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Applying the USA National Phenology Network's Growing Degree Day Maps in Making Management Decisions

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Abstract

The USA National Phenology Network generates daily growing degree day maps for the United States at fine spatial resolution (2.5–3.0 km) using a January 1 start date and two common base temperatures. Maps are available up to 6 days into the future and can be viewed and manipulated using an online visualization tool or downloaded as image or raster files. By exploring these maps through the visualization tool, it is possible to see how heat accumulation over the course of the year varies from average conditions and to anticipate when heat accumulation thresholds will be met.

Keywords: accumulated heat, growing degree days, pest management, temperature threshold, USA National Phenology Network

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Introduction

Spring-season life cycle events such as leaf-out or egg hatching in many plants and animals occur following the accumulation of winter warmth. A measure commonly used to express accumulated warmth, or heat, is the growing degree day (GDD), which is defined as the number of degrees the mean daily temperature exceeds a base temperature below which an organism will remain developmentally inactive (Wang, 1960). In many species, the specific amount of heat required to trigger an event is known (e.g., Herms, 2004; Murray, 2008). Therefore, accumulated GDDs at a location can be tracked over time to anticipate when a particular event—such as leafing or fruiting in agricultural crops or emergence and reproduction of insect pests—will occur. Combining known accumulated GDD threshold values with local temperature measurements can guide planning and allow for effectively timed seasonal management actions, including timing the application of pesticides to coincide with pest emergence (Murray, 2008), timing deliveries of plant stock to nurseries to coincide with peak flowering (Fisher, Runkle, Blanchard, Erwin, & MacKay, 2012), and assessing crop suitability (Uzes & Skinkis, 2016). Clearly, GDD data can be useful to Extension professionals in providing clientele with guidance, and, indeed, Extension professionals have expressed interest in accessing readily available GDD information (Diehl et al., 2017; Templeton, Perkins, Aldridge, Bridges, & Lassiter, 2014).

