Amarillo's Average Wind Speeds: A 21-Year Study

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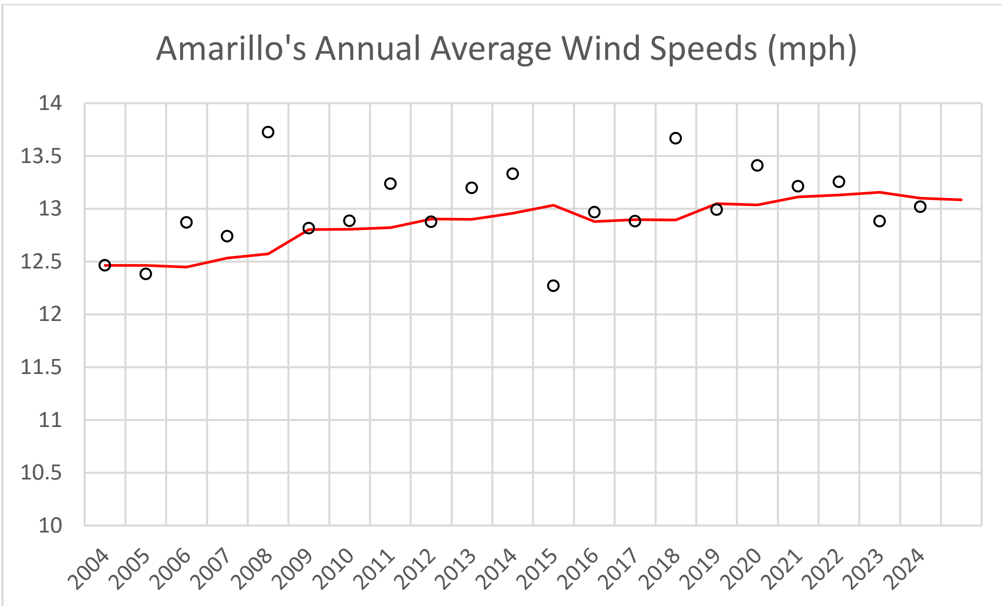
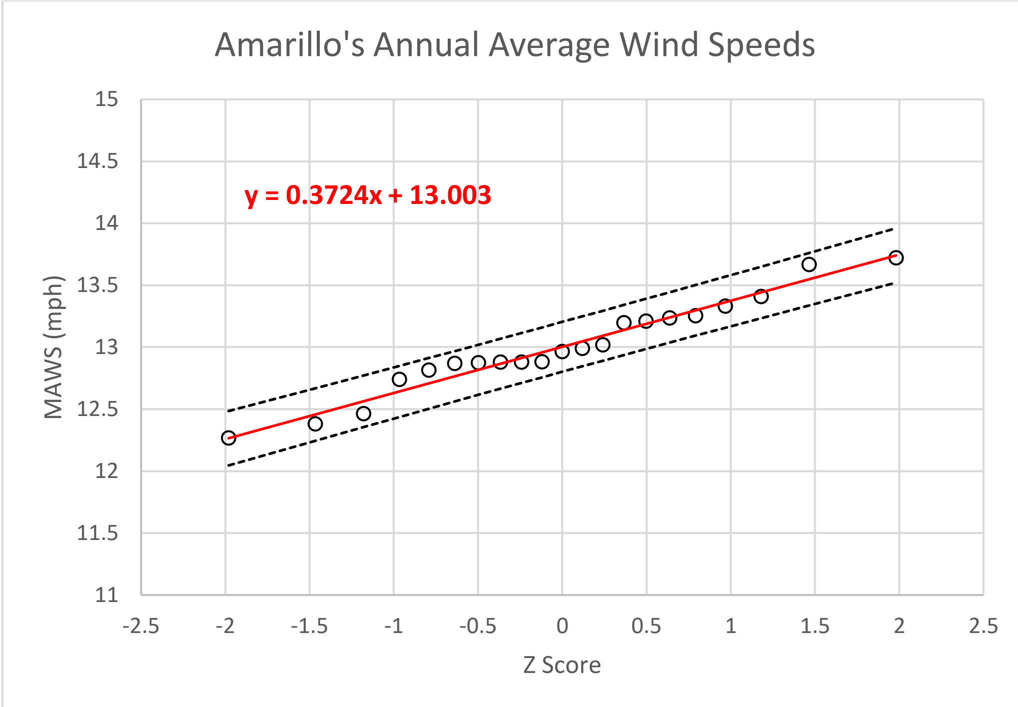
Amarillo's local weather station reports a daily average wind speed. I've looked at these data dating back to January 1, 2004. The calmest day was September 4, 2006, with an average speed of 2.5 mph. The windiest day was December 27, 2015, with an average speed of 34.5 mph.

