# April 2nd, 2003 Heavy Snow Event
# A WES Case Study

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## INTRODUCTION

Widespread, heavy snow over the higher terrain of northern California is normally associated with strong frontal systems approaching the region from the eastern Pacific Ocean. These frontal systems tap deep moisture, however, heavy snow with embedded convective elements does occur in less moist air masses (Tardy 2002), especially in an unstable post-frontal environment. The heavy snowfall event of April 2nd, 2003 exemplified this type of event in that it occurred in a relatively low precipitable water environment, but this limitation was able to be overcome by strong forcing from a mid-tropospheric jet, strong cold advection, steep lower-level lapse rates, and favorable orography.

## EVENT SYNOPSIS

Synoptic scale analysis at 12Z on April 2, 2003 indicated a highly amplified upper-air pattern was present over the western United States. A deep trough was present at 500 mb along the west coast, extending from a 521 dm closed low near Vancouver Island southward to near Point Conception on the central California coast (Fig 1). This model analysis and water vapor satellite imagery (Fig. 2) showed several strong vorticity centers embedded within the northwest flow on the backside of the trough, poised to move into northern California.

The airmass over northern California early on the morning of April 2nd was post-frontal in nature, as satellite imagery indicated the main cold frontal cloud band had moved into southern California and weakened. IR imagery indicated plenty of open-cellular cumulus over the eastern Pacific Ocean just offshore of northern California. Morning upper-air soundings over the region at 12Z did not indicate impressive moisture as observed precipitable water was only 0.29 inches at Medford, OR (MFR) (Fig. 3) and 0.52 inches at Oakland, CA (OAK) (Fig 4). However, the morning soundings did indicate significant instability was present in the lower-troposphere (for a winter-type event) across the region, with 0-3 km lapse rates ranging from ~ 6.7 C/km at OAK to ~ 8.1 C/km at MFR, and observed convective available potential energy (CAPE) was 321 J/kg at MFR (Fig 3) and 478 J/kg at OAK (Fig 4).

By 18Z, water vapor imagery was showing a strong cyclonically-curved jet at 700 millibars (50 knots in the core) beginning to push onto the west coast just to the south of the San Francisco Bay Area. In the exit region of this jet, strong upward vertical motion on the order of 7-9 microbars/sec in the 850-500 mb layer was forecast by the ETA over a large region of northern California, stretching from the northern Sierra Nevada northward into the extreme southern Cascade Range. In addition, the ETA forecast soundings indicated that most unstable CAPE (MUCAPE) was in the range of 250-500 J/kg across this same region between 18Z and 03Z (Fig 5). Shortly after 18Z, radar began to show a rapid increase in coverage of showers and thunderstorms over much of northern California. The showers and thunderstorms continued through the afternoon across the entire region, and heavy snow showers persisted over the west slopes of the northern Sierra Nevada well into the evening hours.

## VERIFICATION

Significant precipitation occurred over the higher terrain of northern California from the afternoon through the evening of April 2nd. Gage data indicated that about an average of 0.50 to 1.00 inch of liquid equivalent precipitation fell across the Feather River basin (in the Sierra Nevada northeast of Sacramento), while the American River basin (in the Sierra Nevada east of Sacramento) saw about 0.75 to 1.25 inches of liquid equivalent. The higher elevations of the northern Sierra Nevada saw some impressive snowfall totals, especially for so late in the season. The Sugar Bowl Ski Area near Donner Pass received 11-15 inches of snow, while the Kirkwood Ski Resort to the south (just to the west of Carson Pass) reported 16-24 inches.

In addition, one thunderstorm over the northern Sierra Nevada foothills did manage to reach severe criteria - dropping 1 inch diameter hail in Shingletown (~ 25 miles east of Redding).

## CONCLUSIONS

Moisture is just one of the parameters that must be investigated when evaluating a winter weather event's potential to generate heavy snowfall. Many cases have been documented where less than ideal moisture values were overcome, whether through strong dynamic forcing, instability, favorable cloud microphysics, or orography (Tardy 2002) resulting in heavy snowfall. The GOES sounder offers forecasters an additional tool to the more traditional satellite and radar data, and can be used to follow trends in instability in near real-time (Schrab 2000). This can provide valuable information in the forecast decision process as to whether convection will enhance a snowfall event.

