

# **Symptom of Environmental Change in Siberian Permafrost Region**



**Proceedings of the International Symposium of  
JSPS Core to Core Program  
between Hokkaido University and  
Martin Luther University Halle-Wittenberg  
in 29-30 November 2005  
Sapporo, Japan**

**Editors:  
Ryusuke Hatano and Georg Guggenberger**

2006  
Hokkaido University Press  
Sapporo, Japan

Editors

Ryusuke Hatano

Professor

Hokkaido University

Georg Guggenberger

Professor

Martin Luther University Halle-Wittenberg

© 2006 by Hokkaido University Press

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from this publisher

Hokkaido University Press, Sapporo, Japan

ISBN 4-8329-0342-X

Printed in Japan.

## Preface

A joint research exchange program entitled ‘JSPS Core-to-Core Program’ for up-scaling the evaluation of the symptom of environmental change in Siberian permafrost region is being undertaken by Hokkaido University, Japan, and Martin Luther University Halle-Wittenberg, Germany, together with V.N. Sukachev Institute of Forest, Institute for Biological Problems of Cryolithozone, Permafrost Institute, and Institute of Soil Science and AgroChemistry, Siberian Branch of Russian Academy of Sciences under the funding support from Japan Society of the Promotion of Science (JSPS). The aim of this program is to establish a good collaboration among the researchers from Japan, German, and Russia and to develop and expand the collaboration to other countries in the future. We have been focusing our research activities on the conservation and rehabilitation of Siberian Taiga forests ecosystem under the influence of Climate Change.

With an objective to exchange our scientific research findings and the future research plans, we organized an international symposium on “Symptom of environmental change in Siberian permafrost region” at the end of November 2005 in Hokkaido University. This proceeding is the outcome of the symposium.

A large area of Siberia is characterized by permafrost. Although precipitation is often as low as in the dessert, water melted from the permafrost layer during the summer nurtures a large larch-Taiga area. The Siberian Taiga has been a carbon sink for a long time and has stored 500 Gt carbon, which is 21% of the total terrestrial carbon. Recently, however, forest burning in Siberia has occurred in an area of about 20 million ha every year, which is estimated to release as much CO<sub>2</sub> as the annual CO<sub>2</sub> emission of Germany or Japan.

There are many causes and feedback mechanisms controlling ecosystem functioning in Siberian permafrost ecosystems. The loss of vegetation alters the cycling of carbon and nitrogen, and stimulates melting of the permafrost due to change in heat balance. The melting of permafrost causes methane emission from the ice and increases the amount of soil water. These processes change the quality of soil and stimulate greenhouse gas emissions and nutrient discharge. Furthermore, a rise in temperature by the end of 21<sup>st</sup> century in Siberia is supposed to be one of the most pronounced globally. Degradation of the Taiga ecosystem is supposed to further stimulate the warming processes.

However, there are huge uncertainties in the quantitative evaluation of greenhouse gas emissions and nutrient discharge because of insufficient monitoring data. Thus, data collection of status quo and analysis of controlling factors of green house gas emissions and nutrient discharge are highly required to evaluate the effect of the disturbance of Siberian Taiga on global environmental change. The technique for scaling up of point data is also required to evaluate the large scale of Siberian permafrost region.

This proceeding includes 28 papers, which are grouped in 6 chapters: Greenhouse Gas Emissions, Carbon and Nitrogen Dynamics, Forest Disturbance and Management, Microbiological Functions, Geocryological Function, and Geographical Information. Although the knowledge and information presented here are still inadequate to understand the environmental change in Siberian permafrost region, we hope that the proceeding will be an initiation of exploring new horizons in the Siberian research.

This book is published by the support of JSPS Core-to-Core Program —Integrated Action Initiative-(Project No. 17001). We greatly appreciate it.

Ryusuke Hatano, Professor, Hokkaido University

Georg Guggenberger, Professor, Martin Luther University Halle-Wittenberg

# Contents

## Greenhouse Gas Emissions

1.	CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O fluxes from a larch forest soil in Central Siberia .....	1
	<i>Tomoaki Morishita, Yojiro Matsuura, Olga A. Zyryanova, and Anatoly P. Abaimov</i>	
2.	Greenhouse gas emissions from a Siberian alas ecosystem near Yakutsk, Russia .....	11
	<i>Fumiaki Takakai, Alexey R. Desyatkin, Larry Lopez, Ryusuke Hatano, Alexander N. Fedorov, and Roman V. Desyatkin</i>	
3.	Impact of soil temperature and soil moisture on GHG fluxes from an Eastern Siberian Taiga soil at Yakutsk, Russia .....	27
	<i>Takahiro Koide, Ryusuke Hatano, and Trofim C. Maximov</i>	
4.	Contribution of forest fire and land covers to emissions of CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O in Central Yakutia .....	39
	<i>Ryusuke Hatano, Fumiaki Takakai, Tomoaki Morishita, Gen Takao, and Roman V. Desyatkin</i>	
5.	Changes in surface methane flux after a forest fire in West Siberia .....	55
	<i>Tomoko Nakano</i>	
6.	Landscape controls of CH <sub>4</sub> fluxes and soil organic matter in a catchment of the forest tundra at the lower Yenissej .....	65
	<i>Heiner Flessa, Andrej Rodionov, Jens Dyckmans, and Georg Guggenberger</i>	

