

Arctic Air in Boise:
Climatologically Favorable Upper Air Patterns and
Correlating Minimum Temperatures with 1200 GMT Snow Depth
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Introduction

Predicting the arrival of arctic air in the Treasure Valley is one of Boise's more difficult forecast regimes. We are challenged several times each winter with potential arctic seepage/spillage west of the Continental Divide. Quite often, these frigid air masses lack sufficient depth to spill into Idaho and remain banked up against the Divide. While modified arctic seepage can affect Boise with strong northerly flow aloft, arctic episodes are much more likely when an easterly component to the upper flow exists over southern British Columbia or eastern Idaho.

While medium range models can be relied upon to produce fairly accurate solutions in the three-five-day period, corresponding statistical temperature guidance can be poor. An example from December 1996 demonstrates this problem. In mid-December, Boise MRF statistical guidance (FMRBOI) days 2-5 minimums were all forecast to be below zero. The MRF 500 mb height forecasts verified well for this period, but the FMRBOI's forecast low temperatures were 15 to 20 degrees too cold on these days (Boise's lowest temperature on any of those days was 10 degrees). Contrary to the FMRBOI temperature guidance, the MRF's 500 mb height forecasts were not climatologically supportive for an arctic intrusion in Boise.

With a thorough understanding of climatologically favorable upper air patterns and other significant factors associated with arctic episodes in Boise, we may categorize a given day's model guidance as suspect, and make significant forecast improvements over guidance..

The Study

The goal of this project was to identify the upper level flows which have historically resulted in "arctic" or "modified arctic" air intrusions into Boise. Occurrences of minimum temperatures of 10 degrees or lower in Boise from January 1977 through December 1992 were examined along with their respective 500 mb height patterns. These were cross-checked with Boise's 1200 GMT snow depth. Appendix A shows all occurrences of minimums of 10 degrees or colder during the period, while Appendix B displays all minimums of zero or below from the 16-year period. Observed 1200 GMT snow depth is listed in the right column.

Findings

From 1977-1992, Boise recorded a minimum temperature of 10 degrees or lower 321 times. **In 92% of these cases, at least 1 inch or more of snow was observed on the ground at 12z.** In 4.5 percent of cases, a trace of snow was observed at 1200 GMT. And in **ONLY** 3.5 percent of cases was there no snow observed on the ground at all. It is obvious from these statistics that the extent of cooling realized in Boise is extremely dependent upon snow cover.

Boise recorded minimums of zero or below 105 times from 1977-1992. **In 94% of these cases, at least 1 inch or more of snow was observed on the ground at 1200 GMT.** In 4 percent of cases, a trace of snow was observed at 1200 GMT. And in only 2 percent of cases was there no snow observed on the ground at all (0 degrees, 12/29/78 and -2 degrees, 12/30/78).

Without measurable snow on the ground (trace or greater), the chances of reaching single digits in Boise are quite low. Furthermore, zero or below zero temperatures rarely occur in the absence of snow cover in Boise.

Upper Air Features - Pattern A vs. Pattern B

For arctic air to affect southwest Idaho, a strong shortwave must at some point traverse the Continental Divide, forcing a polar continental/arctic air mass west of the Rocky Mountains. Two general categories of arctic intrusions have been identified, based upon the track of upper level features with respect to the Continental Divide and Idaho.

Arctic intrusion in Boise can result from a shortwave which crosses the divide north of Idaho and drops into Washington and Oregon; These events will be referred to as Pattern A arctic outbreaks. Pattern A regimes force deep arctic air masses southward into Washington, Oregon and Idaho. On the other hand, if a similar Canadian shortwave traverses the divide along the Idaho/Montana border, arctic air may slosh over Monida pass and travel down the Snake River Valley to Boise; These events will be referred to as Pattern B arctic outbreaks.

Last year, Darrell produced a summary of 22 arctic outbreaks affecting Boise; Sixteen of these appeared to be Upper Snake River Valley "sloshers" (Pattern B), the other six came southward from Washington/British Columbia (Pattern A). Most of us are familiar with the upper air patterns associated with these events, but I've included a few examples from past arctic events for reference.

Examples - Pattern A

A good example of a typical Pattern A arctic intrusion in Boise is the December 5-15, 1972 arctic outbreak (Figures 1-10). A 500 mb upper ridge developed along the northern British Columbia coast with strong northerly flow and successive embedded short waves driving the cold air southward into Washington, Oregon and Idaho. Figure 1 shows a strong 500 mb shortwave over southern British Columbia. Note that the flow north of the shortwave is from the northeast with almost entirely over-land trajectory; This flow forces a frigid polar continental air mass west of the Canadian Rockies. Figures 2-10 show 1200 GMT 500 mb analyses from December

4-12, 1972. Note that a 500 mb high remains anchored over the northern British Columbia coast for the duration of the event. Boise experienced lows of -19, -21, -23, and -22 from the 8th through the 11th. **The coldest mornings in Boise occurred when 500 mb upper troughs existed over southwest Idaho at 1200 GMT.**

- why? - because the 500mb trough already (just recently) departed over the SW ID area? Yes, you do mention that later - but I think I would at least put a statement here.

Another good example of a Pattern A arctic occurred in January 1962 (Figures 11-16). In the days preceding the outbreak, a strong upper ridge once again developed over the central and northern British Columbia coast. Strong northerly flow and embedded shortwave troughs to the east of the ridge axis over British Columbia eventually pushed a frigid arctic air mass southward into the Pacific Northwest.

Figures 11-16 show 500 mb analyses from 00z January 20 1200 GMT January 22. Similar to example 1, the 00z January 20 500 mb analysis (Figure 11) shows a strong shortwave driving southward out of British Columbia. Note also that flow to the north British Columbia disturbance is from the northeast, forcing arctic air west of the divide in British Columbia and then southward into Washington, Oregon and Idaho. The disturbance progresses southward over the next 2 days, and eventually develops into a closed low over central California by 1200 GMT January 22. Sub-zero low temperatures were observed in Boise January 20-24, with individual minimums as follows...-6, -12, -11, -12, -4. Six inches of snow were on the ground throughout the event.

Examples - Pattern B

A good example of a Pattern B arctic is from December 1987. Figures 18-26 show the 500 mb flow from December 22-27, 1987. Figure 17 shows a moderate westerly flow at 500 mb over Washington, Idaho and Oregon. The 500 mb trof axis extends southwestward from southern British Columbia to 300 miles off of the Oregon coast while an upstream ridge strengthens and builds eastward around 130 degrees west. At this point, the 500 mb flow resembles that of Pattern A arctics. However, several features distinguish this flow from Pattern A.

The most important of these is the trajectory of the upper flow. At 00z on December 23, the trof axis is now over eastern Washington and Oregon. Note that the upstream flow is strong from the north-northwest and is over-water. Therefore, the flow at this point in time is advecting a colder *marine* air mass into the Pacific Northwest.

Through time, we see that the 500 mb ridge becomes positively tilted in southern British Columbia. By 1200 GMT December 24, the ridge axis is now aligned from southwest to northeast, inducing cyclogenesis in the central Great Basin and an increasing easterly component to the upper flow over Idaho. This modified arctic case is characteristic of Pattern B's in Boise. Arctic seepage typically occurs via Monida Pass and the Idaho Panhandle. However, the cooling is more gradual and less severe than with Pattern A arctics. The lowest temperature recorded in Boise during this scenario was 8 degrees on the December 24. No snow cover was observed.

Another factor distinguishing Pattern A's from Pattern B's is the position and amplitude of the upper ridge along and off of the British Columbia coast. Typically, Pattern A ridges are highly amplified and sharp; Their centers tend to be located along the central and especially northern British Columbia coast. Pattern B ridges are usually much flatter and are located further south, typically between 50 and 55 degrees north. The "flop-over" of the Pattern B ridge induces an easterly component to the upper flow, forcing arctic air to seep west of the divide.

A more recent Pattern B arctic occurred in Boise in January 1997. Unfortunately, no data is available from this event, but the evolution of the 500 mb height pattern closely resembles example 1 above. On January 11, 1997, arctic air spilled over Monida pass and down the Snake River Valley into Boise. Initially, a 500 mb ridge was located along the central and southern British Columbia coast. By the afternoon of January 11, the ridge became positively tilted with its axis aligned from central Saskatchewan to the southwest B.C. coast. This "flop-over" induced cyclogenesis and a strong northeast/east flow aloft over Montana and Idaho, which forced arctic air west of the divide through Monida Pass.

By Sunday morning January 12, a closed 500 mb low was located over south central Idaho, and a modified arctic airmass lay over Idaho and much of eastern Washington and Oregon. Two consecutive morning low temperatures of 8 degrees were recorded in Boise on January 12 and 13; A trace of snow lay on the ground both mornings. In all likelihood, minimums both mornings would have dipped below zero had an inch or more of snowcover lay on the ground.

Comparison of Patterns A and B

Patterns A and B are similar in that large 500 mb high centers are located along the British Columbia coast. In addition, moderate to strong northeast-east upper flow drives arctic air west of the Continental Divide in both patterns.

While pattern A arctics occur at least 50% less frequently than Pattern B's, they are historically more severe and of longer duration than Pattern B's. Pattern A arctics abruptly deliver a complete arctic airmass to southwest Idaho, while Pattern B's tend to gradually seep modified arctic or continental polar air masses into southwest Idaho over an extended period of time.

Snow

Accumulating snow is much more likely to occur in Boise with Pattern A arctics, as seen in the above cases. Strong westerly flow induced to the south of strong southward-moving British Columbia shortwaves increase the likelihood for accumulating snows before arctic air arrives.

In the January 1962 case, 5 inches of snow fell on January 20 before the arctic air arrived. Clear skies combined with the snowcover to produce rapid cooling from sunset through midnight. The January 20 low (-6 degrees F) was recorded at 11:59 PM. In the 1972 Pattern A case, 2 inches of snow fell on December 3, and 4 inches fell on the December 6 from successive shortwaves tracking southward along the B.C./Washington coastline. Both shortwaves induced a west-southwest over-water trajectory, transporting Pacific moisture into southern Idaho.

In general, Pattern B systems are usually very dry, and are typically moisture-starved by the time cold air arrives in southwest Idaho. However, Pattern B's will occasionally share Pattern A's tendency to increase westerly flow and moisture ahead of the cold air (note the first Pattern B example above), producing snow in Boise. However, most snowfall amounts associated with Pattern B's are light (usually less than one inch).

Conclusions

Arctic air intrusion west of the continental divide is a significant and common winter forecast problem in Idaho. Familiarity with climatologically favorable upper air patterns and an understanding of the correlation of sub-zero temperatures with snowcover in Boise increases short-medium range forecasting skill and can help us overcome statistical guidance assumptions and/or biases.

The intrusion of an arctic airmass in and of itself will not often produce sub-zero temperatures in Boise. Snowcover of an inch or more greatly increases the likelihood of Boise's minimum temperature reaching 10 degrees or colder, and is required in all but the coldest of air masses for minimum temperatures to drop to zero or below in Boise.

MINIMUM TEMPERATURES $\leq 10^{\circ}$ F, 1977-1992 (Boise)
APPENDIX A

Sunday, February 09, 1997

IDTPT3

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Station	Month	Date	Max	Min	Pcpn	Snow	(Inches) Snow on Ground
BOI	1.00	1/4/77	30.00	8.00	1.00	2.00	5
BOI	1.00	1/5/77	21.00	3.00	-1.00	-1.00	↓
BOI	1.00	1/6/77	18.00	-4.00	0.00	0.00	↓
BOI	1.00	1/7/77	9.00	-5.00	-1.00	-1.00	↓
BOI	1.00	1/8/77	6.00	-14.00	-1.00	-1.00	↓
BOI	1.00	1/9/77	16.00	-13.00	0.00	0.00	↓
BOI	1.00	1/10/77	10.00	-8.00	0.00	0.00	↓
BOI	1.00	1/11/77	24.00	7.00	0.00	0.00	↓
BOI	1.00	1/12/77	24.00	8.00	1.00	1.00	↓
BOI	1.00	1/15/77	31.00	8.00	-1.00	-1.00	4
BOI	1.00	1/26/77	23.00	10.00	-1.00	-1.00	3
BOI	2.00	2/4/77	24.00	7.00	-1.00	-1.00	3
BOI	12.00	12/31/77	33.00	8.00	4.00	7.00	1
BOI	1.00	1/1/78	26.00	7.00	0.00	0.00	1
BOI	2.00	2/16/78	38.00	10.00	0.00	0.00	3
BOI	11.00	11/10/78	33.00	10.00	-1.00	-1.00	0
BOI	11.00	11/13/78	37.00	10.00	0.00	0.00	0
BOI	12.00	12/7/78	28.00	10.00	0.00	0.00	0
BOI	12.00	12/14/78	32.00	10.00	0.00	0.00	0
BOI	12.00	12/15/78	34.00	10.00	-1.00	-1.00	0
BOI	12.00	12/28/78	28.00	7.00	0.00	0.00	0
BOI	12.00	12/29/78	17.00	0.00	0.00	0.00	0
BOI	12.00	12/30/78	16.00	-2.00	0.00	0.00	0
BOI	12.00	12/31/78	11.00	-9.00	2.00	2.00	0
BOI	1.00	1/1/79	14.00	-10.00	0.00	0.00	0
BOI	1.00	1/2/79	16.00	7.00	1.00	1.00	1
BOI	1.00	1/3/79	23.00	6.00	3.00	4.00	1
BOI	1.00	1/4/79	22.00	6.00	3.00	3.00	↓
BOI	1.00	1/5/79	22.00	10.00	-1.00	-1.00	↓
BOI	1.00	1/6/79	13.00	-6.00	-1.00	-1.00	↓
BOI	1.00	1/7/79	17.00	-10.00	0.00	0.00	↓
BOI	1.00	1/8/79	18.00	-9.00	-1.00	-1.00	↓
BOI	1.00	1/18/79	24.00	6.00	1.00	2.00	2
BOI	1.00	1/19/79	25.00	3.00	-1.00	-1.00	↓
BOI	1.00	1/22/79	27.00	4.00	0.00	0.00	↓
BOI	1.00	1/23/79	28.00	3.00	0.00	0.00	↓
BOI	1.00	1/24/79	23.00	10.00	10.00	14.00	↓
BOI	1.00	1/25/79	22.00	3.00	4.00	4.00	3
BOI	1.00	1/26/79	23.00	-8.00	-1.00	-1.00	↓
BOI	1.00	1/27/79	23.00	2.00	6.00	8.00	↓
BOI	1.00	1/28/79	21.00	10.00	2.00	2.00	↓
BOI	1.00	1/29/79	15.00	-8.00	1.00	-1.00	↓
BOI	1.00	1/30/79	17.00	-13.00	-1.00	-1.00	↓
BOI	1.00	1/31/79	17.00	-12.00	-1.00	-1.00	↓
BOI	2.00	2/1/79	15.00	-5.00	2.00	7.00	4
BOI	2.00	2/2/79	21.00	-12.00	0.00	0.00	4
BOI	2.00	2/3/79	24.00	0.00	7.00	9.00	↓
BOI	11.00	11/27/79	32.00	8.00	0.00	0.00	↓
BOI	11.00	11/28/79	20.00	4.00	0.00	0.00	3
BOI	11.00	11/29/79	25.00	6.00	0.00	0.00	↓
BOI	11.00	11/30/79	25.00	5.00	0.00	0.00	↓
BOI	1.00	1/27/80	19.00	-7.00	6.00	8.00	1
BOI	1.00	1/28/80	16.00	-4.00	0.00	0.00	↓
BOI	1.00	1/29/80	19.00	0.00	1.00	1.00	↓
BOI	1.00	1/30/80	24.00	0.00	0.00	0.00	↓
BOI	12.00	12/7/80	32.00	7.00	0.00	0.00	↓
BOI	12.00	12/8/80	32.00	9.00	0.00	0.00	↓
BOI	12.00	12/9/80	32.00	8.00	0.00	0.00	↓
BOI	12.00	12/10/80	31.00	10.00	0.00	0.00	↓
BOI	12.00	12/30/81	27.00	5.00	1.00	1.00	7
BOI	12.00	12/31/81	33.00	5.00	6.00	8.00	9

