

## **Nominated Discussion**

**J. Sun**

## **Assessment on the Potential Impacts of Climate Change on China Applying the Asian-Pacific Integrated Model (AIM)**

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### **Abstract**

The specifications on natural, socioeconomic dimensions of China associated with climate change issues are discussed in this paper. In the case study on the potential impact of climate change on China's crop productivity, the Asian-Pacific Integrated Models (AIM) gave a very encouraging performance: the results from AIM agree well with those calculated by a statistical model (established to check the results from AIM, so as to optimize the application of the AIM); results from the case study show that, with the grain crop planting area of 1993 in China, yields of rice wheat and maize will increase due to the changes in temperature and precipitation (under doubled efficient CO<sub>2</sub> concentration in the atmosphere) by about 2,456 thousand tons, 1,324 thousand tons and 1,047 thousand tons respectively (although climate warming may bring about negative impacts on crop yield in some regions in China for each type of crop). Some suggestions on furthering the development and application of IAMs to be used to represent the climate change issues are also provided in this paper.

### **Introduction**

With the development of current material civilization, fossil fuel has been consumed, rice planted and ruminants raised without any control, which has induced the continuous increase in the concentration of greenhouse gases in the atmosphere. It is revealed from scientific research that the greenhouse effect is likely to cause global climate change. Meanwhile, pollutants from industries have been emitted into atmosphere with no limitation, forest and vegetation have been ruined, grasslands have been degenerating, and land desertifying. All these can carry unmeasurable effects on climate. Although the current climate warming and sea level rises have been considered as representing facts of the intrinsic fluctuation of climatic variables by some scholars, other scientists are confident that the sharp increase in greenhouse gases in the atmosphere possibly brings about obvious climate warming. Though it has not been fully verified that global warming is due to human activities, the implication about potential impacts of climate warming on human kind has generated intensive consideration by scholars, civilians and national chiefs all over the world; and the global climate change issue has become one of the important global environmental problems. Consequently, a great number of researches have been motivated by the climate change issues, and they account for a large range of dimensions and approaches (Neild, R.E. *et al* 1979; Semenov, M.A. and Porter, J.R. 1995; Nonhebel, S. 1994; Riha, S.J., Wilk, D.S. and Simoens, P. 1996; Rosenzweig, C. 1990; Naiquan Xin and Shiqi Wang 1990; Duchang, Cui 1991). Among them, Integrated Assessment Models (IAMs) weighs a lot (Weyant, J. *et al* 1996). Using a computer program to link an array of component from the various contributing disciplines, IAMs makes it easier to ensure consistency among the assumptions input to the various components of the models and introduce feedbacks absent in conclusions available from individual disciplinary fields. Due to the large inherent complexities and uncertainties, perhaps more than other issues global climate change and its potential impact

issue requires integrated assessment, which help to make rational, informed social decisions on global climate change.

# **1. Specifications of China associated with integrated assessment on the potential impacts of climate change**

China, a typical developing country, has several natural and socioeconomic characteristics determined by its special geographical and development history, which deserve more efforts to be dealt within the integrated assessment associated with climate change.

Firstly, there are three principal different background climatic zones across China (eastern monsoon climate; northwest dry climate, and southwest plateau climate). Thus, climate conditions are highly complicated and unsteady, which may cause climatic damages frequently in China. The eminent civilization established under such surroundings by the Chinese is being threatened by changing climate and environment.

Meanwhile, great changes in society and economy have been taking place while a series of new socioeconomic development policies have been taken into action since 1978 in China. Enormous progresses in economy, technology and living level etc. have been made rapidly during the last two decades. More importantly, China is very rich in several kinds of natural resources, and the development of many dimensions such as agriculture, water resource, human health etc., greatly depends on these natural resources including climatic resources. Therefore, agricultural and industrial production is very sensitive to climate change, particularly during the current special period when China has been stepping into the midst of development of the economy and system reforming.

Furthermore, because of the considerable diversities of natural environment and climatic zones across China, there exist considerable differences of social and economic dimensions between both northern and southern, eastern and western China.

For all discussed above, it is a hard task to assess integratedly the potential impacts of climate change on China, and it is also impossible to employ some extant general IAM to cope with the issue (though the IAM may be considered advanced enough of its own). So many more efforts should be taken to develop IAMs, or improving extant IAMs associated with climate change issues in China.

