U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 245

Evaluation of LFM Forecasts Run From Analyses Using VAS Sounding Data for Two April 1981 Cases: Part 2 of 2

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This is an unreviewed manuscript, primarily intended for informal exchange of information among NMC staff members.

Introduction

This report describes the results of a two-case comparison between the operational LFM forecast and an LFM run from an analysis using VAS data in the eastern Pacific. The VAS data covered an area between 28°N to 46°N and 122°W to 146°W (Fig. 5, O.N. 244) at two synoptic times:

12Z 14 April 1981 (Case A)

12Z 15 April 1981 (Case B)

Evaluation of the Forecasts

Evaluation of the forecasts consists of the following:

1. Subjective comparisons of analyses and 12, 24, 36, 48 hr forecasts of 500 mb geopotential/vorticity, and surface p/1000-500 mb thickness against verifying operational analyses.
2. SUMAC statistical summaries of S1, bias and rms error of geopotential, temperature and vector wind at 500 and 250 mb.
3. Comparison of 12 hr precipitation patterns without verification.

II. Case A - 12Z 14 April 1981

A. Subjective Comparison of 500 mb, surface and precip forecasts

As one might expect, the 500 mb, analyses (Fig. 1) are identical except for the details of a short wave centered near the northwest corner of the VAS area and a weak trough off the southern California coast. The center of the short wave with VAS is 20 m deeper and about one degree farther south than w/o VAS. Also, both the height and the vorticity isopleths in the VAS case have more narrow meridional extent. The positive vorticity associated with the weak trough has been reduced in the VAS analysis while the upstream ridge has been intensified.

After 12 hours the eastward movement of the short wave (Fig. 2a) with VAS has lagged behind the w/o VAS case, and both the center and the vorticity maximum are closer to the verifying position.* The southern trough has moved eastward and become less organized . This weakening is captured by the VAS case while the w/o VAS forecast maintains a relatively strong vorticity maximum in southwestern Arizona.

Both 12 hour surface forecasts (Fig. 2b) are identical east of the Rockies. The VAS forecast has better definition of the elongated trough on the California-Nevada border. The low in the northeast Pacific along longitude 140 W has moved east less rapidly than indicated in the w/o VAS forecast.

At 24 hours the N.E. Pacific wave (Fig. 3a) with VAS continues to lag (correctly) behind the w/o VAS case. All that remains of the weak southern trough in the VAS case is a vorticity maximum in N.W. Mexico; the w/o VAS trough remains (although weakening) in Arizona. A strong vorticity maximum appearing in the verifying analysis near Guadaloupe Island may be spurious.

By 24 hours the surface forecasts (Fig. 3b) begin to show small differences in the Great Plains. The VAS forecast continues to correctly retard the low off the Coast of B.C. compared to the w/o VAS case. Rainfall patterns (fig. 3c) are similar except for the frontal precip off the Pacific coast where the VAS forecast lags by about two degrees.

The short wave off the coast of Washington in the 36 hr 500 mb VAS forecast (Fig. 4a) agrees well with the verification while the w/o

* At this point a caveat is in order - any comparison of trough position vis-a-vis the verifying analysis must be tempered by the fact that the scarcity of conventional data in this region casts doubt on accuracy of the analysed position.

VAS case brings the vorticity maximum all the way into Southern Vancouver Island. The remnants of the weak trough exists as a small vorticity maximum in S.W. Wyoming. The VAS prog carried the vorticity maximum too far east into the Nebraska panhandle while the w/o VAS forecast is closer to truth but extends the vorticity too far south into New Mexico. Both VAS and w/o VAS forecasts underestimate the strength of the ridge through the Missouri Valley.

At the surface (Fig. 4b) a low over Queen Charlotte Island is handled reasonably well in both cases. The VAS forecast is two degrees to the NW of the verifying position and 9 mb too shallow. The w/o VAS forecast is deeper but has reached the mainland prematurely; both cases suggest the extension of the trough through British Columbia to Montana.

Frontal precipitation (Fig. 4c) in the w/o VAS case has entered the Pacific northwest while the VAS case keeps it just off shore reflecting the relative positions of the surface lows. The w/o VAS forecast also shows greater amounts in the big bend area of Texas.

After 48 hours, the 500 mb analysis (Fig. 5a) shows a short wave over the Nebraska Panhandle with a well-defined vorticity center. The VAS forecast indicates a much weaker wave over central Nebraska while the w/o VAS case places the vorticity maximum in extreme northern Texas. A vorticity maximum just north of Idaho in the verification splits the difference between the predicted features.

The surface low north of Montana (Fig. 5b) was moved too far east in both progs although the w/o VAS case suggests greater low level south-westerly winds through the Great Plains.

The precipitation in Texas and Oklahoma (Fig. 5c) is more widespread in the w/o VAS case due to the position and intensity of the Texas vorticity maximum. Precipitation coverage w/o VAS is also greater in the Pacific Northwest.

B. SUMAC Statistical Summary

Tables 1 and 2 present a side-by-side comparison of error statistics for 500 and 250 mb forecasts over the NA110 station network. The performance of both forecasts is comparable. The VAS case holds a small but consistent advantage in 500 mbs winds but looses it at 250 mb. Forecasts w/o VAS hold a slight edge in temperature prediction at both levels. Verification of geopotential is inconclusive.

III. Case B - 12Z 15 April 1981

A. Subjective Comparison of 500 mb, Surface and Precipitation Forecasts

As with Case A, the 500 mb analyses for 12Z 15 April (Fig. 6) exhibit significant differences in the shortwave features off the coast of Washington state and lower California. The northern trough with VAS is 40 m deeper and has a slightly stronger vorticity maximum than the operational analysis. The center of the southern trough with VAS is one degree farther northeast and has a weaker, though more concentrated vorticity center.

Despite the marked differences in initial conditions, the 12 hr 500 mb forecasts (Fig. 7a) are remarkably similar off the West Coast. Both forecasts bring the northern vorticity center eastward to about the same place and extend a well defined trough line southward into central California. Although this trough line does not show up in the verifying analysis, the position of the center is very good. The southern shortwave is almost identical in both forecasts although the VAS case correctly extends more vorticity out over the ocean. A minor vorticity maximum in north central Colorado in both forecasts is slightly east of the verifying position.

The 12 hr MSL forecasts (Fig. 7b) do an excellent job on the low off Queen Charlotte Island. Precipitation patterns (Fig, 7C) are also similar in both cases.

After 24 hrs, the vorticity center in the Pacific northwest (Fig. 8a) has moved inland to the southeast corner of British Columbia. The VAS forecast has a closed vorticity center in the right place while the w/o VAS forecast has weakened this feature considerably and shows little evidence of it in the height field.

Judging by the strength of the vorticity maximum over Baja, the VAS forecast has a better handle on the southern trough than the w/o VAS case. Both forecasts show another short wave around 40°N, 140°W with the trough line slightly east of the verifying position. An interesting feature has appeared in both forecasts south of the Aleutians. A strong westerly jet (as indicated by a tight height gradient) is producing a vigorous positive/negative couplet of shear vorticity in this region. The origin of this feature first appears in the 12 hr forecasts on the northwestern edge of the grid. The proximity of this feature to the grid boundary and its absence from the verifying analysis suggest that it is caused by a boundary condition problem.

At the surface (Fig. 8b) both forecasts show a well-defined low near Juneau, Alaska that is deeper than the verification but near the correct location. The low located on the Alberta-Saskatchewan border is handled better in the VAS forecast with respect to depth and position.

Precipitation (Fig. 8c) is again similar in both forecasts with slightly larger coverage in Washington and Oregon by VAS.

At 36 hours (Fig. 9a), both forecasts have correctly predicted the position and strength of the short-wave over western Iowa. Although both move the southern extent of this wave (formerly off Baja) too far east, the VAS case still maintains a strong vorticity center near the verifying position. The unusual vorticity couplet in the eastern Pacific persists and has moved eastward. Again, no evidence of this feature appears in the verification. The vorticity maximum in southern Saskatchewan is handled very well by the VAS forecast while the w/o VAS center is too weak.

The major feature on the 36 hr MSL map (Fig. 9b) is the low along the U.S. Canada border. Both progs move the center and its associated thermal ridge slightly too far east with the VAS case half-way between the w/o VAS and verifying positions. Also both forecasts correctly show a minor high near four corners. Overall, these are excellent MSL forecasts.

Predicted precipitation areas (Fig. 9c) agree closely. The VAS forecast, however, does bring rain farther south into northern California.

By 48 hr., a vigorous short wave (Fig. 10a) has developed off the California coast. The VAS prog brings a weak wave into the west coast and has a ridge along the verifying trough position. The w/o VAS wave is also out of phase but about 5 degrees farther west than the VAS case. The VAS prog places a vorticity center over International Falls which is very close to the verifying position on the south side of Lake Winnipeg. The w/o VAS prog has a much weaker center 5 degrees east of the verifying position. Both progs show an elongated vorticity trough from Lake Michigan southward into Texas; this is farther east than the verifying position by about 3 degrees.

The surface VAS forecast (Fig. 10b) continues to split the difference between the verifying position of the low over International Falls and the w/o VAS low near Sault-Saint Marie. The VAS forecasts deepens this feature to 998 mb while w/o VAS maintains the 36 hr central pressure.

Neither prog does a good job on the deep thickness trough off the west coast. However, in spite of the aforementioned boundary problem on the northwest edge of the grid, both runs correctly produce a strong surface low south of the Aleutians.

In Fig. 10c, the VAS prog continues to generate more precipitation in the northwestern U.S. while the coverage east of the Mississippi is similar in both forecasts.

B. SUMAC Statistical Summary

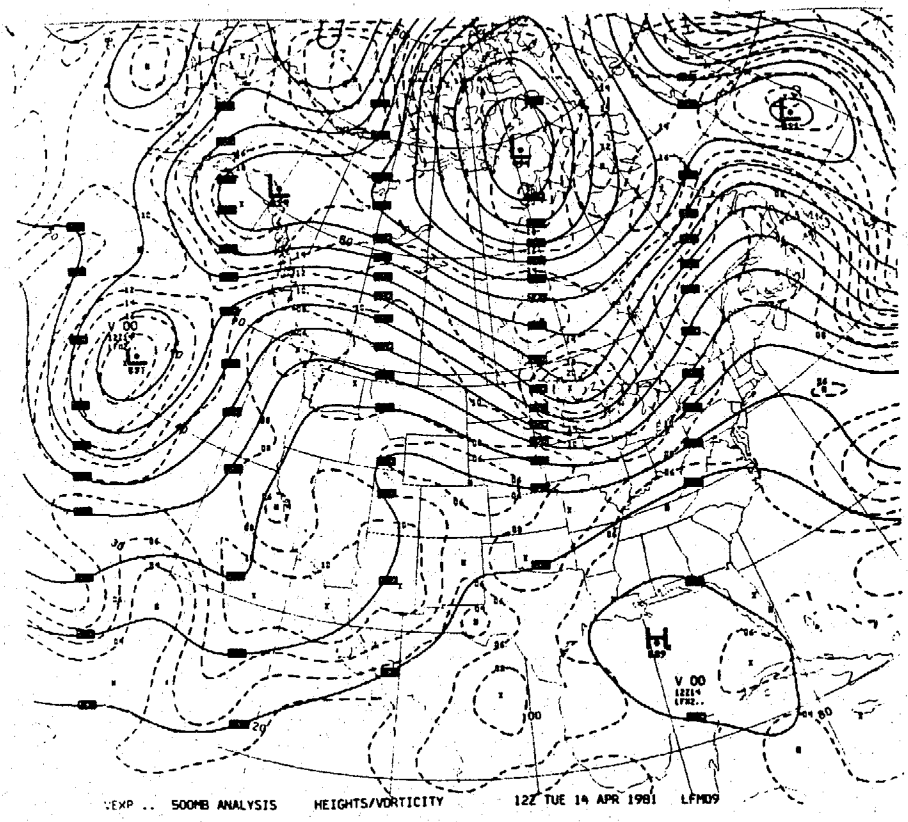
Statistical verification of Case B is shown in Tables 3 and 4. The rms error and bias of 500 mb heights show a steady improvement of the VAS prog's advantage over w/o VAS after 12 hours. S1 height scores, on the other hand, give the w/o VAS prog a small but consistent edge throughout the forecast period. Temperature statistics at 500 mb indicate comparable performance of both progs; the w/o VAS run beats VAS by very small margins 7 to 1 with 3 ties. Likewise VAS consistently trails w/o VAS in vector wind, but by insignificant amounts.

A similar relationship between the two progs appears in the 250 mb statistics (Table 4). Again, the VAS prog pulls ahead of w/o VAS in rms height error and bias during the last half of the forecast period. Both temperature and vector wind statistics are too close to declare a clear winner.

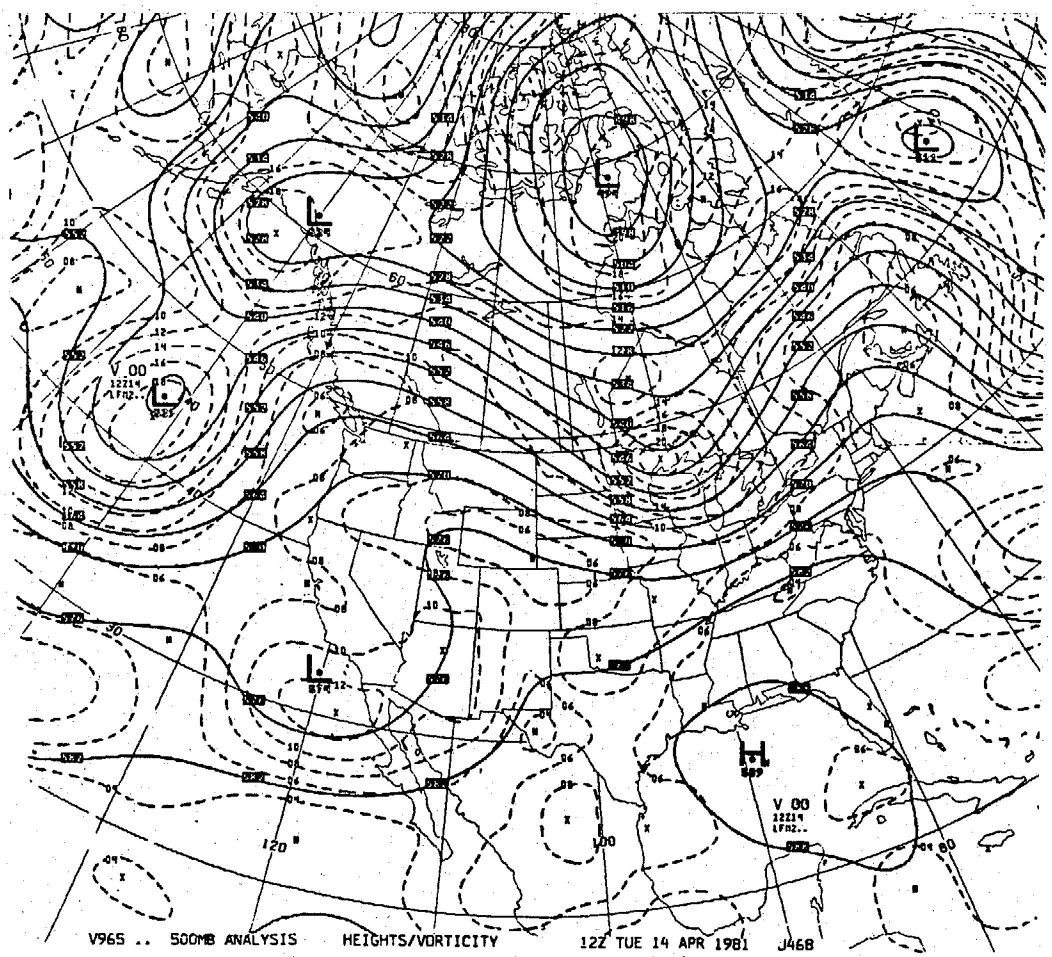
IV. Conclusion

Overall, both LFM forecasts did a creditable job of predicting the strength and position of the major systems. In Case A. the VAS run neither degraded nor improved the model's performance to any significant degree. The results of Case B, however, indicate that the inclusion of VAS data in the analysis produced small but consistent improvements over the operational (w/o VAS) product. Error statistics generated by the SUMAC program did not reveal a significant difference between the two runs.

Admittedly, little can be deduced about model performance by evaluating only two cases. However the respectable performance of the VAS progs vis-a-vis the operational forecasts suggests that further testing is justified.



