Rice yield gap analysis for Sub-Saharan Africa: how did AfricaRice use results from GYGA

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Global Yield Gap Atlas Workshop #4
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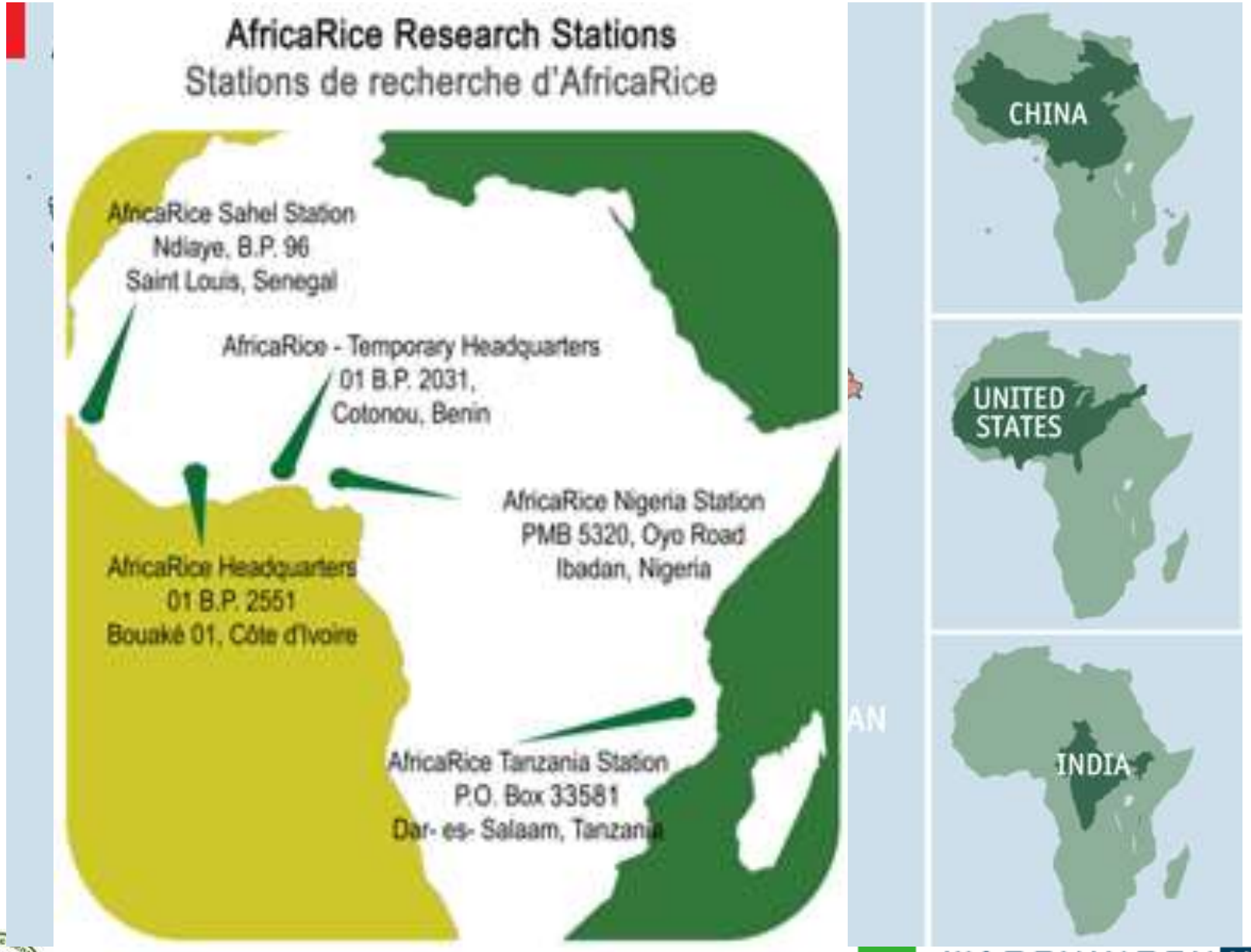
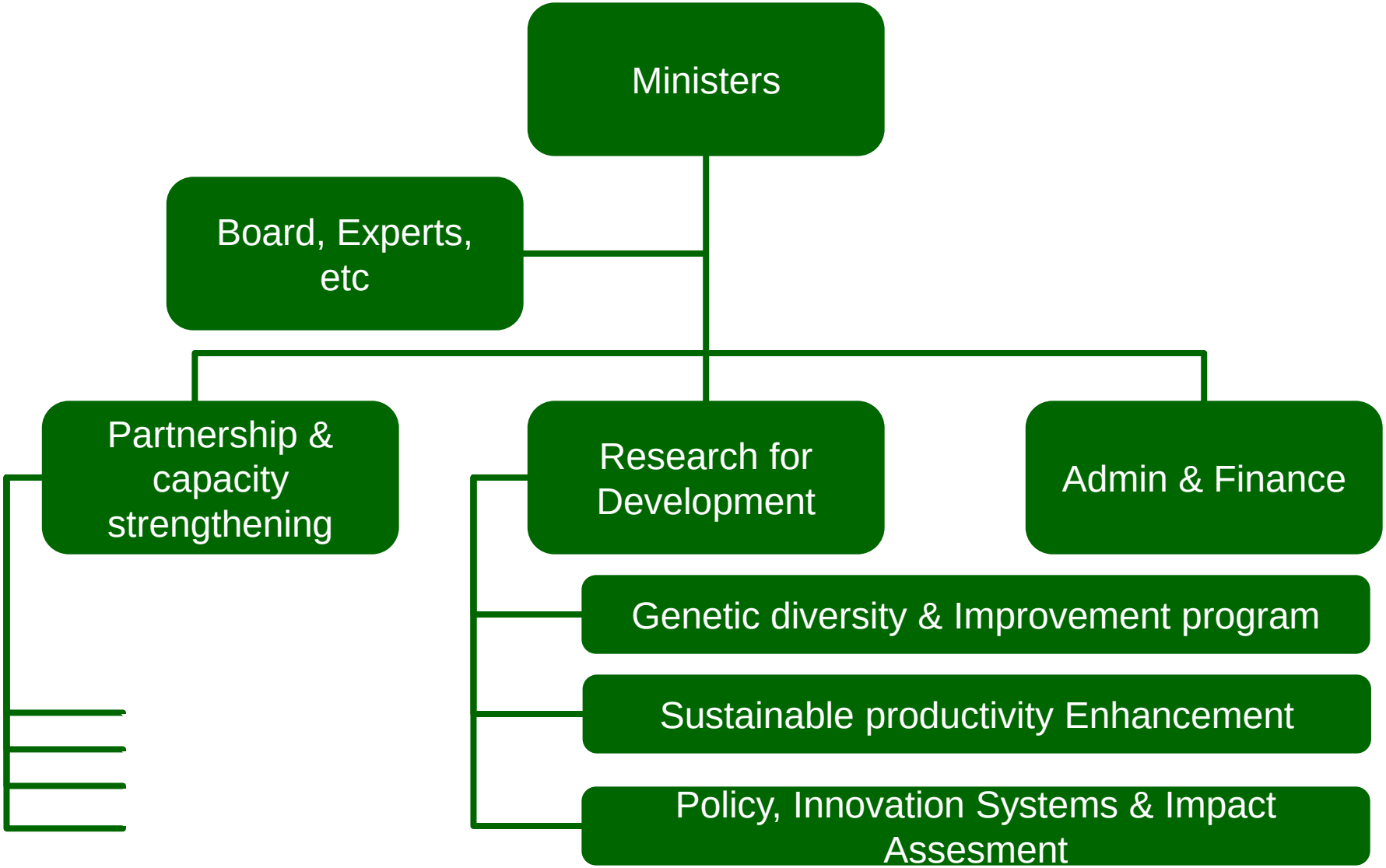
Outline

