Global risk assessment of climate-induced food production shocks: from seasonal scale to the end of this century

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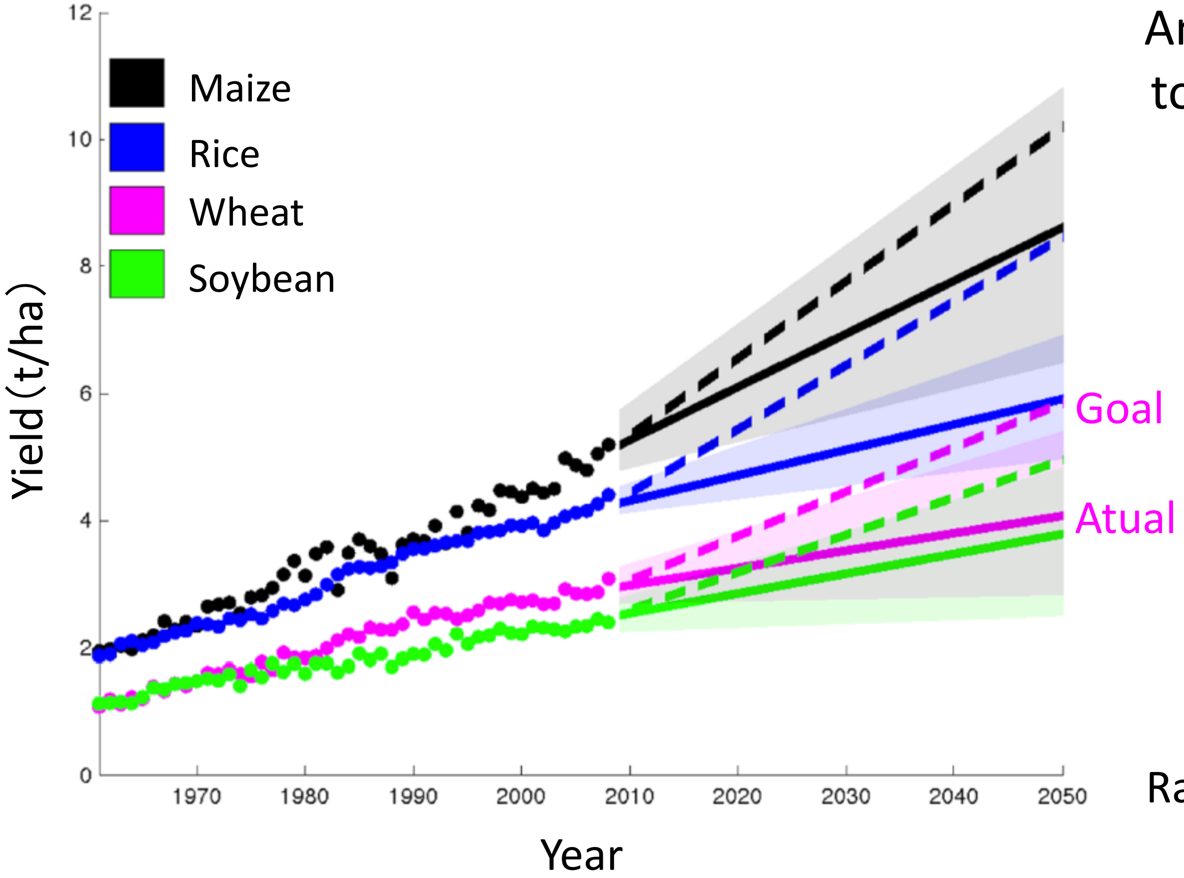
Key findings of GRASP project and next challenges

- Global Risk Assessment toward Stable Production of Food (GRASP):
  - a 5-year project launched April 2011 at NIAES and will end March 2016.
  - aims to develop a methodology and assess the risk of crop production induced by climate change.
  - Key findings
    --Climate change impacts on global production of major crops;
    --Seasonal crop yield prediction as an adaptation technology
  - Next challenges

Feeding 9+ billion by 2050 under changing climate



Annual rate of increase in yield to double food supply without the expansion of cropland

Goal：2.4%/year

Actual rate in 1989-2008：

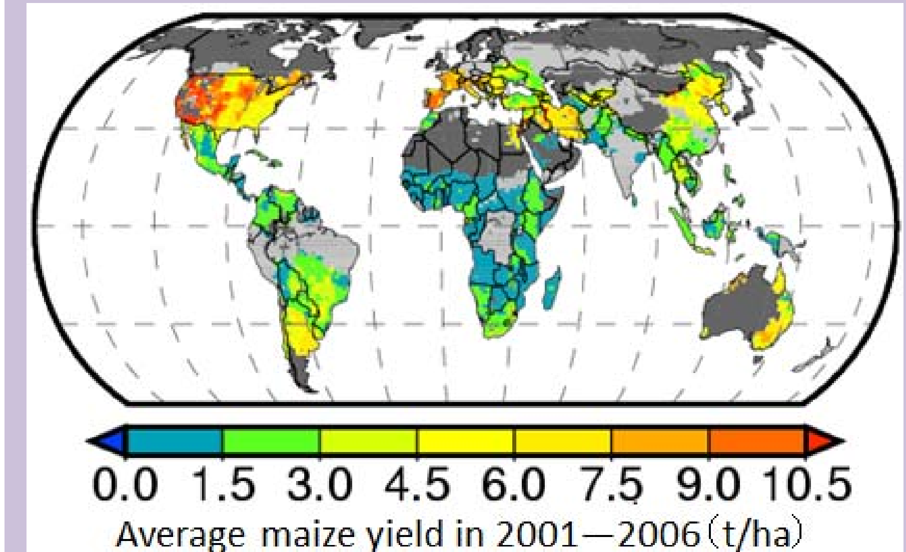
0.9～1.6%/year

Ray et al. (2013) *PLOS ONE*

Global demands for food, feed and biofuels is expected to double by 2050, relative to 2005. How will global crop production transit in response to projected changes in climate and socioeconomy?

Model calibration

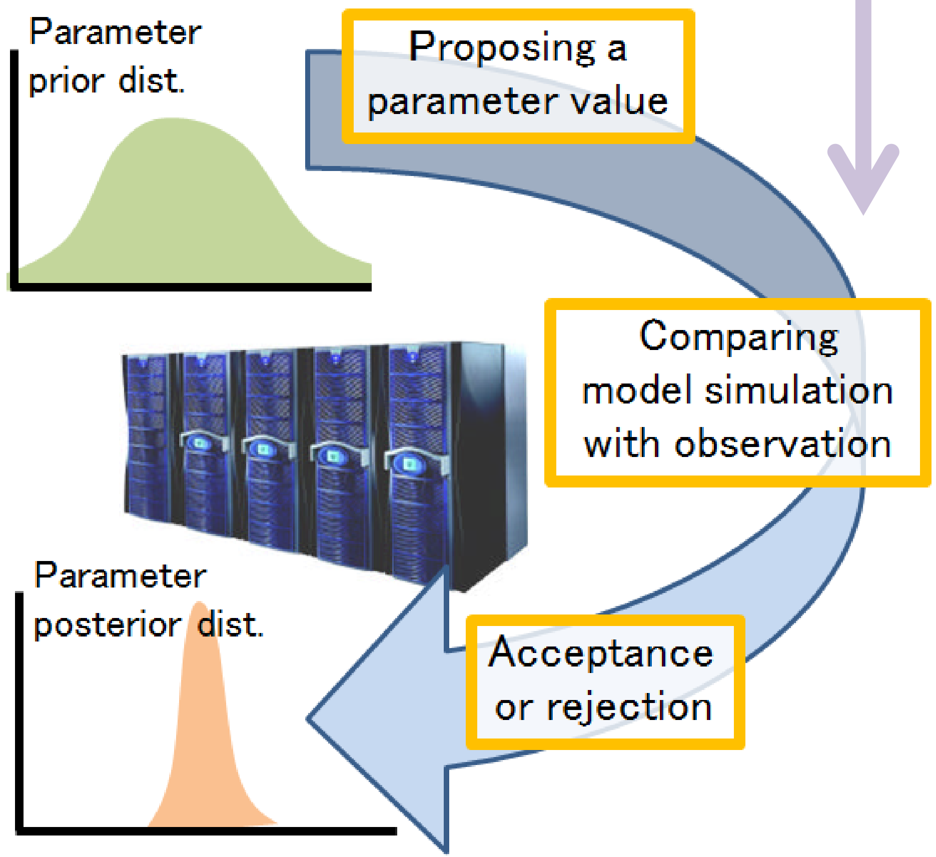
Global data set of historical yields



Iizumi et al., (2014) *Global Ecology & Biogeography*

Grid-cell calibrated
PRYSBI-2 global crop model

Bayesian calibration
with cross-validation technique



With HPC support by JAMSTEC

Scenarios: GHG emission & climate

- 4 Representative Concentration Pathways (RCPs):
  2.6, 4.5, 6.0 & 8.5 W m^{-2}
- 5 Global Climate Model (GCMs) outputs (bias-corrected):
  GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM & NorESM1-M

