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Université de Liège

Royal meteorological Institute of Belgium

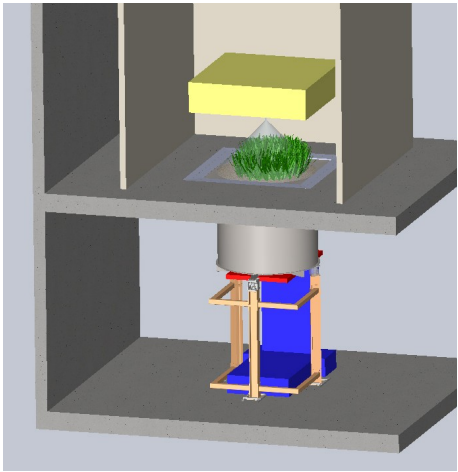
Selection of meteorological conditions to apply in an Ecotron infrastructure

Introduction

Vincent Leemans (1), Lesley De Cruz (2), Benjamin Dumont (1), Rafiq Hamdi (2), Pierre Delaplace (1), Bernard Heinesh (1), Sarah Garré (1), François Verheggen (1), Nicolas Theodorakopoulos (1), and Bernard Longdoz (1)

(1) ULg, GxABT, EnvironmentIsLife, Gembloux, Belgium (vincent.leemans@ulg.ac.be)
(2) Royal Meteorological Institute of Belgium

- Ecotrons are designed for studying the impact of climate change on (agro-)ecosystems behaviour and vice-versa
- Researchers using the Ecotron would like to study “climatic conditions”, for instance around 2050
- Climatic conditions are statistics; to drive an Ecotron you need meteorological quantities
- This presentation is about algorithms to obtain these meteorological quantities that may represent actual or future climates



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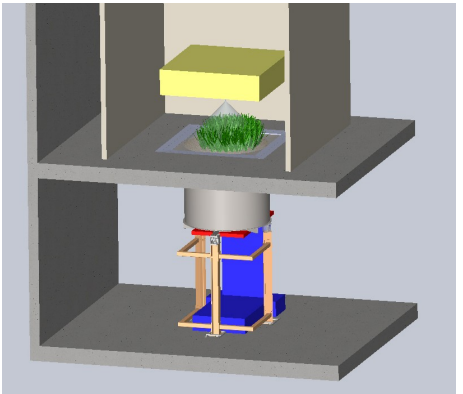
Presentation of the Ecotron @ ULg

- Ecotrons are designed for studying the impact of climate change on (agro-)ecosystems behaviour and *vice-versa*
- Several quantities are controlled, namely
  - air temperature, air humidity, irradiation, wind turbulences
  - [CO_2], [O_3]
  - soil temperature and water potential



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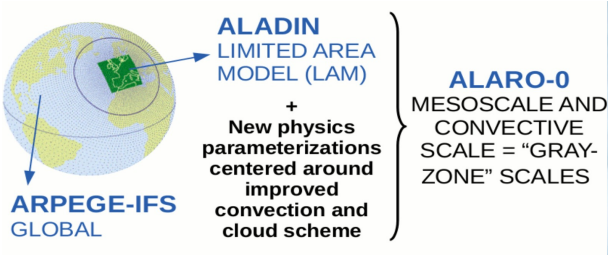
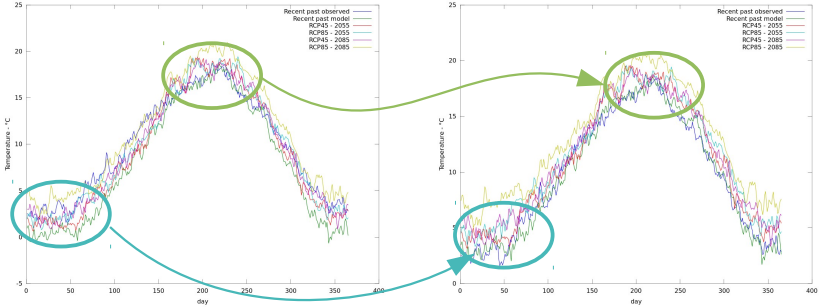
Meteorological quantities generation

- Based on Alaro-0
  - ARPEGE
  - Aladin
  - Recent past; 2040-2070; 2070-2100
  - RCP 4.5; RCP 8.5
- Local recent past observation
  - Data debiasing





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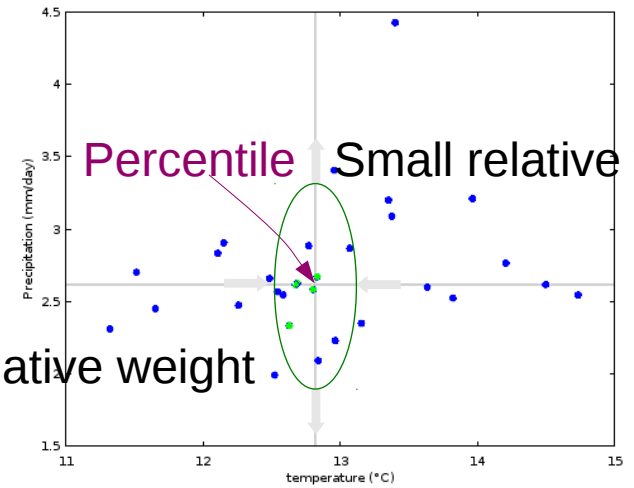
Meteorological year selection

- Selection of the period and RCP scenario
- Definition for each climatic variate of
  - a percentile
  - a weight



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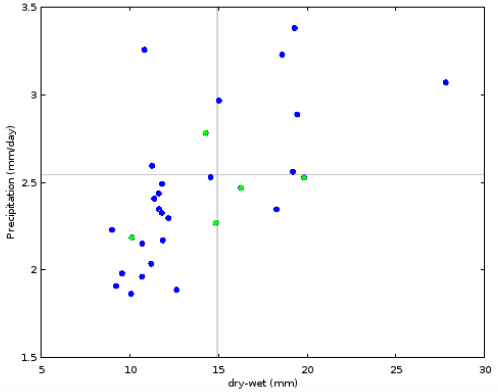
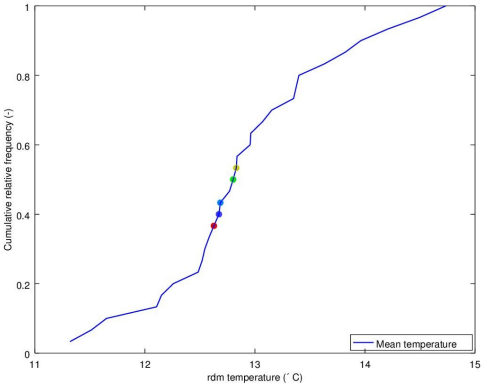
Discussion

