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Variation of Precipitation in the Mátra-Bükk Region in the Period of 1960-2012

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ABSTRACT

The paper analyses the precipitation data of the Mátra-Mátraalja and Bükk-Bükkalja regions during the years of 1960-2012 and presents the research results. For the period investigated, the monthly and annual precipitation data of a total of 38 precipitation measurement stations (settlements) have been analyzed. In addition, the statistical properties of the average and maximum values of variation have been separately assessed. The paper presents the number of days of precipitation within a year and the variation in maximum daily values. On the basis of the analysis of the density-distribution functions of the distribution of precipitation values, the paper provides probability/frequency properties.

Analyzing the changes over time of annual precipitation and of annual absolute precipitation, the result indicates that in the Mátra-Bükk region, annual average precipitation was constant at 600 mm/year over the half-century period. Absolute maximum annual precipitation, however, forming a constant value over the 50 years, indicates a falling rate, showing a tendency of reduction from 800 mm/year to 700 mm/year.

If you study the variation over time of precipitation values in relation to carbon dioxide concentration in the atmosphere, in line with the relevant literature, similarly to the time-relation/lack of relation, the results indicate that alongside the increase of atmospheric CO_2 concentration from 310 ppm to 390 ppm, annual precipitation remained constant (600 mm/year) and the absolute minimum annual values show a tendency of reduction.

Keywords: *Mátra-Bükk region, precipitation, average, maximum*

1. INTRODUCTION

Disregarding slight variations, the amount of water in the atmosphere is constant over time, as the amounts of precipitation and of evaporation counterbalance each other and therefore are equal over a longer period. The water circulation of the earth's surface and the atmosphere is characterized by water balance in a given region. Such surface water movements as runoff, seepage, evaporation and water abstraction (drinking water, industrial water, agricultural use) play a fundamental role in surface and near surface water circulation, while in the deeper geological regions, it is water protection/water lifting in mining and water mining (drinking water and thermal waters) that are important influencing factors.

Besides other sources, both the detailed and simplified descriptions of the water balance equation are provided in Professor József Juhász's book entitled Hidrogeológia ('Hydrogeology'). [1] In the simplified equation, the factor with decisive influence on the 'credit' side is precipitation while 'debit' members are evaporation, infiltration into the ground and surface runoff. In a given region, precipitation can be 'measured' relatively precisely, runoff can also be measured or approximately calculated on the basis of the surface soil-rock-vegetation coverage, and evaporation is basically related to temperature and can be measured or calculated by experiments. Infiltration can be estimated as a remainder member if we know the previous properties but calculating flow and recharge under the surface is very difficult even if the topographical and geological circumstances are known.

This study presents the results of examining the properties and variation over time of precipitation values that define the 'positive' side of the water balance equation in the Mátra-Bükk region in Northern Hungary.

2. SUBJECT OF INVESTIGATION AND ANALYSIS

During the research, the specific precipitation features of the Mátra-Mátraalja region and those of the Bükk-Bükkalja region have been investigated separately. We have regarded the River Zagyva as the western border of the Mátra region and the Stream Laskó as the eastern border, which practically meant the area west of the Eger-Füzesabony line (running in a north-south direction). The Bükk area is situated east of this line as far as the Stream Hejő, including mainly the catchment area of the River Eger, and the precipitation data of the catchment areas between the Streams Kácsi and Csincse, and Laskó and Hór have also been analyzed.

To determine the general precipitation features, we have used the data of the measurement stations situated west of the Eger-Füzesabony line: namely the data of Bátor, Bodony, Domaháza, Ecséd, Kápolna, Erdőkövesd, Erdőtelek, Gyöngyöspata, Gyöngyössolymos, Heves, Kápolna, Kékestető (Gyöngyös), Kerecsend, Kompolt, Ludas, Parád (Parádóhuta), Parádsasvár, Pétervására, Sirok (Recsk), Tarnalelesz, Vécs Verpelét and Zabor measurement stations. To characterize the variation of precipitation in the other area, i.e. the eastern (Bükk) area, the data of

Bélapátfalva, Bogács, Borsodnádasd, Bükkábrány, Bükkzsérc-Hosszúvölgy, Cserépfalu, Eger-

Almár, Egerfarmos, Felsőtárkány-Kusnádas, Füzesabony, Mezőcsát, Mezőkeresztes, Mezőkövesd, Répáshuta and Szilvásvárad-Szalajkavölgy have been used.

From among the data of the Hydrological Annals [2] and research reports [3] for 1973-2006 (34 years), the precipitation data of the above 38 precipitation measurement stations have been processed. The material presented in tables includes the following: place and registration number of measurement stations, values of monthly precipitation (mm/month) and total annual precipitation values (mm/year), number of rainy days per year, daily maximum precipitation in the given year (mm/day) and its date (calendar day). We have calculated the 34 year average monthly precipitation values and have given the maximum precipitation values (mm/month) for each calendar month (January, February, etc.). In the 36 lines of the tables, there are 16 columns of data, totalling 576 data, which means 21,888 pieces of information for the 38 measurement stations.