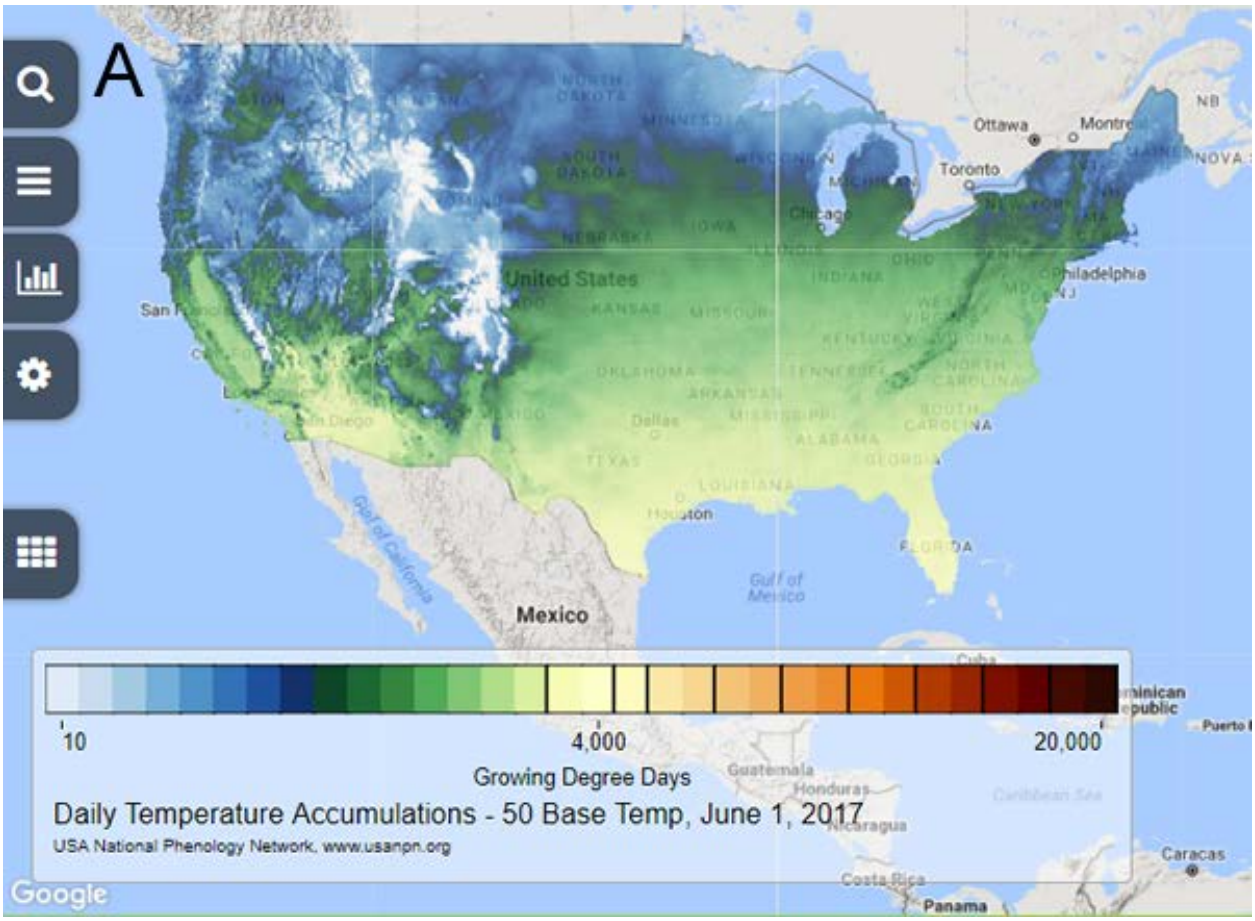
Available Daily GDD Map Products

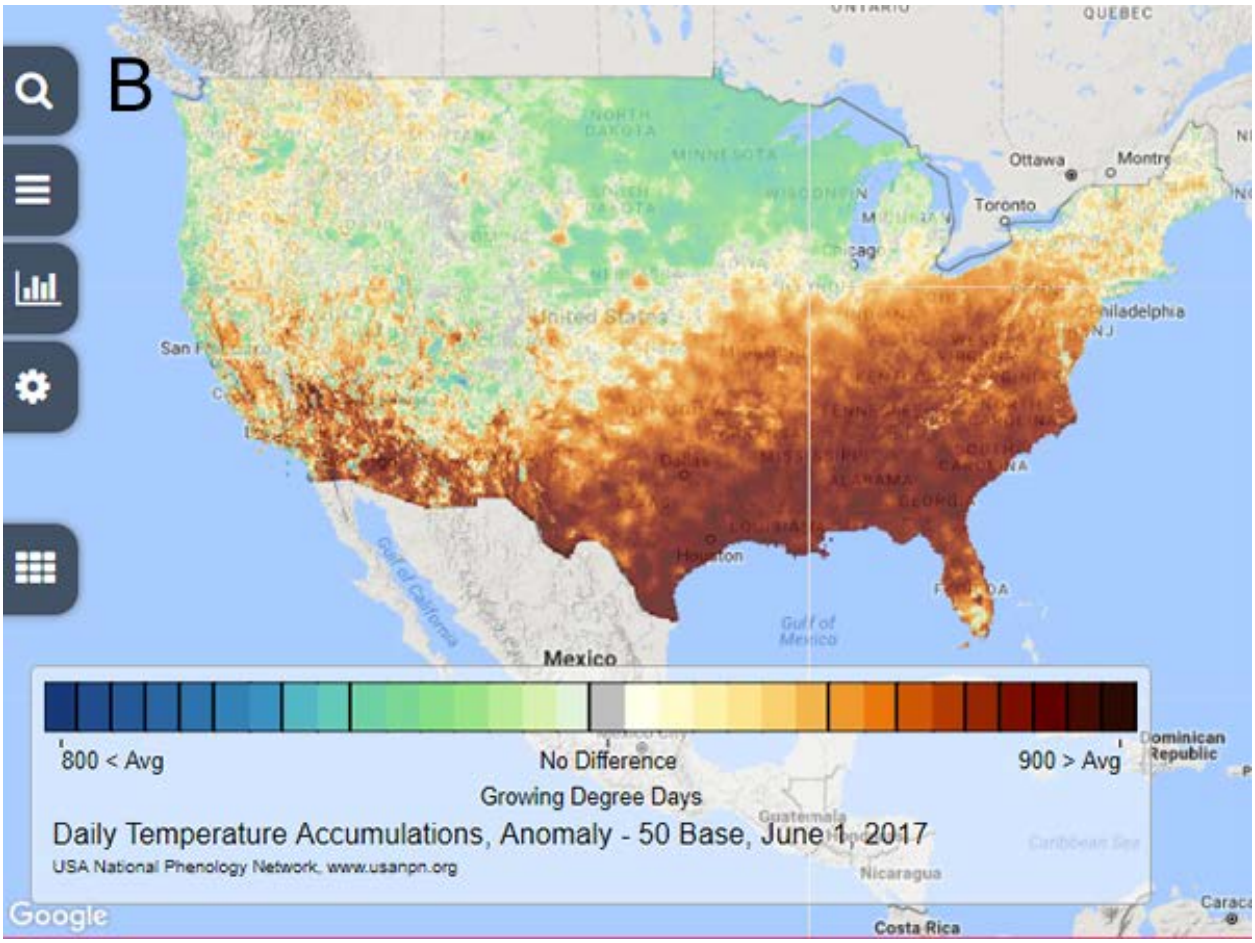
The USA National Phenology Network (USA-NPN) generates and distributes daily GDD maps for the entire continental United States and Alaska at fine spatial resolution (2.5 km and 3.0 km, respectively) using a January 1 start date and two commonly used base temperatures, 32°F (0°C) and 50°F (10°C). These maps are available for every day of the year up to the current day as well as 6 days into the future. USA-NPN constructs the maps using the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction's Real-Time Mesoscale Analysis system (http://www.nco.ncep.noaa.gov/pmb/products/rtma/), the NOAA National Digital Forecast Database (https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/national-digital-forecast-database-ndfd), and PRISM Climate Group's gridded temperature products (http://prism.oregonstate.edu) (Crimmins et al., 2017). USA-NPN also offers daily GDD anomaly maps, generated by differencing the accumulation for the current day of year to the 30-year (1981–2010) mean for the same day of year.

