Cherry Blossom Prediction

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Predicting peak bloom dates for the cherry blossoms every year is critical to the planning of many well-known festivals and cultural events around the world. Moreover, peak blooms dates for cherry blossoms have been displaying a pattern of earlier and earlier blooms since the 19th century and has even surpassed the 30-year average for some areas, including Washington D.C.[1]

The large-scale burning of fossil fuels like methane and CO_2 has caused temperatures to rise, a process called the "greenhouse effect." Since most of the Sun's heat remains trapped inside Earth's atmosphere, global warming has had a significant impact on the Earth's climate over the course of recent centuries.[4] The common inference is that climate change is the major cause of the earlier blooming dates.[2]

Weather patterns are impacted by climate change as well, and factors such as warmer or colder winter temperature also affect peak bloom dates. It is suggested that cherry blossoms need "a full month of cold weather below 41 degrees [fahrenheit] in order to bloom properly." [7] We decided to explore the relationship between winter temperature, specifically average temperature in January and February, and the bloom dates in Washington, D.C, Kyoto, and Liestal. For Kyoto and Liestal we used the ghcnd_stations() and meteo_nearby_stations() functions in the R package *rnoaa* to find and retrieve weather data from the National Oceanic and Atmospheric Administration.

Heat accumulation is commonly used to predict phenological transitions such as peak bloom dates. A common metric for heat accumulation is aggregate growing degree days (AGDD). This measure is useful since it assesses how soon a transition is likely to occur, so long as the growing degree threshold for that particular organism is known.[6] The equation for calculating AGDD is

$$AGDD = ((T_{max} + T_{min})/2) - T_{base}$$

Since temperature is incorporated in the equation for AGDD, that means AGDD is affected by climate change as well.

Our model is a multiple regression with AGDD, average January temperature (in degrees Celsius) and average February temperature (in degree Celsius) as predictors for peak bloom date. The equation for the model is

$$bloom\ doy = \beta_0 + \beta_1 agdd + \beta_2 Jan_{avg} + \beta_3 Feb_{avg} + \epsilon,$$

Where β_0 is the y-intercept, β_1 is the slope coefficient for AGDD, β_2 is the slope coefficient for average January temperature, β_3 is the slope coefficient for average February temperature, and ϵ represents the model's residual errors.

After all covariables were analyzed and tested using the multiple linear regression analysis, the data was then ensured to be a stationary set so that it can be incorporated into a vector autoregressive model for multivariate time series analysis (VAR model). The formula for a VAR model is

$$\mathscr{X}_{t,n} = \alpha + \Phi_{t1}\mathscr{X}_{t-1,n} + \Phi_{t2}\mathscr{X}_{t-1,n} + \ldots + \Phi_{tn}\mathscr{X}_{t-1,n} + e_{t,n}$$

Where $\mathscr{X}_{t,n}$ represents the time series variables for the bloom dates for all *t* (years from 1980-2021) with *n = 41* lags (where *lag* is the value of a variable in a previous time period), Φ is the time-invariant matrix (makes data into matrix form), and the error term *e*. The VAR model was used to predict the bloom date values for all locations for the next 10 years (2022 - 2031).

Preparing for the future is just one of the many steps needed to solve the issues caused by climate change. Climate change can incite changes in weather patterns, such as drought and flooding.[6] Analyzing the peak bloom dates for cherry blossoms around the world can give insight towards many future environmental outcomes. This can ensure that the proper preparations can be met to help mitigate the negative effects of climate change.

Citations:

1. Burnett, Elena. “What the Cherry Blossom Bloom Can Tell Us about Climate Change.” *NPR*, 5 Apr. 2021, <https://www.npr.org/2021/04/05/984470981/what-the-cherry-blossom-bloom-can-tell-us-about-climate-change?t=1646096687231.>

2. “Effects of Climate Change.” *Met Office*, <https://www.metoffice.gov.uk/weather/climate-change/effects-of-climate-change#:~:text=Warmer%20air%20can%20hold%20more,of%20changes%20in%20wind%20patterns.>

3. “Causes of climate change.” *Met Office.* <https://www.metoffice.gov.uk/weather/climate-change/causes-of-climate-change#:~:text=The%20evidence%20is%20clear%3A%20the,the%20planet%20to%20heat%20up.>

4. “The greenhouse effect: Discovering ecology and Climate change.” *British Geological Survey*. <https://www.bgs.ac.uk/discovering-geology/climate-change/how-does-the-greenhouse-effect-work/>

5. “Climate change impact.” *National Oceanic and Atmospheric Association*, 13 Aug. 2021. <https://www.noaa.gov/education/resource-collections/climate/climate-change-impacts#:~:text=The%20impacts%20of%20climate%20change%20on%20different%20sectors%20of%20society,availability%2C%20and%20limit%20worker%20productivity.>

6. “Accumulated Growing Degree Day Products.” *National Phenology Network*. <https://www.usanpn.org/data/agdd_maps>

Data Sources

- (Kyoto data) <https://www.data.jma.go.jp/obd/stats/etrn/view/monthly_s3_en.php?block_no=47401&view=12>

- (Liestal temperature and precipitation data) https://www.meteoswiss.admin.ch/home/climate/swiss-climate-in-detail/homogeneous-data-series-since-1864.html?region=Table

  https://www.meteoswiss.admin.ch/product/output/climate-data/homogenous-monthly-data-processing/data/homog_mo_BAS.txt

- (Liestal wind data, 1985 - 2021) <https://weatherspark.com/h/m/56447/1985/4/Historical-Weather-in-April-1985-in-Basel-Switzerland#Figures-WindSpeed>

- (Liestal wind data, 1980-1984) <https://www.meteoswiss.admin.ch/home/climate/the-climate-of-switzerland/monats-und-jahresrueckblick/the-swiss-weather-archive.html>

  <https://www.meteoswiss.admin.ch/product/input/documents/annals/annalen-1980.pdf>

  <https://www.meteoswiss.admin.ch/product/input/documents/annals/annalen-1981.pdf>

  <https://www.meteoswiss.admin.ch/product/input/documents/annals/annalen-1982.pdf>

  <https://www.meteoswiss.admin.ch/product/input/documents/annals/annalen-1983.pdf>

  <https://www.meteoswiss.admin.ch/product/input/documents/annals/annalen-1984.pdf>

- (Vancouver data) <https://vancouver.weatherstats.ca/download.html>

- (DC temperature data) <https://www.npr.org/2021/04/05/984470981/what-the-cherry-blossom-bloom-can-tell-us-about-climate-change>

- (DC precipitation data) <https://www.weather.gov/wrh/Climate?wfo=lwx>

- (DC wind data) <https://www.visualcrossing.com/weather/weather-data-servi