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USING NORMALIZED CONVECTIVE AVAILABLE POTENTIAL ENERGY TO FORECAST MOIST CONVECTION IN NORTHERN CALIFORNIA

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[Note: Because of the large number of figures, only the text will be published in hard copy. The figures can be accessed on the Web version at http://www.wrh.noaa.gov under Technical Attachments.

Introduction

Moist convection by definition includes cumulus development, showers and thunderstorms. Moist convection is a challenge to forecast consistently and accurately with sufficient lead time no matter where you are in the United States. It is especially difficult across California because of the complex terrain and often marginal instability and available moisture. The Sierra Nevada often provides a focusing mechanism for surface-based moist convection; however, the lower Sacramento Valley often is negatively affected by surface divergence due mainly to a marine influence through the Carquinez Strait and Delta. Techniques and numerical model parameters that may work well in one part of the country may have little relevance in another. Such is the case in California where, unlike many areas, the majority of heavy showers and thunderstorms that occur in the Central Valley develop after a cold frontal passage (i.e., post-frontal). The exceptions to this rule would include subtropical moisture interacting with short waves during the summer months, a monsoonal flow developing over elevated terrain which initiates thunderstorms, and pre-frontal bands of heavy rain with embedded thunderstorms.

Over the years, there have been numerous studies to determine which individual, or combination of numerical model parameters, yield the best result in forecasting thunderstorms. Recently, the practice of using Convective Available Potential Energy, or CAPE, has become widespread among National Weather Service (NWS) meteorologists. The CAPE was first introduced by Moncrieff and Miller in 1976. Using CAPE from a model sounding alone has proven to be very useful in forecasting moist convection and even severe thunderstorm potential. The primary reason for the success of CAPE is because it is an integrated measure of a parcels buoyant energy in units of joules per kilogram (Jkg^{-1}). The CAPE is defined as an integrate value of the positive energy observed on a sounding between the Level of Free Convection (LFC) and the Equilibrium Level (EL). Most recently, a new concept has been studied which focuses on the aspect ratio of the positive area rather than just the depth. This has been defined as the Normalized CAPE (NCAPE) in a study by Blanchard (1998). The purpose of this paper will be to show how NCAPE can be a very useful tool in forecasting moist convection across northern California. This paper will explore several cases in order to show how this instability parameter can be applied to forecasting different types of moist convection, and will attempt to establish criteria.

Normalized CAPE

It is important to recognize that variation in values of CAPE can be related to the geograpical location or season, therefore having a standardized instability index could be more practical. The use of NCAPE (Eq. 1) appears to fulfill this need very well as long as the numerical models are reasonably accurate in depicting the atmospheric profiles.

Equation:

NCAPE = CAPE/FCL **(1)**

where FCL = $Z_{EL} - Z_{LFC}$

It must be pointed out that instability alone is not sufficient to produce moist convection, and that other crucial parameters, such as a lifting mechanism (e.g., terrain, boundary) and sufficient moisture, are essential for thunderstorm activity. The NCAPE, or CAPE, can be used as methods of finding areas of potential moist convection since they consider both instability and moisture. However, the forecaster still needs to further investigate these regions by considering climatology and topography, while examining other forecast parameters before making the final determination of the actual threat for shower and thunderstorm development.

The equation above defines Normalized CAPE as the total CAPE divided by the depth of the free convective level (FCL). The units of NCAPE are $Jkg^{-1}m^{-1}$ which can be reduced to a more useful expression of acceleration in units of meters per second squared (ms^{-2}). This now is representative of the average buoyancy, or acceleration, for the positive area of the sounding. The study by Blanchard (1998) shows that the strength of acceleration within the lower levels is more important than the depth of the instability in determining the intensity of a thunderstorm updraft. The use of NCAPE can be thought of as the density of the available potential energy rather than the depth or quantity. Therefore, a sounding with a great depth of CAPE may be equally or less capable of producing thunderstorms than one that shows a shallow but "fat" region of instability. Many showers and thunderstorms in California occur in an environment with shallow instability in a depth of 20,000-ft or less. This type of instability is often under-estimated or not recognized using the more common parameters such as the K Index, Lifted Index (LI) or CAPE. The best way to identify this shallow instability is to view model forecast soundings and determine the NCAPE.

Events

For each of the events in this study, the Eta model forecast sounding was analyzed using software known as the Buffalo Toolkit [(BUFKIT) (Mahoney and Niziol, 1997)]. The BUFKIT software will display hourly forecast soundings from the Eta model at various, but limited, grid points. All the common indices are clearly displayed next to the sounding, including a value for NCAPE (Mahoney, 2000). The model run that would have most likely been available to a forecaster prior to the event was used in this study. The available sounding that was closest to the convective activity was chosen to analyze. These particular cases were chosen to show a variety of examples that demonstrate the broad potential benefits and seasonal applicability of using NCAPE and model soundings to forecast moist convection. Other cases were examined for this paper but not included to avoid repetition. The cases are presented based on ranges of NCAPE similar to Table 1. The majority of the cases in the study had NCAPE values ranging between 0.04 and 0.08 ms^{-2}.

NCAPE $\leq$ 0.03

(A)

Figure 1 shows a GOES-10 visible (.65 microns [μm]) image at 2345 UTC 28 April 1999. This satellite image depicts an unstable air mass over most of California. This case is a good example of model output showing very small CAPE values (less than 100 Jkg^{-1}), but NCAPE values that indicate a presence of shallow instability. From the 1200 UTC Eta run on 28 April 1999, NCAPE values at Blue Canyon (KBLU) were forecast to be 0.04 ms^{-2}, while both the KSAC and KRDD profile showed 0.03 ms^{-2} (not shown). This instability was sufficient to produce a few thunderstorms across the Sierra Nevada, and cumulus in the less favorable surface moisture convergence in the Central Valley. It is notable in Figure 1 that a north flow is evident by the north to south orientation of the clouds. A north flow is less favorable for developing or sustaining moist convection across interior Northern California, however the forecaster needs to consider the effect of terrain and the time of year. Figure 1 annotates the moist convection that occurred over the entire region.

(B)

An unseasonably strong short wave (not shown) enhanced numerous showers on 22 September 2000. An extremely deep marine layer (5,000-ft) provided the necessary moisture that was needed given the shallow instability that was forecast by the Eta model run at 0000 UTC 22 September. A KDAX composite reflectivity shows the intense showers that developed on the east side of the Sacramento Valley (Fig. 2). The author observed the heavy rain shower near Roseville, and despite reflectivity values as high as 62 dBZ, there was not any lightning associated with the shallow moist convection. Maximum rainfall amounts of 19.1-mm (0.75 inches) were observed. An Eta profile displayed in BUFKIT at 2200 UTC 22 September shows that the NCAPE was forecast to be 0 .03 ms^{-2} (Fig. 3). It may appear that Eta was under-forecasting the instability, however given the strength of the short wave and the steep shallow lapse rates seen on the model sounding this may have been a reasonable representation of the airmass. In this case, the moist convection was shallow which likely indicates weaker updrafts (i.e., lower NCAPE) within the storms. However, the Eta model may not have been accurately depicting the available moisture given that the source was from a marine layer intrusion which is a meso-scale phenomena. This case was included to show the usefulness of NCAPE and model soundings even during a not so typical convective event.

(C)

On 15 February 2001, Eta soundings showed NCAPE values of 0.03 ms^{-2} for KSAC (Fig. 4). There was little upper air support (i.e., omega) on this day, and the soundings show a rather strong inversion over the shallow instability. The LI's reflected the warm air in the upper levels with a value of 8.5. The KSAC sounding's NCAPE value was more useful in this case than KBLU, though shallow instability (i.e., steep lapse rates but NCAPE was not produced) was forecast at Blue Canyon. When forecasting moist convection in complex terrain, it may sometimes be useful to view several nearby BUFKIT model soundings. The air mass in the region under consideration may be more accurately represented at one forecast location versus the other. The GOES-10 .65 µm satellite images show scattered cumulus that developed near Sacramento on the eastern foothills of the Sacramento Valley at 2300 UTC (Fig. 5). Most noticeable is the solid deck of cumulus that developed along the west slope of the Sierra Nevada. In this case, moisture and shallow instability was sufficient, however higher terrain (i.e., upslope effects) was necessary to support moist convection. The NCAPE proved to be valuable in identifying the potential for moist convection and the forecaster needed to consider terrain effects.

NCAPE 0.04 to 0.08

(D)

Case D is a common example of post-frontal moist convection that occurs in northern California. The BUFKIT sounding for KRDD seen in Figure 6 depicts an inversion height. The difference in this profile is the very stable atmosphere suggested by a LI of 10.5. Despite the stable layer present above 11,000-ft, below this level it was rather unstable. A NCAPE value of 0.04 ms^{-2} at 2200 UTC 9 March 1999 was forecast by the 1200 UTC 8 March 1999 Eta run (Fig. 6). The KBBX WSR-88D showed numerous showers, possibly with thunder, that occurred over the Northern Sacramento Valley and the Sierra Nevada foothills (Fig. 7).

(E)

On 20 November 1999, rather strong and shallow moist convection occurred in the Sacramento Valley (Fig. 8). Figure 9 shows the BUFKIT KSAC profile at 2300 UTC 20 November 1999 from the 0000 UTC 20 November Eta run. The NCAPE value was 0.04 ms^{-2} and the LI was shown to be a rather high 6.4. The sounding clearly shows the shallow instability that was forecast between 3,000 and 10,000-ft. In this case, there was sufficient atmospheric lift and further destabilization as the result of a weak secondary short wave that moved through the region resulting in moist convection. This short wave was depicted well by the Eta forecast (not shown). Considering that there was no report of thunderstorms (weaker updrafts and shallow storm tops) suggest that the relatively small NCAPE of 0.04 ms^{-2} was reasonably accurate.

