The impact of a changing and variable climate on horticultural tree crops in Australia

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SARDI, Climate Applications

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Outline

- Implications of climate change to agriculture and horticulture
- Crop risk phenology calendar
- Chilling and flowering time
- High temperature and heatwaves
- Rain, ET and Irrigation

Main points

- We have and will continue to have a variable climate
- Climate change is the change from the usual
- Understand your crop and the role weather and climate has on its development, yield and your profitability
- Look to neighbors and how they manage weather and climate risks
- Prepare for a warmer and more water constrained future

Implications

High confidence of temperature increases

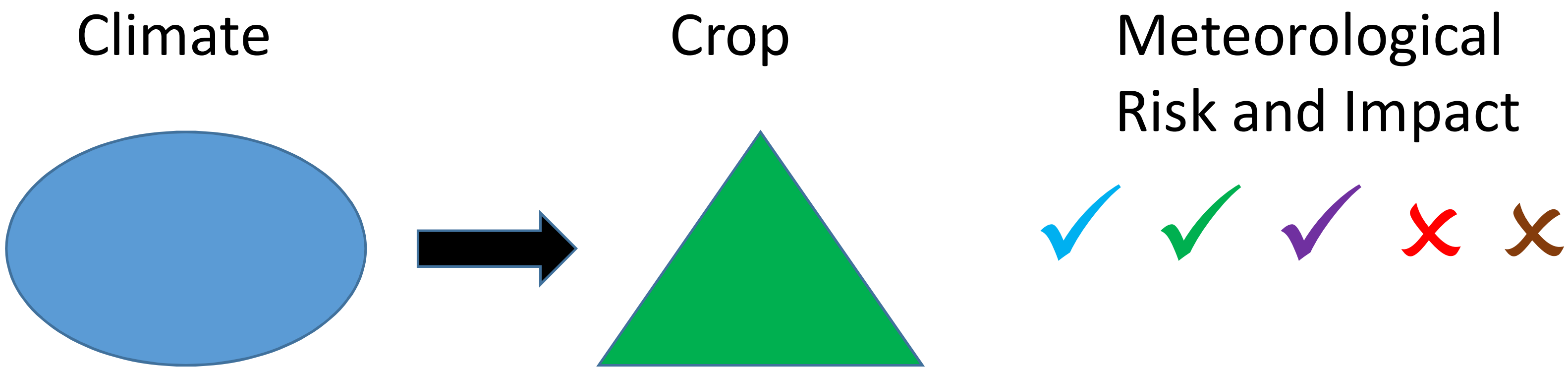
- Warmer seasons
- Decline in winter chill
- Flowering time shifted
- Faster development; harvest time shifted
- Change in optimal photosynthetically active hours
- More hot days and heatwaves and heat stress (heat and sun damage, bud formation and differentiation, photochemical damage…) possibly reducing yield
- Fewer frosts

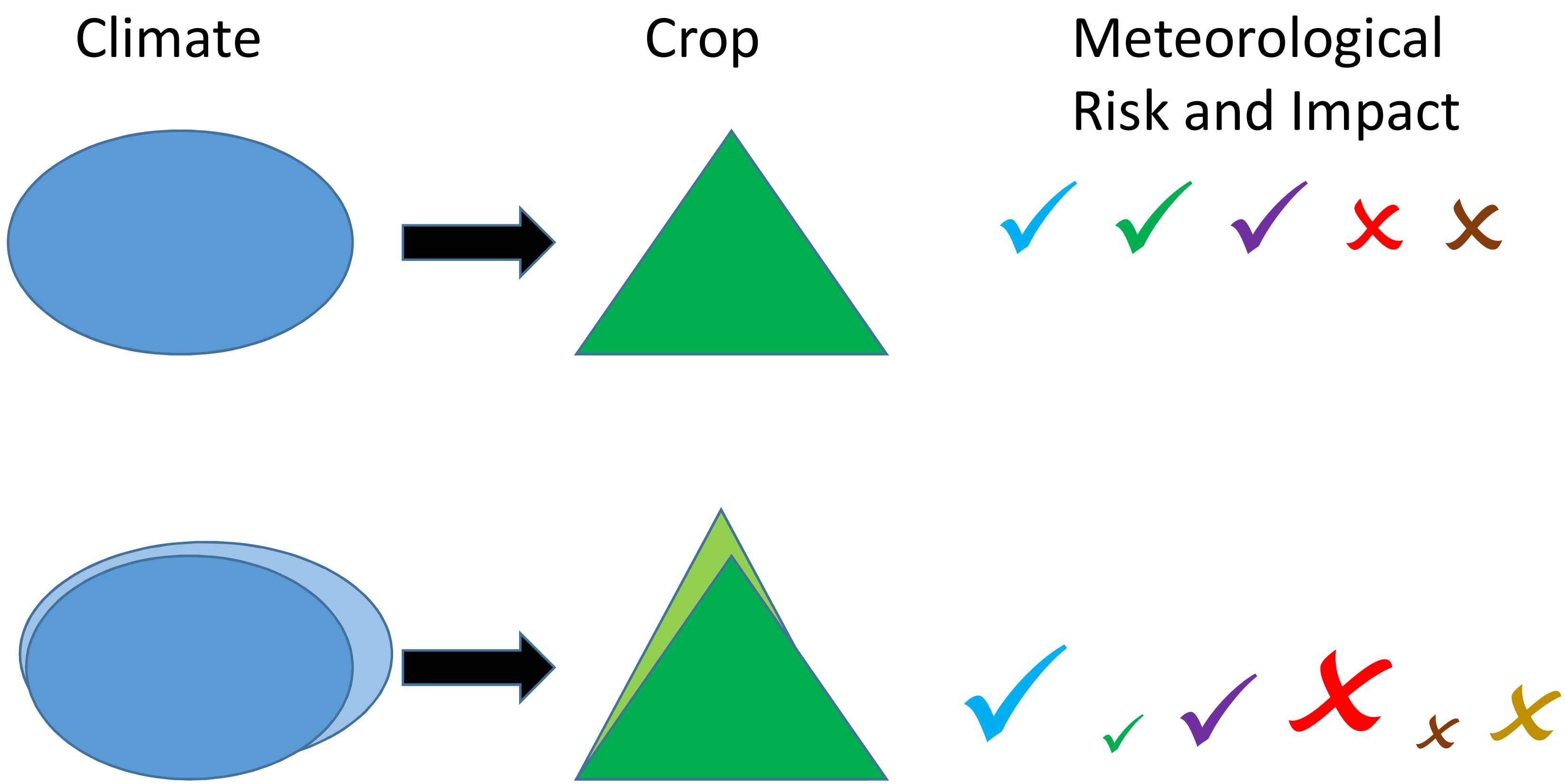
Implications

Lesser confidence of changes in rainfall

- Greater uncertainty in rainfall but overall less rainfall and change in seasonality of rainfall. More certainty of declines in Winter and Spring rain.
- Extreme droughts occur more frequently and of a longer duration
- Less run-off and less water for irrigation (and for managing heatwaves)
- Increased heavy precipitation events and storm intensity: crop damage, uprooting of trees, soil erosion, land cultivation

- Lower humidity
- More evapotranspiration due to warmer and drier atmosphere although the higher CO_2 concentration may negate this increase. Uncertain impact on leaf temperature.


