# **OLIVECAN**: A BIOPHYSICAL MODEL OF OLIVE ORCHARDS CAPABLE OF SIMULATING RESPONSES TO FUTURE CLIMATIC SCENARIOS

Luca Testi, Álvaro López-Bernal, Francisco J. Villalobos

University of Córdoba and IAS-CSIC

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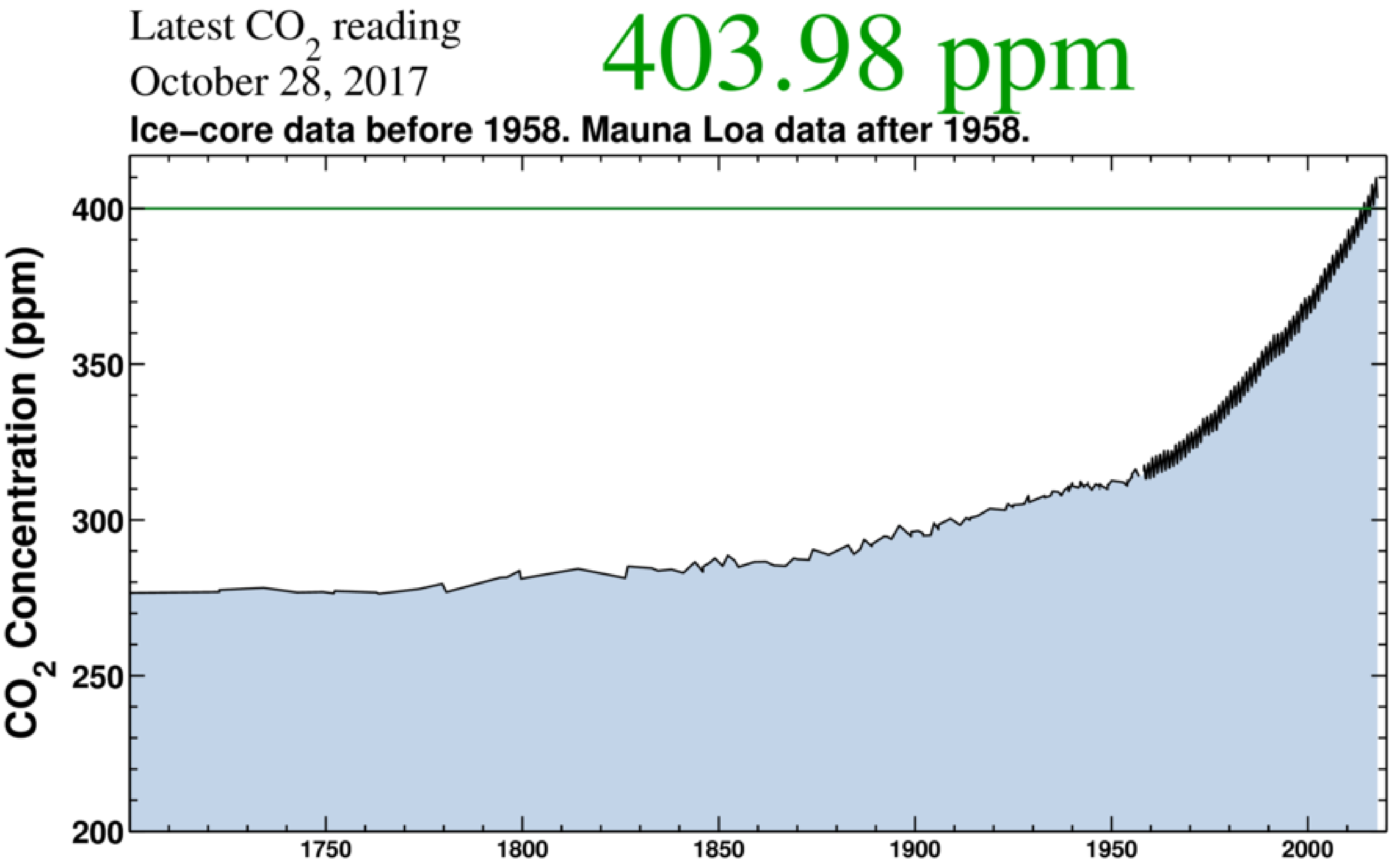
# What is happening?



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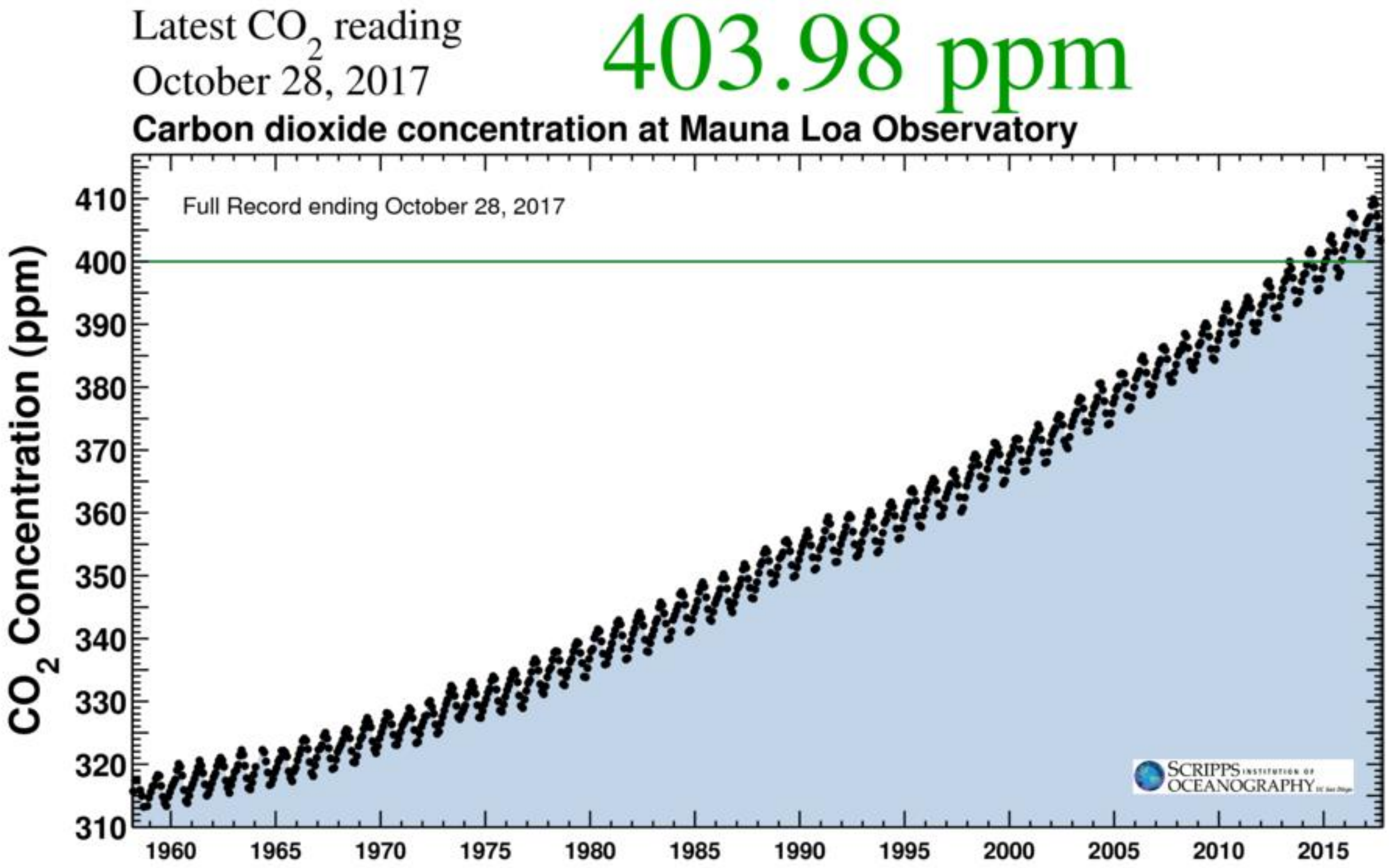

