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14. Hydrology, Limnology and Hydrogeology

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14. Hydrology, Limnology and Hydrogeology

Massimiliano Zappa, Michael Doering, Tobias Jonas, Michael Sinreich, Bettina Schaefli

Swiss Society for Hydrology and Limnology SGHL,
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Swiss Hydrogeological Society SGH

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14.1 Normalization and trends of damage due to floods and landslides in Switzerland

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Natural hazards can cause considerable damage to infrastructure and settlements. Since 1972 damage due to floods, debris flows and landslides are collected in the Swiss flood and landslide damage database at the Swiss Federal Research Institute WSL (Hilker et al. 2009). We analysed this data and addressed questions about trends in the damage data and a potential connection to climate change. For the first time, the data set of the Swiss flood and landslide damage database was normalized with three different approaches and trend tests were applied for the yearly damage data of the period 1972-2016. In the normalization approaches, socio-economic developments like the development of the inflation, population and wealth were accounted for as suggested by Pielke & Landsea (1998). When applying normalization procedures, the question has to be asked how much a former event would cost nowadays under current societal conditions. Hence, we normalized the past loss data since 1972 for each year to 2016 values.

The normalization of the nominal damage data results in much higher values in the earlier years of the study period, especially for the high damage years (e.g. 1977, 1978, and 1987; see Figure 1). The total sum of damage as well as the mean is around twice as high after normalization. Around 71-75% of the total (nominal and normalized) damage occurs from June until August and spatial analysis shows highest damage in central Switzerland and along river reaches in the main Alpine valleys. The results reveal no statistically significant increase for the yearly nominal and normalized damage data (with all three normalization approaches). Potential effects of climate change on flood, debris flow and landslide damage data could therefore not be detected.

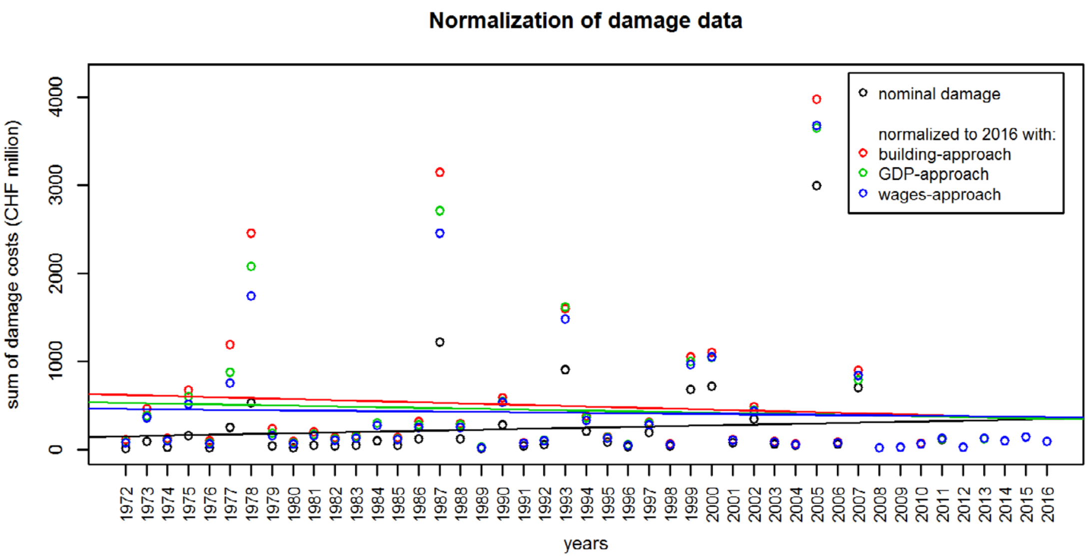

Figure 1. Normalization of yearly damage data (in CHF million) to 2016 with three different approaches: Building-approach, GDP-approach and wages-approach. The coloured lines represent the regression lines of nominal and normalized damage data. Note that none of the data sets show a statistically significant trend with the linear regression model (Figure 1 is part of a paper submitted to the Journal of Flood Risk Management in May 2018).

REFERENCES

Hilker, N., Badoux, A., Hegg, C. 2009: The Swiss flood and landslide damage database 1972-2007, Natural Hazards and Earth System Science, 9, 913-925.

Pielke Jr., R. A. & Landsea, C. W. 1998: Normalized hurricane damages in the United States: 1925-95, Weather and Forecasting, 13 (3), 621-631.

14.2
meteolakes.ch – An online platform for monitoring and forecasting the 3D bio-physical state of Swiss lakes

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The exceptional variability of lakes has been studied numerous times, yet no unique framework capable of reproducing the wide range of lake dynamics observed in various regions of the World (or within Switzerland itself) has been formulated. Increasingly facing external pressures, inland waters adaptation and change have to be understood and monitored efficiently to provide timely, scientifically credible, and policy-relevant environmental information.
Such monitoring capabilities and their importance for understanding the spatial and temporal heterogeneity in the distribution of all lake trophic levels is now largely recognized. Over the last decades, various research communities addressed this problem using different information sources, such as in-situ measurements, remote sensing observations and numerical simulations. The goal of this study is to couple those sources through adapted parameterization and data assimilation algorithms. This coupling approach implies mutual feedback mechanisms among those three information sources; model simulations are improved through the assimilation of in-situ measurements and remotely sensed products, remote sensing image processing is improved through parametrization with in-situ measurements and forecasts of hydrodynamic and biological models. Finally, in-situ measurements achieve a better representativeness when carried out along instantaneous gradients known from remotely sensed products and model simulations during the planning and sampling stages.
An online platform, *meteolakes.ch*, is developed with such aim for monitoring and forecasting the bio-physical state of Swiss lakes. Meteolakes is a web/Android-application that disseminates results of 3D coupled hydrodynamic-biological model forecasts out to 4.5 days for several Swiss lakes using real-time atmospheric, rivers and WWTPs data. With direct impacts at scientific and community level, this integrated data-model system also aims at assisting stakeholders in evidence-based decision-making and towards the sustainable management of our lakes.

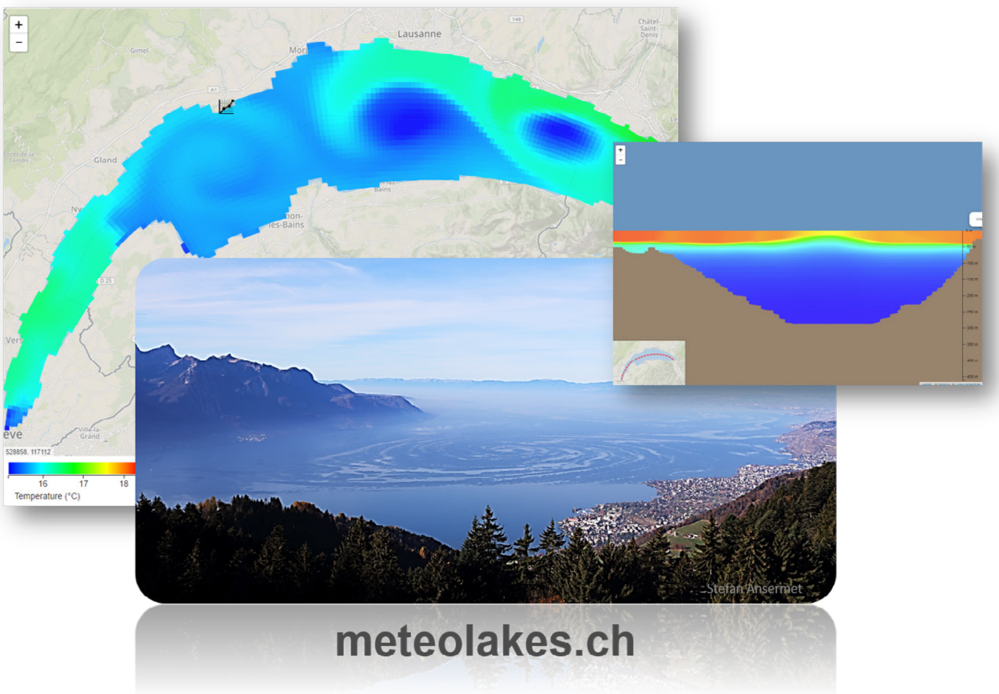

Figure 1. Surface temperature of Lake Geneva as displayed on meteolakes.ch (upper picture), transect of Lake Geneva temperature structure showing a thermocline uplift (mid picture), gyre observed over Lake Geneva (lower picture).

14.3
A multitracer experiment on a vegetated lysimeter to measure water transit times in the subsurface

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Flow velocities, residence times and tracer breakthroughs in the subsurface are known to be affected by matrix properties and preferential flow. Despite their relevance to trasport processes, however, the relative timing of preferential flow, and its link to transit times through the soil block, is still poorly described. Here, we present and analyze tracer data from a large vegetated lysimeter experiment conducted within the EPFL campus. A solution of two fluorobenzoid acid (FBA) tracers added to 18 mm of isotopically labeled rain was injected as a pulse and then followed with a series of tracer-free controlled rainfall events for 5 months. Timeseries of soil water samples at three different depths and bottom drainage samples were collected and analyzed. Unlike past lysimeter experiments, a willow tree grown within the lysimeter exerted strong evapotranspiration fluxes. After the injection, all the tracers took around 35-40 days to be first recorded in soil water at 150 cm depth, while they only needed 15-20 days to be found in the bottom drainage at 250 cm depth (Figure 1). This implies that a solute could percolate and reach an aquifer twice as fast as observed through soil water samples, with implications for e.g. the propagation of pollutants spills. Tracer recovery indicates that roughly 30-40% of the labeled rainfall returned to the atmosphere via evapotranspiration, while the remaining 60-70% was released through the bottom outlet over roughly 5 months. Besides assessing the interplay between slow vertical percolation and fast recharge through macropores, our results highlight the effect of vegetation uptake on water and solute transport.

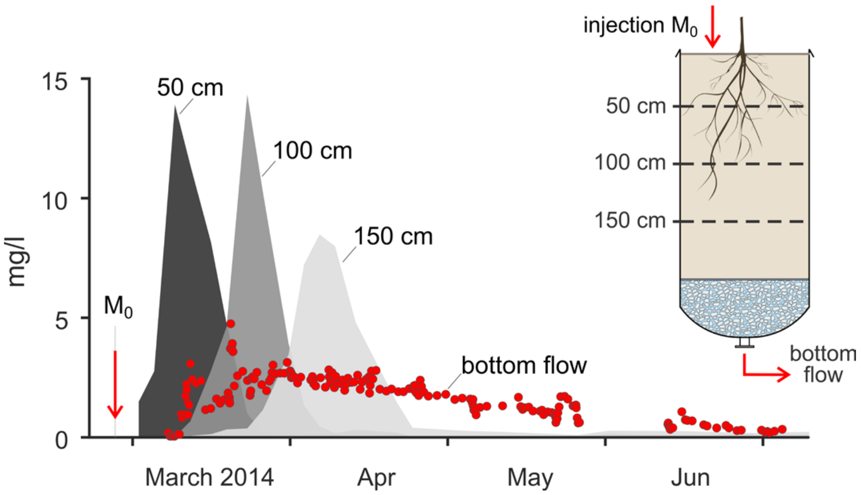

Figure 1. Concentration breakthrough curve for the FBA tracers obtained for the lysimeter base drainage (red dots) and for soil water samples (grey polygons) extracted at 50, 100 and 150 cm depths. The inset cartoon illustrates the general experimental setting.

14.4
Interactions between Surface Water and Groundwater in a regulated alpine gravel-bed River (Maggia)

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While the importance of renewable energy sources is constantly rising and hydropower represents an increasingly fundamental means of energy production in Switzerland, the potential negative impact of hydropower production on downstream rivers remains an important issue. In many alpine basins, hydropower systems store water in headwater reservoirs and divert it to produce electricity, sometimes bypassing long reaches of downstream rivers. This potentially affects the hydrology, sedimentology and ecology of the impacted river reaches. The prediction of short- and long-term impacts of such changes on the river morphology, riparian vegetation, groundwater levels, and aquatic habitat requires the development of numerical tools which combine hydrodynamic simulations with riparian vegetation growth and aquatic habitat modules. Furthermore, these tools also have to be validated with ground measurements where possible.

Our goal in this research is to develop an integrated river simulator with which the response of river and groundwater systems to different environmental flow strategies, i.e. mandatory releases downstream of hydropower systems (e.g. constant releases, seasonal releases, artificial floods, etc.), as well as the evolution of riparian vegetation and aquatic habitat in such scenarios can be predicted. We achieved the first target through the design and combination of appropriate numerical tools for flow analysis, including a coupled model of river-aquifer interactions suitable for complex gravel-bed braided river floodplains (Ruf et al., 2008; Shaad, 2015). We illustrate here the river-aquifer coupling in the Maggia River, which is highly regulated by a hydropower system and intensively monitored by our group, as streamflow and groundwater levels, river bed morphology, riparian vegetation, etc. are kept under observation through sensors installed in the field.

