ZHydro Seminar 2017

Seminar in Hydrology

Program and teasers for the presentations

as of November 21, 2017

November 22, 2017
ETH Zürich, GEP-Pavillion (MM C 78.1)

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Program

Time	Speaker	Title
8.45	Arrival and coffee	
9.00	Welcome and introduction	
9.10	**Anna Costa** (ETHZ, IfU-Hydrology)	Basin-scale sediment dynamics of a large Alpine catchment
9.25	**Andrea Betterle** (Eawag, Hydrogeology)	What do they have in common? Drivers of streamflow spatial correlation and continental-scale prediction of flow regimes
9.40	**Sandra Pool** (Uni ZH, Dep. Of Geography)	Prediction of runoff in almost ungauged catchments: informing regionalization with a limited number of runoff measurements.
9.55	**Wouter Berghuijs** (ETH, Institute of Terrestrial Ecosystems)	The relationship between contrasting ages of groundwater and streamflow
10.10	**James Kirchner** (ETH, Institute of Terrestrial Ecosystems)	Quantifying new and recent precipitation in streamflow using ensemble hydrograph separation
10.25	Coffee break and posters	
10.45	**Eleonora Secchi** (ETH, Institute of Environ. Engineering)	The flow of a bacterial suspension around a pillar: broken symmetry and biofilm formation
11.15	**Dani Or/Peter Lehmann** (ETH, Soil and Terrestrial Environ. Physics)	Surface evaporative capacitance – soil type and rainfall characteristics provide an upper bound for soil evaporation
11.30	**Daniel Vivroli** (Uni ZH, Dep. Of Geography)	A lowland view on highland water resources
11:45	**Konrad Bogner** (WSL, Mountain Hydrology and Mass Movements)	Hydrological short to extended range forecasting including post-processing methods
12.15	Individual lunch and posters	
13.30	**Clemens Schwingshackl** (ETH, Land-climate Dynamics)	A climatological view on the effect of soil moisture on near-surface air temperature
13.45	**Wim Thiery** (ETH, Land-climate Dynamics)	Impacts of irrigation on the 20th century climate
14.00	**Sämi Bickel** (ETH, Soil and Terrestrial Environ. Physics)	Micro geography from grains to biomes: Impact of climate and soil characteristics on microbial abundance, diversity and spatial patterns
14.15	**Jan Rajczak** (ETH, Inst. For Atmospheric and Climate Sci.)	Projections of future precipitation extremes over Europe: a multi-model assessment of climate simulations
14.30	Coffee break and posters	
15.00	**Mohammad Reza Jalali** (ETH, Engineering Geology)	Multi-scale Hydraulic Characterization of Stimulated Fractured Crystalline Rock at Grimsel Test Site
15.30	**Anja Bretzler** (Eawag, Hydrogeology)	Multi-tracer investigations of arsenic-affected fractured bedrock aquifers in West Africa
15.45	**Gabriele Manoli** (ETH, IfU-Hydrology)	Trading water for carbon with oil palm plantations
16.00	Final notes, planning of ZHydro 2018, etc	
16.30	End of ZHydro 2017	

Teasers for the oral presentations

9.10 Anna Costa (ETHZ, IfU-Hydrology): **Basin-scale sediment dynamics of a large Alpine catchment**

We investigate the impacts of climate and hydropower systems on the sediment regime of Alpine catchments. To quantify the impact of hydropower operations on local bedload transport and grain size distribution, we develop a network–scale model for fractional sediment transport. We analyse the link between climate and fine sediment dynamics by conceptualising the catchment as a series of sediment sources that are activated by three main hydroclimatic factors related to precipitation and temperature: erosive rainfall (defined as liquid precipitation over snow free areas), snowmelt and icemelt. We focus on the Swiss Rhone basin, a large Alpine catchment heavily regulated by hydropower since 1960s. Results show that a strong climatic signal can persist even in highly human impacted catchments.

9.25 Andrea Betterle (Eawag, Hydrogeology): **What do they have in common? Drivers of streamflow spatial correlation and continental-scale prediction of flow regimes**

We present an analytical model to estimate the streamflow correlation between arbitrary pairs of river sections and we show that correlation can be used to quantify the similarity of flow dynamics along hydrographic networks. The model enables the assessment of how spatial patterns of hydrological drivers (e.g. climate, landscape, morphology) affect the variability of flow dynamics within river systems and can be used to estimate streamflow statistics in absence of discharge data.

9.40 Sandra Pool (Uni ZH, Dep. Of Geography): **Prediction of runoff in almost ungauged catchments: informing regionalization with a limited number of runoff measurements**

Hydrological models are often used for runoff prediction in ungauged catchments. For such ungauged catchments model parameters are usually estimated by some form of regionalization of the model parameters. Alternatively, it has been demonstrated that a limited number of runoff measurements taken at strategic points in time in the (almost) ungauged target catchment can already be informative for model calibration. This study aims at combining these two approaches and evaluates the proposed regionalization approach on more than 500 catchments spread across the contiguous United States using the bucket type HBV runoff model.

