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Developing a bud burst model for grapevine to assess future late frost risk in Luxembourg

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Introduction

Late frost damage represents a significant hazard to grape production in cool climate viticulture regions such as Luxembourg. Spring frost injuries on grape may occur when young green parts are exposed to air temperature below 0°C. The potential risk is determined by: (i) the day of bud burst and (ii) the day of the last frost event in the season.

So far it is unknown if climate change will increase or decrease the risk of severe late frost damages for Luxembourg's winegrowing region.

The aim of this study was to analyze the frequency of severe late frost these events for Luxembourg viticulture in the future.

Figure 1: Grape shoot damaged by a late frost event in Luxembourg in May 2011.

Materials and Methods

1) **Development of a budburst model for the variety Rivaner**

- DORMPHOT model: developed for the simulation of budburst; it takes into account photoperiod(Caffarra et al. 2011)
- Calibrated and validated using a large phenological dataset composed of data from 7 different sites in Europe and the U.S. (n=109): Remich (L), Geisenheim (D), Neustadt (D), Veitshöchheim (D), Klosterneuburg (A), Grand Junction (USA) and Crosano (I).
- It considers the action of cool (chilling) temperatures for dormancy release, and the action of warm (forcing) temperatures for subsequent bud growth.

2) **Projection of future climate conditions in Luxembourg**

- To project the future climate conditions, seven regional climate change projections from the FP6 ENSEMBLES project (spatial resolution = 25km; A1B emission scenario) were incorporated.
- The use of multi model ensemble of climate change projections allows for a better quantification of the uncertainties. A bias corrections scheme, based on local observations, was applied to the model output.

3) **Combining climate projections with the new budburst model**

- Projected daily minimum air temperatures, up to 2098, were compared to the projected date of bud burst in order to quantify the future frost risk for Luxembourg.

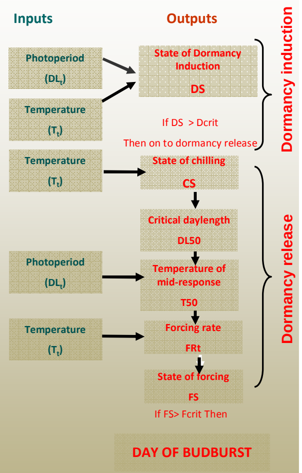

Figure 2: Conceptual scheme of the phenological model

Results and discussion

Projected budburst and last frost events.

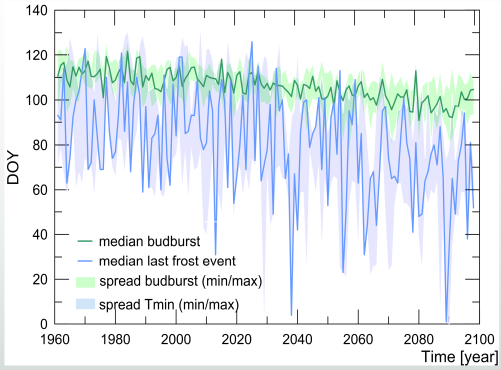

Figure 4: Projected days of budburst (green) and days of last frost (blue) in the period 1961 to 2098. Lines represent the median of the 7 Ensemble members. Spread is indicated in (budburst date) in terms of the minimum and maximum value and in (last frost event) in terms of +/- the standard deviation.

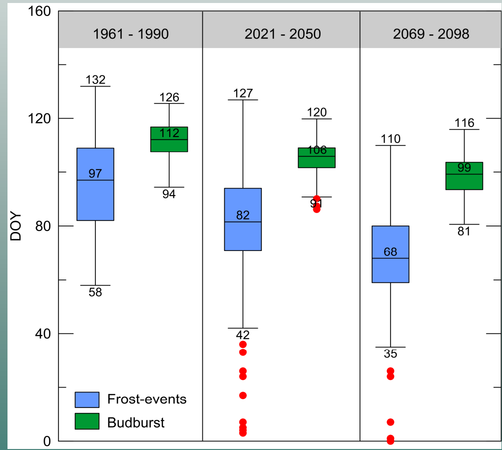

Figure 5: Projected days of the last frost in the season and days of budburst in the past (time slice 1961-1990), in the near future (2021-2050) and the far future (2069-2098). Box plots are indicating the medians and the 25% and 75% percentiles, whiskers are limited to 1.5 times the quartile ranges, outliers are marked with red spots.

- Future climate projections show that both date of budburst and the date of the last frost event will advance (Figures 4 and 5). This advance will be more marked for the last frost event than for budburst, I.e. the time period between last frost event and budburst will increase leading to a lower frost risk. However, even in the far future (2069-2098) frost after budburst can not be excluded.

Results and discussion

Phenological model validation

- High average modelling efficiency (74%) and low mean absolute error (3 days)
- The model structure was suited to the dataset and the noise in the series did not affect the parameter values.
- The consistently accurate budburst predictions by the DORMPHOT model in warm years suggest that it is robust on extreme years and can be applied to future climate scenarios (Figure 2).

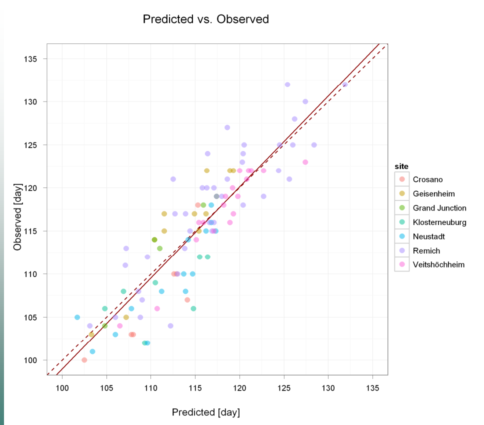

Figure 3: Predicted days of budburst according to the developed model plotted against the observed days of budburst. Dashed line: y=x; solid line: predicted vs. observed regression line.

Conclusions

- The grapevine budburst model was robust when predicting the data from a range of different locations and climates
- Climate change will lead to the advance of both grapevine budburst and the last frost event
- The time period between last frost and budburst will increase.

According to our projection the risk of frost damage events in the Luxembourg viticultural region is projected to decrease in the future, however, frost after budburst can not be excluded even in the far future.

References

Caffarra, A., Donnelly, A. & Chuine I. (2011) Modelling the timing of budburst of Betula pubescens budburst . II. Integrating complex effects of photoperiod into process-based models of budburst. Climate Research 46: 159-170.

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