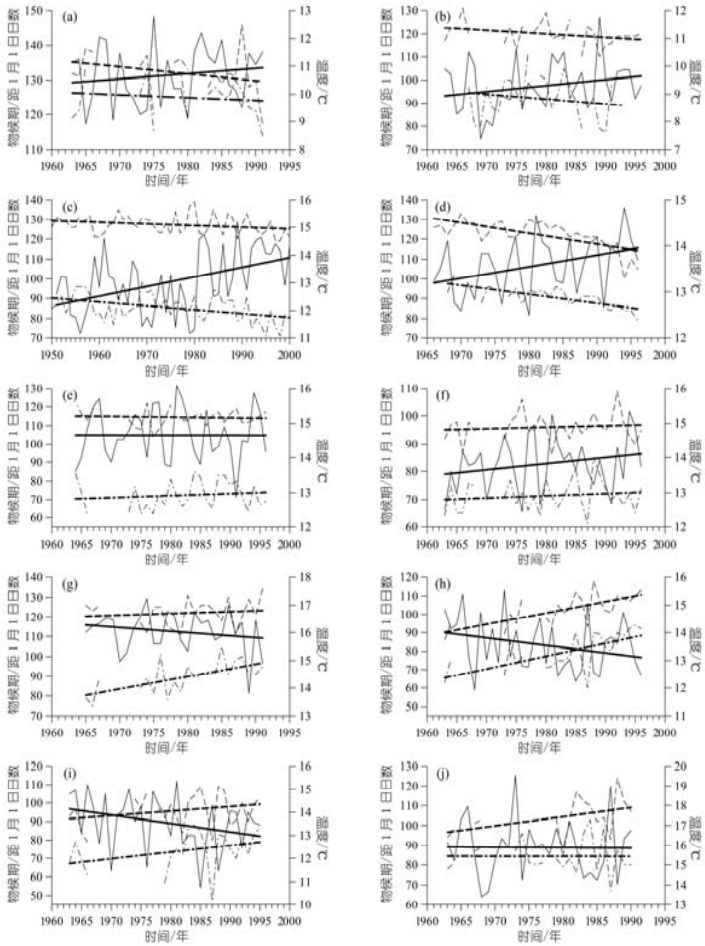
Climate Change: Impact on Agriculture and Building the Sustainable Adaptive Capacity

Lin Erda 林而达
CAAS, Beijing
China

Observed Impacts in China

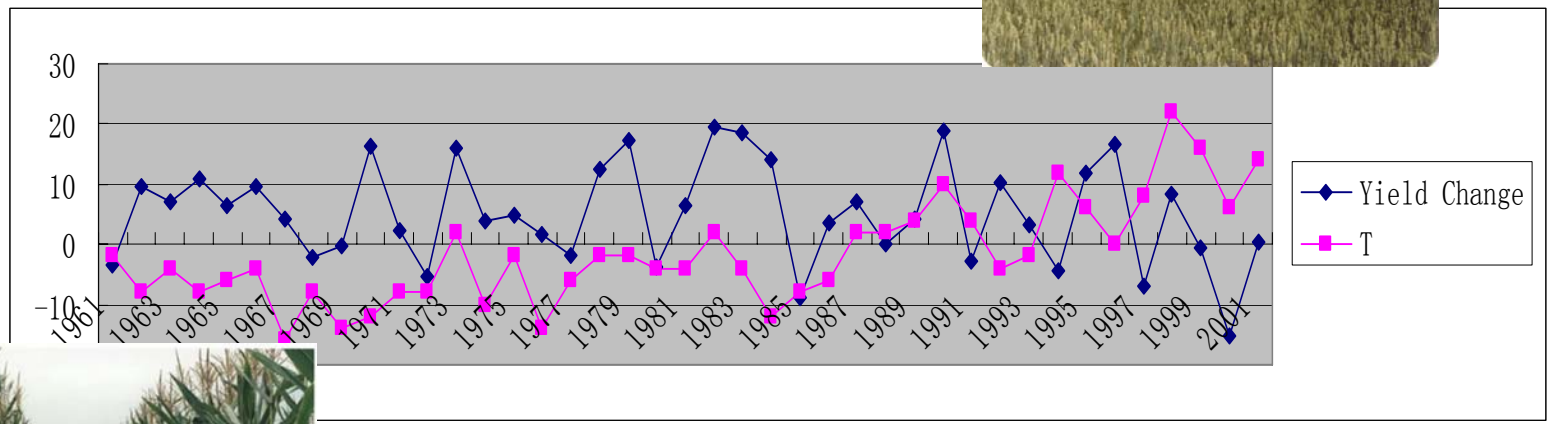


Recent trends in phenology and species dynamics *has shown that the distinct*

changes in temperature

Current sensitivity/vulnerability:

- Climate variability is a major determinant of fluctuations in the productivity of agricultural, forestry, and fisheries systems.

