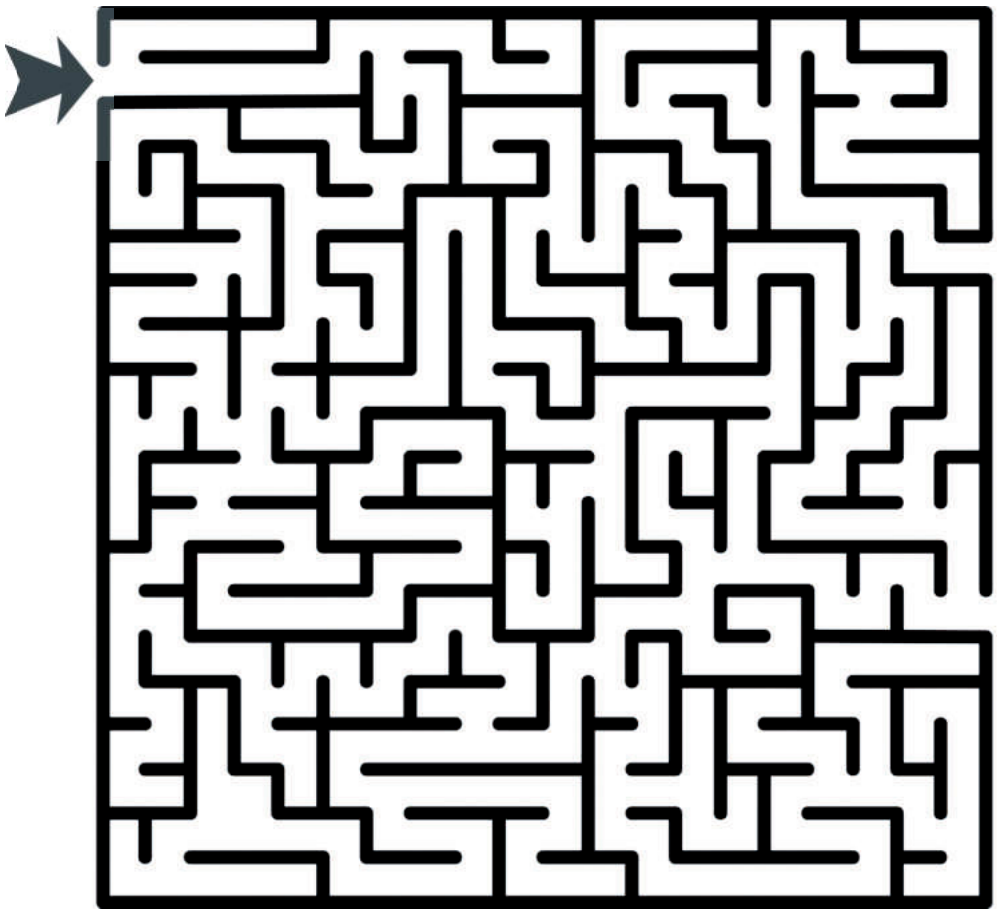
D-BAUG

Department of Civil, Environmental and Geomatic Engineering

Annual Report 2008

Finding solutions



Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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Even strictly scientific research cannot advance without free play of the imagination. Those unable of taking their thoughts beyond reason now and then will never enrich science with new ideas.

Max Planck

Preface

Dear readers

After the turbulent events of the previous years the ETH year 2008 was marked by the return to the usual academic life. The Management Board of the ETH with the President, Prof. Dr. R. Eichler, the Rector, Prof. Dr. H. Wunderli-Allenspach and the Vice President Research, Prof. Dr. P. Chen, was supplemented by the Vice President Personnel and Resources, Prof. Dr. R. Boutellier, and the Vice President Finance and Controlling, Dr. R. Perich. The previous Vice President Planning and Logistics, Prof. Dr. G. Schmitt, is now responsible for international institutional affairs.

Our Department is undergoing a significant change in its academic staff. Due to retirements of professors, a considerable number of selection procedures for new chairs had to be conducted during the report period. Retirements in 2008 concerned Profs. A. Carosio (geoinformation systems), H.E. Minor (hydraulic structures) and W.A. Schmid (landscape and environmental planning). In 2009, Profs. H.G. Kahle (geodesy), H.R. Schalcher (planning and management) and A. Grün (photogrammetry) will be retiring.

Dr. Adrienne Grêt-Regamey was appointed associate professor of landscape and environmental planning, effective 1 October 2008; Dr. Markus Rothacher was appointed professor of mathematical and physical geodesy, effective 1 January 2009; and Dr. Robert Boes was appointed professor of hydraulic structures, effective 1 February 2009.

The selection procedures for the new chairs in spatial information systems, photogrammetry and infrastructure management have not yet been completed.

To ensure an overlap with Prof. W. Gujer's current chair, Dr. Eberhard Morgenroth was appointed professor of process engineering in urban water management, effective 1 August 2009. Finally, a new chair in earth observation is about to be appointed.

Regarding the development of student numbers, the positive trend observed during the previous years continued in the areas of civil and environmental engineering. However, the student numbers in the area of geomatics and planning remained low; considering the new chairs in this area, a significant improvement is expected during the coming years. An initiative of our Department, in collaboration with the ETH Foundation, to raise funds for supporting excellent master students has been very successful. Many institutions, companies and alumni responded to our request in a most generous way so that today, there is a solid basis for this new activity. The first three scholarships could already be granted. The pages 6 - 7 of this report provide further information on this new activity.

We would like to sincerely thank our partners in Switzerland and abroad for the trust placed in us and the assistance rendered, and we are looking forward to their continued support.

