East Wind Events at Double Eagle II Airport

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1. Introduction

East canyon wind events are notorious for their strength and sudden onset in New Mexico's Rio Grande Valley. Locations below canyons opening into the valley from the east commonly experience surface winds at speeds from 15 to 25 mph with gusts around 35 mph during east canyon wind events, and these gap winds can be much stronger depending on the strength of the surface pressure gradient and other factors. Along with their gusty nature, east canyon winds can significantly impact aviation operations in the Albuquerque area because of the turbulence and wind shear they produce within the lowest few thousand feet of the atmosphere. Their quick development also forces changes in runway usage at both the Albuquerque International Sunport (Sunport) and Albuquerque's Double Eagle II Airport (Double Eagle). Furthermore, east canyon winds can produce significant crosswinds on takeoff and landing at Double Eagle. Forecasters at the Albuquerque National Weather Service Forecast Office are knowledgeable on both the development and impact of east winds on the Sunport, but less is known about east winds at Double Eagle. Therefore, this study focused on understanding the development and impact of east canyon wind events on Double Eagle II Airport. To help weather forecasters, Double Eagle management, and pilots better anticipate east wind events and their impacts, this report quantifies and describes the effects of 14 east wind events on Double Eagle II Airport. The report begins by explaining the methodology used to obtain and analyze the data. Then, results are discussed and findings are summarized.

2. Methodology

This study examined hourly wind reports from 14 east canyon wind events in the Rio Grande Valley to better understand the development and impact of east canyon winds at Double Eagle II Airport. The period of study covered the period from 2002 through 2005. Hourly wind reports from the Double Eagle Automated Weather Observing System (AWOS) are archived starting in 2002 by the National Climatic Data Center (NCDC), while observations from the Sunport Automated Surface Observing Systme (ASOS) are available for a longer period. The short overlap limited the period of study. Because weather observations at the Sunport respond quickly to the development and demise of east canyon winds in the Rio Grande Valley, Sunport weather observations were obtained starting in 2002 to identify numerous east wind events for potential study. With around 34,000 hourly wind reports, the Sunport's data set was much larger than the hourly data set from Double Eagle, which only contained around 21,000 hourly wind reports. The much greater number of missing wind reports from the Double Eagle II AWOS was a significant limitation of this study.

East wind events were identified using hourly wind data available from both airports. First, Sunport observations of generally east winds (50^o – 130^o) with speeds greater than or equal to 15 m/s (29.2 kt) for at least one hour were considered. Surrounding observations were included until they trended below 9 m/s (17.5 kt) and/or their directions trended away from the generally easterly direction (i.e., out of the $50^o – 130^o$ range). The events for which Double Eagle also had data were included in the study. The number of events included in the study was increased by searching the Sunport data set for the top 34 east wind gusts within the range $50^o – 130^o$, and identifying other events with matching data at Double Eagle II Airport. Twelve east wind events for which data was available at both airports (including events with missing data) were originally selected for study. Two east wind events that occurred during June 2007 were later added to the list of events for study, even though the strength of the June 2007 events did not rank them among the top east wind events at the Sunport. Table 1 (below) lists the dates and hours of the 14 east wind events examined. (The number of events with matching data could possibly be doubled or tripled given time for further research, especially since data for 2006 and 2007 is now available).

East Wind Events Studied

03/16/02 01-17 UTC
03/22/02 00-06 UTC
04/03/02 00-13 UTC
01/06/03 22 UTC
11/12/03 20 UTC – 11/13/03 22 UTC
02/12/04 02-23 UTC
03/11/04 04-23 UTC
03/20/04 21 UTC – 03/21/04 13 UTC
04/03/04 19 UTC – 04/04/04 22 UTC
06/03/04 06-18 UTC
05/26/05 01-17 UTC
07/26/05 23 UTC – 07/27/05 19 UTC
06/27/07 04-10 UTC
06/28/07 04-11 UTC

Table 1. Dates and times of data that was analyzed for the 14 Rio Grande Valley east wind events.

Using observations from all 14 cases simultaneously, wind roses and wind gust roses were plotted for both airports (Fig. 1) with Lakes Environmental's WRPlot View (Version 5.3). A wind rose depicts the percentage of time that the wind blows from various directions and the percentage of time that the wind blows at certain ranges of speed. A wind gust rose depicts the same information using wind gust data. The wind roses and wind gust roses illustrated wind direction and wind speed tendencies for both airports during east wind events. Additionally, wind speed frequency distributions were plotted in bar graphs using Microsoft Excel (Fig. 3). These bar graphs further illustrated the tendencies of wind speed and wind gust strength at both airports during east wind events. Results are presented in the next section.

Finally, to better understand the impact of east wind events on aviation operations at Double Eagle II Airport, the crosswind component of the sustained wind and wind gusts on both of Double Eagle's runways for each hourly wind report used in the study was calculated. The crosswind component is the portion of the wind vector that is perpendicular to the runway. The frequency distributions of the crosswinds were plotted (Fig. 4) using Microsoft Excel to illustrate the strength of crosswinds on both runways.

3. Results and Discussion

In this section, wind direction and wind speed tendencies at Double Eagle II Airport during the 14 east canyon wind events are first described then compared to the better understood east wind tendencies of the Albuquerque International Sunport. Meteorological and physical reasons for these tendencies are also proposed. Additionally, crosswind data from the east wind events is documented to help aviators and forecasters better understand the impact of east wind events on Double Eagle operations. As an aid Fig. 1 displays wind roses and wind gust roses for Double Eagle II Airport and the Albuquerque International Sunport from the 14 east wind events, Fig. 3 displays the frequency distribution of wind speeds and wind gusts for both airports, and Fig. 4 displays the frequency distribution of crosswind components from the sustained wind and wind gusts for both of Double Eagle's runways.

