Global Yield Gap Atlas

Global Yield Gap Atlas

Mapping for sustainable intensification

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ICRISAT Science with a human face

Food security and availability

- Demand for food will increase (+70%?)
- Adequate supply (+70%) at affordable prices is at the foundation of food security: “necessary, but not sufficient”
- Sustainable intensification is one of the main routes to achieve this production increase
- How much food, how much land, how much water, and in what time frame?

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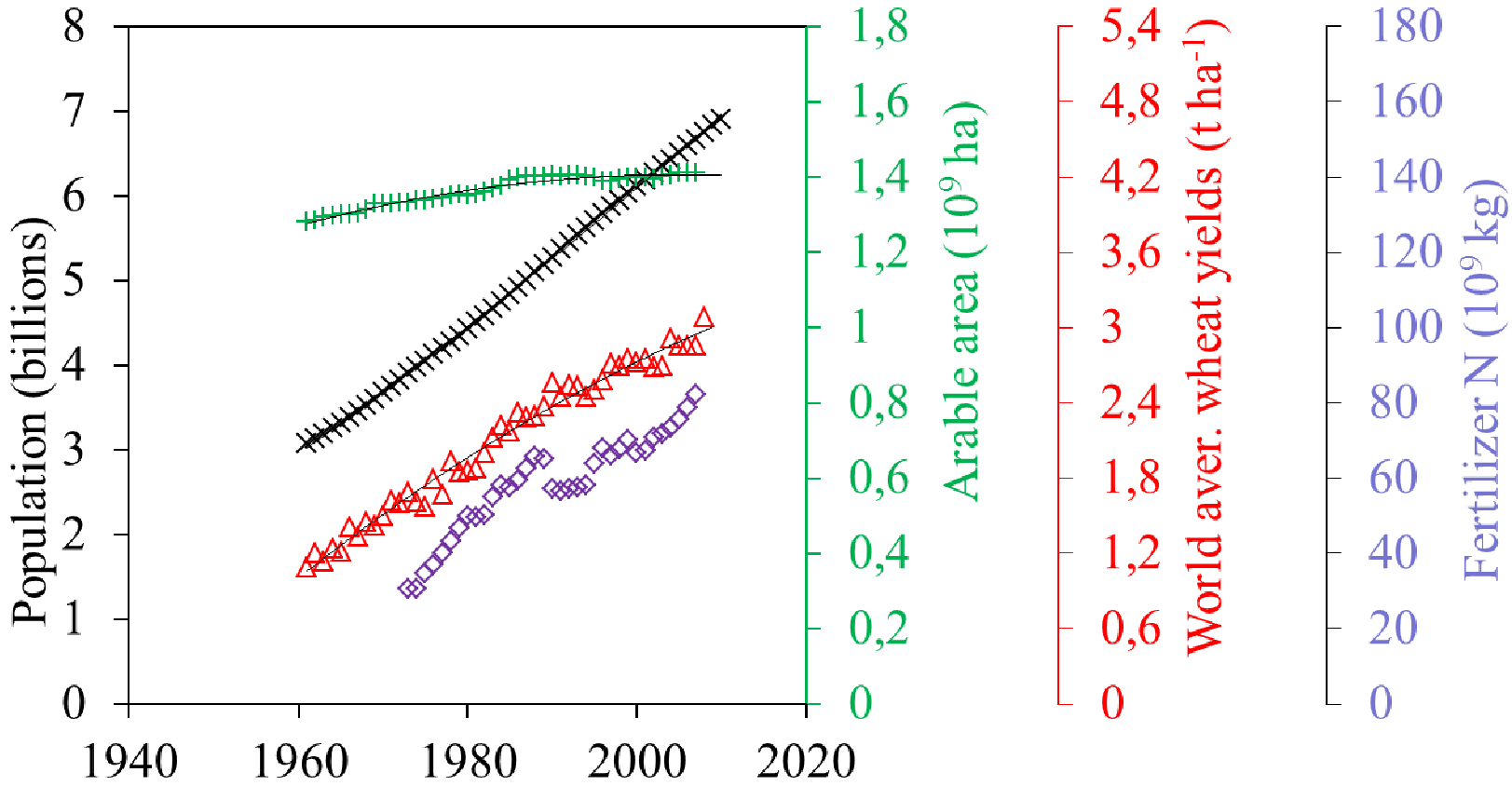
Required growth for food and feed is not new



But conditions in 2013 very different than in 1960

Updated from Evans, 1998

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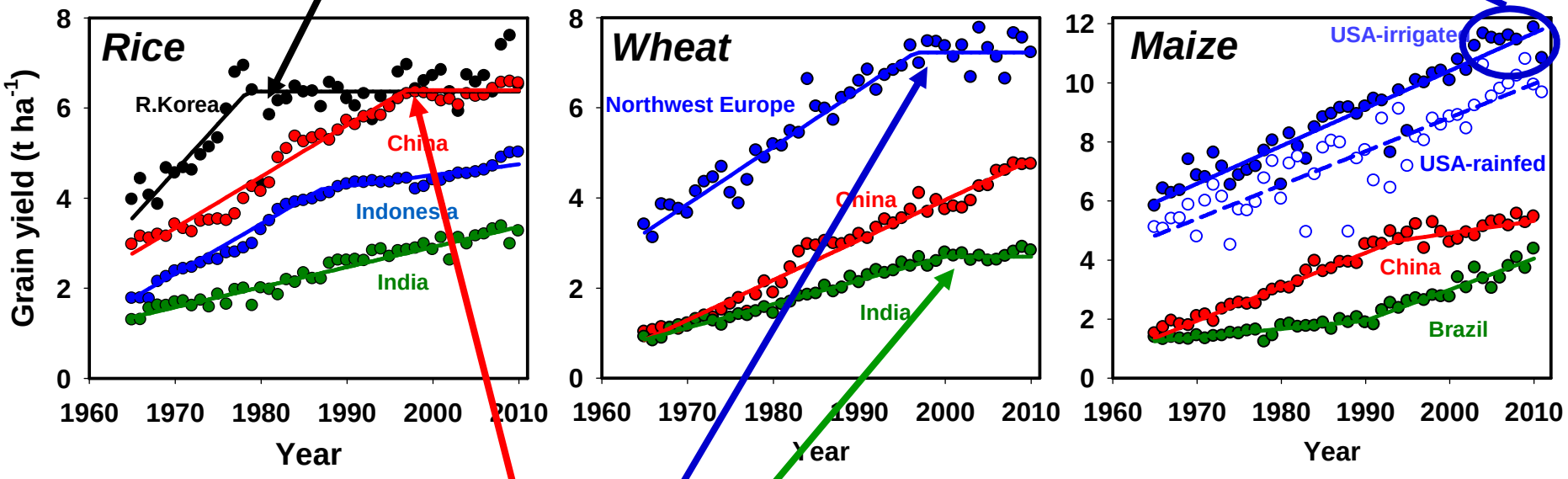
Yield plateaus?

Grassini et al., 2011. FCR 120:142-152

Cassman, 1999. PNAS, 96: 5952-5959



Cassman et al., 2003, ARER 28: 315-358

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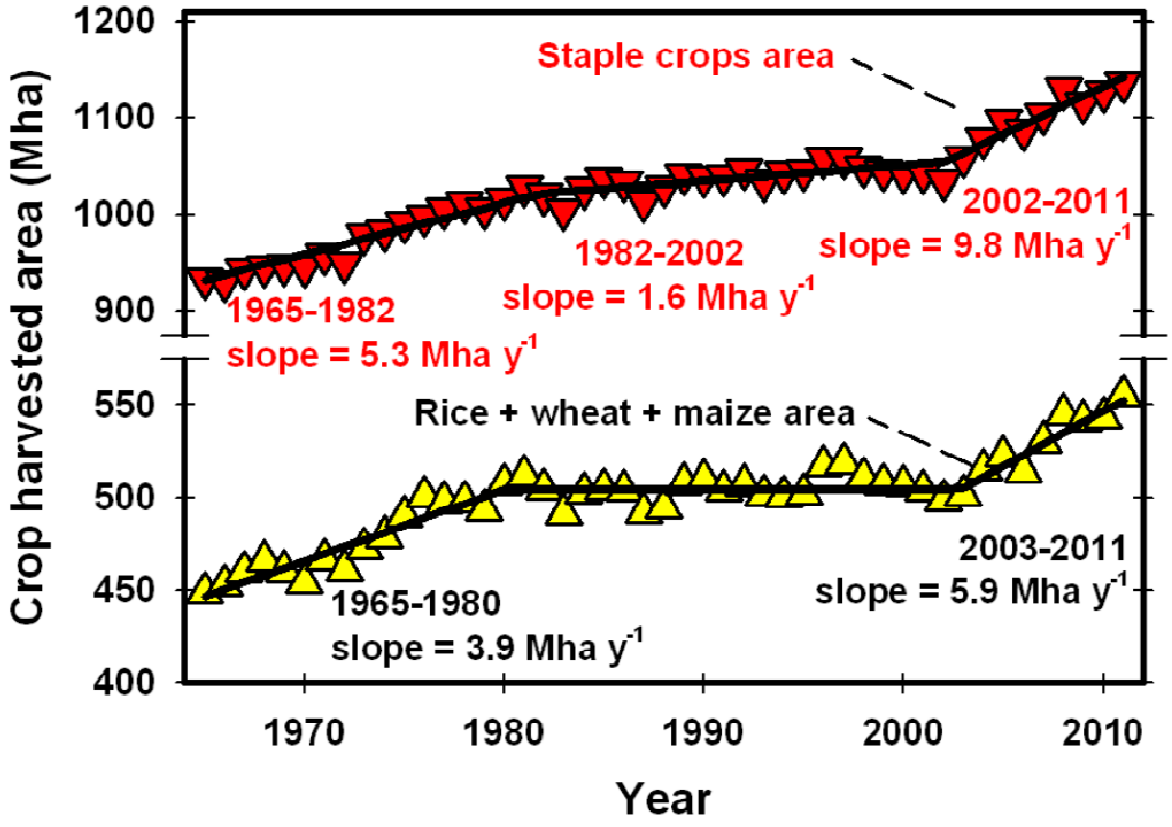
Indications that crop areas increase again



Staple-crop area includes cereals, oilseed, pulses, sugar, root, fiber, and tuber crops.

Grassini, Eskridge & Cassman,
Nature Communications (In Press)

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Why yield gap analysis?

