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THE WINDSTORM OF 16 DECEMBER 1992 AT PORTLAND, OREGON

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Introduction

On the evening of 16 December 1992, a windstorm hit Portland, Oregon. At 0316 UTC 17 December (1916 PST 16 December), a peak wind gust of 26 m s^{-1} (52 knots) from the southwest occurred, which is the highest wind gust at the Portland airport in the month of December since peak wind records began in 1959. The low pressure center producing the high winds had a west to east track just north of Portland. This differs from the "classical" windstorm track (such as the 1962 Columbus Day storm) that has an intense low pressure center moving northward off the Oregon coast. This Technical Attachment will discuss the mesoscale structure of the December 1992 storm and show the performance the models' forecast 12 hours in advance. Several windstorms had a similar track (e.g. Northrop 1988). The December 1992 windstorm will be compared to the "Columbus Day" storm, which had many similarities despite the different storm track. The similarities among the storms will suggest some physical processes that are important for producing strong southerly winds at Portland.

Topography

Topography is influential in determining the preferred directions for strong winds at Portland. Portland is located in the north end of the Willamette Valley. The valley is approximately 40 km wide and gradually slopes downward from about 140 m MSL at Eugene, which is about 160 km south of Portland, to sea level at Portland. The eastern wall of the Willamette Valley is the Cascade Range, which crests above 1500 m MSL, and the western wall is the Coast Range with crests above 900 m MSL. The preferred direction for wind gusts of 22 m s^{-1} (43 knots) or greater at Portland is from the south and southwest, which is down the axis of the Willamette Valley. The remaining gusts over 22 m s^{-1} are from the east, which results from flow through the Columbia River Gorge.

Analysis of December 1992 Windstorm

Salem, Oregon is in the Willamette Valley about 100 km south of Portland. The Salem sounding (Fig. 1) at 0000 UTC 17 December 1992 (1600 PST 16 December) had winds of 20 m s^{-1} to 30 m s^{-1} from the south between 950 mb and 850 mb, which is nearly parallel to the axis of the Willamette Valley. A moist adiabatic layer was present from about 925 mb to 825 mb with a more stable layer from 925 mb to the surface.

Figure 2 shows sea level pressure at Eugene, Salem, and Portland and the observed winds at Portland. From 0000 to 0200 UTC (1600 to 1800 PST), winds were from the southeast indicative of the flow through the Columbia Gorge. From 0200 to 0300 UTC, the winds shifted to a very gusty southerly flow. The surface isobaric analysis at 0300 UTC (Fig. 3) identifies the low pressure center that moved eastward from just off the coast near Astoria (AST) at 0000 UTC to north of Portland (PDX) at 0300 UTC. At Portland, the wind shift and rise in temperature of about 3.3°C (6°F) from 0100 to 0300 UTC indicated the passage of a warm front. Between 0300 and 0600 UTC, lightning was occasionally observed at Portland indicative of an unstable airmass over Portland. When the peak gust of 26 m s^{-1} (52 knots) from the southwest occurred at 0316 UTC, the pressure was rapidly rising at Portland, and a strong north to south pressure gradient[1] was present in the Willamette Valley as seen by the Salem to Portland pressure difference (Fig. 2).

The low pressure center continued to move eastward, and by 0500 UTC it was not discernable in the surface isobaric analysis possibly due to the low center being masked by the mountainous terrain. A weaker north to south pressure gradient existed in the Willamette Valley resulting from lower pressure off the Washington coast. Southwesterly winds at Portland generally had speeds of 7 to 10 m s^{-1}.

Prediction of December 1992 Windstorm

Figure 4 shows a plot of the 500 mb height field at 0000 UTC 17 December (1600 PST 16 December) and the 12 hour NGM predicted field from the 1200 UTC (0400 PST) 16 December run. The NGM (as well as the Eta and AVN) underpredicted the strength of the trough diving southward along the west coast. East of the trough, strong diffluence caused strong rising motion over southwestern Washington resulting in the development of the strong, compact low pressure center. Only after deducing the development of the low center off the coast and its subsequent movement eastward could the appropriate wind warnings be issued.

