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RAFS PROBLEMS IN THE WEST

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[Editor's Note - The attached information was provided by Norm Phillips, NMC. This paper details a forecast problem exhibited by the NGM in the West since early September.]

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N. Phillips 7 October 1986

Summary

Recent forecasts from the RAFS have been very bad in the western states. Circumstantial evidence is presented that indicates two factors may be involved:

1. Analysis problems around and west of the coast.
2. Not enough friction over the mountains in the new RAFS surface drag formulation.

A strong effort to correct these problems is recommended.

NMC forecast systems have often had difficulty in forecasting the correct movement of vorticity centers across the west coast and into the mountain states. During the last half of September and early October 1986 an active trough was located on or just west of the coast. The forecasts by the NGM were very poor, characteristically moving a vorticity maximum into the Wyoming-Montana area too quickly, and producing a sea-level low in that area that did not verify. Forecasts from other models (including that from ECMWF) also erred this way, but not as often as the RAFS. The LFM has a history of somewhat similar errors, as documented by N. Junker.[1]

Until recently it was not practical to decide whether this problem was due mostly to analyses or mostly to model deficiencies. D. Deaven has recently provided one way to focus on this aspect of the problem by using the new hemispheric LFM (i.e. "Cressman") analysis as input to the NGM forecast system. Two reruns of the NGM in this mode were accomplished recently, from 00Z 19 September, and from 12Z 1 October.[2] Both reruns gave a significant improvement over the operational NGM forecasts.

Fig. 1 shows the initial 500-mb 0-hour vorticity fields from the LFM and NGM at 12Z 1 October. The vorticity isolines for the NGM show more detail than from the LFM; the 10 isoline reaches up to Salt Lake City, the ridge of large vorticity on the California-Nevada border is more pronounced, and there is a pronounced extension of cyclonic vorticity southwestward from San Francisco. (Normally there is no data at 500 mbs in this region, but on this date satellite data seems to have been used west of San Francisco and to the south.)

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[1] <u>Recognizing characteristic model errors and incorporating them into precipitation forecasts</u>. Preprint for the November 1985 AMS+NWA Conference on Hydrometeorology, in Indianapolis, Indiana.)

[2] These reruns had to be made before the operational forecast verified, since the hemispheric Cressman analyses are recycled every 24 hours. Steps are under way to archive these analyses for a period of one month.

Fig. 2 shows the verifying LFM analysis at 12Z Oct. 3 (upper left), together with the 48-hour forecasts from the LFM and NGM. The operational NGM (upper right) forecast a major center (+22 vorticity) in west-central Nebraska that did not verify. It had an error of -120 meters in height there, replacing the correct anticyclonic curvature of the height contours with cyclonic curvature. The operational LFM(lower left) was much better, its main error being the weak vorticity center (+15) in northeastern Colorado. Thus both the LFM and NGM forecast too much vorticity near the upper part of the Colorado-Nebraska border, with the NGM being much too extreme.

The lower right chart in Fig. 2 shows the result of running the NGM from the hemispheric Cressman analysis that was used operationally by the LFM. The forecast is much more like the LFM, i.e. a major improvement. But it still has more vorticity in northeast Colorado than does the LFM or the verifying analysis. The area enclosed by the +16 vorticity contour on the initial and 48-hour LFM analyses is about the same. The LFM forecast shrank this area slightly. However, the NGM forecast from the LFM analysis doubled the area, wrongly so in central Colorado and southern Wyoming.

The effective surface drag coefficient in the NGM is now determined by the surface roughness length, as defined mostly by vegetation type. The older version of the NGM used the drag coefficient developed by G. Cressman in the early 1960's, which varied mostly in response to height of the ground. It very likely gave larger frictional effects over the Rockies than does the new NGM formulation. The LFM still uses the Cressman formulation of the drag coefficient.

Fig. 3 shows the differing results at sea-level. The deep low forecast by the NGM did not verify, whereas the LFM --except for an underemphasis of the low in Illinois-- is a good forecast.[3] The rerun of the NGM from the LFM analysis (lower right panel) is much closer to reality, its main error being too strong an anticyclone in south-central Canada.

A very similar improvement (not shown) of very similar errors was experienced when the 00Z 19 September case was rerun. In this case the original vorticity center was off the Washington-Oregon coast. The operational NGM moved a +22 vorticity center into western Montana and developed a 1007 sea-level low in eastern Montana, neither of which verified. The rerun from the Cressman LFM analyses corrected both faults but again showed some excess of vorticity in the affected area, just like the October 1 case discussed above.

