PHENOLOGY MODEL FOR THE JACARANDA BLOSSOMS

GROUP MEMBERS[1]

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Outline

Background

Background

- Jacaranda refers to the tree species Jacaranda Mimosifolia.
- Introduced to South Africa from Brazil in the late 1800s as ornamentals to the pavements of the CBD of Pretoria. and later expanded through Pretoria, Johannesburg, and later to smaller cities of Pietermaritzburg, Pongola, Paarl, etc.

Introduction

- Pretoria referred to as the 'Jacaranda City', and the trees form part of what has become one of the world's largest urban forests Classified as a category 3 invasive species, replanting and sale of these trees is prohibited, but existing trees do not need to be removed.
- Given the aesthetic and identity importance, these trees therefore represent a relatively unique flagship invasive species, and there is considerable public interest in protecting the existing trees.
- Jacarandas flower in early summer with clustered purple blossoms.

Introduction

- In the 1920s, Jacarandas were blossoming in mid- to late-November.
- In 2019, the blossoms in Gauteng appeared in mid-September; the same was true in 2017 and 2018. In 2015 and 2016 they appeared in the last week of September
- This shift in the timing of flowering has been observed across almost all plants.
- This is termed a phenological shift, and is occurring as a result of climate change.

Whats the future for jacaranda?

- This phenological shift poses a threat to the future of these trees .
- However, these shifts cannot occur indefinitely, at which point the plant is at risk?

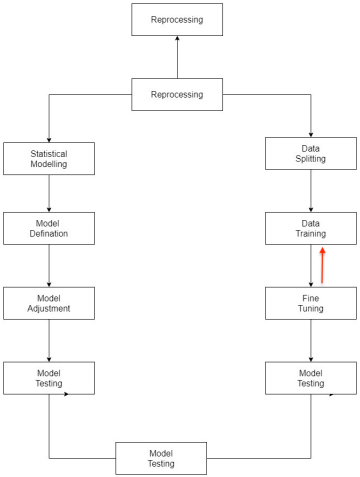
Existing Models

- A number of models have been proposed for other plants.
- These models use temperature, rainfall, sunshine, etc.
- Temperature is recognized to be the main variable which regulates the timing of budburst.
- Some of these models have been used in Germany and France for the case of apples, cherries, etc .

Existing Models

- Depends on temperature.
- Performed in Europe in Germany and France.
- Pollen data was used in the model.

Methodology.



Statistical Modeling:Progressive Utah Model.

The model takes the following general form:

$$GDH(k) = GHD(k-1) + \sum_{h=1}^{24} \max\left\{0, (T_h(k) - T_b)\left[1 + \left(\frac{GDH(k-1)}{GDH_{in.flow}}\right)^2\right]\right\}$$

where
k is the generic day for that particular year
GDH is growing degree hours
$T_h(k)$ is hourly temperature at any given time calculated using sine based formula
T_b threshold value (To be estimated it)
$GDH_{in.flow} = f(slope, aspect, climatic\ mean\ T)$ initial flowering

Parameter Estimates

Day:

$$T_h(k) = T_h(k) = (T_{\max} - T_{\min}) \cdot \sin\left(\frac{\pi \cdot t_a}{DL + 4}\right) + T_{\min} \quad (1)$$

Night:

$$T_h(k) = T_{ss} - \frac{T_{ss} - T_{\min+1}}{\ln(24 - DL)} \cdot \ln(t_b) \quad (2)$$

where $T_{\max}$ and $T_{\min}$ is average maximum and minimum temperature, DL is day length, t_a time in hours after sunrise, t_{ss} temperature at sunset obtained from 1, t_b time in hours after sunset.

Chilling Units

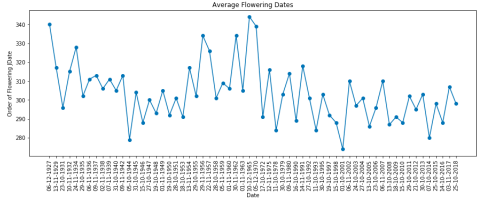
Temperature [°C]	CU
$T<1.4$	0
$1.5<T<2.4$	0.5
$2.5<T<9.1$	1
$9.2<T<12.4$	0.5
$12.5<T<15.9$	0
$16<T<18$	−0.5
$T>18$	−1

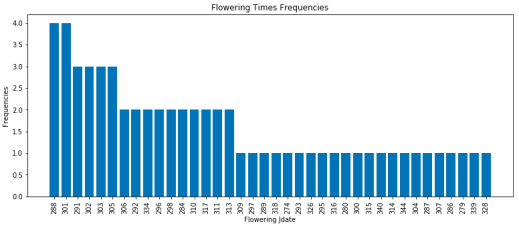
- Growing degree hours is very promising method to use because Jacaranda trees have a predictable development pattern based on heat accumulation.
- The method has been recognized to interpret heat more accurately.