Zurich, March 2009

Peter Marti

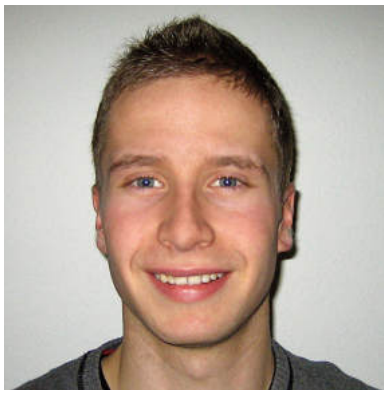
MSc Excellence Scholarships

Fabian Griewisch

Born on 11 October 1983, from Wipperfürth, Germany. He is a good surfer and enjoys relaxing evenings with his friends. He would love to travel around the world. Fabian worries about the climate change and finds looking for accommodation in Zurich stressful.

Notable achievement

Fabian received the MSc excellence scholarship for his academic achievement during his studies at the University of Applied Sciences in Karlsruhe. He finished his degree there with the best overall grade in his year.



Lukas Blank

Born on 29 September 1984, from Worben, Switzerland. Lukas finds Oliver Pocher entertaining and wants to become a good electric guitar player. He gets annoyed when he hasn't got any change for the coffee machine, is not easily frightened, and would like to be friends with John Frusciante from the band Red Hot Chili Peppers so he can teach him some of his guitar tricks.

Notable achievement

Lukas received the MSc excellence scholarship for his outstanding academic achievement during his studies at Lucerne University of Applied Sciences and Art.

Marcel Ortner

Born on 26 December 1984, from Florida, USA. He hates being stuck in a traffic-jam, wants to sail around the world, and is afraid of spiders and snakes. He admires President Barack Obama and is happy when he is part of a team that successfully finishes a project or game. Marcel would like to lose some weight.

Notable achievement

Marcel finished his BSc in Civil and Environmental Engineering at Florida International University with magna cum laude.

Donators D-BAUG

We are like dwarfs sitting on the shoulders of giants. Our glance can thus take in more things and reach farther than theirs. It is not because our sight is sharper nor our height greater than theirs. It is that we are carried and elevated by their height.

Bernhard von Chartres

We'd like to thank the following companies, foundations und individuals who supported us during the last years, and likewise those who do not want to be mentioned by name (per end of 2008):

Companies and Foundations

Albert Lück-Stiftung, Zürich
ARP Rotzetter + Partner AG, Zürich
Basler & Hofmann AG, Zürich
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Dalla Vedova, Gian Carlo
Vetsch, Walter
Vollenweider, Hans
Vollenweider, Ulrich, Dr.
Wilk, Willy, Prof. Dr.
Windler, Hansjakob
Winkler, Maximilian
Wüthrich, Willy, Dr.
Zanetti, Alfeo
Zumstein, Walter
Zundel, Walter

Development of Student Figures

Teaching concentrates on three Bachelor and four Master curricula: Civil Engineering *(CE)*, Environmental Engineering *(EE)*, Geomatics and Planning *(GP)* and Spatial Development & Infrastructure Systems (*SDIS,* only MSc). Teaching to support doctoral studies and continuing professional education also forms a key aspect of our mission.

by Patrick Dilger, Planning & Controlling D-BAUG

Positive Development

From the year 2000 onwards, figures for new incoming students have taken a positive trend and have actually more than doubled, since D-BAUG was established in 1999 (Fig. 1), surpassing the figures of the early 1990s. The number of new female students has increased to 56, reaching 23% last year. [1]

Master's Degree

The recently initiated Master's degree course is developing nicely. Since the MSc programme was introduced in 2006, the number of incoming students has risen from 70 to 120 (Fig. 2). In fact, 2008 saw the first Master's degree certificates being awarded since the Bologna Reform (Fig. 3).

Doctual Graduates

The number of doctoral graduates has been constantly increasing over the years, reaching 38 graduates last year. There were 191 registered doctoral students at D-BAUG at the end of 2008 (Fig. 4).

[1] See section Facts & Figures for additional figures.

New incoming students at D-BAUG (BSc-level)

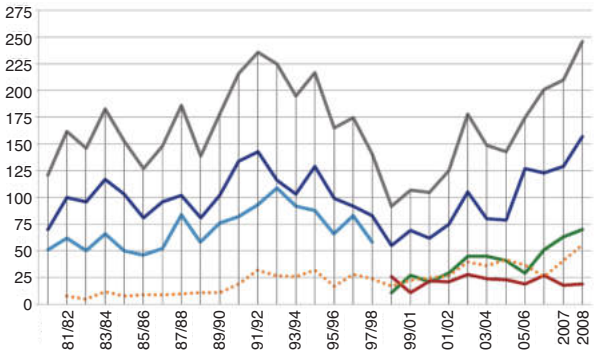


Fig. 1

- BSc new incoming total
- CE
- Rural Engineering and Surveying
- EE
- GP
- BSc new female students

New incoming students at D-BAUG (MSc-level)

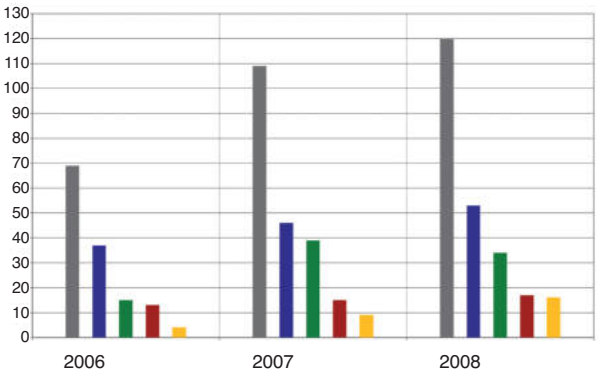


Fig. 2

- MSc new incoming total
- CE
- EE
- GP
- SDIS

MSc degrees (MSc ETH)

