CRH SSD
OCTOBER 1989

CENTRAL REGION TECHNICAL ATTACHMENT 89-32

GUST FRONT PRODUCES HIGH WINDS IN SOUTHEAST COLORADO
--- A CASE STUDY ---

Michael K. Holzinger
National Weather Service Forecast Office
Denver, Colorado

1. Introduction

On Wednesday, October 19, 1988, a line of showers and thunderstorms developed unexpectedly east of the Rockies and moved southeastward through eastern Colorado. The winds associated with the gust front reached or exceeded severe thunderstorm wind criteria at Pueblo and La Junta. This was a potentially life threatening situation, especially to aviation interests. The causative event was a moderately strong short wave which moved southeastward across Colorado. In general the event was not handled well by the models or by the forecasts.

The purpose of this paper is to create a heightened awareness on the part of forecasters for this type of event, which is not all that unusual in eastern Colorado. Also, some precursors to look for in the future are presented.

2. Description of Event

Upper air analyses at 12Z on Wednesday showed a trough over eastern Idaho with a generally west northwesterly flow aloft over the western U.S. and a closed low over Baja, California. The trough had a well defined wind shift plus colder air aloft associated with it (see hand-drawn 500 mb analysis -- Fig. 1). Although the LFM 12Z 500 mb initial analysis (Fig. 2) was reasonably good, the LFM and other 12-hr forecasts were not very good for that afternoon. Numerical guidance does not handle minor compact short waves in northwesterly flow aloft over Colorado. Guidance tends to lose the strength of the features and/or misplace them, giving the forecaster very little help in his/her forecast. The NGM often provides the best guidance in these situations since it maintains the strength of short waves the best. This was the case for this event even though it was not strong enough with the intensity of the trough.

Due to the lack of moisture, forecasts down-played both the threat of precipitation and convection in general. Through the morning hours there had not been much weather associated with the trough with only a few clouds and almost no precipitation reported west of the mountains. At 18Z (surface analysis, Fig. 3), there was a weak Pacific cold front moving into northwestern Colorado. Satellite pictures showed convective-looking clouds developing just east of the Rockies along the foothills.

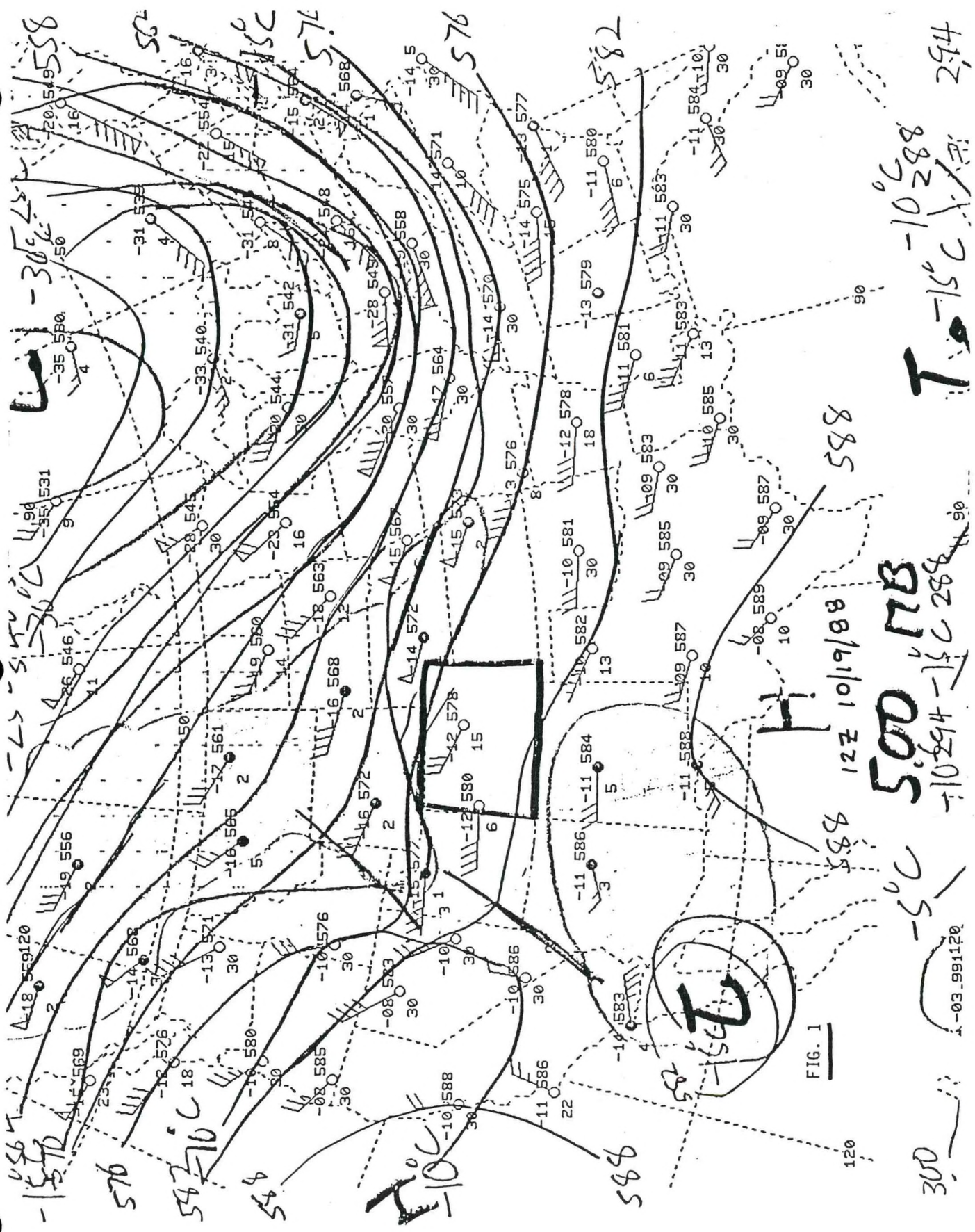
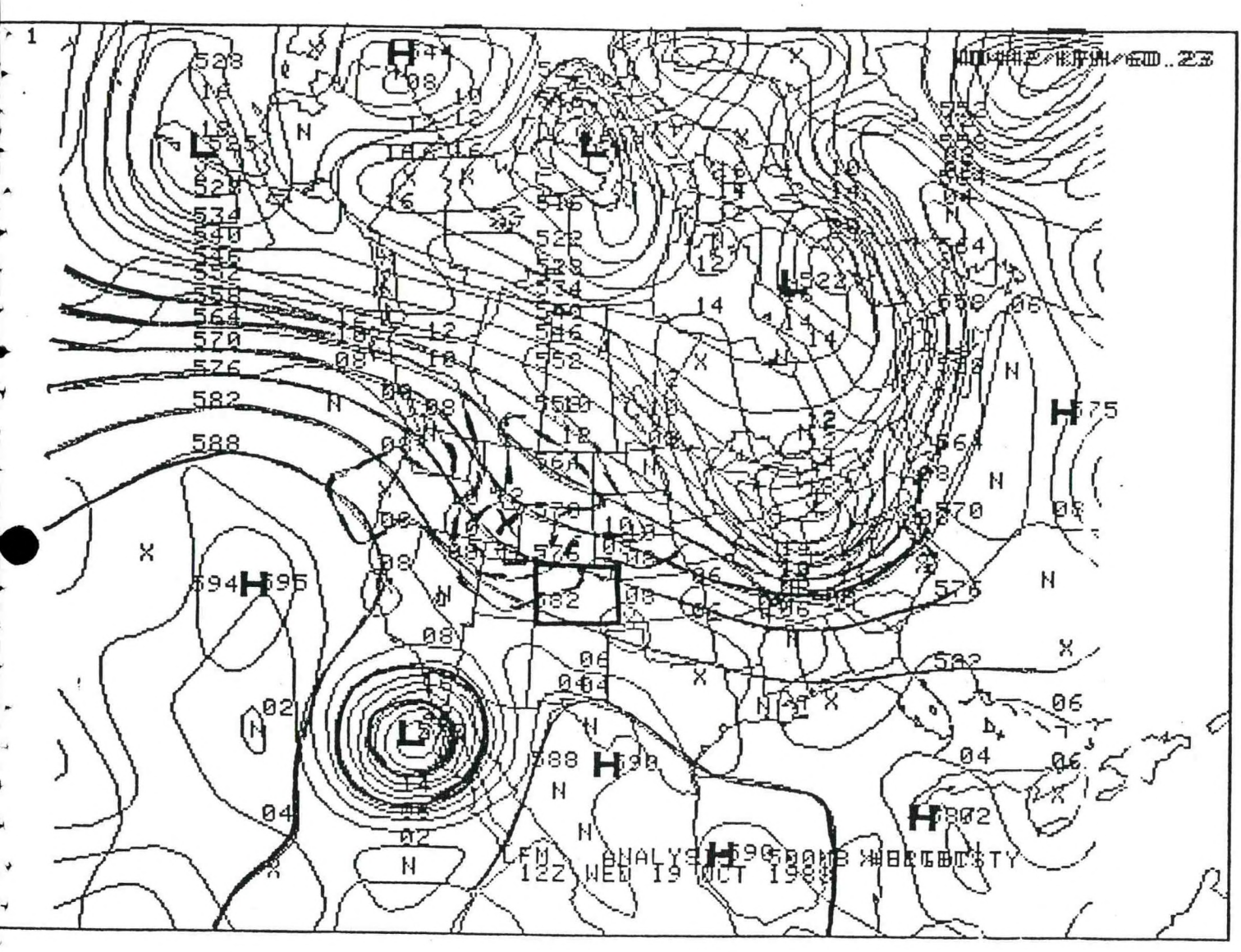


