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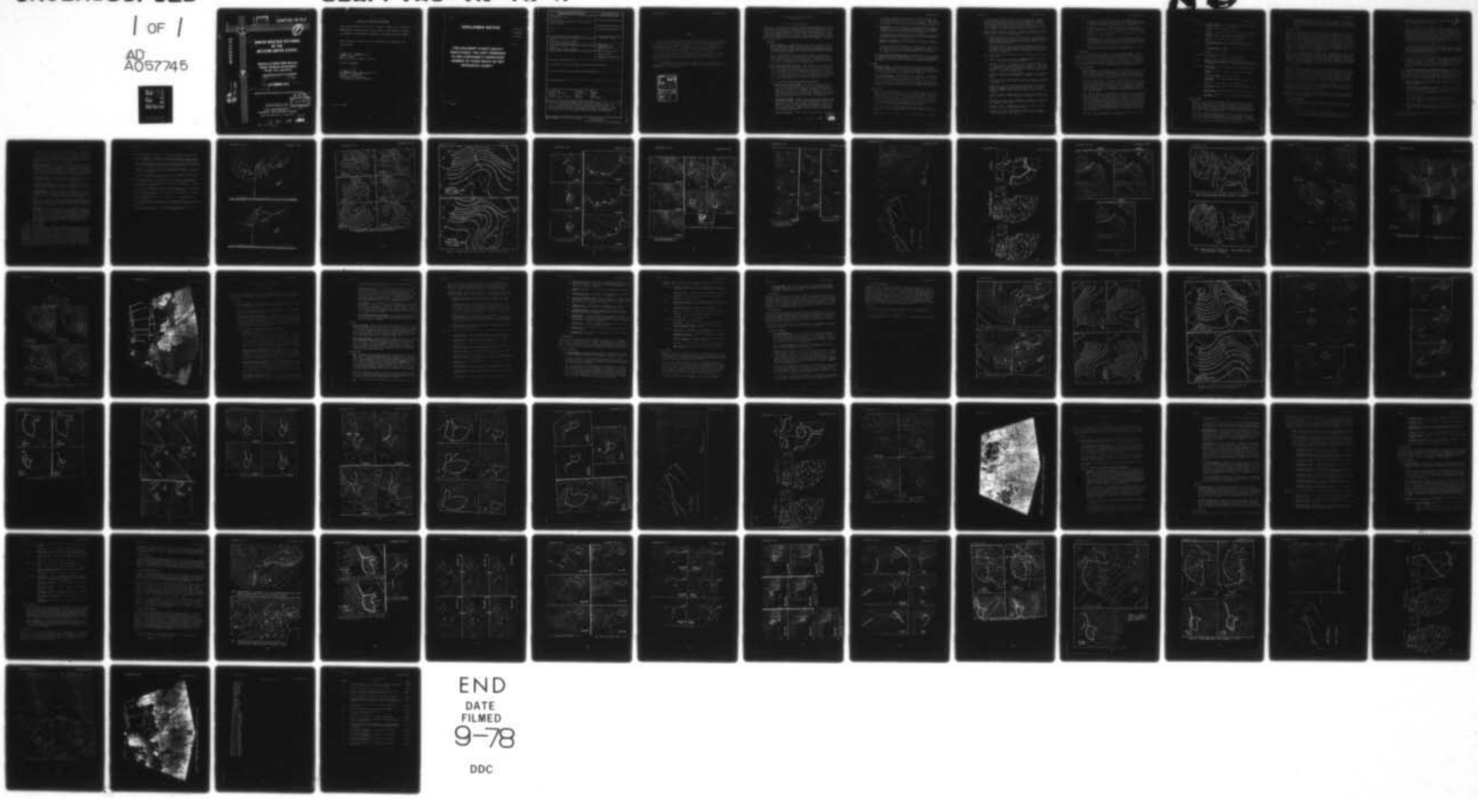

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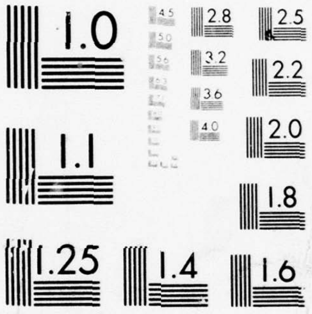

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(6) WINTER WEATHER PATTERNS OF THE WESTERN UNITED STATES.

(Reprints of NOAA/NWS Western Region Technical Attachments 73-42, 74-1, and 74-3)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Reprints of Western Region Technical Attachments 73-42, 74-1, and 74-3 are compiled to furnish an excellent climatic guide to winter weather patterns over the western United States. The data covers the months of December, January, and February and concerns most of the normally-observed weather parameters.

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PREFACE

These excellent NOAA Western Region Technical Attachments have been reprinted with permission. AWS detachments located within the western portion of the United States should find these reports useful and it is for them that USAFETAC has published this Technical Note. Distribution has been limited to AWS wing and squadron headquarters and AWS detachments in the western United States.

Every effort has been made to reproduce the figures as clearly as possible. However, the original figures were not generally of good enough quality to read them in detail. The figures should, however, indicate general synoptic and upper-air patterns.

This technical note is the last one of a series that covers weather in the four seasons in the western United States. Additional copies can be obtained from USAFETAC/CBT, Scott AFB, IL 62225.

WESTERN REGION TECHNICAL ATTACHMENT
November 27, 1973
No. 73-42

DECEMBER WEATHER PATTERNS

December is the month when Mother Nature pulls out all the meteorological stops. In some ways, it is easier on forecasters than November because there is not too much difference from the type of weather regimes that have been handled in November, especially the latter half of that month. Also, because of the frequency of severe weather conditions in December, there are more objective studies available for guidance [1] [2] [3] [4] [5]. One of the major forecast problems is that there are more frequent significant disagreements between the barotropic and 6-layer 500-mb prognoses, and it must be decided what weight to give each of them on a given day.

1. Upper Air

a) Normal Patterns: The normal December 500-mb flow is given in Figure 1. There is very little change over the eastern Pacific and western United States. The biggest change is along the coast of Asia, where the cold-air production in Siberia results in a strengthening and more southerly position of the jet stream. This results in the westerlies being more eccentric than in November.

The 24-hour variability of 500-mb heights (Figure 2) shows that the changes from November to December are small. Actually, there is a decrease in the mean over western America. This is probably associated with long-wave patterns being more stationary in December than November. The increase of persistence of a surface high over the Great Basin also is related to less variability of the westerlies.

b) Predominant Circulation Types [6]: Type 1 (zonal) (see Figure 3) is the most frequent with 123 occurrences in December out of 356 total winter cases. The strong meridional types of 2, 4, 11, 13, and 19 occur most often in December. Note that the strongest troughs occur over land. Cut-off-low types were observed infrequently in December. Out of the 26 cases of cut-off-low types (i.e., types #21 through 25), there were only 4 cases in December (see Figure 4). Flow patterns with weak closed lows over California and Arizona can be correlated highly with Type #5 (Figure 4). Note that this type also occurred infrequently in December (i.e., 9 out of 52 cases).

c) Specific Examples of Significant December Developments:

(1) Negative-Tilt Difluent Troughs. The negative tilted trough (i.e., NW to SE trough line) that is difluent (i.e., stronger winds upstream than downstream from trough line) usually develops rapidly and often is associated with long-wave retrogression regimes. December 29-31, 1959, is a good example (see Figure 5). The 29th shows precedent conditions. By the 30th, the trough entering North America is negatively tilted and difluent. The subsequent development retrograded the long-wave trough from the Midwest to the western United States.

(2) Dispersion of Energy. Years ago Rossby showed that a sudden release of potential to kinetic energy is dispersed downstream about twice the zonal wind speed. Thus a sudden deepening of a trough is followed in 24 to 36 hours with a rapid intensification of the next downstream trough. A not-too-spectacular example is given in Figure 6. From the 24th to 25th of December, 1958, the trough near 155E deepened strongly. Twenty-four hours later, the downstream trough deepened near 140°W.

(3) Heavy Rain Patterns. Flooding rains on the West Coast often occur

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in December. They are associated with persistent southwest flow that extends westward 20 to 30 degrees longitude. An example is the northern California flood of 1955 (see Figure 7). The two main criteria are persistence of a long fetch of southwest flow, and good thermal gradient (i.e., quasi-stationary ENE-WSW frontal zone).

(4) Heavy Snows. Deep, sharp upper troughs near the coast are associated with heavy snows in coastal and inland states. The regime of December 16 to 18, 1970 (see Figure 8), resulted in heavy snows in the Great Basin. Note precipitation area in Figure 8.

Heavy snows in Arizona and southern Nevada and Utah are associated with slow-moving closed lows at 500 mb. The record snow case of December 7-9, 1971, is given in Figure 9.

(5) Arctic Air Outbreaks. In Montana Arctic air can move southward in spite of strong southwesterly flow aloft. See Figure 10 as an example.

Ice storms and Arctic air intrusions into the Pacific Northwest are associated with closed lows that move southward from Canada. An especially severe ice-and-snow storm occurred over Washington, Oregon, Idaho, and Montana during the December 26-28, 1968, period (see Figure 11).

d) PE Model 36-hour 500-mb Height Errors: Because NMC is planning to change the boundary area of the 6-layer model from the octagon configuration to the equator, no error charts are presented. It is quite possible this boundary area change will result in new 500-mb height error patterns in the Pacific.

2. Surface

a) Cyclonic Activity: December is a month of maximum cyclonic activity in the Gulf of Alaska; more lows are found here than in any other part of the Northern Hemisphere. The principal storm tracks (Figure 12) continue to be displaced southward. In December (and January) storm tracks enter the West Coast near the United States/Canadian border.

b) Anticyclonic Activity: A major feature is the continued intensification of anticyclonic activity over the Great Basin (Figure 13). The number of highs in this area reaches a maximum in December. The track of the North Pacific highs into western United States lowers to about 40°N or northern California. The frequent intrusion of Arctic and Polar highs into the Great Plains and portions of the Intermountain Area continues. Overall, the surface sea-level pressure patterns show little change from November.

3. Precipitation

a) Rain: In December, the rainy season is fully developed over the Pacific Northwest and California (Figure 14). Precipitation reaches its maximum monthly amounts in Washington and some locations in Oregon. Monthly amounts of 15-20 inches in 25 rainy days are common over the coastal and mountain locations of western Washington and western Oregon, and 7-15 inches in 15-20 rainy days over inland valleys of this area. Precipitation shows a marked increase (Figures 15 and 16) in California (30-60% increase over November) and monthly precipitation amounts reach 10-15 inches over the coastal and mountain areas of that state.

December marks the beginning of the winter precipitation regime in Arizona. Precipitation shows a marked increase over November (50-100% increase) with monthly amounts reaching 2 inches or more in the higher mountains.

b) Snow: Most of the precipitation in the Intermountain Area from Montana to northern Arizona falls as snow. Two to four snowy days during the month can be expected over most of the Intermountain Area. Snowfall amounts continue to decline in eastern Montana, compared to November, with monthly precipitation amounts ranging from only 1/3 to 3/4 inch. This area has the least precipitation in the region in December. Significant amounts of freezing rain and glaze can occur over eastern portions of Washington, Oregon, and the Columbia River Gorge.

c) Storms: Major floods have occurred in December from heavy and prolonged rains over river basins in the Pacific Northwest and California. The major floods in the past two decades were:

(1) December 16-26, 1955, the big California flood. In two weeks Blue Canyon (elevation 5,280 feet) had 35.74 inches of precipitation; the monthly total was 45.12 inches. Record monthly precipitation occurred at many central and northern California locations. Sixty-four lives were lost [7][8].

(2) December 19-22, 1964. Major floods were reported over northern California, western Oregon, and southwestern Washington. Torrential rains fell on deep snow cover; record floods followed. Eugene received 21 inches of precipitation for the month. Forty-five lives were lost [9][10].

Other significant storms or weather events over the Western Region during December were:

(1) December 2-11, 1972. Cold wave. Maximum temperature below zero for 10 consecutive days in Glasgow, Montana.

(2) December 4-15, 1972. Cold spell, wind, snow. Record low temperatures over portions of Washington, Oregon, Nevada, and Utah. Western Washington had nine consecutive days--a record--of below-freezing temperatures. Temperatures reached 1° at Newport on the Oregon coast and -12° at Salem. This cold spell was one of the earliest, longest, and severest in recent years.

(3) December 8, 1938. One hundred degrees at La Mesa, California (near San Diego)--a record high temperature in December for the United States.

(4) December 8-9, 1971. Snow in southern Arizona. New all-time record--24-hour snowfall at Tucson with 6.8 inches; Fort Huachuca received 18.3 inches.

(5) December 8-9, 1971. Snowstorm and wind over area from eastern Washington and eastern Oregon across northern Idaho into Montana. Example of damaging winds and blizzard conditions in the high country of Montana, where wind gusts reached 105 mph in the Livingston area.

(6) December 11, 1932. Coldest day in San Francisco, with maximum of 35° and minimum 27°; also Sacramento, with maximum of 34°, minimum 17°.

(7) December 12-19, 1967. Record snowfall at Flagstaff of 86 inches for the month and a maximum with 83 inches on the ground. Record 24-hour snowfall of 27.3 inches.

(8) December 14, 1924. Temperatures at Helena fell 79° in a 24-hour period and 88° in a 34-hour period on 14-15.

(9) December 16-18, 1970. Major snowstorm over Utah, with 24-hour record amount at Salt Lake City, 13.4 inches. Over 36 inches in 24 hours accumulated in the mountains.

(10) December 17, 1964. Preceding the floods of December 1964, a severe Arctic outbreak over the Northwest with blizzard conditions in portions of Washington, Oregon, and Idaho. Heavy snows received in coastal areas--Walla Walla reported -20°, Billings -26°.

(11) December 22-26, 1971. Two major snowstorms over Nevada with 2 feet of snow in valleys and 4 feet in mountains during storm period. December 1971 was one of the coldest Decembers of record for Nevada.

(12) December 23, 1970. Substation at Mt. Rainier, Washington, reported three feet of snow in one day.

(13) December 27-31, 1968. Severe ice, snowstorm, and cold wave over Washington, Oregon, Idaho, and Montana. Columbia River Gorge highway was closed to all traffic for two days. Temperatures reached -53° on December 29 at Loma, Montana (50 miles northeast of Great Falls), -46° at Havre, and -43° at Great Falls.

(14) December 31, 1933. Flash floods in Los Angeles County, California. Los Angeles received 7.36 inches of rain in 24 hours.

4. Temperatures

December continues the seasonal decline in temperatures with daytime readings lowering another 5-10° over November, and minimum temperatures another 3-8°. In Montana, subfreezing daytime temperatures can be expected on 13-17 days, and practically all nights will fall below the freezing threshold. Subzero weather in Montana ranges from 5-13 days in December. A few days of subzero weather can also be expected over some locations in the Intermountain Area. Only southern California and southern Arizona will continue to have mild temperatures, with daytime readings in the 60s and low temperatures in the upper 30s and 40s.

5. Aviation Weather

a) General Weather: Winter becomes well-established over the region during December, with even the southern portion of the region likely to receive winter aviation hazards quite frequently. Storms bring the usual spectrum of aviation hazards, as well as high-pressure systems with their stable conditions and associated valley fog problems. In general, December can be said to be a poor month for flying over most of the region.

Storminess continues to move southward along the Pacific Coast during the month, with a number of stations in Washington and Oregon receiving their highest monthly rainfall during December. The southward movement of the storm track helps decrease the fog problem along the southern California coast, but does increase other aviation hazards. Arctic outbreaks continue to be a major problem over the northern portions of the region during the month, also bringing a potential for freezing rain to the Pacific Northwest.

b) Fog: Daylight reaches its minimum during December, with approximately 8-1/2 hours at 50N, 9-1/4 hours at 40N, and 10 hours over southern California and Arizona. The minimum in solar insolation is conducive to fog formation and persistence. Most valley locations in the region experience their greatest fog occurrences during December. The interior valleys of California and western Oregon are very susceptible to maximum days of fog, low ceilings, and low visibilities. The Intermountain Area is also likely to have a persistent fog situation when the Great Basin High becomes established during the month. On the bright side, the fog situation does improve somewhat over November along the Pacific Northwest Coast and southern California Coast, but still poses a hazard to aviation interests.

c) Examples: The following are a few comparisons between November and December at a number of Western Region airports:

WASHINGTON	Olympia, Seattle: Wettest month, freezing rain or drizzle threat; decrease in fog from November.
	Yakima: Wettest and foggiest month.
	Spokane: Foggiest month; freezing rain or drizzle threat.
OREGON	Portland: Marked improvement over November in fog, but still a serious flying hazard; wettest month.
	Medford: Worst fog month and wettest month.
MONTANA	Great Falls, Helena: Arctic outbreaks, upslope conditions of low ceilings and poor visibilities. Chinook still a problem.
IDAHO	Boise, Pocatello: Increase in fog occurrence and poor flying weather due to storms.
	Lewiston: Foggiest month.
NEVADA/UTAH	Salt Lake City: Increase in fog and storms.
	Elko: Increased storminess; second wettest month.
ARIZONA	Phoenix, Tucson, Winslow: Increased storminess and associated aviation hazards; month with highest potential for fog occurrence.
CALIFORNIA	Bakersfield: Worst fog month; visibility less than 2 miles most frequent.
	Burbank: Decrease in dense fog from November; increased storminess.
	Fresno, Sacramento: Worst month for fog.
	Los Angeles: Increased storminess; large increase in precipitation.
	Red Bluff: Large increase in precipitation and fog.
	Santa Maria: Second wettest month; slight decrease in dense fog from November.
	San Francisco: Second wettest month; low ceilings and storminess increased.
	San Diego: Decrease in fog from November; large increase in precipitation.

6. Marine Weather

a) Swells: In December the primary storm tracks continue along the Aleutian Chain and in the Gulf of Alaska (see Figure 12). The chief difference from the November tracks is a greater amount of cyclogenesis off the mouth of the Columbia River near 130W longitude. Consequently, we would expect the distribution of storm-generated swells along the West Coast to be similar to November except for higher frequency of elevated wave heights along the Oregon coast.

Comparison of the mean-sea-level pressure charts for November (see Figure 20 in WR Technical Attachment No. 73-41 [USAFETAC TN 75-4]) and December (see Figure 13) indicates little significant change. Therefore, average swell amplitudes should remain essentially unchanged for December.

Winter season wave-height charts are given in Figures 17 and 18.

b) Coastal Weather: The climatology of coastal stations indicates that the mean cloud cover continues to increase along the West Coast. Winds also continue to increase from central California northward. However, mean December wind speeds along the southern California coast reach an annual minimum.

7. Agriculture

Meteorological support to frost protection activities during December is concentrated in the great interior valley of California (Sacramento, San Joaquin) through southern California and into western Arizona. Crops vary according to variety. During December, grapefruit are generally from half to near ripe; lemons vary from bud and blossom to half mature; navel oranges range from showing color to being mature and picked; while valencias are in the small-fruit stage. Specialized vegetable crops, as well as non-citrus fruits (e.g., avocados) are important in southern California. Critical temperatures vary according to plan development and preceding conditions, vigor of the plant, moisture conditions, etc. Generalizations of critical temperatures indicate damage at 27° for small to medium-size valencias, increasing to 28° at half-ripe stage. Lemons greater than 1/2 inch, but still green, are susceptible at 29°, while buds, blossoms, and ripe fruit will be damaged at 30°.

In areas of the Western Region where the normal growing season has ceased, there can be considerable damage due to extremely cold temperatures of long duration, for example the Arctic outbreak of December 1972. Also, nursery stocks are susceptible at this time of year. Acclimation and hardening are the terms used to describe the change from a susceptible to a resistant condition. This resistant condition is not fixed, but varies according to certain threshold values; therefore, it is extremely important to highlight the threat and outbreak of extreme cold following well-above-normal conditions.

8. Air Pollution

As in November, the Great Basin High becomes the predominant feature over the Western Region during December. Figure 13 indicates the mean surface pressure pattern with the anticyclone center over southern Idaho. The mean winter afternoon mixing heights are shown in Figure 19. From autumn these heights decrease markedly in all areas of the region with the exception of the coastal areas. This highlights the increased stagnation and pollution potential for December. Figure 20 indicates the mean winter wind speeds averaged through the afternoon mixing layer. The velocities are very similar to those computed during the autumn months with the strongest wind in the chinook zone of Montana [11].

The shortest days and longest nights of the year are experienced this month and the sun's angle is at its lowest level in the southern horizon. Air-pollution episodes develop rapidly with strong anticyclogenesis. The build-up of pollution under these conditions can be at a rapid rate. Fog episodes are rather common associated with anticyclone activity.

Coastal and interior valleys of California experience the lowest levels of air pollution in the months of December and January. Meteorological parameters are favorable for increased dispersion and vertical mixing with limited amounts of photo-chemical ozone produced.

9. Avalanche Patterns

Ski areas generally go into full operation in December. Heavy snowfalls also increase in number during this month, and heavy snowfalls portend avalanches.

a) Examples:

(1) STEVENS PASS, WASHINGTON - December 30, 1962

Ten inches of snow fell on December 28 (Figures 21 and 22) and Saturday, December 29, added 4 more inches (Figures 23 and 24). Rising temperatures occurred Saturday afternoon and evening, and on

Sunday morning Barrier Bowl was foggy and no new snow had fallen. The slide occurred adjacent to the Seventh Heaven Chairlift (Figure 25), but resulted in no fatalities.

(2) BRIDGER BOWL, MONTANA - December 28-31, 1961

In 1961, winter came earlier than usual to the Bridger Bowl area in Montana. Snow began falling early in October, and temperatures ranged slightly below normal through December. The usual alternate warm spells occurred sporadically until the end of December, interspersed with more light snow layers. By late December, three to six feet of well-stratified snow covered the slopes. On December 31, 24 hours or more had elapsed since the most recent foot of new snow had fallen, December 28-29 (see Figures 26 and 27*). Four skiers were engulfed in the avalanche and two were severely injured.

(3) SIERRA NEVADA, CALIFORNIA - December 4-8, 1972

Last December's storms along the West Coast will long be remembered for the record low temperatures set during that month. In addition to the low temperatures, heavy snow fell in the Sierra Nevada and resulted in many, many avalanches. The 500-mb charts for December 4-8 are shown in Figures 28 through 32.

(4) PARK CITY, UTAH - December 31, 1965

On December 31, 1965, an avalanche at Treasure Mountain (Park City) resulted in one fatality (Figure 33). The avalanche hazard by late December was high in all ski areas of the Western Wasatch Mountains. On the 29th and 30th (Figures 34-37), storms dropped 16 inches of new snow on the area. By the 31st, while there was no snow falling, wind speeds were moderately high and considerable drifting was reported.

b) Storm Characteristics Relating to Avalanche Potential: No two storms are the same. Nevertheless, in the avalanche forecasting system developed by the U. S. Forest Service, a set of ten "contributory factors" is considered during the progress of each storm. While not all of the factors are independent and fundamental parameters, they are readily observable, and experience has shown that they provide a reliable indication of the onset of avalanche hazard. Briefly, they are:

(1) Depth of old snow. The snow already lying on the mountainside at the beginning of a storm serves to smooth the slide paths by submerging irregularities.

(2) Surface condition of the existing snow. A smooth icy crust, especially one glazed by rain, by melt, or by wind action, offers little resistance to sliding, and it is unlikely to bond with the new snow at sub-freezing temperatures. However, if the crust or the new snow is at or near the melting point, a secure bond between them is possible.

(3) Depth of new snow. The deeper the new snow, the higher is the shear stress along the interface between old and new snow. The depth of new snow gives a good measure of the quantity of snow likely to be released.

(4) Type of new snow. Stellar crystals and spatial dendrites form loose and fluffy deposits. When deposited under cold, calm conditions, this type of snow may be stable initially; but it is prone

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* This pattern is similar to weather types shown by Woerner in NOAA Technical Memorandum NWS WR63 [12].

to release in the form of loose snow avalanches as the original crystal structures are destroyed by metamorphism. Crystals of simple shape, iced grains, and wind-shattered fragments of more complex crystals all tend to pack closely when deposited, thus favoring the formation of intergranular bonds. This type of snow is likely to produce firm, coherent slabs. Rime-free crystals tend to form an unstable deposit which slides readily. Thick layers of graupel lead to formation of slab avalanches.

(5) Density of new snow. The product of depth times density gives the weight of overlying snow, and hence determines the stress at any given depth. Density increases with time, depending upon the overburden pressure and snow temperature. It has been observed that when new snow density at a particular site departs widely from the mean density for that site, avalanches are likely. Abnormally high densities are associated with slab avalanches, and abnormally low densities are associated with release of loose snow avalanches.

(6) Snowfall intensity. Rapid accumulation is a danger signal. If the build-up of new snow is very rapid, stress increases without any significant increase in strength over the initial strength.

(7) Precipitation intensity. This is the snow accumulation rate expressed in terms of equivalent water. Experience in the U. S. has shown that sustained deposition with a precipitation intensity of 0.1/hour or more indicates high avalanche probability.

(8) Snow settlement. The faster snow settles, the faster it gains strength, generally speaking. Low-density snow has little initial strength but settles rapidly; high-density snow has high initial strength but settles slowly. The absolute settlement rate, thus, depends both on temperature and initial density of the snow.

(9) Wind. When high wind accompanies snowfall, snow crystals are fragmented and transported in the wind stream by turbulent suspension. The deposit laid down under blizzard conditions is typically composed of fine particles and is packed to high density. This snow is almost sure to form slabs.

(10) Temperature. It has been found that in most cases the probability of avalanche release tends to increase as temperature decreases over the usual range of sub-freezing temperatures. At temperatures near the melting point, the new snow bonds well with the old snow, and it stabilizes quite rapidly by settling to higher density and by forming intergranular bonds, so that potential instability is of short duration. When snow is deposited at low temperature--although it may be less prone to immediate release--it is slow to gain strength, and thus remains in a precarious state for an extended period.

10. Satellite Meteorology

A summary of mean cloud cover for December at 1400LST is shown in Figure 38. (See Figure 27 is WR Technical Attachment No. 73-41 [USAFETAC TN 75-4] for comparison.) In these figures, the dark shade (black) is 0 Octas ranging to a pure white shade, or 8 octas cloud cover. These cloud-cover-depiction photos give mean values for a four-year period from 1967 to 1970. Whereas cloud climatology based on station reports suggests predominantly cloudy days in some areas for the month of December, the satellite photo suggests that, at 1400LST, the instantaneous view gives greater than 4 octas of sky cover mainly over the mountainous areas. Since these were obtained by computer processing of reflectance in the visible spectral range, some contamination is unavoidable. Most of the reflectance values from snow cover were screened out. However, the brighter values normally obtained from desert topography remained and are included in the satellite cloud cover depiction.

REFERENCES:

[1] WILLIAMS, PHILIP, JR., "Map Types for Heavy Snowstorms in the Salt Lake City, Utah, Forecast District." Weather Burueau Manuscript, 1964.

[2] YOUNKIN, RUSSELL J., "Circulation Patterns Associated with Heavy Snowfall Over the Western United States." Monthly Weather Review, December 1968.

[3] KORTE, AUGUST F., DONALD L. JORGENSEN, AND WILLIAM H. KLEIN, "Charts Giving Station Precipitation in the Plateau States from 850- and 500-MB Lows During Winter." NWS Technical Memo TDL 25, September 1969.

[4] NELSON, BERT L., PAUL M. FRANSIOLI, AND CLARENCE M. SAKAMOTO, "A Synoptic Climatology for Snowstorms in Northwestern Nevada." NOAA Technical Memo NWS WR 73, February 1972.

[5] DICKEY, WOODROW W., AND ROBERT N. WING, "Arctic Outbreaks into the Pacific Northwest." Weather Bureau Manuscript, 1963.

[6] AUGULIS, RICHARD P., "Precipitation Probabilities in the Western Region Associated with Winter 500-mb Map Types." NWS WR 45-1, December 1969.

[7] ANDREWS, JAMES F., "The Weather and Circulation of December 1955." Monthly Weather Review, December 1955.

[8] COLE, ROBERT O. AND JOHN P. SCANLON, "Flood-Producing Rains in Northern and Central California." Monthly Weather Review, December 1955.

[9] POSEY, JULIAN W., "The Weather and Circulation of December 1964." Monthly Weather Review, March 1965.

[10] "General Summary of River and Flood Conditions." Climatological Data, National Annual 1964.

[11] HOLZWORTH, GEORGE C., "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States." EPA, AP-101, January 1972.

[12] WOERNER, NORRIS E., "700-MB Warm Air Advection as a Forecasting Tool for Montana and Northern Idaho." NWS WR 63, February 1971.

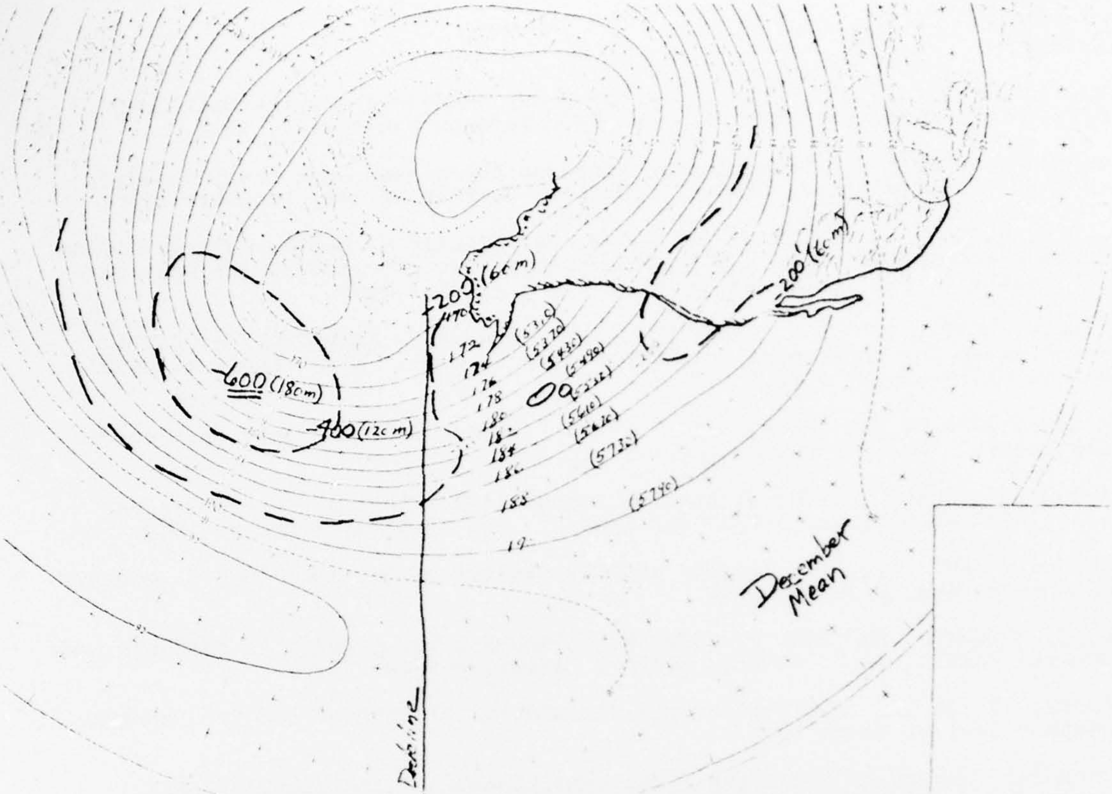


FIGURE 1. MEAN 500-MB HEIGHT FIELD FOR DECEMBER. SOLID LINES ARE CONTOURS IN HUNDREDS OF FEET (METERS). DASHED LINES INDICATE CHANGES IN FEET (METERS) FROM NOVEMBER TO DECEMBER.

