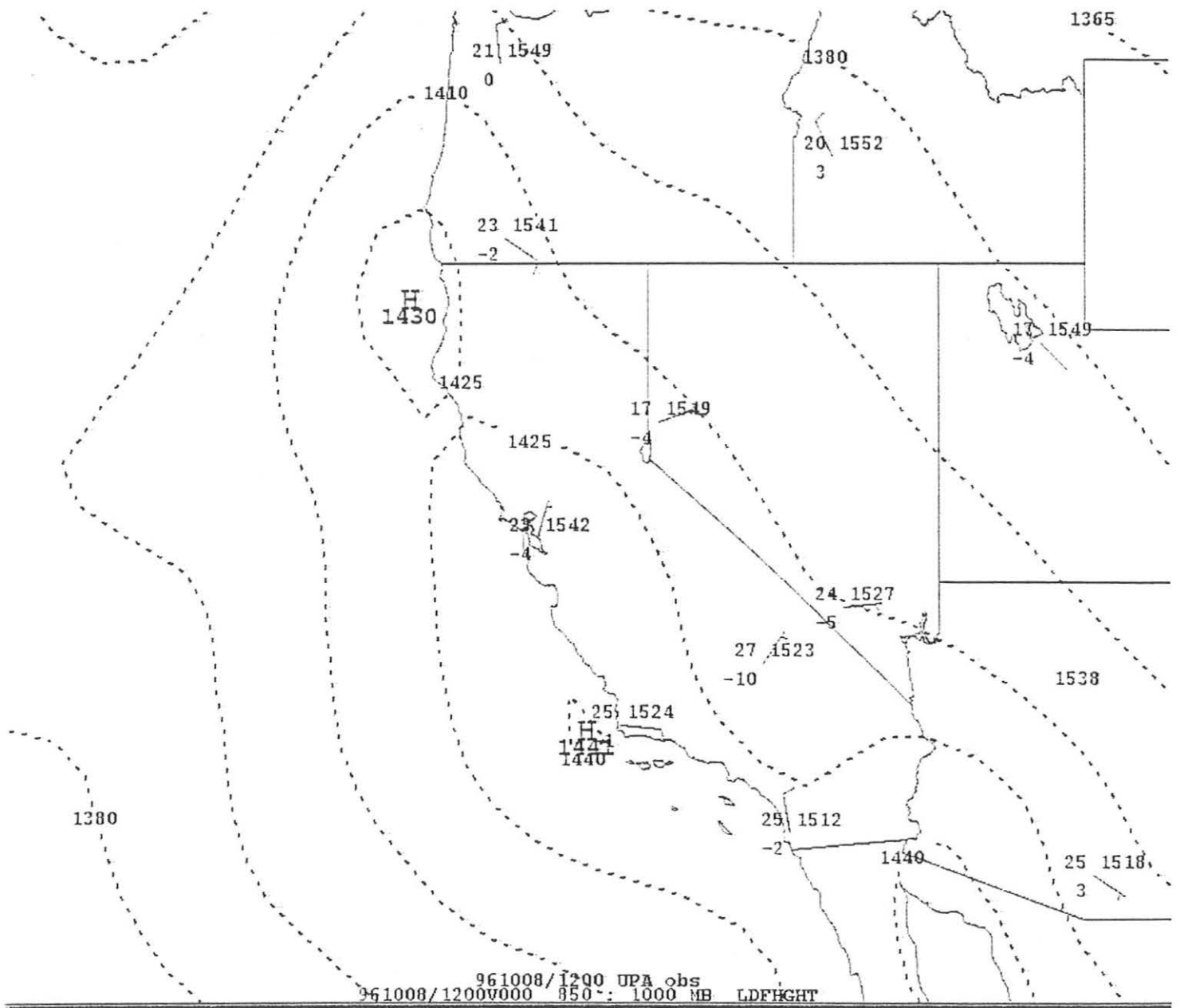


Fig. 3. 00 hr Eta model 12z Oct 8th 1996. 1000-850 mb thickness and 850 mb obs.

