

Climate change and the spread of brown-rot disease in peach orchards: insights from an epidemiological model

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Overview

- 1 Introduction
- 2 Climate corrected model
- 3 Climate changes and model forecasts
- 4 Conclusions

Brown rot and stone fruit

Brown rot, a fungal disease caused by *Monilinia* spp.



- Attacking stone fruit (e.g. peach, cherry, plum, etc.)
- Reducing yield in the pre- and post-harvest

The existing model

Bevacqua et al. 2018, *Phytopathology*



$$\frac{dS}{dt} = -\lambda SI + \eta E$$

$$\frac{dE}{dt} = \lambda SI - \eta E - \sigma(t)E$$

$$\frac{dI}{dt} = \sigma(t)E - \rho I$$

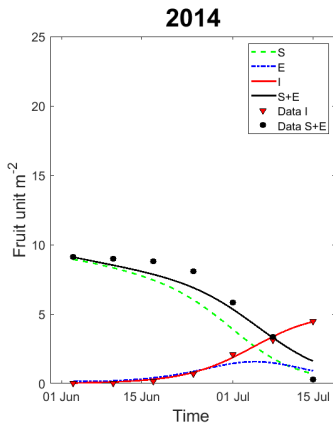
$$\sigma(t) = \begin{cases} 0 & \text{if } w(t) < w_c \\ \gamma w(t) & \text{if } w(t) \geq w_c \end{cases}$$

where

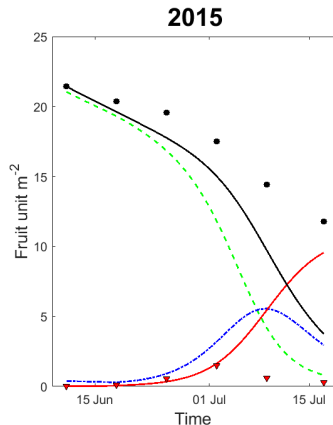
$$w(t) = \frac{w_b w_m}{w_b + (w_m - w_b)e^{-r(t-t_b)}}$$

Param.	Definition
λ	spore exposure
η	spore death
$\sigma(t)$	infection
ρ	fruit death
γ	infection constant
w_b	initial fruit weight
w_m	max. fruit weight
r	fruit growth
t_b	blooming time
t	time

Model calibration and validation



Calibrated



Validated ?

Research questions

Do model parameters rely on climate conditions ?

Can a climate corrected model simulate patterns of 2014 and 2015?

Which are the consequences of spatial and temporal variation of climate conditions over peach cultivation ?

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Model parameters and climate conditions

	Constant	Climate corrected
Spore exposure	λ_c	$\lambda(P) = \begin{cases} 0, & \text{if } P = 0 \\ \lambda_0, & \text{if } P > 0 \end{cases}$
Fruit infection	γ_c	$\gamma(P) = \begin{cases} 0, & \text{if } P(t - \tau) = 0 \\ \gamma_0, & \text{if } P(t - \tau) > 0 \end{cases}$
Spore death	η_c	$\eta(T) = \eta_0 e^{-E_\eta/kT}$

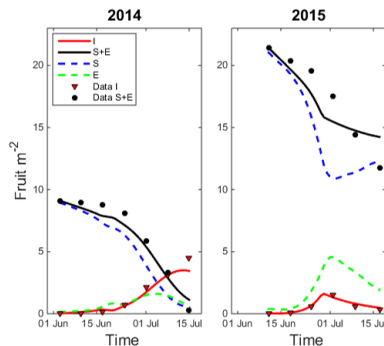
where P is precipitation, T is temperature, τ is a lag time, k the Boltzmann factor, E is the kinetic energy for a given reaction.

$2 \times 2 \times 2 = 8$ Candidate models of different complexity

Model selection

Akaike Criterion

Model	λ	γ	η	Prms	ΔAIC
M1	λ_c	$\gamma(P)$	$\eta(T)$	4	0
M2	λ_c	$\gamma(P)$	η_c	3	2.6
M3	λ_c	$\gamma(P)$	$\eta(T)$	5	17.9



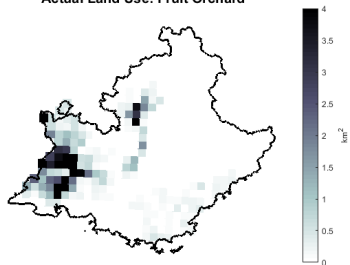
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The study case: the PACA region



