Transitioning Cereal Systems to Adapt to Climate Change

November 13-14, 2015

Funded through Award #2011-68002-30191 from USDA National Institute of Food and Agriculture

New findings for climate change and food security in China

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New Findings for Climate Change and Food Security in China

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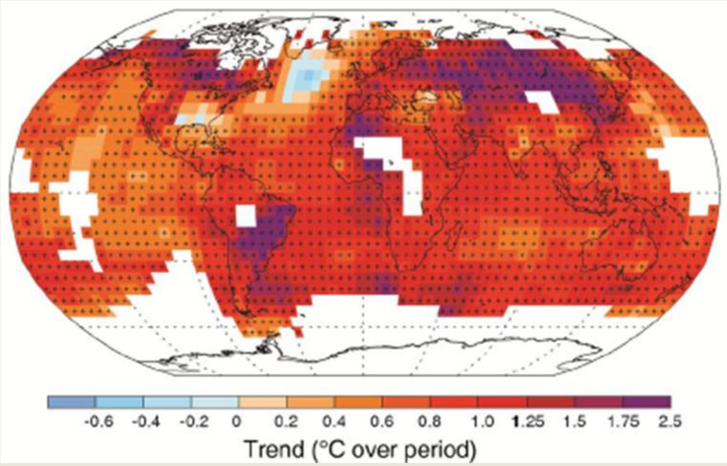
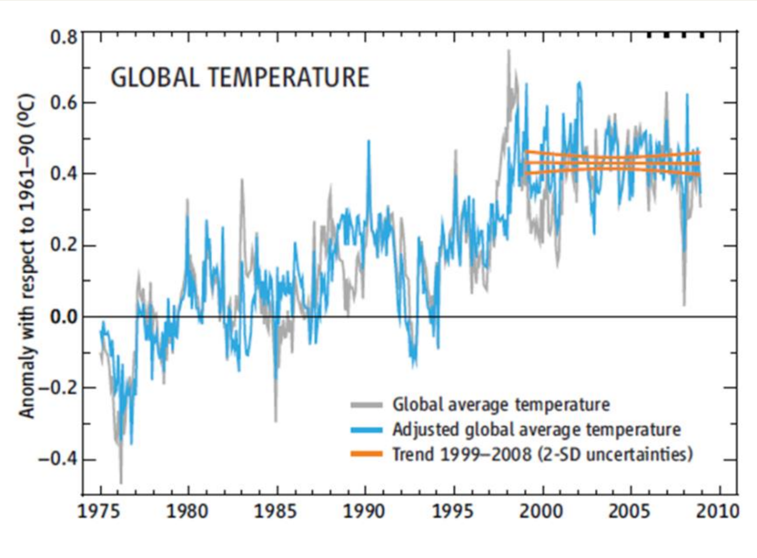
United Nations Framework Convention on Climate Change

Contents

With high levels of warming that result from continued growth in greenhouse gas emissions, risks will be challenging to manage, and even serious

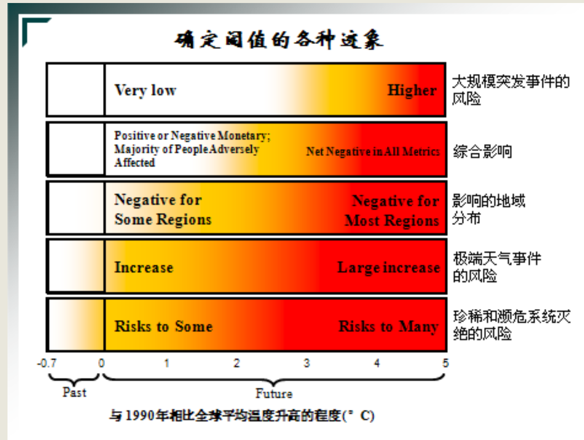
以更多的观测和研究证据证明了全球气候变暖毋庸置疑





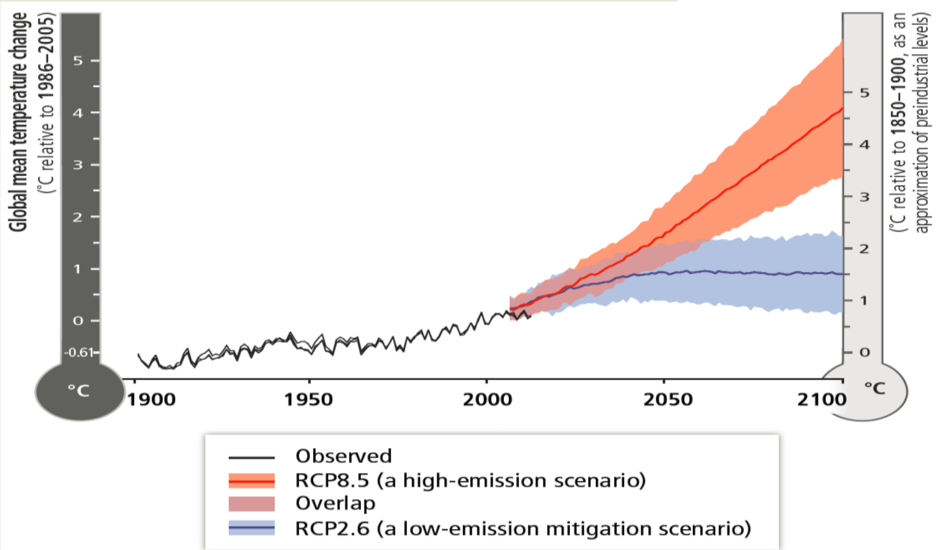
近130年（1880−2012）年全球地表平均温度升高了0.85℃。1850−1900年与2003−2012年间的全球地表平均温度上升0.78℃

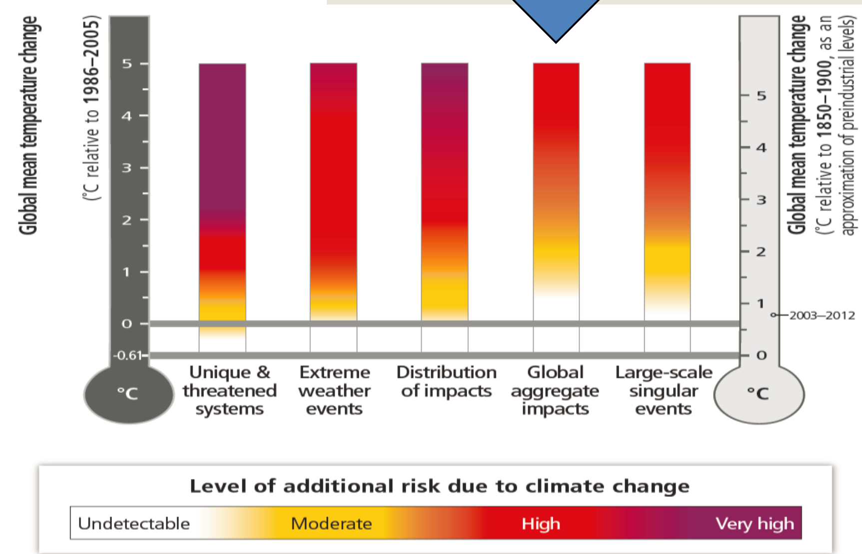
2, New Progress: Key Risks are integrated into five reasons for concern(RFCs)



TAR

典型浓度路径（RCP）和社会经济情景（SSP）下影响的风险水平综合评估



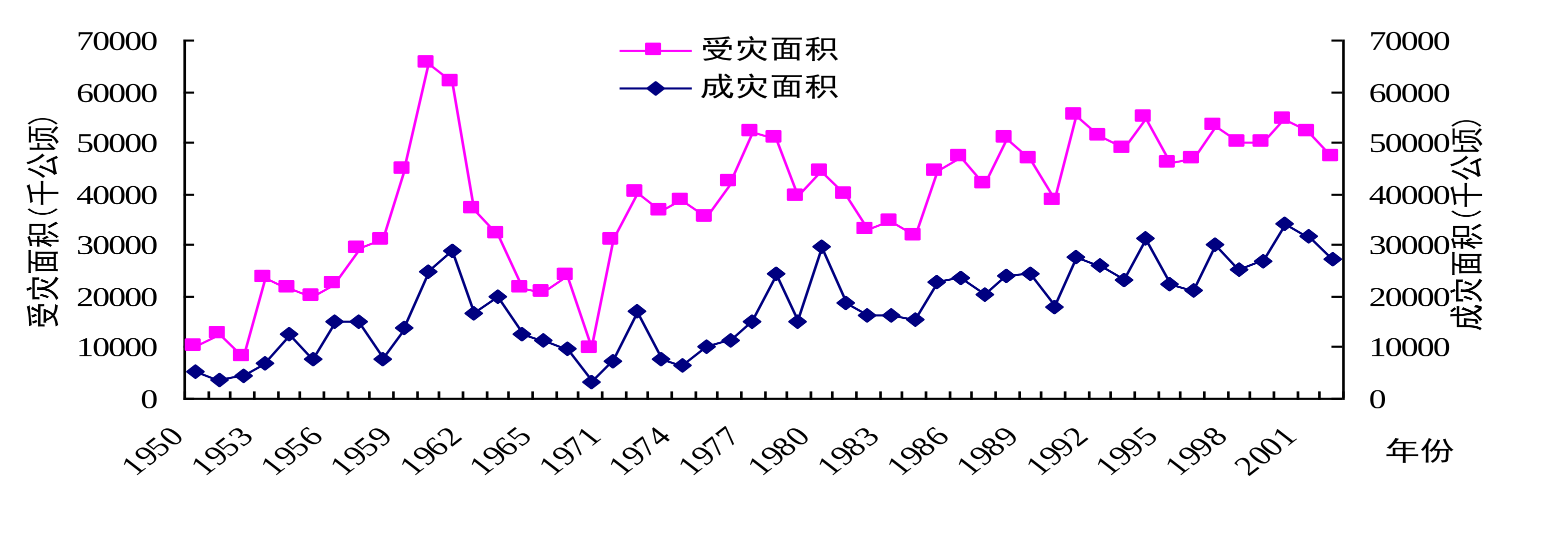


Risks of global aggregate impacts are moderate for additional warming between 1–2° C, in high risks around 3° C additional warming,. Aggregate economic damages accelerate with increasing temperature ,but few quantitative estimates have been completed for additional warming around 3° C or above.