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(inches) Page 2

Station	Month	Date	Max	Min	Pcpn	Snow	(inches) 12 Z
BOI	1.00	1/3/82	33.00	8.00	0.00	0.00	11
BOI	1.00	1/6/82	15.00	-10.00	0.00	0.00	10
BOI	1.00	1/7/82	13.00	-1.00	0.00	0.00	↓
BOI	1.00	1/8/82	19.00	4.00	0.00	0.00	↓
BOI	1.00	1/9/82	19.00	0.00	0.00	0.00	↓
BOI	1.00	1/10/82	21.00	-2.00	0.00	0.00	9
BOI	1.00	1/11/82	18.00	-2.00	0.00	0.00	8
BOI	1.00	1/21/82	27.00	10.00	15.00	20.00	4
BOI	2.00	2/4/82	17.00	3.00	-1.00	-1.00	1
BOI	2.00	2/5/82	16.00	1.00	0.00	0.00	↓
BOI	2.00	2/6/82	17.00	0.00	0.00	0.00	↓
BOI	2.00	2/7/82	20.00	3.00	1.00	1.00	↓
BOI	2.00	2/8/82	19.00	0.00	0.00	0.00	↓
BOI	2.00	2/9/82	21.00	1.00	1.00	8.00	↓
BOI	2.00	2/10/82	20.00	1.00	0.00	0.00	2
BOI	2.00	2/11/82	22.00	3.00	0.00	0.00	↓
BOI	2.00	2/12/82	33.00	7.00	0.00	0.00	↓
BOI	12.00	12/24/82	34.00	9.00	0.00	0.00	3
BOI	12.00	12/25/82	31.00	9.00	0.00	0.00	3
BOI	12.00	12/27/82	25.00	2.00	-1.00	-1.00	4
BOI	12.00	12/28/82	24.00	2.00	0.00	0.00	↓
BOI	12.00	12/29/82	19.00	0.00	-1.00	-1.00	↓
BOI	12.00	12/30/82	18.00	1.00	-1.00	-1.00	↓
BOI	12.00	12/31/82	20.00	5.00	-1.00	-1.00	↓
BOI	1.00	1/1/83	21.00	-1.00	-1.00	-1.00	↓
BOI	1.00	1/2/83	18.00	-2.00	1.00	1.00	↓
BOI	12.00	12/2/83	33.00	9.00	3.00	3.00	↓
BOI	12.00	12/4/83	30.00	4.00	-1.00	-1.00	6
BOI	12.00	12/5/83	30.00	10.00	3.00	3.00	↓
BOI	12.00	12/19/83	28.00	5.00	1.00	3.00	1
BOI	12.00	12/20/83	16.00	-6.00	-1.00	-1.00	2
BOI	12.00	12/21/83	14.00	-8.00	1.00	-1.00	↓
BOI	12.00	12/22/83	7.00	-15.00	-1.00	-1.00	↓
BOI	12.00	12/23/83	4.00	-18.00	-1.00	-1.00	↓
BOI	12.00	12/24/83	14.00	2.00	51.00	67.00	3
BOI	12.00	12/27/83	22.00	-4.00	19.00	23.00	9
BOI	12.00	12/28/83	21.00	-4.00	0.00	0.00	11
BOI	1.00	1/11/84	30.00	9.00	8.00	9.00	6
BOI	1.00	1/12/84	32.00	10.00	3.00	3.00	↓
BOI	1.00	1/14/84	22.00	5.00	-1.00	-1.00	7
BOI	1.00	1/16/84	17.00	3.00	-1.00	-1.00	↓
BOI	1.00	1/17/84	15.00	-7.00	0.00	0.00	↓
BOI	1.00	1/18/84	7.00	-13.00	0.00	0.00	↓
BOI	1.00	1/19/84	7.00	-10.00	0.00	0.00	↓
BOI	1.00	1/20/84	9.00	-8.00	0.00	0.00	↓
BOI	1.00	1/21/84	12.00	-2.00	3.00	3.00	↓
BOI	12.00	12/16/84	25.00	3.00	1.00	1.00	3
BOI	12.00	12/17/84	20.00	7.00	0.00	0.00	↓
BOI	12.00	12/18/84	19.00	-1.00	0.00	0.00	↓
BOI	12.00	12/19/84	13.00	-6.00	0.00	0.00	↓
BOI	12.00	12/20/84	10.00	-5.00	8.00	15.00	↓
BOI	12.00	12/21/84	16.00	-1.00	4.00	3.00	5
BOI	1.00	1/1/85	30.00	10.00	0.00	0.00	2
BOI	1.00	1/3/85	28.00	10.00	0.00	0.00	↓
BOI	1.00	1/4/85	29.00	8.00	0.00	0.00	↓
BOI	1.00	1/5/85	24.00	10.00	0.00	0.00	↓
BOI	1.00	1/10/85	23.00	10.00	-1.00	-1.00	↓
BOI	1.00	1/13/85	25.00	10.00	-1.00	-1.00	↓
BOI	1.00	1/14/85	24.00	7.00	0.00	0.00	↓
BOI	1.00	1/15/85	29.00	5.00	0.00	0.00	↓
BOI	1.00	1/16/85	27.00	10.00	0.00	0.00	↓
BOI	1.00	1/18/85	28.00	9.00	-1.00	-1.00	↓

MINIMUM TEMPERATURES
 £ 10, 1977-1992

Sunday, February 09, 1997

IDTPT3

(inches) Page 3

Station	Month	Date	Max	Min	Pcpn	Snow	Notes on Ground
BOI	1.00	1/26/85	26.00	5.00	0.00	0.00	2
BOI	1.00	1/27/85	25.00	7.00	0.00	0.00	↓
BOI	1.00	1/28/85	21.00	6.00	8.00	8.00	3
BOI	1.00	1/29/85	29.00	7.00	0.00	0.00	↓
BOI	1.00	1/30/85	19.00	-7.00	0.00	0.00	↓
BOI	1.00	1/31/85	15.00	-2.00	-1.00	1.00	↓
BOI	2.00	2/1/85	18.00	-1.00	-1.00	1.00	4
BOI	2.00	2/2/85	18.00	5.00	3.00	11.00	↓
BOI	2.00	2/3/85	13.00	-9.00	2.00	3.00	↓
BOI	2.00	2/4/85	13.00	-12.00	-1.00	-1.00	↓
BOI	2.00	2/5/85	16.00	-4.00	4.00	8.00	5
BOI	2.00	2/6/85	21.00	1.00	1.00	2.00	↓
BOI	11.00	11/18/85	31.00	7.00	-1.00	-1.00	2
BOI	11.00	11/19/85	30.00	7.00	2.00	2.00	1
BOI	11.00	11/21/85	24.00	-2.00	0.00	0.00	2
BOI	11.00	11/22/85	30.00	-3.00	1.00	3.00	3
BOI	11.00	11/23/85	18.00	2.00	0.00	0.00	2
BOI	11.00	11/24/85	16.00	5.00	27.00	35.00	2
BOI	11.00	11/25/85	24.00	3.00	-1.00	-1.00	5
BOI	11.00	11/26/85	15.00	-3.00	-1.00	-1.00	↓
BOI	11.00	11/27/85	15.00	2.00	-1.00	-1.00	↓
BOI	11.00	11/28/85	21.00	8.00	38.00	47.00	↓
BOI	12.00	12/10/85	25.00	5.00	6.00	15.00	8
BOI	12.00	12/11/85	17.00	-2.00	-1.00	-1.00	7
BOI	12.00	12/12/85	13.00	-3.00	-1.00	-1.00	↓
BOI	12.00	12/13/85	17.00	0.00	0.00	0.00	↓
BOI	12.00	12/14/85	12.00	-6.00	-1.00	-1.00	↓
BOI	12.00	12/15/85	15.00	-5.00	0.00	0.00	↓
BOI	12.00	12/16/85	18.00	-2.00	0.00	0.00	↓
BOI	12.00	12/17/85	16.00	-2.00	0.00	0.00	↓
BOI	12.00	12/18/85	17.00	-3.00	0.00	0.00	↓
BOI	12.00	12/19/85	16.00	-3.00	-1.00	-1.00	↓
BOI	12.00	12/20/85	12.00	-1.00	-1.00	-1.00	6
BOI	12.00	12/21/85	13.00	-3.00	-1.00	-1.00	↓
BOI	12.00	12/22/85	18.00	-5.00	0.00	0.00	↓
BOI	12.00	12/23/85	13.00	-6.00	0.00	0.00	↓
BOI	12.00	12/24/85	17.00	-5.00	0.00	0.00	↓
BOI	12.00	12/25/85	12.00	-6.00	0.00	0.00	↓
BOI	12.00	12/26/85	13.00	-8.00	-1.00	-1.00	↓
BOI	12.00	12/27/85	14.00	-7.00	-1.00	-1.00	↓
BOI	12.00	12/28/85	13.00	-9.00	0.00	0.00	↓
BOI	12.00	12/29/85	13.00	-7.00	0.00	0.00	↓
BOI	12.00	12/30/85	13.00	-7.00	0.00	0.00	↓
BOI	12.00	12/31/85	19.00	2.00	0.00	0.00	↓
BOI	1.00	1/7/86	32.00	10.00	0.00	0.00	7
BOI	1.00	1/11/86	35.00	7.00	-1.00	-1.00	↓
BOI	1.00	1/12/86	24.00	6.00	-1.00	-1.00	↓
BOI	1.00	1/13/86	20.00	1.00	-1.00	-1.00	↓
BOI	1.00	1/14/86	30.00	4.00	0.00	0.00	↓
BOI	1.00	1/12/87	31.00	9.00	0.00	0.00	↓
BOI	1.00	1/15/87	31.00	6.00	-1.00	-1.00	↓
BOI	1.00	1/16/87	27.00	0.00	0.00	0.00	↓
BOI	1.00	1/17/87	31.00	7.00	0.00	0.00	↓
BOI	1.00	1/19/87	36.00	6.00	0.00	0.00	↓
BOI	1.00	1/21/87	31.00	5.00	0.00	0.00	↓
BOI	1.00	1/22/87	30.00	9.00	0.00	0.00	↓
BOI	12.00	12/24/87	31.00	8.00	0.00	0.00	0
BOI	12.00	12/27/87	34.00	10.00	0.00	0.00	0
BOI	1.00	1/1/88	25.00	5.00	0.00	0.00	3
BOI	1.00	1/2/88	24.00	0.00	0.00	0.00	↓
BOI	1.00	1/3/88	22.00	1.00	0.00	0.00	↓
BOI	1.00	1/17/88	30.00	4.00	1.00	2.00	↓

