Analysis of a Severe Thunderstorm Event in Western Oregon Using the Weather Event Simulator (WES)

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Introduction

On April 30, 2003, severe thunderstorms developed over parts of western Oregon, an area that rarely experiences such events. A cold upper low produced the dynamic conditions known to be favorable for strong convective development. These thunderstorms produced frequent lightning, funnel clouds, and severe size hail. Many long time residents over western Oregon said this was one of the most spectacular lightning displays they had seen in many years.

Convective activity with this system was forecasted well in advance. However, some interesting details emerged after a WES review of this event by the Portland WFO forecasters. This paper describes these findings which helps explain the evolution of this severe event.

Synoptic and Mesoscale Discussion

A deep closed upper low originating from the Gulf of Alaska dropped south and stalled along the southern Oregon coast (figure 1). The position of the upper low put most of western Oregon under the favorable upper diffluent sector of the cold upper trough (figure 2). Sufficient daytime heating allowed surface temperatures to easily surpass the convective temperature (16 C). In fact, temperatures below 850 mb were +5 C warmer than the previous day when cloud cover dominated. With cold air advection occurring aloft, a very steep lapse rate resulted. Table 1 summarizes the general instability values based on the 00Z Salem sounding, taken near the time of the severe reports.

Surface based LI (C) -3.8

Lapse Rates (C/km)

1000-700 mb 7.90
1000-500 mb 8.24

Total Totals 61

CAPE (J/kg) 773

Table 1. Instability parameters derived from Salem sounding.

Pulse type convection began by mid afternoon with cells cycling roughly every 15 minutes. However, from 00Z to 01Z, convection became sustained along a rough line extending from the East slopes of the Coast Range northeast through Portland into southwest Washington. Very little cell movement was noted due to the weakening flow aloft as seen on the 00Z sounding (figure 3). Cells developed rapidly with core reflectivity values increasing up to 65 dbz. An interrogation of the MSAS and LAPS surface wind data shows a steady upvalley wind component, which is common on warm days (figure 4). From 01Z to 02Z, the surface wind increased and became onshore over the extreme Northwest part of Oregon. This change in wind direction resulted in a boundary between the onshore flow and upvalley flow. At 02Z, surface observations clearly show a southwest to northeast oriented boundary which likely provided the additional upward forcing needed for sustained convective development (figure 5). It is also likely this boundary provided the directional sheer necessary for funnel cloud development.

Funnel clouds can develop out of relatively weak sheering conditions, and may not be indicated by radar. One particular cell near Beaverton produced a confirmed funnel cloud around 0150Z. In this case, an evaluation of velocity scans surrounding the reported funnel shows both broad areas of cyclonic rotation as well as gate-to-gate sheer (figure 6). At 0153Z, a cyclonic sheer maximum was noted on the 3.4 degree velocity scan at the time of maximum cell intensity (Table 2).

Additionally, the very low freezing level on this day was a strong indicator that hail would occur with thunderstorms. Indeed, many reports of pea to marble size hail were received from across the CWA. It was later learned that one cell produced 1 1/8 inch hail in Keizer, northwest of Salem. This particular cell developed along the aforementioned boundary and remained at peak intensity for approximately 25 minutes (Table 3).

Time 0153Z

Maximum Composite Refl. (dbz) 65

Echo Top (ft) 35,000

VIL kg/m2 35

Velocity 3.4 Deg. (kts) 50

VIL Density (kg/m3) 3.37

Table 2. Radar data from funnel-producing cell (near Beaverton) at time of maximum intensity.

Time 0209Z

Max Composite Refl. (dbz) 60

Echo Top (ft) 35,000

VIL (kg/m2) 35

VIL Density (kg/m3) 3.37

Freezing Level (kft) 6.0

Table 3. Radar data from severe hail producing cell (2 miles northwest of Salem) at time of maximum intensity.

Conclusion

Analysis of the MSAS surface wind data was particularly useful. The high resolution wind field clearly shows the intersection of the upvalley wind component and the onshore wind flow component. Surface observations overlaid on composite radar imagery reveal the line of strongest convection developed roughly along this boundary. The boundary may have also provided a sheering component necessary for the funnel cloud development. Use of the WES software was clearly helpful in the review process. Forecasters were able to gain additional insight into the evolution of this event.