FIGURE 2. STANDARD DEVIATION OF DAILY VALUES OF 500-MB HEIGHT FOR DECEMBER IN FEET. DASHED LINE INDICATES CHANGES IN FEET (METERS) FROM NOVEMBER TO DECEMBER.

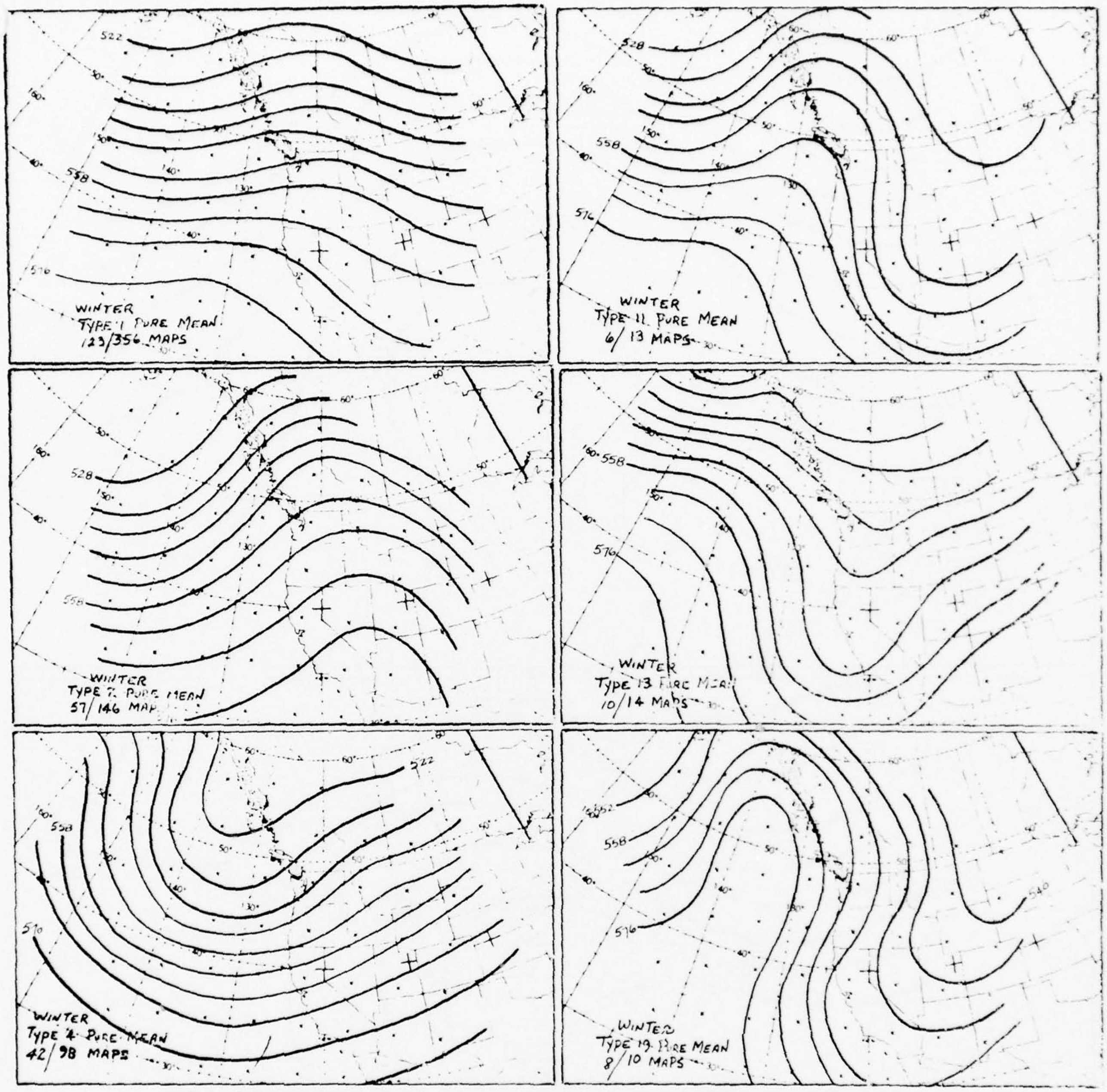


FIGURE 3. WESTERN REGION 500-MB TYPE MAPS. FRACTION IN LOWER LEFT CORNER INDICATES NUMBER OF TIMES THE TYPE OCCURRED IN DECEMBER COMPARED WITH THE TOTAL NUMBER OF TIMES THE TYPE OCCURRED IN THE WINTER SAMPLE.

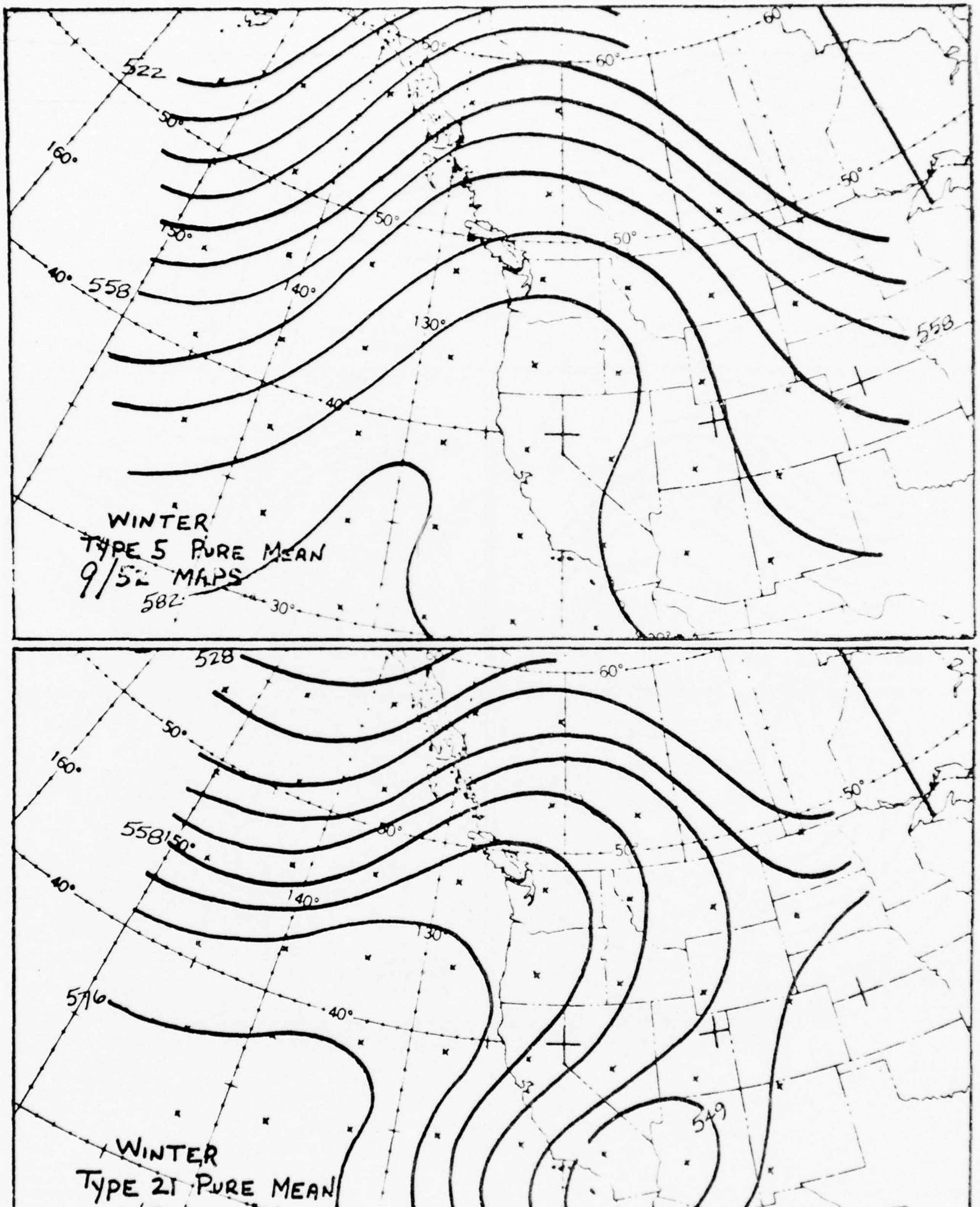


FIGURE 4. WESTERN REGION 500-MB TYPE MAPS. LEGEND SAME AS FIGURE 3.

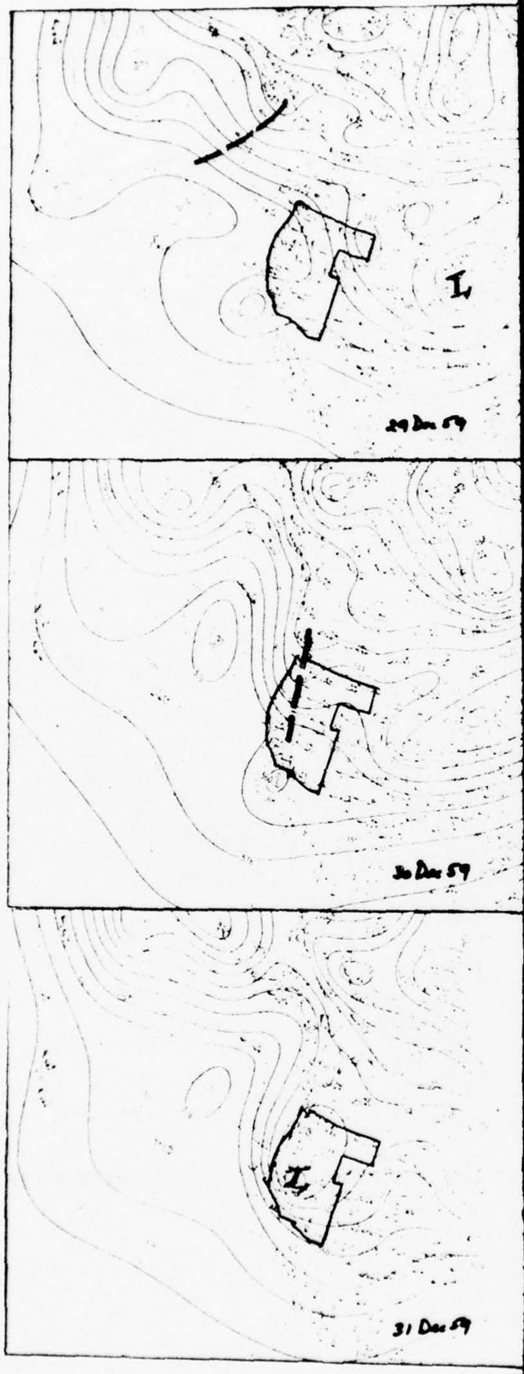


FIGURE 5. SURFACE CHARTS FOR DECEMBER 29 - 31, 1959, ILLUSTRATING NEGATIVE-TILT DIFLUENT TROUGH.

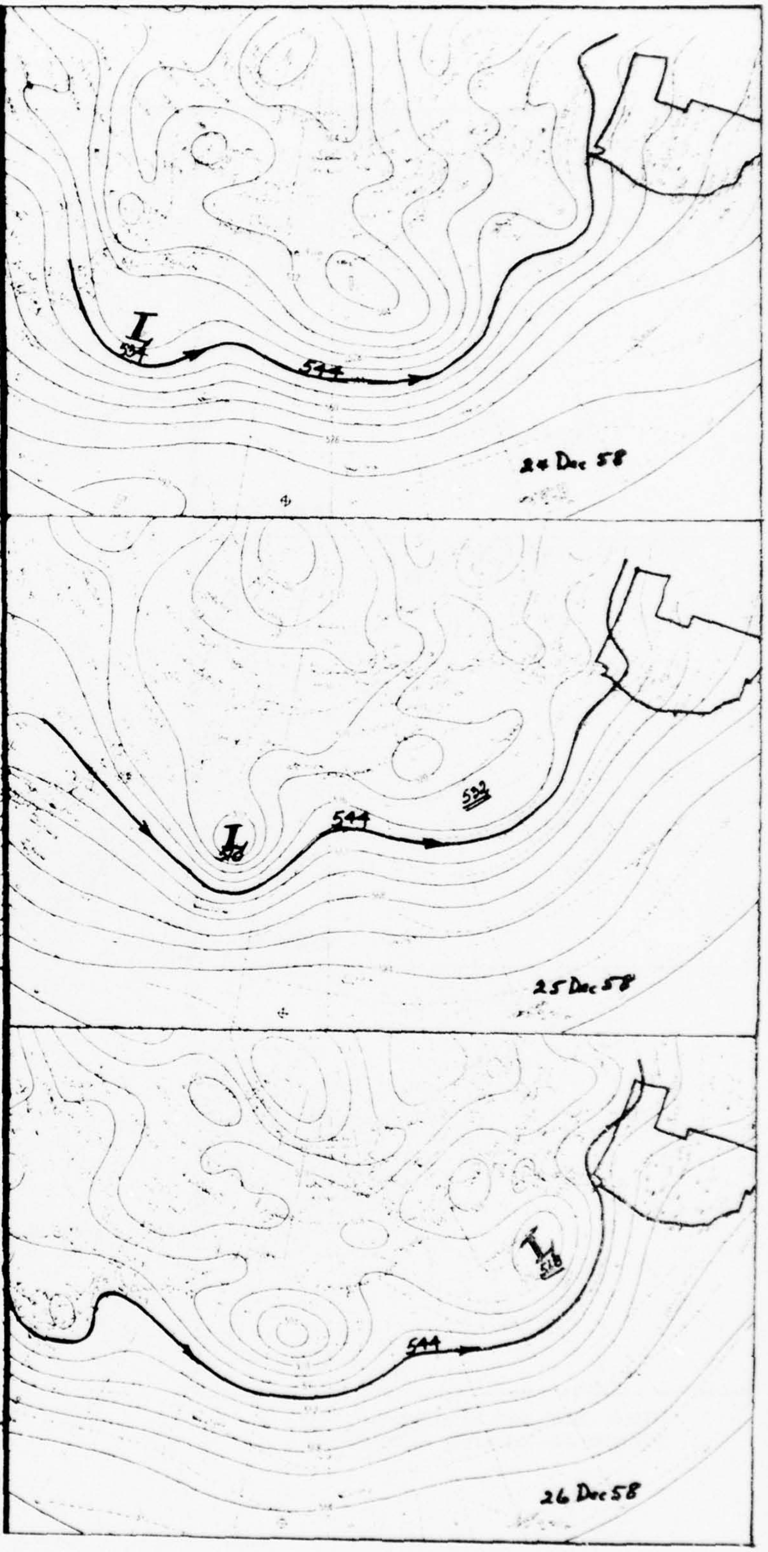


FIGURE 6. 500-MB CHARTS FOR DECEMBER 24 - 26, 1958, ILLUSTRATING RAPID DEEPENING.

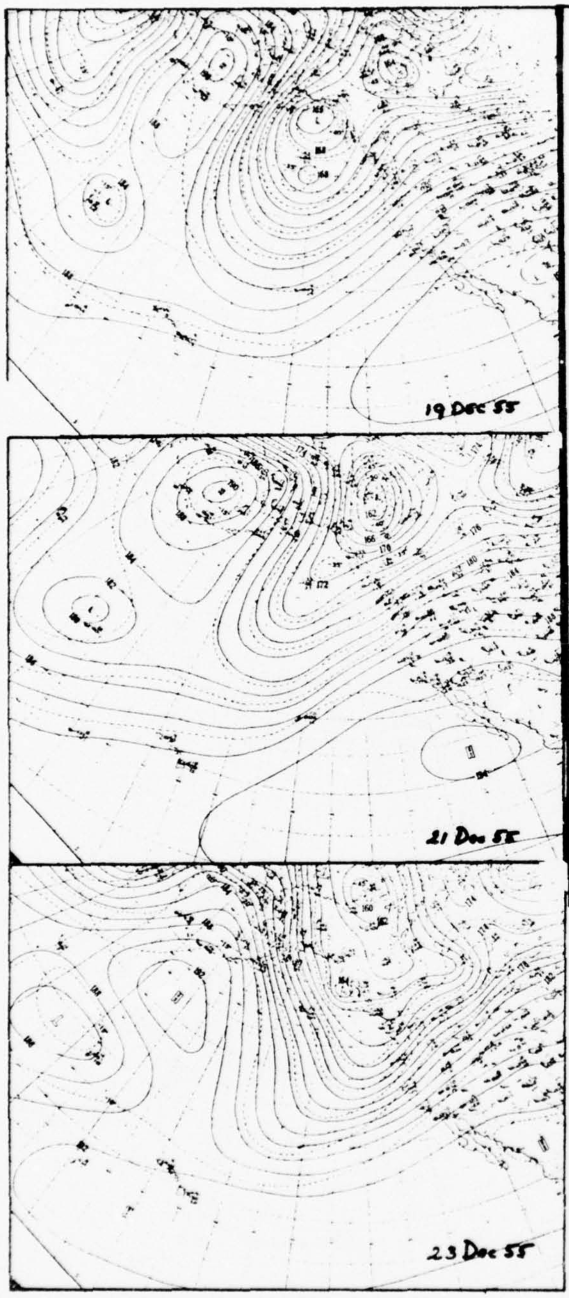


FIGURE 7. SURFACE CHARTS FOR DECEMBER 19 - 23, 1955, ILLUSTRATING HEAVY RAIN PATTERN FOR WEST COAST.

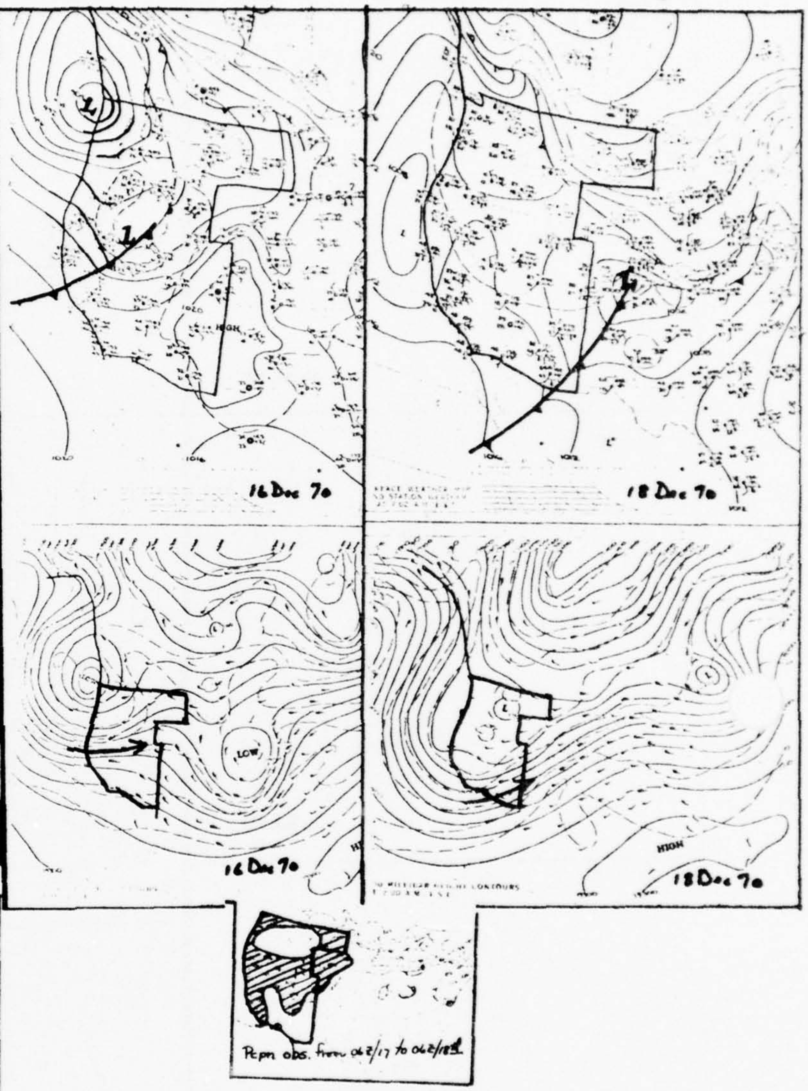


FIGURE 8. SURFACE AND 500-MB CHARTS FOR DECEMBER 16 - 18, 1970, ILLUSTRATING HEAVY SNOWS IN THE GREAT BASIN.

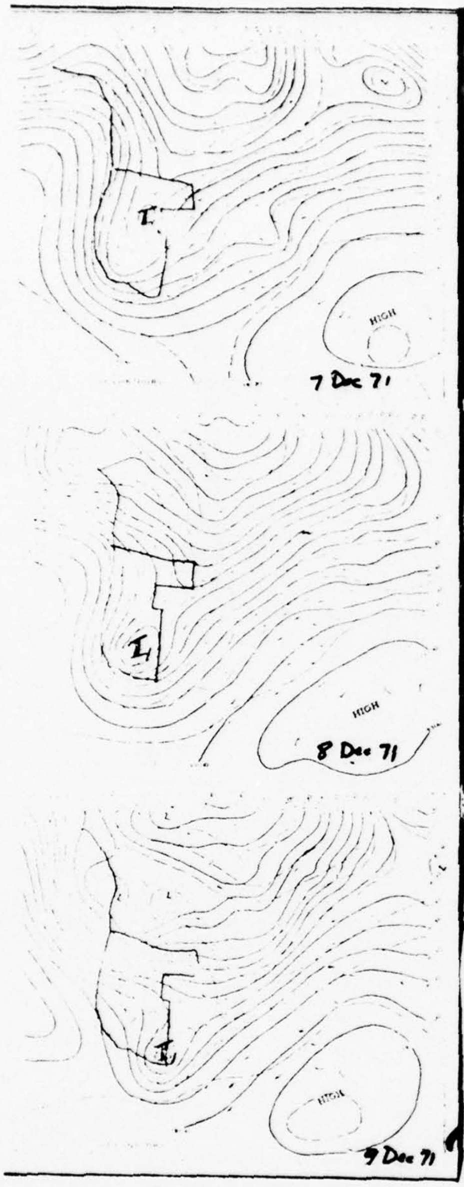


FIGURE 9. 500-MB CHARTS FOR DECEMBER 7 - 9, 1971. ILLUSTRATING SLOW MOVING UPPER CLOSED LOW AND ASSOCIATED HEAVY SNOWS IN ARIZONA AND SOUTHERN PORTIONS OF NEVADA AND UTAH.

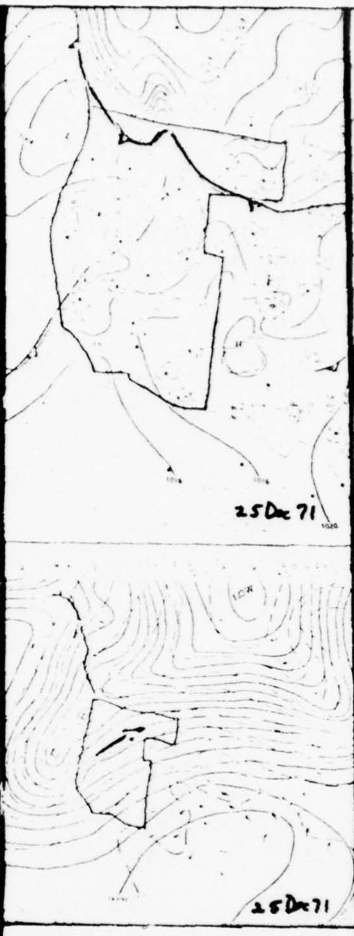


FIGURE 10. SURFACE AND 500-MB CHART FOR DECEMBER 25, 1971. ILLUSTRATING ARCTIC OUTBREAK IN MONTANA.

FIGURE 11. 500-MB CHARTS FOR DECEMBER 26 - 28, 1968. ILLUSTRATING UPPER CLOSED LOW MOVING SOUTHWARD FROM CANADA BRINGING SEVERE WINTER STORM TO NORTHERN STATES.

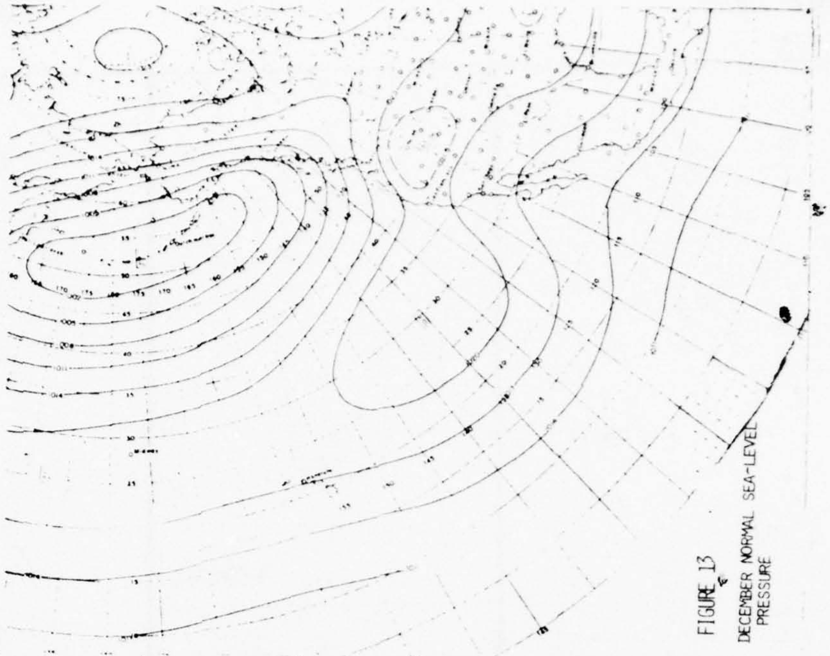


FIGURE 13

DECEMBER NORMAL SEA-LEVEL PRESSURE

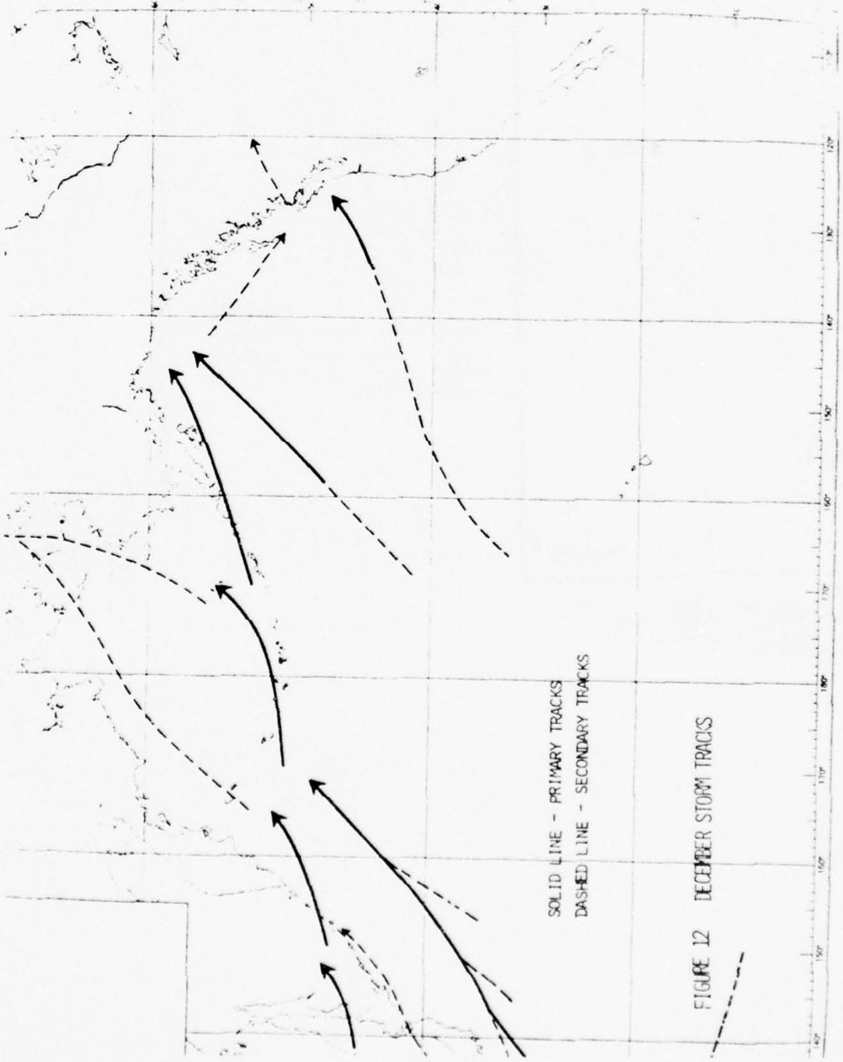


FIGURE 12 DECEMBER STORM TRACKS

FIGURE 14

DECEMBER PRECIPITATION NORMALS BY DIVISIONS

1941 - 1970

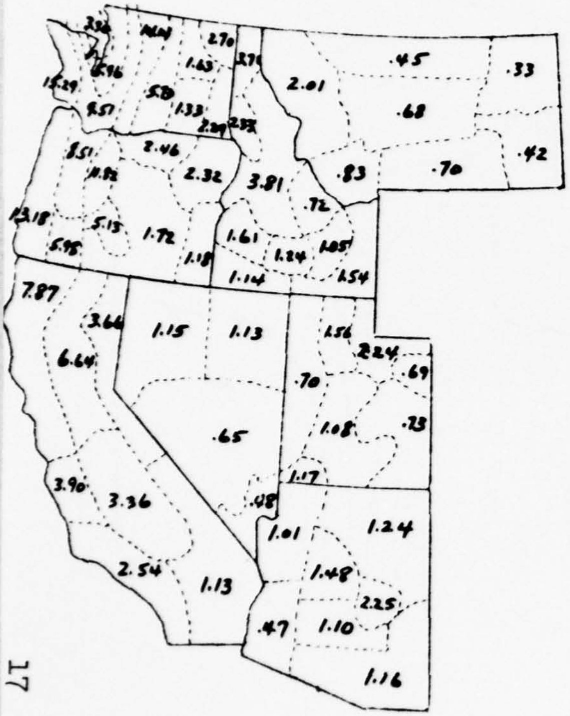


FIGURE 15

COMPARISON OF NORMAL PRECIPITATION, DECEMBER vs NOVEMBER
SHOWN AS PERCENT (DECEMBER/NOVEMBER TIMES 100)

