Available online at www.sciencedirect.com

ScienceDirect

Advances in Climate Change Research 6 (2015) 159–170

www.keaipublishing.com/en/journals/accr/

How similar are annual and summer temperature variability in central Sweden?

ZHANG Peng[a,*], Deliang CHEN[a], Hans W. LINDERHOLM[a], ZHANG Qiong[b]

[a] Regional Climate Group, Department of Earth Sciences, University of Gothenburg, Gothenburg 40530, Sweden
[b] Bert Bolin Centre for Climate Research, Department of Physical Geography and Quaternary Geology, Stockholm University, Stockholm 10691, Sweden

Received 30 June 2015; revised 25 October 2015; accepted 3 November 2015
Available online 14 November 2015

Abstract

Tree-ring based temperature reconstructions have successfully inferred the past inter-annual to millennium scales summer temperature variability. A clear relationship between annual and summer temperatures can provide insights into the variability of past annual mean temperature from the reconstructed summer temperature. However, how similar are summer and annual temperatures is to a large extent still unknown. This study aims at investigating the relationship between annual and summer temperatures at different timescales in central Sweden during the last millennium. The temperature variability in central Sweden can represent large parts of Scandinavia which has been a key region for dendroclimatological research. The observed annual and summer temperatures during 1901–2005 were firstly decomposed into different frequency bands using ensemble empirical mode decomposition (EEMD) method, and then the scale-dependent relationship was quantified using Pearson correlation coefficients. The relationship between the observed annual and summer temperatures determined by the instrumental data was subsequently used to evaluate 7 climate models. The model with the best performance was used to infer the relationship for the last millennium. The results show that the relationship between the observed annual and summer temperatures becomes stronger as the timescale increases, except for the 4–16 years timescales at which it does not show any relationship. The summer temperature variability at short timescales (2–4 years) shows much higher variance than the annual variability, while the annual temperature variability at long timescales (>32 years) has a much higher variance than the summer one. During the last millennium, the simulated summer temperature also shows higher variance at the short timescales (2–4 years) and lower variance at the long timescales (>1024 years) than those of the annual temperature. The relationship between the two temperatures is generally close at the long timescales, and weak at the short timescales. Overall the summer temperature variability cannot well reflect the annual mean temperature variability for the study region during both the 20th century and the last millennium. Furthermore, all the climate models examined overestimate the annual mean temperature variance at the 2–4 years timescales, which indicates that the overestimate could be one of reasons why the volcanic eruption induced cooling is larger in climate models than in proxy data.

Keywords: Annual temperature; Summer temperature; Central Sweden; Climate model simulation; Scale-dependent similarity

1. Introduction

Annual mean temperature is a traditionally-used indicator for global climate change, since it reflect a mean state of the Earth surface temperature, and can be more directly linked to Earth energy balance than seasonal mean temperature (Sutton et al., 2015). To improve our understanding of climate change and variability prior to the industrial revolution, as well as set the current warming in a long-term context, many efforts have

* Corresponding author.
E-mail address: peng.zhang@gvc.gu.se (ZHANG P.).

Peer review under responsibility of National Climate Center (China Meteorological Administration).

ELSEVIER Production and Hosting by Elsevier on behalf of KeAi

http://dx.doi.org/10.1016/j.accre.2015.11.001

1674-9278/Copyright © 2015, National Climate Center (China Meteorological Administration). Production and hosting by Elsevier B.V. on behalf of KeAi. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

been made to reconstruct annual mean temperature back in time (Mann et al., 2009). However, most existing annual mean temperature reconstructions have difficulty to infer precise annual-decadal-resolution variability due to the leak of proxy data which can be precisely dated and can reflect annual mean temperature (Marcott et al., 2013).

Tree-ring data is one of the most widely used high-resolution climate proxies due to its annual resolution and exact dating. Compared to other proxies, tree-ring data from high latitudes/altitudes provides precise inter-annual to multi-centurial changes of growing seasonal/summer temperatures, which are used to further our understanding of local to regional climate change and variability during the last several thousand years (Grudd et al., 2002; Helama et al., 2002). However, tree-ring data can only reflect the growing seasonal/summer temperature variability.

If summer temperature are similar with annual mean temperature at some timescales regarding some features (e.g. variability, variance), we may use reconstructed summer temperature to infer some features of past annual mean temperature at these timescales, which will further our knowledge of past climate variability. Therefore, to what extent can summer temperature variability represent the variability of mean state of surface air temperature (i.e. annual mean temperature) is important for gaining deep insights into past mean climate variability. The question is even more important for regions where large amounts of temperature-sensitive tree-ring proxies exist, since the past summer mean temperatures in the regions have been already inferred.

