NCTM math SIGHTINGS

Forecast Accuracy

Did you wear a coat today? Shorts? A hat? Did you reach for sunscreen or for gloves and boots? Having an accurate weather forecast—whether from your phone, TV, or the newspaper—can be important. Forecasts are expected to be detailed and accurate, but we have all seen them go wrong, and we tend to look at them with a bit of a sneer. Why can't the forecasters get it right? Can you trust what you are told regarding high temperatures for tomorrow? For a few days from now? How good is a 10-day forecast?

This seems like fertile ground for some very practical mathematics and science, and we can go forward in so many ways. A simple approach might involve questions like these: For my community, and for some particular forecast mechanism (e.g., the app on my phone), how accurate are the forecasts for daily high temperatures, and does that accuracy change as they extend further into the future? If today is Tuesday and the forecast is for a high of 52 degrees Fahrenheit (° F), but by the end of the day we got to only 49° F, that's off by 3 degrees. If I can record the predictions I find on my phone, which extend out for the next 9 days, then I can check their accuracy against a verified source as these days go by. The difference between the prediction and the verification is a simple measure of accuracy, and I am interested in whether that accuracy changes with short or extended forecasts. Table 1 shows the forecasted high (fc), the actual recorded maximum temperature or verification (v), and the absolute value of the difference (|fc – v|) for 1-, 2- and 3-day forecasts for 4 summer days in Seattle.

Table 1. Sample high temperature forecast and verification data

	1-Day Forecast			2-Day Forecast			3-Day Forecast		
Prediction	fc	v	|fc – v|	fc	v	|fc – v|	fc	v	|fc – v|
29 August	72	7	0	64	66	2	6	67	1
30 August	70	6	4	70	67	3	6	67	1
31 August	70	6	3	70	67	3	6	67	1
1 September	66	6	1	66	67	1	6	65	3

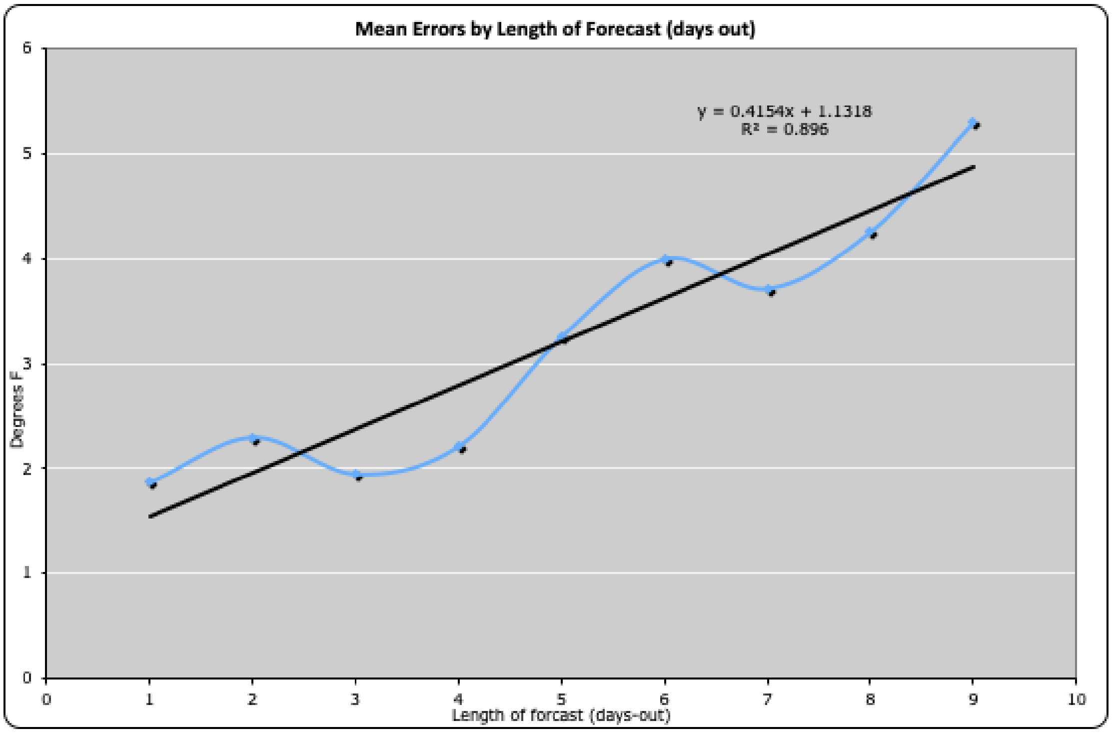
Although table 1 shows only 1-, 2-, and 3-day forecasts, I recorded these high temperature forecasts each day for all 9 days that my phone app would give me. I also recorded the verification temperatures (the actual high temperatures that occurred) each day for 23 days, from late August through mid-September. This allowed me to calculate a mean for the absolute values of the differences—the errors—for 1-day forecasts, 2-day forecasts, and so on. I used a spreadsheet to facilitate this work; table 2 shows the means.