Although there are a number of different integrated assessment researches with respect to the climate change in China (Jijia Zhang *et al* 1992; Hulme, M., Wigley, T. and Tao Jiang *et al* 1992; Suhua Gao, Yaru Pan and Qinchun Zhang 1991; Mingcha Zhao 1993), due to the limitations of China listed below, the progress made has not been so satisfactory.

- 1) At least by now, impacts of climate change on China have not been the most important concerns of developing China. So, studies on climate change issues have not yet got enough consideration, and the inputs to related studies are consequently limited.
- 2) Due to the nature of integrated assessment research on climate change issues (such as long time durations, the demands of many research requirements, the lack of obvious instant benefits) research can't be done spontaneously.
- 3) Due to the great geographical and socioeconomic breadth of China, financial support to collect, arrange and normalize the enormous data required by integrated assessment research is severely inadequate.
- 4) Most advanced modeling and assessing technologies are insufficient.

## 2 A case study

### 2.1 dimension

In this study, the potential impact of climate change on China's agriculture is chosen to be assessed. The following logic accounts for this choice.

In China, agriculture is the backbone of national economy, and the underlying food supply. The important role of agriculture in China should not be questioned at any time. However, the dependence of agricultural production on weather and climate can not be avoided, even if nowadays the scientific and technological levels are highly improved. Moreover, with the development of social material civilization, and the accompanying increase in social demands, agriculture has been expected to provide society with more and more material goods. Thus, impacts of climate change on agriculture deserve more concern. Furthermore, among ecosystems known to be vulnerable to climate change, one of particular importance to human welfare is agriculture (Bingwei Huang 1993; CAST 1992; OTA 1993). As described above, the impacts of climate change on agriculture consequently have the highest priority among all the impacts associated with climate change; it is also of great theoretical and practical importance to study principles about the impacts of climate change on agriculture, so as to make rational adaptive and mitigation measures by crop and region, and accelerate China's agriculture production. So, in this paper, the potential impact of climate change on China's crop productivity is assessed as a case study associated with the integrated assessment study on global climate change in China.

### 2.2 Approach

There are considerable complexities and uncertainties inherent in agriculture production as well as in the climate processes. The appropriate approach used to represent the potential impacts of climate change on agriculture production should take the dominant factors affecting agriculture production into account.

When China is considered, in addition to the agrometeorological variables (e.g. temperature, precipitation, radiation etc.), agriculture production is also affected by socioeconomic factors (such as technological level, social economic inputs, labor quality and input, national agricultural policies and land use status etc.) especially during the special period when China has been in the midst of developing and reforming, which has brought about obvious effects on agriculture production.

The Asian-Pacific Integrated Model (AIM) (Morita *et al* 1993; Morita *et al* 1994) which has been developed to assess integratedly the potential impacts of climate change on Asian-Pacific regions, focuses on the plant physiological mechanism of crop production and takes such key socioeconomic factors as technological choice, land type and labor level etc. into account. More importantly, AIM deals with these factors appropriately, neither too specially nor generally, through classifying these components into several categories. It has been confirmed that the AIM framework can preliminarily represent the crop producing process. However, as has been pointed out above, there are several different climatic and socioeconomic zones across China, which induce quite differences of crop producing process in various areas all across China. Thus, it is impossible for any large scale (e.g. regional, global etc.) IAM (of course, including AIM) to describe the detailed specifications of crop production in different areas across China.

Therefore, in order to check the results from AIM, and provide some useful opinions on how AIM can improve so as to represent the realities of China's crop production perfectly, (though the AIM can reflect the overall trend to a satisfactory degree) it is necessary to perform independent detailed study on the potential impacts of climate change on the crop production in China. Under this consideration, a multi-dimension statistic model was

established, based on the historical data of climatic variables, crop yields and the broadly used climate scenario under doubled efficient CO<sub>2</sub> concentration in the atmosphere in China .

