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Dangerous Level of Climate Change and Building the Adaptive Capacity for Sustainable Development

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Abstract: The key vulnerability and dangerous level of climate change are hot issues in current international climate change research. This paper briefly outlines the basic concept of dangerous climate change and its uncertainties to determine quantitatively the dangerous anthropogenic interference with the climate system. Simulation results suggest that a 2.2−3.9℃ warming in next 50−80 years with adaptation will not threaten wheat and maize production severely. To mitigate or avoid dangerous climate change, the strategy of adaptation is suggested for regional sustainable development in China.

Key words: climate change; sustainable development; adaptation; dangerous level

Introduction

In recent years the discussion of dangerous level of climate change has drawn extensive attention in the world. There were a series of symposiums on stabilizing atmospheric greenhouse gases concentration and avoiding dangerous climate changes in Europe. On the workshop held in Beijing in Oct. 2004, scientists from Potsdam Institute for Climate Impact Research (Germany) proposed a view point that a global mean warming above 2℃ is a dangerous level, risks would increase very substantially, and socio-economic damages increases. Scientists of DEFRA (UK) and WBGU (Germany) summarized different responses of natural ecosystems and socio-economies to different temperature rising in 2005. Chinese scientists are also carrying out the study on key vulnerability and integrated assessment. The staggered new findings have been gotten [1−4].

Because it is difficult to make exact prediction for climate change, and socio-economic and technological development, which are main factors for determining the dangerous level, so the current conclusions of dangerous level contain larger uncertainties, even the impacts of climate change is likely to be felt most severely in the majority of developing countries of Asia because of resources and infrastructure constraints.

Based on relevant studies, this paper briefly outlines the basic concept of the dangerous level of climate changes and the uncertainties in determining quantitatively the dangerous anthropogenic interference (DAI) with the climate system. It also discusses the relationship between adaptation and dangerous level of climate change, and the assessment of key vulnerability and the dangerous level of climate change. The roles of scientists and policy makers in the complex domain of science and policy should propose some suggestions for sustainable development in China.

1 Dangerous level of climate change

The term of dangerous climate change comes from Article 2 of UNFCCC−Objective: "The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the 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." There-

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fore, dangerous climate change is a value judgment of policy makers. The criterion will change on different position. Even though there is no common criterion to determine the dangerous climate change, some cardinal principles can apply, for example, a) universal human rights, b) needs of future generations (sustainable development). In addition, science can provide the basic, e.g., what kind of impacts and damage will occur in future? And we want to know whether the impacts of climate change will threaten the food security, ecology security and sustainable development. It is likely that the method of critical value as threshold is currently the rage, but it is difficult to set a reasonable threshold as dangerous, because it is limited by more completed factors, such as initial conditions, boundary influence and its damage, costs or valuation, irre-versibility and adaptation, mitigation options, and so on.

2 Uncertainties

Recently studies suggest that northeast China can adapt to the climate change and benefit from the past warming, but future climate change might be more pronounced than one currently projected. The assessments of impacts on agriculture, water, ecological systems and coastal areas have got larger progress, but the impacts include both climate change and other direct human activities, most of them are difficult to discriminate, and more important is that there are a lot of uncertainties in future climate change, socio-economy and technique developments, so only some simulated results are not enough to get the quantitative conclusions of dangerous climate change. Even if a threshold of temperature change for adverse impacts can be determined, the GHG concentration threshold still cannot be determined exactly, because of uncertainties caused by different emission scenarios of different development models. Figure 1 gives the relations between global mean temperature changes and CO_2 concentration under different emission scenarios by GCM simulation. It is shown that there is no simple linear relation, the CO_2 concentration may reach 530−850 mL/m^3 or more when temperature raising 3℃.

