Monitoring of short term geoelectric tracer experiments to investigate the shallow interflow in small alpine micro-catchments

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Preferential subsurface runoff processes in soil and the geological substrate are still poorly understood at different scales. Dominant runoff processes in alpine catchments due to extreme precipitation can be analyzed either by field experiments or model simulations. But only a combination of both approaches will bring a sufficient insight in the characteristic of interflow processes. At the moment only few models are available, enabling considerations of soil and substrate characteristics in a near process manner. But for routine applications in flood estimation in practice, easy to use precipitation runoff models, describing runoff processes close to reality, are urgently needed. Therefore a step to a solution for bridging the knowledge deficits between plot scale and catchment scale as well as the requests of the practitioners in precipitation/runoff modeling is necessary.

Within the still ongoing project "Assessment of bandwidths of shallow interflow in alpine catchments (SHALLOW INTERFLOW)" financed by the Austrian Academy of Science (ÖAW), Commission of Hydrology, investigations on the interdependency of precipitation and storage capacity / near surface runoff potential of different groups of substrates in the Eastern Alps by use of a combination of different investigation methods in the field have been carried out so far in three catchment areas of the eastern Alps. For rain simulation, a transportable spray irrigation installation for large plots (50 m² up to 1200 m²) for simulating long term rain events was used to generate long term rain events on representative geological substrates of the Eastern Alps at four different test sites.

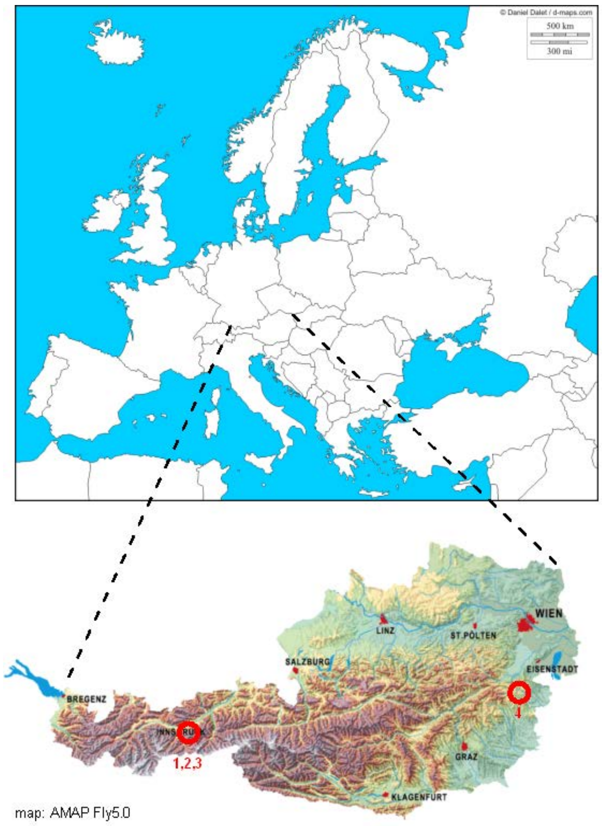

Fig. 1: Location of test sites in Austria.

The locations of the test sites are depicted in Figure 1. During the field experiments interflow velocities are measured with different measuring devices (TDR-waveguides, FD-probes, geoelectrics, changes of conductivity in antecedent water courses, and others) for the assessment of bandwidths of lateral and vertical conductivity during and after long-lasting rainfall. In this study the bandwidth of near surface interflow and subsurface water flow has been investigated on different hillslope complexes at the military training centre Lizum/Walchen in Tyrol (test sites 1,2,3) and in a region in Lower Austria (test site 4). The experimental layout is exemplified in Figure 2 (test site 1, 2, 3).

