modextreme

agriculture facing extreme climatic events

European Project n° 613817

2nd Annual Meeting

Modelling the impact of extreme events on phenology and fruit set in grapes

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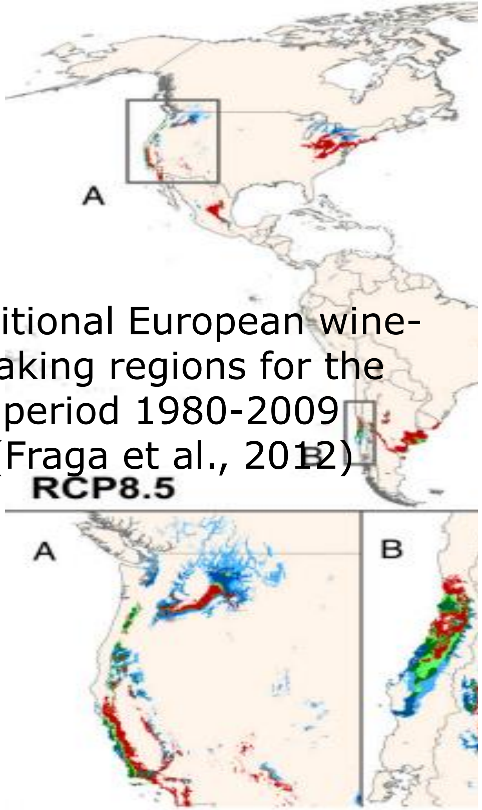
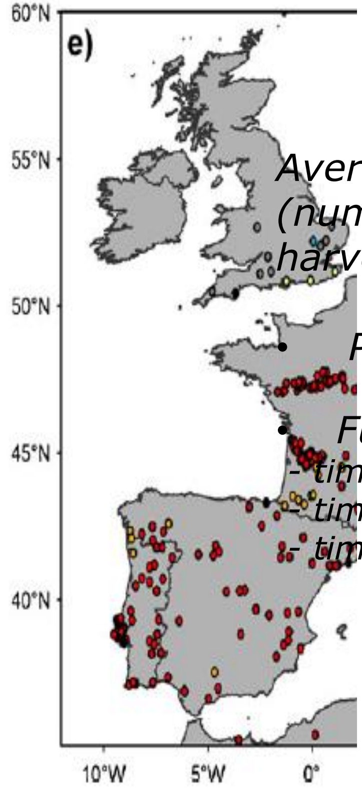
Climate change impact on grapevine

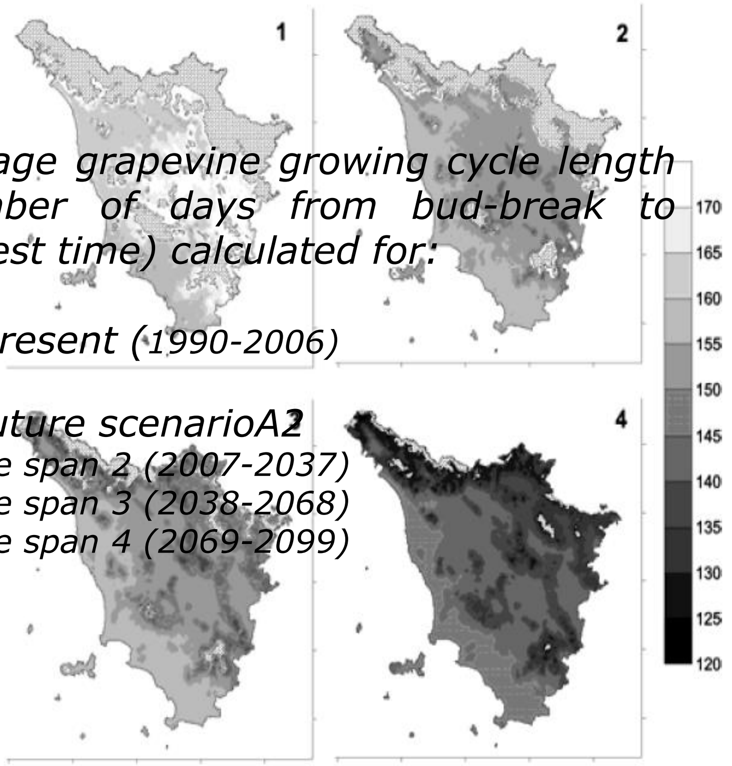
Grape suitability is expected to decrease by midcentury in the most of important and traditional wine-making regions while an increase is projected for the North America and Europe (Hannah et al., 2013).

In Mediterranean basin, the increase in temperature will have a strong impact on grape growth, development and yield.



