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Trend of Dropping in Temperature Over Global Climate

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Abstract: A novel multi-timescale analysis method, Empirical Mode Decomposition (EMD), is used to diagnose the variation of the annual mean temperature data of the global, China from 1881 to 2002. The results show that it contains four timescales quasi-periodic oscillations, 3 year and 6 year on interannual scales, interdecadal scales involving 20 year and 60 year and a trend, respectively. And the contributions of CO_2 concentration to global temperature change is embodied by the trend signal, its influencing weight is not more than 40.19%, smaller than that of the rest four timescales climate natural variability in IMF1, IMF2, IMF3 and IMF4 (3, 6, 20 and 60 year, respectively). Though the increasing trend in atmospheric CO_2 concentration, the modes of IMF2, IMF3 and IMF4 of global temperature are all in falling. Hence if maintains CO_2 concentration constant at present, well then the radiation forcing of greenhouse warming is deficient to countercheck the natural change in global climate cooling in the future 20 years. In quasi 60 year timescales, abrupt temperature changes of China precede global temperature change, which provides a denotation for global climate change.

Key words: Empirical mode decomposition, CO_2 greenhouse effect, climate change

Introduction

For interdecadal timescales, global climate continues warming or decreasing in 20 years, is not only a hot spot but also a nodus in global climate change investigation (Stott and Kettleborough, 2002; Schneider, 2001; Schneider and Held, 2001; Gabriele, 1998; Plaut and Ghil, 1995; Michael and Jeffrey, 1995).

In recent decades, scientists have paid more attention to the greenhouse effects of CO_2. Several modeling studies (Caldeira and Philip, 2000; Sarmiento *et al*., 1998; Sarmiento and Quere,1996; Manabe and Stouffer, 1993; Siegenthaler and Sarmiento, 1993) have indicated a relatively large Southern Ocean sink for anthropogenic CO_2.

Many studies (Houghtou *et al*., 2001; 1995; Manabe and Stouffer, 1994; Maier-Reimer *et al*., 1996; Joos *et al*., 1999; Pagani *et al*., 1999) show that when the doubled CO_2 in the atmosphere, the global mean temperature will increase about 1.5 to 4.5°C. That means the global mean temperature will increase due to increasing CO_2. It is now apparently that content of CO_2 in the atmosphere isn't decreasing and then does the global temperature keep warming in the following decades like the 20th century? To answer this question, it is primary to ravel whether climatic period (quasi period) variation in various timescales or natural variation trend is affected by the variety of CO_2 concentration in the atmosphere?

Materials and Methods

In this study, Empirical Mode Decomposition (EMD) method is adopted, which was developed by Huang *et al.* (1998, 1999) and be applied to study the nonlinear and non-stationary properties of

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a time series. The fluctuations of various timescales or trend in the signal (data) are decomposed into a number of characteristic Intrinsic Mode Function (IMF) components. This decomposition method is adaptive and therefore, highly efficient. Thus, we could extract the variation trend from the data.

The EMD method can simply use the envelope calculations defined by the local maxima and minima separately. Once the extrema are identified, all the local maxima and minima are connected by a cubic spline interpolation line as the upper and lower envelopes. Their mean is designated as m_1 and the difference between the data and m_1 is the first component, h_1, i.e.,

$$h_1 = x(t) - m_1 \tag{1}$$

However, h_1 is still not a stationary oscillatory pattern, by repeating the above process, with h_1 replace by x(t), m_2 is the mean envelope of h_1,

$$h_2 = h_1 - m_2 \tag{2}$$

By repeating the above process time after time, once the mean of the envelope is close enough to zero, or the sifting process can be stopped by a criterion: standard deviation, SD, A typical value for SD can be set between 0.2-0.3, or less than it the first IMF results.

