On local changes of temperature regime of the soil-atmosphere system around the Caspian Sea in the 20th century

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Abstract
In this paper the results of investigations of changes of temperature and water regimes for a long time period for a medium-size area are presented. The location of the experiments is in different soil-climatic zones of Azerbaijan: in a humid subtropical zone, in a middle moist subtropical zone and in a dry subtropical zone. We used the data of temperature changes over a period of more than one hundred years (1889-2008), thus we could compare the change of temperature on a long-term basis. The most important results are those of the second half of the 20th century, especially between 1970 and 2008. The comparison of three locations regarding climatic changes shows different characteristics. For example, in the humid subtropics according to the decadal data during fifty years, the average annual temperature is characterized by its increasing and decreasing. It is reflected in the thermo-physical characteristics of soils (Gerayzade 1989). During these periods according to temperature of a surface soil heat exchange in soil periodically changes its direction, playing a part in soil formation processes. Heating of different layers of earth creates certain streams of heat in the soil profile, and naturally also promotes moisture redistribution. The special changes on temperature here can be observed on the decadal data for 1970-1979, 1980-1989, 1990-1999 and 2000-2009. Though, specific trends in air and soil temperature are not observed.

Key Words
Global warming, soil temperature regimes

Introduction

The forecasting of the process of global warming is one of the difficult problems of the present day. First, because natural processes depend on many various factors, secondly, because it is difficult to predict volumes of green house gases in the last decades. According to the Japanese Meteorological Agency and the World Meteorological Organization relative to 1891 the average index of temperature of 2008 compared to 1891 has exceeded on 0.2^0C and has taken the tenth place among the warmest years (http://www.jma.go.jp/jma/indexe.html). Considering the average temperature of the atmosphere between 1971 and 2000 there have been 5 an abnormal warm years: 1998 (0.37^0C), 2002, 2003, 2006 (0.31^0C), 2005 (0.32^0C). Therefore we decided to check up on changes in values of temperature using long-term data for different part of Azerbaijan, particularly in regions next to the Caspian Sea. The intervention of man accelerates desertification processes. Unsystematic cutting down of woods (Amirov 1997) , building the megacities and the corresponding communications are the reasons of releasing superfluous quantities of carbonic gas to the atmosphere, increasing the greenhouse effect which is the principal cause of climate warming (Mammadov and Khalilov 2005).

Methods

In order to study the dynamics of temperature change in the soil-atmosphere system in the period 1970-2008, data about dynamics of temperature on the hydrometeorological stations, located in the research area have been collected. On the basis of the received data the average values of temperature for months and years from 1970 to 2000 are calculated (Safarov 2000). Further generalization is conducted concerning to the calculated average values. On the basis of the collected data adequate tables and diagrams are made. The temperature and humidity changes in soil-atmosphere system have been established. The created temperature gradient also generates the humidity gradient both in air and soil. The evaporation increases negative influences on environment water balance as a whole, thus the balance established by centuries is disturbed. The major factors defining the thermal condition of environment are also the vegetative cover, the water-air regimes, the nutrients, the biological properties of soils (Ulanova and Sirotenko 1968).

At the same time, on the formation of temperature fields in the soil influences its thermo-physical properties: the thermal capacity, the thermal conductivity and the temperature conductivity which in their turn are functions of soil-physical properties, such as humidity, granulometric structure, density, porosity, the maintenance of organic substance, temperature, etc. All of them cause the heterogeneity of thermo-physical parameters of soils (Gerayzade 1989). Therefore the knowledge of thermo-physical properties of soils in interrelation with their genetic features, character and degree of natural humidifying, consolidation and aeration of a soil profile is essential for analyses of the genetic characteristic of soils, as well as for and the forecast of changes of hydrothermal properties of soil horizons under influence of anthropogenous factors (Masimov 1999).

The last decades were characterized by mass cutting down of woods in a number of areas of Azerbaijan, and also growth of forest parks around cities. All of these have cardinally changed the heat and moisture regimes in their vicinities (Imanov, etc 2002). Therefore the experimental definition of the thermo-physical characteristics of soils and finding-out the features of their changes in the soil profile depends on soil-physical factors; the establishment of laws of hydrothermal modes and dynamics of thermo-physical factors of investigated soils, finding out the influence of area of woods on hydrothermal modes and thermal properties of soils becomes a requirement.