3. DEFINITION OF PRECIPITATION PROPERTIES

For clarity and to show the general tendencies, we have provided the data of the tables by measurement station and in monthly distribution, and we have defined the expected values and their probability properties on the basis of the frequency and distribution functions of the data. [4] The graphical imaging of the Mátra and Bükk data sets and the statistical properties (average, frequency distribution, function) have yielded similar results, so we have defined 'common' properties for the Mátra-Bükk region on the basis of the combined data.

Table 1 presents the monthly precipitation average values and total annual specific precipitation calculated on the basis of the **data of 34 years**.

Table 1: Monthly average precipitation values in the Mátra-Bükk region during the years 1973-2006

	Mátra	Bükk	Mátra+Bükk
January	31	32	31.5
February	31	32	31.5
March	33	35	34
April	46	50	48
May	67	69	68
June	72	85	78.5
July	67	72	69.5
August	62	65	63.5
September	42	49	47
October	45	49	47
November	46	46	46
December	40	41	40.5
total annual average [mm/year]	**582**	**624**	**603**

In the Mátra-Mátraalja region, the total (average) value of precipitation in four months from May to August is 268 mm, which is 46% of the annual total while in Bükk-Bükkalja, it is 291 mm, which is 47% of the annual total, and on the basis of the combined (Mátra, Bükk) data, it is 279.5 mm, which makes 46.4% of the annual average precipitation.

The monthly absolute maximum values show similar results in the two areas. Table 2 presents the average values of monthly absolute maximum precipitation (mm/month) in the region.

Table 2: Monthly absolute maximum precipitation values in the Mátra-Bükk region

January	100	February	82	March	87
April	105	May	164	June	187
July	210	August	180	September	128
October	206	November	120	December	121

The monthly maximum precipitation values have been assessed on the basis of the combined data for the Mátra-Bükk region using statistical methods and defining the frequency and distribution functions. On the basis of the combined data, the expected/average value of maximum monthly precipitation (for the 50 % probability level) is 115 mm/month, the probability of a value greater than 100 mm/month is 67.5 %, and the probability of precipitation greater than 300 mm/month is 0.6-0.7% (the same being 1.1 % in the Mátra).

In the two areas, the distribution of the daily precipitation values according to magnitude shows a similar tendency/character. The frequency of the daily maximum precipitation in June, July and August is nearly the same, i.e. it is around 17-20% (from the annual 100%), and in the four months from May to August, during one third of the year, it is 66.5% in the Mátra and 70.6% in the Bükk, and it is 68.3% jointly in the Mátra-Bükk, which is exactly two thirds of total annual frequency.

Analyzing the number of rainy days in a year, we have found 80 rainy days in the Mátra, and in three years, there was rain on more than 110 days. Similarly, there were 80 rainy days in the Bükk on average, and during the 34 years there was no rain for longer than a period of 100 days.

The frequency and distribution function of daily maximum precipitation in the Mátra and the Bükk were practically identical (as regards values). On the basis of the statistical analysis of the combined data, the expected value of maximum daily precipitation is 30 mm/day (50% frequency), there is a 13 % probability of 50 mm/day precipitation (0.13 frequency), and there is a 1.1 % probability of daily precipitation in excess of 100 mms, which value is 1.7 % in the Mátra and 0.2 % in the Bükk.

The examination of the precipitation properties of 34 years is of special significance because the annual specific precipitation values primarily define the positive side of the water balance, which means the water

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recharge, the amount of evaporation and infiltration for a bigger area. From the point of view of agriculture, the monthly distribution/tendency of annual precipitation is also an important factor.

On the basis of the statistical analysis, that is, the frequency and distribution functions, in the Mátra-Mátraalja region, the probability of 'drought' years with precipitation below 400 mm/year is 20 %, the probability of 600 mm/year is 55-60 %, and there is only a 5 % probability of precipitation over 800 mm/year, and among the 756 annual measurements (23 stations 34 years) there were 9 cases of a value over 1,000 mm/year, which amounts to a rate of 1.2 %.

According to the data of Bükk-Bükkalja, the probability of precipitation below 400 mm/year is also 20 % while the probability of precipitation over 600 mm/year is exactly 30 % (in the Mátra, this rate is exactly 40 %). In Bükk-Bükkalja, no precipitation value over 1,000 mm was recorded during the period investigated.

4. VARIATION IN ANNUAL SPECIFIC PRECIPITATION IN THE YEARS 1960-2012

The examination of variations in annual precipitation (by years) is especially topical today owing to a hotly debated and widely discussed phenomenon. Values of global warming are prognosticated with reference to certain, hardly verifiable data and climate models – highlighting as a cause the atmospheric CO_2 concentration resulting from anthropogenic effects – and in consequence mainly negative changes are forecast for the future of the human kind: the rise of sea level due to the melting of the icebergs, the expansion of the deserts, and with regard to this research, the decrease in the amount of precipitation, and the rise of frequency of exceedingly high amounts of precipitation and floods.

