

CARAIB USER'S GUIDE

version 2.0

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Reference: Minet, J., Jacquemin, I. & François, L. *CARAIB user's guide - version 2.0*, Université de Liège, Liège, Belgium, 2021.

1 Introduction

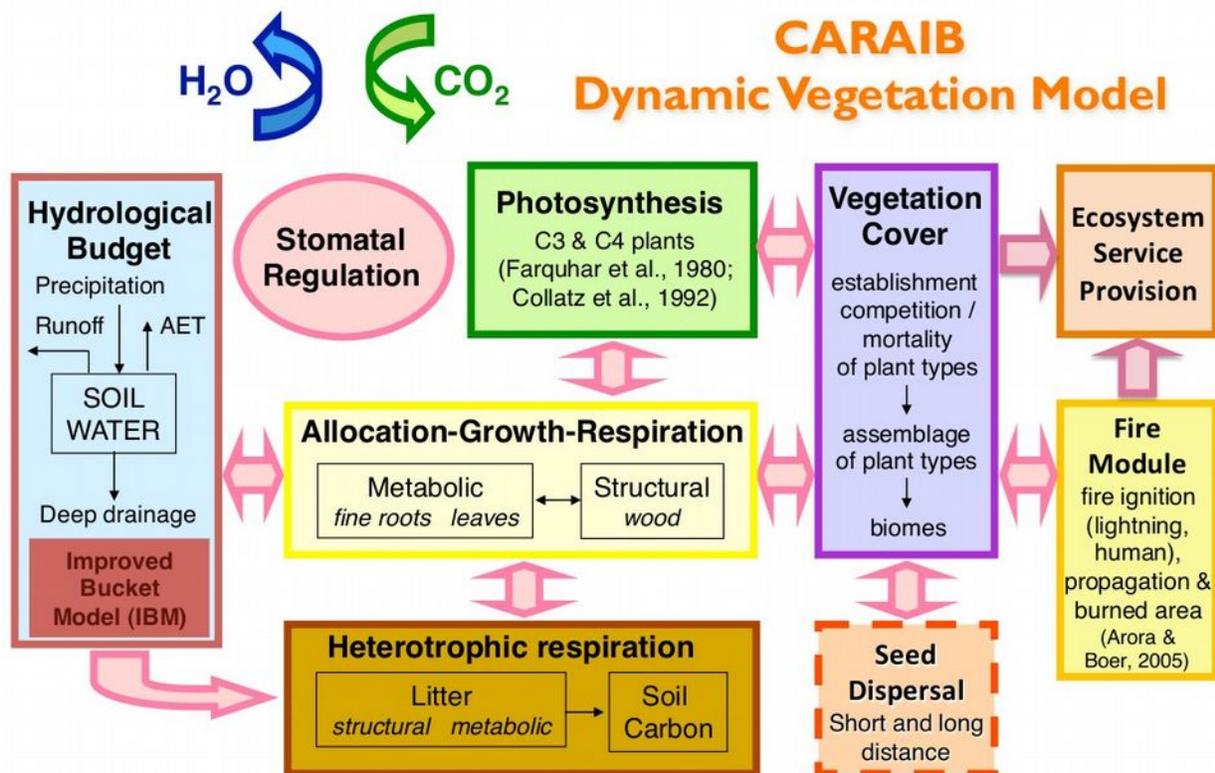
CARAIB is a dynamic vegetation model (DVM) written in FORTRAN and developed at University of Liège. It can simulate vegetation growth from the local to the global scales, for various crops and natural vegetation, and has been applied to past and future ecosystems.

This is the version 2.0 of CARAIB user's guide. This guide is written to help you make your first steps with the CARAIB model. It focuses on the description of the inputs and outputs files. It contains a brief description of the model, as well as an example of configuration file and a list of the routines used in the model.

2 Theoretical concepts

2.1 Main structure

CARAIB is a mechanistic model describing vegetation response to climate forcing and soil parameters. It is built to cover various time and spatial scales, from local vegetation and diurnal cycle to global cover over centuries. It is composed of several modules that were progressively added to the model. The figure below presents the current modules of the model with their inter-relationships.



2.2 Carbon and water

The present version of CARAIB includes two main modules:

1. a hydrological module (Improved Bucket Model (IBM), *Hubert et al., 1998*) that calculates available soil water.
2. a carbon module, calculating carbon fluxes and pools in the biosphere (*Otto et al., 2002*).

These two modules have been created separately. This fact may induce discrepancies. It is why an iteration may be performed running the hydrological module and the carbon module for one complete year until their outputs became coherent (steady state with equilibrium between water, carbon cycle and vegetation distribution).

2.3 Evolution and competition

Simulations performed yet represent principally vegetation in equilibrium with climate but CARAIB was built to simulate also transient situations. So, even for steady state runs, plants began as seeds and grow up until maturity. Competition for light and water are included. Different land use fractions can be represented: natural vegetation (of which forests), croplands, pastures, urban areas, rock/bare soil areas, and water bodies. Vegetation can grow only on the first three types of land use. Over the first type (natural vegetation), two vegetation storeys are simulated: the first including trees and the second corresponding to shrubs and herbs. Also, on this type of land use, vegetation can vary dynamically from year to year, which means that at the end of each year, seeds fill gaps created in the canopy by tree mortality. The amount of seeds of each plant type (PFT, BAG or species, see below) is in proportion of its primary productivity, so that the most productive plant types are selected as time progresses in the model. Over the second and third land use types, only one vegetation storey is simulated. Management can be defined for changing vegetation from year to year on these two land use types.

Plant types can be ‘plant functional types’ (PFTs), ‘bioclimatic affinity groups (BAGs; Laurent et al., 2008)’ or species. Nitrogen or other nutrient cycles are not simulated. Nitrogen concentrations in the leaves and in the structural plant parts (wood) are important to calculate photosynthesis and autotrophic respiration rates. They are taken into account as C/N input parameters characterizing each simulated plant type. A dispersion module is now implemented in CARAIB, although it is not fully operational.

2.4 Plant types, characteristics and presence

In the version/example available (caraib_Iv_2020), the model is prepared and calibrated for simulations over Belgium and for vegetation species with:

- 2 herbaceous BAG (n° 5 and 8, in annex 1);
- 14 tree species,
- 12 crops species (2 different varieties of the 6 Belgian main crops in annex 1).

2.5 References

An alphabetic list of references related to CARAIB can be found in section 6 of this document. The

most comprehensive and first reference is the PhD thesis of Pierre Warnant, ULiège, 1999, written in French. Alongside with this document is the paper describing the model and its first application to the global scale (Warnant et al., 1994). The soil respiration mechanisms were introduced by Nemry et al. (1996). Hubert et al. (1998) latter improved the description of the hydrological processes using a new hydrological model called the Improved Bucket Model (IBM). Then, Otto et al. (2002) improved the model by introducing two vegetation storeys (respectively trees, and herbs & shrubs). Lastly, a fire module simulating the occurrence and the propagation of fires was introduced by Dury et al. (2011).

3 Code, inputs and outputs

3.1 Directory tree

All the code is gathered in a directory with files and subdirectories, which are the following:

- *caraib.f*: Fortran code of the CARAIB model;
- *caraib.out*: compiled version of *caraib.f*;
- *caraib.dat*: configuration file, with list of inputs and input and output files;
- /clim: directory containing climatic input files;
- /common: directory containing all commons used by CARAIB;
- /gene: directory containing the weather stochastic generator;
- /plantparam: directory containing plant parameters files for the BAGs;
- /results: directory containing all output files.

These files are comprehensively described in the sections hereafter.

3.2 Description of input files

3.2.1 The configuration file *caraib.dat*

CARAIB works with a configuration file in which all input parameters and paths to input files are set. It is the most important file for CARAIB users. CARAIB reads in this file the specific parameters for each run. If you change the name of this file, pay attention to change it in the main code (around line 374 in *caraib.f*, or search after “.dat” in *caraib.f*).

This file looks like that:

```
isteady,ny0max : 1 200
1 to call generator: 1
ifrac (1=calc frac): 0
ifrac_rd,ilai_rd : 1 0
idayf,ifull,jc1only: 1 0 0
ilu,imanag : 1 0
ilusp_rd,isowd_rd : 1 0
```

```

ncropvar,icvar_rd : 0 0
ifire,iclim,ilgtree: 1 0 0
jdownCO2,jrd_accl : 2 2
imig,isp,imig_rd : 0 6 0 ; isp= 6 or 8 (species which is dispersed)
nyrmax,ileap : 1 1
itmt(too much time): 0
nyrprt,nstprt : 1 1
iread,iczon : 0 1
idaily_in,idaily_ou: 1 1
idtem,isol : 0 1
pixel number : 31243
igtyp,declg,declat : 0 0.01400 0.00900
prec_co : 3.e-4
ipar,exc,obl,xlsper: 0 0.016724 23.447 282.16
nher,nbush,ntree,nc: 5 7 13 9 fil
ext inp weather :.dat
fil ext results :.res
soil texture :./clim/eco.dat
pixel corners :./ pixelcorners.dat
climate data :./ climate_data.dat
air temp (climatol):0 ./clim/tem.dat
units,netcdf : 0.0 1.0 &tem
precip (climatol) :0 ./clim/prc.dat
units,netcdf : 0.0 1.0 &prc
air temperature :1 ./clim/tem
units,netcdf : 0.0 1.0 &tas
Max air temp. : 1 ./clim/dte
units,netcdf : 0.0 1.0 &tasmax
Min air temp. : 1 ./clim/dte
units,netcdf : 0.0 1.0 &tasmin
precipitation/solar fl:1 ./clim/prc
units,netcdf : 0.0 1.0 0 &pr
sunsh hour/solar fl:1 ./clim/shr
units,netcdf : 0.0 1.0 0 &rsds
air relat. humidity:1./clim/rhu
units,netcdf : 0.0 1.0 0 &rhu
wind speed :1 ./clim/wnd
units,netcdf : 0.0 1.0 0 &wind
management :0 ./manag.dat
lightning data :0 ./clim/lightning.dat
land use cover :0 ./frac/land_use.dat
LU species rel abun:0 ./frac/crop_frac.dat
crop sowing dates :0 ./sowing_dates.dat
crop cultivars :0 ./cultivars.dat
migration rate :0 ./dispersion/Heterogeneity.dat
species refugia :0 ./distribution/Fagus_pa_10k.txt
path for generator :./gene/
PFT alb zzra t1 t2 :./plantparam/bagibm.dat
PFT tolerances :./plantparam/bagtol.dat
PFT parameters :./plantparam/bagpar.dat
PFT age class para :./plantparam/claspar.dat
PFT C:N of veget :./plantparam/curn.dat
PFT 1/gkfall :./plantparam/gkfall.dat
PFT gama1, gama2 :./plantparam/gama.dat
PFT carb_init :./plantparam/carbinit.dat
Crops seasonality :./plantparam/bagseas.dat
print clim tem :0 /raid3/umccb/
print clim dte :0 /raid3/umccb/
print clim prc :0 /raid3/umccb/
print clim shr/fsol:0 /raid3/umccb/
print clim rhu :0 /raid3/umccb/

