Article

Some thoughts on global climate change: will it get warmer and warmer?

WenJun Zhang, Chunhua Liu
School of Life Sciences, Sun Yat-sen University, Guangzhou 510275, China; International Academy of Ecology and Environmental Sciences, Hong Kong
E-mail: zhwj@mail.sysu.edu.cn, wjzhang@iaees.org

Received 16 September 2011; *Accepted 3 November 2011*; *Published online 10 March 2012*
IAEES

Abstract
Many studies discussed climate change without considering the complexity of climate system. In our view, climate system is a complex and non-linear system. It possesses all properties that a complex system will have, such as non-linearity, chaos, catastrophe, multiple stable or unstable equilibrium states, etc. It is increasingly obvious that the equilibrium state of climate system is being broken by destructive human activities. There are several possibilities that global climate will proceed. We would not exactly predict what outcome will finally occur if destructive human activities continue. In the farther future, in addition to the scenario of continuous warming, there is also possibility that the climate would proceed and reach a new stable or unstable equilibrium state, and the new equilibrium state would be realized in a smooth and continuous way, or realized in an abrupt way by jumping or plummeting. Recent years' and the coming tens of years' unusual change in global climate would be a prelude for dramatic climate change in the far future. We found that global annual mean temperature since 1880 has been rising in sinusoidal-type, similar to a superposition of sine curve and exponential curve, in which a periodicity of about 60 years existed and in the first ~40 years the temperature rose and in the second ~20 years it declined or approximately to be constant. Accordingly, we predicted that the global annual mean temperature had reached a peak around 2005, and would decline or be approximately constant until around 2030. Some models, equations and parameters on climate change were also developed based on past hundreds of years' historical records.

Keywords climate change; climate system; complex system; nonlinearity; uncertainty; equilibrium state.

1 Introduction

Global climate change is a controversial issue (Kintisch, 2009b). Many people believe that global climate is warming, due to human activities (Kerr, 2007a, b; Kintisch, 2009a; McCarthy, 2009). Some scientists and civilians, however, argue that present global warming is a natural fluctuation which was not caused by human activities (natural law, i.e., change of solar radiation, El Nino, La Nino, etc.). Global warming is facing an inconvenient challenge after the release of new temperature data showing the planet has not warmed for the past 15 years (Cai, 2012; Henan Commercial Daily, 2012) and figures suggest that we could even be heading for a mini ice age. This deepens the judgment of the natural law. In this study, we tried to propose some thoughts on global climate change (in present study we only treat global annual mean air temperature) based on both data and theoretical analysis.

2 Materials and Methods

The data on changes of global annual mean air temperature (global air temperature; ºC), global concentration of atmospheric CO_2 (ppm), and global carbon emission from fossil fuels since 1751, were collected from Angell (2009), Hansen et al. (2009), Lugina et al. (2006), and internet resources: http://cdiac.ornl.gov/trends/temp/angell/data.html, http://data.giss.nasa.gov/gistemp/tabledata/GLB.Ts.txt, http://en.wikipedia.org/wiki/Temperature_record, http://www.ncdc.noaa.gov/oa/climate/research/msu.html, etc.

The data were analyzed using such methods as linear regression, differential equation modeling and data smoothing, etc.

3 Relationship between Global Air Temperature, Concentration of Atmospheric CO_2, and Carbon Emission

Using the data between 1751 and 2006 (Fig. 1), we developed a dynamic model for changes of carbon emission accumulation from fossil fuels, represented by a differential equation as the following:

$$dx/dt=(0.04964242-0.00008584(t-1750))x,$$

where x-total carbon emission accumulation from fossil fuels (million tons), t-year; r^2=0.9948, p≈0.

According to this model, carbon emission accumulation from fossil fuels since 1751 has reached 3.73×10^{11} tons (Zhang et al., 2010).

Based on the raw data, annual growth rate of carbon emission accumulation from fossil fuels, during recent years, is 2.48±0.14%.