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3 The precipitation forecasts from the operational NGM east of the Rockies were better in most respects than those from the LFM, in spite of the sea-level pressure failure. The NGM precipitation forecasts from the LFM analysis were not quite as good as those from the operational NGM, especially in the southern part of the Mississippi Valley. This suggests, as might be expected, that the use of significant level data by the RAFS analysis, and the finer vertical resolution of the NGM compared to the LFM, is an important contributor to the NGM precipitation forecasts. The NGM reruns used the LFM humidity analysis, which does not access significant level data, and is done on the coarse vertical resolution of the LFM .

Fig. 4 shows the average 500-mb flow pattern in September (NGM 0-hour fields) and the 12-hour errors from three models:

b: The forecast from the global assimilation program that is used as the first guess for the RAFS and for the LFM analyses. (Verification is the NGM 0-hr fields)

c: The LFM 12-hour forecasts (Verification is the LFM 0-hour fields)

d. The NGM 12-hour forecasts (Verification is the NGM 0-hour fields)

Panel b of Fig. 4 can also be interpreted as the negative of the average changes made by the RAFS analysis (and NGM initialization) to the first guess field from the global assimilation program. There appears to be little systematic change. However, both the LFM and the NGM produce systematic negative errors at 12 hours in California.[4] This, in combination with the small changes shown on Fig. 4b, suggests that either

(a) the first guess may have systematic errors further off the coast that show up at 12 hours in both the NGM and LFM forecasts, or

(b) both the RAFS optimal interpolation analysis and the LFM Cressman analysis do something to the first guess off the coast (perhaps at 250 or 300 mbs where there is data) that produces in each of the models a negative 500-mb error in California 12 hours into the forecast.

Fig. 5 shows the average evolution of the 12-hour errors for the two models as forecast time progresses to 24,36, and 48 hours. The NGM seems to refuse to get rid of the 12-hour error and amplifies it somewhat.[5] The LFM seems to sweep it down to the ocean area west of Baja California.

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[4] Isolines on any of the panels on Figure 4 + 5 should be viewed with caution and distrust over the ocean, where little data is available.

[5] The NGM radiation package is known to contribute to a cold bias in the lower troposphere. This shows up in the overall negativeness on Fig. 4d and 5d, and Fig. 5f,

This problem in the western part of the United States merits a concerted effort to diagnose the source of the errors and to correct them.

1. In the NGM model, studies should be made of the frictional drag effect in the western states. The introduction of an enhanced drag effect similar to the Cressman field may be worth testing, as may consideration of the "gravity wave drag" that has recently been introduced into the UK and ECMWF models.

2. Considerable diagnostic effort is needed in the analysis procedure. Among the many possibilities that have been mentioned by various people are the following.

   a. Approximations are made in the optimal analysis procedure in implementing the idea that the rms error of the first guess is larger over the oceans than it is over land. Are these approximations ok?

   b. The optimal analysis procedure uses a spatial structure for the correlation (or covariance) matrix for the first guess errors that is based on fits to radiosondes over North America. There seems to be little or no reason why the horizontal and vertical length scales of the 12-hour errors over the data-rich part of North America should also be typical of first-guess errors over the data-poor oceans.

   c. Satellite temperatures are used by the RAFS if they are available in time. They are not used by the LFM.

      (1) Information about satellite data used off the west coast, and its fit to the first guess, etc., must be made a routine output of the <u>operational</u> and experimental RAFS analysis codes.
      (2) In the GDAS, information about the horizontal distribution of satellite temperatures available for the analysis, and its fit to the first guess must also be made a routine output of the operational analysis codes.

   d. Bad aircraft winds are not a rarity. How are they treated?

   e. The area off the west coast is characterized not only by the usual oceanic situation of data at only surface and aircraft level, but the aircraft data is on two narrow flight paths. Does this contribute to the strange vorticity malformations evidenced on Fig. 1?

   ~~f. How severe is the occurence of too strong an extrapolation~~ of analysis changes in a region characterized by a one-sided distribution of data?

g. <u>Perhaps the most useful step would be to raise the monitoring attention given to analyses to a level approximating the daily attention given to forecasts</u> at NMC (as in the afternoon map discussions on the 4th floor). Such devotion might be psychologically impossible to maintain for long periods, but even quasi-daily attention might lead to benefits.

