1.2 - Introduction to medfate modelling framework

Miquel De Cáceres, Rodrigo Balaguer-Romano

Ecosystem Modelling Facility

2022-11-30

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

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.

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.

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.

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).

1. Purpose and development context

Development context

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.

1. Purpose and development context

Development context

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*.

1. Purpose and development context

Development context

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)
- 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)
- …

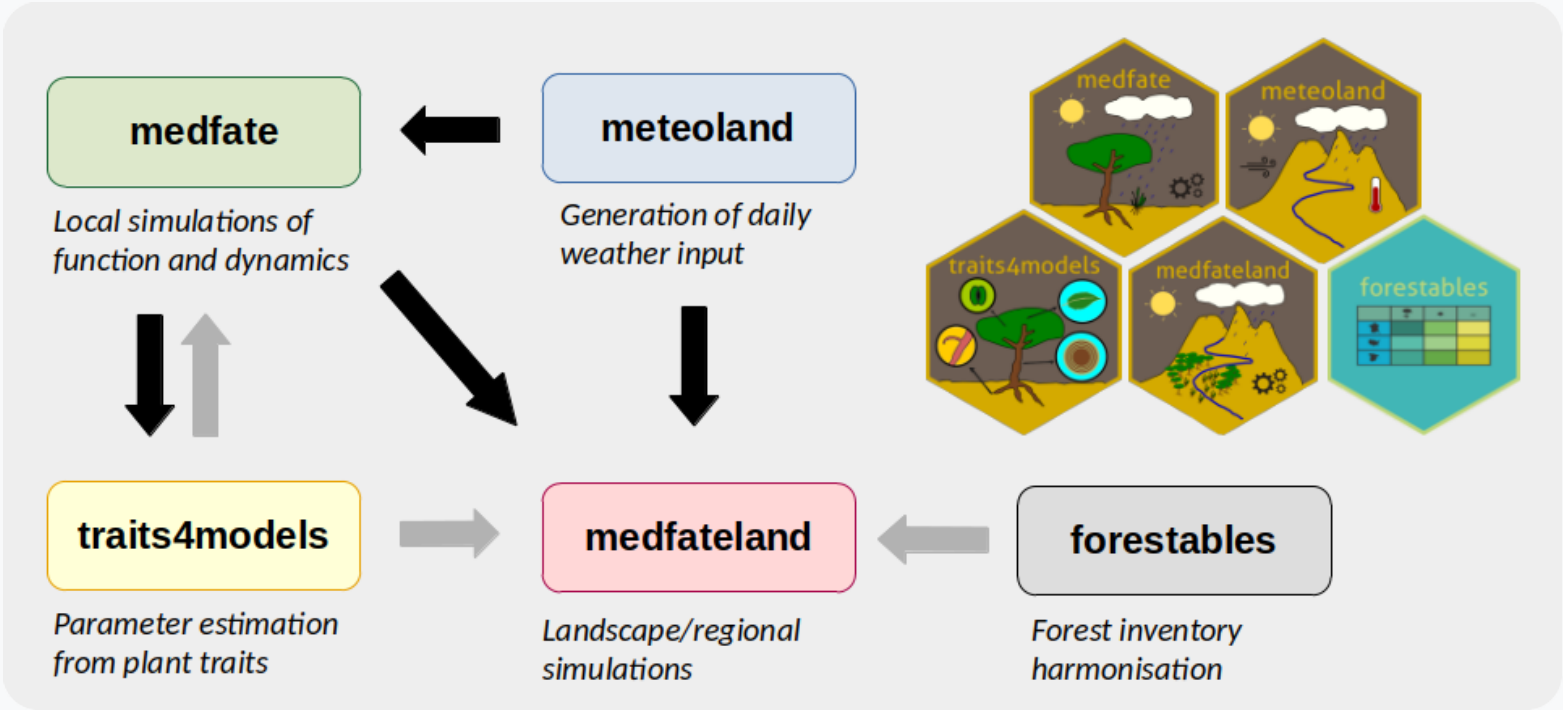
2. Set of R packages

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

2. Set of R packages

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")
```

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")
```

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.

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.