Climate
Crop
Meteorological
Risk and Impact



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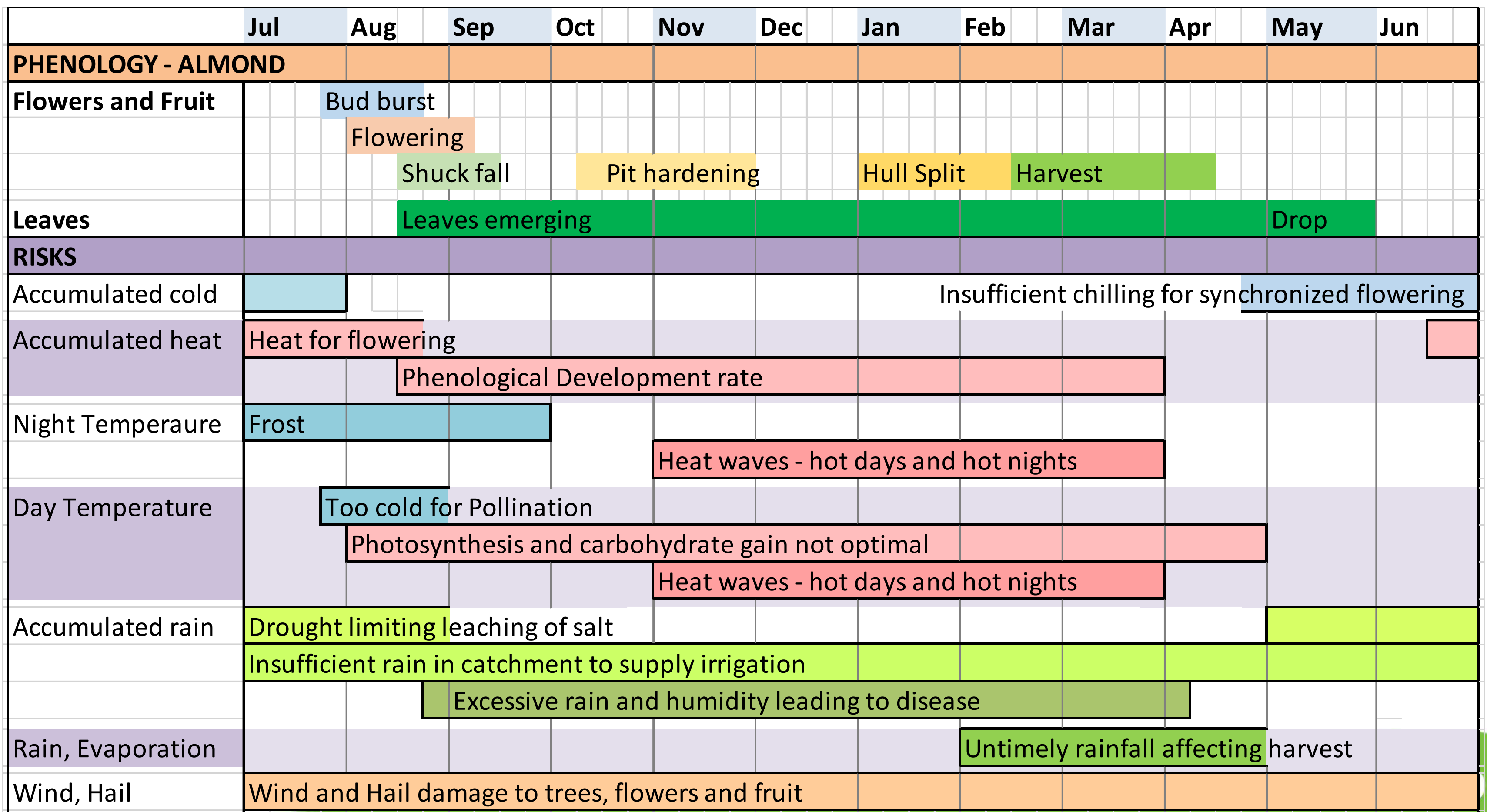
Phenology calendar for almonds

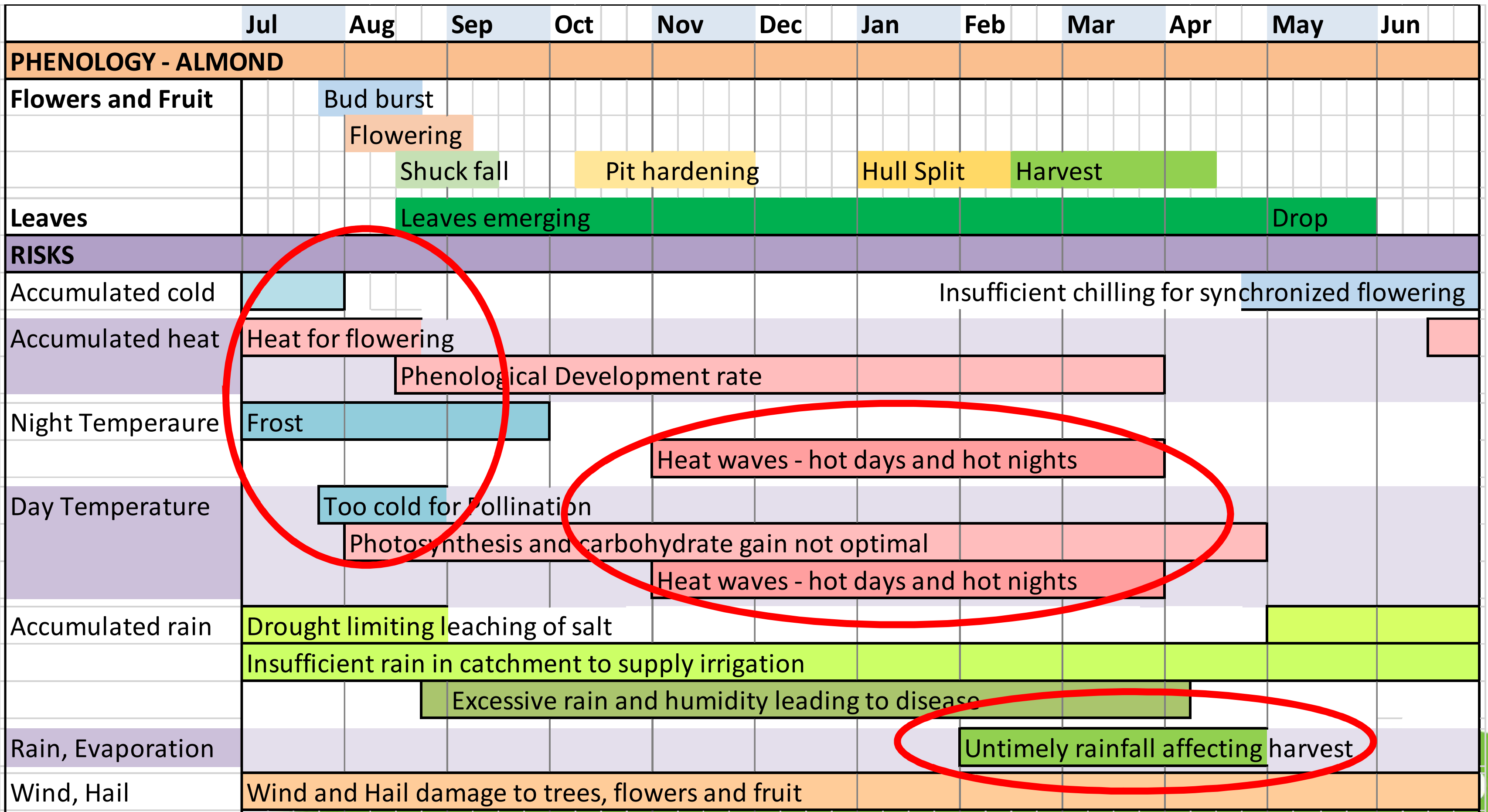
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
PHENOLOGY - ALMOND												
Flowers and Fruit	Bud burst											
		Flowering										
		Shuck fall		Pit hardening			Hull Split	Harvest				
Leaves		Leaves emerging									Drop	
RISKS												
Accumulated cold												
Accumulated heat												
Night Temperaure												
Day Temperature												
Accumulated rain												
Rain, Evaporation												
Wind, Hail												