- The method seems more efficient when few quantities are given an important weight
- This is partly due to correlation between quantities
- This is probably linked to the sample size generated, 30 years





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- Ecotrons are designed
  - for studying Agro-ecosystems (plants -crops and weeds-, animals -insects an other invertebrates- and micro-organisms)
  - To simulate in a realistic way the actual and future environmental conditions, including air and soil conditions
  - The studies focus on the plant growing dynamic, in interaction with environmental growing factors and under biotic and abiotic stresses
- With the aim to
  - Evaluate the effect of global warming on the agro-ecosystems ;
  - Measure the green house gas exchanges in the ecosystems in order to assess the impact of the agro-ecosystems and their management on the global warming ;
  - Develop adaptation strategies to reinforce the plant tolerance to the pressures induced by the global warming

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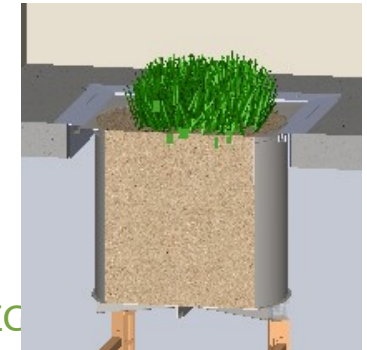
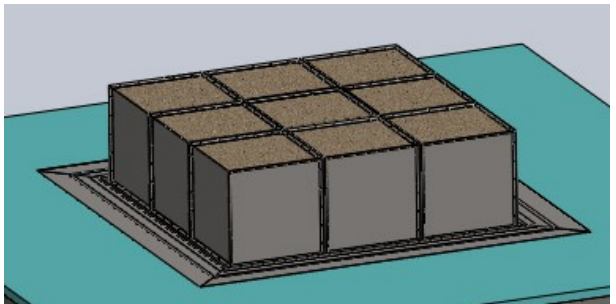
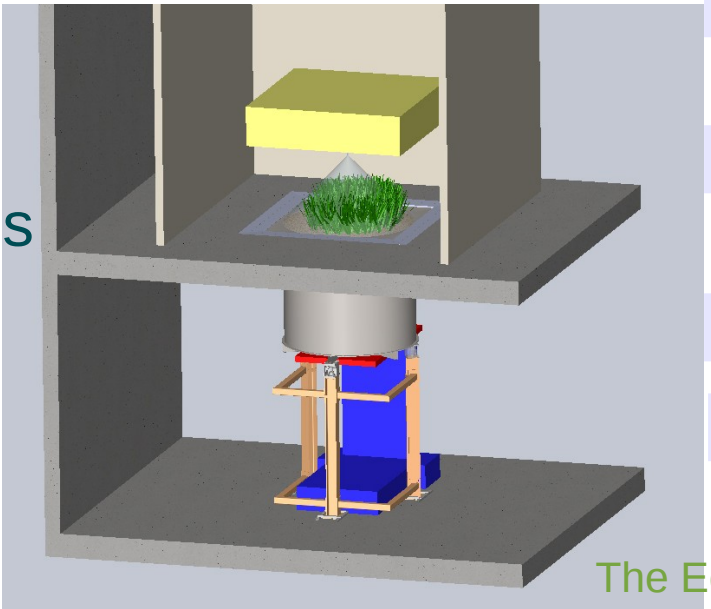
- Physical description
  - Crop area : ~2m²
  - Chamber volume : 50 m³
  - Soil volume : up to 3m³
- Either 1 lysimeters or 9 mesocosms







