Effects of inter-annual climate variability on grape harvest timing in rainfed hilly vineyards of Piedmont (NW Italy)

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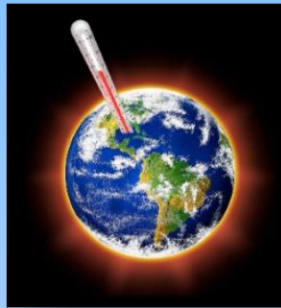
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[4] Regione Piemonte - Settore Fitosanitario - Sez. Agrometeorologia - Torino, Italy
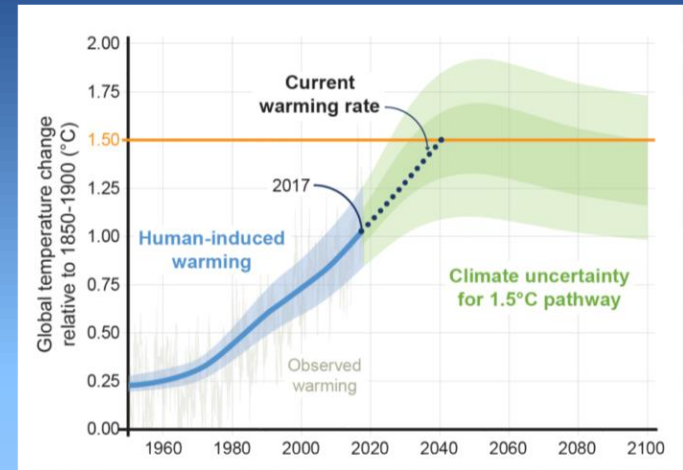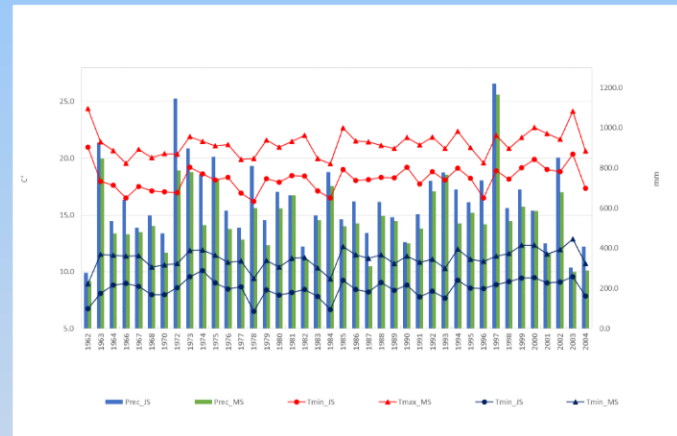
Main issue: Global warming

Numerous effects of the observed climate changes on the natural and human activities

Source: "IPCC Global Warming of 1.5°C", 2018

The availability of long-lasting, complete and accurate data series is a fundamental "added value" to predict and react to climate variability
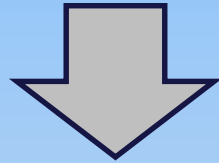
Many studies investigated the sharp impacts of climate change on different agricultural sectors

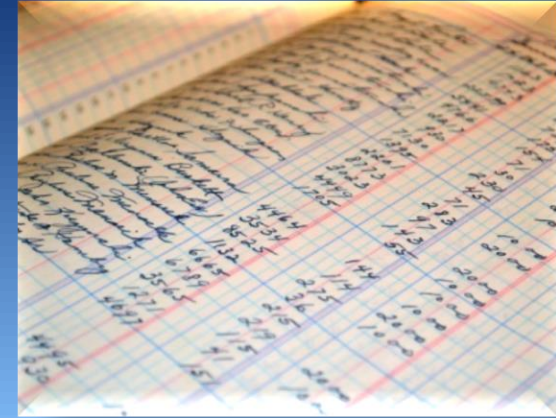Viticulture: the climate significantly influences grape and wine quality

Inter-annual climate variability determines effects on the onset and duration of phenological stages and, ultimately, on the grape harvest and yield

Climate data series

Agronomical data series

Are climate changes reflected by changes by onset (and duration) of phenological stages and grape harvest?

Research purposes:

1. Is there any trend within long-time climate data series, during the vine growing season?

2. Is there any trend within harvest dates for some local wine grape varieties?

3. Is there any relationship between climate variables and harvest parameters?
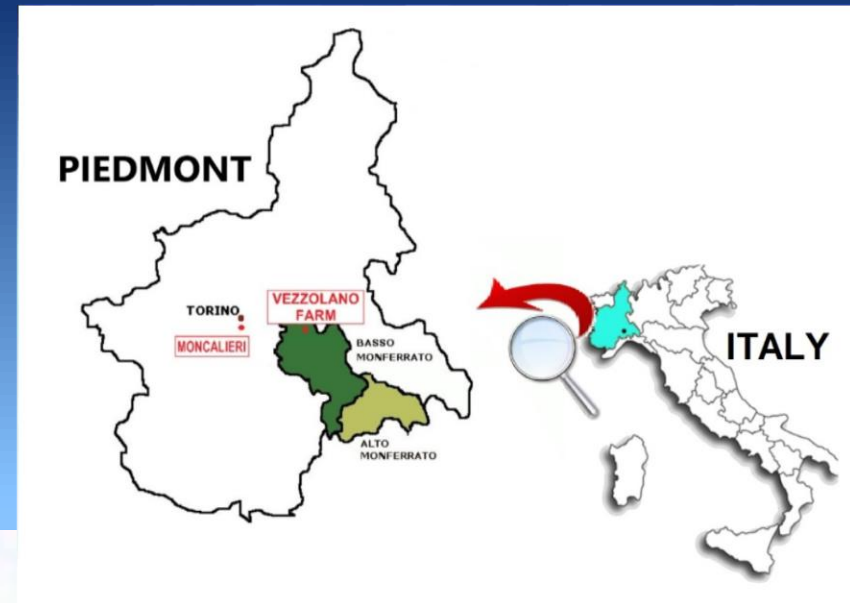
The study area

