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Views & Comments

Sustainable Management and Action in China under the Increasing Risks of Global Climate Change

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1. Introduction

In the past 100 years, earth's changing climate has resulted in widespread and significant impacts, with the strongest and most comprehensive evidence of climate change being seen in natural systems. Some impacts on human systems have also been observed, including impacts on water resources and hydrological systems, species shifting and migration, and negative impacts on crop yields. The most noticeable impacts are believed to result from extreme climate-related events such as those that have recently occurred, including heat waves, droughts, floods, tropical cyclones, and wildfires.

The impacts of such climate-related extreme events also include the alteration of ecosystems, disruption of food production and water supplies, damage to infrastructure and settlements, morbidity and mortality, and consequences for mental health and human wellbeing [1]. The impacts of extreme events are of primary concern, as they can often induce severe and abrupt hazards and, in particular, compound disasters [2]. Climate-related hazards exacerbate other stressors, often with negative outcomes for livelihoods, especially for those of people living in poverty; direct negative outcomes include reduction in crop yields and the destruction of homes, while examples of indirect negative outcomes include increased food prices and food insecurity.

In the future development of humanity and human society, many kinds of risks will be met. The six highest environmental risks confronting humanity are as follows:

- Extreme weather and climate events, and especially the emergence of compound disaster events;
- The failure of human mitigation of and adaptation to climate change;
- Large-scale loss of biodiversity and collapse of ecosystems;
- Increasing supply shortage of water resources and food, particularly for developing countries;
- Large-scale natural disasters, including rapid sea-level rise and Arctic sea ice melting; and
- Anthropogenic environmental damage and disasters, including persistent air and water pollution.

Each of these risks is closely or directly related to climate change. Therefore, global climate change is a core risk that is ranked as the second most serious global risk.

2. Climate warming in China and its causes

Fig. 1 shows the global mean annual temperature anomaly for 1850–2016. Global warming over the past 100 years is clearly characterized by an increasing trend of the time series of temperature, although two accelerating warming periods (1915–1945 and 1980–1998) are visible, along with two warming hiatus periods (1950–1979 and 2000–2015). The trend of the annual surface temperature anomalies averaged in China for 1901–2016 (Fig. 2) is very similar to the trend shown Fig. 1, implying that the climate in China shows a good regional response to global climate warming. Fig. 3 presents recent atmospheric carbon dioxide (CO_2) concentrations at representative stations in the United States and China (Mauna Loa in Hawaii, USA, and Waliguan Mountain in Qinghai Province, China). The two CO_2 curves are very close to each other, and show a linear upward trend. In 2016, the CO_2 concentration exceeded 400 ppm by volume (ppmv), the highest value (by about 280 ppmv) in the past 800 000 years. Detection and attribution studies have shown that anthropogenic CO_2 emissions are a dominating contributor to external forcing to global climate warming, as well as to climate warming in China [3] (Figs. 4 and 5 [4]). As the Intergovernmental Panel on Climate Change (IPCC)'s Fifth Assessment Report (AR5) (2014) states, the warming of the climate system is unequivocal and, since the 1950s, many of the observed changes are unprecedented over decades to millennia.

3. From the dangerous levels listed in the FCCC to the 2 °C target of the Paris Agreement

In climate change studies, key risks and potentially severe impacts are referred to as the results of "dangerous anthropogenic interference with the climate system." Risks are considered to be key risks if they present a high hazard or expose a high vulnerability in society or systems, or both. Some climate-change-related risks are considerable at 1 °C or 2 °C above preindustrial levels.

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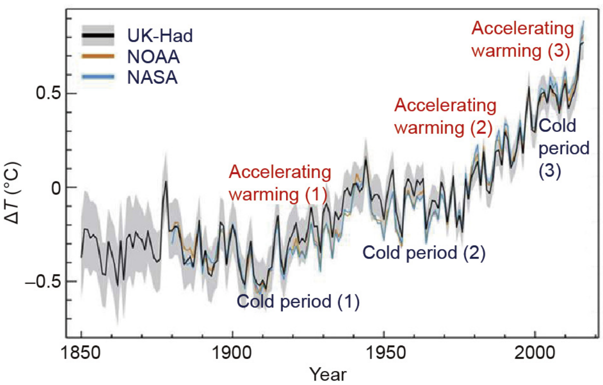

Fig. 1. The global mean annual temperature anomaly change for 1850–2016 (relative to 1961–1990) (unit: °C; source: World Meteorological Organization, 2017). UK-Had: Met Office Hadley Center for Climate Science and Services; NOAA: National Oceanic and Atmospheric Administration; NASA: National Aeronautics and Space Administration.

