Some results of long-term variability of avalanche activity of CIS mountains

L.A.Kanaev, Y.G.Kakurina

Central Asian Research Hydrometeorological Institute (SANIGMI)
72, K.Makhsumova, 700052 Tashkent, Uzbekistan

ABSTRACT. The work present the analysis of the long variation of avalanche activity of former USSR (CIS) mountains by the data of regular observations. There were determined the periods of activigation and reduction of avalanche formation with different synchronization of separate groups of regions. The common territorial time curves of the avalanche activity were derive for 11 of 13 mountains areas of CIS being analyzed. For Tien Shan and Caucasus the generel tendencies of the long-term variation of avalanche formation was differentiated in more details. For some regions the relationship is established between the avalanche formation and climatic factors (air temperature, winter precipitation).The tendency to the avalanche activity decrease on the course of the last few years, revealed on the basis of the analysis is testified by the independent observational data.

INTRODUCTION

The problem of studying the long-term variations of hydrometeorological characteristics, e.g. : precipitation, river flow, avalanche activity and other is of great scientific and practical importance, that is why it attracts the attention of scientists since the long time. Druzhinin I.P.(1970) determined that sudden change of the sun activity is the cause of the turning point of the long-term trend of numerous natural processes,including atmospheric circulation and relevant meteorological elements.The problems of the long-term variation of avalanching in former USSR attracted the attention of such scientists as V.I.Turmanina (1970),A.D.Oleinikov (1983),Y.G. Kakurina (1987),V.F.Okolov (1986),V.M.Sezin (1982) determined the relationship between the avalanche activity and atmospheric circulation, it may be envisaged also,that avalanching periods can be connected with regularity of the atmospheric processes which are mainly determined by the turning points of sharp variations corresponding to 11-years periods. In this regard this work attempts following the former investigations, to present the long-term variations of avalanche activity on the European territory of CIS, Caucasus,Kazahkstan, Central Asia, Siberia and Far East.In their trends there were distinguished the period with the low and high number of avalanches, comparing with the mean long-term values. And there was also revealed the homogeneity of the intensity of variations of avalanching in separaten regions. Here it was taken into account that the tendency of the extreme avalanche activuty was observed in the years,preceeding sun reference years i.e., in the years of the change of the sign of the solar activity increment. This is described in (Kakurina,1987).

DATA

The long-term variations of the avalanche activity were estimated by the data of the areas of stationary comprehensive avalanche observations. The longest data series characterize such areas as Khibins (54 years), Eastern Caucasus (42 years),Western Tien Shan (34 years). The data series of the majority of the snow-avalanche stations (SAS) has observational period less than 20 years(62,4 %), and their data were used only for Siberia and Far East territories. With the purpose of synchronous analysis 30-year period of observations from 1960-61 up to 1989-90 was taken as the most representative one (with the most comprehensive observational data). 43 stations were selected from which 17 are on the European territory of CIS and Caucasus, 13 - Kazakhstan and Central Asia and 13 - Siberia and Far East.

METHOD

In the study of the long-term variations of different elements the running averaging were used. The essence of this technique is in the smoothing of the observations series by averaging through consequent year periods. One can more clearly imagine the cyclic variations without any displacement of the interphase limits between the cycles of the intensive and low avalanche activity when applying the differential integral curves or summarized curves of deviations from the mean long-term value (Ed.of & G.P.Kalinin,1967), for the construction of which the continuos observational series is used. For the calculations of such curves $f(t)=S(k_i-1)/C_v$,the deviation of modulus coefficient of chronologic series of the avalanching

occurence from their mean value (k_{av}-1) were consequently symmarized. The distinguishing of the periods of the intensive and low avalanche activity was made on the main turning curve points. The time period in which k_{av}-1 >0, corresponds to the phase of increase of the avalanche activity and the period in which k_{av}-1<0 corresponds to its decrease, i.e.,at k_{av}-1 = (l_k-l_n),where l_k is the end coordinate of integral curve, l_n - the beginning one,n - number of years in the taken period. For the determination of general regulaties of cyclic variations three principal gradations were used: phases of the increased, moderate and decreased avalanche activity. The detection of these phases was made on differential integral curves by the principal turning points.Negligible waves in the change of avalanche activity caused not by macrosynoptic processes, but, probably, by local anomalies, were not taken into account.

