Onset of the rainy season and crop yield in Cameroon: Tools and perspectives for Cameroon

P. Laux[1*], H. Kunstmann[1], G. Jäckel[1], T. R. Munang[2]

1 Institute for Meteorology and Climate Research (IMK-IFU), Garmisch-Partenkirchen, Germany
2 Climate Change Adaptation Unit, Division of Environmental Policy Implementation (DEPI), United Nations Environment Programme (UNEP), Nairobi, Kenya

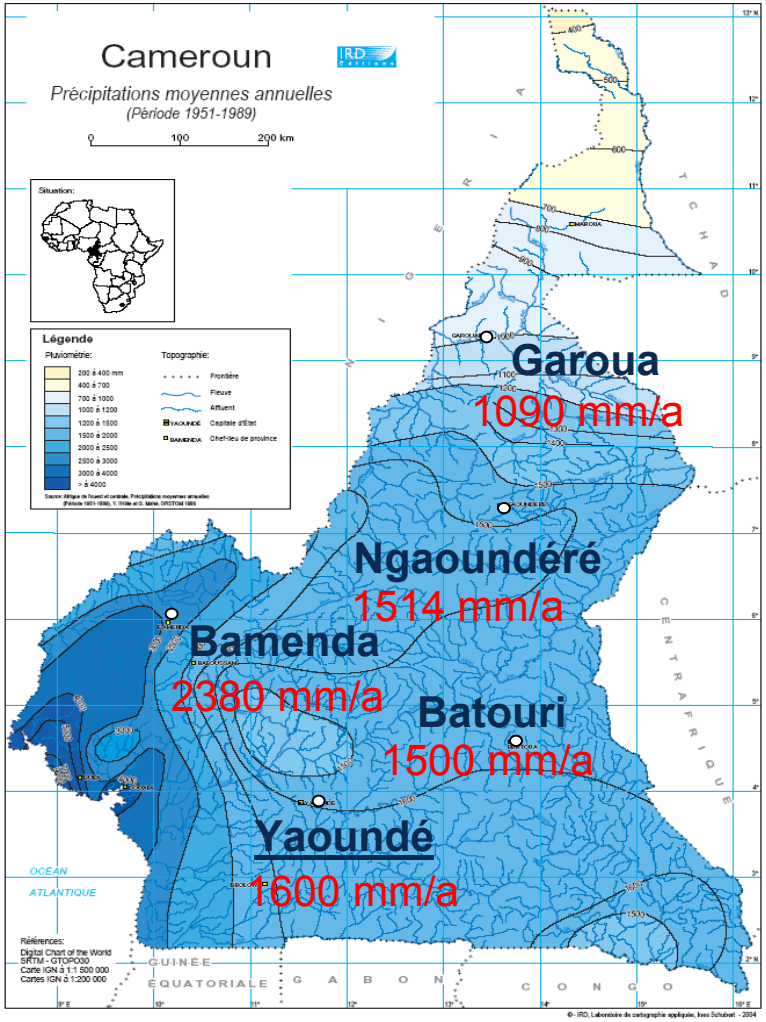
Motivation

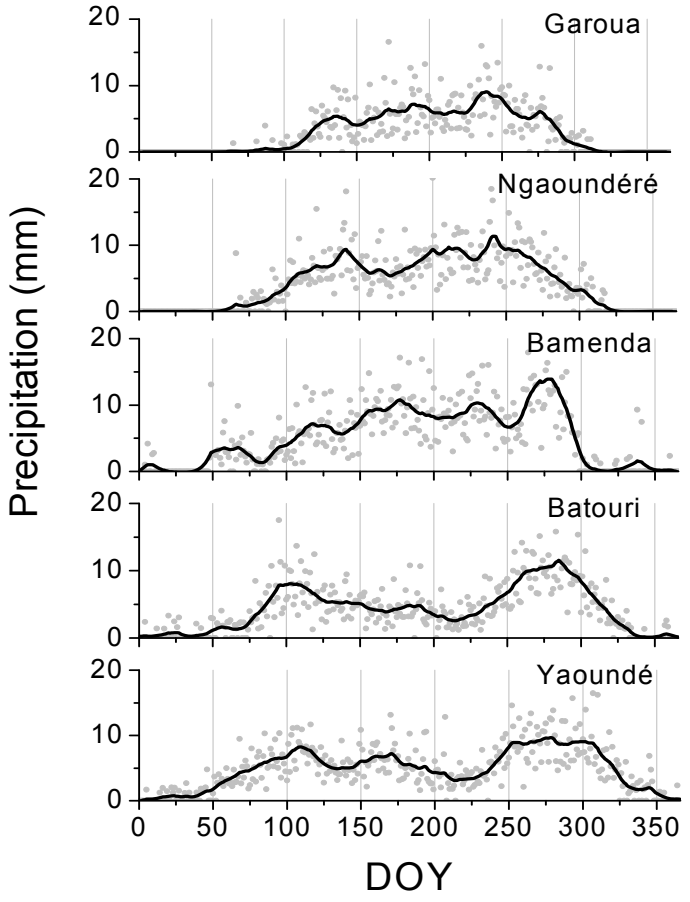
- **Rainfall** = major limiting factor for agriculture in sub-Sahara
- **Economies of SSA** highly exposed to rainfall v
  - Agriculture accounts for 35% of the GD % of population
  - > 95% of cropland managed und **nditions**
  - High rainfall variability on i ter-annual and decadal scales (e.g. severe dr s and 1980s)
- Crucial problem griculture (intra-annual):

