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Spatial distribution and geophysical characterization of natural pipes in Ultisols

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Piping is a type of subsurface erosion caused by subsurface water and is considered one of the most difficult erosive processes to study. The nature of this erosion process makes it very difficult to study and quantify. The aim of this study was to characterize the surface and subsurface distribution of the pipes and to understand the network architecture of pipe systems in tropical forested areas. The study area is situated at the Experimental Station of Tupi, state of São Paulo, Brazil. We conducted a Digital Elevation Model allied to a superficial pipe mapping, and 2D and 3D geophysical surveys. The subsurface erosion identified by surface mapping and geophysical surveys appeared at two depths: one more superficial, in the upper part of the study area, and one at greater depth, in the lower part of the study area. The higher topographical positions presented the pipes at less developed stages (closed depressions and simple sinkholes), while the lower topographical positions showed the most advanced features (multiple sinkholes and blind gullies). The method of electroresistivity showed zones where low resistivity values correspond to water saturation (~ 70 ohm m) and high values (> 4040 ohm m) that define the pipe; this method was efficient in detecting the presence of collapsed and non-collapsed pipes. We concluded that the use of different methods (superficial and subsuperficial) was essential for the characterization of pipe systems. The integrated analysis of the results obtained from the superficial and 2D subsurface mapping allowed us to infer the spatial continuity of the pipes. The 3D geophysical survey was efficient in mapping soil pipe and the connectivity in situ. The 3D modeling of the pipes revealed the connection and connectivity of the pipe network's complexity and morphology.