A Forecast and Analysis of Severe Thunderstorms over Northwest California, on 4 August 2003

Stan Rose, NWS Eureka, California

INTRODUCTION

Numerous strong thunderstorms developed over the mountainous terrain of Humboldt and Trinity Counties in Northwest California, during the afternoon and evening hours of 4 August 2003. Severe thunderstorm warnings were issued for several of these storms, which exhibited supercellular characteristics. One inch hail was reported for the first of these warned storms, near the town of Willow Creek at 2200 UTC. While summer thunderstorms are common over the interior of Northwest California, severe storms are relatively rare. An examination of numerical model prognostics and observational data for this event provides insight into the potential for severe weather in the region, and the implications for convective forecasting during the summer months.

SYNOPTIC AND MESOSCALE FEATURES

The synoptic pattern for 4 August 2003 was characterized by a 500 hPa ridge in the central Pacific, a long-wave trough over Alaska and northwest Canada, a cutoff low in the eastern Pacific, and a ridge over the rocky mountains. The 'trigger' for thunderstorm activity was the presence of the cold core upper low located approximately 600 km southwest of Cape Mendocino the morning of 4 August (Fig 1). The low was cutoff, however an active subtropical jet and several upstream shortwaves moving through the base of the longwave trough to the north were progged to carry the core of the upper low over northern California by 5 August. This scenario would bring southerly low to mid-level flow across the region for 4 August, along with 500 hPa temperatures of -13 to -14 degrees Celsius, providing steep mid-level lapse rates and strong dry instability.
A mid level jet maximum of about 40 knots was also anticipated to round the base of the upper low, providing sufficient deep layer sheer for organized convection. While upper winds were generally light, the pronounced diffluent region to the east of the low hinted at good synoptic scale forcing for convection. Water vapor imagery provided evidence that a narrow stream of moisture in the mid to upper levels would be advected over the region (Fig 2). Model relative humidity fields at 700 hPa also showed the presence of mid-level moisture. Thus, the key elements for severe convection were all present: instability, shear, moisture, and a lifting mechanism.

Model forecasts from the Mesoeta the morning of 4 August provided significant guidance for anticipating the mode and severity of convection that day. Forecasts indicated lifted indices of between -2 and -6 over much of Trinity county and eastern Humboldt county by 21 UTC, indicating strong dry instability (Fig 3). Low level winds were forecast to be from the southeast at 5 to 15 knots, while mid-level winds were expected from the south at 30 to 35 knots. The potential for about 30 knots of vertical shear indicated the potential for rotating updrafts. The speed and directional sheer, in conjunction with forecast CAPE of 1700 to 2700 J/kg, indicated that any storms that formed could acquire supercellular characteristics. A model sounding taken over the region of interest in western Trinity County is particularly illustrative (Fig 4). CAPE is nearly 2700 J/kg, and the Lifted Indice is minus 8, indicating strong instability. Storm motion is from the south-southwest at 12 knots. Low-level sheer is modest, and thus storm-relative helicity is not very great. However, the mid level speed maximum of 35 knots is not insignificant and provides ample vertical sheer. The Equilibrium Level provides a good indication of storm/echo tops (which were verified by radar and observation to be from 35 to 40,000 feet). While low-level moisture is somewhat lacking, the mid levels are relatively moist, and the wet bulb zero height of under 11 thousand feet indicates the potential for large hail (it is relatively low for August in this region). It is also significant that little inhibition is evident from the sounding, so convective initiation would be likely from the local forcing over mountainous terrain.

Visible satellite for the region by 2130 UTC August 4 2003 shows convective initiation occurring along the crest of South Fork Mountain and ridge lines over the Yolla Bolly Mountains in eastern Mendocino County. A deep marine layer evident in the satellite image limited convective activity over the coastal plains and foothills. Vertical shear is evident from lower plumes blowing to the north, while anvils over the eastern ranges are blowing toward the northeast. (Fig 5). Radar shows several strong cores developing near the northern border of Trinity and Humboldt Counties. Within 10 minutes of an observed cell division of the northernmost cell, composite reflectivity shows the highest dBZ return (66 dBZ, Fig 6). At this time, one inch hail was reported just south of the core at the Willow Creek Ranger Station. Both cells rapidly dissipated as they moved to the northwest and north, respectively, although the right-moving storm remained stronger. While neither cell exhibited low-level rotation signatures on radar, mid-level SRM indicated the likelihood of a mesocylone, with 40 knots of gate-to-gate sheer present in the right-moving storm (Fig 7). Interestingly, both cells exhibited mid-level cyclonic rotation, which suggests that the observed split could have been related to influences of terrain in addition to the actual storm dynamics. While neither storm was observed to exhibit low level features commonly associated with supercells (rain-free bases, outflow or inflow bands, etc) and were short-lived (behaving more like pulse storms), the symmetrical and crisp appearance of the core and anvils did suggest supercellular attributes.

DISCUSSION

The synoptic pattern associated with thunderstorms over the Eureka CWA on 4 August 2003 is a common summer occurrence that forecasters should be familiar with. The potential for severe weather could also be anticipated in this case from model forecasts that indicated strong instability and adequate vertical wind shear over the area of concern. While the availability of deep low-level moisture and lack of strong low-level shear were factors that limited the severe potential for these storms, adequate mid-level moisture and steep mid-level lapse rates suggested the potential for large hail. The relatively low Wet Bulb Zero heights, and the potential for rotating updrafts gave further support for the risk of large hail. The presence of complex terrain in the area provided a focus for convective initiation, but also made the prediction of storm development and behavior more difficult. Forecasters should become familiar with the elements that indicate the potential for severe thunderstorms in this region, while remaining aware of the possibility that storm behavior may not follow traditional rules.

