chinese agriculture

Summary

Understanding how China's climate may change in the future

The project, *Impacts of Climate Change on Chinese Agriculture*, sought to understand how climate change will affect agricultural yields and how agriculture could adapt to climate change.

Phase I (2001–2004) of this joint UK/China collaboration examined the impact of climate change on crop yields. Phase II (2005–2008) built on this work to investigate the impacts of climate change on national cereal production and the cereal quantities available to each person in China to 2100. This pamphlet gives an overview of the main findings of Phase II relating to the development of future climate scenarios for China. The results represent the state-of-the-art in assessments of climate scenarios.

Developing scenarios of future climate change for China

The response of cereal crops to future climate change is a major concern in China where food production is a fundamental component of its economy. But to plan effectively for climate change we need to develop descriptions of how we think the climate may change in the future. The most widely used and best way of doing this is to use results from computer models of the climate system.

Many uncertainties remain about how the climate will respond to increasing concentrations of greenhouse gases and we do not yet have definite predictions of future climate change. When we use the terms 'scenarios' or 'projections' in this pamphlet, they do not refer to predictions or forecasts of future climate but describe a range of plausible future climate conditions.

We present climate change scenarios for China in two ways:

- A regional climate model, PRECIS (Providing Regional Climates for Impacts Studies), developed by the UK Met Office Hadley Centre, is used to provide detailed maps and statistics of climate change across China during the 2020s (2011-2040), 2050s (2041-2070) and 2080s (2071-2100).
- We computed the average of the values for potential changes in temperature and precipitation (rainfall) during the 2020s and 2050s for China given by different global climate models from research institutes around the world, most of which are used in the 2007 Intergovernmental Panel on Climate Change (IPCC) assessment. We then compared these 'multi-model' averages with the values from PRECIS.

Climate scenarios from the regional climate model PRECIS

The speed and magnitude of future climate change depend on the rate of emissions of greenhouse gases. Because the level of future emissions is uncertain, we used two emission scenarios developed by the IPCC (for full definitions see *Special Report on Emissions Scenarios, IPCC, 2000*):

- **A2 scenario**: medium-high emissions from a continuously increasing global population
- **B2 scenario**: medium-low emissions and lower population growth

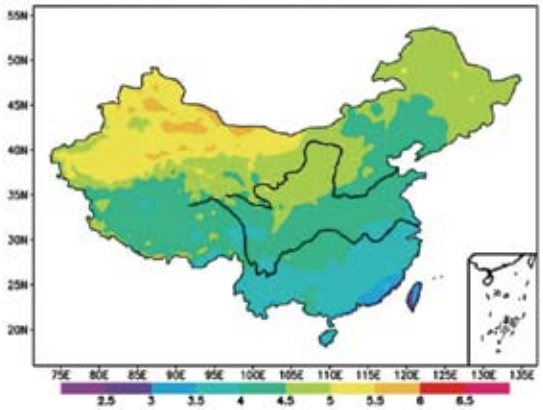
These emission scenarios for greenhouse gases incorporate different possible social, economic and technological developments and have been widely used in the analysis of climate change impacts and possible approaches to alleviate these impacts.

We used the A2 and B2 scenarios with PRECIS to develop future climate change scenarios in China for the 2020s, 2050s and 2080s (Table 1- *right*). The changes increase in magnitude as we move further into the future, and the two emissions scenarios give similar results until around the 2050s, after which A2 warms at a greater rate.

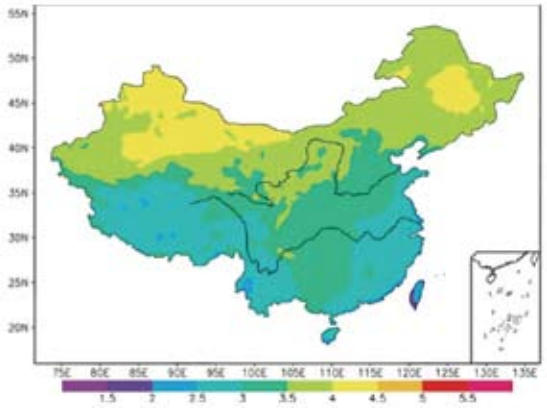
The changes in annual temperature and precipitation over China for the two scenarios for the 2080s compared with current conditions are shown in Figure 1.

In general temperatures increase more in the north and west and the largest precipitation increases are in the south.

Figure 1: Changes over China from PRECIS simulations for the 2080s relative to the baseline period (1961-1990)



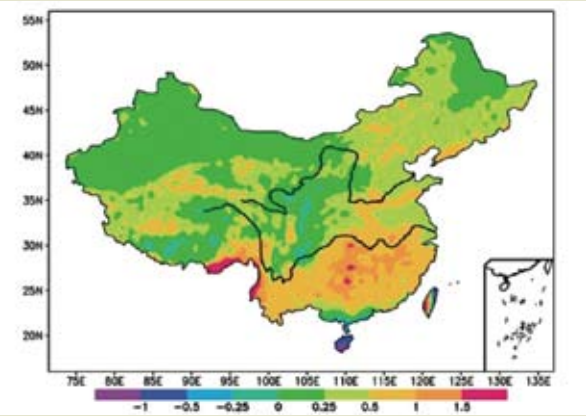
(a) Changes in mean annual temperature (°C) under the A2 scenario (medium-high emissions)



