A Rare Severe Thunderstorm Event in the Rogue and Umpqua Basins of Southeastern Oregon

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Lead-up

On the morning of June 4th, a large scale, negatively tilted trough was pushing towards the Pacific Northwest, and was due to pass onshore later in the day. The associated surface low was already beginning to move through the Medford CWA, and the center of the low would eventually pass almost directly overhead between 1800 and 1900Z. Warm front passage occurred around 10 AM local time, with the cold front quickly following behind. Considerable cloudiness and light shower activity was present in the area ahead of and along the warm front, but rain had mostly moved east of the Cascades by mid-morning.

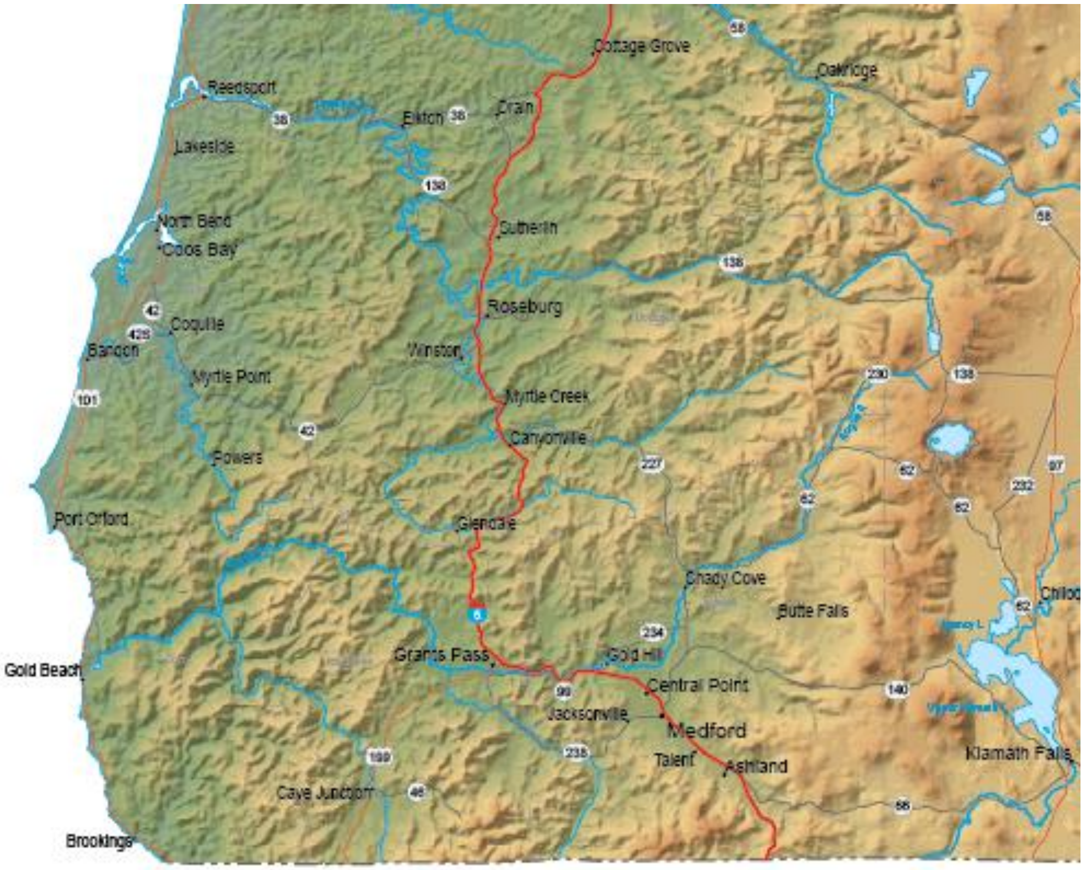

Figure 1: A map of southwestern Oregon containing the area of concern. The Rogue Valley is defined as the area around Medford and Grants Pass, while the Umpqua Valley is the area surrounding Roseburg.