The coupled model consists of a two-dimensional shallow water flow simulator (2dMb) iteratively coupled to a groundwater model (MODFLOW) on a high resolution regular grid (~10 m). The saturated hydraulic conductivity of the alluvial fill and the conductance of the river bed are key parameters to satisfactorily reproduce observed groundwater fluctuations in response to floods in boreholes close to the river (Fig. 1). The fluctuations occur with a very short response time, which requires high resolution monitoring and an accurate numerical coupling scheme. Surface roughness parameters in 2dMb were calibrated with water depth measurements. The surface flow model simulates flow depth, velocity and bed shear stress, which are crucial variables for sediment transport and erosion potential. Finally, the coupled river-aquifer model allows us to estimate the rates and areas of infiltration and/or exfiltration along the river system, and thereby to quantify river-aquifer connectivity, which is of great importance for aquatic ecosystems.

The next step is to integrate the river-aquifer flow simulator with long-term riparian vegetation modelling in the floodplain. To this end, the flow variables and groundwater levels will be used as drivers of vegetation growth, i.e. water stress by flood inundation and drought at low groundwater levels. Groundwater has been shown to have the potential to drive long-term changes in riparian vegetation succession (Bätz et al., 2016).

The modelling approach will allow us to examine and predict the effects of different environmental flow policies on riparian vegetation, and produce a model-based quantitative assessment of the response of surface water, groundwater and riparian vegetation to various flow releases. The ultimate goal is to develop a modelling framework with which we will be able to optimise flow releases in the least disruptive way with regards to the riparian system in the Maggia Valley, and possibly applicable in other alpine streams.

REFERENCES

Bätz, N., Colombini, P., Cherubini, P. & Lane, S. N. 2016: Groundwater controls on biogeomorphic succession and river channel morphodynamics, J. Geophys. Res. Earth Surf., 121, 1763–1785, doi:10.1002/2016JF004009.

Ruf, W., Foglia, L., Perona, P., Molnar, P., Fäh, R. & Burlando, P. 2008: Modelling the interaction between groundwater and river flow in an active alpine floodplain ecosystem, Peckiana, 5, 5–16.

Shaad, K. 2015: Development of a distributed surface-subsurface interaction model for river corridor hydrodynamics, doctoral thesis submitted to attain the degree of Doctor of Sciences of ETH Zürich.

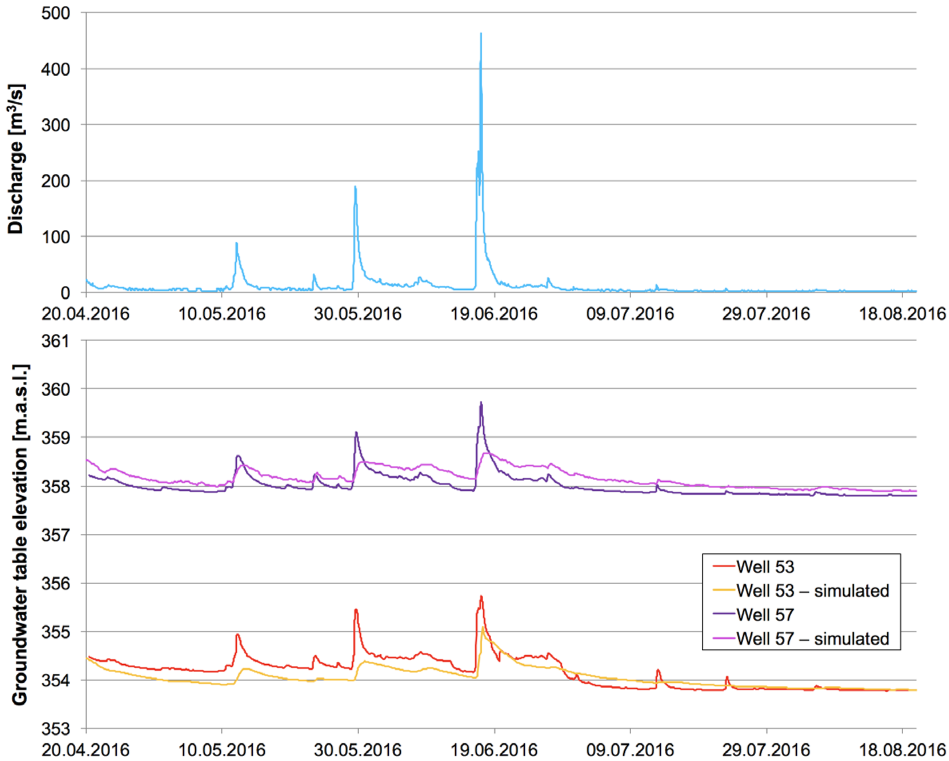

Figure 1. Discharge and corresponding groundwater level heads measured in the field and simulated by the coupled model for a 4-month period in 2016.

14.5
Development of a two-component linear mixing model to quantify the influence of rainfall and snowmelt in groundwater recharge

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Stable isotopes of water have been used for over half a century to quantify the amount of groundwater recharge that comes from rainfall vs snowmelt. Classically, this has been done by solving a linear equation with one unknown variable, which in this case is snow fraction. In order to improve the reliability of the estimates of snow fraction, Bayesian mixing models have been proposed over the last decade. Such models assume a probability distribution function (pdf) for rainfall, snowmelt and groundwater and then by formal Bayesian inversion, obtain the coefficient of the snow fraction. A major caveat in this approach is the assumed pdf, which becomes hard to justify as the number of data points for the isotopic ratios are generally very low. We propose a frequentist alternative that does not assume any pdf function on the rainfall, snowmelt or groundwater, and also gives reliable uncertainty estimates for snow fraction. In this approach, each combination of rainfall and snowmelt isotopic ratios is mixed with each combination of groundwater isotopic ratio. We assume the error in the estimates to be normally distributed with zero mean and constant variance. By assuming a uniform prior distribution for snow fraction, we infer its value by applying a maximum likelihood procedure. As this is not formal Bayesian inference, the pseudo-posterior of snow fraction gives an estimate of its mean along with an uncertainty bound around it. Using a series of synthetic tests, we compare our estimates with those of the conventional Bayesian mixing model estimates. A key advantage of our method is that it uses the whole dataset instead of relying on the first few moments. Also in our method, it becomes much easier to account for other processes that may affect the amount of snow in groundwater. We demonstrate this by accounting for the spatial heterogeneity in a catchment induced by elevation gradient and homogenization induced by snow metamorphism.

14.6
Water shortages under current and future extreme streamflow conditions in Switzerland

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In Switzerland, water is currently abundant on a national scale but regional and local water shortages might occur in dry years when water demand exceeds natural water availability. The development of such shortages might be exacerbated by climate induced changes which lead to a shift in runoff regimes with relatively less runoff in summer when water demand is highest. These regime shifts are caused by both increasing temperatures which lead to glacier retreat, a reduction in snow cover, and earlier snowmelt and shifts in the seasonality of precipitation from summer to winter precipitation.

Water shortages have negative economic impacts related to a potential reduction in crop yields, hydropower, or artificial snow production and negative ecological impacts on e.g. fish populations or tree communities. To reduce such negative effects, water management plans have to be developed or adapted such that water demand can be reduced and/or water availability be increased e.g. by reservoir operation targeted at increasing water supply.

The development of such management plans requires reliable estimates on potential water shortages under extreme streamflow conditions. Such estimates are not yet available for Switzerland neither for current nor future conditions. Here, we therefore investigate which regions in Switzerland might be most affected by water shortages under current climate conditions and assess how water shortage situations caused by extremely low streamflow conditions might change under future climate conditions. To do so, we quantified both natural water availability and water demand for 22 large hydrological regions in Switzerland. Natural water availablity was simulated using the hydrological model PREVAH (Viviroli et al., 2009), on the one hand, driven with observed meteorological data and, on the other hand, with climate model simulations. Water demand was estimated for various water use categories including drinking water (domestic and tourism), industry (second and third sector), agriculture (irrigation and livestock), ecology, and hydropower production. Potential water shortages were then computed for mean and extreme streamflow conditions under current and future climate conditions as the difference between water availability and water demand.

Extreme streamflow conditions were defined in the form of annual design hydrographs for specified reoccurrence intervals of 10 and 100 years. To estimate such annual design hydrographs, we used three different techniques among which two account for the multivariate nature of the esimtation problem. The first approach involves a univariate frequency analysis of discharges of individual months (Coles, 2001). The second approach performs frequency analysis on the flow duration curve (Claps and Fiorentino, 1997) and uses a typical runoff regime for the reassignment of seasonality. The third approach performs frequency analysis on the annual hydrographs directly by using a functional data representation (Cuevas et al., 2007). The subsequent comparison of extreme annual hydrographs with regional water demand allowed for the identification of seasons and regions that are/will be affected by water shortages.

Our results show that water shortages can regionally and seasonall already occur under current extreme streamflow conditions (see Figure 1 for two example regions). Regions with rainfall dominated runoff regimes, such as northeastern Switzerland, are mostly affected by water shortages in summer while regions with snowmelt dominated regimes, such as the Valais, are mostly affected by winter water shortages. The results also show that these potential shortages are likely to get more severe under future extreme streamflow conditions. This knowledge about possible future regional and seasonal water shortages will help water managers to adapt water management and reservoir operation plans in order to ensure a save water supply.

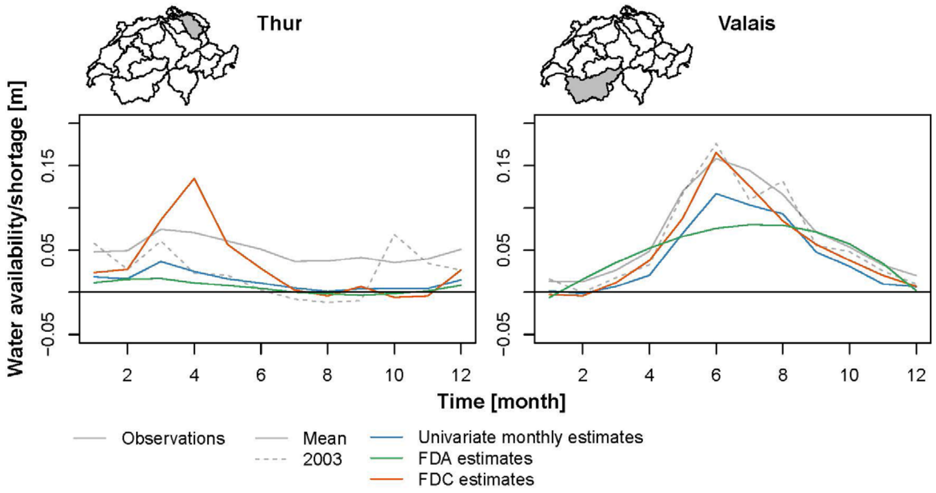

Figure 1. Water availability and shortages for two example regions (Thur and Valais) for the mean annual hydrograph, the hydrograph of the dry year 2003, and three extreme annual hydrographs derived using different estimation techniques under current climate conditions for a return period of 10 years. The extreme hydrographs include univariate monthly estimates, estimates derived by functional data analysis (FDA) and by flow duration curves (FDC).

REFERENCES

Claps, P. and Fiorentino, M.: Probabilistic Flow Duration Curve for Use in Environmental Planning and Management, Integr. Approach to Environ. Data Manag. Syst., (31), 255–266, doi:10.1007/978-94-011-5616-5, 1997.

Coles, S.: An introduction to statistical modeling of extreme values, Springer, London., 2001.

Cuevas, A., Febrero, M. and Fraiman, R.: Robust estimation and classification for functional data via projection-based depth notions, Comput. Stat., 22, 481–496, doi:10.1007/s00180-007-0053-0, 2007.

Viviroli, D., Zappa, M., Gurtz, J. and Weingartner, R.: An introduction to the hydrological modelling system PREVAH and its pre- and post-processing-tools, Environ. Model. Softw., 24, 1209–1222, doi:10.1016/j.envsoft.2009.04.001, 2009.

14.7
Effects of eutrophication on sedimentary organic carbon cycling in five Swiss lakes

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Eutrophication due to anthropogenic activities can have severe impacts on aquatic ecosystems. The increased nutrient load can lead to high primary production and thereby oxygen depletion due to increased organic matter (OM) degradation. Yet, the effects of eutrophication on total organic carbon (TOC) accumulation and degradation, are not well known. We study these effects using sedimentary records of five Swiss lakes covering the last 180 years. We investigate changes in content, stable isotopic composition of TOC, TOC accumulation rates and microbial OM remineralization in response to increased phosphorus (P) loadings due to eutrophication. Our results show elevated P concentration in the lake water column coincide with increased TOC and Chla content and TOC accumulation rates. In addition, the attempts to decrease eutrophication by reducing P loadings lead to decreased TOC accumulation rates. The sediments of eutrophic lakes show higher microbial respiration rates with a higher contribution of methanogenesis. Furthermore a clear redox zonation of dominant microbial respiration reactions is absent in all lakes. Our results suggest that in the studied lakes, anthropogenic P inputs have the potential to regulate TOC accumulation and methane production rates.