Traditional European wine-making regions for the period 1980-2009 (Fraga et al., 2012)





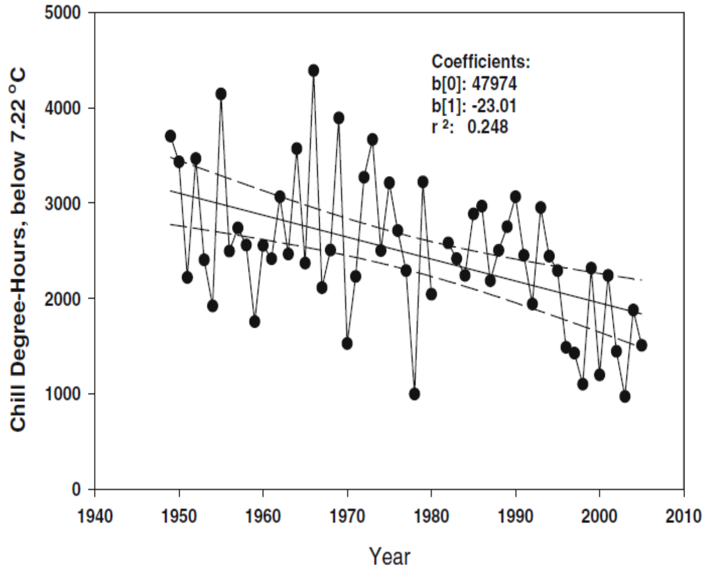
Average grapevine growing cycle length (number of days from bud-break to harvest time) calculated for:

- *Present (1990-2006)*
- *Future scenarioA2*
  - *- time span 2 (2007-2037)*
  - *- time span 3 (2038-2068)*
  - *- time span 4 (2069-2099)*

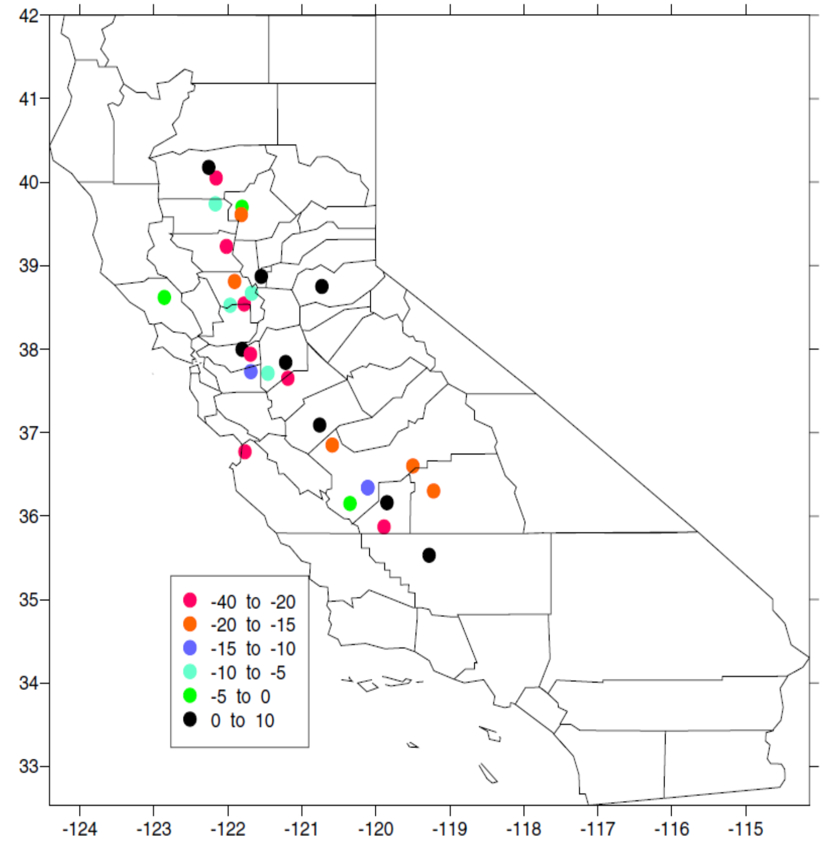
Effects of changes caused by mean climate

Phenology

- In a context of global warming, the number of chilling unit accumulated by fruit trees will be reduced (Baldocchi and Wong, 2008).



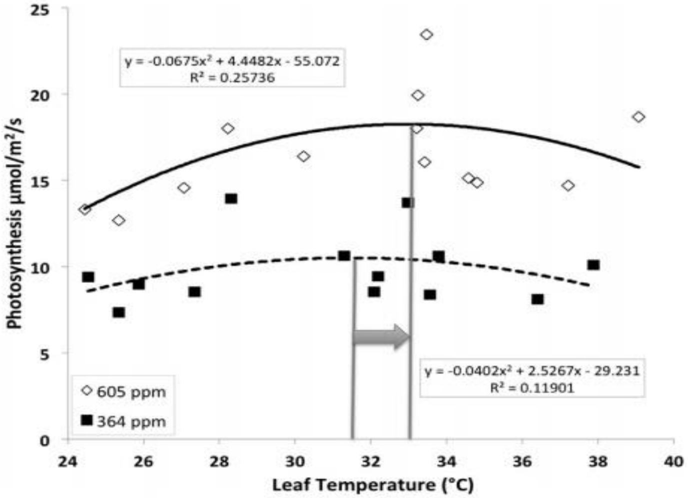
Long term trend in accumulated chill hours (Baldocchi and Wong, 2008)



Trends in Winter Chill Hour Accumulation (hours per year) November-March, 0 to 7.22 C (Baldocchi and Wong,2008)

Yield

- A future increase in temperature may lead to a higher level of photosynthesis in high CO_2 concentration levels (Moriondo et al., 2015).
- Grape yield may be reduced because of insect and diseases infestations.