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Station	Month	Date	Max	Min	Pcpn	Snow	Snow on Ground 12z
BOI	1.00	1/18/88	24.00	-1.00	-1.00	-1.00	3
BOI	1.00	1/19/88	25.00	-2.00	-1.00	-1.00	↓
BOI	1.00	1/20/88	27.00	6.00	-1.00	-1.00	2
BOI	1.00	1/21/88	29.00	8.00	0.00	0.00	4
BOI	1.00	1/24/88	38.00	9.00	0.00	0.00	3
BOI	12.00	12/26/88	21.00	3.00	0.00	0.00	↓
BOI	12.00	12/27/88	20.00	2.00	0.00	0.00	8
BOI	12.00	12/28/88	14.00	-4.00	0.00	0.00	↓
BOI	12.00	12/29/88	24.00	1.00	22.00	22.00	1
BOI	1.00	1/6/89	31.00	8.00	1.00	1.00	↓
BOI	1.00	1/7/89	27.00	8.00	1.00	3.00	↓
BOI	1.00	1/8/89	28.00	9.00	14.00	17.00	↓
BOI	1.00	1/23/89	27.00	5.00	0.00	0.00	↓
BOI	1.00	1/24/89	23.00	1.00	-1.00	-1.00	↓
BOI	1.00	1/25/89	20.00	0.00	0.00	0.00	↓
BOI	1.00	1/26/89	23.00	4.00	0.00	0.00	↓
BOI	1.00	1/27/89	18.00	0.00	0.00	0.00	↓
BOI	1.00	1/28/89	24.00	6.00	0.00	0.00	↓
BOI	1.00	1/29/89	27.00	6.00	0.00	0.00	↓
BOI	2.00	2/3/89	15.00	3.00	5.00	6.00	↓
BOI	2.00	2/4/89	3.00	-14.00	1.00	1.00	↓
BOI	2.00	2/5/89	7.00	-15.00	0.00	0.00	↓
BOI	2.00	2/6/89	9.00	-11.00	0.00	0.00	↓
BOI	2.00	2/7/89	11.00	-13.00	0.00	0.00	↓
BOI	2.00	2/8/89	17.00	-10.00	0.00	0.00	↓
BOI	2.00	2/9/89	23.00	-7.00	0.00	0.00	↓
BOI	2.00	2/11/89	30.00	7.00	-1.00	-1.00	↓
BOI	2.00	2/13/89	31.00	10.00	0.00	0.00	↓
BOI	1.00	1/2/90	32.00	7.00	3.00	3.00	↓
BOI	1.00	1/3/90	31.00	6.00	-1.00	-1.00	↓
BOI	2.00	2/15/90	34.00	8.00	-1.00	-1.00	0
BOI	12.00	12/14/90	32.00	7.00	0.00	0.00	2
BOI	12.00	12/16/90	27.00	5.00	-1.00	-1.00	2
BOI	12.00	12/19/90	29.00	9.00	15.00	42.00	T
BOI	12.00	12/20/90	9.00	-8.00	7.00	11.00	5
BOI	12.00	12/21/90	-3.00	-23.00	1.00	1.00	↓
BOI	12.00	12/22/90	-6.00	-25.00	0.00	0.00	↓
BOI	12.00	12/23/90	-2.00	-18.00	0.00	0.00	↓
BOI	12.00	12/24/90	0.00	-20.00	6.00	14.00	6
BOI	12.00	12/25/90	7.00	-20.00	10.00	17.00	7
BOI	12.00	12/26/90	14.00	2.00	-1.00	-1.00	7
BOI	12.00	12/27/90	31.00	6.00	8.00	11.00	6
BOI	12.00	12/28/90	30.00	9.00	13.00	27.00	7
BOI	12.00	12/29/90	10.00	-17.00	-1.00	-1.00	8
BOI	12.00	12/30/90	8.00	-9.00	-1.00	-1.00	7
BOI	12.00	12/31/90	19.00	6.00	-1.00	-1.00	↓
BOI	1.00	1/1/91	19.00	-4.00	0.00	0.00	↓
BOI	1.00	1/2/91	21.00	-4.00	0.00	0.00	↓
BOI	1.00	1/3/91	15.00	-5.00	-1.00	-1.00	↓
BOI	1.00	1/4/91	11.00	-9.00	0.00	0.00	↓
BOI	1.00	1/5/91	6.00	-12.00	-1.00	-1.00	↓
BOI	1.00	1/6/91	16.00	-5.00	0.00	0.00	↓
BOI	1.00	1/29/91	36.00	6.00	0.00	0.00	0
BOI	12.00	12/4/92	24.00	9.00	0.00	0.00	T
BOI	12.00	12/5/92	19.00	2.00	0.00	0.00	T
BOI	12.00	12/6/92	23.00	0.00	0.00	0.00	T
BOI	12.00	12/18/92	26.00	5.00	7.00	9.00	1
BOI	12.00	12/19/92	28.00	7.00	0.00	0.00	2

MINIMUM TEMPERATURES ≤ 0°F 1977-1992 (Boise)

APPENDIX B

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Station	Month	Date	Max	Min	Pcpn	Snow	(inches) Snow on Ground
BOI	1.00	1/6/77	18.00	-4.00	0.00	0.00	5
BOI	1.00	1/7/77	9.00	-5.00	-1.00	-1.00	5
BOI	1.00	1/8/77	6.00	-14.00	-1.00	-1.00	5
BOI	1.00	1/9/77	16.00	-13.00	0.00	0.00	5
BOI	1.00	1/10/77	10.00	-8.00	0.00	0.00	5
BOI	12.00	12/29/78	17.00	0.00	0.00	0.00	0
BOI	12.00	12/30/78	16.00	-2.00	0.00	0.00	0
BOI	12.00	12/31/78	11.00	-9.00	2.00	2.00	0
BOI	1.00	1/1/79	14.00	-10.00	0.00	0.00	0
BOI	1.00	1/6/79	13.00	-6.00	-1.00	-1.00	1
BOI	1.00	1/7/79	17.00	-10.00	0.00	0.00	1
BOI	1.00	1/8/79	18.00	-9.00	-1.00	-1.00	1
BOI	1.00	1/26/79	23.00	-8.00	-1.00	-1.00	3
BOI	1.00	1/29/79	15.00	-8.00	1.00	-1.00	3
BOI	1.00	1/30/79	17.00	-13.00	-1.00	-1.00	3
BOI	1.00	1/31/79	17.00	-12.00	-1.00	-1.00	3
BOI	2.00	2/1/79	15.00	-5.00	2.00	7.00	3
BOI	2.00	2/2/79	21.00	-12.00	0.00	0.00	4
BOI	2.00	2/3/79	24.00	0.00	7.00	9.00	4
BOI	1.00	1/27/80	19.00	-7.00	6.00	8.00	1
BOI	1.00	1/28/80	16.00	-4.00	0.00	0.00	1
BOI	1.00	1/29/80	19.00	0.00	1.00	1.00	1
BOI	1.00	1/30/80	24.00	0.00	0.00	0.00	10
BOI	1.00	1/6/82	15.00	-10.00	0.00	0.00	10
BOI	1.00	1/7/82	13.00	-1.00	0.00	0.00	10
BOI	1.00	1/9/82	19.00	0.00	0.00	0.00	10
BOI	1.00	1/10/82	21.00	-2.00	0.00	0.00	10
BOI	1.00	1/11/82	18.00	-2.00	0.00	0.00	10
BOI	2.00	2/6/82	17.00	0.00	0.00	0.00	10
BOI	2.00	2/8/82	19.00	0.00	0.00	0.00	10
BOI	12.00	12/29/82	19.00	0.00	-1.00	-1.00	10
BOI	1.00	1/1/83	21.00	-1.00	-1.00	-1.00	10
BOI	1.00	1/2/83	18.00	-2.00	1.00	1.00	10
BOI	12.00	12/20/83	16.00	-6.00	-1.00	-1.00	10
BOI	12.00	12/21/83	14.00	-8.00	1.00	-1.00	10
BOI	12.00	12/22/83	7.00	-15.00	-1.00	-1.00	10
BOI	12.00	12/23/83	4.00	-18.00	-1.00	-1.00	10
BOI	12.00	12/27/83	22.00	-4.00	19.00	23.00	10
BOI	12.00	12/28/83	21.00	-4.00	0.00	0.00	10
BOI	1.00	1/17/84	15.00	-7.00	0.00	0.00	10
BOI	1.00	1/18/84	7.00	-13.00	0.00	0.00	10
BOI	1.00	1/19/84	7.00	-10.00	0.00	0.00	10
BOI	1.00	1/20/84	9.00	-8.00	0.00	0.00	10
BOI	1.00	1/21/84	12.00	-2.00	3.00	3.00	10
BOI	12.00	12/18/84	19.00	-1.00	0.00	0.00	10
BOI	12.00	12/19/84	13.00	-6.00	0.00	0.00	10
BOI	12.00	12/20/84	10.00	-5.00	8.00	15.00	10
BOI	12.00	12/21/84	16.00	-1.00	4.00	3.00	10
BOI	1.00	1/30/85	19.00	-7.00	0.00	0.00	10
BOI	1.00	1/31/85	15.00	-2.00	-1.00	1.00	10
BOI	2.00	2/1/85	18.00	-1.00	-1.00	1.00	10
BOI	2.00	2/3/85	13.00	-9.00	2.00	3.00	10
BOI	2.00	2/4/85	13.00	-12.00	-1.00	-1.00	10
BOI	2.00	2/5/85	16.00	-4.00	4.00	8.00	10
BOI	11.00	11/21/85	24.00	-2.00	0.00	0.00	10
BOI	11.00	11/22/85	30.00	-3.00	1.00	3.00	10
BOI	11.00	11/26/85	15.00	-3.00	-1.00	-1.00	10
BOI	12.00	12/11/85	17.00	-2.00	-1.00	-1.00	10
BOI	12.00	12/12/85	13.00	-3.00	-1.00	-1.00	10
BOI	12.00	12/13/85	17.00	0.00	0.00	0.00	10
BOI	12.00	12/14/85	12.00	-6.00	-1.00	-1.00	10
BOI	12.00	12/15/85	15.00	-5.00	0.00	0.00	10
BOI	12.00	12/16/85	18.00	-2.00	0.00	0.00	10
BOI	12.00	12/17/85	16.00	-2.00	0.00	0.00	10
BOI	12.00	12/18/85	17.00	-3.00	0.00	0.00	10
BOI	12.00	12/19/85	16.00	-3.00	-1.00	-1.00	10
BOI	12.00	12/20/85	12.00	-1.00	-1.00	-1.00	10
BOI	12.00	12/21/85	13.00	-3.00	-1.00	-1.00	10

Station	Month	Date	Max	Min	Pcpn	Snow	Snow on Ground
BOI	12.00	12/22/85	18.00	-5.00	0.00	0.00	6
BOI	12.00	12/23/85	13.00	-6.00	0.00	0.00	
BOI	12.00	12/24/85	17.00	-5.00	0.00	0.00	
BOI	12.00	12/25/85	12.00	-6.00	0.00	0.00	
BOI	12.00	12/26/85	13.00	-8.00	-1.00	-1.00	
BOI	12.00	12/27/85	14.00	-7.00	-1.00	-1.00	
BOI	12.00	12/28/85	13.00	-9.00	0.00	0.00	
BOI	12.00	12/29/85	13.00	-7.00	0.00	0.00	
BOI	12.00	12/30/85	13.00	-7.00	0.00	0.00	
BOI	1.00	1/16/87	27.00	0.00	0.00	0.00	T
BOI	1.00	1/2/88	24.00	0.00	0.00	0.00	3
BOI	1.00	1/18/88	24.00	-1.00	-1.00	-1.00	
BOI	1.00	1/19/88	25.00	-2.00	-1.00	-1.00	
BOI	12.00	12/28/88	14.00	-4.00	0.00	0.00	
BOI	1.00	1/25/89	20.00	0.00	0.00	0.00	1
BOI	1.00	1/27/89	18.00	0.00	0.00	0.00	
BOI	2.00	2/4/89	3.00	-14.00	1.00	1.00	
BOI	2.00	2/5/89	7.00	-15.00	0.00	0.00	
BOI	2.00	2/6/89	9.00	-11.00	0.00	0.00	
BOI	2.00	2/7/89	11.00	-13.00	0.00	0.00	
BOI	2.00	2/8/89	17.00	-10.00	0.00	0.00	
BOI	2.00	2/9/89	23.00	-7.00	0.00	0.00	
BOI	12.00	12/20/90	9.00	-8.00	7.00	11.00	5
BOI	12.00	12/21/90	-3.00	-23.00	1.00	1.00	
BOI	12.00	12/22/90	-6.00	-25.00	0.00	0.00	
BOI	12.00	12/23/90	-2.00	-18.00	0.00	0.00	
BOI	12.00	12/24/90	0.00	-20.00	6.00	14.00	6
BOI	12.00	12/25/90	7.00	-20.00	10.00	17.00	
BOI	12.00	12/29/90	10.00	-17.00	-1.00	-1.00	5
BOI	12.00	12/30/90	8.00	-9.00	-1.00	-1.00	7
BOI	1.00	1/1/91	19.00	-4.00	0.00	0.00	
BOI	1.00	1/2/91	21.00	-4.00	0.00	0.00	
BOI	1.00	1/3/91	15.00	-5.00	-1.00	-1.00	
BOI	1.00	1/4/91	11.00	-9.00	0.00	0.00	
BOI	1.00	1/5/91	6.00	-12.00	-1.00	-1.00	
BOI	1.00	1/6/91	16.00	-5.00	0.00	0.00	
BOI	12.00	12/6/92	23.00	0.00	0.00	0.00	T

