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Global Change Research Program of P. R. China (2011–2020)

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Abstract: The Global Change Research Program of P. R. China (2011–2020) (China-GCRP) has been implemented since 2011. This paper describes the progress of China-GCRP in the 12th and 13th Five-Year Plans (2011–2015, 2016–2020) of China under the "National Major Research Program on Global Change". During the 12th Five-Year Plan, China-GCRP implemented 62 projects with a total budget of RMB 1.526 billion. Major achievements in 2010–2015 include: (1) a remarkable increase in understanding on global change, including facts, processes and mechanisms, the anthropogenic driving forces, the impacts and adaptation; (2) the enhancement of integrated Earth observation and data collection, and the development of a series of Earth system models; (3) more contributions to international global change research activities; (4) effective service to meet the national need of climate change affairs and socio-economic development; and (5) improvement in basic research capacity on global change. In the 13th Five-Year Plan of 2016–2020, China-GCRP has been renamed as "Global Change and Response" and research tasks have been rearranged into five issues: (1) integrated observation, data assimilation, establishment and application of big data platforms of global change studies; (2) facts, key processes and dynamic mechanisms of global change; (3) development of Earth system models, and prediction and projection using these models; (4) assessment of impacts and risks of global change; (5) mitigation, adaptation of global change and sustainable transition. A budget of RMB 0.57 billion was allocated for the 29 projects for fiscal years 2016. It is expected to fund 25 priorities with about RMB 0.52 billion in 2017.

Keywords: global change; China-GCRP; 12th five-year plan; 13th five-year plan

1 Introduction

Global change refers to global-scale changes in the Earth system caused by natural and human factors[1]. Global change has impacted and will continue to impact human survival and development. It is now more than just a scientific topic, and has become a major international political, economic and diplomatic issue.

Scientific research on global change has thus become one of the most active fields of re-

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search in Earth Sciences. International studies on global change started in the 1980s, led by a number of international scientific research programs. The current one is the "Future Earth Plan (Future Earth)" (2014–2023)[2], jointly launched in 2012 by the International Council for Science, the International Social Science Council and other international organizations. On the national level, many developed countries such as Europe and the United States have set up their own global change research programs. For example, since the United States developed the United States Global Change Research Program in 1989, global change has continuously been one of its priority funding areas[3]. These international and national research programs have strongly influenced international global change research.

China has actively participated in the initiation, organization and implementation of the global change research programs since the 1980s. To promote the global change research in China, a large number of projects have been funded by the National Basic Research Program of China, the National High Technology Research and Development Program of China, the National Science and Technology Support Program, the National International Science Cooperation Program, the National Natural Science Foundation of China, the Chinese Academy of Sciences and the Ministry of Education[4].

In 2005, China issued its "Outline of National Medium and Long Term Science and Technology Development Plan (2006–2020)", in which, "Global Change and Regional Response" was one of its 10 basic research fields coping with national strategic demands. In response to the outline, the Ministry of Science and Technology of China (MOST) issued a "Global Change Strategy Research Report of China"[5] in 2009. Based on this report, China started to coordinate its major global change research activities at a national level (Global Change Research Program of P. R. China, China-GCRP) since 2010. This effort was substantialized through its Five-Year Plans. In the 12th Five-Year Plan (2010–2015), China-GCRP was named as the "National Major Research Program on Global Change Research" (hereinafter referred to as the "Global Change Major Program", GCMP), and in the 13th Five-Year Plan (2016–2020), China-GCRP has been a National Key Research and Development Program and renamed as "Global Change and Response" (hereinafter referred to as the "Global Change Key Program", GCKP).