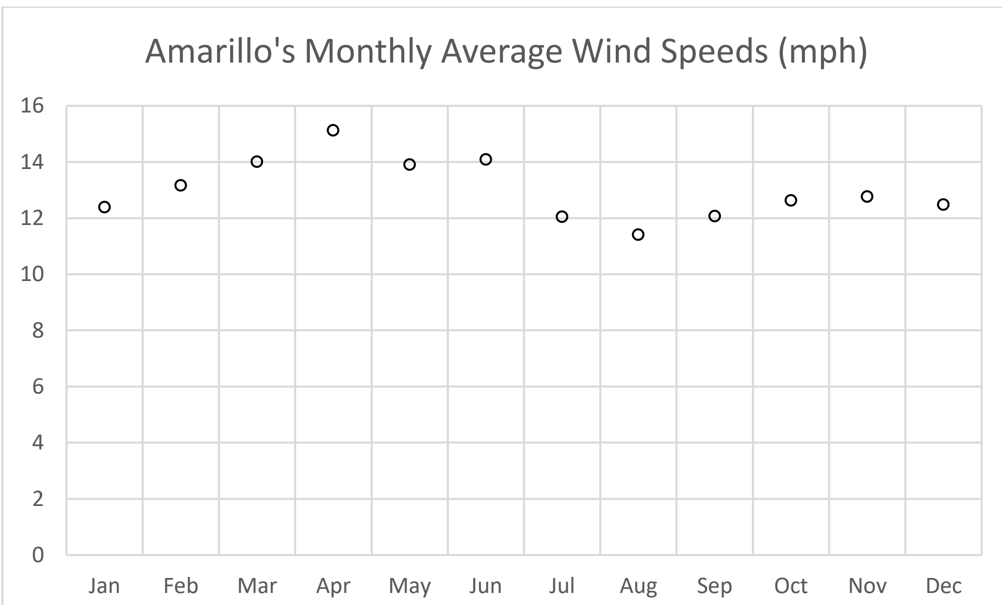
This graph shows the annual average wind speeds for the period of interest.



There is no apparent trend in these data, and the following graph shows that the annual average wind speeds are normally distributed with μ = 13.003 mph and σ = 0.3724 mph.



This graph shows the monthly average wind speeds for the period of interest.



April is our windiest month, while August is the calmest. But it's windy in Amarillo all year.

The next step was to look at the cumulative distribution of daily average wind speeds and determine a mathematical model. The bins used for the distribution ranged from 2 mph to 35 mph, in increments of 1.0 mph. Then the cumulative frequencies were converted to quantiles using Hazen's formula,

$$q_i = \left(\frac{cf_i - \frac{1}{2}}{n} \right)$$

where q_i is the i[th] quantile, cf_i is the i[th] cumulative frequency, i ranges from 1 to the number of bins, and n is the number of data points. A plot was then made with the quantiles on the y-axis and the wind speeds on the x-axis, as shown in Figure 1.

