# CLIMATE CHANGE IMPACT ON GROWING DEGREE DAY ACCUMULATION VALUES

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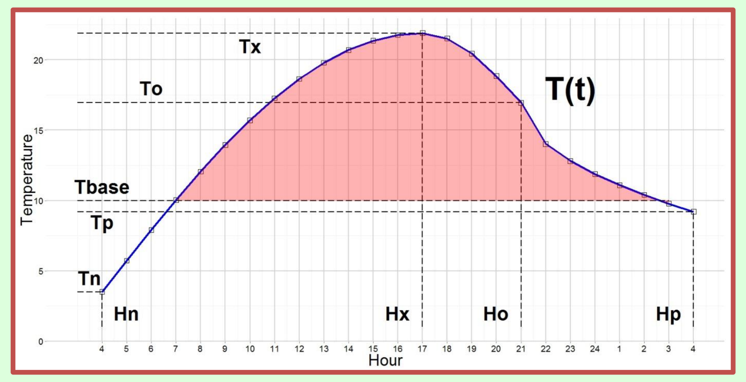
## Introduction

The climate change affects many industries. The aim of this study was to evaluate consequences in climatology of plant development. Strawberry bloom, first and second fruit times were used as an example case . Growing degree days(GDD) methodology was used to evaluate bloom and harvest times.

## Methodology for calculation of daily growing degree days

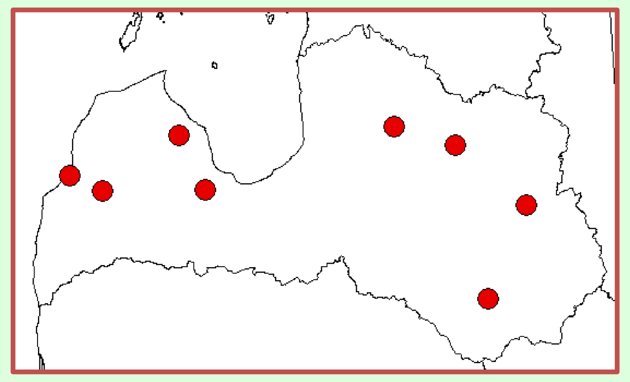
To estimate temperature cycle from daily minimum and maximum temperature methodology by Cessaraccio et al. (2011) was used. This method uses two sine functions and square-root function to estimate daily temperature cycle $T(t)$. The amount of GDD is calculated as area between base temperature and $T(t)$ and divided by 24.

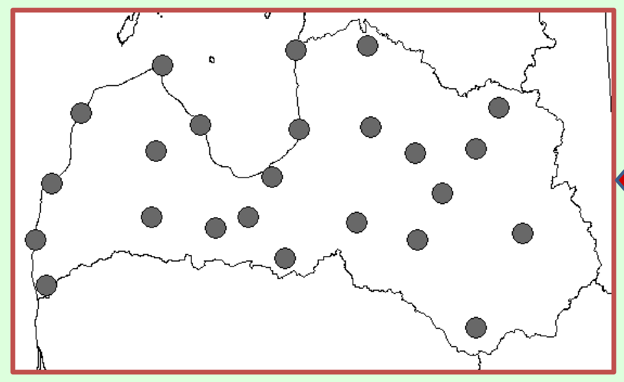
$Hn$ – sunrise hour, $Hx$ – time of maximum temperature, $Ho$ – sunset hour, $Hp$ – sunrise of the next day.




## Methodology for estimation of the base temperature and GDD sum

**1.** Strawberry observations fields. Observations in these locations contained calendar dates of bloom, first and second fruit for years 2010-2013.





**2.** Observations of minimum and maximum air temperature from meteorological stations in Latvia. These observations were interpolated to strawberry field locations.

**3.** Iteration process through different base temperatures and GDD sums (similar to Snyder R. L. et al, 1999) was carried out for minimum and maximum temperature observations. For each set of calculated bloom, fruit days RMSE between calculated and observed bloom, fruit days was evaluated. Result with smallest RMSE was chosen (see table).

