Western Region Technical Attachment
No. 95-16
May 23, 1995

CONVECTIVE HORIZONTAL ROLL VORTICES AS VIEWED BY WSR-88D

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Introduction

Convective horizontal roll vortices are parallel lines of vertical circulations which develop in the boundary layer under certain conditions. On 21 April 1995, the WSR-88D at NWSO Sacramento indicated the development of these vortices and then their dissipation. To the author's knowledge, this is the first documentation of this phenomena in California.

Convective Horizontal Roll Development

The development process of convective horizontal roll vortices in the boundary layer is one which is not entirely known. Through research in other portions of the United States, two conditions for formation have been determined. These conditions are:

1) The wind speed must increase with height throughout the boundary layer, but remain unidirectional.

2) The lapse rate must be dry adiabatic in the boundary layer due to vertical heat flux.

These rolls develop parallel to the mean wind in the well-mixed boundary layer. Typically, "cloud streets" develop as small cumulus develop due to the enhanced vertical circulation which occurs between these convectively-driven horizontal rolls (Fig. 1). However, they will not develop when moisture values are not sufficient for the Lifted Condensation Level (LCL) to be reached. Another interesting feature of these rolls is that they rotate in opposite directions from their neighbors.

It has been found that convective horizontal roll vortices are typically easier to notice in reflectivity data; however, due to the inversion that morning, ground clutter obscured the horizontal roll signature. The signature was much easier discerned in the base velocity product (Fig. 2) which clearly indicated bands of concentrated particulates. These particulates, mainly insects and dust, were organized into bands by the low-level convergence which is a feature of these convectively-driven horizontal roll vortices.

Synoptic Situation 21 April 1995

Over the early morning hours of 21 April 1995, an area of high pressure built over the Pacific Northwest. Due to the pressure gradient across northern California, northerly winds developed over the Central Valley. When the sun began to rise, convective horizontal rolls began to develop aligning themselves north to south along the mean wind vector. As the sun continued to rise, these lines became prevalent through the entire valley surrounding the radar site (Fig. 2). The VAD wind profile at this time indicated that the first condition stated above was satisfied (Fig. 3). Wind speeds increased with height with northerly winds of 10 kt being reported at the surface increasing to 25 kt at 2000 feet. Due to solar insolation underneath the radiative inversion, the lapse rate was certainly dry adiabatic, thus satisfying condition number two. The boundary layer was well mixed up to a height of around 1000 feet.

As the heating continued, the boundary layer finally mixed through the radiative inversion. As this happened, easterly winds, which were located above the inversion, were mixed down, along with cooler air, which resulted in a lapse rate which was more stable. Then, with unfavorable conditions for continued development, the roll vortices rapidly diminished after 1900 GMT.

Conclusion

On the morning of 21 April 1995, convectively driven horizontal roll vortices developed over the southern Sacramento Valley. These mesoscale circulations developed as solar insolation acted with laminar north flow in the valley to produce parallel bands of shallow vertical motion. As the sun continued to heat the ground, these vortices mixed through the radiative inversion bringing down less dry air, and easterly winds, causing the necessary conditions to no longer be satisfied. At this point the horizontal rolls rapidly fell apart. This phenomena represents the first documentation of this feature in the Central Valley (according to the author) and is representative of the new features which can now be determined through the use of the WSR-88D.

