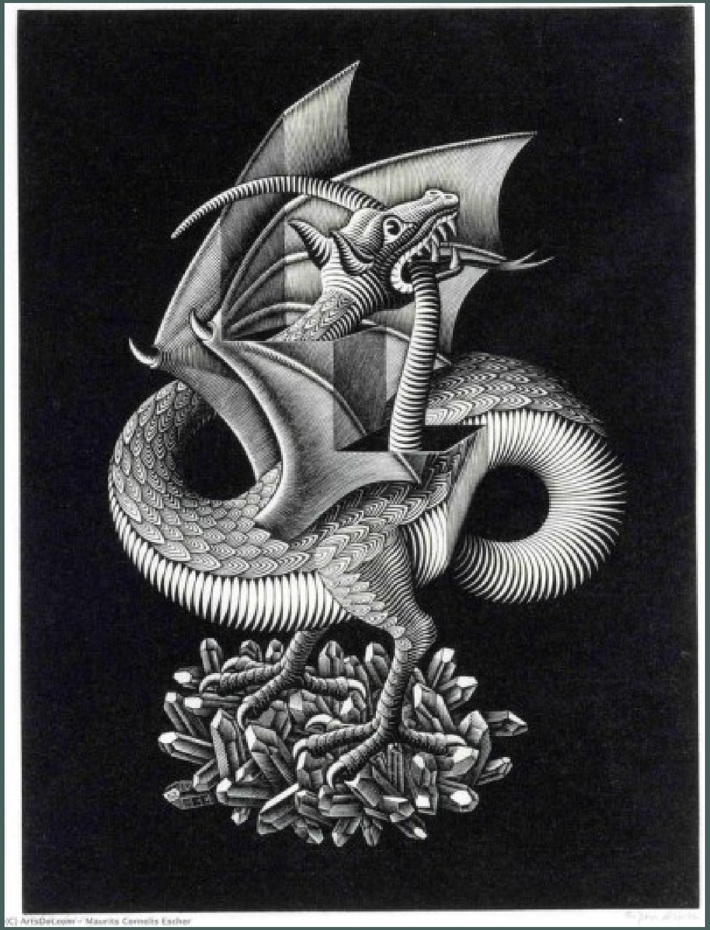
1.3 - Model inputs



Miquel De Cáceres, Rodrigo Balaguer-Romano

Ecosystem Modelling Facility

2022-11-30

Outline

1. Species parameters
2. Forest input
3. Vertical profiles
4. Soil input
5. Simulation control
6. Simulation input object
7. Weather forcing

1. Species parameters

Simulation models in **medfate** require a `data.frame` with species parameter values.

1. Species parameters

Simulation models in **medfate** require a `data.frame` with species parameter values.

The package includes a default data set of parameter values for 217 Mediterranean taxa.

```
data("SpParamsMED")
```

1. Species parameters

Simulation models in **medfate** require a `data.frame` with species parameter values.

The package includes a default data set of parameter values for 217 Mediterranean taxa.

```
data("SpParamsMED")
```

A large number of parameters (157 columns) can be found in `SpParamsMED`, which may be intimidating.

1. Species parameters

Simulation models in **medfate** require a `data.frame` with species parameter values.

The package includes a default data set of parameter values for 217 Mediterranean taxa.

```
data("SpParamsMED")
```

A large number of parameters (157 columns) can be found in `SpParamsMED`, which may be intimidating.

You can find parameter definitions in table `SpParamsDefinition`:

```
data("SpParamsDefinition")
```

1. Species parameters

The following table shows parameter definitions and units:

Show 6 entries Search:

	ParameterName	ParameterGroup	Definition	Type	Units	Strict
1	Name	Identity	Plant names (species binomials, genus or other) used in vegetation data	String		true
2	SpIndex	Identity	Internal species codification (0,1,2,♂)	Integer		true
3	AcceptedName	Taxonomic identity	Accepted scientific name of a taxon (genus, species, subspecies or variety) used for parameterization	String		false
4	Species	Taxonomic identity	Taxonomic species of accepted name	String		false
5	Genus	Taxonomic identity	Taxonomic genus of accepted name	String		true
6	Family	Taxonomic identity	Taxonomic family of accepted name	String		true

Showing 1 to 6 of 156 entries

Previous 1 2 3 4 5 … 26 Next

2. Forest input

Forest class

Each *forest plot* is represented in an object of class `forest`, a list that contains several elements.

```
forest <- medfate::exampleforest
```

2. Forest input

Forest class

Each *forest plot* is represented in an object of class `forest`, a list that contains several elements.

```
forest <- medfate::exampleforest
```