The framework of the statistical study can be described as the following (Figure 1):

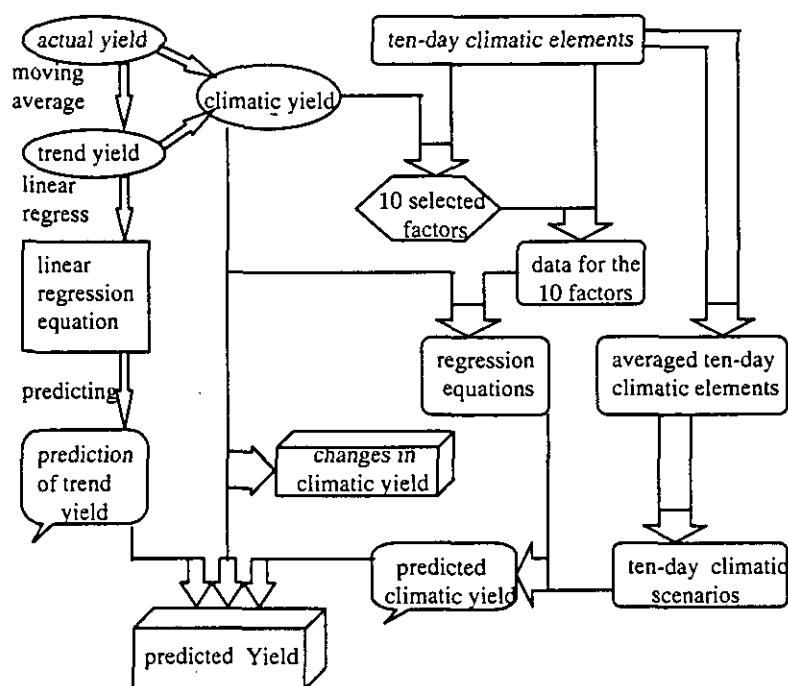


Figure 1: Framework for Statistical Study

Referring to the recent outputs, which have being broadly used in China, of some typical GCMs, the climatic scenarios used in the statistical study is as illustrated the following (Table 1):

Table 1: climate scenario used in the model

Climatic Factor	Area	Changes			
		spring	summer	fall	winter
Temperature	North to 30°N	1.5	1.2	1.5	1.8
	South to 30°N	1.35			
	Coastal areas	1.21			
Precipitation	Yangtze River	+10%			
	Southwest China	-10%			
	Other areas	0			

The results from the model are shown in Figures 2 to 7.

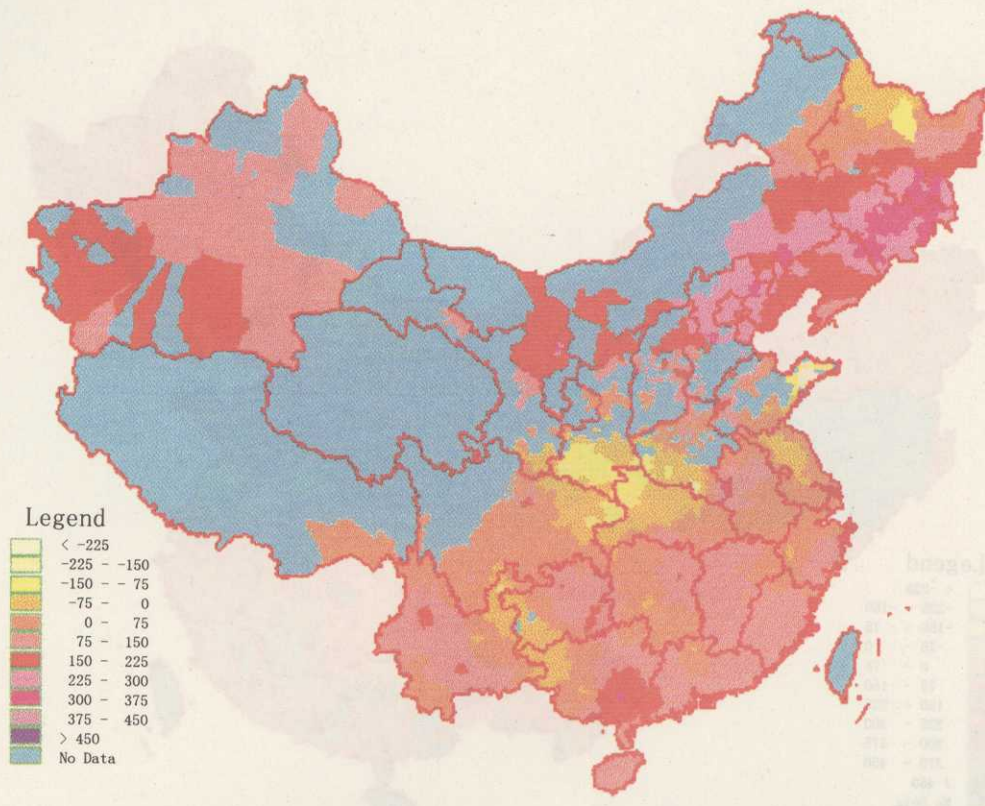


Figure 2: Changes in the climatic yield of rice in China under doubled CO<sub>2</sub> (Kg/ha)

