Abstract Volume
10th Swiss Geoscience Meeting

Bern, 16th – 17th November 2012

12. Advances in applied hydrology and limnology

Swiss Academy of Sciences
Akademie der Naturwissenschaften
Accademia di scienze naturali
Académie des sciences naturelles

UNIVERSITÄT
BERN

12. Advances in applied hydrology and limnology

Bettina Schaefli, Tobias Jonas, Michael Doering, Massimiliano Zappa

Commission for Hydrology CHy
Swiss Society for Hydrology and Limnology SGHL
Operational Hydrology Working Group GHO

TALKS:

12.1 Fischer B.M.C., Rinderer M.: Investigating spatial and temporal runoff generation mechanisms in a Swiss pre-alpine catchment

12.2 Halder J., Vennemann T.: Application of stable water isotopes to evaluate tributary mixing and micropollutant fate in Swiss lakes

12.3 Jörg-Hess S., Fundel F., Jonas T., Zappa M.: A statistical approach to refining snow water equivalent climatologies in the Swiss Alps

12.4 Malard A., Vouillamoz J., Weber E., Jeannin P.-Y., Eichenberger U.: NRP61/SWISSKARST Project. Mapping karst water resources using KARSYS approach. Application to the Bernese Jura (BE, Switzerland)

12.5 Meeks J., Hunkeler D., Pronk M.: Assessing controls on cold-season recharge: The Vers Chez Les Brandt study site in the Swiss Jura Mountains

12.6 Rinta P., van Hardenbroek M., Schilder J., Stötter T., Heiri O.: Environmental factors affecting methane concentrations in Central and Northern European lakes

12.7 Sommer T., Carpenter J.R., Schmid M., Wüest A.: Temperature and salinity staircases in Lake Kivu

12.8 Tilg A.-M., Marty C., Jonas T., Kuhn M.: Trend analysis of snow water equivalent

12.9 Wever N., Fierz C., Jonas T., Lehning M.: The dual nature role of the snow cover in rain on snow events and a note on latent heat

POSTERS:

P 12.1 Darvishi Khatouni J., Lak R., Mohammadi Ali: Hydrogeochemistry and Brine Evolution of Urmia Lake (NW of Iran)

P 12.2 Rinderer M., Kollegger A., Fischer B.M.C.., Stähli M., Seibert J.: Sensing with boots and trousers - A new qualitative field method to capture shallow soil moisture patterns in wet environments

P 12.3 Schaefli B., Nicótina L.: Accounting for precipitation and temperature co-variation for design flood estimation in Alpine environments

P 12.4 Sideris I., Gabella M., Sassi M., Germann U.: Operational implementation design of radar and raingauge combination in Switzerland

P 12.5 Tobin C., Rinaldo A., Schaefli B.: Snowfall limit forecasts for hydrological modeling

12.1

Investigating spatial and temporal runoff generation mechanisms in a Swiss pre-alpine catchment

Fischer Benjamin M. C.[1], Rinderer Michael[1]

[1] *University of Zurich, Department of Geography - Hydrology and Climate (benjamin.fischer@geo.uzh.ch)*

Spatial and temporal rainfall and runoff data of mountainous catchments are generally sparse and even when they exist, more detailed information such as groundwater levels or isotopic data are usually lacking. This makes difficult to identify runoff generation processes and system conditions.

Here we present first results from a new data set collected during three years of measurements in the Zwäckentobel, a 4.3 km^2 Swiss pre-alpine catchment in the Alptal. The high annual precipitation input, flashy character of stream flow dominant wet conditions and the existence of long-term data for one sub-catchment make this catchment an exciting study area for investigating rainfall-runoff processes. An open challenge is the runoff contribution of sub-catchments and the response of individual streams to storm flow in space and time.

The presented research projects try to address these issues at different temporal and spatial scales and with different approaches but one final goal: Advancing the understanding of runoff generation processes of steep pre alpine catchments in space and time. At a larger scale the focus was on comparing several sub-catchments, which differ in size, topography and land-cover. The aim was to learn from differences, similarities and to put each catchment into perspective at different scales. Three snapshot campaigns were made during steady flow conditions with about 100 water sampling locations. From this information spatial patterns and their underlying ordering mechanisms were extracted. During storm flow the basic question was whether different sub-catchments respond differently to rainfall and if so whether the runoff contribution processes could be used to explain the differences? For the Zwäckentobel, six sub-catchment were instrumented in addition to the one long term reference catchment and rainfall, runoff and isotope concentrations were measured and compared among the sub-catchments.

To capture surface- and subsurface flow processes in detail one of the sub-catchments (20 ha) was selected and instrumented with a spatially distributed groundwater measuring network. Sites were distributed to cover a representative range of wetness conditions and morphology. Within the sub-catchment stream flow discharge of seven nested sub-watersheds was constantly measured. The aim of this detailed study was to identify governing controls of groundwater dynamics, which can then potentially be transferred to ungauged site within the sub-catchment or neighbouring catchment to predict groundwater dynamics under consideration of system conditions and precipitation input.

Here we present first results of this combined study applying hydrometric, hydrochemical and isotope data in a complementary manner to learn more about the key controls of runoff generation in wet pre-alpine catchments.

12.2

Application of stable isotopes of water to evaluate tributary mixing and micropollutant fate in Swiss lakes

Halder Janine[1], Vennemann Torsten[1]

[1] *Institute of Earth Sciences, University of Lausanne, Anthropole, 1015 Lausanne (Janine.Halder@Unil.ch)*

The isotope network of Switzerland (ISOT) is regularly measuring the isotope compositions of surface water, precipitation and groundwater at 23 sampling locations (BAFU 2009). This provides a large data base and wide range of applications. In the framework of this study ISOT data were used in combination with stable isotope compositions of water, obtained from depth profiles taken throughout Lake Geneva. The overall research goal was to study the hydrodynamics of the lake and evaluate micropollutant transport. In principal the research idea is based upon the fact that rivers, which originate from high altitude, do have a distinct oxygen and hydrogen isotopic compositions compared to a lake, which is also fed by other water sources with a watershed at lower altitude. The presented method may therefore be applicable for several peri-alpine lakes in Switzerland and elsewhere.

Results of stable isotope compositions show that the Rhône River is interflowing in the metalimnion during stratification and Rhône River water could be traced for the first time for about 55 km throughout the lake. In summary, these findings suggest an alternative method compared to more conventional methods such as, for example, conductivity to trace river water dispersion and to monitor future changes in the hydrodynamics of Lake Geneva. This issue may become more important considering the extension of reservoirs as well as renaturalisation projects in the watershed, which may potentially change Rhône River water density. In combination with the induced warming of the lake epilimnion due to global warming (CIPEL 2011), changes in the interflow depth of the Rhône may have an impact on the oxygenation and nutrient cycling in Lake Geneva.