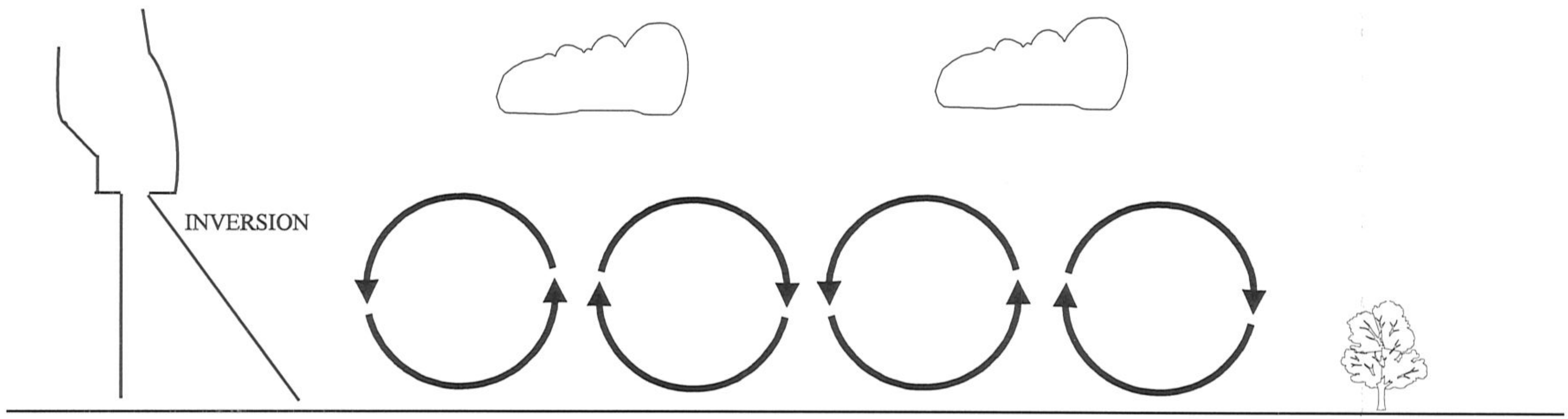
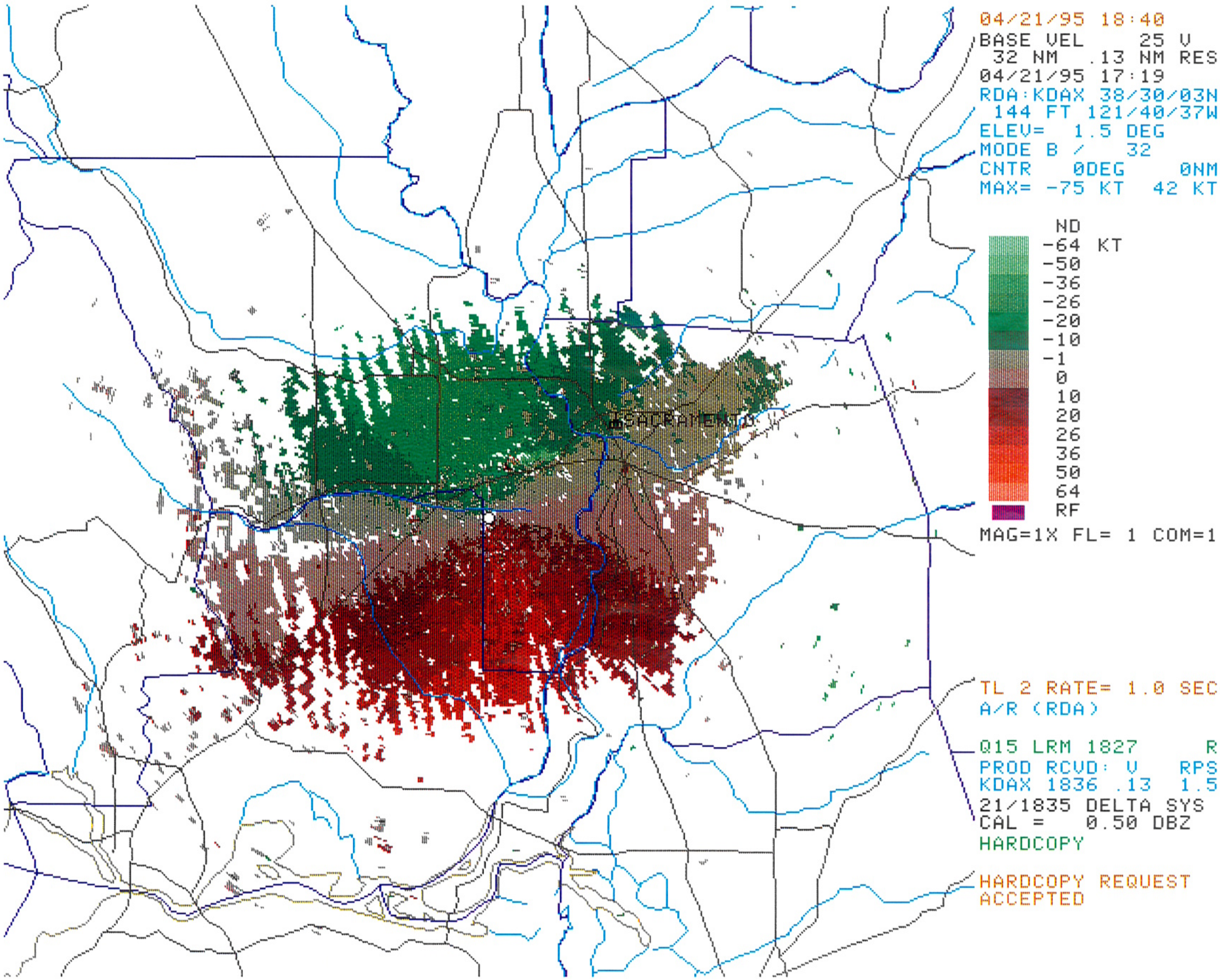


