PICREVAT Workshop: "Predictability of climatic information to reduce vulnerability of Tropical Agriculture"

20th -22nd February 2012 - Izaak Walton Inn, Embu (Kenya)

Calibration and application of a spatially distributed process-based crop model: A case study for maize cropping in Burkina Faso

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Plan

- Context and challenges
- Study area
- General Large Area Crop Model (GLAM)
- Data and calibration methodology
- Calibration performance
- Planting date (PD) as agricultural decision rule
- Investigation of PD impact on crop maize productivity
- Conclusion

Context and challenges

CV and CC → major environmental challenge to the world today, with significant threats to **ecosystems, food security, water resources** and **economic stability** overall.

Developing countries →
- Increase in predicted population growth
- Agriculture activities are the main source of income

(vulnerable to CV and CC)

African agriculture →
- heavy reliance on low- input rainfed agriculture
- low adaptive capacity.

(more affected by CV and CC)

West Africa → rainfed agriculture is by far dominant

As result, the issue of sustainability of rainfed agriculture and food security remain a challenge for stakeholders.

Context and challenges

To tackle this issue, climate research applied to agriculture can play a major role in focusing on how to **minimize the effects of adverse climate conditions** and how to **maximize the benefit of favorable climate conditions**.

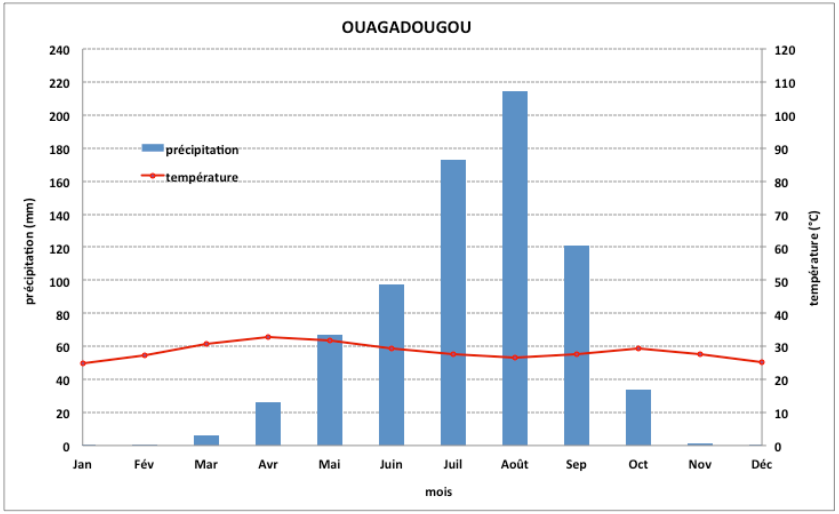
Focus on

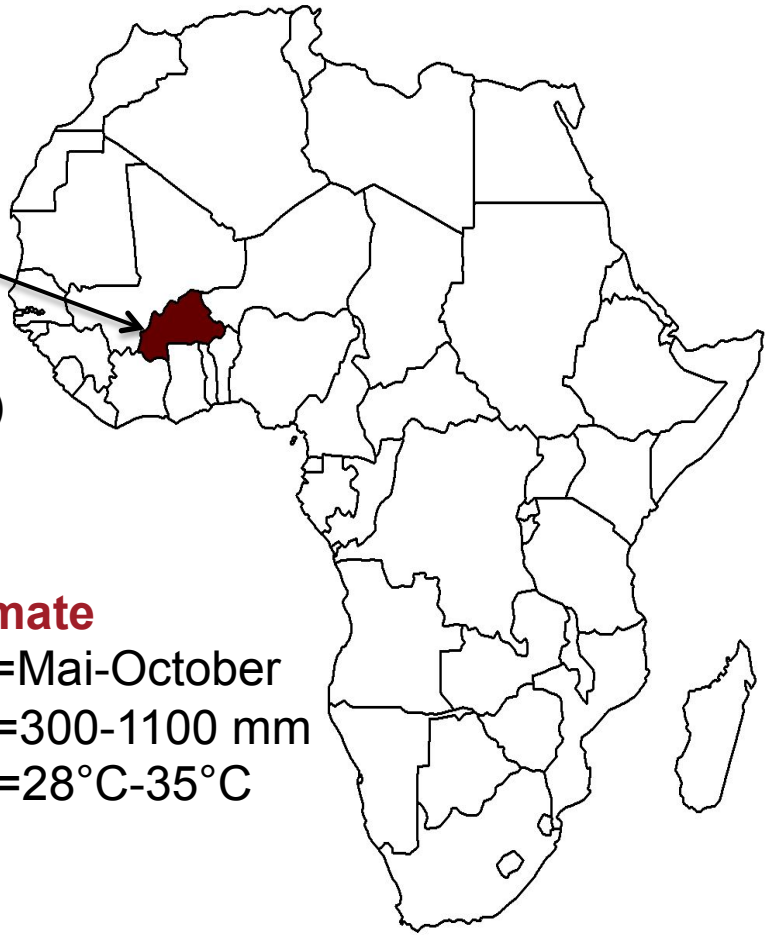
- ✓ **GLAM calibration (maize yield in BF)**
- ✓ **Relevant rainfed agriculture management strategy (planting date)**
- ✓ **Impact of planting dates on Maize yield**

Study area

Burkina Faso

Area = 274 200 km2, 45 provinces
Population ≈ 13 million
Capital city: Ouagadougou
Population main activity: agriculture (80%)
Main cereal crops: millet, sorghum, maize
Main cash crop: cotton (30% of GDP)





Climate

RS=Mai-October
RR=300-1100 mm
Tm=28°C-35°C

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General Large Area Crop Model (GLAM)

Crop models are mathematical models which describe the growth and development of a crop interacting with soil.
There are two groups of crop models:

Statistical crop models

- ✓ **use statistical regressions**
- ✓ **low input data**
- ✓ **less adaptable to different spatio-temporal conditions**

Process-based crop models

- ✓ quantify the relationships (crop growth, weather, crop management)
- ✓ Often perform well at the field scale
- ✓ high input data requirement

GLAM is a **process based crop model** designed to operate on spatial scales corresponding in size to those of global and regional climate models. It aims to simulate the impact of climate on crop yield.

