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Comparative Analysis of the Distribution of Number of Days with Hail Per Annum on the Territory of Kakheti According to the Data of the Meteorological Stations and State Insurance Service of Georgia

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ABSTRACT

The results of the comparative analysis of distribution on the territory of Kakheti of the number days with the hail per year according to the data of Hydrometeorological Department (8 stations - Akhmeta, Gurjaani, Dedoplistskaro, Telavi, Lagodekhi, Sagarejo, Signagi, Kvareli; the registration of all days with the hail) and the State Insurance Service of Georgia (123 locations, the registration of the days with hail fall, which led to the damage of agricultural crops) are represented. Period of the study: 1982, 1984-1989 for State Insurance Service data and 49-94 year(including 2016) for data of Hydrometeorological Department of Georgia. In particular it is obtained that for the points Akhmeta, Gurjaani, Sagarejo, Signagi and Kvareli on the meteorological stations the larger number of days with the hail was recorded, than by the State Insurance Service in the same territories. For the points Dedoplistskaro, Telavi and Lagodekhi this difference is insignificant. The detailed analysis of distribution on the territory of Kakheti of the number of days with hail according to the data of both indicated organizations also is carried out.

Key Words: Hail climatology, statistical analysis.

Introduction

Georgia is small mountain country with 15 climatic zones, on which territory from time to time proceed geophysical catastrophes of different types (earthquakes, landslides, mudflows, avalanches, mountain collapses, strong wind, rain, snow, hail, fogs, thunder-storms, extreme air temperatures, droughts, floods, sea storms, etc.) [1-5]. With the this on the changeability of repetition and intensity of the majority of the types of dangerous hydrometeorological phenomena (Including hail processes) essential influence render the processes of urbanization [1,6,7], climate change [8-11], aerosol and gas pollution of the atmosphere [6,7,12-15].

Concerning hail damages, Georgia is one of the hail-dangerous countries of world [1,3,16-19]. Therefore, to the problem of hail in this country are dedicated numerous works, that covers the wide spectrum of studies, beginning from the hail climatology [20-30] and long-term variations of hail processes [31-38], ending with the methods and the results of action on the hail processes [39-42].

Material and methods

The data about the number of days with hail per year of the Hydrometeorological Department of Georgia (8 stations - Akhmeta, Gurjaani, Dedoplistskaro, Telavi, Lagodekhi, Sagarejo, Signagi, Kvareli; the

registration of all days with the hail) and State Insurance Service of Georgia (123 locations, the registration of the days with hail fall, which led to the damage of agricultural crops) are used. Period of the study: 1982, 1984-1989 for State Insurance Service (below – SIS) data and 1982, 1984-1989, 49-94 year for data of Hydrometeorological Department of Georgia (below – HD).

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods [43]. The following designations will be used below: Min – minimal values, Max - maximal values, Range - variational scope, St Dev - standard deviation, σ_m – standard error, R - coefficient of linear correlation, R^2 – coefficient of determination, α - the level of significance.

Results and discussion

Results in the Table 1 and Figures 1-11 are presented.

Table 1

The statistical characteristics of number of days with hail per year in Kakheti

	Kakheti	Akhmeta	Gurjaani	Dedoplistskaro	Telavi	Lagodekhi	Sagarejo	Signagi	Kvareli
	I. Municipality - 1982, 1984-1989, Data of State Insurance Service of Georgia								
Mean	0.64	0.55	0.83	0.52	1.07	0.34	0.46	0.43	0.57
Min	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Max	2.57	1.14	1.43	1.00	2.57	1.29	0.86	0.86	1.00
St Dev	0.45	0.34	0.39	0.25	0.65	0.30	0.20	0.20	0.26
σ_m	0.04	0.10	0.09	0.07	0.15	0.08	0.05	0.06	0.08
Count	123	12	21	14	21	15	16	13	11
	Kakheti	Akhmeta	Gurjaani	Dedoplistskaro	Telavi	Lagodekhi	Sagarejo	Signagi	Kvareli
	II. Data of Meteorological Station - 1982, 1984-1989								
Mean	1.30	1.57	2.29	0.71	1.29	0.29	1.29	1.43	1.57
Min	0.29	0	0	0	0	0	0	0	0
Max	2.29	4	5	2	4	1	3	3	3
St Dev	0.60	1.27	1.70	0.76	1.38	0.49	1.11	0.98	0.98
σ_m	0.23	0.52	0.70	0.31	0.56	0.20	0.45	0.40	0.40
Count	8	7	7	7	7	7	7	7	7
α, Differ. (II-I)	0.005	0.05	0.05	Not sign	Not sign	Not sign	0.05	0.015	0.015
	III. Data of Meteorological Station - All Years								
Mean	1.78	1.66	2.14	1.31	2.17	1.14	2.03	2.13	1.64
Min	1.14	0	0	0	0	0	0	0	0
Max	2.17	8	7	4	7	5	5	6	8
St Dev	0.40	1.37	1.61	0.96	1.49	1.28	1.32	1.44	1.36
σ_m	0.15	0.15	0.17	0.14	0.16	0.15	0.14	0.18	0.16
Count	8	83	86	49	83	77	94	64	76
α, Differ. (III-II)	0.05	Not sign	Not sign	0.05	0.07	0.005	0.07	0.07	Not sign

In the Table 1 the statistical characteristics of number of days with hail per year in Kakheti according to the data of Hydrometeorological Department of Georgia and State Insurance Service are presented. In the figures 1-4 distribution on the territory of Kakheti of the average number of days with hail per year are presented: for 123 locations (Fig. 1, Data of SIS), average for 8 municipalities (Fig. 2, Data of SIS), average for 8 meteorological stations of the municipal centers of Kakheti (Fig. 3 - 1982, 1984-1989; Fig 4 – all years, Data of HD).