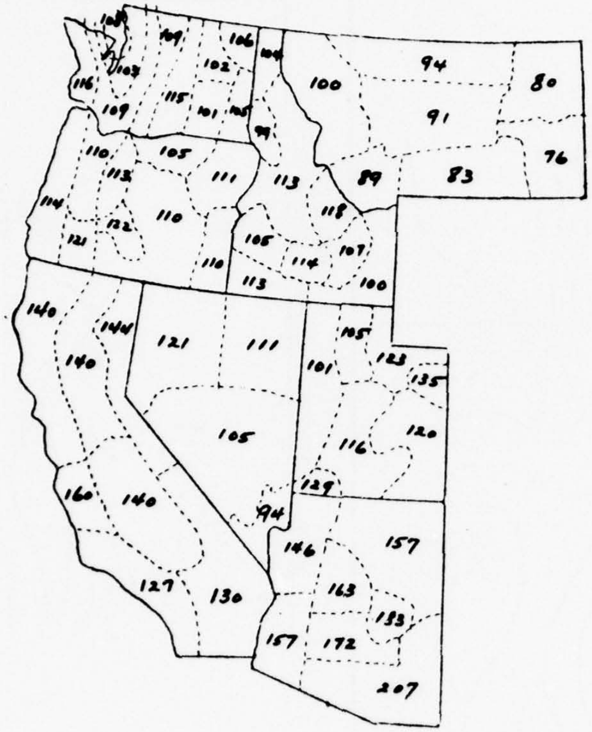
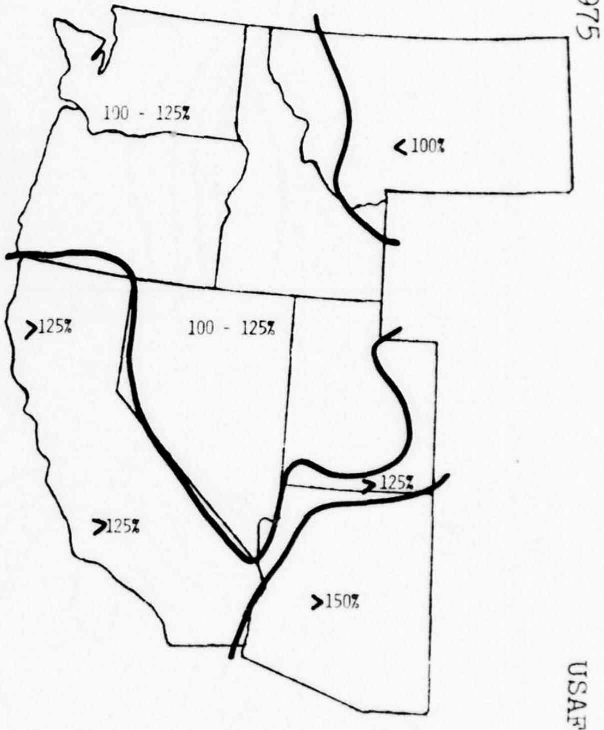


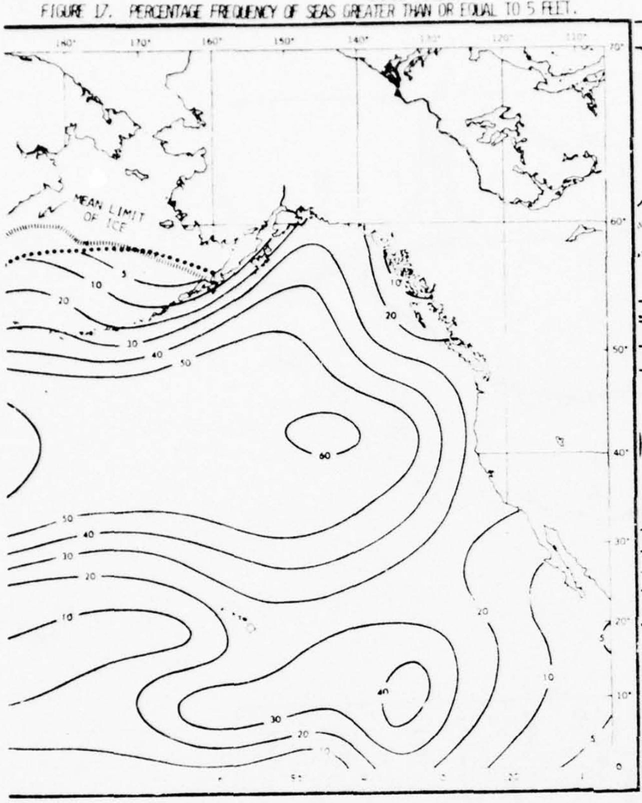
FIGURE 16

ANALYSIS OF FIGURE 15



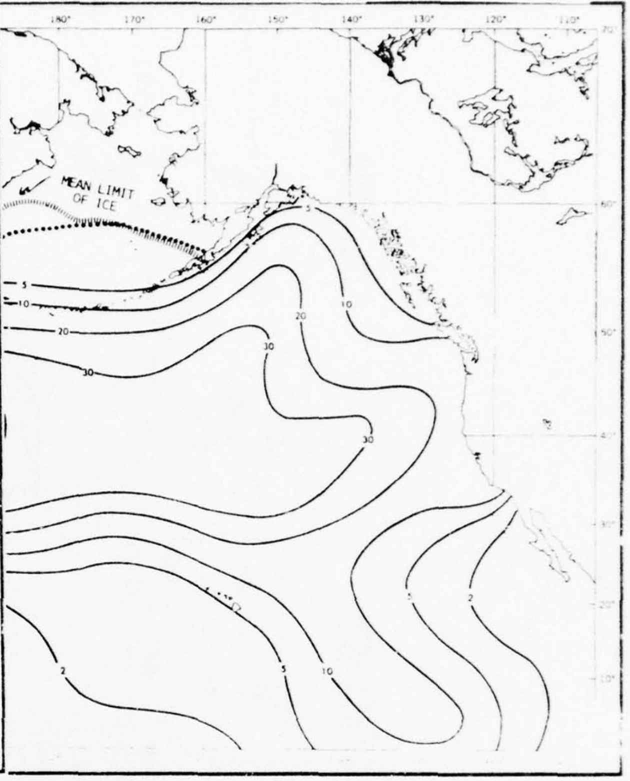
WINTER

FIGURE 17. PERCENTAGE FREQUENCY OF SEAS GREATER THAN OR EQUAL TO 5 FEET.



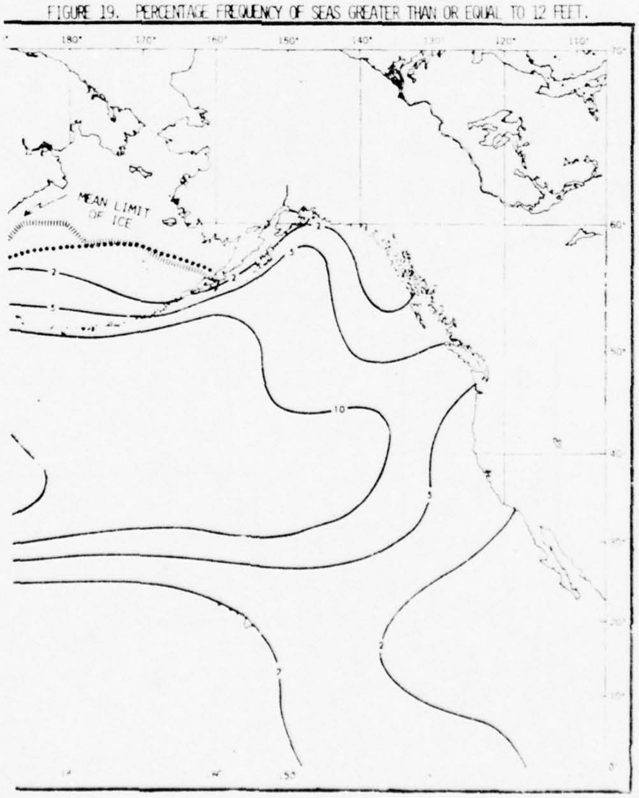
WINTER

FIGURE 18. PERCENTAGE FREQUENCY OF SEAS GREATER THAN OR EQUAL TO 8 FEET.



WINTER

FIGURE 19. PERCENTAGE FREQUENCY OF SEAS GREATER THAN OR EQUAL TO 12 FEET.



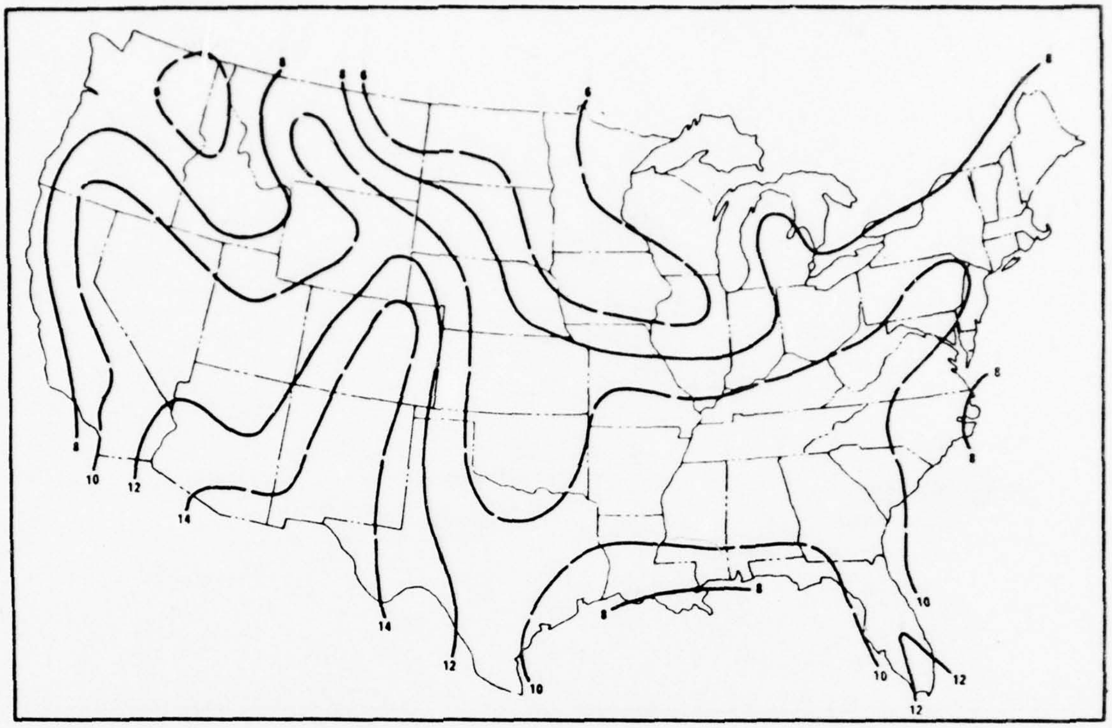


FIGURE 19. MEAN WINTER AFTERNOON MIXING HEIGHTS, ISOPLETHS, M x 10^2 (FROM [11]).

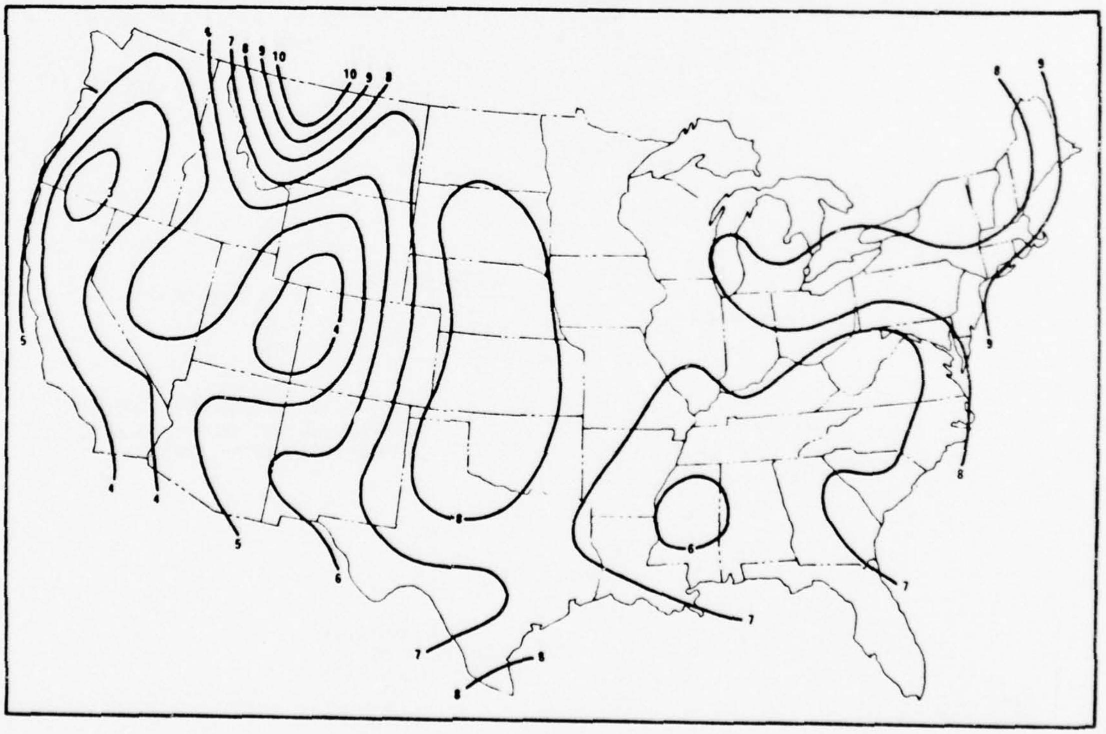


FIGURE 20. MEAN WINTER WIND SPEED, ISOPLETHS, M SEC^{-1}. (AVERAGED THROUGH THE AFTERNOON MIXING LAYER, FIGURE 19.) (FROM [11].)

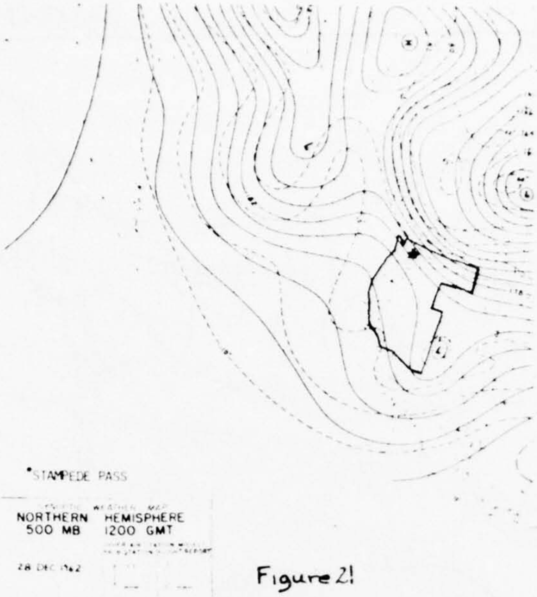


Figure 21

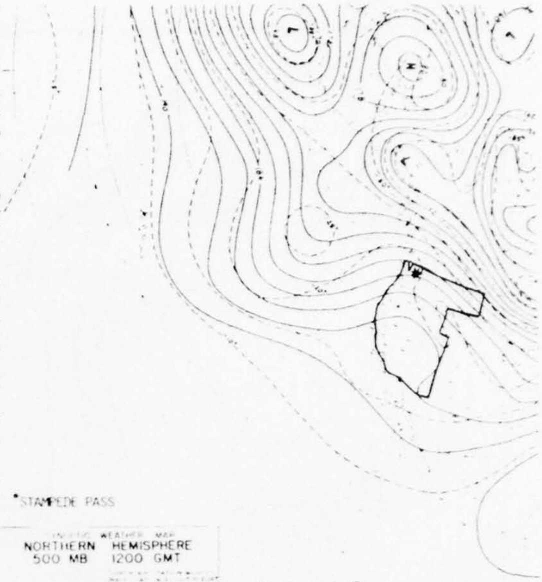


Figure 23

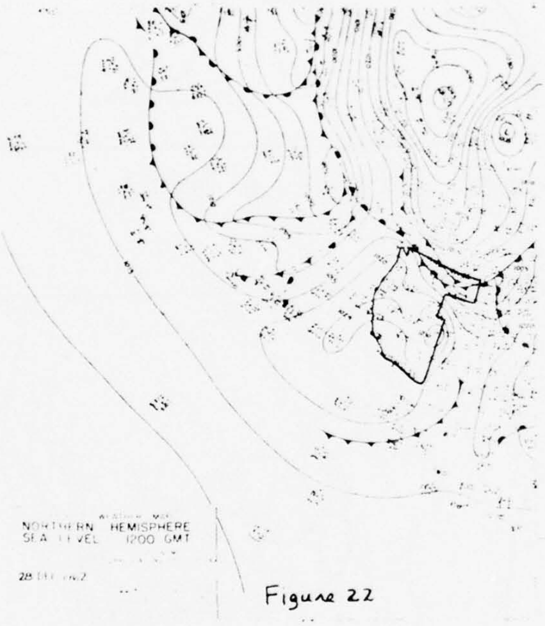


Figure 22

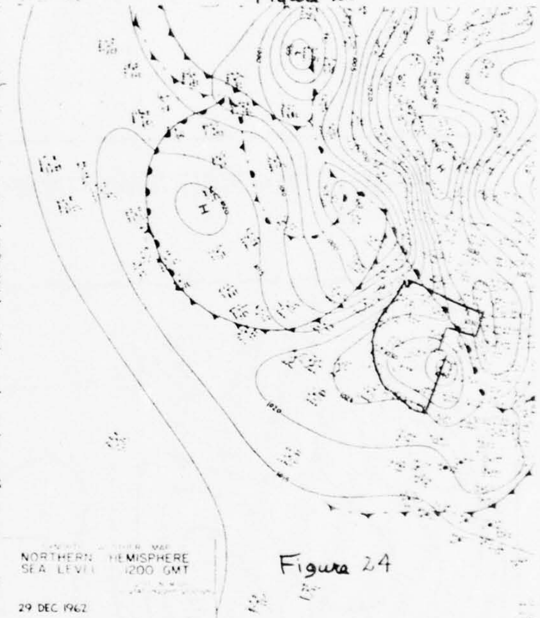
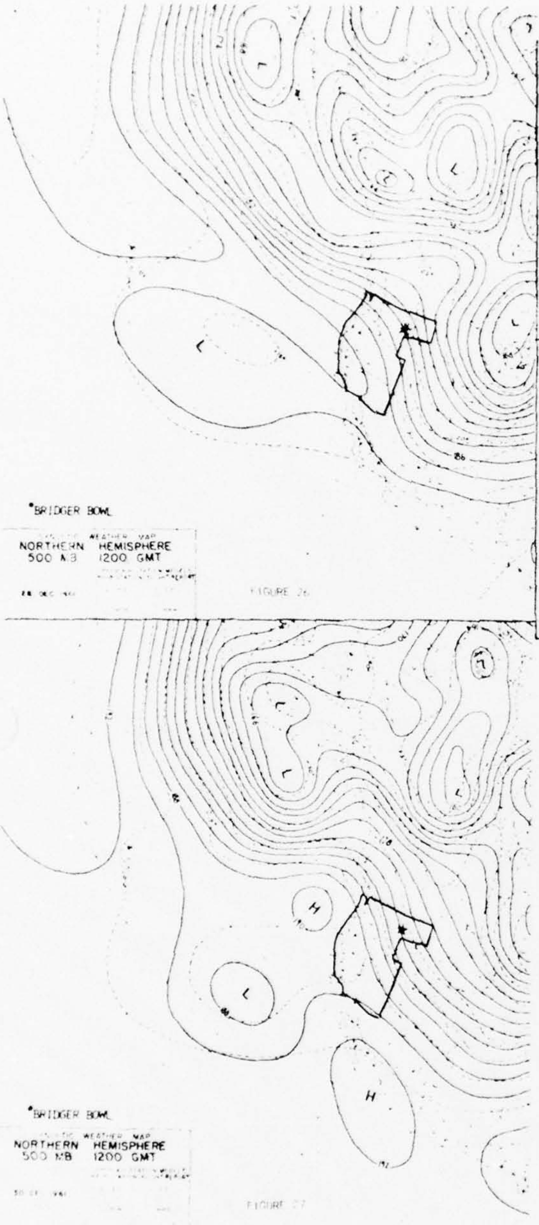


Figure 24

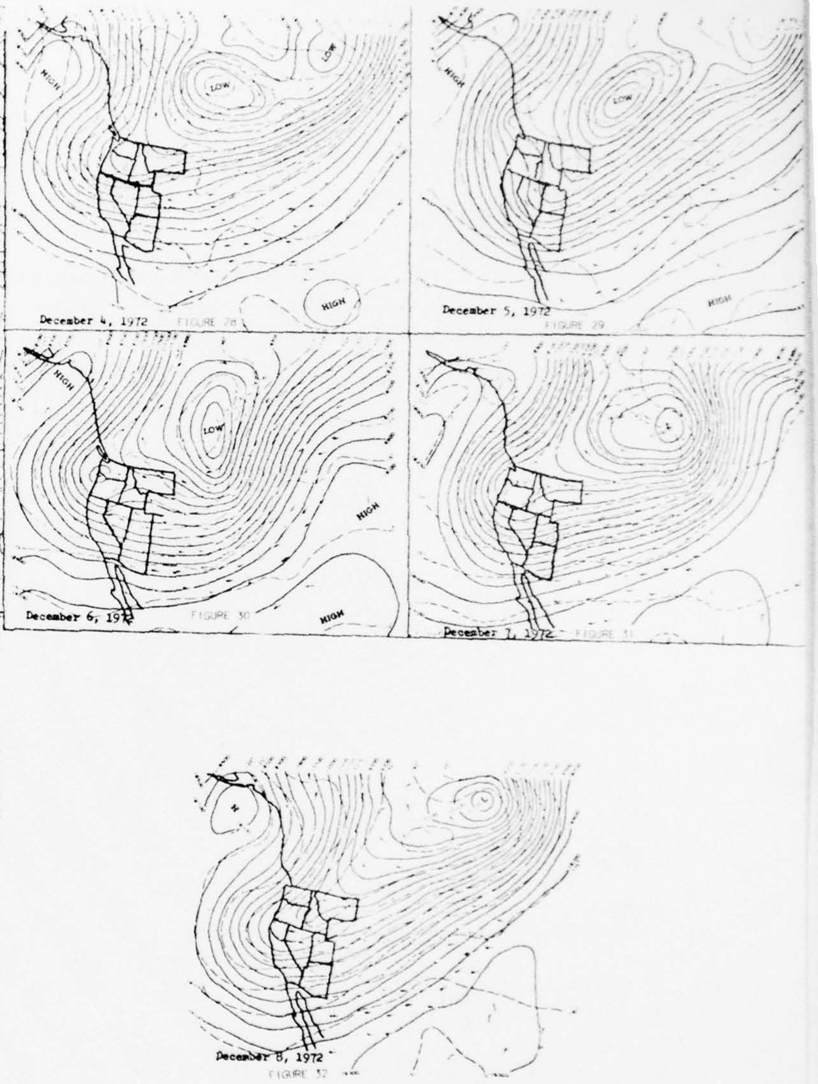
FIGURES 21 - 24. 500-MB AND SURFACE CHARTS FOR DECEMBER 28 - 29, 1962, SHOWING CONDITIONS PRIOR TO AVALANCHE AT STEVENS PASS, WASHINGTON.

Figure 25

FIGURE 25. AVALANCHE OF DECEMBER 30, 1962, AT STEVENS PASS, WASHINGTON.



FIGURES 26 AND 27. 500-MB CHARTS FOR DECEMBER 28 AND 30, 1961, SHOWING UPPER AIR PATTERNS PRIOR TO AVALANCHE AT BRIDGER BOWL, MONTANA.



FIGURES 28 - 32. 500-MB CHARTS FOR DECEMBER 4 - 8, 1972, SHOWING CONDITIONS THAT RESULTED IN MANY AVALANCHES IN SIERRA NEVADA, CALIFORNIA.

FIGURE 33. AVALANCHE OF DECEMBER 31, 1965, AT PARK CITY, UTAH.

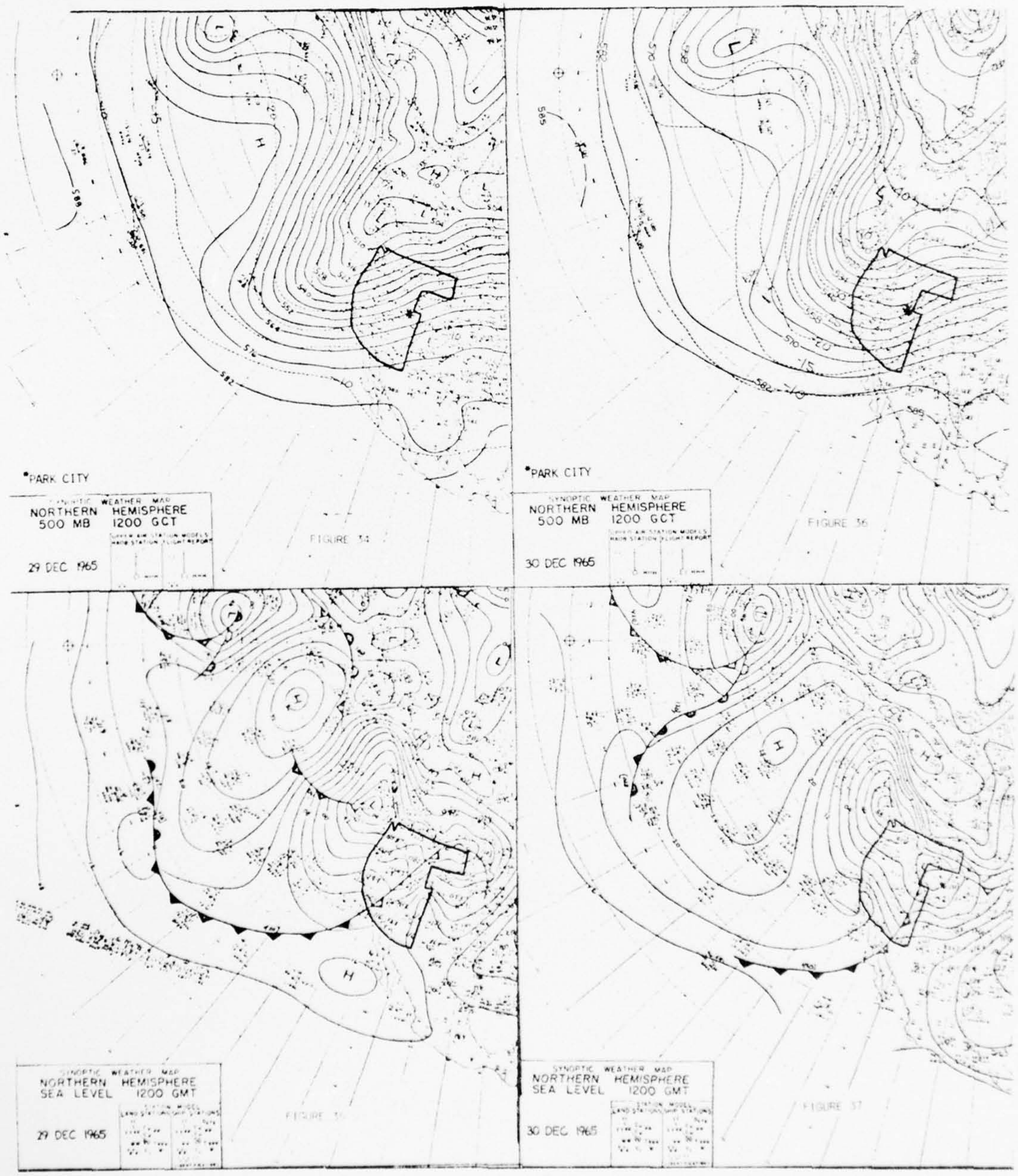


FIGURE 34 - 37. 500-MB AND SURFACE CHARTS FOR DECEMBER 29 - 30, 1965, SHOWING CONDITIONS PRIOR TO AVALANCHE AT PARK CITY, UTAH.

FIGURE 38. DECEMBER MEAN CLOUD COVER AT 1400 LST, IN OCTAS (1967 - 1970).

WESTERN REGION TECHNICAL ATTACHMENT
January 2, 1974
No. 74-1

JANUARY WEATHER PATTERNS

January can be characterized as a cold, stormy month with only small changes in weather patterns from late December. The "January thaw" is often hoped for during the month, but climatological data show that this phenomenon is a myth more than fact.

1. Upper Air

a) Normal Patterns. Normal January 500-mb flow is given in Figure 1. The changes from December are slight with some new ridging off the coast and deepening of trough inland.

The day-to-day variability of 500-mb heights (Figure 2) increases slightly along the southeast Alaskan Coast. The maximum variability center shifts a little westward to the Aleutian Chain.

b) Predominant Circulation Types [1]. Zonal type #1 occurred 135 out of 356 winter cases, but 41 of these were recorded in 1964. Types 3, 5, 6, and 8 (Figure 3), which occurred most frequently in January, are characterized by the 500-mb ridge being on or west of the coast. This coincides well with the normal pattern (Figure 1) of a ridge off the coast. Type 5 usually persists for several days at a time. In contrast, type 2 (Figure 4) was the January type least frequently observed of the types occurring more than 50 times in studied sample.

c) Specific Examples of Significant January Development.

(1) Blocking. The Rex-type blocking patterns [2] (i.e., split flow) are occasionally significant in January. If the split flow (i.e., approximately equal flow in each branch of westerlies) covers at least 45° longitude and lasts for 3 days, climatological statistics indicate it will last for 2 weeks 80% of the time. An example is January 1967 from the 17th to the 31st (See Figure 5). Early January 1965 (Figure 6) shows a different type of persistent blocking pattern where the nonadiabatic heating of cold Alaskan air moving over the ocean helps keep a trough along the Alaskan southeast coast. This flow pattern was associated with record 24-hour snowfalls at Stevens Pass (45") and Snoqualmie Pass (44") in Washington.

(2) Negative-Tilt Difluent Trough. In the December Summary [3] we called attention to the strong subsequent development of negative-tilted difluent troughs. There are exceptions, and a good example occurred on January 9-10, 1969 (See Figure 7). A clue to lack of development is thought to be the lack of a good inflection point upstream in the strong northwesterly flow and flow of cold Alaskan air over the relatively warm Gulf of Alaska.

(3) Confluent Positive-Tilt Troughs. Strong confluent troughs (i.e., southwest flow east of trough stronger than northwest flow to west) such as occurred on January 15, 1966 (Figure 8), are normally associated with a subsequent weakening of the trough and building of the downstream ridge. Note that the building of the ridge in the 1966 case contributed to the development of a closed low over Arizona on the 16th. Strong retrogression was associated with a confluent trough January 3-6, 1962 (Figure 9).

(4) Downstream Trough Blocks Ridge. Normally we give special attention to the flow upstream from us in deciding the changes expected over the Region. In January a strong persistent flow of Arctic air into the plains just east of the Rockies can have a pronounced effect on

keeping a West-Coast ridge almost stationary. A good example is January 18-24, 1961 (See Figure 10).

(5) Heavy Rain Situations. On January 19-20, 1962 (Figure 11), heavy precipitation occurred in the northern part of the region as a trough in southern branch of blacked westerlies combined with a trough in the northern branch moving southward out of Canada. Note the rapid development on surface between the 19th and 20th. January 15-22, 1970 (Figure 12), is a typical blocking pattern that brings heavy rains to coastal states. In this instance, the moist southwest flow persisted over northern California, resulting in heavy rains and serious flooding in Sacramento River Basin.