1. AfricaRice
2. Model validation/calibration for GYGA
3. Food Security Scenarios
4. Options for closing the yield gap
5. Conclusions
6. Outlook
7. Publications
8. Modesty in modeling

1.1 AfricaRice



1.2 AfricaRice: organogram



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2.1 Key soil parameters

Objective: identify sensitivity of rainfed rice yield to soil properties

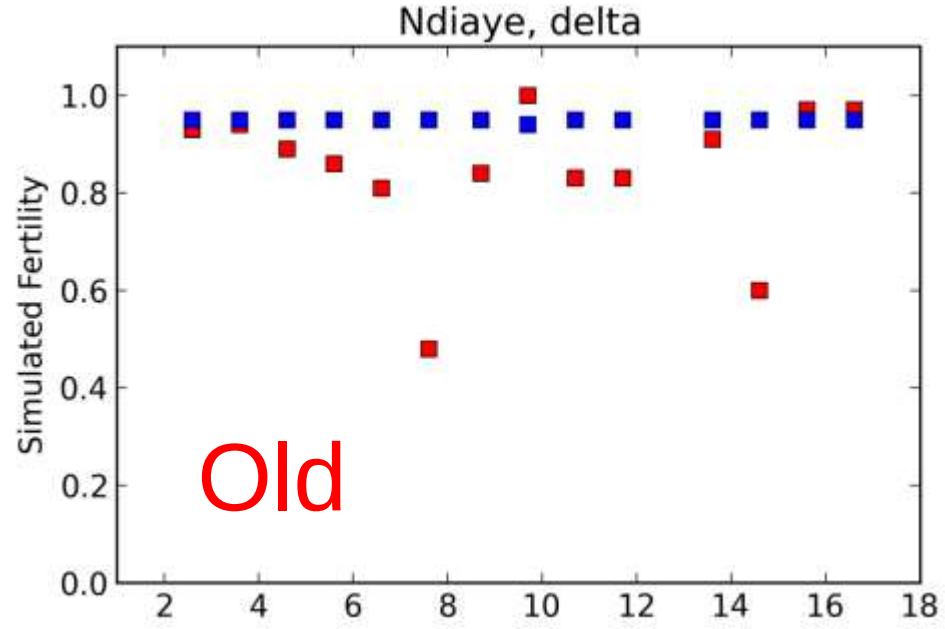
Method:

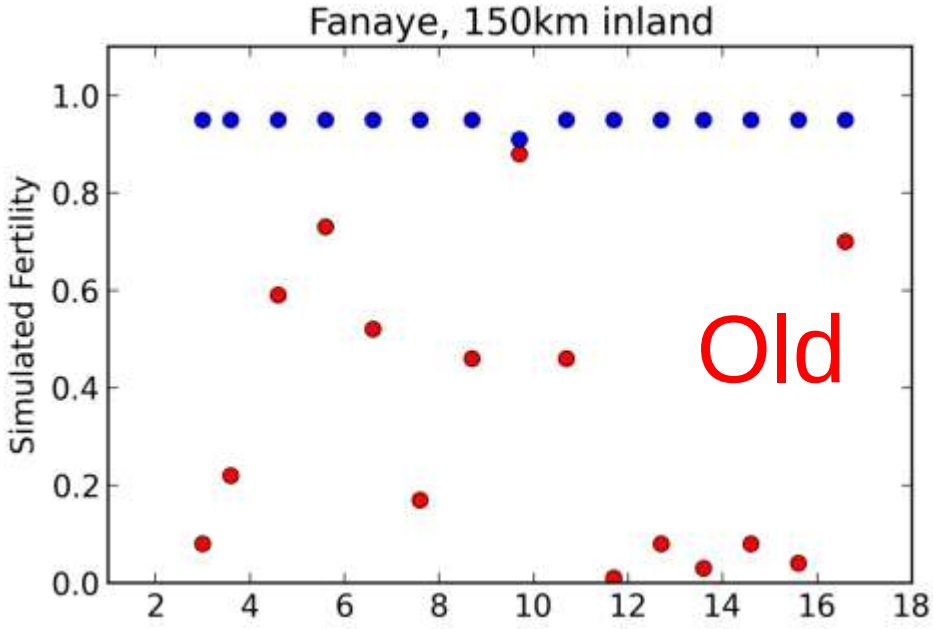
- vary soil parameters, then quantify their effect on simulated yields
- Study interaction effects of parameters
- Parameters varied within reasonable range