## REFERENCES

Schrab, Kevin, 2000: Using GOES DPI on AWIPS to Track Instability on Convective Winter Day (Feb. 14, 2000). National Weather Service Western Region TA-Lite 2000-01.

Tardy, Alexander, 2002: Significant Snow in the Sierra Nevada from Maritime Polar Origins. National Weather Service Western Region Technical Attachment No.02-04.

Tardy, Alexander, 2002: Thundersnow in the Sierra Nevada. National Weather Service Western Region Technical Attachment No. 02-13.

**Figure 1**

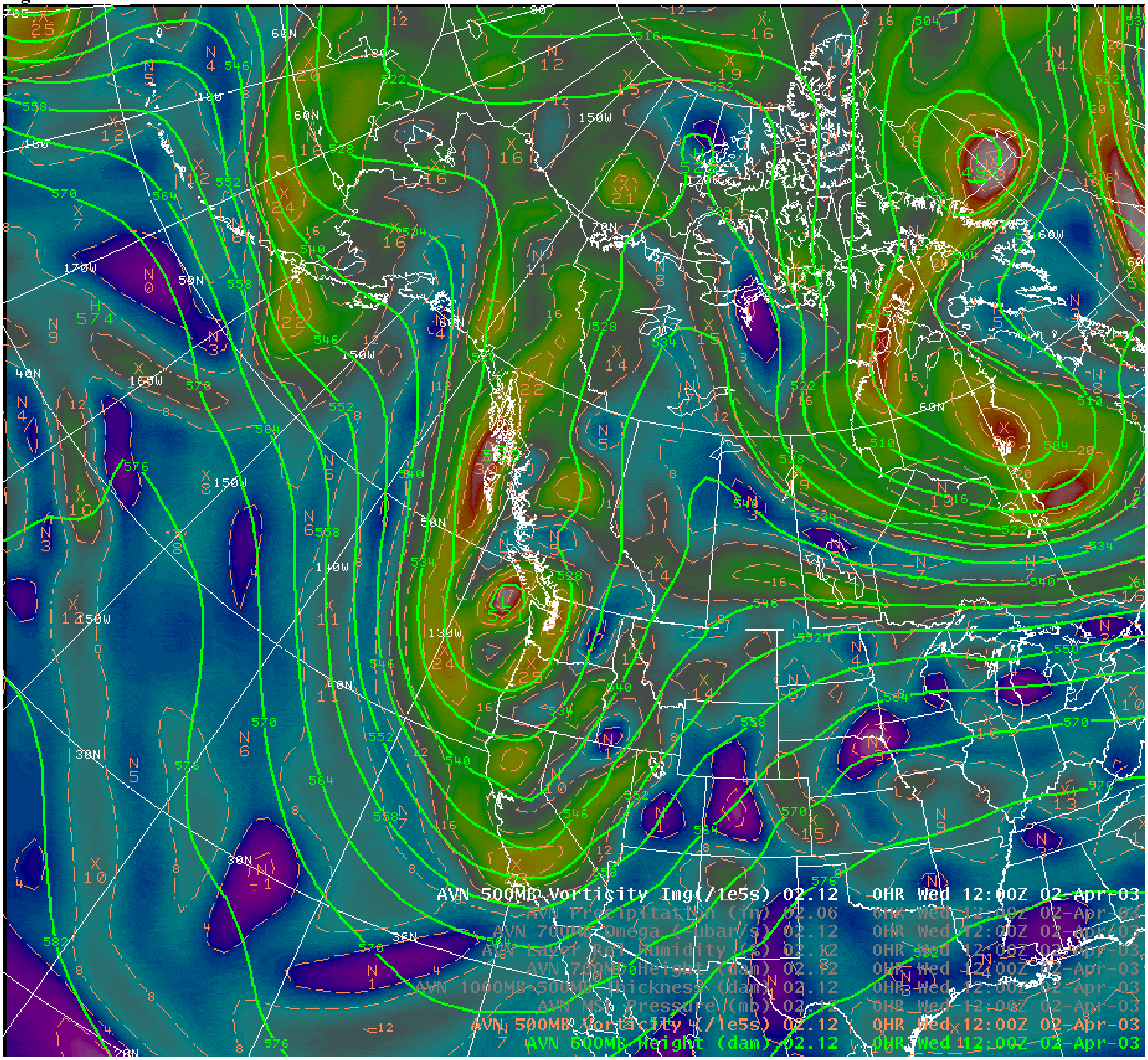



**Figure 2**

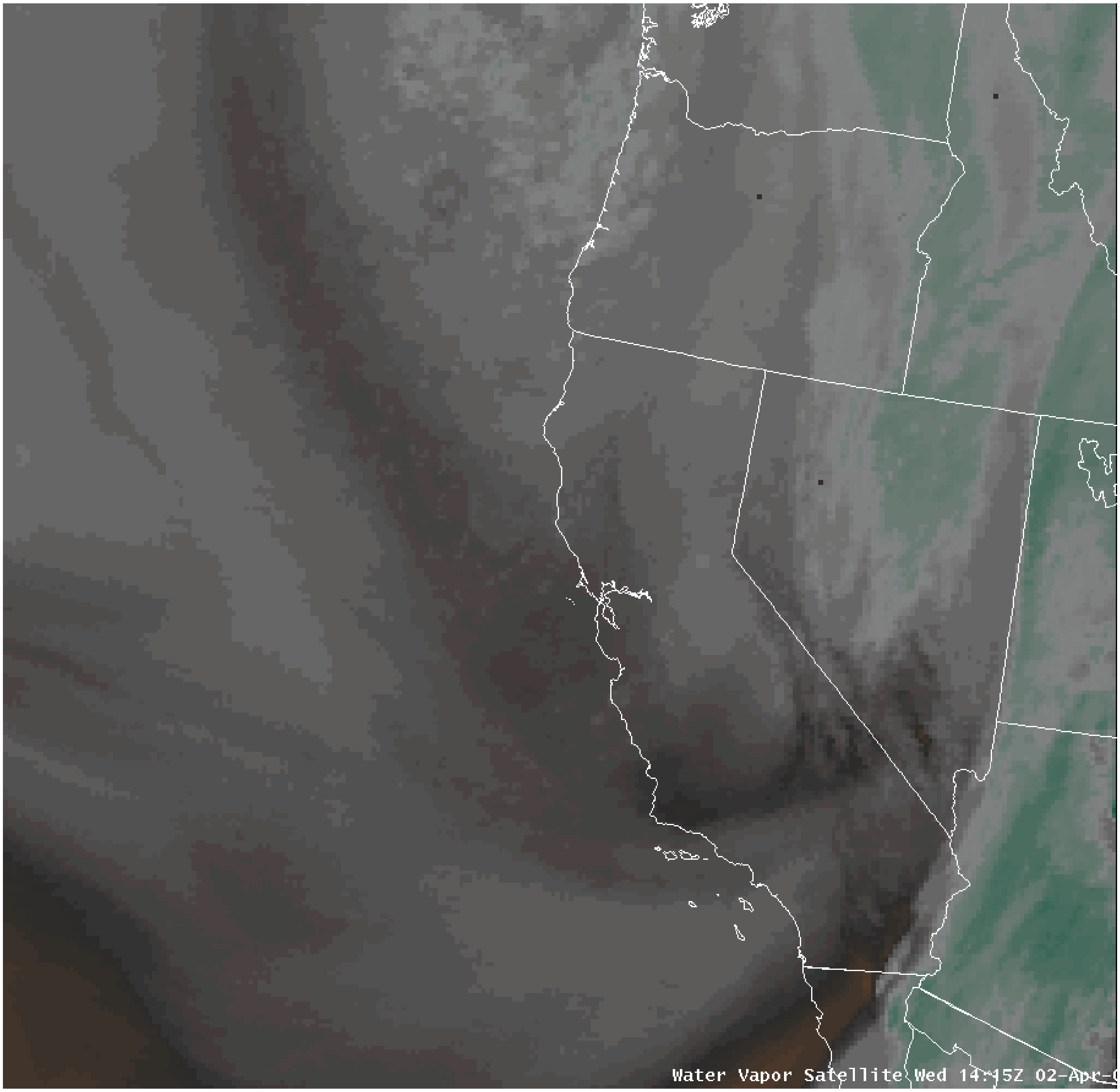



**Figure 3**

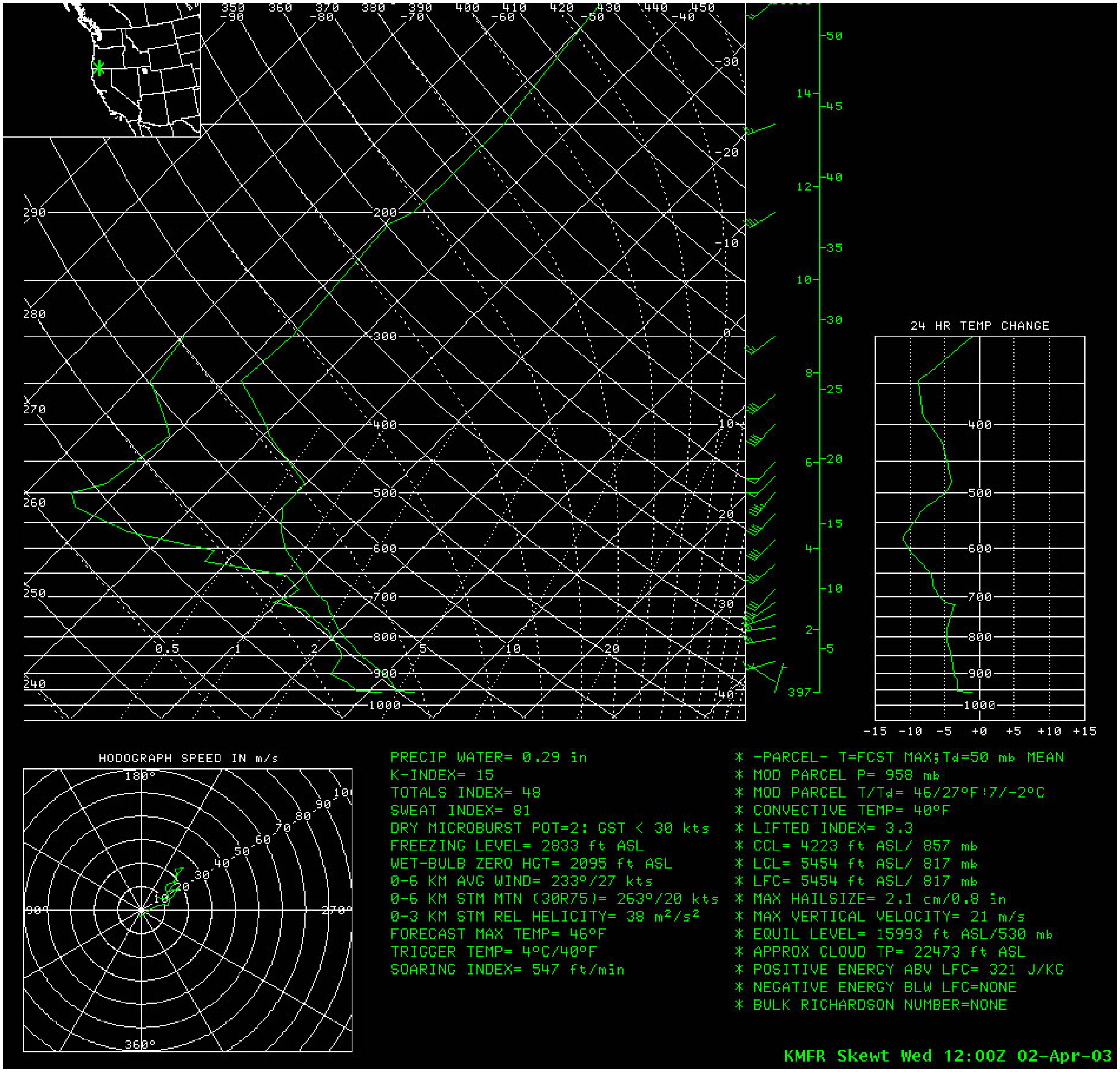

24 HR TEMP CHANGE
HODOGRAPH SPEED IN m/s
PRECIP WATER= 0.29 in
K-INDEX= 15
TOTALS INDEX= 48
SWEAT INDEX= 81
DRY MICROBURST POT=2: GST < 30 kts
FREEZING LEVEL= 2833 ft ASL
WET-BULB ZERO HGT= 2095 ft ASL
0-6 KM AVG WIND= 233°/27 kts
0-6 KM STM MTN (30R75)= 263°/20 kts
0-3 KM STM REL HELICITY= 38 m²/s²
FORECAST MAX TEMP= 46°F
TRIGGER TEMP= 4°C/40°F
SOARING INDEX= 547 ft/min
* -PARCEL- T=FCST MAX;Td=50 mb MEAN
* MOD PARCEL P= 958 mb
* MOD PARCEL T/Td= 46/27°F:7/-2°C
* CONVECTIVE TEMP= 40°F
* LIFTED INDEX= 3.3
* CCL= 4223 ft ASL/ 857 mb
* LCL= 5454 ft ASL/ 817 mb
* LFC= 5454 ft ASL/ 817 mb
* MAX HAILSIZE= 2.1 cm/0.8 in
* MAX VERTICAL VELOCITY= 21 m/s
* EQUIL LEVEL= 15993 ft ASL/530 mb
* APPROX CLOUD TP= 22473 ft ASL
* POSITIVE ENERGY ABV LFC= 321 J/KG
* NEGATIVE ENERGY BLW LFC=NONE
* BULK RICHARDSON NUMBER=NONE
KMFR Skewt Wed 12:00Z 02-Apr-03