NPS 915 MHz Profiler: Fort Ord, CA — Low Mode

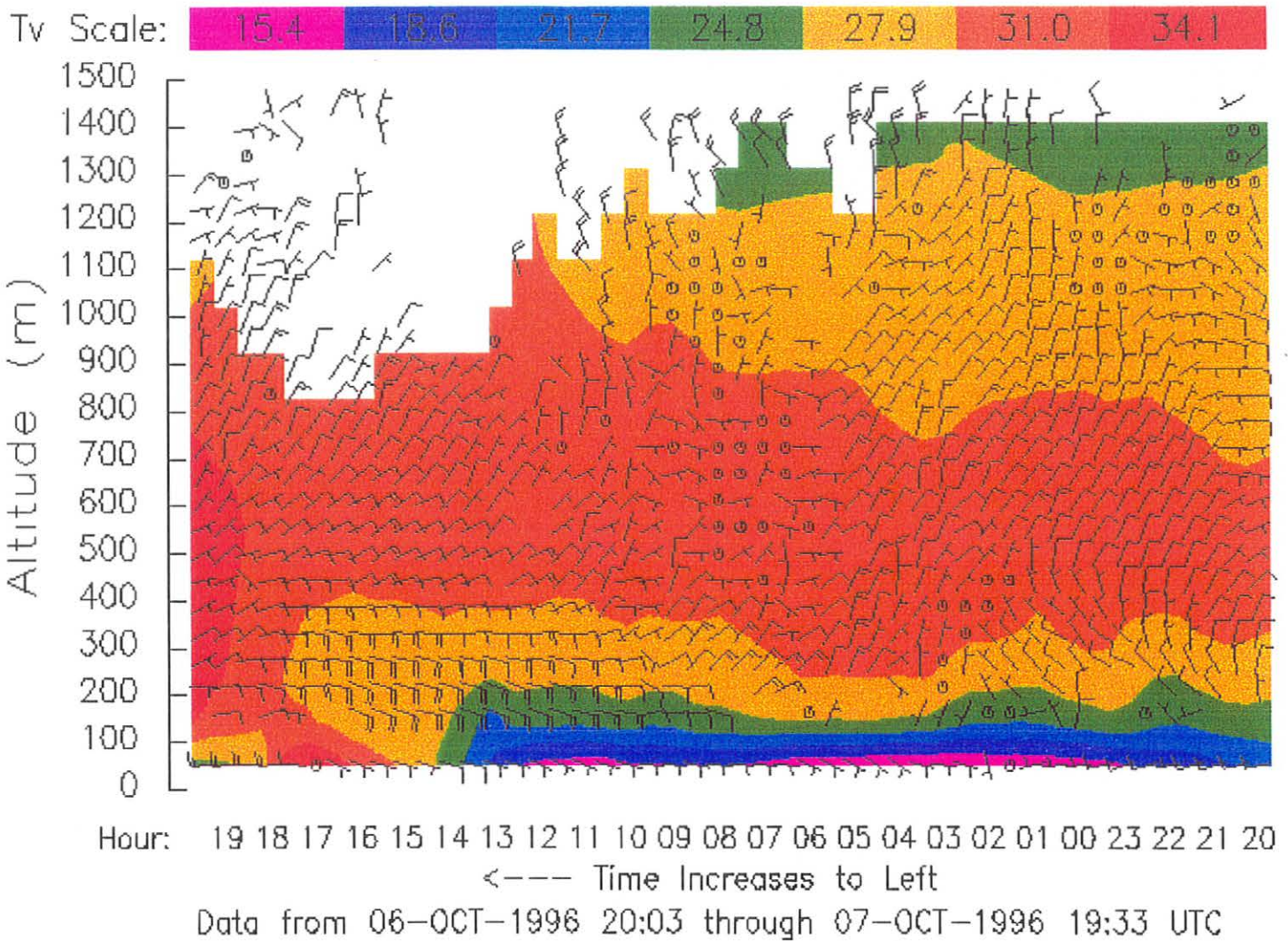


Fig. 4. Profiler Fort Ord, CA 20z Oct 6th-19z Oct 7th 1996. Altitude in meters, temperatures in Centigrade and winds in knots.