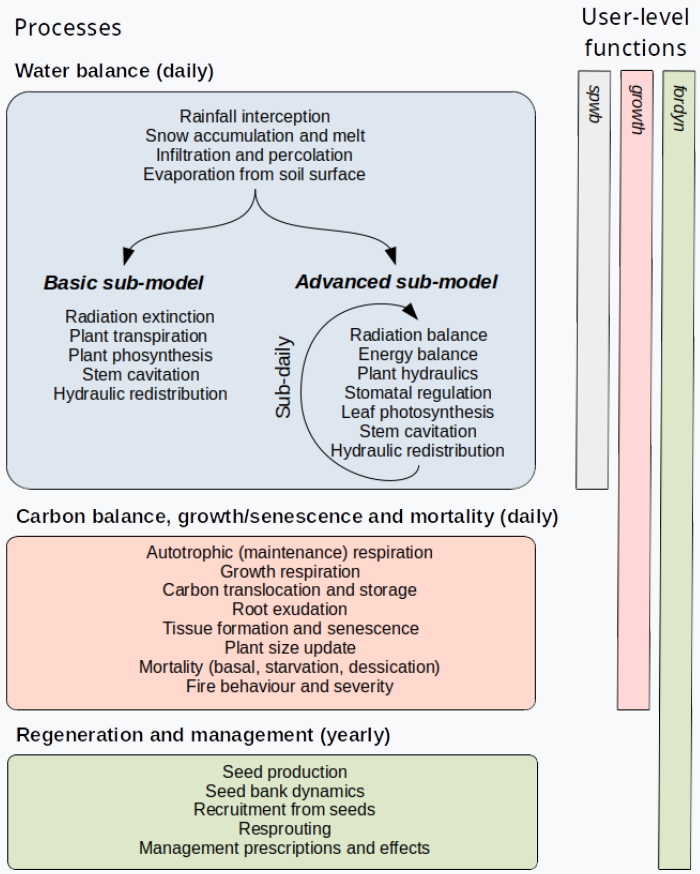
A more complete and detailed documentation of the models included in the package, including formulation and parameterization, can be found in the medfatebook.

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



4. Overview of medfate package functions

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.

4. Overview of medfate package functions

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

4. Overview of medfate package functions

Sub-model functions

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

4. Overview of medfate package functions

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).

4. Overview of medfate package functions

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

4. Overview of medfate package functions

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*:

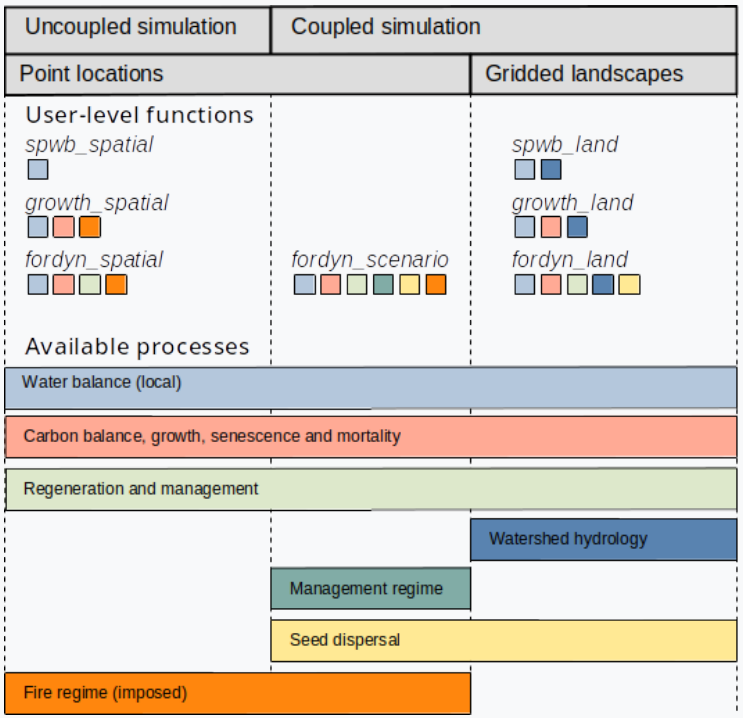
Group	Description
`biophysics_*`	Physics and biophysics
`carbon_*`	Carbon balance
`fuel_*`	Fuel properties
`fire_*`	Fire behaviour
`hydraulics_*`	Plant hydraulics
`hydrology_*`	Canopy and soil hydrology
`light_*`	Light extinction and absortion
`moisture_*`	Live tissue moisture

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:



5. Overview of medfateland package functions

M.C. Escher - Reptiles, 1943