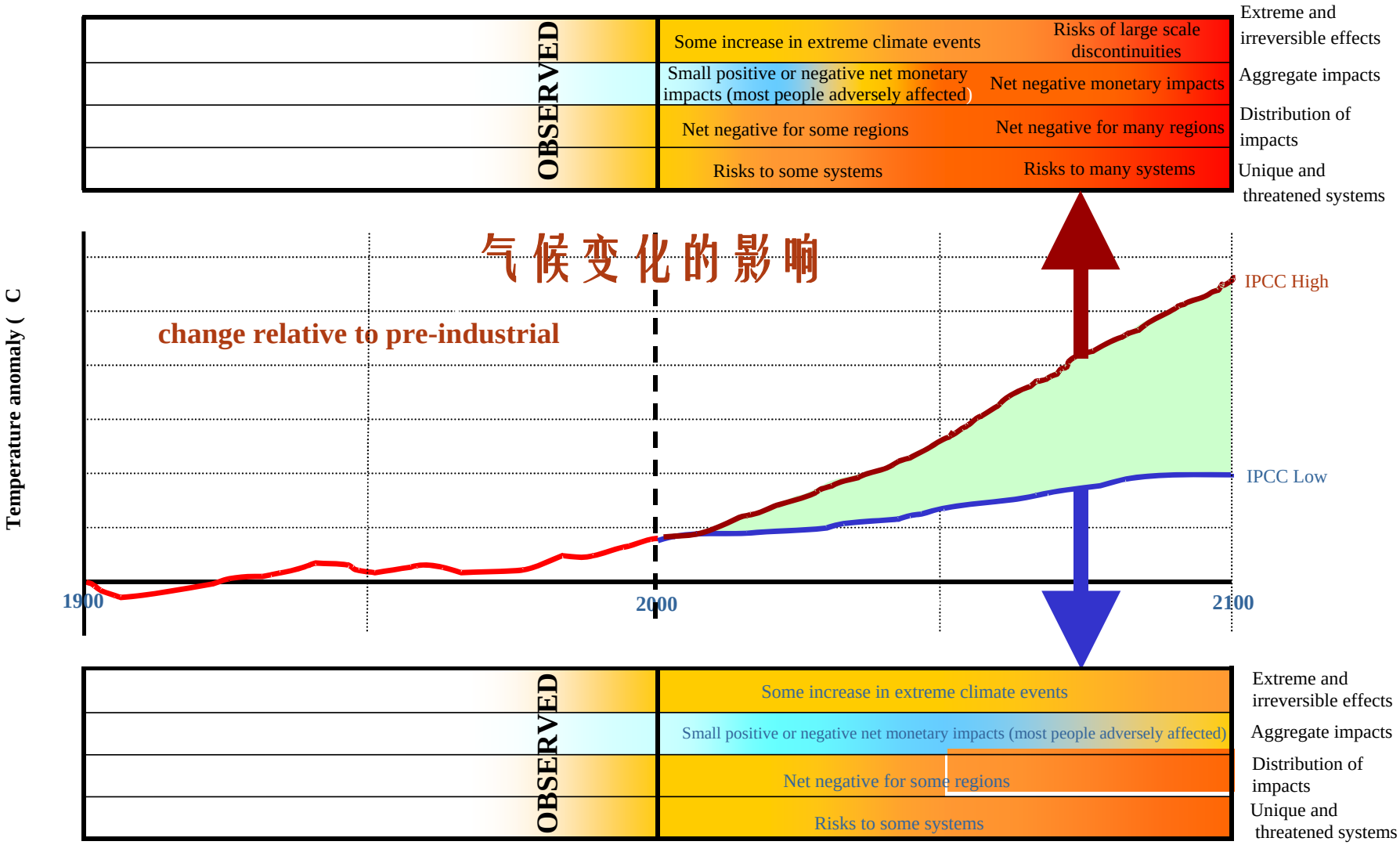


Article II of UNFCCC

气候公约的目标

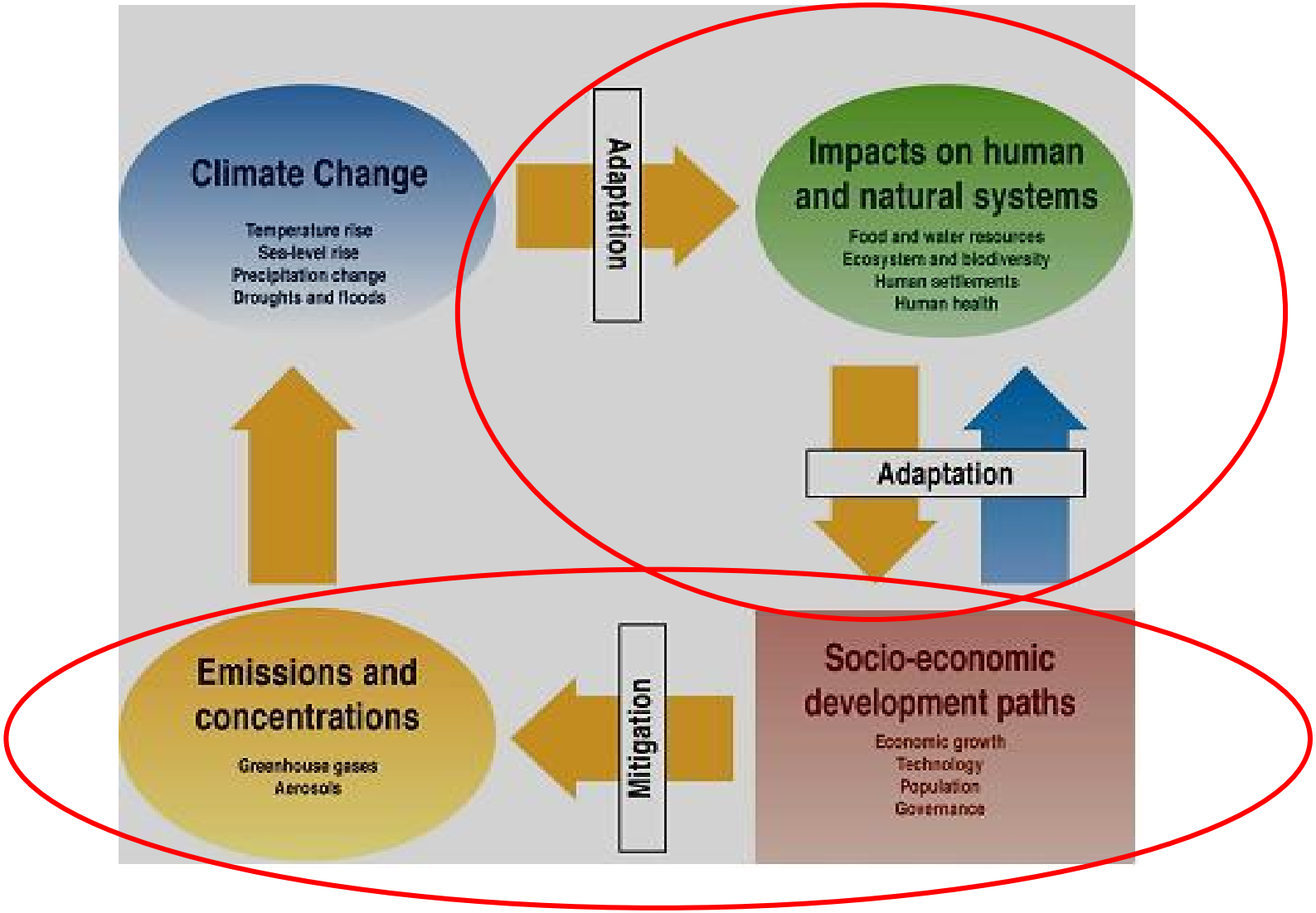
- The ultimate objective of this Convention…, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, **to ensure that food production is not threatened** and to enable economic development to proceed in a sustainable manner.

IMPACTS FOR HIGH WARMING SCENARIO



IMPACTS FOR LOW WARMING SCENARIO

Conceptual Framework

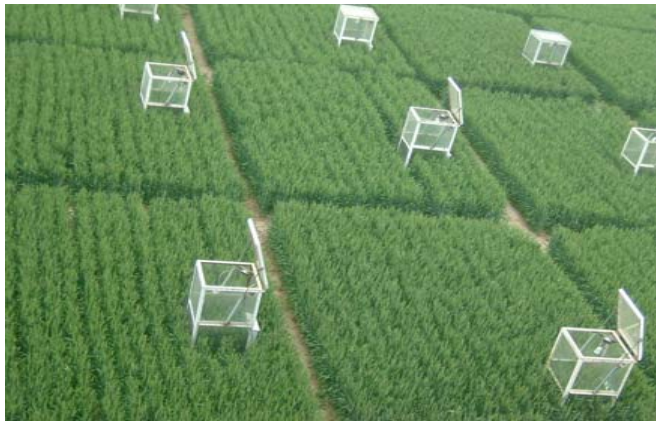


Resource: IPCC, TAR

Bilateral cooperation: Investigating the Impacts of Climate Change on Chinese Agriculture

UK/China

US/China



Australia/China

Canada/China

Progress

- The capacity of the Hadley Centre model to simulate the present climate in China has been validated with observed data.
- This has been used to develop climate change scenarios for China.