PATTERN A - EXAMPLE #1

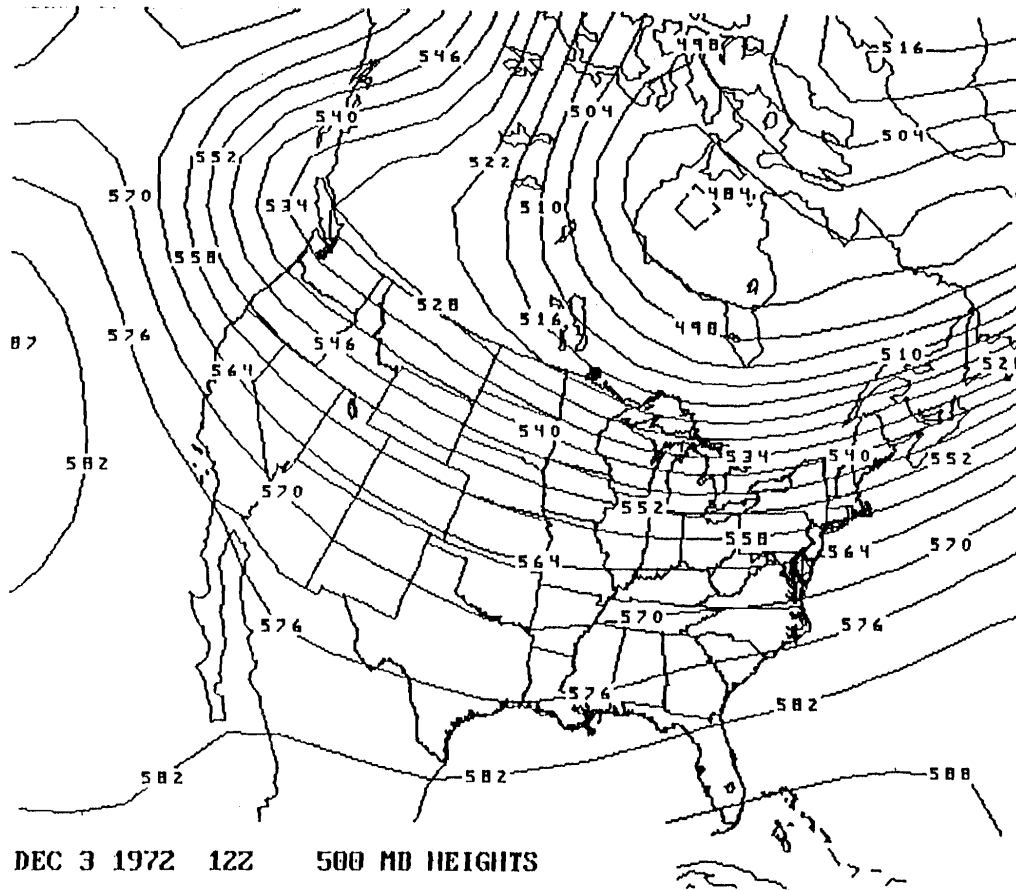


FIGURE 1

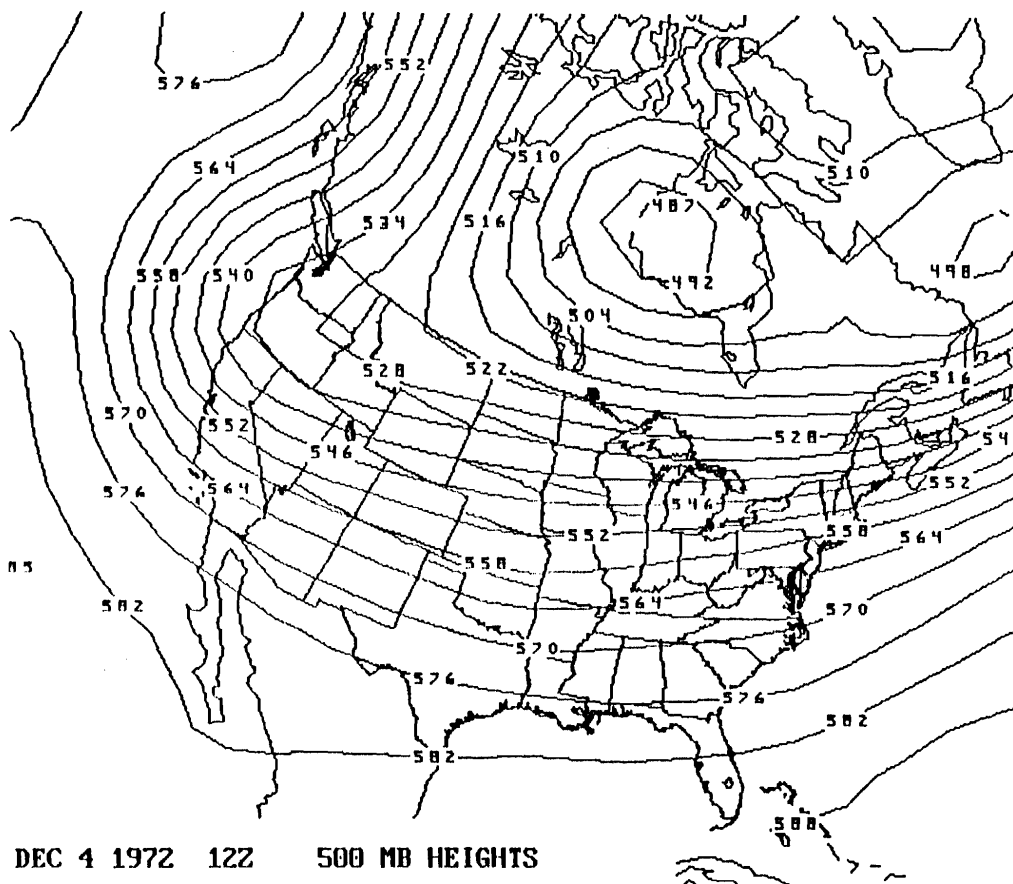
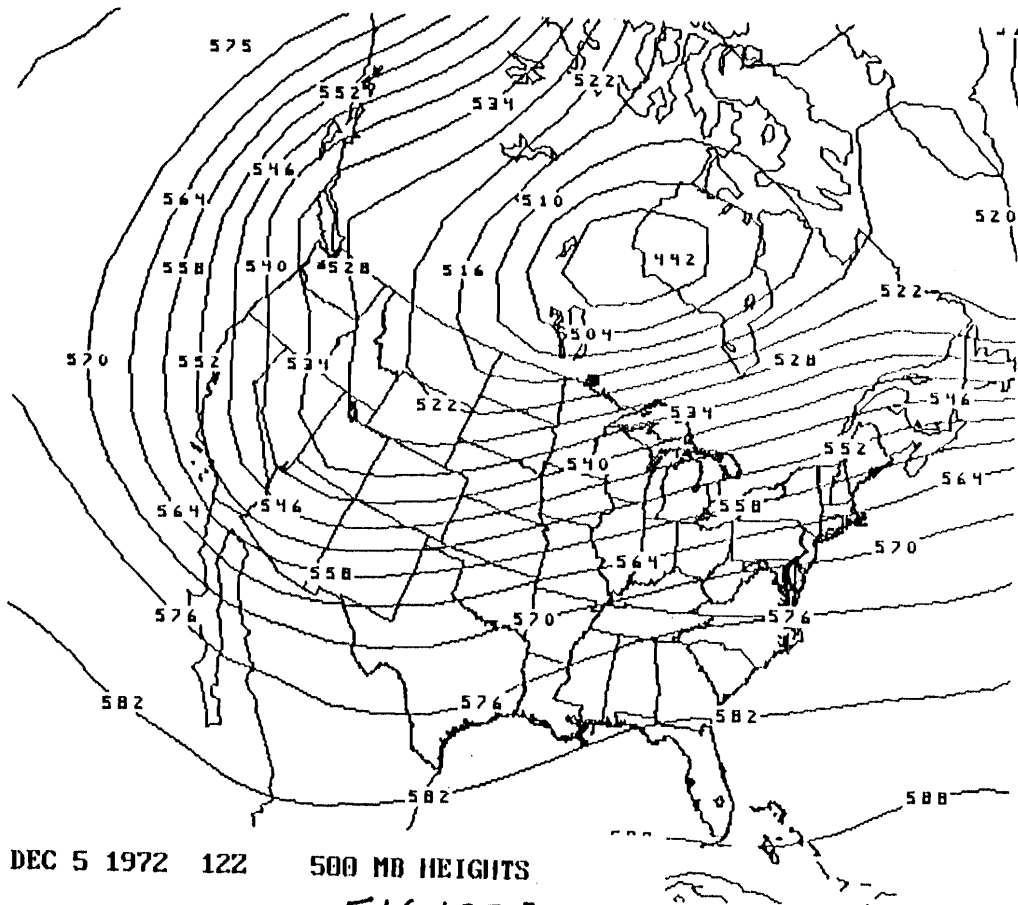
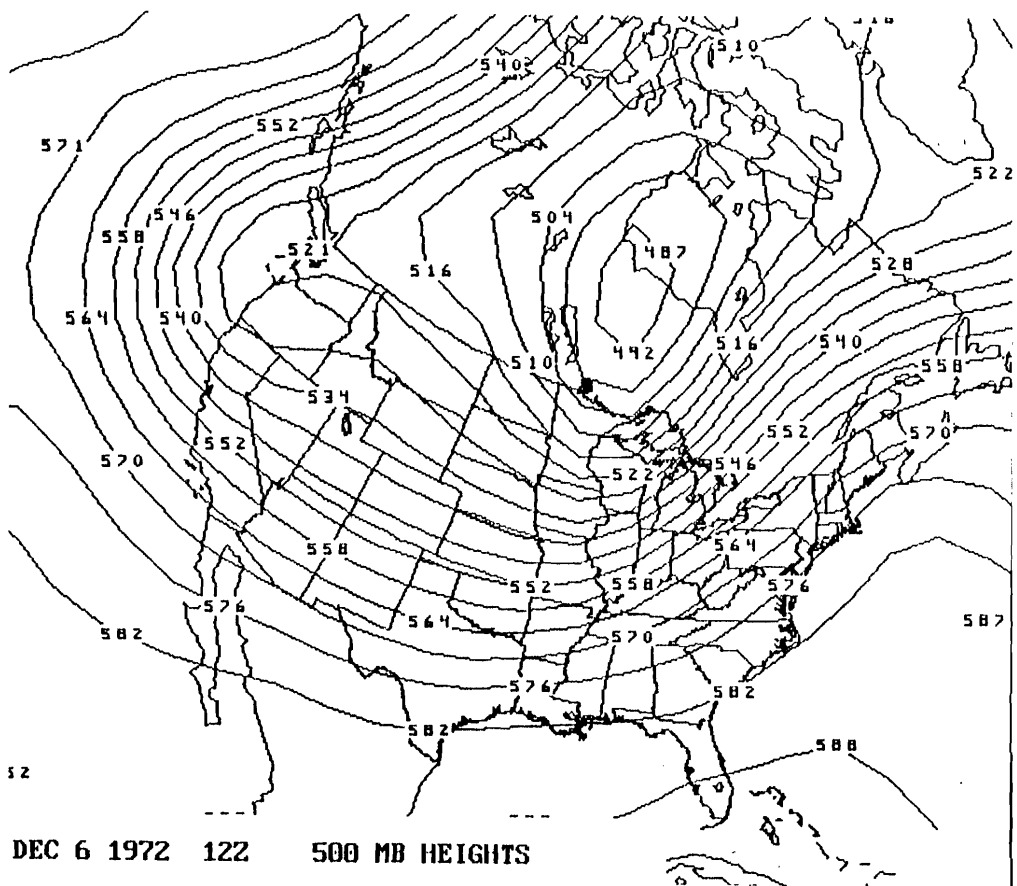


