INTERVIEW

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Dahe Qin: time is limited to curb global warming

By Ling Wang and Zhonghe Zhou

The landmark international accord reached in the UN climate meeting in Paris last December stipulates the goal of limiting global warming to less than 2°C by 2100. This goal has a solid scientific basis, defined after intensive global research by scientists of the Intergovernmental Panel on Climate Change (IPCC) through modeling future landscapes under different global warming scenarios, showing that 2°C of global warming is the upper limit for maintaining a sustainable Earth. Dahe Qin, an Academician of the Chinese Academy of Sciences and Co-Chair of IPCC Working Group, has participated in climate change research for more than two decades, and knows very well the consequences of 2°C warming. In a recent interview with NSR, Qin says quite clearly, 'Since time is limited for us to halt global warming, to achieve the rosy 2°C target, we must decrease human-produced green-house gas emissions by 40%–70% by 2050, as compared to levels from 2010, and zero (additional) emissions by 2100. This goal is unlikely to be achieved in the high-carbon emission scenario'. Currently, Qin is busy preparing the IPCC 6th Assessment Report (AR6) of IPCC with other scientists to be released in 2022. He indicates that the AR6 report will propose 'Shared Socioeconomic Pathways (SSPs)' that emphasize the local effects of global warming, and bring out constructive and specific recommendations for each area and country to deal with the threat and to maintain sustainable development.

CRYOSPHERE: THE BAROMETER OF CLIMATE CHANGE

NSR: You have been studying the cryosphere since the 1980s. Why is the cryosphere so important?

Qin: The cryosphere is the component of the Earth System that contains water in its frozen state, including sea ice, snow, glaciers, ice sheets, lake ice, river ice, and frozen ground (permafrost). While these elements of the cryosphere exist at many locations on Earth, they are most common in the polar regions (Arctic and Antarctic). The cryosphere is one of the five spheres of the Earth System (i.e. atmosphere, hydrosphere, lithosphere, and biosphere). The cryosphere influences climate and the global environment through its high surface reflectance (albedo), ability to transfer heat and carbon release from and storage in frozen ground (permafrost).

The cryosphere also is a vital fresh water resource for arid and semiarid areas, and the key for survival in desert oases. For example, the Tibetan Plateau and its associated glaciers are the sources of the Yellow, Yangtze, and Mekong Rivers. Thus, the cryosphere in Asia supports the lives of one-third of world's population. Furthermore, the cryosphere influences international sea-lanes, military deployment, and geopolitics.

NSR: How exactly does the cryosphere impact the climate, and vice versa?

Qin: To put it simply, variation in the cryosphere is an outcome of climate change, and variation in the cryosphere in turn modulates global climate. In the far distant past of Earth history, it was once an icy ball of severe coldness; while there was no ice at all during warmer periods. It is worth noting that in the past 50 years, the cryosphere has retreated and shrunk globally, powerful evidence of global warming. In other words, according to the patterns of climate change in Earth history, greenhouse gases would decrease, and temperature would decline from the start of 21 century, but on the contrary, concentration of greenhouse gases is continually increasing, and the temperature has risen during the past 15 years; and human activity is clearly a culprit.

Dahe Qin, Co-Chair of IPCC Working Group. *(Courtesy of Dahe Qin)*

> As the IPCC AR5 pointed out, the Greenland and Antarctic ice sheets have been losing mass more quickly in the last 20 years.
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NSR: How can climate change in Earth history be understood? Is the cryosphere a database of past climate change?

Qin: The cryosphere, in particular polar glaciers, is a treasury for the study of climate change. To be more accurate, there are two types of glaciers: montane glaciers and polar ice sheets (including the Antarctic and Greenland ice sheets). Ice sheets form when snow accumulates over time, turns to ice and begins to flow outwards and downwards under the pressure of its own weight, and the glacial ice often appears blue when it has become very dense (https://nsidc.org/cryosphere/glaciers/life-glacier.html). The movement of ice from the top of glacier down to its base takes about 1 million years; while the history of Antarctic ice sheet can be traced back 14 million years. Ice cores extracted from glacial ice with trapped air bubbles reveal past atmospheric composition, temperature variations, and types of vegetation. With those ice cores, past eras can be reconstructed, showing how and why climate changed, and how it might change in the future.