Leading up to the event, thunderstorms were in the forecast for the area, and SPC was forecasting a general risk for thunderstorms east of the Oregon Coastal Range. Unfortunately, the models were producing a wide range of precipitation solutions. The smaller scale models, such as the NAM and RUC were producing very little instability in the morning runs, with CAPE values of less than 120 J/kg and Lifted Indices greater than -0.5, mostly centered along the Cascade range. However, the morning GFS runs/analyses were producing between 450-525 J/kg of CAPE and Lifted Indices of around -2.5 farther west, with areas of higher instability values concentrated over the Rogue and Umpqua Valleys. See Figure 2 as an example. The GFS also produced an area of relatively "thick" CAPE within the hail growth sector. The discrepancies between the models were mostly due to differences in the handling of the system's cold sector off-shore; the NAM and RUC were much warmer in the mid-levels, while the GFS was more in-tune with reality of an anomalously cold pool of mid-level air. This will be further discussed in a later section.

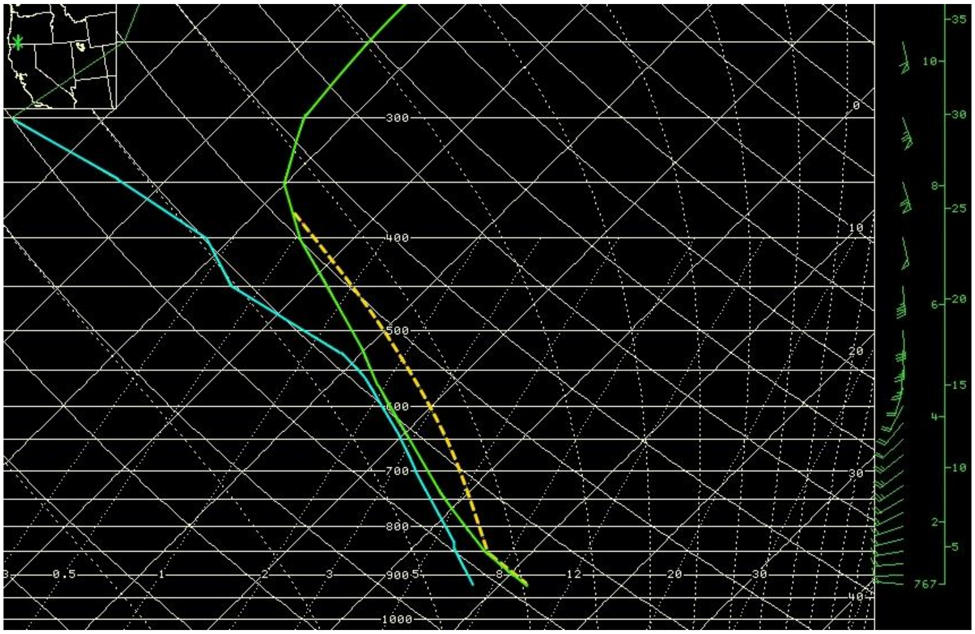

Figure 2: 18Z GFS forecast sounding for 0000Z June 5 at Medford. Sounding shows a lifted index of -2.6 and CAPE value of over 500 J/kg.

Moisture was also a key factor in the event. Previous rainfall and a significant push of moisture from an atmospheric river over the Pacific (Fig 3) kept humidity high in the lower levels, but significant dryness in the mid to upper levels kept precipitable water suppressed at 0.60-0.90 inches during the afternoon. A review of the anomalously high moisture values will be discussed later.

