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agriculture facing extreme climatic events

Impacts of extreme events on grapevine: experimental and modelling activities

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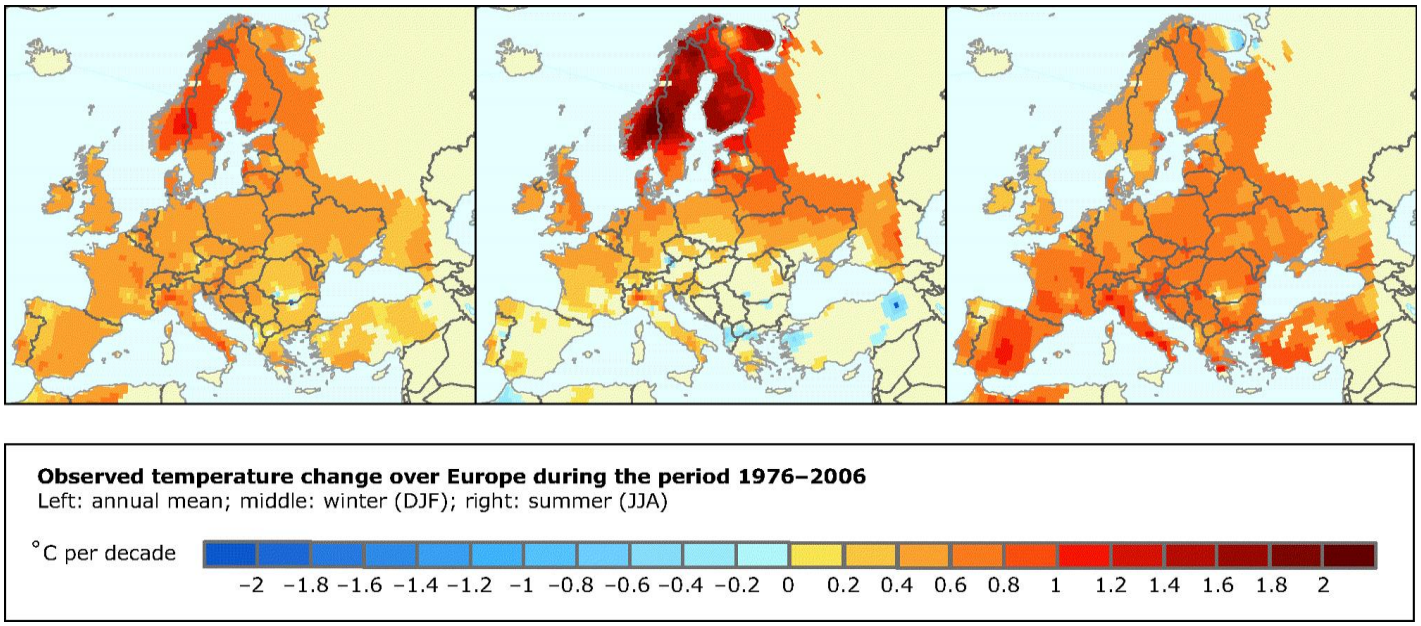
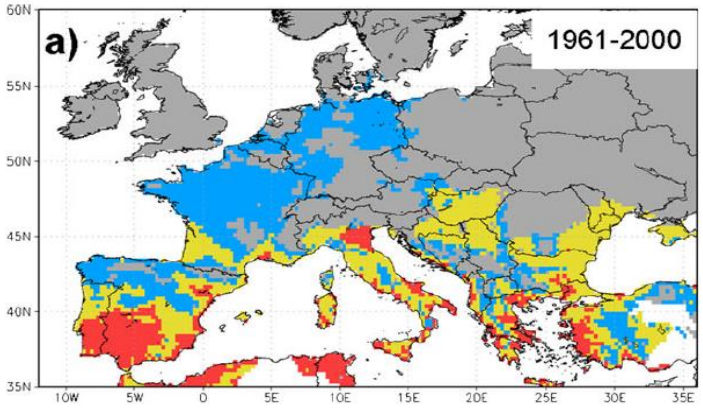
Climate change

Climate change in **Mediterranean basin** is expected to have a **great impact** on agriculture and in particular on crop growth and yield.