With disaster increased and more risk, climate change impacts getting serious

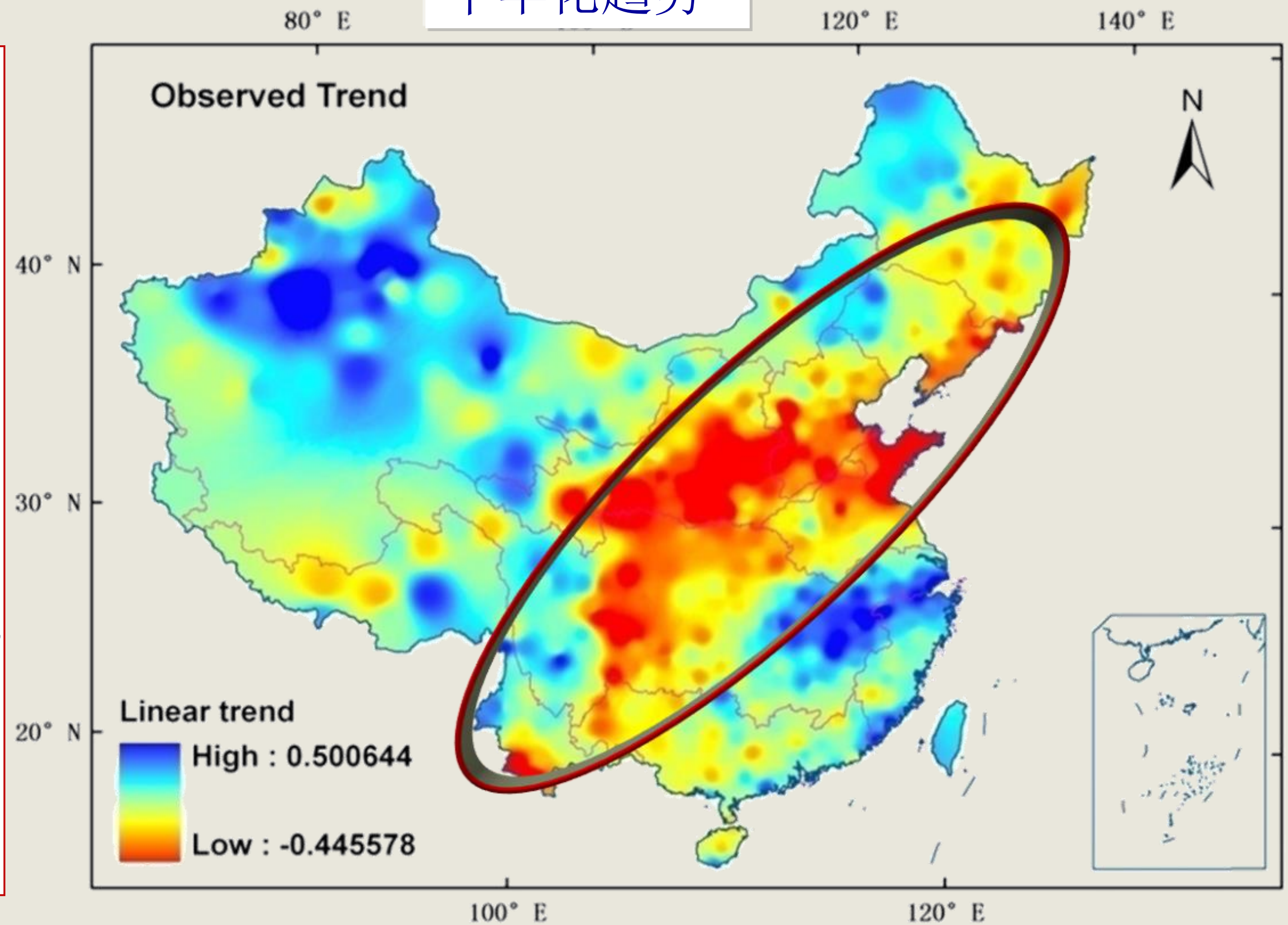
自然灾害增多，危险加大，证明气候变化危害

Suffered area and disaster area



Regional dry risk getting serious
区域性干旱加剧，干旱风险增加

干旱化趋势



我国每年平均农业受旱面积为2443万公顷，近60年干旱的频率和受灾面积均呈上升趋势。近15年中等以上干旱日数东北增加37%，华北增加16%，西南增加10%。

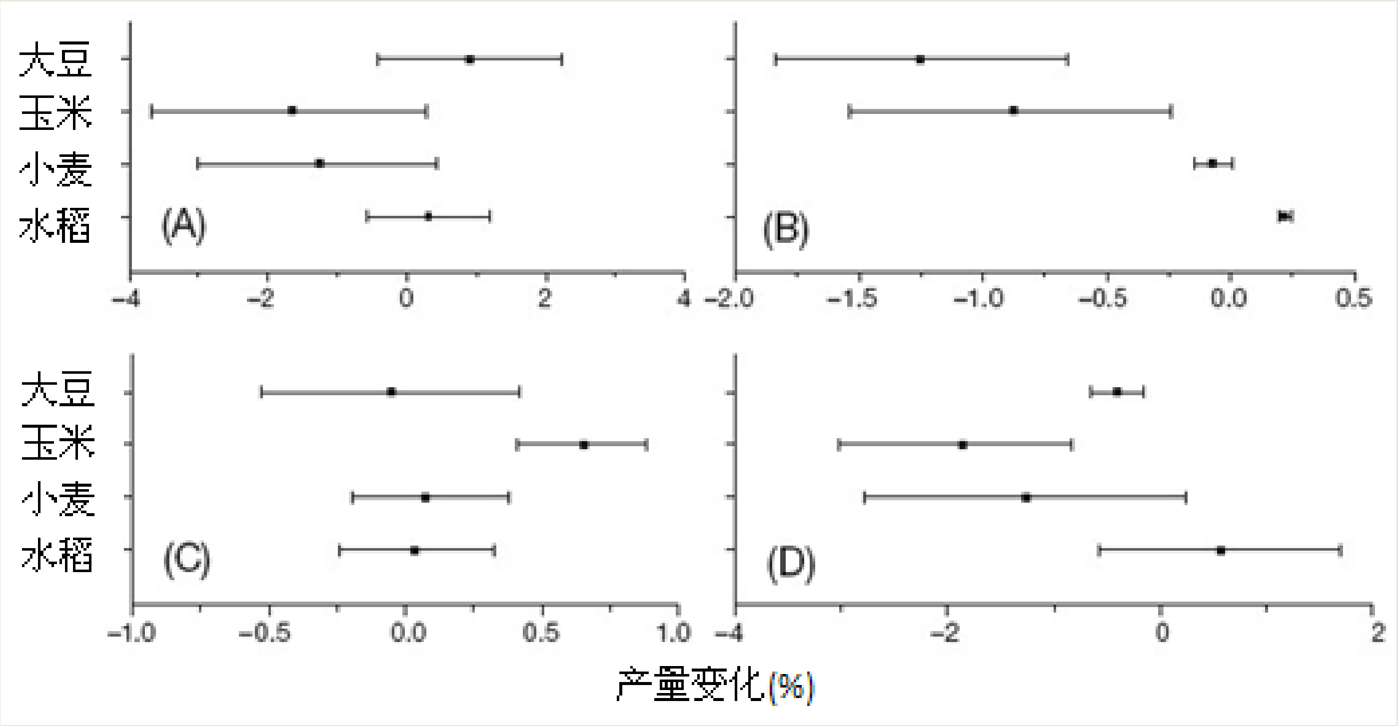


图4 气候变化对1980—2008年中国作物单产影响的贡献程度Impacts of climatic factors on Crop yield 1980-2008（A）气温变化Temperature；（B）降雨变化rainfall；(C)辐射变化radiation；（D）气候总体变化Total

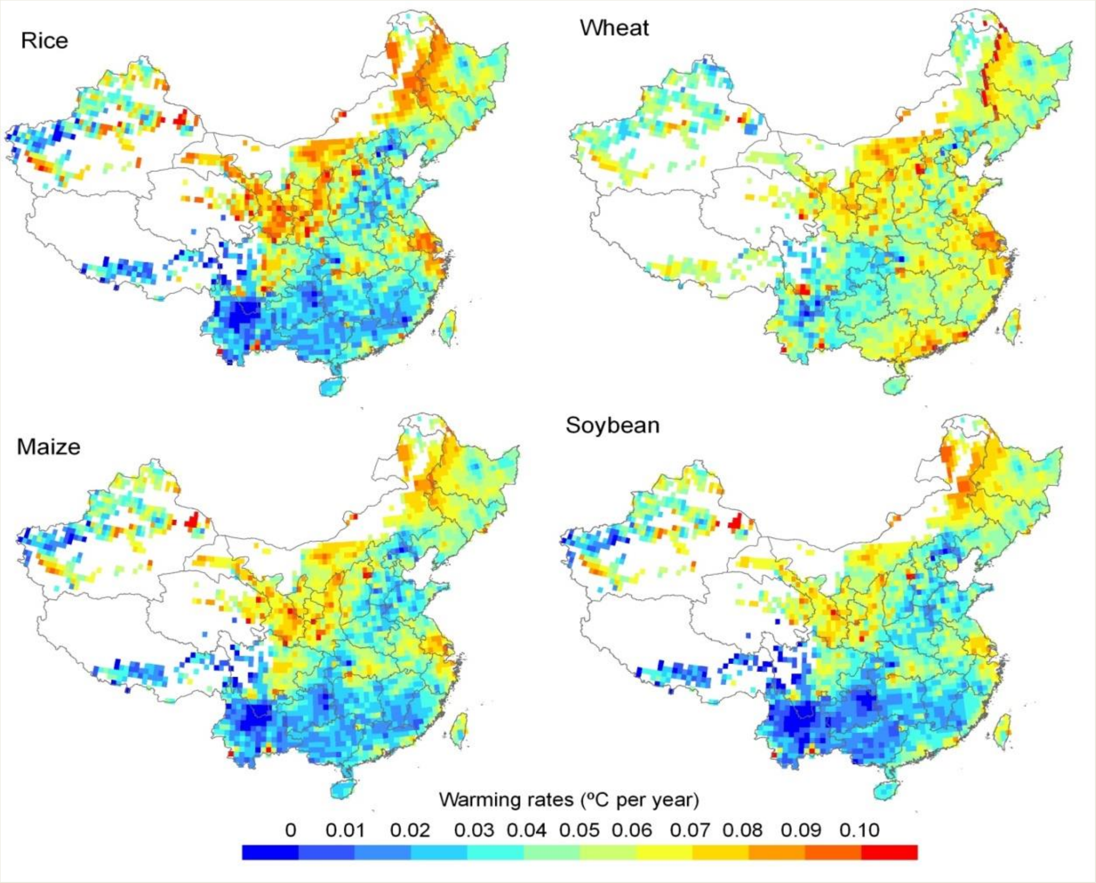
- ✓ 1980—2008年以来的气候总体变化引起的大豆、玉米、小麦单产分别降低0.41%、1.73%、1.27%，水稻单产增加0.56%，受气候变化影响最敏感的作物是我国北部和东北部干旱和半干旱区的玉米和小麦(Tao et al.， 2012b)

