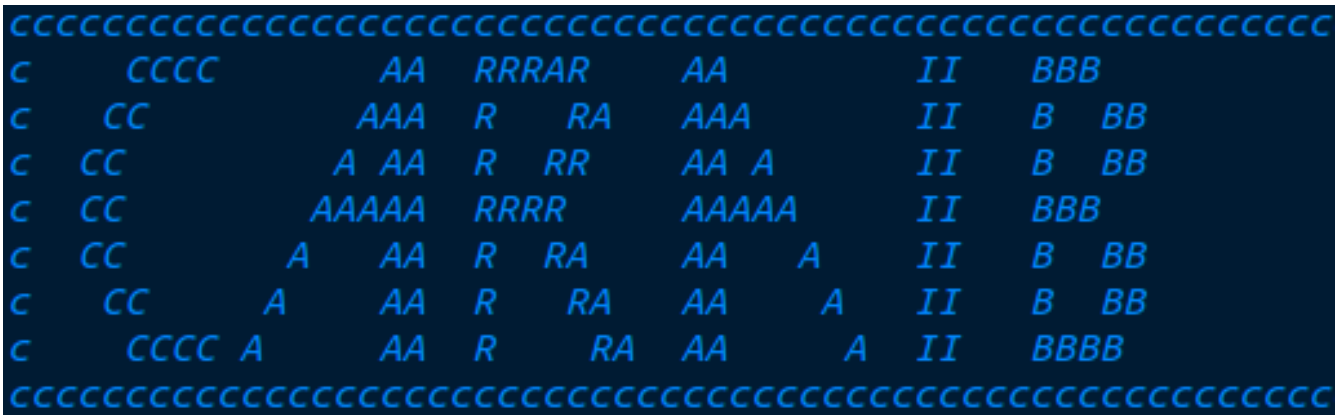

CARAIB USER'S GUIDE

version 1.0

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Table of Contents

Reference: Minet, J. ; Jacquemin, I. & François, L. *CARAIB user's guide*, Université de Liège, Liège, Belgium, 2013

1 Introduction

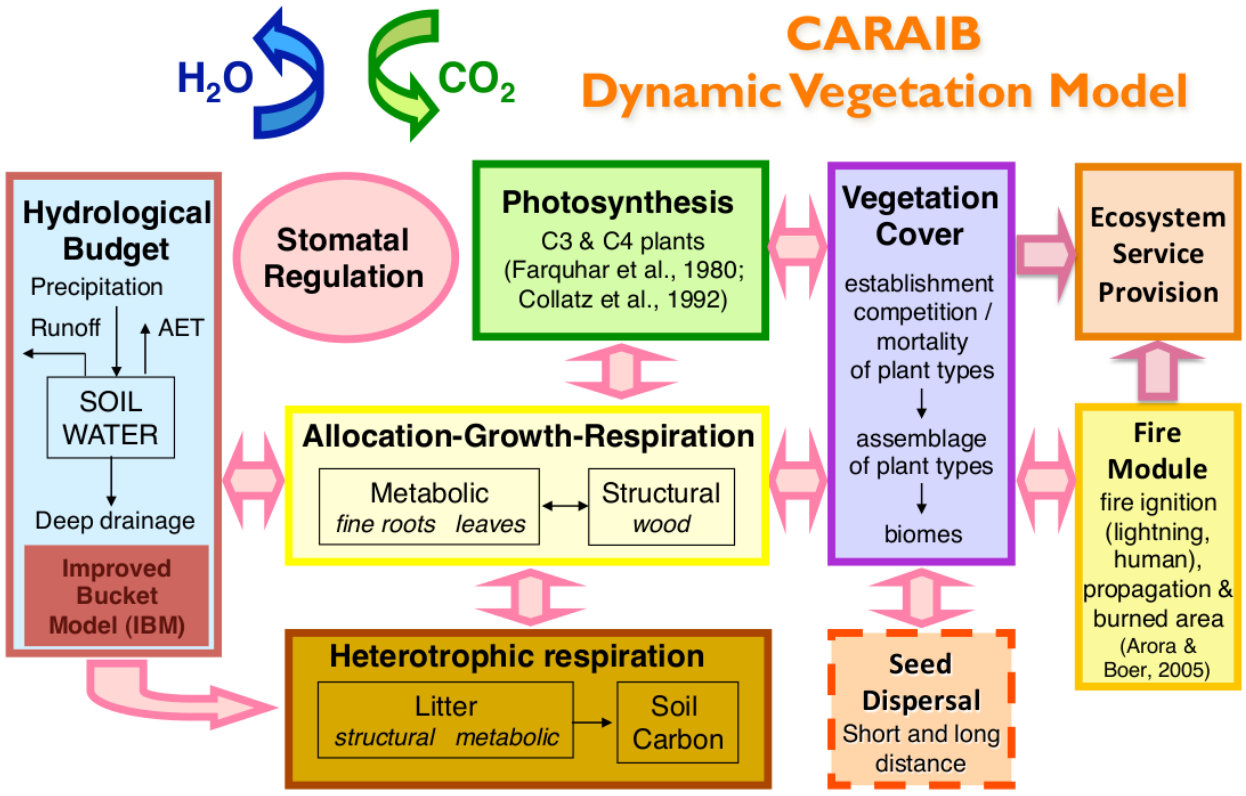
CARAIB is a dynamic vegetation model (DVM) written in FORTRAN and developed at Université de Liège. It can simulate the vegetation growth from the local to the global scales, for various crops and natural vegetation, and has been applied for past and future ecosystems.