The most important items are two data frames, `treeData` (for trees):

```
forest$treeData
```

```
##             Species   N   DBH Height Z50  Z95
## 1 Pinus halepensis 168 37.55    800 100  600
## 2     Quercus ilex 384 14.60    660 300 1000
```

2. Forest input

Forest class

Each *forest plot* is represented in an object of class `forest`, a list that contains several elements.

```
forest <- medfate::exampleforest
```

The most important items are two data frames, `treeData` (for trees):

```
forest$treeData
```

```
##             Species   N   DBH Height Z50  Z95
## 1 Pinus halepensis 168 37.55    800 100  600
## 2     Quercus ilex 384 14.60    660 300 1000
```

and `shrubData` (for shrubs):

```
forest$shrubData
```

```
##              Species Cover Height Z50  Z95
## 1 Quercus coccifera  3.75     80 200 1000
```

2. Forest input

Forest class

The two data frames share many variables…

2. Forest input

Forest class

The two data frames share many variables...

Tree data

Variable	Definition
`Species`	Species numerical code (should match `SpIndex` in `SpParams`)
`N`	Density of trees (in individuals per hectare)
`DBH`	Tree diameter at breast height (in cm)
`Height`	Tree total height (in cm)
`Z50`	Soil depth corresponding to 50% of fine roots (mm)
`Z95`	Soil depth corresponding to 95% of fine roots (mm)

2. Forest input

Forest class

The two data frames share many variables...

Tree data

Variable	Definition
`Species`	Species numerical code (should match `SpIndex` in `SpParams`)
`N`	Density of trees (in individuals per hectare)
`DBH`	Tree diameter at breast height (in cm)
`Height`	Tree total height (in cm)
`Z50`	Soil depth corresponding to 50% of fine roots (mm)
`Z95`	Soil depth corresponding to 95% of fine roots (mm)

Shrub data

Variable	Definition
`Species`	Species numerical code (should match `SpIndex` in `SpParams`)
`Cover`	Shrub cover (%)
`Height`	Shrub total height (in cm)
`Z50`	Soil depth corresponding to 50% of fine roots (mm)
`Z95`	Soil depth corresponding to 95% of fine roots (mm)

2. Forest input

Forest class

The two data frames share many variables…

Tree data

Variable	Definition
`Species`	Species numerical code (should match `SpIndex` in `SpParams`)
`N`	Density of trees (in individuals per hectare)
`DBH`	Tree diameter at breast height (in cm)
`Height`	Tree total height (in cm)
`Z50`	Soil depth corresponding to 50% of fine roots (mm)
`Z95`	Soil depth corresponding to 95% of fine roots (mm)

Shrub data

Variable	Definition
`Species`	Species numerical code (should match `SpIndex` in `SpParams`)
`Cover`	Shrub cover (%)
`Height`	Shrub total height (in cm)
`Z50`	Soil depth corresponding to 50% of fine roots (mm)
`Z95`	Soil depth corresponding to 95% of fine roots (mm)

Important: medfate's *naming conventions* for tree cohorts and shrub cohorts uses `T` or `S`, the row number and species numerical code (e.g. `"T1_148"` for the first tree cohort, corresponding to *Pinus halepensis*).

2. Forest input

Creating a 'forest' object from forest inventory data

Forest inventories can be conducted in different ways, which means that the starting form of forest data is diverse.

2. Forest input

Creating a 'forest' object from forest inventory data

Forest inventories can be conducted in different ways, which means that the starting form of forest data is diverse.

Building `forest` objects from inventory data will always require some data wrangling, but package **medfate** provides functions that may be helpful:

2. Forest input

Creating a 'forest' object from forest inventory data

Forest inventories can be conducted in different ways, which means that the starting form of forest data is diverse.

Building `forest` objects from inventory data will always require some data wrangling, but package **medfate** provides functions that may be helpful:

Function	Description
`forest_mapShrubTable()`	Helps filling `shrubData` table
`forest_mapTreeTable()`	Helps filling `treeData` table
`forest_mapWoodyTables()`	Helps filling a `forest` object

2. Forest input

Forest attributes

The **medfate** package includes a number of functions to examine properties of the plants conforming a `forest` object:

- `plant_*`: Cohort-level information (species name, id, leaf area index, height…).
- `species_*`: Species-level attributes (e.g. basal area, leaf area index).
- `stand_*`: Stand-level attributes (e.g. basal area).

```
plant_basalArea(forest, SpParamsMED)
```

```
##    T1_148    T2_168    S1_165
## 18.604547  6.428755        NA
```

```
stand_basalArea(forest)
```

```
## [1] 25.0333
```

2. Forest input

Forest attributes

The **medfate** package includes a number of functions to examine properties of the plants conforming a `forest` object:

- `plant_*`: Cohort-level information (species name, id, leaf area index, height…).
- `species_*`: Species-level attributes (e.g. basal area, leaf area index).
- `stand_*`: Stand-level attributes (e.g. basal area).

```
plant_basalArea(forest, SpParamsMED)
```

```
##    T1_148    T2_168    S1_165
## 18.604547  6.428755        NA
```

```
stand_basalArea(forest)
```

```
## [1] 25.0333
```

```
plant_LAI(forest, SpParamsMED)
```

```
##     T1_148     T2_168     S1_165
## 0.84874773 0.70557382 0.03062604
```

```
stand_LAI(forest, SpParamsMED)
```

```
## [1] 1.758585
```

2. Forest input

Aboveground data

An important information for simulation model is the estimation of initial **leaf area index** and **crown dimensions** for each plant cohort, which is normally done using *allometries*.

2. Forest input

Aboveground data

An important information for simulation model is the estimation of initial **leaf area index** and **crown dimensions** for each plant cohort, which is normally done using *allometries*.

We can illustrate this step using function `forest2aboveground()`:

```
above <- forest2aboveground(forest, SpParamsMED)
above
```

```
##          SP        N   DBH Cover   H        CR   LAI_live LAI_expanded LAI_dead LAI_nocomp ObsID
## T1_148 148 168.0000 37.55    NA 800 0.6605196 0.84874773   0.84874773        0 1.29720268  <NA>
## T2_168 168 384.0000 14.60    NA 660 0.6055642 0.70557382   0.70557382        0 1.01943205  <NA>
## S1_165 165 749.4923    NA  3.75  80 0.8032817 0.03062604   0.03062604        0 0.04412896  <NA>
```

where species-specific allometric coefficients are taken from `SpParamsMED`.

2. Forest input

Aboveground data

An important information for simulation model is the estimation of initial **leaf area index** and **crown dimensions** for each plant cohort, which is normally done using *allometries*.

We can illustrate this step using function `forest2aboveground()`:

```
above <- forest2aboveground(forest, SpParamsMED)
above
```

```
##          SP        N   DBH Cover   H        CR   LAI_live LAI_expanded LAI_dead LAI_nocomp ObsID
## T1_148 148 168.0000 37.55    NA 800 0.6605196 0.84874773   0.84874773        0 1.29720268  <NA>
## T2_168 168 384.0000 14.60    NA 660 0.6055642 0.70557382   0.70557382        0 1.01943205  <NA>
## S1_165 165 749.4923    NA  3.75  80 0.8032817 0.03062604   0.03062604        0 0.04412896  <NA>
```

where species-specific allometric coefficients are taken from `SpParamsMED`.

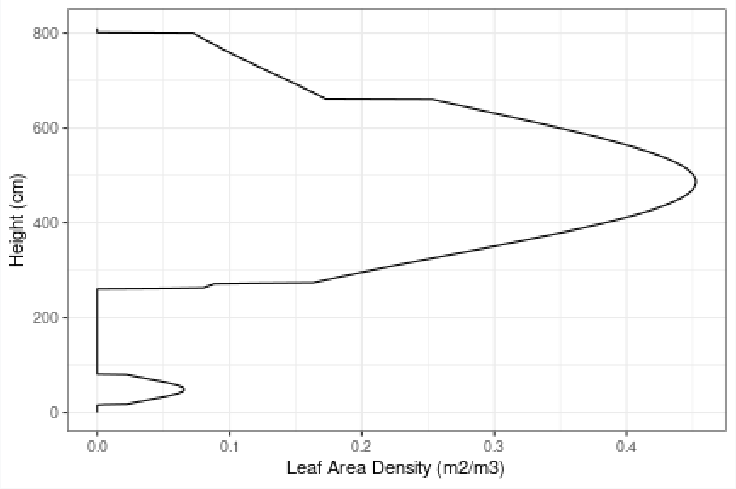
Users will not normally call `forest2aboveground()`, but is important to understand what is going on behind the scenes.

