BE YOUR OWN GROUNDHOG

By analyzing data collected at citizen-science websites, students can test predictions about the arrival of spring

Christine Gregory

Each year during my childhood in the Pennsylvania hills, we anxiously awaited Punxsutawney Phil to emerge from his burrow on February 2, Groundhog Day. If the weather was cloudy, according to folklore, spring would come early. If it was sunny out, Phil would see his shadow and retreat underground, and we could expect six more weeks of winter (see "On the web" for more on Groundhog Day).

Technically, March 19, 20, or 21 (depending on the year and your location) is the vernal equinox, the first day of spring, regardless of atmospheric conditions or groundhog activity. The date results from a calculation of Earth's position in its orbit around the Sun.

But this rather clinical calculation doesn't mean that we should ignore observational science, such as that practiced by Phil, the great prognosticator. In fact, we may be able to improve upon Phil's down-to-earth methodology. The observational science called *phenology* considers the timing of natural events, in this case, the biological and physical markers of spring. It is the basis of the "Be your own groundhog" project in my grades 9–12 Earth and environmental sciences courses, in which students use citizen science databases to research the physical changes that signal the arrival of spring.

Databases to mine

Students begin by researching historical weather data on Weather Underground (see "On the web"), which collects data provided by citizen and private weather stations. We invite local community members with weather stations, who students find on this website, to visit our classroom, and many students also visit the local stations in person. The personal weather stations (PWS) (see "On the web") used by Weather Undergound members are simple automated stations available for purchase from a variety of manufacturers. Once registered, they relay data about current conditions to Weather Underground, which compiles them into a database and allows the public to view current and historical information about precipitation, temperature, and wind speed and direction. Some devices also note atmospheric pressure; dew point; visibility; cloud cover; and health hazards such as UV, pollen, and smog counts.

From the Weather Underground website, students gather at least 10 data sets of abiotic factors—for example, average daily temperature, high daily temperature, low daily temperature, dew point, precipitation, and length of day. They then graph these factors for each of five years for the period from January 1 to May 30, creating at least 50 graphs. On each graph they also mark the date of the vernal equinox.

Next, students access the citizen science sightings database at the website of Journey North, "a global study of wildlife migration and seasonal change" (see "On the web"). Here, students can report signs of spring at their locale as well as browse a database of sightings since 1997. The database includes sightings by date and latitude and longitude of robins, red-winged blackbirds, croaking frogs, monarch butterflies, milkweed, blooming tulips, leaf growth, and many other seasonal markers. Students select one biological sign of spring from the Journey North database and note when it first appeared at their own latitude and longitude, plotting the dates on each graph.

Most students are initially overwhelmed by the sheer size of the data sets they compile from the two websites. This provides an excellent context in which to explain the value of graphical analysis and computational software. (Students in my classes have used Microsoft Excel or OpenOffice Calc to create their graphs.) One student, Jacob S., noted: "For once graphs weren't just busy work. They helped us see what couldn't see from a bunch of numbers on a page."

