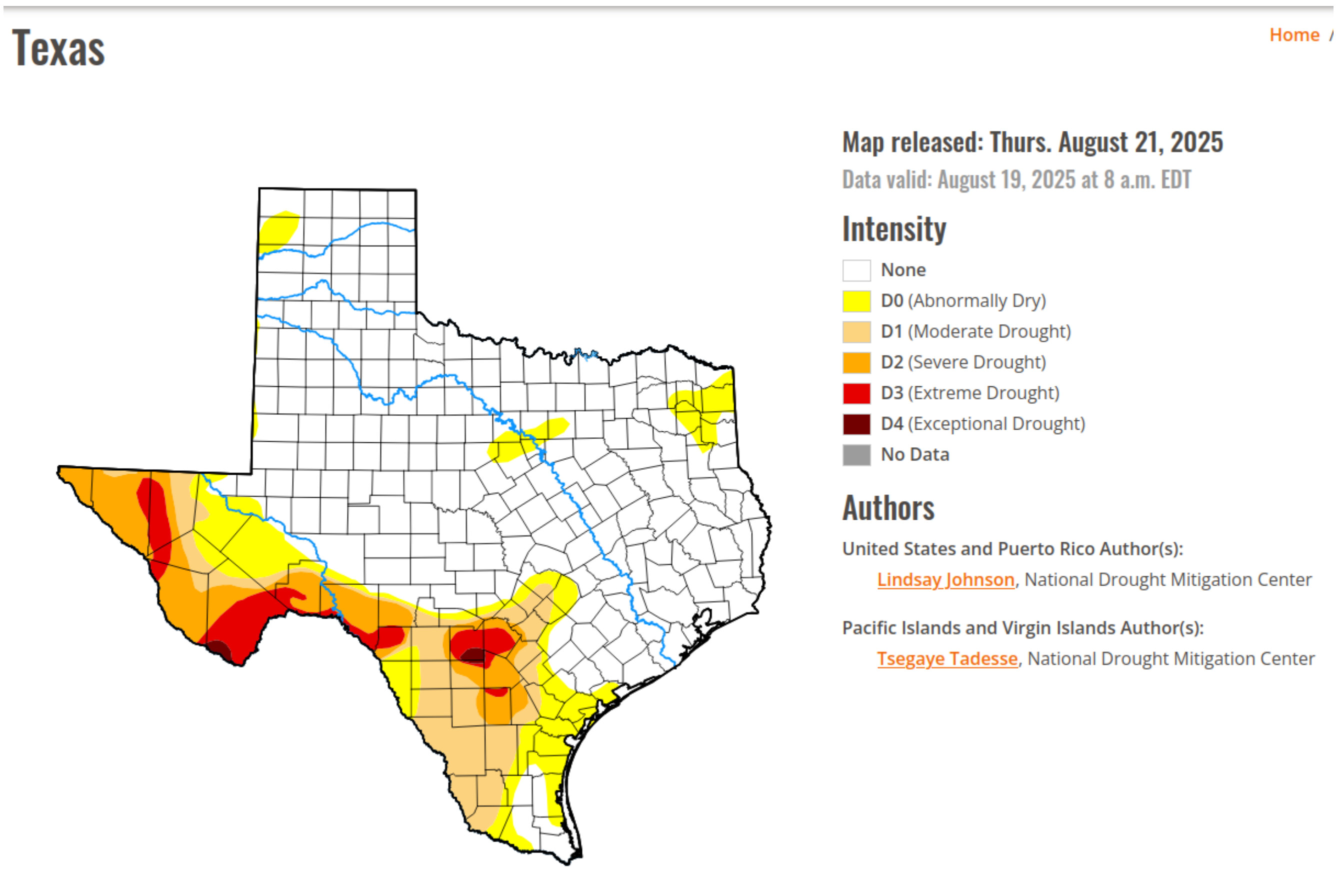
Bi-monthly Educational Topic #16 for CCGCD
by Texas Hill Country Weather Services, LLC
August 25, 2025

<u>Current conditions:</u>

Wow! As of August 21, 2025, one-half, the northern half, of Kendall County is OUT of drought. For the southern half of the county, the intensity of the drought ranges from D0 (abnormally dry) to D2 (severe drought) per the latest available US Drought Monitor map provided below. Our tropics will continue to remain active. This weather pattern is still expected to give us decent chances of rainfalls through September into, at least, the early portion of our Fall season.



This topic is a follow-on from Topic #15. A brief review of the last topic follows. A rainfall forecast was given for Kendall County for the weekend of July 26/27 using weather modeling datasets from the July 26 00z runs. 48-hr model total precipitation forecasts were tabulated in which an actual rainfall total forecast for Kendall County was provided on the District's Facebook page. So, did the provided forecast to the Facebook page verify relative to what actually happened? Yes. The forecast verified well and the calculations associated with the modeled dataset verified fairly well.