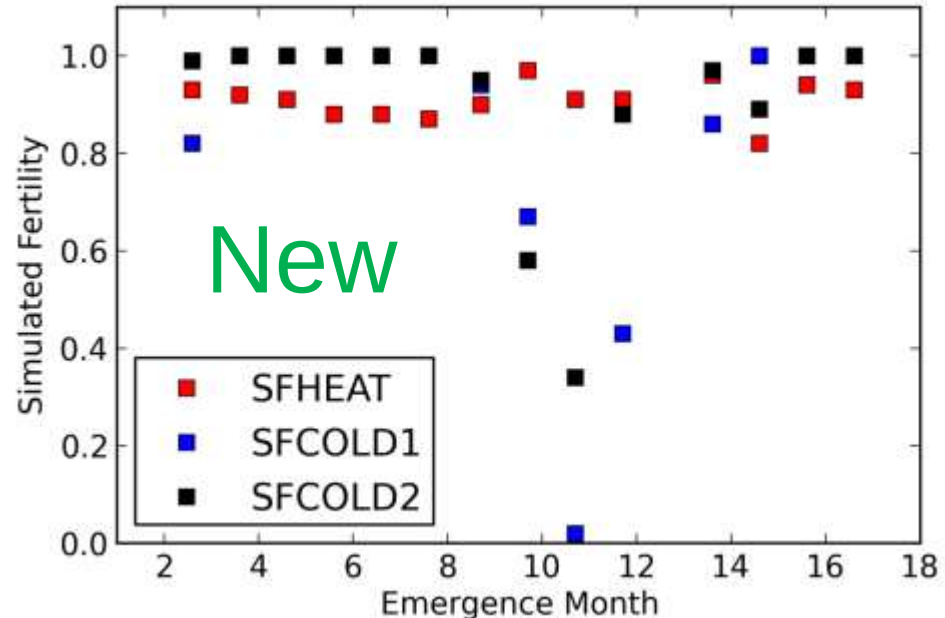
2.2 Key soil parameters

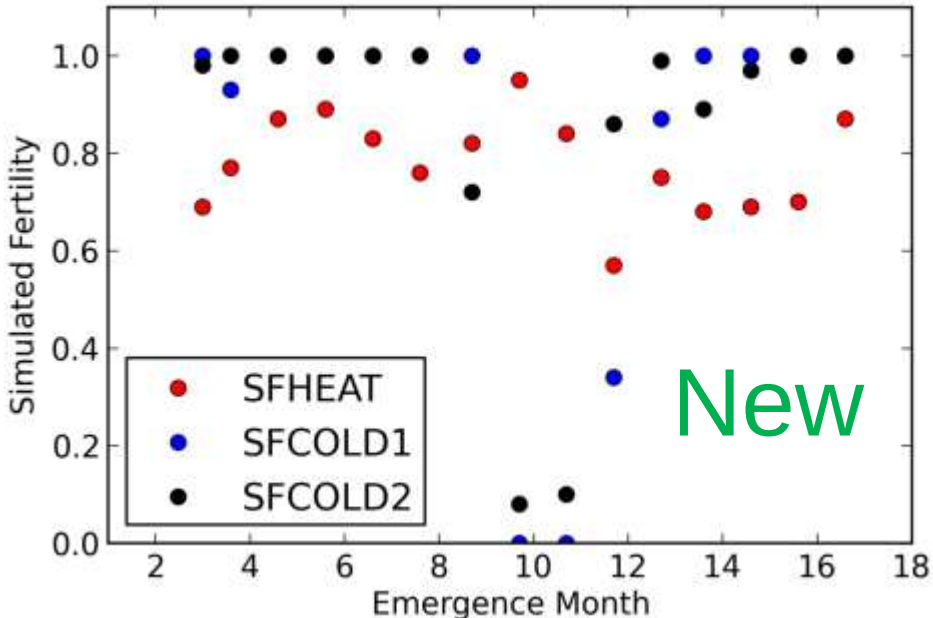
Soil & water parameter	Relative yield increase from default (%) (average over all the buffer zones for rainfed systems)	Range (%)
percolation rate / groundwater depth	257	106 to 595
Plow sole	59	-36 to 420
Puddling	57	-21 to 337
Bunds	11	-1 to 101
Soil texture	-1	-23 to 57

