AN ANALYSIS OF A HEAVY SNOWFALL EVENT OVER SOUTHWESTERN OREGON AND NORTHERN CALIFORNIA

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INTRODUCTION

From approximately 7 p.m. PST January 7 through 7 a.m. PST January 9, 2005 heavy snow fell across southwest Oregon and northern California in association with a strong and cold closed low pressure system. While only 2.4 inches of snow were received at the National Weather Service Weather Forecast Office (WFO) in Medford, Oregon during this 36-hour period, snowfall amounts exceeded 12 inches in many locations of WFO Medford's forecast area, with a maximum of 41 inches recorded on the Sexton Summit in southwest Oregon. As conditions worsened during the evening of January 7, travel became difficult or impossible in many locations; especially over the Siskiyou Summit on Interstate Highway 5 – the highest point (4310 feet MSL) of the Highway between the Mexican and Canadian borders – which either carried chain restrictions or was completely closed for practically the entire first weekend of the New Year. This paper will examine the ingredients that came together to produce this heavy snowfall event, along with forecast model performance, as well as some of the actions taken by WFO Medford before, during and after the event.

SYNOPTIC OVERVIEW AND EVENT SETUP

The strong and cold low pressure system that caused the heavy snowfall event originated in the Gulf of Alaska and dropped southward over the eastern Pacific Ocean from January 4-6, 2005. Initial indications on January 4 pointed to the possibility of a significant snowfall event impacting the area during the coming weekend from January 7-9, thus a Winter Storm Outlook was issued by WFO Medford early on the 4th to highlight this possibility. By early January 6, a Winter Storm Watch was issued for snow amounts ranging from 24 to 36 inches for portions of northern California where significant upslope flow and moisture conveyor-belt effects were anticipated.

At 1200 Universal Time Coordinated (UTC) (0400 Pacific Standard Time) January 7, a 500 millibar (mb) trough was located just off the Pacific Northwest coast (Fig. 1). A closed low in the base of the trough with a 500 mb minimum geopotential height of 5220 decameters was centered just west of British Columbia. A surface cold front extended across the eastern Pacific Ocean from a low pressure center located just northwest of Portland, Oregon through a point approximately 250 miles west of Eureka, California (Fig 2). The upper levels of the atmosphere over Oregon and northern California were devoid of any significant jet dynamics.

Because of the highly varied topography of WFO Medford's forecast area, heavy reliance was placed on the National Center for Environmental Prediction's ETA12 forecast model for this event due to its ability to more accurately resolve topographical influences. The 1200 UTC January 7 run of the ETA12 indicated that the eastern Pacific upper level trough and embedded closed low would continue southward during the day with the closed low becoming centered approximately 250 miles west of Portland, Oregon at 0400 UTC January 8. In response to the anticipated position of the closed low, a strong, moist and persistent southerly flow was expected to develop across the entire WFO Medford forecast area, with winds in the 850-700 mb layer of 25 to 45 knots (29 to 52 mph). Satellite imagery indicated no moisture connection into the sub-tropics, however, precipitable water values over the area were forecast to exceed 0.50 inches, at times, from January 7-9. This was due, in part, to significant over-water air trajectories, which would allow for the efficient entrainment of evaporated ocean water into the maritime air mass. Snow amounts gleaned from this model run for the most favored upslope areas in California remained in the 24 to 36 inch range for the previously defined 36-hour period, which reinforced confidence in precipitation forecasts generated by medium-range forecast models for this same area days before. Snow forecasts for the remainder of the forecast area indicated that heavy snow warnings or snow advisories would be necessary during this event.

The 1200 UTC January 7 run of the ETA12 model also indicated that a 500 mb short-wave trough and the previously identified surface cold front would move inland from the eastern Pacific after 0400 UTC January 8. Time-height sections generated from this same model run for points around the forecast area indicated moderate to high values of negative Omega (upward vertical velocity) during the evening of January 7 and again from very late January 8 through very early January 9 (Fig. 3). The negative Omega values were connected with two shortwave troughs and their associated surface cold fronts, which were prognosticated to sweep inland during these time periods amidst the strong south to southwest flow aloft. Model relative humidities were to exceed 80 percent in a layer from the surface to around 600 mb and this layer was bounded by temperatures roughly between 0 °C and -23 °C. This was an important factor since findings by Auer and White (1982) indicated that when strong vertical velocities were present in the middle atmosphere, temperatures were between -12 and -18° C, and the layer was saturated, snowflake production was maximized. Auer and White stated that because clouds were more likely to contain ice nuclei at these temperatures, the environment became increasingly supersaturated with respect to ice, which made the dendritic formation process most efficient. Additionally, even larger snowflakes could be produced over lower elevations since aggregation (sticking of snowflakes) would be maximized near 0º C, the temperature expected across much of the forecast area during this event.

