

# Investigating the links between climate, phenology and soils in a Mediterranean forest with the ForSAFE model

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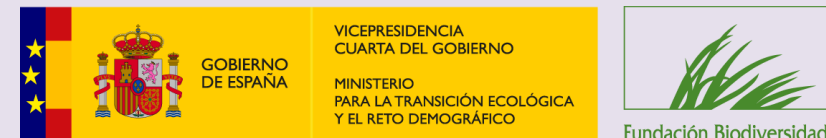
R. Alonso, I. González-Fernández, H. Pérez-Jordán, I. Rábago, R. Ruiz-Checa

A.I. Cardona, M.A. Clavero, J.L. Garrido, M.G. Vivanco

**Ciemat**  
Centro de Investigaciones  
Energéticas, Medioambientales  
y Tecnológicas



With the support of:



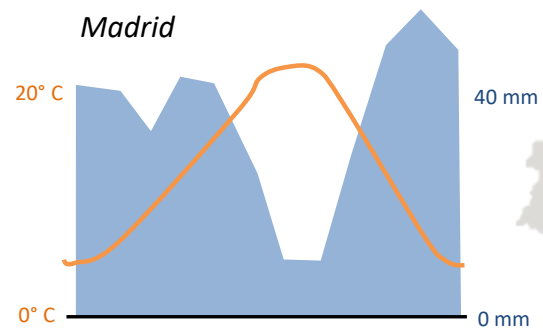
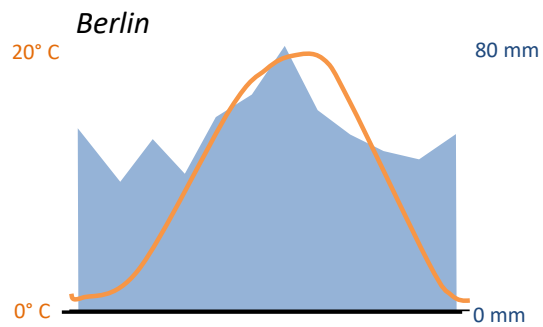
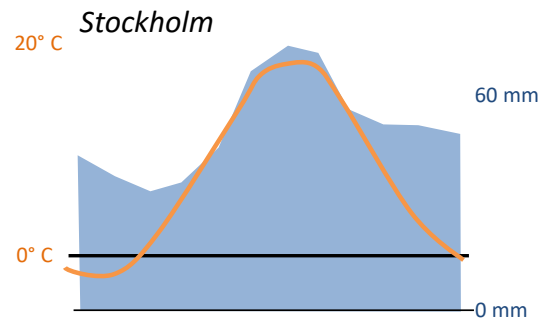


# INTRO

**Key particularities for Mediterranean forests**



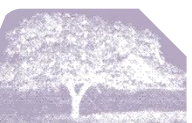
# Modeling Mediterranean and other water-limited ecosystem in Europe



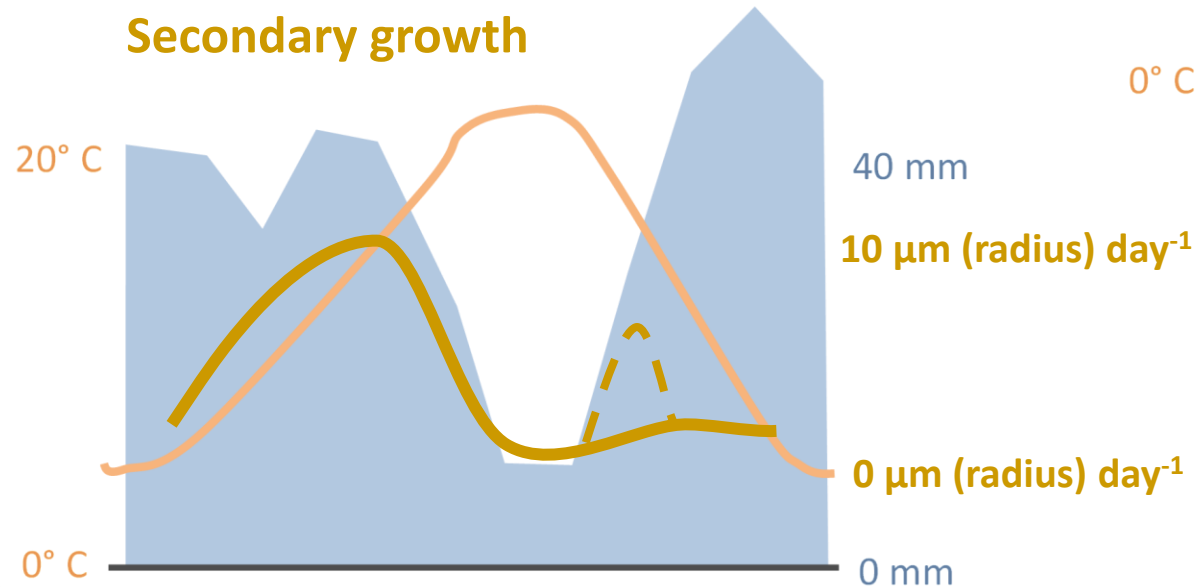
temperature limited  
– winter –



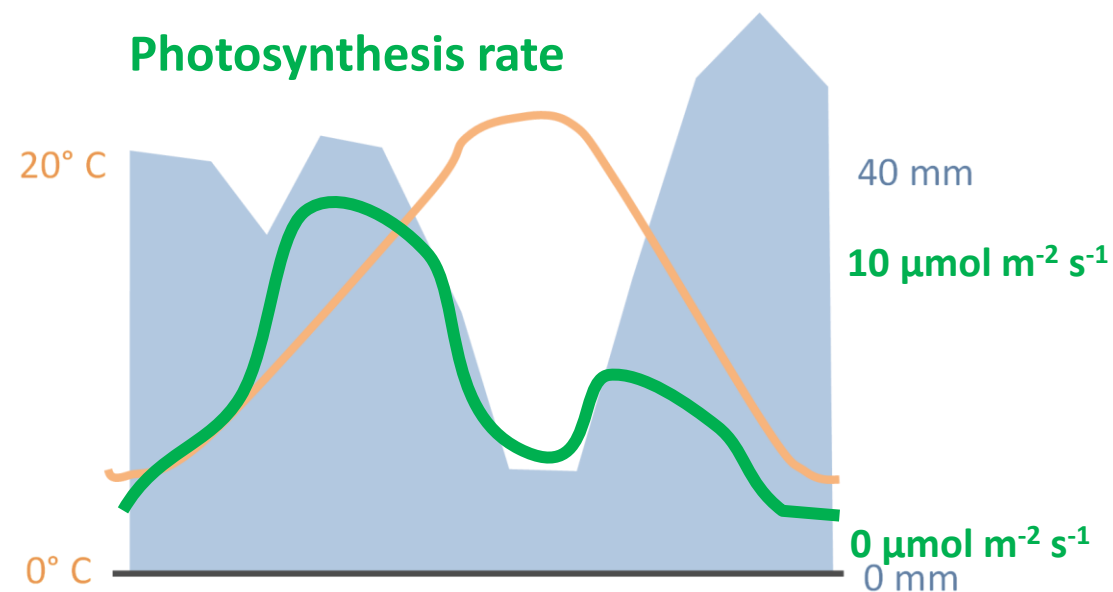
water limited  
– summer –



## HIGH SEASONALITY OF PLANT ACTIVITY



Adapted from Albuixech et al. 2012 (Forest Systems, 21(1): 9-22)



Adapted from Flexas et al. 2014 (Environ. Exp. Bot. 103: 12–23)