➤ **Basso Monferrato** (Piedmont, NW Italy)

➤ **Climate**: pre-alpine ÷ sublitoranean

- **Precipitation**:
  Mean annual rain: **846 mm**

  Mainly concentrated in **May** (109 mm),
  driest month **January** (43 mm)

- **Temperature:**

  Mean annual air temperature: 11.8°C

Vezzolano Experimental Farm

Cantina Sociale del Freisa «Terre dei Santi»

PIEDMONT

ITALY

The **Monferrato** vine-growing area (NW Italy):
UNESCO World Heritage Site for Vineyard Landscape

The data series

Stations		Timeline	Measured Variables
	WS1 - Vezzolano **Mechanical station** *(CNR-IMAMOTER)* *Location: 45°08'N, 7°96'E* *426 m a.s.l.*	**1962÷2004**	Temperature, relative humidity, precipitation, wind run, evaporated water, global solar radiation
	WS2 - Vezzolano **Automatic station** *(Regione Piemonte)* *Location: 45°08'N, 7°96'E* *426 m a.s.l.*	**2003÷2019**	Temperature, relative humidity, precipitation Piedmont Regional Agrometeorological Network (RAM)
	WS3 - Moncalieri **Mechanical – Automatic station** *(SMI[1])* [1] *Italian Meteorological Society* *Location: 44°59'N, 7°41'E* *267 m a.s.l.*	**1960÷2019**	Temperature, relative humidity, air pressure, precipitation, global solar radiation, wind speed and direction.

CONSIDERED VARIABLES

Climate data

- ✓ **Tmin** (January÷September)
- ✓ **Tmax** (January÷September)
- ✓ **Prec** (January÷September)
- ✓ **Huglin Index** (January÷September)
- ✓ **Tmin** (March÷September)
- ✓ **Tmax** (March÷September)
- ✓ **Prec** (March÷September)
- ✓ **Huglin Index** (March÷September)

From WS1, WS2; WS3

- Minimum and maximum daily temperature, and daily precipitation from the each weather stations were used.

- For each year (1962 ÷ 2019), temperature and precipitation variables were summarized for the *growing season*, from March to September (MS) and from January to September (JS), and the **Huglin index** was calculated.
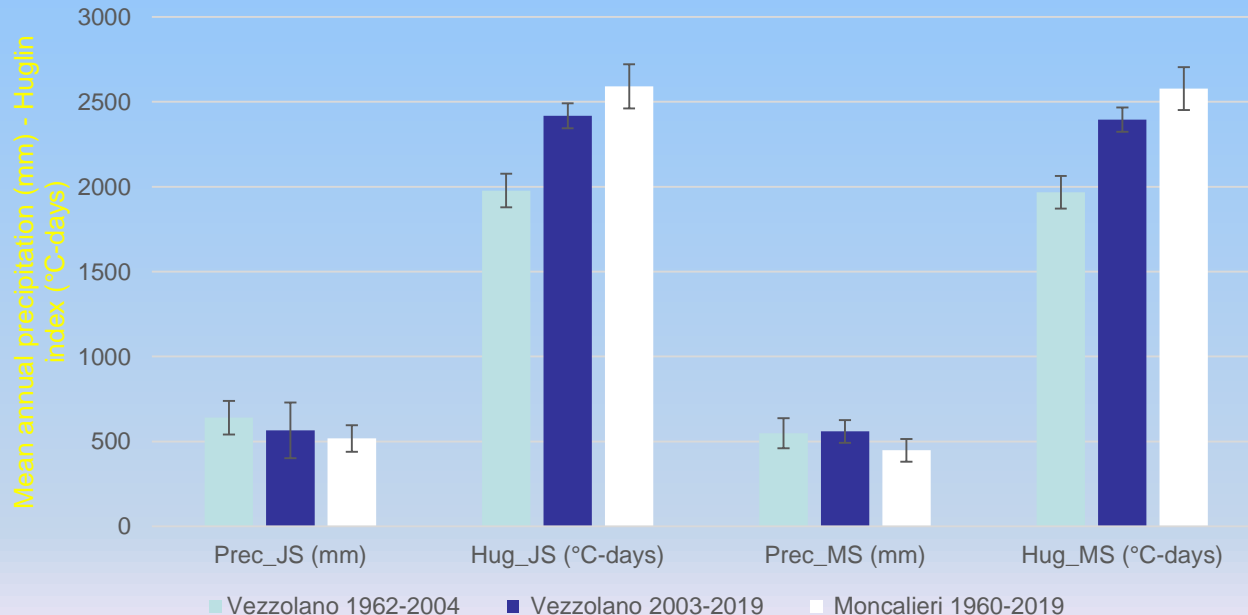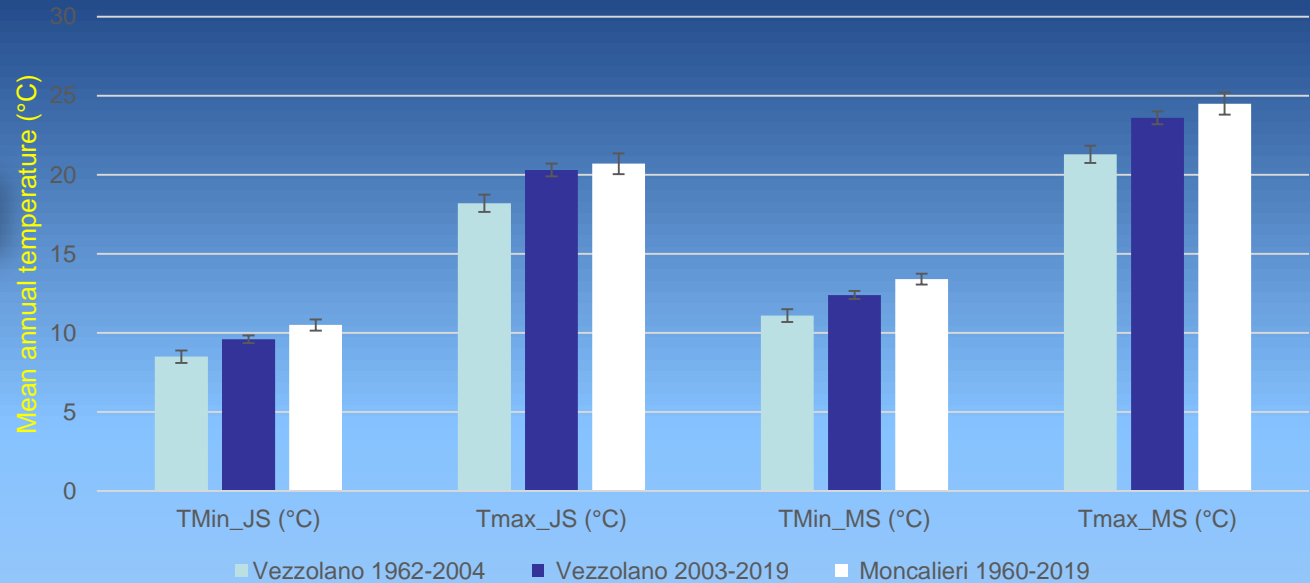
Huglin bioclimatic heat index calculated in Piedmont vine areas from April 1 underestimates the real thermal contribution useful for the vine, since in March but often already in February can be accumulated many degree days useful for the phenological development of the vine (*Spanna & Lovisetto,2000* and *Lisa & Spanna, 2003)*.
Hence the choice to consider the period *January-September* for the calculation of the Index. However, the calculation for the *March-September* period was also tested.