Figure 1

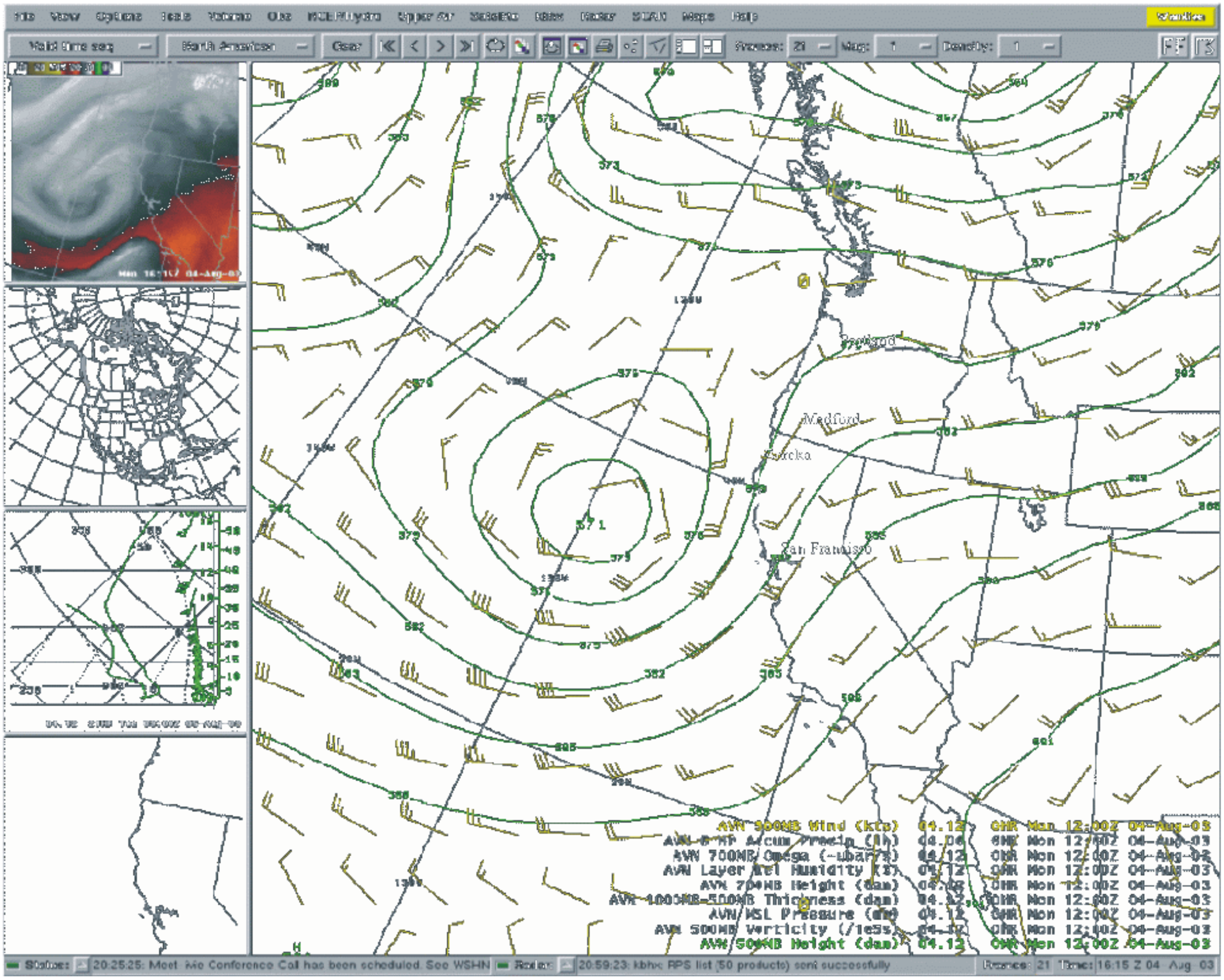

Portland
Medford
Eureka
San Francisco
AVN 500MB Wind (kts) 04.12 0HR Mon 12:00Z 04-Aug-03
AVN 700MB Omega (-ubar/s) 04.12 0HR Mon 12:00Z 04-Aug-03
AVN Layer Rel Humidity (%) 04.12 0HR Mon 12:00Z 04-Aug-03
AVN 700MB Height (dam) 04.12 0HR Mon 12:00Z 04-Aug-03
AVN 1000MB-500MB Thickness (dam) 04.12 0HR Mon 12:00Z 04-Aug-03
AVN MSL Pressure (mb) 04.12 0HR Mon 12:00Z 04-Aug-03
AVN 500MB Verticity (/1e5s) 04.12 0HR Mon 12:00Z 04-Aug-03
AVN 500MB Height (dam) 04.12 0HR Mon 12:00Z 04-Aug-03
20:25:25: Meet. Mic Conference Call has been scheduled. See WSHN
20:59:23: kbhx: RPS list (50 products) sent successfully
Frames: 21 Time: 16:15 Z 04 Aug 03