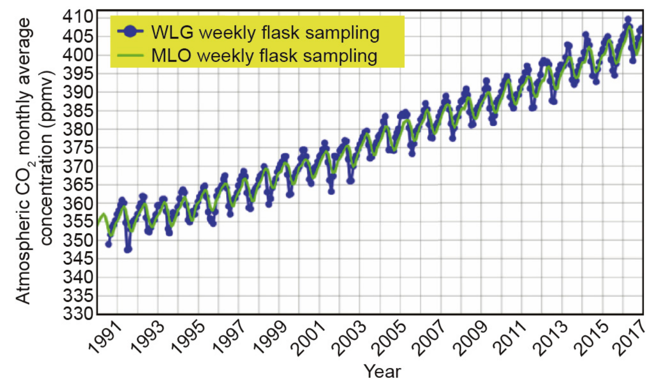

Fig. 3. Recent atmospheric CO_2 concentrations at the Waliguan (WLG) Station in China (36° 17′ N, 180° 54′ E, 3816 m above sea level) and at Mauna Loa (MLO) in Hawaii, USA (unit: ppmv; source: China Meteorological Administration, 2017). The atmospheric CO_2 monthly average data are from one of the 31 Global Atmosphere Watch global stations.

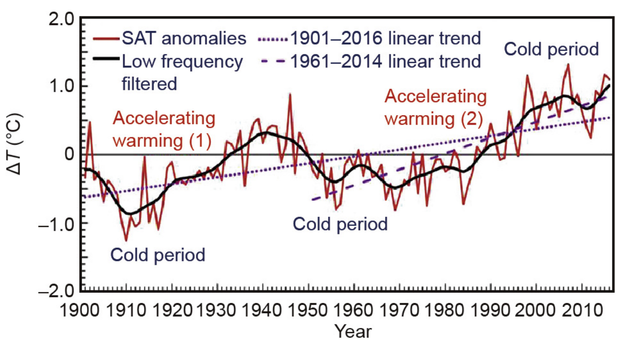

Fig. 2. Annual mean surface temperature anomalies over China for 1901–2016 (unit: °C; source: National Climate Center, 2017). SAT: surface air temperature.

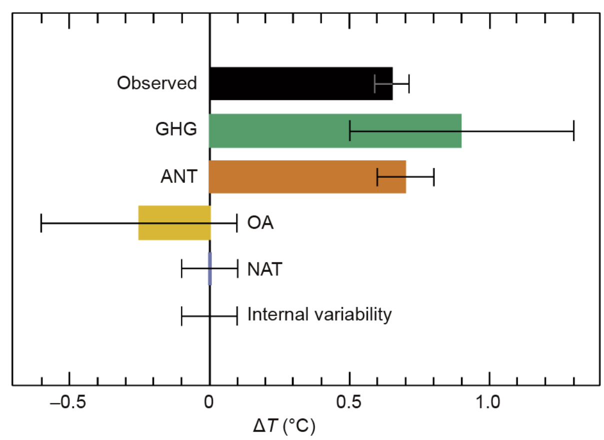

Fig. 4. Attribution of global warming trends over the 1951–2010 period to well-mixed greenhouse gases (GHGs), anthropogenic forcing (ANT), aerosols (OA), natural forcing (NAT), and internal variability.

However, global climate-change-related risks are rated as "high to very high" with a global mean temperature increase of 4 °C or more [5].

The ultimate objective of the United Nations' Framework Convention on Climate Change (FCCC) in 1992 was, first, to achieve "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."