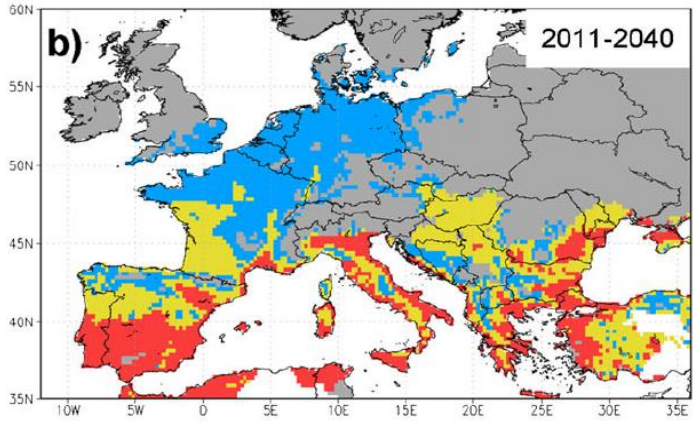


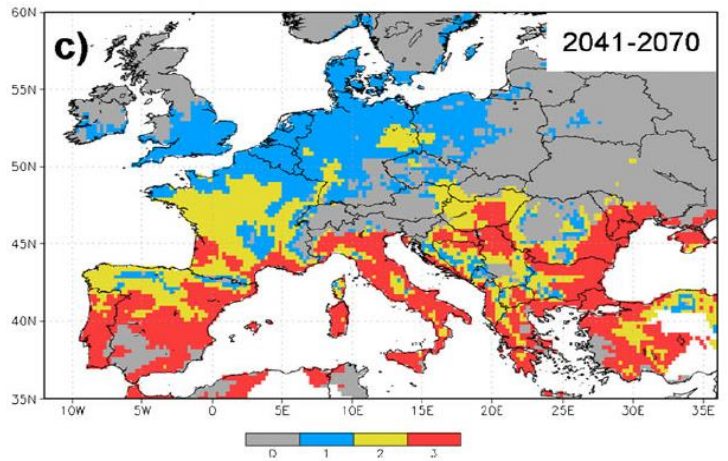
Changes in the **frequency** of **extreme events** should be considered as a reliable climate change impact assessment on agriculture (Challinor et al., 2005).

Future winemaking regions



The future **winemaking regions** which are currently positioned in the central and south europe, **will change their location** in the future. These regions will **shift toward north** where the climatic zones will be characterized by good conditions for grapevine growth. (Fraga et al., 2012).





The main categories in CompI for the Huglin index classes (1,2,3) during a baseline period (a) and two future periods (b,c).

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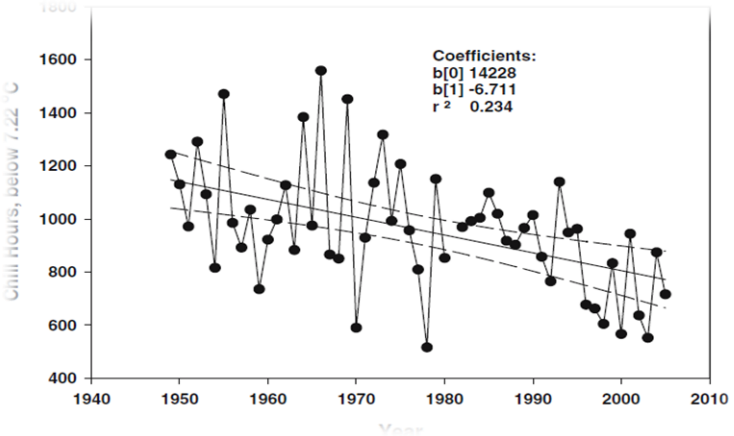
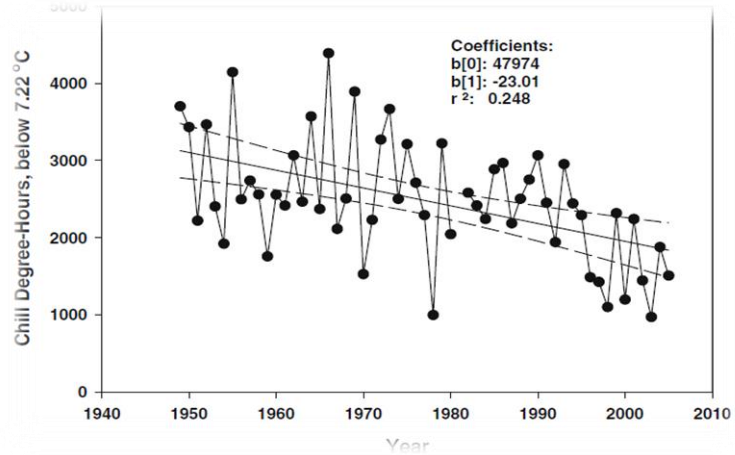
Effects of changes in mean climate on grapevine