Figure 1

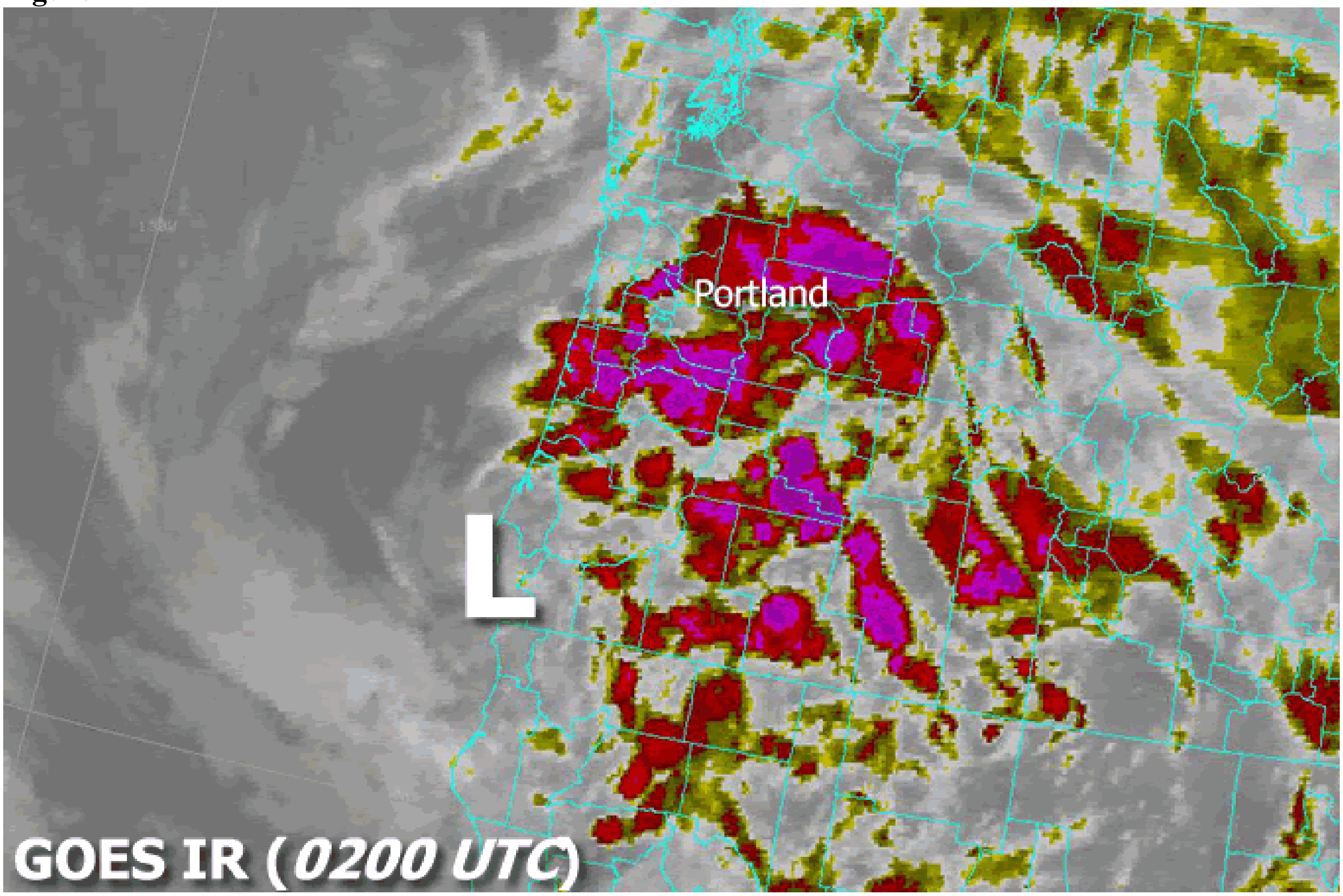


Figure 2

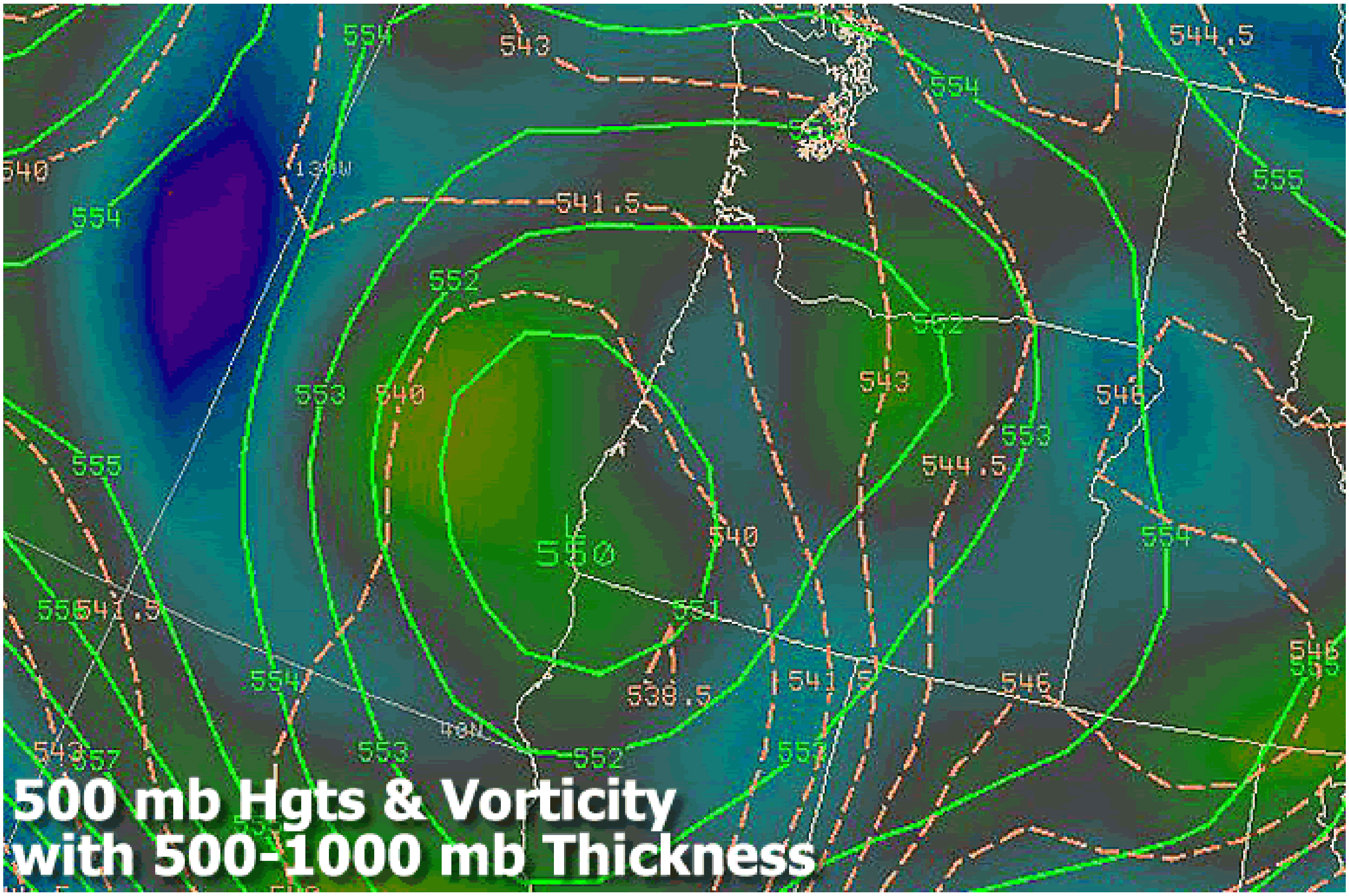


