Rainfall Simulator Workshop

30 June – 01 July 2011
Trier, Germany

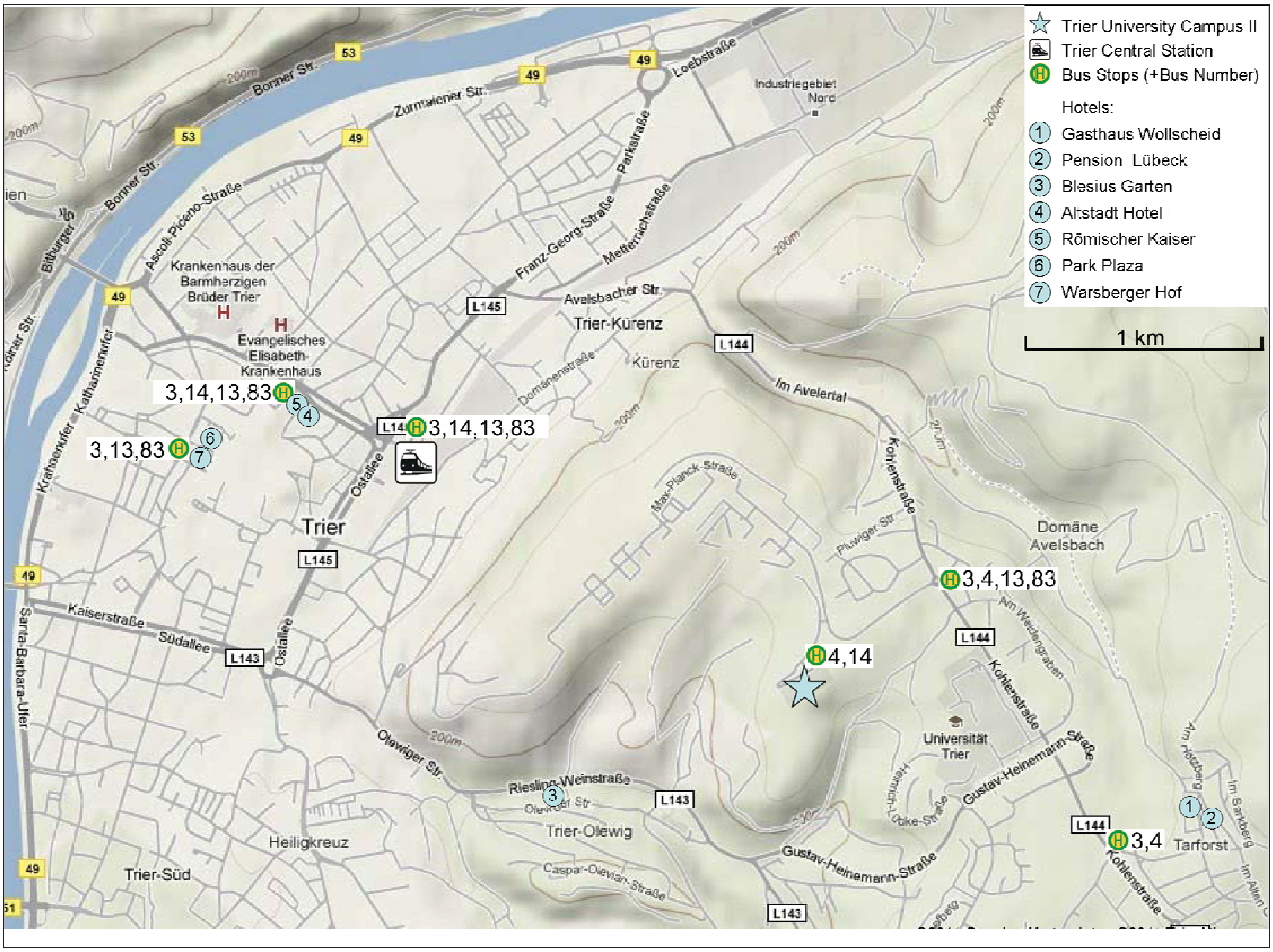
Department of Physical Geography • Trier University
Campus II • Behringstraße • 54286 Trier, Germany

Proceedings

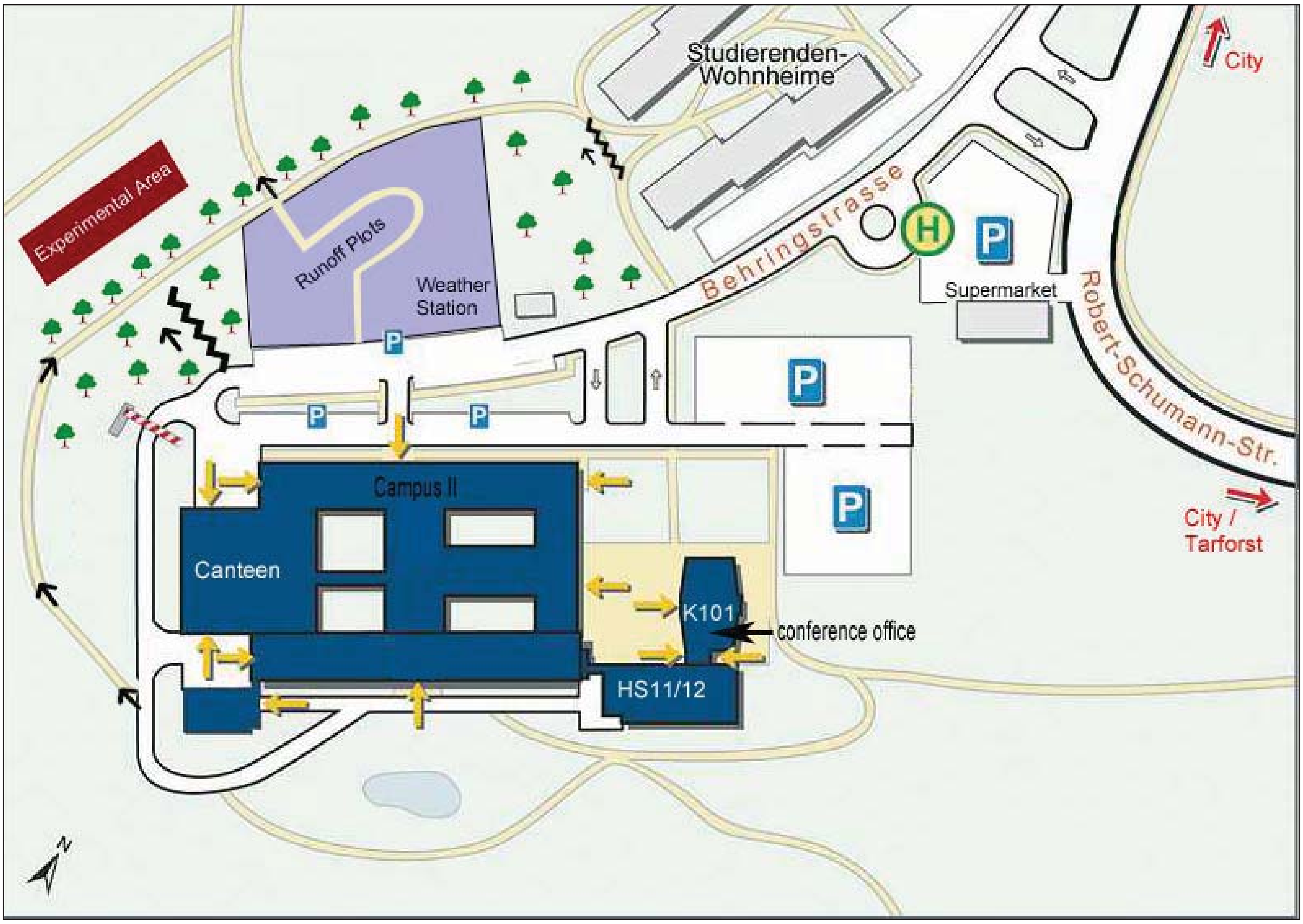
Physische Geographie DFG Deutsche Forschungsgemeinschaft Universität Trier

Rainfall Simulator Workshop

Map 1: City of Trier



Map 2: Campus II, Trier University



Workshop Programme

Wednesday 29.06.2011: 19:00 Ice-Breaker (Room: K101)

Thursday, 30.06.2011

09:00 – 10:30 Oral Session I (Room: K101) Chairman: João L.M.P. de Lima

09:00 – 09:20	***Johannes B. Ries**: Opening*
09:20 – 09:50	***Donald Gabriels:*** Key note lecture
09:50 – 10:10	***Marcus Schindewolf** & Jürgen Schmidt:* Assessing EROSION 2D/3D soil parameters using a small-scale rainfall simulator and upstream runoff device
10:10 – 10:30	***Artemi Cerdà** & A. Giménez Morera & F. Á. González Peñaloza & F. J. León Miranda:* Rainfall simulators to be use under field conditions. The SEDER (Soil Erosion and Degradation Research Group) contribution

10:30 – 11:00 Coffee Break

11:00 – 12:00 Oral Session II (Room: K101) Chairwoman: Maite Echeverría Arnedo

11:00 – 11:20	***Frédéric Darboux** & Bernard Renaux & Lionel Cottenot:* The Indoor Rainfall Simulator of INRA-Orléans (France)
11:20 – 11:40	***Thomas Scholten** & Christian Geißler & Peter Kühn:* A new splash cup to measure the kinetic energy of rainfall
11:40 – 12:00	***Uta Ulrich** & Antje Dietrich & Cindy Hugenschmidt & Nicola Fohrer:* Transport behaviour of selected herbicides in surface runoff during intermittent rainfall

12:00 – 13:00 Lunch

13:00 – 16:30 Rainfall Simulation Experiments (Experimental Area)

Small Portable Rainfall Simulators from Basel, Freiberg, Trier, Tübingen, Valencia, Wageningen, Zaragoza

