# SPATIAL VARIABILITY OF SNOW CHARACTERISTICS AND SNOW STABILITY

Pavel A. Chernous, Nikolay V. Barashev, Yuri V. Fedorenko
Center for Avalanche Safety, "Apatit" JSC, Kirovsk, Murmansk Region, Russia
Murmansk State Technical University, Murmansk, Russia
Polar Geophysical Institute, Apatity, Murmansk Region, Russia

ABSTRACT: It is commonly recognized that spatial variability of snow characteristics is an obstacle for precise snow stability assessment. The work has been done to answer how the data about snow, obtained in a relatively small part of a slope, are tied to those for the whole slope, how the variability depends on scale, and how variable are characteristics of the surface and buried snow layers. Numerous measurements of snow thickness, density, shear strength and temperature have been carried out to describe the variability at specially chosen study plots in the Khibini Mountains. The correlation and spectral analyses have been used for the obtained data processing. Different numerical parameters of spatial statistical structure of the snow characteristics are submitted. Statistical simulation of the snow characteristics fields is described. The errors of interpretation of the snow characteristic point measurements for snow stability assessment are considered. The research was supported by RFBR (grant 08-05-00883-a).

KEYWOKRDS: avalanches, snow variability, stability assessment.

It has been found as a result of the carried out researches, that the most essential factor, influencing on quality of estimation of snow stability on a slope, is spatial variability of snow properties, controlling its stability. Temporal variability of snow characteristics (its random component) is not so high and influences on quality of stability estimation to lesser degree.

Measuring of spatial distributions (along the surface parallel to the slope) of snow thickness, density and shear strength has shown that variability of these characteristics in bury snow layers less, than for the layers of snow on or near to the surface of snow cover.

It is difficult to describe variability of snow characteristics along of perpendicular to slope surface due to their high anisotropy caused snow layering.

Errors in estimation of some parameters of the fields of snow characteristics have been assessed for some types of snow on the basis of study of their spatial statistical structure, described by a correlation theory (Chernous, 1994; Gandin and Kagan, 1976; Kagan, 1965; Zhukovsky, 1976). Indexes of spatial statistical structure such snow characteristics as thickness, density and shear strength, obtained in the Khibini Mountains, are significantly higher than ones for the Tien-Shan (Chirkova, 1977; Kanaev, 1969) and the Caucasus (Voitkovsky and others, 1986). It is explained more variable climate in the Khibini Mountains and, in particular, frequent snowstorms and high snow drift. The spectral analysis of empiric spatial correlation functions showed that the contributions of different scale variability to variences of snow characteristics are very near.

For the estimation of influence of spatial variability of snow characteristics on its stability numerous simulations have been carried out in which the spatial distributions of

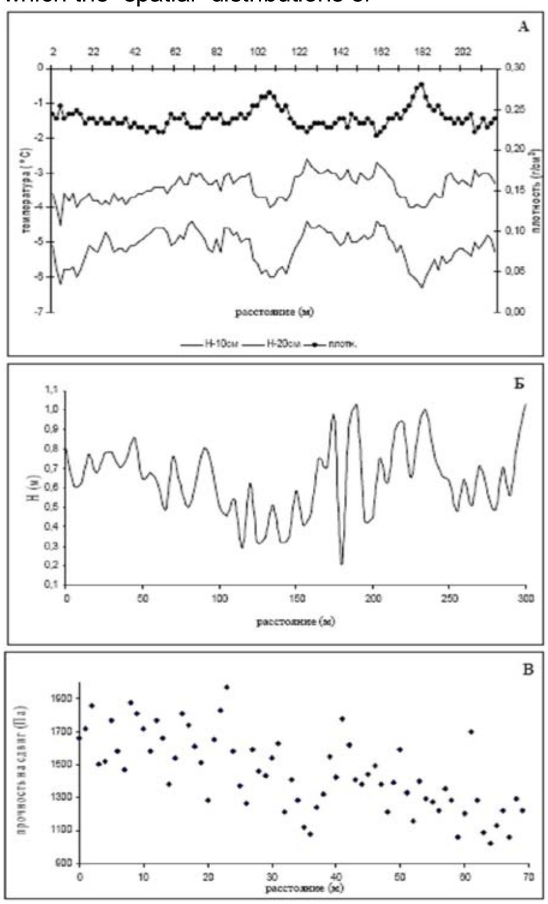


Fig. 1. Examples of spatial distributions of snow characteristics measured along horizontal profiles on the slopes in the Khibini Mountains: A – density of a top layer, temperature at depth 10 and 20 cm; Б – thickness; B – shear strength.

Chernouss and Fedorenko, 1998). Examples of the simulation are presented on a fig. 2.

The simulation showed that at the same mean and variances of snow characteristics controlling its stability, steep slopes in regions with high spatial variability are not so dangerous, as in regions with low one.

Probability of avalanche release on a slope of given steepness is determined the parameters of spatial variability of snow characteristics, controlling its stability, and by the area of the slope.

REFERENCES

Chernouss P. 1994. Statistical modeling of snow cover stability in mountain slopes. Proceedings of the International Snow Science Workshop, 6-10 October 1994, Snowbird, Utah. Snowbird, AAAP, 341-345.