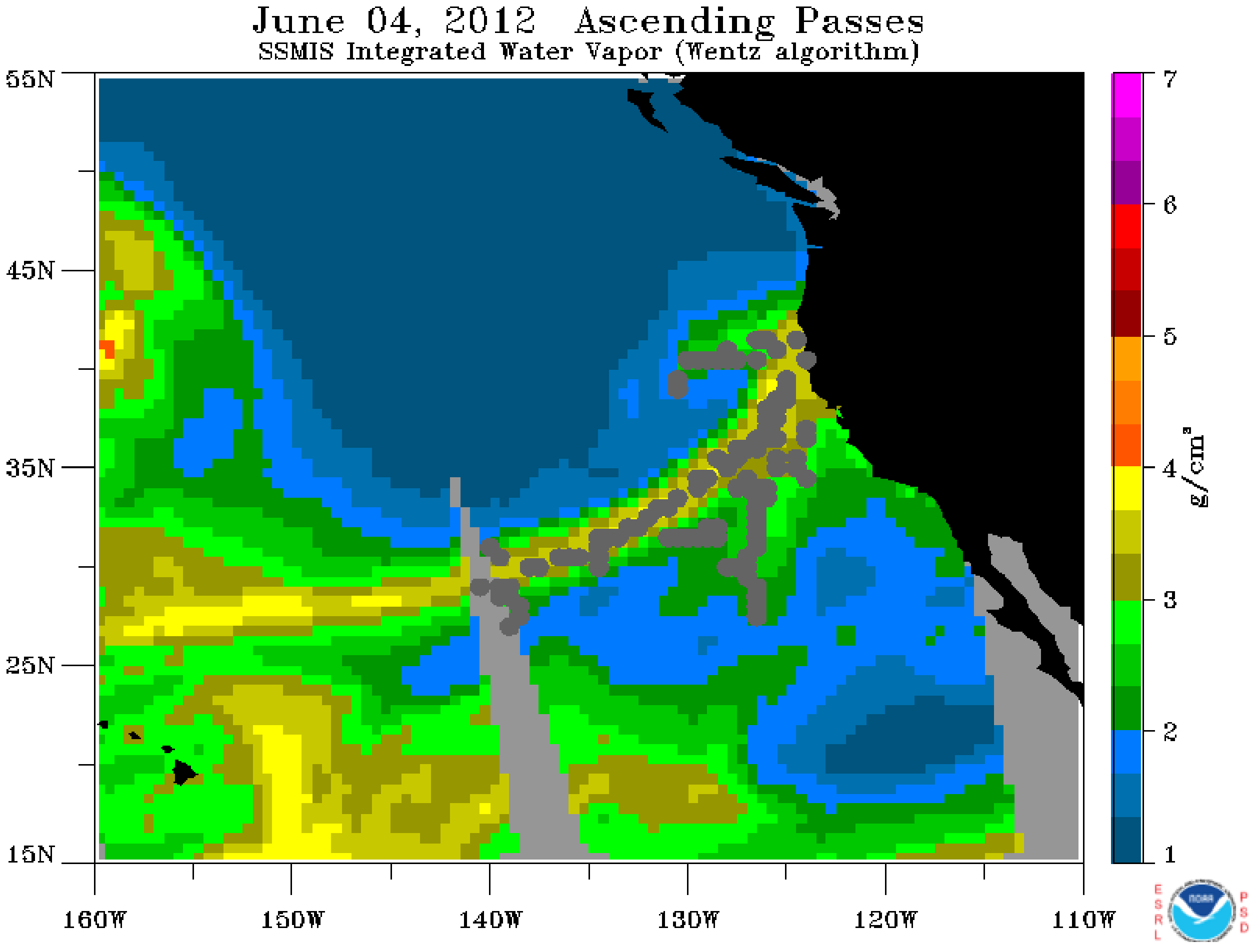

Figure 3: Diagram showing atmospheric river feeding moisture into the area of concern. Blue colors represent areas of less moisture content, with yellow designating higher moisture content. Grey circles represent algorithm points denoting path of atmospheric river.

Event

Once the cold front passed over the inland valleys west of the Cascades, a small break in cloudiness followed, giving roughly 2 to 3 hours of sunshine to those areas. This break would allow for enough surface heating that surface-based instability was produced beneath the newly arriving low and mid-level cold air (Figure 4). This is well illustrated by low level lapse rates of 7-7.5 C /km that developed within the region (Figure 5). Other "classic" features were also in place that would support development. The right entrance region of the jet stream was located directly above the area, which also aligned with an area of localized maximum divergence aloft. There was also an axis of shear maxima that stretched north to south just west of the Cascades, which was well aligned with the surface based CAPE contours (compare Figures 4, 5, and 6, as well as ground truth from 0000Z sounding in Figure 7)

Figure 4: Surface based CAPE from 2000Z SPC mesoanalysis. Note area of local max within oval.