FIG. 1



912 507:
912 506:

LFM 500mb Vorticity 19-OCT-1988 12:00
LFM 500mb Height 19-OCT-1988 12:00

FIG. 2

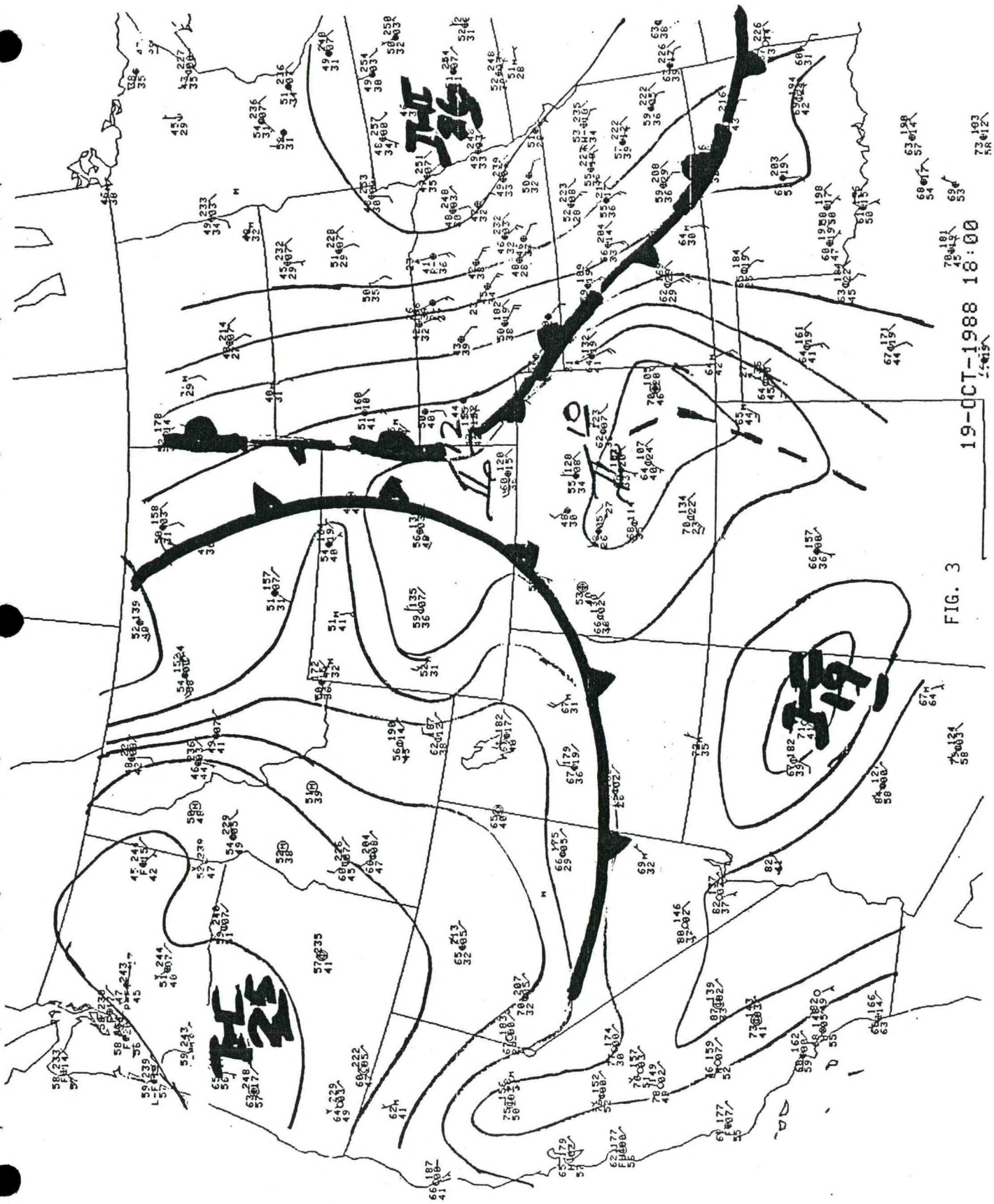


FIG. 3

At 18Z, the lowest surface pressure in the western U.S. was at Colorado Springs, and there was a moderately strong south-southeasterly low level jet over western Nebraska and western Kansas. But with dew points in the 30's in eastern Colorado, the forecaster decided to stay with the current forecast, keeping PoP's (probability of precipitation) low (10 percent or so).