**Figure 4**

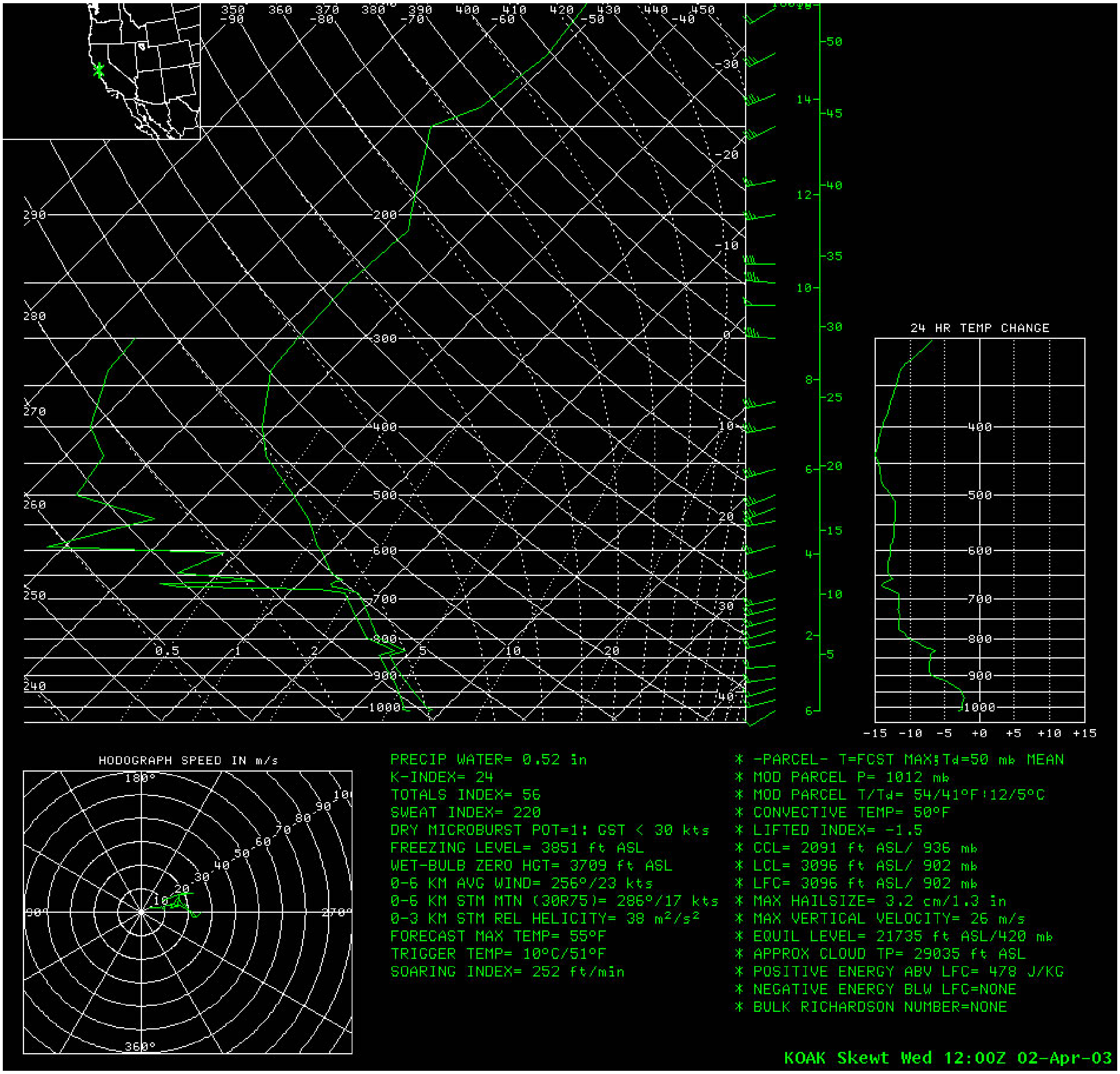