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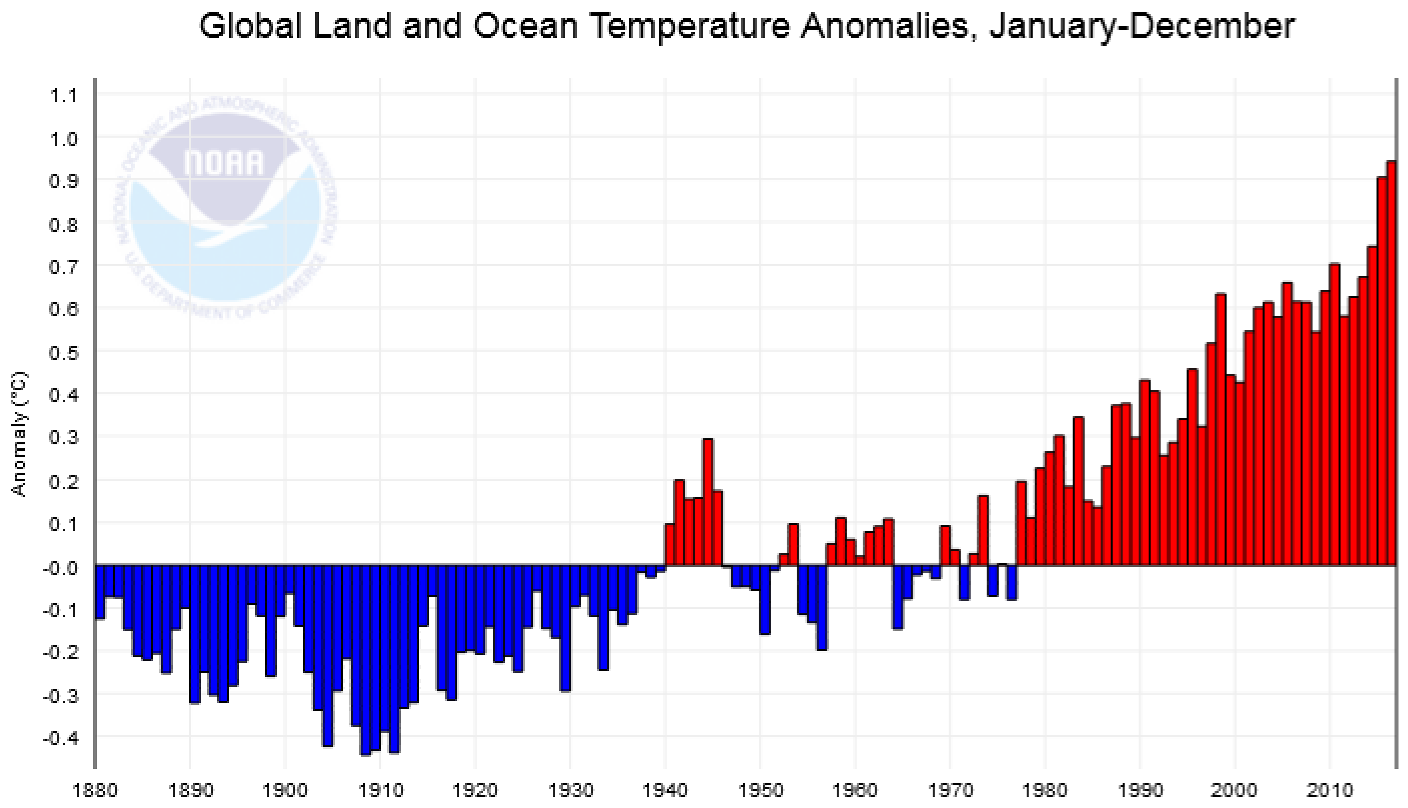


Source: NOAA

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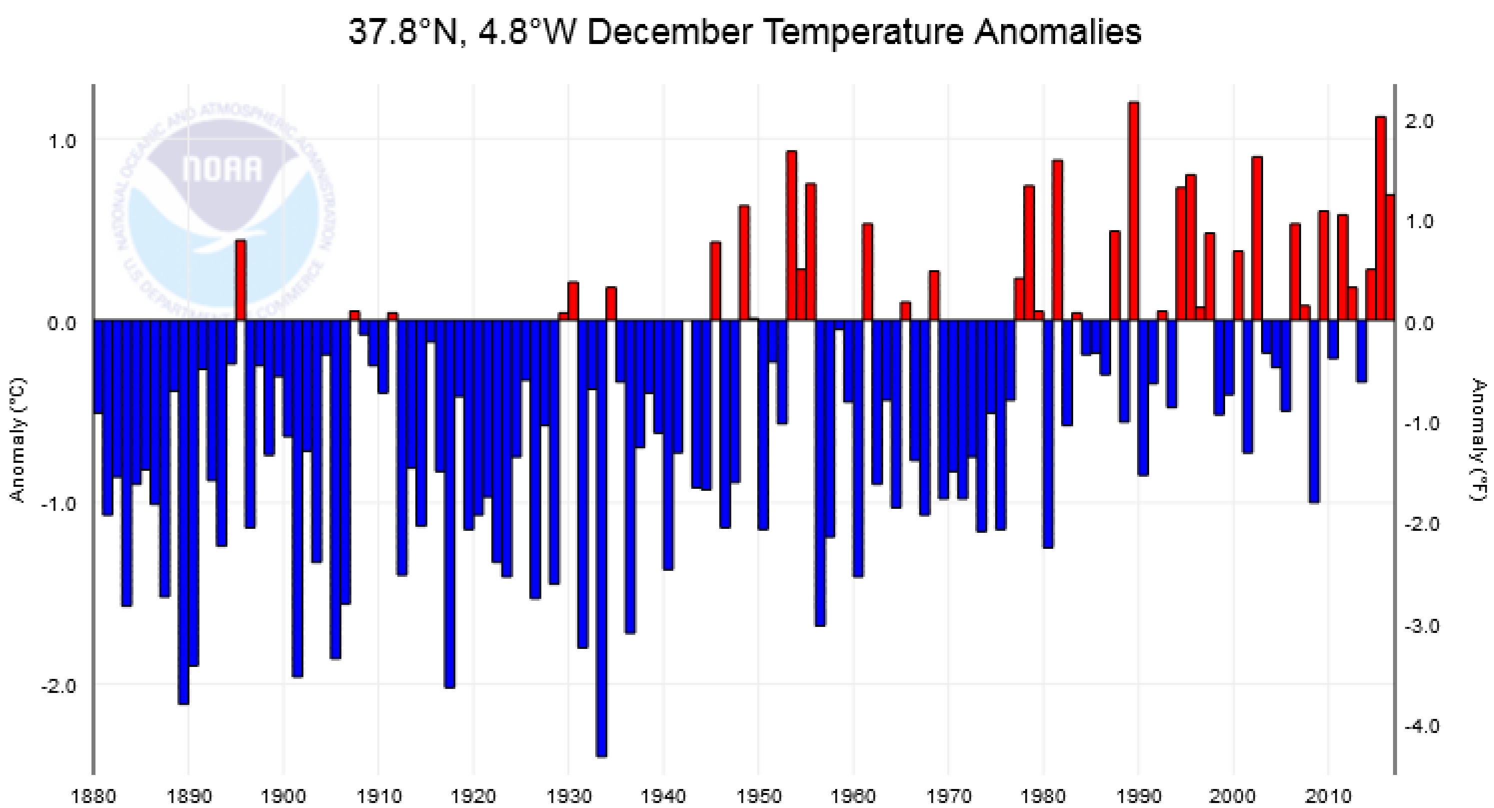
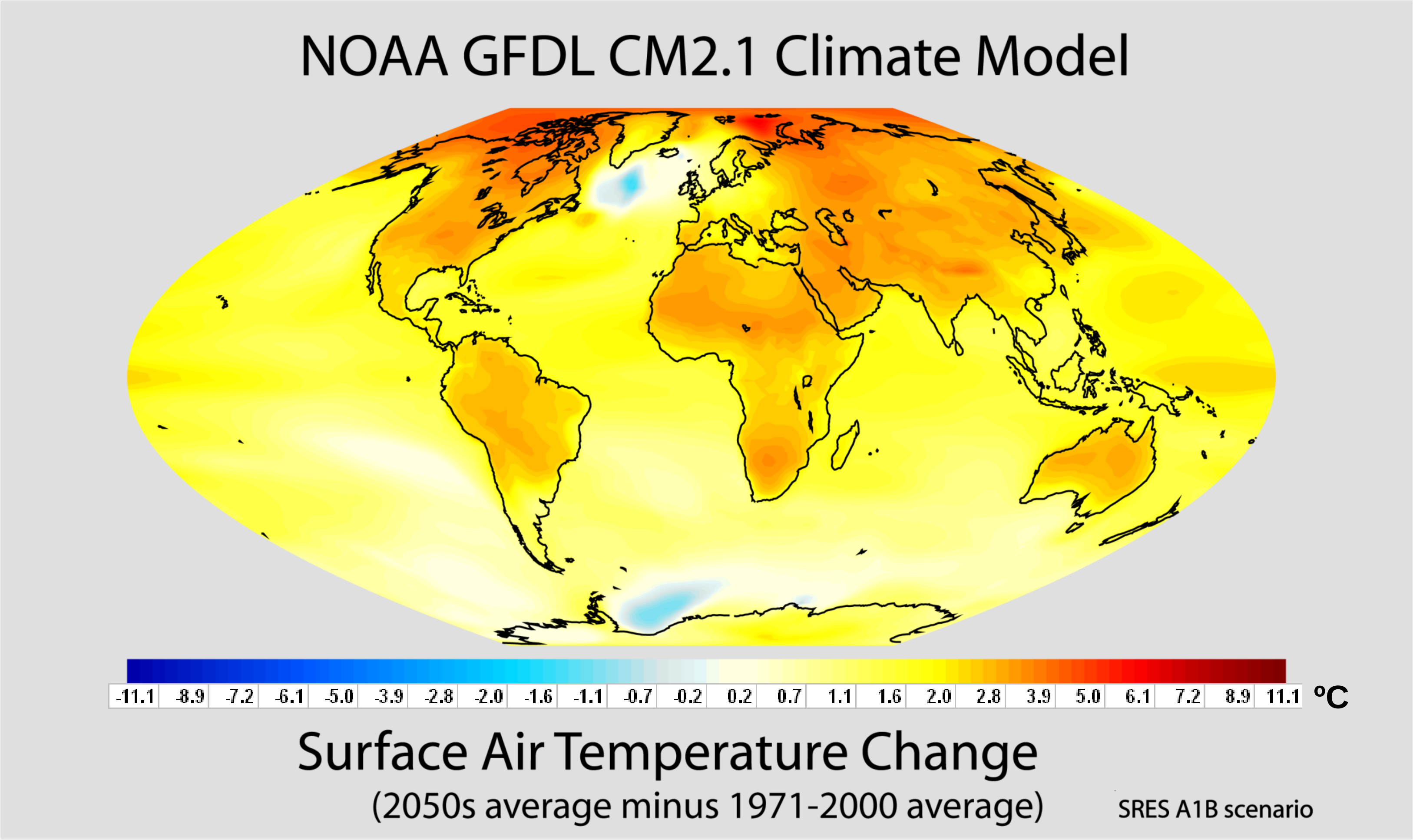