Analyzing the graphs

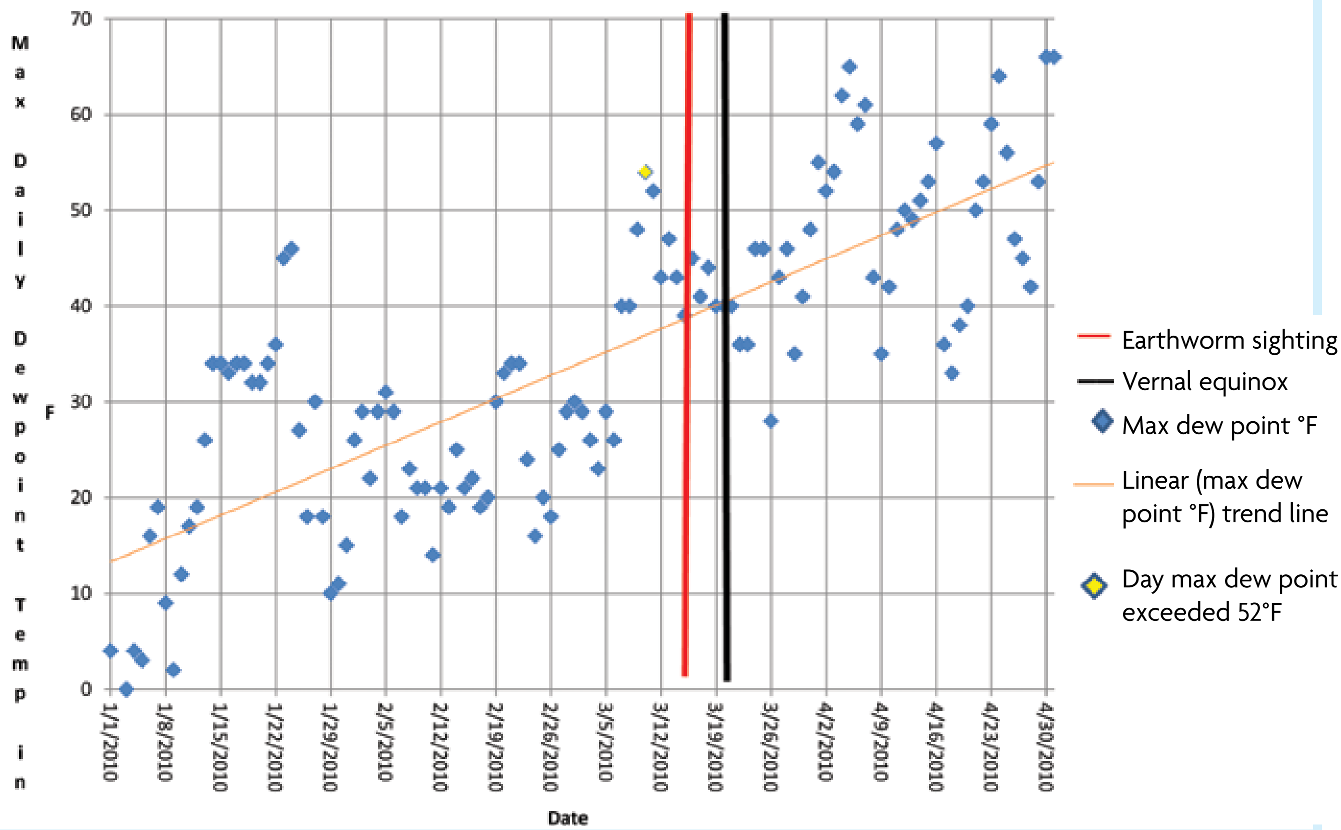
Students are then asked to analyze their graphs for patterns in the data. An example of a research topic might be "compare the arrival of the first wave of migrating blackbirds with daily high temperature, daily low temperature, daily average temperature, photoperiod, daily precipitation, total year-to-date precipitation, daily maximum dew point, daily minimum dew point, daily percent cloud cover, and average daily percent humidity to determine which, if any, of these factors is correlated to migrating blackbird arrival."

Students also look at whether trend lines, individual data lines, or certain data points seem more predictive of the spring event they are tracking. For example, a group might hypothesize that robins begin to sing when the temperature first reaches 48°F, but then realize that using an individual data point offers no way to anticipate when the event will occur. The students might decide to use a trend line instead, predicting that robins will first sing when the trend line of daily high temperatures crosses 48°F. The trend line, drawn ahead of time and extended through 48°F, allows students to predict the event. In this way, students discover the value of looking at trends within large data sets. In Figure 1 (p. 66), you can see a sample graph where students included both a data line and a trend line.

Students are also asked to create predictive "when-then" statements that are testable. For example, in the 2011 exercise, one group predicted: "When the dew point exceeds 52°F, then earthworms appear above ground within one week." Then, in the 2012 example, another group said: "When the high dew point average exceeds 33°F, earthworms appear above ground after 14 days." Interestingly, both groups used the graph of highest daily dew point as their predictor. The 2011 group used 2005–2010 data. The 2012 group used 2006–2011 data. So four (overlapping) years of the data were identical in both cases. But the 2011 group chose an individual data point—52°F—as their predictor and found that it was limited in how far in advance they could realistically predict

FIGURE 1

2010 data data shows maximum daily dew point by date in Springfield, Ill.



