IC4.3: The Effect of Elevation, Wind Direction, and Time of Year on Temperatures at Three Airports in West Texas

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Introduction: A common misconception about west Texas is that the entire area is flat and essentially without topographical features. However, in our CWA we have elevation differences in a few populated areas which impact daily weather. While climatology data provides a general picture of temperature differences, this report uses weather data from October 2010 through September 2011 and takes a brief look into the temperature differences of Midland, Marfa, and Pecos based on elevation, wind direction, and time of year. The weather data is taken from the Midland International Airport (MAF), the Pecos Municipal Airport (PEQ), and the Marfa Municipal Airport (MRF). MAF has an elevation of 2,890 feet. PEQ has an elevation of 2,580 feet and is located roughly 85 miles southwest of MAF. MRF has an elevation of 4,810 feet and is located about 150 miles southwest of MAF (Fig. 1).

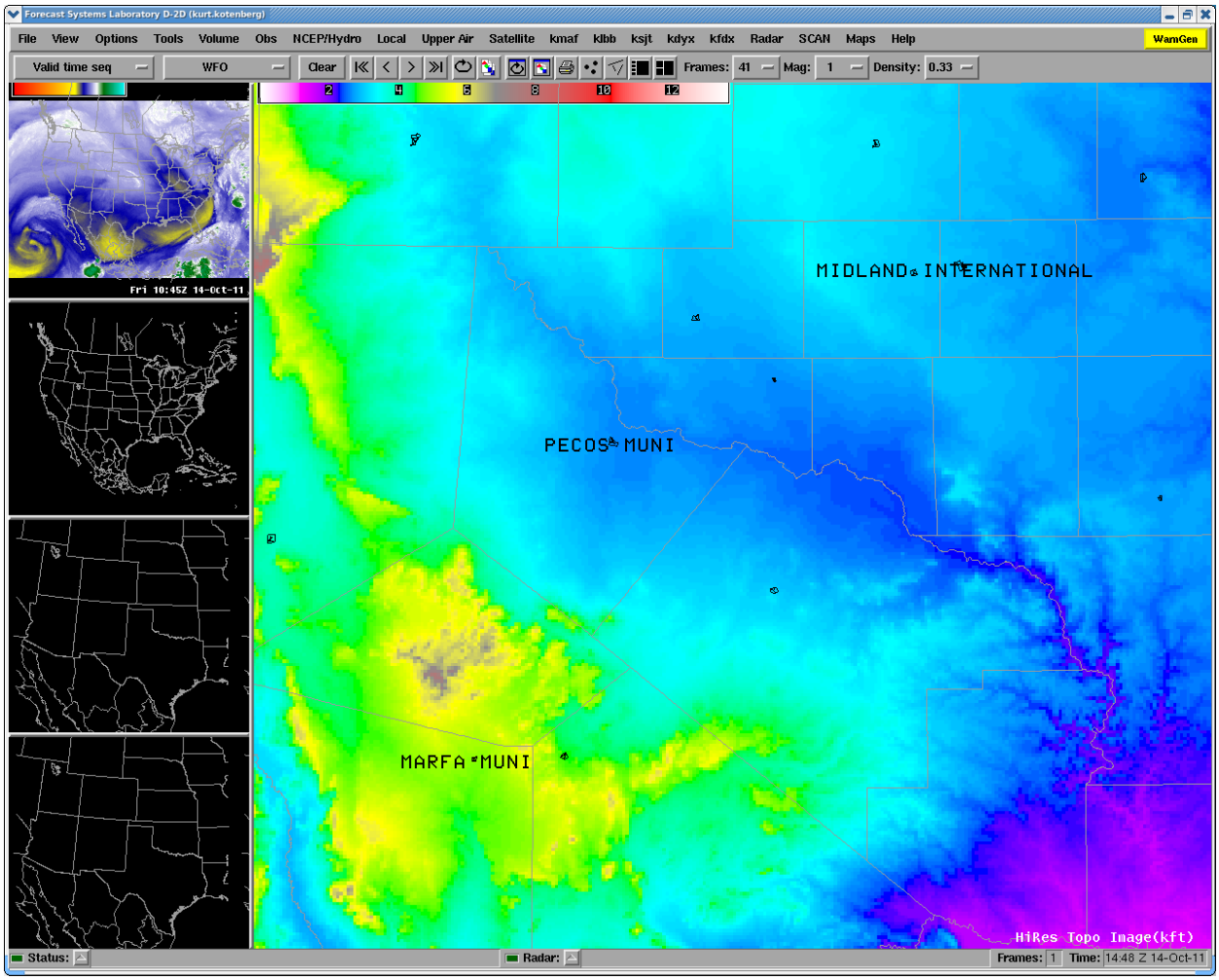

Figure 1. *A topographic image which includes Midland International Airport, Pecos Municipal Airport, and Marfa Municipal Airport*