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(dc_i - d_i)^2}{n}}$$

$dc_i$ - calculated number of days, $d_i$ - observed number of days, $n$ - number of obs.

| Process | Base T | GDD sum | $n$ | $RMSE$ |
|---|---|---|---|---|
| **Bloom** | 0 | 586 | 19 | 4.3 |
| **Fruits 1** | 6 | 284 | 16 | 7.3 |
| **Fruits 2** | 10 | 95 | 13 | 2.6 |

## Methodology for regional climate models

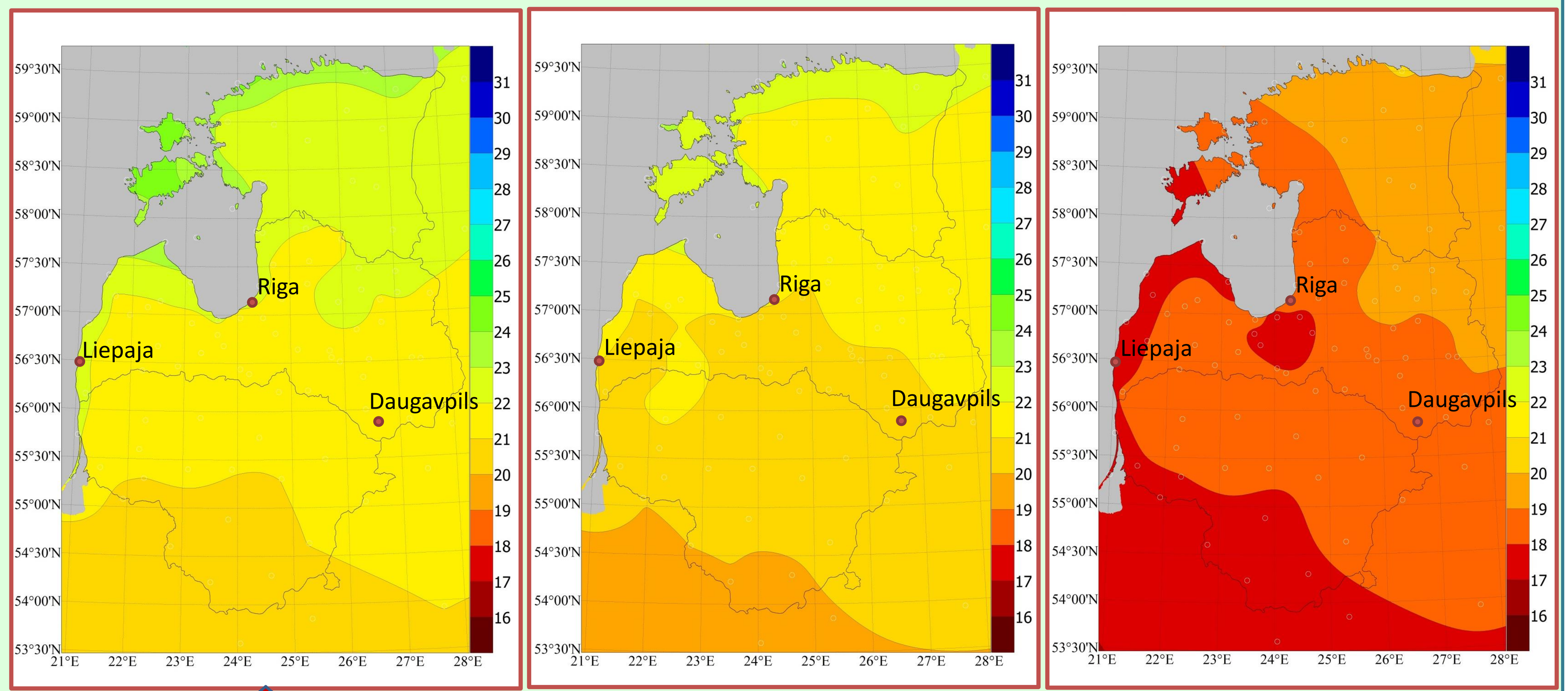
**1.** The models used in this study are an ensemble of Regional Climate Models (RCM, ENSEMBLES project, 15 runs are considered). The data used are continuous time series of daily minimum and maximum air temperature at 2 meters for years 1951-2099. All of time series are bias corrected (Sennikovs J., 2009).
**2.** For each of time series day of bloom, first and second fruits was calculated as average of periods of 30 years.
**3.** Multimodal statistics – median and 20th and 80th percentile - of all results were calculated.

## Strawberry bloom and first fruit times

Following graphs show bloom and fruit times as weeks since beginning of the year. These times are calculated as median of all model results.

