

## Original Papers On the natural component of climate change

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journal or publication title	Tsukuba geoenvironmental sciences
volume	14
page range	1-7
year	2018-12-27
URL	<a href="http://doi.org/10.15068/00154206">http://doi.org/10.15068/00154206</a>

# On the natural component of climate change

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## Abstract

Climate change consists of both natural change and man-made change. However, it is not possible to identify and estimate the man-made component of temperature change without subtracting the natural component from observed temperature change. As a first approximation, one of the methods to infer the natural component is to learn the past climate change. Based on various past natural phenomena (including, for example, the retreat of glaciers), it is shown that the temperature change from about 1850 to the present can be understood mostly in terms of combined effect of a linear increase of  $0.5^{\circ}\text{C}/100$  years and a quasi-periodic oscillation, called the Pacific Decadal Oscillation (PDO). The observed linear trend is likely to be “recovery” from the Little Ice Age (LIA), which lasted from 1200 to 1800. Thus, various prediction efforts by present computer simulations based on the claim by the IPCC (2007) that the temperature increase between 1975 and 2000 is “very likely” to be caused by the effect by the greenhouse gases, tend to overestimate the greenhouse effect. In fact, contrary to the predicted rise, the temperature rise after about 2000 to the present has been halted. The failure of predicting this halting is a result of lack of efforts of subtracting natural components. It is urged to learn causes of the natural components.

**Key words:** natural component, global warming, Little Ice Age, warming hiatus, climate prediction

## 1. Introduction

During the last few decades, climate change has become a major issue. In particular, the temperature rise from about 1975 to 2000 has been attributed to “very likely” be due to the effect of the greenhouse gases by the IPCC (2007); this claim tends to overestimate the predicted temperature in 2100. Unfortunately, in predicting future climate change, it has been forgotten that natural change is always present and is also in progress.

Therefore, in attempting to predict the expected tem-

perature in 2100, it is crucial to identify, estimate and predict the temperature rise due to the natural component. In this paper, it can be shown that the claim that the temperature rise from 1975 to 2000 to be due “very likely” to the greenhouse effect is not substantiated, and in fact that it is mainly a combined result of two natural changes, a near-linear change and a quasi-periodic change. The purpose of this paper is to emphasize the importance of natural change. The natural change will be discussed in Section 2.1 in terms of LIA and the PDO (see Akasofu, 2010).

## 2. Linear change from 1850 to 2000: Recovery from the Little Ice Age

Fig. 1 shows both the temperature change from 1880 to 2000 and the temperature change inferred from tree-ring records from 800 to 2000 (Esper *et al.*, 2002); note that in their paper, the same temperature change is shown with a different baseline. It can be seen that the temperature increase from 1880 occurred after the long cooling period of about  $1^{\circ}\text{C}$ , called the Little Ice Age (LIA) which lasted from about 1200 to 1800. Thus, the increase of the temperature from 1800-1880 to about 2000 may be described as “recovery” from the LIA, which is definitely a natural change; the LIA began in about 1200 after the so-called “Medieval warming” in around 1000. The rate of the rise between 1800-2000 is about  $1^{\circ}\text{C}/200$  years or  $0.5^{\circ}\text{C}/100$  years.

The near-linear increase of the temperature from about 1800-1850 deduced from the tree-ring study can be supported by several changes of natural phenomena, including retreat of glaciers (Fig. 2), sea level increase (Fig. 3), advance of river breakup date and break-up of river/lake ice (Figs. 3 and 4) etc., even if they are not digital temperature records. It is clear that the glacier retreat began in about 1800-1850 in many parts of the world, so that it is not just an European (Alps) phenomenon. The sea level increase began also in about 1850.

Thus, these changes can be interpreted in terms of “recovering” from the LIA, a natural change. Thus, this near-linear change of the rate  $0.5^{\circ}\text{C}/100$  years must be subtracted from the observed change in inferring the contribution of the greenhouse gases to the warming in recent years.