```

print clim win :0 /raid3/umccb/
initial veget frac :./results/frac.res
initial Min Max LAI:./results/xlai_min_max.res
read initial cond :./results/biomass.res
read lai limit :./results/ylailim.res
read ini cond crops:./results/cropino.dat
read prev year CO2 :./results/co2prev.dat
read prev year temp:/ results /temprev.dat
read prev year LU :./crop_frac/land use.dat
initial propagation:./dispersion/prop09999.res
initial side pres :./dispersion/side09999.res
initial pixel pres :./dispersion/pres09999.res
in/out climate zone:./results/zone.res
in/out stoch.fields:./results/stochas.gen
ibm results (full) :./results/water.full
1st day of year res:./results/biomass
monthly lai limit :./results/ylailim
1st part crops :./results/cropino
wri prev year CO2 :./results/co2prev
wri prev year temp :./results/temprev
results (test file):./results/water.tes
test (problems) :./results/carbon.problem
current pixel-date :./results/water.time
annual hydr results:1 ./results/water_yr
annual frc per pft :1 ./results/frc
mon/day mean sw :1 ./results/sw
mon/day mean sw(mm):1 ./results/swmm
mon/day mean rtr :0 ./results/rtr
monthly mean pet :1 ./results/pet
monthly mean aet :1 ./results/aet
monthly mean runoff:1 ./results/run
monthly mean fsn :1 ./results/fsn
mon/day mean snd :1 ./results/snd
mon/day mean srun :1 ./results/srun
monthly mean drain :1 ./results/drn
monthly mean vs ev :1 ./results/sve
mon/day mean int ev:1 ./results/eint
mon/day mean transp:1 ./results/etr
mon/day mean soilev:1 ./results/eso
monthly mean rbl :1 ./results/rbl
mon/day mean albsv :1 ./results/albsv
mon/day mean albs :1 ./results/albs
mon/day mean albv :1 ./results/albv
monthly mean albedo:1 ./results/alb
monthly mean Rn :1 ./results/rn
monthly mean gr flx:1 ./results/grf
monthly mean Ts :1 ./results/ts
monthly mean fgs :1 ./results/fgs
monthly mean LAI(w):1 ./results/lai
month mean IRdown :1 ./results/fird
monthly mean H :1 ./results/xh
monthly mean LE :1 ./results/xle
monthly mean Fsol :1 ./results/fsol
monthly mean sn fal:1 ./results/sf
monthly mean sn ev :1 ./results/sne
monthly mean sn mel:1 ./results/sml
monthly mean emisf :1 ./results/emisf
mon/day mean emins :1 ./results/emisfns
mon/day mean z0tot :1 ./results/z0
monthly mean biom :1 ./results/biommmth
monthly mean gpp :1 ./results/gppmmth
mon/day mean Ra :1 ./results/rammmth
monthly mean npp :1 ./results/nppmmth
monthly mean nep :1 ./results/nepmmth
mon/day mean Rh :1 ./results/rhmmth
monthly mean lai(C):1 ./results/laimmmth
mon/day fire emi :0 ./results/emifiremmth

```

mon/day burned lit :0 ./results/emiblitmth
mon/day mean nbp :1 ./results/nbpmth
mon/day mean harv :1 ./results/harvmth
mon/day mean fapar :1 ./results/faparmth
veget cover frac :1 ./results/frac
annual npp plant :1 ./results/npp
Rmin :1 ./results/Rmin
Min Max LAI :1 ./results/xlai_min_max
GPP :1 ./results/gpp
PFT auto resp Ra :1 ./results/ra
PFT fire emission :0 ./results/emifire
Cveg :1 ./results/Cveg
Csoil :1 ./results/Csoil
C13 fractionation :0 ./results/frcC13
Mean LAI :1 ./results/laimoy
Tmin :1 ./results/Tdmin
Tc :1 ./results/Tmmin
GDD :1 ./results/gdd
probability of fire:0 ./results/pfire
burned pix fraction:0 ./results/fburn
burned area :0 ./results/aburn
harvested biomass :0 ./results/harvest
yield :1 ./results/yield
aboveground biomass:1 ./results/agbiom
aboveground biomass:1 ./results/bgbiom
maturity date :1 ./results/maturity
lucdfr (LU frac ch):1 ./results/lucdfr
lucflx (emi & lit) :0 ./results/lucflx
fire mort coef :0 ./results/yfburn
temp mort coef :0 ./results/ftomin
water mort coef :0 ./results/ftotw
total mort coef :1 ./results/ftot
gdd5 coef :1 ./results/Fgdd5
Tmmin coef :0 ./results/FTmmin
watmin coef :0 ./results/Fwatmin
propagation :0 ./results/prop
pixel side pres :0 ./results/side
pixel pres :0 ./results/pres
year pco2 nys ipr clim iprt filext (between col. 31 and 63) filexti (between col. 65 and 98) idayct
1991 355.02 0 - 0 1 1991 1991 47847
!
```

a) Inputs parameters

The first lines of the configuration file contain general parameters that mainly serve to define the type of the simulation.

parameter name	Description
isteady	1 for transient run (= will simulate ny0max times the same year before the first year of simulation as a warm-up of the model); 0 for steady state run ¹
ny0max	Number of (year) iterations between water and carbon modules (if isteady = 1). This time delay expressed in years is used to allow the model to reach the equilibrium (warm-up of the model).
1 to call generator	Must be set to 1 to call weather generator (not needed with daily climatic inputs)
ifrac	1 if you want to calculate fraction of the pixel covered by each BAG, 0 for fixed fractions (ifrac_rd must be set to 1 with ifrac = 0)
ifrac_rd	1 if you read the fraction of the pixel covered by each BAG to initialise the run.
ilai_rd	1 if you want to read min and max LAI to initialise hydrological module.
idayt	1 to include diurnal cycle in the hydrological cycle, 2 otherwise.
ifull	1 to write daily results of IBM (will generate huge amounts of outputs, so it is recommended to avoid setting ifull to 1, except for test simulations performed on one single pixel), 0 otherwise
jclonly	1 allows printing climatic files without running the model, 0 performs all calculations.
Ilu	0 to run the model without land use (only natural vegetation), 1 to allow the use of land use.
imanag	0 to run the model without management (for the cutting of pastures), 1 to allow the use of management
ilusp_rd	0 to use equal fraction (land use fraction divided by then number of crop or pasture), 1 to use factions given by the user (only if ilu equal 1)
isowd_rd	0 to use the sowing date given in the crop parameter (1 date per variety), 1 to read a file given a sowing date for each pixel
cropvar	/ (defined for GGCM simulations)
icvar_rd	/ (defined for GGCM simulations)
ifire	1 to call the fire module
iclim	1 for reading the climatic zone in a unique file, 0 to determine it with the two climatologic files?
ilgtree	Mortality impact on Fnat ?
jdownco2	0 for no downregulation at high CO2, 1 for a downregulation of Vcmax, Jmax and Rd, 2 for downregulation of Vcmax, Jmax but not Rd
jrd_accl	0 no acclimation of leaf respiration to temperature, 1 long-term (several years) acclimation for all plant part and 2 for mid-term (several months) acclimation for leaves and long-term (several years) acclimation for structural parts
imig	1 for using the migration module, 0 otherwise
Isp	/ module migration
imig_rd	/ module migration
nyrmax	Total number of years (1 for steady state run or 1 year run, more otherwise)

¹ We strongly recommend to make a steady state run with a timeserie composed of :

- A repetition of a timeserie of reference to obtain by another way equilibrium (for example : 7 times the period 1960 to 1999 but noted at the end of caraib.dat as a run between 1720 to 1999)
- Your timeserie over which you want run CARAIB (for example : 2000 to 2100).

ileap	0 to don't take leap year into account, 1 for leap year taken into account depending on the year number defined in "myear" variable (subroutine open_file).
itmt	0 for fewer calls to the subroutine gpp_call (usefull for longer simulation).?
nyrprt	Number of years for which IBM results are printed. Usually 1.
nstprt	Timestep of printing for IBM (if ifull = 1)
iread	0 to calculate initial value of soil water content and carbon content, 1 to read it in biomass.res and in ylailim.res for all pfts, 2 to read it for natural pfts only. It required the copy of files from a previous simulation in directory "results".
iczon	1 to calculate climate type of each pixel, otherwise read climate type in zone.res
idaily_in	1 to read daily weather data in the climatic files, 0 otherwise. If set to 1, daily weather data must be available in the climatic input directory. If set to 0, yearly weather data are used in combination with the weather generator to generate daily values.
idaily_ou	1 to write daily output in the results files, 0 otherwise.
idtem	0 to read de temperature difference (=dte) and 1 calculate the temperature difference (with the reading of Tmax and Tmin files)
Isol	0 to use relative sunshine hours, 1 to use solar fluxes (only with daily timestep : idaily_in = 1)
pixel number	Number of pixel.
igtyp	0 for regular pixels (square) or 1 for irregular pixels (ex. Plots of lands)
declg	Shift in longitude between pixel corners
declat	Shift in latitude between pixel corners
prec_co	Resolution precision
ipar	1 to calculate orbital parameters of the three parameters here below, 1 to call the detailed module (for long term simulation?)
Exc	Eccentricity of Earth's orbit [degree]
Obl	Earth's obliquity [degree]
xlsper	Longitude of perihelion of Earth's orbit [degree]
nherb	Number of herbaceous (BAGs or species)
nbush	Number of shrub (BAGs or species)
ntree	Number of tree (BAGs or species)
Nc	Number of crop (BAGs or species)
fil ext inp weather	Extension of the input files for weather. Usually set to ".dat"
fil ext results	Extension of the output files. Usually set to ".res"

b) Paths for input files

The following lines set the paths of the input files for environmental, meteorological and plant physiology data. The contents of the input files are fully described in another section below.

Parameter name	File number	Description
soil texture	1	Path for the soil texture parameters (ecotxt.dat)
Pixel corners	97	Path for the pixel corners data.
Climate data	666	Path for the climatic type for each pixel (if iclim=0). Path for the monthly or daily average air temperature data (climatological values used to determine the pixel climatic type (if iclim = 1) 0 if the data units of the files match with the units require by the model, if 1, use a correction factor (ex. -273.15 if the file contains temperature data in Kelvin). 0 if the data timescale of the files match with the units require by the model, if 1, use a correction factore (ex. 86400 1 for netcdf files, 0 otherwise.
air temp (climatol)	81	This remark applies to the next 8 files. Path for the monthly or daily average precipitations data (climatological values used to determine the pixel climatic type)
precip (climatol)	82	Path for the monthly or daily temperatures for the studied year (climate for steady state run) [°C]. This path refers to a set of files with one file per year, following the format temYEAR.dat with “YEAR” being the year (e.g., tem2012.dat). This remark applies to the next 7 files.
air temperature	2/222	Path for the monthly or daily maximum temperatures for the studied year (climate for steady state run) [°C].
Max air temp	3/333	Path for the monthly or daily minimum temperatures for the studied year (climate for steady state run) [°C].
Min air temp	301/311	Path for the monthly or daily values of precipitations for the studied year [mm/month]
precipitation	4/444	Path for the monthly or daily values of percentage of sunshine hours [%].
sunsh hour/solar fl	7/777	Path for the monthly or daily values of air relative humidity for the studied year [%]
air relat. Humidity	8/888	Path for the monthly or daily values of wind speed at the surface for the studied year [m/s]
wind speed	9/999	Path for the management data for pastures. Path for the monthly or daily values of lightning flash frequency for the studied year [number of flashes per km2 per month]. Used in the fire module only.
management	92	Path for the values of the fraction of the land use classes for each pixel.
lightning data	93	Path for the values of the fraction of each crop (+ 1 for pasture)
Land use cover	94	Path for the sowing data (per pixel).
LU species rel abun	194	Path for the information about crop cultivar (per pixel).
Crop sowing dates	294	Path for the migration rate values.
Crop cultivars	295	Path for the species refugia data.
Migration rate	95	Path for the directory containing the weather stochastic generator (/gene)
Species refugia	96	Path for the parameter file used by hydrological module IBM (bagibm.dat)
path for generator	11/12	Path for the parameter file of « climatic » limits for BAG presence (bagtol.dat)
PFT alb zzra t1 t2	13	Path for the parameter file of carbon module parameters (bagpar.dat)
PFT tolerances	14	Path for the parameter file of age classes parameters (claspar.dat)
PFT parameters	15	Path for the parameter file of C/N of metabolic (leaves) and structural (“wood”) pools (curn.dat)
PFT age class para	111	Path for the parameter file of characteristic times of leaves fall and “wood” dead (gkfall.dat).
PFT C:N of veget	16	Path for the parameter file of multiplying factor for litter (+ ₁) and soil carbon (+ ₂) decomposition (gama.dat)
PFT 1/gkfall	17	Path for the parameter file of carbon content of “seed” (carbinit.dat)
PFT gama1, gama2	18	
PFT carb_init	19	

Crops seasonality	112	Path for the parameter file of crop phenology parameters (bagesas.dat)
Initial veg frac	20	Path for the initialization file containing the fraction of the different BAG, PFT or species.
Initial Min Max LAI	21	Path for the initialization file of the leaf area index (LAI).
Read initial cond	25	Path for the initialization file of the biomass.
Read lai limit	125	Path for the initialization file of the LAI limits.
Read ini cond crops	525	Path for the initialization file of the crop gross primary productivity.
Read prev year CO2	325	Path for the initialization file of the CO2 pressure of the previous year
Read prev year temp	225	Path for the initialization file of the temperature of the previous year
Read prev year LU	425	Path for the initialization file of the temperature of the previous year
Initial propagation	176	Path for the initialization file of the seed propagation
Initial side pres	177	Path for the initialization file of the presence of a specie on the neighborhood of a pixel
Initial pixel pres	178	Path for the initialization file of the presence of a specie on a given pixel

c) Paths for output files

The following lines (and the 6 ones between “crops seasonality” and “initial veget frac”) set the paths of the output files of the simulation results. Most of these paths refer to a set of files with one file per year, following the format temYEAR.dat with “YEAR” being the year (e.g., sw2012.dat).

