Assessment of the future effects of temperature and precipitation regimes over Europe using a combination of downscaling approaches and quantitative impact models

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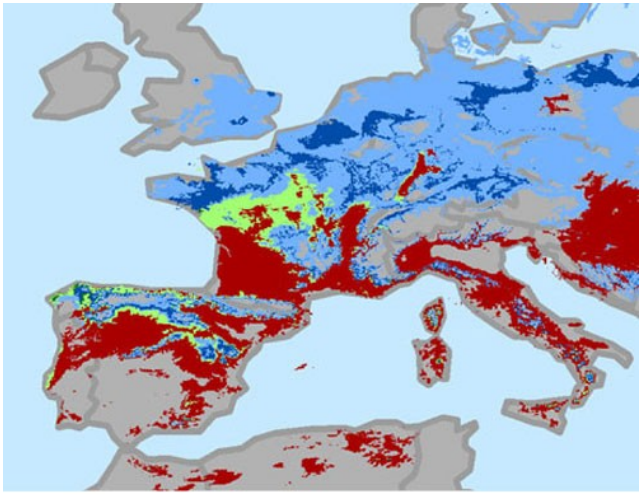
1. Motivations

- **Europe** is one of the world's largest and most productive suppliers of food and fiber (Easterling et al., 2007).
- **Agriculture** covers about 35% of the total land area of western Europe (Rounsevell et al., 2006).

According to the **IPCC** (Chapter 23, 2013):

*Changes in mean temperature and precipitation will likely affect **agricultural crop** and livestock production*



From Conservation International

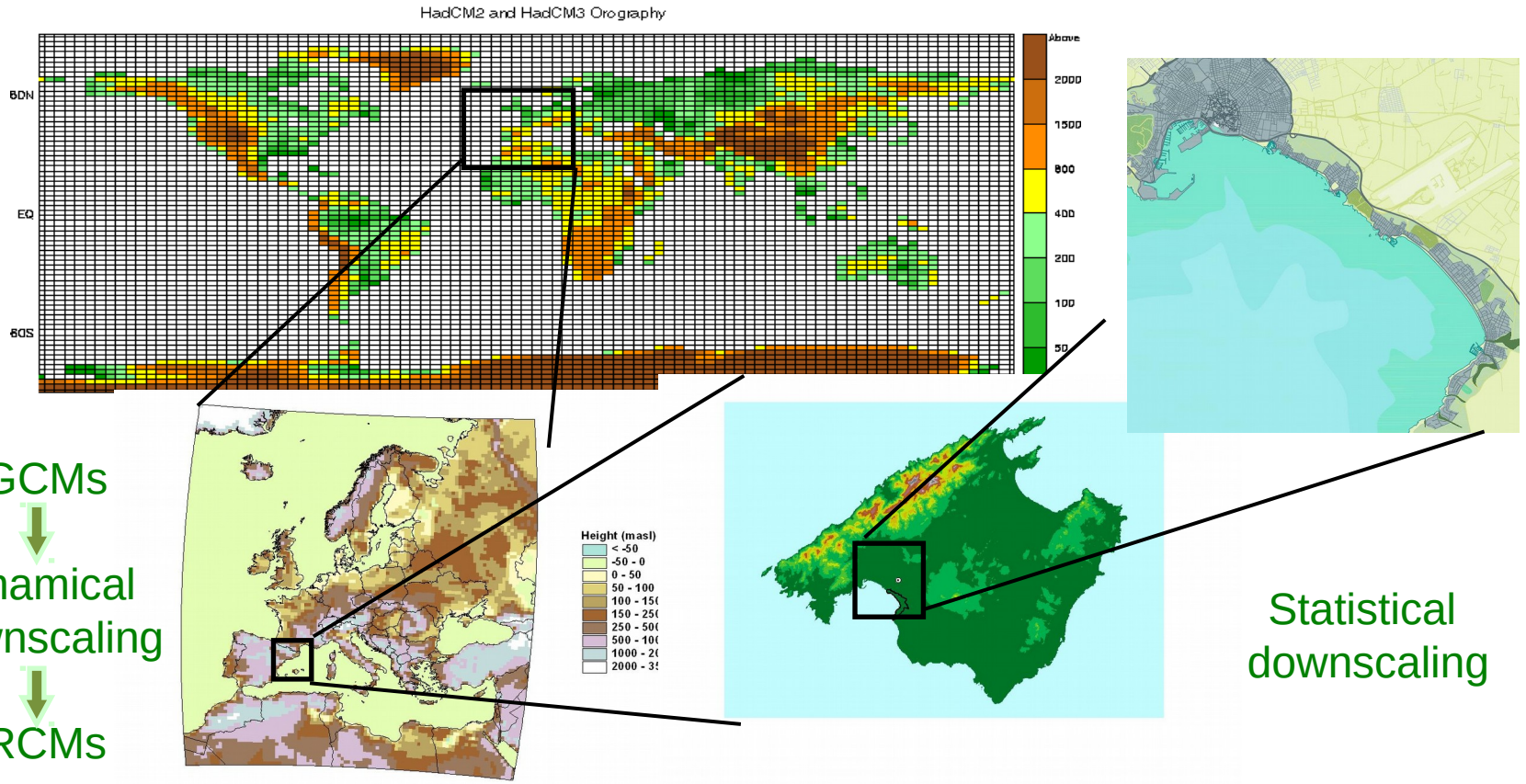
Different effects depending on the crop (grapevine, chickpeas, tomato, almonds..)

Most scenario studies suggest that agricultural land areas in Europe will continue to decrease in the future (Busch et. al 2006)

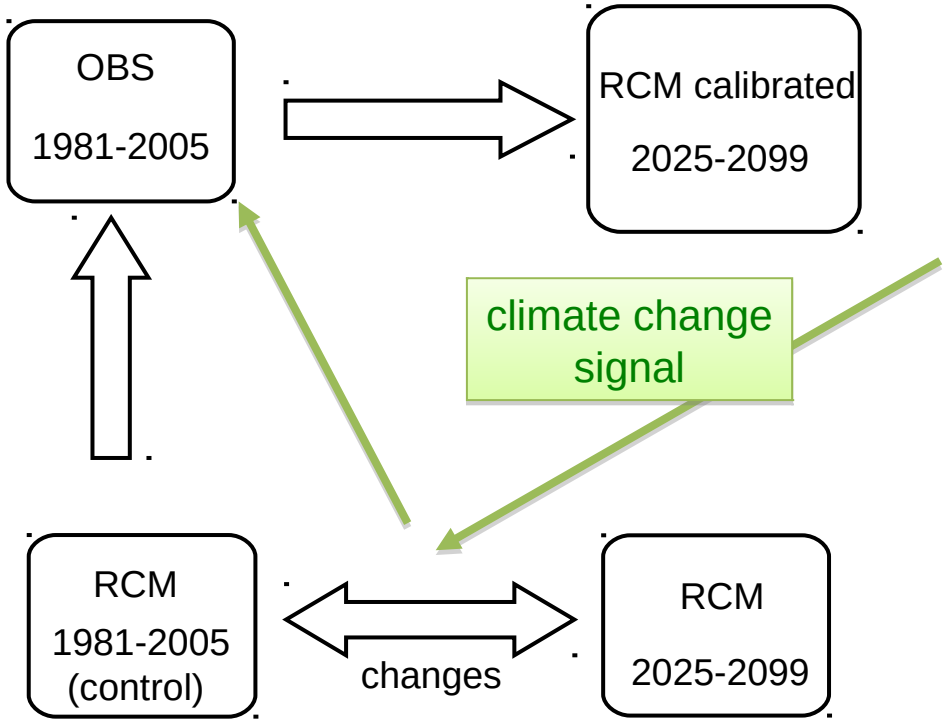
Tools for exploring climate change impacts