FIGURE 1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04/21/95 17:19
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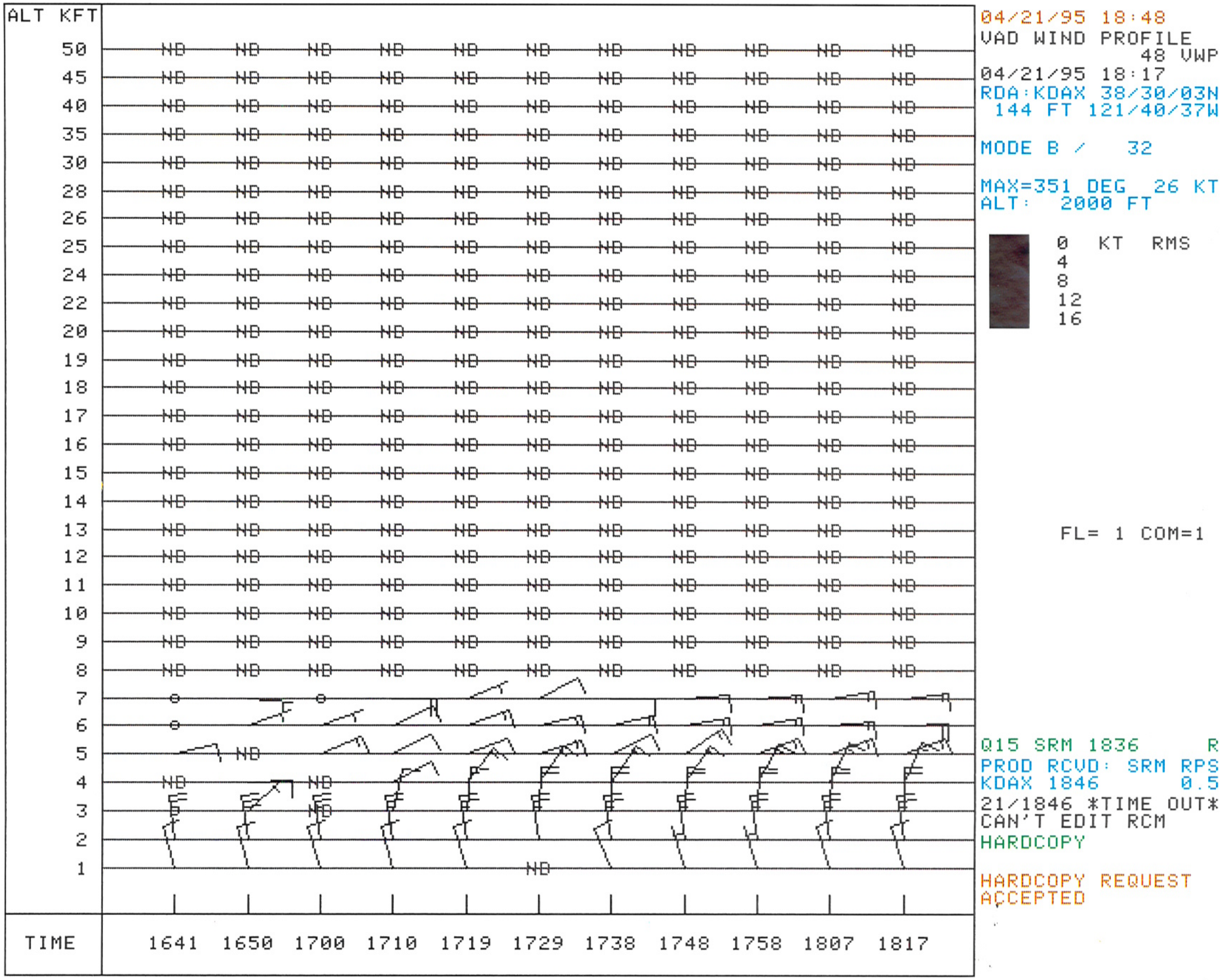
MODE B / 32
CNTR 0DEG 0NM
MAX= -75 KT 42 KT
ND
-64 KT
-50
-36
-26
-20
-10
-1
0
10
20
26
36
50
64
RF
MAG=1X FL= 1 COM=1
SACRAMENTO
TL 2 RATE= 1.0 SEC
A/R (RDA)
Q15 LRM 1827 R
PROD RCVD: V RPS
KDAX 1836 .13 1.5
21/1835 DELTA SYS
CAL = 0.50 DBZ
HARDCOPY
HARDCOPY REQUEST
ACCEPTED

Fig. 2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40
35
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26
25
24
22
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
ND
TIME
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04/21/95 18:48
VAD WIND PROFILE
48 VWP
04/21/95 18:17
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MODE B / 32
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ALT: 2000 FT
0 KT RMS
4
8
12
16
FL= 1 COM=1
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PROD RCVD: SRM RPS
KDAX 1846 0.5
21/1846 *TIME OUT*
CAN'T EDIT RCM
HARDCOPY
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ACCEPTED

Fig. 3