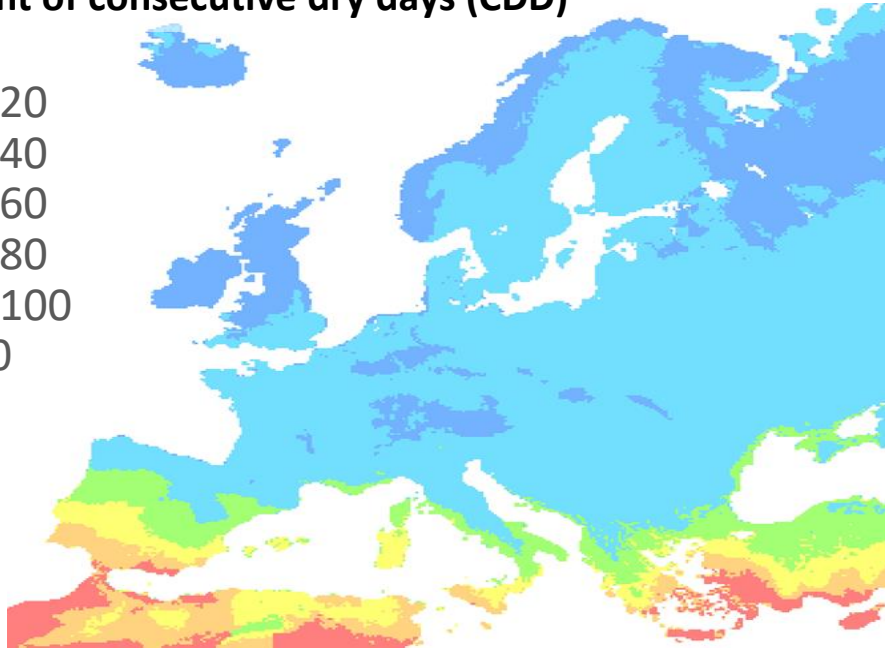
*Quercus ilex*

Mediterranean  
eschlerophyllous forests



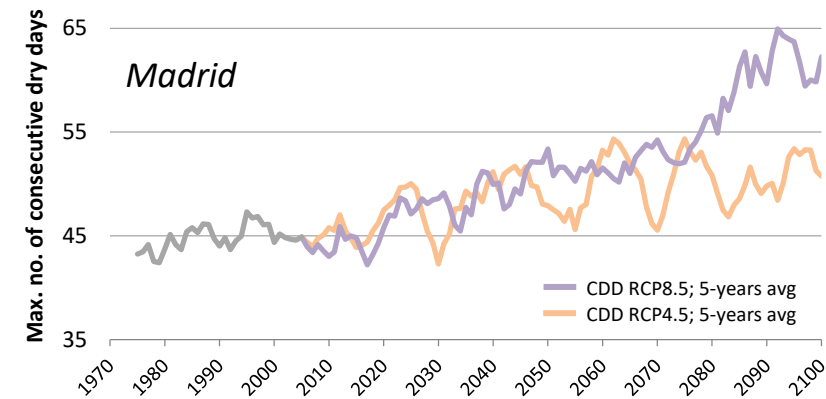
# What can we expect in a context of climate change?

## Max. lenght of consecutive dry days (CDD)



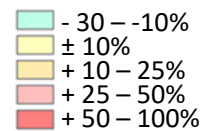
## Climate change:

expected increase in lenght of dry periods

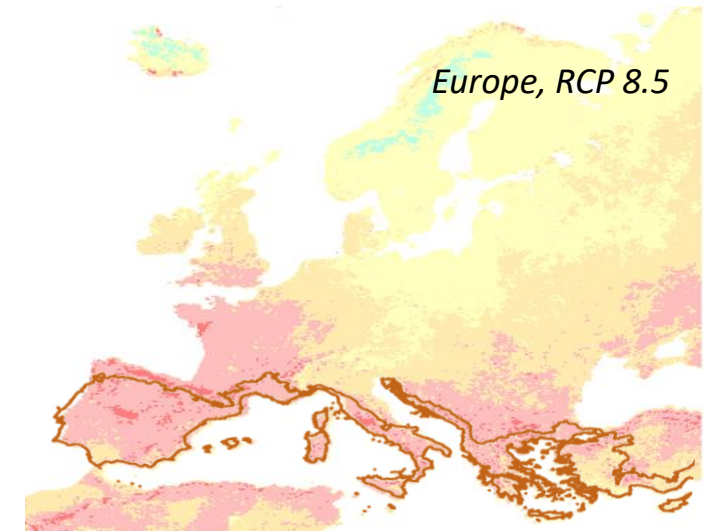
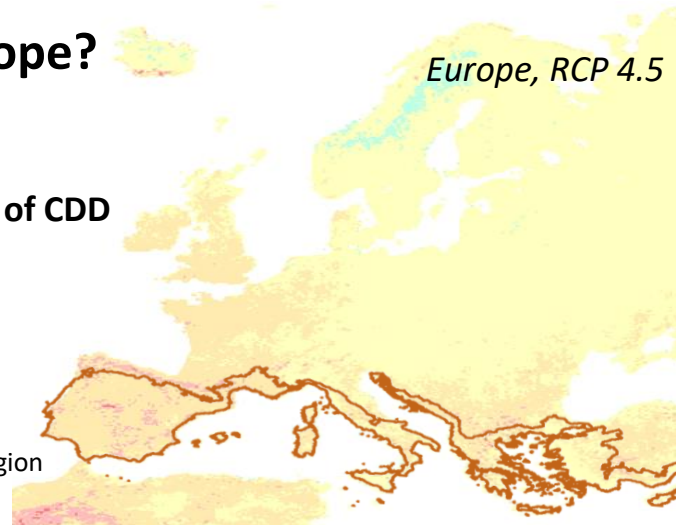


## How could it affect the rest of Europe?

### Modeled variation of CDD



Mediterranean region  
In Europe

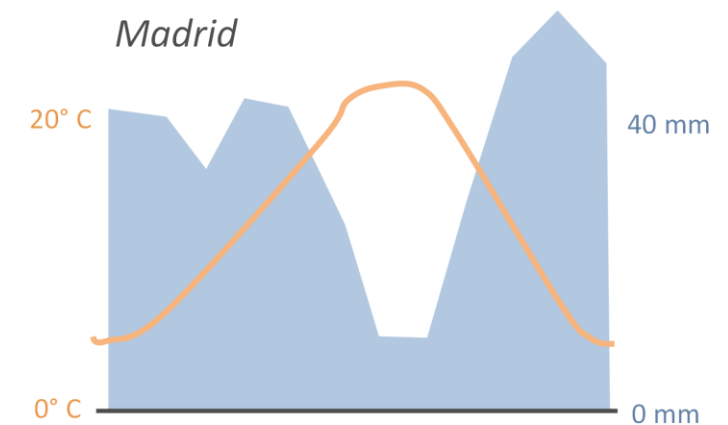




# EXPECTED EFFECTS OF PRECIPITATION SEASONALITY ON HYDROLOGY AND DEPOSITION

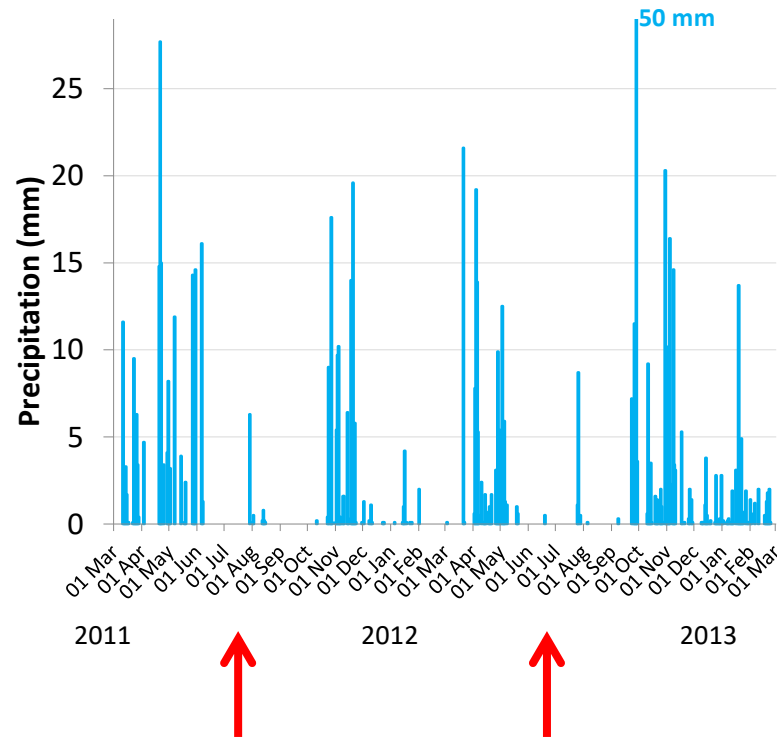
RESULTS BASED ON OBSERVATIONS [2011 - 2013]