Climate change and food production in past 12 years China
近12年我国的气候变化与粮食生产

年	Production(100Mt)	Temperature ℃	Precipitation (100mm)	Suffered area(1000 ha)	Area without harvest (1000ha)	Sown area(100M ha)	Effective irriga（10M ha)
2001	4.5264	9.5	5.8	52215		1.0608	5.5013
2002	4.5706	9.6	6.4	46946		1.03891	5.5517
2003	4.307	9.5	6.1	54506		0.99411	5.5858
2004	4.6974	9.6	5.8	37650	4333	1.01606	5.4478
2005	4.8402	9.4	6.31	38755	4188	1.04278	5.5029
2006	4.9804	**9.9**	5.8	41110	**4942**	1.04958	5.5751
2007	5.016	**10.1**	6.08	49614	**5798**	1.05638	5.6518
2008	5.285	9.5	6.5	39990	4133	1.06793	5.8472
2009	5.308	**9.8**	5.74	47214	**4918**	1.08986	5.9262
2010	5.4641	9.5	**6.82**	37426	**4963**	1.09876	6.0348
2011	5.7121	9.5	5.55	32471	2891	1.10573	6.1682
2012	5.8957	9.4	6.69	24962	1826	1.11205	6.3036
2013	6.0193	**10.2**	6.53	31350	3840	1.11956	6.3351
12年平均（rate）	(3.27%)	9.7	6.10	38650	**(-1.2%)**	(1.03%)	(1.5%)

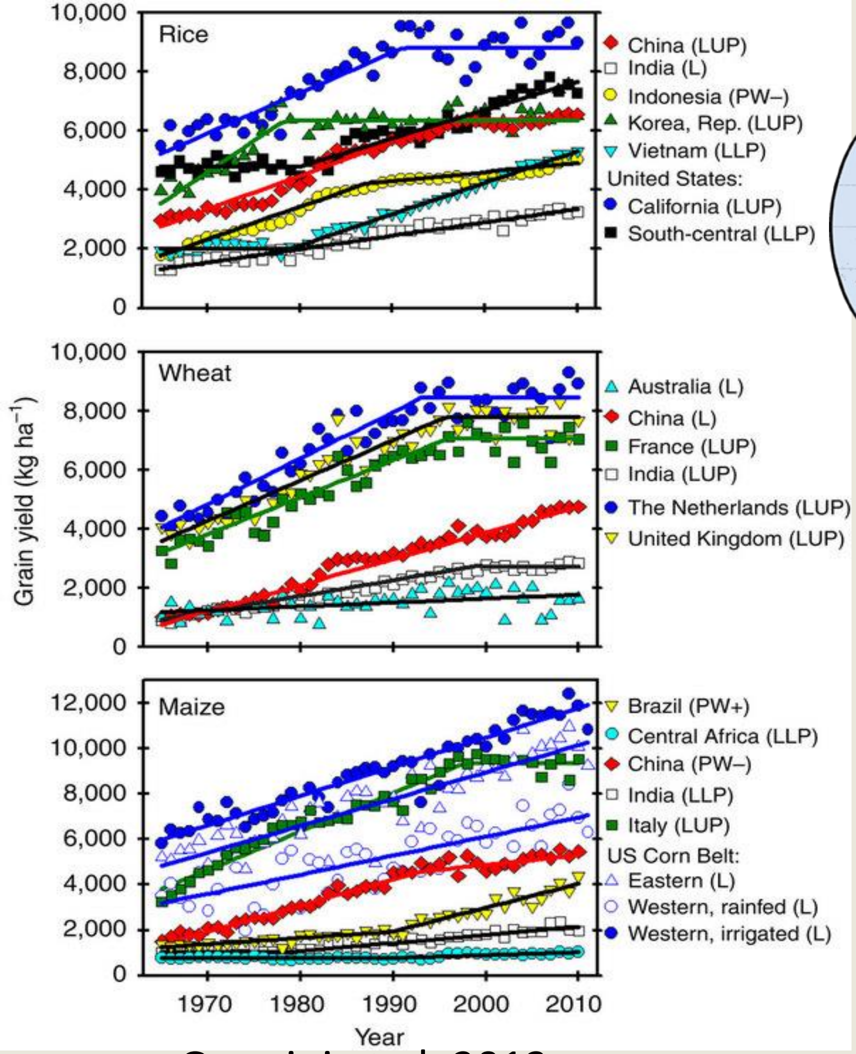
Warming was notable since 1980 in China colliding with widespread yield stagnation
值得注意的变暖与广泛的单产停滞冲突

- The growing- season warming was significant for all crops, with 0.43, 0.58, 0.45 and 0.45 ºC per 10 years since 1980, respectively, for rice, wheat, maize and soybean.
- Spatial differences are obvious for different crops.

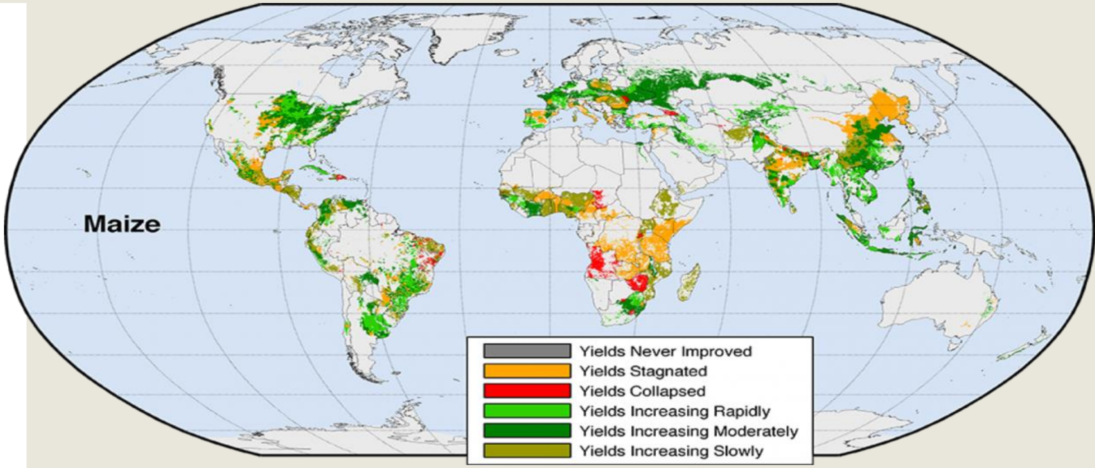


Xiong et al. 2014

Warming has been blamed as a driver for past yield stagnation
变暖已经归因为过去单产停滞的驱动因子

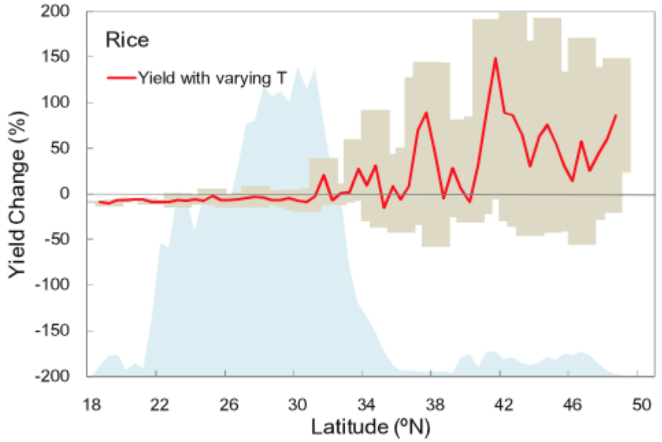


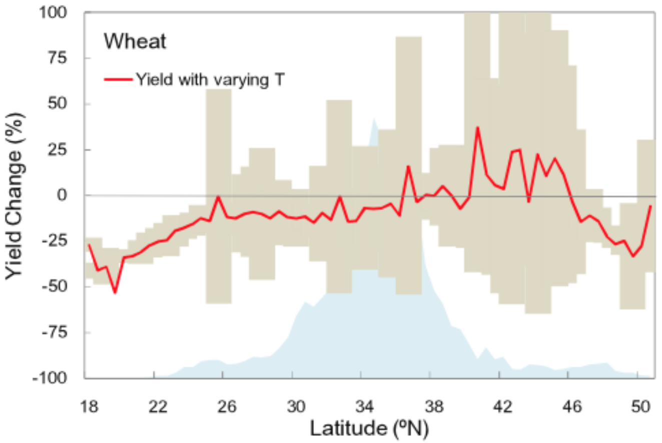
Grassini et al. 2013

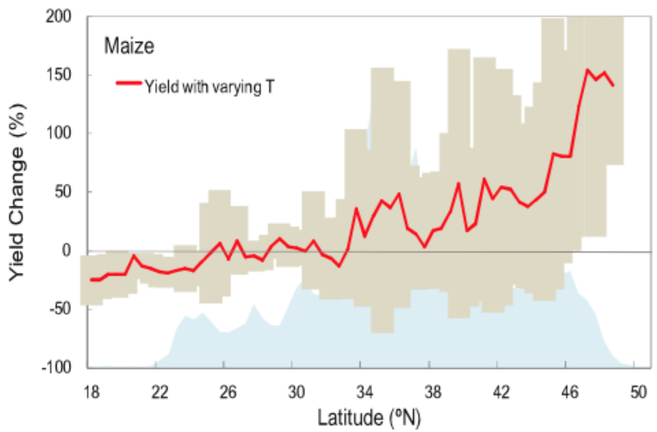


Ray et al. 2012

Warming is considered as a factor for recent yield slowing, because the yield decrease and temperature increase shown notable correlations at both temporal and spatial matters (Xiong et al. 2014b).