What is PRECIS?

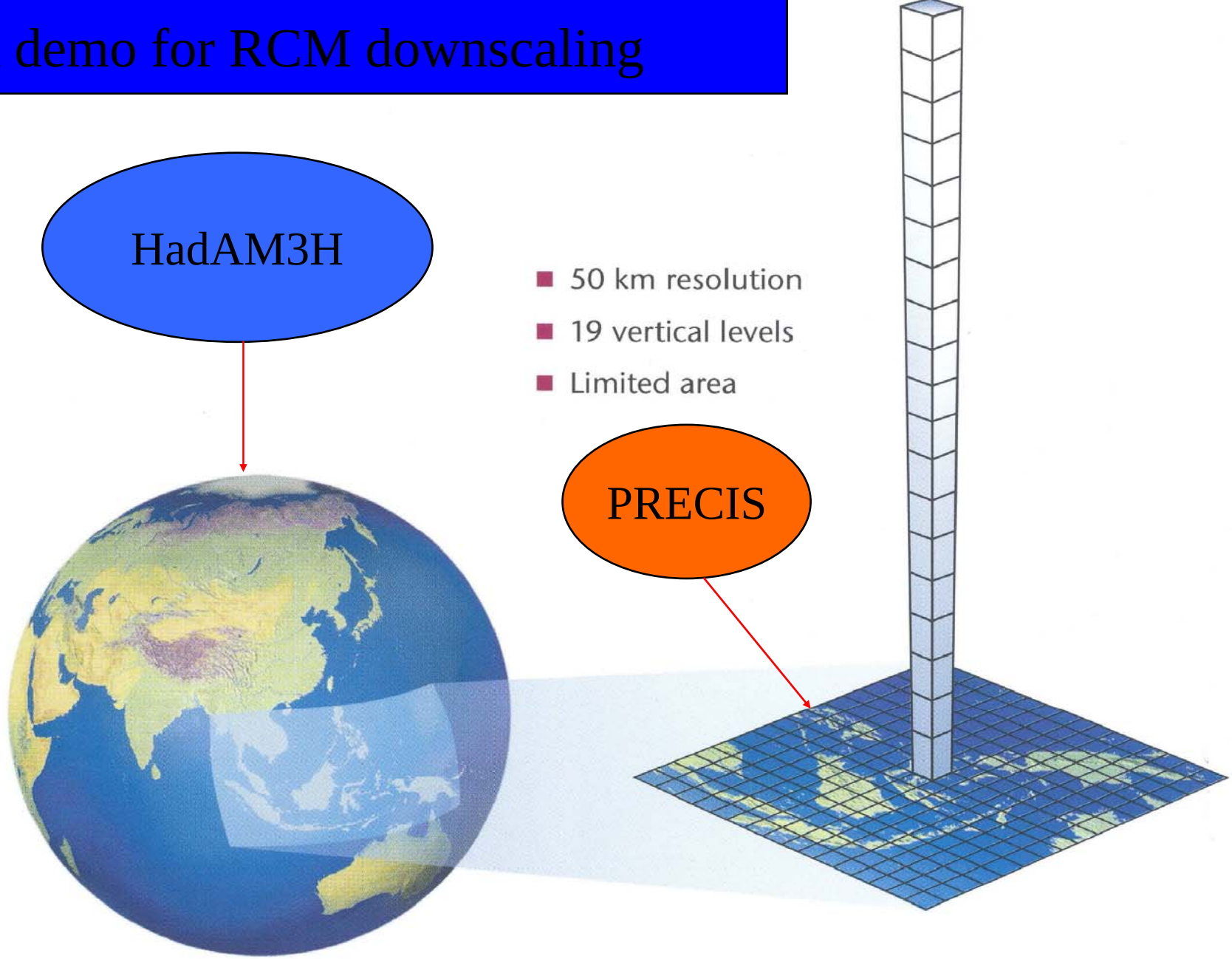
- PRECIS—Providing Regional Climates for Impacts Studies
- Purpose 1: to develop the regional-level SRES climate scenarios over the world
- Purpose 2: to provide the datasets for the impacts assessments of climate change at the regional-level

A demo for RCM downscaling

HadAM3H

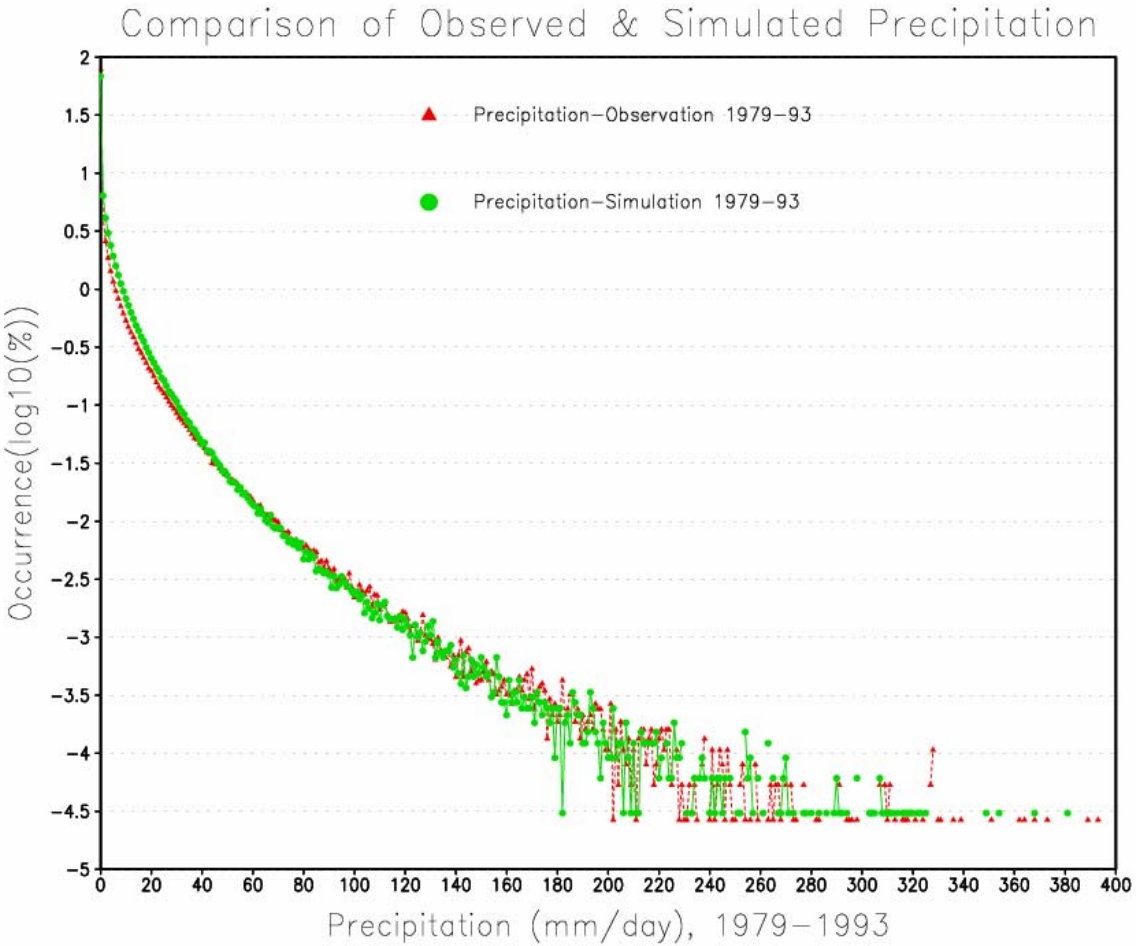
- 50 km resolution
- 19 vertical levels
- Limited area