Climate data

For variables related to **temperature**, the mean values including in the computation the months of January and February resulted in being lower of about 3.1 °C.

Mean annual temperature (°C) chart — TMin_JS (°C), Tmax_JS (°C), TMin_MS (°C), Tmax_MS (°C); legend: Vezzolano 1962-2004, Vezzolano 2003-2019, Moncalieri 1960-2019

Mean annual precipitation (mm) - Huglin index (°C-days) chart — Prec_JS (mm), Hug_JS (°C-days), Prec_MS (mm), Hug_MS (°C-days); legend: Vezzolano 1962-2004, Vezzolano 2003-2019, Moncalieri 1960-2019

Precipitation resulted lower when January and February were not computed.

For the **Vezzolano** site, Tmin and Tmax for 2003-2019 period were about 1-2 °C higher than for 1962-2004; this also resulted in more than 400 degree-days difference for Huglin index.

Moncalieri station recorded higher temperatures and lower precipitations than Vezzolano.
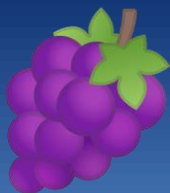
Grape harvest data

CONSIDERED VARIABLES
- ✓ BH (begin harvest)
- ✓ EH (end harvest)

From 2 databases:
- Vezzolano
- Terre dei Santi

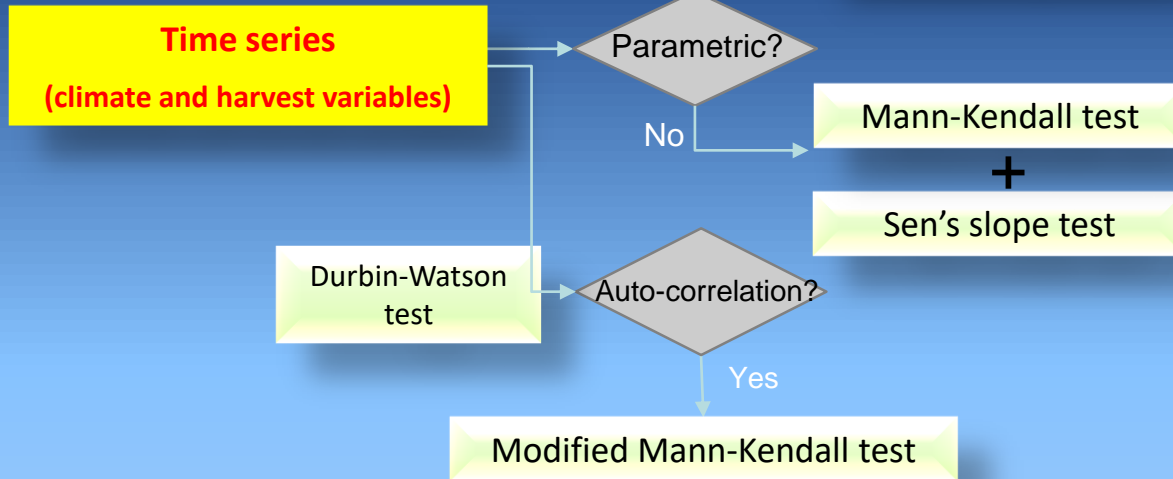| Database		Timeline	Grape varieties	Collected Variables
	Vezzolano Experimental Farm of CNR-IMAMOTER	**1961÷2019**	Malvasia	Begin harvest (BH_MAV)
			Freisa/Barbera	Begin harvest (BH_FBV)
	"Cantina Sociale del Freisa – Terre dei Santi" of Castelnuovo Don Bosco	**1958÷2019**	Different local varieties	Begin harvest (BH_TS)
				End harvest (EH_TS)

