East Wind Storms at Albuquerque, NM

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1. Introduction

Most residents of central New Mexico, including the Albuquerque metropolitan area, are familiar with the occasional strong east wind events which are a feature of our weather. Examination of a wind rose (Fig 1) illustrates that on an annual basis, winds from the east and east southeast occur frequently, approximately 13 percent of the time. Additionally, the strongest winds, those greater than 17 knots (19.5 mph, or green and cyan on the wind rose), occur with the most frequency from the east and east southeast.

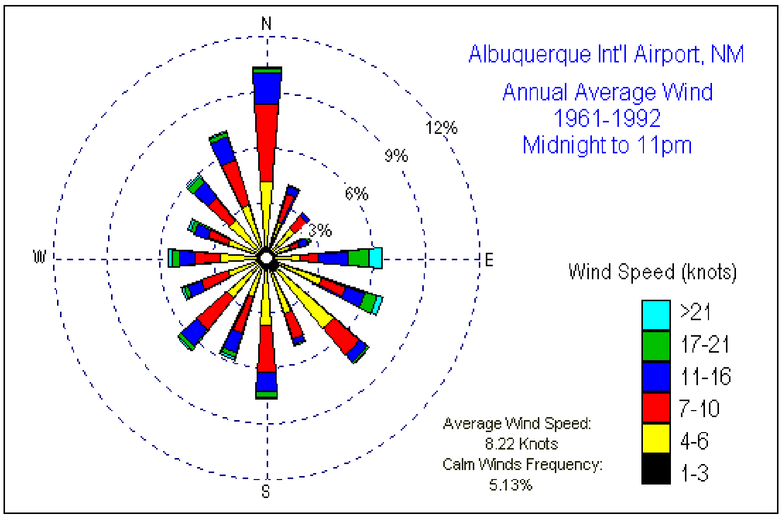

Figure 1. Annual wind rose for Albuquerque for years 1961-1992.

For the forecaster, these winds are a challenging yet important component of the forecast. Aside from the immediate impact of the strong winds themselves, there are considerations pertaining to the precipitation forecasting for the city and indeed for all of central New Mexico. Aviation interests and land-based transportation industries can also be greatly affected by the gusty winds, clouds, precipitation and visibility restrictions associated with strong east wind events.

This paper describes the basic concepts associated with both the development of east winds and the forecasting of these events. Three types of east wind storms occur in Albuquerque and other local areas of the central Rio Grande valley: 1) gap or canyon winds, 2) spillover winds, and 3) wave induced winds. In the following sections, a brief description of each type of wind event, the associated synoptic patterns, and basic aspects of the forecasts are presented.

2. Gap Winds

In Albuquerque, the most common type of east wind is the “gap” wind, often referred to as a canyon wind. These are the usual mountain pass winds at Albuquerque and other locales near the westward extent of east-west gaps in the ridgeline of our central mountains. Wind speeds are generally strongest at the canyon mouths. For much of Albuquerque, the east “gap” winds result when the wind is channeled through Tijeras Canyon. Areas to the west of the canyon receive the strongest winds, while winds in other sections of the city remain light.

The gap winds form when surface pressure to the east of the Sandia and Manzano mountains is greater than the pressure to the west, and is often accompanied by a different air mass on either side of the central mountains. Fig. 2 illustrates the surface pressure pattern generally associated with gap winds, with a surface high centered over the Great Plains and lower surface pressures to the west. Note the east-to-west pressure gradient from the Texas panhandle to central New Mexico. This type of surface pressure pattern will result in surface winds with an easterly component across the eastern plains of New Mexico. An example of winds on either side of the Sandia/Manzano Mountains during a gap wind event is shown in Fig. 3. The topography is illustrated in 1000 foot increments. To the east of the mountains, or the dark orange/brown areas, Clines Corners (CQC) has a mean sea level pressure of 1016.7 mb and an east wind of 15 mph, while west of the mountains, and near the mouth of Tijeras canyon at the Albuquerque Airport (ABQ) the mean sea level pressure is 1014.1 mb, with winds out of the east at 20 mph with gusts to 30 mph. At the same time, light southeast winds less than 10 mph are observed on the west mesa (Double Eagle Airport, AEG).