In addition to river mixing the method also allows to trace wastewater dispersion, which is discharged into the Bay of Vidy, Lausanne. Micropollutants, which have been detected in the Bay of Vidy (Bonvin et al. 2011) seem to be derived mainly from the wastewater treatment plant, however may also originate from diffusive sources. The stable isotope compositions of water allows to quantify the Rhône River water interflow into the Bay of Vidy, as well as to estimate of the fractions of wastewater, dilution factors and sources of micropollutants.

REFERENCES

BAFU 2009: ISOT module. Available from:
http://www.bafu.admin.ch/grundwasser/07498/07522/07528/index.html?lang=en [Accessed: 29.08.2012]

Bonvin, F., Rutler, R., Chèvre N., Halder, J. & Kohn, T. 2011: Spatial and temporal presence of a wastewater-derived micropollutant plume in Lake Geneva. Environ Sci Technol. 45(11), 4702-9.

CIPEL 2011: Rapport de la Commission Internationale de la Protection des Eaux du Lac Léman contre pollution, Campagne 2010. Évolution physico-chimique des eaux du Léman (éléments majeurs), p.35.

12.3

A statistical approach to refining snow water equivalent climatologies in the Swiss Alps

Jörg-Hess Stefanie[1], Fundel Felix[1], Jonas Tobias[2], Zappa Massimiliano[1]

[1]*Swiss Federal Research Institute WSL, Zürcherstrasse 111, CH-8903 Birmensdorf (stefanie.joerg@wsl.ch)*
[2]*Swiss Federal Research Institute WSL/SLF, Flüelastrasse 11, CH-7260 Davos Dorf*

Reliable information about snow water equivalent (SWE) is important for estimating water resources in specific areas. SWE also is a relevant state variable in hydrological models set up for alpine areas. In Switzerland the density of available monitoring networks allow to directly generate highly resolved SWE maps using data interpolation and assimilation techniques. However, varying station densities over the past decades pose difficulties when trying to calculate spatially-explicit SWE anomalies or compare current with past snow situations. At the same time, accurate evaluations of this sort are becoming increasingly important in lake and reservoir management during the spring melt. This contribution elaborates on the effect of station density on assimilated SWE maps. We come up with a procedure to enhance maps from years with limited availability of monitoring data based on spatial patterns recorded in years for which more data is available.

Two distributed SWE climatologies have been produced: A short climatology of daily SWE maps over 9 years (2001-2009) based on 203 measuring stations and a longer climatology (39 years) based on data from 110 stations. In a first step the quality of the shorter climatology is evaluated by cross validation against station data. This short climatology is considered as reference data set and represents the most accurate distributed snow information available. By utilizing a quantile mapping approach (Panofsky and Brier, 1968; Fig 1), the 39-year climatology is improved based on calibration to the reference climatology. The approach accounts for elevation, region, season and amount of snow, and is done separately for each grid cell and day.

First, the results of the quantile mapping are tested for the nine overlapping years 2001-2009. As a result of the calibration, the difference between the two SWE climatologies could nearly be removed in most regions. Additionally an independent evaluation is performed, using four additional stations that were not used for the reference data set. The quantile mapping is further evaluated for the non-overlapping period 1971-2000 with an independent dataset. Finally, the value of the enhanced long climatology will be illustrated by way of three sample applications. The first application uses the hydrological model PREVAH. In the second application the SWE distributions of the three climatologies are compared. The predictability of discharge using SWE is shown in the third application.

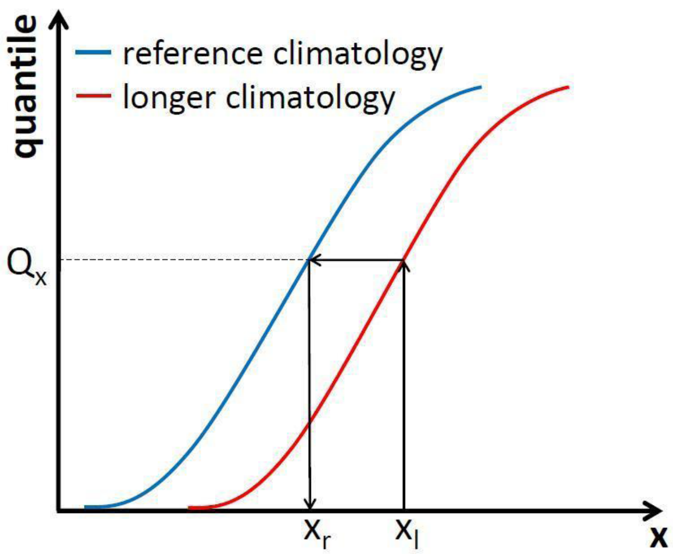


Figure 1: Illustration of quantile mapping. The quantile of the long climatology value is replaced by the value of the same quantile of the reference climatology.

REFERENCES
Panofsky, H.A., and Brier, G.W., 1968, Some applications of statistics to meteorology: University Park, Pennsylvania, Earth and Mineral Sciences Continuing Education College of Earth and Mineral Sciences The Pennsylvania State University, 224 p.

12.4

NRP61/SWISSKARST Project. Mapping karst water resources using KARSYS approach. Application to the Bernese Jura (BE, Switzerland)

MALARD Arnauld[1], VOUILLAMOZ Jonathan[1], WEBER Eric[1], JEANNIN Pierre-Yves[1] & EICHENBERGER Urs[1]

[1] *Swiss Institute for Speleology and Karst Studies – info@isska.ch*

Karst hydrogeological systems and aquifers have been represented by a large type of hydrogeological maps in the past. The use of the full 3D approach KARSYS (Jeannin et al. in press) reveals that none of these representations are really adequate to depict specificities of recharge and flow organization in karst. In the frame of the Swisskarst project – part of the NRP61 - and thank to additional funding provided by the Amt für Wasser und Abfall des Kantons Bern, a new concept of karst hydrogeological map has been developed along with a study of groundwater resources in the Bernese Jura. Result seems satisfying, reproducible and usable. The map includes the following indications: catchment boundaries, specific recharge modalities (autochthonous, allochtonous or mixed), specific flow mechanisms (diffluence/convergence), specific 3D geometry of main flow paths and the location of confined/unconfined saturated part(s) of the aquifer. It also introduces the concept of sub-catchment units which refers to an area with a uniform type of recharge and uniform flow properties at the considered scale (see on Figure 1).

Advantages of this map are: (i) the possibility of representing subcatchments (parts of catchments) belonging simultaneously to two or more adjacent karst systems - this is relevant for the respective water balance assessments - (ii) a clear superimposition of the mechanisms concerning on the one hand surface characteristics (catchment location, distinction in the recharge types) and, on the other hand the flows at depth; (iii) the possibility of indicating the water path from various parts of the catchment to the spring(s) or to the temporary outlets according to various water stages.

