Contribution ID: **96** Type: **Oral Presentation**

The HiPerBorea project: permafrost modeling from the pore scale to the headwater catchment scale with open source, high performance computing tools

Wednesday, 15 May 2024 11:40 (15 minutes)

This presentation aims at giving an overview of the porous media related activities of the HiPerBorea project, an ANR-funded project in its 5th and last year. The objective of this project is to enable quantitative and predictive modeling of the evolution under climate change cold regions hydrosystems. Arctic and sub-arctic areas, which are highly vulnerable to global warming, are largely covered by permafrost –soil that is year-round frozen at depth. Permafrost-affected areas, which represent 25% of emerged lands of the northern hemisphere, are prone to major biogeochemical and ecological transformations due to permafrost thaw, with strong associated feed-backs on greenhouse gas cycling (degradation of previously permanently frozen organic carbon pools).[1] Permafrost thaw has also important impacts on local populations and activities, for instance by generating soil instabilities which damage infrastructures above[2]. In order to anticipate these major changes, there is a need of modelling tools of permafrost dynamics, i.e. of heat and water transfer in variably saturated and variably frozen soils. The considered porous media are constituted of four phases, the solid phase, the liquid water phase, the ice phase and the air phase. The freeze/thaw processes induce large and abrupt variations of the transfer properties of the porous media, such as hydraulic conductivity or thermal conductivity. Then the numerical resolution of this strongly coupled and non-linear problem requires fine spatial and temporal discretizations, and thus large computation times.[3] To tackle this issue, HiPerBorea develops and uses the cryohydrogeological simulator permaFoam, an OpenFOAM solver for permafrost modelling,[4],[5] aiming at quantifying the permafrost evolution under climate change at the headwater catchment scale.[6] Meanwhile, in order to assess the transfer properties of the porous media relevant to permafrost dynamics, pore-scale studies on water and heat flow are conducted using tomographical observations and direct numerical simulations as well as pore-network modelling.[7] The main outcomes of the HiPerBorea project will be presented, and open questions related to the upscaling of numerical results from the pore scale to the headwater catchment scale will be put forward. Finally, the perspective of applications of the developed approaches will be discussed.

Acceptance of the Terms & Conditions

Click here to agree

Student Awards

Country

France

Porous Media & Biology Focused Abstracts

This abstract is related to Porous Media & Biology

References

[1] Miner, K.R., Turetsky, M.R., Malina, E. et al. (2022). Permafrost carbon emissions in a changing Arctic. Nat Rev Earth Environ 3, 55–67. https://doi.org/10.1038/s43017-021-00230-3 [2] Hjort, J., Streletskiy, D., Doré, G. et al. (2022). Impacts of permafrost degradation on infrastructure. Nat Rev Earth Environ 3, 24–38. https://doi.org/10.1038/s43017-021-00247-8 [3] Walvoord, M.A. and Kurylyk, B.L. (2016). Hydrologic Impacts of Thawing Permafrost—A Review. Vadose Zone Journal, 15: 1-20 vzj2016.01.0010. https://doi.org/10.2136/vzj2016.01.0010 [4] Orgogozo L, Prokushkin AS, Pokrovsky OS, et al. (2019). Water and energy transfer modeling in a permafrost-dominated, forested catchment of Central Siberia: The key role of rooting depth. Permafrost and Periglac Process. 2019; 30: 75–89. https://doi.org/10.1002/ppp.1995 [5] Orgogozo L., Xavier T., Oulbani H., et al. (2023). Permafrost modelling with OpenFOAM®: New advancements of the permaFoam solver, Computer Physics Communications, 282, 2023, 108541, ISSN 0010-4655, https://doi.org/10.1016/j.cpc.2022.108541 [6] Xavier T., Orgogozo L., Prokushkin A.S., et al. (submitted). Future permafrost degradation under climate change in a head watershed of Central Siberia: quantitative assessment with a mechanistic modelling approach. [7] Cazaurang, S., Marcoux, M., Pokrovsky, et al. (2023). Numerical assessment of morphological and hydraulic properties of moss, lichen and peat from a permafrost peatland, Hydrol. Earth Syst. Sci., 27, 431–451, https://doi.org/10.5194/hess-27-431-2023

Primary authors: Dr ORGOGOZO, Laurent (Geoscience Environnement Toulouse (GET), CNRS, UMR5563, Toulouse, 31400, France); Dr XAVIER, Thibault (Geoscience Environnement Toulouse (GET), CNRS, UMR5563, Toulouse, 31400, France); Dr CAZAURANG, Simon (Geoscience Environnement Toulouse (GET), CNRS, UMR5563, Toulouse, 31400, France); Dr POKROVSKY, Oleg (Geoscience Environnement Toulouse (GET), CNRS, UMR5563, Toulouse, 31400, France / BIO-GEO-CLIM Laboratory, Tomsk State University, Tomsk, Russian Federation); Dr LOIKO, Sergey (BIO-GEO-CLIM Laboratory, Tomsk State University, Tomsk, Russian Federation); Dr PROKUSHKIN, Anatoly (V.N. Sukachev Institute of Forest SB RAS, Russian Federation); MARCOUX, Manuel (Institut de Mécanique des Fliudes de Toulouse); QUINTARD, Michel (Institut de Mécanique des Fluides de Toulouse)

Presenter: Dr ORGOGOZO, Laurent (Geoscience Environnement Toulouse (GET), CNRS, UMR5563, Toulouse, 31400, France)

Session Classification: MS17

Track Classification: (MS17) Complex fluid and Fluid-Solid-Thermal coupled process in porous media: Modeling and Experiment