(6) "Dirty Ridges". As in December, there are some cases of significant precipitation to the east of upper ridge lines in moist west-northwest and even westerly flow. January 10, 1972 (Figure 13), is a good example for Washington and Oregon. Snows of several inches are often associated with such "dirty ridges" farther inland, too. Satellite pictures and low-dew-point depressions at 700 and 500 mb are clues to when a ridge is "dirty".

(7) Arctic Outbreaks West of Mountains. Arctic air is more likely to come west of the mountains in January than December. January 26-28, 1963 (Figure 14), is a typical upper-air pattern associated with this type of Arctic outbreaks.

2. Surface

a) Cyclonic Activity. Maximum cyclonic activity continues during January in the Gulf of Alaska. Pacific storms tend to converge in this area enhanced by topographic and thermal factors and give this area the greatest number of days with lows than any other area in the Northern Hemisphere (Figure 15). Another primary storm track enters the North American continent near Vancouver Island. Lows also tend to originate and redevelop in two continental areas that affect the Western Region. The first area produces the Alberta low and the second, the Colorado low.

b) Anticyclonic Activity. Migratory highs are primarily of two types: Those which originate in midlatitudes and move generally eastward, and those which originate at high latitudes and move southward. In January the midlatitude type continues to predominate since the Great Basin high (Figure 16) remains at the same level of intensity as in December. In addition, frequent outbreaks of Arctic and Polar Highs from Canada and Alaska plunge into the Midwest and occasionally cross the Continental Divide into the Intermountain Area.

3. Precipitation

a) Rain. Although the rainy season continues at a level very similar to that of December along the West Coast, there are some minor differences (Figure 17). In western Washington and western Oregon, monthly precipitation amounts decline from 1-10% in January compared to December; whereas, in California January precipitation continues to increase from 4-22% over December (Figures 18 and 19). Monthly amounts of 15-20 inches in 25 rainy days are common in western Washington and western Oregon. In California monthly amounts reach 10-15 inches in 13-17 rainy days in the coastal and mountain areas. Although rare, heavy rains of 2-5 inches can fall in the Intermountain Area valleys in mid-winter (See Paragraph c, below, Item 14).

The winter precipitation regime continues in Arizona, although monthly amounts are generally slightly less in January than in December. This difference primarily reflects the slightly lower temperatures over this area, which affects the air capacity to hold moisture.

b) Snow. Over the Intermountain Area, much of the precipitation falls as snow or rain changing to snow from major storm systems that cross the area. Two to four snowy days during the month (1 inch or more) can usually be expected. Monthly amounts do not depart significantly from December. Freezing rain and glaze remains a threat over the eastern portions of Washington and Oregon and in the Columbia River Gorge.

c) Storm and Floods. Like December, January is a major storm month. Major floods from rainy spells or rain falling on heavy snowpack do occur in the three coastal states. Some of the major floods in recent years were:

(1) January 17-21, 1953. Prolonged wet spell in Oregon with severe flooding west of the Cascades. Record flood stage on the Klamath River.

(2) January 18-28, 1969. Heavy rains over southern California resulted in major floods. Damage was estimated at $125 million in Los Angeles County, and about $10 million in the central valley. Forty-seven deaths. Monthly precipitation of 53.70" at Mt. Baldy Notch (7735 feet), about 40 miles northeast of Los Angeles. Greatest one-day precipitation of 21.61" on January 25 at Lytle Creek Ranger Station (2730 feet) near Mt. Baldy.

(3) January 8-27, 1970. Heavy rains in the Sacramento River Basin, California, with peak flooding on January 23-24. Pit River Powerhouse (1418 feet), about 20 miles southeast of Mt. Shasta, received 45.94" for the month, and Blue Canyon had record January precipitation of 33.86".

(4) January 20-21, 1972. Heavy rains over Cascades in Washington and Oregon resulted in considerable flooding. "Flood of record" on Chehalis River in Washington.

Other significant storms or weather events over the Western Region in January were:

(1) January 1, 1934. New Year's Day flood in Los Angeles County. Forty lives lost; 8.50" of precipitation in 24 hours at Pomona.

(2) January 2, 1965. Record 24-hour amount snowfall at Stevens Pass, Washington, 45"; Snoqualmia Pass, Washington, 44".

(3) January 10, 1968. Winds of 80 miles per hour at Reno, Nevada.

(4) January 10, 1962. Record highest sea-level pressure for conterminous United States at Helena, Montana, 1063.3 mb.

(5) January 11-16, 1971. Snowstorms from Washington to northern California. Eugene, Oregon, received 19"; Quillayute, 24".

(6) January 17-26, 1972. Frequent snows in Washington Cascades--158" of snow at Mt. Rainier. On January 23-25, snowstorm and blizzard conditions over the state of Washington.

(7) January 18, 1971. Temperatures reach 95° in Los Angeles--all-time January record.

(8) January 18, 1943. Temperature reached -60°, Island Park Dam, Idaho, 70 miles north-northeast of Idaho Falls--coldest ever in Idaho.

(9) January 20, 1954. Temperatures reached -70° at Rogers Pass, Montana, 50 miles southwest of Great Falls--a record for conterminous United States.

(10) January 20, 1972. Record 24-hour snowfall at Summit Mountain, Montana (5233 feet), with 44 inches.

(11) January 21-24, 1964. Heavy snows and high winds culminated in one of the worst avalanche periods for the Wasatch Mountains, Utah. During this period, 51 inches of snow fell in the mountains. (See Section 9 on avalanche patterns.)

(12) January 21-29, 1969. Period of damaging wind storms in northwest Utah.

(13) January 22-24, 1971. Heavy snows in Washington Cascades with 58" in two days and 104" in four days on Mt. Rainier.

(14) January 29-February 2, 1963. Heavy precipitation in northern Utah. The unusual factor was that precipitation was in the form of rain. Storm total of 10.13" at Deer Creek Dam, 30 miles southeast of Salt Lake City (5.08 inches in 24 hours).

(15) January 29, 1921. Great Olympic "blow-down" along Oregon and Washington coasts with deep low and hurricane-force winds.

(16) January 30-31, 1968. Rain and snowstorm in California Sierra. Six feet of snow in 48 hours near Donner Pass, heavy rains, and some flooding at lower elevations.

(17) January 1969. Coldest month on record in portions of Montana, northern Idaho, Washington, Oregon, and northern California. Seasonal snowfall in northern Sierra, Cascades, and Wasatch Mountains, Utah, at record to near-record amounts.

January 15-31. Severe Arctic weather across northern portion of Region. Major floods in southern California.

(18) January 1972. No precipitation entire month at Los Angeles--driest in 72 years.

(19) January 1973. Only a trace of precipitation for month at Havre, Montana--a 93-year record.

4. Temperature

January temperatures show a decline of another 3-5 degrees (4-7° in Montana) over December. In Montana subfreezing daytime temperatures can be expected on 15-25 days, and subzero weather on 7-20 days. Subzero weather can also be expected in the Intermountain Area, with expected frequency ranging upward to 7 days. Southern California and southern Arizona continue with mild temperatures--daytime readings in the 60s and nighttime readings in the upper 30s and 40s.

5. Aviation Weather

a) General Weather. January continues the pattern established in December of similar weather and related aviation hazards. Thus, on the average, January is another poor month for aviation over most of the Region.

Storminess continues its southward trek across the Region during the month with increasing precipitation occurrence over the central and southern sections. Arctic outbreaks continue to be a major problem over the northern portion of the Region.

b) Fog. Daylight shows a slow increase during January; but since there is still a near minimum in solar insolation, fog continues to be a major aviation problem at most valley locations in the Region. The interior valleys of California, Oregon, and Washington still show a high number of fog days with associated low ceilings and visibilities during the month. Any development of the Great Basin High will increase the fog problem over the Intermountain Region. Some decrease in fog continues along the Pacific Coast as the jet stream drops southward.

c) Examples. The following are a few comparisons between December and January at a number of Western Region airports:

WASHINGTON	Olympia, Seattle:	Trend of a small decrease in heavy fog occurrence, but a continuation of frequent low ceilings and visibility.
	Spokane, Yakima:	Second wettest and second foggiest month.
OREGON	Portland:	Month with lowest ceilings and visibilities.
	Medford:	Fog problem continues.
MONTANA	Great Falls, Helena:	Arctic outbreaks, upslope conditions of low ceilings and visibilities. Chinook winds still a problem.
	Glasgow, Miles City:	Frequent Arctic outbreaks.
IDAHO	Boise:	Second foggiest month; month with lowest ceilings.
	Pocatello:	Foggiest month; month with lowest ceilings.
	Lewiston:	Worst month for flying locally.
NEVADA/UTAH	Salt Lake City:	Foggiest month.
	Reno, Elko:	Wettest month; month with lowest ceilings.
ARIZONA	Phoenix, Tucson, Winslow:	Month with lowest ceilings; increased threat of winter storms.
CALIFORNIA	Bakersfield:	Continuation of poor visibilities; second worst fog month; month with lowest ceilings.
	Burbank, Los Angeles:	Increasing precipitation occurrence; mild Santa Anas possible.
	Fresno, Sacramento:	Frequent low ceilings and visibilities due to fog; month with lowest ceilings.
	Red Bluff:	Second poorest month for VFR flying locally.
	Santa Maria:	Lowest fog month, but wettest month due to Pacific storms.

6. Marine Weather

a) Swells. In January the primary storm tracks continue along the Aleutian Chain and across the Gulf and Alaska (See Figure 15). These tracks are displaced one to three degrees of latitude farther south than in December. Consequently, swells generated by these storms are present farther south along the West Coast than they were in December.

Swells from the fetch between the Aleutian Low and the eastern Pacific High (See Figure 16) are propagated to the West Coast of North America from the San Francisco Bay Area northward. It is interesting to note in comparing the mean December and January surface charts that even though the Aleutian Low is near its peak development, its position is farther west so that the mean gradient in the eastern Pacific between 40°N and 50°N decreases in January. In the mean, therefore, we would expect swells to be a little lower in January than in the preceding month.

The winter sea-height charts presented in last month's climatological Technical Attachment, TA 73-42 (Figures 17-19), apply to January.

b) Coastal Weather. The climatology of coastal stations indicates that wind speeds along the Oregon and Washington coasts reach their maximum in January. Mean cloud cover north of Cape Mendocino decreases in January while it increases to the south.

7. Agriculture

Meteorological support to frost-protection activities continues into January in the great valleys of California through southern California into western Arizona. Grapefruit and navel oranges are maturing and being harvested. Lemons and Valencia oranges are increasing in size and showing some color. Critical temperatures for various fruit crops were given in the December Technical Attachment. Nursery stock can sustain considerable damage due to extremely cold temperatures of long duration. It is important to highlight the outbreak and threat of extremely cold temperatures following above-normal conditions.

8. Air Pollution

Again this month the predominant feature is the Great Basin High. Figure 16 indicates the mean surface pressure pattern with the anticyclone center over southern Idaho. Following December with the shortest days and longest nights of the year, January shows a small increase in the amount of daylight. Nevertheless, in moderate-to-strong anticyclones where stagnation predominates, there is still a net radiational loss at night. Pollution build-up and fog episodes develop rapidly under these stable conditions.

Santa Ana conditions in southern California continue to a maximum from December into January, with offshore gradients and meteorological parameters conducive to minimum air pollution.

9. Avalanche Patterns

a) Storm Characteristics. In TA 73-42, there were listed 10 storm characteristics used by the U. S. Forest Service in avalanche forecasting. It was stated that in most cases, the probability of avalanche release tends to increase as temperature decreases. In the Cascades of Washington and Oregon and the Sierra Nevada of California, however, increased instability can result with increased temperature. A fall of "wetter" snow on top of a dry snow is very unstable.

In considering temperature trends during a snowstorm, it has been found that a progressive decrease in temperature often promotes stability, while rising temperature has a converse effect.

b) Example. One of the worst avalanche periods in recent years in January for the Wasatch Mountains occurred during January 21-24, 1964. Throughout November and December, the snow cover was shallow with many periods of fair weather. This led to extensive "depth hoar" formation. Snowstorms of early mid-January brought extensive avalanching due to the fragile depth hoar layer. (Depth hoar is induced by a steep temperature gradient within the snow cover. The crystals are of different character than the original snow and often are cup-shaped and layered. Cohesion is very poor between crystals.)

A period of high winds, reaching 50 to 60 mph, preceded the storm on the 20th and 21st of January. Precipitation began early in the afternoon of the 21st with the arrival of a strong cold front. Snow began to fall again the night of January 21-22, reached its highest intensity on the morning of the 22nd, and continued to fall throughout that day. A total of 51 inches of snow fell during this storm.

By the morning of the 24th, the situation for avalanches had reached the critical point. Control measures were initiated, and over 20 avalanches were triggered in the Alta area by firings from a 75mm howitzer.

10. Satellite Meteorology

A summary of mean cloud cover for January at 1400 LST is shown in Figure 21. (See Figure 38 in WR Technical Attachment No. 73-42 for comparison.) In these figures, the darkest shade (black) is 0 Octas ranging to a pure white shade, or 8 octas cloud cover. These cloud-cover-depiction photos give mean values for a four-year period from 1967 to 1970. The satellite photo suggests that at 1400 LST the instantaneous view gives greater than 4 octas of sky cover mainly over areas north of 40°N latitude and mountains. Since these were obtained by computer processing of reflectance in the visible spectral range, some contamination is unavoidable. Most of the reflectance values from snow cover were screened out; however, some were retained. (Note brighter area over Sierra Nevada.) The brighter values normally obtained from desert topography remained and are included in the satellite cloud-cover depiction.

REFERENCES:

[1] AUGULIS, RICHARD P., "Precipitation Probabilities in the Western Region Associated with Winter 500-mb Map Types". NWS WR 45-1, December 1969.

[2] REX, D. R., Tellus, Vol. 2, No. 3, 1950.

[3] Western Region Technical Attachment, No. 73-42, December Weather Patterns, November 27, 1973.

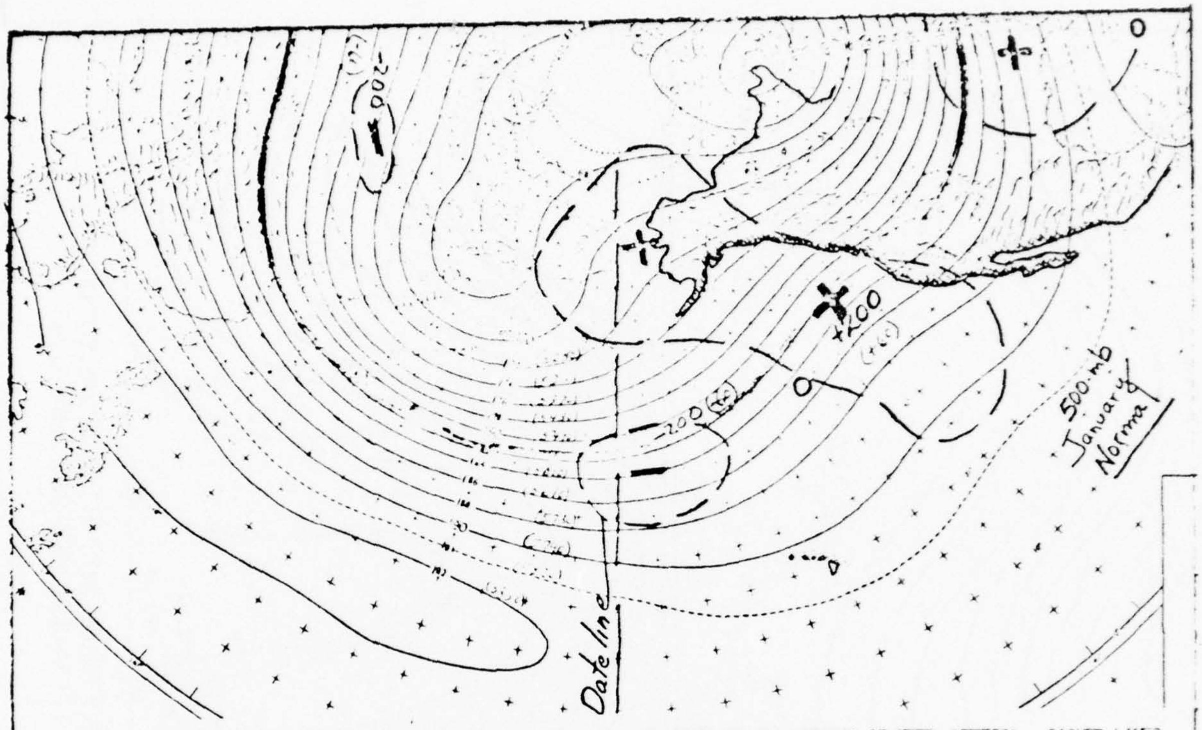


FIGURE 1. MEAN 500-MB HEIGHT FIELD FOR JANUARY. SOLID LINES ARE CONTOURS IN HUNDREDS OF FEET (METERS). DASHED LINES INDICATE CHANGES IN FEET (METERS) FROM DECEMBER TO JANUARY.

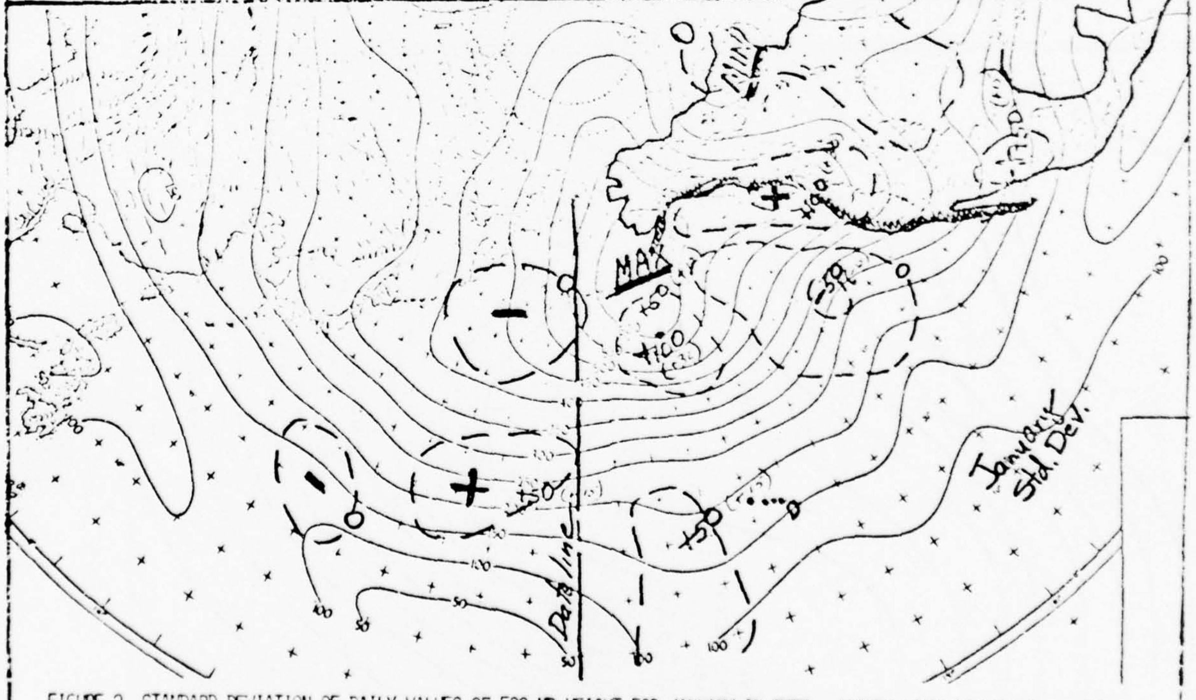


FIGURE 2. STANDARD DEVIATION OF DAILY VALUES OF 500-MB HEIGHT FOR JANUARY IN FEET. DASHED LINE INDICATES CHANGES IN FEET (METERS) FROM DECEMBER TO JANUARY.

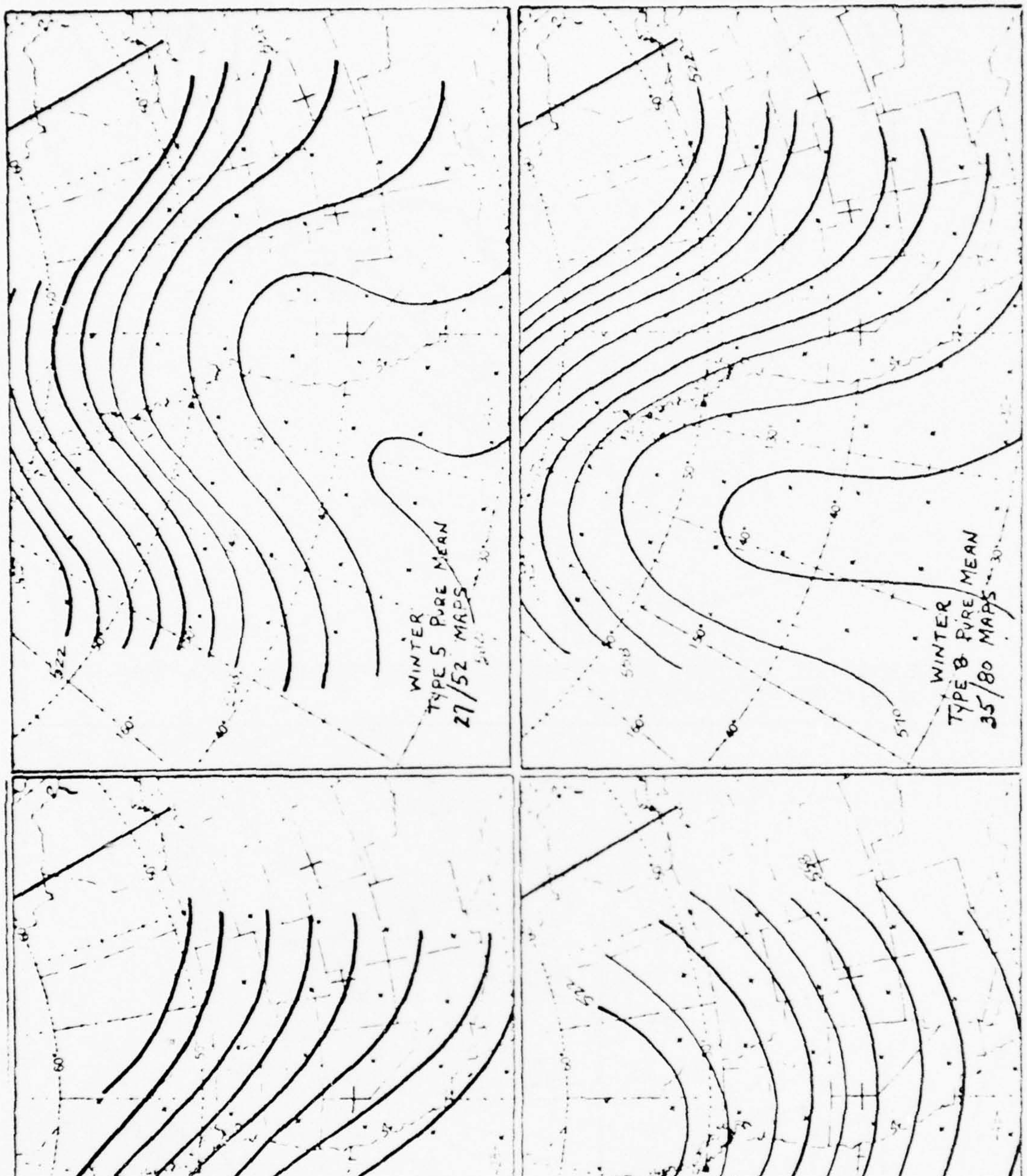


FIGURE 3. WESTERN REGION 500-MB TYPE MAPS. FRACTION IN LOWER LEFT CORNER INDICATES NUMBER OF TIMES THE TYPE OCCURRED IN JANUARY COMPARED WITH THE TOTAL NUMBER OF TIMES THE TYPE OCCURRED IN THE WINTER SAMPLE. TYPE 12 (NOT SHOWN) IS SIMILAR TO TYPE 6 AND OCCURRED 17 OUT OF SAMPLE OF 26.

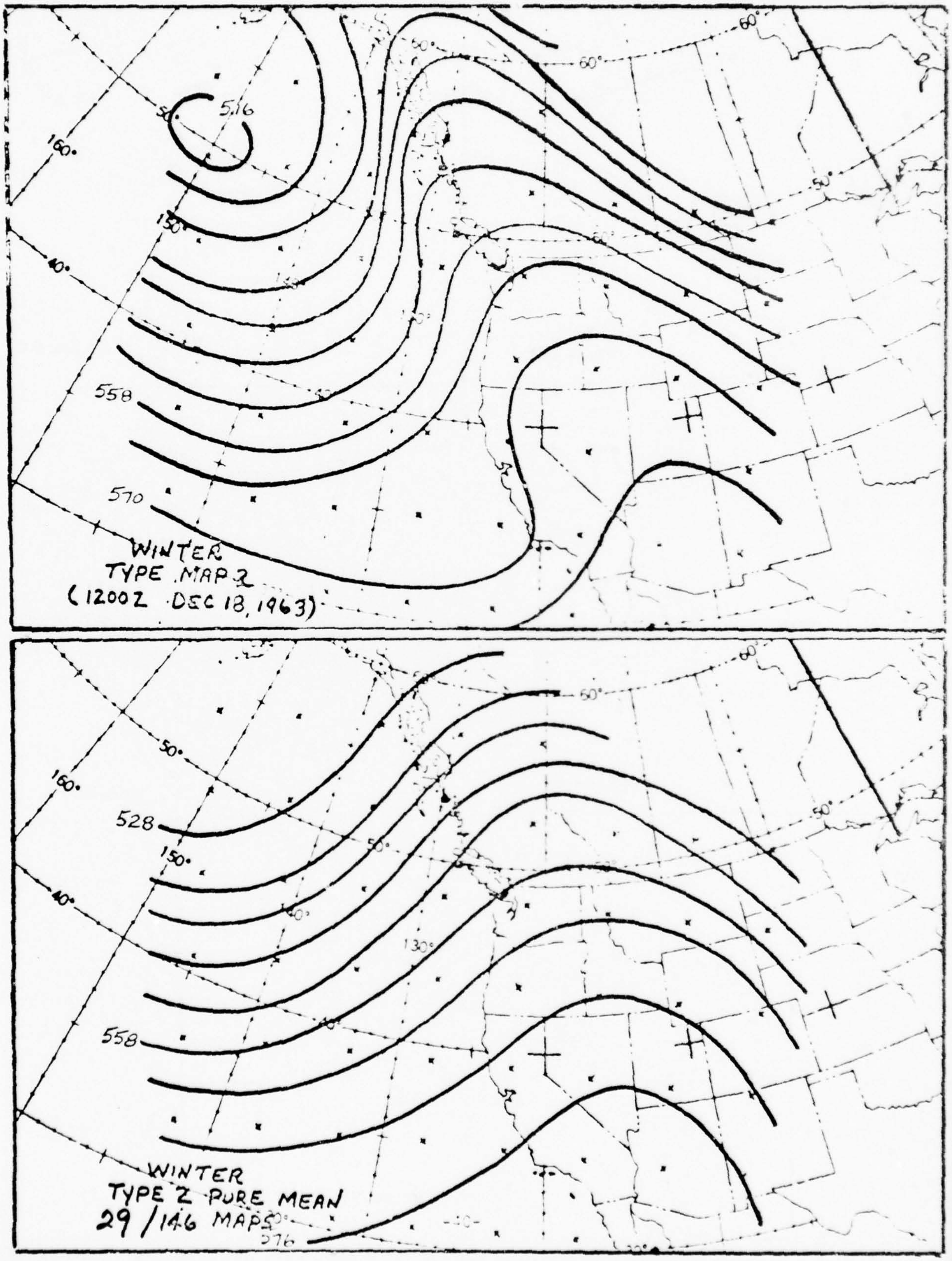


FIGURE 4. TYPE LEAST OBSERVED IN JANUARY OF WINTER TYPES OCCURRING MORE THAN 50 TIMES IN STUDIED SAMPLE.

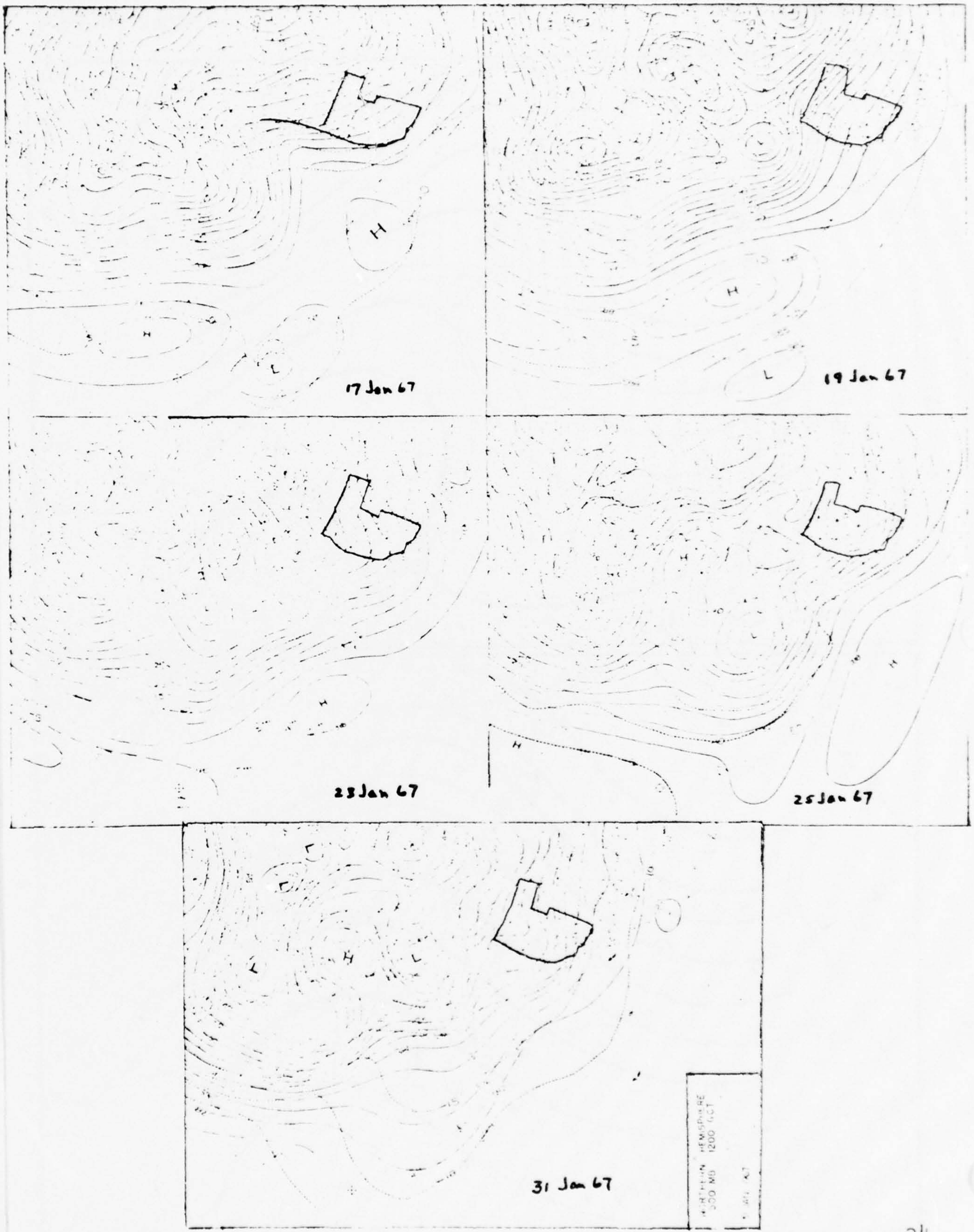


FIGURE [illegible]. PERSISTENT BLOCKING PATTERN JANUARY [illegible] 1967. REPRESENTATIVE FLOW PATTERNS DURING THE PERIOD ARE SHOWN. JANUARY [illegible] IS THE FLOW PRECEDING DEVELOPMENT OF BLOCK.

