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Bioclimatic indices in the context of biodiversity, Karkonosze/Giant Mts., SW Poland

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Abstract

A number of bioclimatic indices were calculated for Szrenica in Karkonosze Mts. The analysis for the years 1961-2015 showed an temperature increase from 2.1 °C in 1961-70 to 3.4 °C in 2001-15. The other bioclimatic indexes values that were calculated did not show any significant changes throughout the analyzed period.

Keywords

Bioclimatic indices; Biodiversity; Climate change; Karkonosze Mts.; Sub-alpine zone

Introduction

The mountain area of the Karkonosze Mts. due to the relatively small transformations of land use by man, is a good place for credible climate research. Furthermore, a sensitive ecosystem with high biodiversity is very susceptible to any environmental change, including climate change. Progressive warming of the climate is also observed in the Karkonosze Mts. and cannot be carried out without changes in the environment.

Research area and methods

Szrenica (φN 50°44' and λE 15°44'; 1362 m a.s.l., meteorological station at 1335 m a.s.l.) is a peak in Western Karkonosze, situated within the dwarf pine belt. According to the classification by ELLENBERG (1978), Szrenica belongs to the sub-alpine climate zone. It's located in the Karkonosze National Park, which is also an area of Transboundary Biosphere Reserve Karkonosze (Poland-Czechia).

Based on thermal data from period 1961-2015 at Szrenica Mt., a number of bioclimatic indices were calculated: mean annual temperature, annual temperature range, Gorczinski Continentality Index (GORCZYŃSKI 1920), JOHANSSON-RINGLEB's continentality index (1926, by OKOŁOWICZ 1969), De Martonne aridity index (DE MARTONNE 1925), Ellenberg's climate quotient (ELLENBERG 1988). Temperature and precipitations from period 1961-2000 were measured at station belonging to University of Wroclaw. Data's from 2001-15 are reconstructed on values from Labská Bouda which was founded in 1979 and is managed by Czech Hydrometeorological Institute (ČHMÚ). Both stations are close together (about 3 km), at near altitude (respectively 1335 and 1320 m a.s.l.). Temperature correlation between stations in period 1981-2000 (when both stations were in operation) is about 0.99. Precipitation correlation is weaker, probably in case of significant influence of wind, but still it is 0.84.

Results

Mean annual temperature in 1961-2015 was 2.6 °C. Since the late 1980's a noticeable increase in average annual temperature has been observed (Fig. 1.). Higher temperature is reflected in the extension of the growing season. Average growing season in the period 2001-15 lasted 162 days compared to 143 days in 1991-00, 141 days in 1961-70 and also in 1981-90 and 130 days in 1971-80.

Value of the Gorczinski index (K_G), based on annual temperature range, varies throughout the whole analyzed period between 25% and 55% (Fig. 2.) and average was 42% (where 100% means extremely continental climate in Verkhoyansk). This shows the lack of change between the continental and oceanic influences of air masses though the years. Similar conclusions can be drawn from Johansson-Ringleb's (K_{JR}) index values, which was also stable throughout the analyzed period. Unlike the K_G index, K_{JR} index takes into account the temperature difference between autumn and spring.

Ellenberg (EQ) and De Martonne(I_{dm}) indexes uses besides thermal values also annual precipitation value. EQ index (which include temperature of the warmest month in year) shown steady course over the years (Fig. 3.) with slight deviations due to the rising temperature of the warmest month of the year as well as the increase annual sum of precipitation. The resulting average value of 8.7 is typical for subalpine zone (EQ<10). I_{dm} index indicates a steady course since the mid 80's (Fig. 4.). Previous large fluctuations were due to greater annual variability of annual average temperature. The average value of 65 in analyzed period puts the subalpine zone in Karkonosze Mts. in extremely humid climate zone (I_{dm}>55).