Phenology calendar for almonds



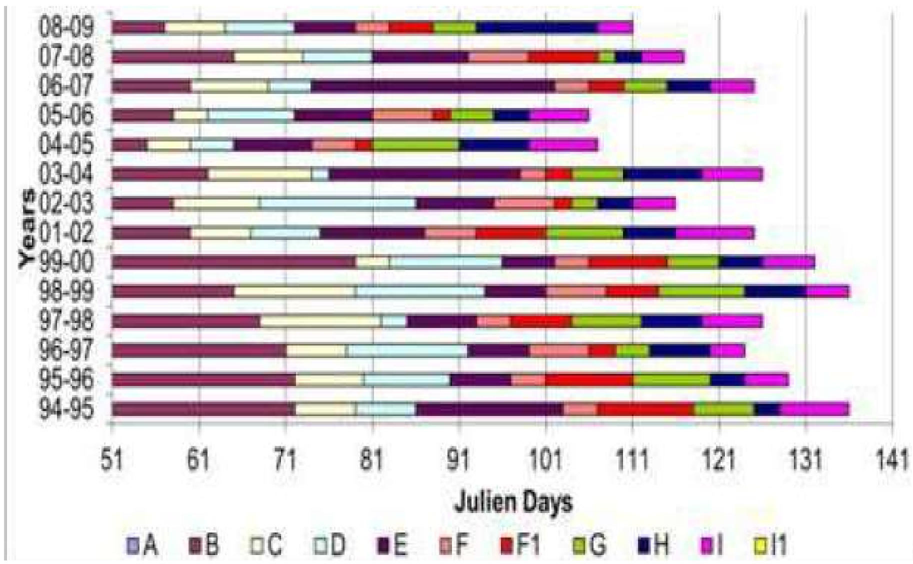
Phenology calendar for almonds

Ranking risks by economic importance



Phenology calendar for olive

'Chemlali' Olive in Tunisia



B. Vegetative development

C. Inflorescence emergence

F. Flowering start; F1 Full flowering

H. Fruit set

Graph from Mounir and Monji 2015. The effects of climate change on olive tree phenology. *Journal of Global Biosciences*. 4:2513-2517

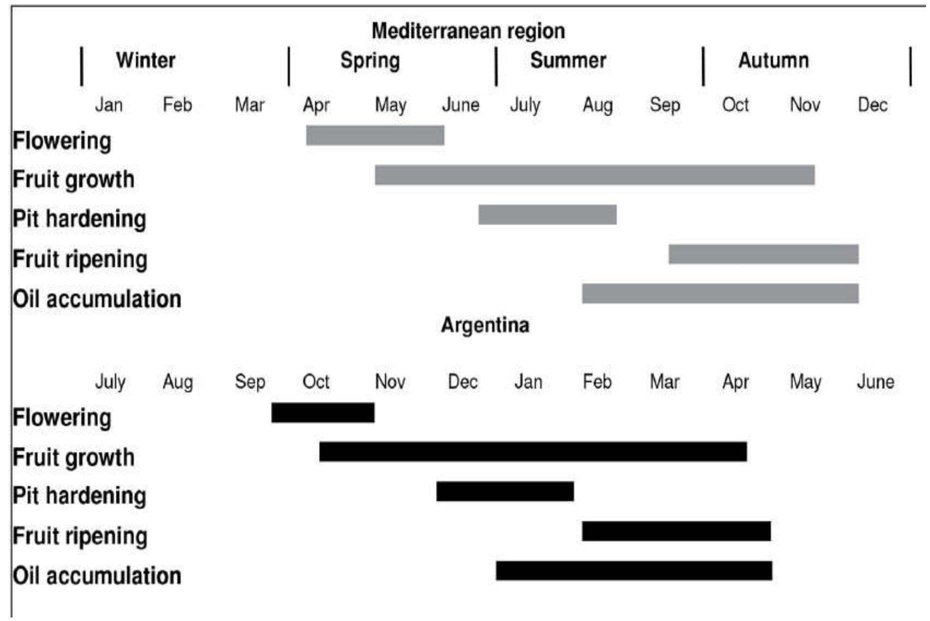
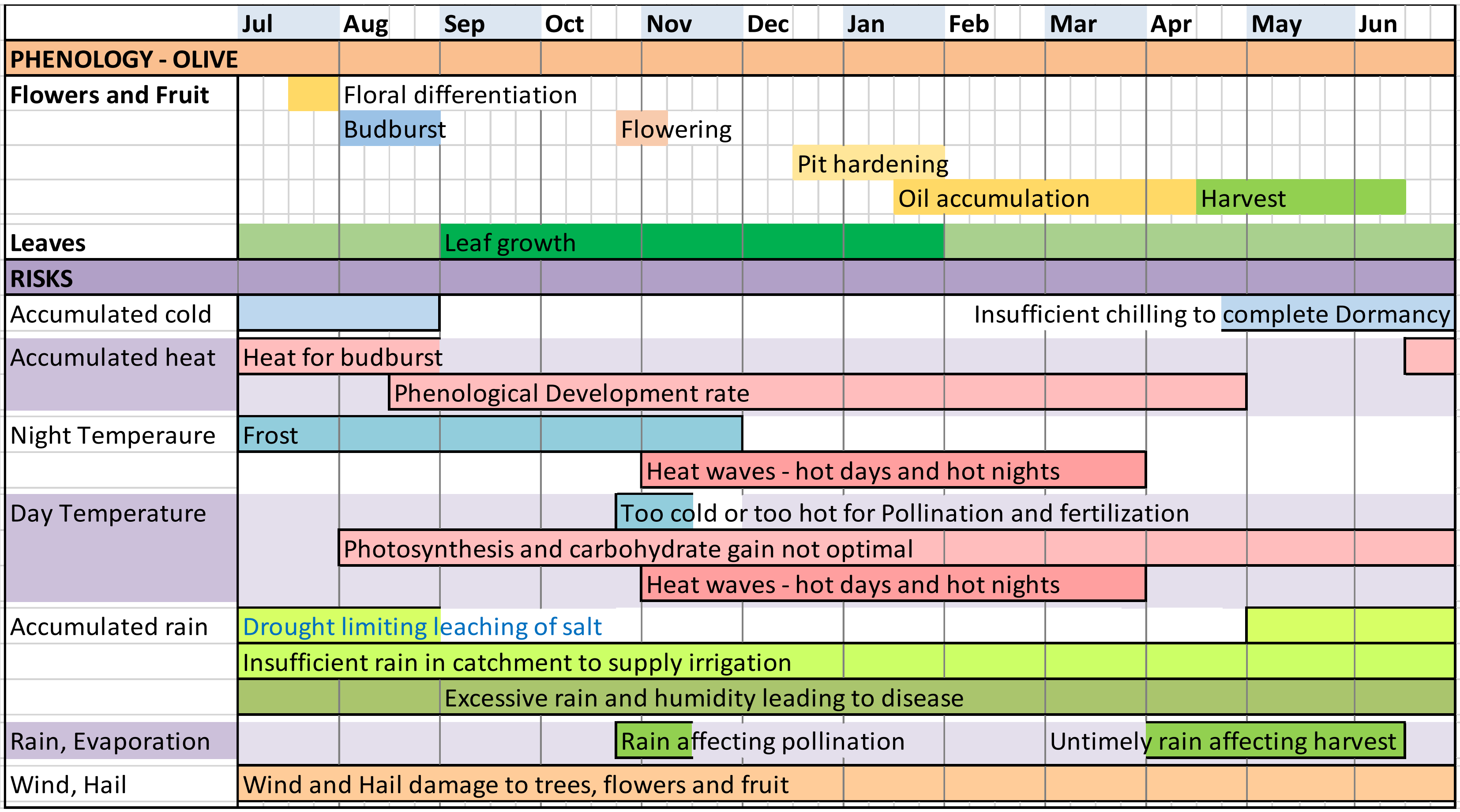


