FORECAST OF AVALANCHES OF FRESH, WET AND DRIVEN SNOW IN THE UKRAINIAN CARPATHIANS

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***Abstract*:** Snow avalanches occupy a very particular place among dangerous hydrometeorologycal phenomena causing losses to national economy. Their formation is stipulated by a complex of closely interacting factors: topography, climate and hydreometeorological conditions, vegetation and human activity. The variety of these factors determines formation of slides of different types, size and frequency of run-off occurrence. The methods of the prediction of avalanches of fresh-fallen, wet and driven snow connected with avalanche forming phenomena: snowfalls, snowstorms and thaws are presented in this article.
***Key words*:** snow avalanche, snowfall, snowstorm, thaw, avalanche forecasting of various genesis

VORHERSAGEN DER LAWINEN AUS FRISCHFALLENDEM, SCHNEESTÜRMISCHEM UND FEUCHTEM SCHNEE IN DEN UKRAINSCHEN KARPATEN

***Zusammenfassuy*:** Schneelawinen nehmen außerordentliche Stelle zwischen gefährlichen hydrometeorologischen Erscheinungen, die Schaden für die Landesökonomik bringen. Ihre Formierung wird durch Complex der engwechselseitigen Factoren bedingt. Es sind Topographie, Klima und hydrometeorologische Verhältnisse, Pflanzenreich und Menschentätigkeit. Die Veränderlichkeit dieser Faktoren rufen Bildung, Ausmaß und Wiederholung der Lawinenerscheinungen hervor.
***Schlüesselworte*:** Schneelawine, Schneefall, Schneesturm, Tauwetter, Vorhersagen der Lawinen verschiedener Güenesis.

Snow avalanches occupy a very particular place among dangerous hydrometeorologycal phenomena causing losses to national economy. In Ukrainian Carpathians snow avalanches are very common and, since this mountain area is densely populated and economically developed the damage from snow slides is rather significant. Many hundreds hectares of forests and hundreds kilometers of mountain roads have been destroyed by them. A special danger is that of snow slides crossing tourist routs.

Formation and run-off of snow avalanches are stipulated by a complex of closely interacting factors: topography, climate and hydrometeorological conditions, vegetations and business activities. The variety and different combinations of these factors determine formation of slides of different types, size and frequencies of run- off occurrence.

Together with the relief, climate and meteorological conditions are very important for the avalanche formation. Cyclonic weather with abundant snowfalls, frequent snowstorms and thaws during the winter determine peculiarities of avalanche formation in Ukrainian Carpathians.

All known occurrences of avalanche run-off were analyzed before of working out avalanche forecast methods using questionnaires of workers of hydrometeorologycal service, forestry, tourism and local residents.

More than 2000 avalanches were analyzed and in 173 cases their genesis was not identified. 55.5 % of the total were the wet ones and most of them were observed in February (468 cases) and March (527 cases) when thaws are especially frequent. The rest of avalanches are of driven and fresh snow.

Stationary special snow-avalanche investigations were started at the stations Posheshevska (1440 m a.s.l) and Pliy (1330 m a.s.l.) in the Ukrainian Carpathian at the end

of the seventieths. The data of these stations gave a possibility to make forecast of different genesis avalanches.

We define the driven snow avalanches as running-off during or right after the snowfall when the wind speed exceed 5 m/sec. Fresh snow avalanches run off during or after the snowfall when no wind or wind under 5 m/sec blows. The avalanches of both these types are formed at temperatures below zero centigrade. Wet snow avalanches are defined as those that are caused by thaws.

Presently there exist three main methodological approaches in avalanche forecast. The first one is based upon the analyses of meteorologycal factors of avalanche formation (air temperature, Precipitation rate, snow depth, etc), the second – upon the analyses of the processes inside the snow cover and direct measurements of their parameters (statigraphy change rate, phisico-mechanical properties of snow cover, etc.). The third method utilizes the data on synoptic processes that determine the avalanche formation.

To develop the methods of avalanche forecast we selected 29 events of run-off of driven snow avalanches, 10 – fresh snow and 31 – wet snow slides. The factors of avalanche hazard (precipitation rate, wind velocity, air temperature, thaw intensity etc.) were analyzed beginning from the start of the avalanche-forming event (snowfall, snowstorm, thaw) to the run-off of the first slide in particular avalanche-hazardous period. If the exact moment of the run-off is unknown and snowstorm and/or thaw have been going on, it was conditionally set as 9:00 p.m. Snowfall, snowstorm and/or thaw were considered as non-stop if they did not break for more than for 12 hours.

As the results of the analysis of avalanche hazard signs it was ascertained that most informative signs of possible driven snow slide were maximal snowfall rate i_{max}[mm/hour] and snowstorm intensity Q[mm/hour] at negative (centigrade) air temperature, precipitation of more than 8 mm/day and wind velocity of 5 m/sec and more. For fresh snow slides they were: thaw average intensity i_{th} [^{0}C/hour] and duration T_{th}[hours], minimal snow surface temperature before the thaw $t_{min\ ss}$[^{0}C] that usually observed at 9:00 a.m.

To classify the situation as avalanche-hazardous the well-known Akkuratov technique was applied (Akkuratov, 1960). It implies the search for the “risky” and “safe” domains on the graphs of avalanche run-offs occurrence versus different meteorological parameters (Figs 1-3).