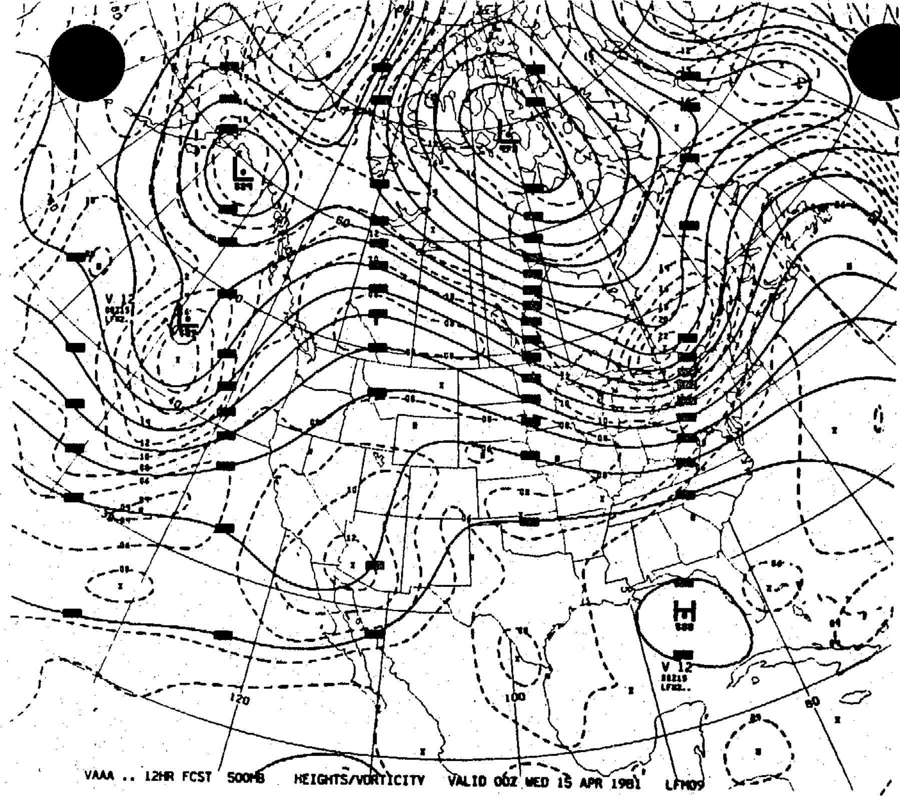
WITH VAS



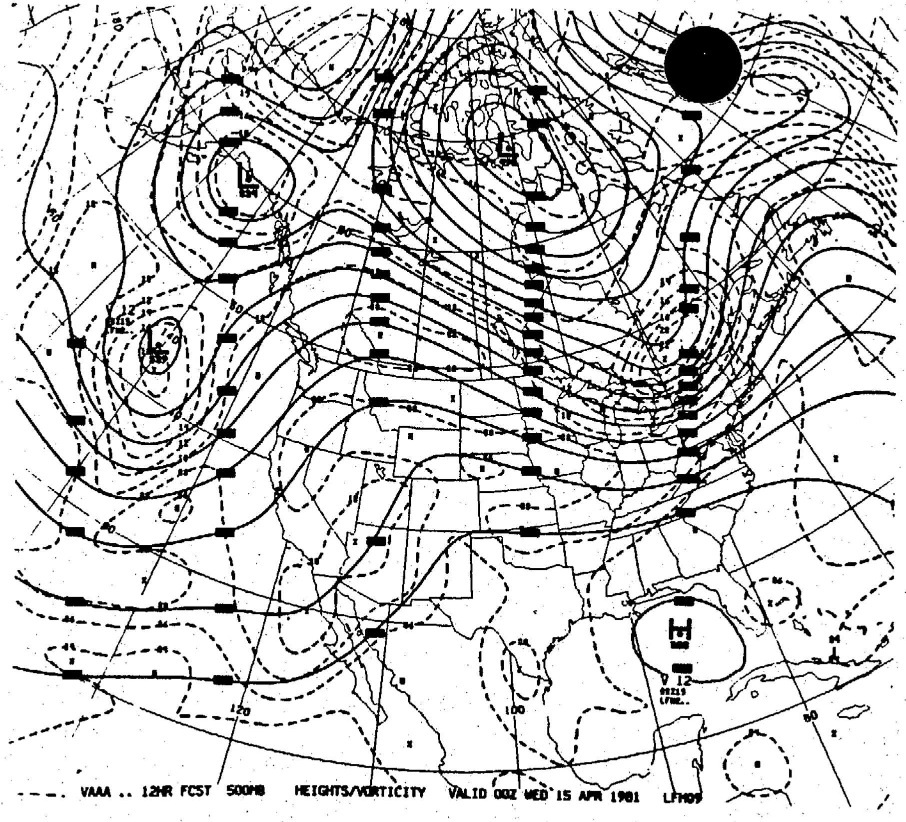
W/O VAS

500MB HEIGHT/VORTICITY ANALYSIS 12Z 4/14/81

FIG. 1



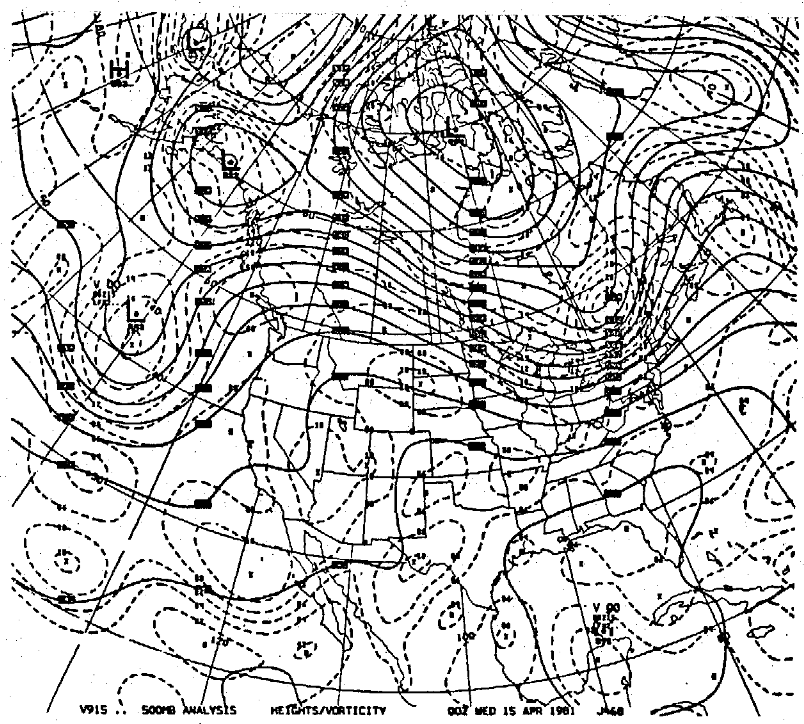
W/O VAS



WITH VAS

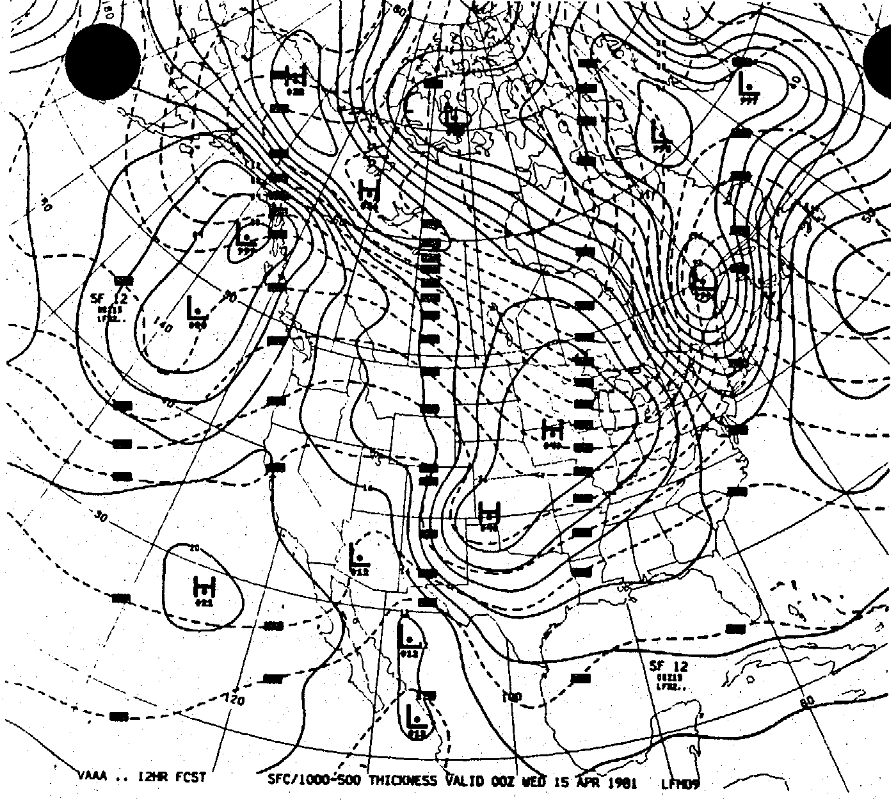
12HR FCST

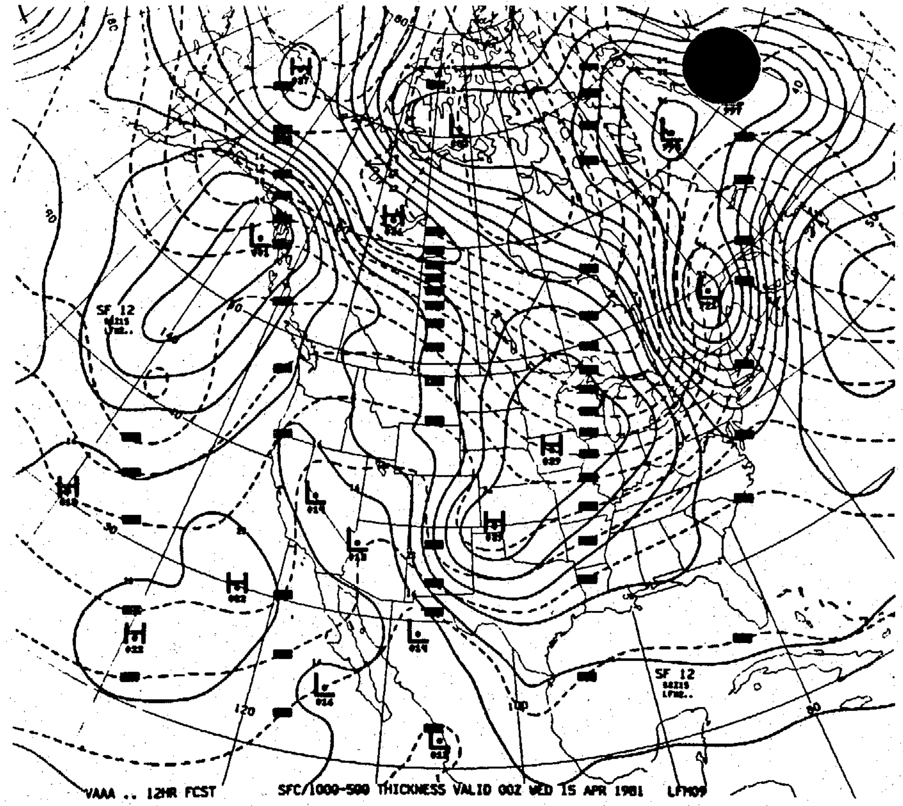
500MB HEIGHT/VORTICITY



VERIFICATION

FIG. 2a



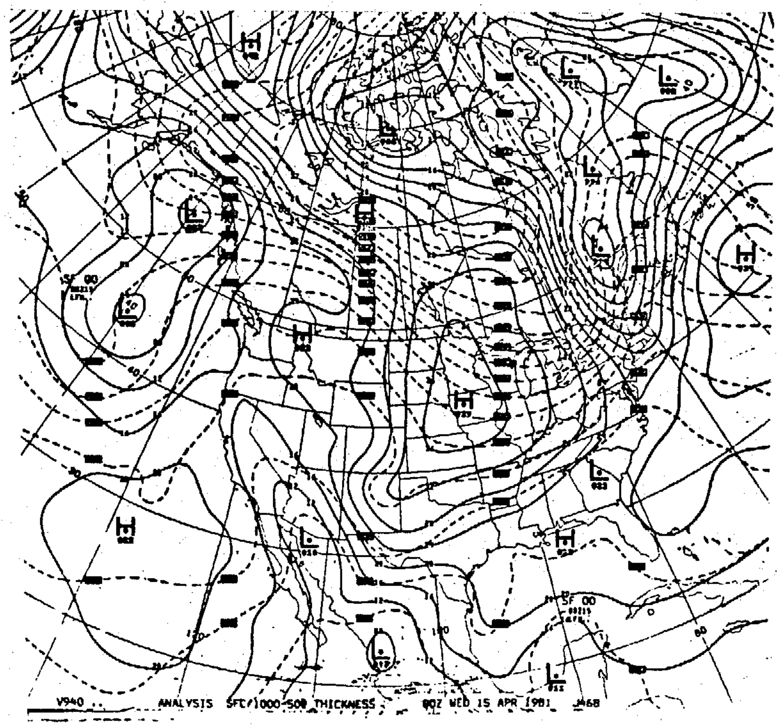


w/o VAS

WITH VAS

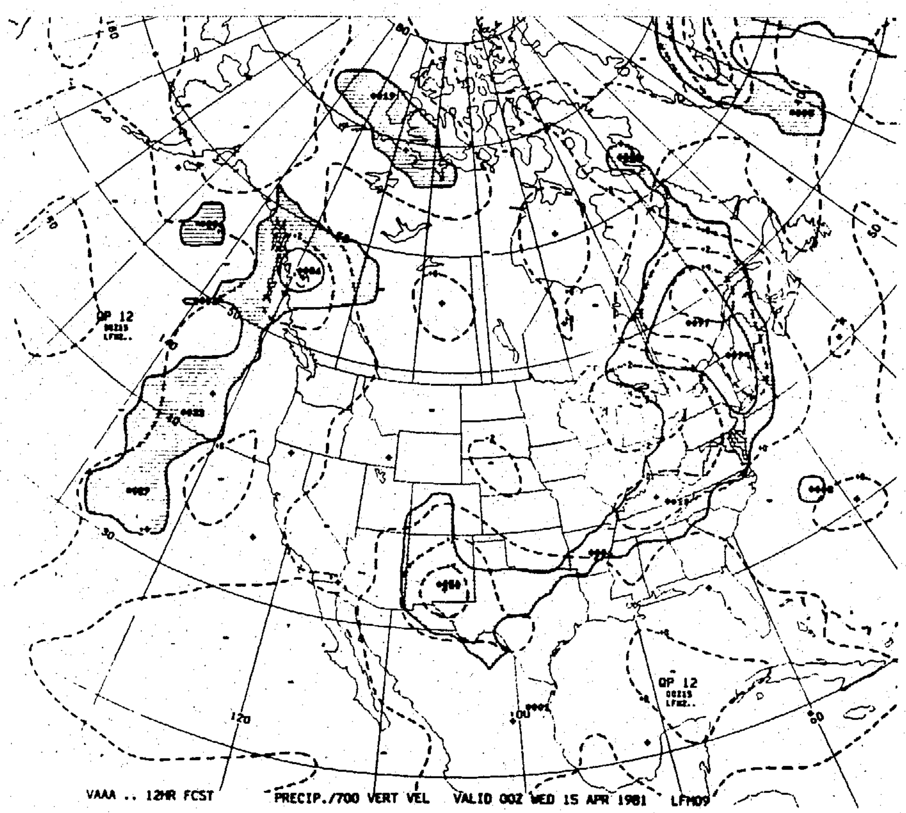
12HR FCST

SFC/1000-500MB THICKNESS

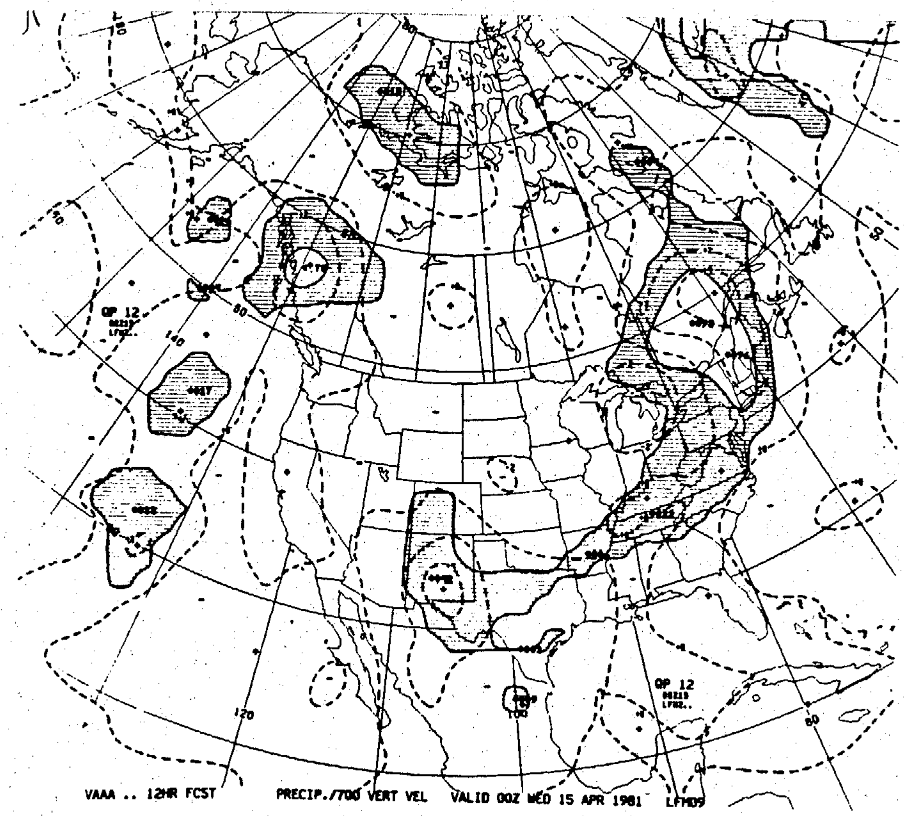


VERIFICATION

FIG. 2b



W/O VAS

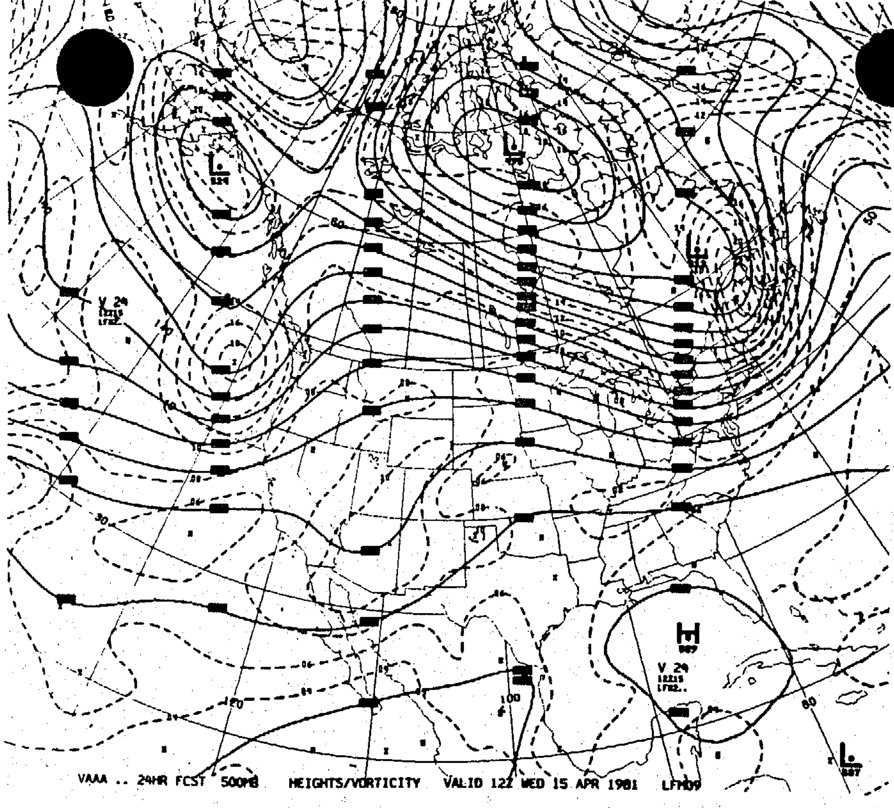


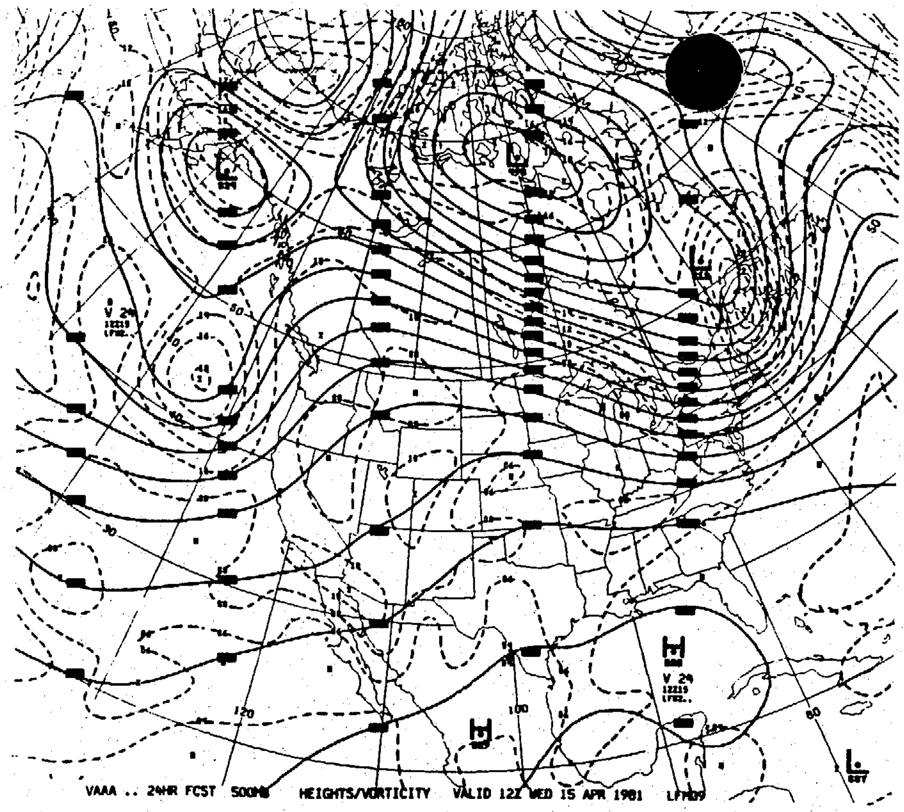
WITH VAS

12HR FCST

PRECIP

FIG. 2c





w/o VAS

WITH VAS

24HR FCST

500MB HEIGHT/VORTICITY

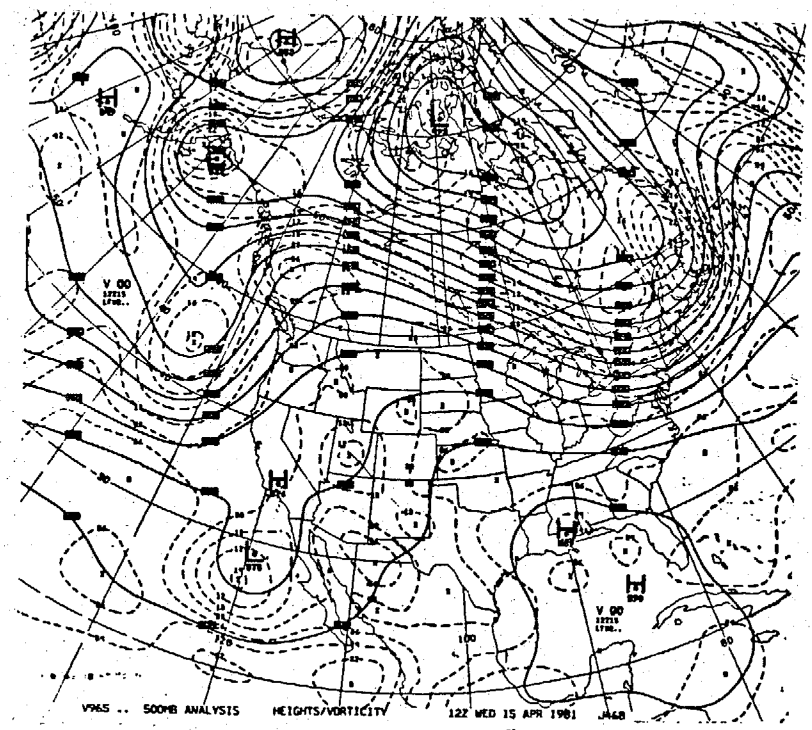
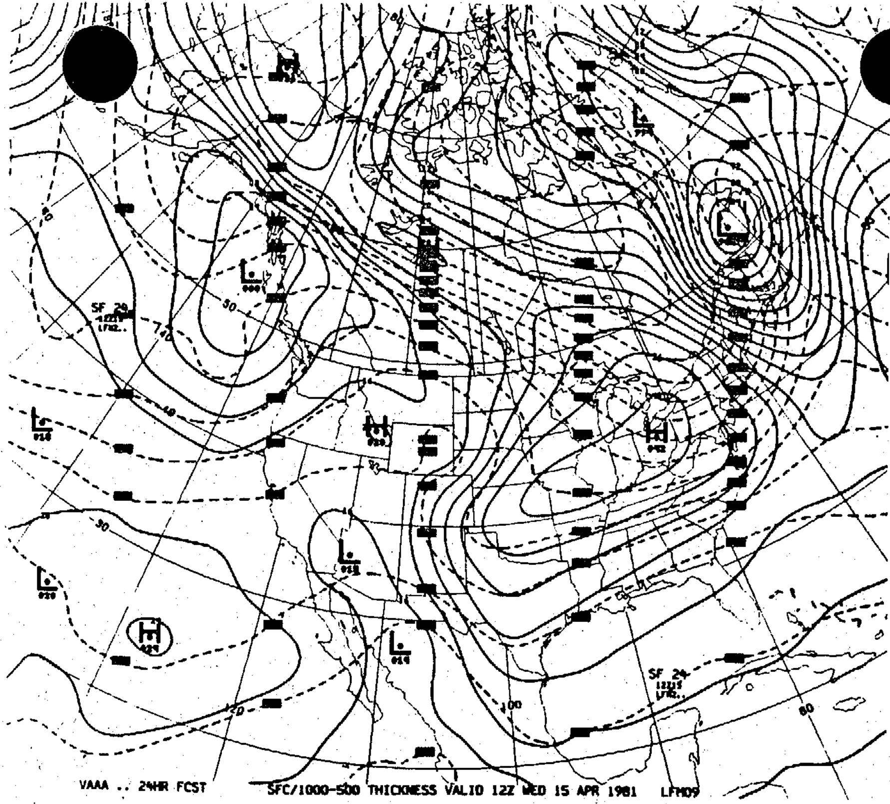
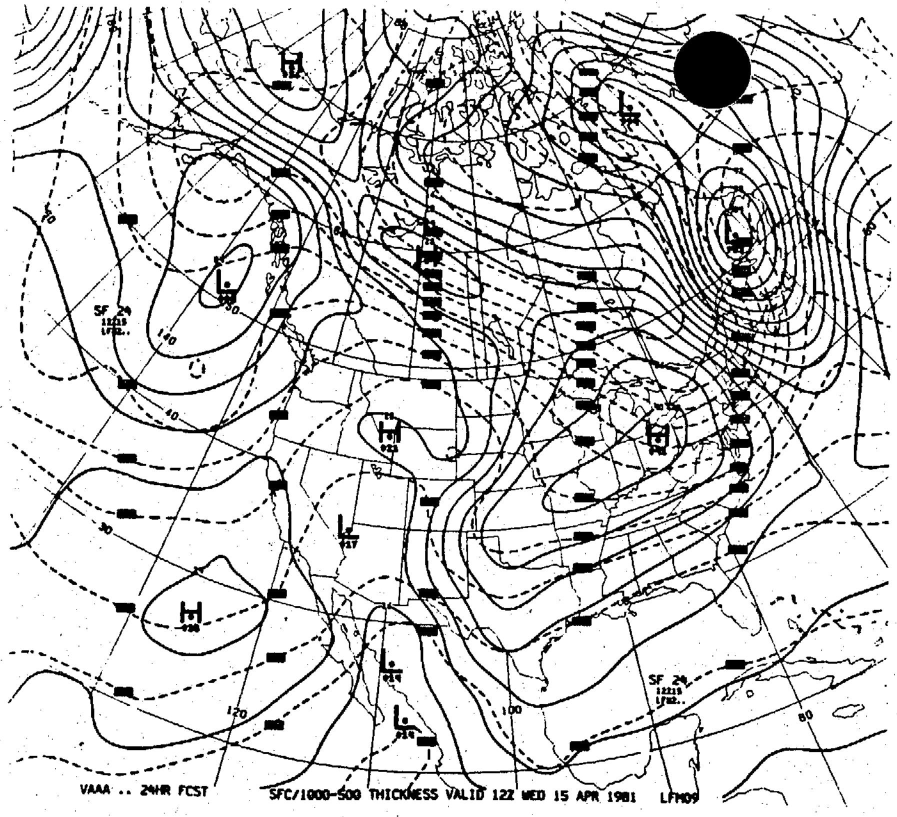