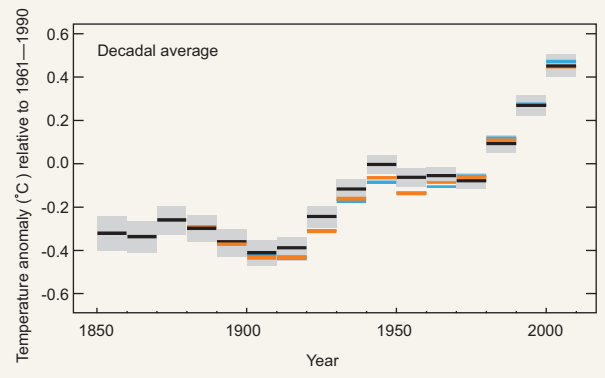
From the ice core record we can conclude that the Earth's climate changes over a cycle of about 100 000 years. During that cycle, the interglacial period lasts approximately 10 000 years, and the rest of the cycle is composed of the glacial and interim periods.

NSR: How do you extract data from an ice core? Is it very difficult?

Qin: Yes, we need to free the air that is trapped in the ice core and analyze the ratio of stable isotopes (^{16}O and ^{18}O) in the ice, and then determine the age of sample, and composition of ancient air. Through comparing ice samples over different ages, we get information about changes to the climate.

NSR: You participated and led the expeditions to Antarctica in the 1980s. What are they bringing to cryosphere research in China?

Qin: I collected abundant samples from the Antarctic ice sheet, including cross sections of 1000 km in the southeast and 6000 km across the sheet. When I returned to China, our group systematically analyzed the materials and enriched our understanding of the evolution of the Antarctic ice sheet. In addition, geologist Xiaohan Liu and I won the right for our country to sample Dome A, which is in the center of the Antarctic ice sheet and the ideal spot to extract a deep ice core. Before that, Dome C was explored mainly by the European Union, and Dome F was analyzed mainly by Japan. The oldest ice found in Dome C is 800 000 years old, and the science community speculates that they hope to recover an ice core extending back 1 000 000 years in Dome A, which is not yet achieved.



Global warming is accelerating. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. *(Source: IPCC, 2013: Summary for Policymakers)*

NSR: Why is it so difficult to get the oldest ice cores?

Qin: I think there are two main reasons. One is that to find an older ice core scientists need to drill deeper into a glacier. An ice core extending back 1 000 000 years would be about 3–4 km deep from the top of the glacier, and difficult to drill. Another reason is related to the lack of efficient cooperation among various parts of the scientific units in our country, resulting in slow progress.

ACCELERATING GLOBAL WARMING

NSR: As you just mentioned, variation in the cryosphere provides obvious evidence of global climate change, as global warming accelerates. How does the cryosphere change?

Qin: As the IPCC AR5 pointed out, the Greenland and Antarctic ice sheets have been losing mass more quickly in the last 20 years. The average rate of ice loss from the Greenland ice sheet has increased from 34 Gt yr^{-1} over the period 1992–2001 to 215 Gt yr^{-1} over the period 2002–2011. The average rate of ice loss from the Antarctic ice sheet has increased from 30 Gt yr^{-1} over the period 1992–2001 to 147 Gt yr^{-1} over the period 2002–2011, with the losses mainly from the northern Antarctic Peninsula and the Amundsen Sea sector of West Antarctica.

NSR: There is still doubt about the accelerating pace of global warming. Some believe that global warming is slowing down or even stagnant over the past 10 years. What is your point of view?

Qin: That is an interesting dispute. Some marine scientists think that global warming would change oceanic circulation, which would counteract the warming effect, and lower the ground temperature, leading to a slowdown of global warming. However, a recently peer-reviewed paper published in *Science* held the opposite view, suggesting that the ocean would intensify global warming, and it turned out that 2014 was the hottest year in last 30 years.

Research results also indicate that temperature increases do not have a linear relationship with time, but support a complex non-linear warming process. Each of the last three decades has been successively warmer on the Earth's surface than any preceding decade since 1850. Since 1880, the highest global

mean surface temperature occurred in 2014; the second highest occurred in 2005, but that record will not last long. According to the World Meteorological Organization, 2015 is likely to replace 2014, and become the warmest year on record.

NSR: The current El Niño started in 2014 and grew stronger in 2015. Some scientists say it may be the strongest El Niño ever recorded. How will this climate event influence China? And is there some link between El Niño and global warming?

