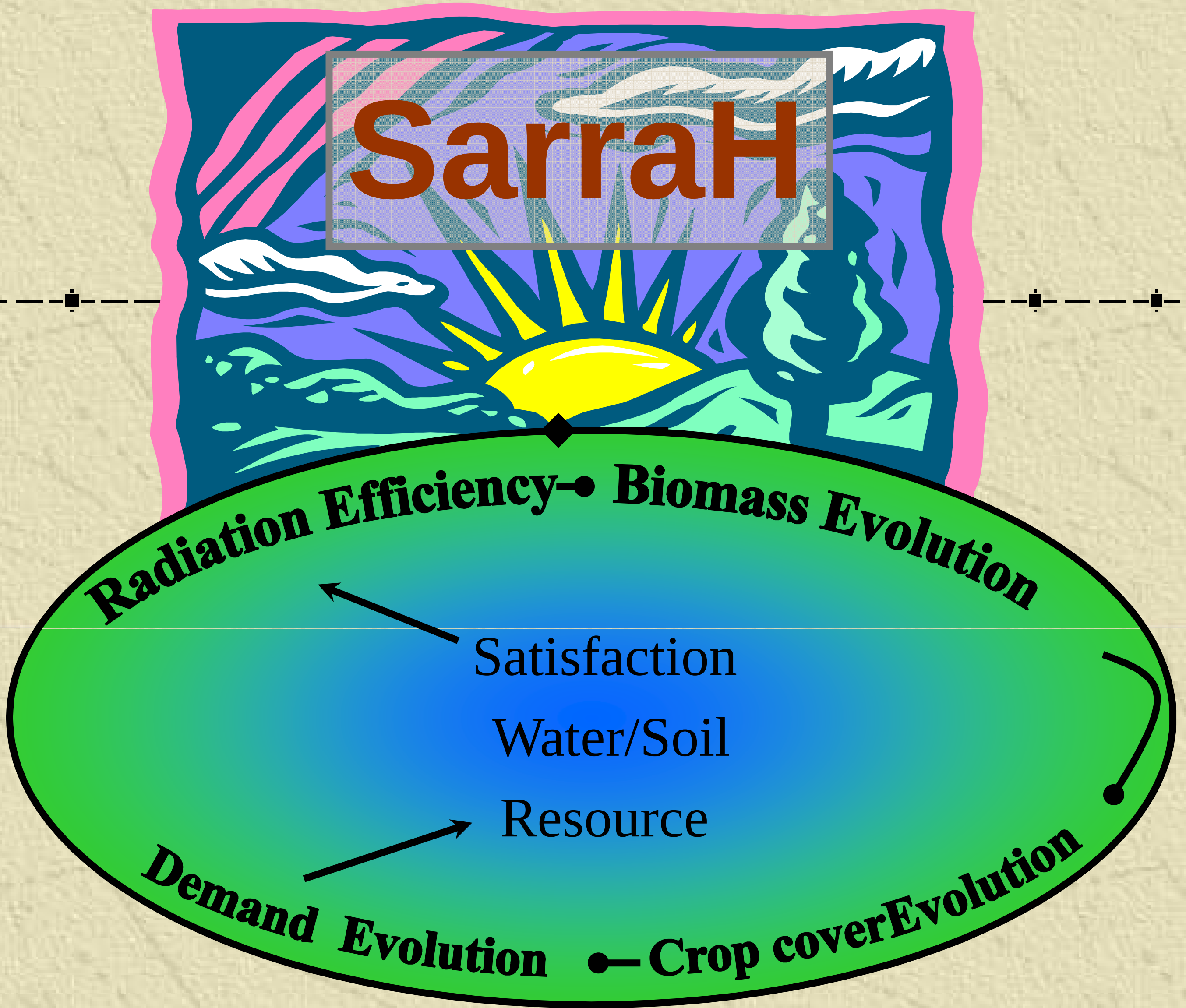


CEREALES

Presentation : Christian Baron

The model needs:

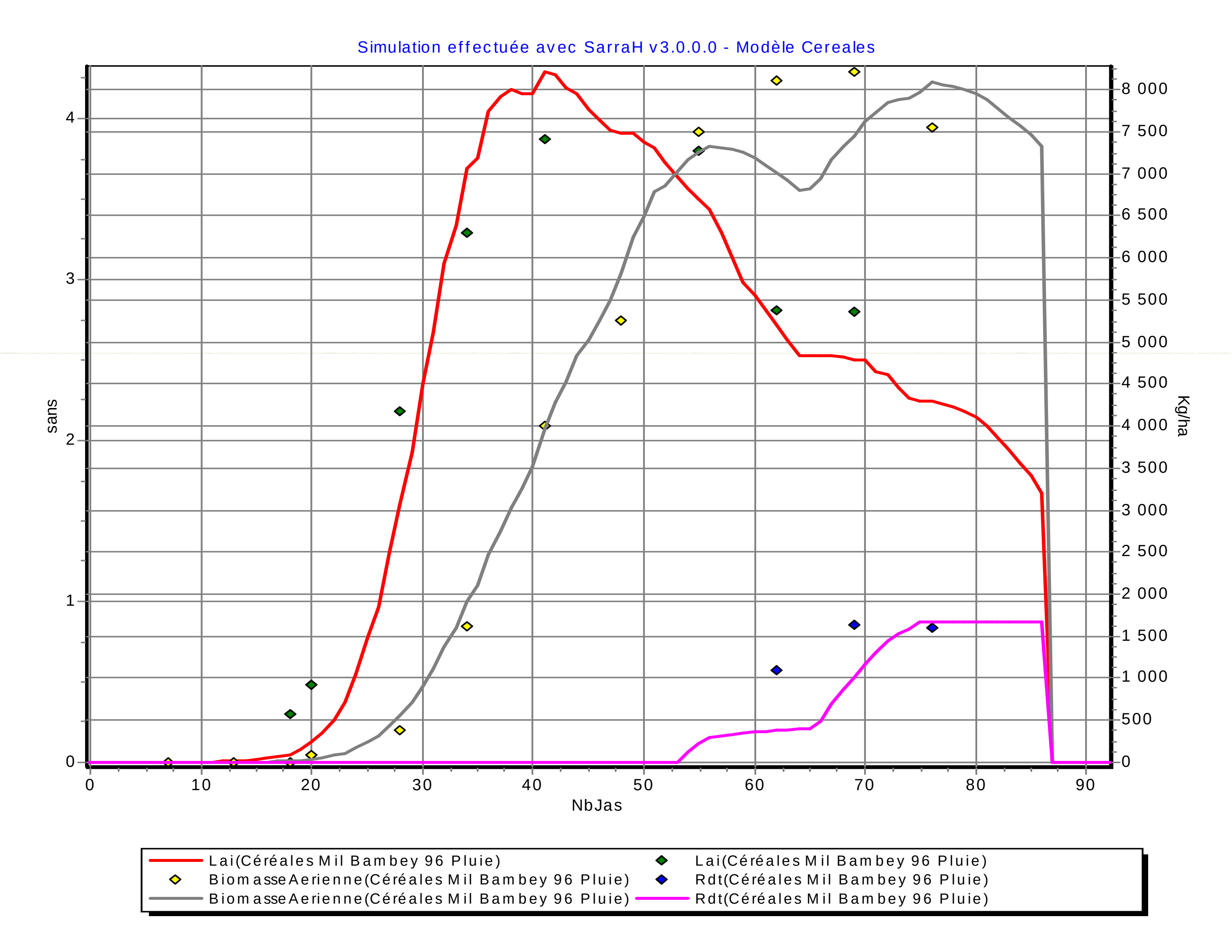
input data and parameters

Simulating LOCAL PROCESS

Environmental……	Agronomic……….	Genotype………..
Solar Radiation	Sowing date	Cardinal temperatures
Evaporative demand	Sowing density	Photoperiod sensitivity
Air temperature	Fertiliser level (Conceptual)	Extinction Coefficient (mean leaf angle)
Photoperiod	Irrigation	Assimilate partitioning parameters (roots, leaves, fruits…)
Soil texture (water holding capacity)	Mulch	Potential radiation use efficiency
		Potential root system depth and dynamics

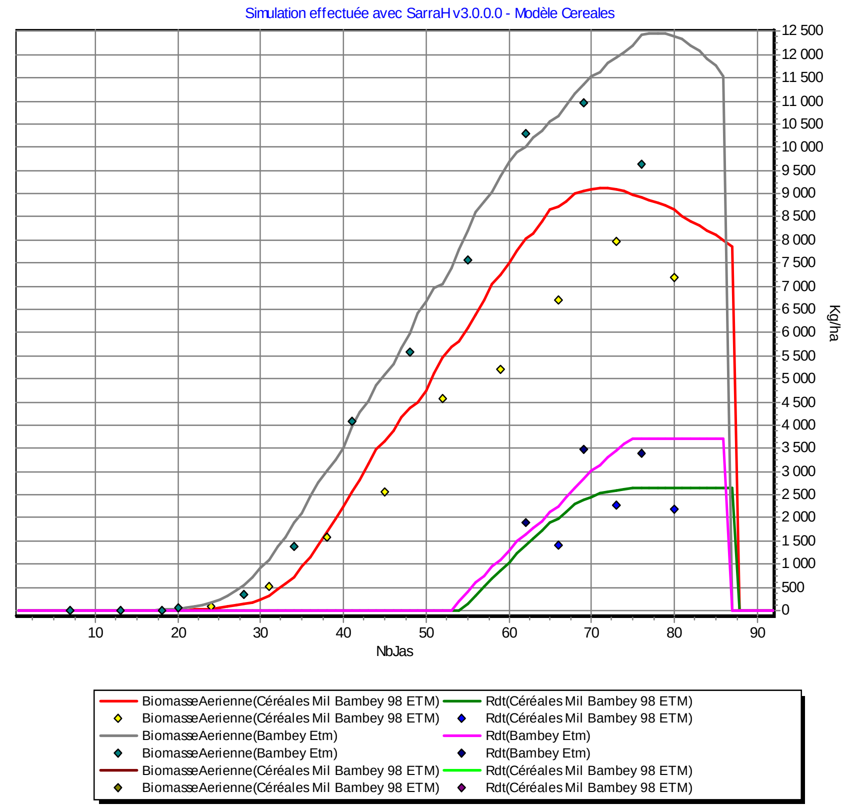
Examples

Observed (point) & Simulate (line): Rainfed (Calibration)