Figure 2

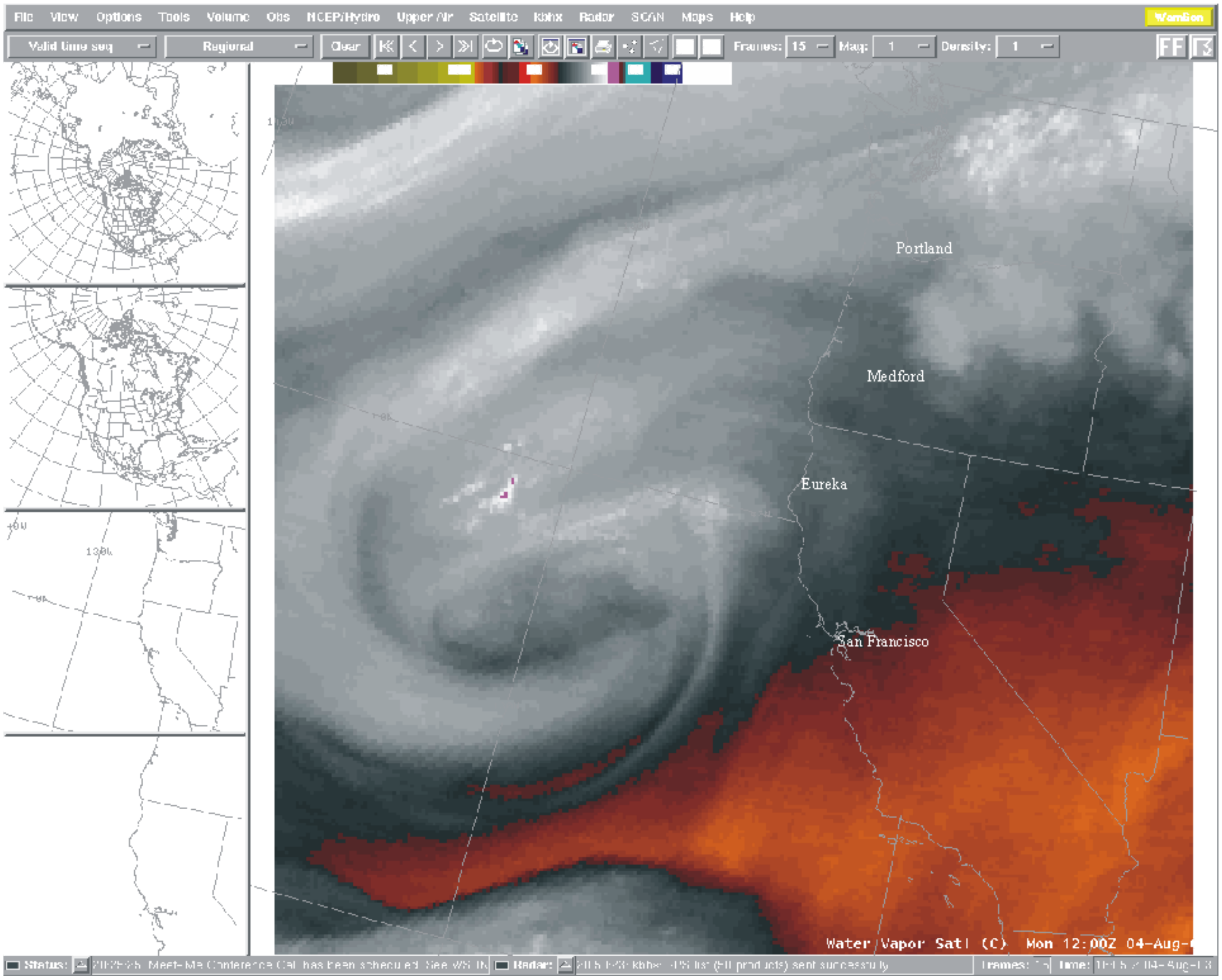
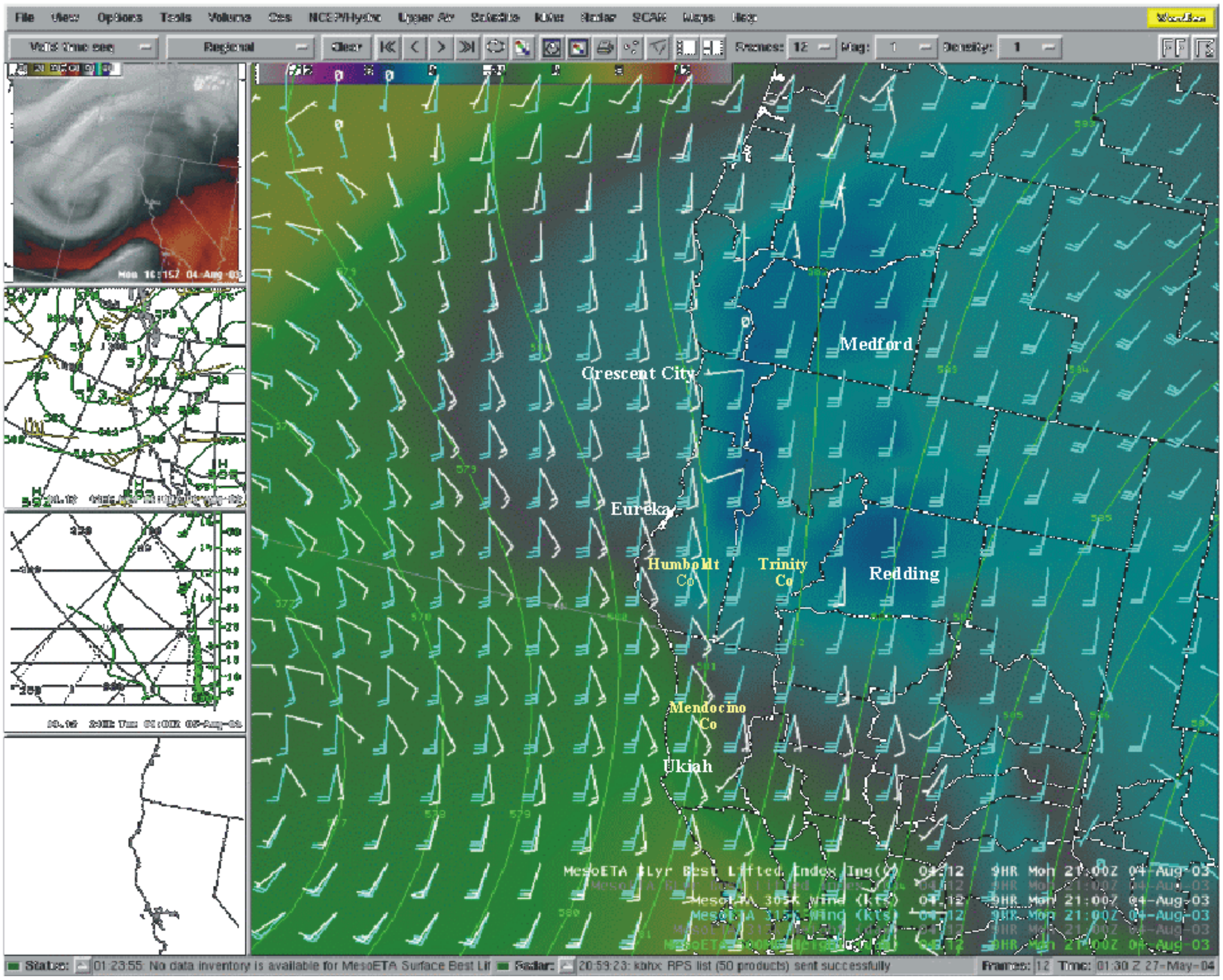