(F)

An unseasonably strong upper trough of low pressure was present over Northern California on 2 September 2000 (not shown). The 0000 UTC 2 September 2000 Eta forecast maximum NCAPE values of 0.04 ms^{-2} at KRDD and 0.03 ms^{-2} at SAC between 2000 and 0200 UTC (not shown). The GOES-10 .65 μm images showed that moist convection was widespread during the afternoon of 2 September (Fig. 10). Numerous cumulus and cumulus congestus, along with a few showers occurred near Sacramento. Further north near Redding, showers developed during the same time but continued into the evening hours. A secondary short wave trough (not shown) was responsible for the longer duration of showers in the northern Sacramento Valley. This case was included to show that NCAPE is useful even during the typical dry season of California.

(G)

As previously discussed, California often experiences moist convection that is post-frontal. This has been found to be most common in the northern Sacramento Valley. Figure 11 shows a BUFKIT sounding for Redding (KRDD) on 20 January 1999 at 0100 UTC from the 0000 UTC 19 January run. The most noticeable feature of this sounding is the strong temperature inversion around 11,000-ft. A quick look suggests that deep moist convection is not favorable with this sounding. The LI at this time was forecast to be positive 4, however the NCAPE value was 0.05 ms^{-2} with a CAPE value of 152 Jkg^{-1}. A composite reflectivity image from the Beale (KBBX) Weather Surveillance Radar - 1988 Doppler (WSR-88D) shows a thunderstorm north of Redding at 0033 UTC (Fig. 12). This thunderstorm was producing dime-sized (2-cm or 0.75-in) hail just north of Redding. Though it appears the Eta model under-estimated the instability on this day based on the LI, it is clear that the model sounding and the use of NCAPE were better indicators of the convective potential.

(H)

Figure 13 shows a KDAX composite reflectivity at 2039 UTC 29 November 2000. Showers and thunderstorms developed behind a cold front in the Central Valley. The Eta sounding for Sacramento International Airport (KSMF), displayed in BUFKIT, using the 0000 UTC 29 November run, showed a good potential for shallow moist convection with a NCAPE value of 0.07 ms^{-2} (Fig. 14). The sounding shows that NCAPE was the best predictor for the potential instability in this case. Similar to case F, a secondary short wave (not shown) helped organize and enhance the showers and thunderstorms. Hail was not reported with these thunderstorms, however the rain was locally very heavy.

(I)

Numerous post-frontal showers and isolated thunderstorms developed on 6 February 2001 in the southern Sacramento Valley (Fig. 15). Small hail (< 2-cm or < 0.75-in) was reported with a few thunderstorms. This moist convection developed as a secondary short wave passed over the region. The KDAX VAD wind profiles showed northwest wind above 1,000-ft, however surface observations showed a period of south wind which supports surface moisture convergence in the Central Valley (not shown). Eta soundings for KSAC showed moderate shallow instability at 0000 UTC 7 February with a NCAPE value of 0.07 ms^{-1} (Fig. 16). As found in previous cases, LI was not useful in this case since at 0000 UTC the LI was forecast to be 4.5.

NCAPE 0.09 to 0.13

(J)

The Eta sounding for Sacramento (KSAC) shown in this case is similar to examples D and G, except the NCAPE value of 0.10 ms^{-2} is more than twice as large (Fig. 17). This sounding for KSAC is at 2200 UTC on 31 March 1999 from the 0300 UTC 31 March Eta run. Despite a substantial shallow region of instability, the LI for this sounding was 6.8 and the K-index was 10. Figure 18 shows the Davis (KDAX) WSR-88D composite reflectivity image at 0020 UTC 1 April 1999, which depicts numerous showers and thunderstorms moving south. A few thunderstorms developed over the coastal mountain range and moved south in the north flow affecting the major populations of Fairfield and Vacaville that evening. Small hail was reported with these thunderstorms.

(K)

On 28 June 2000, a monsoonal flow brought subtropical moisture into the Sierra Nevada, which led to explosive thunderstorm development along its' crest. This case was included to show that NCAPE can be used during any season and is applicable to all surface based moist convection. A BUFKIT sounding for KBLU at 2300 UTC 28 June 2000 from the 1200 UTC June Eta run showed a very unstable sounding (relative to California) with a NCAPE value of 0.11 ms^{-2}, CAPE of 670 Jkg^{-1}, and a LI of -2.2 (Fig. 19). The airmass was most unstable south of KBLU, however this site is the only available Eta forecast sounding on the west side of the Sierra Nevada. A thunderstorm over the Sierra Nevada, south of Blue Canyon, was shown to have vertically integrated liquid water (VIL) values as high as 65 kgm^{-2} (not shown). This storm was likely producing large hail, but was in an unpopulated region over high terrain. Other storms that day, showing similar intensity, were observed to produce 4-cm diameter (1.5-in) sized hail at Yosemite National Park. The relatively high NCAPE in this case was accurately depicting the potential for strong vertical accelerations which could support severe thunderstorms.

NCAPE 0.14 or greater

(L)

The sounding in Fig. 20 is more representative of a profile that would be expected to support thunderstorm development. Cold air aloft provided steep lapse rates, which is common in the spring months. This Eta forecast sounding at KSAC shows a deep positive (unstable) area between the EL and the LFC which is reflected in a CAPE value of 807 Jkg^{-1}. This sounding at 2100 UTC 8 April 1999 was from the 0000 UTC 8 April Eta run. The NCAPE value of 0.14 ms^{-2} indicates a high potential for strong and relatively shallow convection. The KDAX composite reflectivity at 2211 UTC showed that organized lines of thunderstorms formed through out the Central Valley of California, as well as the surrounding foothills and mountains (Fig. 21) ahead of a short wave. More significantly, there were several reports of non-severe hail (< 0.75-in or < 2-cm) with these thunderstorms.

(M)

This example is similar to case K in which the model soundings where depicting a deep layer of instability. Figure 22 shows a GOES-10 .65 µm image at 0000 UTC 26 May 1999 depicting intense deep moist convection over the Sierra Nevada. Eta NCAPE values for KBLU were as high as 0.14 ms^{-2} (not shown). Some of these thunderstorms were producing hail, and a few might have been capable of severe-size hail ($\geq$ 0.75-in). An upper low pressure area in southeast Nevada provided the moisture (not shown). It should be noted that on 24 May 1999, thunderstorms of similar intensity produced 4-cm (1.5-in) sized hail over the Sierra Nevada crest.

Results and Applications

The results from this study show that considering NCAPE values and model soundings can be very useful towards successfully forecasting different types of moist convection during all seasons. This includes the development of cumulus, cumulus congestus, showers and thunderstorms. The NCAPE and CAPE indicate instability through the entire sounding and also reflect the available moisture. The majority of the showers and thunderstorms that occur in northern California are shallow and post-frontal. This study showed that NCAPE does a superior job at identifying areas of potential shallow instability that might otherwise not be indicated by traditional parameters such as LI. The paper showed that NCAPE is the most useful in situations where there is shallow instability colocated in regions of surface moisture convergence. This parameter can also be effective in showing the potential strength of thunderstorm updrafts (vertical acceleration) in the Central Valley, or across the Sierra Nevada, which could lead to widespread thunderstorms or even severe weather. This paper does not suggest a direct correlation between NCAPE and severe weather, since many other factors are involved with forecasting severe thunderstorms.

The NCAPE, like any atmospheric instability parameter, has to be used in conjunction with indicators of available moisture and a source of lift to obtain the LFC. Once these parameters are deemed sufficient for moist convection, other factors such as unfavorable surface wind directions (i.e., downslope and divergent wind) and temperature inversions (cap) need to be considered. The BUFKIT soundings provide a quick and quantitative method to obtain most of this information. This study showed that NCAPE can be far superior to using traditional parameters such as LI when a forecaster is diagnosing the potential for cumulus, showers or thunderstorms. Table 1 is an attempt at providing the forecaster with some guidelines with which to apply NCAPE based on the data seen in these cases and other events not included. In situations when the traditional instability parameters fail to identify an unstable airmass, NCAPE has especially proven to be more effective in showing the potential for shallow moist convection and sometimes deep moist convection in Northern California.

Conclusion

Numerous cases were examined for this study in an attempt to find how NCAPE, a new convective parameter, can be applied to moist convection forecasting across interior Northern California during any season. The NCAPE was found to be a better and more consistent indicator for moist convection than the traditional parameters such as CAPE, LI and K Index. The NCAPE, along with the use of numerical model soundings viewed in BUFKIT, was especially useful for identify post-frontal shallow instability. Like any parameter, it should not be used alone. In order to most effectively make use of NCAPE, the forecaster must consider terrain effects and any negative factors such as surface divergence or strong inversions caused by synoptic scale subsidence or warming. Sufficient instability and moisture may be enough to produce moist convection over favorable terrain, such as mountains and locally convergent zones caused by topography, but may be dependent on additional synoptic or meso-scale interactions in the Central Valley.

Table 1 is an attempt to categorize NCAPE by establishing criteria for forecasting applications in northern California. These values are only suggested guidance, and will not be valid if the model data is not reasonably predicting the instability and moisture profiles. Additional case studies should prove beneficial to the early but significant results of this study.

Table 1. This table shows the type of moist convection that may be associated with a range of NCAPE values in northern California. Favorable terrain would include elevated mountainous areas and the regions in proximity to this, and surface convergent zones induced by topography and surface boundaries. Unfavorable terrain refers to the central and southern Sacramento Valley.