Analysis of Some Previous Windstorms

The most notable windstorm in Portland in recent history is the 1962 Columbus Day storm, which had a peak wind gust at the Portland airport of 46 m s^{-1} (90 knots). This windstorm had a 960 mb low moving northward at 100 to 300 km off the Oregon coast. Lynott and Cramer (1966), in their detailed analysis of the storm, indicated that the strongest winds occurred immediately after the passage of a warm occlusion. Before the frontal passage, the winds were relatively light with an easterly component. The winds from near the surface to at least 500 mb were from the south and stronger than 25 m s^{-1}.

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[1] In the mathematical definition of gradient, the positive direction is toward higher values. A north to south pressure, therefore, has lower pressure to the north and higher pressure to the south.

Lynott and Cramer (1966) report that a noticeable drop in the dewpoint temperature occurred at Portland immediately after the frontal passage. The drying suggests that strong vertical mixing occurred since the air at 800 mb had the same mixing ratio as the air at the surface immediately after the frontal passage. The strongest winds occurred when the pressure was rising rapidly, the low center was located at the same latitude or north of the latitude of the station, and a substantial north to south pressure gradient was present in the Willamette Valley.

Coparanis (1982) performed a study of storms similar to the Columbus Day storm. These storms moved north to northeast off the Oregon coast, east of longitude 130°W. Like the Columbus Day storm, the strongest winds occurred when the low center was at a latitude north of a location and the pressure was rising rapidly. Both these conditions would occur following a warm front or warm occlusion passage, and there likely was a strong north to south pressure gradient in the Willamette Valley. The northward track of the storms indicate that a middle and upper tropospheric trough was located off the west coast, resulting in southerly component winds to a significant height over Oregon.

Physical Processes for Strong Winds

The December 1992 windstorm had many similarities with the Columbus Day storm of 1962 (and other similar storms) despite having a different cyclone track. The strongest winds occurred shortly after a warm front passage. The pressure was rising rapidly, and a strong north to south pressure gradient was present in the Willamette Valley. The atmosphere was unstable with significant vertical mixing occurring. One noticeable difference during the December 1992 storm is that the strong southerly winds only extended to about 800 mb with the winds becoming westerly by 500 mb. The Columbus Day storm (and very likely similar storms) had strong southerly winds to a greater depth.

The similarities of meteorological conditions associated with strong winds among many storms, even with different tracks, suggest some physical processes important for winds in Portland. The strong north to south pressure gradient would tend to accelerate the southerly winds in the Willamette Valley. The channeling of the winds in the valley would not allow the winds to turn in response to the coriolis force. The unstable atmosphere behind the warm front is another potential factor for strong winds. With unstable conditions, the southerly momentum from the strong winds aloft can be mixed downward to the surface, and thunderstorm downdrafts can locally strengthen this southerly momentum. Because the winds are along the valley axis, significant terrain obstacles are not present to slow the winds.

Another factor for the strong winds is isallobaric wind. Bluestein (1992) shows that the isallobaric winds are proportional to the horizontal gradient of the change in pressure with time.

$$V_a = -\frac{1}{\rho f^2} \nabla_z \left(\frac{\partial P}{\partial t} \right)$$

The strongest winds in the Willamette Valley occur soon after a frontal passage with pressure rising rapidly. In the December 1992 storm, the pressure at Portland rose 3.5 mb from 0300 to 0400 UTC while at Toledo, Washington, which is about 150 km to the north of Portland, the pressure rose 0.4 mb. A gradient in pressure rise of 3 mb h^{-1} over a distance of 150 km gives an isallobaric wind of over 40 m s^{-1}, demonstrating that the isallobaric wind can be a major factor in windstorms at Portland.

The three physical processes mentioned above appear to be important for strong southerly winds at Portland. These physical processes are not totally independent, and other factors may also be important for windstorms at Portland. Mesoscale and synoptic-scale analyses of many storms, as well as numerical modeling, would provide more definitive information on the physical processes producing strong south to southwesterly winds at Portland.

References

Bluestein, H.B., 1992: *Synoptic-Dynamic Meteorology in Midlatitudes Volume I Principles of Kinematics and Dynamics.* Oxford Press, 173-175.

Coparanis, D.J., 1982: Columbus Day type storms as they affect Portland, 27p., Available from WSFO Portland, OR.