  Decision timal planting date
  - arly as possible to avoid wasting of valuable growth time
  - too early may lead to crop failures and high economic losses

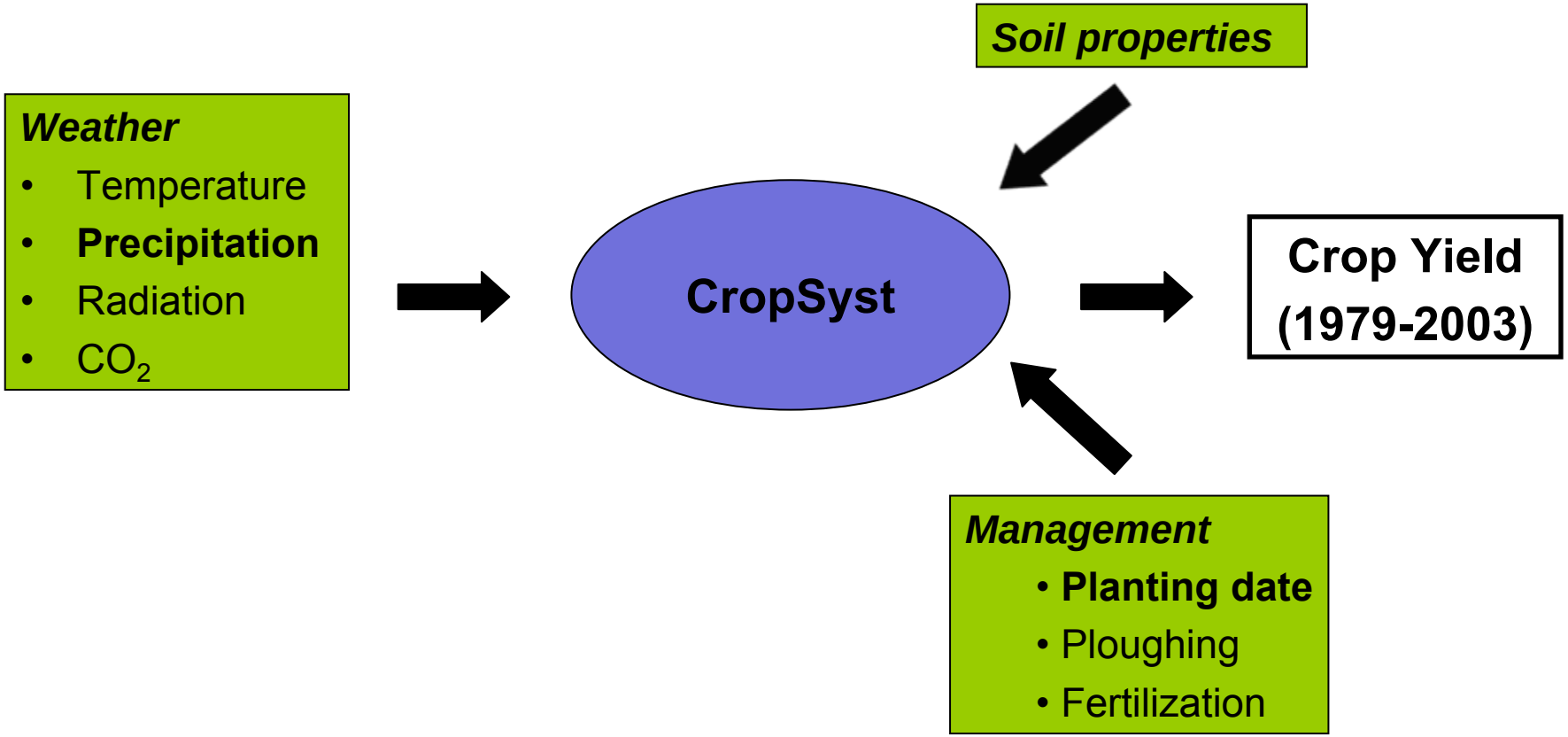
Global climate change is expected to aggravate rainfall variability and water scarcity in 21. Century (IPCC, 2007)