2.3 Heat and cold sterility, Senegal

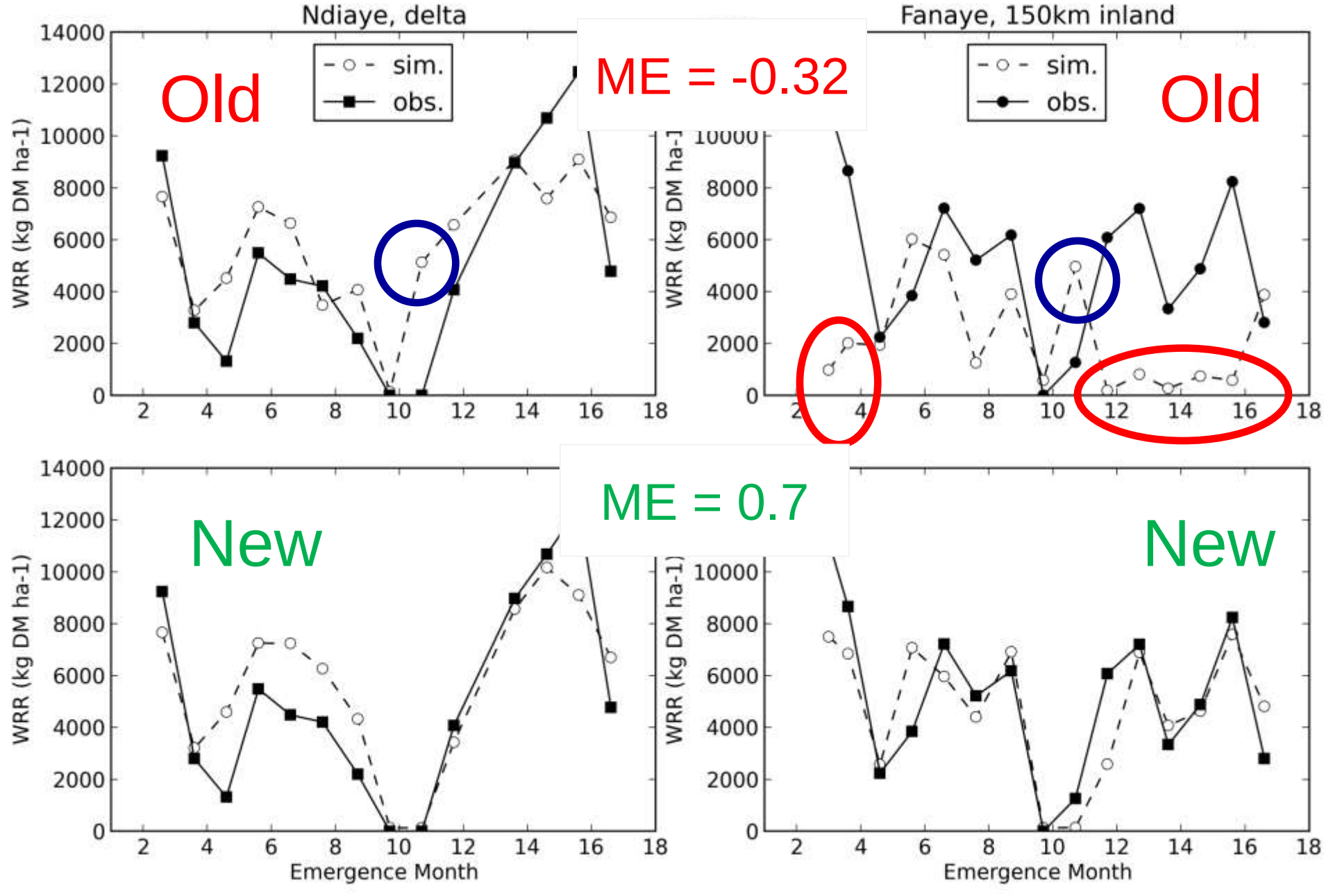








2.4 Heat and cold sterility

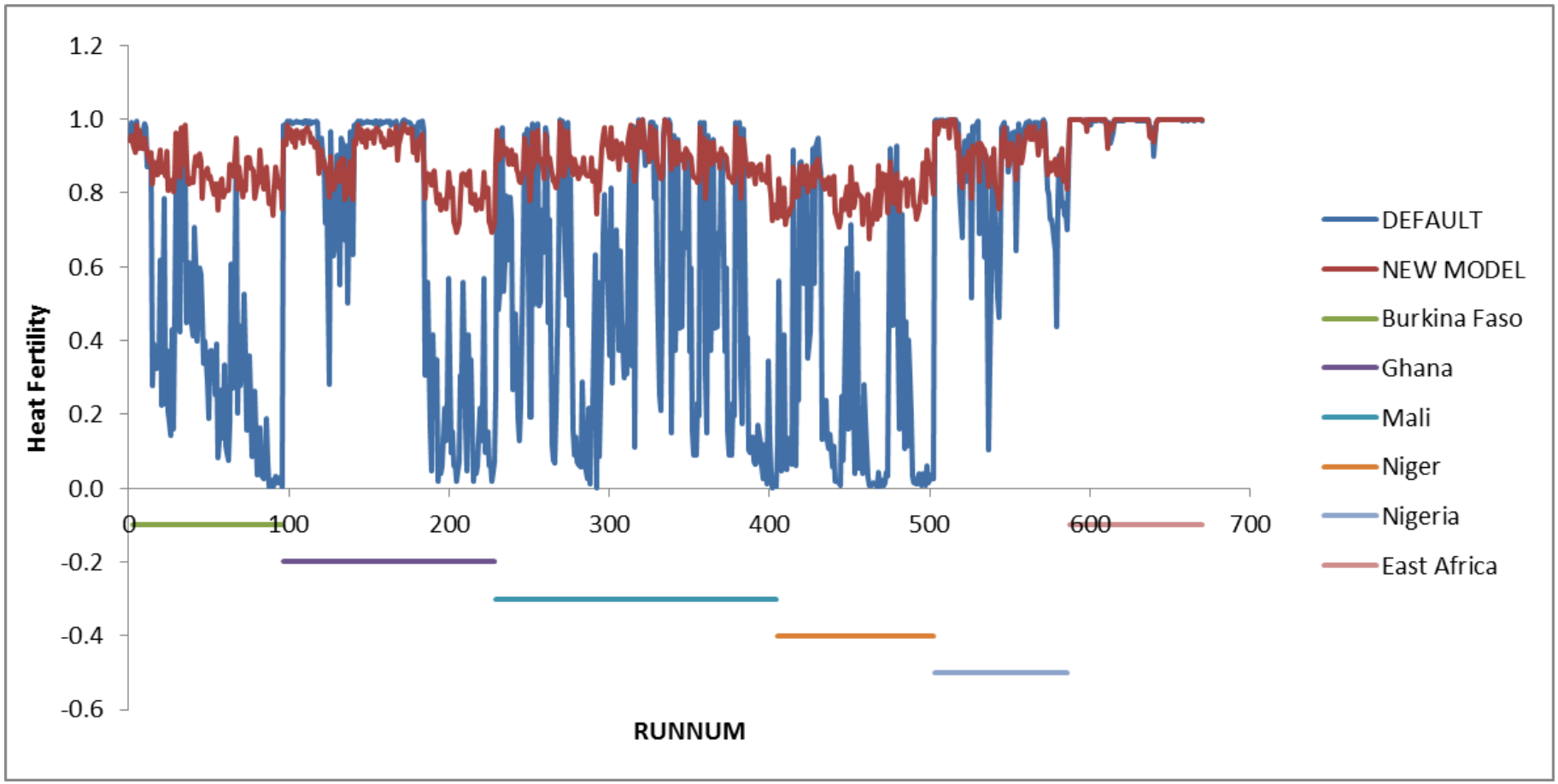


2.5 Heat sterility

Two key mechanisms reduce risk of heat sterility

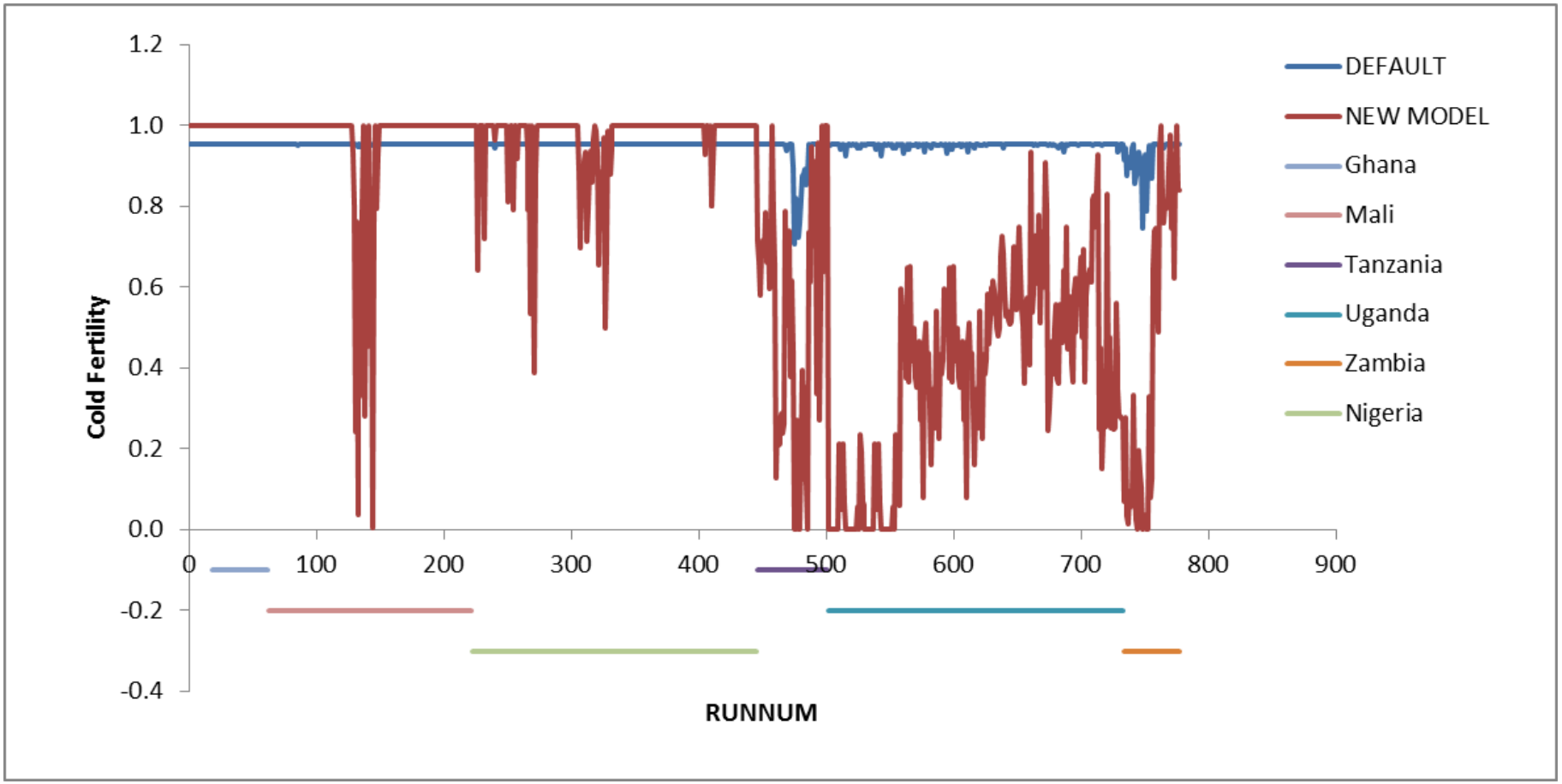
1. Flowering early in the morning
2. Transpirational cooling

