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Robert Atlas

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Goddard Space Flight Center
Greenbelt, Maryland 20771

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by

Robert Atlas

Laboratory for Atmospheric Sciences
Goddard Space Flight Center
Greenbelt, MD 20771

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CONTENTS

1. Introduction

The evaluations of the impact of satellite sounding data on weather forecasting, for the Data Systems Tests (DST), have led to substantially different conclusions regarding the utility of satellite data. On the basis of the DST-5 experiment, Tracton and McPherson (1977) found the impact on the National Meteorological Center's (NMC) analysis and forecast system to be slight, and speculated that satellite sounding data would actually degrade higher resolution forecasts. Ghil et al. (1979a) found a modest but statistically significant beneficial impact of DST-6 sounding data on coarse mesh (400 km resolution) GLAS model forecasts. Desmaris et al. (1978), using the NMC 6-level model with a horizontal resolution of 381 km, obtained a smaller beneficial influence of satellite sounding data with the DST-6 sounding data. In their report, they argued that the difference between the GLAS and NMC results might be due to the poorer forecast skill of the GLAS model and analysis system, thereby allowing more room for the satellite data to produce a larger beneficial impact.

A repetition of the DST-6 forecast experiments with a higher (280 km) resolution version of the GLAS model, has shown that the influence of satellite data on numerical forecasts was actually enhanced by the increased resolution (Atlas et al. 1979, Ghil et al. 1979b). A subjective evaluation of the impact of satellite data for eleven forecast cases (Atlas 1979), revealed no examples of significant negative impact. Two cases of significant forecast improvements compared to either the GLAS high resolution NOSAT or the NMC 6-level model NOSAT were found: the 72 hour forecasts from 0000 GMT 19 and 11 February 1976.[1]

[1]Additional experiments (not reported here) with the new fourth order coarse mesh GLAS model (Kalnay-Rivas 1979) agree well with the results obtained with the high resolution, second order GLAS model.

In this report the GLAS SAT predictions for both of these cases are compared with the corresponding NOSAT forecasts from the new NMC 7-level model. This model, which has a horizontal resolution of 190.5 km, has shown considerable improvement over the coarser mesh 6-level model, and has been adopted by NMC as their operational forecasting model. Comparison of the GLAS SAT forecasts with the NMC high resolution NOSAT forecasts should provide additional evidence concerning the meteorological significance of the GLAS sounding data impact results.

2. Forecasts from 0000 GMT, February 19, 1979

The initial analysis for this case showed a moderately intense low pressure system, associated with an upper level short wave trough, located off the northwest coast of the U.S. As this system moved inland, a new low developed along an already existing stationary front and became the dominant feature by 1200 GMT on 19 February. During the next 24 hours, the cyclone moved southeastward and intensified, after which time it recurved and then accelerated toward the northeast. The storm produced heavy snow, blizzard, or near-blizzard conditions in Colorado, Kansas, Nebraska, Iowa, Michigan, and Wisconsin. Tornadoes or severe thunderstorms were reported in Kansas, Oklahoma, Texas, Arkansas, Missouri, Illinois, Louisiana, and Mississippi. The majority of the severe weather occurred toward the end of the forecast period after recurvature of the cyclone to the northeast.

Figures 1-6 depict the NMC 7-level NOSAT and GLAS SAT 72-hour sea level pressure (solid lines) and 1000-500 mb thickness (dashed lines) forecasts and corresponding verification at twelve hour intervals. Comparison of the two forecasts reveals that the GLAS SAT prediction of the cyclone's 72-hour evolution is significantly better than the NMC NOSAT prediction.

At twelve hours (Fig. 1), the error of the cyclone's position is reduced by 51% and the cyclone's central pressure error is reduced by 66%. At twenty-four hours (Fig. 2), no cyclone is evident in the NMC prognosis. At thirty-six hours (Fig. 3), the differences between the two sea level pressure forecasts are smaller. However a more intense cyclonic circulation is predicted by the GLAS SAT, and the greater amplitude of the associated thickness pattern in the SAT forecast is also in better agreement with the analysis. At forty-eight hours (Fig. 4), just prior to the outbreak of severe thunderstorms and tornadoes, major differences between the GLAS SAT and NMC NOSAT prognosis are evident. The structure, intensity, and position of the SAT cyclone is substantially better than in the NMC NOSAT. The position error has been reduced by 84%; the reduction of central pressure error is 45%. This trend continues to sixty hours (Fig. 5), where the position error is reduced by 88% and the central pressure error by 46%. At 72 hours (Fig. 6), there is a 34% reduction in position error and a 75% reduction in central pressure error.

To investigate the effect of these differences further, the Computerized Severe Storm Model (CSSM) developed by Atlas (1978) has been applied to both the GLAS SAT and NMC NOSAT predictions. The CSSM consists of an objective procedure for computing and combining specific measures of instability and destabilization to yield a prediction of high, moderate, low, or neglible potential for severe local storm development. The SAT prediction of high potential accounted for 70% of the severe thunderstorm and tornado occurrences while the NMC NOSAT CSSM did not predict any areas of high potential. The differences between the two CSSM forecasts were due primarily to a substantially improved prediction of differential equivalent potential temperature advection and convective instability in the SAT system.