Cameroon: Spatio-temporal rainfall variability





Process-based crop modelling at 5 stations



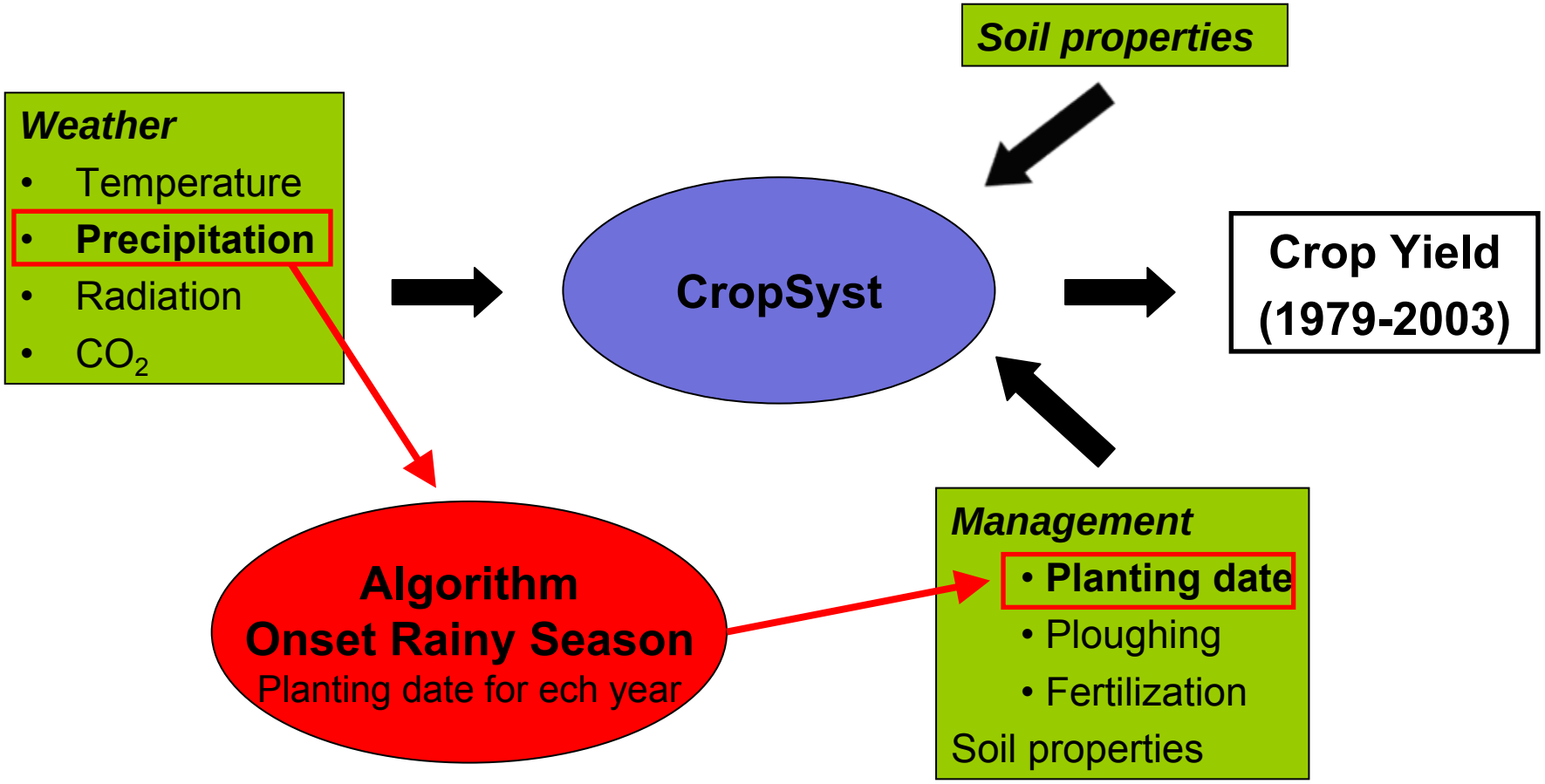
CropSyst model (Stöckle et al., 2003)

- **Multi-year, multi-crop process-based simulation model** to study the effect of climate, soil, and management on productivity and environment of cropping systems

- **Calibration:** Parametrisation of phenological (IRA, Cameroon) and crop-specific values (literature)

- **Validation**
  - Difference modeled and observed yields acceptable (< 10%)
  - Represents inter-annual and spatial variability of observed crop yield

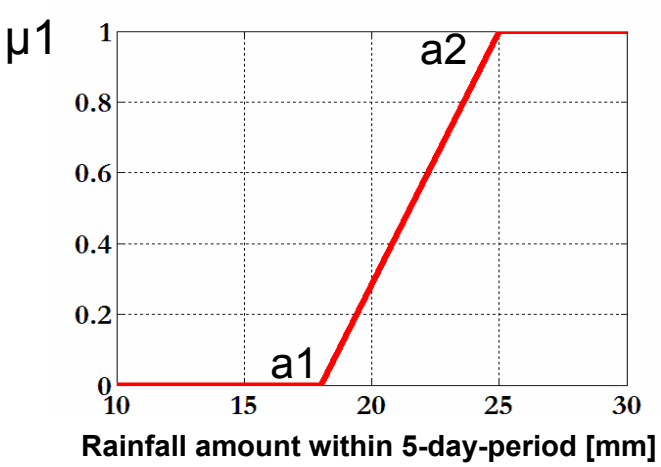
Coupled Planting Date - Crop Modelling



Algorithm Onset of the Rainy Season (ORS)

