A Nocturnal Thunderstorm Event on August 6, 2003

A Weather Event Simulation

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Introduction

On August 6, 2003, a broad upper-level low pressure system was located over the northeast Pacific between 130 and 140 degrees west longitude. A smaller upper-level closed circulation moved onshore over southwest Oregon during the afternoon (Fig. 1), and moved northward across central Oregon during the evening and across eastern Oregon/Washington overnight (Fig. 2). Afternoon thunderstorms developed across central and northeast Oregon prior to the arrival of the short wave (not shown). Surface-based CAPE estimates during the afternoon were less than 200 J/kg, and the thunderstorms were weak and short-lived. However, thunderstorm intensities increased markedly after 8 pm and continued overnight (Table 1) as synoptic scale lift from the aforementioned short wave encountered mid-level potential instability. As the potential instability was released overnight, there was also sufficient wind-shear to support several organized storm cells lasting for 2 to 3 hours. Most of the storms remained over unpopulated areas. However, urban flooding was reported in Bend, OR and nickel size hail was reported near Prosser, WA.

Table 1. Hourly Lightning Counts on August 6 and 7, 2003 for a rectangular area slightly larger then the PDT County Warning Area.

Hour (PDT)	3 pm	4	5	6	7	8	9	10	11	12 am	1	2	3	4	5	6	7	8	9
Count	2	19	1	34	50	67	116	214	99	316	714	318	457	486	382	439	196	148	37

Model Forecasts Leading Up To the Event

Leading up to the event, model forecasts did not provide good guidance for the shortwave moving across eastern Oregon overnight. For example, figure 3 shows the Eta model 36, 24 and 12-hour forecasts that verify at 12z on August 7. The lower-right panel of figure 3 shows the verifying analysis. The Eta model forecasts improved with each successive model run, but even the 12-hour forecast (lower-left panel) failed to capture the strength of the shortwave. GFS model solutions (not shown) were similar. McMurdie and Mass (2004) show that poor initializations of systems like this one are not uncommon over the data sparse northeast Pacific. Moreover, as the shortwave moved onshore, the relatively small diameter of the closed circulation, around 200 km, made it even more difficult for numerical initialization schemes to capture the dynamics of the short wave.

Storm Environment

Despite poor initializations from earlier runs, the 00z 07 August run of the Eta model seems to do a good job capturing the forcing and instability associated with the event.

Lift (model omega) north of the shortwave roughly coincided with the location and timing of the thunderstorms (Figs. 4 and 5). Eta model soundings suggest that temperature advection was not a significant factor in destabilizing the air mass. However, model soundings suggest that steep mid-level lapse rates were already in place. For example, figure 6, an Eta model sounding at Pendleton, OR, showed steep lapse rates between 700 and 500mb. Furthermore, cross sections across the region of deep convection showed a layer of potential instability. For example, figure 7, a cross section between Redmond, OR and Ephrata, WA, showed a level of theta-e decreasing with height between 850 and 600 mb. Moisture was not a limiting factor for this event. Precipitable water and surface dewpoint values were well above normal (not shown), around 0.9 inches and in the 50s respectively.

Surface observations indicated that thunderstorm cloud bases were around 5,000 feet AGL, a lower than usual level for elevated convection in the Intermountain West. Three factors probably contributed to these lower than typical bases: (1) above normal moisture availability, (2) the evening timing of the short wave did not provide time for a deeper stable surface based layer to develop, and (3) the bottom of the layer of potential instability was fairly low (around 850 mb).

The 00z Eta model showed bulk shear values through the 1-6 km or 0-6 km layers (Fig. 8) in the 40-50 kt range, strong enough to support organized (tilted) thunderstorms. The KPDT 88-D VAD wind profile observations support these model estimates of shear values. For example, figure 9 shows the KPDT wind profile around 12z, shortly after thunderstorms passed about 50 miles west of Pendleton. Figure 9 shows (1) westerly wind below 3,000 feet AGL, the result of outflow from the thunderstorms west of Pendleton, and (2) the layer of shear above the cloud base (the Pendleton ASOS observed the cloud base at 8,500 feet AGL). The model sounding from the Eta model captures these features fairly well (fig. 6), with the exception, of course, of the westerly outflow.