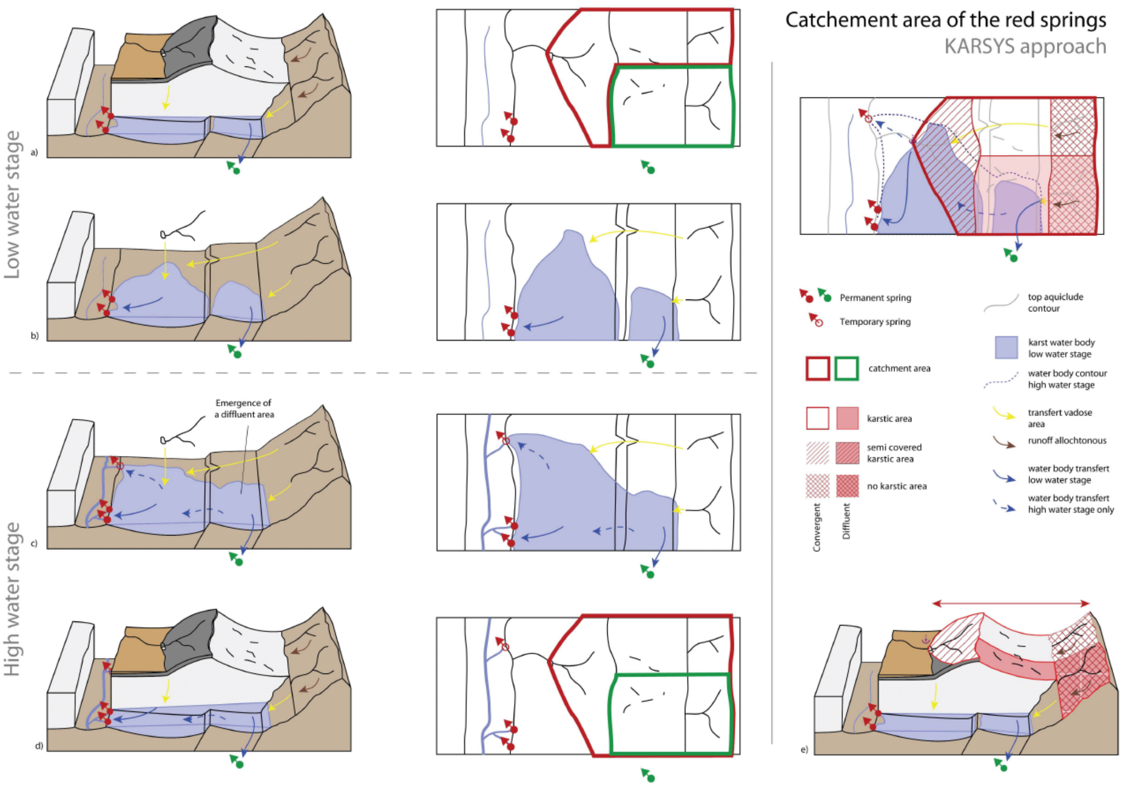
One disadvantage of this map is the representation of karst features depending on the selected scale: Some small scale features often induce huge effects on the system hydrology (local fault, old conduits, etc.) and are not drawn - or even not detected. As the readability of the map could be strongly disturbed by the presence of superimposed aquifers (e.g. Malm & Dogger) we suggest a separate map for each aquifer. The main weakness of the map is to represent vertical exchanges between aquifers evidenced by the 3D-analysis, especially in folded/overlapped contexts. Questions remain concerning the depth considered in the hydrogeological interpretation (e.g. interactions between Malm and Dogger aquifers or even deeper ones).

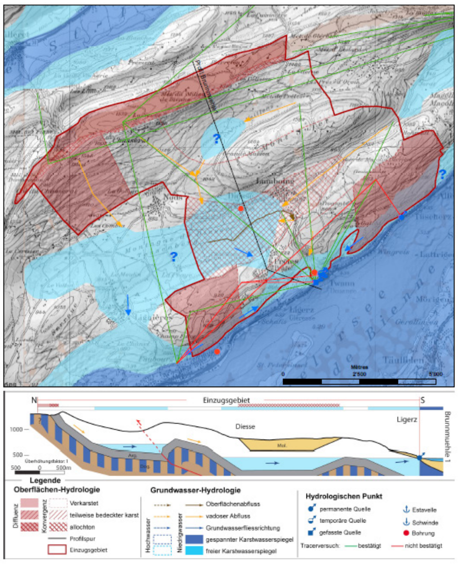
Application on the field of the Bernese Jura (500 km^2, >50'000 citizens) leads to the characterisation of 17 significant karst systems, describing their properties as well as the connections they have with adjacent ones. Mapping the karst hydrogeological organization at the scale of these aquifers (close to 1/25 000) shows the presence of seven main groundwater bodies (i.e. saturated part), and reveals exchange processes previously suspected or even proven by dye tracer tests. It also depicts areas where geological data or structural interpretations do not match together with the karst hydrogeological interpretation (Malard et al. 2012). Recent applications in other cantons prove the efficiency und usefulness of this approach. Improvements, especially on the way of mapping are still on-going and any input in order to make the map accessible also to non-hydrogeologists is welcome.

REFERENCES

Jeannin PY, Eichenberger U, Sinreich M, Vouillamoz J, Malard A et al. (in press) KARSYS: a pragmatic approach to karst hydrogeological system conceptualisation. Assessment of groundwater reserves and resources in Switzerland. Environmental Geology.

Malard A, Vouillamoz J, Weber E, Jeannin PY (2012) Swisskarst Project – toward a sustainable management of karst water in Switzerland. Application to the Bernese Jura. Actes du 13e Congrès National de Spéléologie, Muotathal, Suisse. 29 sept au 01 oct 2012.





↑ Figure 1. Principles of the KARSYS approach and the resulting karst hydrogeological map. This example focuses of the karst system with springs in red.