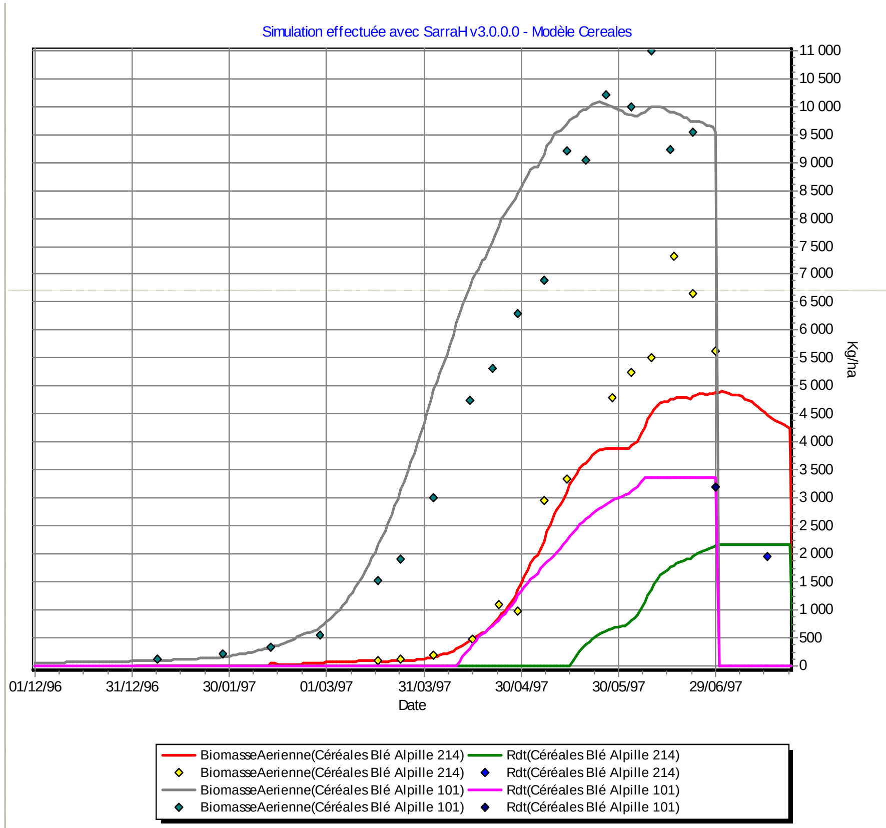


A robust modele : contrasting climate and other cereals

Mil Souna 3 experimentation
Senegal, Bambey in 1996 and 1998



Farmer fields, durum wheat Armet,
Avignon, sowing oct. 96 et fév. 97



Same moduls (model), only change plant parameters: C3, C4… varities…

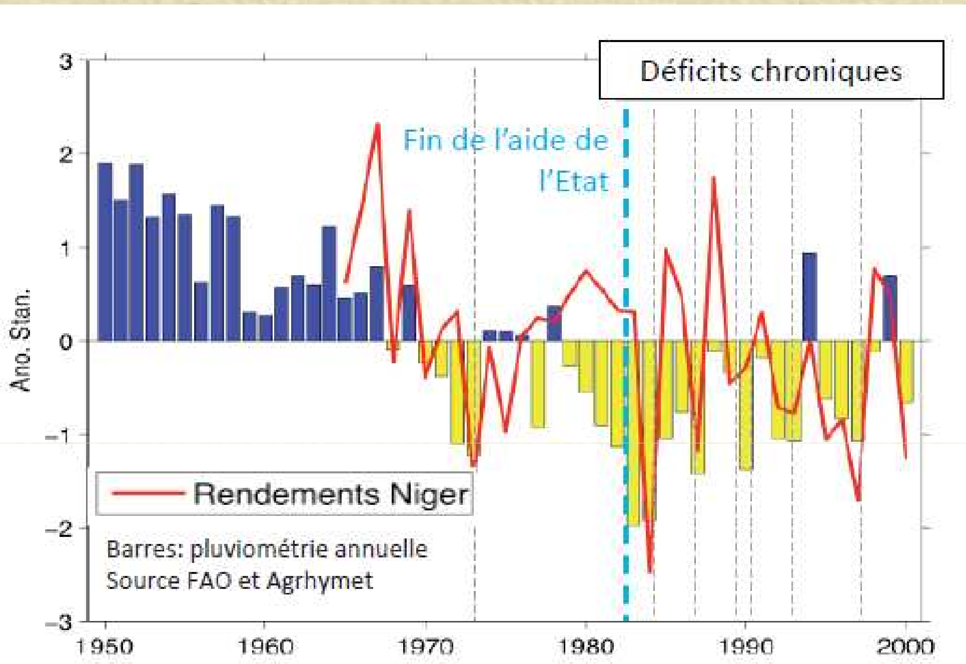
Applications

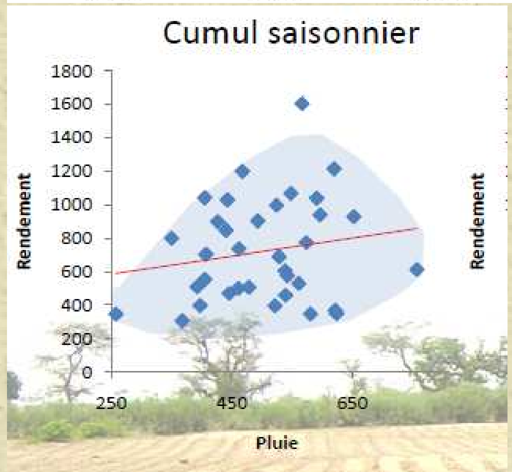
- Diagnostic and survey
- Early warning system
- Short term and seasonal forecast
- Informed basis for breeding

We may define:

- Climate Scenarios vs farmer's strategies (practices & varieties)

BUT what are we talking about ?

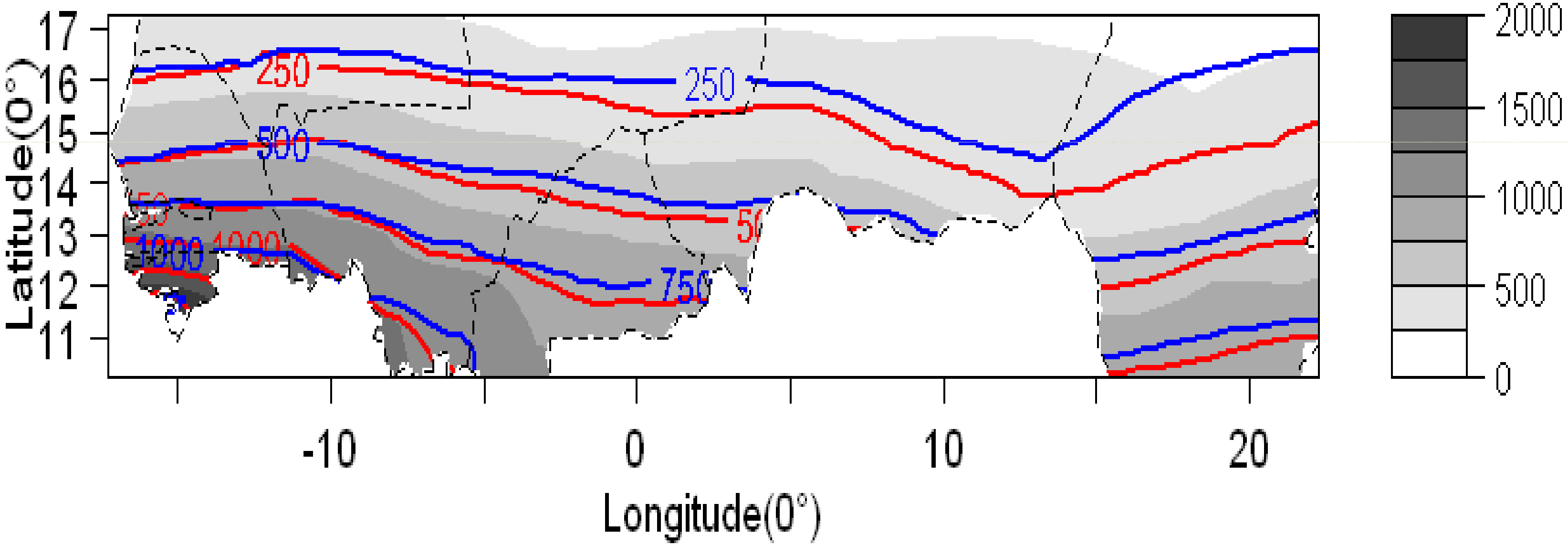




- •**Socio economic constraint (market, state…)**
- • **environmental constraint (soil, climate..)**
- • **farming practices**
- •**…**

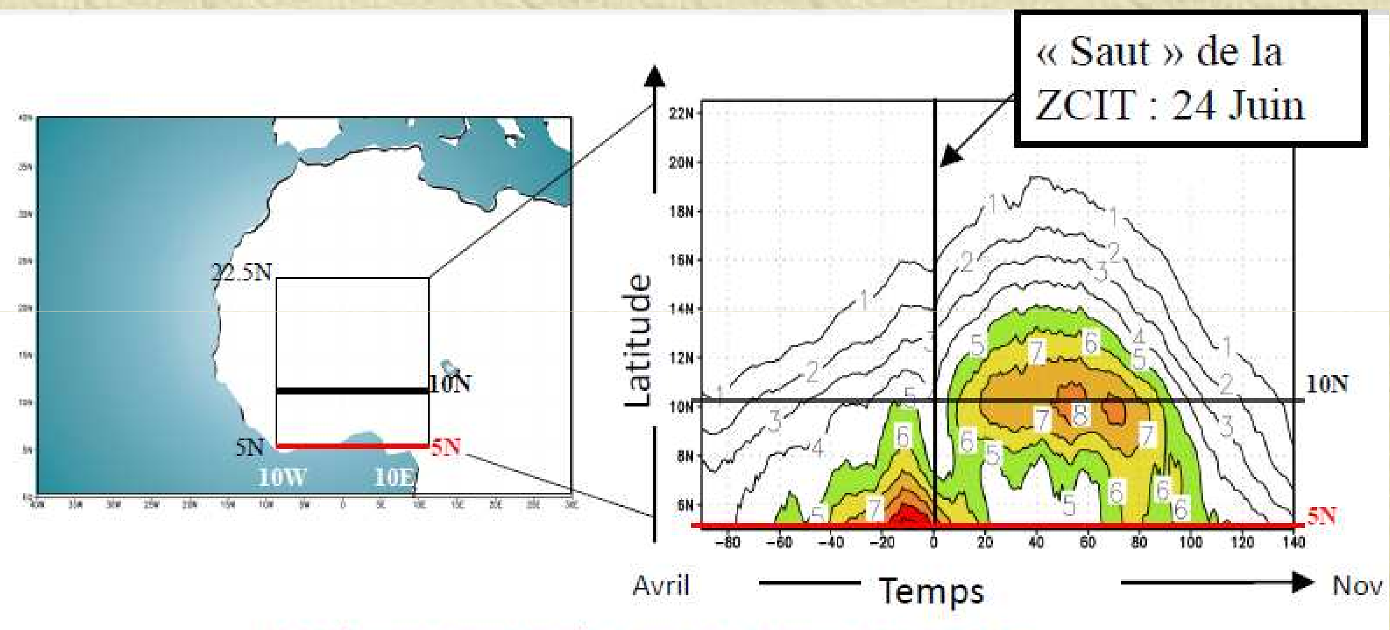
A simple seasonal rainfall approach is not enough

Wich time and space scale?



1950 – 1969 : grey boundaries, 1970 – 1989: red lines, 1990 – 2009: blue lines
Présentation Abdu Ali, SMHI, Ouaga 2010

Rainy season?