3. Forecasts from 0000 GMT, February 11, 1976

In this case, a weak cyclone formed along a stationary front in southwest Canada, moved southeastward while intensifying during the first 40 h of the period, and then recurved to the east-northeast.

Figures 7-9 depict the NMC 7-level NOSAT and GLAS SAT 72-hour sea level pressure (solid lines) and 1000-500 mb thickness (dashed lines) forecasts and corresponding verification at twenty-four hour intervals. Comparison of these charts reveals the significant forecast improvements that have occurred in the GLAS SAT system.

At twenty-four hours (Fig. 7), there has been a 66% reduction of position error and an 87% reduction of central pressure error of the cyclone located in southwest Canada. Similarly at forty-eight hours (Fig. 8), there has been a 76% reduction of position error and a 25% reduction of central pressure error of this cyclone, now centered near the Great Lakes. The position and orientation of the pressure trough extending southwestward from this cyclone, and the position of the anticyclone located off the east coast of the U.S. are better forecast by the GLAS SAT. In addition, a spurious cyclone, forecast by the NMC NOSAT to be over southwest Canada and the northwestern U.S., does not appear in the GLAS SAT. At 72 hours (Fig. 9), the GLAS SAT is significantly better than the NMC NOSAT in its prediction of the cyclonic circulation over southeastern Canada and the northeastern U.S., the anticyclone over the midwest, the pressure trough extending southeastward from southwest Canada, and the shallow pressure troughing off the west coast of the U.S. The NMC NOSAT is slightly better in its prediction of the cyclone located off the northwest coast of the U.S. and also has a 26% smaller position error of the cyclone now located in eastern Canada. However the central pressure error of this cyclone has been reduced by 53% in the GLAS SAT.

4. Summary

Two cases where NMC's operational model in 1976, had serious difficulties in forecasting for the United States have been examined. Some improvements to the forecasts in these cases resulted from the use of the higher resolution NMC 7-level model. However, the GLAS model, when utilizing initial conditions which included satellite sounding data, was still able to significantly improve upon the current operational model's predictions. This suggests that the satellite temperature soundings have the potential to correct gross analysis errors, which infrequently occur in the operational NMC system in data sparse regions.

Acknowledgement

The author wishes to acknowledge Drs. J. Brown and J. Stackpole of the NMC Development Division for providing copies of their 7-level model forecast outputs for these case studies.

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Ghil, M., M. Halem, and R. Atlas, 1979a: Time-continuous assimilation of remote-sounding data and its effect on weather forecasting. Mon. Wea. Rev., 107, 140-171.

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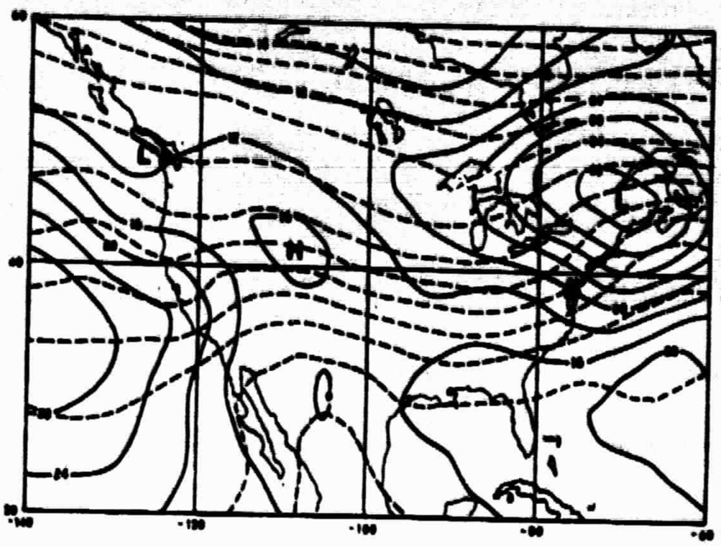
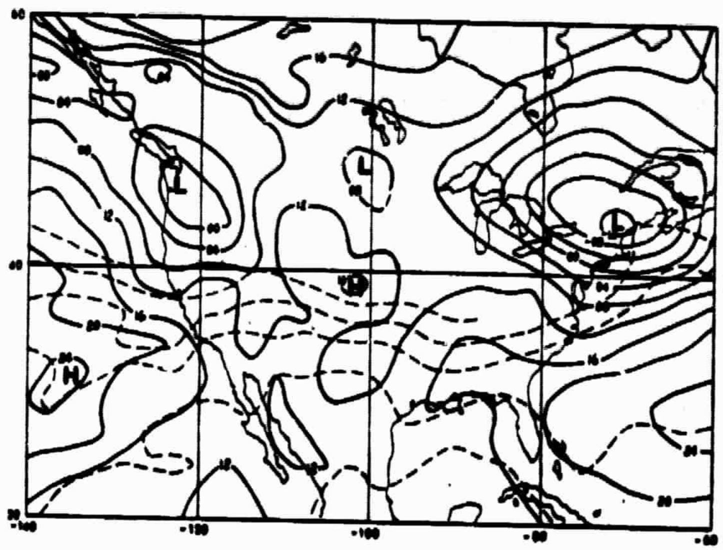
Kalnay-Rivas, 1979: Personal communication.