As follows from Fig. 1 and Table 1 the number of days with hail per year in 123 locations of Kakheti according to the data of SIS changes from 0.14 to 2.57 with average value – 0.64. The maximum repeatability of the number of days with hail per year falls on the range 0.14 - 0.5 (47.2%), the minimum - on the range >2.0-2.6 (1.6%), (Fig. 2).

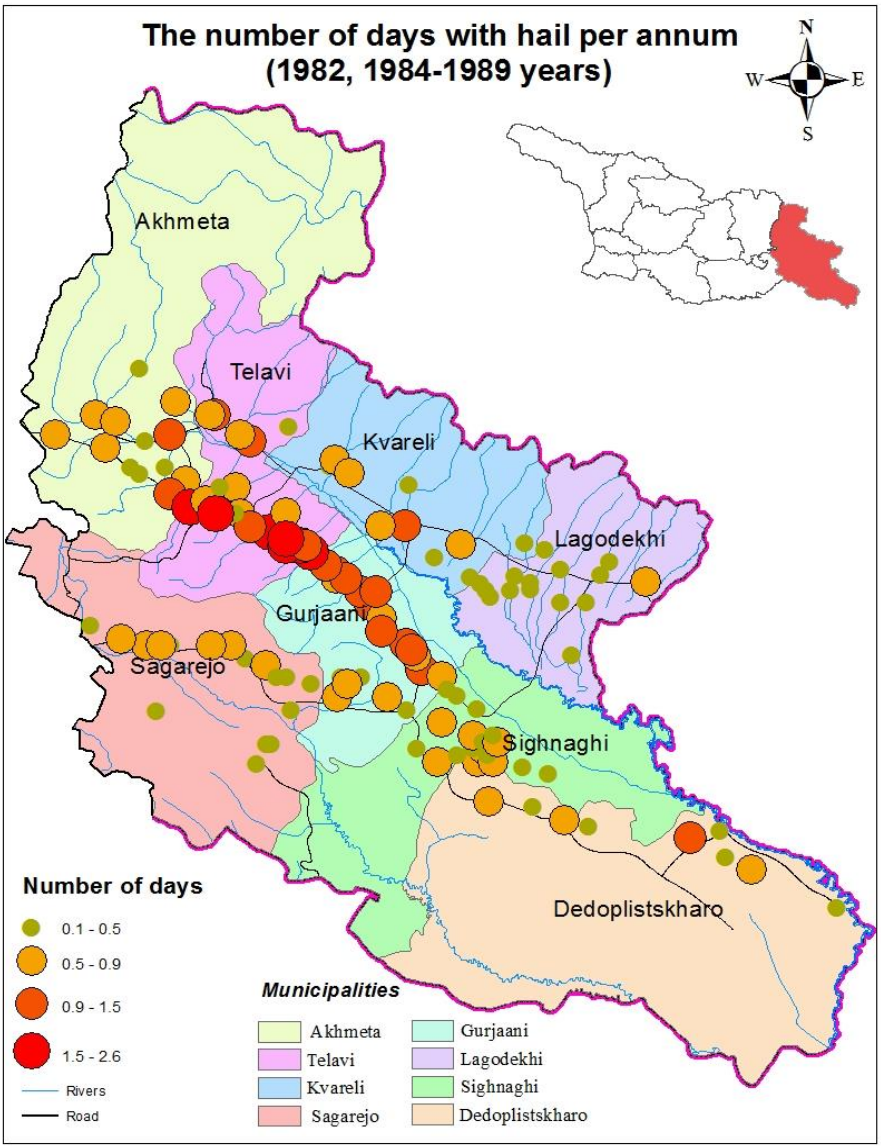

Fig. 1. The average number of days with hail per year in 123 locations of Kakheti in 1982, 1984-1989 (Data of SIS).

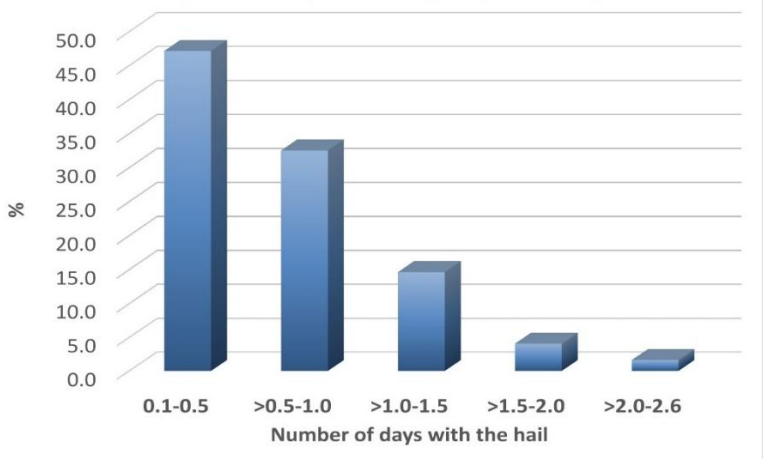

Fig. 2. Repetition of the average number of days with the hail in the separate locality of Kakheti (Data of SIS).