16:30 – 17:00 Coffee Break

17:00 – 18:30 Poster Presentation with Discussion (Room: K101) Chairman: Markus Casper

***F. Javier León** & C. Álvarez, & D. Badía & M. Echeverría & C. Martí & F. Peréz Cabello & P. Ibarra:* Rainfall Simulations and Forest Fires by the group of Zaragoza (GEOFOREST)

***Gil Eshel** & Shaheen Awieenat & Eli Argaman & Naftali Goldshlager & Shmuel Arbel & Roey Egozi:* The rotated disc rainfall simulators

***Sarah Pariente** & Eyal Sachs:* Runoff generation on arid soil under natural and laboratory conditions

***Anna Smetanova** & Markus Dotterweich & Nicola Fohrer:* Examining erodibility of biochar and terra preta substrates (Preliminary results)

***Sevastel Mircea**:* Utilization of the runoff plots in selecting the best crops on the arable slopes in Romania

***Roman Juras** & Jiří Pavlásek & Pavel Děd:* Simulation of rainonsnow events by rainfall simulator

***Verena Butzen** & M. Seeger & M. Casper & C. Müller & M. Hümann & J.B. Ries*: Variability of surface processes in Central European forested areas - an experimental approach

***Christine Brings** & Rosemarie Cordie & Johannes B. Ries*: Recent geomorphodynamics in the vicinity of the Vicus Belginum / Hunsrück

***Marco Hümann** & Steffen Schobel & Christoph Müller & Raimund Schneider:* A rainfall simulator for characterising dominant runoff processes on the scale of hillside segments

***Daniel Peter** & Johannes B. Ries & Irene Marzolff & Sebastian d'Oleire-Oltmanns:* Surface Runoff and Soil Erosion in agro-industrially used Landscapes between High and Anti-Atlas

19:00 Dinner (Gasthaus Wollscheid, Trier-Tarforst)

Workshop Programme

Friday, 01.07.2011

08:40 – 10:00 Oral Session III (Room HS11/12) Chairman: Donald Gabriels	
08:40 – 09:00	***Wolfgang Fister*** *& Thomas Iserloh & Miriam Marzen & Manuel Seeger & Reinhard-G. Schmidt & Johannes B. Ries:* Experimental investigation of in situ soil erosion rates by wind-driven rain
09:00 – 09:20	***J.L.M.P. de Lima****:* Using a rainfall simulator in the laboratory to study sediment transport and overland flow generated by moving storms
09:20 – 09:40	***Nikolaus Kuhn*** *& Harald Hikel & Wolfgang Schwanghart & Aaron Yair:* Experimental investigation of climate change effects on plant available water on rocky desert slopes
09:40 – 10:00	***Naftali Goldshleger****:* Soil reflectance as tool for assessing physical crust arrangement in typical soils from Israel and the USA

10:00 – 10:30 Coffee Break

10:30 – 12:30 Methods & Results (Experimental Area + Room HS11/12) Chairman: Artemi Cerdà	
10:30 – 11:30	***Thomas Iserloh*** *& Johannes B. Ries:* Presentation of rainfall calibration methods (Experimental Area)
11:40 – 12:00	***Thomas Iserloh*** *& Johannes B. Ries:* Calibration of small portable rainfall simulators (Room HS11/12)
12:00 – 12:30	***J.B. Ries & T. Iserloh & A. Cerdà & M. Echeverría Arnedo & W. Fister & Ch. Geißler & B. Hahnewald & N. Kuhn & F.J. Leon Miranda & P. Peters & M. Schindewolf & J. Schmidt & T. Scholten & M. Seeger***: Results of rainfall simulation experiments (Room HS11/12)

12:30 – 13:30 Lunch

13:30 – 16:00 Open Discussion Session (Room: HS11/12) Chairman: Manuel Seeger

→ Discussion about standardized calibration methods for the artificially generated rainfall.
→ Discussion about ways towards a better comparability of the results (runoff, infiltration and eroded material).

16:00 – 16:30 Coffee

19:00 Dinner with wine tasting (Gebr. Steffes, Waldrach)

Saturday, 02.07.2011

Excursion: Trier and its environs; guided by Dr. R. Hansen
(Time and venue will be announced)

Abstracts

Opening Speech

Johannes. B. Ries

Dep. of Physical Geography, Trier University

In erosion research, rainfall simulations are used for the improvement of process knowledge as well as in the field for the assessment of overland flow generation, infiltration, and erosion rates. In all these fields of research, rainfall experiments have become an indispensable part of the research methods. In this context, small portable rainfall simulators with small test-plot sizes of one square-meter or even less, and devices of low weight and water consumption are in demand. Accordingly, devices with manageable technical effort like nozzle-type simulators seem to prevail against larger simulators. The reasons are obvious: lower costs and less time consumption needed for mounting enable a higher repetition rate. Regarding the high number of research questions, of different fields of application, and not least also due to the great technical creativity of our research staff, a large number of different experimental setups is available. Each of the devices produces a different rainfall, leading to different kinetic energy amounts influencing the soil surface and accordingly, producing different erosion results. Hence, the questions for the methodical discussion panel during the workshop contain the definition, the comparability, the measurement and the simulation of natural rainfall and the problem of comparability in general.

Another important discussion topic will be the finding of an agreement on an appropriate calibration method for the simulated rainfalls, in order to enable a comparison of the results of different rainfall simulator set-ups. In most of the publications, only the following „nice“ sentence can be read: *"Our rainfall simulator generates a rainfall spectrum that is similar to natural rainfall!".* The most substantial and critical properties of a simulated rainfall are the drop-size distribution, the fall velocities of the drops, and the spatial distribution of the rainfall on the plot-area. In a comparison of the most important methods, the Laser Distrometer turned out to be the most up-to-date and the best measurement method for drop-spectra and drop fall velocities. The measured rainfall amounts resulting from the different methods differ by two orders of magnitude, due to the different exposure times and measuring areas, and thus the efficiency also ranges between 0.2 and 108 %. This also shows that a standardized method for the calibration of simulated rainfall should be determined.

As a third point, the three major challenges for the experimental soil erosion research of the Physical Geography Department in Trier will be presented: 1) Influence of land-use and treatments, 2) Influence of Sheep (goat) trampling and 3) Influence of wind-driven rain. The presented results indicate increases of the sediment yields due to wind influence between 113 % and at the maximum even 1100 %, that equals one order of magnitude.

The main conclusions of this opening presentation are:

- Rainfall simulations are an adequate tool for soil erosion studies with different experimental set-ups.
- A calibration of the simulated rainfall is necessary, and an appropriate method should be found in the discussion at this workshop.
- Rainfall simulations with small portable simulators show discriminative results depending on land-cover types and treatments.
- Wind-driven rain increases the soil erosion rate, while the runoff stays almost unaffected. This fact has to be considered for the interpretation of rainfall simulation results gained excluding wind influence, as it is usually the case.

Physische Geographie DFG Deutsche Forschungsgemeinschaft Universität Trier

Use of field and laboratory rainfall simulators
for assessing the factors of the soil erosion process.

Donald Gabriels

UNESCO Chair of Eremology
Department of Soil Management, Ghent University, Belgium.
donald.gabriels@UGent.be

Rainfall simulation is used extensively in field and laboratory research for understanding and assessing the factors governing the soil erosion process including both the runoff and the soil loss or sediment transport processes. Among the main advantages are: (a) the ability to take many measurements quickly without having to wait for natural rain; (b) to be able to work with controlled rain, thereby eliminating the erratic and unpredictable variability of natural rain.
Any consideration of using rainfall simulators must start by defining exactly what information is required. The aim of using a rainfall simulator is not only 'simulating' a rainfall event but also to combine the power of the rainfall to cause runoff and erosion with the ability of the soil (or the land) to withstand that rain. This ability can be expressed in terms of 'infiltrability' and 'land or soil erodibility'. The ability of the rain to cause runoff and erosion can be called 'rain erosivity'. The susceptibility of the soil to runoff and erosion is a function of both the soil characteristics (infiltrability, texture, structure..) and soil management systems(topography, soil cover, soil tillage, practice..).

Rainfall simulation can help in assessing the effect on runoff and erosion of one soil characteristic or soil management system by keeping the others constant and this under controlled conditions of rainfall erosivity. This approach is rather difficult to attain under natural rainfall conditions because measurements of runoff and soil losses from natural sites need long periods of time in order to allow representation of a large variety of rainfall events and soil surface conditions.

Simulated rain is used to study the properties of a particular material, the impacts of a particular management practice, or can be used to the understanding of a particular process of infiltration, runoff or erosion.
Rainfall simulation will speed up the runoff and erosion process during short periods of time. This can be done in the field as well as in the laboratory.

The International Centre for Eremology, with the UNESCO Chair on Eremology and the Department of Soil Management, Ghent University, Belgium has a long time experience on the use of rainfall simulators in the laboratory, in the field and with the combined rainfall simulator/windtunnel unit for inclined rainfall research on runoff and erosion.

The final goal of rainfall simulator research should be the collection of accurate, useful data, not trying to develop a 'perfect' rainfall simulator.

Assessing EROSION 2D/3D soil parameters using a small-scale rainfall simulator and upstream runoff device

Marcus Schindewolf and Jürgen Schmidt

Technical University Freiberg, Soil and Water Conservation Unit,
Agricolastrasse. 22, D-09599 Freiberg, Germany
Corresponding author's full contact details:
Tel.: +49 3731 39 2679; fax: +49 3731 39 2502,
marcus.schindewolf@tbt.tu-freiberg.de

The specific soil parameters of erosion models as resistance to erosion, hydraulic roughness etc. are usually determined by simulated rainfall experiments. Due to the required plot length of usually 22 meters (USLE standard plots) these experiments can only be carried out with an enormous effort of time and manpower. In this study we present a small scale-rainfall simulator enhanced by a runoff feeding device, which multiplies the plot length virtually by supplying sediment loaded runoff from upstream. Thus it is possible to restrict the plot length to 3 m and nevertheless simulate flow conditions similar to those using standard plots. The described method has been already tested successfully under laboratory conditions. In the present study this method is used to determine input parameters for the soil loss and deposition model EROSION 2D/3D under field conditions. Based on the model parameters "soil resistance to erosion and surface roughness" the experimental approach is described exemplarily. The experimental results demonstrate that results from large-scale rainfall simulations with plot's length of 22 m can be reproduced successfully.