In this latter question, the examination of the annual specific precipitation data of Mátra-Bükk has been extended to half a century (53 years), to the examination of the data of the years between 1960-2012. The data set examined in the previous section has been extended from 1960 to 2012, with the calculation of annual total values partly from the Hydrological Annals [2], and partly from the precipitation data measured by the National Meteorological Service (OMSz) during 2007-2012.

The data of the Mátra area came from the land registers of the following measurement stations: Bodony, Ecséd, Gyöngyöspata, Gyöngyössolymos, Parád(Óhuta), Parádsasvár, Pétervására and Verpelét; while the data for the Bükk area came from the land registers of the following measurement stations: Bélapátfalva, Bogács, Bükkábrány, Bükkzsérc, Cserépfalu and Eger-Almár. For areas, annual average specific precipitation and annual maximum specific precipitation values have been calculated both separately and on the basis of combined data. [4]

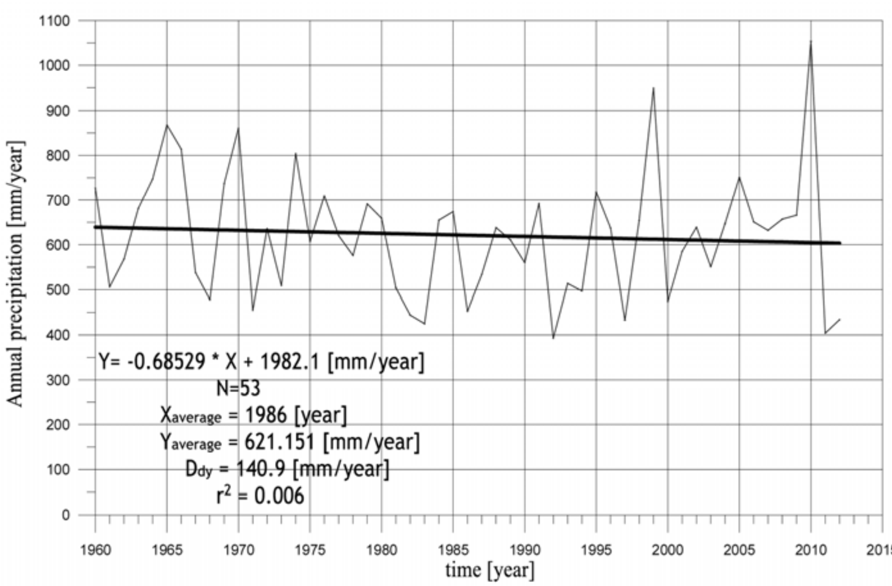

Fig 1: Variation in annual average precipitation in the Mátra region

Vol. 4, No. 8 August 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

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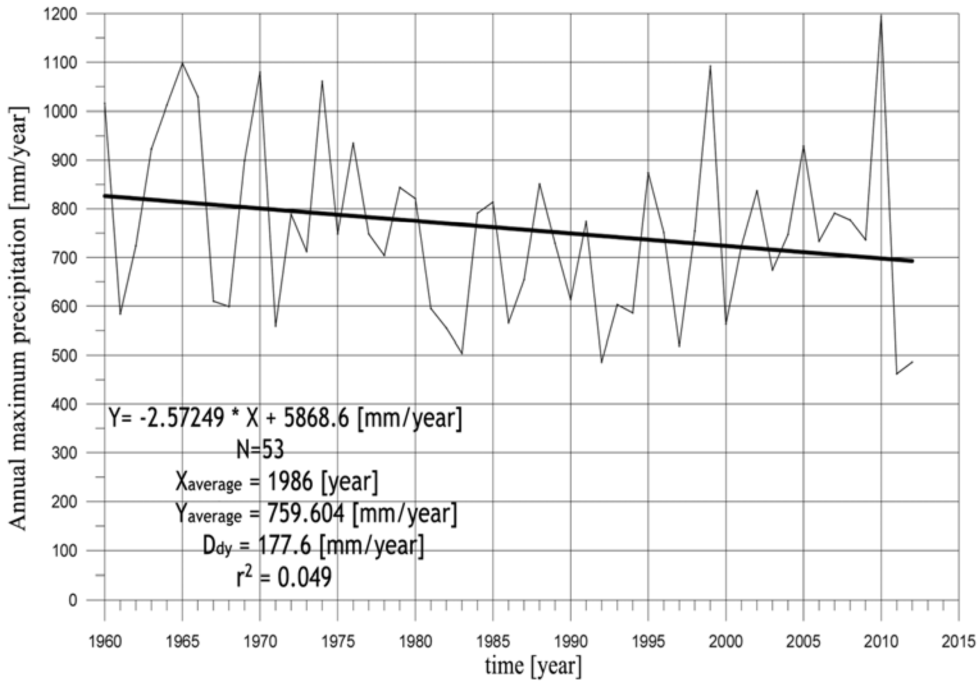