The output files can be written or not depending on the flag number that is written between the results name and the path name of the output file, with this number equals to 1 or 0, for writing and not-writing respectively. For instance: the following line tells CARAIB to write the results of soil water to the file swYEAR.dat:

```
monthly mean sw :1 ./results/sw
```

The paths are not detailed here. Please refer to the configuration file *caraib.dat* printed out above in this document. The content of the output files are fully described in another section below.

d) Lines for the years of simulation

The last lines of the configuration file *caraib.dat* are for the years of simulation. The first column is an ordinary list of the years from 1 to the number of years. The second column (pco2) is for the CO2 concentration in the atmosphere in [ppm]. The third column (iprt) is to set the printing (1) or not (0) the results for that year. The last two columns are for the file extension of the output files (filext) and the input files (filexti). Those lines must be repeated for each year in a transient run, while for a steady state simulation with climatological fields, only one set of values (one line) is necessary.

3.2.2 Environmental input file (*ecotxt.dat*)

The input file *ecotxt.dat* (file number : 1) holds information, for each pixel, about the physical characteristics of the simulated areas, including geographic localisation, soil type and soil texture. There is one line per simulated pixel. It contains 10 parameters, arranged as columns, that are:

1. Pixel number
2. Longitude [decimal degrees]
3. Latitude [decimal degrees]
4. The FAO soil number (determining each texture percentage – Zobler, 1986)
5. Clay content in [%]
6. Silt content in [%]
7. Sand content in [%]
8. Elevation above sea level [m]
9. Soil color (0 is black, 1 is white)

3.2.3 Climatic input files

The input climatic files contain meteorological data for each simulated pixel. There is one line per simulated pixel. All these files start with the longitude and latitude of the simulated pixel (first two columns). The data are on a monthly or a daily basis, depending on the value of the input parameter *idaily_in* (respectively 0 or 1), resulting in 12 or 365 more columns respectively. For each meteorological variable, there is a set of files with one file per year, following the format *filenameYEAR.dat* with “YEAR” being the year (e.g., *tem2012.dat* is the input file for temperatures in 2012).

File name (+ YEAR + .dat)	File number	Meteorological variable	Units*
Climate_data.dat	666	Reading of the Koppen zone	/
Tem_WC.dat	81	Temperature means (climatology) for the Koppen zone calculation	°C
Prc_WC.dat	82	Precipitation means (climatology) for the Koppen zone calculation	mm
tem	2/222	Mean temperature	°C
Dte / Tmax	3/333	Amplitude of temperature (Tmax-Tmin) or maximum temperature	
Dte / Tmin	301/311	Amplitude of temperature (Tmax-Tmin) or minimum temperature.	°C
prc	4/444	Precipitation	mm
Shr / fsol	7/777	Sunshine hours or solar fluxes	%
rhu	8/888	Relative humidity	%
wnd	9/999	Wind speed	m/s
Lightning	93	Rate of lightning	#flashes/km ²

* The units are to be considered on a monthly or a daily basis according to the user's choice (*idaily_in*)

3.2.4 Plant parameters input files

The input plant parameters files contain physiological data for each Bio-Affinity Group, Plant Functional Type (PFT) or species/crops that is defined in the model. A list of the already simulated one is listed in annex 1 (and a full list of the species in each BAG can be found in annex 2). Given the configuration file, in which the vegetation must be follow the order (1) herbaceous vegetation, (2) shrubs, (3) trees and (4) crops. This order must be respected in all the plant parameters input files.

There are 9 plant parameters input files that contains several plant parameters that are comprehensively detailed below:

File	File number	Parameter name	Description	Units
<i>bagibm.dat</i>	13	alvsw	Short wave albedo	/
		alvlw	Long wave albedo	/
		rdveg	Root depth of the vegetation	mm
		t1	Temperature for beginning of LAI increase	°C
		t2	Temperature for end of LAI increase	°C
		xlmin	Minimal LAI value before t1	/
		xlmax	Maximal LAI value before t2	/
		z0vw	Roughness length in winter	m
		z0vs	Roughness length in summer	m
		disd	Displacement height	m
		zzra	Reference height for wind measurements	m
		emv	Emissivity of vegetation cover	/
		wai
		alvwd
<i>bagpar.dat</i>	15	g0	intercept for the stomatal conductance	$\mu\text{mol}/\text{m}^2 \text{ s}$
		g1	slope for the stomatal conductance	/
		splai	specific leaf area	m^2/gC
		delc2	Fractionation linked to diffusion through stomatal cavities for each species	/
		xi(1)	Parameter of the equation for carbon allocation to pool	$(\text{gC}/\text{m}^2)^x$
		xi(2)	Parameter of the equation for carbon allocation to pool	$(\text{gC}/\text{m}^2)^x$
		resecf	Parameter of the equation for available biomass for bud	
		xk		/
		rootf	Fraction of the assimilates that are allocated to the roots	/
		rvcm567	downregulation factor for V_{cmax}	...
		rjm567	downregulation factor for J_{max}	...
		rootsh	Root to shoot ration	/
		phi_L	Fraction used for the fire carbon emission of the leaves.	/

		phi_S	Fraction used for the fire carbon emission of the shoot.	/
		phi_R	Fraction used for the fire carbon emission of the root.	/
		phi_D	Fraction used for the fire carbon emission of the litter.	/
		psi_L	Fraction used for the litter production due to fire from leaves.	/
		psi_s	Fraction used for the litter production due to fire from shoot.	/
		psi_r	Fraction used for the litter production due to fire from roots.	/
<i>bagtol.dat</i>	14	ipft	BAG's number	/
		ic4	1 for C4 plant; else 0	
		idec	1 for deciduous plan, else 0	
		tmin1	Minimum threshold for stress (pool 1)	°C
		tmin2	Minimum threshold for stress (pool 2)	°C
		tmax1	Maximum threshold for stress (pool 1)	°C
		tmax2	Maximum threshold for stress (pool 2)	°C
		wat1	Soil water content (expressed as a fraction of field capacity)	/
		wat2	Soil water content (expressed as a fraction of field capacity)	/
		xpar1	Solar energy threshold	MJ/day
		xpar2	Solar energy threshold	MJ/day
		gdd5_min	Minimum value of GDD base 5°C	Σ°C
		tmax_germ	Maximum temperature for germination	°C
		watmax_germ	Maximum soil water content for germination	/
		pgerm	Germination probability	
		bag_h	...	
		jbbag	...	
		quantile	...??	
<i>carbinit.dat</i>	19	carb_init pool n°	Initial value of carbon pool (pool 1)	gC/m ²
		carb init pool n°	Initial value of carbon pool (pool 2)	gC/m ²
<i>claspar.dat</i>	111	nclas	Number of age classes for this BAG	/
		nclas values	Follow-up of the age classes for this BAG	/
		iyear_max	Lifespan max	year
<i>csum.dat</i>	16	csum	C/N ratio for this BAG (pool 1)	%
		pool n°	C/N ratio for this BAG (pool 2)	%
<i>gama.dat</i>	18	gama1 pool n°1	Fraction allocated to "green litter"	/
		gama1 pool n°2	Fraction allocated to "not green litter"	/
		gama2	Fraction integrating the soil organic carbon (rest in the atmosphere)	/
<i>gkfall.dat</i>	17	1/gkfall	6 values for the mortality characteristic time (per 2 for pool 1 and pool 2 ; 2 first for natural mortality, the 2 next values are related to temperature stress and the 2 last are related to water stress). without or with stress and for pool 1 and pool 2)	year

<i>bagseas.dat</i>	112	1/gkboom	Characteristic time for bud formation	year
		sowing date	Sowing date. For crops only. Set to -999 for the natural vegetation BAGs.	Julian day
		temp base	Base temperature for the plants. Does not apply for the natural vegetation BAGs.	°C
		gdd_germ	Sum of degrees-days needed for germination.	°C.days
		gdd_harv	Sum of degrees-days needed for harvest.	°C.days
		gr_seas	Maximum length of the growing season	Days
		fl_harv	Leaves fraction which is harvested.	/
		fs_harv	Shoot fraction which is harvested.	/
		fr_harv	Root fraction which is harvested.	/
		ind_harv	Harvest index.	/
		wc_harv	Water content of the plant (especially the fruit or harvested part of the plant)	%
		carbon content	Ratio between the carbon and dry matter content.	/

3.2.5 Other input files

Other files are also needed in input and can be of 2 types :

- In the first table, these files are prepared by the user,
- In the second table, the files are almost all coming from a previous simulation and used to initialize the current simulation (land_use1999.res can be used for another simulation -with the same characteristic- starting in 2000). They are going to be described in the “output files” section (page 17).

File name	File number	Information	Units*
Pixelscorners.dat	97	?	/
Manag.dat	92	Management file for the cutting of the biomass. The first two columns are for the longitude and latitude. The third column is the flag variable for enabling cutting (0 or 1), the fourth is the number of cuts during the year. Then, the following columns are the day of the year of cutting, the LAI after cutting (m ² leaves/m ² surface), and the dry matter after cutting in (gC/m ²).	
Human_frac.dat	94	Fraction of pixel area covered by the following 5 classes : natural vegetation, crops, urban, water bodies, rocks. The sum of the fractions must be equal to 1. It can be read for the previous (file number : ??) and the simulated year (file number	
Frac_crop.dat	194	Fraction of crop area (defined in human_frac.dat) covered by the different crops simulated. The sum of the fractions must be equal to 1.	
Crop sowing dates	294	Sowing date given by pixel and for the different crops simulated.	
Crop cultivars	295	Mainly used for global vegetation, this file allows the definition of one cultivar per pixel (instead of prepare the frac_crop.files).	
Migration rate	95	?	
Species refugia	96	?	
Grazing		Management file for the grazing of the biomass. The first two columns are for the longitude and latitude. The third column is the flag variable for	

enabling grazing (0 for nothing, 1 for cutting and 10 for grazing), the fourth is the number of grazing days during the year. Then, the following columns are the day of the year when grazing occurs, the animal density in [animal/ha], and the dry matter intake in [kgC/animal]

File name	File number	Information
<i>Initial veget frac</i>	20	See output (file n°60)
<i>Initial Min max LAI</i>	21	See output (file n°64)
<i>Read initial cond</i>	25	See output (file n°26)
<i>Read lai limit</i>	125	See output (file n°126)
<i>Read ini cond crops</i>	525	See output (file n°526)
<i>Read prev year CO2</i>	325	See output (file n°326)
<i>Read prev year temp</i>	225	See output (file n°226)
<i>Read prev year LU</i>	425	See input (file n°94)
<i>Initial propagation</i>	176	See output (file n°76)
<i>Initial side pres</i>	177	See output (file n°77)
<i>Initial pixel pres</i>	178	See output (file n°78)

3.3 Description of output files

Output (or results) files are ASCII files. For most of files, the output data are on a daily or a monthly basis, depending on the choice of the user (parameter *idaily_ou* in *caraib.dat*). There is one line per simulated pixel. Most of these files start with the longitude and latitude of the simulated pixel (first two columns). Hereafter is a description of all possible output files. The file number refers to an identifier number in the code *caraib.f*. There are two groups of output files: (1) output files that are printed and with one file for all years of simulations, (2) output files that are printed or not depending on the user's choice and with one file per year of simulation.

The output files of the first group are detailed below:

File	File number	Parameter name	Description	Units
<i>zone.res (read if iczon≠1)</i>	22		Determining of the climate zone for all pixels	
<i>stochas.gen (read if ngener≠1)</i>	23		Initialisation of the weather generator : calculation of different probabilities for the 176 climatic zones of Koppen	
<i>water.full (open if ifull=1)</i>	24		Write (full and) daily results	
<i>water.tes</i>	28	Daily results if ifull = 1	Write calculation for average surface temperature	
<i>carbon.problem</i>	61	Problem	Some error messages can be printed in this file	
<i>water.time</i>	29		File use to reinitialize annual net budget (hydrology)	

The output files of the second group are detailed below, in alphabetic order. There are actually a set of

files with one file per year, following the format *filenameYEAR.res* with “YEAR” being the year.