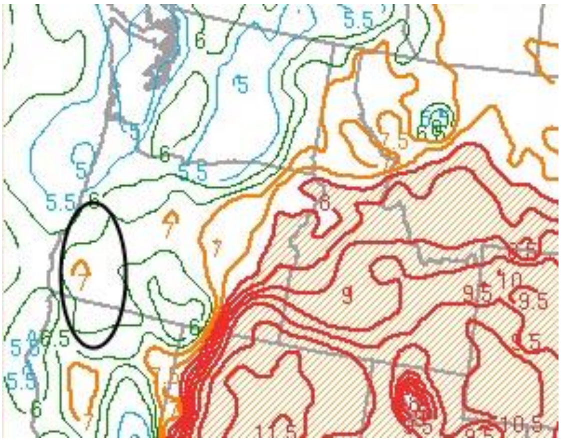

Figure 5: SPC mesoanalysis of 2000Z 0-3km lapse rates. Note area of local max within oval.

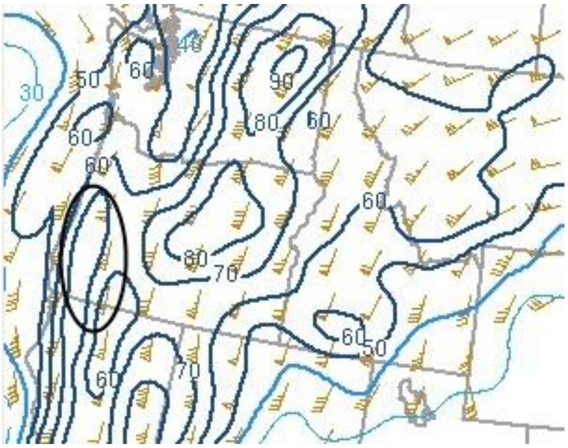

Figure 6: 2000Z 0-6km shear from SPC mesoanalysis. Narrow band just inland in southwestern Oregon has values of 70 kts or greater. Note area of local max within oval.

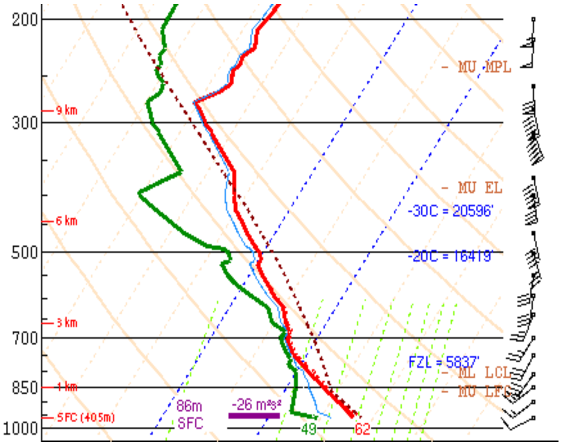

Figure 7: Observed 0000Z sounding from KMFR. Observed Cape was over 600 J/kg, 0-3 Km lapse rates were over 8 C/km, but 0-6km shear was 48 kts.