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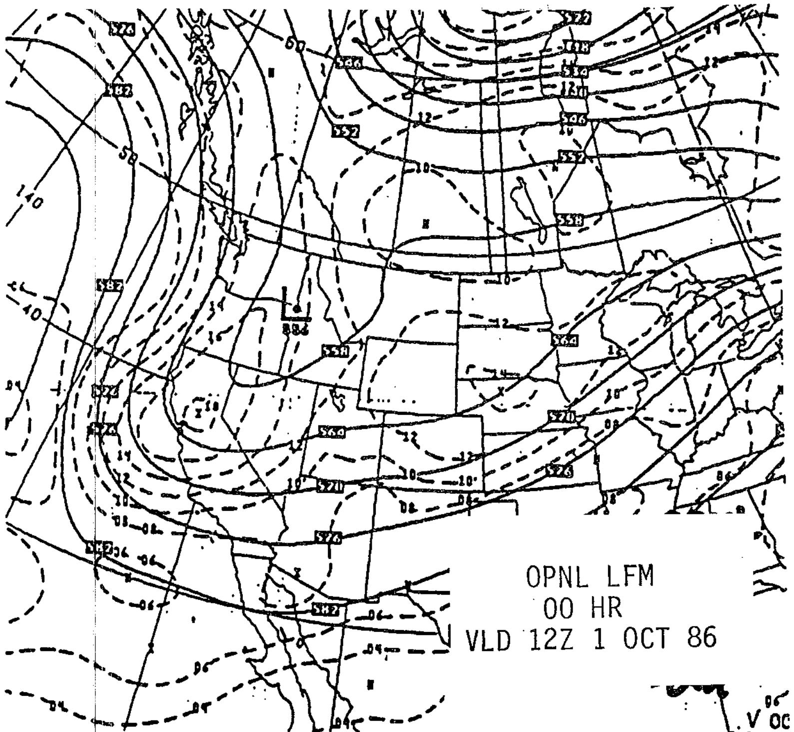
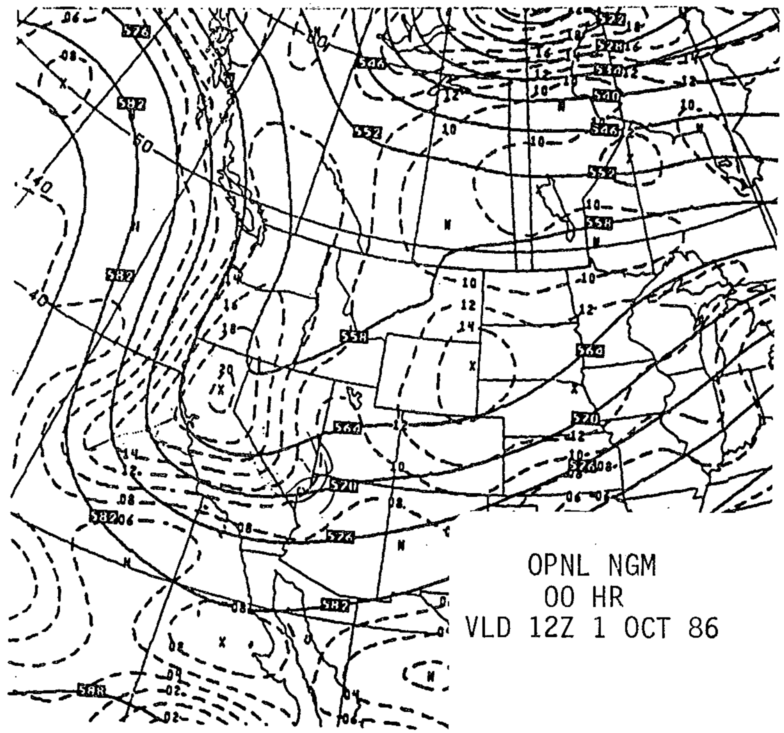




