

## CLIMATE AND BIOCLIMATE VARIATIONS IN SLOVENIA AND THEIR APPLICATION FOR TOURISM

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### ABSTRACT

Slovenia has a well-developed winter and summer tourism industry, which benefits many economic branches. Climatic and bioclimatic conditions are of importance for such tourism. Although there are plenty of places with pleasant thermal conditions even during high summer, heat waves can be oppressive from time to time for the tourist destinations in Slovenia. This paper will examine climate and bioclimate variations in Slovenia, and their application for tourism. For assessing these conditions meteorological stations with long data series were selected. Three lowland stations, and one in the Julian Alps, were selected to represent the variety of climatic conditions in Slovenia. We expect that climate change will not have the same impact on the tourism industry in all regions; the most vulnerable branch of tourism seems to be winter tourism.

The daily mean, maximum and minimum air temperature, relative humidity, wind speed and cloud cover have been included in the analysis. From these parameters we have calculated, on a daily basis, the mean radiant temperature, and also one of the most used thermal bioclimatic indices, derived from the human energy balance: Physiological Equivalent Temperature (PET). There were significant differences in seasonal trends of the input parameters and PET. On the annual scale a rather sharp change in trend sign was noticed for all stations. One of our aims was also to compare variability of basic climatic variables with variability of derived thermo-physiological relevant variables, and their change over the last fifty years - but the main question was which period was the most representative for describing the ongoing changes.

**KEYWORDS:** *Climate, Climate variability and change, Thermal comfort, Bioclimate, Tourism*

### INTRODUCTION

Four major European geographic regions meet in Slovenia: the Alps, the Dinaric area, the Pannonian plain, and the Adriatic sea. The highest peak is Mt. Triglav (2864 m). As a small,

beautiful and picturesque country with a well-preserved environment, Slovenia makes a great tourist destination. Mountains, lakes, waterfalls, forests, caves, hills, plains, rivers and the sea can be found within a modest 20.273 km<sup>2</sup>. Forests cover half of the country; remains of primeval forests are still to be found, the largest in the Kocevje area. Approximately 8 % of Slovenia's territory is formally protected - the largest area with such a regime is the Triglav national park, with a surface area of 848 km<sup>2</sup>. You can ski in the morning and surrender yourself to the luxury of the Adriatic Sea in the afternoon. In most of Slovenia a continental climate of cold winters and warm summers prevails. The average rainfall is 1000 mm for the coast, up to 3500 mm for the Julian Alps, 800 mm for the northeast, and 1400 mm for central Slovenia. Climate had a dominant impact on architecture and agriculture in the past, and the landscape of regions was determined by climate.

Tourism is one of the most promising sectors of the economy in Slovenia. Every year 1.2 million foreign tourists visit Slovenia. Tourism represents 9.1 % of GDP (1). It is enhancing the economic value of natural resources and cultural heritage. Tourism is a highly adaptive and responsive branch of the economy, because it depends upon many external factors. One of them is climate change, but right now tourist resorts are more concerned about climate variability.

For the tourism industry the extremely warm, sunny and dry summer of 2003 was welcome. However, green winters, one after another, at the end of eighties and beginning of nineties were almost a disaster for winter tourism. Even with the existing climate variability the tourism industry has to be flexible and adaptive, looking to develop alternative programs. Thus, general knowledge about past, and current, climate and bioclimate conditions is relevant and important for the tourism industry because of its dependence on weather and climate.

