Reconstruction and Prediction of Variations of Total Ozone and Associated Variations of UV-B Solar Radiation for Subarctic Regions Based of Dendrochronologic Data

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Introduction

Variations of dendrochronologic parameters, especially annual ring density, significantly reflect the physiological tree response to systematic variations of solar UV-B radiation, taking place on monthly and longer timescales during growing season. Such variations of UV-B radiation are totally governed by variations of total ozone (TO). Thus, in any dendrochronologic signal, especially for coniferous trees, there is also a recorded response to TO variations, characterizing variations of UV-B radiation.

Because a monitoring of global TO distribution is regularly performed since 1979 using TOMS satellite instrumentation, there appears a possibility to reconstruct TO behavior in the past practically at any point of dendrochronologic monitoring network. The reconstruction is performed by the method of linear regression, based on significant correlation of annual ring density of coniferous trees and TO for coordinates of denrochronologic signal (Zuev and Bondarenko 2002, 2003). The present report considers the Subarctic latitudes, which are characterized by considerable TO variations in the second half of twentieth century.

We performed analysis of a set of dendrochronologic data for Subarctic regions and selected chronologies according to maximum density of annual tree rings of coniferous species, namely Siberian spruce and ordinary pine, growing in plain terrain 25-300 m above sea level (26 chronologies in all). Statistical analysis of dendrochronologic and TO data for warm period from May to September has shown a significant correlation for a sample of 13-16 points. Unfortunately, dendrochronologic data, available in Internet for the chosen region, end in 1992-1994. Higher correlation coefficients between TO and annual ring density were obtained for Siberian spruce (0.8-0.96) and at significance level for pine (0.5-0.66).

The results of TO reconstruction for certain coordinates, namely 61°3 N/59°3 E (North Urals) and 65°35 N/69°5 E (Lower Reaches of Ob), are presented in Figure 1.

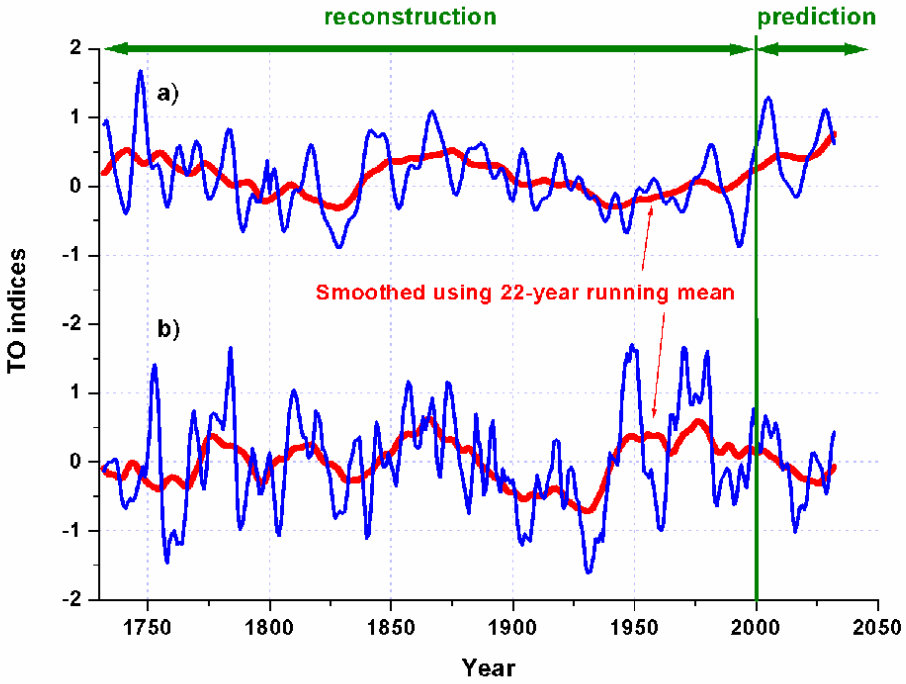

Figure 1. Results of long-term prediction of ozonosphere variations from reconstructed data for the regions of (a) North Urals and (b) West Siberia

Also shown in the figure are the results of prediction of TO behavior in the future for these coordinates; the confidence of this prediction is determined by the length of reconstructed time series. As seen from Figure 1, for neighboring regions of North Urals and Lower Reaches of Ob the tendencies in behavior of TO indices are practically 180° out of phase for the aforesaid regions. This is due to spatiotemporal inhomogeneity of TO field, caused by atmospheric circulation; this is clearly seen from Figure 2 which is based on instrumented TOMS data obtained for meridional variations along Subarctic latitude 63°.