There is no sea ice observation over the whole Arctic

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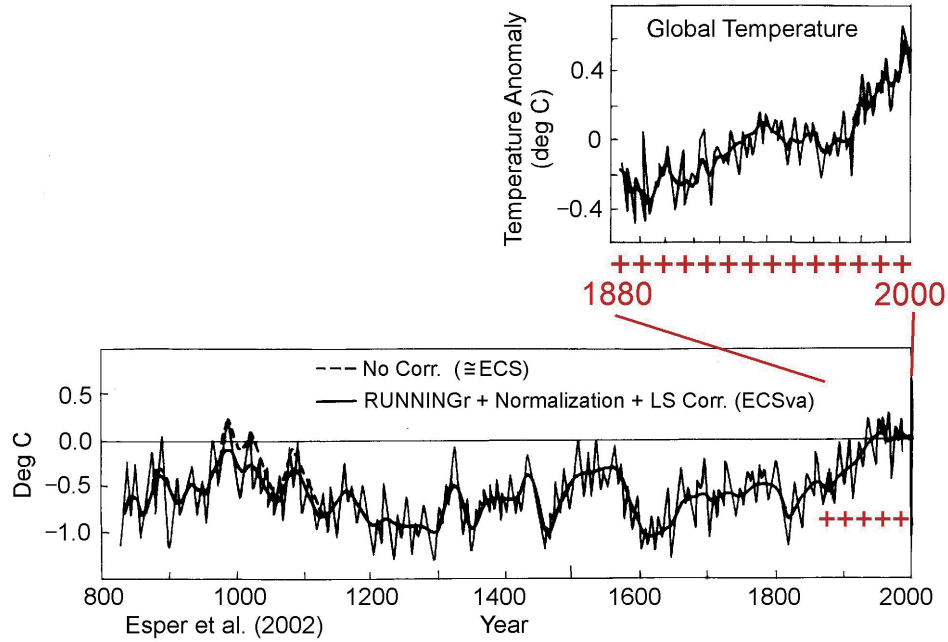


Fig. 1 The temperature change from 1880 to 2000 (Courtesy of J. Hansen), and also the temperature change from 800 to 2000, which was determined by a tree ring study (Esper *et al.*, 2002). Note that in their paper, the same temperature change is shown with the different base line.

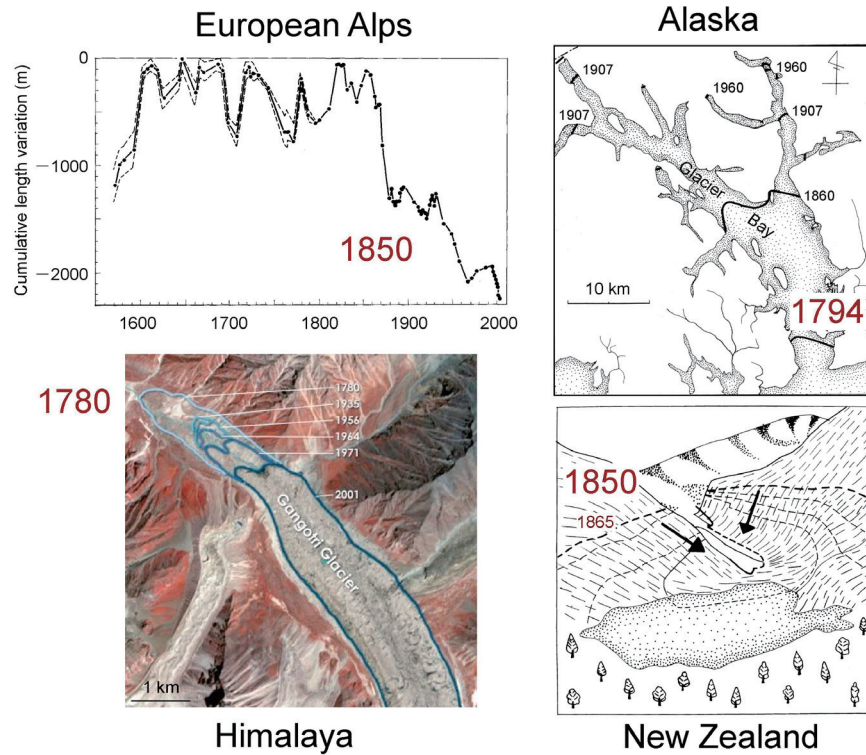


Fig. 2 Well-documented retreat of glaciers in the world. An approximate beginning of the retreat is indicated: The European Alps glacier (1850) -- (von Michael Kuhn, 2007), Alaskan glacier (1974) -- (Molina, 2008), Himalayan glacier (1780) -- (Kargel, 2007), and New Zealand glacier (1850) -- (Grove, 1988). There are other examples from Greenland, Alaska, the South America and Africa.