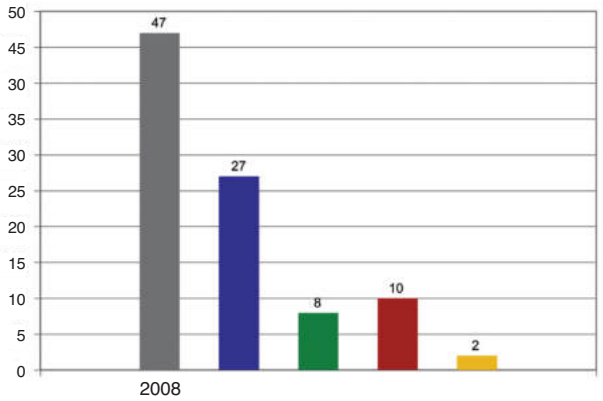


Fig. 3

- MSc total
- MSc CE
- MSc EE
- MSc GP
- MSc SDIS

Doctoral students and dissertations

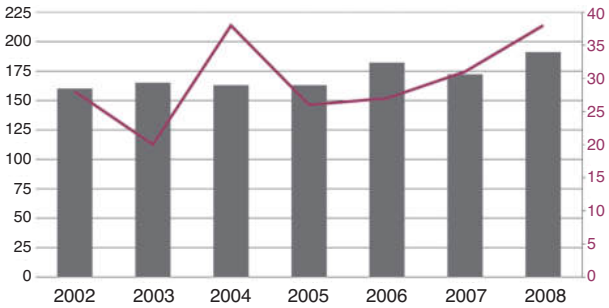


Fig. 4

- Doctoral students
- Dissertations

Travelling Exhibition: «ETH on the Road»

In 2004, when the ETH travelling exhibition was initiated as a pilot project, the Department of Civil, Environmental and Geomatic Engineering (D-BAUG) actively participated even then in the exhibition with its three Bachelor progammes.

by Enrico Manna, Dipl. Bauing. ETH, Head of Civil Engineering Study Administration Office

On its way

In 2005, the ETH jubilee year, the running of «ETH on the Road» was further optimised, and, in 2008, when ETH tools provided a professional platform for its organisation, the exhibition was well on its way to directly establishing contact with upper-secondary level students.

Goal

All along, the goal has remained the same: to give prospective students insight into science and studying at tertiary level, to highlight the diverse career prospects open to ETH graduates, and to encourage dialogue not only with the schools and parents, but also with the political and economic bodies of the cantons visited.

Various exhibits

ETH provides a dynamic image of the different disciplines and research areas through its various exhibits, hands-on experiments, films, lectures, and panel discussions. The travelling exhibition, "ETH on the Road", is run every year from November to March, visiting secondary and upper-secondary schools (grammar schools) throughout Switzerland.