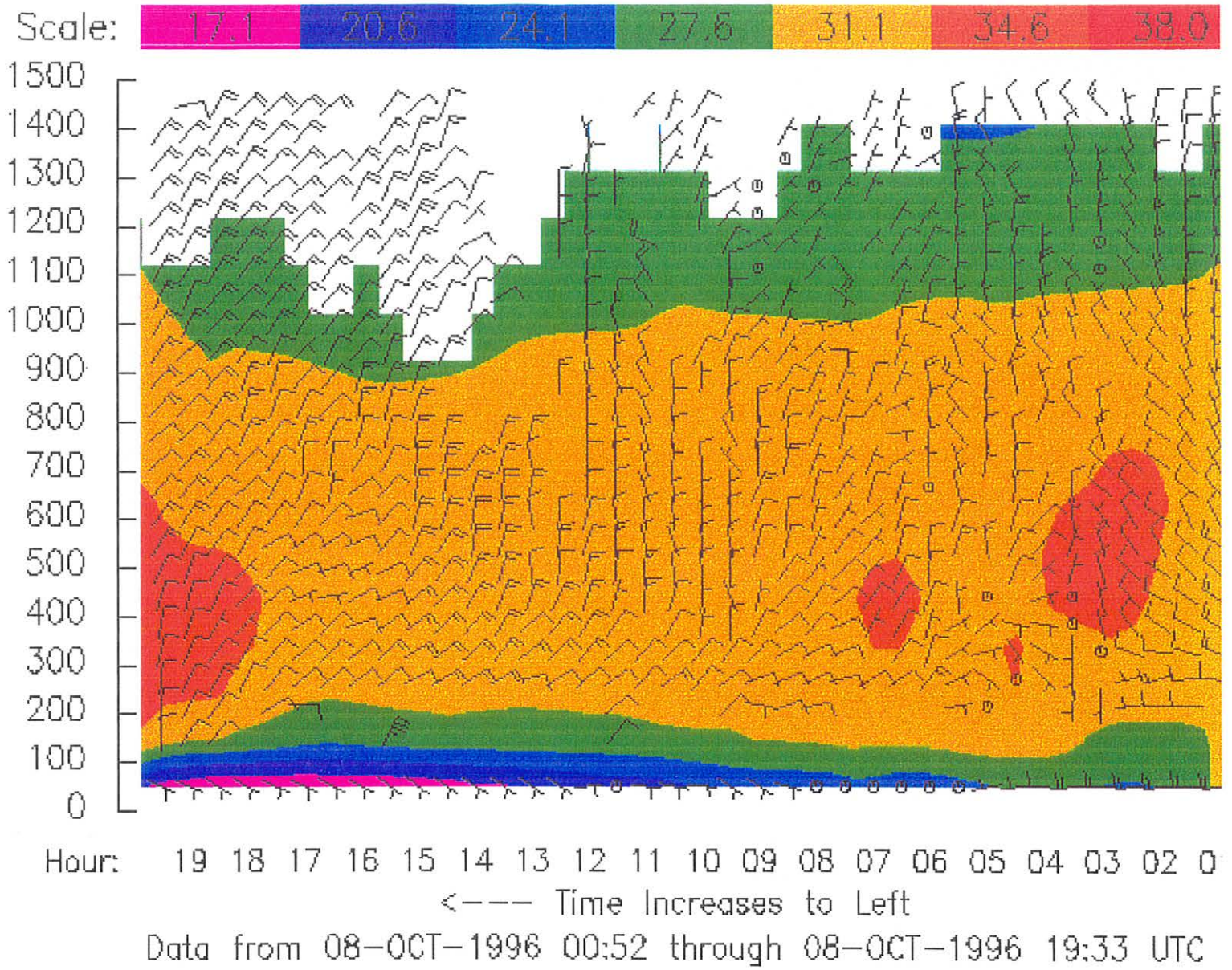


Fig. 5. Profiler Fort Ord, CA 01z Oct 8th-19z Oct 8th 1996. Altitude in meters, temperatures in Centigrade and winds in knots.