Source: NOAA

# What is going to happen?




Source: NOAA

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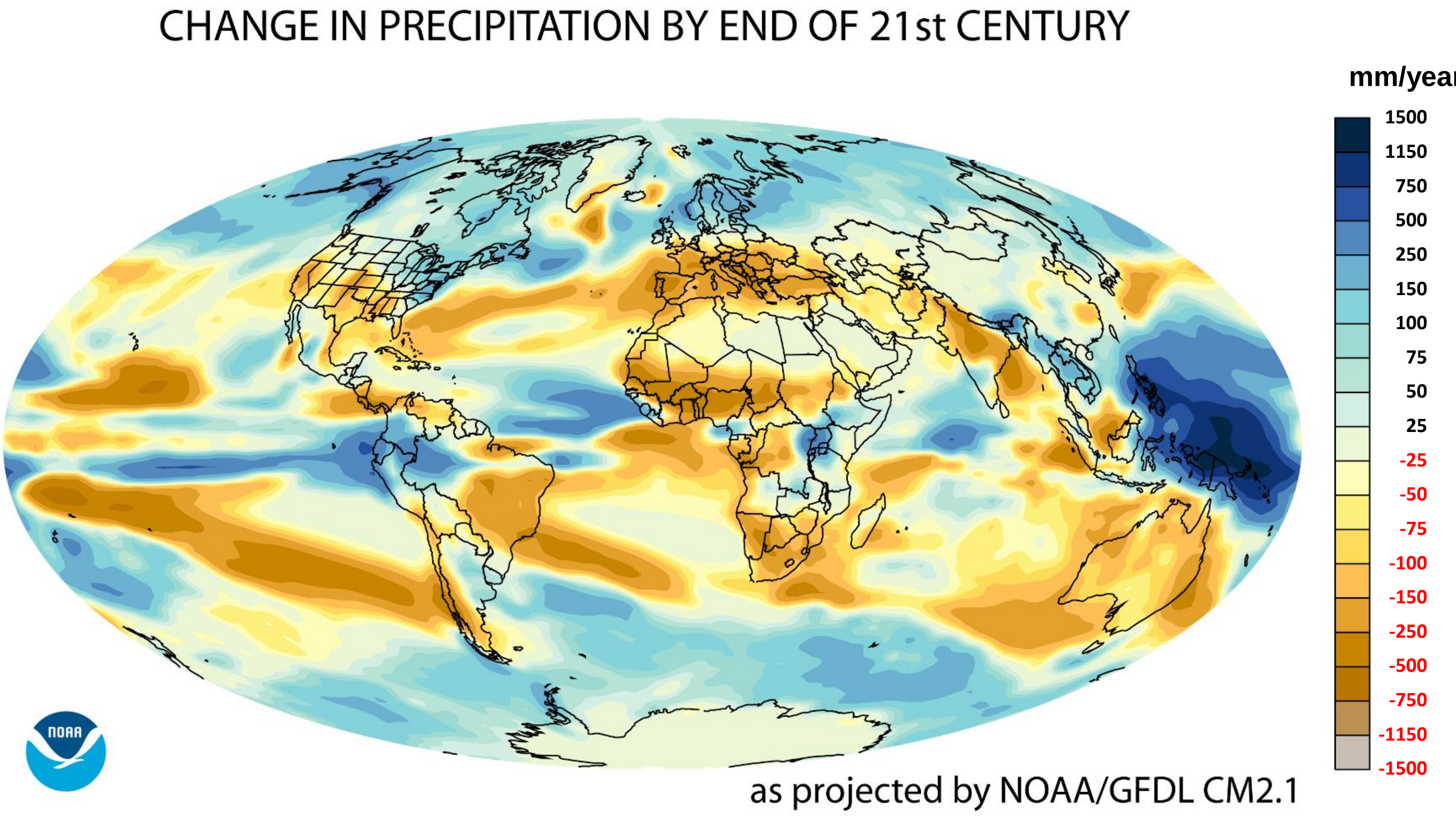
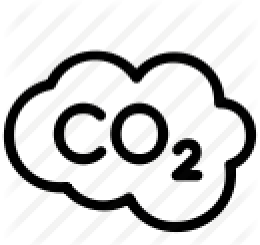
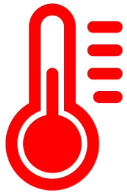


# What is going to happen?

worst scenarios forecasts for the Mediterranean basin at the end of the 21th century




$CO_2$ concentration : 700-800 ppm



temperature: +2 / +3 ºC

rainfall: -10% / -30%

# Why do we need a model?

What are the expected effects of these new conditions?
Let's analyze some processes qualitatively:

green = positive effect
grey = neutral or depending on site/time conditions
yellow= negative effect

# Why do we need a model?

↑ $[CO_2]$ in air

↑ Temperature

↓ Precipitation

increased photosynthesis rate

increased water use efficiency

complex effect over stomatal opening

complex effect over photosynthesis (depends)

major effect on phenology (chill, cycles…)

increased ET and water requirements

increased respiration

heat shocks (flowering...)

water stress

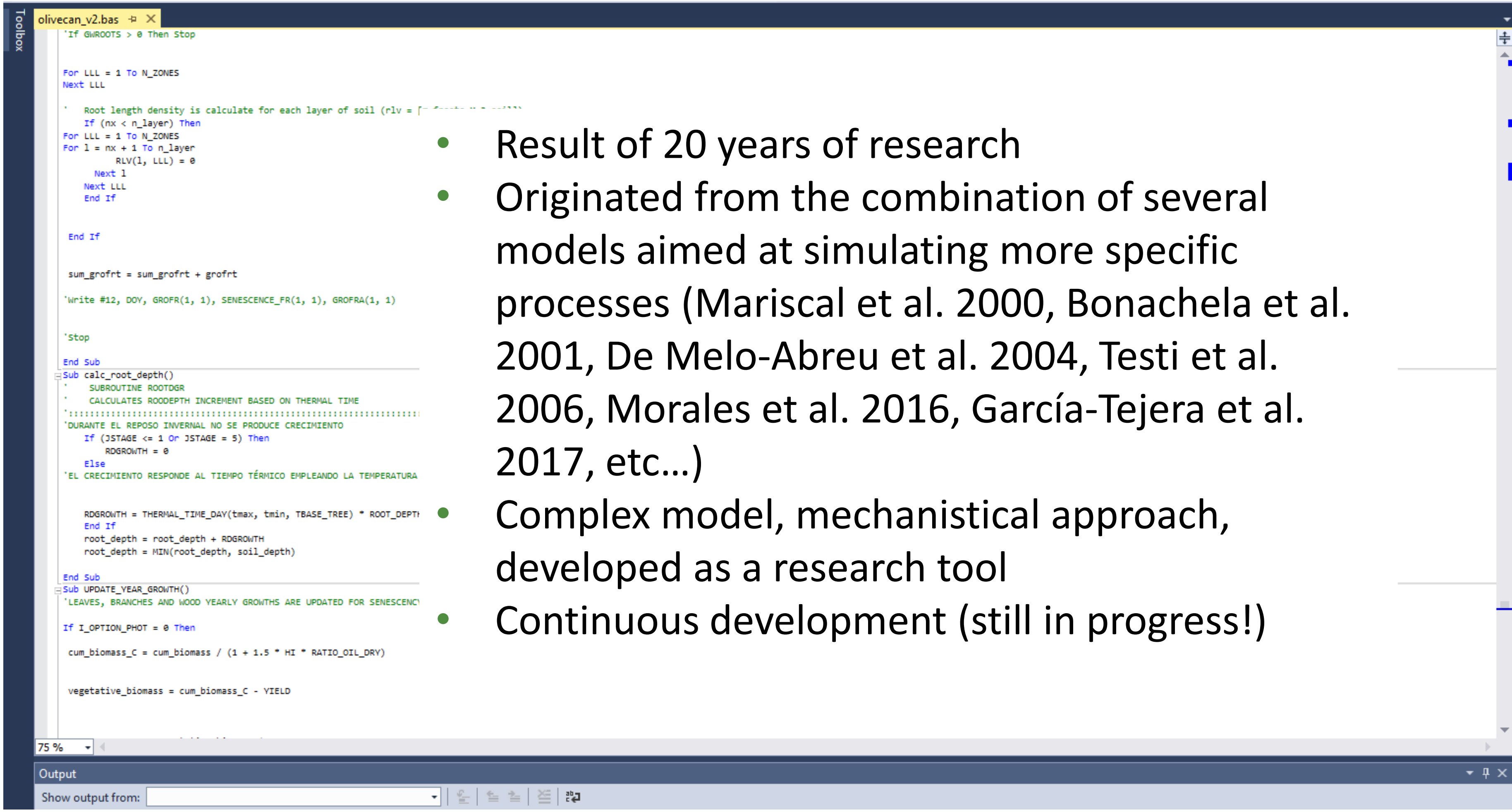
- lower growth, photosynthesis and C assimilation in rainfed conditions
- increased irrigation needs