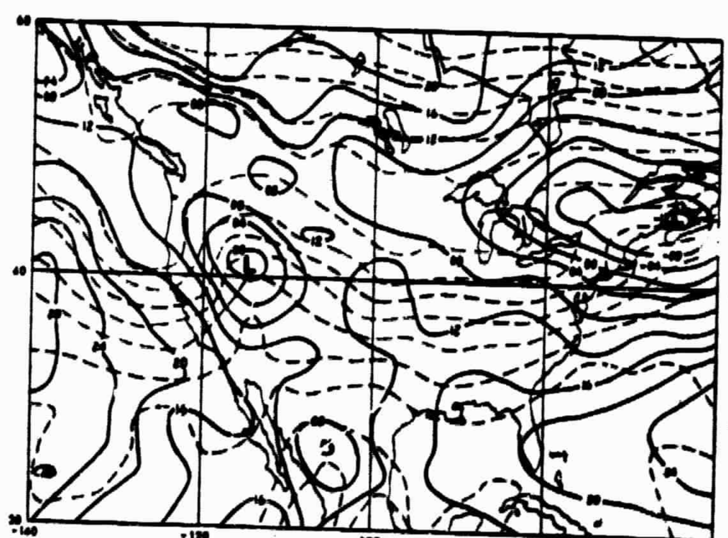
Tracton, M. S. and R. D. McPherson, 1977: On the impact of radiometric sounding data upon operational numerical weather prediction at NMC. Bull. Am. Meteorol. Soc., 58, 1201-1209.



a) 12 hr. NMC 7L NOSAT Forecast

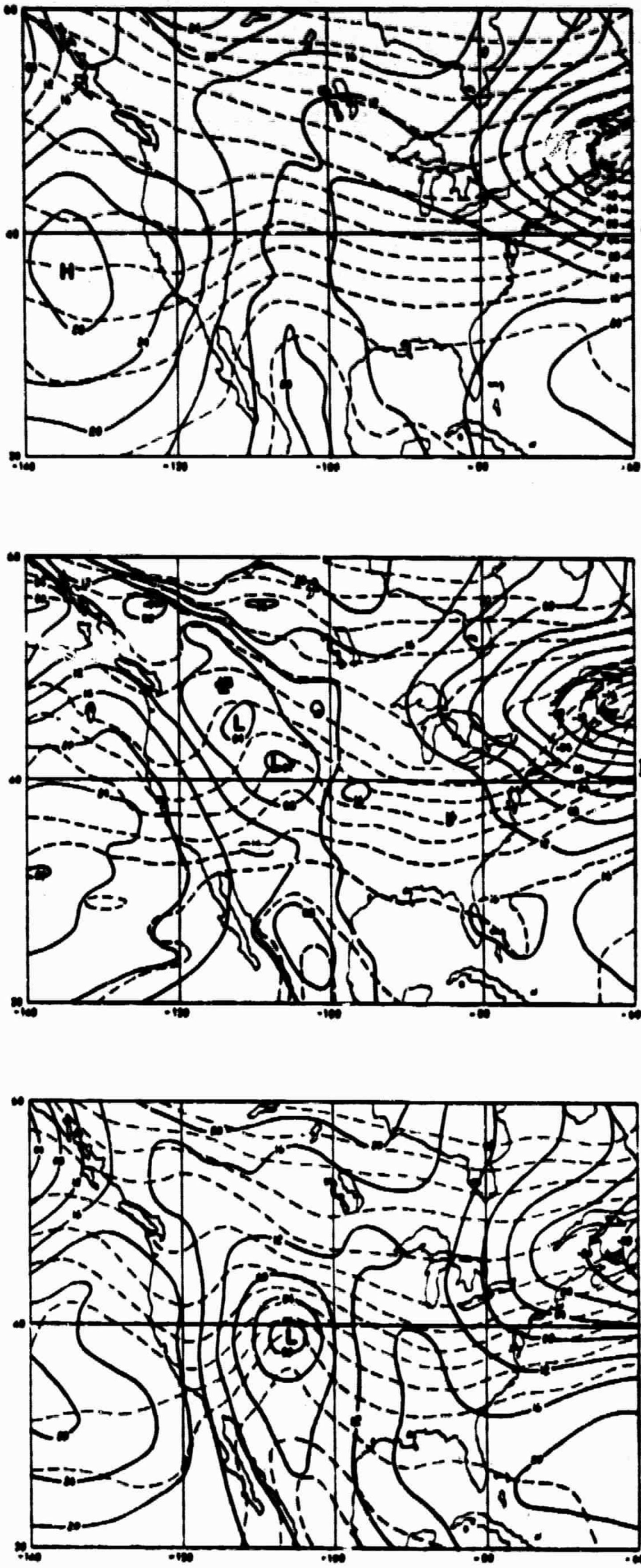


b) 12 hr. GLAS SAT Forecast



c) Analysis

Fig. 1. Sea level pressure/1000-500 mb thickness maps for 1200 GMT 19 Feb. 1976.