3. Vertical profiles

Leaf distribution

Vertical leaf area distribution (at the cohort-, species- or stand-level) can be examined using:

```
vprofile_leafAreaDensity(forest, SpParamsMED)
```

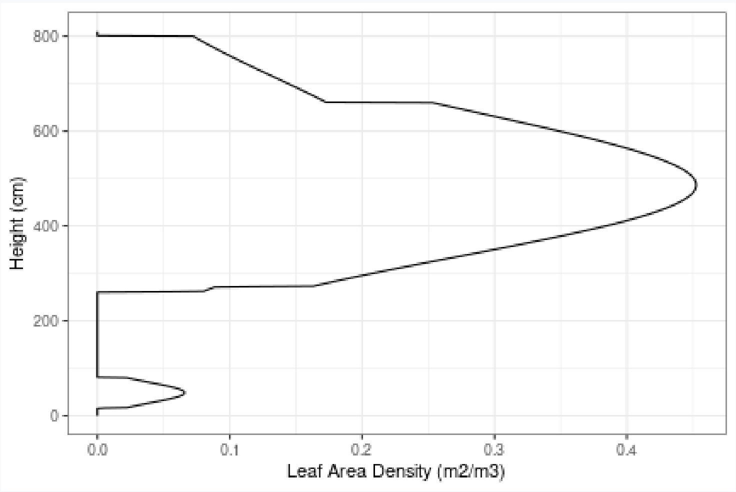


3. Vertical profiles

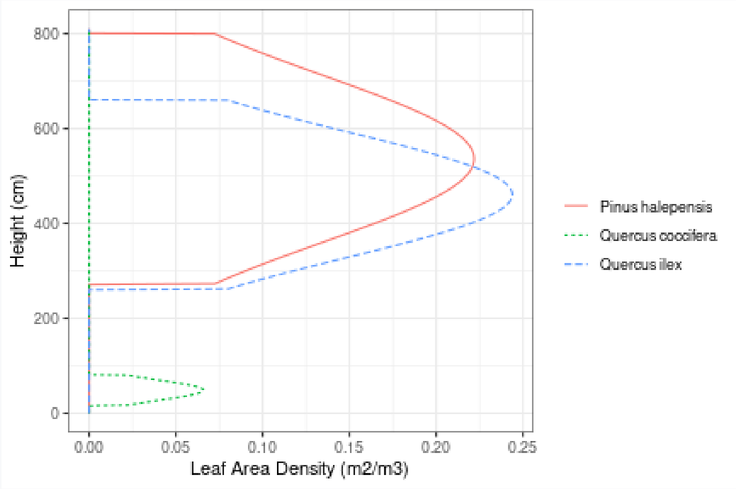
Leaf distribution

Vertical leaf area distribution (at the cohort-, species- or stand-level) can be examined using:

```
vprofile_leafAreaDensity(forest, SpParamsMED)
```




```
vprofile_leafAreaDensity(forest, SpParamsMED,
   byCohorts = TRUE, bySpecies = TRUE)
```

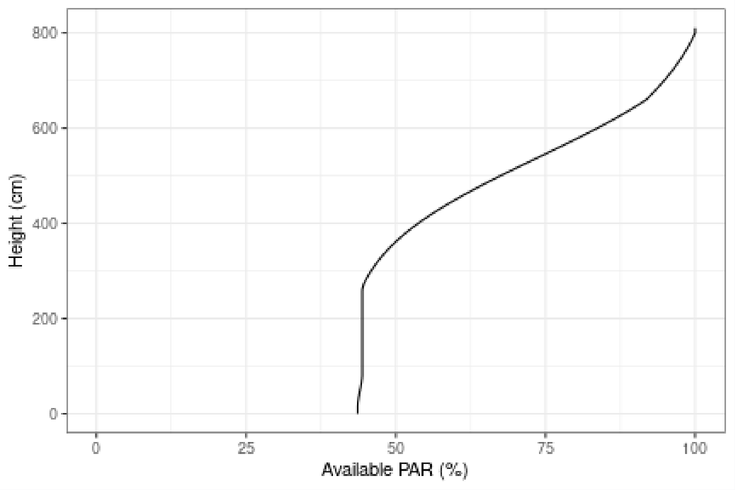


3. Vertical profiles

Radiation extinction

Radiation extinction (PAR or SWR) profile across the vertical axis can also be examined:

```
vprofile_PARExtinction(forest, SpParamsMED)
```