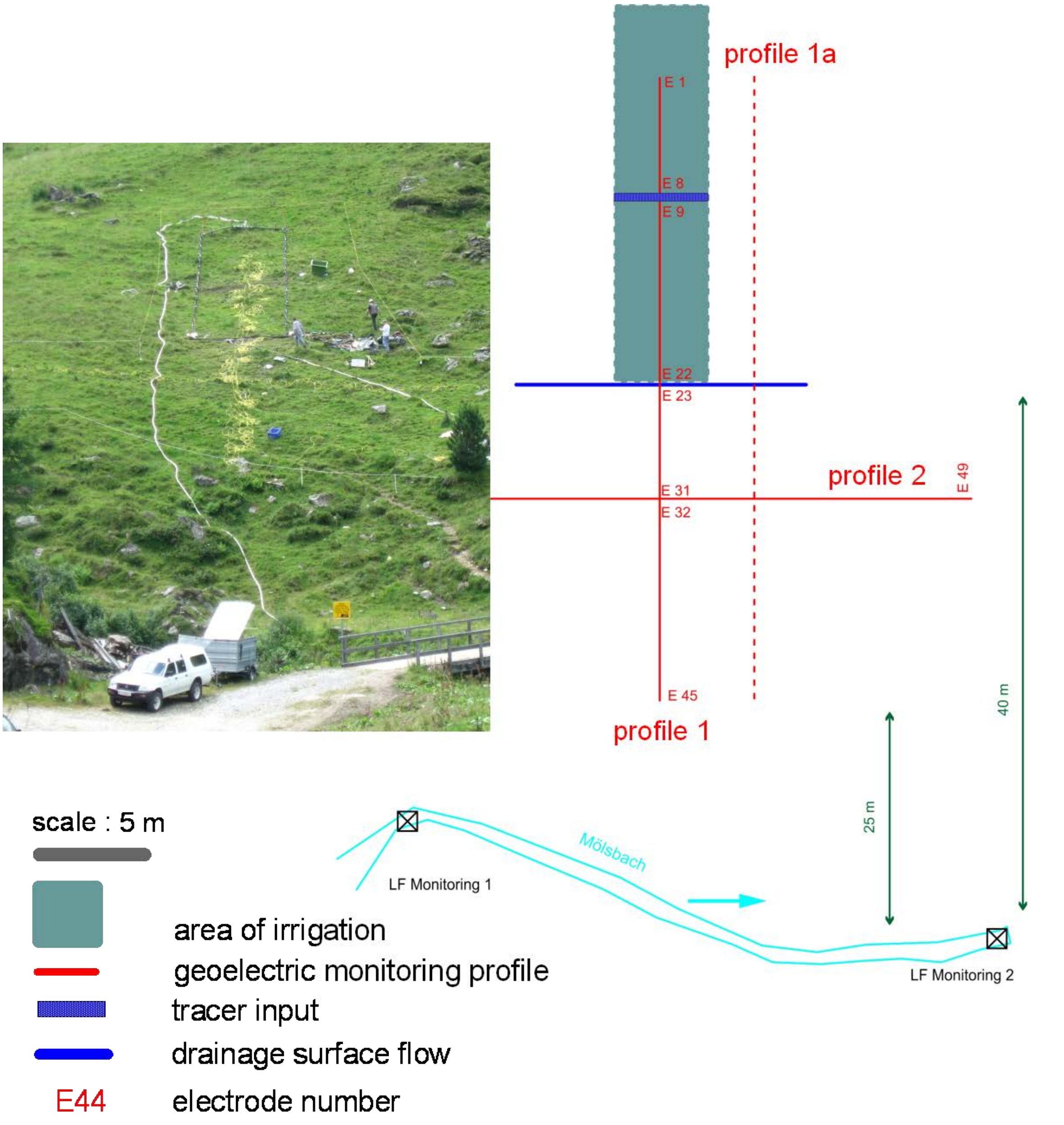

Fig. 2: Exemplified experimental layout (here: test site 1) for the assessment of shallow interflow velocities.

High amounts of precipitation (about 250 mm) – partially in combination with salt tracer - have been applied within a few days with the transportable spray irrigation. Surface runoff was registered and changes in soil moisture were measured with buried TDR-waveguides – arranged in four profiles from 15 cm to 115 cm soil depth in maximum. Expansion of the wetting front has been documented by different geoelectric profiles, which were measured periodically before, during and after the rain simulation experiments. Figure 3 illustrates the results of geoelectric monitoring (difference plots to base measurement) of electrical conductivity for test site 1. The first profile at 09:53 shows no difference to the first measurement at 14.07. 08:54, before precipitation and salt tracer. After salt tracer input and irrigation for few hours the effect of the salt tracer movement is obvious. Also the short-term triggering of the interflow water course after restarting the precipitation is clearly visible. After 6:43 hours after the last irrigation, the effect of the salt tracer almost disappeared and is, aside from the lower part of the slope, only observable at the position of the trench and the drainage of the surface flow.