# Why do we need a model?

It is self-evident that the system is too complex

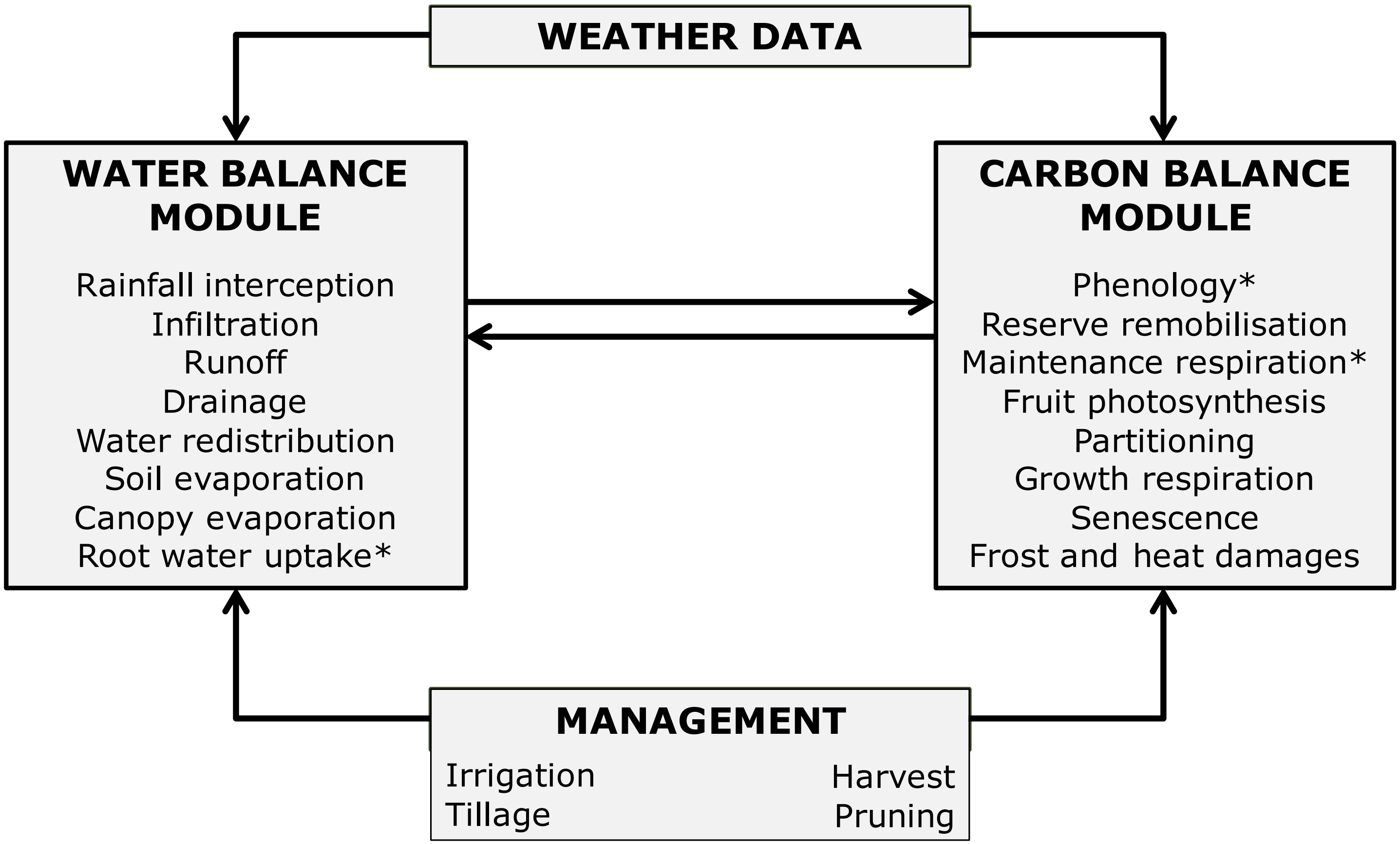
way too complex to make reliable forecasts about yield, consumptions, risks or requirements for olive crop in changed conditions without the help of a biophysical model, as mechanistic as possible.

# OliveCan (V3)




- Result of 20 years of research
- Originated from the combination of several models aimed at simulating more specific processes (Mariscal et al. 2000, Bonachela et al. 2001, De Melo-Abreu et al. 2004, Testi et al. 2006, Morales et al. 2016, García-Tejera et al. 2017, etc…)
- Complex model, mechanistical approach, developed as a research tool
- Continuous development (still in progress!)