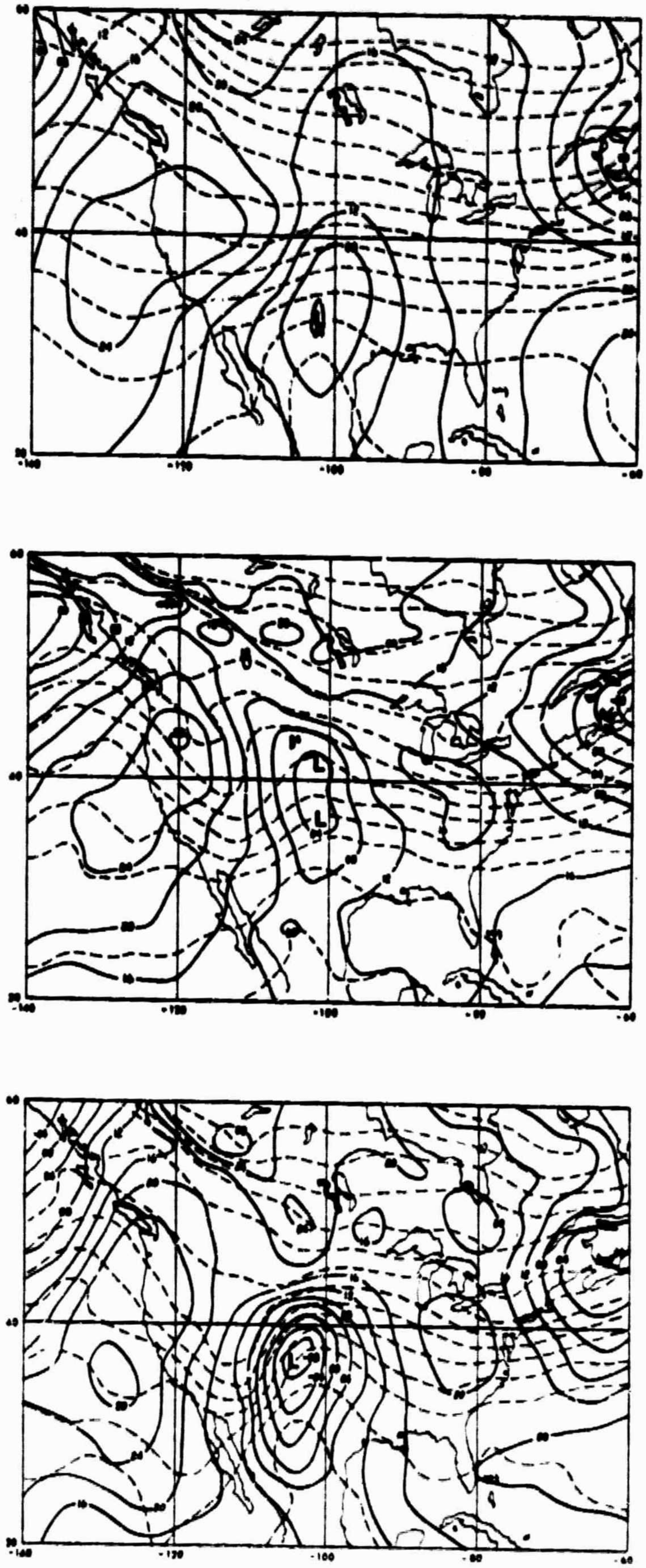


a) 24 hr. NMC 7L NOSAT Forecast

b) 24 hr. GLAS SAT Forecast

c) Analysis

Fig. 2. Sea level pressure/1000-500 mb thickness maps for 0000 GMT 20 Feb. 1976.