The regression relationship (from years 1832 to 2006) between global concentration of atmospheric carbon dioxide and carbon emission accumulation from fossil fuels (since 1751) was developed as

$$y=290.3818+0.0003x$$
$$r^2=0.9749,\ p\approx 0$$
$$0.0003 \le \text{coefficient } b \le 0.0003$$

where y- global concentration of atmospheric carbon dioxide (ppm), and x- carbon emission accumulation from fossil fuels (million tons).

Based on this equation, about 3.3333 billion tons of carbon emission from fossil fuels will lead to 1 ppm increase of global concentration of atmospheric carbon dioxide (Fig. 2).

In addition, annual growth rate of global concentration of atmospheric carbon dioxide is 0.54±0.17% during recent years.

The regression relationship (from years 1880 to 2008) between global air temperature and global concentration of atmospheric carbon dioxide (Fig. 3) was developed as

$$y=11.0117+0.0094x$$
$$r^2=0.7615,\ p\approx 0$$
$$0.0085 \le \text{coefficient } b \le 0.0103$$

where y-global air temperature(°C), x-global concentration of atmospheric carbon dioxide (ppm).

It is obvious that 1 ppm increase of global concentration of atmospheric carbon dioxide will lead to averaged 0.0094 °C (0.0085°C~0.0103°C) increase of global air temperature.