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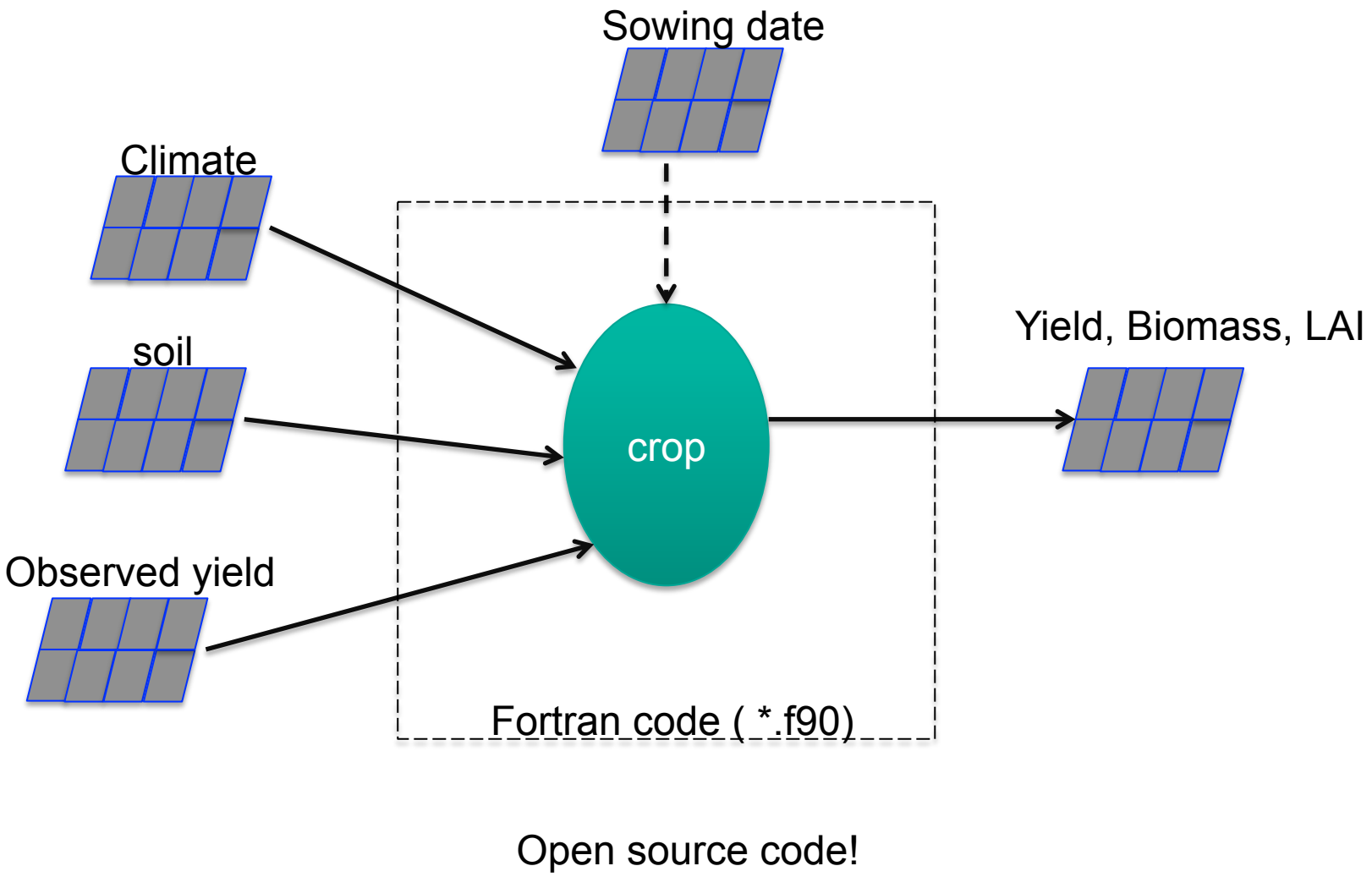
General Large Area Crop Model (GLAM)



Open source code!

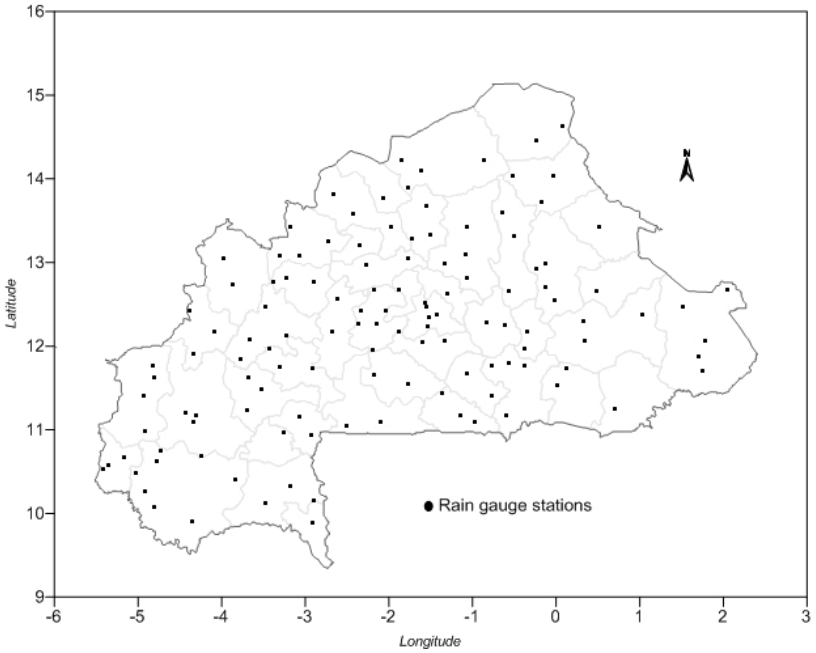
Data and calibration methodology

Data

Meteorological data

ECMWF : ERA interim data (daily Tx, Tn, Rad) at 1°x1° from 2000-2010

BF National Meteorological Services : Daily precipitation (2000-2010)