9.55 Wouter Berghuijs (ETH, Institute of Terrestrial Ecosystems): **The relationship between contrasting ages of groundwater and streamflow**

Tracer data demonstrate that waters in aquifers are often much older than the stream waters that drain them. This contrast in water ages has lacked a general quantitative explanation. We show that the age distribution of water stored in a catchment can be directly estimated from the age distribution of its outflows, and show that the mean age of stored water can range from half as old as the mean age of streamflow (for plug flow conditions) to almost infinitely older (for strongly preferential flow). Preferential release of young streamflow implies that most groundwater is exchanged only slowly with the surface and consequently is very old.

10.10 James Kirchner (ETH, Institute of Terrestrial Ecosystems): **Quantifying new and recent precipitation in streamflow using ensemble hydrograph separation**

In recent years, long-term isotope time series have been collected in many research catchments, and new technologies have emerged that allow quasi-continuous measurements of isotopes in precipitation and streamflow. These new data streams create new opportunities to study how rainfall becomes streamflow following the onset of precipitation. Here I present novel methods for quantifying the fraction of current rainfall in streamflow across ensembles of precipitation events. Benchmark tests with nonstationary catchment models demonstrate that this approach quantitatively measures the short tail of the transit time distribution for a wide range of catchment response characteristics. In combination with reactive tracer time series, this approach can potentially be extended to measure short-term chemical reaction rates at the catchment scale. Applications using high-frequency tracer time series from several experimental catchments demonstrate the utility of the new approach outlined here.

10.45 Eleonora Secchi (ETH, Institute of Environ. Engineering): **The flow of a bacterial suspension around a pillar: broken symmetry and biofilm formation**

Across many different habitats bacteria are often found within surface-attached communities known as biofilms. Biofilms greatly enhance bacterial resistance to harsh environmental conditions and antimicrobial treatments, which makes their removal more difficult in industrial and clinical settings. Although bacteria are ubiquitously exposed to liquid flow in natural environments, the influence of hydrodynamics on the transport and attachment of bacteria to surfaces and the formation of biofilms remains poorly investigated and understood. Here, we show that a laminar flow around a pillar can trigger the formation of suspended filamentous biofilm structures known as streamers. Experiments with pillars of different diameters and with different flow rates allowed us to assess the effect of hydrodynamics on bacterial transport and biofilm formation and to discover with the latter dominated by the interplay between a secondary flow around the pillar and the viscoelastic nature of EPS.

11.15 Dani Or/Peter Lehmann (ETH, Soil and Terrestrial Environ. Physics): **Surface evaporative capacitance – soil type and rainfall characteristics provide an upper bound for soil evaporation**

The reliable separation of evapotranspiration (ET) to evaporation (E) and transpiration (T) components for linking the water-carbon cycle, water resource management and hydrologic isotope fractionation remains a challenge. Regional estimates of soil evaporation often rely on plant-based (Penman-Monteith) ET estimates in which E is deduced as a residual or a fraction of potential evaporation. We propose a method for estimating E from soil properties and regional rainfall characteristics by accounting for concurrent internal drainage that shelters soil water from evaporation (without relying on PM formulation). A soil-dependent evaporative characteristic length defines a soil depth below which soil water cannot be pulled by capillarity to the surface - it determines the maximal soil evaporative capacitance (SEC). The soil "capacitor" is recharged by rainfall and subsequently emptied at a rate determined by competition between drainage and surface evaporation (we also consider canopy interception evaporation) until next rainfall event. The SEC was applied for case studies spanning different soil types and climates. Surprisingly, we found that the ratio of soil evaporation (E) to potential evapotranspiration (ET_0) is relatively small across soil types and climates, and globally E/ET_0 is less than 0.1 for 75% of terrestrial surfaces.

11.30 Daniel Vivroli (Uni ZH, Dep. Of Geography): **A lowland view on highland water resources**

Highland areas, and especially mountains, can provide disproportionally high runoff. While this importance as the world's "Water Towers" is well-proven today, we will here shift our viewpoint to the lowland areas and look upstream from there: How many people depend on critical contributions from highland water resources, where do they live, and what changes are they facing under climate and global change? This view will be complemented with an outlook into the importance of highland water resources for food production in the lowlands.