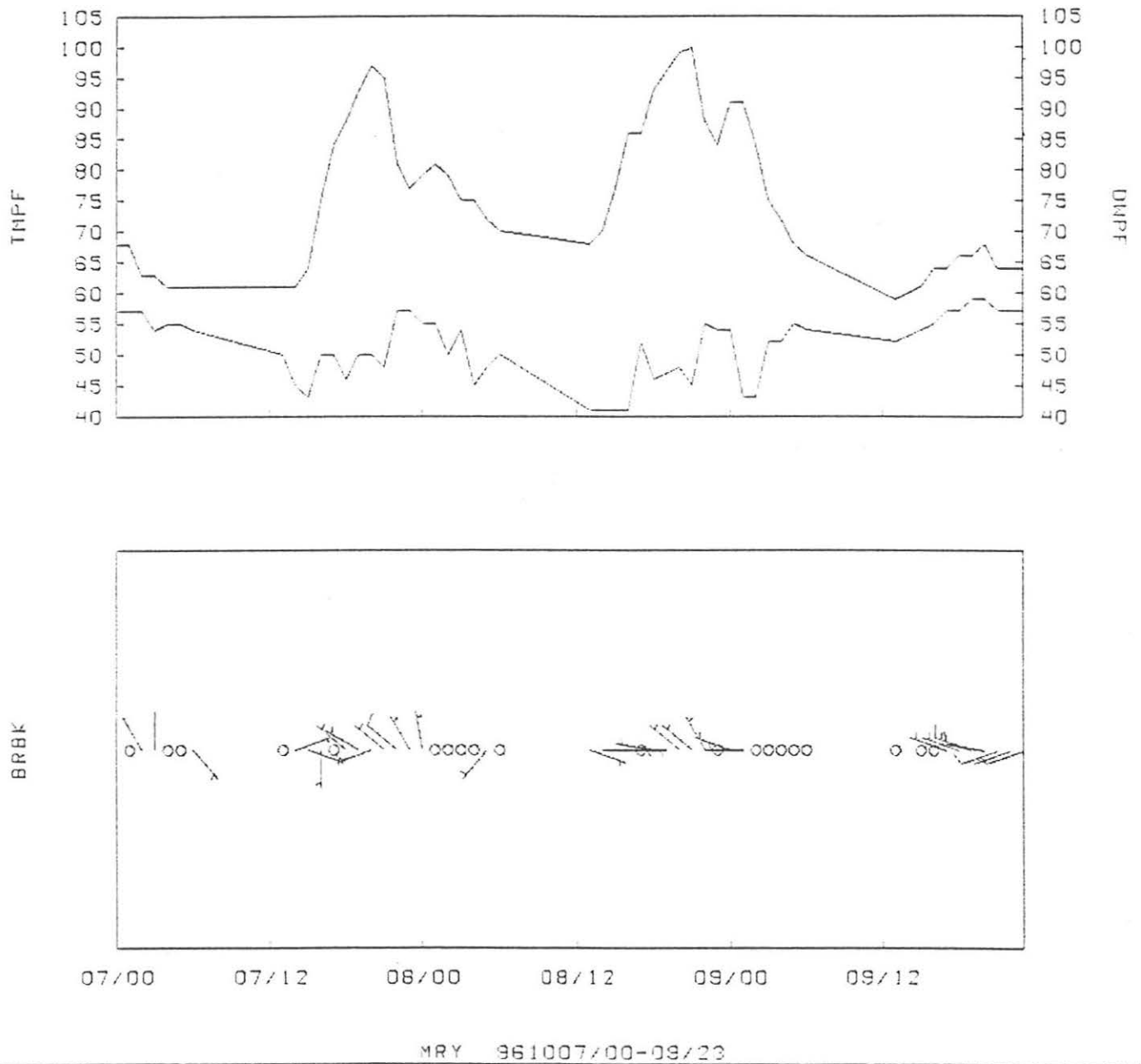
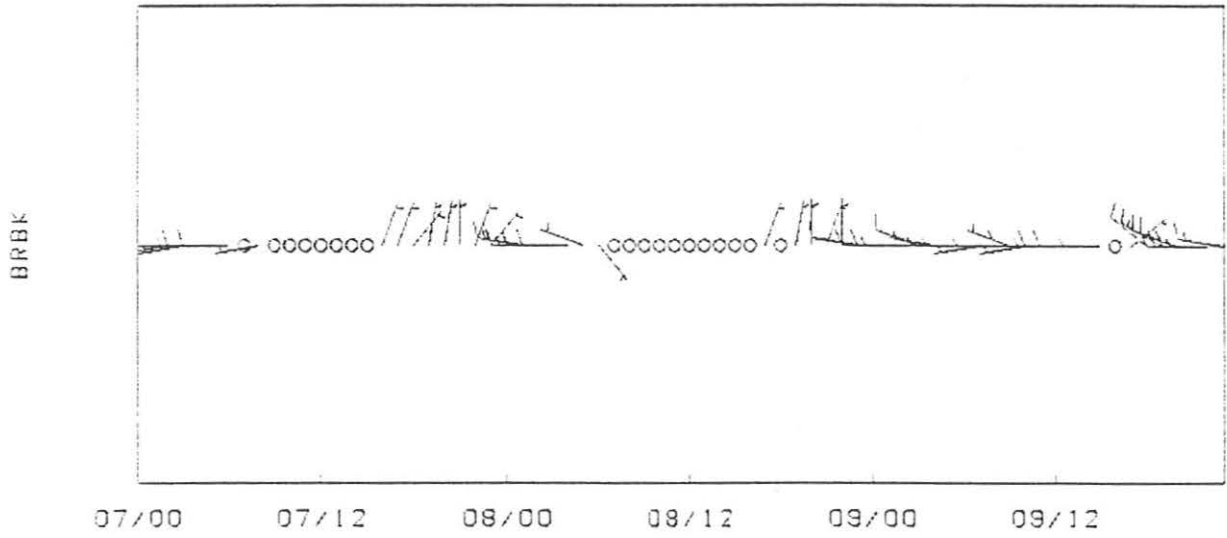