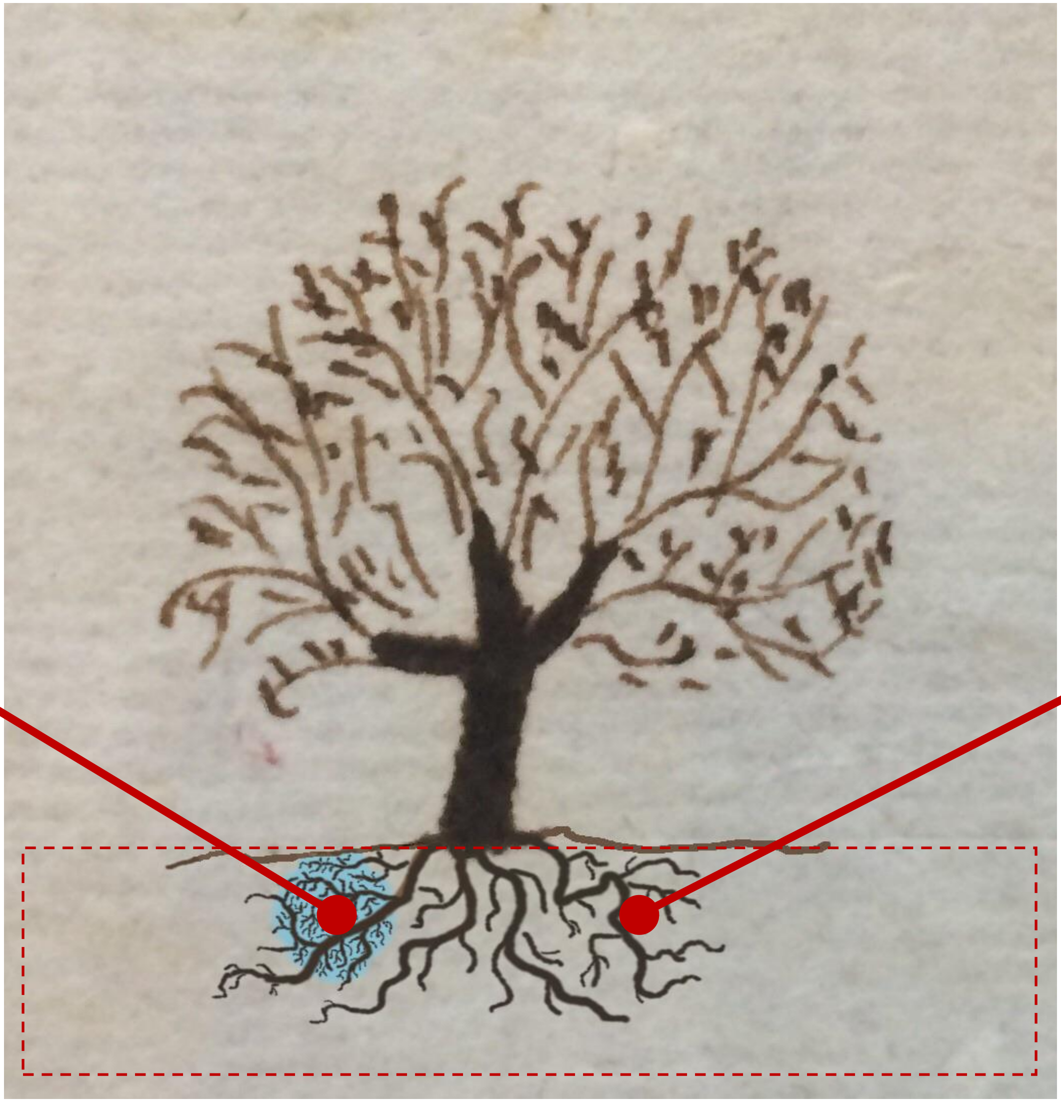
# OliveCan description




All processes are simulated at daily time steps except for those marked with an "*"
Processes marked with an "*" are simulated at customizable sub-day time steps

# OliveCan description – Water Balance

How much water comes from the wet bulb?



How much from the rest of the soil?

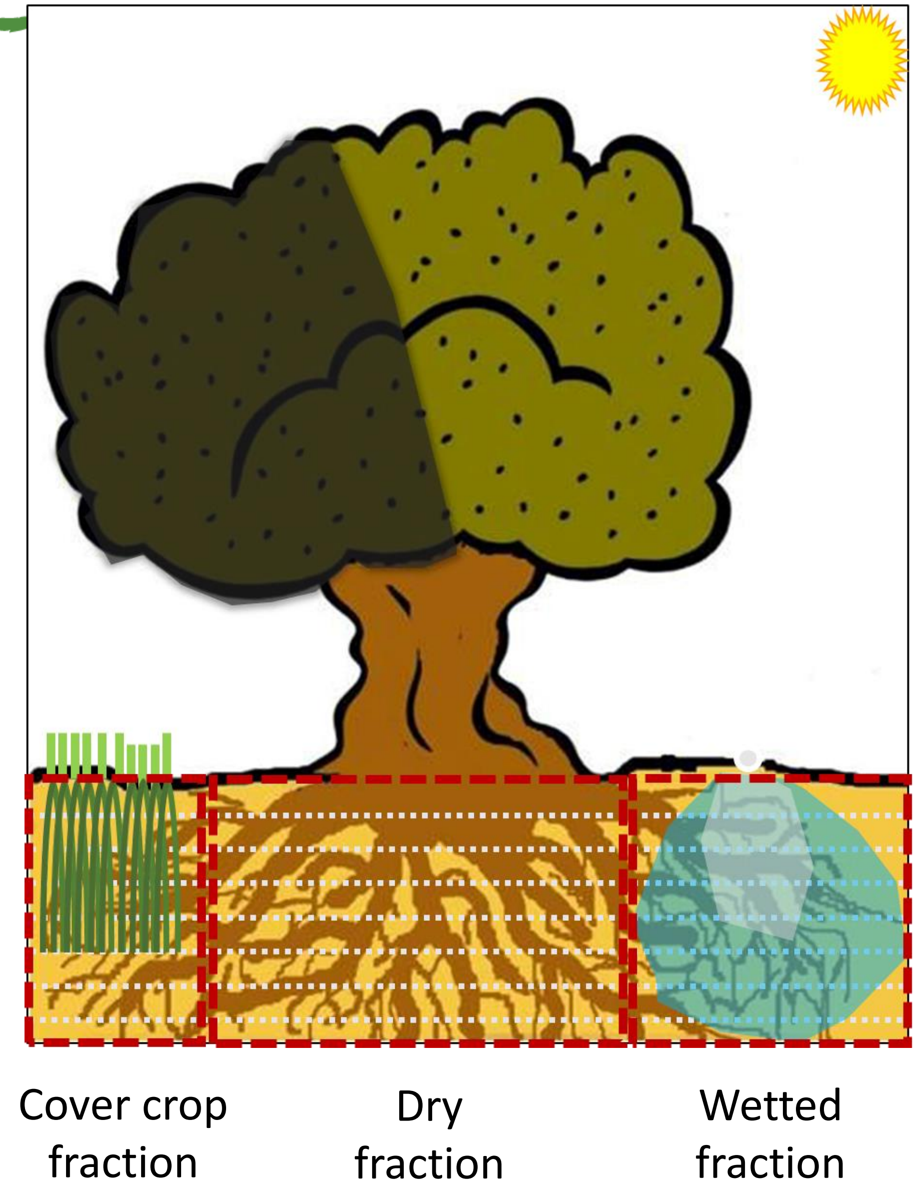
The average water content or potential is useless

# OliveCan description – Water Balance

The soil is sub-divided in three multi-layer compartments representing the fractions of soil

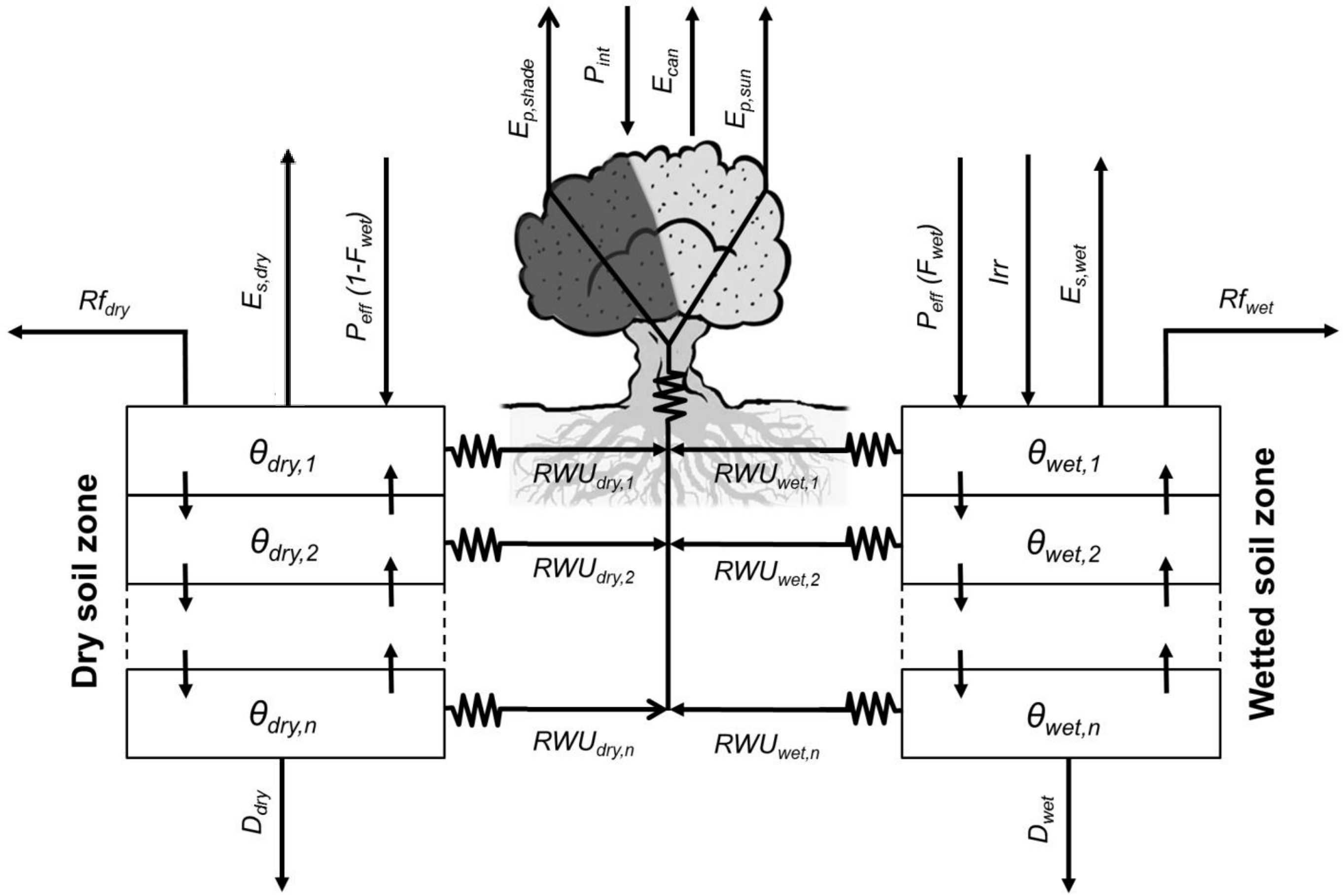
- wetted by emitters
- covered by grass cover crop, when simulated
- neither wetted nor covered by grass