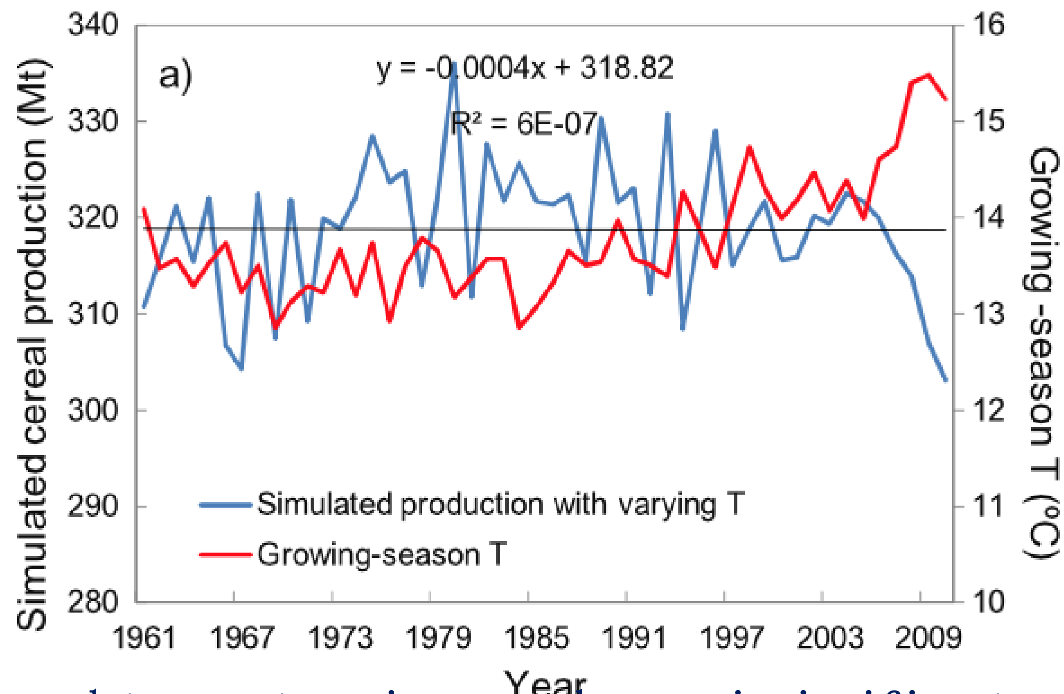






But the effects of warming largely cancelled out in different latitude (positive in high latitude while negative in low latitude), showing a small net effects of warming on China's food production

变暖的作用随纬度而不同，对中国总产影响不大

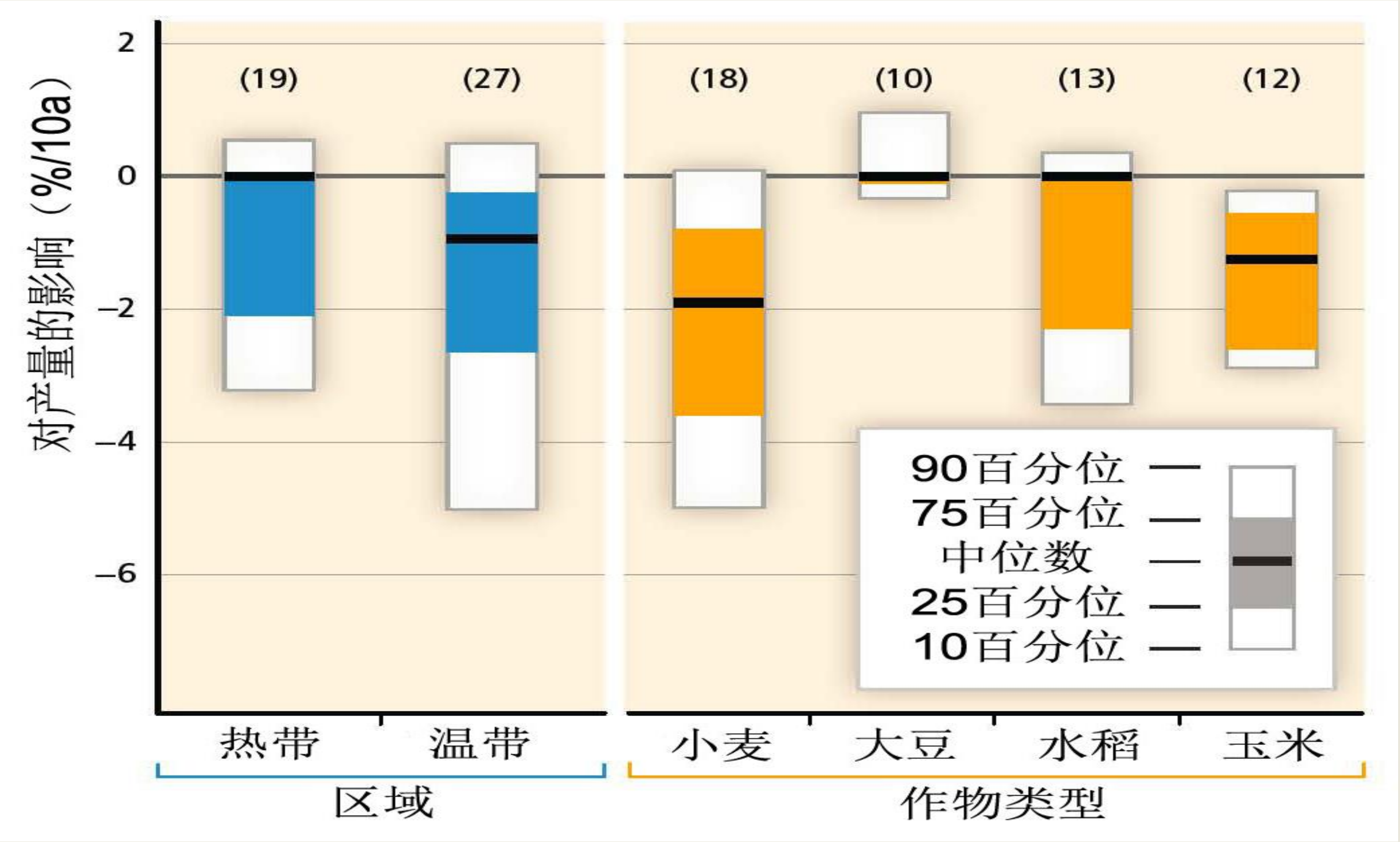


Observed temperature increase has an insignificant effect on China' s food production (simulated production 1961-2010 with observed T while unchanged other climatic variables)

Xiong et al. 2012

Negative impacts of climate change on crop yields have been more common than positive impacts

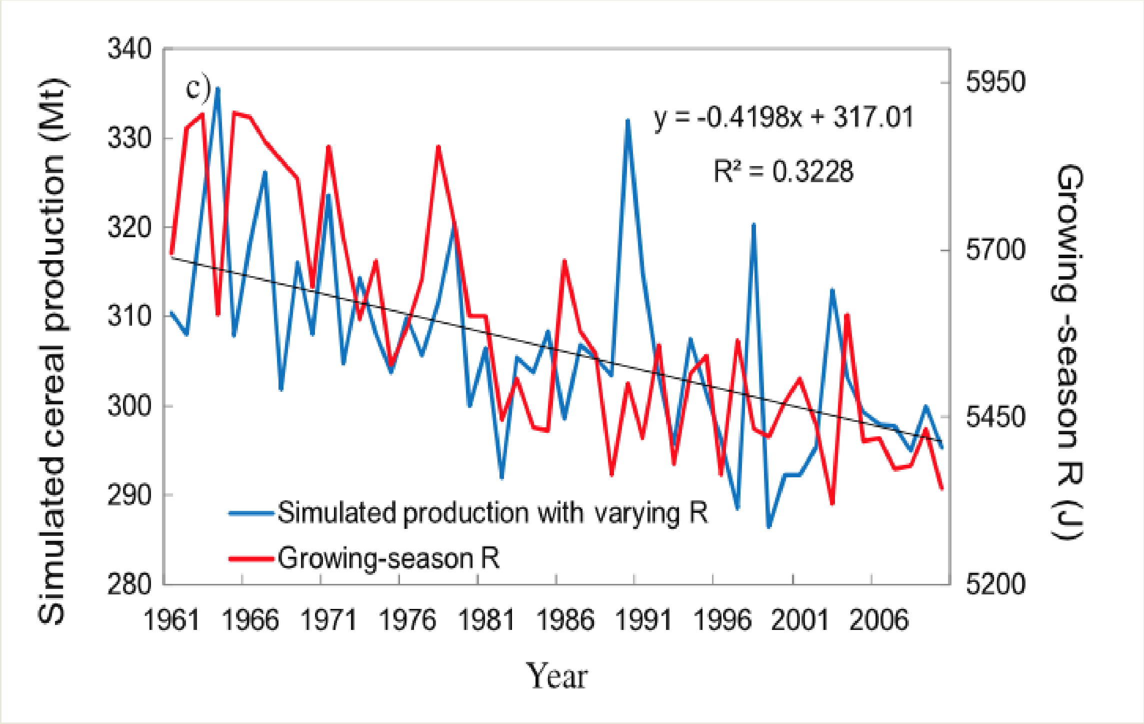
气候变化对粮食产量的不利影响比有利影响更为显著

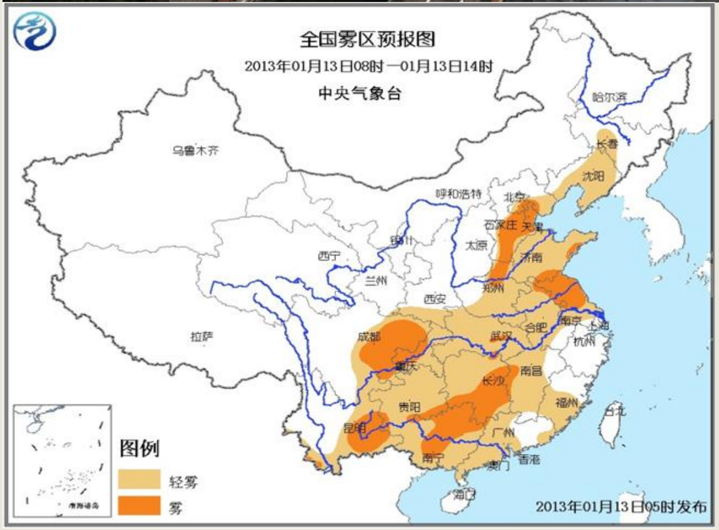


小麦和玉米受气候变化不利影响相对水稻和大豆更大，小麦和玉米减产平均约为每10年1.9％和1.2％

Increased pollution was another important player for reducing crop yields over last decades