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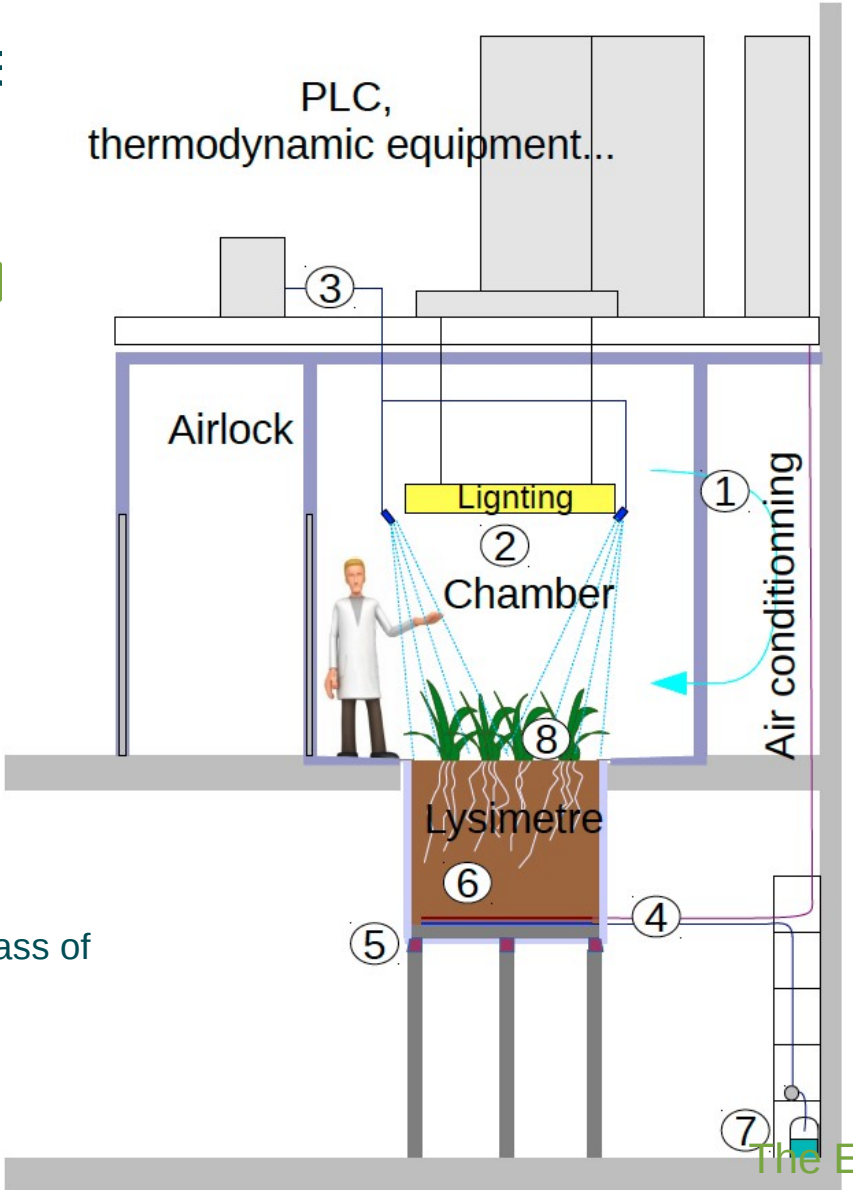
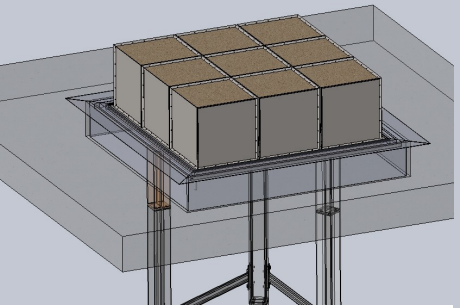
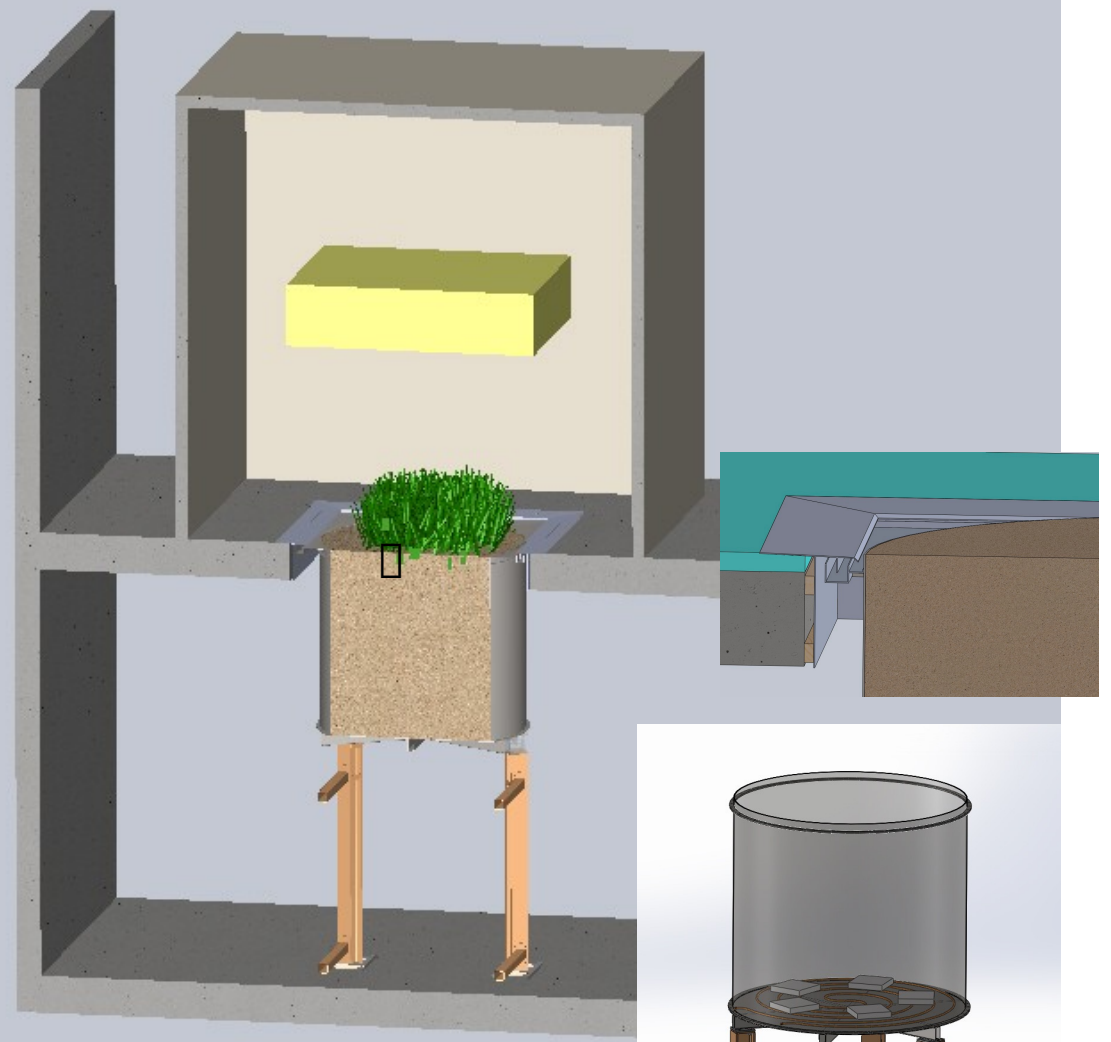
- Physical description
  - Crop area : 2m²
  - Chamber volume : 50 m³
  - Soil volume : 3m³
- Several quantities are controlled, namely
  - air temperature, air humidity (1), irradiation (2), precipitations (3), wind turbulences, air renewal
  - $[CO_2]$, $[O_3]$
  - soil temperature and water potential
- Time step : 5 minutes
- Chambers are air-thight and protected against trespass of insects and micro-organisms







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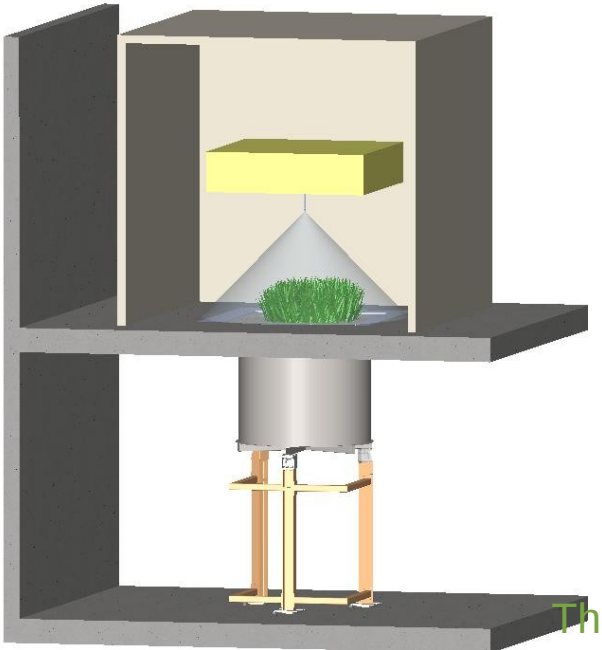
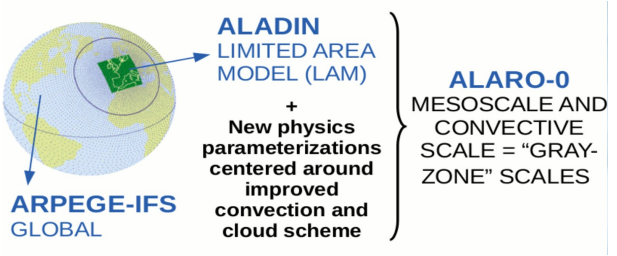
- http://www.gembloux.ulg.ac.be/environmentislife/
- Manager :
  - vincent.leemans@ulg.ac.be
- Chair :
  - bernard.longdoz@ulg.ac.be



