The statistical structure of visibility in Tbilisi

Teimuraz Bliadze[1], Alexandre Chankvetadze[1], Rusudan Danelia[2]

[1]Mikheil Nodia Institute of Geophysics of Ivane Javakhishvili Tbilisi State University
[2]Ivane Javakhishvili Tbilisi State University
danelia_ru@yahoo.com

1. INTRODUCTION

Visibility presents one of the important meteorological parameters. Visibility depends on many factors, including the aerosol pollution of the atmosphere [Svanidze, Papinashvili, 1992]. In the work [Amiranashvili et al., 2010] some preliminary results of the complex monitoring of the intensity of solar radiation, total cloudiness, visibility and air temperature in Tbilisi in the period from June 2009 through May 2010 are represented. In this work the statistical structure of the visibility in Tbilisi in the period from 1980 through 2008 is studied.

2. METHOD AND DATA DESCRIPTION

The data of the Hydrometeorological department of Georgia about the number of days per annum with the visibility of different intensity for 9,12 and 15 hours of observations are used. The analysis of data is carried out with the use of the standard statistical analysis methods of random events and methods of mathematical statistics for the non accidental time-series of observations [Kendall, 1981; Kobisheva, Narovlianski, 1978].

The following designations will be used below: V(9) - the number of days per annum with the visibility of 9 point in scale, V(6+5) - the number of days per annum with visibility 6 and 5 point in scale , etc., Min – minimal values, Max - maximal values, Range - variational scope, Range/ Mean (%) - relative variational scope, σ - standard deviation, σ_m - standard error (68% - confidence interval of mean values), C_v - coefficient of variation (%), A - coefficient of skewness, K - coefficient of kurtosis, R - coefficient of linear correlation, R^2 – coefficient of determination, R_s – Spearman's rank correlation coefficient, R_k – Kendall's rank correlation coefficient, R_a - autocorrelation coefficient with a Lag = 1 year, K_{DW} – Durbin-Watson statistic, α - the level of significance. The gradations of the meteorological visibility on the point in scale in table 1 are presented [Sternzat, 1978].

Table 1. Gradations of the meteorological visibility on the point in scale.

Point in scale	Distance to object (km)		Point in scale	Distance to object (km)	
	Obj. is visible	Obj. is not visible		Obj. is visible	Obj. is not visible
0		Less 0.05	5	2	4
1	0.05	0.2	6	4	10
2	0.2	0.5	7	10	20
3	0.5	1	8	20	50
4	1	2	9	More 50	

3. RESULTS

The results in table 2 and fig. 1-4 are given.

Table 2. The statistical characteristics of the number of days per annum with the visibility of different intensity in Tbilisi in 1980-2008 for 9, 12 and 15 hours