## Carbon and Nitrogen Dynamics

7.	The contribution of black carbon to the carbon storage in a permafrost ecosystem ....	75
	<i>Georg Guggenberger, Andrej Rodionov, Matthias Grabe, Oleg A. Kasansky, Olga Shibistova, and Heiner Flessa</i>	
8.	Soil organic carbon losses from seasonally-frozen soils of agricultural ecosystems in West Siberia for the 20 <sup>th</sup> century .....	85
	<i>Olga Rusalimova, Oleg Savenkov, Natalia Smirnova, and Pavel Barsukov</i>	
9.	Decomposition of labile and recalcitrant soil organic matter of Gleyic Cryosols in permafrost region of Siberia .....	93
	<i>Olga Rusalimova and Pavel Barsukov</i>	
10.	Comparative study on soil carbon storage of permafrost ecosystems in northeastern Eurasia .....	103
	<i>Yojiro Matsuura</i>	

11. Soil nitrogen dynamics in a larch forest, Central Siberia: A short review of preliminary results .....	109
<i>Satoru Hobara, Naoko Tokuchi, Kazuma Kondo, Anatoly Prokushkin, Muneto Hirobe, Yojiro Matsuura, Takuya Kajimoto, Akira Osawa, and Anatoly P. Abaimov</i>	
12. DOC in streams and soils in forested watershed underlain by continuous permafrost: a seasonal pattern .....	113
<i>Anatoly S. Prokushkin, Satoru Hobara, Irina V. Tokareva, Stanislav G. Prokushkin, and Anatoly P. Abaimov</i>	
13. Dissolved N <sub>2</sub> O and CH <sub>4</sub> in seepage and stream water in Yakutsk .....	123
<i>Takuji Sawamoto, Fumiaki Takakai, Alexey R. Desyatkin, Roman V. Desyatkin, and Ryusuke Hatano</i>	
14. Surface water chemistry in a continuous permafrost region, Central Yakutia, Eastern Siberia .....	129
<i>Osamu Nakahara, Fumiaki Takakai, Alexey R. Desyatkin, Ryusuke Hatano, and Roman V. Desyatkin</i>	
15. Fate of dissolved organic matter (DOM) in forest tundra soil systems with differing permafrost regime .....	135
<i>Masayuki Kawahigashi</i>	
16. Continuous measurement of soil respiration at a larch forest in Eastern Siberia .....	151
<i>Takashi Hirano, Larry Lopez, Yoshikazu Kobayashi, Takashi Machimura, Go Iwahana, Satoshi Tamura, Yuji Kodama, Alexander N. Fedorov, and Masami Fukuda</i>	

## **Forest Disturbance and Management**

17. Safe sites of larch seedlings in the lightly burnt forest in Eastern Siberia .....	159
<i>Tetsuo Shirota, Hideyuki Saito, Trofim C. Maximov, Alexander P. Isaev, Kunihide Takahashi</i>	
18. Future perspectives of forest management in a Siberian permafrost area .....	163
<i>Kunihide Takahashi</i>	

## **Microbiological Functions**

19. Both sand particles and organic substances enhance activity of free-living, nitrogen-fixing bacteria inhabiting soil of permafrost terrain in East Siberia .....	171
<i>Yasuyuki Hashidoko, Tomoya Ohchi, Ryusuke Hatano, and Satoshi Tahara</i>	
20. Effects of soil freeze-thaw cycles on microbial biomass and organic matter decomposition, nitrification and denitrification potential of soils .....	177
<i>Yosuke Yanai and Koki Toyota</i>	
21. Dynamics of CO <sub>2</sub> evolution of arctic soils from Northern Siberia and Scandinavia ....	193
<i>Manfred Bölter, Rolf Möller, Wiebke Müller-Lupp, and Nathalie Soethe</i>	

## **Geocryological Function**

22. Preliminary results of the micro-topographical change and its effects on the active layer in boreal forest near Yakutsk, Eastern Siberia ..... 207  
*Yuki Sawada*
23. Thermokarst transformation of soil cover on cryolithozone flat territories ..... 213  
*Roman V. Desyatkin and Alexey R. Desyatkin*
24. Present post-disturbance dynamics of permafrost in Central Yakutia ..... 225  
*Alexander N. Fedorov*
25. Salt and water movement in a Forest-Alas ecosystem in Central Yakutia, Eastern Siberia ..... 233  
*Larry Lopez, Anatoli Brouchkov, Hiroyoshi Nakayama, Fumiaki Takakai, Alexander N. Fedorov, and Masami Fukuda*
26. Influence of clear-cutting on thermal and hydrological regime in the active layer near Yakutsk, Eastern Siberia ..... 241  
*Go Iwahana, Takashi Machimura, Yoshikazu Kobayashi, Alexander N. Fedorov, and Masami Fukuda*

## **Geographical Information**

27. Disturbance and forest cover change mapping in Siberia with Earth observation ..... 255  
*Soren Hese, Christiane Schmullius, and the SIBERIA-II Team*
28. Use of remote sensing for estimating global warming potential at permafrost area in East-Siberia ..... 267  
*Sonoko D. Kimura, Gen Takao, Keiji Kushida, Fumiaki Takakai, Takahiro Koide, and Ryusuke Hatano*

- Index** ..... 277