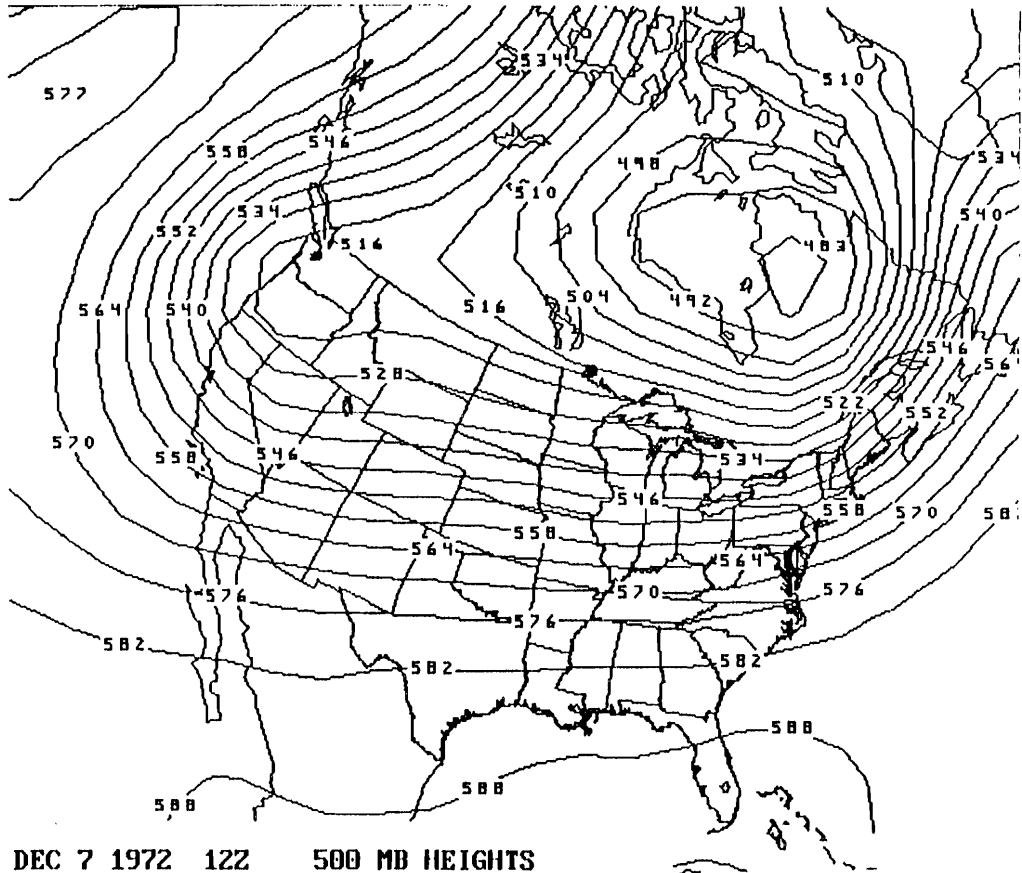
FIGURE 2



DEC 5 1972 12Z 500 MB HEIGHTS
 FIGURE 3

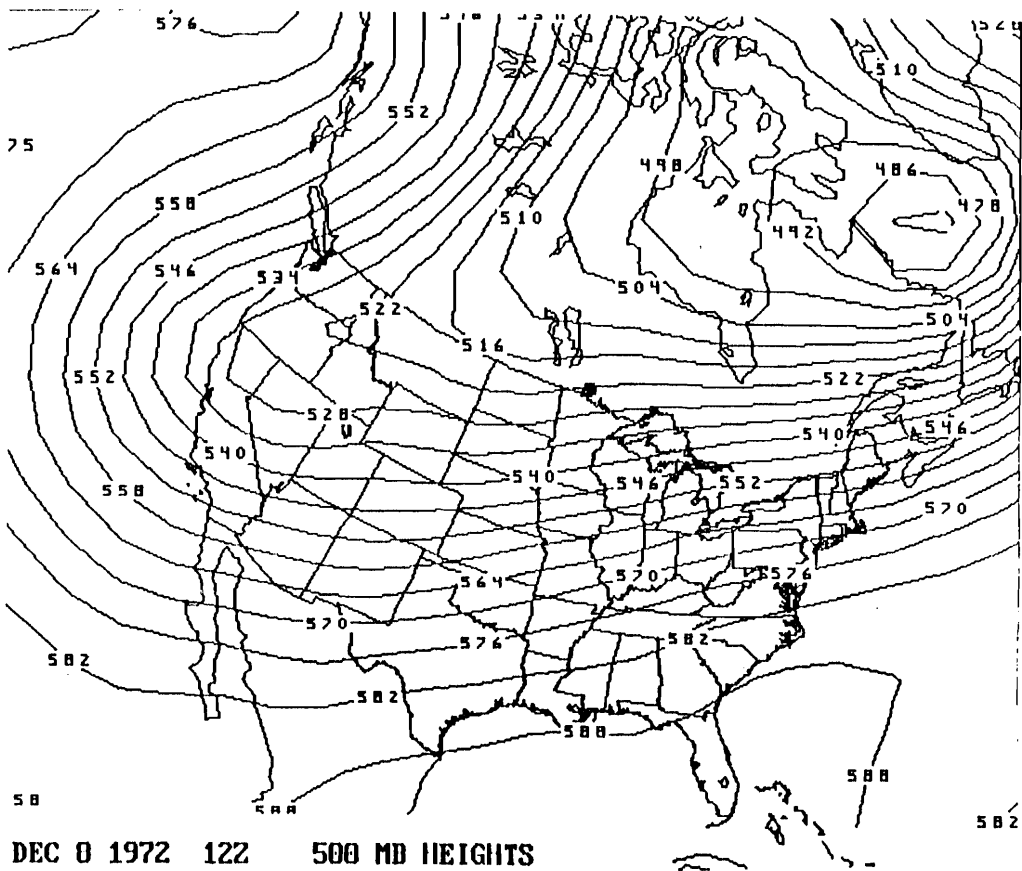


DEC 6 1972 12Z 500 MB HEIGHTS
 FIGURE 4



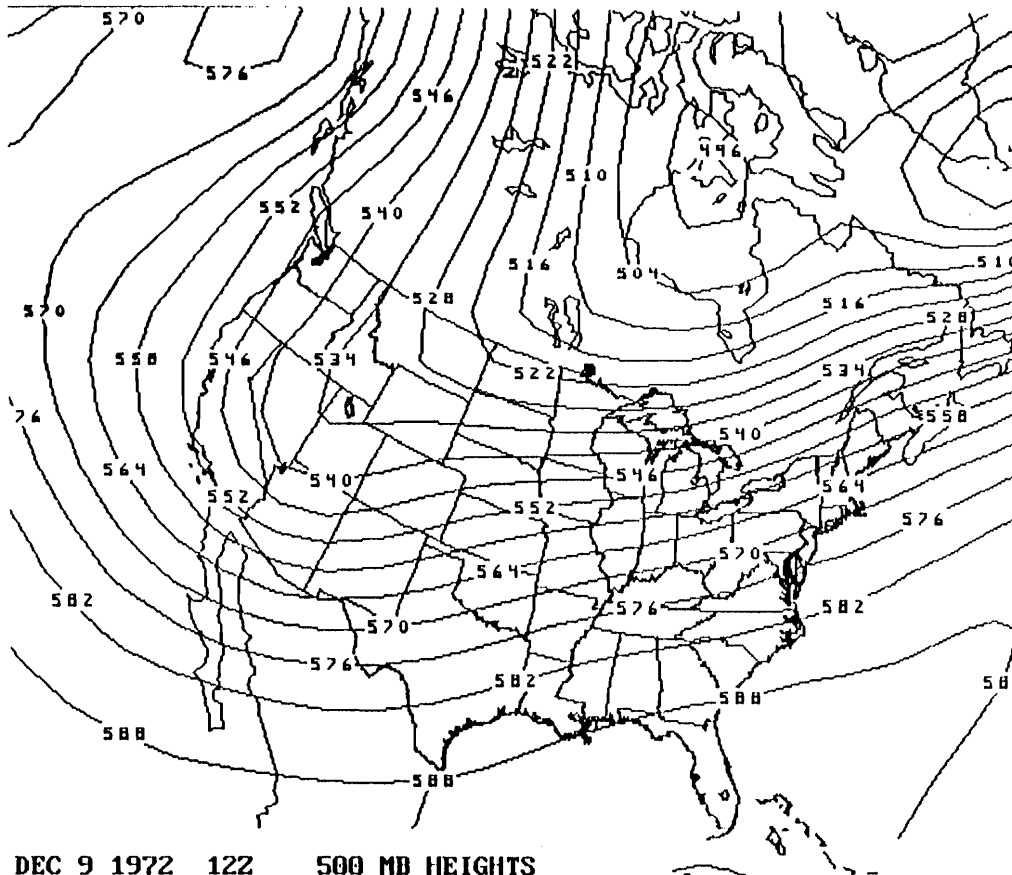
DEC 7 1972 12Z 500 MB HEIGHTS

FIGURE 5

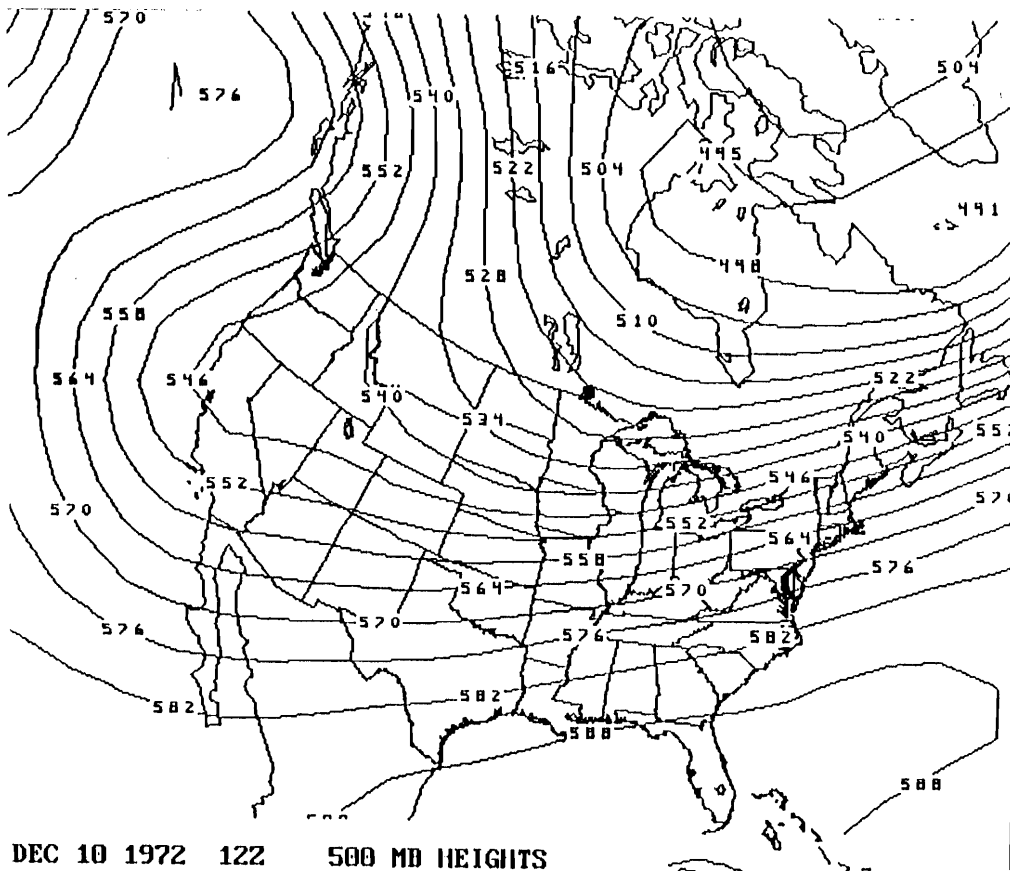


DEC 8 1972 12Z 500 MB HEIGHTS

FIGURE 6



DEC 9 1972 12Z 500 MB HEIGHTS
 FIGURE 7



DEC 10 1972 12Z 500 MB HEIGHTS
 FIGURE 8

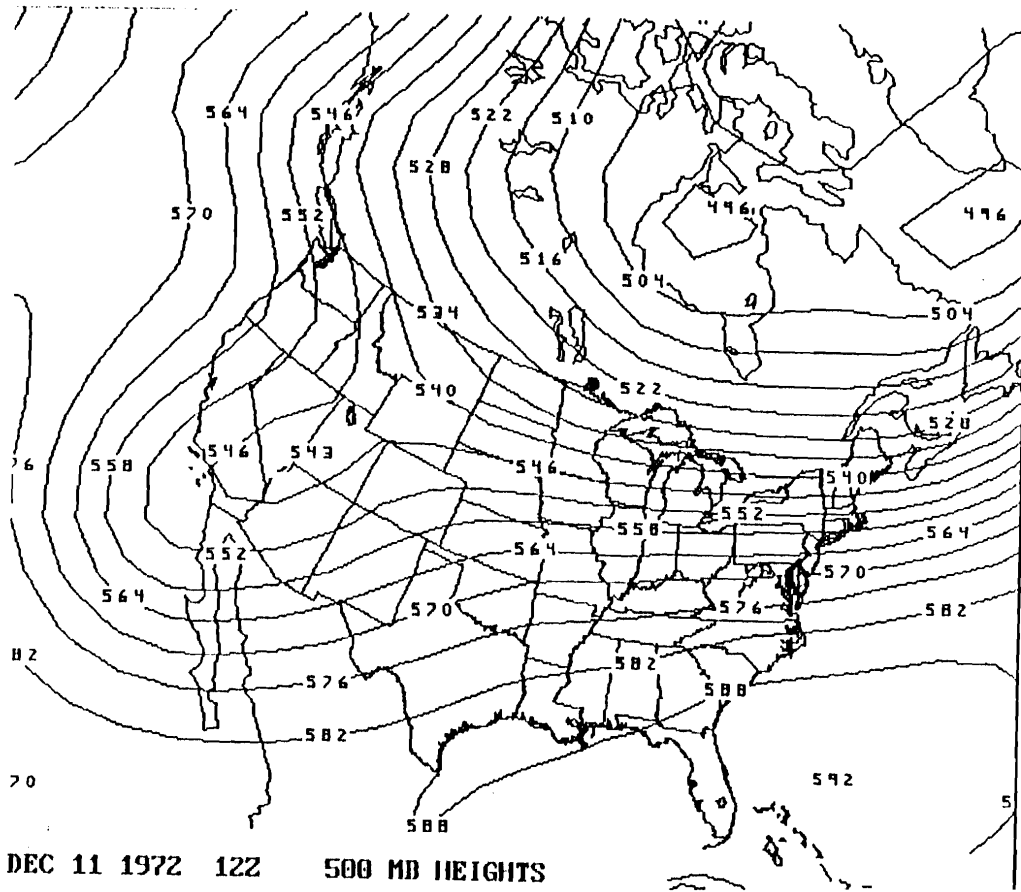


FIGURE 9

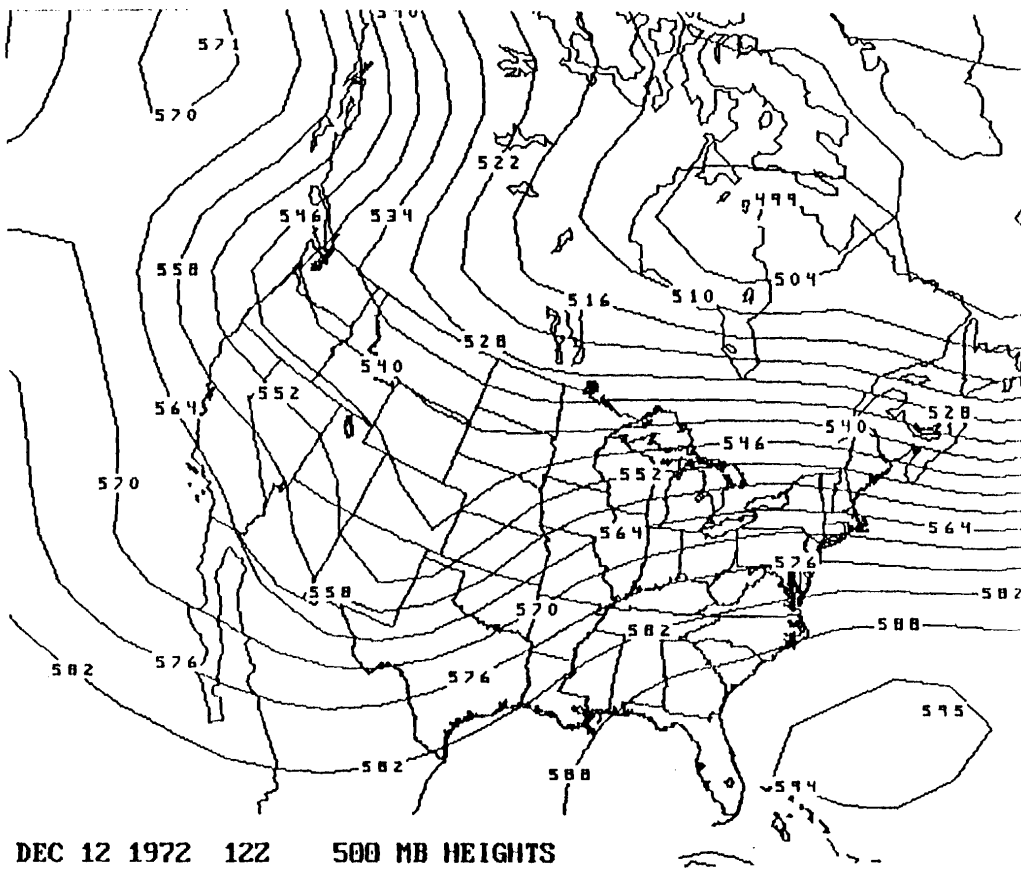
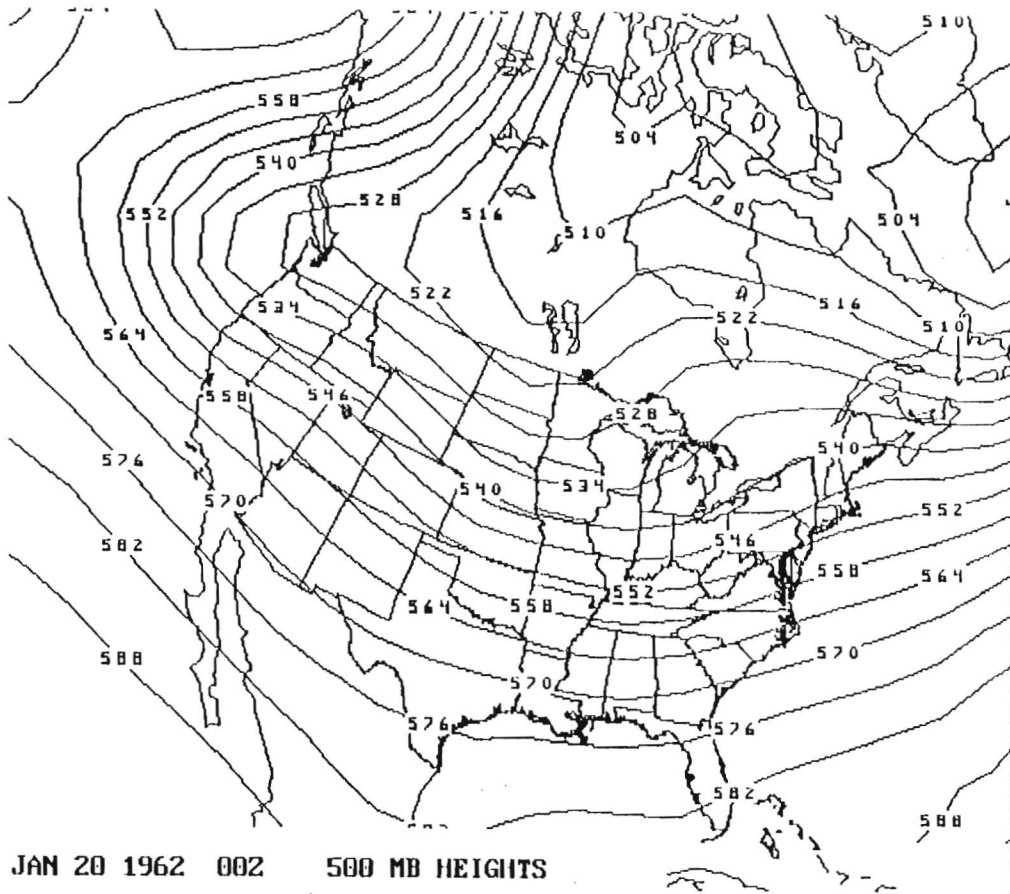