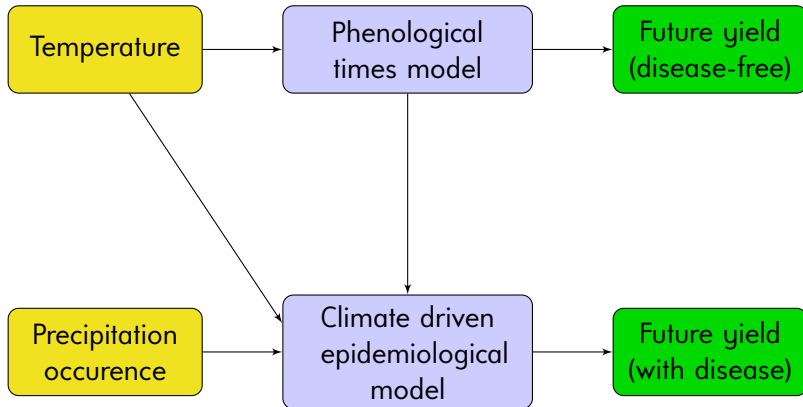
Actual Land Use: Fruit Orchard



van Gogh - Peach Trees in Blossom, 1889

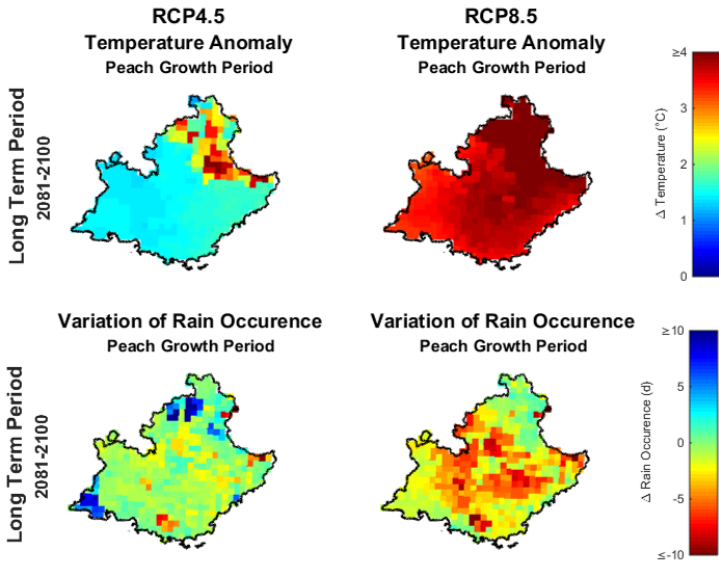
Scenarios of climate change impact at the regional scale

Procedure



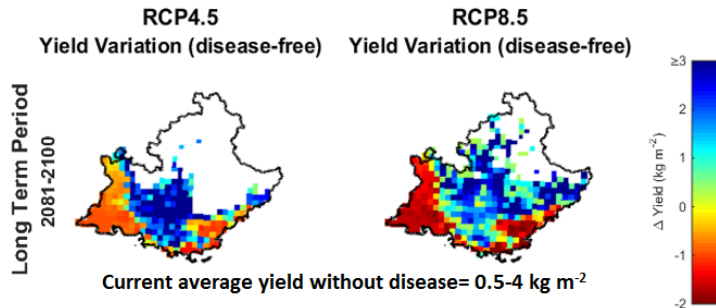
Climate change

Temperature and Precipitation (reference period 1996-2015)



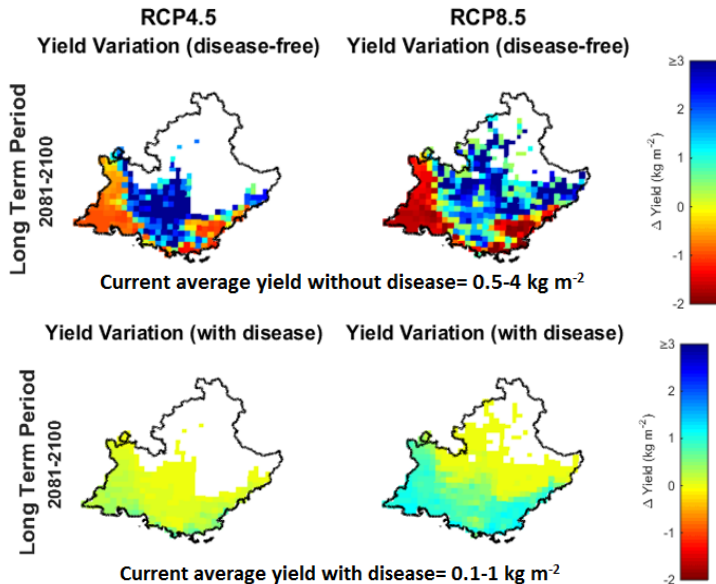
Yield variation

(reference period 1996-2015)



Yield variation

(reference period 1996-2015)



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Conclusions

Do model parameters rely on climate conditions?