Methodology: Daily high and low temperatures, the average wind direction and speed, and precipitation were taken for all three airports. The daily weather reports were broken down by days with precipitation and days with no precipitation. The days with precipitation were discarded since too many variables would be introduced into the temperatures for the purpose of this exercise. Wind directions were broken into four groups based on the four cardinal directions; group 1 had wind directions ranging from 1 to 90 degrees, group 2 had 91-180 degrees, group 3 had 181-270 degrees, and the last group had 271-360 degrees. The differences of the high and low temperatures between MAF and MRF were charted and placed into the appropriate group based on the average wind direction for each day. The same comparison was done for MAF and PEQ. Both sets of data were then separated and averaged by month.

Results: In total for the past 12 months, MRF has a high temperature that has averaged 3.8˚F cooler than the MAF, and a low temperature that has averaged 9.4˚F cooler than MAF. For the same time frame, PEQ has had a high temperature that has averaged 4.7˚F warmer than MAF, and a low temperature that has averaged 0.5˚F warmer than MAF. The results are presented below separately for each airport's temperature comparison to MAF, and broken down by wind direction and time of year.

Wind Direction- MRF: There is a notable difference for both high and low temperatures when the temperatures for MRF are compared to MAF, based on wind direction.

When the winds were from the north (271˚-90˚), the high temperature for MRF averaged 3.0˚F cooler than MAF, and the low temperature averaged 7.6˚F cooler than MAF.

When the winds were from the south (91˚-270˚), the high temperature for MRF averaged 4.7˚F cooler than MAF, and the low temperature averaged 11.4˚F cooler than MAF.

When the winds were from the east (1˚-180˚), the high temperature for MRF averaged 2.6˚F cooler than MAF, and the low temperature averaged 8.8˚F cooler than MAF.

When the winds were from the west (181˚-360˚), the high temperature for MRF averaged 5.0˚F cooler than MAF, and the low temperature averaged 10.0˚F cooler than MAF.

Recall MRF has a high temperature that averaged 3.8˚F cooler than the MAF, and a low temperature that averaged 9.4˚F cooler than MAF overall. From October 2010 to September 2011, when the winds were from the north and east, MRF was warmer than usual when compared to MAF. When the winds were from the south and especially the west, MRF was cooler than it usually is when compared to MAF.

Wind Direction- PEQ: During the past 12 months, PEQ has had a high temperature that has averaged 4.6˚F warmer than MAF, and a low temperature that has averaged 0.5 ˚F warmer than MAF. Wind direction still seems to have a slight influence on temperature differences when PEQ is compared to MAF; however these temperature differences are not as significant as the temperature differences of MRF versus MAF.

When the winds were from the north (271˚-90˚), the high temperature for PEQ averaged 4.6˚F warmer than MAF, and the low temperature averaged 1.4˚F warmer than MAF.

When the winds were from the south (91˚-270˚), the high temperature for PEQ averaged 4.7˚F warmer than MAF, and the low temperature averaged 0.5˚F cooler than MAF.

When the winds were from the east (1˚-180˚), the high temperature for PEQ averaged 5.3˚F warmer than MAF, and the low temperature averaged 0.5˚F warmer than MAF.

When the winds were from the west (181˚-360˚), the high temperature for PEQ averaged 3.9˚F warmer than MAF, and the low temperature averaged 0.3˚F warmer than MAF.

Time of year- MRF: There is a notable difference for both high and low temperatures when MRF is compared to MAF based on time of year. The temperatures, especially low temperatures, in the summer were much cooler than MAF, whereas MRF's temperatures in the winter months were not as much cooler than MAF as usual. When looking into temperature differences based upon time of year, it surely must be noted that the data for this exercise is comprised of only one year's worth of data. Further research would be recommended to ensure greater accuracy.

In December-January-February the high temperature for MRF averaged 1.2˚F cooler than MAF, and the low temperature averaged 7.4˚F cooler than MAF.