$$SD = \sum_{t=0}^{T} \left[\frac{\left| (h_{i-1}(t) - h_i(t)) \right|^2}{h_{i-1}^2(t)} \right] \tag{3}$$

c_1 is the first IMF component from the data. We can substract c_1 from the original timeseries by

$$r_1 = x(t) - c_1 \tag{4}$$

r_1, still containing information of longer period components, is treated as the new data and subjected to the same sifting process as described above. This process can be repeated on all r_i and the result is:

$$r_1 = x(t) - c_1,\ r_2 = r_1 - c_2, \ldots, r_n = r_{n-1} - c_n \tag{5}$$

i.e.,

$$x(t) = \sum_{i=1}^{n} c_i + r_n \tag{6}$$

Thus, we achieve a decomposition of the data into IMFs and a residue, r_n, which can be either the mean trend or a constant.

The testing result indicates that EMD method is the best method for extracting data sequence trend at the present time (Deng *et al*., 2001). The boundary effect is dealt by extending both extreme points by the addition of typical waves (Hao, 2001).

The results presented in this study are based on a 122 year (1881-2002) globally annual mean air temperature for land surface dataset provided by IPCC and the same epoch temperature dataset of China provided by literature (Wang *et al*., 1998). The CO_2 records presented here is provided by the Carbon Dioxide Information Analysis Center (CDIAC), Trends Online: A Compendium of Data on Global Change, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tennessee. The data during 1881-1978 are derived from three ice cores obtained at Law Dome, East Antarctica from 1987 to 1993 (Etheridge *et al*., 1998; Etheridge *et al*., 1996; Morgan *et al*., 1997). The data of 1979-2002 is measured by the Mauna Loa site.

Results

Figure 1 shows that the global mean temperature is decomposed into four IMF and a trend (Res) by EMD. The IMF1, IMF2, IMF3 and IMF4 correspond to 3 year, 6 year, 20 year and 60 year cycle, respectively. And the trend indicates century-scale oscillation. By calculating the variance contribution of IMF1-IMF4 and Res components, it shows that the variance contribution of the trend is the maximum (40.19%), following by the quasi 60 year low frequency oscillation IMF4 (24.15%).

Figure 1 reveals that IMF3, quasi period oscillation of 20 year and IMF4, quasi period oscillation of 60 year, have been decreasing since this century. Hence, we have concluded that global climate change has been falling at 20-60 year timescales in the following 20 years.

To understand global temperature change in the future more clearly, the trend and IMF4, variance contribution amounting to 64.34%, are used to reconstruct mean temperature (Fig. 2).

From Fig. 2, we can draw a conclusion that global climate change will be falling at century scale in the following 20 years.

In Fig. 3, the time series of CO_2 concentration in the atmosphere is separated into IMF1, IMF2 and a trend.

Because the variance contribution of trend of CO_2 is 99.48% and the rest of IMF1, IMF2 of CO_2 is 0.27 and 0.25%, respectively. Since their variance explained only account for a mere 0.52%, we