Figure 3

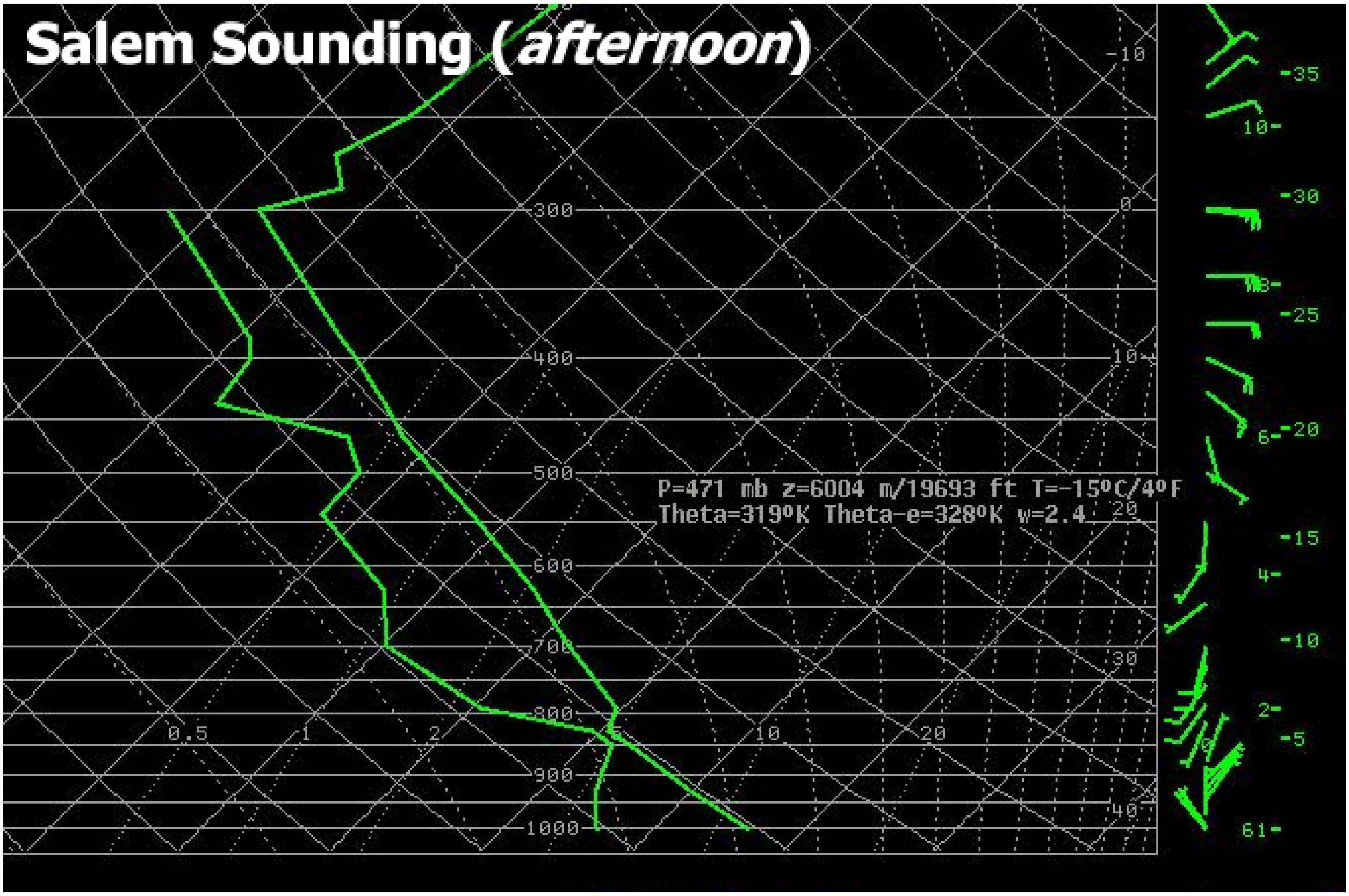

Salem Sounding (*afternoon*)
P=471 mb z=6004 m/19693 ft T=-15ºC/4ºF
Theta=319ºK Theta-e=328ºK w=2.4

