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New insights from high spatio-temporal measurements at the pedosphere-atmosphere interface

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The pedosphere-atmosphere interface provides the focus of critical zone science. Its temperature acts as a master variable which drives terrestrial ecohydrological, biogeochemical and micrometeorological processes, regulating carbon storage and release, water use efficiency, metabolic processes and species competition. These responses are characterised by complex non-linear interactions that are defined by short lived extremes or spatially isolated events rather than averaged environmental conditions. Despite this, our state-of-the-art characterisation of sub canopy surface temperatures is determined though isolated, spatially discrete thermal logging instrumentation that has been widely applied for decades. Using northern peatlands as an exemplar ecosystem, we explore the thermal behaviour of this critical interface at a high spatiotemporal resolution. Peatland systems are globally important ecosystems for the cycling and storage of carbon and freshwater, accounting for one third of the global soil carbon pool and 10% of the liquid surface freshwater. These systems exhibit high spatiotemporal variability in species compositions, biogeochemical and hydrological processes. Through a unique experimental design, sub canopy surface temperatures were measured with the application of Fibre Optic Distributed Temperature Sensor (DTS) technology. Approximately 10 million measurements of sub canopy surface temperatures were obtained across as 10×10 m forested peatland plot under undisturbed, felled (tree canopy removed) and cleared (sub canopy removed) conditions over a period of eight days. We highlight the small scale spatial and temporal variability in temperatures, ranging by up to 35oC at a given point in time. Through integration with intensive high spatial resolution characterisation of canopy and surface properties pre and post disturbance, we highlighted the primary controls on this thermal response, its spatial organisation and variability. We explore the extent to which this small scale spatial complexity and organisation drives critical zone science and consider the extent to which understanding of such small scale variability is required to accurately understand the emergent plot to landscape scale fluxes and their responses to disturbances.