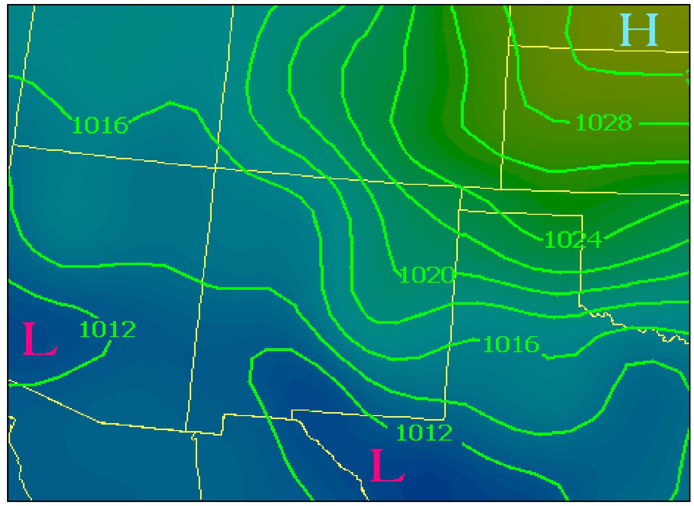

Figure 2. Surface pressure (mb) pattern associated with gap wind events.

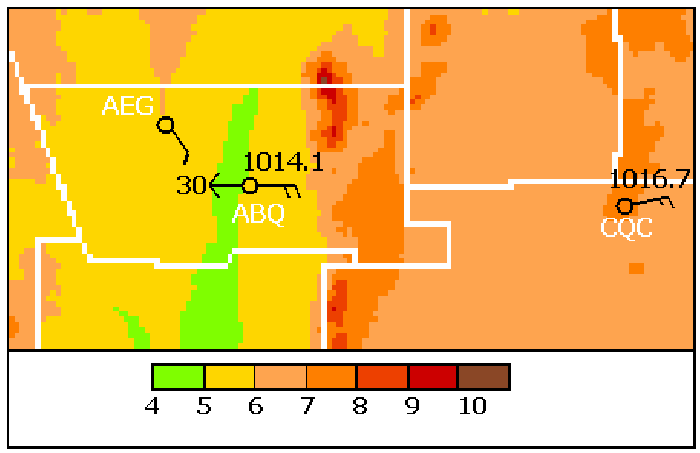

Figure 3. Observations from a gap wind event. Note the difference in wind speeds between Albuquerque (ABQ) and Clines Corners (CQC), and Double Eagle Airport (AEP). Elevation in thousand feet intervals is also depicted.

The east-to-west surface pressure gradients to support gap winds can develop at any time of the year; however, gap winds are more likely to develop in the spring, summer and autumn months and are less frequent in the winter months. The cold polar or arctic air masses that surge southward down the Great Plains behind cold fronts in winter are associated with very high surface pressures. The cold air, however, is quite dense which often results in a shallow airmass which may not attain a sufficient depth to break through the mountain canyons. The airmass to the east of the mountains must reach a depth greater than 7200 feet above sea level in order to break through the Tijeras Canyon and into Albuquerque. Therefore, in winter months very strong east-to-west pressure gradients may not result in strong east winds at Albuquerque if the cold airmass over the plains is too shallow.

Surface pressure gradients need not be strong for gap winds to develop during the warmer seasons. Most cold fronts sweeping down the plains are capable of producing gusty east winds at Albuquerque during spring, summer and autumn. In general, winds will be in the 15 to 30 mph range with a few events producing gusts to near 40 mph. Wind forecasts can be adjusted upward or downward depending upon whether the cold surge (and pressure gradient) behind the front is "weak" or "strong". During "weak" events the east winds will usually not develop during the day because the east wind layer (near the surface) will be mixed with winds aloft which are likely to be from a different direction. The east winds will more likely develop near or shortly after sundown as mixing with winds at higher altitudes diminishes and the air becomes more stratified. "Strong" events can break through at any time, but winds are frequently at their maximum during the nighttime hours. Typically, these events persist for 12 to 24 hours.

During the summer, convective clusters (thunderstorms) can result in strong east winds at Albuquerque. Thunderstorms can form or move east of the central mountains on days when the surface pressure gradients are neutral or even unfavorable for east wind development. These convective clusters can produce a small scale surface high pressure which is associated with the rain cooled air. The smaller scale "mesohigh" provides an east-to-west gradient (or enhances a weak gradient) which produces a gap wind in Albuquerque.