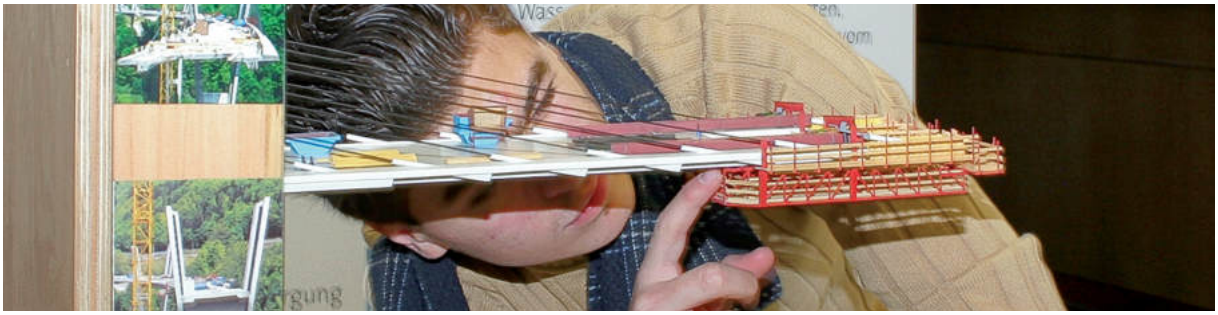
Competition

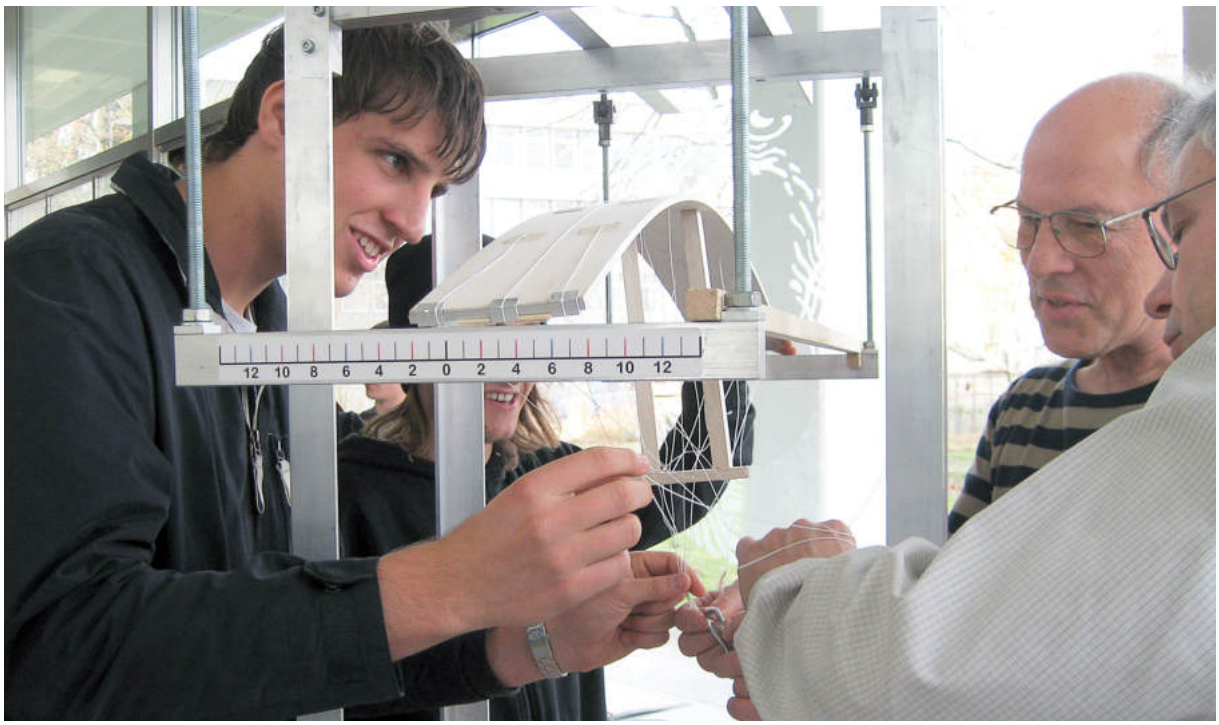
«ETH on the road» comprises manned information stands and supporting activities, such as short lectures on different topics, or the Civil Engineering bridge competition, which challenges students to construct a bridge with the following dimensions: not heavier than 100 g, a span of 96 cm, with its strongest bearing capacity being in the middle. To date, the best constructions built by school pupils were partly able to support more than 500 N.

Visited Schools

In 2008, «ETH on the Road», incorporating D-BAUG's two study programmes, Civil Engineering and Environmental Engineering, visited grammar schools at the following locations:

- Trogen (AR).
- Oberwil (BL)
- Mendrisio (TI)
- Schwyz (SZ)
- Rychenberg Winterthur (ZH)
- Zurich «Unterland» in Bülach (ZH)
- Laufental Thierstein in Laufen (BL)
- Kirchenfeld, Bern (BE)

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UMWELTINGENIEURE
WISSENSCHAFTEN
BAUINGENIEURE
WISSENSCHAFTEN

Latest Acquirement at the D-BAUG Metal Workshop

And now it is ours! After such a long wait, the latest piece of equipment has come to stay. Its dimensions are perfect and its new metallic look is spectacular.

by Peter Jenni, Mechanical Workshop

Top form

Weighing 3000 kg, it belongs to the good middle-class and its stability is just right. Still masked by protective packaging, namely a finely transparent synthetic sheathing, this jewel looks at us rather timidly. But it will soon reveal its full temperament and reach its top form.

Supermodel

No, we are not talking about a fashion super model, but rather a top model manufactured by Gildemeister: our newly operating NEF 400 lathe. After two years of clarifying which lathe would best suit our needs, it was finally delivered on 5 August 2008. Clearly, emphasis was placed on the constant adjustment of our machinery to today's modern manufacturing technology. In addition, improving safety measures for the user was also a high priority. Nowadays, at the processing stage, using modern tool technology requires a high speed range, intensive cooling of the material being processed, and a closed workshop. Furthermore, this new machine certainly improves the training facilities for our co-workers when focussing on processing technology.

Obstacles

Once we knew which model served our purposes, the financial aspects had to be tackled which led to negotiations between the Department representatives and the Executive Board. As soon as all issues had been resolved, the lathe was finally ordered at DMG/Switzerland in March 2008.

Finally

From our side, the lathe's location, with all the necessary circuit points, had been well prepared in advance when, at last one morning, it was finally delivered. This jewel had to be unloaded using a crane, safety straps and grommets, was pulled to its end location in the metal workshop on heavy steel castors, and carefully placed upon its own legs using the workshop crane. The next day it was connected up to the electric circuit and intensively checked out. By that same evening, all the tests had been successfully carried out and the test report could be signed.

With many thanks

And so we will certainly enjoy using this jewel for our lathe work once we are fully familiar with all its wonders. We would like to thank the Executive Board, the Department of Civil, Environmental and Geomatic Engineering, and our managers, who supported this investment and made this purchase possible.

NEF 400 Technical Data

- **Operating capacity:**

swing diameter	350mm
collet chuck diameter	200mm
plan hub	220mm
inter-run undercut	700mm
steering mechanism	Siemens
840D Powerline	

- **Headstock:**

spindle diameter	90mm
spindle drilling	65mm

- **Main drive:**

engine performance	11.5kW

- **Electrical connection:**

total connected load	21kVA
voltage	400 V
fuse protection	35A

- **Weight:**
  3000 kg

Studying at the Department of Civil, Environmental and Geomatic Engineering (D-BAUG)

Every summer, during my school holidays, I used to work as a handyman on a building site. Working outdoors was a pleasant contrast to being at school and I enjoyed it.

by Diego Somaini, MSc ETH Bau-Ing.

The decision

Since I grew up close to the San Bernardino north-south transit axis, there were plenty of interesting construction projects going on, and so I had the opportunity to work as an iron layer, a slab cleaner or a cement layer on many different Misox building sites. Not only did I get a nice suntan and managed to stock up my savings account, but working actively on these building sites also sparked my interest for the building trade, and I soon decided to become a civil engineer.

