Geophysical Research Abstracts
Vol. 15, EGU2013-12371, 2013
EGU General Assembly 2013


# Changing Permafrost in the Arctic and its Global Effects in the 21st Century (PAGE21): A very large international and integrated project to measure the impact of permafrost degradation on the climate system

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The northern permafrost region contains approximately 50% of the estimated global below-ground organic carbon pool and more than twice as much as is contained in the current atmos-pheric carbon pool. The sheer size of this carbon pool, together with the large amplitude of predicted arctic climate change im-plies that there is a high potential for global-scale feedbacks from arctic climate change if these carbon reservoirs are desta-bilized.
Nonetheless, significant gaps exist in our current state of knowledge that prevent us from producing accurate assess-ments of the vulnerability of the arctic permafrost to climate change, or of the implications of future climate change for global greenhouse gas (GHG) emissions. Specifically:
• Our understanding of the physical and biogeochemical processes at play in permafrost areas is still insuffi-cient in some key aspects
• Size estimates for the high latitude continental carbon and nitrogen stocks vary widely between regions and research groups.
• The representation of permafrost-related processes in global climate models still tends to be rudimentary, and is one reason for the frequently poor perform-ances of climate models at high latitudes.

The key objectives of PAGE21 are:
• to improve our understanding of the processes affect-ing the size of the arctic permafrost carbon and nitro-gen pools through detailed field studies and monitor-ing, in order to quantify their size and their vulnerability to climate change,
• to produce, assemble and assess high-quality datasets in order to develop and evaluate representations of permafrost and related processes in global models,
• to improve these models accordingly,
• to use these models to reduce the uncertainties in feed-backs from arctic permafrost to global change, thereby providing the means to assess the feasibility of stabili-zation scenarios, and
• to ensure widespread dissemination of our results in order to provide direct input into the ongoing debate on climate-change mitigation.

The concept of PAGE21 is to directly address these questions through a close interaction between monitor-ing activities, proc-ess studies and modeling on the pertinent temporal and spatial scales. Field sites have been selected to cover a wide range of environmental conditions for the validation of large scale mod-els, the devel-opment of permafrost monitoring capabilities, the study of permafrost processes, and for overlap with existing monitoring programs. PAGE21 will contribute to upgrading the project sites with the objective of providing a measurement baseline, both for process studies and for modeling programs. PAGE21 is determined to break down the traditional barriers in permafrost sciences between observational and model-supported site studies and large-scale climate modeling. Our concept for the interaction between site-scale studies and large-scale modeling is to establish and maintain a direct link be-tween these two areas for developing and evaluating, on all spatial scales, the land-surface modules of leading European global climate models taking part in the Coupled Model Inter-comparison Project Phase 5 (CMIP5), designed to inform the IPCC process.

The timing of this project is such that the main scientific results from PAGE21, and in particular the model-based assessments will build entirely on new outputs and results from the CMIP5 Climate Model Intercomparison Project designed to inform the IPCC Fifth Assessment Report.
However, PAGE21 is designed to leave a legacy that will en-dure beyond the lifetime of the projections that it produces. This legacy will comprise
• an improved understanding of the key processes and parameters that determine the vulnerability of arctic

permafrost to climate change,
• the production of a suite of major European coupled climate models including detailed and validated representations of permafrost-related processes, that will reduce uncertainties in future climate projections pro-duced well beyond the lifetime of PAGE21, and
• the training of a new generation of permafrost scien-tists who will bridge the long-standing gap between permafrost field science and global climate modeling, for the long-term benefit of science and society.