Selection of meteorological conditions to apply in an Ecotron infrastructure

Meteorological quantities generation

- Based on Alaro0
  - ARPEGE
  - Aladin
  - Recent past; 2040-2070; 2070-2100
  - RCP 4.5; RCP 8.5
  - Point close to Gembloux on a 4*4 km grid, one set of quantities every 3 hours
- The data generated :
  - Near surface air temperature
  - Near surface air humidity
  - Precipitations
  - Cloud cover
  - Wind speed



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Meteorological quantities generation

- Local recent past observation
  - Meteorological station at Ernage
    - Daily data
    - 1980 - 2010
  - Lonzée terrestrial observatory – ICOS
    - Every half hour
    - 2004 - present

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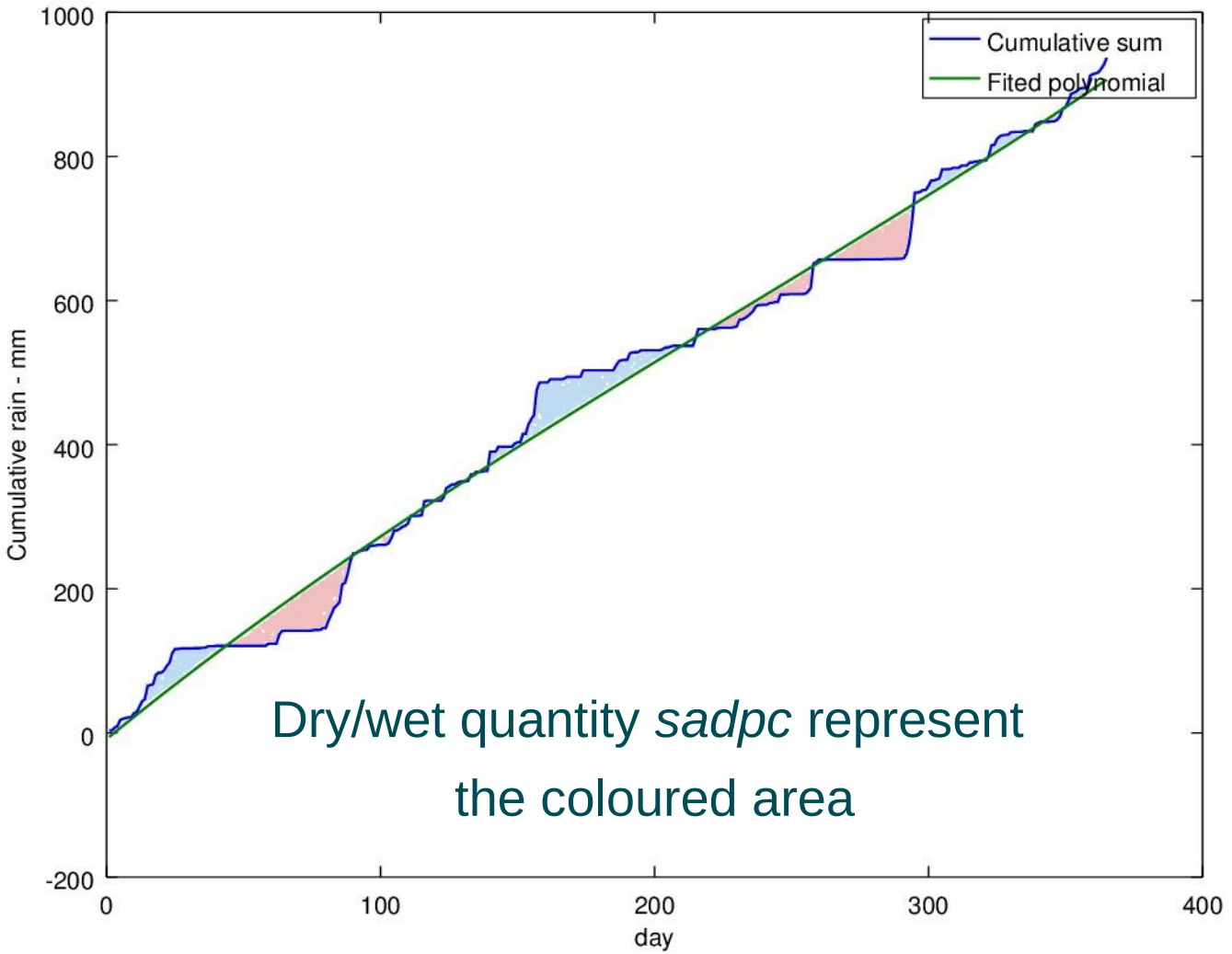
Meteorological quantities generation

- Conversion of the data types :
  - t°, relative humidity, precipitations are given in correct units
  - A parameter *sadpc* was computed to estimate dry/wet period
    - Computation of the sum of precipication
    - Computation of the trend by fitting of a polynomial (degree 5) on the sum
    - Computation of the sum of absolute difference between the sum and the trend

- Con
  - t°
  - A
    -
    -
    -



Dry/wet quantity *sadpc* represent the coloured area

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Meteorological quantities generation

- Conversion of the data type :
  - t°, relative humidity, precipitations are given in correct units
  - A parameter *sadpc* was computed to estimate dry/wet period
  - The Ecotron require irradiation in µmol.m^{-2}.s^{-2} while the model return the cloud cover
    - Cloud cover *clt* is converted in relative daily sunshine duration (S/S_0) by a transform taking into account physical and astronomical parameters (for debiasing purpose)
    - S/S_0 is converted into radiation *G* by linear equation (Angström's α and β), the parameter being adjusted on the observed data (Lonzée)

$$S/S_0 = (1 - clt) * \left(\frac{t_{G>120[Wm^2]}}{t_{G>0}} \right)$$

$$G = G_0 * \cos(z) * (\alpha S/S_0 + \beta)$$

With G0 the solar constant and z the declination of the sun

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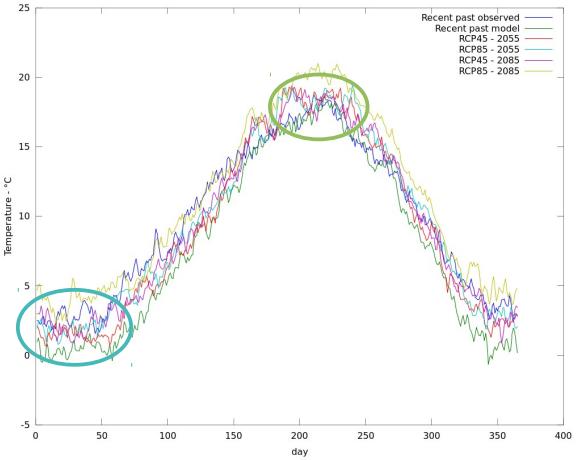
Meteorological quantities generation