This is the first version of the CARAIB user's guide. This guide is to help you making your first steps using the model CARAIB. It focuses on the description of the inputs and outputs files. There are a brief description of the model as a pseudocode and a list of the routines used in the model.

2 Theoretical concepts

2.1 Main structure

CARAIB is a mechanistic model studying vegetation behaviour as a function of climate and soil. It is built to cover many 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 is 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. Dispersion module is now implemented in CARAIB and competition for light and water are included. Two strata of vegetation are simulated: the first including principally trees and the second one concerning shrubs, herbs and crops. Competition for nutrient is only induced by C/N dependent parameters. The fraction of each pixel covered by a given Bioclimatic Affinity Group (BAG) is calculated as being proportional to the BAG's Net Primary Productivity (NPP).

2.4 Plant types, characteristics and presence

Vegetation is distributed in 26 BAGs (*Laurent et al., 2004*) representing both the functional type and the adaptation to climate. The example version of CARAIB also includes 8 plant species for which carbon pools and fluxes are calculated separately (the results here are not included in pixel means). In the newest versions, CARAIB does also include crops.

2.5 References

See at this end of the document for a alphabetic list of references related to CARAIB. The most comprehensive and first reference is the PhD thesis of Pierre Warnant, ULg, 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
idayt,ifull        : 1  0
ifire              : 0
nyrmax,stept       : 8  1.
nyrprt,nstprt      : 1  1
iread,iczon        : 0  1
idaily_in,idaily_ou: 1  1
pixel number       : 20
resolution (lg*lat): 0.02778
exc,obl,xlsper     : 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
air temp (climatol):./clim/tem.dat
precip   (climatol):./clim/prc.dat
air temperature    :./clim/tem
temp. daily vari.  :./clim/dte
precipitation      :./clim/prc
sunshine hour      :./clim/shr
air relat. humidity:./clim/rhu
wind speed         :./clim/wnd
lightning data     :./clim/lightning
human coverage     :./clim/human_frac
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/csurn.dat
PFT 1/gkfall       :./plantparam/gkfall.dat
PFT gama1, gama2   :./plantparam/gama.dat
PFT carb_init      :./plantparam/carbinit.dat
Crops seasonality  :./plantparam/bagseas.dat
```