FIG. 3a

VERIFICATION



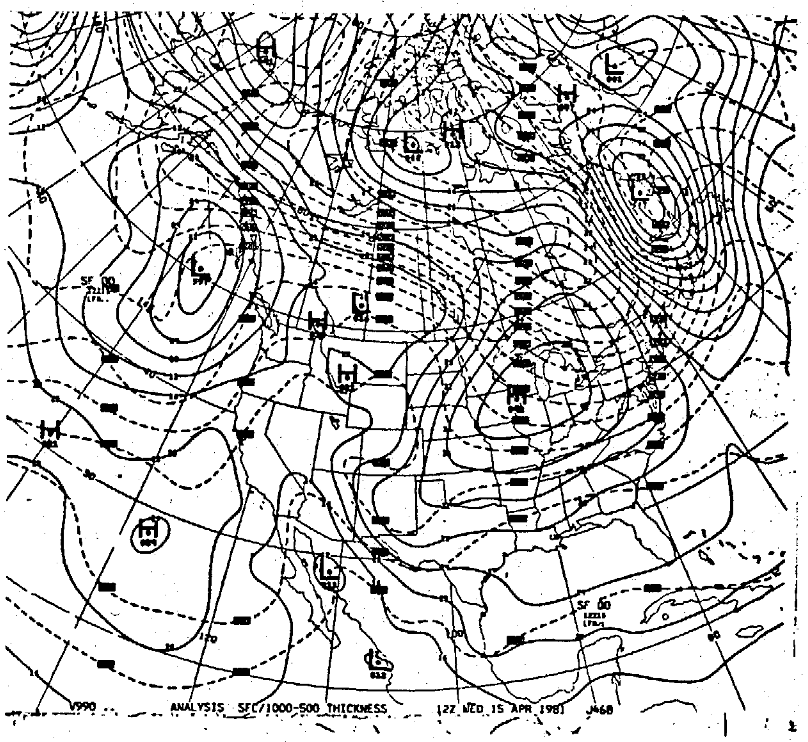
w/o VAS



WITH VAS

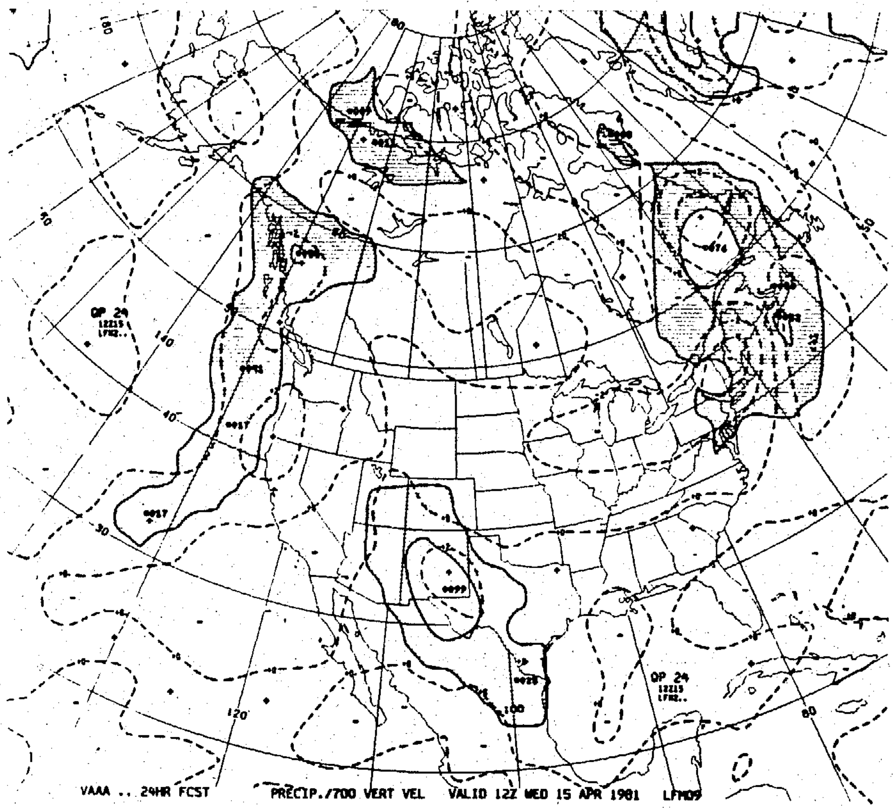
24HR FCST

SFC/1000-500MB THICKNESS

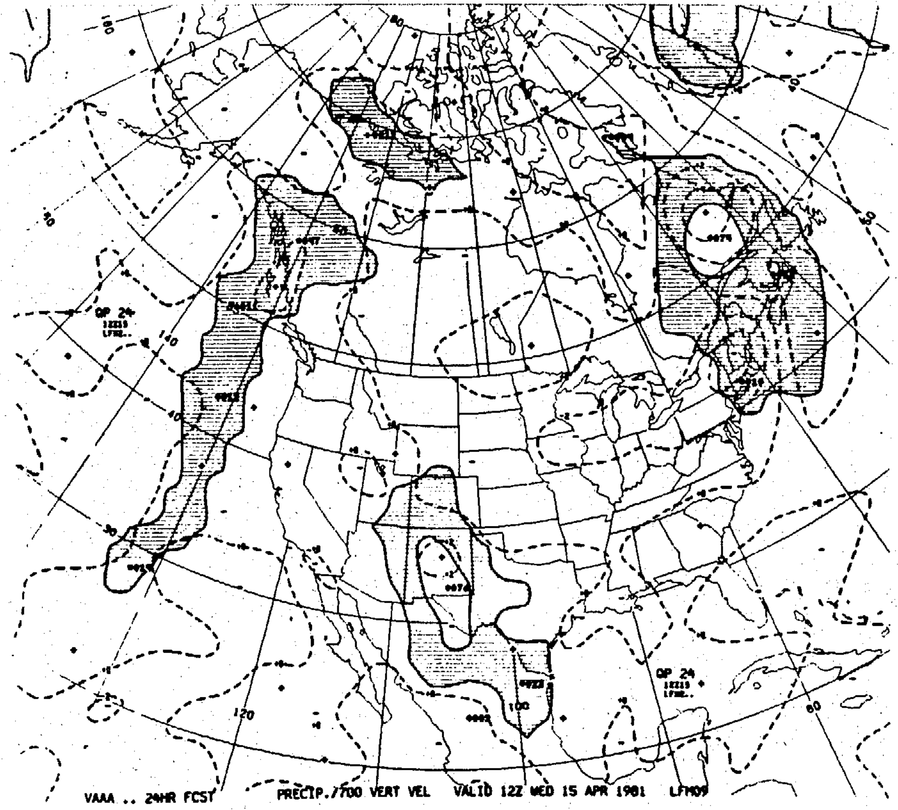


VERIFICATION

FIG. 3b



w/o VAS

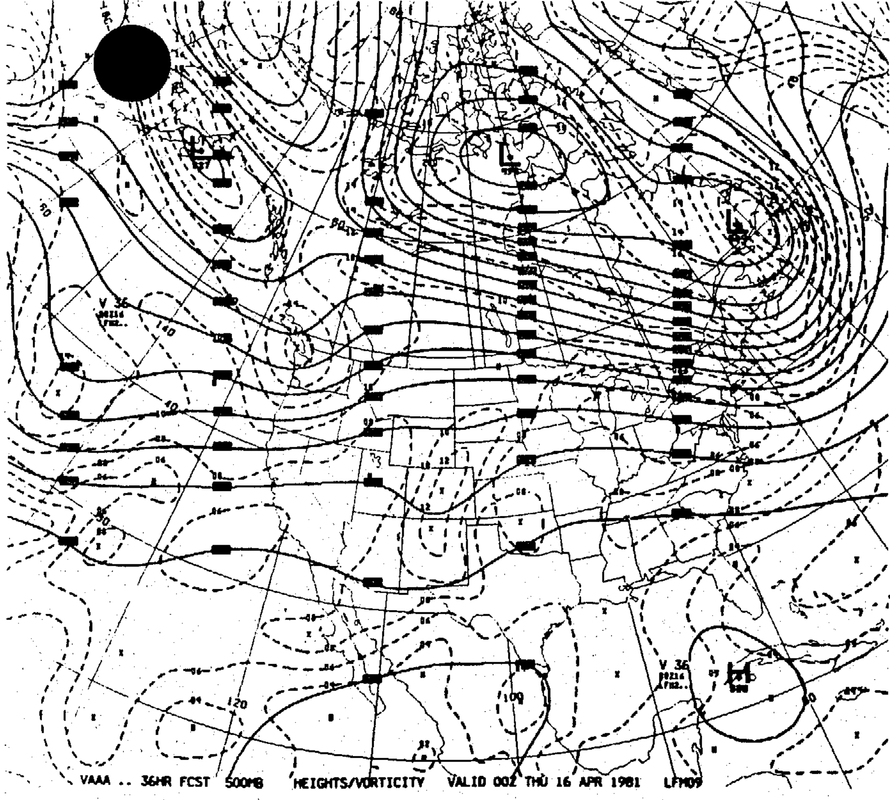


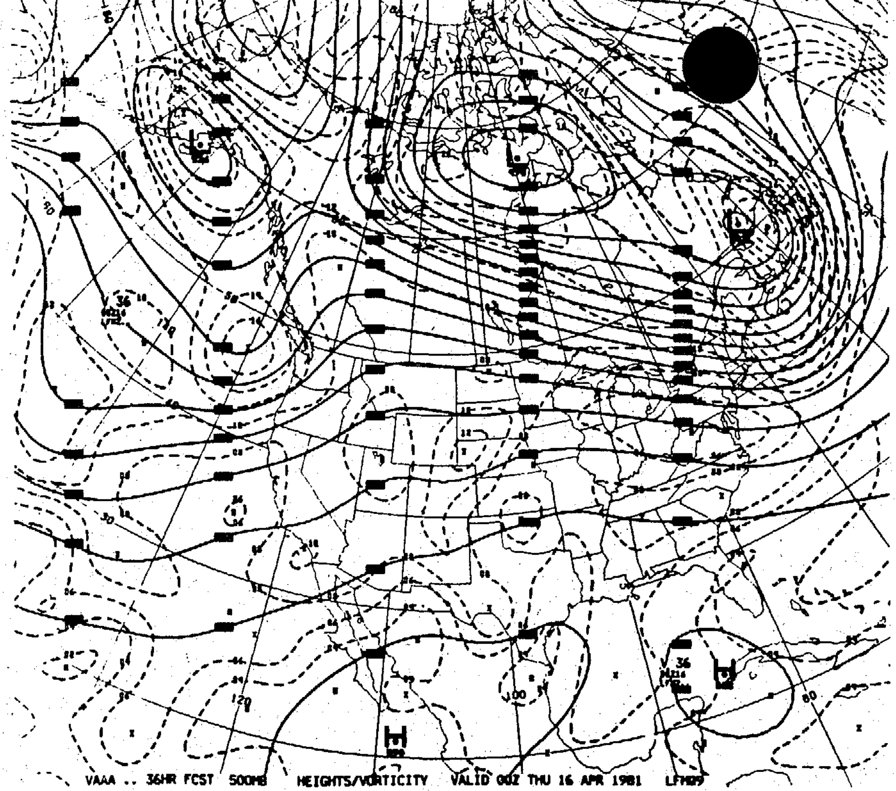
WITH VAS

24HR FCST

PRECIP

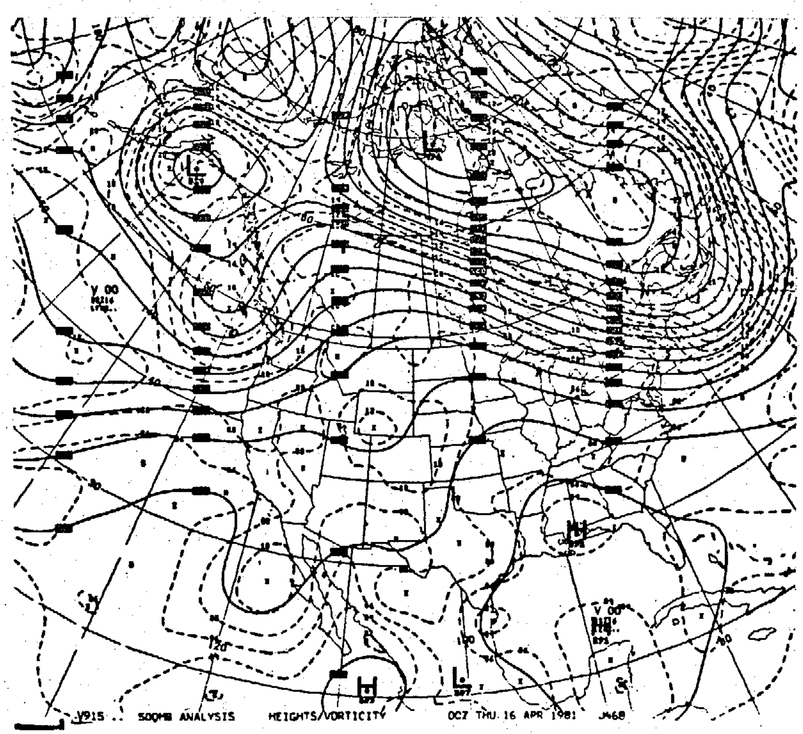
FIG. 3c





w/o VAS

WITH VAS

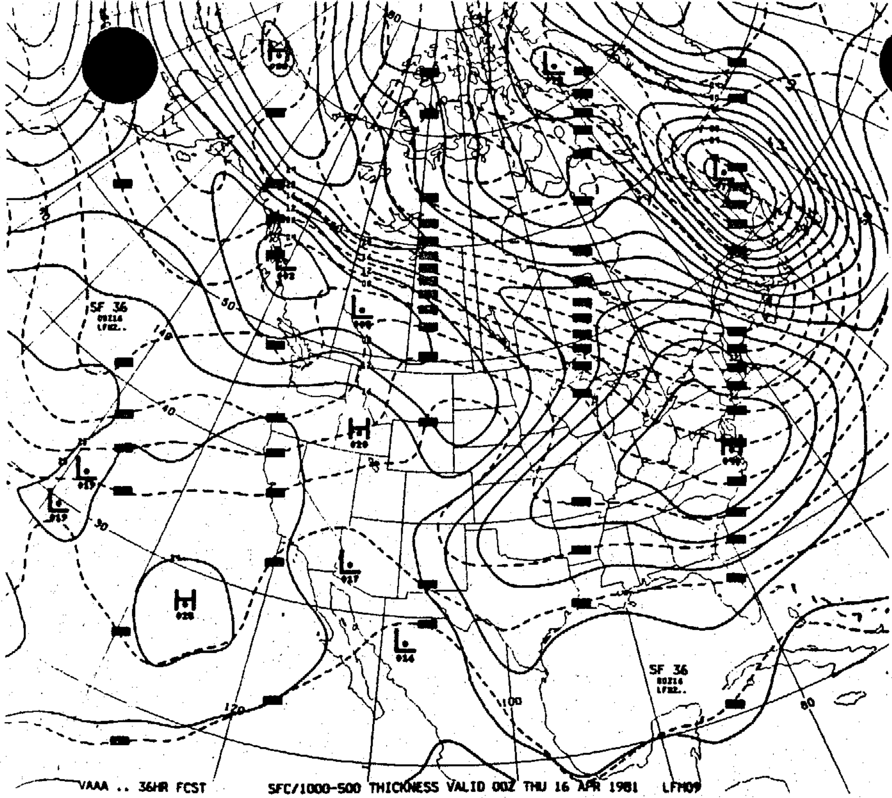


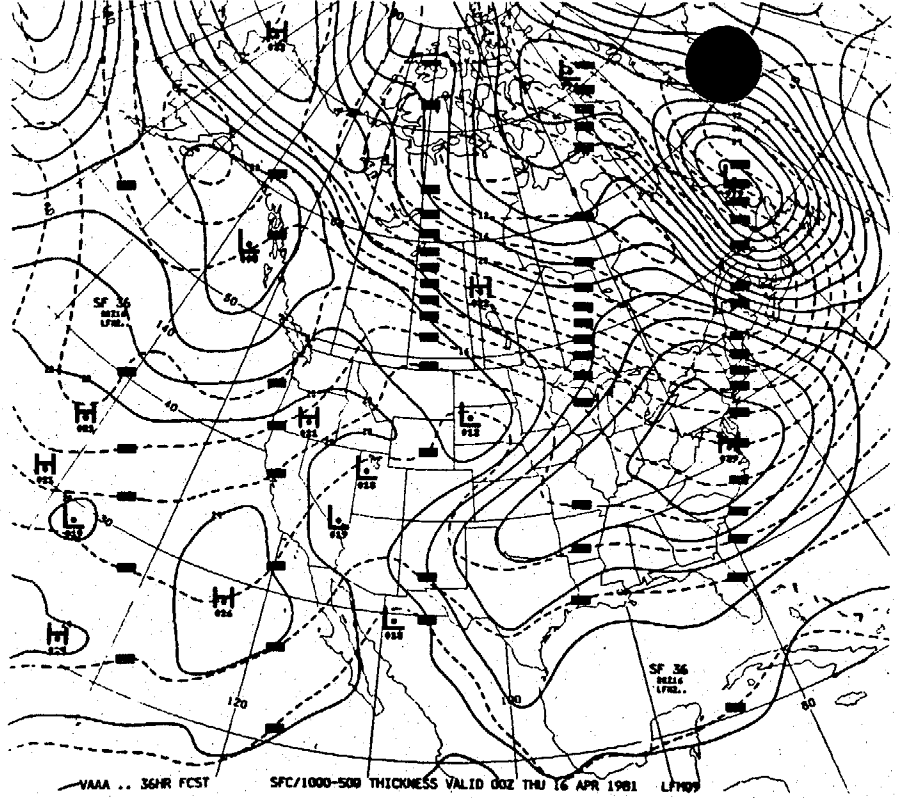
36HR FCST

500MB HEIGHT/VORTICITY

FIG. 4a

VERIFICATION





w/o VAS

WITH VAS

36HR FCST

SFC/1000-500MB THICKNESS

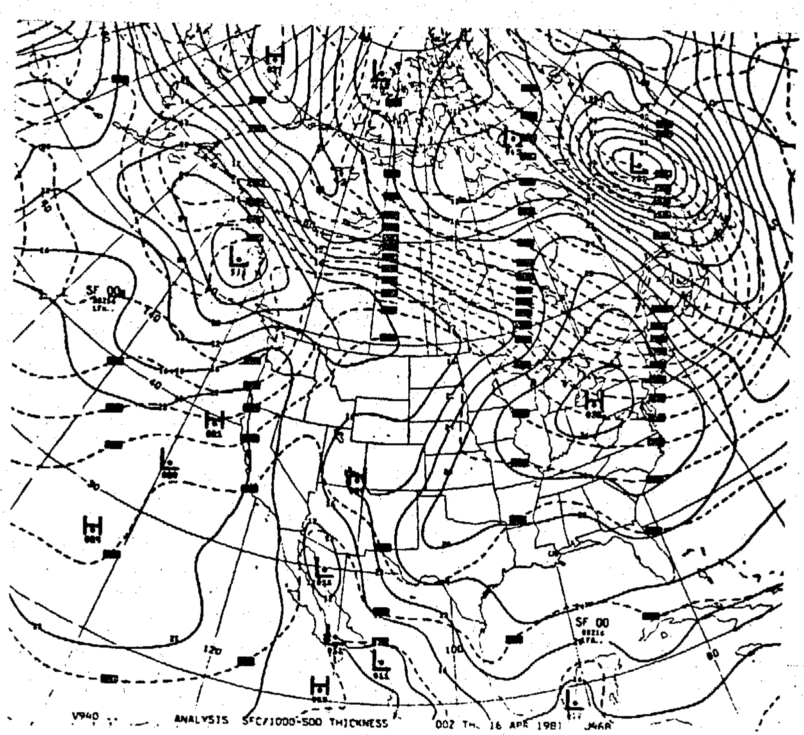
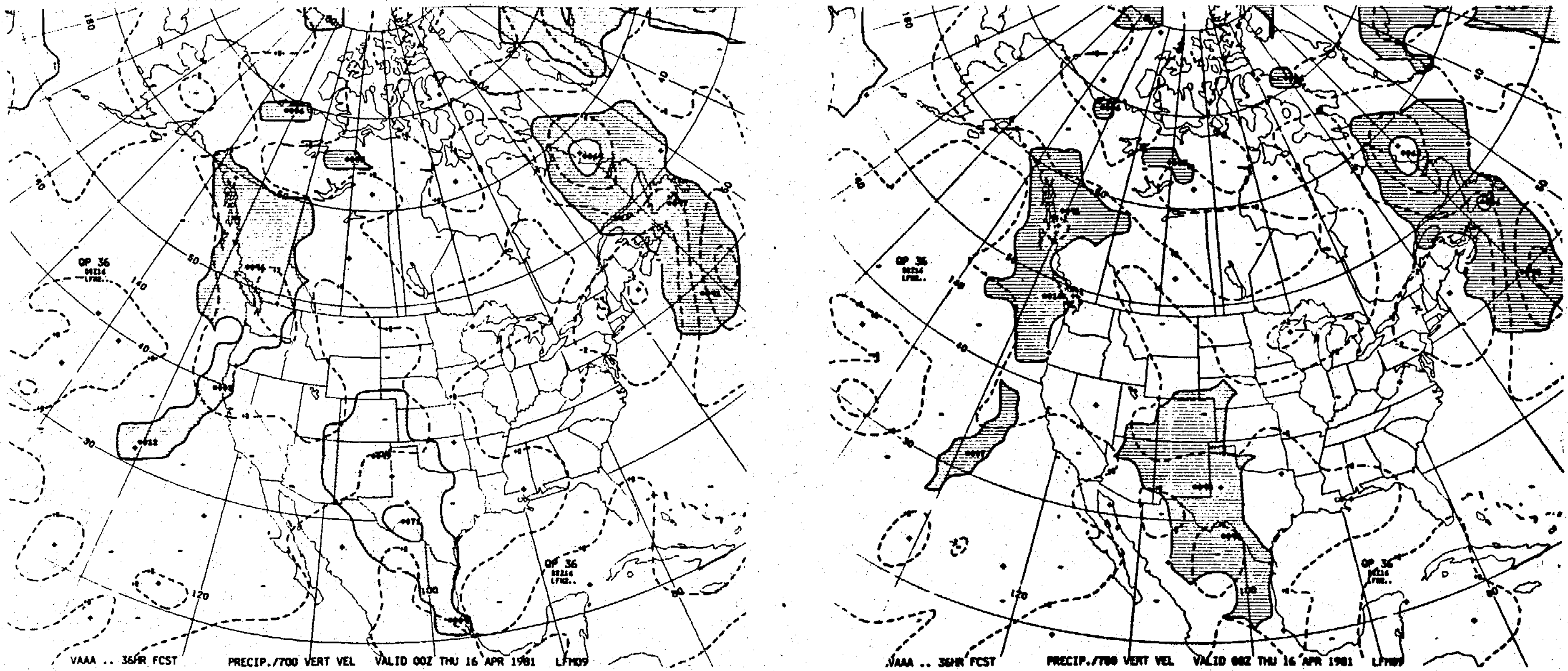


FIG. 4b

VERIFICATION



W/o VAS

WITH VAS

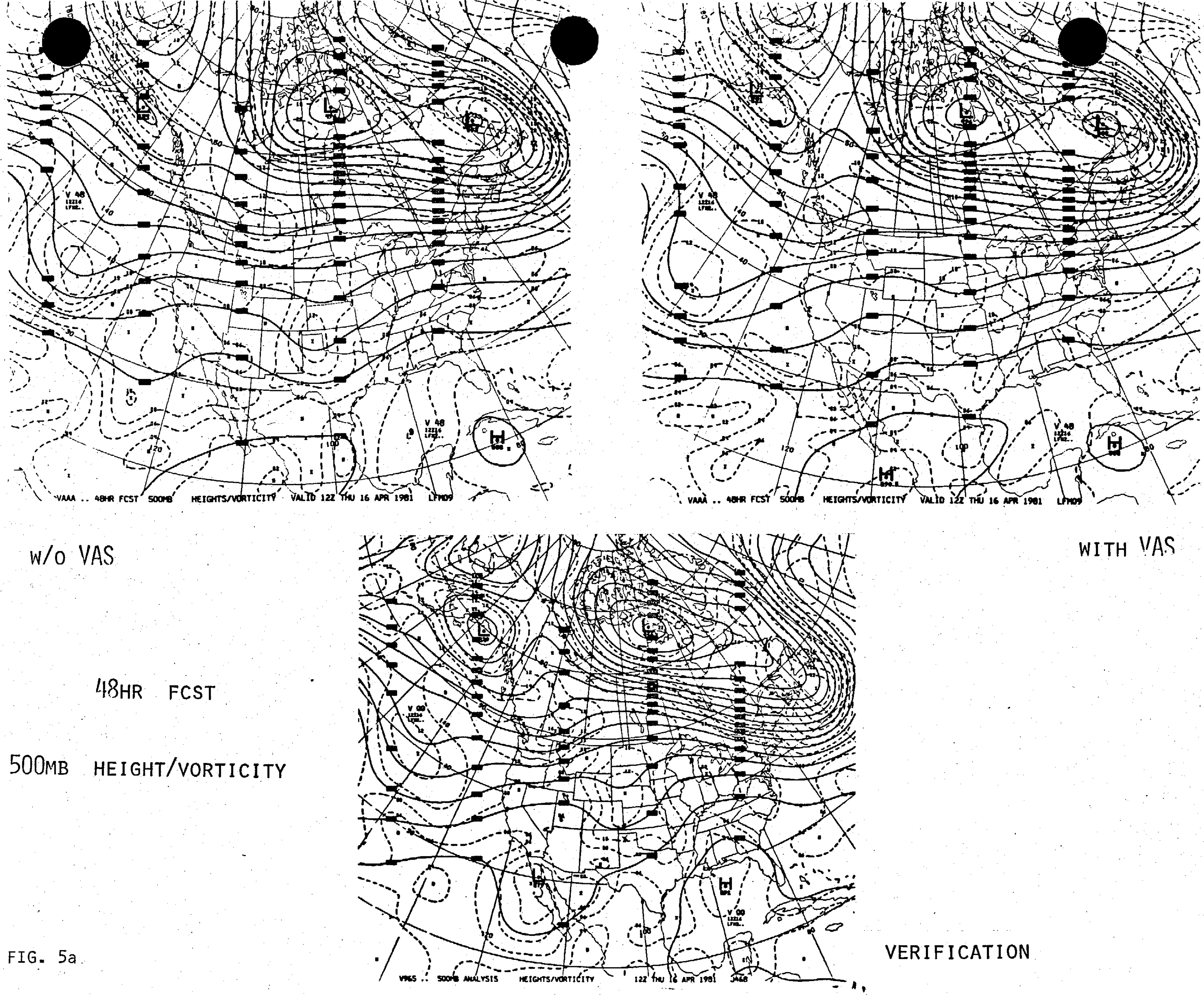
36HR FCST

PRECIP

FIG. 4c

w/o VAS

WITH VAS

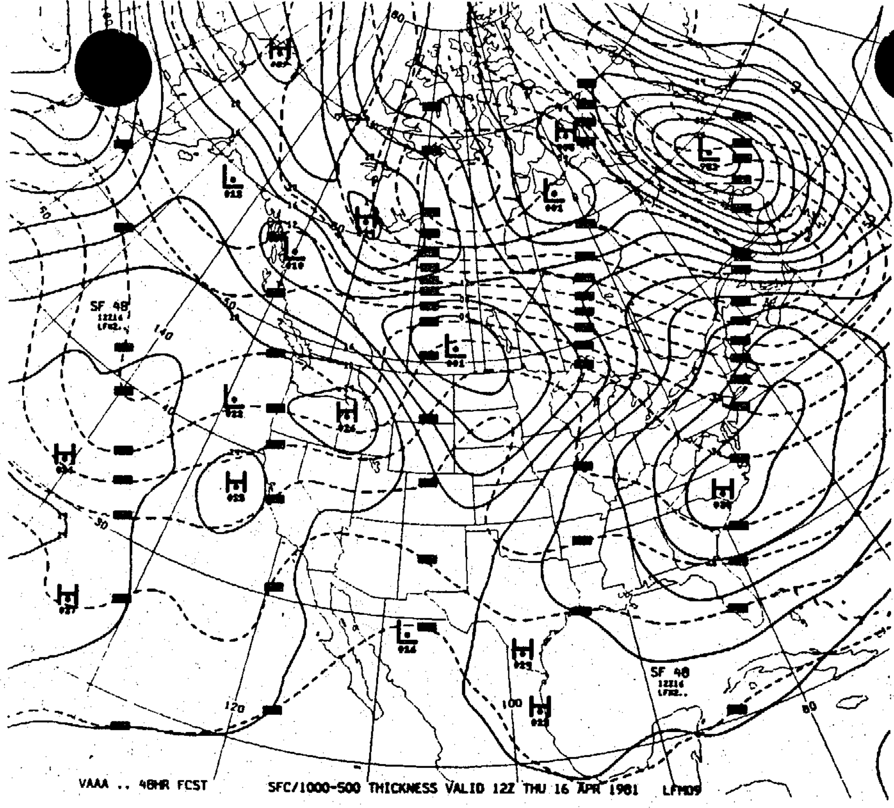


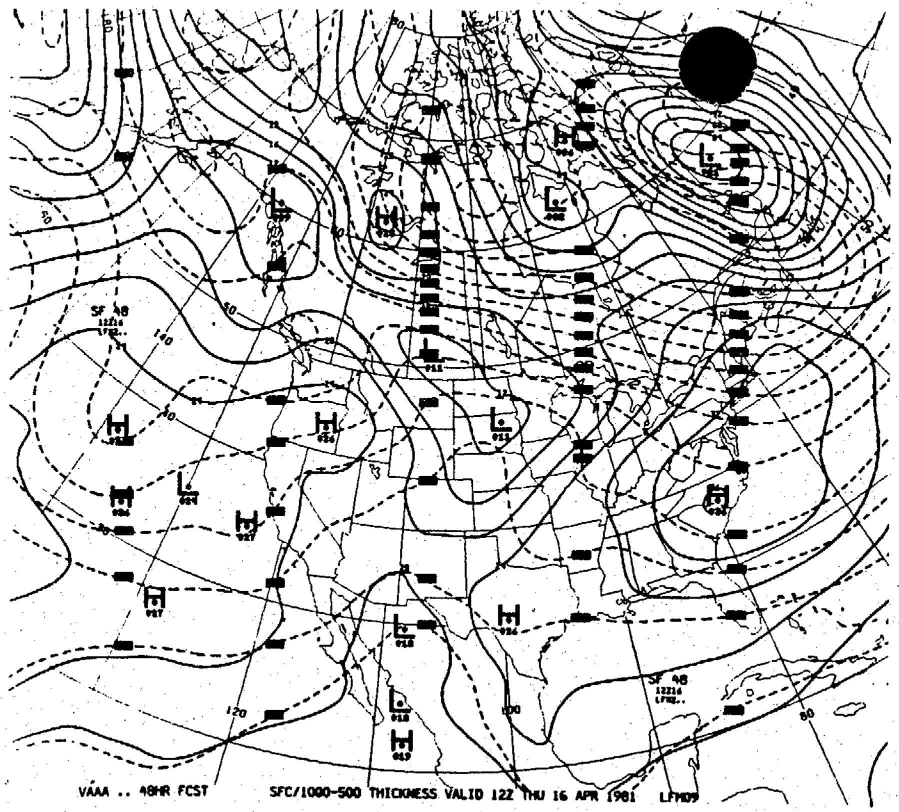
48HR FCST

500MB HEIGHT/VORTICITY

VERIFICATION

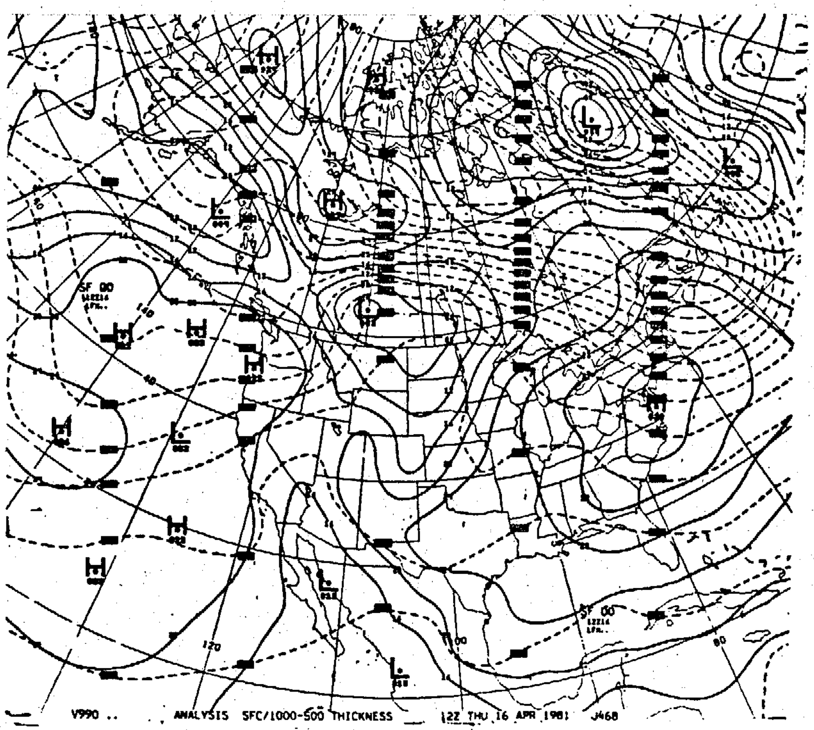
FIG. 5a





W/o VAS

WITH VAS

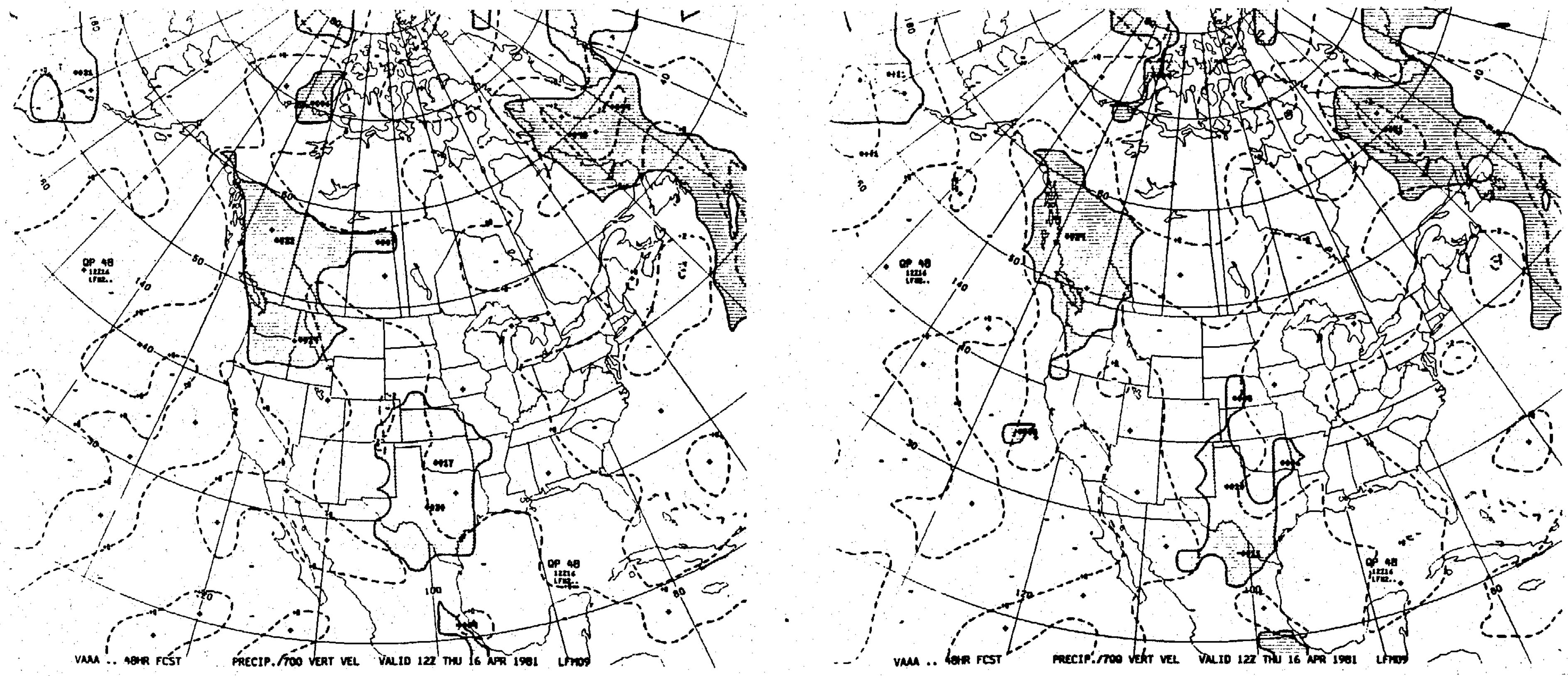