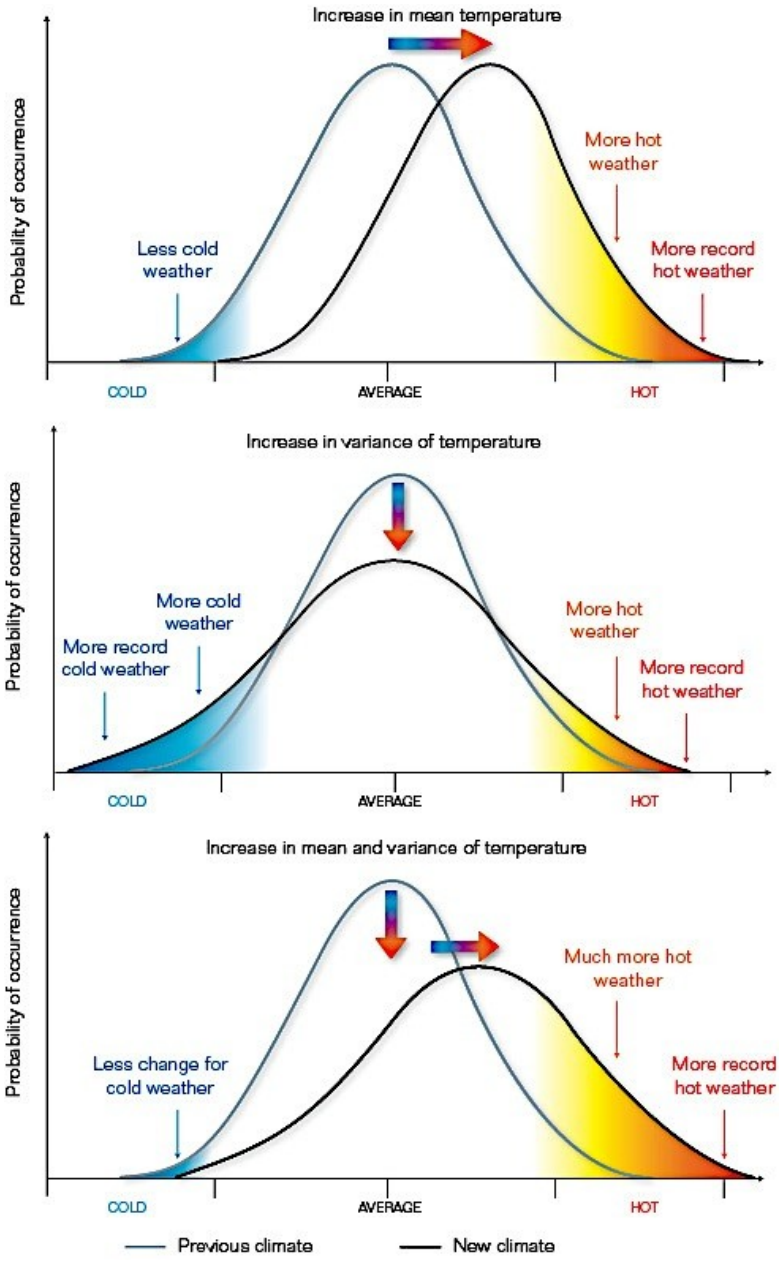
- GCMs → RCMs

  - Regional scales: Dynamical downscaling. Regional Climate Model (RCMs)
  - Local scales: Statistical downscaling and model calibration from RCMs



Statistical downscaling of RCM outputs

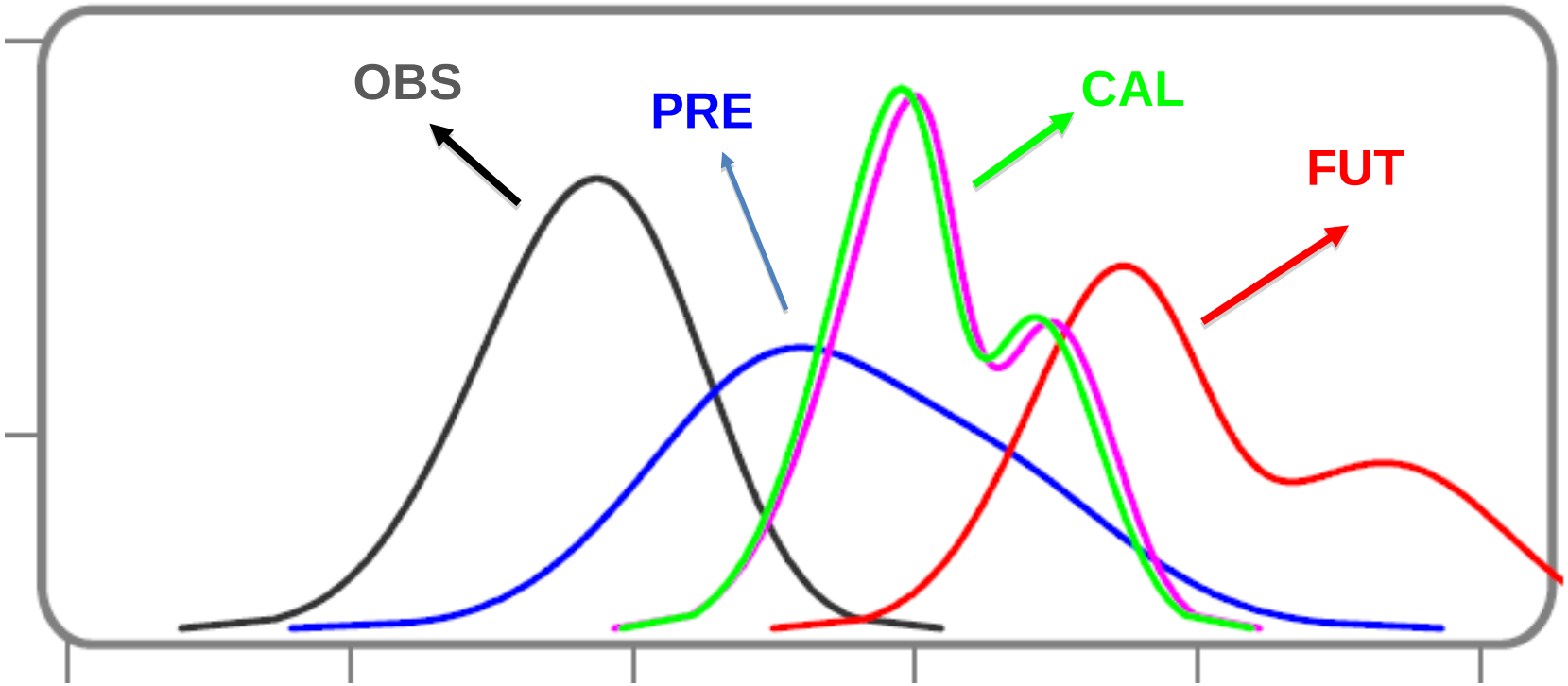




Quantile-Quantile adjustment

(Amengual et al. 2012)