- Data debiasing
  - Adjustment of the mean value and of the standard deviation of the recent past model data on the observed recent past data (Ernage)



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Meteorological quantities generation

- Data debiasing
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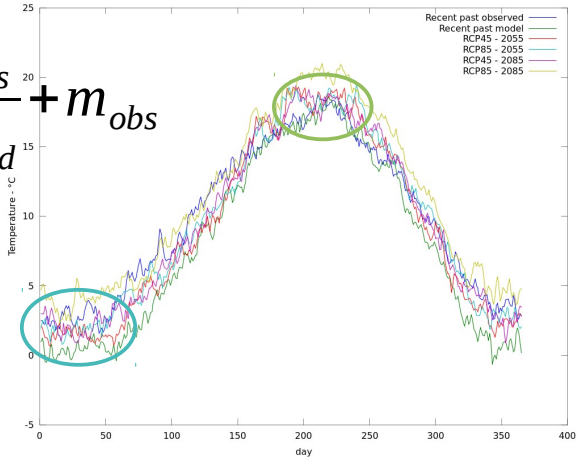
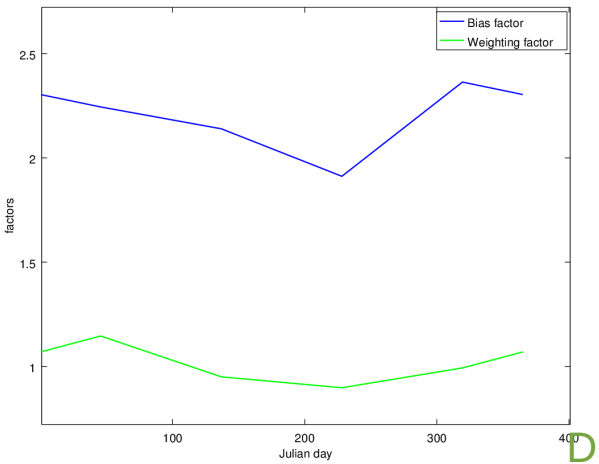
$$x_{cor} = (x_{mod} - m_{mod}) \frac{s_{obs}}{s_{mod}} + m_{obs}$$

For precipitations :

$$x_{cor} = b\, x_{obs}^{\ a}$$





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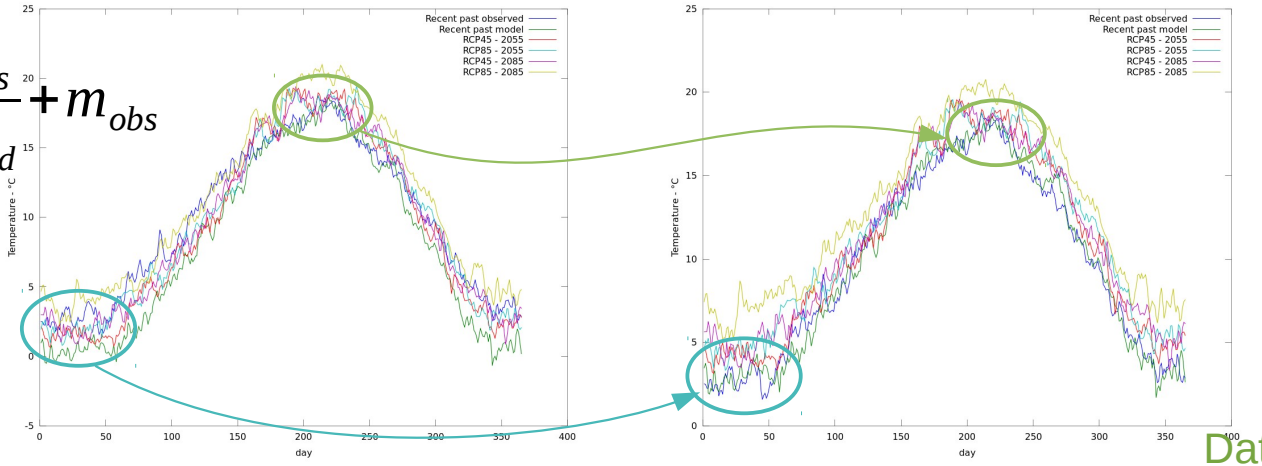

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of the standard deviation
ne observed recent past data

Quantity	1995 (observed)	1995 (model)	1995 (debiaised model)
air temperature (°C)	9,7 3,4 5,3 0,8	8,1 3,3 6,7 0,7	9,8 3,4 5,8 0,7
relative humidity (%)	84,0 12,1 4,5 6,3	85,4 12,1 7,0 1,4	84,8 12,1 8,0 1,6
cloud cover (%)	66,2 30,3 10,1 4,8	54,2 25,1 6,2 1,8	66,3 30,3 9,8 2,1
Precipitation (mm/3h)		0,32 0,75 0,22 0,04	
(mm/day)	2,2 4,2 0,9 0,4	2,54 4,2 0,97 0,29	2,32 4,16 0,90 0,32
(mm/year)	821 1539 321 146	929 2198 644 105	846 1519 330 117
Detrended cumulative sum of Prec. (mm)	13,8 3,0	12,8 3,5	12,8 3,7

The annual mean (m_y)
The "daily" standard deviation, that is to say the mean over the year of standard deviation between years at each time step
The standard deviation of the quantity during the year
The standard deviation of the means of each year

Used to quantify each year,

9 variables

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Meteorological year selection

- Scientist decisions :
  - Selection of the time period
    - 1980-2010, 2040-2070, 2070-2100
  - Selection of the RCP scenario
    - 4.5; 8.5
  - Definition of the crop period
    - For example, from end of October up to end of July
  - For each climatic variate, for the mean and for the annual standard deviation, provide
    - a percentile *p*
    - a weight *w*

For example, p=0.7
means one is looking for a year above the normal (more hot, more wet, ...)