Parameter	Visibility, point in scale							
	V(9)	V(8)	V(7)	V(6)	V(5)	V(4)	V(6+5)	V(5+4)
	Real data							
Mean	694	176	136	55	29	4	85	33
Min	494	49	60	27	0	0	34	0
Max	914	264	280	101	116	16	194	124
Range	420	215	220	74	116	16	160	124
Median	680	183	132	58	15	2	69	22
Mode	636	179	-	34	4	0	65	10
σ	117	57	56	19	31	4	41	33
σ_m	21.7	10.6	10.4	3.5	5.7	0.8	7.6	6.1
C_v (%)	16.8	32.2	41.0	34.6	104.2	125.3	48.5	98.9
A	0.16	-0.55	1.02	0.49	1.17	1.52	1.14	1.11
K	-0.70	-0.45	1.17	-0.25	0.78	1.75	1.15	0.59
σ_m /Mean (%)	3.1	6.0	7.6	6.4	19.3	23.3	9.0	18.4
Range/ Mean (%)	60.5	122	162	134	393	452	189	375
	The non-randomness characteristic of time series							
R with year	0.4	0.03	-0.38	-0.09	-0.79	-0.45	-0.63	-0.8
(α) R	0.1	-	0.1	-	0.005	0.05	0.01	0.005
R_k	0.27	0.005	-0.29	0.005	-0.61	-0.22	-0.41	-0.63
(α) R_k	0.043	0.97	0.027	0.97	0	0.095	0.0017	0
R_s	0.43	0.035	-0.49	-0.02	-0.81	-0.33	-0.59	-0.82
(α) R_s	0.025	0.85	0.01	0.9	0	0.08	0.0017	0
R_a , Lag = 1	0.46	0.39	0.46	0.09	0.64	0.5	0.47	0.63
(α) R_a	0.05	0.05	0.05	-	0.05	0.05	0.05	0.05
Visibility	Trend							
V(9)	$Y= 0.01033 \cdot X^4 -0.6294 \cdot X^3 + 12.33 \cdot X^2 -77.7 \cdot X + 489.2$ $R^2=0.26$; $K_{DW}=1.37$							
V(8)	Random process							
V(7)	$Y= -0.0000394 \cdot X^6 + 0.003901 \cdot X^5 -0.149897 \cdot X^4 + 2.7998 \cdot X^3 -25.9965 \cdot X^2$							
V(6)	Random process with autocorrelation							
V(5)	$89.578 \cdot 0.9156^X$ $R^2=0.609$; $K_{DW}=1.77$							
V(4)	$17.53 \cdot X^{-0.7596}$ $R^2=0.584$; $K_{DW}=1.67$							
V(6+5)	$Y= 0.23256 \cdot X^2 - 10.0285 \cdot X + 120.4$ $R^2=0.53$; $K_{DW}=2.12$							
V(5+4)	$102.28 \cdot 0.912^X$ $R^2=0.67$; $K_{DW}=2.09$							
Visibility	Correlation Matrix (Left – Real data. Right – Random components)							
V(9)	1	-0.80	-0.87	-0.37	-0.52	-0.09	-0.56	-0.50
V(8)	-0.82	1	0.60	0.14	0.06	-0.17	0.11	0.03
V(7)	-0.91	0.68	1	0.09	0.34	-0.03	0.29	0.31
V(6)	-0.28	0.14	0.18	1	0.32	0.29	0.70	0.34
V(5)	-0.18	0.10	0.06	0.26	1	0.37	0.90	0.99
V(4)	0.12	-0.27	-0.19	0.09	0.04	1	0.42	0.49
V(6+5)	-0.31	0.15	0.16	0.69	0.81	0.03	1	0.90
V(5+4)	-0.17	0.06	0.03	0.29	0.99	0.20	0.81	1

Fig. 1 Trend of of the number of days per annum with the visibility of 9 point in scale for 9, 12 and 15 hour in 1980-2008