Qin: El Niño refers to a periodic warming in sea surface temperatures across the central and eastern equatorial Pacific, which is linked to the development and suppression of convections respectively over the central and eastern equatorial Pacific and western Pacific leading to the disturbance of global climate. For example, during an El Niño event, countries in South America always suffer disastrous rainstorms and floods; and areas like Indonesia, eastern Australia and the southeastern part of Africa are plagued instead by drought, reducing food production steeply.

As for China, El Niño events with moderate strength or stronger typically lead to more rainfall in the southern part while less rainfall to the north of the Yangtze River in autumn and winter, and a warmer winter. In the summer time of the following year, more rainfall tends to occur in the Yangtze River and to its south.

The El Niño which began in May 2014 is still developing. As compared to the previous 13 El Niño phenomena recorded since 1951, this event is weaker near its start, but is strengthening since May 2015. It has a significant impact on China's climate. Due to its impact, only five typhoons hit land in 2014 and no one hit land in August 2014, a decrease compared to the average. The rain belt was located mainly to the south of the Yangtze River, showing an 'abundant in the south while scarce in the north' aspect. China also had a warm winter in 2014 with average January and February temperatures breaking historic records.

In general, the relationship between El Niño and global warming is complicated. El Niño is a significant signal that affects climate across one or several years. However, global warming is a longer lasting trend. El Niño on one hand would contribute to global warming, and on the other hand, given a background of global warming, the frequency and strength of future El Niños probably will be enhanced.

THREATENING SIGNAL

NSR: The IPCC AR5 came out in 2014. What are its key points?

Qin: The IPCC AR5 adopted five independent data sets, which could offset any imperfection of an individual data set, and ensure the overall accuracy and reliability of the research results. Its Synthesis Report lists three key messages: human influence on the climate system is clear; the more we disrupt our climate, the more likely we risk severe, pervasive and irreversible impacts; and we have the means to limit climate change and build a more prosperous, sustainable future.

On 2 November 2014, the press conference for the IPCC AR5 Synthesis Report occurred in the capital of Denmark, Copenhagen. The Secretary of the United Nations, Ban Ki-moon, stated in his presentation, 'the scientific evidence is sound that global warming is an undoubted fact, leaders must take actions, and time is urgent'.

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Actually, what Ban said is expressed clearly in the Assessment Report. Take the cryosphere as an example, from 1979–2012, the annual mean Arctic sea ice extent decreased at a rate of 3.5%–4.1% (about 450 000–510 000 square kilometers) per decade. In the last three decades, retreat of Arctic sea ice extent during summer was unprecedented.

As for greenhouse gases, the atmospheric concentrations of CO_2 and CH_4 are 393 ppm and 1819 ppb and exceeded the preindustrial levels by 41% and 160%, respectively. The more terrifying fact is that the global concentration of CO_2 reached nearly 400 ppm in 2014, a new historical record.

Also, there is a very important concept worth attention in the report, radiative forcing (RF). RF is used to quantify the change in energy fluxes of the earth system caused by some drivers such as greenhouse gases and aerosols. Positive RF leads to surface warming, and negative RF leads to surface cooling. The total anthropogenic RF in 2011 is 2.29 (1.13–3.33) W m^{-2}, which is 43% higher than that reported in AR4 for the year 2005. If RF follows the RCP8.5 scenario, the Arctic Ocean would have no ice cover in September in the middle of this century, which is terrible.

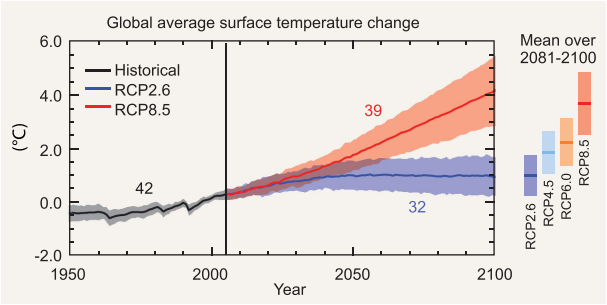
NSR: How can we deal with the acceleration of global warming?

Qin: There is limited room for us to take measures immediately. Global warming level at the end of 21st century is dependent on the cumulative emissions of CO_2. Until 2011, an amount of 515 (445–585) GtC that is equivalent to 1890 (1630–2150) $GtCO_2$ was already emitted. To achieve the 2°C target by the end of this century, we have to cut 40%–70% of CO_2 emissions by 2050 (as compared to 2010 levels), and achieve zero emissions by 2100. In the high emission scenario, we probably will break the 2°C global warming limit.