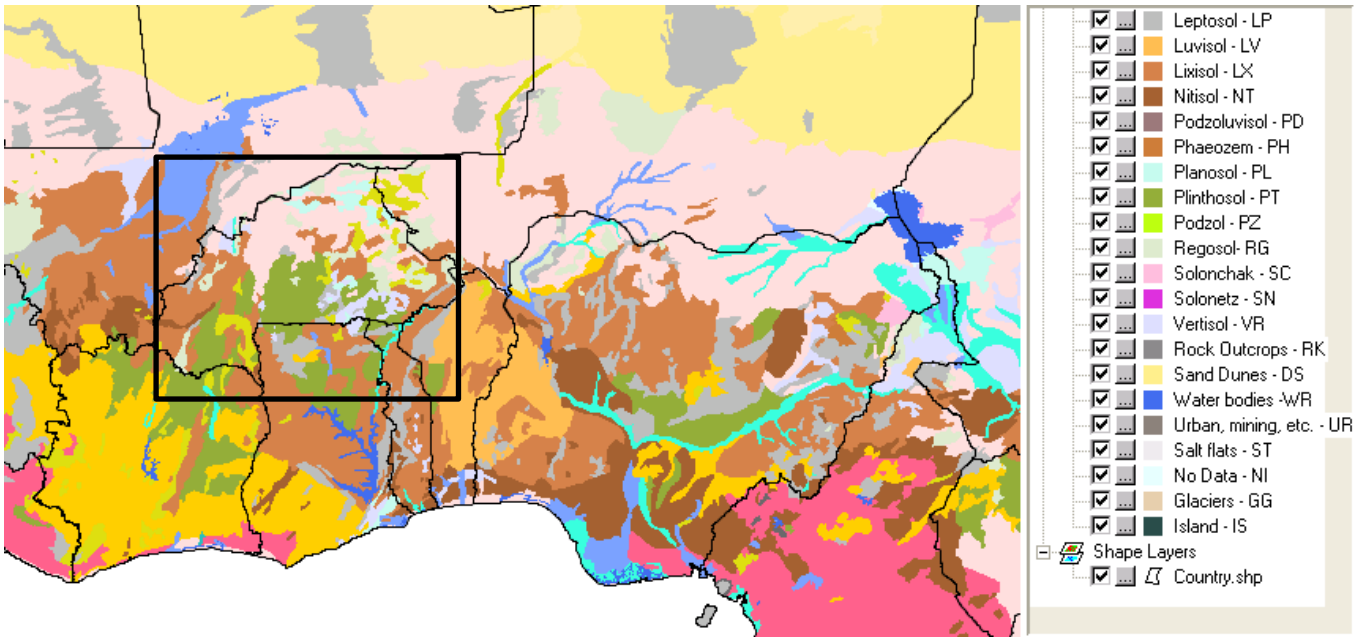


Data and calibration methodology

Data

Soil data

FAO : Harmonized World Soil Database (HWSD), 1km of resolution

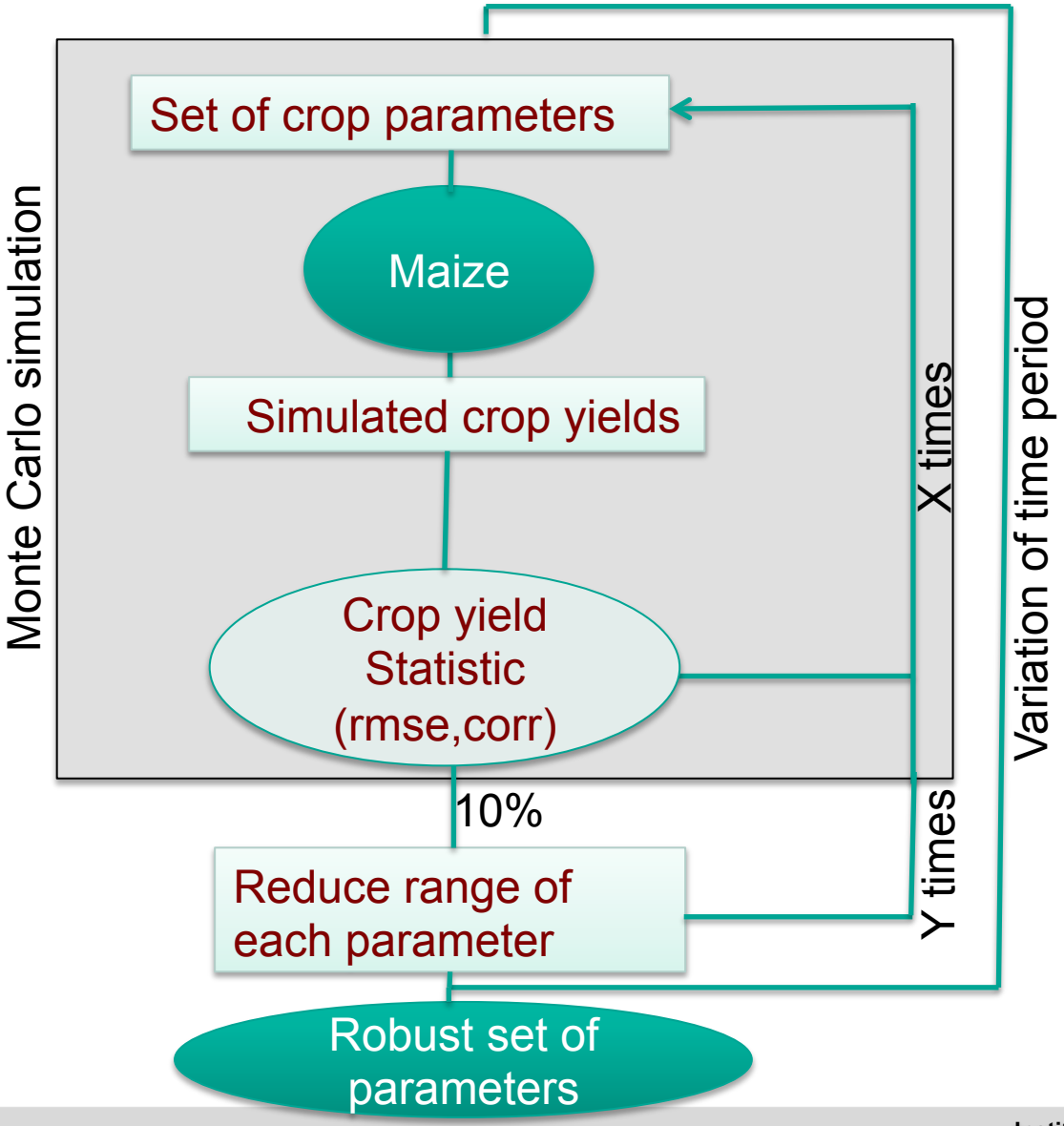


Data

Observed crop yield

BF Agricultural Production and Statistics Services : district (province level) Maize yield from 2000-2010 via Regional Center AGRHYMET

Data and calibration methodology



GLAM simulation

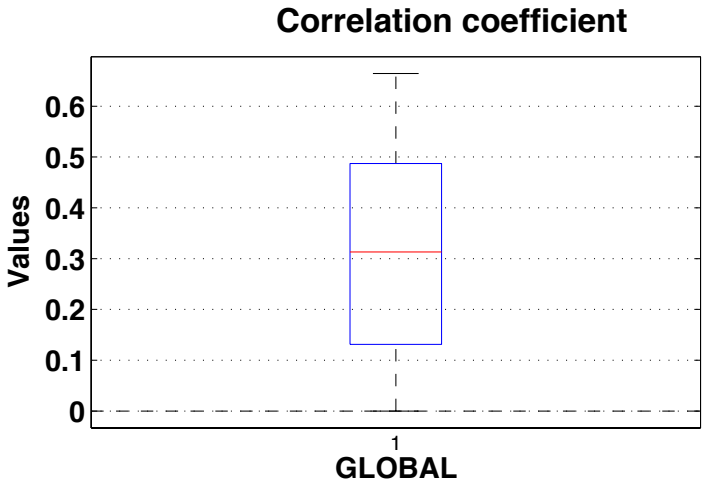
Two type of simulation:

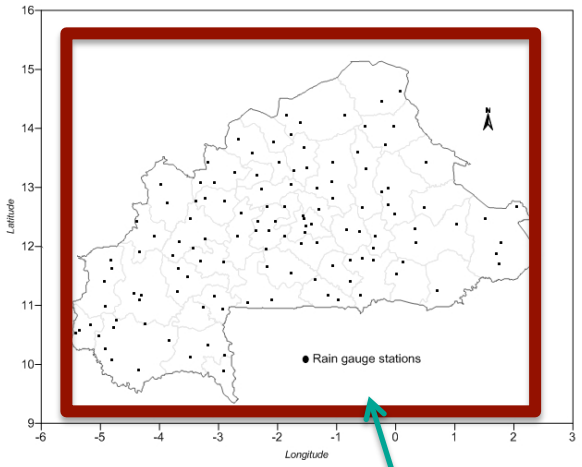
SET simulation: one run. It is often use after calibration of the model. YGP should be set to :
1 : potential simulation, no reduction of yield, biomass or LAI
0<YGP<1: for non optimal condition (non-optimize management, pest and crop diseases)
YGP>1: non optimal condition for only yield option
-99: a path of an ASCII file of YGP by location is given

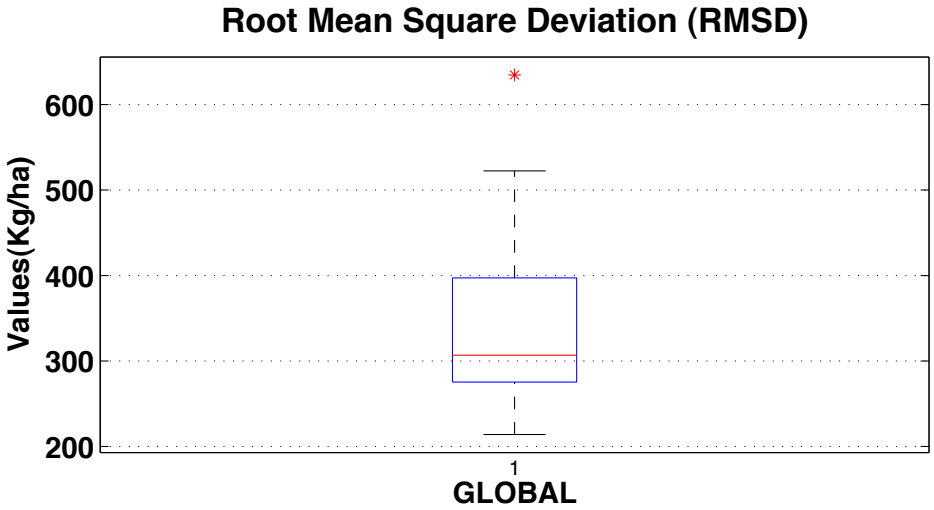
HYP simulation: loop run (iteration of SET run) for sensitivity analysis or for model calibration. A YGP file can be derive from the HYP run and then use it for the SET run.