Heading for Zurich

Now that I had been able to view bridges from all angles, I wanted to understand the theory behind them and started studying at ETH Zurich in 2002. The first year was really hard work with a lot of brain-jogging, which, in my opinion, was not necessarily career-oriented. Everyone wants to construct something and not just juggle matrices full of letters! Looking back on that first year, I felt I was only working with mechanics. Of course that was not the case, but this subject fascinated me, and thus I remember it best.

When the going gets tough

The first year passed very quickly and I had finally gotten used to being in 'little big city', Zurich. In Roveredo, the village in which I spent the first 16 years of my life, everyone knows each other. In the town of Chur, where I went to grammar school, I also knew many people. Zurich, being bigger and impersonal, limits one's friendships to fellow students, students from other disciplines, and earlier acquaintances. The atmosphere among the civil engineering students is friendly which contributed considerably to studying successfully.

Summer 2003 was marked by preparing for the examination session for the first-year exams. I remember it as a long and intense summer in which we students had to "swot our butts off". No sooner were the exams over than lectures recommenced, and you still did not know whether you had passed the exams. Holidays were a rarity.

Boosted motivation

Lectures in the second year were more interesting and enhanced our motivation. However, the workload became more intense: Catching up on lecture notes and doing complex exercises required an increasing amount of time. In addition, the session exams were held twice a year. It was quite a tough programme: The semester began mid-October and lasted for 10 weeks followed by 2 weeks of Christmas holidays, then four more weeks of lectures, two weeks to learn and revise, followed by the 5-week examination session.

If you were unlucky with your exam dates, you just had one weekend to relax before facing into the new semester. The only difference in summer was that you had more time to learn and you could even take a few weeks' holiday. However, I did not have much time to improve my budget by working on building sites.

Nowadays, student life is much better: 2008 saw both semesters being scheduled to take place in the same calendar year. Students thus have a two weeks' holiday after the examination session ends and before the semester recommences. This also means that, by the time the semester recommences, students usually know their exam results.

Fig. 1: Alumni 2008 Civil Engineering (in the lobby of the hotel Burj al Arab in Dubai).

Fig. 2: Sheikh Zayed Road in Dubai.

Fig. 3: Construction site Metro Dubai.

Fig. 4: View from Burj al Arab.

Highlights

In my opinion, the highlights of the first three years of the study programme were the core subjects: Structural Analysis, Structural Steel, Structural Concrete, and writing up the Bachelor's thesis. This was my first big project in which I along with a fellow student, designed, calculated and constructed a fictional structure in detail. On the one hand, we realised how much we had learnt during the three-year basic studies whilst, on the other hand, we soon recognised that we still had a lot to learn before we could work on a real construction.

The Master

When I completed my Bachelor's degree, I took up the Master programme for which I had to select two from six specialised courses (majors). Of course I wanted to take Structural Engineering. Choosing the second specialised course was not so easy: I was constantly pulled between Geotechnical Engineering and Water Resources Management. I eventually decided on Water Resources Management, but I also attended some electives in the field of Geotechnical Engineering.

At this stage, students are no longer anonymous, but rather the small groups of students, who had built up friendships from the first year onwards, had now formed one big group of fellow students. Students had gotten to know each other from the numerous group-work activities, excursions, and from working together in the drawing rooms. The professors even knew our first names!

New ideas and variety

Similar to the Bachelor's degree programme, the first semester of the Master's studies comprised many lectures and exercises. In the second and third semesters of the Master's degree programme, the two projects became increasingly important. These projects were much more interesting, since they linked the knowledge acquired during the lectures, and gave us the freedom to develop new ideas. They did, however, take up a lot of time sometimes resulting in the non-attendance of lectures! It goes without saying that after having followed lectures for almost four years, you have had your fill of sitting quietly and listening.

Many excursions were organised during both study programmes, which were not just informative, but also a welcome change to constantly studying. Some of the trips we went on were to a power station in Engadin, a bridge construction site near Solothurn, and the Uetliberg tunnel construction site.

Climax: Dubai

The most impressive trip was without doubt our one-week stay in Dubai. Thanks to many generous sponsors, we were able to marvel at the greatest and strangest constructions and building sites. As a result, my idea of a building construction took on a new dimension. We could visit several big construction sites and, from close proximity, gain an impression of their huge magnitude. Thousands of workers are employed on such enormous construction sites. When I was working on the building sites in Ticino, there were no more than 30 employees in peak times.

After this marvellous trip, I only had to complete my Master's thesis, which I carried out with other fellow students in what had become for us the 'cosy' drawing rooms of the HIL building on Hönggerberg.

Great years

My five years of studying in Zurich did not just focus on learning and 'swotting'. The ASVZ sport facilities are first-rate and it was really impossible to go to all the student parties. Yes, there were enough opportunities to spend the evening with friends. Looking back, they were in fact five very nice years.

Fig. 1: Burj Dubai Tower, supposed to become the world's tallest tower, current height: 688m (Eiffel Tower: 324m).

Fig. 2: Hotel Burj al Arab, one of the most luxurious and expensive hotels of the world, has even its own helicopter landing place.

Fig. 3: Nanin bridge, Mesocco (Grisons).

Climate Change in High Alpine Regions – Evaluation and Interpretation of the World's Longest Glacier Mass Balance Measurements

Glaciers are an outstanding indicator of climate change. When ice masses retreat, the effect of climate warming is evident, even to the layperson. For almost 100 year long measurement series on Alpine glaciers show that in the 1940s – in spite of lower air temperatures – more snow and ice was melted than in the last 10 years.

by Matthias Huss / VAW

Unique mass balance measurements

The mass balance at a point on the glacier surface (that is, the total of solid precipitation and melting over the course of one year) is the most direct indicator of the influence of climate on the glacier.