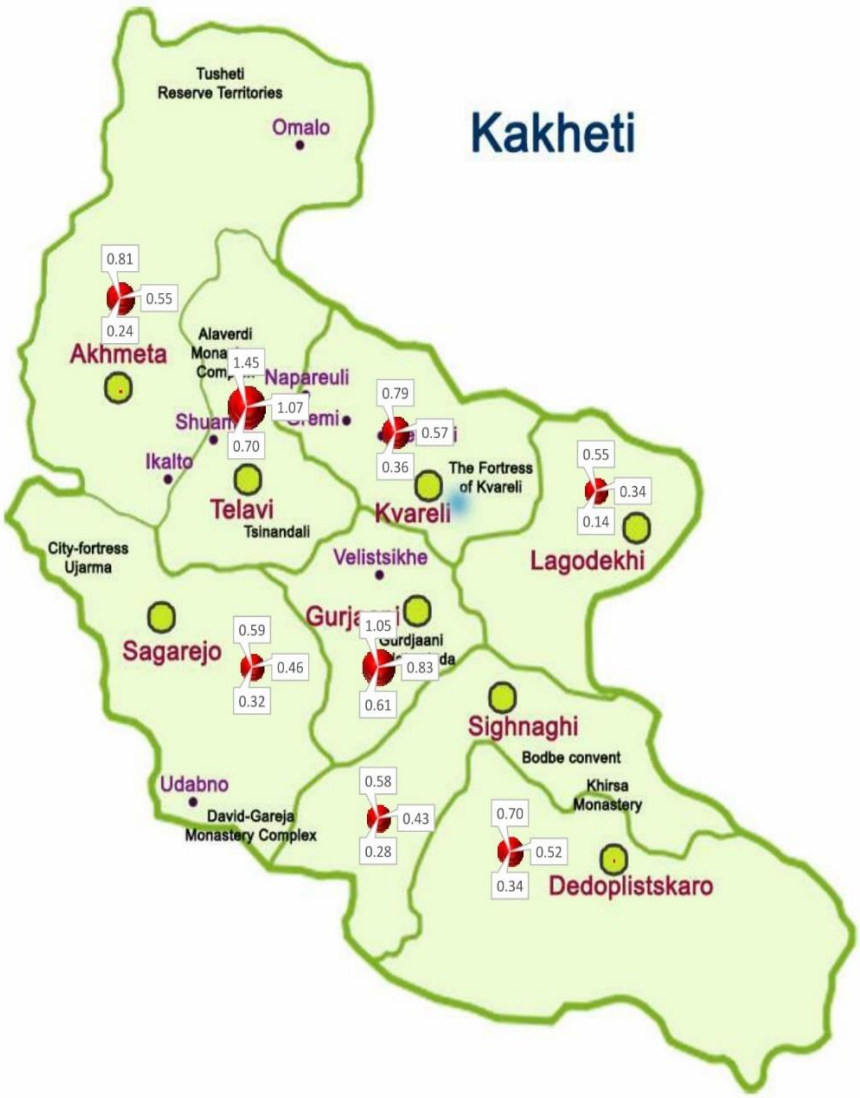

Fig. 2. The average number of days with hail per year (right) and 99% the upper and lower levels of confidence interval on the territories of 8 municipalities of Kakheti in 1982, 1984-1989 (Data of SIS).

According to the data of SIS (Table 1, Fig.2) the maximum average value of number of days with hail per year on the territory of Telavi municipality is observed - $0.70 \leq 1.07 \leq 1.45$, the minimum - on the territory of Lagodekhi municipality - $0.14 \leq 0.34 \leq 0.55$. For other municipalities the average value of number of days with hail per year are: Signagi - $0.28 \leq 0.43 \leq 0.58$, Sagarejo - $0.32 \leq 0.46 \leq 0.59$, Dedoplistskaro - $0.34 \leq 0.52 \leq 0.70$, Akhmeta - $0.24 \leq 0.55 \leq 0.81$, Kvareli - $0.36 \leq 0.57 \leq 0.79$, Gurjaani - $0.61 \leq 0.83 \leq 1.05$ (Table 1, Fig.2).

The number of days with hail per year at 8 meteorological stations of the municipal centers of Kakheti in 1982, 1984-1989 (Data of HD) changes from 0.29 to 2.29 with average value – 1.30. The maximum average value of number of days with hail per year on the Gurjaani meteorologycal station is observed - $0.49 \leq 2.29 \leq 4.08$, the minimum - on the meteorologycal station of Lagodekhi - $0.00 \leq 0.29 \leq 0.80$. For other meteorological stations the average value of number of days with hail per year are: Dedoplistskaro - $0.00 \leq 0.71 \leq 1.51$, Telavi and Sagarejo - $0.00 \leq 1.29 \leq 2.74$ and $0.11 \leq 1.29 \leq 2.46$ respectively, Signagi - $0.40 \leq 1.43 \leq 2.46$, Akhmeta and Kvareli - $0.23 \leq 1.57 \leq 2.91$ and $0.54 \leq 1.57 \leq 2.60$ respectively (Table 1, Fig.3).

