Introduction to medfate modelling framework

Miquel De Cáceres, Rodrigo Balaguer
Ecosystem Modelling Facility, CREAF

Outline

1. Purpose and development context
2. Set of R packages
3. Package installation and documentation
4. Overview of medfate package functions
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*.

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

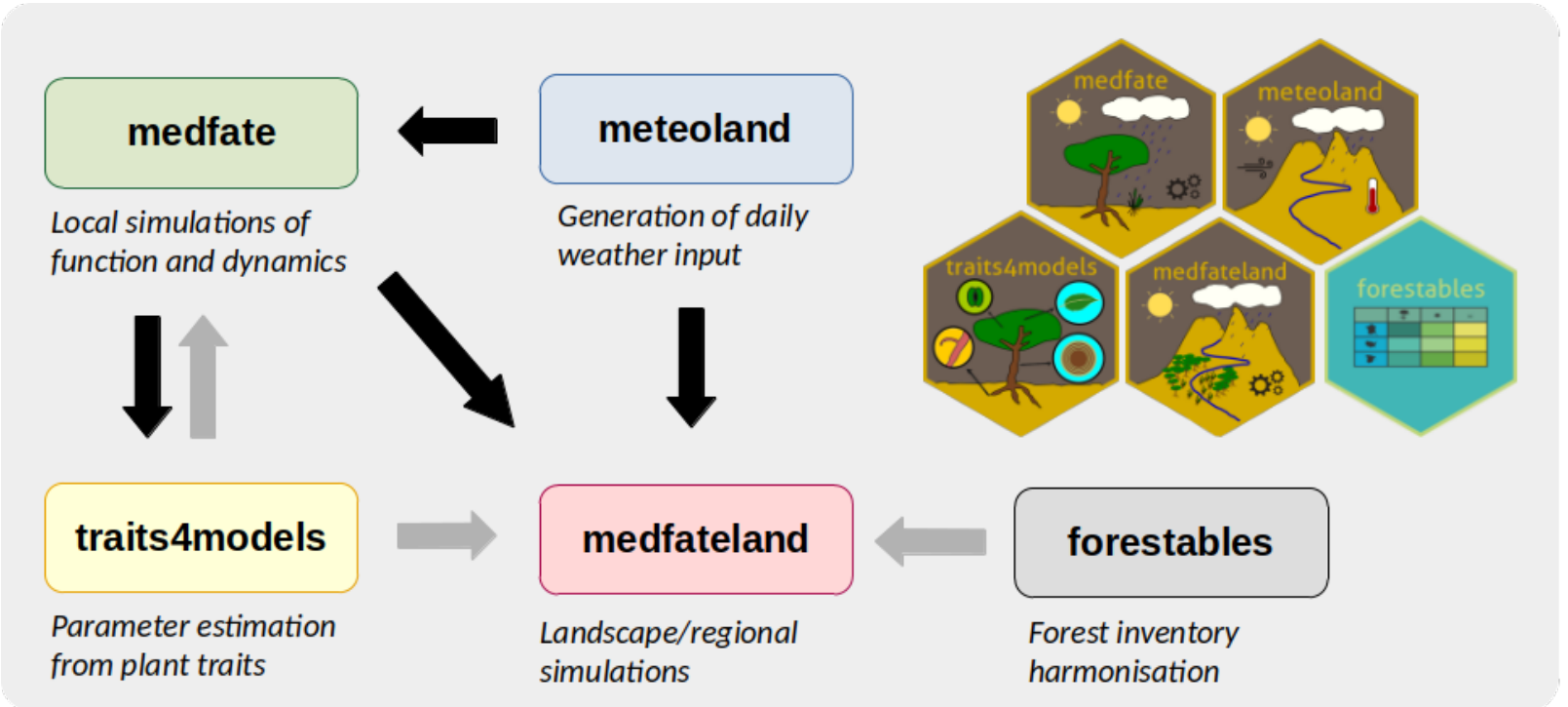
Jordi Martínez-Vilalta (CREAF-UAB, Spain), Maurizio Mencuccini (ICREA, Spain), Juli G. Pausas (CIDE-CSIC, Spain), Pilar Llorens (CSIC, Spain), Rafa Poyatos (CREAF, Spain), Lluís Brotons (CREAF-CSIC, Spain), Antoine Cabon (WSL, Switzerland), Roberto Molowny (EMF-CREAF, Spain), Victor Granda (EMF-CREAF, 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**:

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

Documentation

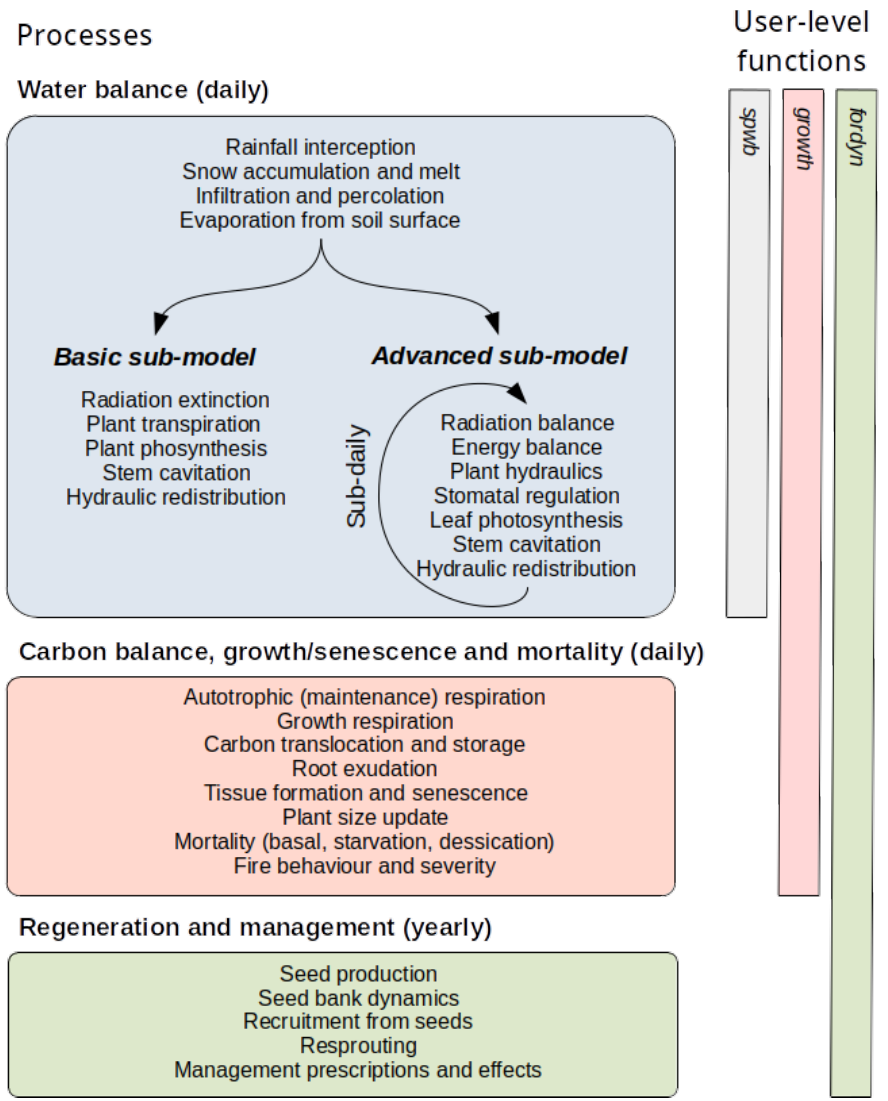
Several vignettes, describing creation of model inputs and how to perform simulations, are available at the web pages of medfate and medfateland.

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



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.

Post-processing functions

Some package functions are meant to be used on simulation results (some of them implementing static ancillary models) and produce time series of additional properties.

Function	Description
`droughtStress()`	Plant drought stress indices
`waterUseEfficiency()`	Water use efficiency metrics
`resistances()`	Hydraulic resistances to water transport
`fireHazard()`	Potential fire behaviour

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
`biophysics_*`	Physics and biophysics
`carbon_*`	Carbon balance
`fuel_*`	Fuel properties
`fire_*`	Fire behaviour
`hydraulics_*`	Plant hydraulics
`hydrology_*`	Canopy and soil hydrology
`light_*`	Light extinction and absortion
`moisture_*`	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