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Meteorological year selection

- Algorithm :
  - Computation of the difference *d* between each quantity (*x*, could be either the mean or the standard deviation of the quantity) to the corresponding percentile divided by the interquartile range *iqr* (so that different quantities can be compared
  - Computation of the weighted distance *R* based on *d*

$$d_i = \frac{x_i - p_i}{iqr_i}$$

$$R = \boldsymbol{d}' \boldsymbol{W} \boldsymbol{d}$$

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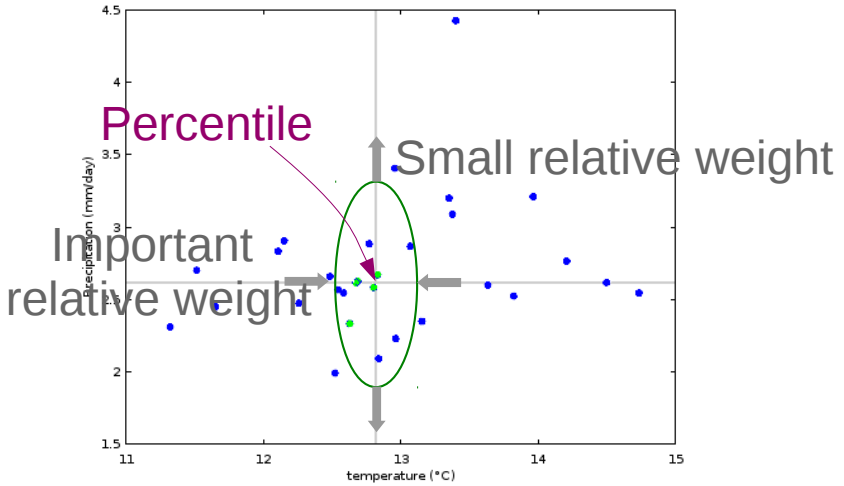
Meteorological year selection

- Result :
  - The distance R represent an hyper-ellipsoid in the 9 variable space

$$d_i = \frac{x_i - p_i}{iqr_i}$$

$$R = \boldsymbol{d}' \boldsymbol{W} \boldsymbol{d}$$



Meteorological year selection

- Decision aid tools :
  - Presentation of the data so that the scientist could make a choice, for each variables :
    - Tables

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Pre-selected year :
Rank : 3, 13, 15, 4, 14
Year : 1983, 1993, 1995, 1984, 1994

Climate case : HO
Chosen years : 1983, 1993, 1995, 1984, 1994

	temperature (°C)	hum. rel. (%)	cloud cov. (%)	Precipitations (mm/d)	Precipitations (mm/y)	Dry/wet periods mm
For the chosen years :						
means						
Quantile	10.0	83.3	66.2	2.28	831	13.8
1983	9.8	82.1	65.9	2.25	823	13.1
1993	9.9	82.5	67.8	2.43	887	13.1
1995	10.5	83.2	67.2	2.10	765	12.4
1984	9.7	82.3	66.2	2.07	755	10.7
1994	9.5	80.6	68.8	2.25	822	11.8
dXy						
Quantile	2.7	8.5	23.9	2.85	1039	
1983	2.4	8.0	23.6	2.73	997	
1993	2.4	7.9	23.8	2.84	1036	
1995	2.5	8.4	22.9	2.61	954	
1984	2.7	8.3	24.0	2.56	934	
1994	2.8	9.5	23.9	2.91	1063	
std						
1983	6.5	11.1	29.3	4.20	1532	
1993	6.2	10.9	29.8	4.76	1738	
1995	5.9	13.1	29.6	4.08	1488	
1984	6.7	11.0	29.4	3.96	1444	
1994	6.1	14.0	29.8	4.60	1678	

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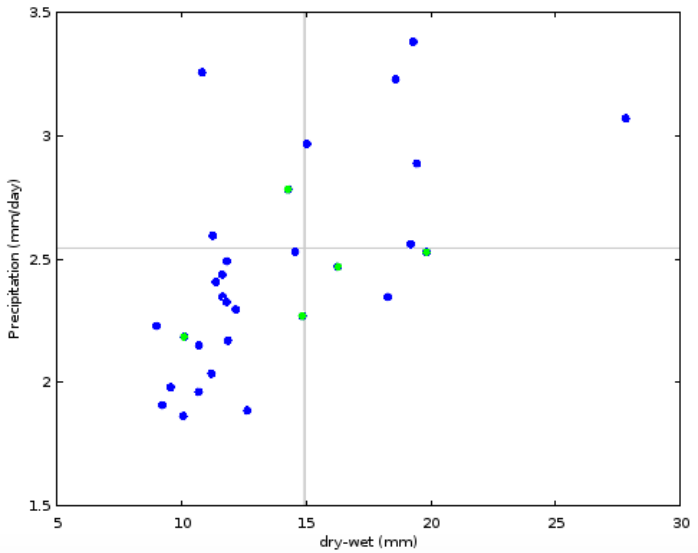
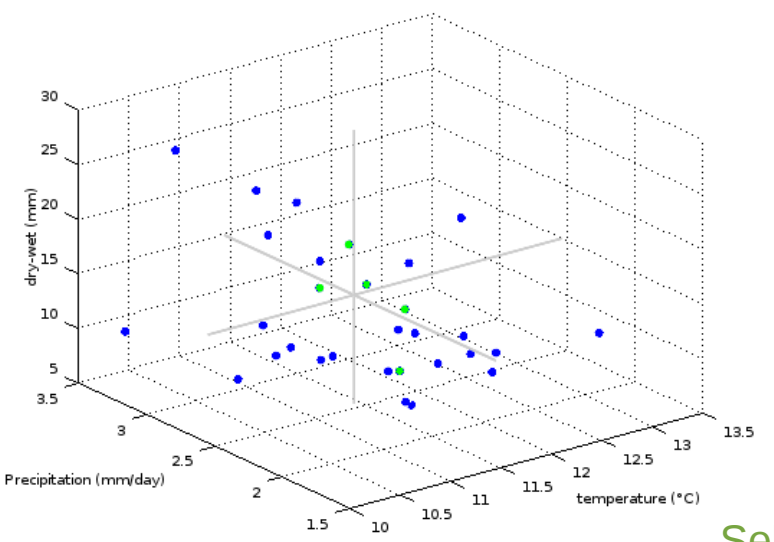
Meteorological year selection

- Decision aid tools :
  - Presentation of the data so that the scientist could make a choice, for each variables :
    - Scatter diagrams





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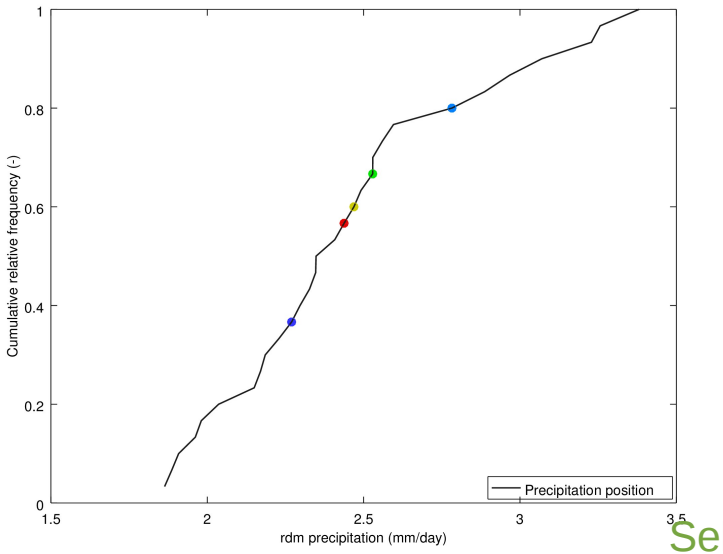
Meteorological year selection