Grape harvest data

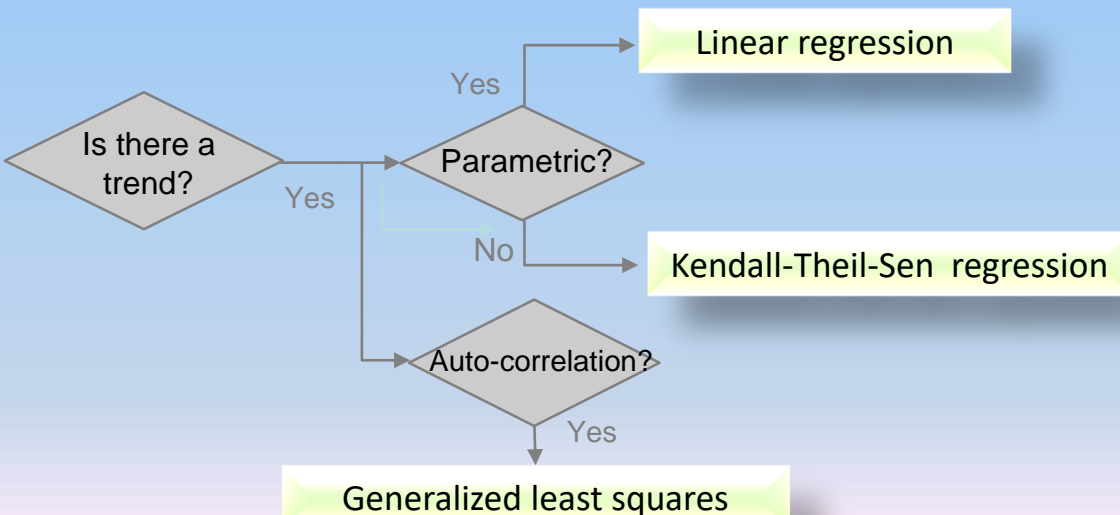- Mean harvest dates differ from each other according to grape varieties.
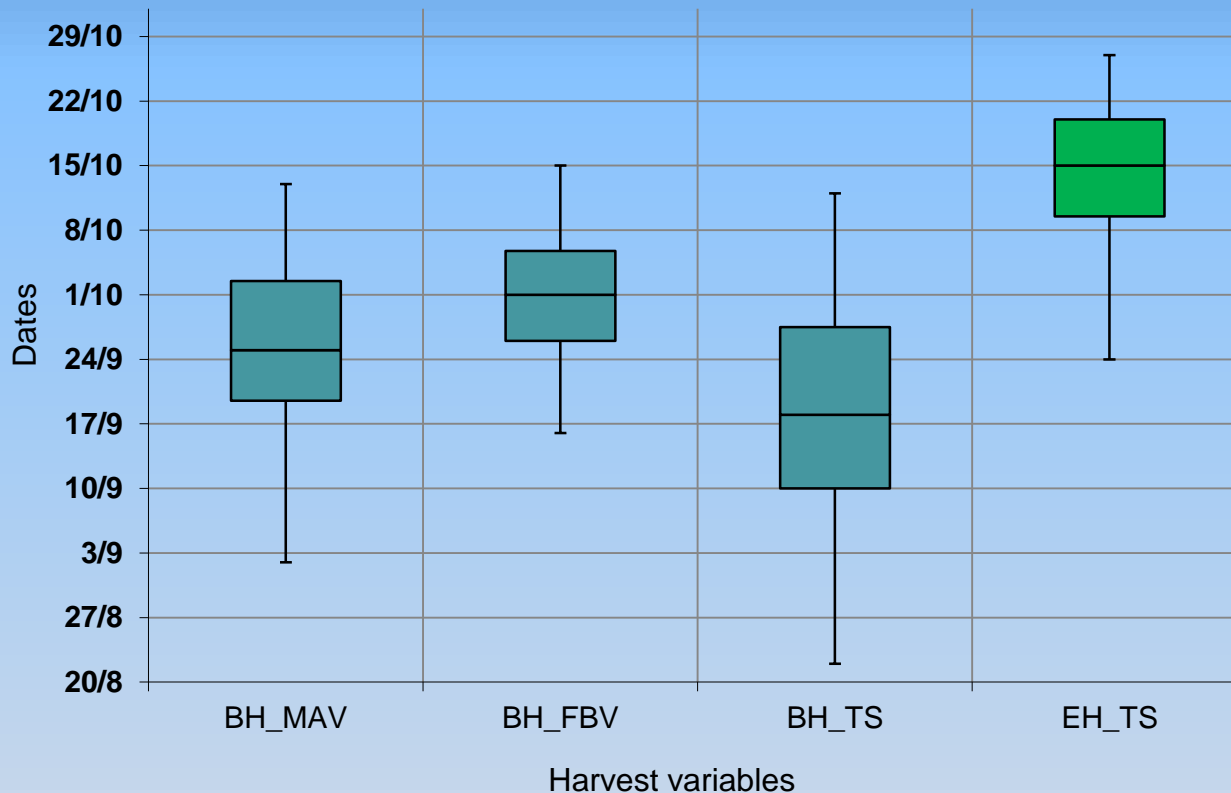
- Mean onset dates of harvest (BH) range between the **19th of September and the 2nd of October**

- Mean ending date of harvest (EH) is the **15th of October**. On average, the recorded dates vary 210 across years in a range between 7 and 12 days.