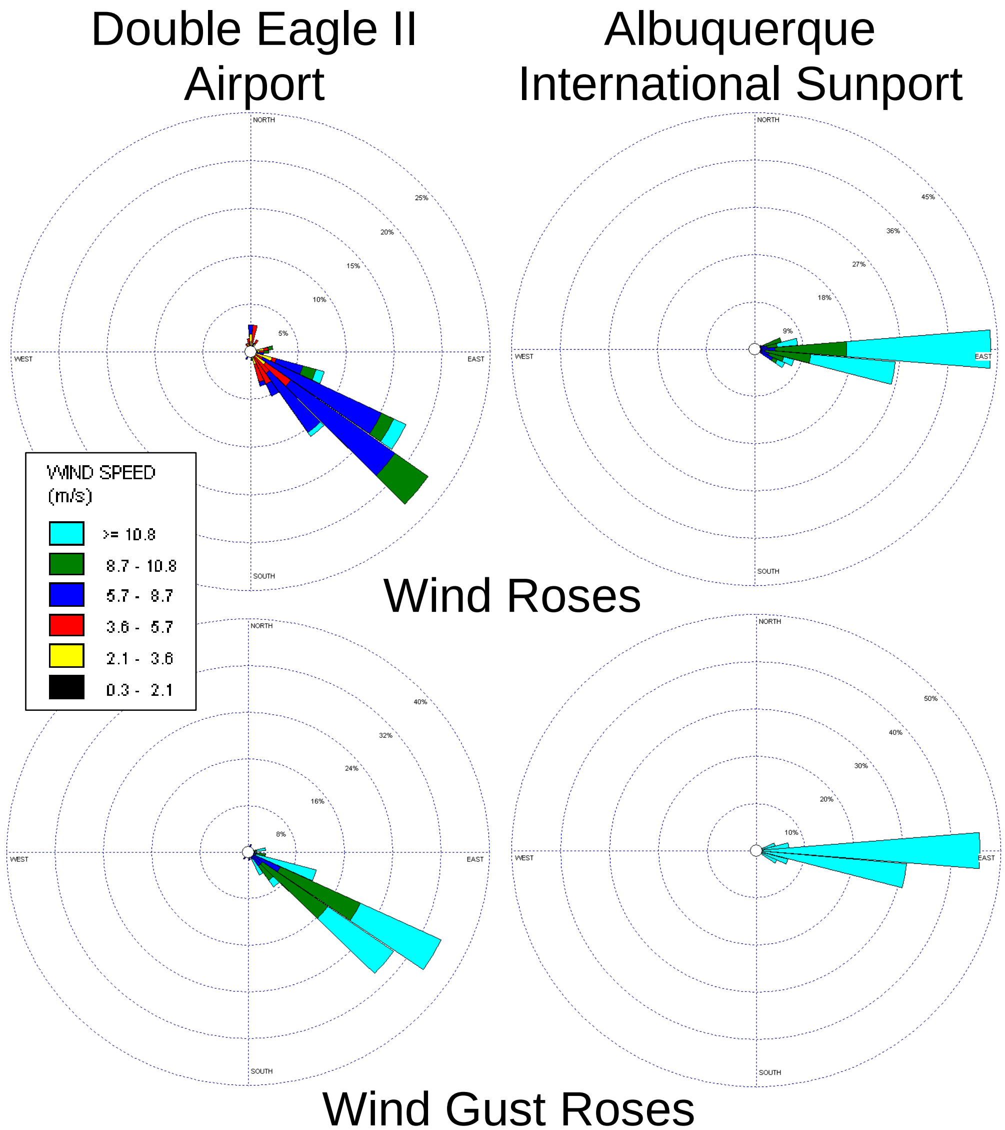


Figure 1. Wind roses (top) and wind gust roses (bottom) from Albuquerque's Double Eagle II Airport (left) and International Sunport (right) for the 14 east wind events studied.

a. Wind Direction Characteristics – Wind roses and wind gust roses for Double Eagle and the Sunport for the 14 east wind events are illustrated in Fig. 1. Wind direction data from these 14 east wind events indicates: (1) Winds blow primarily from the southeast at Double Eagle during east wind events, rather than the east direction at the Sunport. (2) Double Eagle wind direction also tends to be more variable than winds at the Albuquerque Sunport during east wind events. These wind direction and directional-variability differences between the two airports can be explained by differences in their distance and direction from Tijeras Canyon, and possibly also by the proximity of Double Eagle II Airport to the volcanoes and escarpment of the Petroglyph National Monument.

Tijeras Canyon, located about 23 miles southeast of Double Eagle II Airport and about 12 miles due east of the Albuquerque International Sunport, is the largest gap between the Sandia Mountains and the Manzano Mountains. Both the Sandias and Manzanos are north-south-oriented ranges reaching over 10,000 feet above mean sea level, and they form an effective barrier against most easterly winds impinging on Albuquerque and the Rio Grande Valley. Terrain drops approximately 1,200 feet from the entrance of Tijeras Canyon on the east slopes of the Sandia and Manzano Mountains to the exit of the canyon into the Rio Grande Valley west of the mountains. Acceleration due to the force of gravity adds to the impact of the pressure gradient force as cool and dense air flows westward through Tijeras Canyon, causing winds to flow into the valley faster than can be explained by the pressure gradient force alone during east wind events. More importantly, the funneling effect of forcing air through the narrow canyon significantly augments the strength of east winds. Double Eagle II Airport is located on the opposite side of the Rio Grande and Albuquerque from Tijeras Canyon, just west of an escarpment and a row of north-south-oriented volcanoes that form the Petroglyph National Monument. Since terrain rises at the escarpment and volcanoes, Double Eagle at an elevation of 5,837 feet overlooks Albuquerque. In contrast, the Albuquerque International Sunport is located in southeast Albuquerque, on the same side of the Rio Grande as Tijeras Canyon, at an elevation of 5,300 feet. Photo 1 in the Appendix shows Double Eagle II Airport in relation to the Sandia Mountains and Tijeras Canyon, as well as the Petroglyph National Monument. Photos 2 and 3 (also in the Appendix) show the volcanic cinder cones relative to Double Eagle II Airport from slightly different perspectives. Fig. 2 provides a topographic map of Tijeras Canyon, the Rio Grande Valley, and the eastern portion of the Petroglyph National Monument.