```
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
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
results (test file):./results/water.tes
test (problems)    :./results/carbon.problem
current pixel-date :./results/water.time
yearly mean results:1 ./results/water_yr
monthly mean sw    :1 ./results/sw
monthly mean pet   :1 ./results/pet
monthly mean aet   :1 ./results/aet
monthly mean runoff:1 ./results/run
monthly mean fsn   :1 ./results/fsn
monthly mean drain :1 ./results/drn
monthly mean vs ev :1 ./results/sve
monthly mean rbl   :1 ./results/rbl
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
monthly mean biom  :1 ./results/biommth
monthly mean gpp   :1 ./results/gppmth
monthly mean npp   :1 ./results/nppmth
monthly mean nep   :1 ./results/nepmth
monthly mean lai(C):1 ./results/laimth
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
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
daily species npp  :1 ./results/nppd
year  pco2   iprt   filexto (must start in column 21) filexti (must start in column 26)
   1  380.      1   2002 2002
   2  380.      1   2003 2003
```

```
    3  380.      1   2004 2004
    4  380.      1   2005 2005
    5  380.      1   2006 2006
    6  380.      1   2007 2007
    7  380.      1   2008 2008
    8  380.      1   2009 2009
  !
```

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
ifire	1 to call the fire module.
iprt_fire	1 to print fire module results.
nyrmax	Total number of years (1 for steady state run or 1 year run, more otherwise)
stept	Iteration step in IBM (1. for normal run)
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 (copied files from a previous simulations 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.
pixel numb	Number of pixel.

[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).

resolution (lg*lt)	Spatial resolution [degree^2], which is equals to the product of the longitude by the latitude. (e.g., 0.25 for a simulation on a 0.5° X 0.5° grid in longitude – latitude)
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
nbush	Number of shrub BAGs
ntree	Number of tree BAGs
nc	Number of crop BAGs
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 content of the input files are fully described in another section below.

Parameter name	Description
soil texture	Path for the soil texture parameters (eco.dat)
air temp (climatol)	Path for the monthly or daily average air temperature data (climatological values used to determine the pixel climatic type)
precip (climatol)	Path for the monthly or daily average precipitations data (climatological values used to determine the pixel climatic type)
air temperature	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.
temp. daily vari.	Path for the monthly or daily values of diurnal variation of the temperature (daily difference between maximal and minimal temperatures) for the studied year [°C]
precipitation	Path for the monthly or daily values of precipitations for the studied year [mm/month]
sunshine hour	Path for the monthly or daily values of percentage of sunshine hours [%].
air relat. humidity	Path for the monthly or daily values of air relative humidity for the studied year [%]
wind speed	Path for the monthly or daily values of wind speed at the surface for the studied year [m/s]
lightning data	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.
human coverage	Path for the values of the fraction of the land use classes for each pixel.
path for generator	Path for the directory containing the weather stochastic generator (/gene)
PFT alb zzra t1 t2	Path for the parameter file used by hydrological module IBM (bagibm.dat)
PFT tolerances	Path for the parameter file of « climatic » limits for BAG presence (bagtol.dat)
PFT parameters	Path for the parameter file of carbon module parameters (bagpar.dat)
PFT age class para	Path for the parameter file of age classes parameters (claspar.dat)
PFT C:N of veget	Path for the parameter file of C/N of metabolic (leaves) and structural ("wood") pools (csurn.dat)
PFT 1/gkfall	Path for the parameter file of characteristic times of leaves fall and "wood" dead (gkfall.dat).