However, at the time of the FCCC's publication, dangerous anthropogenic greenhouse gas (GHG) levels were not well defined. After 17 years, a consensus on limiting global climate change to a 2 °C threshold was established at the Copenhagen conference on

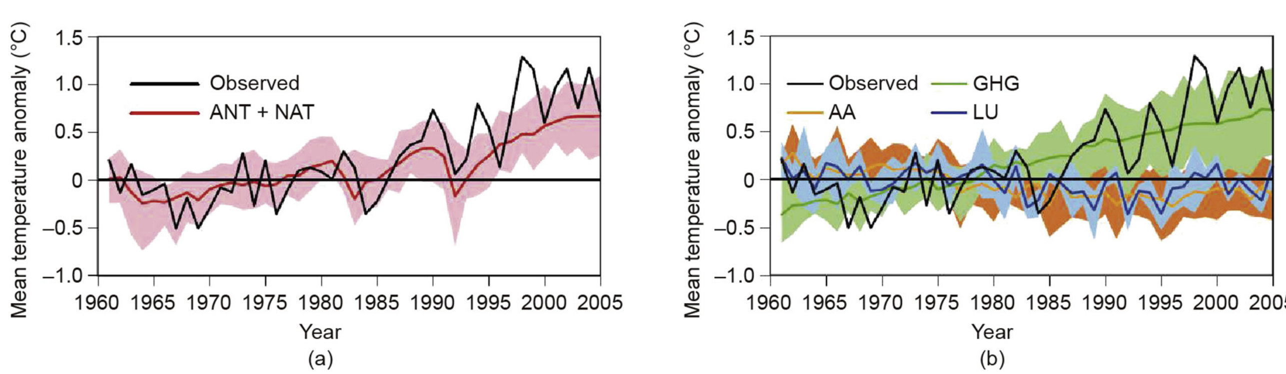

Fig. 5. Attribution of the change in mean temperature anomalies in China in 1961–2005 to well-mixed GHGs. (a) A comparison of observed (black) and simulated (red) mean temperature; (b) contributions made from aerosols (AA), land use (LU), and NAT [4].

climate change in 2009 in Denmark. A few years later, in 2015, the 2 °C threshold for global temperature rise was formally set up as the common global target; that is, it was decided that the temperature change caused by anthropogenic GHG emissions should be kept to less than 2 °C or, preferably, to below 1.5 °C relative to preindustrial levels. Fig. 6 [6,7] presents a time series of the annual mean surface air temperature (SAT) anomalies in China in 1861–2005, along with a time series of the annual mean SAT anomalies in China under the IPCC's Representative Concentration Pathway (RCP) 2.6 (relative to the 1871–1900 period) [6]. In fact, in the last 100 years, the mean temperature rise in China has been less than 1 °C (Fig. 6(a)). However, in the 21st century, the temperature rise will exceed 1.5 °C under RCP 2.6, which is the lowest emission scenario. Thus, the future emission pathway for China will, at least, follow this emission scenario in order to limit the temperature rise to below 2 °C (Fig. 6(b)). Fig. 7 [7,8] presents the emission pathway under different scenarios of global climate change from 1990 to 2100. China will reach its emission peak in 2030, or even earlier. Other emission pathways will cause the global temperature rise to exceed 2 °C.

4. Mitigation and adaptation actions for the implementation of the Paris Agreement in China

As its total target for the implementation of the Paris Agreement in China, China will: ① reach its carbon emission peak before 2030; ② transform into and enter an era of low-carbon and green energy development; and ③ pursue the sustainable development and management of society and the economy by greatly improving the state of the environment, ecosystems, human health, water supplies and security, and so forth. Under this target, China must take an irreversible road of low-carbon, green, and clean energy development (Fig. 8 [8]). To achieve this goal, China will expend great efforts to rapidly develop renewable energy and geo-engineering.

Many countries have recently taken steps to develop new renewable energy sources. Low-carbon energy sources in China accounted for 17.9% of the total energy consumption in 2015. Renewable energy production accounts for 25% of the total energy production in China, making China the world leader in renewable energy production in terms of scope [9–13].