Because of such a TO behavior, it is difficult to obtain a generalized TO chronology for long-term variations of UV-B radiation in entire Subarctic latitudinal belt. For this purpose, the studied sample of reconstructed TO chronologies was differentiated into groups using cluster analysis.

Figure 3 presents a clustering of studied sample of 26 chronologies for different coordinates. Numbers identify groups for which in averaging of reconstructed TO chronology, we used 7 (1), 12 (2), and 7 (3) chronologies.

These three generalized TO chronologies in absolute values for Subarctic, smoothed using 50-year running mean, are presented in Figure 4. They specularly reflect most typical behavior of UV-B radiation for vast territory of Subarctic Eurasian region.

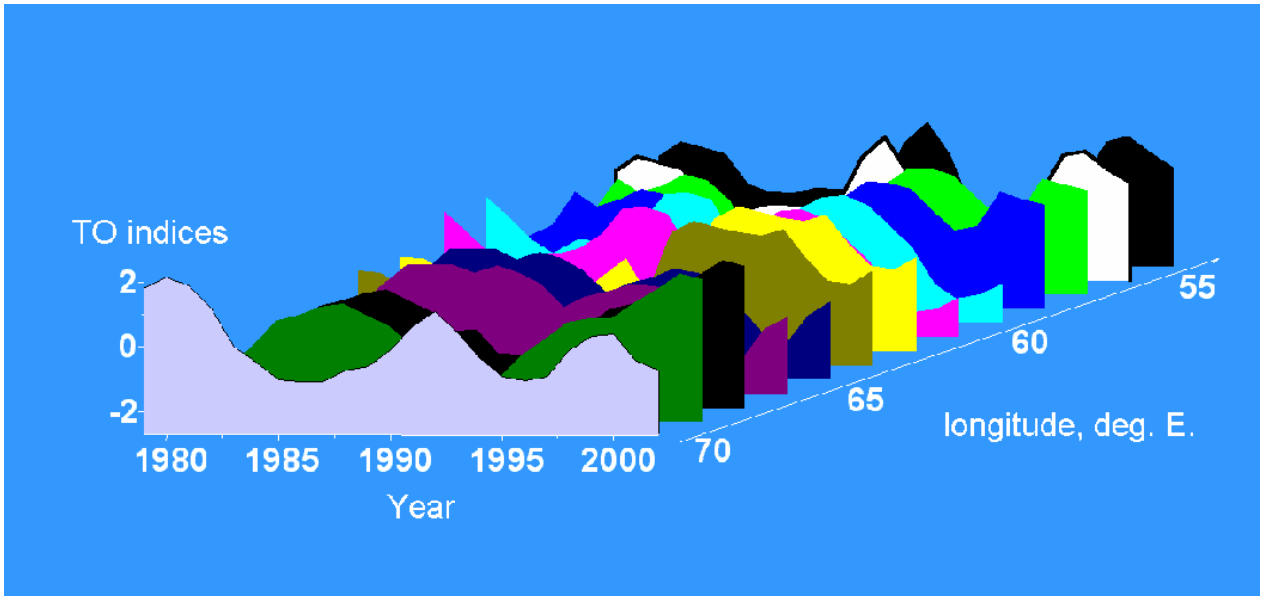

Figure 2. Spatiotemporal inhomogeneity of TO field from TOMS data for Subarctic.