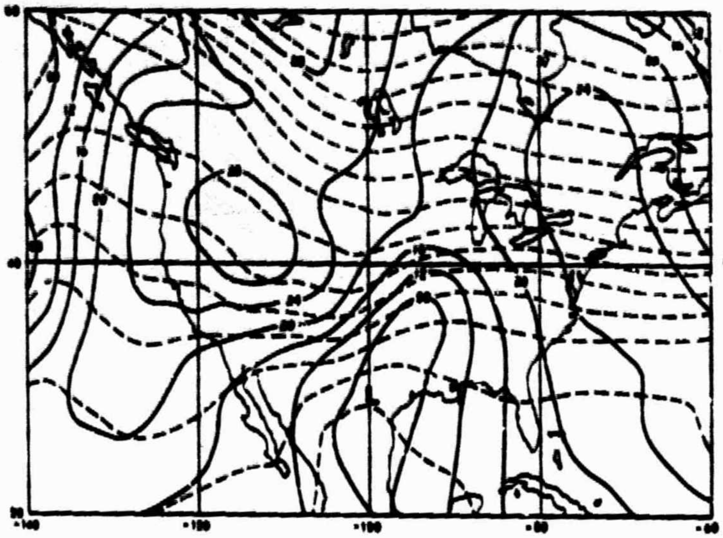


a) 36 hr. NMC 7L NOSAT Forecast

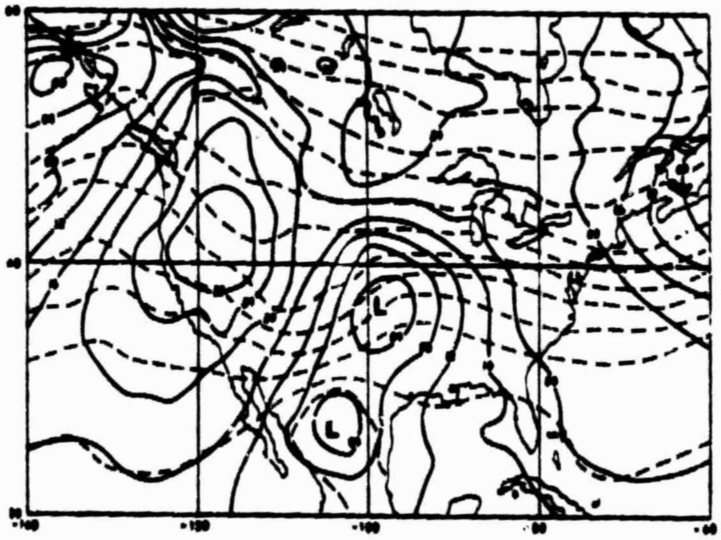
b) 36 hr. GLAS SAT Forecast

c) Analysis

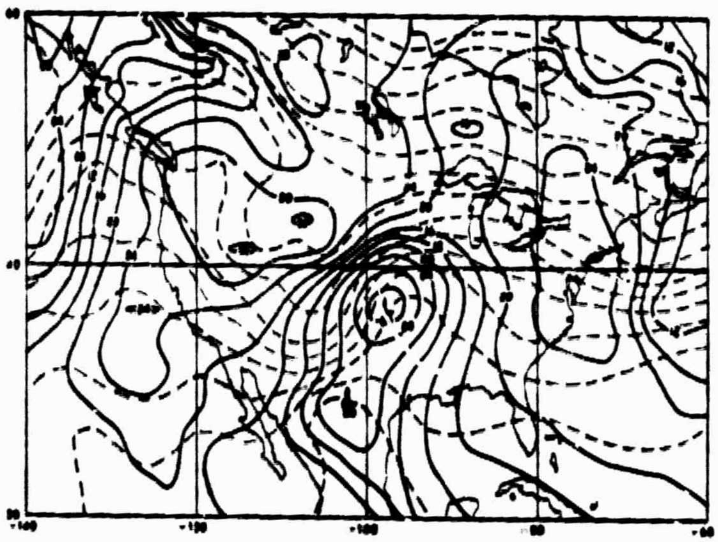
Fig. 3. Sea level pressure/1000-500 mb thickness maps for 1200 GMT 20 Feb. 1976.



a) 48 hr. NMC 7L NOSAT Forecast

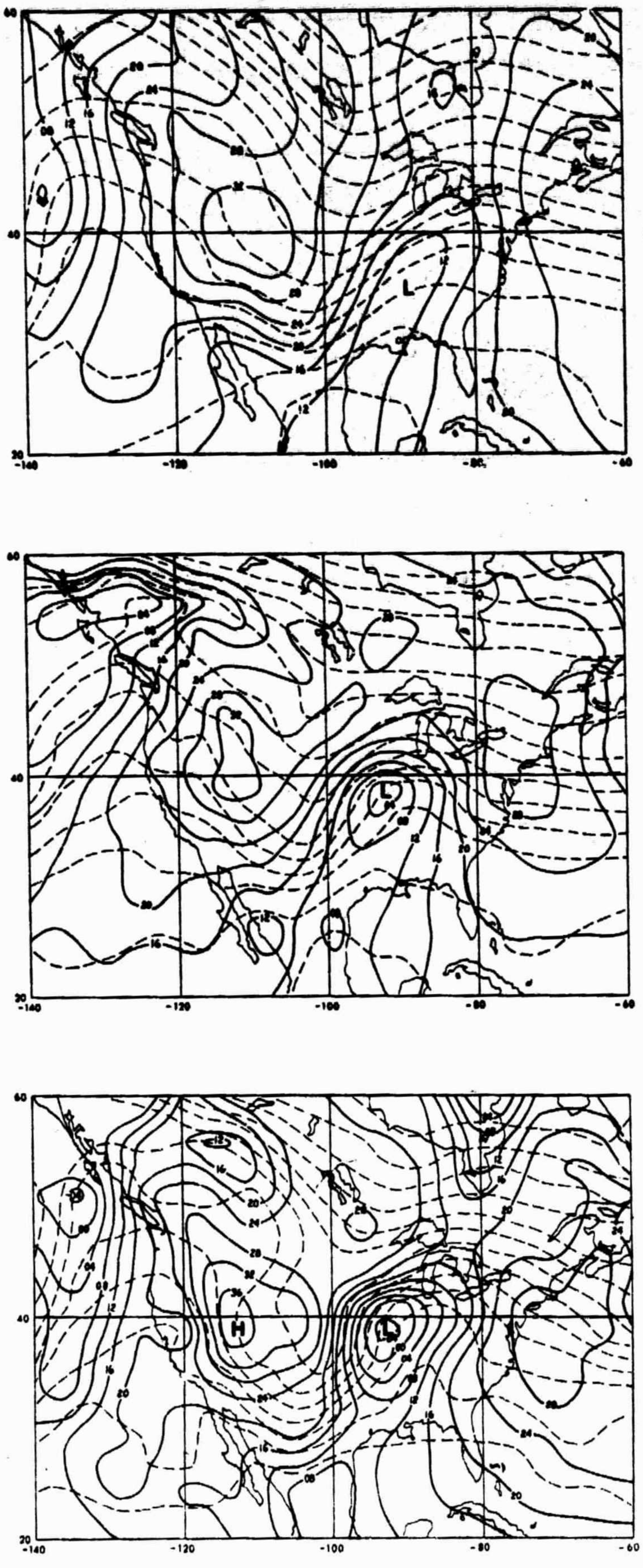


b) 48 hr. GLAS SAT Forecast



c) Analysis

Fig. 4. Sea level pressure/1000-500 mb thickness maps for 0000 GMT 21 Feb. 1976.