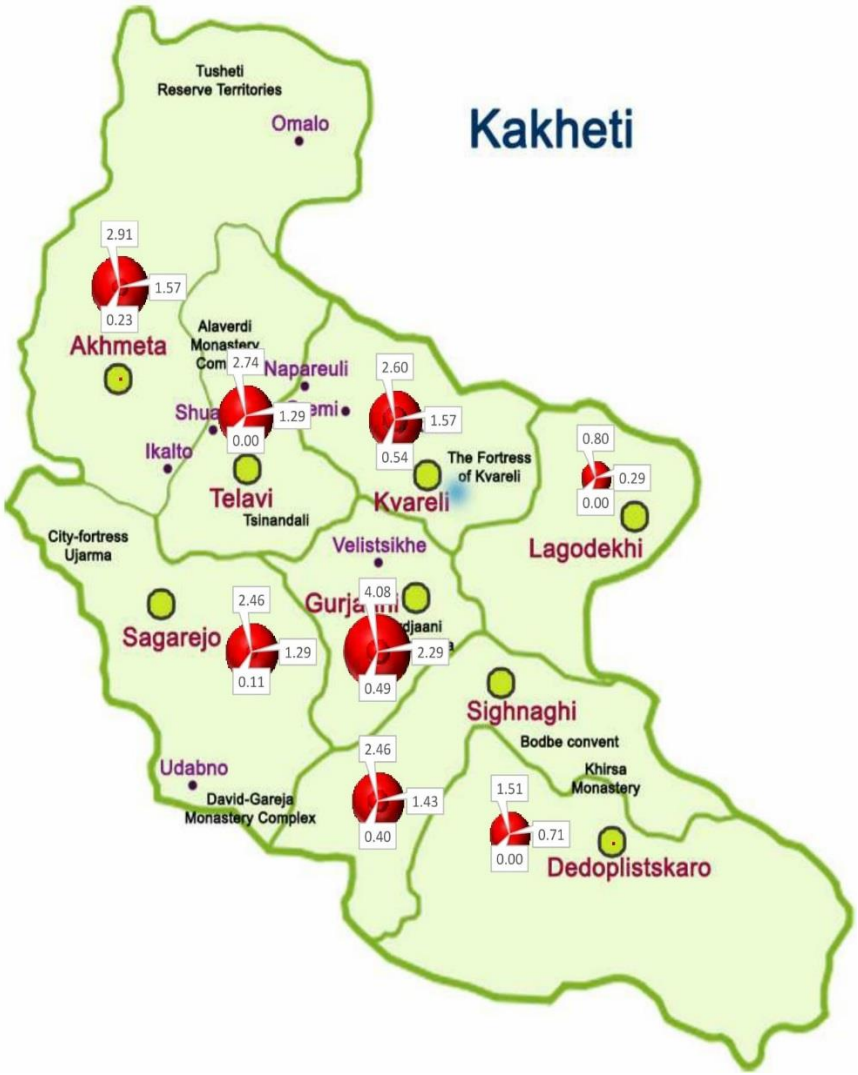

Fig. 3. The average number of days with hail per year (right) and 99% upper and lower levels of confidence interval at 8 meteorological stations of the municipal centers of Kakheti in 1982, 1984-1989 (Data of HD).

As follows from Table 1 and Fig.4 the number of days with hail per year at 8 meteorological stations of the municipal centers of Kakheti according to all observation data of HD changes from 1.14 to 2.17 with average value – 1.78. The maximum average value of number of days with hail per year on the meteorologycal station of Telavi is observed - $1.74 \leq 2.17 \leq 2.59$, the minimum - on the meteorologycal station of Lagodekhi - $0.76 \leq 1.14 \leq 1.52$. For other meteorological stations the average value of number of days with hail per year are: Dedoplistskaro - $0.95 \leq 1.31 \leq 1.66$, Kvareli -$1.24 \leq 1.64 \leq 2.05$, Akhmeta - $1.27 \leq 1.66 \leq 2.05$, Sagarejo - $1.68 \leq 2.03 \leq 2.38$, Signagi - $1.66 \leq 2.13 \leq 2.59$, Gurjaani - $1.69 \leq 2.14 \leq 2.59$.

The comparison of the average number of days with the hail per year according to the data of SIS and HD into 1982, 1984-1989 shows the following. As a whole, for the territory of Kakheti the number of days with the hail per year according to the data of HD is higher than according to the data of SIS. On the meteorological stations Akhmeta, Gurjaani, Sagarejo, Signagi and Kvareli the larger number of days with the hail, than by the State Insurance Service on the average on the territories of the same municipalities was recorded. At the meteorological stations Dedoplistskaro, Telavi and Lagodekhi and the territories of similar municipalities on the average the identical number bottom with the hail was recorded (Table 1).

The comparison of the average number of days with the hail per year according to the data of SIS into 1982, 1984-1989 and HD on all years of observations shows that on all meteorological stations the larger number of days with the hail, than on the average on the territories of the corresponding municipalities was recorded (Table 1).