48HR FCST

SFC/1000-500MB THICKNESS

FIG. 5b

VERIFICATION



W/O VAS

WITH VAS

48HR FCST

PRECIP

FIG. 5c

SUMAC STATISTICAL VERIFICATION
OF LFM FORECASTS

Initial time: 12Z 4/14/81 Level: 500MB Area: NA110

12HR

S 1	A	B
Z	27.5	28.4
T	44.0	43.8
V	N/A	N/A

BIAS	A	B
Z	-21.0	-20.3
T	-0.6	-0.6
V	5.2	5.3

RMS ERROR	A	B
Z	29.6	28.4
T	1.5	1.5
V	6.0	6.1

24HR

S 1	A	B
Z	30.8	30.3
T	49.3	48.3
V	N/A	N/A

BIAS	A	B
Z	-16.3	-17.0
T	-0.2	-0.0
V	6.0	9.2

RMS ERROR	A	B
Z	28.3	28.1
T	1.8	1.7
V	7.0	10.9

36HR

S 1	A	B
Z	31.8	31.6
T	47.7	49.2
V	N/A	N/A

BIAS	A	B
Z	-26.5	-29.0
T	-0.2	-0.0
V	6.5	6.8

RMS ERROR	A	B
Z	44.6	44.3
T	1.9	1.8
V	7.3	7.7

48HR

S 1	A	B
Z	30.2	29.6
T	59.5	59.8
V	N/A	N/A

BIAS	A	B
Z	-19.5	-18.8
T	-0.5	-0.1
V	7.3	7.4

RMS ERROR	A	B
Z	44.5	44.3
T	2.5	2.2
V	8.5	8.6

A - with VAS data, B - w/o VAS data

TABLE 1

SUMAC STATISTICAL VERIFICATION
OF LFM FORECASTS

Initial time: 12Z 4/14/81 Level: 250 MB Area: NA110

12HR

	S 1 A	S 1 B	BIAS A	BIAS B	RMS ERROR A	RMS ERROR B
Z	27.0	26.4	-41.4	-41.8	50.1	49.5
T	65.9	66.2	0.5	0.3	2.0	1.8
V	N/A	N/A	8.4	7.9	10.2	9.7