Data

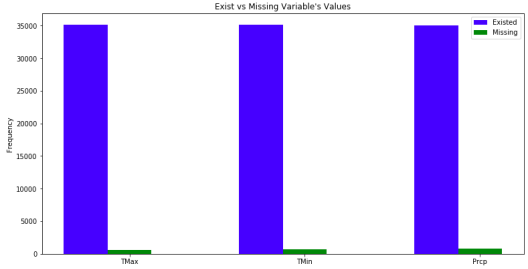
- Minimum and maximum emperature data (Source: South African Weather Service from 1946 to 2018).
- Flowering data (Source: Newspapers from 1921 to 2018).
- Rainfall data.
- Day length, sunrise and sunset time.

Exploratory Data Analysis

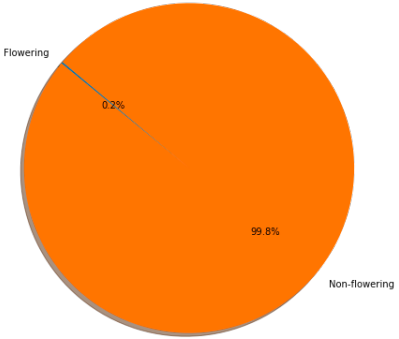


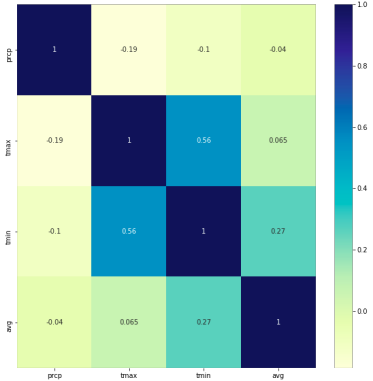


Exploratory Data Analysis



Exploratory Data Analysis



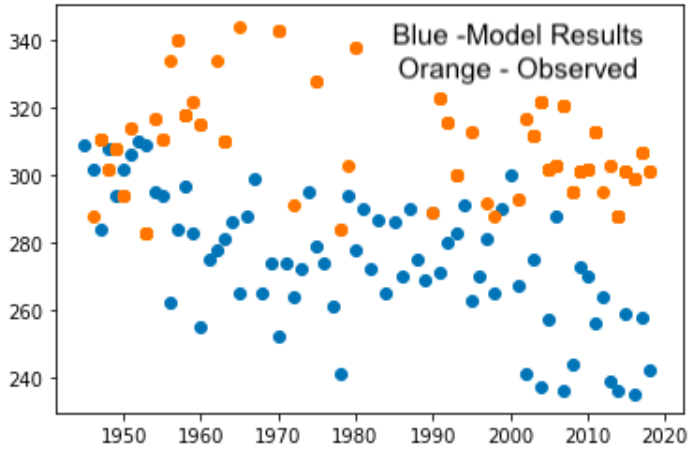


Preprocessing

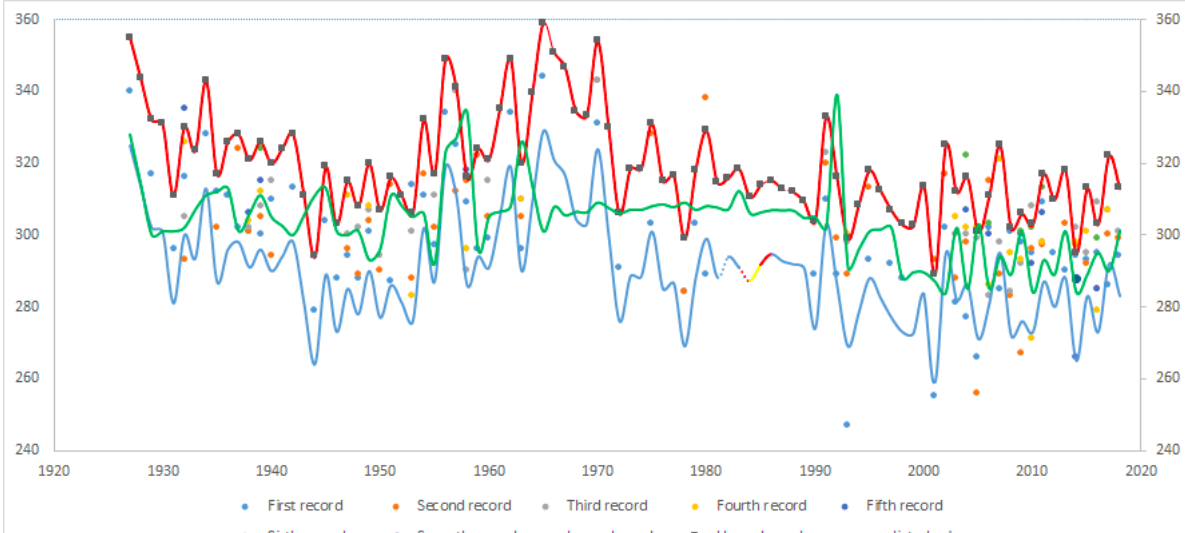
Generating new variables

1. Temperature Average
2. Forst temperature
3. Start rain
4. end rain

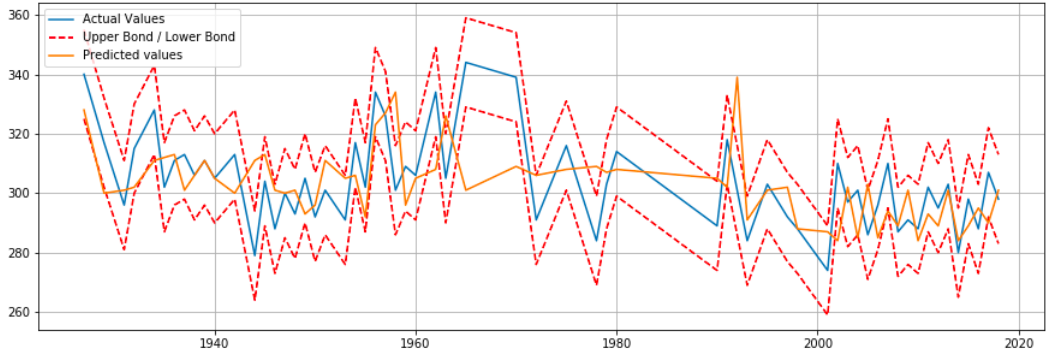
Results from Model



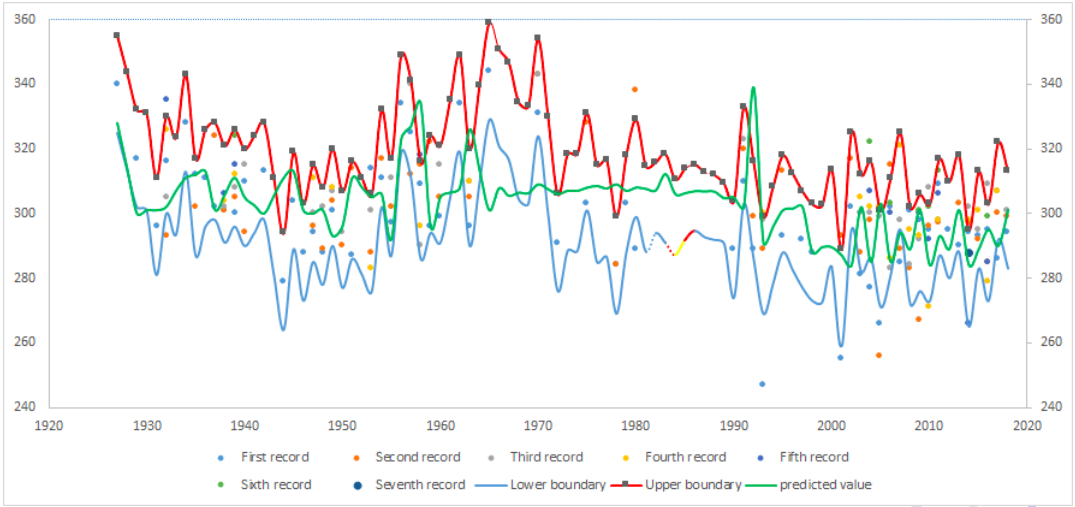
Results


360
340
320
300
280
260
240
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
First record
Second record
Third record
Fourth record
Fifth record

Results


Actual Values
Upper Bond / Lower Bond
Predicted values
360
340
320
300
280
260
1940
1960
1980
2000
2020

Results


360
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1950
1960
1970
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1990
2000
2010
2020
First record
Second record
Third record
Fourth record
Fifth record
Sixth record
Seventh record
Lower boundary
Upper boundary
predicted value

Machine Learning

file:///Users/user/Downloads/RandomForest-SemiFinal-Copy1.html

Conclusion

- Issues with missing data
- Limited time
- Machine learning method performed better than the Progressive Utah model.