## **METHODS**

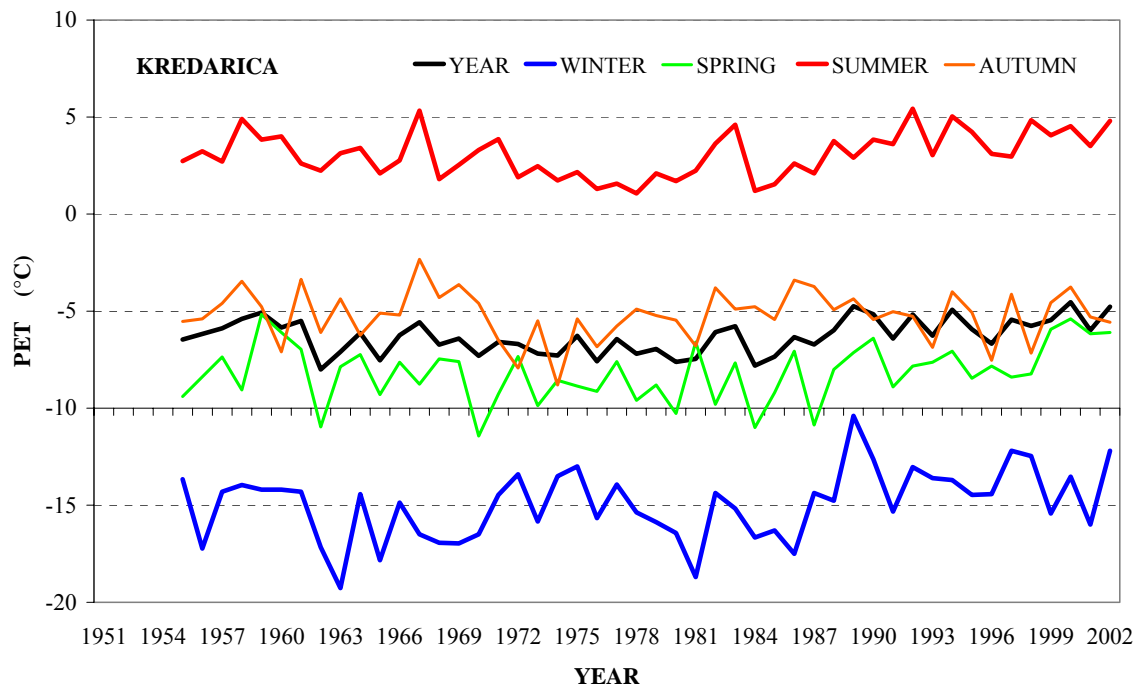
Methods used to assess climatic conditions, based on half a century of data, from selected stations are common in everyday climatological praxis at the Meteorological Office in Slovenia (2) e.g. anomalies, moving averages, and trends. Because at the annual time scale data showed a changing point around the beginning of the eighties (in some seasons also a well pronounced periodicity), and it is well known that climate is a complex nonlinear system, we are trying to make recommendations to the tourism industry based on moving average features. Using only the linear trend would, most of the time, lead to an underestimation of ongoing change. For example, in the case of periodic changes in the winter season, the length of the analysed period could have a dominant impact on the calculated trend magnitude.

The climatic analysis was complemented with Physiological Equivalent Temperature (PET) calculated by means of the RayMan model which takes into account all of the relevant

meteorological variables that have an impact on human thermal comfort/discomfort (3). The methodology of adapting human-biometeorological methods for the assessment of thermal bioclimate is described and explained in this book (4, 5). For the application of tourism climatology results, in tourism and recreation, we included PET and the precipitation in this analysis. Of course additional parameters like sunshine duration and basic climatological parameters were relevant, but they were included in an indirect way: through the thermal comfort analysis. In conclusion, we assume that a quantification of the tourism climate, in a basic manner, can be accessed by the combination of PET and precipitation.

