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Towards improving the Central Asian dendrochronological network—New data from Tajikistan, Pamir-Alay☆

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ABSTRACT

Millennial long tree-ring records are crucial for better understanding temperature and hydroclimatic variability over the globe. Juniper is one of particularly long-lived species, which can provide more than a thousand-year record, especially in Central Asia. However, there is a lack of dendrochronological series from the Pamir Mountains. Here we report the first 1010-year (AD 1005–2014) juniper tree-ring chronology from the mountain ranges of north-western Tajikistan, the western Pamir-Alay. We present the potential of *Juniperus semiglobosa* and *Juniperus seravshanica* in developing millennia-long records. We sampled three study sites at the elevations from 2200 to 3500 m. In general, the climate-growth analyses show that radial growth of the Himalayan pencil juniper is positively correlated with the winter precipitation and spring temperature. At some sites tree rings were also positively correlated with summer temperature. Our findings demonstrate the importance of developing the tree-ring data network for the Pamir-Alay and its potential for reconstruction of hydroclimatic variability over the last thousand years in this region.

1. Introduction

Understanding the full range of natural climate variability is possible only through the climate proxies that provide multi-century context of research. Long-term climate reconstructions require various precise and well-dated proxy data from many places around the globe. The last Millennium is especially important because it is the best documented interval, which enables regional comparison. There were phases with drier and warmer conditions as well as more humid and cooler periods of time. The existing studies have come to the conclusion that these periods were not homogeneous in terms of their precise timing and regional expression. However, there are not many millennia-long records available (Jansen et al., 2007).

Mountain systems of Central Asia represent an extreme continental climate; it is therefore important to investigate a climatic variation and changes specific for this region. Long-term climate changes in Central Asia based on an instrumental series were studied by Giese et al. (2007), who described the intensity of the modern warming. Also, the test results for Tajikistan suggest a rise in temperature in recent decades (Makhmadaliev et al., 2008). However, studies of climate variability over centuries require long and reliable measurement series. Existing instrumental data for the study area rarely extend further than the last 100 years. Therefore, the development of proxy data series is crucial for better understanding the long-term climate changes in this region. One of the best sources of high-resolution paleoclimatic information is tree rings. Significant increases in the spatial coverage of tree-ring chronologies all over Asia can be noticed. Studies focusing on past temperature and moisture variations have been already published for mountain ranges of Central Asia and the number of papers has expanded tremendously over the last decades e.g.: the Karakorum

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Table 1
Characteristics of the sampling sites (JUSE = *J.seravschanica*, JUSM = *J.semiglobosa*, Lat = Latitude, Long = Longitude, Exp = Exposition).

Site	Site code	Species	Lat °N	Long °E	Elevation (m a.s.l.)	Exp	Slope (°)	Description
Kulikalon Lower	KULI_1	JUSM	39.15	68.11	2800–2900	–	~5	Flat valley surface of ground morain
Kulikalon Upper	KULI_2	JUSM	39.15	68.10	3000–3500	W	~25	Slope of marginal moraine
Iskanderkul	ISKN	JUSE	39.04	68.22	2200–2300	NE	~30	Terminal moraine of Pleistocene Iskanderkul Glacier

