Impacts of climate change on rice production in China

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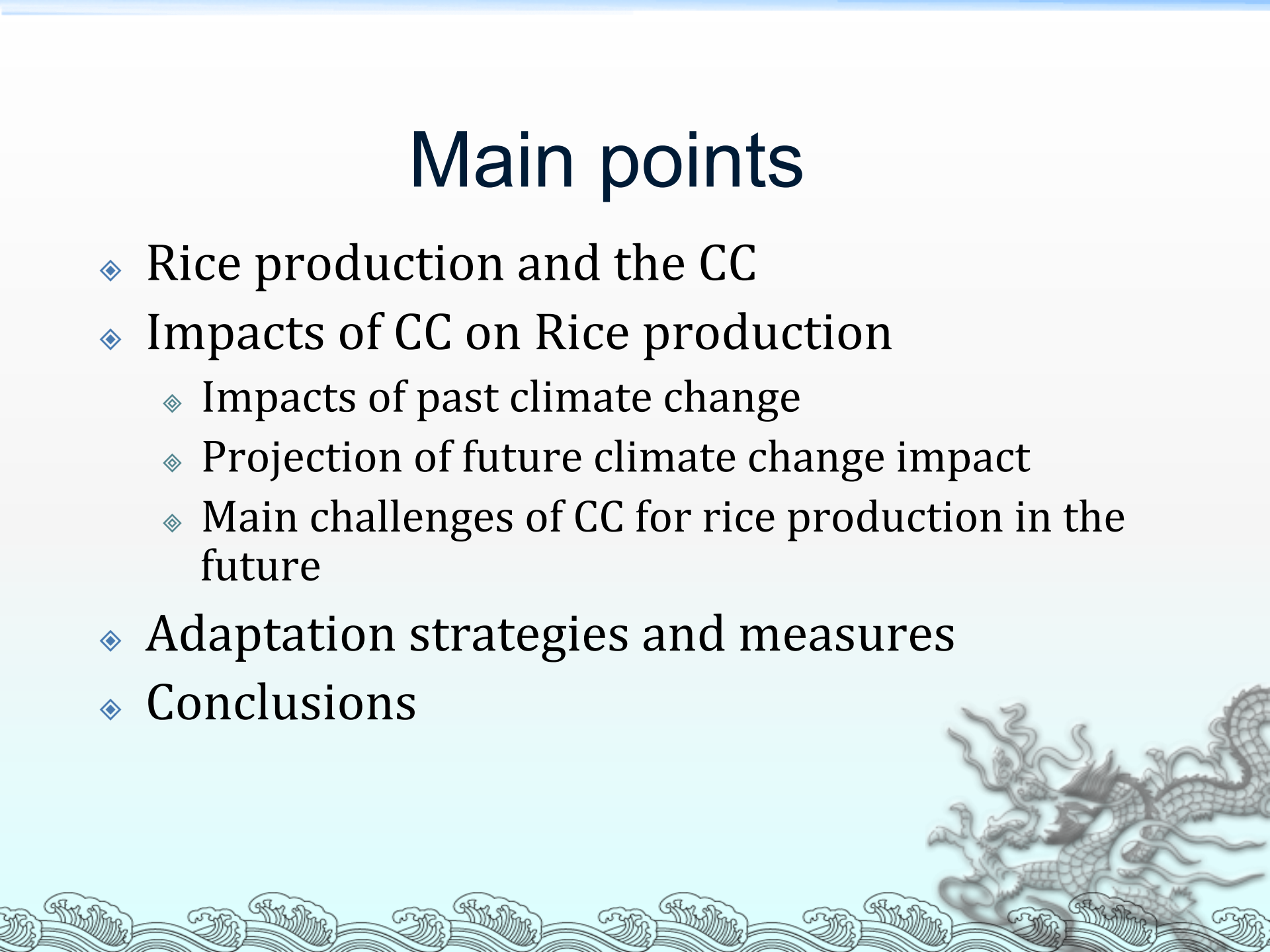
Main points

- Rice production and the CC
- Impacts of CC on Rice production
  - Impacts of past climate change
  - Projection of future climate change impact
  - Main challenges of CC for rice production in the future
- Adaptation strategies and measures
- Conclusions