## RESULTS

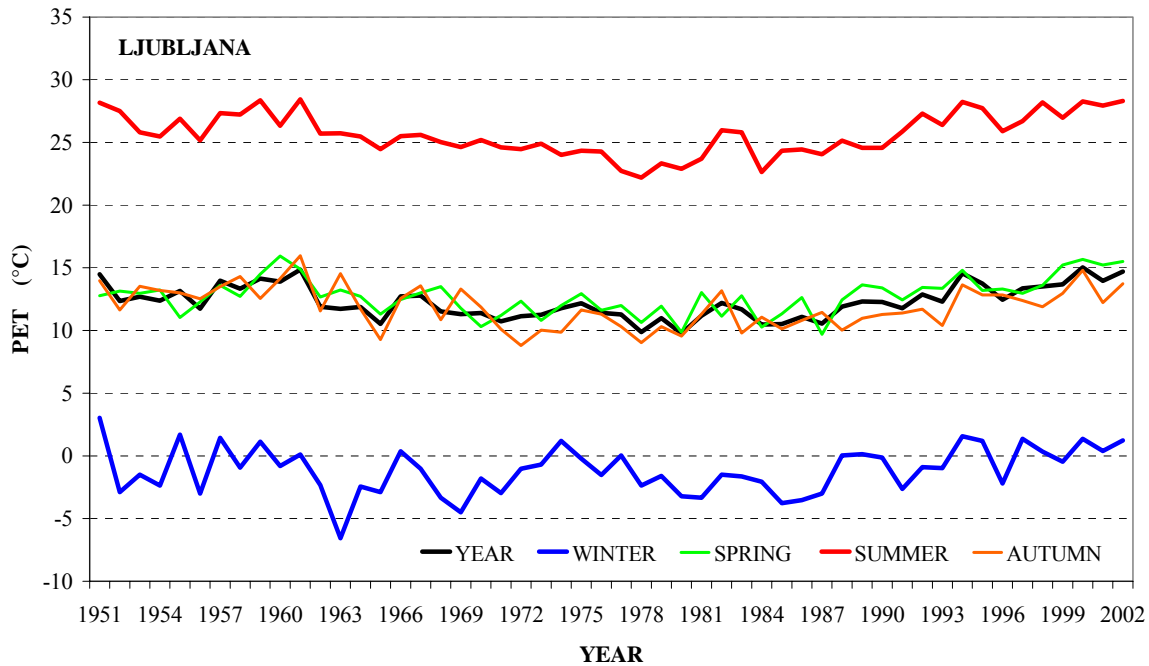
There is evidence that mean annual temperature is increasing in the mountains and in low-land areas. Also, absolute humidity is showing an increasing trend, although not so relevant as air temperature. No change can be detected in mean annual cloudiness; it seems that mean annual sunshine duration is increasing too. Positive trends have also been observed for some bioclimatological indicators (Figures 1 and 2). PET increased by almost 3 °C during the last 25 years in Ljubljana and on Kredarica, and these trends are significant.



**Figure 1: Mean annual and seasonal PET for Kredarica**

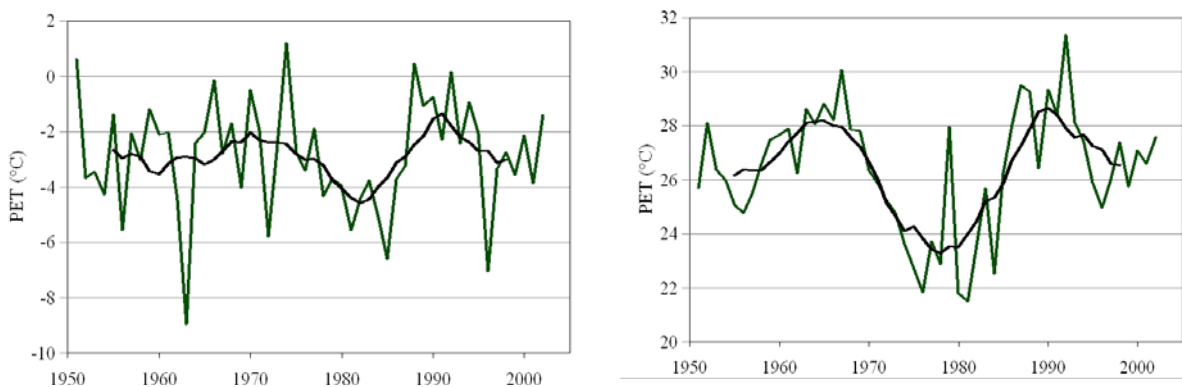
Comparing seasonal and annual PET values for different locations it becomes evident that values, cycles, and tendencies show significant differences. It is clear that for assessment of climatic and thermal conditions it is necessary to take into account local conditions and local meteorological

data. Local peculiarities are often neglected, sometimes because of lack of data or poor knowledge of local geographic conditions.