Box plot of Dates (y-axis) versus Harvest variables (x-axis: BH_MAV, BH_FBV, BH_TS, EH_TS). Y-axis labels: 20/8, 27/8, 3/9, 10/9, 17/9, 24/9, 1/10, 8/10, 15/10, 22/10, 29/10.

Step1: Trend analysis

Time series

(climate and harvest variables)

Yes → Linear regression

Parametric?

No → Mann-Kendall test

+

Sen's slope test

Durbin-Watson test

Auto-correlation?

Yes → Modified Mann-Kendall test

Trend analyses of the different climate and harvest parameters were carried out by *linear regression* when all conditions for parametric analysis were satisfied, otherwise the non-parametric *Mann-Kendall test* and *Sen's slope test* were carried out to determine significance and slope of the trend. The time series were assessed for *auto-correlation* using the *Durbin-Watson* statistic. When the time series had autocorrelation, the *modified Mann-Kendall test* using prewhitening technique was applied.

Step2: Relationship between harvest dates and climatic variables

Is there a trend?

Yes →

Yes → Linear regression

Parametric?

No → Kendall-Theil-Sen regression

Auto-correlation?

Yes → Generalized least squares

A *linear regression* between climate and harvest dates was applied to identify the relationships between climate and harvest variables. *Generalized least squares method* was used in case of autocorrelation, and *Kendall-Theil-Sen non-parametric regression* was used when conditions for parametric linear regression were not satisfied.

Trend analysis – Climate variables
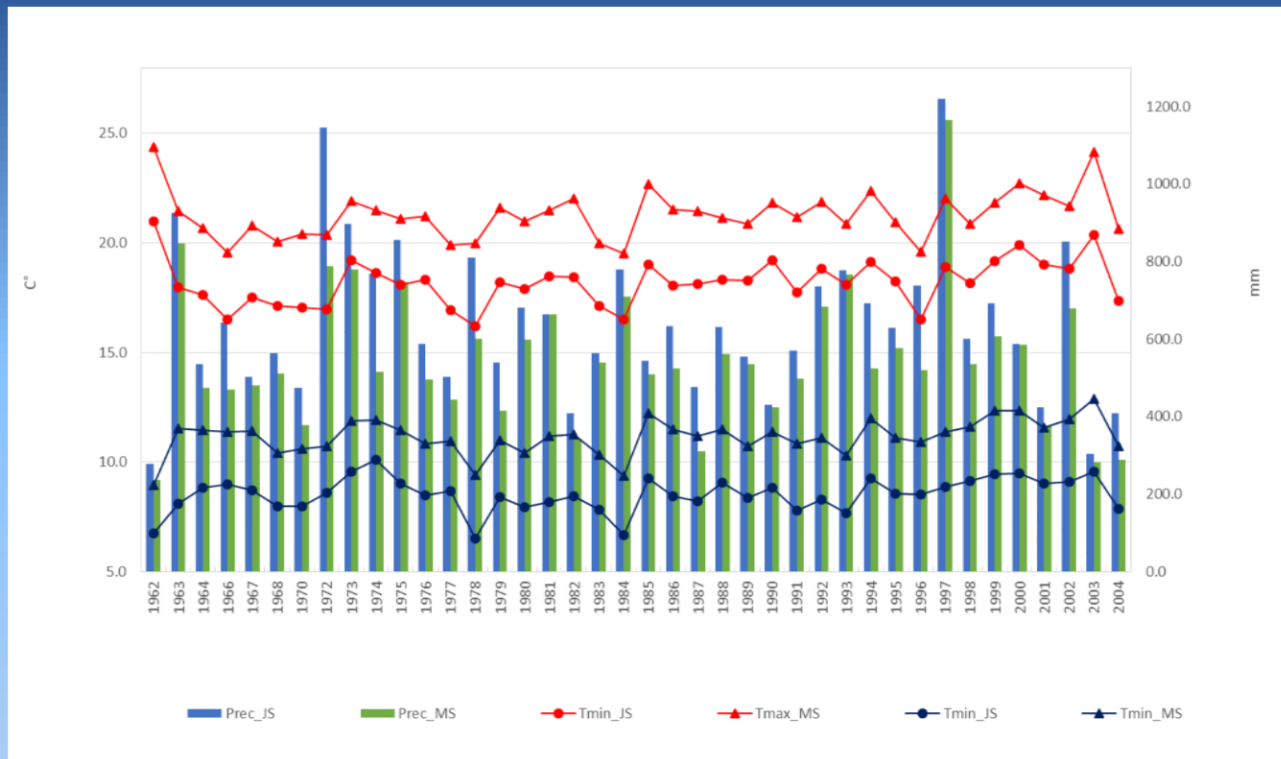
Climate variables show significantly increasing trends for temperature variables (minimum and maximum temperatures and Huglin index). Precipitation showed no significant trends.

Vezzolano's 1962-2004 series: min and max temperature increased on average **0.02 ÷ 0.03 °C per year**.