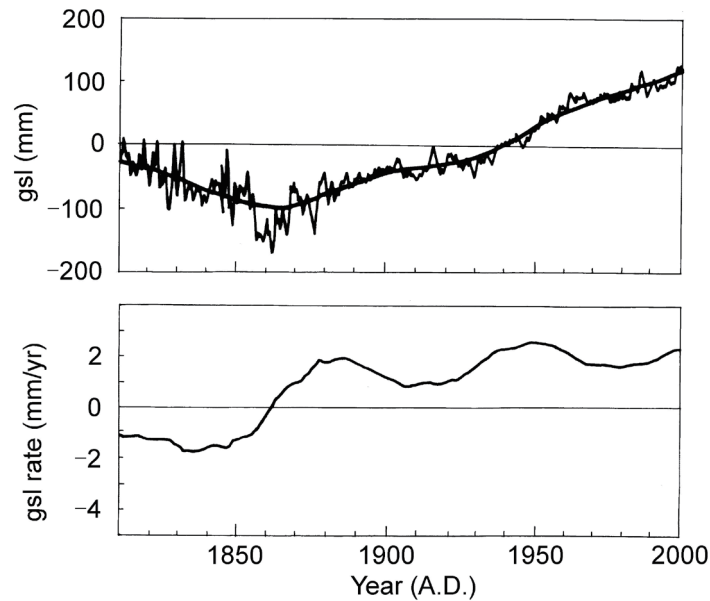


Fig. 3 The upper part: Global sea level change from 1800 to 2000. The lower part: The rate of change of the sea level (Jevrejeva *et al.*, 2008). This is discussed in Section 3.

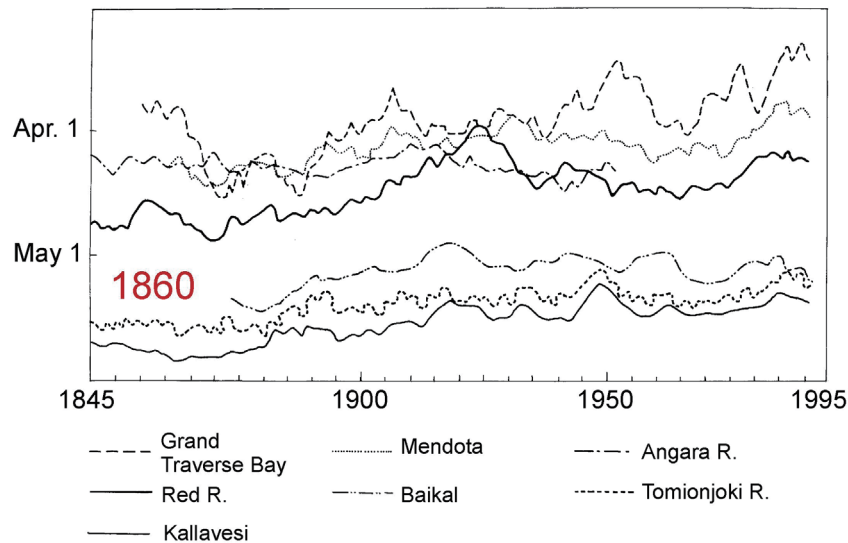


Fig. 4 Breakup dates of lakes and rivers in the Northern hemisphere from 1845 to 1993 (Magnuson *et al.*, 2000).

Ocean until satellites began to monitor sea ice in 1970 or so. However, Norwegian fishermen had good records of the southern edge of sea ice in the Norwegian Sea, indicating that the southern edge of sea ice in the Norwegian Sea began to retreat after 1800 (Vinje, 2001).