(Moriondo et al., 2015)

Effects of changes caused by extreme events

Dormant | Early Bud Swell | Late Bud Swell | Bud Burst | 1-to 3-inch shoots

4-to 8-inch shoots | 10-to 16-inch shoots | Immediate pre-bloom | First bloom | Full bloom

Buckshot berries | Bunch closure | Veraison | Harvest

Budbreak

- At budbreak date, frost events (**Tmin<-2°C**) cause shoot loss and lower yield (Narcico et al., 1992; Mullins et al., 1992).

Flowering

- A lower ovule fertility, caused by a decreasing in organic nutrients available to the ovaries, may occurs at temperature of **35°C or 40°C** (Kliewer, 1977).

Veraison and Post-veraison

- Temperature higher than **35°C** during berry ripening cause lower yield and the production of small berries (Kliewer, 1977).

Extreme events effect on grape flowering

Optimum temperature for ovule fertility and fruit-set range between 20°C and 30 °C (day) and 10-20°C (night) (Buttrose and Hale,1973; Haeseler and Fleming, 1967;May 2004; Winkler et al., 1974).

Temperature of 25°C during bloom-fruit set period carried out to greater size and fresh weight of Cabernet Sauvignon berries respect to temperature of 32.5°C and higher (Kliewer, 1977) .

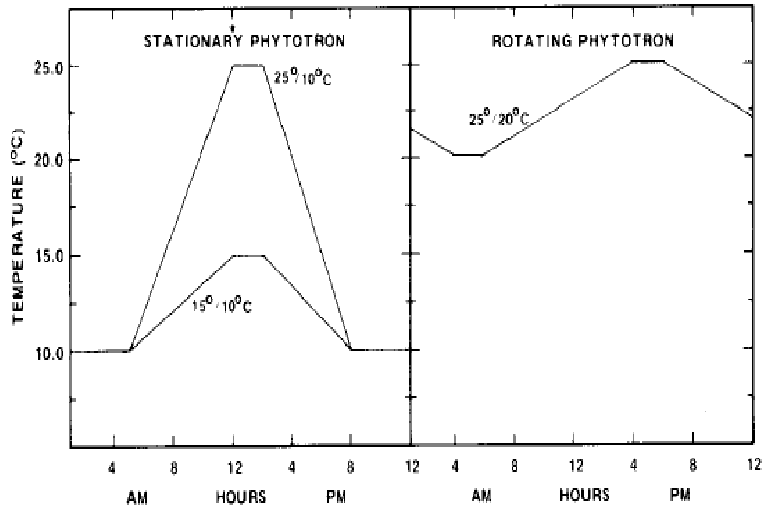
Related studies

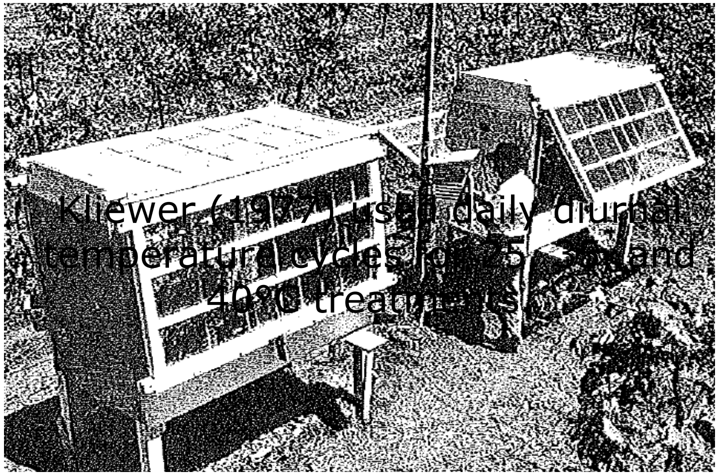
Temperature exposure were:

1954	1955	1956
68°F	61°F	65°F
78°F	64°F	69°F
85°F	73°F	79°F
- - -	82°F	89°F

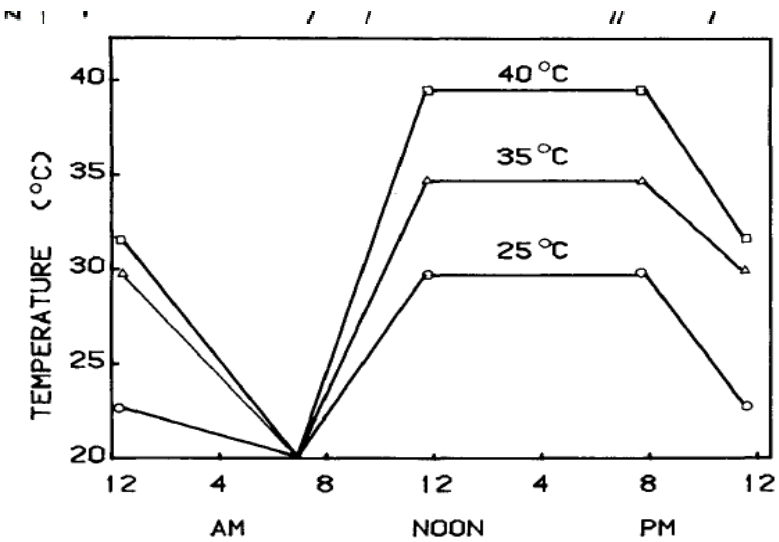
treatments for maximum day/minimum night temperatures:

- 25°/10°C
- 15°/10°C
- 25°/20°C



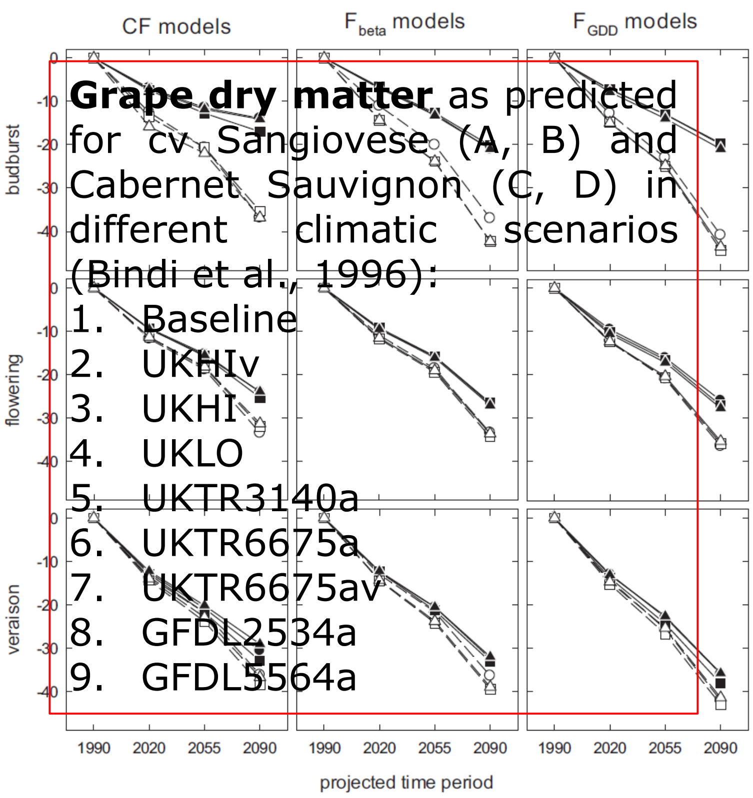


Kliewer (1977) used daily diurnal temperature cycles for 25, 35 and 40°C treatments



The contribution of the simulation models

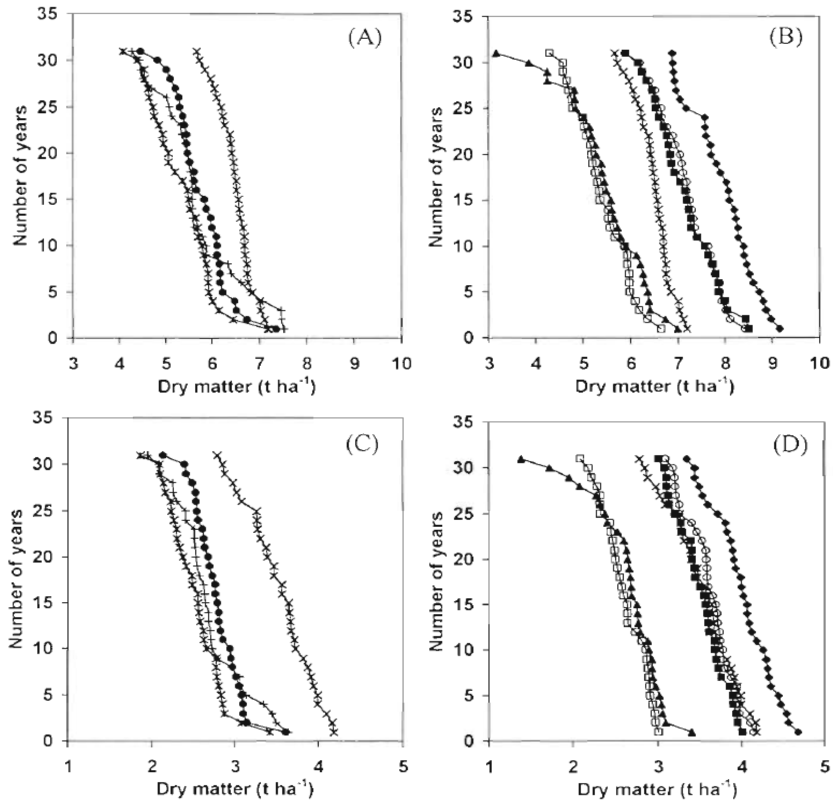
Crop simulation models represent useful tools for evaluating the impact of mean climate change on crop growth and development in present and future scenarios.