2 Implementation of the GCMP (2010–2015)

2.1 Objectives

The objectives of the GCMP (2011–2015) were: to achieve breakthroughs in a number of key scientific issues on global change for highly promoting China's international ranks and innovative capacity in global change research; to provide basic scientific support for building eco-friendly society, mitigating greenhouse gas emissions and involvement in international climate change negotiations; and to significantly improve China's research capacities by improving global change observation and data sharing, developing advanced Earth system models and high-resolution climate system models, establishing national research bases for global change, enhancing international cooperation on global change research and fostering a number of world-class research teams on global change.

2.2 Main Research Tasks

The GCMP contained the following five tasks:

(1) Study of the facts, processes and mechanisms of global change, including: the facts,

causes and multi-scale interactions of global climate change; the processes and mechanisms of ocean-land-atmosphere interactions and their roles in driving global climate change; the sensitivity, unexpected events, abrupt changes and the predictability of the climate system; the mechanism for and prediction of climatic and environmental changes in the regions sensitive to global change; and the impacts of the Sun-Earth relationship and deep Earth processes on global change.

(2) Study of the anthropogenic driving forces of global change, including: the detection (monitoring) technology system used for global greenhouse gas emissions and carbon cycle; the impacts of large-scale land and coastal use on global change; the impacts of anthropogenic aerosol emissions on global change; and the contribution of human activities on global warming since the 20th century.

(3) Study of the impacts of global change and adaptation, including: the response and regulation of the structure and function of ecosystems to climate change; the changes and impacts of the cryosphere; the impacts of climate change on water resources and the marine environment and human adaptation; the variability and impacts of extreme weather and climate events and adaptation to the extremes; the adaptation to the impacts of global change on food security and human health; global change economics, the Earth system governance and integrated risk prevention; and the resilience and adaptable thresholds of the Earth system to global change.

(4) Study of comprehensive observation and data integration, including: the comprehensive observation (monitoring) of key parameters and processes of global change; principles and methods for calibrating the satellite observational data; and the quality control, assimilation, fusion, integration and sharing mechanism of multi-source observation data.

(5) Development of Earth system models, including: the development and application of high-resolution climate system models, Earth system models, near-Earth space environmental models and solid Earth models; and the development of supporting environments for Earth system modeling.

2.3 Implementation of Projects

During 2011–2015 (the 12th Five-Year Plan), 62 projects were implemented in the GCMP, including one project-group for major scientific issues and four projects for young scientists, with a total allocation of RMB 1.526 billion. The budget is summarized by research task (Table 1) and by affiliation of lead organization (Table 2)[6].

Table 1 GCMP budget summarized by research task (2011–2015)

	Main research tasks	Project		Budget	
		Number	Percentage (%)	RMB (100 M)	Percentage (%)
1	Facts, processes and mechanisms of global change	32	51.5	7.73	50.5
2	Anthropogenic driving forces of global change	4	6.5	1.02	6.7
3	Impacts of global change and adaptation	18	29.0	4.44	29.1
4	Comprehensive observation and data integration	4	6.5	1	6.6
5	Development of Earth System Models	4	6.5	1.08	7.1
Total		62	100	15.27	100

Table 2 GCMP budget summarized by affiliation of lead organization (2011–2015)

	Affiliations of lead organization	Project		Budget	
		Number	Percentage (%)	RMB (100 M)	Percentage (%)
1	Ministry of Education (Universities)	28	45.2	6.75	43.2
2	Chinese Academy of Sciences (Institutes)	27	43.5	6.59	44.2
3	Other Agencies	7	11.3	1.92	12.6
Total		62	100.0	15.26	100.0

3 Main Achievements of the GCMP (2011–2015)

As outlined above, the implementation of the GCMP during 2011–2015 has promoted the development of research on global change in China. The program has provided strong scientific support for China to adopt effective strategies and policies to cope with global change and to participate in global climate governance and international climate negotiations. The objectives of the GCMP during the 12th Five-Year Plan have been successfully achieved.