Le déplacement méridien saisonnier de la ZCIT

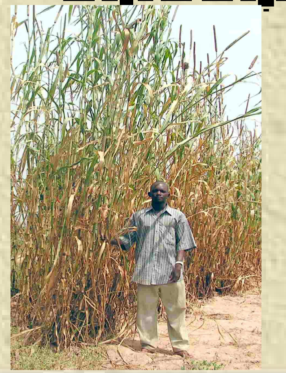
From North to the South high seasonal variability,

Modal to bi-modal rainy season,

But also specific trends (Sultan & Janicot, 200,2003)

We have to adapt:

Same Plant



Semis 17 Juin

Same guy

Semis 17 juillet

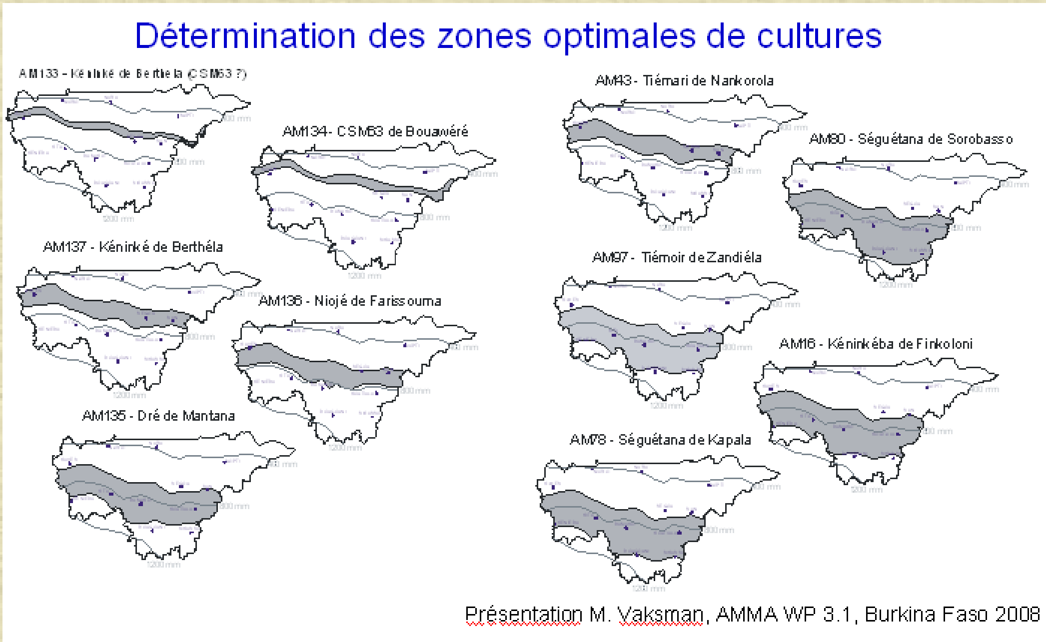
Sowing dates change

Semis 17 Aout

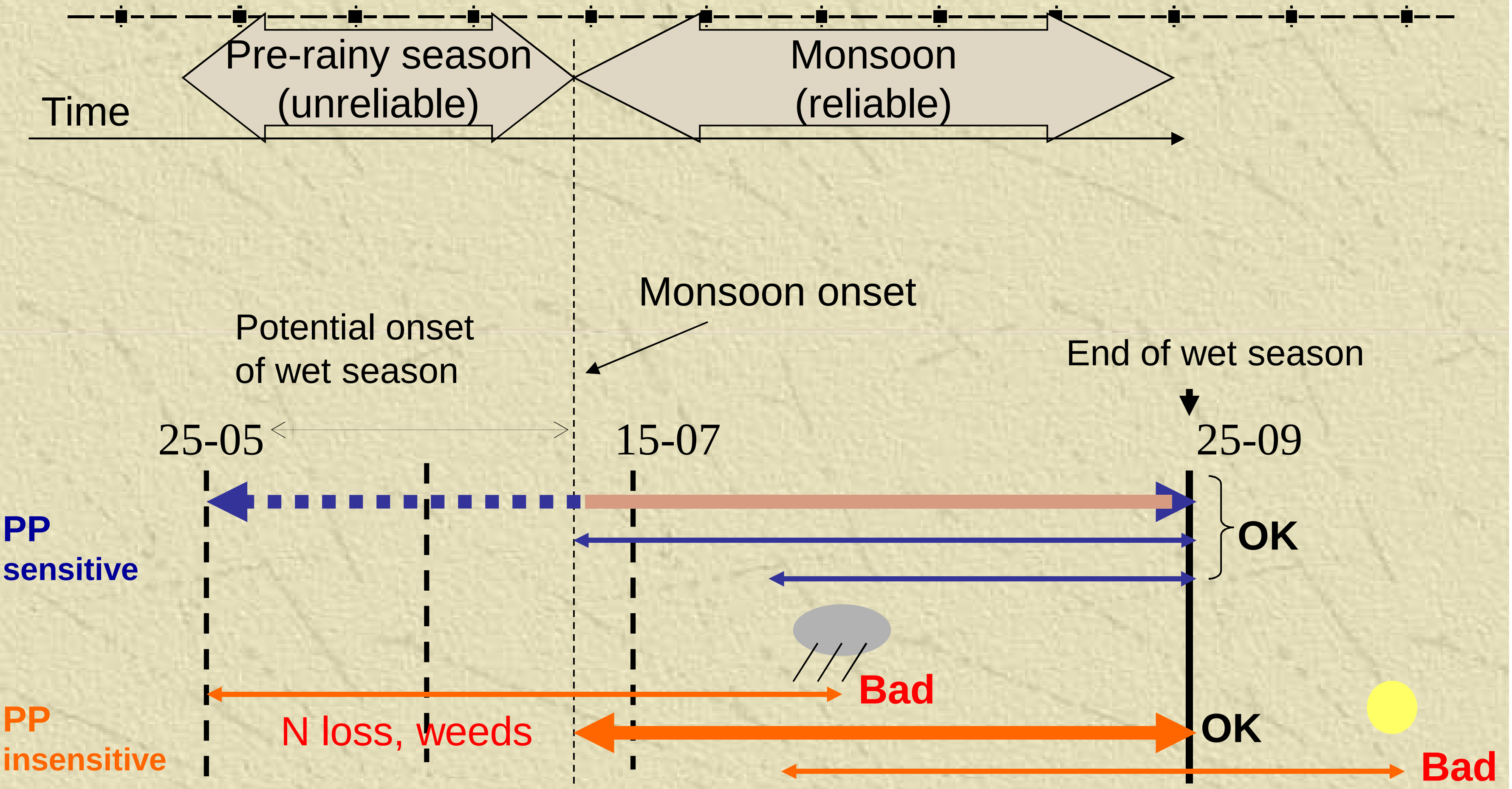
Simulating biodiversity &

Farmers strategies

Locate
this diversity



We have to simulate this diversity



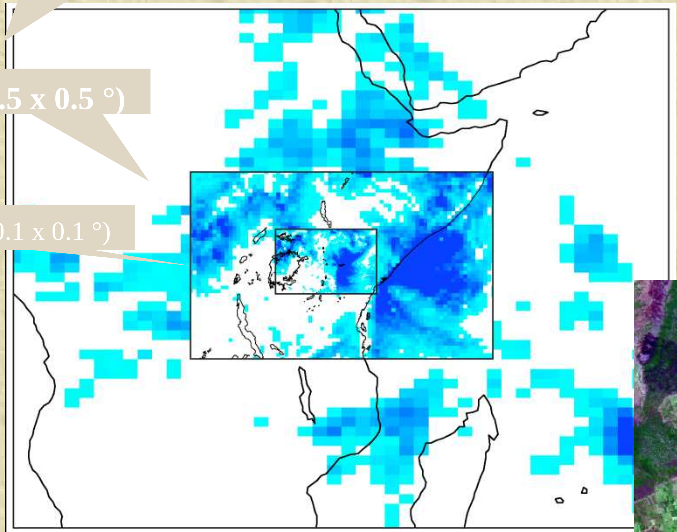
Dingkuhn & al., Amodel of sorghum photoperiodism using the concept of threshold-lowering during prolonged appetence, 2007

We have to adapt scales issues

GCM (2.5 x 2.5 °)

RCM (0.5 x 0.5 °)

RCM (0.1 x 0.1 °)

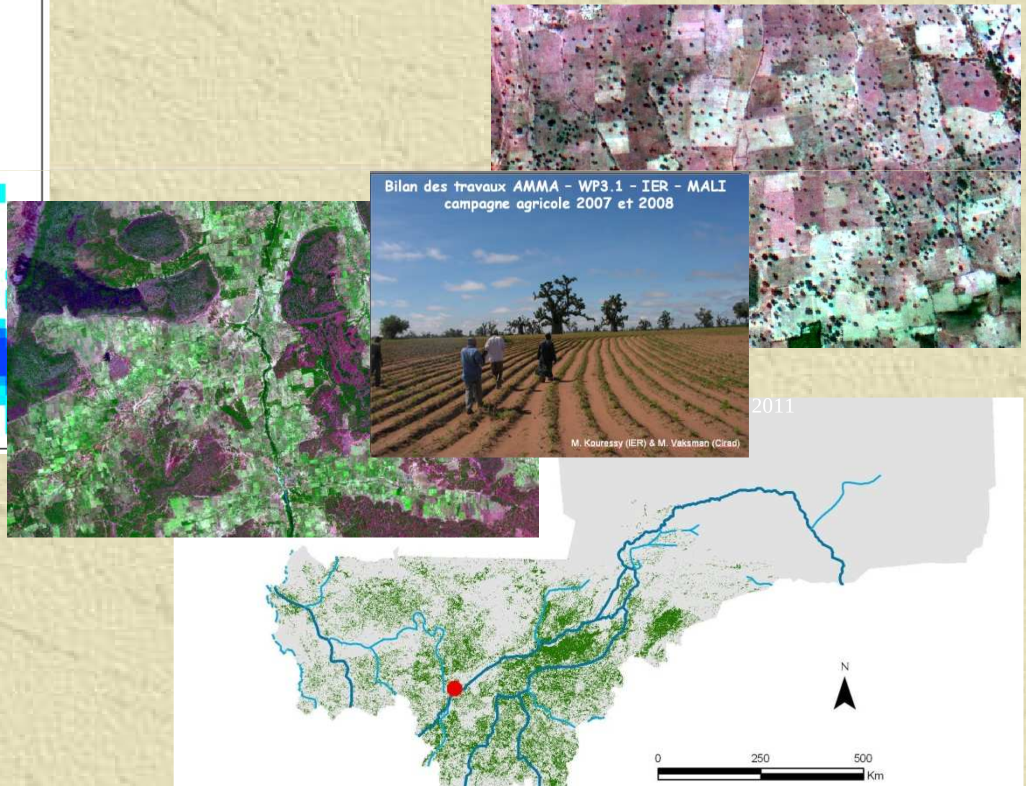


Disaggregation of climate models output:

62 500 km² to 100 km² to 1 km²…

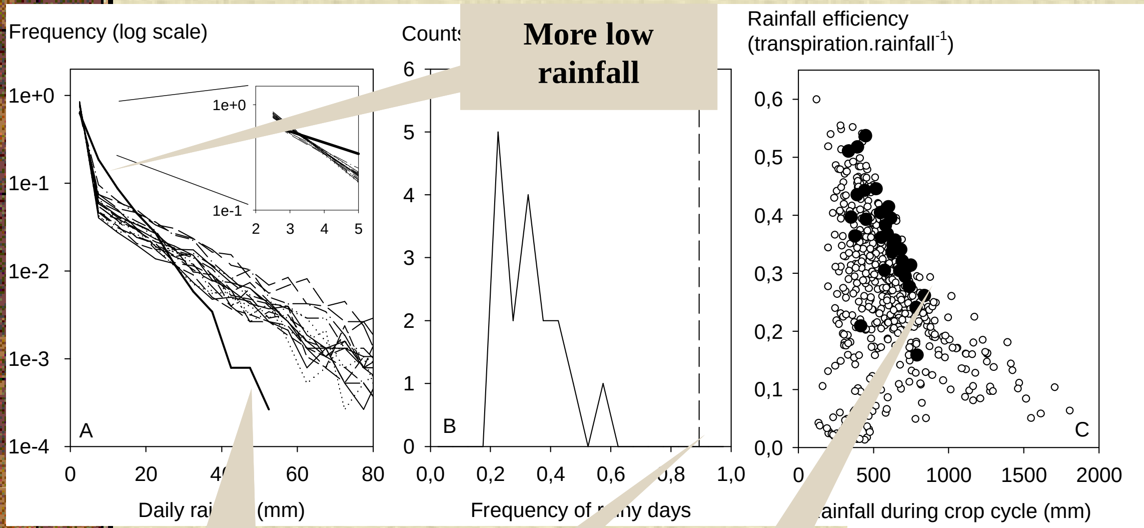
Crop Yield and production aggregate output:

field-> village -> region



Elodie Vintrou & Al., 2011, “Crop area mapping in West Africa using landscape stratification of MODIS time series and comparison with existing global land products”

From GCM to Plot!



More low rainfall

Less high rainfall and lowest amount

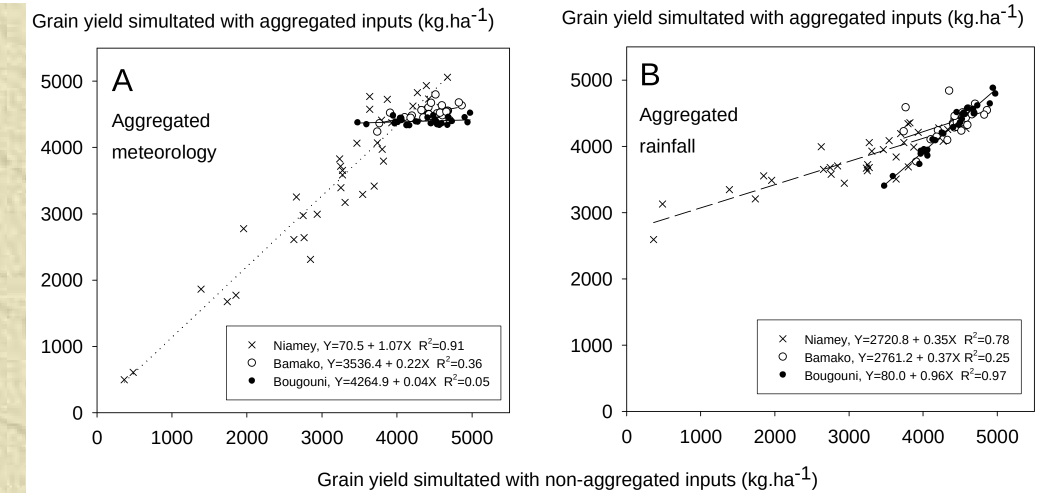
Nearly daily rainfall!

Most efficient for the plant

GCM are calibrated on historic data reanalysis over grid where each cell represent about 62 500 km²

We aggregate the daily value of 17 ground climatic stations covered same area of one cell GCM grid in Senegal analysis the accuracy.

Impact differ from North to the South



At plant local scale, African monsoon looks like Indonesian monsoon !!!!

Baron & al., From GCM to plot, Royal Society, 2005

SARRAH

Process simulated

by the crop model

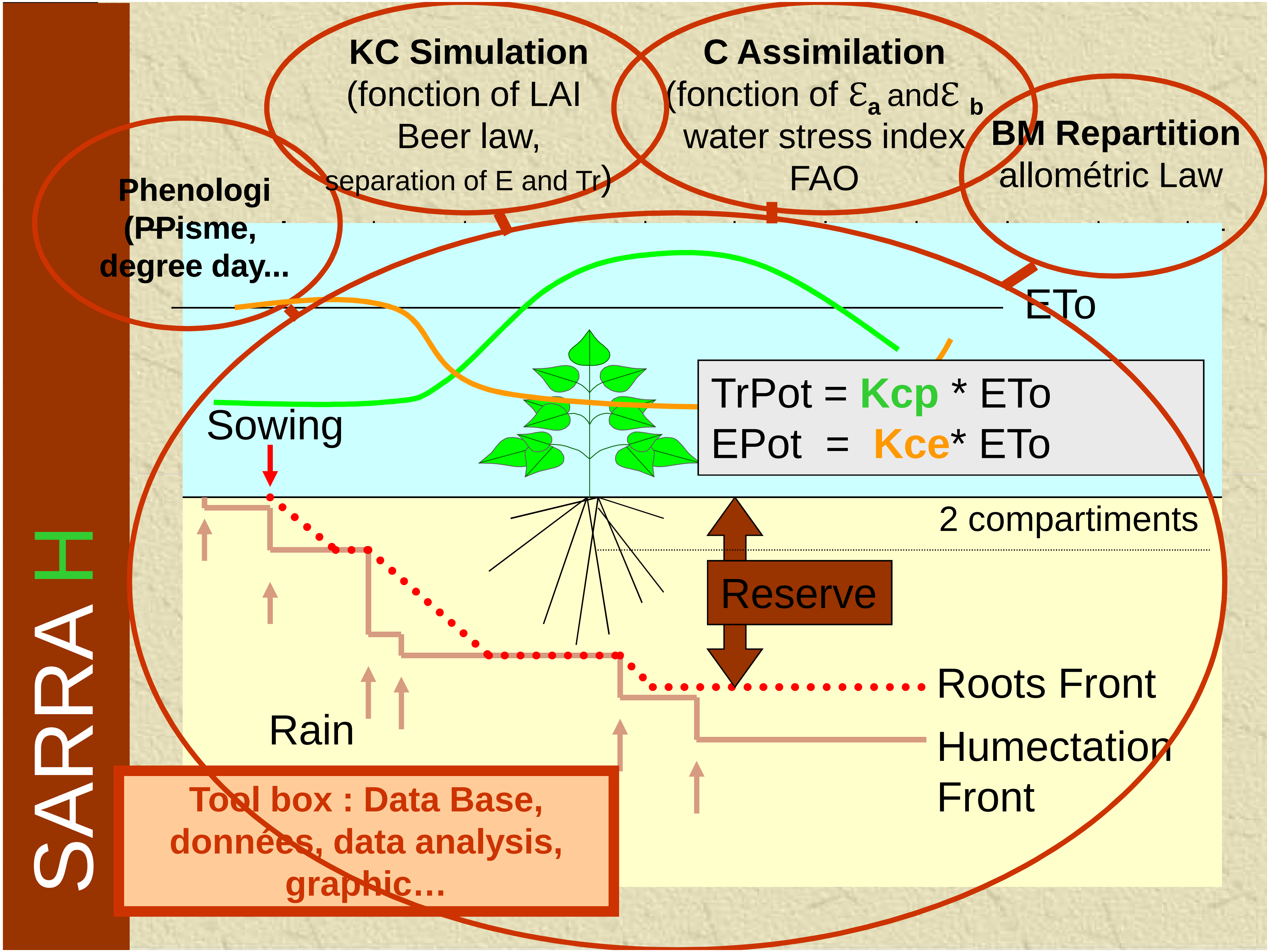
Combining two approach

- Under phenologic control
  - Water Use Efficiency (WUE) :

    Water-> biomass (WB based on reservoirs, KC)
  - Radiation Use Efficiency (RUE) :

    Radiative Energie -> biomass

    (CB based on Sinclair, LAI)

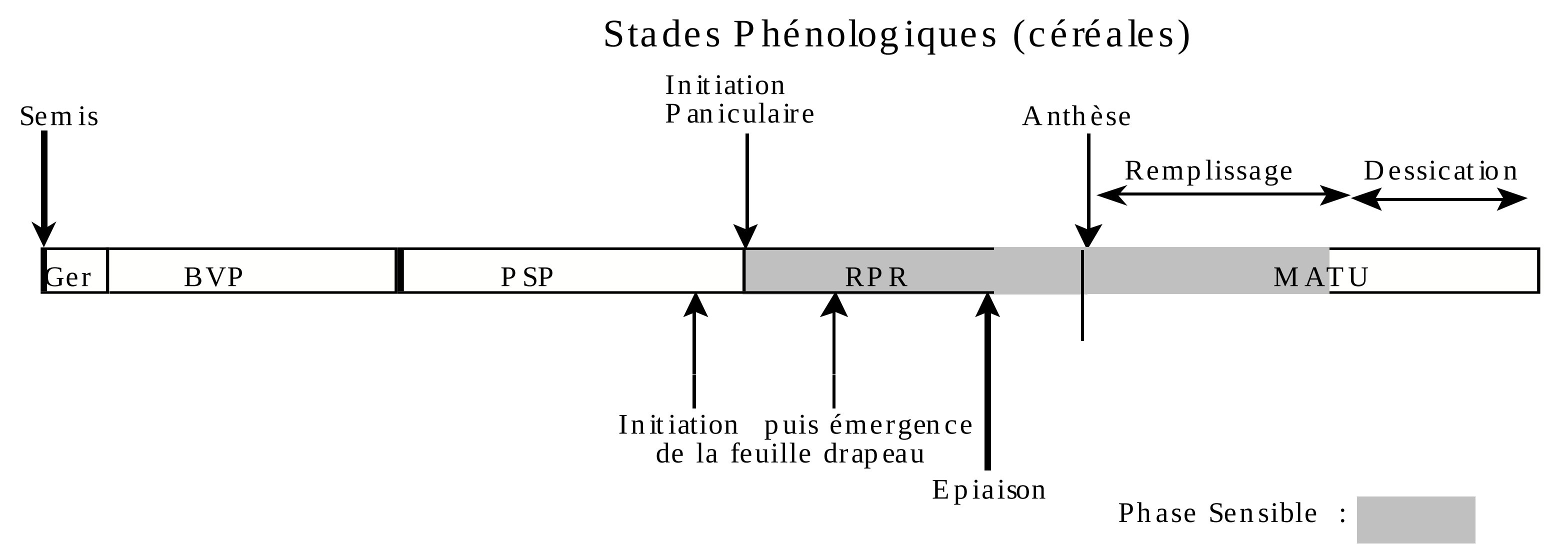


KC Simulation
(fonction of LAI
Beer law,
separation of E and Tr)
C Assimilation
(fonction of Ɛa andƐ b
water stress index
FAO
BM Repartition
allométric Law
Phenologi
(PPisme,
degree day...
ETo
Sowing
TrPot = Kcp * ETo
EPot = Kce* ETo
2 compartiments
Reserve
Roots Front
Humectation
Front
Rain
Tool box : Data Base,
données, data analysis,
graphic…
SARRA H