Note the vertical lines indicating the vernal equinox (black) and actual date earthworms were first sited in 2010 (red) according to the Journey North database. Yellow data point indicates the day the data reached what the 2011 group considered the "tipping point" for earthworm sighting, a dew point at or exceeding 52°F.

SUZIE S. AND ERIC L., 2011

earthworm appearances. The 2012 group used a trend line as their predictor, making earlier predictions possible.

In their final analysis (see "The Final Test" below) students were asked to comment on differences in their approach with previous years' groups. They they examined their data across several years to see if their predictive statements were supported. If the data was consistent, students were then asked to find another location and create another five-year set of graphs for only the relevant data set.

For example, Omaha, Nebraska, dew-point graphs were a second test case for the when-then statement made by the 2012 earthworms group. It usually took three to seven iterations of creating a proposed when-then predictive statement and supporting it or refining it before students were confident of the reliability of their predictive statement. Shawn W., a member of the robin sighting group, shared that he was "sure I would never find an answer, even Googled 'when will robins arrive' for hints." But when he couldn't find the answer online, "that's when I realized I was doing real science."

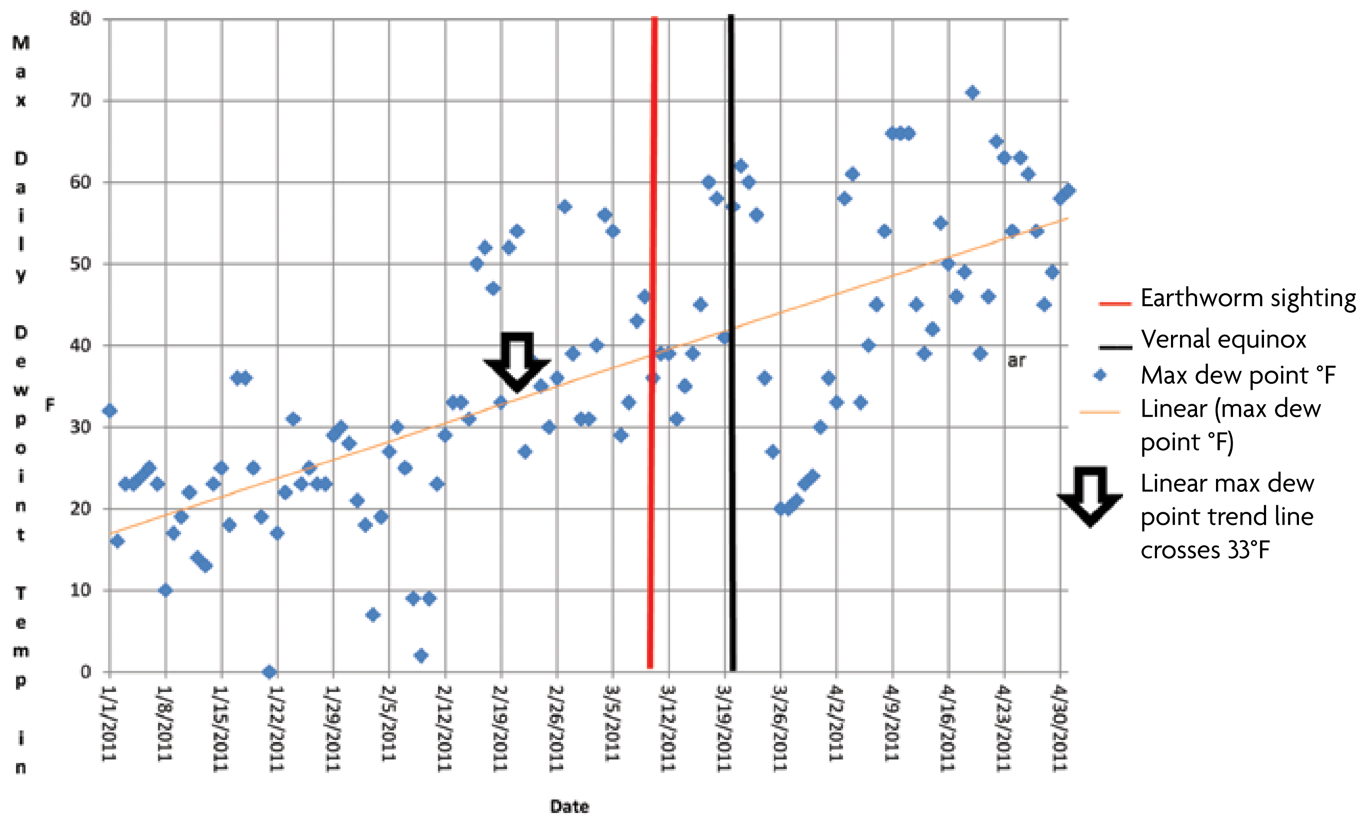
The final test

The last phase of this project was to test the prediction in the current spring. Students were asked to create a graph of the relevant data set for the current year-to-date and extend a trend line through May 1. Then, based on their predictive statement, they hypothesize what date their sign of spring would first arrive locally.