大气污染加重是另一个降低作物单产的原因



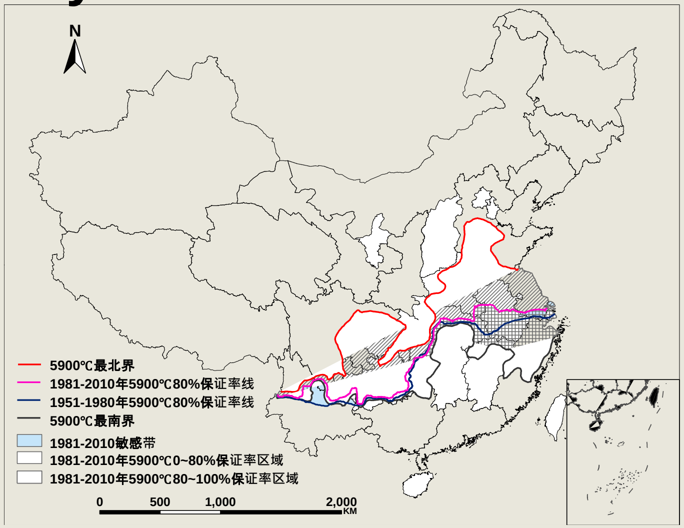


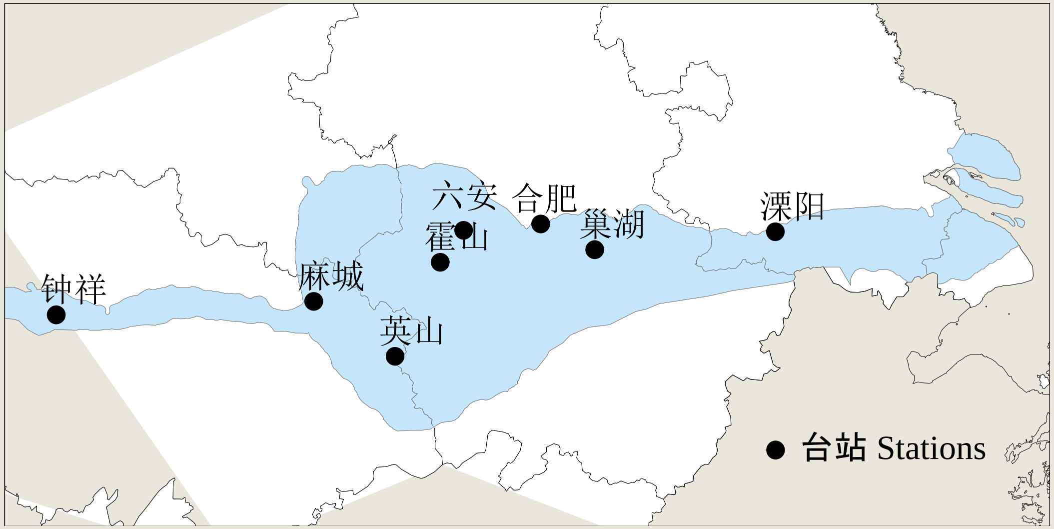
The large contribution of decreasing radiation (global dimming) reminds us of the importance of radiation, suggesting the increased risks on food production caused by air pollution in developing counties.

Warming related adaptation benefited the production but still had huge potentials
适应变暖有利于总产增加仍有巨大潜力

- Expansion of the food planting areas to the north is obvious
- Harvest times actually increase in number

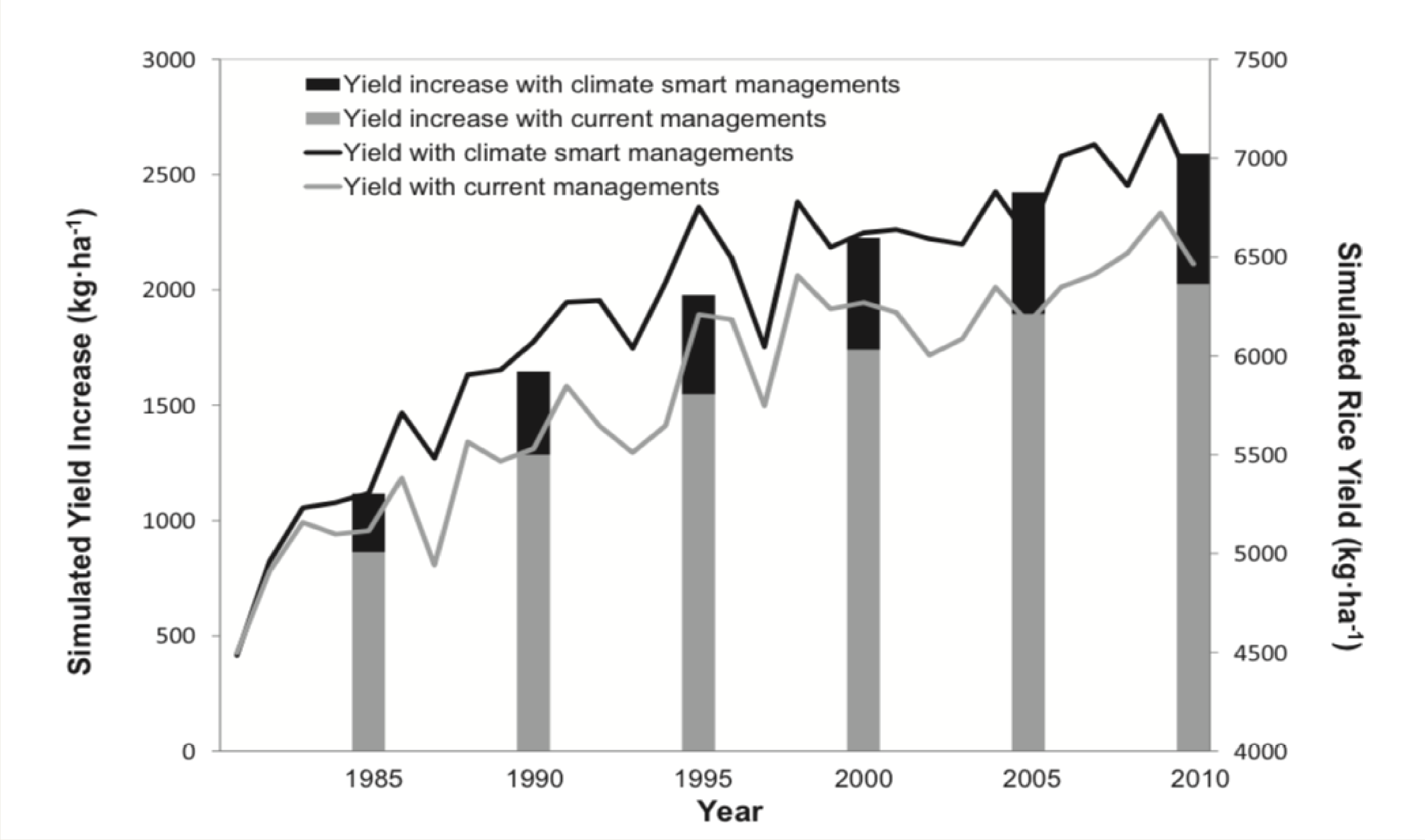
Changes of planting area for triple harvest per year during past 50 years





Large potential exits for production if applying the climate-smart agriculture

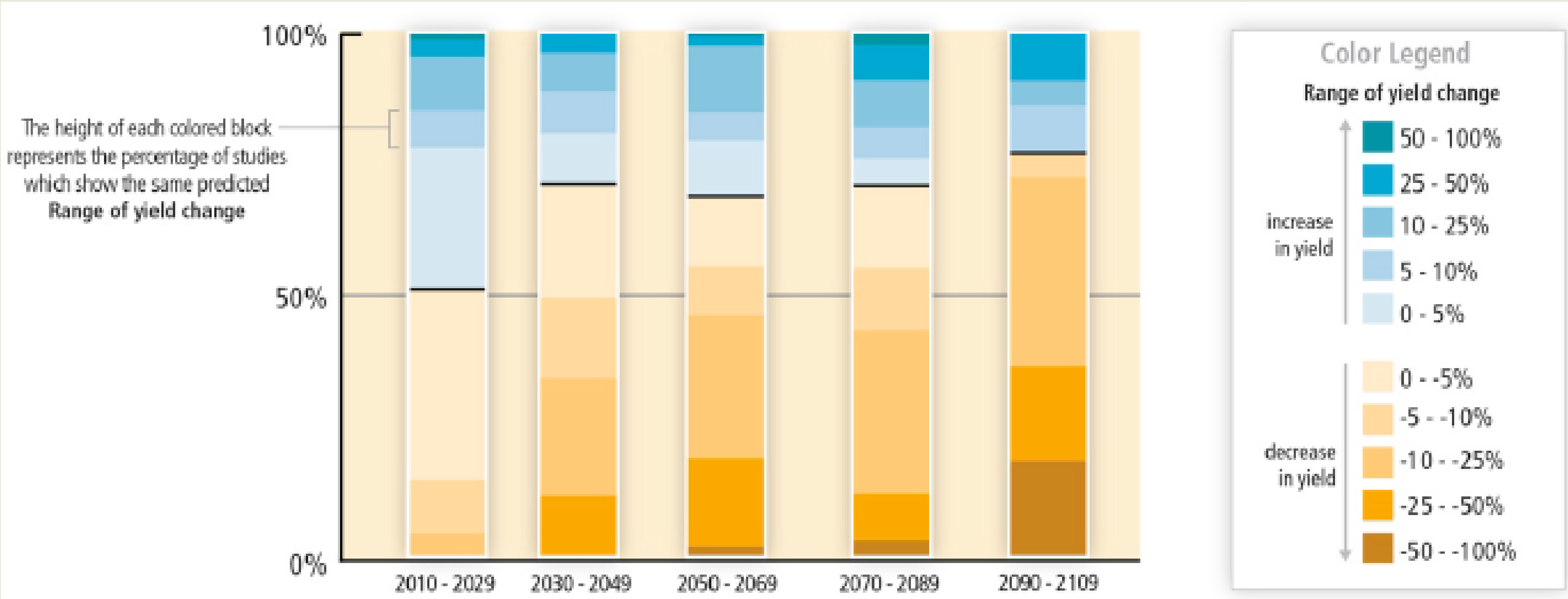
实行气候智慧型农业对总产提高有巨大潜力



National rice yield could increase by up to 15~30% if applying climate optimized crop cultivar and management practices (Xiong et al 2014a)

IPCC AR5 New findings for agriculture

- 如果缺乏适应措施，相比20世纪末期增温2℃或更高，会对热带和温带地区主要作物（小麦、水稻和玉米）的产量产生负面影响（尽管个别地区可能会受益）For the major crops (wheat, rice, and maize) in tropical and temperate regions, climate change without adaptation is projected to negatively impact production for local temperature increases of 2° C or more above late-20th-century levels, although individual locations may benefit (medium confidence). 如果全球温度上升约4℃或更高,同时粮食需求不断上升,将会给全球和区域粮食安全带来巨大风险. Global temperature increases of ~4° C or more above late-20th-century levels, combined with increasing food demand, would pose large risks to food security globally and regionally (high Confidence).
- 平均起来适应改善单产相当于当前产量的15%~18%Averagely,adaptation improve yield correspond 15%~18% of current yield
- 未来农村的主要影响将发生在近期对水供应、粮食安全和农业收入的影响之后。Major future rural impacts are expected in the near term and beyond through impacts on water availability and supply, food security, and agricultural incomes, including shifts in production areas of food and non-food crops across the world (high confidence).气候突变及其它因素的共同影响将使粮价上升。国际农业贸易存在适应选择，进口粮食能帮助调整气候变化引起的国内生产波动，而低收入国家短期食物不足可通过粮食援助解决。All aspects of food security are potentially affected by climate change, including food access, utilization, and price stability (high confidence).