Once the area of clearing passed through the area (Figure 8), numerous areas of convection developed within the Rogue and Umpqua basins, beginning around 1900Z. The first lightning-producing cell developed in the upper Umpqua Valley (Western Douglas County) at roughly 1930Z, followed by additional development along the Umpqua Divide around 2000Z. From there, convection spread south, forming a line of thunderstorms stretching roughly from Roseburg to south of Grants Pass. The line then tracked east, passing through Medford at around 2130Z, before continuing into the Cascades and weakening by 2200Z (see Figures 9, 10, and 11). The storms prompted 5 separate Severe Thunderstorm Warnings, a special weather statement, and also an urban flood advisory for the City of Medford. 1” hail was reported in Grants Pass, with many reports of pea to dime sized hail scattered around the area. Gusty winds were also reported, with an estimated top gust of 60 mph recorded in the Myrtle Creek area. Heavy rain was reported with nearly every cell. The Medford Airport received 0.52 inches of rain, and recorded rainfall rates in excess of 5 inches an hour for several minutes. A map of the reports can be seen in Figure 12.

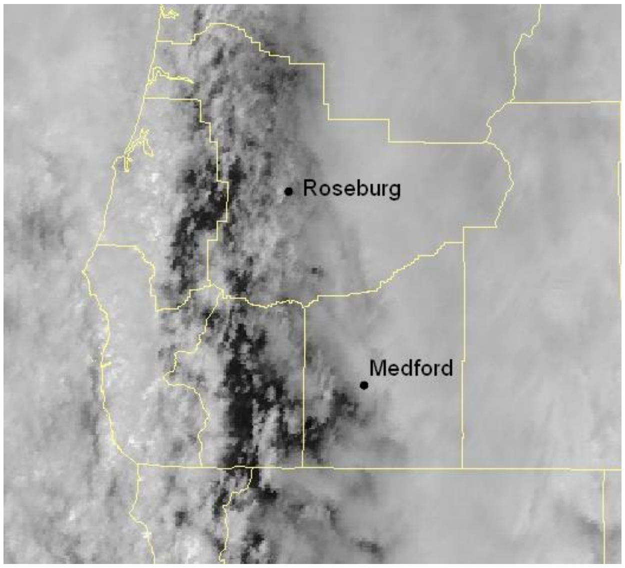

Figure 8: Visible satellite image from 1900Z. Note area of clearing just inland from coastline.

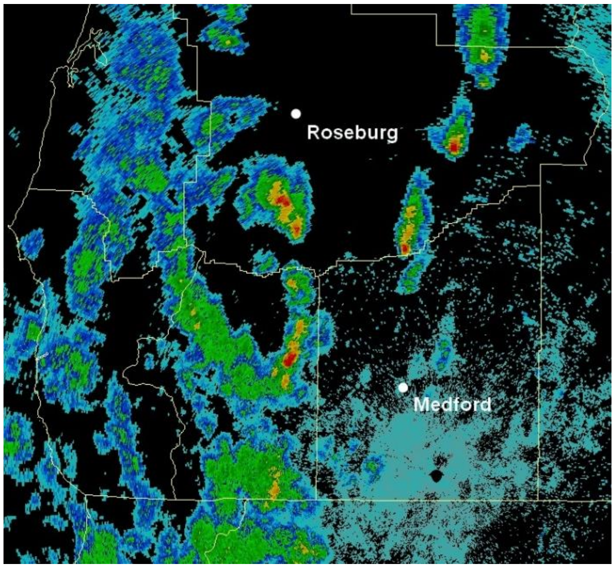

Figure 9: Radar image from 2030Z.

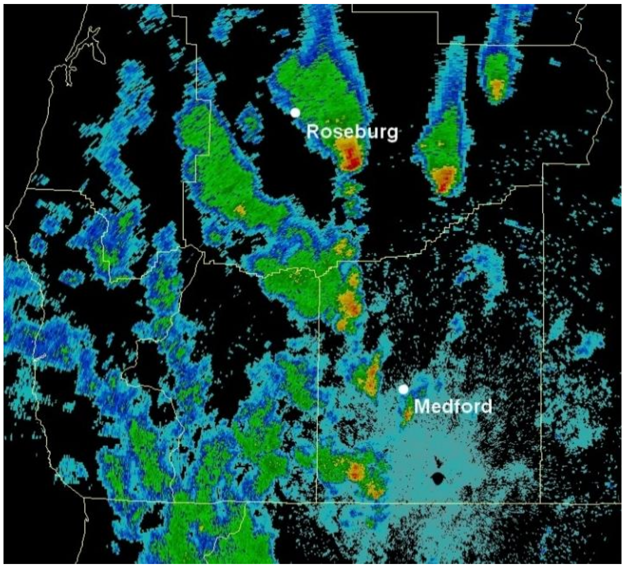

Figure 10: Radar image from 2110Z.