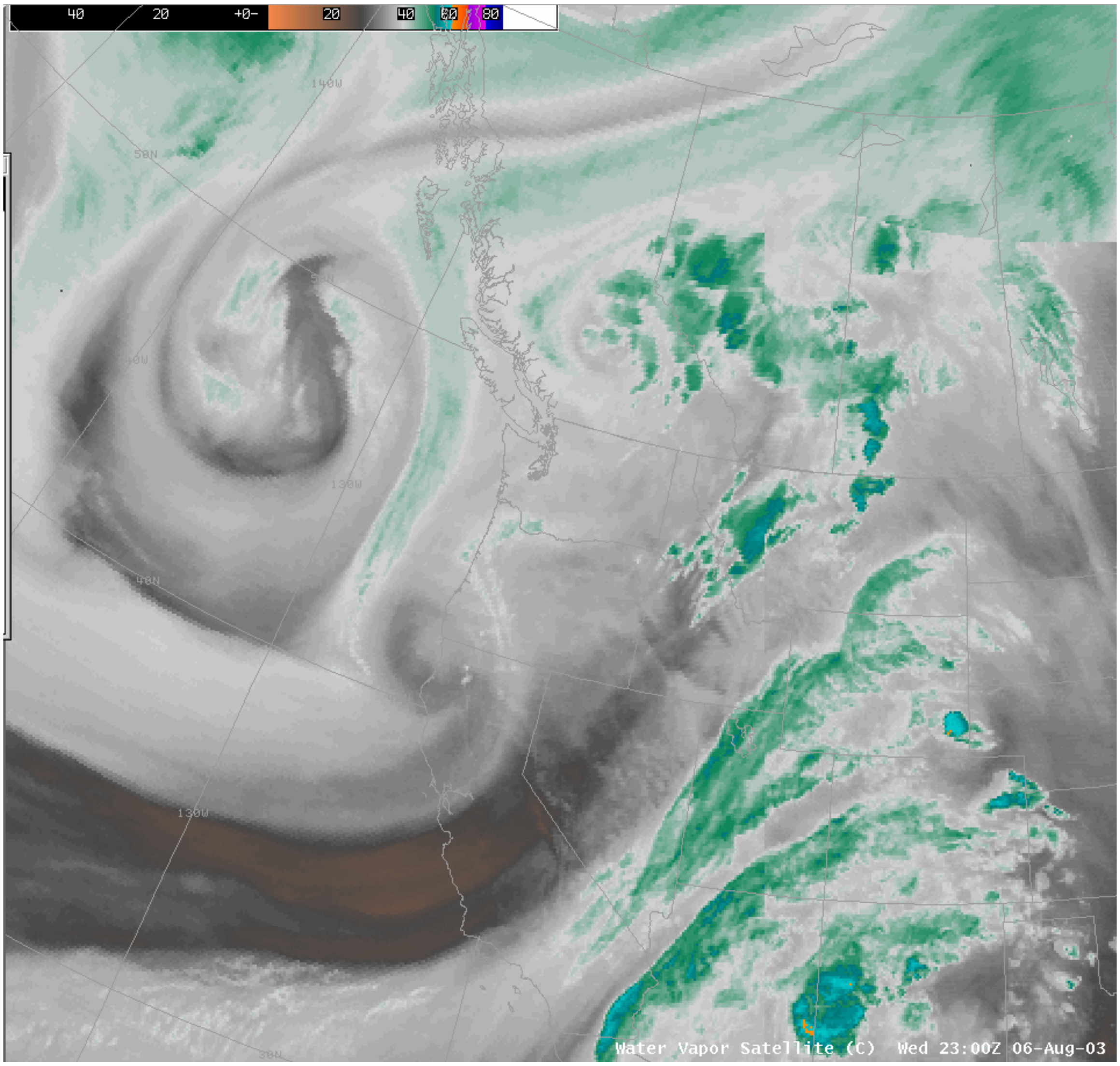
Discussion

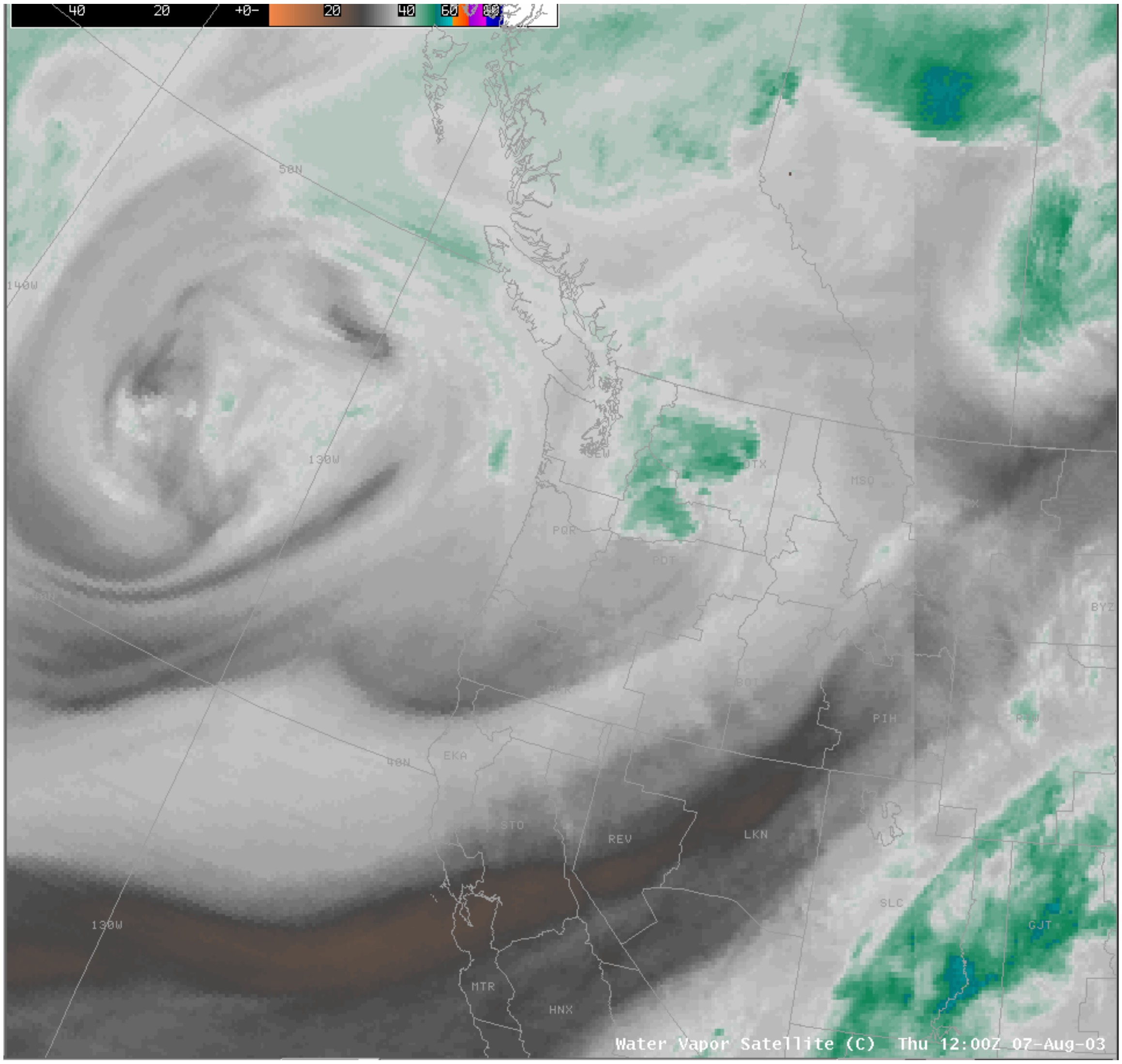
The ingredients for thunderstorms were not as strong with this event as they were for the nocturnal supercell event described by Solomon and Birch (1998). Nonetheless, this event is a good training exercise for the Weather Event Simulator (WES) because it challenges the forecaster to recognize the poor model initializations leading up to the event and the potential for nocturnal thunderstorms impacting a large geographic area. Further, more than half a dozen cells were strong and possibly severe, providing a good opportunity for the practice of radar analysis and warning decision making.