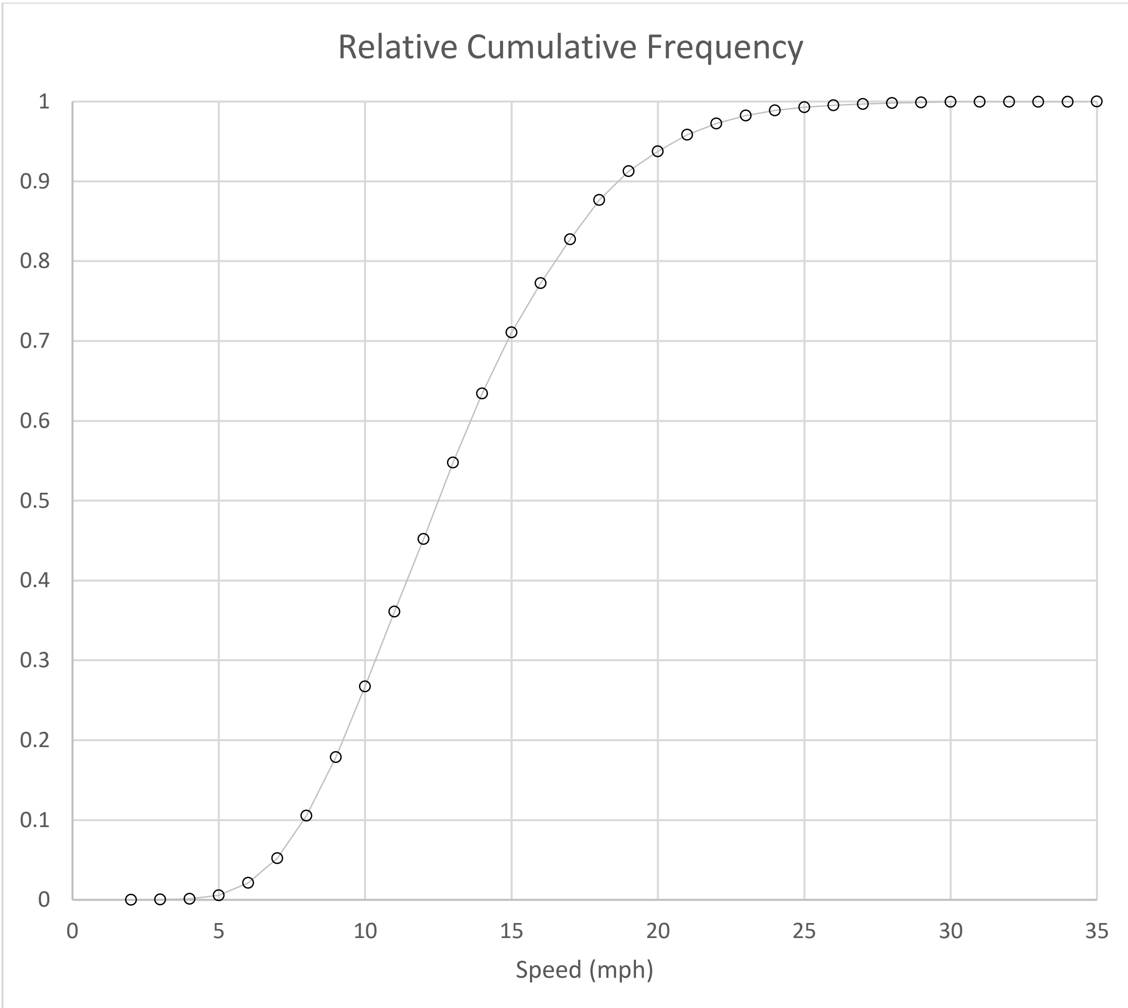


Figure 1. The cumulative distribution of Amarillo's daily average wind speeds

The data appear to be roughly "S" shaped, but are not symmetric, since the right tail is longer than the left tail. Thus, we can rule out a normal distribution. Several asymmetric distributions were considered, such as log normal, square root normal, etc., but the distribution that fit the data the best was a modified Weibull curve. Its equation is

$$F(z) = 1 - exp\left[-\left(\frac{z}{\lambda}\right)^k\right] \quad \text{where } z = ln\left(\frac{s}{s_{min}}\right)$$

The symbols are as follows: s is the daily average wind speed in mph, s_{min} = 2.5 mph, $F(z)$ is the proportion of daily average wind speeds that will be less than or equal to s mph, and λ and k are parameters to be determined by a least squares regression.