Students in the 2012 earthworm prediction team (Figure 2) predicted that when the dew point average exceeds 33°F, earthworms would appear above ground after 14 days. When comparing this pattern to the previous year's group, students noted how using the data points (blue) limited how early a predicted date could be identified. A trend line pattern (orange line) allowed students to predict earlier in the year but

FIGURE 2

2011 data shows maximum daily dew point by date in Springfield, Ill.



Note the vertical lines indicating the vernal equinox (black) and actual date earthworms were first sited in 2011 (red) according to the Journey North database. Black arrow indicates the day the trend line average of maximum dew points reached what the 2012 group considered the predictor for earthworm sighting, a trend line crossing 33°F.

LINDSAY W. AND LINDSEY M., 2012

gave a less consistent result with greater margin for error. Based on early data for 2012, students predicted that earthworms would be spotted within 14 days of Feb. 21, when the trend line they made showed dew point exceeding 33°F. This hypothesis is indicated by the red line on Figure 3 (p. 68).

Students posted their hypotheses publically and did a number of public service announcements in the school and community to encourage citizen reports of sightings. Then they waited. In 2012, earthworms were spotted locally on March 1. That fell within the students' predicted date range, but students said that perhaps a two-week window was too wide and believe this prediction scheme could be refined by future groups.

As part of their semester final, students were asked to reflect on the process, whether their hypothesis was supported by the current year's data and their experiences. Amy K. wrote, "I saw a robin on prom night; he was two days late! I was so excited that I called my mom to have her put the sighting in the report. She cracked up when I told her I interrupted prom for a robin sighting."