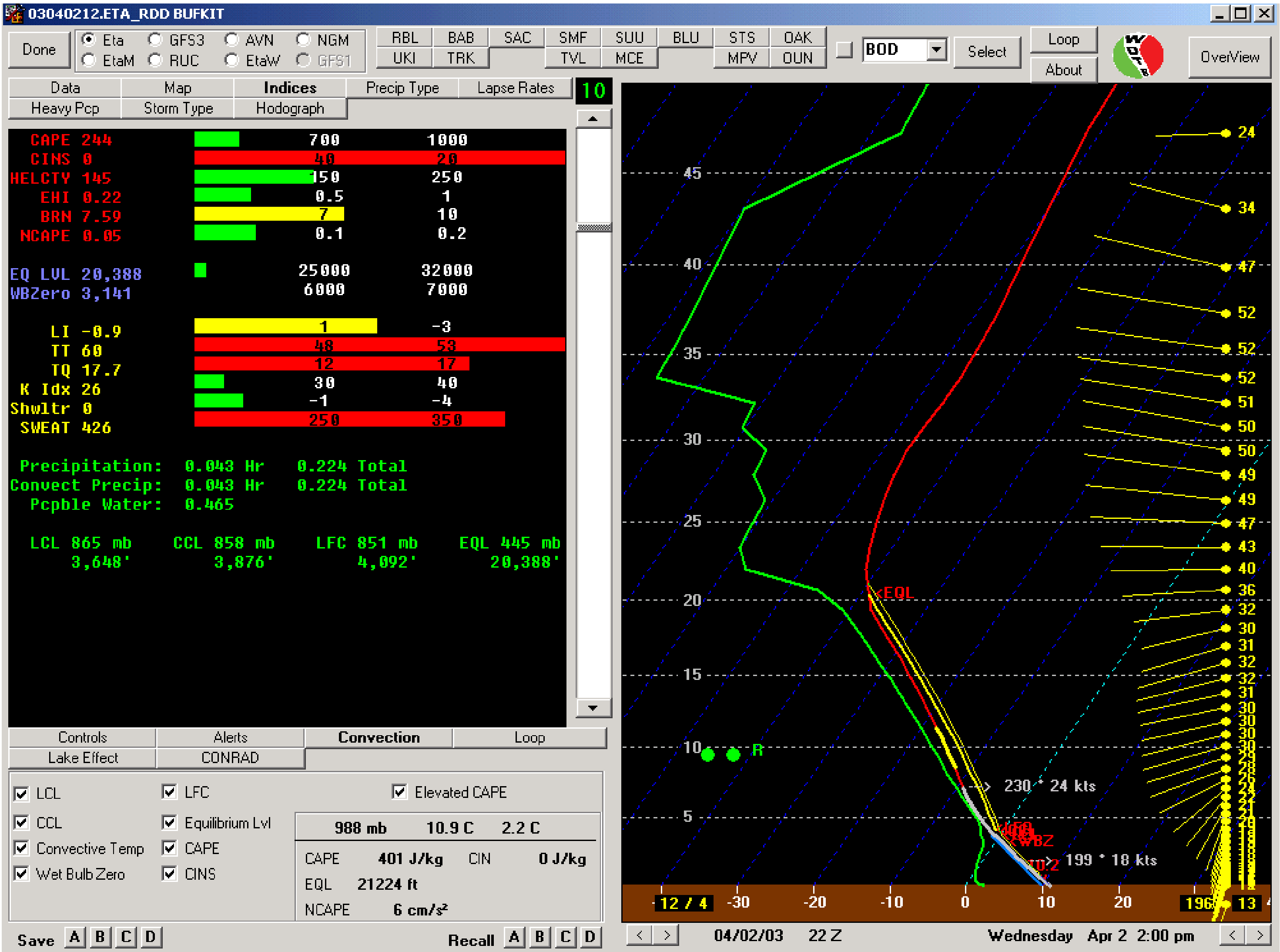