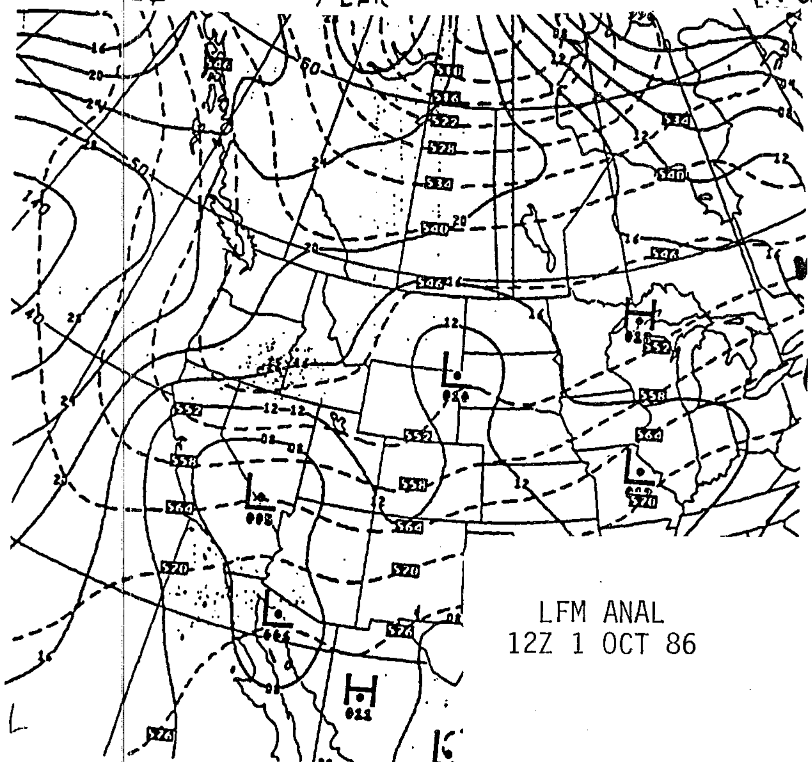


FIG 1
INITIAL FIELDS
12Z OCT 1