Calibration performance

Maize simulated yield *vs* Observed yield (2000-2007)







Simulation area

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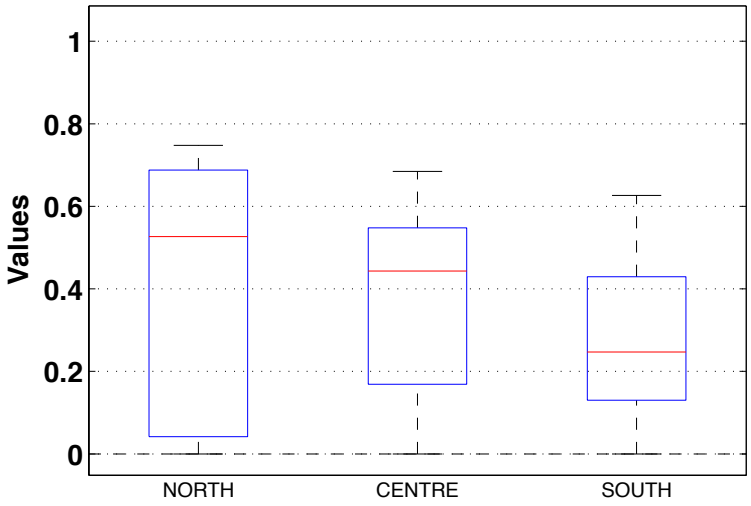
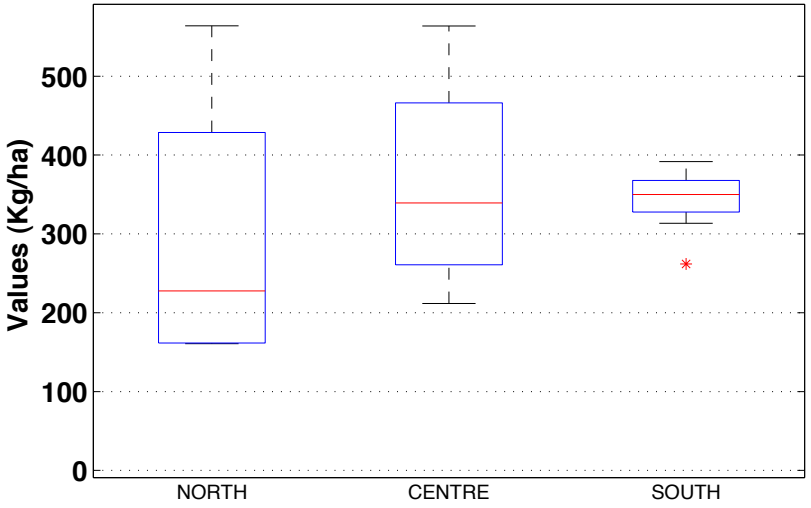
Calibration performance

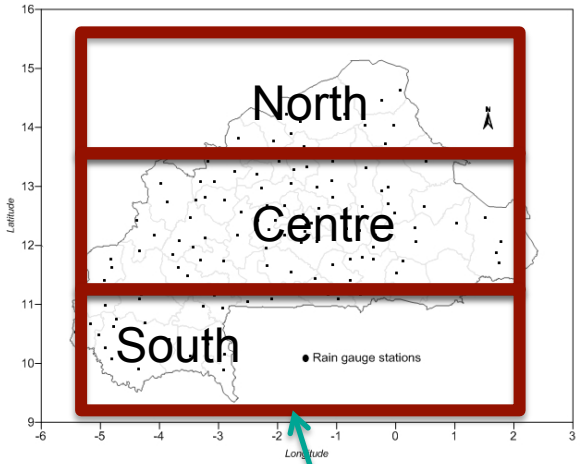
Maize simulated yield *vs* Observed yield (2000-2007)

Regionalized correlation coefficient



Regionalized root mean square deviation





3 simulation areas

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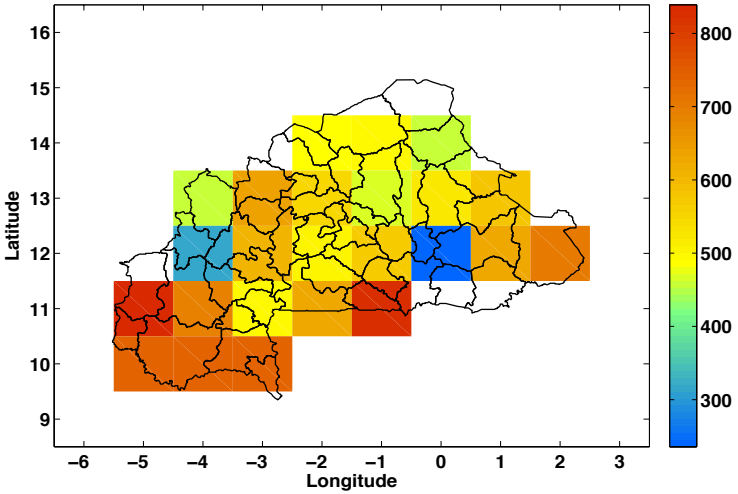
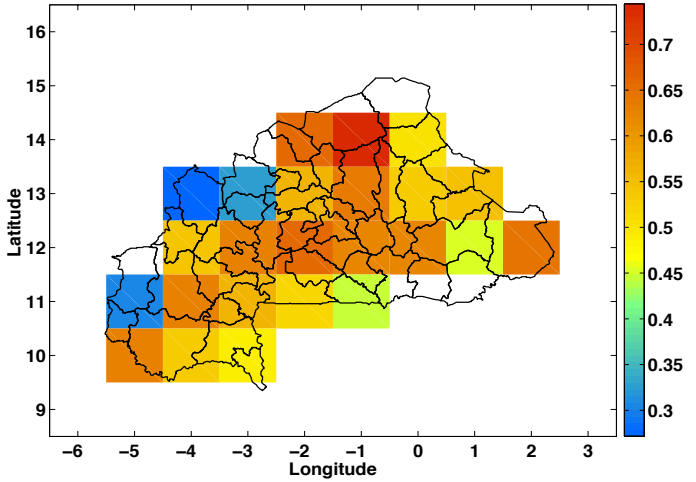
Calibration performance

Maize simulated yield *vs* Observed yield (2000-2007)

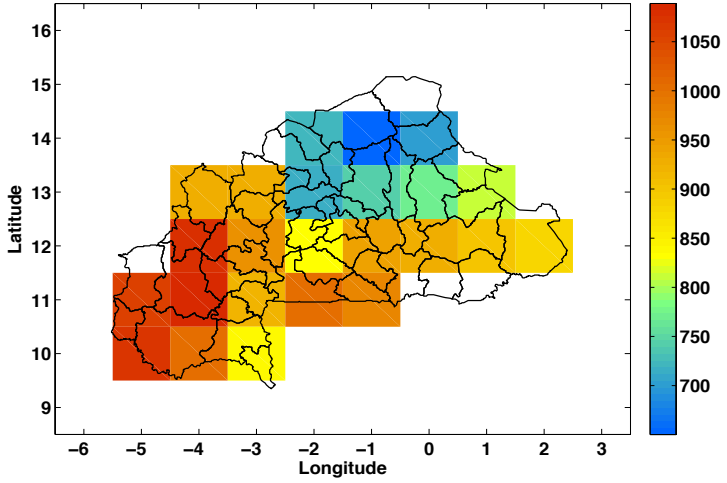
Gridded annual precipitation (average of 2000–2010) in mm