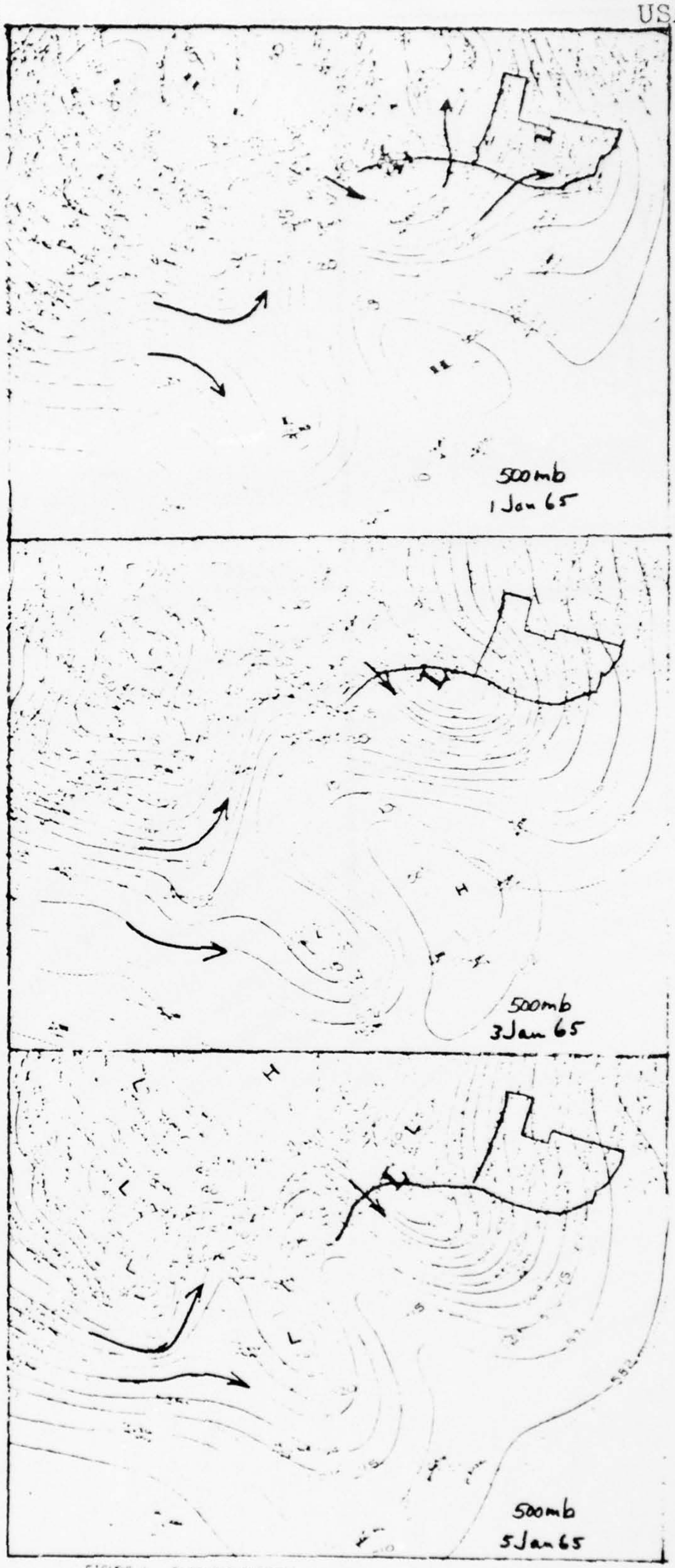


FIGURE 6. BLOCKING PATTERN JANUARY 1 - 5, 1965, ILLUSTRATING CONTRIBUTING ROLE OF NONADIABATIC HEATING IN GULF OF ALASKA.

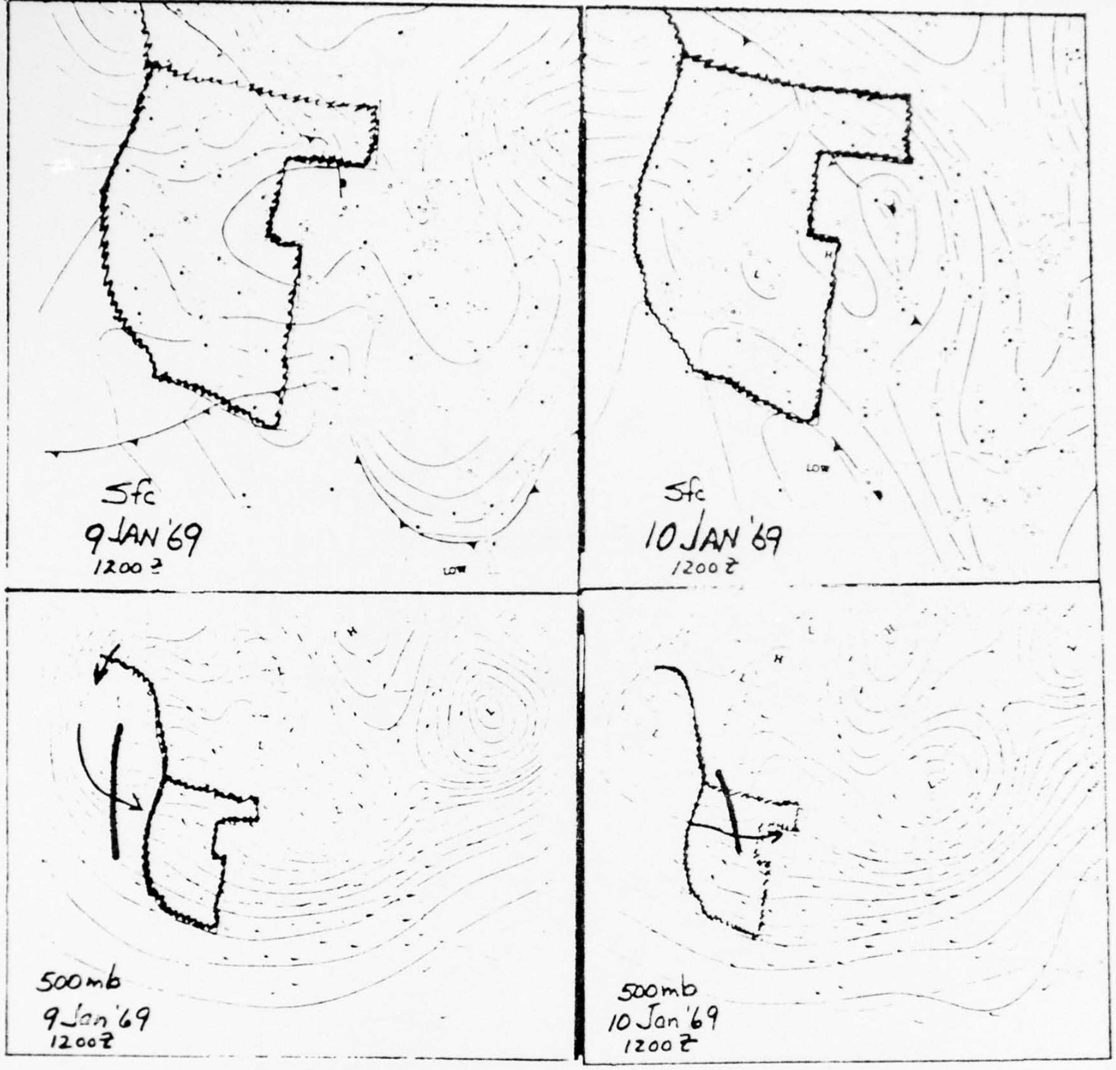


FIGURE 7. NONDEVELOPING NEGATIVE-TILT DIFLUENT TROUGH--JANUARY 9 - 10, 1969.

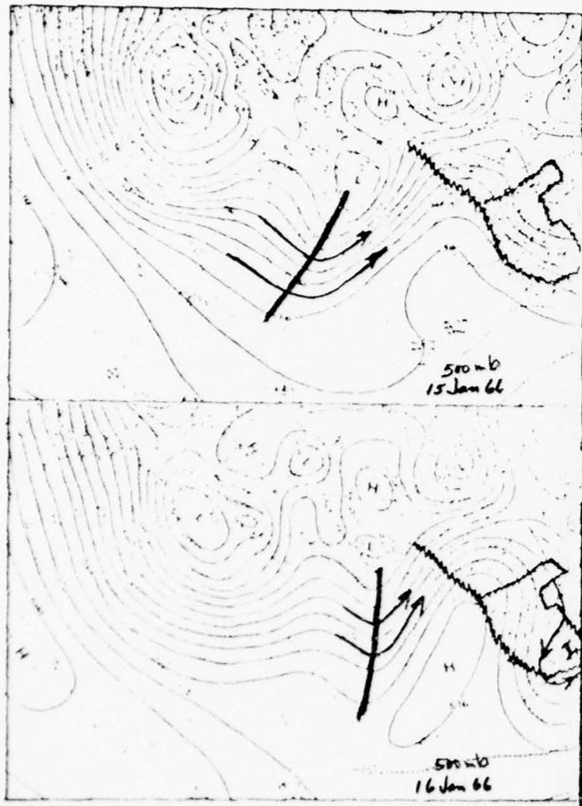


FIGURE 8. NONDEVELOPING CONFLUENT TROUGH--JANUARY 15 - 16, 1966.

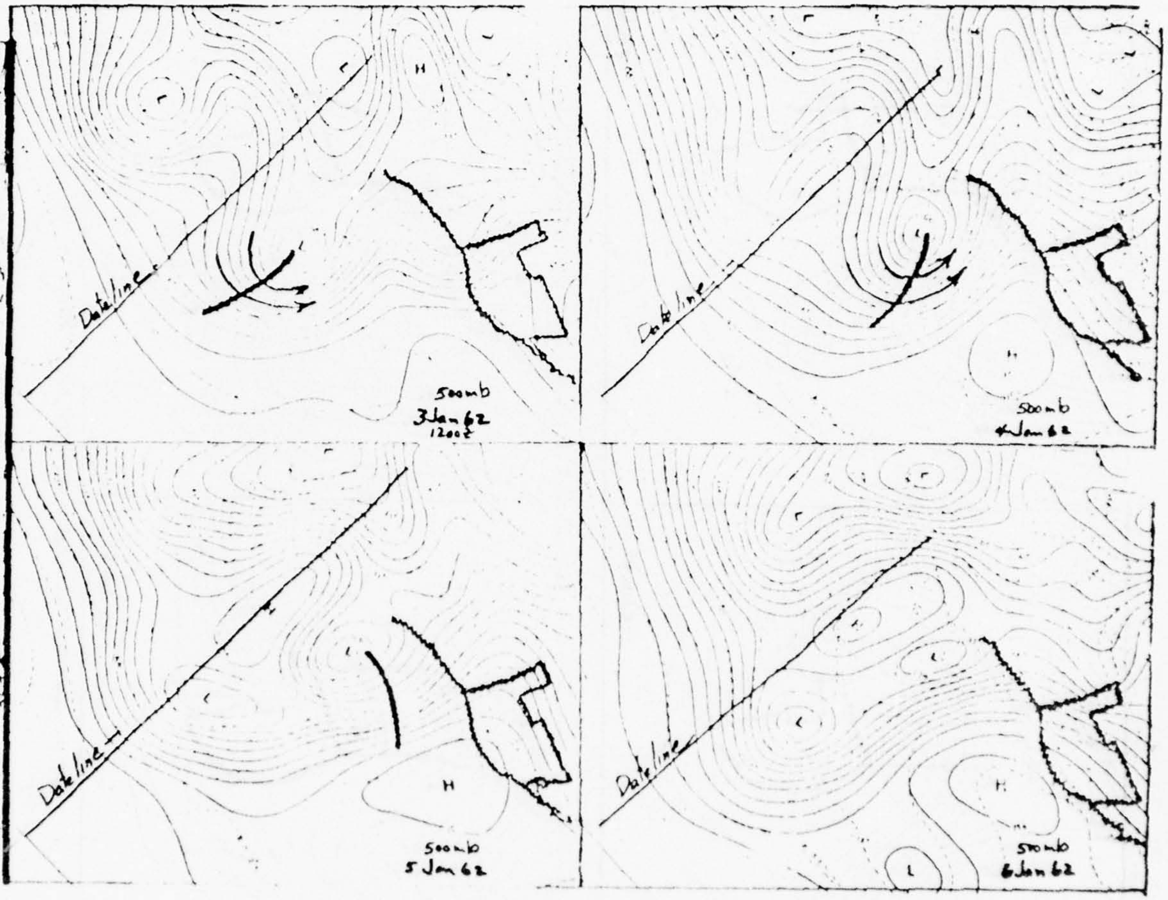


FIGURE 9. CONFLUENT TROUGH ASSOCIATED WITH REGRESSION--JANUARY 3 - 6, 1962.

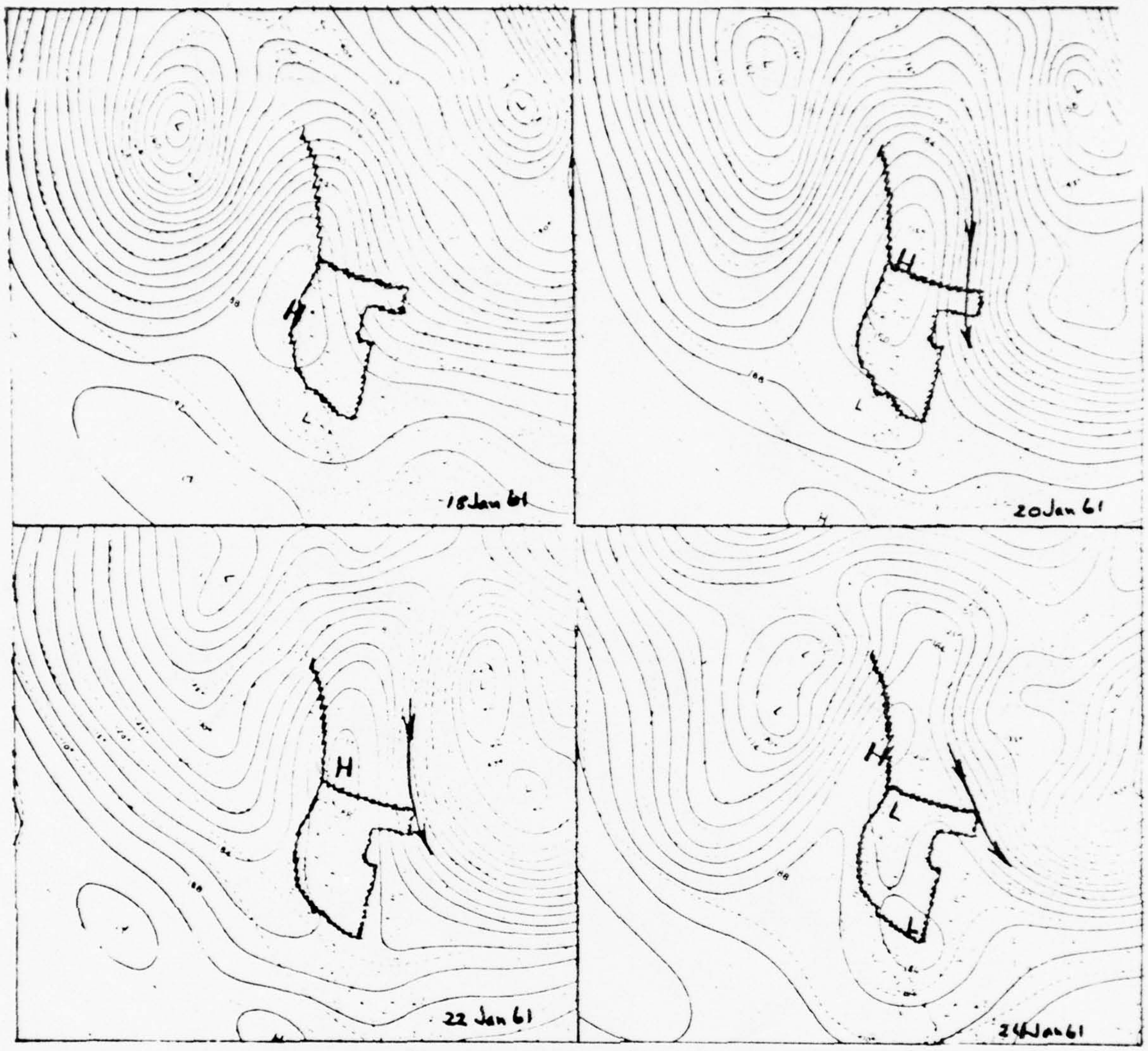


FIGURE 10. DOWNSTREAM TROUGH BLOCKS WEST COAST RIDGE--JANUARY 18 - 24, 1961.

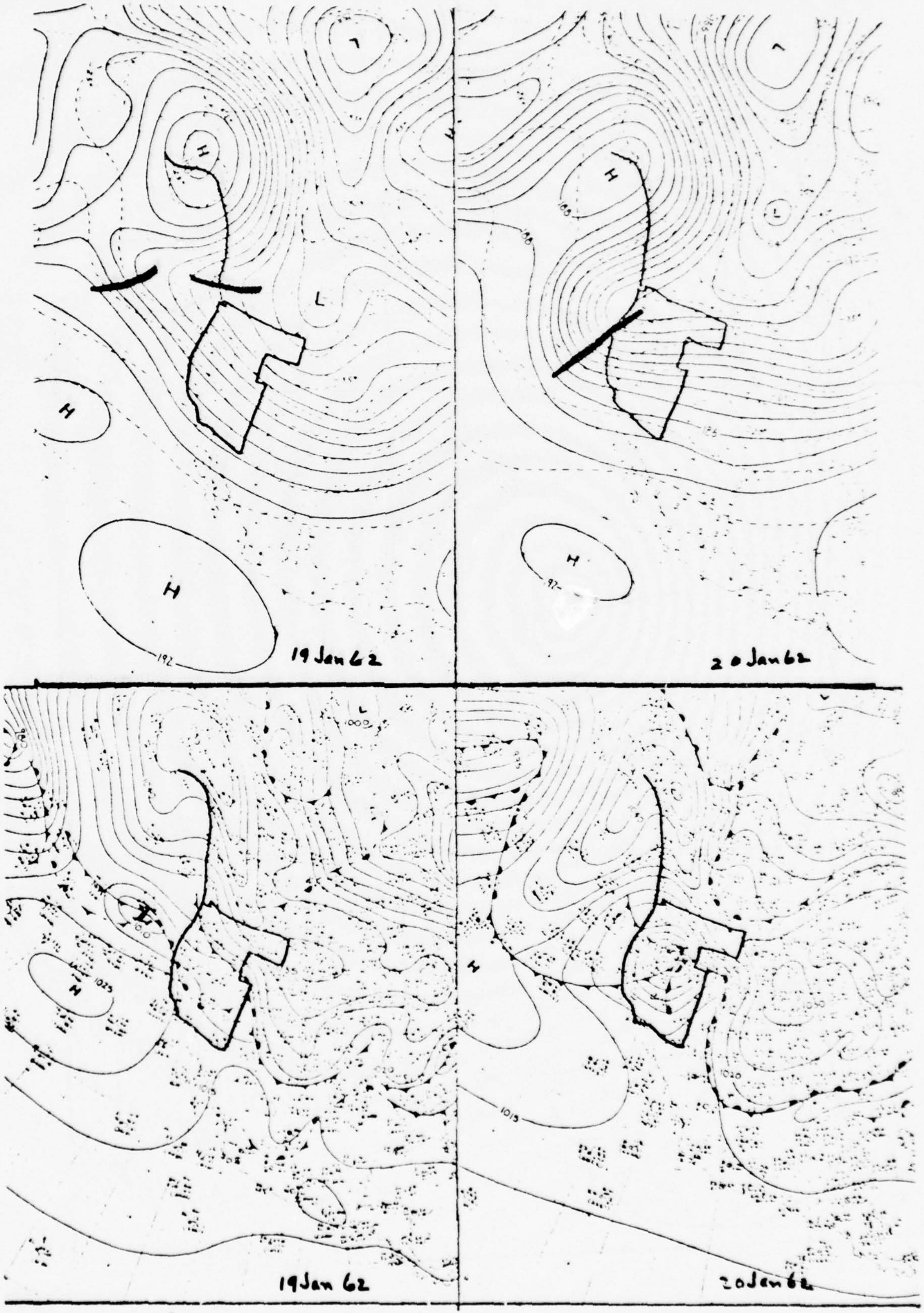


FIGURE 11. HEAVY RAIN PACIFIC NORTHWEST--JANUARY 19 - 20, 1962.

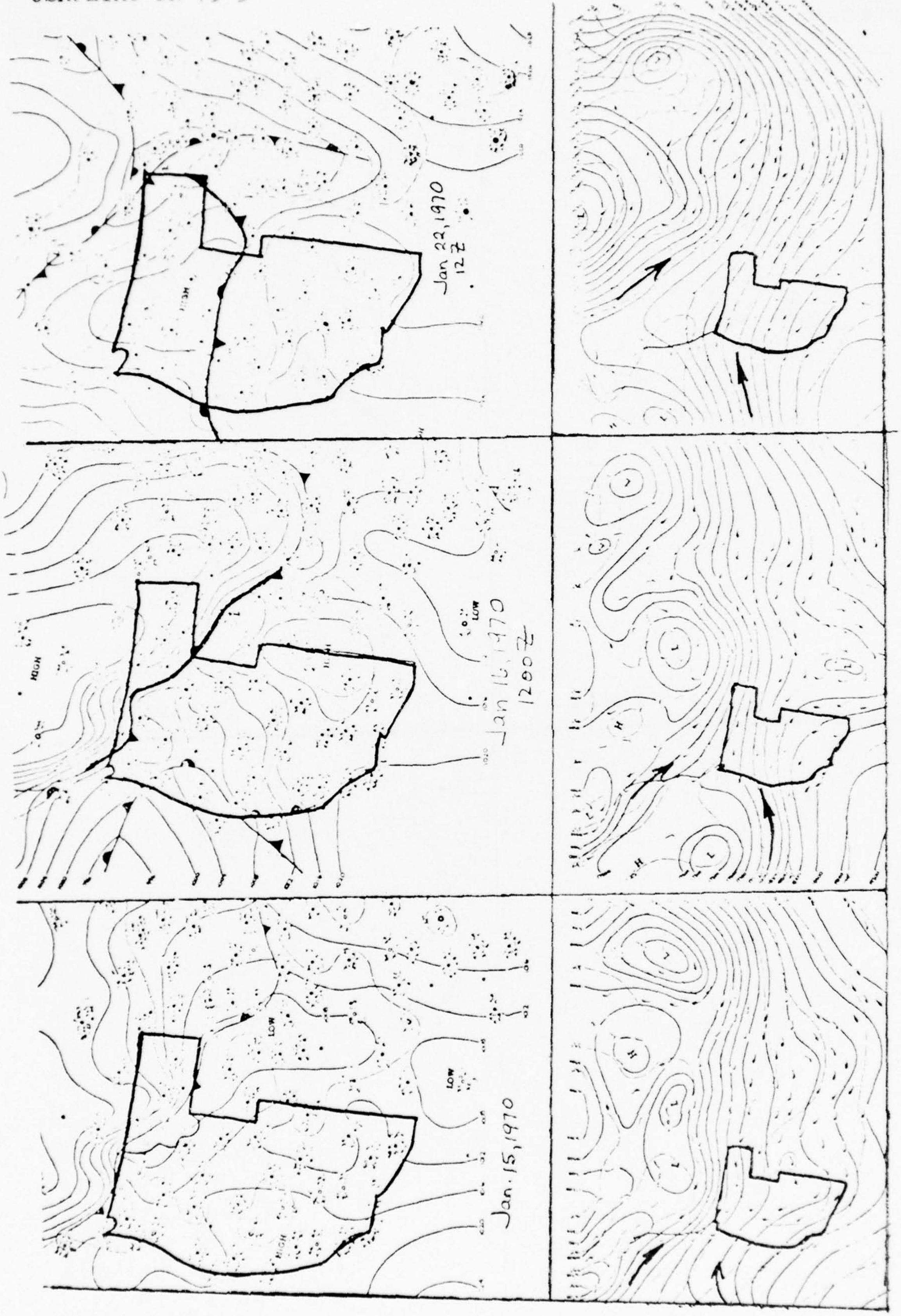


FIGURE 12. HEAVY RAIN SITUATION FOR NORTHERN CALIFORNIA--JANUARY 15 - 22, 1970.

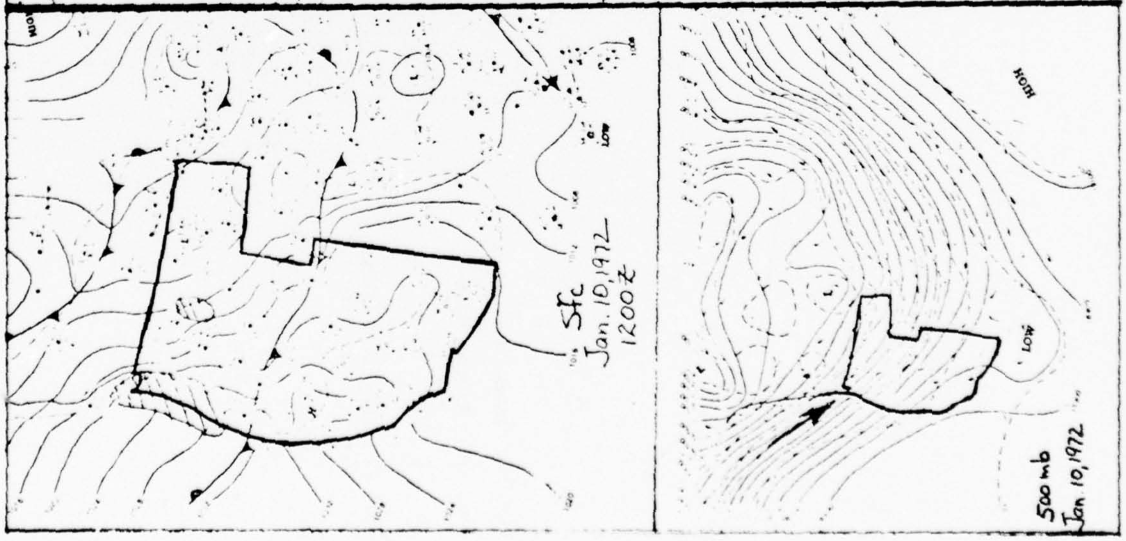


FIGURE 13. DIRTY RIDGE: HEAVY RAIN AND SNOW IN WEST-NORTHWEST FLOW IN WASHINGTON AND OREGON, JANUARY 10, 1972.

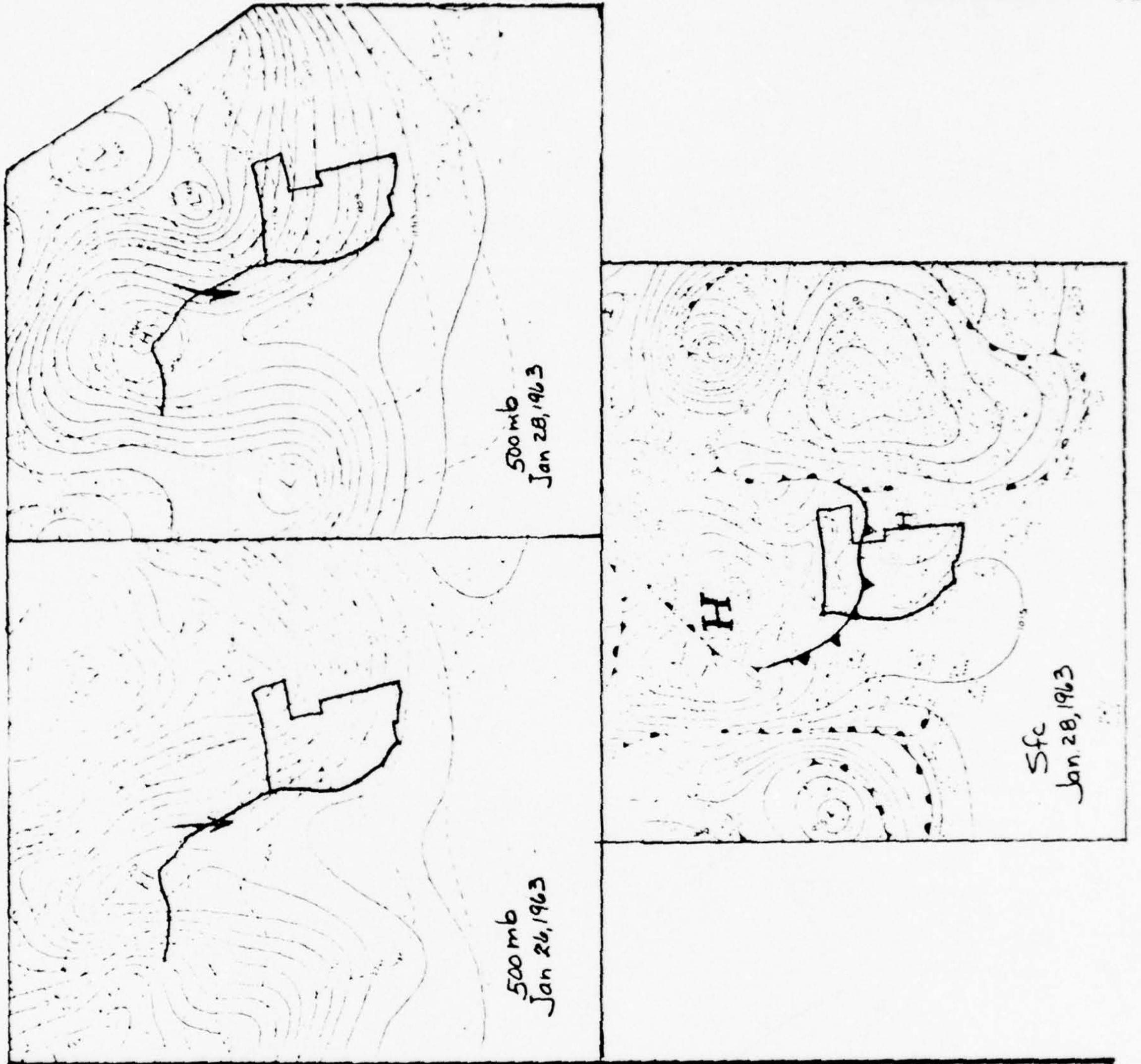


FIGURE 14. ARCTIC AIR WEST OF MOUNTAINS--JANUARY 26-28, 1963.