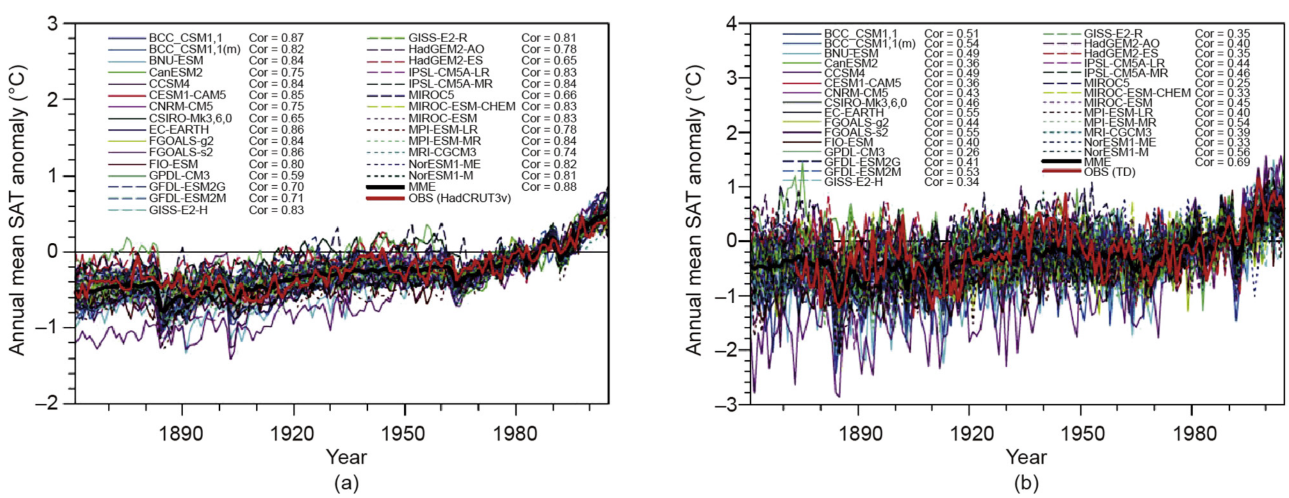

Fig. 6. (a) Time series of annual mean SAT anomalies in China from 1861 to 2005. The solid black line is the multi-model ensemble (MME) time series of 29 Coupled Model Intercomparison Project Phase 5 (CMIP5) models, and the red line denotes observations (OBS). The total correlation coefficient (Cor) between the model simulation and observations is 0.69. (b) Time series of annual mean SAT anomalies in China under RCP 2.6 (relative to the 1871–1900 period) [6,7].

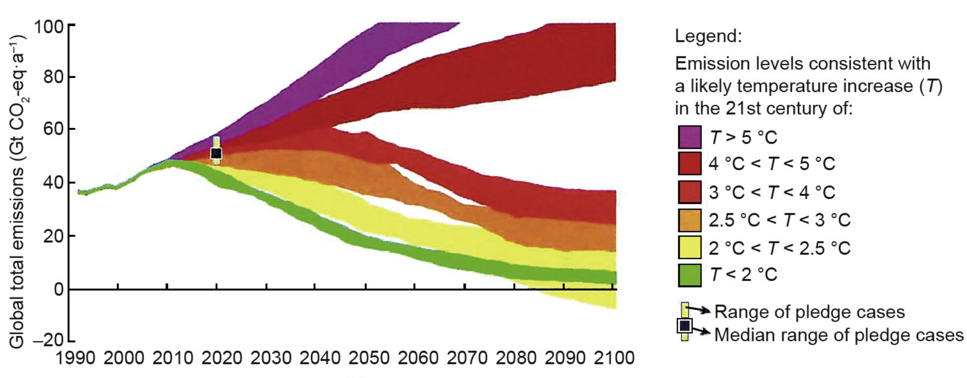

Fig. 7. Emission pathways under different scenarios of global climate change from 1990 to 2100 [8]. Likely avoided temperature increase of integrated assessment model (IAM) scenarios. Bar superimposed in 2020 shows expected emissions from the pledges. CO_2-eq: CO_2 equivalent.