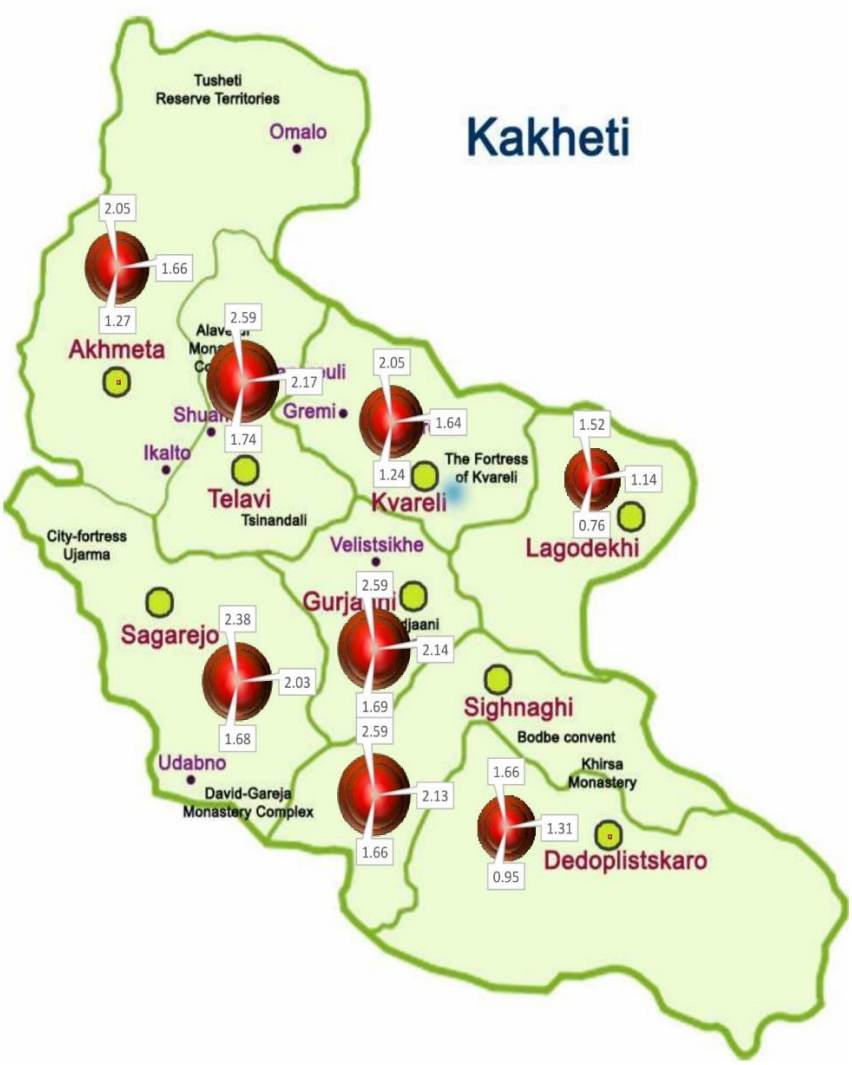

Fig. 4. The average number of days with hail per year (right) and 99% upper and lower levels of confidence interval at 8 meteorological stations of the municipal centers of Kakheti for all years of observation (Data of HD).

The comparison of the average number of days with the hail per year according to the data of HD into 1982, 1984-1989 and for all years of observations shows that on the average for the territory of Kakheti and meteorological stations Dedoplistskaro, Telavi, Lagodekhi, Sagarejo and Signagi the number of days with the hail, averaged in all years, are higher than averaged in 7 years. For the meteorological stations Akhmeta, Gurjaani and Kvareli this difference is insignificant (Table 1).

In the Fig. 5 data about correlation between number of days with hail per year on the meteorological stations and their average value in 8 municipalities of Kakheti in 1982, 1984-1989 is presented. Correlation between the indicated parameters is moderate ($R = 0.48$, $\alpha = 0.23$).

In the Fig. 6 data about correlation between number of days with hail per year on the meteorological stations (all data of HD) and their average value in 8 municipalities of Kakheti in 1982, 1984-1989 according of data of SIS is presented. Correlation between the indicated parameters is noticeable ($R = 0.57$, $\alpha = 0.15$).

Correlation between number of days with hail per year on the meteorological stations in Kakheti according to all data and data of 1982, 1984-1989 of HD (Fig. 7) is strong ($R = 0.74$, $\alpha = 0.025$).

As a whole the linear correlation between number of days with hail per year and altitude in Kakheti for 123 locations is significant, but is very weak ($R = 0.14$, $\alpha = 0.1$). A certain tendency of an increase in the number of days with the hail with an increase in altitude of locality is noticeable (Fig. 8).

However, with the averaging of data of 123 locations for different altitude ranges the clearer picture of the dependence of the number of days with the hail from the height of locality is observed (Fig. 9). As follows from Fig. 9 dependence between the averaged values of the number of days with the hail per year and the height of locality is very strong and has the form of the third power polynomial ($R^2 = 0.996$, $\alpha = 0.001$). Approximately to the height of 550 m above sea level an increase in the number of days with the hail bringing damage to agricultural crops is observed, then - decrease.

From Fig. 10 follows, that correlation between number of days with hail per year on the meteorologycal stations and altitude in Kakheti according to data of HD is very weak (R = 0.14 and 0.22, α is insignificant).

Concerning the correlation between number of days with hail per year and mean altitude of hail-damaged area of 8 municipalities in Kakheti in 1982, 1984-1989 according to data of SIS (Fig. 11), that here dependence is noticeable ($R^2 = 0.3585$, $\alpha = 0.12$). As in the preceding case (Fig. 9), in this case the dependence of the number of days with the hail from the height of locality also takes the form of the third power polynomial (Fig. 11).