Phenology

- In a context of global warming, the number of **chilling unit** accumulated by fruit trees **will be reduced** (Baldocchi and Wong, 2008).
- If chilling requirement is not reached, an **erratic budburst** occurs in grape and a decreasing in **shoots number** is shown (Lavee and May, 1997).
- The increasing of the number of days with temperature > 30°C, in flowering-veraison, will **advance harvest** (Jones and David, 2000).
- The increase in precipitation over the budburst-flowering interval, will produce a **delay in flowering** (Jones and David, 2000).





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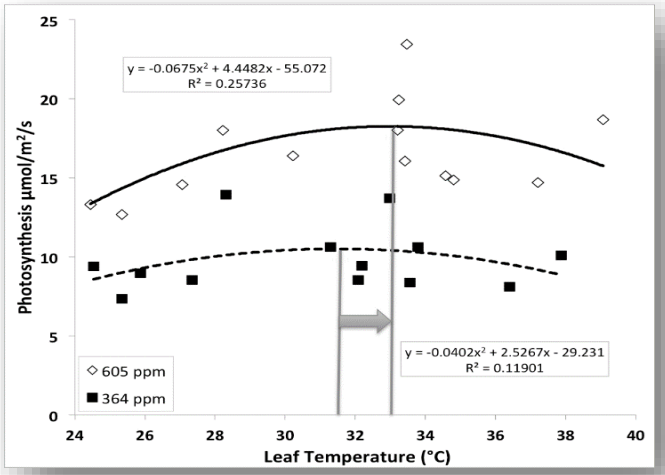
Grape yield

Advantages:

- A future increase in temperature may lead to a **higher** level of **photosynthesis** in high CO_2 concentrations.

Disadvantages:

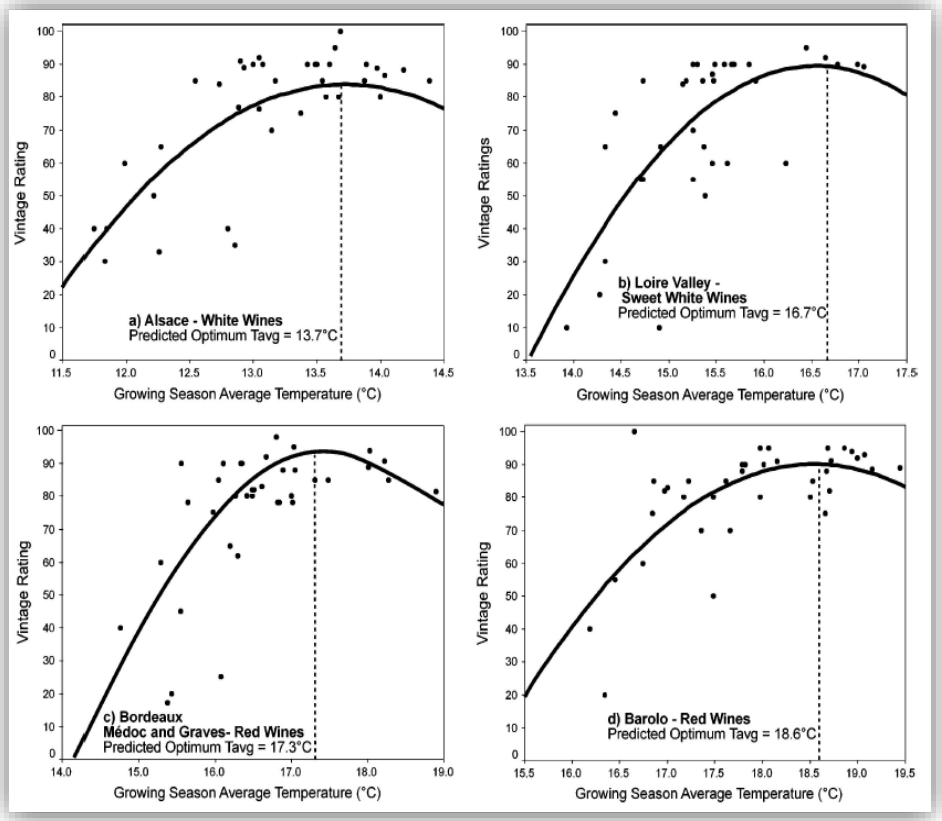
- Grape **yield** may be **reduced** because of insect and diseases infestations.
- The increase in temperature produces a major vineyard's **susceptibility** to the European Grapevine Moth and powdery mildew (Caffara et al., 2012).
- Higher temperature may reduce rapidly the **soil water content**. The provision of effective drip-irrigation may be useful to guarantee a consistent yield (Lereboullet et al., 2013).