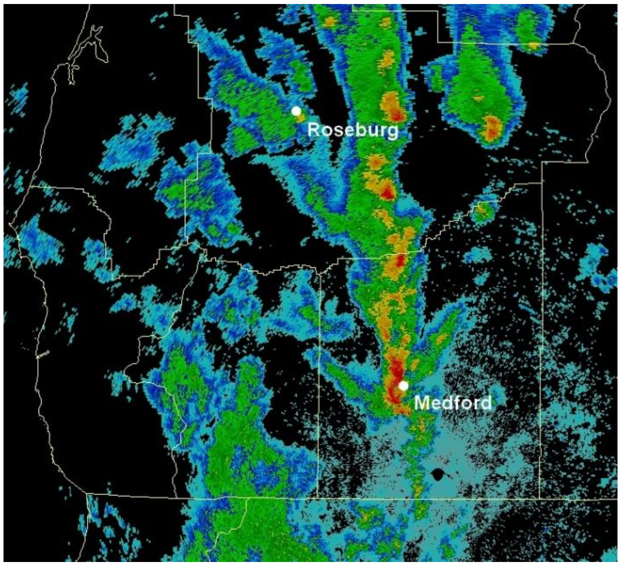

Figure 11: Radar image from 2142Z.

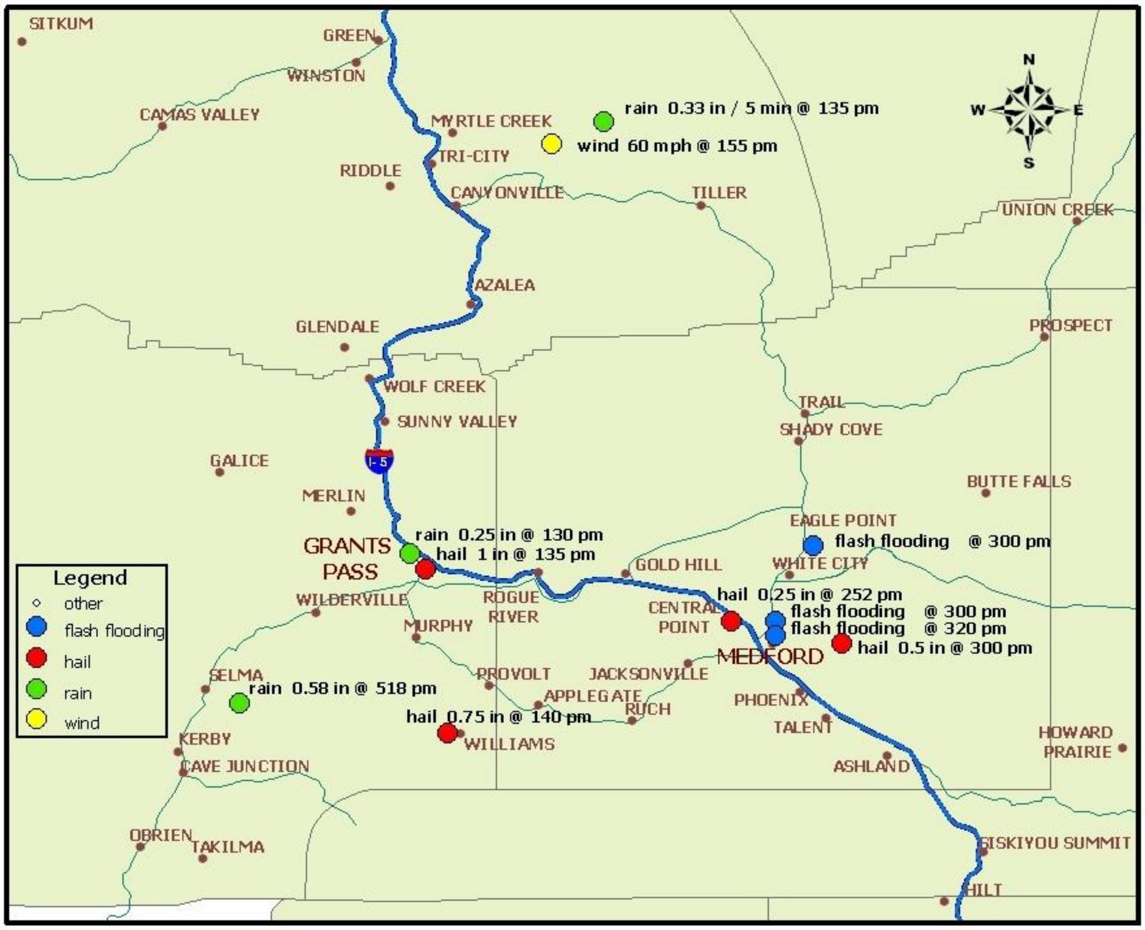

Figure 12: Map showing spotter reports from event. Image by C. Clarstrom.

Anomalies

Severe thunderstorms are not common in the valleys of southwestern Oregon; therefore anomalous situations are needed to produce such an event. The storms demonstrated how several highly anomalous features came together to produce heavy rainfall, large hail, and strong winds. The first was the push of cold mid-level air. Analysis of 700mb temperatures revealed that the cold sector of the mid-latitude system was up to 3.0 standard deviations (σ) below normal as a whole (Fig 13). This significantly colder air was pushing into the area above a layer of residual warm air trapped in the valleys. This warm air was then reinforced by solar heating under somewhat clearer skies