(1) Directional Tendency – Winds blow primarily from the southeast at Double Eagle during east wind events, rather than the east like the Sunport. The wind roses in Fig. 1 illustrate that prevailing winds blew from a southeasterly direction in 69.3% of the hourly wind reports during the 14 east wind events at Double Eagle. The bulk of the southeast winds fell in the 120^o–140^o range, which captured 51.4% of the hourly wind reports. Double Eagle's wind gust rose in Fig. 1 illustrates that wind gusts favored the southeast direction during the east wind events even more so, with 91.6% of hourly wind gusts coming from a southeasterly direction. The bulk of the southeast wind gusts fell in the 120^o–130^o range, which captured 65.2% of the hourly wind gust reports.

In contrast, Fig. 1 also shows that winds blew from a generally easterly direction in all of the hourly wind reports during the 14 east wind events at the Sunport. The bulk of the east winds fell in the 90^o–100^o range, which captured 69.7% of the hourly wind reports. The Sunport's wind gust roses depict that wind gusts similarly favored the 90^o–100^o range in 76.5% of the hourly observations.

The most compelling reason for Double Eagle's winds to blow predominantly from the southeast during Rio Grande Valley east wind events is because Tijeras Canyon is located southeast of Double Eagle. The amount that the Petroglyph National Monument's volcanoes and escarpment influence wind direction readings by Double Eagle's Automated Weather Observing System (AWOS) is uncertain. Following the naming convention established in Photo 1 in the Appendix, V_3 is the largest of the 5 volcanoes rising to an altitude of 6,033 feet, followed by V_4 at 5,986 feet and V_5 at 5,944 feet. Since the AWOS sits near 5,837 feet and is only a little over a mile east northeast of the largest volcano, it is possible that winds flowing around or between this and the other volcanoes may have some influence on wind direction. Both wind roses and wind gust roses in Fig. 1 depict the largest decrease in the number of hourly wind reports between any two adjacent directions occurring from 120^o to 110^o. Does volcano V_3 block the winds at 110^o, inhibiting their ability to reach the AWOS at that angle, and funneling them into the 120^o and 130^o radials? This would not only explain the sharp decrease in the number of wind readings from 120^o to 110^o, but also help to explain the large percentage of wind reports in the 120^o-130^o range and the spike of wind gusts at 120^o. However, a dense network of wind measurement equipment would need to be installed, or a computer model would need to be developed to simulate the airflow in order to verify this conclusion. Also worth considering and modeling would be the channeling that the escarpment could be producing as winds flow over it from a southeasterly direction (notice the southeast-to-northwest protrusions in the portion of the escarpment located southeast of the Double Eagle AWOS in Photo 1).

Likewise, the most compelling reason for the Sunport’s winds to blow predominantly from the east during Rio Grande Valley east wind events is because Tijeras Canyon is located due east of the Sunport. Examination of the topographic map in Fig. 2 (below) reveals that much of the canyon is oriented in a northeast to southwest direction, before it opens toward the west and southwest into the Rio Grande Valley. Since the flow is directed toward the west and southwest upon leaving the canyon, locations west and southwest of the canyon will tend to experience a stronger and more persistent east wind during east canyon wind events. Furthermore, the Sunport is almost twice as close to Tijeras Canyon than Double Eagle, so winds leaving the canyon have less time to spread or fan out in direction before reaching the Sunport’s Automated Surface Observing System (ASOS). Since Double Eagle is located northwest of Tijeras Canyon and out of the main stream of the low level east wind, east canyon winds need to spread in direction toward the northwest in order to reach Double Eagle. Spreading of the wind as it leaves the canyon not only helps to explain the wind direction tendency at both airports during east wind events, but also the variability of the wind direction, which will be explained next.