Figure from Torres et al. 2017. Olive cultivation in the southern hemisphere: flowering, water requirements and oil quality responses to new crop environments. *Frontiers in Plant Science*. Volume 8. DOI 10.3389 /fpls.2017.01830

Phenology calendar for olive



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Chilling requirements for dormancy and flowering

Amount of chill depends on your location
Critical level of chill depends on the crop and cultivar

Olives can flower in low chill years, BUT low chill can result in low quality flowers, deformed fruit and low set.
How much chill is enough?
Possibly more chill required by Olives in ON years than OFF years.

Pictures from Torres et al., 2017. Olive cultivation in the southern hemisphere: flowering, water requirements and oil quality responses to new crop environments. *Frontiers in Plant Science*. Volume 8. DOI 10.3389 /fpls.2017.01830

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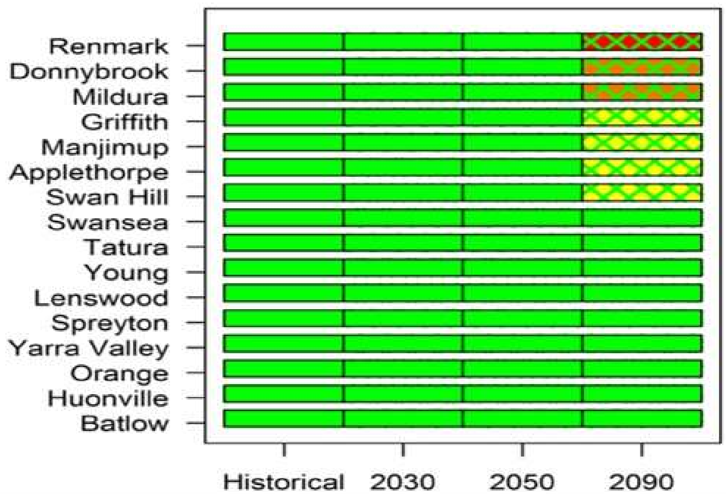
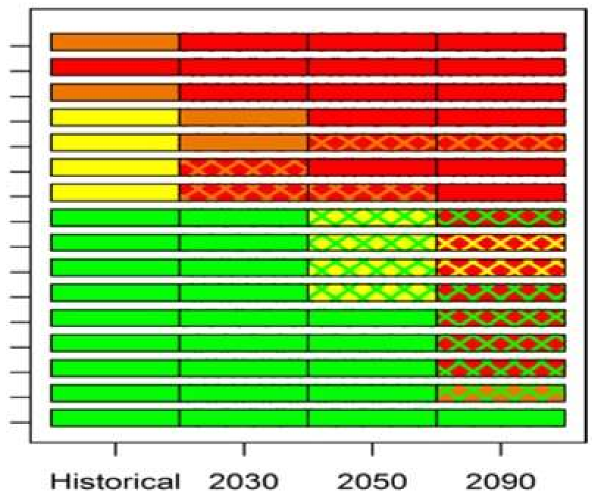
What is the likelihood of chill declining to dangerous levels?

The reduction in winter chill with climate change will occur sooner in warmer locations

Almond ‘Nonpareil’
23 Chill Portions



Apricot ‘Orange Red’ (A higher chill Apricot)
67 Chill Portions



Green = OK,
Red = Insufficient chill

Graphs from Darbyshire et al., 2016. A crop and cultivar-specific approach to assess future winter chill risk for fruit and nut trees. *Climate Change*. 137: 541-556.

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Where will olives be grown in the future?

"They concluded that with the further temperature rise it could be necessary to introduce new varieties with lesser chilling requirements; otherwise, it would be required to move production into other areas with lower temperature".

Excerpt from Tanasijevic et al. 2014 referring to olive growing locations in Spain and Italy.

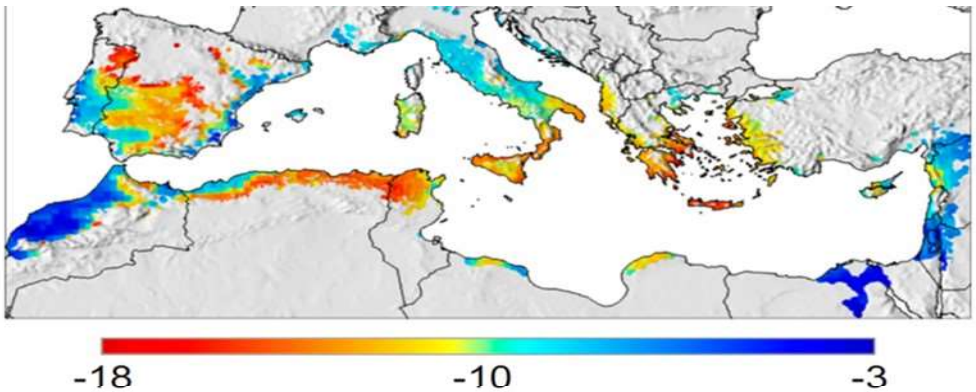
Tanasijevic et al. 2014. Impacts of climate change on olive crop evapotranspiration and irrigation requirements in the Mediterranean region. *Agricultural Water Management*. 141:54-68.

Flowering time and crop phenology

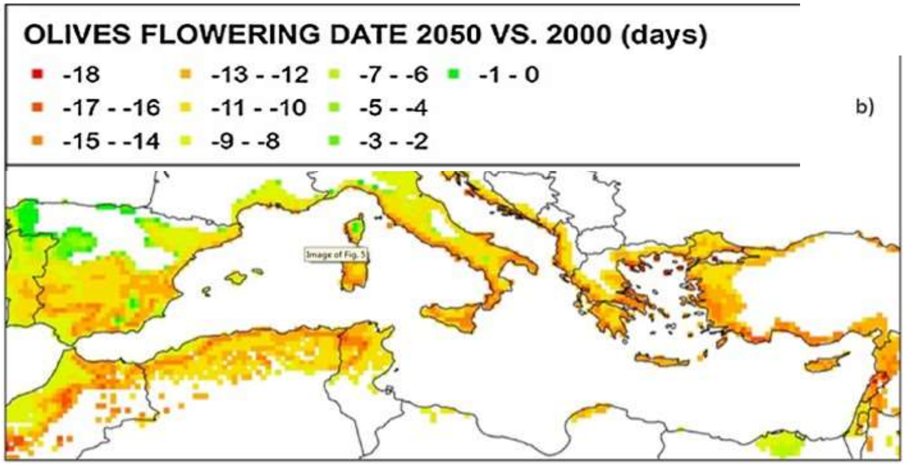
Flowering time depends on chill and subsequent heat. Depending on crop, cultivar and location, a warmer temperature can advance, retract or have no impact on flowering time.

