Quaternary International xxx (2015) 1–7

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Dendroclimatic reconstruction of late summer temperatures from upper treeline sites in Greater Caucasus, Russia

Iulian-Horia Holobâcă*, Olimpiu Pop, Dănuț Petrea

Babeș-Bolyai University, Faculty of Geography, 5-7 Clinicilor, Cluj-Napoca, Cluj, Romania

A R T I C L E I N F O

Article history:
Available online xxx

Keywords:
Climate variability
Ring-width
Summer temperature
Dendrochronology
Elbrus

A B S T R A C T

Recent evidence suggests an acceleration of the glacier retreat in the Greater Caucasus after 1980. A significant summer temperature warming trend and little or no change in precipitation variation have been observed during the same period. This study aims to find similar past climatic conditions after the Little Ice Age (LIA) using a dendroclimatic approach. A dendroclimatological sampling of Scots pines (*Pinus sylvestris* L.) has been made in Irik Valley, near Elbrus glacier. The dendroclimatic indexes (average sensitivity, PC1, and RBAR) indicate a medium response of the radial growth to the variation of the climatic factors. The July and August (JA) temperatures of the current year and May and June (MJ) temperatures of the previous year have a significant correlation with tree ring width. No significant correlation with precipitation has been noticed. A tree-ring width chronology has been used to reconstruct July–August (JA) temperatures back to 1830. The warming (during 1981–2009) is well preserved in our reconstructed July–August temperatures and seems to be an important warm sequence.

1. Introduction

The proxy methods (e.g. dendrochronology, sediment analysis, ice-core, pollen analysis, etc.) are suitable to reconstruct long-term climate variability. Generally, the instrumental climatic data cover mainly the 20th century, and more than 100-year-old weather stations are rather far from the remote areas. Dendroclimatological research methods make use of the information contained in tree-rings to produce valuable information on the interannual variability of the climate in a certain territory (Fritts, 1976).

The trees that grow close to the upper altitudinal limit of the vegetation react rapidly to the stress of thermal variations during the vegetation season (Tranquillini, 1979). This relation between annual growth and climatic parameters provides annually-resolved, proxy historical records to which modern climate conditions can be compared.

Dendroclimatology uses a reliable statistics theory (Fritts, 1976; Schweingruber, 1985, 1996; Cook and Kairiukstis, 1990), so that significant results in the global climate research are obtained at hemispheric and regional scale (Eckstein and Aniol, 1981; Hughes et al., 1994; Briffa et al., 1990, 2001; Briffa et al., 2002 etc.). Jansen et al. (2007) highlighted the importance of high resolution individually-calibrated local reconstruction in the context of the large differences between a series of low-frequencies reconstructions.

Despite a high dendrochronological potential, there is a notable spatial gap in the regional coverage of dendroclimatic reconstructions in the Caucasus Mountains where only limited dendroclimatological research has been completed. A quantitative reconstruction of air temperature for the warm period in the Caucasus was based on dendrochronological data (Dolgova and Solomina, 2010). This previous study presents a June–September temperatures reconstruction back to 1800 and uses a tree-ring density method. In this paper, we present the preliminary results of a dendroclimatic reconstruction of late summer temperatures in Greater Caucasus by using a tree-ring width method.

Generally, glaciers are retreating in the Caucasus after LIA in response to the observed climatic warming trend. Accelerated retreat is observed since 1980, as over 90% of the glaciers retreated between 1985 and 2000 while the total glaciated area decreased by 10% (Stokes et al., 2006). Former studies have shown an important increase in the temperature (0.5 C°/decade) and no significant change in the precipitation during the same period in the high altitude areas of the Caucasus (Shahgedanova et al., 2005; Holobaca, 2013). Dendroclimatological reconstructed climatic

* Corresponding author.
E-mail address: holobaca@geografie.ubbcluj.ro (I.-H. Holobâcă).

http://dx.doi.org/10.1016/j.quaint.2015.10.103
1040-6182/

data should be important for the understanding of the glacial dynamics in the Caucasus area after the LIA.

2. Methods and data

2.1. Study area

The studied area is located in the North Caucasus Mountains in the Russian Federation near to Elbrus (5624 m), the highest peak in Europe, Russia, and the Caucasus. Mount Elbrus is an extinct volcano with twin cones. Elbrus is about 100 km from the Black Sea and about 400 km from the Caspian Sea (Fig. 1). The volcano was formed more than 2.5 Ma (Masurenkov and Sobisevich, 2012). The post-volcanic activity is still present, sulfurous gases are emitted on its eastern slopes, and there are many mineral springs along its descending streams (see Fig. 2).

Elbrus has a continental temperate climate with high precipitation in summer and cold winters. A total area of 111 square km (in 2007) of Elbrus is covered by ice (Holobâcă, 2013). Mount Elbrus is covered with a well-developed ice cap which descends down to 3500 m. From this ice cap, glacier tongues are radiating from a common accumulation area. These valley glaciers descend to 2300 m and feed the Kuban River and some of the headwaters of the Terek.