NCAPE range of values	If in *favorable* terrain, or if associated with short wave in *unfavorable* terrain	If associated with short wave or strong surface forcing in *favorable* terrain
≤ **0.03** Cases A*, B, C, H*	Cumulus or cumulus congestus, isolated to widely scattered showers	Numerous cumulus, isolated to scattered showers, isolated to widely scattered thunderstorms
0.04 to 0.08 Cases A, D, E, F, G, H, I	Numerous cumulus congestus, scattered showers, isolated to widely scattered thunderstorms	Numerous showers, scattered thunderstorms, isolated to widely scattered severe possible
0.09 to 0.13 Cases J, K	Scattered to numerous showers, widely scattered to scattered thunderstorms, severe possible	Numerous thunderstorms, isolated to scattered strong thunderstorms, severe potential for strongest storms
0.14 or higher Cases L, M	Thunderstorms likely, some strong and possibly severe	Numerous thunderstorms, scattered strong thunderstorms, a few severe thunderstorms probable

*Case A sounding for Redding and Sacramento
*Case H sounding for Sacramento

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Moncrieff, M. W., and M. J. Miller, 1976: The dynamics and simulation of tropical cumulonimbus and squall lines. Quart. J. Roy. Meteor. Soc., 102, 373-394.

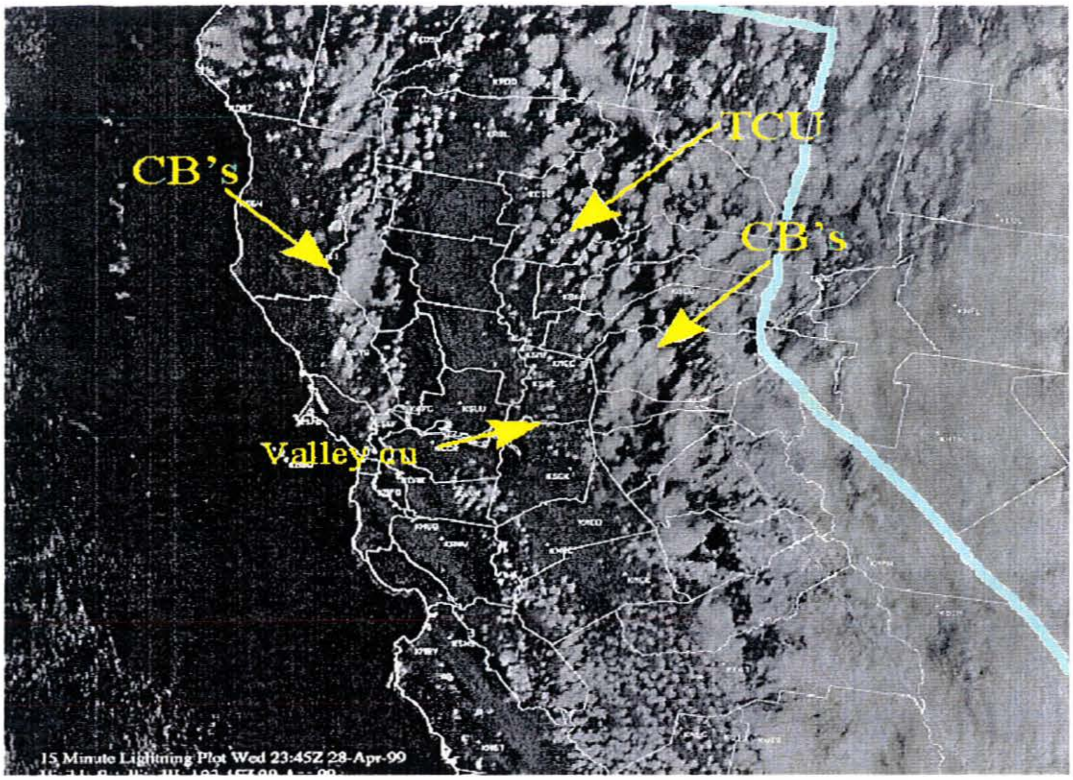

Figure 1. GOES-10 visible image at 2345 UTC 28 April 1999. Valley cumulus (CU) and higher terrain cumulus congestus (TCU) and cumulonimbus (CB) are noted.

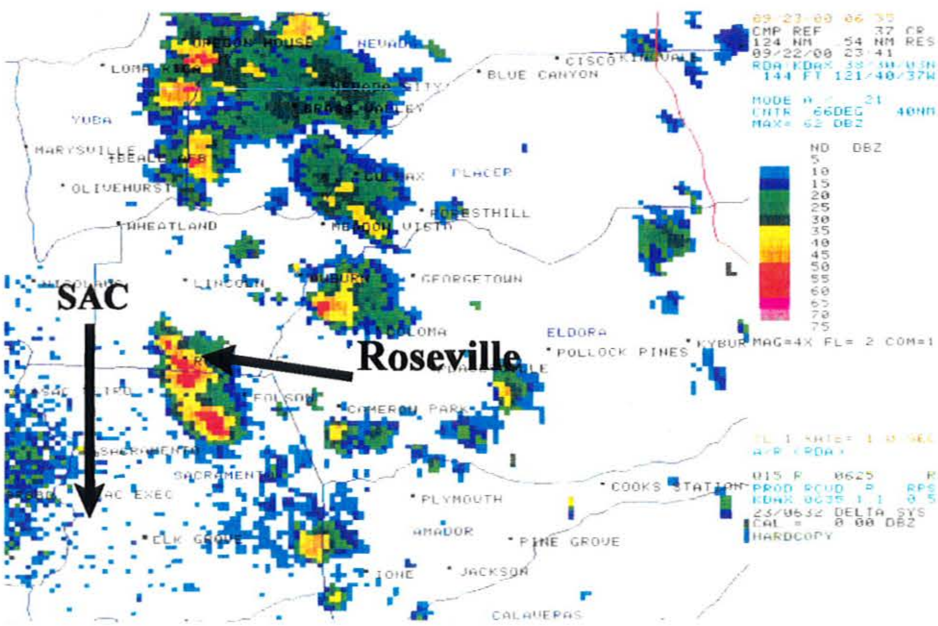

Figure 2. KDAX composite reflectivity at 2341 UTC 22 September 2000 showing intense rain showers on the east side of the Sacramento Valley. Maximum reflectivities were 62 dBZ, however thunder was not reported and there was not any lightning detection from these cells.

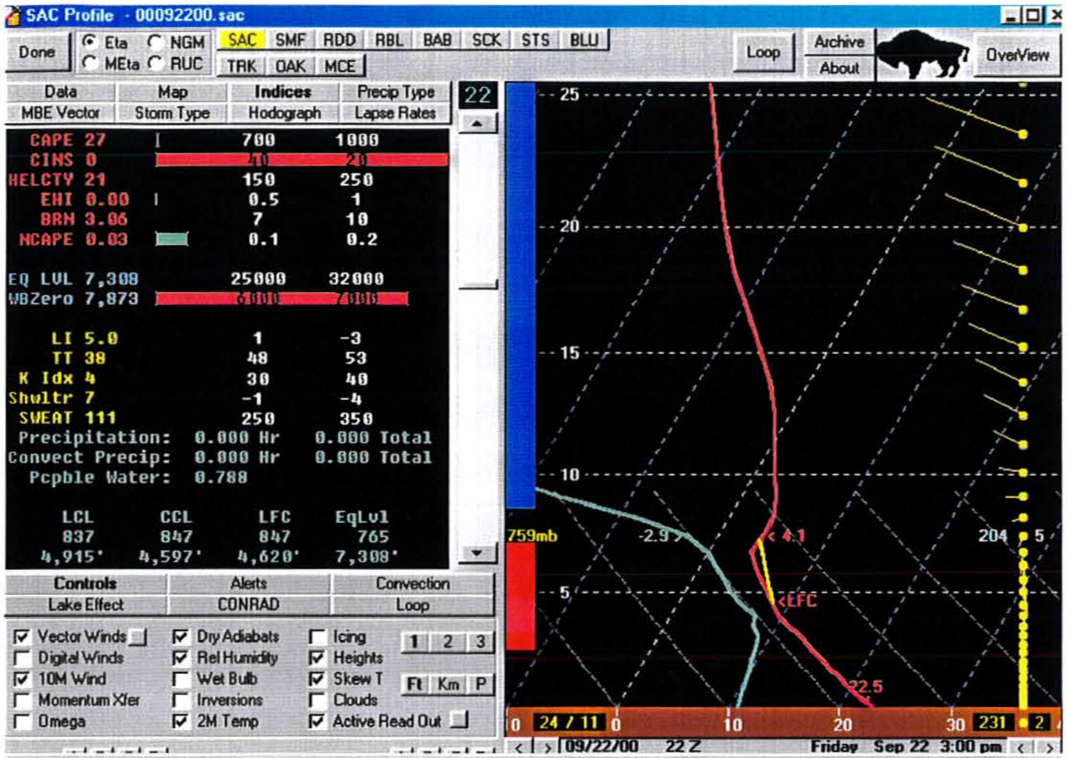

Figure 3. BUFKIT profile for KSAC at 2200 UTC 22 September 2000 from the 0000 UTC 22 September Eta run. NCAPE value of 0.03 ms^{-2} was produced with steep lapse rates below 7,000-ft. The LI was 5.0 and CAPE was only 27 Jkg^{-1} as seen on the left side of the display (Mahoney 2000).