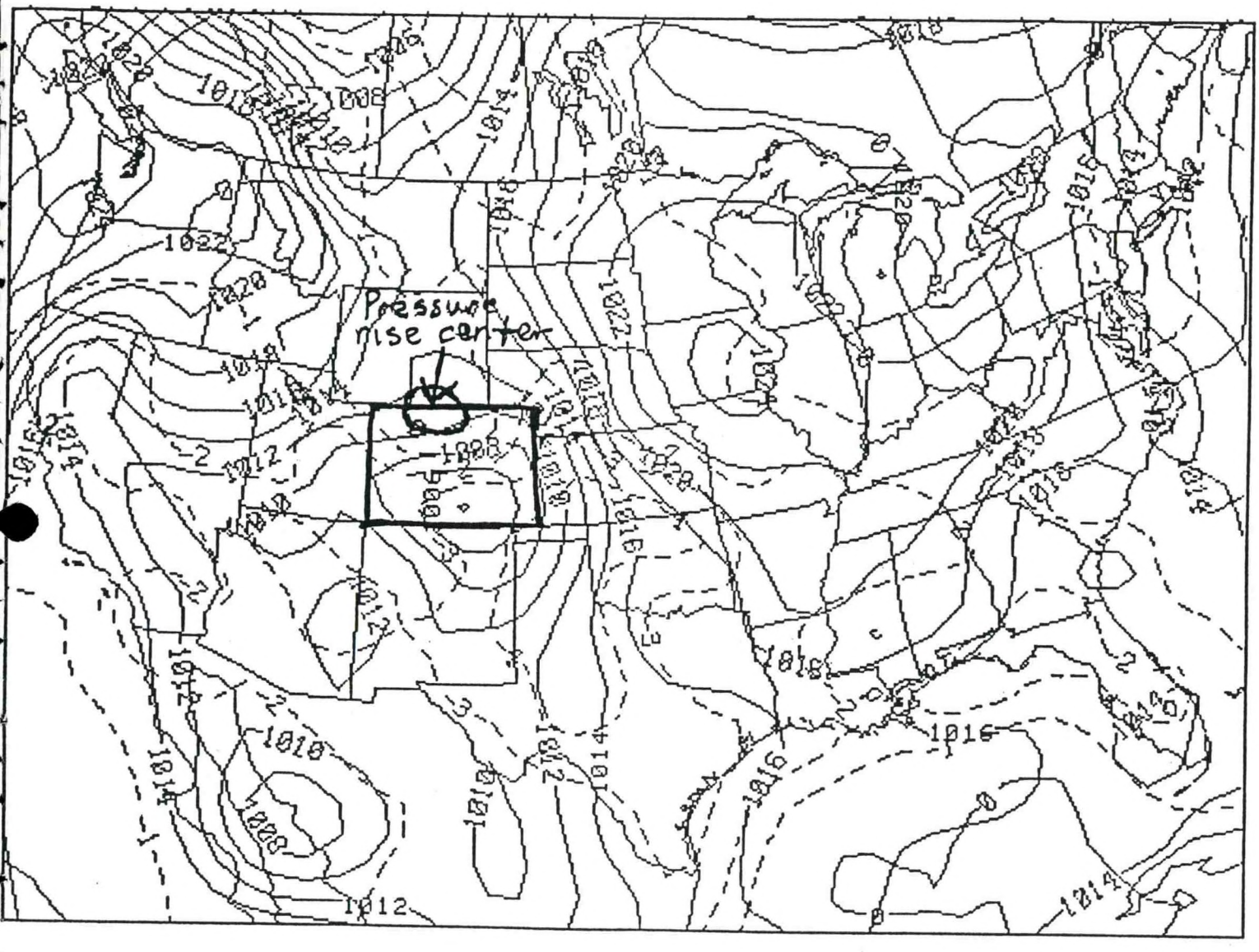
At 20Z, a line of showers and thunderstorms had moved off the foothills and was pushing through the Denver metro area. Temperatures at Denver reached only into the lower 60's ahead of the front. The maximum temperature-dew point spread was about 25 degrees. The PROFS (Program for Regional Observing Forecasting Services) surface analyses package (also called MAPS for "Mesoscale Analysis Prediction System") for 20Z (which updates every hour in the DARRRE work station) showed a weak surface pressure rise center over the central Wyoming-Colorado border (Fig. 4). The observations from Stapleton International Airport at Denver never showed any wind gusts worth mentioning. Limon radar showed some VIP level one and two echos in the area with a few VIP threes over the foothills southwest of Denver. CP2 (Doppler radar) was not available.

Near 21Z, a line of showers moved through Colorado Springs and winds gusted to 45 knots. Limon radar showed a line of three and four level echos developing over the Palmer Divide between Colorado Springs and Limon but only one and two level echos near Colorado Springs. Ahead of the front, the temperature at Colorado Springs reached 74 degrees with a temperature-dew point spread of nearly 50 degrees.

Near 22Z, a gust front went through Pueblo with wind gusts reaching 52 knots. Prior to passage, the temperature at Pueblo had reached 82 degrees with a temperature-dew point spread of 50 degrees. The gust front reached La Junta near 23Z with gusts reaching 55 knots. Ahead of the gust front, the temperature at La Junta had reached 75 degrees with a temperature-dew point spread of about 35 degrees.

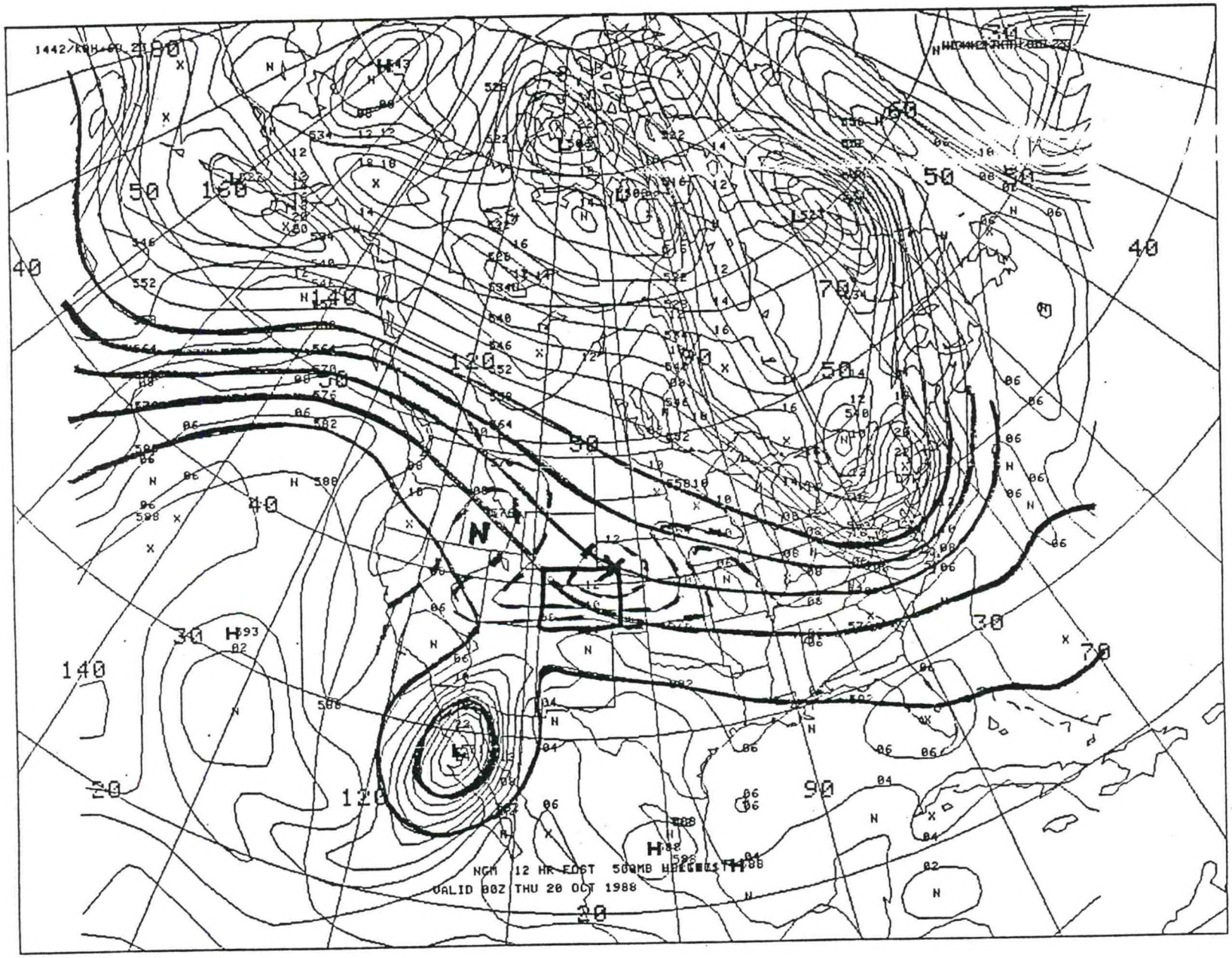
Denver, Colorado Springs, Pueblo, and La Junta, all received a shower but all had a trace of rain and no more. Of those stations, only Denver actually reported thunder.