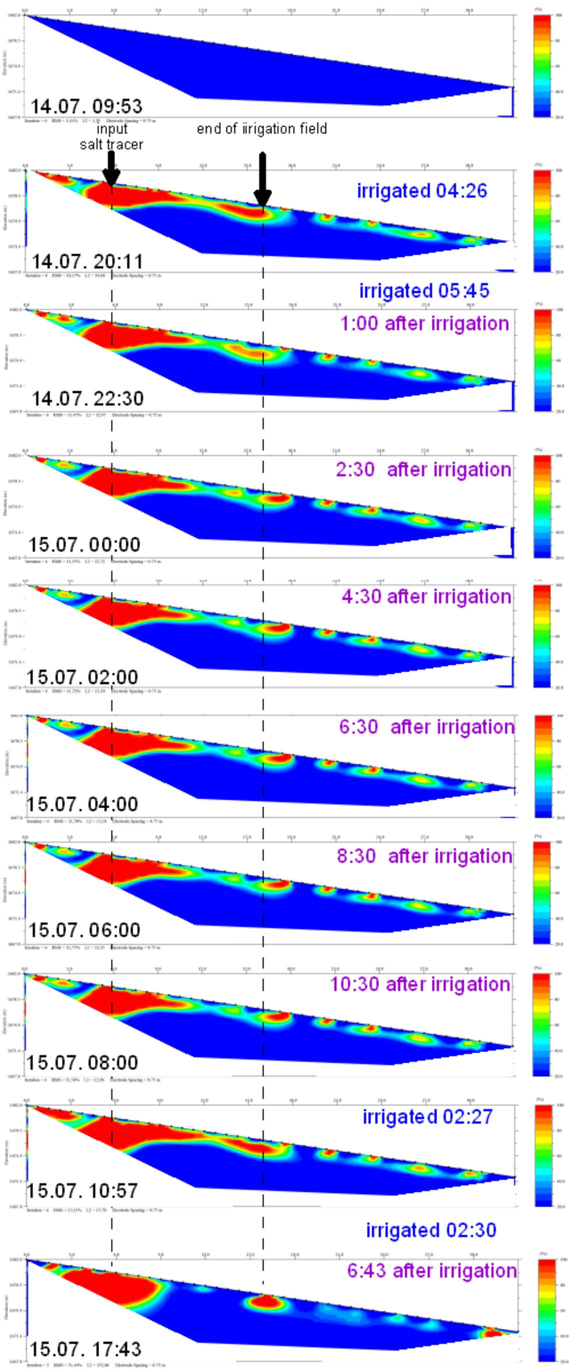

Fig. 3: Results of geoelectric monitoring of test site 1, profile 1 (difference plots of electr. conductivity to base measurement).

A similar experiment was carried out in the eastern part of Austria. The experimental layout for test site 4 is exemplified in Figure 4.