24HR

	S 1 A	S 1 B	BIAS A	BIAS B	RMS ERROR A	RMS ERROR B
Z	29.4	28.8	-34.7	-36.8	53.2	52.5
T	58.8	51.4	0.7	0.1	2.5	1.9
V	N/A	N/A	10.1	9.2	12.0	10.9

36HR

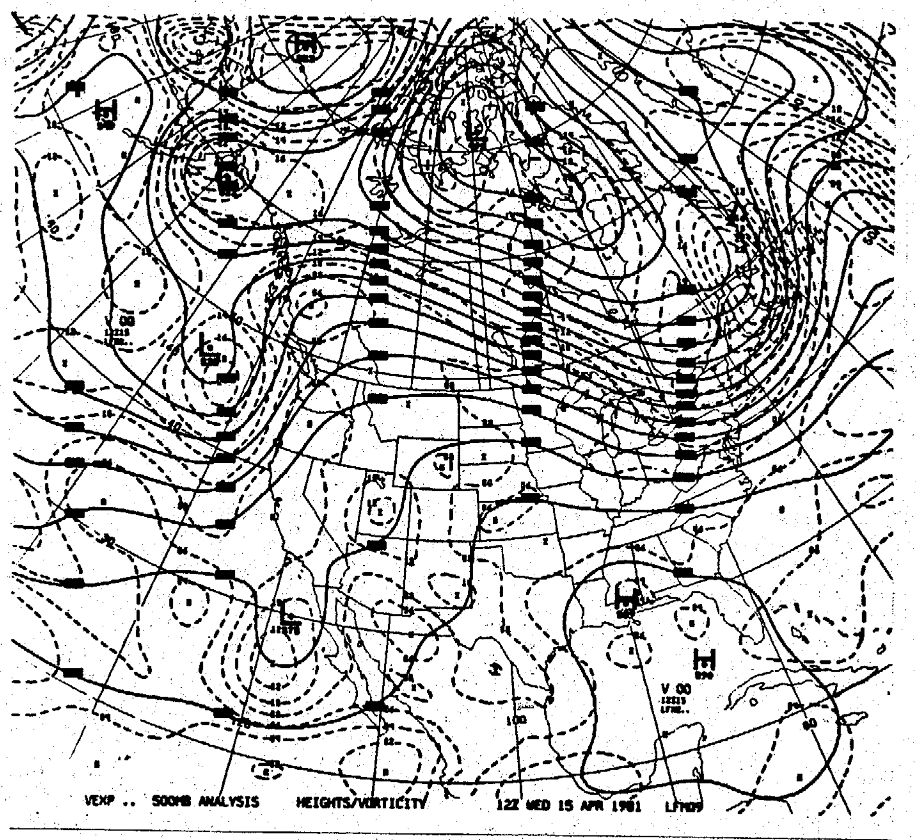
	S 1 A	S 1 B	BIAS A	BIAS B	RMS ERROR A	RMS ERROR B
Z	32.7	34.7	-47.4	-55.4	75.2	75.5
T	68.1	64.1	-0.2	-0.7	2.6	2.3
V	N/A	N/A	12.7	11.3	14.4	12.8

48HR

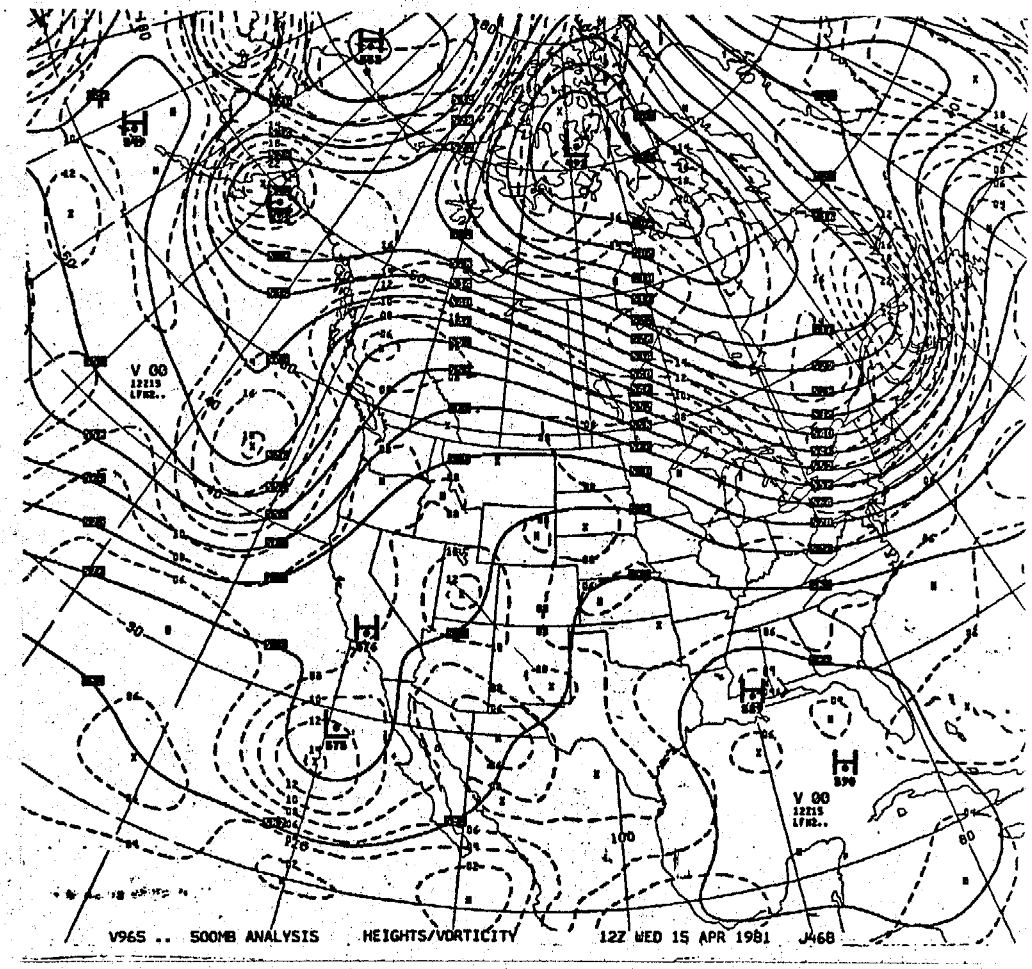
	S 1 A	S 1 B	BIAS A	BIAS B	RMS ERROR A	RMS ERROR B
Z	33.7	34.1	-37.9	-41.6	77.1	73.0
T	75.7	73.7	0.0	-0.9	2.7	2.4
V	N/A	N/A	13.5	12.6	15.4	14.2