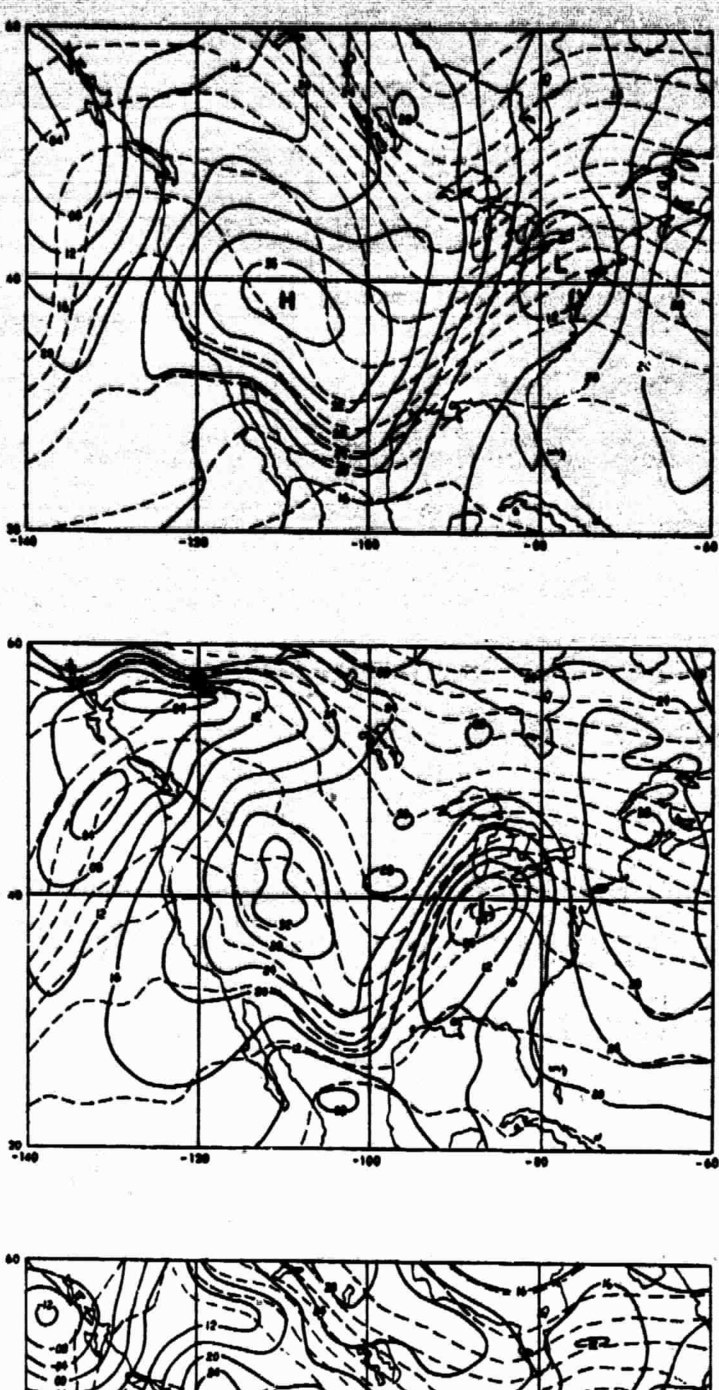


a) 60 hr. NMC 7L NOSAT Forecast

b) 60 hr. GLAS SAT Forecast

c) Analysis

Fig. 5. Sea level pressure/1000-500 mb thickness maps for 1200 GMT 21 Feb. 1976.