11:45 Konrad Bogner (WSL, Mountain Hydrology and Mass Movements): **Hydrological short to extended range forecasting including post-processing methods**

At the Swiss Federal Institute WSL there are several forecast systems running operationally targeting two divergent objectives, one for providing information about droughts in general and low flow conditions at selected catchments in Switzerland and one for forecasting flood events (for example at the Sihl river). According to these target diversities different forecast horizons are relevant. In order to increase the quality of model simulations and forecasts pre- and post-processing methods have been developed for the removal of bias and dispersion errors and to derive predictive uncertainties. Additionally various novel statistical methodologies have been tested for the optimal combination of different (probabilistic) forecast systems .

13.30 Clemens Schwingshackl (ETH, Land-climate Dynamics): **A climatological view on the effect of soil moisture on near-surface air temperature**

Soil moisture can affect near-surface air temperature on various timescales. Focusing on climatological scales (30 years), we estimate the sensitivity of near-surface air temperature to soil moisture variations in both the transitional and wet soil moisture regimes. We find strong impacts of soil moisture on temperature in models, re-analyses and observation-based datasets. Moreover, we show that about 50% of interannual local temperature variability in the current (and future) climate can be explained by local land-atmosphere coupling processes, including soil moisture.

13.45 Wim Thiery (ETH, Land-climate Dynamics): **Impacts of irrigation on the 20th century climate**

Irrigation is an essential practice for sustaining global food production and many regional economies. Emerging scientific evidence indicates that irrigation substantially affects mean climate conditions in different regions of the world. Yet how this practice influences temperature extremes is currently largely unknown. Here we use gridded observations and ensemble simulations with the Community Earth System Model to assess the impacts of irrigation on hot extremes. While the influence of irrigation on annual mean temperatures is limited, we find a large impact on temperature extremes, with a particularly strong cooling during the hottest day of the year (-0.78 K averaged over irrigated land). The strong influence on hot extremes stems from the timing of irrigation and its influence on land-atmosphere coupling strength. Together these effects result in asymmetric temperature responses, with a more pronounced cooling during hot and/or dry periods. The influence of irrigation is even more pronounced when considering subgrid-scale model output, suggesting that local effects of land management are far more important than previously thought. Finally we find that present-day irrigation is partly masking GHG-induced warming of extreme

temperatures, with particularly strong effects in South Asia. Our results overall underline that irrigation substantially reduces our exposure to hot temperature extremes and highlight the need to account for irrigation in future climate projections.

14.00 Sämi Bickel (ETH, Soil and Terrestrial Environ. Physics): **Micro geography from grains to biomes: Impact of climate and soil characteristics on microbial abundance, diversity and spatial patterns**

The spatial distribution of soil microorganisms and their abundance and diversity across scales are inherently linked. While abundance is driven primarily by the system's carrying capacity, diversity is shaped by dispersal and habitat fragmentation. We present a heuristic modeling framework that spans scales from grains to climatic zones for linking geographic regions, biomes and climatic processes with microbial habitats. Datasets on precipitation and NPP carbon inputs and soil characteristics are analyzed regarding their impacts on microbial habitats towards disentangling microbial abundance and diversity in soil.

14.15 Jan Rajczak (ETH, Inst. For Atmospheric and Climate Sci.): **Projections of future precipitation extremes over Europe: a multi-model assessment of climate simulations**

Projections of precipitation and its extremes over the European continent are analyzed in an extensive multi-model ensemble of 12 and 50 km resolution EURO-CORDEX regional climate simulations (RCMs) forced by RCP2.6, RCP4.5 and RCP8.5 aerosol and greenhouse gas emission scenarios. A systematic inter-comparison with ENSEMBLES RCMs is carried out, such that in total information is provided for an unprecedentedly large dataset of 100 RCM simulations. An evaluation finds very reasonable skill for the EURO-CORDEX models in simulating temporal and geographical variations of (mean and heavy) precipitation at both horizontal resolutions. Heavy and extreme precipitation events are projected to intensify across most of Europe throughout the whole year. All considered models agree on a distinct intensification of extremes by often more than +20% in winter and fall and over Central and Northern Europe. A reduction of rainy days and mean precipitation in summer is simulated by a large majority of models in the Mediterranean area, but inter-model spread between the simulations is large. In Central Europe and France during summer, models project decreases in precipitation but more intense heavy and extreme rainfalls. Comparison to previous RCM projections from ENSEMBLES reveals consistency but slight differences in summer, where reductions in Southern European precipitation are not as pronounced as previously projected. The projected changes of the European hydrological cycle may have substantial impact on environmental and anthropogenic systems. In particular, the simulations indicate a rising probability of summer-time drought in southern Europe and more frequent and intense heavy rainfall across all of Europe.

