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# NOAA Technical Memorandum NWS TDL-41

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

# Twice-Daily Mean Monthly Heights in the Troposphere Over North America and Vicinity

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Systems
Development
Office

SILVER SPRING, MD.

June 1971

NOAA TECHNICAL MEMORANDA

National Weather Service, Techniques Development Laboratory Series

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(Continued on inside back cover)

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# TWICE-DAILY MEAN MONTHLY HEIGHTS IN THE TROPOSPHERE OVER NORTH AMERICA AND VICINITY

August F. Korte

Systems Development Office
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| 551.5 | Meteorology |
| .547 | Upper air pressure |
| .3 | Variations of upper air pressure |
| .510.52 | Troposphere |
| 912.43:551.54 | Maps of atmospheric pressure |
| "54" | Monthly |
| (7) | North America |

CONTENTS

# TWICE-DAILY MEAN MONTHLY HEIGHTS IN THE TROPOSPHERE OVER NORTH AMERICA AND VICINITY

August F. Korte

ABSTRACT. The mean maps show average geopotential metric heights for the 850-, 700-, 500-, and 300-mb pressure surfaces at 0000 and 1200 GMT for each month of the year. The maps were derived by computer from objectively analyzed grid-point data for November 1961 through January 1969. The use of these maps is briefly described to obtain the average monthly height for any day and 12-hour period.

## INTRODUCTION

Recently completed investigations (Jorgensen et al. 1967a, 1967b; Klein et al. 1968; and Korte et al. 1969) into the synoptic climatology of precipitation for the Intermountain West during winter utilized mean maps to obtain an intensity classification of upper lows according to their height departures from "normal" (DN).* Mean charts of heights in the Northern Hemisphere were readily available and are briefly described in an earlier study (Klein et al. 1968) of the upper levels at 850, 700, 500, and 300 mb. Several of these charts were applicable to only one time of day. The diurnal (12-hr) variability of the mean heights during winter was considered small enough not to affect greatly the DN classification of the lows. Although the 12-hour variability of mean heights during spring, summer, and fall may be great enough to affect the DN classes of the lows, no charts or data were then available to enable us to take account of these diurnal differences.

To obtain upper level data in a convenient form and at a reasonable cost, upper air historical fields of pressures, temperatures, and humidities at 1000, 850, 700, 500, and 300 mb were extracted from the files of the Fleet Numerical Weather Central (FNWC) in Monterey, Calif. (Stevenson and Woodworth 1968; and Woodworth 1969), from November 1961 through January 1969. The Techniques Development Laboratory (TDL) used these data to develop mean height maps centered upon the midmonth for each of the 12 months of the year at both the 0000 and 1200 GMT observations. The resulting mean maps were obtained by a computer and are presented in the appendix, separately for each month, for each time, and for each of four levels (850, 700, 500, and 300 mb).

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*Here the term "normal" is replaced, to be more exact, by the word "mean" or "norm."

Since these maps were prepared, Crutcher and Meserve (1970) published additional and more detailed hemispheric mean maps applicable at 0000 GMT only. Earlier, O'Connor (1961) published 700-mb mean height charts for a 12-year period. Hesse and Stevenson (1968) showed recent mean surface maps produced by FNWC and also referred to a similar unpublished study of diurnal height differences at 500 mb.

Recent papers by Teweles (1970); Morrissey and Brousaides (1970); and Colton (1970) show that since about 1960, the humidity measurements obtained with U.S. radiosondes have been in general too low. The magnitude of this effect has not yet been absolutely determined, but it will tend to lower heights in daylight by amounts up to the order of 10 meters.

## USE OF THE MEAN MAPS

The maps in the appendix can be applied to our synoptic climatological charts derived recently for winter and spring. The TDL charts can also be used for investigations of recent 12-hourly mean heights and their changes over and adjacent to North America. The scope of this memorandum is limited to the relatively small area of North America because the larger hemispheric charts (Crutcher and Meserve 1970) are now available for general climatological use.

The derived mean maps can be used to obtain the average monthly height for any day of the month, after which the related departure from the mean (DN) for each low center is obtained. The following procedure is used for date and height interpolation:

1. Locate the position of the upper low on the appropriate initial mean chart in the appendix for a date period that includes the given date. Then from the chart obtain an average height for the beginning (16th day) of the date interval. This date interval of 30 days extends from the 16th of the initial month to the 15th of the following month. Note that each monthly chart represents the mean height data applicable to the 15th day (i.e., the central date) of each month. In each case, a month is assumed to be 30 days (including February) to make a linear interpolation of height to the day of the month desired. Where exactness can be sacrificed, the median between adjacent months is utilized as an estimate of the desired height; however, in our study we can just as easily interpolate to the exact day, and this procedure will be followed hereafter. All heights are indicated in geopotential meters (gpm).

2. Locate the position of the upper low on the <u>following</u> appropriate mean monthly chart of the interval for the given date and obtain an average height from that chart for the ending (15th day) of the date interval.

3. Obtain the algebraic (mean height) difference for the 30-day interval by subtracting the average height obtained earlier in step 1 from the related height obtained in step 2.

4. Enter table 1 with the 30-day mean monthly height change and its algebraic sign obtained in step 3 above and, under the corresponding day of the month, read the linear-interpolated height change for the given day with the algebraic sign retained. For greater height accuracy, a parabolic rather than a linear interpolation may be used (Whittaker and Robinson 1944); otherwise, the tabulated heights are somewhat underestimated (overestimated) for the month of maximum (minimum) heights.

5. Algebraically, add the interpolated mean height change from step 4 above to the initial average height from step 1 above to obtain the more exact mean height desired.

An example of this procedure follows using a low that occurred at 850 mb on November 1, 1952, at 0300 GMT, latitude 44°N, and longitude 108°W. This location is near Worland, Wyo., in the north-central part of that State.

Step 1. The given date (November 1, 1952) lies within the 30-day interval from October 16 through November 15. The upper low has a corresponding mean height of 1,495 gpm on October 16 for the beginning of the 30-day date interval.

Step 2. The mean chart for November indicates a height of 1,477 gpm on November 15 for the ending of the date interval.

Step 3. The algebraic difference of the height for November 15 (step 2) less the height for October 16 (step 1) is therefore -18 gpm.

Step 4. Enter table 1 with -18 gpm, the monthly height change at the given date (November 1, 1952), and read -10 gpm, the height change accrued to that date.

Step 5. Algebraic addition of the -10 gpm (step 4) to the October height gives an approximate interpolated height of 1,485 gpm.

## CHANGES IN MEAN HEIGHTS IN THE INTERMOUNTAIN WEST

A study was made of differences in heights over the Intermountain West between the mean maps used earlier during winter and those shown here. A spot check was made by comparing the January (midwinter) mean map shown at 700 mb in an earlier paper (Jorgensen et al. 1967b), the 850- and 500-mb mean maps in a following study (Korte et al. 1969), and the corresponding map in this memorandum. The average height contours of the Jorgensen et al. paper, which were harmonically smoothed, generally compare well with each other. Usually the mean contours are slightly south of the corresponding harmonic-mean contours and indicate a maximum height difference of 20 gpm at 850 mb, 7 gpm at 700 mb, and 24 gpm at 500 mb.

Table 4.-- The Linear Interpolation (Geopotential Meters) of Normal Height for Each Day Between Successive Months for Each Level and for All Seasons.
(Note: Algebraic sign of the interpolated height is the same as the monthly height change.)

| Monthly Height Change (gpm) | Day of the Month | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 1-5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | -- | -- | -- | -- | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 6-10 | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 8 | 8 | -- | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |
| 11-15 | 7 | 7 | 8 | 8 | 9 | 9 | 10 | 10 | 10 | 11 | 11 | 12 | 12 | 13 | 13 | -- | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 |
| 16-20 | 10 | 10 | 11 | 11 | 12 | 13 | 13 | 14 | 14 | 15 | 16 | 16 | 17 | 17 | 18 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 5 | 6 | 7 | 7 | 8 | 8 | 9 |
| 21-25 | 12 | 13 | 14 | 15 | 15 | 16 | 17 | 18 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 8 | 9 | 10 | 11 | 12 |
| 26-30 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 31-35 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 29 | 30 | 31 | 32 | 33 | 1 | 2 | 3 | 4 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 17 |
| 36-40 | 20 | 22 | 23 | 24 | 25 | 27 | 28 | 29 | 30 | 32 | 33 | 34 | 35 | 37 | 38 | 1 | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 11 | 13 | 14 | 15 | 16 | 18 | 19 |
| 41-45 | 23 | 24 | 26 | 27 | 29 | 30 | 32 | 33 | 34 | 36 | 37 | 39 | 40 | 42 | 43 | 1 | 3 | 4 | 6 | 7 | 9 | 10 | 11 | 13 | 14 | 16 | 17 | 19 | 20 | 22 |
| 46-50 | 26 | 27 | 29 | 30 | 32 | 34 | 35 | 37 | 38 | 40 | 42 | 43 | 45 | 46 | 48 | 2 | 3 | 5 | 6 | 8 | 10 | 11 | 13 | 14 | 16 | 18 | 19 | 21 | 22 | 24 |
| 51-55 | 28 | 30 | 32 | 34 | 35 | 37 | 39 | 41 | 42 | 44 | 46 | 48 | 49 | 51 | 53 | 2 | 4 | 5 | 7 | 9 | 11 | 12 | 14 | 16 | 18 | 19 | 21 | 23 | 25 | 27 |
| 56-60 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 |
| 61-65 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 55 | 57 | 59 | 61 | 63 | 2 | 4 | 6 | 8 | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 32 |
| 66-70 | 36 | 39 | 41 | 43 | 45 | 48 | 50 | 52 | 54 | 57 | 59 | 61 | 63 | 66 | 68 | 2 | 5 | 7 | 9 | 11 | 14 | 16 | 18 | 20 | 23 | 25 | 27 | 29 | 32 | 34 |
| 71-75 | 39 | 41 | 44 | 46 | 49 | 51 | 54 | 56 | 58 | 61 | 63 | 66 | 68 | 71 | 73 | 2 | 5 | 7 | 10 | 12 | 15 | 17 | 19 | 22 | 24 | 27 | 29 | 32 | 34 | 37 |
| 76-80 | 42 | 44 | 47 | 49 | 52 | 55 | 57 | 60 | 62 | 65 | 68 | 70 | 73 | 75 | 78 | 3 | 5 | 8 | 10 | 13 | 16 | 18 | 21 | 23 | 26 | 29 | 31 | 34 | 36 | 39 |
| 81-85 | 44 | 47 | 50 | 53 | 55 | 58 | 61 | 64 | 66 | 69 | 72 | 75 | 77 | 80 | 83 | 3 | 6 | 8 | 11 | 14 | 17 | 19 | 22 | 25 | 28 | 30 | 33 | 36 | 39 | 42 |
| 86-90 | 47 | 50 | 53 | 56 | 59 | 62 | 65 | 67 | 70 | 73 | 76 | 79 | 82 | 85 | 88 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 23 | 26 | 29 | 32 | 35 | 38 | 41 | 44 |
| 91-95 | 50 | 53 | 56 | 59 | 62 | 65 | 68 | 71 | 74 | 77 | 81 | 84 | 87 | 90 | 93 | 3 | 6 | 9 | 12 | 16 | 19 | 22 | 25 | 28 | 31 | 34 | 37 | 40 | 43 | 47 |
| 96-100 | 52 | 56 | 59 | 62 | 65 | 69 | 72 | 75 | 78 | 82 | 85 | 88 | 91 | 95 | 98 | 3 | 7 | 10 | 13 | 16 | 20 | 23 | 26 | 29 | 33 | 36 | 39 | 42 | 46 | 49 |
| 101-105 | 55 | 58 | 62 | 65 | 69 | 72 | 75 | 79 | 82 | 86 | 89 | 93 | 96 | 100 | 103 | 3 | 7 | 10 | 14 | 17 | 21 | 24 | 28 | 31 | 34 | 38 | 41 | 45 | 48 | 52 |
| 106-110 | 58 | 61 | 65 | 68 | 72 | 76 | 79 | 83 | 86 | 90 | 94 | 97 | 101 | 104 | 108 | 4 | 7 | 11 | 14 | 18 | 22 | 25 | 29 | 32 | 36 | 40 | 43 | 47 | 50 | 54 |
| 111-115 | 60 | 64 | 68 | 72 | 75 | 79 | 83 | 87 | 90 | 94 | 98 | 102 | 105 | 109 | 113 | 4 | 8 | 11 | 15 | 19 | 23 | 26 | 30 | 34 | 38 | 41 | 45 | 49 | 53 | 57 |
| 116-120 | 63 | 67 | 71 | 75 | 79 | 83 | 86 | 91 | 94 | 98 | 102 | 106 | 110 | 114 | 118 | 4 | 8 | 12 | 16 | 20 | 24 | 27 | 32 | 35 | 39 | 43 | 47 | 51 | 55 | 59 |
| 121-125 | 66 | 70 | 74 | 78 | 82 | 86 | 90 | 94 | 98 | 102 | 107 | 111 | 115 | 119 | 123 | 4 | 8 | 12 | 16 | 21 | 25 | 29 | 33 | 37 | 41 | 45 | 49 | 53 | 57 | 62 |
| 126-130 | 68 | 73 | 77 | 81 | 85 | 90 | 94 | 98 | 102 | 107 | 111 | 115 | 119 | 124 | 128 | 4 | 9 | 13 | 17 | 21 | 26 | 30 | 34 | 38 | 43 | 47 | 51 | 55 | 60 | 64 |

A comparison of current height means (Crutcher and Meserve 1970) with the corresponding mean heights in this memorandum during July at 700 mb, 0000 GMT in each case, indicates general agreement. The maximum height difference noted over the Intermountain West is about 12 gpm. The 700-mb mean charts of O'Connor (1961) are similar to a median of those presented here (appendix) for 700 mb at both 0000 and 1200 GMT.