Lynott, R.E. and O.P. Cramer, 1966: Detailed analysis of the 1962 Columbus Day windstorm in Oregon and Washington. *Mon. Wea. Rev.*, **94**, 105-117.

Northrop, D., 1988: Northwest Oregon's tempest of the 10th of January 1988. Available from WSFO Portland, OR.

Fig. 1. Salem, Oregon sounding at 0000 UTC 17 December 1992.

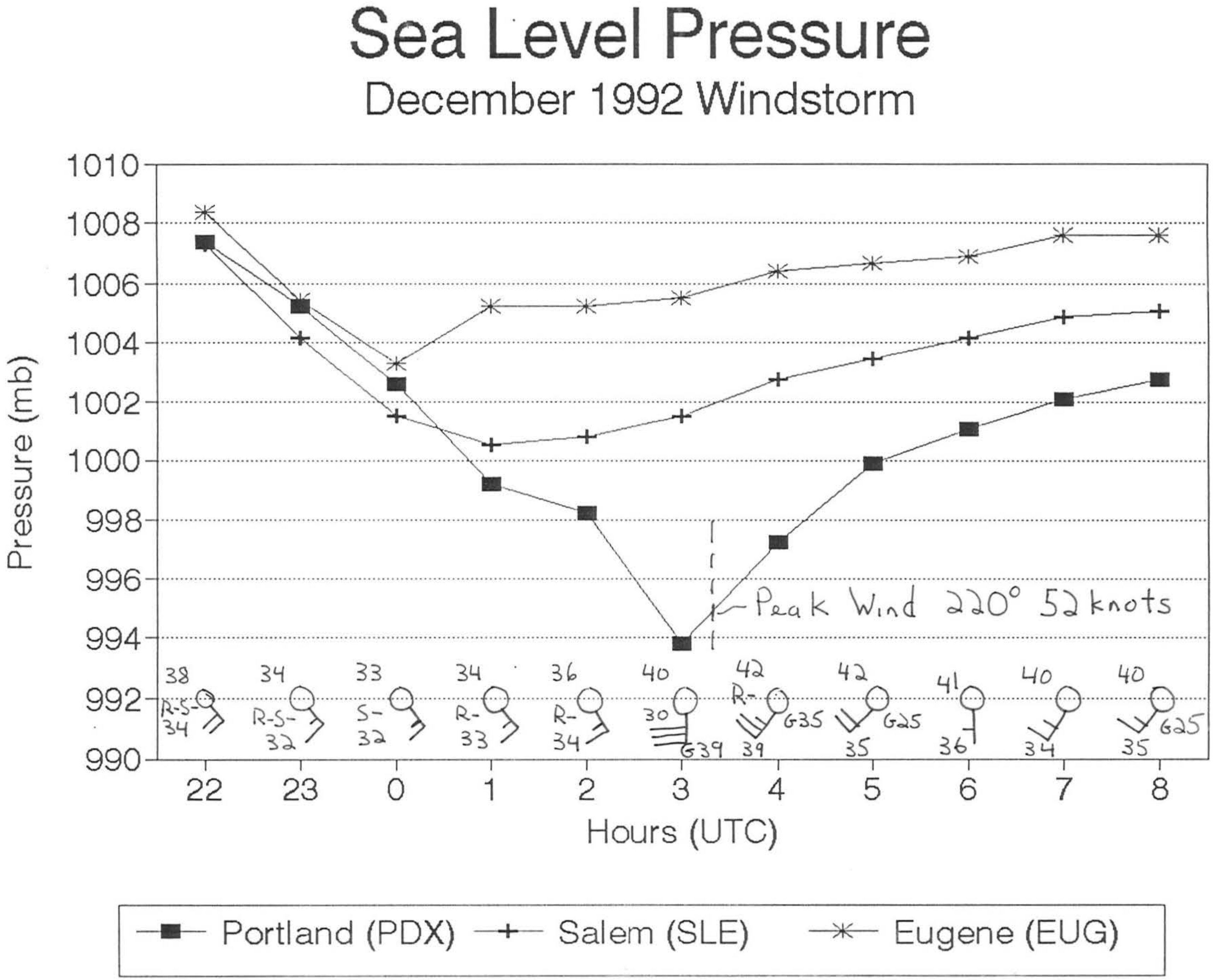

Fig. 2. Sea level pressure at Portland, Salem, and Eugene and the surface observations at Portland from 2200 UTC 16 December to 0800 UTC 17 December 1992.