An example of a summer gap wind event is depicted in Figs. 4 through 7. During the afternoon of June 11, 1999 southwest winds gusting to near 25 mph were reported at Albuquerque from 1:00 to 4:00 pm MST (20 to 23Z). An upper air sounding (Fig 4), taken at 5:00 pm (00Z) shows southwest winds throughout the depth of the atmosphere. At the time of the sounding, convection was limited to extreme northeast New Mexico. Five hours later, convection covered much of the northeast quadrant of the state, as shown in Fig. 5. East winds near 20 mph and

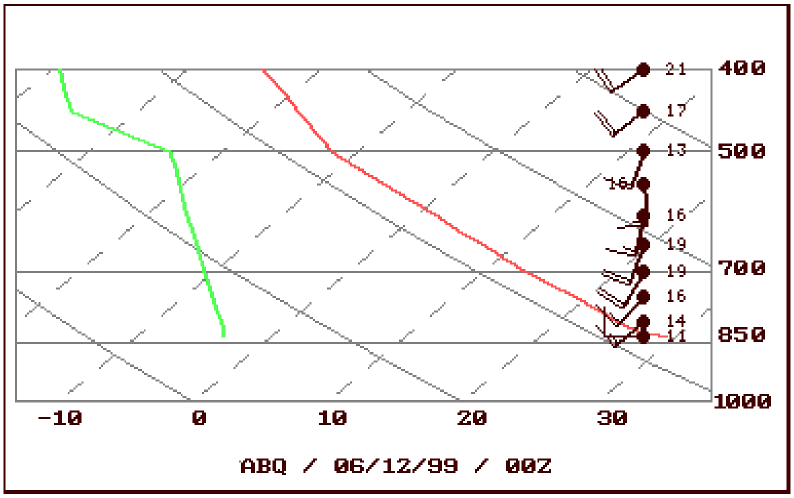

Figure 4. Sounding data (below 400mb) for Albuquerque on June 12, 1999 at 00Z.

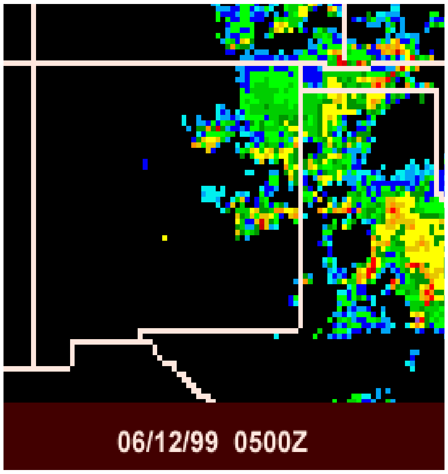

Figure 5. Radar reflectivity mosaic (from NCDC) on June 12, 1999 at 05Z.

gusting to 32 mph were reported from 11:00 pm to 6:00 am (06 to 13Z). The surface analysis from NCEP (National Centers for Environmental Prediction) for 06Z depicted the surface high and outflow boundaries generated by the convection. In Fig. 7, the 12Z sounding (5:00 a.m.) shows the east winds at Albuquerque, which are strongest near the surface, or through the "gap".

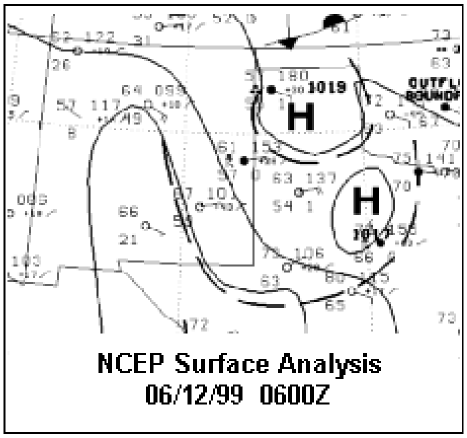

Figure 6. Surface analysis for June 12, 1999 at 0600Z.

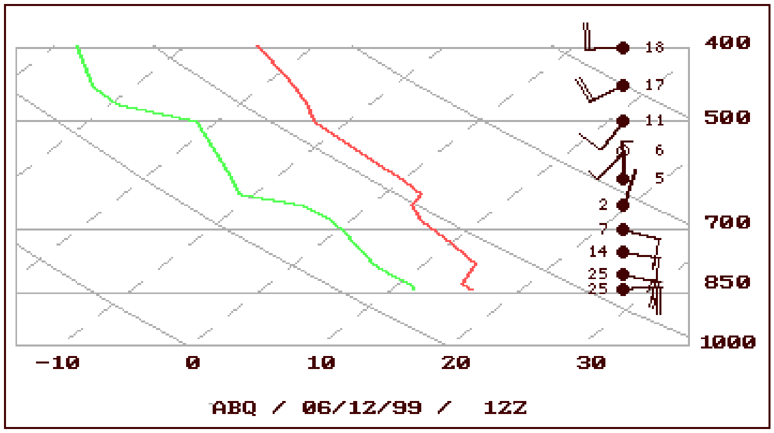

Figure 7. Sounding data (below 400 mb) for Albuquerque on June 12, 1999 at 12Z.