Effects of changes in mean climate on grapevine

Grape Quality

- A warmer climate affects grape quality producing unbalanced wine with **higher alcohol content** and **lower acidity** (Jones et al., 2005).
- The current **cool climate regions** may guarantee the production of the best quality wine with the current varieties of *Vitis vinifera* L. (Jones et al., 2005).
- Changes in vineyard and winery technologies can reduce the **quality variability** over the time (Jones et al., 2005).



Effects of changes in extreme events on grapevine

Budbreak

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

Under very dry air conditions, the freeze injury may not occur until temperatures reach **-3.3°C** or **-3.8°C** (Wolf and Boyer, 2003).

Effects of changes in extreme events on grapevine

Flowering

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

- A **lower ovule fertility** may occurs at temperature of 35°C or 40°C (Kliewer, 1977).
- **Fruit set** is strongly **reduced** when temperature fall below 18.3°C or exceed 37.8°C because of the inhibition of pollen growth tube and ovule fertilization (Dokoozlian, 2000).

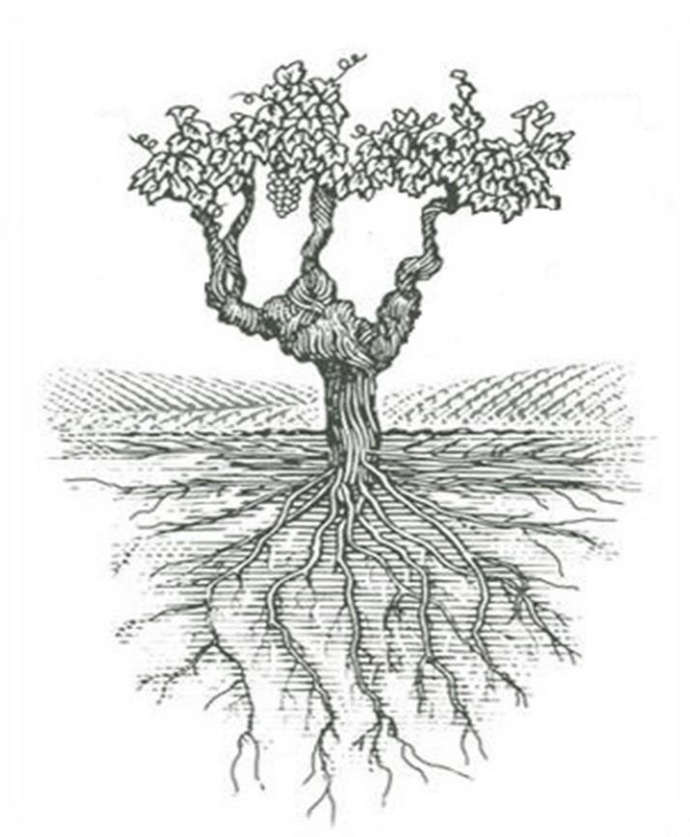
Responses to prolonged drought period

Prolonged drought stress may play a role in changing the biomass partitioning pattern to increase root growth.