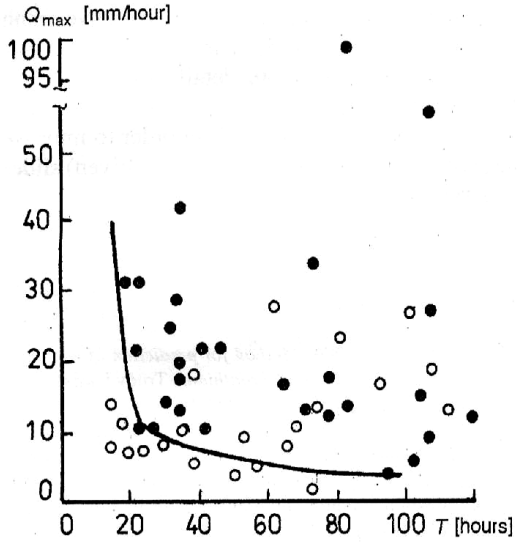

Fig. 1. Relation between driven snow avalanche run-off event and maximal snow storm discharge Q_{max} [mm/hour] and snow storm duration T [hours]. • — snow slide has occurred, o — has not occurred

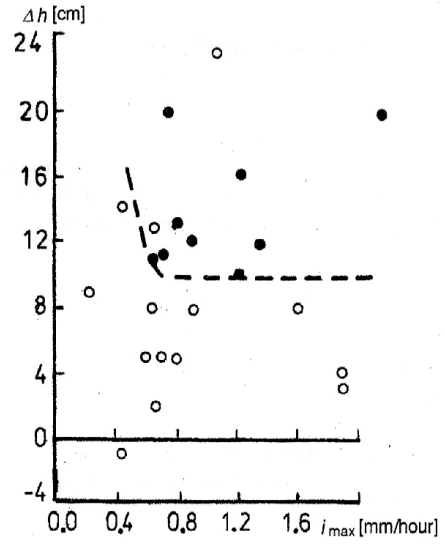

Fig. 2. Relation between fresh snow avalanche run-off event and snow increment Δh [cm] and maximal intensity i_{max} [mm/hour] of snowfall. • — snow slide has occurred, o — has not occurred

We have tested the method with independent data. The test has shown a high reliability of the prediction graphs for fresh and driven snow avalanches (about 90%). The reliability of wet avalanche predictions turned out to be slightly lower (85%).

The methods described by Grishchenko (Grishchenko, 1985, 1986, 1987) are inculcated to hydrometeorological service everyday work, but they are of diagnostic type and cannot be used beforehand. We have developed another method of wet snow slides forecast with an advance of 12-24-36 hours. It is based upon the use of synoptic information for the prediction of the temperature in the region of interest and subsequent computation of avalanche forming parameters of thaw (its intensity, duration, minimal temperature of snow surface and use of the predictive graph introduced earlier (Fig.3).

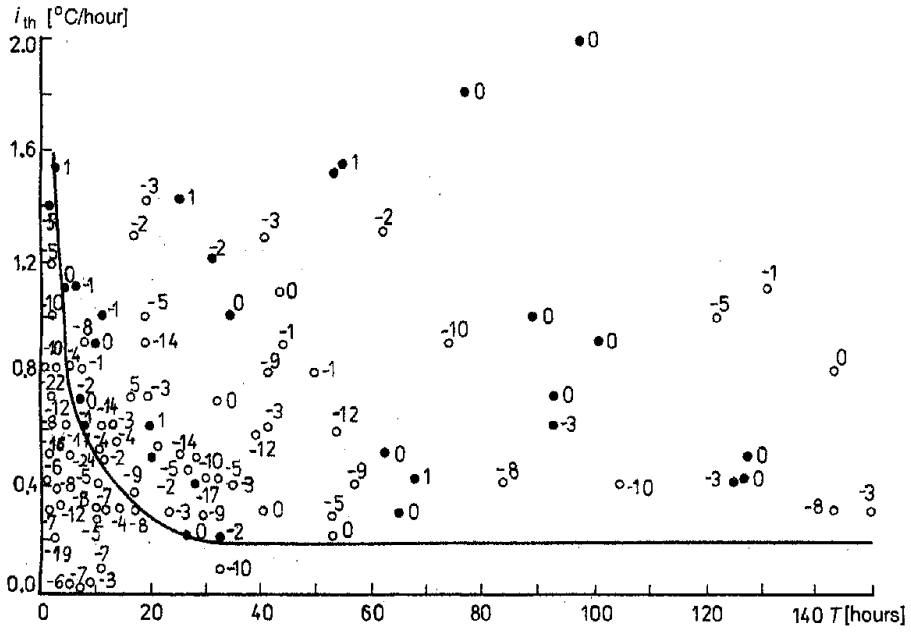

Fig. 3. Relation between wet snow avalanche run-off event and thaw intensity and duration with the threshold minimal temperature of snow surface taken into account. • — snow slide has occurred, o — has not occurred

The essence of the method is described in more detail elsewhere (Grishchenko et. al., 1991).

Using of synoptic prognostic predictions decrease a degree of proving to be correct a forecast on 2-3%, but considerably extent it advance (during a period since 1988 to 2001 they made up correspondently 92% and 80%).

Presently the new research in order to improve the predictions of avalanches of different genesis is carried out.

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