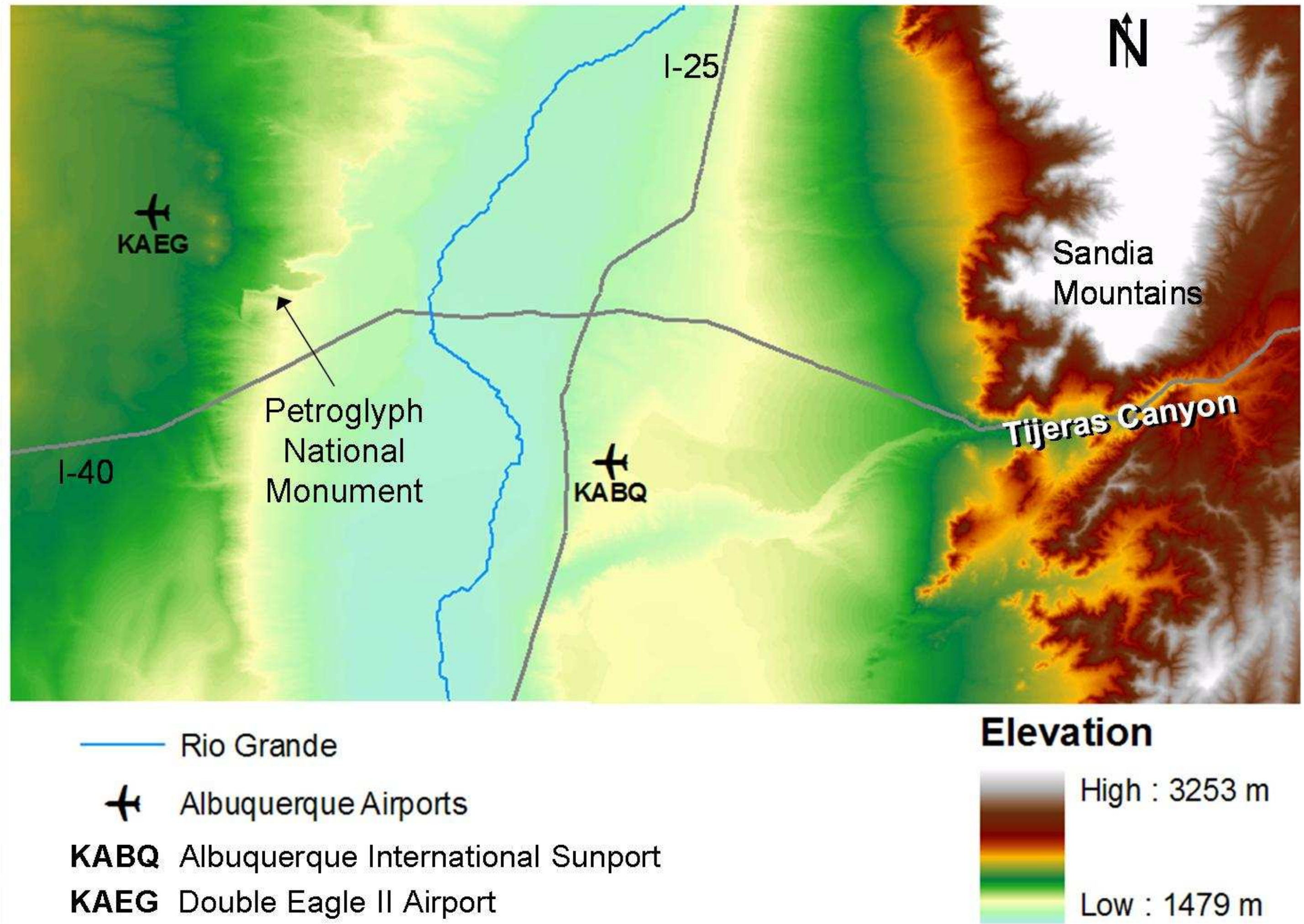


Figure 2. Topographic map of Tijeras Canyon, the Rio Grande Valley, and Albuquerque's two airports.

(2) Directional Variability – Double Eagle wind direction tends to be more variable than winds at the Albuquerque Sunport during east wind events. The wind roses in Fig. 1 indicate that prevailing winds blew from directions other than the most common southeast directions (120^o-140^o) in 41.1% of the hourly wind reports during the 14 east wind events at Double Eagle. Similarly, wind gust directions varied from the most common wind gust directions (120^o-130^o) in 35.5% of gusting hourly wind reports at Double Eagle. Conversely, winds at the Sunport blew from directions other than the most common easterly direction (90^o-100^o) in only 30.3% of the hourly wind reports during the east wind events. Wind gust directions at the Sunport varied from the most common wind gust directions (90^o-100^o) in only 22.8% of gusting hourly wind reports.

The greater variability of Double Eagle's wind direction and the greater persistence of the Sunport's wind direction during east canyon wind events are again related to the distance and direction of both airports from Tijeras Canyon. As the east canyon wind spreads from its low level core in order to reach Double Eagle, it tends to weaken and the direction becomes more variable due to frictional effects within the lowest levels of the atmosphere. Wind reports received by the National Weather Service from locations throughout Albuquerque during east canyon wind events consistently reflect this effect in weaker readings for locations further northwest of Tijeras Canyon. Additionally, friction influences the east wind more significantly as terrain rises west of the Rio Grande River, and especially over the Petroglyph National Monument in route to Double Eagle.

Upon closer inspection, the Double Eagle wind rose indicates that, aside from a generally southeast direction, the next favored direction for winds during Rio Grande Valley east wind events is from the north, with 11.1% of hourly wind readings from the 330^{o}-30^{o} range. Data from 2002 to 2006 indicates that Double Eagle tends to experiences a light north and north northwest wind late at night and into the early morning, as cooler and denser air settles from higher terrain further north into the Rio Grande Valley. During sufficiently weak and sporadic east wind events, there may be times when this drainage wind is strong enough to overpower the east wind influence at Double Eagle's range from Tijeras Canyon. During stronger east wind events, drainage winds are less likely to develop because the strong east winds keep the lower atmosphere too well mixed for pooling and settling of cooler air to develop. It is also possible that northerly winds can develop at Double Eagle during east wind events when east winds wash around the northern end of the Sandia Mountains into the Rio Grande Valley in a large eddy with a strong northerly component to the wind flow in the vicinity of Double Eagle[*]. A dense network of wind measurement equipment, and/or numerical modeling of flow around the Sandia Mountains, could confirm the significance of both these possibilities.

Additionally, there was a small percentage of time (11.6%) that the Double Eagle AWOS reported winds from directions other than generally northerly and generally southeasterly during the 14 events studied. This variability may have occurred at times when east canyon winds weakened enough to allow other influences, like outflow boundaries and smaller scale pressure gradients, to override east canyon wind strength at Double Eagle's range from Tijeras Canyon. We will discuss the strength of east canyon winds at Double Eagle Airport next.

*In private conversation with the author, pilots described encountering these eddies in the wake of the Sandia Mountains on both their northern and southern ends. This low level airflow pattern is associated with significant wind shear in the Rio Grande Valley during east wind events.