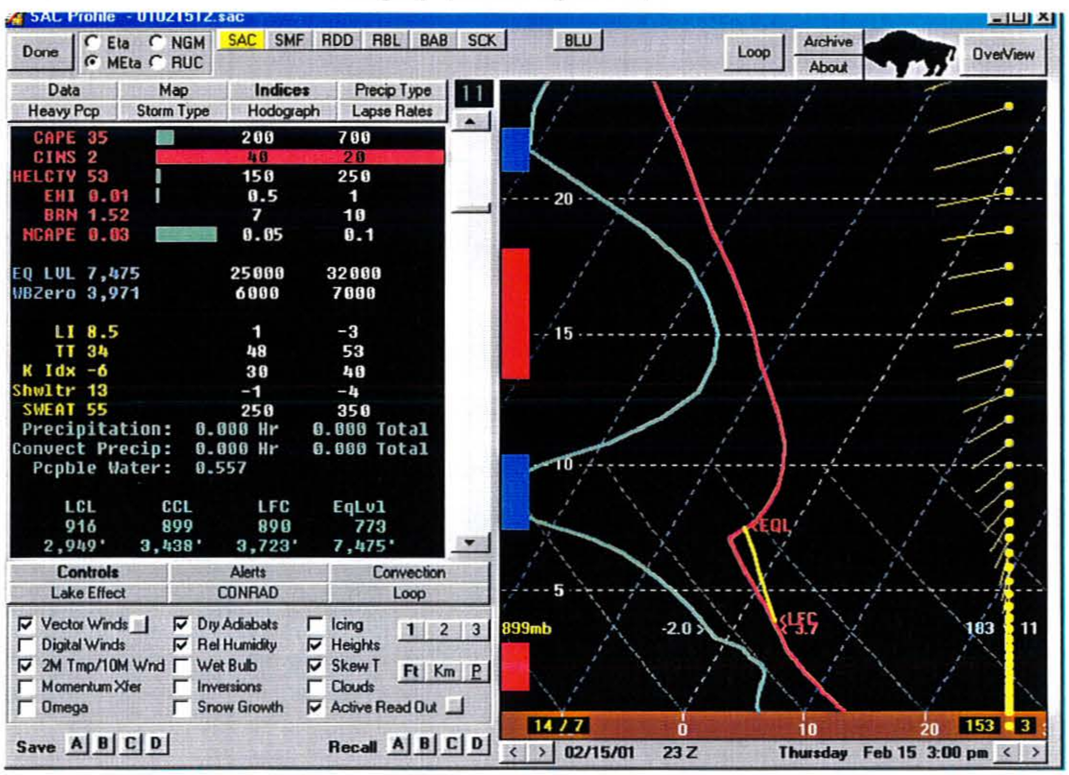

Figure 4. BUFKIT Eta at 2300 UTC 15 February 2001 for KSAC from the 1200 UTC run. Notice the shallow instability under the inversion. NCAPE was 0.03 ms^{-2}, CAPE was 35 Jkg^{-1} and LI was 8.5 in this display.

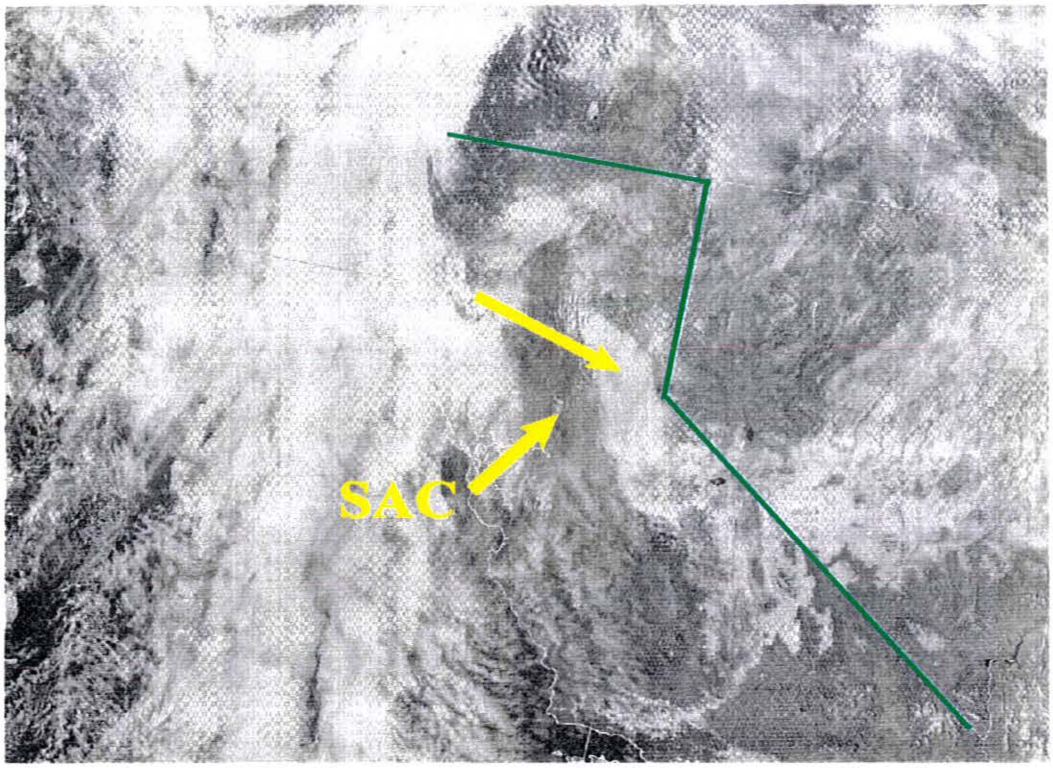

Figure 5. GOES-10 .65 µm image at 2300 UTC 15 February 2001. Notice the solid area of clouds over the higher terrain and the scattered cumulus near Sacramento (SAC).

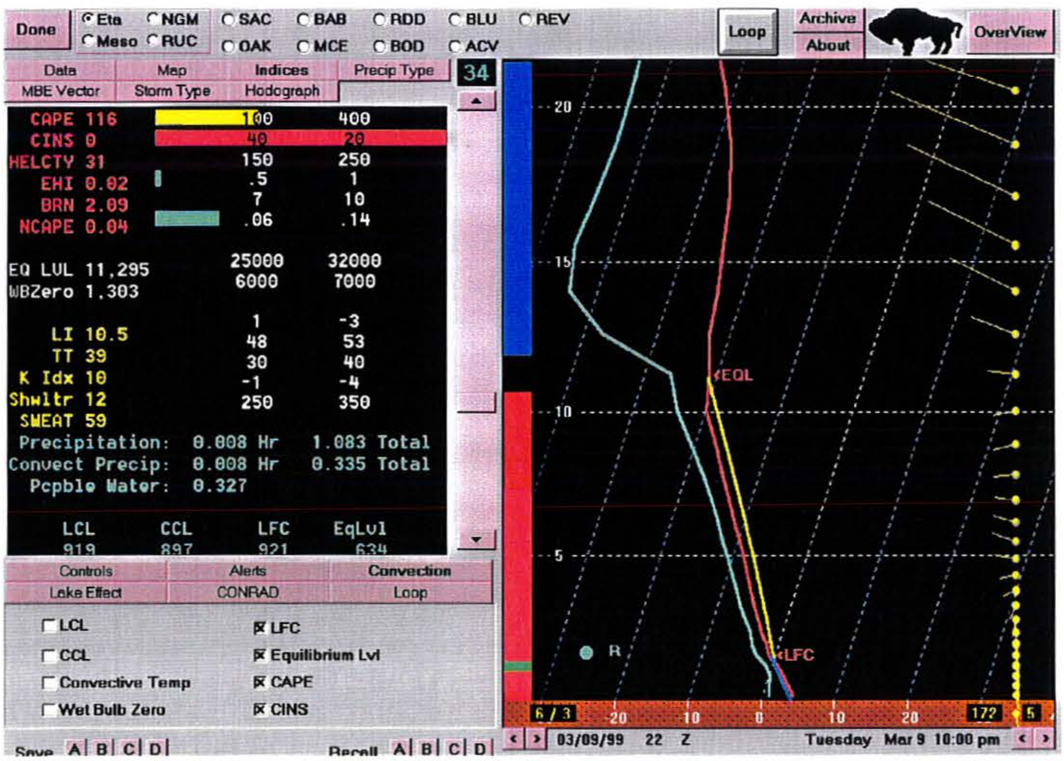

Figure 6. BUFKIT Eta at KRDD on 2200 UTC 9 March 1999 from the 1200 UTC 8 March run. Note the convective precipitation that is forecast with a NCAPE value of 0.04 ms^{-2} and LI of 10.5 shown on the left side of the display.

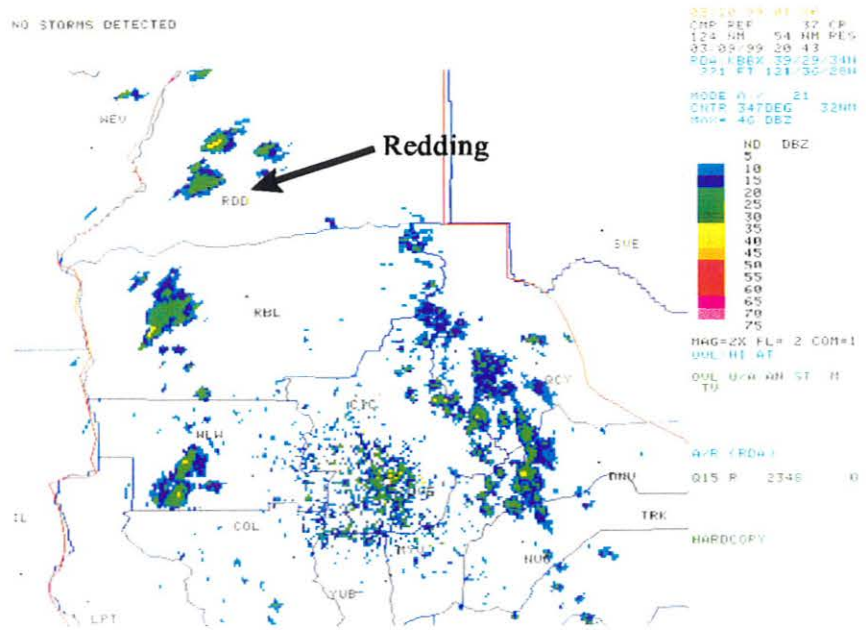

Figure 7. KBBX composite reflectivity image at 2043 UTC on 9 March 1999.