In general, these convective-driven east winds will also range from 15 to 30 mph with higher gusts, but can be even stronger if a "gust front" associated with the thunderstorms propagates westward through the canyon. These events are typically of short duration, ranging from a couple of hours up to around 12 hours. One byproduct of these late spring/early summer events is that the gap winds can transport moisture from the east plains to drier areas west of the mountains, consequently increasing the probability of precipitation in central New Mexico the following day.

During the late spring/early summer when moist air capable of supporting convection is present east of the central mountains but absent in the west, the convection-driven events can be forecast with some confidence. North to northwest steering level winds seem particularly good for moving the cells into a favorable position. Once into the "wet" season (July and August) when thunderstorms are as likely to occur west of the mountains as they are to the east, forecasting these event becomes more difficult. A forecaster may be reduced to forecasting "strong gusty winds near thunderstorms."

3. Spill Over Winds

The second type of east wind event is referred to as spill over winds. These wind events are frequently mistaken as canyon or gaps winds. Spill over winds occur when cold air to the east has a sufficient depth (approximately 10,000 ft about sea level) to "spill over" the Sandia and Manzano mountains, rather than being restricted to the passes and canyons. In these cases, east winds are more widespread and often stronger across Albuquerque and the central valley.

There are two patterns that can produce spill over wind storms. Very rarely (less than once in 10 years) a closed upper high and a strong surface high will form over the Great Basin and the central Rockies. The clockwise flow around the high pressure results in easterly flow at all levels across New Mexico, and easterly winds of 15 to 30 mph with higher gusts may develop in Albuquerque.

A more common scenario for spill over winds occurs when a closed upper low develops to the west of New Mexico (left panel, Fig. 8) while a surface high pressure airmass pushes southward over the Great Plains (right panel, Fig. 8) resulting in an east-to-west pressure gradient across New Mexico which is not restricted to the surface. Mountaintop level winds will become south-southwest to southeast. Winds may often reach 30 to 50 mph range with higher gusts in Albuquerque, and can result in considerable damage. The duration of these events can range from around 12 to as much as 48 hours.

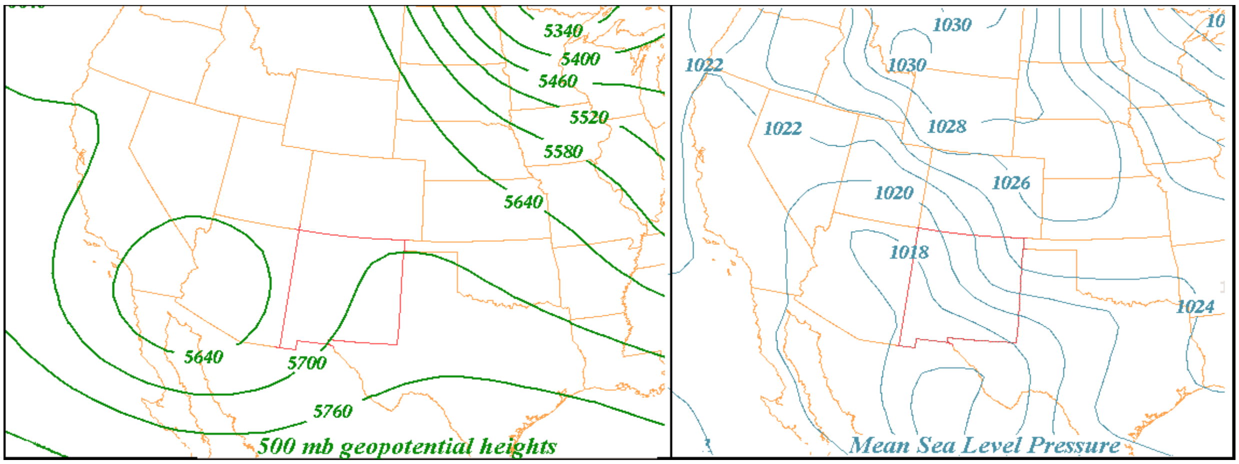

Figure 8. Synoptic pattern for spill over winds with 500 mb heights (left) and mean sea level pressure (right).