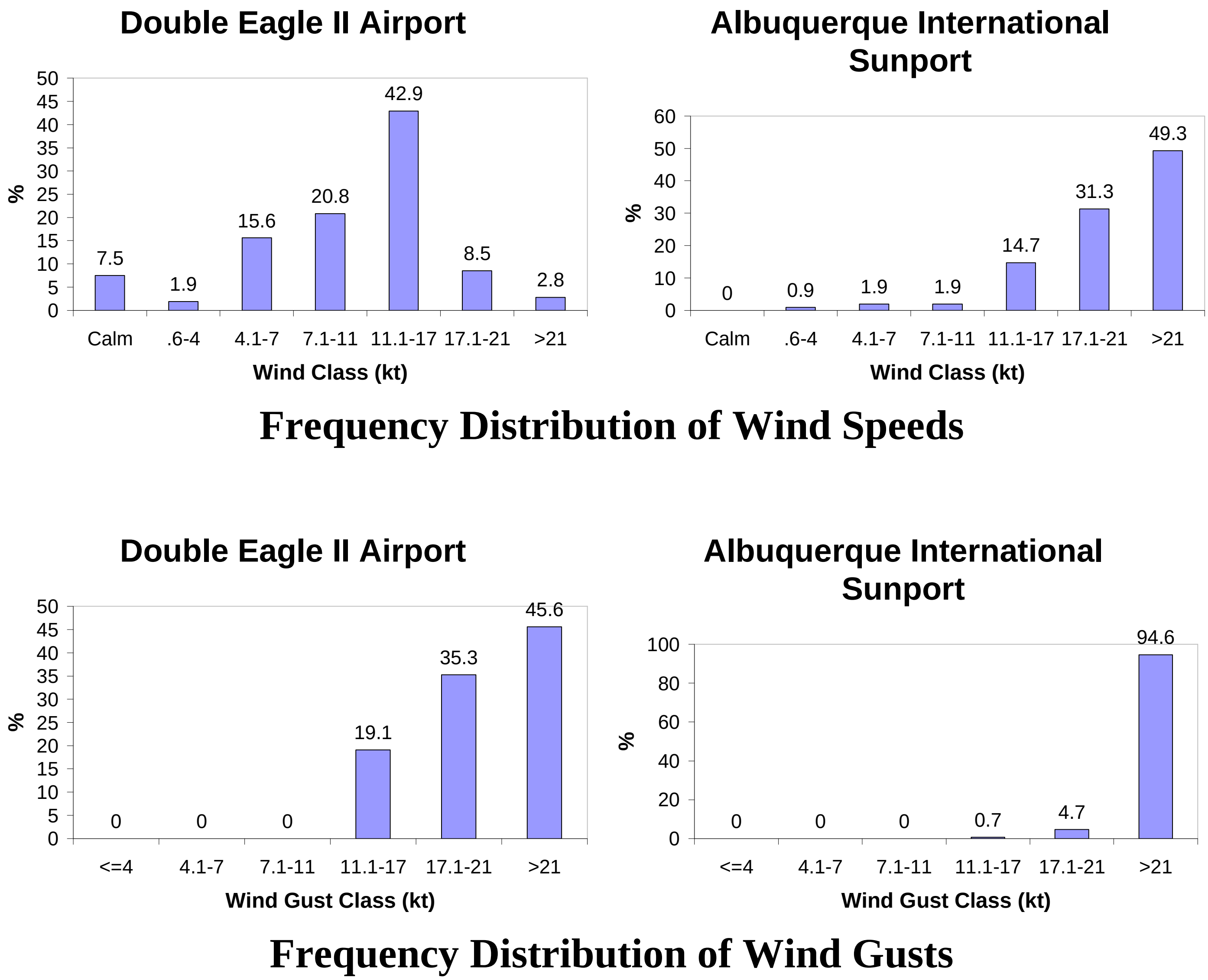


Figure 2. Frequency Distribution of wind speeds and wind gusts at Double Eagle II Airport and the Albuquerque International Sunport for the 14 Rio Grande Valley east wind events studied.

b. Wind Speed Characteristics – Wind speed data from these 14 east canyon wind events indicates that east winds tend to be much stronger, gustier, and more persistent at the Sunport than they are at Double Eagle. The wind class frequency distributions in Fig. 3 illustrate this most clearly, with 80.6% of the Sunport's hourly wind reports at or above 17.1 kt compared to only 11.3% at Double Eagle. At 42.9%, the 11.1-17.0 kt wind class was by far the most common wind class observed at Double Eagle. Double Eagle wind gusts reached the highest wind class (greater than 21 kt) in 45.6% of observations with gusts. Meanwhile, at 49.3%, the highest wind class was the most common wind class observed at the Sunport, and 94% of the Sunport's gusts reached the highest wind class. During the east wind events studied, 32% of the hourly wind readings from Double Eagle II Airport reported gusts, compared to 70% at the Sunport. Also noticeable in Figure 3 is the difference in the percentage of hourly wind reports with calm winds at Double Eagle (7.5%) compared to the Sunport (0%). The percentage of calm winds, frequency of gusts, and variability of wind directions at the two airports (discussed above) indicate that when they develop, east canyon winds are more persistent at the Sunport, and that they tend to be more sporadic at Double Eagle sometimes changing directions or briefly calming.