Keywords:
rainfall simulator, infiltration, resistance to erosion, surface roughness, tillage practices

Rainfall simulators to be use under field conditions.
The SEDER (Soil Erosion and Degradation Research Group) contribution

Artemi Cerdà[1], Antonio Giménez Morera[2], Félix Ángel González Peñaloza[1] and Francisco Javier León Miranda[3]

[1]*Soil Erosion and Degradation Research Group. Departament de Geografia, Universitat de València, Av. Blasco Ibáñez, 28, 46010 València. artemio.cerda@uv.es; felix.gonzales@uv.es*
[2]*Departamento de Economía y Ciencias Sociales, Escuela politécnica superior de Alcoy, Universidad Politécnica de Valencia. Paseo del Viaducto, 1, 03801 Alcoy (Alicante) Spain. angimo1@doctor.upv.es*
[3]*Departamento de Geografía y Ordenación del Territorio. Universidad de Zaragoza, Departamento de Geografía y Ordenación del Territorio, Universidad de Zaragoza, Pedro Cerbuna, 12, 50009-Zaragoza. fjavierlmiranda@gmail.com*

The Soil Erosion and Degradation Research Group have twenty years of research experience applying simulated rainfall. The rainfall simulators that are being used are sprinklers that can apply the rainfall on variable surface areas and in rugged terrain. The facilities used by the SEDER group are nozzles, detachable iron structures, wind protectors, pumps, and tubes that allow the researchers to perform rainfall simulations at different intensities and areas.

All the rainfall simulators uses are based on metal frames (7500 x 2500 x 2000 mm) with telescopic legs, which were detachable for easy transport. All equipment is covered with plastic during water applications to reduce the effect of wind on droplet dispersion. A diesel, electrical and manual pumps are used to supply water to the nozzles.

Very fine scale (0.25 m^2) experiments. The 0.25 m^2 circular (radius of 22.5 cm) plots use a one-nozzle (Hardi-1553-12), that has a Christiansen coefficient ((1 – variation coefficient) x 100) of 91% under laboratory conditions at 1.45 bars pressure, is used to apply deionized water at a constant pressure from a 2 m height. Mean drop size was 2.63 mm with a mean drop velocity of 3.5 m s^{-1}, and mean kinetic energy of 7.5 J m^{-2} mm^{-1}. A simulated rainfall intensity of 35-80 mm h^{-1} can be applied for 1 hour to a 1 m^2 area (0.25 m^2 study plot and a 0.75 m^2 buffer) using the protocols discussed in Cerdà (1997; 1999). All plots were surrounded by 1 mm thick galvanized iron sheet (1 mm thick x 100 mm height x 140 mm length) as a border, and fitted with a 20 mm drain pipe (outlet) to collect runoff samples downslope from the plot.

Fine scale (1.0 m^2) experiments. A three-nozzle (Hardi-1553-12) rainfall simulator, having a Christiansen coefficient of 85.7% under laboratory conditions, is used to apply deionised water from a 2 m fall height to twelve paired 1 m^2 plots (6 with ant mounds and 6 controls). Mean drop size was 2.68 mm with a drop velocity of 3.78 m s^{-1} and kinetic energy of 9.34 J m^{-2} mm^{-1} at a pressure of 1.75 bars. Simulated rainfall of 68.2 mm h^{-1} for 1 hour was applied to twelve 3 m^2 areas (1 m^2 plot and 2 m^2 buffer). Each rectangular plot (1250 mm x 800 mm) was surrounded by galvanized iron with a PVC collector of 800 mm long and 150 mm wide and 100 mm deep to collect runoff samples downslope from the plot.

Medium scale (12 m^2)

A two nozzle lechler 461.008 rainfall simulator is used to apply deionised water to six paired 12 m^2 plots (3 with ant mounds and 3 controls), according to the protocols in Cerdà (1998). This simulator had a Christiansen coefficient of 82.9 % under laboratory conditions at a pressure of 0.78 bars. Mean drop size was 2.57 mm, with a drop velocity of 3.98 m s^{-1} and kinetic energy of 10.5 J m^{-2} mm^{-1}. Simulated rainfall of 69.3 mm h^{-1} was applied to a 32 m^2 area (12 m^2 plot and 20 m^2 buffer) from a 2 m height for 1 hour using a pressure of 1.3 bars. This nozzle has been used in other studies, but at lower operating pressures (Salles and Poesen, 1998; Oostwoud et al., 1999). The 2 m x 6 m rectangular plots were surrounded by 1 mm thick galvanized iron sheets (1 mm x 100 mm x 2000 mm) with a 2000 mm long, 150 mm wide, and 100 mm deep collector. A drain pipe (outlet) was used to collect runoff samples below each plot.

Runoff measurements. Runoff water was collected from each plot at 1-minute intervals, and sediment concentration measured every 5 minutes. Time to runoff (t_r) was taken as the time from beginning of the water application to when runoff began to occur on the plot surface (Cerdà and Doerr, 2008; Cerdà and Jurgensen, 2008). Time to ponding (t_p), an indicator of soil wettability, was measured from the onset of the rainfall initiation to the development of ponds on ca 40 % of the plot surface area. Sediment concentration was determined either by dessication or filtering

References:

Cerdà, A. 1998a. Effect of climate on surface flow along a climatological gradient in Israel. A field rainfall simulation approach. Journal of Arid Environments 38, 145-159. doi:10.1006/jare.1997.0342

Cerdà, A. 1999a. Parent material and vegetation affect soil erosion in eastern Spain. Soil Science Society of America Journal 63, 362-368

Cerdà, A., Doerr, S.H. 2010. The effect of ant mounds on overland flow and soil erodibility following a wildfire in eastern Spain. Ecohydrology, DOI:10.1002/eco.147.

Cerdà, A., Jurgensen, M.F. 2008. The influence of ants on soil and water losses from an orange orchard in eastern Spain. Journal of Applied Entomology 132, 306–314.

Cerdà, A.., Doerr, S.H. 2008. The effect of ash and needle cover on surface runoff and erosion in the immediate post-fire period. Catena 74, 256- 263. doi:10.1016/S0341-8162(02)00027-9

Oostwoud Wijdenes, D.J., Ergenzinger, P. 1998. Erosion and sediment transport on steep marly hillslopes, Draix, Haute-Provence, France: an experimental field study. Catena 33, 179-200.

Paton, T.R., Humphreys, G.S., Mitchell, P.B. 1995. Soils: a new global view. Yale University Press, New haven.

Salles, C. Poesen, J. 1999. Performance of an optical spectro pluviometer in measuring basic rain erosivitty characteristics. Journal of Hydrology 218, 142-156.

Cerdà, A., Ibáñez, S. & Calvo, A. 1997. Design and operation of a small and portable rainfall simulator for rugged terrain. Soil Technology, 11, (2) 161-168.

The Indoor Rainfall Simulator of INRA-Orléans (France)

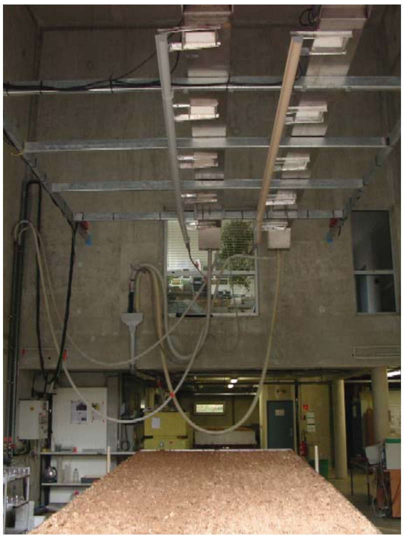
Frédéric DARBOUX, Bernard RENAUX and Lionel COTTENOT

(contact: Frederic.Darboux@orleans.inra.fr)
INRA, UR 0272 Science du sol, Centre de recherche d'Orléans,
CS 40001, F-45075 Orléans Cedex 2, France.

The indoor rainfall simulation laboratory of INRA Orléans allows to work in controlled experimental conditions all year round. It has been used mostly for environmental studies including hydraulics, soil erosion, pesticide or phosphorus transfer and compost lixiviation. It reproduces spatially-uniform rainfalls with an oscillating-nozzle system for areas up to 10 m². It can be setup for rainfall intensities ranging from 5 to 100 mm/h. Drop sizes can be adjusted by changing the nozzles. Based on the original design of Foster *et al.* (1979), this rainfall simulator uses 2 troughs. By default it is fed by rain collected from the rooftop and stored in a tank but deionised water or tap water can also be used.
The rainfall simulator has been funded by INRA (French Institute for Agronomical Research) and Région Centre and it has been operating since 2002. The facility is opened to research teams from both private and public sectors. Its use costs between 500 to 2000 € per day of rainfall. Users can benefit from all the measurement devices available within the soil science research laboratory. This includes an instantaneous-profile laser scanner (to measure soil microtopography with a sub-millimetric resolution), laser diffraction granulometry (to measure the particule size distribution of samples), tensiometers (to measure water pressure within the samples), optical and electronic microscopes. Often, users have limited knowledge of capabilities and limitations of rainfall simulators. Hence, their experimental procedure needs to be thoroughly discussed before the actual experiment is carried out.