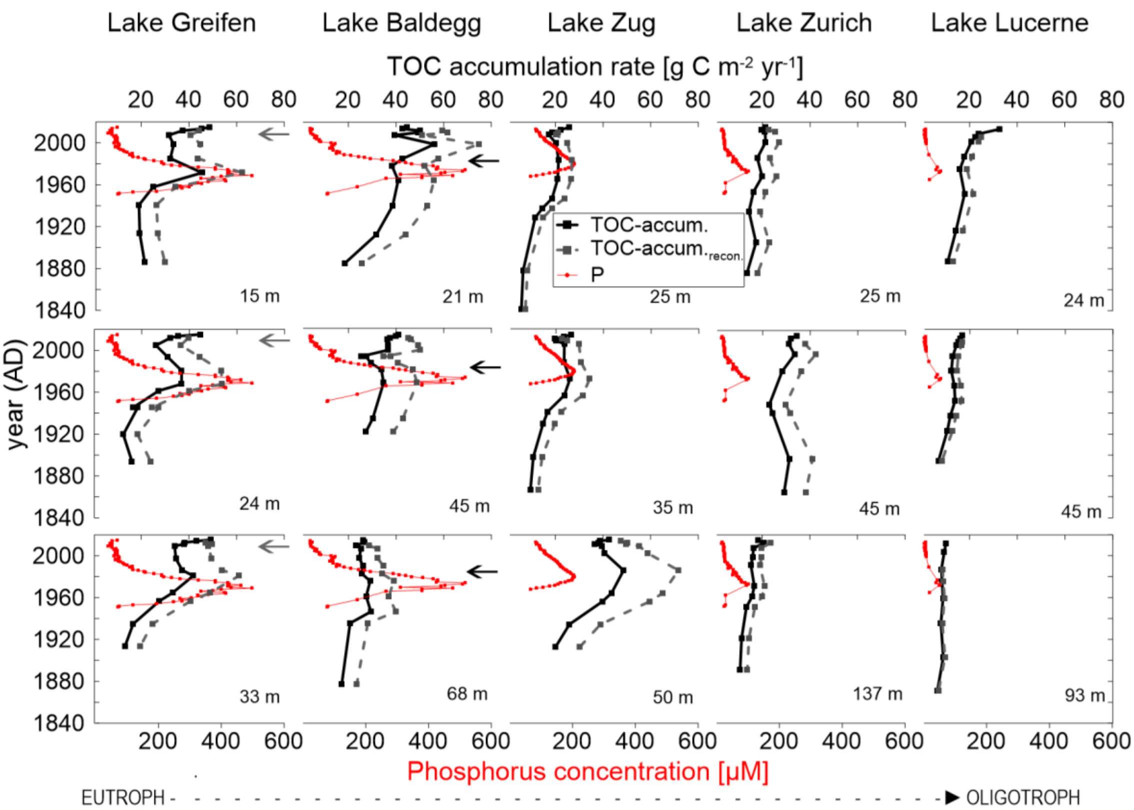

Figure 1. Carbon accumulation rates in black solid lines and reconstructed carbon accumulation rates [g C m^{-2} yr^{-1}] in dashed grey lines as well as water column phosphorus concentrations in red solid lines [µM] vs. age for each station of the five lakes, water depths of sampled stations are indicated at the bottom of each subplot. Grey and black arrows indicate onset of artificial mixing and aeration respectively.

REFERENCES

Anderson, N. J., Bennion, H., and Lotter, A. F.: Lake eutrophication and its implications for organic carbon sequestration in Europe, Global Change Biol, 20, 2741-2751, 2014.

Anderson, N. J., Dietz, R. D., and Engstrom, D. R.: Land-use change, not climate, controls organic carbon burial in lakes, P Roy Soc B-Biol Sci, 280, 2013.

Bastviken, D., Cole, J., Pace, M., and Tranvik, L.: Methane emissions from lakes: Dependence of lake characteristics, two regional assessments, and a global estimate, Global Biogeochem Cy, 18, 2004.

Canfield, D. E., Kristensen, E., and Thamdrup, B.: Aquatic Geomicrobiology, Aquatic Geomicrobiology, 48, 1-640, 2005.

Cole, J. J., Prairie, Y. T., Caraco, N. F., McDowell, W. H., Tranvik, L. J., Striegl, R. G., Duarte, C. M., Kortelainen, P., Downing, J. A., Middelburg, J. J., and Melack, J.: Plumbing the global carbon cycle: Integrating inland waters into the terrestrial carbon budget, Ecosystems, 10, 171-184, 2007.

Middelburg, J. J.: A Simple Rate Model for Organic-Matter Decomposition in Marine-Sediments, Geochim Cosmochim Ac, 53, 1577-1581, 1989.

14.8
Low flow seasonality across Switzerland – Climatic drivers and the influence of landscape

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Low flows impact society and the environment. Thus they are an important consideration when water is used for drinking, irrigation and agriculture, artificial snow, and hydropower purposes (Blanc & Schädler, 2013). In Switzerland, lowflow characteristics vary regionally (Wehren et al., 2010) and these variations are mostly caused by regional differences in climate and landscape properties (e.g. topography, morphology, geology, soils). In this work we provide a country-wide overview of the primary driving mechanisms of low flows that could support water management strategies during extended dry periods.

We collected discharge data of 380 gauges from BAFU and Cantons across Switzerland. We use seasonality statistics to identify and quantify lowflow (NM7Q) seasonality and its driving mechanisms in the studied catchments over the period 2000-2016. To infer what drives low flows, we compare the timing and magnitude of NM7Q to the timing and magnitude of several climatic characteristics derived from gridded precipitation and air temperature data (MeteoSwiss). To understand the role of the landscape, we relate the seasonality and magnitude of low flows to several physical catchment characteristics such as elevation, slopes, landuse, and geology.

Results show distinct regional patterns in the seasonality of low flows and their elevation dependency (Figure 1). Also the climatic drivers of low flows are regionally consistent and elevation-dependent. In low elevation regions of the Swiss Plateau low flows occur almost exclusively in late summer and early autumn, and are the result of high evapotranspiration and low precipitation. In the high-elevated Alpine catchments, low flows are mostly driven by below zero temperatures that result in no liquid water being released to the catchments.

The timescale over which a system changes from median flow (Q50) to low flow (NM7Q) is below two months in lower elevation areas, but this timescale increases with elevation. We found that occurrence and magnitude of low flows are primarily controlled by several weeks of specific weather conditions (e.g. low precipitation, high evapotranspiration) rather than showing log-term memory effects to climatic conditions of prior months and years.

We identified specific landscape features influencing the magnitude of low flows. There are distinct differences comparing low-flow contributions from different geologies, e.g. from Molasse layers along the Swiss Plateau or various quaternary sediment deposits in higher elevations. Also, elevation is an important control on low flows in Switzerland, mostly through its effect on climatic variables and associated hydrological processes of runoff generation. Therefore, elevation is a powerful indicator for when and why low flows are expected to occur across the mountainous landscape of Switzerland.

REFERENCES

Blanc P, Schädler B. 2013. Das Wasser in der Schweiz – ein Überblick. Schweizerische Hydrologische Kommission. Available at: ISBN: 978-3-9524235-0-9

Wehren B, Weingartner R, Schädler B, Viviroli D. 2010. General characteristics of Alpine waters. In Alpine Waters, Bundi U (ed.).Springer: Berlin; 17–58. DOI: info:doi/10.1007/978-3-540-88275-6_2

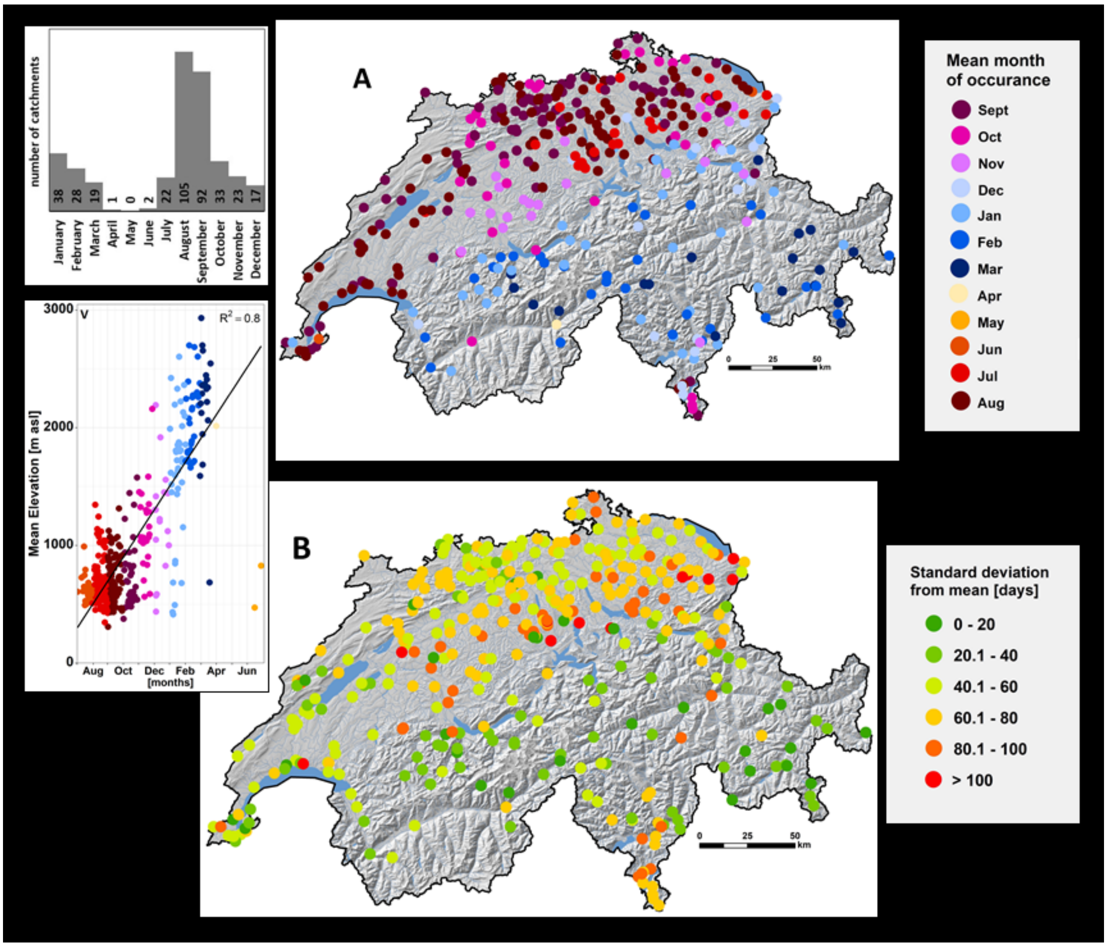

Figure 1: Low-flow seasonality across 380 gauges in Switzerland. The maps show (A) the mean date of occurrence of the lowest annual 7 consecutive day Q (NM7Q) and (B) the standard deviation from the mean date of occurrence in days for the years 2000–2016. The mean date of occurrence of NM7Q is related to elevation (inset figure)

14.9
A roadmap towards a short-term flood impact forecasting system

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Recently, relevant progress has been made in river discharge forecasting.These forecasts support local crisis intervention forces in undertaking emergency measures, such as the temporary evacuation of people from hazard zones, the removal of movable goods (e.g. cars) from the potentially flooded areas, or the dislocation of movable household items from lower floors to upper floors in endangered houses. However, a reliable and precise forecast of an extreme precipitation's impact is fundamental for these interventions to be a valuable additional flood risk management option.

The prediction of the direct consequences of a forecasted rainfall event in the short-term (lead times of 6-24 h), and in particular the prediction of site-specific flood losses are poorly investigated topics. A translation of the discharge forecast to the potential impacts in terms of damage potential is therefore needed. Several models are used to research extreme events including numerical weather forecast models, hydrological models, hydrodynamic models, and damage and loss models. Although these model types are well established, and coupling two to three of these models has been successful, only recently an assessment of a full and comprehensive model chain from the atmospheric to local scale flood loss models has been conducted (Felder et al. 2018). The development of these model chains provides the basis for a spatially explicit prediction of local impacts of intense precipitation events.

Here we present a roadmap towards predicting flood impacts for short lead times. The concept bases on the experience gained from previous projects in elaborating full model chains from rainfall to flood losses at the single building scale. We will extend our investigations including a multi-model approach for the rainfall-runoff simulation, a routing system, and a fast-to-run surrogate model for predicting the flood losses (Zischg et al. 2018).

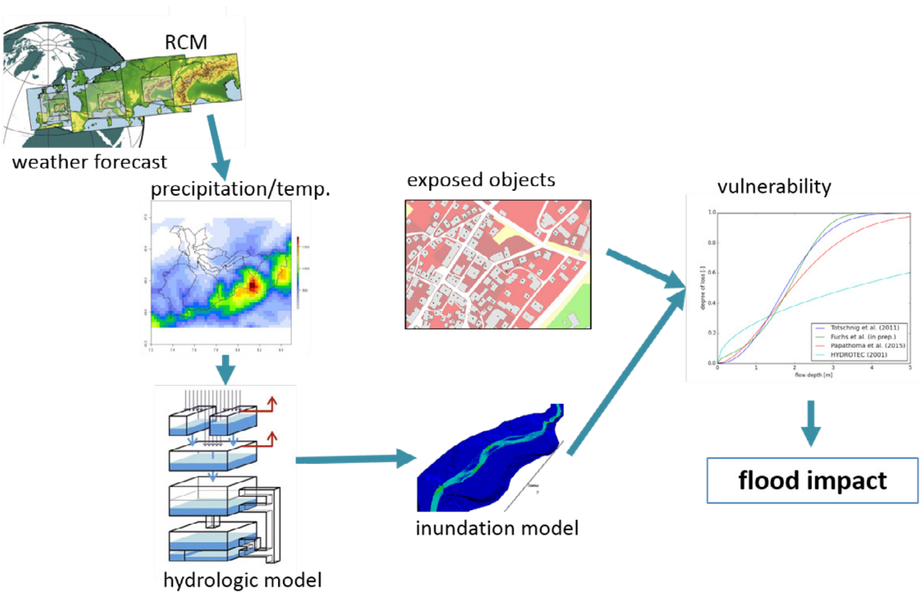

Figure 1. Schema of the flood impact forecasting system.