Charts similar to those in the appendix, but for the Northern Hemisphere, have been derived in TDL and may be reproduced later by the National Climatic Center.

## ACKNOWLEDGMENTS

This study was completed through the financial support of the U.S. Department of the Interior, Bureau of Reclamation, and was supervised by William H. Klein and Donald L. Jorgensen. Frank Lewis and Clifton K. S. Chun performed the computer processing of data and calculations used to develop the mean maps. James A. Bunce, Jr., James R. Noffsinger, and Margaret A. Dalton assisted in manually processing the data. DeVer Colson and Harold Crutcher critically read the manuscript.

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# APPENDIX

## TWICE-DAILY MEAN MONTHLY CHARTS

The following charts describe mean heights in geopotential meters at 850, 700, 500, and 300 mb for each month of the year. These heights are shown twice daily each month by Figures 1a through 12a for 0000 GMT and by Figures 1b through 12b for 1200 GMT. Each height represents an arithmetic average of objectively analyzed grid-point data for November 1961 through January 1969. All charts are shown on Form Map 1608, 4-65, scale 1:30,000,000, Polar Stereographic Projection, true at latitude 60°N.

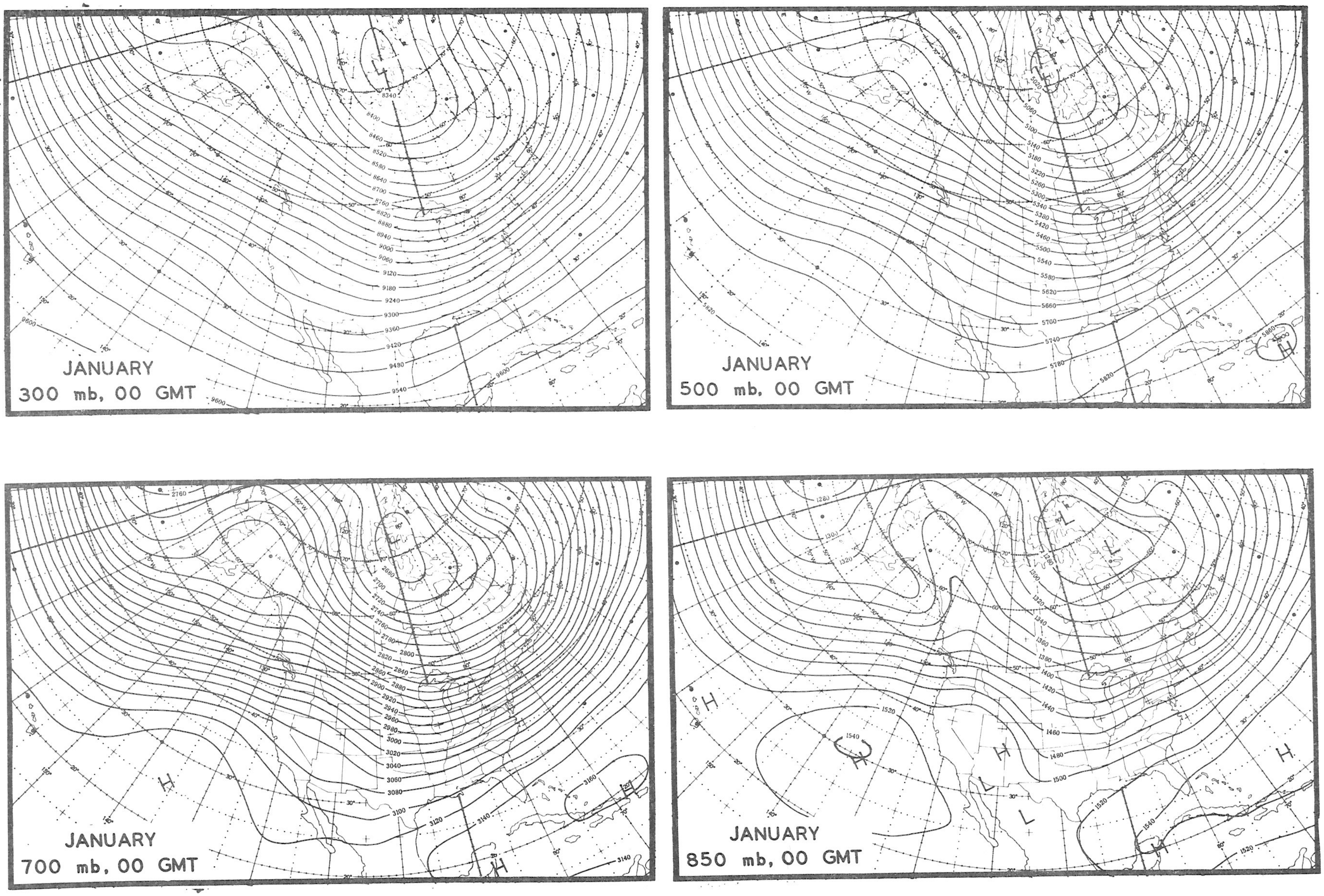


Figure 1a. -- Mean monthly heights, 0000 GMT, January

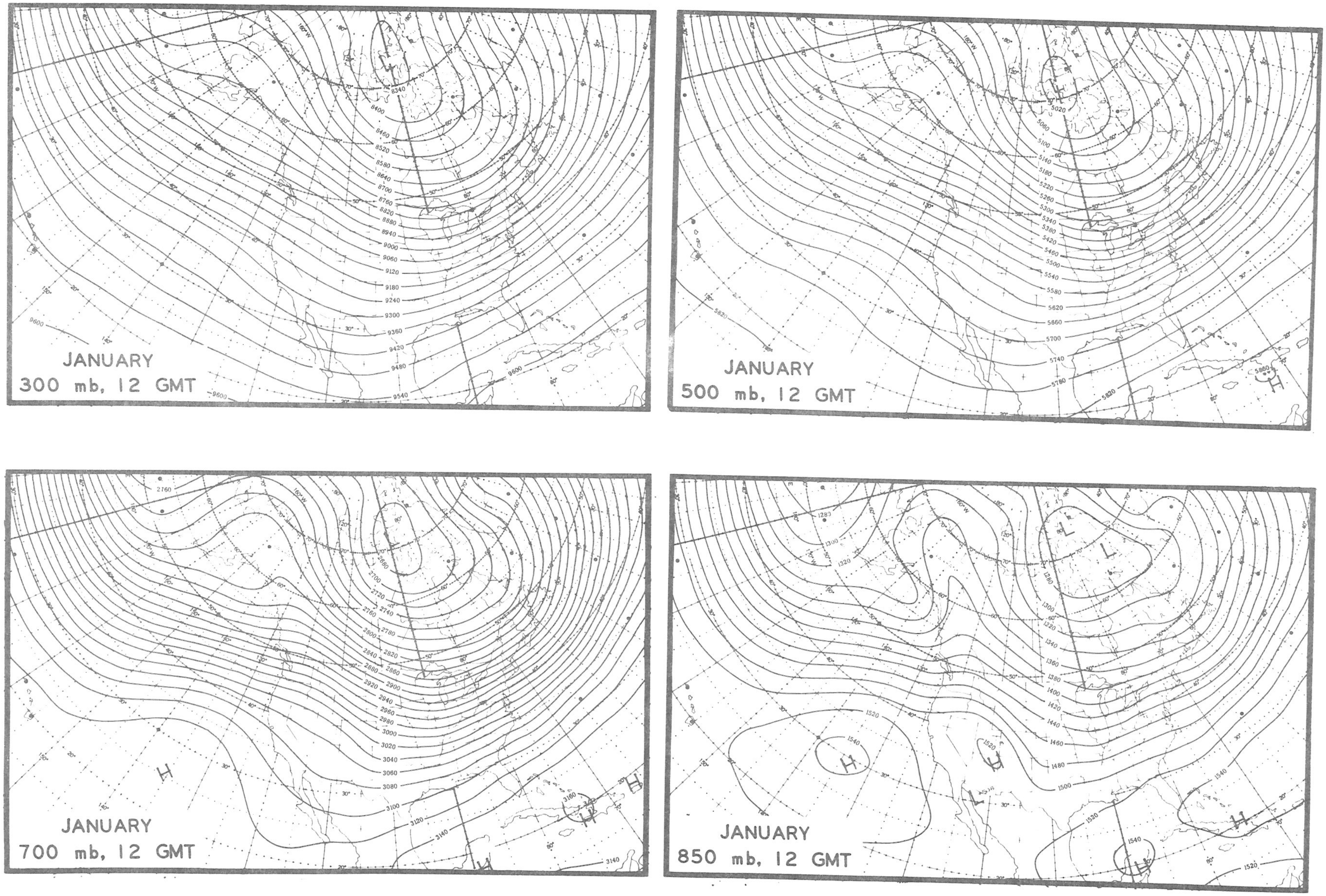


Figure 1b. -- Mean monthly heights, 1200 GMT, January

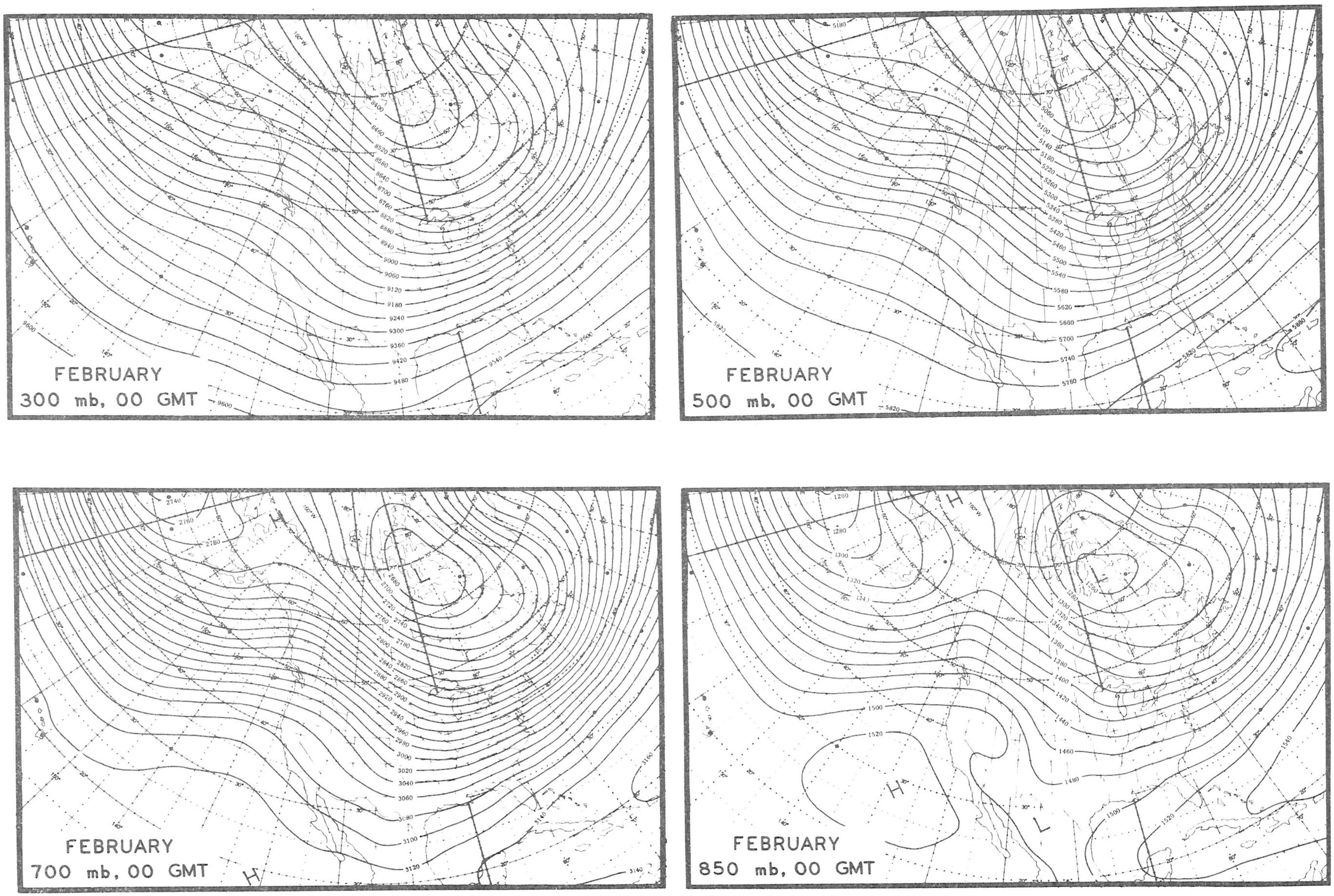


Figure 2a. -- Mean monthly heights, 0000 GMT, February

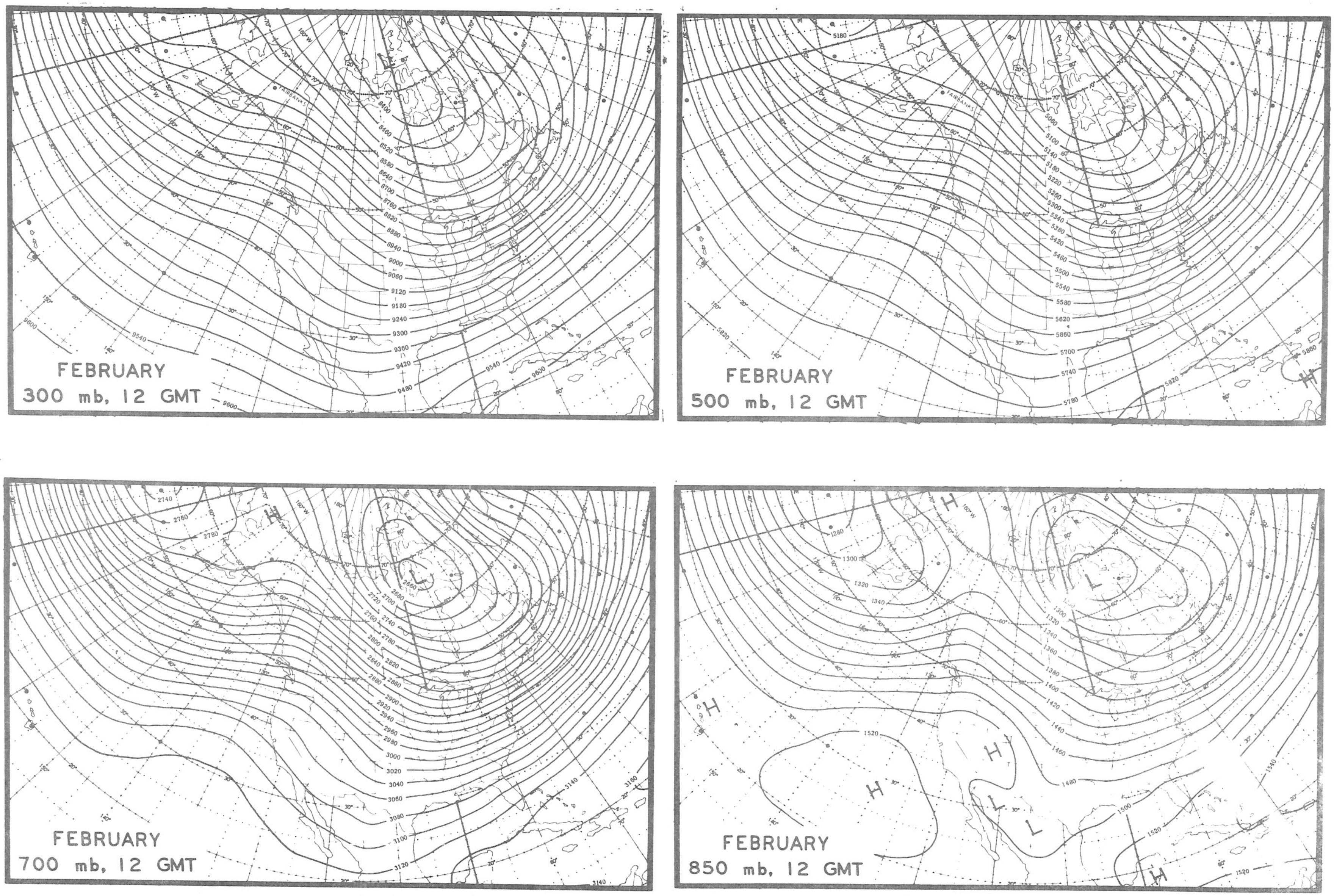


Figure 2b. -- Mean monthly heights, 1200 GMT, February

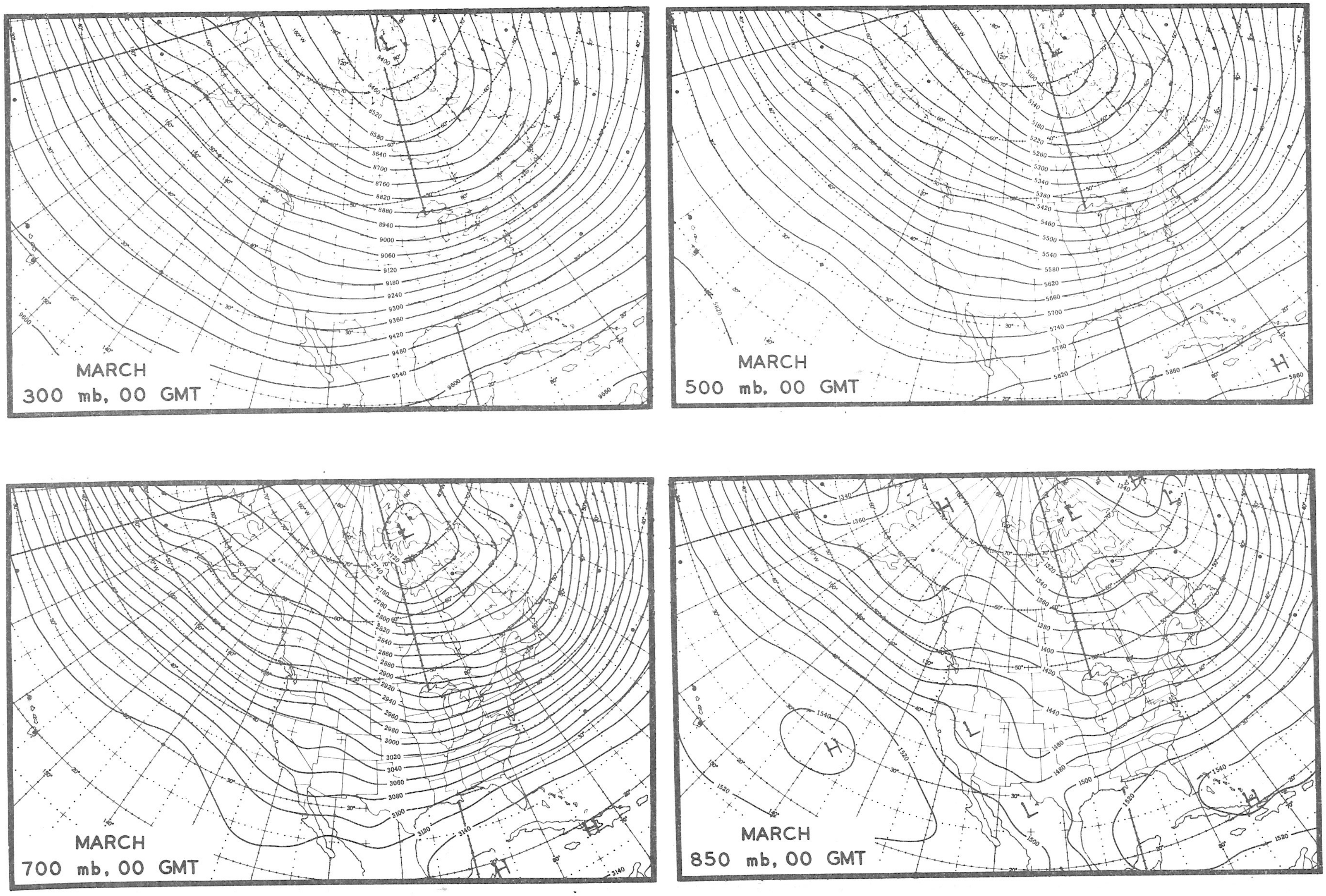


Figure 3a. -- Mean monthly heights, 0000 GMT, March

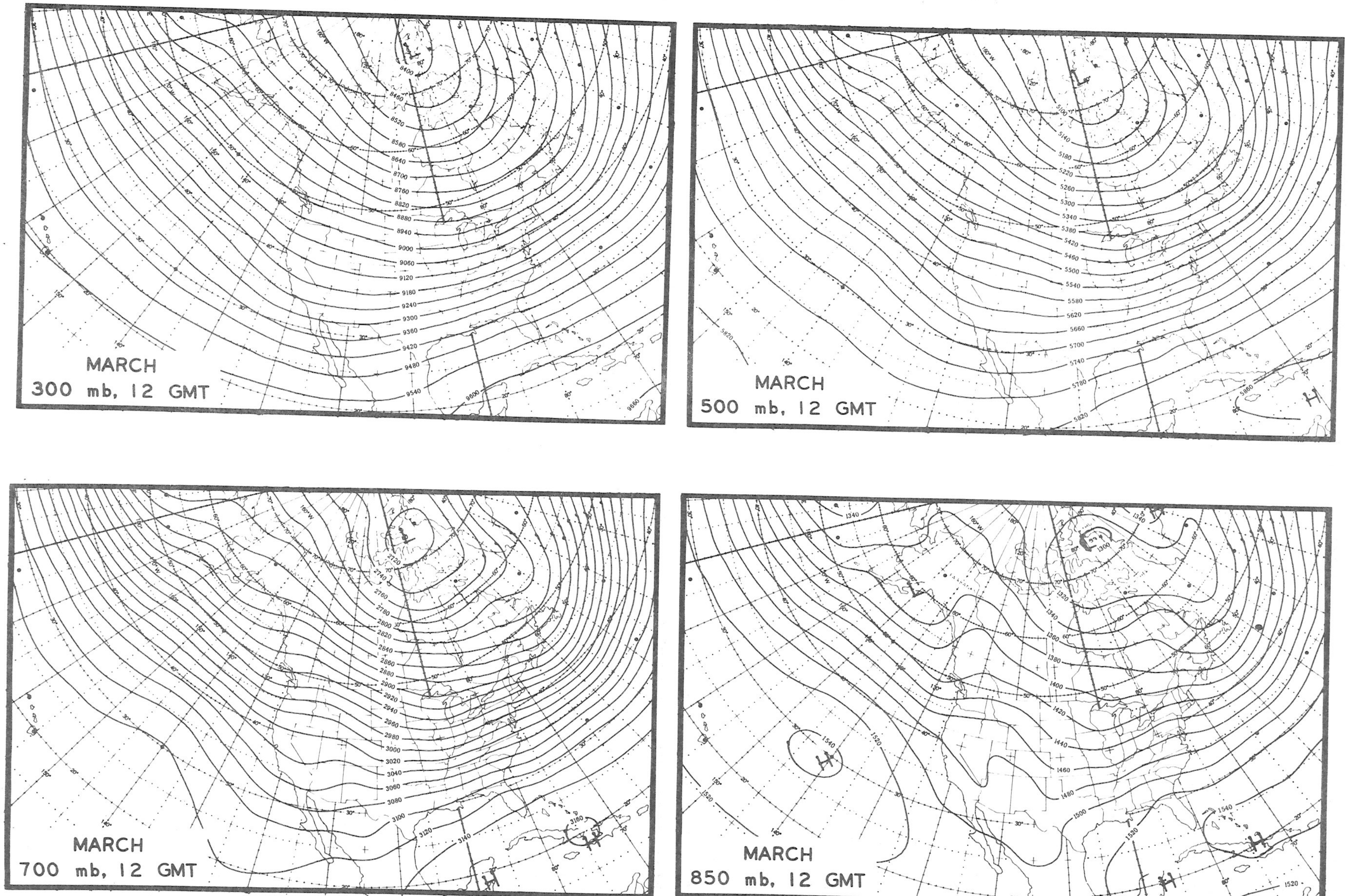