PFT gama1, gama2	Path for the parameter file of multiplying factor for litter (γ_1) and soil carbon (γ_2) decomposition (gama.dat)
PFT carb_init	Path for the parameter file of carbon content of "seed" (carbinit.dat)

Crops seasonality	Path for the parameter file of crop phenology parameters (bagseas.dat)

c) Paths for output files

The following lines 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 (filexto) 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 (*eco.dat*)

The input file *eco.dat* 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)	Meteorological variable	Units*
tem	Mean temperature	°C
dte	Daily amplitude of temperature (Tmax-Tmin)	°C
prc	Precipitation	mm
shr	Sunshine hours	%
rhu	Relative humidity	%
wnd	Wind speed	m/s
lightning	Rate of lightning	#flashes/km²
human_frac	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.	/
manag	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 the cutting, the LAI after cutting [$m^2_{leaves}/m^2_{surface}$], and the dry matter after cutting in [gC/m^2]	/
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]	

*** 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 BAG that is defined in the model. There are currently 25 BAG of natural vegetation and 9 cultivated crops. The natural vegetation BAG can be classified in herbaceous vegetation (BAG 21-25), shrubs (BAG 14-20) and trees (BAG 1-19). A full list of the species in each BAG can be found in Annex I.

BAG number	Main species
25	Achillea, Alchemilla, Angelica, Campanula
24	Brassicaceae, Caltha, Cardamine, etc
23	Anthemis, Artemisia, Bidens, Calystegia, etc
22	Asteraceae asteroideae, Poaceae, etc
21	Anemone, Gypsophila, Helleborus, etc
20	Ephedra, Ulex
19	Alnus vir, Arctostap., A.alpinus, B. nana

18	Sambucus, Frangula a, Prunus, Sorbus, Vaccinium
17	Berberis vul., Crataegus, Genista, Rhamnus
16	Artostaphylos uva-ursi, Calluna vul., Daphne
15	Buxus sempervirens, Hedera h., Ilex acquif.
14	Cistus, Myrtus
13	Betula, Salix
12	Alnus, A gl, Corylus, Q. robur, Populus, Tilia
11	Acer, Fraxinus, F excel, Tilia cordata, Ulmus
10	Acer campestre, Carpinus, Fagus syl, Tilia pla
9	Castanea, Juglans, Ostrya, Q. pubescens
8	Olea eur, Pistacia, Phillyrea, Q ilex, Q suber
7	Larix decidua
6	Picea abies, Pinus, Pinus sylvestris
5	Abies
4	Cupressaceae, Juniperus, Juniperus communis
3	Pinus Cembra
2	Abies Alba, Taxus
1	Cedrus, Pinus halepensis, Pinus pinaster
c1	Orge d'hiver
c2	Orge de printemps
c3	Froment d'hiver
c4	Froment de printemps
c5	Pommes de terre
c6	Betterave
c7	Colza
c8	Mais d'ensilage
c9	Faba bean

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

File	Parameter name	Description	Units
bagibm.dat	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	/
bagpar.dat	g0	intercept for the stomatal conductance	µmol/m² s
	g1	slope for the stomatal conductance	/
	splai	specific leaf area	m²/gC
	delc2	Fractionation linked to diffusion through stomatal cavities for each species	/
	xi(1)	Parameter of the equation for carbon allocation to pool	$(gC/m^2)^{-\chi}$
	xi(2)	Parameter of the equation for carbon allocation to pool	$(gC/m^2)^{-\chi}$
	resef	Parameter of the equation for available biomass for bud	
	xk		/
	rootf	Fraction of the assimilates that are allocated to the roots	/
bagtol.dat	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		
carbinit.dat	carb_init pool N°	Initial value of carbon pool (pool 1)	gC/m²
	Carb init pool N°	Initial value of carbon pool (pool 2)	gC/m²
claspar.dat	nclas	Number of age classes for this BAG	/
	nclas values	Follow-up of the age classes for this BAG	/
	iyear_max	Lifespan max	year
csurn.dat	csurn	C/N ratio for this BAG (pool 1)	%
	pool N°	C/N ratio for this BAG (pool 2)	%

gama.dat	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)	/
gkfall.dat	1/gkfall	4 values for the mortality characteristic time (without or with stress and for pool 1 and pool 2)	year
	1/gkboom	Characteristic time for bud formation	year
bagseas.dat	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

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 and (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