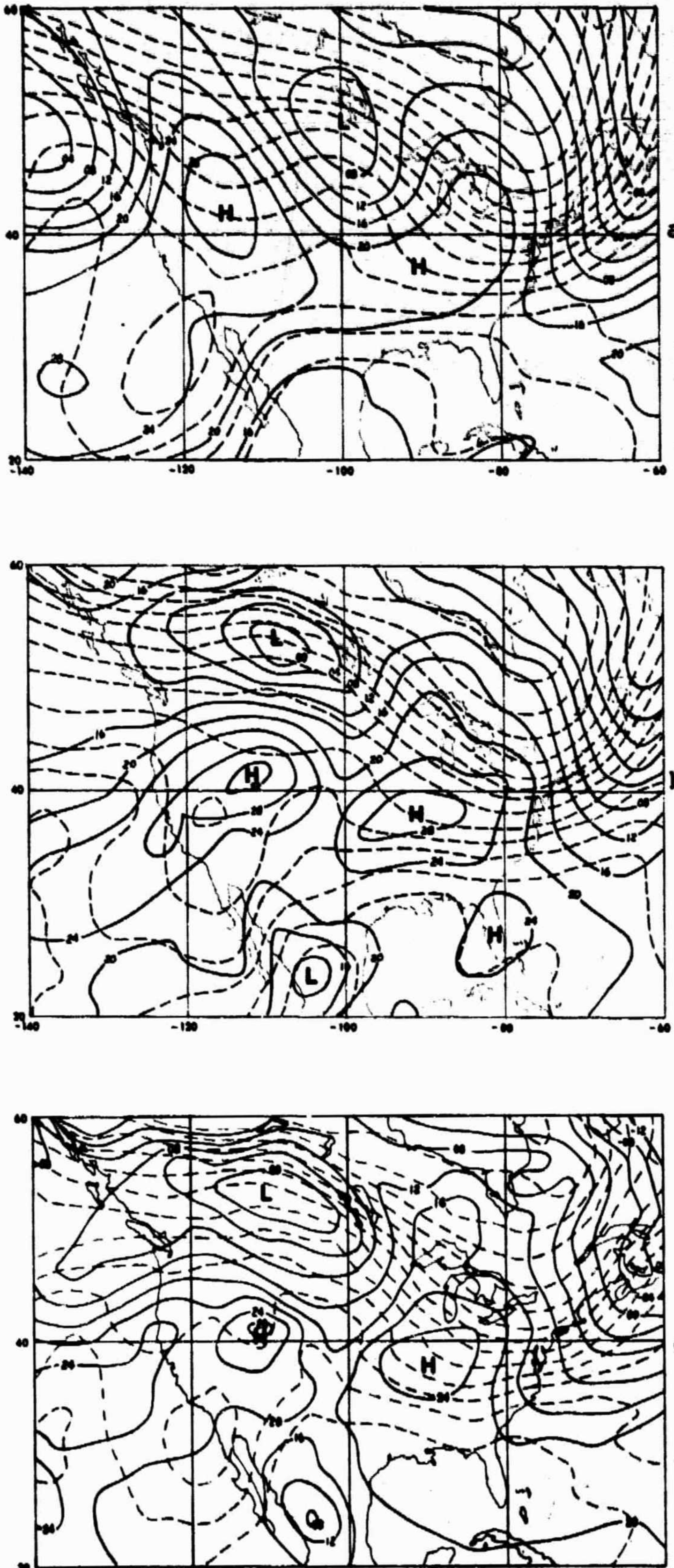


a) 72 hr. NMC 7L NOSAT Forecast

b) 72 hr. GLAS SAT Forecast

c) Analysis

Fig. 6. Sea level pressure/1000-500 mb thickness maps for 0000 GMT 22 Feb. 1976.