A - with VAS data, B - w/o VAS data

TABLE 2



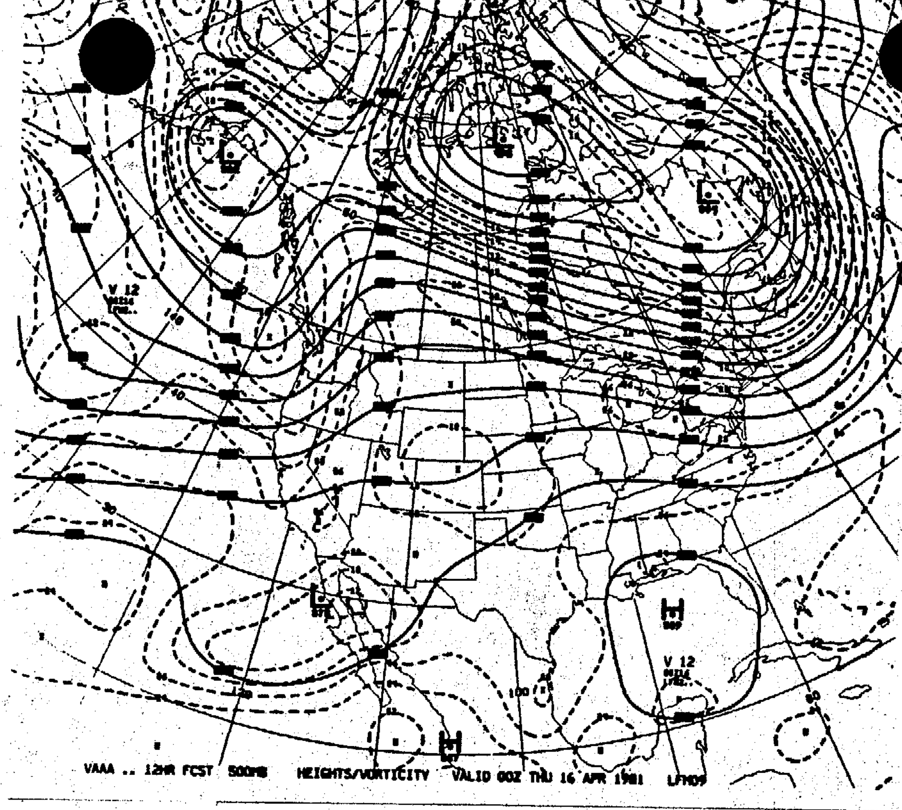
WITH VAS



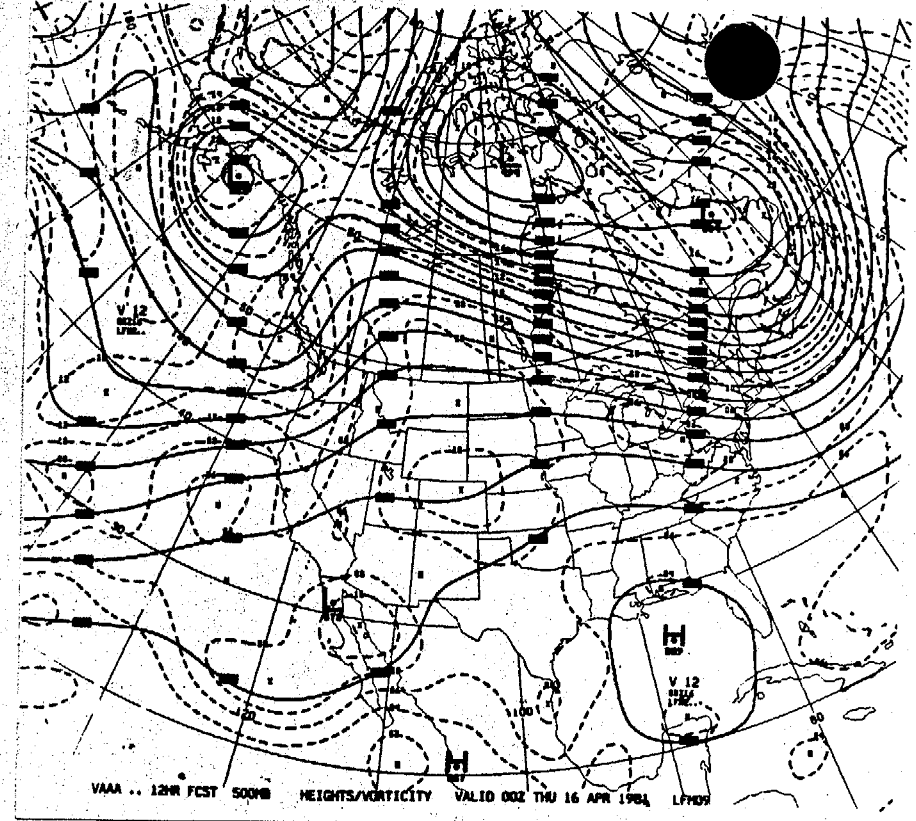
w/o VAS

500MB HEIGHT/VORTICITY ANALYSIS 12Z 4/15/81

FIG. 6



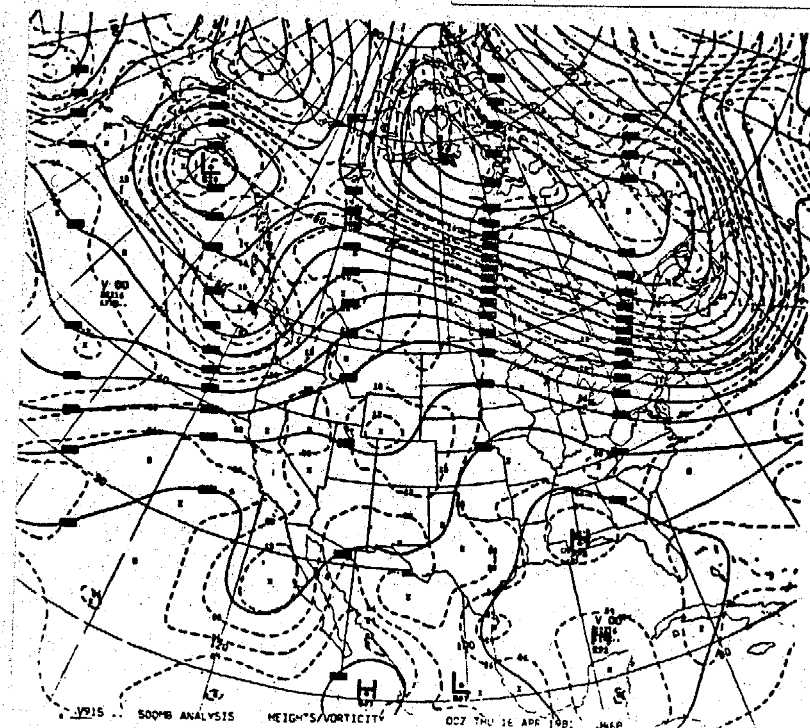
w/o VAS



WITH VAS

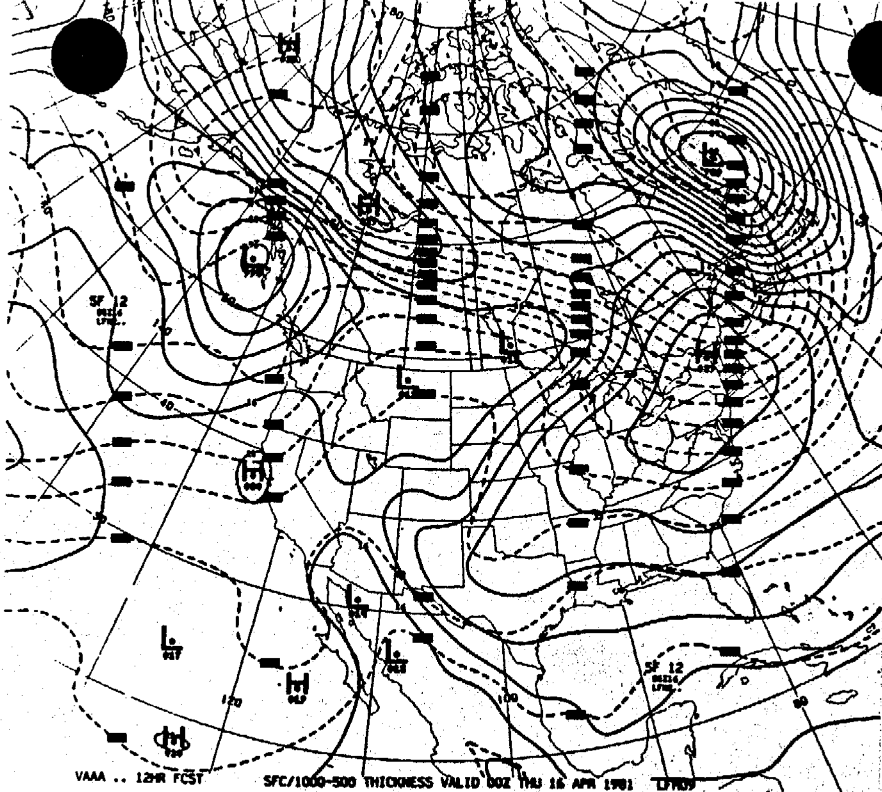
12HR FCST

500MB HEIGHT/VORTICITY

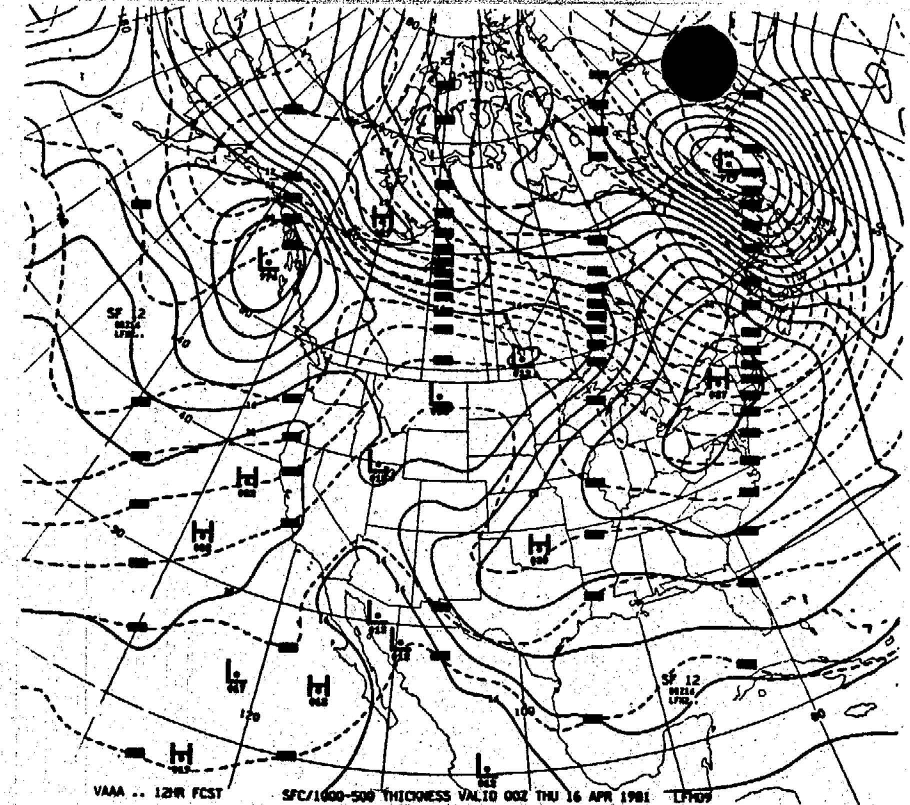


VERIFICATION

FIG. 7a



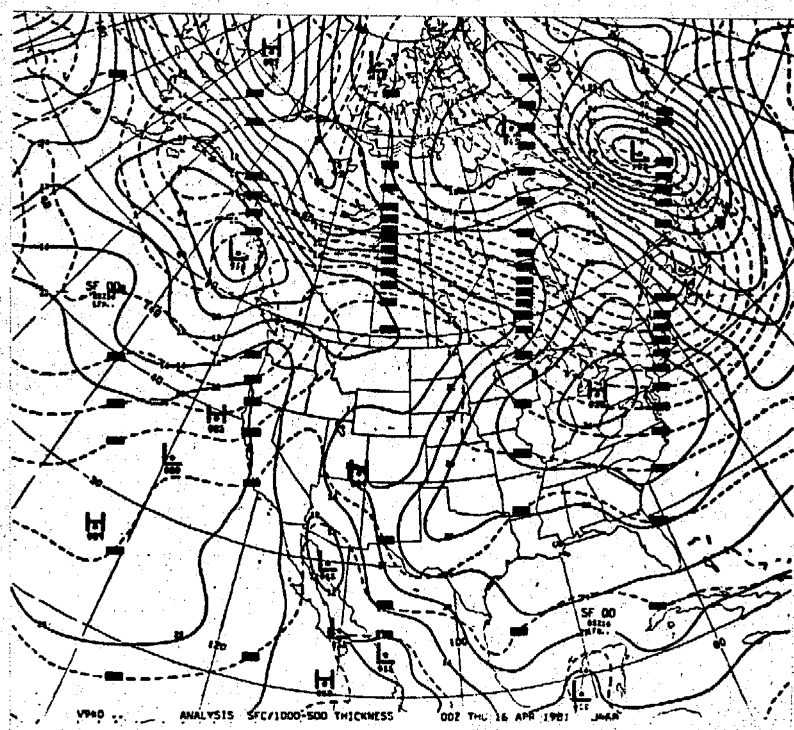
W/O VAS



WITH VAS

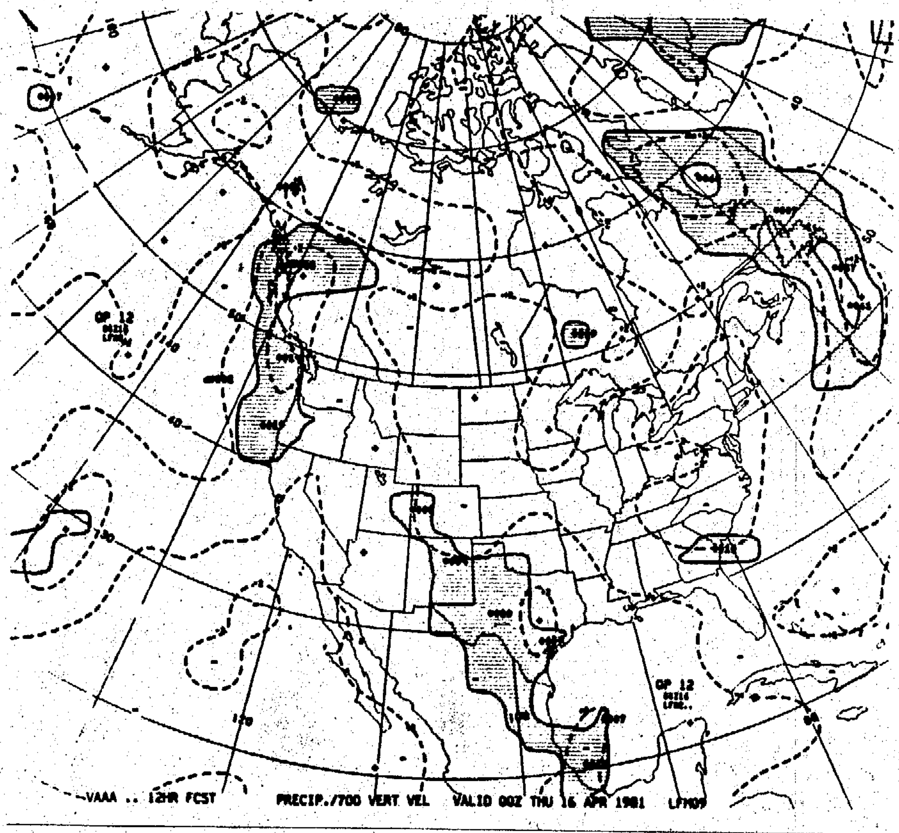
12HR FCST

SFC/1000-500MB THICKNESS

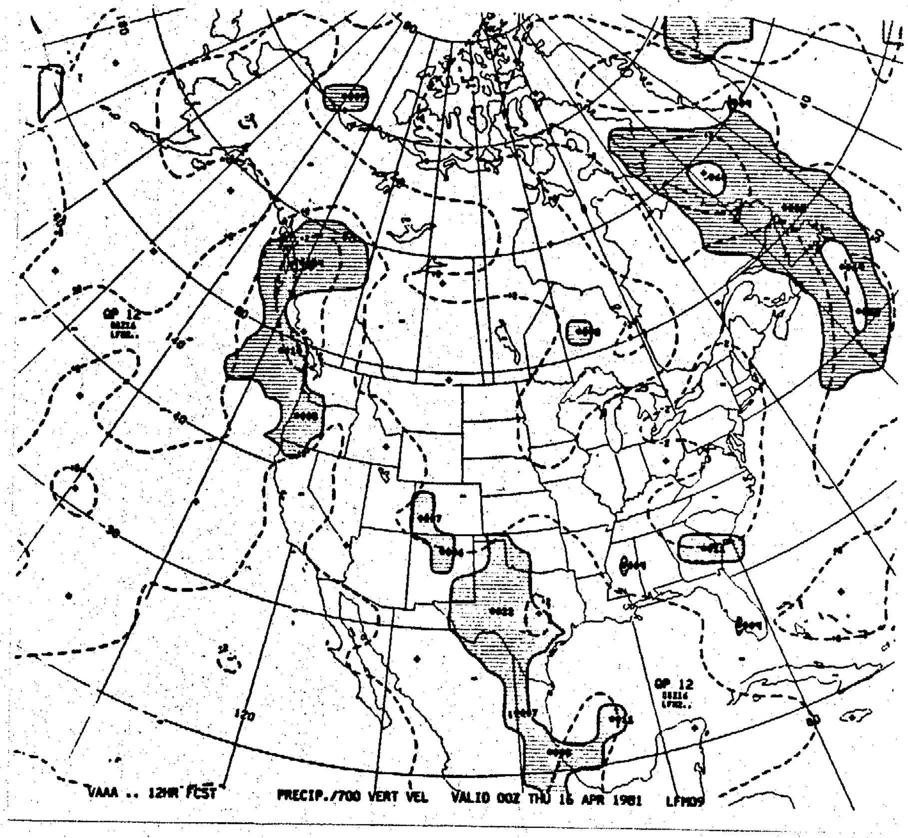


VERIFICATION

FIG. 7b



W/O VAS

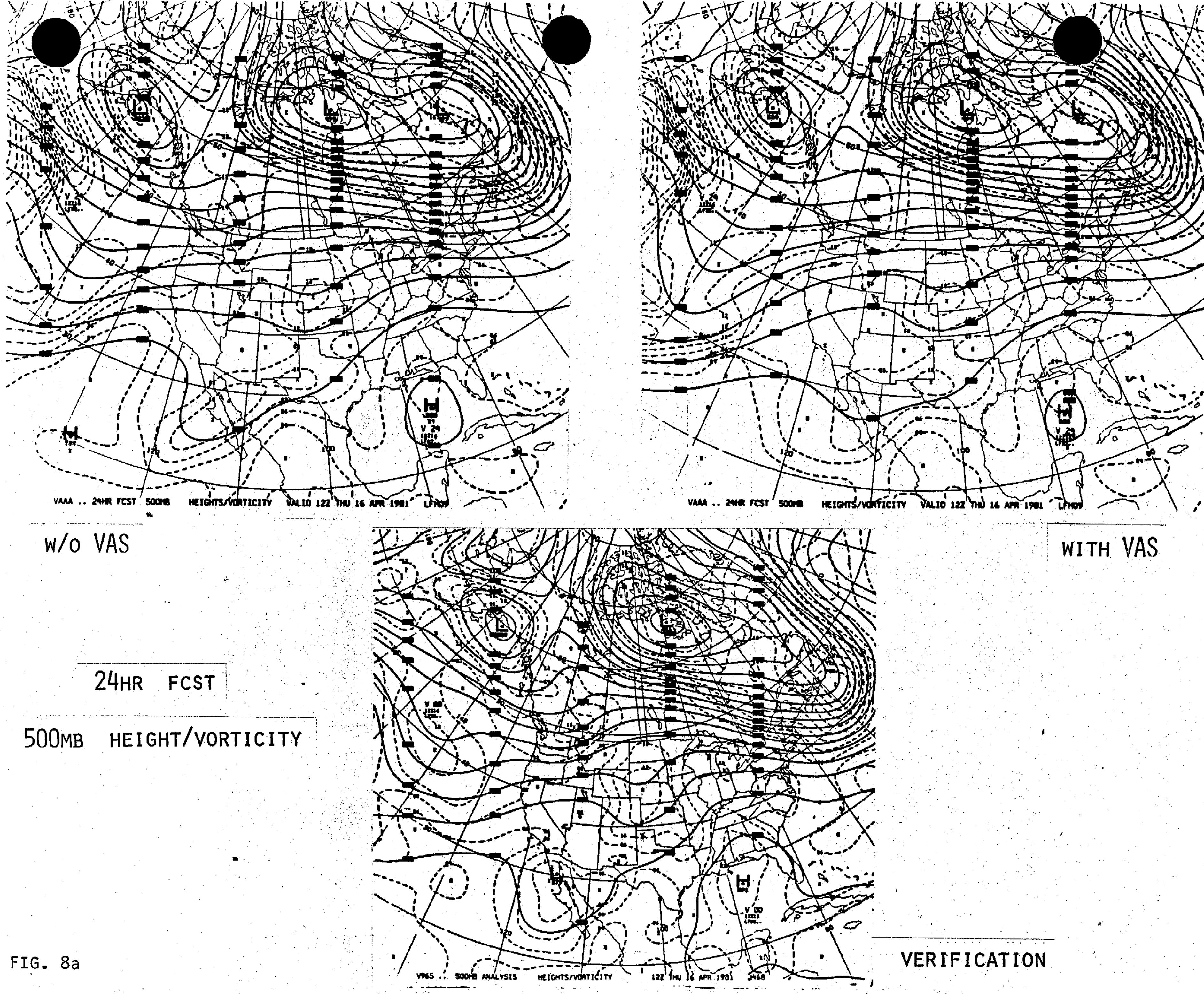


WITH VAS

12HR FCST

PRECIP

FIG. 7c



W/O VAS

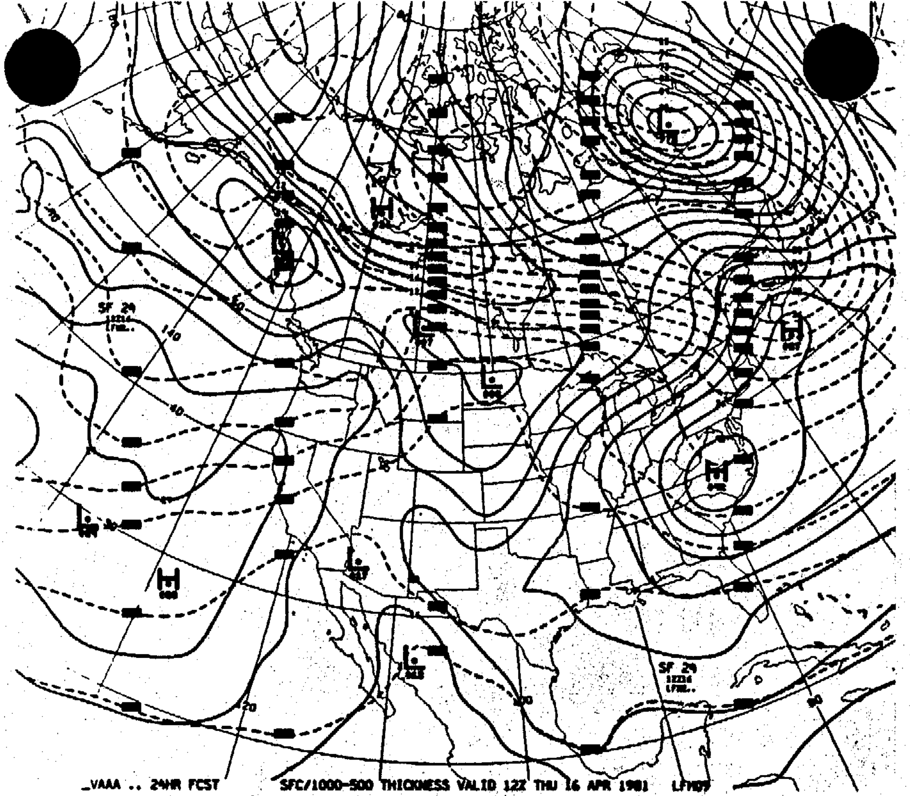
WITH VAS

24HR FCST

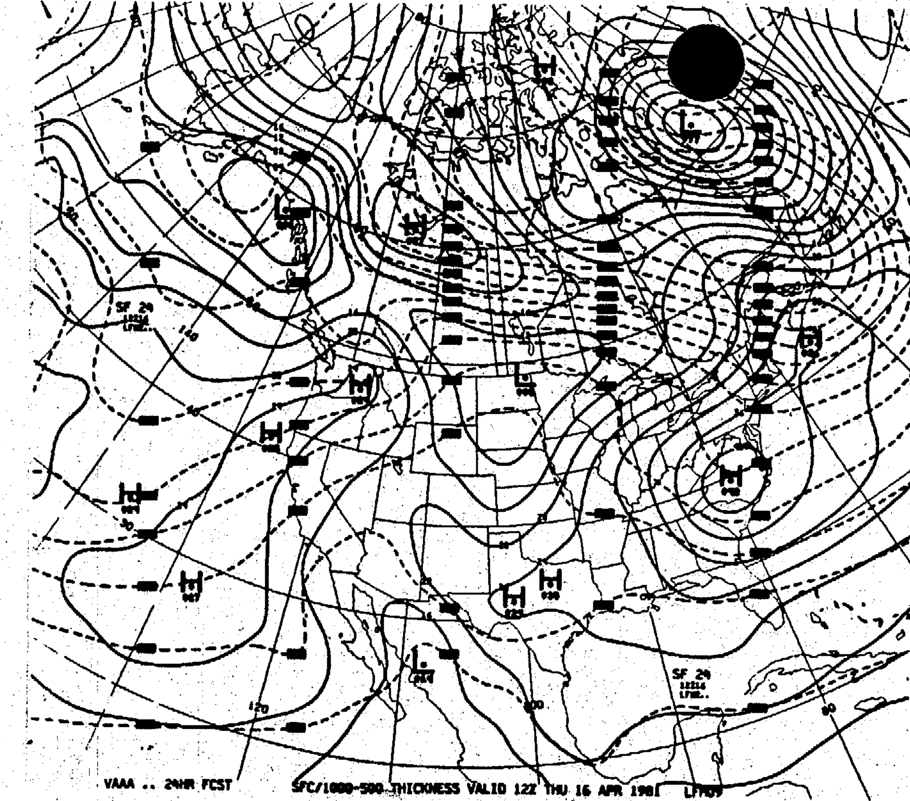
500MB HEIGHT/VORTICITY

VERIFICATION

FIG. 8a



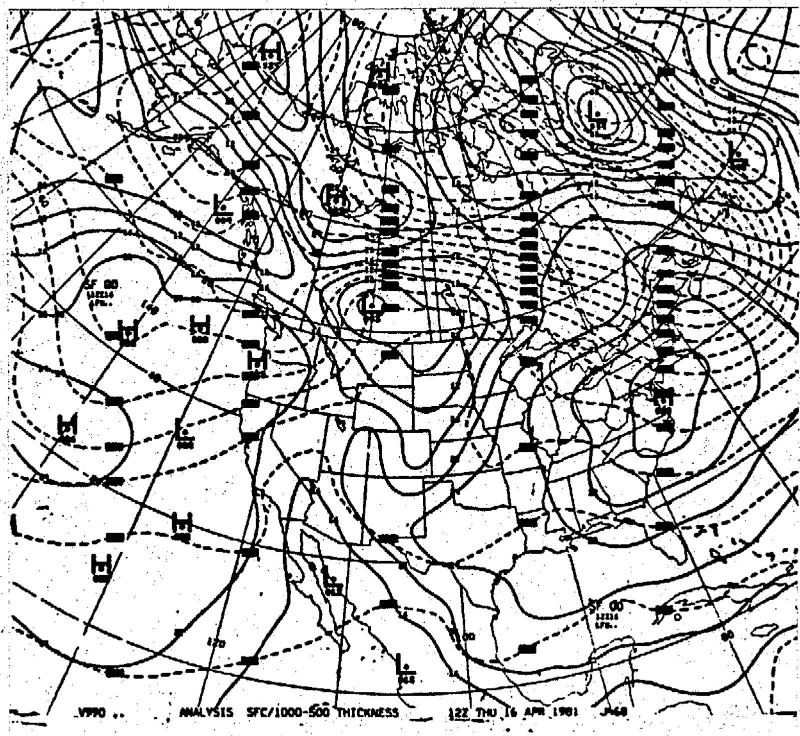
W/O VAS



WITH VAS

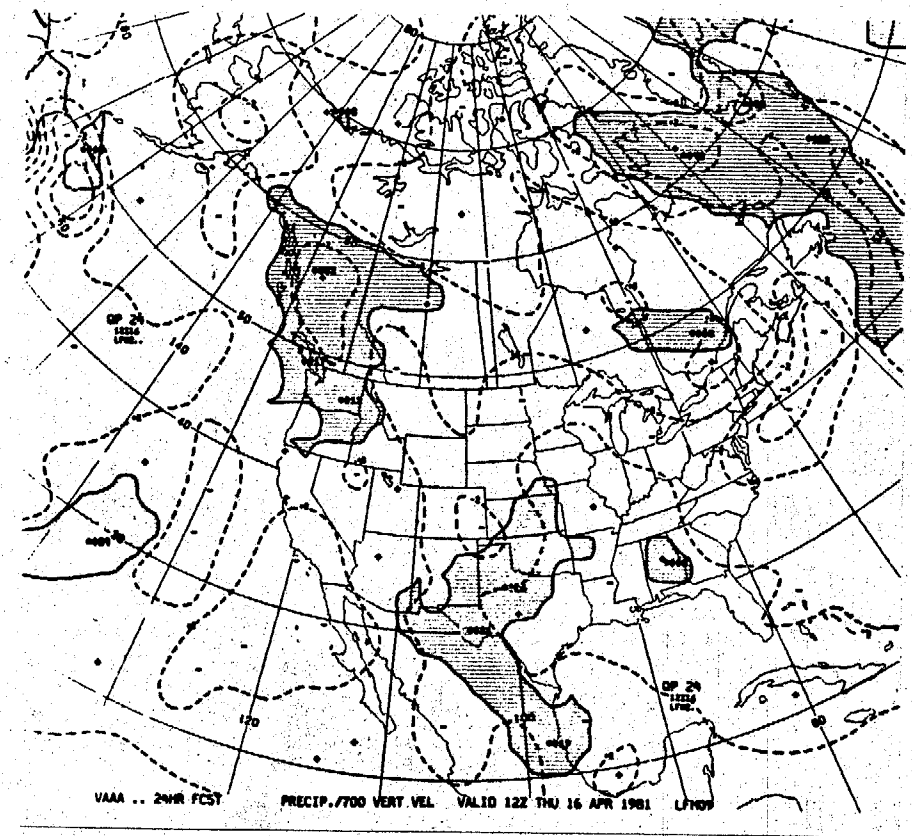
24HR FCST

SFC/1000-500MB THICKNESS

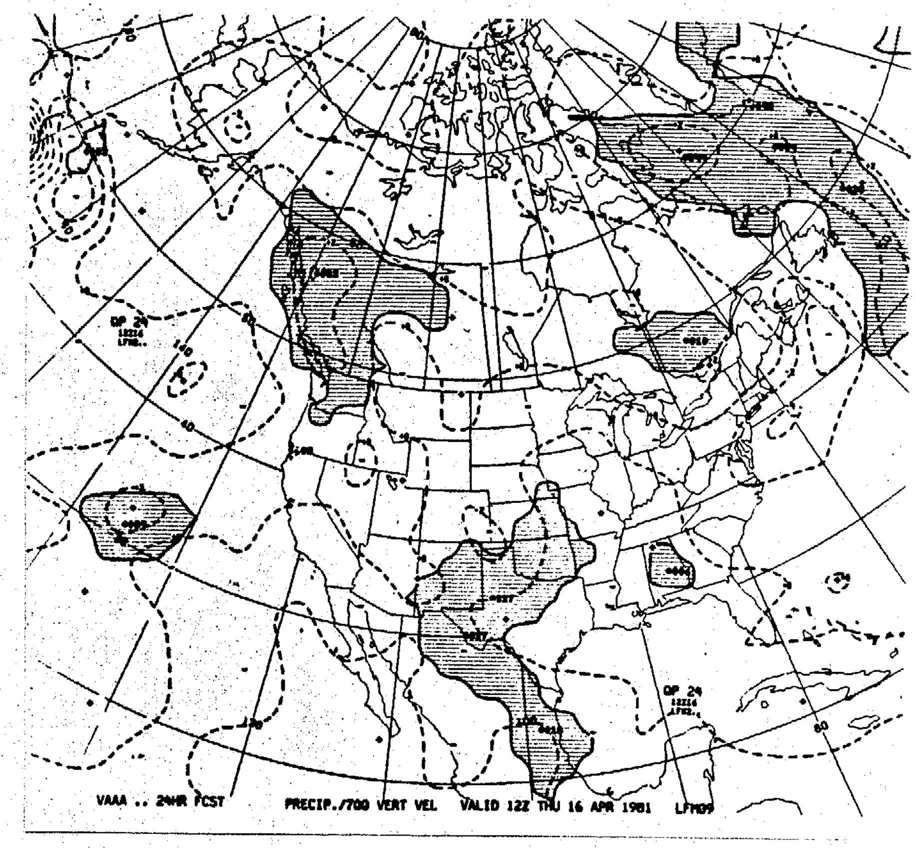


VERIFICATION

FIG. 8b



w/o VAS

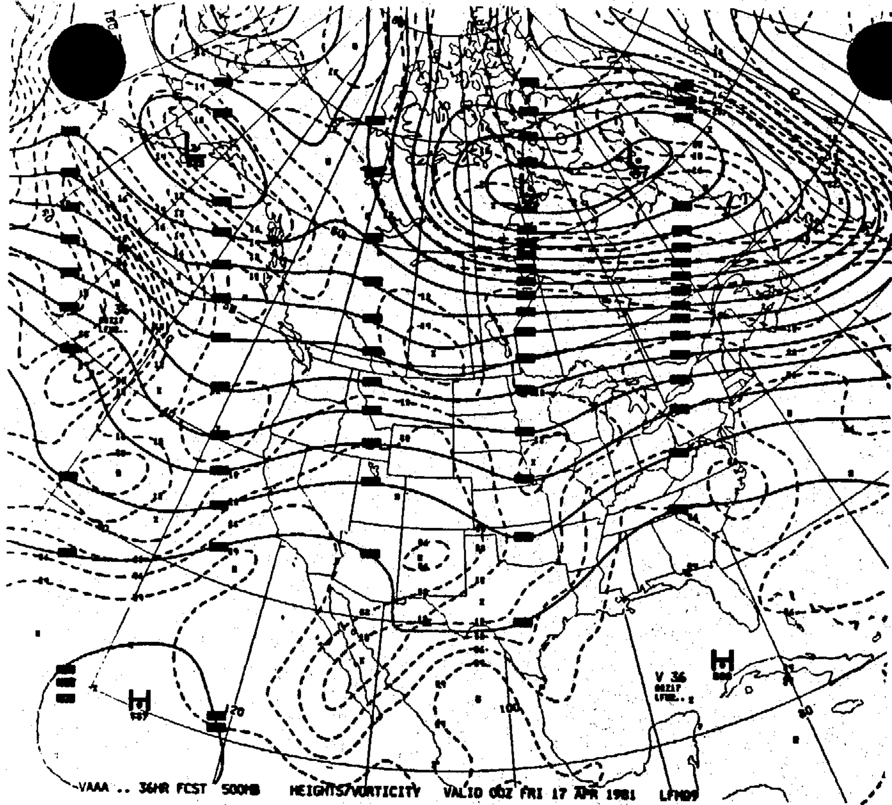


WITH VAS

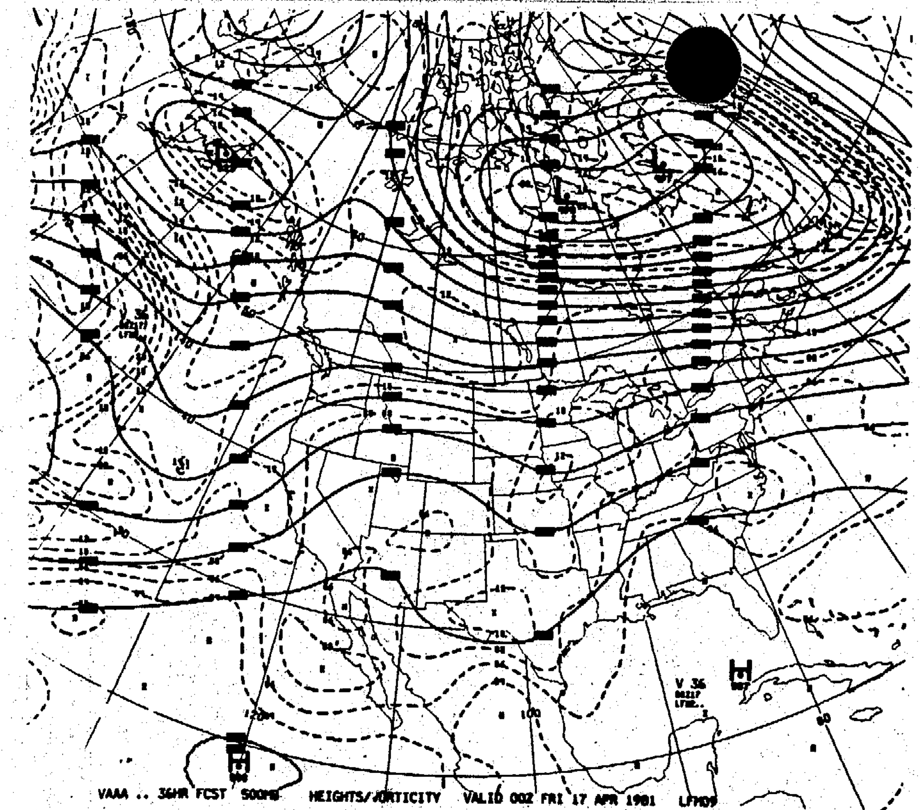
24HR FCST

PRECIP

FIG. 8c