- ✓ 2030—2049年相对于20世纪末期，约10%的预测认为产量增加会超过10%，另有10%的预测显示产量损失超过25%。
- ✓ 2050年以后，更剧烈的产量变化风险增加了，程度大小取决于升温幅度。

Selection of adaptation适应技术的选取:
Crop responses to elevated CO_2 concentration
农作物对CO_2浓度升高的适应能力

FACE自由大气CO2富集系统， 研究农作物的反应:

Different Cultivars have significant results不同品种间有明显差异

FACE new results oppugn IPCC AR3 and AR4 conclusion ：在大气中 CO_2 浓度达到550ppm情况下，如果没有其他胁迫，C3作物产量将平均增加 10-25%，C4 作物增加 0-10% （可能高估50%）

Regional Crop Modeling

输入

Soil polygon file

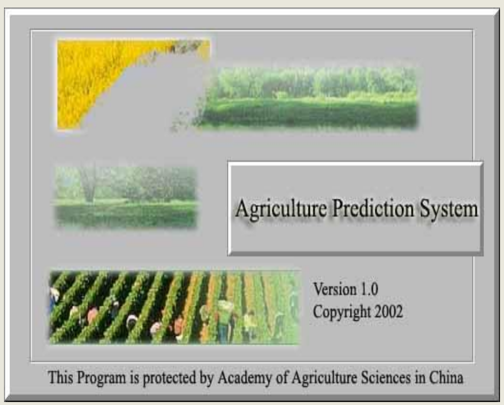
Crop variety polygon file

Socioeconomic polygon file

PRECIS

Model Shell (Reading polygon input files, writing output files, Running model repeatedly based on the Polygon definition.)

CERES



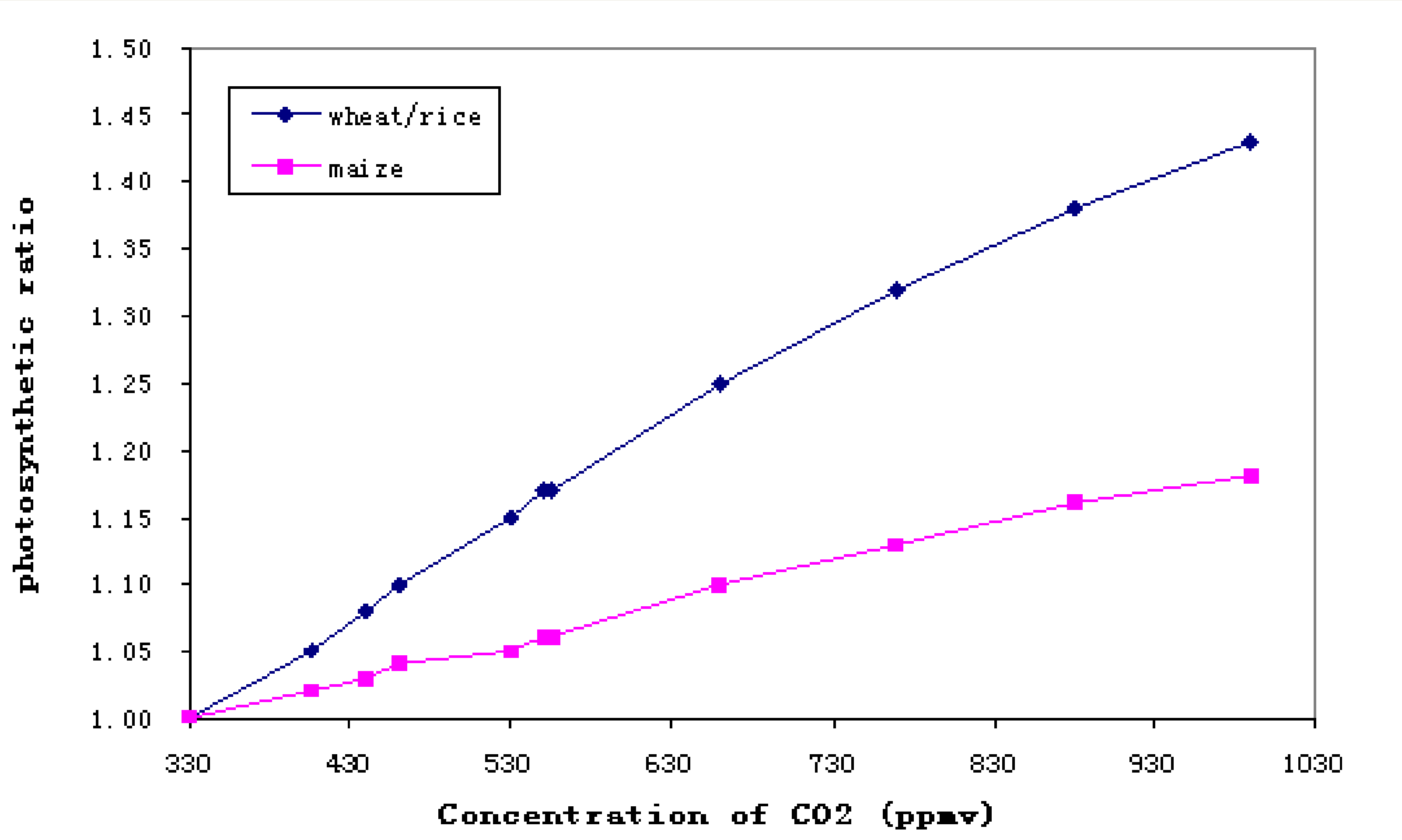
输出

Biomass output

Water output

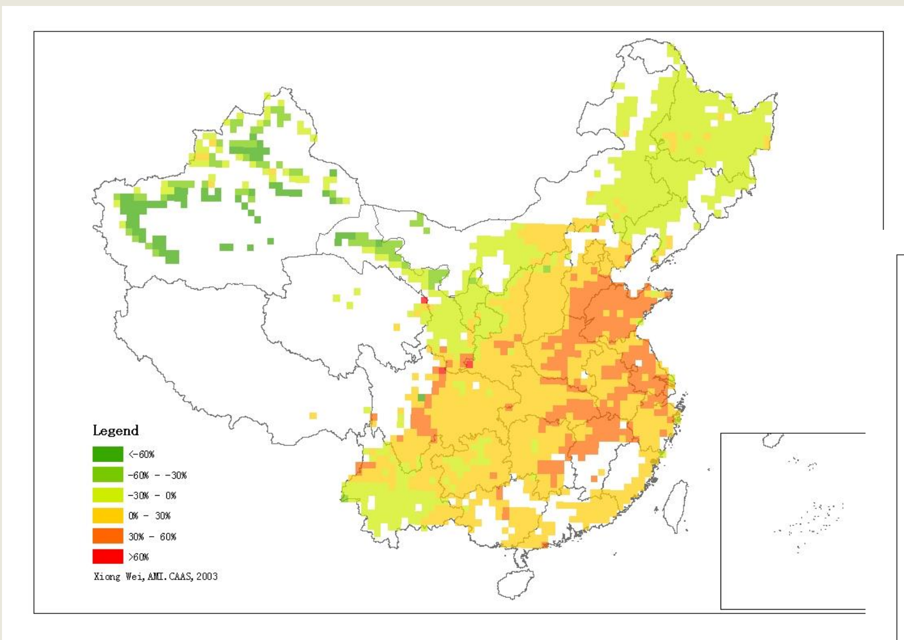
Growth output

模拟结果的不确定性：Elevated CO_2 increases photosynthesis in C_3 plants but the effect appears to be small in C_4 plants

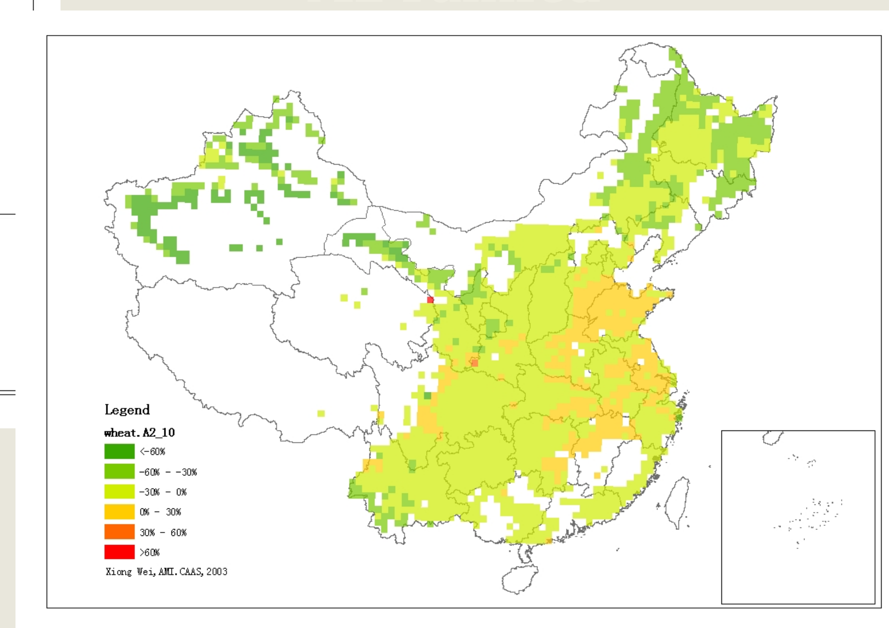


Projected yield changes for wheat, 2080 (with CO_2 fertilisation effect)

对未来小麦单产影响的预测



A2 rainfed



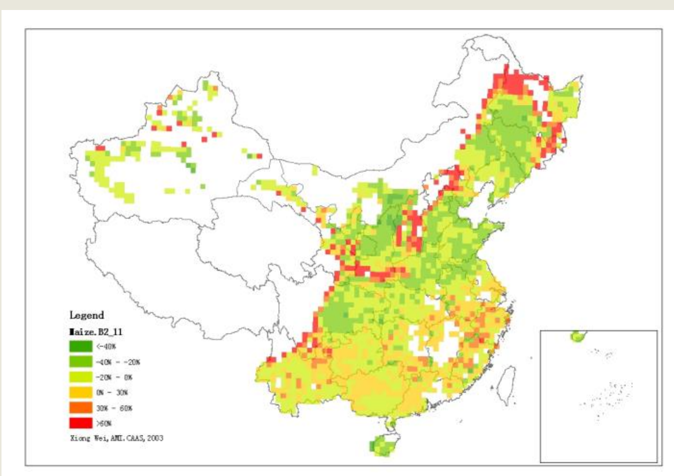
A2 irrigated

Ju Hui

Projected changes in average maize yield compared with yield under baseline

对未来玉米单产影响的预测

	Change in average yield (%)*					
	With CO_2 fertiliser effect			Without CO_2 fertiliser effect		
	2020s	2050s	2080s	2020s	2050s	2080s
A2: rainfed	9.8	18.4	20.3	-10.3	-22.9	–36.4
A2: irrigated	-0.6	-2.2	-2.8	-5.3	-11.9	–14.4
B2: rainfed	1.1	8.5	10.4	-11.3	-14.5	–26.9
B2: irrigated	-0.1	-1.3	-2.2	0.2	-0.4	-3.8