References:

McMurdie, L. and Mass, C., 2004: **Major Numerical Forecast Failures over the Northeast Pacific.** *Weather and Forecasting.* Vol. 19, No. 2, pp. 338–356.

Solomon, J. and Birch S., 1998: **Examination of the Mesocyclone Core Evolution of a Nocturnal Supercell Thunderstorm in Central Oregon.** *Western Region Technical Attachment.* No. 98-25.

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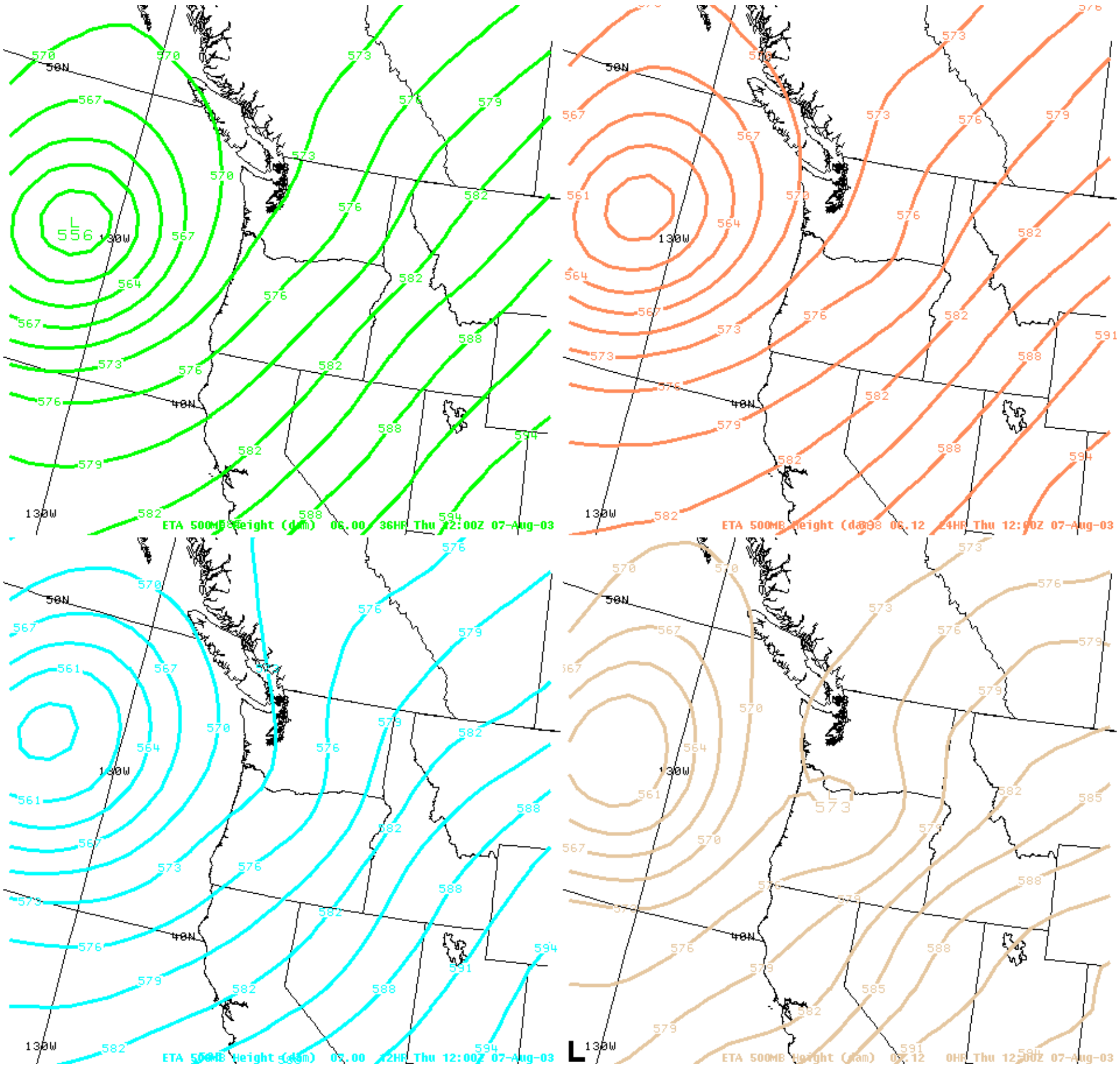
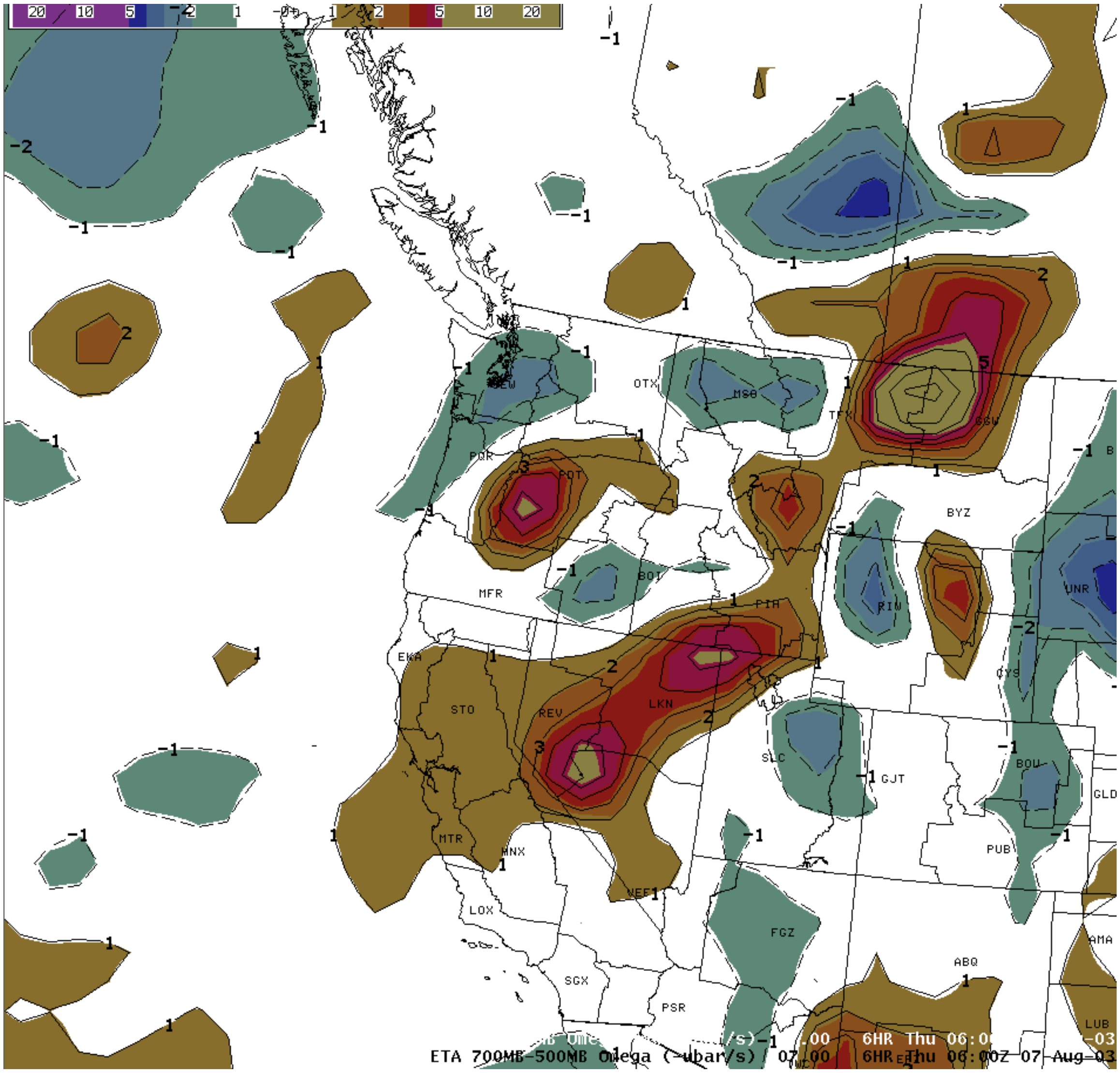
MTR
HNX
Water Vapor Satellite (C) Thu 12:00Z 07-Aug-03


50N
40N
130W
ETA 500MB Height (dam)
36HR Thu 12:00Z 07-Aug-03
24HR Thu 12:00Z 07-Aug-03
12HR Thu 12:00Z 07-Aug-03
0HR Thu 12:00Z 07-Aug-03