However, not all weather forecasts will verify well. In fact, there is some level of measurable error in every single weather forecast, especially if the communicated forecast contains details and specifics. The less specifics and details provided, there will be less error. To be transparent, forecast error is not inherently a bad circumstance because error needs to be expected for an outcome to potentially occur in the future. Forecast error will occur, expect error and then try to understand the significance of the error.

Now how can we attempt to understand the significance of the forecast error? First, a different way to ask the same question is how can we attempt to understand the significance of forecast skill? We want to know if the forecast has skill or not. The key to develop forecast skill in which the public and the District could build trust with the weather forecaster and with the weather forecast models being used is to conduct a statistical verification exercise to compare the combination of the forecast to actual occurrence and to repeat this exercise for every combination sample.

A private weather intelligence company, Tomorrow.io (https://www.tomorrow.io), based out of Boston, MA, produced an excellent technical paper written on the topic of weather forecast validation and verification. This paper is titled *Best Practices for Weather Forecast Validation: Technical Approach Guidelines for Data Analysis (March 2021). https://cms.tomorrow.io/wp-content/uploads/2021/08/tm-exec-summary-validation.pdf* is the link to the paper used for this educational topic as described below in simplicity.

One way to depict forecast skill, statistically to compare a forecast to occurrence, is to use a contingency table, and this table and its statistics will be the only skill detection tool discussed within this topic, referencing the March 2021's technical paper listed above.

		Observed	
		Yes	*No*
Forecasted	*Yes*	Hits	False Alarms
	No	Misses	Correct Rejections

Figure 1. A traditional contingency table used for tabulating forecast-observation outcomes.

The contingency table is based on four yes/no forecast-occurrence (observation) categorical outcomes. A forecast hit is a yes-yes outcome. A forecast false alarm is a yes-no outcome. A forecast miss is a no-yes outcome. A forecast correct rejection is a no-no outcome. Each forecast fits into only one of the four outcomes.

The verification statistics, using the table, to validate, let's say, a set of several daily discrete precipitation forecasts, for their daily precipitation occurrences at a specific location in space are described below:

- Probability of detection (POD) is defined as the fraction of "yes" forecasts correctly forecasted. POD = (Hits/(Misses+Hits)). If POD = 1, the forecaster skill is perfect skill; anything less than 1 is decreasing skill. A POD value of 0 means the forecaster has no skill at all.
- False alarm ratio (FAR) is defined as the fraction "yes" forecasts that did not occur. FAR = (False Alarms/(False Alarms+Hits)). If FAR = 0, the forecaster skill is perfect skill; anything greater than 0 is decreasing skill. A FAR value of 1 means the forecaster has no skill at all.

- Critical success index (CSI) is defined as the performance of “yes” forecasts compared to the “yes” observations ignoring the “no” observations.
  CSI = (Hits/(Hits+False Alarms+Misses)). If CSI = 1, the forecaster skill is perfect skill; anything less than 1 is decreasing skill. A CSI value of 0 means the forecaster has no skill at all.
- Frequency bias (FB) is defined as the performance of “yes” forecasts that did occur.
- FB = ((Hits+False Alarms)/(Hits+Misses)). If FB is nearest 1, the forecaster skill is better skill; anything less than 1 is increasing under-forecast skill. A FB value greater than 1 is increasing over-forecast.
- Accuracy (ACC) is defined as the fraction of the forecasts were correctly forecasted.
  ACC = ((Hits+Correct Rejections)/T) where T = Correct Rejections+Misses+False Alarms+Hits. Closer to 1 is better suggesting improving forecaster skill.

Now, let’s test the contingency table and the validation statistics with one random example below to verify the forecast skill of a weather forecaster that hypothetically provides a total of 30 precipitation forecasts for Boerne, TX for July 2025. This is a completely made-up example to conduct the verification process.

T = 30;
Hits = 5;
False Alarms = 2;
Misses = 1;
Correct Rejections = 22;

POD = (5/(5+1)) = 5/6 = 0.83, good skill;
FAR = (2/(2+5)) = 2/7 = 0.29, good skill;
CSI = (5/(5+2+1)) = 5/8 = 0.63, decent skill;
FB = ((5+2)/(5+1)) = 7/6 = 1.17, good skill but bias is towards over-forecast; and
ACC = ((5+22)/30 = 27/30 = 0.90, good skill.

In this random example, the conclusion is that the weather forecaster has good skill.

However, you might be asking, why does this topic matter to CCGCD? This contingency table verification tool can be used for any discrete forecast variable, whether that variable being tested is precipitation, drought occurrence, well level, aquifer level, etc. The District can use this tool for any yes-no, forecast-occurrence/observation combination process to test forecast skill.

Stay tuned into CCGCD’s website page, as TXHCWS will soon be providing more educational materials.