<u>Reference:</u>

Foster, G. R.; Eppert, F. P. & Meyer, L. D. (1979) A programmable rainfall simulator for field plots Proceedings of the Rainfall Simulator Workshop. Tucson, Arizona. March 7-9, Agricultural Reviews and Manuals, ARM-W-10. United States Department of Agriculture - Science and Education Administration, Oakland, CA, 45-59



The rainfall simulation building (left) and the rainfall simulator (right)

A new splash cup to measure the kinetic energy of rainfall

Thomas Scholten[1], Christian Geißler[1] and Peter Kühn[1]

[1]*Institute of Geography, Eberhard Karls University Tübingen, Germany*

Splash cups have long been successfully used for both the quantification of kinetic energy of rainfall and the detachability of soil particles by rainfall impact, the so-called “splash erosion”. Measurements of kinetic energy, however, have been difficult to operate in the field especially in remote areas, on steep slopes and in forests since boundary conditions need to be controlled precisely. We introduce a new splash cup based on Ellison’s archetype that reliably and accurately measures kinetic energy as a function of sand loss under a large variety of conditions. The Tübingen splash cup (T splash cup) is relatively easy to operate under harsh field conditions and it can be used in experimental designs with a large number of plots and replications at reasonably low costs. The cup is constructed from plastic laboratory flasks and plastic pipes from water supply equipments. The unit sand is held by a removable carrier system that can easily be replaced in the field. The splash cups have been calibrated in combination with a laser distrometer using a linear regression function with $r^2 = 0.98$. They measure kinetic energy over a wide range of rainfall intensities from 0.6 to 40 $l*m^{-2}*h^{-1}$. Kinetic energy per area varies between 10 and 250 $J*m^{-2}$. Two years of field test measurements in a subtropical forest ecosystem in China proved the reliability, durability and usability of our new splash cups and allowed detecting differences in kinetic energy between different tree species and biodiversity levels.

Transport behaviour of selected herbicides in surface runoff during intermittent rainfall

Uta Ulrich, Antje Dietrich, Cindy Hugenschmidt and Nicola Fohrer

Institute of the Conservation of Natural Resources, Department of Hydrology and Water Resources Management, Christian-Albrechts-University Kiel, Germany

The significance of surface runoff transporting pesticides from agricultural fields to non-target areas is documented in several studies as well as simulated with different models. Especially the contamination of water bodies with pesticides has the potential to cause adverse effects on aquatic life in water bodies, constraining the ecosystem functions and services reversibly or even irreversibly or contaminating drinking water. The main processes governing the loss of pesticides on the soil surface are runoff and erosion. As pesticide dislocation via surface runoff is a phenomenon which also occurs in lowlands, it is essential to evaluate the processes taking place under these conditions.

Representing lowland characteristics, soil-filled containers (80x90x40 cm) with a slope of 6 % were exposed to intermittent artificial rainfall of 13 mm/h, with six days of rainless period between rainfall events. A capillary rainfall simulator (A=1 m²) installed 8.5m above the soil-filled containers provided the artificial rain. During one-hour rainfall events, runoff was sampled at 10-minute intervals. The samples were analyzed for volume of the water phase, sediment weight and herbicide concentration of the water phase. Fates of Metazachlor, Terbuthylazine and Flufenacet were observed.

Maximum concentrations in the water phase of the surface runoff were 3184 µg Metazachlor/l, 661 µg Terbuthylazine/l and 207 µg Flufenacet/l. Herbicide losses amounted to 345 - 440 µg Metazachlor/0.2 m² (plot), 310 - 318 µg Terbuthylazine/0.2 m² and 87 - 111 µg Flufenacet/0.2 m². These loads correspond to 1.92 % and 2.5 % (Metazachlor), 5.7 – 6.6 % (Terbuthylazine) and 2.1 – 3.8 % (Flufenacet) of the amount applied. The proportion of herbicide loss relate to their physical-chemical properties. Hence, Terbuthylazine loss was higher than that of Metazachlor and Flufenacet, due to lowest water solubility and moderate mobility in soil. Furthermore, the results show that highest concentrations were observed during the first interval of surface runoff but that highest loads occurred during the second rainfall event after surface runoff generated the first time, when surface runoff volume increased greatly, and herbicide concentrations were below the maximum. The artificial setup of intermittent rainfall revealed that with every new rainfall event after a rainless period, a higher amount of herbicides was released from the plot compared to the prior event. During the rainless periods soil surface alterations occurred, which caused this effect.

Rainfall simulations and forest fires by the group of Zaragoza (GEOFOREST)

León, F.J.[1], Álvarez, C.[2], Badía, D.[3], Echeverría, M.[1], Martí, C. [3], Peréz Cabello, F.[1] and Ibarra, P.[1]*

[1]Departamento de Geografía y Ordenación del Territorio. Universidad de Zaragoza. Pedro Cerbuna, 12, 50009 Zaragoza. España. Tel. +34 976761000; [2]Department of Environmental Sciences. Wageningen University. The Netherlands; [3]Departamento de Agricultura y Economía Agraria. Escuela Politécnica Superior de Huesca. Universidad de Zaragoza. Cª de Zaragoza, s/n, 22071-Huesca. España. Tel. +34 976761000; [1]fcojleon@unizar.es*

Wildfire can be an important cause of hydrological and geomorphological changes in fire-prone landscape. The loss of vegetation and litter cover represents the clear changes in the burned landscape. The lack of litter and plant canopies increase the final drop impact energy on bare soil surface, and the root system can act as a preferential flow path for infiltration. On the other hand, soil heating kind of modify some properties (Badía and Martí, 2003a, 2003b, 2008) as soil aggregate stability, infiltration and water repellency (DeBano, 2000; Cerdà and Doerr, 2005; Doerr et al., 2006). Rainfall simulation experiments give the opportunity to compare the soil erodibility in selected micro-plots with specific fire, terrain, and rainfall characteristics.

Four rainfall simulators were used to analyze the hydrogeomorphological behaviour of the soil after the fires in the central sector of the Ebro Basin. Different spatial scenarios have been selected both in burnt (forest, shrub) and unburnt areas, on two different substrates, gypsiferous and calcareous soils. In addition, rainfall simulation tests were conducted on plots covered with woodchip-mulching.

The area of study was affected by the last fire of August 2009 that burned some 6.700 ha and it is located in the Montes de Castejon, left bank of the Ebro River, about 50 km Northwest of the city of Zaragoza. This fire affected scrub - gorse (*Genista scorpius* L.), broom (*Retama sphaerocarpa* L.), rosemary (*Rosmarinus officinalis* L.) as well as small forests of Aleppo pine (*Pinus halepensis* Mill) and Kermes oak (*Quercus coccifera* L.). This region has a semiarid Mediterranean climate, with an average annual rainfall ca 560 mm and a mean annual temperature of 12.5ºC. The potential annual evaporative demand, estimated by Thornthwaite method is ca 950 mm. The relief is represented by plataforms and slopes (200-748 m) and the lithological substrate consists of limestones and gypsiferous marls, dated from the middle Miocene. Where calcareous and gypsiferous soils are developed.

The last rainfall simulations were carried out, with a two stroke motor-pump (Matabi) and a cone-atomizing nozzle (Lechler) was used on a series of 12%-average-slope plots applying a rainfall intensity of about 60 mm h^{-1} for half an hour on a 0.21-m^2-wide and ca 2.2-metre-high plot. The rainfall simulator was calibrated with a Laser Disdrometer (Thies) with the collaboration of Iserloh of Trier University. Rainfall characteristics were 97.8% of Christiansen Coefficient for the rainfall distribution at 52.5 mm h^{-1}, with a mean drop-size of 0.5•1 mm (D50), and a Kinetic energy of 4.16 J m^{-2} mm^{-1}. The vegetation cover of the plots was represented by shrubs or trees. Also, the effect of mulching with Aleppo pinewoodchips was analysed using the same plots, to observe how runoff affected. Finally the runoff was collected and the concentration of sediment yield determined the erosion rate and water quality.

The results show that the infiltration rates and the runoff and sediment production are strongly affected by soil type and the remains of vegetation cover after the fire. Higher infiltration rates were obtained on burned forest areas compared to burned shrub ones, and on limestone compared to gypsum areas. The application of mulching is an effective measure to reduce runoff.

References:

Badía, D., Martí, C., (2003a). Plant and heat intensity effects on chemical and physical properties of two contrasting soils. Arid Land Research and Management 17, 23-44.

Badía, D., Martí, C., (2003b). Effect of simulated fire on organic matter and selected microbiological properties of two contrasting soils. Arid Land Research and Management 17, 55-69.

Badía, D., Martí, C., (2008). Fire and rainfall Energy effects on soil erosion and runoff generation in semi-arid forested lands. Arid Land Research and Management 22, 93-108.

Cerdá, A., Doerr, S.H., (2005). Influence of vegetation recovery on soil hydrology and erodibility following fire: An 11-any investigation. International Journal of Wildland Fire 14, 423-437.

DeBano, L.F. (2000). The role of fire and soil heating on water repellence in wildland enviroments: a review. Journal of Hydrology 231, 195-206.

Doerr, S.H., Shakesby, R.A., Deker, L.W., Ritttsema, C.J., (2006b). Ocurrence, predition and hydrological effects of water repellency amongst major soil and land-use types in a humid temperature climate. European Journal of Soil Science 57, 741-754.