SARRAH : BH & BC (WUE x RUE)

- A phenological motor, control the process' evolutions
- *Water Balance: tanks dynamics*
- *Carbon Balance: biomass dynamics*

Six phenological stages



- Temperature thresholds delimit the degree-day calculation stages; When a threshold is reached (sum of temperatures, sum of f(PP), we change phase
- PSP phase depends on the sensitivity of a variety to the photoperiod, duration varies depending on the latitude and sowing date

SARRAH : BH & BC (WUE x RUE)

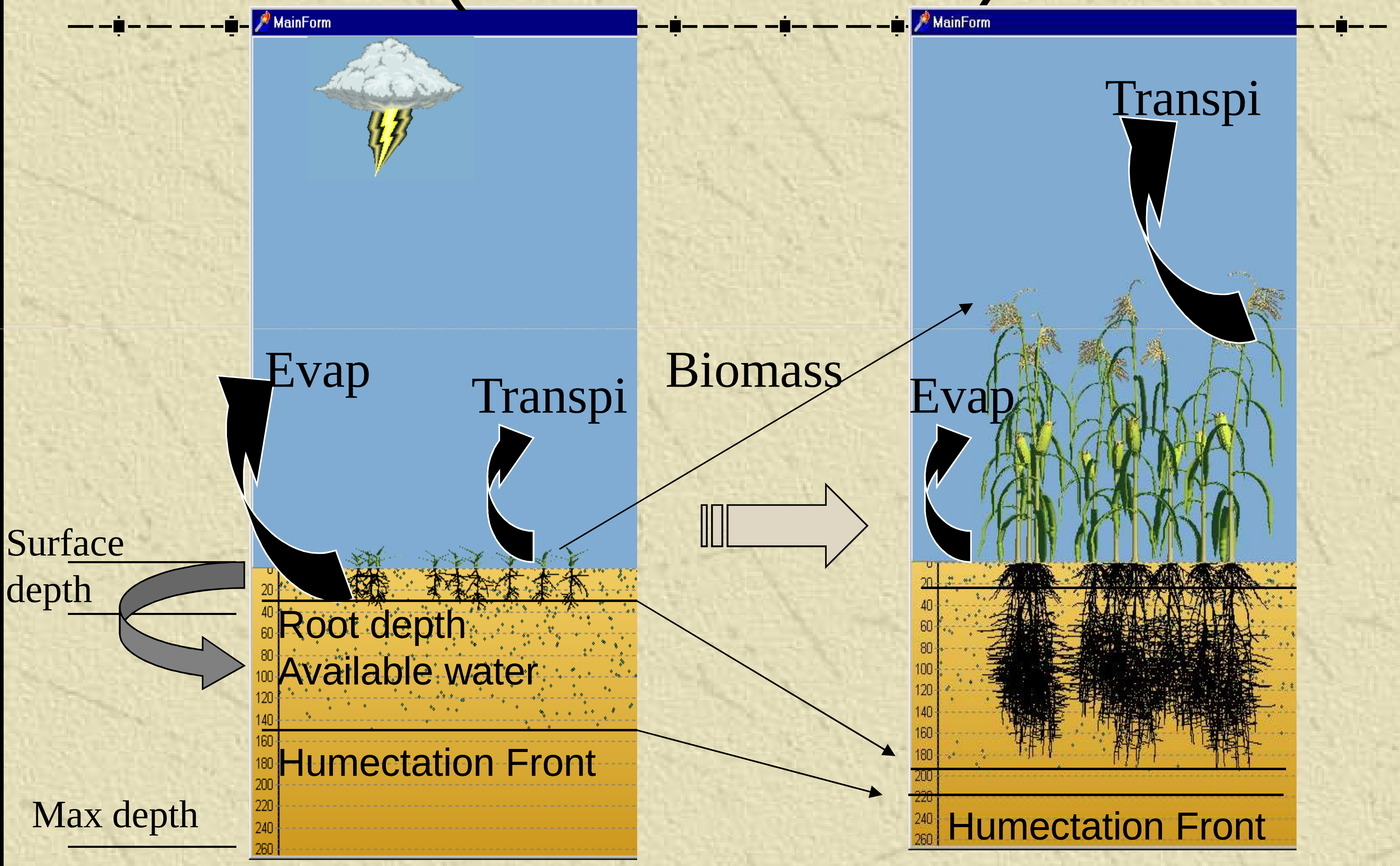
- *A phenological motor, controlled the process' evolutions*
- Water Balance: tanks dynamics
- *Carbon Balance: biomass dynamics*

Water Balance:
A reservoir type approach

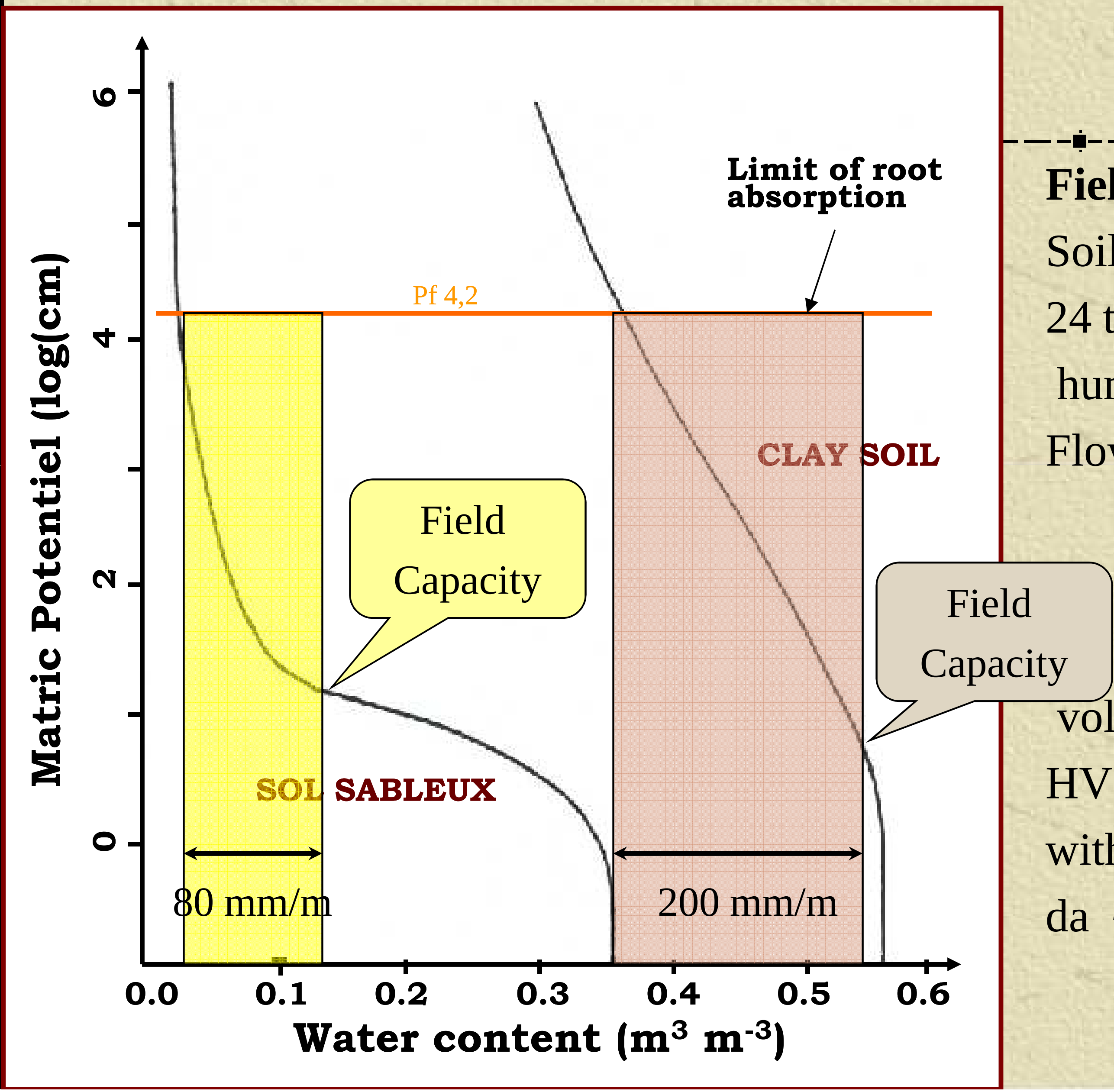
Rain + IRR - RUNOFF - ETR - DR = Δ S

- **Available water: Rainfall – Runoff + net irrigation**
- **Runof: treshold approach**
- **Filling: <u>uniformly distributed inside a reservoir</u> (from surface and overflows into the following reservoir)**
- **Drainage : overflowing from the last reservoir**
- **Evaporation : only calculated for the surface reservoir**
- **Transpiration : calculated for the entire root reservoir**

Water balance: 2 reservoirs (base SARRA)



Matric Potential & Water Holding Capacity



Field Capacity :

Soil water storage

24 to 48 h after full

humectation , concept of

Flow rate

Nota :

volumetric moisture

HV = HP * da

with

da ~ 1.5 for sandy

1 for clay

Field scale process

- LTR : Soil Light transmission exp(-kdf * LAI)
  - kdf leaf angle indice
  - LAI Leaf Area Indice (0 to 5-6…)
- Surface soil reservoir Evaporation :
  - EvPot : ETo * LTR
  - Ev : EvPot * (FESW)^2
- Root reservoir Transpiration:
  - TrPot : ETo * (1-LTR) * KcMax
  - Tr : TrPot * Cstr
    - Cstr : fn(FTSW, ETo) Pfactor FAO

SARRAH : BH & BC (WUE x RUE)

- *A phenological motor, controlled the process’ evolutions*
- *Water Balance: tanks dynamics*
- Carbon Balance: biomass dynamics

Assimilation : sugar amount

- Assimlates produced are simulated in sugar equivalent
- Assimilates :

$$PAR * \varepsilon_{\mathbf{a}} * \varepsilon_{\mathbf{b}} * \text{Water constraint}$$

PAR : photosynthetically active radiation (~0,5 * RG)

$\varepsilon_{\mathbf{a}}$: leaf cover rate(1- LTR)

LTR : Exp(-kdf * LAI)