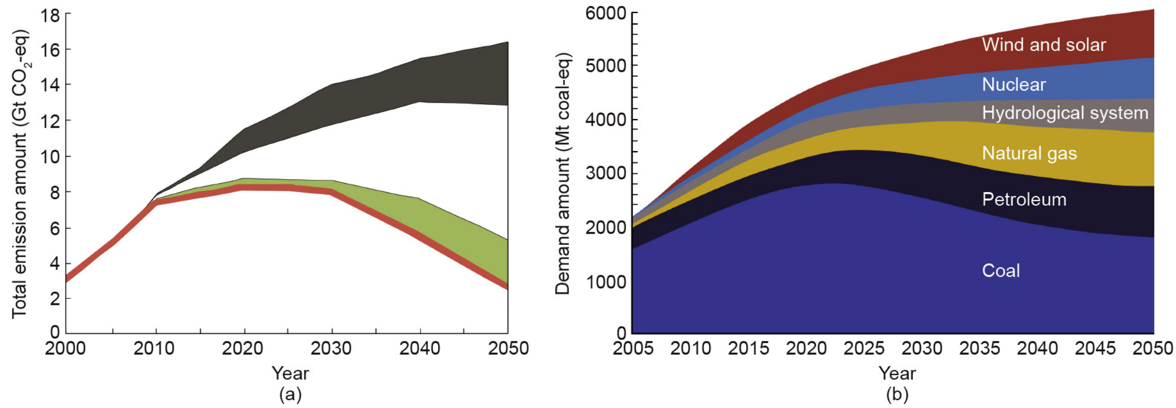

Fig. 8. Future mitigation action in China after the Paris Agreement. (a) Total emission trends for 2000–2050 (unit: Gt CO_2-eq); (b) future changes in the energy structure in China (unit: Mt coal-eq). Low-carbon and green energy will have an increasing trend in China [8]. Coal-eq: coal equivalent.

5. Preserving the earth for future generations

The future of the earth depends on the world's efforts to reduce GHG emissions, and on the adaptation policies we adopt. There are two possible futures for the generations to come: a peaceful, secure, and sustainable future; or an irreversible, degraded, and disastrous one. A sustainable future implies clean air and a comfortable climate for future generations (Figs. 9 and 10 [1]).

As the IPCC has stated (Fig. 10) [1]: "① Our world is threatened by multiple stressors that impinge on earth's resilience from many directions, represented here simply as biophysical and social stressors. Stressors include climate change, climate variability, land-use change, degradation of ecosystems, poverty and inequality, and cultural factors. ② Opportunity space refers to decision points and pathways that lead to a range of ③ possible futures with differing levels of resilience and risk. ④ Decision points result in actions or failures-to-act throughout the opportunity space, and together they consistent the process of managing or failing to manage risks related to climate change. ⑤ Climate-resilient pathways (in green) within the opportunity space lead to a more resilient world through adaptive learning, increasing scientific knowledge, effective adaptation and mitigation measures... ⑥ Pathways that lower resilience (in red) can involve insufficient mitigation, maladaptation, failure to learn and use knowledge...; and they can be irreversible in terms of possible futures" [1].

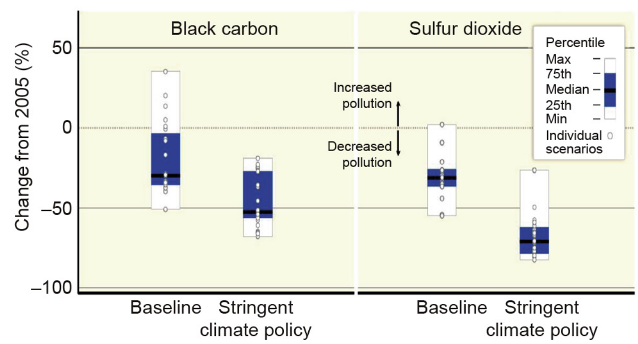

Fig. 9. Air pollutant emission levels for black carbon and sulfur dioxide in 2050 relative to 2005. Baseline scenarios without additional efforts to reduce GHG emissions beyond those in place today are compared with scenarios with stringent mitigation policies, which are consistent with the goal of reaching about 450–500 (430–530) ppmv CO_2-eq concentrations by 2100 [1].