frac.res (read if ifrac_rd=1)	20	Vegetation fraction	It is the fraction of each BAG for each pixel. This file is actually an input file and output file as the BAG fraction can evolve following the dissemination of BAG depending on evolving climatic conditions in the model. Not to be mistaken with *human_frac.dat* that refers to the fraction of land use (see above).	/
xlai_min_max.res read if ilai_rd=1)	21	Initial Min Max LAI	Minimal and maximal value for LAI values of the BAGs that are modeled in CARAIB. First are the minimal values for all the BAG that are used, then the maximal values for hydrological module.	m^2/m^2
biomass.res (read if iread=1)	25	Initial values	Initial values for soil water content, carbon in the two pools, for bud, litter and human frac	
ylailim.res (read if iread=1)	125	LAI limitation	Initialisation of xlmin and xlmax (cf bagibm.dat)	
zone.res (read if iczon≠1)	22		Determination of the climate zone for all pixels	

stochas.gen (read if ngener≠1)	23		Initialisation of the weather generator : calculation of different probabilities for the 176 climatic zones of Koppen	
water.full (open if ifull=1)	24			
biomass	26		Write sngl, carbon content of pools, parameter of the equation for available biomass for bud, litter and humus values	
ylailim	126		Write xlmin and xlmax (cf bagibm.dat)	
water.tes	28	Daily results if ifull = 1	Write calculation for average surface temperature	
carbon.problem	61	Problem	Some error messages can be printed in this file	
water.time	29			

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
aburn.res	75	Burned area	Monthly or daily burned area.	m²
aet.res	33	Actual evapotranspiration	Monthly or daily values of actual evapotranspiration.	mm
alb.res	39	Albedo	Monthly or daily values of the average albedo of the pixel.	/
Csoil.res	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
Cveg.res	66	Amount of carbon	Amount of carbon stocked per BAG.	gC
drn.res	36	Drainage	Monthly or daily values of drainage.	mm
emisf.res	52	Surface emissivity	Monthly or daily values of the surface emissivity.	/
fburn.res	74	Burned pixel fraction	Monthly or daily burned pixel fraction.	/
fgs.res	43	Snow-free green cover	Monthly or daily values of the snow-free green cover fraction.	/
fird.res	45	Downward infrared radiation	Monthly or daily values of the downward infrared radiation.	W/m²
frac.res	60	Fraction of each BAG		/
frcC13.res	68	Isotopic fraction of C13	Isotopic fraction of C13 per BAG.	???
fsn.res	35	Fraction of snow	Monthly or daily values of fraction of snow.	/
fsol.res	48	Incoming solar radiation	Monthly or daily values of the incoming solar radiation.	W/m²
gdd.res	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
gpp.res	65	Gross Primary Productivity	Annual sum of GPP per BAG.	gC/m²
gppmth.res	56	Gross Primary Productivity	Monthly or daily values of the GPP.	gC/m²
grf.res	41	Ground flux	Monthly or daily values of the heat flux to the ground.	W/m²
lai.res	44	Leaf area index	Monthly or daily values of the leaf area index.	m²/m²
laimoy.res	69	LAI per BAG	Yearly average of LAI per BAG.	m²/m²
laimth.res	59	Leaf area index	Monthly or daily values of the leaf area index.	m²/m²

nepmth.res	58	Net Ecosystem Productivity	Monthly or daily values of the NEP.	gC/m²
npp.res	62	Net Primary Productivity	Annual sum of NPP per BAG.	gC/m²
nppd.res	76	NPP per day	Daily values of NPP per BAG.	gC/day
nppmth.res	57	Net Primary Productivity	Monthly or daily values of the NPP.	gC/m²
pet.res	32	Potential evapotranspiration	Monthly or daily values of potential evapotranspiration.	mm
pfire.res	73	Probability of fire	Monthly or daily probability of fire.	/
rbl.res	38	aerodynamic resistance for water	Monthly or daily values of aerodynamic resistance for water (averaged over vegetation and soil)	s/m
Rmin.res	63	Ratio of LAImin / LAImax	Ratio of minimal LAI over maximal LAI per BAG.	/
rn.res	40	Net radiation	Monthly or daily values of mean net radiation	W/m²
run.res	34	Runoff	Monthly or daily values of runoff.	mm
sf.res	49	Snow fall	Monthly or daily values of the snow fall.	mm