3.1 Summary of Main Scientific Progress

The implementation of the GCMP during 2011–2015 has enabled China to achieve internationally recognized progress in the key scientific issues of earth system science and global change. Significant progress has been made in the development of a new generation of Earth system models, data assimilation and absorption, and application of global change satellites and Earth observation technologies. During 2011–2015, more than 4,000 papers searchable by the Science Citation Index system were published by Chinese scholars, which were funded by the GCMP (see Figure 1 for each field). It is expected that the total SCI papers will reach about 8,500 when the all projects implemented during the 12th Five-Year Plan period but finished in the 13th Five-Year Plan are taken into account. Some of the products have been published or featured in Science, Nature or Nature Series, and other top-level international journals. Major achievements are listed below.

(1) Facts, Process and Mechanisms of Global Change

Understanding of the historical background on multi-time scales, and the natural and anthropogenic causes of global warming in the 20th century has been further improved. On orbital and sub-orbital scales, past global warming has increased monsoon precipitation. Monsoon variation on the orbital scale is governed by a low-latitude solar component (opposite phases in the north and south hemispheres) and a glacial-interglacial component (same phases in the north and south hemispheres). The latter is also affected by the asymmetric evolution of north and south polar ice sheets associated with the orbital parameter, which may be beneficial to continue the current interglacial climate in the northern hemisphere[7]. In the past 2,000 years, there have been several warm periods that were similar to the warmth of the 20th century. However, the warming in the 20th century was almost synchronous in the northern hemisphere, in contrast to the warming in the Medieval Warm Period (or Medieval Climate Anomaly), which showed spatial differences in amplitude and phase. The warming in the Medieval Warm Period was affected by an ocean thermostat mechanism mainly driven by solar radiation, while that in the 20th century was affected by an atmospheric stability mechanism mainly controlled by greenhouse effects[8].

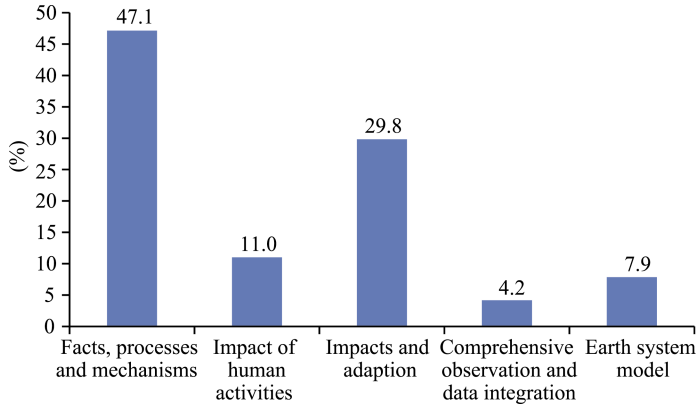

Figure 1 Percentage distribution of published SCI papers in different research fields

New understanding on the predictability of the influence of interactions among ocean, land and the atmosphere in Asia on global change and the East Asian monsoon, and the thermal effect of the Tibetan Plateau on the Asian monsoon has been achieved. It was found that there is a cold tongue mode for the long-term cooling trend in the Sea-Surface Temperature (SST) of the tropical eastern Pacific under global warming. A dynamic theoretical model, named the obstacle theory of SST spread, has been proposed to indicate the influence of the cold tongue mode on the El Niño and Southern Oscillation (ENSO). The cold tongue mode could suppress the warming in the tropical eastern Pacific and result in central El Niño. The main decadal variation mode of the Hadley circulation has been found, and the SST for the tropical India Ocean-Western Pacific Ocean was clarified to be an important driver for decadal variations of atmospheric circulation, as well as an important regulator of the drought in subtropical zones on a global scale. It has been found that the entire Asian summer monsoon is affected by the land-ocean distribution and the thermal effect of the large landforms, of which, the Southern Branch of the South Asian summer monsoon is mainly affected by the land-ocean distribution, the northern branch of the South Asian summer monsoon is mainly affected by the thermal effect of the large landforms in Asia, and the East Asian monsoon is affected by the both[9].