File	File number	Parameter name	Description	Units
<i>aburn.res</i>	75	Burned area Actual	Monthly or daily burned area.	m ²
<i>aet.res</i>	33	evapotranspiration	Monthly or daily values of actual evapotranspiration.	mm
<i>agbiom.res</i>	881	Aboveground biomass	Monthly or daily values of aboveground biomass	gC
<i>alb.res</i>	39	Albedo	Average albedo (soil, vegetation and snow cover)	/
<i>albs.res</i>	339	Soil albedo	/	/
<i>albsv.res</i>	239	Soil and vegetation albedo	Average albedo of the soil and the vegetation (weighted by the fraction covered)	/
<i>albv.res</i>	439	Albedo of vegetation cover	/	/
<i>bgbiom.res</i>	882	Belowground biomass	Monthly or daily values of belowground biomass	gC
<i>biomass.res</i>	26 (25*)	Final/Initial values	Final (or initial*) values for soil water content, carbon in the two pools, for bud, litter and humus values.	/
<i>biommth.res</i>	55	Biomass	Daily or monthly mean total biomass	gC
<i>co2prev.res</i>	326 (325*)	CO ₂ level	Records of the CO ₂ level of the given (or previous*) year.	ppmv
<i>cropino.res</i>	526 (525*)	Final/Initial values	Final (or initial*) values of GDD, GPP et NPP.	/
<i>csoil.res</i>	67	Amount of carbon	Amount of carbon stocked in the following pools: Total Carbon Leaf Carbon Structural Carbon (i.e., in trunks) Soil Carbon	gC
<i>cveg.res</i>	66	Amount of carbon	Amount of carbon stocked per BAG.	gC
<i>drn.res</i>	36	Drainage	Monthly or daily values of drainage.	mm
<i>eint.res</i>	537	Intercepted water evapotranspiration	Monthly or daily values of the intercepted water (from precipitation) re-evaporated.	mm
<i>emiblitmth.res</i>	560	Litter fire emission	Monthly or daily values of carbon emission due to burned litter	gC
<i>emifire.res</i>	665	PFT fire emission	Monthly or daily values of carbon emission due to burned vegetation (per PFT)	gC
<i>emifiremth.res</i>	559	Fire emission	Monthly or daily fire emission	
<i>emisf.res</i>	52	Surface emissivity	Monthly or daily values of the surface emissivity.	/
<i>emisfns</i>	152	Surface emissivity (no snow)	Monthly or daily values of surface emissivity without snow cover	/
<i>eso</i>	539	Soil evaporation	Monthly or daily values of soil evaporation.	mm
<i>etr</i>	538	Plant transpiration	Monthly or daily values of plant transpiration.	mm
<i>faparmth</i>	98	Fapar	Monthly or daily values of Fapar.	
<i>fburn.res</i>	74	Burned pixel fraction	Monthly or daily burned pixel fraction.	/
<i>fgdd5</i>	87	Coefficient gdd5	Coefficient based on the GDD5 to reduce the seed production.	/
<i>fgs.res</i>	43	Snow-free green cover	Monthly or daily values of the snow-free green cover fraction.	/
<i>fird.res</i>	45	Downward infrared radiation	Monthly or daily values of the downward infrared radiation.	W/m ²
<i>frac.res</i>	60 (20*)	Fraction of each BAG/species		/
<i>frc.res</i>	530	Frc per pft	Fraction of ?	
<i>frcc13.res</i>	68	Isotopic fraction of C13	Isotopic fraction of C13 per BAG.	???
<i>fsn.res</i>	35	Fraction of snow	Monthly or daily values of fraction of snow.	/
<i>fsol.res</i>	48	Incoming solar radiation	Monthly or daily values of the incoming solar radiation.	W/m ²
<i>ftmmin.res</i>	88	Tmin coefficient	Coefficient based on the minimum temperature	/

			threshold to reduce the establishment of the given PFT/BAG/species.	
<i>ftomin.res</i>	84	Tmin coefficient	Coefficient based on the minimum temperature threshold to reduce the fraction of the given PFT/BAG/specie.	/
<i>ftot.res</i>	86	Total PFT/BAG/specie fraction	Total vegetation fraction (per PFT, BAG or specie).	/
<i>ftotw.res</i>	85	Water shortage coefficient	Coefficient based on the minimum water content threshold to reduce the fraction of the given PFT/BAG/specie.	/
<i>fwatmin.res</i>	89	Water shortage coefficient	Coefficient based on the minimum water content threshold to reduce the establishment of the given PFT/BAG/species.	/
<i>gdd.res</i>	72	Cumulated degree-days	Yearly cumulated degree-days: gdd0 and gdd5 are presented. Gdd0 is the sum of degrees-days above 0°C, Gdd5 is the sum of degrees-days above 5°C,	°C.day
<i>gpp.res</i>	65	Gross Primary Productivity	Annual sum of GPP per BAG.	gC/m ²
<i>gppmth.res</i>	56	Gross Primary Productivity	Monthly or daily values of the GPP.	gC/m ²
<i>grf.res</i>	41	Ground flux	Monthly or daily values of the heat flux to the ground.	W/m ²
<i>harvest.res</i>	79	Harvested biomass	Harvested or (management) cut biomass removed from site per PFT, BAG or specie.	gC
<i>harvmth.res</i>	562	Harvested biomass	Monthly or daily harvested biomass.	gC
<i>lai.res</i>	44	Leaf area index	Monthly or daily values of the leaf area index.	m ² /m ²
<i>laimoy.res</i>	69	LAI per BAG	Yearly average of LAI per BAG.	m ² /m ²
<i>laimth.res</i>	59	Leaf area index	Monthly or daily values of the leaf area index.	m ² /m ²
<i>lucdfr.res</i>	251	Land use differences	Fraction difference between the old and the new land use.	/
<i>lucflx.res</i>	252	Land use changes impacts	Carbon emission and litter production fluxes from land use change	/
<i>maturity.res</i>	883	Date of maturity	Date at which crops reach the GGDmax.	Day #
<i>nbpmth.res</i>	561	Net biome productivity	/	gC
<i>nepmth.res</i>	58	Net Ecosystem Productivity	Monthly or daily values of the NEP.	gC/m ²
<i>npp.res</i>	62	Net Primary Productivity	Annual sum of NPP per BAG.	gC/m ²
<i>nppmth.res</i>	57	Net Primary Productivity Potential	Monthly or daily values of the NPP.	gC/m ²
<i>pet.res</i>	32	evapotranspiration	Monthly or daily values of potential evapotranspiration.	mm
<i>pfire.res</i>	73	Probability of fire	Monthly or daily probability of fire.	/
<i>pres.res</i>	78 (178*)	Presence	Presence of the a given specie on the pixel (migration module).	/
<i>prop.res</i>	76 (176*)	Propagation	Seed propagation (if migration module is used).	/
<i>ra.res</i>	565	Autotrophic respiration	Autotrophic respiration per PFT, BAG or specie.	gC
<i>ramth.res</i>	556	Autotrophic respiration	Monthly or daily autotrophic respiration.	gC
<i>rbl.res</i>	38	Aerodynamic resistance for water	Monthly or daily values of aerodynamic resistance for water (averaged over vegetation and soil)	s/m
<i>rhmath.res</i>	558	Heterotrophic respiration	Monthly or daily heterotrophic respiration.	gC
<i>rmin.res</i>	63	Ratio of LAImin	/	/
<i>rn.res</i>	40	LAImax	Ratio of minimal LAI over maximal LAI per BAG.	/
<i>rn.res</i>	40	Net radiation	Monthly or daily values of mean net radiation	W/m ²
<i>rtr.res</i>	532	Evaporation ratio	Ratio of plant transpiration to soil and vegetation evapotranspiration.	/

<i>run.res</i>	34	Runoff	Monthly or daily values of runoff.	mm
<i>sf.res</i>	49	Snow fall	Monthly or daily values of the snow fall.	mm
<i>side.res</i>	77 (177*)	Neighborhood presence	Presence of a species on a pixel (migration module).	/
<i>sml.res</i>	51	Snow melt	Monthly or daily values of the snow melt.	mm
<i>snd.res</i>	535	Snow depth	Monthly or daily snow depth	mm
<i>sne.res</i>	50	Snow evaporation	Monthly or daily values of the snow evaporation.	mm
<i>srun.res</i>	536	Surface runoff	Monthly or daily surface runoff	mm
<i>sve.res</i>	37	Soil and vegetation evapotranspiration	Monthly or daily values of soil and vegetation evapotranspiration. It includes all evapotranspiration except snow evaporation and evaporation of intercepted water.	day-1
<i>sw.res</i>	31	Soil water	Monthly or daily values of soil moisture. Expressed in relative units such as it equals 0 at the wilting point, 1 at the field capacity and is superior to 1 beyond field capacity and saturation.	mm
<i>swmm.res</i>	531	Soil water	Monthly or daily values of soil water content.	/
<i>tdmin.res</i>	70	Min. and max. daily temperature	Yearly minimal and maximal daily temperature.	mm
<i>temprev.res</i>	226 (225*)	Temperature conditions	Records of the temperature conditions of the given (or previous*) year.	°C
<i>tmmmin.res</i>	71	Min. and max. monthly temperature	Yearly minimal and maximal monthly temperature (month average).	°C
<i>ts.res</i>	42	Temperature of the surface	Monthly or daily values of the temperature of the surface.	°C
<i>water_yr.res</i>	30	Yearly water budget	Yearly water budget for each pixel. This file summarizes all components of the water budget over a year. The following parameter are written: Pixel number - igr longitude - ylongi latitude - ylati water height at saturation [mm] - fsi water height at field capacity [mm] - fci water height at wilting point [mm] - wpi root depth [mm] - rootd Annual sum of precipitation [mm] - prcy Sum of runoff [mm] - runy Sum of evapotranspiration [mm] - svey Sum of interception of rainfall [mm] - eiry Sum of snow evaporation [mm] - sney Sum of potential evaporation [mm] - pety wbody - wbody Minimal soil water content [m ³ /m ³] - aswmin fractional vegetation cover - fveg	mm or m ³ /m ³ for soil water content
<i>xlai_min_max.res</i>	64 (21*)	Min. and max. LAI	Yearly minimal and maximal values of LAI per BAG. Minimal values are written first for each BAG, then maximal values.	m ² /m ²
<i>xh.res</i>	46	Sensible heat flux	Monthly or daily values of the sensible heat flux.	W/m ²
<i>xle.res</i>	47	Latent heat flux	Monthly or daily values of the latent heat flux.	W/m ²
<i>yfburn.res</i>	83	Non burned fraction	Yearly cumulated non-burned fraction	/
<i>yield.res</i>	880	Yield	Yearly yield for each BAG, PFT or species, but mainly designed for crop species.	T/ha
<i>ylailim.res</i>	126 (125*)	Min and max LAI	Initialisation of the min and max lai (cf bagibm.dat).	/
<i>z0.res</i>	252	Roughness length	Mean pixel roughness length (drag coefficient approach).	/

* file number (or file) when read as input (see section "other input files")

3.4 Description of the code

The CARAIB model is coded in a unique FORTRAN file that is usually called *caraib.f*. This file is described in this section.

3.4.1 Pseudocode

Below is a brief description of the code of the CARAIB model, namely the pseudocode. This pseudocode is not exhaustive but presents all the important steps of the model. The names of the subroutines are shown in *italic*.

```
Read caraib.dat input file (open_input5) Call
routines for computing some constants LOOP
over years
  Read time-dependent input files (open_file)

  IF stated, call the weather generator (generator) ELSE,
  read weather data
  ENDIF
  IF it is the first year,
    Read time-independent input files (read_eco) Read
    initial conditions files (read_init) Determine the
    climate zone for all pixels
  ENDIF
  LOOP over pixels
    Read climatic, vegetation and soil data (read_in) Read
    crops cover fractions (read_cult)
    Determine the climate zone for the pixel
    Estimate daily climatic conditions (daily_weather) Calculates
    solar fluxes and related parameters (solar)

    Set vegetation fraction (set_frac)
    Calculates drainage (drainage)
    Set initial conditions for some hydrological variables (init_c)
    Set PFT establishment (pft_estab)
    Calculate the external conditions (i.e., air temperature, air relative humidity, irradiance
    and aerodynamic and boundary resistance) at an hourly time step (cal_in)
    Initialisation of some variables (ponc_init) Set
    carbon pool values (set_cools)
    Initialisation of the LAI limitation due to water stress (lailim_init) Calculate
    the NPP (npp_cal)
    Run the fire module (fire) Calculate
    the mortality (mortality)
    Calculates the correction - linked to the fire module (correction) Calculates
    the soil respiration (soil_resp)
    Calculates the vegetation succession, i.e., the vegetation dynamics (new_frac) Gather
    pixel results (record_grid)
  ENDDO
  Write results (wri_1st)
ENDDO
```

3.4.2 Frequently used variables

- *ny0* is the counter of the number of years, up to *nyrmax*, the total number of years;
- *ngt* is the counter of the number of pixels, up to *n_pix*, the total number of pixels;
- *ip* is the counter of the number of PFT, up to *npft0*, the total number of PFT;
- *idn* is the day number;
- *stept* is the integration step;

3.4.3 Subroutines

The following table lists all subroutines that are used in the model and written in *caraib.f*. The reader is referred to the code to look into details what these routines do.

