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Satellite-derived changes in the permafrost landscape of central Yakutia, 2000-2011: wetting, drying, and fires

Julia Boike (1), Thomas Grau (2), Birgit Heim (1), Frank Günther (1), Moritz Langer (1), Sina Muster (1), Isabelle Gouttevin (3), and Stephan Lange (1)

(1) Alfred Wegener Institute Helmholtz Center for Polar and Marine Research, Potsdam, Germany, (2) Helmholtz Center for Environmental Research, Department Computational Hydrosystems, Leipzig, Germany, (3) Unité de Recherche Hydrologie-Hydraulique, Villeurbanne CEDEX, France

The focus of this research has been on detecting changes in lake areas, vegetation, land surface temperatures, and the area covered by snow, using data from remote sensing. The study area covers the main (central) part of the Lena River catchment in the Yakutia region of Siberia (Russia), extending from east of Yakutsk to the central Siberian Plateau, and from the southern Lena River to north of the Vilyui River. Approximately 90% of the area is underlain by continuous permafrost. Remote sensing products were used to analyze changes in water bodies, land surface temperature (LST), and leaf area index (LAI), as well as the occurrence and extent of forest fires, and the area and duration of snow cover. The remote sensing analyses (for LST, snow cover, LAI, and fire) were based on MODIS–derived NASA products for 2000 to 2011. Changes in water bodies were calculated from two mosaics of (USGS) Landsat high resolution (30 m) satellite images from 2002 and 2009. Within the study area's 315,000 km^2 the total area covered by lakes increased by 17.5% between 2002 and 2009, but this increase varied in different parts of the study area, ranging between 11% and 42%. The land surface temperatures showed a consistent warming trend, with an average increase of about 0.12°C/year.
The average rate of warming during the April-May transition period was 0.15°C/year and 0.19°C/year in the September-October period, but ranged up to 0.45°C/year in some areas during April-May. Regional differences in the rates of land surface temperature change, and possible reasons for the temperature changes, are discussed with respect to changes in the land cover.
Our analysis of a broad spectrum of variables over the study area suggests that the spring warming trend is very likely to be due to changes in the area covered by snow. The warming trend observed in fall does not, however, appear to be directly related to any changes in the area of snow cover, or to the atmospheric conditions, or to the proportion of the land surface that is covered by water (i.e. to wetting and drying). These results suggest a complex interplay between different mechanisms affecting the land cover and land surface temperatures that warrants further investigation, possibly making use of higher resolution satellite data together with local and regional modeling, and taking into account the influence of lakes on the regional energy exchange.

Supplementary data (original data, digitized version of the maps, metadata) are archived under PANGAEA (http://dx.doi.org/10.1594/PANGAEA.855124).