A theoretical framework of ocean warming heterogeneity dynamics under global warming has been proposed, which could unify the debates on the interpretation of the distribution of tropical precipitation variation. The SST distribution could cause anomalies in ascending activities at the equatorial area and sinking movements at the two sides, which remain unchanged all year round. At the same time, the ascending motions could increase the precipitation by uplifting the wetter airs in the North and South[10].

(2) Anthropogenic Driving Forces of Global Change

A systemic assessment of global forest carbon budgets to date has been made. It was found that, from 1990 to 2007, the forest was a significant carbon sink with about 4.0 Pg C (1 Pg=10^{15} g) fixed per year, which is equivalent to half of the carbon emissions from fossil fuels during the same period. However, the net fixed amount around the world was about 1.1 Pg C, because there was about 2.9 Pg C emitted due to human activities such as tropical deforestation. From 1977 to 2008, the carbon sink of forest biomass in China was 1,896 Tg C (1 Tg=10^{12} g) with an annual increase of 70.2 Tg C. As forest planted in the late 1970s and early 1980s in China has entered into a middle-aged strong growth period in the past 10 years, all components (biomass carbon, litter carbon, woody debris and soil organic carbon) of the forest carbon cycle perform as significant carbon sinks. The total annual value of for-

est carbon sink is 186.7 Tg C/a in China, which is equal to that in the United States[11].

The effects of Land Use/Cover Changes (LUCC) on tropospheric temperature and the annual temperature variability have been diagnosed by modelling. It was found that LUCC could lead to a decrease in tropospheric temperature, with the most pronounced cooling in East Asia occurring in spring and autumn, when a peak drop occurred in the lower troposphere and middle and upper troposphere, respectively. Significant temperature drops in Europe and North America can be extended from the lower troposphere to 300–400 hPa, with the maximum cooling occurring in the lower troposphere during summer when the temperature decreases by about 0.8 °C. LUCC could also significantly affect the annual variability of surface air temperature, which is weakened in autumn and winter in Huanghuai Plain to Baikal Lake area and increased in the Indian Peninsula and Indochina Peninsula[12].

Historical duties to global warming measured by accumulative greenhouse gas emissions have been quantitatively assessed for both developed and developing countries. The duty of each country was compared with its committed contribution to mitigation of greenhouse gas emissions. During 1850–2005, the historical duty of developed countries to global warming was 61%–63%, while that of developing countries was only 37%–39%, but the committed future mitigation by the developed countries does not match their historical duties[13].

(3) Impacts of Global Change and Adaptations

An integrated environmental risk assessment model and a cohesion model for comprehensive risk prevention, which can quantify, simulate and predict integrated environmental risks, have been developed. Based on the model, regionalization of environmental risk in China has been compiled, and the world ranking of environmental risk in China and its "east-west differentiation" characteristics have been revealed. By integrating the concepts of "vulnerability, resilience and adaptability", the "cohesion model" system has constructed a basic theoretical framework of environmental risk co-adaptation and comprehensive risk prevention with a core of "cohesion", which was established on the basis of four basic principles of cooperative amplification, cooperative constraint, cooperative decentralization and cooperative tolerance[14].

Impacts of global warming on the scope of arid areas have been diagnosed and simulated. It has been shown that global warming could lead to expansion of arid areas. Under the Representative Concentration Pathways (RCP) 8.5 and RCP4.5 scenarios, the increasing rate of expansion of arid zones could convert more than half of the global land to arid areas by the end of the 21st century, which would result in reduced terrestrial carbon sinks and enhanced regional warming[15].

A new concept model for predicting the three patterns of summer rainfall in eastern China under global warming has been established. It was found that the relationship between summer rainfall in China and ENSO and the North Pacific Oscillation has changed due to global warming since the late 1970s, which has lowered the prediction accuracy of traditional rainfall patterns in eastern China. Based on the new background of climate change on a decadal scale, the early signs of the three patterns of summer rainfall in eastern China have been identified. New PNA and EU indices have been defined, and a new conceptual model for the three patterns of rainfall in eastern China, which could respond to the forecast in the Chinese rain season, has been established[16].