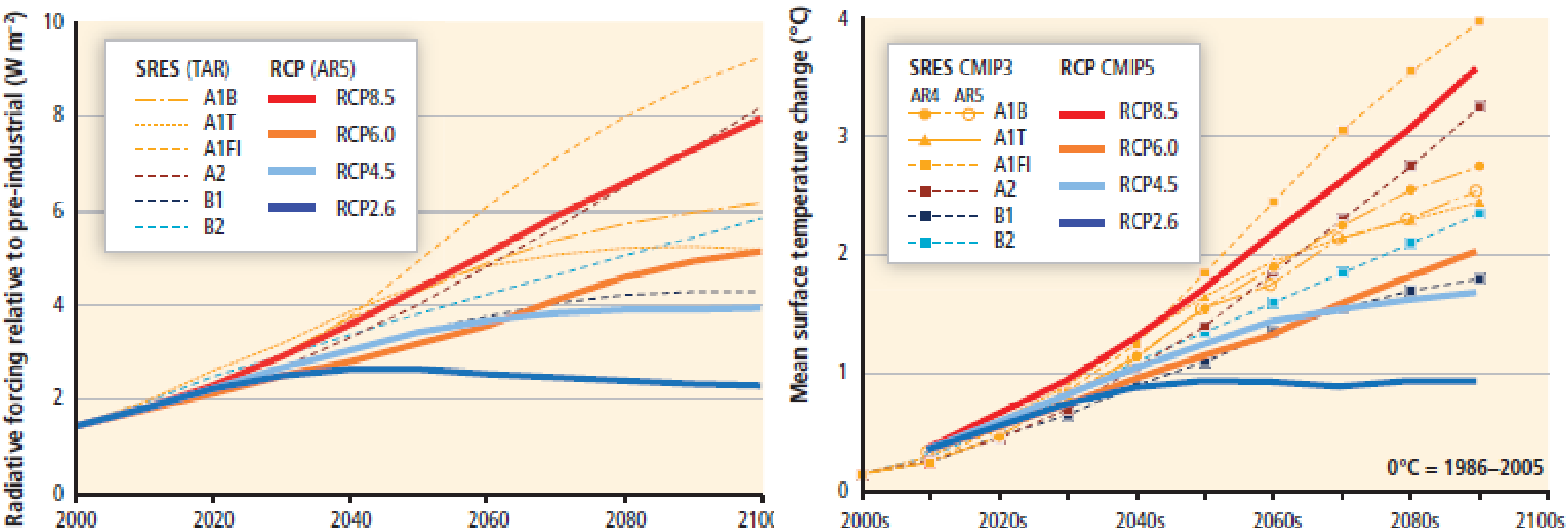
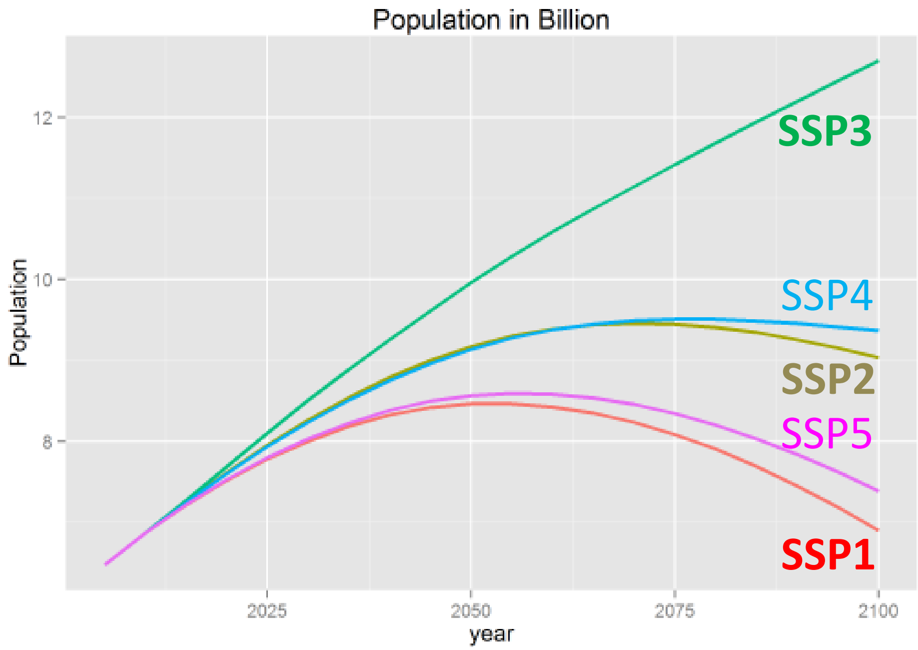
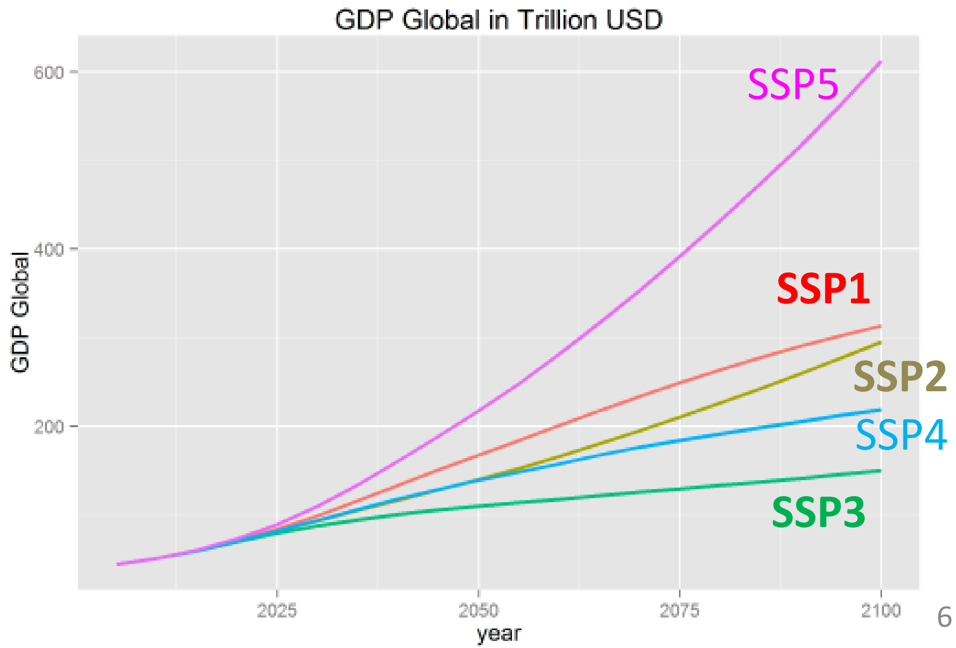


Figure 1.4 of IPCC WGII Part A (2014)

Scenarios: socioeconomy

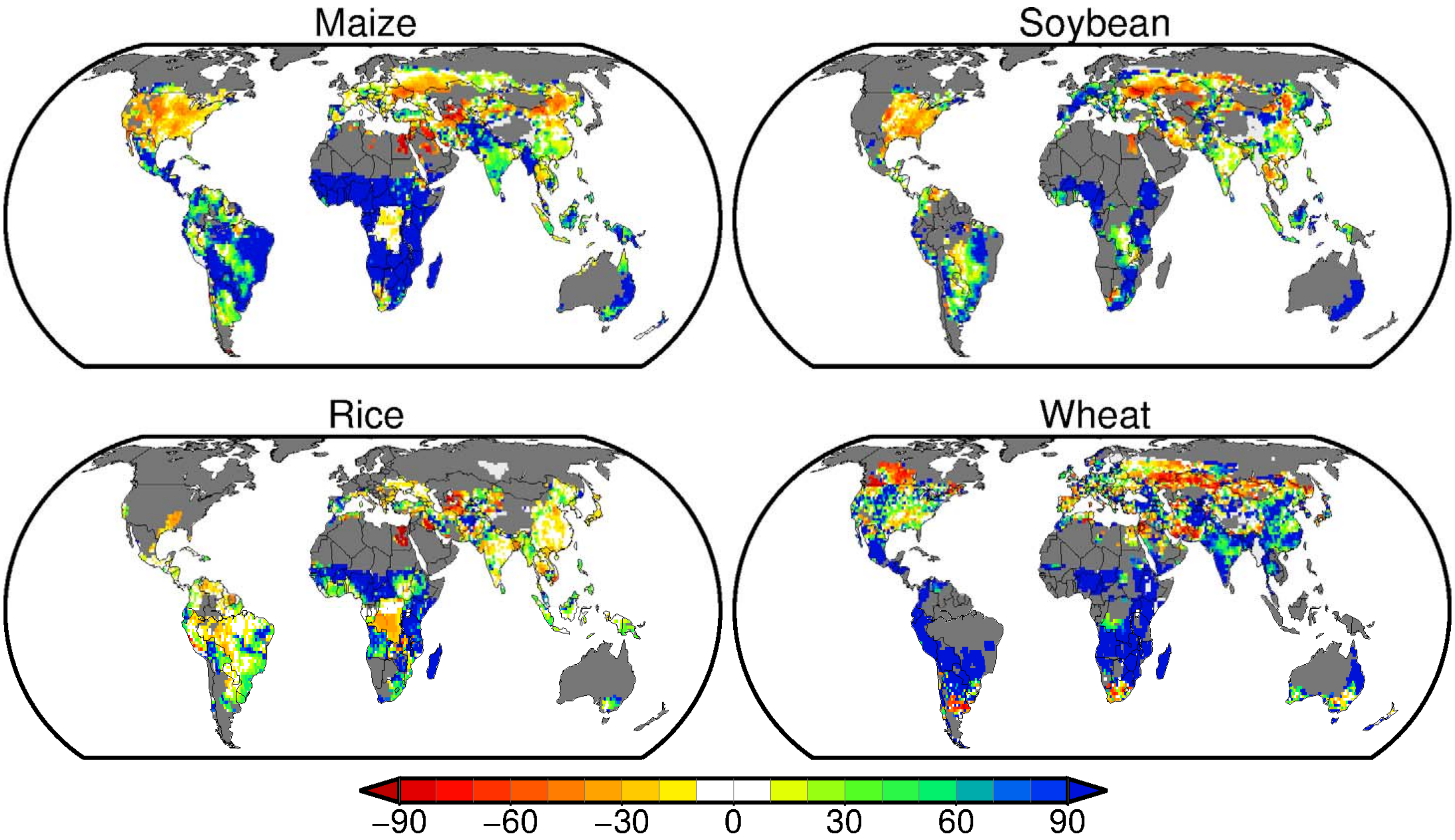
- 3 Shared Socioeconomic Pathways (SSPs): 1, 2 & 3
- SSP-based land-use map: NIES