The rotated disc rainfall simulators

Eshel Gil, Shaheen Awieenat, Eli Argaman, Naftali Goldshlager, Shmuel Arbel and Roey Egozi

The Soil Erosion Research Station, Ministry of Agriculture and Rural Development, Israel

One of the main requirements in simulating rain is to produce a range of raindrops sizes as close as natural rainfall, even in low rainfall intensity. The rotating disc simulator that has been used in research since its development by Prof. Morin during the mid-sixties in the Soil Erosion Research Station is one of the first rain simulators that implement this requirement. The concept of the rotating disc is that a disc with different opening portion is spinning below the nozzle and by changing the size of the opening portion of the disc, it is possible to control on rain intensity without reducing the raindrop size. Since the development of the simulator numerous studies have been conducted with the fixed version (in the laboratory), while the portable version (for in situ field studies) has been rarely used due to his large physical size which makes its portability expensive and complicated. Along our presentation we will presents the two versions of the rotated rain simulator, its rain characteristic and will discuss the advantages and the drawbacks of each version.

Runoff generation on arid soil under natural and laboratory conditions

Pariente Sarah and Eyal Sachs

Laboratory of Geomorphology and Soil, Department of Geography and Environment, Bar-Ilan University

Runoff is of considerable importance in the functioning of a desert ecosystem. The hydrological characteristics of runoff developing on arid soil under natural field conditions and those of runoff occurring in laboratory-controlled rain simulation experiments using the same type of soil were investigated.

Runoff and erosion measurements were carried out in small plots (0.2-0.8 m^2) on a south-facing hillslope in the northern Negev, Israel (90 mm ave. annual rainfall). Soil from the area near to the runoff plots was collected for the rain simulation experiments conducted in the laboratory. The soil was collected from 0-1 cm and 1-5 cm depths, and then placed within boxes (1.16 m long and 0.55 m wide) in the laboratory in the same order as they had been in the field. Representative surface stones were collected in the field and scattered randomly on the soil surface in the laboratory boxes. In some of the laboratory experiments soil, 5 cm in depth, was placed on a geotechnical sheet on a metal screen, while in other experiments, soil of 5 cm depth was placed on a Terzaghi filter. Rain simulator used had a rotating disk with a tilted nozzle to simulate raindrop size dispersion and kinetic energy of natural rain. The sprinkling intensity was set at a rate of 18 mm/hour.

Soil crusts in the field were more stable than those created in the lab for two standard tests: Emerson - immersion test, and the 'single water drop' test. Whereas weak activity of microphytes was found in the field there was no such activity in the lab.

The rain depth until runoff in the field was less than under laboratory conditions, while the sediment yield was greater in the field than in the laboratory (8.64 g/m^2 versus 0.58 g/m^2). The rain simulator experiments that had included a Terzaghi filter showed significantly higher final infiltration rate (7.5 mm/h versus 4.2 mm/h), shorter accumulated watering depth until stabilization of soil seal formation (100-200 mm versus 50 mm), and smaller fraction of clay in the crust (4.2% versus 6.8%), than the experiments that done without this filter. Therefore, it is conceivable that there is a suction of thin material from the surface while capillary pressures are activated, result in sub-surface seal formation (washed-in layer). This can lead to differences between runoff-forming processes existing in the laboratory set-up and processes that occur under natural field conditions.

Examining erodibility of biochar and terra preta substrates (Preliminary results)

Anna Smetanová[1], Markus Dotterweich[2] and Nicola Fohrer[3]

[1] *DBU Fellow , Institute of Geography , Johannes Gutenberg-University, Mainz , Germany, smetanov@uni-mainz.de*

[2] *Heisenberg Fellow, Institute of Geography , Johannes Gutenberg-University, Mainz, Germany*

[3] *Department of Hydrology and Water Resources Management, University of Kiel, Germany*

Biochar and charcoal enriched terra preta substrates are recently under debate as a tool for soil amelioration and conservation. They are characteristic by high water holding capacity and high nutrient content. However a little is know about their influence on runoff formation, soil erosion by water and leaching of nutrients. The study presents preliminary results of laboratory rainfall experiments examining the runoff response of biochar and terra preta substrates and their mixtures with sand under different slope and rainfall conditions. Their effect on soil stabilization is evaluated.

Keywords:
biochar, terra preta substrate, water erosion, soil conservation, rainfall simulation

Utilization of the runoff plots in selecting the best crops on the arable slopes in Romania

S. Mircea

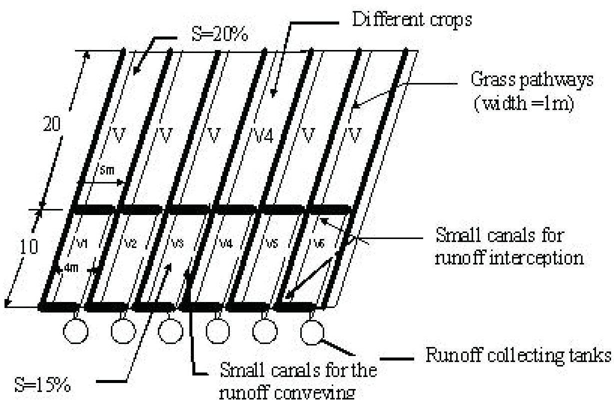
University of Agricultural Sciences and Veterinary Medicine, Bucharest-Romania
smircea@usamv.ro

The paper presents some of the main findings of a longtime research carried out within a representative Research Station on Soil Erosion and Conservation, as well as on some adjacent torrential watersheds, concerning soil loss, mainly under different crops, slopes and climatic conditions. Based on the field measurements conducted on the runoff plots, regarding both the liquid and solid runoff, in the period 1993-2010, the role of the vegetation and crop factor from the USLE model were then checked. Also, some correlations were established between soil loss on different slope steepness and vegetation cover, under similar climatic and pedological conditions.

The Research Station, belonging to the University of Agricultural Sciences and Veterinary Medicine, Bucharest, is located the Subcarpanthians Curvature zone, Slanic River watershed, Aldeni village in Buzau county. The studied area is one of the most and well-known hilly regions affected both by severe water erosion (surface and gully erosion) as well as landslides in Romania. As an eloquent example, soil loss reaches here about 30-45 tons/ha/year, as against to the natural regenerative capacity of the soil, which is about 5 - 6 tons/ha/year, only.

The research is continuously carried out every year during the vegetation period, on the 12 runoff plots located on different slopes and cultivated with different arable crops (Fig. 1). The runoff plots have a surface of 40 sqm and 100 sqm, and the slopes of 15% and 20%. The mean annually amount of precipitation is about 450 mm, out of which about 350 mm are fallen during the vegetation period, and from pedological point of view, there are mainly loamy textured chernozems.

Fig. 1. General view of the Research Station for Soil Erosion, Aldeni/BZ, and sketch of runoff plots



After each rain producing runoff (unfortunately, there is no a workable rain simulator, yet) there have been measured the runoff and soil loss under different crops in rotation, such as corn, winter wheat, sugar beet, soybean etc., as well as perennial grass crops. Evaluation of the protection capacity of the vegetation over the soil have been established by doing the ratio between the soil loss under different species or associations of plants and the soil loss under the bare soil, or a crop that can offer a poor protection to the soil. Reports are done in relative values, considering the bare soil as a reference or etalon runoff plot, having the value equal 1.

Based on the direct field determinations of the soil loss on the runoff plots, during the vegetation period of the years 1993-2010, there have been established the correction coefficients C function of crop, specifics to the real conditions from the Subcarpanthians Curvature region.

Simulation of rain-on-snow events by rainfall simulator

Roman Juras[1], Jiří Pavlásek[1] and Pavel Děd[2]

[1] – *Czech University of Life Sciences Prague – Faculty of Environment*
[2] – *Czech University of Life Sciences Prague – Technical Faculty*

Rainfall simulators are mostly used for simulation of rain events for the purpose of water infiltration to the soil or for soil erosion investigation. Another purpose for rainfall simulators could be simulation of rain-on-snow events. This kind of events is potentially very dangerous, because they can generate floods or avalanches. So it is very important to have accurate knowledge of liquid water behaviour inside the snow cover. This behaviour is mostly driven by snow properties. Snow cover represents retarding factor for rain water and part of it can be stored in the snow cover. The important question is, how much can snow inhibit water rate and how much can rain contribute to snowmelt, eventually to floods.

The rainfall simulator constructed at Czech University of Life Sciences Prague was used in a field during winter 2011 where liquid water behaviour from artificial rain was investigated within several experiments. Crucial factor for water movement in snow is its liquid water holding capacity (defined as the maximum amount of liquid water that a snowpack can hold against gravity at a given stage of metamorphism and density), snow density and snow hardness which effected water flow rate in snow. The simulator can generate different rain intensities from 40 mm/h to more than 400 mm/h, but in practice only intensities up to 90 mm/h were simulated. The intensity of rain is driven by water pressure in the nozzles and by their vertical position above the snow plot. Water droplets are generated by FullJet Nozzles 1/8 GG3 6SQ with a squared coverage. Number of nozzles is used according to required rain intensity from one to four. These nozzles are stable (do not waggle) and emitted range of droplets with size from 600 to 3100 microns. The structure of the rainfall simulator is made of steel and it is fully portable. For the rain simulation a wind protection tarpaulin has to be used, because the rain droplets are very light and could be even by gentle wind. The simulator covers an area up to 100 x 100 cm.

Before each measurement, a snow sample dug is necessary, represented by a snow cube of 110 x 110 cm x snow depth lying undisturbed and bared at four vertical sides. The snow plot must be larger than 100 x 100 cm to minimize the edge effect. Impermeable layer on the bottom of snow sample was represented by a metal plate, which was pushed into the snow so all gravity water can drain out above it. The outflow water is measured by a tipping bucket flowmeter. Data from flowmeter are sent directly to the datalogger, which also collects data of several temperatures: inflow water, outflow water, air temperature inside the simulator, air temperature outside the simulator, snow temperature at three levels and intensity of solar radiation. Changes of these magnitudes are later investigated after rain event. Lag time of water drainage is also measured as very important information for rain-on-snow events. Durations of artificial rain were chosen from 15 to 45 minutes. After the rain event all gravitation water drains out and then the change of free water content is measured. Stored liquid water is calculated by changes in snow density.