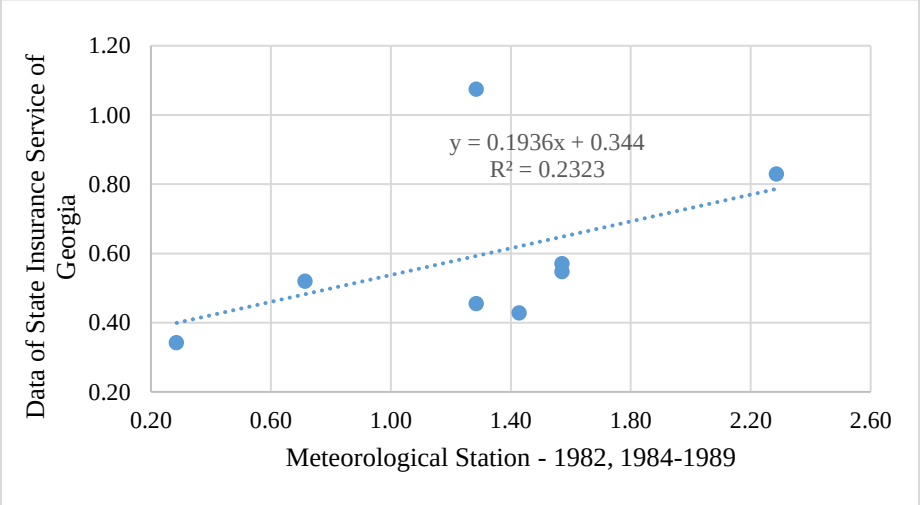

Fig. 5. Linear correlation between number of days with hail per year on the meteorological stations (Data of HD) and their average value in 8 municipalities of Kakheti in 1982, 1984-1989 (Data of SIS).

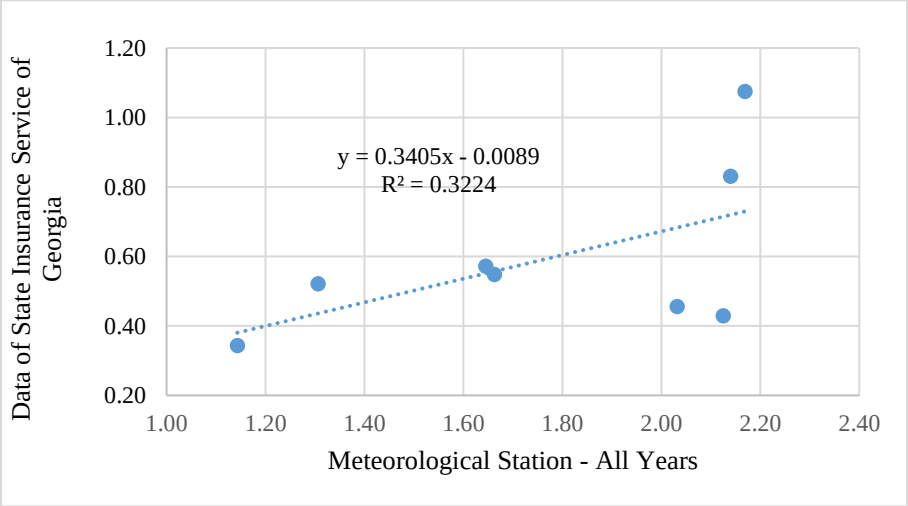

Fig. 6. Linear correlation between number of days with hail per year on the meteorological stations (all data of HD) and their average value in 8 municipalities of Kakheti in 1982, 1984-1989 according of data of SIS.

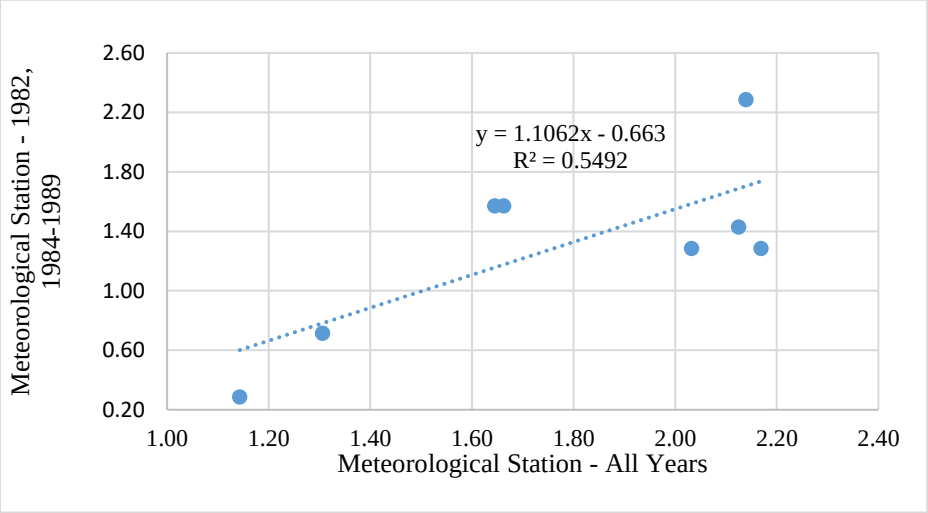

Fig. 7. Linear correlation between number of days with hail per year on the meteorological stations in Kakheti: all data and data of 1982, 1984-1989 of HD.