Daily GDD and GDD anomaly maps are available through USA-NPN's online visualization tool (data.usanpn.org/npn-viz-tool/) (Figure 1) for those interested in exploring spatial patterns in heat accumulation on a specific day of the year. They also are available via web services for advanced applications.

Figure 1.

(A) Accumulated Growing Degree Days as of June 1, 2017, and (B) Accumulated Growing Degree Day Anomaly on June 1, 2017, for the Continental United States (50°F Base Temperature)





Note: Accessed at http://data.usanpn.org/npn-viz-tool/.

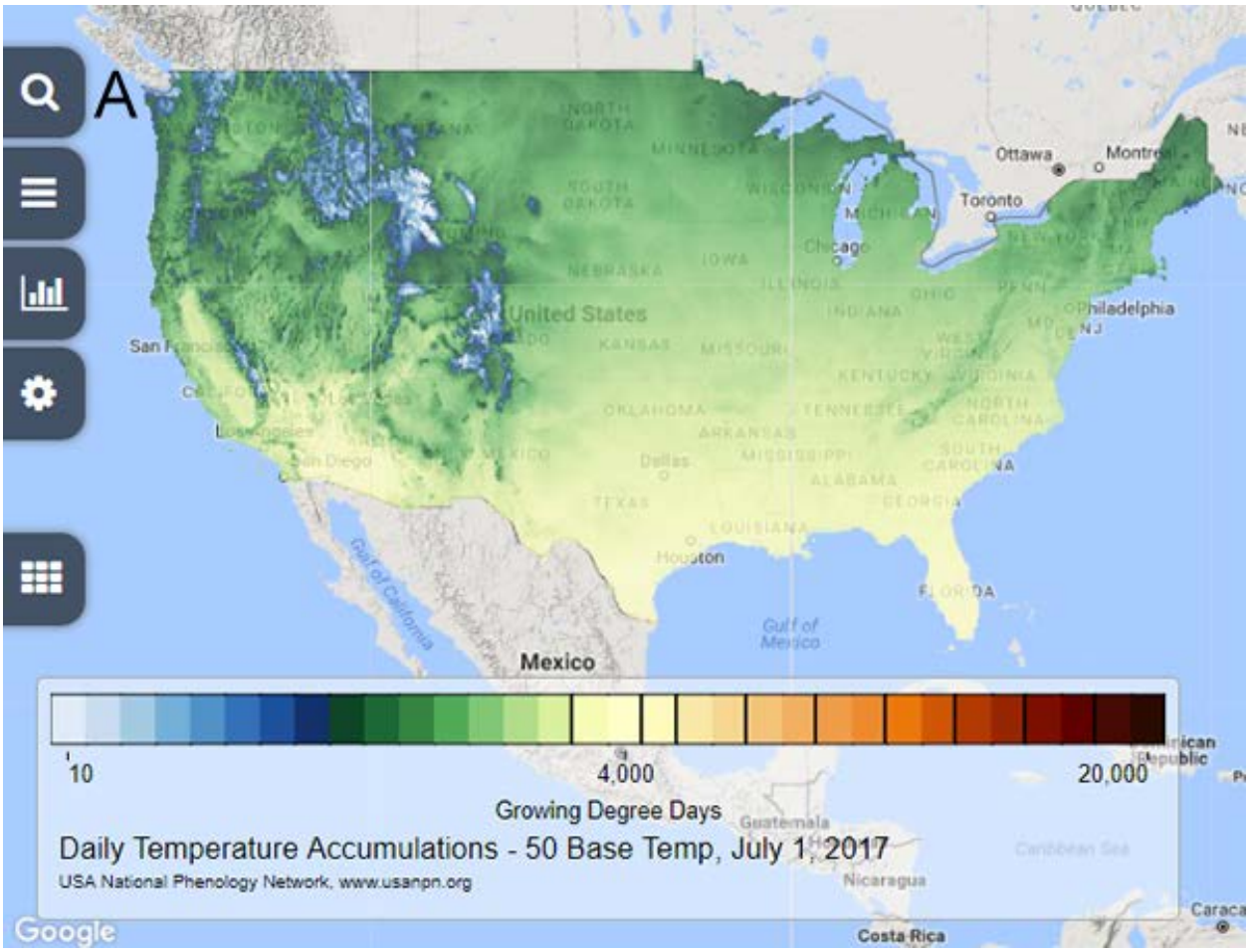
Using Daily GDD Map Products to Support Management Decisions