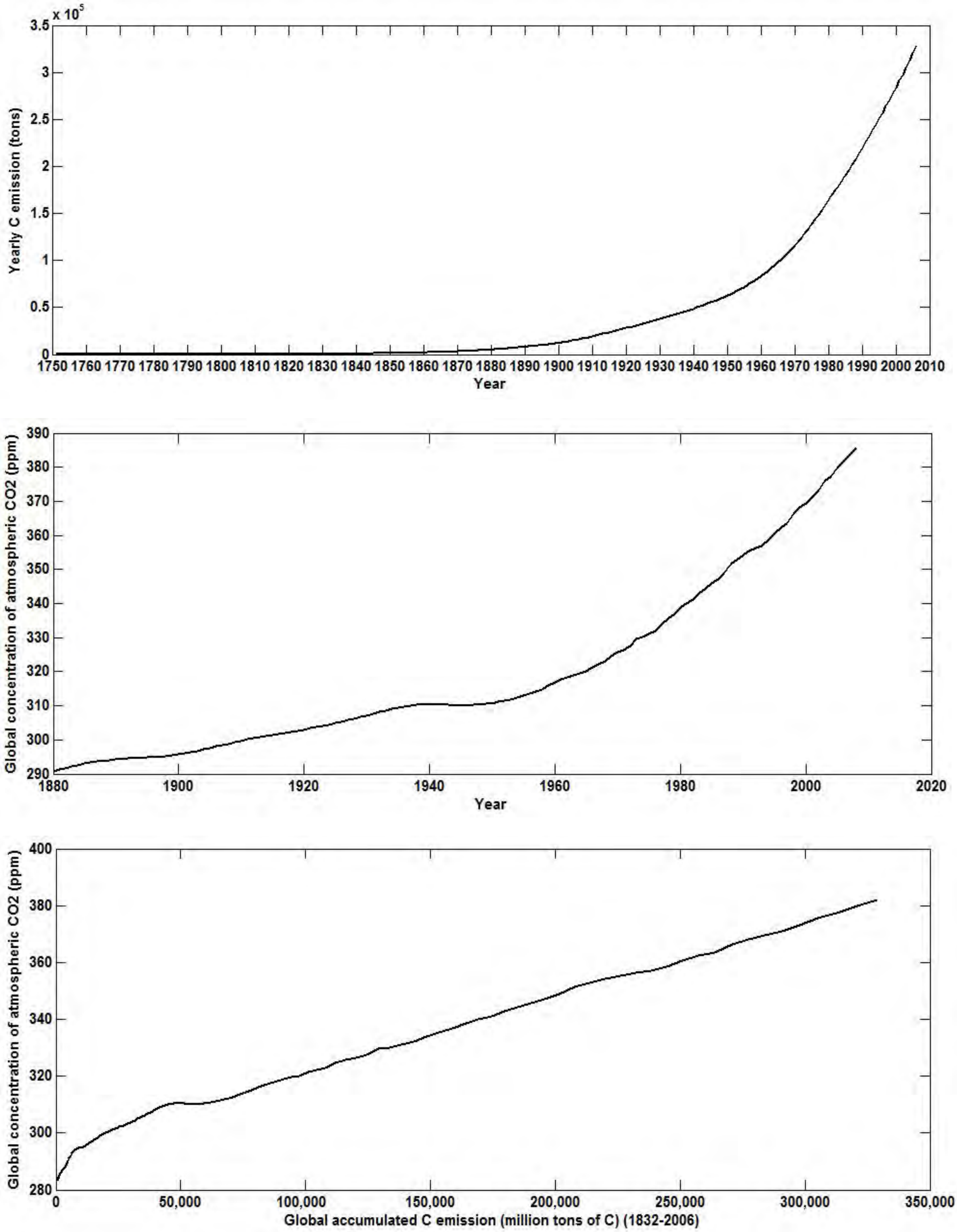

Fig. 1 Dynamics of carbon emission from human activities and global concentration of atmospheric CO_2, and their relationship.

From the parameter r^2, we can find that 76% of change of global air temperature was caused by the change of global concentration of atmospheric carbon dioxide while 24% of that was caused by other green house gases (methane, water vapor, etc.), natural forces (change of solar radiation, volcano eruption, El Nino, La Nino, Southern Oscillation, etc.), and other destructive human activities (deforestation, desertization, etc.)

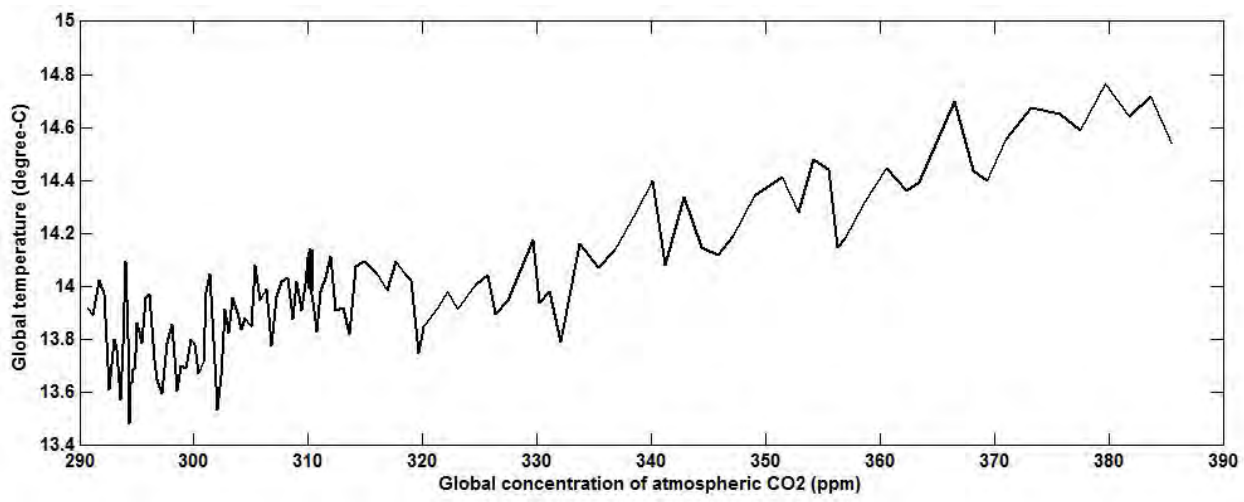

Fig. 2 Realtionship between global concentration of atmospheric CO_2 and global air temperature