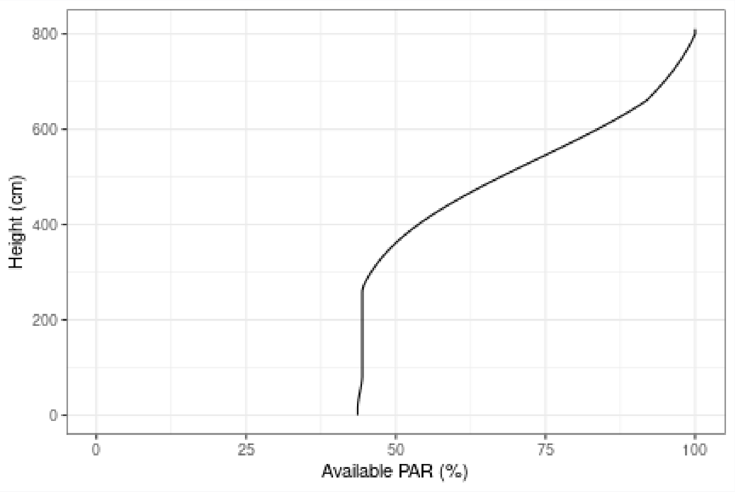


3. Vertical profiles

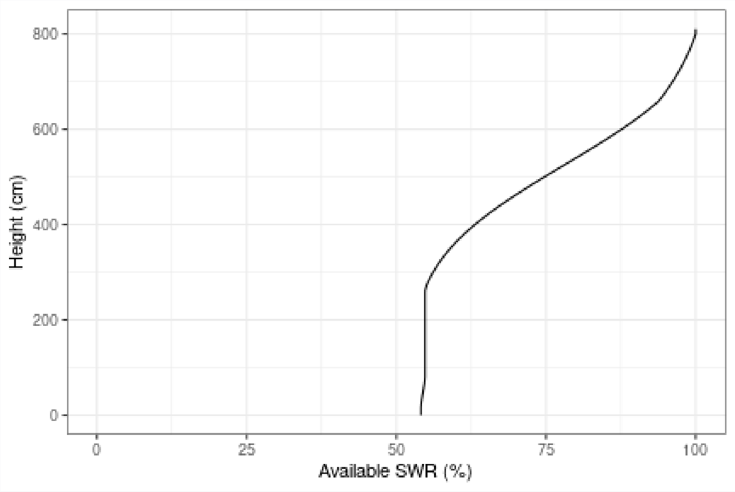
Radiation extinction

Radiation extinction (PAR or SWR) profile across the vertical axis can also be examined:

```
vprofile_PARExtinction(forest, SpParamsMED)
```




```
vprofile_SWRExtinction(forest, SpParamsMED)
```

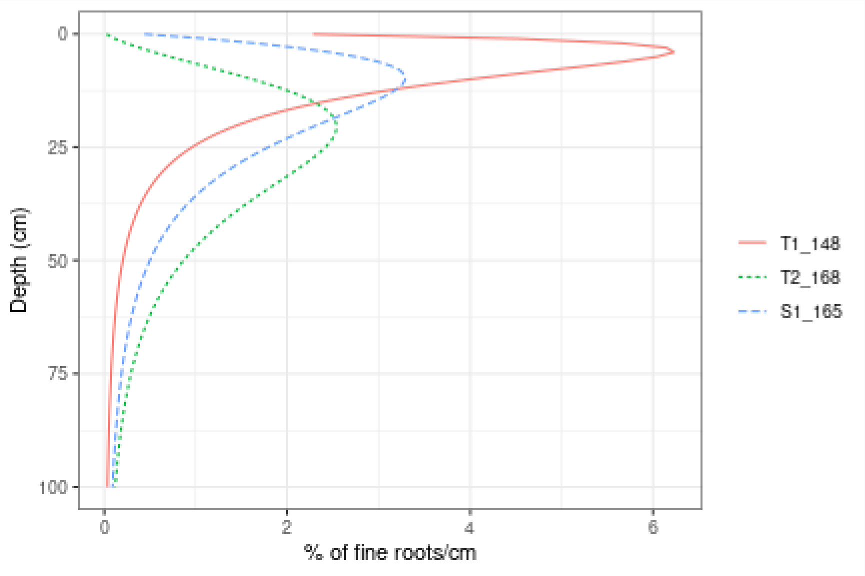


3. Vertical profiles

Belowground root distribution

Users can visually inspect the distribution of fine roots of `forest` objects by calling function `vprofile_rootDistribution()`:

```
vprofile_rootDistribution(forest, SpParamsMED)
```



3. Vertical profiles

Interactive forest inspection

Function `shinyplot()` is a more convenient way to display properties and profiles of `forest` objects:

```
shinyplot(forest, SpParamsMED)
```

4. Soil input

Soil physical description

Soil physical characteristics are specified using a **data.frame** with soil layers in rows and attributes in columns:

- `widths` - layer widths, in mm.
- `clay` - Percentage of clay (within volume of soil particles).
- `sand` - Percentage of sand (within volume of soil particles).
- `om` - Percentage of organic matter per dry weight (within volume of soil particles).
- `nitrogen` - Total nitrogen (g/kg). Not used at present.
- `bd` - Bulk density (g/cm3)
- `rfc` - Rock fragment content (in whole-soil volume).