An early signal of abrupt changes in the ecosystem has been extracted by paleolimnological and simulation methods. Using ancient lake sediments and modern lake monitoring data, together with model analysis, the conversion characteristics and early signals of abrupt changes of ecosystem structure during the eutrophication process at Erhai Lake in Yunnan

Province have been identified. It was demonstrated that for a strong disturbance, there were frequent fluctuations in the ecosystem before abrupt changes occurred (i.e. the flickering phenomenon). These findings provided a new approach for using paleolimnological and simulation methods to research the long-term changes of complex ecosystems[17].

(4) Comprehensive Observation and Data Integration

A novel optimization system for carbon sinks of the terrestrial ecosystem has been established. The system integrated remote-sensing inversion, model simulation, atmospheric inversion and land atmosphere assimilation. A global carbon assimilation system has been developed that can simultaneously optimize carbon flux and model parameters of the ecosystem. Using the system, the characteristics and driving mechanism of terrestrial carbon sink evolution in different regions of the world in the past 30 years have been simulated and investigated, and the intensity and distribution patterns of land carbon sinks in China since the 21st century have been clarified[18].

A remote-sensing observation network, an aerosol observation experiment and multi-parameter ground-atmosphere-space integrated aerosol observation system had been established. The decadal variability of major anthropogenic aerosol concentrations and direct radiative forcing in China during the 20th century has been analyzed by simulation[19].

(5) Development of Earth System Models

A global high-resolution climate system model, BCC_CSM2, has been developed, which has improved the parameterization scheme of several important physical processes in the model. It has enhanced the simulation ability of small-medium-scale processes such as tropical cyclones and typhoons[20]. A first version of ecological and environmental system model has been developed[21]. The models have same global simulation capability as the advanced models around the world, and have some advantages for simulating the East Asian monsoon region.

3.2 Further Contributing to International Global Change Studies

The outputs from the GCMP have enabled Chinese scientists to effectively participate in international global change studies.

In the scientific assessment reports of the Intergovernmental Panel on Climate Change (IPCC), the number of Chinese authors has increased from 7 in the First Assessment Report (published in 1990) to 43 in the Fifth Assessment Report (AR5, published in 2013–2014), which gave China the most number of authors among the developing countries. Additionally, Chinese scientists have served as co-chairs of Working Group I consecutively from the third to the fifth assessment reports. Nearly 1,000 papers written by Chinese scientists were cited by IPCC AR5, of which 450 papers were cited by IPCC AR5 Working Group I accounting for 4.9% of its total cited papers. The Earth system models and the high-resolution climate models, funded by the GCMP, have been included in IPCC AR5 and other climate change modeling experiments, and have gained a worldwide positive influence.

The GCMP has effectively supported the Integrated Risk Governance Project initiated by China, which has been one of the core plans of the Future Earth Plan now. Also under the support of the GCMP, China has taken over the program office of the Climate Variability and Predictability Research, Chinese scholar has been chair of the Asia2k Working Group of the 2k Network in the Past Global Changes (PAGES). The Marine Biogeochemistry and Carbon Sink Forum, initiated by Chinese scientists, has been set up as a permanent forum by the famous Gordon Science Frontier Forum. More people involving in the GCMP are holding important positions in international academic organizations and well-known journals in the field of global change.

3.3 Meeting Major National Demands

The scientific achievements of the GCMP have helped to meet major demands to design the national strategies and policies for coping with global change and participating in climate governance and international climate affairs during 2011–2015 as follows.

(1) The scientific findings on key issues of global change have provided strong support for decision-making on climate change in China. A large number of papers have been cited by national assessment reports such as the "Third National Climate Change Assessment Report" and the "China National Extreme Weather, Climate Events and Disaster Risk Assessment Report".