So far, the only resembling change with the tree-ring study in Fig. 1 is changes of solar activity represented by cosmic radionuclide records ( $^{10}\text{Be}$  and  $^{14}\text{C}$ ), which shows a long-term decrease from 1200 to 1850 (Muscheler *et al.*, 2007).

Fig. 5 shows the Greenland ice core data (Greenland

GISP Ice Core project). It can be seen that the period of the LIA is just one of short periods during which several warm and cold periods occurred after the recovery from the Great Ice Age. The baseline used in Fig. 1 is indicated by the red-dash line. The temperature changes from 1000 to 2000 are similar to those of the tree-ring study, except that the temperature during the medieval period (around 1000) is higher than that of the tree-ring study. This figure shows that the temperature of the earth is continuously changing. Obviously, most of the changes in the figure are natural changes.

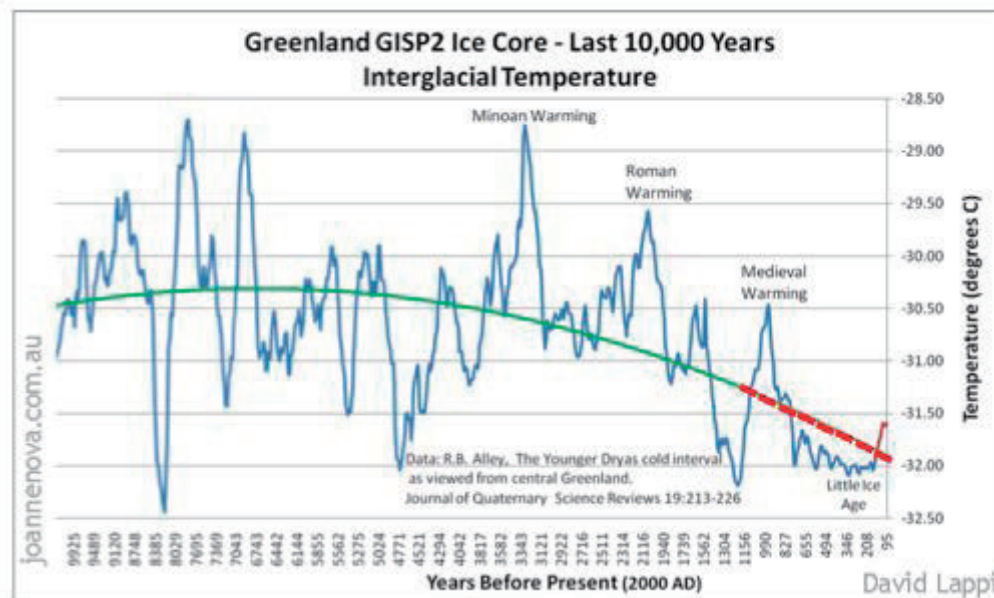


Fig. 5 The temperature change during the last 10,000 years (Greenland GISP2 Ice Core project). The tree ring record in Fig. 1 is shown in the last part in the 10,000 year record. The baseline used in the tree ring study (Fig. 1) is marked by the red dash-line. The linear change (recovery of the LIA) is also indicated by the red line.

### 3. Quasi-periodic change

Changes of the temperature from 1880 to 1975 has been analyzed by Bryant (1997) who showed that the changes can be approximated by a straight line with 95% confidence. The upper part of Fig. 6a shows his analysis. Based on an extensive spectral analysis for the same period, Wu *et al.* (2007) showed that the change consists of a near-linear change and a quasi-periodic change. The quasi-periodic change is shown in the lower part of Fig. 6a (Wu *et al.*, 2007). It has an amplitude of  $0.007^{\circ}\text{C}/\text{year}$  (or the range of  $0.014^{\circ}\text{C}$ ).

The IPCC is particularly concerned with the rise of the temperature between 1975 and 2000. The observed increase due to the PDO effect between 1975 and 2000 is  $0.175^{\circ}\text{C}$  ( $= 0.007^{\circ}\text{C}/\text{year} \times 25$  years).