2.6 Heat sterility



x-axis =700 model runs, for ~29 bufferzones x cropping intensity (1 or 2) x 10-20 years; irrigated rice only

2.7 Cold sterility



x-axis =700 model runs, for ~49 bufferzones x 10-20 years; rainfed rice only

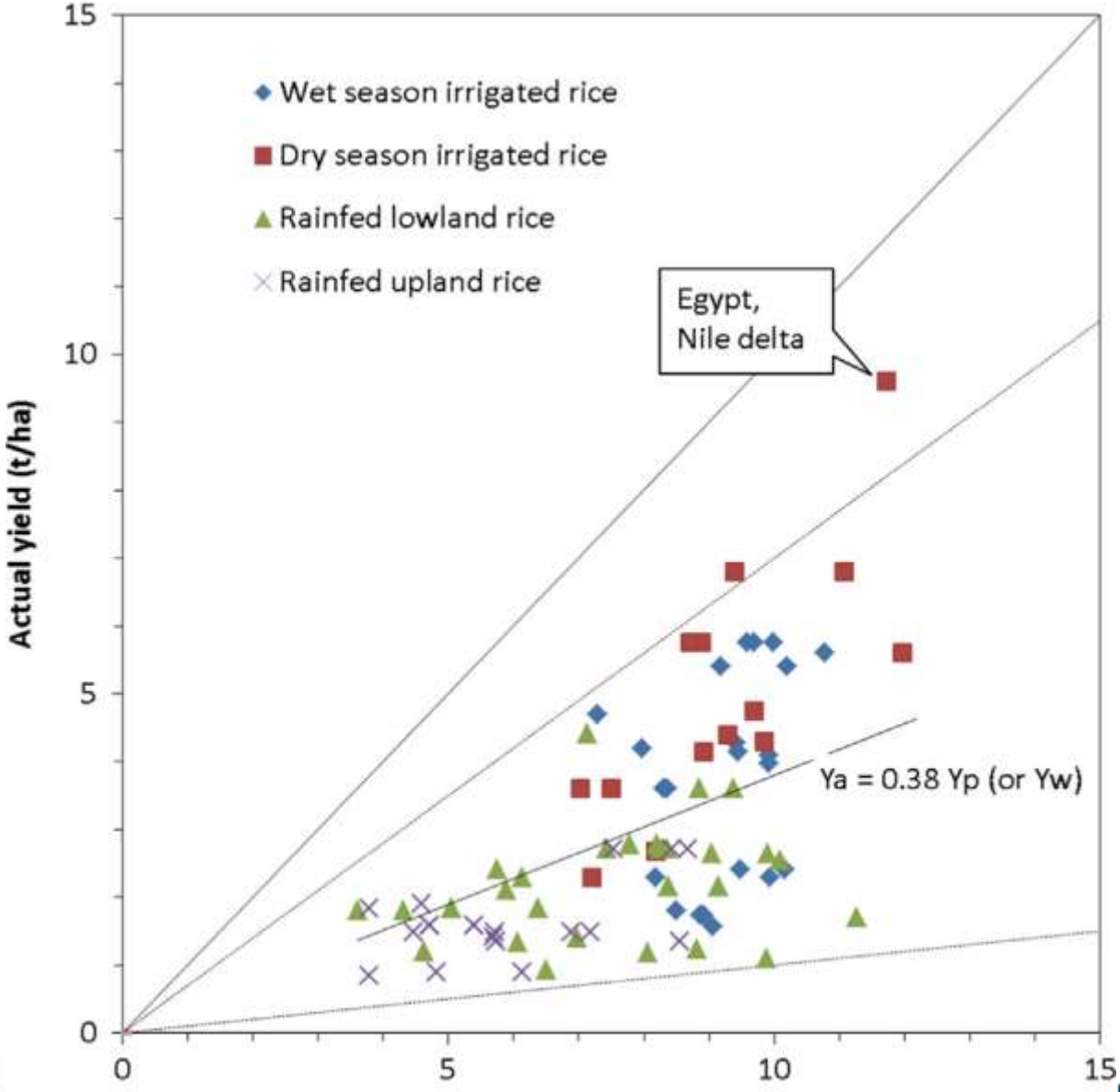
2.8 Cold sterility

Problem!

1. Default model in ORYZA2000
    1. Wrong for Senegal: underestimation
    2. Wrong for East Africa: underestimation
2. New model
    1. Correct for Senegal
    2. Wrong for East Africa? overestimation?
3. Truth somewhere in the middle?