Grape dry matter as predicted for cv Sangiovese (A, B) and Cabernet Sauvignon (C, D) in different climatic scenarios (Bindi et al., 1996):

1. Baseline
2. UKHIv
3. UKHI
4. UKLO
5. UKTR3140a
6. UKTR6675a
7. UKTR6675av
8. GFDL2534a
9. GFDL5564a

Fila et al. (2014)



Bindi et al. (1996)

Objective

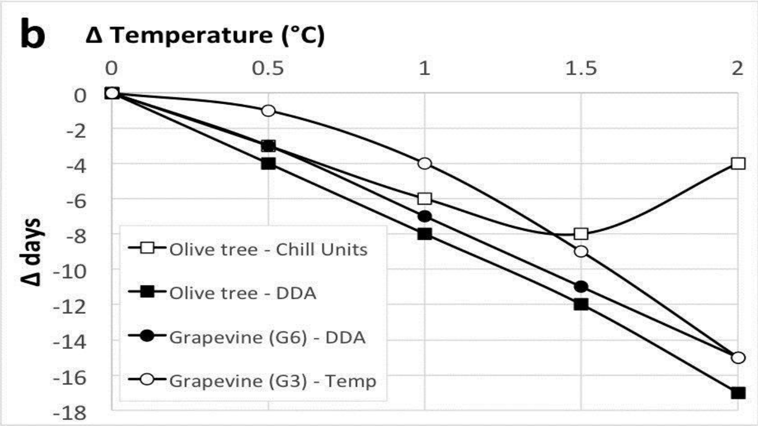
Grape model implementation

a) Phenology:

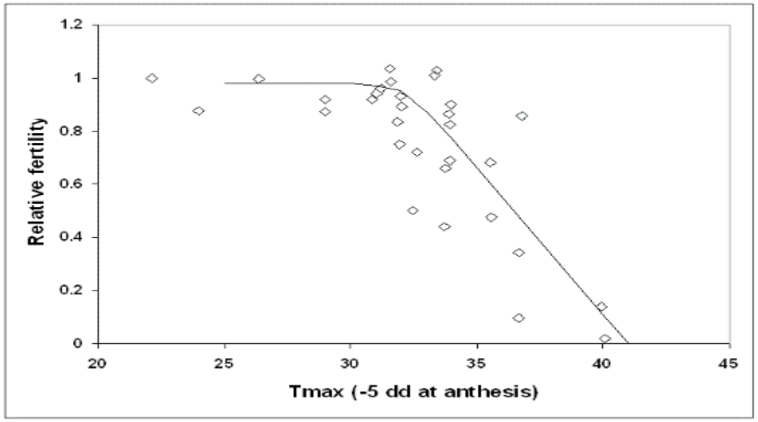
Chilling unit will be implemented in order to define better the budbreak date.

b) Extreme events:

Extreme events consider the effects on: *fertility and yield*

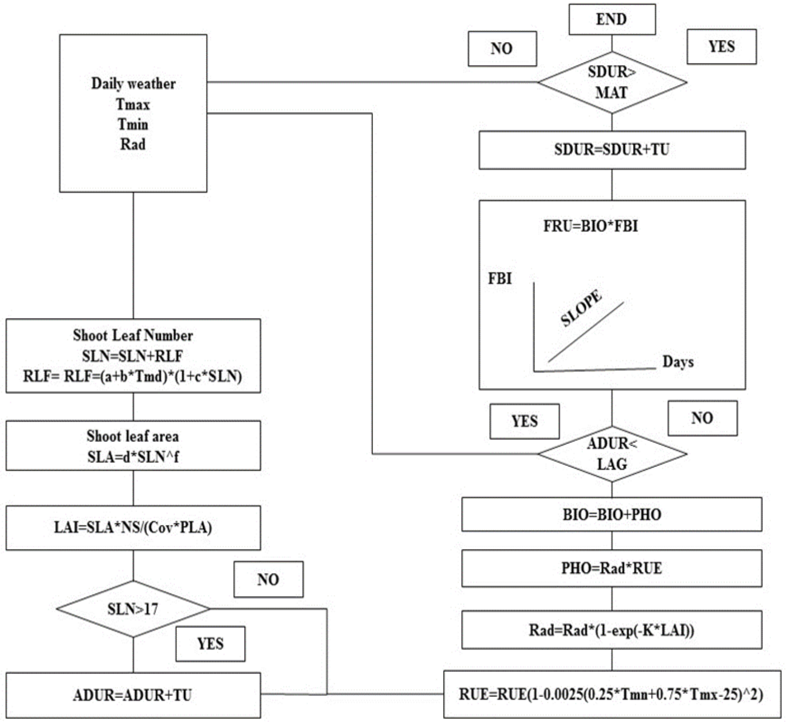


Temperature increase cause changes in anthesis days (Moriondo et al., 2015)



Relationship between Relative fertility and Maximum temperature (Moriondo et al., 2011)

Methodology



Phenology: was estimated using cumulative maximum temperature and degree days.