**1951-1980** | **2001-2030** | **2070-2099**

**Bloom**

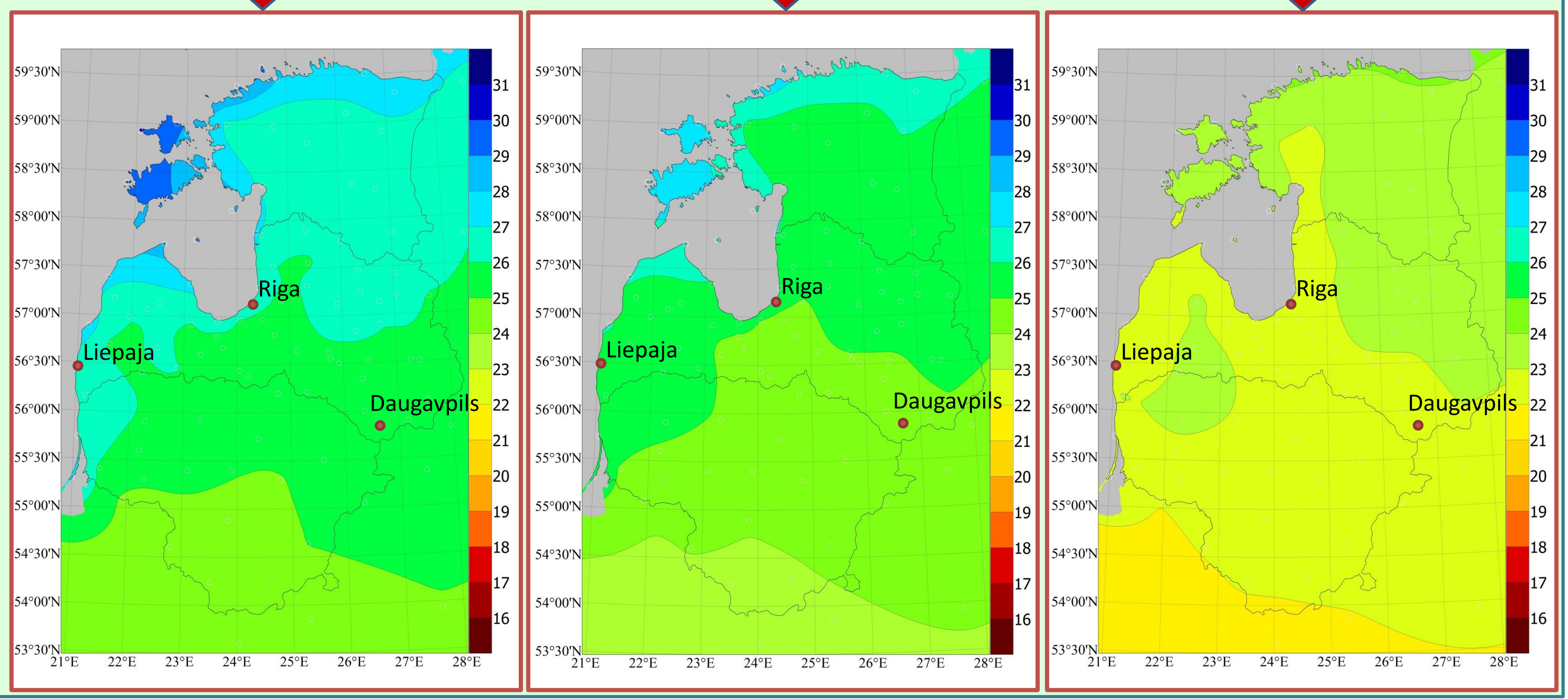



Bloom happens in second half of May, first half of June (week 20-24). First fruits are in June, beginning of July (week 23-29).

Bloom happens in May, beginning of June (week 19-23). First fruits are in June (week 23-27).

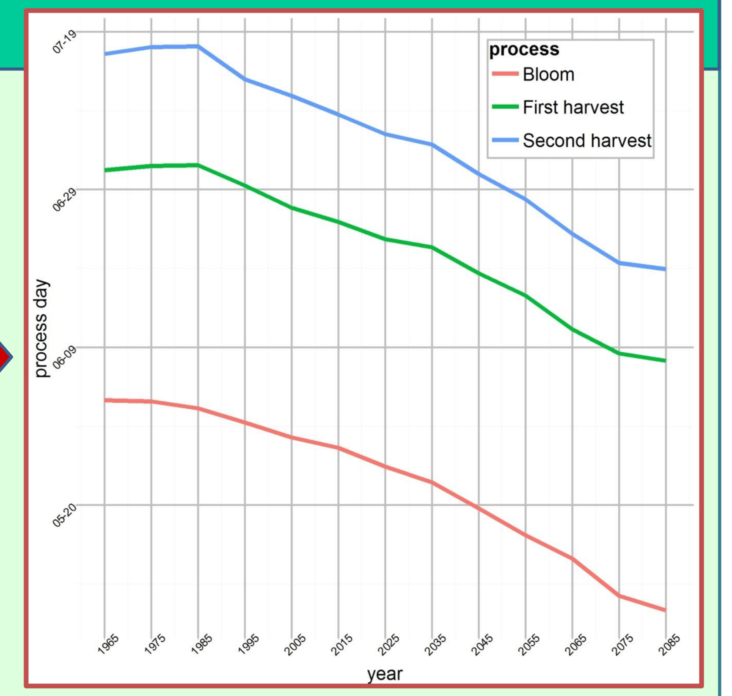
Bloom happens at the end of April, in May (week 17-20). First fruits are in May, beginning of June (week 20-24).