$$p_i = o_i + g\overline{\Delta} + f\Delta'_i,$$



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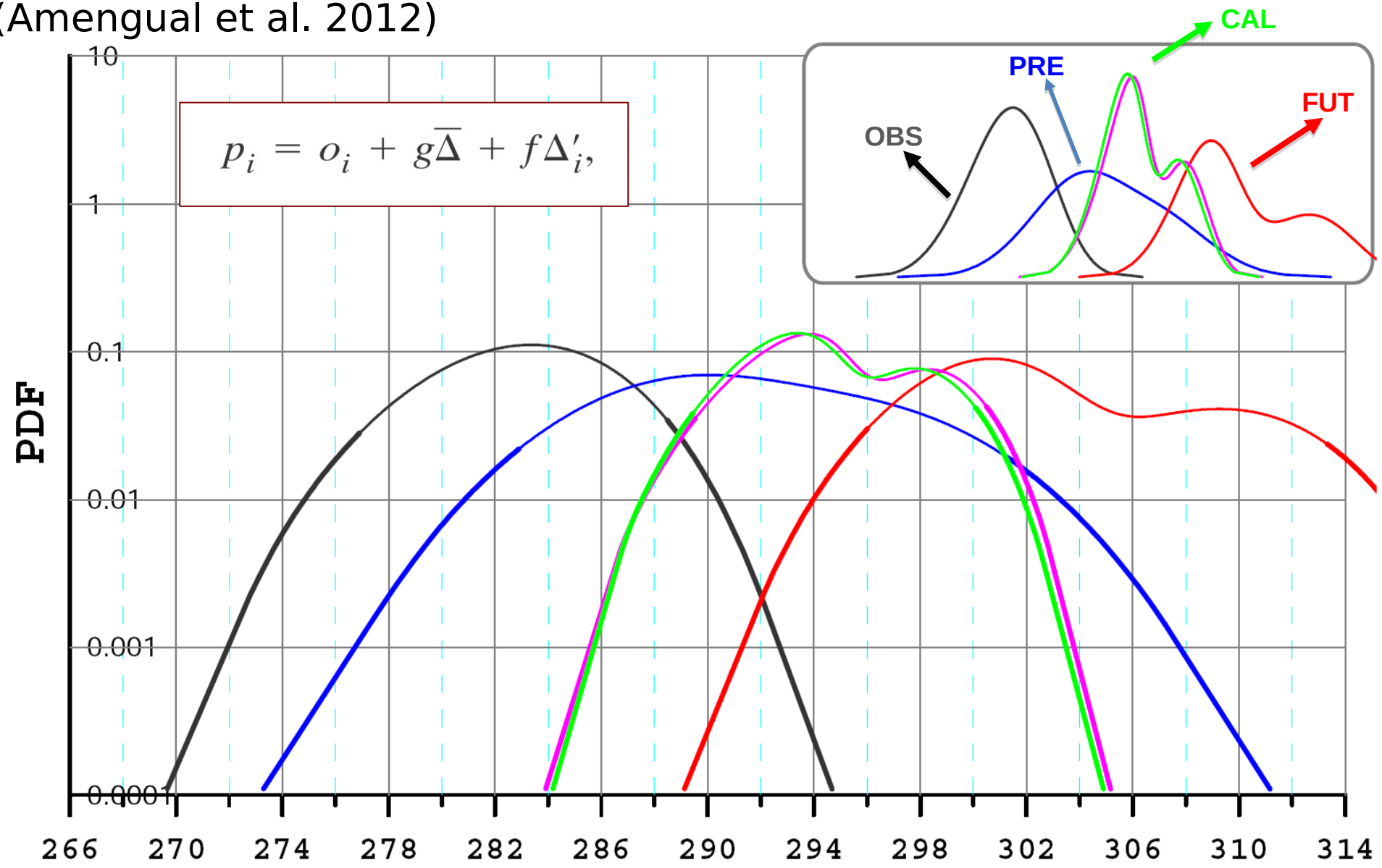
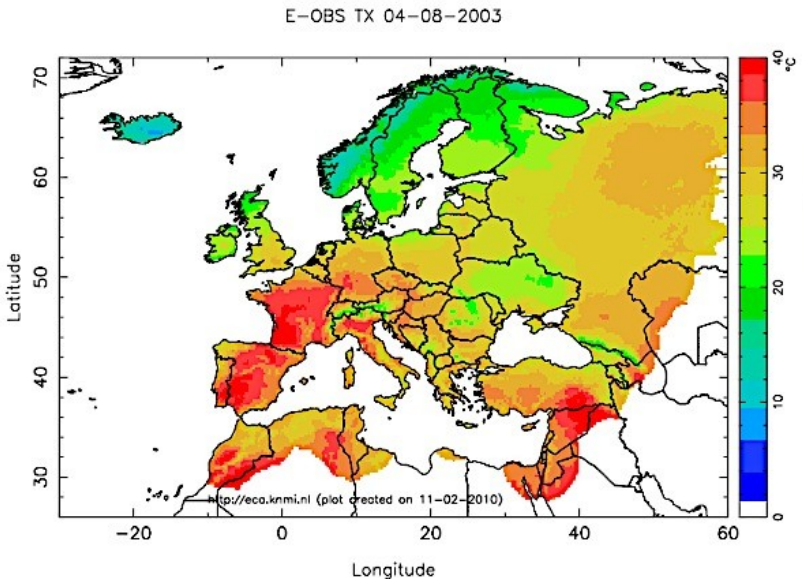
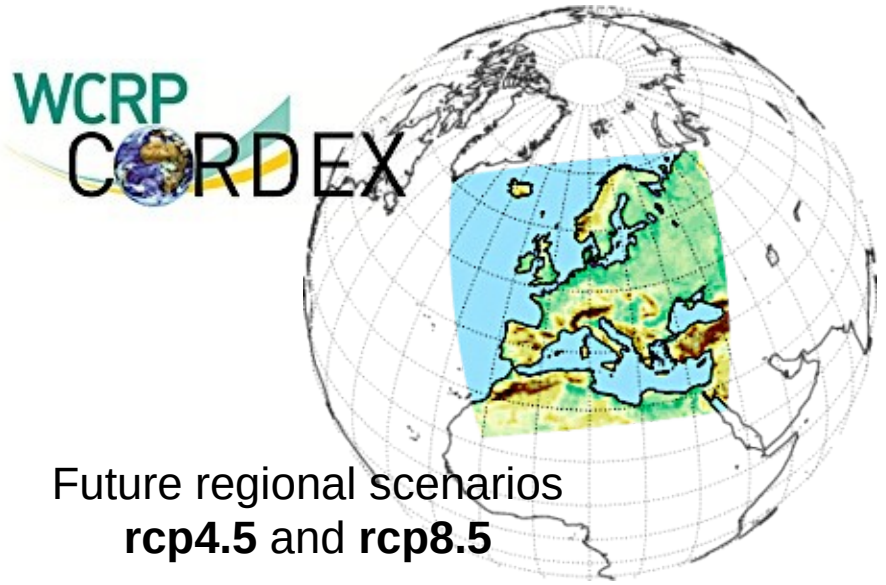


2. Database and methodology

E-OBS gridded dataset (25 km)



EURO-CORDEX (12,5 km)



Future regional scenarios
rcp4.5 and **rcp8.5**

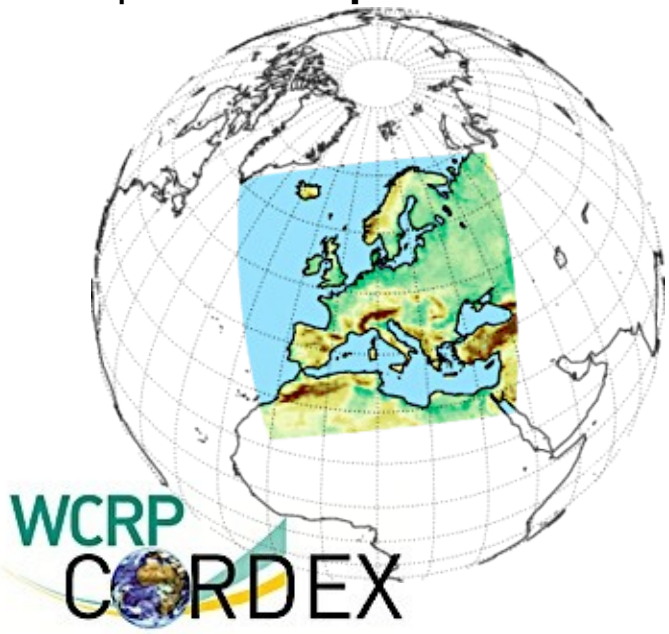
Daily series of:

- 2-m **minimum** and **maximum temperatures**
- **Accumulated precipitation**

Climate change projections

Compute changes in calibrated CDFs between a 25-year past (i.e. control/observed; 1981-2005) and successive 25-year RCM time-slices (2021-2045; **2046-2070**; 2071-2095)

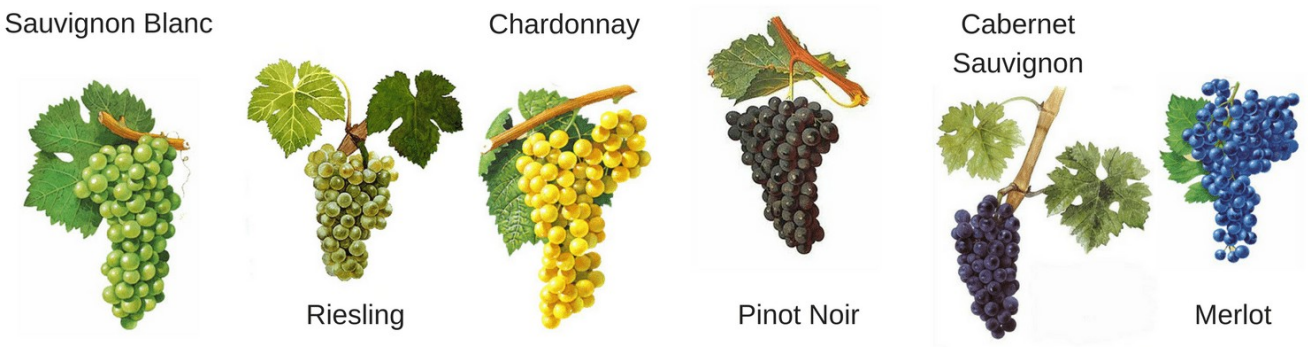
Future regional scenario
rcp4.5 and **rcp8.5**



