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Computational study of smouldering combustion and the depth of burn in vertical samples of peat soils

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Smouldering combustion is the slow, low-temperature, flameless burning of porous fuels and the driving phenomenon of wildfires in peatlands. Smouldering fires propagate horizontally and vertically through organic layers of the ground and can reach deep into the soil. These threaten to release ancient carbon stored in the soil. Once ignited, they are particularly difficult to extinguish despite extensive rains, weather changes, or fire-fighting attempts, and can persist for long periods of time. In this work, we establish a computational model of a reactive porous media with the open-source code Gpyro to investigate the in-depth spread of smouldering fires into peat samples with varying profiles of moisture content, density, intert content and porosity. The model predicts the transient temperature, species, and reaction profiles during ignition, spread, and extinction. The results reveal that the depth of burn and the critical moisture content to sustain in-depth spread are not uniform but depend on fire conditions upstream of the column, the thickness of the moist layers and the thermal penetration of the drying front. The influences of the dry and moist layer thicknesses are investigated and the results compared to the experimental results with field organic soil samples published in the literature. The study allows to explain in heat transfer terms the previous observations of smouldering propagation in soils layers.