Thus, the combined rise of both the linear increase  $0.125^{\circ}\text{C}$  ( $0.5^{\circ}\text{C} \div 4$ ) and the PDO effect ( $0.175^{\circ}\text{C}$ ) between 1975 and 2000 is as much as  $0.30^{\circ}\text{C}$ . Thus, it is inappropriate to claim the observed increase between 1975 and 2000 is “very likely” to be due the effect of the greenhouse gases.

Fig. 6b shows the observed POD and the quasi-periodic change determined by Wu *et al.* (2007). Although the phase is a little different, there seems to have some relationship between the observed multi-decadal oscillation and PDO. Mantus and Hare (2002) noted that the causes of the PDO remain unclear. In a more recent paper, Newman *et al.* (2016) gave a comprehensive review of the

PDO and suggest that the PDO is not a single physical mode of climate variability, but instead largely represents a combination of few processes. The PDO is obviously natural change (representing a great effect of the Pacific Ocean on climate change), so that it must be subtracted from the observed temperature change. It is urgent to find the causes of the PDO and include the result for future prediction studies.

### 4. The present halting of global warming.

Fig. 7 shows the most recent temperature change from Climate4you update June 2018 (Humlum, 2018). It can be seen that the global warming trend discussed in the earlier section, particularly between 1975 and 2000, is halted from about 2000 to the present, except two impulsive changes (which are due to El Nino). This is a clear indication that unknown natural components are occurring or that the PDO effect may be suppressing the greenhouse effects (Akasofu, 2010, 2013), so that the basis of the present prediction is inaccurate (overestimate) or incorrect without considering natural change.

### 5. Summary

On the basis of the above discussion, the temperature change from about 1800 is summarized in Fig. 8. The period between 1975 and 2000 is shown by a thick red line. Although this particular increase of temperature is claimed to be due “very likely” to the greenhouse effect



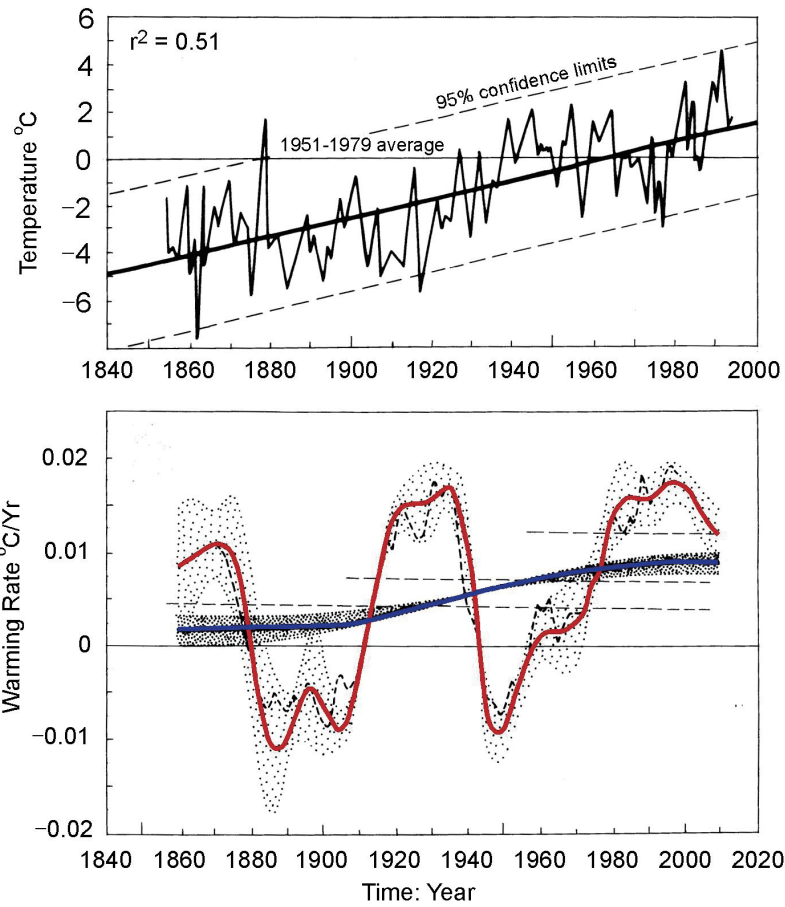


Fig. 6a Upper: It shows that temperature change from 1850 to 2000. It can be approximated by a linear change (Bryant, 1997). Lower: temperature changes from 1860 to 2000 consist of a near linear change and periodic change (Wu *et al.*, 2007).

