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Proximal remote sensing to quantify plot-scale overland flow connectivity

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Irrigation of crops and grazed pastures can lead to harmful losses of nutrients via overland flow across the edge of the field. While good irrigation design can assist with avoiding overland flow, soil surface conditions can change rapidly and lead to surface flow even under well-designed irrigation systems. Therefore, real-time methods to detect emerging flow conditions, early enough to prevent substantial flow from the field during irrigation, is a potential mitigation option. But these methods require a prediction of the initiation of overland flow conditions in order to make the connection with real-time observations.

On a naturally-rough agricultural soil, triggering of overland flow is primarily related to the process of gradual filling of small (~50 mm across) depressions. As depressions fill, hydraulic connections are established with their neighbours and this eventually leads to sufficient connectivity that overland flow is initiated. The initiation of overland flow generally occurs at a critical value of connectivity (C_{OF}); the proportion of the soil surface that is connected via a water-filled pathway to an exit point of the field. As water ponding in, and flowing through, local depressions increases, the C_{OF} of the field increases and this leads to flow across the field boundaries. Quantifying the development of C_{OF} during an irrigation event, therefore, is key to predicting the initiation of overland flow.

We propose a method to continuously monitor the development of C_{OF} during an irrigation event that requires two elements. The first is a new proximal sensing technique, which exploits acoustic technology to continuously monitor A_{sw}, the proportion of the soil surface covered in water. The acoustic method comprises directional acoustic transmitter and receiver arrays. The directionality of the arrays provides a well-defined footprint area on the ground beneath the instrument. The A_{sw} can be reliably estimated from changes in the amplitude of reflected sound waves. The second element is a ponding and redistribution model which simulates the flow of water over a rough soil surface and assists by converting A_{sw} into C_{OF}.

Our preliminary results show that this real-time method of monitoring C_{OF} has a considerable scope in a variety of environments where prediction of overland flow initiation is desirable.