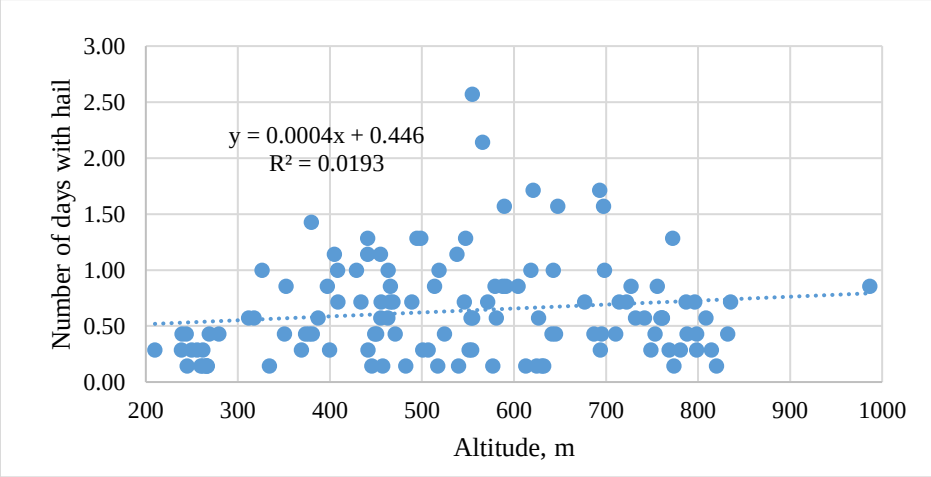

Fig. 8. Linear correlation between number of days with hail per year and altitude in Kakheti for 123 locations in 1982, 1984-1989 (Data of SIS).

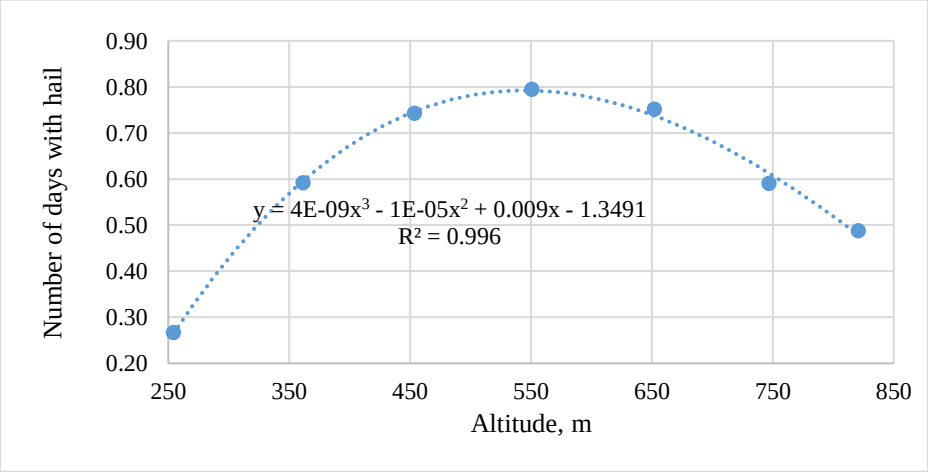

Fig. 9. Dependence of the average number of days with hail per year on the mean height of the terrain in Kakheti for 123 locations in 1982, 1984-1989 (Data of SIS).

Averaging is carried out in a range of heights: 210-280 m – 15 points, 312-400 m – 14 points, 405-500 m -25 points, 501-591 m – 23 points,605-698 m - 19 points, 711-774 m – 15 points, 787 – 987 m – 12 points,

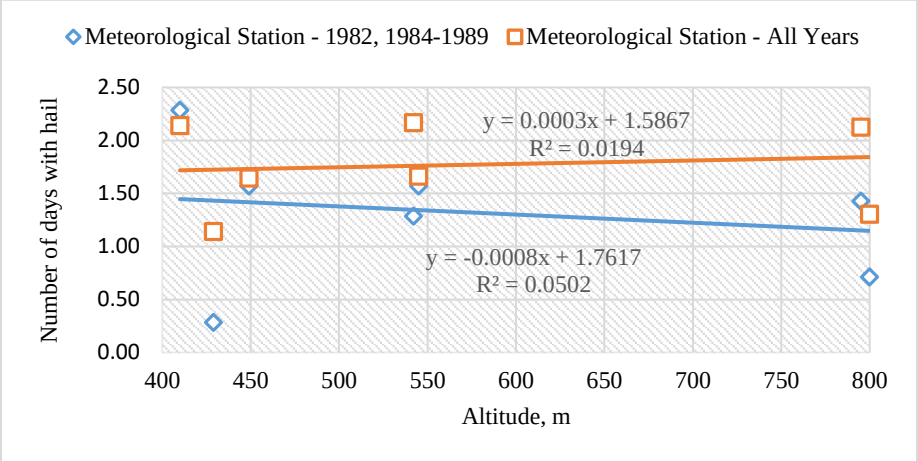

Fig. 10. Linear correlation between number of days with hail per year on the meteorologycal stations and altitude in Kakheti (Data of HD).

