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Development, calibration, and performance of a novel biocrust wetness probe (BWP) measuring the water content of biological soil crusts and surface soils

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The surface layer of soils as transition zone between pedosphere and atmosphere plays a crucial role in exchange processes of nutrients, atmospheric gases and water. In arid and semiarid regions, this uppermost soil layer is commonly colonized by biological soil crusts (biocrusts), which cover about 46 million km^2 worldwide being highly relevant in the global terrestrial carbon and nitrogen cycles. Their water status is of major concern, as activity of these poikilohydric organisms is directly controlled by their water content. On-site analyses of both bare and crusted soils thus are urgently needed to correctly model exchange processes of water, nutrients and trace gases at the soil surface.

In this study we present the biocrust wetness probe (BWP), which is the first low-cost sensor to reliably measure the water content within biocrusts or the uppermost 5 mm of the substrate. Using a weak alternating current, the electrical conductivity is assessed and an automatic calibration routine allows calculating the water content and precipitation equivalent of the surface layer over time.

During one year of continuous field measurements, 60 BWPs were installed in different types of biocrusts and bare soil to measure at 5-minute intervals in the Succulent Karroo, South Africa. All sensors worked reliably and responded immediately and individually upon precipitation events. Upon completion of field measurements, soil and biocrust samples were collected from all measurement spots to compile calibration curves in the lab. In most soil and biocrust samples the water content rose linearly with increasing electrical conductivity values and only for few samples an exponential relationship was observed. Measurements revealed characteristic differences in biocrust and soil wetness patterns, which affect both the water regime and physiological processes in desert regions.

Thus BWPs turned out to be well suited sensors for spatio-temporal monitoring of soil water content, allowing for modeling of soil water fluxes, nutrient allocation and growth.