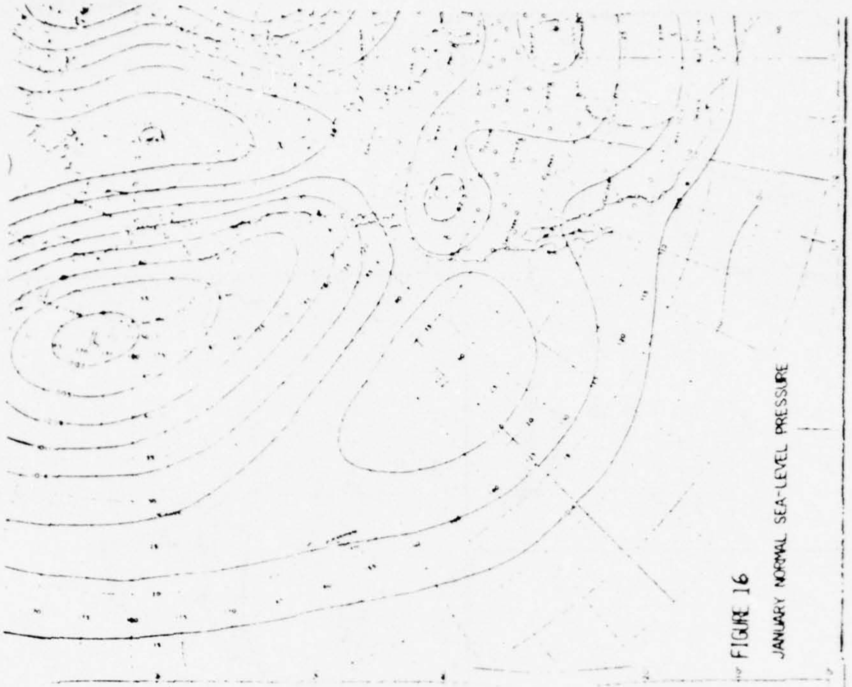
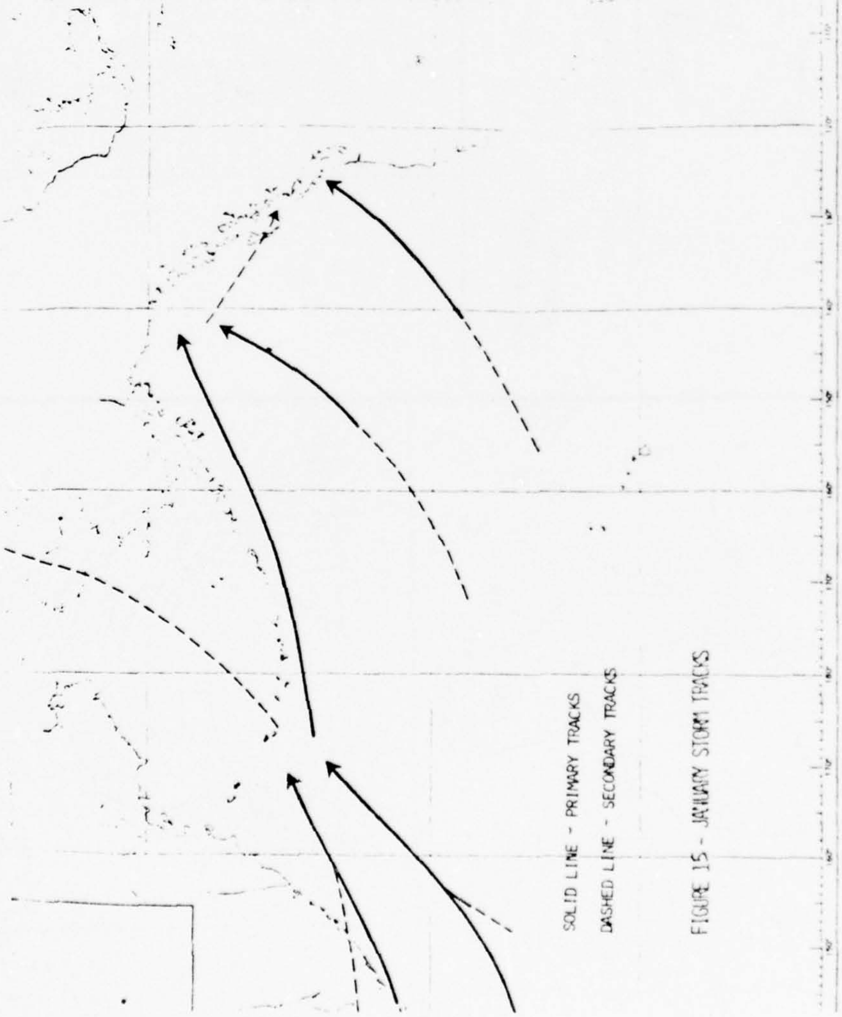


FIGURE 16

JANUARY NORMAL SEA-LEVEL PRESSURE



SOLID LINE - PRIMARY TRACKS

DASHED LINE - SECONDARY TRACKS

FIGURE 15 - JANUARY STORM TRACKS

FIGURE 17

JANUARY PRECIPITATION NORMALS BY DIVISIONS
1941 - 1970

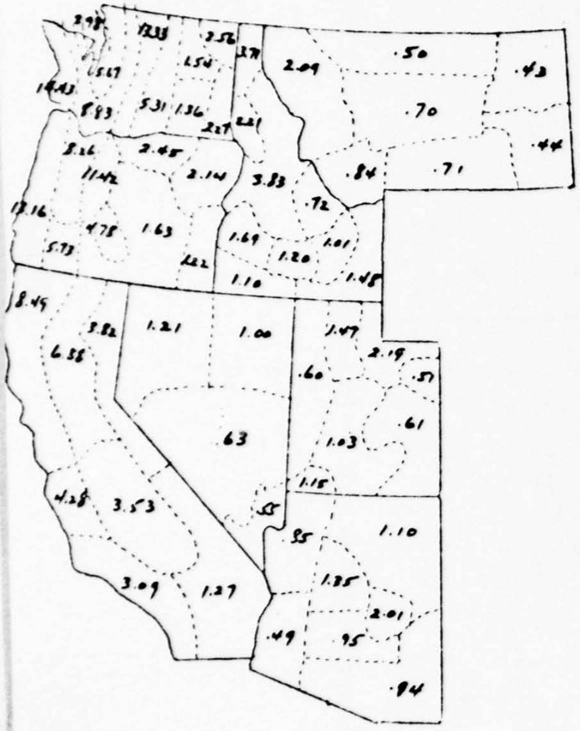


FIGURE 18

COMPARISON OF NORMAL PRECIPITATION, JANUARY vs DECEMBER
SHOWN AS PERCENT (JANUARY/DECEMBER TIMES 100)

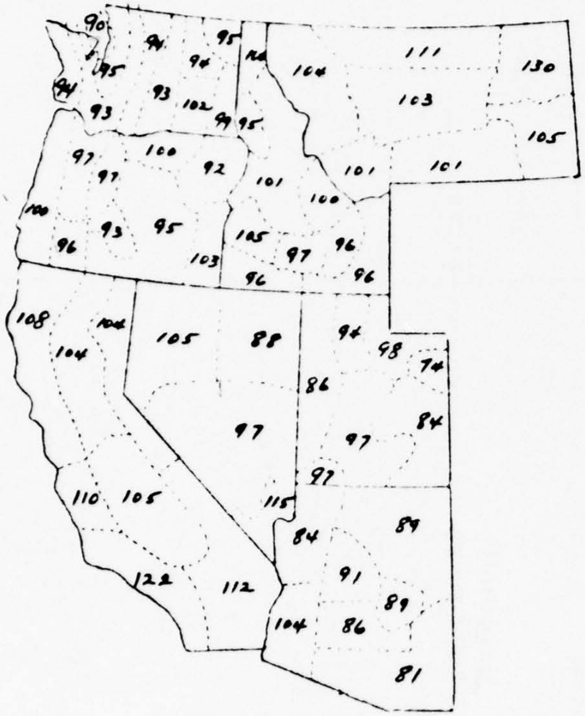
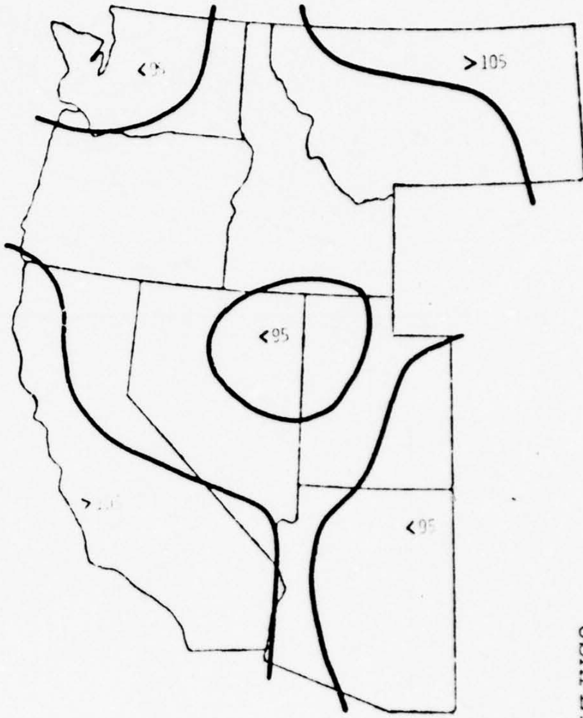
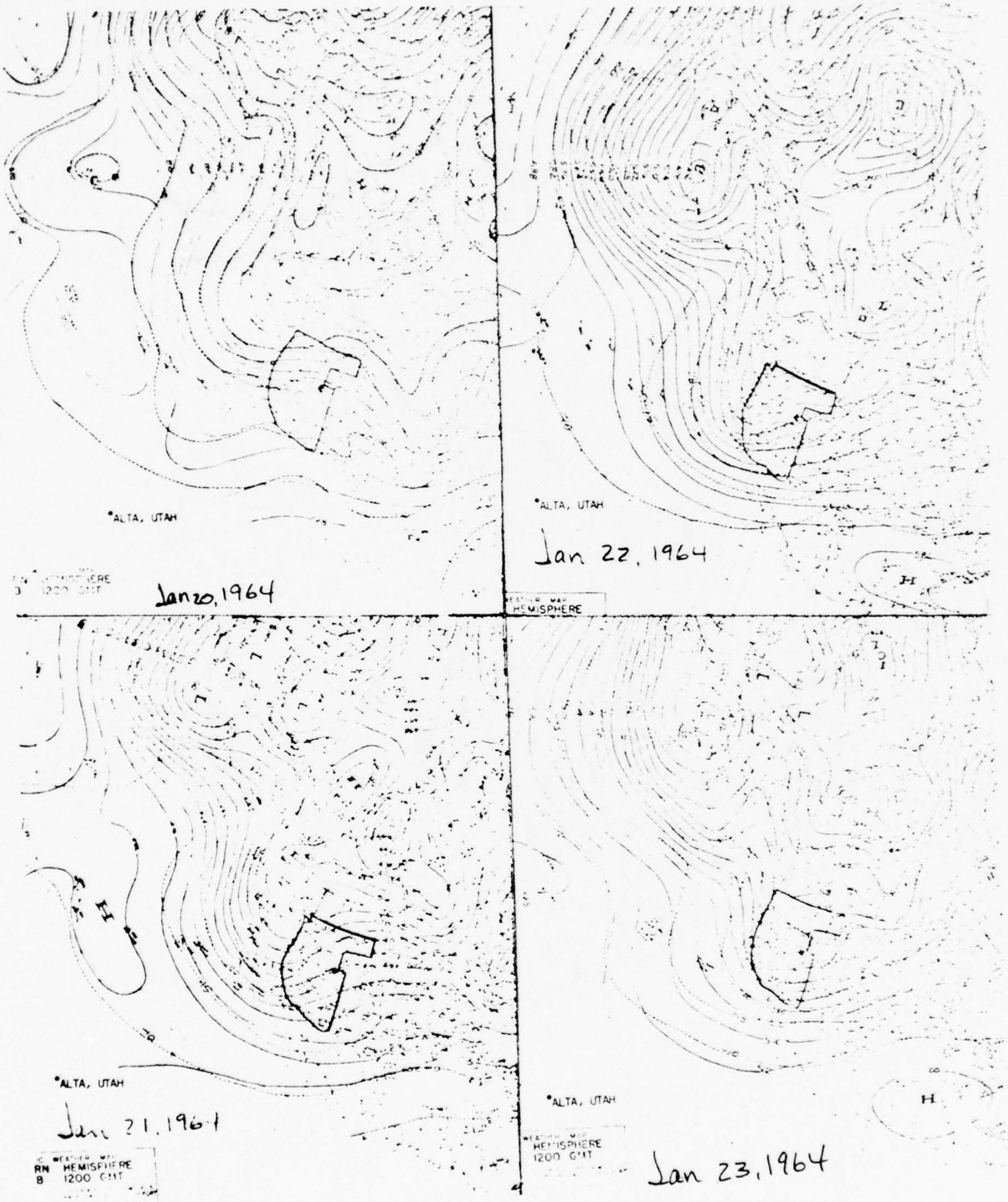


FIGURE 19

ANALYSIS OF FIGURE 17





Jan 20, 1964

Jan 22, 1964

Jan 21, 1964

Jan 23, 1964

FIGURE 20. 500-MB CHARTS FOR JANUARY 20 - 23, 1964, SHOWING CONDITIONS PRIOR TO AVALANCHES IN WASATCH MOUNTAINS, UTAH.

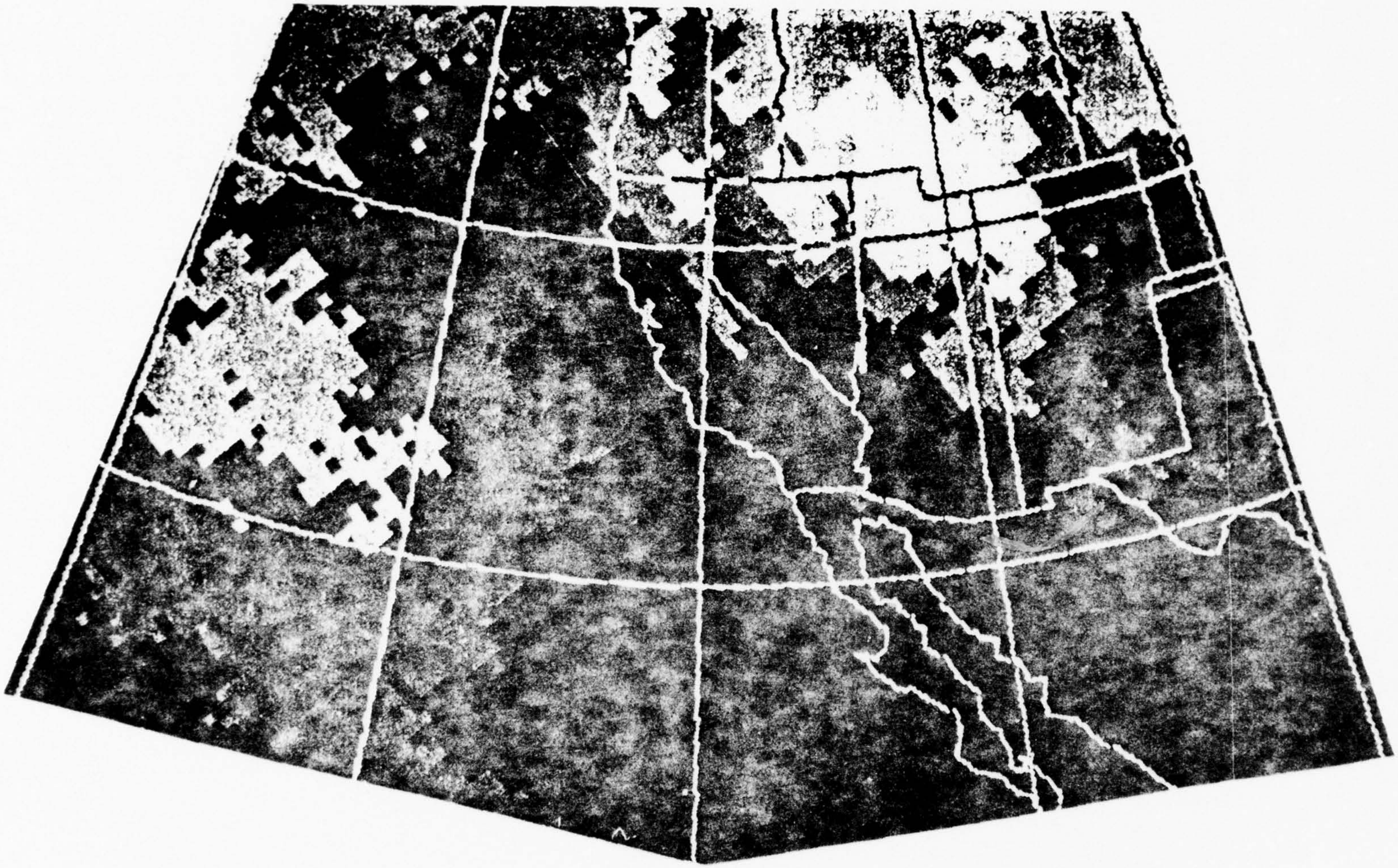


FIGURE 21. JANUARY MEAN CLOUD COVER AT 1400LST, IN OCTAS (1967-1970).

WESTERN REGION TECHNICAL ATTACHMENT
January 22, 1974
No. 74-3

FEBRUARY WEATHER PATTERNS

February is a stormy month similar to January. However, toward the end of the month there are some signs of spring arriving as blocking patterns increase in frequency and mean temperatures begin rising. February is 10% shorter than January. This affects monthly statistics, *and when not taken into account can give* the wrong impression regarding increases or decreases of phenomena from January to February.

1. Upper Air

a) Normal Patterns. Normal February 500-mb flow is given in Figure 1. The changes from January (dashed lines) *are very small.* The day-to-day variability of 500-mb heights (Figure 2) also changes very little.

b) Predominant Circulation Types [1]. Zonal type #1 occurred most frequently, 98 times out of a winter sample of 356. This type usually persisted only a day and therefore must be considered a transitional type in February. The most predominant February types were those involving a ridge off the coast, i.e., *types* 3, 7, 8, and 9. Type 9 is given in Figure 3. These types are quite persistent once established.

The least frequently observed types are those involving a trough over the region or along the coast. Type 6 given in Figure 4 is an example, occurring only 11 times in 64 winter cases; and type 14 (not given) occurred only 17 in 98 cases.

These trough types are transitional except when associated with blocking situations.

c) Specific Examples of Significant February *Developments.*

(1) Blocking. Rex-type blocking patterns [2] are on the increase climatologically during February (see Figure 5a). The longitude of the block (i.e., the split) is most frequent around 150°W (see Figure 5b). Obviously, this year the frequency of blocking can't increase much--if at all--as a blocking pattern existed through most of January 1974. *However, it is a pattern* that should always be kept in mind over the next four months, because it is so persistent (usually lasting 10 days or more). This persistence often results in a week or more of abnormal weather. A recent example was the devasting rains of the Pacific Northwest in January 1974.

Much of February 1963 was characterized by blocked flow (note Figure 6). *Split flow (confluent)* persists over eastern Pacific through the 7th, and a ridge persists over the region through the 13th. The rather strong trough approaching the West Coast on the 6th is reduced to a small indentation of this ridge by the 7th. Cut-off developments as shown from the 7th to 9th in vicinity of 135W are typical in blocked flow. February 1963 was one of the warmest Februarys on record.

Figure 7, February 19-21, 1962, shows one of the typical beginnings of a blocking pattern. The PE model usually forecasts this type of development.

One problem with handling blocking patterns is that we try to terminate them too soon. Climatology says that if a block persists for 3 days, there is an 80% chance it will last for 10 days or more. Figure 8 is an example. On the 14th it looks as if the westerlies are consolidating only to have the block (i.e., split) reappear on the 16th. The map of the 14th is somewhat similar to the 19th (Figure 7).

It is wrong to believe that rapid cyclogenesis will not take place in blocked flow. February 14-16, 1959 (Figure 9), shows explosive cyclogenesis off the West Coast during blocking. Satellite pictures probably give the best indications of such rapid developments.

(2) Difluent Troughs. Previous monthly weather pattern discussions have called attention to the development of negative-tilt difluent troughs. A good February example is Figure 10 (February 8-10, 1965). The difluence (i.e., spreading of the contours downstream) is probably more important than the tilt, at least in winter. Note the development of a positive-tilt difluent trough in Figure 11 (February 12-13, 1964) and zero-tilt difluent trough in Figure 12 (February 28-29, 1964).

(3) Retrogression. Long-wave discontinuous retrogression is an important development to look for all months of the year. The weather consequences are especially important in winter. The case of February 17-19, 1960 (Figure 13), is of special importance when compared with the 1963 blocking regime given in Figure 6. In 1963 the troughs approaching the West Coast weakened as they moved inland. In contrast, the 1960 trough intensified. The clue to the difference was the retrogression of the long-wave trough in 1960 from around 175E on the 17th to 150E on the 19th. The trough at 135W on the 17th subsequently deepened and retrogressed the North American long-wave trough with strong cyclogenesis over the Western Region.

(4) Strong-Wind Situation. Damaging strong winds in Washington, Oregon, and Montana are often associated with a short-wave trough moving through a stationary long-wave ridge; a situation when you don't normally look for damaging weather phenomena. Figruary 15-16, 1972 (Figure 14), is an example. Gusts to 88 mph were observed at Seattle, with 114 mph at Richland, Washington; and 82 mph at Havre, Montana. Another example is February 10, 1971 (Figure 15). Wind and dust storms occurred in eastern parts of both Washington and Oregon on the 10th.

Strong canyon winds in Utah are common occurrences in February when closed-low situations develop such as given in Figure 16 (February 19-20, 1971). Note the development of this closed low was associated with a negative-tilt difluent trough.

2. Surface

a) Cyclonic Activity. In February the westerlies at low latitudes are normally stronger than during any other month. This feature can be associated with the presence of a secondary storm track from the eastern Pacific across northern California into Nevada (Figure 17). Other storm tracks in February are quite similar to the January patterns with maximum cyclonic activity in the Gulf of Alaska. The Aleutian low is not quite as deep as in January, and is displaced about 5° eastward (Figure 18).

b) Anticyclonic Activity. The principal anticyclonic tracks for February closely resemble those for January in all parts of the Northern Hemisphere. The Great Basin high which had been so well established from November through January now weakens considerably. This high (Figure 18) is now replaced by a col area on the February mean sea level pressure chart.

3. Precipitation

February precipitation over most of the Region is less than in January (Figure

19). The main exception to this pattern is in southern California, where some locations--Bakersfield, Sandberg, Santa Maria, for example--show that February is the wettest month of the year. If February precipitation were normalized for 31 days like January instead of 28 days, about 17% of California locations would show a February maximum. Over the Pacific Northwest, February precipitation is 70-75% of January; the number of rainy days is generally reduced by 3-4 days as compared to January. In eastern Montana, February is the driest month of the year--detailed comparison of February precipitation with January is given in Figures 20 and 21.

a) Snow. Much of the precipitation of the Intermountain Area continues to fall as snow or rain changing to snow. The mountain areas continue to receive appreciable snow to add to their seasonal snow pack.

b) Storms and Floods. February is a major storm month, much like January. Early spring winds and duststorms in the Columbia Basin of Washington and Oregon make their first appearance in February. February marks the first month when funnel clouds are reported in southern California and southern Arizona, and waterspouts just offshore of southern California. Flooding--due to ice jams from rain falling on snow pack and/or the frozen ground, etc.--becomes more common in February. Some of the major floods in recent years were:

(1) February 22-24, 1973. Flooding--rapid snowmelt in Arizona mountains resulted in flooding over Gila River basin.

(2) February 4-15, 1973. Heavy rains, winds, and floods in southern California. Most damaging on 10th and 11th. Numerous mud and earth slides. Trees uprooted in San Diego County.

(3) February 27-29, 1972. Wind, rains, and floods - western Washington to northern California. Flooding and slides.

(4) February 13-20, 1971. Floods--eastern Montana. Snow melt and ice jams causing flooding on numerous rivers.

(5) February 20-26, 1969. Winds, rains, and floods--central and southern California. Heavy rains gave flooding and slides. Twelve people killed. Max storm precipitation over 24 inches.

(6) February 7-13, 1962. Floods--southeastern Idaho, eastern Nevada, and northern Utah. Rain on snow and frozen ground resulted in many valley floods; max record flood on Portneuf River, Idaho.

(7) February 23-27, 1957. Flooding--Snake River and tributaries in southern Idaho, eastern Oregon, and southeastern Washington. Floods from rain on snow or frozen ground.

(8) February 9-12, 1951. Flooding--western Washington. Heavy rains gave severe flooding on streams and rivers.

Other significant storms and/or weather events over the Western Region in February were:

(1) February 3, 1963. 92° in Los Angeles--highest February temperature.

(2) February 4-6, 1972. Ice and glaze storm, northwestern Oregon.

(3) February 5, 1887. San Francisco's great snowstorm--3.7 inches downtown; 7 inches western hills.

(4) February 5, 1965. Windstorm, southern Washington and southern Oregon. Winds reached 100 mph along coast and 60-70 mph inland valley. Extensive damage southeastern Washington.

(5) February 9, 1933. Severe cold wave. Temperatures reached -66° Riverside Ranger Station, Yellowstone Park.

(6) February 10, 1971. Winds and severe duststorm, eastern Washington and eastern Oregon.

(7) February 15-16, 1972. Windstorm, Washington, northern Idaho, and western Montana. Seattle, 88 mph; near Richland, 114 mph; and Havre, 82 mph.

(8) February 18-19, 1970. Santa Ana windstorm, southern California.

(9) February 20, 1971. Windstorm, northern Utah. Damaging east canyon winds along Wasatch Front.

(10) February 23-26, 1969. Heavy snows and windstorm in Nevada. Worst storm period in years. Heavy snows into Utah.

(11) Warmest Februarys in past decade were 1968, 1967, and 1963.

4. Temperature

February marks the first month when mean temperatures start their upward seasonal climb. Both maximum and minimum temperatures in February average 1 to 5° warmer than January. Nevertheless, the all-time record low temperatures have occurred in February at some locations in the states of Montana, Oregon, Utah, and Washington. The threat of freezing temperatures decreases considerably over the agricultural areas of southern California and southern Arizona.

5. Aviation Weather

a) General Weather. Climatologically, February is considered the last winter month. Although in general its characteristics are similar to December and January, some weather changes signal the coming of the spring season.

Storminess continues to dominate most of the Region during this month with some areas in southern California receiving their highest monthly rainfall of the year during February. Arctic outbreaks are still a problem over the northern portion of the Region. So in general the aviation forecaster continues to be plagued by weather hazards similar to those of the previous two months.

b) Fog. Daylight shows a substantial increase during February with approximately one-and-a-half hour's gain at 50° latitude, a little over an hour at 40° latitude, and a little less than an hour at 35° latitude. This gain in solar insolation during the month shows as a significant decrease in dense fog occurrences, i.e., 25 to 50 percent at many valley locations. However, there are some locations which show no appreciable change in dense fog occurrence between January and February. This decrease in fog is especially significant in the valleys of Idaho, western Oregon, and California. Also, coastal cloudiness shows a decrease from January. As in January, overrunning-type weather continues to be a problem during February.

c) Examples: The following are a few comparisons between January and February at a number of Western Region airports:

WASHINGTON Olympia, Seattle: Slight decrease in heavy fog occurrence and in IFR conditions.

Spokane: Average 20% decrease in heavy fog occurrence.

Yakima: Average 50% decrease in heavy fog occurrence.

OREGON	Portland: Continued decrease in low ceilings and fog occurrence.
	Medford: Average 50% decrease in heavy fog occurrence.
MONTANA	Great Falls: Slight increase in ceilings below 1000 feet and/or visibilities below 3 miles. Winds still a problem.
IDAHO	Boise, Lewiston: Average 25% decrease in heavy fog occurrence.
	Pocatello: Average 75% decrease in heavy fog occurrence.
NEVADA/UTAH	Elko: Little significant change from January.
	Reno: Decrease in heavy fog and low ceiling occurrence.
ARIZONA	Phoenix, Tucson, Winslow: Low ceilings associated with winter storms still a threat.
	Prescott: Best chance of heavy fog occurrence.
CALIFORNIA	Bakersfield: Average 60% decrease in heavy fog occurrence and average 33% decrease in occurrence of visibilities of 2 miles or less. Also wettest month.
	Burbank, Los Angeles: Average 25% decrease in heavy fog occurrence.
	Fresno, Sacramento: Average 40% decrease in heavy fog occurrence.
	Red Bluff: Average 65% decrease in heavy fog occurrence and sharp decrease in IFR weather.
	San Francisco, Santa Maria: Little change in heavy fog occurrence.
	San Diego: Most frequent month of visibilities zero to one-half mile.

6. Marine Weather

a) Swells. In February the primary storm tracks continue along the Aleutian Chain and cross the Gulf of Alaska (see Figure 17). The tracks in the Gulf of Alaska shift slightly northward in February. Comparison of the mean sea level pressure charts for January and February (see Figure 18) indicate a slightly weaker gradient in February. Therefore, we would expect swells to have a similar distribution along the West Coast but have slightly lower amplitude. The winter season wave-height charts are given in Figures 17 to 19 of Technical Attachment No. 73-42.

b) Coastal Weather. The climatology of coastal stations indicates a decrease in the mean wind speed along the Oregon and Washington coasts. However, winds along the California coast increase in February. There is a marked tendency toward a decrease in cloud cover and number of days with heavy fog in February.

7. Agriculture

February is still considered a winter month, but temperatures begin to moderate over most of the region. Field activities begin to increase this month, especially in portions of the Pacific Northwest. Plowing and pruning operations are now under way. These operations can be hampered by prolonged periods of precipitation and by strong wind conditions. Pastures are greening up in some areas, with slight growth in winter wheat.

Frost-protection activities continue in the agricultural valleys of California southward into Arizona. Picking of navel oranges and grapefruit in the citrus districts remains active. Valencia oranges continue to make good growth, and the harvest begins in February. If rain has been lacking, irrigation of groves is under way.

8. Air Pollution

Figure 18 shows that the central pressure of the Great Basin high has decreased over two millibars from the previous two months. Fog and pollution episodes are less frequent, shorter duration, and not as severe as observed in December and January. Pollution problems can increase in the valleys of California and Arizona. Ozone again becomes one of the predominant pollutants due to the increase in the sun's angle and due also to meteorological conditions that result in less offshore flow.