REFERENCES

Felder, G., Gómez-Navarro, J.J., Zischg, A.P., Raible, C.C., Röthlisberger, V., Bozhinova, D., Martius, O., Weingartner, R., 2018. From global circulation to local flood loss: Coupling models across the scales. Science of The Total Environment 635, 1225–1239. 10.1016/j.scitotenv.2018.04.170.

Zischg, A.P., Felder, G., Mosimann, M., Röthlisberger, V., Weingartner, R., 2018. Extending coupled hydrological-hydraulic model chains with a surrogate model for the estimation of flood losses. Environmental Modelling & Software 108, 174–185. 10.1016/j.envsoft.2018.08.009.

14.10
Global simulated distribution of periodic diffuse groundwater recharge response to climate variability

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Groundwater depletion is a problem worldwide that requires groundwater management decisions using knowledge about spatiotemporal patterns in recharge. Global-scale climate variability can result in transient recharge rates, but under some circumstances dampen within the vadose zone, resulting in a constant rate. In this study, we show when and where steady-state and transient recharge is expected worldwide, and provide guidelines regarding damping depth of recharge fluxes on a global scale. We use the output of an analytical solution of the Richards equation to demonstrate how variability in fluxes at land surface dampen with depth in the vadose zone for monthly, seasonal and annual periods of flux variations. We also considered interannual and decadal periods of flux variations, which are generally consistent with global-scale climate variability of the Pacific-North American Oscillation (PNA), North Atlantic Oscillation (NAO), El Niño/Southern Oscillation (ENSO), and Pacific Decadal Oscillation (PDO). In addition, we use our newly compiled global dataset of site-specific recharge rates to validate the results.

We demonstrate that for vadose zone soils with large sand content and large recharge rates, it is likely to obtain transient recharge fluxes, especially from interannual to decadal climate variability. For the (semi-) arid regions with relatively small recharge fluxes, climate signals are preserved in the transient recharge flux when the depth to the water table is less than 10 m, which is rarely met for these regions. Only when focused or preferential recharge significantly increase the local recharge rates then transient recharge conditions might occur. The depth to the shallow water table is less than 70 m for the majority of the globe and therefore, transient recharge associated with teleconnection patterns such as the PNA, NAO, ENSO, and PDO are detectable at the water table depths in most aquifers worldwide.

Our global-scale assessment generally explains why some periodic infiltration fluxes associated with climate variability are absent in groundwater level fluctuations while others result in transient recharge rates and dynamic groundwater levels. These findings have important implications for climate change impact studies on recharge rates and mechanisms and global groundwater sustainability.

14.11
Basin-scale gyres: Rotationally-driven mixing in Lake Geneva

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In large lakes, similar to oceans, the interaction between wind forcing and Earth's rotation can induce the formation of mesoscale rotational features known as gyres. These phenomena enhance horizontal transport throughout the water column and can persist for days to weeks. In this study, we explore the dynamics of gyres in Lake Geneva, using a buoyancy driven autonomous underwater vehicle (known as a glider; Slocum). The scientific payload includes sensors to sample water quality parameters (e.g. temperature, dissolved oxygen, etc.) but the focus of this work was a newly equipped sensor to measure mixing in the water column laterally over the entire lake. These observations offer high-resolution spatial measurement of temperature gradients, water quality parameters, and turbulence estimates, which are important for the understanding of lake-internal processes. The lateral temperature structure will be compared to hydrodynamic numerical model results from meteolakes.ch. Additionally, direct field measurements of currents were made in the eastern region of Lake Geneva's central basin (Figure 1) to further understand the dynamics of the gyres. From the two, quasi-stationary, basin-scale gyres that develop in Lake Geneva, we can use the solution of the geostrophic balance equation to estimate horizontal flow velocities using the observed doming structure measured with the glider. These gyres will also result in both vertical upwelling and downwelling of nutrients (depending on their cyclonic or anticyclonic nature) within the lake that have persistent influence on the ecosystem dynamics.

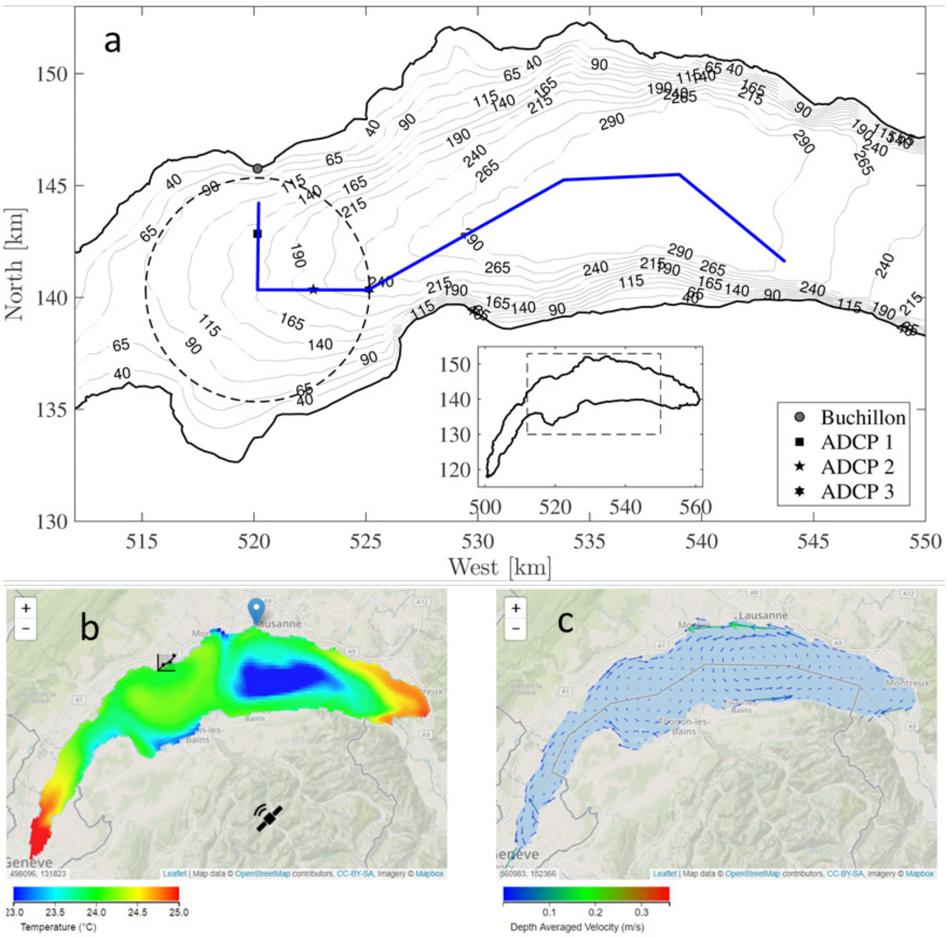

Figure 1. Inset of Lake Geneva with the geometry of one of the main gyres west of Morges (a), shown together with sur-face temperature of meteolakes.ch which strongly indicates a second gyre in the main basin (blue, b) and the depth-averaged currents (c).

14.12
Integrated hydrological modelling of a steep, geologically complex, snow-dominated Alpine catchment

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The complex bedrock arrangements present in the European Alps can exert a strong influence on the broader hydrological cycle, especially in calcareous regions. At the same time, ongoing climate change is threatening the established function of the Alps as "water towers". Moreover, the responses of the various system components (snow, vegetation, groundwater, permafrost etc.), as well as their associated interactions and feedbacks, are likely to be complex. Despite this situation, conceptual, reservoir-based hydrological models, which employ highly simplified representations of groundwater and physical processes more generally, continue to form the basis of most predictions of climate change impacts upon Alpine water resources.

In this context, we are currently developing a physically-based, spatially-distributed, fully-integrated (i.e. snow, surface water, unsaturated zone, and saturated zone flows) hydrological model for the Vallon de Nant and Vallon de La Vare catchments (western Swiss Alps). A key benefit of such models to studies of mountain hydrology is their ability to account for the modulating influence of geology on subsurface water movement whilst simultaneously representing surface flows that can have high relevance for flood risk and sediment transport. More specifically, our model firstly enables the quantification of the water balance over recent years explicitly in time and space. Secondly, it represents a tool with which the sensitivity of predictions of interest (e.g. stream discharges, groundwater levels) to alternative representations of forcing data or model structure (e.g. daily vs. hourly and spatially-distributed vs. uniform meteorology, fine vs. course mesh discretisation etc.) can be assessed. Ultimately, it will be applied to explore the overall hydrological implications of combinations of expected future changes in climate, vegetation and permafrost.

This contribution will provide an update on progress to date (both field data collection and model development), and will conclude by outlining our future intentions.

P 14.1
A spatially distributed numerical model for simulating sediment connectivity at the catchment scale

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In cultivated areas and populated river basins, excessively high rates of soil erosion and sediment production cause a number of problems, such as reduced crop productivity, decreased water quality, excessive sedimentation in rivers and streams, increased flood risk and reservoir siltation. A compelling understanding of these phenomena and their cause-effect relationship is necessary for water and land management, and can only be achieved with a catchment scale perspective on the sediment balance. Important elements are the sources and pathways of sediment in the catchment, their hydrological activation and connectivity to the fluvial network.

In this work, we develop a physically based numerical model for simulating sediment connectivity in time and space in river basins. The model is an extension of the spatially distributed TOPKAPI-ETH hydrological model (Fatichi et al., 2015) with new modules for overland flow erosion on hillslopes and for bedload and suspended sediment transport in the river network.

A first application of the model has been performed on the Kleine Emme river catchment (477 km^2, Canton Lucerne), by using a homogeneous parameterization of erodibility in the catchment. The model reproduces (a) erosional and depositional patterns that are coherent with the topographical features in the basin (Fig. 1); (b) bedload sediment yield that compares well with estimates reported in the literature (Heimann et al., 2015); and (c) a variable suspended sediment concentration to discharge (SSC-Q) relation that reflects the spatial variability of sediment production in the model (Fig. 2).

As a next step, the main sediment source areas and the dominant processes of sediment production will be identified throughout the catchment, based on geomorphological mapping in the basin (Schwab et al., 2008; Schlunegger and Schneider, 2005), field observations, and correlation between simulated overland flow and measured concentrations at the outlet. By parameterizing and calibrating the model based on potential sediment production rates in different areas of the catchment, we expect to be able to capture the main observed sediment sources and to better reproduce the scatter of the measured SSC-Q relationship at the basin outlet. This is a novel way to parameterize spatially distributed models with concurrent information on both hydrology (overland flow) and sediment transport.

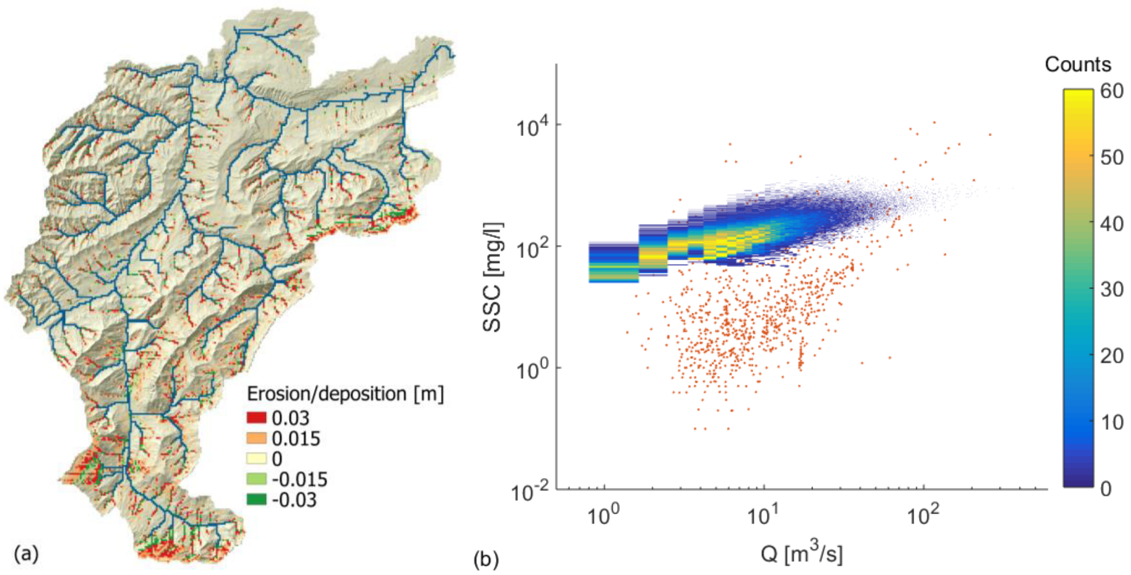

Figure 1. (a) Modelled erosion (red, >0) and deposition (green, <0) in the Kleine Emme catchment at the end of a 10 year simulation. (b) Modelled (histogram) and measured (red dots) suspended sediment concentration at the Kleine Emme River outlet for the period 2001-2009.