(2) The conclusions on historical duties for greenhouse gas emissions have directly served in international negotiations to cope with climate change. They have been cited by Chinese delegations in various multilateral and bilateral negotiations such as the United Nations Climate Change Conference, and it is written in relevant conference documents that the emission mitigation commitments by developed countries do not match their historical responsibilities.

(3) Results on impacts and risks of climate change have supported relevant industries and regions for coping with climate change and making sustainable development. The GCMP has submitted dozens of advisory reports to relevant departments focusing on the problems of water resources and ecological hydrology in Northwest China, the drought, flood and disaster risk in Huang-Huai-Hai region, and the impact of climate change on food security of China. Some of these reports have been approved by state leaders, or adopted and referenced by relevant departments. They have been used to serve production and improve capabilities to cope with climate risks, and have gained remarkable economic and social benefits.

(4) The data, analytical methods, models and data assimilation techniques have been applied to operational processes. For example, the model developed on the basis of time-scale separation (annual and decadal) has been applied to the operational prediction platform of the National Climate Center (NCC), which provides strong support for predicting precipitation in the flood season of China.

3.4 Significantly Strengthening Basic Research Capacity

The GCMP has gained notable achievements in the training of professionals and in team and platform building, specifically in the following aspects.

(1) Data Acquisition: Significant breakthroughs have been made in the construction of global-scale datasets. The data sharing has been greatly improved. Some of the representative data products are listed as follows.

Past climate data: newly reconstructed 45 (23 of them over 1,000 years in length) high-resolution (10 years or more) climate change sequences for China and its sub-regions; 8 series of national socio-economic sequences with a length of 2,000 years at a 10-year resolution; and the northern hemisphere temperature for the last 1,000 years with an annual resolution, which is the first global series reconstructed by Chinese scholars cited in the IPCC assessment reports till now.

Data observation: a carbon cycle measurement network (24 reference points) has been established, which can provide basic calibration parameters for the development and improvement of the carbon budget model in China. In addition, a sectional observation at 18°N of the South China Sea implemented by China has independently provided long-term data for marine and meteorological research.

Satellite data inversion and assimilation: a comprehensive quality assessment on the data

acquired by the FY-3A/B microwave thermometer and the hygrometer has been conducted for the first time, which has laid a solid foundation for the application of FY-3A satellite data and the development of new devices.

Global-scale dataset: the data products of global vegetation structure data, global terrestrial carbon sinks and the inventory of anthropogenic CO_2 emissions for China have been developed; some of the datasets, such as the multi-scale inventory of aerosol emissions with high temporal and spatial resolution have been adopted by several international large-scale research projects.

(2) Significant progress has been made in the development of climate and Earth system models. The high-resolution climate models and corresponding evaluation system developed in China have a similar performance in global simulation to the advanced models around the world, and have certain advantages in the East Asian monsoon region. Models of global vegetation dynamics, aerosol and atmospheric chemistry, and the biochemical cycles of carbon and nitrogen over land and ocean have been developed, and a first version of ecological and environmental systems model has been developed.

(3) Achievements on research base construction and personnel training have been remarkable. Of all the 62 chief scientists of the projects, 6 are academics of the Chinese Academy of Sciences or the Chinese Academy of Engineering; 47 have been awarded the title of Outstanding Youth, the Thousand Talents Plan, the Ten Thousand Talents Plan, Hundred Talents Plan and the Changjiang Scholar, of whom 3 academics and 13 other candidates have been promoted during the implementation of the project. Supported by the GCMP, the construction of key laboratories, the improvement of equipment and data sharing related to global change in China have been further strengthened. The laboratories have become the foundations that link high-level research with talent on global change. In addition, the Chinese Academy of Sciences and many universities have also established a number of collaborative innovation centers and research institutes on global change.

