Geophysical Research Abstracts
Vol. 21, EGU2019-7038, 2019
EGU General Assembly 2019

Characterizing soil piping networks in Loess-derived soils using ground-penetrating radar

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Soil piping refers to the formation of sub-surface pipes due to the erosive action of water flowing through the soil. These natural pipes can be considered as the largest category of macropores and may form subterranean networks with significant hydrological connectivity. Despite their substantial impacts on water transfer in numerous locations around the world, the origin and hydrological functioning of soil pipes is not yet fully understood, in particular in Loess-derived soils. One of the main limitations regarding the study of this singular process for this purpose is the characterization of the pipe networks (defining the number, position, dimension and connectivity of pipes). In this context, non-invasive sub-surface imaging using ground-penetrating radar (GPR) seems to be a promising technique.

This research presents results from 3D, high-resolution GPR surveys performed in Loess-derived soils in order to characterize pipe networks with little prior information about their location. The adopted methodology relies on high spatial resolution scanning, 3D sub-surface imaging and automated detection of reflection hyperbolas using a 200 MHz centre-frequency antenna. Two small watersheds known to be affected by piping were investigated in Sippenaeken and Kluisbergen (Belgium). Over the two scanned zones, results revealed various continuous network patterns. Even though the most obvious patterns corresponded to recent or past anthropic activities (e.g., drainage pipes), validation tests confirmed that the chosen methodology may be used for pipe network characterization as the presence of two small pipes extending over tens of meters could be confirmed (a fairly small pipe was detected and validated over more than 100 m). Nevertheless, the presence of numerous artefacts and the high variability in size, depth and orientation of the pipes imply that GPR may only be effective at detecting pipes larger than those commonly observed at the present study sites (<10 cm in diameter). The results also point to the fact that operating at different frequencies may be advantageous to cope with such pipe variability.