THE 1ST INTERNATIONAL SUMMER SCHOOL ON ADVANCED SOIL PHYSICS

MODELING WATER FLUXES IN THE SOIL-PLANT SYSTEM

MODELLING ROOT ARCHITECTURE - CPLANTBOX

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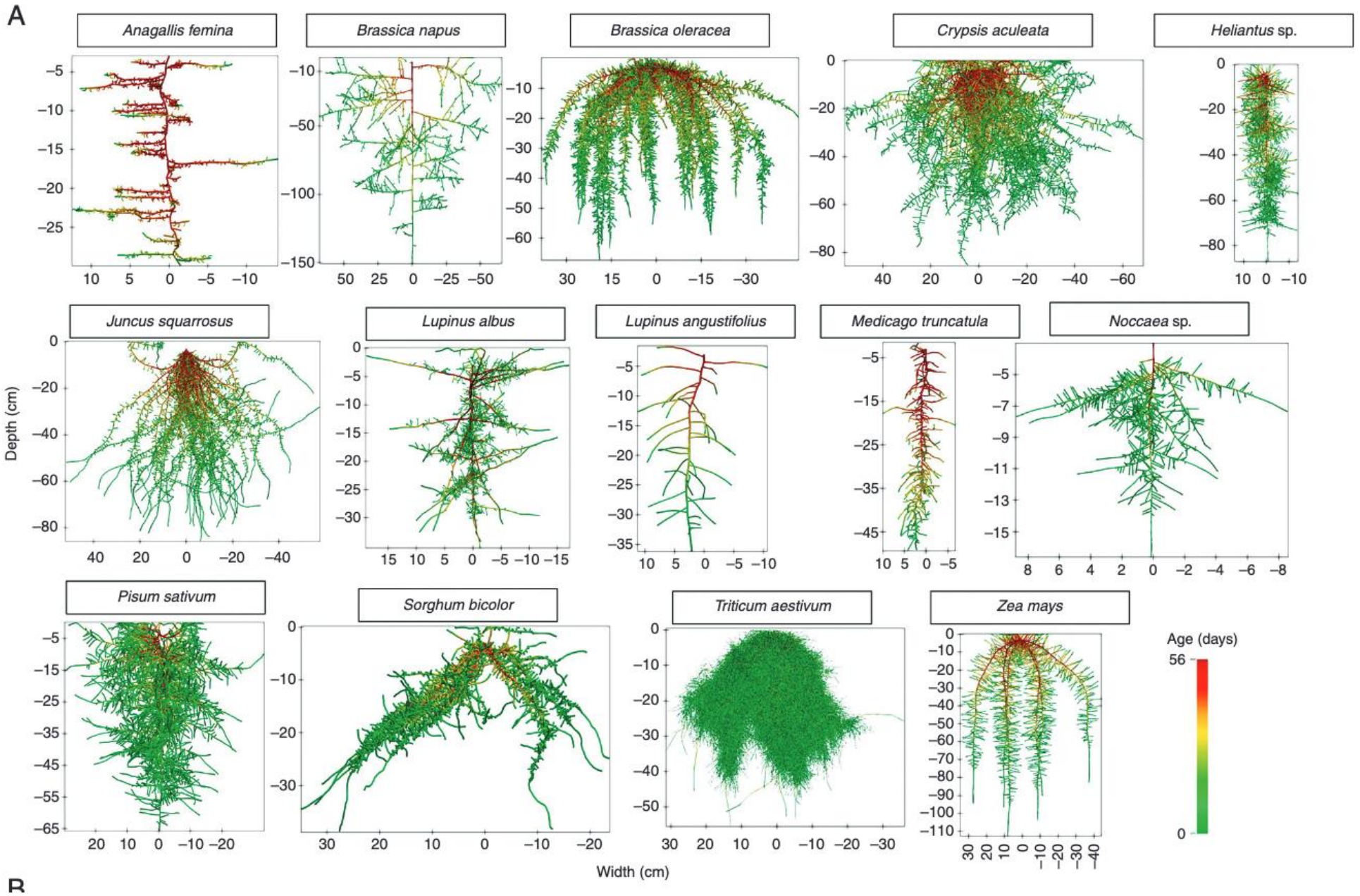
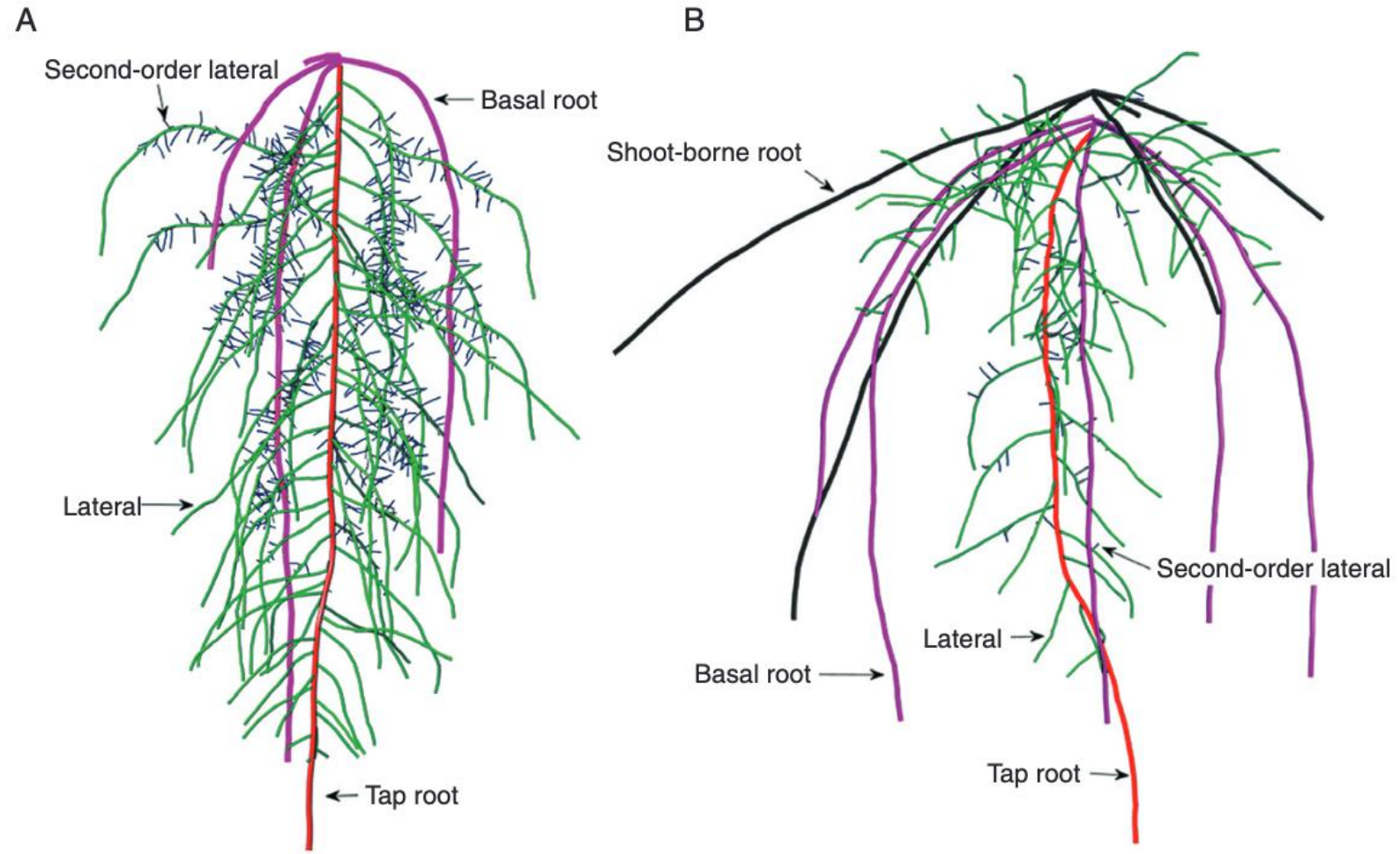
ENVITAM