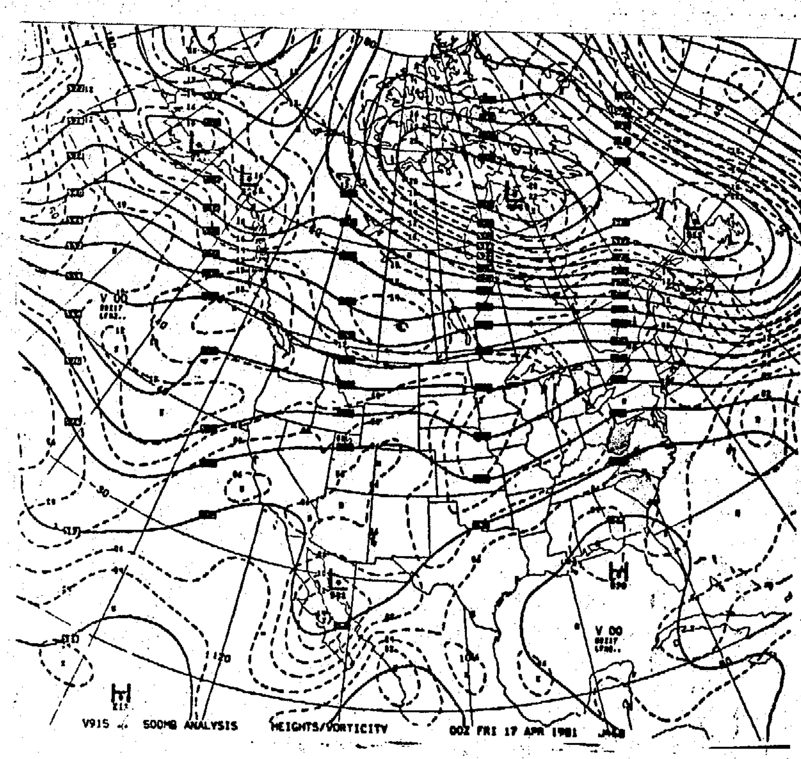
W/O VAS



WITH VAS

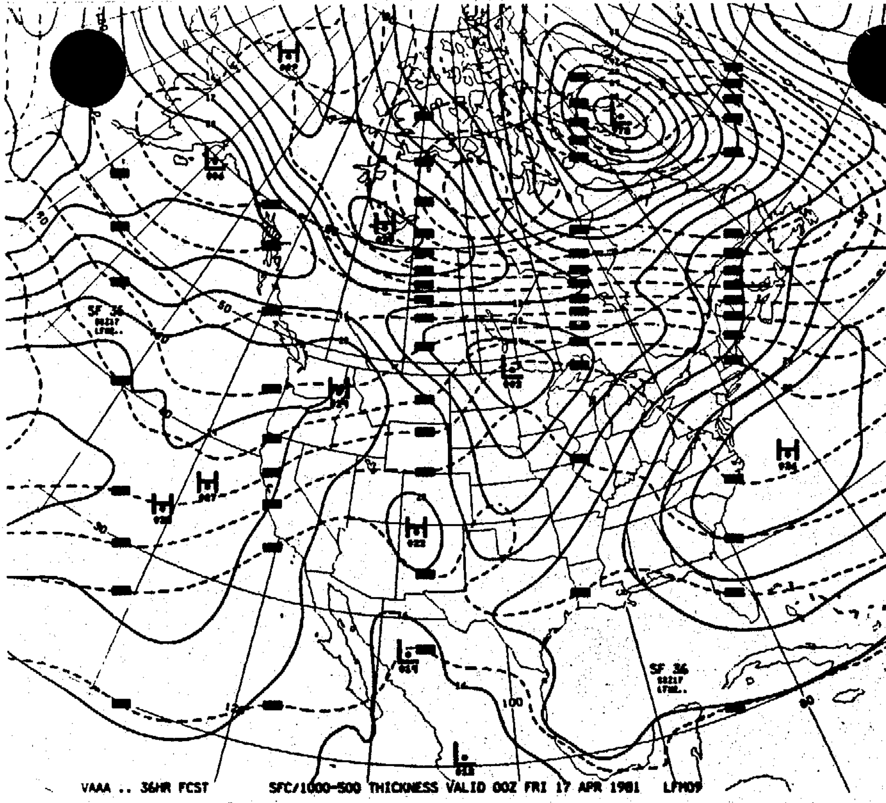
36HR FCST

500MB HEIGHT/VORTICITY

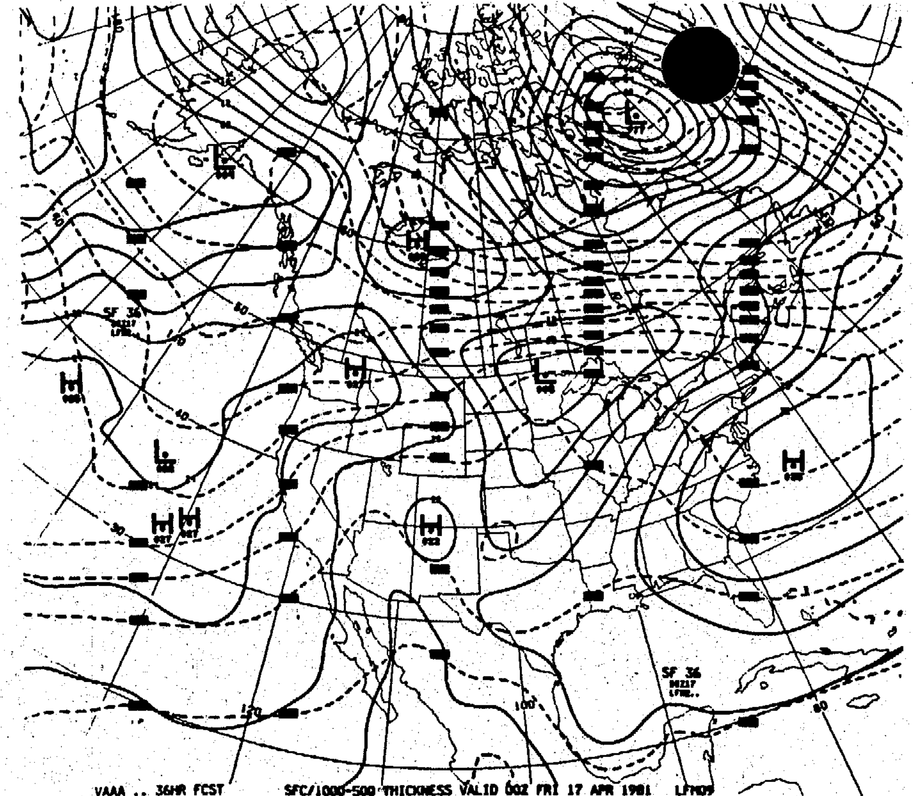


VERIFICATION

FIG. 9a



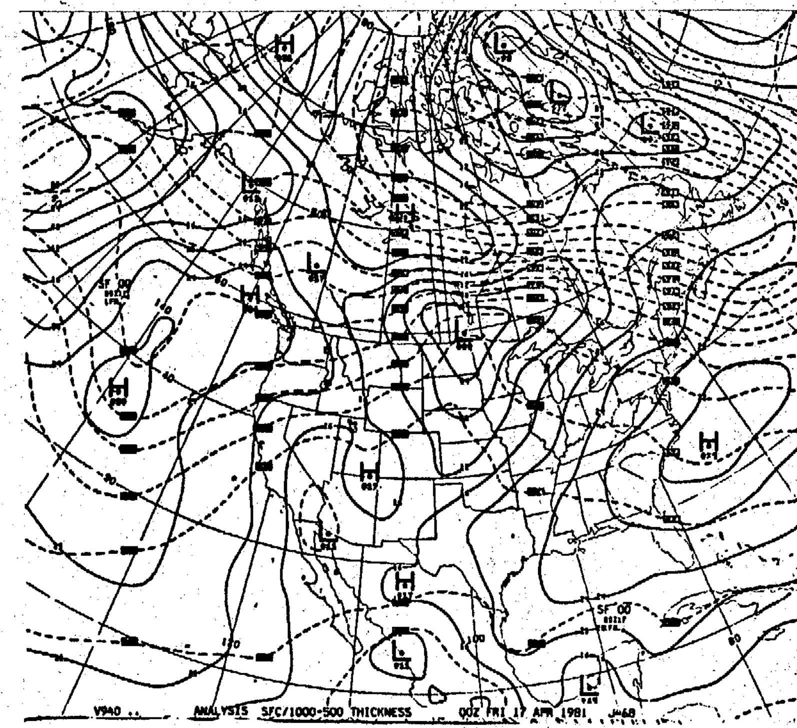
W/O VAS



WITH VAS

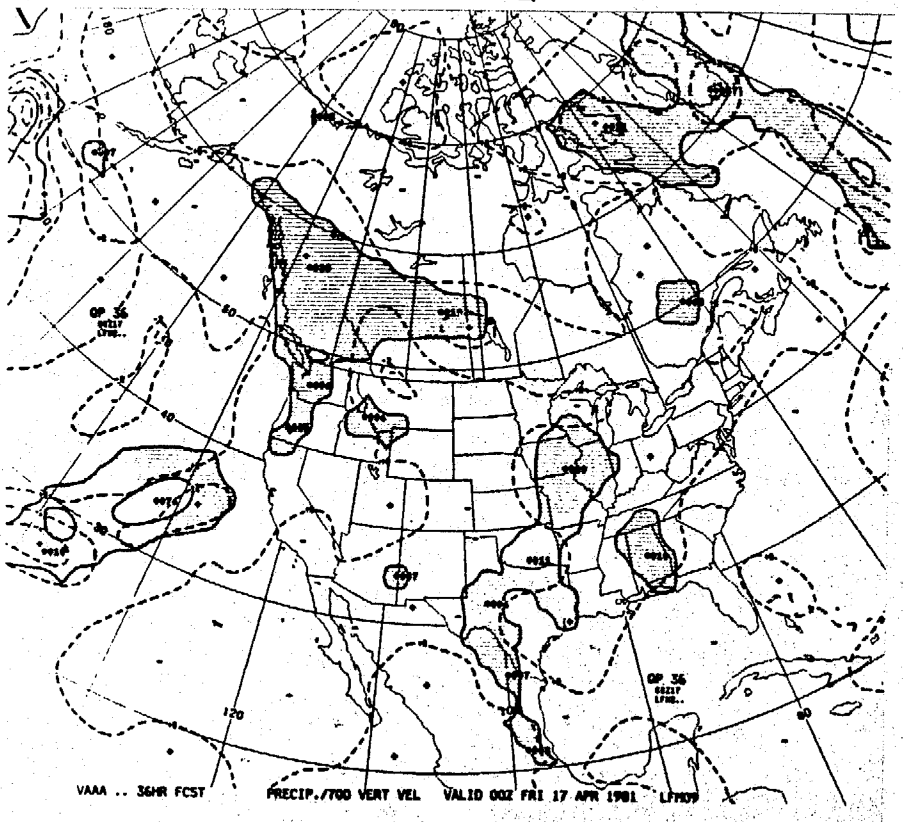
36HR FCST

SFC/1000-500MB THICKNESS

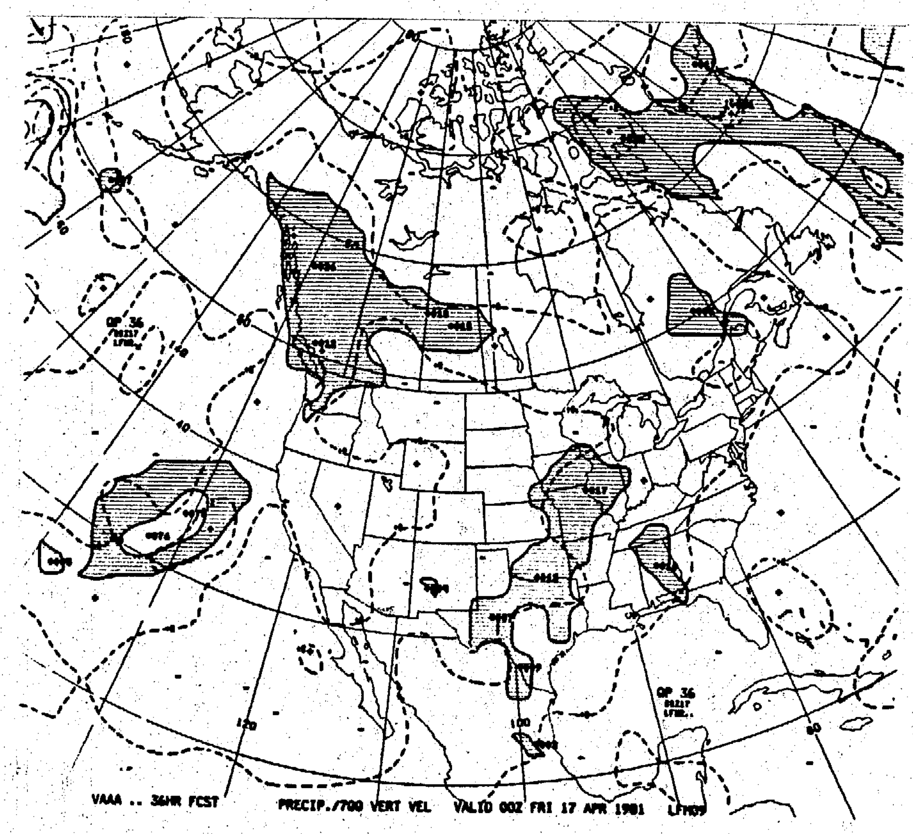


VERIFICATION

FIG. 9b



W/O VAS

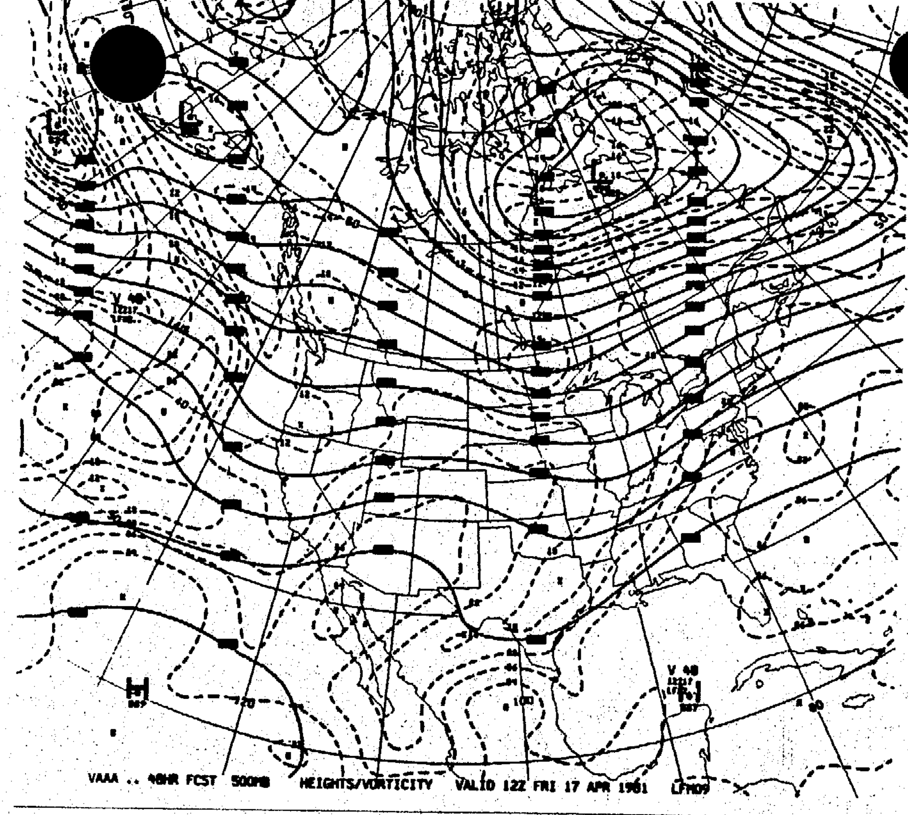


WITH VAS

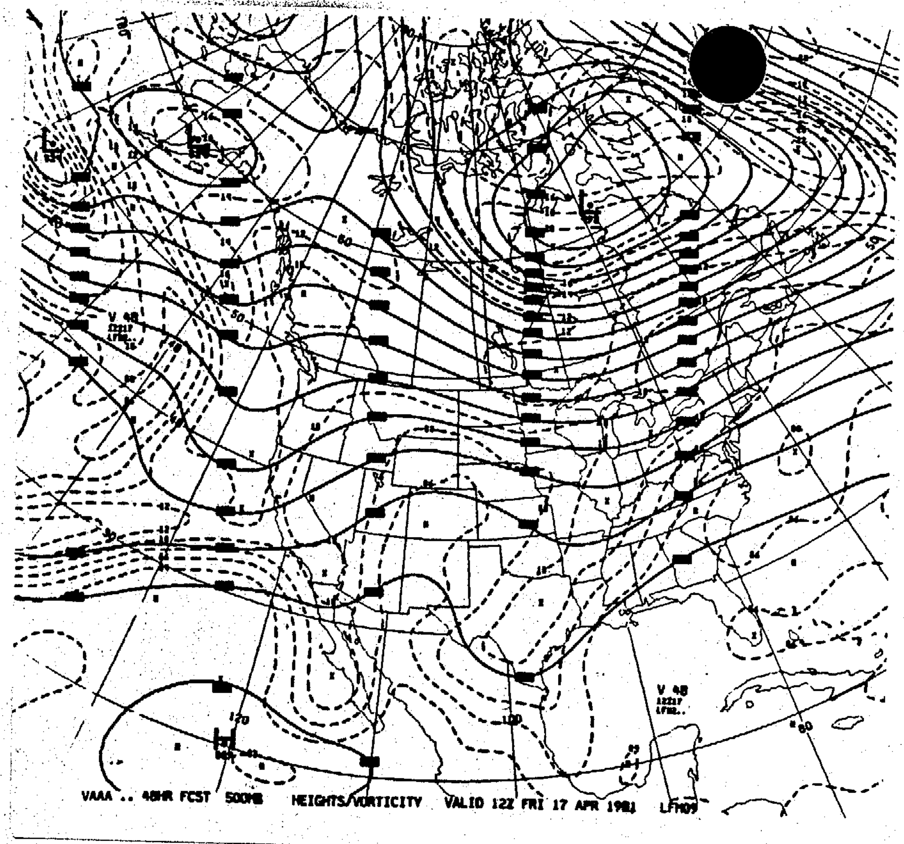
36HR FCST

PRECIP

FIG. 9c



w/o VAS



WITH VAS

48HR FCST

500MB HEIGHT/VORTICITY

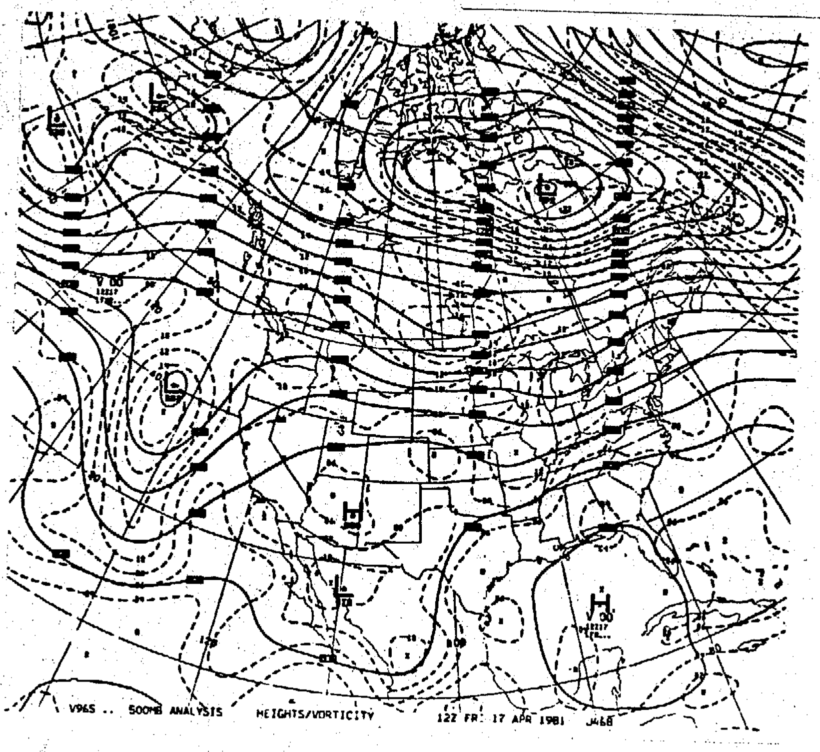
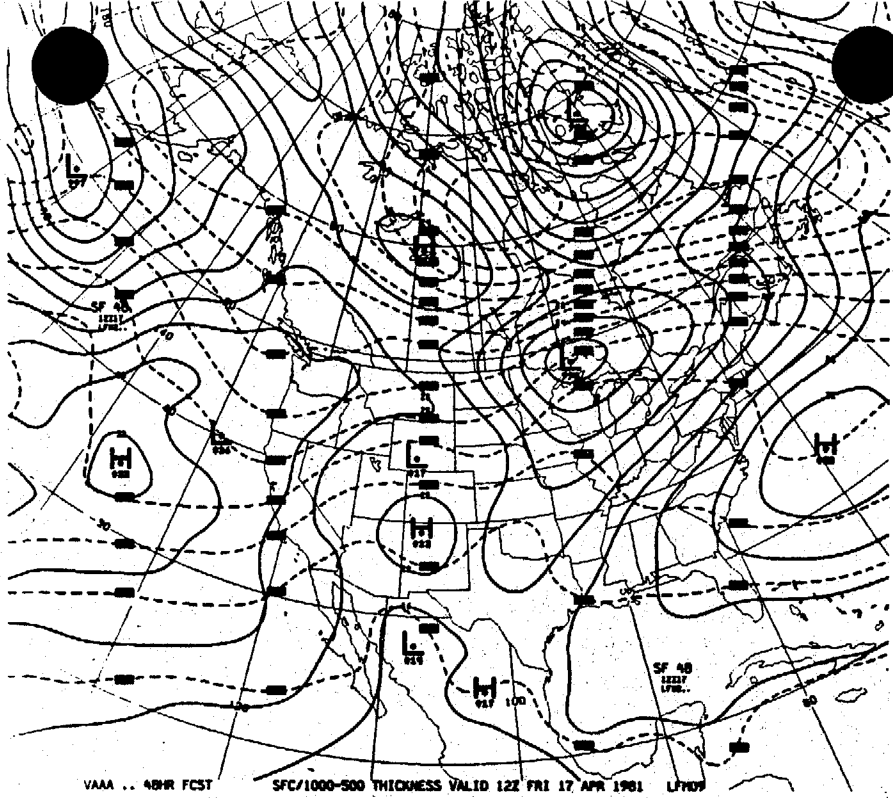
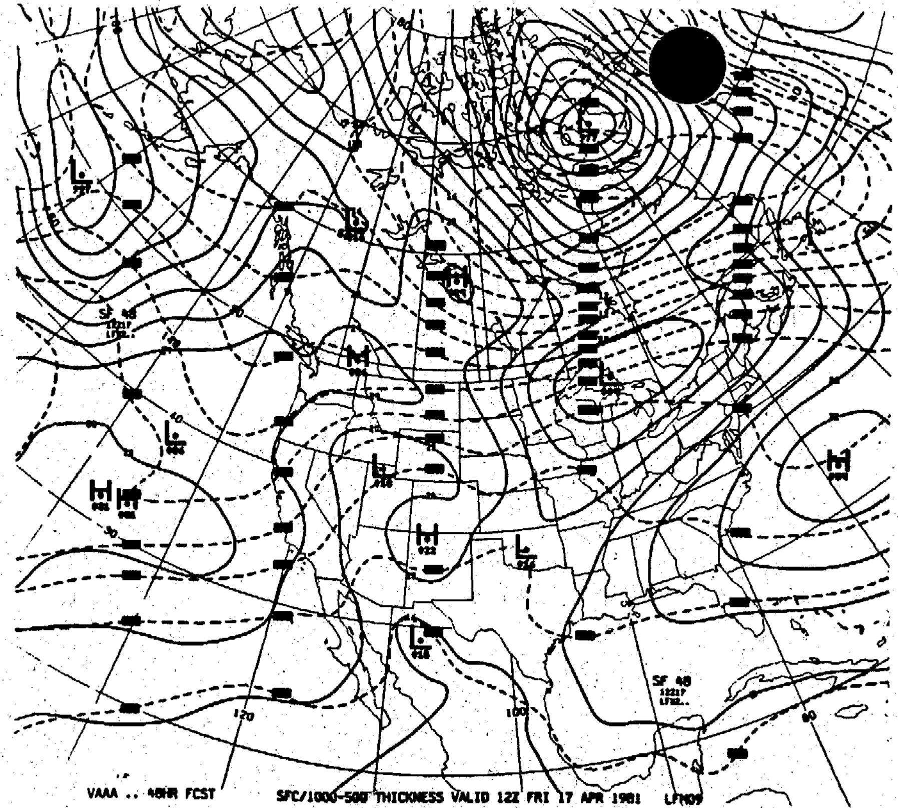


FIG. 10a

VERIFICATION



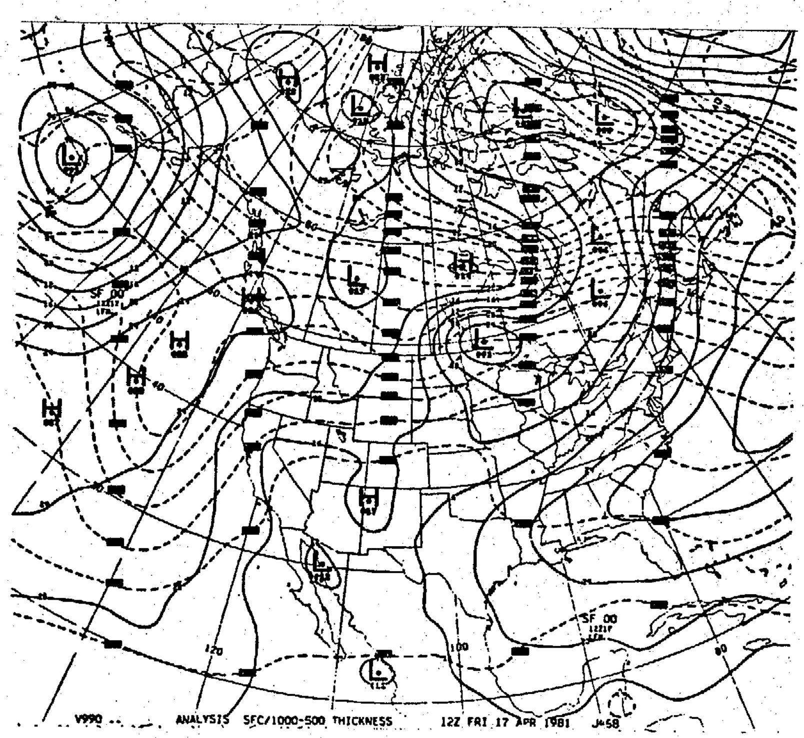
W/o VAS



WITH VAS

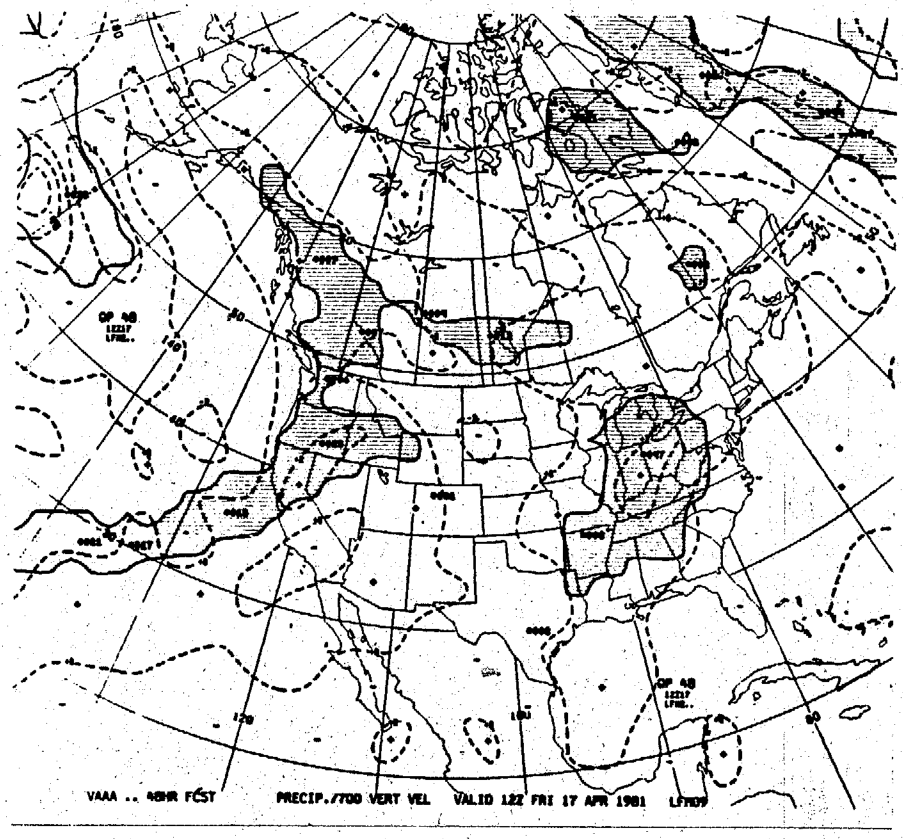
48HR FCST

SFC/1000-500MB THICKNESS

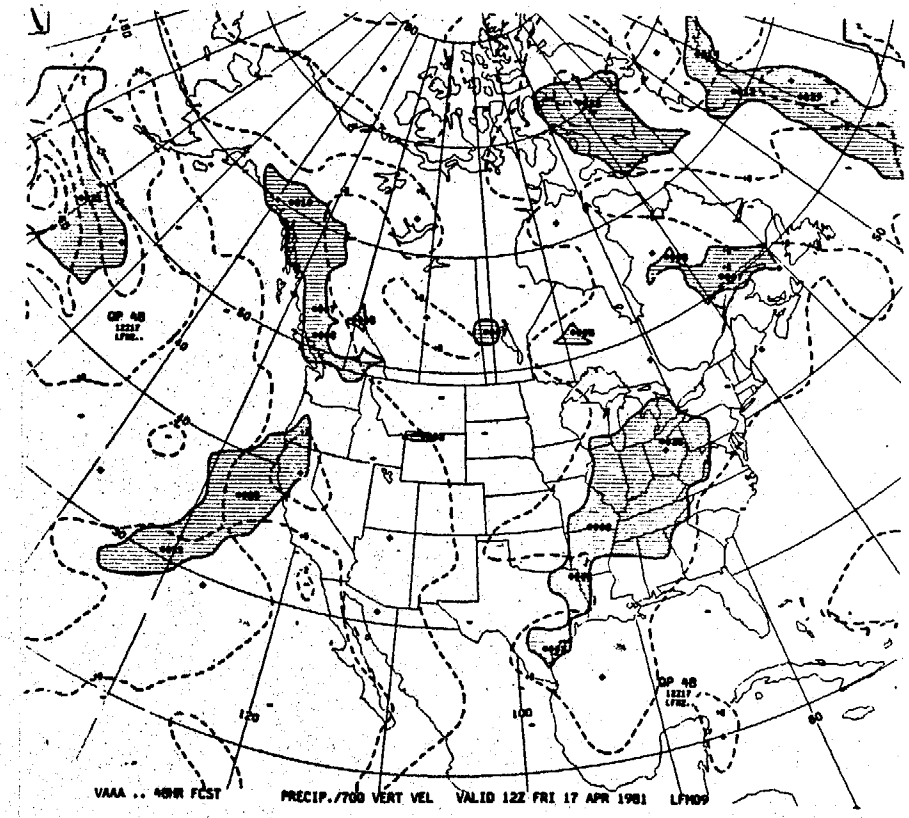


VERIFICATION

FIG. 10b



w/o VAS



WITH VAS

48HR FCST

PRECIP

FIG. 10c

SUMAC STATISTICAL VERIFICATION
OF LFM FORECASTS

Initial time: 12Z 4/15/81 Level: 500MB Area: NA110

12HR

S 1	A	B
Z	28.0	28.9
T	44.7	45.1
V	N/A	N/A

BIAS	A	B
Z	-16.5	-13.9
T	0.0	0.0
V	4.7	4.7

RMS ERROR	A	B