15.00 Mohammad Reza Jalali (ETH, Engineering Geology): **Multi-scale Hydraulic Characterization of Stimulated Fractured Crystalline Rock at Grimsel Test Site**

Natural and induced fractures make flow in oil and gas reservoirs, nuclear waste repositories and enhanced geothermal systems strongly heterogeneous and anisotropic. In such environments, characterization of the fractured medium through a combined multi-scale and multi-component approach could result into an improved understanding of the physical setting and behavior of the medium of interest. As part of the In-situ Stimulation and Circulation (ISC) experiment at the

Grimsel Test Site (GTS), which is located in the central Swiss Alps, a comprehensive hydraulic characterization campaign has been conducted in order to evaluate the efficiency of hydraulic fracturing and hydraulic shearing on the permeability enhancement and heat exchange capacity of the granitic host rock. The hydraulic characterization consists of tests of varying scale, ranging from single-hole (e.g. pulse injection and oscillatory injection tests) to cross-hole (e.g. constant rate injection and oscillatory interference tests) and reservoir scale (e.g. ling-term constant rate injection test). Moreover, various components in addition to hydraulic tests have been added to these measurements such as thermal and conservative tracer tests, single-hole and cross-hole geophysical measurements and strain/deformation measurements. The results obtained indicate enhancement of permeability as well as non-integer flow dimension, and thereby natural heat exchange efficiency of the fractured zones. In addition to that, the characteristic of the thermo-hydro-mechanical (THM) behavior on the influenced fractures during the hydraulic/thermal characterization tests has been affected as more flow paths now contribute to the hydraulic system after the hydraulic stimulation. Finally, combinations of all above mentioned methods provide new insights on the heat exchange efficiency of the stimulated rock mass.

15.30 Anja Bretzler (Eawag, Hydrogeology): **Multi-tracer investigations of arsenic-affected fractured bedrock aquifers in West Africa**

Shallow to moderately deep (< 100 m) fractured bedrock aquifers provide drinking water to tens of millions of people in semi-arid Burkina Faso and neighbouring countries. Groundwater quality may be compromised by high geogenic arsenic concentrations, stemming from the oxidation of sulphide minerals in mineralised zones. Very little is known about groundwater residence time distribution in these aquifers and possible influences of residence time on arsenic mobility. Using noble gas tracers, 3H, 2H and 18O in addition to hydrochemical analyses, we could show a high variability in chemical and physical groundwater properties occurring on spatial scales of a few hundred metres. Groundwater portions with residence times >> 1000 years (indicated by very low 3He/4He ratios) co-occur with younger water (< 50 years) influenced by recent recharge, contradicting previous studies that presumed the dominance of modern groundwater. The occurrence of arsenic, on the other hand, is not linked to groundwater residence times.

15.45 Gabriele Manoli (ETH, IfU-Hydrology): **Trading water for carbon with oil palm plantations**

Oil Palm (OP) is the highest yielding cash-crop in the world and, given its ability to provide food and raw materials, is driving significant tropical forest losses. Existing research has focused on the effect of OP on ecosystem degradation, biodiversity losses, and carbon emissions, but little is known on the ecohydrological changes occurring from forest clearing to OP maturity. Here we combine model calculations with field observations to quantify OP-induced changes in evapotranspiration, infiltration/runoff, gross primary productivity and surface temperature. Our results demonstrate that, compared to forests, young OP plantations decrease evapotranspiration and increase surface temperature (+2-3°C), while mature plantations transpire more water that the forests they have replaced (+3-8%). Hence, the high fruit productivity of OP comes at the expense of water consumption, corroborating anecdotal evidence of water scarcity issues in OP-dominated landscapes.

Poster program

Dembélé M., Mariéthoz G., Schaefli B. (Institute of Earth Surface Dynamics, UNIL): **Gap filling of streamflow time series using Direct Sampling in data scarce regions.**

Martin Hirschi, Dominik Michel, Irene Lehner & Sonia I. Seneviratne (Institute for Atmospheric and Climate Science, ETH) :**A site-level comparison of lysimeter and eddy covariance flux measurements of evapotranspiration.**

Michelon A., Ceperley N., Beria H., Larsen J., Schaefli B. (Institute of Earth Surface Dynamics, UNIL):**Role of snowcover on water balance and melt dynamics in the Vallon de Nant, Switzerland.**

Nadav Peleg, Simone Fatichi, Athanasios Paschalis, Peter Molnar & Paolo Burlando (Hydrology and Water Resources Management Institute of Environmental Engineering (IfU) ETH): **AWE-GEN-2d: A new gridded stochastic weather generator.**

Ramgraber, M., & Schirmer, M. (Water Resources & Drinking Water, Eawag): **Online calibration and data assimilation in groundwater models using nested particle filters**

Urs Schönenberger, Max Maurer & Christian Stamm (Environmental Chemistry, Eawag): **The most neglected pesticide transport pathway?**

von Freyberg, J., Studer, B., & Kirchner, J.W. (ETH Zurich, Dept. of Environmental Systems Science & Swiss Federal Research Institute WSL): **Insights into streamflow generation mechanisms using high-frequency analysis of isotopes and water quality in streamflow and precipitation**