- *Quercus ilex* open forest (≈72% cover)
- Semi-arid Mediterranean climate (≈400 mm)
- Madrid region (central Spain)



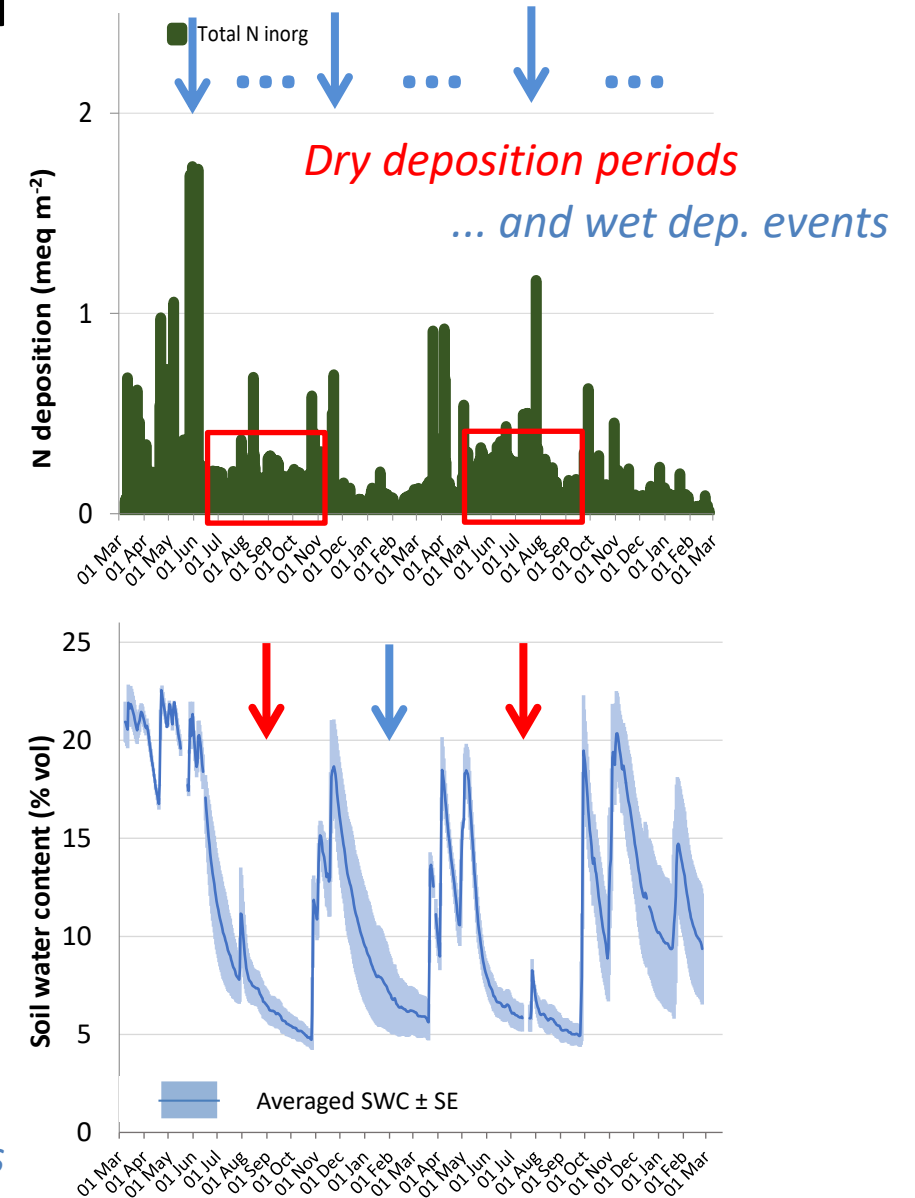
## DAILY VALUES: METEOROLOGY AND SOIL WATER CONTENT

Seasonality on precipitation causes  
seasonality on **hydrology** and **N deposition**



*Growth and metabolic activity are limited during summer*

*... and maybe some winters*





# MODELED EFFECTS OF MEDITERANEAN SEASONALITY BASED ON FORSAFE 3.0 SIMULATIONS

Daily resolution simulations

Parameterized for *Quercus ilex*

Set-up for a highly conductive soil





## The integrated, self-contained model ForSAFE 3.0:

Daily time resolution

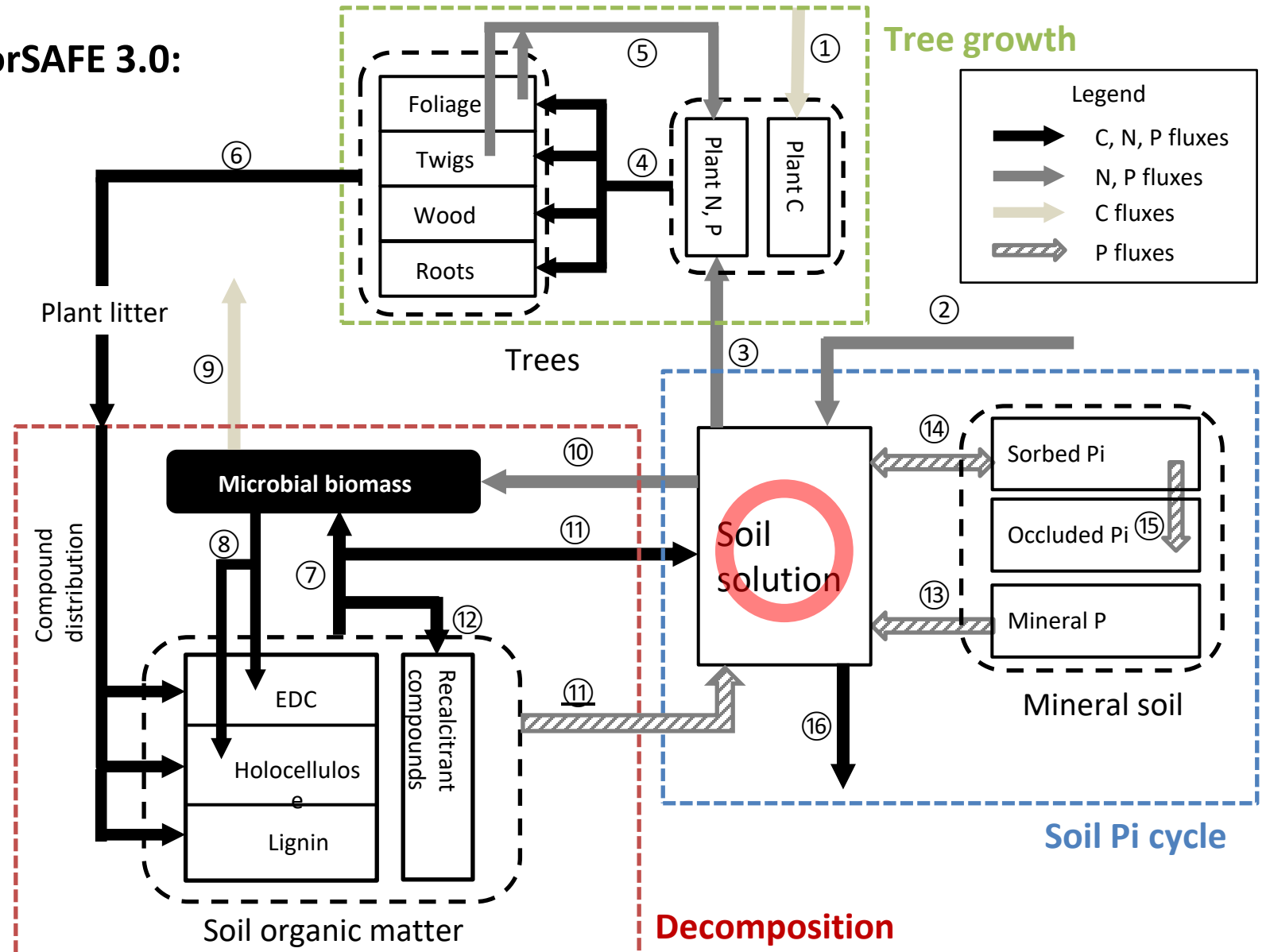
P cycle

Trees:

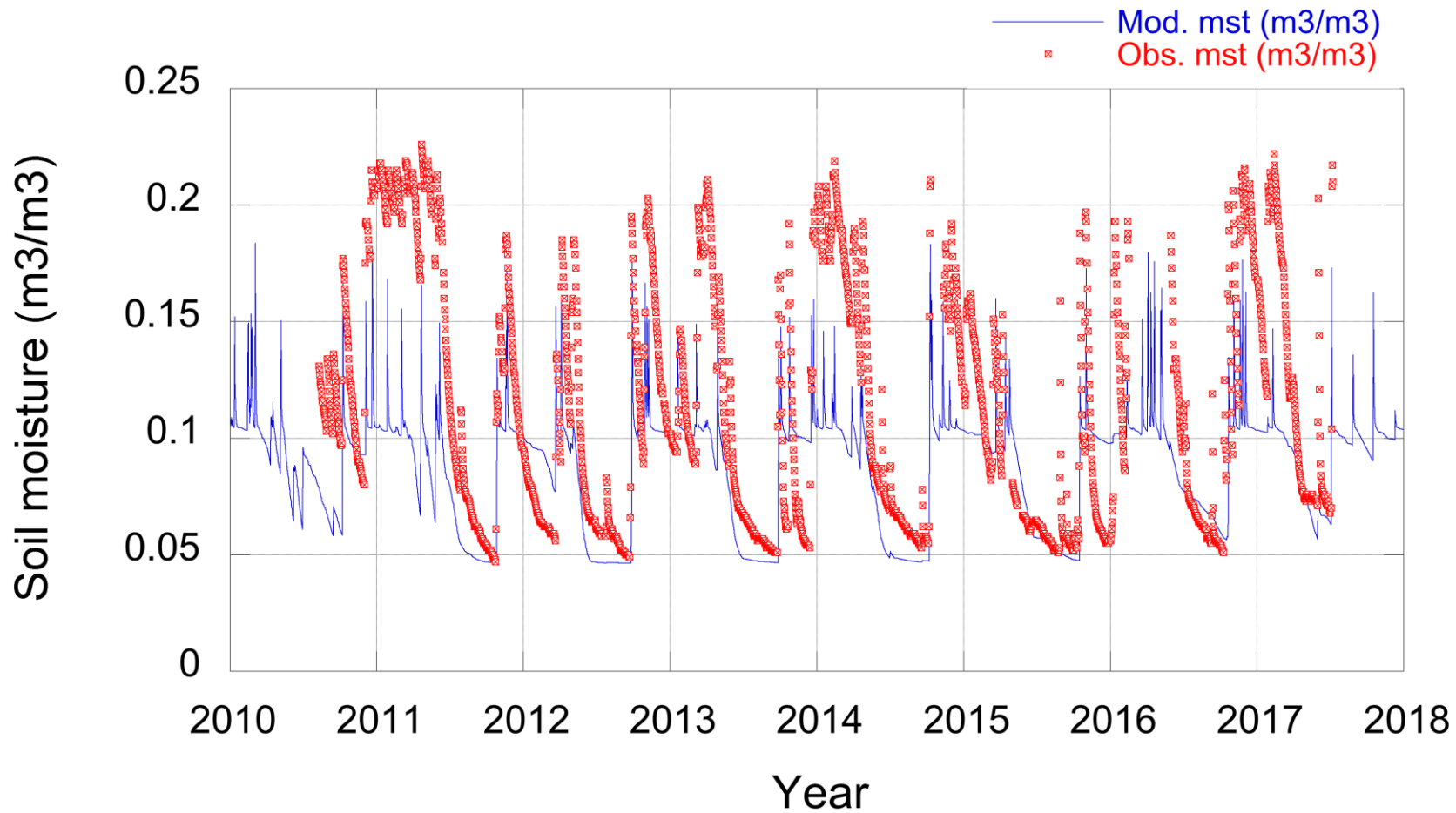
- Twigs and branches
- New phenology

Soil:

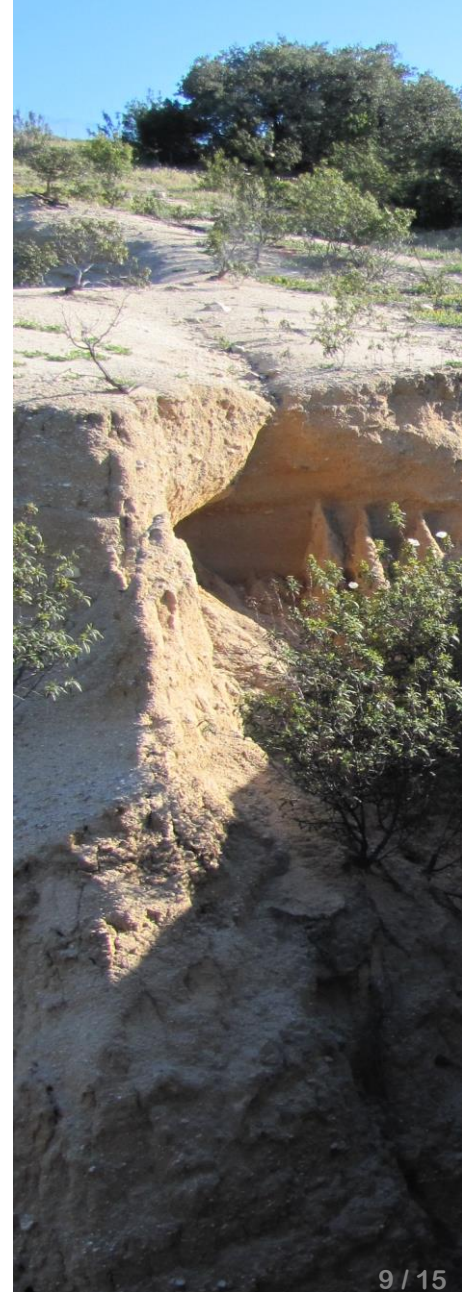
- Explicit simulation of soil microbial processes
- Improved hydrological processes
  - conductivity
  - lateral flow



## PRELIMINARY TEST RESULTS



Depletion of water during dry periods is well captured by the model  
Periods of sustained high soil water content are not maintained in the simulation