In Europe a warmer climate is expected to advance olive flowering; although reports differ to what extent.

Flowering in an earlier and cooler time of the year could reduce any negative effects of a warming climate on olive fertilization.



Graph from Ponti et al. 2013. Fine-scale ecological and economic assessment of climate change on olive in the Mediterranean Basin reveals winners and losers. *PNAS*. 111: 5908-5603



Graph from Tanasijevic et al. 2014. Impacts of climate change on olive crop evapotranspiration and irrigation requirements in the Mediterranean region. *Agricultural Water Management*. 141:54-68.

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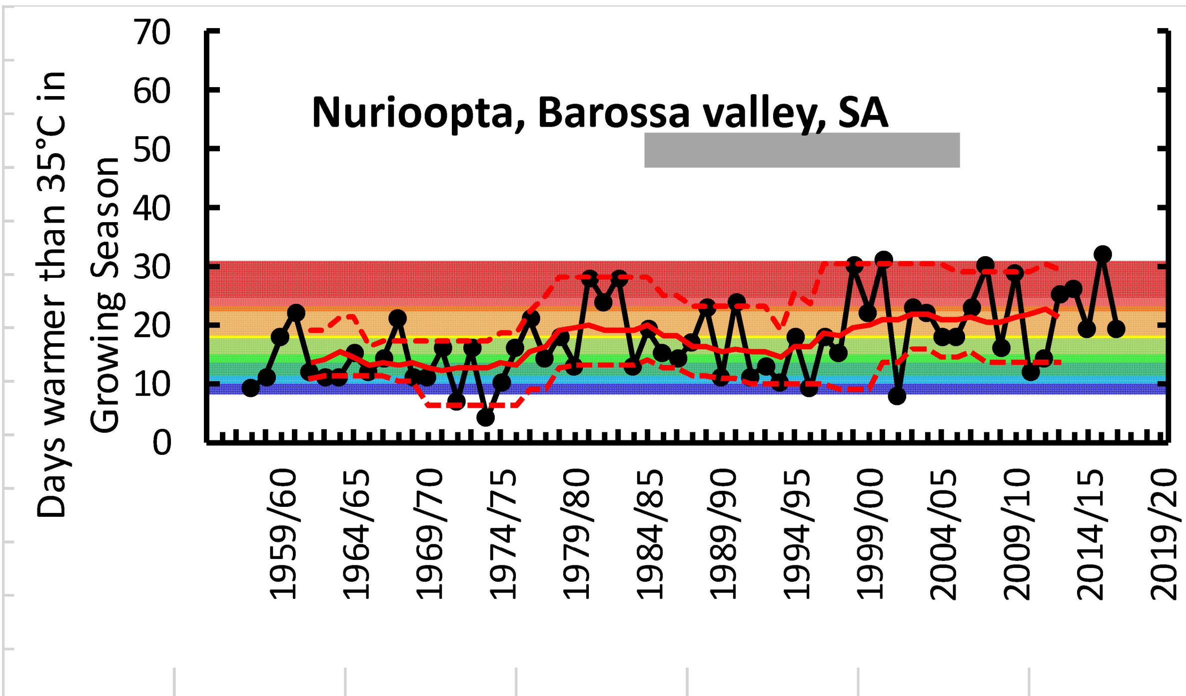
How is low chill mitigated in other industries?

- Rest breaking agents
- Breeding for low chill
- Evaporative cooling during the day to overcome warm daytime temperatures
- Kaolin clay sprayed onto buds to reflect sunlight and reduce heating of buds
- Change of location

Hot temperatures and heatwaves

The number of hot days have increased and more are expected in coming years



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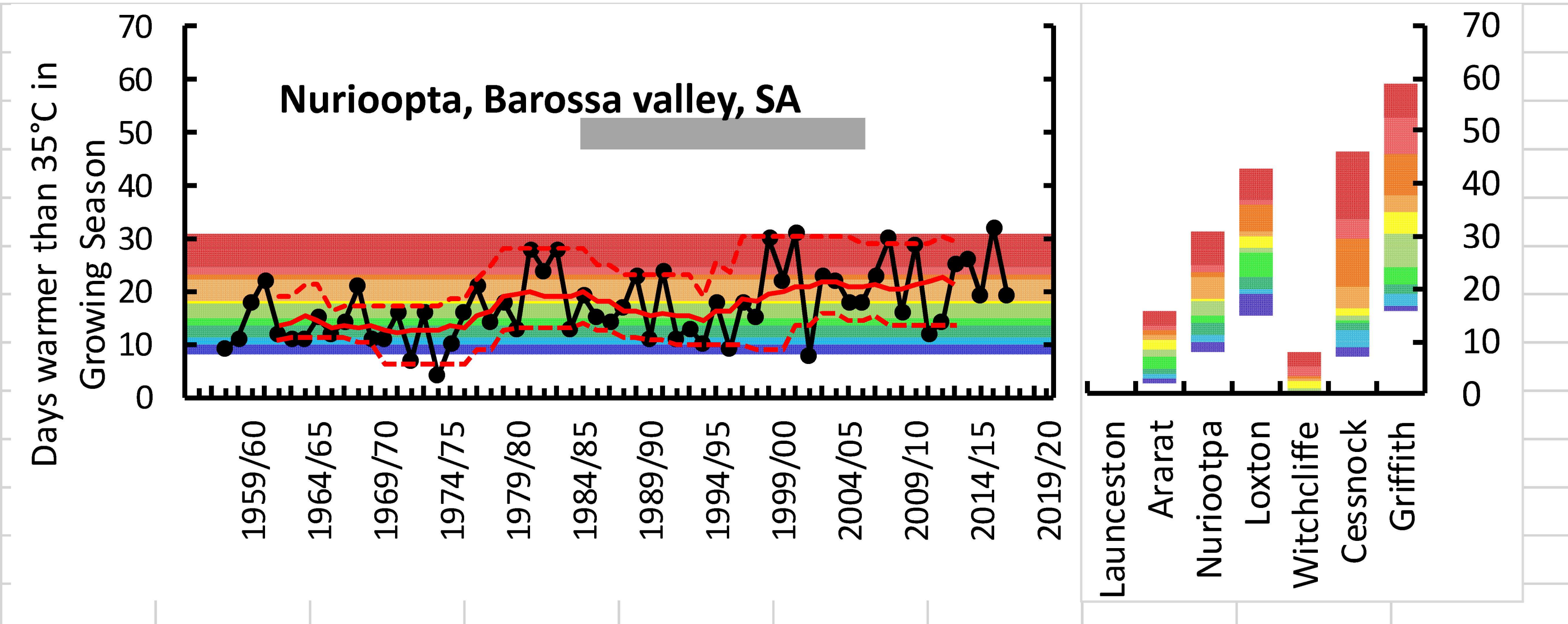