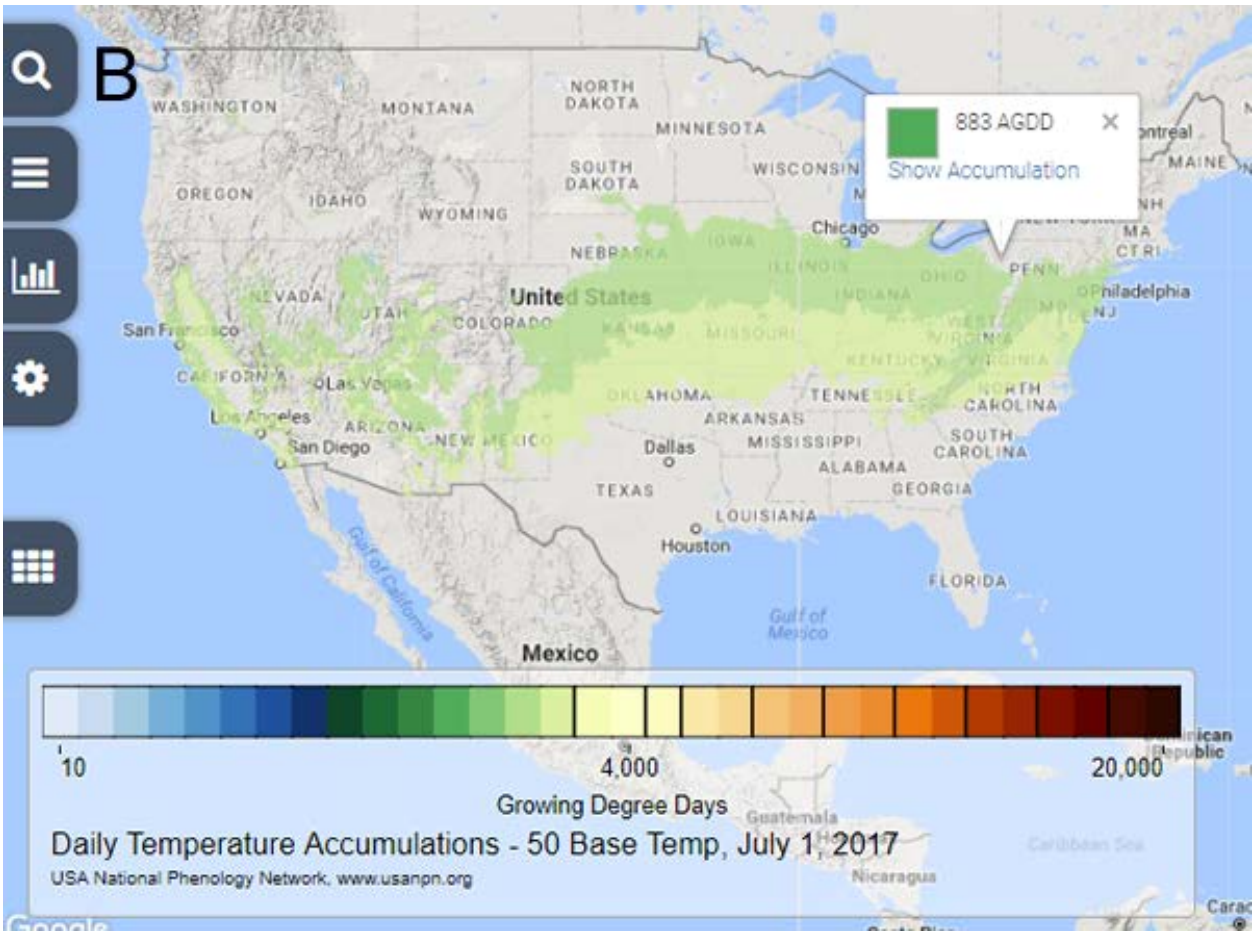
Using daily GDD maps, it is possible to evaluate where particular thresholds have been met on a particular date as well as to estimate when a threshold will be met at a particular location. For example, apple maggot (*Rhagoletis pomonella*) is a destructive agricultural pest that leads to premature fruit drop. Pesticides are most effective at controlling the spread of these insects when they are applied after adults emerge and before they lay eggs in apples. Adults begin emerging around 900 GDDs and are most abundant between 1,400 and 1,700 GDDs (January 1 start date, 50°F base temperature) (Delahaut, 2012; Wise, Epstein, Gut, & Teixeira, 2010). Adults lay eggs approximately 8–10 days later, so treatment is critical in this brief window between emergence and egg laying. Pest management experts recommend checking sticky traps for adults beginning around 900 GDDs so that when adults are first spotted, pesticide spraying can be initiated (Wise et al., 2010). By tracking GDD accumulation at a particular site over the course of the spring, it is possible to pinpoint the ideal time period for applying pesticides to maximize effectiveness and minimize waste.

The USA-NPN GDD daily maps and short-term forecasts, available through the USA-NPN visualization tool, simplify the process of tracking accumulated GDDs at a site during the period leading up to an event such as apple maggot emergence. Figure 2 Part A shows temperature accumulation in the continental United States as of July 1, 2017. Figure 2 Part B shows locations that had accumulated between 1,000 and 2,000 GDDs as of this date and where apple maggot pesticide treatment would be appropriate. Locations to the north of the band highlighted in Figure 2 Part B, such as the northeastern Pennsylvania site selected by the pin, had not yet reached 1,000 GDDs as of July 1, 2017.

Figure 2.