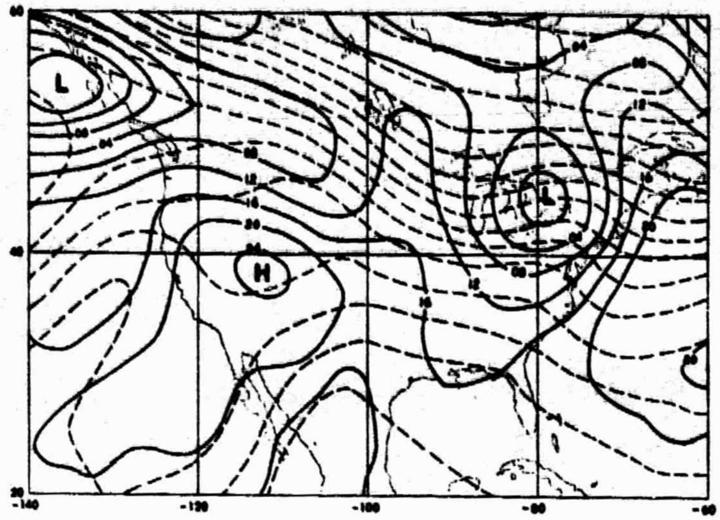


a) 24 hr. NMC 7L NOSAT Forecast

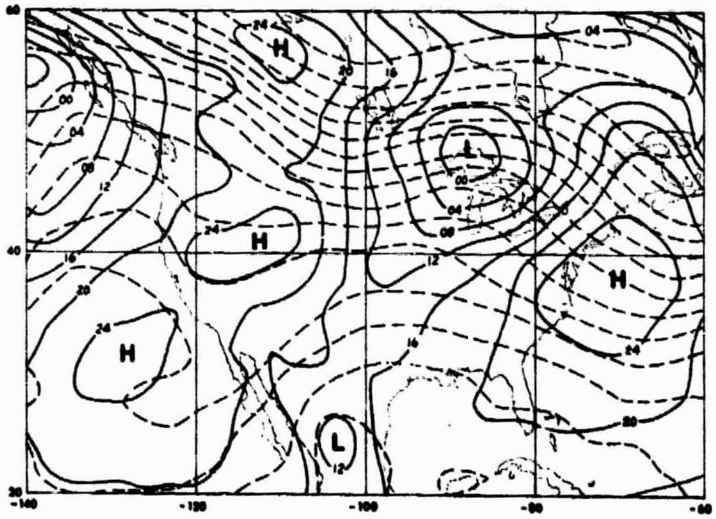
b) 24 hr. GLAS SAT Forecast

c) Analysis

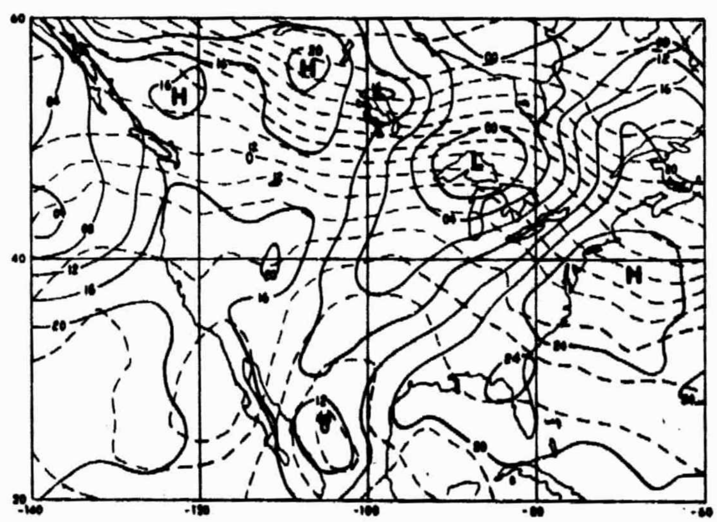
Fig. 7. Sea level pressure/1000-500 mb thickness maps for 0000 GMT 12 Feb. 1976.



a) 48 hr. NMC 7L
NOSAT Forecast

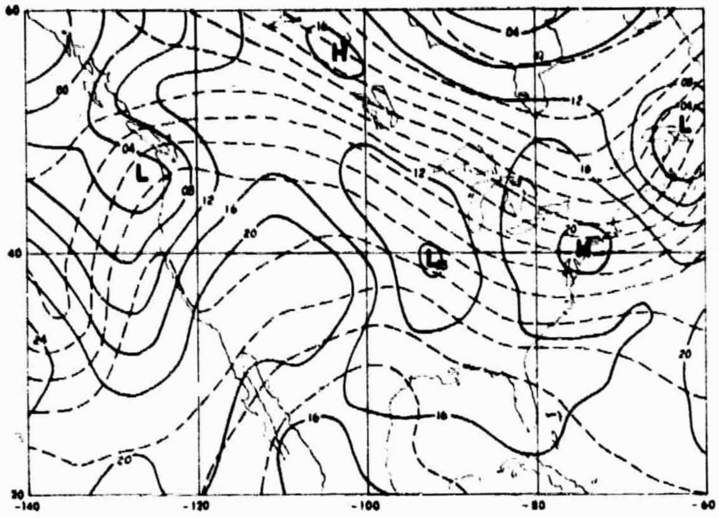


b) 48 hr. GLAS
SAT Forecast

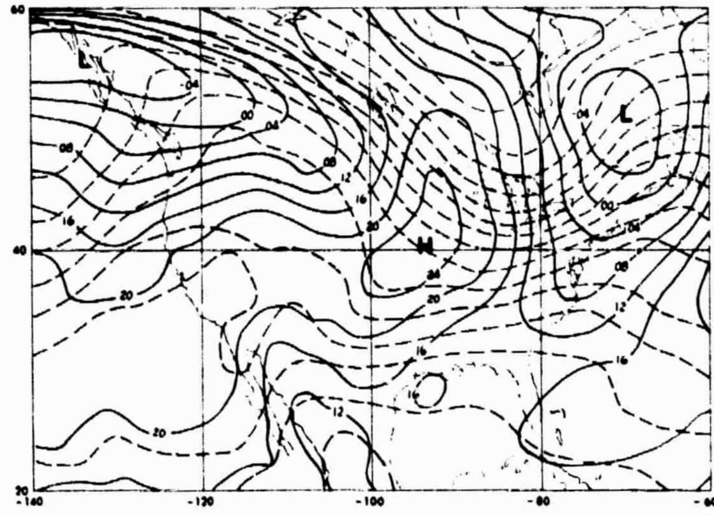


c) Analysis

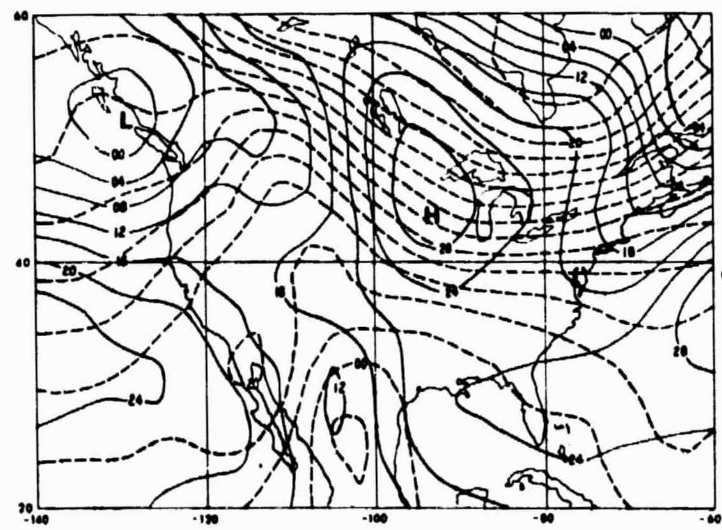
Fig. 8. Sea level pressure/1000-500 mb thickness maps for 0000 GMT 13 Feb. 1976.



a) 72 hr. NMC 7L NOSAT Forecast



b) 72 hr. GLAS SAT Forecast



c) Analysis

Fig. 9. Sea level pressure/1000-500 mb thickness maps for 0000 GMT 14 Feb. 1976.