MEDFIRE

User's guide v.1

22 March 2020

The MEDFIRE model

Model's aim

MEDFIRE is a landscape dynamic model that integrates the main factors of change in Mediterranean forest landscapes. It allows exploring the spatial and temporal interactions between land-cover changes, fire regime, forest managment, fire management and vegetation dynamics. The main model's aim is to generate spatially explicit scenarios of urban-agro-forest landscape change corresponding to pre-designed scenario storylines.

Each model scenario dictates which ecological and anthropogenic processes are active. Though, the chronological order of the processes included in the model is fixed as follows:

1. Land-cover changes
2. Forest management
3. Fires and fire suppression
4. Prescribed burns
5. Drought
6. Post-fire regeneration
7. Cohort establishment after drought-induced mortality
8. Afforestation (i.e. colonization of scrublands by tree species)
9. Forest growth and aging

If applies, climatic data is updated at the beginning of the time step, before any other process happens.

Working directory structure

MEDFIRE is a spatially explicit model implemented in R and structured in the following folders:
- **inputfiles** contains the text files with the current version of model's parameters.
- **inputlyrs** contains the initial state in raster and Rdata format of the model.
- **mld** contains the R-scripts files of the model, sub-modules and reporting functions.
- **output** contains one sub-folder for each scenario, and for each scenario *scn.def.r* and *scn.custom.def.r* describe the initialization of model's parameters.
- **rscripts** contains auxiliar R-scripts to run the model, build model's inputs and analyze model's outputs.

Functions of the model

The current version of the model is implemented thought the following functions (in alphabetic order):

- **afforestation(...)** simulates the colonization of shrublands by tree forest species according to the age of the shurb, the slope, the percentage of mature forest in a neihbourhood (only if they are within their potential climatic niche).

- **auxiliars(...)** contains several simple functions used to count cells fullfiling a certain criteria. These functions are used by main functions of the model.

- **cohort.establish(...)** simulates forest regeneration after drought-induced mortality. It depends on a secondary species matrix (accounting for the presence of secondary species as function of dominant species in Mediterranean forest ecosystems) and the percentage of forest species in a neighborhood.

- **define.scenario(...)** initializes the scenario parameters and the global variables of the model.

- **drought(...)** simulates drought-induced mortality of forest species falling out their potential climatic niche.

- **fire.regime(...)** simulates fire events under three synoptic weather conditions. Fires spread as wind-driven, convective or topographic fires.

- **forest.management(...)** simulates sylvicultural practices (e.g. thining, clear-cutting) and implements a set of rules based on the forest species, biomass, site quality index and forest age.

- **growth(...)** simulates vegetation productivity (increment of biomass) and ageing.

- **land.cover.change(...)** simulates land-cover transitions (e.g. urbanization, rural abandonment, agriculture conversion) following a demand allocation approach.

- **land.dyn.mdl(...)** is the **MEDFIRE** model. The function loads the spatial state variables, the initialization of model's parameters, creates the scenario output sub-folder and schedules the processes, e.g. land-cover changes, forest managment, wildfires, drought, post-disturbance regeneration and vegetation dynamics.

- **post.fire(...)** simulates forest regeneration after fire as function of the secondary species matrix and the percentage of forest species in a neighborhood.

- **prob.igni(...)** calculates the probability of fire ignition depending on elevation, slope, precipitation, density of roads, and land interfaces.

- **read.climatic.vars(...)** reads climatic raster files at 1 km resolution according to a climatic scenario (`rcp45` or `rcp85`) and a climatic model (`KNMI-RACMO22E_ICHEC-EC-EARTH`, `KNMI-RACMO22E_MOHC-HadGEM2-ES`, `SMHI-RCA4_CNRM-CERFACS-CNRM-CM5`, `SMHI-RCA4_MPI-M-MPI-ESM-LR`, or `SMHI-RCA4_MOHC-HadGEM2-ES`) and builda a data frame with annual minimum temperature and annual total precipitation at 1 ha for each decade, from 2010 to 2100.