Huglin index: increased between **4.96** (MS growing season) **and 5.14 °C-days per year** (JS).

Moncalieri's series: min and max temperatures showed a significant increase of **0.03 and 0.06 °C per year**. For Huglin index the increasing trend observed in Moncalieri's series was particularly relevant, indeed this variable demonstrated the higher significant average increase of **11.71 °C-days per year**.
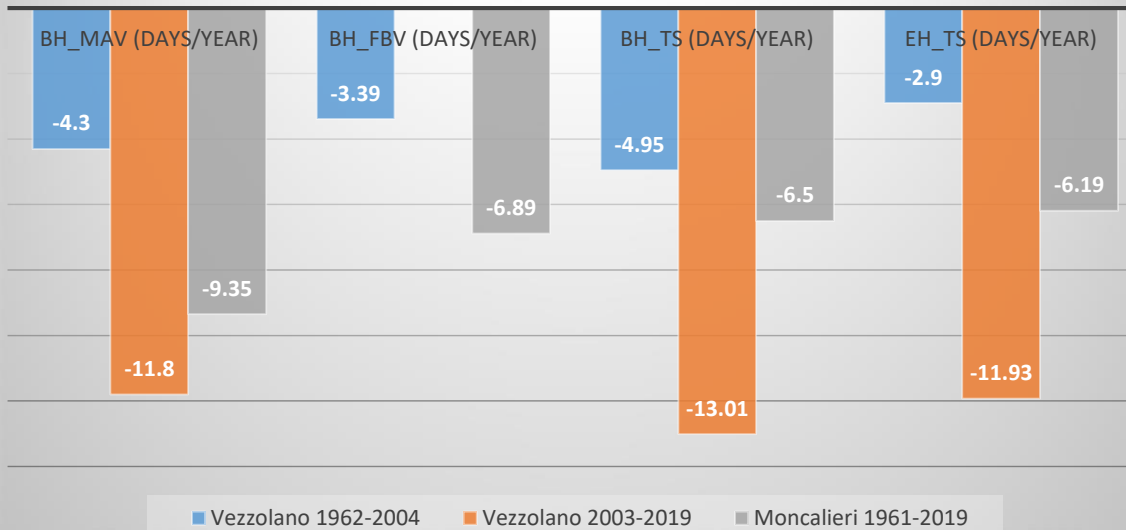
Trend analysis – Grape harvest dates
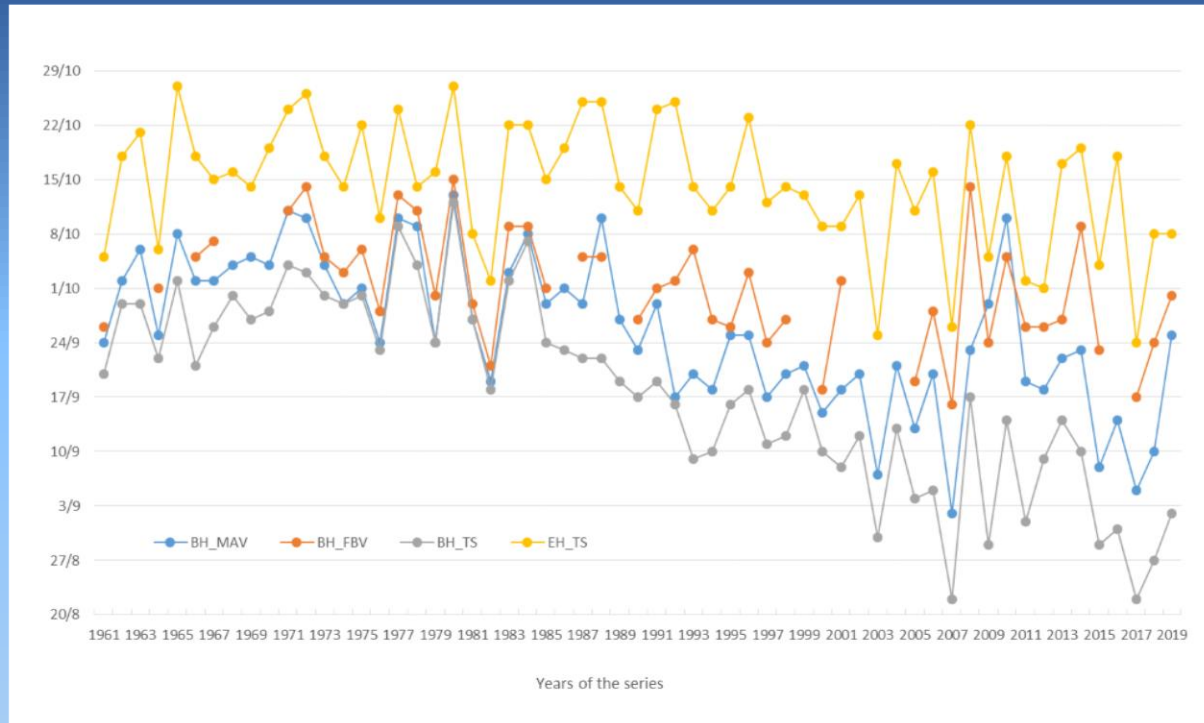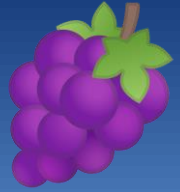
The trends of the harvest dates were statistically significant for all the considered variables and resulted in a general anticipation for the beginning and the end of the harvest period.
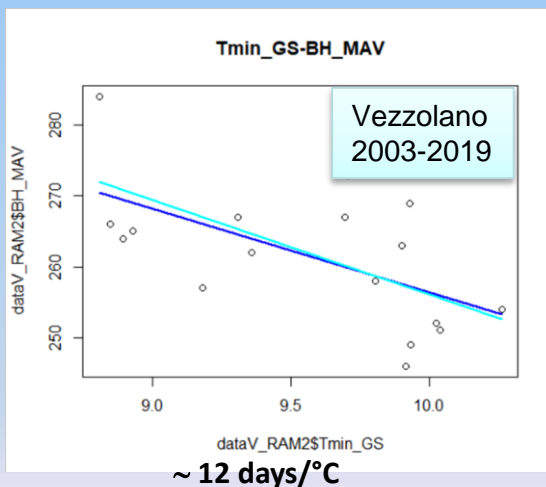
Maximum change ratio: **-5.9 days in 10 years** for starting (BH_TS) dates from "Terre dei Santi" Cellars.