- Fuzzy logic-based ORS approach of Laux et al. (2008) for Volta Basin of West Africa, modified approach of Stern et al. (1981)

- 3 membership functions:

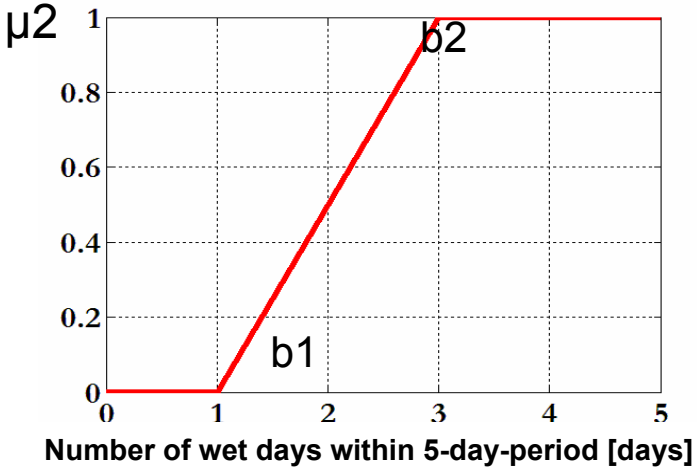


- μ1: 2 parameters a1, a2
- Sufficient water at planting stage

Algorithm Onset of the Rainy Season (ORS)

- Fuzzy logic-based approach of Laux et al. (2008) for the Volta Basin of West Africa, modified approach of Stern et al. (1981)

- 3 membership functions:

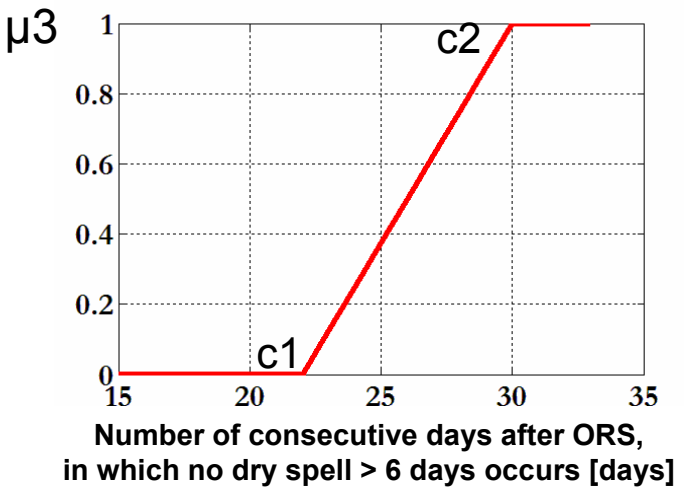


- μ2: 2 parameters b1, b2
- exclude single heavy showers as ORS

Algorithm Onset of the Rainy Season (ORS)

- Fuzzy logic-based approach of Laux et al. (2008) for the Volta Basin of West Africa, modified approach of Stern et al. (1981)

- 3 membership functions:



- μ3: 2 parameters c1, c2
- exclude total crop failure

Algorithm Onset of the Rainy Season (ORS)

- Fuzzy logic-based approach of Laux et al. (2008) for the Volta Basin of West Africa, modified approach of Stern et al. (1981)

- Total membership grade:

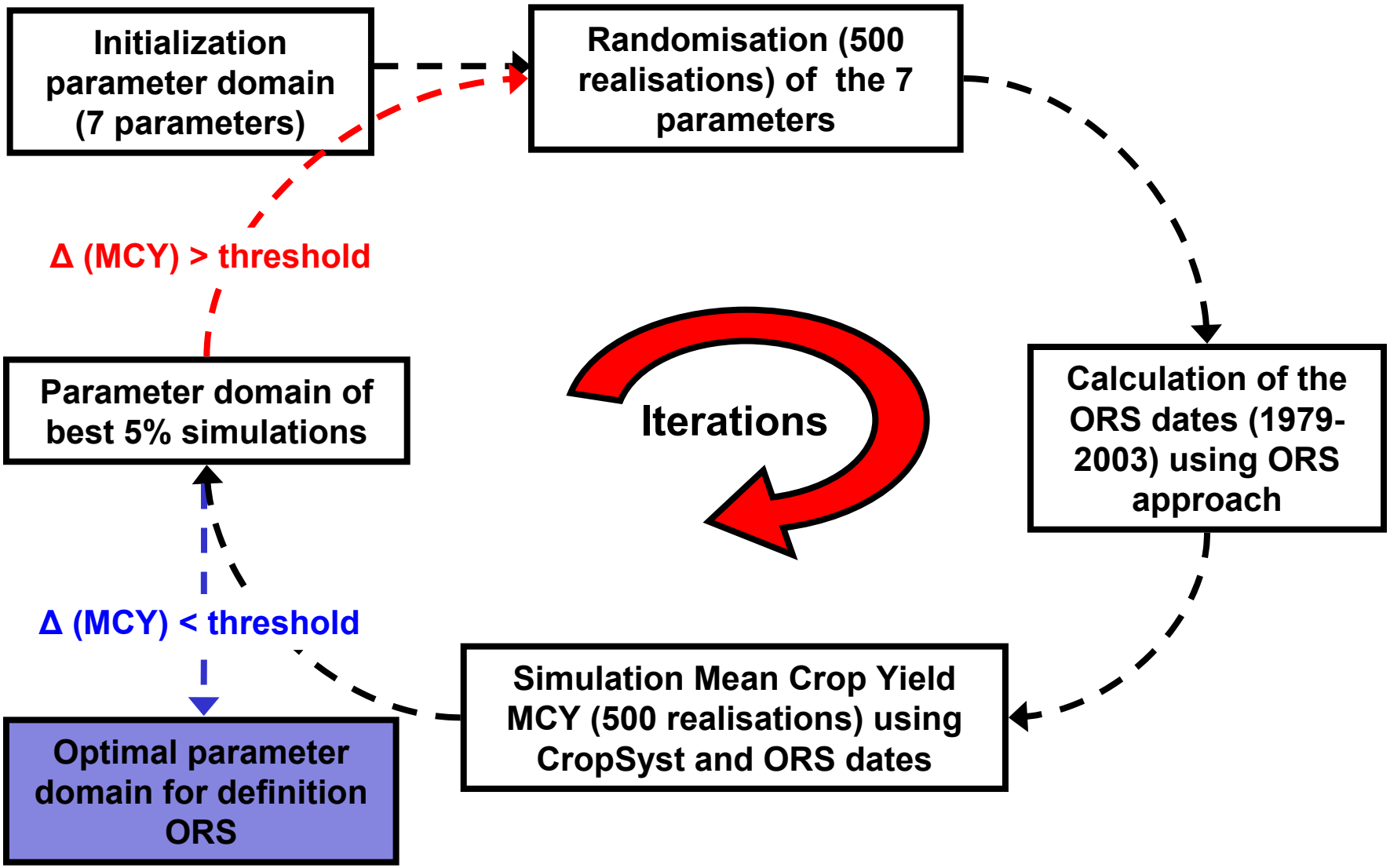
$$\mu_{TOT} = \mu 1 \cdot \mu 2 \cdot \mu 3$$

IF μ_{TOT} > threshold k [0,...,1], THEN Onset Rainy Season

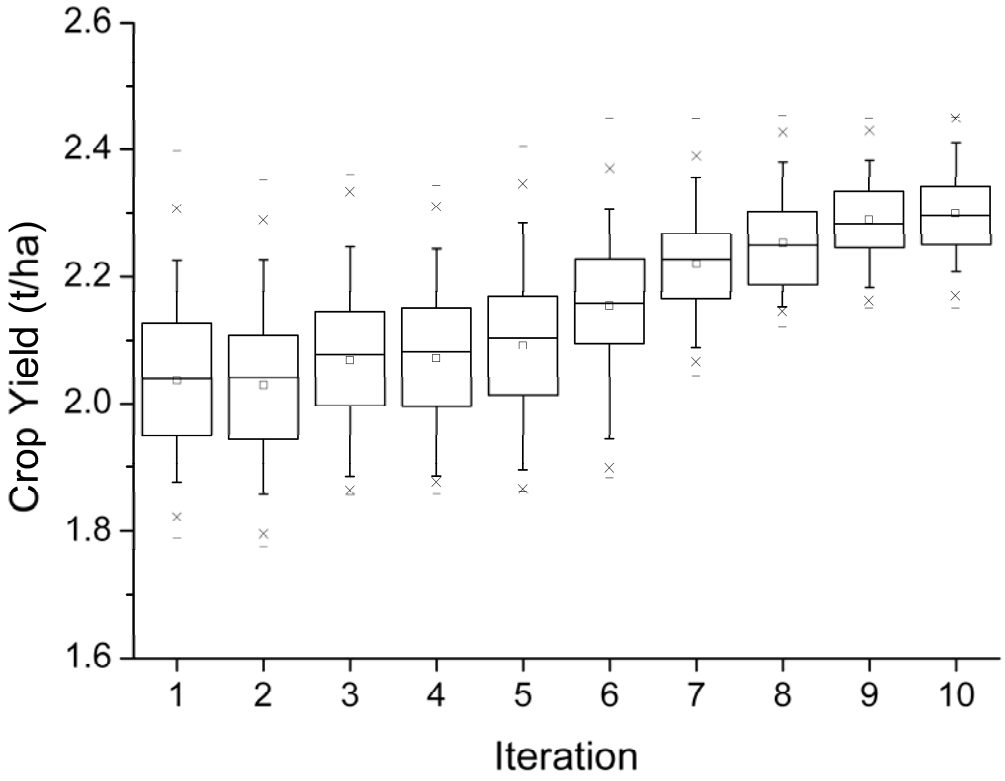
- ORS approach with 7 parameters: k, a1, a2, b1, b2, c1, c2