REFERENCES

Fatichi, S., Rimkus, S., Burlando, P., Bordoy, R. and Molnar, P., 2015. High-resolution distributed analysis of climate and anthropogenic changes on the hydrology of an Alpine catchment. Journal of Hydrology, 525, pp.362-382.

Schwab, M., Rieke-Zapp, D., Schneider, H., Liniger, M. and Schlunegger, F., 2008. Landsliding and sediment flux in the Central Swiss Alps: A photogrammetric study of the Schimbrig landslide, Entlebuch. Geomorphology, 97(3-4), pp.392-406.

Schlunegger, F. and Schneider, H., 2005. Relief-rejuvenation and topographic length scales in a fluvial drainage basin, Napf area, Central Switzerland. Geomorphology, 69(1-4), pp.102-117.

Heimann, F.U.M., Rickenmann, D., Böckli, M., Badoux, A., Turowski, J.M. and Kirchner, J.W., 2015. Calculation of bedload transport in Swiss mountain rivers using the model sedFlow: proof of concept. Earth Surface Dynamics, 3(1), p.35.

P 14.2
Estimating the precipitation in a high-alpine catchment combining local meteo stations and Swiss-wide meteo products

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Mountainous regions are often considered as water towers with above average precipitation and seasonal storage under a solid form. This water is a paramount resource during spring and summer for natural ecosystems but also many human activities. Due to its high spatio-temporal variability, defining the precipitation over an entire catchment is still a challenge. This is especially true in mountainous terrain where precipitation measurement is biased by numerous processes including in particular wind undercatch, station representativity, precipitation phase. In this study, our aim is to define the precipitation over the Vallon de Nant, a small high-alpine catchment in the Swiss Alps. We are comparing different sources of data from classic instruments (tipping bucket rain gauge, radar precipitation sensor), grided products (CombiPrecip and RHIRES from MCH), model output (COSMO1) and indirect estimates derived from snow depth measurements. In a first step, we are comparing data at the point scale and then interpolate them over the entire catchment. We show the advantages of having different sources of data and the potential limitations of each of them.

P 14.3
Reconstructing long-term trends in surface water summer temperature in a high-altitude lake: A modelling approach

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During the last century, climate change has lad to the warming of lakes worldwide (Schneider & Hook 2010), with lakes in the Alpine region warming at particularly high rates. While temperature trends in large lowland lakes have been thoroughly studied thanks to the availability of historical data series of water temperature (either measured or reconstructed from infrared satellite data; Lepori & Roberts 2015; Pareeth et al. 2017), so far, the analysis of long-term temperature patterns in high-altitude lakes has been hampered by a dearth of data. In this study, we developed a mathematical model to reconstruct a long-term series of surface-water temperature of a high lake located in the North-western Alps where a monitoring program has been recently established (Lago Nero, Canton Ticino, 2385 m asl). The model, based on a simplified heat budget and spatially-interpolated meteorological conditions, was calibrated and validated using recent data (monthly and daily temperatures, Figure 1) and subsequently used to simulate summer surface-water temperatures from the early 1900s. Preliminary results indicate a warming trend, but also suggest that the warming has been irregular in time and affected different indicators of thermal conditions (minimum, maximum, mean) in different ways. These patterns, which will be analysed further, suggest probable increases of thermal stress to cold-water organisms and alterations of lake-ecosystem function.

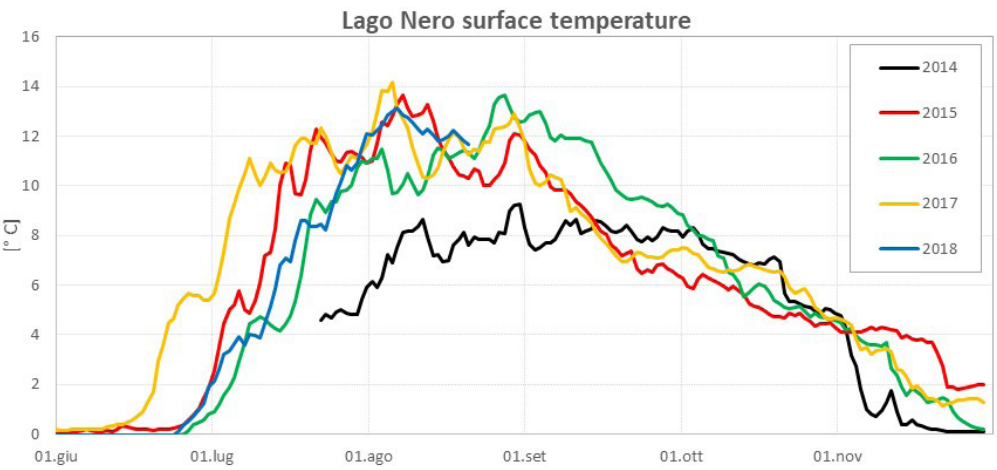

Figure 1. Daily evolution of summer and autumn surface temperature of the lago Nero.

REFERENCES
Schneider, P. & Hook S.J. 2010: Space observations of inland water bodies show rapid surface warming since 1985. Geophysical Research Letters 37(22).
Lepori, F & Roberts J.J. 2015: Past and future warming of a deep European lake (Lake Lugano): What are the climatic drivers? Journal of Great Lakes Research 41(4), 973–81.
Pareeth, S., Bresciani, M., Buzzi, F., Leoni, B., Lepori, F., Ludovisi, A., Morabito, G., Adrian, R., Neteler, M. & Salmaso N. 2017: Warming trends of perialpine lakes from homogenised time series of historical satellite and in-situ data. Science of The Total Environment 578, 417–426.

P 14.4
Moisture Fronts Linked to Precipitation over Europe – Case studies and a Climatology

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This study investigated the impacts of moisture fronts, which have strong humidity contrast but weak thermal difference, on precipitation by implementing two case studies and climatological analysis over Europe. The two case studies revealed that two different mechanism can trigger the convection along the moisture fronts. The first case study showed that the large-scale pressure pattern leads to a strong confluence over France, Switzerland, and northern Italy (Figure 1a). The persistent flow induces an elongated line of a sharp moisture front. There was no precipitation over the front, but the convection was initiated by the large-scale upward motion in the vicinity of the moisture boundary. The precipitation was intensified on the moisture front, and continued for about 36 hours even though the large-scale forcing that initiated the convection was not available anymore. The moisture front obtained self-sustainability due to a cyclogenesis caused by the PV production at low and mid-tropospheric levels. The second case had the similar synoptic-scale condition but was initiated by a different mechanism (Figure 1b). The convection was initially suppressed by a thermodynamic energy barrier, but initiated over Mediterranean when the energy barrier moved away and conditional instability was generated near the moisture boundary. Its evolution was quite similar with the first case. It continued for about 36 hours with the support of the PV production by condensation. Climatological analysis revealed a clear temporal and spatial pattern in their occurrence (Figure 2). In general, more moisture fronts occur in summer than in winter. But the seasonality highly depends on geographical features (e.g., topography and climate features). Most of moisture fronts in flat terrains over western Europe are synoptic-scale. It is shown that they prevails in spring and autumn than in winter and summer. On the other hand, fronts over complex terrain such as Alps and Balkan Peninsula are determined by local-scale processes within the boundary layer. They are dominate in summer, because of the higher boundary layer and stronger radiative forcing. The local-scale moisture fronts also had a clear diurnal cycle as the boundary layer depth does: more frequent in afternoon than in night and early morning.

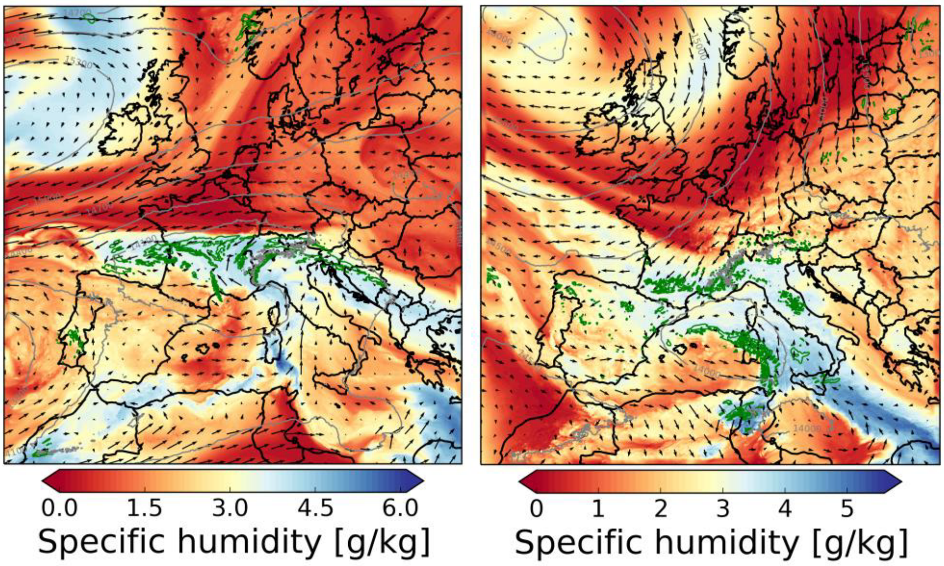

Figure 1. Specific humidity fields at 700 hPa over Europe on 0000 UTC 9 April 2002 (left) and 1800 UTC 3 April 2007 (right). Green contour represents precipitation greater than 1 mm/hr.

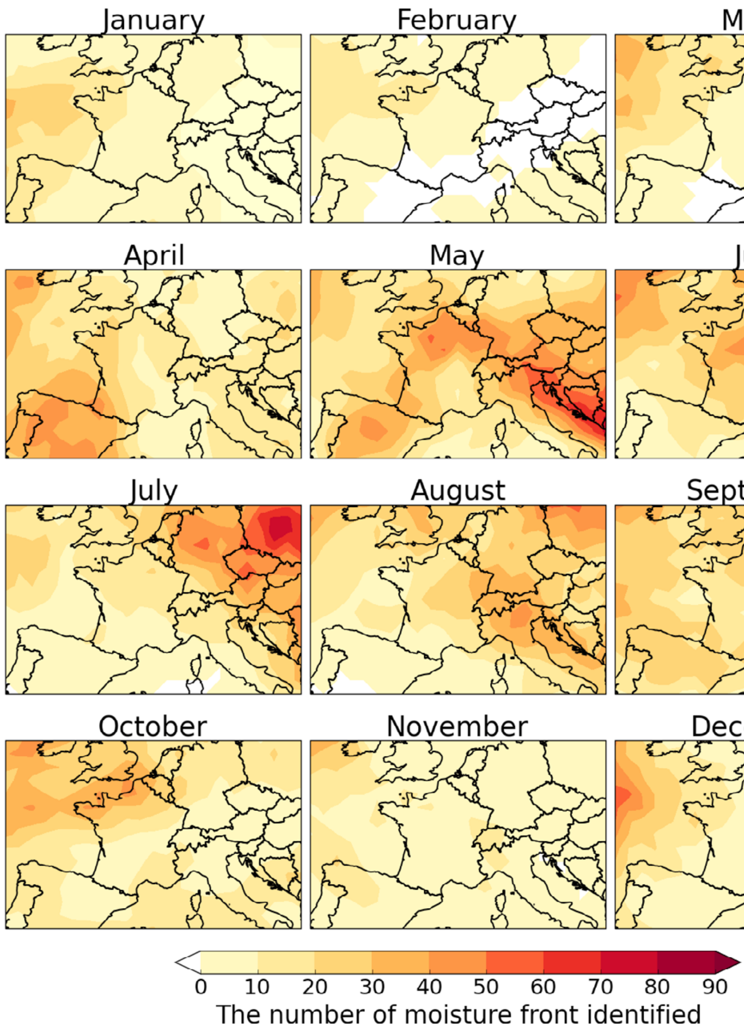

Figure 2. The numer of moisture fronts linked to precipitation which had taken place over Europe from 2000 to 2008.

P 14.5
Buoyancy-driven cross-shore flows in lakes induced by night-time cooling: field observations

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Cross-shore flows in lakes connect the littoral to the pelagic zones with major biogeochemical implications through the transport of nutrients, dissolved gases, particles and organisms (e.g., MacIntyre & Melack, 1995). One type of cross-shore exchange, referred to as “thermal siphon”, is driven by horizontal temperature gradients associated with differential cooling/heating (Monismith et al., 1990). In this study, we investigate the cooling-driven thermal siphon. This occurs during night-time, in the nearshore region of lakes. For uniform heat flux conditions over the lake surface, shallower regions cool faster than deeper regions: nearshore waters become negatively buoyant and start to plunge creating a cold downslope density current that can reach the pelagic zone. This underflow differs from the density currents commonly studied in quiescent environments because it propagates into a turbulent environment, characterized by the presence of a convective mixed layer at the surface.