http://doc.witchmodel.org/ssp_implementation

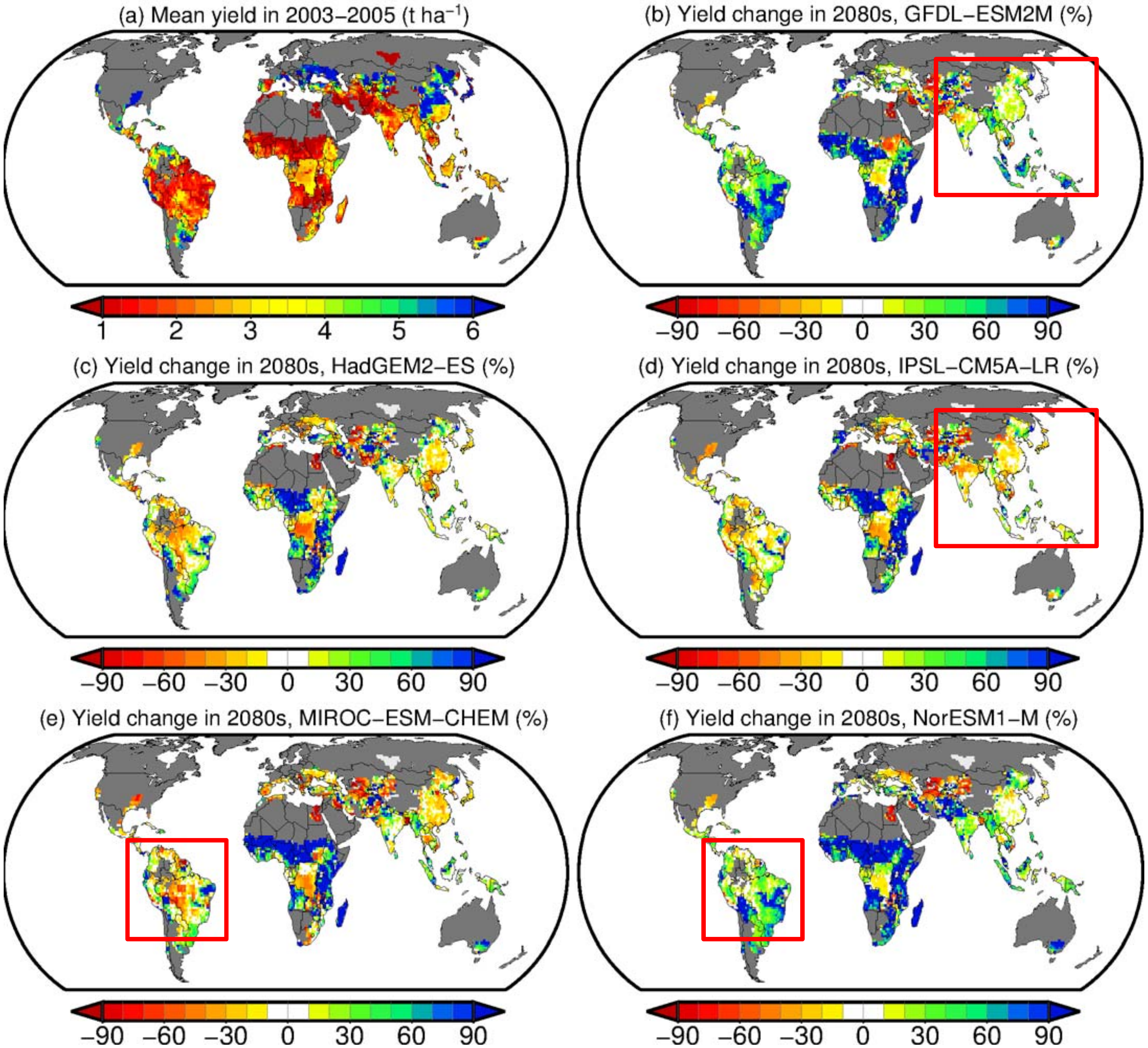
Projected yield change in 2080s



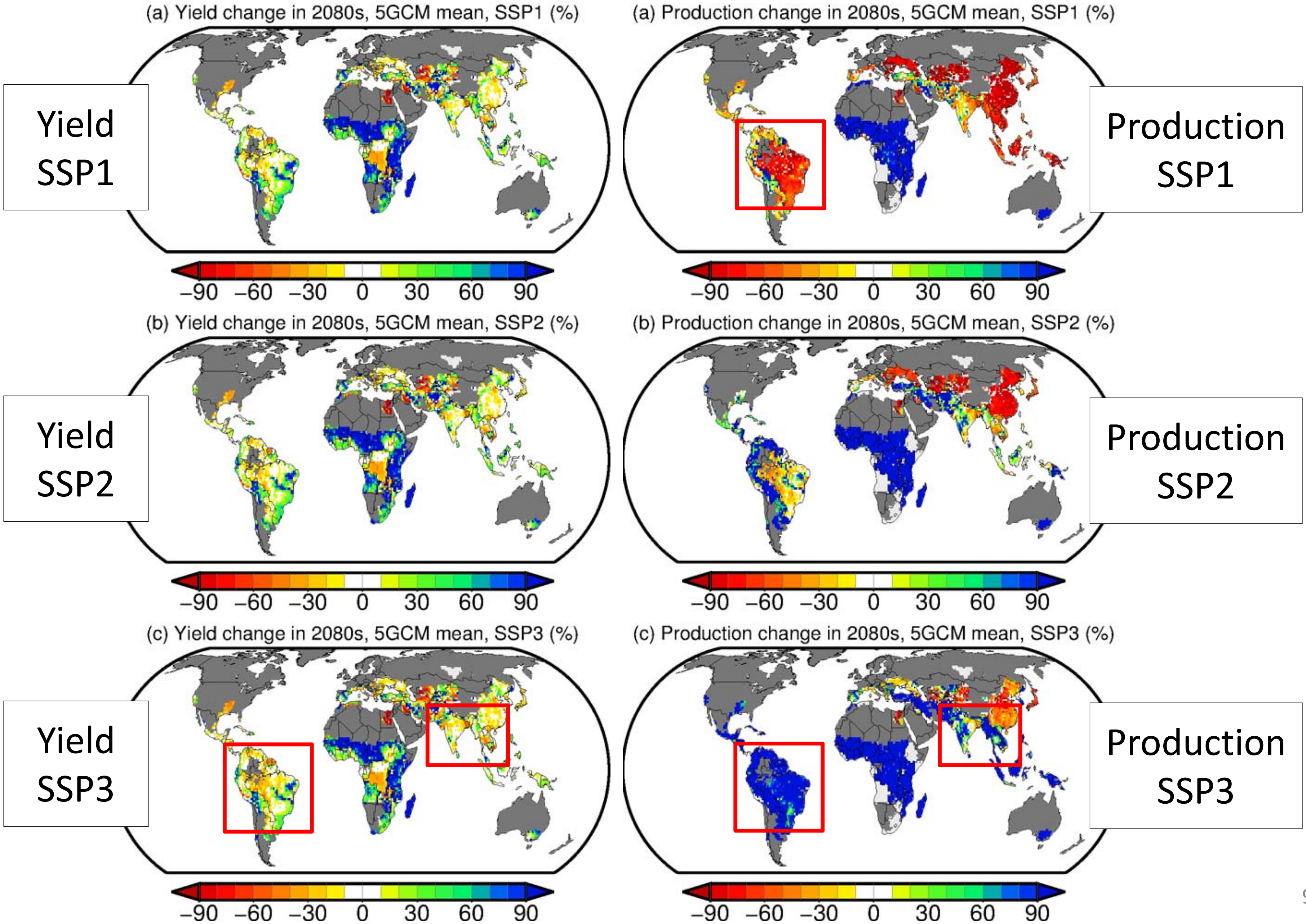
Simulated mean yield change in 2070-2099 relative to 2003-2005
under RCP8.5/5GCMs/SSP2 scenario (%)