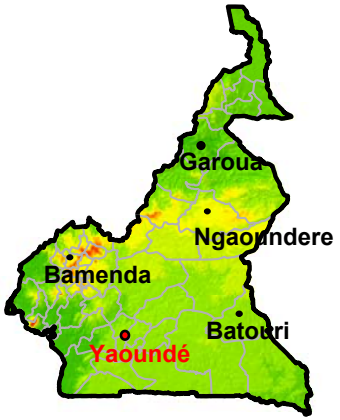
- Parameters depend on region (weather, soil) and plant physiological aspects

ORS parameter optimisation



Results of iteration process: station Yaoundé

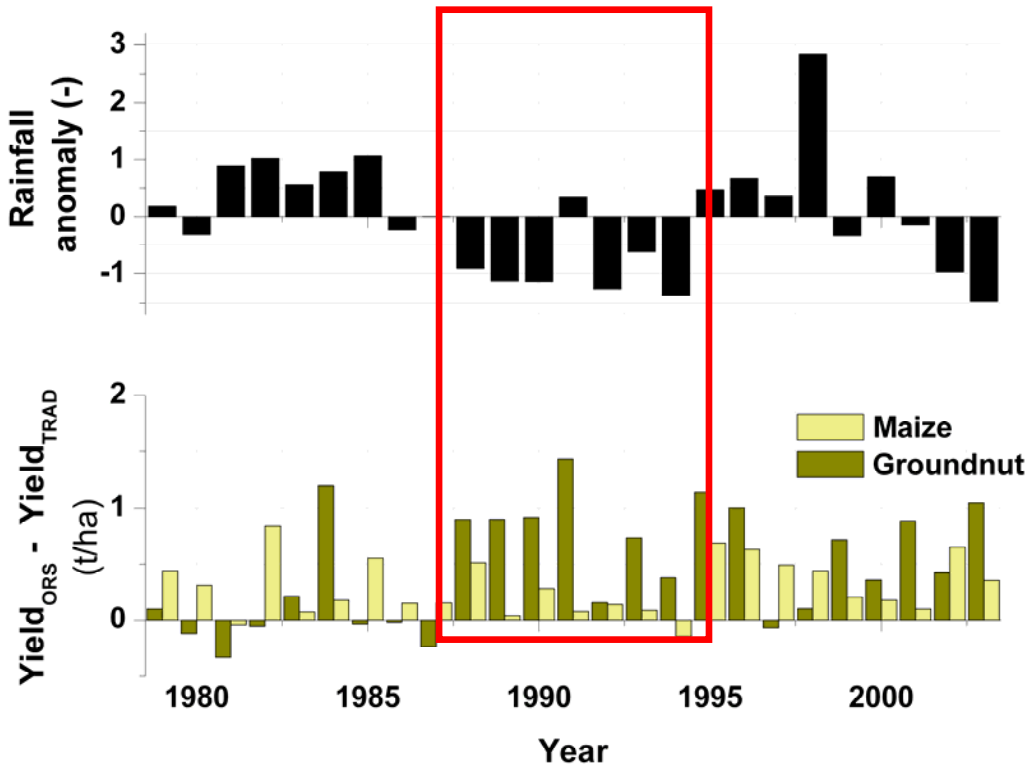


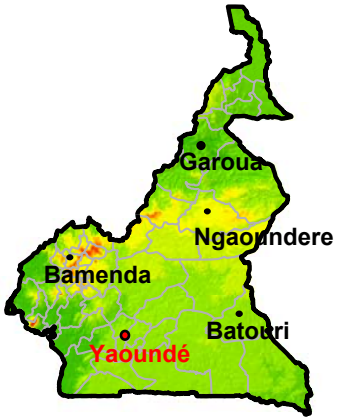


→ Mean attainable crop yield (1979-2003) increases per iteration

→ Distribution narrows (CV decreases)

