Geophysical Research Abstracts
Vol. 17, EGU2015-11507, 2015
EGU General Assembly 2015

Comprehensive soil surface characterisation by RADAR

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The characteristics of the soil's surface have been revealed to be extremely relevant for soil surface processes. Texture, aggregates and roughness are interdependent across scales and have a strong influence on infiltration, runoff generation, water flow velocity as well as on particle detachment and transport. They also have shown to be relevant for splash detachment and initialisation of concentrated flow. But these soil surface characteristics are also highly variable during erosive events, and thus, their impact on the processes mentioned above may change.
Therefore it is necessary to develop methods for a comprehensive and quantitative characterisation of the soils' surface across scales.
Here, we present a first approach using a frequency modulated polarimetric radar to characterise different surfaces (from flat to rough in a scale of cm to dm size of the roughness elements) and of different materials (steel plates as strong reflector, sand [0.5-1 mm], fine [2-4 mm] and coarse [15-30 mm] rock fragments.
The radar is a prototype built by IMST GmbH (Kamp-Lintfort, Germany), emitting on the 24 GHz band, allowing for a frequency modulation between 500 and 2500 MHz with variable ramp times. The emission is on a circular clockwise polarisation, whilst it is able to receive both, clockwise and counter-clockwise polarisations.
We tested also the dependency of the reflected signals on imaging position and angle, as well as on the different emission parameters, such as amplitude modulation and ramp time.
The results show that the angle of acquisition influences clearly the received signal intensity (in both polarisation directions). This implies the need to develop topographical corrections for further applications. In addition we could observe a significant influence of the device position on the results, which implies, on one hand, a high sensitivity relating to the soil's surface, but on the other hand it leads to a high level of uncertainty.
The reflection characteristics of the different targets, as expressed by the median and the standard deviation of the intensity of both received polarisations, allow the differentiation of different roughness levels. In addition, the radar signals allow also the differentiation of the different mineral substrates. Thus, the radar system shows a capability to characterise soil surface characteristics at different scale levels between mm and dm size of the elements. But until now, the signal composition and their evaluation did not make it possible to develop a clear index for the different surface properties. This makes the development of further evaluation routines mandatory, but also the development of comprehensive indexes for characterising soil surface roughness.