Open-ended inquiry and the science practices

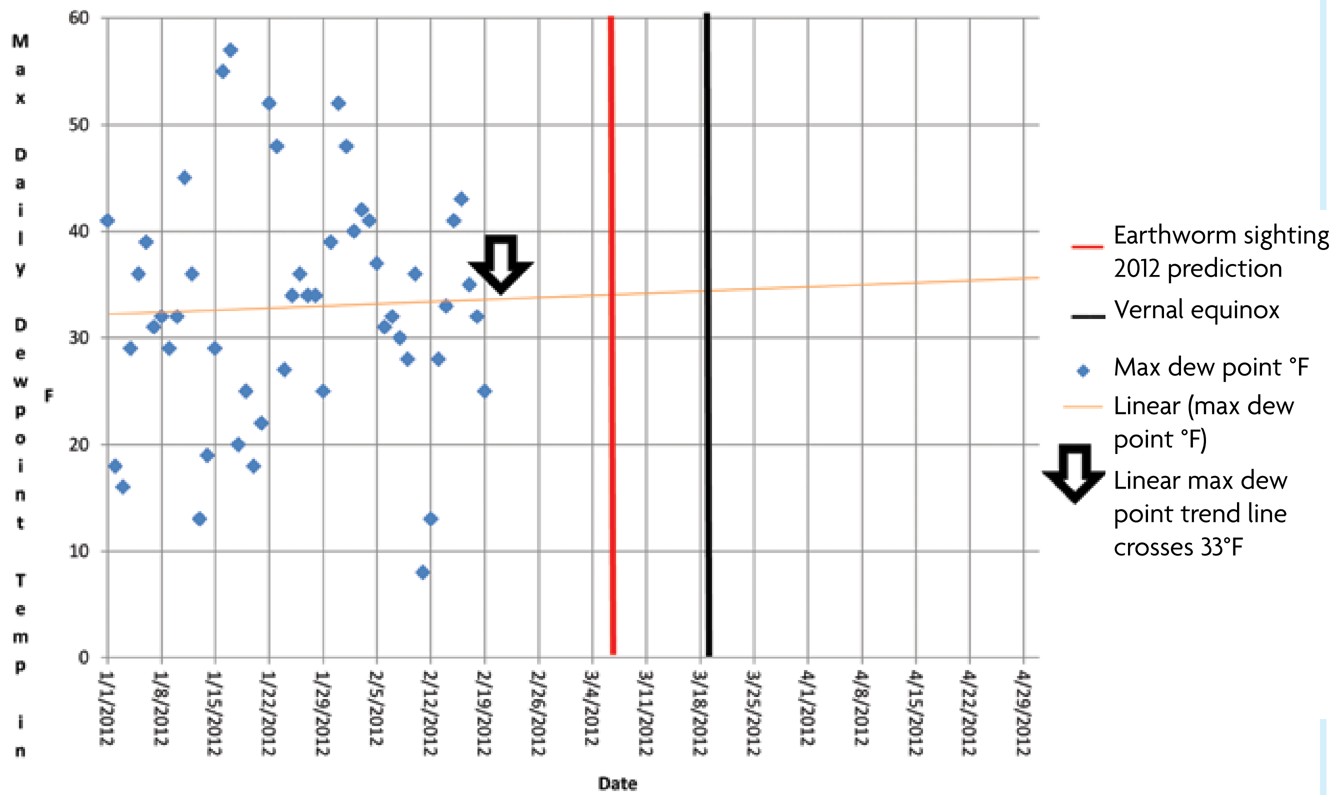
Science teachers are likely to have different ideas of what it means to encourage students to do inquiry. I like using definitions of science practices as a guide, and to incorporate science practices in a differentiated manner, meeting each student at his or her own level, from sophomores to seniors.

The science practice definitions I use include those from the *Framework:*

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models

FIGURE 3

2012 data shows maximum daily dew point by date in Springfield, Ill.



This graph is based on data taken through Feb. 19 with a trend line extended through May 1. Note the vertical lines indicating the vernal equinox (black) and predicted date of first earthworm sighting (red). The prediction was based on the trend line crossing the 33°F threshold (black arrow).

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- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information (NRC 2012)