Leaf area: was estimated using the number of actively growing shoots and the rate of leaf appearance and expansion.

Total biomass: was calculated from radiation intercepted and radiation use efficiency (RUE).

Harvest index: The increase allows to estimate daily fruit growth.

Original Bindi's model (Fortran code)

Phenology

$$C_c = \sum_{n=1^{st}\ August}^{N_{db}} C_u \qquad where\ C_u = Q_{10c}^{\frac{-Tx(n)}{10}} + Q_{10c}^{\frac{-Tn(n)}{10}}$$

C_c = chilling unit requirement
N_{db} = threshold for dormancy break
C_u = critical amount of chilling units
T_x = daily maximum temperature
T_n =daily minimum temperature
Q_{10c} = rate of the geometric progression of the thermal dormancy response.

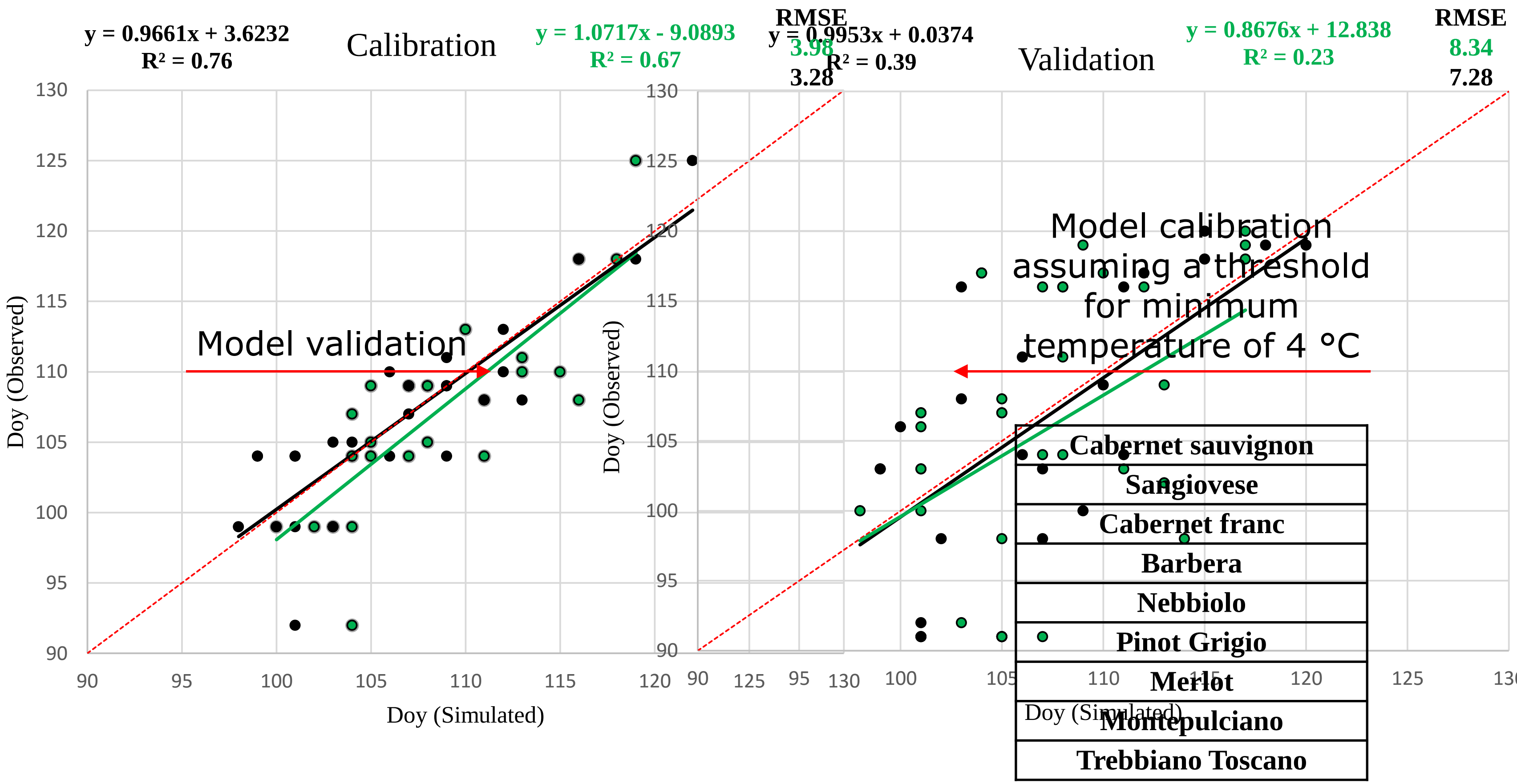
Extreme events

$$f_t = \left(\frac{T - T_0}{T_{Opt} - T_0}\right)^q \cdot \left(\frac{T'_0 - T}{T'_0 - T_{Opt}}\right)$$