- A larger leaf area increase transpiration and consequently the vine's **susceptibility to water stress**.

- Under water stress conditions, grapevine showed **reduced shoot length** and **smaller leaves** (Christensen, 2000).

- Water stress may **alter** the **assimilate distribution pattern** especially towards the trunk and roots with a reduced contribution to clusters (Bota et al., 2004).



Effects of changes in extreme events on grapevine

Veraison and Post-veraison

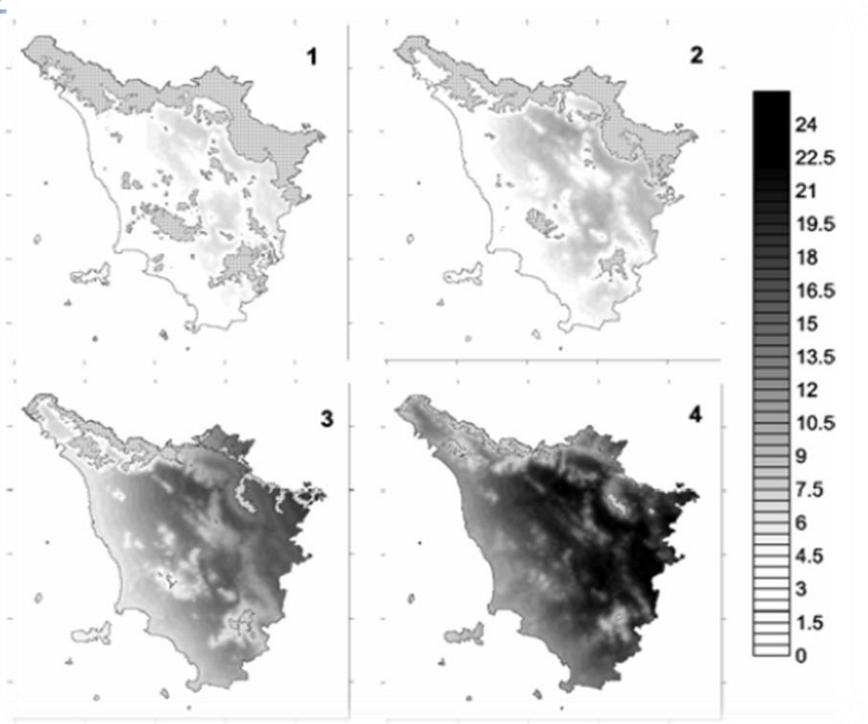
- Temperature higher than **35°C** during berry ripening cause **lower yield** and the production of small berries (Kliever, 1977).

- During berry ripening phase **heat stress** produce **lower sugar accumulation** and reduced berry colouring (Sepulveda and Kliewer, 1986; Kliewer and Torres, 1972).

Grapevine simulation models

The contribution of simulation models

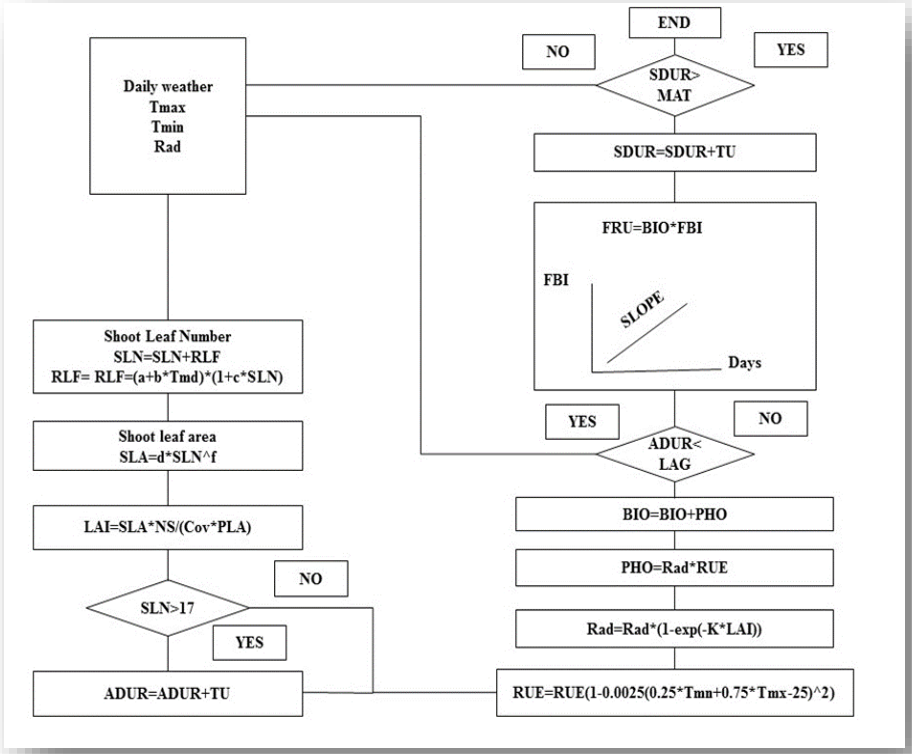
- Crop models considered the **effect of the mean climate on crop phenology** as is an important aspect involved in the final yield assessment.
- Few crop simulations models took into account the **effects of extreme events** on crop growth stages and final yield.
- Moriondo and Bindi (2005) showed the **effects** of the **heat stress** on grape quality in Tuscany region.