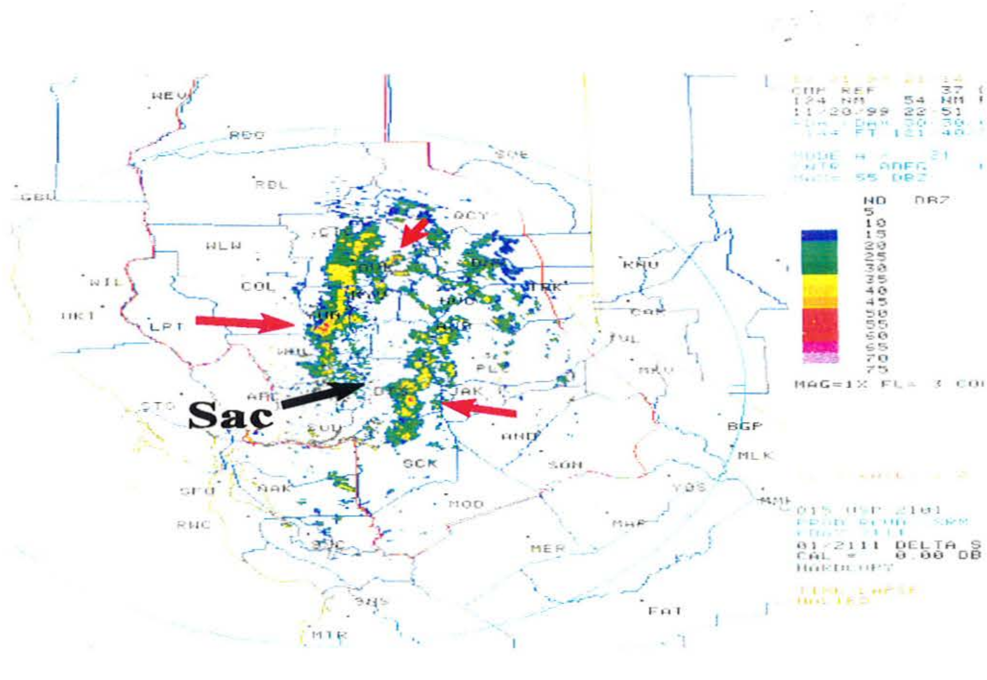

Figure 8. KDAX composite reflectivity at 2251 UTC 20 November 1999. Maximum echo tops were 18,000-ft. Red arrows point to reflectivity values of 50 dBZ or higher.

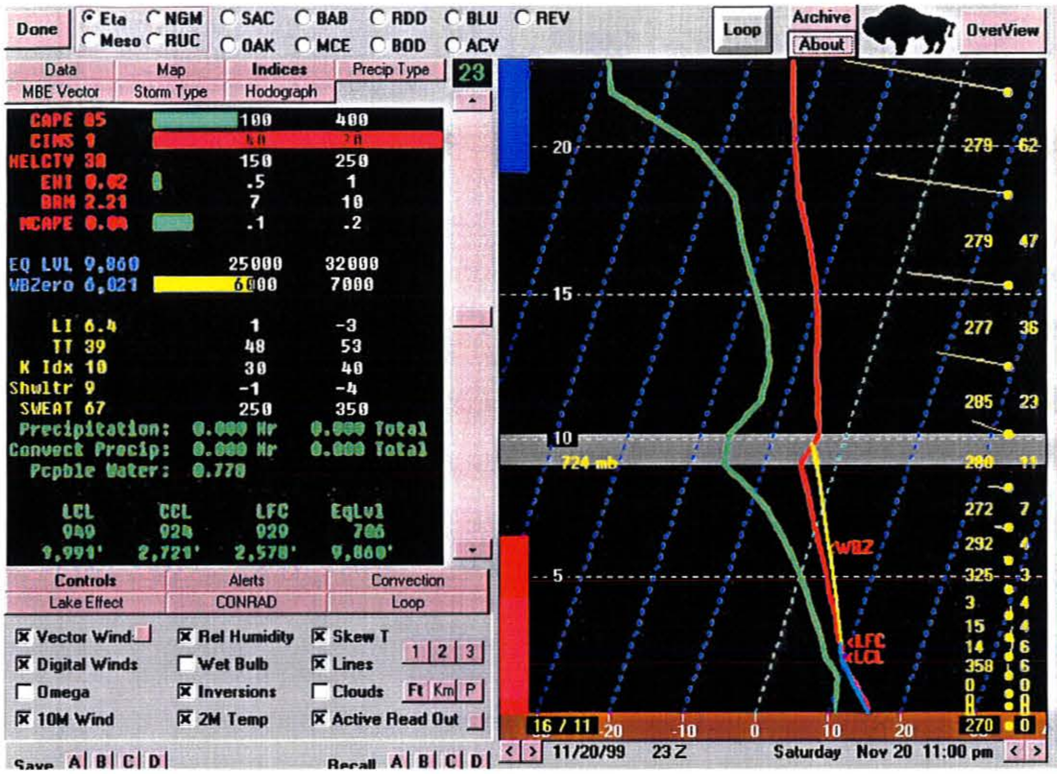

Figure 9. BUFKIT KSAC at 2300 UTC 20 November 1999 from the 0000 UTC Eta run. The NCAPE value was 0.04 ms^{-2} with a LI of 6.4. The sounding clearly shows a shallow layer of instability with the yellow line of buoyancy between 3,000 and 10,00-ft.

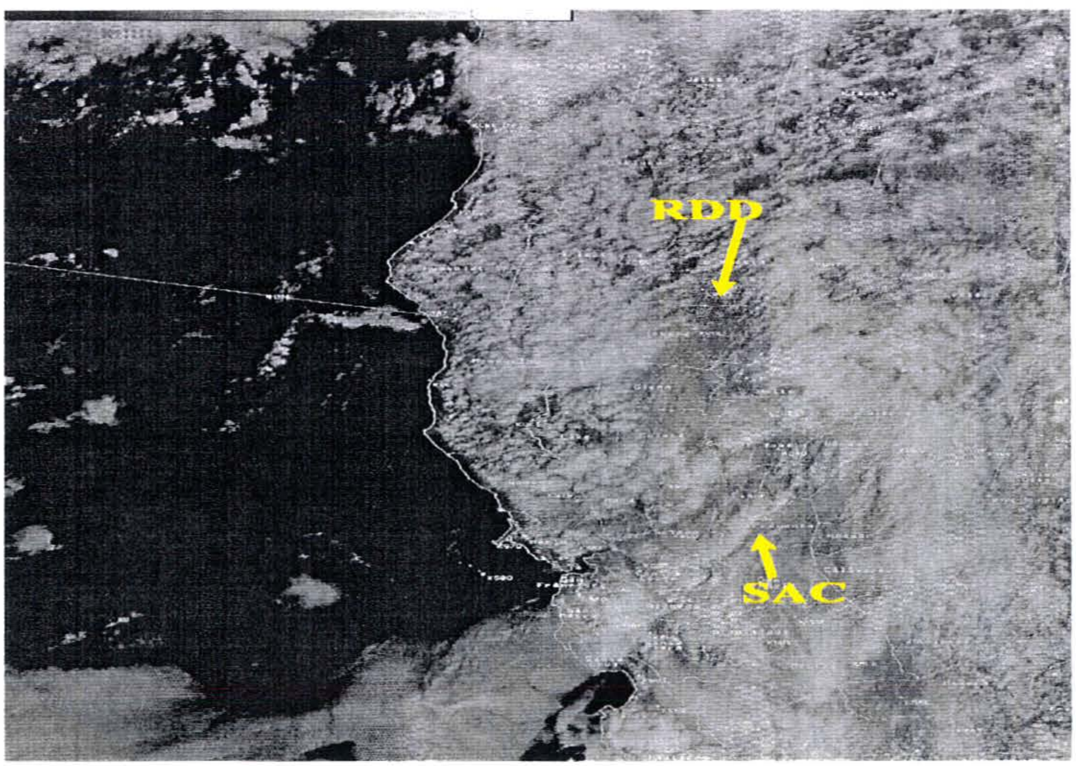

Figure 10. GOES-10 .65 μm image showing widespread cumulus in the Sacramento Valley. Scattered showers developed near Sacramento (SAC) during the afternoon of 2 September 2000. Numerous showers developed near Redding during the afternoon which continued into the evening.