A
Anagallis femina
Brassica napus
Brassica oleracea
Crypsis aculeata
Heliantus sp.
Juncus squarrosus
Lupinus albus
Lupinus angustifolius
Medicago truncatula
Noccaea sp.
Pisum sativum
Sorghum bicolor
Triticum aestivum
Zea mays
Depth (cm)
Width (cm)
Age (days)
56
0
B


A
Second-order lateral
Basal root
Lateral
Tap root
B
Shoot-borne root
Second-order lateral
Lateral
Basal root
Tap root

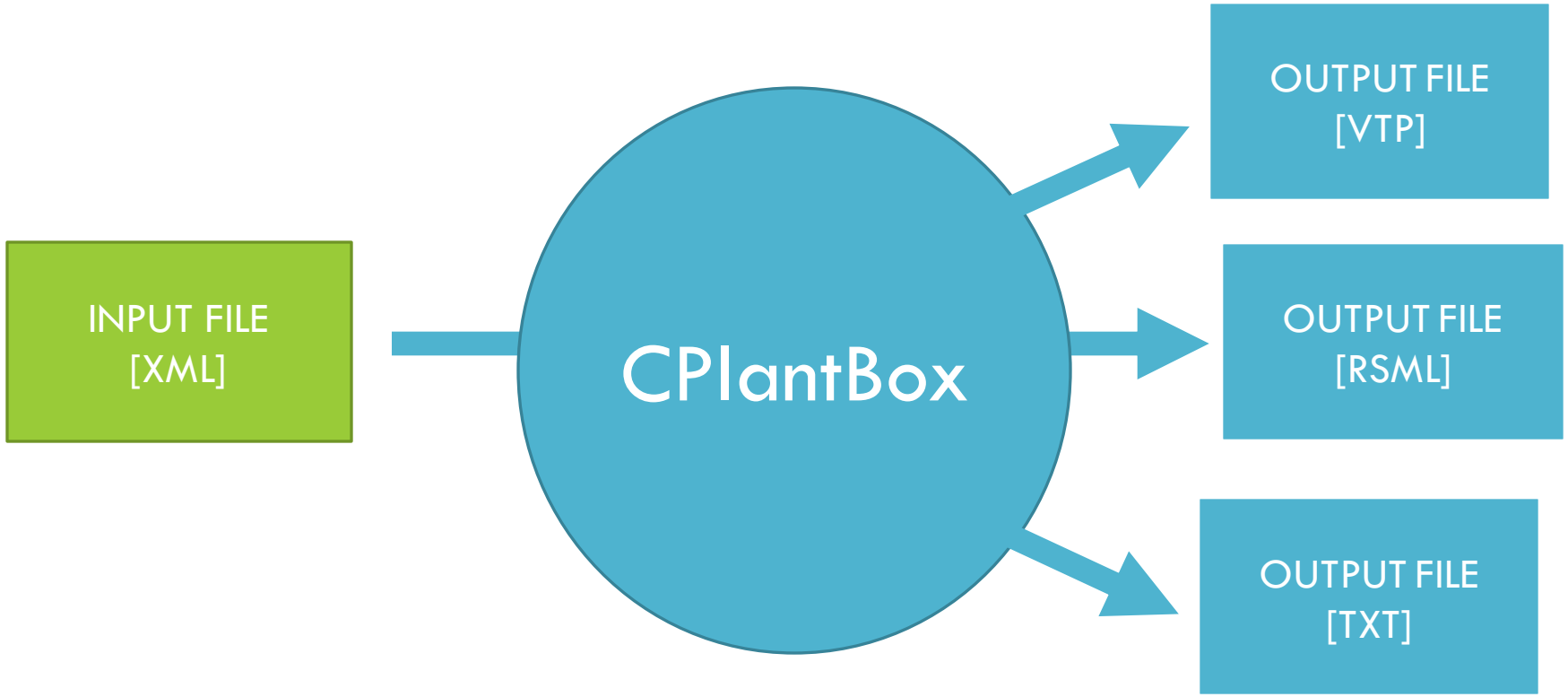
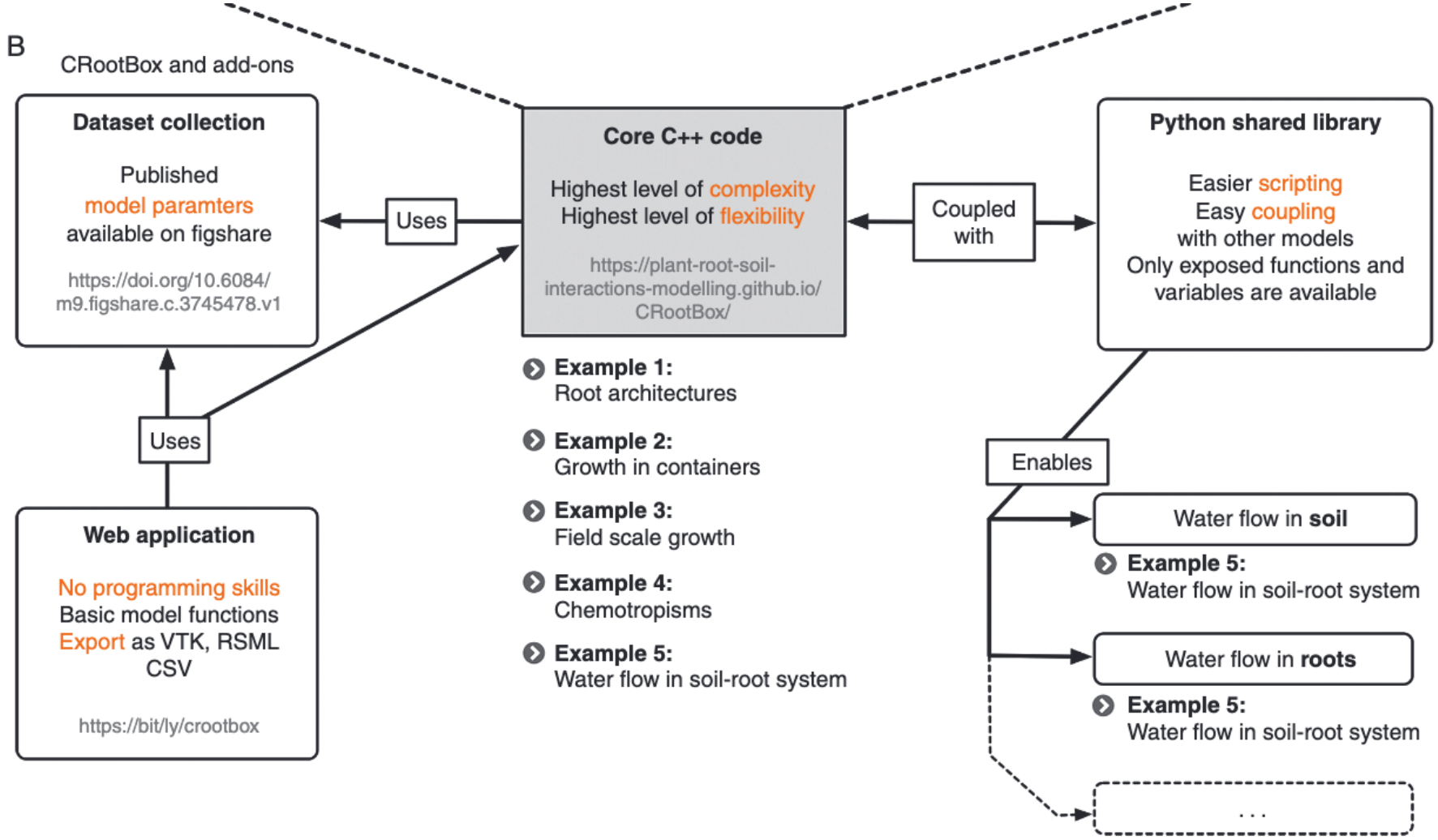