Average number of heat stress events (Tmax>35°C) per year during grape maturation for present (1) and future conditions (2,3,4) (Moriondo and Bindi, 2005).

Grapevine simulation models

A simplified approach



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).

The increase in **harvest index** permits to estimate daily fruit growth.

Grapevine simulation models

New implementations

- **Phenology:**

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

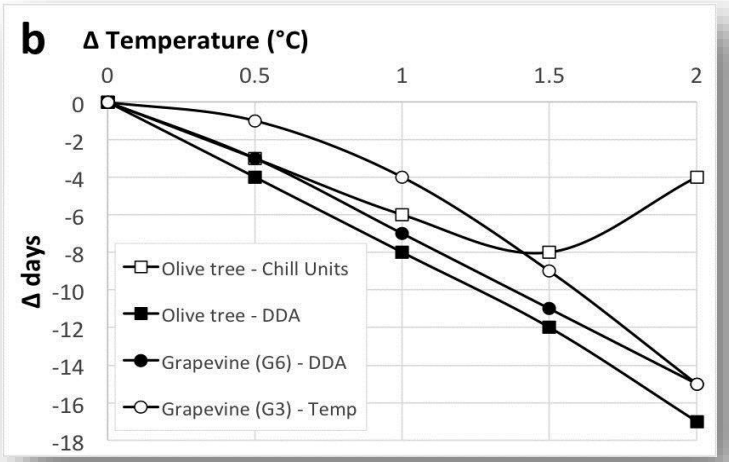
- **Grape growth and yield:**

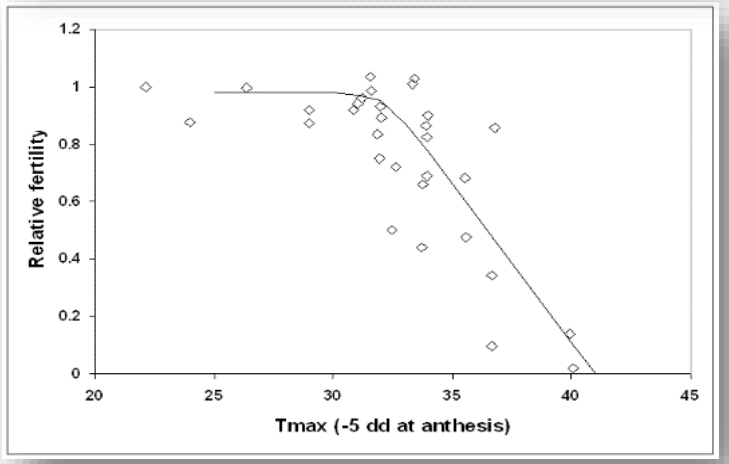
Nitrogen balance will be introduced to take into account the distribution of N into the plant.