Of the 12-hour 500 mb progs, the NGM came closest to reality (Fig. 5), showing the short wave closest in position and strength to observed conditions. Satellite pictures at 00Z and the hand-drawn 500 mb analysis (Fig. 6) revealed a moderately strong vorticity maximum near Limon at that time with a northeast-southwest trough from Akron to Alamosa. The MAPS analysis for 00Z (Fig. 7) and hand-drawn analysis (Fig. 8) showed a strong pressure surge moving through eastern Colorado. Profilers (Figs. 9 and 10) were very useful in identifying the location and passage of the trough axis. The Denver 00Z radiosonde (Fig. 11), when compared to the 12Z radiosonde (Fig. 12), confirmed that there had been cooling aloft and that a marked wind shift had occurred above 700 mb.



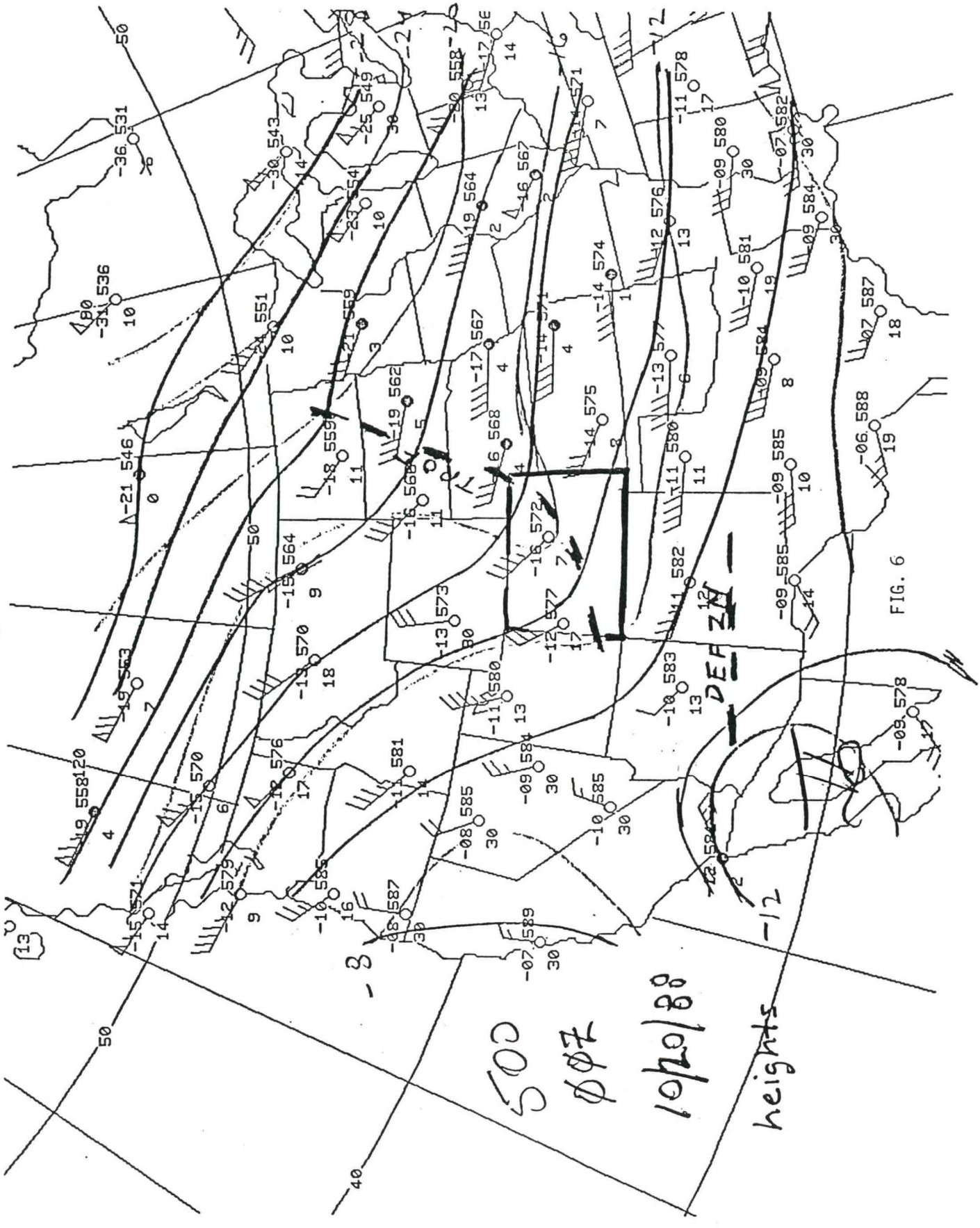
MAPS Anal 3-hour Pres Chg (mb) ending 19-Oct-1988 20:00
MAPS Anal Surfc Sea Level Pres (mb) 19-Oct-1988 20:00