Comparing your location with other locations is a useful way to gauge resilience

A warming climate increases the chance that a year will have more hot days and heatwaves

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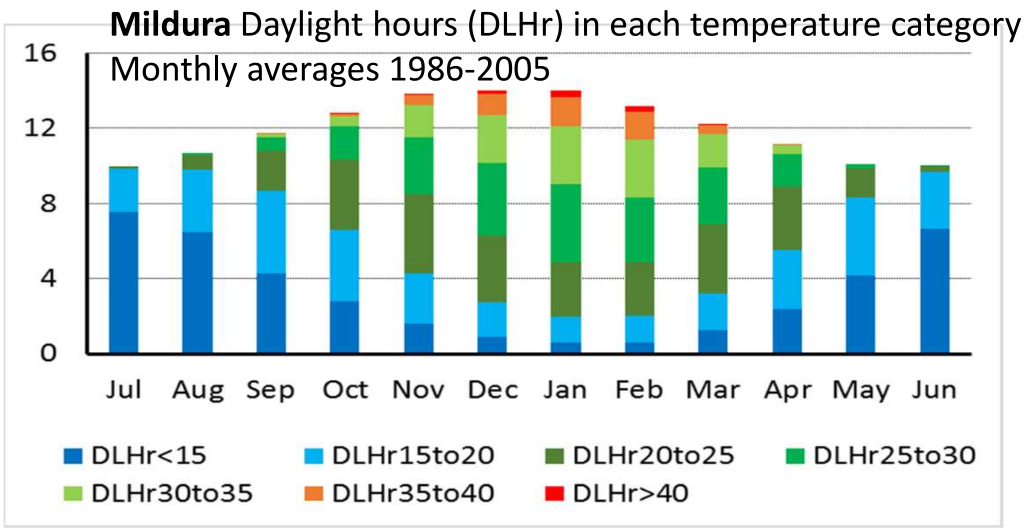
Photosynthetically optimal hours

Photosynthesis and carbohydrate gain (yield) depends on temperature with a broad optimum of about 20 to 30°C.

The number of daylight hours within each temperature category changes with season.



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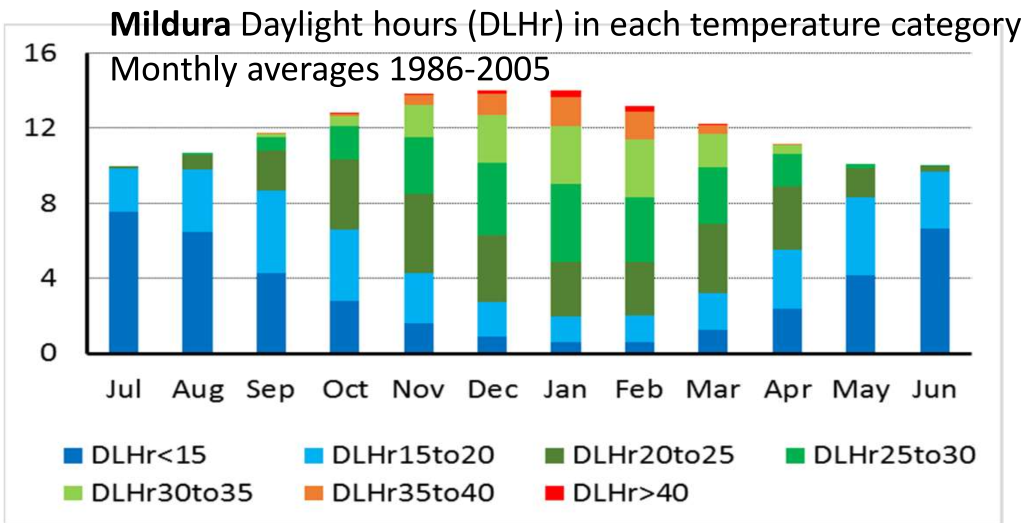
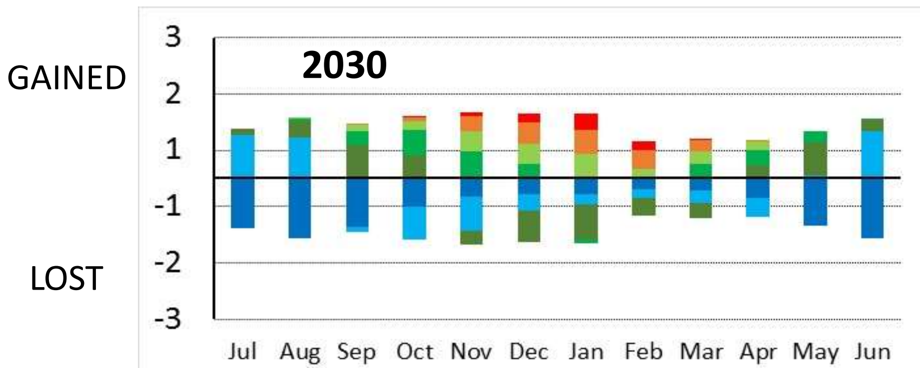
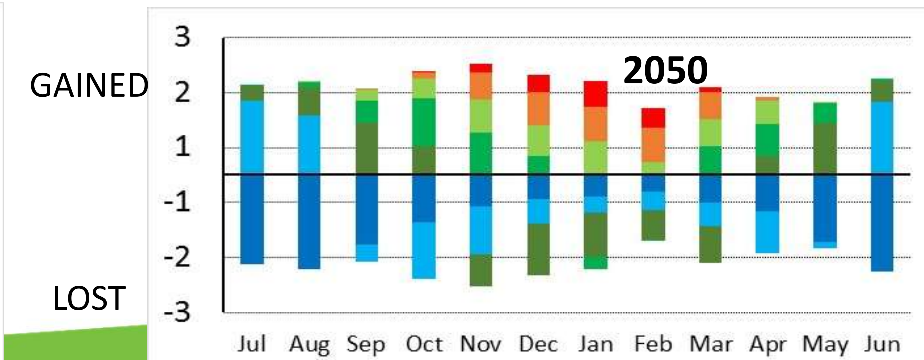


Warming conditions will increase the occurrence of supra-optimum temperatures.
Will there be a trade-off between a longer growing season and number of optimal hours?





Water

Rainfall Declines expected although less confidence in projections.