In the canopy, two leaf classes are considered (sun & shade)

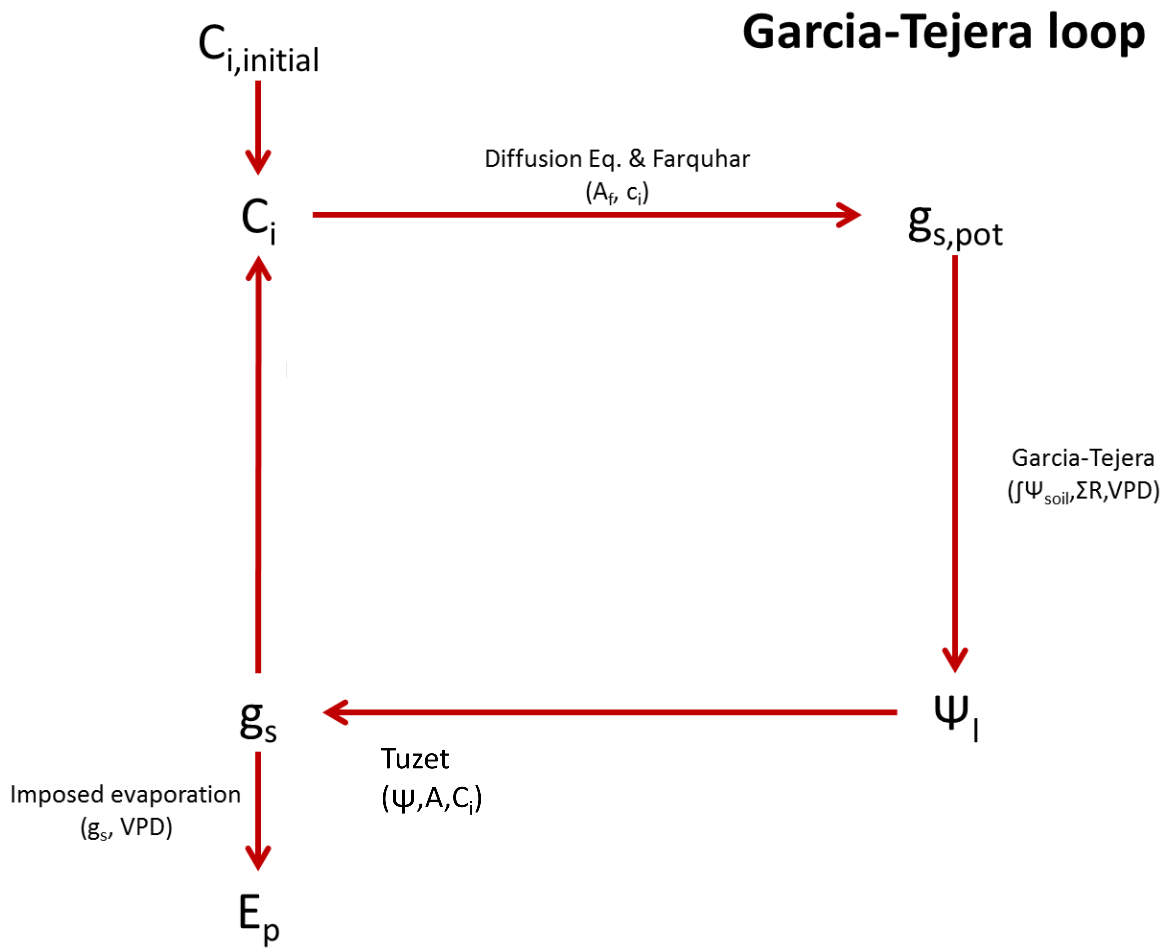


# OliveCan description – Water Balance

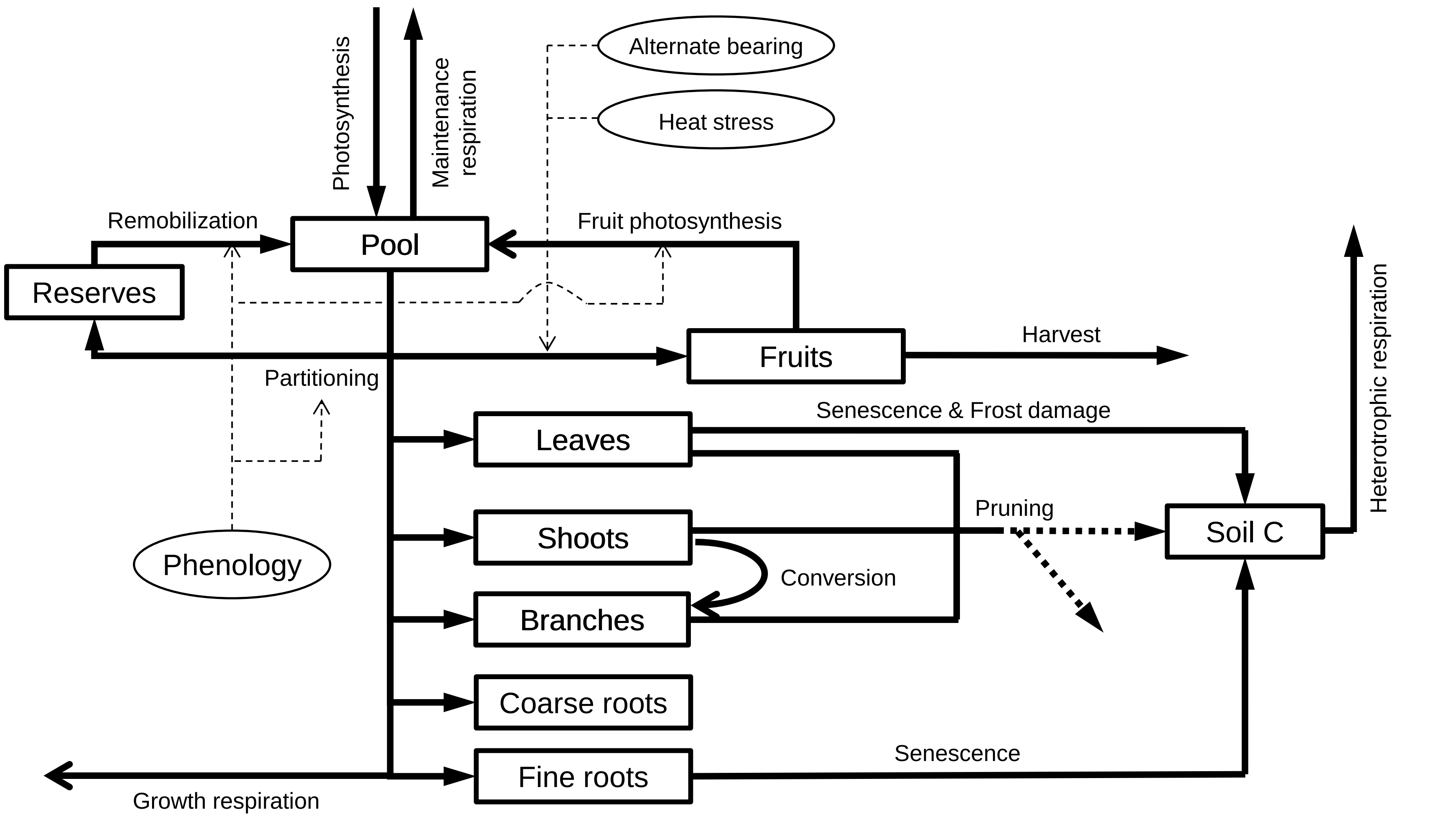
## The Water Balance



# OliveCan description – $H_2O$/C Balance



# OliveCan description – Carbon Balance



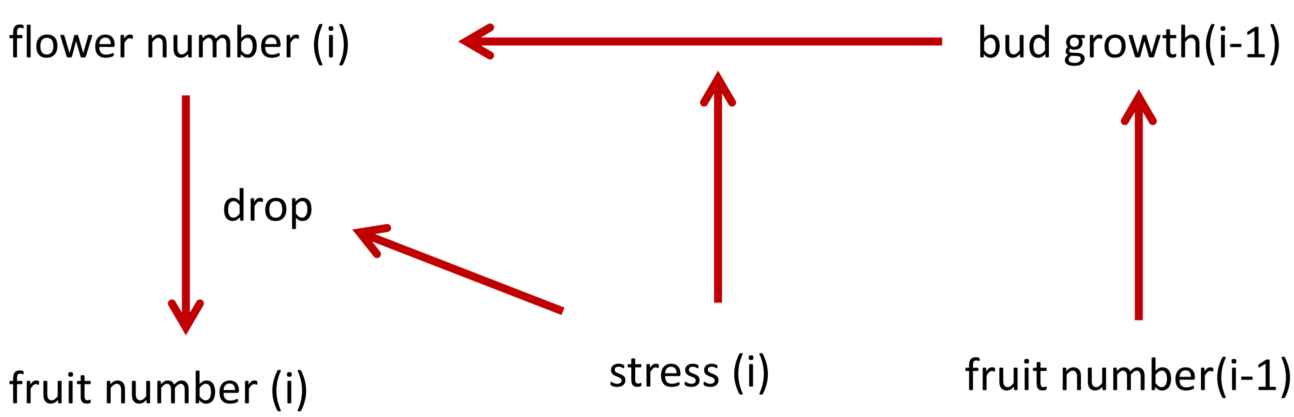

**NEE = Gross Photosynthesis + Fruit Photosynthesis – Maintenance Respiration – Growth Respiration – Heterotrophic Respiration + (Grass Net Assimilation )**

