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D4.2 Validation of permafrost modules implemented in AOGCMs

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Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the Consortium (including the Commission Services)	

D4.2 Validation of permafrost modules implemented in AOGCMs

Soil freezing is a major feature of boreal regions with substantial impact on climate. A scheme for the thermal and hydrological effects of soil freezing has been implemented in the land surface module ORCHIDEE of the fully coupled climate model IPSL-CM4. A detailed validation of this soil freezing scheme is documented in the manuscript:

Gouttevin I., G. Krinner, P. Ciais, J. Polcher, and C. Legout, 2011. Multi-scale validation of a new soil freezing scheme for a land-surface model with physically-based hydrology. Submitted to *The Cryosphere Discussions*, **5**, 2197-2252, doi:10.5194/tcd-5-2197-2011.

The manuscript has been submitted to *The Cryosphere Discussions* and is now going through the review process. The results of this work are briefly summarized below. The new soil freezing scheme is evaluated against analytical solutions and in-situ observations at a variety of scales in order to test its numerical robustness, explore its sensitivity to parameterization choices and confront its performances to field measurements at typical application scales.

It is shown that the appropriate vertical discretization to represent the thermal freezing dynamics is centimetric, and the appropriate freezing window is 1 to 2 °C wide. Furthermore, linear and thermodynamical parameterizations of the liquid water content lead to similar results in terms of water redistribution within the soil as a consequence of freezing.

The new soil freezing scheme considerably improves the representation of runoff and river discharge in regions underlain by permafrost and subject to seasonal freezing. A thermodynamical parameterization of the liquid water content appears more appropriate for an integrated description of the hydrological processes at the scale of the vast Siberian basins. The use of a subgrid variability approach and the representation of wetlands could help capturing the features of the Arctic hydrological regime with more accuracy.

The modelling of the soil thermal regime is generally improved by the representation of soil freezing processes. In particular, the dynamics of the active layer is captured with an increased accuracy by the soil freezing module, which is of crucial importance in the prospect of simulations involving the response of frozen carbon stocks to future warming. A realistic simulation of the snow cover and its thermal properties, as well as the representation of an organic horizon with specific thermal characteristics, are confirmed to be a pre-requisite for an accurate modelling of the soil thermal dynamics in the Arctic.