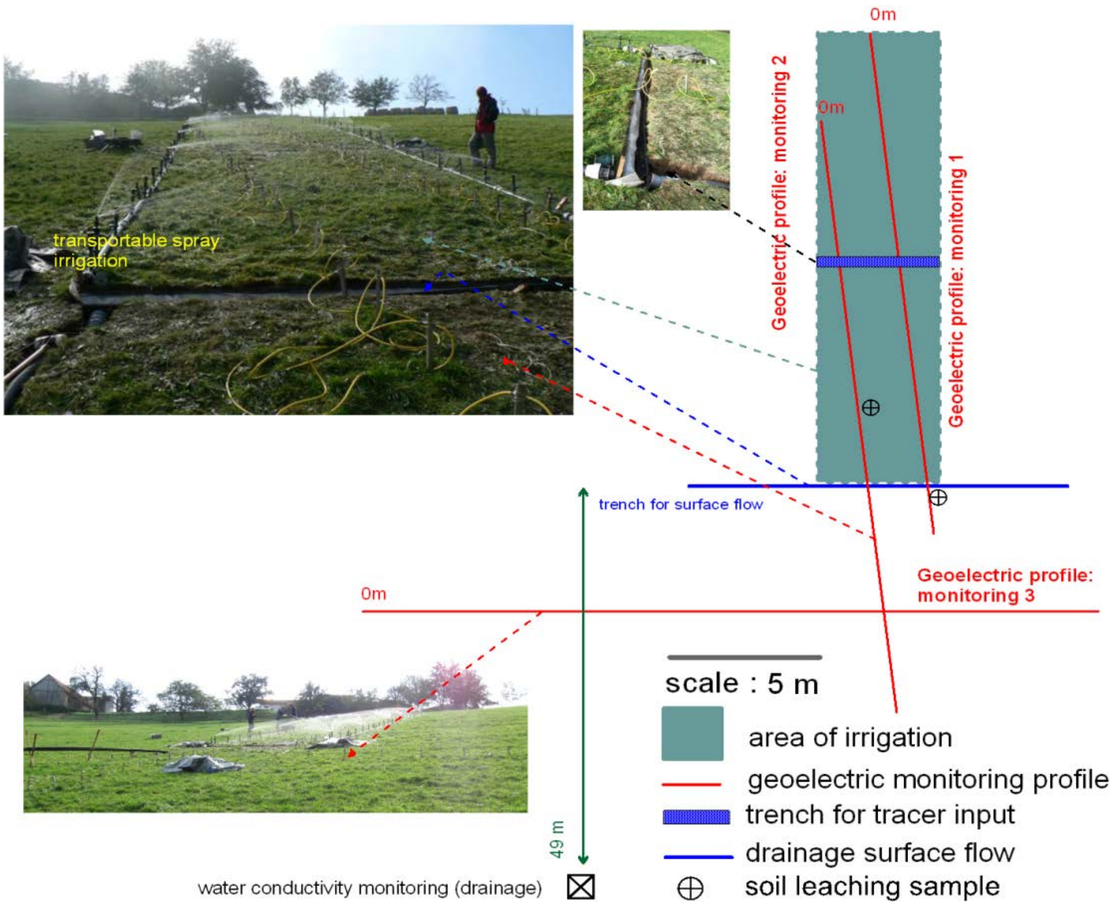

Fig. 4: Test arrangement for test site 4.

Figure 5 depicts the results of geoelectric monitoring (difference plots to base measurement) of electrical conductivity (and TDR measurements) for test site 4. The interpretation of the time lapse results show that already after 1 hour of precipitation, 20.10 14:30 – before the salt tracer input – the effect of the interflow is evident. With the input of the salt tracer, the differences enlarge. Also the dynamic of the interflow behavior can be derived from the time lapse results. After the irrigation stops, interflow decreases rapidly and vice versa. Also a 2D profile of the preferential flow path was interpreted. This geoelectric time lapse interpretation could be confirmed by the TDR profile and a soil sample leaching.