ETA 700MB-500MB Omega (-ubar/s) 07.00 6HR Thu 06:00Z 07-Aug-03
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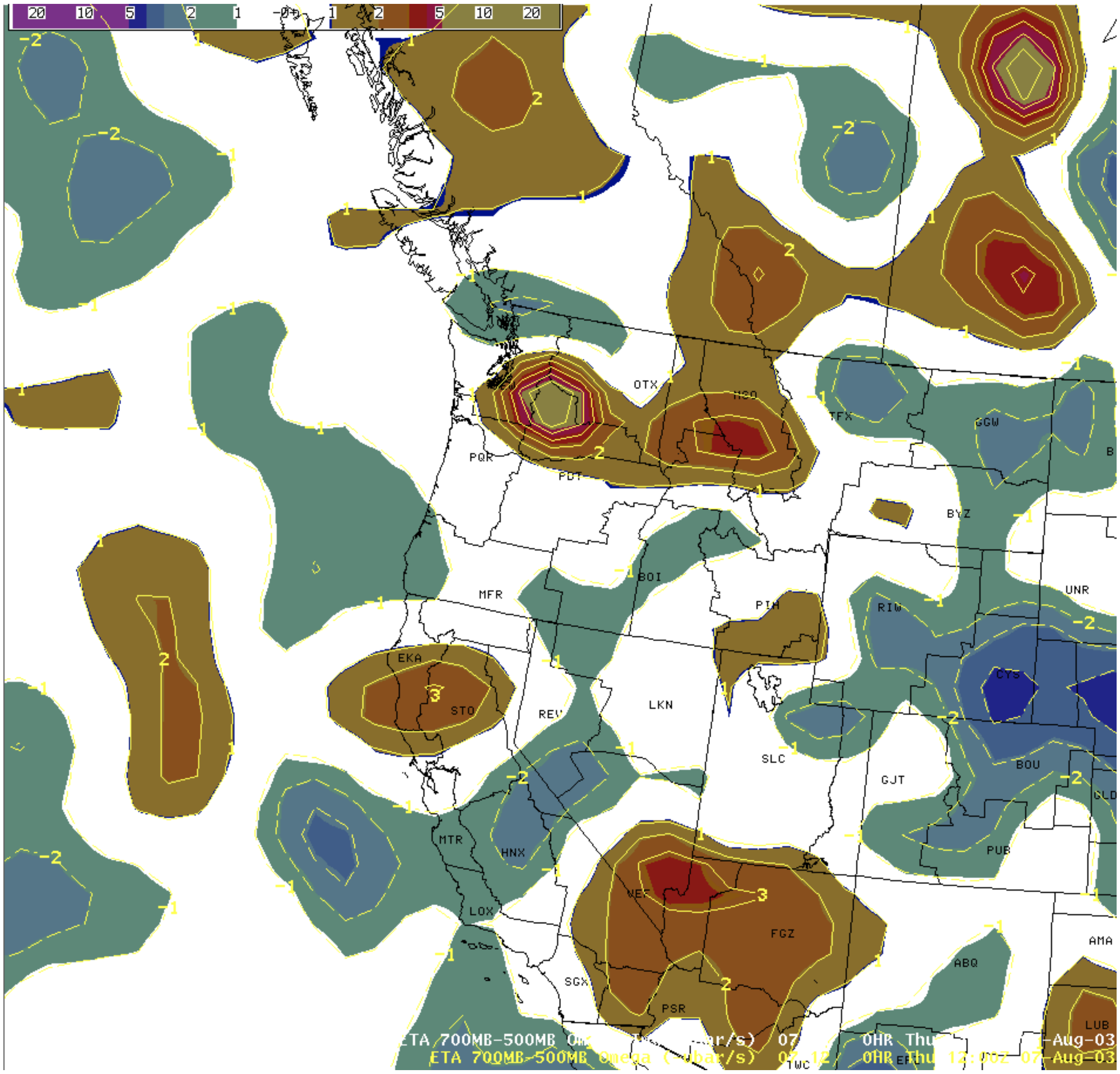
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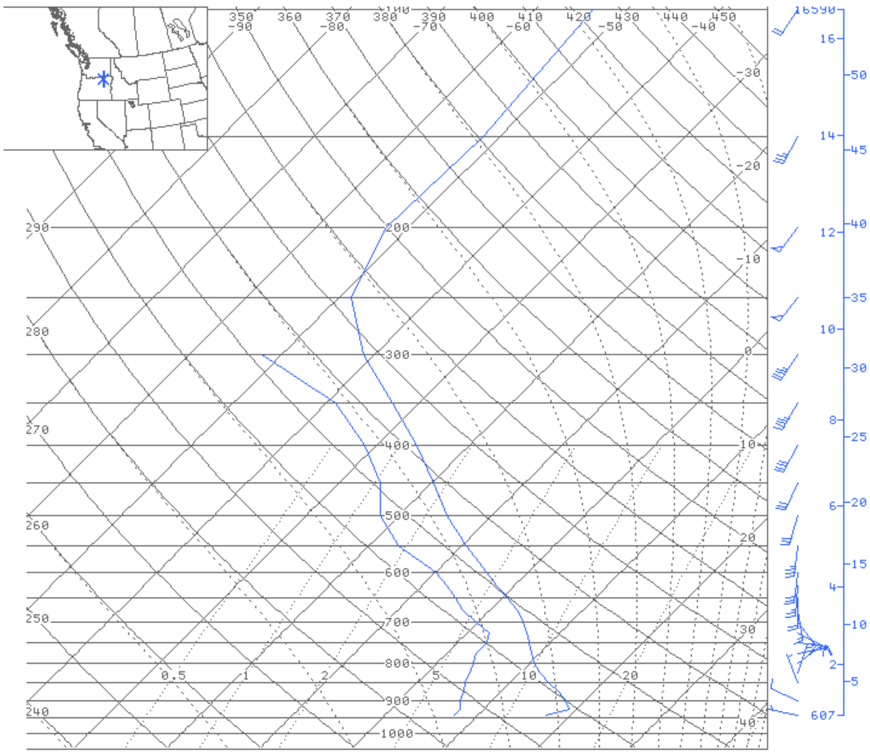
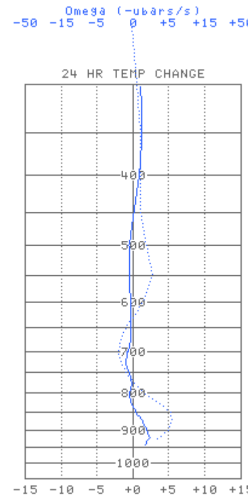
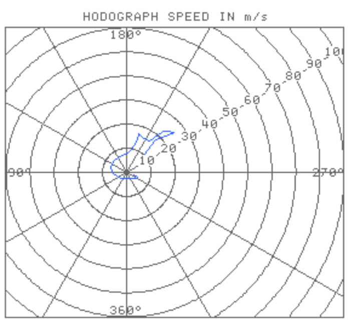
ETA 700MB-500MB Omega (-ubar/s) 07_12 0HR Thu 12:00Z 07-Aug-03