RESULT

The use of differential integral curves makes it possible to investigate the cyclic variations of avalanche activity by the data of snow-avalanche stations of different regions,i.e. to reveal the degree of phase synchronity or asynchronity of avalanche formation. For the solution of this problem 3 types of synchronous curves of avalanche activities were chosen and averaged from 13 avalanche prone areas (Khibins,Carpatians,Northern Caucasus, Caucasus,Zailiyskiy Alatau, Tien Shan, Pamir, Altai, Kuznetskiy Alatau, Baikal region, Zabaikalje,North East, Sakhalin Island). The first type includes the curves with avalanching decrease phase (14-17 years duration) and avalanching increase phase (15-17 year duration). Such regions as Khibins, Carpatians, Caucasus,some basins of Tien Shan, North East, Kuznetskiy and Zailiyskiy Alatau, Northern Caucasus and Sakhalin Island belong to this type. In the last 4 regions less qualitative information was used, basing on the limited actual but restored by the regression equations of observational series. The Caucasus region is subdivided into 2 subregions: Western Caucasus and Eastern Caucasus. In the western subregion the phase of the avalanching increase is longer with module coefficient k_i= 1,72.The second subregion is characterized by significanly less duration of this phase (for 3 years) and greater module coefficient k_i=1,97. It can be supposed that this is connected with continental nature of the Eastern Caucasus climate. The second type includes the curves where the phase of low avalanching activity is 9-12 years at 15-17 years duration of the increased avalanche activity. Such regions as Pamir, Zabaikalje and some basins of Tien Shan belong to this type. The third type is characterized by 16 year - period of the increased avalanching and 8-11 year period of the reduced avalanche activity. Some regions of Tien Shan, Baikal region and Altai belongs to this type. It is to be mentioned that for Altai the duration of period of the avalanche activity increasing is limited by the incomplete data series. The most avalanche studied area - the Tien Shan region was differentiated by all 3 curves types. Here even within one mountain region like the Western Tien Shan some snow-avalanche stations belong to the 1-st type (Kamchik, Naugarzan), the other - to the 2-nd (Angren, Kyzylcha) and some - to the third one (Dukant, Oigaing). In a whole, the identification of more detailed characteristics of periodical processes within one big region can, from one side, testify to the bad availability of statistical sampling, and from another side - it demonstrate some sub-genetical effects of avalanche-formation. However, the snow-avalanche stations, where constructive metamorphizm is more active or due to the wind activity growth caused by low temperature and insignificant snow cover are mainly related to the first type. It should be noticed the regions, identified before as belonging to the first type, are also characterized by relatively active wind activity,excluding Zailiyskiy Alatau. The snow-avalanche stations with sufficiently large snow amount and suppressed constructive metamorphism are related to the 3-rd type. As for the 2-nd type the avalanching conditions of Angren and Itagar are nearly the same, but Kyzylcha by the snow accumulation conditionch and weak wind activity is objectively attributed more to the 3-rd type,that's why its inclusion into the 2-nd type subregion can't be explained yet (Table 1).

Table 1

Distribution of the longest duration of diffrent avalanche formation phases (n) and their average module coefficient (K_1,K_2,K_3) for regions

№	Regions	Avalanche formation phases					
		low activity		hight activity		moderate activity	
		n	k_1	n	k_2	n	k_3
1	Khibins	15	0.74	14	1.29	-	-
2	Carpatians	14	0,76	15	1,28	-	-
3	Northern Caucasus	15	0,37	10	1,84	5	1,10
4	Caucasus 1 type	14	0,22	16	1,71	-	-
5	Caucausus 2 type	15	0,35	13	1,97	-	-
6	Zailiyskiy Alatau	15	0,56	6	2.06	9	1,02
7	Tien Shan 1 type	11	0,62	16	1,30	1	0,97
8	Tien Shan 2 type	10	0,38	15	1,49	-	-
9	Tien Shan 3 type	15	0,73	6	1,77	-	-
10	Pamir	12	0,55	15	1,35	-	-
11	Altai	11	0,76	3	1,86	-	-
12	Kuznetskiy Alatau	14	0,40	11	1,88	3	1,05
13	Baikal region	8	0,62	7	1,44	-	-
14	Zabaikalje	9	0,50	17	1,33	-	-
15	North East	18	0,38	12	1,99	-	-
16	Sakhalin	17	0,60	8	1,58	-	-
	Average	14	0,53	12	1,63	4	1,03