4. Soil input

Soil physical description

Soil physical characteristics are specified using a **data.frame** with soil layers in rows and attributes in columns:

- `widths` - layer widths, in mm.
- `clay` - Percentage of clay (within volume of soil particles).
- `sand` - Percentage of sand (within volume of soil particles).
- `om` - Percentage of organic matter per dry weight (within volume of soil particles).
- `nitrogen` - Total nitrogen (g/kg). Not used at present.
- `bd` - Bulk density (g/cm3)
- `rfc` - Rock fragment content (in whole-soil volume).

They can be initialized to default values using function `defaultSoilParams()`:

```
spar <- defaultSoilParams(2)
print(spar)
```

```
##   widths clay sand om nitrogen  bd rfc
## 1    300   25   25 NA       NA 1.5  25
## 2    700   25   25 NA       NA 1.5  45
```

… and then you should modify default values according to available soil information.

4. Soil input

Drawing soil physical attributes from *SoilGrids*

SoilGrids is a global database of soil properties:

Hengl T, Mendes de Jesus J, Heuvelink GBM, Ruiperez Gonzalez M, Kilibarda M, Blagotic A, et al. (2017) SoilGrids250m: Global gridded soil information based on machine learning. PLoS ONE 12(2): e0169748. doi:10.1371/journal.pone.0169748.

4. Soil input

Drawing soil physical attributes from *SoilGrids*

SoilGrids is a global database of soil properties:

Hengl T, Mendes de Jesus J, Heuvelink GBM, Ruiperez Gonzalez M, Kilibarda M, Blagotic A, et al. (2017) SoilGrids250m: Global gridded soil information based on machine learning. PLoS ONE 12(2): e0169748. doi:10.1371/journal.pone.0169748.

Package **medfateland** allows retrieving Soilgrids data by connecting with the SoilGrids REST API

4. Soil input

Drawing soil physical attributes from *SoilGrids*

SoilGrids is a global database of soil properties:

Hengl T, Mendes de Jesus J, Heuvelink GBM, Ruiperez Gonzalez M, Kilibarda M, Blagotic A, et al. (2017) SoilGrids250m: Global gridded soil information based on machine learning. PLoS ONE 12(2): e0169748. doi:10.1371/journal.pone.0169748.

Package **medfateland** allows retrieving Soilgrids data by connecting with the SoilGrids REST API

To start with, we need a spatial object of class `sf` or `sfc` (from package **sf**) containing the geographic coordinates of our target forest stand:

```
cc <- c(1.32, 42.20)
coords_sf <- sf::st_sf(geometry = sf::st_sfc(sf::st_point(cc), crs=4326))
```

4. Soil input

Drawing soil physical attributes from *SoilGrids*

SoilGrids is a global database of soil properties:

Hengl T, Mendes de Jesus J, Heuvelink GBM, Ruiperez Gonzalez M, Kilibarda M, Blagotic A, et al. (2017) SoilGrids250m: Global gridded soil information based on machine learning. PLoS ONE 12(2): e0169748. doi:10.1371/journal.pone.0169748.

Package **medfateland** allows retrieving Soilgrids data by connecting with the SoilGrids REST API

To start with, we need a spatial object of class `sf` or `sfc` (from package **sf**) containing the geographic coordinates of our target forest stand:

```
cc <- c(1.32, 42.20)
coords_sf <- sf::st_sf(geometry = sf::st_sfc(sf::st_point(cc), crs=4326))
```

We then call `add_soilgrids()` along with a desired vertical width (in mm) of soil layers:

```
sf_soil <- medfateland::add_soilgrids(coords_sf, widths = c(300, 700, 1000))
```

4. Soil input

Initialized soil

The soil initialized for simulations is a data frame of class `soil` that is created from physical description using a function with the same name:

```
examplesoil <- soil(spar)
class(examplesoil)
```

```
## [1] "soil"       "data.frame"
```

4. Soil input

Initialized soil

The soil initialized for simulations is a data frame of class `soil` that is created from physical description using a function with the same name:

```
examplesoil <- soil(spar)
class(examplesoil)
```

```
## [1] "soil"       "data.frame"
```

The initialised soil data frame contains additional columns with soil hydraulic parameters and state variables for moisture (`W`) and temperature (`Temp`):

```
examplesoil
```

```
##   widths sand clay      usda om nitrogen  bd rfc  macro     Ksat VG_alpha     VG_n VG_theta_res
## 1    300   25   25 Silt loam NA       NA 1.5  25 0.0485 5401.471 89.16112 1.303861        0.041
## 2    700   25   25 Silt loam NA       NA 1.5  45 0.0485 5401.471 89.16112 1.303861        0.041
##   VG_theta_sat W Temp
## 1     0.423715 1   NA
## 2     0.423715 1   NA
```