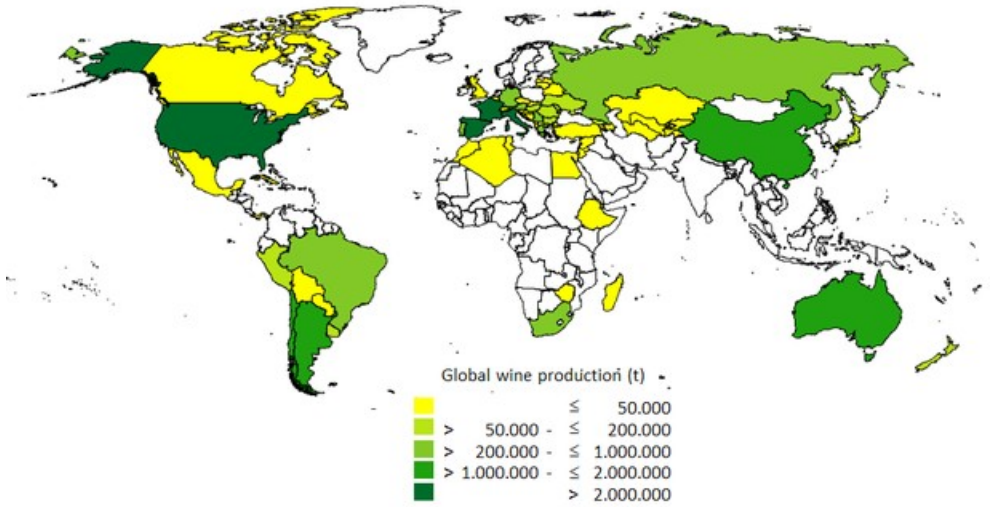
Driving GCM	RCM	Institute
CNRM-CM5-LR	CCLM4-8-17	CLMcom
EC-EARTH	CCLM4-8-17	CLMcom
HadGEM2-ES	CCLM4-8-17	CLMcom
MPI-ESM-LR	CCLM4-8-17	CLMcom
EC-EARTH	RACMO22E	KNMI
HadGEM2-ES	RACMO22E	KNMI
EC-EARTH	HIRHAM5	DMI
NorESM1-M	HIRHAM5	DMI
CNRM-CM5	ALADIN53	CNRM
CNRM-CM5	RCA4	SMHI
EC-EARTH	RCA4	SMHI
HadGEM2-ES	RCA4	SMHI
MPI-ESM-LR	RCA4	SMHI
IPSL-CM5A-MR	RCA4	SMHI

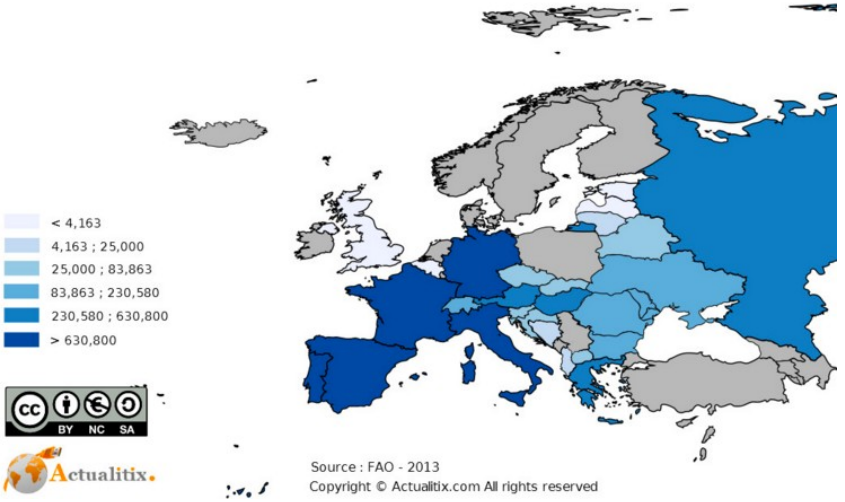
VITIS

Vitis (grapevines) is a genus of 79 accepted species of vining plants (family Vitaceae) predominantly from the **Northern hemisphere**.

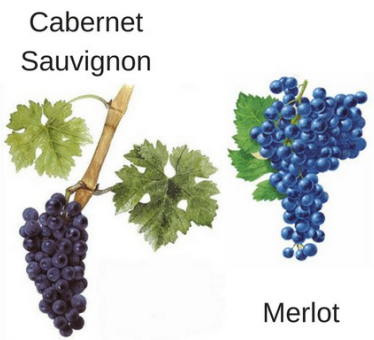


Wine - Production (Tons)





The cultivation of grapes for **wine production** → one of the agricultural sectors with more **economic importance**



One of the most **sensitive to climate modifications**

Temperature

1. Mean summer maximum temperature
2. Mean temperature April-October
3. Winkler Index
4. Huglin warmth index

Precipitation

1. Real evapotranspiration and water balance

3. Results

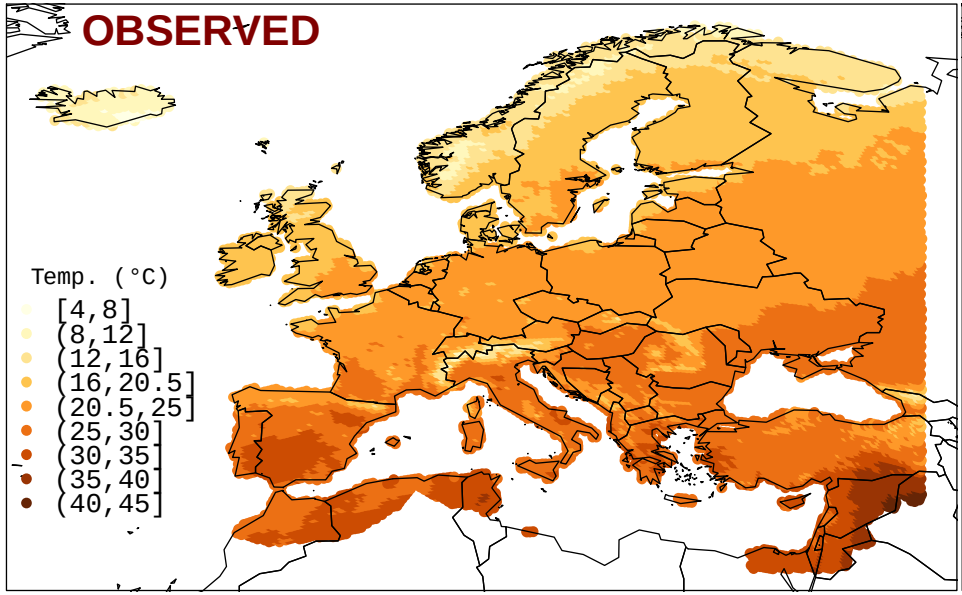
Temperature

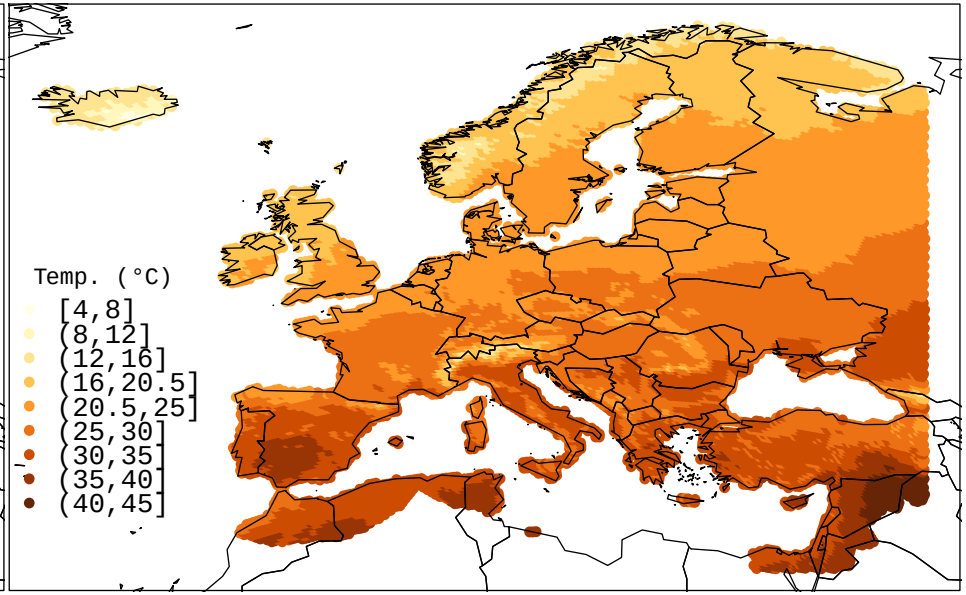
- Ripening season of grapevines (mid-summer and early autumn)
- Optimum maximum temperature in summer: 25°C
- Optimum temperature for the development of the fruit: 20-30°C