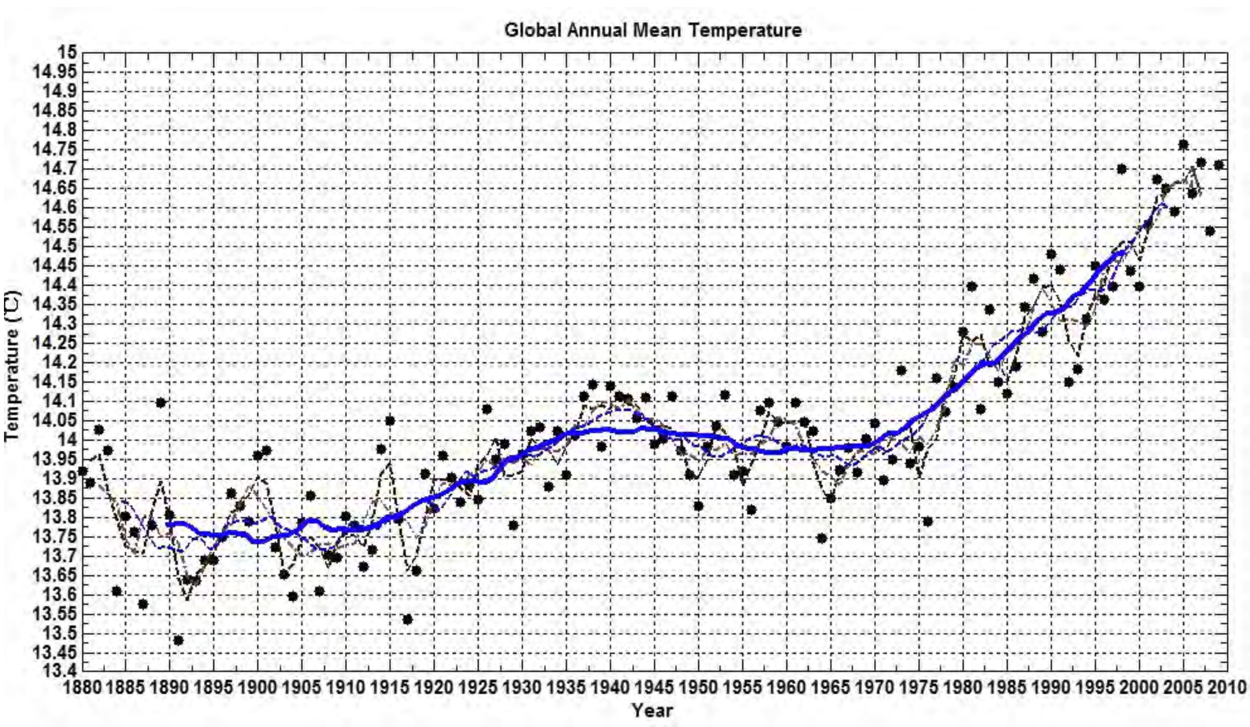

Fig. 3 Realtionship between global concentration of atmospheric CO_2 and global air temperature. Bold blue curve: 20 years' smoothing; dash curves: 10, 5, and 3 years' smoothing.

4 Foresight on Global Climate Change

4.1 A short-term forecast

We had made 20, 10, 5, and 3 years' data smoothing on global air temperature data collected for since 1880 (Fig. 3; Zhang, 2009). We found that 20 years' smoothing is particularly representative. It was found that global annual mean temperature has been rising in sinusoidal-type, similar to a superposition of sine curve and exponential curve, in which a periodicity of about 60 years existed and in the first ~40 years the temperature rose and in the second ~20 years it declined or approximately to be constant. Accordingly, we predicted that in the near future, the global annual mean temperature have reached a peak around 2005, and would decline or be approximately constant before 2030 or so. Since then, the temperature would rise again, or be hard to be estimated.

Analysis by experts at NASA and the University of Arizona showed that magnetic-field measurements 120000 miles beneath the sun's surface suggested that the peak of Cycle 25, which affects the earth's climate, is due in 2022 (Cai, 2012). This is basically coincident with my estimation on short-term climate change. This supports our supposition that the above climate periodicity was caused by some periodicity of solar radiation. Hence, a relatively short-term decline in global air temperature may be not sufficient to represent a long-term trend in climate change.