Part 1: Rice production and the Climate Change

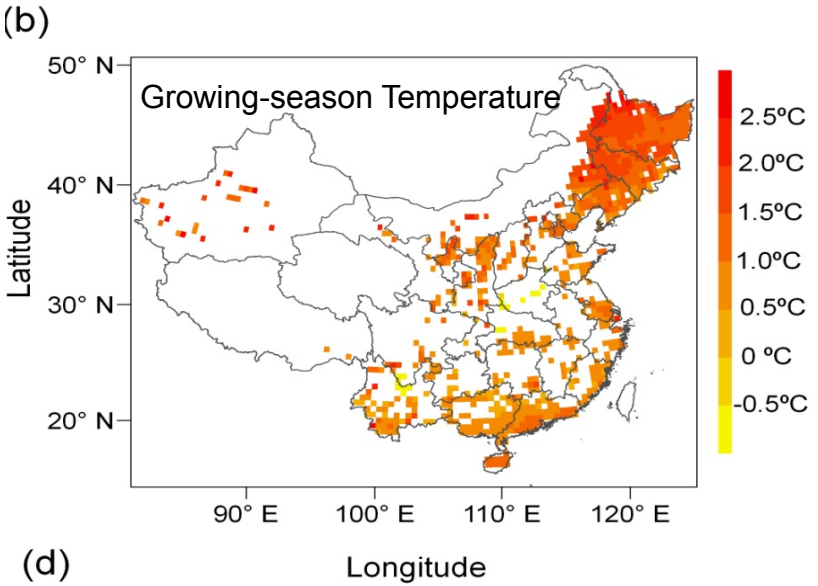
Rice production in China

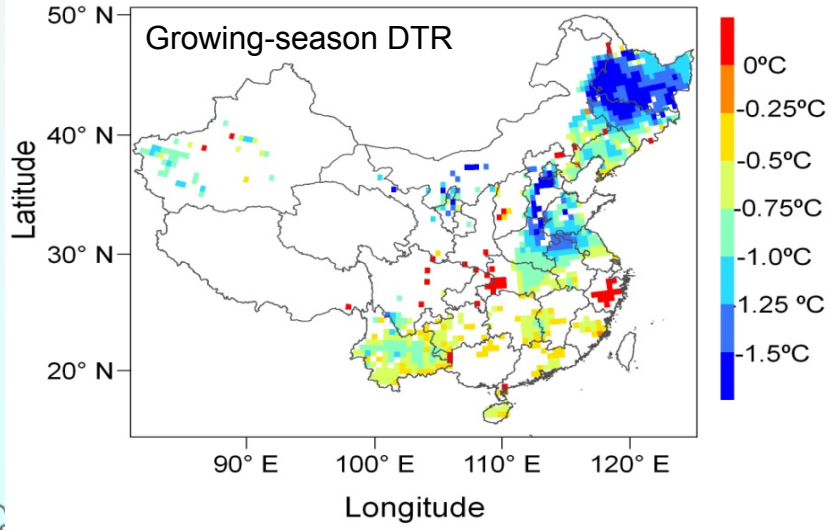
- Rice is an essential component of the diet in more than half the world's population, and it is the most socially and economically important crop in China;
- China is the world’s top producer and consumer of rice. It produces and consumes a third of the world’s rice, about 200 million tons a year.
- Rice yields in China increased dramatically with the introduction of high-yield dwarf rice. These scientifically-bred have been so successful that farmers have been able to raise more rice on less land.

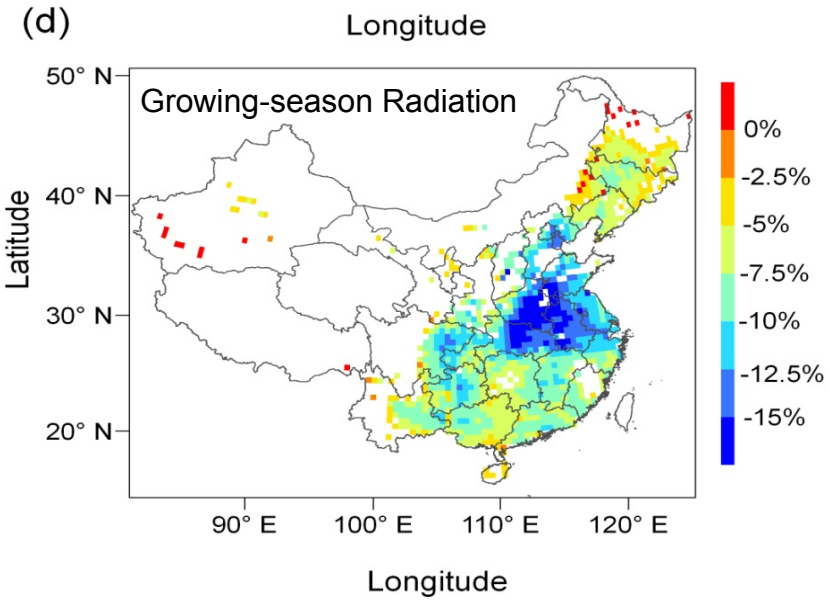
China’s rice output came from four different crops. The early rice crop grows primarily in provinces along the Yangtze River and in provinces in the south (34%), Intermediate and single-crop late rice grows in the southwest and along the Yangtze River(34%), Double-crop late rice (25%), and rice grown in the north (7%).

The climate change in rice area

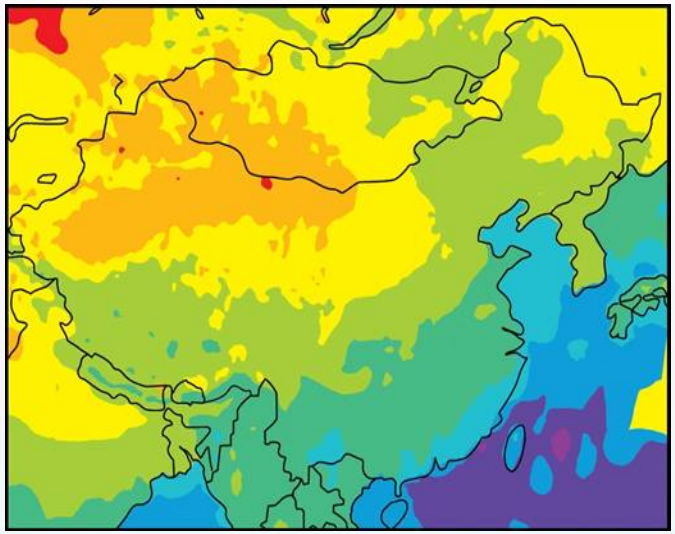
The temperature increased by 1.0 ℃ since 1960s, less than the increase of annual temperature, with larger in the NE and smaller in the south. No significant change in precipitation for the majority of rice area. Substantial decreases in Diurnal Temperature Range and growing-season radiation were also observed.