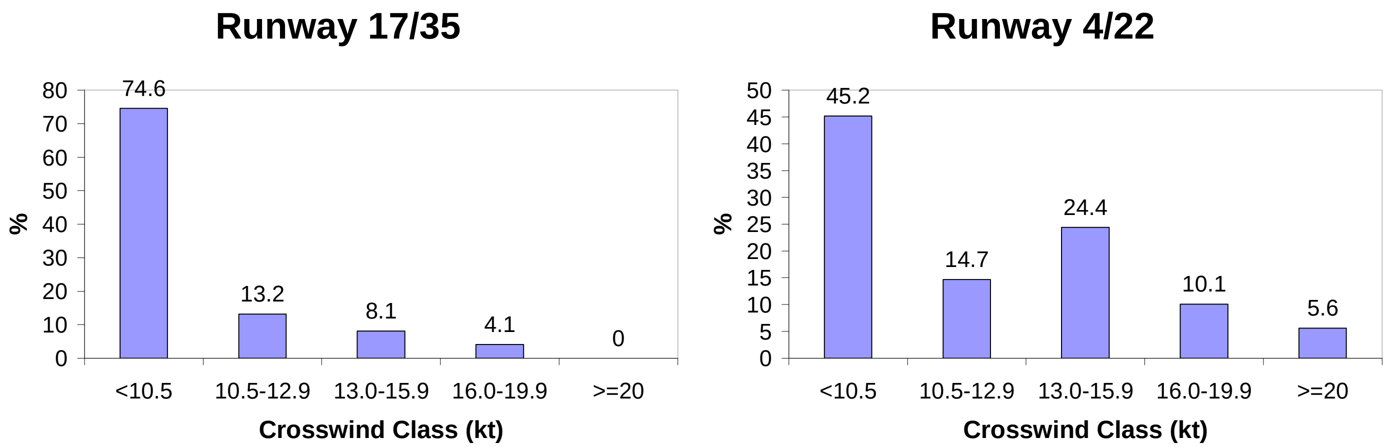
As explained previously, the main reason for the difference in the strength of east wind events and their persistence at the two airports is due to the fact that the Sunport is nearly twice as close to Tijeras Canyon as Double Eagle, and the Sunport is due west of the canyon while Double Eagle is northwest. The Sunport is in the main stream of the east wind at a distance where the wind is stronger. Winds encounter greater friction as they spread from the main stream in order to reach Double Eagle at a farther range. This friction causes wind strength to weaken and wind directions to vary more. At times when the east canyon wind weakens, winds at Double Eagle may become calm or even change direction due to other influences like outflow boundaries, drainage winds, or small scale pressure gradients.

Double Eagle may also have weaker winds during east wind events than the Sunport because the Sunport does not have obstructions to the east wind flow, like the volcanoes and escarpment of the Petroglyph National Monument. Pilots have reported that east and southeast winds produce updrafts with significant turbulence and wind shear along the volcanoes and the escarpment, especially on the approach end of Double Eagle's Runway 17/35. If these obstructions to the low level winds can impact airflow aloft, they should be able to influence the strength of the surface winds at the AWOS location, which is only a little over a mile northwest of the widest and tallest volcano (V_3 in Photos 1 and 2). Furthermore, aircraft approaching Runway 17/35 from the south cross the main stream of the east wind in the vicinity of Interstate 40 (I-40), which is due west of Tijeras Canyon at that range. Since this runway approach encounters stronger winds near I-40, one would expect greater turbulence and wind shear as the stronger wind rises over the escarpment. Again, a computer model or dense network of wind measurement equipment would be required to confirm and quantify the influence of the terrain on the wind speed and direction at Double Eagle.

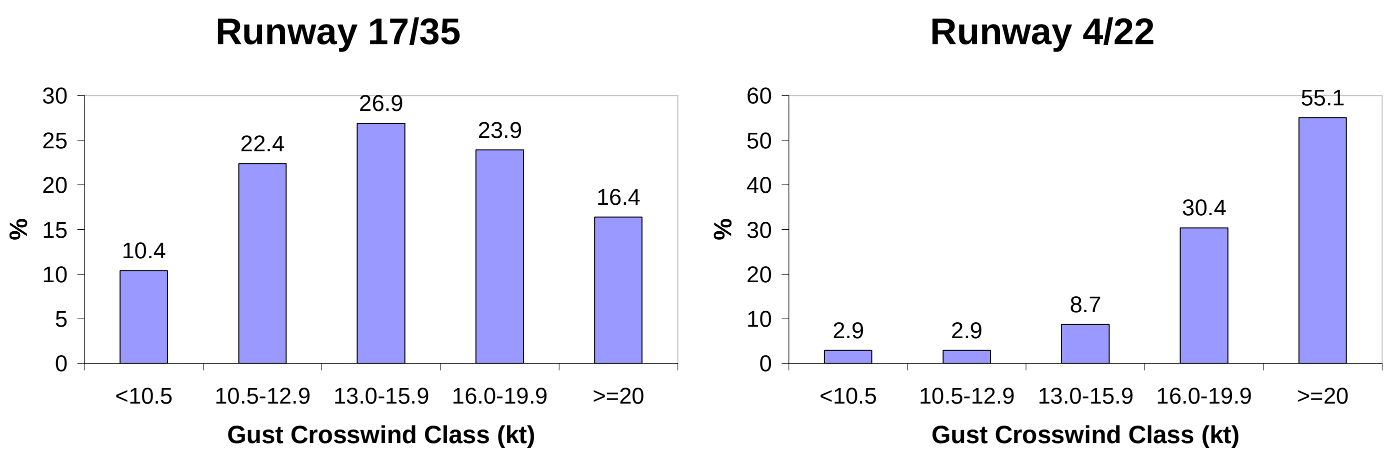
c. Crosswinds – According to the National Transportation Safety Board's accident database, 60.7% of the weather-related aircraft accidents that occurred in New Mexico between 1996 and 2006 were primarily attributed to strong and gusty winds or crosswinds. This is far more than any other weather hazard. Because crosswinds pose such a significant threat to aviation safety, this study also examined the occurrence of crosswinds at Double Eagle II Airport during the Rio Grande Valley east wind events. The Albuquerque International Sunport uses an east/west runway during east wind events, which mitigates the impact of crosswinds. However, this study found that Double Eagle's runway configuration can leave the airport susceptible to significant crosswinds during east wind events.