4. Soil input

Initialized soil

The soil initialized for simulations is a data frame of class `soil` that is created from physical description using a function with the same name:

```
examplesoil <- soil(spar)
class(examplesoil)
```

```
## [1] "soil"       "data.frame"
```

The initialised soil data frame contains additional columns with soil hydraulic parameters and state variables for moisture (`W`) and temperature (`Temp`):

```
examplesoil
```

```
##   widths sand clay      usda om nitrogen  bd rfc  macro     Ksat VG_alpha     VG_n VG_theta_res
## 1    300   25   25 Silt loam NA       NA 1.5  25 0.0485 5401.471 89.16112 1.303861        0.041
## 2    700   25   25 Silt loam NA       NA 1.5  45 0.0485 5401.471 89.16112 1.303861        0.041
##   VG_theta_sat W Temp
## 1     0.423715 1   NA
## 2     0.423715 1   NA
```

We can skip calling function `soil()` in our scripts to run simulations, but again is good to know what is behind the scenes.

4. Soil input

Water retention curves

The **water retention curve** is used to represent the relationship between soil water content (θ ; %) and soil water potential (Ψ ; MPa).

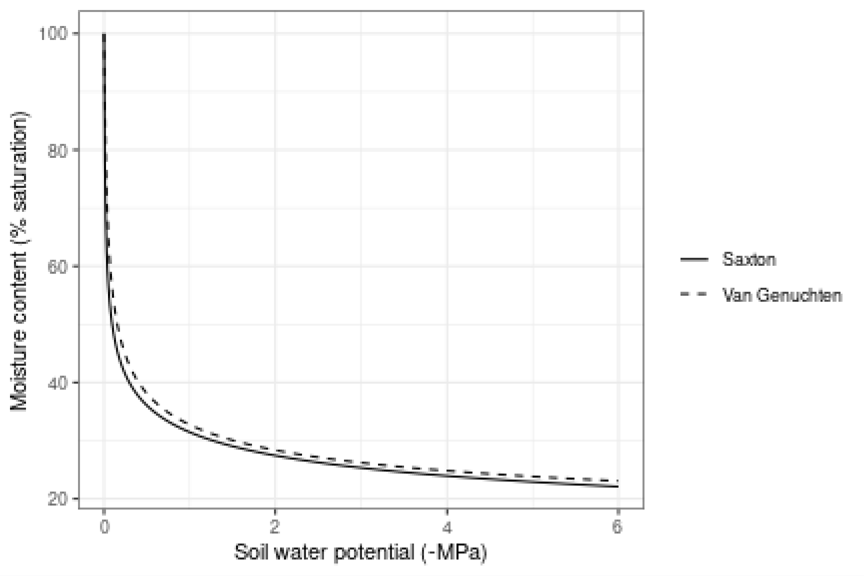
4. Soil input

Water retention curves

The **water retention curve** is used to represent the relationship between soil water content (θ ; %) and soil water potential (Ψ ; MPa).

The following code calls function `soil_retentionCurvePlot()` to illustrate the difference between two (Saxton and Van Genuchten) water retention models in this soil:

```
soil_retentionCurvePlot(examplesoil, model="both")
```



5. Simulation control

The behaviour of simulation models can be controlled using a set of **global parameters**.

5. Simulation control

The behaviour of simulation models can be controlled using a set of **global parameters**.

The default parameterization is obtained using function `defaultControl()`:

```
control <- defaultControl()
```

5. Simulation control

The behaviour of simulation models can be controlled using a set of **global parameters**.

The default parameterization is obtained using function `defaultControl()`:

```
control <- defaultControl()
```

A large number of control parameters exist:

```
names(control)
```

Control parameters should be left to their **default values** until their effect on simulations is fully understood!

6. Simulation input object

Functions spwb() and growth()

Simulation functions `spwb()` and `growth()` require combining forest, soil, species-parameter and simulation control inputs into a *single input object*.

6. Simulation input object

Functions spwb() and growth()

Simulation functions `spwb()` and `growth()` require combining forest, soil, species-parameter and simulation control inputs into a *single input object*.

The combination can be done via functions `spwbInput()` and `growthInput()`:

```
x <- spwbInput(forest, examplesoil, SpParamsMED, control)
```

6. Simulation input object

Functions spwb() and growth()

Simulation functions `spwb()` and `growth()` require combining forest, soil, species-parameter and simulation control inputs into a *single input object*.

The combination can be done via functions `spwbInput()` and `growthInput()`:

```
x <- spwbInput(forest, examplesoil, SpParamsMED, control)
```

Function fordyn()

Function `fordyn()` is different from the other two models: the user enters forest, soil, species parameters and simulation control inputs *directly* into the simulation function.