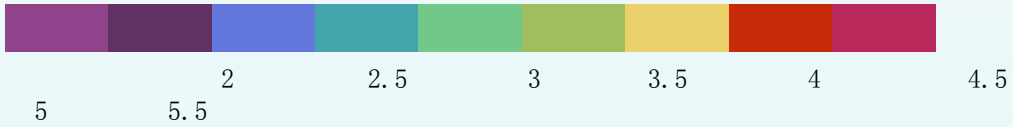






The trend of future climate change





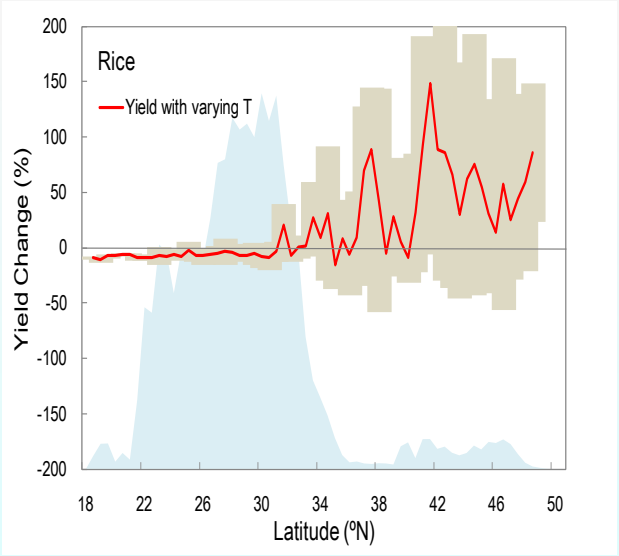
Climate Change Scenarios

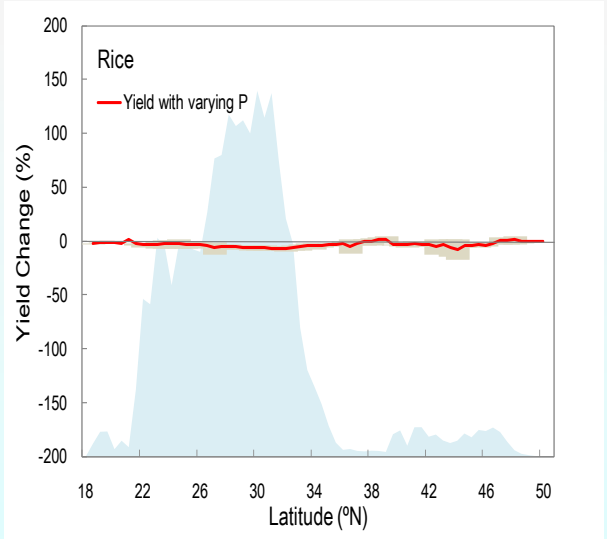
Temperature to increase by 3~4℃ and rainfall to increase 10~12% by 2080s

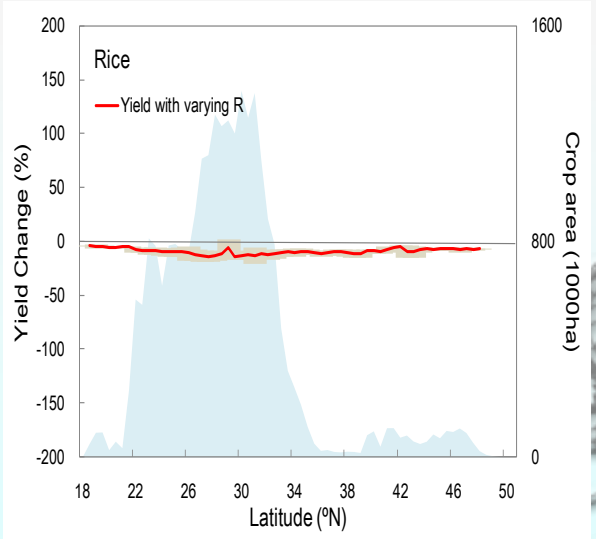
Part 2: Impacts of CC on rice production