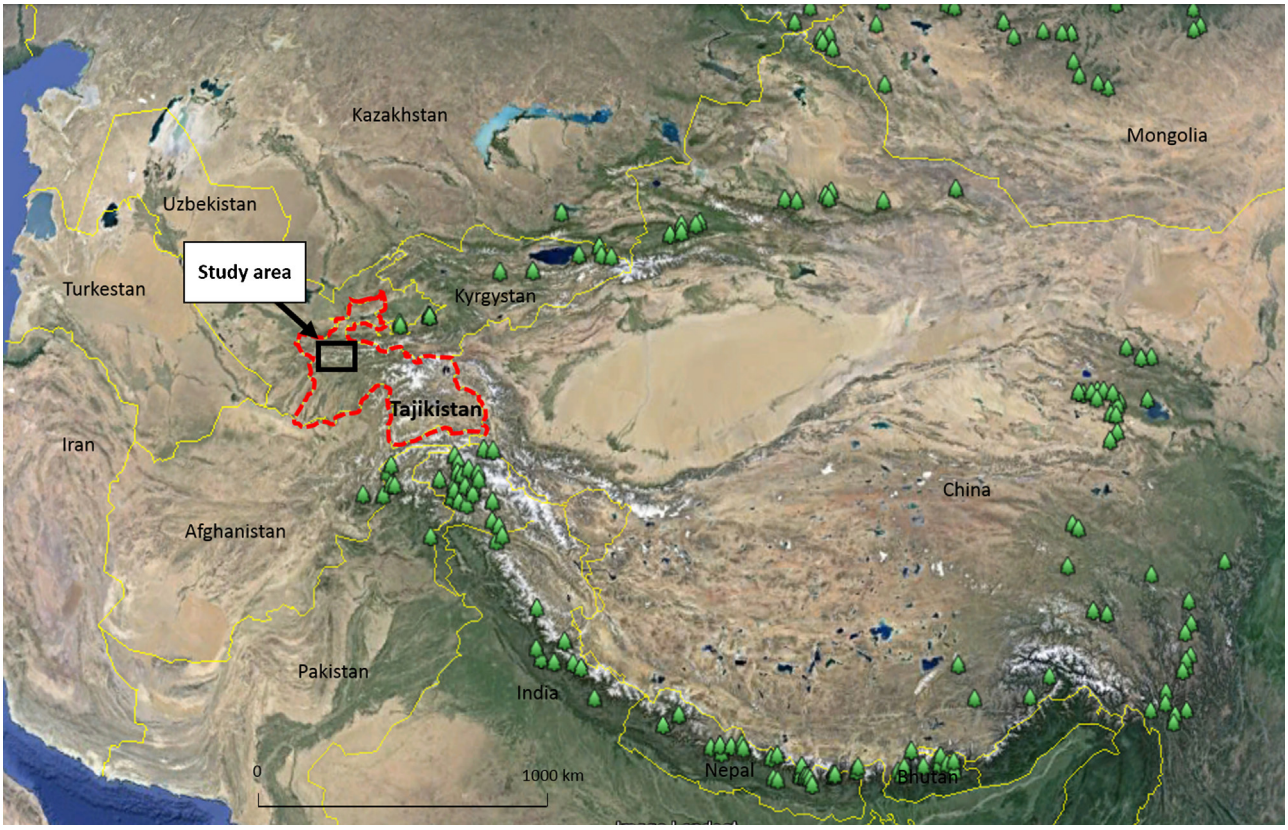

Fig. 1. Location of the Tajikistan with study area and existing tree-ring chronologies in high mountains of the Central Asia marked as trees (data from the International Tree-Ring Data Bank, 2015).

(Esper, 2000; Esper et al., 2002, 2007; Ahmed et al., 2010), Tien Shan (Esper et al., 2002, 2003, 2007; Li et al., 2006; Chen et al., 2013, 2015; Yuan et al., 2013; Solomina et al., 2014; Zhang et al., 2015), Hindu Kush (Ahmed et al., 2011; Khan et al., 2013; Siddiqui et al., 2013) and Himalaya (Bhattacharyya and Yadav, 1992; Hughes, 1992; Yadav et al., 1997; Borgaonkar et al., 1999; Cook et al., 2003; Singh et al., 2009; Yadav, 2013; Liang et al., 2014; Krusic et al., 2015). A lot of attention is also given to the Tibetan Plateau (Bräuning, 1994, 2001; Zhang et al., 2003; Huang and Zhang, 2007; Zhang and Qiu, 2007; Gou et al., 2007; Liang et al., 2009; Yang et al., 2009, 2010; Shao et al., 2010; Zhu et al., 2011). Against this background, it is surprising there are no dendrochronological series from mountain ranges of Tajikistan (Fig. 1). With the exception of one series from Maksimov and Grebenyuk (1972), the dendroclimatological studies for the large areas of the Pamir and Pamir-Alay are broadly missing.

Therefore, the objective of our study was to close the gap in the Central Asian dendrochronological network. In this paper, we introduce the newly developed tree-ring width data from the mountainous area of Lakes Kulikalon and Iskanderkul in western Tajikistan. We provide details on basic statistics of three juniper chronologies, as well as climatic signals embedded in them. The obtained results were used to discuss the potential of these tree-ring data for paleoclimatic reconstructions of the Pamir-Alay Mountains.

2. Materials and methods

2.1. Characteristics of the study area

The study area is located in the Zarafshan Range in northwestern Tajikistan (Fig. 2A). The range, which is the western part of the extensive Pamir-Alay mountain system, extends over 350 km in the east-west direction. The northern border of the range is determined by the latitudinal Zarafshan River valley. The Fann Mountains, the highest part of the range (Chimtarga Peak—5489 m), connect this part of the Pamir-Alay with the Gissar Range to the south (Susłow, 1961; Trohimow, 1968; Shahgedanova, 2002). This entire mountain area is a part of the Hercynian (Variscan) geosynclinal-folded region which was uplifted during the Alpine orogeny. The geological structures include mainly Upper Palaeozoic and, to a lesser extent, Carboniferous and Neogene rocks. They comprise mainly schists, dolomites, limestones, conglomerates and granites. The Quaternary deposits are common in river valleys and include fluvial, glacifluvial, glacial and aeolian (loess) material (Geological Map of Tajikistan, 2006; Rahmonov et al., 2014). The Zarafshan Range has typical high mountain relief. Steep slopes with large debris cones and U-shaped valleys with Pleistocene glacial moraine ridges are dominant elements in the morphology of these mountains. The upper parts of the mountains are covered with small valley glaciers. Two research sites located in the central and