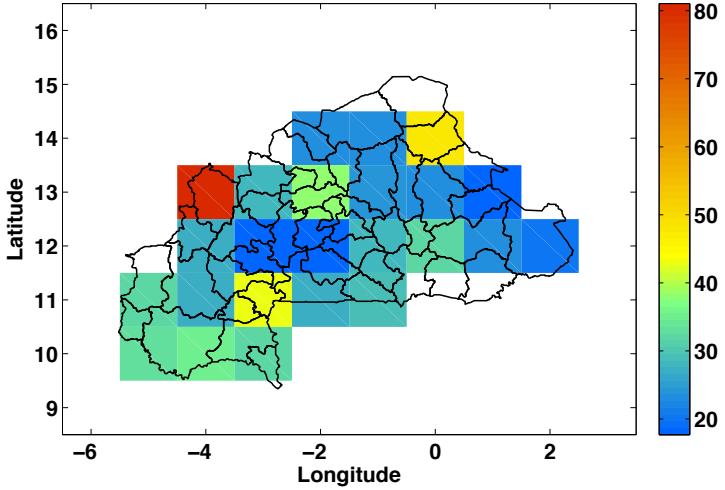
Correlation coefficient



Maize gridded mean yield from 2000–2010 (Kg/ha) in Burkina Faso



Maize simulated yield (Normalized RMSD) (%)



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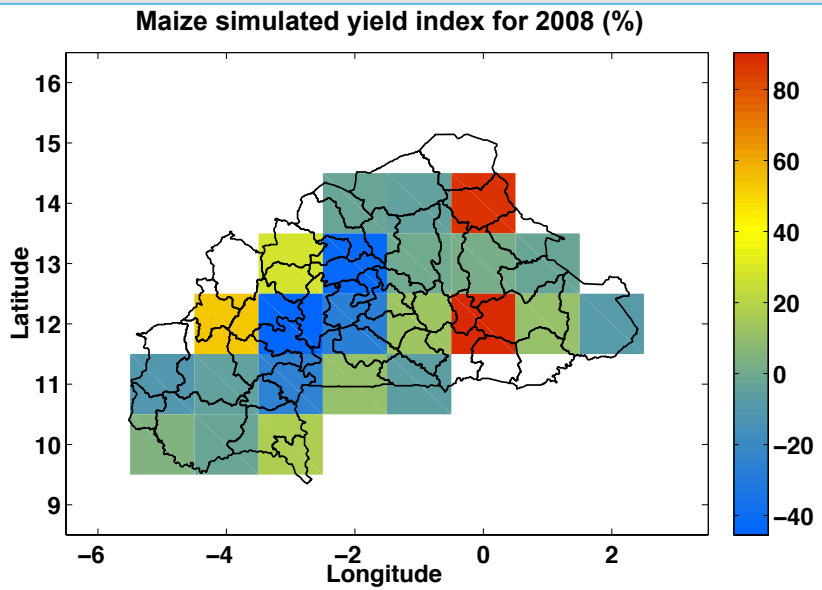
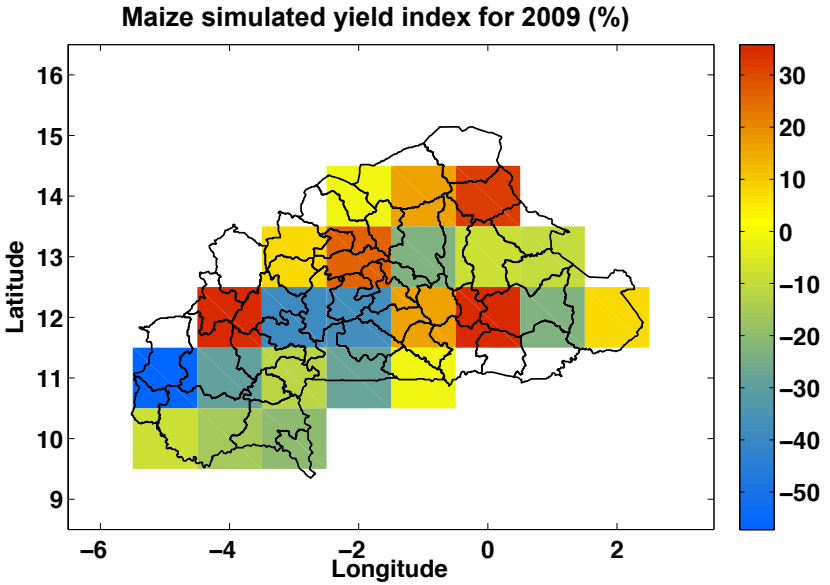
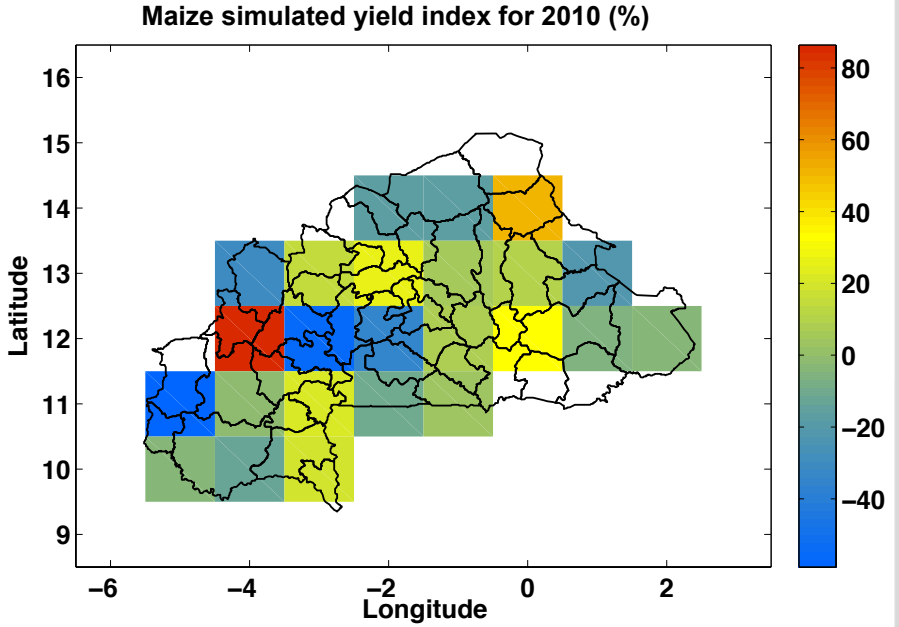
Maize simulated yield for evaluation period







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Planting date (PD) as agricultural decision rule

Different approaches to estimate PD dates exist.