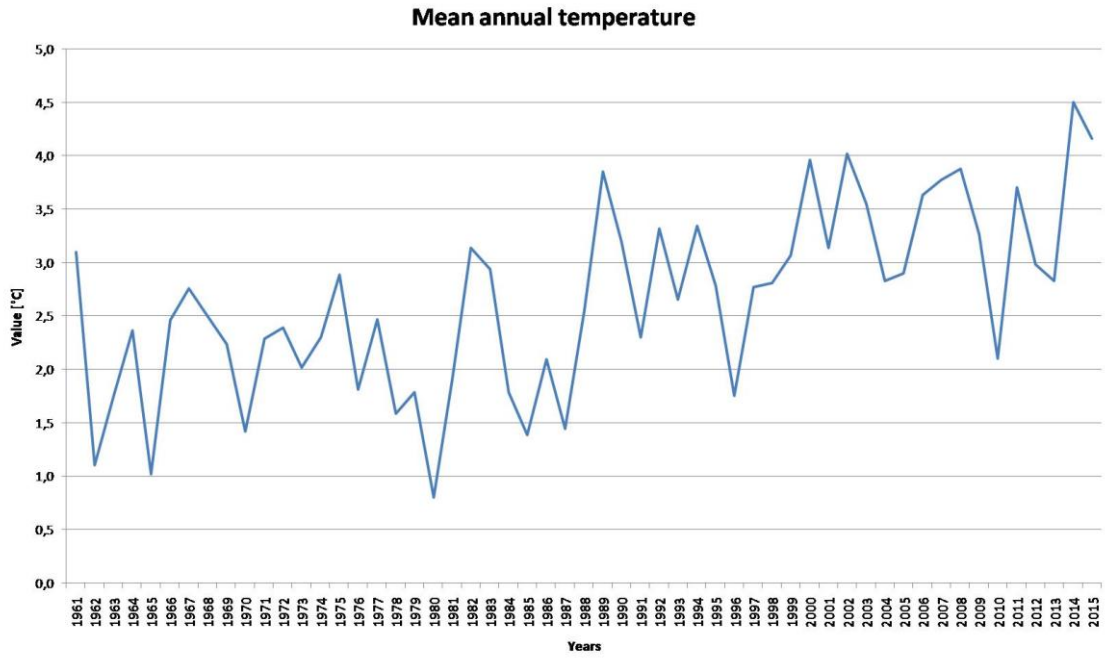

Figure 1: Mean annual air temperature at Szrenica, 1961-2015 period

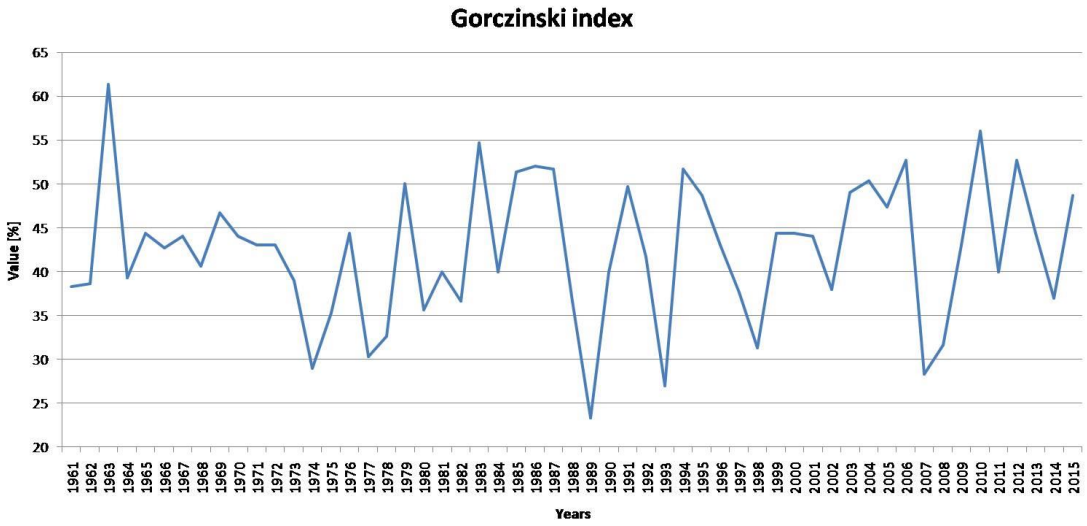

Figure 2: Gorczinski index value at Szrenica, 1961-2015 period

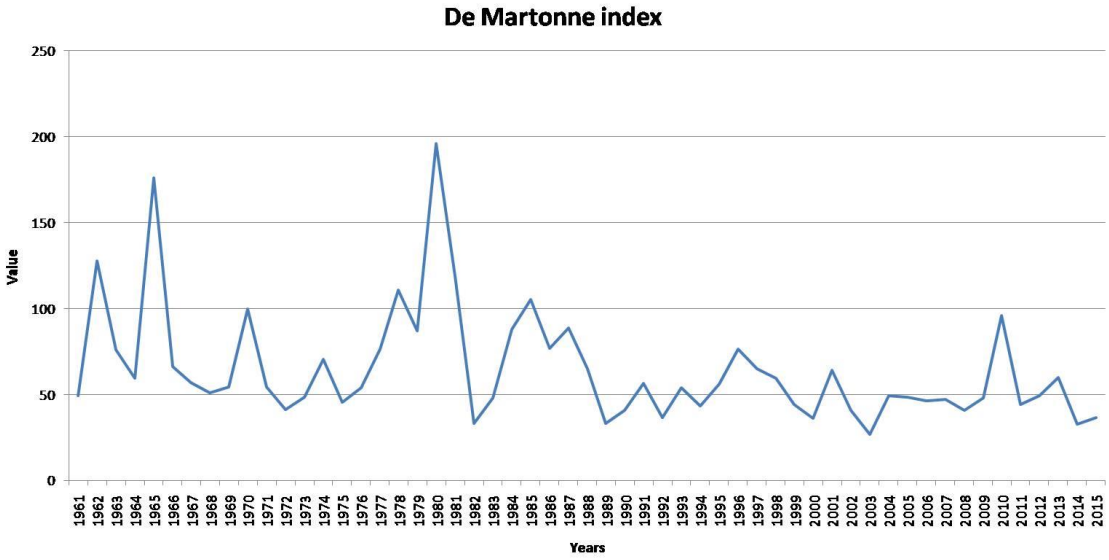

Figure 3: De Martonne index at Szrenica, 1961-2015 period

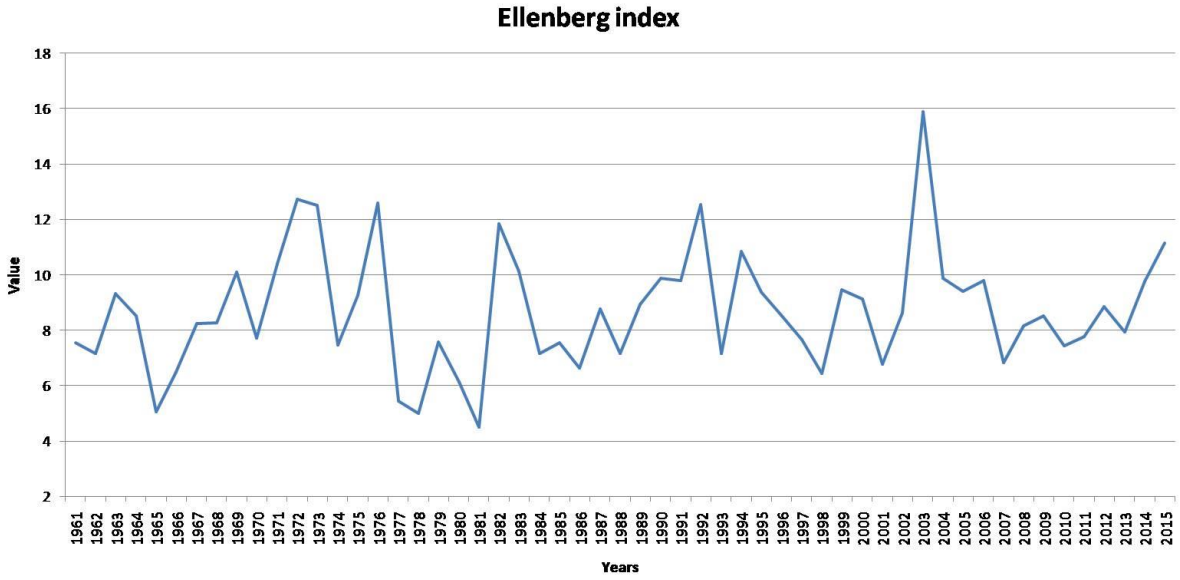

Figure 4: Ellenberg index at Szrenica, 1961-2015 period

Discussion and conclusion

The vast majority of bioclimatic indices show no significant change in values between 1961 and 2015. This proves the preserved balance between oceanic and continental air masses through the year. Also no important change in annual precipitation value was observed. The only major change is the increase in air temperature.
The steady rise in temperature, that has occurred over the last 30 years, undoubtedly leads to environmental changes affecting plant habitats. Research on the Czech side of the Karkonosze Mts. has shown the raising of the tree line (TREML 2004), but you cannot forget that climatic conditions are not the only factor influencing the location of the upper forest border. Higher temperature throughout the year, shorter snow cover and extension of the growing season by almost a month in the period 2001-15 compared to the period 1961-90 will be reflected in the environmental conditions.

The temperature increase of 2-2.5 °C degrees predicted by the end of this century (IPCC 2013) will result in the disappearance of up to 80% of the habitat area of 30-50% of subalpine plant species in different mountain ranges of Europe (ENGLER et al. 2011). The question is how much will this impact on biodiversity in the Karkonosze Mts.?

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