INPUT FILE
[XML]
CPlantBox
OUTPUT FILE
[VTP]
OUTPUT FILE
[RSML]
OUTPUT FILE
[TXT]

TABLE 3. *Complete list of parameters used by CRootBox for each root type*

Description	Parameter name	Units
Root radius	a	cm
Initial elongation rate	r	cm d^{-1}
Insertion angle	θ	rad
Length of basal zone	l_a	cm
Length of apical zone	l_b	cm
Length between lateral branches	l_n	cm
Maximal root length	l_{max}	cm
Tropism type	*type*	{0,1,2,3}[1]
Number of trials (tropism strength)	N	1
Standard deviation of random angular change	σ	cm^{-1}
Root successor types	*successor*	[type, probability; …]
Name of the root type	*name*	String
Root colour	*colour*	RGB
Resolution along root axis	*dx*	cm
Root life time	*rlt*	day
Type of root elongation	*gf*	{1,2}[2]
Scale elongation	*se*	Function[3]
Scale branching probability	*sbp*	Function[3]
Scale branching angle	*sa*	Function[3]

TABLE 2. *List of plant parameters needed for the root architecture development of dicotyledonous and monocotyledonous plants*

Description	Parameter name	Unit	Plant type
Planting depth	*depth*	cm	Dicot and monocot
First emergence of basal roots	$first_B$	day	Dicot and monocot
Time period between basal roots	$delay_B$	day	Dicot and monocot
Maximal number of basal roots	max_B	1	Dicot and monocot
First occurrence of shoot-borne roots	$first_S$	day	Monocot
Time period between shoot-borne roots	$delay_S$	day	Monocot
Number of shoot-borne roots per root crown	n_S	1	Monocot
Distance between root crowns along the shoot	dz_S	cm	Monocot


B
CRootBox and add-ons
Dataset collection
Published
model paramters
available on figshare
https://doi.org/10.6084/
m9.figshare.c.3745478.v1
Uses
Core C++ code
Highest level of complexity
Highest level of flexibility
https://plant-root-soil-
interactions-modelling.github.io/
CRootBox/
Coupled
with
Python shared library
Easier scripting
Easy coupling
with other models
Only exposed functions and
variables are available
Example 1:
Root architectures
Example 2:
Growth in containers
Example 3:
Field scale growth
Example 4:
Chemotropisms
Example 5:
Water flow in soil-root system
Uses
Web application
No programming skills
Basic model functions
Export as VTK, RSML
CSV
https://bit/ly/crootbox
Enables
Water flow in soil
Example 5:
Water flow in soil-root system
Water flow in roots
Example 5:
Water flow in soil-root system
. . .

CRootBox

This app displays the capabilities of the CRootBox model. Choose a dataset, unleash CRootBox, then try changing the parameters.

Daniel Leitner, Guillaume Lobet, Magdalena Landl, Mirjam Zorner, Shehan Morandage, Trung Hieu Mai, Cheng Sheng, Jan Vanderborgth, Andrea Schnepf

Forschungszentrum Juelich GmbH

1. Load parameter set

1. Select root system dataset

Brassica napus a

The algorithmic beauty of plant roots – an L-System model for dynamic root growth simulation
Leitner D, Klepsch S, Knieß A, Schnepf A
Mathematical and Computer Modelling of Dynamical Systems, 16, 575-587, 2010
View paper

☐ Black and white root system

Unleash CRootBox

2. Update parameters

2. Select root type

taproot

Select parameter to change

Length of basal zone [cm]

Parameter mean:

0 4 8
0 0.8 1.6 2.4 3.2 4 4.8 5.6 6.4 7.2 8

Parameter deviation [%]:

0 5 50
0 5 10 15 20 25 30 35 40 45 50

Length of basal zone [cm]
Length of the unbracnhed basal zone of the root

3. Select plant parameter to change

Planting depth [cm]

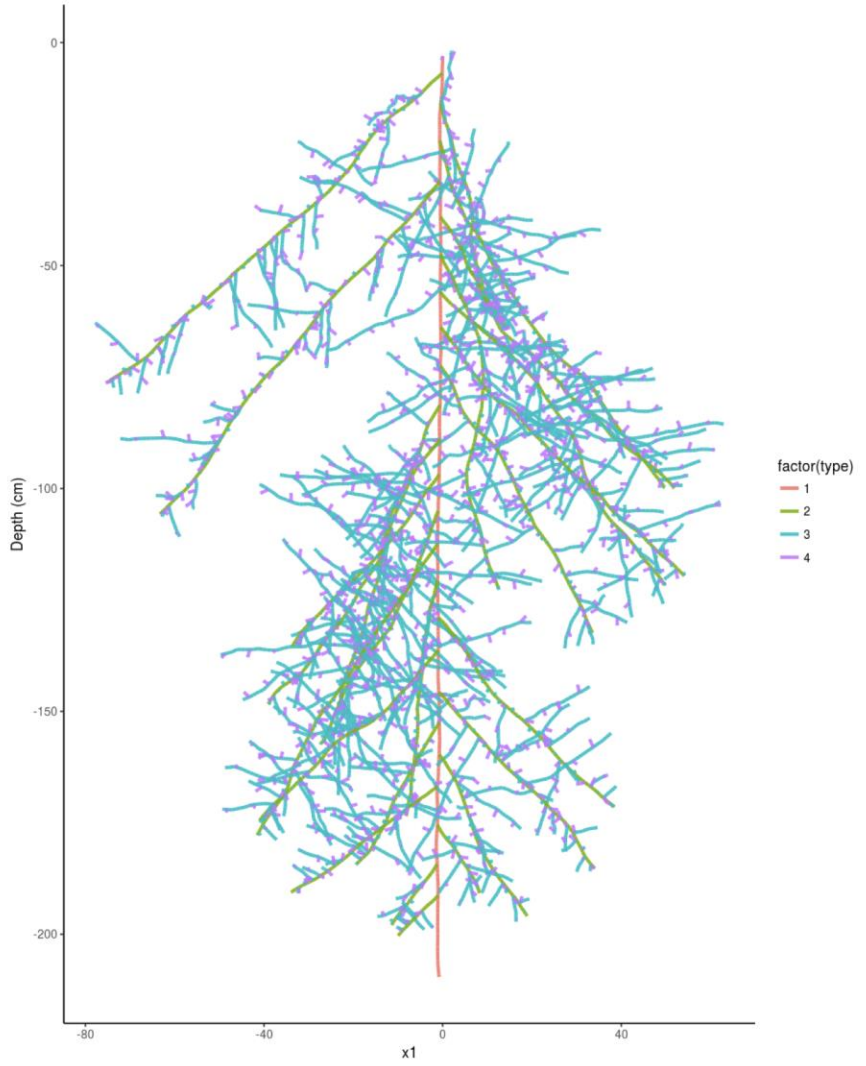
Parameter value:

0 3 6
0 0.6 1.2 1.8 2.4 3 3.6 4.2 4.8 5.4 6

Planting depth [cm]
The depth, in cm, at which the seed is placed in the soil

Update root system

Root system representation | Root length profile



EXERCICE

https://github.com/water-fluxes/day-3-plant-scale-cplantbox

https://plantmodelling.shinyapps.io/shinyRootBox/

- Try to web interface to play with the parameters
- Run the jupyter notebook in colab
- Try modifying the parameters directly in the input files
- Generate one specific architecture for every group (see printed documents)