Need more research on cold sterility → further model improvement

2.9 Yield gaps



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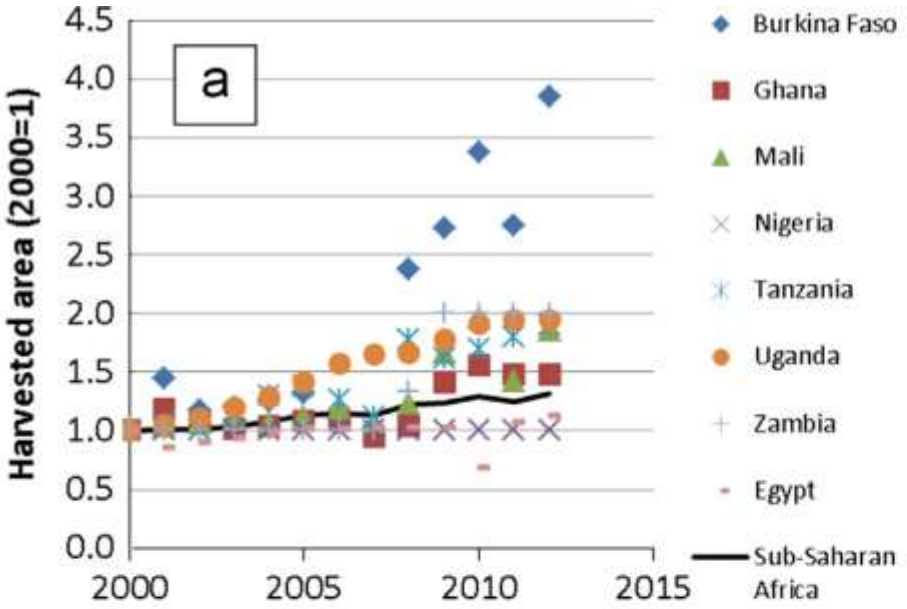
After GYGA1 ...

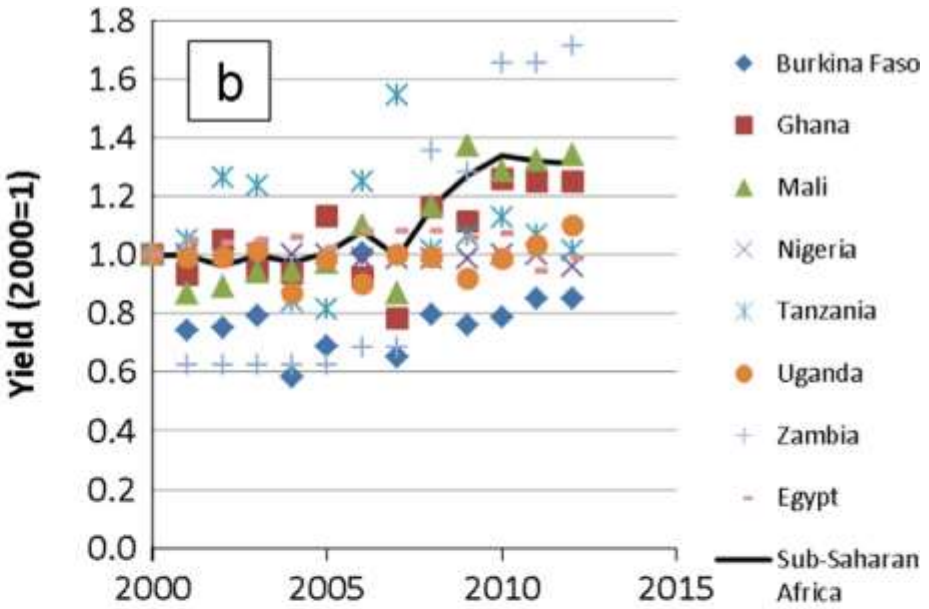
- Knowing the yield gap alone is not enough ...
- But can be useful to know ...
- Can we use it to provide more “actionable” information ...