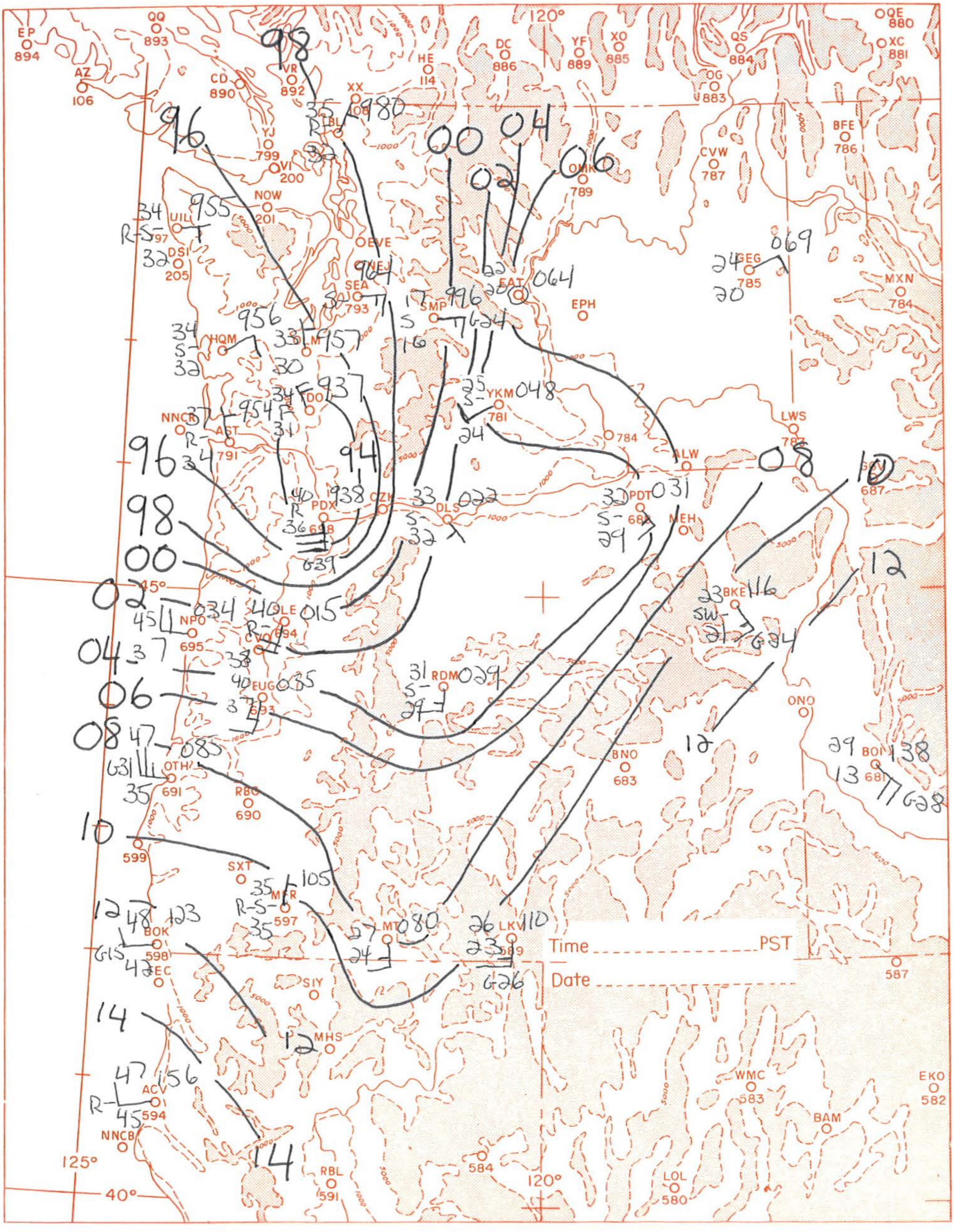

Fig. 3. Surface analysis at 0300 UTC 17 December 1992. Isobars are plotted every 2 mb. Temperature and dewpoint temperature are in °F. Elevations are in feet.