The longer duration of the increase or decrease avalanche activity is up to 18 years, while the most often

recorded duration of the decrease phase of avalanche activity doesn't exceed 14 years, and of its increase - not more than 12 years. The shortest period of the sudden increase of avalanche activity was recorded in 1968-1969 in the 3-rd subregion of Tien Shan, which is characterized by abnormal increase of avalanche activity observed along - with the general pattern of its decrease.As the analysis of the natural anomalies of that period shows(Aksarin,1973,&Konovalov,1973) the hydrometeorological cataclysms at this time were determined by the intensive development of the northern meridional processes during 4 months of winter period (1968-1969) and by the formation of blocking anticyclones on the eastern part of European territory of USSR, characterized by extreme stability during 2 months, which caused the abnormal intensive and extensive precipitation which, in turn, determined extensive avalanches in the areas, where they were not recorded before . The interesting result was observed in the analysis of the territorial distribution of module coefficient of the increase and decrease phases of the avalanche activity. It was determined that to the south and east from Khibins the module coefficients of the decrease phase of avalanche activity drop: Khibins (k_1=0,74), Caucasus (k_1=0,35), Kuznetskiy Alatau (k_1=0,40), Tien Shan (k_1=0,54), Zabaikalje (k_1=0,50), North East (k_1=0,38); and they increase for the phases of the increased avalanche activity: Khibins (k_2=1,71),Kuznetskiy Alatau (k_2=1,88),Caucasus (k_2=1,71), Tien Shan (k_2=1,55), Altai (k_2=1,86), North East (k_2=1,98). As it is known, the effect of conteninentality becomes more manifested in the southern and eastern directions which is also reflected in the module coefficients distribution. The analysis of differential integral curves of avalanche activity has shown that the starting time,duration and module coefficients of the increase and decrease phases of avalanche activity are different at different stations. Nevertheless, despite the individual features of the long-term variations of avalanche activity, in certain regions the similar character of these phase beginning was observed. The diagramm (Fig.1) was constructed for getting more clear idea of the spatial distribution of the long-term variations of avalanche activity. Considerable similarity is observed in the change of phase of cyclic variation of avalanche activity,practically in all regions except Tien Shan and Zabaikalje. Up to the middle of 70-s everywhere the phase of weak avalanche activity is observed, then the phase of its increase follows. In Tien Shan subregion with the curve of 3-d type the increase of avalanche activity is noted since 1962 ; in the 2-nd subregion (2 type) - since 1969; in the 3-rd subregion (1 type)- since 1983. It is like "even transition" of the phase of the increased avalanche activity from one region into another,i.e. the increased avalanche activity in one subregion is compensated by weak avalanche activity in other two subregions. Synphase change of the avalanche activity in the distinguished areas are connected with the direction of the principal air flows, cyclones and anticyclone movement, and, correspondingly, by precipitation amount and air tempetature. The degree of the avalanche danger in winter is determined not only by the snow amount or total precipitation; such factors as precipitation regime and temperature conditions of the cold period are also playing significant role (Oleinikov,1983,1988).

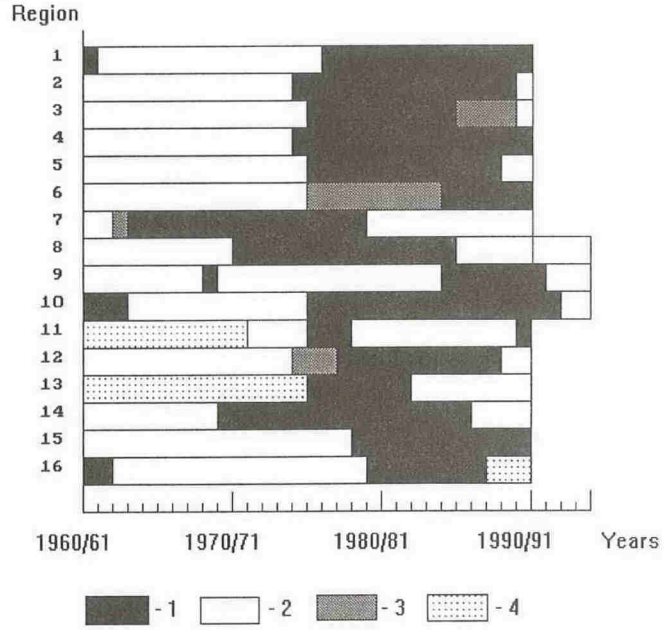

Fig.1 Diagramm of cyclic variations of the avalanche activity in mountain regions of CIS
1 - low activity, 2 - high activity, 3 - moderate activity, 4 - data is absent.