3 Adaptation measures and dangerous level

The function of adaptation may be considered as delaying the occurrence of dangerous climate change or raising the dangerous level, and even avoiding it. Table1 and 2 summarized the wheat and maize yield changes of China simulated by CERES crop models driven by PRECIS

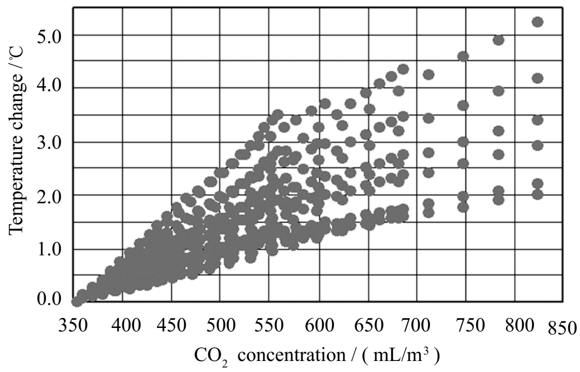

Fig.1 Global mean temperature changes (relative to 1961−1990) and CO_2 concentration under different GHG emission scenarios (IPCC TAR Draft)

regional climate scenarios [5−6]. Results of the tables show that without adaptation (rainfed and no CO_2 fertilization), under 3.9℃ warming (2071−2080), the wheat yield will only decrease 2.7%−3.2% more than those under 1℃ warming (2011−2020) with A2 and B2 Scenarios, respectively, and the maize yield will decrease 16%−26% more in the same situation; however, with adaptation, e.g. CO_2 fertilization can be realized via water and nutrient supply sufficiently, food production will not be threatened by warming in next 80 years.

Table 1 Projected changes in average wheat yield adopted adaptation of CO_2 and irrigation compared with yield under baseline

Scenarios	Change in average yield /%					
	With CO_2 fertilization			Without CO_2 fertilization		
	2020s	2050s	2080s	2020s	2050s	2080s
A2: rainfed	15.4	20.0	23.6	−18.5	−20.4	−21.7
A2: irrigated	13.3	25.1	40.3	−5.6	−6.7	−8.9
B2: rainfed	4.5	6.6	12.7	−10.2	−11.4	−12.9
B2: irrigated	11.0	14.2	25.5	−0.5	−2.2	−8.4

Table 2 Projected changes in average maize yield adopted adaptation of CO_2 and irrigation compared with yield under baseline

Scenarios	Change in average yield /%					
	With CO_2 fertilization			Without CO_2 fertilization		
	2020s	2050s	2080s	2020s	2050s	2080s
A2: rainfed	9.8	18.4	20.3	−10.3	−22.8	−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

The effects of elevated CO_2 and other factors on crop yields are well understood. In terms of final food, the increasing range of observed responses under elevated CO_2 is about 0−50%, due to differences in species, sector and management regimes interactions, and modulated optimal leaf responses. It is shown that CERES simulation results of CO_2 fertilization seem to be too high. In more recent FACE (Free-Air CO_2 Enrichment) experiments (closer to typical field conditions), elevated CO_2 of 550 mL/m^3 resulted in smaller increases reported on average 5%−15% increases in final biomass and grain yield under the fields condition. The reported results in China were 17%−20% in the same situation. Comparing results in the two tables, a conclusion is that a 2.2−3.9℃ warming in next 50−80 years with adaptation will not threaten wheat and maize production severely.

Of course, the realization of effects of CO_2 fertilization in practice needs breeding of suitable cultivars and meeting their demands for water and nutrients, i.e. adaptation techniques. Because crop cultivars selection may alter the consequence of climate change impacts from increased yield to decreased yield, a detailed understanding of CO_2 fertilization should be taken into account in developing adaptation technology, including crop endurance to critical temperature and its sensitivity to changing climate. From this point of view, the dangerous climate change level should be such a change, which exceeds the new critical temperature after adopting adaptation technologies. Adopting suitable adaptation may delay even avoid the damage resulted from dangerous climate change. Due to lack of the quantitative assessment of adaptation, it is difficult to determine the critical level of the climate changes threatening food production now.

4 Key vulnerability assessment and dangerous level of climate change

Due to no consensus on the dangerous level and threshold of climate change, there were no such terms in the outline of IPCC WGII's contribution to the Fourth Assessment Report (AR4), and instead key vulnerability and risk were used. Vulnerability is a property of the interactive human-natural system. There is a value judgment embedded in terms of the undesirability of the outcome. Risk is typically defined as probability times consequence. Climate change can pose an additional risk, and in some cases depending on the risk, the vulnerability may become key, and therefore relevant in terms of Article 2 of UNFCCC. It is believed that this outline reflects the understanding of the human society in current and near future. Any extreme actions are no benefit for scientific development.

For agricultural key vulnerability study, extreme events are main influence factors, which are difficult to forecast so that climatic change thresholds for food production security are difficult to be determined.