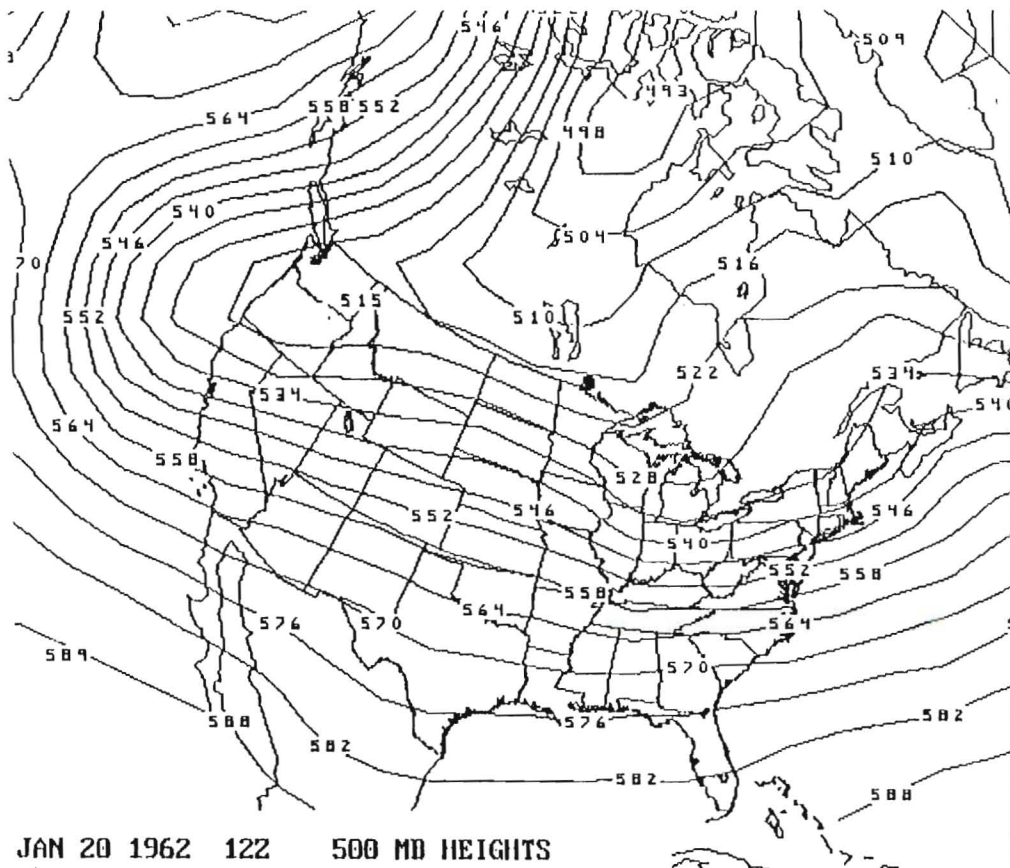
FIGURE 10

PATTERN A - EXAMPLE #2



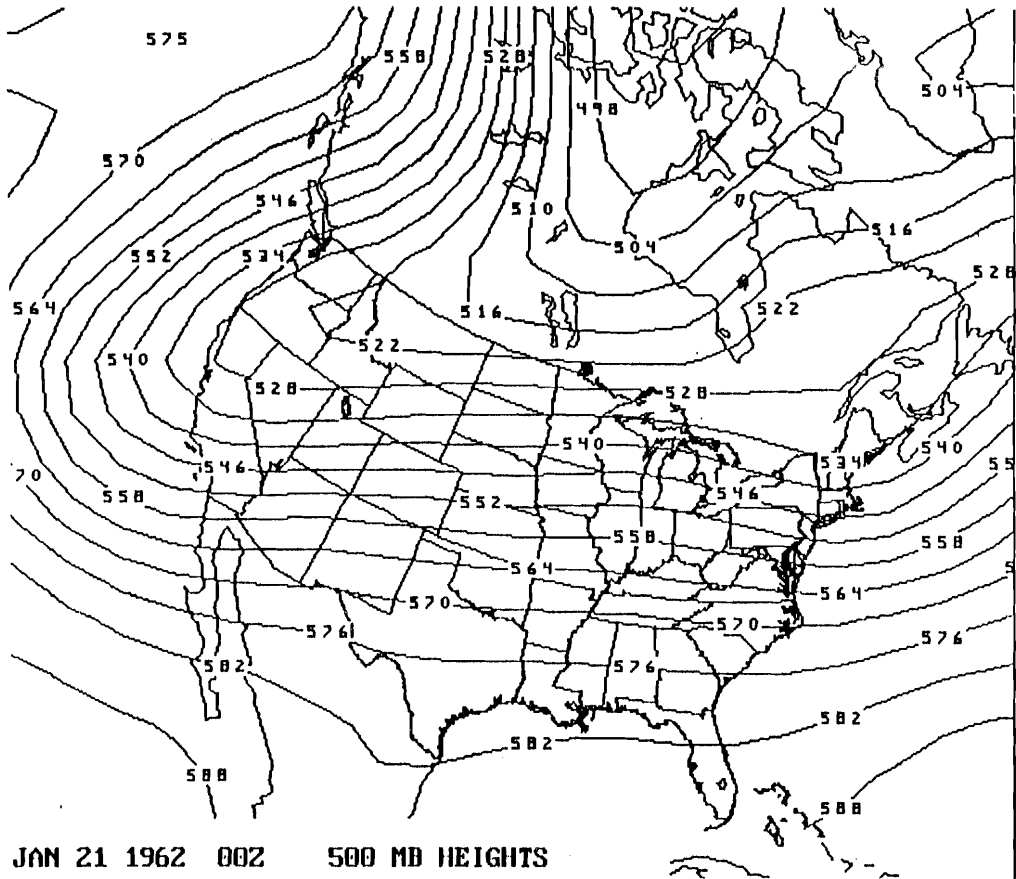
JAN 20 1962 00Z 500 MB HEIGHTS

FIGURE 11

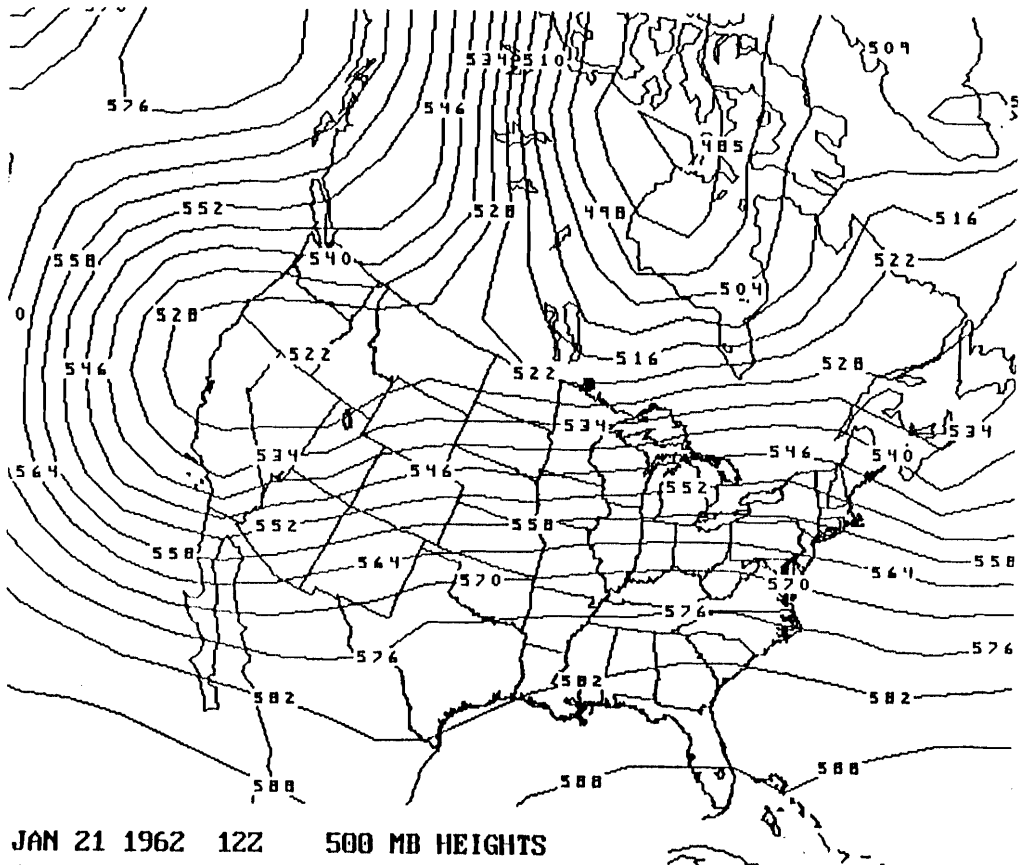


JAN 20 1962 12Z 500 MB HEIGHTS

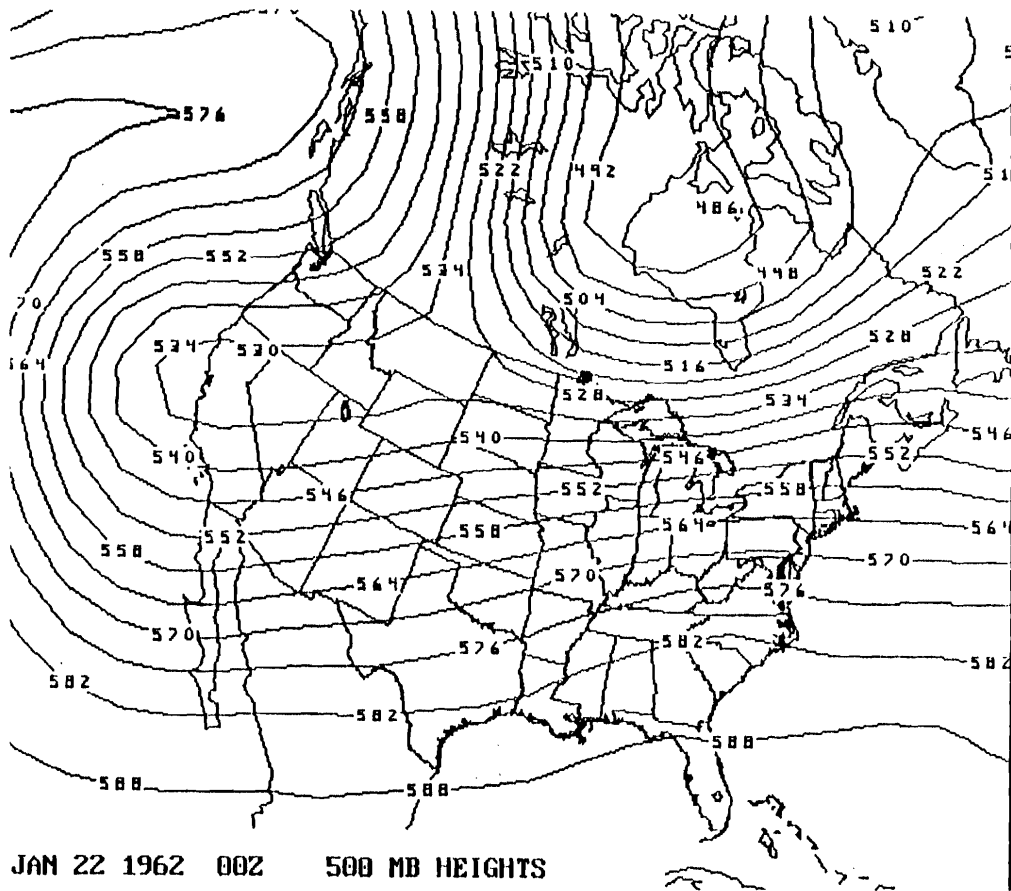
FIGURE 12



JAN 21 1962 00Z 500 MB HEIGHTS
 FIGURE 13

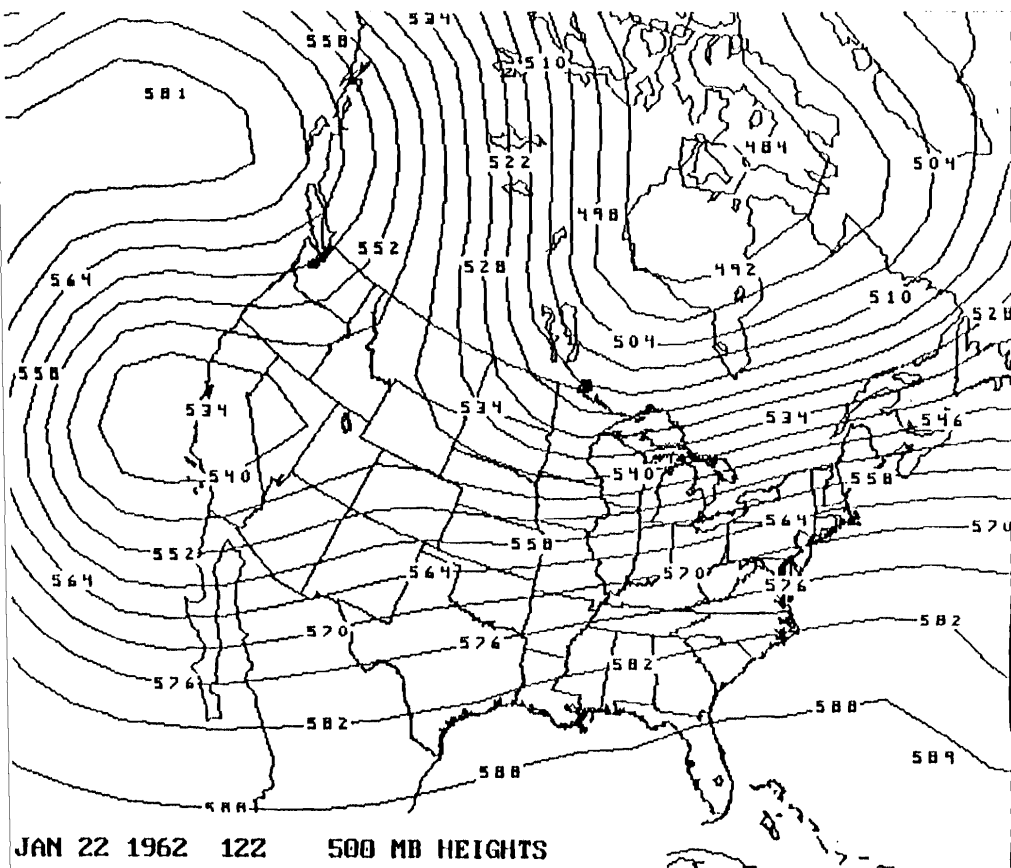