Uncertainty in rice yield impact associated with GCMs

RCP8.5
SSP2



SSP-induced uncertainty in rice yield and production

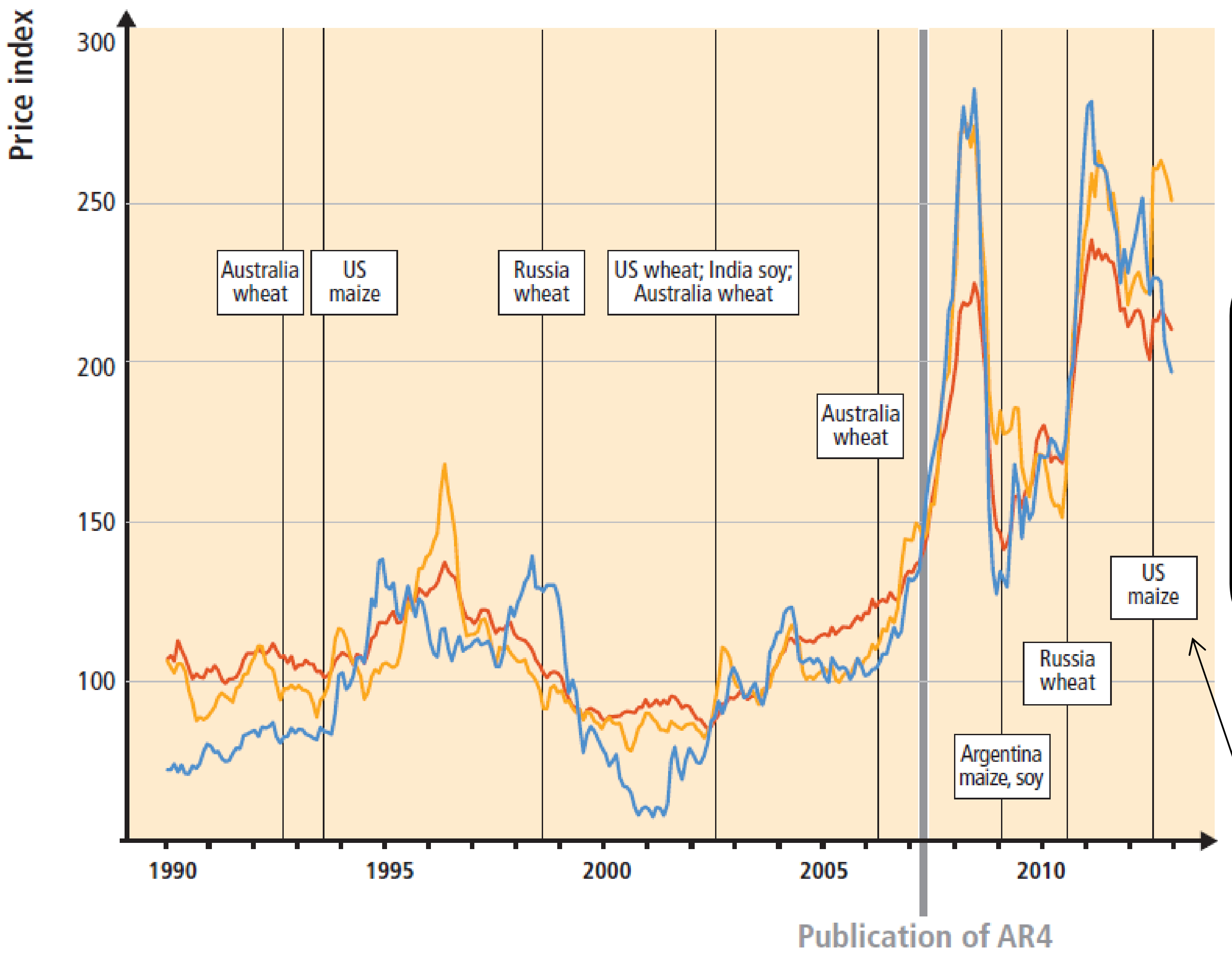


Remarks

- Projected global yield growth would be insufficient to double food supply by 2050, suggesting a substantial need for adaptation, cropland expansion and investment for high-yielding technology in coming decades to meet supply goal.
- This challenge should accompany with mitigation efforts. Both challenges have to be achieved under limited funding, suggesting the need to compare adaptation and mitigation costs.
- Yield change is an important factor to determine production impact. However, future socioeconomic scenario and resulting cropland scenario emerged as the key sources of uncertainty in production impact in some developing countries.

Recent food price spikes & climate extremes

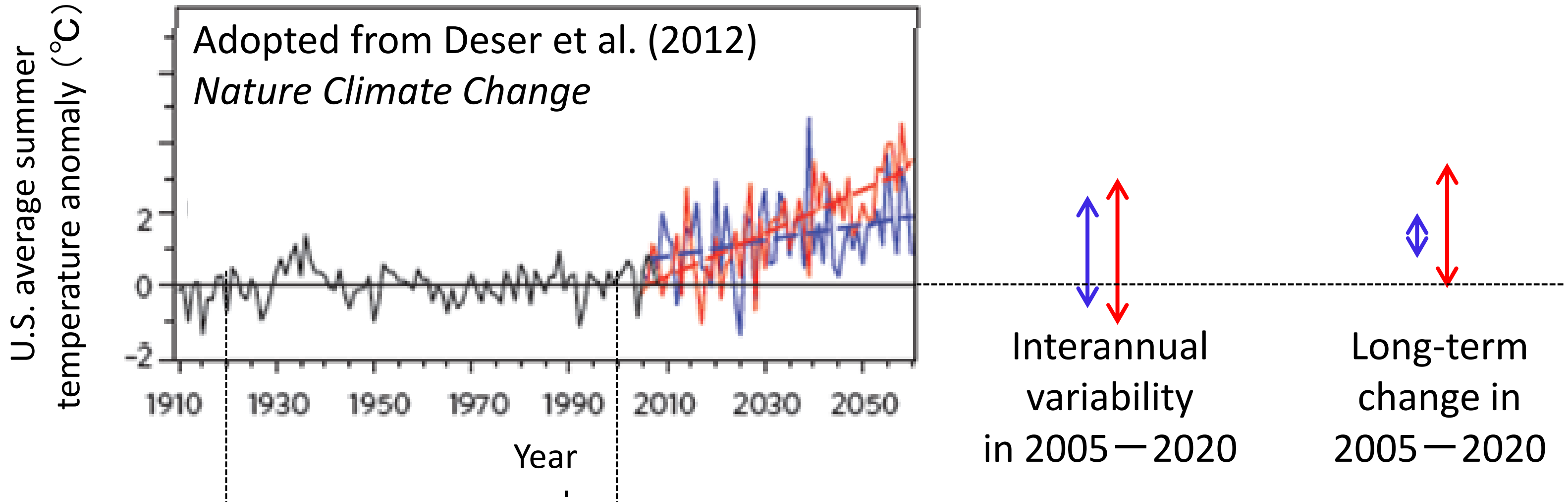
IPCC WG2 AR5 (2014)

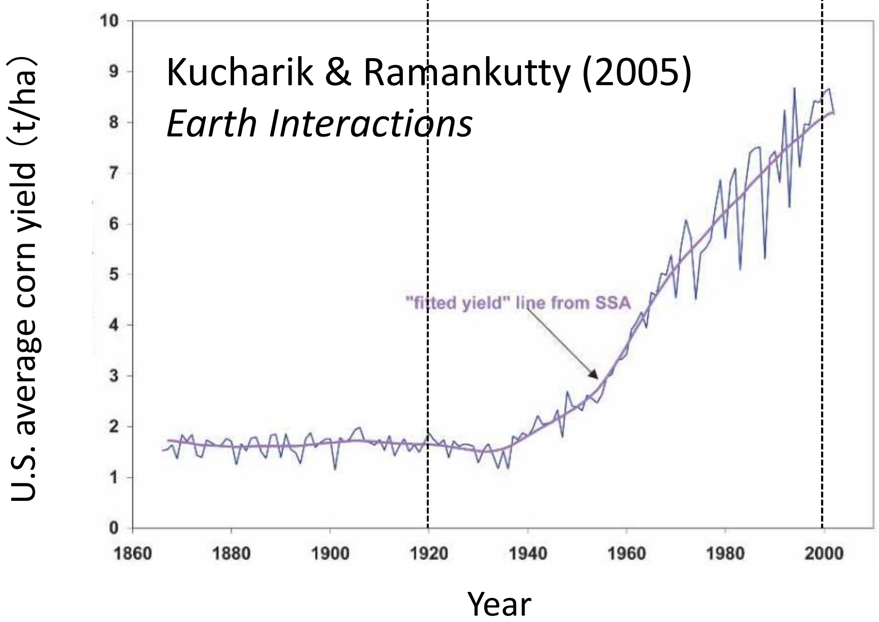


OXFAM Canada (2013)

Events when a top five producer of a crop had yields 25% below trend line

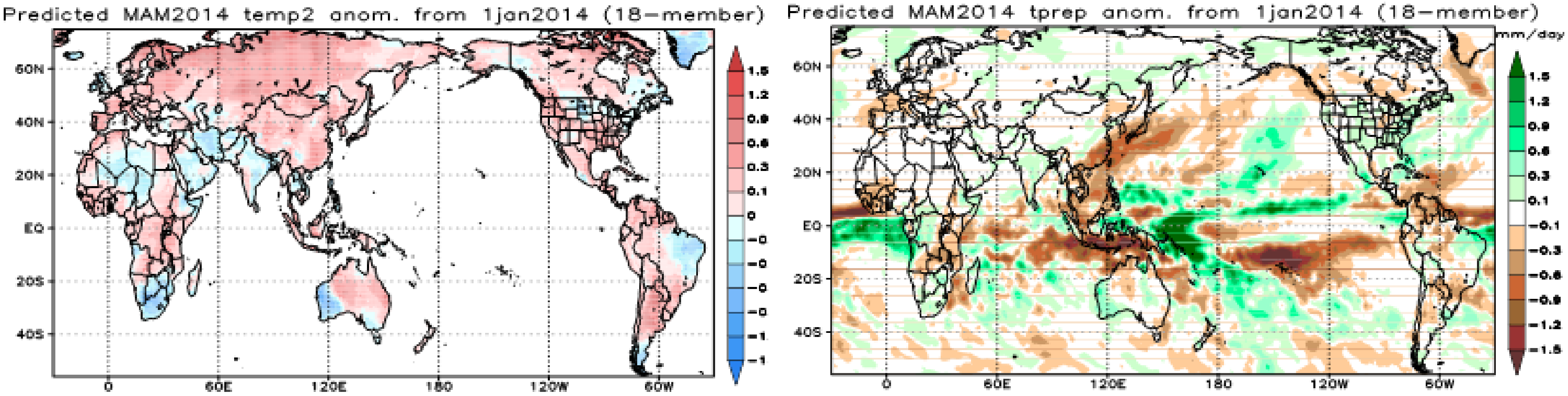
Climate variability as the test bed of adaptation