Keywords:
snow liquid water holding capacity, free water content, water rate in snow, modelling

Variability of surface processes in Central European forested areas - an experimental approach

V. Butzen[1], M. Seeger[2], M. Casper[1], C. Mueller[3], M. Huemann[3] and J. B. Ries[1]
[1]Dep. of Physical Geography, Trier University
[2]Dep. of Land Degradation and Development, Wageningen University
[3]Dep. of Soil Sciences, Trier University
Correspondence to: V. Butzen (butzen@uni-trier.de)

The contribution of forested areas to the flood and erosion dynamics is usually regarded to be negligible under humid climate conditions in Central Europe. Nevertheless, also forest areas can be sources for overland flow and sediment, particularly the artificial linear structures like forest roads and harvester tracks, or other human impacts like water engineering measures.

Another factor that is usually disregarded in the context of overland flow generation in forests, is the water repellency of the soil surface, that can pre-eminently be observed under rather dry soil moisture conditions in summer. Especially facing the expected climate change, it is becoming more and more important to get a spatially distributed, quantitative understanding of the processes occurring in forested catchments.

The EU-INTERREG-IVb-project ForeStClim (Transnational Forestry Management Strategies in Response to Regional Climate Change Impacts) aims at the development of forestry management strategies in order to secure the future economic stability of forestry in North-West-Europe and an efficient protection of forest ecosystems. In the framework of the ForeStClim-project a combination of experimental methods has been applied for the investigation of the spatial variation and intensity of overland flow generation and soil erosion processes in three forested low mountain range catchments in Luxembourg and in Rhineland-Palatinate, Germany.

The applied experimental method is a small-plot scale rainfall simulator. By means of the rainfall simulator, in altogether 73 rainfall simulations, overland flow generation and suspended sediment load have been determined. Due to the combination of the experimental measurements with a detailed mapping of soils and geomorpho-dynamics, it becomes possible to determine the spatial distribution of overland-flow generating areas and the occurrence of possible soil erosion processes in the study areas. The results of the experimental measurements and mappings will be used for the development of improved forest management strategies in adaptation to climate change in the framework of the ForeStClim project.

Recent geomorphodynamics in the vicinity of the Vicus Belginum / Hunsrück

Christine Brings[1], Rosemarie Cordie[2] and Johannes B. Ries[1]

[1]Dep. of Physical Geography, Trier University
[2]Archaeological Park Belginum, Morbach-Wederath, Germany
Corresponding author's e-mail address: brings@uni-trier.de

The work deals with the quantification and assessment of soil erosion and surface runoff on former Celtic and Roman territory, the Vicus Belginum (Morbach / Hunsrück), which is currently used for agriculture. Erosion processes not only lead to on-site and off-site damage to the cultural landscape, but also to a change in the positions of archaeological finds and a change of soil composition. For example, dikes from a Roman military camp have only been preserved in deeper areas, suggesting a one-meter soil loss. In addition, many archaeological finds thin out with distance from the actual place of origin increases. For this reason, there is a question of what effects erosion has on ancient architectural structures and their preservation.
To answer the questions about runoff and erosion rates, as well as spatial differentiation, two field cases with precipitation collectors were installed on three different arable lands, which had been planted with grain. Furthermore, the soil erosion and surface runoff were tested by nine rainfall simulations, three for each test site.
Altogether, after nine rainfall simulations, only 8.36 g of suspended load (total removal) and 1.87 l of surface runoff (total runoff) were measured. For removal, the average erosion rate is 0.93 g. The median and the Huber M-estimator are close together, with the median measuring 0.62 g and the M-estimator measuring 0.68 g. The removal rates vary between 2.40 g and 0.06 g, thus showing a wide spread. The average volume of runoff is 0.21 l, the median is only 0.054 l and the Huber M-estimator is 0.078 l. The flow rates vary between 0.76 g and 0.004 g. The suspended load shows very large variation, with concentrations of 2.27 g/l and 44.56 g/l.

A rainfall simulator for characterising dominant runoff processes on the scale of hillside segments

Marco Hümann[1], Steffen Schobel[2], Christoph Müller[1] and Raimund Schneider[1]

[1] *Trier University, Faculty of Geosciences, Department of Soil Science, Trier, Germany, m.huemann@uni-trier.de*

[2] *Federal Research Institute for Rural Areas, Forestry and Fisheries, Institute of Forest Ecology and Forest Inventory, Eberswalde, Germany*

At present time it is common to use different kinds of hydrologic models or GIS applications to simulate runoff generation. Otherwise, especially the spatial variability of soil conditions and a lack of essential soil data make it difficult to identify the specific mechanism of discharge generation at the plot scale or even at catchment scale. For this reason, sprinkling experiments combined with multi-attribute soil analysis are still a basic prerequisite for a realistic and knowledge-based assessment, which offers also the possibility of validating models in a second step.

In several studies we performed sprinkling experiments for different land use types and a number of different substrates using the portable rainfall simulator according to Karl & Toldrian. The configuration consists of a U-shaped pipe system: Two parallel, 10 m long iron pipes are oriented along the slope line, and at their rear end, connected by an additional, 5 m long pipe (50 m²). Six standpipes (70 cm height) with low-pressure-nozzles irrigate the area homogeneously. The open side of the U was located in downhill direction with a soil pit at the bottom. To measure the discharge of several runoff processes (overland flow, subsurface flow), a large soil pit of 3 m width was prepared with angled sheet metals in different depths. The effective experimental area is about 30 m² as a consequence of two adjacent one meter wide also irrigated border lines which act similar to a double ring of an infiltrometer setup. The used irrigation schedule is adapted to the flood events in winter time of 1993 and 1995 with a sum of 120 mm precipitation in three days. Four 15-minute intervals of 10 mm precipitation were applied each day. Nevertheless, only sprinkling experiments are not suitable for identifying the key-parameters dominating the respective runoff processes. For this purpose, auxiliary field experiments and soil analysis are necessary. The conventional setup includes tracer irrigation, infiltration experiments and soil physical analysis (texture, pore size distribution, hydraulic connectivity, bulk density) as well as the survey of earthworm burrows in different layers amongst others.

The large-sized rainfall simulator ensure the adequate scale to take impacts from land use into account as well as to measure and assess significant runoff processes accurately. Some examples of sprinkling experiments will be presented and discussed critically with respect to technical aspects and scientific significance.

Surface runoff and soil erosion in agro-industrially used landscapes between High and Anti-Atlas

Daniel Peter[1], Johannes B. Ries[1], Irene Marzolff[2] and Sebastian d'Oleire-Oltmanns[2]

Trier University, Dep. of Physical Geography, 54296 Trier (Germany)
Johann Wolfgang Goethe University, Dep. of Physical Geography, Frankfurt am Main (Germany)

The Souss basin is characterised by high population dynamics and changing land use. Plantations of citrus fruits and bananas replace the traditional agriculture. A precipitation of only 150 mm enforces the irrigation of cultivation by deep wells. The spatial vicinity of highly engineered irrigation areas, which are often created by land-levelling measures, and housing estates with highly active gully systems and rapid badland development presents a risk to both the agro-industrial land use and the population settlements. It is investigated whether the levelling measures influence surface runoff and soil erosion and thereby affect the further gully development. The influences of surface characteristics on runoff and soil erosion are analysed. Therefore 91 rainfall simulation experiments using a small portable rainfall simulator and 33 infiltrations by means of a single ring infiltrometer are carried out on seven test sites nearby the city of Taroudant.
The rainfall simulations (30 minutes, 40 mm h^{-1}) show an average runoff coefficient of between 54 and 59 % on test sites with land-levelling measures and average runoff coefficients ranging between 36 and 48 % on mostly non-levelled test sites. The average of soil erosion lies on levelled test sites between 52.1 and 81.8 g m^{-2}, on non-levelled test-sites between 13.2 und 23.2 g m^{-2} per 30 minutes. Accordingly, all the test sites have a rather low infiltration capacity. This can also be confirmed by the low average infiltration depth of only 15.5 cm on levelled test sites. There is often a clear borderline at horizons with a high bulk density caused by compaction. In contrast, on non-levelled test sites, the average infiltration depth reaches 22.2 cm. Reinforcing factors for runoff and soil erosion are slope and soil crusts. Vegetation cover has a reducing influence on surface process activity. Medium rock fragment cover shows high rates of runoff and soil erosion.
Hitherto collected data show an explicit difference between levelled and non-levelled test sites. Land-levelling measures clearly influence the generation of surface runoff and soil erosion and consequently, advance the further gully development.

The study is founded by the DFG-project "Gully-Erosion in agro-industriel landscapes between the High Atlas and the Anti-Atlas (Morocco)" (Ri 835/5-1).

Experimental investigation of in situ soil erosion rates by wind-driven rain

Wolfgang Fister[1], Thomas Iserloh[2], Miriam Marzen[2], Manuel Seeger[3],
Reinhard-G. Schmidt[2] and Johannes B. Ries[2]

[1]Physical Geography and Environmental Change, Dept. of Environmental Sciences, University of Basel, Switzerland (Wolfgang.Fister@unibas.ch)
[2]Physical Geography, Dept. of Geography/Geosciences, Trier University, Germany
[3] Land Degradation and Development, Wageningen University, The Netherlands

The differentiation of soil detachment rates by wind, wind-driven rain and windless rain is often very difficult, because of their simultaneous occurrence. So far, laboratory experiments and field measurements with passive sediment traps have fundamentally improved our understanding of involved processes, but they were not able to fully assess the differences in detachment rates for wind-driven and windless rain. The problems of these studies are either the lack of natural soils as test subject, or the possibility to clearly differentiate between windless and wind-driven soil detachment.