9. Snow Avalanche Patterns

Extended periods of cold weather in January are often followed by warm periods in February. The cold periods generally end with several inches of "dry" snow that changes to "wet" snow. Further warming will change the form of precipitation from snow to rain. Avalanches result as the snow accumulates on the hardened surface beneath it, or if the existing snowpack becomes saturated.

Such a situation--minus the rain, however--was responsible for the Wardner, Idaho, disaster of February 5, 1957. Nine houses were destroyed or damaged by three slides. Numerous smaller slides were additionally reported in the Wallace-Wardner-Kellogg area. One person was killed and several were injured, some seriously. Temperatures during the last week of January ranged from 20 degrees above zero to 18 degrees below. January 31 and the first few days of February brought significant warmings to the area. By February 5, the daytime temperature reached 30 degrees. Snow depths increased by some 33 inches in this same period. The new snow on the hard crust created the hazardous conditions.

February can also bring large falls of "cold" snow. Between 1 p.m., February 10, 1959, and 3 p.m., February 11, 34 inches of snow fell at Ketchum and nearly 40 inches on Bald Mountain in Sun Valley. The ski area on Bald Mountain was closed. Five avalanches occurred and demolished two lift houses, partially burying one lift operator. Other operators escaped by climbing the lift towers. One slide crossed three avalanche stabilization benches. Figure 22 shows the synoptic conditions prior to the avalanches.

10. Satellite Meteorology

A summary of mean cloud cover for February at 1400 LST is shown in Figure 23 (see Figure 21 in WR Technical Attachment 74-1 for comparison). In these figures the darkest shade (black) is 0 octas ranging to a pure white shade or 8 octas cloud cover. These cloud-cover-depiction photos give mean values for a four-year period from 1967 to 1970. The instantaneous view at 1400 LST shows a reduction of cloud cover greater than 4 octas along the coasts of Washington and Oregon and in the Snake River Valley. Since these were obtained by computer processing of reflectance in the visible spectral range, some contamination is unavoidable. Most of the reflectance ralues from snow cover were screened out; however, some were retained (note brighter area over Sierra Nevada). The brighter values normally obtained from desert topography remained and are included in the satellite cloud-cover depiction.

REFERENCES:

[1] AUGULIS, RICHARD P., "Precipitation Probabilities in the Western Region Associated with Winter 500-mb Map Types."

[2] REX, D. F., Tellus, Vol. 2, No. 3, 1950.

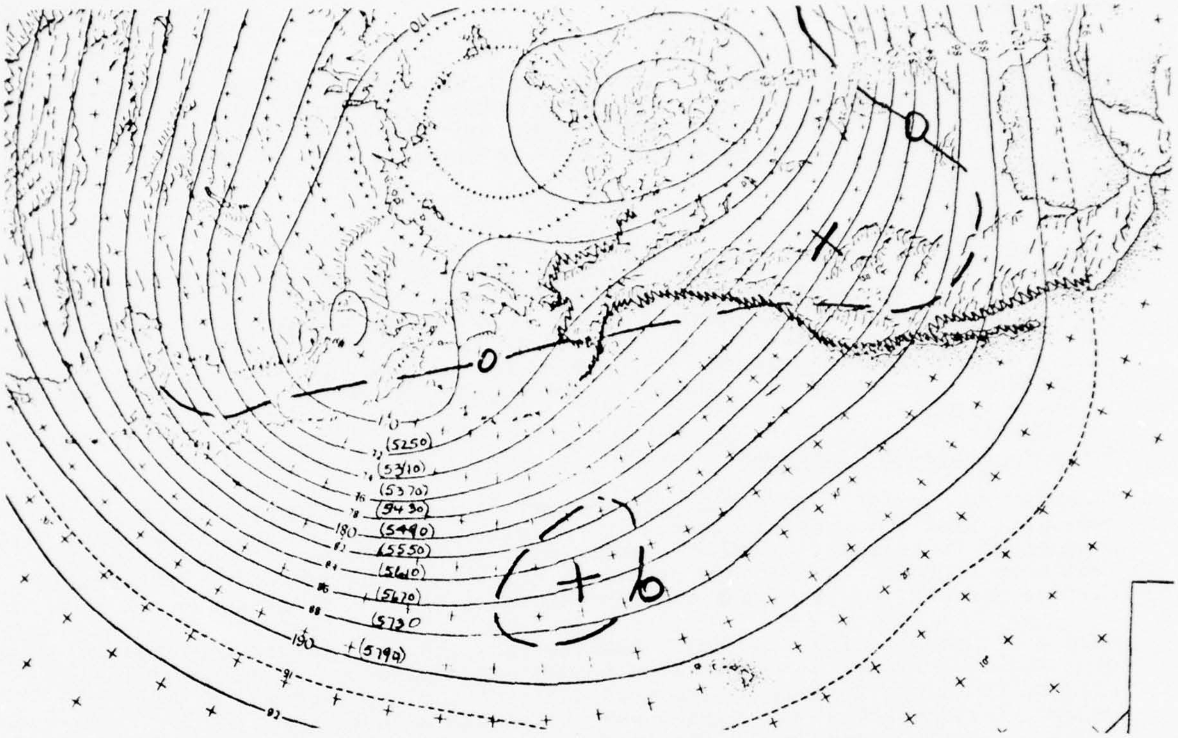


FIGURE 1. MEAN 500-MB HEIGHT FIELD FOR FEBRUARY. SOLID LINES ARE CONTOURS IN HUNDREDS OF FEET (METERS) DASHED LINES INDICATE CHANGES IN FEET (METERS) FROM JANUARY TO FEBRUARY.

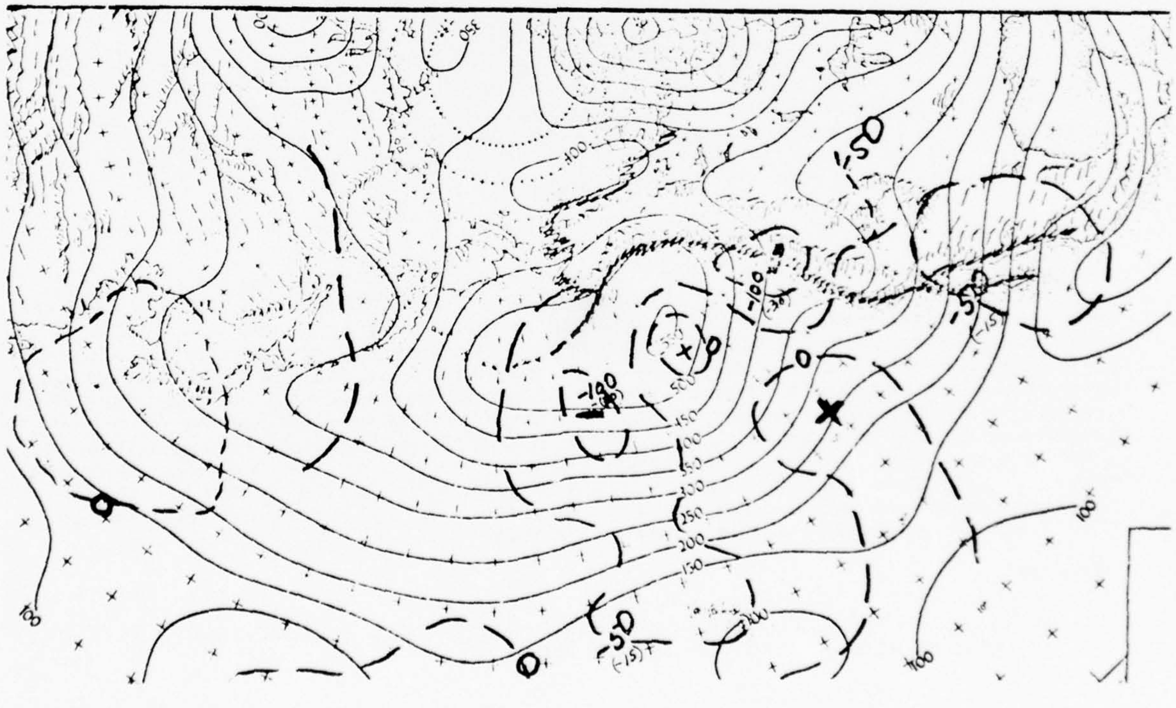


FIGURE 2. STANDARD DEVIATION OF DAILY VALUES OF 500-MB HEIGHT FOR FEBRUARY IN FEET. DASHED LINE INDICATES CHANGES IN FEET (METERS) FROM JANUARY TO FEBRUARY.

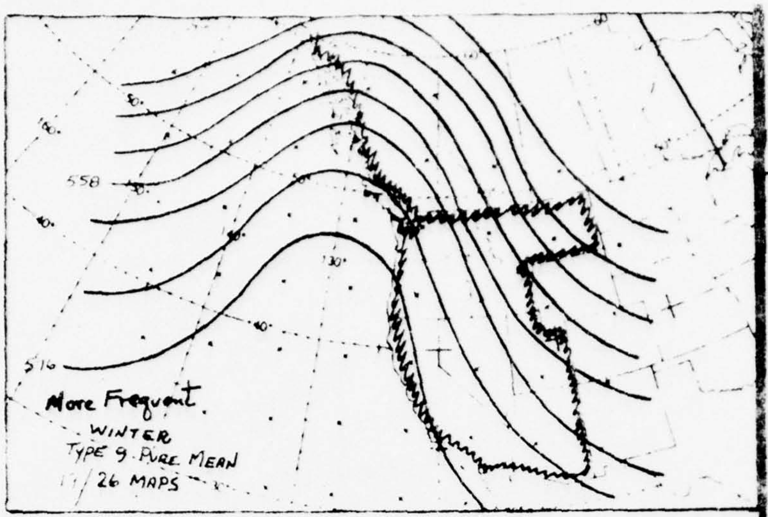


FIGURE 3. MORE FREQUENT WESTERN REGION 500-MB TYPE MAPS. FRACTION IN LOWER LEFT CORNER INDICATES NUMBER OF TIMES THE TYPE OCCURRED IN FEBRUARY COMPARED WITH THE TOTAL NUMBER OF TIMES THE TYPE OCCURRED IN THE WINTER SAMPLE.

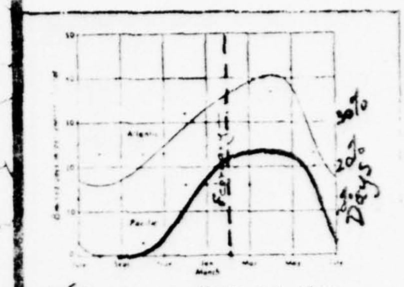


Fig 5a. [illegible] variation in blocking activity. Atlantic ([illegible]) and Pacific (30 [illegible]) [illegible] the percentage of [illegible] dominated by blocking action are shown by month [From [2]]

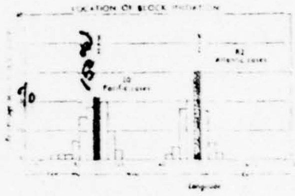


Fig 5b. Geographical distribution of block [illegible] [illegible] and 19[illegible]—19[illegible] inclusive [From [2]]

FIGURE 5. CLIMATOLOGY OF FREQUENCY AND LOCATION OF REX-TYPE BLOCKING SITUATIONS.

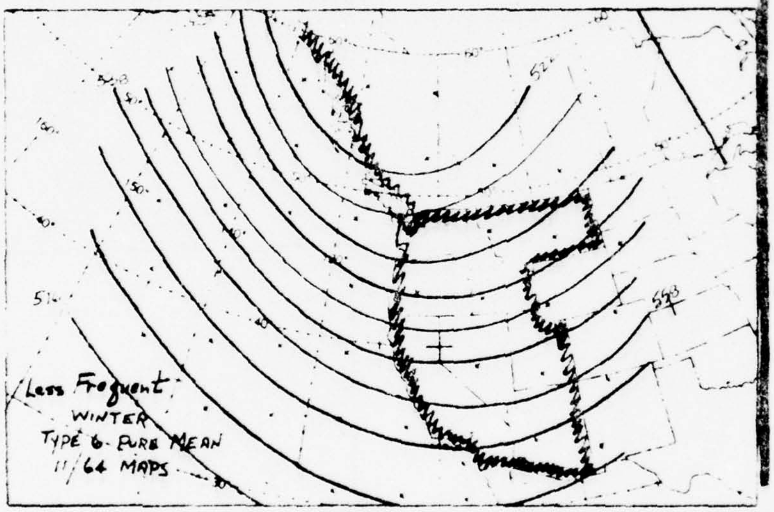


FIGURE 4. LESS FREQUENT WESTERN REGION 500-MB TYPE MAPS. FRACTION IN LOWER LEFT CORNER INDICATES NUMBER OF TIMES THE TYPE OCCURRED IN FEBRUARY COMPARED WITH THE TOTAL NUMBER OF TIMES THE TYPE OCCURRED IN THE WINTER SAMPLE.

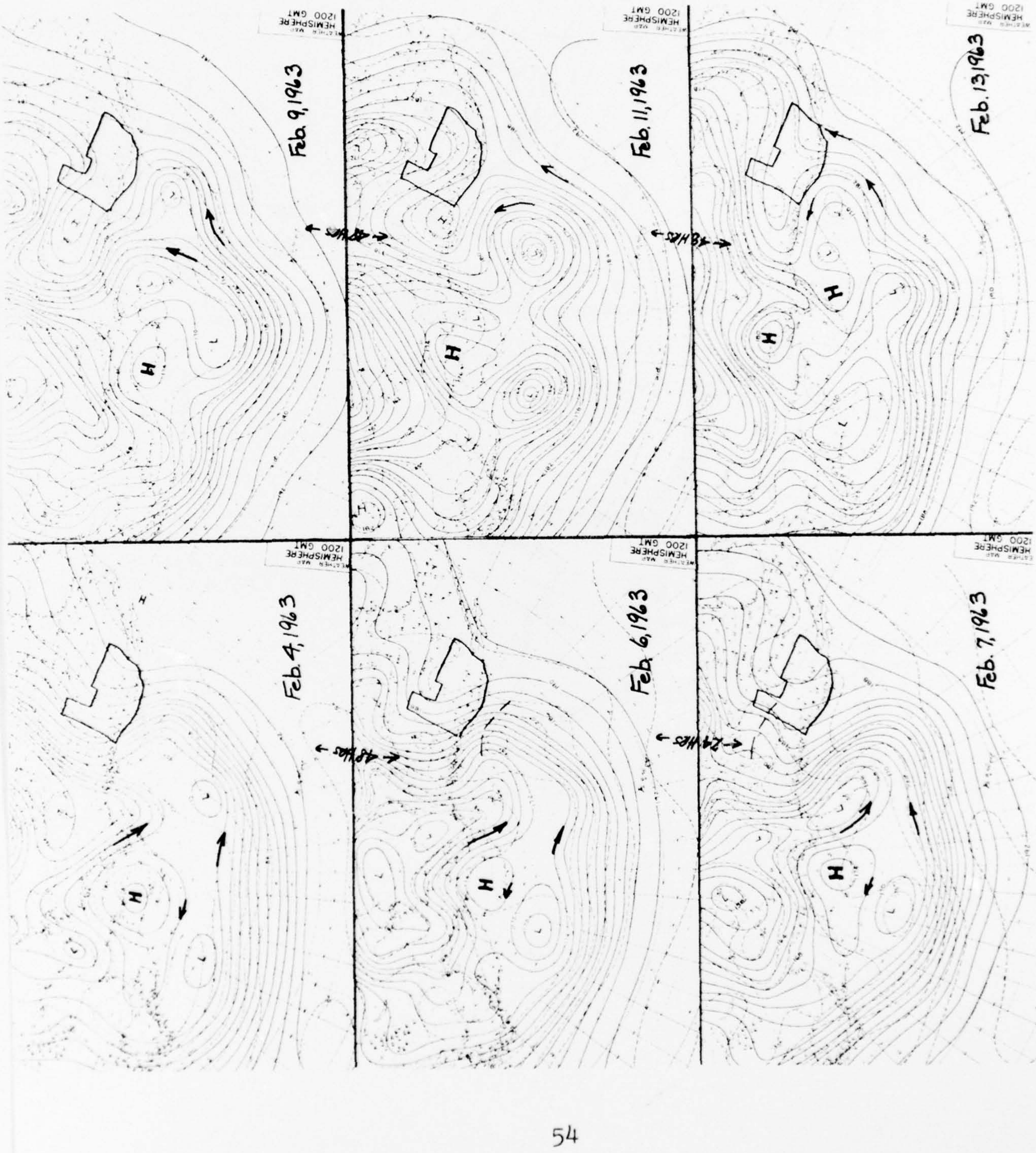


FIGURE 6. PERSISTENT BLOCKING PATTERN, FEBRUARY 4 – 13, 1963.

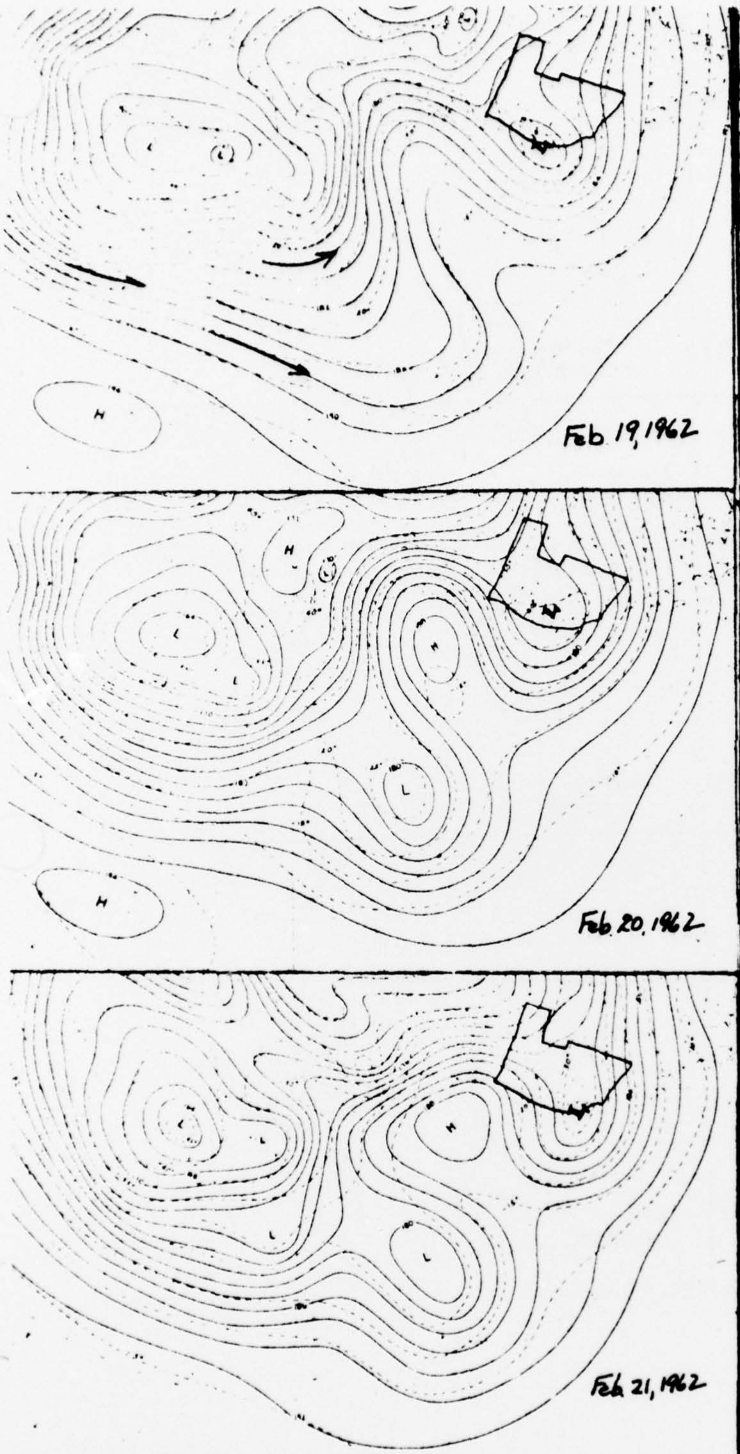


FIGURE 7. DEVELOPMENT OF BLOCKING PATTERN, FEBRUARY 19 - 21, 1962.

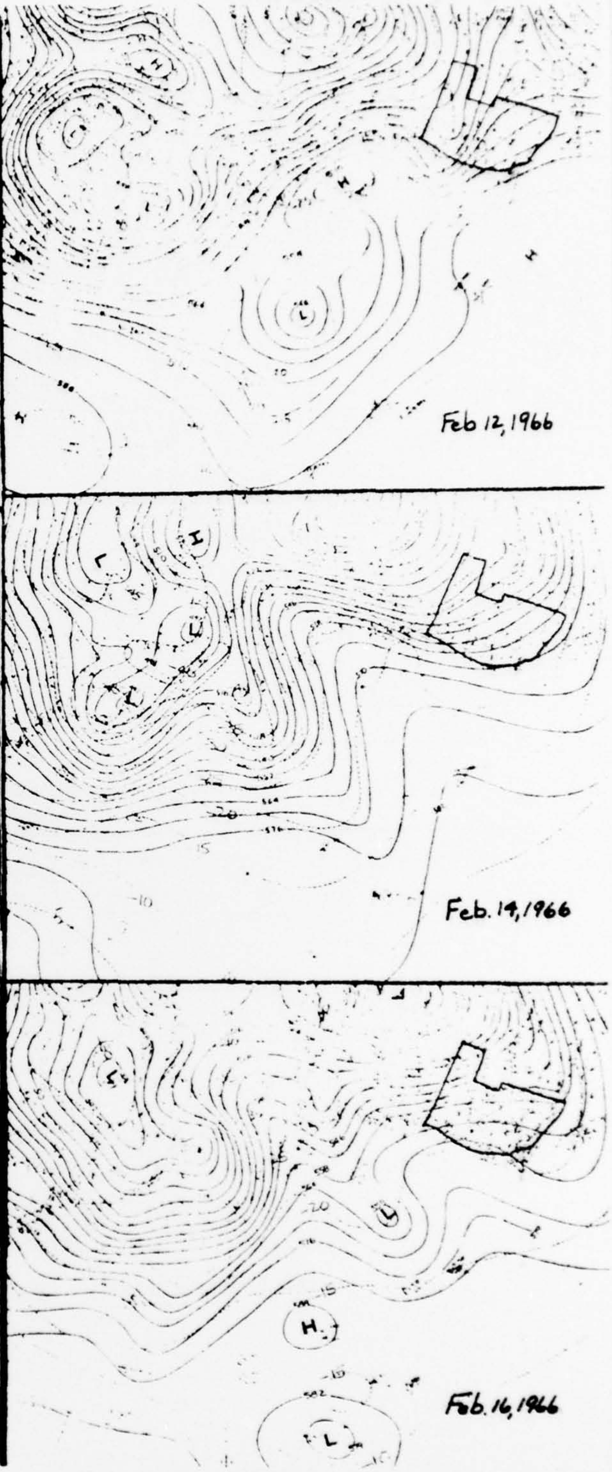


FIGURE 8. TEMPORARY LOSS OF BLOCKING PATTERN, FEBRUARY 12 - 16, 1966.

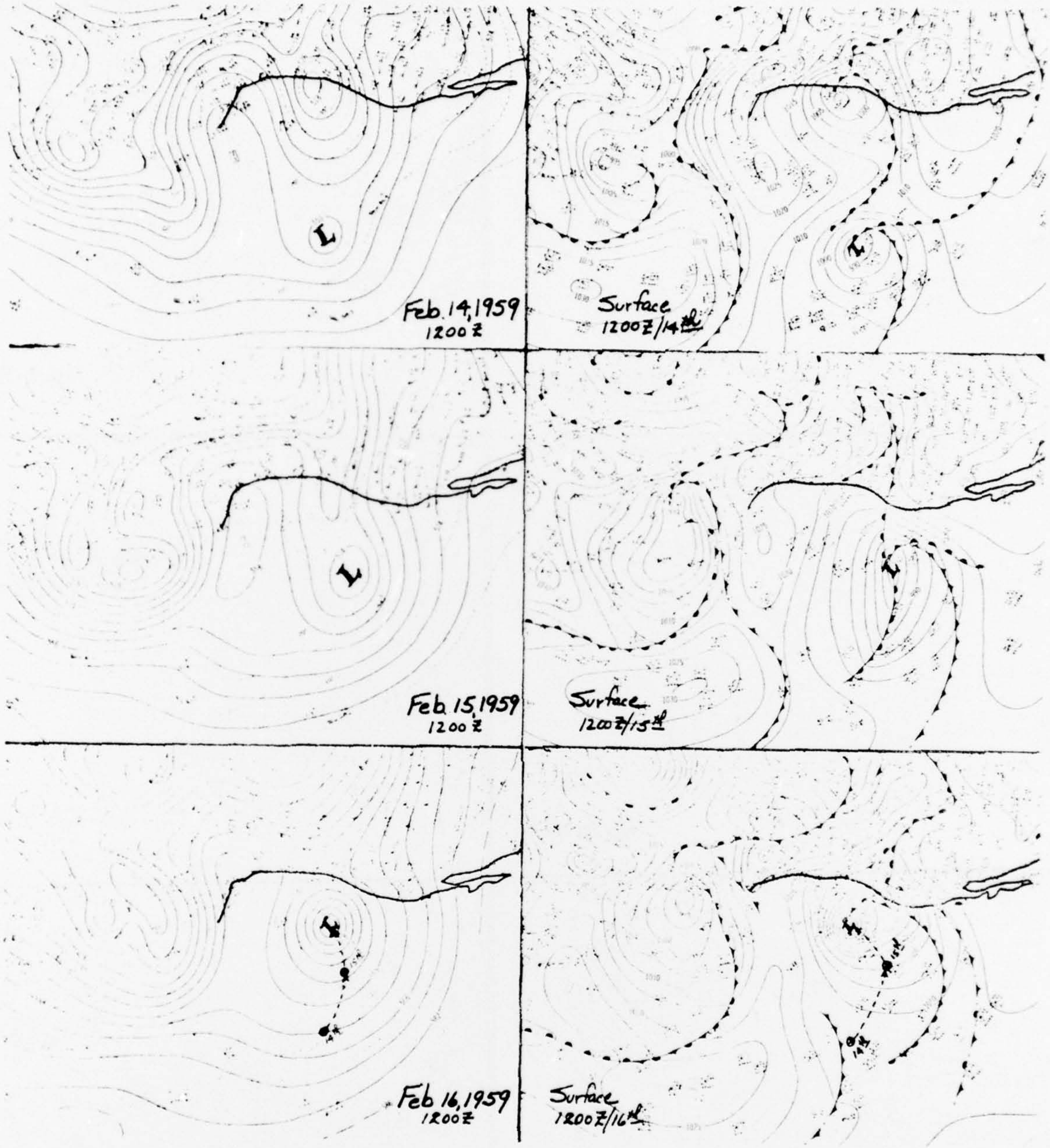


FIGURE 9. EXPLOSIVE CYCLOGENESIS IN BLOCKING PATTERN, FEBRUARY 14 - 16, 1959.

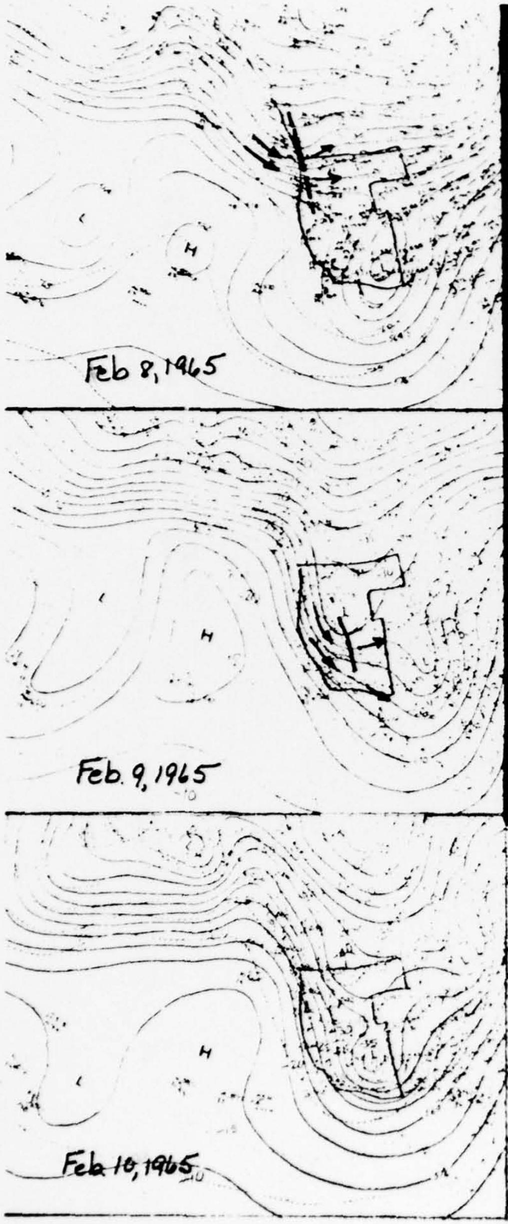


FIGURE 10. NEGATIVE-TILT DIFLUENT TROUGH DEVELOPMENT, FEBRUARY 8 - 10, 1965.

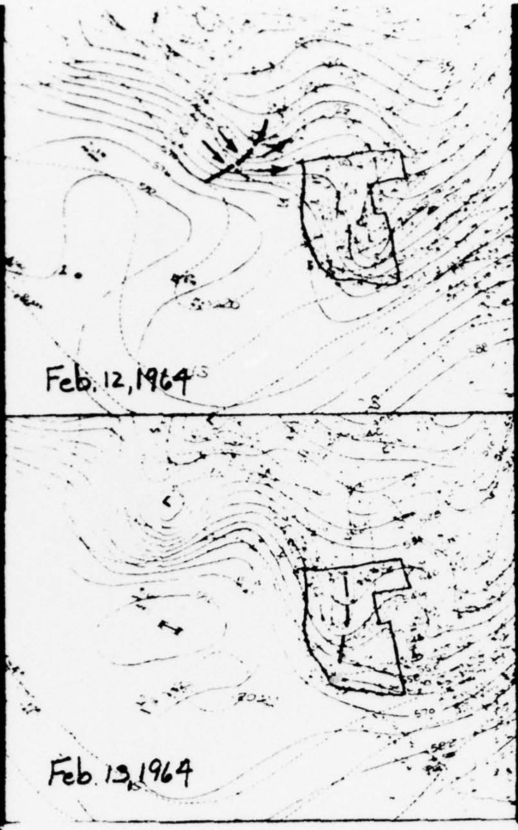


FIGURE 11. POSITIVE-TILT DIFLUENT TROUGH DEVELOPMENT, FEBRUARY 12 - 13, 1964.