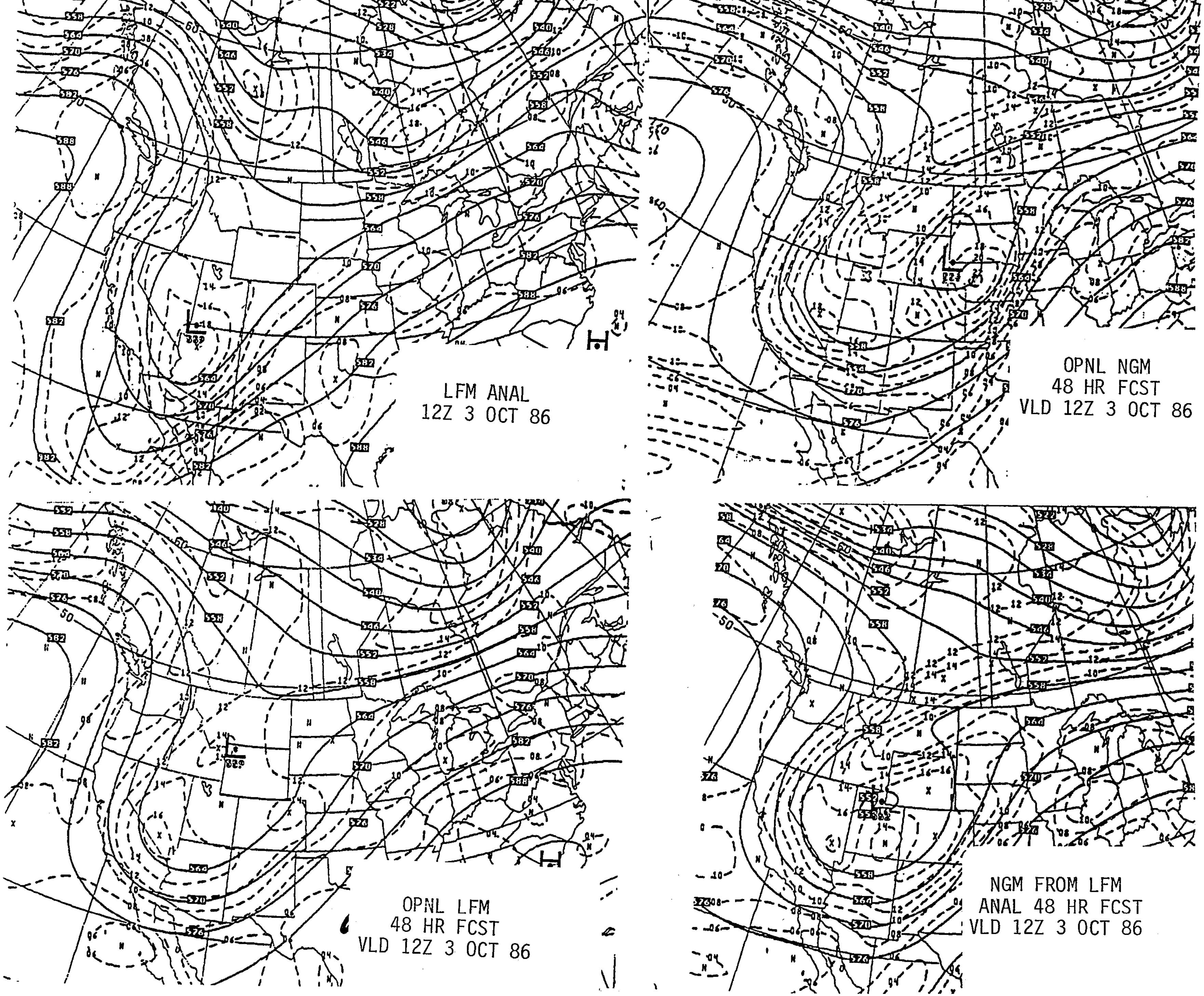


FIG 2
500MB 48 HR
FIELDS VALID
12Z 3 OCT 86