Figure 4

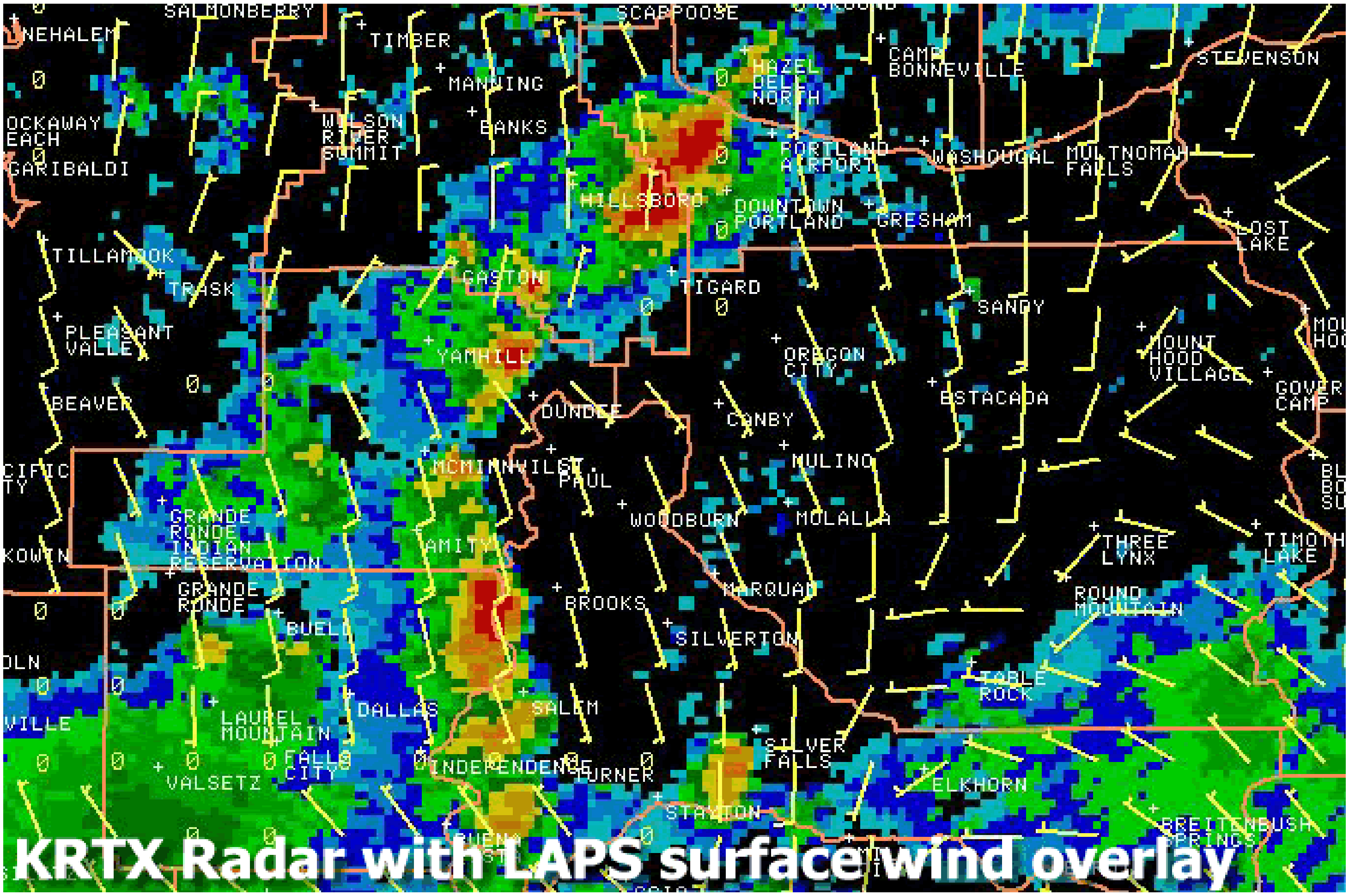


Figure 5

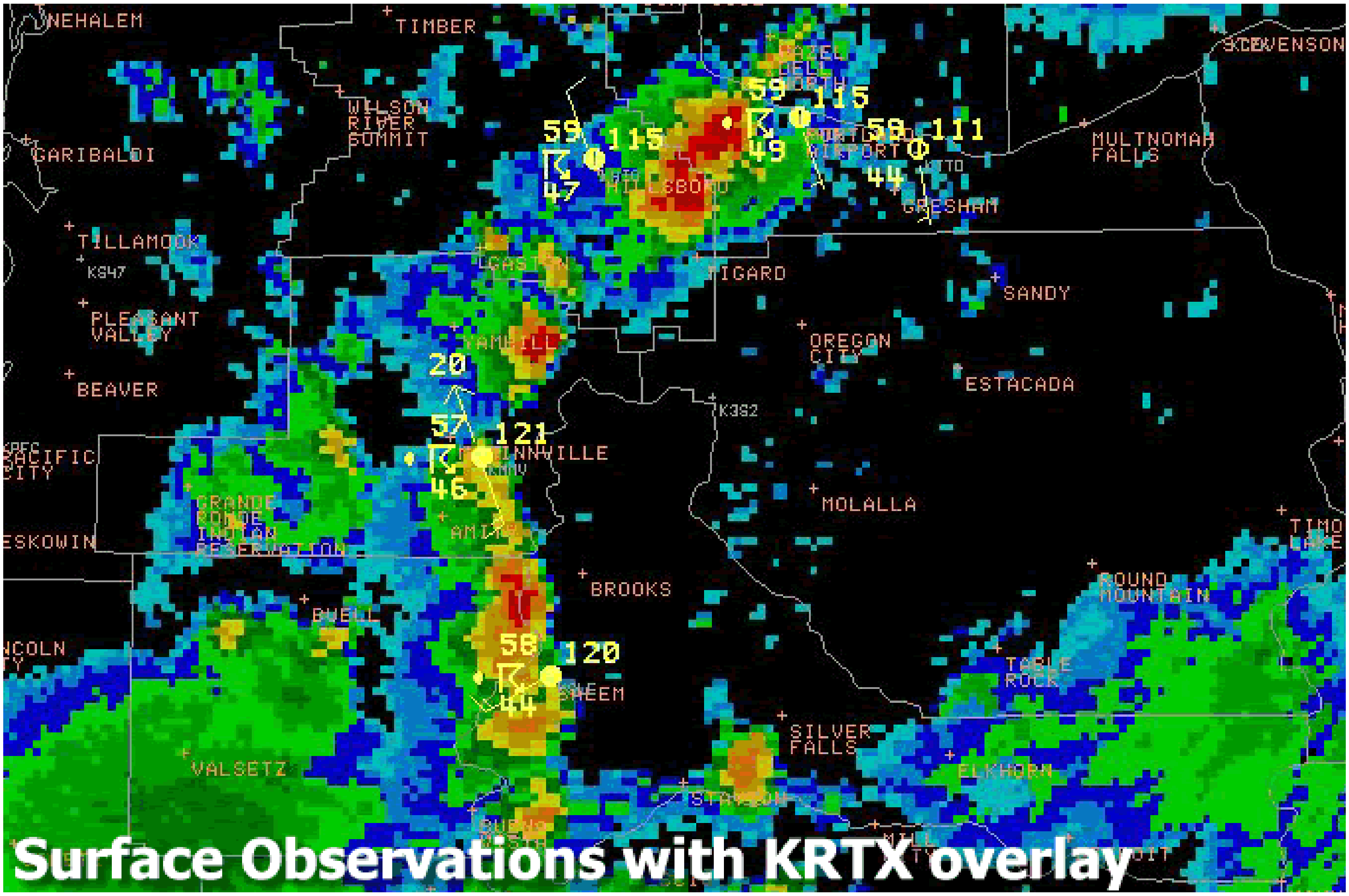
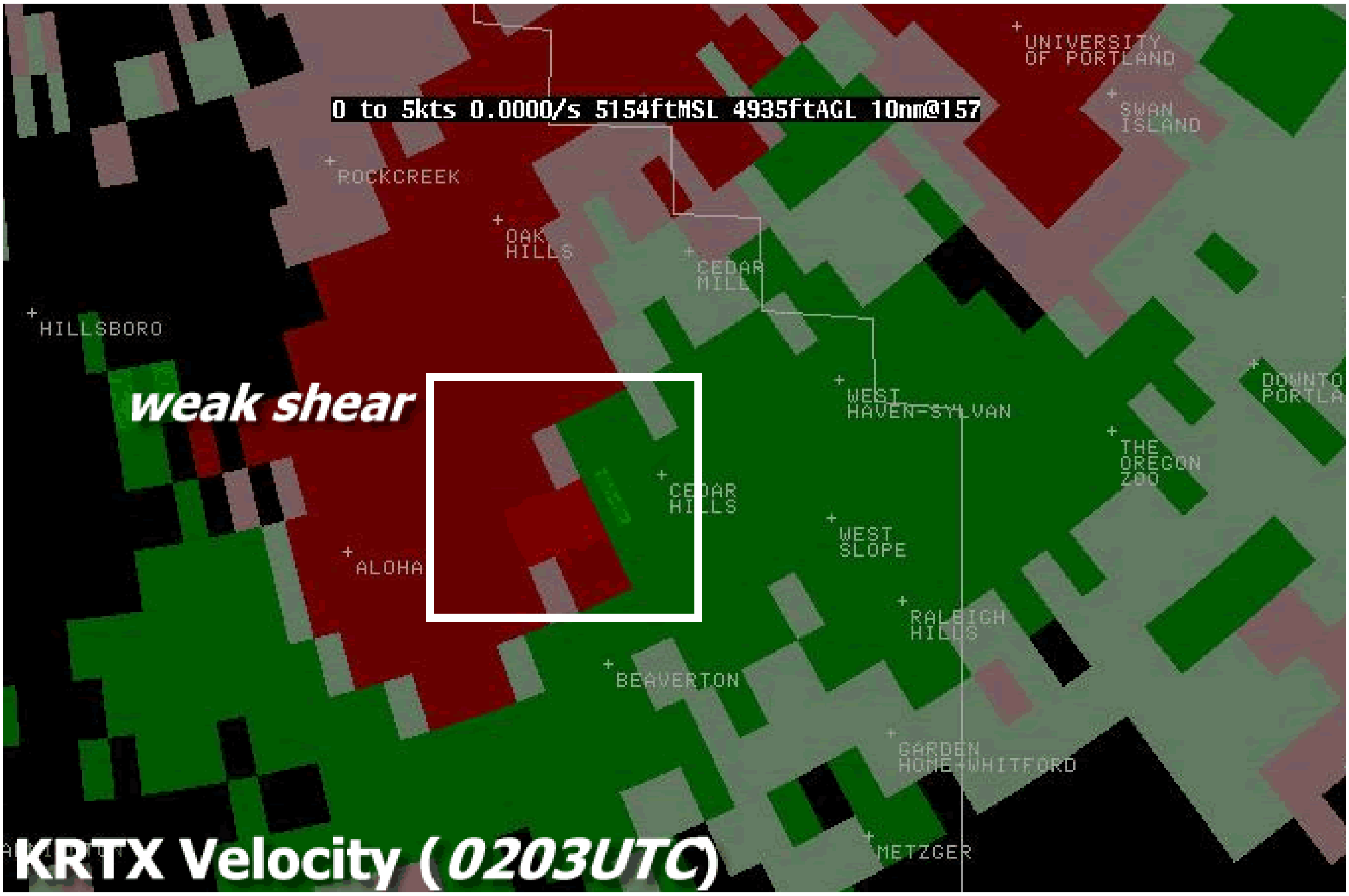

Surface Observations with KRTX overlay
NEHALEM
TIMBER
STEVENSON
WILSON RIVER SUMMIT
GARIBALDI
MULTNOMAH FALLS
HILLSBORO
GRESHAM
TILLAMOOK
GASTON
TIGARD
SANDY
PLEASANT VALLEY
YAMHILL
OREGON CITY
BEAVER
ESTACADA
MOLALLA
GRANDE RONDE INDIAN RESERVATION
BROOKS
ROUND MOUNTAIN
BUELL
TABLE ROCK
SILVER FALLS
VALSETZ
ELKHORN
59
115
49
58
111
44
47
20
57
121
46
58
120
44

Figure 6



0 to 5kts 0.0000/s 5154ftMSL 4935ftAGL 10nm@157
UNIVERSITY OF PORTLAND
SWAN ISLAND
ROCKCREEK
OAK HILLS
CEDAR MILL
HILLSBORO
weak shear
WEST HAVEN-SYLVAN
DOWNTO PORTLA
THE OREGON ZOO
CEDAR HILLS
WEST SLOPE
ALOHA
RALEIGH HILLS
BEAVERTON
GARDEN HOME-WHITFORD
METZGER
KRTX Velocity (0203UTC)