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Snow Cover Changes over Northern Eurasia from in Situ Observations

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Data.
In addition to a standard suite of synoptic snow observations (snow depth, snow type, state of the ground at the meteorological site and its surroundings), we used in our study the national snow survey data set archived at the Russian Institute for Hydrometeorological Information. This dataset has routine snow surveys run throughout the cold season each decade (during the intense snowmelt, each 5 days) at all meteorological stations of the former USSR, thereafter in Russia, since 1966. Prior to 1966 snow surveys are also available but the methodology of observations has substantially changed at that year and our analysis includes data of 958 Russian stations from 1966 to 2011 with a minimal number of missing observations. Surveys run separately along all types of environment typical for the site for 1 to 2 km, describing the current snow cover properties such as snow density, depth, water equivalent, and characteristics of snow and ice crust.

Background.
During the period of widespread instrumental observations in Northern Eurasia (since 1881), the annual surface air temperature has increased by 1.5°C (in the winter season by 3°C. Close to the north in the Arctic Ocean, the late summer sea ice extent has decreased by 40% providing a near-infinite source of water vapor for the dry Arctic atmosphere in the early cold season months. There is also evidence of more frequent thaw days over northern latitudes of western Eurasia. All these factors affect the state of snow cover.
Methods. Regional analysis of snow cover data was carried out using quasi-homogeneous climatic regions. Maps (climatology, trends) are presented mostly for visualization purposes. The area-averaging technique using station values converted to anomalies with respect to a common reference period (in this study, 1966–2011). Anomalies were arithmetically averaged first within 1°N x 2°E grid cells and thereafter by a weighted average value derived over the quasi-homogeneous climatic regions. This approach provides a more uniform spatial field for averaging.

Results.
In the recent decades, the Russian territory has experienced an increase in snow depth, both winter average and maximum snow depths, against the background of global temperature rise and sea ice reduction in the Arctic Ocean. Generalized regional characteristics of maximum snow water equivalent show an increase in water supply in the north of the East European Plain (by 4.5%/10yr in the west and by 6%/10yr in the east). This characteristic also increases in the southern forest zone of West Siberia and in the Far East (by approximately 6%/10yr) and in central Eastern Siberia (by 3.4%/10yr). Only in the southwest of the East European Plain, we found a tendency for decrease in water supply (by -6.4%/10yr) along the forested snow courses. Among the two competing factors that can cause a systematic change in the maximum and mean snowpack density over Northern Eurasia, increase in maximum snow depth and a decrease in number of days with snow cover, the second factor (that causes a decrease in snow density) appeared to be more significant during the past 43 years.