- Currently not possible to provide reliable answers to critical questions of policy makers and R&D organizations:

- What is the food production potential for a region or country if farmers adopted best management practices?
- Will it be possible for country X to be self-sufficient in food production by 2030 or 2050?
- When and where can we predict crop yields to stagnate because they reach biophysical yield ceilings?
- What are the causes of yield gaps and how to overcome them?
- What are the regions to target experimentation and what are extrapolation domains?

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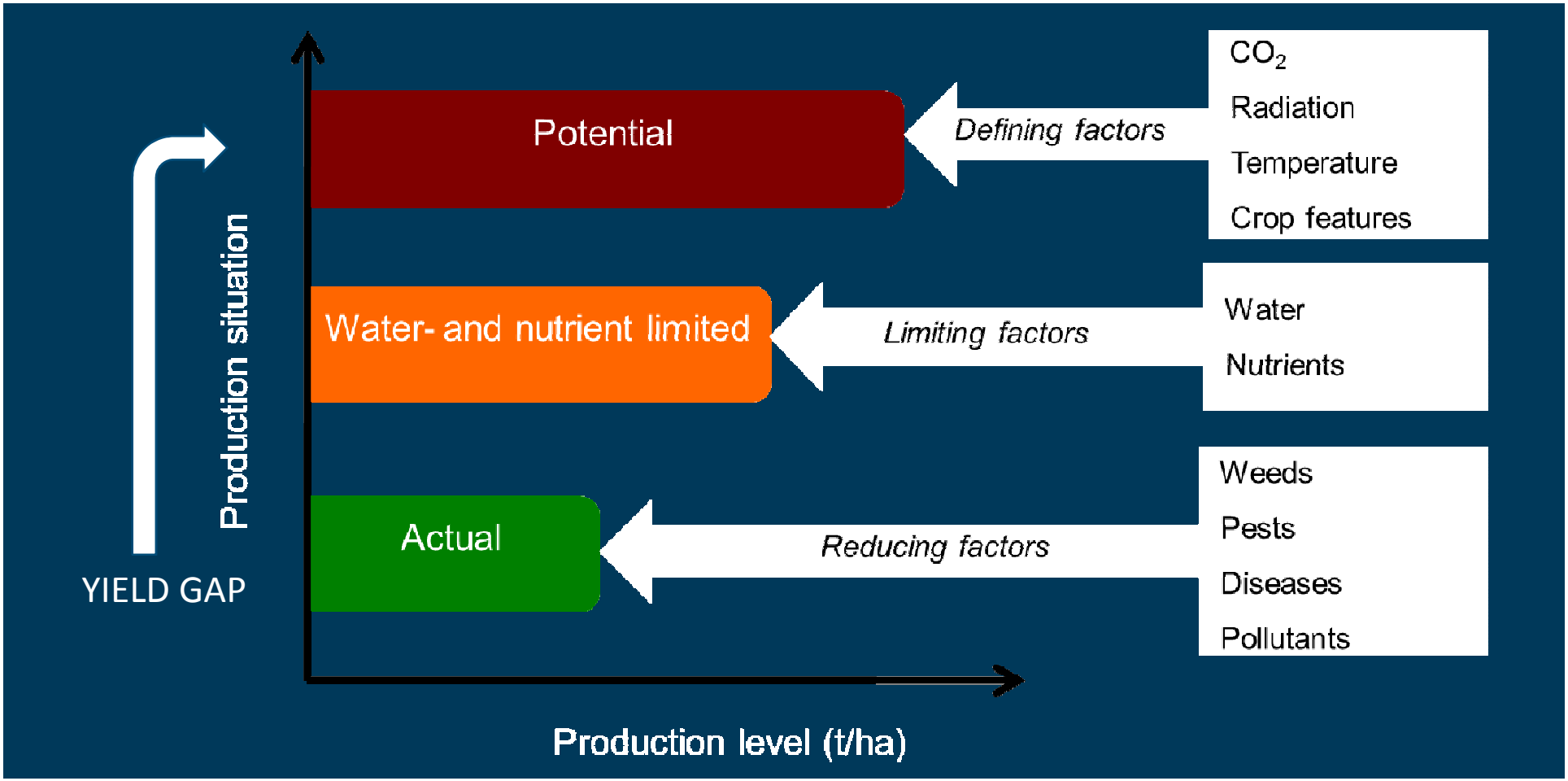
Production ecological principles



Lovenstein et al., 1995; Van Ittersum and Rabbinge, 1997; Van Ittersum et al., 2013

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Yield gap

Photo: Ken Giller

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Definitions

- Yield potential (Potential yield) - Yp: yield of a crop cultivar under defined weather conditions, when grown with no nutrient and water stress and biotic stresses effectively controlled
- Water-limited yield - Yw: same as Yp, but water supply is limiting (and hence soil type and topography matter)
- Actual yield – Ya: Average (past 5+ years) yield achieved by farmers in a given region under dominant management practices and soil properties
- Yield gap – Yg: difference between Yp (or Yw) and Ya
- Crop water productivity – WP: ratio between yield and seasonal water supply (PAW at planting + in-season rainfall + irrigation – PAW at harvest)

Van Ittersum et al., 2013. Field Crops Research 143, 4-17.

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Previous yield gap studies

- Global and regional (local) focus
- Regional studies:
  - crop growth models, experiments, best management practices
  - local relevance, but not possible to compare them mutually, due to inconsistent concepts and methods
- Global studies:
  - statistical procedures or generic crop growth models
  - consistent, but generally too coarse, lacking local detail and hence agronomic relevance

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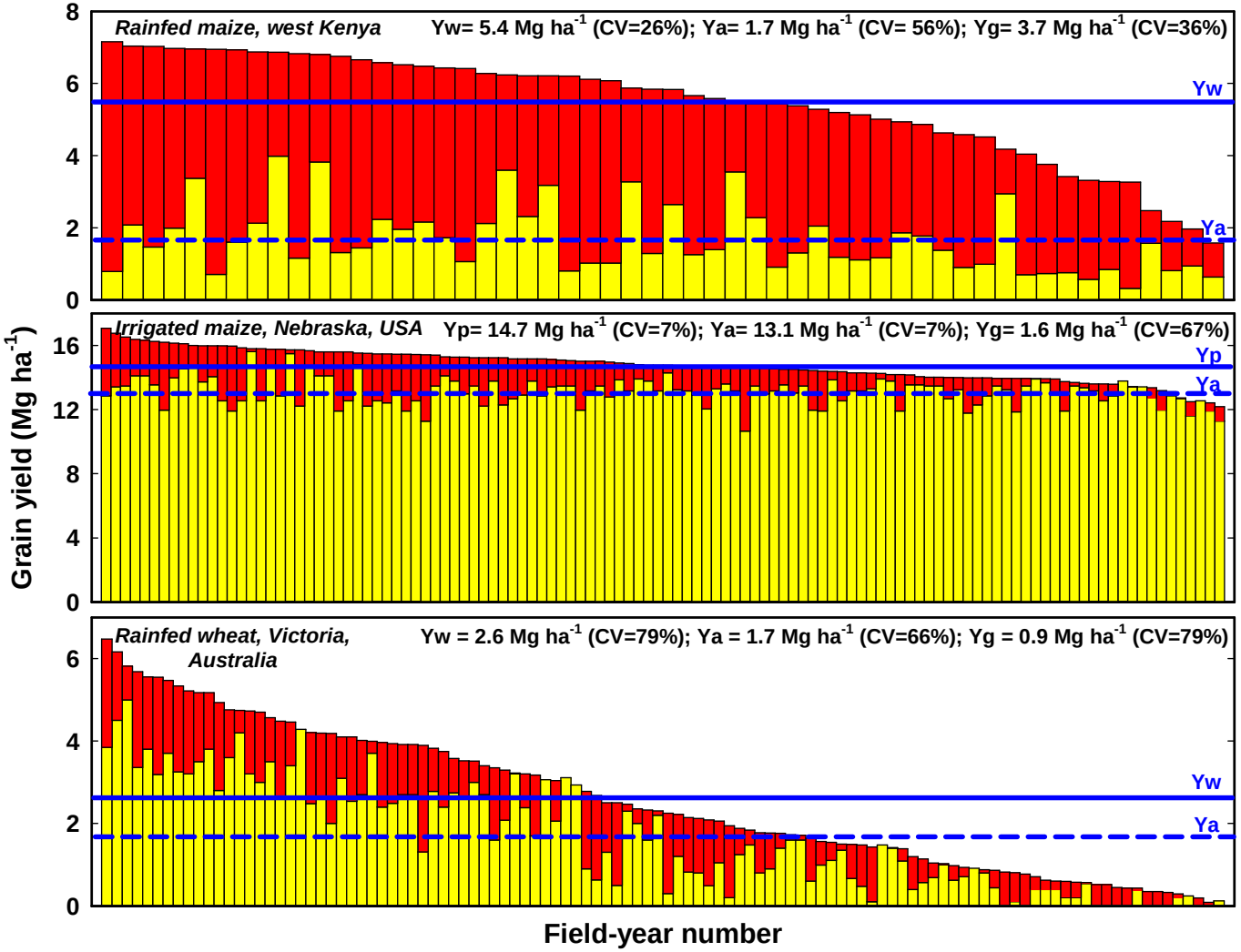
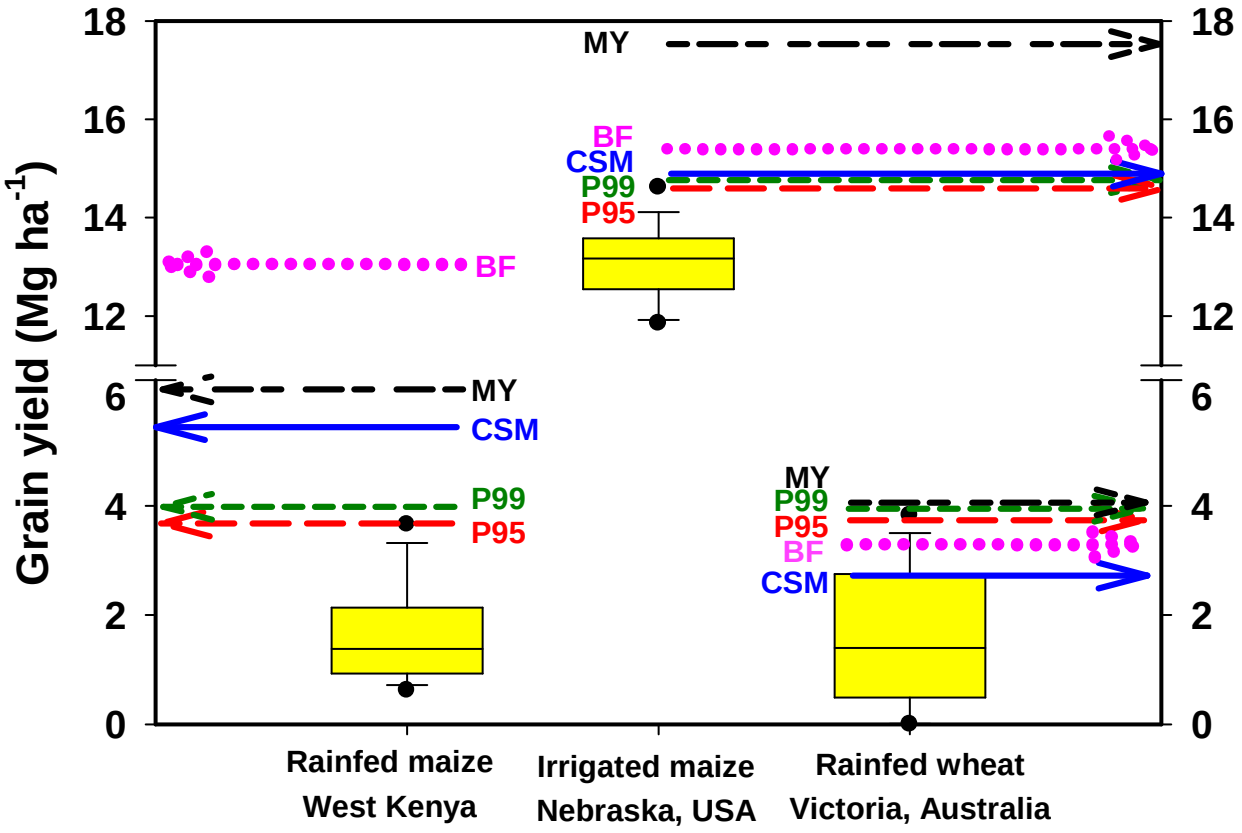
Crop simulation: example 3 regions