Figure 8 illustrates the 500mb and sea level pressure patterns associated with a spillover wind event on March 7-8, 2001. East winds were recorded at the Albuquerque airport for 25 consecutive hours. In addition to the brisk winds, rain showers, thunderstorms and snow above 6500 feet accompanied this storm. See the March 2001 weather highlights for more about this event.

Not coincidentally, this pattern often produces major winter storms over New Mexico with heavy snow, blowing and drifting snow, and extreme wind chills particularly along and near the east slopes of mountain ranges. In Albuquerque, any amount of snow can result in blizzard-like conditions, even with little snow accumulation. Typically, less snow falls in the Albuquerque metro area than in surrounding areas because of the downslope effects of the east winds. However, exceptions to the “reduced snow” effect in Albuquerque can and do occur in the following areas:

1. Near the mouth of Tijeras Canyon, where snow blowing out of the canyon can create severe icing and greatly reduced visibilities;
2. Near the foothills of the Sandia/Manzano mountains (east of Juan Tabo Blvd.), where occasionally snow is blown over the top of the mountains and deposited on the lee (west) side;
3. In some outlying parts of the metro area where east winds diminish, snow can reach the ground, rather than being blown horizontally.

Visible satellite images can illustrate the spatial variations observed in snowfall during east wind events. In Fig. 9, images from three winter storms during which spill over winds developed are shown. In the left panel, visible imagery following a snow storm on January 27-28, 2001 depicts fairly widespread snowfall with the Rio Grande valley, including Albuquerque, receiving two to six inches of snow during a 30 hour period of strong east winds. The middle panel is a visible image following the winter storm of January 16, 2001 and shows an interesting pattern in the snow accumulations. Two snow void regions are evident, one around Albuquerque and the other south of Ruidoso (KSRR). These "voids" in the snow cover occurred in areas where the local east winds had a downslope component, which acted to inhibit precipitation in this case. The third (right) panel is a visible satellite image taken during the winter storm of March 31, 2000. In this case mostly clouds rather than snow cover are shown, but snow is accumulating over the western and central mountains and the eastern plains. Note that nearly the entire length of the Rio Grande valley is both precipitation and cloud free.

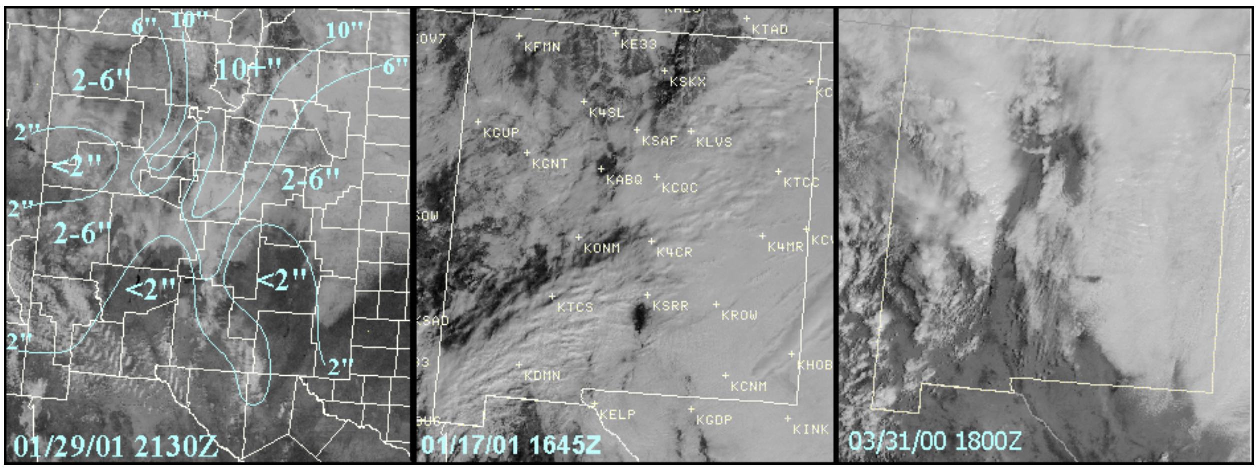

Figure 9. Visible satellite images during or following spill over wind events.