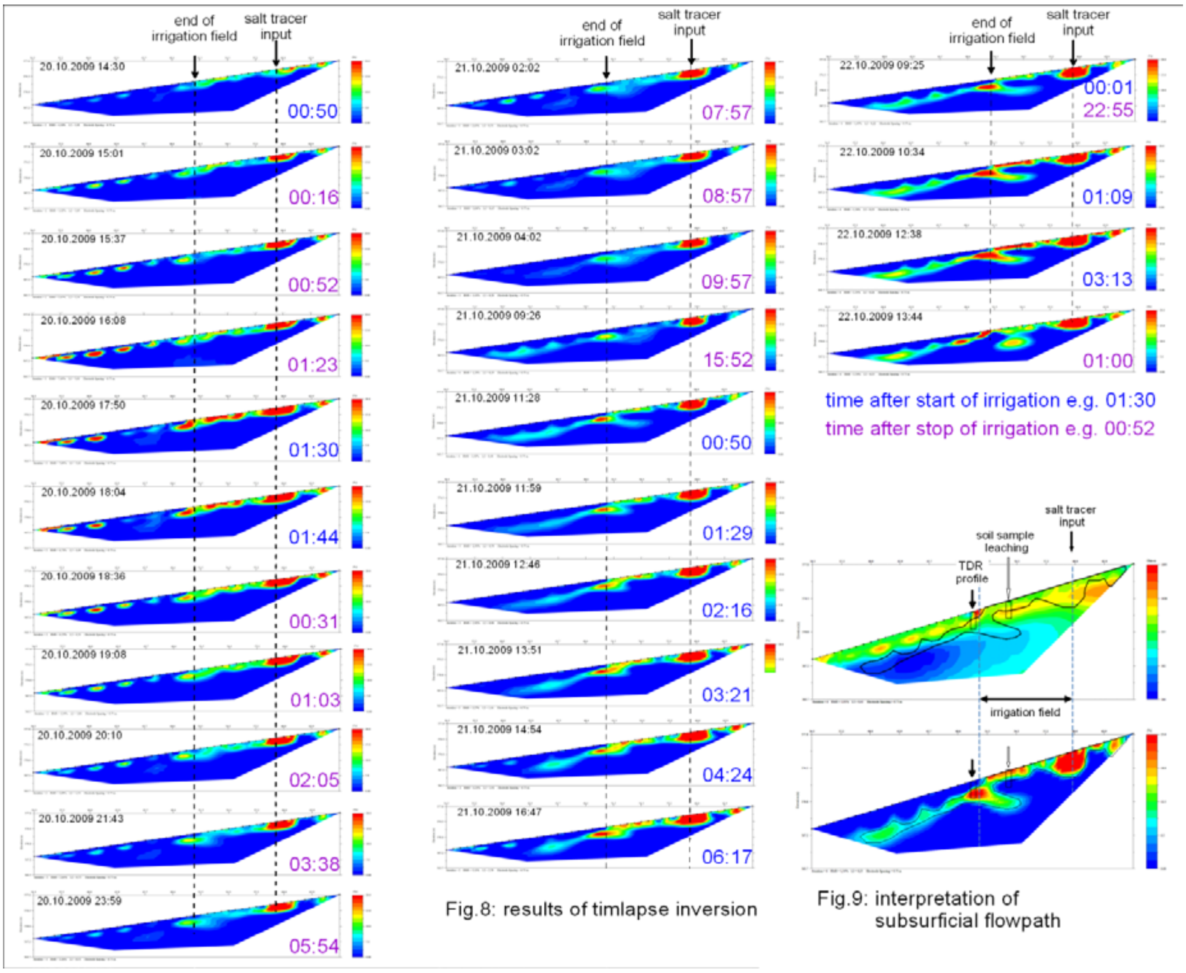

Fig. 5: Results of geoelectric monitoring of test site 4, profile 1 (difference plots of electr. conductivity to base measurement).

Table 1 shows the results of the estimation of shallow interflow velocities (SIV) from different field experiments for different substrata.

Location	Substratum	Method	SIV (m/h)
Wattener Lizum	carbonate talus	conductivity probe	25
	moraine	geoelectric, TDR	1 – 2
	alluvial fan,silty	geoelectric	0,4
Bromberg	weathered mica slate	geoelectric	0,3 – 0,75

Tab. 1: Results of the derived interflow velocities for different substrates.

On very high permeable substrates (group 1), results from tracer measurement of changes in conductivity at the receiving water course forms an easy and appropriate means for receiving reliable values of interflow velocities. E.g. at the test site P2 mean velocities about 25 m h^{-1} were measured. For permeable to very low permeable substrates (group 2) an integrated test arrangement (rain simulation, geoelectrics, soil moisture measurements, measurement of

conductivity at the receiving water course) allows detailed quantification of interflow velocities and detection of potential preferential flow paths.
Within the ongoing project the following further research work is aspired:

- Characterization of further substrates.
- Areal extension of parameters with geoelectrics & aerogeophysics.
- Test of P/R- Models - Recalculation of runoff events under long term rain conditions.

The investigations jointly offered by the Geological Survey of Austria (GBA) and the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW) can make a significant contribution for optimization of input parameters for well-established precipitation/runoff models in practical use. Based on data derived from the here described investigations, shallow interflow velocities for a selection of the most important groups of geological substrates are presented. This information will allow a better understanding of the dominant runoff processes in the prevailing groups of substrates and will lead to a better assessment of runoff contributions from different sub-catchments.

By use of these improved parameters results of well established precipitation/runoff-models (e.g. Time/Area-Concept, ZEMOKOST, HEC-HMS) in practice shall be optimized. The project shall also form the beginning of the development of a catalogue / handbook for assessment of interflow velocities which will be permanently under enhancement.

The report finishes with an overview on the state of research on the theme “Contributions of quick interflow to catchment runoff in persistent rain“ and suggestions for future development of field research on determination of input parameters of practical relevance for precipitation / runoff models.