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Emission bursts of nitrous oxide and methane during the freeze-thaw cycle in the wetlands of Northeast China

J. B. Yu (1,3), J. S. Liu (1), J. D. Wang (1), W. D. Sun (2), F. X. Meixner (3,4)

(1) Key Laboratory of Wetland Ecology and Environment, Northeast Institute of Geography and Agricultural Ecology, Chinese Academy of Sciences. Changchun, 130012, P. R. China, (2) Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Wuhan, Guangzhou 510640, P. R. China, (3) Max Planck Institute for Chemistry, Biogeochemistry Department, P. O. Box 3060, D-55020 Mainz, Germany, (4) Physics Department, University of Zimbabwe, POBox MP 167, Mount Pleasant, Harare, Zimbabwe (JbYu@mpch-mainz.mpg.de / Fax: ++49-6131-305-579)

Recent studies indicate that in temperate climates about 70% of the total annual N_2O flux occurred within a few days during thawing. The nature of this remarkable emission burst is controversially discussed, it might be due to (a) the increased amount of microbial organic carbon, (b) soil nitrate (NO_3^-) liberated during freezing and consequently metabolized during thawing, or (c) enhanced biological processes.

From 2002 to 2004, we monitored N_2O and CH_4 fluxes from freshwater marshes (no standing water) at the Sanjiang Experimental Station of Marsh Wetland Ecology, Chinese Academy of Sciences, Heilongjiang province, China (47˚35′N, 133˚31′E). Static chambers have been applied to obtain fluxes in weekly to monthly intervals. The results show that N_2O and CH_4 emission fluxes increased slowly from May to July; then big emission bursts occurred in late July and early August followed by sharp declines; finally the emissions decreased gradually to zero level and changed even sign from late August to October. In mid July, emission peaks appeared about one week after the soil had thawed completely. Our results indicate, that significant amounts of N_2O and CH_4 originated from somewhere underneath the frozen layer, detailed observations trace the depth of production down to a 20 cm deep layer underneath the bottom of the frozen soil. This layer was continuously depressed downward during progressive freezing. At a depth of 90 cm, the highest concentrations of N_2O and CH_4 (1560

ppb and 5.5ppm, respectively) were firstly observed, and remained there with constant concentrations until June. We believe that the frozen soil limits the oxygen transport from the atmosphere into soil, while freezing increases the nutrient supplies which produce an anoxic organic-rich environment underneath the frozen layer. There, the formation of N_2O and CH_4 is facilitated through denitrification and anoxic digestion of organic matters, respectively.