It is widely concerned that relationship between dangerous climate change and future GHG emission ceiling is closed, but different countries have different value judgment. There are no final conclusions on dangerous climate change as well as key vulnerability now. Challenges include: What is key vulnerability? Is it the key regions or key sectors or threshold? What is scaling effect? How to summarize global dangerous level? Which sectors are most threatened? Besides food production, ecosystems and sustainable development, what else will suffer key impacts? When thresholds will happen under different scenarios? How to delay or avoid it? and is it by reducing climate change rate or raising threshold (e.g. to increase flexibility and adaptability of systems)? It is expected that in a following period, there will be some heated arguments on priority to deal with climate change, e.g., prior mitigation emphasizing reducing GHG emission or prior adaptation emphasizing adaptation technology, before determining what dangerous climate change is. Scientific society can provide more evidences but rather replace the value judgment by policymakers.

5 Sustainable development and adaptive capacity building

Sustainable agricultural development is an ongoing priority for China. In spite of yield improvements at a national level, crop yields vary considerably among regions. It is shown that available technologies are not suitable for all economic, cultural and environmental conditions. China still needs more advanced technologies and finances to adapt to climate change. For this purpose, it is necessary to speed technology transfer, especially the transfer of those benefiting sustainable development technologies, from industrial countries to China and other developing countries.

Establishing reasonable adaptation and strengthening adaptive capacity will play very important role in reducing adverse impacts of climate change and promoting sustainable development in different regions. Recommended options for whole nation include: 1) strengthening agricultural infrastructure construction, cultivating stress-resistant varieties, and enhancing dimensions of planting zones for superior products; 2) strengthening water conservancy infrastructure construction, and raising abilities to deal with flooding, drought and water supply with consideration of the load carrying capacity of water resources; 3) expanding afforestation and reforestation, and raising the adaptive capacity of plants to environment changes; 4) feeding animals based on climate and grassland, altering over-pasture, avoiding the degeneration of grassland, and preventing desertification; 5) raising the design standard of coastal infrastructure against the tide; 6) setting up and strengthening the monitoring, forecasting, warning and controlling network for climate-caused health problems.

Recommended adaptation options for local governments include: in Northeast China, adopting the northward expanding of winter wheat planting area and increasing the rice area to benefit food production from global warming; in North China, constructing a water-conservation society, and preventing and controlling desertification; in Northwest China, raising the adaptive ability of dryland farming, and reasonably using water and developing water-saving agriculture; in coastal areas, raising the design standard of coastal infrastructure against the tide based on the sea level rise trend.

Improving adaptive capacity is an important measure to deal with the adverse impacts of climate change and to accelerate sustainable development. Adaptation needs more input, so it is additional burdens in the developing process for developing counties. But adaptation may reduce part of adverse impacts and benefit socio-economic development. So, we suggest that activities for adaptation to climate change should be induced in the middle and long term planning for state socio-economic development to meet the challenges of climate change on own initiative.

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References

[1] Xu Yinlong, Huang Xiaoying, Zhang Yong, *et al*. Statistical analyses of climate change scenarios over China in the 21st century [J]. Adv. Clim. Change Res., 2006, 2(Suppl.1): 50−53.

[2] Xiong Wei, Lin Erda, Ju Hui, *et al*. A study of the threshold of climate change impact on food production in China [J]. Adv. Clim. Change Res., 2005,1(2): 84−87 (in Chinese).

[3] Wu Shaohong, Zhao Huixia, Yin Yunhe, *et al*. Recognition of ecosystem response to climate change impact [J]. Adv. Clim. Change Res., 2006, 2(Suppl.1): 59−63.

[4] Fan Daidu, Li Congxian. Complexities of China's coast in response to climate change [J]. Adv. Clim. Change Res., 2006, 2(Suppl.1): 54−58.

[5] Xiong Wei, Xu Yinlong, Lin Erda, *et al*. Regional simulation of maize yield under IPCC SRES A2 and B2 scenarios [J]. Chinese Agricultural Meteorology, 2005, 26 (1): 11−15 (in Chinese).

[6] Ju Hui, Xiong Wei, Xu Yinlong, *et al*. Impact of climate change on wheat yield in China [J]. Acta Agronomica Sinica, 2005, 31 (10): 1340−1343 (in Chinese).