Fig. 4 (below) plots the frequency distribution of crosswind components for the sustained wind and wind gusts on Double Eagle's two runways: 17/35 and 4/22. Crosswinds generally have a greater impact on small aircraft, like those used at Double Eagle, than on large aircraft. Nearly all small general aviation aircraft can operate safely with crosswinds under 10.5 knots. With 74.6% of crosswinds under 10.5 knots, the data indicates that Runway

17/35 has the fewest crosswind problems during east wind events, compared to only 45.2% on Runway 4/22. Crosswind components over 10.5 knots can become problematic for small aircraft, and crosswinds over 20 knots are especially dangerous. Fortunately, during the 14 east wind events studied, crosswind components of the sustained wind did not exceed 20 knots on Runway 17/35. However, 16.4% of wind gusts had crosswind components greater than or equal to 20 knots on 17/35. Because of its perpendicular orientation to the southeast wind that develops at Double Eagle during Rio Grande Valley east wind events, Runway 4/22 faired significantly worse, with 5.6% of sustained winds bearing crosswind components greater than or equal to 20 knots and over 55% of wind gusts exceeding that threshold. For this reason, aviators have indicated they prefer to use Runway 17/35 during east wind events. However, as mentioned previously, using Runway 17/35 during east wind events exposes aircraft more directly to wind shear and turbulence as east winds rise over the escarpment and volcanoes of the Petroglyph National Monument.



Frequency Distribution of Sustained Crosswinds



Frequency Distribution of Crosswinds due to Wind Gusts

Figure 3. Frequency distribution of crosswind components plotted by class (top) for the two runways at Double Eagle II Airport, from the 14 Rio Grande Valley east wind events studied. The frequency distribution of wind gust crosswind components is also plotted (bottom).

4. Summary

In this study, wind reports from 14 east canyon wind events in the Rio Grande Valley were analyzed to better understand the development and impact of east canyon winds at Double Eagle II Airport. The data revealed that east canyon winds blow from a southeasterly direction at Double Eagle (120^o-140^o), rather than an easterly direction like the Albuquerque International Sunport (90^o-100^o). Double Eagle winds also tend to be weaker, less gusty, and more variable than winds at the Sunport during east wind events, sometimes changing to another direction or becoming calm. The data also showed that significant crosswinds can develop during Rio

Grande Valley east wind events at Double Eagle II Airport. Because of their tendency to gust out of the southeast at this airport, Rio Grande Valley east wind events have a greater impact on Runway 4/22 than on Runway 17/35. Using Runway 17/35 will help pilots minimize the impact of crosswinds during east wind events; however, users of this runway must also deal with greater wind shear and turbulence on approach and landing because it is located very closely along the escarpment and volcanoes of the Petroglyph National Monument (see Photo 1).

There are many reasons why east canyon wind events impact Double Eagle II Airport differently than the Albuquerque International Suport. Some of the more important reasons discussed in this report include: (1) Double Eagle is almost twice as far from Tijeras Canyon as the Sunport, enabling frictional effects to more strongly influence Double Eagle's winds. (2) Unlike the Sunport, Double Eagle is not located directly in the main flow of the low level east wind exiting Tijeras Canyon, and instead is impacted by an east canyon wind that spreads in a northwesterly direction prior to reaching the airport. (3) The volcanoes and escarpment of the Petroglyph National Monument lie between Double Eagle and Tijeras Canyon, and probably block and channel the east canyon wind to some extent before reaching the Double Eagle AWOS.

There appears to be too much missing data in the historical record of Double Eagle II Airport weather observations to determine accurately the percentage of east wind events that have a significant impact on Double Eagle; however, this information could possibly be surmised by studying the frequency of east wind events that occur at the Albuquerque International Sunport. This approach would require an understanding of how strong east winds need to be at the Sunport in order for them to reach operationally significant levels at Double Eagle, which this study did not attempt to determine. Future studies of east wind events at Double Eagle could double or triple the number of cases examined in this study by considering events with weaker east winds than considered here, and by including data from years after 2005. The archive of reliable Double Eagle II weather observations dates back to 2002.

5. References

a. Benchmark Maps, 2006: *New Mexico Road and Recreation Atlas*, Fifth Edition. Benchmark Maps, pp. 88-89.

b. Hoe, G., 2007: e-mail consultation.

c. McVinnie, D., 2007: e-mail consultation.

d. Slad, G. W., 2007: e-mail consultation.

e. Telfair, D., 2007: phone and e-mail consultations.

Appendix. Photos of Double Eagle Airport.