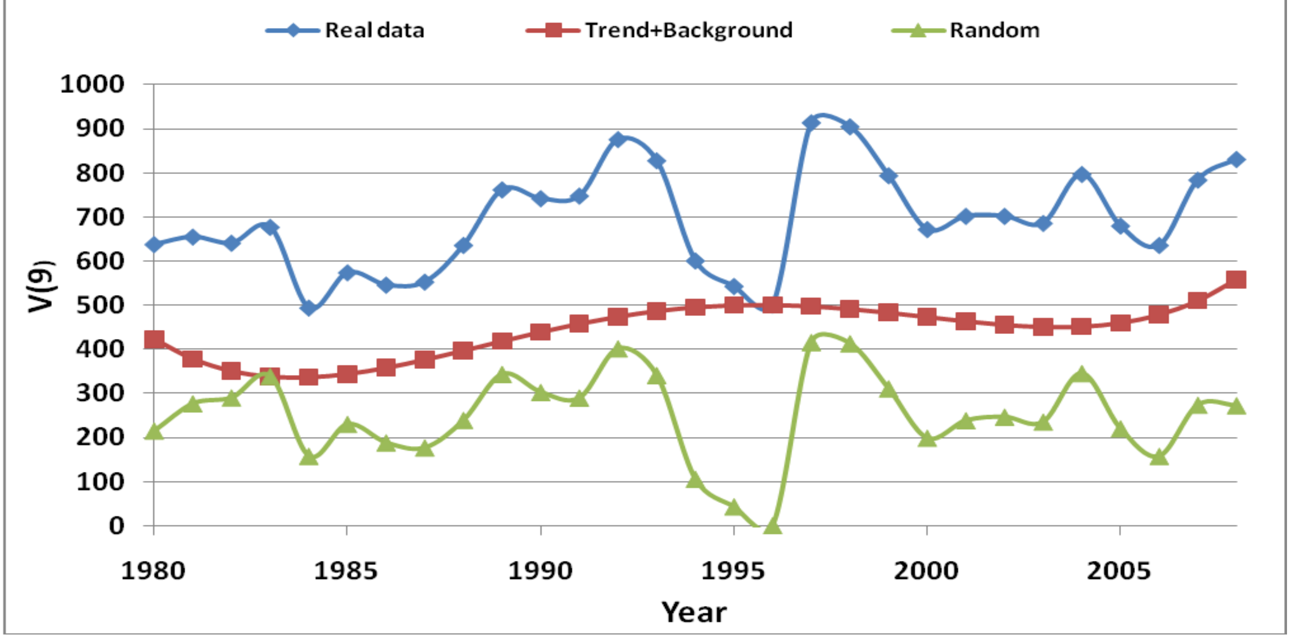
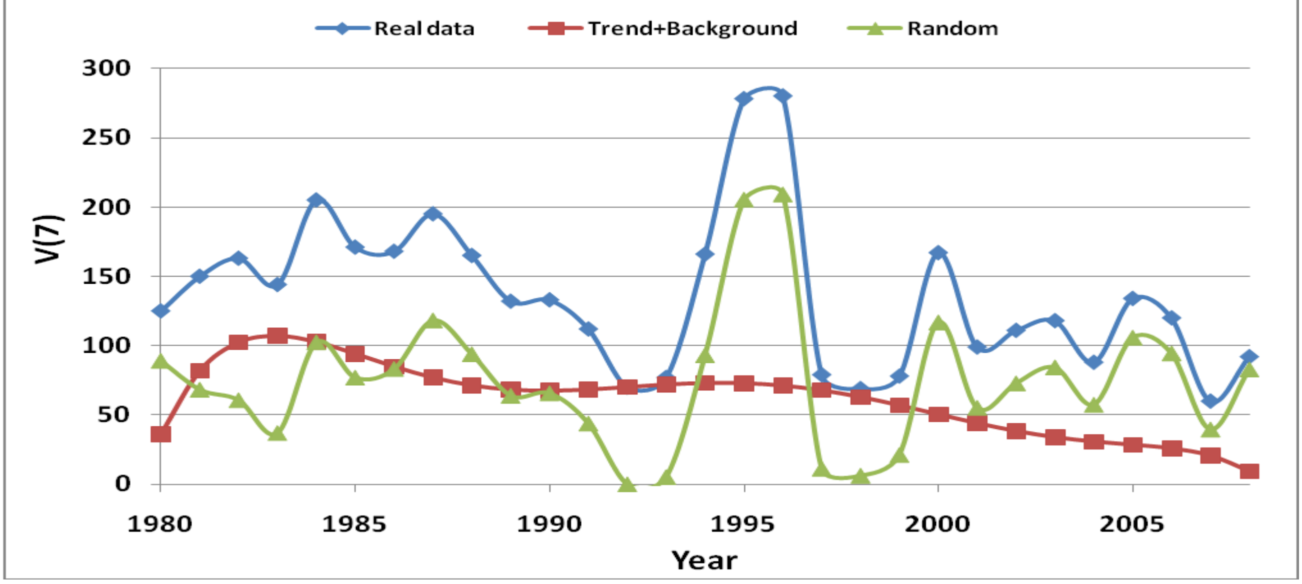
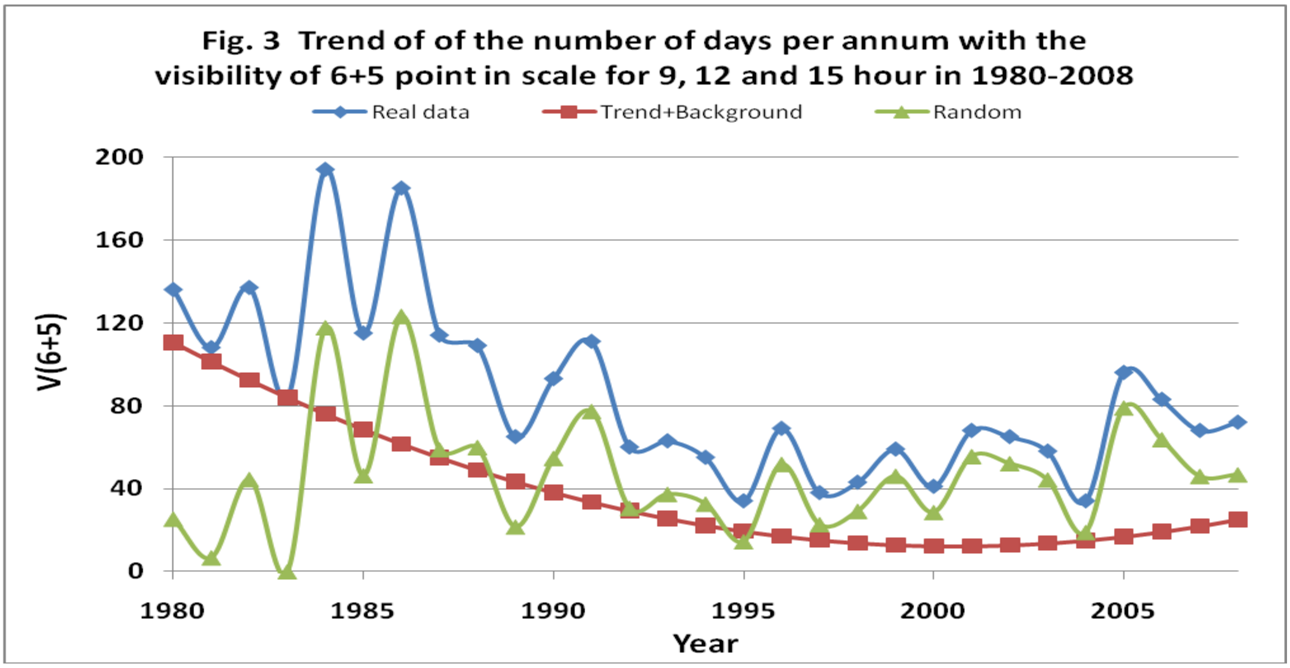