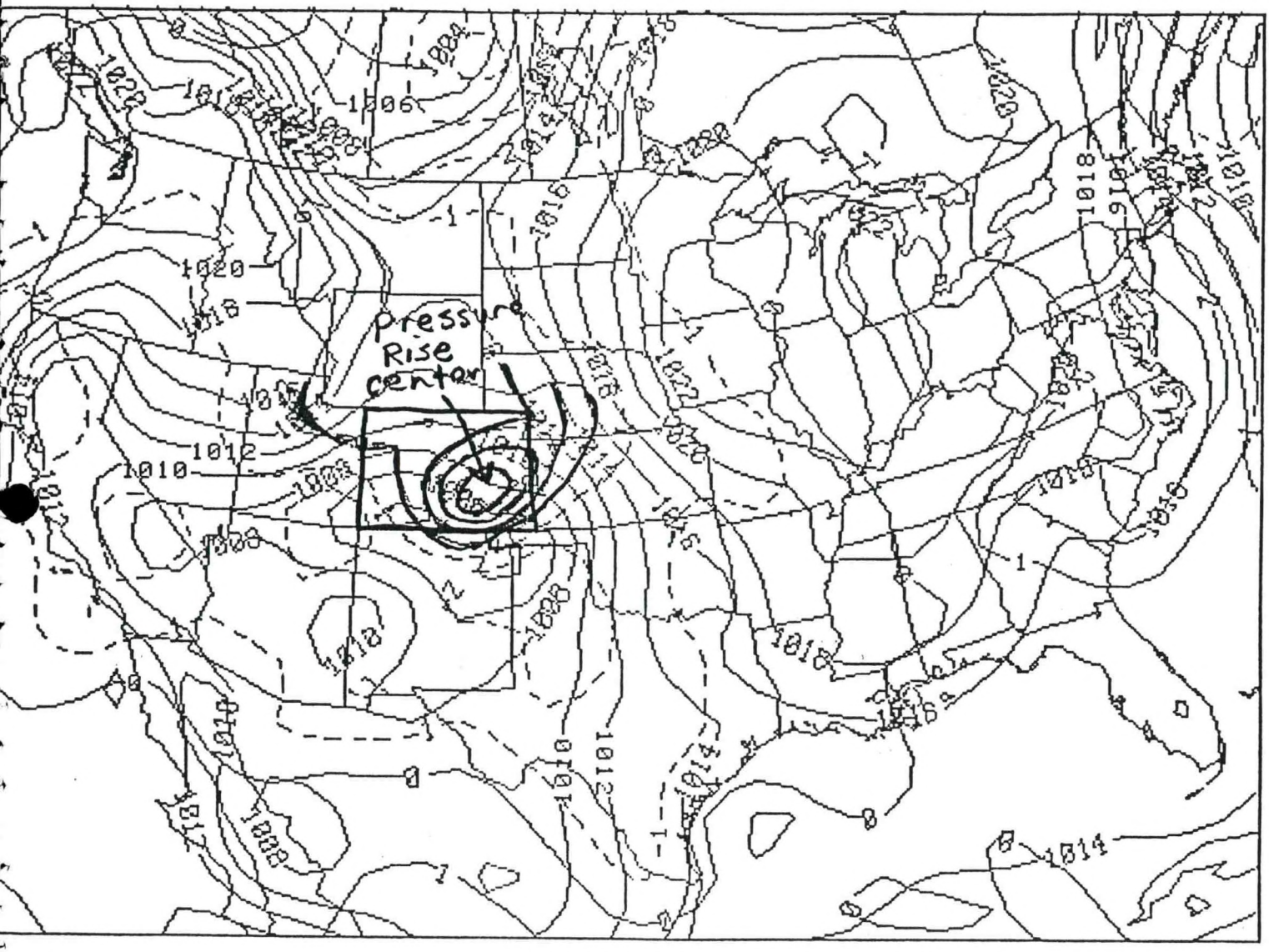
FIG. 4



1912 52V: 12h NGM 500mb Vorticity Forecast v Thu 20-OCT-1988 00:00
1912 52H: 12h NGM 500mb Height Forecast v Thu 20-OCT-1988 00:00

FIG. 5


500
Φ07
10/10/88
heights
DEA
FIG. 6



MAPS Anal 3-hour Pres Chg (mb) ending 20-Oct-1988 00:00
MAPS Anal Surfc Sea Level Pres (mb) 20-Oct-1988 00:00