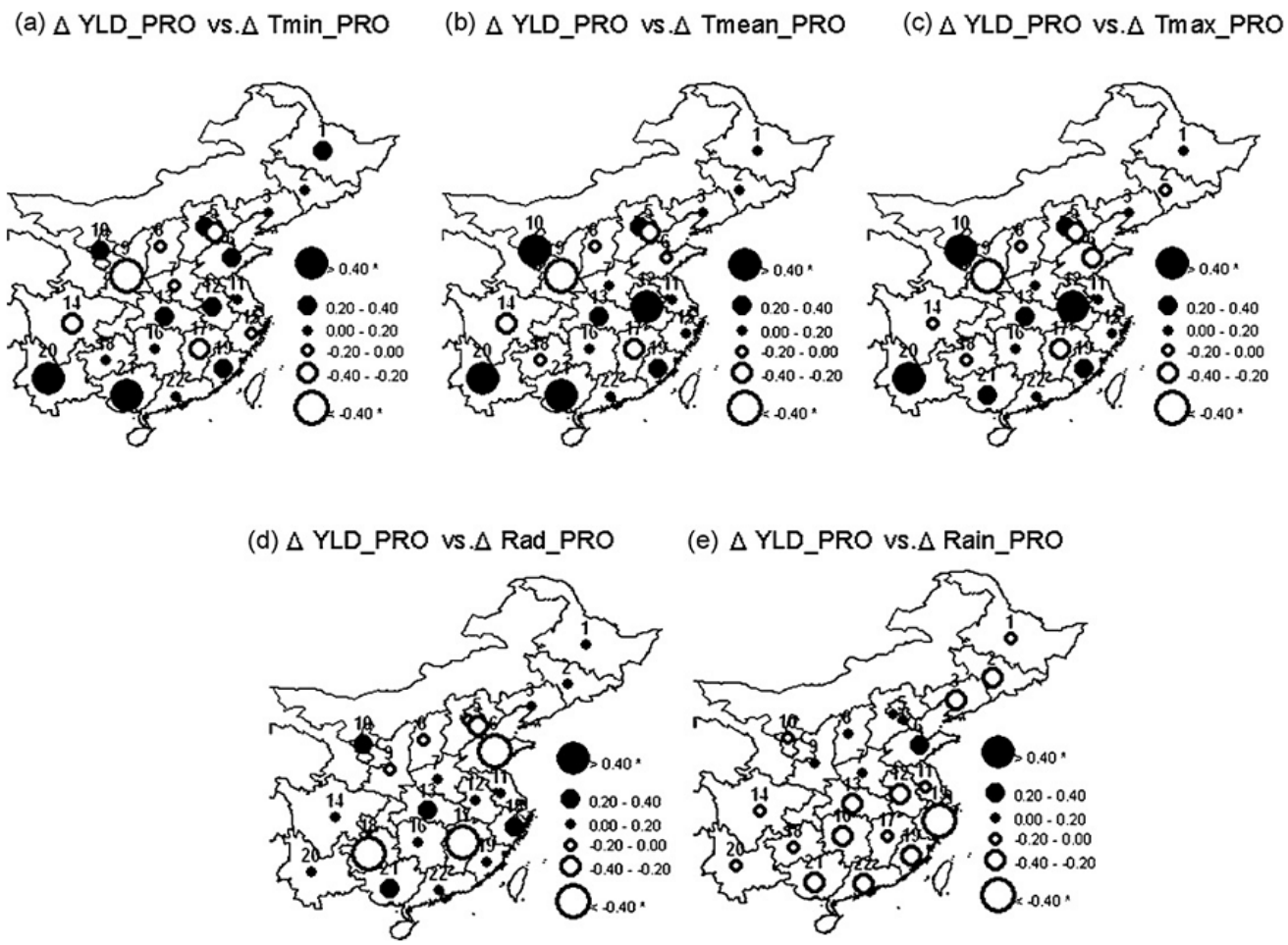
Impacts of past climate change

- Yield: A comprehensive simulation research revealed that past climate change since 1960s decreased rice yield by 12.4%, but with largest contribution coming from dimming radiation. The warming effect is less obvious because the effects in individual regions (positive in north China and negative in south China) are cancelled out when averaged over latitude. (Xiong et al. 2012, *Environmental Research Letter*)





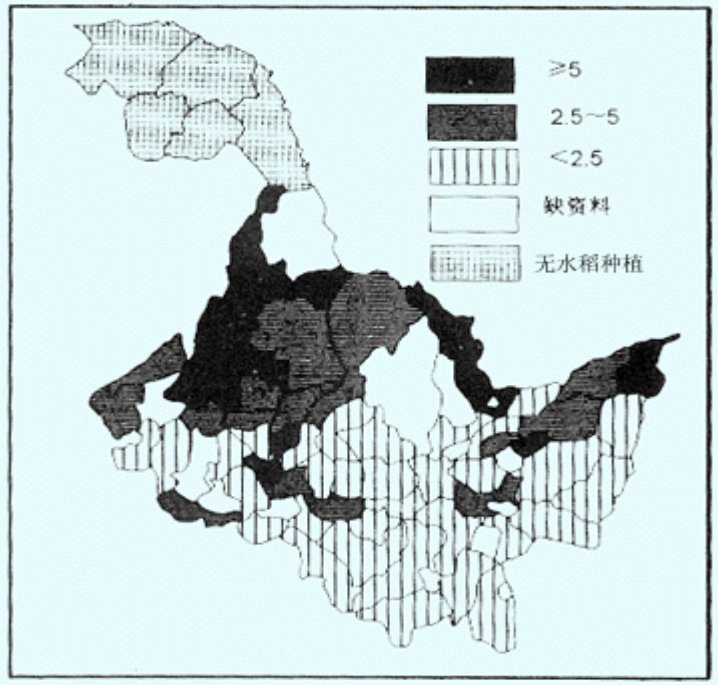


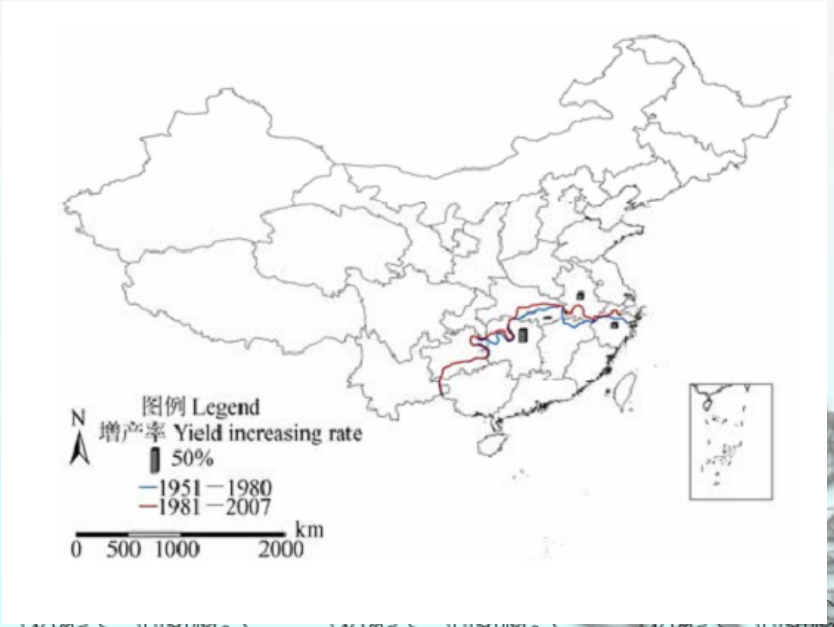


- Yield: Statistic analysis between climate variables and observed yield also demonstrated positive yield positive to warming in north part of China, and negative yield response in south China. Radiation has larger impacts on rice yield in many regions. (Zhang et al. 2009, *Agricultural and Forest Meteorology*)

