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Wildfires caused by self-heating ignition of carbon-rich soil

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Carbon-rich soils, like peat, cover more than 3% of the earth's land surface, and store roughly three times more carbon than the earth's plants. Carbon-rich soils are reactive porous materials, prone to smouldering combustion if the inert and moisture content are low enough. An example of carbon-rich soil combustion happens in peatlands, which are prone to wildfires both in boreal and tropical regions and where combustion is a commonly seen phenomena. The experimental work presented here focuses on understanding one of the ways carbon-rich soil can ignite. The ignition phenomenon is known as self-heating, which is due to soil undergoing spontaneous exothermic reactions in the presence of oxygen. In this work we investigate the effect of soil inorganic content by creating under controlled conditions soil samples with inorganic contents ranging from 3% to 86% of dry weight. Combining oven experiments with the Frank-Kamenetskii theory of ignition, the lumped kinetic and thermal parameters are determined. We then use these parameters to upscale the laboratory experiments to soil layers of different depths for a range of ambient temperatures ranging from 0 °C to 40 °C. Experimental results show that self-heating ignition in the different soil layers is possible. The kinetic analysis predicts the critical soil layer thicknesses required for self-ignition. For example, at 40 °C a soil layer of 3% inorganic content can be ignited through self-heating if it is thicker than 8.8 m. This is also the first experimental quantification of soil self-heating showing that indeed it is possible that wildfires are initiated by self-heating of the soil.