In Switzerland, there are four data series of mass balance measurements, unique in the world. They were begun already in 1914 and have been maintained, virtually without a break, since that time. Every spring and every autumn, the snow depth and the amount of snow- and icemelt is determined at one accumulation pole each on Grosser Aletschgletscher and Silvrettagletscher, and at two on Claridenfirn. The measurement sites are located at elevations between 2,700 and 3,350 m a.s.l.

Data evaluation

As part of this study, these four data series were standardized and interpreted in a systematic way. To this end, a simple model was adapted to the measurement values every year. By using meteorological data in daily resolution (air temperature and precipitation), the influence of varying lengths of annual measurement periods on the mass balance could be corrected and gaps in the data series were filled. Furthermore, the two components of mass balance measurable in the field – solid precipitation and melt – could be separated from one another. When there is a surplus of energy over snow- and ice surfaces, it is consumed for melt. Direct information about the energy balance at high elevations and its changes throughout the 20th century is thus provided by the total amount of melt over one year, which is obtained from the seasonal measurements on the glacier using the model and meteorological data.

Large fluctuations over time

The time series of the stakes located in different regions and altitudes show similar fluctuations over time and were averaged for further analysis. Figure 1 shows the relative deviations of energy consumed for melting from the long-term mean. In the 1940s as well as since 1985 the climatic forcing on glaciers was significantly above average, whereas in the 1960s and '70s, there was much less snow- and ice melt (Fig. 1).

Dramatic summer in 1947

The immensely hot summer of 2003 is still fresh in our minds; the summer that is considered as an absolute extreme in history. However, according to our data, the summer of 1947 had an even more dramatic impact on the glaciers. One decade between 1942 and 1952 experienced a climate forcing higher by 4% compared to the years from 1998 until present (inset in Fig. 1). This is intriguing when one considers that the air temperatures in the 20th century were never consistently as high as nowadays (broken line in Fig. 1). This is to say that the glaciers melted at a faster rate in the 1940s, although the temperatures were lower!

Change in the heat budget

These observations can be explained with a change in the heat budget in the Alps. The rate of snow- and icemelt is not only determined by air temperature, but also by shortwave solar radiation. Long-term measurements at Davos show that solar irradiance was higher by almost 10% in the summer months of the 1940s compared to today (Fig. 2B).

This is both due to an increasing trend in cloudiness and to a dimming effect of aerosols. The aerosol content of the at-

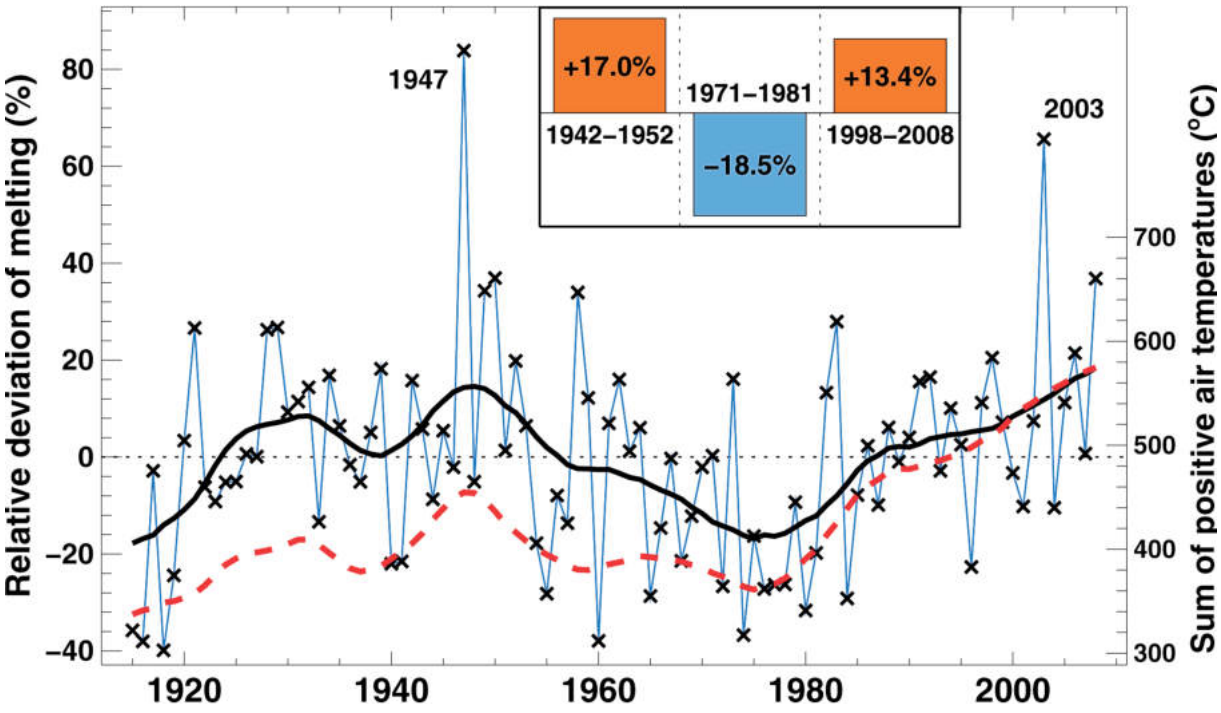


Fig. 1: Relative deviation of the energy consumed for melting from the long-term mean (crosses: individual years; solid line: 10-yr moving average). Broken line: Moving average of the annual sum of air temperatures above 0°C. The inset displays the mean percental deviation in three selected periods. More heat was consumed for snow- and icemelt in the 1940s than in the last decade.