Minimum change ratio: -1.8 days in 10 years for ending (EH_TS) dates from "Terre dei Santi" Cellars.

Vezzolano farm: the starting date of harvest was anticipated by **3.7 and 2 days in 10 years**, for Malvasia and Freisa-Barbera varieties, respectively.

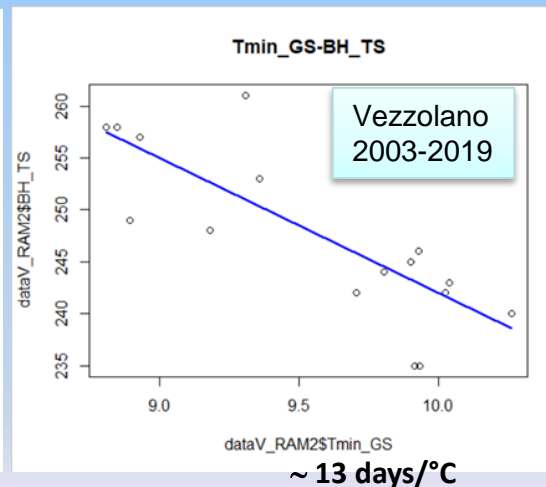## Relationship between harvest dates and climatic variables

Tmin_JS (days/°C)

BH_MAV (DAYS/YEAR): -4.3, -11.8, -9.35
BH_FBV (DAYS/YEAR): -3.39, -6.89
BH_TS (DAYS/YEAR): -4.95, -13.01, -6.5
EH_TS (DAYS/YEAR): -2.9, -11.93, -6.19

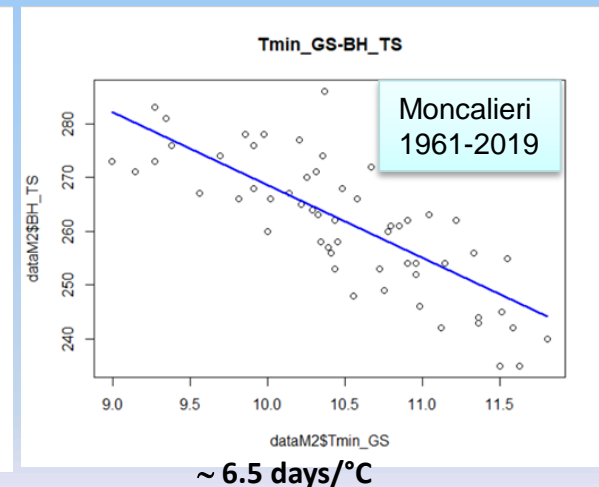■ Vezzolano 1962-2004   ■ Vezzolano 2003-2019   ■ Moncalieri 1961-2019

Harvest date exhibited a **negative correlation with** the average **minimum and maximum** growing season **temperature** (Tmin_JS, Tmax_JS, Tmin_MS. Tmax_MS).
The change ratios for Tmin_JS were the highest (in absolute terms) for the 2003-2019 Vezzolano series, and, for the Moncalieri long-term series, higher than those for the Vezzolano 1962-2004 series, with, also, a higher significance level.
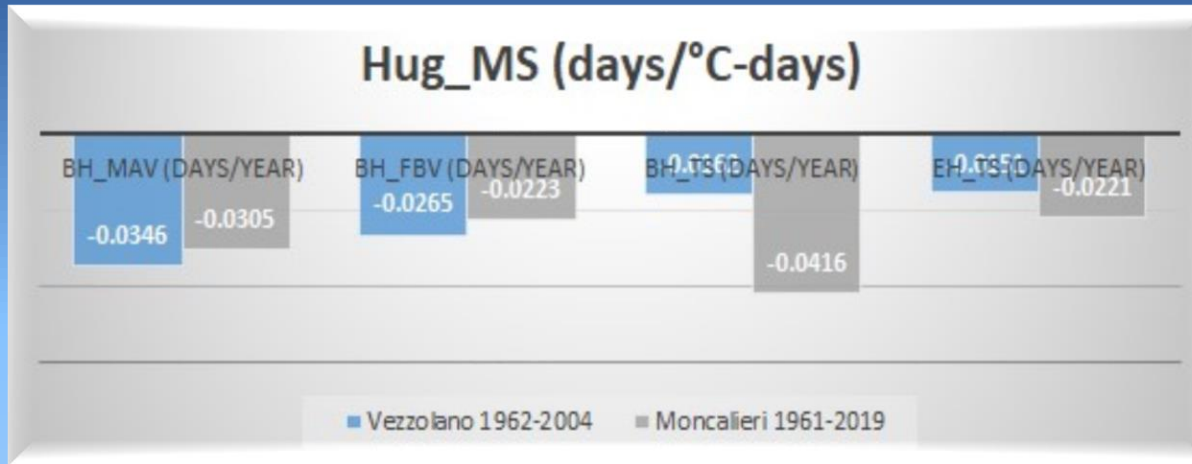