Portland
Medford
Eureka
San Francisco
Water Vapor Satl (C) Mon 12:00Z 04-Aug-

Figure 3



Medford
Crescent City
Eureka
Humboldt Co
Trinity Co
Redding
Mendocino Co
Ukiah
MesoETA 305K Wind (kts) 04.12 9HR Mon 21:00Z 04-Aug-03
01:23:55: No data inventory is available for MesoETA Surface Best Li
20:59:23: kbhx RPS list (50 products) sent successfully
Frames: 12 Time: 01:30 Z 27-May-04

Figure 4

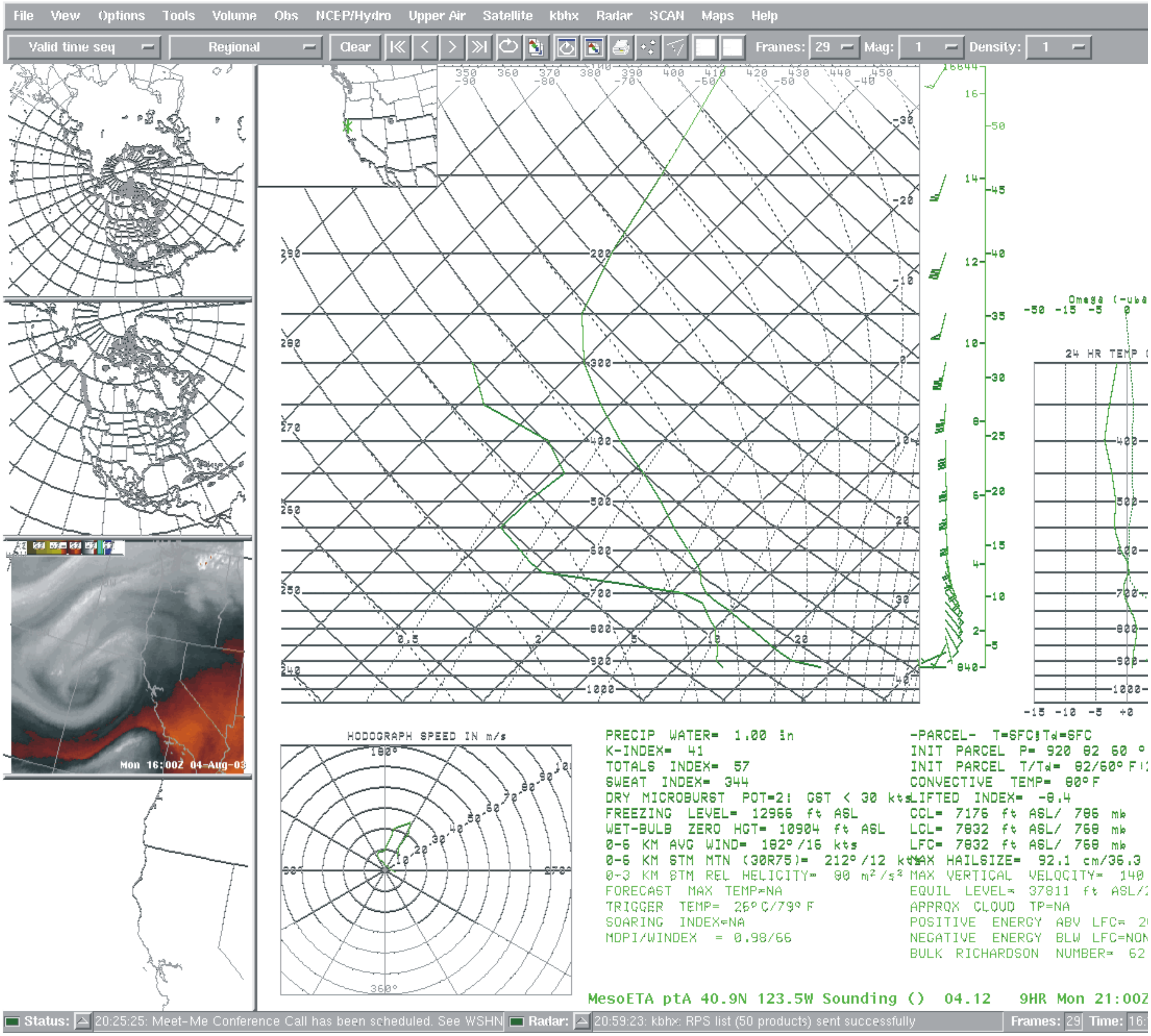
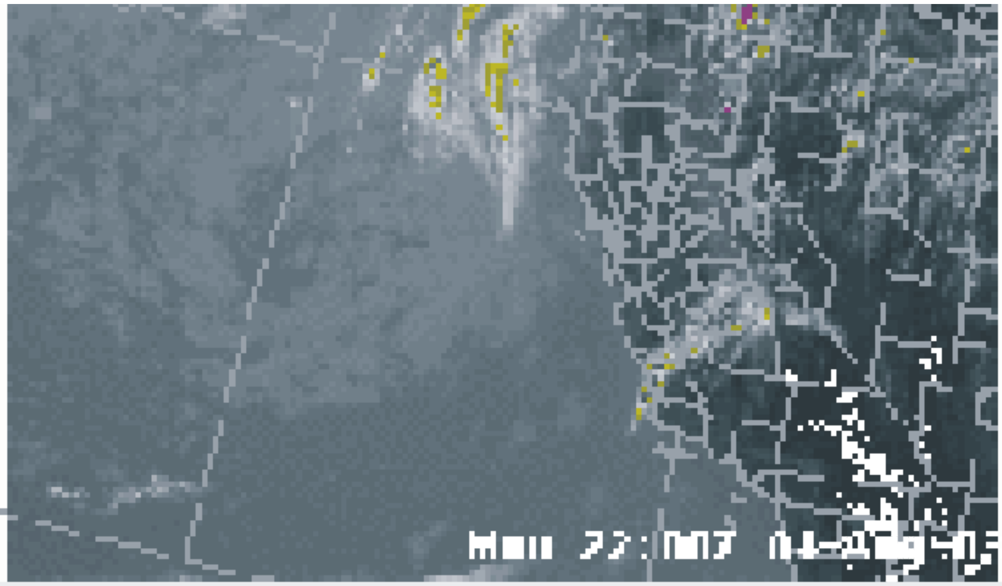
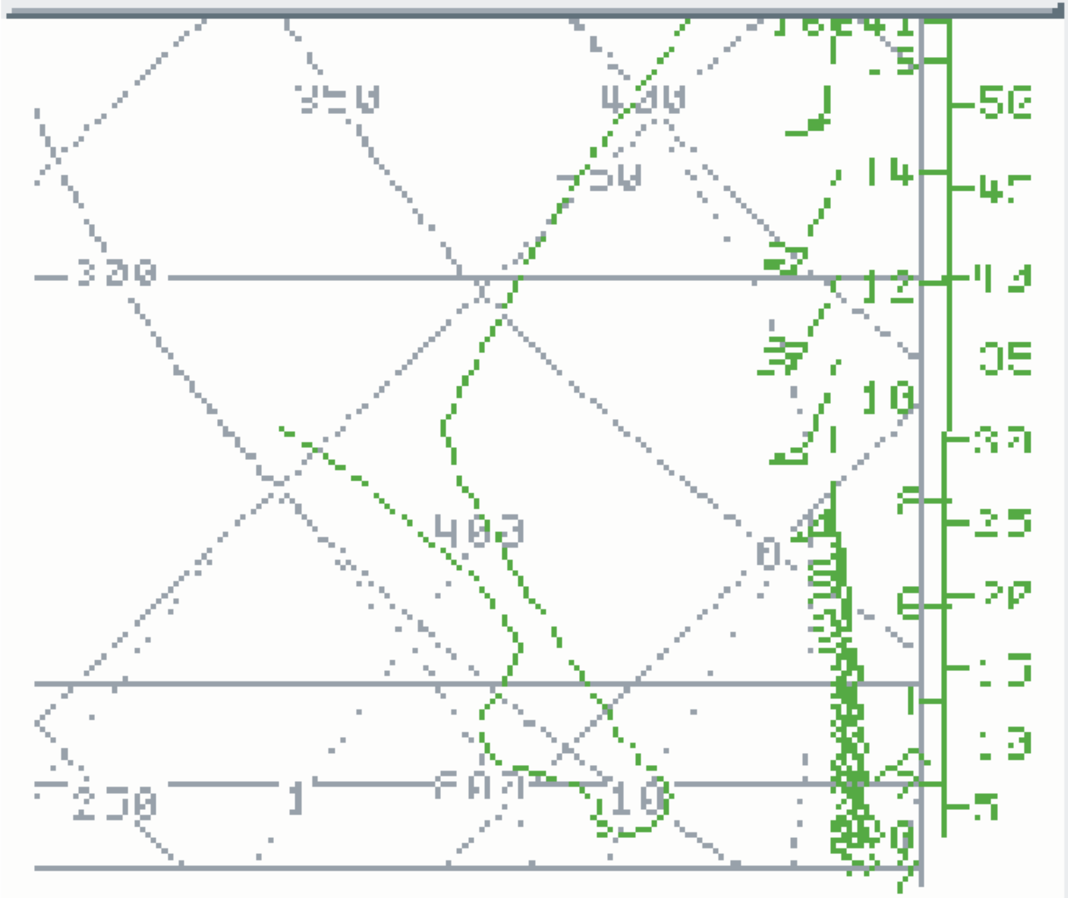
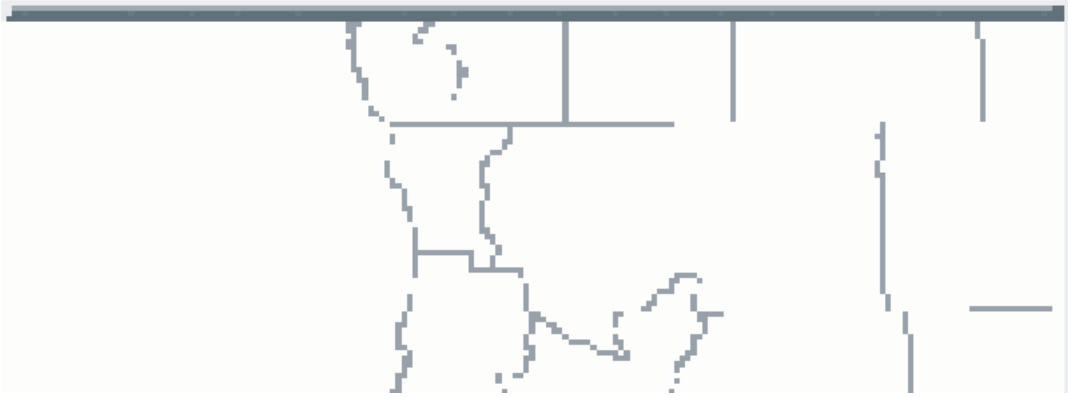

