Analyzing Sakura Flowering Trends Under Climate Change*

Predicting Bloom Dates Using Historical Records and Temperature Data

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November 28, 2024

This study uses historical and modern data to analyze the impact of temperature and long-term trends on sakura flowering in Japan. Linear regression highlights a significant shift toward earlier flowering dates, while generalized additive models (GAMs) capture non-linear relationships. Model comparison via AIC favors the GAM, showing its effectiveness in handling complex patterns. Predictions under future climate scenarios (+1°C, +2°C, +3°C) indicate flowering dates may advance by 5–15 days by 2070. These results underscore the sensitivity of sakura flowering to climate change and its broader ecological and cultural implications.

1 Introduction

In Japan, cherry blossoms, or "sakura," have been a significant cultural and historical symbol, representing the transient beauty of life. The practice of "hanami," or flower viewing, dates back centuries. During the Heian period (794-1185), aristocrats would gather to appreciate the blossoms' fleeting beauty while composing poetry (Japan National Tourism Organization (n.d.)). Hanami has developed into a deeply ingrained cultural tradition that transcends social classes, with its economic significance growing in modern times. Recent research by Katsuhiro Miyamoto indicates that the economic impact of hanami in Japan is expected to double this year, highlighting its role as a cultural event and an economic activity (Kaneko (2024)).

However, a concerning trend has surfaced in recent decades: sakura blossoming earlier each year, attributed mainly to rising global temperatures. According to The Economist, the earlier blooming of cherry blossoms is closely tied to climate change, raising concerns about the long-term implications for Japan's cultural heritage and biodiversity (The Economist (2017)). This shift in flowering trends serves as a reminder of humanity's impact on the environment and a

*Code and data are available at: https://github.com/leemarik/sakura-flowering-trends.git.

pressing scientific challenge to understand the intricate relationships between climate variables and flowering dates.

The estimand of this analysis is the relationship between average March temperatures, year, and the Sakura flowering dates. By analyzing centuries of historical and modern sakura data, my goal is to determine how changes in temperature and long-term climate trends have impacted the timing of sakura blooming. Additionally, I aim to forecast future flowering dates under various climate scenarios, providing insights into the potential effects of climate change on this culturally significant phenomenon.

Despite the historical documentation of sakura flowering trends, there is a critical gap in understanding how these changes will evolve in the future under various climate scenarios. This analysis addresses this gap by using historical and modern data on sakura flowering dates and temperatures to determine the impact of climate change on flowering dates. I used statistical modeling techniques of linear regression and generalized additive models (GAMs) to explore the relationship between temperature, year, and flowering dates. These models provide insights into past trends and enable predictions for future scenarios under different temperature increases.

The findings indicate that rising temperatures strongly correlate with earlier blooming dates, which have accelerated over the last century. By modeling these patterns, the analysis offers a framework for predicting future sakura blooming dates and assessing the broader implications of climate change on cultural and ecological systems. This research contributes to scientific understanding and highlights the urgency of climate mitigation efforts to preserve cherished cultural practices like hanami.

The structure of this paper is as follows: Section 2 reviews the data sources and preprocessing methods used in this analysis. Section 3 details the modeling approaches, specifically Linear Regression and Generalized Additive Models. Section 4 presents the results, followed by a discussion in Section 5 on the implications, limitations, and future directions.

2 Data

2.1 Overview

Overview text

2.2 Measurement

Some paragraphs about how we go from a phenomena in the world to an entry in the dataset.

2.3 Outcome variables

Add graphs, tables and text. Use sub-sub-headings for each outcome variable or update the subheading to be singular.

Talk more about it.

Talk way more about it.

2.4 Predictor variables

Add graphs, tables and text.

Use sub-sub-headings for each outcome variable and feel free to combine a few into one if they go together naturally.

3 Model

To determine the impact of temperature on sakura flowering dates over centuries and develop predictive models for future trends under different climate scenarios, I used a linear regression model (LM) as a baseline and a generalized additive model (GAM) for capturing non-linear relationships in the data.

3.1 Linear Regression Model

The linear regression model I will be using is:

3.2 Generalized Additive Model (GAM)

Where:

3.2.1 Model justification

4 Results

5 Discussion

Appendix

A Additional data details

B Model details

B.1 Posterior predictive check

B.2 Diagnostics

References

Japan National Tourism Organization. n.d. "Sakura History: The Story Behind Japan's Cherry Blossoms." https://www.japan.travel/en/au/experience/cherry-blossoms/sakura-history/#:~:text=For%20many%20Japanese%2C%20the%20blooming,watching\XeTeXglyph\numexpr\XeTeXcharglyph"0027\relax{}%20parties%20known%20as%20hanami.

Kaneko, Karin. 2024. *Economic impact of hanami expected to double this year. The Japan Times*. https://www.japantimes.co.jp/news/2024/03/15/japan/society/hanami-economic-impact/.

The Economist. 2017. "Japan's Cherry Blossoms Are Emerging Increasingly Early." *The Economist*. https://www.economist.com/graphic-detail/2017/04/07/japans-cherry-blossoms-are-emerging-increasingly-early.