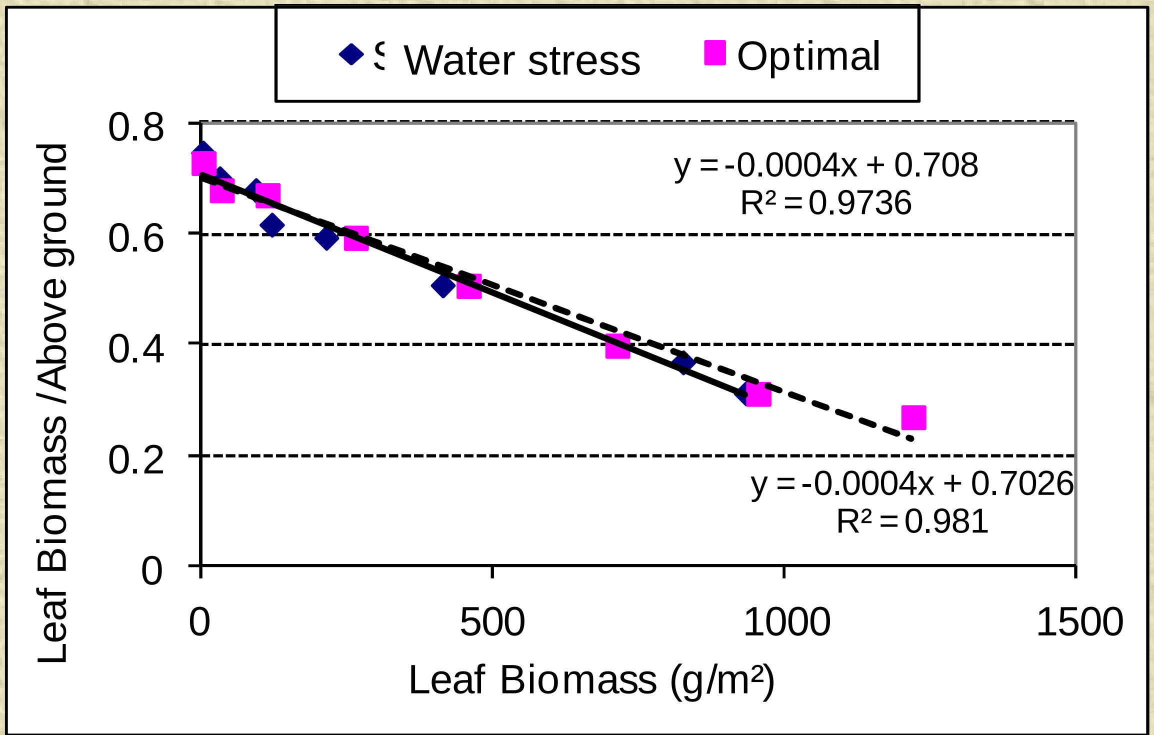
$\varepsilon_{\mathbf{b}}$: coefficient of light energy conversion into dry matter (génotype, ie C3 (stem cereals, colza, tournesol, soja...), C4 (sorghum, milllet, maize, sugar canne)

Water constraint: Tr/TrPot

Biomass Dynamic

- Two main assimilate repartition dynamic in links with two main stages:
  - Before flowering: vegetativ and reproductiv phase (total biomass elaboration & size of reproductive organs)
  - *After flowering: grain filling and dessication phase*

Robustness based on allometric relation

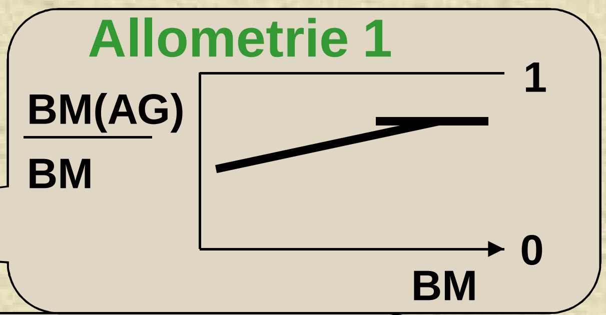


Experimental Station, B. Sarr, Ceraas, Senegal, 1996

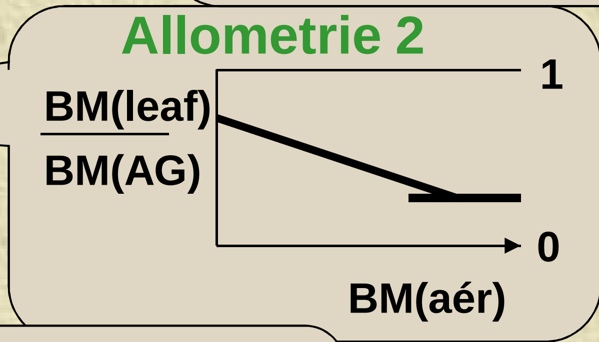
Assimilation: a big leaf type approach

$$\text{Assim} = \underline{f(RG, \varepsilon_a, \varepsilon_{btot}, \text{constraints})} \quad \underline{f(T, BM_i)}$$

$$\underline{BM_{i+1}} = BM_i + dBM - Rm$$

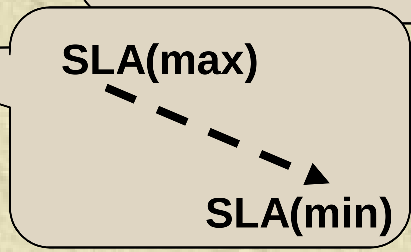


$$\underline{BM(AG)} + BM(root)$$



$$\underline{BM(leaf)} + BM(stem)$$

$$LAI = BM(leaf) \times SLA$$



* BM(AG) = Above Ground biomass

LAI: deduced from leaf biomass

LAI = BM(leaf) x SLA

SLA(max)

SLA(min)

Variation in SLA

<u>Objectif :</u> How simulate the conversion of leaf biomass in leaf area

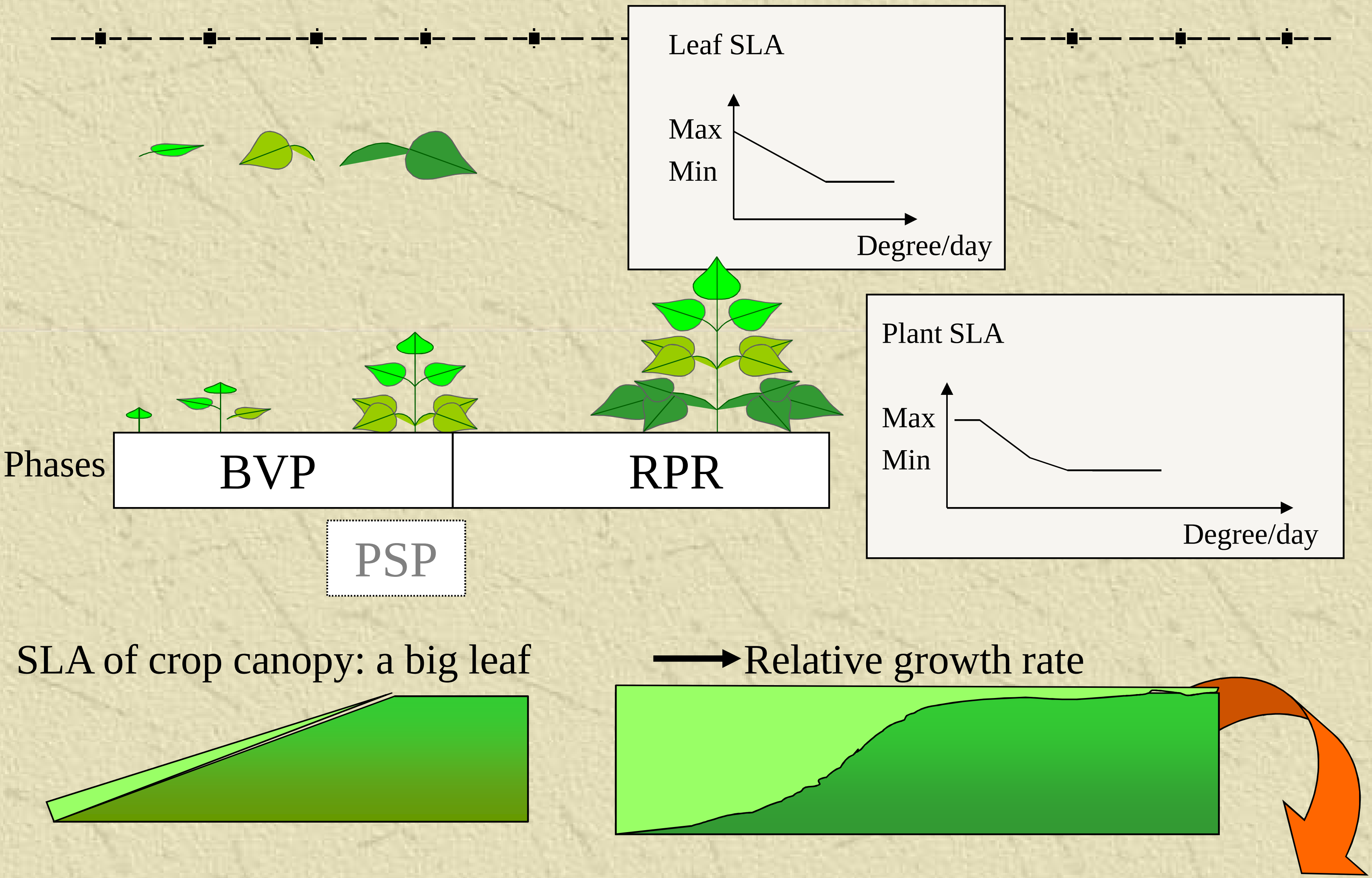
- **Decreasing SLA = épaississement des feuilles**
  - **- leaf scale (phyllochron)**
  - **- plant scale (length cycle)**

<u>Inovative concept:</u>

- **Leave: SLA_{max} , $SLA_{min,}$, slope= genetic parameter**
- **Couvert : SLA_{daily}**
  - **New leaf biomass have higher SLA_{max} later decrease**
  - **Compute SLA_{daily} weighting by…**
    - **- new leaves = SLA_{max}**
    - **- present leaves (SLA decrease from max to min)**

<u>Result:</u> SLA value is a function of relative growth rate

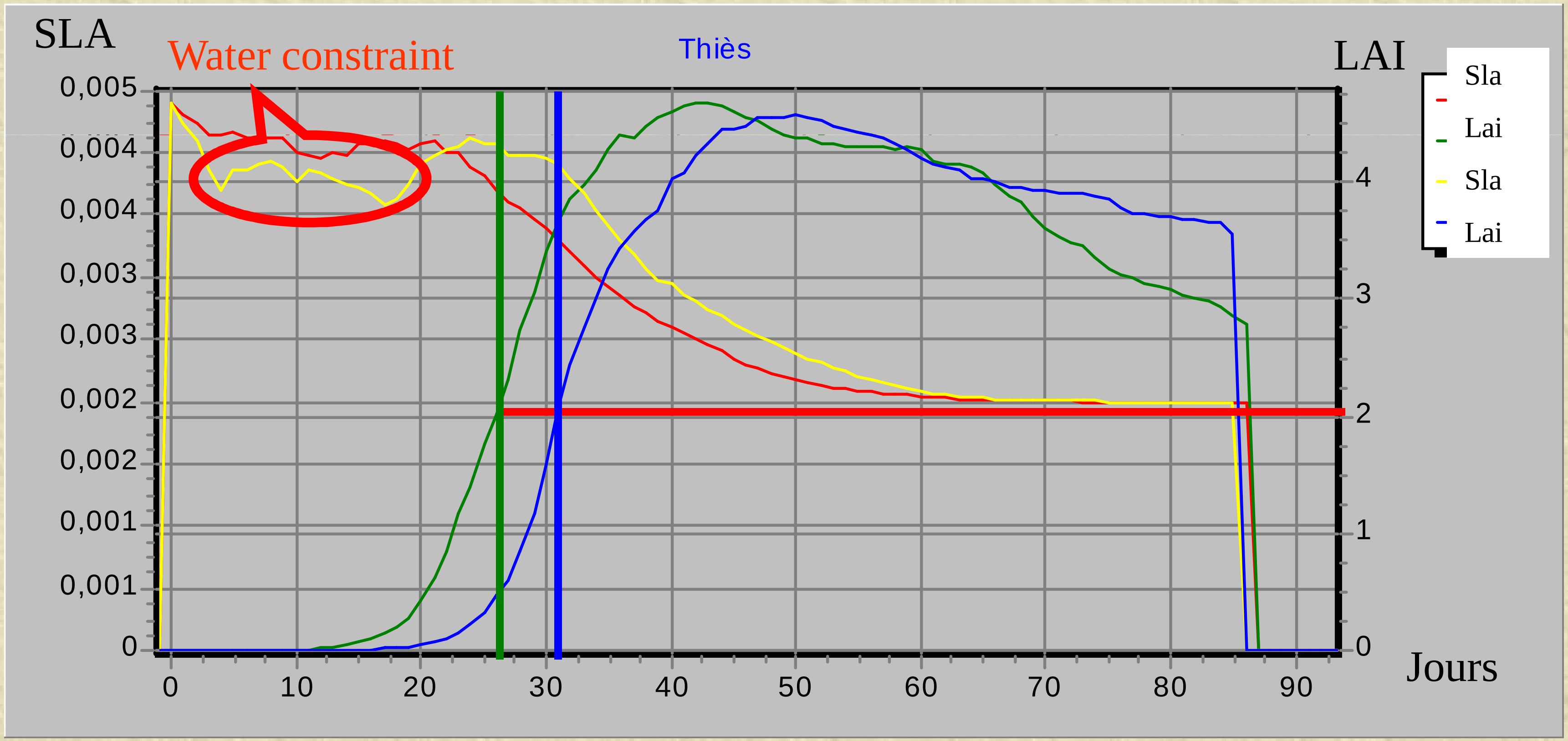
Specific leaf area dynamic (SLA)