sml.res	51	Snow melt	Monthly or daily values of the snow melt.	mm
sne.res	50	Snow evaporation	Monthly or daily values of the snow evaporation.	mm
sve.res	37	Soil+vegetation evapotranspiration	Monthly or daily values of soil+vegetation evapotranspiration. It includes all evapotranspiration except snow evaporation and evaporation of intercepted water.	mm
sw.res	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 to1 beyond field capacity and saturation.	/
Tdmin.res	70	Min. and max. daily temperature	Yearly minimal and maximal daily temperature.	°C
Tmmin.res	71	Min. and max. monthly temperature	Yearly minimal and maximal monthly temperature (month average).	°C
ts.res	42	Temperature of the surface	Monthly or daily values of the temperature of the surface.	°C
water_yr.res	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 | wbudy - wbudy | Minimal soil water content [m³/m³] – aswmin | fractional vegetation cover - fveg |	mm or m³/m³ for soil water content
x_lai_min_max.res	64	Min. and max. LAI	Yearly minimal and maximal values of LAI per BAG. Minimal values are written first for each BAG, then maximal values.	m²/m²
xh.res	46	Sensible heat flux	Monthly or daily values of the sensible heat flux.	W/m²
xle.res	47	Latent heat flux	Monthly or daily values of the latent heat flux.	W/m²

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

itochar2(i,ch)	Convert an integer into a character
koppen2(climate)	Used in zonepxl2.
lai_limit_w	Calculates monthly lai limits to assure coherence between CARAIB and IBM
lailim_init	Reads initial value of lai limitation due to water stress
mortality	Calculates the mortality rate
moulton(stept,drv,y,ynew)	Linear multistep Adams-bashforth method
new_frac(ngt)	Calculates the vegetation succession.
nonlineq(xa,xb,nint,x,fx,ermax,nitmax,imeth,num)	Solves a non linear equation of the type
npp_cal(ngt,ny0,iread)	Calculates the net primary productivity and the co2 carbon pools.
ode(tbegin,tend,y,stept,niter,ipr)	Resolves ordinary differential equations (used in givedrv).
open_file(iread)	Open input and output files.
open_input5(nyrmax,stept,iread)	Open and read caraib.dat.
pft_estab	Estimates establishment success for plant types.
polfit(xi,yi,ni,aj,ndeg,err,cj,sl)	Numerical computation
ponc_init	Performs the initialisation of some variables (ynpp, ygpp, ynep, xmnpp, xmgpp, zgpp)
printing(ipr,time,y,drv)	Summarizes and writes some variables.
puiss(x,k,xk)	Numerical computation
randnum(seed,frnd)	Returns a random number between 0 and 1
read_cult(ngt)	Reads the PFT fraction over the pixel
read_eco(ngt)	Reads the different environmental inputs as well as vegetation characteristics.
read_in(ngt)	Read environmental and vegetation inputs and compute some environmental parameters.
read_init(iread,ngt)	Reads initial conditions files
record_grid(y,ngt)	Records soil water, biomass, soil carbon and leaf area index in vectors for initialisation at the beginning of the next year
remember(drv)	Saves the derivatives and back differences at previous time step
runkut4(stept,time,y,drv)	Runge-Kutta method
set_cpools(ngt)	Reads initial value of carbon pools and set them in the right form.
set_frac(ngt)	Reads the different environmental inputs as well as vegetation characteristics and sets them in the right form.
soil_resp	Estimates the monthly soil respiration rate
solar	Calculates the solar irradiance at the earth surface
solar_flux	Calculates the radiative transfer within the canopy.
solar_trees(ngt)	Used in npp_cal
tau(aa,bb,fnet,rdep,drk0,X0,XN,TAUI,NI)	Used in drainage.
TDT(mlength,mondec,flag,tabrT,tabrDT,zone,seed)	Random estimation for temperatures
timedep(stept,time)	Arranges variables at different time steps.
wat_limit	Determines the maximum lai when soil water is missing.
wri_1st(y,nyear,ngt)	Writes first year results
wri_res	Writes results to results files
year_iteration	Integrates variables over the year
zone2(reg,region)	Used in zonepxl2.
zonepxl2(iprint)	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. Using this software, the code is compiled using the following command on UNIX systems:

```
ifort caraib.f
```

Then, the model is run by typing in the command line:

```
./a.out
```

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

5 List of abbreviations

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

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Annexe 1.1

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

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

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

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
	Papaver	*Papaver alpinum, P. apulum, P. arenarium, P. argemone, P. chibinense, P. croceum, P. dahlianum, P. dubium, P. guerlekense, P. hybridum, P. laestadianum, P. lapeyrousianum, P. lapponicum, P. macrostomum, P. pinnatifidum, P. purpureomarginatum, P. radicatum, P. rhoeas, P. rupifragum, P. somniferum*	Pavots
	Paronychia	*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*	Paronyque
	Plantago lanceolata	*Plantago lanceolata*	Plantain lancéolé
	Polygonum aviculare	*Polygonum aviculare*	Renouée des oiseaux
	P. bistorta	*P. bistorta*	Renouée bistorte
...	*P. persicaria*	*P. hydropiper, P. lapathifolium, P. minus, P. mite, P. persicaria*	Renouée persicaire
21	*Sanguisorba*	*Sanguisorba officinalis, S. minor*	Sanguisorbe
	S. minor	*S. minor*	Petite pimprenelle
	S. officinalis	*S. officinalis*	Pimprenelle officinale
	Saxifraga	*Saxifraga adscendens, S. aizoides, S. cernua, S. cespitosa, S. cotyledon, S. granulata, S. hirculus, S. oppositifolia, S. rivularis, S. stellaris, S. tridactylites*	Saxifrages
	S. aizoides	*S. aizoides*	Saxifrage faux-aizoon
	Scleranthus	*Scleranthus annus, S. perennis, S. uncinatus*	Scléranthe
	Spergula	*Polycarpon diphyllum, P. tetraphyllum, Spergula arvensis, S. morisonii, S. pentandra, S. viscosa, Spergularia echinosperma, S. maritima, S. rubra, S. rupicola, S. salina, S. segetalis*	Spergule
	Succisa pratensis	*Succisa pratensis*	Succise des prés
	Urtica	*Urtica atrovirens, U. dioica, U. kioviensis, U. membranacea, U. morifolia, U. pilulifera, U. rupestris, U. urens*	Orties
	Urticaceae	*Forsskalea, Parietaria, Soleirolia, Urtica*	Urticacées

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
22	*Asteraceae asteroideae*	*Achillea, Adenostyles, Andryala, Antennaria, Arctium, Arnica, Arnoseris, Artemisia, Aster, Bellis, Bidens, Buphthalum, 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*	Asteroidées ou Tubuliflores
	Asteraceae cichorioideae	*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, Thrincia, Tolpis, Tragoporon, Urospermum*	Cichorioidées ou Liguliflores
	Gramineae	*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, Milium, Molinia, Nardurus, Nardus, Oryza, Oryzopsis, Paspalum, Phalaris, Phleum, Poa, Polypogon, Psilurus, Scleropoa, Sesleria, Setaria, Sporobolus, Stypa, Trisetum, Vulpia,*	Graminées
	Myriophyllum	*Myriophyllum alterniflorum, M. spicatum, M. verticillatum*	Myriophylle
	Umbelliferae	*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*	Ombellifères

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

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
24 ...	*Caltha*	*Aquilegia vulgaris, Caltha palustris, Isopyrum thalictroides, Myosurus minimus*	Populage des marais
	Cardamine	*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. kitaibelii, 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*	Cardamines