The 24-hour 500 mb height forecast derived from the 1200 UTC January 7 run of the ETA12 model, showed that the 500 mb closed low, which was to be centered west of Portland, Oregon during the night of the 7th, would move north and become centered, once again, just west of the British Columbia coast. The closed low was also forecast to deepen to a minimum central geopotential height of 5110 decameters (Fig. 4). A surface front was forecast to extend from a low pressure area centered west of Seattle, Washington south-southwestward through a point approximately 400 miles west of Eureka, California (Fig. 5).

RESULTS

The 1200 UTC January 8 500 mb geopotential height analysis (Fig. 6) showed the 500 mb closed low embedded in the trough over the eastern Pacific had indeed shifted slightly north during the past 12 hours and was now centered approximately 250 miles west-southwest of Seattle, Washington. The low had also deepened to a central pressure of 5160 decameters. This correlated somewhat poorly with modeled 500 mb heights for this time period, as depicted in Figure 4, which forecast the low center to be approximately 50-100 miles farther to the north and 50 decameters lower. The surface plot for this same time period showed that a cold front was located over the eastern Pacific from approximately 150 miles west-northwest of Portland, Oregon to approximately 250 miles west of Eureka, California (Fig. 7). This correlated with modeled surface features, as seen in Figure 5, much better than modeled 500 mb heights for this same time period.

As the first shortwave trough and associated surface cold front of this event moved onshore the night of January 7, widespread snow developed along and just ahead of the front at elevations around 700 feet mean sea level (msl) and above. During the next 12 hours, the shortwave trough and surface cold front moved rapidly northeastward ushering in a colder maritime air mass. A second shortwave trough and front moved onshore after sunset on January 8, following roughly the same trajectory as the first trough and front. A combination of strong vertical velocities associated with the advancing shortwave troughs and surface cold fronts, persistent topographic forcing and a favorable moist thermodynamic profile for dendritic crystal growth resulted in moderate to heavy snowfall over a broad area of southwest Oregon and northern California from late January 7 through early January 9. A Special Weather Statement issued by WFO Medford in the afternoon of January 10 provided a preliminary summary of 33 snow reports gathered from various sources. By January 11, over 100 snow reports from various sources were compiled for the record and these reports were later plotted for graphical viewing (Fig. 8).

The ETA12 performed exceptionally well for this event when it came to modeled snow forecasts over the favored upslope areas in northern California. Over this area, reports of 36.0 inches of snow were not uncommon. However, the ETA12 significantly under forecast snow amounts over heavily topographically influenced areas of Oregon west of the Cascades, especially in Josephine County. The greatest snowfall report for this entire event of 41.0 inches was reported on the Sexton Summit in northeastern Josephine County of Southwest Oregon. Modeled snow amounts had not exceeded 16 inches for this area.

CONCLUSIONS

The main factor that led to the heavy snow received during this event was the strong and persistent topographical forcing associated with a slow moving closed low pressure system centered west of the Washington coast. The performance of the ETA12 model for this event, especially with regard to snowfall totals, was excellent in northern California areas that are repeatedly influenced by significant upslope flows. However, the ETA12 in most locations significantly under forecast snow amounts in areas which do not typically exhibit strong influences related to upslope flows, especially in Oregon, and in heavily topographical influenced areas of Oregon west of the Cascades. The total accumulated snowfall of 2.0-2.5 inches modeled for WFO Medford during this event was very accurately forecast when compared to the 2.4 inches of snow that fell. Due to WFO Medford's valley location, snow received at the WFO was not subject to topographic forcing.

Further study is needed to determine exactly why the ETA12 snow amounts were so under forecast in western Oregon, and especially in orographic locations. This could include the review of forecast snow amounts from other computer models for this storm, a closer look at the vertical velocity, moisture, and stability fields, and an examination of the ETA12 snow algorithm.

ACKNOWLEDGMENTS

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Auer, A. H. Jr., and J. M White, 1982: The Combined Role of Kinematics, Thermodynamics, and Cloud Physics Associated with Heavy Snowfall Episodes, J. Meteor. Soc. Japan, 60, 591-597.