- **read.sdm(...)** reads species distribution models, that is potential climatic niche according to a climatic scenario and climatic model for each decade, from 2010 to 2100.

- **read.state.vars(...)** initialize state dynamic variables: land-cover forest map, vegetation biomass, forest age and time since last disturbance.

- **read.static.vars(...)** initiazlie spatially explicit static model variables: cell coordinates, mask, elevation, aspect, slope, density of roads per ha, 1 km UTM grid, mask for topographic-driven fires, mask for wind-driven fires, probability of North wind, probability of North-west wind, and probability of West wind.

- **update.clim(...)** updates climatic data according to the selected climatic scenario.

- **update.interface(...)** updates land interface layer.

Running MEDFIRE

How to run a test scenario

1. Clone or download the Github repository MEDFIRE in a local folder, e.g. C:/WORK/MEDFIRE.
2. In R, clean the working space.

```
rm(list = ls())
```

3. Set the working directory to the previous local folder.

```
setwd("C:/WORK/MEDFIRE")
```

4. Load the model.

```
source("mdl/landscape.dyn5.r")
```

5. Run the model.

```
land.dyn.mdl(scn.name)
```

How to create and run a new scenario

1. Do steps 2. to 4. and load the function to set the default scenario's parameters.

```
rm(list = ls())
setwd("C:/WORK/MEDFIRE")
source("mdl/land.dyn.mdl.r")
source("mdl/define.scenario.r")
```

2. Give a name to the new scenario, e.g. *"MyTest"*, and call the **define.scenario** fucntion to load model's parameters with the default initialization.

```
scn.name <- "MyTest"
define.scenario(scn.name)
```

3. Customize the initialization of some parameters

```
file.clim.severity <- "ClimaticSeverity_test"
file.sprd.weight <- "SprdRateWeights_C"
nrun <- 3
```

4. Write the name of all the above updated parameters in the following call of the **dump** function. It copies these R objects into the file **outputs/MyTst/scn.custom.def.r** (do not change the name of this file).

```
dump(c("file.clim.severity", "file.sprd.weight", "nrun"),
     paste0("outputs/", scn.name, "/scn.custom.def.r"))
```

5. Run ths scenario calling the **land.dyn.mdl** function. A sub-folder named *"MyTest"* will be created in the folder *outputs*. Model's output files, **scn.def.r** and **scn.custom.def.r** are saved in it.

```
land.dyn.mdl(scn.name)
```

How to create and run a series of scenarios

```
# Clean the workspace
rm(list = ls())

# Change the working directoyr
setwd("C:/WORK/MEDFIRE")

# Load functions
source("mdl/land.dyn.mdl.r")
source("mdl/define.scenario.r")

# Recursive run MEDFIRE with customized parameters
for(i in LETTERS[1:5]){
  scn.name <- paste0("TestFire", i)
  define.scenario(scn.name)
  file.clim.severity <- "ClimaticSeverity_test"
  file.sprd.weight <- paste0("SprdRateWeights_", i)
  nrun <- 3
  dump(c("file.clim.severity", "file.sprd.weight", "nrun"),
       paste0("outputs/", scn.name, "/scn.custom.def.r"))
  land.dyn.mdl(scn.name)
}

# Recursive run MEDFIRE with customized parameters
list.scn <- paste0("TestFire_", c("01", "02", "03"))
rpb <- c(0.5,1,1.5)
for(j in 1:3){
  scn.name <- list.scn[j]
  define.scenario(scn.name)
  file.clim.severity <- "ClimaticSeverity_test"
  rpb.sr <- rpb[j]
  dump(c("file.clim.severity", "rpb.sr"),
       paste0("outputs/", scn.name, "/scn.custom.def.r"))
  land.dyn.mdl(scn.name)
}
```