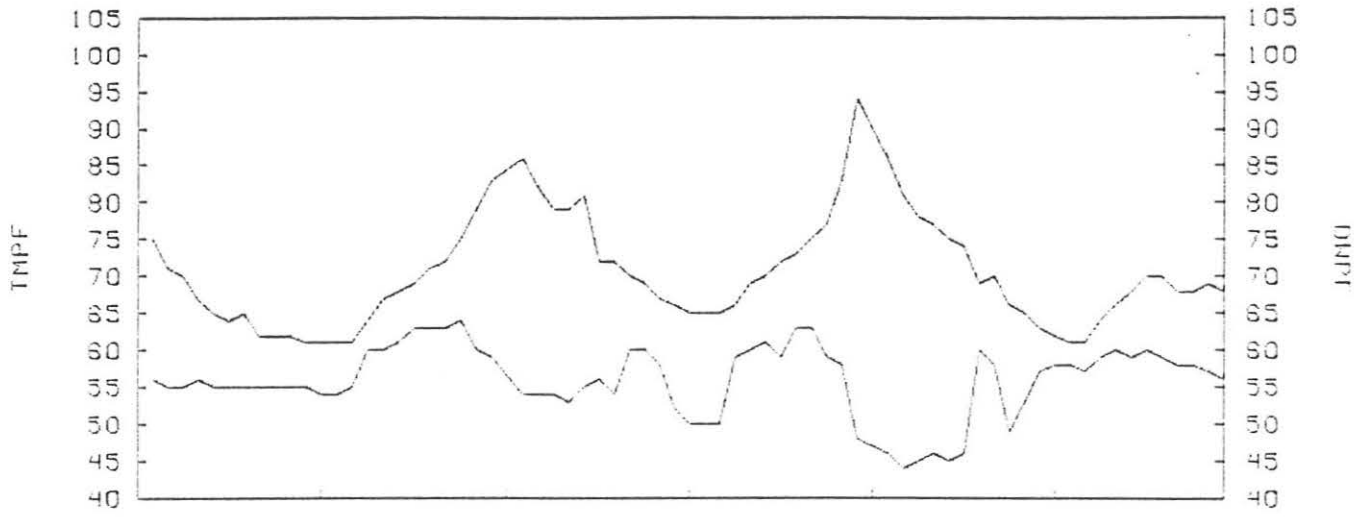