Although buoyancy-driven cross-shore flows have been the focus of several laboratory and modelling studies in the past (e.g., Sturman et al., 1999; Mao et al., 2010), field observations are limited (e.g., Monismith et al., 1990; Fer et al., 2002). In particular, little is known about (1) the temporal and spatial variabilities of the thermal siphon in lakes, (2) the turbulent mixing induced by the density current and its interactions with surface penetrative convection and (3) its effects on transport and biogeochemical cycles.

The present study aims at filling these three gaps by extensively monitoring both penetrative convection and buoyancy-driven cross-shore flows in Lake Cadagno, a small meromictic lake located in Ticino (Switzerland), at 1920 m above sea level (Fig. 1). Three vertical moorings M1, M2, M3 consisting of a chain of thermistors were deployed along a cross-shore transect from June to September 2018. They allowed to identify cross-shore temperature gradients driven by differential cooling. In addition, the evolution of the surface mixed layer could be examined. The vertical and horizontal temperature distributions were also obtained from CTD profiles collected along different transects. Two near-bed moorings were used to measure lake temperature 30 cm above the sediment and provided information on the thermal structure in the cross-shore (M4) and along-shore directions (M5). The flow velocity was recorded by three Acoustic Doppler Current Profilers (ADCP) located near each vertical mooring. Turbulence intensity in the surface mixed layer was estimated from temperature microstructure profiles collected from an offshore platform. Finally, surface heat fluxes, buoyancy flux and wind forcing were computed from meteorological data recorded by a weather station on the lake shore.
Preliminary results from the 2018 experiments will be presented and discussed.

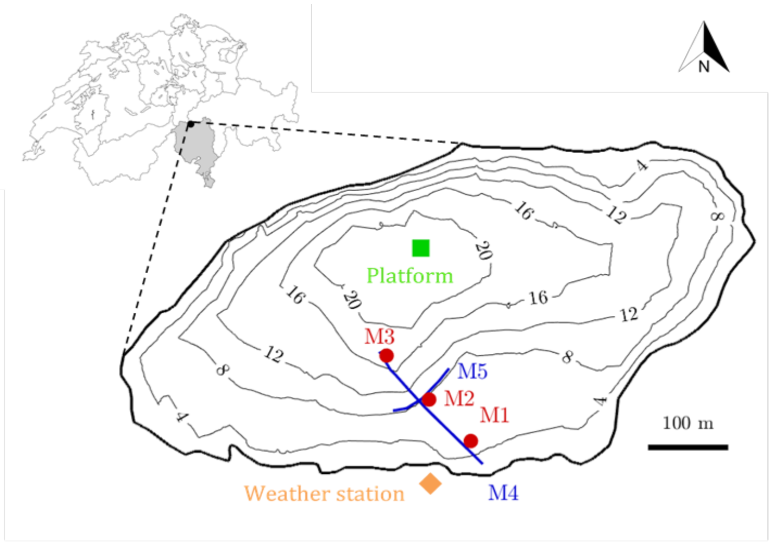

Figure 1. Location and bathymetric map of Lake Cadagno. The three vertical moorings are indicated in red and the two near-bed moorings in blue.

REFERENCES

Fer, I., Lemmin, U., & Thorpe, S. (2002). Winter cascading of cold water in Lake Geneva. Journal of Geophysical Research: Oceans, 107(C6).

MacIntyre, S., & Melack, J. M. (1995). Vertical and horizontal transport in lakes: linking littoral, benthic, and pelagic habitats. Journal of the North American Benthological Society, 14(4), 599–615.

Mao, Y., Lei, C., & Patterson, J. C. (2010). Unsteady near-shore natural convection induced by surface cooling. Journal of Fluid Mechanics, 642, 213–233.

Monismith, S. G., Imberger, J., & Morison, M. L. (1990). Convective motions in the sidearm of a small reservoir. Limnology and Oceanography, 35(8), 1676–1702.

Sturman, J., Oldham, C. E., & Ivey, G. N. (1999). Steady convective exchange flows down slopes. Aquatic Sciences, 61(3), 260–278.

P 14.6
Characteristics of meltwater passage through the proglacial area at Adygine complex, Northern Tien Shan

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The retreat of mountain glaciers has raised concern especially in those regions of the world, where the population is strongly dependent on glacier meltwater (Sorg et al., 2012). As the internal workings of glacier and proglacial systems have a significant influence on the overall hydrological regime of a glacierized basin (Moorman and Michel, 2000), mountain areas are the most important zones for water generation. That is particularly valid for dry Central Asia, where glacier meltwater contributes up to 40-70% to summer runoff (Aizen et al., 1996).

Groundwater sourced from periglacial landforms like rock glaciers or moraines has been shown to be important both in timing and quantity of alpine watershed discharge (Winkler et al., 2016). However, they represent a complicated system where layers of varying permeability occur (fine and coarse sediments, boulders, buried ice) and thus several drainage systems (delayed and fast water flow) may be present (Winkler et al., 2016). Although it is clear that proglacial lakes and landforms play an important role in transmitting and temporarily storing water, their internal hydrological processes and pathways are still not well understood.

In this study, we present research on meltwater passage through proglacial area, its influence on hydrological regime of lakes, and we test methods for revealing characteristics of subsurface drainage system. The used data include water level fluctuation of the main proglacial lakes forming the first part of the meltwater route, water samples from tarn lakes analysed to determine the isotopic composition, and a breakthrough curve based on a tracer experiment of the underground water passage.

Monitoring of lakes' water level fluctuation confirmed typical glacial regime in both seasonal and daily scale. The fluctuation characteristics of the individual lakes depend on amount of water inflow, position of a lake in terms of meltwater routing, and type and capacity of lake drainage channels. Isotopic composition of water in tarn lakes situated on the moraine complex revealed their linkage to meltwater and the influence of evaporation on their hydrological balance. Together with results of a tracer test this output enables us to outline the moraine's hydrological system. The relatively high water passage velocity suggests an efficient routing through highly permeable layer, however, there are likely multiple flow systems within the moraine complex.

REFERENCES

Aizen, V. B., Aizen, E. M., Melack, J. M. 1996: Precipitation, melt and runoff in the northern Tien Shan. J Hydrol, 186, 229-251.

Moorman, B. J., Michel, F. A. 2000: Glacial hydrological system characterization using ground-penetrating radar. Hydrol Process, 14(15), 2645-2667.

Sorg, A., Bolch, T., Stoffel, M., Solomina, O., Beniston, M. 2012: Climate change impacts on glaciers and runoff in Tien Shan (Central Asia). Nat Clim Change, 2(10), 725.

Winkler, G., Wagner, T., Pauritsch, M., Birk, S., Kellerer-Pirklbauer, A., Benischke, R., Leis, A., Morawetz, R., Schreilechner, M. G., Hergarten, S. 2016: Identification and assessment of groundwater flow and storage components of the relict Schöneben Rock Glacier, Niedere Tauern Range, Eastern Alps (Austria). Hydrogeol J, 24(4), 937-953.

P 14.7
Sensitivity of statistical precipitation downscaling to the choice of an atmospheric reanalysis

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Hydrological climate impact assessment relies on climate variables that are dynamically and/or statistically downscaled to a relevant spatial scale. Some of these downscaling methods are based on perfect prognosis approaches (Maraun et al., 2010), which rely on statistical relationships between observed synoptic predictors and the local variable of interest, here daily precipitation. The synoptic predictors are often extracted from global atmospheric reanalyses, considered as pseudo-observations. Global atmospheric reanalyses are useful to fulfill this role, as they provide gridded large-scale variables that are available for any location in the world. Reanalyses are produced using a single version of a data assimilation system coupled with a forecast model constrained to follow observations over a long period. They provide multivariate outputs that are physically consistent, which contain information in locations where few or no observations are available, also for variables that are not directly observed (Gelaro et al., 2017). Their accuracy depends on both the quality of the model physics and that of the analysis process, and thus indirectly on the quantity and quality of the assimilated observations (Dee et al., 2011). Europe is a data-rich region, and the reanalyses are often considered as equivalent over the European domain. Thus, their impact on the downscaled variables is not often considered.

The present work focuses on the analogue method, which is a statistical downscaling technique that relies on the hypothesis that similar synoptic situations are likely to result in similar local effects, plus a certain variability that is not explained by the considered predictors (Lorenz, 1969). The local variable of interest, here, is daily precipitation. Different versions of AMs exist, relying on various predictors considered over domains of variable size. In order to take into account the unexplained variability, several analogue days are usually selected and their observed precipitation values are used to provide an empirical conditional distribution that is the statistical prediction for the considered target date.

The present work assessed the impact of ten reanalyses on the performance of seven variants of analogue methods for statistical precipitation downscaling at 301 stations in Switzerland. Significant differences were found between reanalyses and their impact on the performance of the method was found to be even higher than the choice of the predictor variables (Fig. 1).

Other properties of the reanalyses were analyzed, such as the spatial resolution. The use of datasets with a long period coverage, or providing multiple members, was also investigated, resulting in warnings about potential misuse.

REFERENCES

Dee, D. P., Uppala, S. M., Simmons, A. J., Berrisford, P., Poli, P., Kobayashi, S., … Vitart, F. 2011: The ERA-Interim reanalysis: Configuration and performance of the data assimilation system, Quarterly Journal of the Royal Meteorological Society, 137(656), 553–597. DOI:10.1002/qj.828

Gelaro, R., McCarty, W., Suárez, M. J., Todling, R., Molod, A., Takacs, L., … Zhao, B. 2017: The modern-era retrospective analysis for research and applications, version 2 (MERRA-2), Journal of Climate, 30(14), 5419–5454. DOI:10.1175/JCLI-D-16-0758.1

Lorenz, E. 1969: Atmospheric predictability as revealed by naturally occurring analogues, Journal of the Atmospheric Sciences, 26, 636–646. DOI:10.1175/1520-0469(1969)26<636:aparbn>2.0.co;2

Maraun, D., Wetterhall, F., Chandler, R. E., Kendon, E. J., Widmann, M., Brienen, S., … Thiele-Eich, I. 2010: Precipitation downscaling under climate change: Recent developements to bridge the gap between dynamical models and the end user, Reviews of Geophysics, 48(RG3003), 1–34. DOI:10.1029/2009RG000314

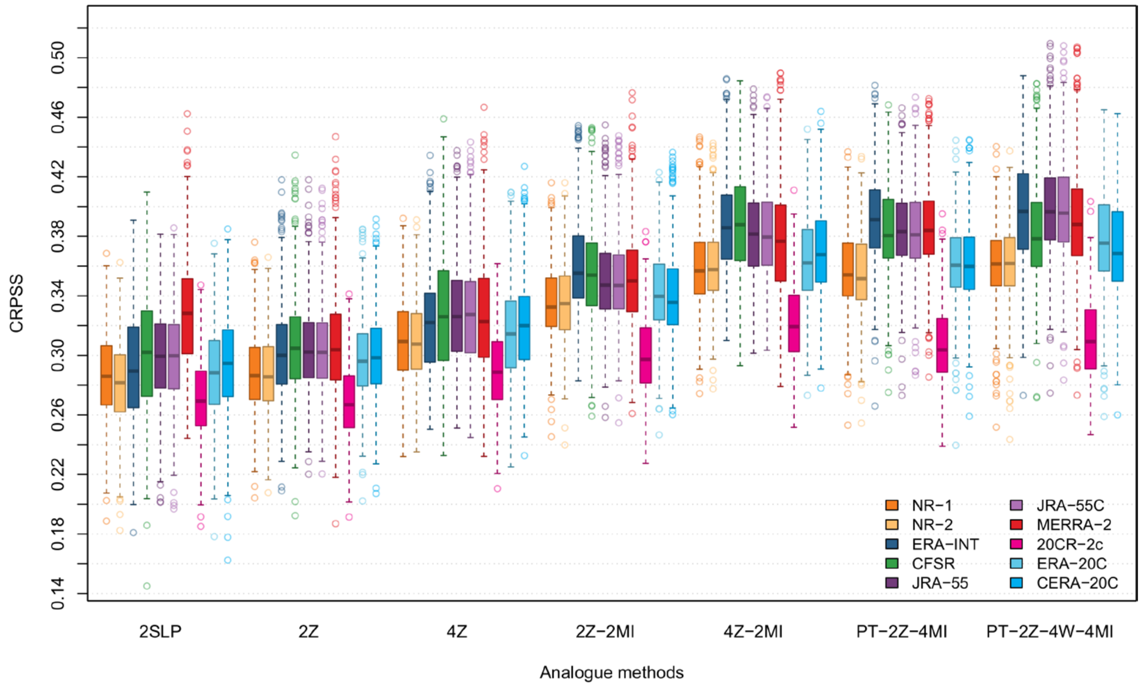

Figure 1. CRPSS (Continuous Ranked Probability Skill Score) for all stations, and for all considered analogue methods and reanalysis datasets on the validation period. A higher CRPSS means better performance. The parameters of the analogue methods were calibrated for every station, every dataset, and every method. The boxes show the 25th, 50th, and 75th percentiles. The whiskers extend to the most extreme data point which is no more than 1.5 times the interquartile range.