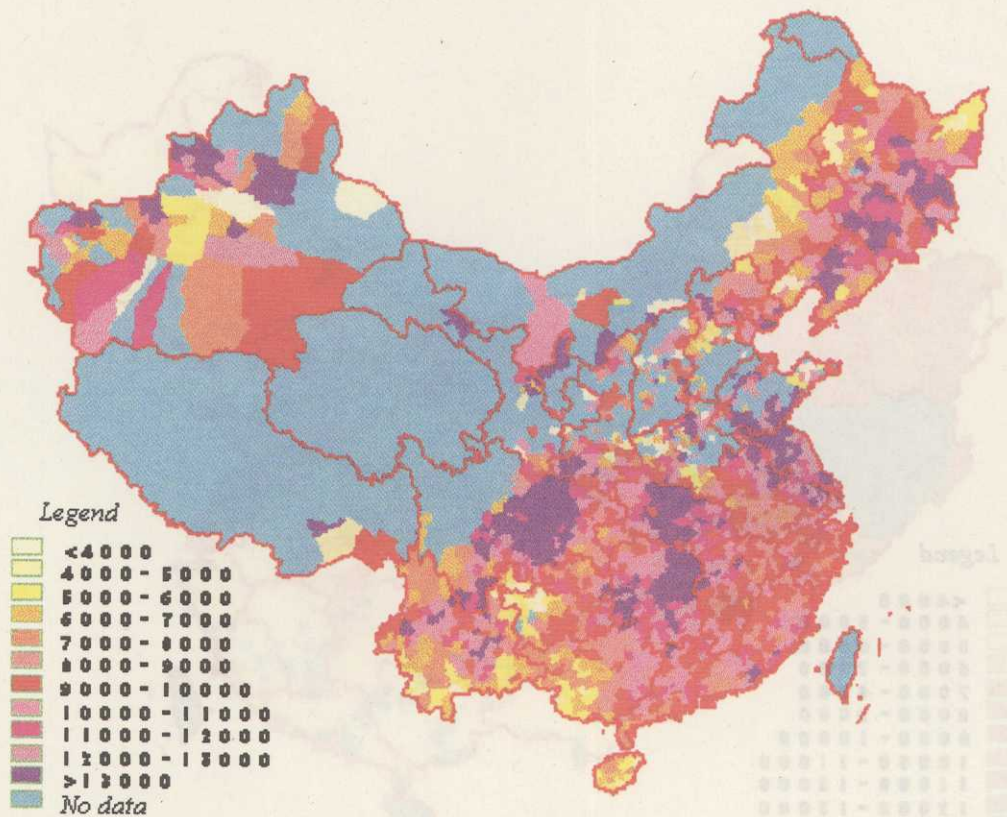


Figure 3: Predicted Yield of rice in China under doubled CO<sub>2</sub> (Kg/ha)