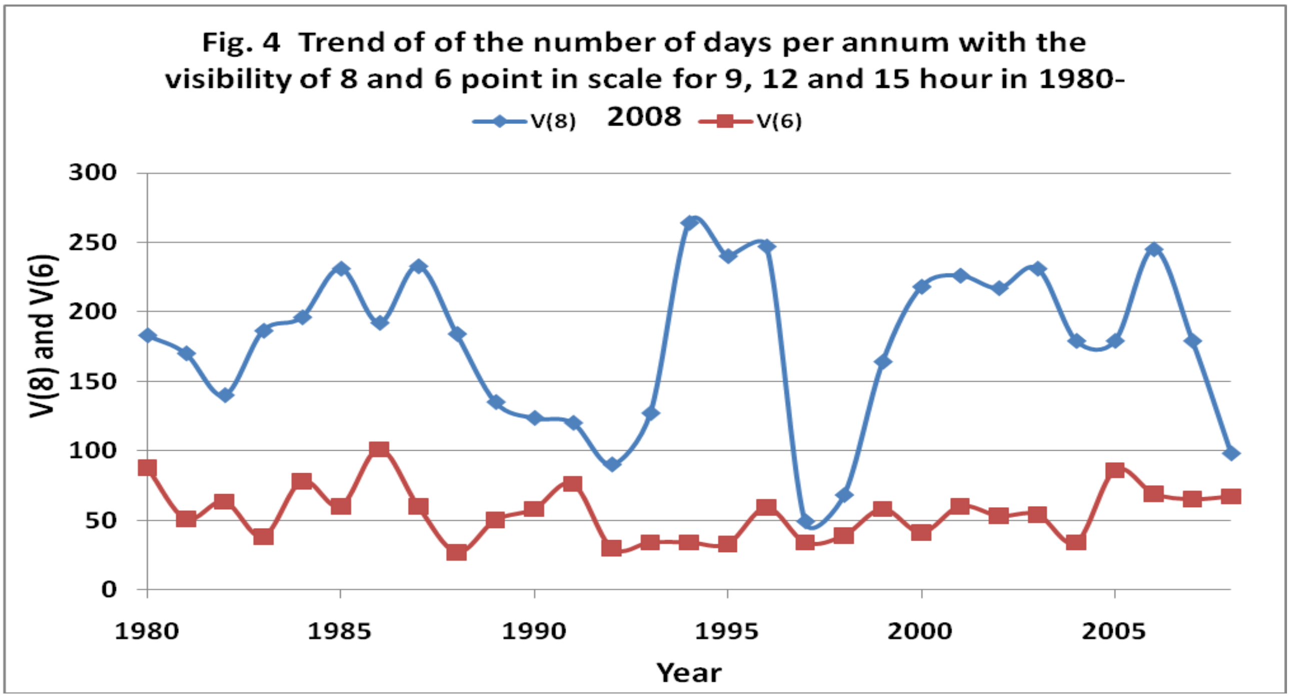
Fig. 2 Trend of of the number of days per annum with the visibility of 7 point in scale for 9, 12 and 15 hour in 1980-2008