JAN 21 1962 12Z 500 MB HEIGHTS
 FIGURE 14



JAN 22 1962 00Z

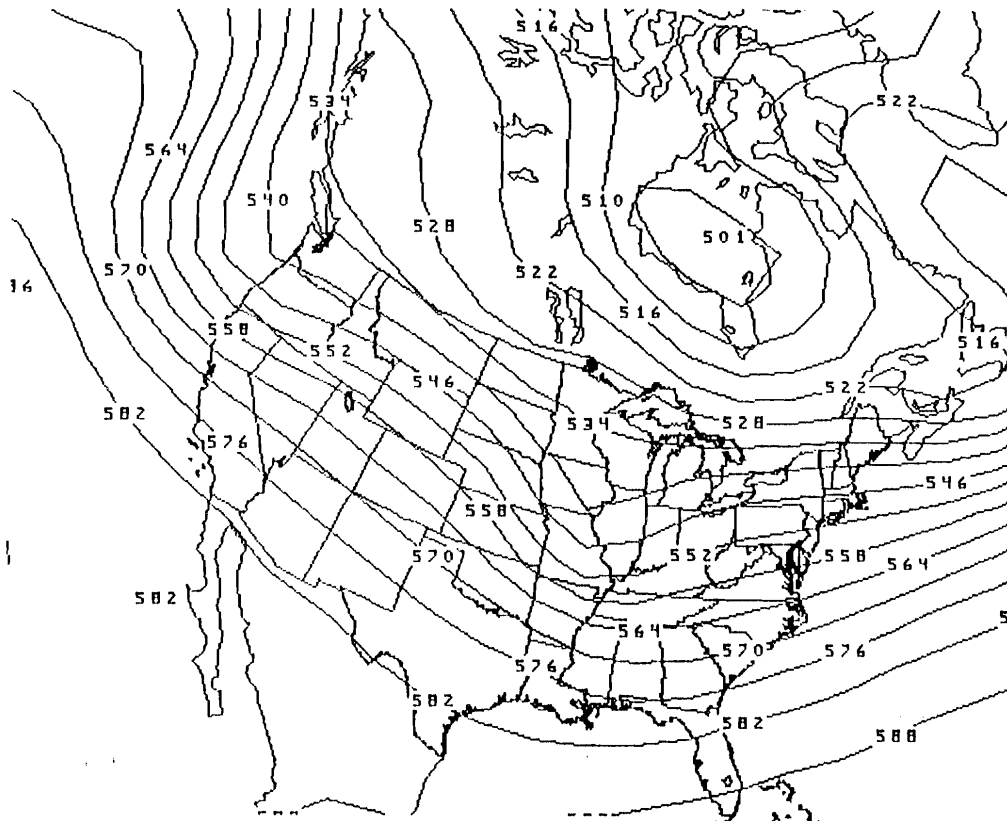
FIGURE 15



JAN 22 1962 12Z

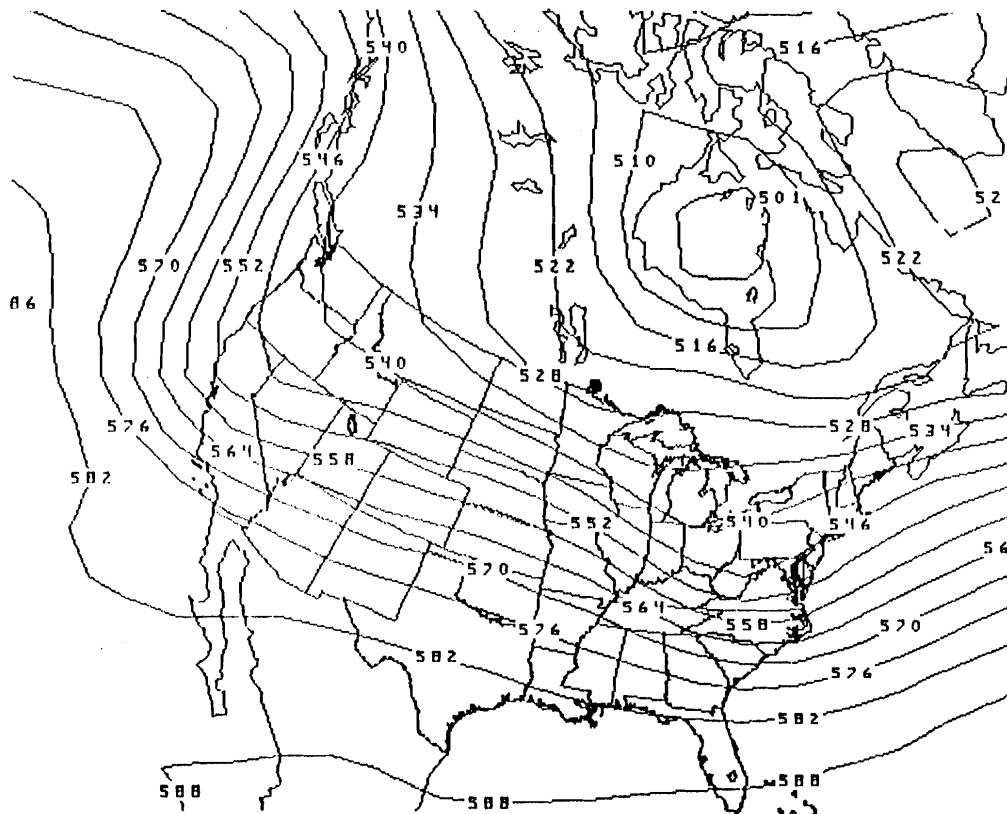
FIGURE 16

PATTERN B - EXAMPLE 1



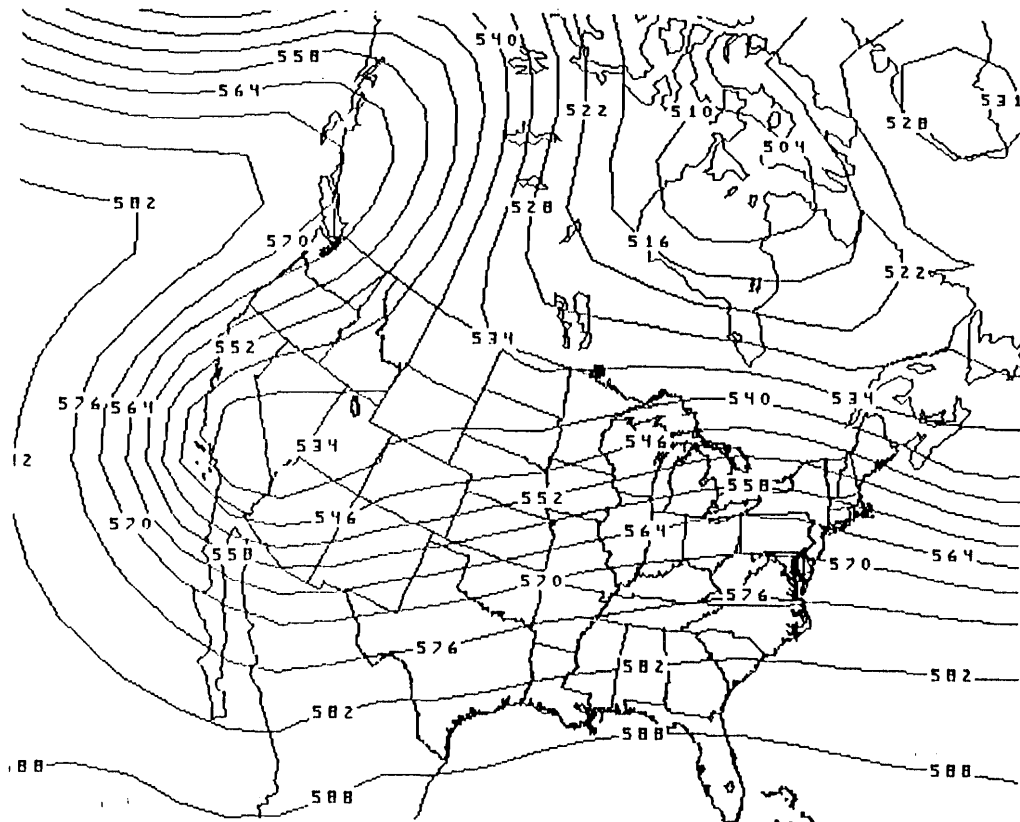
DEC 22 1987 12Z 500 MB HEIGHTS

FIGURE 17



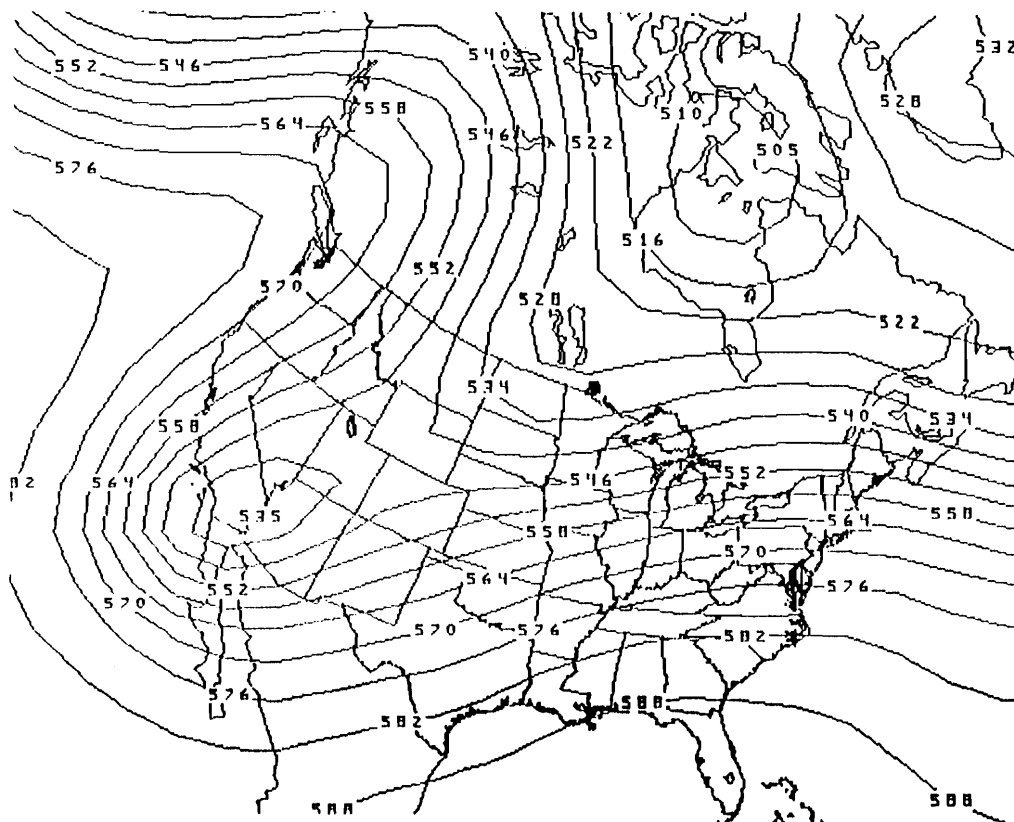
DEC 23 1987 00Z 500 MB HEIGHTS