PRECIS

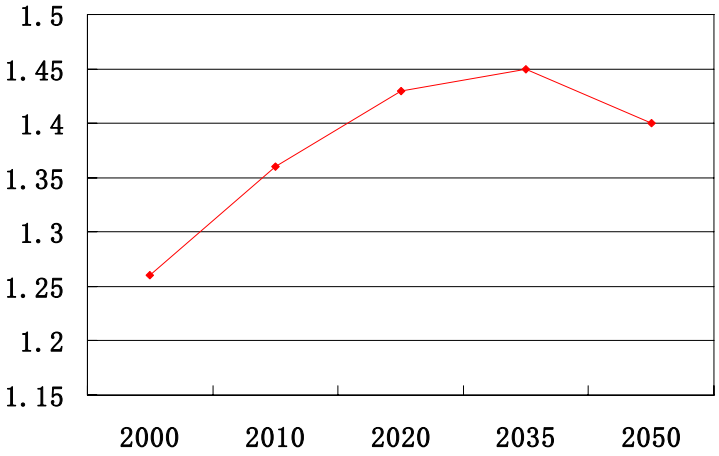


Schematic diagram of the resolution of the Earth's surface and the atmosphere in the Hadley Centre regional climate model.

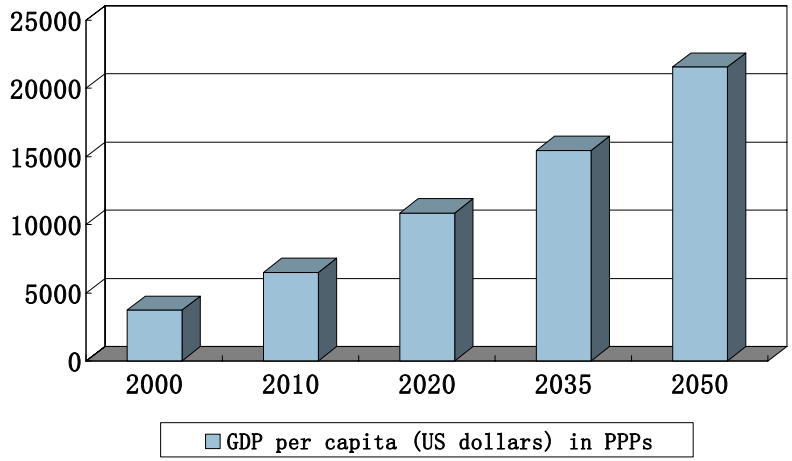
PRECIS has a strong ability to simulate daily precipitation



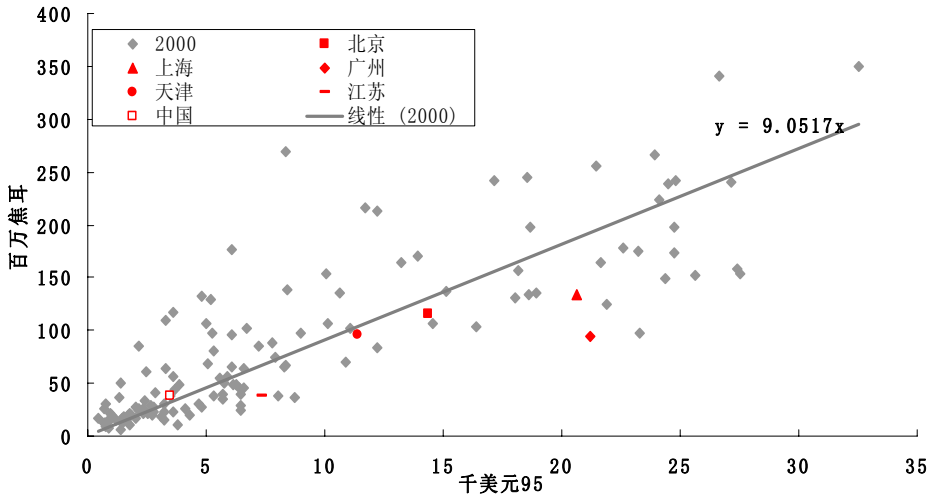
Population growth



Economic growth (GDP)



Energy consumption per capita and GDP

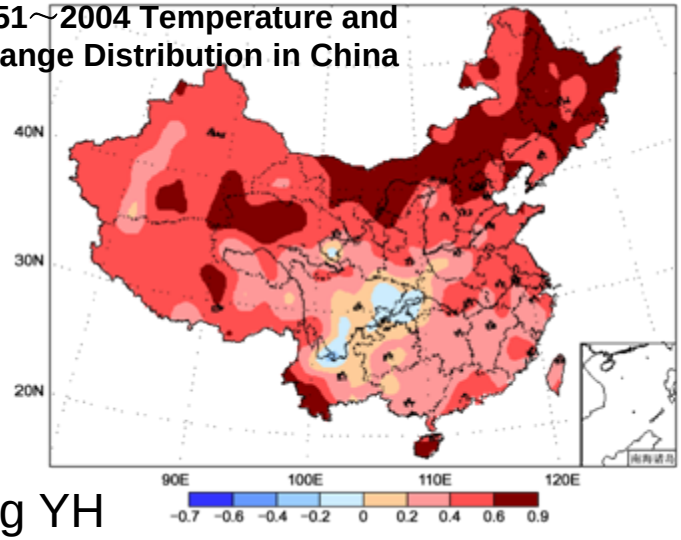


Xiaohua Zhang

Climate Change Scenarios based on

- · A2 –globally inhomogeneous economic development, with a continuous increase in the world's population and a medium-high rise in greenhouse gas emissions.
- · B2 – regional sustainable development, with a slower (but continuous) increase in the world's population and a medium–low rise in greenhouse gas emissions.