File View Options Tools Volume Obs NCEP/Hydro Upper Air Satellite kbhx Radar SCAN Maps Help
Valid time seq
Regional
Clear
Frames: 29
Mag: 1
Density: 1
Mon 16:00Z 04-Aug-03
HODOGRAPH SPEED IN m/s
PRECIP WATER= 1.00 in
K-INDEX= 41
TOTALS INDEX= 57
SWEAT INDEX= 344
DRY MICROBURST POT=2: GST < 30 kts
FREEZING LEVEL= 12966 ft ASL
WET-BULB ZERO HGT= 10904 ft ASL
0-6 KM AVG WIND= 182°/16 kts
0-6 KM STM MTN (30R75)= 212°/12 kts
0-3 KM STM REL HELICITY= 90 m²/s²
FORECAST MAX TEMP=NA
TRIGGER TEMP= 26°C/79°F
SOARING INDEX=NA
MDPI/WINDEX = 0.98/66
-PARCEL- T=SFC;Td=SFC
INIT PARCEL P= 920 82 60
INIT PARCEL T/Td= 82/60°F
CONVECTIVE TEMP= 80°F
LIFTED INDEX= -8.4
CCL= 7176 ft ASL/ 786 mb
LCL= 7032 ft ASL/ 768 mb
LFC= 7032 ft ASL/ 768 mb
MAX HAILSIZE= 92.1 cm/36.3
MAX VERTICAL VELOCITY= 140
EQUIL LEVEL= 37811 ft ASL/
APPROX CLOUD TP=NA
POSITIVE ENERGY ABV LFC=
NEGATIVE ENERGY BLW LFC=NON
BULK RICHARDSON NUMBER= 62
24 HR TEMP
Omega
MesoETA ptA 40.9N 123.5W Sounding () 04.12 9HR Mon 21:00Z
Status: 20:25:25: Meet-Me Conference Call has been scheduled. See WSHN
Radar: 20:59:23: kbhx: RPS list (50 products) sent successfully
Frames: 29
Time:

Figure 5


Valid time seq
State(s)