(A) Accumulated Growing Degree Days as of July 1, 2017, and (B) Locations with 1,000–2,000 Growing Degree Days as of July 1, 2017



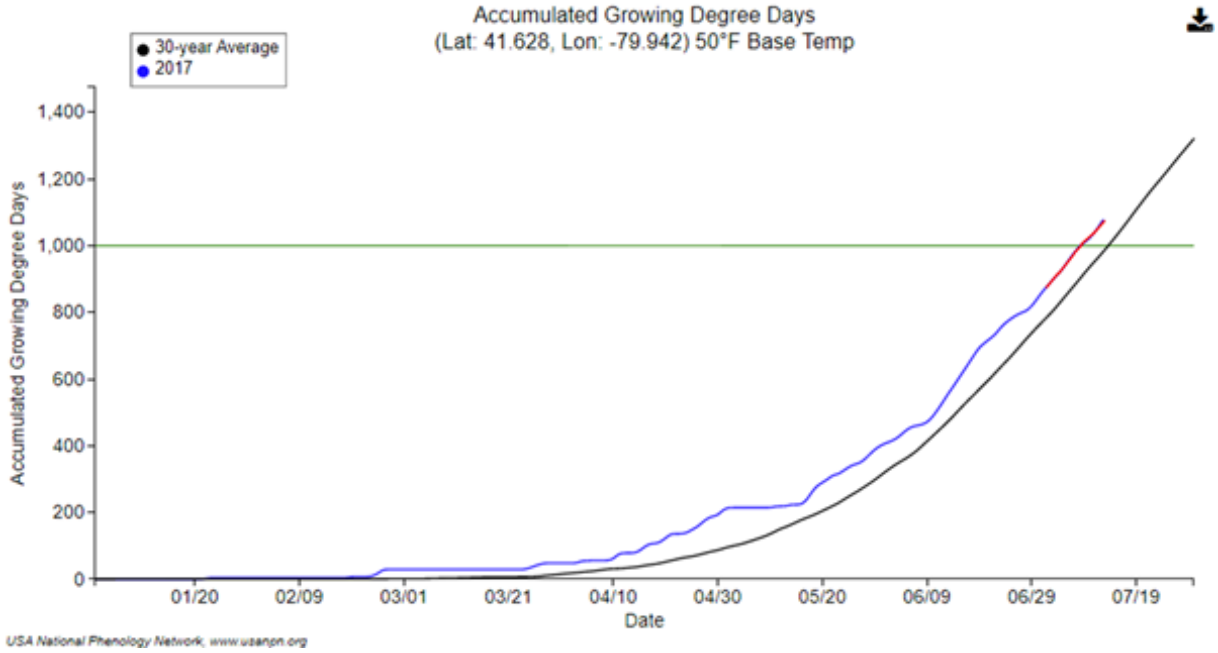


Note: Accessed at http://data.usanpn.org/npn-viz-tool/.

Daily site-specific heat accumulation information can also be useful in determining whether a particular threshold has been met or for estimating the date the threshold will be met. Figure 3, also accessed via the USA-NPN visualization tool, shows the year-to-date temperature accumulation at the location in northeastern Pennsylvania marked by the pin in Figure 2 for the year 2017 (blue line) compared to the long-term average accumulation (black line). The 6-day forecast is shown in red. As of July 1, this site was predicted to reach 1,000 GDDs on July 7, providing a 6-day advance warning for watching for the first emergence of adult apple maggots.

Figure 3.

Accumulated Growing Degree Days at a Location in Northeastern Pennsylvania on July 1, 2017



Note: Accessed at http://data.usanpn.org/npn-viz-tool/.