Fennoscandia is one of the key regions for dendroclimatic research due to its large areas of forests with climate-sensitive trees and limited human influence (Linderholm et al., 2010). Recently, a millennium-long reconstruction of warm-seasonal temperatures in central Scandinavia was presented, and it was shown that the reconstruction represented the temperature variability for a large part of Fennoscandia (Zhang et al., 2015). A clear relationship between annual and summer temperatures in this region may help to increase our understanding of the past temperature in Scandinavia.

In central Scandinavia, instrumental temperature records cover more than 100 years. However, the lengths of these records are still too short to explore the relationship between the annual and summer temperatures beyond the industrial period. In order to go further back in time and have the possibility to investigate variation at longer timescales, we need to use the data from paleoclimate model simulations. Paleoclimate Modelling Intercomparison Project Phase III (PMIP3, Braconnot et al., 2012) has recently released data from a series of last millennium simulations which date back to 850 CE. However, initially the climate models must be evaluated on their capabilities in replicating the observed relationship between the annual and summer temperatures.

This study focused on improving our understanding of the relationship between the annual and summer temperatures in central Scandinavia at different timescales during the last millennium. Specifically, the objectives of this study are 1) to investigate the relationship between observed annual and summer temperatures at different timescales in central Sweden during 1901–2005; 2) to validate the performance of 7 PMIP3 atmosphere-ocean general circulation models (AOGCMs) in replicating the observed scale-dependent relationships between the annual and summer temperatures and the variance percentage of the annual and summer temperatures at different timescales; 3) to investigate the scale-dependent relationship between the two temperatures for the last millennium using simulations of the most reliable model evaluated. This paper is organised as follows. Section 2 describes the study area; Section 3 documents the data and methods used; results are presented in Section 4; the results are discussed in Section 5, and lastly a summary and conclusions are provided in Section 6.

2. Study region

The study region is located at central Sweden as shown in Fig. 1. The region is one of the key areas for dendroclimatological studies in the world. In this area, summer temperature has been reconstructed for the past 3600 years based on *Pinus sylvestris* L. (Scots pine) tree-ring width data (Linderholm and Gunnarson, 2005) and warm-season (April–September) temperature has been reconstructed for the past 1200 years using tree-ring density data from the same tree species (Zhang et al., 2015). The climate in this area is strongly influenced by the North Atlantic Oscillation (NAO) throughout the year (Chen and Hellström, 1999; Busuioc et al., 2001; Folland et al., 2009) as well as the proximity to the North Atlantic Ocean (Sutton and Dong, 2012). The annual total precipitation is 857 mm in the west (Storlien, 583 m a.s.l.) and 628 mm in the east (Duved, 400 m a.s.l.), and the annual mean temperature is 1.1 °C (Storlien) in the west and 1.3 °C in the east (Duved) based on the statistics during 1961–1990 (Alexandersson et al., 1991). The leading mode of Atlantic sea surface temperature (Atlantic Multi-decadal Oscillation (AMO)) has been found to have impacts on the temperature variability in this region at multi-decadal to century timescales (Sutton and

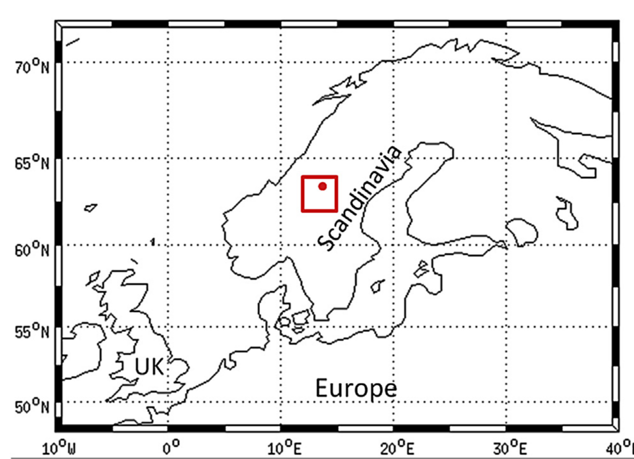

Fig. 1. A map showing the selected grid cell (the red dot) of CRU TS 3.22 dataset 2.5° longitude × 2.5° latitude and the area of 12–15°E, 62–64°N (marked by red frame).

Download English Version:

https://daneshyari.com/en/article/4673571

Download Persian Version:

https://daneshyari.com/article/4673571

Daneshyari.com