Impacts of past climate change

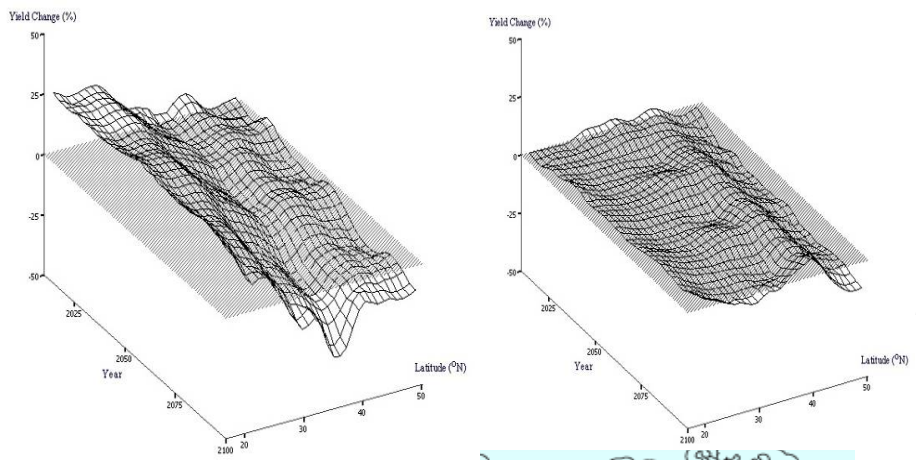
- Production: expansion of the rice planting to north part of China is obvious due to the global warming, which in part mitigated the negative effects of past climate change.
- Considering other adaptation measures (e.g. improved management), the impacts of past climate change on national rice production is less than 5%, with detrimental effects in south, while gains in north

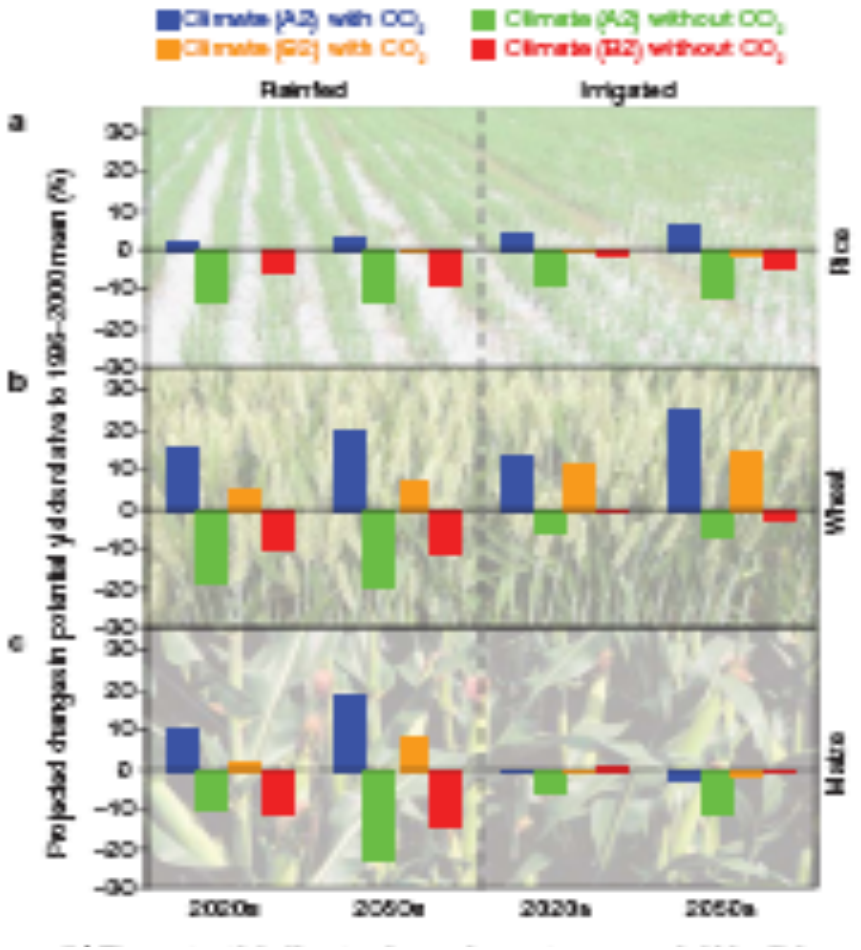




Impacts of future climate change

- Yields: likely to decrease in China under most of climate change scenarios, but elevated CO2 concentration cancel out the negative effects, and finally increase rice yield in all cases