Acquiring Additional Information and Context from GDD Anomaly Maps

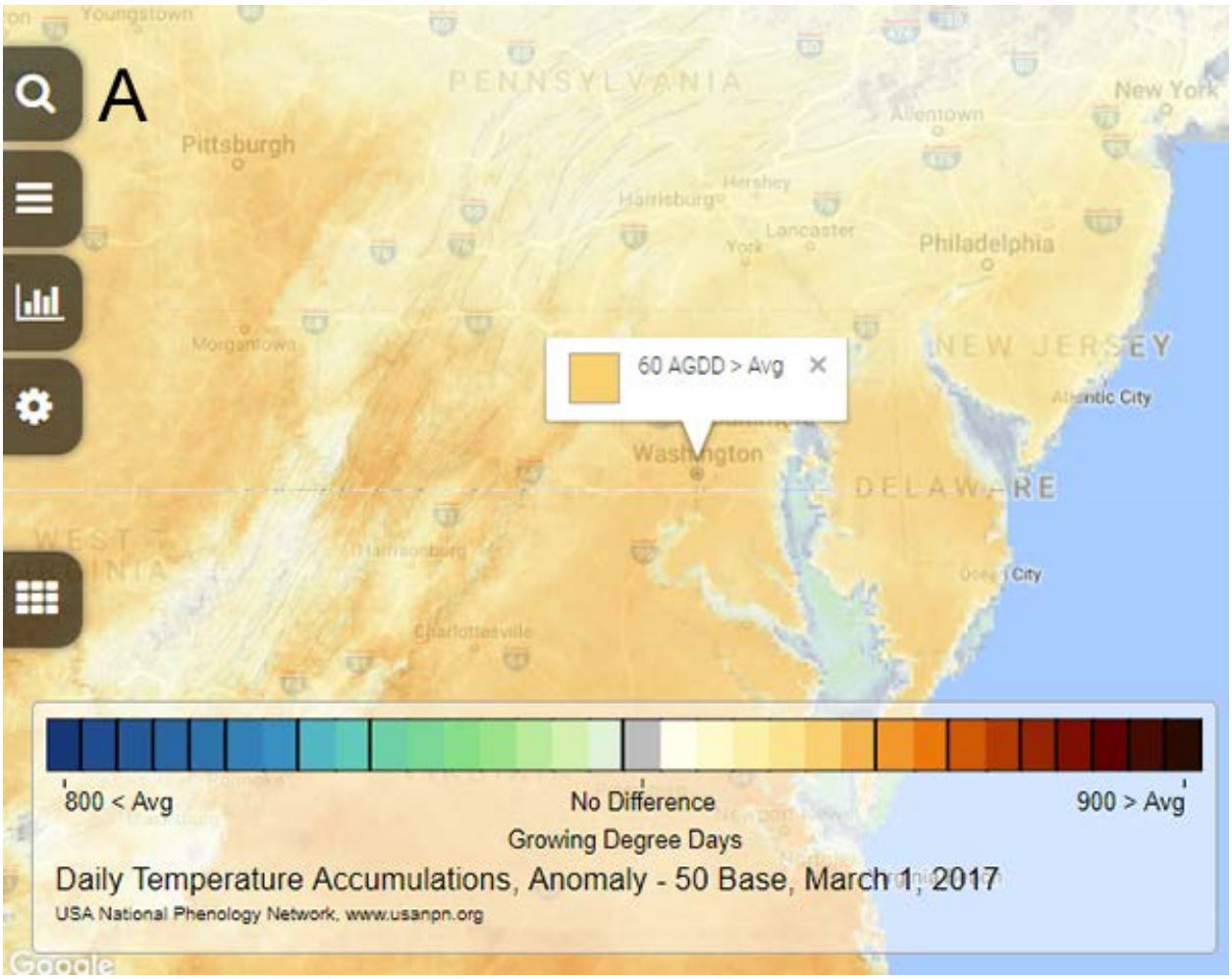
USA-NPN's daily GDD anomaly maps provide, for a particular location, a quantification of how the amount of heat accumulated on a particular day compares to how much heat typically has accumulated by that day of year, based on 1981–2010 average conditions. This information can provide a general sense of whether seasonal events or activities—such as the appearance of seasonal pests, a start to the allergy season, or flowering of important species—will occur earlier or later than normal.