Van Ittersum, Cassman, Grassini, Wolf, Tittonell, Hochman, 2013. Field Crops Research , 143, 4-17.

Comparing four methods



Van Ittersum, Cassman, Grassini, Wolf, Tittonell, Hochman, 2013.
Field Crops Research , 143, 4-17

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Global studies: a comparison at local level

Location	Stehfest et al. (2007)		Deryng et al. (2011)		Müller (2012)		Licker et al. (2010)	Neuman et al. (2010)
	Yp	Yw	Yp	Yw	Yp	Yw	Yp or Yw	Yp or Yw
Nebraska-maize 40.5-41.0°N; 101.5-102.0°W	10.2	3.1	11.6	6.1	8.1	3.3	8.0	9.4
Nebraska-wheat 40.5-41.0°N; 101.5-102.0°W	4.2	0.9	9.7	6.8	11.2	6.6	3.1	3.5
Kenya-maize	Na	1.8	9.1	6.3	6.2	3.6	3.4	5.1
Netherlands-wheat	9.5	9.8	6.2	5.4	8.9	8.3	6.3	Na

Van Ittersum, Cassman, Grassini, Wolf, Tittonell, Hochman, 2013. Field Crops Research 143, 4-17.

Global Yield Gap Atlas

Global Yield Gap Atlas: vision and goal

- Comprehensive, graphically intuitive, public: www.yieldgap.org
- Widely used by policy makers, researchers, students, and industry
- Transparent, robust and agronomically relevant protocol
- Bottom-up approach based on actual (point-based) data for weather, cropping systems and soils
  - up-scaled up to national and regional levels

Global Yield Gap Atlas

Global Yield Gap Atlas: vision and goal

- Focus on major food crops (cereals, soybean, groundnut, potato, cassava, ...) in all countries
- Global partnership involving scientists in Africa, Asia, Europe, Latin America, North America, Oceania

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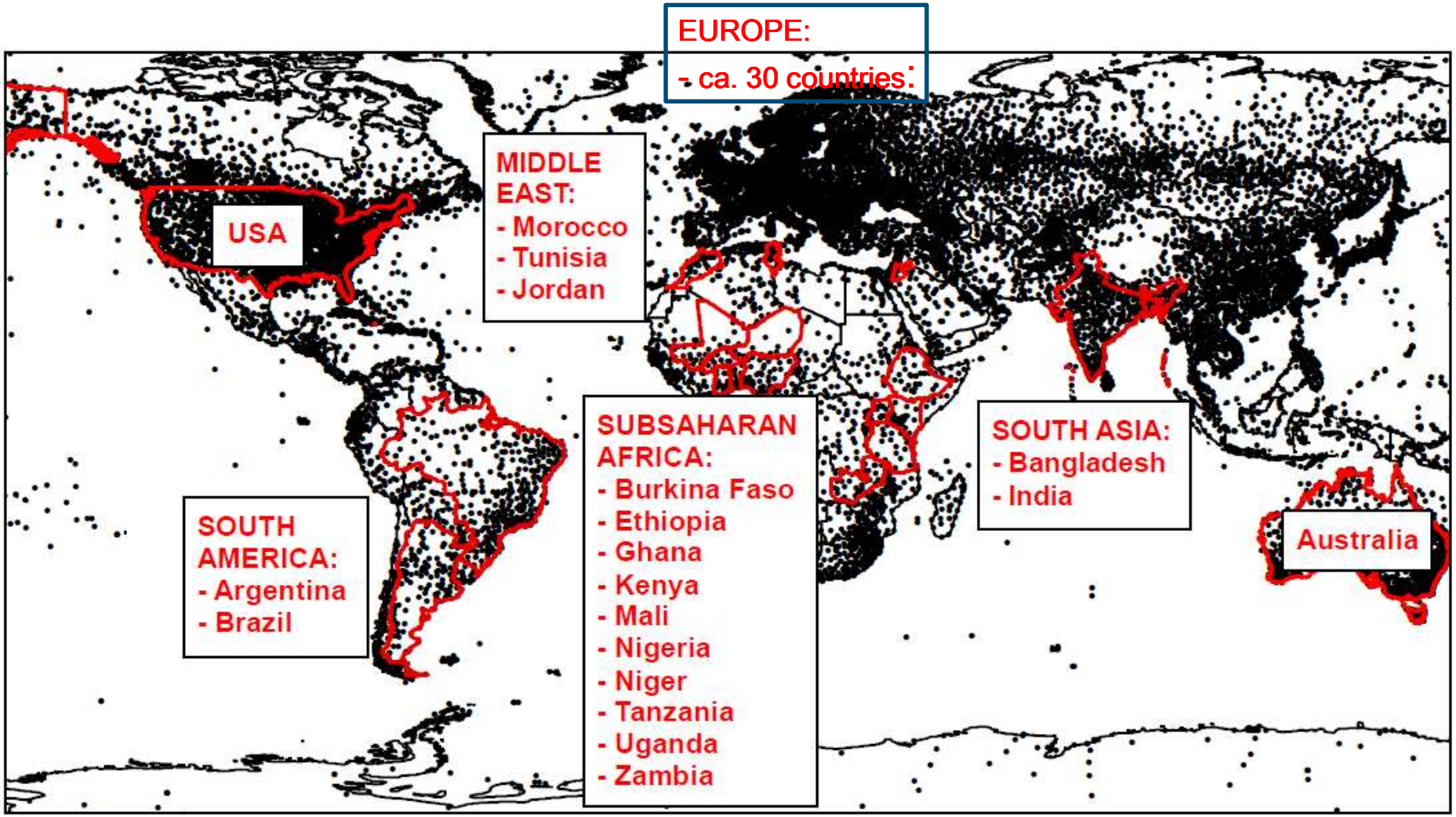
Global coverage of cropland; currently >20 countries



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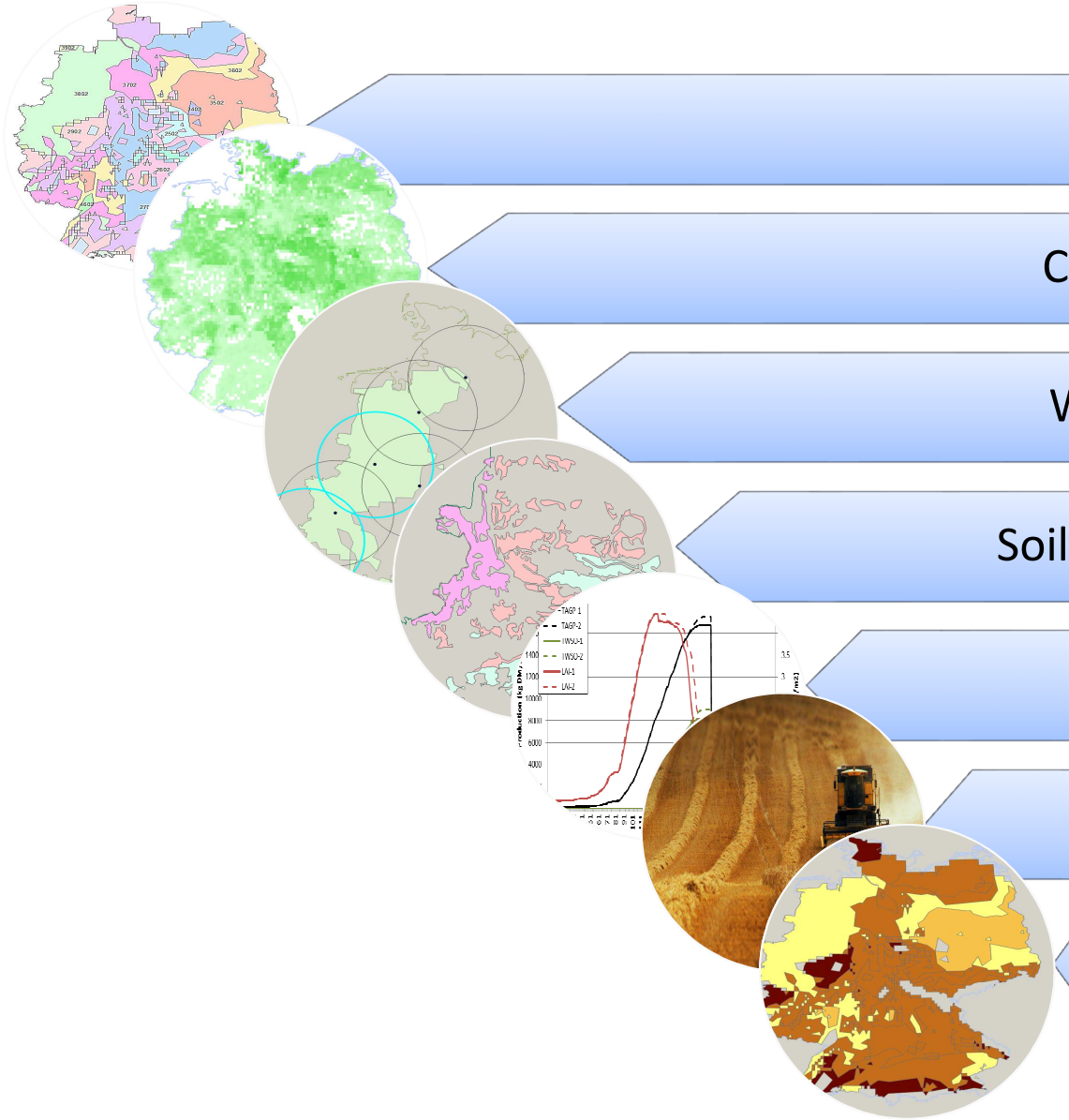
Yield gap analysis: protocol