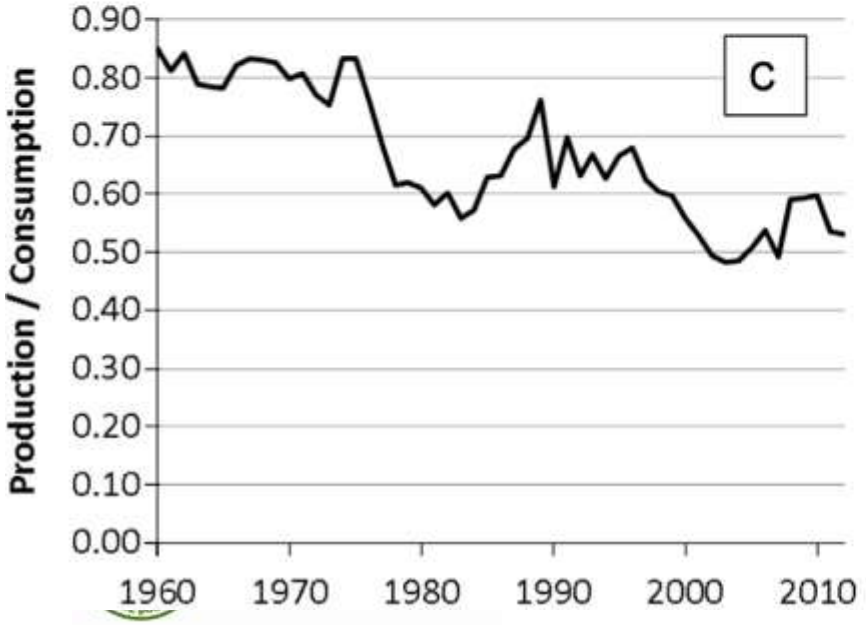
→Food security scenarios

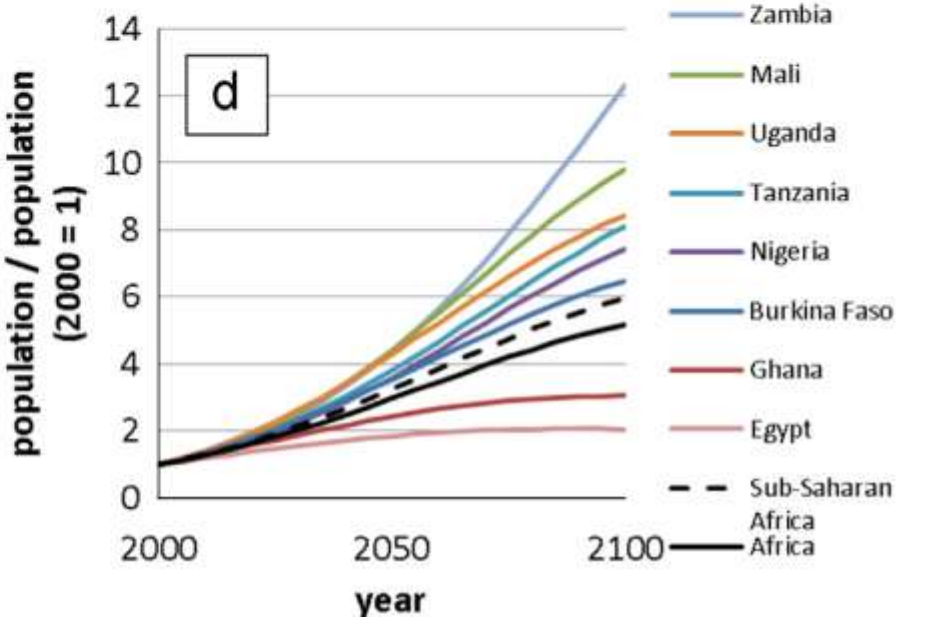
→Advice for breeders & agronomists

3.1 Food Security: Big picture









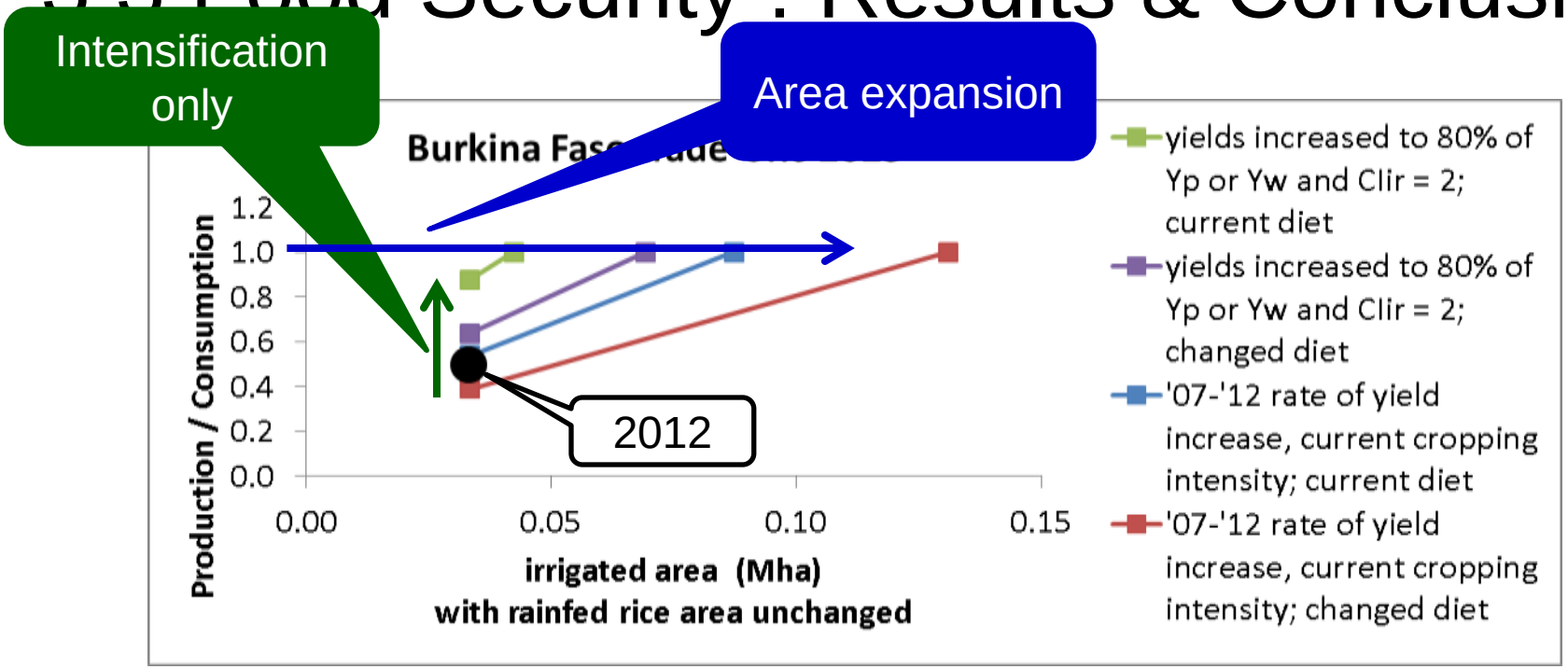
3.2 Food Security: scenarios

Can African countries become self sufficient in rice?

Is it possible on existing land, or is more land needed?

- Population scenarios (UN data)
- Per capita rice consumption trends (USDA-PSD & UN data)
- What if yield gaps are closed? (GYGA data)
- What if cropping intensitity is increased in existing irrigated area (GYGA data)

3.3 Food Security : Results & Conclusion



Conclusion

- Want self sufficiency? -> Area expansion
- Where?
- How much spare land available?

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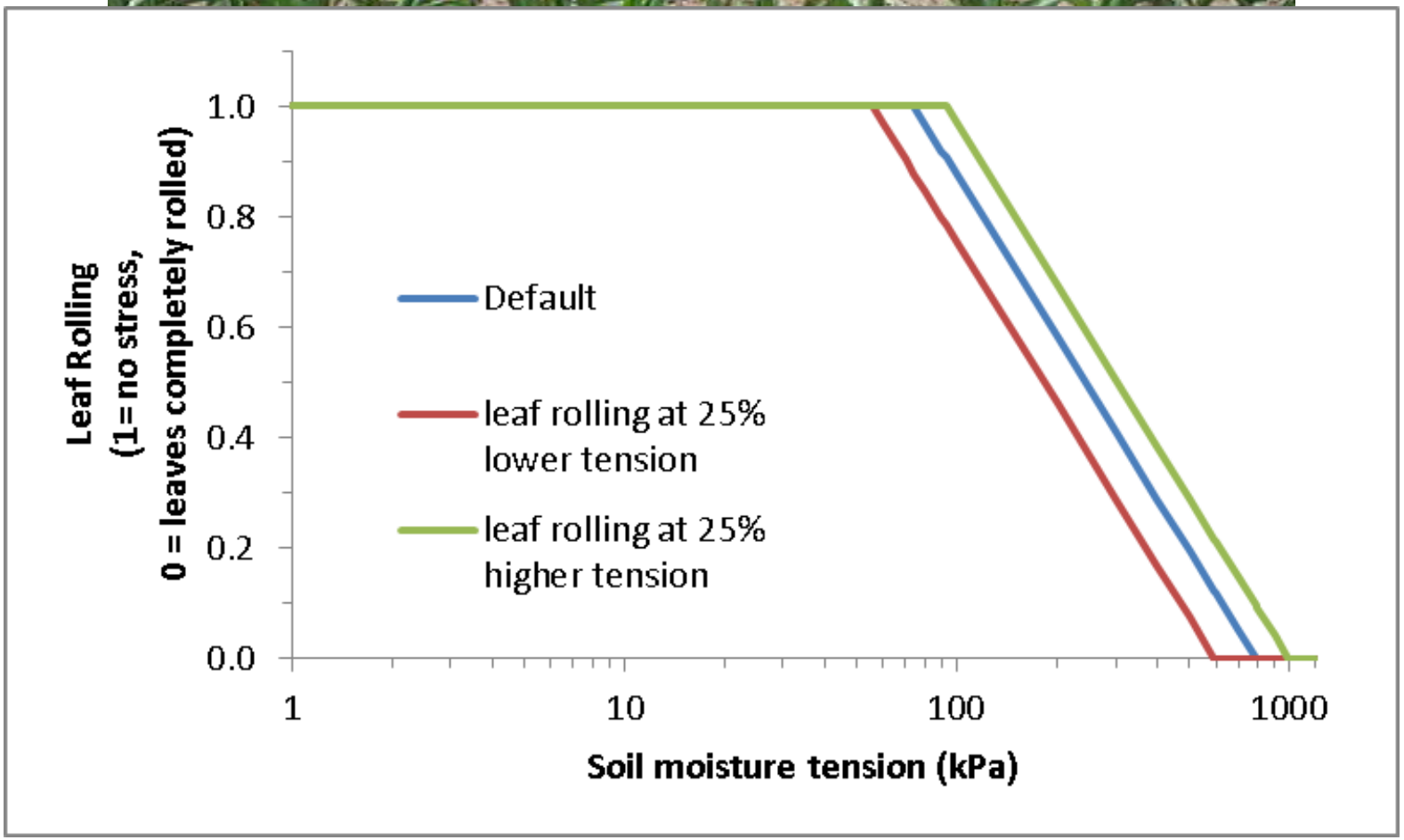
4.1 RICE-CI & STRASA project