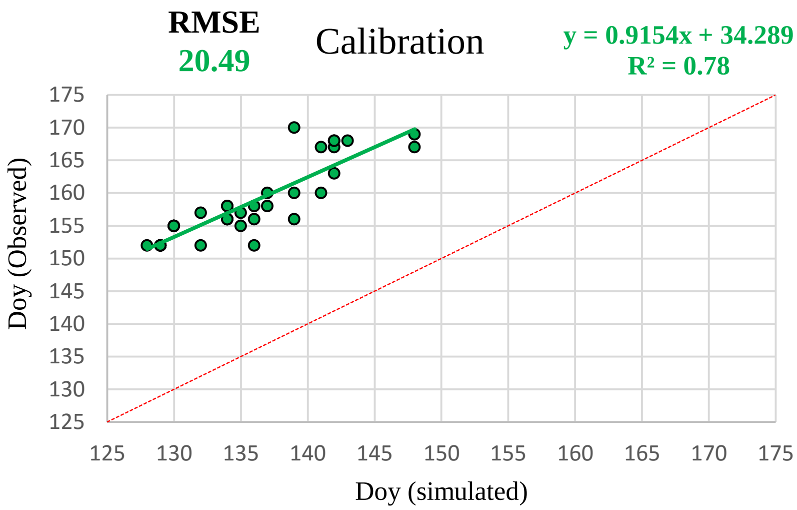
f_t = temperature factor
T = daily temperature
T_0= base temperature
T_{Opt}= optimum temperature
T'_0 =cut off temperature
q= exponent that determines the shape of the curve