6. Simulation input object

Functions spwb() and growth()

Simulation functions `spwb()` and `growth()` require combining forest, soil, species-parameter and simulation control inputs into a *single input object*.

The combination can be done via functions `spwbInput()` and `growthInput()`:

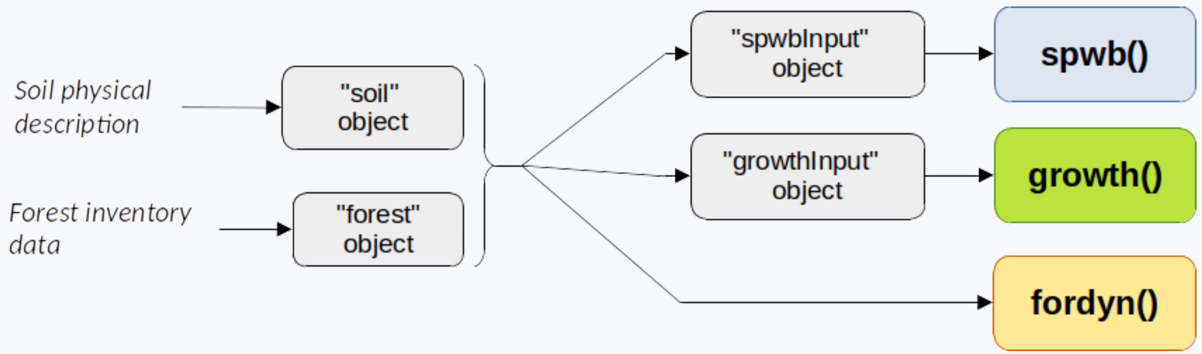
```
x <- spwbInput(forest, examplesoil, SpParamsMED, control)
```

Function fordyn()

Function `fordyn()` is different from the other two models: the user enters forest, soil, species parameters and simulation control inputs *directly* into the simulation function.

Summary

The following workflow summarises the initialisation for the three functions:



7. Weather forcing

All simulations in the package require **daily weather** forcing inputs in form of a `data.frame` with dates as `row.names` or in a column called `dates`.

7. Weather forcing

All simulations in the package require **daily weather** forcing inputs in form of a `data.frame` with dates as `row.names` or in a column called `dates`.

Variables	Units
Maximum/minimum temperature	^{o}C
Precipitation	$l \cdot m^{-2} \cdot day^{-1}$
Maximum/minimum relative humidity	%
Radiation	$MJ \cdot m^{-2} \cdot day^{-1}$
Wind speed	$m \cdot s^{-1}$

7. Weather forcing

All simulations in the package require **daily weather** forcing inputs in form of a `data.frame` with dates as `row.names` or in a column called `dates`.

Variables	Units
Maximum/minimum temperature	$°C$
Precipitation	$l \cdot m^{-2} \cdot day^{-1}$
Maximum/minimum relative humidity	%
Radiation	$MJ \cdot m^{-2} \cdot day^{-1}$
Wind speed	$m \cdot s^{-1}$

An example of daily weather data frame is included in package **medfate**:

```
data(examplemeteo)
head(examplemeteo, 2)
```

```
##        dates MinTemperature MaxTemperature Precipitation MinRelativeHumidity MaxRelativeHumidity
## 1 2001-01-01     -0.5934215       6.287950      4.869109            65.15411            100.0000
## 2 2001-01-02     -2.3662458       4.569737      2.498292            57.43761             94.7178
##   Radiation WindSpeed
## 1  12.89251  2.000000
## 2  13.03079  7.662544
```

7. Weather forcing

All simulations in the package require **daily weather** forcing inputs in form of a `data.frame` with dates as `row.names` or in a column called `dates`.

Variables	Units
Maximum/minimum temperature	$^{\circ}C$
Precipitation	$l \cdot m^{-2} \cdot day^{-1}$
Maximum/minimum relative humidity	%
Radiation	$MJ \cdot m^{-2} \cdot day^{-1}$
Wind speed	$m \cdot s^{-1}$

An example of daily weather data frame is included in package **medfate**:

```
data(examplemeteo)
head(examplemeteo, 2)
```

```
##        dates MinTemperature MaxTemperature Precipitation MinRelativeHumidity MaxRelativeHumidity
## 1 2001-01-01     -0.5934215       6.287950      4.869109            65.15411            100.0000
## 2 2001-01-02     -2.3662458       4.569737      2.498292            57.43761             94.7178
##   Radiation WindSpeed
## 1  12.89251  2.000000
## 2  13.03079  7.662544
```

Simulation functions have been designed to accept data frames generated using package meteoland.

M.C. Escher - Dragon, 1952