# OliveCan description – Carbon Balance

## Alternate bearing:

Yield calculated by Yield Components (or fixed HI, user decides)

YC approach allows to account for the dynamic nature of the fruit number (**alternate bearing**)



# OliveCan description – Management

| Operation | Options | Inputs | Impacts |
|---|---|---|---|
| HARVEST | | Date | Yield |
| TILLAGE | (0) No tillage<br>(1) Tillage | Date | Curve Number |
| PRUNING | (0) Burn/exported<br>(1) Incorporated | Dates, pruning interval, pruning fraction, residues management switch | Biomass of leaves, shoots and branches; org. matter decomp. [if burn=1]; NEE |
| COVER CROP | (0) Bare soil<br>(1) Cover crop | Sowing and harvest dates, fraction of soil covered | Water balance, NEE |
| IRRIGATION | (0) Rainfed<br>(1) Irrigation plan<br>(2) Irrigation program | Strategical params<br>Dates and amounts | Water balance |

# OliveCan options (I)

**Dynamic**
- (0) Reinitialize biomass state variables at the start of every year
- **(1) Dynamic all the time**

**Carbon balance**
- (0) Not simulated
- **(1) Simulated**

**Canopy size**
- (0) Static all the time
- **(1) Dynamic**

**Transpiration**
- (0) proportional to daily solar radiation
- (1) proportional to hourly solar radiation
- (2) based on resistances
- **(3) Garcia-Tejera et al. SPAC model**

**Photosynthesis**
- (0) based on rue
- (1) based on rue(tday) derived from Farquhar
- (2) based on Farquhar
- **(*)** If transp = (3) → **bypass to SPAC model**

# OliveCan options (II)

| | |
|---|---|
| Number of fruits | (0) Not simulated<br>**(1) Simulated** |
| Root lenght density | (0) Fixed and static<br>**(1) Dynamic** |
| Leaf Area Density | **(0) Constant LAD**<br>(1) LAD is a function of tree height<br>(2) LAD is a function of canopy volume |
| Phenology | (0) Fixed phenology dates selected as inputs<br>**(1) De Melo-Abreu et al.** |
| Soil Evaporation | **(0) based on Bonachela et al.**<br>(1) Based on resistances |
| Drainage | (0) drainage is impeded<br>**(1) Drainage is simulated** |
| Curve Number | (0) Fixed<br>**(1) Based on Gomez et al.** |

# OliveCan – Parametrization

- Around 100 parameters
- Literature sources and dedicated experiments
- Literature gaps in some cases (use of reserves, alternate bearing, fruit photosynthesis, dynamics of root growth)
- Cultivar-specific parameters only available for the simulation of flowering and frost vulnerability

# OliveCan – Inputs

Orchard

- **Latitude, altitude**
- **Tree spacing**
- **Canopy dimensions** (**ground cover**, **Rzx**, LAD, LAI)

Weather

- **Maximum and minimum daily temperature** (ºC)
- **Daily solar radiation** (MJ/m2/d)
- **Average daily wind speed** (m/s)
- **Rainfall** (mm/d)
- **Vapour pressure** (kPa)

Soil

- **Soil depth**
- **Soil textural classes**
- Water content limits (saturation, field capacity, wilting points)
- Others (pH, organic matter, slope)

Management

- **Harvest date**
- **Pruning** date, frequency and 'intensity' (*when required*)
- Daily **irrigation** amounts and fraction of soil wetted by emitters (*when irrigated*)
- **Grass cover crop management**: emergence and removal dates and fraction of soil covered) (*when a cover crop is used*)

# OliveCan – Outputs

**Phenology**

- Full flowering date
- Bud break date

**Yield components**

- Yield
- Number of fruits

**Water balance components**

- ET, Transpiration, Drainage Runoff

**Tree growth**

- Time course of canopy dimensions (LAI, GC. LAD)

**Carbon balance components**

- NEE, GPP
- Soil respiration
- WUE

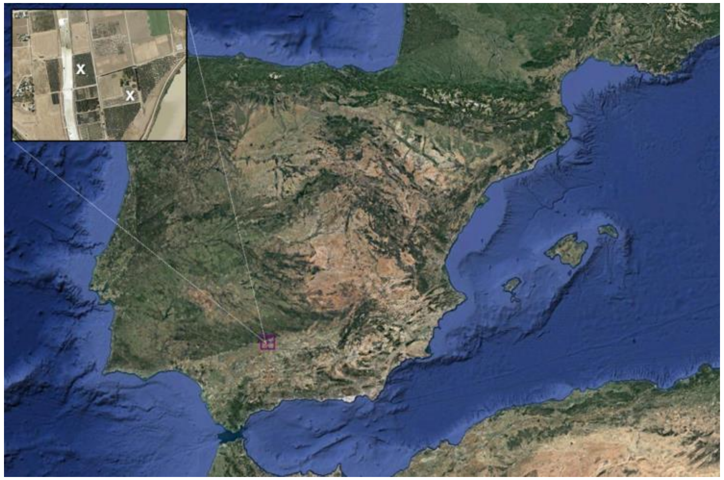
….and many others

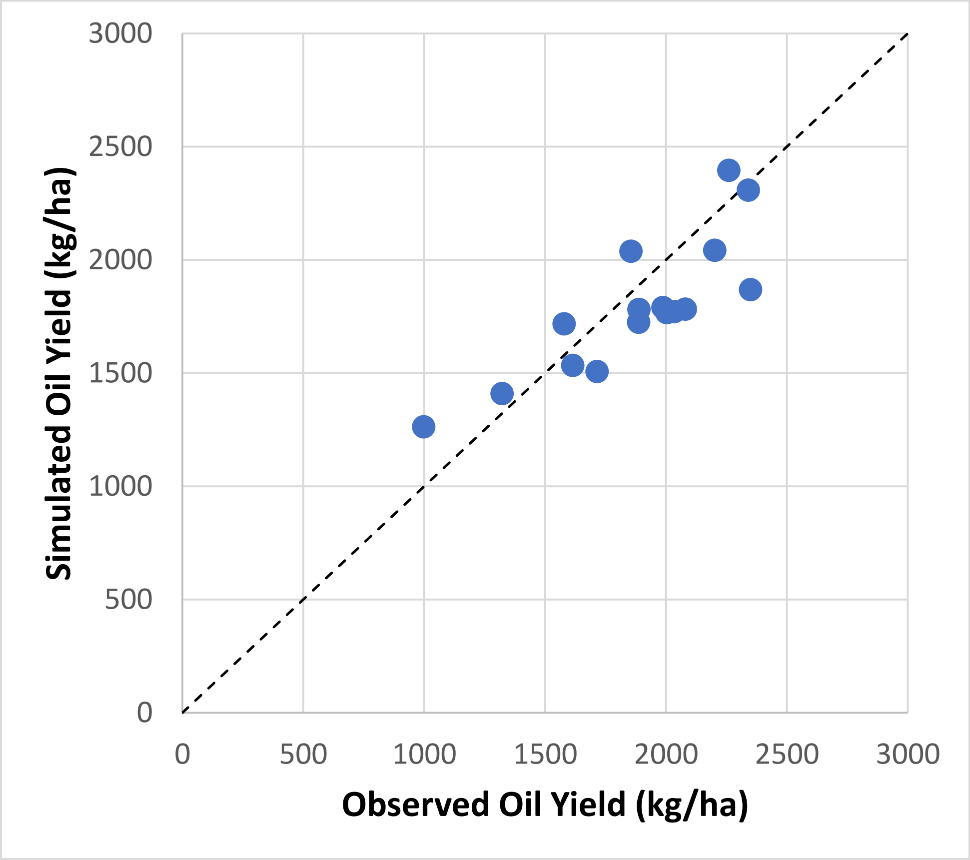
# OliveCan, what it does not do

- There is no nutrient balance nor nutrient stress effects (NPK or micro). This means that only optimal fertilization conditions are considered.
- There is no salinity or toxicity effects routines. Sorry, no salt.
- There is no modelling of pests or diseases damage.
- There is no "oil quality" simulation. We are very far from simulating the biological synthesis of oil chemical components. Some semi-empirical approach may be possible in the near future, though.
- No cultivar sensitivity so far, except (partially) for phenology. This is a main path of development for the near future (an ongoing AGL project is targeting this issue)

