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Large-scale assessment of spatial-temporal variability of the characteristics of snow cover within a uniform area.

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The spatial-temporal variability of the snow cover and identification of the snow intra-annual structure changes can be assessed using different techniques. However, each of them has certain limitation, caused both by natural conditions and human factor, or subjectivity of manual in-situ measurements. Thus, the aim of the study was to estimate and compare the variability in snow cover characteristics acquired by different methods. Here we present the results of the investigation of snow structure and stratigraphy based on snow strength and density distribution within the snowpack as well as their variability as provided by the SnowMicroPen high-resolution penetrometer and manual box cutter in-situ density measurements.
Horizontal areas with uniform underlying surface and not-varying vegetation were selected at the Meteorological observatory of the Lomonosov Moscow State University for the stratigraphic studies with the aim to avoid the possible influence of slope aspects and relief on spatial variability. Analysis of the information obtained in winter 2017/18 allowed us to construct detailed scheme of the snow cover evolution at Moscow site and to assess the inter-annual variability of snow structure. The works included 4 series of SnowMicroPen measurements along 20-m length transects. Consecutively with SMP measurements, snowpits were built and described along the same lines, providing direct data on snow cover structure, density and stratigraphy and representing the conditions of snowpack during different phases of its evolution during 2017/18 winter season in Moscow. All the measurements were conducted with a 50 to 100 cm horizontal resolution. On the basis of density measurements detailed schemes of snow density distribution within snowpits where constructed.
The data analysis showed high spatial and temporal variability of the structure and properties of snow cover even at a homogeneous area, usually described by measurements in a single point. It was observed that the spread of average values of density and water equivalent between two adjacent measurement points in the period of maximum accumulation of snow can exceed 30% even within a uniform flat area. It was also determined that, within the limits of one layer, the difference in the values of the density and water equivalent between the adjacent measurement points can reach 100% or more. Significant variability of snow properties within a homogeneous landscape should be taken into account when choosing representative points for assessing water equivalent and other characteristics over large areas. For each region, the snow cover monitoring network should be designed taking into account its own spatial and temporal statistical structure of snow characteristics.