Forecasting winter spill over wind events involves examining pressure gradients and wind speeds near 700 mb and 500 mb (1500m and 3000m) and surface pressure gradients. Determination of the depth of the cold air to the east of the central mountains is an important component of the forecast, but can be difficult to determine. The length of an event similar to that depicted in Fig. 8 depends on the movement of the upper level low and the surface pressure pattern over the southern Great Plains. In general, once the upper level trough moves east of Albuquerque, or the surface high moves south or east of the Texas panhandle, the event is over.

3. Mountain Wave Induced Winds

Mountain wave induced winds are the third type of east wind event to affect the central Rio Grande valley. These events are actually a subset of the spill over winds, where exceptionally strong winds, at times with speeds greater than winds aloft, can reach the surface. Because of the wave-type structure of these events, the winds are rather erratic at the surface, bringing damaging winds to some areas while missing other areas.

Mountain wave induced wind events are more common on the east side of mountain ranges, where the wave is set up by more frequent strong westerly winds across a mountain range. For central New Mexico, wave induced winds occur when the upper low to the west is very strong, and far enough south that the winds aloft (1500 to 3000 m) over central New Mexico become southeast or easterly. Exceptionally strong winds can be transported to the surface.

Fortunately, these storms are relative infrequent but when they do occur they can cause severe damage and can be life-threatening. An example of a wave induced wind storm occurred on December 13-14, 1987. The pattern associated with this major event was similar to that shown in Fig. 8. On December 13 at 00Z, a surface low was developing over the southern AZ/NM border while a strong pressure gradient formed between west Texas and Albuquerque. At upper levels, a low pressure trough was positioned over the Great Plains. A major snow storm was developing in New Mexico. Unlike events in which the cold air is limited to eastern plains, the sounding for 12Z on December 13, 1987 (Fig. 10) indicates that cold air had moved over the entire state (note that the entire sounding is colder than 0 °C). The sounding also depicts low level east winds which had already been gusting to 45 mph at the airport. Over the next 12 hours, the upper level low increased in strength. Surface winds in Albuquerque with gusts between 50 and 70 mph were reported at the airport. Wind reports from around the Albuquerque metro area included a peak wind of 71 mph at the airport, 97 mph at the Sandia Tramway (base) and gusts between 80 and 90 mph at Coronado Airport.

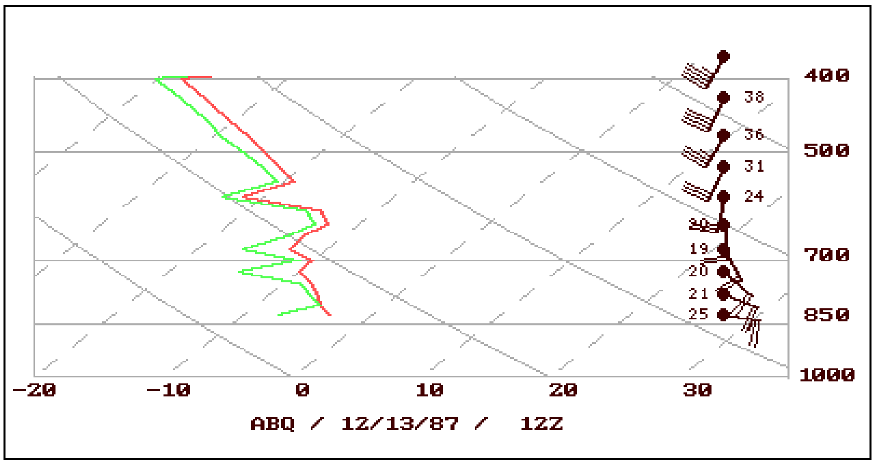

Figure 10. Sounding data (below 400 mb) for 12Z on December 13, 1987.

4. Summary

In this paper, three types of east wind events which affect the Albuquerque area were discussed. Topography has an important role in the formation of these storms. Many of the storms are well-documented because of the observation network at the Albuquerque airport. It is important to note that all three types of east wind events discussed here can and do occur in other sections of the state, but lack of data prevents documentation of the events in other areas.

For east wind events to occur in the Albuquerque areas, a low-level easterly wind pattern must first be established. Exaggerated wind speeds result near the western ends of the canyons in gap wind events. For spill over wind events, the easterly wind pattern must exist through a deeper layer, with the enhanced winds blowing across much of the Rio Grande Valley. The strongest, and rarest, events in Albuquerque occur when east winds across the central mountains result in a mountain wave.