Climate zones

Crop-specific harvested areas

Weather station buffer zones

Soil types and cropping systems

Crop model simulations

Actual yields

Yield gaps

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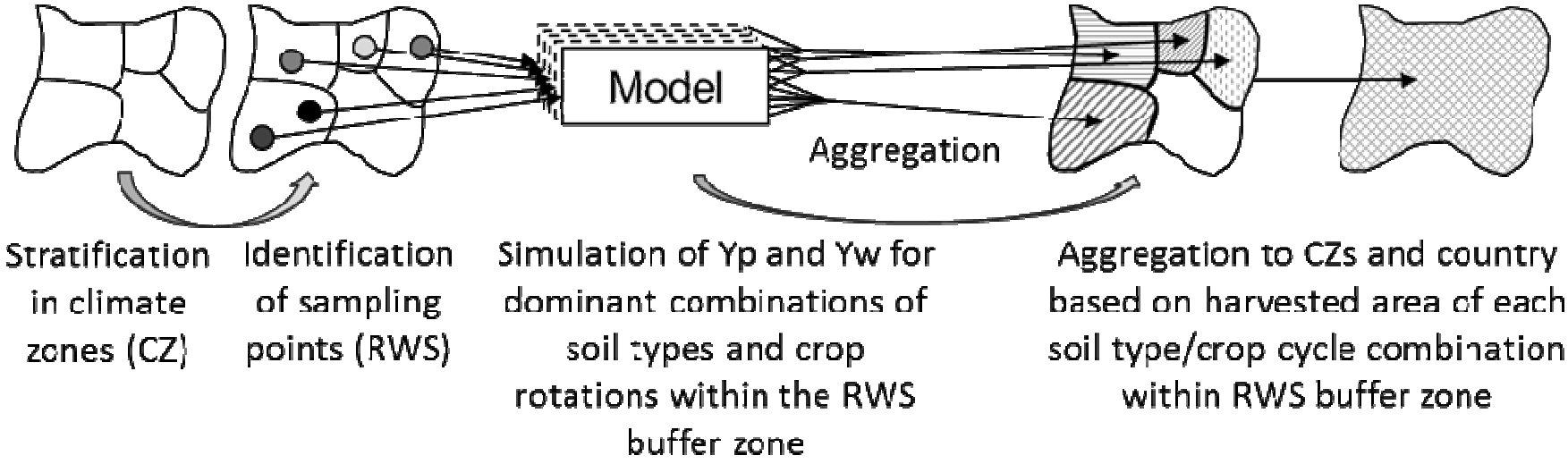
Spatial framework and upscaling



Ewert, van Ittersum et al., 2011. Agriculture, Ecosystems & Environment 142, 6-17.

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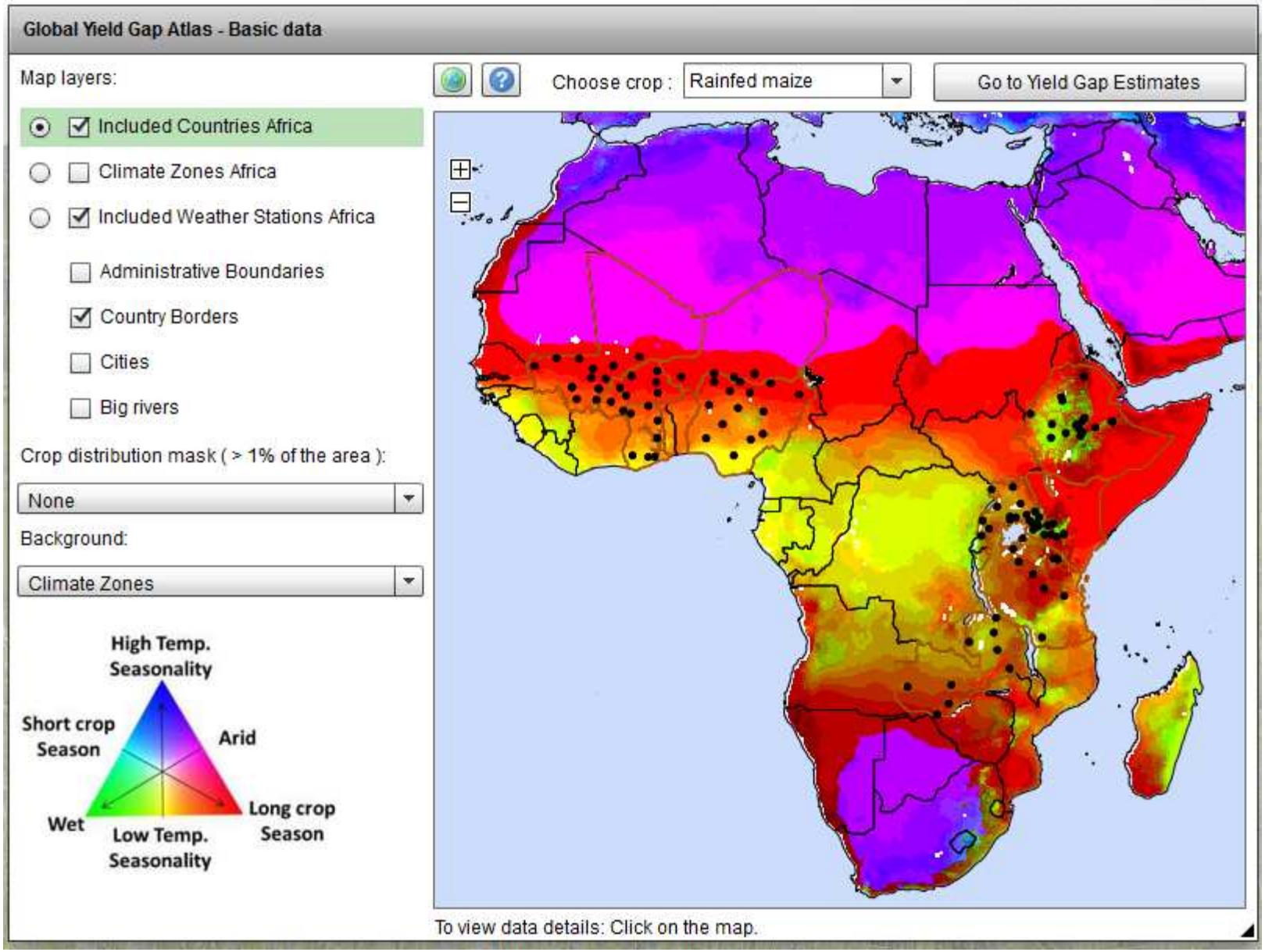
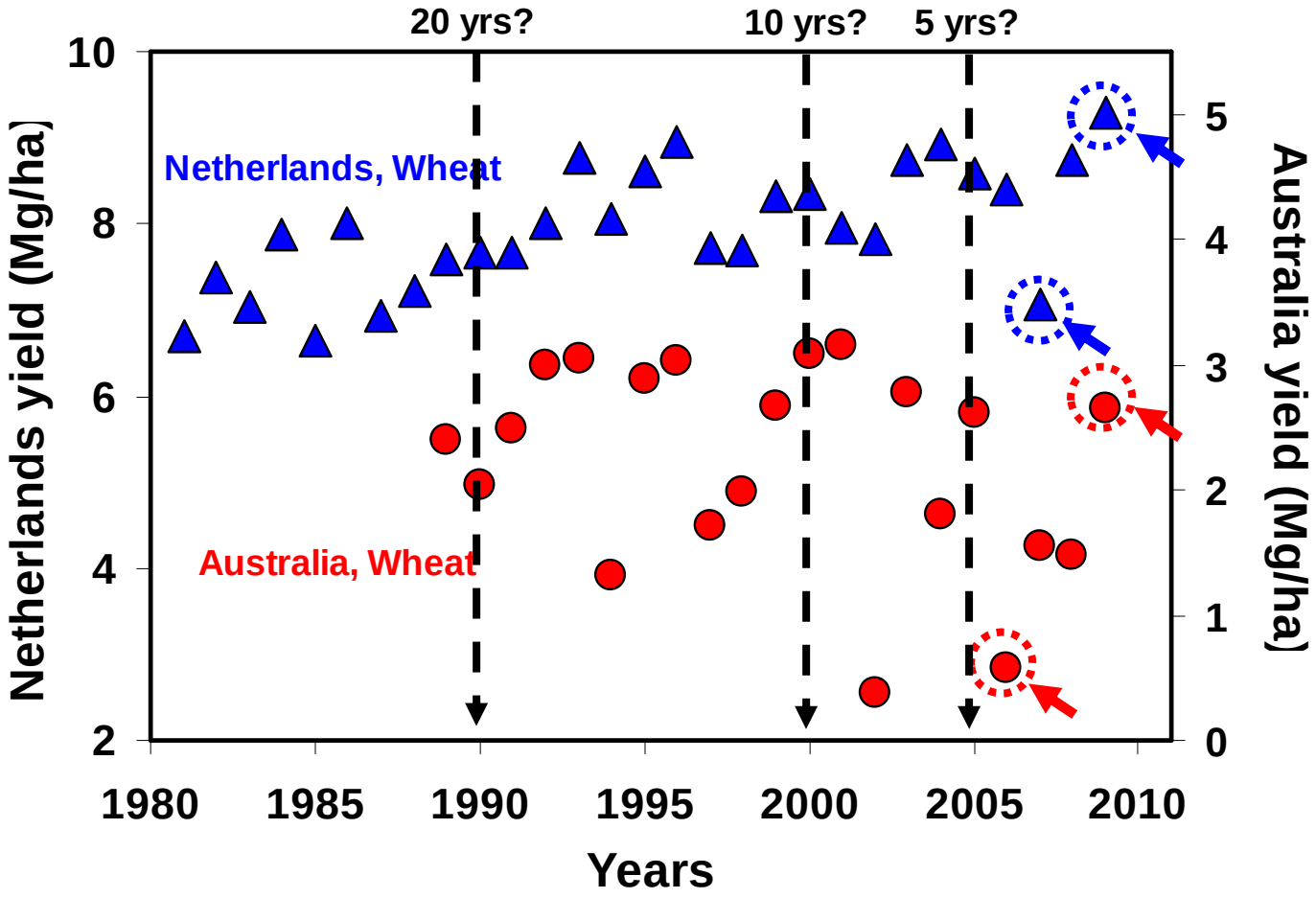
Climate zonation



Van Wart et al., 2013. Field Crops Research 143, 44-55.