← Figure 2. Hydrogeological map of the Brunnmühle karst system (also available on http://www.swisskarst.ch /images/Resultats/Bern/Brunnmuehle-carte.pdf)

12.5

Assessing controls on cold-season recharge: The Vers Chez Les Brandt study site in the Swiss Jura Mountains

Meeks Jessica[1], Hunkeler Daniel[1], Pronk Michiel[1]

[1] *Centre for Hydrogeology and Geothermics, University of Neuchatel, Emile-Argand 11, CH-2000 Neuchatel (jessica.meeks@unine.ch*

The scientific community has ubiquitously acknowledged that climate change could shift the volume and temporal distribution of groundwater recharge, particular in cold-regions, drastically altering available groundwater resources. As seasonal snow pack plays a significant role in storage and redistribution of water, many studies have addressed recharge and runoff processes attributed to spring onset snowmelt. However, previous work has failed to identify inter-cold-season recharge processes and their relationships to climatic conditions prior to spring snowmelt, particularly in low alpine, karstic environments. If cold-region aquifers are to be sustainable and effectively managed, the dependency of winter recharge on climatic conditions should be identified and their relationships quantified. The Vers Chez les Brandt test site, where water infiltrating from a zone of approximately 2500m2 drains towards a single water arrival point in a cave 53m below its recharge zone, is an ideal location to study unsaturated recharge processes. A weather station and snow depth sensor were installed within the site's recharge area while the upper meter of soil-water was vertically profiled for physical parameters including water content, electrical conductivity, and temperature. Vadose water draining into the karst cavity was assessed for discharge, electrical conductivity, and temperature. Through time-series analysis and bivariate statistical regression of climatic data with that of soil and unsaturated zone waters, we derive the relative impacts of climatic variables on infiltration throughout winter months, thereby shedding light on the information gap concerning inter-cold-season recharge. This detailed approach revealed that, even with a shallow soil frost and an established meter thick snowpack, air temperature strictly governs infiltration; with positive air temperatures of even just 1oC resulting in observable increases in soil water content and vadose zone outflow. Results imply that equal consideration should be given to winter recharge as is afforded to that historically given to spring on-set snowmelt within groundwater modeling applications and management practices. Additionally, temporally detailed site temperature data is crucial for accurate assessments of recharge within the winter months.

12.6

Environmental factors affecting methane concentrations in Central and Northern European lakes

Rinta Päivi[1], van Hardenbroek Maarten[1], Schilder Jos[1], Stötter Tabea[1] & Heiri Oliver[1]

[1] *Oeschger Centre for Climate Change Research & Institute of Plant Sciences, University of Bern, Altenbergrain 21, CH-3013 Bern (paivi.rinta@ips.unibe.ch)*

Lakes are a significant source of methane (CH_4) to the atmosphere, contributing 6-16 % of total natural methane emissions (Bastviken et al. 2004). However, observations of CH_4 concentrations and emissions in lakes in different geographical areas are still sparse and factors controlling the CH_4 dynamics in different lake types are not well described.

We sampled CH_4 concentrations and physiochemical parameters of water in different depths of the water column in 32 small, central and northern European lakes were sampled (Figure 1). This unique and methodological consistent dataset, including also information on $\delta^{13}C$ of CH_4 and dissolved inorganic carbon (DIC), is well suitable for analyzing which factors controls the CH_4 dynamics in temperate and boreal lakes. Here we present the first findings of the relationship between CH_4 and environmental variables.

The studied lakes differed strongly in their morphology and size (surface area from 0.3 to 343 ha, maximum depth from 2 to 30 m) as well as in their nutrient status which ranged from oligotrophic to hypertrophic. In 24 out of 32 lakes the hypolimnion was anoxic in late summer when the lakes were sampled. Concentrations of dissolved CH_4 in different depths of the water column varied highly between lakes. In general, highest CH_4 concentrations were observed above the sediment surface in the deepest sections of the lakes where concentrations reached up to 2900 µM. In most of the lakes, concentrations decreased dramatically in the upper hypolimnion and further in the mixed surface layer, where the highest registered concentrations were only 20 µM. However, no statistically significant correlation between bottom and surface water concentrations was found.

First results suggest that hypolimnetic CH_4 concentrations are strongly related to environmental variables describing hypolimnetic conditions, such as oxygen ($r^2 = 0.60$, $p = 0.001$) and nutrient concentrations in the lake bottom water (total nitrogen $r^2 = 0.60$, $p = 0.001$ and total phosphorus $r^2 = 0.40$ $p = 0.01$). Also, CH_4 concentrations in the bottom water seem to be related to water temperature and lake surface area. On the contrary, the results of this study indicate that CH_4 concentrations in surface water are more difficult to predict based on other environmental variables. Weak links exists between CH_4 concentrations in surface water and factors associated to water column mixing and gas transport. These can be represented for example, as difference between surface and bottom temperatures, lake area or relationship of area and maximum depth.

The study will be continued with more detailed statistical analyses on $\delta^{13}C$ of CH_4 and DIC and variables representing catchment land cover and climate. Furthermore, an additional 16 lakes will be sampled to enlarge the dataset and ensure that it covers wide gradients in limnological conditions.

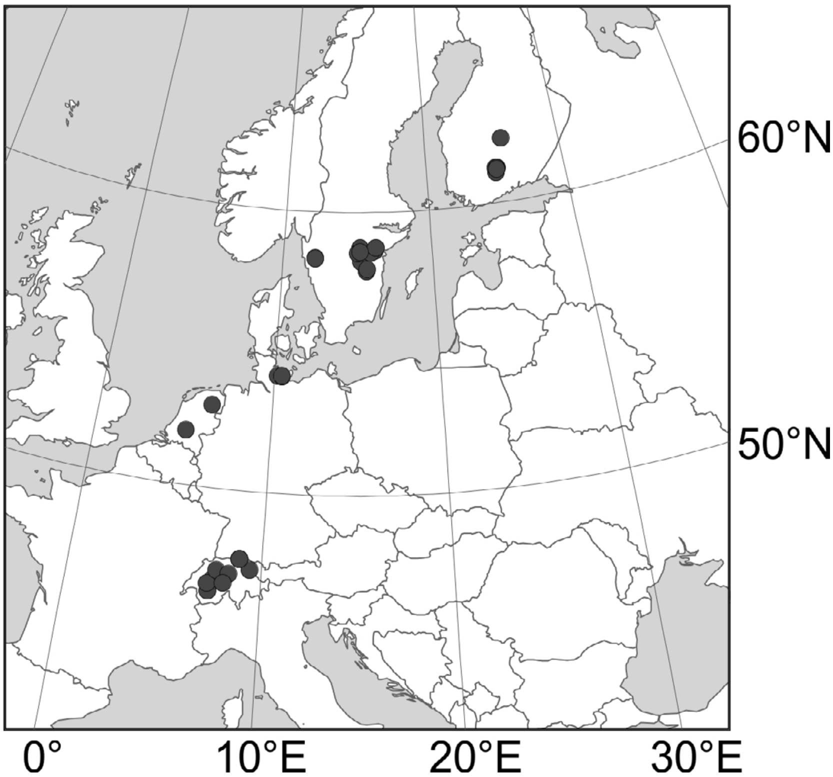


Figure 1. Geographical distribution of the studied lakes.

REFERENCES

Bastviken, D., Cole J., Pace M. & Tranvik L. 2004: Methane emissions from lakes: Dependence of lake characteristics, two regional assessments, and a global estimate, Global Biogeochemical Cycles, 18, 1-12.