Trophic Relationship: LAI & SLA

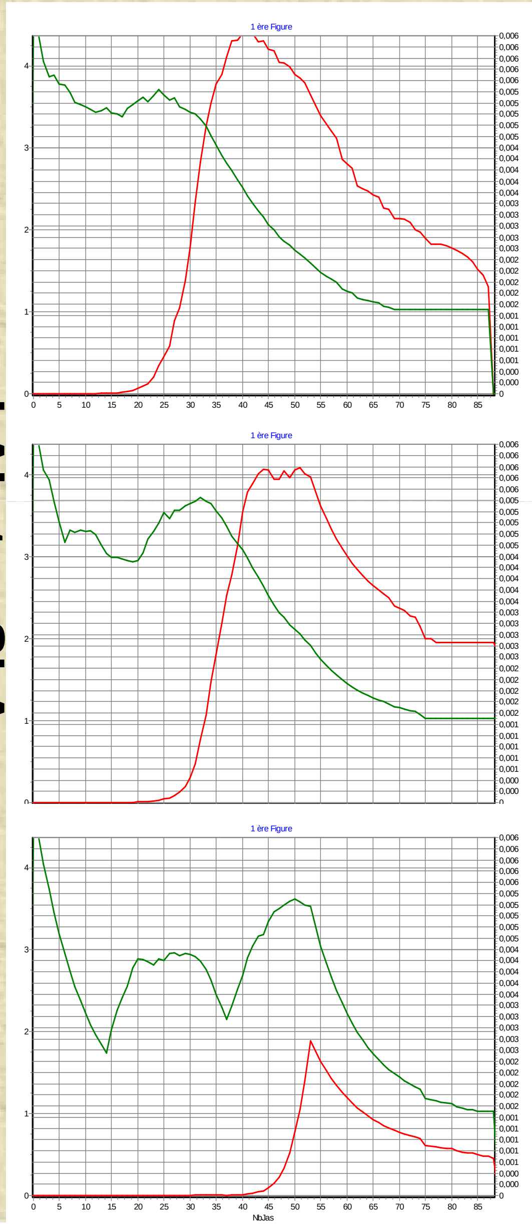
LAI = Leaf Biomas * SLA

SLA Fn(dBMLeaf/BMLeaf...)



Constraints & dynamics

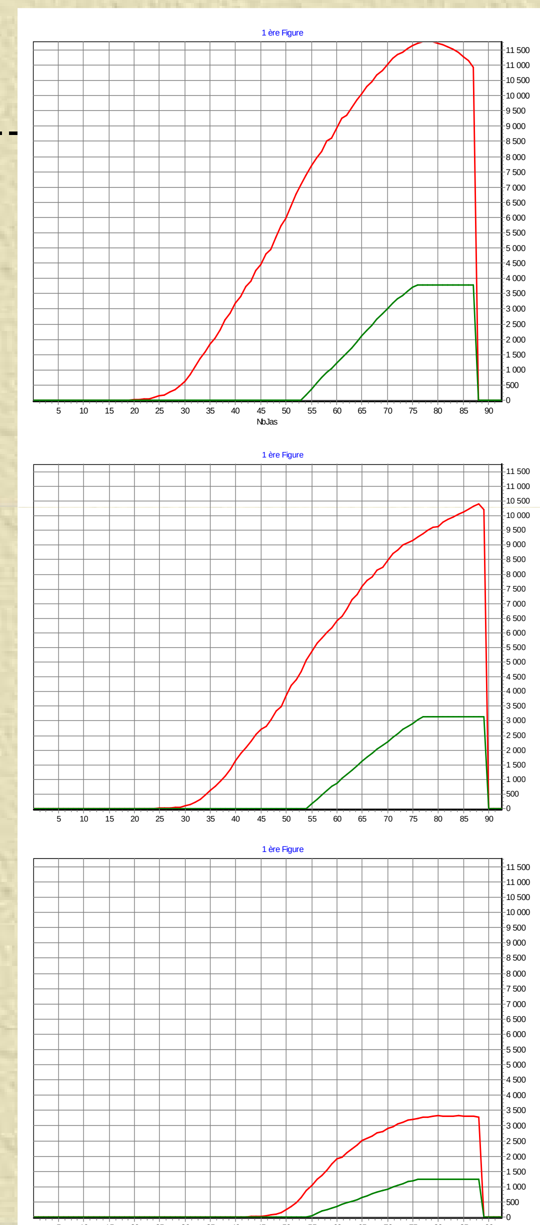
LAI et SLA



Low constraint
Normal dynamic

Hight initial constraint
Retrieve the dynamic

Hight initial constraint
During 2 periods
dynamiccompletly
disrupted



BiomAero et RDT

Justification

Trophic controled by LAI:

- Physiologic reality, ressources sensitivity
- Control the hypersensitivity to initial values:
  - Thanks to the control of the assimilates repartition thrugh the allométric relationship (concept of dilution curves) **and not by phenologic stade**
  - Easy to configure (mesurable), robust

Adoption of SLA concept:

- Distinction between ecotypes (=> Functional ecology)

Biomass Dynamic

- Two main assimilate repartition dynamic in links with two main stages:
  - *Before flowering: vegetativ and reproductiv phase (total biomass elaboration & size of reproductive organs)*
  - After flowering: grain filling and dessication phase

Yield Elaboration

- **Sink dimensioning (garins number) during reproductiv phase depending of plant state**

  RPR : panicules initiation to flowering,

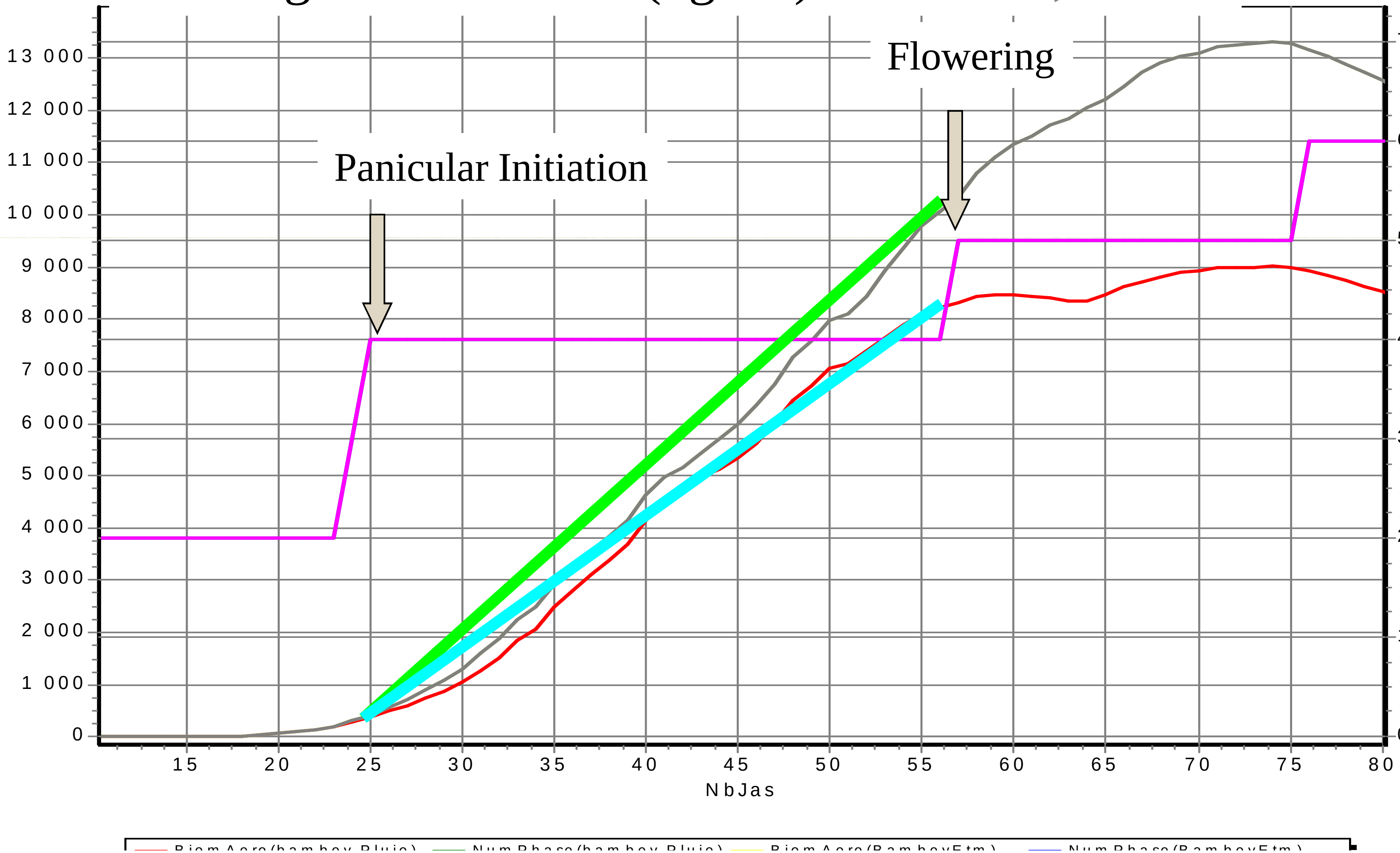
  State: fn(biomass dynamic)
- **Grain filling, source/sink concept : competition index (IC = Supply/Demand)**

  ie : net assimilates / reproductive demand
- **Leaves reallocation : IC < 1 and senescence**