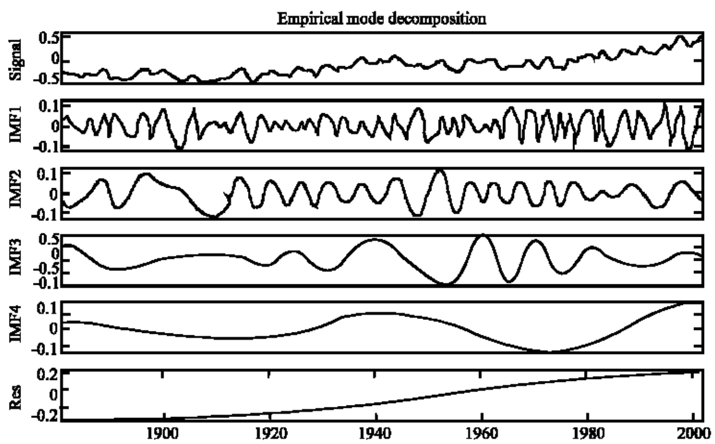

Fig. 1: IMF1-4 and Res components of average temperature in global

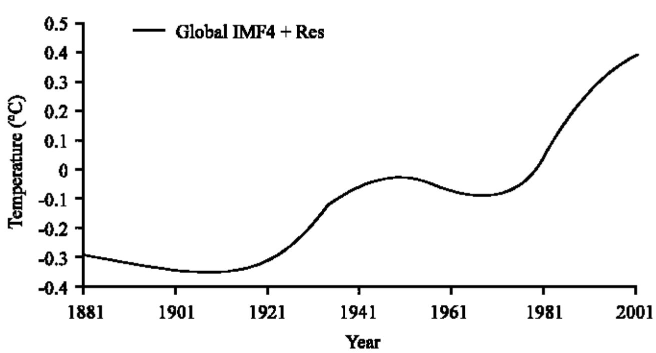

Fig. 2: Reconstructed century scale of IMF4 and Res components for mean temperature in global during 1881-2002

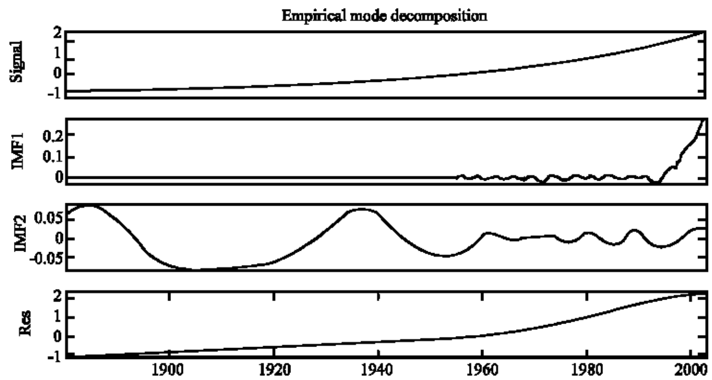

Fig. 3: IMF1-2 and Res components of CO_2 concentration during 1881-2002

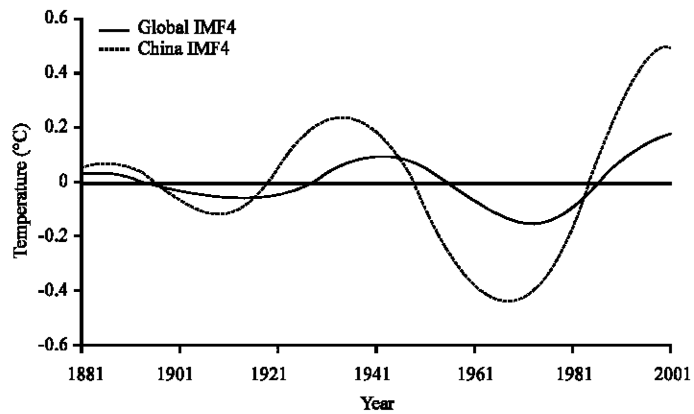

Fig. 4: IMF4 components of average temperature in Global (realline) and China (dashed)

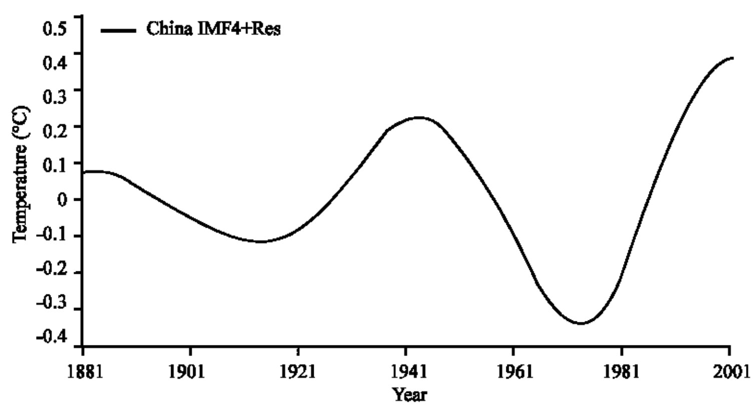

Fig. 5: Reconstructed components of IMF4 and Res components for mean temperature in China during 1881-2002 year