Fig 2: Variation in annual absolute maximum precipitation in the Mátra region

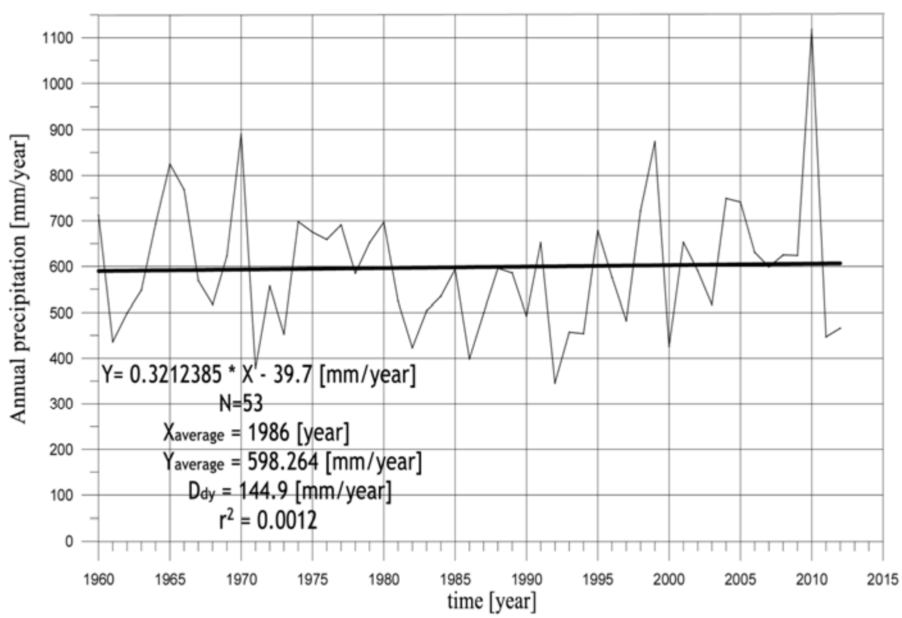

Fig 3: Variation in annual average precipitation in the Bükk region

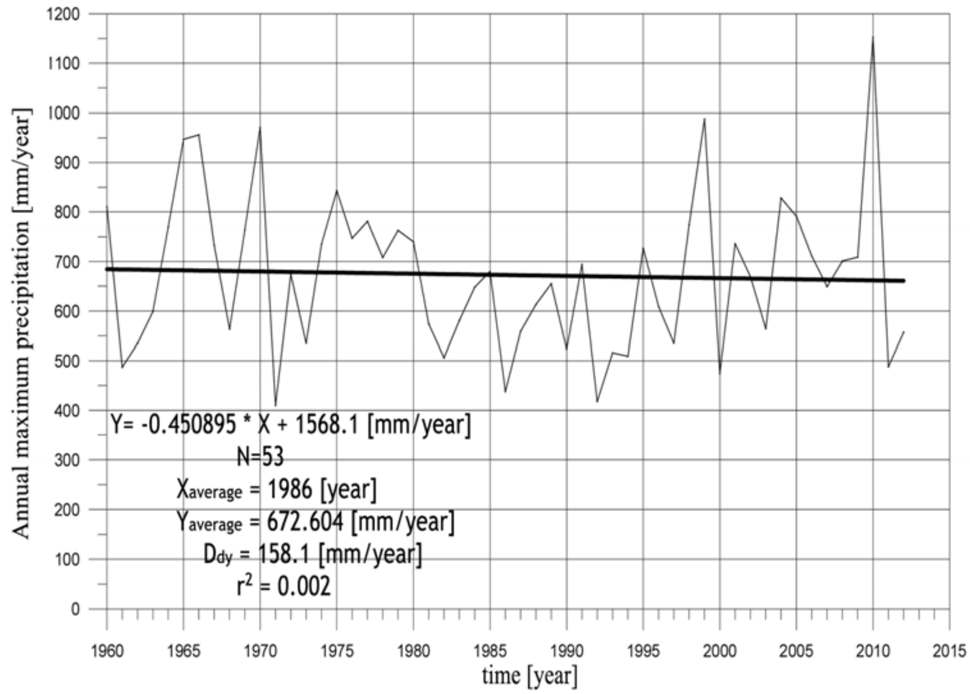

Fig 4: Variation in annual absolute maximum precipitation in the Bükk region

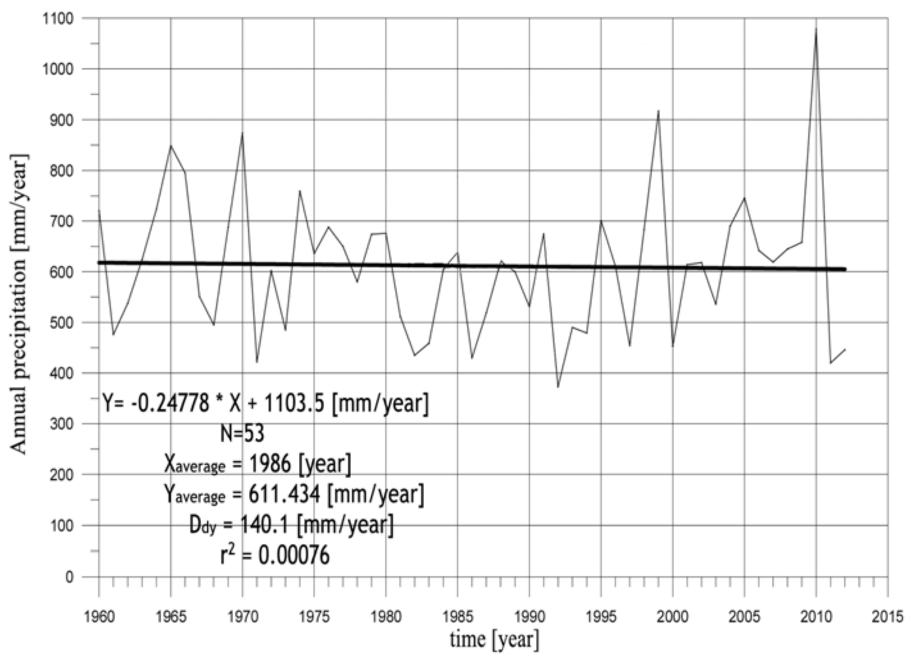

Fig 5: Variation in annual average precipitation in the Mátra-Bükk region

Vol. 4, No. 8 August 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

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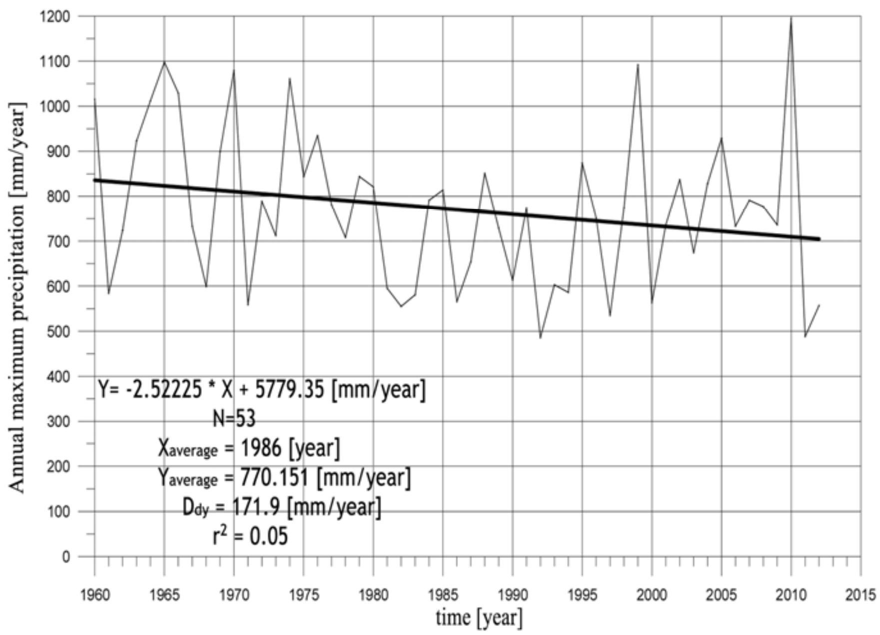

Fig 6: Variation in annual absolute maximum precipitation in the Mátra-Bükk region

The conventional regression method has been used for calculating the variation over time of specific precipitation, the 'time-function' of average annual precipitation and annual absolute maximum precipitation, and the 'goodness-closeness of the time-precipitation relation. (The defined properties are presented in the figures.)

Figure 1 shows/verifies the 'constancy' and independence of time of the annual precipitation average over 53 years in the Mátra area. (r^2 = 0,006) The regression function for the Mátra-Mátraalja area in Figure 2 shows the decreasing tendency of the annual absolute maximum values – with 825 mm/year for the year 1960 and 695 mm/year in 2012.

Figure 3 presents the annual precipitation total/average values for the Bükk-Bükkalja region, and Figure 4 seems to indicate/verify the constancy – over 53 years – of annual absolute maximum values (r^2 = 0,0012, r^2 = 0,002).

The regression function in Figure 5 – based on the combined data of Mátra-Mátraalja + Bükk-Bükkalja – indicates/verifies the constancy of the average value of annual precipitation, and in a statistical sense, its independence of time (r^2 = 0,00076). Figure 6 shows the decreasing tendency of the annual absolute maximum precipitation values over 53 years, which refutes the frequently voiced common opinion that the extreme weather phenomena – in this case, precipitation – have become more frequent recently.

5. VARIATION IN PRECIPITATION CONDITIONS/SPECIFIC IN THE PAST 50 YEARS AND ATMOSPHERIC CARBON DIOXID CONCENTRATION

Certain professional opinions and laymen's views mentioned above indicate the increase in atmospheric CO_2 concentration as a cause of extreme meteorological phenomena (within the phenomenon of the so-called global warming). (The next is the main cause, the use of fossil fuels, primarily that of coal.)