**First fruits**

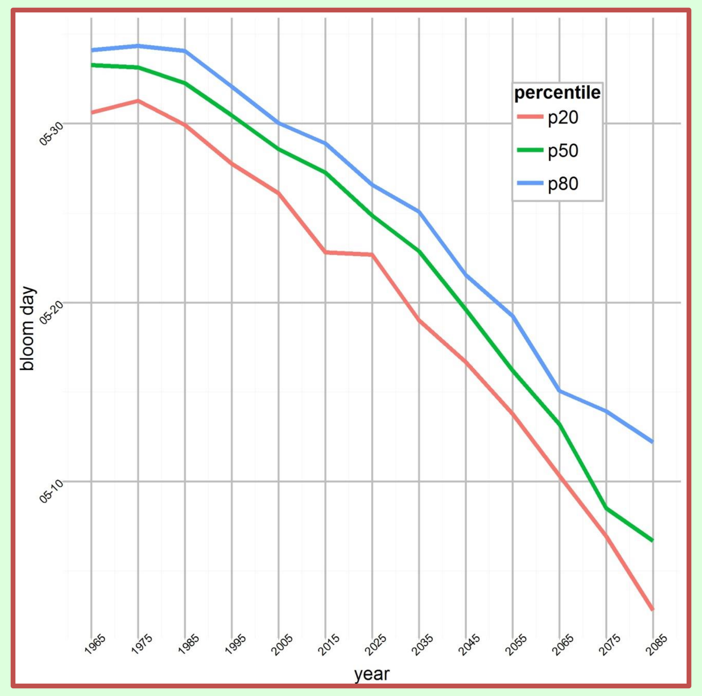



## Comparison

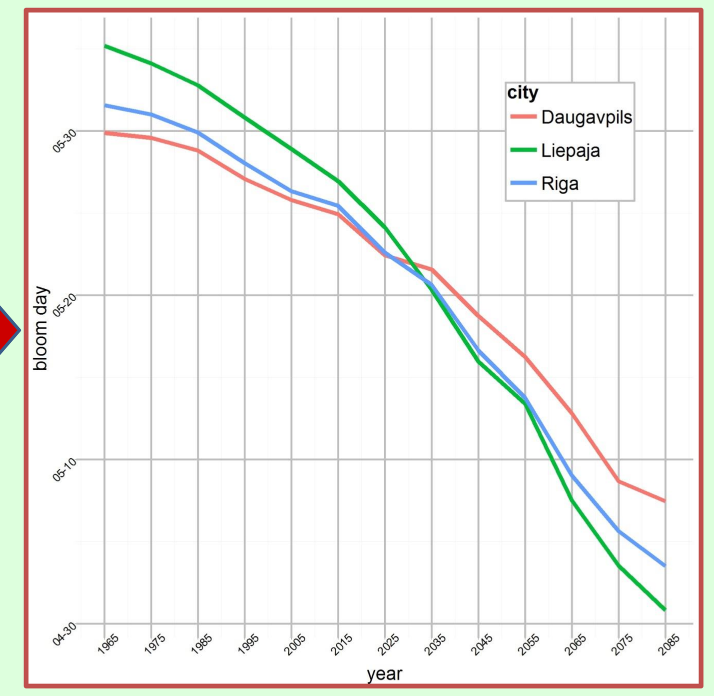
Graph of blooming, first and second fruits in Liepaja (seaside location). There is a similar decrease in weeks required for bloom, first and second fruits.




Graph of bloom in Liepaja. In addition to median also value of 20th and 80th percentile of all model results are displayed.




Graph of blooming in different locations – seaside (Liepaja), Gulf of Riga (Riga), inland (Daugavpils). In seaside location change in bloom time is more rapid resulting in switch of relative blooming times between different locations.




## Conclusions

- The ensemble model results shows that bloom and fruit happens earlier when comparing past to present and present to future.
- This change is more rapid in seaside locations.
- A change of relative bloom times between different location can be observed, as well as point in time when these processes happen simultaneously.

**References**
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