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SPECIAL TOPIC ON REGIONAL CLIMATE CHANGE IMPACTS AND ADAPTATION

Climate Change in Southwest China during 1961–2010: Impacts and Adaptation

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Abstract

Due to climate change, the regional agro-climatic conditions in Southwest China have undergone changes. The heat sources for the growth of crops have been improved. The number of days with temperatures steadily above 0°C and 10°C (two criteria) have increased during 1960–2010. The area suitable for multiple cropping has increased; the growth period has shortened; the climatic potential productivity has declined; the pest damage has worsened. During 1961–2010, the desired cooling degree days in Southwest China has increased 38.9°C d per decade. Forest fires and pests have increased. The area of meadow and wetlands has decreased. Heterogeneous invasion has intensified; endangered animal and plant species have increased. The tourism landscape has been damaged. The risk of human health has increased.

In the 21st century, with the increase of temperature and precipitation, the number of days with temperature steadily above 10°C and the accumulated temperature will continue to increase, most notably in the Qinghai-Tibetan Plateau. The area of intercropping will expand; multiple cropping will move to higher altitudes. The impacts of agro-meteorological disasters, pests and diseases will intensify. The summer cooling energy consumption continues to increase; energy supply will show larger variability; the gap between energy supply and demand will be widened. The phenology will keep on changing, and the habitat will be worsening. Biological population will move northward and to higher altitudes. Some species are at risk of extinction. Negative effects on health will increase.

Keywords: climate change; impact assessment;agriculture; energy; human health

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1 Introduction

The global climate has undergone a significant change characterized by warming in the last 100 years or so [*IPCC*, 2007]. In China, the climate has changed basically in tune with the globe. Projections indicate that in the next 50–100 years, the global and China's climate will continue warming. During 1961–2010, annual mean temperature in Southwest China had increased 0.12°C per decade, and annual precipitation had slightly decreased [*Ma et al.*, 2013]. Global warming has significant impacts on the ecosystem and socio-economic system [*Li et al.*, 2010b]. This article shall analyze the observed and potential impacts of climate change on the vulnerable aspects of Southwest China, such as agriculture, biodiversity, etc., and explore the countermeasures of adaptation to climate change.

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2 Observed impacts of climate change in Southwest China

2.1 *Agriculture*

Climate changes in Southwest China have great impacts on agriculture. The first day with tempera-

ture steadily above 0°C and 10°C has become earlier, usually at a rate of 2 d per decade, for some area at 4–5 d per decade. The last day with temperature steadily above 0°C and 10°C has postponed at an insignificant rate of 1 d per decade. The number of days with temperature steadily above 0°C and 10°C and the cumulative temperature showed increasing trends.

The planting areas of one crop and two crops per year have decreased, but the area of three crops per year has increased. The sequential cropping index continued to increase. For example in dry land cultivation of Sichuan province, the area of one crop per year has decreased from 489×10^3 hm^2 to 198×10^3 hm^2, and the sowing ratio of the planting area of two crops per year to the total has dropped from 43.0% to 25.9% during 1986–2008. Although the area of three crops per year reduced 2.63 hm^2, the area ratio increased from 35.5% to 42.3%. The proportion of multiple cropping of paddy increased, too. Due to the increasing temperature, the developmental stage starts earlier, the growth period has shortened, and the climatic potential productivity has declined. In Sichuan, each developmental stage for corns starts earlier. Sowing has advanced at a rate of 4–5 d per decade during 1980–2008; tasseling and maturation have advanced at a rate of 2–3 d per decade. The durations from sowing to jointing for winter wheat and spring wheat in Tibet have shortened. In Nyingchi during 1990–2009, the durations from sowing to tillering and from sowing to stop-growing have prolonged at the rate of 16.2 d per decade and 7.4 d per decade, respectively. However, the durations from sowing to reviving, to jointing, and to flowing have shortened at the rate of 3.6, 1.3 and 4.9 d per decade, respectively. The whole growth period show a shortening trend of 4.1 d per decade in Nyingchi [*Danzeng*, 2007]. In particular, since the 1990s the climatic potential productivity in Sichuan and Yunnan has decreased persistently [*Wang et al.*, 2009a; *Li et al*, 2010a]. The area of rust and other pest disaster has increased.

2.2 *Energy*

During 1961–2009, the heating degree day in Southwest China first increased and then decreased. The heating degree day decreased at the rate of 99.6°C d per decade from 1980 to 2009, and most notably in the Qinghai-Tibetan Plateau. On the contrary, cooling degree day decreased at first and then increased, with the increasing rate of 36.1°C d per decade in 1961–1980 and the decreasing rate of 38.9°C d per decade in 1986–2010. The cooling energy consumption in summer increased, especially in southern Yunnan, northern and western Sichuan Basin. The period with not only the lowest heating degree day but also the highest cooling degree day was 2001–2009.

The run-off in the Yangtze River and its tributaries (including the Minjiang River, the Tuojiang River, the Jialingjiang River, the Brahmaputra River, and the West River) was decreasing during 1960–2010. Drought had significant impacts on hydroelectric power generation. During the drought in the summer of 2006, once-in-100-year low water level was observed in the Fujiang River, the Jialingjiang River and the Yangtze River. As a result, the hydropower had a 1.2×10^6 kW reduction.

The annual mean wind speed had decreased at the rate of 0.08 m s^{-1} per decade during 1960–2010 [*Ma et al.*, 2013]. When the mean wind speed decreases, the amount of wind power generation would decrease. Increase in mean temperatures would lead to decrease in electricity generated by wind turbines under the same wind speed. During 1961–2010, the annual mean sunshine duration in Southwest China showed a statistically significant decreasing trend of 33.3 h per decade, and most noticeably since the mid-1980s [*Ma et al.*, 2013]. And regional differences were significant in the trend of sunshine duration in Southwest China. Decreasing in sunshine duration in Panxi of Sichuan and Yunnan was not conducive to the exploration of solar energy. Although climate change mainly has negative impacts on renewable clean energy, high temperature favors biomass accumulation [*Shi et al.*, 2008]. The overall effects of climate change on southwestern biomass were positive.

2.3 *Natural ecosystem*

Southwest China is one of the most typical and concentrated areas of diversified species. During 1960–2010, forest fires and forest pests increased due to the climate warming and the droughts. The annual area of forest fires was as high as 0.25×10^6 hm^2. From the 1950s to the 1980s, the area of pest in Southwest China doubled every 10 years, with the annual area of 0.86×10^6 hm^2 (1950s), 1.44×10^6 hm^2 (1960s),