- Decision aid tools :
  - Presentation of the data so that the scientist could make a choice, for each variables :
    - Scatter diagrams
    - Cumulative frequency distributions



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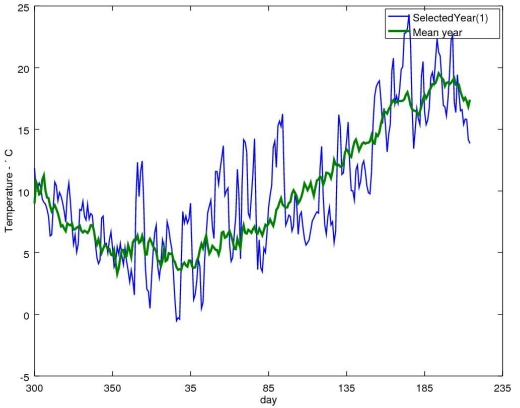
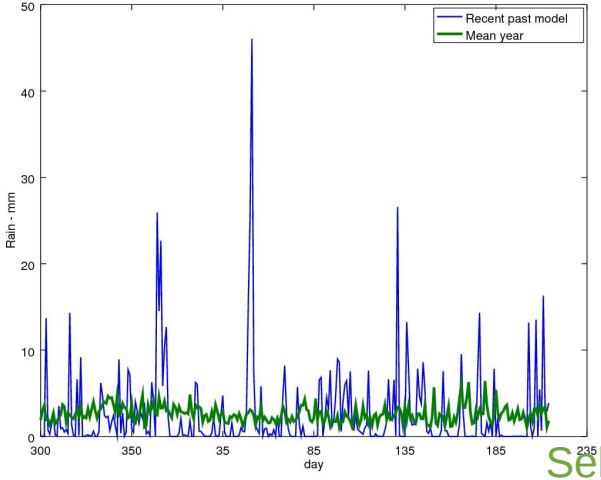
Meteorological year selection

- Decision aid tools :
  - Presentation of the data so that the scientist could make a choice, for each variables :
    - Scatter diagrams
    - Cumulative frequency distributions
    - Time series





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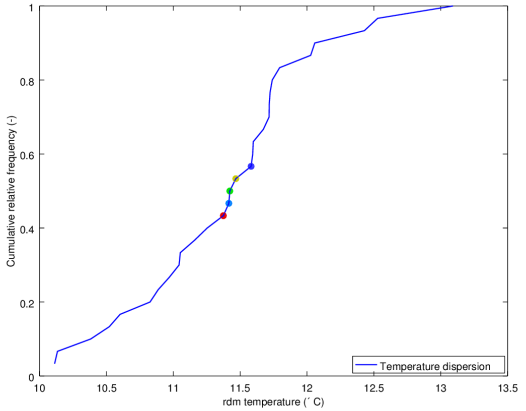
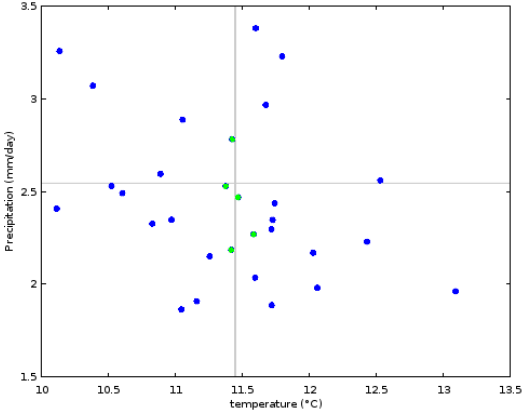
Discussion

- The method seems more efficient when few quantities are given an important weight
  - Case 1 : only the temperature has a non null *w* (p=0.5)
  - The points are close to the median





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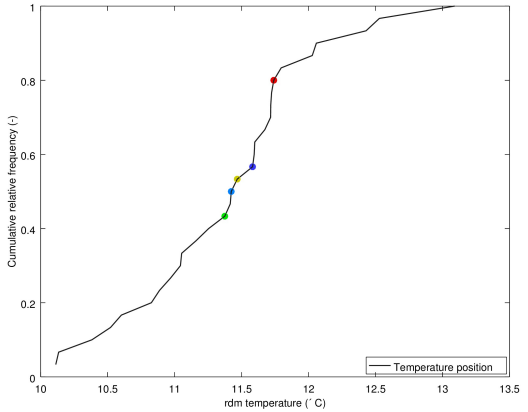
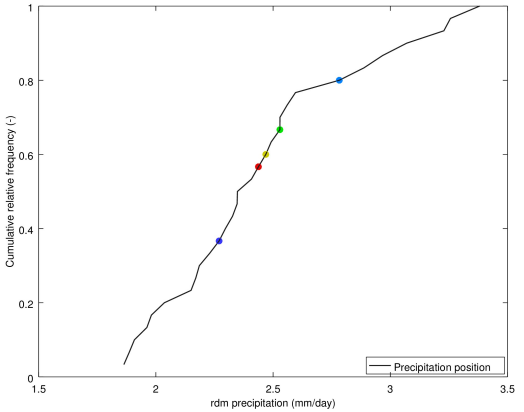
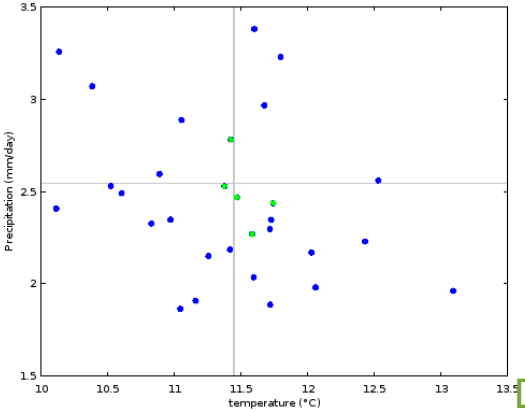
Discussion

- The method seems more efficient when few quantities are given an important weight
  - Case 2 : Temperature (p=0.5, w=2) and precipitation (p=0.7, w=1)
  - Point spread around the chosen percentiles