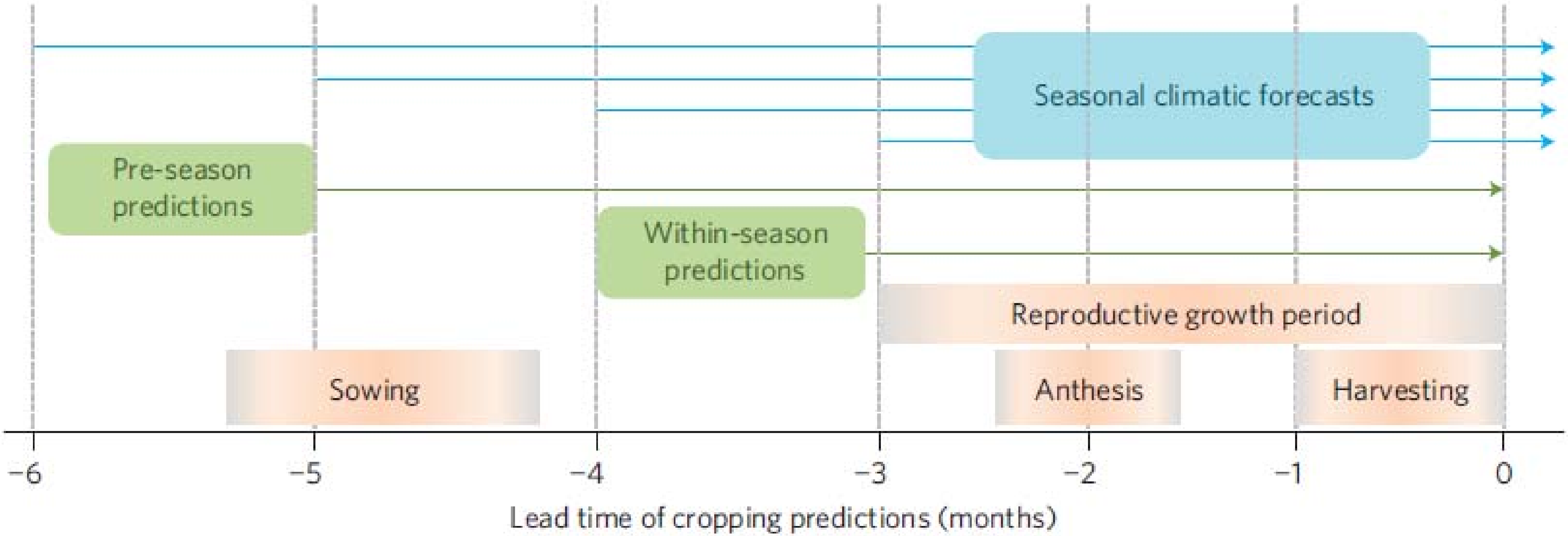


- The amplitude of interannual T variability is larger than long-term T change.
- Responding better to seasonal climate-induced supply shocks will increase human's capability to adapt climate change by up to the middle of this century.