behind the cold front. The significance of the system's strength and amount of cold air can also be shown from the 500mb height anomaly (Fig 14). The maximum height anomaly occurred just after the event, with the center of the trough reaching 2.5 σ below normal. The anomalously cold air that pushed into the area is the primary reason that moderate solar heating immediately behind a cold front was able to produce instability sufficient for strong thunderstorm development.

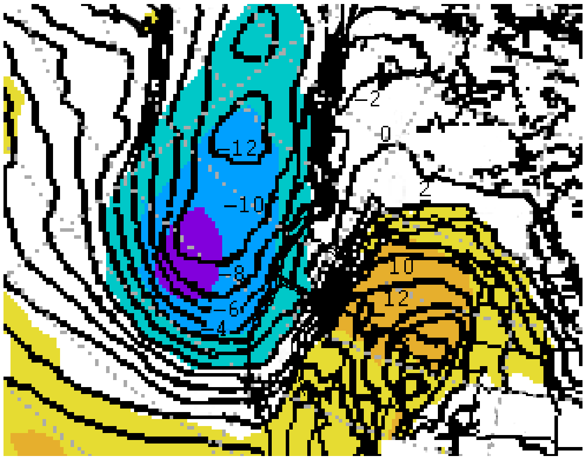

Figure 13: 0000Z GFS 700mb temperatures. Standardized anomalies are indicated in color. Note blue and purple shades indicating below normal σ. Light blue denotes σ of -1, ranging to values of -3 or more within the purple area.

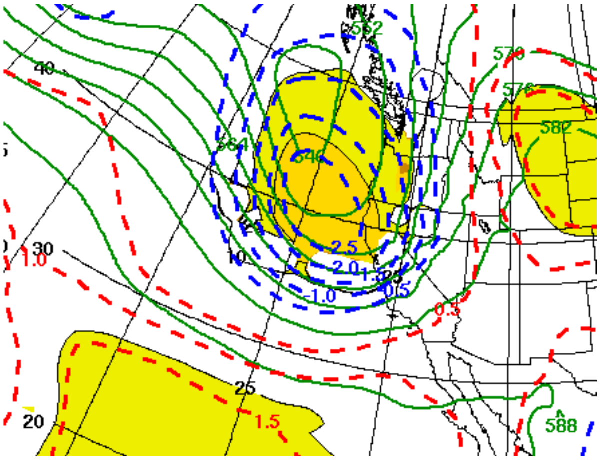

Figure 14: 0000Z GFS 500mb heights and standardized anomalies (red and blue dashed contours).