12.7

Temperature and salinity staircases in Lake Kivu

Tobias Sommer[1,2], Jeffrey R. Carpenter[1,3], Martin Schmid[1] & Alfred Wüest[1,2,4]

[1] *Eawag, Surface Waters – Research and Management, Seestrasse 79, CH-6047 Kastanienbaum (tobias.sommer@eawag.ch)*
[2] *Institute of Biogeochemistry and Pollutant Dynamics, ETH Zurich, CHN G50.3, Universitaetstrasse 16, CH - 8092 Zurich*
[3] *Department of Geology and Geophyics, Yale University, 210 Whitney Avenue, New Haven, CT 06511, USA*
[4] *Physics of Aquatic Systems Laboratory, ENAC, EPFL, CH-1015 Lausanne*

Temperature and salinity in Lake Kivu (Central-Africa) are both increasing toward the sediment. Curiously, this increase happens step wise over large sections of the profiles: Several hundred mixed layers, with nearly constant temperature and salinity, are separated by thin and stable interfaces (Fig.1). This phenomenon is known as double diffusion. Our goal is to understand how such staircase structures are maintained, how they transform over time and how the vertical and horizontal fluxes of heat and salt are affected. Direct numerical simulations, supported by laboratory experiments and microstructure observations, suggest that vertical fluxes through the central part of the interfaces are molecular and can thus be determined by accurately measuring interfacial gradients of temperature and salinity. We present the most detailed microstructure observations of temperature and salinity staircases up to date, including the full resolution of interfaces down to vertical scales of about 1 mm. On average temperature interfaces were found thicker than salinity interfaces by a factor of 2.6. This difference in interface thickness causes density inversions (and thus local instabilities) above and below interfaces which can detach as blobs or thermals and drive the mixing in the adjacent layers. We compare our observations to theory and test whether measured molecular fluxes through interfaces support existing flux laws.

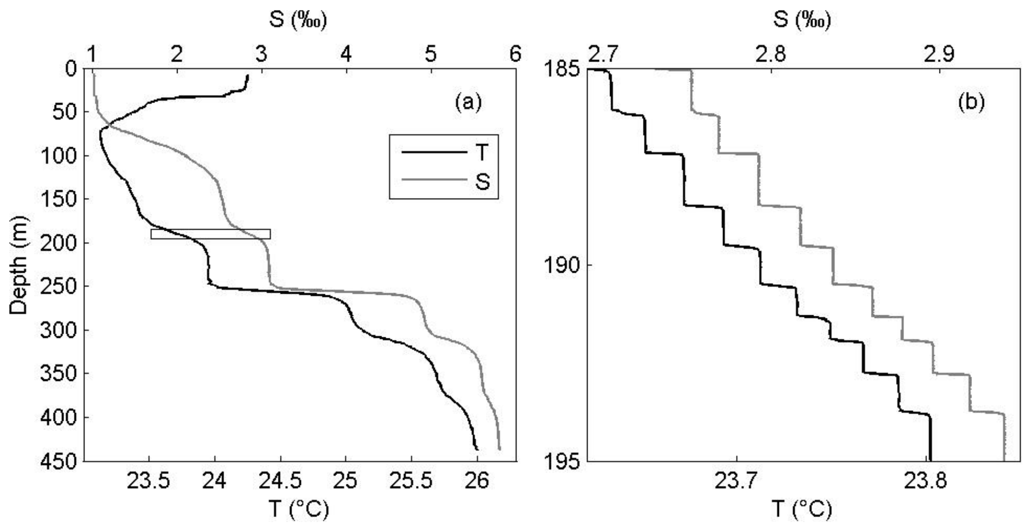


Figure 1. (a) Typical Lake Kivu profiles of temperature and salinity. (b) Double-diffusive staircases within the 10 m long section marked by the rectangle in (a)

12.8

Trend analysis of snow water equivalent

Tilg Anna-Maria[1], Marty Christoph[2], Jonas Tobias[2], Kuhn Michael[1]

[1]*Institute of Meteorology and Geophysics, University of Innsbruck, Innrain 52, A-6020 Innsbruck (Anna-Maria.Tilg@student.uibk.ac.at)*
[2]*WSL – Institut für Schnee- und Lawinenforschung SLF, Flüelastr. 11, CH-7260 Davos Dorf*

The temporary storage of water in form of snow plays an important role in the water cycle. It impacts the seasonal discharge and the water supply in lots of areas of the world. Especially in spring the snow water equivalent (SWE) is of particular significance to forecast the magnitude of snowmelt runoff to issue possible flood warnings. The regional and annual variability of SWE is important for the maximum snow load codes or the hydropower industry, which is interested in detailed forecasts of the discharge for efficient energy production.

Moreover, it is also important to analyse the long-term variability and trends of SWE measurements to determine how climate change impacts the snow water resources. The last similar analysis is 20 years old (Rohrer et al., 1994) and found no trends for the annual maximum SWE.
We will reveal first results of long-term biweekly measured SWE data from different regions in Switzerland. The measurement sites are located between 1200 and 2500 m asl. More than a dozen of these sites are operational since 50+ years. Mid-winter and spring snow pack trends will be investigated separately. We will also show the performance of different SWE parameterizations, which can be used to fill gaps in the existing data series.

REFERENCES

Rohrer, M., Braun, L.N., Lang, H. 1994: Long-term records of snow cover water equivalent in the Swiss Alps: 1.Analysis. Nordic Hydrology, 25, 53-64

12.9

The dual nature role of the snow cover in rain on snow events and a note on latent heat

Wever Nander[1], Fierz Charles[1], Jonas Tobias[1], Lehning Michael[1]

[1] *WSL Institute for Snow and Avalanche Research SLF, Flüelastrasse 11, CH-7260 Davos Dorf (wever@slf.ch)*

Rain on snow events often cause flooding and are severe threats in many areas of the world. Analysing a case study in the Swiss Alps of 10 October 2011, we show that the status of the snow cover before the event can modify the runoff response significantly. In a region located in the Bernese Alps of Switzerland, a rather shallow snow cover was quickly turned into a melting snow cover and aggravated the runoff from warm precipitation causing local flooding and severe damage. Other regions in Switzerland, where the precipitation event had similar characteristics, were affected less, mainly because a much thicker snow cover was able to store some of the precipitation and therefore caused a more moderate runoff reaction. It is further shown that latent heat exchange has a significant role in the warming of the snow cover, amounting to approximately 50% of the total energy for melt. The snow melt due to latent heat exchange thereby strongly exceeds the melt energy from the rain itself. With climate change, rain on shallow alpine snow covers is expected to become more frequent and the process should be properly represented in warning scenarios.

