4. Contribution of fire and land cover to CO_2, CH_4 and N_2O emissions in Central Yakutia

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Abstract

Large area of Siberian taiga underlain by permafrost is a carbon sink for a long time. However, frequent forest fires have reduced the carbon sink recently and have emitted large amount of greenhouse gases, CO_2, CH_4 and N_2O. Moreover, permafrost thaws if forest ecosystems destroyed completely, then the ground collapses and it makes wetlands which are the significant sources of CH_4. In this study, we estimated the magnitude of the contribution of these sinks and sources of CO_2, CH_4 and N_2O in permafrost area around Yakutsk city (62°N, 129°E).

We divided the land area of 4500 km^2 around Yakutsk city into four types of land covers which is forest, dry and wet grasslands and pond by using LANDSAT image data of 1999. Burned land area during the forest fire in 2002 was also considered by using the statistical data from IFFN (2003). Proportion of forest, dry and wet grasslands and pond was 71.4, 15.7, 1.3 and 1.47 %, respectively. Forest fire in Yakutsk, 2002 burned 50279 km^2 which corresponds to 1.62 % of whole land area of Republic Sakha.

Gas fluxes during the fire and from the area with each land cover were estimated by combining the values from measurements and literatures. Field observation showed that the carbon release amount and emission ratios of CH_4 and N_2O to CO_2 during the fire in 2002 in Yakutsk well agreed with the values from literatures. Using the value of 12.2 tC/ha/y estimated by carbon release model for Siberian forest fire by Conard (2002), CO_2, CH_4 and N_2O emissions during the fire were estimated as 10.7 tC/ha/y, 0.0868 tC/ha/y and 0.00268 tN/ha/y, respectively. The net ecosystem production for CO_2 (tC/ha/y) was 1.40 in forest, -1.60 in dry grassland, 0.39 in wet grassland and -1.01 in pond. CH_4 flux (tC/ha/y) was -0.00013 in forest and -0.000068 in dry grassland, 0.096 in wet grassland and 0.237 in pond. N_2O flux (tN/ha/y) was 0.0000093 in forest, 0.000042 in dry grassland, 0.00095 in wet grassland and -0.000017 in pond.

The global warming potential (GWP) was calculated by using a 100-year time horizon recommended by IPCC (factors of 23 for CH_4 and 296 for N_2O). Total GWP uptake was 1.66 $MtCO_2$, of which CO_2 uptake of forest accounted for 99.9 %. On the other hand, total GWP emission was 0.820 $MtCO_2$, of which CO_2 emission from dry grassland and forest fire accounted for 50.5 and 34.8 %, respectively. Other major contributors were CH_4 and CO_2 emissions from pond of 5.60 and 2.84 %, respectively. In permafrost area, forest fire not only reduces CO_2 fixation of forests and emits greenhouse gases, but also changes the land cover from forest to pond then grassland, which stimulates green house gas emissions.