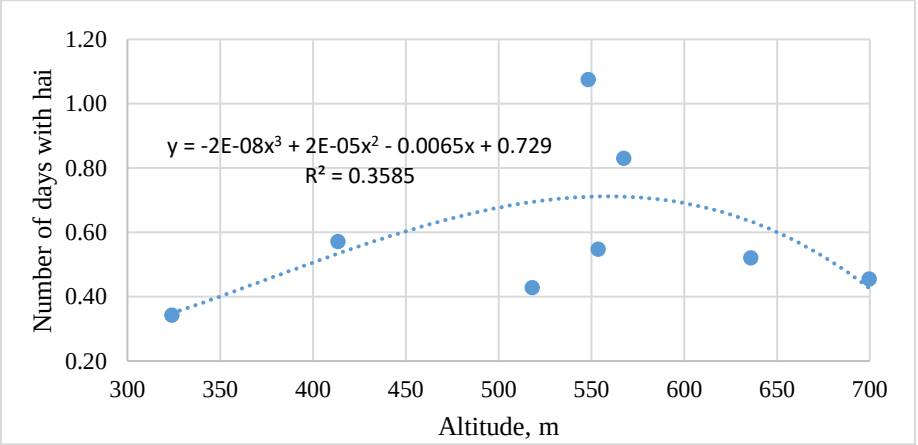

Fig. 11. Correlation between number of days with hail per year and mean altitude of hail-damaged area of 8 municipalities in Kakheti in 1982, 1984-1989 (Data of SIS).

Conclusion

According to the data of State Insurance Service of Georgia (SIS) for 123 locations of the territory Kakheti, in comparison with the data of the Hydrometeorological Department of Georgia (HD) for the 8 meteorological stations, the understated number of days with the hail per year was recorded (approximately two times less in comparison with data for 1982, 1984-1989 and almost three times less in the comparison with data for all years of observations at the meteorological stations - from 49 to 94 years).

The linear correlation between the average number of days with hail per year in 8 municipalities of Kakheti (1982, 1984-1989, data of SIS) and on the corresponding meteorological stations of municipalities centers of Kakheti (data of HD) are moderate (1982, 1984-1989, data of SIS and HD) and noticeable (1982, 1984-1989 data of SIS and all data of HD).

In the range of heights from 410 to 802 m the average number of days with the hail per year according to the data of 8 meteorological stations does not depend on height. The vertical distribution of averaged number of days with the hail per year according to the data of 123 locations of Kakheti (data of SIS, the range of mean altitudes from 254 to 821 m) takes the form of the third power polynomial.

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კახეთის ტერიტორიაზე წელიწადში სეტყვიანი დღეების განაწილების შედარებითი ანალიზი მეტეოროლოგიური სადგურების და საქართველოს სახელმწიფო სადაზღვევო სამსახურის მონაცემების მიხედვით

ა.ამირანაშვილი, თ.ბლიაძე, ნ.ჯამრიშვილი,
თ.ხუროძე,
მ.ფიფია, ხ.თავიდაშვილი

რეზიუმე

წარმოდგენილია კახეთის ტერიტორიაზე წელიწადში სეტყვიანი დღეების განაწილების შედარებითი ანალიზის შედეგები ჰიდრომეტეოროლოგიური დეპარტამენტის (8 სადგური - ახმეტა, გურჯაანი, დედოფლისწყარო, თელავი, ლაგოდეხი, საგარეჯო, სიღნაღი, ყვარელი; ყველა სეტყვიანი დღეების დაფიქსირება) და საქართველოს სახელმწიფო სადაზღვევო სამსახურის (123 პუნქტი, დაფიქსირებულია ის სეტყვიანი დღეები, როდესაც სასოფლო-სამეურნეო კულტურები

დაზიანდა). კვლევის პერიოდი: 1982 და 1984-1989 წლები სახელმწიფო სადაზღვევო სამსახურის მონაცემებით და 49 – 94 წელი (2016 წ. ჩათვლით) საქართველოს ჰიდრომეტეოროლოგიური დეპარტამენტის მონაცემებით. მიღებულია კერძოდ, რომ პუნქტებისთვის ახმეტა, გურჯაანი, საგარეჯო, სიღნაღი და ყვარელი დაფიქსირებულია მეტი სეტყვიანი დღეები, ვიდრე სახელმწიფო სადაზღვევო სამსახურმა დააფიქსირა იმავე ტერიტორიაზე. პუნქტებისთვის დედოფლისწყარო, თელავი, ლაგოდეხი ეს სხვაობა არ არის ნიშნადი. ჩატარებულია აგრეთვე კახეთის ტერიტორიაზე წელიწადში სეტყვიანი დღეების განაწილების დეტალური ანალიზი ორივე ხსენებული ორგანიზაციის მონაცემების მიხედვით.

Сравнительный анализ распределения количества дней с градом в год на территории Кахетии по данным метеорологических станций и службы государственного страхования Грузии

А.Г. Амиранашвили, Т.Г. Блиадзе, Н.К. Джамришвили, Т.В. Хуродзе, М.Г. Пипиа, Х.З. Тавидашвили

Резюме

Представлены результаты сравнительного анализа распределения на территории Кахетии числа дней с градом по данным гидрометеорологического департамента (8 станций - Ахмета, Гурджаани, Дедоплисцкаро, Телави, Лагодехи, Сагареджо, Сигнаги, Кварели; регистрация всех дней с градом) и службы государственного страхования Грузии (123 пункта, регистрация дней с градобитиями, приведших к повреждению сельскохозяйственных культур). Период исследования: 1982, 1984-1989 годы по данным Службы государственного страхования и 49-94 года (включая 2016 год) по данным Гидрометеорологического департамента Грузии. В частности получено, что для пунктов Ахмета, Гурджаани, Сагареджо, Сигнаги и Кварели на метеорологических станциях регистрировалось большее число дней с градом, чем службой государственного страхования на тех же территориях. Для пунктов Дедоплисцкаро, Телави и Лагодехи эта разница незначимая. Проведен также детальный анализ распределения на территории Кахетии числа дней с градом по данным обеих указанных организаций.