Figure 3b. -- Mean monthly heights, 1200 GMT, March

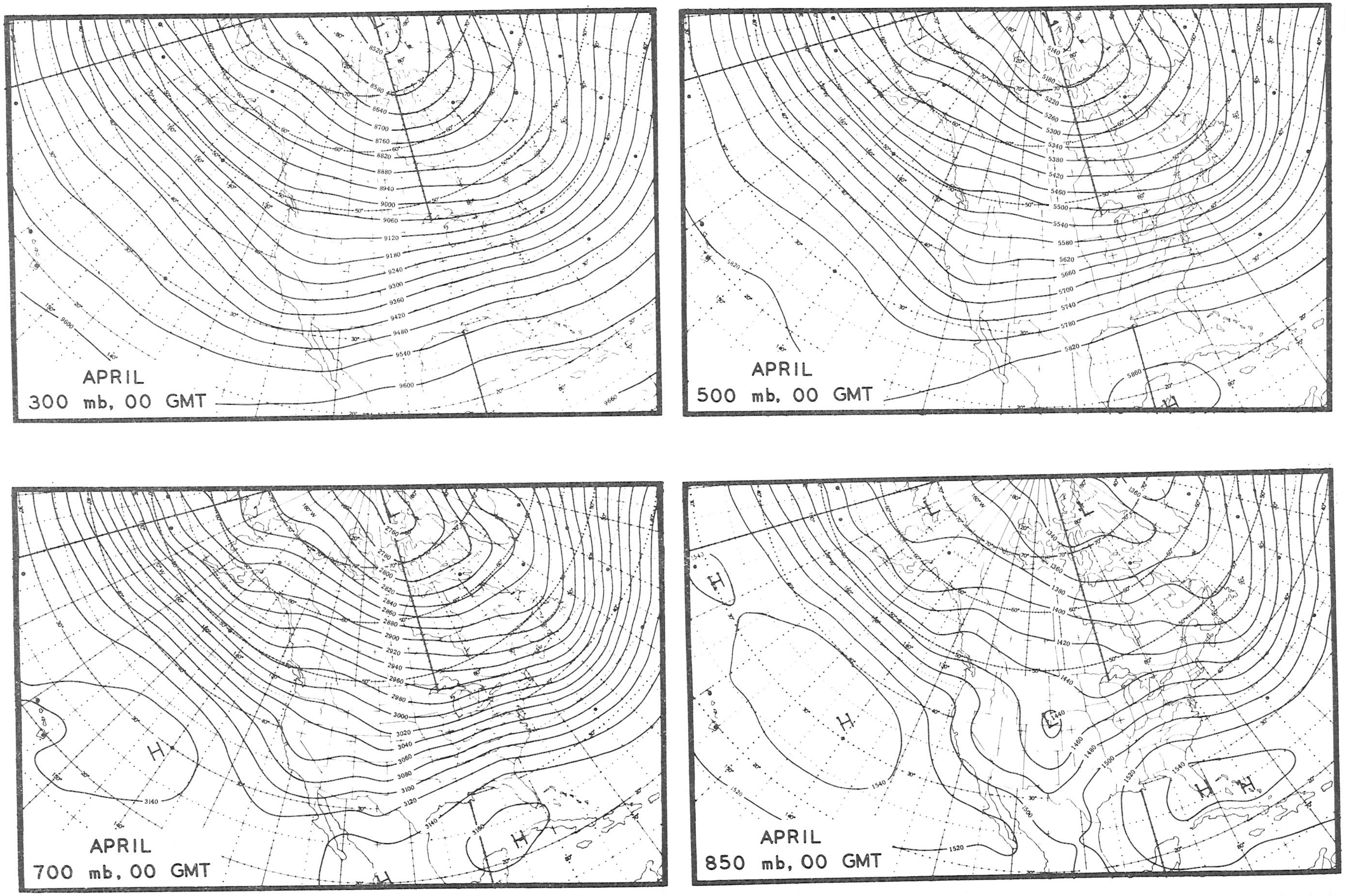


Figure 4a. -- Mean monthly heights, 0000 GMT, April

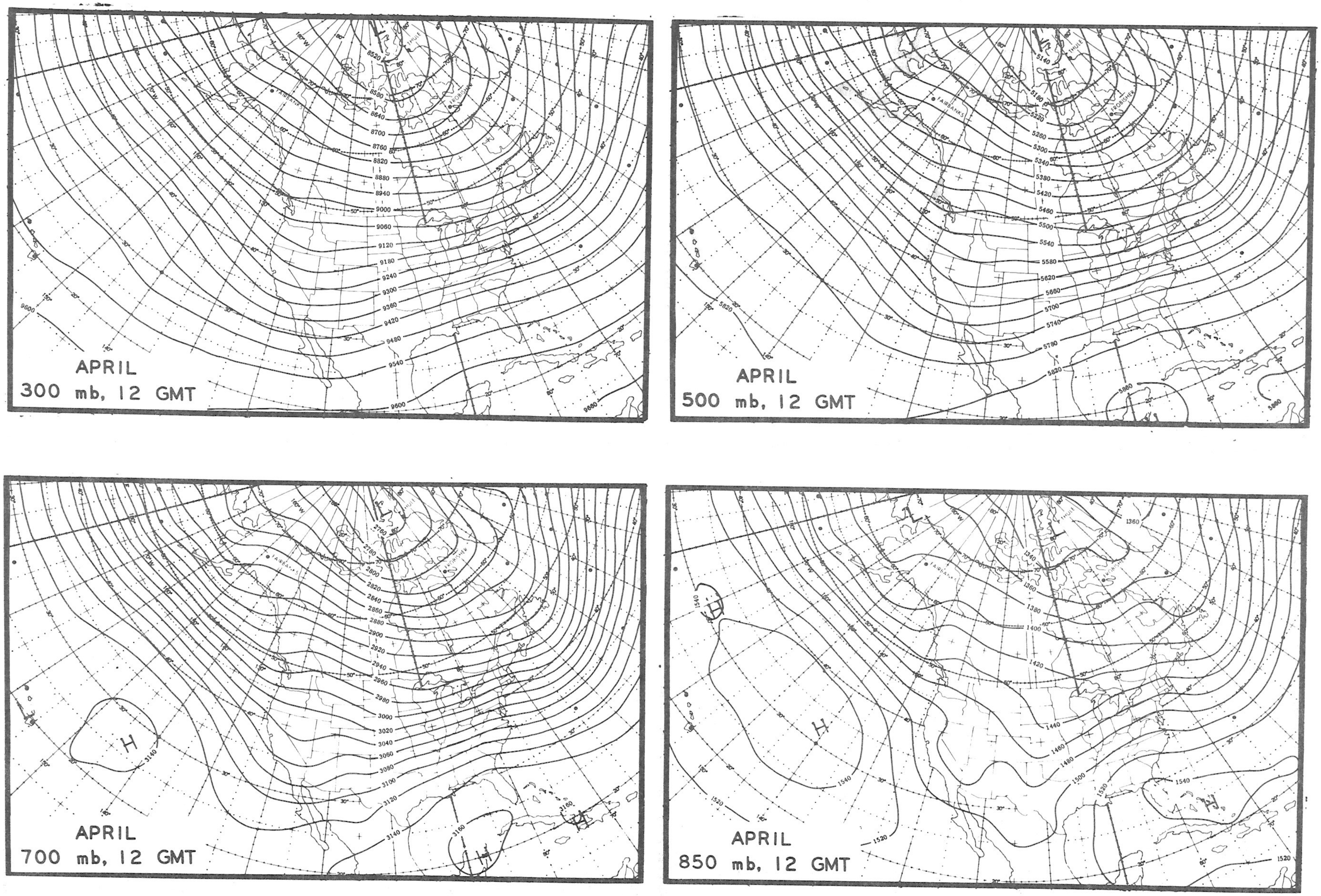


Figure 4b. -- Mean monthly heights, 1200 GMT, April

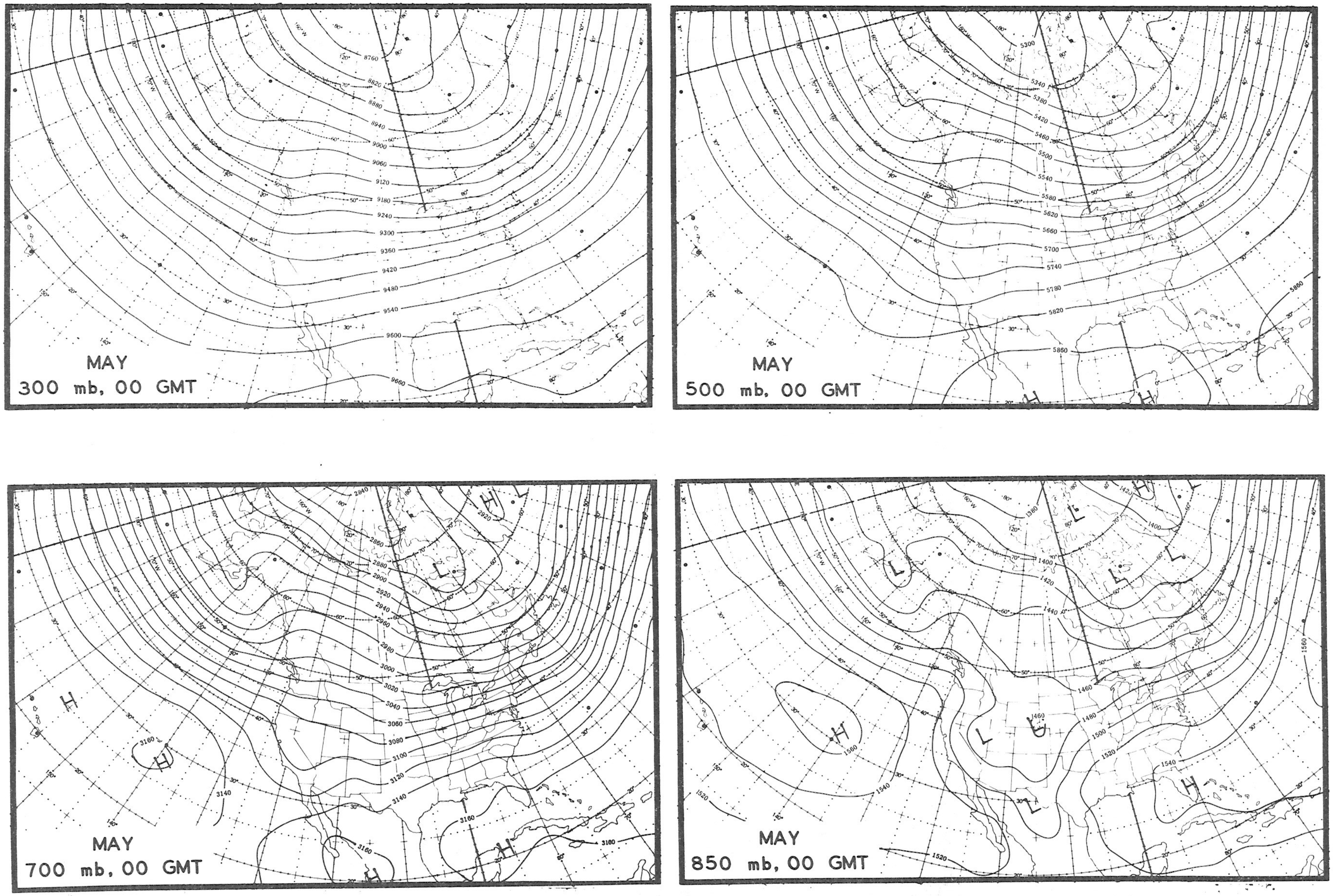


Figure 5a. -- Mean monthly heights, 0000 GMT, May

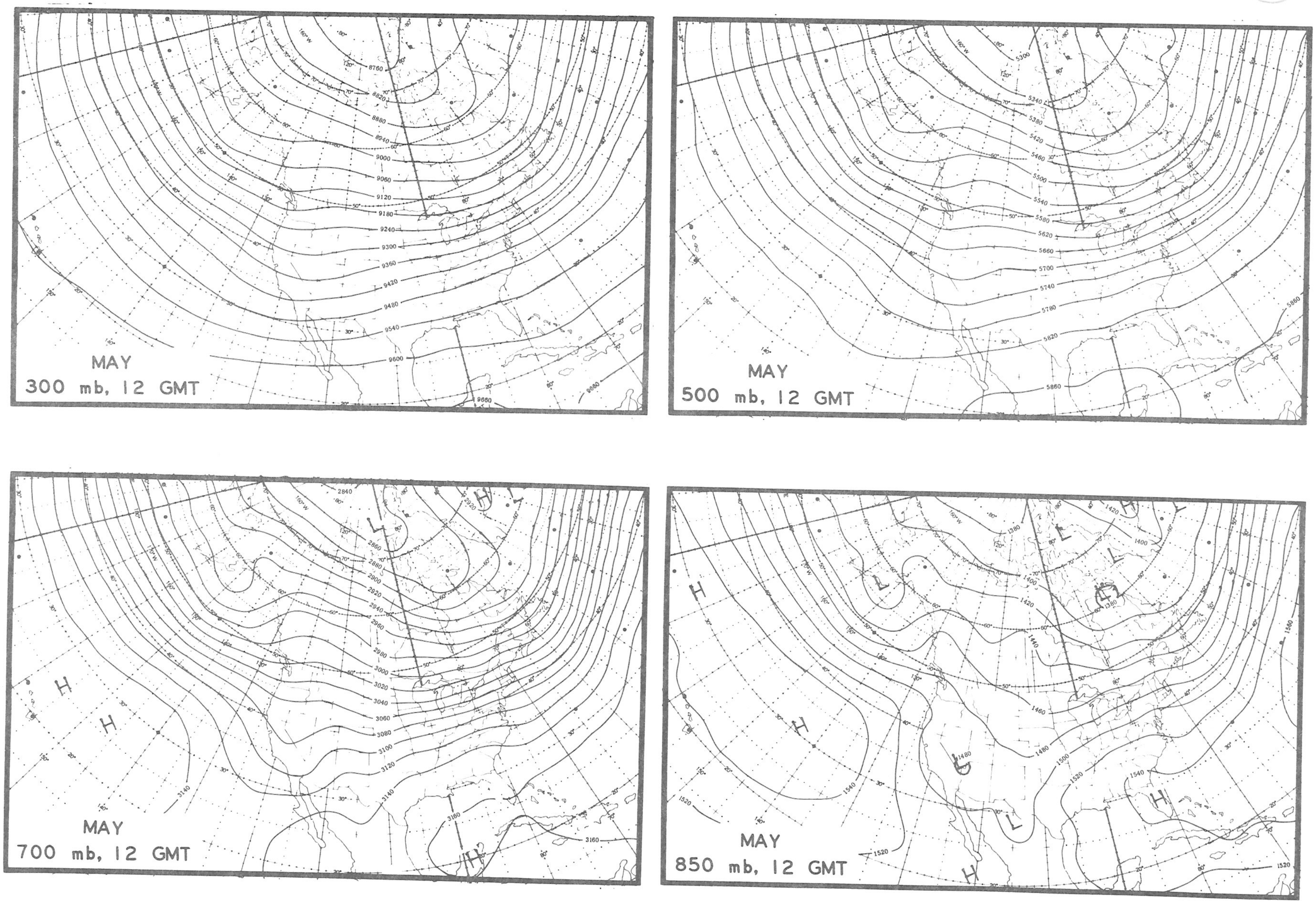


Figure 5b. -- Mean monthly heights, 1200 GMT, May

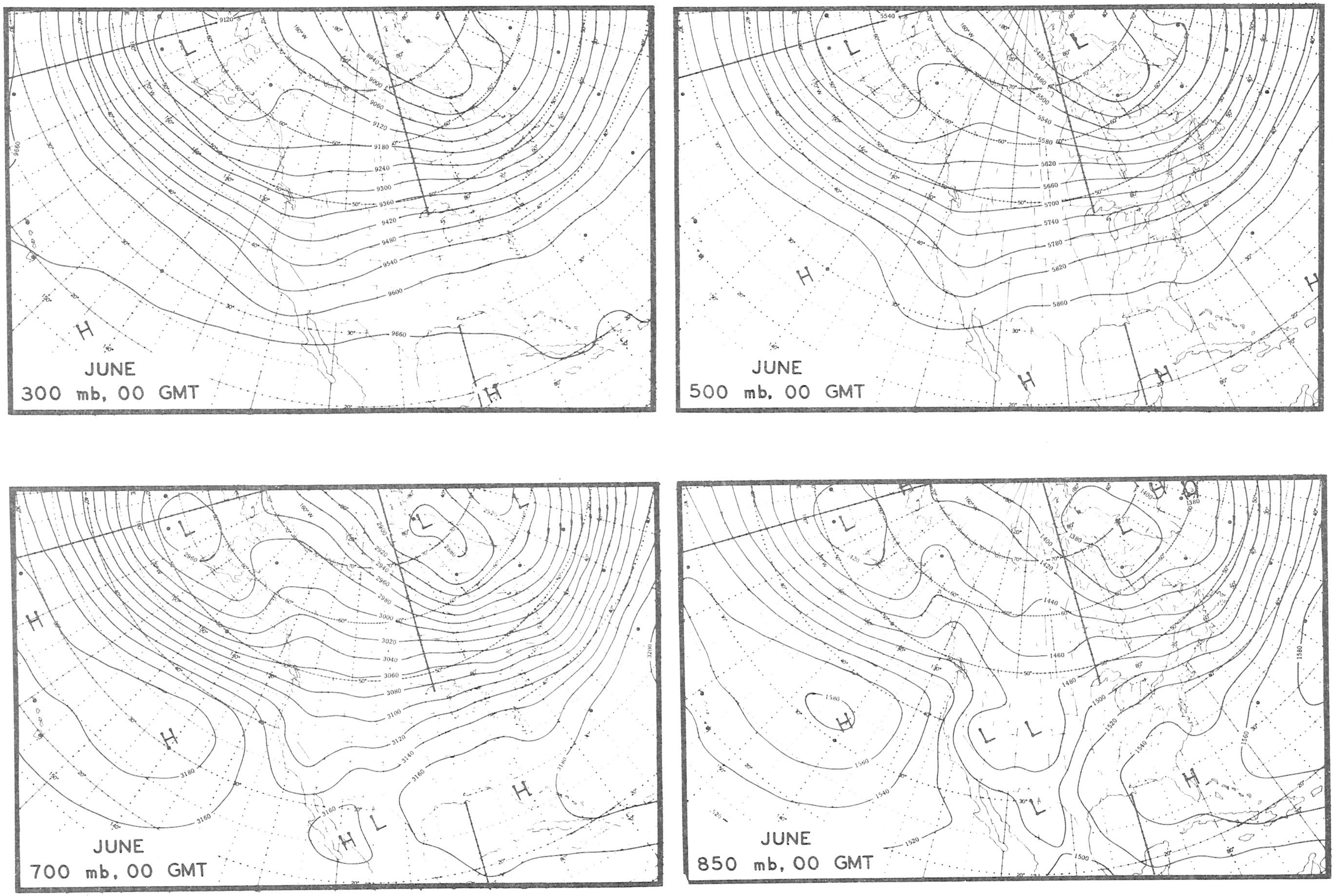


Figure 6a. -- Mean monthly heights, 0000 GMT, June

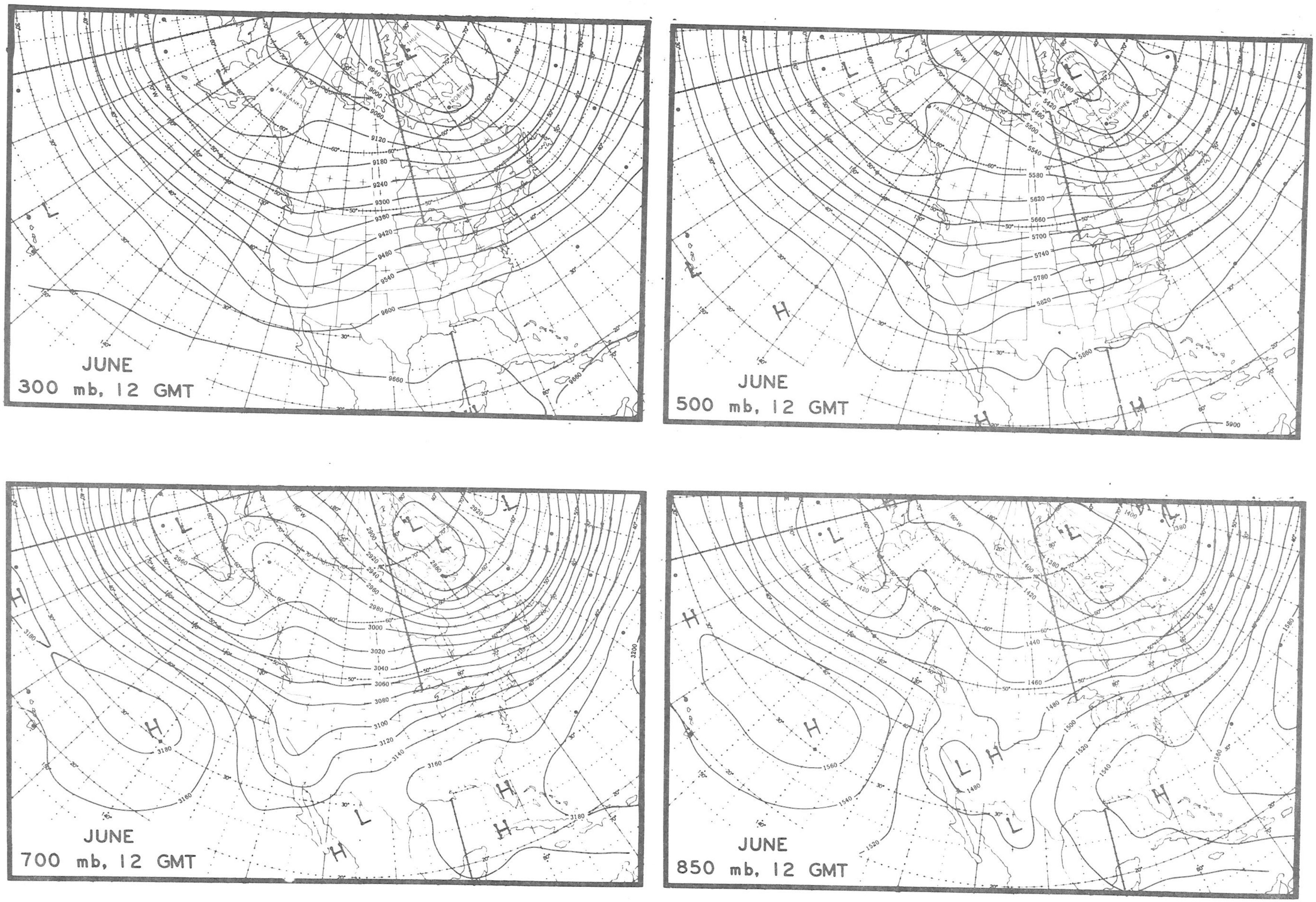