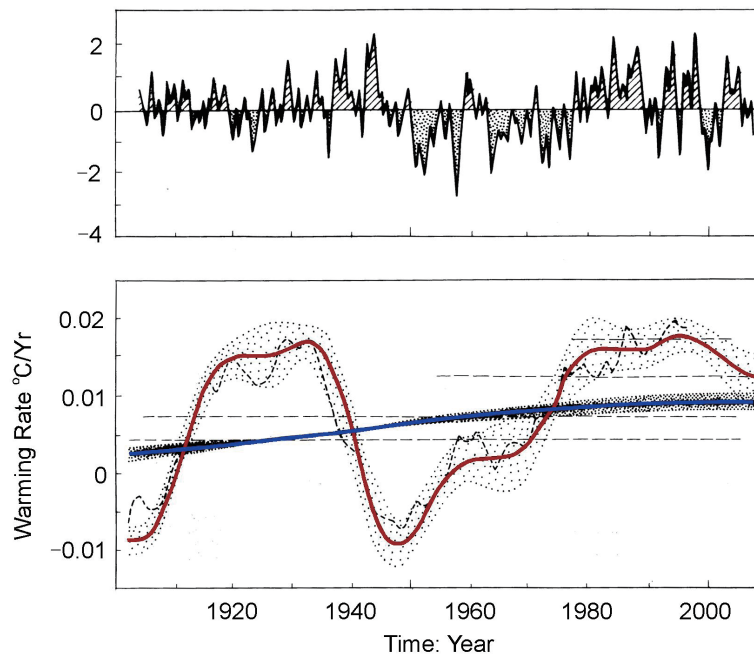


Fig. 6b Upper: the PDO index (University of Washington, 2008) and the quasi-periodic change deduced by Wu *et al.* (2007).

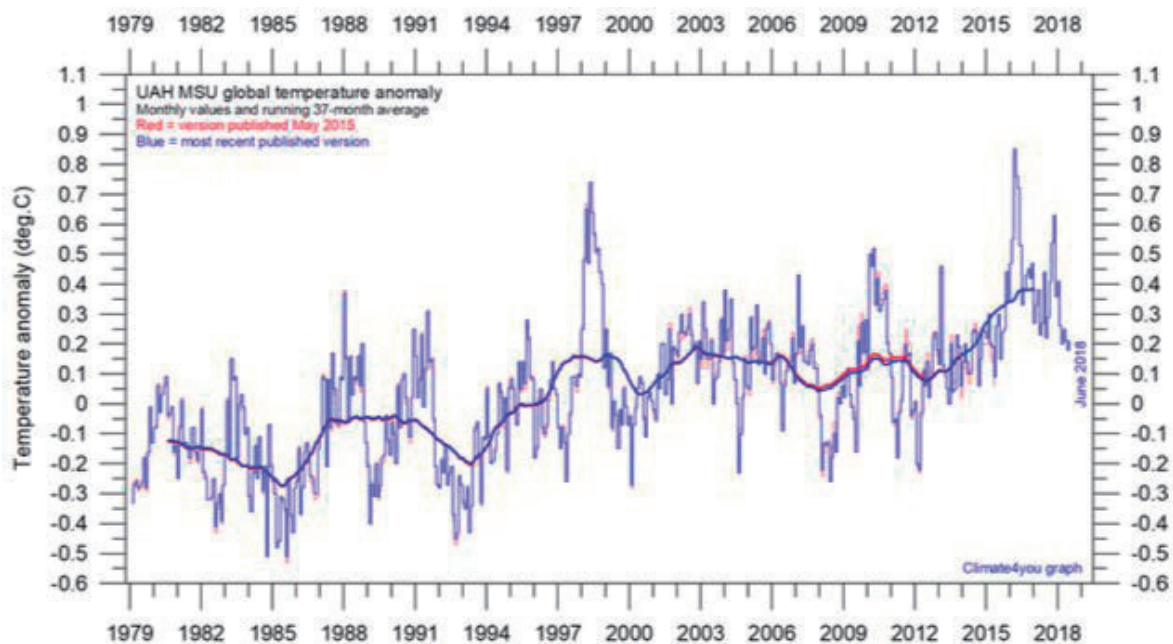


Fig. 7 The temperature change from 1979 to 2018 (University of Alabama at Huntsville) from Climate4you update June 2018 (Humlum, 2018)