P 14.8
Renewal of the high-resolution map of direct and indirect connectivity of erosion risk areas to surface waters in Switzerland

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Nutrient and pesticide inputs from agriculture into waters through surface runoff and soil erosion is a current environmental problem in Switzerland. In recent years, especially the off-site effects of soil erosion have increasingly gained importance in research. As a result, the potential soil erosion map of Switzerland was created in 2010 (Gisler 2010 et al., Prasuhn 2013 et al.). Additionally, an associated high-resolution map of direct and indirect connectivity of agricultural erosion risk areas to surface waters was created in 2015. As a support tool, the map in many cases helped to develop environmentally efficient and cost effective soil erosion mitigation options (Alder et al. 2015). The results showed, that even areas that are far away from open water bodies can be indirectly connected and thus have to be taken into account as well when implementing mitigation measures. However, likewise the erosion risk map, the connectivity map only shows the potential risks of the agricultural areas. The actual risk can only be assessed by adding land cover information by using the map in the field. Despite this fact, the maps showed to be very practical for many applications.

As of today, both maps are outdated as they are based on the old Vector25 database and the DTM-AV topographic model from the Federal Office of Topography (Swisstopo). With the introduction of the updated high precision digital elevation model of Switzerland swissALTI^{3D} new possibilities for mapping erosion risk have become available. Furthermore, with the topographic landscape model TLM fully being released in 2019, Swisstopo introduced an immense database for three-dimensional geodata. Based on up-to-date aerial images, information about buildings, roads, bodies of water and land cover information were selected, resulting in a never-seen before map of Switzerland with accurate data. Based on this newly available data, the high resolution connectivity map of the agricultural area is being renewed as of today. With GIS, runoff generation and flow pathways are calculated with multiple-flow accumulation algorithms. Furthermore, based on the TLM data and swissALTI^{3D} an extended drainage system with drained roads, farm tracks and slope depressions indicating thalwegs are defined. With this, the probability and type of connection of today's agricultural area is calculated.

Figure 1 shows an extract of the old connectivity map by Alder et al. (2015). All agricultural areas can be divided into three types of connectivity. In blue colours, areas with low, moderate and high direct connectivity with a water body or a thalweg leading to a water body are represented. Orange to brown colours indicate an indirect connection through drained roads or thalweg that lead to drained roads. Finally, agricultural areas in white indicate no connection to surface waters, as these areas are too flat or too far away from the extended drainage system. The results of the older map showed, that most areas are indirectly connected through inlet shafts and drained roads. These results, however, are not entirely valid as of today due to the old data used. To reach the goals of the national action plan about pesticides passed in 2017, which include a reduction of the risk of pesticides by a half and promoting a sustainable usage of pesticides, a renewed map of direct and indirect connectivity of erosion risk areas to surface waters is inevitable (Bundesrat 2017).

REFERENCES

Alder, S., Prasuhn, V., Liniger, H., Herweg, K., Hurni, H., Candinas, A., & Gujer, H. U. (2015). A high-resolution map of direct and indirect connectivity of erosion risk areas to surface waters in Switzerland - A risk assessment tool for planning and policy-making. Land use policy, 48, 236-249.

Bundesrat (2017). Aktionsplan zur Risikoreduktion und nachhaltigen Anwendung von Pflanzenschutzmitteln. Bericht des Bundesrates vom 6. September 2017.

Gisler, S., Liniger, H. P., & Prasuhn, V. (2010). Technisch-wissenschaftlicher Bericht zur Erosionsrisikokarte der landwirtschaftlichen Nutzfläche der Schweiz im 2x2-Meter-Raster (ERK2). CDE Universität Bern und ART Zürich-Reckenholz.

Prasuhn, V., Liniger, H., Gisler, S., Herweg, K., Candinas, A., & Clément, J. P. (2013). A high-resolution soil erosion risk map of Switzerland as strategic policy support system. Land use policy, 32, 281-291.

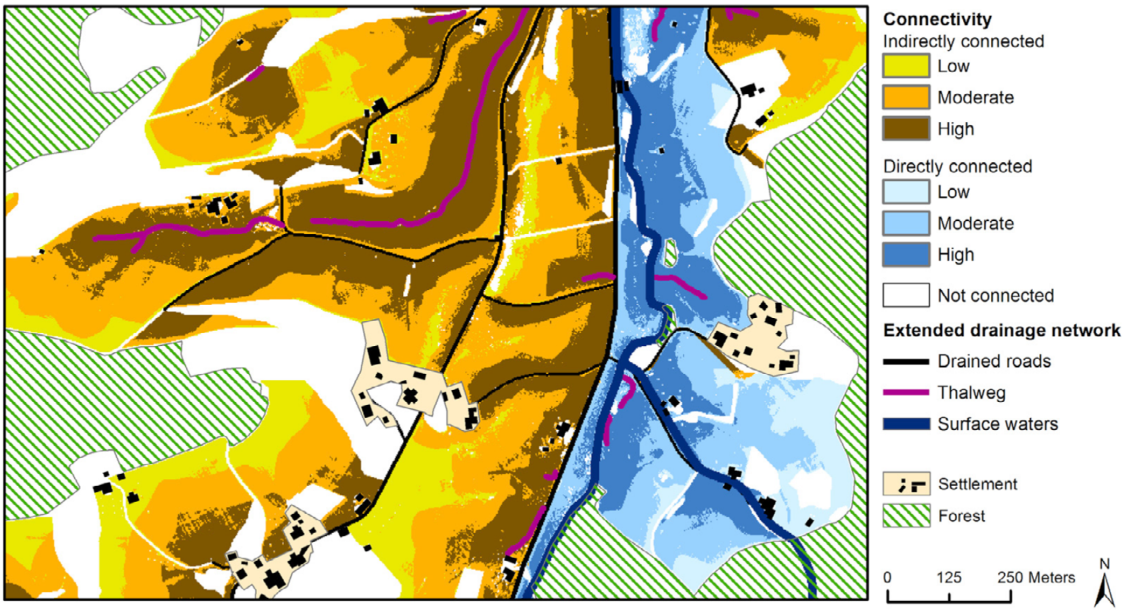

Figure 1. (Alder 2015 et al.) Extract of the connectivity map showing the probability of any area to be connected directly with a water body or a thalweg leading to a water body (a), or indirectly through drained roads or a thalweg leading onto a drained road (b), or not at all (c).

P 14.9
Identification of pre-event water sources to streamflow and uncertainty associated with end-member characterization

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In End Member Mixing Analysis (EMMA), changes in streamwater chemistry and isotopic composition during rainfall or snowmelt events are used to determine the relative contributions of different source waters to streamflow. Usually only one (or a few) groundwater samples are used to characterize the groundwater component, although it is recognized that catchment groundwater storages are rarely well mixed and that not all parts of the catchment are continuously hydrologically connected to the stream. Similarly, for isotope based hydrograph analyses the pre-event streamflow sample is assumed to represent all pre-event water. However, the pre-event streamflow sample may reflect only a certain part of the groundwater storage if groundwater has a different chemical signature in different parts of the catchment and not all parts are connected to the stream during baseflow conditions. Therefore, in order to better understand which parts of the catchment contribute to streamflow during baseflow and rainfall events it is important to understand the spatial and temporal variations in groundwater chemistry.

We combined the results from nine baseflow sampling campaigns and detailed stream sampling for four events to identify the stream water sources in a 20-ha steep mountainous catchment in the Swiss pre-Alps. During the nine baseflow sampling campaigns, shallow groundwater was sampled from 34 to 47 wells, streamflow at seven locations and soil water at 13 to 18 sites. During the four stormflow campaigns, streamwater samples were taken at regular intervals at the catchment outlet, and for two of the campaigns also at an additional site half-way up the stream network. The samples were analyzed for major and trace ions and stable water isotopes (δ^2H and $\delta^{18}O$).

The results of the baseflow sampling campaigns indicated that the spatial variability in pre-event water chemistry is very large. For example, the Electrical Conductivity (EC) in groundwater ranged from 68 – 610 μS/cm during the campaign with the highest antecedent moisture conditions and from 194 – 780 μS/cm for the campaign during the driest conditions. The spatial variability in the isotopic composition of the groundwater was smallest in early summer and autumn (standard deviation: δ^2H 2.3 ‰ and 3.4 ‰, respectively) and largest during the dry conditions in late August (standard deviation: δ^2H 9.5 ‰). Based on the differences from the catchment average concentrations, we could distinguish four groundwater clusters, of which three corresponded to the main hydro-geomorphic units: riparian zone-like, hillslopes and areas with small upslope contributing areas, deeper groundwater. The fourth cluster was characterized by high magnesium and sulfate concentrations that likely reflect different bedrock material. The soil water was as variable as the groundwater: Electric Conductivity ranged from 10 – 668 μS/cm (standard deviation: 157 μS/cm) and the standard deviation of δ^2H per campaign ranged from 5.3 ‰ (May 2017) to 13.7 ‰ (August 2016).

Baseflow was not an equal mixture of the different groundwater clusters. During the majority of the baseflow campaigns streamflow chemistry at all but one site most strongly resembled groundwater from the riparian-like cluster, but the similarity to groundwater from the hillslope cluster was larger shortly after snowmelt, reflecting differences in hydrologic connectivity. Streamflow chemistry changed from the composition of shallow groundwater during the stormflow events, shifting in composition towards that of the incoming precipitation. However, there were marked differences in estimations of event water inputs when different tracers were used, or when the pre-event water component reflected the composition of a specific shallow groundwater cluster.

For instance, in two cases the isotope hydrograph separation results suggested that stormflow more strongly resembled pre-event water, while a mixing diagram with chloride and sodium concentrations of the same event indicated a much stronger influence of event water. Additionally, estimations of the pre-event water fraction changed up to 22% (using calcium as a tracer) when limiting the characterization of the pre-event water composition to samples from a single groundwater cluster rather than including all groundwater measurements. These results show how the spatial variability in different pre-event water compartments can be used to identify sources to streamflow and highlights the need of an adequate representation of the pre-event water component when analysing streamflow sources.

P 14.10
Resolution matters: numerical analysis of the effect of subgrid heterogeneities with a physically based hydrological model

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In Switzerland most of the natural hazards are triggered by precipitation, but the soil status prior to the rainfall event is an important factor. That is true, for example, for floods and landslides, which were responsible collectively for a loss of 7630 million Euros between 1972 and 2007 (Hilker et al., 2009). The water table height and soil saturation necessary to predict the occurrence of these natural hazards accurately are typically calculated employing hydrological models (e.g. Prevah, Viviroli et al., 2009). While in some cases high resolution small scale models are developed for specific case studies, there is also a need for regional scale warning system which provide a first order estimate of the vulnerability across the country (Staehli et al., 2015). These coarse scale models face problems of subgrid variability in topography and soil water dynamics and their effects on slope stability may be complex.

Here we use synthetic numerical experiments to address the effect of heterogeneities within a cell of the size typically used for regional hydrological applications. We chose the hydrological model ParFlow-CLM (Maxwell and Miller, 2009), which is an integrated, fully coupled, physically based model, which solves water and energy budgets, surface and subsurface flows. The reference simulation is represented by a domain of 400*400 m without any heterogeneities within. This setup corresponds to the information content of a cell of a regional scale model. Results are compared to those using similar domains, where heterogeneities in slope (creating a v-shape domain) or soil layering (permeability contrasts or soil thickness) are added (Fig 1a). These experiments aim to provide insights on what the under/over estimation of water pressure and soil saturation could be when using coarser resolutions which average out heterogeneities.

Different climates and soil properties are also investigated by comparing the results with the climatic forcing and soil properties for the site Napf in Switzerland (wet temperate) and Niwot in Colorado (semiarid). Forcing is found to be the main factor controlling dynamics and seasonalities of the snowpack and evapotranspiration, while soil properties influence greatly runoff generation mechanisms as well as the timing and intensity of runoff. All these conditions lead to very different scenarios in terms of calculated soil water pressure.

Finally, in order to quantify the effect of potential over/under estimation of soil water pressure and soil saturation for one possible application, the stability of the domains is calculated choosing the most critical point (where highest pressures are developed) following a simple infinite slope. The biggest differences are observed between flat domains and those that have any magnitude of side slope (first column in Fig 1a vs the other two columns). This can be observed for example comparing the different domains with forcing and soil properties from Colorado(Fig 2b). With a flat domain, soil water pressures and saturations in the central part of the domain are highly underestimated and the Factor of Safety remains approximately constant, always well above 1. When when some side slope is introduced which induces lateral flow, the FoS drops below 1 in May and June, when snowmelt has saturated the soil as well as in September, due to some intense rainfall events.

These results provide useful information on the potential errors when utilizing a regional hydrological model with such “coarse” resolution, which is particularly critical when the ultimate objective is predicting flooding and landsliding.

REFERENCES

Hilker, N., Badoux, A., and Hegg, C. 2009: The Swiss flood and landslide damage database 1972–2007, Nat. Hazards Earth Syst. Sci., 9, 913-925.

Maxwell, R.M., & Miller N.L. 2009: Development of a coupled land surface and groundwater model. Journal of Hydrometeorology, 6(3):233–247.

Stähli, M., Sättele, M., Huggel, C., McArdell, B.W., Lehmann, P., Van Herwijnen, A., Berne, A., Schleiss, M., Ferrari, A., Kos, A. and Or, D., 2015: Monitoring and prediction in early warning systems for rapid mass movements. Natural Hazards and Earth System Sciences, 15(4), pp.905-917.