In order to produce the heavy rain and hail that was observed, abundant moisture was needed. Precipitable water was only observed to be in the range of 0.70– 0.90 inches during the event, which is not necessarily high. However, for the time of year in SW Oregon, this amounted to 1.5 to 2.0 σ above normal, or close to 175% of normal (Fig 15). This placed the region on the low side of the generally accepted “rule” of 2.0-4.0 σ producing a high end heavy rainfall event (Grant and Grumm, 2012). Moisture was also fed into the storms by an atmospheric river, which can be illustrated by the moisture flux associated with the system (Fig 16). Moisture fluxes leading into the region were on the level of 4.0-5.0 σ above normal. This is highly significant considering that only 2.0-4.0 σ is considered necessary for heavy rainfall, as per Grant and Grumm’s presentation (2012).

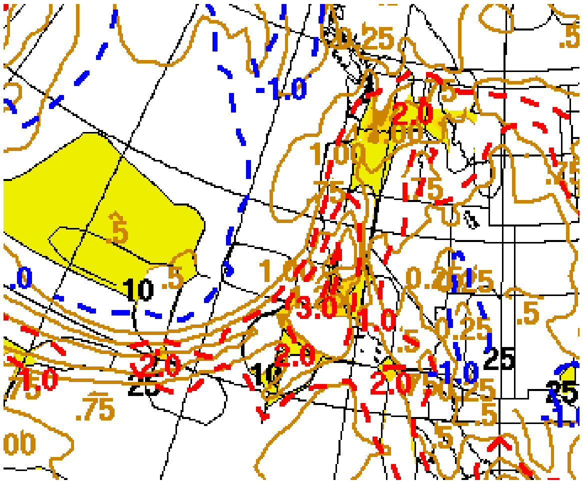

Figure 15: 1200Z GFS precipitable water anomalies (red and blue dashed contours).

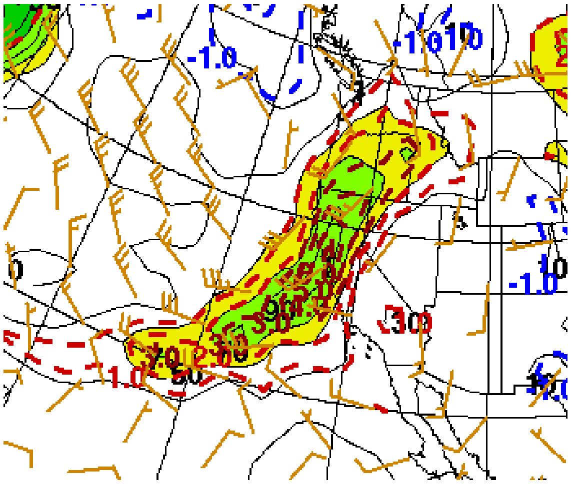

Figure 16: 1200Z GFS moisture flux anomalies (red and blue dashed contours).

Conclusions

A series of anomalous features came together to produce an unusual, and hard to forecast, convective event in southwestern Oregon. Much colder than normal mid-level air pushed into the region while surface heating produced enough instability that higher than normal moisture fields were able to be utilized in the production of heavy precipitation. In short, many anomalous features worked in conjunction to produce a synoptically driven, surface based severe event. Forecast anomaly fields should be monitored as a significant tool in storm prediction, especially if more than one feature is apparent along with the "classic" synoptic and mesoscale patterns that are known to produce such an event.

Acknowledgements

The author would like to thank C. Clarstrom for assistance with graphics, and M. Stavish for editorial advice. Thanks also to R. Grumm for providing select archived data.

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