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Arctic bryophytic cover seen as a porous medium: coupled experimental and numerical thermal properties' assessment

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Thermal regimes of arctic soils are strongly correlated to the presence of perennially frozen soil layers (permafrost). These soils undergo a cyclic annual freeze-thaw phenomenon with the formation of an active layer during summer. A complex patchwork of low vegetation layer consisting of Sphagnum moss, lichen, and peat covers this active layer. Such profiles are found in boreal regions for millions of km².
The latest IPCC reports show that arctic regions are highly vulnerable to climate change.
This vegetation cover proved to be crucial for modelling thermal soil regimes, both at watershed scale [1] and at continental scale [2]. This layer is the main interface between the atmosphere and the geosphere, through which energy and matter fluxes are mainly occurring by evapotranspiration [3]. Assessing morphological, hydraulic and thermal properties of this vegetation layer is thus compulsory to enhance predictive climate change impact models on boreal regions.
However, field measurements are difficult to conduct properly due to the large scale and the poor accessibility of the study area. To do so, some usual porous media study techniques (Representative Elementary Volume study, Pore Network modelling) has been applied in order to quantify morphological properties and hydraulic properties [4]. This first study showed the existence of Representative Elementary Volumes and that the bryophytic cover is highly porous and water conductive.

In the present work, the assumption to consider arctic vegetation cover as a porous medium is extended to thermal properties' assessment. A coupled experimental and numerical approach is set up to cross-validate the results found using both methods.
For this work, 12 dried samples extracted in 2018 at Khanymey Research Station (Siberia) are studied as well as some alive samples extracted from Clarens (Upper-Pyrenees). These samples consist of eight Sphagnum moss samples, two lichen samples and two peat samples.
The experimental setup is based on an enhanced version of the EN 12667 [5] norm for the assessment of thermal conductivity of highly thermal resistive material. Effective thermal conductivity and thermal diffusivity are extracted from thermocouple data and heat flux data coupled with infrared thermography. The values are then averaged to a continuous medium by bisection method.
A two-phase numerical simulation is after conducted on a macroscale tridimensional reconstruction of samples obtained by X-ray tomography.
Samples'thermal conductivity is then fitted to cope with the averaged continuous medium and leads to the cross-validation of the experiments.

The preliminary results show that most of the studied vegetal cover samples are thermally resistive, in-line with field measurements [6]. Infrared thermography shows high heterogeneity in thermal response. Yet, some further work is needed to better understand the linkage between water saturation and hydraulic and thermal properties'variability. Such study allows the generation of computationally-efficient boundary conditions of this bryophytic layer for large scale climate change impact models.

Participation

In-Person

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