24 HR TEMP CHANGE
HODOGRAPH SPEED IN m/s
PRECIP WATER= 0.52 in
K-INDEX= 24
TOTALS INDEX= 56
SWEAT INDEX= 220
DRY MICROBURST POT=1: GST < 30 kts
FREEZING LEVEL= 3851 ft ASL
WET-BULB ZERO HGT= 3709 ft ASL
0-6 KM AVG WIND= 256°/23 kts
0-6 KM STM MTN (30R75)= 286°/17 kts
0-3 KM STM REL HELICITY= 38 m²/s²
FORECAST MAX TEMP= 55°F
TRIGGER TEMP= 10°C/51°F
SOARING INDEX= 252 ft/min
* -PARCEL- T=FCST MAX;Td=50 mb MEAN
* MOD PARCEL P= 1012 mb
* MOD PARCEL T/Td= 54/41°F:12/5°C
* CONVECTIVE TEMP= 50°F
* LIFTED INDEX= -1.5
* CCL= 2091 ft ASL/ 936 mb
* LCL= 3096 ft ASL/ 902 mb
* LFC= 3096 ft ASL/ 902 mb
* MAX HAILSIZE= 3.2 cm/1.3 in
* MAX VERTICAL VELOCITY= 26 m/s
* EQUIL LEVEL= 21735 ft ASL/420 mb
* APPROX CLOUD TP= 29035 ft ASL
* POSITIVE ENERGY ABV LFC= 478 J/KG
* NEGATIVE ENERGY BLW LFC=NONE
* BULK RICHARDSON NUMBER=NONE
KOAK Skewt Wed 12:00Z 02-Apr-03

**Figure 5**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AVN
NGM
EtaM
RUC
EtaW
GFST
RBL
BAB
SAC
SMF
SUU
BLU
STS
OAK
UKI
TRK
TVL
MCE
MPV
OUN
BOD
Select
Loop
About
OverView
Data
Map
Indices
Precip Type
Lapse Rates
Heavy Pcp
Storm Type
Hodograph
10
CAPE 244
CINS 0
HELCTY 145
EHI 0.22
BRN 7.59
NCAPE 0.05
700 1000
40 20
150 250
0.5 1
7 10
0.1 0.2
EQ LVL 20,388
WBZero 3,141
25000 32000
6000 7000
LI -0.9
TT 60
TQ 17.7
K Idx 26
Shwltr 0
SWEAT 426
1 -3
48 53
12 17
30 40
-1 -4
250 350
Precipitation: 0.043 Hr 0.224 Total
Convect Precip: 0.043 Hr 0.224 Total
Pcpble Water: 0.465
LCL 865 mb 3,648'
CCL 858 mb 3,876'
LFC 851 mb 4,092'
EQL 445 mb 20,388'
Controls
Alerts
Convection
Loop
Lake Effect
CONRAD
LCL
LFC
Elevated CAPE
CCL
Equilibrium Lvl
Convective Temp
CAPE
Wet Bulb Zero
CINS
988 mb 10.9 C 2.2 C
CAPE 401 J/kg CIN 0 J/kg
EQL 21224 ft
NCAPE 6 cm/s²
Save A B C D
Recall A B C D
EQL
230 ° 24 kts
199 ° 18 kts
WBZ
12 / 4
-30 -20 -10 0 10 20
13
04/02/03 22 Z
Wednesday Apr 2 2:00 pm