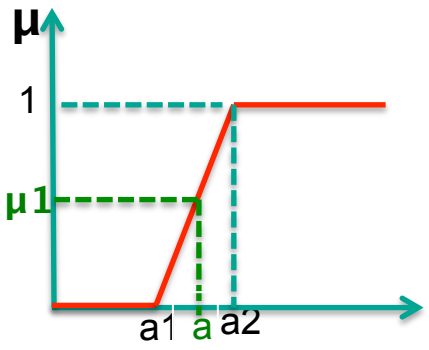
Methods based on different threshold combinations of rainfall amount, dry spell length and number of rainy events. **Determination of potential planting dates**

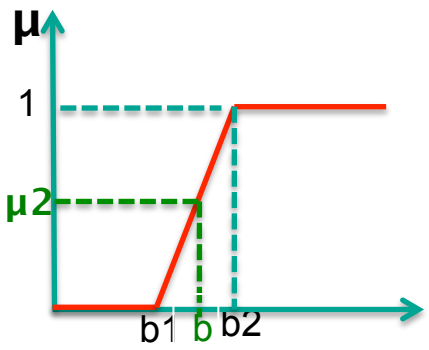
PD definitions:

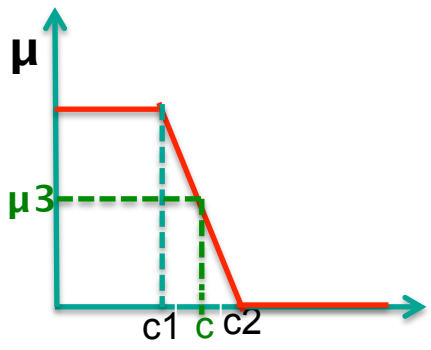
- ***Diallo (2001)****: The date after 1st May, when rainfall accumulated over 3 consecutive days is at least 20 mm and when no dry spell more than 10 days within the next 30 days.*
- ***Dodd & Jolliffe (2001****): The first day of a spell of 5 days in which at least 25 mm of rain falls, on condition that no dry period of more than 7days occurs in the following 30 days.*

Planting date (PD) as agricultural decision rule

- ***Fuzzy logic approach of Laux et al. (2008)*** *: The day with **a** mm of cumulative rainfall amount over **b** rainy days within 5 days spell, with no dry spell more than **c** days in the next 30 days. For computation a1, a2, b1, b2, c1, c2 and k are respectively set to 18 mm, 25 mm, 1 day,3 days, 7days, 10 days and 0.5*

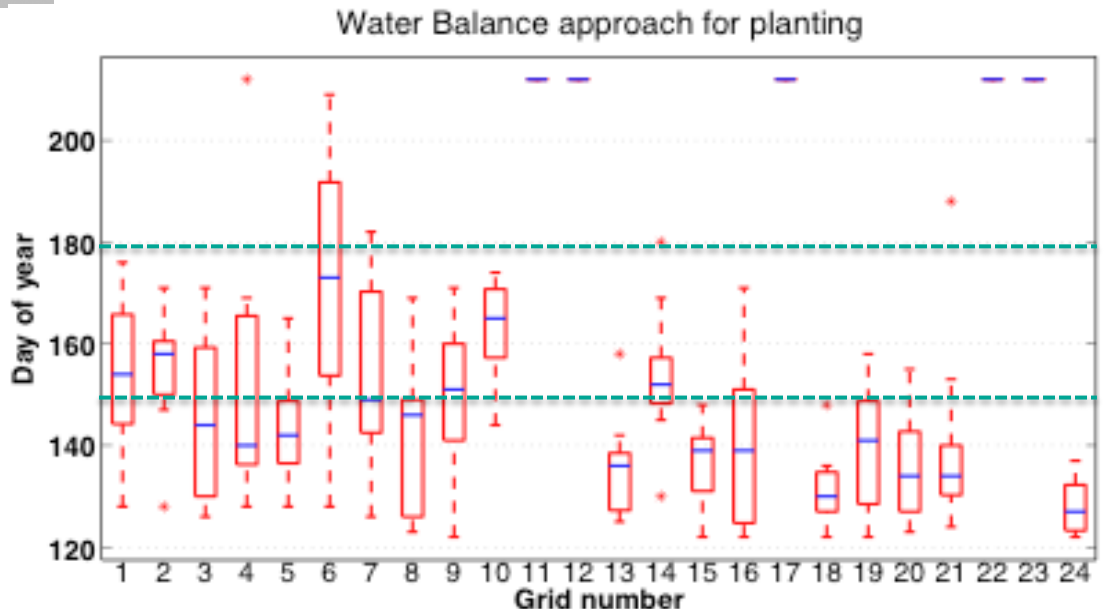


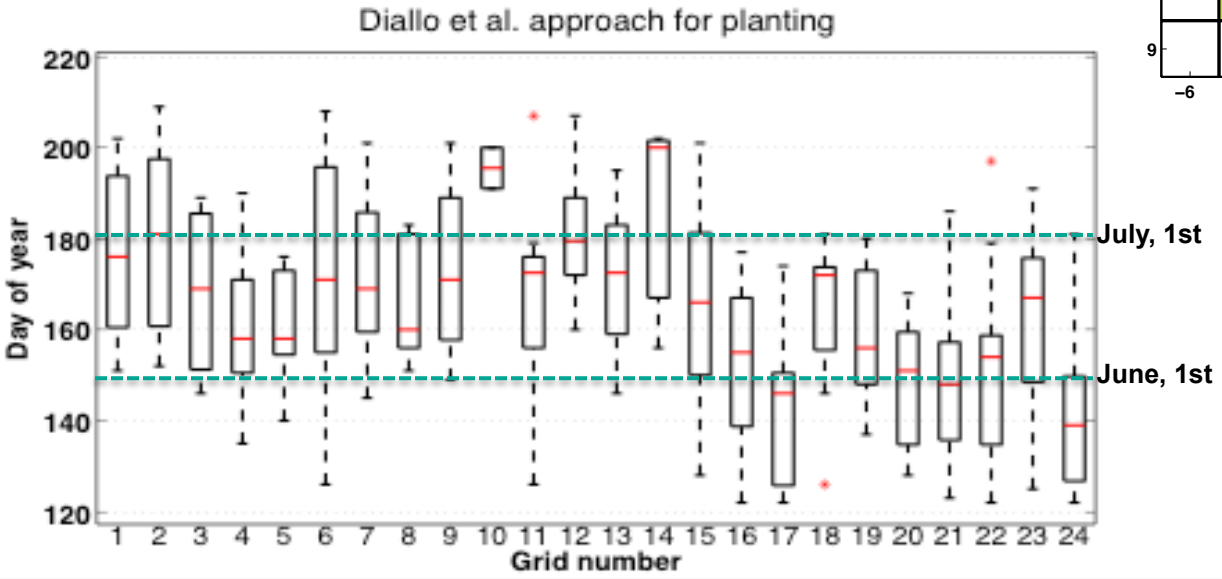


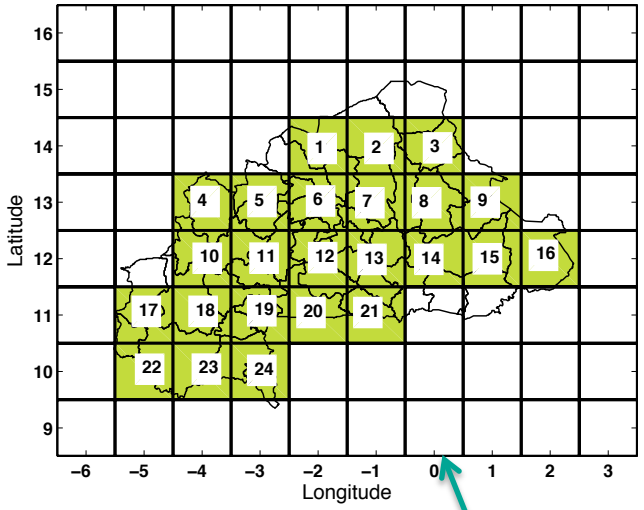


μ1 x **μ2**x **μ3** = k, k ε]0,1]

Potential planting dates (period 2000-2010)