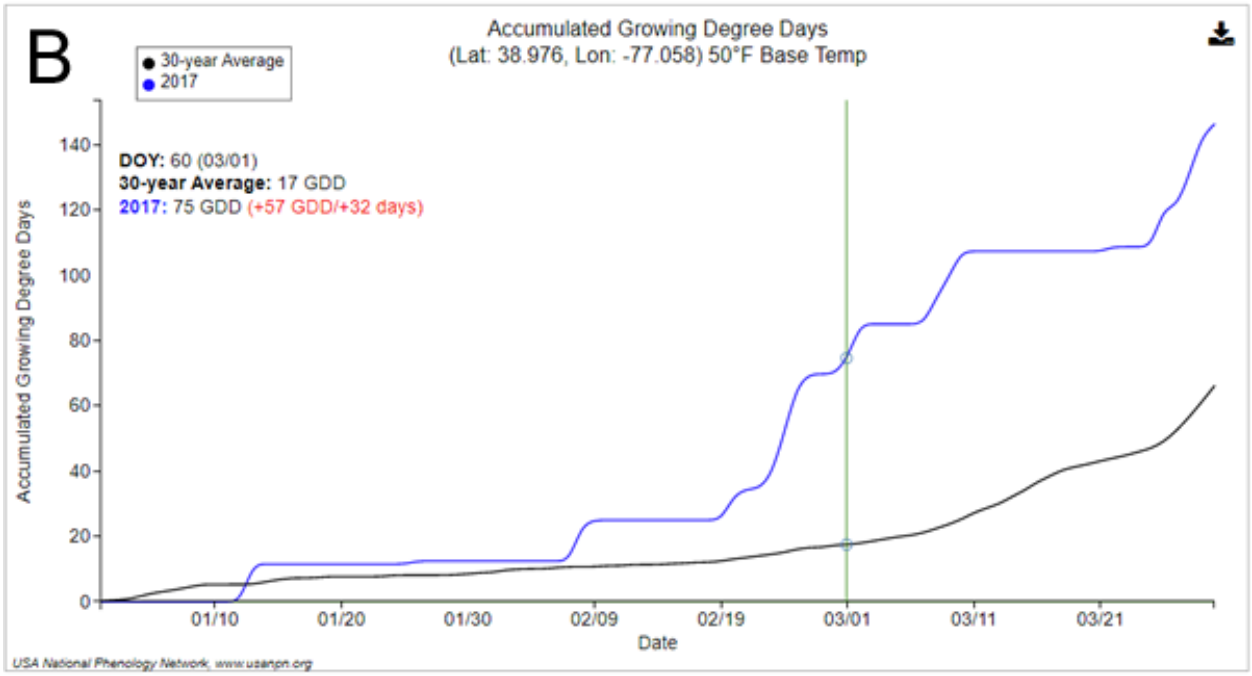
For example, very warm conditions in the Southeast in February 2017 led the National Park Service to predict a record-breaking early peak for the Tidal Basin cherry blossoms in Washington, DC. Peak bloom typically occurs around April 1 (Samenow & Ambrose, 2017). The rapid rate of heat accumulation through the South in January and February 2017 led NPS officials to predict the peak to occur between March 14 and March 17 (Samenow & Ambrose, 2017).

GDD anomaly maps support these observations and predictions. As of March 1, 2017, Washington, DC, was 60 GDDs ahead of schedule, suggesting an earlier peak bloom (Figure 4 Part A). As of March 1, heat accumulation was approximately 2 weeks ahead of schedule (Figure 4 Part B), suggesting an advancement of March-season plant activity of approximately 2 weeks.

Figure 4.

(A) Growing Degree Day Anomaly for the Washington, DC, Region on March 1, 2017, and (B) Heat Accumulation in Washington, DC, January–March, 2017





Note: Accessed at http://data.usanpn.org/npn-viz-tool/.

Additional Information

In addition to the USA-NPN visualization tool, GDD maps are available both as image and raster data files

through an online interface as well as through web services. Those interested can learn more at www.usanpn.org/data/agdd_maps.

USA-NPN evaluates the level of uncertainty in GDD products by comparing calculations of accumulated GDDs based on NOAA National Centers for Environmental Prediction's Real-Time Mesoscale Analysis temperature products to those made using measurements from U.S. Climate Reference Network stations. This information is available at www.usanpn.org/agdd_uncertainty.

Training tools and videos are available via a help section within the USA-NPN visualization tool and at www.usanpn.org/data/visualizations.

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