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Global warming and changes in Siberian terrestrial environments

Tetsuya Hiyama[1*], Shamil Maksyutov[2], Heonsook Kim[2], Takahiro Sasai[3], Yasushi Yamaguchi[3], Atsuko Sugimoto[4], Hitoshi Yonenobu[5], Takeshi Ohta[6], Ayumi Kotani[6], Kazukiyo Yamamoto[6], Takeshi Yamazaki[7], Kazuhiro Oshima[1], Hotaek Park[8]

[1]Research Institute for Humanity and Nature, [2]National Institute for Environmental Studies, [3]Graduate School of Environmental Studies, Nagoya University, [4]Graduate School of Environmental Science, Hokkaido University, [5]Department of Health and Living Sciences Education, Naruto University of Education, [6]Graduate School of Bioagricultural Sciences, Nagoya University, [7]Graduate School of Science, Tohoku University, [8]Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology

High levels of precipitation in the Lena River Basin, Siberia, from 2005 to 2008 led to tremendous changes in terrestrial environments. The changes observed include a deepening and moistening of the active layers, hindrance of tree growth, and the expansion of water surfaces due to floods. The anomalously wet condition of forest soils caused larch trees to wither at our forest monitoring site in the middle part of the basin. However an analysis of satellite data revealed that such tree withering occurred only at certain points. On the basis of our permafrost-ecosystem models, we have identified increases in thawing depth and surface soil moisture, and an increase in net primary production. The annual maximum thawing depth (AMTD) was revealed to have gradually increased (deepened) on a decadal scale. Increase in terrestrial water storage in the Lena River Basin generated increases in river base flows during the open water season. Our results also indicated that between 1950 and 2008 the basin-scale AMTD increased at an average rate of approximately 1 cm/year in the region. Moistening and warming of surface soil affect methane emissions from Siberian terrestrial ecosystems. Regional methane fluxes were estimated using an inversion model with data collected from aircraft and tower measurements in Siberia. In 2007 and 2008, enhanced methane fluxes from the wetlands in Western Siberia were estimated under relatively wet conditions with high temperatures. Interestingly, methane fluxes after 2008 have gradually decreased but those in Eastern Siberia have increased unsymmetrically. Such an unsymmetrical (seesaw) pattern between Western and Eastern Siberia has also been observed for carbon dioxide exchanges in terrestrial ecosystems. Gross primary production and ecosystem respiration in the 2000s were estimated using our permafrost-ecosystem models, which showed a decreasing trend in Western Siberia and an increasing trend in Eastern Siberia. These differences were primarily due to the differences in the trends of temperature and precipitation between the two regions.

Keywords: global warming, waterlogging, permafrost, thawing, green-house gases