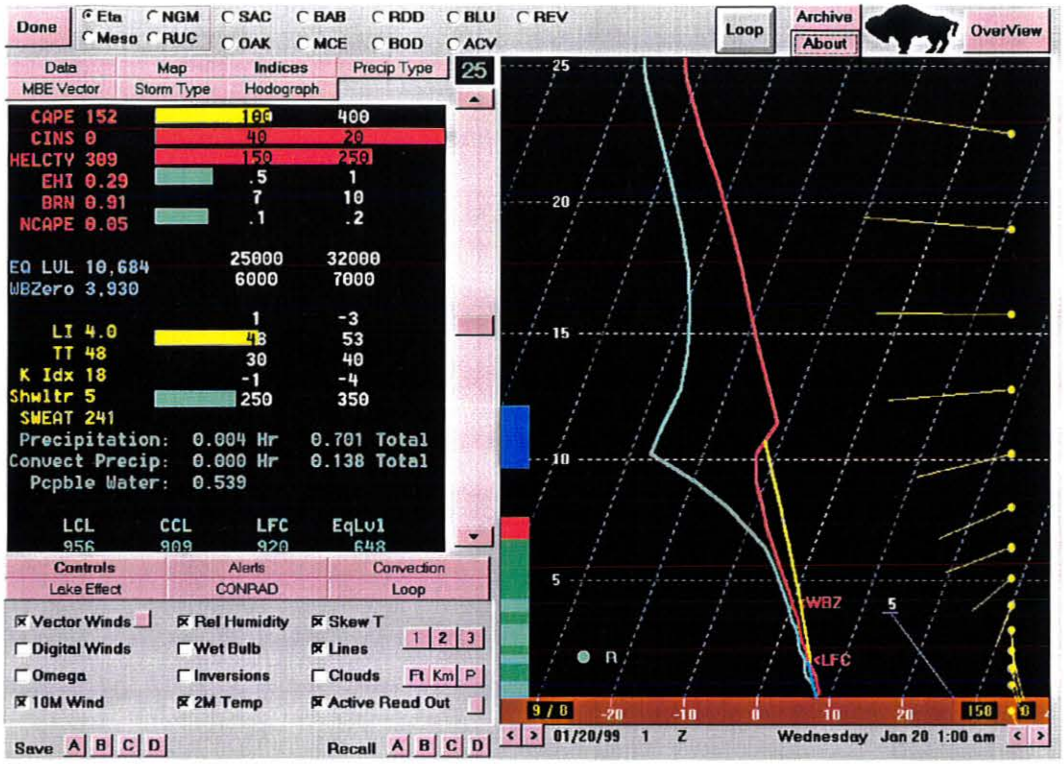

Figure 11. BUFKIT Eta at KRDD from the 19 January 1999 0000 UTC run at 0100 UTC 20 January. The Eta was forecasting a NCAPE value of 0.05 ms^{-2} while the LI was 4.0 which is shown on the left side of the display (Mahoney 2000).

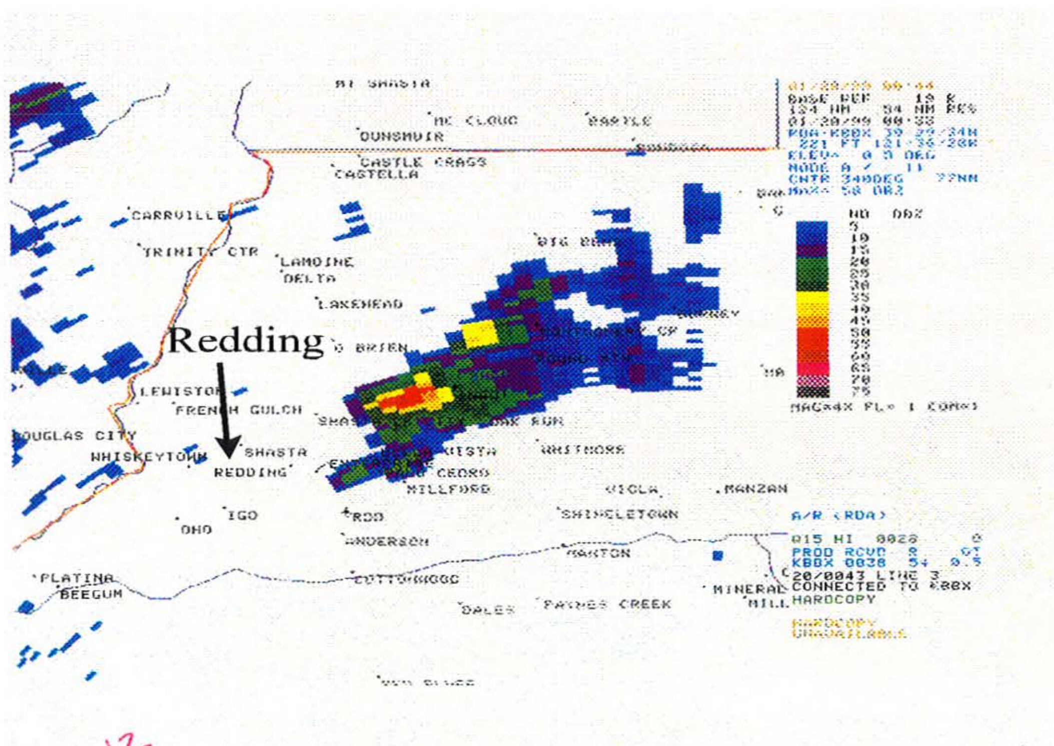

Figure ~~13~~ 12. KBBX composite reflectivity at 0030 UTC on 20 January 1999. This thunderstorm was just east of Redding and produced dime sized (2-cm or 0.75-in) hail. The scale on the right shows the reflectivity scale in values of dBZ.

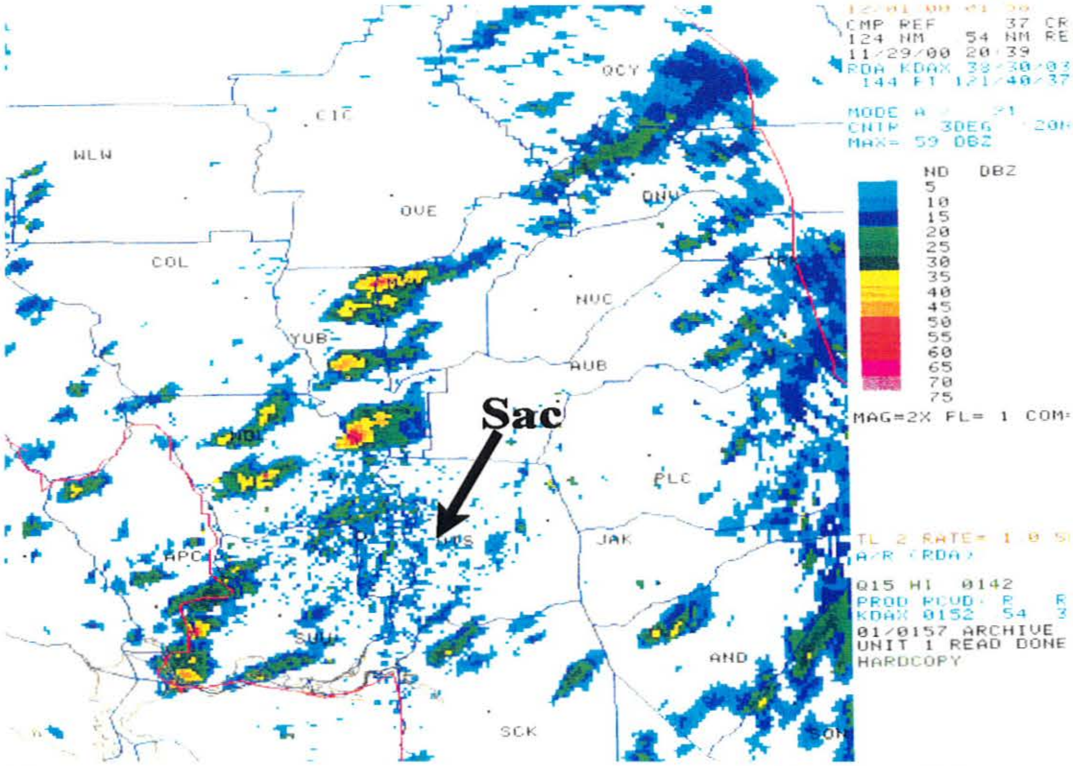

Figure 13. KDAX composite reflectivity at 2039 UTC 29 November 2000 showing numerous showers and isolated thunderstorms in the Sacramento Valley. Maximum reflectivity were 59 dBZ.

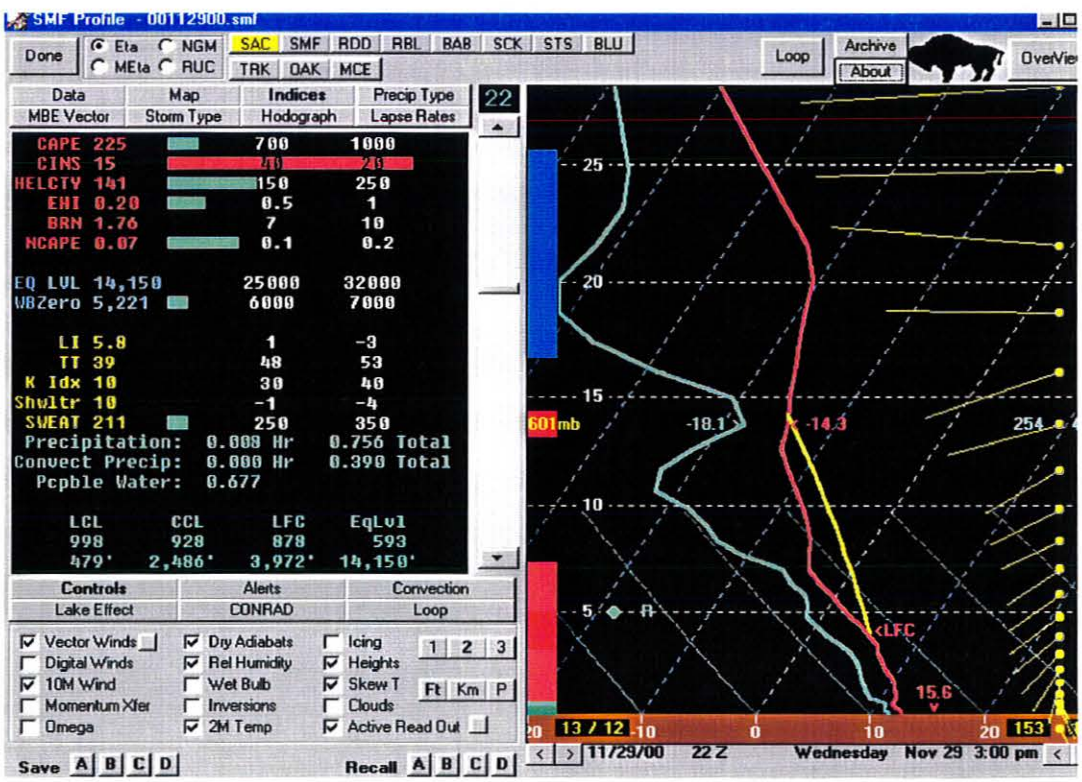

Figure 14. BUFKIT KSMF at 2200 UTC 29 November 2000 from the 0000 UTC Eta. A NCAPE value of 0.07 ms^{-2} is produced with this sounding while the LI was 5.8.