**Figure 2: Mean annual and seasonal PET for Ljubljana**

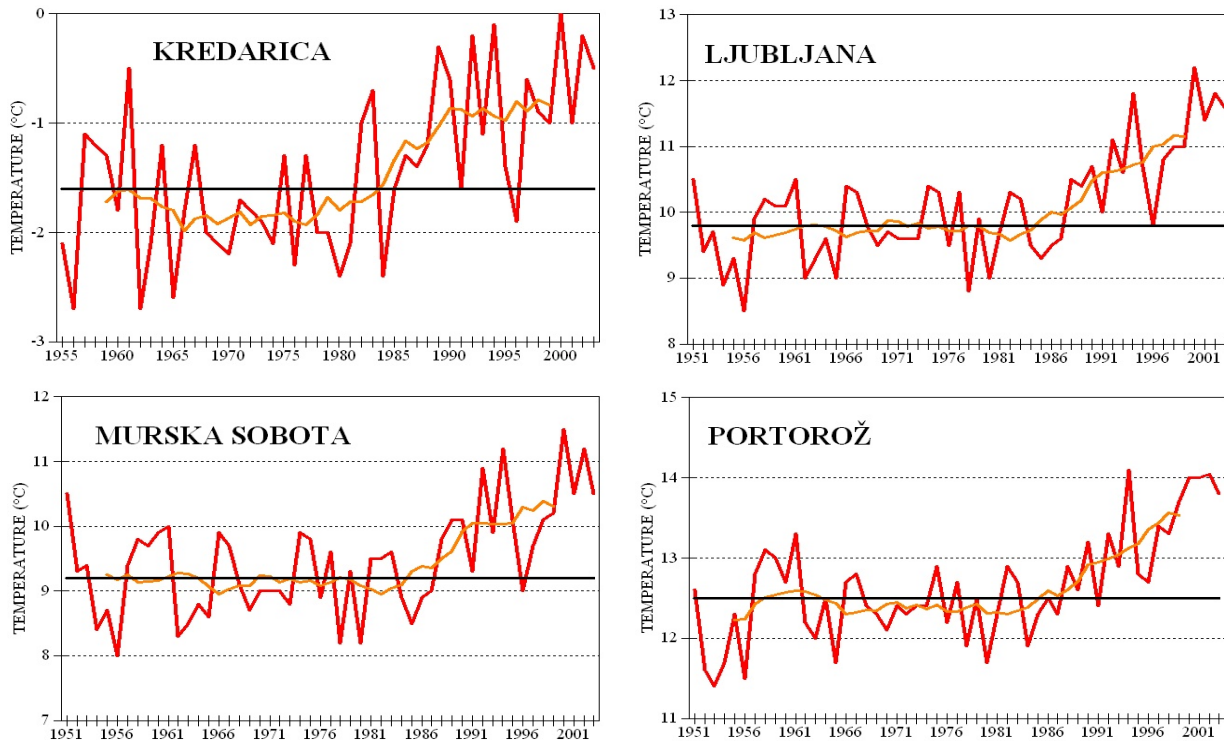
There is an evident difference between the autumn trend in Ljubljana and Kredarica. In the high mountains there is no trend, but in Ljubljana there is an increasing tendency after the mid seventies. The magnitude of the summer trend in Ljubljana during the last three decades was almost twice the one observed in high mountains, although on the annual time scale there was almost no difference between these two stations in trend magnitude. Seasonal features for Murska Sobota show a strong periodic component (Figure 3); in some seasons these periodic changes are also present at other stations.



**Figure 3: Mean winter (left) and summer (right) PET for Murska Sobota**

It has to be noticed that at both stations, Ljubljana and Kredarica, the observing site is the same during the analysed period and the observing method is the conventional one (6), so there is no internal cause for inhomogeneity. However, in Ljubljana, a station in the central part of Slovenia,

there is an impact of increasing urbanization around the station, which could contribute to the magnitude of the increasing trend during the last decades.



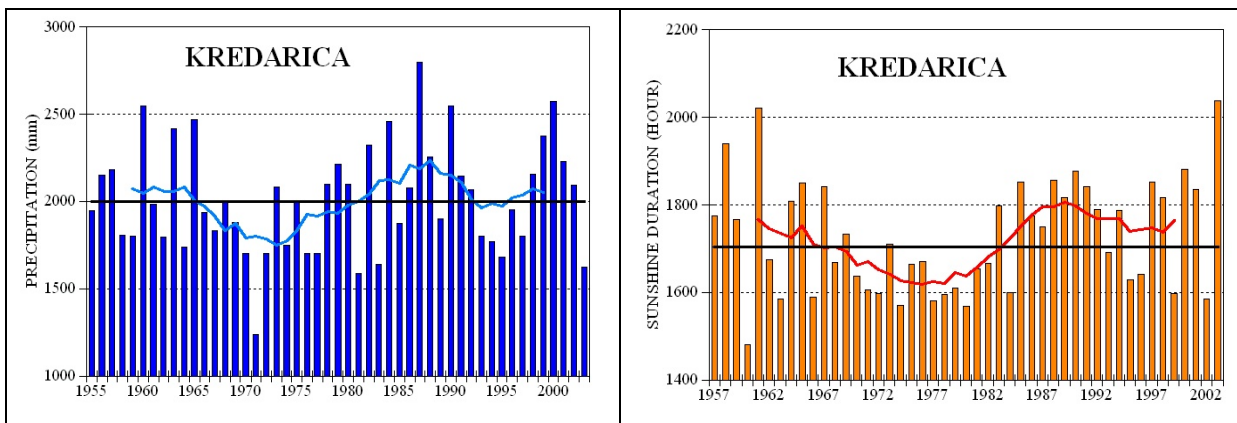
**Figure 4: Mean annual temperature (red line), average of the reference period 1961-1990 (black line) and moving average (yellow line)**