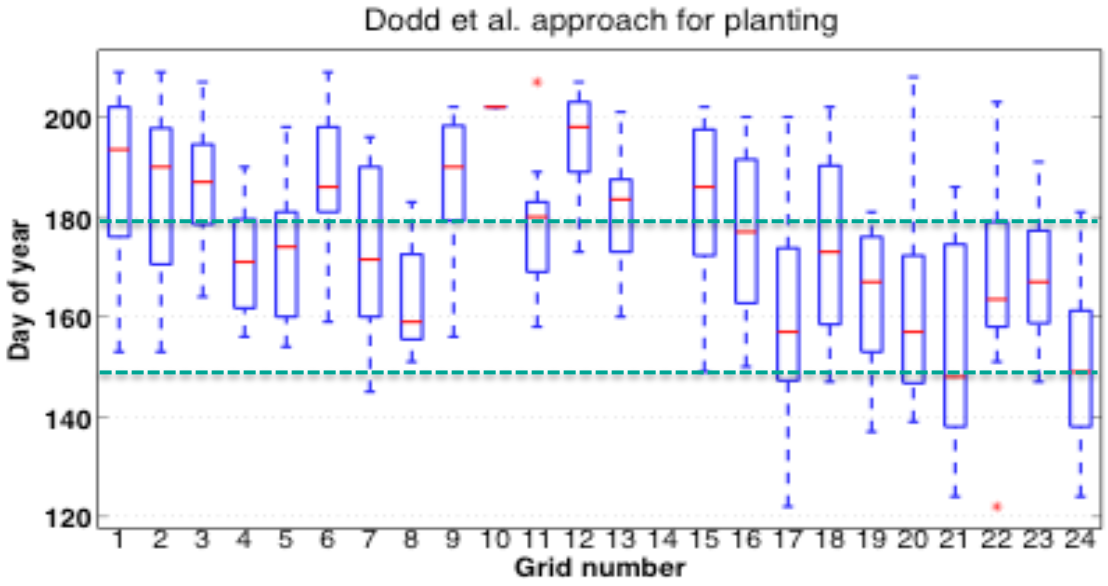


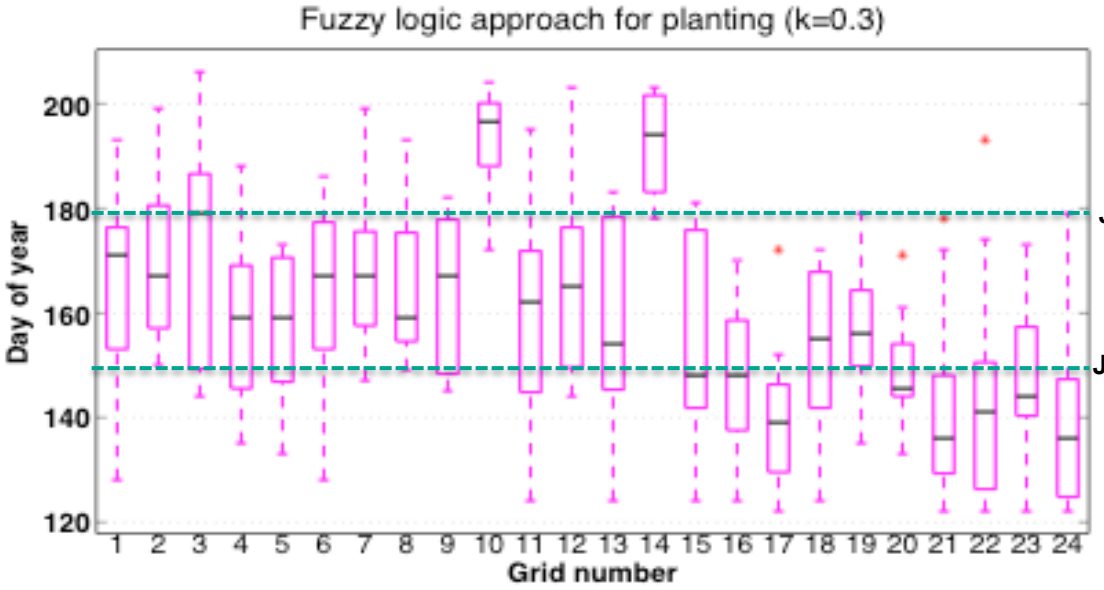




Grid number location

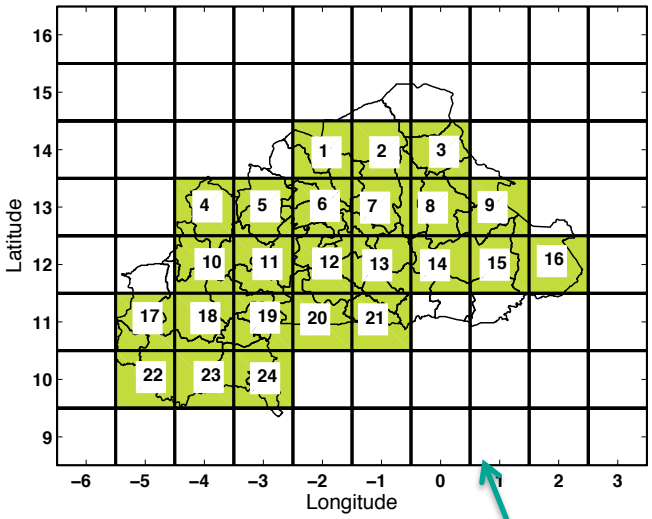
Potential planting dates (period 2000-2010)