Chernouss, P. and Fedorenko, Yu. 1998. Probabilistic Evaluation of Snow Slab Stability on Mountain Slopes. Ann. Glaciol., 26, 303-306.

Chirkova A.A. 1977. Osobennosti strukturnih funkcii glubini snezhnogo pokrova v zavisimosti ot haraktera rel'efa lavinnih ochagov [Peculiarities of structural functions of snow depth in dependence of avalanche starting zones relief]. Trudi SARNIGMI, 37 (118), 43-50. [in Russian.]

Gandin L.S., Kagan R. L. 1976. Statisticheskie metodi interpretacii meteorologicheskih dannih [Statistical methods of meteorological data interpretation]. Leningrad, GIMIZ, [in Russian.]

Kagan R.L. 1965. O tochnosti izmerenii srednei po ploschadi po dannim tochechnih izmerenii [On accuracy in calculating of a mean value for some area according to point measurement data]. Trudi GGO, 175, 117-131. [in Russian.]

Kanaev L.A. 1969. Ob izmenchivosti svoistv snega [On variability of snow properties]. Trudi SARNIGMI, 44(59), 25-42. [in Russian.]

Voitkovsky K.F., Golubev V.N. Voitkovsky V.K. 1986. Prostranstvennaya izmenchivost stroeniya I svoistv snezhnogo pokrova na sklonah gor [Spatial variability of snow structure and properties on mountain slopes]. Vestnik Moskovskogo Universiteta, Ser. 5. Geografiya, , № 1, 80-86. [In Russian with English summary]

Zhukovsky E.B., Kiseleva T.L., Mandelshtam S.M., 1976. Statistichesky analiz sluchainih processov [Statistical analysis of stochastic processes]. Leningrad, GIMIZ. [in Russian.]

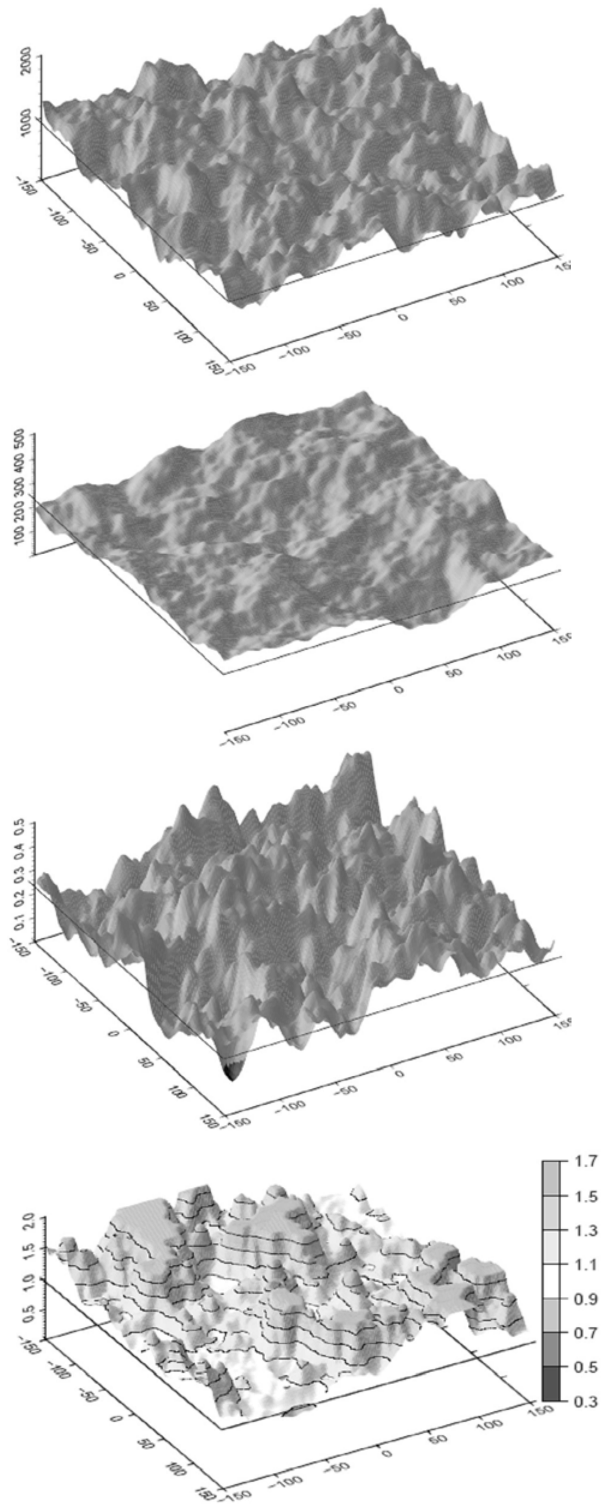


Fig. 2. Example of snow shear strength, density, thickness, stability factor spatial distributions, generated with Monte Carlo method. Slope angle - 35°, $f$ = 0.4, $m_H$ = 1 m, $\sigma_H$ = 0.4 m, $\rho$ =250 kg/m$^3$ $s_\rho$ =30 kg/m$^3$, $C$=1000 Pa, $\sigma_C$ = 200 Pa. Slope area 300*300 m$^2$.