Yes. Particularly, spore mortality and infection rate

Can a climate corrected model simulate patterns of 2014 and 2015?

Yes

Which are the consequences of spatial and temporal variation of climate conditions over peach cultivation ?

Ignoring brown-rot: new suitable areas in the alpine zone, less productivity in the warmer and drier areas.

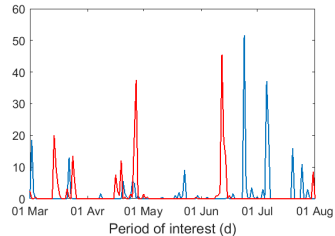
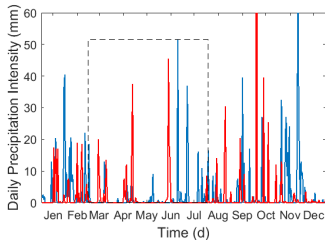
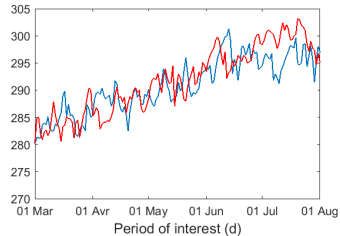
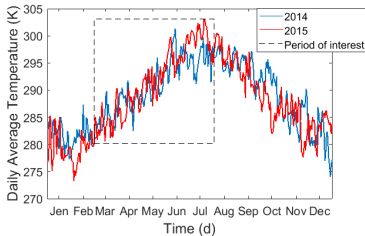
Considering brown-rot: warmer and drier climate might help controlling brown rot

Acknowledgements

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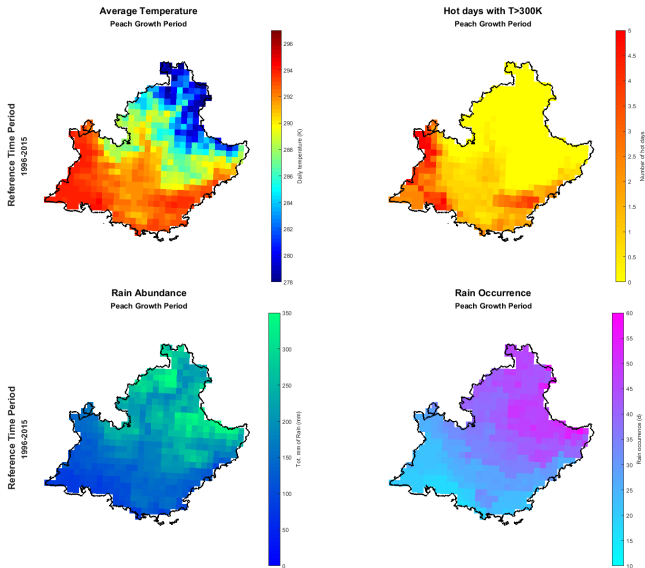
Climate conditions as first suspect drivers

Registered temperature and precipitations in 2014 and 2015



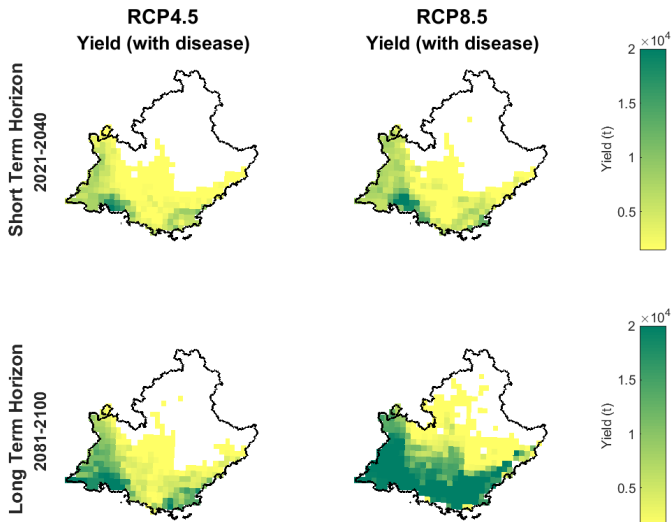
Temperature and precipitation indexes

Reference period 1996-2015



Predicted Yield

The entire region is an orchard



Predicted Yield

Actual orchard surface

Actual yield

