

## Global Warming Distorts the Twenty-Four Solar Terms

Qing H<sup>1</sup>, Zhang X<sup>2</sup> and Yang XJ<sup>3\*</sup>

<sup>1</sup>School of Environmental Science and Engineering, South University of Science and Technology of China, China

<sup>2</sup>Department of Social and Ecological Civilization, Chinese Academy of Governance, China

<sup>3</sup>Department of Environmental Science and Engineering, Beijing University of Chemical Technology, China

\*Corresponding author: Xiao Jin Yang, Department of Environmental Science and Engineering, Beijing University of Chemical Technology, Beijing, 100029, China, E-mail: yangxj@mail.buct.edu.cn

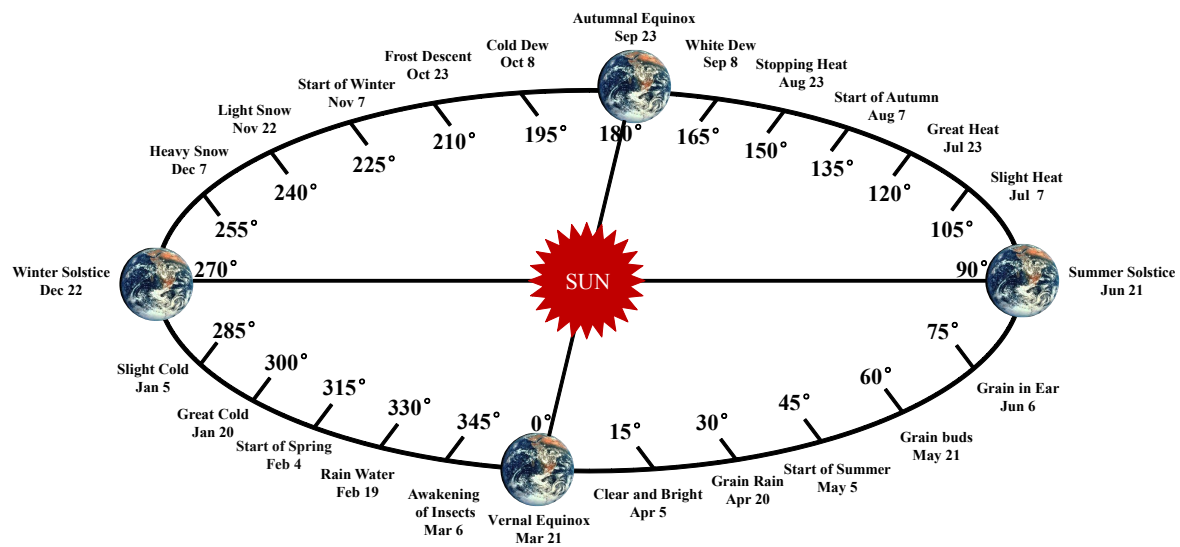
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### Introduction

Two thousand years ago, ancient China created a system of twenty-four solar terms through the observation of the Sun's annual motion and position along the ecliptic, where every 15° segment is a solar term encompassing a period of 15 days. The first term "Start of Spring" begins from the Sun's position at 315° on the day of 4 February in the Gregorian calendar. This solar term means the start of a new year cycle that the coldest weather ends and the planet is going to warm up. Each of the twenty-four solar terms was named to reflect the evolution of natural phenomena, phenological seasons and climates (see the Illustration Figure 1) and has guided agricultural and living activities

across China since their creation. For instance, the third term "Awakening of Insects", which commences on 6 March, the day of Sun's position at 345°, signals a rise in temperature and rainfall, alluding to the fact that animals and insects are awakened from winter hibernation by spring thunder and it is the time to start spring plough in the central plan, the origin of the solar term system. The twenty-four solar terms were crucial for agrarian societies in ancient China and spread to Korea, Vietnam, Japan, and countries in the East Asian cultural sphere. The solar term system was inscribed on the UNESCO's representative list of intangible cultural heritage on 30 November 2016.



**Figure 1:** Illustration of the Earth and Sun's positions and the corresponding solar terms. The date shown for each solar term is approximate and the exact date for each term varies between a day earlier and later (inclusive) depending on the year.

However, the reflection of climate and phenological variations for each twenty-four solar terms has been deteriorating due to global warming. Accelerated global warming has occurred over the past four decades while pronounced warming is obvious in the entire country, particularly in the northern part of China [1]. China's national climate report revealed that the average surface temperature rose by 0.9-1.5°C in China during the period of 1909-2011 and predicted a further increase of 1.3-5°C by the end of the century [2]. As a result, phenological phenomenon starts earlier for each of the first half of the 24 terms (from "Start of Spring" on February 4 to "Start of Autumn" on August 7) and ends later for the remaining 12 terms [3]. For example,

the term "Awakening of Insects" usually began on March 6, but is now coming 12-16 days earlier. The average length of two consecutive terms "Slight Cold and Great Cold" (the average temperature is minus 3.5°C and below) was reduced to 14 days per year in the period of 1998-2007 from 32 days per year in the 1960s while the length of "Slight Heat and Great Heat" increased to 36 days from 20 days per year in the corresponding periods [3]. In Eastern China, the length of thermal growing season was observed to increase by 1.5 days per decade for 1909-2012 [4]. Projection shows that the average temperature is 1-3°C higher between 23 March and 1 April this year than the corresponding period of previous years across the major part

of China. Rising temperature and declining precipitation in the Northern-Eastern, Northern and Central areas of China over the past 50 years have affected agricultural production and increased desertification salinization, schistosomiasis, the morbidity and mortality of cardiovascular, cerebrovascular and respiratory diseases.

It is well recognized that the global warming is primarily the consequence of a steeping increase in greenhouse gas concentration since the industrial revolution. Greenhouse gas carbon dioxide concentration has now increased to nearly 400 parts per million (ppm) from 280 ppm before the industrial revolution. Computer models projected that carbon dioxide concentration would increase to 550-800 ppm by 2100 [5]. In fact, the 1992 United Nations Framework Convention on Climate Change has called for stabilization of greenhouse gas concentrations in the atmosphere to prevent dangerous climate outcomes. Further, the 2015 UN Paris' agreement set a target of 2°C by cutting emissions of greenhouse gases from fossil fuels. Unfortunately, global annual CO<sub>2</sub> emissions rose from about 22 to 41 gigatons per year from 1992 to 2017- a more than 86% increase. Clearly, the world has failed to meet the 1992's goal. And even if all countries hit their targets under the Paris agreement, global carbon dioxide emissions will still far exceed what is needed to keep temperatures from rising above 2°C [6]. The UN's climate talks in Bonn, Germany in November 2017 realized that the goal of the Paris agreement's 2°C seems increasingly difficult to achieve, but few of the more than 170 nations and parties in the talks announced any new initiatives to cut emissions. A recent study revealed that the estimated warming by 2100 is about 15% higher than the best estimate from the Intergovernmental Panel on Climate Change and suggested that steeper emissions reductions are required to achieve any given global temperature stabilization target [7]. Sadly, the global demand for fossil fuels is set to rise until at least 2040 and the United States decided to withdraw from the Paris accord, expecting to increase emissions by 1.8 percent this year.

China has been the world's largest investor in the development of renewable energy since 2013 and hosted 17%, 20.5% and 21.9% of the world's renewable power capacity in 2015, 2016 and 2017 [8-10]. China is playing a leading role in cutting emissions and developing renewable energy [11], influencing the rest of world in dealing with climate change, and building eco-civilization as the third phase of humanity development. With contribution from all of nations to dealing with global warming, we hope ancient China's solar terms continue to be effective all along the humanity development.

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