geosciences

Editorial

Permafrost Landscapes: Classification and Mapping

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Received: 31 October 2019; Accepted: 5 November 2019; Published: 6 November 2019

Abstract: Permafrost landscapes occupy 25% of the world's land area. The formation, dynamics, and evolution of these landscapes are greatly controlled by permafrost processes and thus require special approaches to classification and mapping. Alases, pingoes, edoma, thermokarst mounds, stone streams, low-centre polygonal tundra, and other surface features are associated with the presence of permafrost. Permafrost degradation and greenhouse gas emission due to global climate warming are among the major potential dangers facing the world. Improvements in knowledge about permafrost landscapes are therefore increasingly important. This special issue, titled "Permafrost Landscapes: Classification and Mapping", presents articles on classification, mapping, monitoring, and stability assessment of permafrost landscapes, providing an overview of current work in the most important areas of cold regions research.

Keywords: permafrost landscape; classification; mapping; climate change; anthropogenic disturbance; satellite images; thermokarst; landscape stability

1. Introduction

Permafrost is closely related to landscapes. Landscapes are indicators of permafrost conditions and are linked to sediment ice content, ground temperature, and active-layer thickness. The landscape state, modification, and evolution determine the response of permafrost to anthropogenic impact and global climate change. Considering that 25% of the land area of the earth is underlain by permafrost, research into permafrost-affected landscapes is important and necessary.

Changes occurring in the cold regions draw much attention at present because the effect of recent climate warming is greater than elsewhere. The presence of permafrost with ice-rich surficial deposits makes the landscapes vulnerable to climate warming. Permafrost degradation causes the release of greenhouse gases that can facilitate further warming. Many environmental problems associated with permafrost depend on the dynamics and evolution of the landscapes. Environmental changes have social and economic consequences for people living in the far northern regions.

A publication of the special issue, "Permafrost Landscapes: Classification and Mapping", thus seems to be timely and important. As the first volume focusing on this topic, it is undoubtedly of great value. I hope that it will provide an impetus to further research in this area.

The special issue contains six articles published between November 2018 and August 2019 addressing permafrost-landscape classification, mapping, monitoring, and stability evaluation. Each manuscript was assessed via rigorous peer-reviewing from two or more esteemed experts in the respective field. Overall, the published papers already received four citations in the Web of Sciences and Scopus in the first few months after publication, proving the immediate impact of the published research.

2. Overview of the Special Issue Contributions

Desyatkin et al. [1] discuss the landscape development in thermokarst depressions (alases) in Central Yakutia. Thermokarst associated with permafrost degradation and thawing of ground ice is shown to drastically modify the landscape, produce new types of soil, and alter the biogeochemical cycles. A typical thermokarst depression is a closed system that accumulates all water-soluble substances, such as N/C and soluble salts. The authors identify three main landscape (soil and vegetation) microzones within the alas—steppe meadow, middle meadow, and wet meadow, which differ in the hydrothermal and physicochemical regimes, thaw depth, and greenhouse gas flux. Due to the abundance of organic matter, the alas meadows are significant sources of CO_2 and CH_4, especially in wet years. The dynamic nature of the alas landscapes, especially under the climate warming conditions, requires further research.

Monitoring is one of the primary methods in permafrost-landscape research. Badmaev and Bazarov [2] present a study of soil freezing and thawing processes in the southern margin of the permafrost zone in Transbaikalia, Buryatia, Russia. Their observations revealed spatial and temporal differences in the temperature dynamics that they refer to as the "mirror imaging" of the distribution of heat and cold (frost) in the studied soils of the permafrost zone.

The heat cycle in permafrost soils is an important characteristic in assessing the stability of permafrost landscapes. Kulikov et al. [3] present the scale of thermal energy resistance of permafrost landscapes to external influences. Permafrost soils are characterized by increased annual heat cycle, the value of which usually exceeds 300 MJ/m^2. This is due to the high heat consumption for the phase transformation of moisture, a portion of which always exceeds half of the annual heat cycle. In permafrost landscapes, elementary heat flows in the cold period dominate over flows in the warm period, and the authors use their ratio as a basis for assessing the stability of permafrost landscapes.

Permafrost-landscape mapping techniques are constantly being improved. Kalinicheva et al. [4] used the land surface temperature (LST) retrieved from Landsat-5 satellite images as a mapping parameter, along with commonly used identification parameters. The method was successfully applied to accurately differentiate between frozen and unfrozen areas in discontinuous permafrost on the slopes of Elkon Mountains and the Olekma-Chara Upland in southern Yakutia.

In permafrost research practice, landscape mapping comprises the preliminary stage of investigation. Typically, landscapes are used as indicators of permafrost conditions, and landscape maps provide a basis for permafrost mapping. The Permafrost-Landscape Map of the Republic of Sakha (Yakutia) on a scale of 1:1,500,000 presented in this issue [2] is an independent map that depicts both the cryolithology of permafrost with ice contents, as well as ground temperature and active-layer thickness. For this compilation, the authors used the overlay method linking geological, geomorphological, and biohydroclimatic factors.

Environmental problems associated with anthropogenic disturbance and global warming are of serious concern in the permafrost regions. Tumel and Zotova [5] present a case study of small-scale and large-scale mapping using the expert assessment method for evaluating permafrost-landscape stability on the basis of ground ice content, ground temperature, vegetation recoverability, and development of cryogenic processes. They also present small-scale evaluation maps showing the potential for cryogenic process occurrence in Russia.

3. Key Messages for Future Research

This special issue includes a limited number of articles, but they address very important problems in cold regions research. The permafrost-landscape studies reveal the relationships between permafrost conditions and landscape diversity, which can be used for assessing the environmental impacts and understanding the permafrost changes and evolution in the warming climate when contribution of each environmental factor becomes important for the stability of permafrost. The classification and mapping studies assist in understanding the current state and changes of cold region environments.

The presented studies suggest that some revision of the existing assessment and research methods would be required in future research. Earlier studies of CO_2 and CH_4 fluxes tended to focus on permafrost degradation, but it has become evident that more attention should be given to greenhouse gas emission from the alas landscapes [1]. Monitoring of the dynamics of permafrost landscapes and preliminary stability assessments will continue to be important and necessary [2,3]. The use of land surface temperature (LST) data from the Landsat-5 satellite in combination with other surface indicators has resulted in improvements in permafrost-landscape mapping [4] and has great potential for future applications. Permafrost-landscape classifications and maps [6] will be particularly useful in assessing the environmental impact of human activities and global warming in the cold regions. Small-scale and global ecological assessments of changes in permafrost landscapes [5] are necessary in the educational process. Given the wide audience and the possibility of popularizing knowledge about permafrost, it is necessary to pay attention to these methodological problems of mapping at this level.

Acknowledgments: The guest editor would like to acknowledge all the authors for contributing to the Special Issue and the anonymous peer reviewers for assessing the submitted manuscripts and greatly helping the authors to enhance the scientific quality of their papers. A special thank goes to Richard Li, *Geosciences* assistant editor, for valuable collaboration in the design and setup of the Special Issue.

Conflicts of Interest: The author declares no conflict of interest.

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