Results

In Table 1 decadal averaged sizes of air temperature of a year and months are given (1970-79, 1980-89, 1990-99, 2000-09). Analyzing the given table, one can see increasing or decreasing temperature from 1970 to 2008. For example, the temperature in January, February and March in Khachmaz district gradually increases with regard to their average long-term values (1.9^0C, 2.03^0C, 5.0^0C). The special increase of temperature is observed during the period from 2000 to 2008, their relation to corresponding values of base temperatures are 1,5263; 1,6256 and 1,26. In April and May the temperature of air according to their average long-term values has also changed: in April has slightly decreased, in May, on the contrary, has increased, so indexed parities have made 0,9036 and 1,0080. The average temperature in June and August has slightly increased, in August, on the contrary, has decreased. The average temperature in September, October and November have increased and indexed parities have made 1,095238; 1,097015; 1,077561. In December temperature reduction is observed, accordingly indexed ratio has made 0, 860465.

Analyzing local changes of long-term monthly average temperatures on decades, it is possible to show changes of monthly average and annual temperatures for the concrete period. For drier Khachmaz area average long-term temperature in January from 1970 to 2008 has increased more than 2 ^{0}C. In February this increase was decreased according to the absolute size - approximately 1,6; in March - 1,4; in April and May reduction of monthly average temperatures is accordingly 1,3 and 0,5 ^{0}C. Further again we see the increase of temperature concerning their average long-term values. In June - $0,7^0$C, in July – 0.2; August - 1,9; September - 3,2; October - 1,7; November - $0,7^0$C and in December there is again a temperature recession - $1,1^0$C. As we see it is not a standard course of temperature change according to the months. In whole mid-annual temperature according to

Table 1. The average monthly and annual temperature of air in the experimental areas, ^{0}C

Months	1	2	3	4	5	6	7	8	9	10	11	12	Average
Khachmas district													
1970-1979	0.5	1.7	4.9	11.3	17.3	21.2	24.5	23.5	17.5	13.0	8.1	4.8	12.3
1980-1989	2.7	1.8	4,7	11.0	16.3	21.7	24.8	23.5	19.6	13.1	8.1	3.8	12.6
1990-1999	2.5	2.6	5.4	10.9	16.4	22.0	24.8	24.2	19.6	14.1	8.3	4.3	12.9
2000-2008	2.9	3.3	6.3	10.0	16.8	21.9	24.6	25.4	20.7	14.7	8.8	3.7	13.3
Lenkoran district													
1970-1979	2.5	4.0	7.3	12.9	18.4	22.0	25.0	24.4	21.1	15.6	10.2	5.5	14.1
1980-1989	4.6	4.3	7.1	12.6	17.6	22.7	25.5	24.6	21.2	15.1	10.4	5.7	14.3
1990-1999	4.0	4.3	7.5	12.3	17.8	22.3	25.1	25.1	21.0	16.0	10.3	5.8	14.2
2000-2008	0.4	4.0	9.4	13.2	18.4	22.7	26.0	26.1	21.7	17.0	11.1	5.3	14.6
Astara district													
1970-1979	3.9	5.0	7.5	12.9	18.3	22.2	24.6	24.6	21.5	16.3	11.2	6.9	14.0
1980-1989	4.0	4.1	6.7	12.7	17.7	22.6	25.5	24.6	21.0	15.0	10.5	5.9	14.2
1990-1999	3.0	4.3	6.6	12.5	17.6	22.3	24.6	23.6	20.9	15.1	10.4	5.7	13.9
2000-2008	0.8	5.6	7.9	12.7	17.9	22.8	25.2	25.1	22.3	16.4	11.9	7.2	14.7

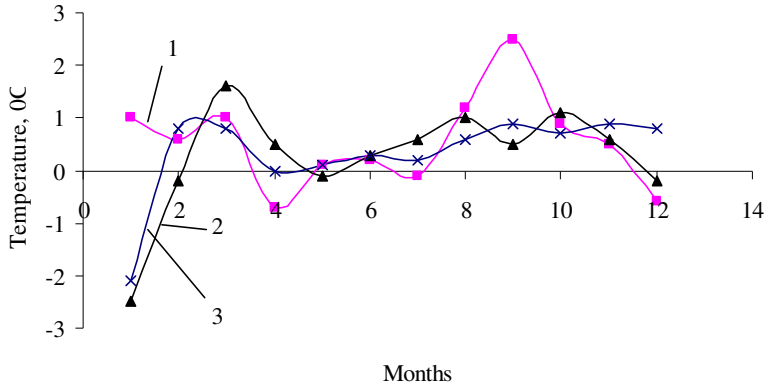

Figure 1. Average changes of month temperature for period from 1970 to 2008. 1 – Khachmaz district; 2 – Lenkoran district; 3 – Astara district

meteorological stations for the last 40 years has increased approximately on 1^{0}C. The similar analysis can be spent for Lenkoran and Astara areas. Mid-annual temperature made on decades (1970-79; 1980-89; 1990-99; 2000-08) since 1970 were consistently increasing by 2008, it reached a difference in 1^{0}C, in Khachmas, in Lenkoran this difference makes 0.5, in Astara - 0.7.