FIG. 7

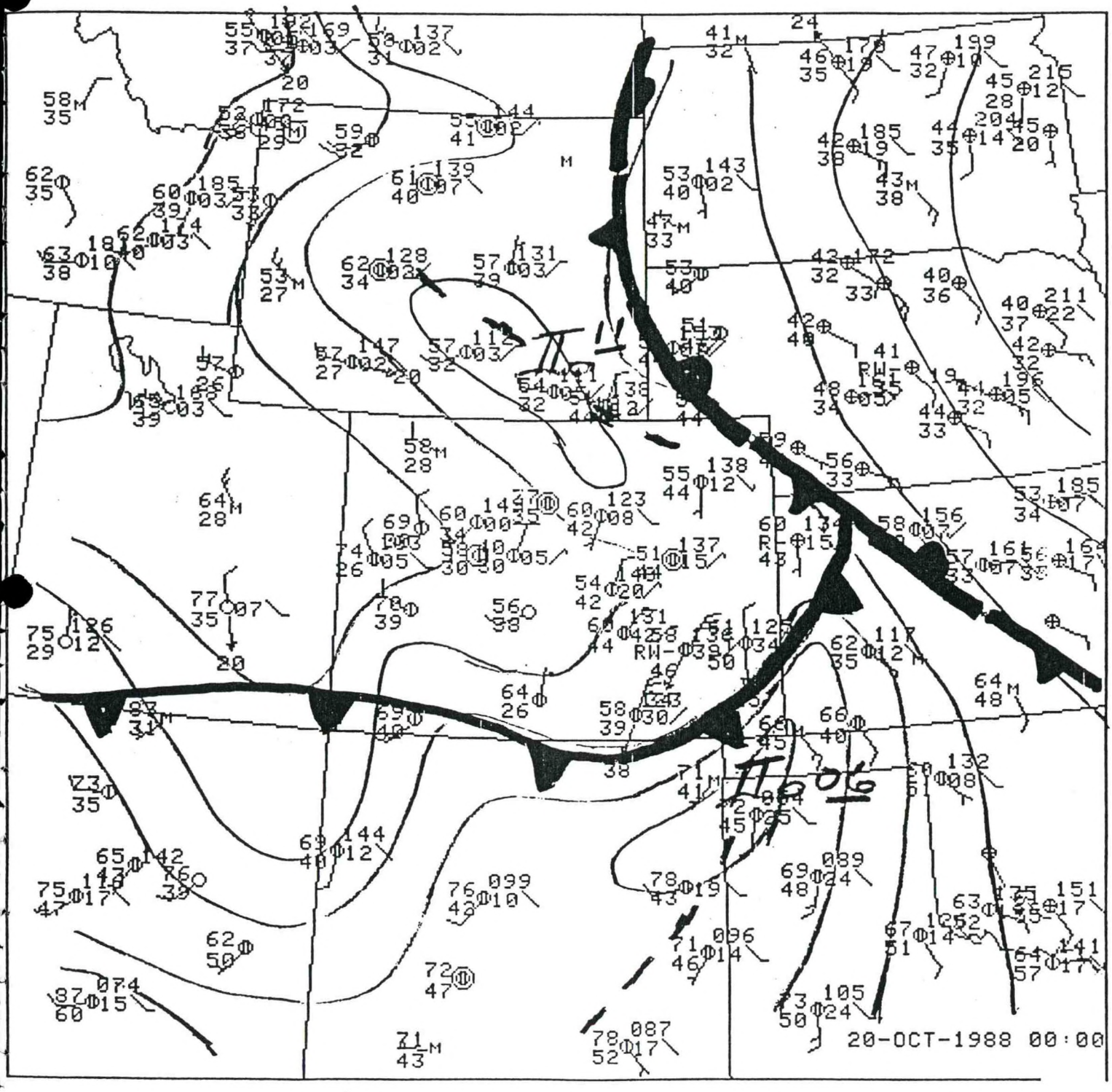


FIG. 8

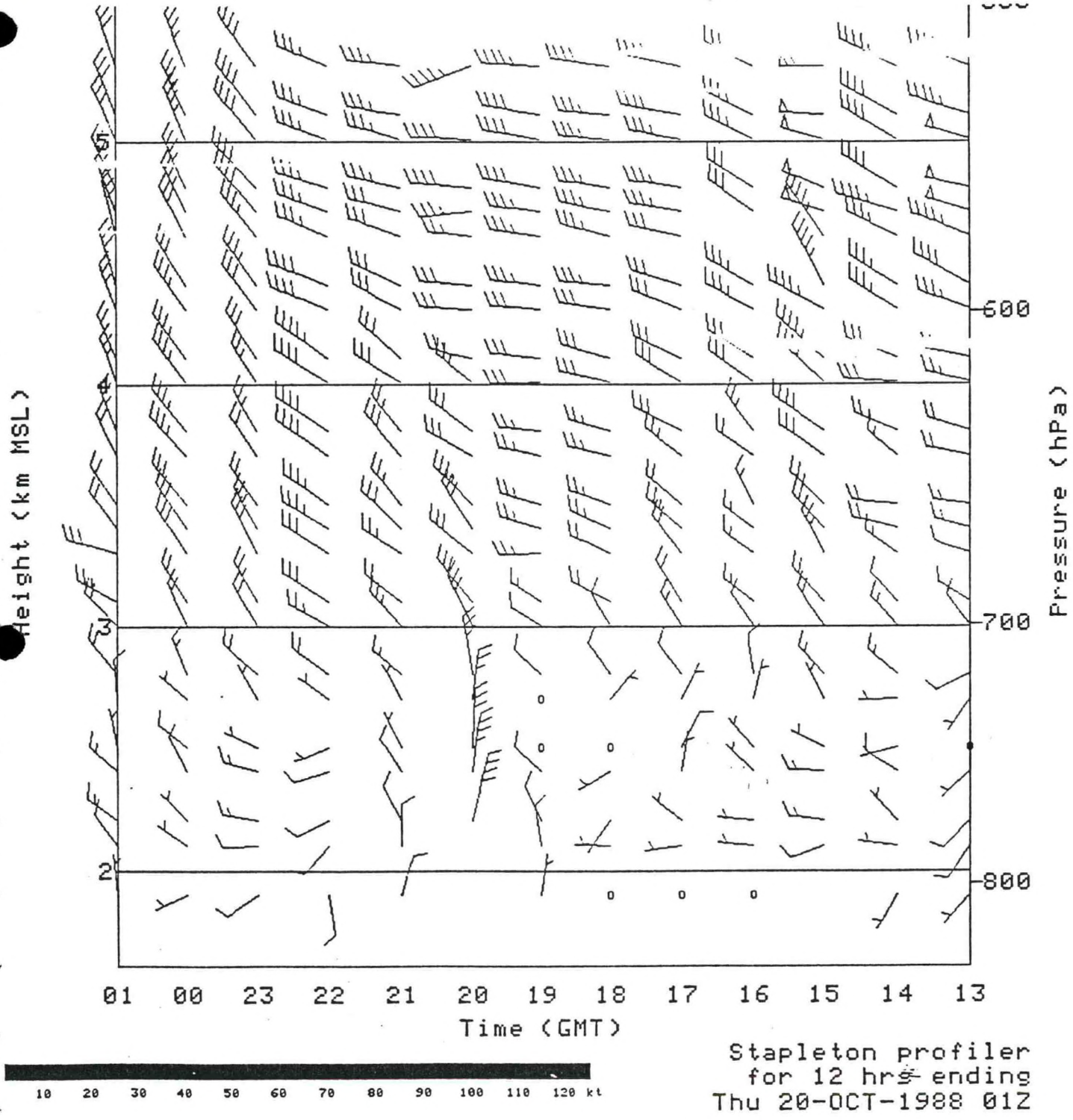

Height (km MSL)
5
4
3
2
600
700
800
Pressure (hPa)
01 00 23 22 21 20 19 18 17 16 15 14 13
Time (GMT)
10 20 30 40 50 60 70 80 90 100 110 120 kt
Stapleton profiler
for 12 hrs ending
Thu 20-OCT-1988 01Z

FIG. 9

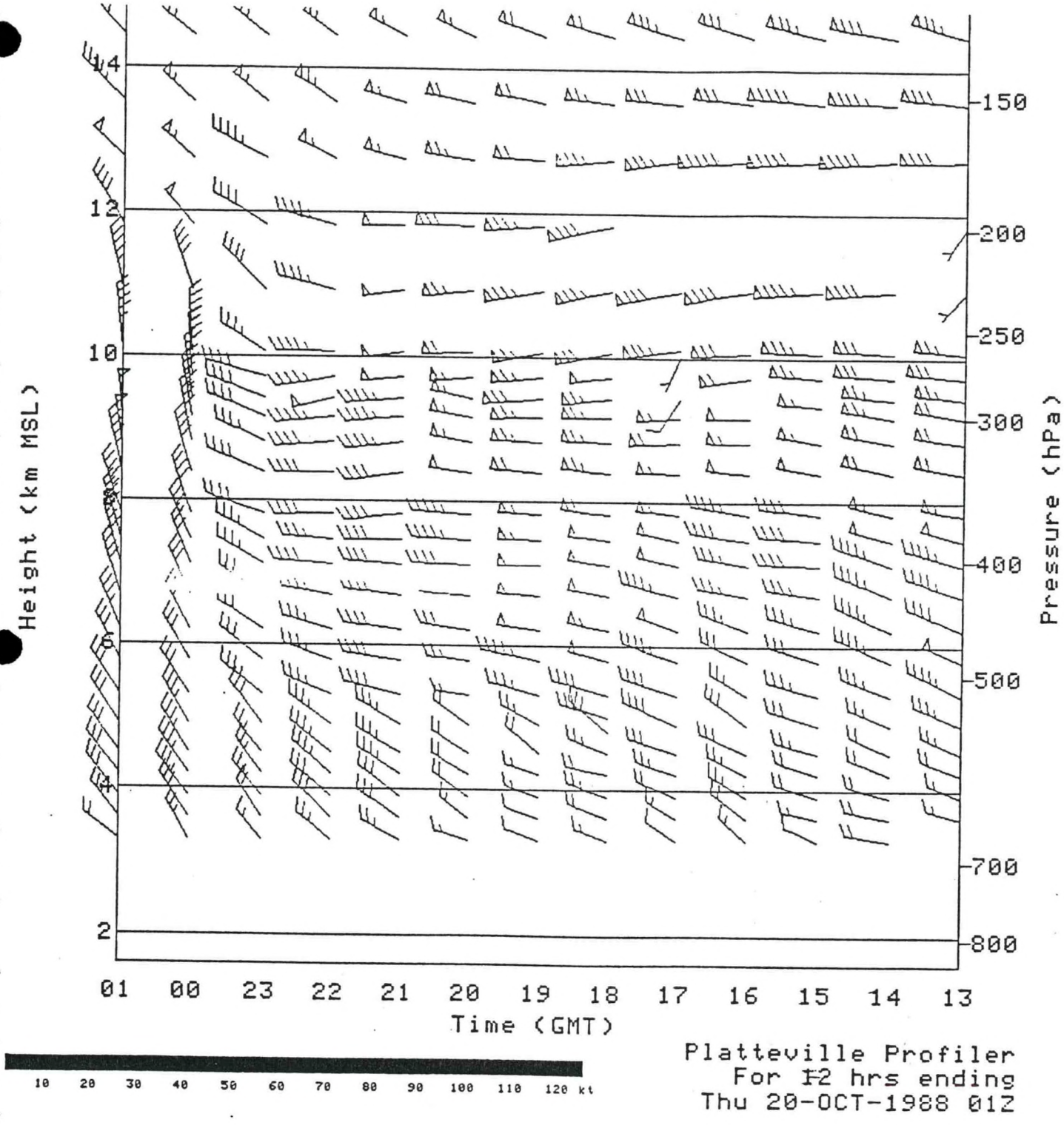

Height (km MSL)
14
12
10
8
6
4
2
Pressure (hPa)
150
200
250
300
400
500
700
800
01 00 23 22 21 20 19 18 17 16 15 14 13
Time (GMT)
10 20 30 40 50 60 70 80 90 100 110 120 kt
Platteville Profiler
For 12 hrs ending
Thu 20-OCT-1988 01Z