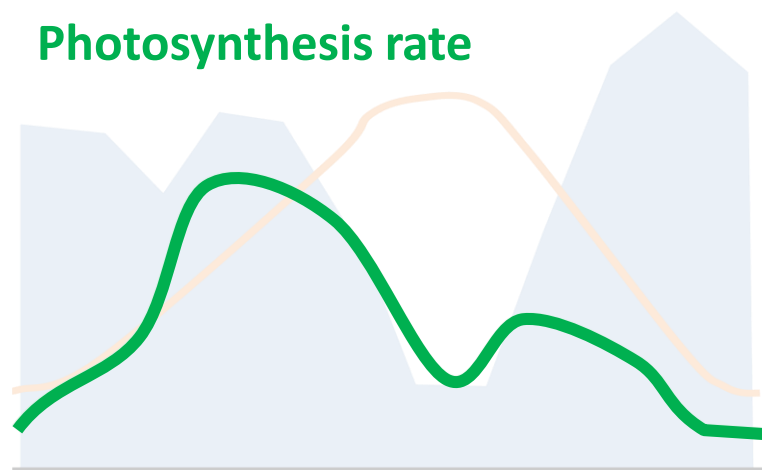


# Can ForSAFE 3.0 simulate seasonality in tree phenology?

## PRELIMINARY TEST RESULTS

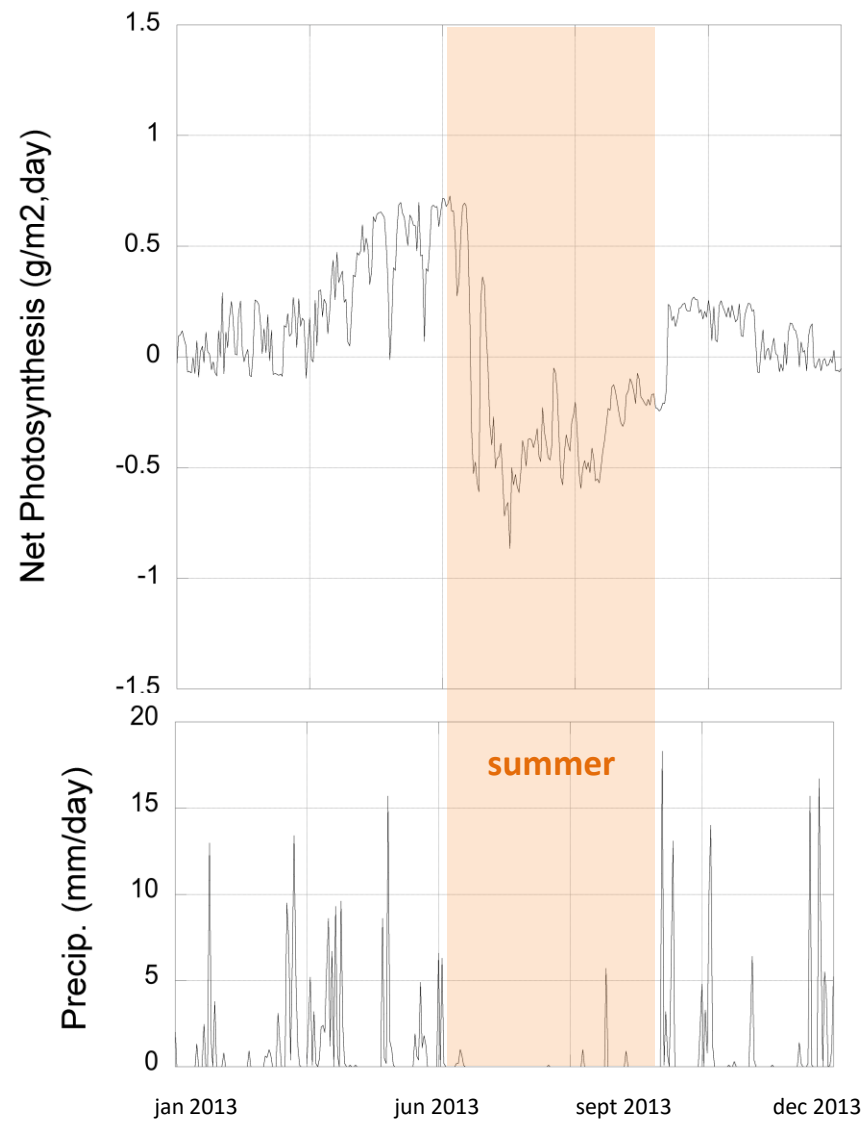


## Photosynthesis rate

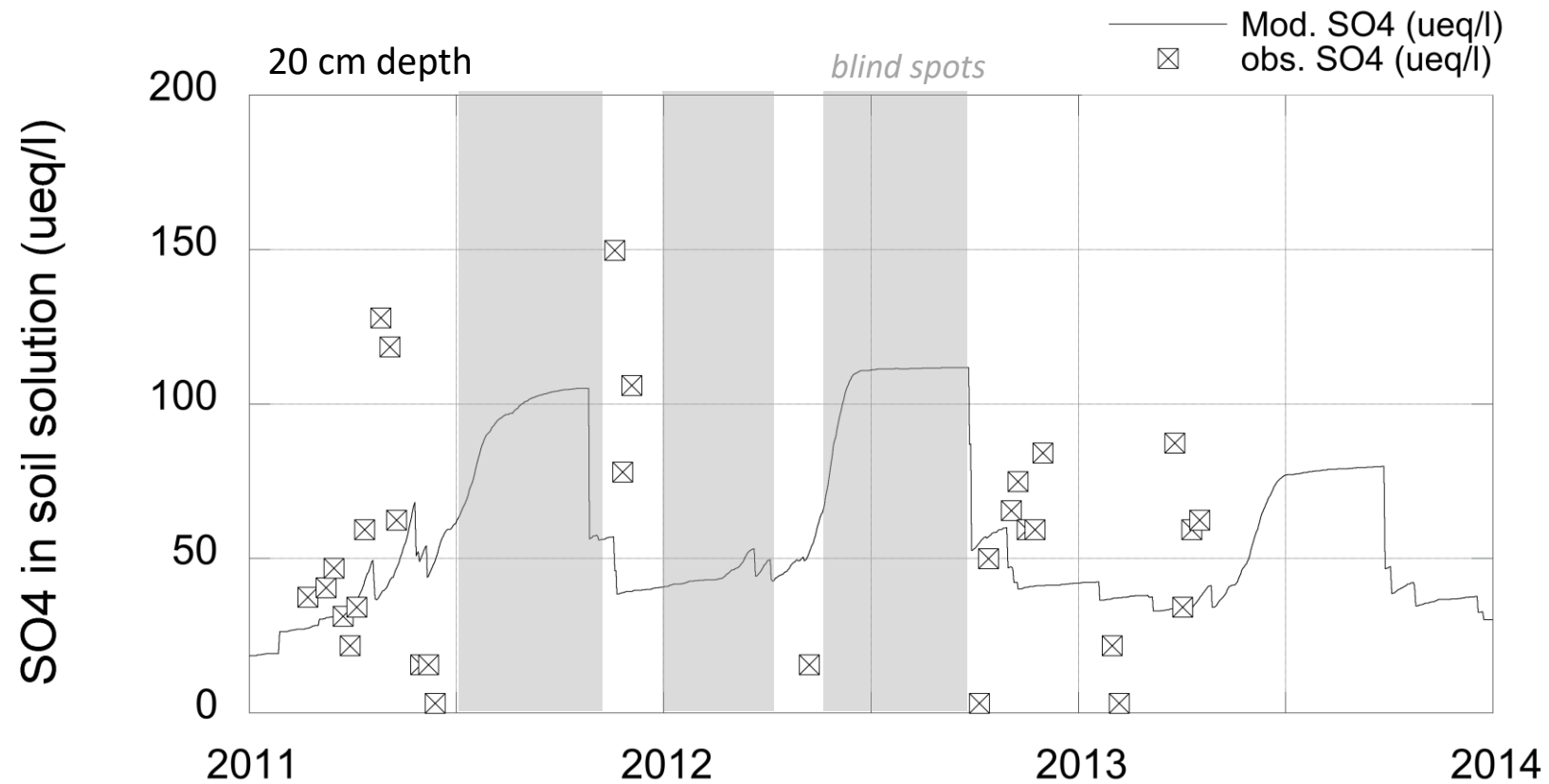


Adapted from Flexas et al. 2014 (Environ. Exp. Bot. 103: 12–23)