As follows from table 2, the mean value of number of days per annum with the visibility of different intensity change from 694 for V(9) to 4 for V(4), the minimal value - from 494 for V(9) to 0 per V(5) and V(4), maximal value - from 914 for V(9) to 16 for V(4), variational scope from 420 per V(9) to 16 for V(4), standard deviation varies from 117 per V(9) to 4 for V(4), standard error - from 21.7 per V(9) to 0.8 for V(4), coefficient of variation from 16.8% for V(9) to 125.3 % for V(4).

Coefficient of skewness varies from -0.55 for V(8) to 1.52 for V(4), coefficient of kurtosis - from -0.70 for V(9) to for 1.75 V(4). The absolute values of the calculated coefficients of skewness (excluding V(4)) and kurtosis are less than the trebled theoretical value of their standard deviations. Accordingly in general set of function of distribution of monthly average values of SOC for all indicated parameters (excluding V(4)) should be close to normal. The relative variational scope change from 60.5% for V(9) up to 452% per V(4) season. Coefficient of linear correlation between real data of indicated parameters change from -0.87 (pair V(9)-V(7)) to 0.99 (pair V(5)-V(5+4)).





The values of stability parameters of number of days per annum with the visibility of different intensity in the low part of table 2 are submitted. Coefficient of linear correlation between the specified values and years varies from -0.8 for V(5+4) to 0.4 per V(9), the values of Kendall's rank correlation coefficient varies from from -0.63 for V(5+4) to 0.27 for V(9), the values of Spearmen's rank correlation coefficient varies from for -0.82 V(5+4) till 0.43 for V(9), the values of autocorrelation coefficient with a Lag = 1 year varies from 0.63 per V(5+4) to 0.09 for V(6). The values of level of significance α for the above mentioned parameters of stability also are given in this table.

As shows the analysis of table2 the time series of number of days per annum with the visibility of different intensity excluding V(6) are autocorrelate. Excluding time series of V(6) and V(8) all trend of indicated parameters has a nonlinear nature. Examples of change of V(9), V(7), V(6+5),V(8) and V(6) in 1980-2008 in fig. 1-4 are given. Let us note that in the period from 2004 to 2008 in comparison with period from 1980-1984 following changes in the visibility are observed: V(9) – 20% increase, V(7) – 37% decrease, V(5) – 90% decrease, V(4) – 68% decrease, V(6+5) – 46% decrease, V(5+4) – 88% decrease.

Coefficient of linear correlation between random components of indicated time series change from -0.91 (pair V(9)-V(7)) to 0.99 (pair V(5)-V(5+4)).

4. CONCLUSIONS

The statistical structure of the number of days per annum with the visibility of different intensity visibility in Tbilisi in the period from 1980 through 2008 is studied. The trends and random components for these time series are determined. Excluding time series of visibility on the point in scale of 6 and 8 all trends of indicated parameters has a nonlinear nature.