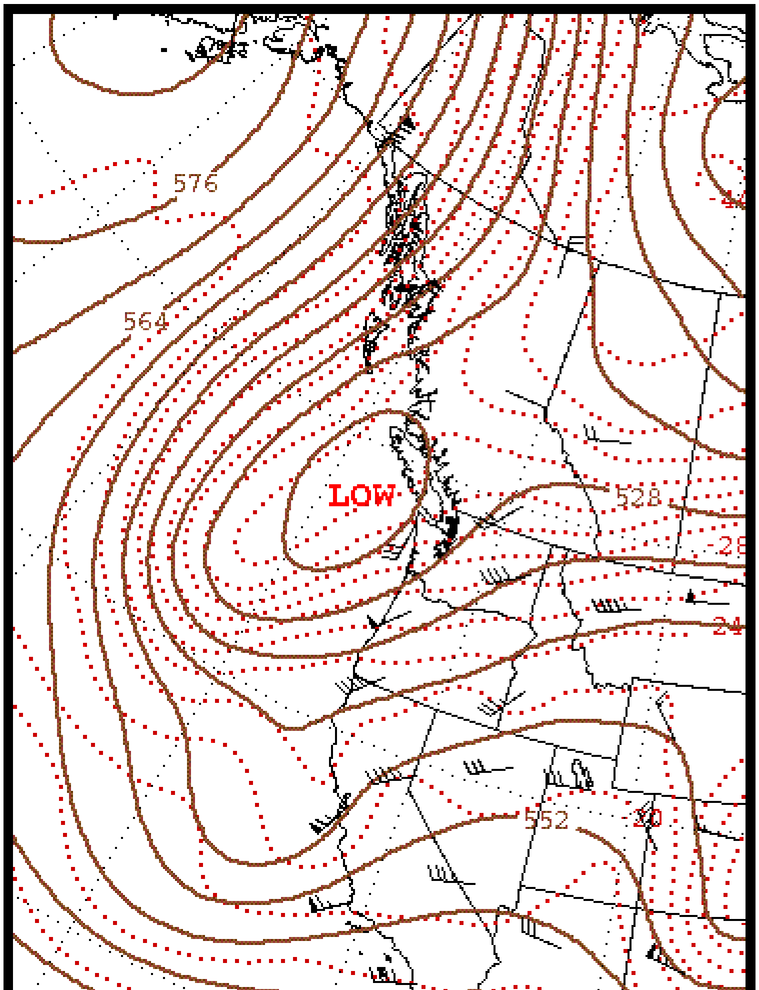

Figure 1. 1200 UTC January 7 2005 500 mb. geopotential height analysis. Chart courtesy of the Climate Prediction Center.