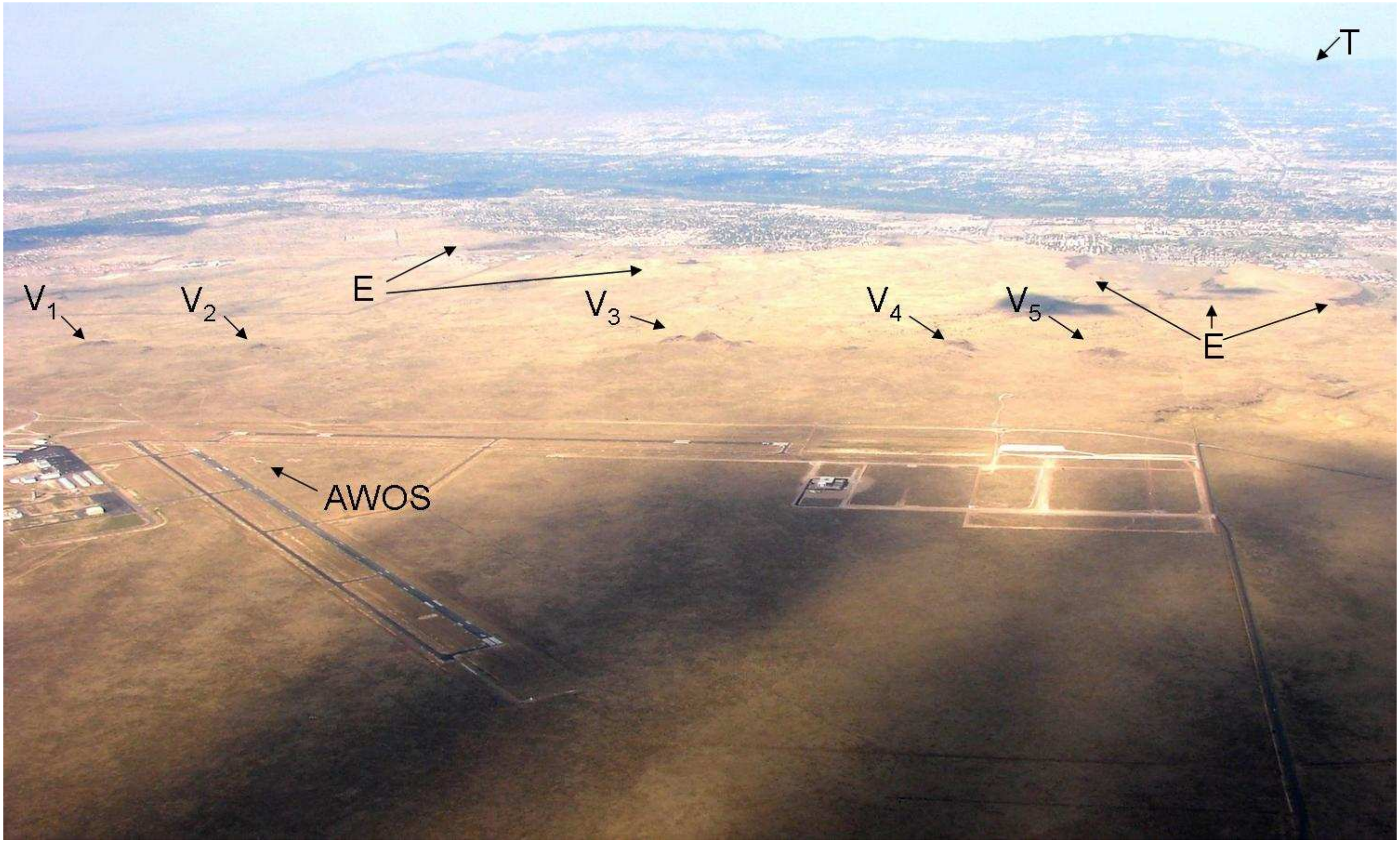


Photo 1. View of Double Eagle II Airport looking toward the east and northeast with the Rio Grande, Albuquerque and Sandia Mountains in the background. Note the location of the AWOS with respect to the volcanoes (V1 – V5) and the escarpment (E) of the Petroglyph National Monument. T points to Tijeras Canyon. Not shown are the Manzano Mountains south of Tijeras Canyon, and the Albuquerque International Sunport on the southeast end of Albuquerque. Photo taken in August 2007, courtesy of Gary Hoe.

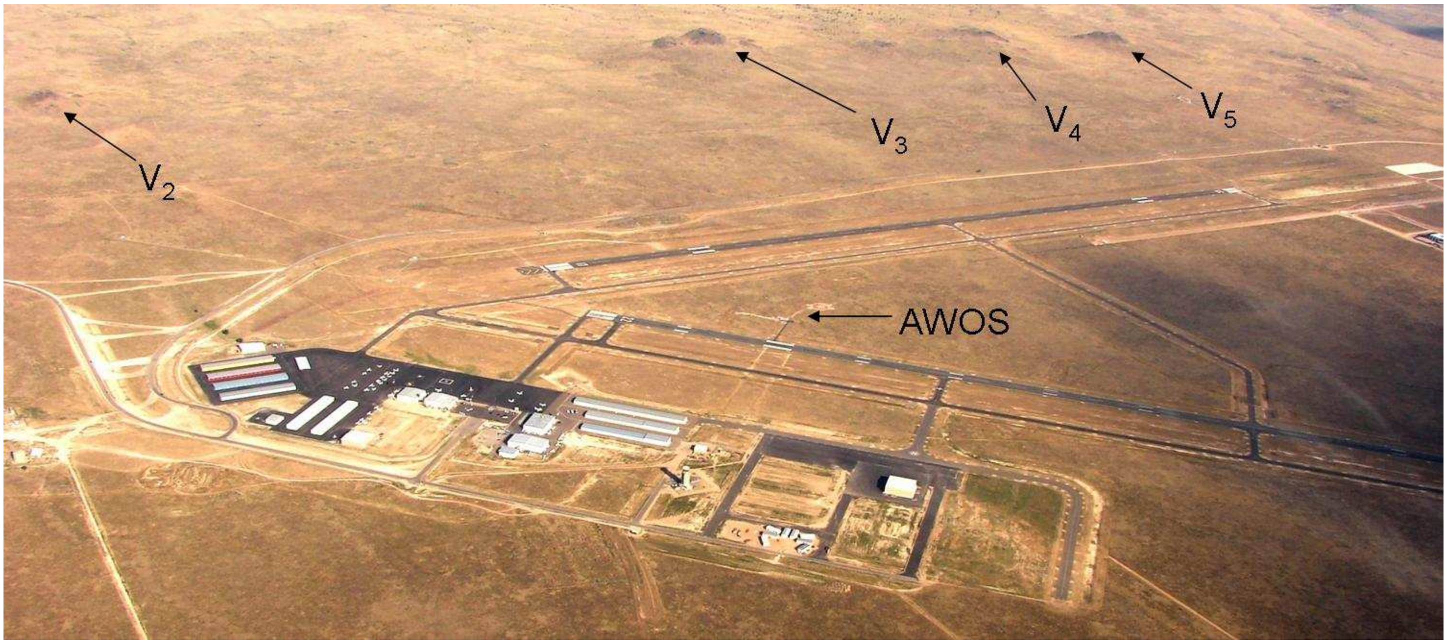


Photo 2. View of Double Eagle II Airport looking toward the Southeast. The southern four volcanoes referenced in Photo 1 are also evident. Photo taken in August 2007, courtesy of Gary Hoe.

Photo 3. View of Double Eagle II Airport and the northern three volcanoes looking toward the north and northeast. Photo taken in August 2007, courtesy of Gary Hoe.