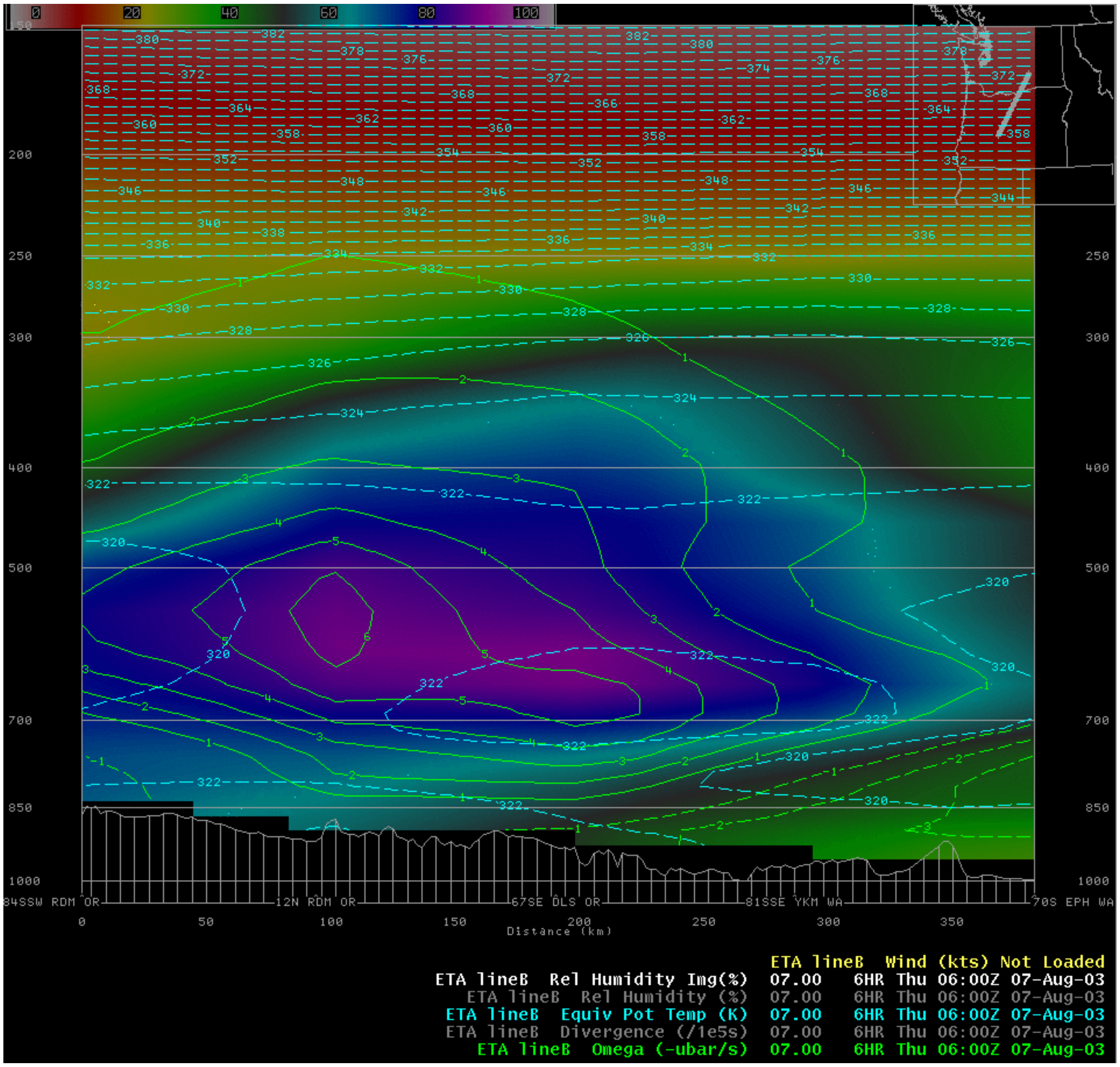


PRECIP WATER= 0.93 in
K-INDEX= 29
TOTALS INDEX= 49
SWEAT INDEX= 103
DRY MICROBURST POT=2: GST < 30 kts
FREEZING LEVEL= 12431 ft ASL
WET-BULB ZERO HGT= 11200 ft ASL
0-6 KM AVG WIND= 194°/12 kts
0-6 KM STM MTN (30R75)= 224°/9 kts
0-3 KM STM REL HELICITY= 165 m^2/s^2
FORECAST MAX TEMP= 83° F
TRIGGER TEMP= 22° C/73° F
SOARING INDEX= 502 ft/min
MDPI/WINDEX = 0.07/0