Objective: drought traits and management options for rainfed rice

Sites

1. Burkina Faso, Mali, Nigeria
2. Upland and lowland

4.2 Example: varieties with different leaf rolling



4.3 RICE-CI & STRASA: Ideotyping

Crop traits:

1. Root depth (30/40/50 cm)
2. Delay in development (yes/no)
3. Leaf rolling (tensions +/-25%)
4. Leaf expansion (tensions +/-25%)
5. Relative transpiration (tensions +/-25%)
6. Leaf death rate (tensions +/-25%)
7. Duration sowing to maturity (+/-10%)

Management

1. Sowing date (+/-10 days)

4.4 RICE-CI & STRASA: Conclusions

1. Sowing date and crop duration biggest impact
2. Roots:
    1. Less deep = very negative effect
    2. Deeper roots = sometimes positive, mostly no effect
3. Main uncertainties
    1. groundwater depth
    2. Average sowing date

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Conclusions

- GYGA = Scientific network, very inspiring
- GYGA = valuable core datasets, weather propagation method, upscaling, website & atlas
- GYGA = Model chain which can be used for rapid large simulations
- GYGA = indirect impacts, often difficult to assess
  - Spin-off for a number of projects
  - Agenda setting (area expansion, hydrology, cold sterility, climate smart agriculture, research priorities)

Outlook

- Adding more countries to GYGA online atlas
- Using the “model chain” & weather data in other projects
- Continued research into causes of yield gaps
- Intensification options:
  - fitting two or three crops into one year?
  - Which set of sowing dates x varieties?
- Climate smart agriculture

Conference Presentations

- Van Oort, P.A.J., 2015. **Modeling rice phenology and cold sterility**. EA RiceAdvice kick-off 6 May 2015, Antsirabe, Madagascar
- Saito, K. 2015. **Challenges and opportunities in rice research in Africa**. Presented at International Seminar and Workshop on "Rice Research Collaboration: Past and Future" 4-5 March, 2015.
- Saito, K. 2014. **What is the prognosis for self-sufficient rice production in Sub-Saharan Africa based on yield gap analysis?** Presented at the sixth global Water for Food Conference, October 19-22, 2014 in Seattle, Washington.
- Saito, K., N'diaye, M.K., Senthilkumar, K., Tanaka, A., Dieng, I., Rodenburg, J., Vandamme, E., van Oort, P.A.J., Johnson, J-M., Ahouanton, K., Niang, A., Cisse, B., Sow, A., Diop, M., Diack, S., Akakpo, C., Segda, Z., Bassoro, I., Allarangaye, M.D., Gbakatchetche, H., Lunze, F., Bayuh, B.A., Jaiteh, F., Bam, R.K., Dogbe, W., Sékou, K., Rabeson, R., Kamissoko, N., Gueye, H., Mossi Maïga, I., Bakare, O.S., Gasore, E.R., Cisse, M., Baggie, I., Kajiru, G., Ablede, K.A., Nanfumba, D. 2014**. Africa-wide Rice Agronomy Task Force: a network for enhancing on-farm rice productivity**. Presented at International Rice Congress, Oct. 2014, Bangkok, Thailand.
- van Oort, P.A.J., Saito, K. Yoshida, H., de Vries, M.E., Tanaka, A. Diagne, A., van Bussel, L.G.J ., van Wart, J., 2014. **Improving heat and cold sterility simulation of ORYZA2000 and its application for yield gap assessment in Africa**. International Rice Congress, Bangkok, Thailand oct. 2014
- van Oort, P.A.J., 2014. **Summary of GYGA-1 yield gap assessments: What did we learn? What does it mean?**. Global Yield Gap Atlas Workshop #3, March 25-27, 2014, Addis Ababa, Ethiopia
- Saito. K., van Oort, P., Shrestha, S., Tanaka, A., Dieng, I., Wopereis, M.C.S. 2013. **Estimating Yield Gaps and Potential Rice Production in Sub-Saharan Africa**. Presented at Nov. 3-6, 2013 ASA, CSSA, and SSSA International Annual Meetings in Tampa, FL, USA.

Peer-reviewed publications

GYGA

- van Oort, P.A.J., Saito, K., Tanaka, A., Amovin-Assagba, E., van Bussel, L.G.J., van Wart, J., de Groot, H., van Ittersum, M.K., Cassman, K.G., Wopereis, M.C.S., 2015. Assessment of rice self-sufficiency in 2025 in eight African countries. Global Food Security 5: 39-49. http://dx.doi.org/10.1016/j.gfs.2015.01.002
- van Bussel, L.G.J., Grassini, P., Van Wart J., Wolf, J., Claessens, L., Yang, H., Boogaard, H., de Groot, H., Saito, K., Cassman, K.G., van Ittersum, M.K., 2015. From field to atlas: Upscaling of location-specific yield gap estimates. Field Crops Research 177 (2015) 98-108. http://dx.doi.org/10.1016/j.fcr.2015.03.005

CCAFS

- van Oort P.A.J., de Vries M.E., Yoshida H, Saito K., 2015. Improved Climate Risk Simulations for Rice in Arid Environments. PLoS ONE 10(3): e0118114. http://dx.doi.org/10.1371/journal.pone.0118114
- van Oort, P.A.J., Saito, K., Zwart, S.J., Shrestha, S., 2014. A simple model for simulating heat induced sterility in rice as a function of flowering time and transpirational cooling. Field Crops Research 156: 303-312. http://dx.doi.org/10.1016/j.fcr.2013.11.007

Birds eating potential yield

https://youtu.be/Bw_RYF381R0