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Changes in Snow Cover Characteristics over Northern Eurasia since 1966

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Data. In addition to a standard suite of snow observations across Northern Eurasia and its surroundings, we used in our study the national snow survey data set archived at the Russian Institute for Hydrometeorological Information. The last 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. Therefore, this analysis includes only data of more than1000 Russian stations from 1966 to 2009 that have 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 past 128 years (since 1881), the annual surface air temperature in Northern Eurasia has increased by 1.5˚C and in the winter season by 3˚C. Nearby to the north in the Arctic Ocean, the late summer sea ice extent decreased by 40% exposing a near-infinite source of water vapor for the dry Arctic atmosphere in early cold season months. As a result of these processes the following ***changes in snow cover characteristics have been observed:*** (a) in autumn the dates of the onset of snow cover have not changed noticeably despite the strong temperature increase in this season; (b) in late spring, snow cover extent has decreased, retreating by 1 to 2 weeks earlier during the past 40 years; and (c) in the cold season maximum snow depth and SWE (at open areas) have increased over most of Russia. In the western half of Eurasian continent days with thaw became more frequent.

Snowmelt duration and ice crust changes. Over Northern Eurasia, the snowmelt process can be lengthy but even the first such melt initiates a process of snow metamorphosis on its surface changing snow albedo and generating snow crust as well as on its bottom generating ice crust. Once formed, the crusts will not disappear until complete snowmelt. These crusts have numerous modes of impact on the wild birds and animals in the Arctic environment as well as on domesticated reindeers. In extreme cases, the crusts may kill some wild species and prevent reindeers' migration and feeding. In the temperate zone, the ice crust can affect the winter crop yield. The warming and earlier snowmelt worldwide signal that the "shoulder" spring period when ice crust remains on the ground may shorten. However, earlier and more frequent thaw occurrence may cause an opposite tendency and lengthen the period with the ice crust. Our study reveals substantial changes in the snow and ice crust characteristics that have practical importance for wildlife and human activity in the Arctic as well as in the major agricultural regions of Russia. Among the two competing factors that can cause a systematic change in the ice crust characteristics over the humid half of Northern Eurasia, i.e., the increase in thaws due to strong regional warming and a potential shortening of the period of snowmelt, the second factor appeared to be more significant during the past 43 years. In particular, the entire process of the spring snowmelt has become shorter in duration and (taking into account a parallel rise in the snow depth across most of Russia) more intense. This might contribute to increasing frequencies and severity of spring floods, and require further studies.