FIGURE 18



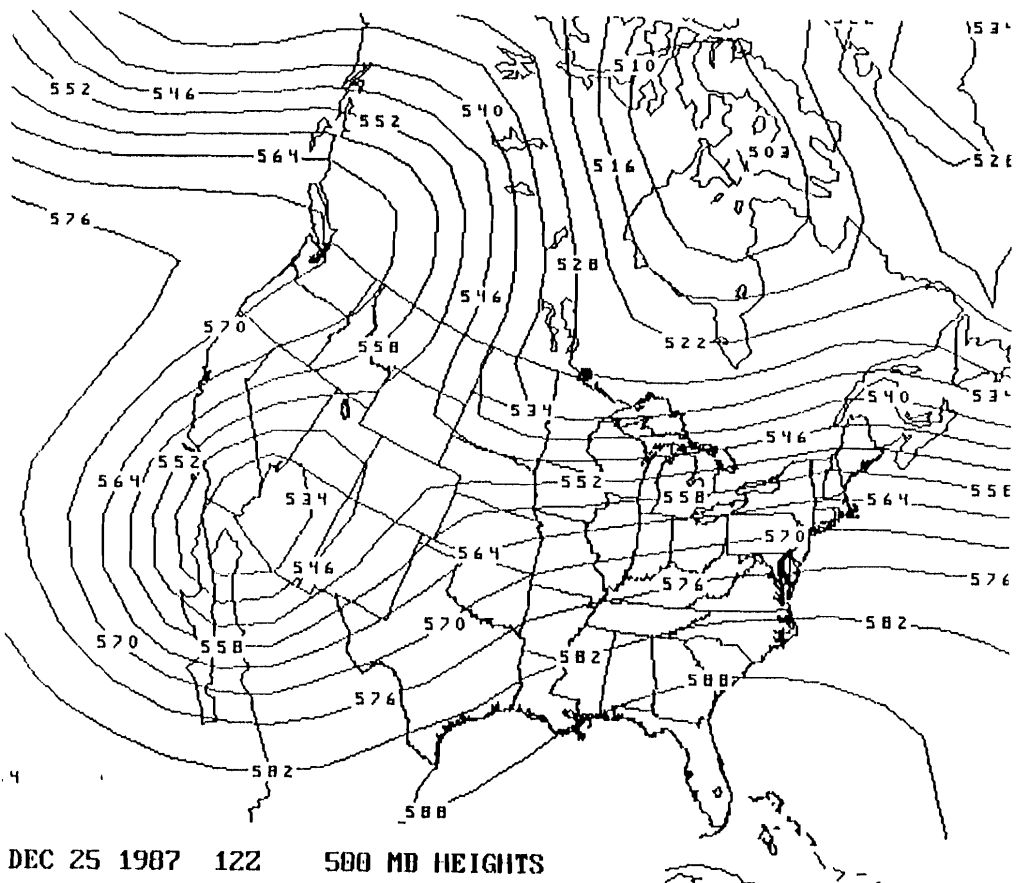
DEC 24 1987 12Z 500 MB HEIGHTS

FIGURE 21

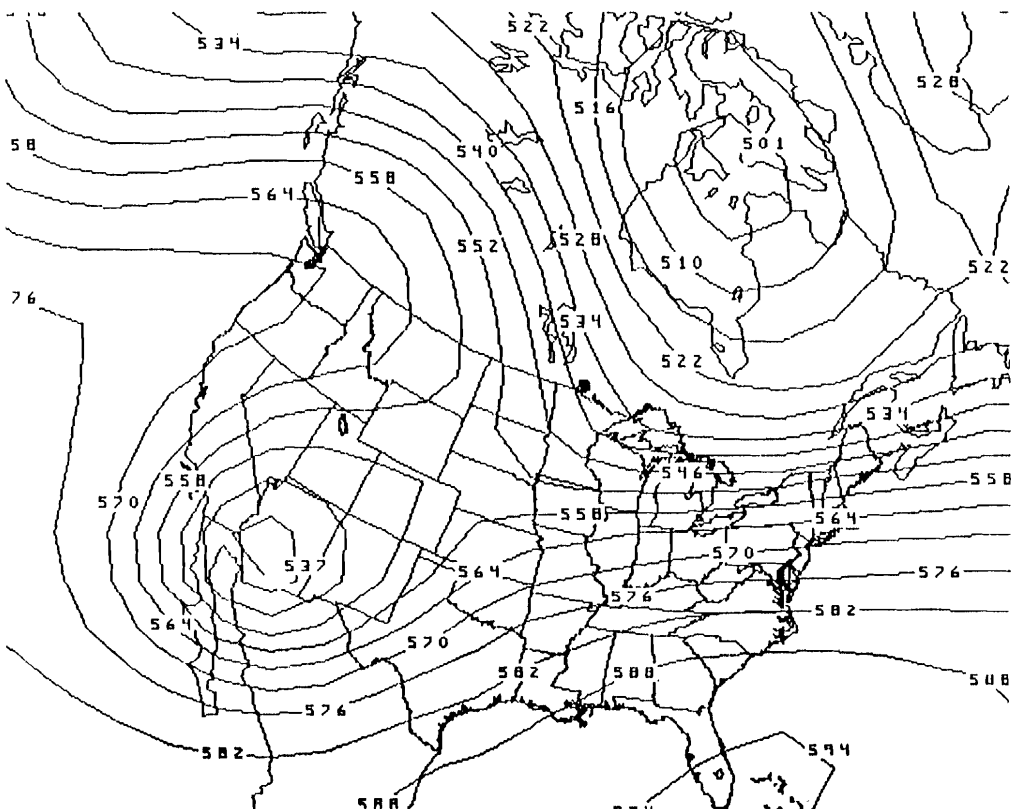


DEC 25 1987 00Z 500 MB HEIGHTS

FIGURE 22



DEC 25 1987 12Z 500 MB HEIGHTS
 FIGURE 23



DEC 26 1987 00Z 500 MB HEIGHTS
 FIGURE 24

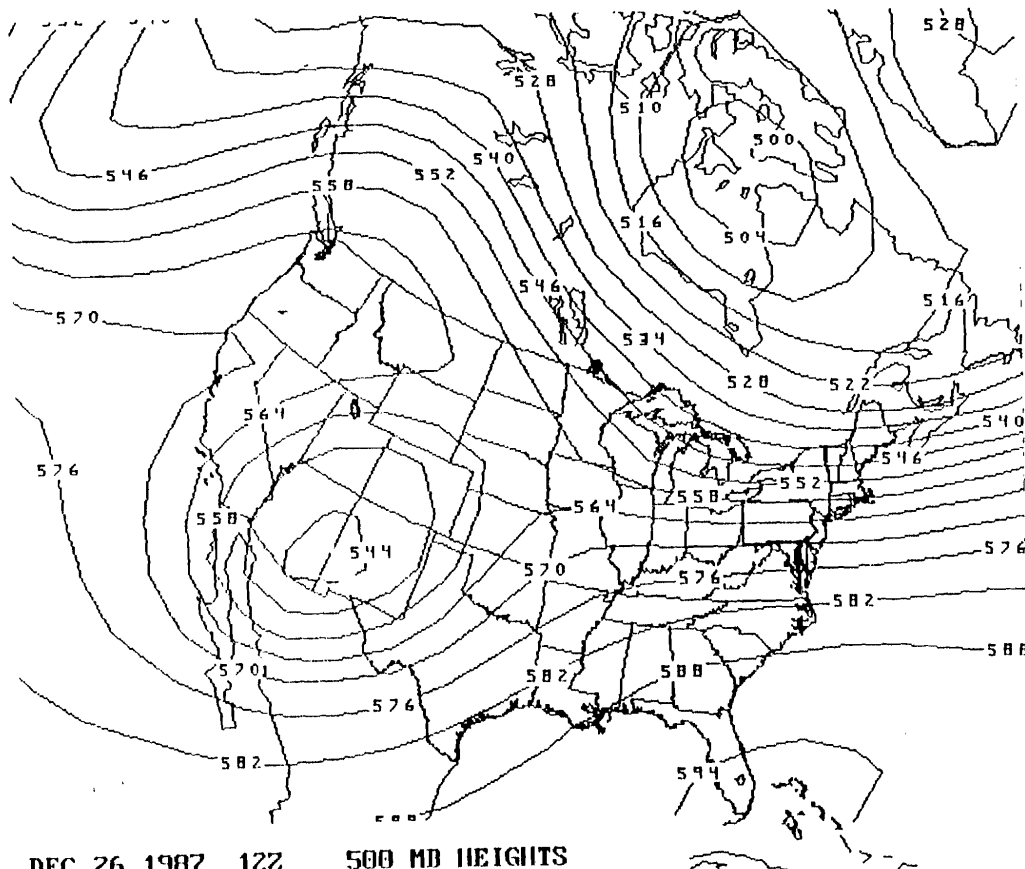


FIGURE 25

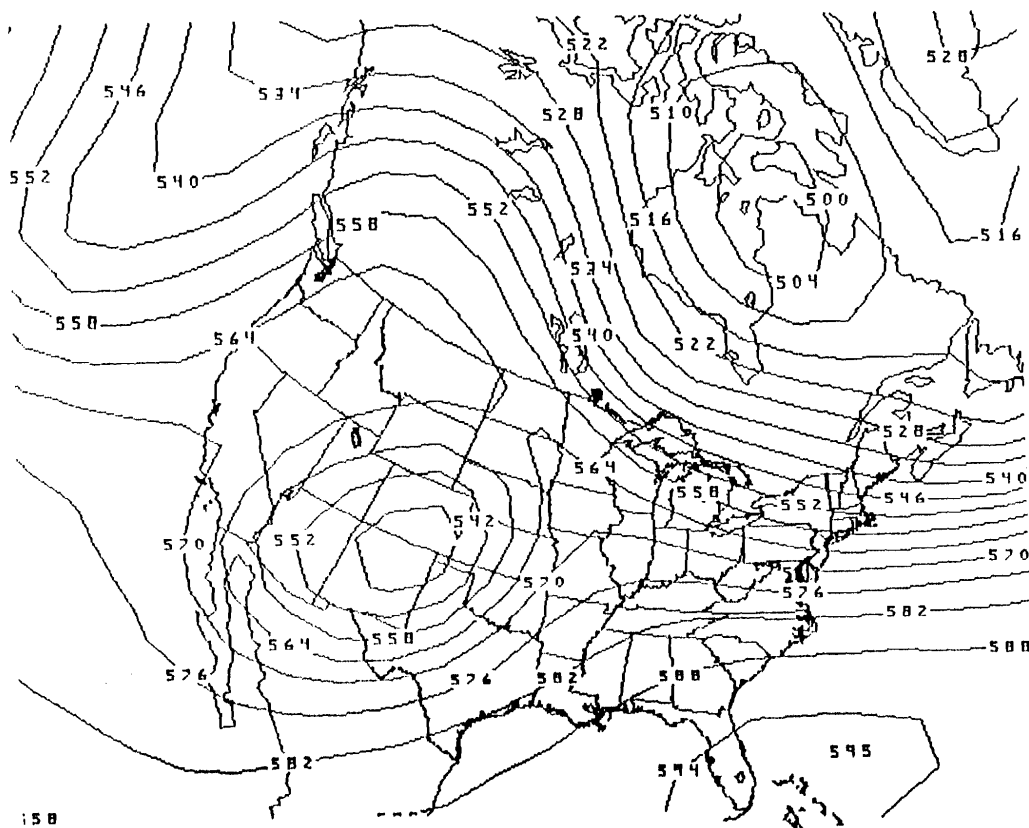


FIGURE 26