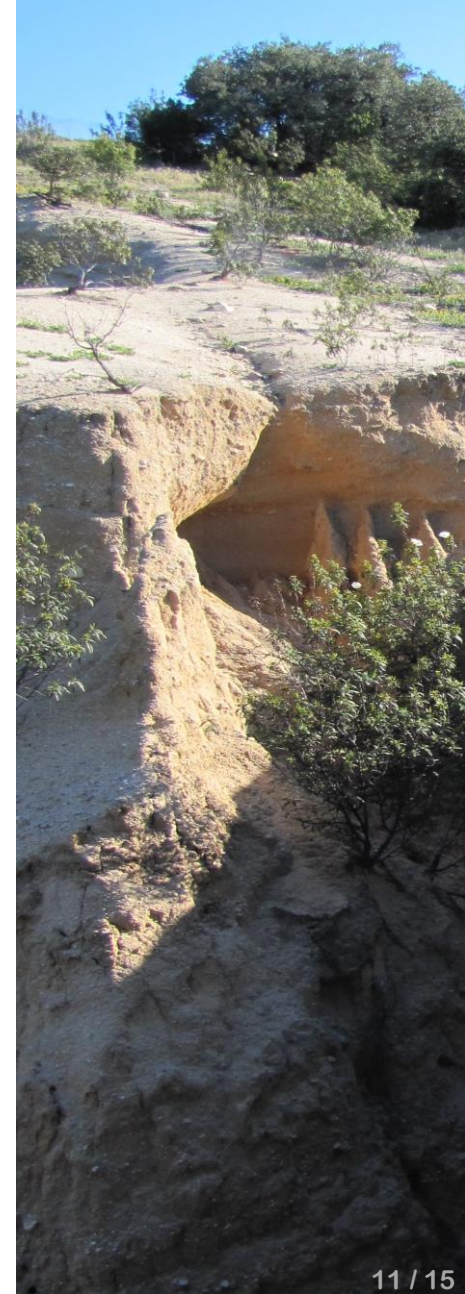
Seasonal activity is well simulated



## PRELIMINARY TEST RESULTS

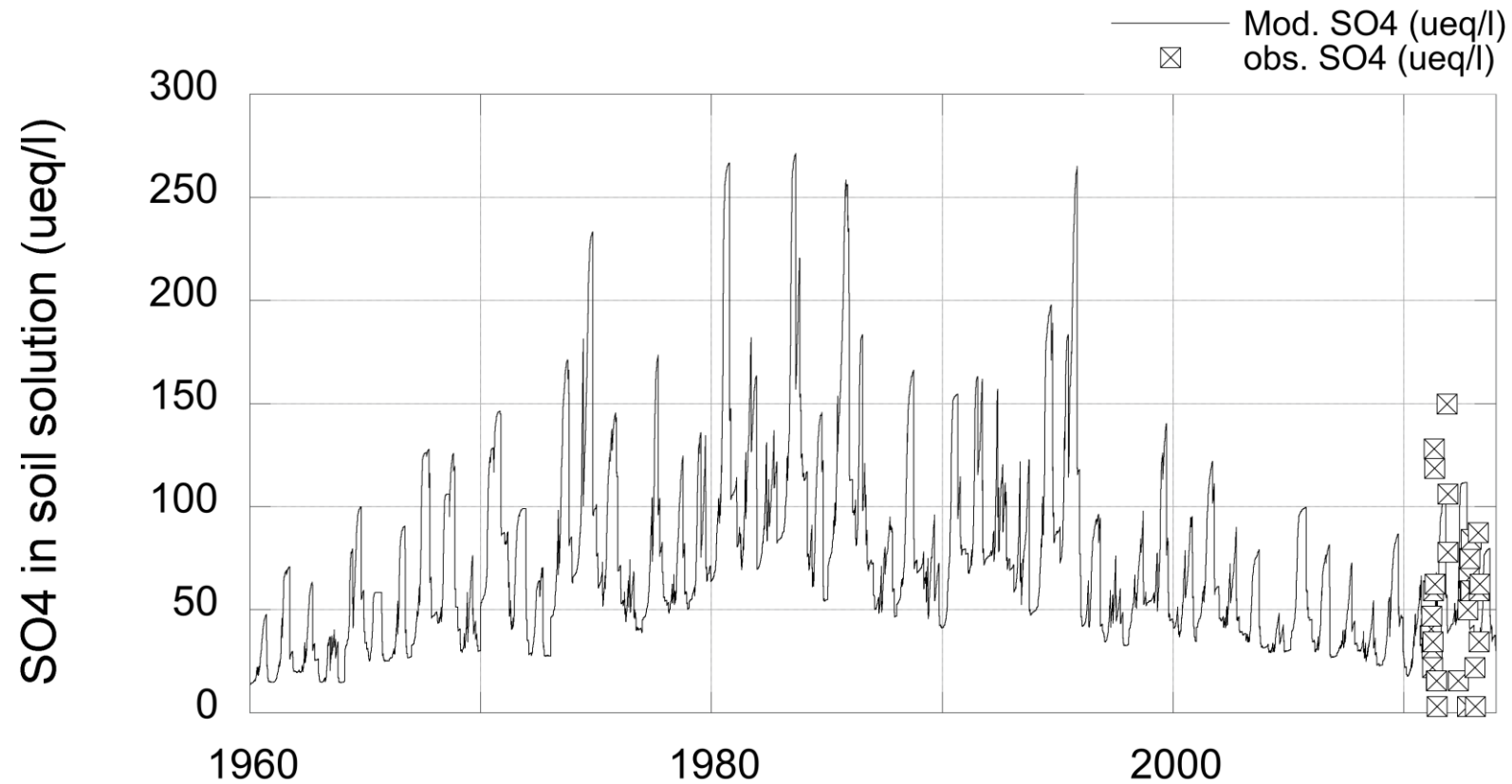


Seasonal (drought) concentration effect was captured  
Lowest and highest values (abrupt changes) were not well simulated