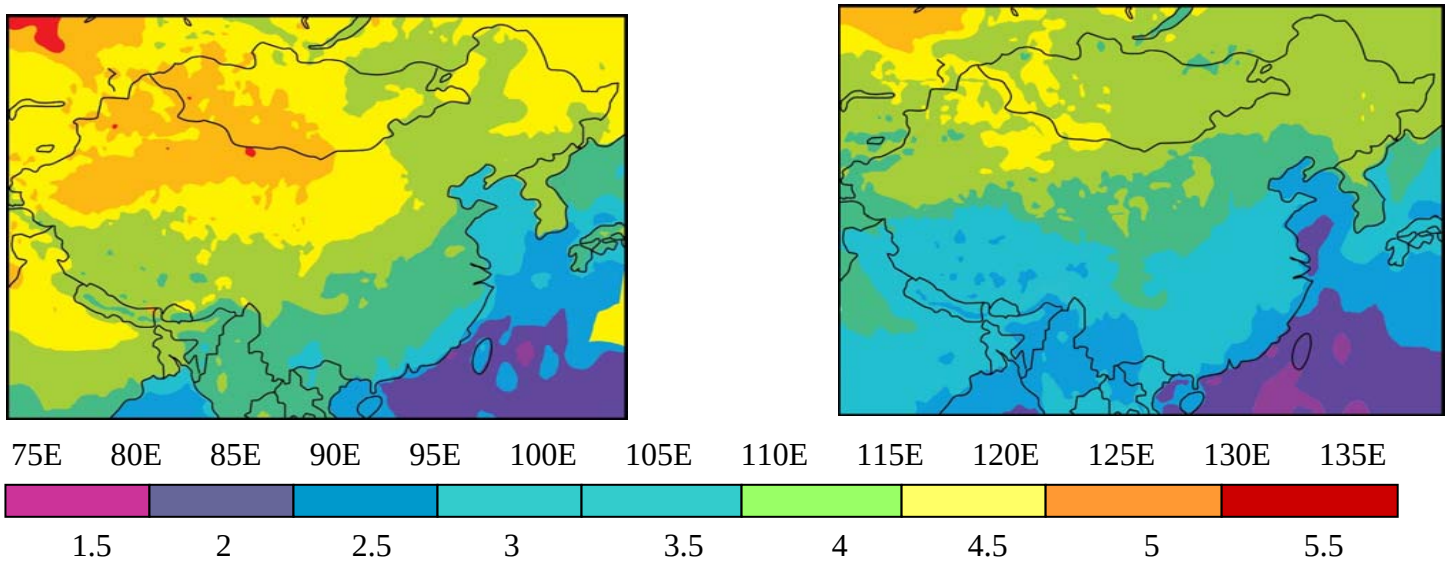
1951～2004 Temperature and Change Distribution in China



Ding YH

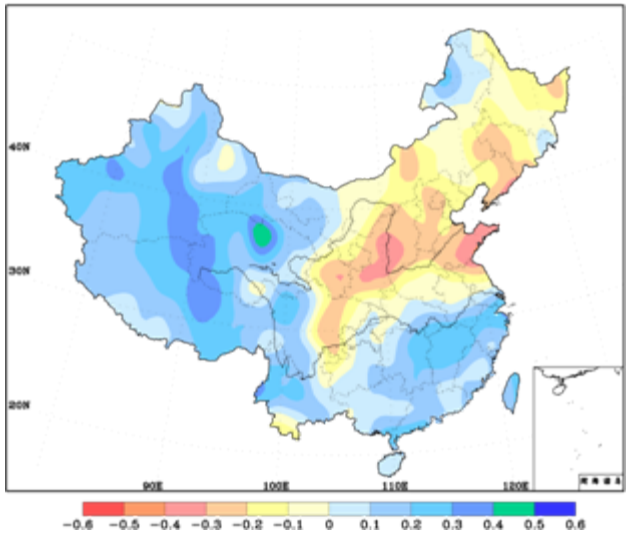
	A2 (medium–high emissions)			B2 (medium–low emissions)		
Time period	Temperatureincrease (°C)	Rainfall increase (%)	CO_2 (ppmv*)	Temperatureincrease (°C)	Rainfall increase (%)	CO_2 (ppmv*)
2010~2019	1.00	3.3	440	1.16	3.7	429
2040~2049	2.11	7.0	559	2.20	7.0	492
2070~2079	3.89	12.9	721	3.20	10.2	561

Xu Yl

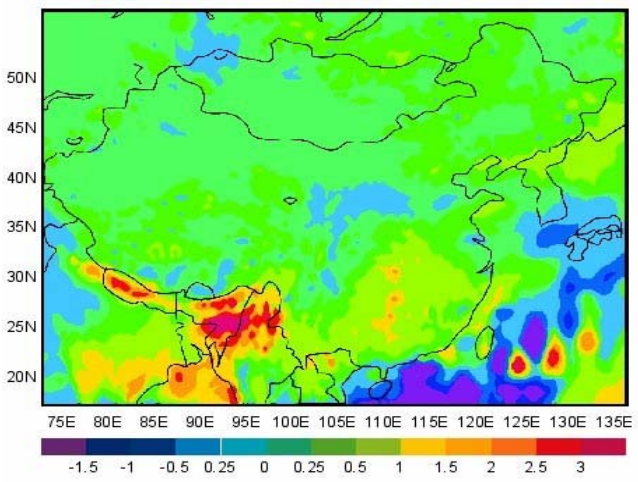


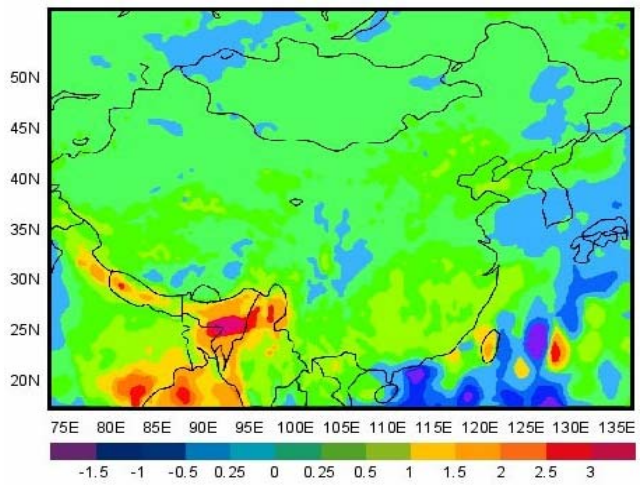
Simulated annual increase (℃) in mean temperature (Tmean) for 2071–2079 under SRES A2 & B2 scenarios from PRECIS relative to baseline (1961–1990)

Current and Future Precipitation



1956～2002 precipitation and Change Distribution in China (Ding YH)