ORS algorithm vs. traditional planting calendar



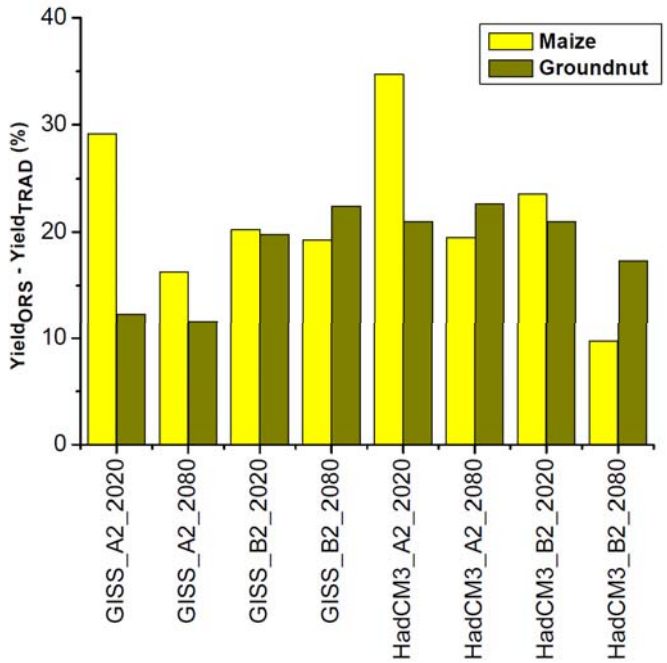


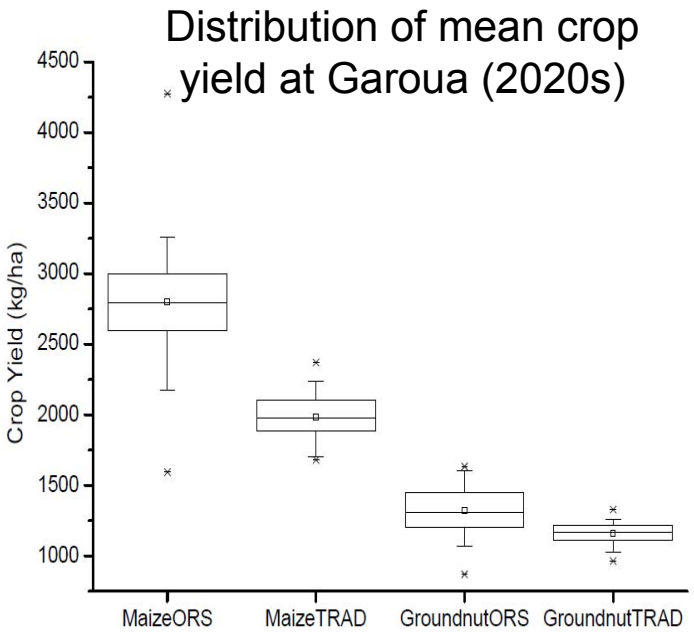
Proposed new method for planting dates would have allowed for:

→ Increase in mean attainable crop yield: Yaoundé **15%**, Garoua **50%**

→ Crop yield increases in anomalous dry years

Impact of planting date adaptations and CC (2020s/2080s)





Compared to traditional planting dates:

→ Increase of groundnut (maize) yields for Garoua and Batouri

→ But: widened distribution for future crop yields: increase in variability!

Summary

- *Coupled Planting Date - Crop Modelling*
  - Deduction of **optimal planting rules (planting dates)**
  - Significant **increase of mean attainable crop yield**, particularly at drier northern stations (Garoua, Batouri)

- *Impact CC on future crop yield estimations*
  - Groundnut yields are expected to increase in the 2020s and 2080s, Maize yields are expected to increase (decrease) in the 2020s (2080s)
  - Using ORS approach reduces negative impacts of CC on maize yield (2080s), i.e. at northernmost stations

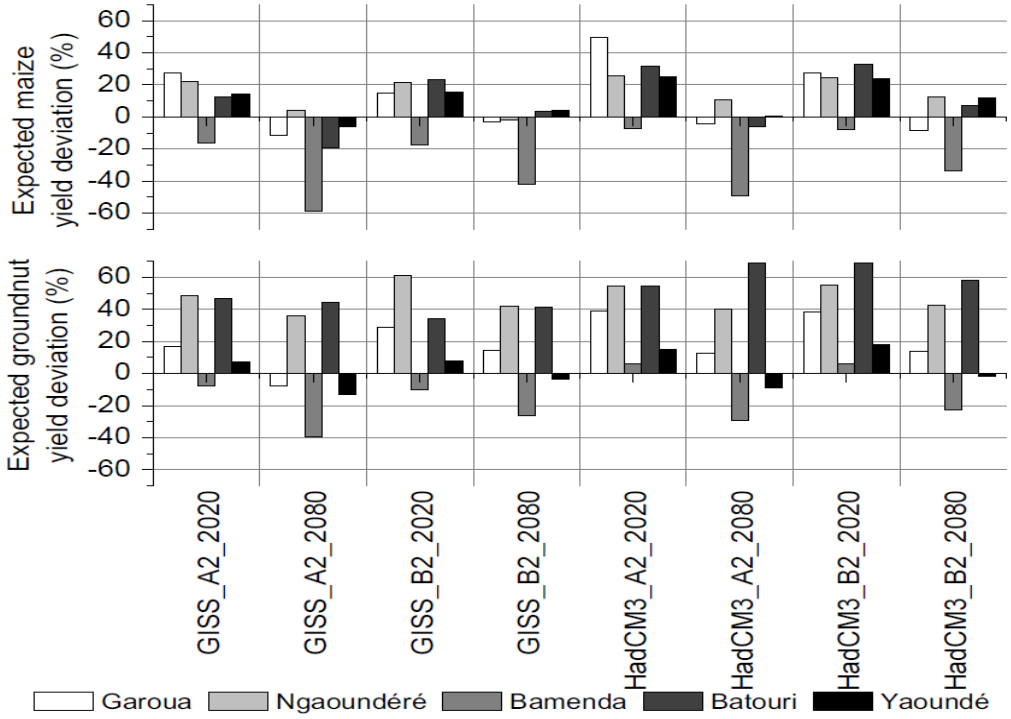
OUTLOOK:

Coupled Planting Date - Crop Modelling for SSA using RCM output

“Challenge” for agricultural management in sub-Saharan Africa

Scientifically sound information about the optimal planting date under present and future climate conditions and weak infrastructure

Direct CO_2 effects + ΔP & ΔT + planting date adaptations



Compared to baseline 1961-1990:

→ Increase of groundnut yields for the 2020s and 2080s

→ Increase (decrease) of maize yields for the 2020s (2080s)

→ Aggravation of growing conditions for Bamenda

Climate change scenarios

- Difference (ratio) of the GCM statistics between modeled future climate and baseline climate
- Application of differences (ratios) on corresponding statistics of observed climate to form a new set of weather generator parameters

Impact of climate change on crop productivity

1. Daily climate scenarios for 2020s and 2080s based on HadCM3 and GISS, and A2 and B2 scenario (8 scenarios for each station)
   - Tmin, Tmax (Solar radiation)
   - Precipitation

2. Atmospheric CO_2 conditions for baseline period 1961-1990, 2020s, and 2080s

3. Crop yield simulations using future climate scenarios under baseline/future atmospheric CO_2 conditions

4. Crop yield simulations with/without adaptations of the planting date

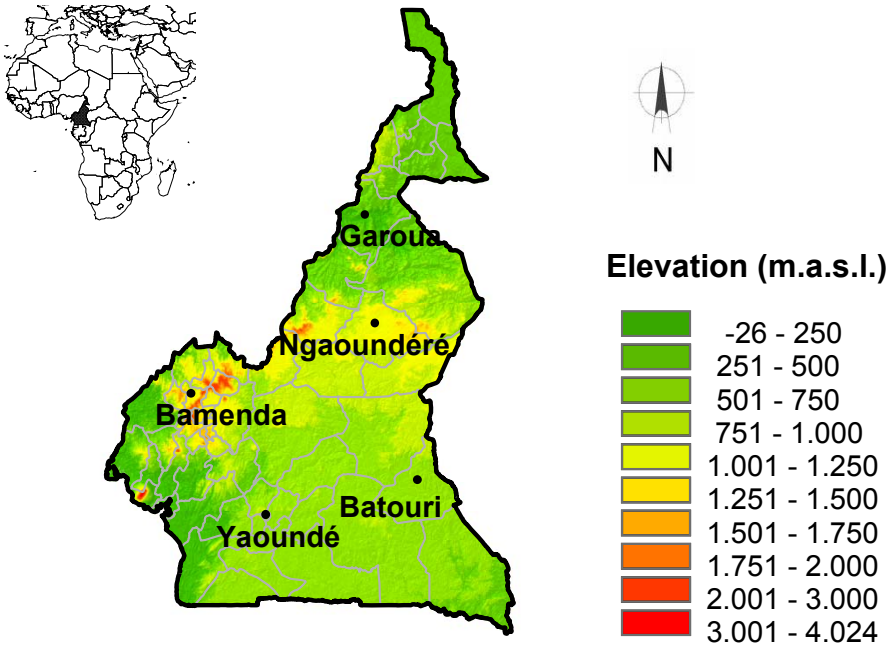
Cameroon: Factors affecting rainfall variability

High spatial and temporal rainfall variability

- Climate: semi-humid (South) to semi-arid (North)
- *Intertropical Convergence Zone* (ITCZ)

  South: bimodal (april/may & september/october)

  North: unimodal (august/september)
- Topography



Calibration/Validation CropSyst

- Parametrisation crop-specific values (maize, groundnut)
  - Publications (e.g. Tingem et al., 2008)
  - CropSyst user manual
- Phenological parametrisation (e.g. GDD)
  - Institute of Agricultural Research (IRA) Cameroon
- Validation: 5-year-period of observed yields:
  - Difference between modeled and observed yields acceptable
  - Interannual and spatial variability of crop yields

Bild Validation