This is why during this research we have 'transformed' the data set of 53 years – by transforming the time (years) coordinate to atmospheric carbon dioxide concentration – and examined the annual average and absolute maximum precipitation values as the function of atmospheric CO_2 concentration (ppm). We have adopted the variation in atmospheric CO_2 concentration in the 20th century from the so-called Keeling-curve in the paper of Mackenzie, F.T., Mackenzie, J.A. (1995) Our Changing Planet – An Introduction to Earth System Science and Global Environmental Change [5]. This is practically a linear curve. We 'have taken' the CO_2 concentration (ppm) value from this curve for each year of the period investigated.

Figures 7, 8, 9, 10, 11 and 12 show the regression functions for the defined x-y, CO_2 concentration-precipitation (average, absolute maximum). The figures show a plainly visible result. Irrespective of the changes in atmospheric CO_2 concentration, the annual average specific precipitation over the 53 years is

Vol. 4, No. 8 August 2014 ISSN 2225-7217
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http://www.ejournalofscience.org

constant, with a value of 600 mm/year (Figures 7-8-9).

According to Figures 10 and 12 (Mátra, and Mátra+Bükk), the annual absolute maximum precipitation values show a decrease, which seems to be a tendency. With/despite the increase of atmospheric CO_2 concentration from 315 ppm to 390 ppm, the 'expected /average' annual absolute maximum has decreased from 800 mm/year to 700 mm/year.

According to the data in Figure 12 (combined Mátra+Bükk data), in the territory of the region, the annual absolute maximum precipitation values show a decreasing tendency over the half century (1960-2012) 'despite' the 23% increase in atmospheric CO_2 concentration.

Let us verify the 'independence' of CO_2 concentration-precipitation (x-y) variations – namely the fact that (on the basis of the presented research results) the amount and changeability of precipitation is not related to atmospheric carbon dioxide concentration – using independent/objective mathematical statistical properties:

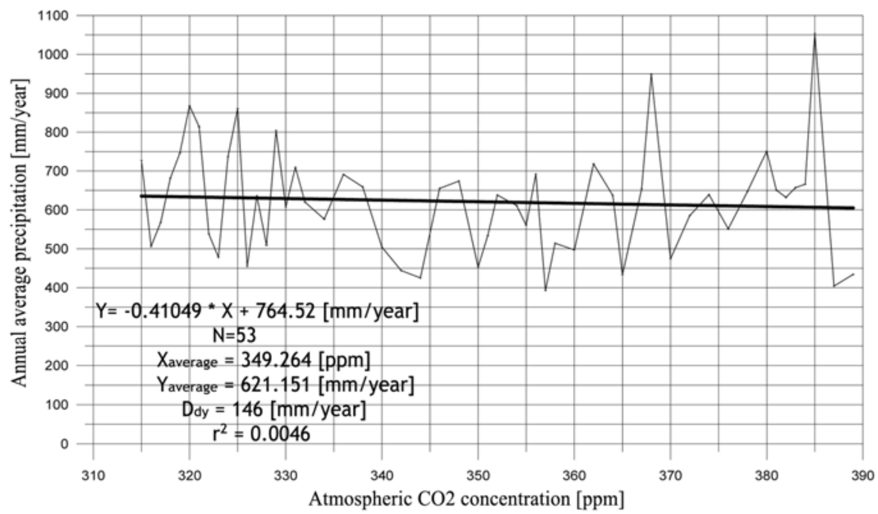

Fig 7: Variation in annual average precipitation in the Mátra region

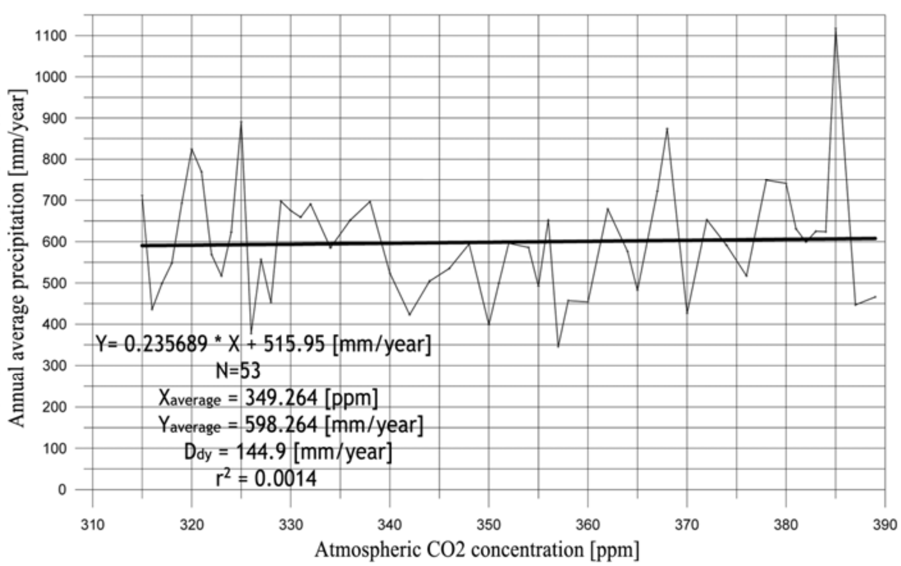

Fig 8: Variation in annual average precipitation in the Bükk region

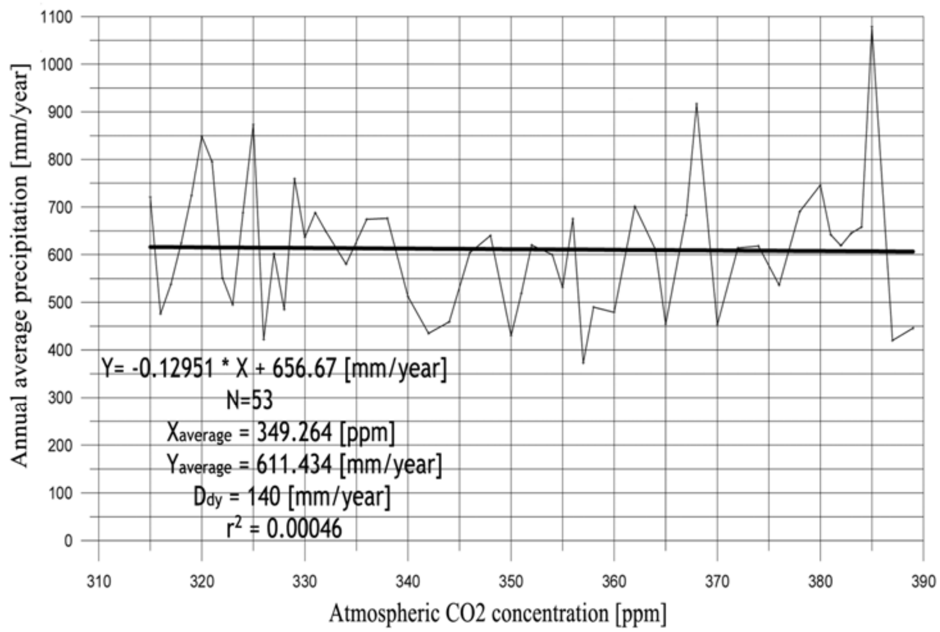

Fig 9: Variation in annual average precipitation in the Mátra-Bükk region

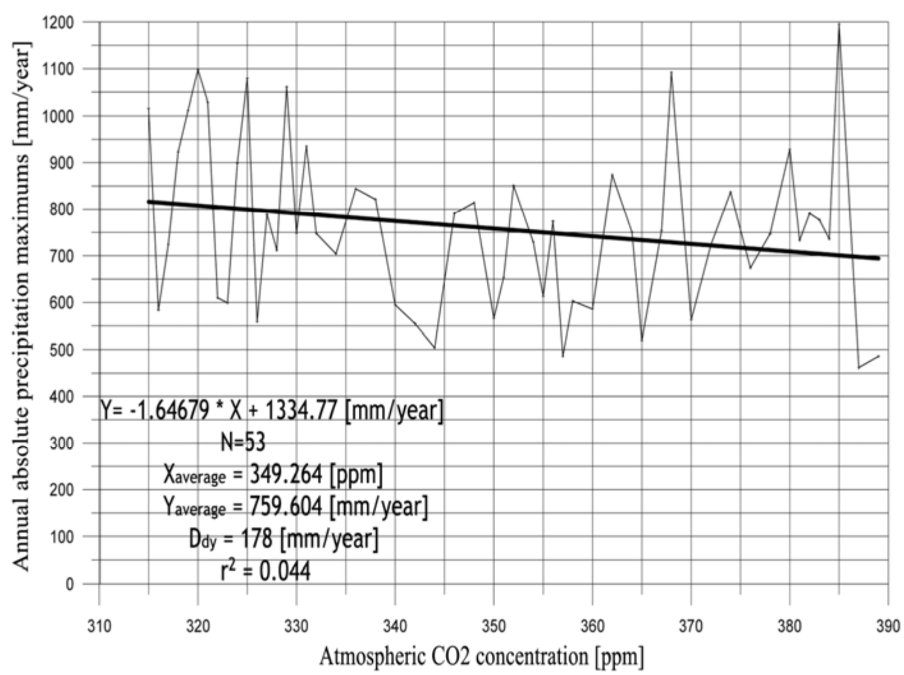

Fig 10: Variation in annual maximum precipitation in the Mátra region

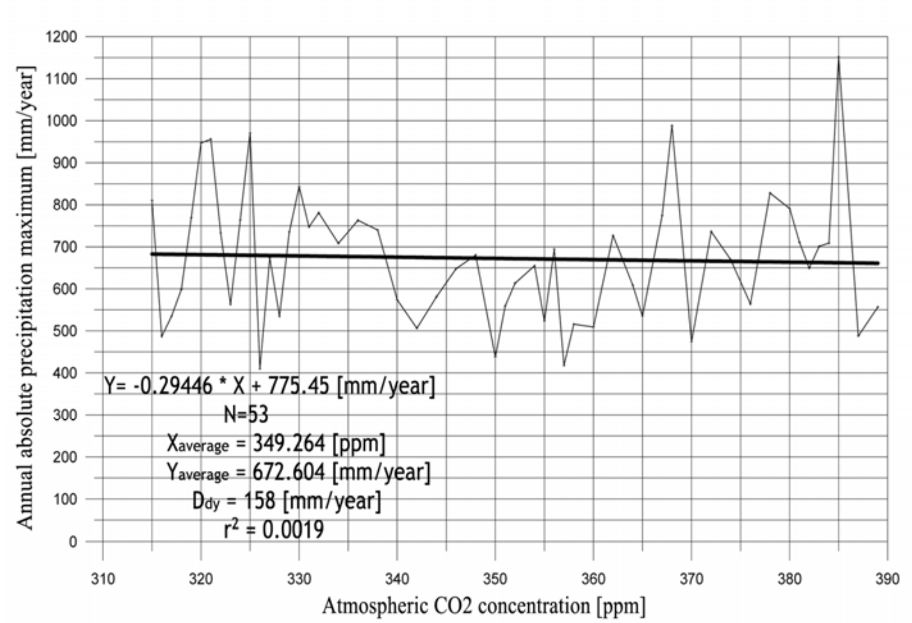

Fig 11: Variation in annual absolute maximum precipitation in the Bükk region

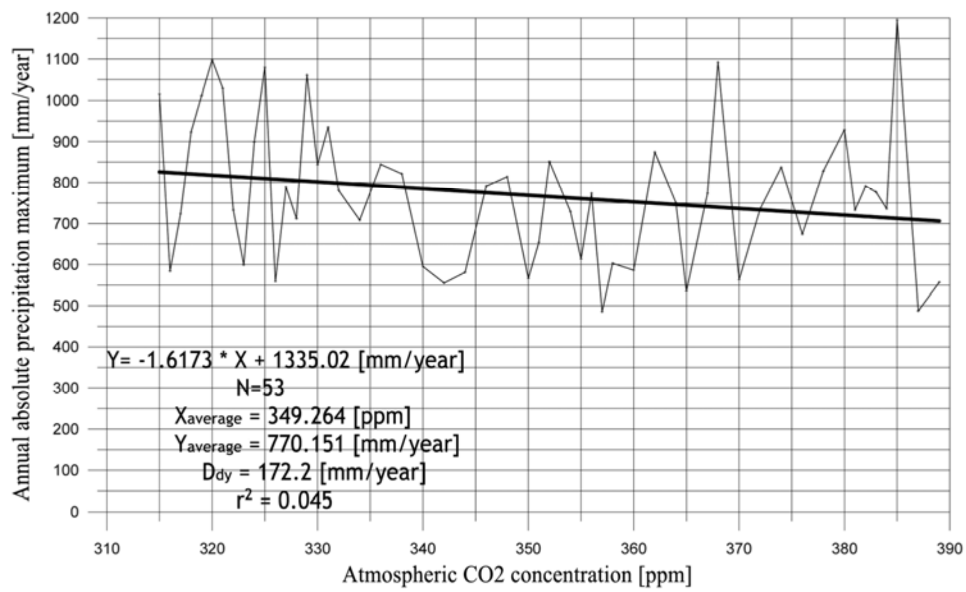

Fig 12: Variation in annual absolute maximum precipitation in the Mátra-Bükk region

- The corrected empirical deviation of the regression calculations (the data) for the $Dy/Y_{average}$ row: Mátra: 0.235 and 0.234; Bükk: 0.242 and 0.235; Mátra+Bükk: 0.229 and 0.224.
- The correlation coefficient (r^2) characterizing the 'closeness' of the functional relation between the variables ('causal' relation) for Mátra: 0.005 and 0.044; Bükk: 0.001 and 0.002; Mátra+Bükk: 0.001 and 0.045.

On the basis of the data presented in the figures and clearly perceivable even to the untrained eye, we seek to answer the following 'rhetorical questions':

- What verifies that the increase in atmospheric CO_2 concentration entails/increases desertification (the permanent decrease of theoretical precipitation), if for instance, according to Figure 9, in the regions studied here (Mátra-Mátraalja, Bükk-Bükkalja), with/despite the increase in atmospheric CO_2 concentration between 1960-2012 from 315 ppm to 390 ppm, annual precipitation remained constant at a value of 600 mm/year as a tendency?
- According to the data in Figures 10 and 12, with/despite the increase in atmospheric CO_2 concentration during 50 years being exactly

25%, the absolute maximum annual precipitation value (one characteristic of extreme weather) showed a decreasing tendency. (According to Figures 6 and 12, in 1960, with 320 ppm concentration, there was the same 1,100 mm/year maximum precipitation as in 1999 and 2010 'with' 370 and 390 ppm concentration respectively).

- How does it work that with the increase of atmospheric CO_2 concentration, desertification, which is the result of decreasing precipitation, increases, if the absolute maximum 736 mm/year precipitation for 2009 for 384 ppm changed, as a result of a 5 ppm increase, to 1,195 mm in 2010, or the 1,195 mm absolute maximum precipitation decreased to 488 mm in 2011 as a result of a 2 ppm increase in concentration?

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