Trends in wheat yields in Netherlands and Australia



Van Ittersum, Cassman, Grassini, Wolf, Tittonell, Hochman, 2013.
Field Crops Research 143, 4-17.

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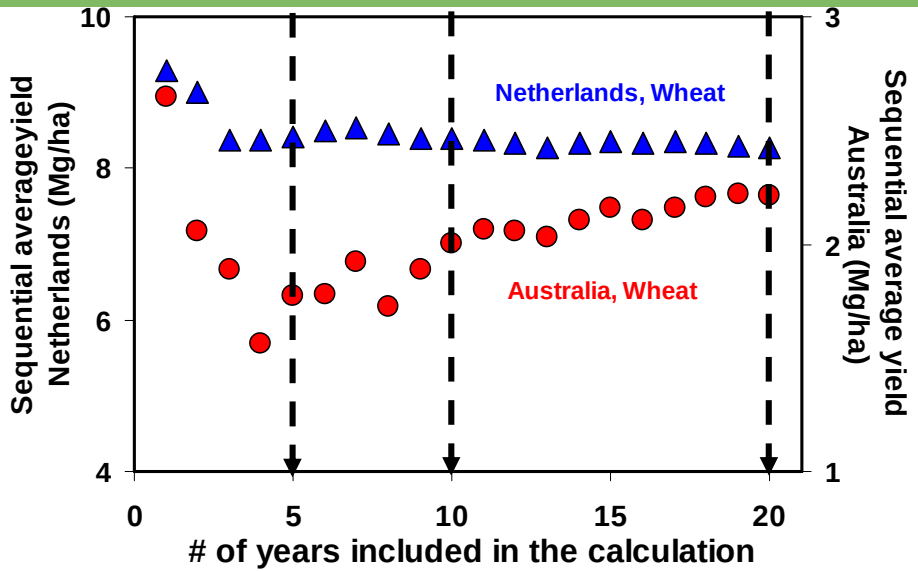
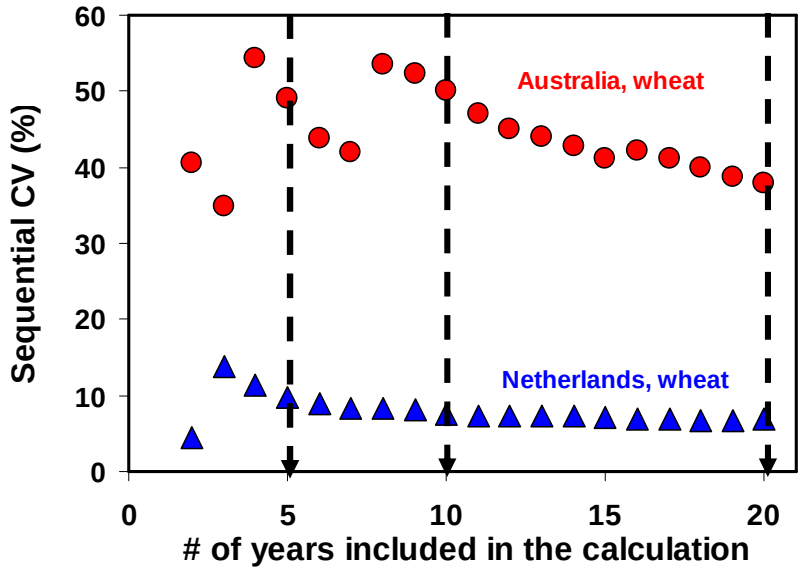
Calculated average yields and CV as a function of # years





5 years (NL) or >10 years (AU) needed for a stable estimation of yield average or CV, but try to avoid the inclusion of technological change and climate c

Van Ittersum et al., 2013. Field Crops Research 143, 4-17.

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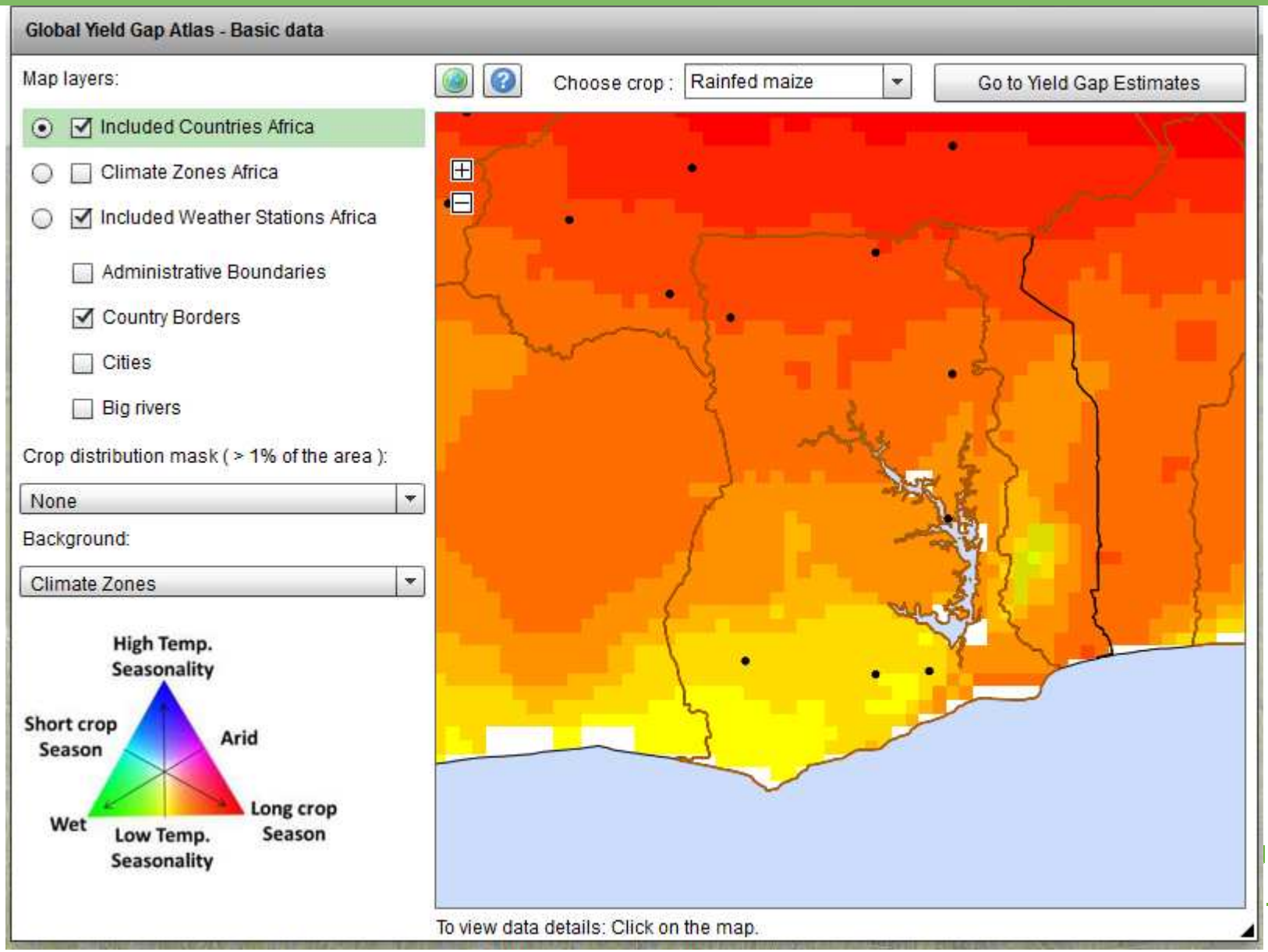
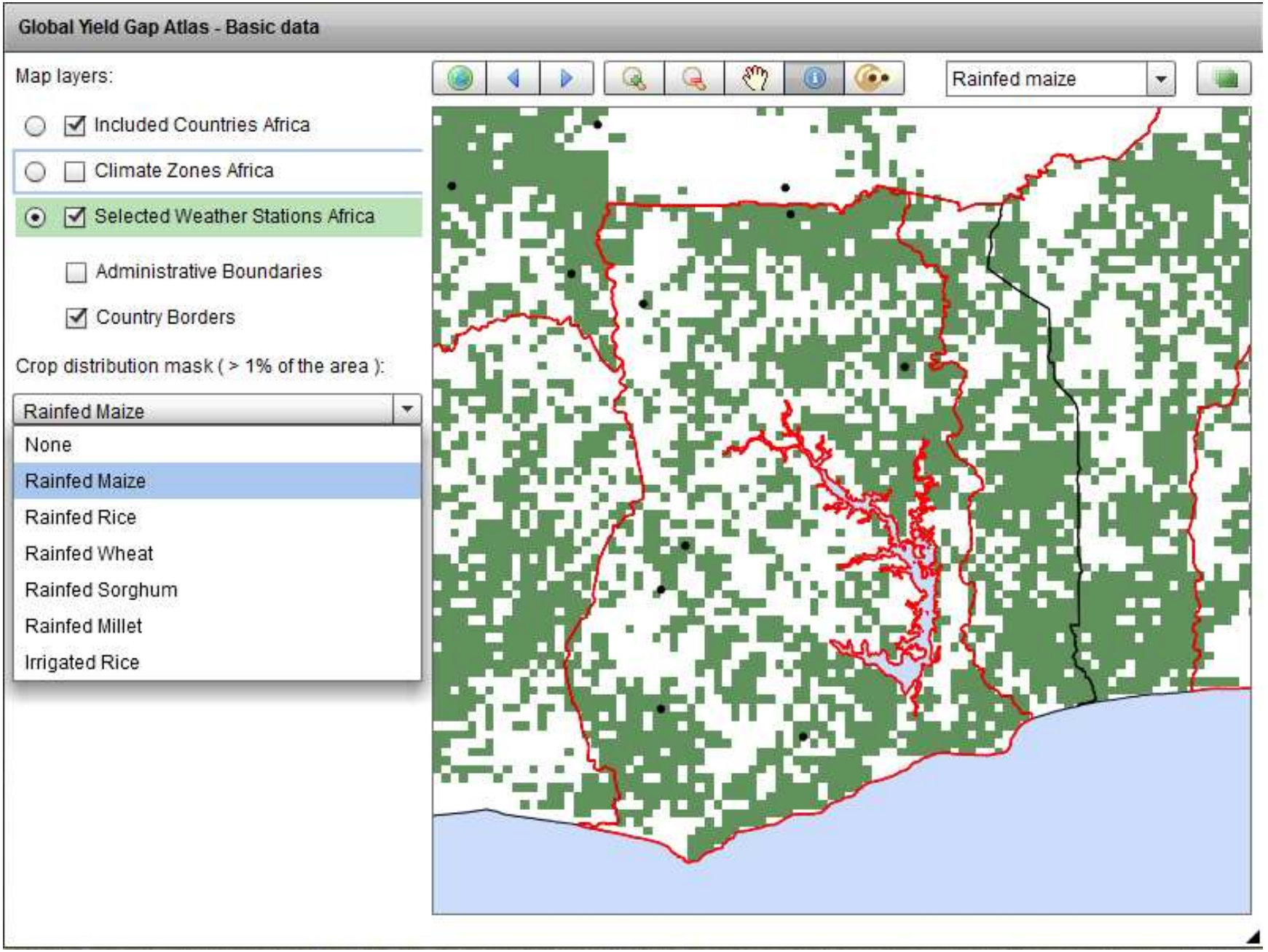
Atlas: www.yieldgap.org