Simulated average change in rainfall (mm/day) for 2071–2079 under SRES A2 scenarios from PRECIS relative to baseline (1961–1990) (Xu Yl)

Regional Crop Model

Input files

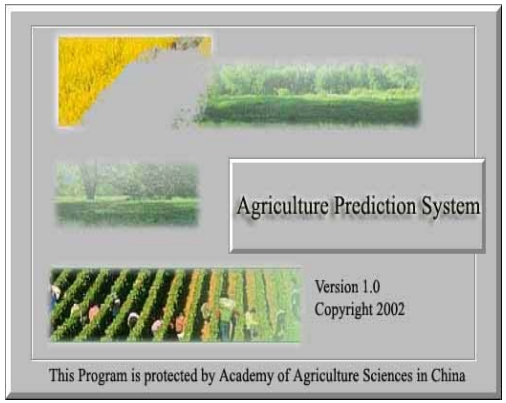
Soil polygon file

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

Output files

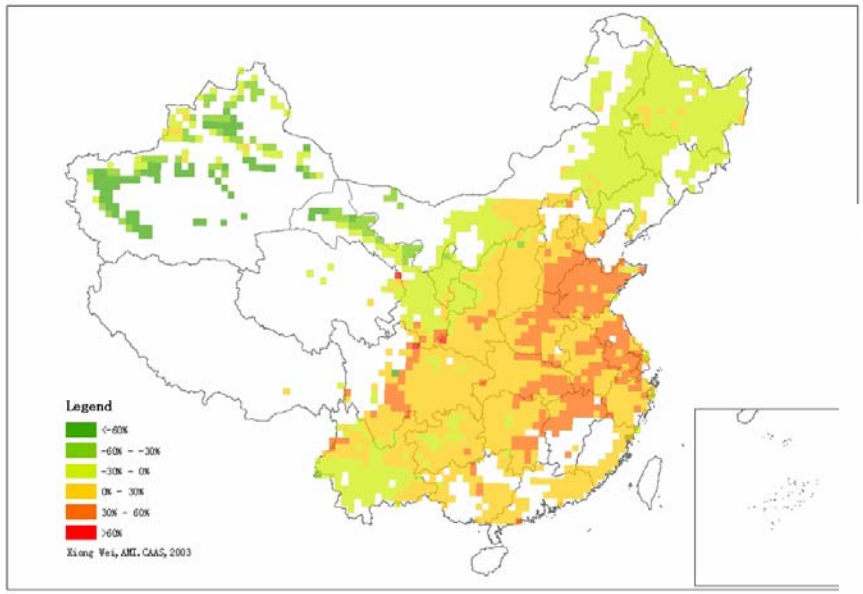
Biomass output

Water output

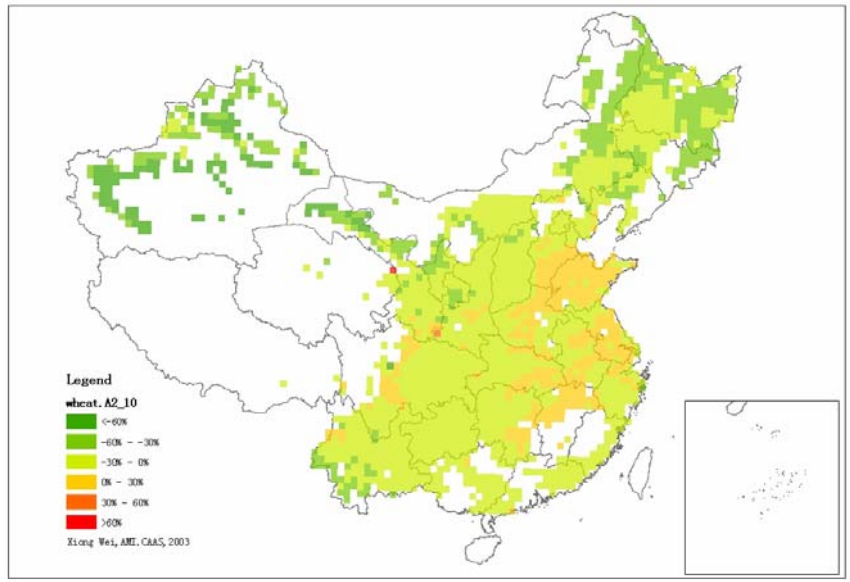
Growth output

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

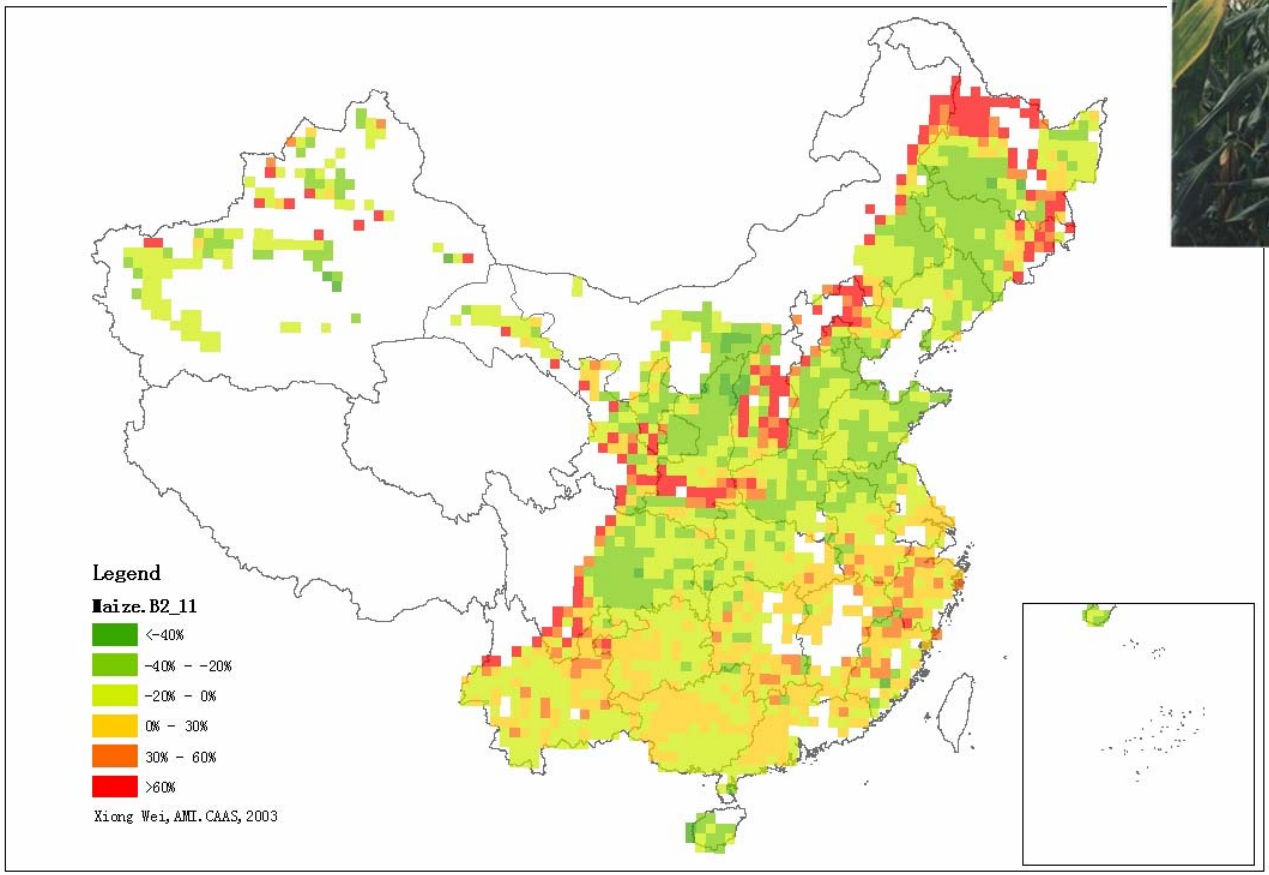
A2 rainfed



A2 irrigated



2080 Irrigated Maize Yield Changes under B2 Scenario



Projected changes in average maize yield compared with yield under baseline

	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

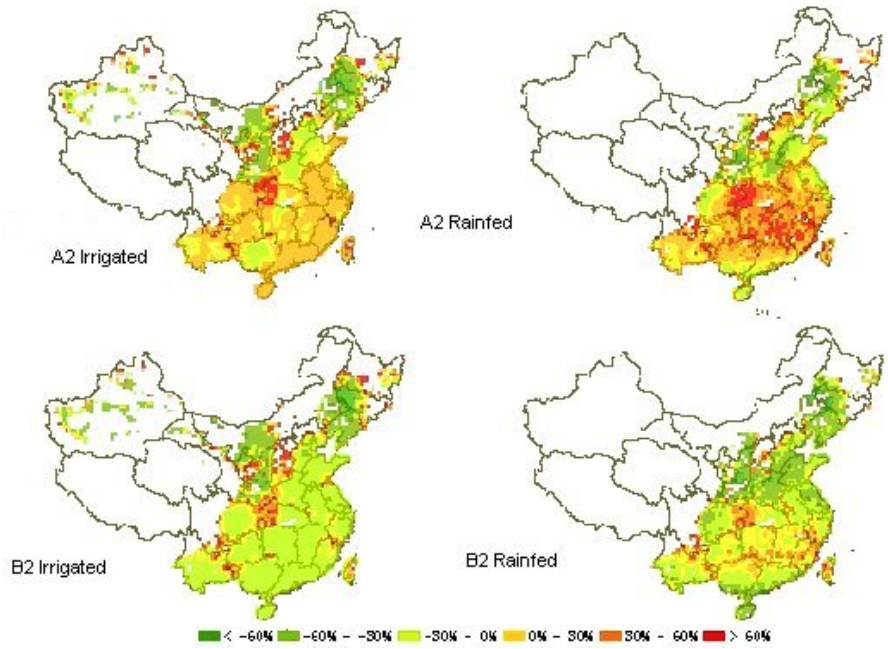
Adaptation can delay dangerous climate change

	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**

Projected changes in average Rice yield compared with yield under baseline