Murska Sobota is representative of the plane in the north east of Slovenia - the region with the most pronounced continental component in climate. Portorož lies on the Slovenian coast; the station has been moved several times during the last decades, but data has been carefully homogenized. In all of the stations the moving average rose above the reference value in the eighties, and remained above for the rest of the period (Figure 4). This increase in mean air temperature was concentrated during the last 25 years - during the first half of the analysed period there was no significant trend. A trend calculated upon the whole period of data was much smaller than the one observed during the last two decades. Which of them could best fit the needs of the tourism industry? According to the forecasted climate changes the one calculated over the whole period would correspond to the most optimistic IPCC forecasted increase in temperature, and the one based on the last two decades is close to the upper limit of forecasted increase. Our advice to the tourism industry is to take into account the trends during the last half of the analysed period, because they are closer to the worst-case scenarios and they fit better the ongoing changes.

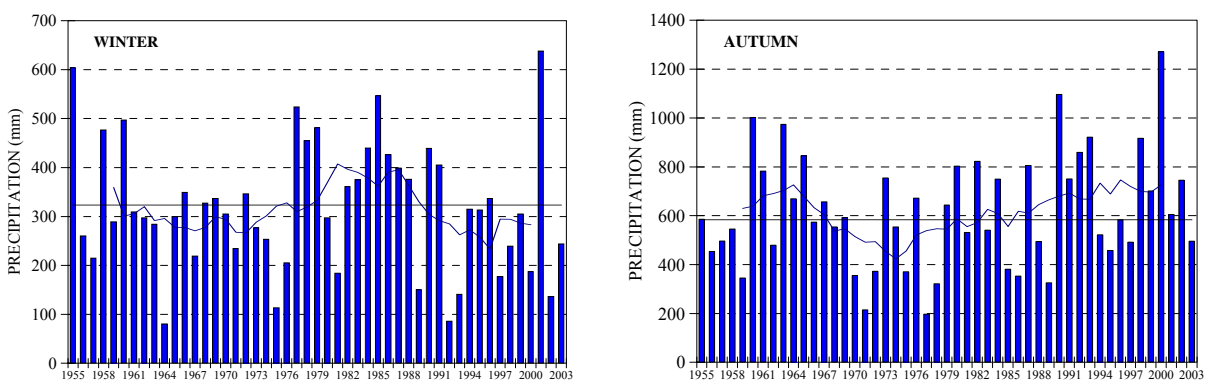
During the end of the seventies and beginning of the eighties there were winters with abundant snow cover, so many ski resorts at a relatively low altitude were established. They were popular

because they were easily accessible, but many of them were closed during the series of green winters at the end of the eighties and beginning of the nineties. It should be noted that there are several processes that combine to create what we experience as our climate: climate change (most of the people associate it to slowly warming atmosphere due to increasing concentration of green house gases), and coincidental variability and cycles (although not enough understood or studied). Reliance only on linear trends is not enough - on the contrary, it sometimes could even be misleading.

Not only do temperature and thermal bioclimatic indicators show fluctuations and trends, there are also pronounced year-to-year fluctuations in the amount of precipitation and sunshine duration for all time resolutions (Figure 5 and 6) as well.