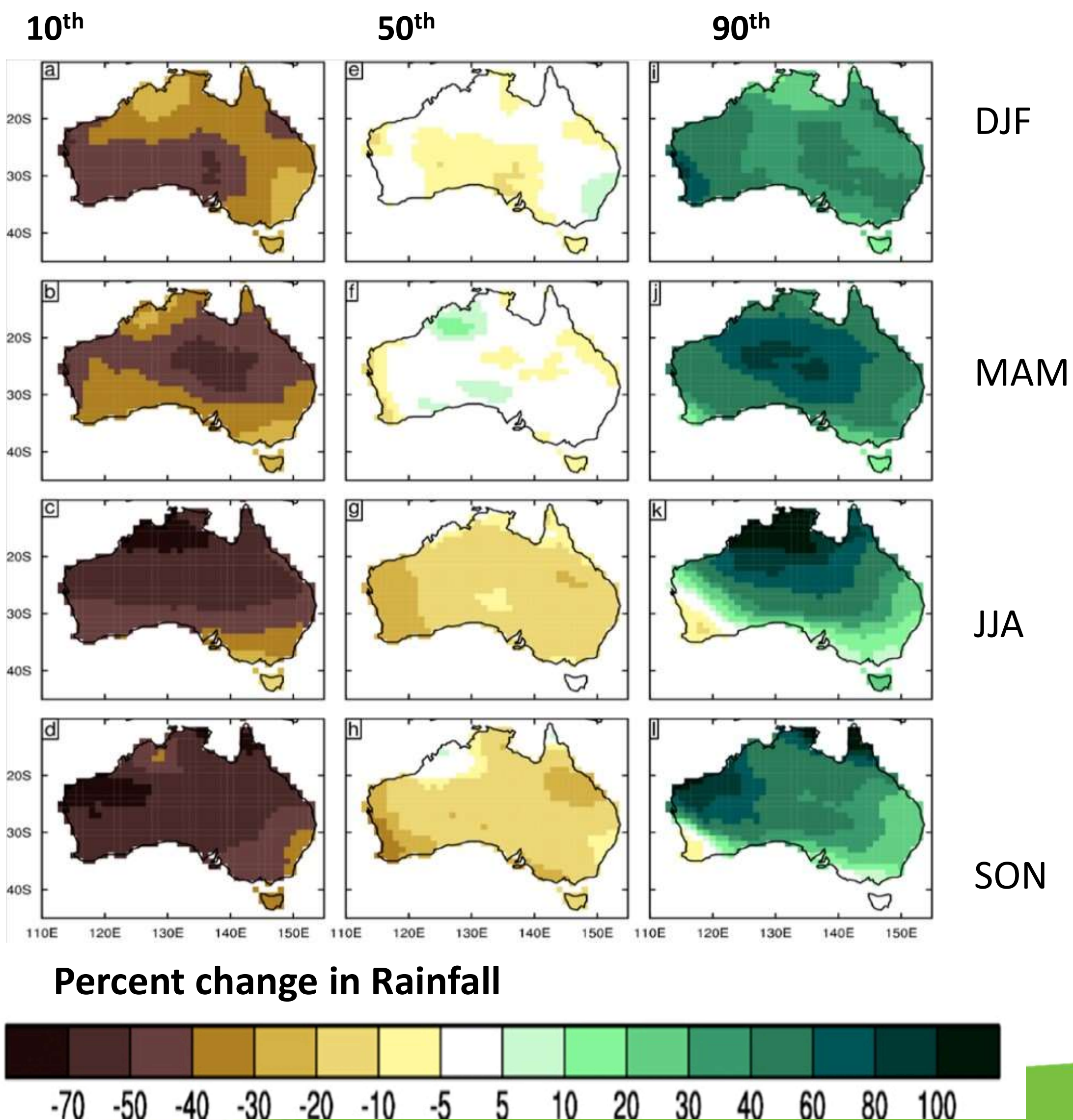
Drought The time in drought is projected to increase with *high confidence* over southern Australia and with *medium* or *low confidence* in other regions. Greater frequency of extreme droughts, and less frequent moderate to severe drought projected for all regions (*medium confidence*).

Run-off 2 to 3 times greater decline than the decline in rainfall.

Evapotranspiration (ET) There is *high confidence* in increasing potential evapotranspiration although there is only *medium confidence* in the magnitude of change.

Crop evapotranspiration (ETc) Uncertainty although likely to increase.

Irrigation requirements (ETc – Rainfall) Likely to increase.



Change in Rainfall

Uncertainty but expected to decline.

Cool season (winter and spring) rainfall in Southern Australia is projected to decrease (*high confidence*).

The winter decline may be as great as 50 % in south-western Australia in the highest emission scenario (RCP8.5) by 2090.

Gridded 10th, 50th and 90th percentile seasonal rainfall changes from CMIP5, 2090 RCP8.5.

Graph from Climate Change in Australia Technical Report. Figure 7.2.5. CSIRO and Bureau of Meteorology 2015, Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report, CSIRO and Bureau of Meteorology, Australia

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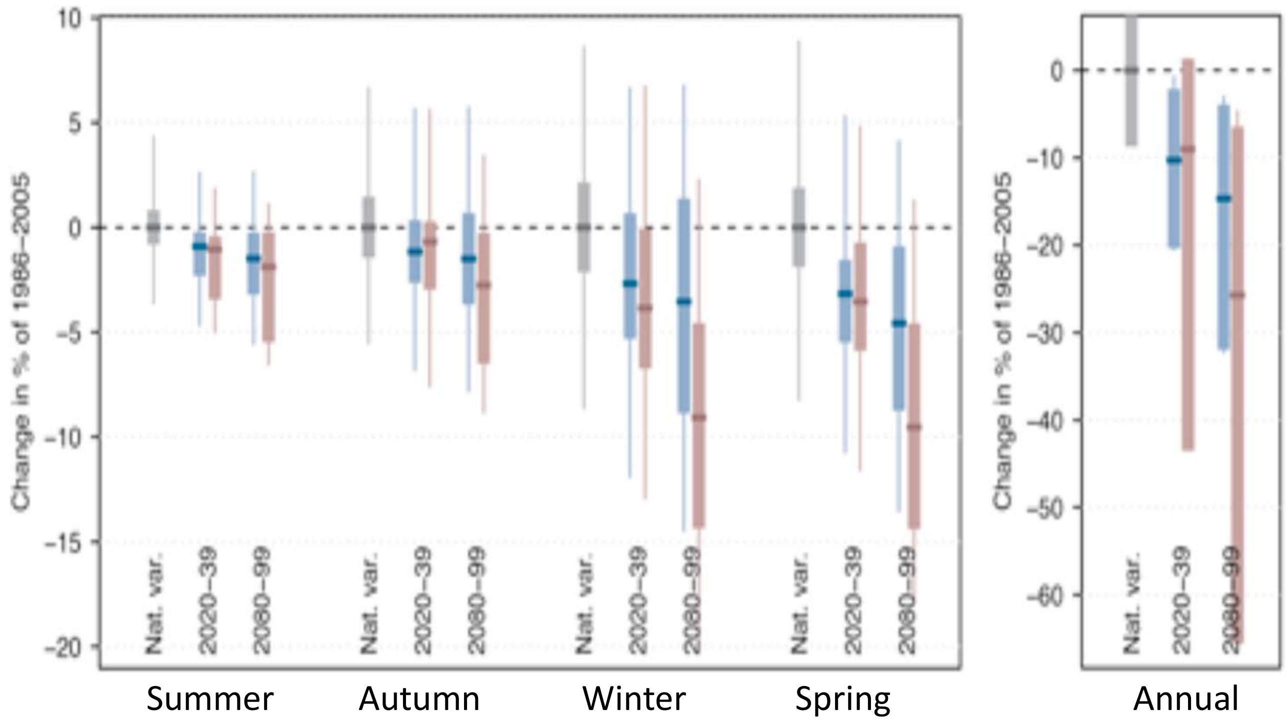
Projected change in seasonal soil moisture and in annual runoff for Southern Australia in 2020-39 and 2080-99 compared to 1986-2005. Two RCPs are shown - RCP4.5 (blue), RCP8.5 (Purple). Bars show median (bar) and 10th to 90th percentile. Lines show the range of individual years.