Figure 6b. -- Mean monthly heights, 1200 GMT, June

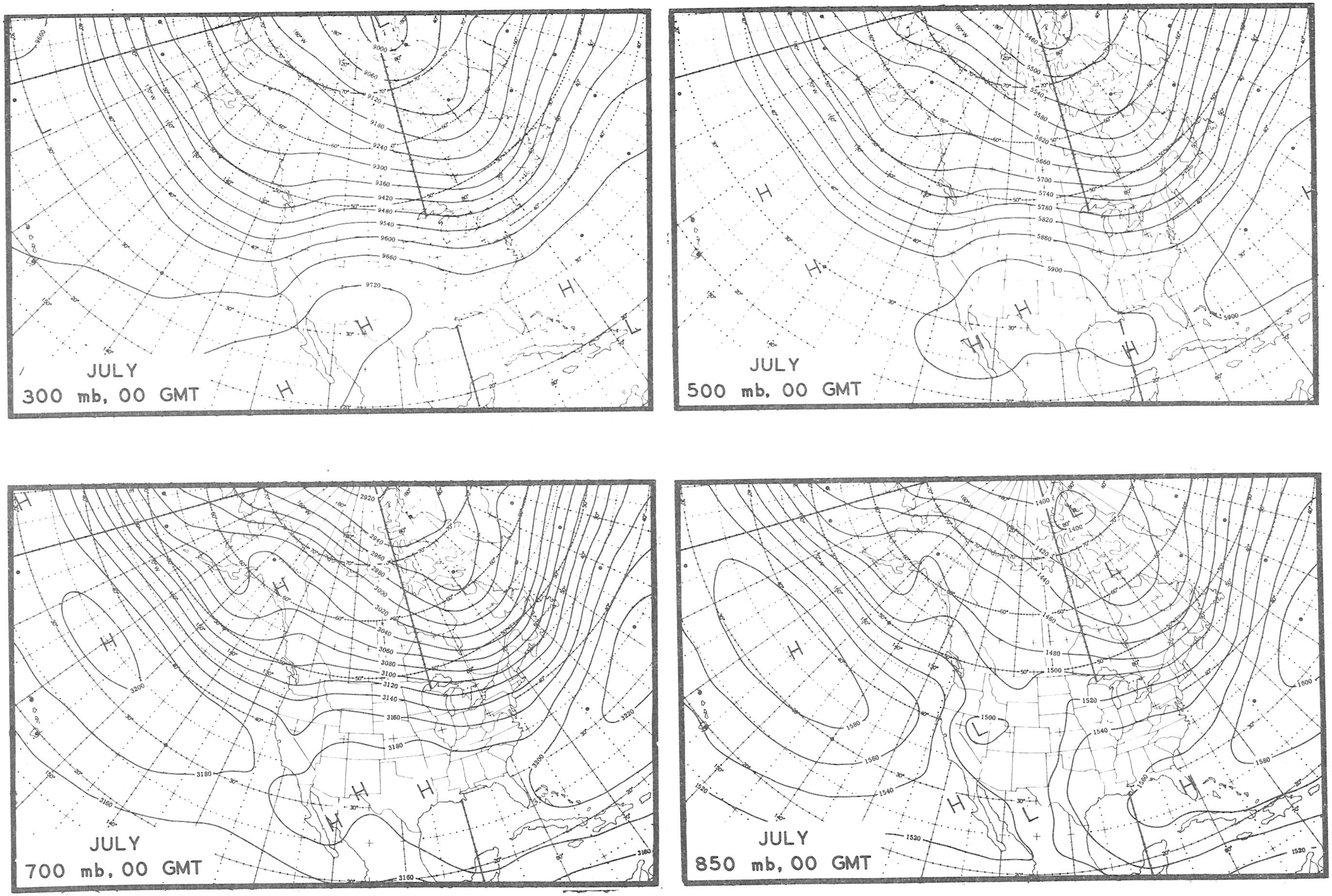


Figure 7a. -- Mean monthly heights, 0000 GMT, July

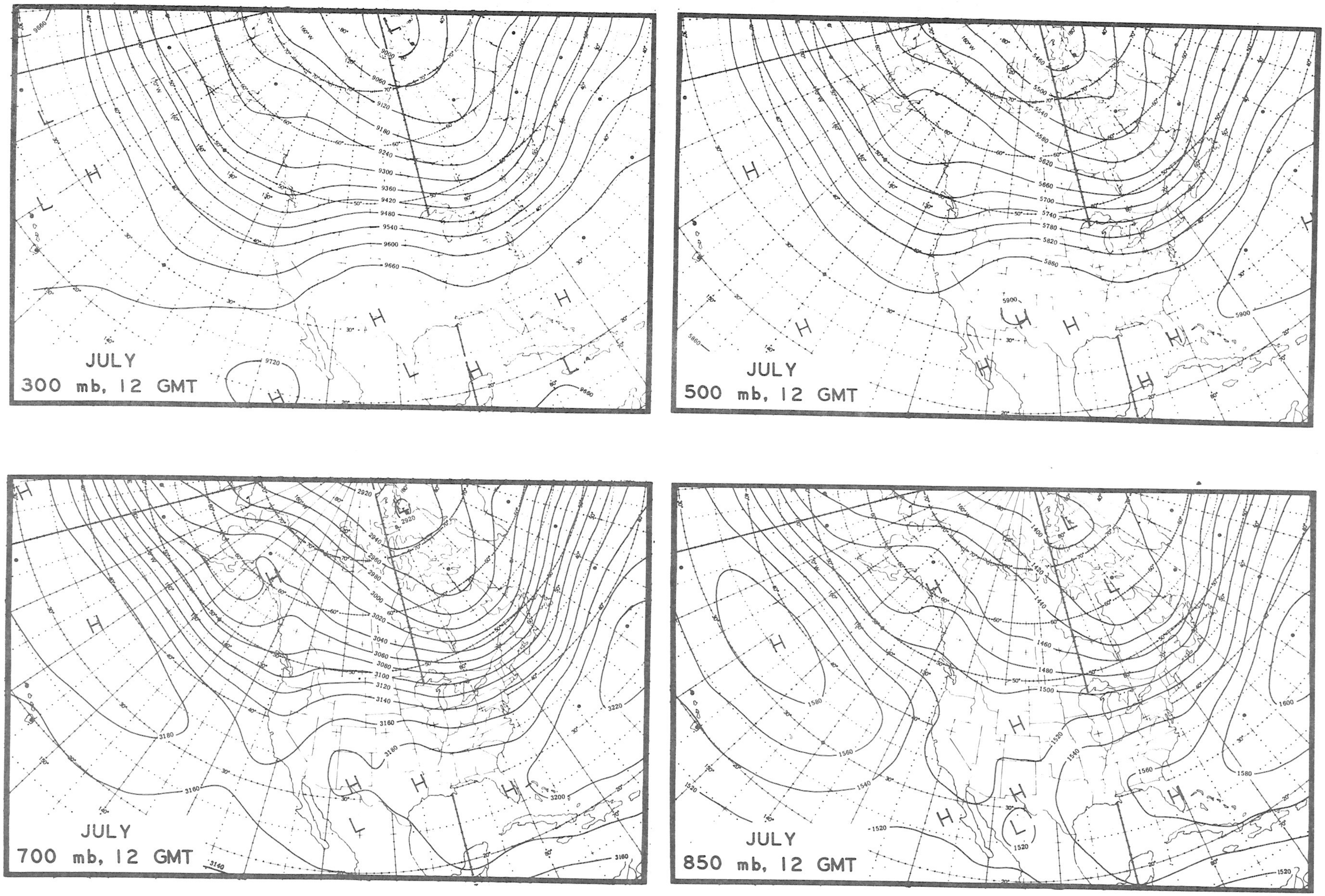


Figure 7b. -- Mean monthly heights, 1200 GMT, July

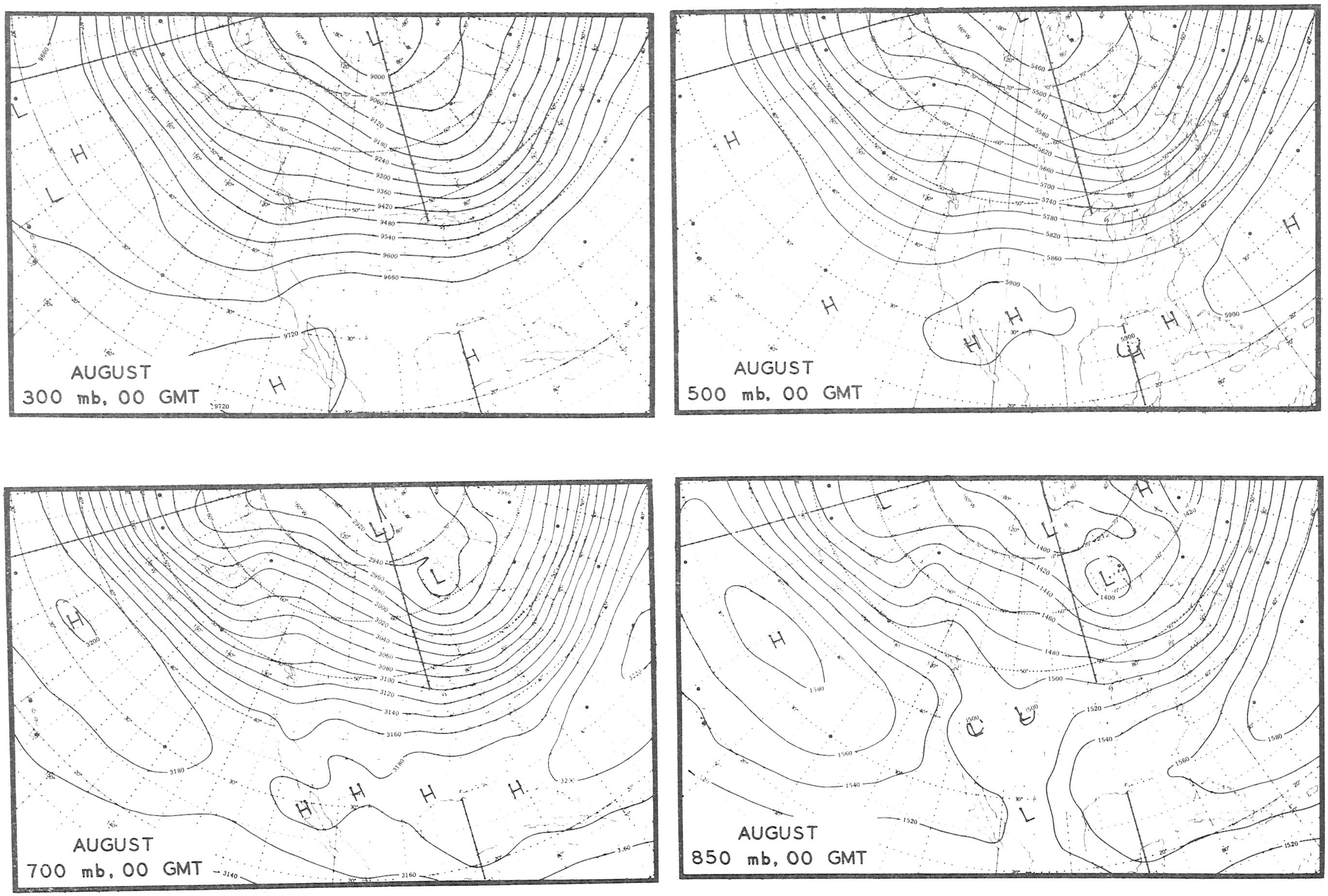


Figure 8a. -- Mean monthly heights, 0000 GMT, August

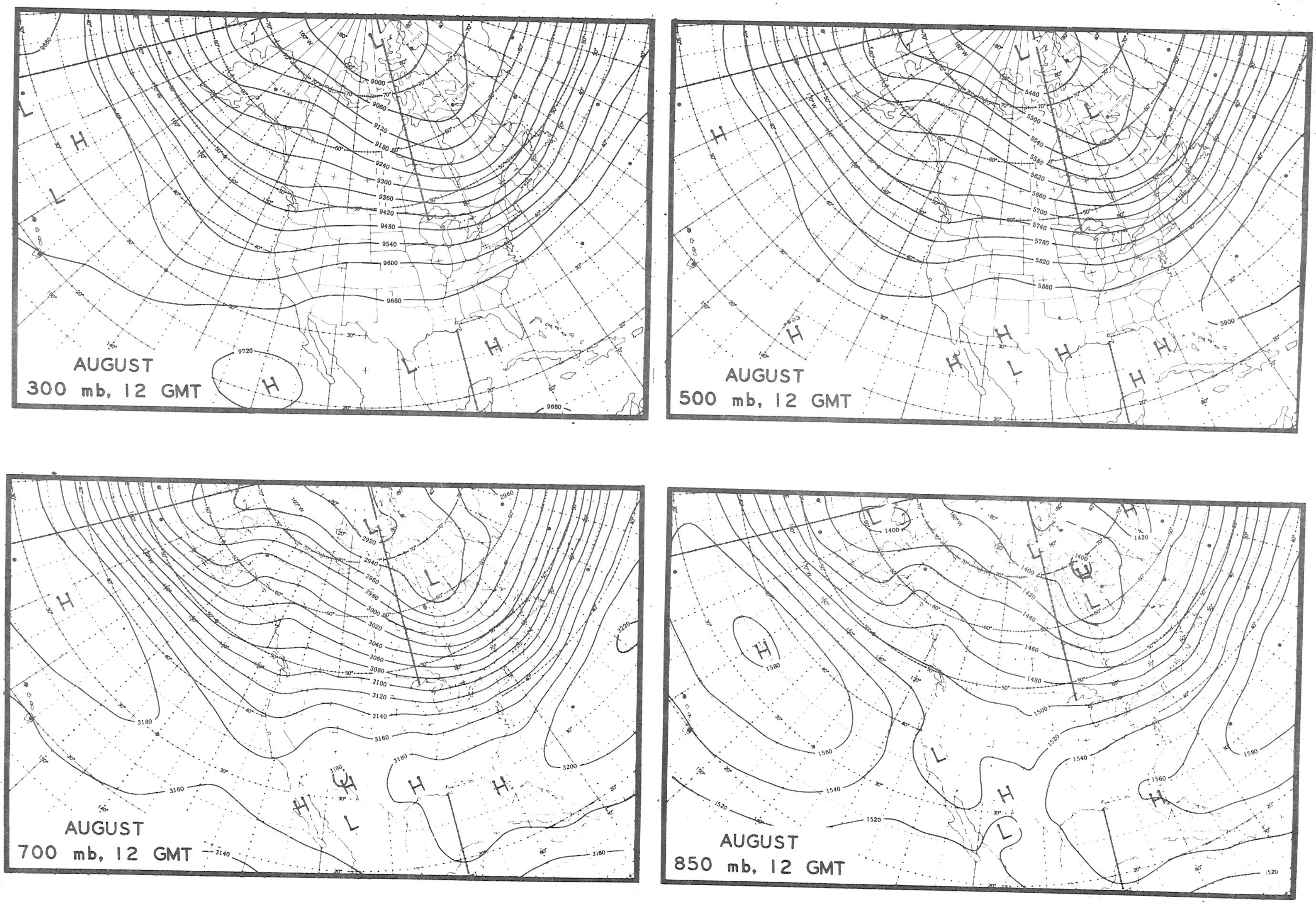


Figure 8b. -- Mean monthly heights, 1200 GMT, August

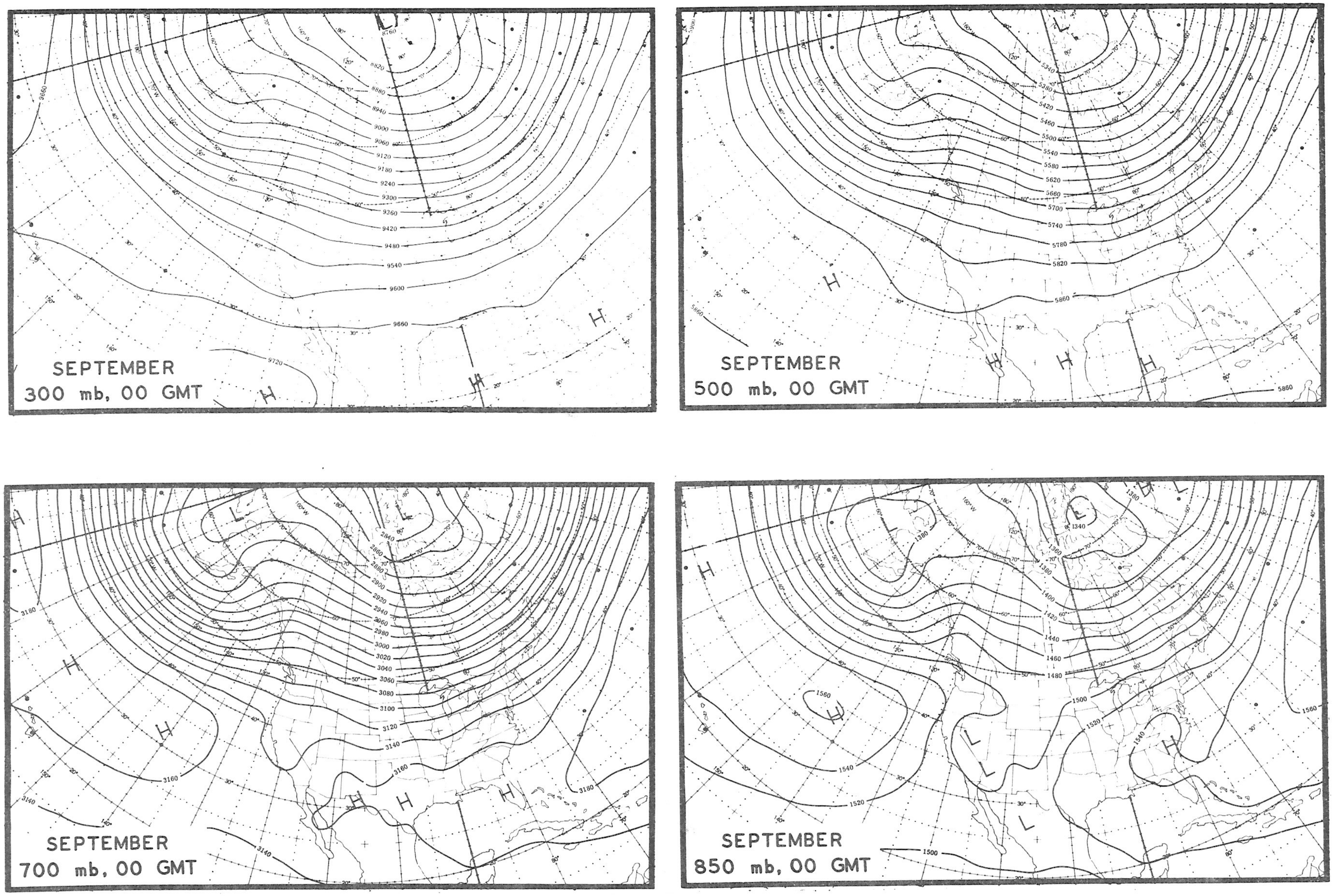


Figure 9a. -- Mean monthly heights, 0000 GMT, September

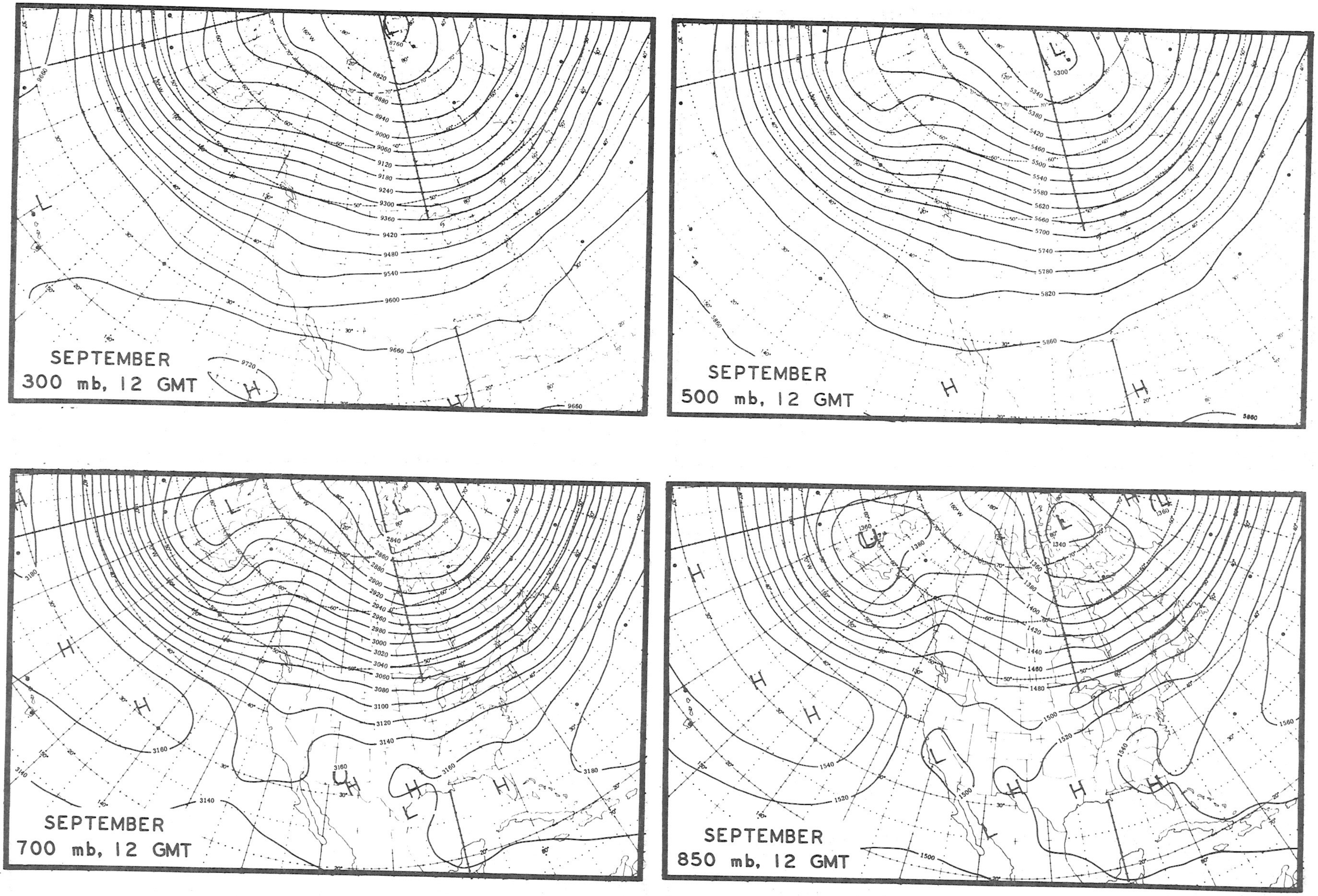