# Validation examples

Data from three-year experiments in two high density olive orchards with different irrigation treatments (Moriana et al. 2003, Iniesta et al. 2009)





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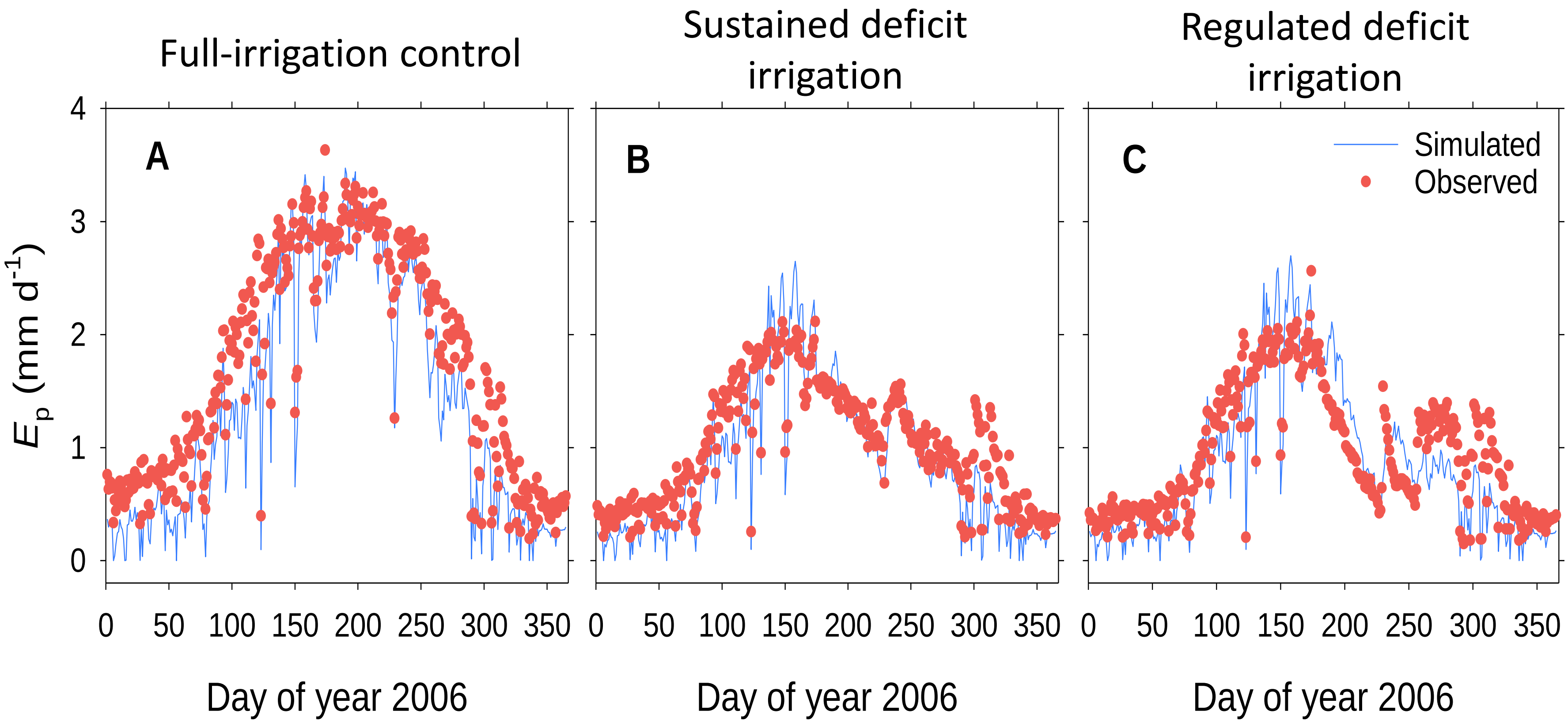
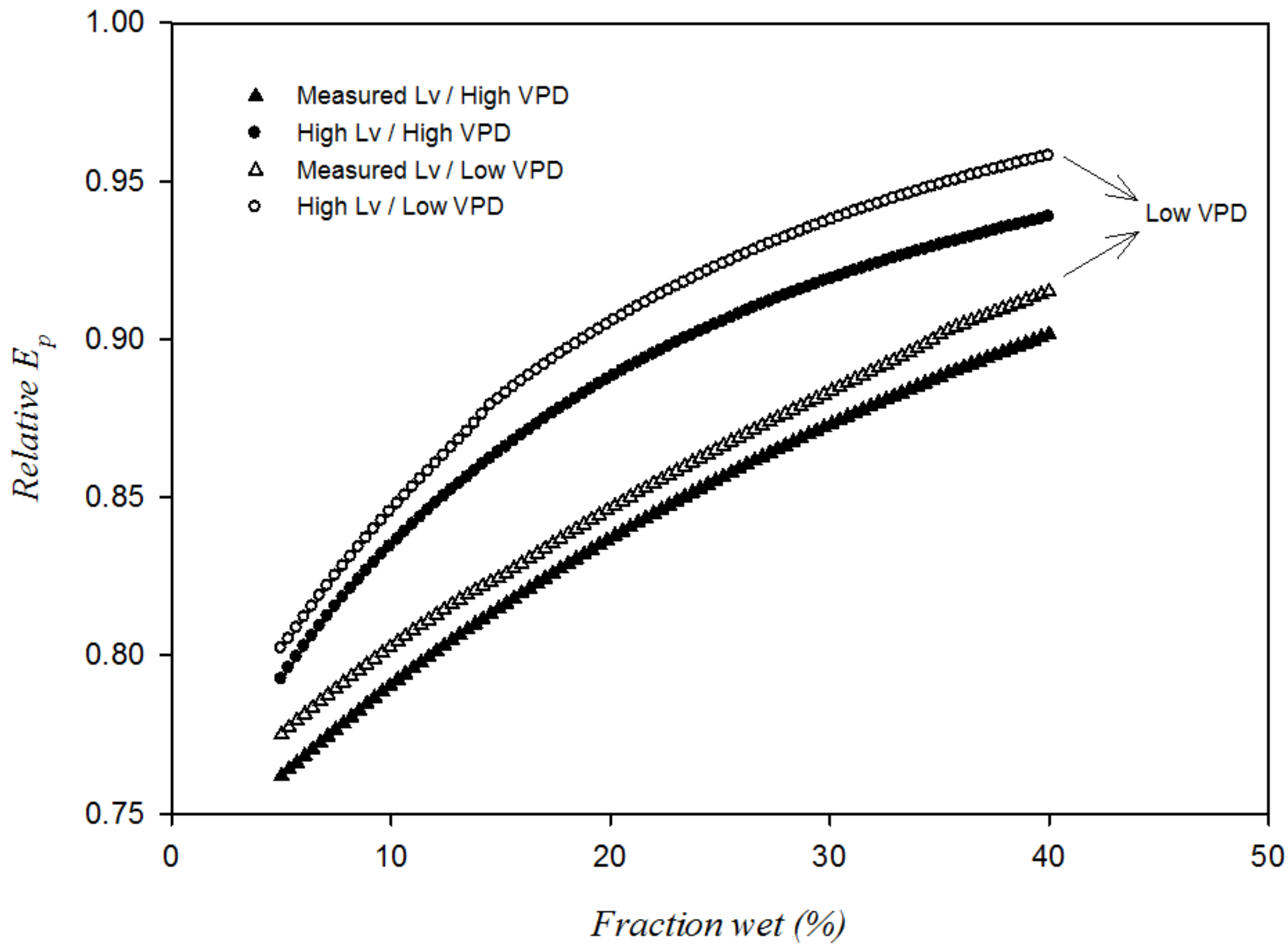


# In conclusion

- Complete model, capable of integrating environment x tree x management interactions
- Mechanistic approach suitable to work with future atm conditions ($CO_2$)
- Simulates any kind of olive orchard and irrigation (or rainfed) management
- Provide information at different time scales (hourly, daily, annual)
- Potential for ideotyping, assessing climate change impacts or estimating CO2 sequestration capacity, among others

# Ideotyping……




García-Tejera, O., López-Bernal, Á., Orgaz, F., Testi, L., Villalobos, F.J., 2017. Analysing the combined effect of wetted area and irrigation volume on olive tree transpiration using a SPAC model with a multi-compartment soil solution. Irrig Sci 35, 409-423.

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# Thanks for your attention.

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OLIVE-MIRACLE
mOdelLIng solutions for improVEd and resilient Management strategies foR olive tree Against future CLimatE change