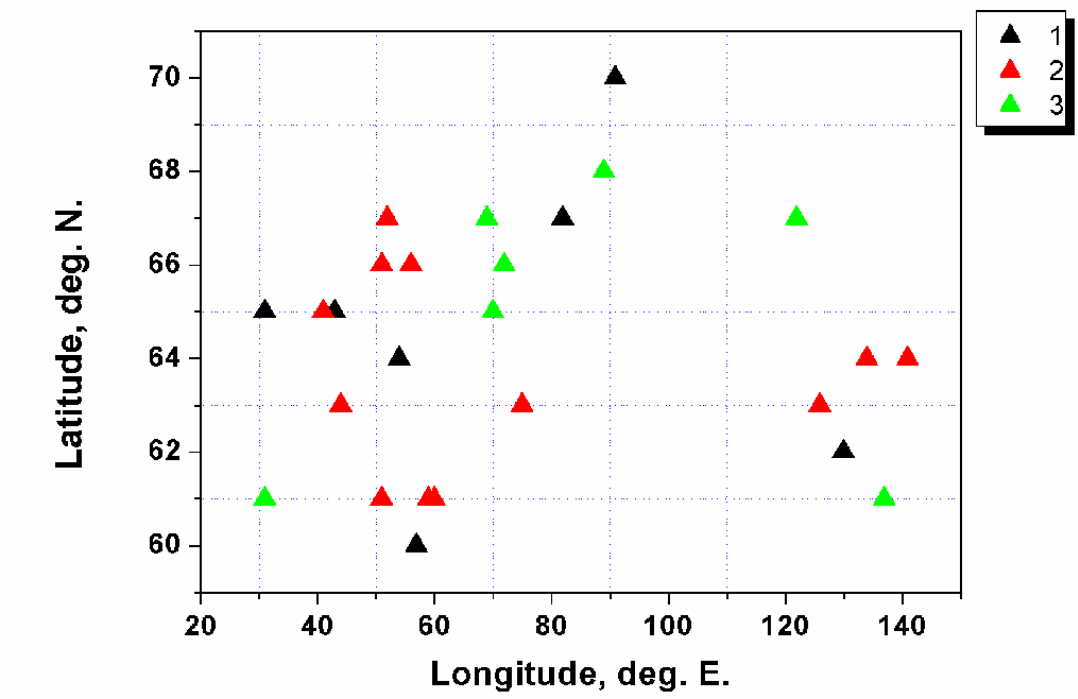

Figure 3. Three groups of TO chronologies after cluster analyses.

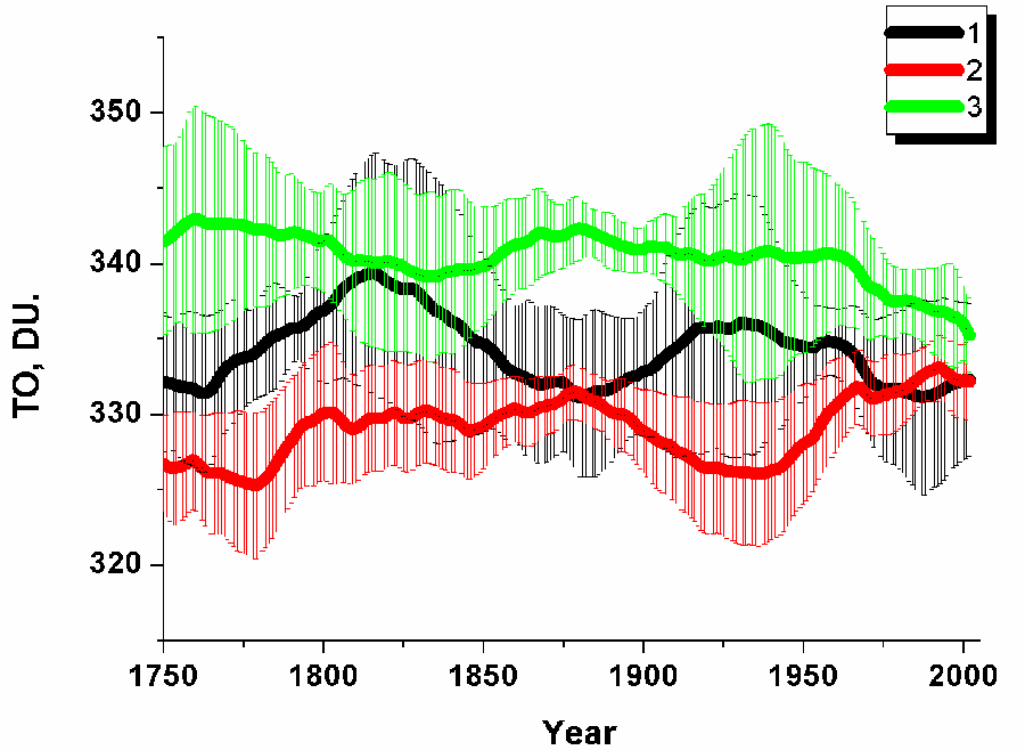

Figure 4. Three generalized TO chronologies.

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Acknowledgments

References

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