Table 2. Means of the differences between predicted and actual high temperatures

	Mean Error |fc – v|
1-day	1.9°
2-day	2.3°
3-day	2.0°
4-day	2.2°
5-day	3.3°
6-day	4.0°
7-day	3.7°
8-day	4.3°
9-day	5.3°

In figure 1, we see a plot with the length of forecast on the *x*-axis and the mean errors on the *y*-axis. For 1-, 2-, 3- and even 4-day forecasts, the predicted high temperatures verify pretty well, only a couple of degrees off. Beyond that, the errors increase; and by the time we get to the 9-day forecast, the average error is more than 5 degrees.

Figure 1. Mean errors and a simple best-fit line



Also in figure 1, a simple line of best-fit line has been applied to the data, allowing us to generalize about the way in which the accuracy changes with the length of the forecast. The slope of this line, the rise over the run, is the change in accuracy that is observed as the length of the forecast increases. What a nice application of slope!

This makes a good activity for the mathematics classroom because students get a chance to use simple math and science to understand an intuitive and easily quantified aspect of the world. The numbers represent a variable, temperature, that is familiar and that may be directly experienced every day. The accuracy of the forecasts matters as we plan our days and as we look forward to rain or shine—and we get to check them!

Further, this activity has a simple basic structure but is highly adaptable. This allows us to individualize and to enable choice, a good way to increase the chances of learner engagement. For example, students working in small groups or as individuals may pick their own town for this investigation. Some may want to check the forecasts for famous or iconic places such as New York City or Furnace Creek in Death Valley. Others may wonder about their own hometown or that of their grandparents or perhaps someplace overseas. The internet makes these data available from all over the globe. (As I write this, today's forecasted high temperature at McMurdo Station in Antarctica is –3° F.)

Assuming that you have students investigating the accuracy of forecasts for different locations, they can share their findings in order to ask and address larger questions. Here are a few examples:

- Do forecasts seem better for some locations than for others? Urban versus rural, West Coast versus East Coast, versus the Plains states, South versus North, and so on?
- Does accuracy seem to change for cities according to any other factors?
- Do some forecast apps or information sources seem more accurate than others?
- What do we consider acceptable accuracy in a forecast for high or low temperature, and therefore how far out do we "trust" the forecast?

There is no end to the questions that may be asked, and the methodology for investigation at any given grade or ability level is basically the same for all. This means that while they are asking their own questions, students are all encountering some version of the same math and science. You might focus on data gathering and the calculation of differences in fifth grade, on summarizing and interpreting data in sixth grade, on the meaning of the slope of the best fit line for the mean errors in seventh- or eighth-grade mathematics, and so on. Ideally, you want students to develop their own ideas about how to use mathematics to investigate the accuracy of forecasts. This may lead them to consider absolute value, for example. In this setting, they will discover a need for the concept as a way to make sense of errors that are either negative or positive, rather than being handed a set of rules and procedures, the need for which is unclear.

I want students to use math and science to make sense of the world they encounter every day. I want them to develop not only the procedural fluency that allows them to see applications and extensions of the central concepts but also a positive disposition that keeps math and science alive in their lives. I believe that caring and thoughtful teachers adapting versatile activities to the needs of the individuals in their classrooms can help to make this happen.

Lesson Plan

Learn more about implementing Forecast Accuracy in your classroom by exploring the Illuminations lesson here! Then, share your experiences using Math Sightings on social media with the hashtag #MathSightings.