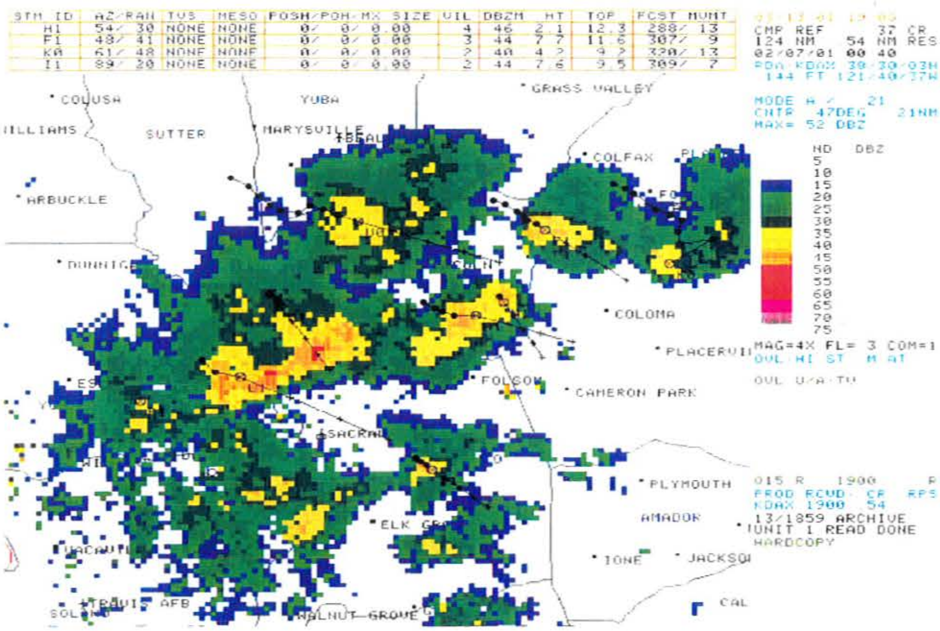

Figure 15. KDAX composite reflectivity at 0040 UTC 7 February 2001. A slow moving area of showers and thunderstorms was approaching the Sacramento region. VAD wind profiles at this time showed a northwest wind at 5 to10 ms^{-1}.

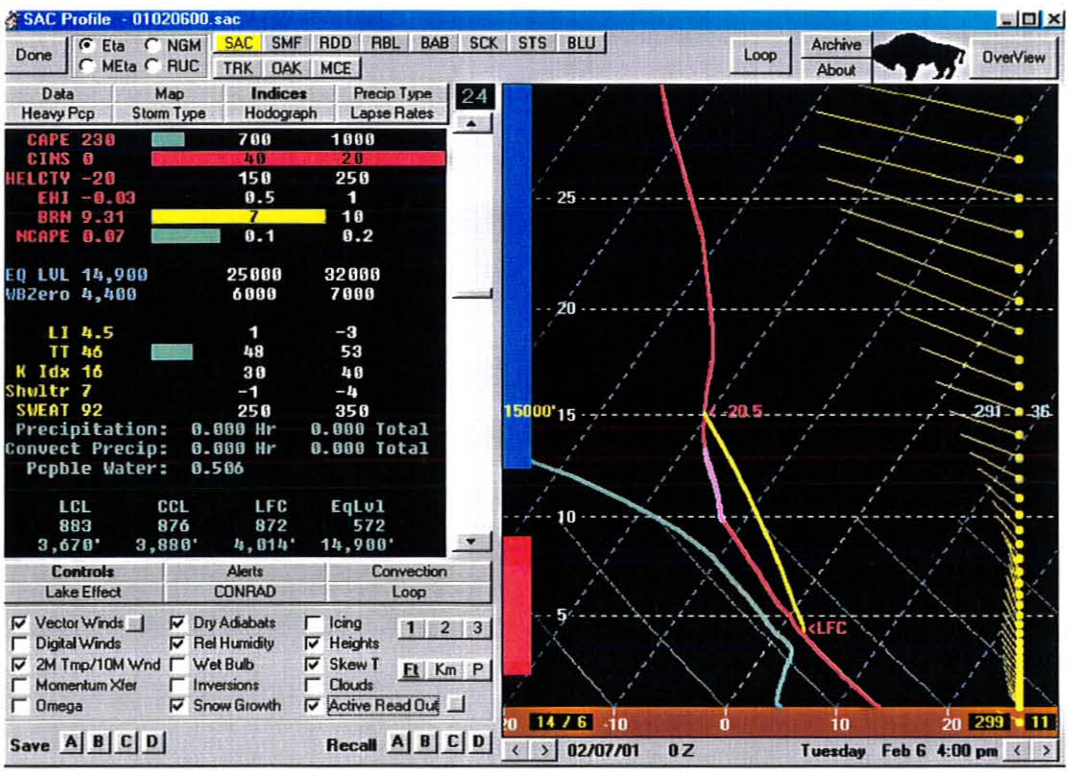

Figure 16. Eta profile at KSAC from the 0000 UTC 6 February 2001 run showing moderate shallow instability at 0000 UTC 7 February. NCAPE was 0.07 ms^{-2}.

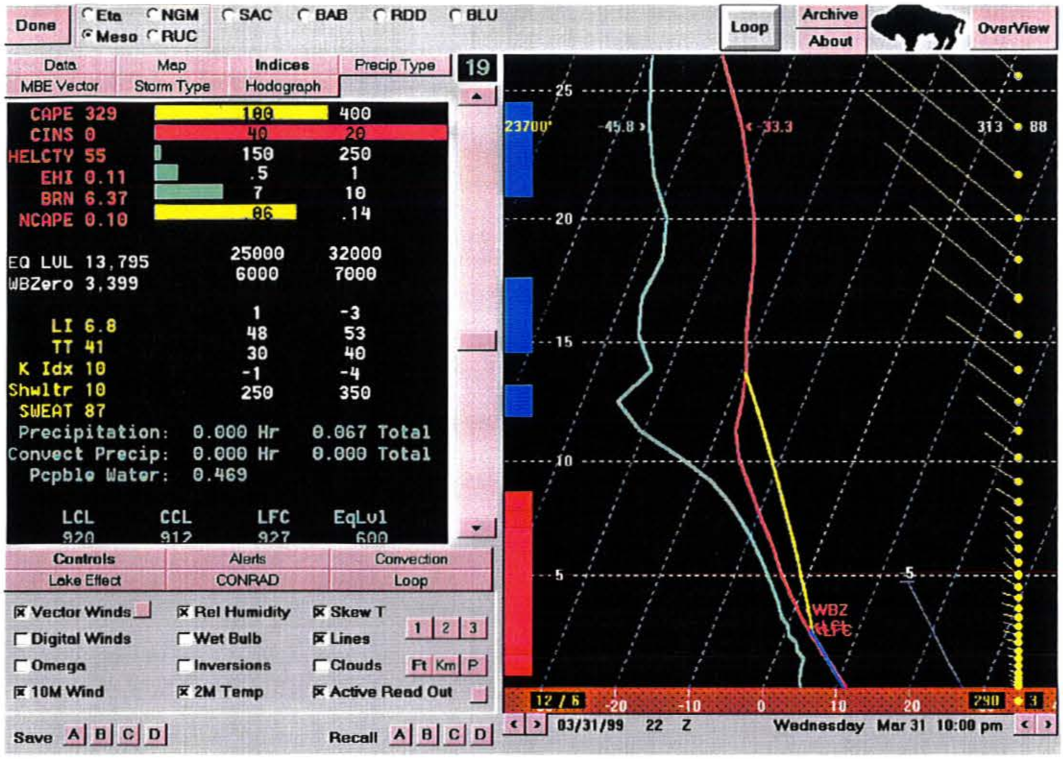

Figure 17. BUFKIT Eta for KSAC at 2200 UTC on 31 March 1999 from the 0300 UTC 31 March run. Note the relatively high NCAPE value of 0.10 ms^{-2} indicating a strong potential for shallow convection while the LI was 6.8 .

