EGU21-5400
https://doi.org/10.5194/egusphere-egu21-5400
EGU General Assembly 2021

A physical model demonstrating critical zone structure and flow processes in headwaters

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Equipped with complex terrain structure, physical models provide an alternative way in understanding and modeling how critical zone shapes hydrologic processes in headwaters for research and education in hydrology. However, this type of physical models is limited by frustrating rain-erosion or gully-erosion. Herein, in order to replace the real-world backfilling soil, we drew on the experience of normal concrete workmanship and adjusted the raw material's proportion for three times. And it is found that saturated hydraulic conductivity (SHC) and field moisture capacity (FMC) are both well correlated with bulk density (BD) for the developed materials in three cases. Thereby, based on the strongest correlation (R^2=0.75) between SHC and BD, two-layer alternative soil has been designed through altering BD in the physical model with complex terrain. The SHC values of alternative soil are close to that of the natural soil while the FMC values are far lower. Additionally, the non-uniform scaling of bedrock terrain was applied for the convenience of teaching and construction by zooming out a steep 0.31-ha zero-order basin 130 times horizontally and 30 times vertically. And multiple observation items, including free water level, temperature and humidity of soil, as well as outflow could provide potential opportunity to explore the role of single or combined critical zone's element in modulating streamflow. We'd like to share this effective tool to facilitate the development of critical zone science and enrich experimental teaching methods.