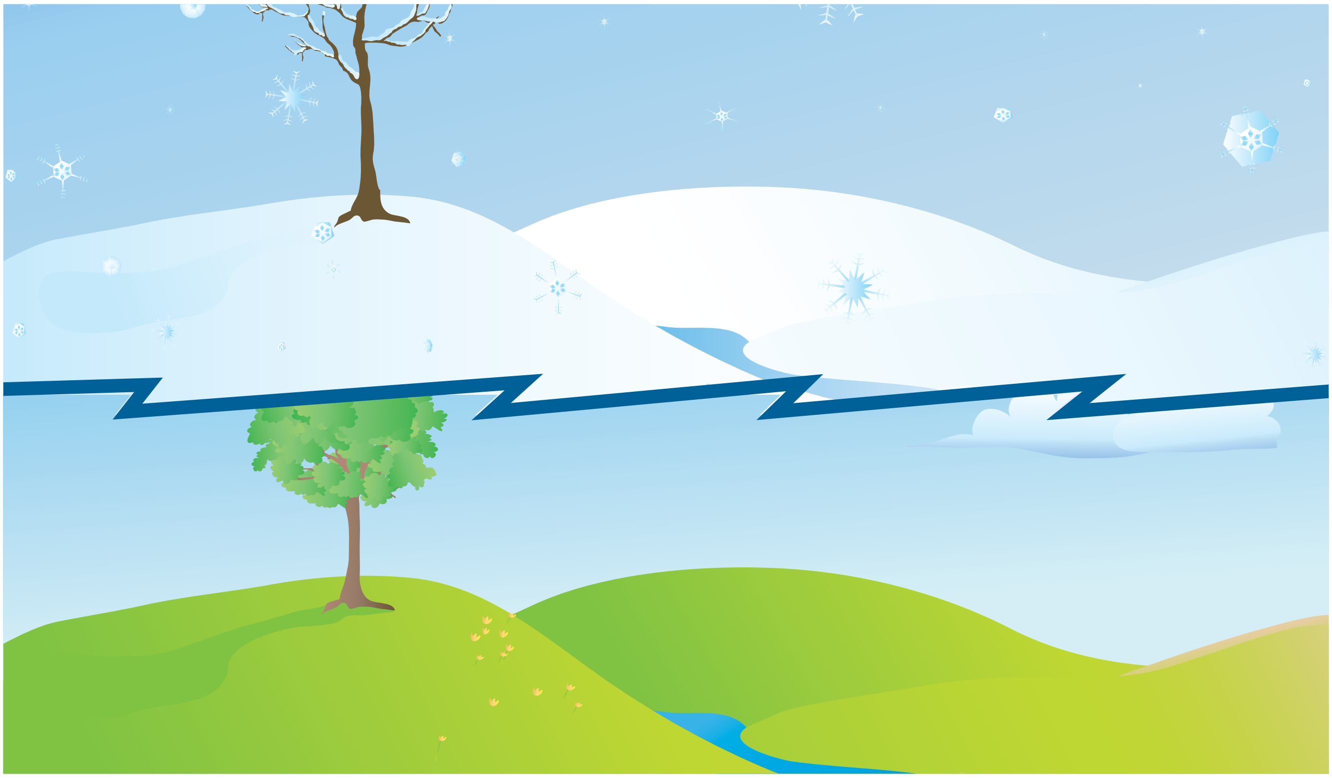
The emphasis in all cases is on student-centered inquiry, which this "Be Your Own Groundhog" project emphasizes. Students are given limited instruction and asked to develop their own research questions and strategies for seeking answers through readily available data. I held brief tutorials on spreadsheet use as needed. The students took the lead.

The worksheets available online (see "On the web") are loose guides, not step-by-step instructions. Certainly, by offering more direction, teachers can adapt this to a lower level of inquiry, as needed.

Rich experiences and revisions

Over the years, my conversations with students about this project have been very gratifying. The project often generates community buzz and has a faithful following but is not without pitfalls. Some take-aways:

- Unless you're targeting graphing with computers as an objective, the lesson can be greatly simplified by saving graphs from year to year. That way, each year students only have to make a graph set for the incomplete data set from the previous year and the current year to date.
- It is next to impossible to find the necessary volume of



local area weather data in metric units. Therefore, allow students to graph and work in English units rather than convert such a high volume of data. You can always have them state their final predictive statement in metric units.

- Reserve computer time for at least a week surrounding Groundhog Day to make sure all students have enough time to complete the project. Use the first tip in this list to make that time shorter if needed.
- Preselect signs of spring for student groups to monitor based on your region. For example, in Illinois it's unlikely that monarch butterflies will be sighted before the end of school in most areas, so red-winged blackbirds, which migrate early, are a better choice.
- To keep students from restating last year's hypothesis, publish only the expected date of arrival, not the reasoning for it in the public service announcements.
- I anticipate eventually having enough longitudinal data that students may begin to investigate different starting questions. For example, is there evidence of climate change in their data? Is the start and duration of spring changing? Is there evidence of migration pattern changes over the years?

Conclusions

This project starts with a simple question, "When will spring spring?" This goes beyond the astronomical date of the vernal equinox to terrestrial meanings of spring—warmth, flowers, migrations. By using the observational science of phenology and data sets contributed by citizen scientists and available online, students create and refine predictive models, demonstrating the science practices described in the *Framework*. Even those students who previously avoided science find this activity engaging and interesting, which is why it will remain a part of my curriculum for years to come. ■

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On the web

Directions for teachers and students, plus an assessment rubric: *www.nsta.org/highschool/connections.aspx*

Journey North: *www.learner.org/jnorth/*

Personal Weather Stations: *www.wunderground.com/weatherstation/index.asp*

Punxsutawney Groundhog Club: *www.groundhog.org*

Weather Underground: *www.wunderground.com/history*

Reference

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.