presume the IMFs of CO_2 are just some noise. Therefore, the greenhouse effect of CO_2 in the atmosphere on global temperature variation is mainly the century scale trend. That is to say, the influencing weight of CO_2 concentration in the atmosphere is not more than 40.19%, which is smaller than that of the rest four timescales climate natural variety in IMF1, IMF2, IMF3 and IMF4 (3, 6, 20 and 60 year, respectively). Though the increasing trend of atmospheric CO_2 concentration, the components IMF2, IMF3 and IMF4 of global temperature change are all in falling. Hence if maintains constant CO_2 concentration at present, well then the radiative forcing of greenhouse warming is deficient to countercheck the natural change in global climate cooling for 20 years in the future. Hence global climate change will be falling in the following 20 years.

Figure 4 presents the IMF4 components of global (real line) and China (dashed). It shows that the China temperature change precedes the global temperature change and phase precedes approximatly 5-10 year.

Reconstructed curve of IMF4, quasi period oscillation of 60 year and Res, secular trend (amount to variance contribution is 60.47%), components of China temperature (Fig. 5). It appears to agree with the upper conclusion: China climate change has been falling at century scales in the future 20 years.

Comparing Fig. 5 with Fig. 2, we can also find that China temperature change precedes global temperature change and phase precedes approximately 5-10 year. So China temperature change has a leading denotation for forecasting global climate change.

Temperature change of China has a leading denotation for forecasting global climate change and whether 60 year timescales (IMF4) or reconstructed curve by IMF4 and Res component of China temperature all display clearly that climate change of China has been falling at century scales in the following 20 years, which indirectly illuminates the global climate change will be falling in the future 20 years.

Discussion

China is among the sensitivity area of climate change in the world. And it lies in Asian monsoon, which is influenced by both monsoon and ocean. So, Asian monsoon is connected to high latitude and the low latitude transmitting the water vapor and energy. At the same time, the climate change of Qinghai-Tibetan Plateau has a leading effect (Tang and Xu, 1984). Many researchers claim to be startup area of climate change. It played an important driving effect to global climate change (Tang and Li, 1992; Yao *et al*., 1991). Here, we found temperature change of China has a leading denotation to global climate change, so we could predict the global temperature change.

The prevailing view was that the global climate gradual warming is due to the increasing greenhouse effect caused by human activity. The climate predictions of greenhouse effect are mostly based on Global Circulation Models (GCMs) simulation. Although GCMs are credible, they are imperfect (Bryant, 1997). At present, many prevail views on the future of climate change, neither have noticed the implicit uncertainty and nor accepted the other mechanisms may cause the observed climate change. Another important factor was the availability of new global warming predictions including both greenhouse gases and aerosols, which gave better agreement between the observed and the predicted temperature patterns. However, the impact of aerosols is still poorly known and the pattern correlations for the greenhouse gas-plus-aerosol forcing although generally higher in the last decades than for the greenhouse gas-only case, are still relatively low. And again, our primary conclusion, i.e., that atmospheric CO_2 concentration is not a major determinant of earth's temperature.

There are some evidences that show the global temperature will be cooling. Researchers find that since the late 1980s to the early 1990s, the Antarctic sea ice area has been the increasing trend (Doran *et al*., 2002). East Pacific entered cryogenic stage abundant in anchovies about 1990s (Francisco *et al*., 2003). It reflects the prospective 60-year cycle of solar activity change energy transmission process and the initial information and global climate cooling indicated. And other researchers believe that the variety of solar system activity has maximum influence on earth climate, are not greenhouse effect. The warming or cooling are in response to amount and size of sun spot. The sun will enter inactive period in the coming decades, the Earth temperature will drop.

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