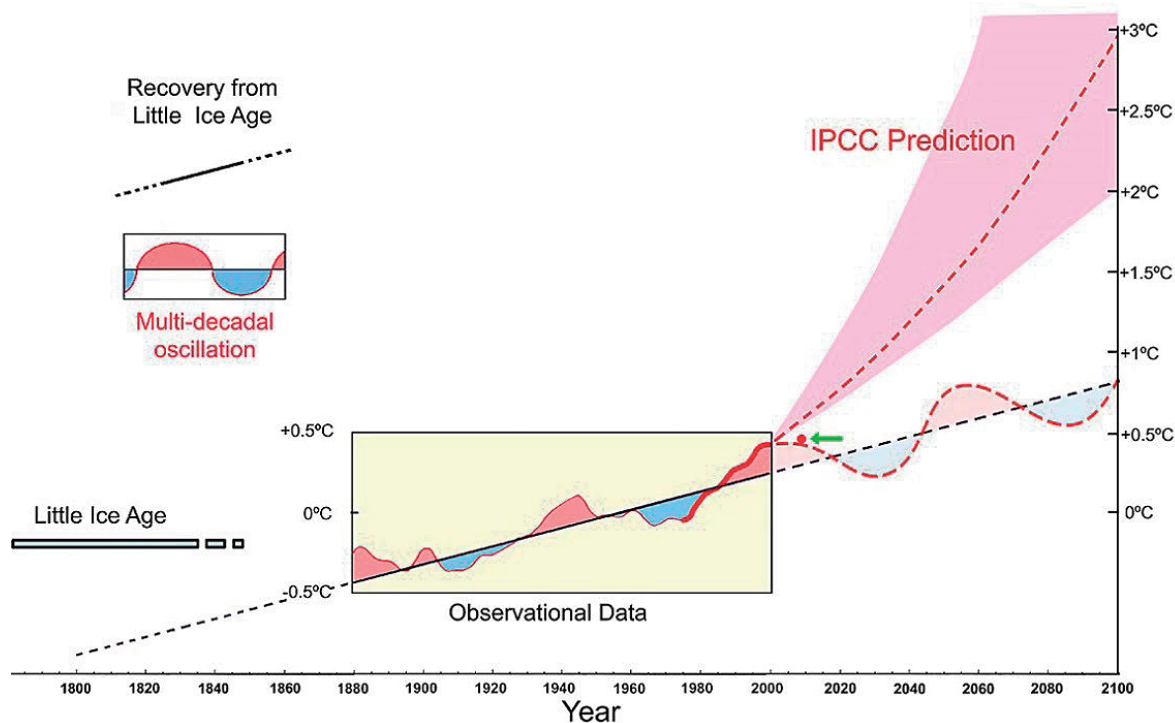


Fig. 8 An attempt to consider that temperature change from 1860 to 2000 consists of a linear change and the superposed quasi-periodic change (yellow box).  
The temperature change after 2000 is assumed to consist of the two changes, while IPCC extrapolated the increase between 1975 to 2000 to 2100.

by IPCC, it is shown that a large portion of this increase can be understood in terms of the combination of the near-linear increase due to the recovery from the LIA and the PDO.

Thus, in predicting the temperature in 2100, an accurate contribution of the greenhouse effect must be determined by learning and then subtracting the natural component from the observed change. Only then, an accurate contribution of the greenhouse gases can be deduced.

### Acknowledgements

I would like to thank many colleagues at the International Arctic Research Center and others for their discussions on climate change.

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Received August 20, 2018

Accepted November 7, 2018