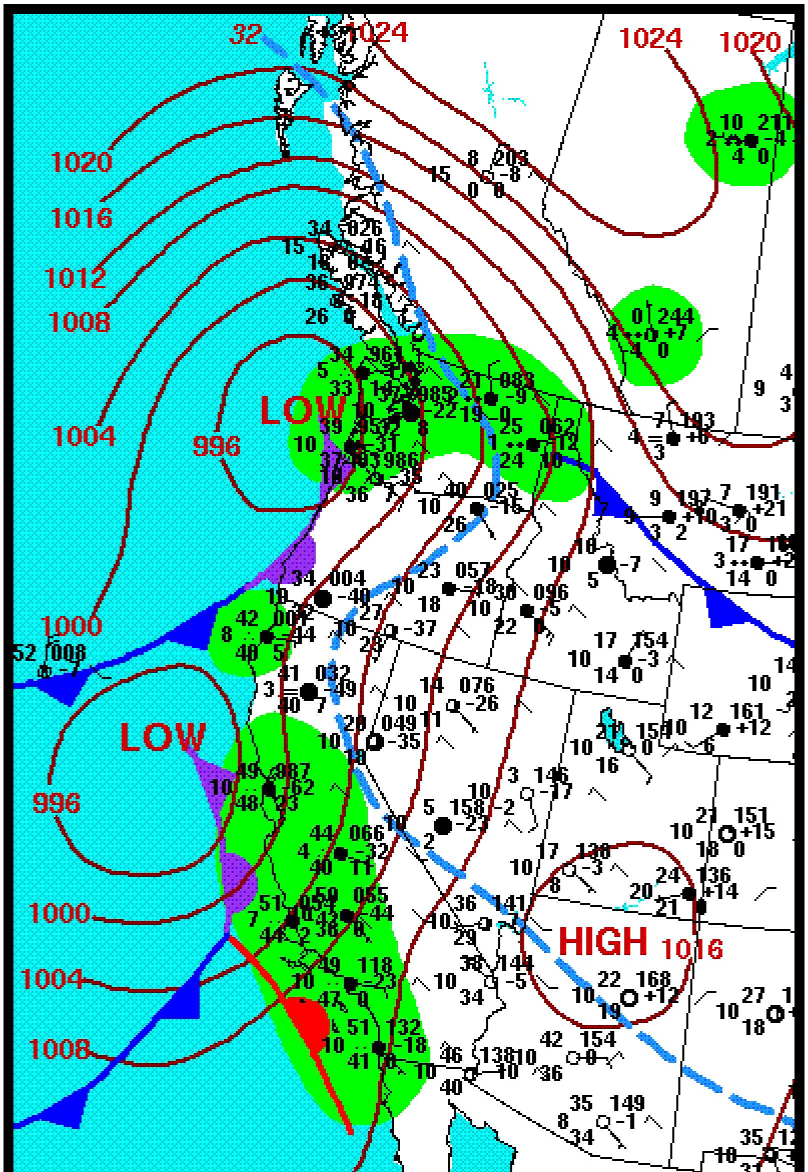

Figure 2. 1200 UTC January 7 2005 surface plot.
Chart courtesy of the Climate Prediction Center.

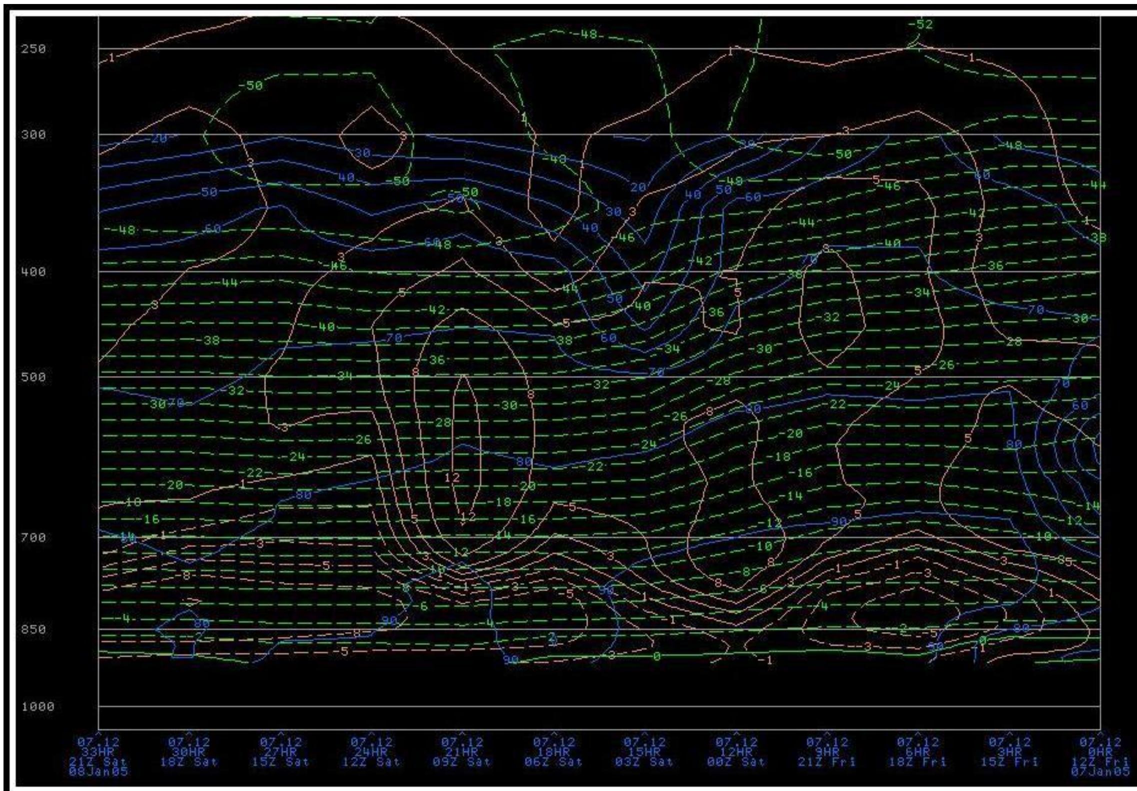

Fig. 3 1200 UTC January 7 2005 ETA12 time-height section from 1200 UTC January 7 2005 to 21Z Saturday January 8 2005 showing relative humidity in percent (blue), temperature in degrees celcius (green) and Omega in microbars (rose).