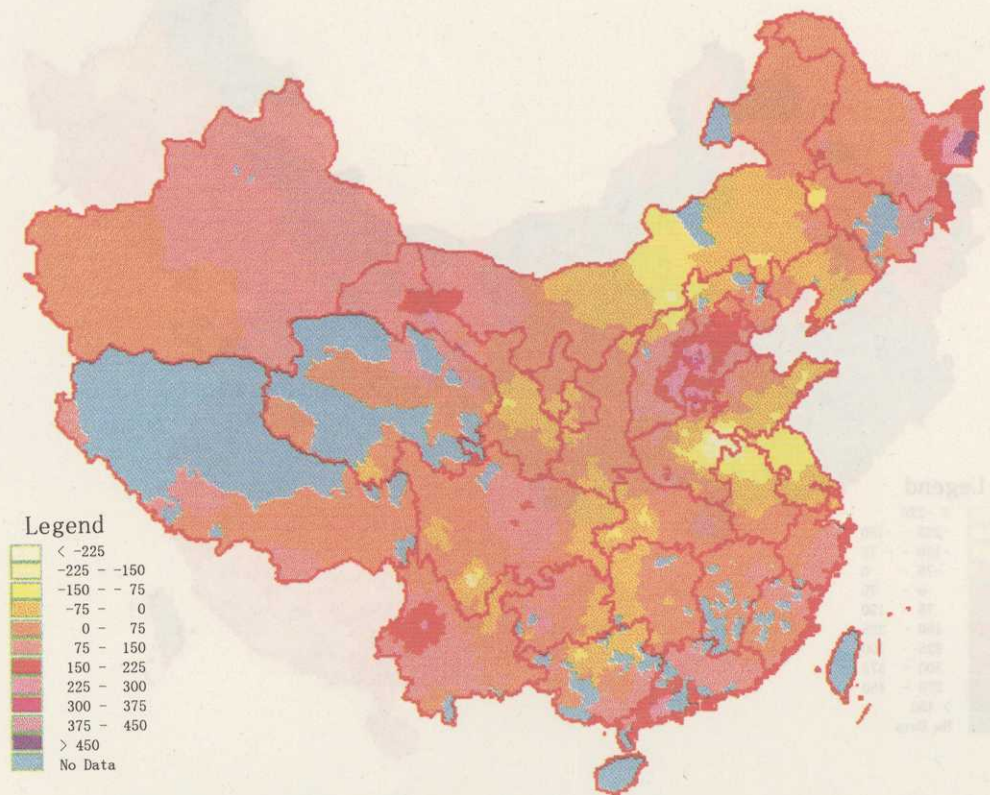


Figure 4: Changes in the climatic yield of wheat in China under doubled CO<sub>2</sub> (Kg/h)

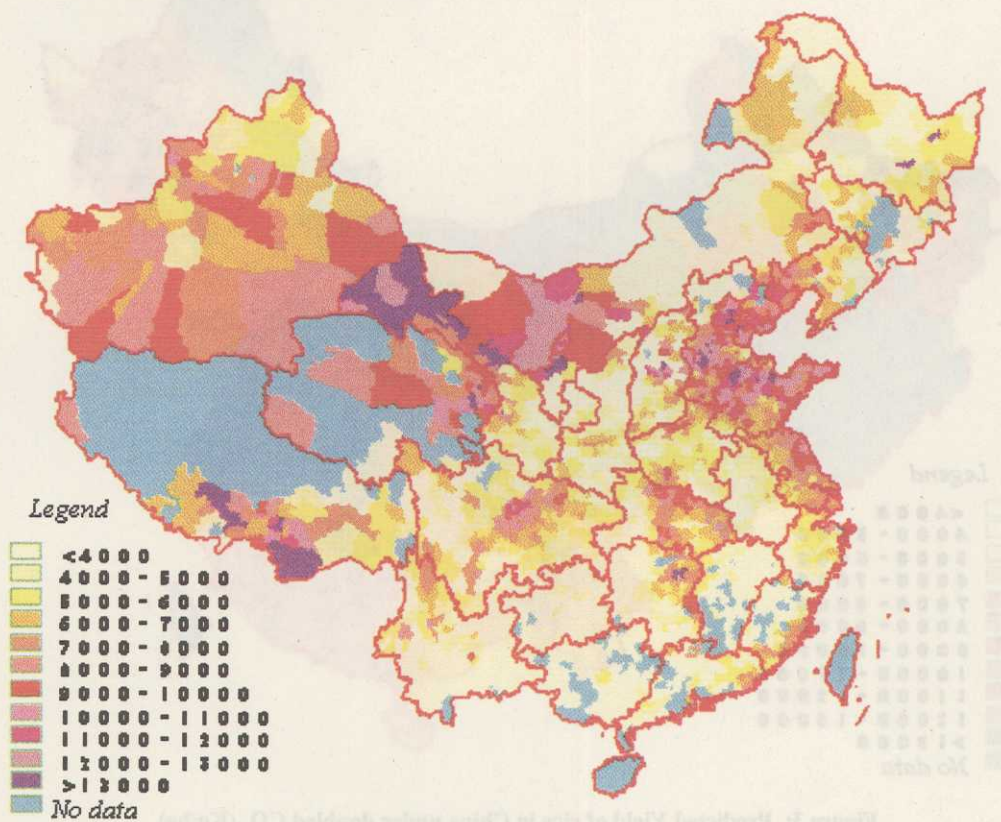


Figure 5: Predicted Yield of wheat in China under doubled CO<sub>2</sub> (Kg/ha)