Subroutine name	Short description
<i>backdiff(drv)</i>	Computes back differences
<i>bashfor(stept,drv,y,ynew)</i>	Linear multistep Adams-bashforth method
<i>cal_in</i>	Calculates the external conditions at an hourly time step.
<i>calrapportprecip(zone,month,r,rapportprecip)</i>	Calculates the value of precipitation ratio
<i>charlen(name,kn)</i>	Counts the number of letters in a character*80 variable
<i>check(stept,time,y,drv)</i>	Arranges variables.
<i>clasparam</i>	Reads or computes various age classes parameters
<i>close_file(iread)</i>	Close all output files.
<i>correction</i>	Used in fire
<i>crops_seas</i>	Reads or computes various age classes parameters
<i>ctgen</i>	Reads constants for weather generator and 'sets' them in commons
<i>cth2o</i>	Reads constants and sets them in commons
<i>daily_weather</i>	Estimates daily weather data from monthly values.
<i>drainage(stept)</i>	Calculates the drainage
<i>dryseas(p,mdry)</i>	Used in koppen2.
<i>esat(tk,es)</i>	Calculates saturation vapour pressure of H2O.
<i>exch(ne,nc,je,sl,diag)</i>	Exchanges rows to get a zero coefficient off the diagonal.
<i>fire</i>	Calculates probability of fire and burned area
<i>frac_herbs(ngt)</i>	Used in npp_cal
<i>frac_trees(ngt)</i>	Used in npp_cal
<i>funcx(x,fx)</i>	Numerical computation
<i>gauss(ne,sl,x)</i>	Solves a system of simultaneous linear algebraic equations by Gaussian elimination and back substitution.
<i>generator(graine,iprint)</i>	Weather generator for precipitation and temperatures
<i>givedrv(stept,time,y,drv)</i>	Runs the hydrological model.
<i>givnletters(z,nlet)</i>	Counts the number of letters in a character*8 variable
<i>gpp_cal</i>	Calculates the co2 net assimilation by leaves
<i>hourly</i>	Arranges variables at an hourly time step.
<i>humiseas(p,mwet)</i>	Used in koppen2.
<i>init_c(y,ngt)</i>	Used in the hydrological model
<i>initbdo</i>	Numerical computation
<i>itochar2(i,ch)</i>	Convert an integer into a character
<i>koppen2(climate)</i>	Used in zonepxl2.
<i>lai_limit_w</i>	Calculates monthly lai limits to assure coherence between CARAIB and IBM

<i>lailim_init</i>	Reads initial value of lai limitation due to water stress
<i>mortality</i>	Calculates the mortality rate
<i>moulton(stept,drv,y,ynew)</i>	Linear multistep Adams-bashforth method
<i>new_frac(ngt)</i>	Calculates the vegetation succession.
<i>nonlineq(xa,xb,nint,x,fx,ermax,nitmax,imeth,num)</i>	Solves a non linear equation of the type
<i>npp_cal(ngt,ny0,iread)</i>	Calculates the net primary productivity and the co2 carbon pools.
<i>ode(tbegin,tend,y,stept,niter,ipr)</i>	Resolves ordinary differential equations (used in givedrv).
<i>open_file(iread)</i>	Open input and output files.
<i>open_input5(nyrmax,stept,iread)</i>	Open and read caraib.dat.
<i>pft_estab</i>	Estimates establishment success for plant types.
<i>polfit(xi,yi,ni,aj,ndeg,err,cj,sl)</i>	Numerical computation
<i>ponc_init</i>	Performs the initialisation of some variables (ynpp, ygpp, ynep, xmnpp, xmgpp, zgpp)
<i>printing(ipr,time,y,drv)</i>	Summarizes and writes some variables.
<i>puiss(x,k,xk)</i>	Numerical computation
<i>randnum(seed,frnd)</i>	Returns a random number between 0 and 1
<i>read_cult(ngt)</i>	Reads the PFT fraction over the pixel
<i>read_eco(ngt)</i>	Reads the different environmental inputs as well as vegetation characteristics.
<i>read_in(ngt)</i>	Read environmental and vegetation inputs and compute some environmental parameters.
<i>read_init(iread,ngt)</i>	Reads initial conditions files
<i>record_grid(y,ngt)</i>	Records soil water, biomass, soil carbon and leaf area index in vectors for initialisation at the beginning of the next year
<i>remember(drv)</i>	Saves the derivatives and back differences at previous time step
<i>runkut4(stept,time,y,drv)</i>	Runge-Kutta method
<i>set_cpools(ngt)</i>	Reads initial value of carbon pools and set them in the right form.
<i>set_frac(ngt)</i>	Reads the different environmental inputs as well as vegetation characteristics and sets them in the right form.
<i>soil_resp</i>	Estimates the monthly soil respiration rate
<i>solar</i>	Calculates the solar irradiance at the earth surface
<i>solar_flux</i>	Calculates the radiative transfer within the canopy.
<i>solar_trees(ngt)</i>	Used in npp_cal
<i>tau(aa,bb,fnet,rdep,drk0,X0,XN,TAUI,NI)</i>	Used in drainage.
<i>TDT(mlength,mondec,flag,tabrT,tabrDT,zone,seed)</i>	Random estimation for temperatures
<i>timedep(stept,time)</i>	Arranges variables at different time steps.
<i>wat_limit</i>	Determines the maximum lai when soil water is missing.
<i>wri_1st(y,nyear,ngt)</i>	Writes first year results
<i>wri_res</i>	Writes results to results files
<i>year_iteration</i>	Integrates variables over the year
<i>zone2(reg,region)</i>	Used in zonepxl2.
<i>zonepxl2(iprint)</i>	Determines the geoclimatic zone corresponding to the studied region

4 Technical issues

4.1 Compilation and run

CARAIB is written in FORTRAN and needs a FORTRAN compiler to be used. The freeware INTEL Fortran Compiler can be recommended. Two files are important for the compilation and the running of the model:

- caraib_unit5.dat, in which you have to provide the path for the configuration file (caraib.dat),
- the executable “runcaraib” in which you have to provide the paths for the “caraib” executable (caraib.out) and the path for the “caraib_unit5.dat” file.

Once these two files are updated, the model is run by typing in the command line :

```
./runcaraib
```

The FORTRAN compiler can be installed on your own PC. Alternatively, you can use a remote desktop dedicated to computation with CARAIB.

Note that if you modify the code of the model (caraib_main_01.dat, carbon_01.dat or hydro_01.dat), you have to compile again the model with “compil.sh”.

5 List of abbreviations

- BAG: Bioclimatic Affinity Group
- CARAIB: CARbon Assimilation In the Biosphere
- GDD : Growing Degree-Days
- GPP: Gross Primary Productivity
- IBM: Improved Bucket Model
- LAI: Leaf Area Index
- NPP: Net Primary Productivity
- PFT: Plant Functional Types

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Annex 1 – Simulated BAG, PFT, species and crops

	BAG (fully described in annex 2)
1	Achillea, Alchemilla, Angelica, Campanula
2	Brassicaceae, Caltha, Cardamine, etc
3	Anthemis, Artemisia, Bidens, Calystegia, etc
4	Asteraceae asteroideae, Poaceae, etc
5	Anemone, Gypsophila, Helleborus, etc
6	Ephedra, Ulex
7	Alnus vir, Arctostap., A.alpinus, B. nana
8	Sambucus, Frangula a, Prunus, Sorbus, Vaccinium
9	Berberis vul., Crataegus, Genista, Rhamnus
10	Artostaphylos uva-ursi, Calluna vul., Daphne
11	Buxus sempervirens, Hedera h., Ilex acquif.
12	Cistus, Myrtus
13	Betula, Salix
14	Alnus, A gl, Corylus, Q. robur, Populus, Tilia
15	Acer, Fraxinus, F excel, Tilia cordata, Ulmus
16	Acer campestre, Carpinus, Fagus syl, Tilia pla
17	Castanea, Juglans, Ostrya, Q. pubescens
18	Olea eur, Pistacia, Phillyrea, Q ilex, Q suber
19	Larix decidua
20	Picea abies, Pinus, Pinus sylvestris
21	Abies
22	Cupressaceae, Juniperus, Juniperus communis
23	Pinus Cembra
24	Abies Alba, Taxus
25	Cedrus, Pinus halepensis, Pinus pinaster

	Tree species
1	Abies alba
2	Alnus incana
3	Betula pendula
4	Carpinus betulus
5	Corylus avellana
6	Fagus sylvatica
7	Fraxinus excelsior
8	Larix decidua
9	Picea abies
10	Pinus sylvestris
11	Populus nigra
12	Pseudotsuga menziesii
13	Quercus petraea
14	Quercus robur

	Crops (calibrated for Belgium)
1	Winter barley
2	Spring barley
3	Winter wheat
4	Spring wheat
5	Potatoes
6	(sugar) Beets
7	Rapeseed
8	(fodder) Maize

	Crops (calibrated for Morocco)
1	Wheat
2	...

Annex 2 – BAG

Attribution des taxons palynologiques aux Groupes à Affinités Bioclimatiques (ou « Bioclimatic Affinity Groups » : BAG).

Correspondances entre taxonomie palynologique, botanique et appellations vernaculaires. Les appellations botaniques sont celles de l' « Atlas Florae Europaeae » (Jalas & Suominen 1972-1994 ; Jalas et al. 1996, 1999) et de l' « Atlas of North European vascular plants : north of the Tropic of Cancer I-III » (Hultén & Fries 1986).

La correspondance avec la taxonomie palynologique provient de Moore et al. (1991) et de Punt et al. (1994). Les noms vernaculaires sont issus de Rameau et al. (1993).