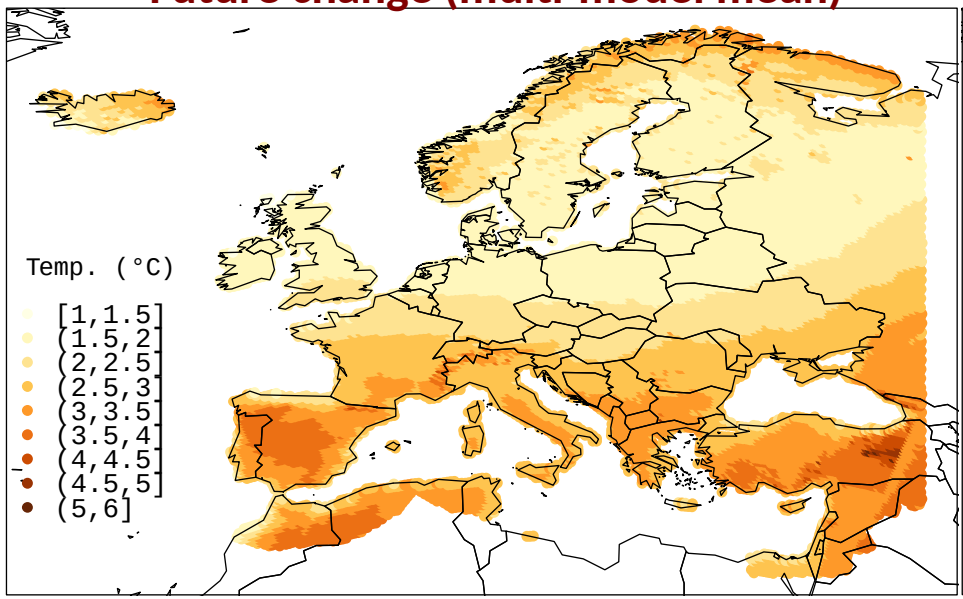
Severe thermal stress conditions

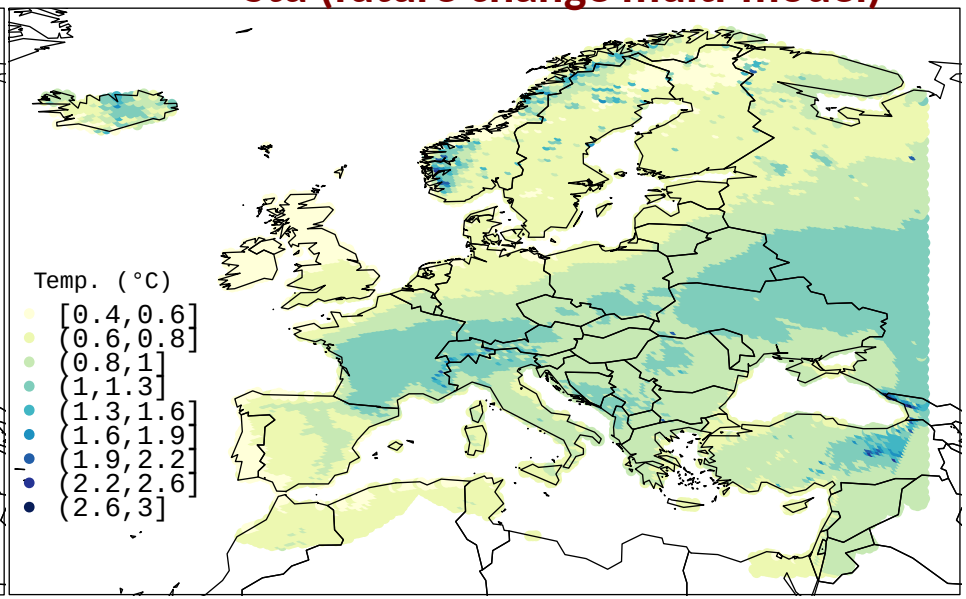
- A reduction in production (Moutinho-Pereir et al., 2004)
- Fast growth and early harvest.
- Fruit with less aromas and loss of pigments (Collins et al., 2006)
- - effect over organic components & quality wine (Yamane et al., 2006)

3.1 Mean summer maximum temperature

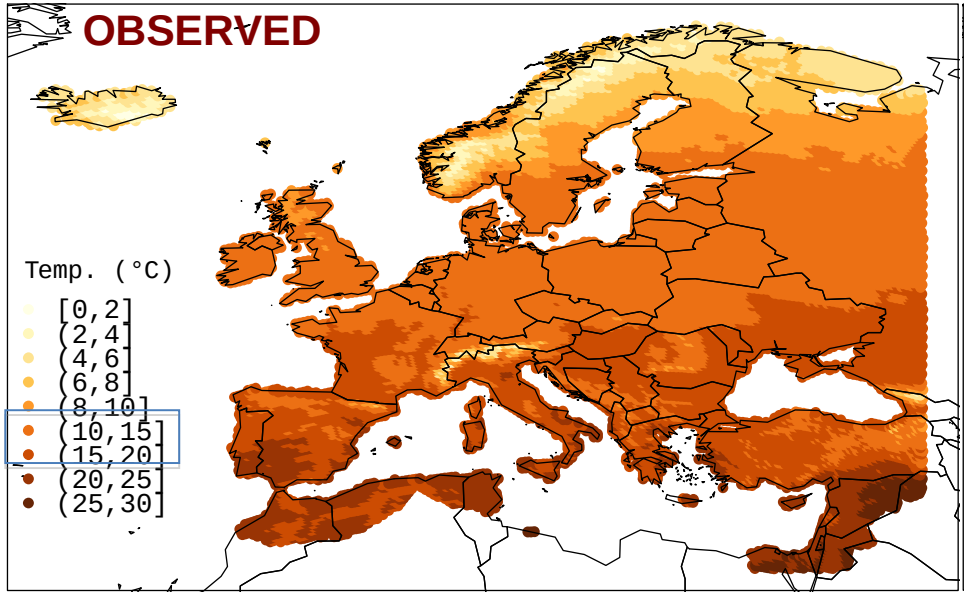




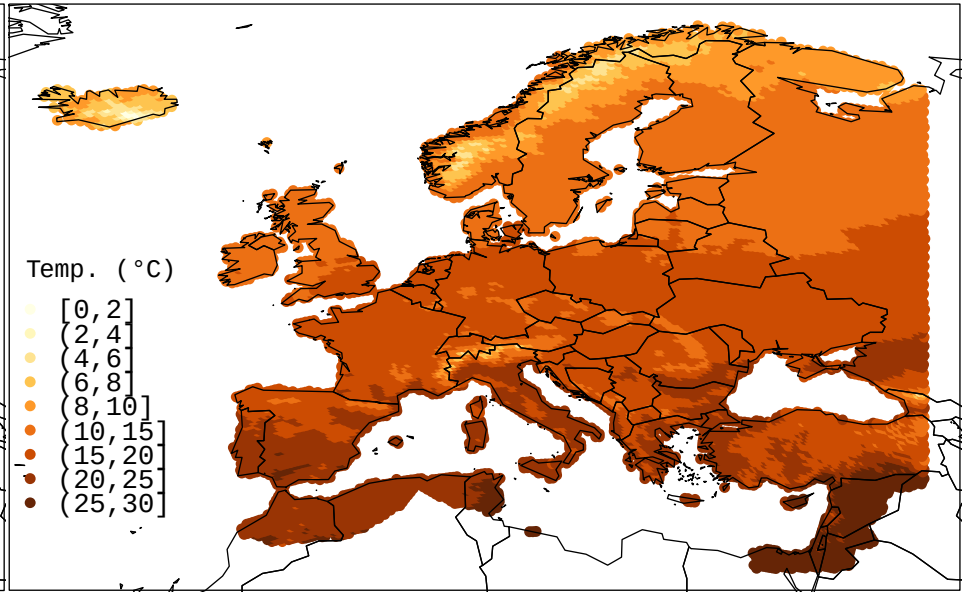




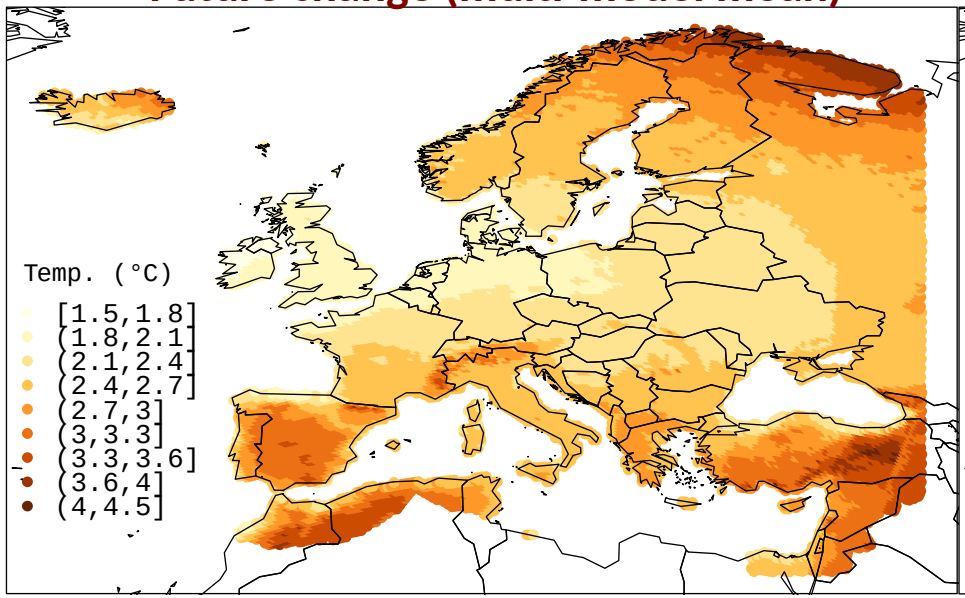
3.2 Mean temperature April-October (ripening season)