	Caryophyllaceae	*Agrostemma, Arenaria, Bolanthus, Bufonia, Cerastium, Chaetonychia, Corrigiola, Cucubalus, Cyathophylla, Dianthus, Drypis, Gypsophila, Hernaria, Holosteum, Honkenya, Illecebrum, Loeflingia, Lychnis, Minuartia, Moehringia, Moenchia, Myosoton, Ortegia, Paronychia, Petrocoptis, Petrorhagia, Polycarpon, Pseudostellaria, Pteranthus, Sagina, Saponaria, Scleranthus, Silene, Spergula, Spegularia, Stellaria, Telephium, Vaccaria, Velezia*	Caryophyllacées
	Cerastium	*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. gibraltaricum, 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. thomasii, 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*	Céraistes
	Chenopodiaceae	*Achyranthes, Agriophyllum, Alternanthera, Amaranthus, Anabasis, Artrhocnemum, Atriplex, Axyris, Bassia, Beta, Bienertia, camphorosma, Ceratocarpus, Ceratoides,*	Chénopodiacées

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
... 24 ...	*Chenopodium*	*Chenopodium, Corispermum, Cycloloma, Girgensohnia, Halimione, Halimocnemis, Halocnemum, Halogeton, Halopeplis, Halostachys, Hammada, Kalidium, Kochia, Microcnemum, Nanophyton, Noaea, Obione, Ofaiston, Petrosimonia, Polycnemum, Salicornia, Salsola, Suaeda 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. jenissejense, C. multifidum, C. murale, C. opulifolium, C. polyspermum, C. pumilio, C. rubrum, C. schraderanum, C. suecicum, C. urbicum, C. vulvaria*	Chénopode, Ansérine
	Cruciferae	*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, Kernera, 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, Rorippa, Schivereckia, Sinapis, Sisymbrella, Sisymbrium, Sobolewskia, Sterigmostemmum, Subularia, Succowia, Tauscheria, Teesdalia, Teesdaliopsis, Tetracme, Thellungiella, Thlaspi, Vella*	Crucifères
	Polygonaceae	*Athraphaxis, Calligonum, Emex, Fallopia, Koeningia, Oxyria, Polygonum, Reynoutria, Rheum, Rumex*	Polygonacées

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
... 24 ...	*Polygonum*	*Polygonum acetosum, P. alpinum, P. amphibium, P. amplexicaule, P. aschersonianum, P. aviculare, P. bistorta, P. capitanum, 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. mesembricum, 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*	Renouées
	Ranunculaceae	*Aconitum, Actaea, Adonis, Anemone, Aquilegia, Callianthemum, Caltha, Ceratocephalus, Cimicifuga, Clematis, Consolida, Delphinium, Eranthis, Garidella, Helleborus, Hepatica, Isopyrum, Myosurus, Nigella, Pulsatilla, Ranunculus, Thalictrum, Trollius*	Renonculacées
	Ranunculus ...	*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. auricomo-binatus, 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,...*	Renoncules

BAG	Taxons palynologiques	Taxons botaniques	Noms vernaculaires
... 24	...	...	...
	Ranunculus	*R. nigrescens, R. nivalis, R. nodiflorus, R. odessanus, R. olissiponesis, R. ololeucos 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. silvisteppaceus, R. sphaerospermus, R. spicatus, R. sprunerianus, R. stojanovii, 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. weyleri*	Renoncules
	Stellaria	*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*	Stellaires
	Thalictrum	*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*	Pigamon

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