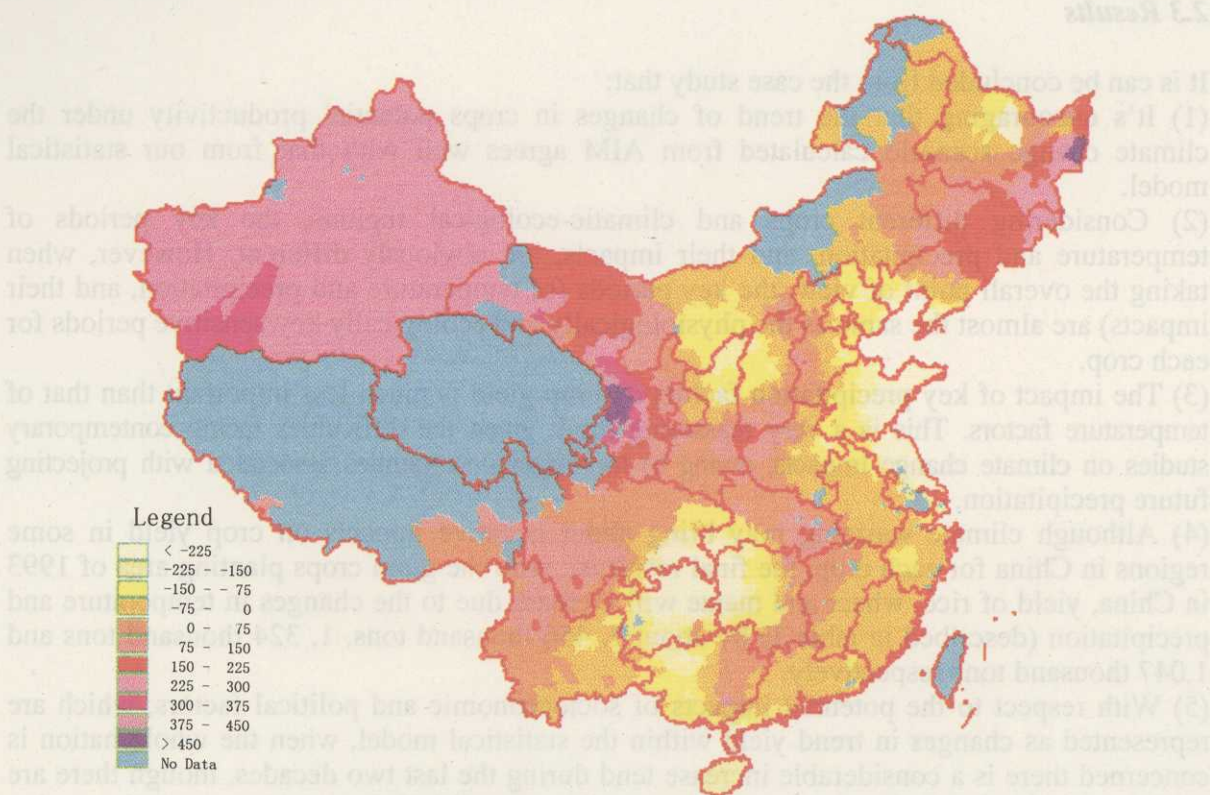


Figure 6: Changes in the climatic yield of maize in China under doubled CO<sub>2</sub> (Kg/ha)