Total biomass will be partitioned among single plant organs

- **Extreme events:**

Extreme events consider the effects on:
Grape phenology (frost events)
Grape fertility and yield





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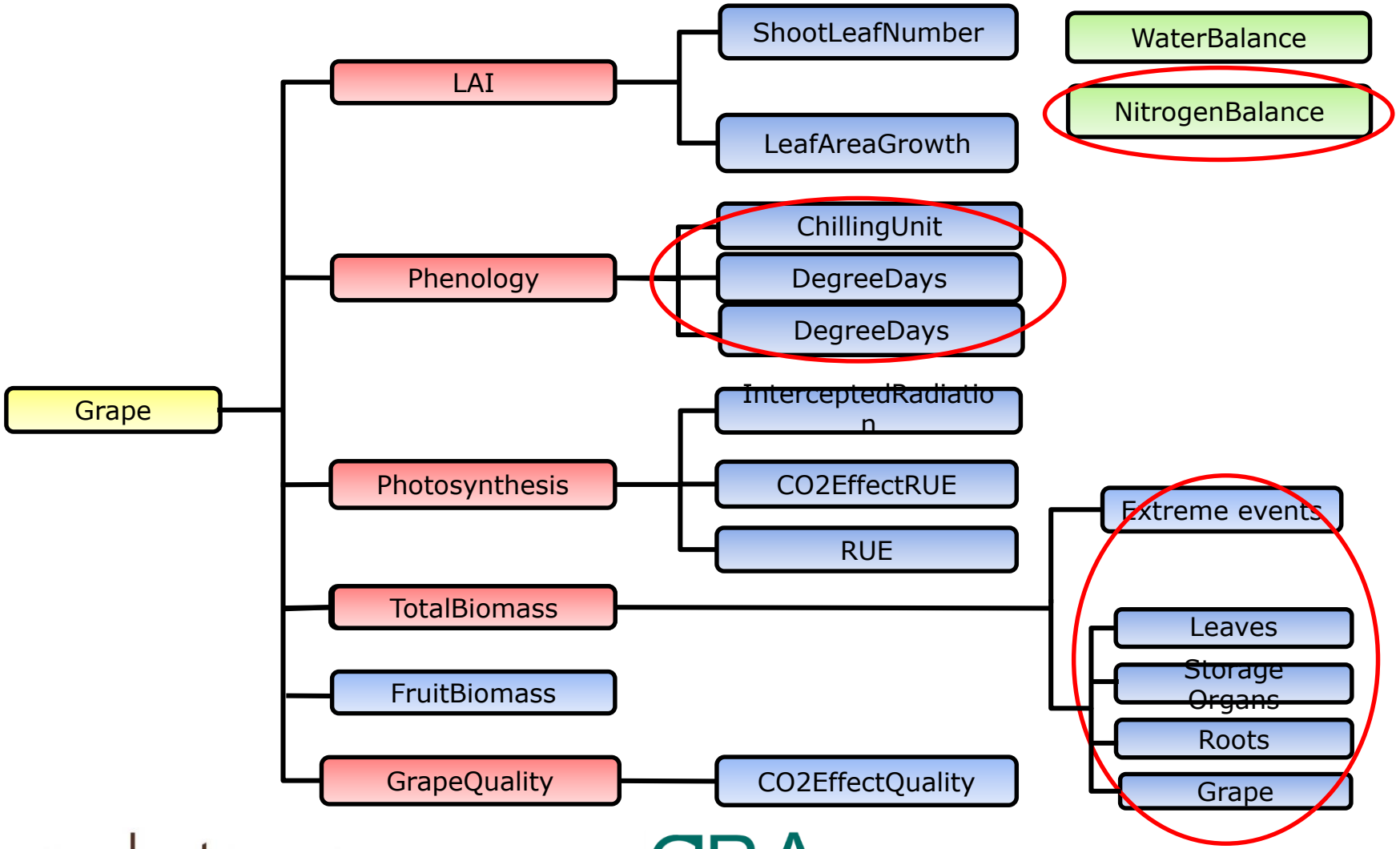

Grapevine simulation models

Extreme events implementations

In collaboration with the research group ISVV-INRA in Bordeaux (France), the objectives are:

- To evaluate the **effects of high temperature on** different **growth phases** (fruit set, veraison and post-veraison).
- To retrieve data from literature and evaluate different modelling solution based on the **effects** of high temperature **on final yield**.
- To assess the **effect** of high temperature on **pollen germination**.

Thank you for your attention

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Acknowledgement

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