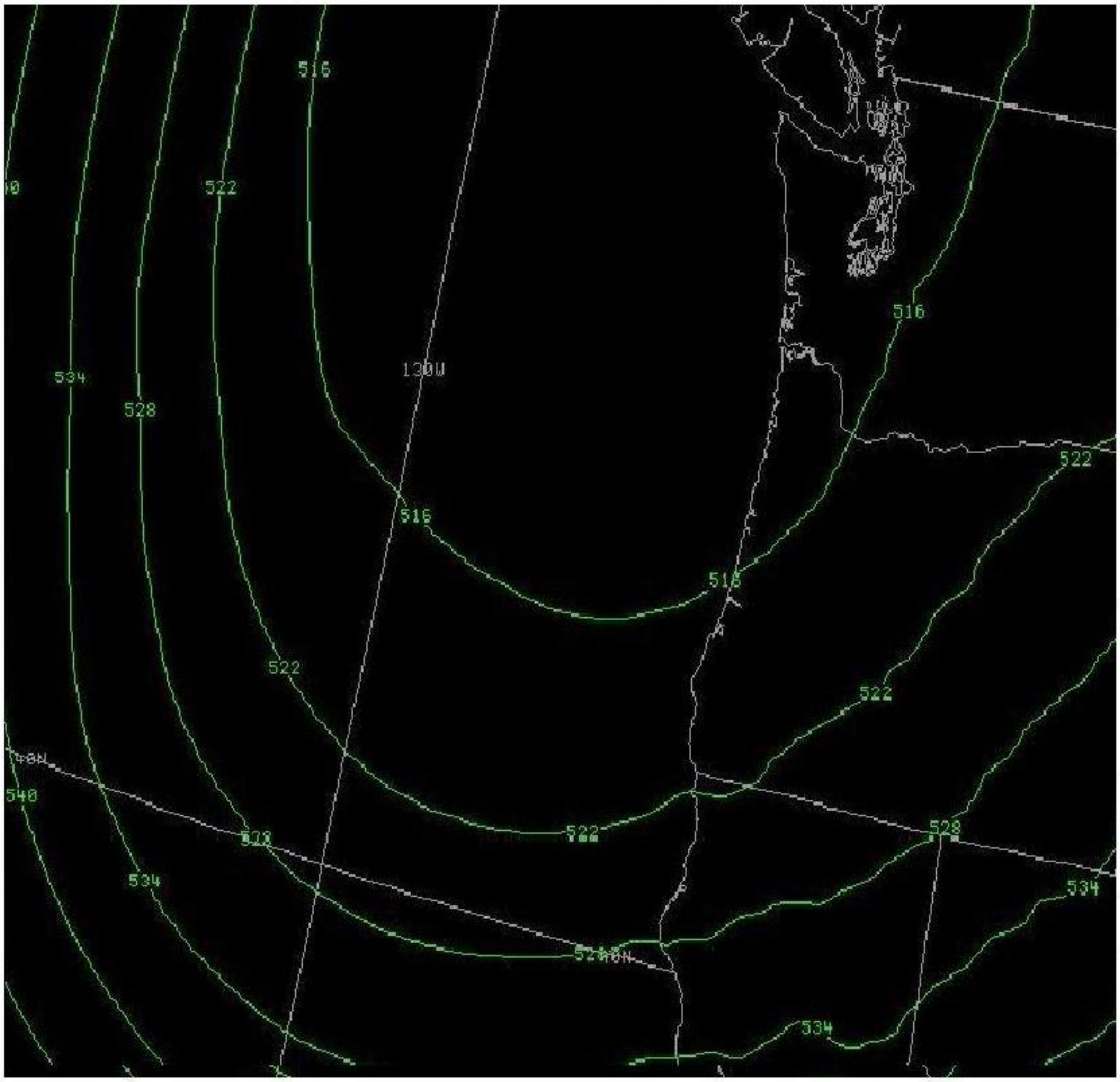

Fig. 4 1200 UTC January 7 2005 ETA12 500 mb. heights for 1200 UTC January 8 2005

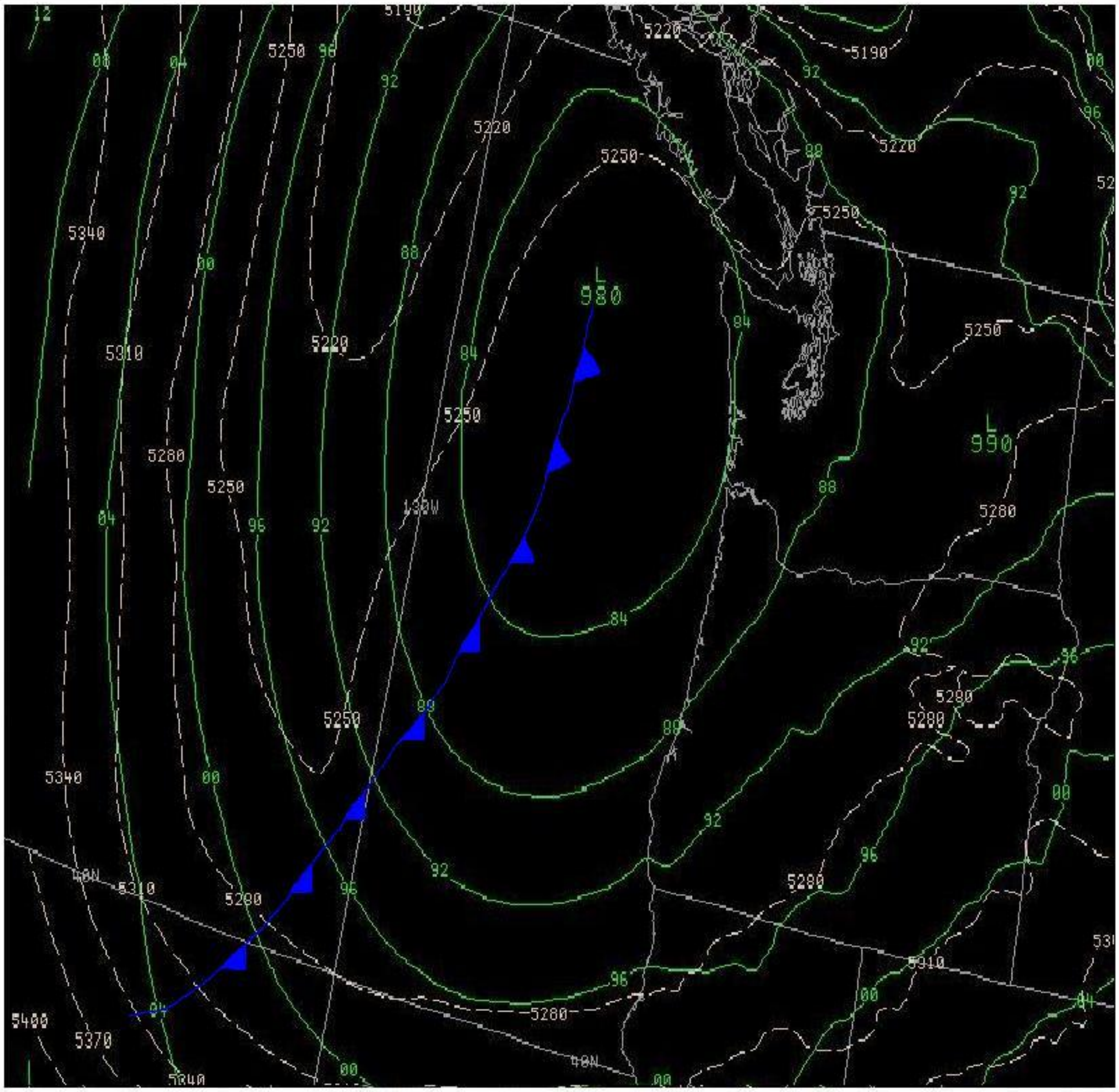

Fig. 5 1200 UTC January 7 2005 ETA12 mean sea level pressure (green), 1000-500 mb. thickness (white) and surface cold fronts (blue) for 1200 UTC January 8 2005