The annual dynamics of deviations of decadal monthly average values of temperatures from 1970 to 2008 concerning their average values (Table 2) are presented in Figure 1. Considering Figure 1 we see that the long-term temperature average in January in Khachmaz is increased for 1 ^{0}C, at the same time in Lenkoran and Astara this indicator has decreased for more than 2 0C. Similar comparisons can be spent for the other months. As for example, in March in all objects of research the temperature increase within 1 ^{0}C is observed, in April in Lenkoran the insignificant increase of temperature is marked, in Astara average statistical the temperature is approximately equal and in Khachmaz it is reduced approximately on 1 ^{0}C. The temperature from May till July slightly increases. Temperature substantial growth is observed from August till December

Table 2. Annual dynamics of monthly average temperatures on their long-term average values, ^{0}C

Month Districts	1	2	3	4	5	6	7	8	9	10	11	12
Khachmaz	1,9	2,7	5,3	10,7	16,7	21,7	24,7	24,1	19,3	13,8	8,3	4,1
Lenkoran	2,9	4,2	7,8	12,7	18,5	22,4	25,4	25,1	21,2	15,9	10,5	5,5
Astara	2,9	4,8	7,1	12,7	17,8	22,5	25	24,5	21,4	15,7	11	6,4

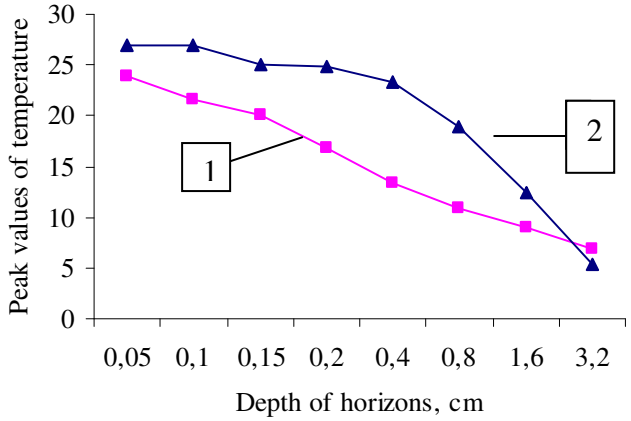

Figure 2. Temperature field of soils Hachmaza. 1 averages for 1885-1935; 2 averages for 1970-2000.

Considering data of Figure 1, it is possible to notice that basically temperature changes occur from January till March and from July till September. From May till June the changes are insignificant. It is possible to notice that in January-February temperature gradients for Lenkoran and Astara are negative, but at the same time in Khachmas during this period temperature change has a positive sign. Vibrating of temperature changes between positive and negative values occurs rather often. As a whole the temperature rising within last 40 years is observed the changes of the temperature field of soils in Hachmaz according data from 1885

to 1935 and from 1970 to 2000 are presented on fig. 2. Data of this drawing evidencely shows the differences in peak values in temperature field between horizons of soils at the expense of temperature change of the soil surface. However it is necessary to notice that the temperature field of the soil profile depends on humidity, density, granulometrical and mineralogical structures, organic substances, etc. as well.

Conclusion

In spite of the fact that research objects are within 500 km along Caspian Sea, they sharply differ in soil covering and according to the climatic indicators. Research objects cover dry, average and damp subtropical zones of Azerbaijan. In the separate years the soil-atmosphere systems are observed both increase and reduction of soil-atmosphere system temperature. However as a whole the increase of temperature of investigated soil-climatic zones is observed. It is especially characteristic for the period from 1990 to 2008. This gives grounds to consider that the global warming of the earth atmosphere is a complex process; it is difficult to predict with what regularity it occurs in the concrete region. In this case the value of Caspian Sea which is the thermal accumulator directly influencing on the temperature conditions of regions should be considered.

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