Selection of meteorological conditions to apply in an Ecotron infrastructure

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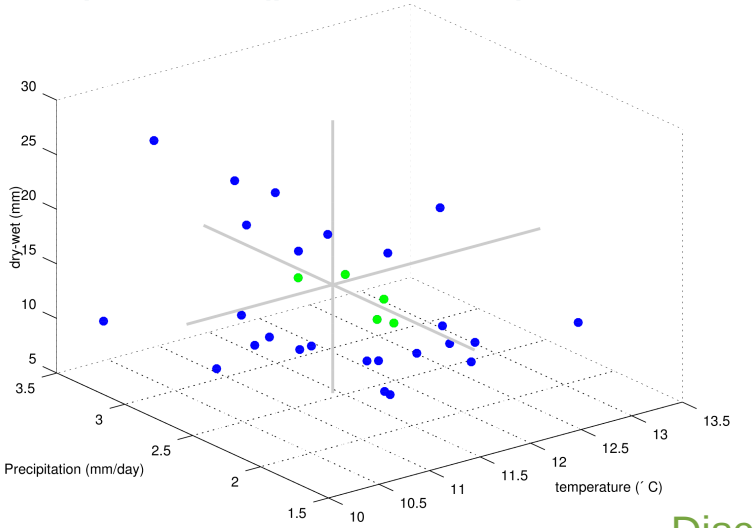
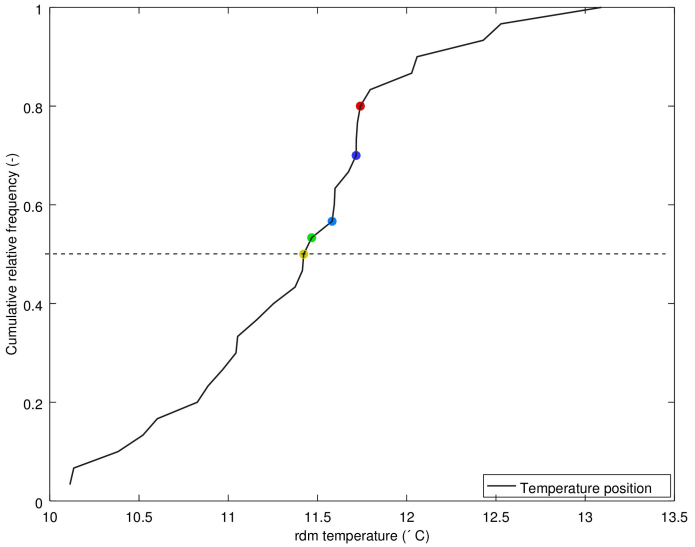
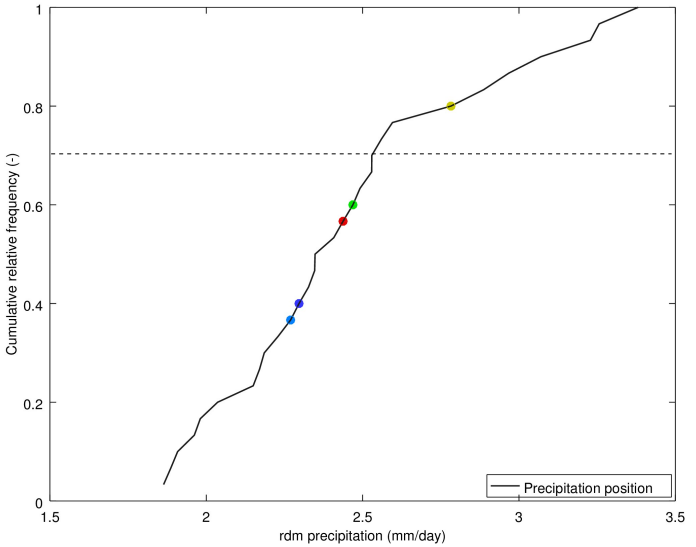
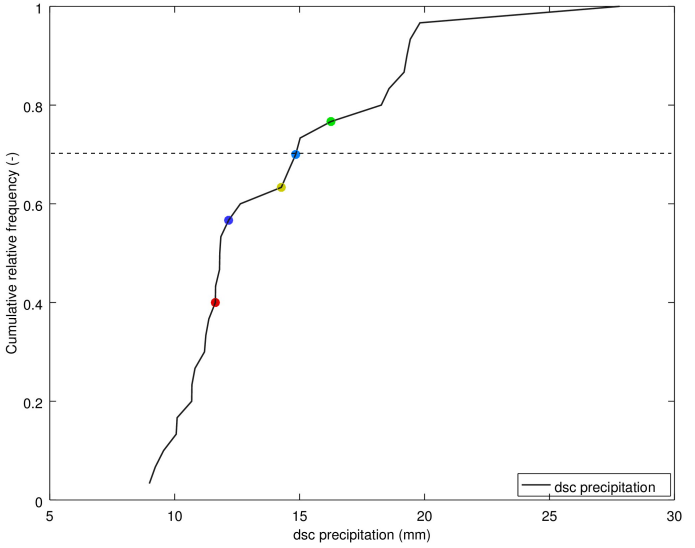
Discussion

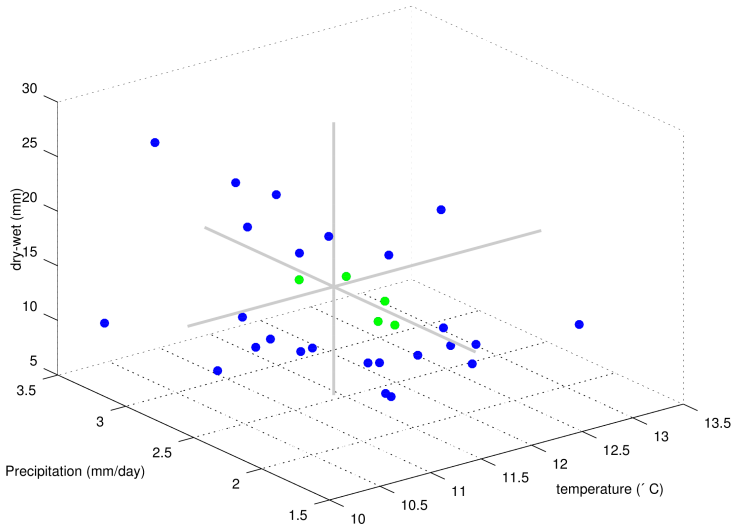
- The method seems more efficient when few quantities are given an important weight
  - Case 3 : Temperature (p=0.5, w=2), precipitation (p=0.7, w=1) and dry/wet periods (p=0.7, w=2)
  - Only two year are reasonably close to the chosen point
    (yellow and green dots, next slide)











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Discussion4

Environment Is Life
Gembloux Agro-Bio Tech
Université de Liège

Royal meteorological
Institute of Belgium

Selection of meteorological conditions to apply in an Ecotron infrastructure

Discussion

- The method seems more efficient when few quantities are given an important weight
- This is partly due to correlation between quantities
- This is probably linked to the sample size generated, 30 years

Thank you for your attention

http://www.gembloux.ulg.ac.be/environmentislife/