Fig. 6. Meteogram for Monterey, CA. 00z Oct 7th-23z Oct 9th 1996.



SFO 361007/00-09/23

Fig. 7. Meteogram for San Francisco airport, CA. 00z Oct 7th-23z Oct 9th 1996.

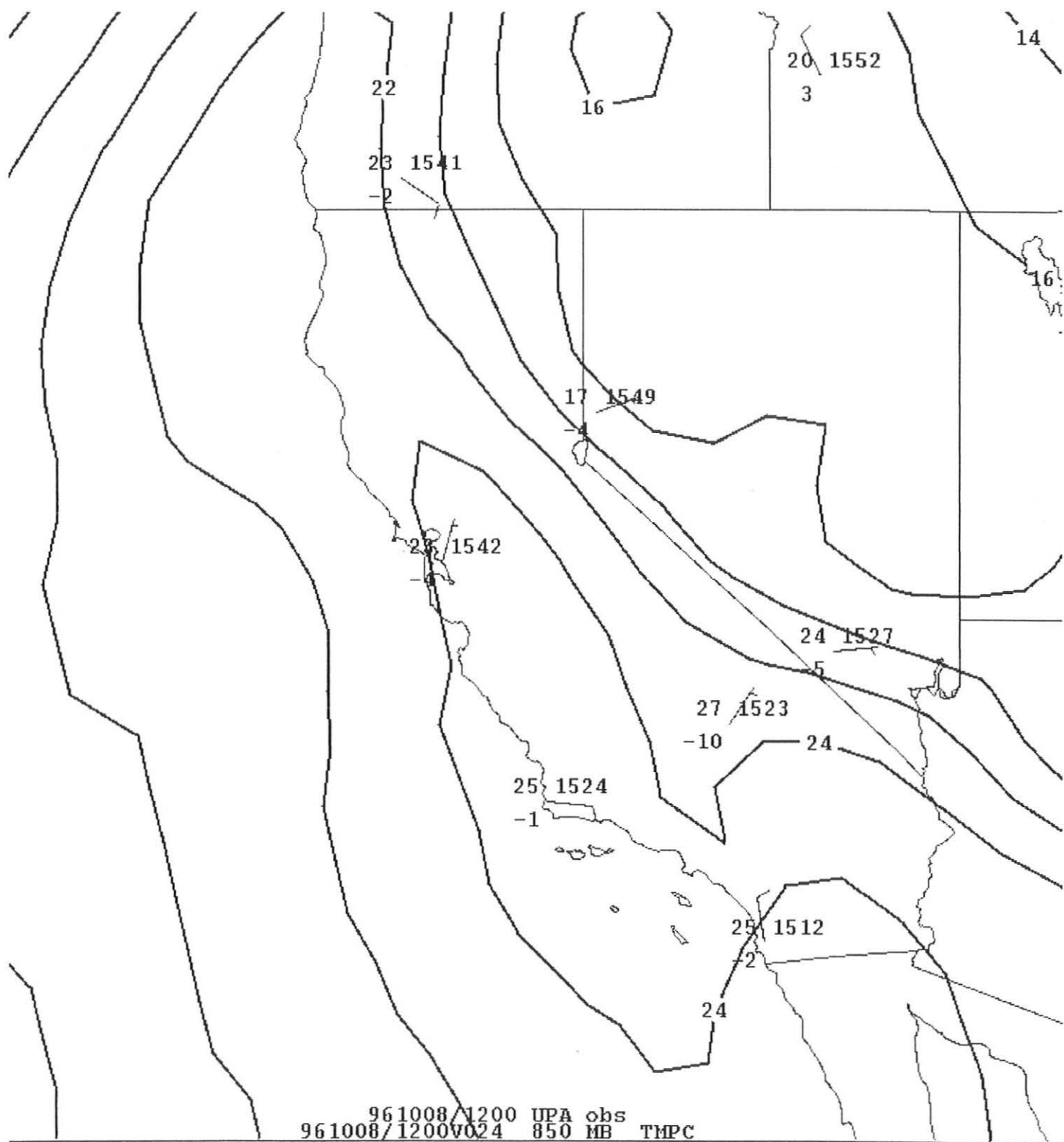


Fig. 8. 24 hr Eta model forecast of 850 mb temperatures (solid lines) valid at 12z Oct 8th and actual 850 mb obs. at 12z Oct 8th 1996.