P 12.1

Hydrogeochemistry and Brine Evolution of Urmia Lake (NW of Iran)

Darvishi Khatouni, Javad.[1] Lak, Razieh.[2] Mohammadi, Ali. [3]

[1] *Marine Geology Department, Geological Survey of Iran*
[2] *Research Institute for Earth Sciences, Iran*
[3] *Geological Institute, ETH-Zurich, Switzerland (ali.mohammadi@erdw.ethz.ch)*

Abstract

Urmia Lake in the northwestern corner of Iran is one of the largest permanent hypersaline lakes in the world and the largest lake in the Middle East. It extends as much as 140 km from north to south and is as wide as 50 km east to west and water body area is about 6000km^2 during high water periods. The lake was declared a Wetland of International Importance by the Ramsar Convention in 1971 and designated a UNESCO Biosphere Reserve in 1976. Due to building one huge dike (Highway) at 1980 in the middle part of Urmia lake, lake actually divided in 2 part (connection pass between two parts is just one channel with 1400m wide).

Hydrochemistry of the water resources basin show mainly chloric and sulfidic brine due to the variable lithology and geology of the surrounding area. Hydrochemical investigations were carried out over a time period from 2007 to 2012 using previous published data with recently(2010, 2012) collected water samples from lake. 120 water samples were used for this research. Results show distinct changes in the brine type over time; from Na-Mg-Cl type in 2007 to 2010 which is comparable with Great Salt Lake in the USA. Chemical composition of lake in 2007, the percentage of Na is higher than Magnesium. In 2011 and 2012 water composition is HCO3<<Ca+Mg. That is, the path of brine composition on the Eugster and Hardie flow diagram has changed from (Na-Mg-Cl) to (Mg-Na-Cl) in 2011 and 2012 due to precipitation and crystallization of Halite. Then estimated Mg-Cl-SO_4 brine type for future of Urmia Lake. Na to Mg ratio is 5.12 in 2007. But this amount in 2011 is 0.68 and 0.56 in 2012. In future with Increasing of Evaporation, Mg to Na ratio will be increases and are becoming more Differences in the composition of brine in the North and South parts of Lake. This rapid changing in hydrochemistry of brine is not normal in this hyper saline lake. Because from 2000 till now more than 10 dam made on the Urmia Catchment Rivers and the water input to the Lake Decreases to near zero and due to huge amount of evaporation (100cm/year), we have catastrophic condition in Urmia Lake.

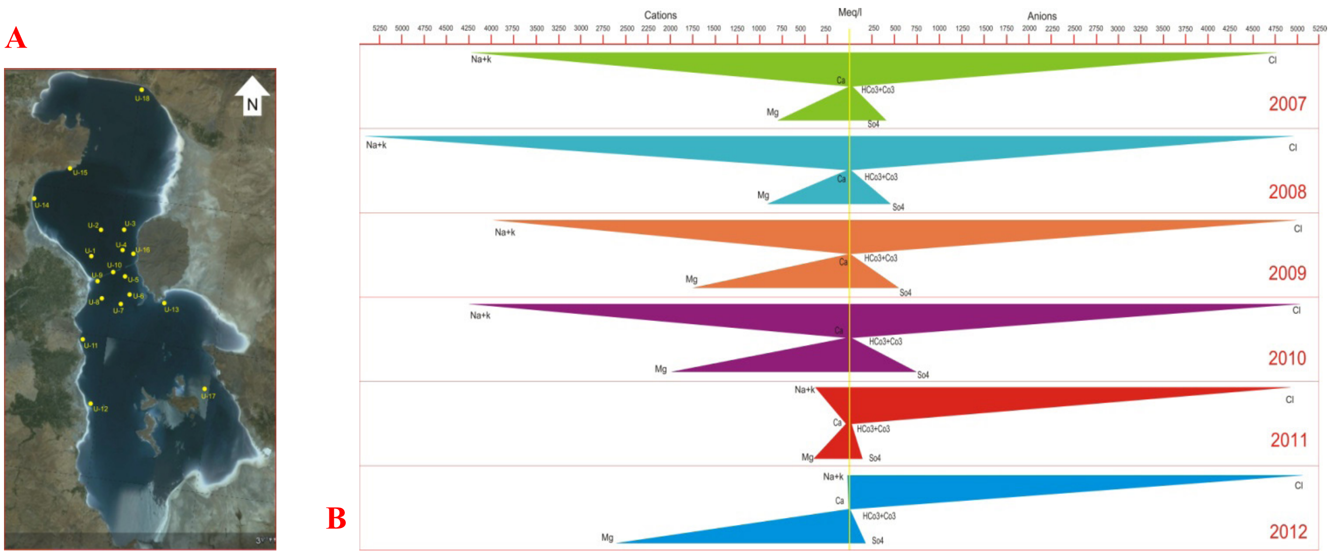


Fig: A) sample point on Urmia Lake. B) Stiff Diagram of the Main Ion in Urmia Lake from 2007-2012.

REFERENCES

-Kelts, K,. Shahrabi, M,. 1986. Holocene sedimentalogy of hypersaline Lake Urmia, northwestern Iran. Paleogeography, Paleoclimatology and Paleoecology, 54:105-130.

-Lak, R. Darvishi Khatooni, J. Mohammadi. 2012. Paleolimnology study and causes of Sudden decrease in water level of Urmai Lake. Journal of Applicable Geology, zahedan university. zahedan uni press. 4:357-372.

-Mohammadi, A,. 2005. Depositional history of Holocene? Deposits in Urmia Lake, based on the cores collected along the SH-K Highway, A thesis in M.SC. Sedimentology and sedimentary petrology, Tehran university, p 127.

P 12.2

Sensing with boots and trousers - A new qualitative field method to capture shallow soil moisture patterns in wet environments

Rinderer Michael[1], Kollegger Andrea[1], Fischer Benjamin M.C[1]., Stähli Manfred[2], Seibert Jan[1]

[1] *University of Zurich, Department of Geography - Hydrology and Climate*
[2] *Swiss Federal Institute for Forest, Snow and Landscape Research WSL* (michael.rinderer@geo.uzh.ch)

Soil moisture patterns and their spatio- temporal dynamics are of central interest in catchment hydrology. It has been demonstrated, that information about these can give insightful information on dominant runoff processes. Common measuring techniques are time consuming and/or destructive (e.g., gravimetric method) or need sometimes expensive instruments (Time Domain Reflectometry, TDR). Furthermore in very wet soils with a high organic content TDR often does not provide reliable results.

Here we present a qualitative field method which has been developed to offer a supplement to common quantitative measuring techniques as it allows a quick and inexpensive mapping of soil moisture conditions. This soil wetness classification scheme is based on qualitative but well-defined topsoil indicators which can easily be mapped in the field. The scheme consists of seven wetness classes from 'very wet', when water is visible at the soil surface to 'very dry', when a person could sit at that spot for some minutes without getting wet trousers. As quantitative methods like this new field method, are often criticized to be affected by subjectivity, we systematically tested the new approach: Two groups of 10 non-expert raters each were asked to classify 52 marked sites of different wetness within a catchment in the Swiss pre-alps (Erlenbach / Alptal).