Above 1000 m of altitude, the forest cover is mainly composed of vast and dense coniferous woods with a predominance of Scots pines (*Pinus sylvestris* L.). Pine stands are pure or mixed with birch (*Betula* spp.). The upper limit of the forest is around 1900–2300 m, but isolated trees can reach up to 2400 m (Turmanina and Volodina, 1978).

2.2. Dendroclimatological reconstruction of the climate variability

Our tree sampling area is situated in the southeast part of the Elbrus glacier, in the upper treeline, on the Irik Valley, at about 2300 m (Fig. 1). In agreement with the dendrochronological principles, 30 Scots pines (*Pinus sylvestris* L.) have been selected for sampling following classical techniques used in dendroclimatology (Cook and Kairiukstis, 1990). Therefore, 60 increment cores have been prepared for analysis (fixed on a wood support, dried, sanded etc.) and then the tree-ring width was measured. Measurement of the ring width has been carried out using a LINTAB 5 positioning table connected to a Leica stereomicroscope and TSAP-Win Professional software station with 0.001 mm precision (Rinntech 2005).

Quality control and data check of the tree-ring measurements have been performed using COFECHA (Holmes, 1983) software. COFECHA fits a 32-year cubic smoothing spline for each of the time series for standardization, and each standardized series is tested against dating master series, segment by segment. Successive segments of 50 years are lagged with a 25 year overlap.

The tree-ring standardization and removing growth trends from ring-width data has been carried out using ARSTAN (Cook and Krusic, 2007) software. The chronology series has been calculated

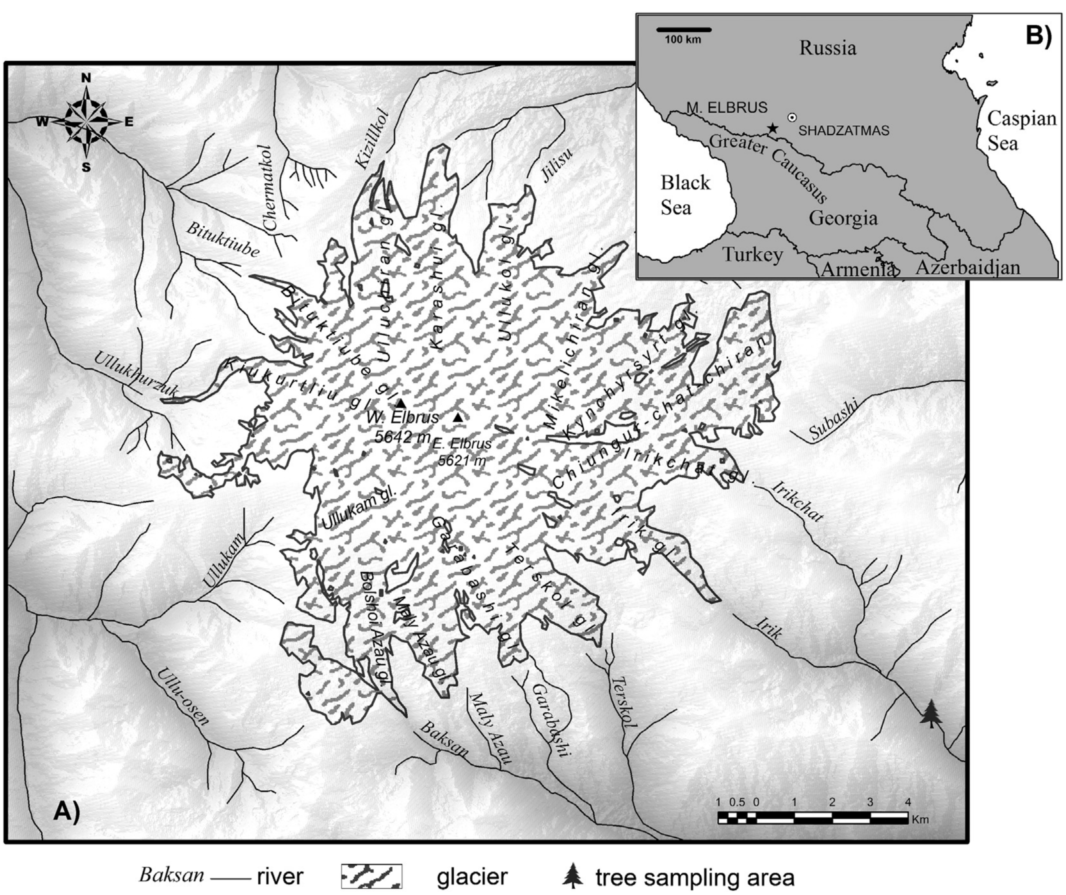

Fig. 1. A) The glaciers of Elbrus in 2007 and the location of the tree sampling area in the Irik valley; B) Geographical position of the Elbrus Mountains and Shadzatmas weather station.