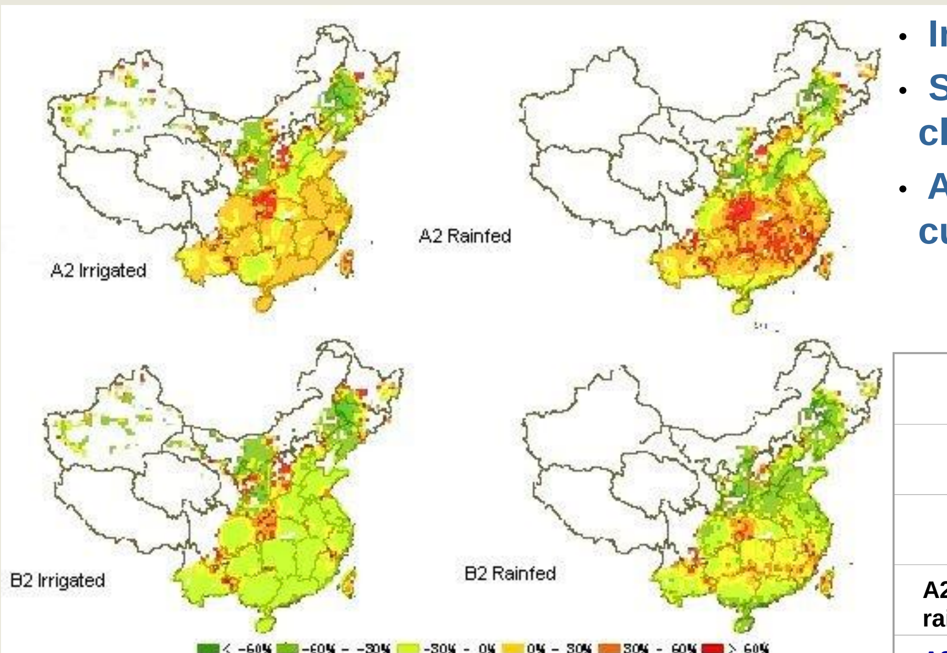
Adaptation can avoid dangerous climate change in a period

Xiong W

Projected changes in average maize yield compared with yield under baseline
对未来水稻单产影响的预测

Rice yields 2080s

- Adjust cropping calendar and crop rotation
- Improve irrigation and water-saving technologies
- Selection of planted crops based on changed climate and prices
- Adopt heat-resistant crops, water-efficient cultivars



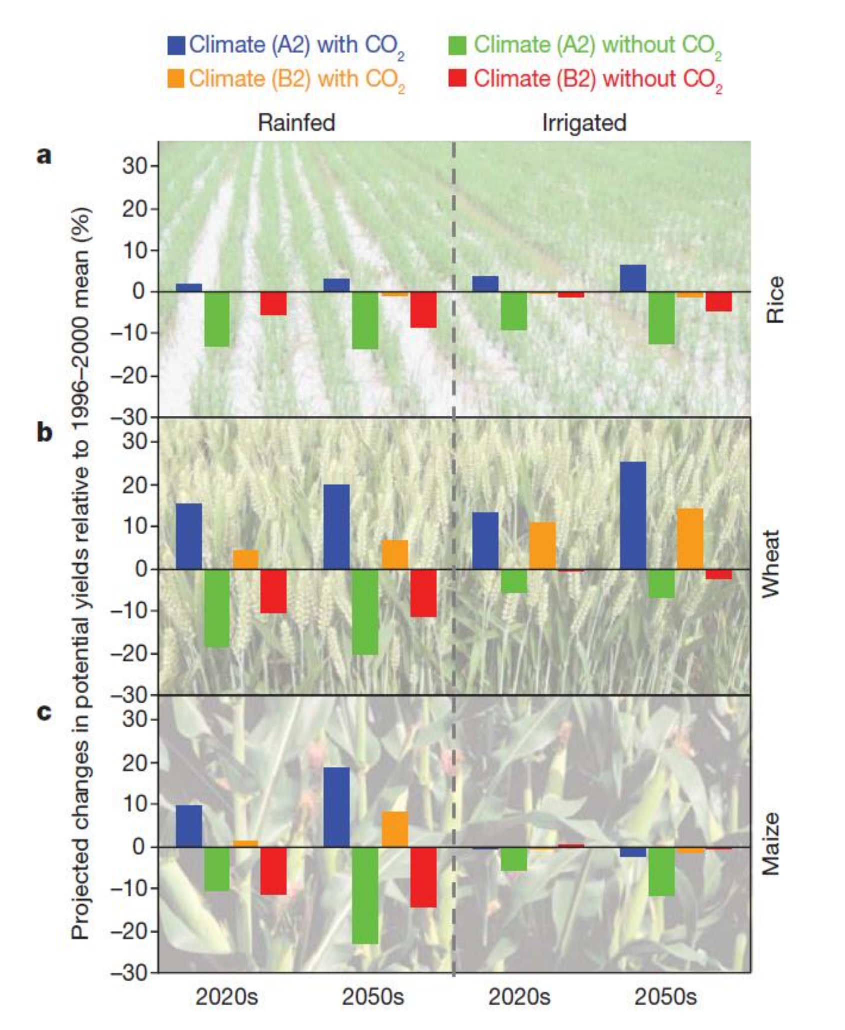
	Change in average yield (%)*					
	With CO_2 fertiliser effect			Without CO_2 fertiliser effect		
	2020s	2050s	2080s	2020s	2050s	2080s
A2: rainfed	2.1	3.4	**4.3**	−12.9	−13.6	**–28.6**
A2: irrigated	3.8	6.2	**7.8**	−8.6	−12.4	**–16.8**
B2: rainfed	0.2	−0.9	**-2.5**	−5.3	−8.5	**–12.7**
B2: irrigated	−0.4	−1.2	**-4.9**	−1.1	−4.3	**–12.4**

Decline in area of arable land by 13%

Wei X & Hui Ju

China's food production can deal with a 2° warming world
中国的粮食生产能适应变暖2度的世界吗

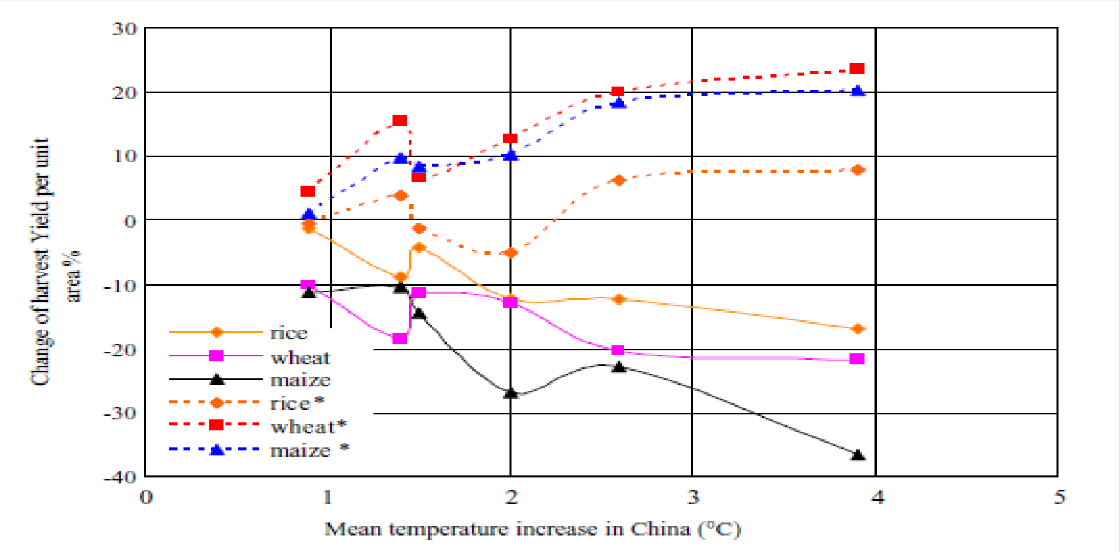
- 2度影响有限 A 2° warming has limited effects (less 5% even without CO_2 effect) on China's total food production
- 现在的技术可以适应Current adaptation can utilize this small warming and turns it to more grain
  - adjustment of sowing date,
  - switch of crop cultivars,
  - improved management practices,
  - redistribution of planting location)



Piao et al. 2010 Nature

Uncertain picture under a 4° C warming
变暖4度的结果难以预料

- A 4° C warming is projected to have no promising, with either large negative (without CO_2 fertilization) or small positive effects (with CO_2 fertilization).
- Interactions from other factors make the determination (CO2, Water, technology, etc.)