Adaptation in agriculture

Rice yields 2080s



Decline in area of arable land by 13%

- **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**

Hui Ju

Highlights of the Phase I

- Modelling suggests that climate change, without the effect of carbon dioxide (CO_2) fertilization, could reduce yields of rice, maize and wheat by 5~10% around, and up to 37% in the next 20 to 80 years.

Field Study on the Effect of CO_2 Fertilization on wheat production

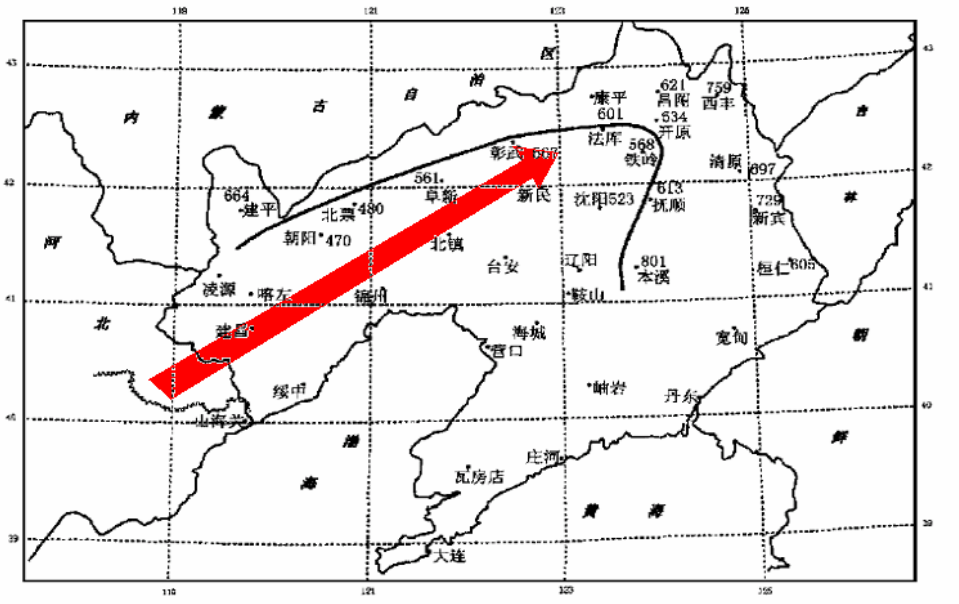
Using a CO_2 Gradient Chamber to simulate the influence of the different raised CO_2 concentration with the warming climate.

Long term treatments of high lever of CO_2 concentration are taking on wheat rice and maize generations

Interaction of 450, 550 and 650ppm CO_2 and 1-3℃ warming represents positive or adverse effects on these crops

Adaptation: changes of northern boundary of areas for winter wheat in the Northeastern China under current and future warming climate