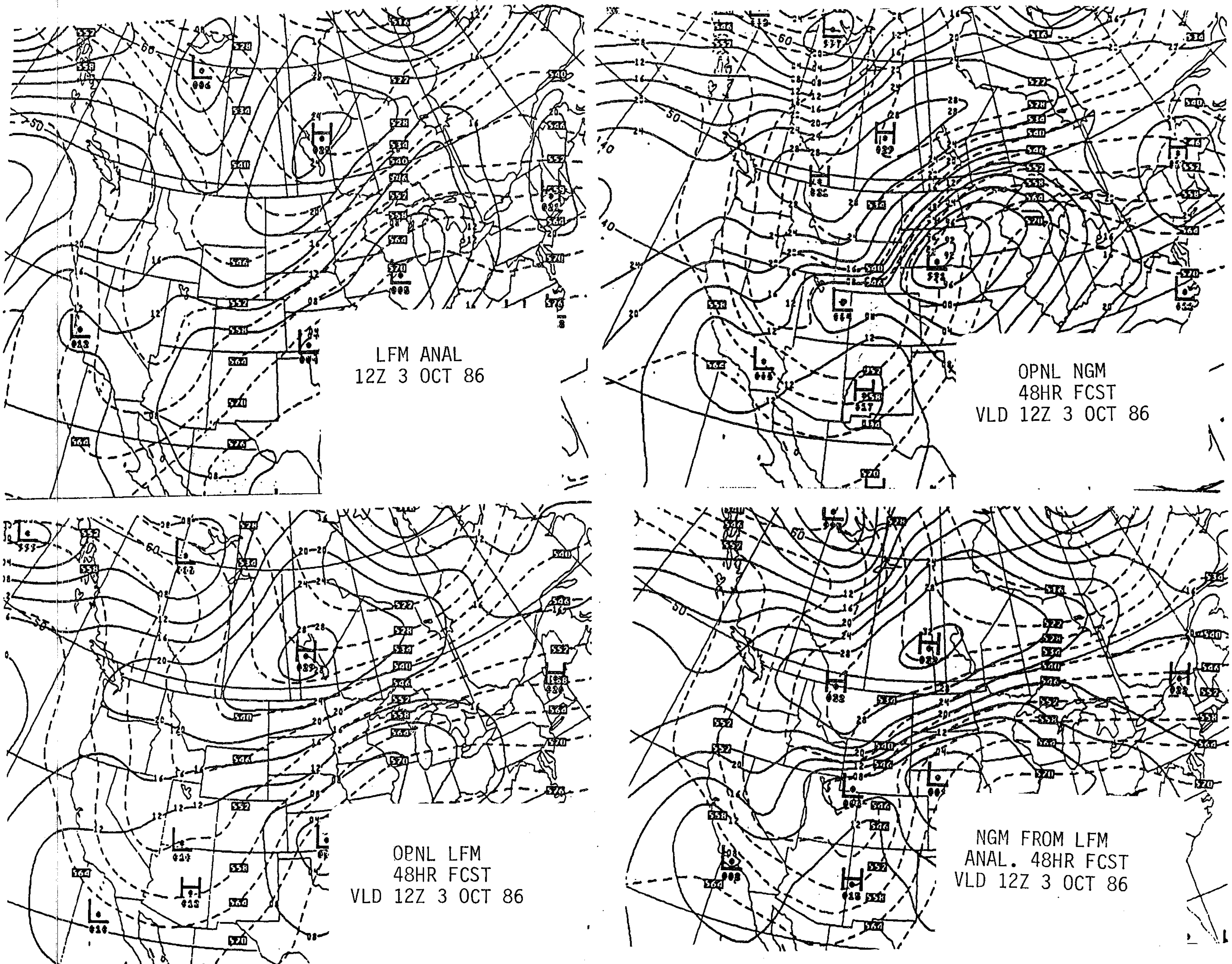
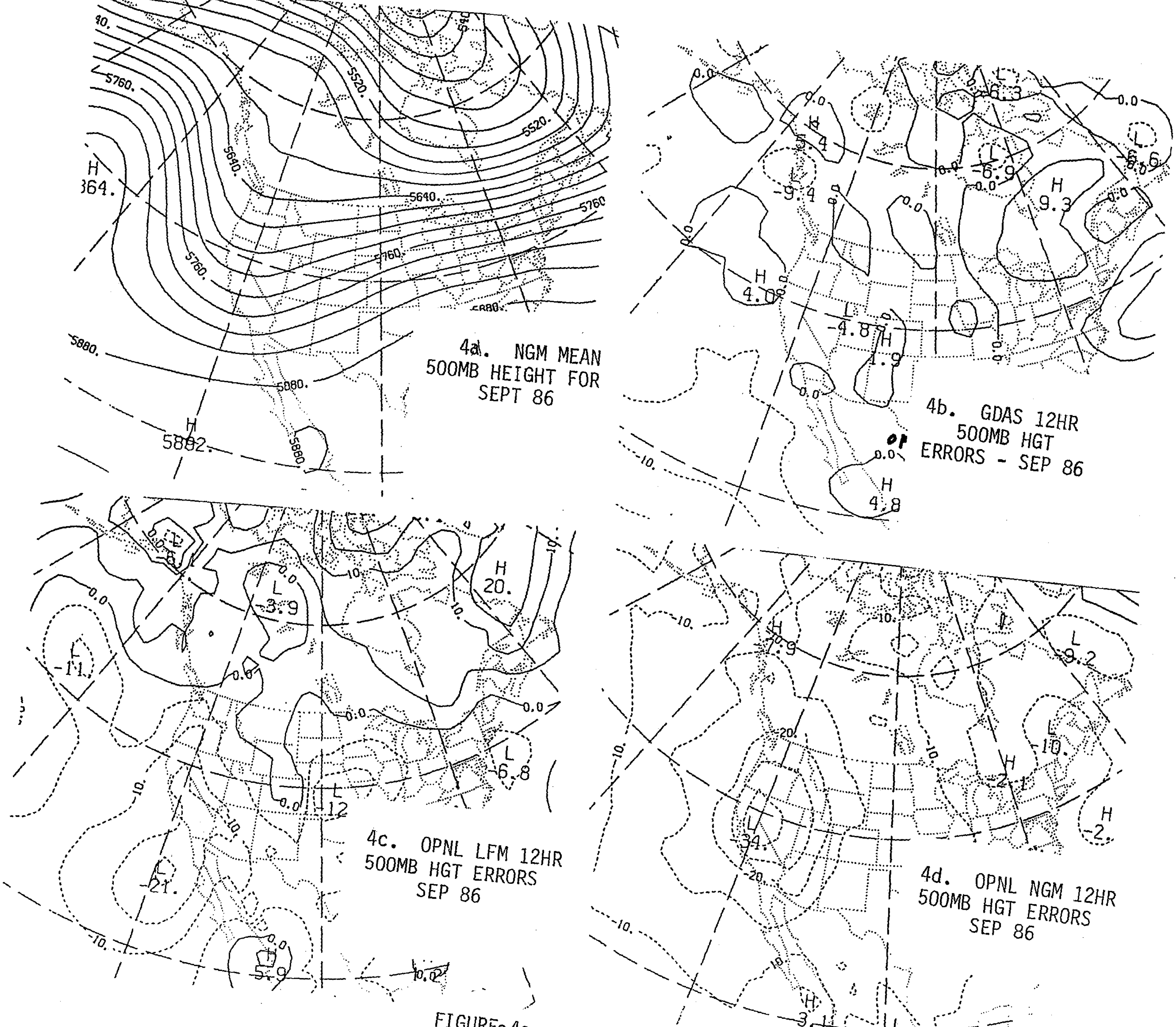