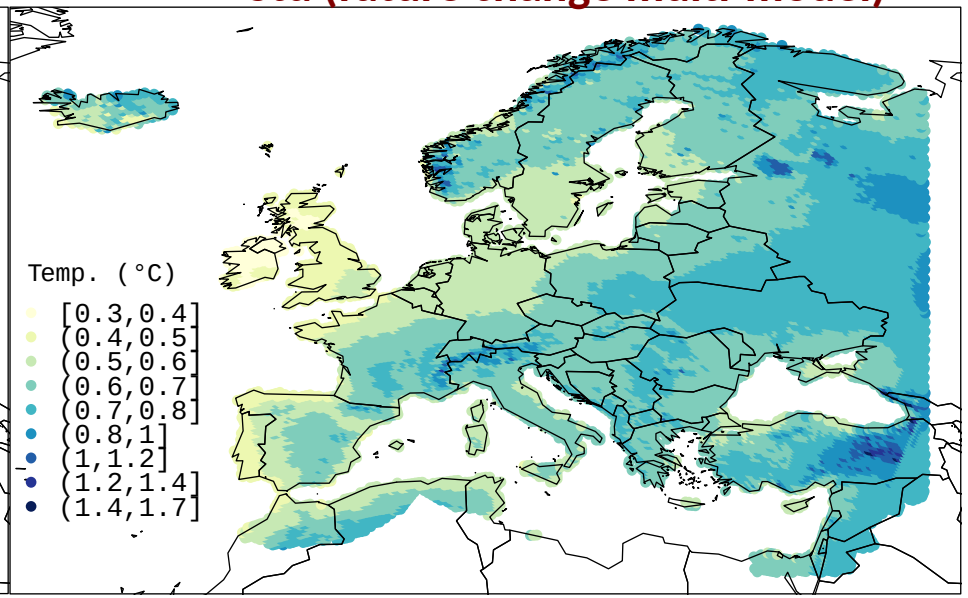
Future projected



Future change (multi-model mean)



Std (future change multi-model)



3.3 Winkler Index

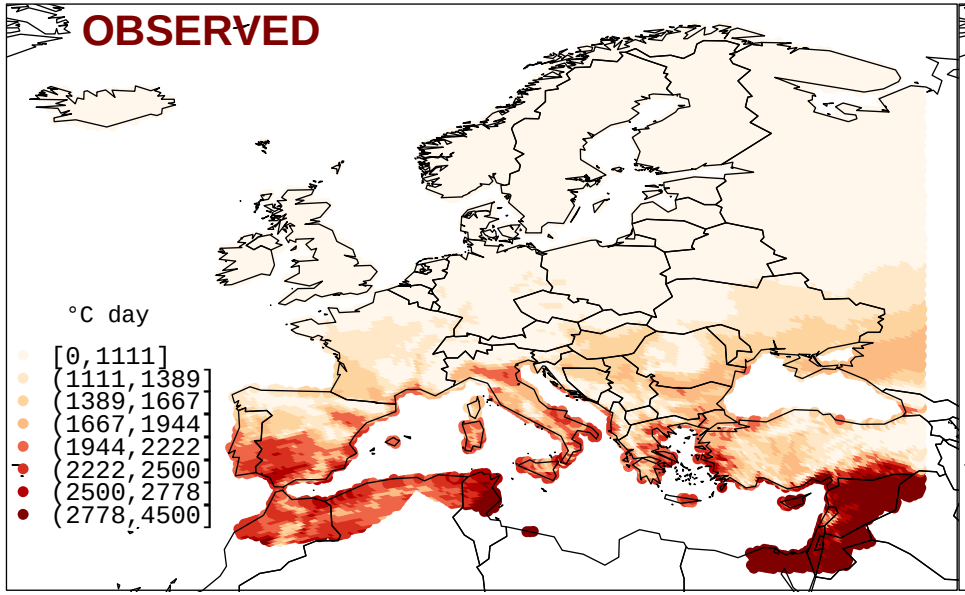
- Measures the heat accumulation or growing degree days above the vegetative zero (10 °C), during the ripening season (Amerine and Winkler, 1944).

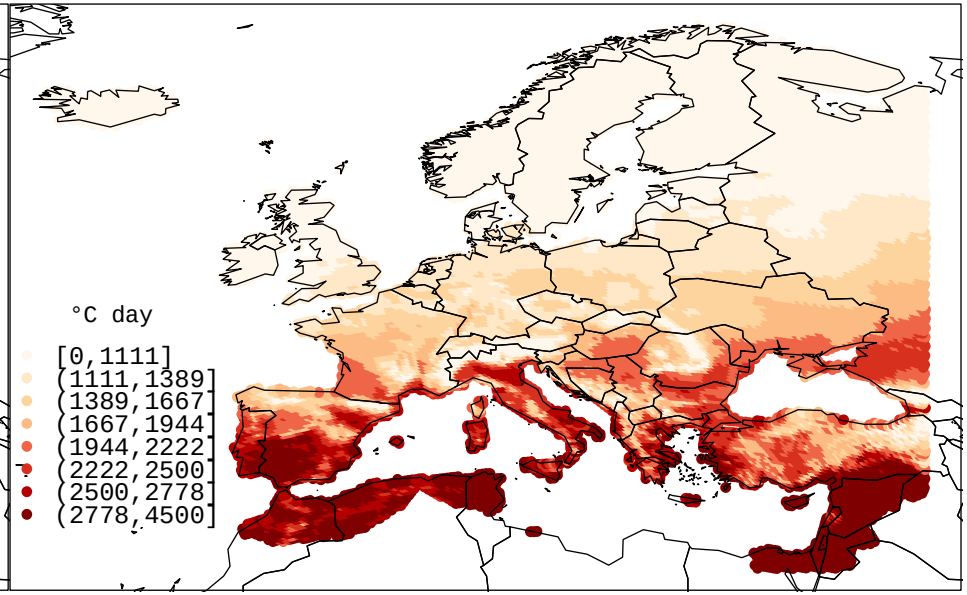
$$WI = \sum_{1abr}^{30oct} (T - 10)$$

Region/class	ºC day	General ripening capability and wine style
Too cold	<1111	Only very early ripening varieties achieve high quality, mostly hybrid grape varieties and some V. vinifera
Region I	1111-1389	Only early ripening varieties achieve high quality, some hybrid grape varieties bust mostly V. vinifera
Region II	1389-1667	**Early and mid-season table wine varieties will produce good quality wines**
Region III	1668-1944	**Favourable for high production of standard to good quality table wines**
Region IV	1945-2222	**Favourable for high production, but acceptable table wine quality at best**
Region V	2222-2500	Typically only suitable for extremely high production, fair quality table wine or table grapes varieties destined for early season consumption are grown
Region VI	2501-2778	Only suitable for extremely high production
Too warm	>2778	No suitable for vitis production

3.3 Winkler Index

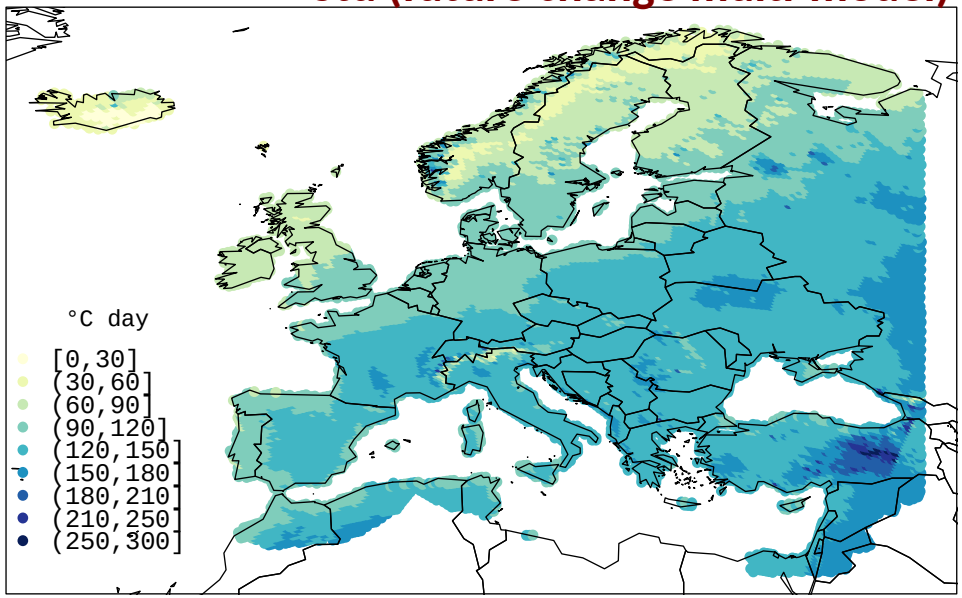
Future projected





- Too cold
- Region I : Chablis, Champagne
- Region II : Bordeaux, Alsace
- Region III : Rioja, Piemonte
- Region IV : Montpellier
- Region V : Greek islands, Sicily
- Region VI
- Too warm