Viviroli, D., Zappa, M., Gurtz, J. and Weingartner, R., 2009: An introduction to the hydrological modelling system PREVAH and its pre-and post-processing-tools. Environmental Modelling & Software, 24(10), pp.1209-1222.

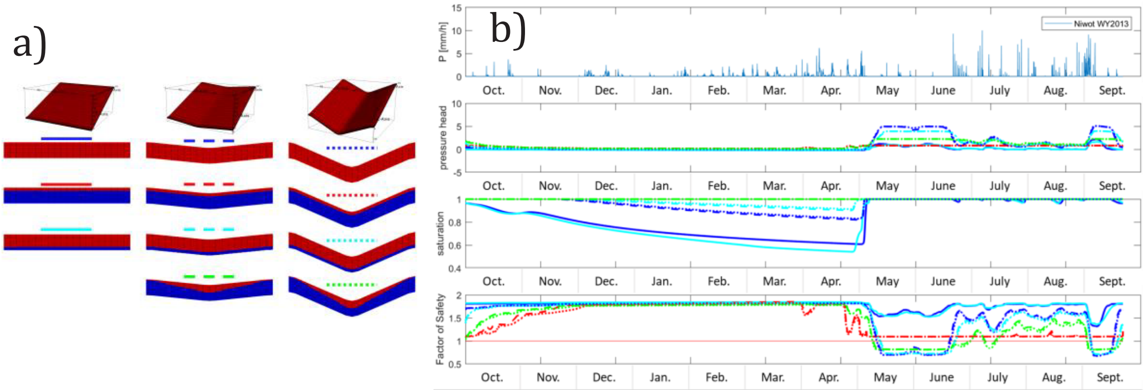

Figure 1. a) Synthetic domains used in the simulations, with increasing side slope (left to right) and changing soil layering: one soil layer, thin layer over bedrock, thick layer over bedrock and erosion soil layer over bedrock. Bedrock is represented in blue and soil in red. b) From top: timeseries of measured precipitation, simulated pressure head, saturation and factor of safety.

P 14.11
Modelling Stream Temperature of Rivers in Switzerland

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While numerous past modelling efforts have attempted to accurately simulate stream discharge, water temperature of streams has obtained much less attention. This is recently changing as a result of potentially significant impact of climate change on stream temperature and therefore indirectly also on water quality, the aquatic fauna and fluvial ecosystem services. The current project addresses modelling of stream temperature in Swiss rivers, based on a chain of physical models, including MeteoIO, Alpine3D and StreamFlow. In a first step, selected watersheds (Dischma, Broye, Rietholzbach, Vallon de Nant) are simulated and results of discharge and water temperature are compared and validated against respective observational time series. This contribution presents results of simulations using the latest version of the mentioned model chain and the selected case studies, with particular focus on soil temperature, water percolation in snow and soil, and available input and forcing data. The ultimate objective is the development of a numerical model suitable for the simulation of thermodynamic response of rivers to climate forcing, climate change, and to develop projections of various scenarios, including adaptation and mitigation measures such as modified riparian vegetation, as well as consequences of potential river renaturation measures.

P 14.12
The other's perception of a streamflow sample: From a bottle of water to a data point

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"Do you take runoff samples?" This seemingly simple question might lead to misunderstandings between two hydrologists if they don't share the same perception of a runoff sample. This study is motivated by such misunderstandings possibly occurring between different hydrological subcommunities, such as field hydrology, statistical hydrology, and hydrological modelling. More specifically, we analyzed the personal perceptions of hydrologists of the widely used terms sample, runoff, discharge, and streamflow. The analysis was based on qualitative and quantitative data from three sources of information: a drawing exercise with 15 hydrologists, a survey with 42 participants, and a literature corpus analysis including several thousand peer-reviewed journal articles. The multiple sources of information revealed distinct, deeply established, but sometimes diverging conceptualizations of these widely used terms. A thoughtful use of apparently common hydrological terms is therefore fundamental for an improved dialogue between hydrologists of different subdisciplines.

P 14.13
New Approach to Quantify Organic Matter Freshness and Paleoproductivity In Lake Sediments Through Spectral Deconvolution of the UV-VIS Absorption Spectra

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Assessments of paleoproductivity and organic matter freshness require accurate identification and quantification of sedimentary chloropigments. Chloropigments quantification by chromatography techniques is impracticable for long time-series at high-resolution because it is expensive, labor intensive, and time consuming. Here, we report on a new rapid and inexpensive approach to extract this information by mathematical analysis of the UV-VIS absorption spectra of untreated extracted sediment samples obtained from spectrophotometers measurements. The methodology consists in two steps, (i) the application of the iterative non-linear least squares fitting to deconvolute the chloropigment bulk absorption peak in two main components [1], Chloropigments-β and Chloropigments-α, (ii) the use of mono or dichroic equations on the deconvolute components. The methodology was developed and validated on standard solutions of known composition and tested on a short sediment core from a varved eutrophic lake, Ponte Tresa, southern Switzerland (1913–2015). Our approach is able to quantify Chlorophyll-β (=0.99; RMSEP~5.9%), Chlorophyll-α (=0.98; RMSEP~5.0%), and Pyropheorbide-α (=0.99; RMSEP~7.80%) in standard solutions and Chloropigments-α (=0.99; RMSEP~3.29%), Chlorophyll-α (=0.98; RMSEP~3.90%) and Chlorins-α (=0.98; RMSEP~5.96%) in lake sediment cores. Chlorophyll-β was not detected. In addition the methodology can be used to calculate the chlorin index and to quantify aquatic paleoproductivity and organic matter freshness. The chlorin index shows that circa the 55%-75% of the organic matter measured in sediment is already degraded on the water column. Chlorins-α reveal eutrophication peaks and paleoproductivity back in time. In conclusion chloropigments-α is an ideal proxy to reveal these processes because does not undertake post burial remineralization in anoxic sediment core (Chlorin index is linearly independent from Chlorins-α, R2= 0.13).

REFERENCES

[1] O'Haver, T. (2018). Toolkit of functions, scripts and spreadsheet templates. https://terpconnect.umd.edu/~toh/spectrum/functions.html, 2018-02-27.

P 14.14
Soil wetness data for landslide early warning

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In mountain areas, landslides triggered by heavy rain present a serious risk to people and infrastructure. Recent major events in Switzerland have demonstrated the numerousness, abruptness and seemingly unpredictability of shallow landslides using meteorological information only. Hence, several research projects have been initiated to advance fundamentals and to develop tools for the early warning of landslides at the regional scale. While most studies focus on the use of precipitation information to assess thresholds for the initiation of landslides (e.g. through intensity-duration-relationships), less work has been put into the utilization of soil wetness information. In this respect, most attempts were made to estimate soil saturation with hydrological models to assess the antecedent soil wetness as a measure for slope stability.

In our study, we assess the value of in-situ soil wetness measurements for its use in a regional landslide early warning system (LEWS). Soil moisture measurements from various research institutions and authorities in Switzerland are compiled for the first time in a comprehensive soil wetness data base. The data set comprises soil wetness time series of 34 measurement sites distributed all over Switzerland, with a total of 300 measurement sensors covering up to 10 years in time. Soil moisture has been measured at different depths using TDR, FDR and capacitance sensors with temporal resolution ranging from 10-minute to hourly time steps.

As the measurement set-ups, data quality and temporal resolution of the different data sets are very heterogeneous, the soil moisture time series had to be homogenized and normalized in a first step. Based on this, soil moisture dynamics were described by variability-mean relationships, by describing the antecedent soil wetness vs. short-term soil moisture changes and through water balance calculations at individual sensors, along specific depth profiles and for entire measurement sites. Finally, these dynamics were compared to a set of shallow landslide events derived from the Swiss flood and landslide damage database (WSL) covering 441 events from 2008 to 2017.

Here we present first results of this analysis showing characteristic patterns of soil moisture dynamics that can serve as a precursor for increased landslide activity and to separate events from non-events. The forecast goodness is assessed using Receiver Operating Characteristic (ROC) analysis. A concentration of landslide events is visible in pre-alpine areas and the Ticino as well as during the summer months (59% of the events happened in June, July and August). While most soil moisture measurements show the lowest seasonal mean soil moisture values during those months, increased soil moisture variability can be observed.

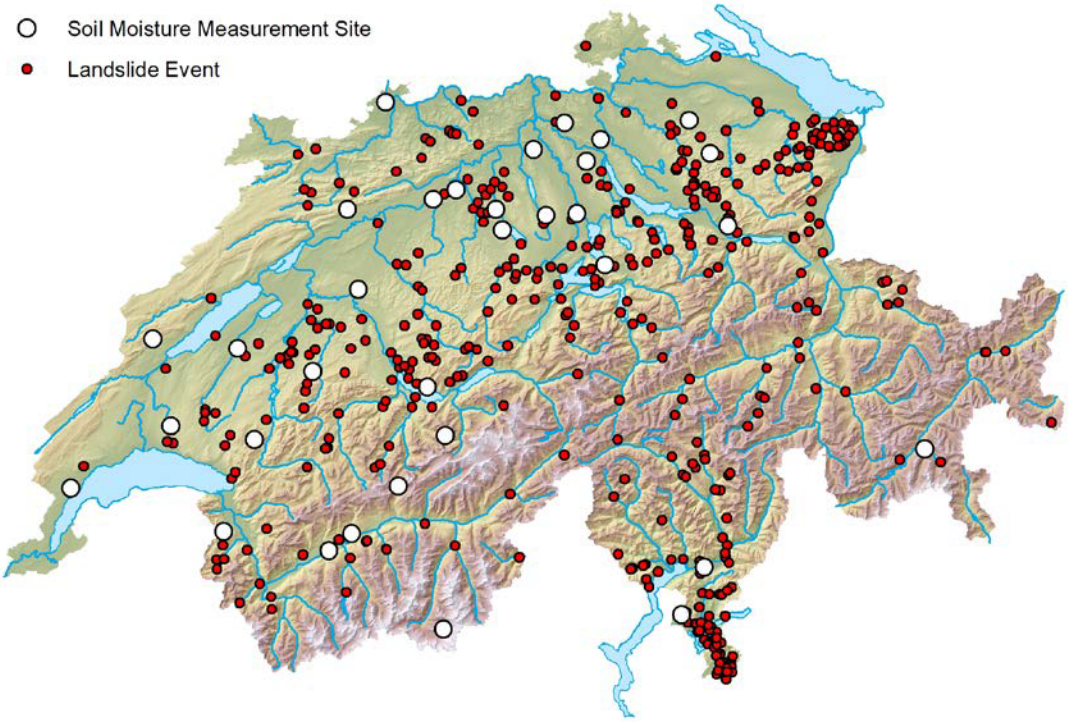

Figure 1. Location of the soil moisture measurement sites (white circles) and the shallow landslide events (period 2008 to 2017).

P 14.15
Combining Hyperspectral Imaging and µXRF data to link varve-formation processes with meteorological data, Lake Zabinskie, Poland

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Varved lake sediments are a valuable resource for paleoclimatological investigations due to the ability to produce proxy records at high-resolution with annually resolved chronologies. New advances in Hyperspectral Imaging (HSI) and Micro X-Ray Fluorescence (uXRF) provide opportunities to study the composition of varves at very high resolution (um scale), with the potential to yield new insights into sub-varve scale depositional processes, and relationships with limnological and meteorological phenomenon.

Hyperspectral Imaging has been demonstrated to be an effective method to measure the abundance of chloropigments in sediment at much higher resolution than would be possible with conventional pigment analysis using liquid chromatography (Butz et al., Journal of Paleolimnology, 2017). In this study we use HSI to determine the abundance of chloropigments (Chlorophyll-a and diagenetic products) in the sediments of Lake Zabinskie, Poland at a spatial resolution of 60 um (equivalent to approximately 70-80 data points per varve). The sediments of Lake Zabinskie contain well-preserved biogenic varves defined by the deposition of calcite and diatom remains in spring and summer, with clay and fine-grained organic matter deposited in winter. Previous work at Lake Zabinskie, Poland has demonstrated a relationship between chloropigments and instrumental measurements of spring (March to May) temperatures during the period 1907-2008 (Amann et al., Global and Planetary Change, 2014). In this study, we extend the calibration to the period 1779-2016 using higher resolution pigment data inferred from HSI. We find a significant positive relationship between green pigments and spring temperatures, however the correlation is much greater during the period 1900-2016. This result indicates that green pigments as measured by hyperspectral imaging may be useful as an indicator of temperature in the past, though caution is warranted due to weak correlation prior to 1900 CE. Additionally, the sub-annual resolution of the hyperspectral and uXRF datasets allow for the investigation of sub-seasonal scale depositional processes, which may be linked to limnological and meteorological conditions.

REFERENCES

Amann, B., Lobsiger, S., Fischer, D., Tylmann, W., Bonk, A., Filipiak, J., & Grosjean, M. 2014: Spring temperature variability and eutrophication history inferred from sedimentary pigments in the varved sediments of Lake Żabińskie, north-eastern Poland, AD 1907–2008. Global and Planetary Change 123, 86-96.

Butz, C., Grosjean, M., Goslar, T., & Tylmann, W. 2017: Hyperspectral imaging of sedimentary bacterial pigments: a 1700-year history of meromixis from varved Lake Jaczno, northeast Polan*d. Journal of Paleolimnology 5*8(1), 57-72.