The dataset comprising of roughly 1000 classification cases was analyzed in terms of degree of agreement: In 70 % of all classification cases raters agreed and in 95 % they were off by maximum one wetness class when assessing the sampling sites (Rinderer et al. in press). Driest and wettest class assignments showed little spread in classification and therefore seem to be well defined and easily recognizable.

Intermediate wetness classes turned out to be more difficult to assign, resulting in a larger spread of class assignments (Fig.1). A few raters showed a tendency to classify sites either too dry or too wet but the mean classification difference was still within the range of one wetness class. In a second step the agreement between qualitative wetness classes and quantitative wetness measurements was assessed: At 45 sites first the quantitative wetness class was determined, then soil water content was measured with a portable TDR device and finally soil samples were taken to the laboratory for gravimetric water content analysis. Results of this test proved an overall agreement between qualitative wetness classes and quantitative measurements. For intermediate wetness classes the median and interquartile range (IQR) however were not clearly distinct from those of neighboring wetness classes.

These findings were similar to the analysis of a third dataset comprising of 454 averaged TDR values and associated qualitative wetness classifications. The data was gathered during 8 days of field champagne between August and October 2010 repeatedly assessing 100 spatially distributed sampling locations in the Erlenbach each time (Kollegger 2010).

Systematic testing of the interrater-agreement and the correspondence of qualitative and quantitative measurements showed the potential of the new qualitative method. It does not intent to replace common quantitative methods but offers a potential to supplement them with the capability of covering a large number of spatially distributed sampling points. Such spatially distributed soil moisture datasets can be of importance for constraining model parameters and for studying hydrological processes, their key-controls and spatial organization.

REFERENCES

Kollegger, A., 2010. Untersuchung der räumlichen und zeitlichen Verteilung der Bodenfeuchtigkeit am Beispiel des Erlenbaches (Alptal/Schweiz). Vergleich einer quantitativen und einer qualitativen Messmethode. University of Zurich.

Rinderer, M., Kollegger, A., Fischer, B., Stähli, M. & Seibert, J., in press. Sensing with Boots and Trousers – Qualitative Field Observations of Shallow Soil Moisture Patterns. Hydrological Processes.

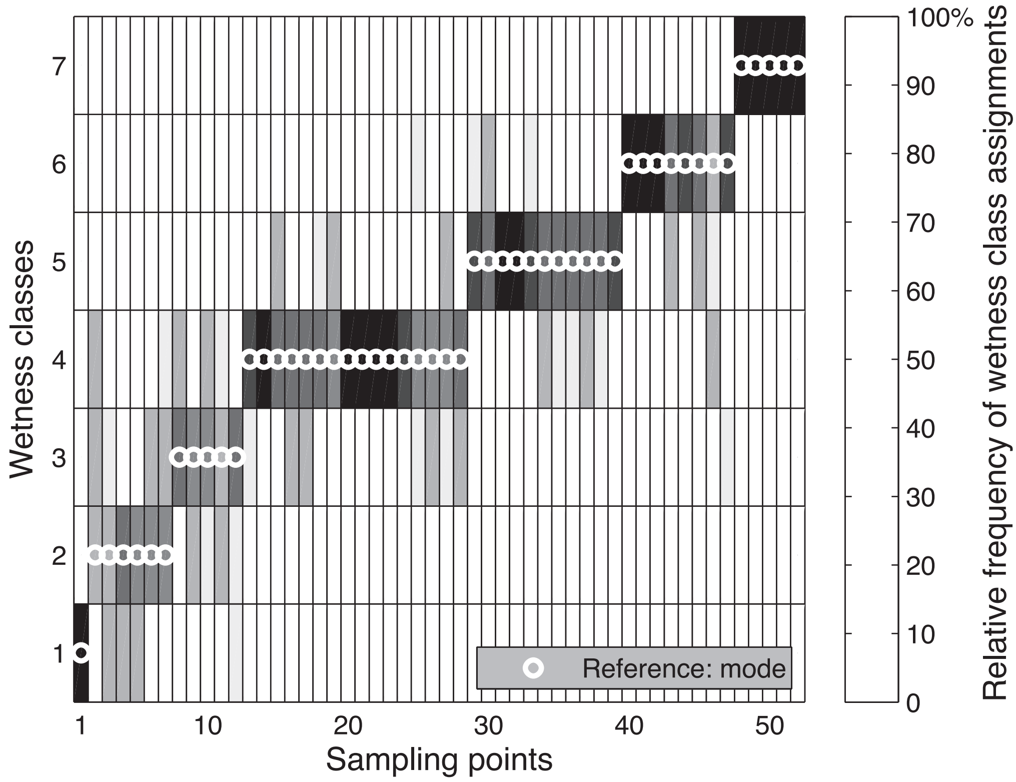


Fig. 1: Wetness class assignments for each of the 52 sampling points numbered and sorted by the mode of class assignments of group 1 for each sampling point. Gray shades indicating relative frequency of wetness class assignments. White circles show the mode as reference (adapted from: Rinderer et al. in press).

P 12.3

Accounting for precipitation and temperature co-variation for design flood estimation in Alpine environments

Schaefli Bettina[1], Nicótina Ludovico[2]

[1] Laboratory of Ecohydrology (ECHO), School of Architecture, Civil and Environmental Engineering (ENAC), Ecole Polytechnique Fédérale de Lausanne (EPFL), Station 2, 1015 Lausanne, Schweiz (bettina.schaefli@epfl.ch)
[2] Risk Management Solutions (RMS), 30 Monument Street, London EC3R 8NB, United Kingdom

Simulation of long discharge time series has become a standard tool for design flood estimation. A key hereby is the generation of appropriate meteorological scenarios to drive the hydrological model with so-called weather generators. These stochastic models generate all required meteorological variables, in particular precipitation and temperature, at one or several locations.

Precipitation (P) is known to depend on temperature (T), yet most weather generators do not explicitly model their co-variation. Accordingly, they do generally not reproduce the observed P-T scaling at time steps relevant for the study of hydrological extremes (hours to days). The use of such weather generators to produce long hydrological time series and for design flood estimation might, thus, lead to unreliable results in snow-influenced environments. Based on a real-world case study – design flood estimation for the Upper Rhone catchment (5000 km^2) in the Swiss Alps - we illustrate potential shortcomings of a classical weather generator (not accounting for P-T co-variation). Proposing a new copula-based approach to relate precipitation to temperature, we discuss the importance of explicitly including P-T co-variation in hydrological simulation for the study of extremes in Alpine or other snow-influenced environments.