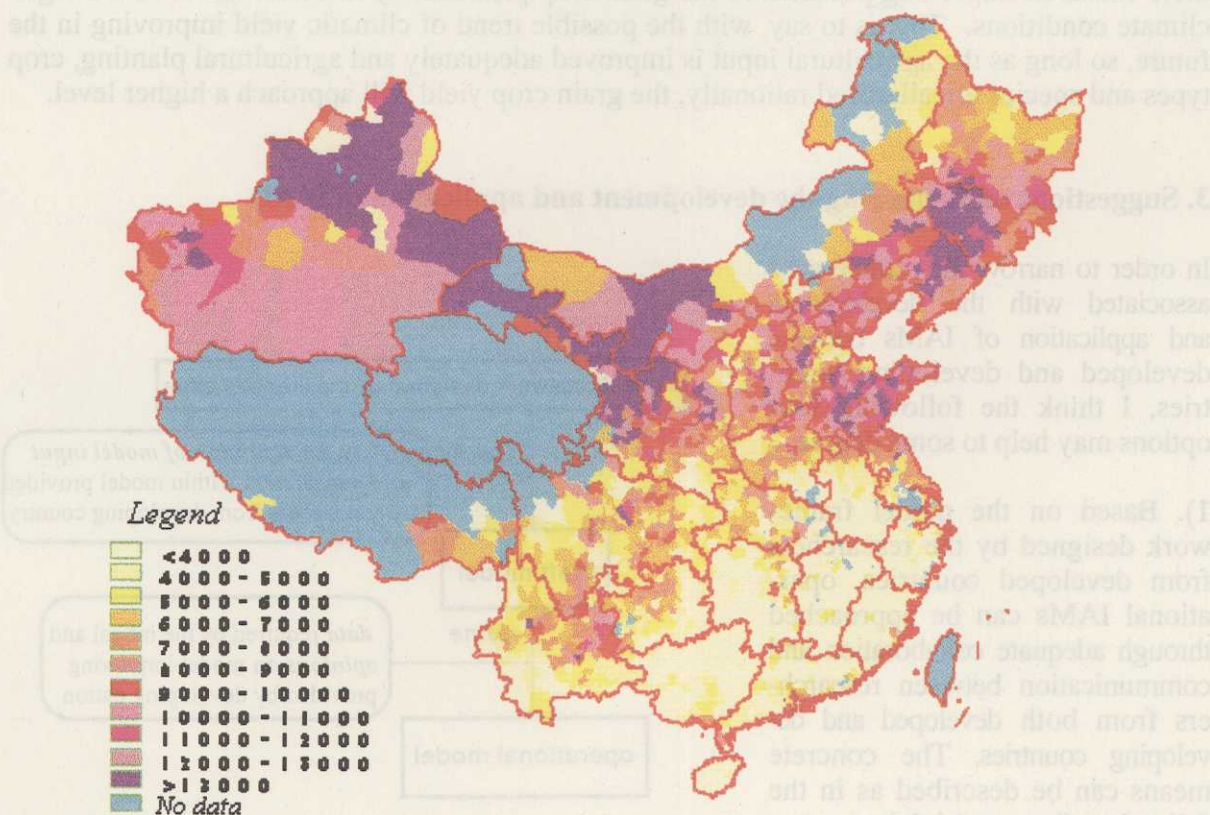


Figure 7: Predicted Yield of maize in China under doubled CO<sub>2</sub> (Kg/ha)



## 2.3 Results

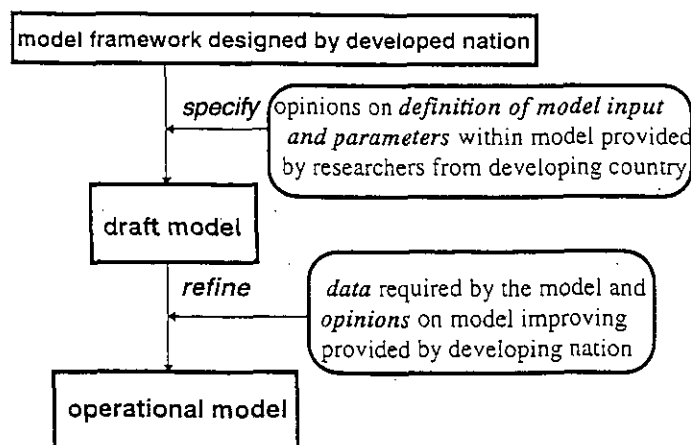
It can be concluded from the case study that:

- (1) It's encouraging that the trend of changes in crops potential productivity under the climate change scenario calculated from AIM agrees well with that from our statistical model.
- (2) Considering different crops and climatic-ecological regions, the key periods of temperature and precipitation, and their impacts, are obviously different. However, when taking the overall point of view, the key periods (of temperature and precipitation, and their impacts) are almost the same as the physiologically and ecologically key/sensitive periods for each crop.
- (3) The impact of key precipitation factors on crop yield is much less important than that of temperature factors. This is a very reassuring result given the difficulties facing contemporary studies on climate change impacts, owing to the larger uncertainties associated with projecting future precipitation.
- (4) Although climate warming may bring about negative impacts on crop yield in some regions in China for each crop, the final result is : with the grain crops planting area of 1993 in China, yield of rice, wheat and maize will increase due to the changes in temperature and precipitation (described in table 1) by about 2, 456 thousand tons, 1, 324 thousand tons and 1,047 thousand tons respectively.
- (5) With respect to the potential impacts of socioeconomic and political factors, which are represented as changes in trend yield within the statistical model, when the whole nation is concerned there is a considerable increase trend during the last two decades, though there are some areas where the changes in socioeconomic and political factors have caused negative changes in crop yield. Thus, given the same pattern continuing for the next two to three decades, the yield improving trend will continue for the whole of China.
- (6) Though we still don't take the upper limit of each crop's biological yield into account, there exists an improving potential in the grain crop productivity in China under the changed climate conditions. That is to say, with the possible trend of climatic yield improving in the future, so long as the agricultural input is improved adequately and agricultural planting, crop types and species are allocated rationally, the grain crop yield will approach a higher level.

## 3. Suggestions on furthering the development and application of IAMs

In order to narrow the sizable gaps associated with the development and application of IAMs between developed and developing countries, I think the following four options may help to some degree.

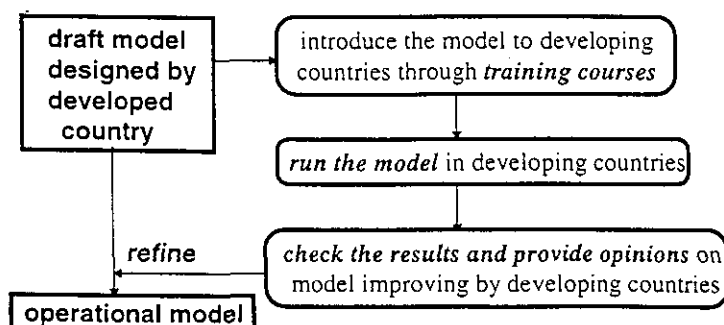
- 1). Based on the model framework designed by the researchers from developed countries, operational IAMs can be approached through adequate collaboration and communication between researchers from both developed and developing countries. The concrete means can be described as in the following diagram (right):



The development of AIM is a successful example of this case.

2). In addition, to employ IAMs from developed countries, developing countries, at the same time, should try to develop integrated assessment models which, base on the natural, socioeconomic and political specifications which can be expected to represent the realities of developing nations.

3). Researchers from a developed country design the draft model, then introduce it to developing countries through some training courses. During the application of the draft model, opinions on model improvement provided by researchers in developing countries can be used to refine the draft model until it is considered operational. This approach can be represented as in the following diagram:



4). Finally, IAMs can be greatly improved, both in representation and applicability, through intensive communication and discourse between researchers from developed and developing nations.

#### 4 Conclusion

(1) As one of the largest developing countries, China has many distinguished characteristics both in natural background and its socioeconomic developing routine, in comparison to developed as well as other developing countries. Therefore, a number of specifications of China should be considered within the IAMs. That is to say, IAMs which works well for other countries will not necessarily do a perfect job for China.

(2) Due to the adequate representation of components associated with the climate change issues, and the intensive participation of researchers from China, AIM can preliminary perform in China when it is used to project the potential impact of climate change on crop productivity. Maybe it can be optimistically expected to also have satisfactory behavioral application in other cases such as water resources, forest, vegetation, human health and economy etc.

(3) The case study reveals that, although climate warming may bring about negative impacts on crop yield in some regions in China for each crop, with the grain crops planting area of 1993 in China, yields of rice, wheat and maize will increase (due to the changes in temperature and precipitation under doubled efficient CO<sub>2</sub>) by about 2,456 thousand tons, 1,324 thousand tons and 1,047 thousand tons respectively.

(4) Through intensive collaboration, discussion and discourse between researchers from both developed and developing countries, and providing the researchers and policy makers in developing countries with adequate access to the development of the models, there exists optimistic prospects for the development and application of IAMs to be used to represent and project climate change issues.

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