4.2 Some theoretical thoughts on climate change

Many studies discussed climate change without consideration of complexity of climate system. In my view, climate system on our planet is a non-linear and complex system. It possesses all properties that a complex system will have. Because it is a non-linear dynamic system with thousands of variables, it will show various non-linear properties as bifurcation, chaos, catastrophe properties, multiple stable or unstable equilibrium states, etc. The stable state of climate system so far is a conditional stability. The climate system is also a self-organizing system. Human activities (including carbon emission from fossil fuels, deforestation, desertization, etc.) are one of driving variables of climate system. Compared to other driving variables as solar radiation, etc., effects of these driving variables are not periodic and are sometimes destructive to the system. If the strength of these driving variables exceeds some threshold, the system would not restore itself and the stability of the system would be destroyed. Climate system would be out of control or collapsed.

In a short term, a varied climate is expected as indicated above. However, for hundreds of years or thousands of years, there are several possibilities that global climate will proceed. We may not exactly predict what outcome will finally occur if destructive human activities continue. However it is increasingly obvious that the equilibrium state of climate system is being broken by destructive human activities. There should be several dynamic patterns for the farther future (Fig. 4): (1) the climate is out of control and becomes warmer and warmer with little fluctuation (Fig. 4 (1)); (2) the climate is out of control and gets colder and colder with little fluctuation, finally falls into an eternal ice age (Fig. 4 (2)); (3) the climate reaches a new stable or unstable equilibrium state (Fig. 4 (3)). A new (stable or unstable) equilibrium state would be realized in a smooth and continuous way, or realized in an abrupt way (by jumping or plummeting). In the unstable equilibrium state, the climate would dramatically change (with temperature downward or upward) if it suffers from great disturbances. Recent years' (and the coming tens of years') unusual climate change (Fig. 5) would be a prelude for dramatic climate change in the future.

Whatever the scenario is, the varied and extreme climate around the world caused by destructive human activities will certainly destroy our environment and livings in the future (Thomas et al., 2004; Collins, 2009).