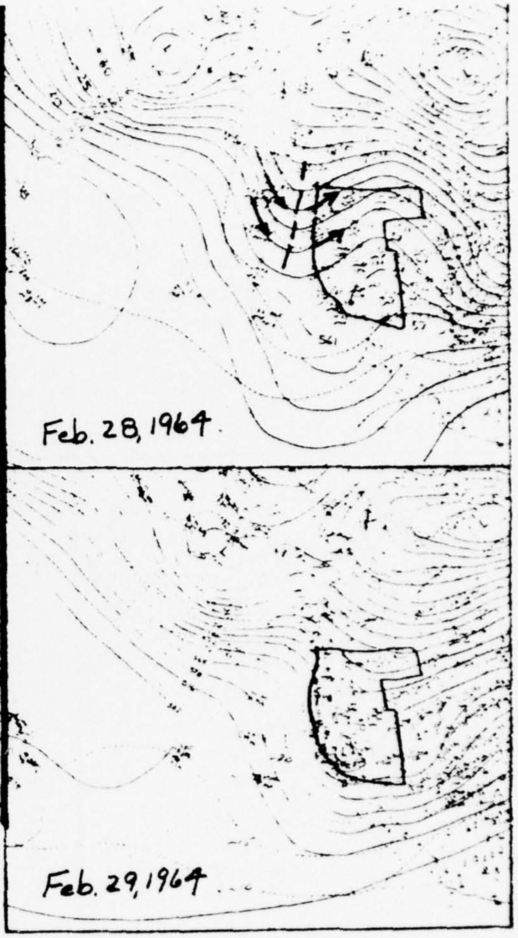


FIGURE 12. NO-TILT DIFLUENT TROUGH DEVELOPMENT, FEBRUARY 28 - 29, 1964.

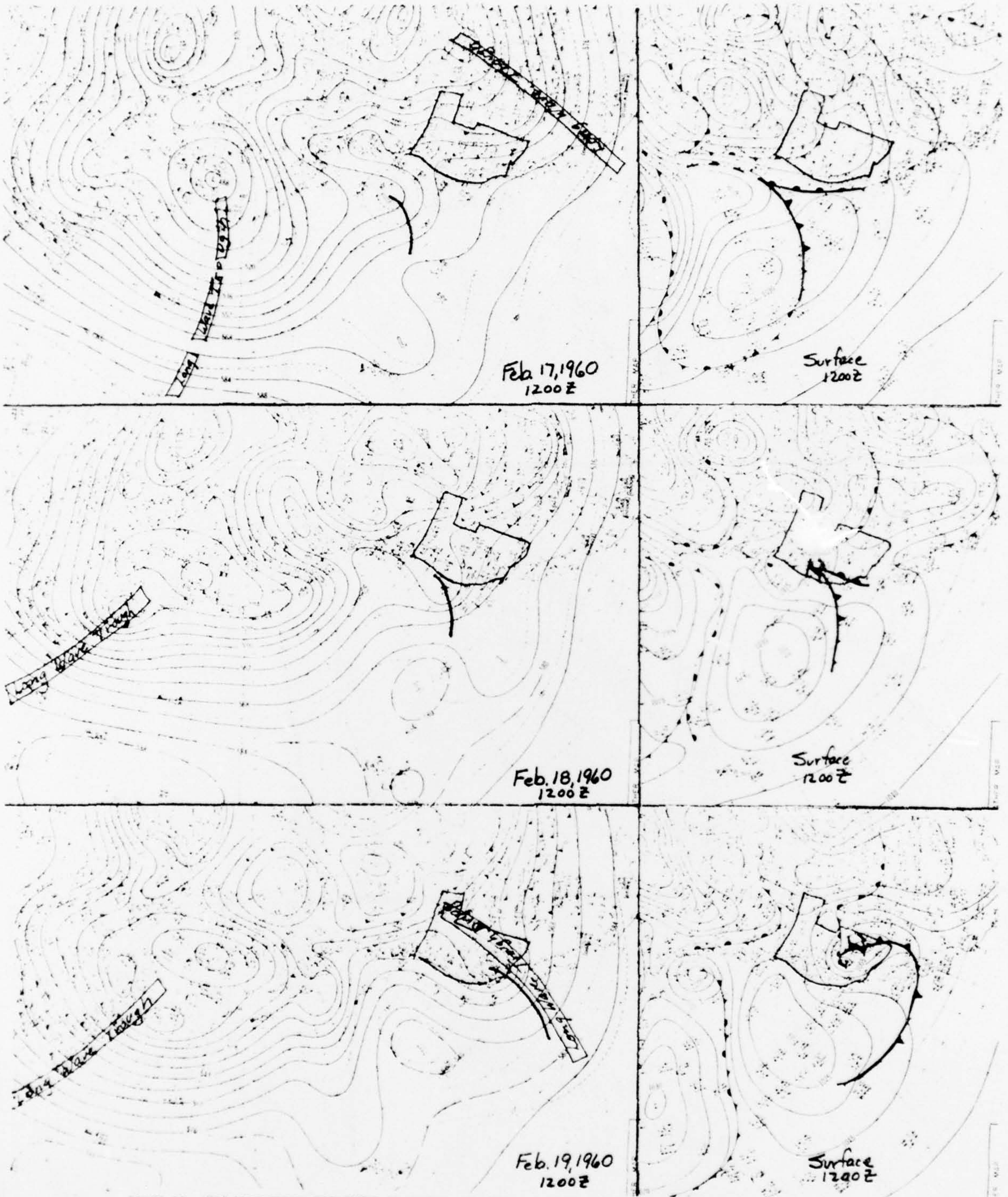


FIGURE 15. WEST COAST TROUGH DEVELOPMENT ASSOCIATED WITH RETROGRESSION OF LONG-WAVE PATTERN, FEBRUARY 17 - 19, 1960.

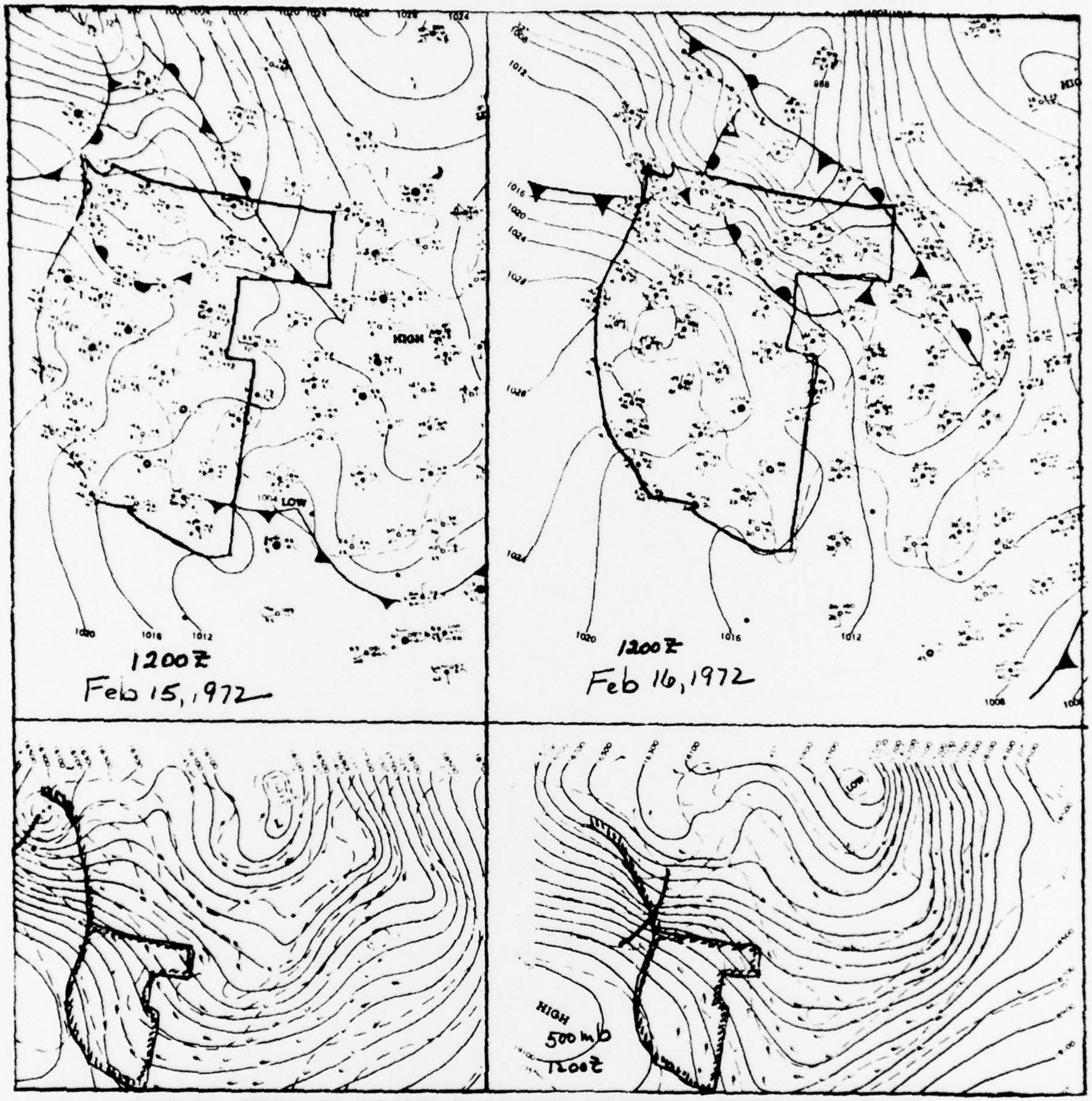


FIGURE 14. STRONG WIND SITUATION IN WASHINGTON AND MONTANA. FEBRUARY 15 - 16, 1972.

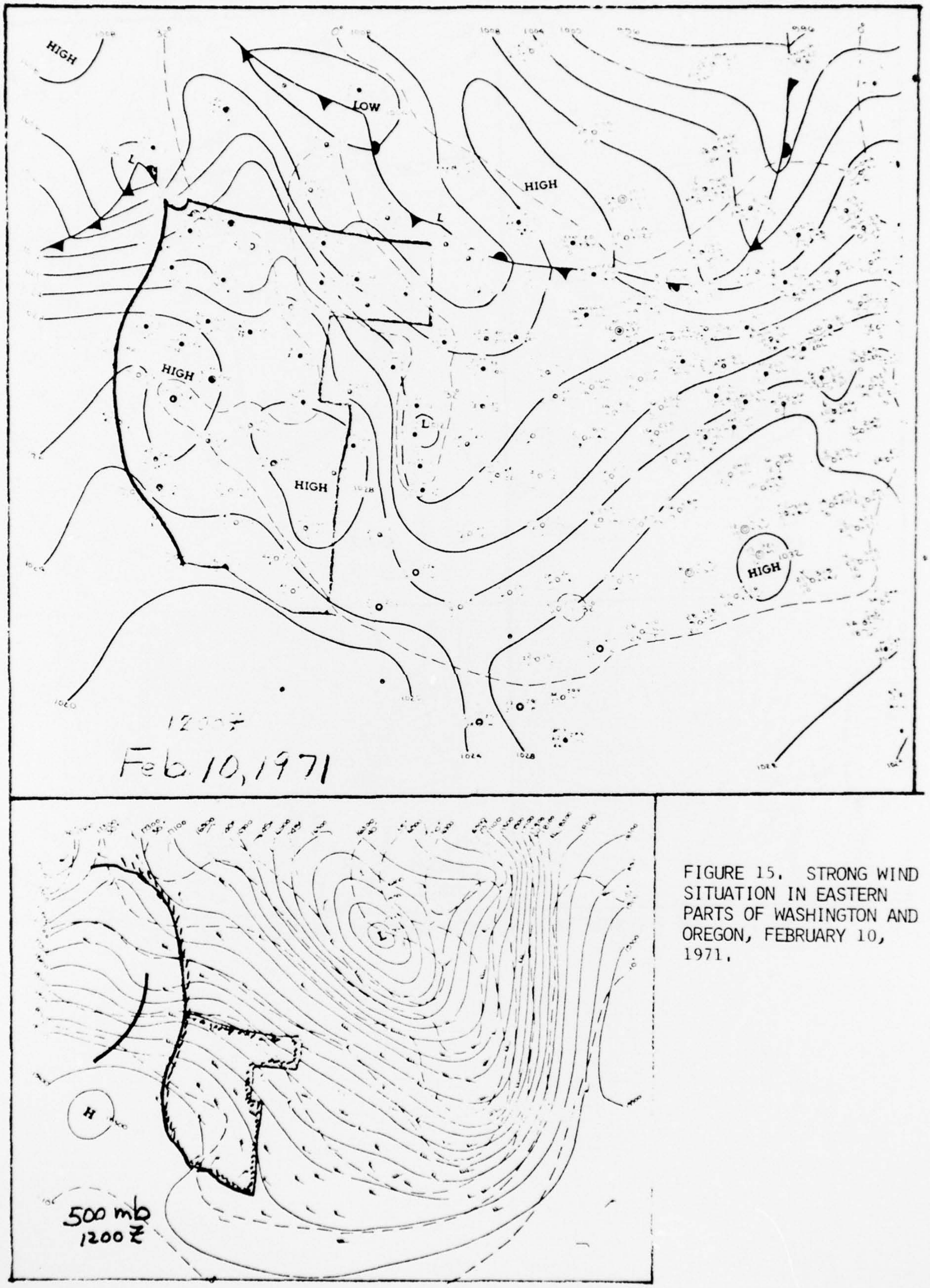


FIGURE 15. STRONG WIND SITUATION IN EASTERN PARTS OF WASHINGTON AND OREGON, FEBRUARY 10, 1971.

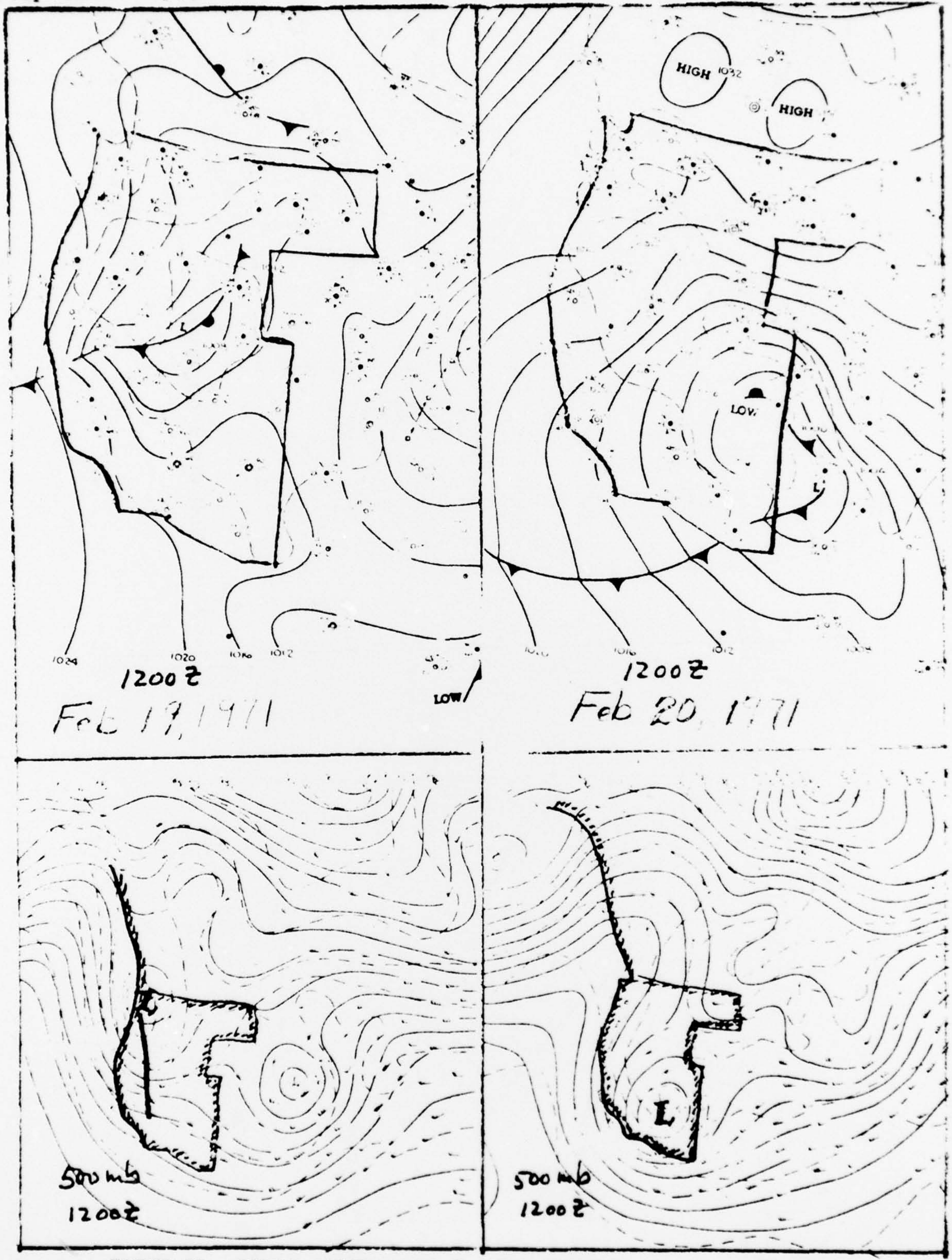


FIGURE 16. STRONG CANYON WINDS IN UTAH, FEBRUARY 19 - 20, 1971.

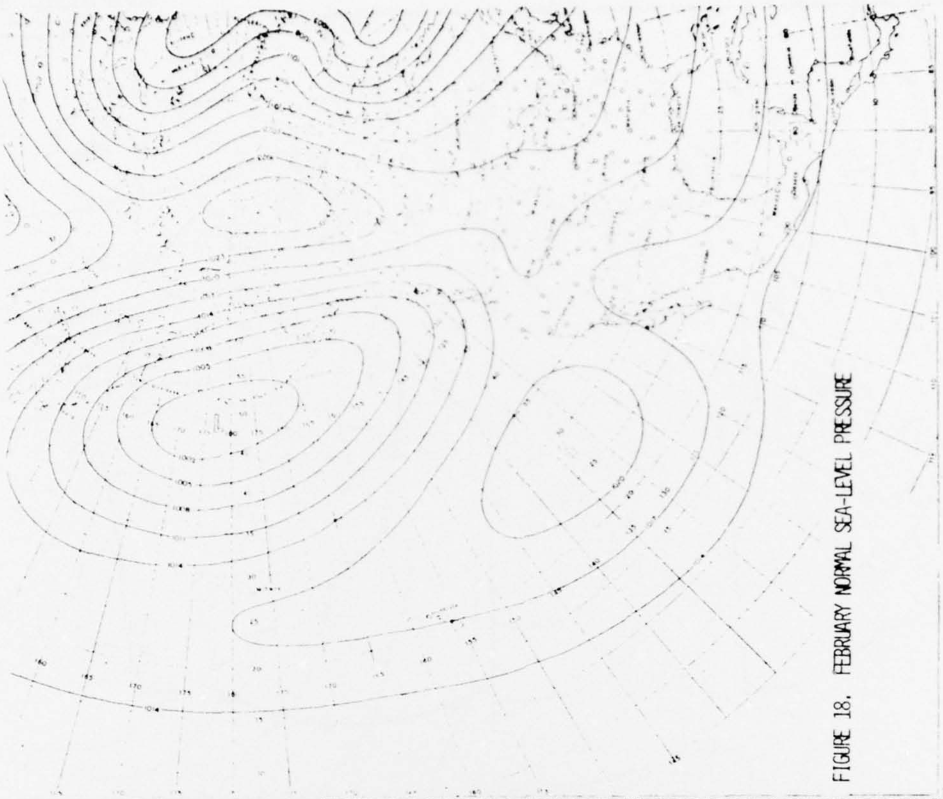
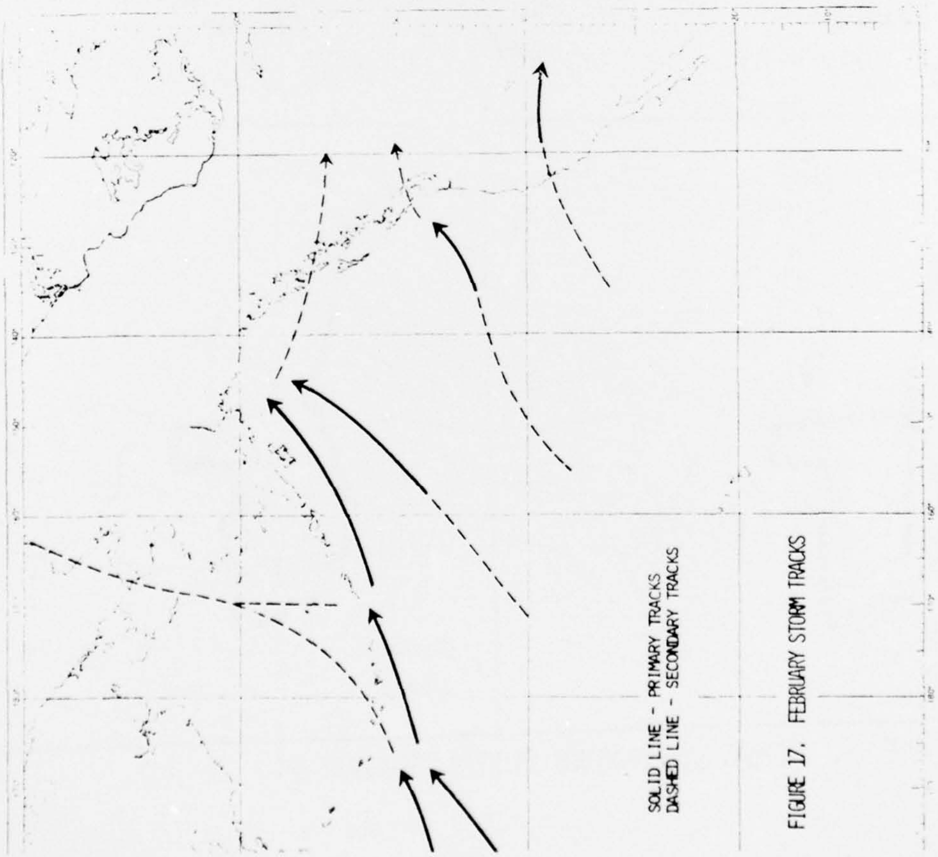


FIGURE 18. FEBRUARY NORMAL SEA-LEVEL PRESSURE



SOLID LINE - PRIMARY TRACKS
DASHED LINE - SECONDARY TRACKS

FIGURE 17. FEBRUARY STORM TRACKS

FIGURE 19
FEBRUARY PRECIPITATION NORMALS BY DIVISIONS
1941 - 1970

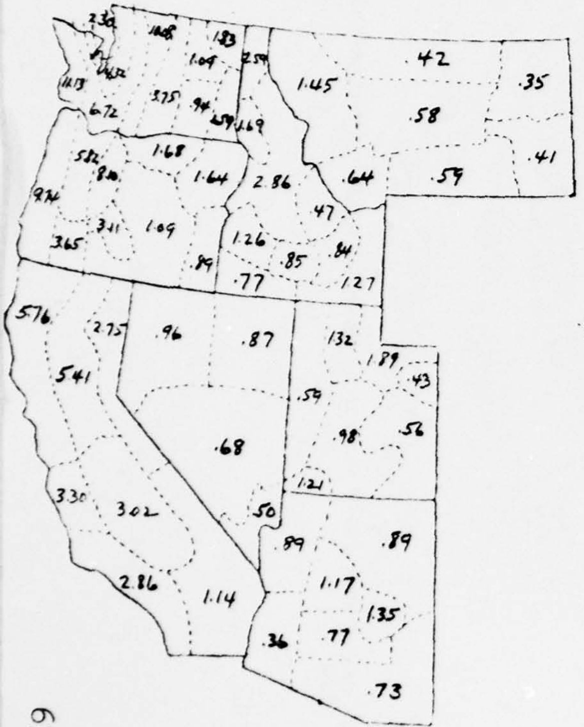
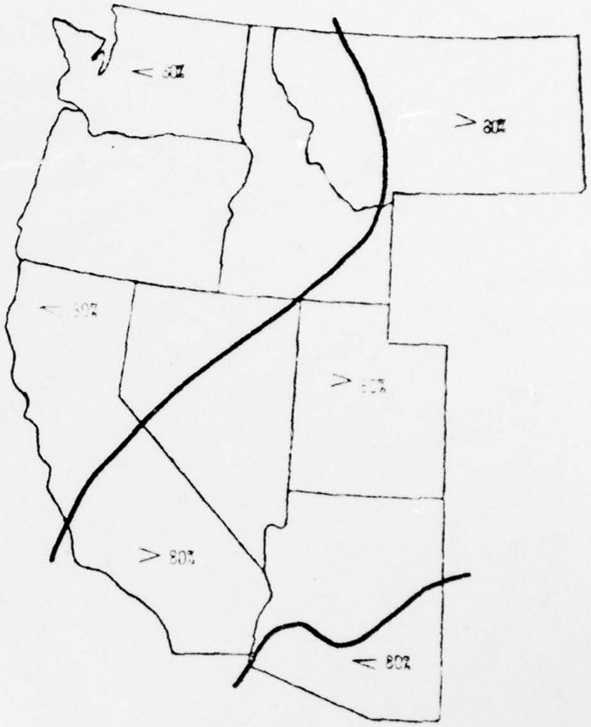


FIGURE 20
COMPARISON OF NORMAL PRECIPITATION, FEBRUARY TO JANUARY
SHOWN AS PERCENT (FEBRUARY/JANUARY TIMES 100)

FIGURE 21
ANALYSIS OF FIGURE 20



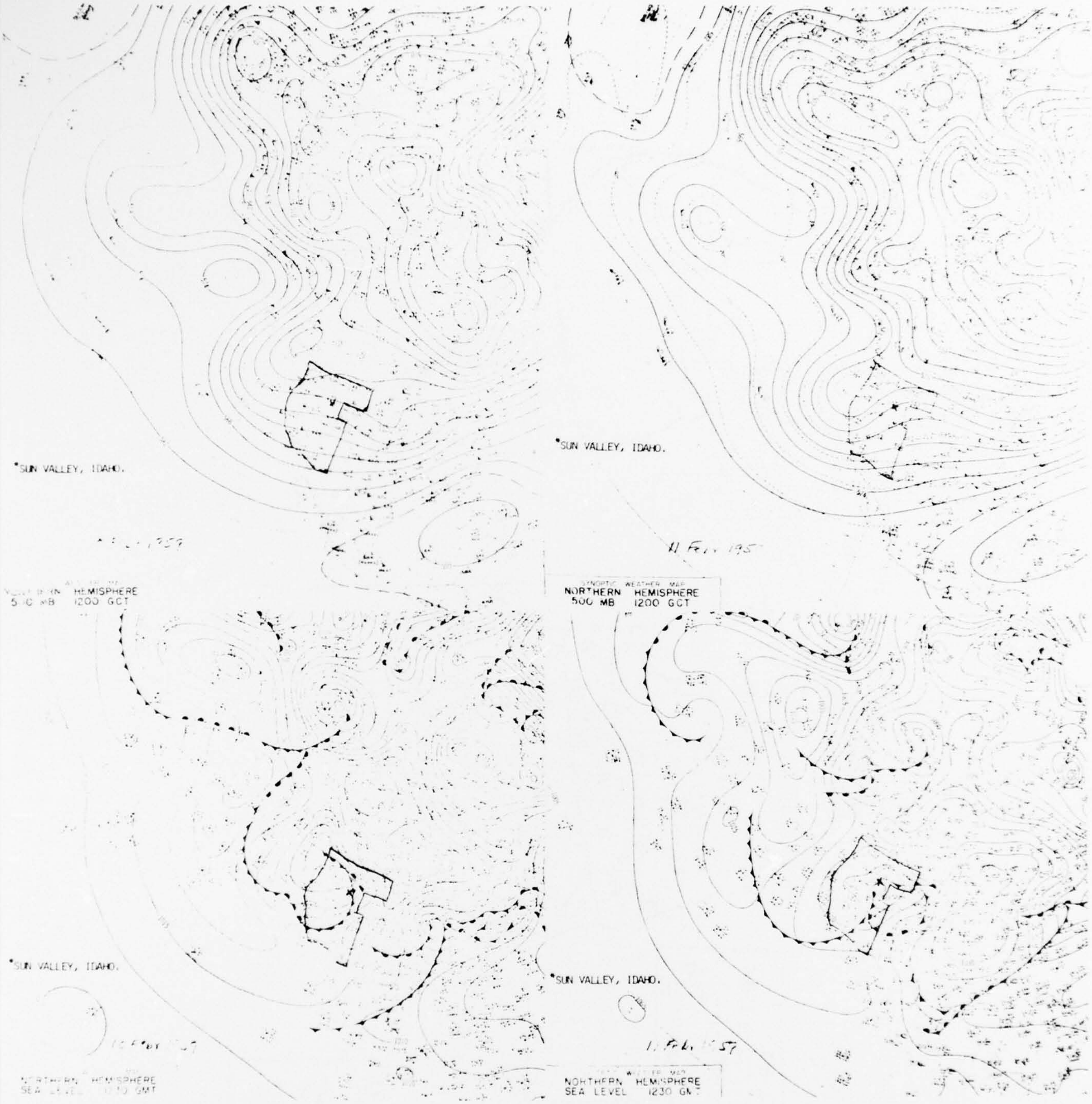


FIGURE 22. SURFACE AND 500-MB CHARTS FOR FEBRUARY 10 - 11, 1959, SHOWING CONDITIONS PRIOR TO AVALANCHES, SUN VALLEY, IDAHO.

FIGURE 23. FEBRUARY MEAN CLOUD COVER AT 1400LST, IN OCTAS (1967 - 1970).

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LIST OF TECHNICAL NOTES

Number	Title	Date
73-1	Interim Instructions for the Use of Air Stagnation Weather Charts and Messages (AWS distribution only)	Jan 73
73-2	The Ocheltree Tornado, A Case Study (AD-768391)	Mar 73
73-3	Listing of Seminars Available at Hq AWS, AWS Wings, and AFGWC (AWS distribution only) (AD-757543)	Mar 73
73-4	USAFETAC Refractive Index Gradient Summaries (AD-762501)	Apr 73
73-5	Short-Range Weather Forecasting: Recent Developments in Air Weather Service, Suggested Techniques (AWS distribution only)	May 73
73-6	A Resumé on the State of the Art for Snow Forecasting (AD-767214)	Jul 73
74-1	Atmospheric Moisture Parameterization (AD-784814)	Jan 74
74-2	Development of a Gridded Data Base (Publication delayed)	Apr 74
74-3	A Precipitating Convective Cloud Model (AD-A002117)	May 74
74-4	A Synoptic-Scale Model for Simulating Condensed Atmospheric Moisture (AD-A002118)	Jun 74
75-1	Estimated Improvement in Forecasts of the SANBAR Hurricane Model Using the Airborne Weather Reconnaissance System (AD-A004097)	Jan 75
75-2	Spring Weather Patterns of the Western United States (Reprints) (AD-A006691)	Mar 75
75-3	Summer Weather Patterns of the Western United States (Reprints) (AD-A009860)	May 75
75-4	Autumn Weather Patterns of the Western United States (Reprints) (AD-A013801)	Jul 75
75-5	Winter Weather Patterns of the Western United States (Reprints) ( )	Sep 75