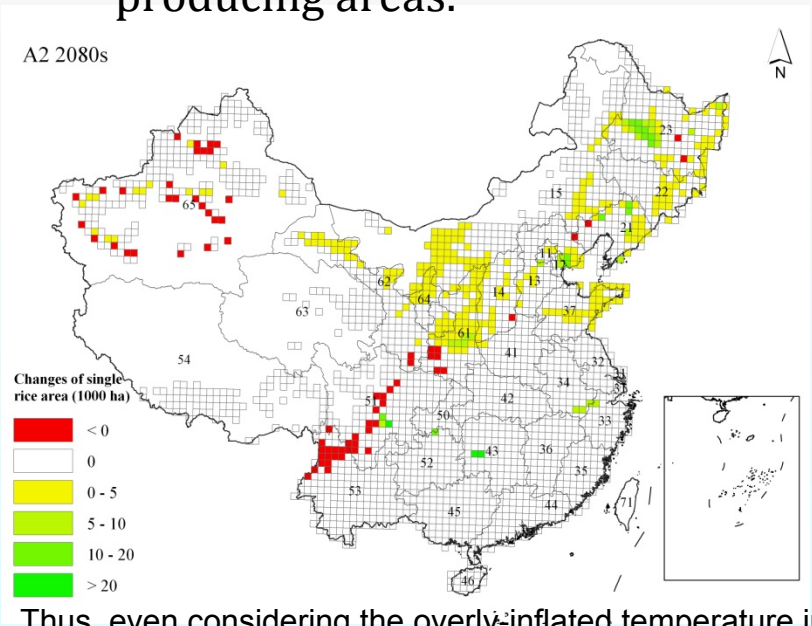


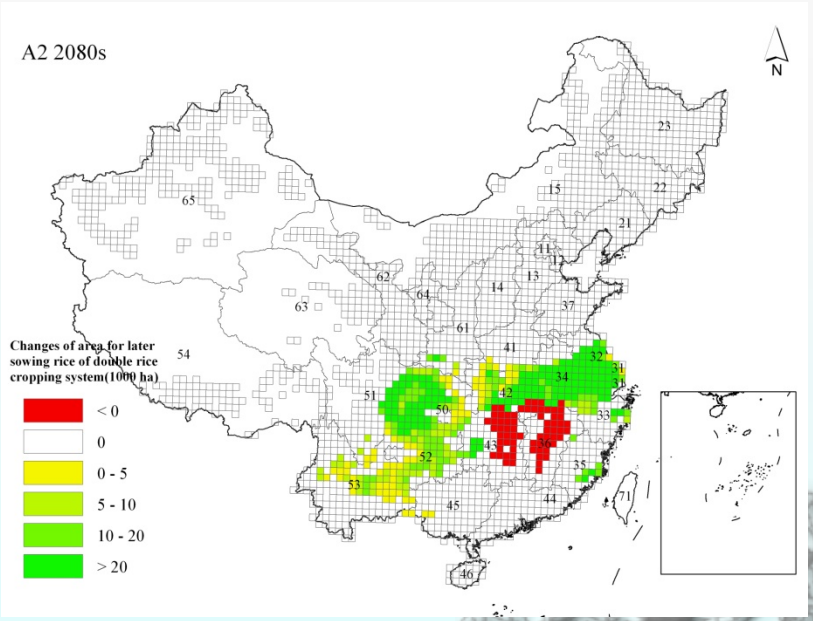


(Piao et al., 2011 Nature)

Impacts of future climate change

- Production can still be benefit under the interaction of global warming, elevated CO2 and changes in producing regions.
  - Single rice cropping may expand further north in China, and double rice cropping may move to the northern portion of the Yangtze River basin.
  - The national mean rice production is estimated to increase by 2.7 to 19.2% considering the combined effects of climate change, CO_2 and shifting rice-producing areas.

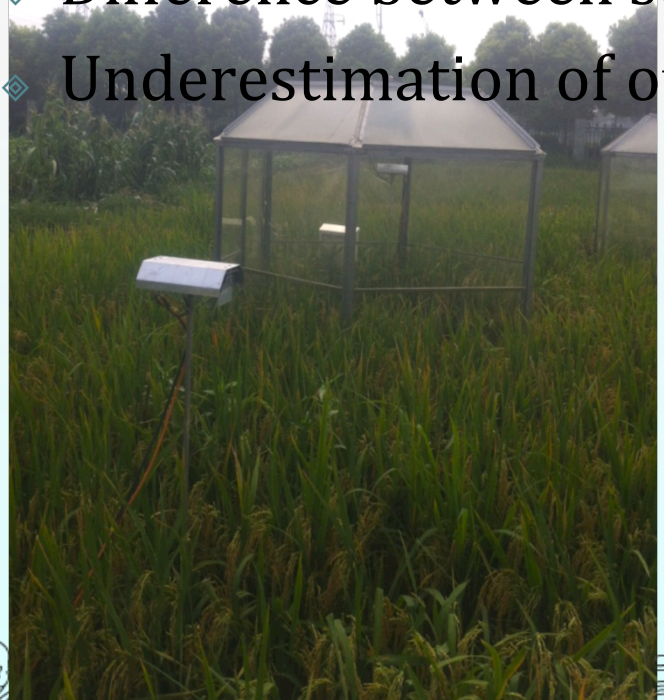


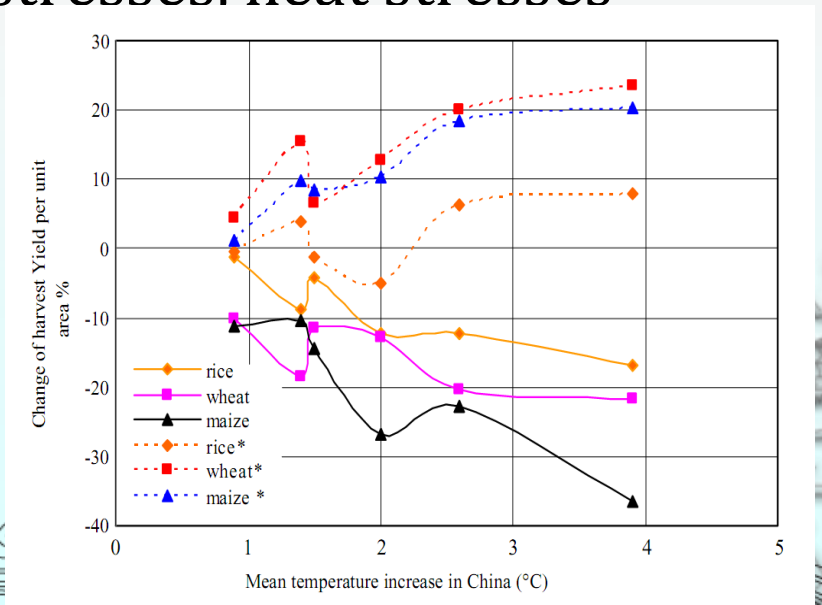


Thus, even considering the overly-inflated temperature increases predicted by the IPCC, the estimated net effect of global warming and concomitant growth in anthropogenic CO_2 emissions ends up producing an increase in rice production in the world's most populated country, where it is the people's single most important food source. This is a *benefit* that simply cannot be ignored.