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
1	<i>Cedrus</i> <i>Pinus halepensis</i> <i>Pinus pinaster</i>	<i>C. atlantica</i> , <i>C. libani</i> <i>Pinus halepensis</i> <i>Pinus pinaster</i>	Cèdres Pin d'Alep Pin maritime
2	<i>Abies alba</i> <i>Taxus</i>	<i>A. alba</i> <i>Taxus baccata</i>	Sapin pectiné If commun
3	<i>Pinus cembra</i>	<i>Pinus cembra</i>	Pin cembro
4	<i>Cupressaceae</i> <i>Juniperus communis</i>	<i>Cupressus</i> , <i>Juniperus</i> , <i>Tetraclinis</i> <i>Juniperus communis</i>	Genévrier commun
5	<i>Abies</i>	<i>A. alba</i> , <i>A. borisii-regis</i> , <i>A. cephalonica</i> , <i>A. nebrodensis</i> , <i>A. pinsapo</i> , <i>A. sibirica</i>	Sapins
6	<i>Picea</i> <i>Pinus</i> <i>Pinus sylvestris</i>	<i>Picea abies</i> , <i>P. omonika</i> <i>Pinus brutia</i> , <i>P. cembra</i> , <i>P. halepensis</i> , <i>P. heldreichii</i> , <i>P. mugo</i> , <i>P. nigra</i> , <i>P. peuce</i> , <i>P. pinaster</i> , <i>P. pinea</i> , <i>P. sibirica</i> , <i>P. sylvestris</i> , <i>P. uncinata</i> <i>Pinus sylvestris</i>	Épicéas Pins Pin sylvestre
7	<i>Larix</i>	<i>Larix decidua</i> , <i>L. sibirica</i>	Mélèzes
8	<i>Olea europaea</i> <i>Phillyrea</i> <i>Pistacia</i> <i>Quercus ilex</i> <i>Quercus suber</i>	<i>Olea europaea</i> <i>Phillyrea</i> <i>Pistacia</i> <i>Quercus coccifera</i> , <i>Q. ilex</i> <i>Quercus suber</i>	Olivier Filaires Pistachiers Chêne vert Chêne liège
9	<i>Castanea</i> <i>Juglans</i> <i>Ostrya</i> <i>Quercus pubescens</i>	<i>Castanea sativa</i> <i>Juglans regia</i> <i>Ostrya carpinifolia</i> <i>Quercus pubescens</i>	Châtaignier Noyer Charme-houblon Chêne pubescent
10	<i>Acer campestre</i> <i>Carpinus</i> <i>Fagus sylvatica</i> <i>Tilia platyphyllos</i>	<i>Acer campestre</i> <i>Carpinus betulus</i> , <i>C. orientalis</i> <i>Fagus sylvatica</i> <i>Tilia platyphyllos</i>	Érable champêtre Charmes Hêtre Tilleul à grandes feuilles
11	<i>Acer</i> <i>Fraxinus</i> <i>Tilia cordata</i> <i>Ulmus</i>	<i>Acer platanoides</i> <i>Fraxinus excelsior</i> , <i>F. ornus</i> , <i>F. oxyphylla</i> <i>Tilia cordata</i> <i>Ulmus glabra</i> , <i>U. laevis</i> , <i>U. minor</i> , <i>Zelkova</i> <i>abelicea</i>	Érable plane Frênes Tilleul à petites feuilles Ormes
12	<i>Alnus</i> <i>Alnus glutinosa</i> <i>Corylus avellana</i> <i>Quercus</i> <i>Quercus robur</i> <i>Populus</i> <i>Tilia</i>	<i>Alnus cordata</i> , <i>A. glutinosa</i> , <i>A. incana</i> , <i>A. viridis</i> <i>Alnus glutinosa</i> <i>Corylus avellana</i> <i>Quercus canariensis</i> , <i>Q. cerris</i> , <i>Q. congesta</i> , <i>Q. crenata</i> , <i>Q. faginea</i> , <i>Q. frainetto</i> , <i>Q. fructicosa</i> , <i>Q. hartwissiana</i> , <i>Q. macrolepis</i> , <i>Q. pedunculiflora</i> , <i>Q. petraea</i> , <i>Q. pubescens</i> , <i>Q. pyrenaica</i> , <i>Q. robur</i> , <i>Q. rotundifolia</i> , <i>Q. sicula</i> , <i>Q. trojana</i> <i>Quercus robur</i> <i>Populus alba</i> , <i>P. canescens</i> , <i>P. nigra</i> , <i>P. tremula</i> <i>Tilia cordata</i> , <i>T. platyphyllos</i>	Aulnes Aulne glutineux Coudrier Chênes Chêne pédonculé Peupliers Tilleuls

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
13	<i>Betula</i> <i>Salix</i>	<i>Betula humilis</i> , <i>B. nana</i> , <i>B. pendula</i> , <i>B. pubescens</i> <i>Salix acutifolia</i> , <i>S. aegyptiaca</i> , <i>S. alba</i> , <i>S. alpina</i> , <i>S. amplexicaulis</i> , <i>S. appendiculata</i> , <i>S. appenina</i> , <i>S. arbuscula</i> , <i>S. arctica</i> , <i>S. atrocinerea</i> , <i>S. aurita</i> , <i>S. bicolor</i> , <i>S. breviserrata</i> , <i>S. burjatica</i> , <i>S. caesia</i> , <i>S. caprea</i> , <i>S. caspica</i> , <i>S. cinerea</i> , <i>S. crataegifolia</i> , <i>S. daphnoides</i> , <i>S. eleagnos</i> , <i>S. foetida</i> , <i>S. fragilis</i> , <i>S. glabra</i> , <i>S. glauca</i> , <i>S. glaucosericea</i> , <i>S. hastata</i> , <i>S. hegetschweileri</i> , <i>S. helvetica</i> , <i>S. herbacea</i> , <i>S. hibernica</i> , <i>S. jennisseensis</i> , <i>S. kitaibeliana</i> , <i>S. laggeri</i> , <i>S. lanata</i> , <i>S. lapponum</i> , <i>S. mielichhoferi</i> , <i>S. myrsinifolia</i> , <i>S. myrsinites</i> , <i>S. myrtilloides</i> , <i>S. nummularia</i> , <i>S. pedicellata</i> , <i>S. pentandra</i> , <i>S. phylicifolia</i> , <i>S. polaris</i> , <i>S. pulchra</i> , <i>S. purpurea</i> , <i>S. pyrenaica</i> , <i>S. pyrolifolia</i> , <i>S. recurvigemmis</i> , <i>S. repens</i> , <i>S. reptans</i> , <i>S. reticulata</i> , <i>S. retusa</i> , <i>S. rosmarinifolia</i> , <i>S. serpillifolia</i> , <i>S. silesiaca</i> , <i>S. starkeana</i> , <i>S. tarraconensis</i> , <i>S. triandra</i> , <i>S. viminalis</i> , <i>S. vinogradovii</i> , <i>S. waldsteiniana</i> , <i>S. wilhelmsiana</i> , <i>S. xerophila</i>	Bouleaux Saules
14	<i>Cistus</i> <i>Myrtus</i>	<i>Cistus albidus</i> , <i>C. monspeliensis</i> , <i>C. salviaefolium</i> <i>Myrtus communis</i>	Cistes Myrte
15	<i>Buxus sempervirens</i> <i>Hedera helix</i> <i>Ilex aquifolium</i> <i>Ligustrum vulgare</i> <i>Viscum</i>	<i>Buxus sempervirens</i> <i>Hedera helix</i> <i>Ilex aquifolium</i> <i>Ligustrum vulgare</i> <i>Viscum album</i> , <i>V. cruciatum</i>	Buis Lièrre Houx Troène Gui
16	<i>Arctostaphylos uva-ursi</i> <i>Calluna vulgaris</i> <i>Daphne</i>	<i>Arctostaphylos uva-ursi</i> <i>Calluna vulgaris</i> <i>Daphne mezereum</i>	Raisin d'ours Bruyère commune Daphnés
17	<i>Berberis vulgaris</i> <i>Crataegus</i> <i>Euonymus europaeus</i> <i>Genista</i> <i>Rhamnus</i> <i>Rhamnus catharticus</i> <i>Sambucus</i>	<i>Berberis vulgaris</i> <i>Crataegus calycina</i> , <i>C. laevigata</i> , <i>C. monogyna</i> <i>Euonymus europaeus</i> <i>Genista anglica</i> , <i>G. germanica</i> , <i>G. pilosa</i> , <i>G. tinctoria</i> <i>Rhamnus alpinus</i> , <i>R. catharticus</i> <i>Rhamnus catharticus</i> <i>Sambucus nigra</i> , <i>S. racemosa</i>	Épine-vinette Aubépines Fusain d'Europe Genêts Nerpruns Nerprun purgatif Sureaux

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
18	<i>Frangula alnus</i> <i>Lonicera</i> <i>Prunus</i> <i>Rubus</i> <i>Sorbus</i> <i>Vaccinium</i> <i>Viburnum</i>	<i>Frangula alnus</i> <i>Lonicera caerulea</i> , <i>L. periclymenum</i> , <i>L. villosa</i> , <i>L. xylosteum</i> <i>Prunus avium</i> , <i>P. padus</i> , <i>P. spinosa</i> <i>Rubus arcticus</i> , <i>R. caesius</i> , <i>R. chamaemorus</i> , <i>R. idaeus</i> , <i>R. plicatus</i> , <i>R. saxatilis</i> <i>Sorbus aria</i> , <i>S. aucuparia</i> , <i>S. hybrida</i> , <i>S. intermedia</i> , <i>S. meinichii</i> , <i>S. obtusifolia</i> , <i>S. rupicola</i> <i>Vaccinium macrocarpum</i> , <i>V. microcarpum</i> , <i>V. myrtillus</i> , <i>V. oxycoccos</i> , <i>V. uliginosum</i> , <i>V. vitis-idea</i> <i>Viburnum opulus</i>	Bourdaïne Chèvrefeuilles Pruniers Ronces Alisiers, Sorbiers Myrtilles, Airelles Viome
19	<i>Alnus viridis</i> <i>Arctostaphylos</i> <i>Arctostaphylos alpinus</i> <i>Betula nana</i> <i>Hippophae rhamnoides</i>	<i>Alnus viridis</i> <i>Arctostaphylos alpinus</i> , <i>A. uva-ursi</i> <i>Arctostaphylos alpinus</i> <i>Betula nana</i> <i>Hippophae rhamnoides</i>	Aulnes vert Busserole Raisin d'ours Busserole des Alpes Bouleau nain Argousier
20	<i>Ephedra</i> <i>Ulex</i>	<i>Ephedra dystachya</i> , <i>E. fragilis</i> , <i>E. major</i> <i>Ulex europaeus</i>	Ephèdre Ajoncs
21	Anemone <i>Chrysosplenium</i> <i>Gypsophila</i> <i>Helleborus</i> <i>Helianthemum</i> <i>Humulus</i> <i>Jasione montana</i> <i>Myrica</i> ...	<i>Anemone altaica</i> , <i>A. apennina</i> , <i>A. baldensis</i> , <i>A. blanda</i> , <i>A. canadensis</i> , <i>A. coronaria</i> , <i>A. dichotoma</i> , <i>A. hortensis</i> , <i>A. narcissifolia</i> , <i>A. nemorosa</i> , <i>A. palmata</i> , <i>A. palvoniana</i> , <i>A. pavonina</i> , <i>A. ranunculoides</i> , <i>A. reflexa</i> , <i>A. sylvestris</i> , <i>A. trifolia</i> , <i>A. uralensis</i> <i>Chrysosplenium alterniflorum</i> , <i>C. oppositifolium</i> <i>Gypsophila acutifolia</i> , <i>G. altissima</i> , <i>G. arrostii</i> , <i>G. belorossica</i> , <i>G. bermejoi</i> , <i>G. collina</i> , <i>G. elegans</i> , <i>G. fastigiata</i> , <i>G. glomerata</i> , <i>G. linearifolia</i> , <i>G. litwinowii</i> , <i>G. macedonia</i> , <i>G. montserratii</i> , <i>G. muralis</i> , <i>G. nana</i> , <i>G. pallasii</i> , <i>G. paniculata</i> , <i>G. papillosa</i> , <i>G. patrinii</i> , <i>G. perfoliata</i> , <i>G. petraea</i> , <i>G. pilosa</i> , <i>G. repens</i> , <i>G. scorzonifolia</i> , <i>G. spergulifolia</i> , <i>G. struthium</i> , <i>G. tomentosa</i> , <i>G. uralensis</i> <i>Helleborus bocconeii</i> , <i>H. dumetorum</i> , <i>H. foetidus</i> , <i>H. lividus</i> , <i>H. multifidus</i> , <i>H. niger</i> , <i>H. odoratus</i> , <i>H. orientalis</i> , <i>H. purpurascens</i> , <i>H. viridis</i> <i>Helianthemum nummularium</i> , <i>H. oelandicum</i> <i>Humulus lupulus</i> , <i>H. scandens</i> <i>Jasione montana</i> <i>Myrica faya</i> , <i>M. gale</i> ...	Anémones Dorines Gypsophiles Hellébore Hélianthèmes Houblons Jasione des montagnes Myrique ...