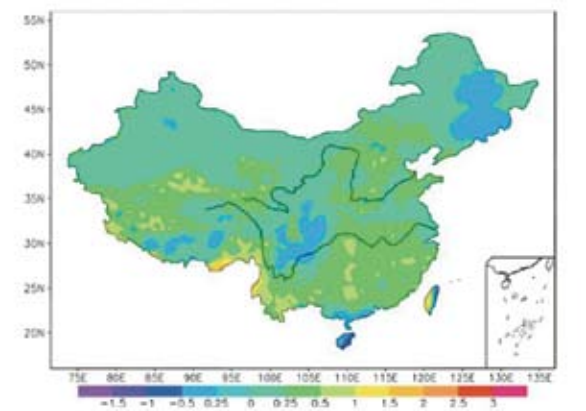
(b) Changes in mean annual temperature change (°C) under the B2 scenario (medium-low emissions)

Table 1: Future changes in annual temperature and precipitation for all China using PRECIS (relative to the average during 1961-1990)

Period	A2 scenario (medium-high emissions)		B2 scenario (medium-low emissions)	
	Temperature change (°C)	Precipitation change (%)	Temperature change (°C)	Precipitation change (%)
2020s	1.3	+5	1.5	+4
2050s	2.6	+10	2.4	+6
2070s	4.5	+17	3.4	+9



(c) Changes in mean annual precipitation (mm/day) under the A2 scenario (medium-high emissions)



(d) Changes in mean annual precipitation (mm/day) under the B2 scenario (medium-low emissions)

Looking at changes in the frequency and magnitude of extremes of weather, PRECIS shows:

- **An increase in the number of days where the maximum temperature exceeds 25°C**
- **A lengthening of the growing season**
- **A fall in the maximum number of consecutive frost days throughout China**
- **Both minimum and maximum temperatures show increasing trends**
- **Extreme precipitation events tend to increase across most of China**

Climate scenarios from the multi-model average

Using the A2 scenario (medium-high emissions), we compared the results from PRECIS with a 'multi-model' average – the average across 17 other recognised global climate models.

For the 2020s, the annual multi-model average warming of the whole of China is 1.2°C; regional differences vary by roughly 0.7°C, with slower warming in the south and east and the most rapid warming in the west. By the 2050s, the multi-model average annual countrywide warming is 2.4°C.

For annual precipitation, the multi-model average increases by +1% for the whole of China by the 2020s, with regional changes varying from -3% in the south to +4% in the west.

By the 2050s, the multi-model average increase for the whole of China is +4% and regional differences vary from -1% in the south to +7% in the west.

How do scenarios from PRECIS compare with the multi-model average?

Overall we found that:

- PRECIS produces warming similar to the multi-model average for China.
- PRECIS produces wetter conditions than the multi-model average for China. For example, for the 2020s, PRECIS increases precipitation by 5% and the multi-model average increases it by 1%.

Thus there is high confidence that China's climate will continue to warm as the century progresses and medium confidence that precipitation will increase across most of China in nearly all seasons.

KEY FINDINGS

- **Substantial warming throughout the century is projected under both emissions scenarios.** Up to the 2020s, the rate of warming under the B2 scenario (medium-low emissions) is faster than under the A2 scenario (medium-high emissions), i.e. an annual temperature increase of 1.5°C compared with 1.3°C (relative to the mean annual temperature 1961–1990). After that the rate of warming slows down under the B2 scenario (though temperatures are projected to continue to increase steadily) and accelerates under the A2 scenario. Hence the A2 scenario gives more extreme warming in the long term; by the 2080s, the annual temperature increase is 4.5°C compared with 3.4°C under the B2 scenario.
- **Precipitation is projected to increase gradually and substantially under both scenarios.** Up to the 2020s, precipitation increases are very similar (about 5%). From then onwards, precipitation increases more rapidly under the A2 scenario; during the 2050s, it is projected to be 10% higher in any one year in the 2050s and 17% higher in the 2080s than an average year during the baseline period of 1961–1990. Under the B2 scenario, precipitation increases are more moderate, reaching only 6% in the 2050s and 9% by the 2080s.
- **PRECIS predicts significant seasonal and geographical variations in the impact of climate change in China as the century progresses.**

CONCLUSIONS

Projections suggest that the climate in all parts of China will continue to warm, possibly by as much as 4.5°C by the 2080s (relative to the mean annual temperature for 1961-1990). Climate models indicate that there will be a consistent and progressive shift to wetter conditions, although some seasons and regions will have moderately drier conditions in the 2020s.

There is considerable uncertainty about the detail of future climate change, especially in how the frequency and magnitude of extreme events will evolve. We have high confidence that heatwaves, temperature extremes and precipitation intensities will increase. The rates of warming are unprecedented in human history and, together with other shifts in China's climate, will lead to significant physical and socio-economic impacts across the country. Other pamphlets in the series explain these potential impacts in relation to crop production and water availability in China.

Key topics for future climate research in China include:

- The reasons for differences between climate model projections for China.
- The causes of, and the ability to model, seasonal and decadal (ten years) variations. This will help to improve the management of natural resources and decision-making on adaptation policies.

FURTHER INFORMATION

The full report, *National Level Study: The impacts of Climate Change on Cereal Production in China*, together with all the other reports and six summary pamphlets from the project, are available from the project website **www.china-climate-adapt.org** .

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