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Irrigation experiments at the Salar Grande (N-Chile) – improving our understanding of hillslope processes in the Atacama Desert

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While rates of hillslope processes and soil formation are known to be typically very low or stagnant under the hyper-arid conditions of the Atacama Desert, information on process rates and the influence of protective gypsum crusts on hillslope morphodynamics is scarce. Within the framework of the DFG-funded CRC 1211 "Earth – Evolution at the dry limit" (sub-projects C03 and Z03), irrigation experiments are thus carried out in order to provide new insights into precipitation thresholds for surface runoff and/or hillslope dynamics. For this purpose, we designed a portable irrigation device allowing for simple handling and easy setup by 2 to 4 persons even in remote places and moderately steep hillslopes. A 3 x 6 m aluminium pavilion is used to attach the spraying nozzles in 2 m height covering the 2 x 5 m irrigation plot. A stainless steel runoff channel at the lower end of the plot enables measuring and sampling of potential surface runoff. With uniformity coefficients of 86 % (high-pressure setup) and 74.2 % (low-pressure setup), calibration measurements document a rather homogeneous rainfall distribution of the circular spraying cones to the rectangular plot. Thus, together with spraying nozzle and drop distribution characteristics, the conditions of the experimental setting are assumed semi-natural.

First field experiments were carried out in the eastern Salar Grande basin (21°S, 70°W, northern Chile) in March and September 2017, where hyper-arid climate conditions prevail at least since the early Miocene, but where geomorphological evidence for hillslope activity is given by tongue-like, 70 m-long and 30 m-wide fine sediment lobes along a 10-20°steep slope. Two different setups were applied: the setup with lower impact works with a pressure of 1 bar, a water flow of about 12 l/min and six nozzles, reaching artificial rainfall intensities of 0.77 $l/m^2/min$ (46 $l/m^2/h$). The second configuration operates with 10.5 l/min, a pressure of 0.5 bar and eight nozzles, resulting in smaller spraying cones and increased drop sizes with a stronger splash-effect, while maintaining overall rainfall intensities of ∼46 $l/m^2/h$. Soil moisture was monitored during and after the experiment using a HydraProbe sensor. Finally, based on a series of high-resolution photos taken before, during and after irrigation, we aimed at documenting surface runoff and, ultimately, at quantifying potential surface displacements by point cloud comparison derived from structure-from-motion techniques. While infiltration was 100 % and none of the experiments initiated surface runoff and/or induced (detectable) slope displacements, soil moisture increased from 0 % to 12 % down to 8 cm below surface (b.s.) directly after the irrigation. Subsurface moisture then gradually moved downwards reaching 6 % in 16 cm b.s. six days after the experiment. Future work will comprise further irrigation experiments at various sites in the Atacama indicated by geomorphological evidence of past and present hillslope activity.