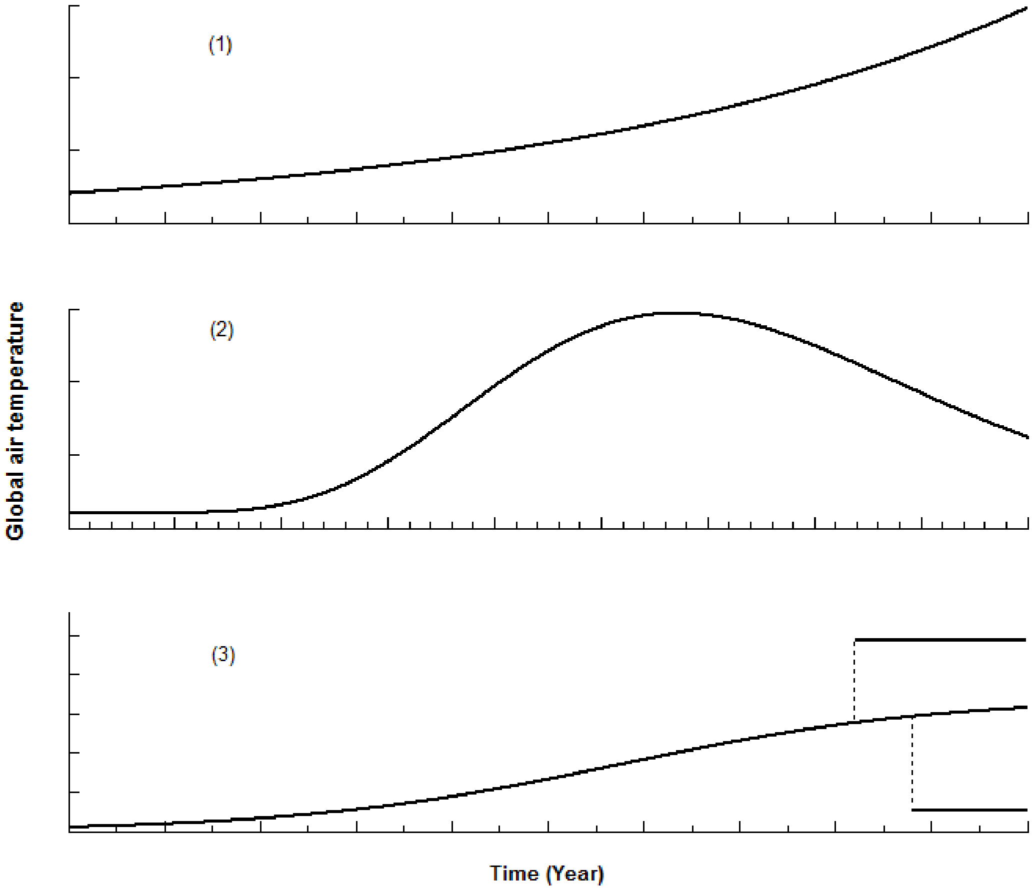

Fig. 4 A simple illustration for long-term trend of global climate change.

(a) (b) (c)

Fig. 5 A catastrophic snowy weather heavily wounded China in 2008, which is the most series snowy weather since 1949. (a) A frozen China Mobile base station in Guangxi, China (http://tech.163.com/08/0202/10/43MIEC1U000915BE.html, 2008); (b) and (c) the snowy and icy catastrophy in Guizhou, China (http://bbs5.news.163.com/bbs/xztp/46033104.html, 2008).

Acknowledgement

We are so grateful for the help of Wu Wei, Xue Zhang, Xiangrong Lui, Hao Zheng, and Bin Chen in the data collection.

References

Angell JK. 2009. Annual and Seasonal Global Temperature Deviations in the Troposphere and Low Stratosphere, 1958-2008. Air Resources Laboratory, National Oceanic and Atmospheric Administration, USA

Cai DM. 2012. Forget global warming - it's Cycle 25 we need to worry about. http://www.chinadaily.com.cn/language_tips/news/2012-02/06/content_14541463.htm (Feb 6, 2012)

Collins S. 2009. Biodiversity under global change. Science, 326: 1353-1354

Hansen JE, Ruedy R, Sato M, et al. 2009. Global Annual Temperature Anomalies (Land+Ocean) (1880-2008). NASA Goddard Institute for Space Studies, New York, USA

Henan Commercial Daily. 2012. Cold winter may sustain for 30 years. http://discovery.163.com/12/0206/09/7PINN1GT000125LI.html

http://cdiac.ornl.gov/trends/temp/angell/data.html

http://data.giss.nasa.gov/gistemp/tabledata/GLB.Ts.txt

http://en.wikipedia.org/wiki/Temperature_record

http://www.ncdc.noaa.gov/oa/climate/research/msu.html

Kerr RA. 2007a. Global warming coming home to roost in the American West. Science, 318: 1859

Kerr RA. 2007b. How urgent is climate change? Science, 318: 1231

Kintisch E. 2009a. Projections of climate change go from bad to worse, scientists report. Science, 323: 1546

Kintisch E. 2009b. Stolen e-mails turn up heat on climate change rhetoric. Science, 326: 1329

Lugina KM, Groisman PYa, Ya K. 2006. Annual and Seasonal Temperature Deviations (60S - 90N), 1881-2005. St. Petersburg, Russia; Asheville, North Carolina and College Park, Maryland, USA

McCarthy JJ. 2009. Reflections on: our planet and its life, origins, and futures. Science, 326: 1646-1655

Thomas CD, Cameron A, Green RE, et al. 2004. Extinction risk from climate change. Nature, 427: 145-148

Zhang WJ. 2009. A forecast on future global air temperature. http://www.iaees.org/forum/forum/b_kantie.asp?tiezi=49

Zhang WJ, Wei W, Zhang X, et al. 2010. Climate change. http://www.iaees.org/environdata/enframe.asp?xuhao=6