In the period from 2004 to 2008 in comparison with period from 1980-1984 following changes in the visibility are observed: V(9) – 20% increase, V(7) – 37% decrease, V(5) – 90% decrease, V(4) – 68% decrease, V(6+5) – 46% decrease, V(5+4) – 88% decrease.

The analysis of the reasons for the revealed changeability of visibility in the time is an object of further experiments.

ACKNOWLEDGMENTS

The designated project has been fulfilled by financial support of the Shota Rustaveli National Science Foundation (Grant N GNSF/ST08/5-437). Any idea in this publication is processed by the authors and may not represent the opinion of the Shota Rustaveli National Science Foundation itself.

თბილისში ხილვადობის სიშორის სტატისტიკური სტრუქტურა

თეიმურაზ ბლიაძე[1], ალექსაბდრე ჭანკვეტაძე[1], რუსუდან დანელია[2]

[1]ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტის მიხეილ ნოდიას გეოფიზიკის ინსტიტუტი
[1]ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი
danelia_ru@yahoo.com

რეზუიმე

შესწავლილია ხილვადობის სიშორის სტატისტიკური სტრუქტურა თბილისში 1980-დან 2008 წლამდე პერიოდისათვის. Gგამოყენებულია საქართველოს ჰიდრომეტეოროლოგიური დეპარტამენტის მონაცემები ხილვადობის სხვადასხვა ბალიანობის მქონე დღეების რიცხვის

შესახებ წელიწადში 9, 12 და 15 საათზე დაკვირვებებისათვის. ქვემოთ გამოყენებულია შემდეგი აღნიშვნები: V(9) – წელიწადში დღეების რიცხვი 9 ბალიანი ხილვადობით, V(6+5) – წელიწადში დღეების რიცხვი 6 და 5 ბალიანი ხილვადობით და ა.შ.

მოყვანილია აღნიშნული დროითი მწკრივების რეგრესიული და კორელაციური ანალიზი (წრფივი კორელაცია, კენდელისა და სპირმენის რანგობრივი კორელაცია, ტრენდის განსაზღვრა). აღმოჩნდა, რომ V(9), V(7), V(5), V(4), V(6+5) და V(5+4) დროითი მწკრივები ავტოკორელირებული და არაშემთხვევითია. ამ შემთხვევისთვის განსაზღვრულია ტრენდები და მწკრივების შემთხვევითი მდგენელები. ასე მაგალითად V(9) დროითი რიგი მეოთხე ხარისხის პოლინომის სახისაა, V(6+5) რიგი – მეორე ხარისხის პოლინომი და ა.შ. კერძოდ, გამოსაკვლევ პერიოდში დაიკვირვებოდა V(5+4) –ის მნიშვნელობათა შემცირება ხარისხოვანი კანონზომიერებით საშუალოდ 93-დან 7-დე. V(8) და V(6) დროითი რიგები შემთხვევითია.

საკვანძო სიტყვები: ხილვადობის სიშორე, დროითი რიგები, ტრენდი, ქალაქის კლიმატი

REFERENCES

Amiranashvili A., Bliadze T., Kirkitadze D., Nikiforov G., Nodia A., Khurodze T., Chankvetadze A., Chikhladze V. - Some Preliminary Results of the Complex Monitoring of Intensity of Solar Radiation, Total Cloudiness, Visibility and Air Temperature in Tbilisi in 2009-2010, Transactions of Mikheil Nodia Institute of Geophysics, vol. LXII, ISSN 1512-1135, Tbilisi, 2010, pp. 207-215, (in Russian).

Kendall M.G., Time-series, Moscow, 1-200, 1981, (in Russian).

Kobisheva N., Narovlianski G. - Climatological processing of the meteorological information, Leningrad, Gidrometeoizdat, 1978, pp. 1-294.

Sternzat M.S. - Meteorological instruments and measurement, Leningra, Gidrometeoizdat, 1978, 392 p., (in Russian).

Svanidze G.G. Papinashvili L.K. (Ed.) - Climate of Tbilisi, St.-Petersburg, Gidrometeoizdat, 1992, 230 p., (in Russian).