In March-April-May the high temperature for MRF averaged 3.2˚F cooler than MAF, and the low temperature averaged 9.7˚F cooler than MAF.

In June-July-August the high temperature for MRF averaged 6.5˚F cooler than MAF, and the low temperature averaged 13.2˚F cooler than MAF.

In September-October-November, the high temperature for MRF averaged 4.6˚F cooler than MAF, and the low temperature averaged 7.5˚F cooler than MAF.

Time of year- PEQ: As a recall, PEQ has had a high temperature that has averaged 4.6˚F warmer than MAF, and a low temperature that has averaged 0.5 ˚F warmer than MAF. There is a slight difference for both high and low temperatures of PEQ compared to MAF based on time of year. As with wind direction, the temperature differences are not as pronounced for PEQ as they are for MRF when both locations are compared to MAF. The most noteworthy temperature difference compared to normal of PEQ versus MAF is the low temperature in the winter months, which is warmer than usual. Also, the low temperature for the summer and falls months seems to be ever so slightly cooler in PEQ than MAF.

In December-January-February the high temperature for PEQ averaged 5.0˚F warmer than MAF, and the low temperature averaged 2.0˚F warmer than MAF.

In March-April-May the high temperature for PEQ averaged 5.0˚F warmer than MAF, and the low temperature averaged 0.3˚F warmer than MAF.

In June-July-August the high temperature for PEQ averaged 4.4˚F warmer than MAF, and the low temperature averaged 0.1˚F cooler than MAF.

In September-October-November, the high temperature for PEQ averaged 4.3˚F warmer than MAF, and the low temperature averaged 0.2˚F cooler than MAF.

Conclusion: It seems both wind direction and time of year, along with elevation, are factors in generating a temperature difference between Midland International Airport, Pecos Municipal Airport, and Marfa Municipal Airport.

MRF is typically almost 4˚F cooler in the daytime and almost 10˚F cooler at night than MAF. MRF is at its coolest, compared to MAF, when winds are from the south (and west) during the summer. Conversely, MRF is at its "warmest", compared to MAF, when winds are from the east (and north) during the winter. MRF has an elevation of 4,810 feet and MAF has an elevation of 2,890 feet, which explains much of the overall difference of temperature between the two locations. Looking into the data, seasonal differences of temperatures had a greater impact than wind directional differences for the 12 months of data that was evaluated. Precipitation occurrence, obviously accompanied by cloud cover, may also have led to temperature differences during the summer afternoons in MRF versus MAF. Days with overcast skies but no precipitation were still counted in the data. MRF had 12 days of precipitation during the summer months, whereas MAF had only 6. The precipitation was generally "daytime heating" based, so clouds that were present during the day would typically dissipate by nightfall. Study of more years of data would be helpful here.

PEQ is typically almost 5˚F warmer in the daytime and 0.5˚F warmer at night than MAF. The difference in temperature variation based on wind speeds and time of year is not as pronounced for PEQ as it is MRF. PEQ is a little bit warmer (especially in the morning) than usual, compared to MAF, when winds are from the north during the winter. Conversely, PEQ is at its "coolest" compared to MAF, when winds are from the south and west during the summer. PEQ is generally warmer than MAF because of its lower elevation of 2,580 feet. Since PEQ is lower in elevation than MAF, the weight of the air above PEQ is greater. The air is also more compressed, and subsequently warmer. For PEQ, it seemed wind direction had a bigger impact on temperature differences than time of year, with the exception of winter morning temperatures, where temperatures were warmer than usual when compared to MAF. To the east-southeast of PEQ is roughly 90 miles of gently decreasing terrain. To the west of PEQ is gently increasing terrain for 50 miles. When wind speeds are from the north, they are typically post-frontal and bring with it cold air advection and inhibit the strong morning inversion typical over this area. Analyzing a post-frontal (cold) sounding, since MAF is higher in terrain, without the inversion, MAF will be cooler than usual when compared to PEQ.

Future work: As suggested above, it would most obviously be beneficial to these results if data from more previous years were incorporated with the October 2010- September 2011 data. Additionally, this was a very strong La Nina year. It would be interesting to see if my findings would vary significantly during a strong El Nino year. In an El Nino year, there would be more rainfall events and cooler temperatures overall in west Texas. Based on the "eyeball test", it didn't seem wind speed had an impact on temperatures, but with more data and time, it would be nice to look into how wind speed impacts the temperature differences for each of the airports as well.