4 GCKP (2016−2020)

MOST and agencies else jointly issued the “Implementation Plan of the National Key Research and Development Program of ‘Global Change and Response’”(GCKP)[22], which is the state-level program during the 13th Five-Year Plan period (2016−2020).

4.1 Objectives

The general objectives of the GCKP are: to make a number of innovative achievements in key scientific issues of global change, to enhance interdisciplinary research capacity, to make more contributions to international global change community, and to provide scientific support for national security and sustainable development.

The scientific objectives are to achieve a number of original and internationally recognized progress and to reduce uncertainty on the understanding of processes, magnitude, impact and risks of global change, in the areas of (1) integrated observations, data assimilation and big data analysis of global change, (2) facts, key processes and dynamics of global change, (3) development of Earth system model, forecast and projection of global change, (4) assessment on impacts and risk of global change, and (5) mitigation and adaptation to global change, and sustainable transitions.

The objectives for meeting the national demands are to provide strong scientific and technological support for participating in global climate governance, for realizing the peak discharge targets in 2030, for assessing the national contribution of major countries to car-

bon emission reduction, for eco-friendly society construction, for the implementation of the major strategies like “the Belt and Road” and new-style urbanization, and for promotion of sustainable socio-economic development and transformation.

The capacity building objectives are to enhance the capacity of multidisciplinary scientific research on global change, to develop a set of databases of global change and Earth system models, to build or improve the public platform for Earth system simulation and experimental simulation and the platform for global change data management, to improve sharing of data, equipment, models and software, and to foster a group of leading research teams and young scientists.

4.2 Major Tasks

The major tasks of the GCKP during the 13th Five-Year Plan are:

(1) Data acquisition: Comprehensive observation and data assimilation of global change, and construction and application of big data platform. This includes comprehensive observation (monitoring) of key processes and important parameters and development of related data products, development of data assimilation and fusion technologies, and construction of big data platform and integration analysis.

(2) Analyses: This includes detection (quantitative reconstruction) and attribution of multi-scale climate changes; analysis of land and ocean carbon pools and sinks, and climate sensitivity to greenhouse gases; study of processes and their climatic and environmental effects of energy and the water cycle of the earth system; study of the aerosol-cloud-radiation process and its interaction with the environment and climate change.

(3) Modeling: Development of earth system models and prediction or projections of climate change. This includes development of high-resolution climate system models and seamless climate prediction; development and improvement of earth system models.

(4) Assessment of impact and risk of global change. This includes identification of the impacts of global change on natural and human social systems, and formation, modeling and assessment of the risks of global change.

(5) Mitigation and adaptation to global change and sustainable transition. This includes global change economics and a comprehensive assessment model of global change impacts; the study of the sustainable transition model in coping with global change; and study of scientific basic for the national strategy of coping with global change.

4.3 Projects 2016–2017

Focusing on the above five fields of global change, the GCKP has already funded 29 projects with about RMB 570 million in 2016[23]. In October 2016, MOST issued guidance on the project application of the GCKP in 2017. It is expected to fund 25 research priorities (one or two projects for each priority) with about RMB 520 million.

5 Prospects

With the implementation of GCKP during 2011–2020, it is expected that research on global change and Earth system science in China will make new achievements. China will further enhance its international leading position in the study of the regional dynamics of the monsoon Asia-Western Pacific-Indian Ocean region. It is also expected to achieve breakthroughs in fields such as processes and dynamics of the Earth system, impacts and risks of global change, adaptation and mitigation. In addition, China will continue to keep its leading position in modeling the Asian monsoon and the Western Pacific-Indian Ocean environment using climate system models. Furthermore, the prediction capacity on decadal scale climate

change in China is expected to be significantly improved. And finally, the capability to meet national demands in global climate governance, risk assessment, mitigation and adaptation, and sustainable development and transformation, and the levels of the monitoring, data products, research base, talent and teams will be greatly improved.

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