Std (future change multi-model)



3.4 Huglin Index

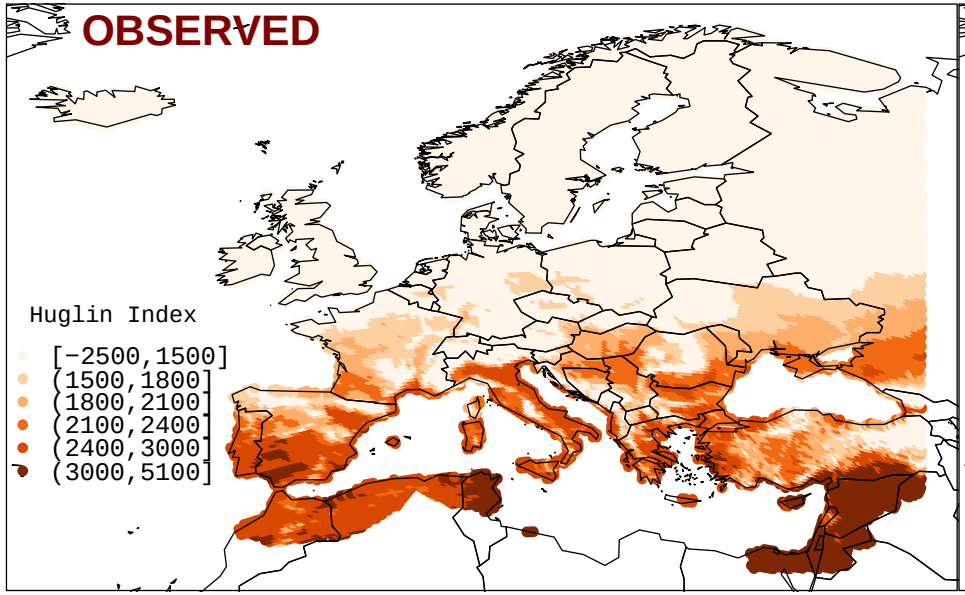
- Estimates the heliothermic potential of a specific climatic condition and is related to the thermal requirements of vine varieties and their potential sugar content.

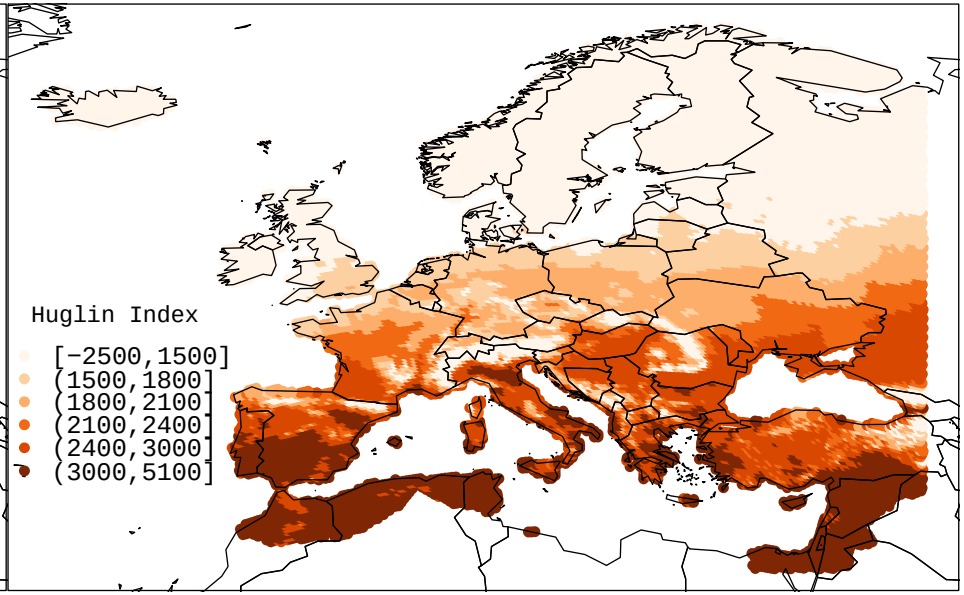
$$HI = \frac{K}{2} \cdot \sum_{1abr}^{30oct} [(T - 10) \cdot (T_{max} - 10)]$$

Region/class	HI	Grape Variety
Very cool	HI <= 1500	No suggestions
Cool	1500 < HI <= 1800	Blauer Portugieser, Pinot blanc, Pinot noir, Chardonnay.
Temper	1800 < HI <= 2100	Cabernet Franc, Chenin blanc, Merlot, Ugni blanc.
Warm Temper	2100 < HI <= 2400	Grenache, Carignan, Aramon.
Warm	2400 < HI <= 3000	
Very warm	HI > 3000	No suggestions

3.5 Huglin Index

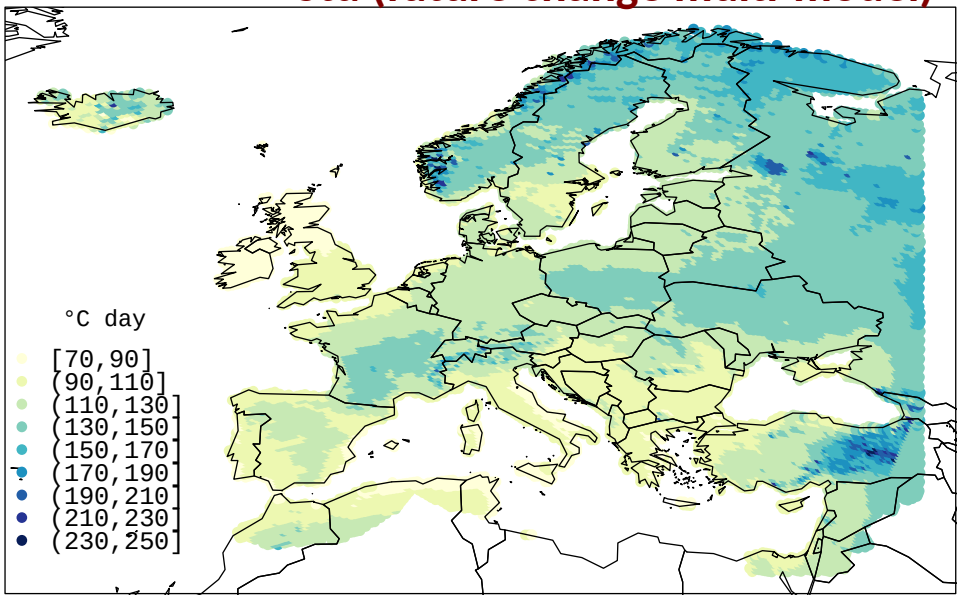
Future projected





- Very cool
- Cool: Pinot blanc, Pinot noir
- Temper Cabernet Franc, Merlot
- Warm temper: Carignan
- Warm
- Very warm