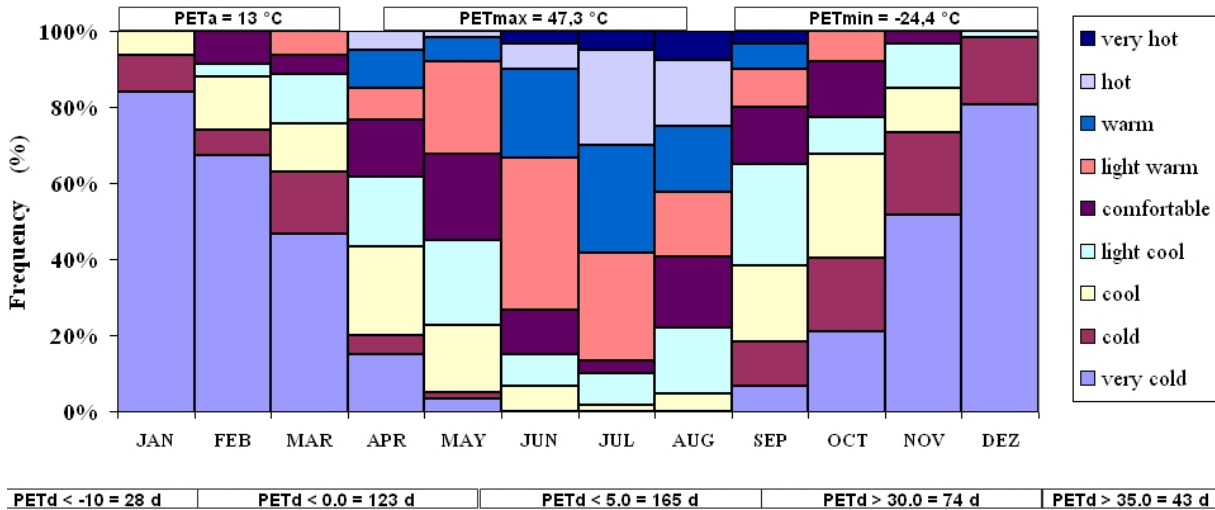
**Figure 5: Kredarica annual precipitation (left) and sunshine duration (right), 1961-1990 mean (black line) and moving average (light blue and red lines)**



**Figure 6: Kredarica seasonal precipitation, 1961-1990 mean and moving average**

Analysis of extreme short-term precipitation for a large number of stations indicates mostly positive trends, but not for all time intervals. Only very few trends are statistically significant. For a very short duration, in some cases 5 minutes, of precipitation negative trends were noticed.

Not only are average values for bioclimatic indices of interest to the tourism industry, but frequency of different degrees of comfort/discomfort is useful. Frequency distribution is certainly more useful for end users than mean value, because it carries more information. An example of frequency representing the occurrence of selected comfort degrees is on Figure 7.



**Figure 7: Frequency distribution of different comfort classes in Ljubljana**

## CONCLUSION

Climate change has enhanced interest in climatic conditions in almost all economic sectors, and the tourism industry is no exception: it is looking to be informed, adapted and prepared for change. In the future climatologists expect: more frequent and intense extreme events, higher air temperature, more hot days, decreased daily amplitude, more droughts, and more floods. Even though uncertainty is related with local predictions, and with phenomena on the local scale, end users, among them the tourism industry, are mainly interested in such local features. They need and expect from the National Meteorological Services detailed descriptions of climatic and bioclimatic features, but also some guidelines about the expected future conditions. One of the possible tools to assess the future climatic and bioclimatic conditions is the use of trends, and the extrapolation of moving averages. It sounds very simple, but there are several problems incorporated in such a projection. The first one is a homogenization of the input data; often there is insufficient metadata available, and even with use of homogenization tests some subjective touch in the final result remains. The second problem is the length of the time series under investigation. We have shown that there are several sub-periods with quite different trend magnitudes, and sometimes even with trends in the opposite direction. Even more confusion is introduced when there is a well-pronounced periodicity in the time series. The climate system is complex; there are many feedbacks and non-linear connections.

Results, based on analysis of historical data, showing that Slovenia's local climate is changing: results show significant spatial and seasonal differences. The magnitude of change in meteorological and also complex measures like PET is such that it should be taken into account when planning future investments and activities. Spatial and seasonal differences suggest that analysis should be made for each individual region, or maybe even each individual location.

It is evident that a change has already started and the projected magnitude is close to the upper predicted interval for the global change. We should take into account: annual as well seasonal variations; possible periodicity when detected; and in the case of data with subsets showing distinctively different trends, the last subset of data. Such rapid changes as we have observed during the last two decades are likely to produce significant changes in the environment and ecosystems. It seems necessary for all climate and weather related economic branches, and tourism industry certainly is on of them, to start adaptation programs, and to take into account the changing climate when planning new infrastructure.

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