Seasonal climate forecast as an adaptation measure

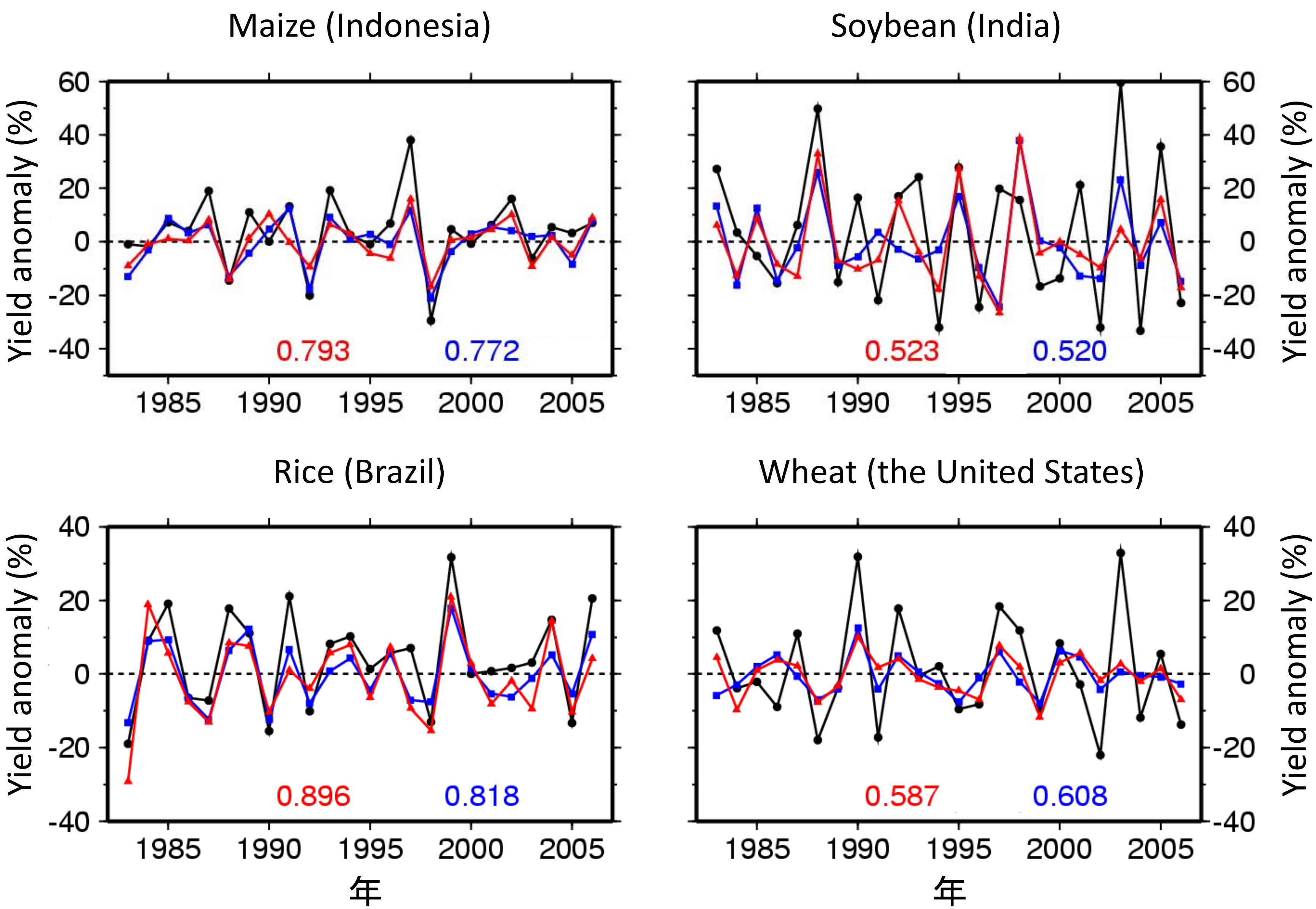


Provided by JAMSTEC/APL



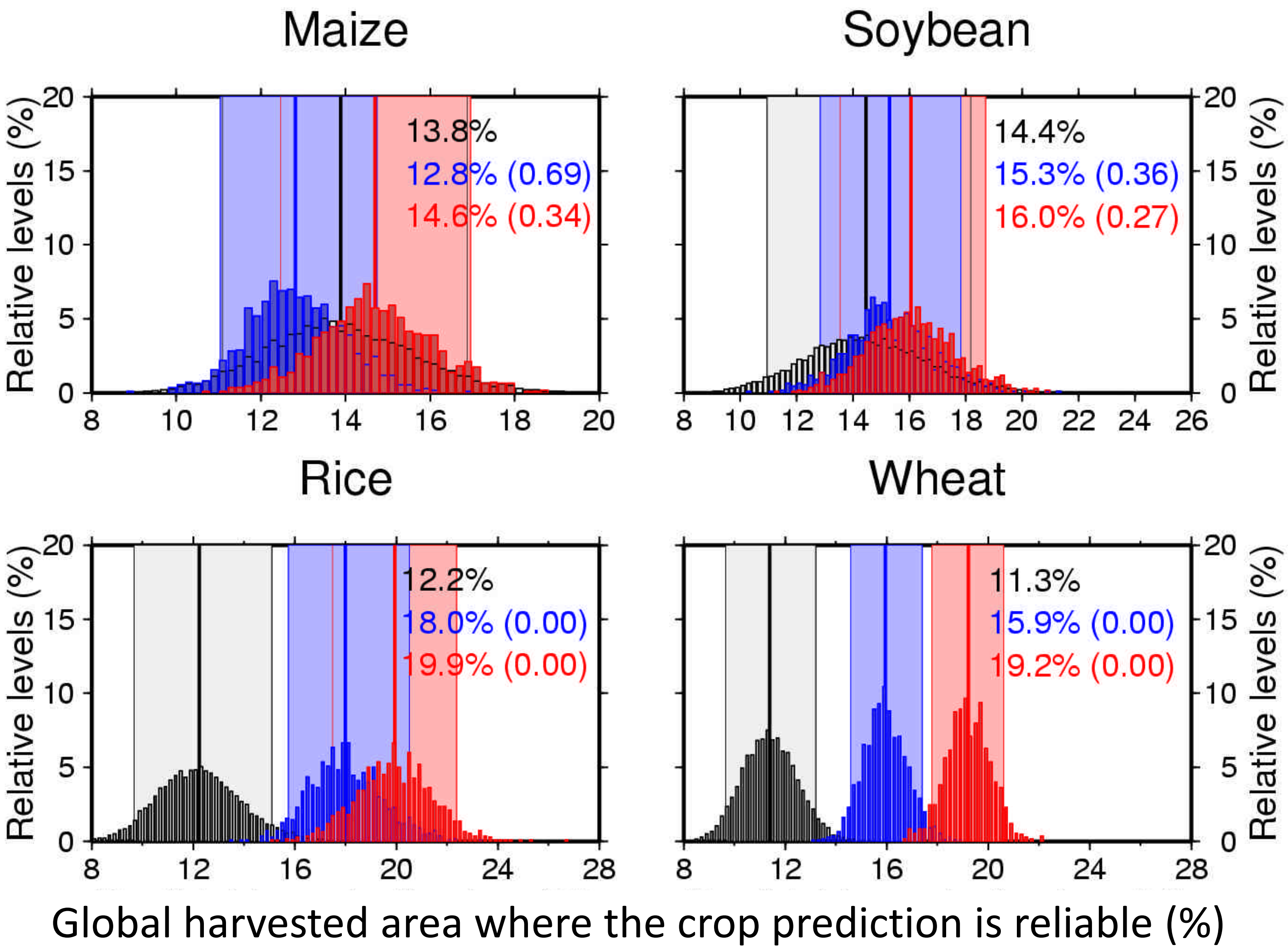
Iizumi et al., (2013) *Nature Climate Change*

Yield prediction using temp. and soil moist. forecasts



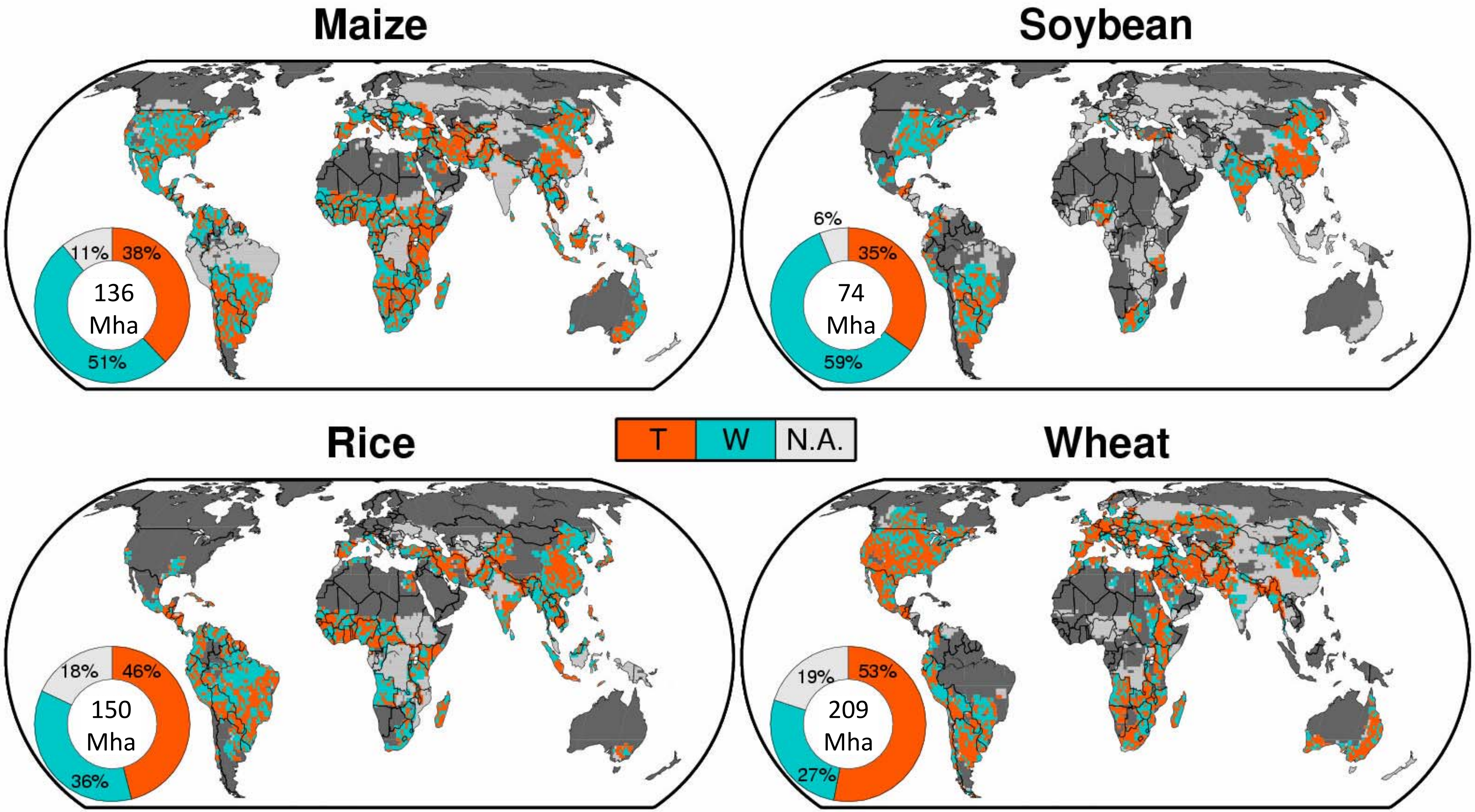
Reference/Within-season prediction/Pre-season prediction

Crop prediction at 3 months before the harvest could be reliable in about 15—20% of the harvested area



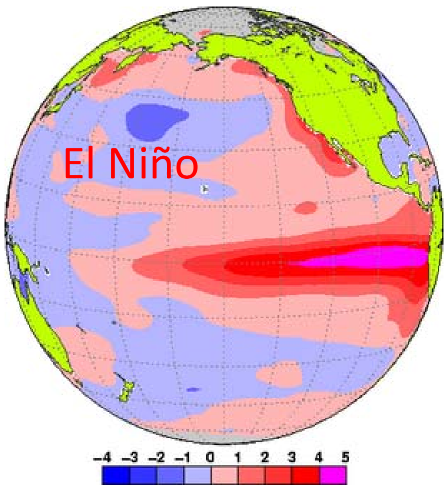
Random/3-month lead/5-month lead

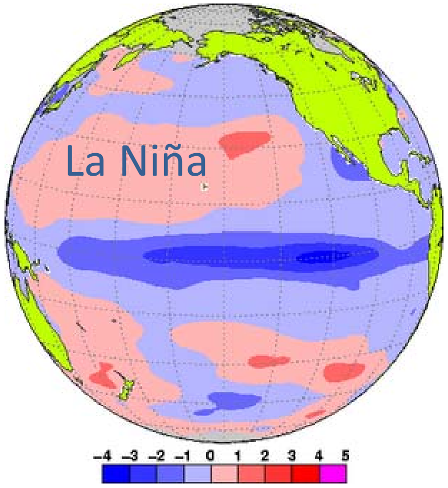
Implications for more targeted adaptation