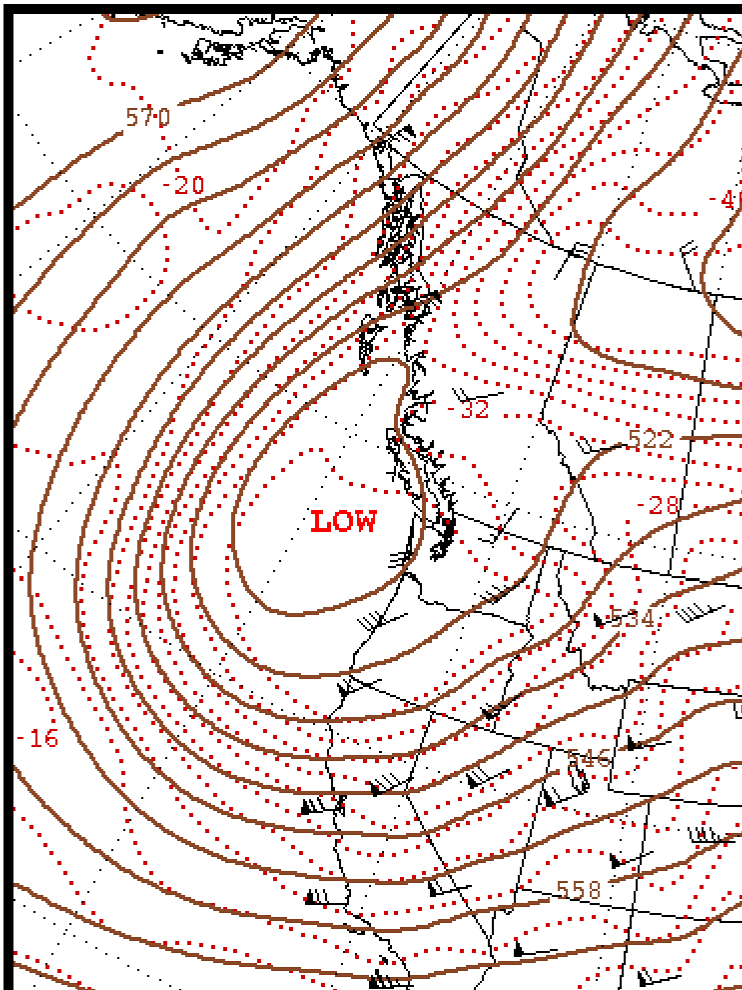

Figure 6. 1200 UTC January 8 2005 500 mb. geopotential height analysis. Chart courtesy of the Climate Prediction Center.