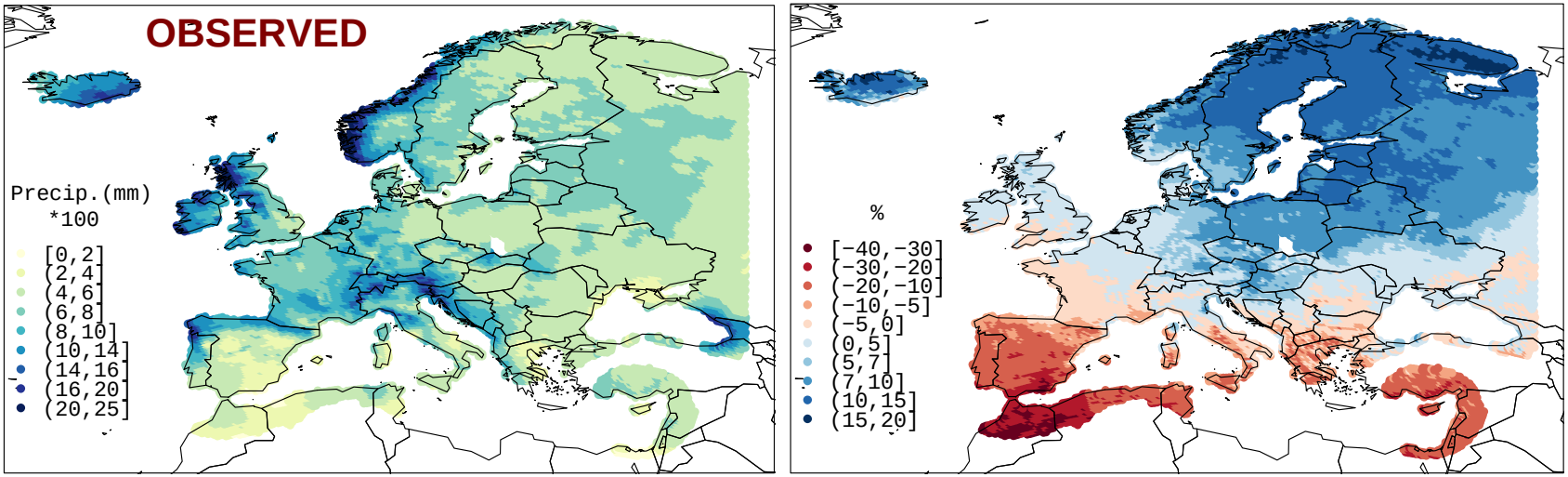
Std (future change multi-model)



Precipitation, real evapotranspiration and water balance

Despite the vine is resistant to drought because it has deep roots, **the water is a limiting factor for growth**

Future change (multi-model mean)



Real evapotranspitation (RET)

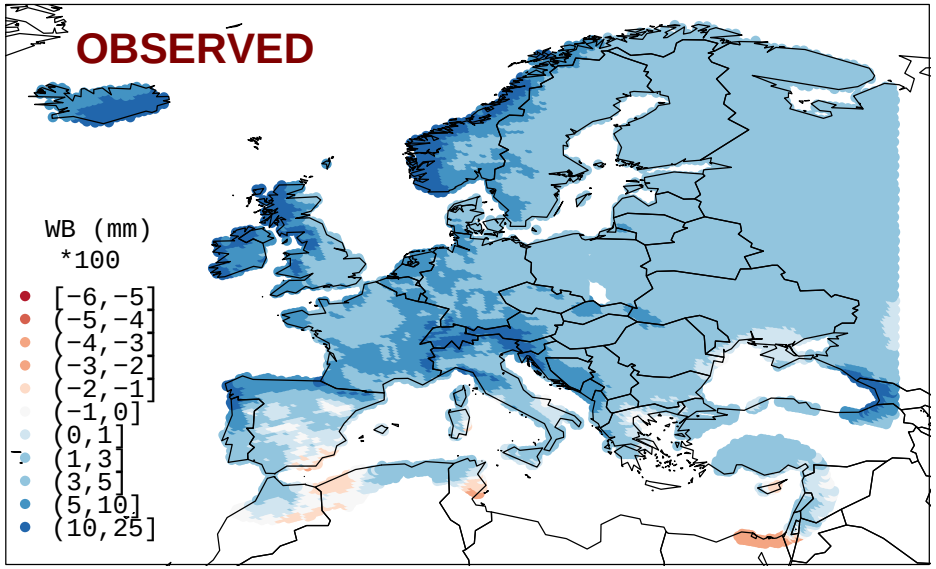
The loss of moisture from a surface by direct evaporation & the loss of water by transpiration of the vegetation

$$ETR = K_c \cdot ETP$$ *(Thornthwaite 1948)*

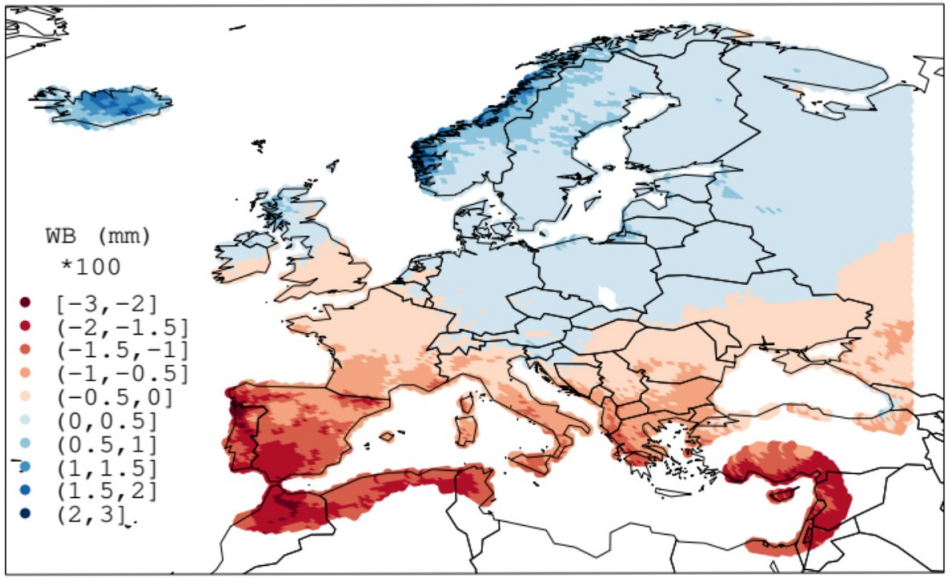
Water balance (WB)

WB= P - ETR

3.5 Water balance



Future change (multi-model mean)



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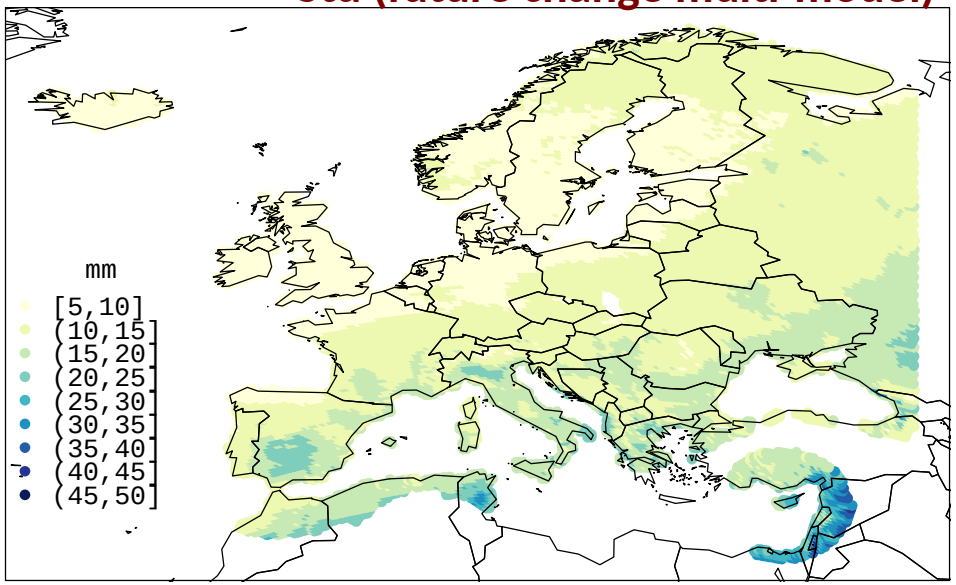

If water deficit increases, the rate of perspiration and therefore heat dissipation is also affected → **increase in leaf temperature** (Hsiao, 1973).

4. Conclusions

- The grapevine will be exposed for longer to excessive temperatures for proper maturation in the near future

- The evolution of the Winkler and Huglin indices represents the change of suitability expected for the southern regions of Europe, where the cultivation of the vine for the production of wine will be progressively less adequate. The areas of northern Europe that were not suitable for the vine can be grown in the near future .

- A generalized decrease of WB for SEM is expected due to the decrease in annual precipitation and the increase in the evaporative demand of the plant.

- The adoption of more efficient irrigation methods should be evaluated, due to the greater consumption of water by the crop and the reduction of rainfall

- The vine may cease to be viable in some regions of the SEM in the near future if no adaptive measures are taken taking into account its current use, mainly the production of wine.

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Amengual A; et al; 2012. A statistical adjustment of regional climate model outputs to local scales: application to Platja de Palma, Spain. J Clim25(3):939–957

Cardell, M.F., et al; 2018a. A quantile-quantile adjustment of the EURO-CORDEX projections for temperatures and precipitation. Submitted to International Journal of Climatology

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