FIG. 10

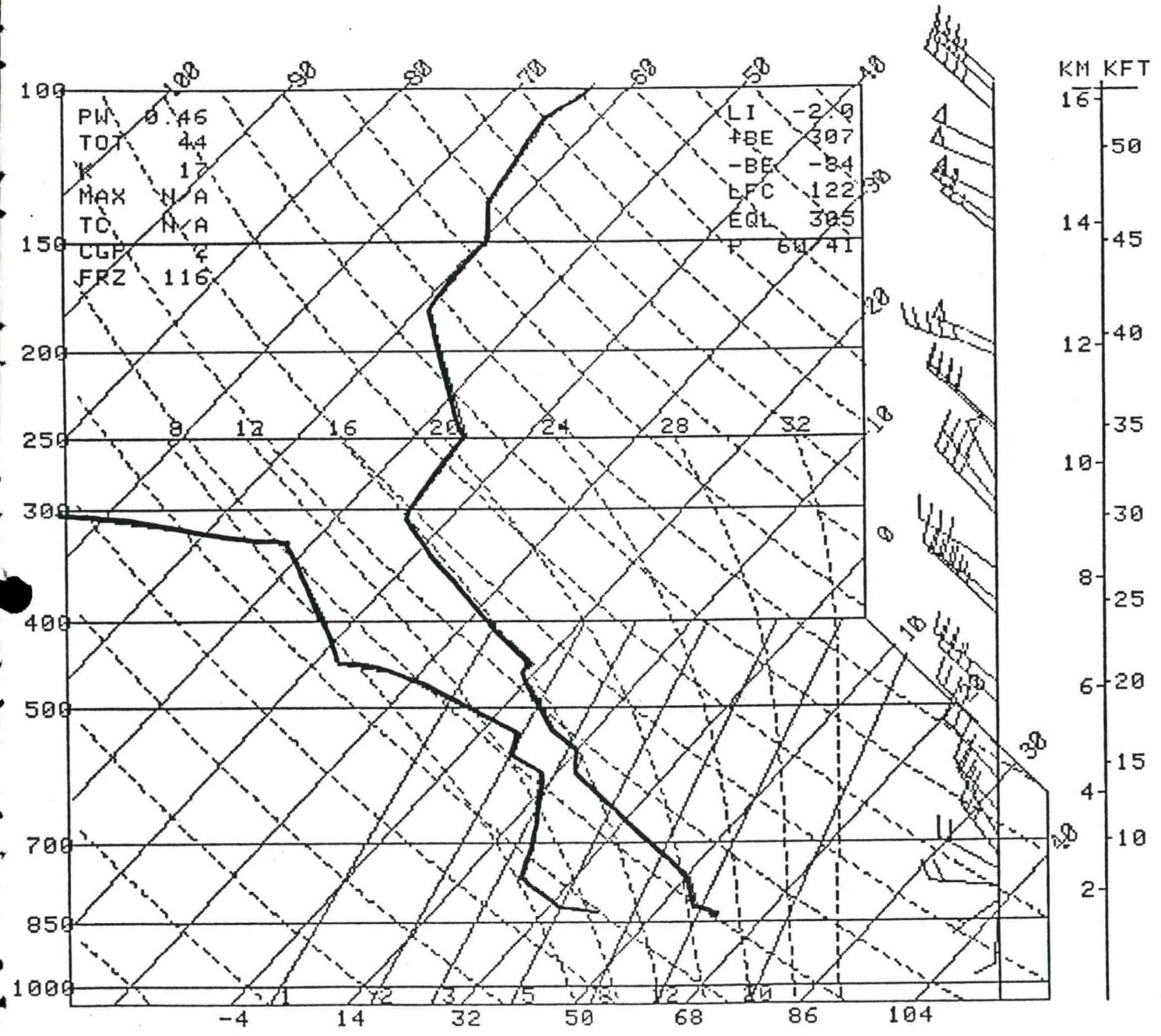

PW 0.46
TOT 44
K 17
MAX N/A
TC N/A
CAP 2
FRZ 116
LI -2.0
+BE 307
-BE -84
LFC 122
EQL 305
P 60/41
KM KFT
100
150
200
250
300
400
500
700
850
1000
-4
14
32
50
68
86
104
Denver CO
20-OCT-1988 00:00

FIG. 11

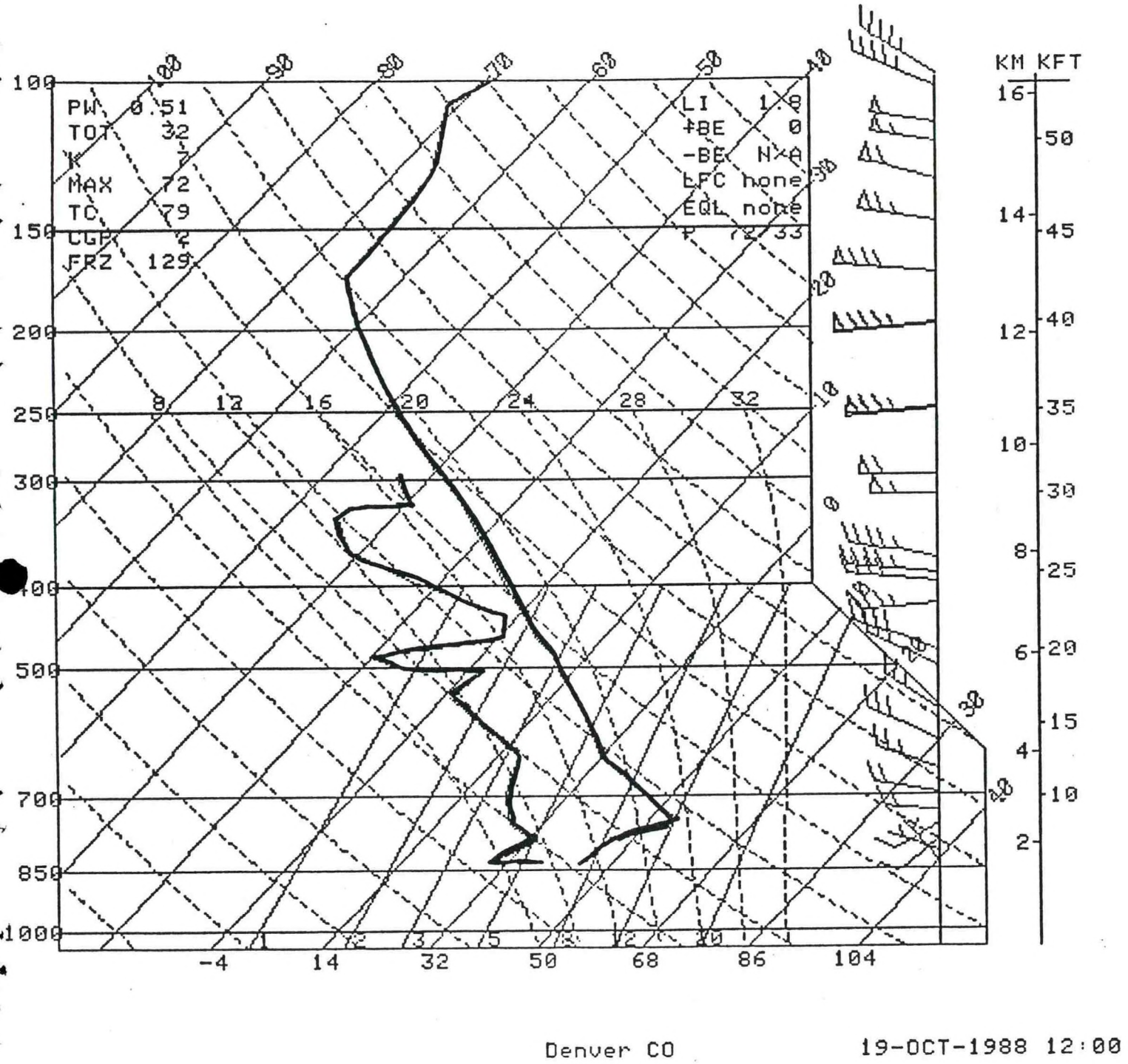

PW 0.51
TOT 32
MAX 72
TC 79
CCP 2
FRZ 129
LI 1.8
+BE 0
-BE N/A
LFC none
EQL none
P 72 33
KM KFT
Denver CO
19-OCT-1988 12:00