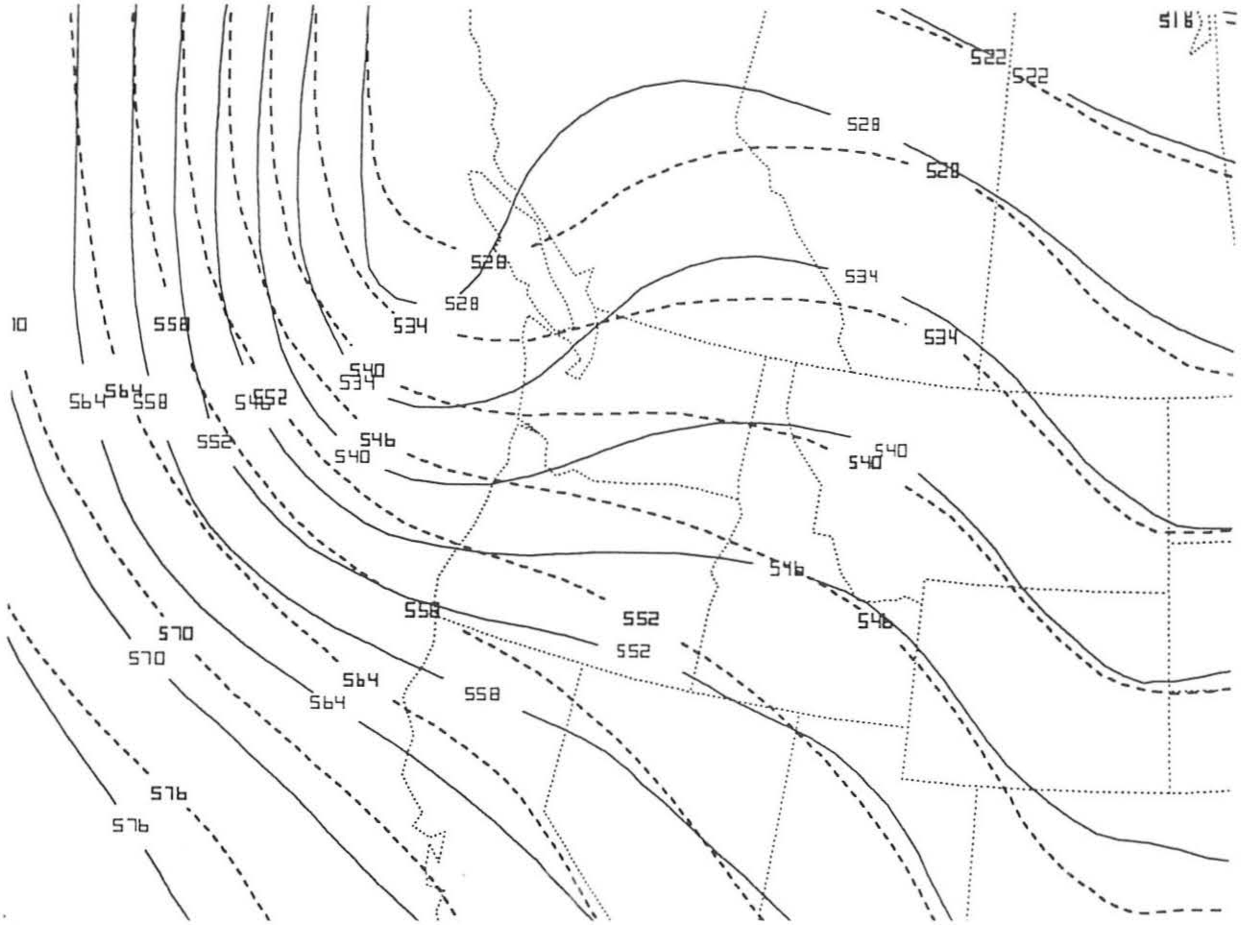

Fig. 4. 500 mb height field at 0000 UTC 17 December 1992 (solid) and 12 hour forecast NGM 500 mb height field from 1200 UTC 16 December 1992 (dashed).