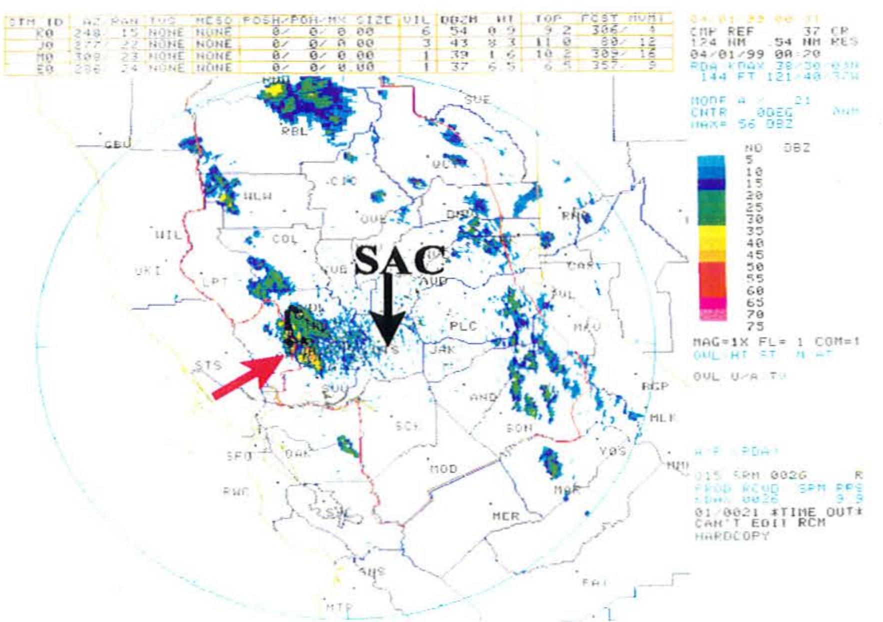

Figure 18. KDAX composite reflectivity at 0020 UTC on 1 April 1999. Showers and thunderstorms were moving southeast and affected several major populations. Small hail was reported (< 2-cm or 0.75 inch). Red arrow indicates reflectivity of 50 dBZ or higher.

Figure 19. A BUFKIT Eta profile at 2300 28 June 2000 from the 1200 UTC 28 June run. The NCAPE value was 0.11 ms^{-1}.

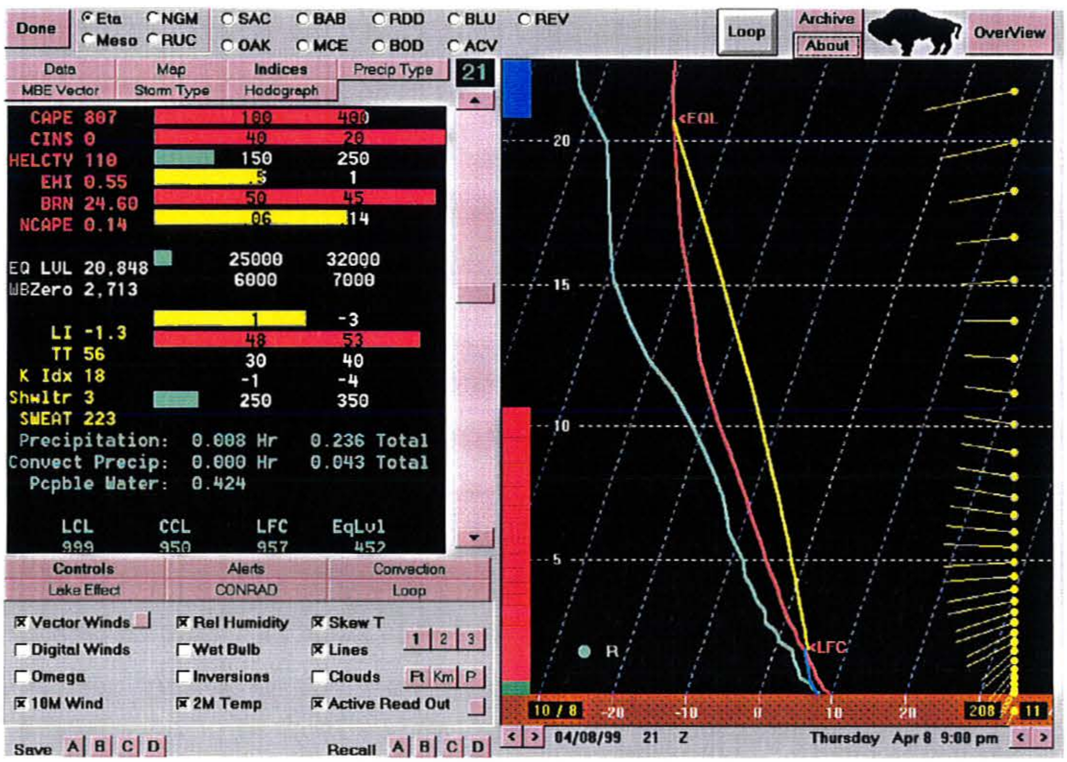

Figure 20. BUFKIT Eta KSAC sounding at 2100 UTC 8 April 1999 from the 0000 UTC 8 April run. Forecast CAPE values were as high as 807 Jkg^{-1} giving an NCAPE of 0.14 ms^{-2} which indicates a high potential for strong moist convection.

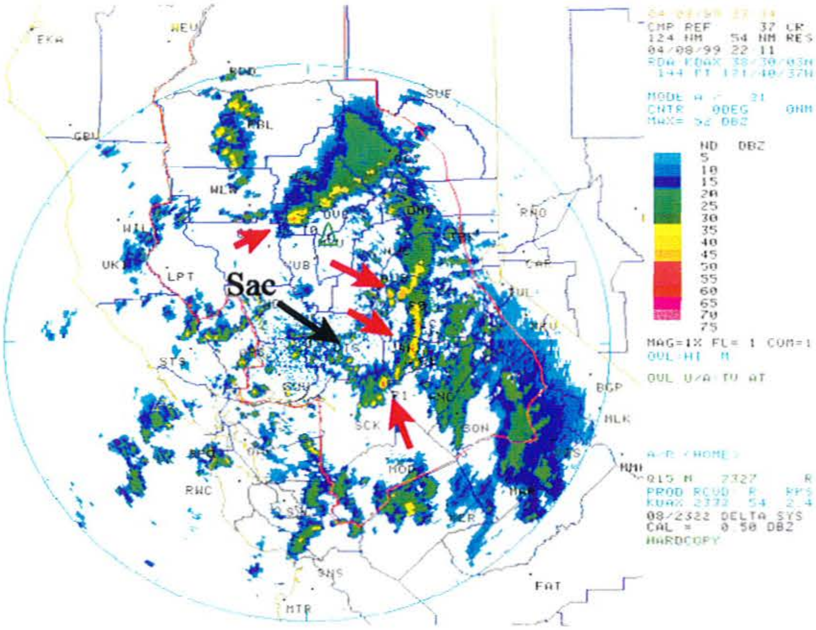

Figure 21. KDAX composite reflectivity on 8 April 1999 at 2211 UTC. There were several reports of hail from these thunderstorms. Small red arrows point to reflectivity values of 50 dBZ or higher.

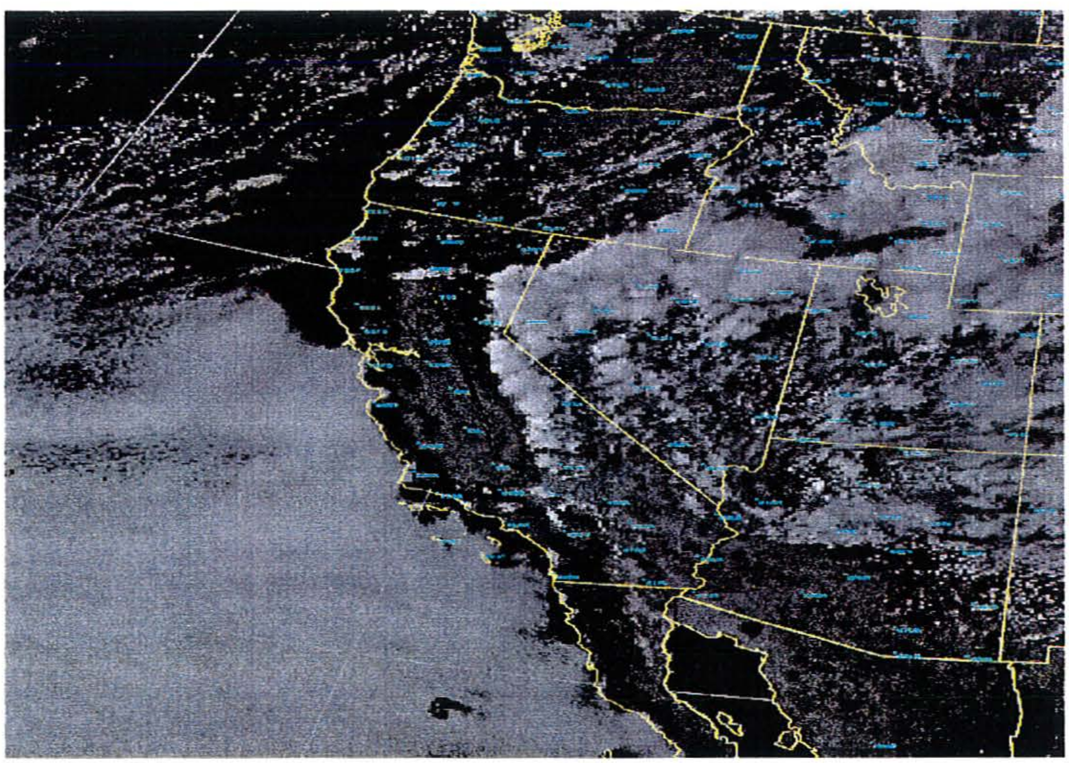

Figure 22. GOES-10 .65 μm image at 0000 UTC on 26 May 1999 depicting deep moist convection over the Sierra Nevada. Eta NCAPE values at KBLU were 0.14 ms^{-2} for this time.