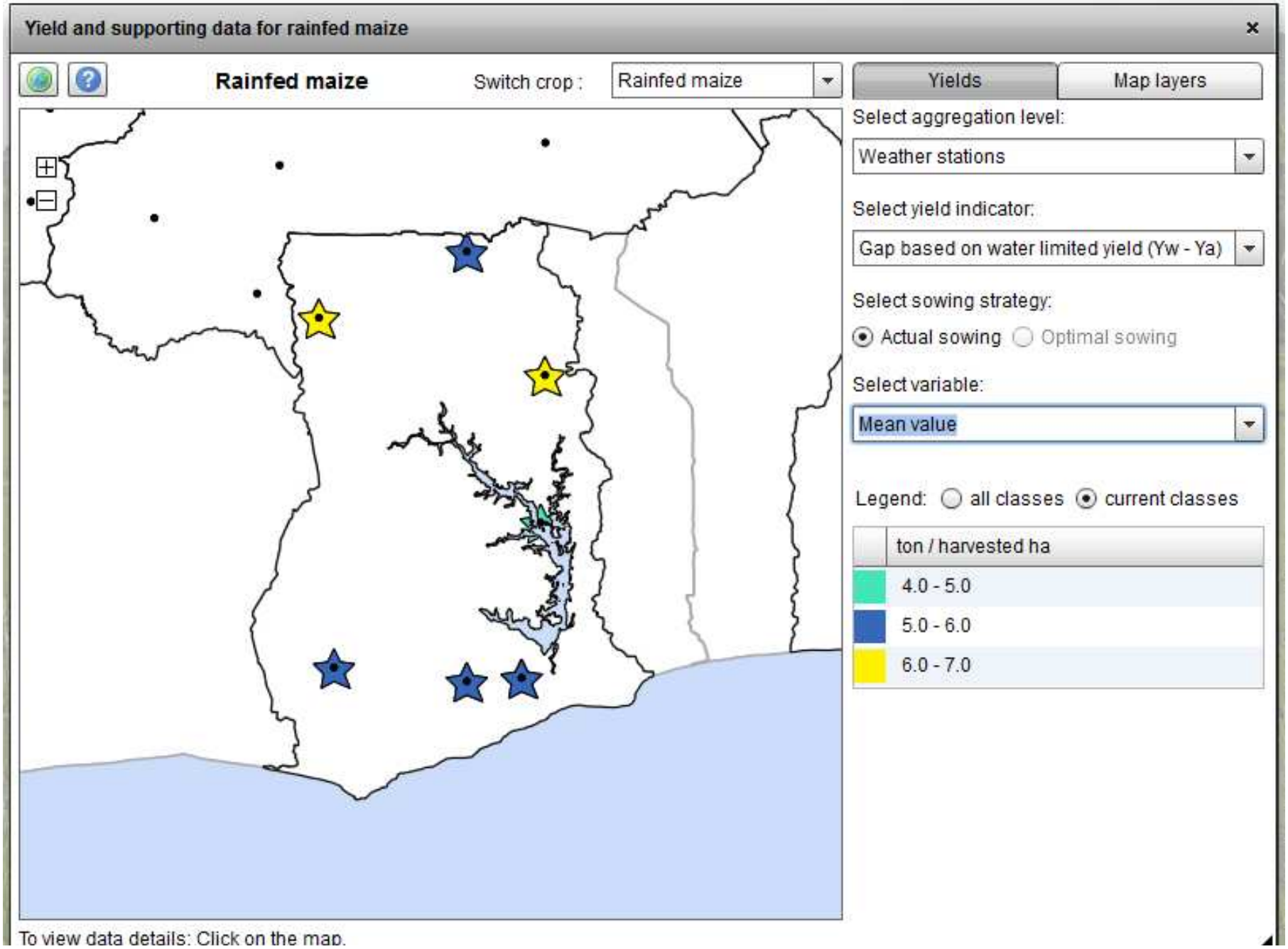


al Yield Atlas

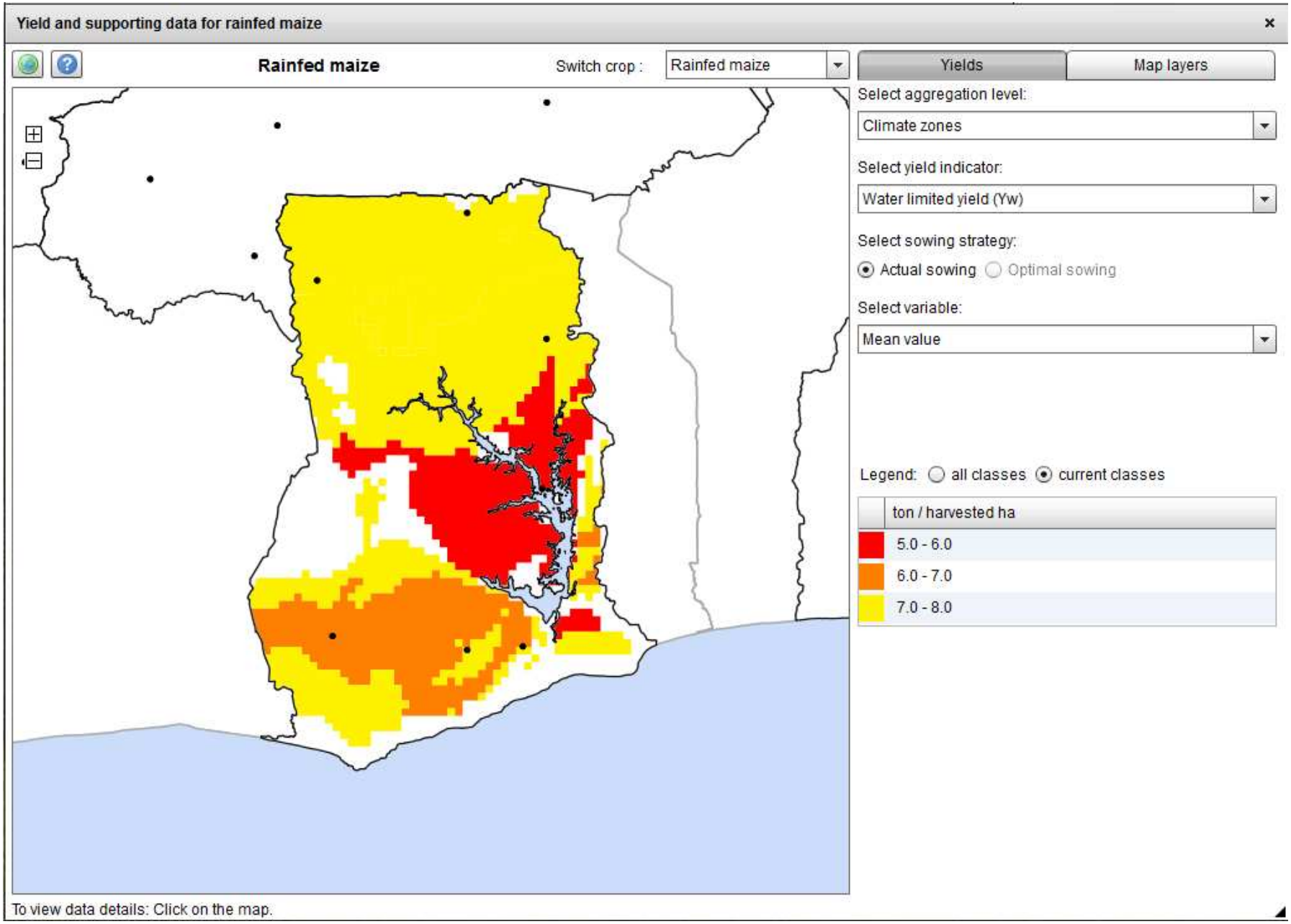
- Rainfed maize area (SPAM map – You et al., 2009)