Tmin_GS-BH_MAV

Vezzolano 2003-2019

~ 12 days/°C
Harvest advance for Vezzolano Malvasia

Tmin_GS-BH_TS

Vezzolano 2003-2019

~ 13 days/°C
Harvest advance for «Terre dei Santi»

Tmin_GS-BH_TS

Moncalieri 1961-2019

~ 6.5 days/°C

Relationship between harvest dates and climatic variables

Hug_MS (days/°C-days)

BH_MAV (DAYS/YEAR) -0.0346 / -0.0305
BH_FBV (DAYS/YEAR) -0.0265 / -0.0223
BH_TS (DAYS/YEAR) -0.0416
EH_TS (DAYS/YEAR) -0.0221

■ Vezzolano 1962-2004   ■ Moncalieri 1961-2019

Harvest date exhibited a **negative correlation with** the **Huglin bioclimatic index** (Hug_JS, Hug_MS). The change ratios for Tmin_JS ranges from **-0.0151 to 0.0416 days/°C-days**. Absolute values of the change ratios for the Huglin index were generally higher considering the period March-September, than including also January and February (JS).
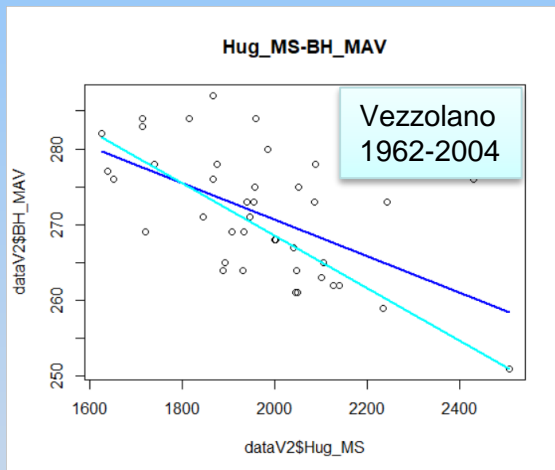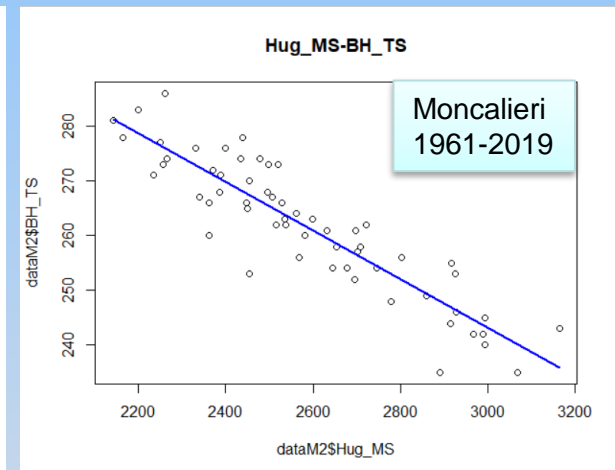

Hug_MS-BH_MAV

Vezzolano 1962-2004

0.0346 days/°C-days
Harvest advance for Vezzolano Malvasia

Hug_MS-BH_MAV

Moncalieri 1961-2019

0.0305 days/°C-days
Harvest advance for Vezzolano Malvasia

Hug_MS-BH_TS

Moncalieri 1961-2019
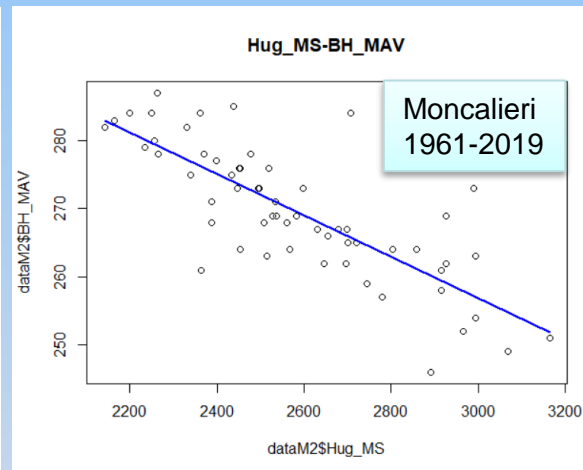
0.0416 days/°C-days
Harvest advance for «Terre dei Santi»

Conclusions

The increasing trends of temperatures observed in the last decades affect the harvest period of grapevine in the Basso Monferrato.
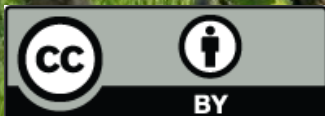
The analysis of long-term homogeneous meteorological series shows:

- a significant, clear, *increasing trend of local temperatures*;

- a *strong relationship* warming *temperatures*-anticipation of *harvest dates*;

- onset *harvest dates*: significant *decreasing trend* from 11.6 to **34.22 days in 58 years**, in line with previous studies;

- minimum temperature: advance of **12-13 days for** each increase of 1 **°C** in the **last 15 years**;

- total *precipitation* did *not* show *significant trend*;

- great *importance* to have continuous and homogenous *datasets*.

Thank you for your attention!

"Treat the earth well: it was not given to you by your parents, it was loaned to you by your children"

Ancient American Natives Proverb