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
21	<i>Papaver</i>	<i>Papaver alpinum, P. apulum, P. arenarium, P. argemone, P. chibinense, P. croceum, P. dahliaenum, P. dubium, P. guerlekense, P. hybridum, P. laestadianum, P. lapeyrousianum, P. lapponicum, P. macrostomum, P. pinnatifidum, P. purpureomarginatum, P. radicum, P. rhoeas, P. rupifragum, P. somniferum</i>	Pavots
	<i>Paronychia</i>	<i>Paronychia albanica, P. arabica, P. aretioides, P. argentea, P. bornmuelleri, P. capitata, P. cephalotes, P. chionaea, P. echinulata, P. kapela, P. macedonica, P. macrosepala, P. polygonifolia, P. pontica, P. rechingeri, P. rouyana, P. suffruticosa, P. taurica</i>	Paronyque
	<i>Plantago lanceolata</i>	<i>Plantago lanceolata</i>	Plantain lancéolé
	<i>Polygonum aviculare</i>	<i>Polygonum aviculare</i>	Renouée des oiseaux
	<i>P. bistorta</i>	<i>P. bistorta</i>	Renouée bistorte
	<i>P. persicaria</i>	<i>P. hydropiper, P. lapathifolium, P. minus, P. mite, P. persicaria</i>	Renouée persicaire
	<i>Sanguisorba</i>	<i>Sanguisorba officinalis, S. minor</i>	Sanguisorbe
	<i>S. minor</i>	<i>S. minor</i>	Petite pimprenelle
	<i>S. officinalis</i>	<i>S. officinalis</i>	Pimprenelle officinale
	<i>Saxifraga</i>	<i>Saxifraga adscendens, S. aizoides, S. cernua, S. cespitosa, S. cotyledon, S. granulata, S. hirculus, S. oppositifolia, S. rivularis, S. stellaris, S. tridactylites</i>	Saxifrages
	<i>S. aizoides</i>	<i>S. aizoides</i>	Saxifrage faux-aizoon
	<i>Scleranthus</i>	<i>Scleranthus annus, S. perennis, S. uncinatus</i>	Scléranthe
	<i>Spergula</i>	<i>Polycarpon diphyllum, P. tetraphyllum, Spergula arvensis, S. morisonii, S. pentandra, S. viscosa, Spergularia echinosperma, S. maritima, S. rubra, S. rupicola, S. salina, S. segetalis</i>	Spergule
	<i>Succisa pratensis</i>	<i>Succisa pratensis</i>	Succise des prés
	<i>Urtica</i>	<i>Urtica atrovirens, U. dioica, U. kioviensis, U. membranacea, U. morifolia, U. pilulifera, U. rupestris, U. urens</i>	Orties
<i>Urticaceae</i>	<i>Forssskalea, Parietaria, Soleirolia, Urtica</i>	Urticacées	

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
22	<i>Asteraceae</i> <i>asteroideae</i>	<i>Achillea, Adenostyles, Andryala, Antennaria, Arctium, Arnica, Arnoseris, Artemisia, Aster, Bellis, Bidens, Bupthalam, Calendula, Carduncellus, Carduus, Carlina, Carthamus, Centaurea, Chrysanthemum, Cirsium, Crupina, Doronicum, Echinops, Erigeron, Eupatorium, Evax, Filago, Galactites, Gnaphalium, Helichrysum, Inula, Leuzea, Matricaria, Mycelis, Pallenis, Petasites, Phagnalon, Pulicaria, Senecio, Serratula, Tussilago</i>	Asteroidées ou Tubuliflores
	<i>Asteraceae</i> <i>cichorioideae</i>	<i>Catananche, Chondrilla, Cicerbita, Cichorium, Crepis, Hedypnois, Hieracium, Homogyne, Hyoseris, Hypochoeris, Lactuca, Lagoseris, Lapsana, Leontodon, Micropus, Picris, Prenanthes, Reichardia, Santolina, Scolymus, Scorzonera, Solidago, Sonchus, Staehelina, Traxacum, Thrinicia, Tolpis, Tragoporon, Urospermum</i>	Cichorioidées ou Liguliflores
	Gramineae	<i>Agropyrum, Agrostis, Aira, Alopecurus, Ammophila, Andropogon, Anthoxantum, Arrhenatherum, Arundo, Avellinia, Avena, Brachypodium, Briza, Bromus, Calamagrostis, Catapodium, Corynephorus, Cynodon, Cynosurus, Dactylis, Danthonia, Deschampsia, Digitaria, Echinochloa, Elymus, Festuca, Gastridium, Glyceria, Holcus, Hordeum, Koelaria, Lagurus, Leersia, Lepturus, Lolium, Melica, Mibora, Miliun, Molinia, Nardurus, Nardus, Oryza, Oryzopsis, Paspalum, Phalaris, Phleum, Poa, Polypogon, Psilurus, Scleropoa, Sesleria, Setaria, Sporobolus, Stypa, Trisetum, Vulpia, Myriophyllum alterniflorum, M. spicatum, M. verticillatum</i>	Graminées
	<i>Myriophyllum</i>	<i>Myriophyllum alterniflorum, M. spicatum, M. verticillatum</i>	Myriophylle
	<i>Umbelliferae</i>	<i>Aegopodium, Aethusa, Angelica, Anthriscus, Apium, Astrantia, Athamanta, Bunium, Bupleurum, Carum, Chaerophyllum, Conopodium, Daucus, Echinophora, Eryngium, Falcaria, Ferula, Foeniculum, Heracleum, Laserpitium, Meum, Myrrhis, Oenanthe, Pastinaca, Peucedanum, Pimpinella, Ptychotis, Sanicula, Scandix, Selinum, Sesli, Silaus, Smyrnium, Torilis, Trinia, Trochischanthes</i>	Ombellifères

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
23	<i>Anthemis</i>	<i>Anthemis arvensis</i> , <i>A. cotula</i> , <i>A. tinctoria</i>	Anthémis
	<i>Artemisia</i>	<i>Artemisia absinthium</i> , <i>A. campestris</i> , <i>A. vulgaris</i>	Armoises
	<i>Bidens</i>	<i>Bidens cernua</i> , <i>B. tripartita</i> , <i>B. radiata</i>	Bidens
	<i>Brassica</i>	<i>Brassica balearica</i> , <i>B. barbelieri</i> , <i>B. biononiana</i> , <i>B. cadmea</i> , <i>B. cretica</i> , <i>B. drepanensis</i> , <i>B. elongata</i> , <i>B. fruticosa</i> , <i>B. glabrescens</i> , <i>B. gravinae</i> , <i>B. incana</i> , <i>B. insularis</i> , <i>B. juncea</i> , <i>B. macrocarpa</i> , <i>B. montana</i> , <i>B. nigra</i> , <i>B. nivalis</i> , <i>B. oleracea</i> , <i>B. oxyrhina</i> , <i>B. procumbens</i> , <i>B. rapa</i> , <i>B. repanda</i> , <i>B. rupestris</i> , <i>B. souliei</i> , <i>B. tinei</i> , <i>B. tournefortii</i> , <i>B. villosa</i>	Choux, moutarde,...
	<i>Calystegia sepium</i>	<i>Calystegia sepium</i>	Liseron des haies
	<i>Carduus</i>	<i>Carduus aca</i> , <i>C. crispus</i> , <i>C. nutans</i>	Chardons
	<i>Euphorbia</i>	<i>Euphorbia cyparissias</i> , <i>E. esula</i> , <i>E. exigua</i> , <i>E. helioscopia</i> , <i>E. palustris</i>	Euphorbes
	<i>Hypericum</i>	<i>Hypericum hirsutum</i> , <i>H. humifusum</i> , <i>H. maculatum</i> , <i>H. montanum</i> , <i>H. perforatum</i> , <i>H. pulchrum</i> , <i>H. tetrapterum</i>	Millepertuis
	<i>Knautia arvensis</i>	<i>Knautia arvensis</i>	Knautie des bois
	<i>Lamium</i>	<i>Lamium album</i> , <i>L. amplexicaule</i> , <i>L. hybridum</i> , <i>L. moluccellifolium</i> , <i>L. purpureum</i>	Lamiers
	<i>Lysimachia</i>	<i>Lysimachia nemorum</i> , <i>L. nummularia</i> , <i>L. thysifolia</i> , <i>L. vulgaris</i>	Lysimaques
	<i>Lythrum</i>	<i>Lythrum portula</i> , <i>L. salicaria</i>	Pourpier et Salicaire
	Papaveraceae	<i>Argemone</i> , <i>Capnoides</i> , <i>Ceratocarpus</i> , <i>Chelidonium</i> , <i>Corydalis</i> , <i>Dicentra</i> , <i>Eschscholzia</i> , <i>Fumaria</i> , <i>Glaucium</i> , <i>Hypocoum</i> , <i>Meconopsis</i> , <i>Papaver</i> , <i>Platycarpus</i> , <i>Pseudofumaria</i> , <i>Roemeria</i> , <i>Rupicapnos</i> , <i>Sarcocarpus</i>	Pavots
	<i>Plantago</i>	<i>Plantago coronopus</i> , <i>P. indica</i> , <i>P. lanceolata</i> , <i>P. major</i> , <i>P. maritima</i> , <i>P. media</i> , <i>P. tenuiflora</i>	Plantains
<i>P. major</i>	<i>P. major</i>	Plantain à larges feuilles	
<i>Polygala</i>	<i>Polygala amarella</i> , <i>P. comosa</i> , <i>P. vulgaris</i>	Polygales	
<i>Potentilla</i>	<i>Potentilla anglica</i> , <i>P. anserina</i> , <i>P. argentea</i> , <i>P. cinerea</i> , <i>P. collina</i> , <i>P. erecta</i> , <i>P. fruticosa</i> , <i>P. heptaphylla</i> , <i>P. norvegica</i> , <i>P. palustris</i> , <i>P. recta</i> , <i>P. reptans</i> , <i>P. rupestris</i> , <i>P. sterilis</i> , <i>P. tabernaemontani</i> , <i>P. thuringiaca</i>	Potentilles	
<i>Sedum</i>	<i>Sedum acre</i> , <i>S. album</i> , <i>S. anglicum</i> , <i>S. annuum</i> , <i>S. reflexum</i> , <i>S. sexangulare</i> , <i>S. telephium</i> , <i>S. villosum</i>	Orpins	
<i>Stachys</i>	<i>Stachys arvensis</i> , <i>S. palustris</i> , <i>S. officinalis</i>	Epiaves	

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
24 ...	<i>Caltha</i>	<i>Aquilegia vulgaris, Caltha palustris, Isopyrum thalictroides, Myosurus minimus</i>	Populage des marais
	<i>Cardamine</i>	<i>Cardamine amara, C. asarifolia, C. bellidifolia, C. bulbifera, C. caldeirarum, C. carnosa, C. chelidonia, C. corymbosa, C. crassifolia, C. enneaphyllos, C. flexuosa, C. glanduligera, C. glauca, C. gracea, C. granulosa, C. heptaphylla, C. hirsuta, C. impatiens, C. kitaibeli, C. macrophylla, C. majovskii, C. maritima, C. montelucii, C. nymanii, C. parviflora, C. pentaphyllos, C. plumieri, C. pratensis, C. quinquefolia, C. raphanifolia, C. schulzii, C. tenera, C. trifida, C. trifolia, C. udicola, C. uliginosa, C. waldsteinii</i>	Cardamines
	Caryophyllaceae	<i>Agrostemma, Arenaria, Bolanthus, Bufonia, Cerastium, Chaetonychia, Corrigiola, Cucubalus, Cyathophylla, Dianthus, Drypis, Gypsophila, Hernaria, Holosteum, Honkenya, Illecebrum, Loeflingia, Lychnis, Minuartia, Moehringia, Moenchia, Myosoton, Ortega, Paronychia, Petrocoptis, Petrorhagia, Polycarpon, Pseudostellaria, Pteranthus, Sagina, Saponaria, Scleranthus, Silene, Spargula, Spegularia, Stellaria, Telephium, Vaccaria, Velezia</i>	Caryophyllacées
	<i>Cerastium</i>	<i>Cerastium alpinum, C. alsinifolium, C. arcticum, C. arvense, C. azoricum, C. banaticum, C. biebersteinii, C. brachypetalum, C. candidissimum, C. carinthiacum, C. cerastoides, C. dahuricum, C. decalvans, C. dichotomum, C. diffusum, C. dinaricum, C. dubium, C. fontanum, C. gibraltarium, C. glabratum, C. glomeratum, C. gracile, C. grandiflorum, C. illyricum, C. jenisejense, C. julicum, C. latifolium, C. ligusticum, C. lineare, C. maximum, C. moesiacum, C. nemorale, C. pauciflorum, C. pedunculare, C. pedunculatum, C. perfoliatum, C. pumillum, C. pyrenaicum, C. rectum, C. regelii, C. runemarkii, C. scaposum, C. scaranii, C. semidecandrum, C. siculum, C. smolikanum, C. soleirolii, C. subtriflorum, C. sylvaticum, C. thomasi, C. tomentosum, C. transsilvanicum, C. uniflorum, C. vagans, C. vourinense, Holosteum umbellatum, Moenchia erecta, Myosoton aquaticum, Stellaria calycantha, S. graminea, S. humifusa, S. longifolia, S. media, S. neglecta, S. nemorum, S. pallida, S. palustris</i>	Céaistes
	Chenopodiaceae	<i>Achyranthes, Agriophyllum, Alternanthera, Amaranthus, Anabasis, Arthrocnemum, Atriplex, Axyris, Bassia, Beta, Bienertia, camphorosma, Ceratocarpus, Ceratoides,</i>	Chénopodiacées