* -PARCEL- T=FCST MAX;Td=50 mb MEAN
* MOD PARCEL P= 944 mb
* MOD PARCEL T/Td= 82/45° F:28/7° C
* CONVECTIVE TEMP= 87° F
* LIFTED INDEX= -2.1
* CCL= 11339 ft ASL/ 671 mb
* LCL= 10355 ft ASL/ 696 mb
* LFC= 12877 ft ASL/ 633 mb
* MAX HAILSIZE= 1.9 cm/0.7 in
* MAX VERTICAL VELOCITY= 19 m/s
* EQUIL LEVEL= 29445 ft ASL/320 mb
* APPROX CLOUD TP=NA
* POSITIVE ENERGY ABV LFC= 261 J/KG
* NEGATIVE ENERGY BLW LFC= -31 J/KG
* BULK RICHARDSON NUMBER= 7.3

MesoETA ptA 45.7N 118.8W Sounding () 06.18 18HR Thu 12:00Z 07-Aug-03

MesoETA ptA 45.7N 118.8W Sounding () 07.06 6HR Thu 12:00Z 07-Aug-03



0 20 40 60 80 100
150
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250
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400
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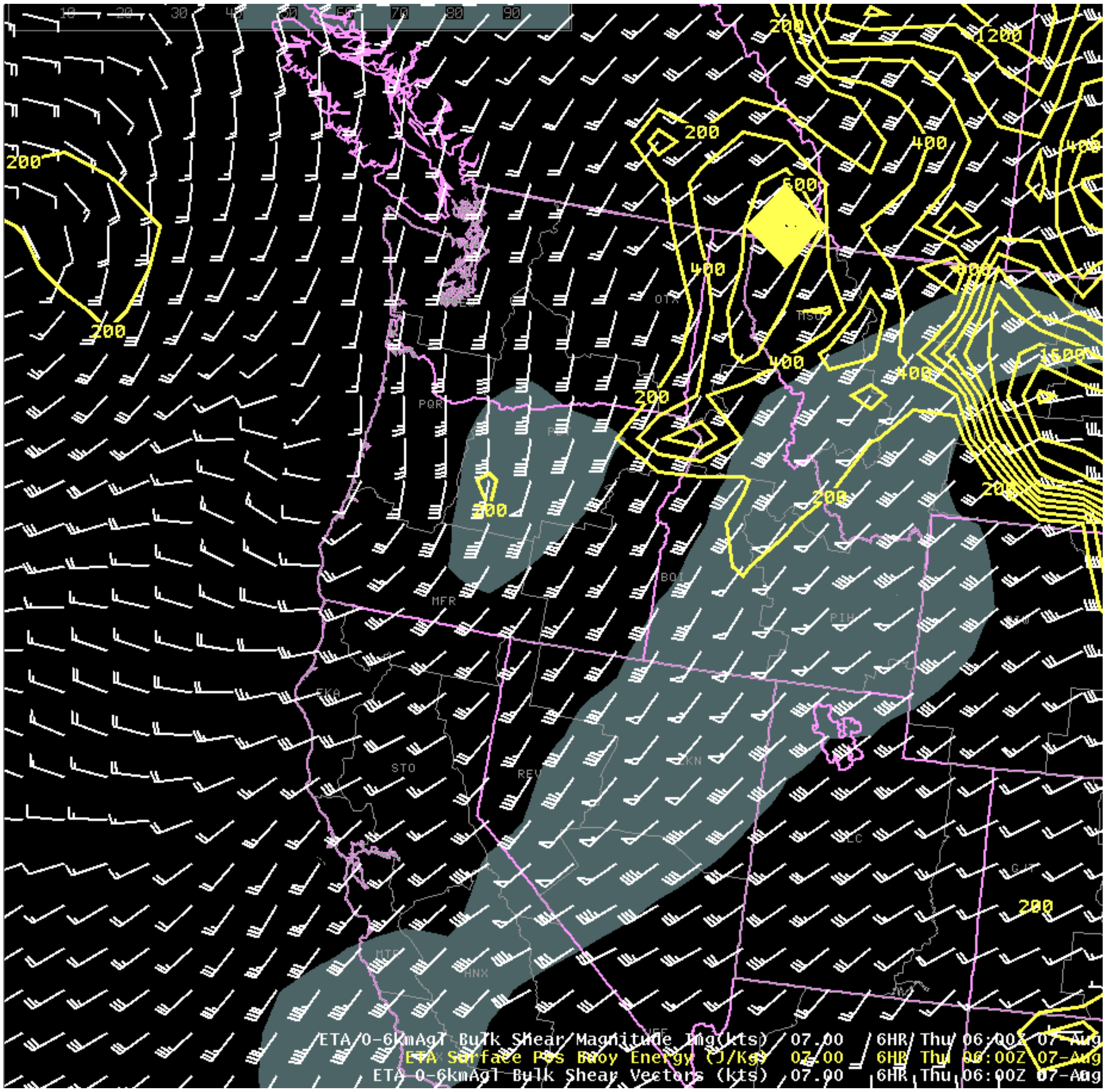
700