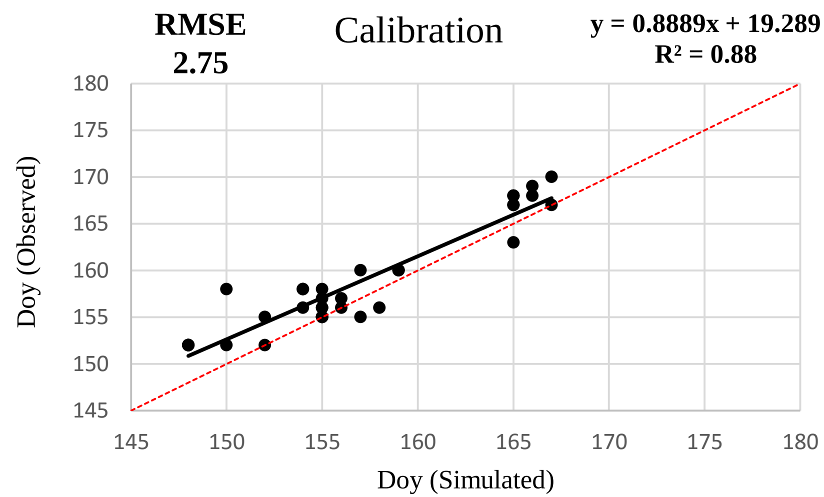
First Results

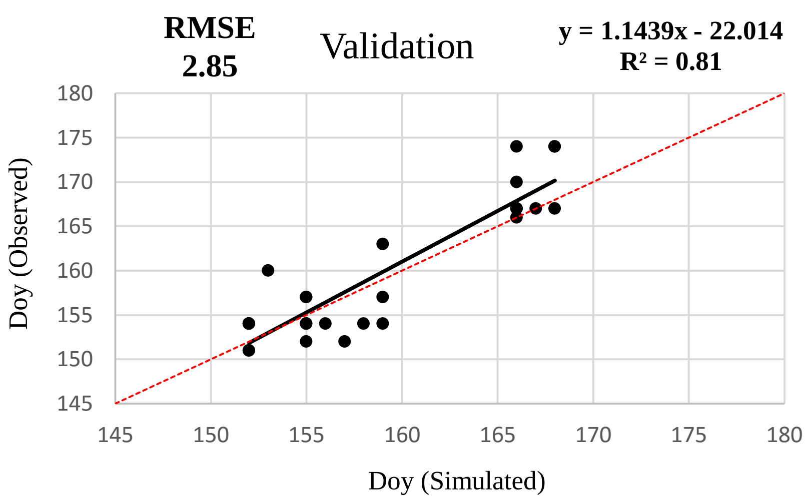
Chilling units requirement

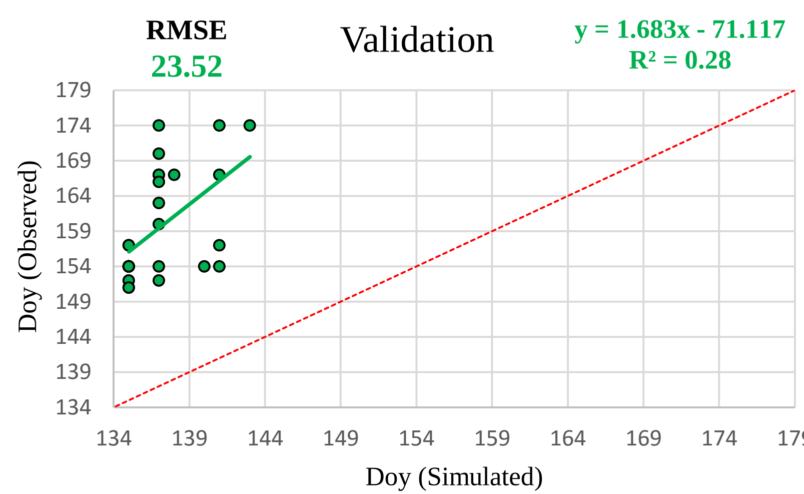


Grape flowering date



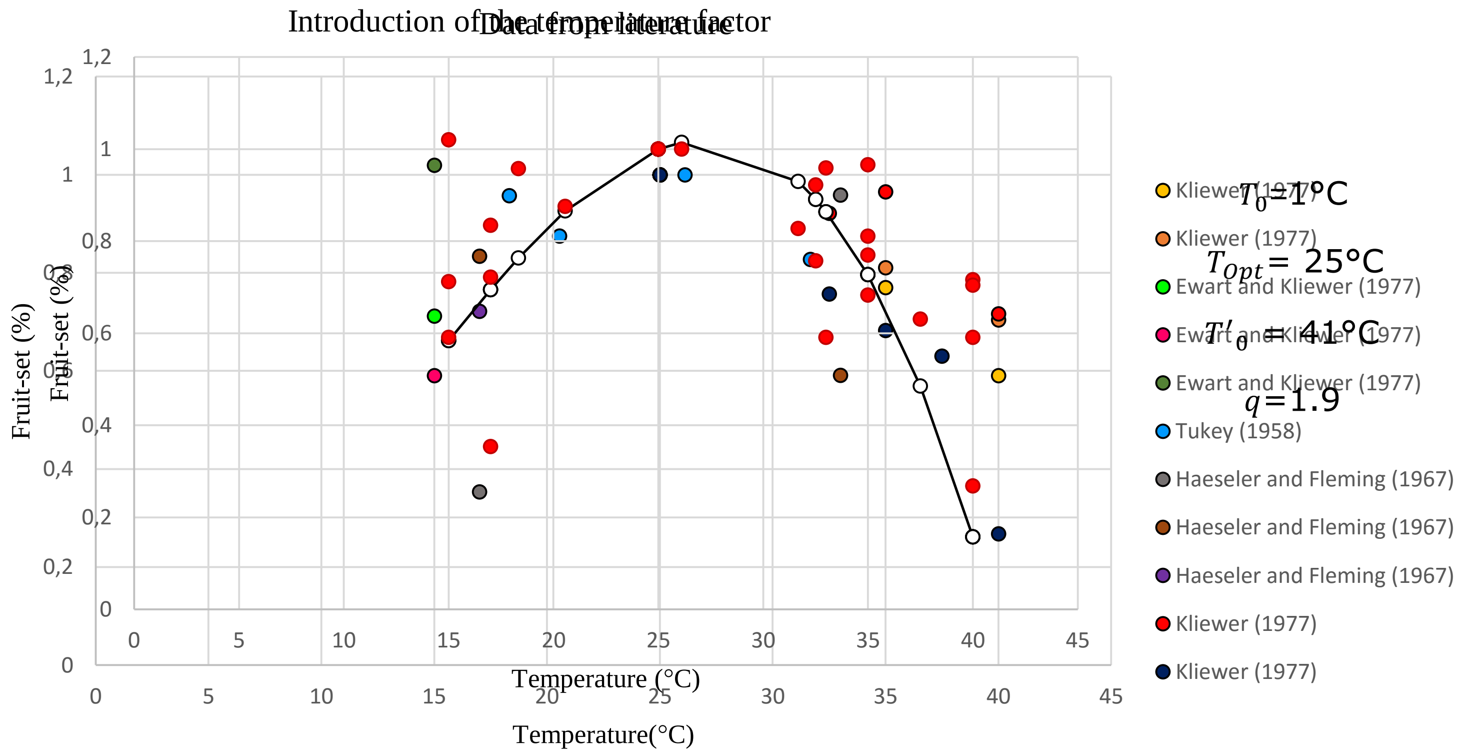






Effects of extreme events on grape flowering

A relationship between high temperature and the percentage of fruit set was established using data from literature
(Haeseler and Fleming, 1967;Ewart and Kliewer, 1977; Kliewer, 1977; Tukey, 1958)



Acknowledgement

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