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
24	<i>Chenopodium</i>	<i>Chenopodium, Corispermum, Cycloloma, Girgensohnia, Halimione, Halimocnemis, Halocnemum, Halogeton, Halopeplis, Halostachys, Hammada, Kalidium, Kochia, Microcnemum, Nanophyton, Noaea, Obione, Ofaiston, Petrosimonia, Polycnemum, Salicornia, Salsola, Suaeda</i> <i>Chenopodium acerifolium, C. album, C. ambrosioides, C. aristatum, C. bonus-henricus, C. botryodes, C. botrys, C. exsuccum, C. ficifolium, C. foliosum, C. giganteum, C. glaucum, C. hybridum, C. jenssejense, C. multifidum, C. murale, C. opulifolium, C. polyspermum, C. pumilio, C. rubrum, C. schraderanum, C. suecicum, C. urbicum, C. vulvaria</i>	Chénopode, Ansérine
	Cruciferae	<i>Aethionema, Allaria, Alyssoides, Alyssum, Andrezeiowskia, Arabidopsis, Arabis, Armoracia, Aubretia, Aurinia, Barbarea, Berteroa, Biscutella, Bivonea, Boleum, Boreava, Bornmuellera, Brassica, Braya, Bunias, Cakile, Calepinia, Camelina, Capsella, Cardamine, Cardaminopsis, Cardaria, Carrichtera, Chorispora, Chrysochamela, Clausia, clypeola, Cochlearia, Coincya, Conringia, Coronopus, Crambe, Degenia, Degenia, Descurainia, Didesmus, Diplotaxis, Diptychocarpus, Draba, Drabopsis, Enarthrocarpus, Eremoblastus, Erophila, Eruca, Erucaria, Erucastrum, Erysimum, Eucidium, Eutrema, Euzomodendron, Fibigia, Goldbachia, Guiraoa, Hesperis, Hirschfeldia, Hornungia, Hugueninia, Hymenolobus, Iberis, Isatis, Jonopsidium, Kerneria, Laevenworthia, Lepidium, Leptaleum, Litwinowia, Lobularia, Lunaria, Lycocarpus, Malcolmia, Maresia, Matthiola, Megacarpaea, Moricandia, Morisia, Murbeckiella, Myagrum, Neotorularia, Neslia, Notoceras, Pachyphragma, Parrya, Peltaria, Petrocallis, Pritzelago, Raphanus, Rapistrum, Rhizobotrya, Ricotia, Ronippa, Schivereckia, Sinapis, Sisymbrella, Sisymbrium, Sobolewska, Sterigmostemmum, Subularia, Succowia, Tauscheria, Teesdalia, Teesdaliopsis, Tetracme, Thellungiella, Thlaspi, Vella</i>	Crucifères
	Polygonaceae	<i>Athraphaxis, Calligonum, Emex, Fallopia, Koenigia, Oxyria, Polygonum, Reynoutria, Rheum, Rumex</i>	Polygonacées

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
	<i>Polygonum</i>	<i>Polygonum acetosum, P. alpinum, P. amphibium, P. amplexicaule, P. aschersonianum, P. aviculare, P. bistorta, P. capitatum, P. cognatum, P. equisetiforme, P. floribundum, P. foliosum, P. graminifolium, P. humifusum, P. hydropiper, P. hydropiperoides, P. icarium, P. idaeum, P. lapathifolium, P. laxmanii, P. maritimum, P. mesembrium, P. minus, P. mite, P. molle, P. nepalense, P. orientale, P. oxyspermum, P. patulum, P. persicaria, P. polystachyum, P. romunum, P. sagittatum, P. salicifolium, P. salsugineum, P. samarense, P. scoparium, P. tenoreanum, P. viviparum</i>	Renouées
	Ranunculaceae	<i>Aconitum, Actaea, Adonis, Anemone, Aquilegia, Callianthemum, Caltha, Ceratocephalus, Cimicifuga, Clematis, Consolida, Delphinium, Eranthis, Garidella, Helleborus, Hepatica, Isopyrum, Myosurus, Nigella, Pulsatilla, Ranunculus, Thalictrum, Trollius</i>	Renonculacées
	<i>Ranunculus</i> ...	<i>Anemone nemorosa, Clematis vitalba, Pulsatilla vulgaris, Ranunculus abnormis, R. acetosellifolius, R. aconitifolius, R. acris, R. aduncus, R. aesontinus, R. affinis, R. allemannii, R. alpestris, R. amplexicaulis, R. angulatus, R. appeninus, R. aquatilis, R. arvensis, R. asiaticus, R. auricomobinatus, R. auricomus, R. auricomus, R. barceloi, R. batrachioides, R. bilobus, R. brevifolius, R. brutius, R. bulbosus, R. bullatus, R. bupleuroides, R. cacuminis, R. carinthiacus, R. carlittensis, R. carpaticus, R. cassubicifolius, R. cassubico-auricomus, R. cassubicus, R. caucasicus, R. chius, R. circinatus, R. clethraphilus, R. concinnatus, R. cordiger, R. cornutus, R. cortusifolius, R. crenatus, R. creticus, R. crimaeus, R. cupreus, R. cymbalaria, R. cymbalariifolius, R. degenii, R. demissus, R. dissectus, R. fallax, R. ficaria, R. ficarioides, R. flabellifolius, R. flammula, R. fluitans, R. fontanus, R. glacialis, R. gmelinii, R. gouanii, R. gracilis, R. gramineus, R. granatensis, R. gregarius, R. grenieranus, R. hayekii, R. hederaceus, R. henriquesii, R. hungaricus, R. hybridus, R. hyperboreus, R. illyricus, R. incomparabilis, R. isthmicus, R. kalinensis, R. kamchaticus, R. lanuginosus, R. lapponicus, R. lateriflorus, R. lingua, R. longipes, R. macrophyllus, R. magellensis, R. malessanus, R. marginatus, R. marschlinsii, R. marsicus, R. megacarpus, R. miliarakesii, R. millefoliatus, R. millii, R. monophyllus, R. monspeliacus, R. montanus, R. montanus, R. muricatus,...</i>	Renoncules
24	...		

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
...	<i>Ranunculus</i>	... <i>R. nigrescens, R. nivalis, R. nodiflorus, R. odessanus, R. olissiponesis, R. oleuleucos, R. omiophyllus, R. ophioglossifolius, R. oreophilus, R. oxyspermus, R. pallasii, R. paludosus, R. pannonicus, R. parnassiifolius, R. parviflorus, R. pedatus, R. peltatus, R. penicillatus, R. platanifolius, R. platyspermus, R. pollinensis, R. polyanthemos, R. polyphyllus, R. polyrhizos, R. pratensis, R. pseudomillefoliatus, R. pseudomontanus, R. psilostachys, R. puberulus, R. pygmaeus, R. pyrenaeus, R. radinotrichus, R. repens, R. reptans, R. revelieri, R. rionii, R. rumelicus, R. sardous, R. sartorianus, R. sceleratus, R. seguieri, R. serbicus, R. silanus, R. silvestraceus, R. sphaerospermus, R. spicatus, R. sprunerianus, R. stajanovii, R. strigulosus, R. subhomophyllus, R. sulphureus, R. thasius, R. thora, R. thracicus, R. traunfellneri, R. trichophyllus, R. trilobus, R. tripartitus, R. velutinus, R. venetus, R. villosus, R. wettsteinii, R. weyeri</i>	... Renoncules
24	<i>Stellaria</i>	<i>Stellaria bungeana, S. calycantha, S. crassifolia, S. crassipes, S. cupaniana, S. fennica, S. graminea, S. hebecalyx, S. holostea, S. humifusa, S. longifolia, S. longipes, S. media, S. neglecta, S. nemorum, S. pallida, S. palustris, S. uliginosa</i>	Stellaires
	<i>Thalictrum</i>	<i>Thalictrum alpinum, T. aquilegiifolium, T. calabricum, T. flavum, T. foetidum, T. lucidum, T. macrocarpum, T. minus, T. morisonii, T. orientale, T. simplex, T. speciosissimum, T. tuberosum, T. uncinatum</i>	Pigamon

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
25	<i>Achillea</i> <i>Alchemilla</i>	<i>Achillea millefolium</i> , <i>A. ptarmica</i> <i>Alchemilla alpina</i> , <i>A. glabra</i> , <i>A. glaucescens</i> , <i>A. glomerulens</i> , <i>A. gracilis</i> , <i>A. monticola</i> , <i>A. murbeckiana</i> , <i>A. plicata</i> , <i>A. propinqua</i> , <i>A. sarmatica</i> , <i>A. subcrenata</i> , <i>A. vestita</i>	Achillées Alchémilles
	<i>Angelica</i> <i>Campanula</i>	<i>Angelica archangelica</i> , <i>A. sylvestris</i> <i>Campanula cervicaria</i> , <i>C. glomerata</i> , <i>C. latifolia</i> , <i>C. patula</i> , <i>C. persicifolia</i> , <i>C. rapunculoides</i> , <i>C. rotundifolia</i> , <i>C. trachelium</i>	Angéliques Campanules
	<i>Cirsium</i>	<i>Cirsium acaule</i> , <i>C. arvense</i> , <i>C. asculentum</i> , <i>C. heterophyllum</i> , <i>C. oleraceum</i> , <i>C. palustre</i> , <i>C. rhizocephalum</i> , <i>C. vulgare</i>	Cirses
	<i>Epilobium</i>	<i>Epilobium angustifolium</i> , <i>E. alsinifolium</i> , <i>E. anagallidifolium</i> , <i>E. collinum</i> , <i>E. davuricum</i> , <i>E. hirsutum</i> , <i>E. lactiflorum</i> , <i>E. montanum</i> , <i>E. obscurum</i> , <i>E. palustre</i> , <i>E. parvifolium</i> , <i>E. roseum</i> , <i>E. tetragonum</i>	Épilobes
	<i>Filipendula</i> <i>Galium</i>	<i>Filipendula ulmaria</i> , <i>F. vulgaris</i> <i>Galium aparine</i> , <i>G. mollugo</i> , <i>G. odoratum</i> , <i>G. palustre</i> , <i>G. pumilum</i> , <i>G. rotundifolium</i> , <i>G. saxatile</i> , <i>G. spurium</i> , <i>G. uliginosum</i> , <i>G. verum</i>	Filipendules Gaillets
	<i>Geranium</i>	<i>Geranium bohemicum</i> , <i>G. columbinum</i> , <i>G. dissectum</i> , <i>G. lanuginosum</i> , <i>G. molle</i> , <i>G. palustre</i> , <i>G. pratense</i> , <i>G. pusillum</i> , <i>G. pyrenaicum</i> , <i>G. robertianum</i> , <i>G. sanguineum</i> , <i>G. silvaticum</i>	Géraniums
	<i>Geum</i>	<i>Geum aleppicum</i> , <i>G. hispidum</i> , <i>G. rivale</i> , <i>G. urbanum</i>	Benoïtes
	<i>Heracleum sphondylium</i>	<i>Heracleum sphondylium</i>	Berce sphondyle
	<i>Hippuris</i> <i>Melampyrum</i>	<i>Hippuris tetraphylla</i> , <i>H. vulgaris</i> <i>Melampyrum arvense</i> , <i>M. cristatum</i> , <i>M. memorosum</i> , <i>M. polonicum</i> , <i>M. prater</i> , <i>M. sylvaticum</i>	Hippurides, Pesses Mélampyre
	<i>Pedicularis</i>	<i>Pedicularis flammea</i> , <i>P. lapponica</i> , <i>P. oederi</i> , <i>P. palustris</i> , <i>P. sceptrum-carolinum</i> , <i>P. sylvatica</i>	Pédiculaire
	<i>Rumex</i>	<i>Rumex acetosa</i> , <i>R. acetosella</i> , <i>R. aquaticus</i> , <i>R. conglomeratus</i> , <i>R. crispus</i> , <i>R. hydrolapathum</i> , <i>R. maritimus</i> , <i>R. obtusifolius</i> , <i>R. palustris</i> , <i>R. sanguineus</i>	Oseilles
	<i>R. acetosella</i> <i>Trifolium</i>	<i>R. acetosella</i> <i>Trifolium alpestre</i> , <i>T. arvense</i> , <i>T. aureum</i> , <i>T. campestre</i> , <i>T. dubium</i> , <i>T. fragiferum</i> , <i>T. hybridum</i> , <i>T. medium</i> , <i>T. montanum</i> , <i>T. pratense</i> , <i>T. repens</i> , <i>T. spadiceum</i> , <i>T. striatum</i>	Petite oseille Trèfles