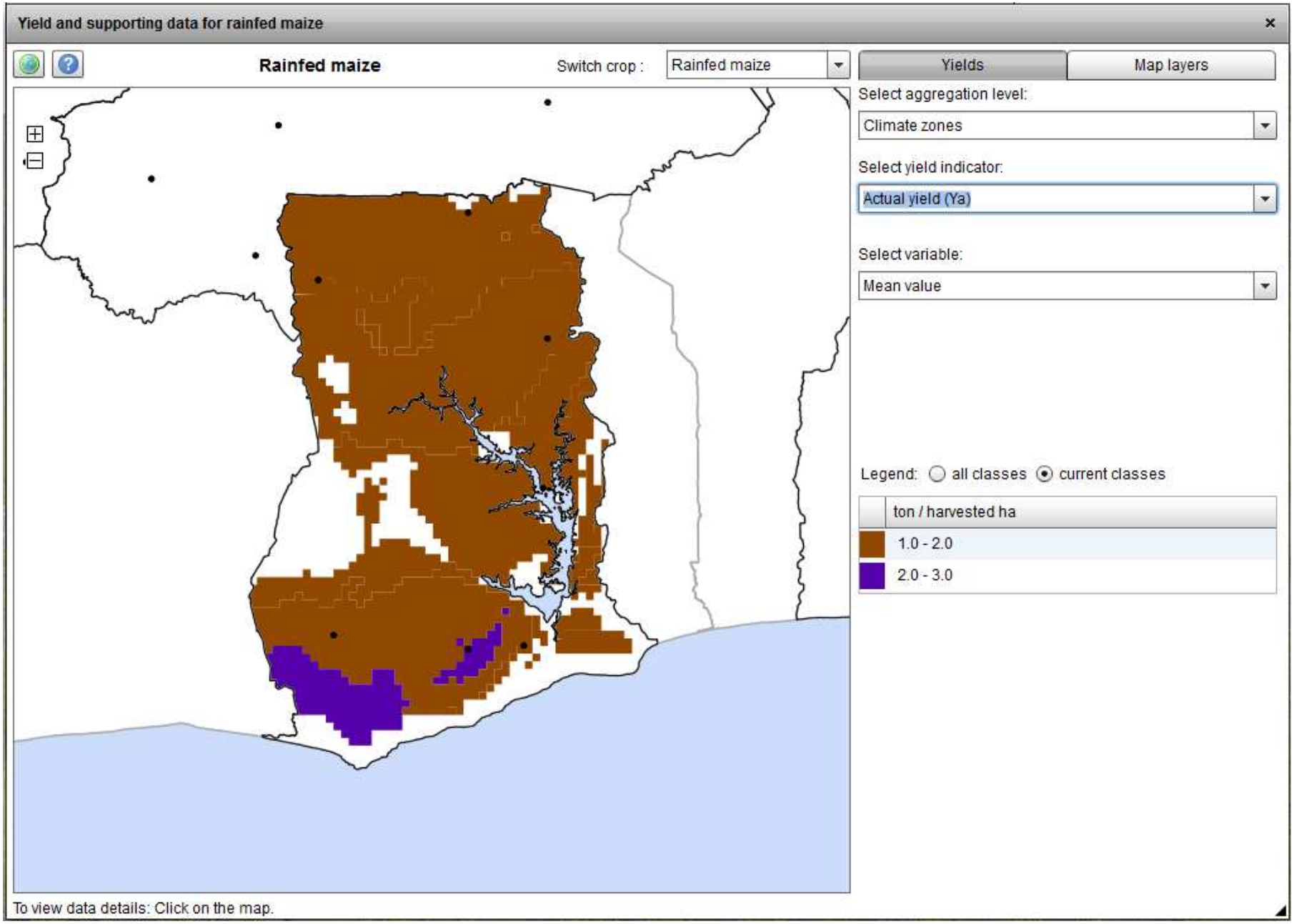
Reference weather stations – rainfed maize



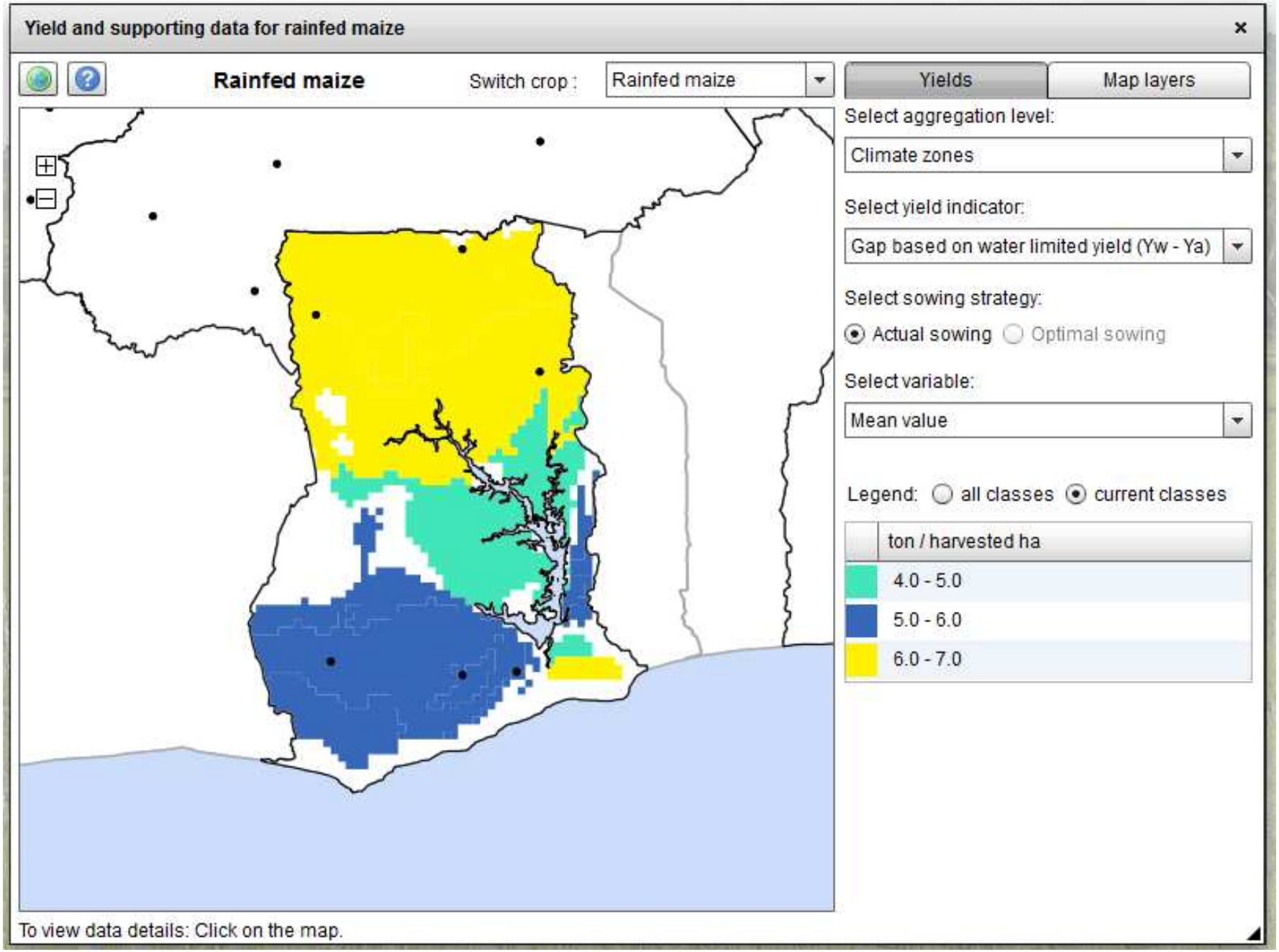
Water-limited yield - maize



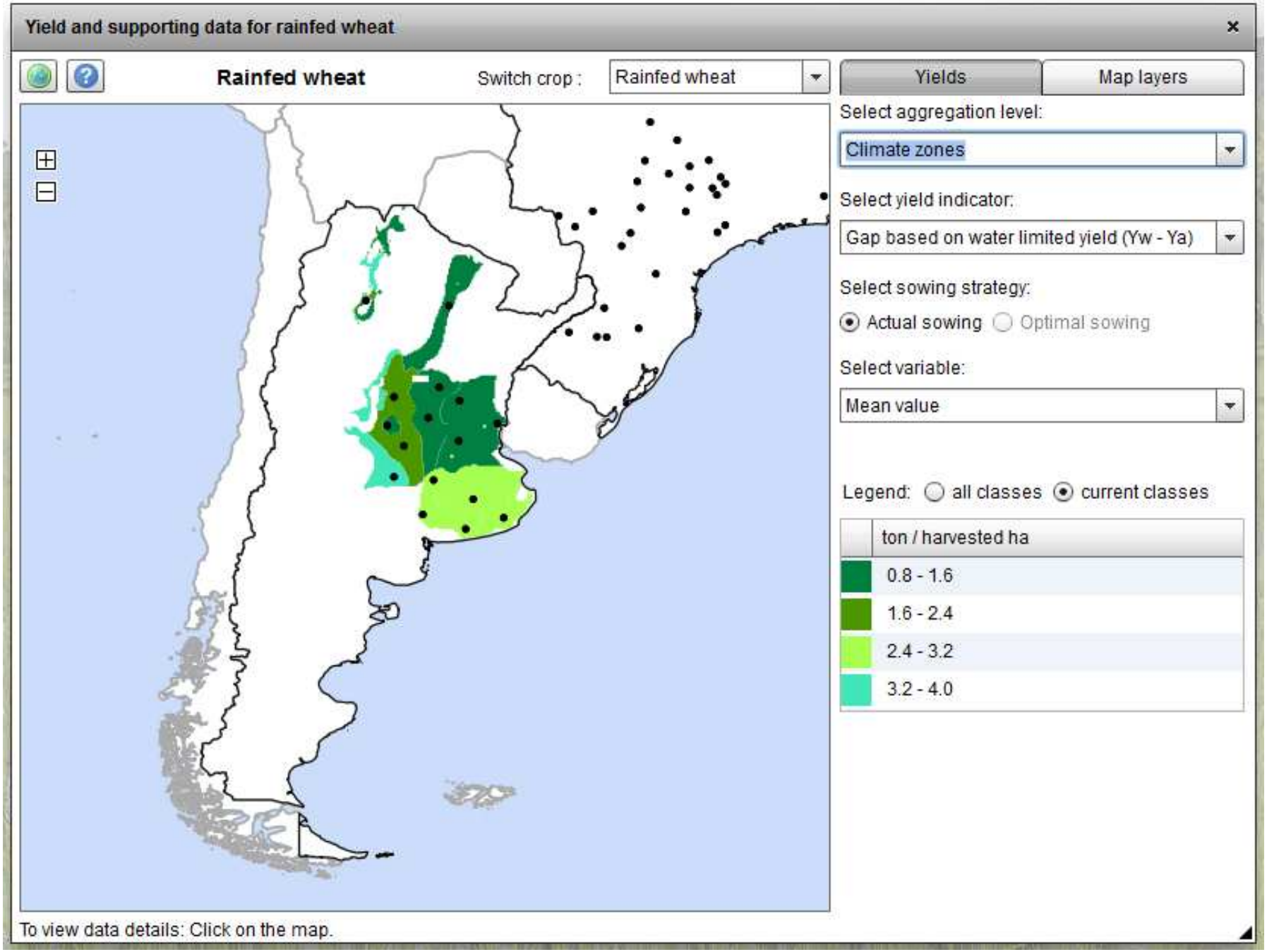
Actual yields - maize



Yield gap - maize



Yield gap - wheat



Yield gaps Argentina (Mg per ha)

	Yw	Ya	Ya/Yw	Yg
Maize	11.7	6.8	58%	4.8
Soybean	3.9	2.7	69%	1.2
Wheat	5.0	3.1	62%	1.9

Monzon et al.