Research results of IPCC also indicate that, if the temperature increases 1°C–2°C as compared to the preindustrial era, global climate risk is moderate to high. If the temperature increase exceeds 4°C, the climate risk is high or very high. In the high risk scenario, extreme weather, and large-scale high impact events are very likely to happen frequently, and species on the brink of extinction will disappear more rapidly.

MORE EXQUISITE STRATEGIES

NSR: IPCC AR6 is in preparation. Compared to earlier editions, what are the biggest differences?



Global average surface temperature change prediction. *(Source: IPCC, 2013: Summary for Policymakers)*

Qin: IPCC AR6 will integrately consider SSPs and Representative Concentration Pathways (RCPs). SSPs quantify the linkage between the RF amplitude and the socioeconomic development level, including how variables like population and GDP would affect the direction, speed and quality of the socioeconomy. It has been a huge challenge for IPCC and also the most unsatisfying part in the report for policy makers. We will put more effort into this problem.

NSR: Does that mean to correlate GDP and population to greenhouse gas emission strength; so that policy makers can easily and directly analyze the data as to facilitate the decision making process?

Qin: To some extent, yes. Actually, we had suggested to establish the linkage of the socioeconomic indicators such as populations, GDP, consumption of primary energy to temperature rise and RF in IPCC AR4. However, there are still defects in the previous report, such as the absence of analysis of the scope of potential warming impacts and a strategy for adaptation to global change. Therefore, the three working groups of the IPCC will closely cooperate, and comprehensively digest information in order to set up SSPs, which will for the first time provide specific and operational policy advice.

NSR: China has made a resolution to greatly decrease greenhouse gas emissions, and it is a difficult endeavor.

Qin: Indeed. Our economy has leapt forward since reform and opening, but in the meantime, we have produced enormous greenhouse gases emission. Today, China is the number one carbon emitter, with an energy consumption per GDP that is five to seven times that of Japan, and three to five times that of the US. There is a lot of room to reduce energy density. On 12 November 2014, China and the USA released a US-China Joint Announcement on Climate Change in Beijing, laying the foundation of 'working together and assuming responsibility according to each country's capability' principle.

China vows to achieve its peak CO_2 emissions around 2030, and to make its best efforts to peak earlier. It intends to increase the share of non-fossil fuels in primary energy consumption to near 20% by 2030.

NSR: The energy resources of China are mostly 'rich coal, meager oil, and little gas', and these primary sources of energy, in particular coal, are the largest portions of overall energy consumption. How can we effectively reduce greenhouse gas emissions?

Qin: It is true that coal makes up 67.5% of primary energy consumption in our country, and we are among the few countries heavily dependent on coal. Therefore, utilization of clean coal technology is far from enough to decrease the amount of emissions, and we need to control the total amount of energy consumed and further increase the share of non-fossil fuels in our energy portfolio. For example, we could utilize climate resources, deploying wind and solar energy more effectively, and develop more environmentally friendly agriculture.

NSR: Is there a contradiction between continuous economic growth and the reduction of emissions?

Qin: China has entered the 'new normal' phase, with annual GDP growth at 6.5%–7% which I consider to be healthy and favorable for the reduction of emissions. China's economic structure will undergo comprehensive and fundamental changes. Technological innovation will not only stimulate energy-saving and pollution control, but also stoke the engine of new economic growth.

To achieve this goal, we must stress the cultivation of engineers and increase scientific management. Articles and projects should not be the only standard for evaluating talents. Countries like Germany and Japan attach the same importance to engineers, as they do to scientists. Thus, these countries are booming and developing sustainably.

NSR: Global warming is a challenge in front all of us, including both developed and developing countries. There are indeed some impediments in promoting plans to curb warming. Do you have faith in the complete halting of the warming trend on Earth?

Qin: I think it is possible under the circumstances that all of us take more positive and effective strategies. The energy department should usher in vital revolution, encourage the utilization of new critical technologies like biofuels, Carbon Capture and Storage, nuclear power, wind power and solar energy to reduce greenhouse gas emissions. Interdepartmental cooperation is essential for the long-term target to be reached and should be started as soon as possible.

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