Z	27.8	26.6
T	1.3	1.3
V	5.4	5.5

24HR

S 1	A	B
Z	25.3	23.7
T	55.4	55.4
V	N/A	N/A

BIAS	A	B
Z	-6.8	-8.1
T	-0.1	-0.1
V	5.6	5.5

RMS ERROR	A	B
Z	26.2	26.7
T	1.7	1.6
V	6.9	6.7

36HR

S 1	A	B
Z	30.9	29.3
T	52.5	49.9
V	N/A	N/A

BIAS	A	B
Z	-11.9	-14.8
T	-0.3	-0.2
V	6.9	6.4

RMS ERROR	A	B
Z	33.7	36.4
T	1.8	1.6
V	8.1	7.7

48HR

S 1	A	B
Z	35.7	34.9
T	53.7	51.9
V	N/A	N/A

BIAS	A	B
Z	-13.1	-17.0
T	-1.0	-0.8
V	8.1	7.9

RMS ERROR	A	B
Z	36.8	41.8
T	2.4	2.2
V	9.4	9.0

A - with VAS data, B - w/o VAS data

TABLE 3

SUMAC STATISTICAL VERIFICATION
OF LFM FORECASTS

Initial time: 12Z 4/15/81 Level: 250MB Area: NA110

12HR

S 1	A	B
Z	31.5	31.1
T	52.2	53.3
V	N/A	N/A

BIAS	A	B
Z	-31.8	-28.8
T	0.3	0.2
V	7.1	7.1

RMS ERROR	A	B
Z	44.4	41.6
T	1.9	2.0
V	8.2	8.3

24HR

S 1	A	B
Z	28.7	27.7
T	66.1	65.8
V	N/A	N/A

BIAS	A	B
Z	-21.1	-23.7
T	0.1	-0.1
V	8.7	8.3

RMS ERROR	A	B
Z	45.8	42.6
T	2.2	2.3
V	10.2	9.8

36HR

S 1	A	B
Z	31.4	30.5
T	62.2	63.5
V	N/A	N/A

BIAS	A	B
Z	-36.9	-40.5
T	0.3	0.0
V	10.7	10.7

RMS ERROR	A	B
Z	56.7	57.2
T	2.1	2.0
V	12.8	12.1

48HR

S 1	A	B
Z	30.4	31.9
T	69.0	62.8
V	N/A	N/A

BIAS	A	B
Z	-30.0	-34.5
T	0.9	0.4
V	12.6	12.9

RMS ERROR	A	B
Z	58.5	62.4
T	2.5	2.1
V	15.8	15.5

A - with VAS data, B - w/o VAS data

TABLE 4