The Portable Wind and Rainfall Simulator (PWRS) was used in two field campaigns with different soil types (crusted silty loam and fine loose sand) and leeward slopes (5-10° and <2°) with the purpose to start filling this gap of knowledge on a plot scale. The ability to clearly differentiate between the particle detachment by wind, windless rain, and wind-driven rain is attained through the simulation of four different combinations of wind and rainfall on the same plot. The simulations with duration of 10 min for wind and 30 min for windless and wind-driven rainfall are applied in following order: (1) single wind test run (10 min), (2) single rainfall test run on dry soil conditions, (3) single rainfall test run on moist soil conditions, 4) simultaneous wind and rainfall test run on moist conditions. The detached material is collected by a gutter system, two wedge shaped and four bottle samplers.

The results show a wide range of soil detachment raging from zero up to 150 gm^{-2} in 30 minutes. On the crusted silty loam highest erosion rates are measured for single rainfall simulations on dry soil conditions (2) due to a high amount of loose particles lying on top of the crust. For wet conditions there is no clear signal if erosion rates by wind-driven rain (4) exceed the ones by windless rain (3). A positive tendency can be assumed, because the values that increase (from 26 to 259 %) clearly exceed the ones that show a decreasing signal (from -7 to -10 %). In contrast, the erosion rates on the flat and loose sandy surface show a clear increase from dry (2) to wet (3) conditions and a further increase from windless (3) to wind-driven simulations (4). The surplus of soil detachment by wind-driven rain over windless rain ranges from 56 % up to 1100 %. The reason for this increase is most likely the force of wind, which increases velocity of surface water flow (a), causes a thinning of flow depth (b), and leads to oriented raindrop trajectories (c).

In conclusion, the results are consistent with previous studies and show that for chosen conditions wind-driven rain creates higher soil detachment rates than windless rain. The relation between the two processes seems to be very dependent on soil conditions and slope angle of the surfaces investigated. Nevertheless, it is necessary to reconsider the order of simulations to improve conclusiveness of data and to increase the amount of data to reduce the influence of soil variability on erosion rates.

Using a rainfall simulator in the laboratory to study sediment transport and overland flow generated by moving storms

J.L.M.P. de Lima

Department of Civil Engineering, University of Coimbra, Rua Luís Reis Santos, Campus II – University of Coimbra, 3030-788 Coimbra, Portugal, and IMAR – Marine and Environmental Research Centre – IMAR-CMA, Portugal, plima@dec.uc.pt

The importance of storm movement, due to the combined effect of wind and rain, on surface flows has long been recognised, at scales ranging from headwater scales to larger catchment basins. On the other hand soil loss from rainstorms moving in different directions across drainage areas are clearly the result of the corresponding overland flow dynamics. All these processes (rainfall, wind, runoff, soil erosion) involved are germane for investigation at different scales. In this study, these processes were investigated in the laboratory.

Several soil flumes of different sizes and shapes were used in the experiments. Several surface slopes were tested. To simulate moving rainstorms, a sprinkling-type rainfall simulator was moved along different directions over the soil surface of the flumes, with or without wind produced by a set of fans. The simulator could also produce non-moving precipitation at any part of the flume.

The main objective of the study was to characterize, in laboratory conditions, the sediments transported in time, by overland flow, for rain events with different characteristics. Conventional hand sieving and optical spectrophotometer method (material below 0.250 mm) were used to characterize the granulometry of the sediment deliveries collected at the outlet of the soil flumes.

The results of the present study show that storm movement, affecting spatial and temporal distributions of rainfall, has a marked influence on the granulometric characteristics of sediments transported by overland flow. Distinct hydrologic responses for storms moving upstream and downstream were identified. Storms moving downslope are the most potentially hazardous in terms of erosion.

Experimental investigation of climate change effects on plant available water on rocky desert slopes

Nikolaus Kuhn (1), H. Hikel (1), W. Schwanghart (1) and Aaron Yair (2)

(1) Institute of Geography, Department of Environmental Sciences, University of Basel, Switzerland (nikolaus.kuhn@unibas.ch / Fax: +41-61-2670740 / Phone: +41-61-2670741),
(2) Department of Geography, Hebrew University Jerusalem, Mt Scopus Campus, Jerusalem, Israel

Deserts and semi-deserts cover more than one-third of the global land surface, affecting about 49 million km^2 with aridity. In many arid regions, slopes are characterized by sparse and patchy soil and vegetation cover, forming so called “fertility islands”. The mosaic of soil and vegetation is dynamically interdependent, controlled by adaption of the ecosystem to limited and spatially as well as temporarily variable precipitation. Commonly, the role of the pattern of rocks and soil is considered to act as a natural water harvesting system. In an ideal system, the rocky area supplying water matches the soil’s infiltration capacity for the given rainfall magnitude. This approach limits the assessment of plant water supply to the amount and intensity of rainfall events, i.e. the supply of water. In reality, the demand of water by the plants also requires consideration. Therefore, the volume of soil storing water is equally important to the ration of soil to rock. Soil volume determines the absolute amount of water stored in the soil and is thus indicative of the time period during which plants do not experience drought related stress between rainfall events. With climate change likely affecting the temporal pattern of rainfall events, a detailed understanding of soil-water interaction, including the storage capacity of patchy soils on rocky slopes, is required.

The aim of the study is to examine the relationship between climate change and plant available water on patchy soils in the Negev desert. Thirteen micro-catchments near Sede Boqer were examined. For each micro-catchment, soil volume and distribution was estimated by laser scanning before and after soil excavation. Porosity was estimated by weighing the excavated soil. Before excavation, sprinkling experiments were conducted. Rainfall of 18mm/h was applied to an area of 1m^2 each. The experiments lasted 25 to 40 minutes, until equilibrium runoff rates were achieved. Based on these data, rainfall required for soil saturation and soil water storage was calculated. The results of the sprinkling indicate that the minimum rainfall amount to saturate a median soil patch with water is only 2.5 mm. Such low rainfall event magnitudes have a high frequency in the Negev, indicating that the soil storage space is filled frequently. Consequently, the storage capacity of the soil is of great relevance for plant water supply during periods without rain. Rainfall records for the period of 1976-2008 show a significant variability of the average duration of periods without rainfall during the wet winter season. Depending on the size of a soil patch, serious drought stress can develop, indicating that only an understanding of soil and rainfall interaction enables a full understanding of the impacts of climate change on hillslope ecohydrology. The study also illustrates how rainfall simulation experiments and the analysis of meteorological records can be combined as a tool for the assessment of environmental change.

Soil reflectance as tool for assessing physical crust arrangement in typical soils from Israel and the USA

Goldshleger N.

Soil Erosion Research Station, Soil Conservation and Drainage Division, Ministry of Agriculture, Israel

In this study, a controlled spectral investigation of the soil structural crust was carried out, using reflectance radiation across the SWIR (1.2-2.5µm) spectral region.
The structural crust is a thin layer (usually 1mm in depth) formed on the upper soil layer as a result of soil particles disintegration and rearrangement that occurred because of the raindrops energy. Soils from Israel and the were subjected to increasing level of rain drop energies in a rainfall simulator device, while their reflectance spectra were measured simultaneously. The results yielded a set of soil samples with various levels of crusting. The spectral references from this set was further studied in order to obtain parameters to assess the soil crust status solely from reference measurement. It was found that soil mineralogy changes is a major factor in the crust that inherent the spectral response of the soil. In the clayey soils, two stages were found: decreasing of albedo at 1.7µm due to particle size difference and increasing of absorption feature at 2.2µm, due to smectitie/kaolinie enrichment. The spectral readings at these two wavelengths enable the detection of the crust formation. In the sandy soil the coarse quartz particles was found to be segregated on the surface and to reflect more energy to the sensor, holding to opposite relationship to the clay enrichment soils. An empirical relationship was found between infiltration rate and reflectance readings, which can serve as a tool for rapid non-destructive, in situ assessment of the crust status in the field.

Calibration of small portable rainfall simulators

Thomas Iserloh and Johannes B. Ries

Trier University, Department of Physical Geography, Trier, Germany

Studies have clearly demonstrated that different calibration methods of artificially generated rainfall lead to different results, so there is an urgent need for research. A set of modern rainfall calibration techniques (e.g. Laser Precipitation Monitor by Thies) is presented. This measurement assembly could be an example for standardization of calibration procedures to characterize simulated rainfall. This is very important, because comparison between different rainfall simulators is not possible so far. Using these methods high-resolution and comparable data of rainfall characteristics can be generated. The data can be used for improvements, comparison of simulators and results, as well as for comparison with different natural rainfall spectra, measured with the same methods.

In the first part of the presentation, methodical improvements of Trier's small portable rainfall simulator focusing on rainfall characteristics (e.g. homogeneous spatial rainfall distribution and better drop spectrum) by means of the calibration methods are demonstrated.

Because of better spraying characteristics and better handling, the previously used hollow cone nozzle (Hardi Syntal 1553-89 10) has been replaced with a full cone nozzle (Lechler 460.608) after testing several nozzles. The water flow is now regulated by a flow metre (Type KSK-1200HIG100) positioned on a separate pole in 1.5 m height. The new setup shows the requested improvements in rainfall characteristics: Regarding drop size distribution, a very close relation to natural conditions (Marshall & Palmer Distribution) can be observed. Due to low fall heights, measured drop fall velocities are slow, maximum velocities ranging between 3.4 to 5 m s^{-1}. Mean kinetic energy expenditure, mean kinetic energy per unit area and unit depth of rainfall and mean momentum are 214 J m^{-2} h^{-1}, 5.8 J m^{-2} mm^{-1} and 0.016 kg m s^{-1}. The spatial rainfall distribution of the small rainfall simulator is homogenous with a Christiansen-Uniformity Coefficient of 91 %, the measured variables show extremely low variation throughout all tests.