## PRELIMINARY TEST RESULTS

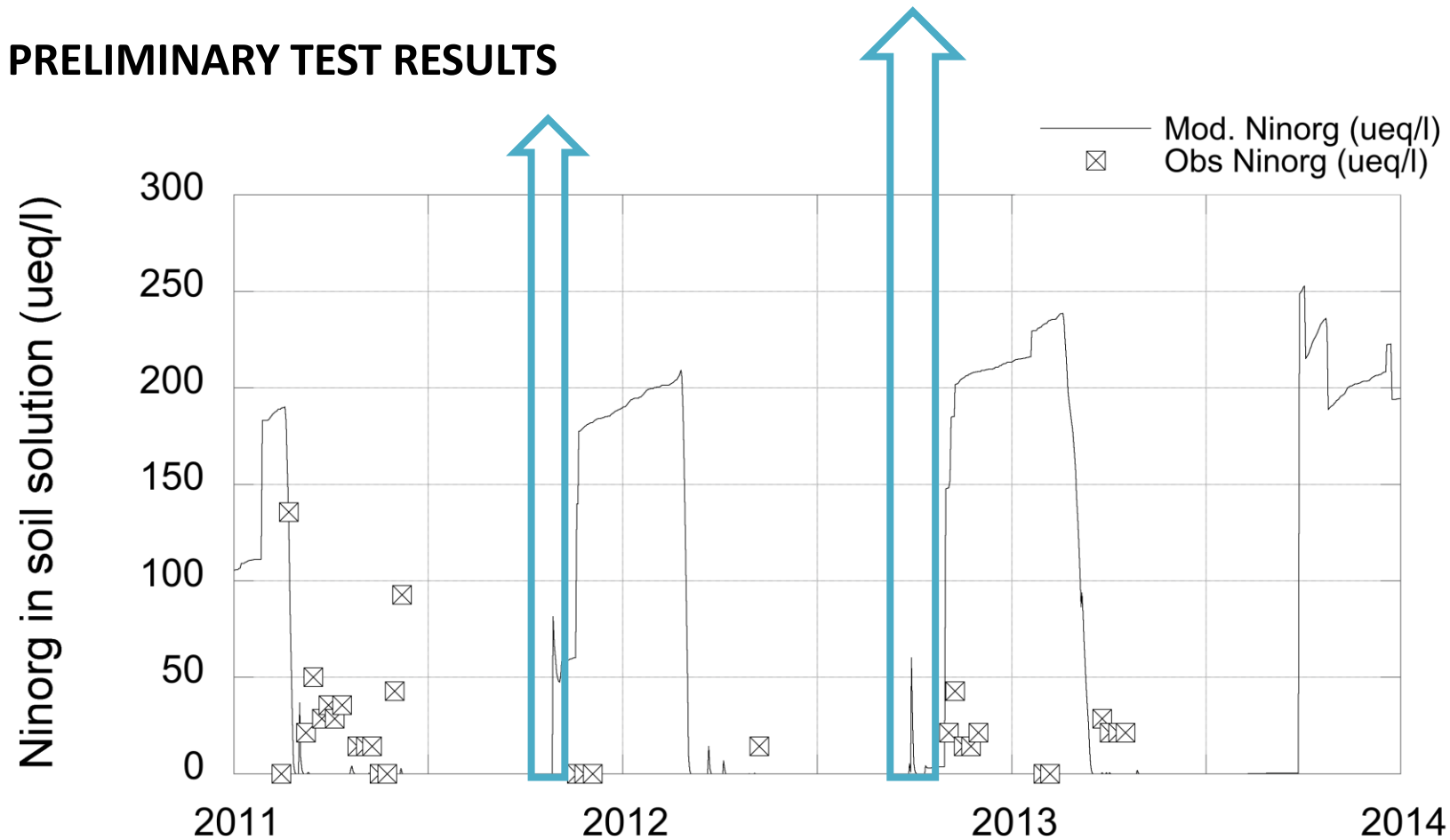


Abrupt changes are not expressed by the model but concentration is in range



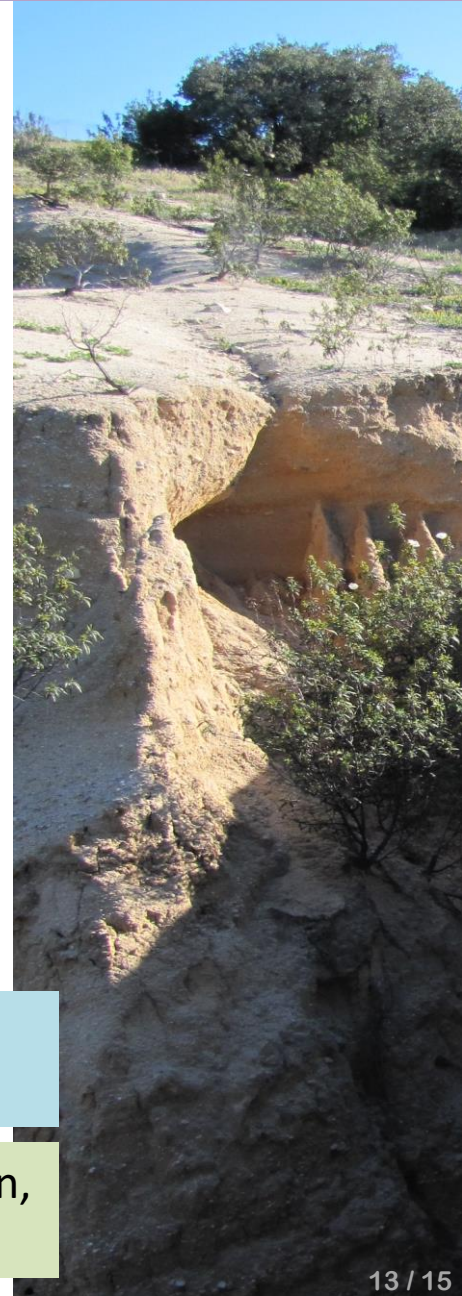
# Can ForSAFE 3.0 simulate seasonality in the chemistry of soil water?

## PRELIMINARY TEST RESULTS



In the simulation, N is only present during the **wet season**, and in higher concentrations than measured  
**Extremely high peaks** measured after drought seasons (not shown here) were not simulated

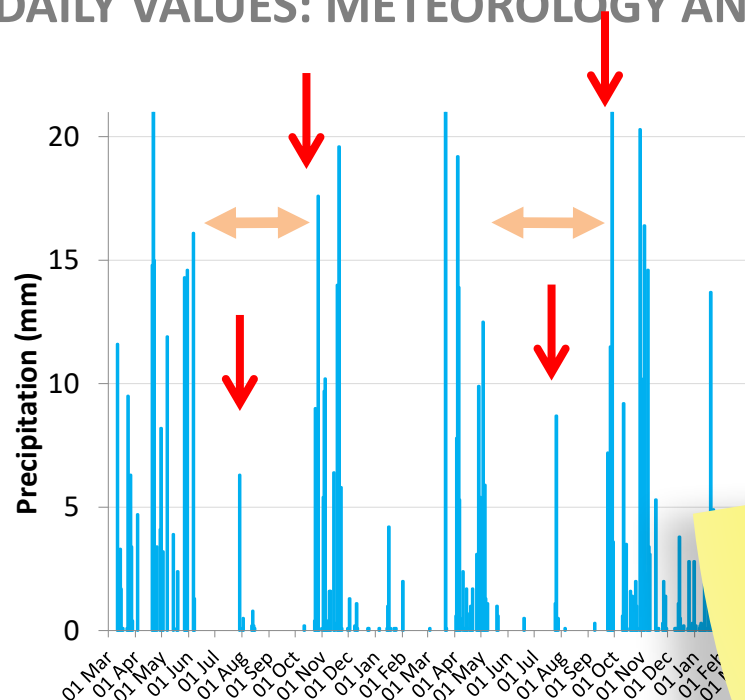
N deposition is distributed in rain by the model (internally) → deposition occurs mainly during wet season, neglecting dry deposition importance and the peaks after drought periods





# Can we expect effects of Mediterranean seasonality on N inputs?

## DAILY VALUES: METEOROLOGY AND ESTIMATED DEPOSITION BASED ON MEASUREMENTS

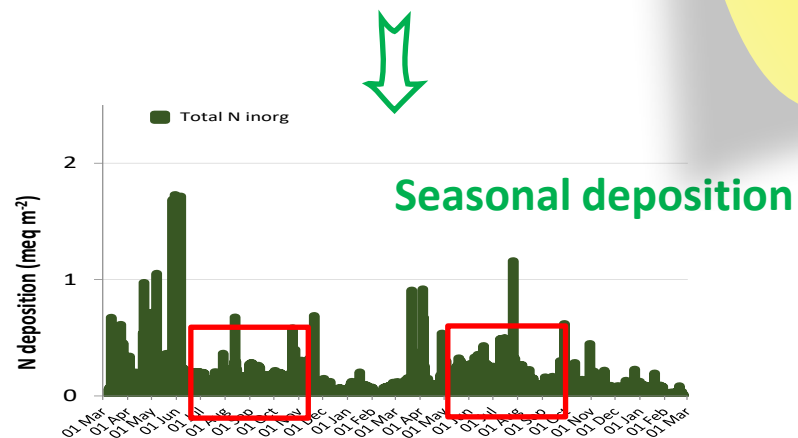


Precipitation seasonality causes wet (and dry) deposition seasonality

Summer conditions enhance dry deposition of N, due to higher concentrations of N gases ( $\text{NH}_3$   $\text{HNO}_3$ )