FIG 3
SEA LEVEL PRESSURE
FIELDS. VALID AT
12Z 3 OCT 86



FIGUREs 4a. - 4d.
NGM 00HR FIELDS
AND 12HR ERROR (m)
FIELDS FROM 3 MODELS

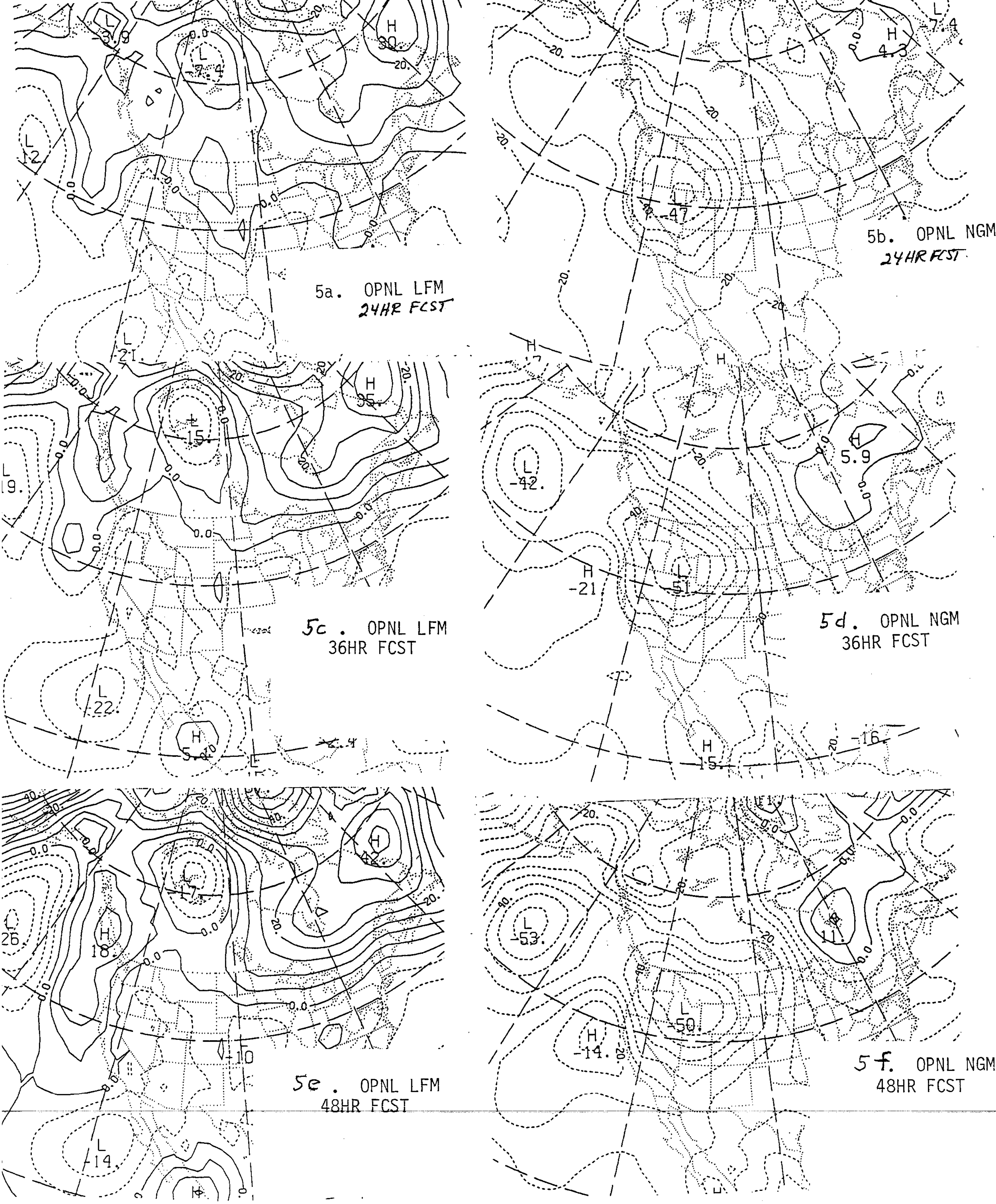


FIG 5. 500MB
HGT ERRORS - SEP 86