# Introduction to medfate modelling framework

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# **Outline**

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- 2. Set of R packages
- 3. Package installation and documentation
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- 5. Overview of medfateland package functions



M.C. Escher - Reptiles, 1943



1. Purpose and development context



## Model scope

- Being able to anticipate the impact of global change on forest ecosystems is one of the major environmental challenges in contemporary societies.
- The set of R packages conforming the **medfate modelling framework** have been designed to study the characteristics and simulate the functioning and dynamics of forest ecosystems.
- Climatic conditions are the main environmental drivers, with a particular focus on drought impacts under Mediterranean conditions.
- Representation of vegetation accounts for structural and compositional variation but is not spatially-explicit (i.e. trees or shrubs do not have explicit coordinates within forest stands).



### **Development context**

#### **Funding**

I have been intensively working on medfate since 2013, when I obtained a Ramon y Cajal research fellowship from the Spanish government. Four other research projects (FORESTCAST, DRESS, BOMFORES, IMPROMED) have funded further developments.

Developments were also supported by CTFC (until March 2021) and CREAF, where I currently coordinate its *Ecosystem Modelling Facility*.

#### Contribution

A large number of people has contributed with ideas, data or code to the project:

Jordi Martínez-Vilalta (CREAF-UAB, Spain), Maurizio Mencuccini (ICREA, Spain), Juli G. Pausas (CIDE-CSIC, Spain), Pilar Llorens (CSIC, Spain), Rafa Poyatos (CREAF, Spain), Lluís Brotons (CREAF-CSIC, Spain), Antoine Cabon (WSL, Switzerland), Roberto Molowny (EMF-CREAF, Spain), Victor Granda (EMF-CREAF, Spain), Adriana Tovar (EMF-CREAF, Spain) Alicia Forner (MNCN-CSIC, Spain), Lluís Coll (UdL, Spain), Pere Casals (CTFC, Spain), Mario Beltrán (CTFC, Spain), Aitor Améztegui (UdL, Spain), Nicolas Martin-StPaul (INRA, France), Shengli Huang (USDA, USA), Enric Batllori (UB-CREAF, Spain), Santi Sabaté (UB-CREAF, Spain), Daniel Nadal-Sala (UB, Spain), María González (UPV, Spain)



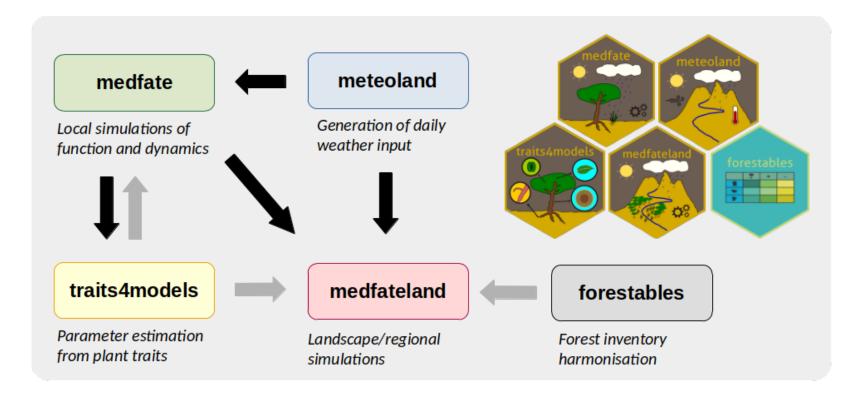
# 2. Set of R packages



## Package suite

During the development of **medfate** ancillary functions were originally included in the package itself...

... but many of them were later moved into more specialized packages:





3. Package installation and documentation



#### Installation

In this course, we will use packages **meteoland**, **medfate**, **medfateland**, which are installed from CRAN (stable versions):

```
install.packages("meteoland")
install.packages("medfate")
install.packages("medfateland")
```

More frequent updates can be obtained if installing from **GitHub**:

```
1 remotes::install_github("emf-creaf/meteoland")
2 remotes::install_github("emf-creaf/medfate")
3 remotes::install_github("emf-creaf/medfateland")
```



#### **Documentation**

A reference book is available for detailed formulation of processes.

Several vignettes are available at the web pages of medfate and medfateland, including:

- a. How to create model inputs
- b. How to perform simulations
- c. Parameter estimation procedures
- d. Evaluation benchmarks
- e. Estimated computational times



4. Overview of medfate package functions



#### **Simulation functions**

Three main simulation models can be executed in **medfate**:

Function	Description
spwb()	Water and energy balance
growth()	Carbon balance, growth and mortality
fordyn()	Forest dynamics, including recruitment and forest management

#### User-level **Processes** functions Water balance (daily) Rainfall interception Snow accumulation and melt Infiltration and percolation Evaporation from soil surface Basic sub-model Advanced sub-model Radiation extinction Radiation balance Plant transpiration Plant phosynthesis Energy balance Plant hydraulics Stem cavitation Hydraulic redistribution Stomatal regulation Leaf photosynthesis Stem cavitation Hydraulic redistribution Carbon balance, growth/senescence and mortality (daily) Autotrophic (maintenance) respiration Growth respiration Carbon translocation and storage Root exudation Tissue formation and senescence Plant size update Mortality (basal, starvation, dessication) Fire behaviour and severity Regeneration and management (yearly) Seed production Seed bank dynamics Recruitment from seeds Resprouting Management prescriptions and effects



# **Plot/summary functions**

Functions are included to *extract*, *summarise* and *display* the time series included in the output of each simulation function:

Function	Description
extract()	Reshapes daily or subdaily output into data frames.
summary()	Temporal summaries of results.
plot()	Display time series of the results.
shinyplot()	Interactive exploration of results.



### **Sub-model functions**

A large number of functions implement sub-models (i.e. modules) on which the simulation functions are built.

They are included in the package, as **internal** (they are not visible in function index).

Sub-model functions are grouped by *subject*:

Group	Description	Group
biophysics_*	Physics and biophysics	pheno_
carbon_*	Carbon balance	photo_
fuel_*	Fuel properties	root_*
fire_*	Fire behaviour	
hydraulics_*	Plant hydraulics	soil_*
hydrology_* Canopy and soil hydrology		transp
light_*	Light extinction and absortion	wind *
moisture_*	noisture_* Live tissue moisture	

Group	Description
pheno_*	Leaf phenology
photo_*	Leaf photosynthesis
root_*	Root distribution and conductance calculations
soil_*	Soil hydraulics and thermodynamics
transp_*	Stomatal regulation, transpiration and photosynthesis
wind_*	Canopy turbulence



5. Overview of medfateland package functions



## **Simulation functions**

Package **medfateland** allows simulating forest functioning and dynamics on sets forests stands distributed across space, with or without spatial processes:

Function	Description	
*_spatial()	Simulation on multiple forest stands	
*_land()	Simulations including spatial processes	
fordyn_scenario()	Regional simulations of climate/ management scenarios	

Uncoupled simulation	Coupled simulation			
Point locations		Gridded landscapes		
User-level functions spwb_spatial growth_spatial fordyn_spatial Available processes Water balance (local)	fordyn_scenario	spwb_land growth_land fordyn_land		
Carbon balance, growth, senescence and mortality				
Regeneration and management				
		Watershed hydrology		
	Management regime			
	Seed dispersal			
Fire regime (imposed)				