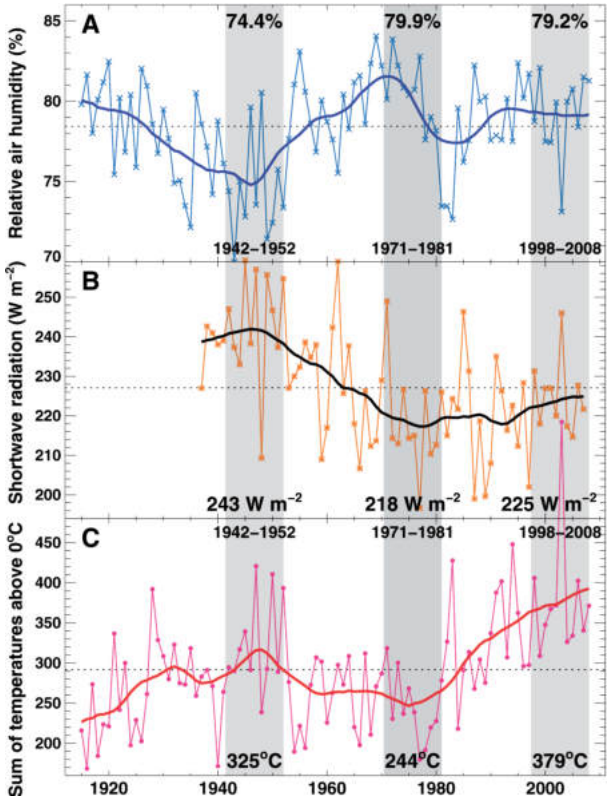


Fig. 2: Measured (A) relative air humidity (Davos, Säntis) and (B) shortwave radiation (Davos) in the summer months (June to August). Bold lines indicate moving averages (10 years time window). Means of the depicted variables in three decadal periods are given. (C) Sum of air temperatures above 0°C in June to August. Since the onset of the measurements solar irradiance was never as strong as in the 1940s. Air temperatures and relative humidity, in contrast, were significantly higher in recent years, indicating enhanced forcing by longwave radiation.

mosphere is related to air pollution and can reduce solar radiation considerably. Studies show that the dimming due to aerosols was most important between the 1970s and mid-'80s. This is a possible reason for the reduced climate forcing acting on the glaciers at that time. Nowadays both summer air temperatures and relative humidity are significantly higher than they were 60 years ago (Fig. 2A and 2C).

This indicates that longwave radiation1 is currently more important for snow- and icemelt than this was the case throughout most of the 20th century. It is essential to understand these changes in the climate system and to adequately describe them in numerical models in order to be able to forecast the impacts of future climate warming on the glaciers.[1]

Serious consequences

An important variable revealing potentially serious consequences for the "health" of glaciers is illustrated in Figure 3. The data show that the amount of solid precipitation (snowfall) as a fraction of the total annual precipitation has diminished by 12% over the past three decades. If precipitation falls as rain and no longer as snow at an elevation of 3'000 m a.s.l. in the Alps, it cannot be retained by the glacier and therefore is lost. This positive feedback effect will act to further accelerate the wastage of glaciers in the future. Simultaneously, the period in which melting occurs has been extended by almost one third since the 1970s, which also has a negative effect on the mass balance of glaciers (Fig. 4).

Unique repository of information

The four long-term data series, the object of dedicated study by generations of glaciologists, represent a unique repository of information about climate change at high elevations. The influence of climatic fluctuations on glacier melt can be quantified over a period of close to one century.

Our results show that the climate forcing acting on the glaciers was even higher in the 1940s than in recent years. In exchange, "chilly" conditions prevailed between the 1960s and '80s leading to an advance of many glacier tongues. This study illustrates that glacier retreat is not a linear process. Significantly differing climate conditions were encountered in the Alps throughout the 20th century, which resulted in both extreme snow- and icemelt, as well as mass gains of the glaciers.

Heat waves about to recur

The current rate of glacier wastage is not outstanding – it was faster in the 1940s. However, the current climate conditions adversary to glacier existence are unique because they persist since 25 years almost without any disruptions. Climate models suggest that this trend will be even amplified in the coming decades. In addition, feedback mechanisms (Fig. 3 and Fig. 4) will further accelerate glacier melt. It is thus probable that summer heat waves like those in 1947 and 2003 will soon recur – with severe consequences for Alpine glaciers.

[1] Longwave radiation is also termed thermal radiation and does not originate from the sun, but from every body with a temperature above -273°C (absolute zero). Longwave radiation providing energy to the glacier surface is mainly determined by the temperature of the atmosphere and its moisture content.