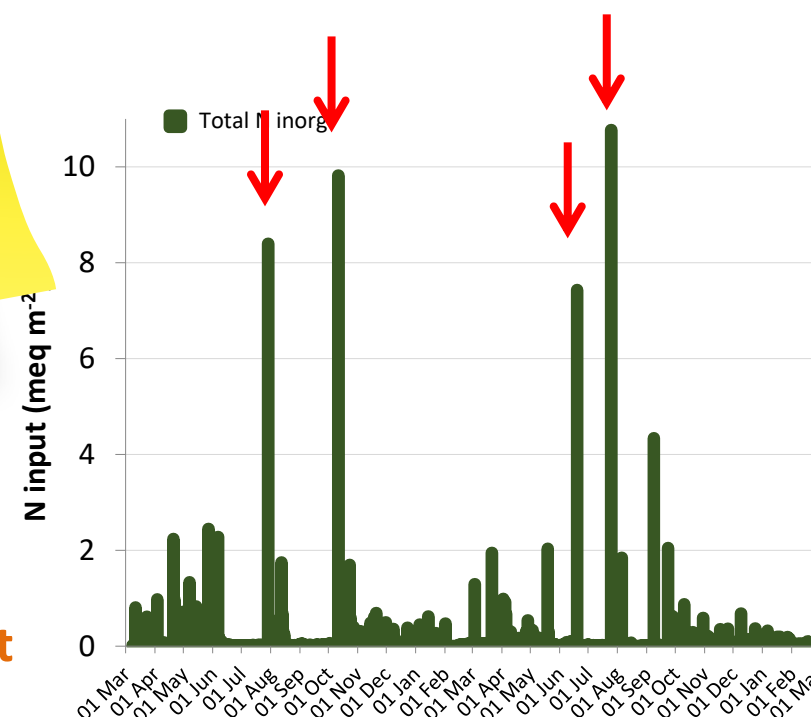
Dry periods causes accumulation of N dry-deposited on canopies

Daily estimations of N inputs will be used in the next iterations



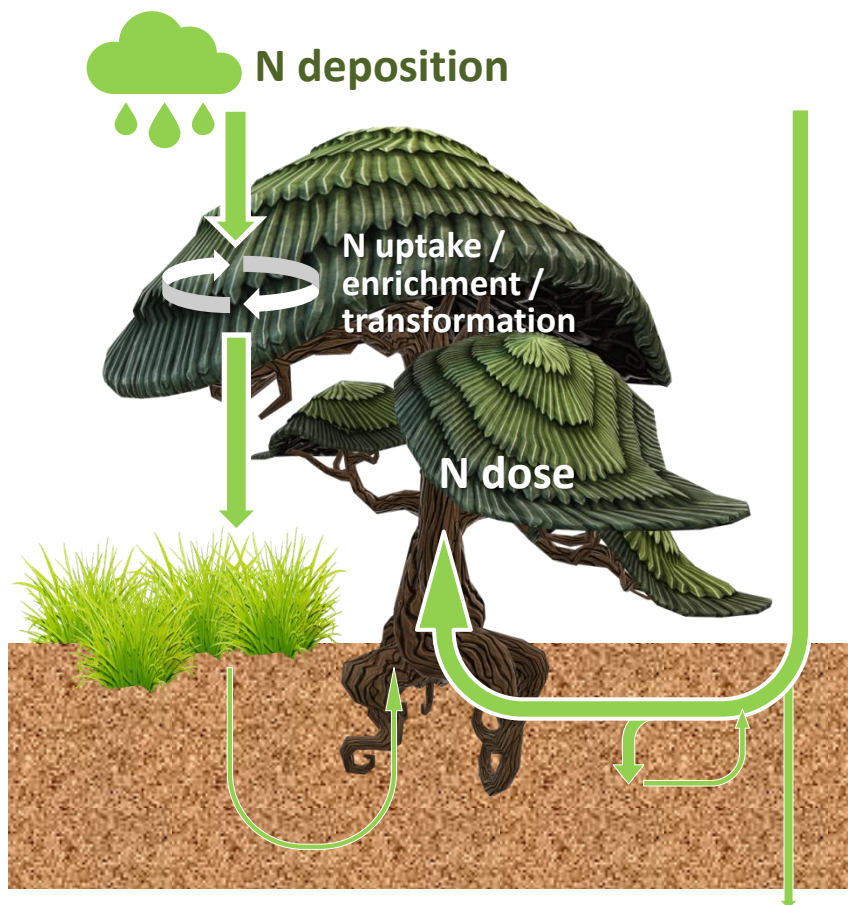
Seasonal deposition

“Pulsating” input

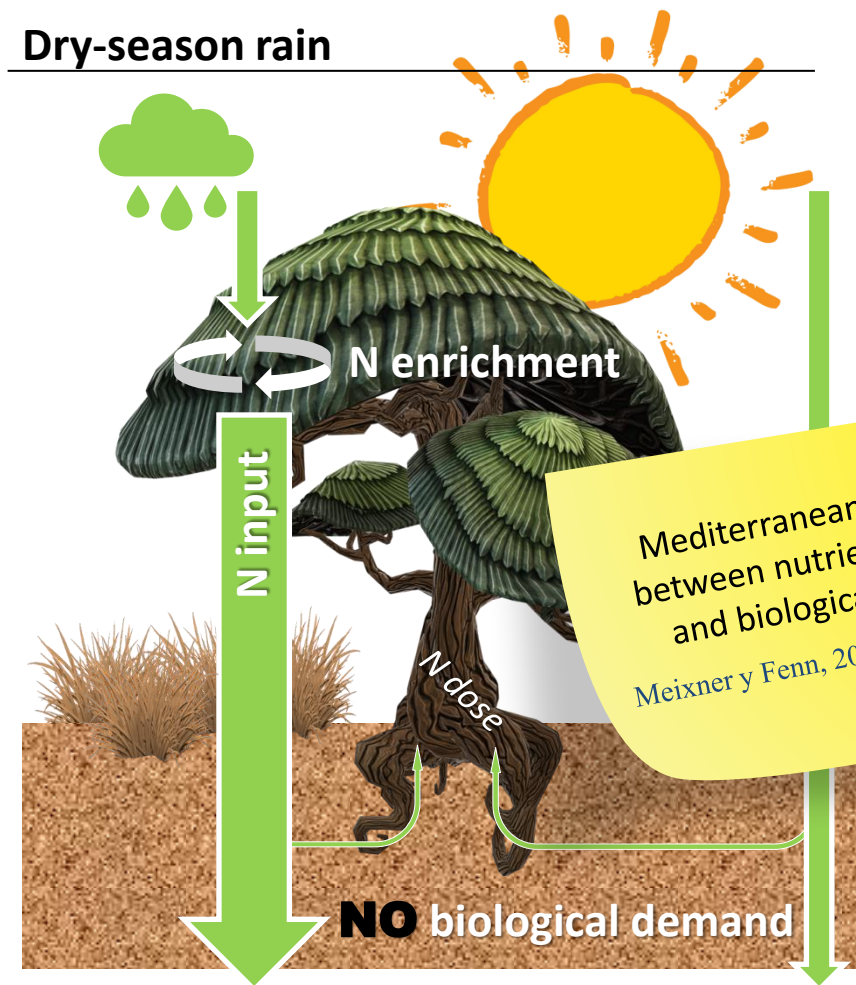


We can use dynamic modeling at high temporal resolution to evaluate target or critical loads

## Wet-season rain



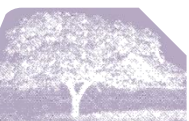
## Dry-season rain



In the dose-response relationship, Mediterranean conditions control the dose

Terrestrial ecosystems:  $\text{Dose} < \text{deposition}$  ... Consequences of N peaks in soil water?

Aquatic ecosystems:  $\text{Dose} > \text{deposition}$  (at large scales)







# Thank you



**MODICO project**

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