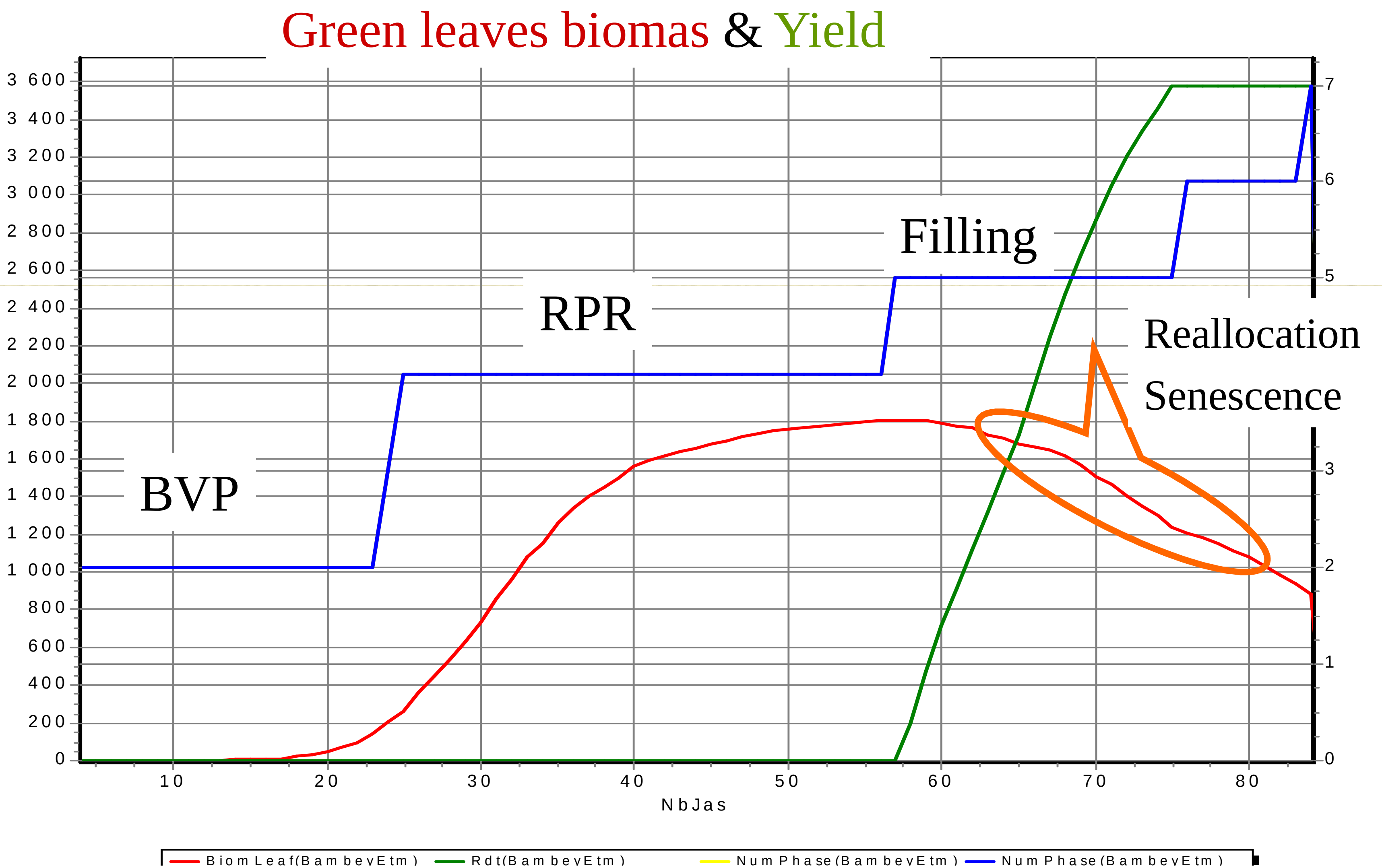
  (reducing the conversion rate ε_b)
- **Green biomass reduction**

Sink dimensionning

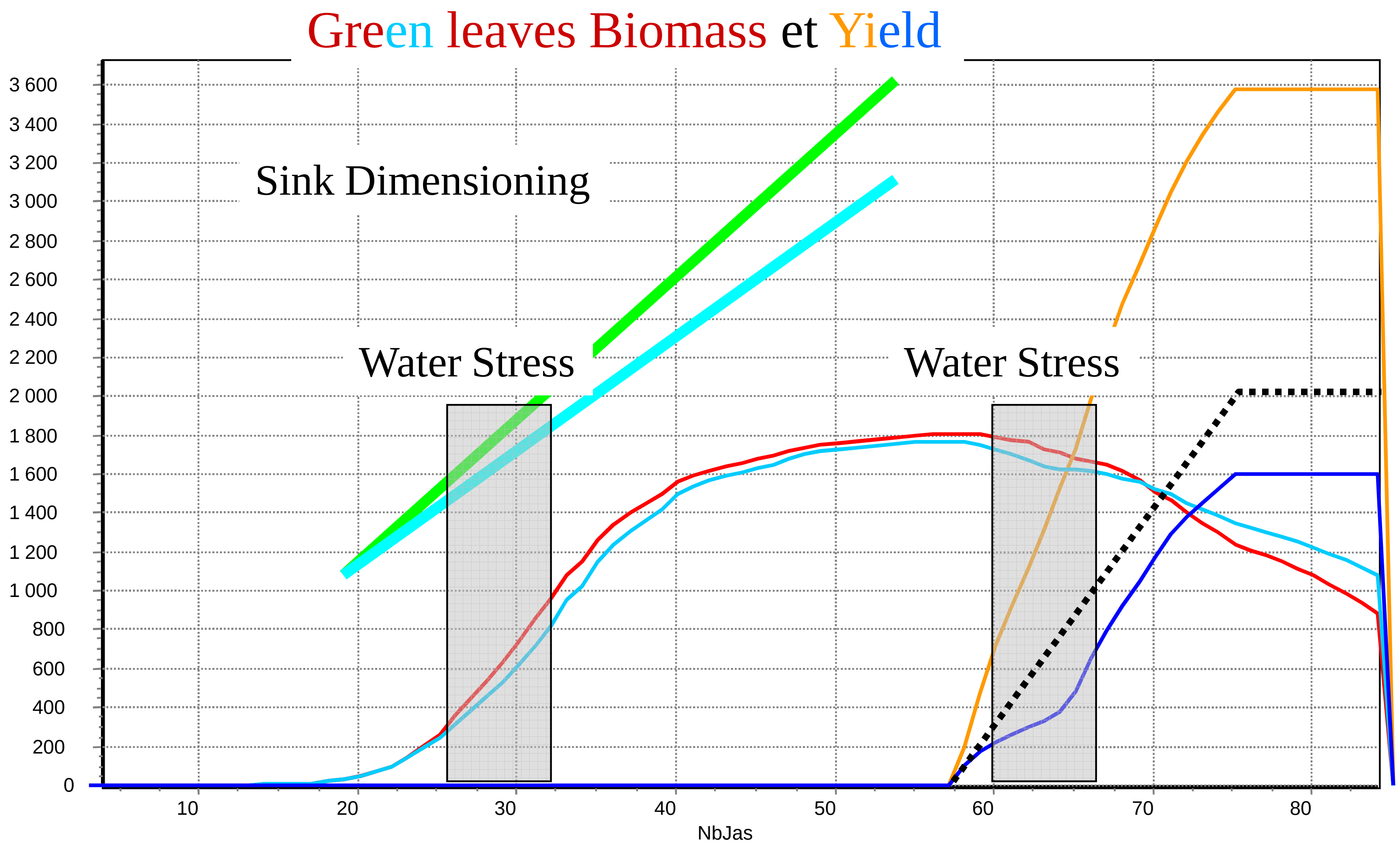
Above ground biomass (kg/Ha) : no Stress, stress



Source/sink competition (IC)



Competition : stress & No stress



SARRAH some publication

- **Vintrou, E., Desbrosse A., Traoré P.C.S., Baron C., Lo Seen D., Bégué A.** (2011). “Crop area mapping in West Africa using landscape stratification of MODIS time series and comparison with existing global land products”. International Journal of Applied Earth Observation and Geoinformation. JAG-D-10-00244R2
- **Oettli P., Sultan B., Baron C., Vrac M.** (2011). “Are regional climate models relevant for crop yield prediction in West Africa”. Environmental Research Letters, Vol 6, pp014008
- **Roudier P., Sultan B., Quirion P., Baron C., Alhassane A., Traoré S.B., B. Muller** (2011) “An ex-ante evaluation of seasonal forecasting for millet growers in SW Niger”. Int. J. Climatol. DOI: 10.1002/joc.2308
- **Genesio L., Bacci M., Baron C., Diarra B., Di Vecchia A., Alhassane A., Hassane H., Ndiaye M., Philippon N., Tarchiani V., Traoré S.B., (2011)** “Early Warning Systems for Food Security in West Africa: Evolution, Achievements and Challenges”. Atmos. Sci. Let., DOI: 10.1002/asl.332.
- **Traoré, S. B., Alhassane, A., Muller, B., Kouressy, M., Somé, L., Sultan, B., Oettli, P., Siéné L., Ambroise C., Sangaré, S., Vaksmann, M., Diop, M., Dingkuhn, M., Baron, C.** (2011) “Characterizing and modeling the diversity of cropping situations under climatic constraints in West Africa”. Atmos. Sci. Let., DOI: 10.1002/asl.332.
- **Marteau R., Sultan B., Moron V., Alhassane A., Baron C., Traoré S.B.,** (2011) “The onset of the rainy season and farmers’ sowing strategy for pearl millet cultivation in Southwest Niger”. Agricultural and Forest Meteorology, Ref. No.: AGRFORMET-D-11-00017R2
- **Mishra A., Hansen J.W., Dingkuhn M., Baron C., Traoré S.B., Ndiaye O., Ward M.N.** 2008. Sorghum yield prediction from seasonal rainfall forecasts in Burkina Faso. *Agricultural and forest meteorology*, **148** (*11*) : 1798-1814. [20081024]. http://dx.doi.org/10.1016/j.agrformet.2008.06.007
- **Baron C., Sultan B., Balme M., Sarr B., Traoré S.B., Lebel T., Janicot S., Dingkuhn M.** 2005. From GCM grid cell to agricultural plot : Scale issues affecting modelling of climate impact. *Philosophical transactions of the Royal Society of London. Biologcial sciences*, **360** (*1463*) : 2095-2108. http://dx.doi.org/10.1098/rstb.2005.1741
- **Sultan B., Baron C., Dingkuhn M., Sarr B., Janicot S.** 2005. Agricultural impacts of large-scale variability of the West African monsoon. *Agricultural and forest meteorology*, **128** (*1-2*) : 93-110. http://dx.doi.org/10.1016/j.agrformet.2004.08.005
- **Sultan B., Janicot S., Baron C., Dingkuhn M., Muller B., Traoré S., Sarr B.** 2008. Les impacts agronomiques du climat en Afrique de l’Ouest : une illustration des problèmes majeurs = Agronomical impacts of the climate in West Africa: An illustration of the main problems. *Sécheresse*, **19** (*1*) : 29-37.