Impacts of future climate change

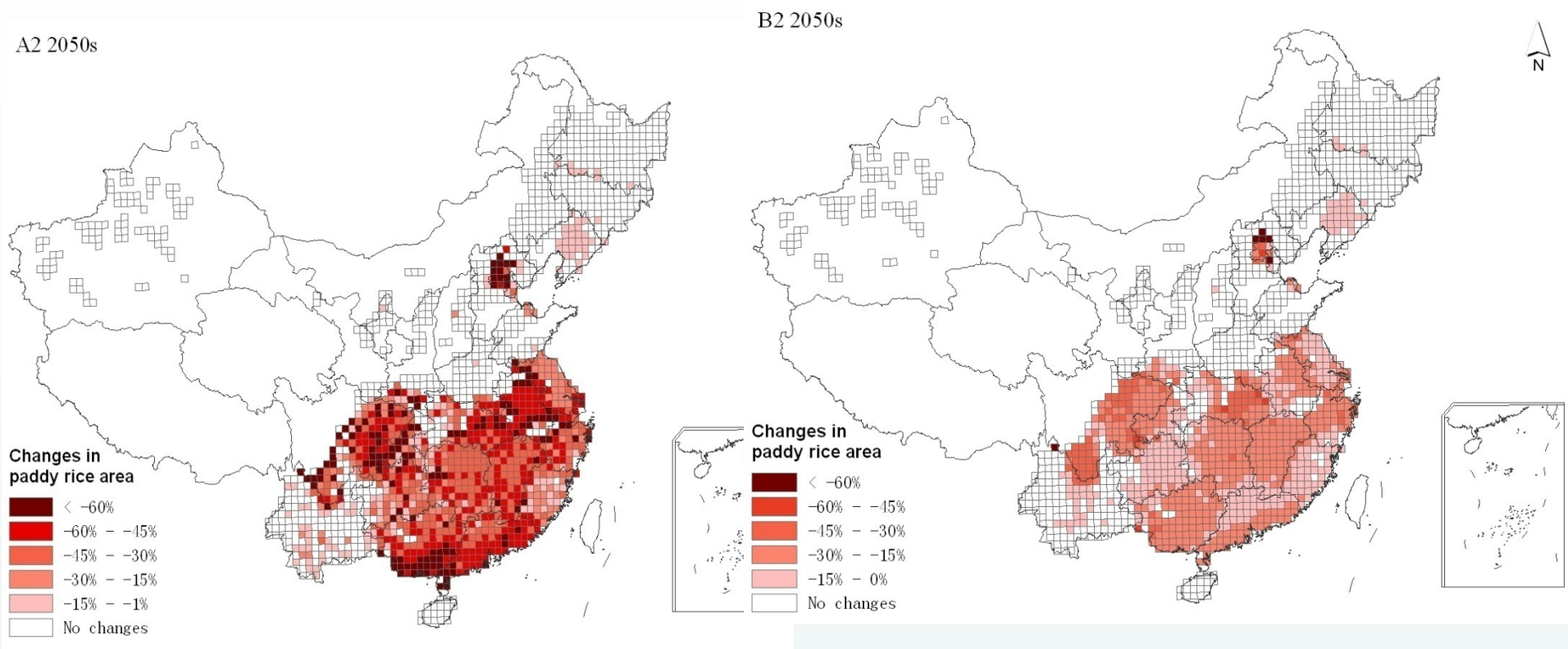
- There are big uncertainties for projected impacts of future climate change
  - CO2 fertilization effects
  - Responding mechanisms (Tmax, Tmin)
  - Difference between scenarios
  - Underestimation of other stresses. heat stresses





Main challenges of CC for rice production in the future

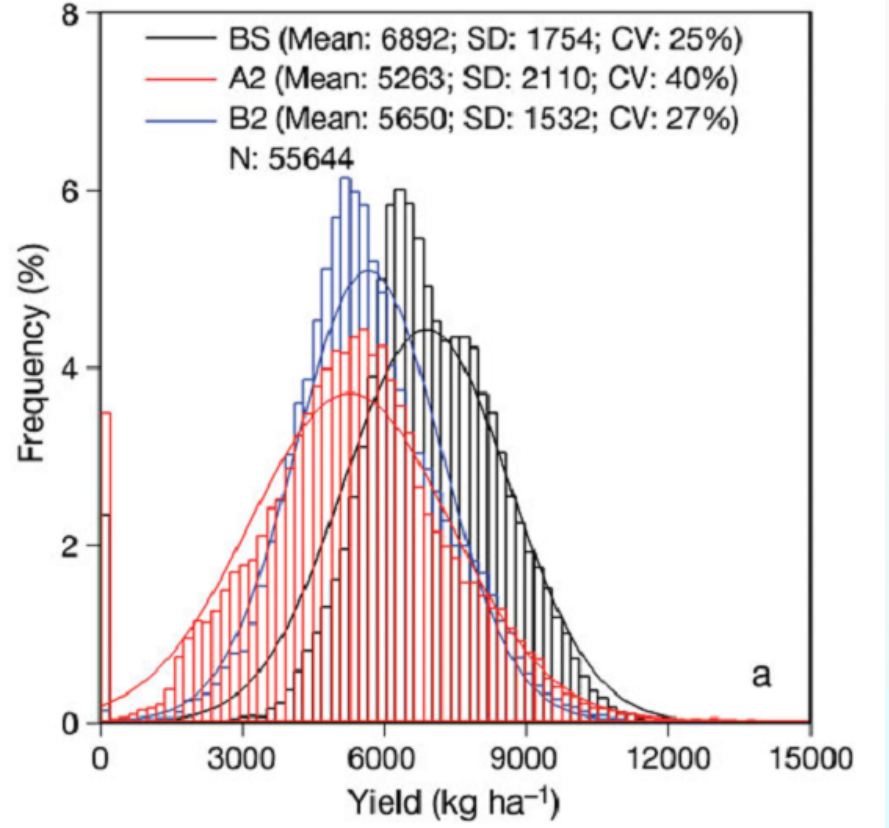
- Other stresses increase under climate change
  - Agricultural water availability
  - Extreme events and larger climate variability
  - Pest/diseases