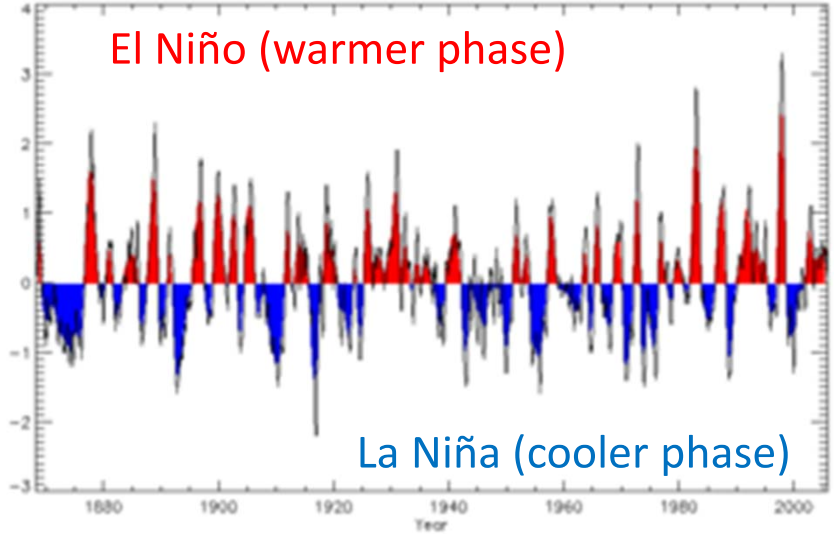


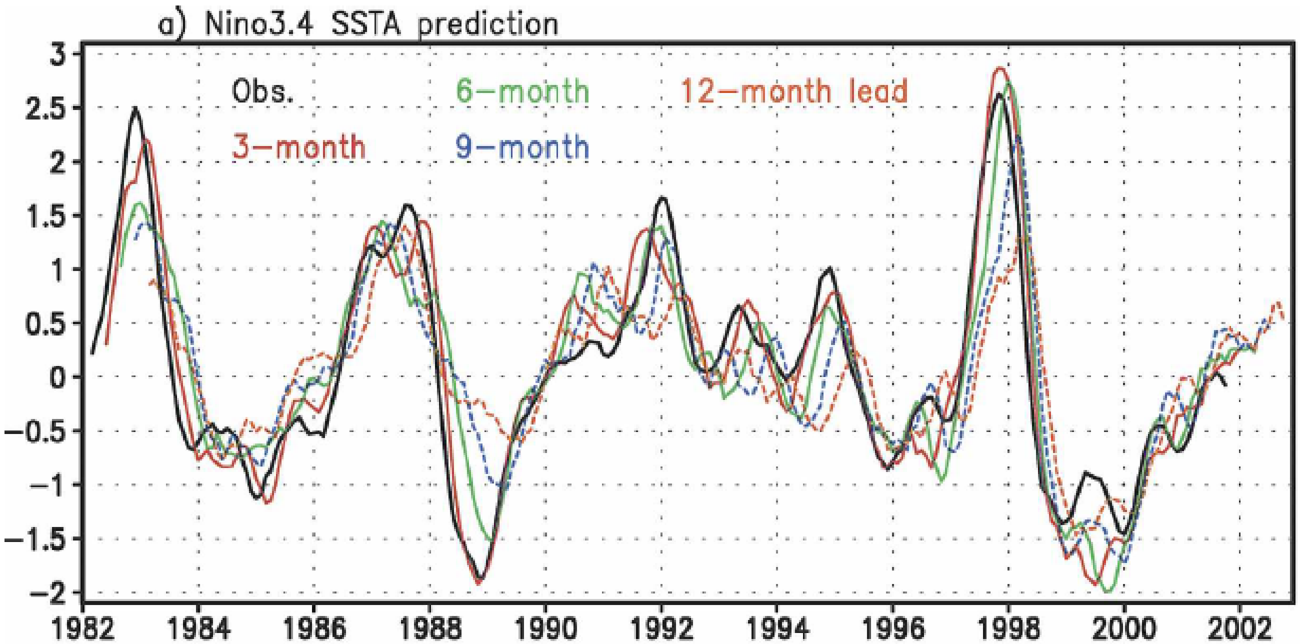
Temperature-sensitive / Soil moisture-sensitive

El Niño Southern Oscillation (ENSO) and predictability





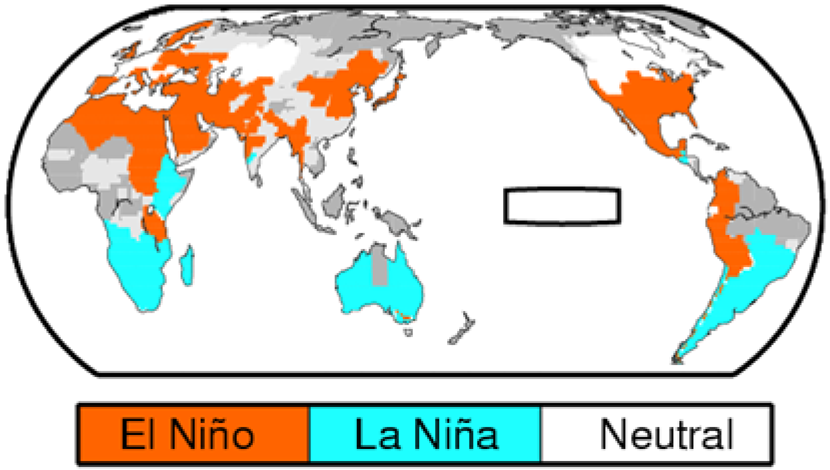


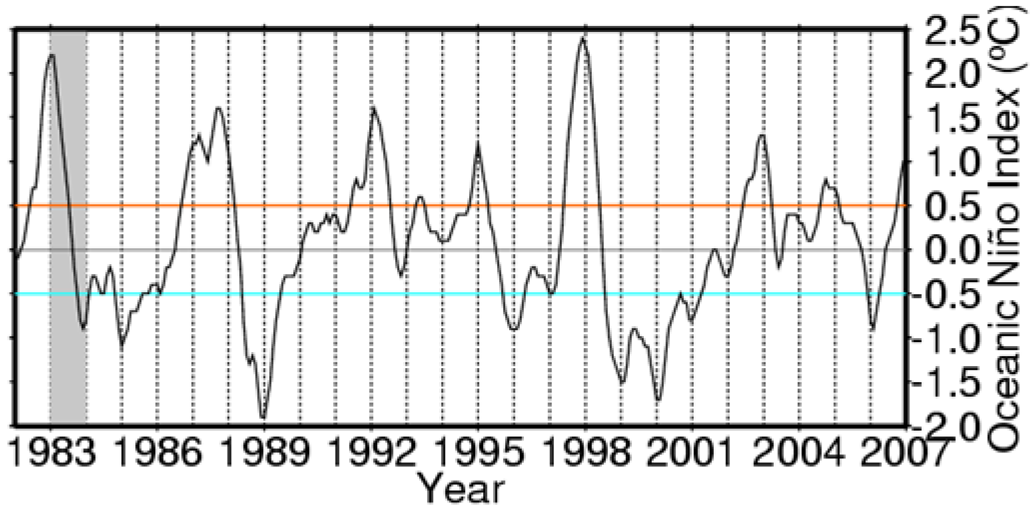


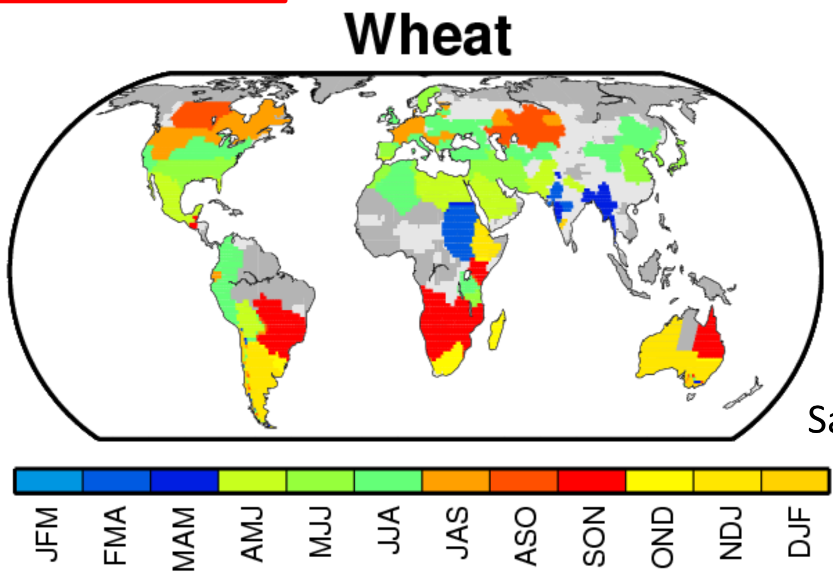
Luo et al. (2005; 2008) *Journal of Climate*