The parameters λ and k were found to be 1.7225955 and 5.4398283, respectively. The resulting curve is shown with the data in Figure 2, and the curve is an excellent approximation to the data.

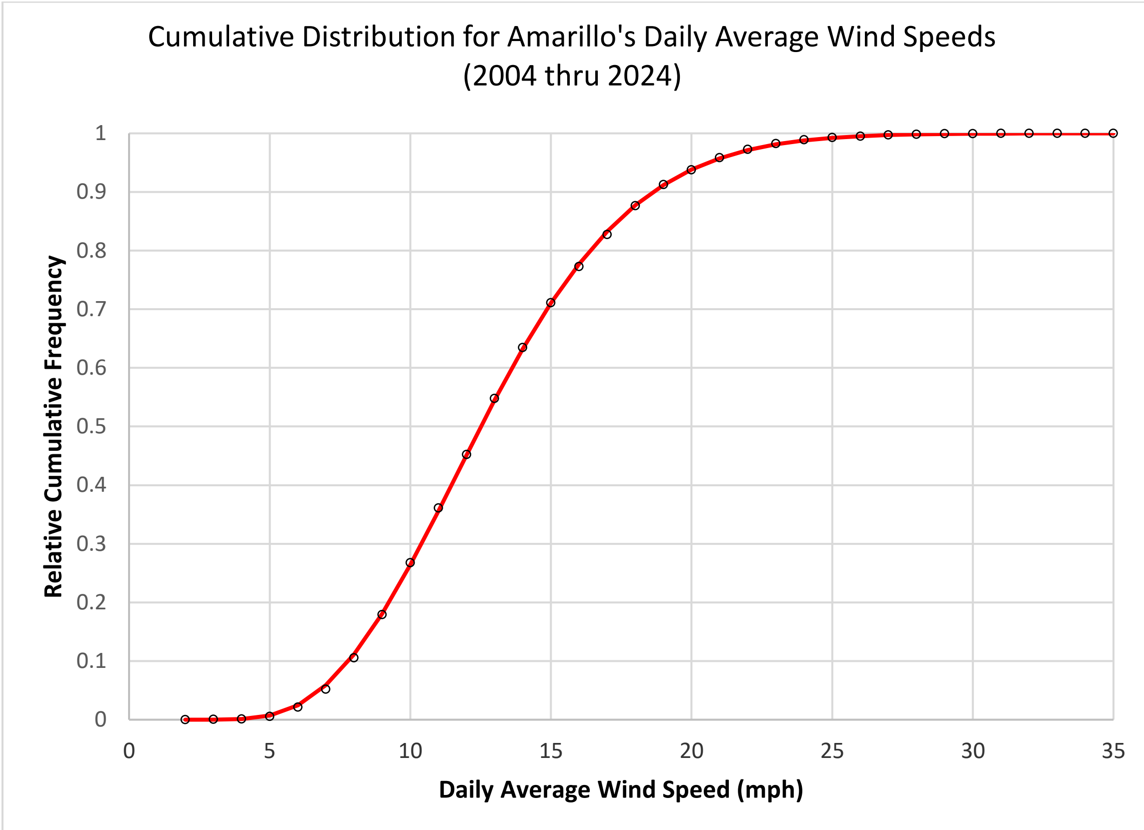


Figure 2. The cumulative distribution with the best fit Weibull Curve

Hence, for the past 21 years, Amarillo's daily average wind speeds have behaved like a random sample from a cumulative modified Weibull distribution.

The annual average wind speeds are approximately normally distributed with parameters $\mu = 13.003$ mph and $\sigma = 0.3724$ mph.