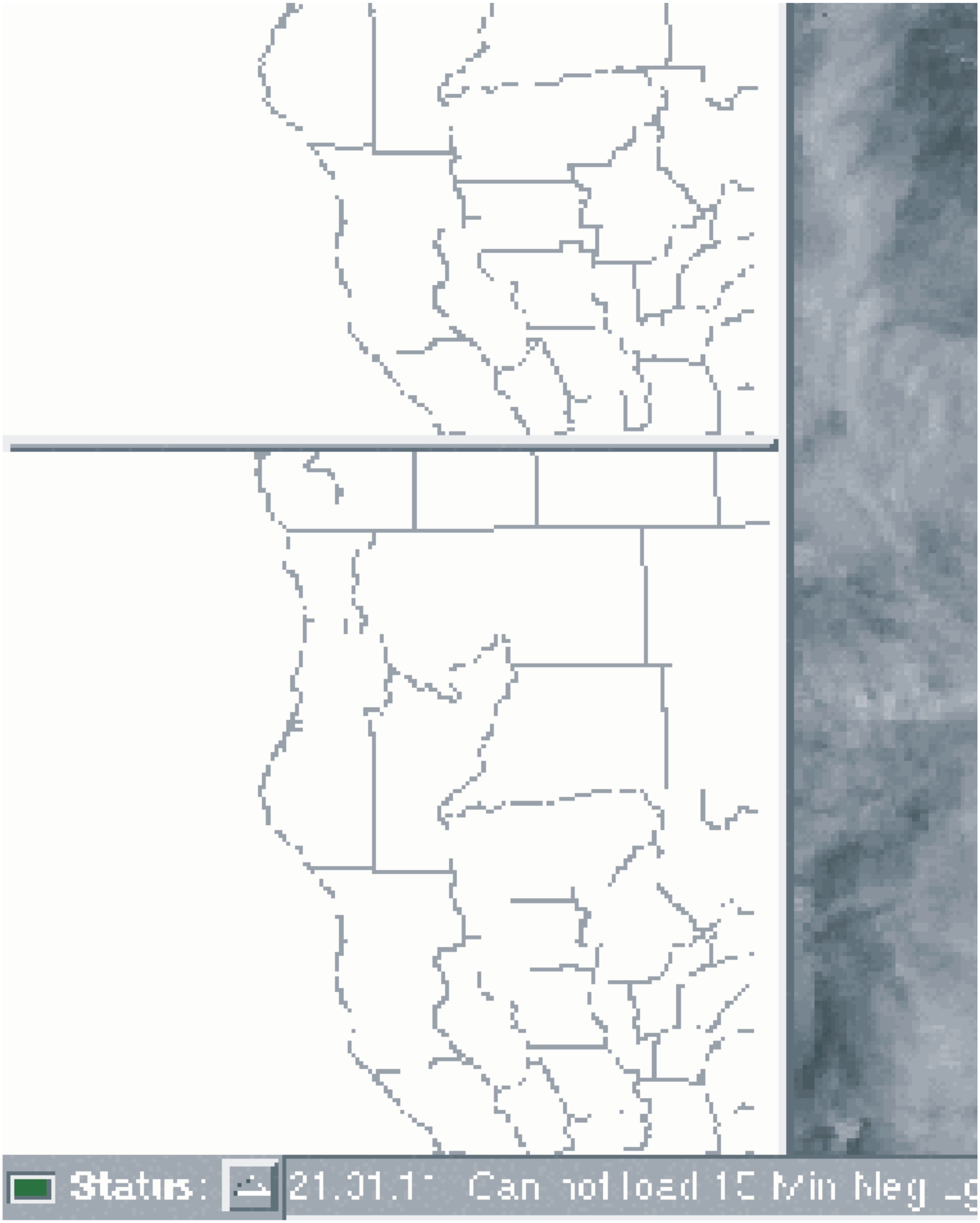


Figure 6

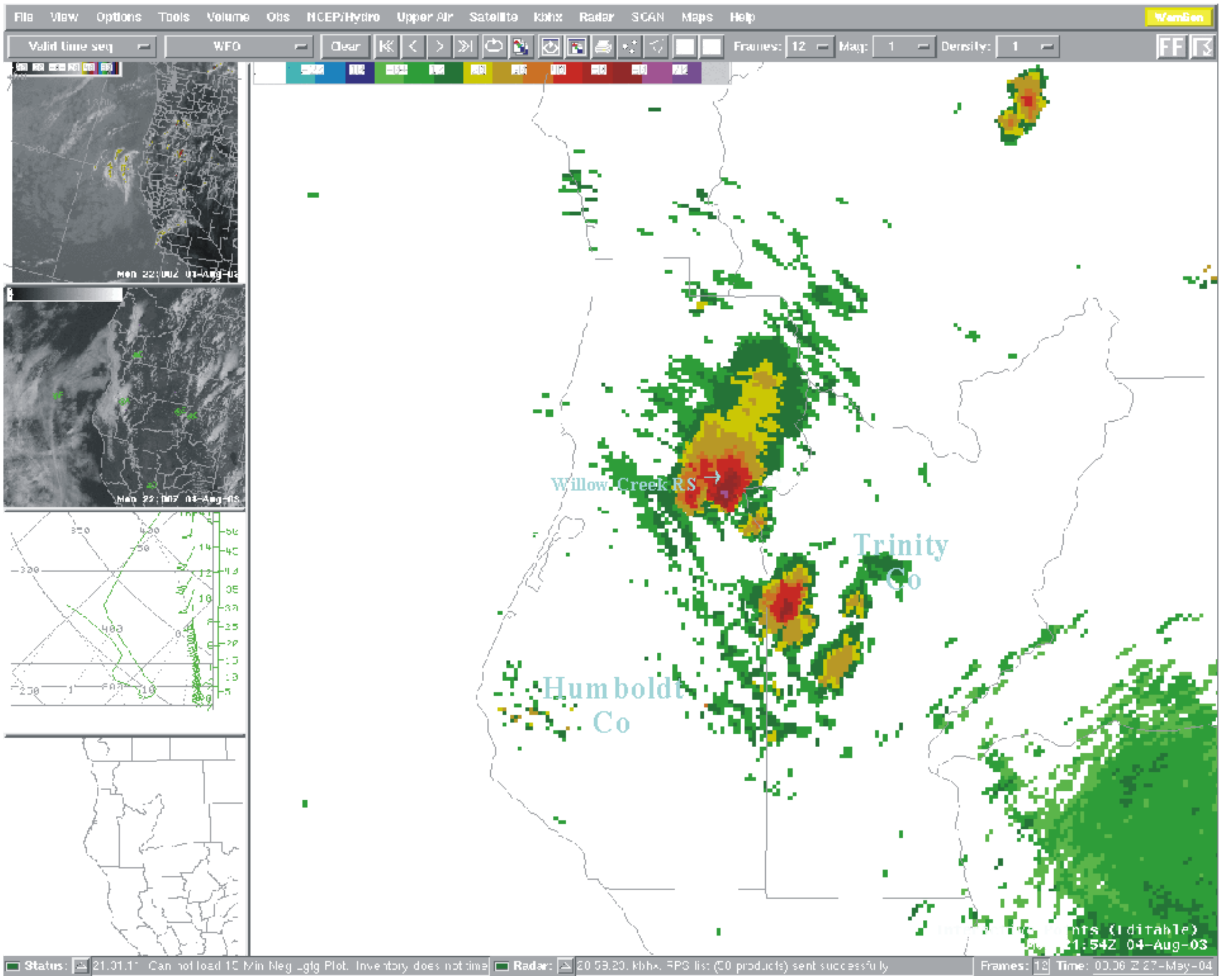
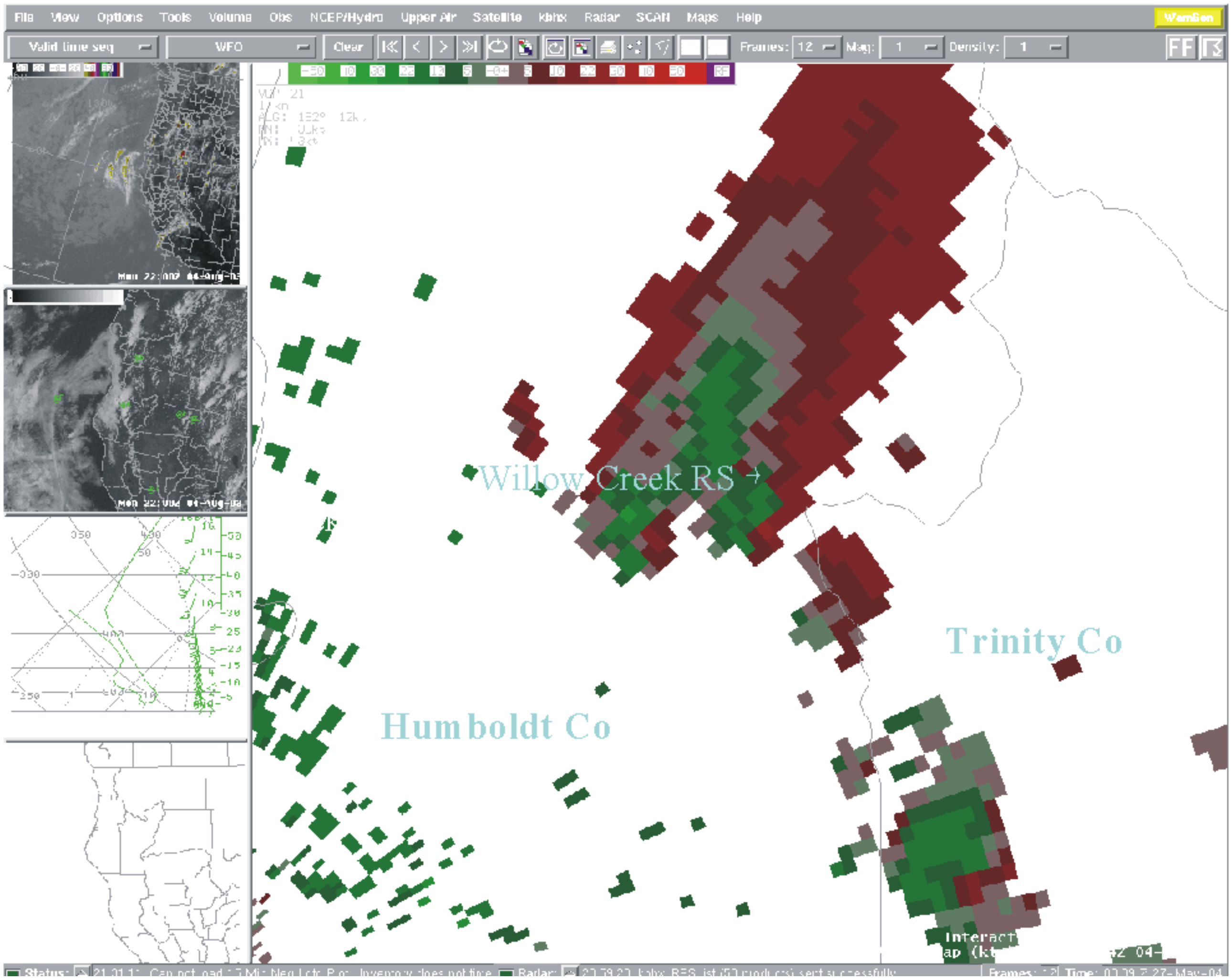


Figure 7


File View Options Tools Volume Obs NCEP/Hydro Upper Air Satellite kbhx Radar SCAN Maps Help
Willow Creek RS
Trinity Co
Humboldt Co