FAUBA Universidad Nacional de Mar del Plata INTAgea

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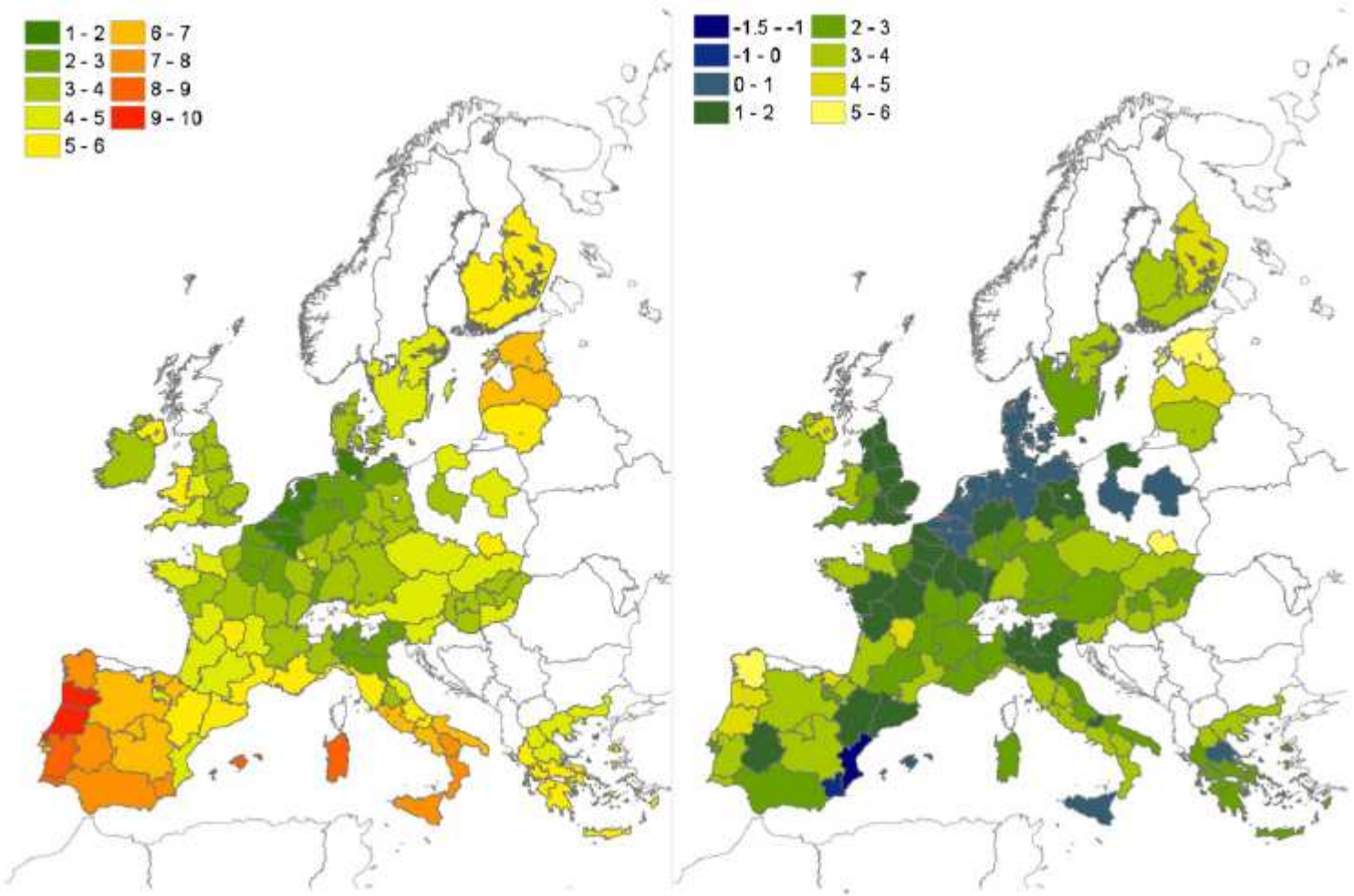
Europe – in progress



Boogaard, Wolf, Supit, Niemeijer, Van Ittersum, 2013.
Field Crops Research.

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Crop yield gap analysis – today

- GYGA and its website (Hugo de Groot et al.)
- Soil data and soil suitability index (Lieven Claessens et al.)
- Weather data (Patricio Grassini et al.)
- Determine and test extrapolation domains for upscaling (Van Bussel et al.)
- Climate change and crop modelling (Senthold Asseng et al.)
- Applications and Food security assessments (Samuel Adjei-Nsiah et al.; Jagadish Timsina et al.; Kazuki Saito et al.; Abdullahi Bala, Justin van Wart et al.)
- Applications in Australia (Zvi Hochman et al.), Argentina (Juan Pablo Monzon et al.), Brazil (Fabio Marin et al.), MENA countries (Haishun Yang et al.)

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Thanks for your attention!

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Bill & Melinda Gates Foundation

University of Nebraska Lincoln

Wageningen University
Wageningen UR

Water for Food
Robert B. Daugherty Institute
University of Nebraska

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Report on Ghana ×

Ghana

View details of Ghana on GYGA website (yieldgap.org)

View FAO stats of Ghana

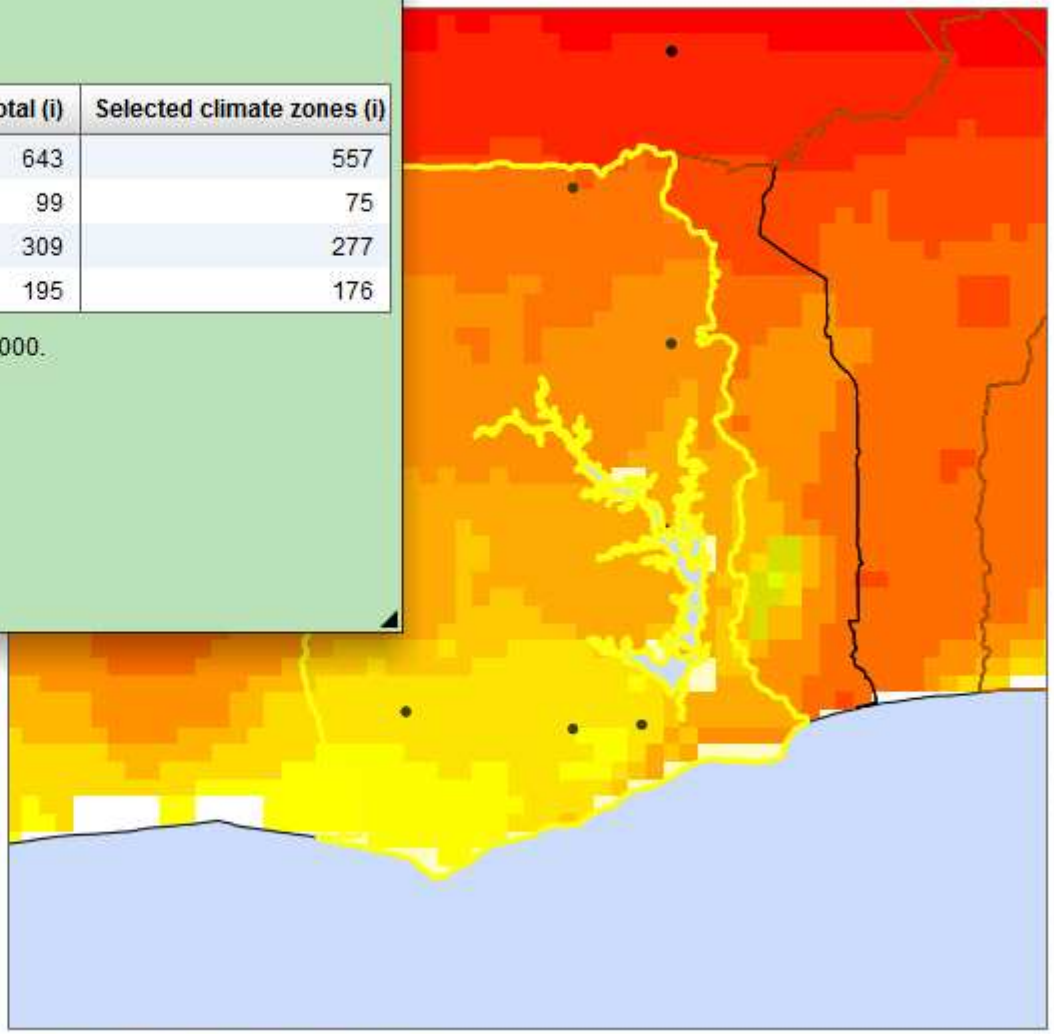
Weather stations
Bolgatanga
Kete-Krachie
Koforidua
Wa
Sefwi- Bekwai
Yendi
Kusi

Crops	Total (i)	Selected climate zones (i)
Maize	643	557
Rice	99	75
Sorghum	309	277
Millet	195	176

(i) Harvested area in ha x 1000.

ed maize

Go to Yield Gap Estimates



To view data details: Click on the map.