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ScienceDirect
Global and Planetary Change 56 (2007) 371–386
GLOBAL AND PLANETARY CHANGE
www.elsevier.com/locate/gloplacha

Potential forest fire danger over Northern Eurasia: Changes during the 20th century

Pavel Ya. Groisman [a,*], Boris G. Sherstyukov [b], Vyacheslav N. Razuvaev [b], Richard W. Knight [c], Jesse G. Enloe [c], Nina S. Stroumentova [c], Paul H. Whitfield [d], Eirik Førland [e], Inger Hannsen-Bauer [e], Heikki Tuomenvirta [f], Hans Aleksandersson [g], Anna V. Mescherskaya [h], Thomas R. Karl [i]

[a] *University Corporation for Atmospheric Research, Boulder, Colorado, USA National Climatic Data Center (NCDC), Federal Building, 151 Patton Avenue, Asheville, North Carolina 28801, USA*
[b] *Russian Institute for Hydrometeorological Information, Obninsk, Russia*
[c] *STG, Inc., Asheville, North Carolina, USA*
[d] *Meteorological Service of Canada, Vancouver, British Columbia, Canada*
[e] *Norwegian Meteorological Institute, Oslo, Norway*
[f] *Finnish Meteorological Institute, Helsinki, Finland*
[g] *Swedish Meteorological and Hydrological Institute, Norrköping, Sweden*
[h] *Main Geophysical Observatory, St. Petersburg, Russia*
[i] *National Climatic Data Center, Asheville, North Carolina, USA*

Received 31 May 2005; accepted 19 July 2006
Available online 31 October 2006

Abstract

Significant climatic changes over Northern Eurasia during the 20th century have been reflected in numerous variables of economic, social, and ecological interest, including the natural frequency of forest fires. For the former USSR, we are now using the Global Daily Climatology Network and a new Global Synoptic Data Network archive, GSDN, created jointly by U.S. National Climatic Data Center and Russian Research Institute for Hydrometeorological Information. Data from these archives (approximately 1500 of them having sufficiently long meteorological time series suitable for participation in our analyses) are employed to estimate systematic changes in indices used in the United States and Russia to assess potential forest fire danger. We use four indices: (1) Keetch–Byram Drought Index, (KBDI; this index was developed and widely used in the United States); (2) Nesterov, (3) Modified Nesterov, and (4) Zhdanko Indices (these indices were developed and widely used in Russia). Analyses show that after calibration, time series of the days with increased potential forest fire danger constructed using each of these three indices (a) are well correlated and (b) deliver similar conclusions about systematic changes in the weather conditions conducive to forest fires. Specifically, over the Eastern half of Northern Eurasia (Siberia and the Russian Far East) statistically significant increases in indices that characterize the weather conditions conducive to forest fires were found. These areas coincide with the areas of most significant warming during the past several decades south of the Arctic Circle. West of the Ural Mountains, the same indices show a steady decrease in the frequency of "dry weather summer days" during the past 60 yr. This

* Corresponding author. Tel.: +1 828 271 4347; fax: +1 828 271 4328.
E-mail address: Pasha.Groisman@noaa.gov (P.Y. Groisman).

0921-8181/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.gloplacha.2006.07.029

study is corroborated with available statistics of forest fires and with observed changes in drought statistics in agricultural regions of Northern Eurasia.
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Keywords: Potential forest fire danger; Climate change; Northern Eurasia; 20th century

1. Introduction

There is a consensus among the scientific community that during the past century there were significant climatic changes documented in various meteorological variables, first of all in temperature and precipitation (IPCC, 2001). The temperature changes have been most prominent in high latitudes and in the cold season and (as recent studies show) more during the nighttime than in the daytime (Karl et al., 1991; Folland and Karl, 2001). Significant climatic changes over the high lattudes in the 20th century have been reflected in many atmospheric, oceanic, and terrestrial variables. A growing concern is that the changes in the mean values will transpire into changes in weather extremes that will directly impact society (IPCC, 1998). In particular, changes in surface air temperature, precipitation, growing season duration, and snow cover cause changes in numerous derived variables of economic, social and ecological interest, including the natural frequency of forest fires. The following rationale for changes in this frequency for high- and mid-latitudes (thus, for Northern Eurasia) can be formulated as follows. Warming, spring snow cover retreat, extension of the growing season and a reduction of the "warm temperatures deficit" acting together promote vegetation growth and, therefore transpiration. At the same time, warmer surface air temperatures themselves increase the "atmospheric demand" for water vapor and increase of potential evaporation. If precipitation increases insufficiently to match this growing demand, we should witness drier surface conditions and so called "summer dryness" (Manabe et al., 1981) and thus, an increase in potential forest fire danger. This scenario is, however, not inevitable. It well can be that in some regions changes in the atmospheric circulation pattern and/or changes in local factors may increase precipitation "sufficiently" to oppose summer dryness (e.g., Groisman et al., 2004; Robock et al., 2005).

Fire is one of nature's primary carbon-cycling mechanisms but human activity interferes with the natural component of this mechanism causing by some estimates more than half of the occurrences of boreal forest fires. When the weather conditions are conducive to the expansion of forest fires, this anthropogenic effect becomes especially pronounced. In this paper we target only the meteorological component of the changes in potential forest fire danger. After a brief overview of climatic changes in the region (below) and the Data Section, the two following sections examine this possibility using meteorological data for the northern extratropics and comparing them with available information about the forest fire areas and frequency. Discussion and Conclusion Sections conclude the paper.

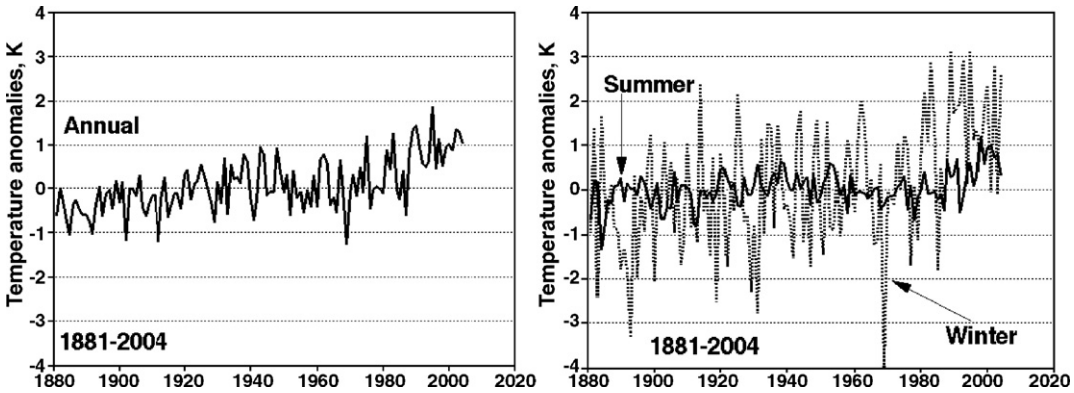

Fig. 1. Changes of the surface air temperature during the period of instrumental observations over Northern Eurasia (continent north of 40° N and east of 15° E). Annual (left) and seasonal (right) temperature variations are presented in anomalies from the mean values for the 1951–1975 reference period. Linear trends of these time series are all statistically significant at the 0.01 level or higher and constitute 2.0 K, 1.2 K, and 0.5 K per 124 yr for winter, year, and summer respectively. Data source: Archive of Lugina et al. (2005).

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