Figure 9b. -- Mean monthly heights, 1200 GMT, September

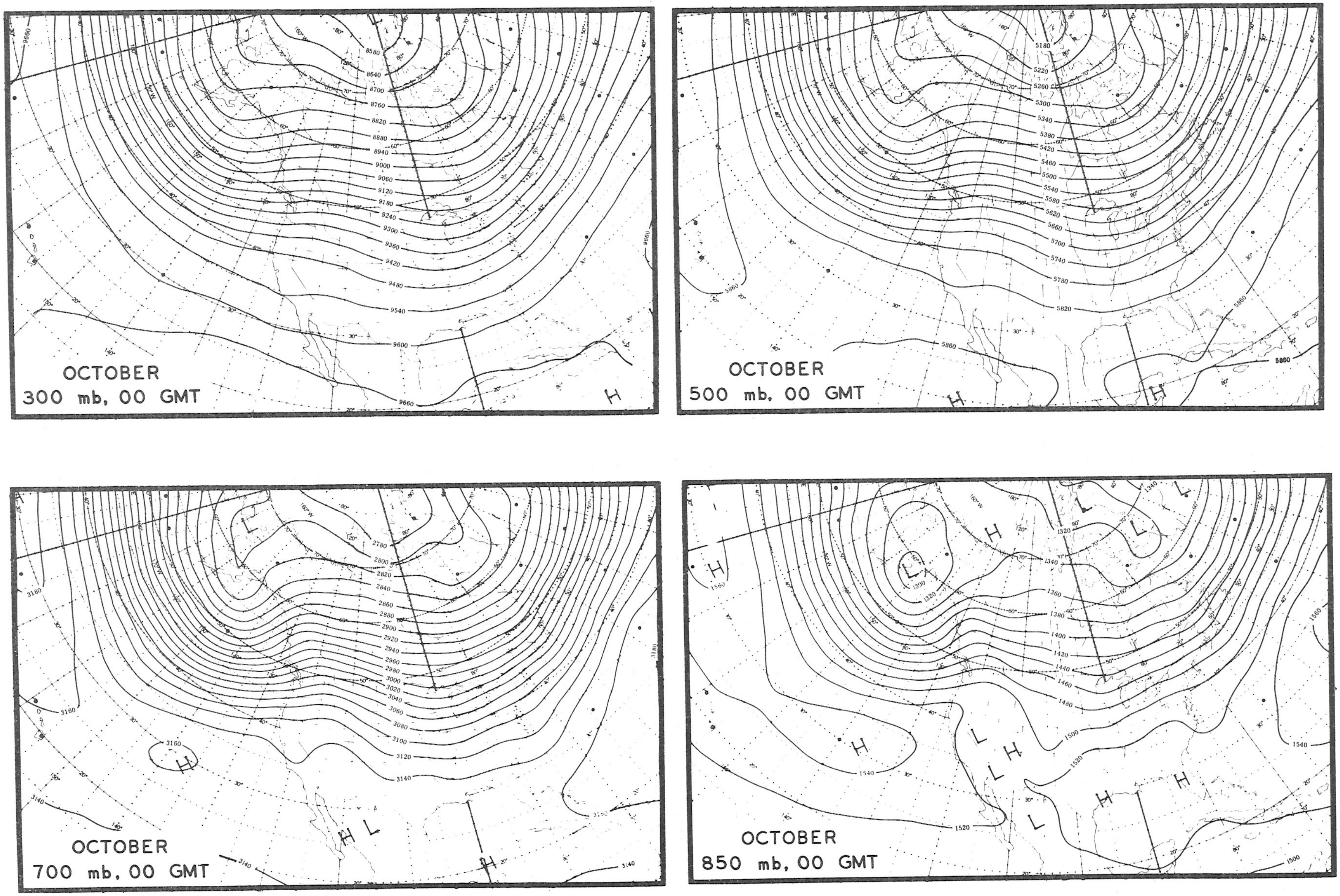


Figure 10a. -- Mean monthly heights, 0000 GMT, October

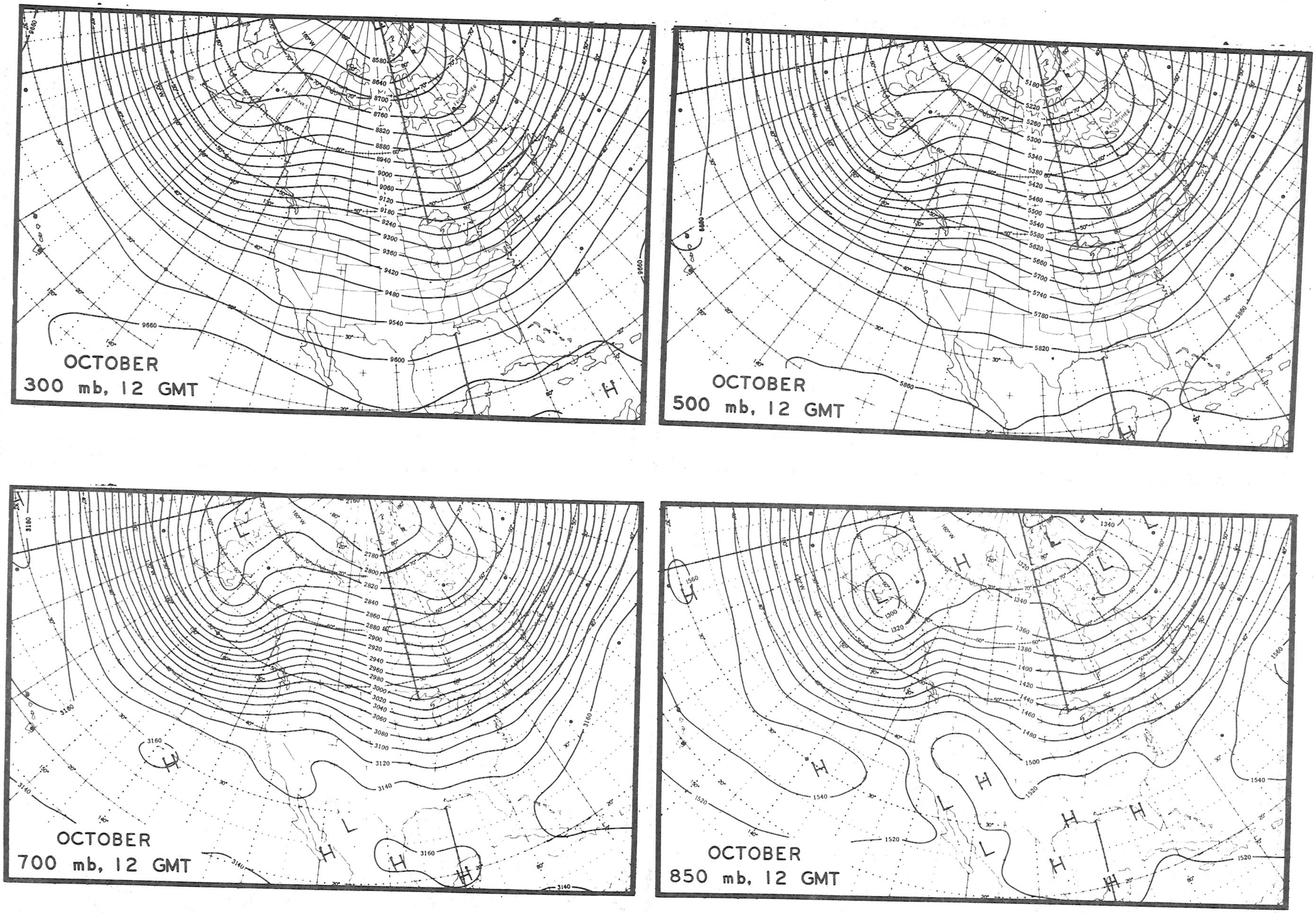


Figure 10b. -- Mean monthly heights, 1200 GMT, October

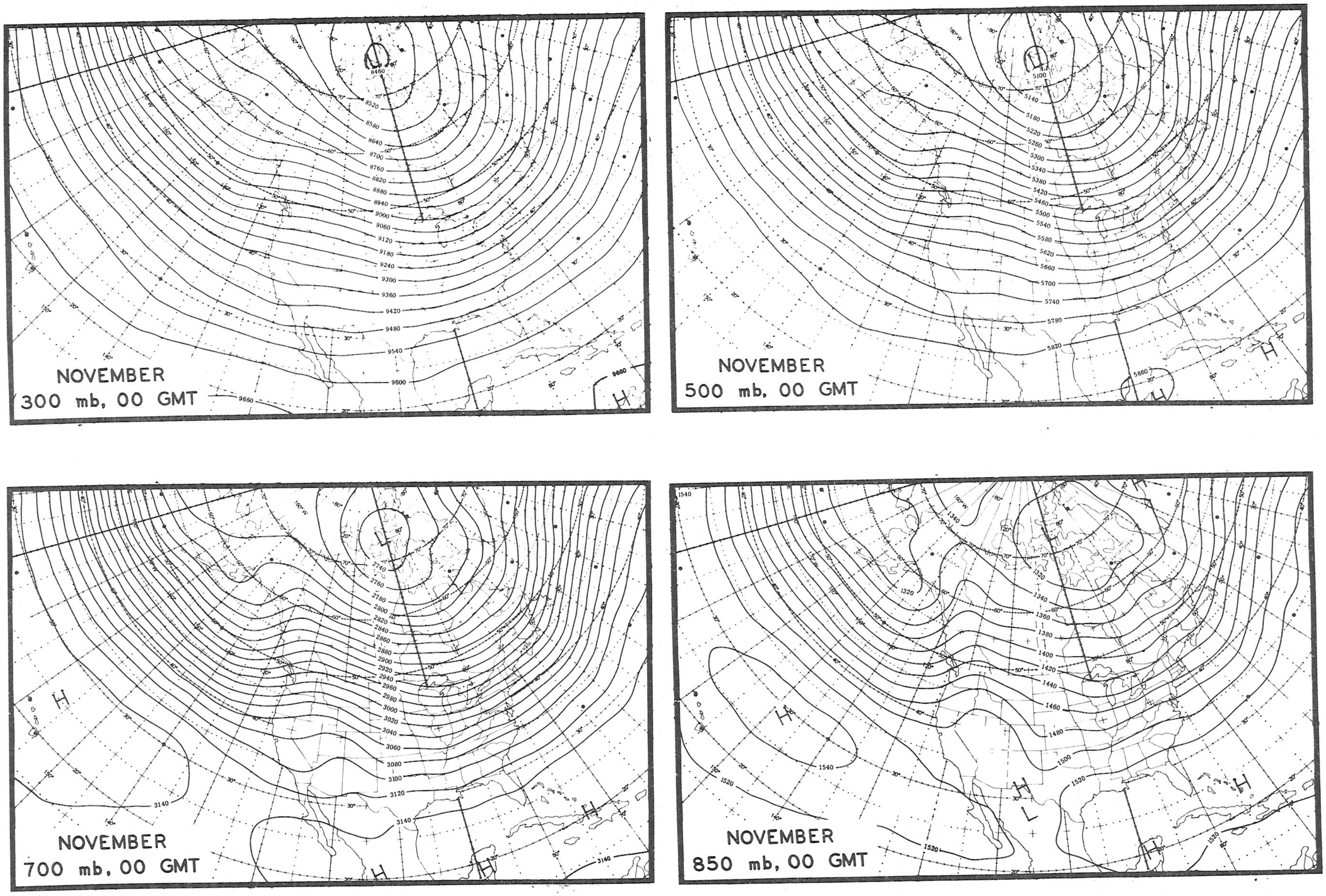


Figure 11a. -- Mean monthly heights, 0000 GMT, November

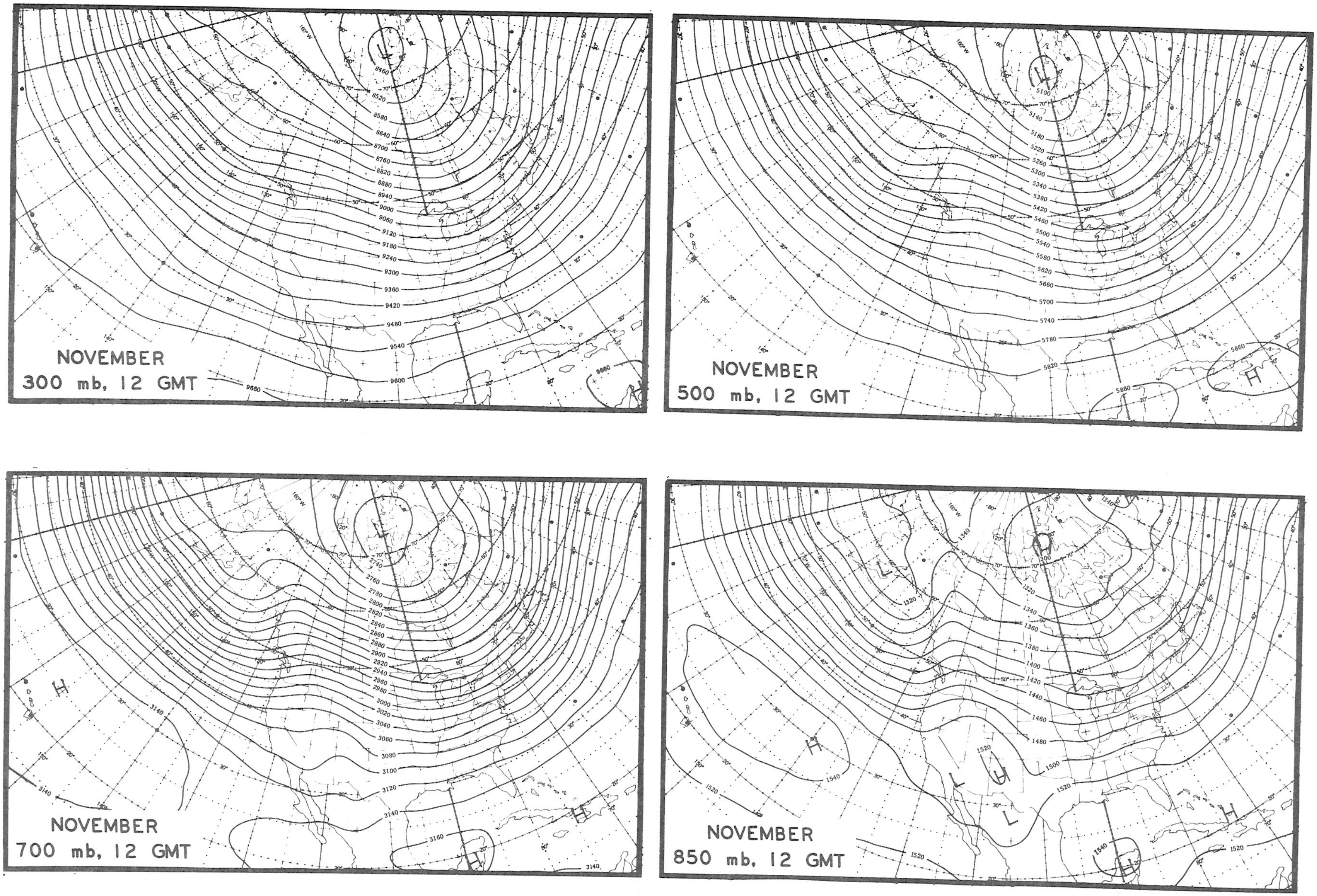


Figure 11b. -- Mean monthly heights, 1200 GMT, November

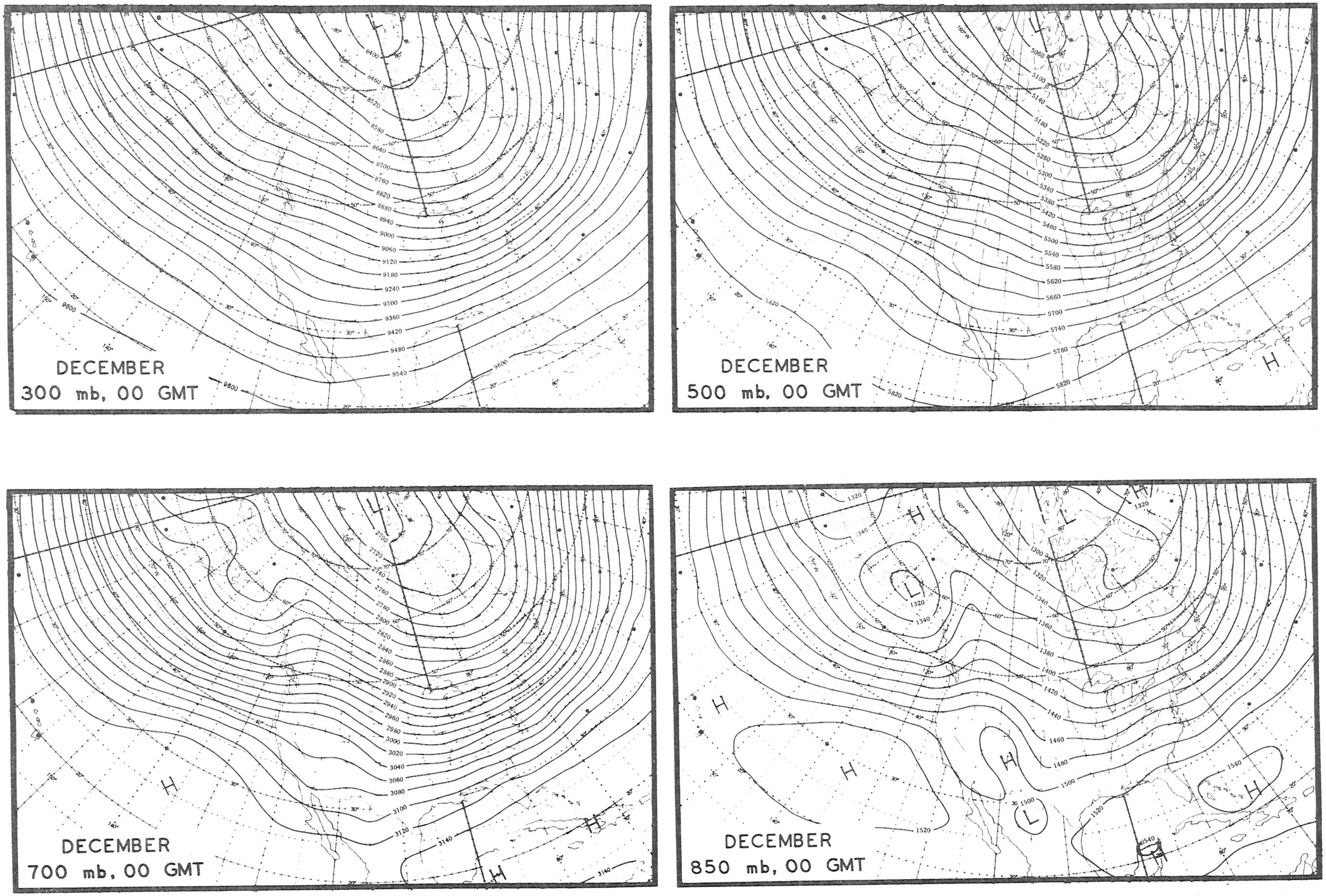


Figure 12a. -- Mean monthly heights, 0000 GMT, December

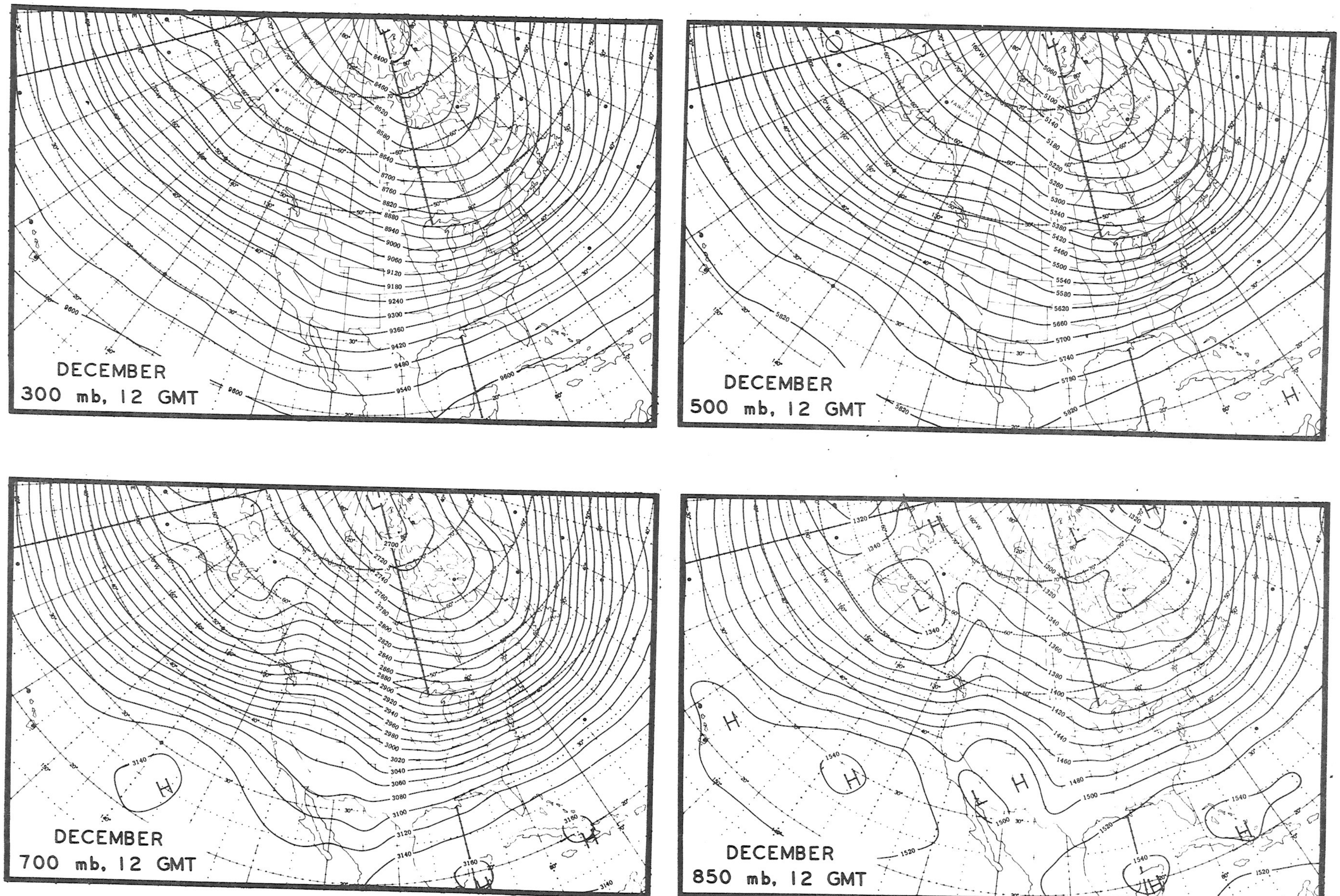


Figure 12b. -- Mean monthly heights, 1200 GMT, December

(Continued from inside front cover)

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|---|---|---|
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| WBTM | TDL 17 | Second Interim Report on Sea and Swell Forecasting. N. A. Pore and Lt. W. S. Richardson, USESSA, January 1969. (PB-182 273) |
| WBTM | TDL 18 | Conditional Probabilities of Precipitation Amounts in the Conterminous United States. Donald L. Jorgensen, William H. Klein, and Charles F. Roberts, March 1969. (PB-183 144) |
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