P 12.4

Operational implementation design of radar and raingauge combination in Switzerland

Sideris Ioannis[1], Gabella Marco[1], Sassi Marco[1] & Germann Urs[1]

[1]*MeteoSwiss, Stabile La Ferriera, Via Luini 12, CH-6600 Locarno (Ioannis.Sideris@meteoswiss.ch)*

Radar monitoring provides a widespread, detail-rich picture of the precipitation over a region of interest. This is typically quite informative regarding where and when it rains, i.e. it provides a vivid picture of trends and outlines of precipitation in a very high temporal resolution. However the involved complexity between transmitting a radio-signal at some overground air-mass volume and producing, based on the backscattered radiation, a final precipitation estimate on-ground, often causes errors, occasionally of significant size. One naturally seeks a remedy in the form of an adjustment of the radar estimates map. Raingauge measurements provide a strong basis for such an adjustment. Undoubtedly, raingauge measurements are by no means error-free, and raingauge networks are typically too sparse to guarantee sufficient representativity, especially when meteorological microvariability is on stage. Still, the fact that raingauges are far less complex than radars and (most importantly) provide direct monitoring of rainfall, renders their measurements almost ipso facto more reliable than radar estimates; commonly they are taken as our "best bet" regarding the ground truth of precipitation depth.

Combining the two monitoring devices in a real-time operational environment involves a gamut of problems, variable in size and complexity. First a suitable method has to be identified and coded. A series of tests over significantly long timeperiods has to take place. Appropriate skill scores have to be collected and studied in a systematic fashion. Behaviour in typical and rare occasions has to be followed and understood. Results of any such suitable method will depend on a number of commonly complex and interacting factors, such as the meteorological condition, the involved topography, and the error structure of the monitoring devices. A real-time operational application depends to a major degree on the sophistication of the code it has been built upon, and the careful configuration of the involved parameters; human intervention has little share after deployment and the focus of such an application is to make correct decisions on how to treat myriads of situations, each of them ultimately unique.

Apart from the scientific part, synchronization of data sources, timely retrieval, production of error-free, correctly-formatted input for the combination process to follow up flawlessly, but also a broad exception-handling on a plethora of points that may not work as expected, should be taken care. Moreover, the output has to be consistent and useful in terms of format and metadata and clients needs, and be transmitted in a continuous and uninterrupted fashion to databases, repositories, or appear as online material.

We will discuss our experience on working on a radar-raingauge combination tool over more than two years. We have employed geostatistical techniques which involve spatiotemporal information to model the correlations between precipitation on raingauge locations, while using the radar field as external drift. The spatiotemporal aspect of our application improves the stability of our algorithm and the dependability of its outcome, while the involvement of the radar field assures that the trend and outline details provided by its monitoring are preserved in the output.

The aim of our application (planned to start operating in the beginning of 2013) is to produce hourly-aggregated raingauge-adjusted radar maps (resolution 1km^2) of precipitation every 10 minutes. For this reason it has been built in a computationally-effective basis, employing numerous vectorized functions which operate simultaneously on all members of sizeable sets such as rasters. It is due to the speed of this approach that our algorithm is able to operate as a real-time tool with a high-resolution update rate.

Although the main requirement is to produce precipitation maps within Switzerland where both radar and raingauge data are available, we employ sophisticated schemes to cope with the (extrapolation) regime outside the swiss border. We will present the concept of the "virtual raingauges" which is promising in producing a foundation for resolving such concerns. Moreover we will show how hourly- aggregations rainfall maps can be disaggregated effectively into shorter temporal scales, such as five-minute maps; this approach could be valuable for situations where very high temporal resolution precipitation maps are of essence.

We expect this new product to be useful for a number of practical applications coming from fields where accurate precipitation estimates are of importance, e.g. civil protection, flash flood warnings, intervention during flooding, flood prevention, hydro power management, agriculture, and tourism. Contact with representatives of these fields is continuously helping us to focus our efforts on targeted goals, but also expand our aim to meet broader needs of various areas.

REFERENCES.
Erdin, R., Master Thesis, ETH, Zurich, 2009.
Gabella M., Joss J., Perona G., Optimizing quantitative precipitation estimates using a non-coherent and a coherent radar operating on the same area, J. of Geophys. Research, 105, 2237-2245, 2000.
Gabella, M., Notarpietro, R., Improving Operational Measurement of Precipitation Using Radar in Mountainous Terrain, IEEE Geoscience and Remote Sensing Letters, 1, 1545, 2004.
Germann U, Galli G, Boscacci M, and M. Bolliger, Radar precipitation measurement in a mountainous region, Q. J. Roy. Meteor. Soc., 132, 1669–1692, 2006.
Sideris I., Gabella M., Erdin R., Germann U., Real-time radar-raingauge merging using spatiotemporal co-kriging with external drift in the alpine terrain of Switzerland, Quarterly Journal of the Royal Meteorological Society, submitted.

P 12.5

Snowfall limit forecasts for hydrological modeling

Tobin, Cara[1], Rinaldo, Andrea[1], Schaefli Bettina[1]

[1] *Laboratory of Ecohydrology (ECHO), School of Architecture, Civil and Environmental Engineering (ENAC), Ecole Polytechnique Fédérale de Lausanne (EPFL), Station 2, 1015 Lausanne, Schweiz (cara.tobin@epfl.ch)*

Hydrological flood forecasting in mountainous areas requires accurate partitioning between rain and snowfall to properly estimate the extent of runoff contributing areas. Many existing forecasting systems rely for this partitioning on the standard hydrological method, which consists of computing the amount of snowfall based on ground air temperature. The most common method consists hereby of computing a linear transition from rain- to snowfall in a given air temperature interval (e.g. between 0 and 2°C). Within a forecasting context, however, such an air temperature-based approach omits the additional forecast information which is contained in the snowfall-limit forecast - a standard product of meteorological forecasts based on limited area models (LAM).

To overcome this shortcoming and to test the value of snowfall limit forecasts for hydrological modeling, we propose a method to make use of snowfall limit information from LAMs for a catchment-scale hydrological model (Tobin et al., 2012). LAMs consider the vertical, humid, atmospheric structure in their snowfall limit calculations. The proposed approach is thus more physically-based than inferring snowfall limit estimates based on (dry) ground temperature.

The presented case study uses forecast re-analyses from the COSMO Limited Area Model as input for discharge simulation in the Viège catchment located in the Valais and part of the forecasting system Minerve (García et al., 2010). Results demonstrate that the use of COSMO snowfall limits during spring snow melt periods can provide more accurate runoff simulations than routine procedures, with practical implications for operational hydrology in Alpine regions.

REFERENCES
García Hernández, J., Horton, P., Tobin, C., and Boillat, J. L.: MINERVE 2010 : Prévision hydrométéorologique et gestion des crues sur le Rhône alpin., Wasser, Energie, Luft, 4, 297-302, 2009.
Tobin, C., Rinaldo, A., and Schaefli, B., 2012: Snowfall limit forecasts and hydrological modeling, Journal Hydrometeorology, In Press.