Linking crop yields with ENSO phase

ENSO phases for wheat harvested in1983



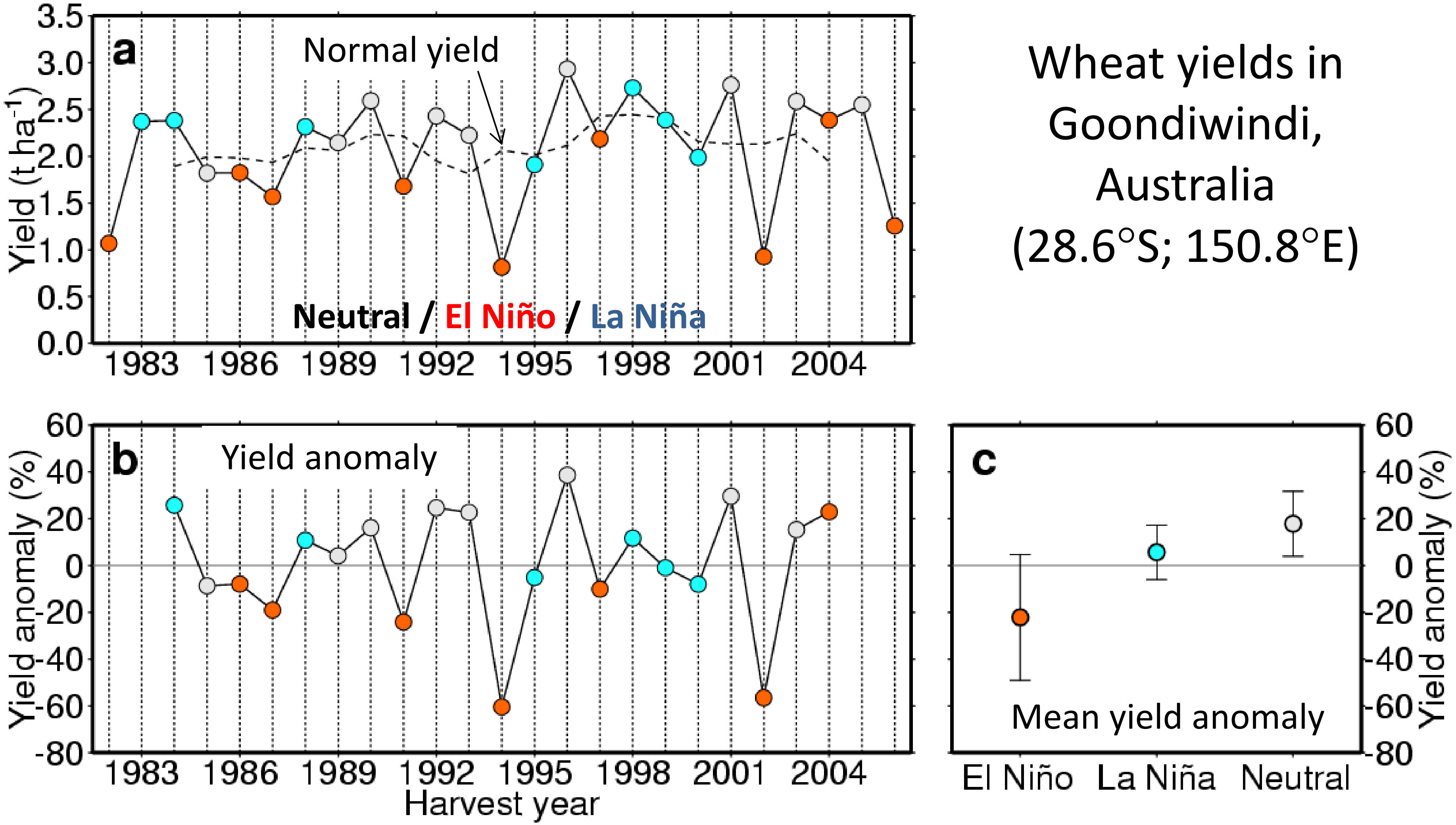




Reproductive growth period

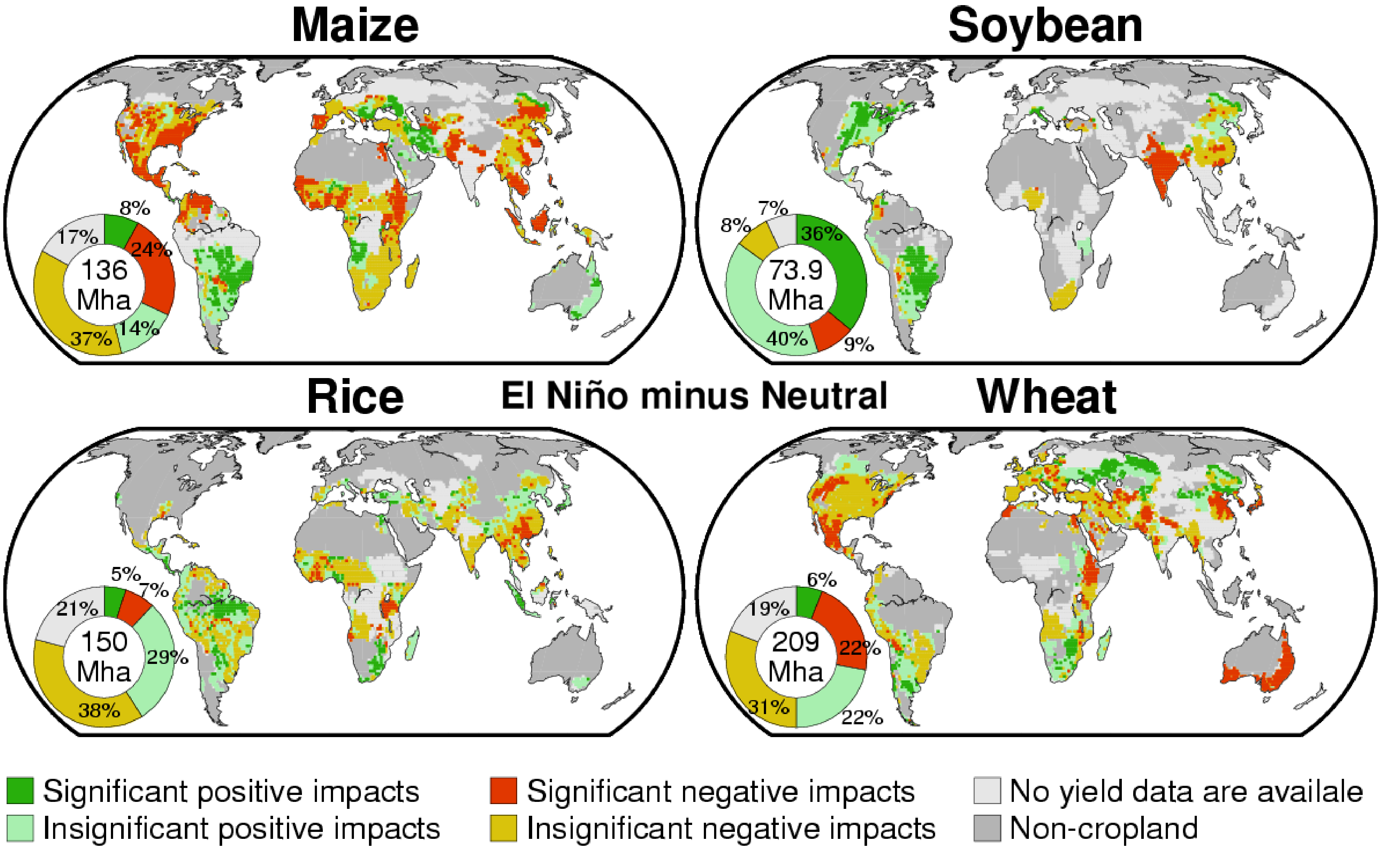
Sacks et al. (2010) *GEB*

An example of detecting the ENSO impacts on yields



Wheat yields in Goondiwindi, Australia (28.6°S; 150.8°E)

Significant impacts could be found in high latitudes



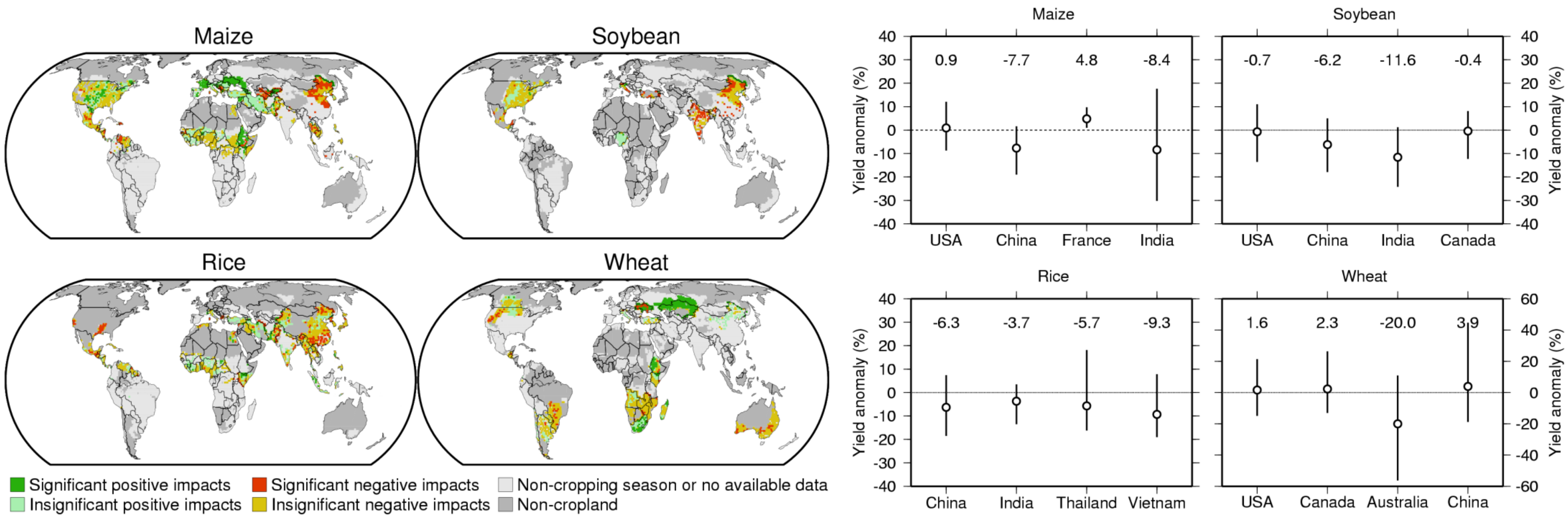
Iizumi et al. (2014) *Nature Communications*

Informing food agency about possible supply shocks

- 2014 summer-fall El Nino was expected in June 2014.
- Prediction of 2014-fall yield was released in July 31, 2014 (with +1 to +6 months lead) via the *Monthly Oversea Food Demand & Supply Report* of MAFF.

  http://www.maff.go.jp/j/zyukyu/jki/j_rep/monthly/201407/pdf/21_monthly_topics_1.pdf (in Japanese)

- This is the first attempt to inform national food agency based on seasonal crop forecasts, but not yet on an operational basis



Remarks

- Climate variability and resulting food production/supply shocks offers the best test bed for societies to test and improve adaptation practices to climate change.

- Yield prediction information, based on seasonal climate forecasts, is an emerging large-scale adaptation technology. Challenges for social implementation of the technology has just started.

Next challenges

- Improving our understanding on climate impacts on cropping area, intensity (number of annual harvests) and yield is necessary to lead to a more completed picture of future food production.
- Estimating and comparing adaptation costs with mitigation costs aid to lead to more efficient goals.
- Social implementation of seasonal crop prediction, which works as climate change adaptation, will lead to various research needs by application.
- Given climate change, globalization of food trade, and the increasing importance of food imports to maintain national food balance in many countries, multicountry-to-global scale studies (and hence relevant data sets) are crucial for these challenges.

Thank you