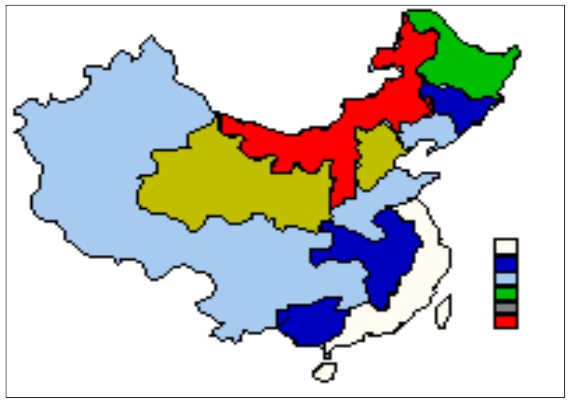
Current



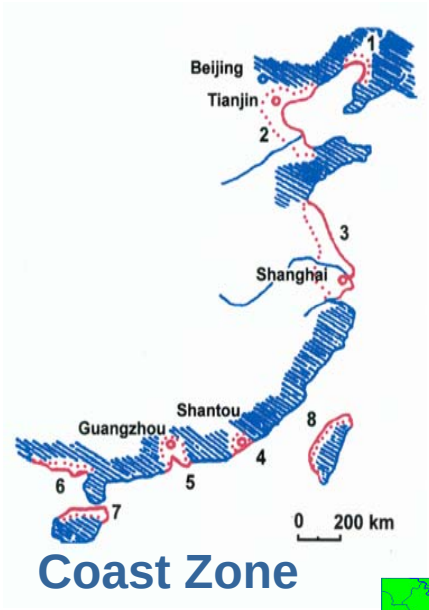
Future

Ju Hui Lin, E

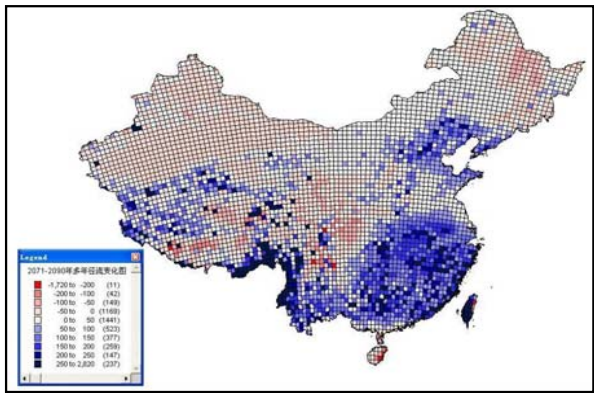
Regions with different Vulnerabilities



Agriculture



Coast Zone

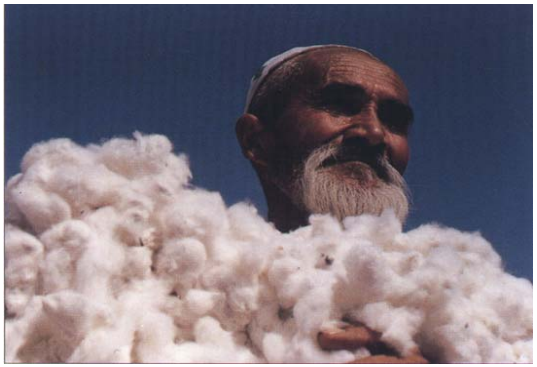


Runoff Changes

Phase II Study

Special emphases:

- Help policymakers understand the negative impacts of climate change on poorest groups.
- Ensure benefits for the poorest groups are optimized – identify appropriate adaptive options through participation.



Adaptation

- Increasing the capacity of subsistence farmers and local people to respond to climate aberrations and to adapt long-term to hotter, drier and most importantly more variable climates will very largely depend on improvements in institutions and policy, as well as understanding multiple processes of change

A Framework of Impacts in China

Warming	1~2℃(2020)	2~3℃(2050)	3~5℃(2080)
water	All regions balance	N China: -2% NW China: -3%; others: balance	N China: -1% NW China: -4%; others: balance;
Agriculture	additional water requirement; Cold disaster alleviated in NE China	Crop yield decrease 5~10%,variation among regions and crops ; 550 ppm CO2 increases C3 crop yield 17%; Adaptation increases all crops above baseline yield	CO2 fertilization effect of 560~720 ppm will set off a decrease of crops production due to the warming climate in 3.2~3.8℃,

Building adaptive capacity

Examples from the agricultural sector

- **Risk management**
  - In many dryland areas, changes in livestock composition, crops and livelihood strategies (e.g. diversification) have been observed
- **Early warning**
  - Early warning systems attempt to predict droughts and other climate events using remote sensing, climate modelling and GIS systems
- **Avoidance and tolerance**
  - Irrigation is a widespread technique that has allowed famers to avoid drought, drainage to avoid flooding
- **Risk mitigation**
  - Crop insurance can provide protection to farmers in the event that farm production is reduced by natural calamities

Building State Adaptive Capacity

- Development of rural infrastructure
- Improved monitoring, early warning and risk mitigation systems
- Enhanced climate awareness
- Diversification for risk management
- Reducing dependence on agriculture
- Increased adaptation research capacity
- Improved policy support; transition policies

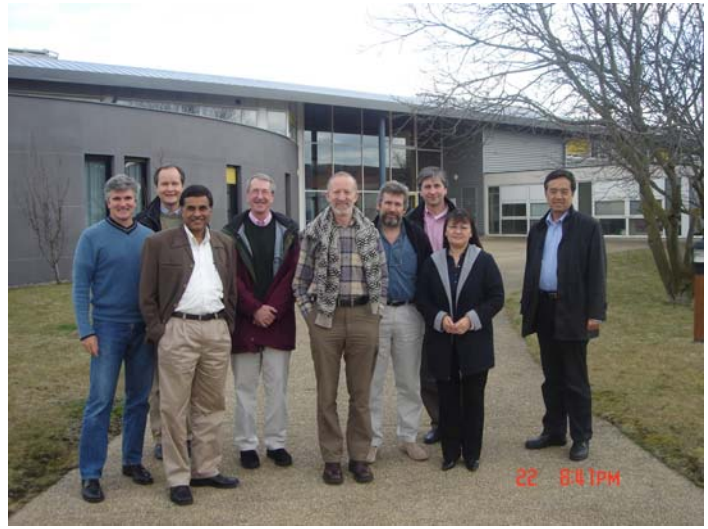
Climate change Impacts on World Agriculture: New results

research	country、crop	scenario	period	Yield change
M.L.Parry et al. (2004)	global、maize/rice	A1F1	2025-2080	-18/-10%
W E. Easterling (2003)	USA、maize	2-6.3 ℃	2025-2080	-2.5/-6.9% (-40%)
R.D.Sands et al. (2005)	USA、soybean/ wheat	2.5 ℃	2025-2080	-18.7%/-6.8%
Singh et al.(2002)	Canada、wheat	2xCO2	2030	-20%~-30%
Howden *et al.* (1999)	Australia, wheat	CSIRO 1996	2030	9%~37%

Possible new conclusion by IPCC Group

- **Moderate local increases in temperature (to 3°C) can have small beneficial impacts on rainfed crops and pastures in temperate regions**

  but even slight warming in seasonally dry and tropical regions reduces yield. Further warming has increasingly negative impacts in all regions.



Possible new conclusion 2

- **Crop model estimates of CO2 fertilisation are in the range of FACE results (mean of +15% at 550 ppm).**
- **Climate changes increase irrigation demand in the majority of world regions—this combines with expected reduced water availability to challenge food availability in some regions**

Possible new conclusion 3

- **There are multiple adaptation options that imply different costs, For example in cereal cropping systems, changing varieties and planting times enable avoidance of a 10-15% reduction in yield.**

Thank you