FIG. 12

Reasons for the unexpectedly strong convection:

1. A stronger short wave than indicated by the progs -- due to poor initial analyses and/or poor 12-hour progs.

2. Cooling aloft in concert with maximum daytime heating create conditional instability.

3. Low level convergence along the eastern foothills ahead of the trough maximized what little moisture was available.

4. Rain and virga-cooled air in and near the foothills provided a strong temperature gradient and pressure surge (which coincided with the Pacific front) which enhanced upward vertical motion and re-enforced the line of convection as it moved over the Plains.

5. Cold air moved downslope -- down the south side of the Palmer Divide -- and was re-enforced by continued showers and thunderstorms along and behind the gust (cold) front.

Some clues to look for in the future -- especially for the potential for winds to reach severe thunderstorm criteria:

1. A moderately strong upper level trough expected to move through eastern Colorado close to maximum heating. The trough may not be forecast well by the models. The forecaster should use satellite pictures and hand-drawn analyses to help locate and forecast the trough's location.

2. Big temperature-dew point spreads, on the order of 40 to 50 degrees, along the eastern foothills.

3. Strong low-level convergence just east of the mountains ahead of the trough.

4. Strong winds showing up somewhere along the eastern foothills in connection with rapidly developing convection which may appear stronger on satellite pictures than on radar. Due to the minimal amount of actual precipitation, Limon radar may be misleading in as far as the potential for strong winds is concerned.

5. Differences in air masses from point to point plus changes in the air mass between 12Z and maximum heating both can limit the usefulness of the computer algorithm used to identify Convective Gust Potential (CGP). In this case, the CGP indicated less potential than was actually present. Stations downslope from the initial strong winds would have the most potential for winds reaching the severe level.

Some additional points that should be made:

During the event, most sites east of the mountains had light showers, thunderstorms, or virga. Denver, Colorado Springs, Pueblo, and La

Junta, all had a trace of rain (see Fig. 13). If the public forecaster had known exactly what would happen, he or she would still be faced with a dilemma for two reasons:

1. PoPs and forecast wording...

As far as the PoPs are concerned, perfect local forecasts for Denver, Colorado Springs, and Pueblo would have been "numerous showers and a few thunderstorms," and "chance of measurable rain 10%." In the temperature/precipitation forecast (CCF), the forecaster would have zeros for PoPs. In the zones, the chance of rain would be higher than 10 percent since a few other stations did get measurable rain (i.e., Fort Collins and Limon). However, PoPs should have been not more than 20 or 30 percent for zones 11 (with Denver) and zone 16 (with Pueblo). Considering the higher terrain of zone 14 (with Colorado Springs) and the fact that radar echos were stronger there, the PoPs in zone 14 should have been in the 40-60 percent range.

This sort of scenario (very few stations getting measurable rain but very many getting a trace) is not at all unusual in eastern Colorado, especially near the foothills. Page 24 of WSOM Chapter C-11 provides guidance for PoP qualifying terms which is followed pretty closely, if not precisely, by forecasters at Denver. Cases like this are evidence that, in order to be able to provide an accurate forecast to the general public, the forecaster needs more flexibility to vary from the PoP qualifying terms guidance in the WSOM. As an example, the forecaster should be able to say, "showers or thunderstorms likely... chance of measurable rain 10 percent."

2. What would be the appropriate public warning to be issued in this case for Pueblo and La Junta? Is it a high wind warning or a severe thunderstorm warning? Winds at both places reached or exceeded the criteria defined locally for high winds (gusts to 60 mph or greater -- no duration required). The wind criteria for severe thunderstorm warning was also reached or exceeded per page 6 in WSOM Chapter C-40 (50 knots or more). However, there were no thunderstorms reported at either location. One might be inclined to think that a severe thunderstorm warning was not appropriate for that reason. On the other hand this was not a Chinook or gradient wind, but was associated with a line of convection and its gust front. So it does not fit the intent of a high wind warning, especially since it was very brief.

Were these severe thunderstorms, severe microbursts, severe macrobursts, severe downbursts, or none of the above? (We can get winds that meet severe wind criteria from microbursts in Colorado.) Obviously the public doesn't care what we call it. They just want to be warned! They would also be confused by terms such as microbursts. For the benefit of the forecaster, it would help to get this clarified. Facing a similar situation in the future, and able to anticipate what would happen, the forecaster, most logically, should issue a severe thunderstorm warning and worry later about whether thunder is actually reported.

DENSTPCO

TTAAOO KDEN 201228

COLORADO TEMPERATURE AND PRECIPITATION TABLE
NATIONAL WEATHER SERVICE DENVER CO
7 AM MDT THU OCT 20 1988

WEATHER AT AM
HIGH TEMPERATURE YESTERDAY
LOW TEMPERATURE PAST 12 HOURS
24 HOUR PRECIPITATION ENDING AT 6 AM
E..ESTIMATED DATA

...COLORADO...

	WEATHER	MAX	MIN	PCPN
AKRON	MOCLR	61	36	.01
ALAMOSA	MISG	73	MM	
ASPEN	CLEAR	61	E35	
BRIGHTON	MISG	E60	E34	
COLORADO SPRINGS	CLEAR	74	39	TRACE
CRAIG	MISG	E62	E22	.01
DENVER	CLEAR	61	35	TRACE
DURANGO	MISG	75	MM	
EAGLE	CLEAR	65	23	
ESTES PARK	MISG	E52	E40	.04
FORT COLLINS	MISG	61	MM	.02
FORT MORGAN	MISG	63	E34	.03
FRASER	MISG	53	MM	
GLENWOOD SPRINGS	MISG	69	MM	
GRAND JUNCTION	CLEAR	77	49	
GREELEY	MISG	62	E34	
GUNNISON	CLEAR	67	12	
LA JUNTA	CLEAR	75	38	TRACE
LAMAR	MISG	79	MM	.05
LEADVILLE	MISG	54	MM	
LIMON	CLEAR	66	36	.11
MONTROSE	CLEAR	72	E36	
PUEBLO	CLEAR	82	33	TRACE
RANGELY	MISG	MM	MM	
SALIDA	MISG	71	MM	
TRINIDAD	CLEAR	79	40	
WHEATRIDGE	CLEAR	67	33	TRACE
WINTER PARK	MISG	54	MM	.15

WILLIAMS

FIG. 13

4. A Final Note

This event caused winds to reach or exceed severe thunderstorm criteria at Pueblo and La Junta and almost at Colorado Springs. It was not a particularly spectacular or dramatic situation, but perhaps could be better forecast in the future. At the same time there are many variables and no two events are the same. Parallels may not come easy.

The most important point to be made is that aviation forecasts may need updating immediately, not only at the station initially affected, but at other stations that may be affected, even though there is a lot of uncertainty. A call to an affected FAA tower may be appropriate if the lead time is short, say 15 minutes or less. Sudden unexpected wind gusts can cause serious aircraft accidents, and an updated terminal forecast may save a life.