Xiong et al. 2007 Climatic Change

Increasing water scarcity in the future

未来水短缺加剧

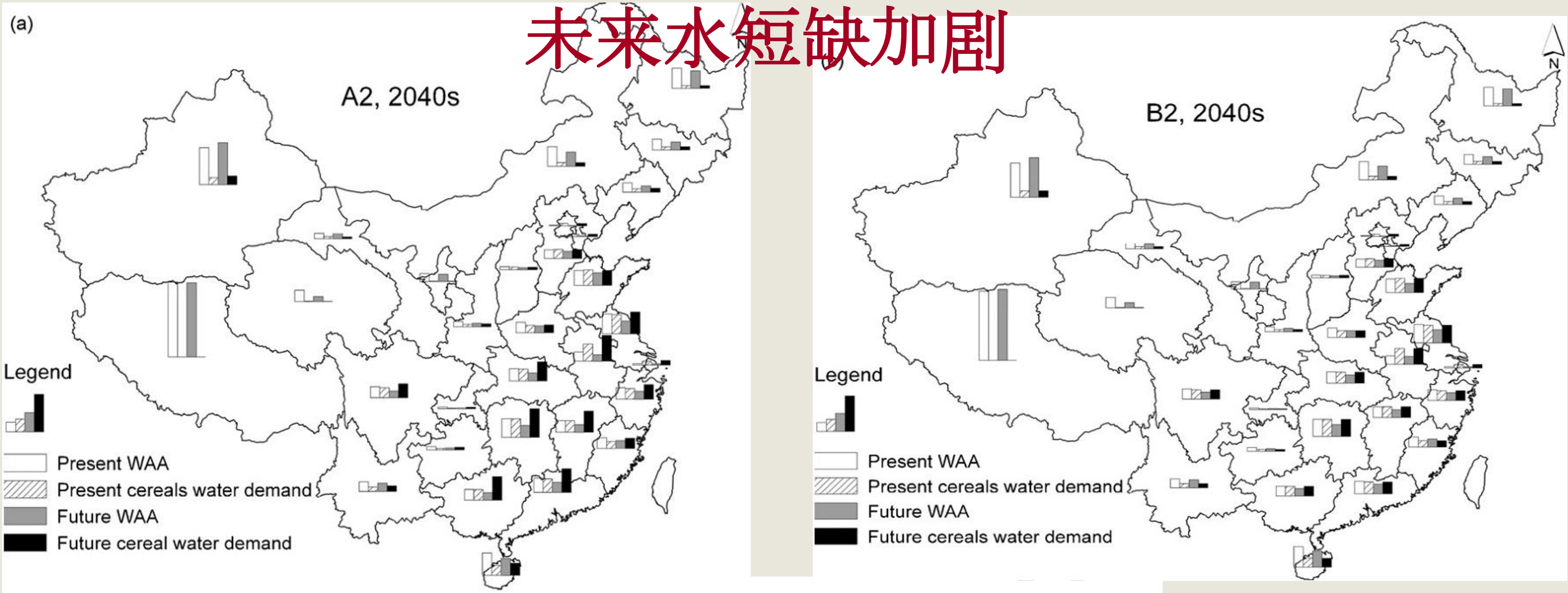
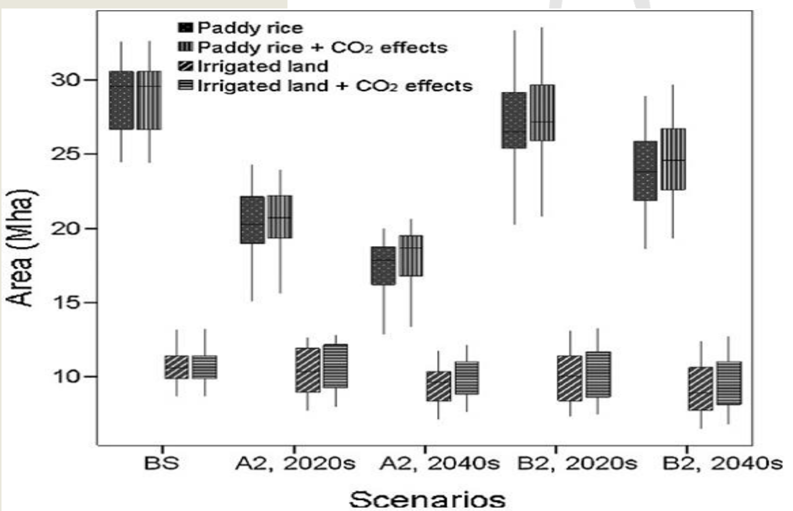


Fig. 6. Agricultural water availability for each province for the 2040s under A2, B2 and present (BS) (unit: Gm^3).

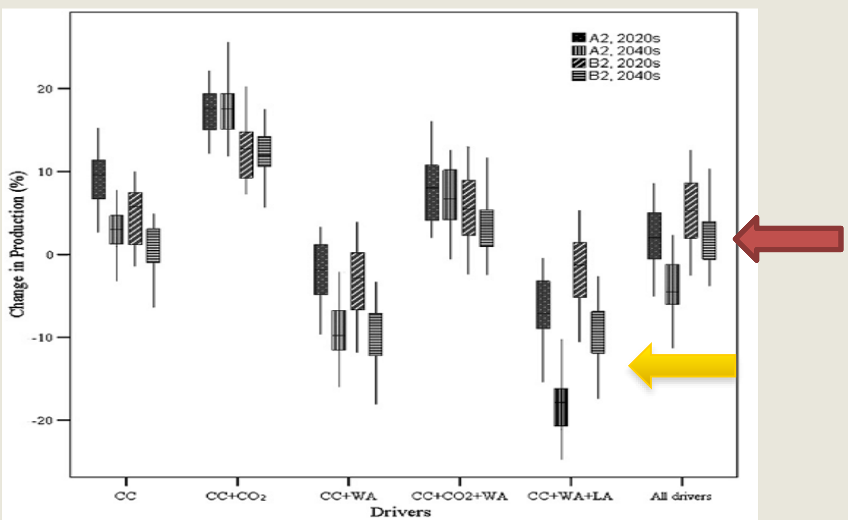


Changes in irrigation areas

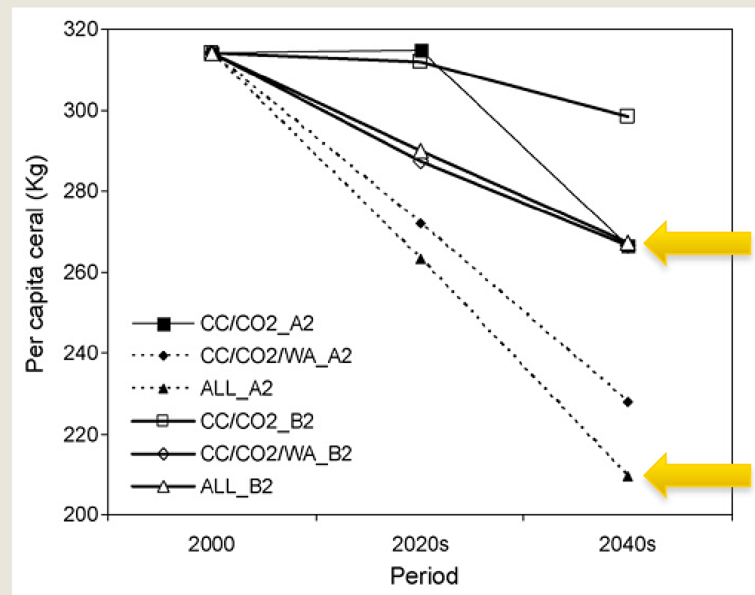
- Water could be one big barrier for future food production
- Decreased agricultural water availability will significantly reduce rice cultivation areas in the south

Food security combing other drivers
其他因子对粮食安全的影响

- Integrated assessment demonstrates the combining drivers pose slight positive to substantial negative effects on food production. (CO2++, Climate change--, Water availability---, land use change -, change in crop plantation areas+)
- Extreme events and diseases/pests will undermine the food production in some years and some areas.



Change in total cereal production under different combinations of drivers (CC, CO2, WA, LA, ALL) (Xiong et al. 2009. Global Envion. Change)



Changes in per capita cereal production under selected combinations of drivers

Impacts on different countries
气候变化对可能进口国农业的影响

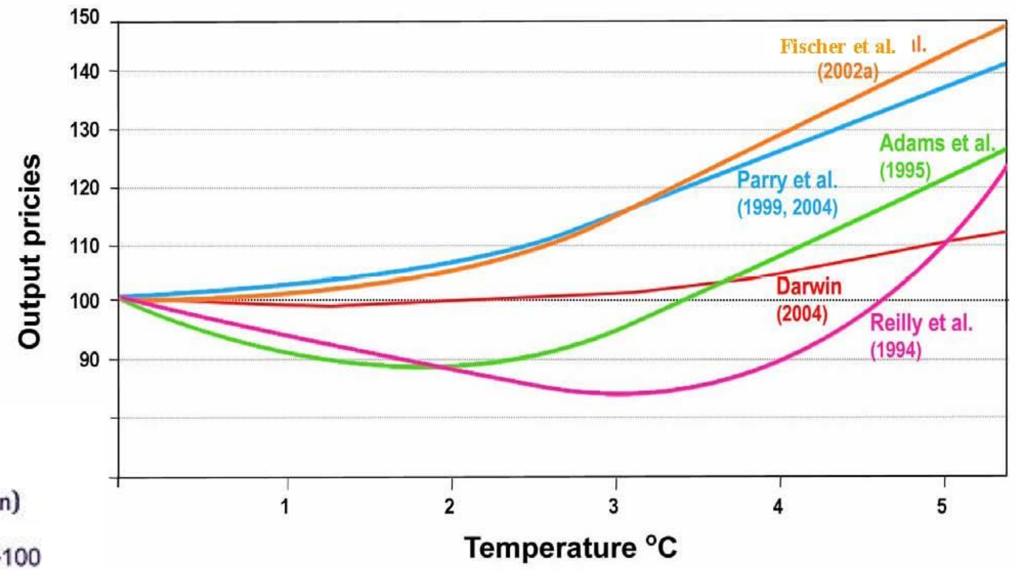
研究者	国家、作物	情景	年代	产量变化(%)
Nelson et al. (2010)	Global、 Maize/Rice	A1B	2050	-10/-1
Stockle et al. (2010)	US、Wheat	A1B	2040	winter19.5-29.5 spring-2.2~-5.6
Iglesias et al.(2012)	Europe: Atlantic North; wheat, maize, soybean	A2, B2; HadcM3	2080	-5 to +22
ECLAC. (2010)	Argentina、 Soybean	Precis –CO2(+CO2)	2080	-25~-14 (14~19)
Singh et al.(2002)	Canada、 wheat	2xCO2	2030	-20~-30
Anwar *et al.* (2007)	Australia, wheat	A2,B2	2080	-12~-29

With climate change food price rise can not be avoided?

随着气候变化粮价上涨不可避免

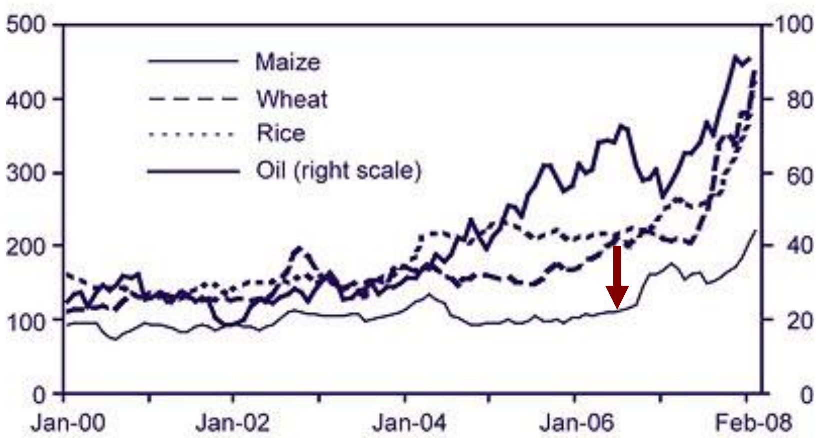
How adapt the price rise?

如何适应粮价上涨?



3: *Food prices (percent of baseline) versus global mean temperature change for major*

World Commodity Prices, January 2000–February 2008 (US$/metric ton)



Sources: FAO international commodity prices database 2008, and IMF world economic outlook database 2007.

温度变化	农产品价格变化
+1 to +2° C	–10 to –30%
+2 to +3° C	–10 to +20%
+3 to +5° C	+10 to +40%

粮食和林产品贸易会随着气候变化而增加，因为大部分发展中国家对粮食进口的依赖加大

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