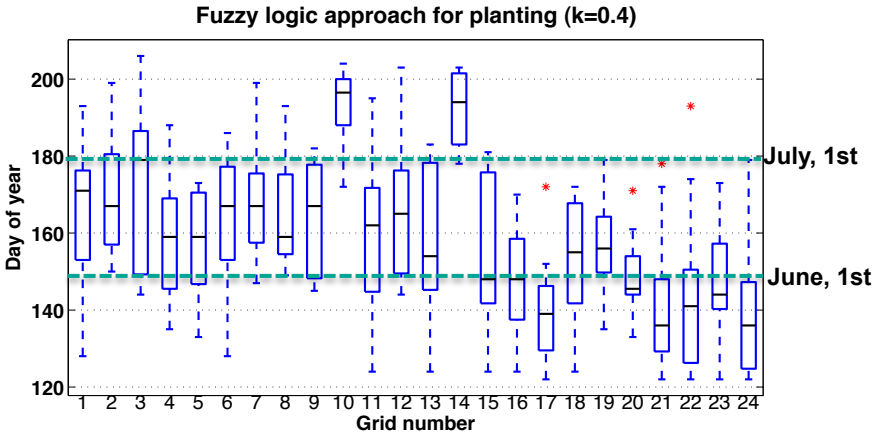
July, 1st

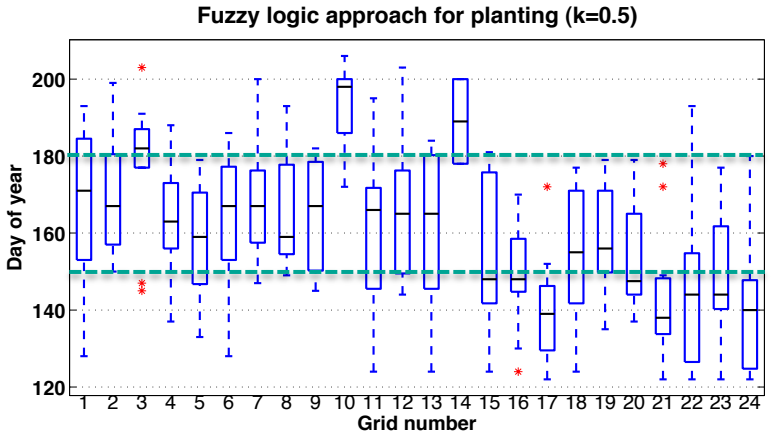
June, 1st

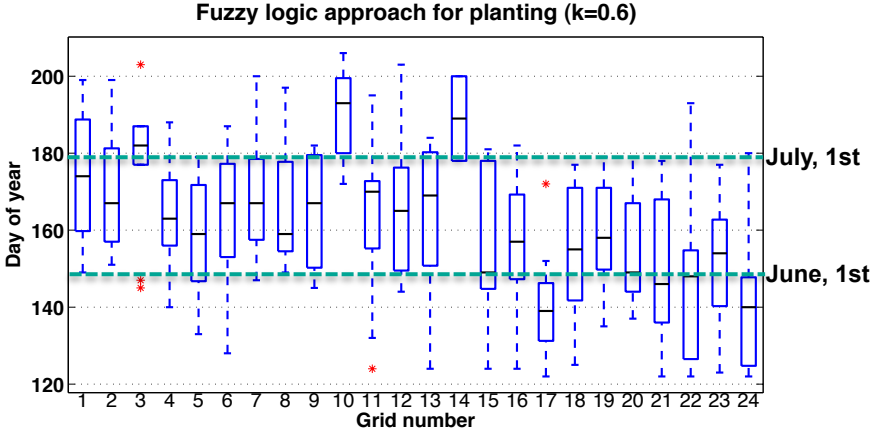


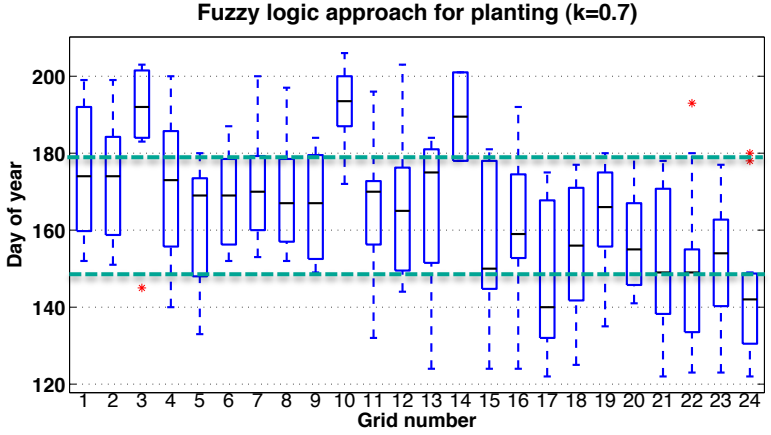
Grid number location

Potential planting dates (period 2000-2010)









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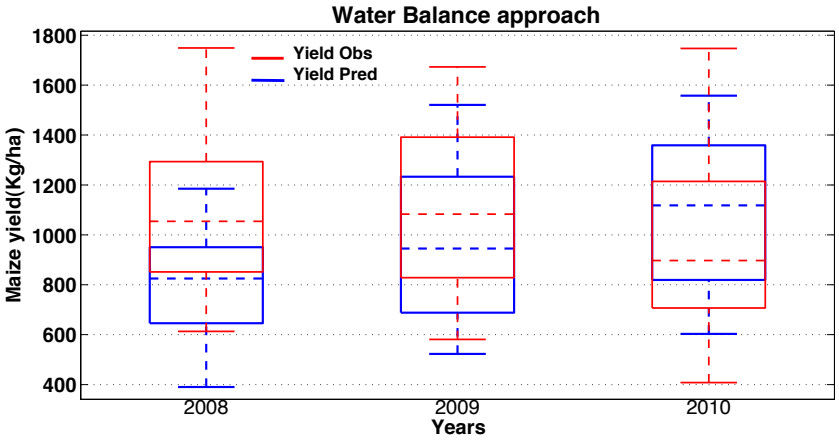
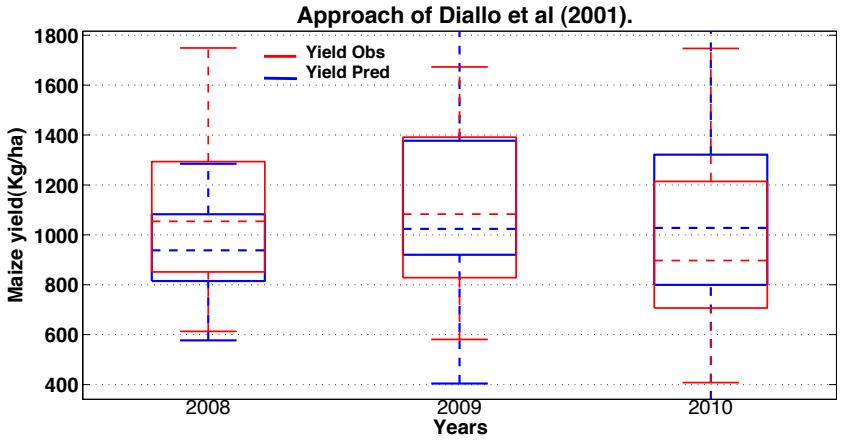
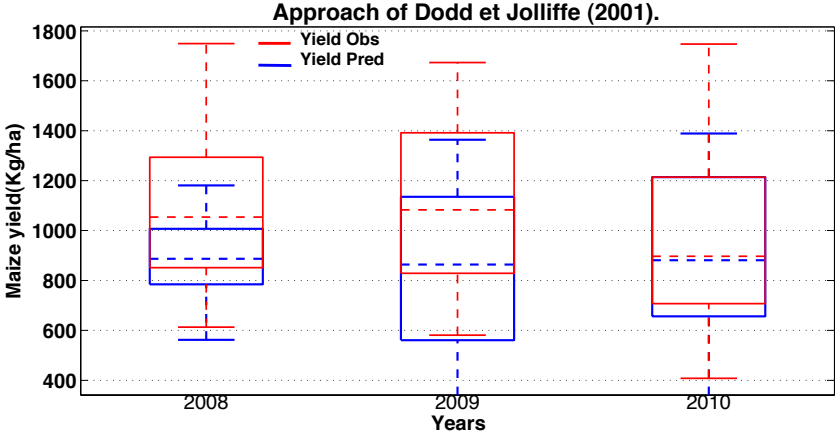
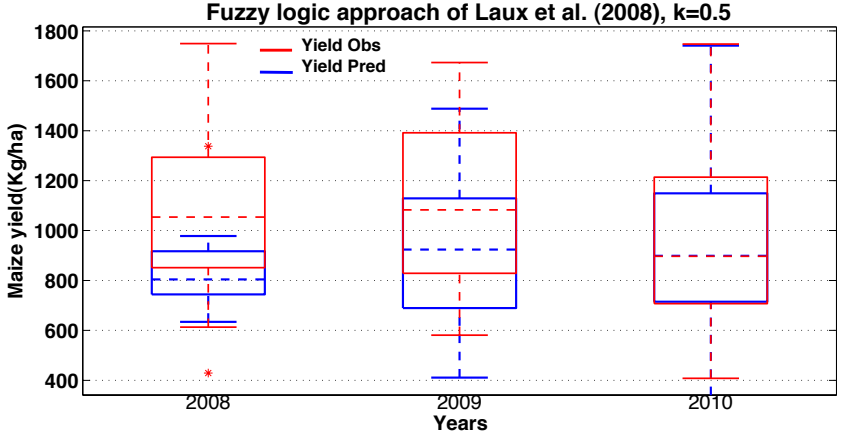
Maize simulated yield variability for different planting dates









CONCLUSION

The impacts of climate change on agriculture are expected to be widespread across the globe.

- The expected crop yield reduction for the future will certainly result in increase in prices of agricultural goods and this impact will be greater for food insecure regions as Africa particularly in West Africa.

- This study figure out that GLAM can be a good candidate to explore the climate impact on agriculture productivity in a regional or sub-regional scale where field scale crop models are enable to deal with.

- Finding the best date for sowing (avoid false starts) is still a challenge in West Africa. In light of CC, investigation on this field using crop models outputs can add a value on decision making processes in agriculture.

THANK YOU FOR YOUR ATTENTION !