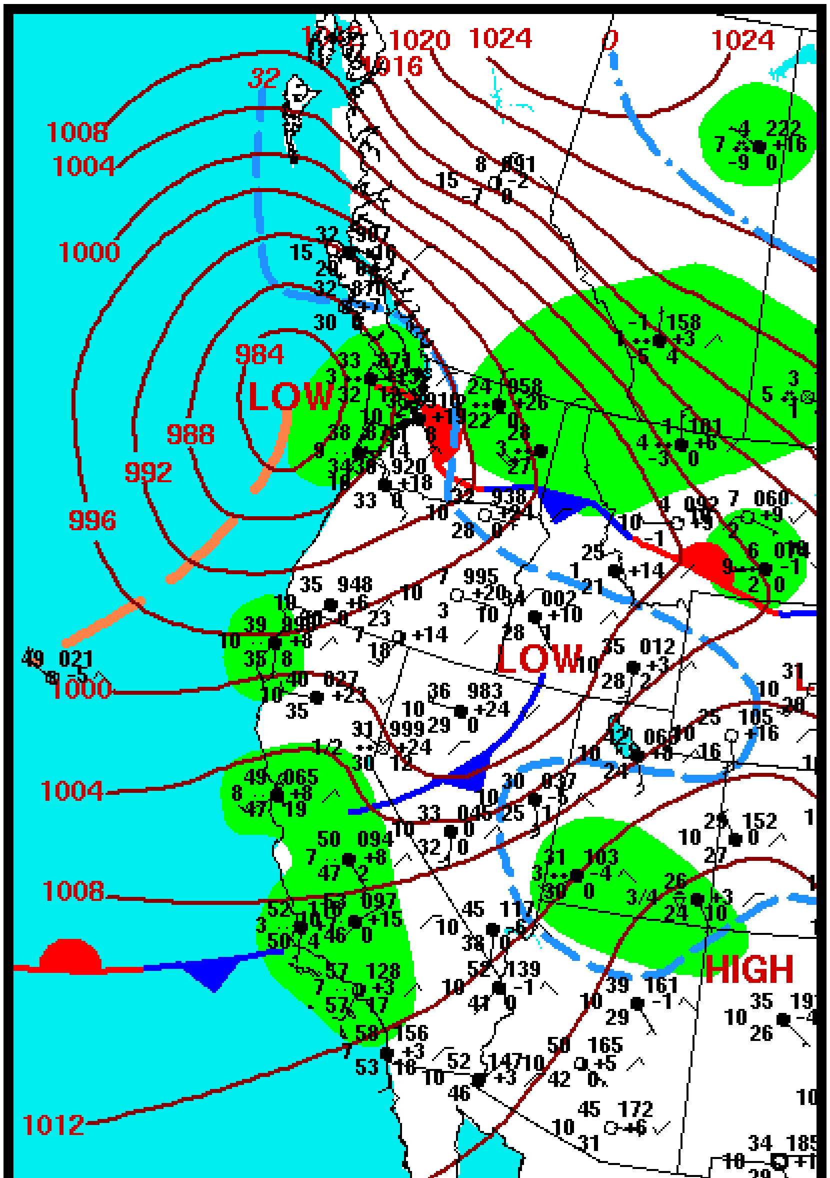

Figure 7. 1200 UTC January 8 2005 surface plot.
Chart courtesy of the Climate Prediction Center.

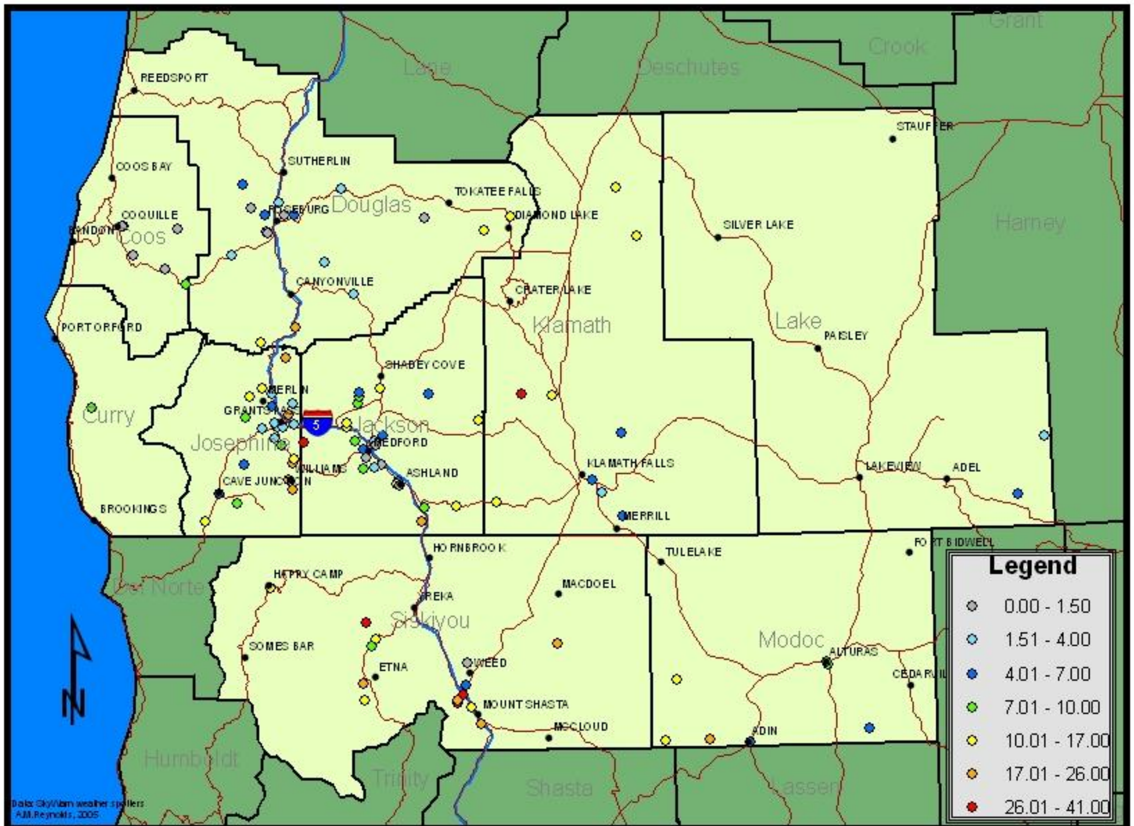

Figure 8. Plot of snowfall reports received from WFO Medford SkyWarn weather spotters on January 10, 2005 for the period of January 7 through January 9, 2005.