850
1000
84SSW RDM OR
12N RDM OR
67SE DLS OR
81SSE YKM WA
70S EPH WA
0 50 100 150 200 250 300 350
Distance (km)
ETA lineB Wind (kts) Not Loaded
ETA lineB Rel Humidity Img(%) 07.00 6HR Thu 06:00Z 07-Aug-03
ETA lineB Rel Humidity (%) 07.00 6HR Thu 06:00Z 07-Aug-03
ETA lineB Equiv Pot Temp (K) 07.00 6HR Thu 06:00Z 07-Aug-03
ETA lineB Divergence (/1e5s) 07.00 6HR Thu 06:00Z 07-Aug-03
ETA lineB Omega (-ubar/s) 07.00 6HR Thu 06:00Z 07-Aug-03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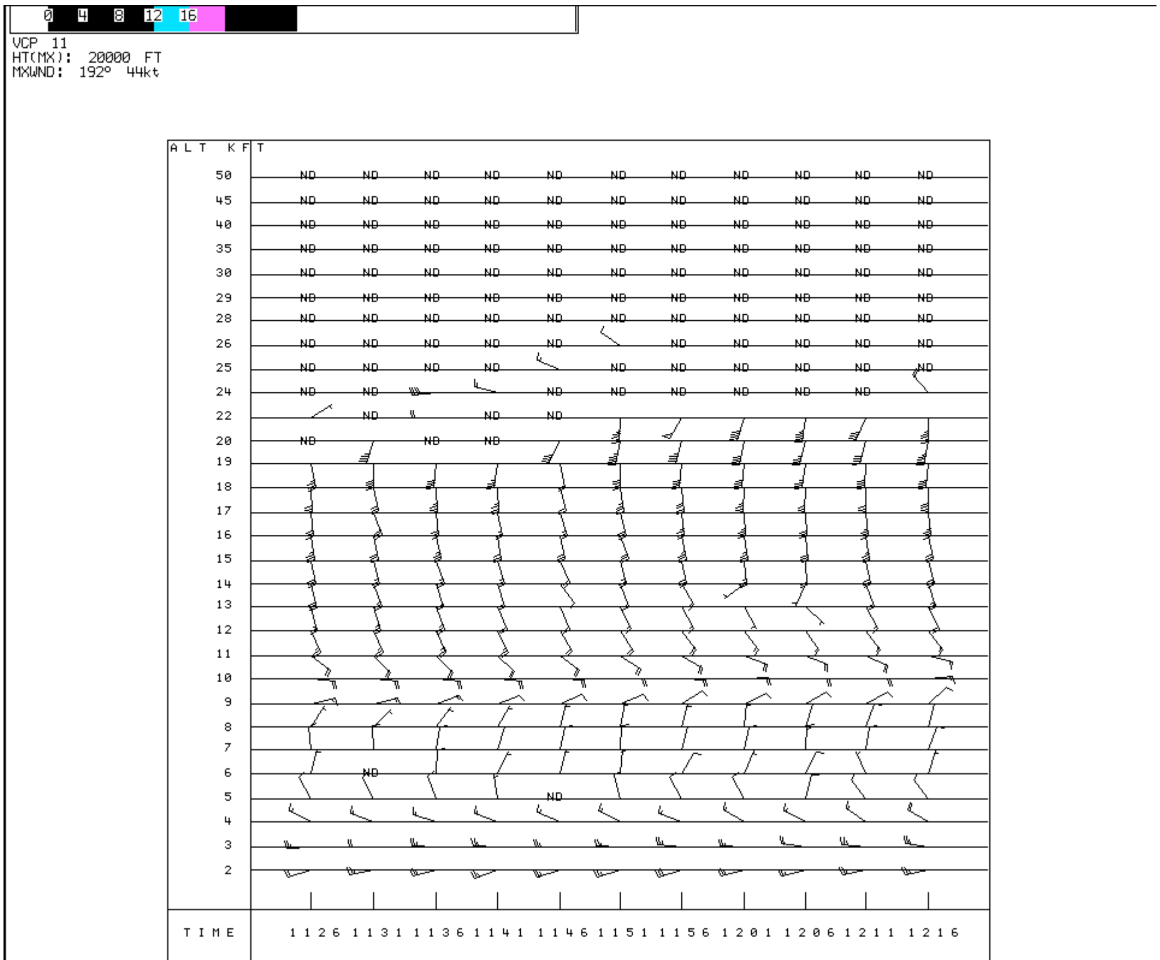
PIH
EKA
STO
REV
LKN
SLC
MTR
HNX
ETA 0-6kmAgl Bulk Shear Magnitude Img(kts) 07.00 6HR Thu 06:00Z 07-Aug
ETA Surface Pos Buoy Energy (J/Kg) 07.00 6HR Thu 06:00Z 07-Aug
ETA 0-6kmAgl Bulk Shear Vectors (kts) 07.00 6HR Thu 06:00Z 07-Aug



kpdt VAD Wind Profile (RMS kts) Thu 12:16Z 07-Aug-03