Graph from Climate Change in Australia Technical Report. Figure 7.7.1. CSIRO and Bureau of Meteorology 2015, Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report, CSIRO and Bureau of Meteorology, Australia

Change in seasonal soil moisture

Change in annual runoff



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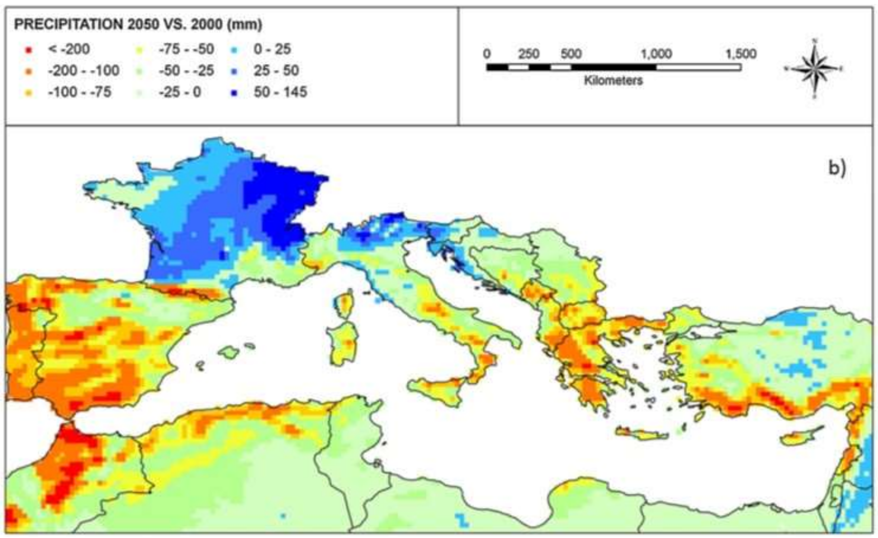
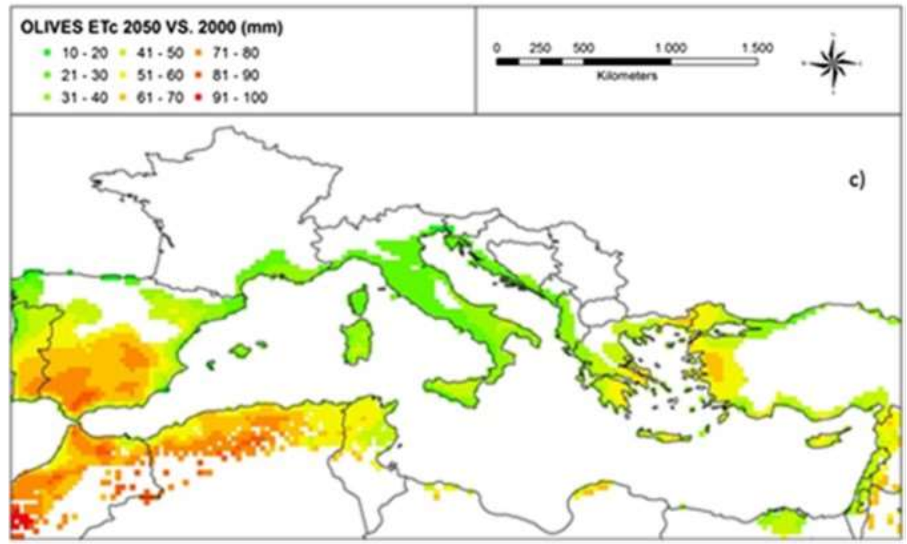
Water – Olives in Europe

Rainfall declines
Change in rainfall by 2050 cf 2000
Red (decline more than 200mm) to
Blue (increase by 50 to 145mm)



ETc increases
Change in ETc by 2050 cf 2000
Red (increase 90-100 mm) to
Green (increase by 10 to 20 mm)



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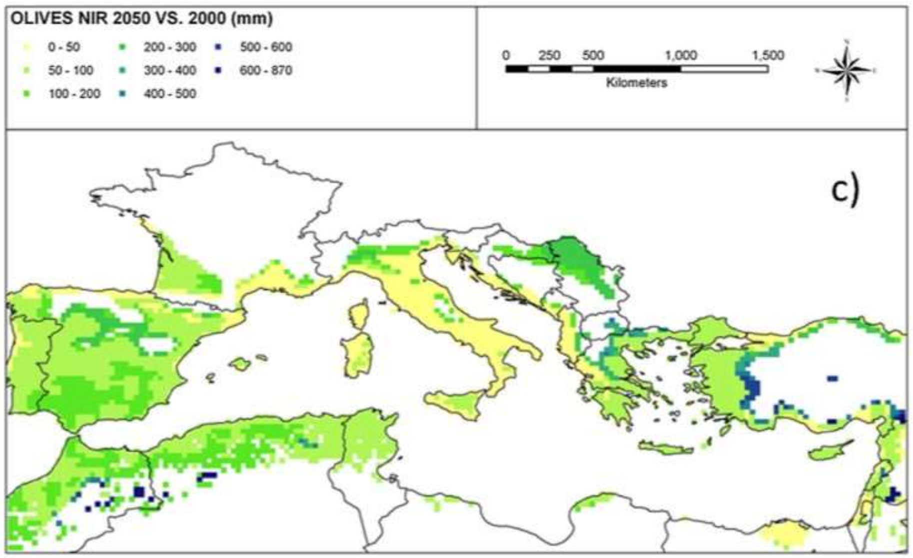
Water – Olives in Europe

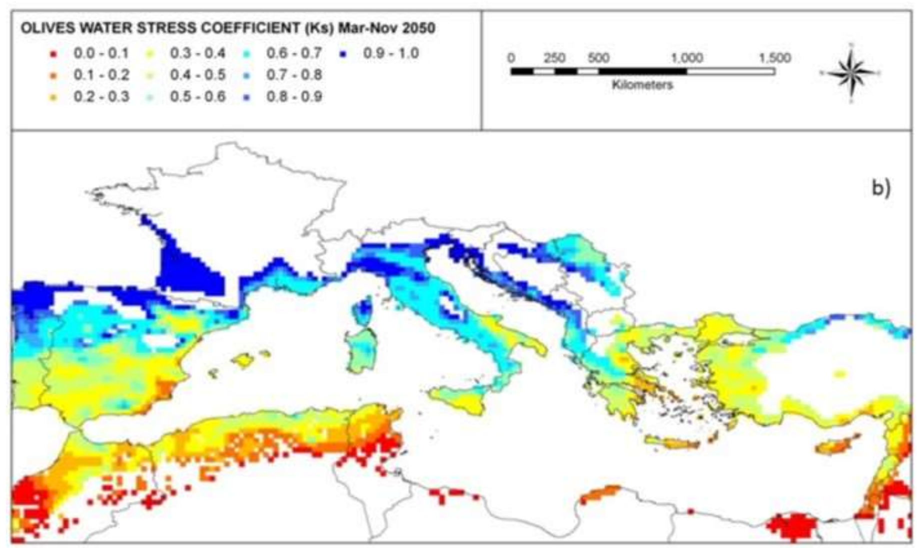
Irrigation Requirements increases

Change in Irrigation Requirements by 2050 cf 2000
Yellow (increase 0-50 mm) to
Blue (increase more than 600 mm)



Water Stress coefficient (Ks) increases

Water Stress by 2050
Red (0-0.1) (More stressed) to
Blue (0.9-1.0) (Less stressed)



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