The second part of the presentation deals with first results of the comparison of rainfall simulators. The artificially generated rainfalls of many European research groups' rainfall simulators were characterized with the above-mentioned methods. In order to promote cooperation, particularly at the operational level and to create comparable data, research groups from the Universities of La Rioja, Zaragoza and Malaga as well as various Spanish CSIC Institutes in Almeria, Cordoba, Granada, Murcia and Zaragoza have been visited. A broad range of data was measured (water efficiency: 4 – 53 %, Intensity: 30 – 149 mmh^{-1}, spatial distribution: 61 – 98 %, spatial variability: 0.5 – 13 %, drop number per minute: 2665 – 26797, mean drop diameters: 0.375 – 5.0 mm, mean kinetic energy expenditure: 25 – 1322 J m^{-2} h^{-1}, mean kinetic energy per unit area and unit depth of rainfall: 4 – 14J m^{-2} mm^{-1} and mean momentum: 0.004-0.05kg m s^{-1}). Similarities among the simulators could be found e.g. concerning drop size distributions (maximum drop numbers are reached within the two smallest drop classes < 1 mm) and low fall velocities of bigger drops due to a general physical restriction.

The comparison provides a good data base for improvements and a consistent picture of the parameters of the simulators. Within the scope of research a criteria catalogue could be provided for the estimation of the different simulators. A general understanding about relevant features of simulators as well as calibration and test procedure strategies would help to concentrate global results and knowledge so as to create a reliable and convincing source of information for decision-makers.

The study is founded by the DFG-project "Comparability of simulation results of different rainfall simulators as input data for soil erosion modelling" (Ri 835/6-1).

Experimental Area – Rainfall Simulation Experiments

(A) Rainfall Simulation Experiments:

- Two Runs, one on dry and one on moist soil
- Duration: 30 min. per run
- During the 30 minutes duration of the experiment, runoff is collected in 500 ml wide-opening plastic bottles that can be reliably closed with a screw plug.
- The passed time between the rainfall simulation start and the set in of runoff is recorded.
- The 30 minutes are partitioned into six intervals of five minutes duration and at the beginning of each interval the bottles have to be exchanged.

(B) Laboratory – Evaluation of Runoff and Eroded Material (directly following the Rainfall Simulations):

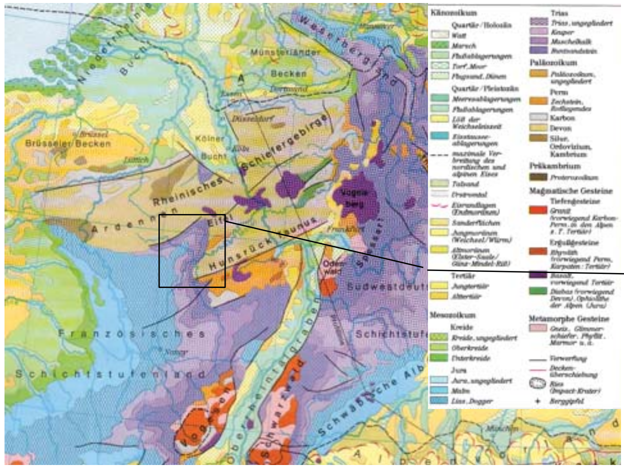
- The plastic bottles with the collected runoff water are weighed. The weight of the runoff water is calculated by subtracting the tare weight and the sediment weight from the previously measured value.
  ➔ Runoff amount in Litres for reasons of simplification is assumed to be the same as the calculated weight in kilograms.
- The collected runoff water in each bottle is filtrated separately with circular filter papers (less than 2 µm mesh-width). First of all, the filters are watered for a few hours to remove glue and loose paper particle residuals. Afterward they are dried in a drying closet at a temperature of 105 °C and then weighed with an accuracy of 0.0001 g.
- Sediment residuals in the runoff collecting bottle are flushed out and added to the filters in the described sequence. The filters are dried in the drying closet at 105 °C. Then the completely dried filters are weighed.

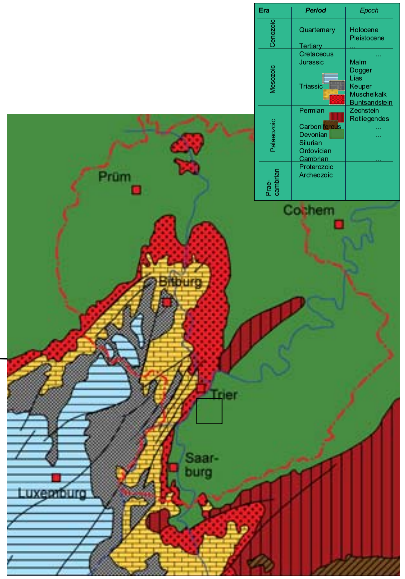
Physische Geographie

Geographical background of the test site

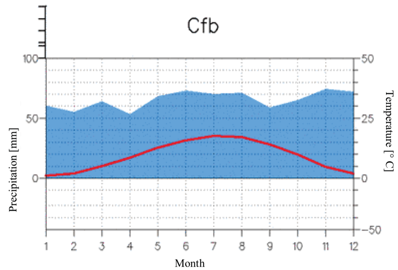
Universität Trier

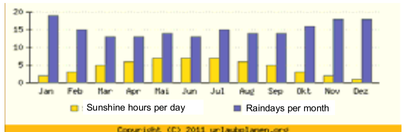
Geology

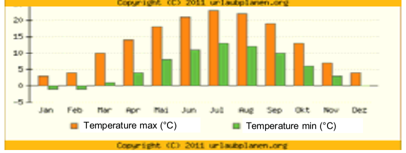




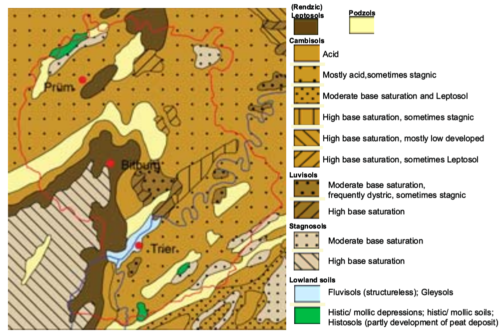
Climate







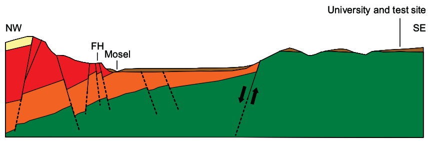
Soils and test site parameters



Test site parameters

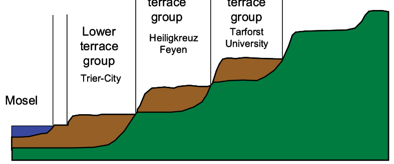
Substrate: Sl4		**Land use:** winter wheat
FAO: Sandy loam- Loam		
Coarse sand (2-0.63 mm)	18%	**Slope:** about 8.5°
Middle sand (0.63-0.2 mm)	25%	
Fine sand (0.02-0.063 mm)	8%	**Soil type:** Cambisol
Coarse silt (0.063-0.02 mm)	11%	
Middle silt (0.02-0.0063 mm)	13%	**Plough horizon:** 15 cm
Fine silt (0.0063-0.002 mm)	10%	
Clay (< 0.002 mm)	15%	

Schematic Profile (vertical exaggeration 2.5 times)



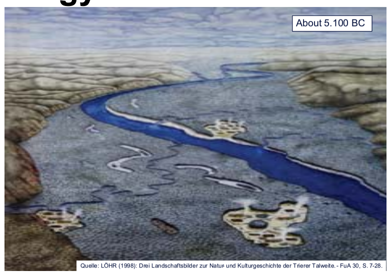
river sediments (Mosel-Pleistocene)
dolomite and marls (Muschelkalk, middle Triassic)
sandstone (Buntsandstein, lower Triassic)
fine grained poorly cemented sandstone (Rotliegendes, lower Permian)
slate (Emsian, lower Devonian)

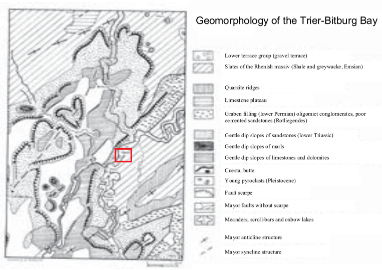
Terrace groups

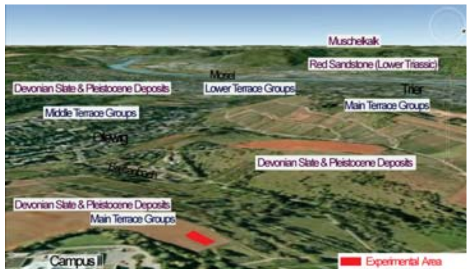


Gravels
Bedrock (solid slate)

Geomorphology

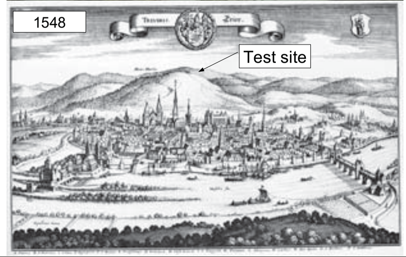






History of the Petrisberg

30 v.Chr: Castrum on Petrisberg (for some month)
16 v.Chr.: Founding of Trier (oldest town in Germany)
Middle Ages: Petrisberg mainly used as pasture land; viniculture in Kürenz, Olewig, Aveler Tal, Brettenbach, Betzengrube
1938: Construction of the 'Kemmel'-baracks on Petrisberg finished
1945: French use the baracks, construction of the hospital (now Campus II)
Trier University: founded in 1473, closed in 1798, new founding in 1970 as part of the University Trier-Kaiserslautern, independant since 1975



Contact: Prof. Dr. J.B. Ries; Trier University, FB VI Geography / Geosciences, Physical Geography, E-Mail: riesj@uni-trier.de, phone: 0049 651 201 4511