For the substantiation of these results the effort was made to assess the degree of correlation between the avalanche activity in certain winter periods and precipitation regime and air temperature of the cold half year. As it is show in Table 2, the significance of this coefficients is rather high.

Table 2

Value of correlation coefficients of the relationship between the avalanche activity and total precipitation (Kx) and mean winter air temperature (Kt) basen on the data of some snowavalanche stations (SAS) for irregular 5-years period

Name SAS	Correlation coefficients	
	K_x	K_t
Angren	0,57	0,92
Naugarzan	0,71	0,68
Severtsov glacier	-	0,74
Itagar	-	0,66
Serebryansk	0,68	0,92
Luzhba	0,87	-
Omsukchan	0,76	-

The sampled cycles of the long-term variations of the avalanche activity for Tien Shan and Pamir were tested on independent material. The data of observations at the snow-avalanche stations of different types were used for 1990-91 - 1993-94. The tendensy for the avalanche activity decrease for Tien Shan subregions and its increase for Pamir was confirmed, besides in 1990-91 - 1991-92 the change of the increase of avalanche activity was recorded on Pamir, and in 1992-93 and further the decrease of avalanche activity was recorded as it can be

expected following the choozen phase of definite duration. Despite the obtained practical effect, it is rather untimely to draw the conclusion that every new cycle of the avalanche activity variation is the repetition of the preceeding one, that is why the forecast of the avalanche activity insensity on the basis of the derived tendencies is to be further clarified. Nevertheless, the determined regularities are not only presented as a basis of independent testing, but they also serve as certain experimental corroboration of possible long-term variations of climate as an argument determining an avalanche activity.

SUMMARY

The main results can be formulated as follows:
- on CIS territory the regions are identified with synchronous variations of avalanche activity for which the longest durations of the phases of low, moderate and high avalanche activity are estimated;
- for different CIS regions the tendency was defined for the correlation between the long-term change of weather conditions and temporal indices of avalanche formation intensity, which, mainly have regional character;
- on the basis of the carried out investigations one can suppose that the indices of the avalanche activity intensity are functionally related to the continental character of the conditions,because the module coefficients become lower with the increase of continentality degree.

ACKNOWLEDGEMENTS

The authors express their thanks to the staff of the CIS Glavgidromets who provided the meteorological and snow-avalanche data.

REFERENCES

1. Aksarin N.N.(1973). The techniques for the long-term forecasting of the river flow and precipitation for the Central Asia territory by the integral index of atmospheric circulation.Proceed. of SARNIGMI, vol.3(84),p.51
2. Aksarin N.N.,Abramenkov N.N.,Konovalov V.G.(1973).The analysis of the spatial and temporal variations of the meteorological factors of runoff in Syrdarja river basin during an extremely wet years.Proceed. of SARNIGMI,vol.3(81),p.2-50.
3. Avalanche geography.(1992).Edited by S.M.Myagkov, L.A.Kanaev. Published by Moscow University,M.,p.140-298.
4. Druzhinin I.P.(1970). The changes of the long-term trend of the natural processes on the Earth and sudden changes of solar activity.Geographical issues, collection 79,"Mysl"Publishing house,M.,p.15-50.
5. Izhboldina V.A.(1975).Aerosynoptical conditions of the formation and avalanching of the snow drift avalanches on Kolskiy peninsula.Snow and avalanche studies in Khibins.L.,p.51-63.
6. Kakurina Y.G.(1987).The results of the analysis of the temporal variations of avalanche activity on the USSR territory based on the Inventory of USSR avalanches.Proceed.of 2-nd all Union Conference on avalanches.L.,Gidrometeoizdat,p.124-130.
7. The long-term variations of runoff and probability techniques of it's calculation (1967) .Edited by V.D.Bykov, G.P.Kalinin. Published by Moscow University,M.,278 p.
8. Okolov V.F.(1986).The relationship between the avalanche activity and atmospheric circualtion.Published by Moscow University,M., 14 p.
9. Oleinikov A.D.(1983).Types of winters and character of the avalanche activity. MGI, vol.47, p.98-103.
10. Oleinikov A.D.(1988).The winters with the highest degree of avalanche danger in Elbrus area. MGI. Vol.64, p.106-110.
11. Sezin V.M.(1982) Synoptic conditions for snow avalanche events in the mountains of the Western Tien Shan.MGI,vol.42,p.94-100.
12. Turmanina V.I.The effect of intrasecular rythms of wetting on vegetation.Geographical issues. Collection 79."Mysl"Publishing House, M., 1970, p.168-181.

---

* MGI - Data of Glaciological Studies