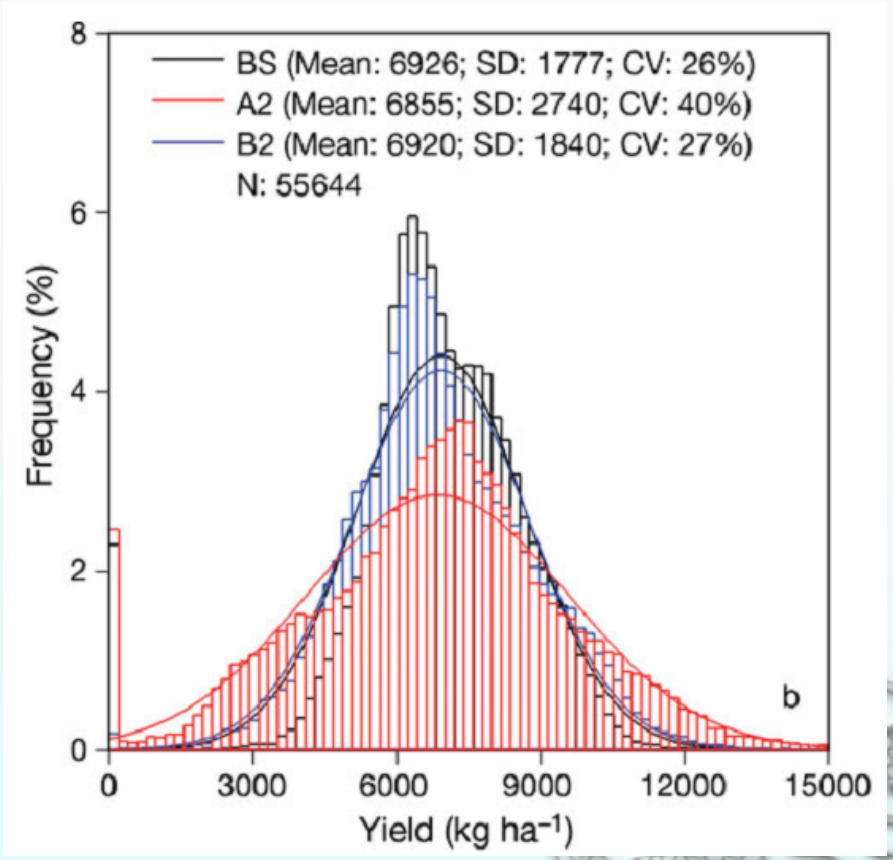


Percentage change in spatial patterns of irrigated paddy rice due to changes in future agricultural water availability (Xiong et al. 2010 AEE)

A integrated simulation combining climate, water and crop simulation revealed that rice area has to decrease substantially in the future in China, due to the decreasing agricultural water availability.

Variability of rice yield will increase under climate change due to the increased climate variability and enhanced extreme events (heat stresses, cold spell), even with consideration of elevated CO2 concentrations, which has great implications for grain price and grain trade.

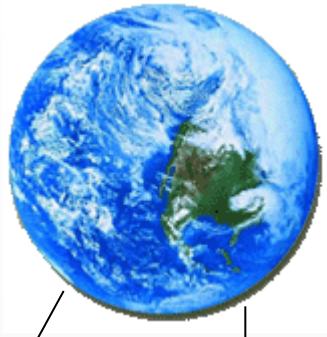




Histograms of yield and their normal distribution curves for baseline, and A2 and B2 in 2080s (Xiong et al. 2009 Climate research)

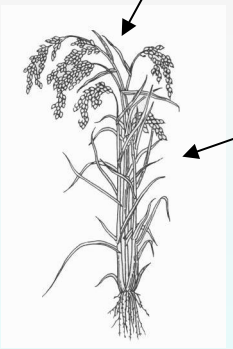
Pest/disease tend to increase under the climate change

Used the three GCMs scenarios (HadCM2, ECHAM4, MaxPI), CERES-Rice crop model, CSW (Chilo Suppresa Lias Walker) to assess the rice production under different climate scenarios and different pest population scenarios (Bejing, 2000, AMI,CAAS).



Global Warming

Chilo suppre-ssalis



Rice

The number of pest generation (Chilo sppre-ssalis) will increase under climate change (2℃), combing with the higher temperature will decrease the rice yield by 8%~25%.

Part 3: Adaptation strategies and measures

Adaptation strategies

- Rice production has to increase 30% in next 10~20 years to feed the increasing population
  - Intensifying rice production in NE
  - Spreading hybrid rice (super grain 14 ton/ha) planting in the south and Yangtze river basin
  - Research and demonstration of Genetically Modified rice
  - Disaster alleviation for rice production

Adaptation measures

- Water saving in rice production
  - Infrastructures
  - Upland irrigated rice to replace paddy rice
  - New irrigation operation schedule
- New cultivars (heat/pest/ diseases resistant cultivars)
- Climate-smart rice production (rice-fish, rice-duck, rice-crab, etc.)

Conclusions

- Past climate change decreases rice yields, with larger contribution coming from decreasing radiation rather than growing-season warming;
- Due to technology progress, China's rice production increase substantially under climate change, changes of rice area from south to North plays significant roles in past yield promotion;
- Rice yields will decrease moderately with projected warming trends, but production can still be kept at current level if effective adaptations were put in place;
- The key challenges for rice production in the future are diminishing agricultural water availability, larger climate variability, and increasing pest/diseases yield losses;
- An integrated impact (direct and indirect) is still unclear so far, need more researches, particularly through international cooperation;
- Adaptation is needed urgently.

Thanks