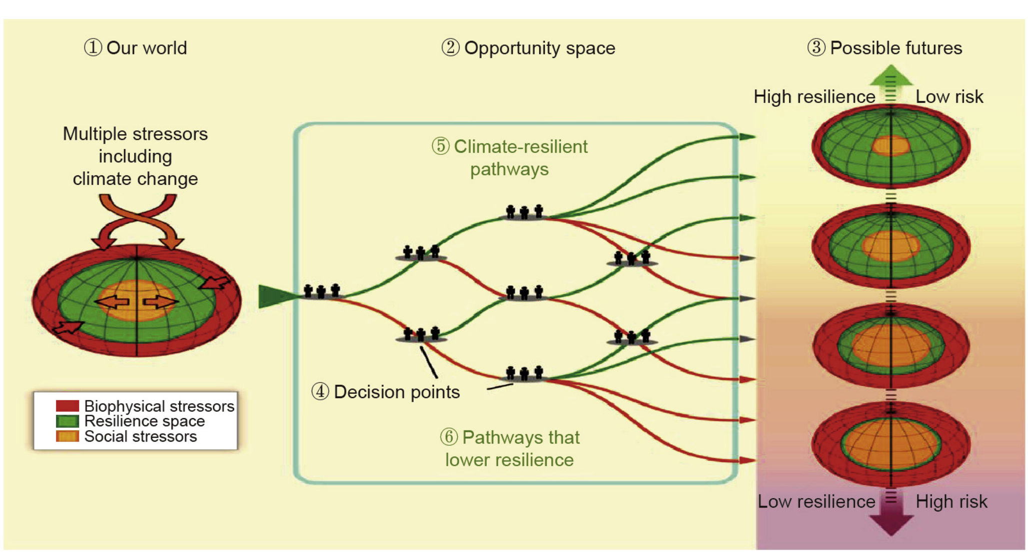

Fig. 10. Opportunity space and the possible future of our earth's climate and climate-resilient pathways [1].

References

[1] Stocker TF, Qin D, Plattner G-K, Tignor MMB, Allen SK, Boschung J, editors. Climate change 2013: the physical science basis. Working Group I contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Report. New York: Cambridge University Press; 2013.

[2] Wahl T, Jain S, Bender J, Meyers S, Luther M. Increasing risk of compound flooding from storm surge and rainfall for major US cities. Nat Clim Change 2015;5(12):1093–7.

[3] Ding YH, editor. The climate change in China and its prediction. Beijing: China Meteorological Press; 2016. Chinese.

[4] Xu Y, Gao XJ, Shi Y, Zhou BT. Detection and attribution analysis of annual mean temperature changes in China. Clim Res 2015;63(1): 61–71.

[5] Regelj J, Elzen M, Hohne N, Fransen T, Winkler H, Schaeffer R, et al. Paris Agreement climate proposals need a boost to keep warming well below 2 °C. Nature 2016;534:631–9.

[6] Zhang L, Ding YH, Wu TW, Xin XG, Zhang YW, Xu Y. The 21st century annual mean surface temperature change and 2 °C warming threshold over global and China as projected by CMIP5 models. Acta Meteorol Sin 2013;71(b):1047–60. Chinese.

[7] Jiang DB, Sui Y, Lang XM. Timing and associated climate change of a 2 °C global warming. Int J Climat 2016;36:4512–22.

[8] Task Research Group to Address the Climate Change, Chinese Academy of Engineering. Scientific and technical research in response to climate change problems. Beijing: Science Press; 2015. Chinese.

[9] Du XW. Responding to global changes as a community of common destiny. Engineering 2016;2(1):52–4.

[10] King D. Global clean energy in 2017. Science 2017;355(6321):111.

[11] Charles FK, Briggs S, Victor DG. Making climate science more relevant. Science 2016;354(6311):421–3.

[12] Obama B. The irreversible momentum of clean energy. Science 2017;355 (6321):126–9.

[13] Zheng N, Ding YH, Pan JH, Wang HJ. Climate change—the Chinese challenge. Science 2008;319(5864):730–1.