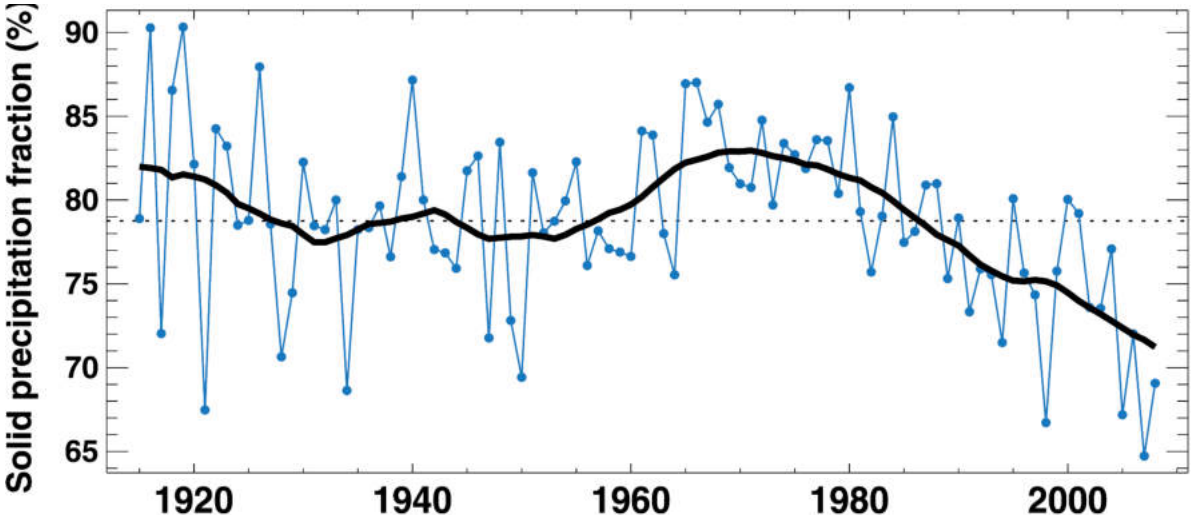


Fig. 3: Amount of solid precipitation as fraction of total annual precipitation. Considerably more precipitation currently falls in the form of rain instead of as snow compared to the 1970s.

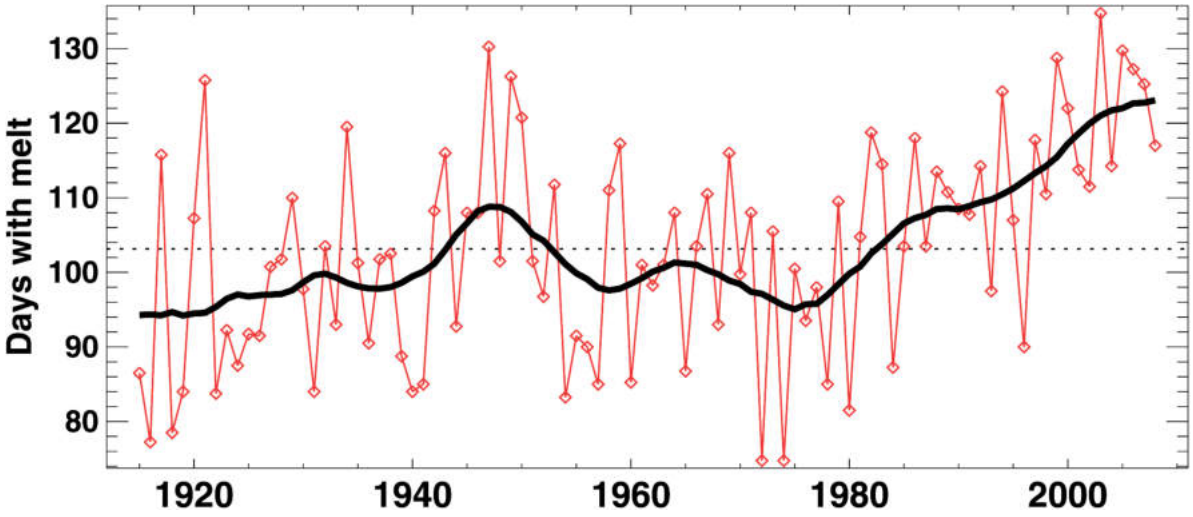


Fig. 4: Number of days per year that experienced melting conditions at the elevation of the study sites (approx. 3000 m a.s.l.). The length of the melting season has increased by one month over the last 30 years. If this trend is continued in the future, glacier retreat will be accelerated considerably.

The complex puzzle of Hydrology

The new challenges posed by climate change and by increased anthropogenic pressure on water resources claim for Hydrology a central role in understanding the physical processes and in formulating prognostic models for engineering applications.

by Paolo Burlando / IfU
(based on research work by Ruzica Dadic, Peter Molnar, Paolo Perona, Maurizio Savina)

Hydrology as a changing science

Since the early 1980s Hydrology has been recognised as autonomous geoscience. Such recognition, the technological progress, which made available better computers and monitoring devices, and the increased worldwide pressure on water resources have generated in the last decades a considerable momentum in hydrological research.

Important drivers of this momentum are several challenges that Hydrology is currently facing. Among them the effects of climate change, natural hazards, and environmental conservation and restoration are likely the most evident. Hydrology is not only facing new challenges, but is also experiencing a change of paradigm in the way processes are looked at and models are formulated. The complex interaction among hydrological processes and those processes that are driven by them has become an important focus of the research, which aims at understanding not only the cause-effect relationships, but also the feedback mechanisms. The reference unit for hydrological processes, the river basin, is not seen anymore as an entity formed by compartments, but as a continuum of processes in space and time, which span over several disciplines, and interact by influencing each other, thereby including the dynamics of socioeconomic systems.

At the Chair of Hydrology and Water Resources Management we have embraced this new avenue since several years with the long-term objective of understanding the incredibly complex (but fascinating) puzzle of Hydrology. Examples of this effort are found in the recent and ongoing projects at the Chair. Some of the highlights are hereafter briefly recalled.

Environmental conservation and restoration

The water rich mountains of Switzerland host a lot of dams, which are mainly used for hydropower. While being important for its renewable character and virtually CO_2-free electricity production, the presence of dams has dramatically altered in most cases the natural streamflow regime of Alpine river corridors. This has, in turn, produced severe impacts on the aquatic ecosystems of the floodplains downstream the impounded systems, due to the reduced amount of those flow ranges that are responsible for the dynamics of the river corridor and its ecosystem. To overcome this problem the current legal framework forces in most cases hydropower companies to release the so called environmental flows. These are expected to maintain throughout the river a constant flow that minimizes the impact of regulation. However, the observation of changes, which may have already led to loss of biodiversity and ecosystem services, call for better understanding of the interaction between hydrology and ecology of river corridors.

An excellent example of this interaction is observed in the Maggia Valley, Canton Tessin, Switzerland. Within the framework of a project, funded by SNF and BAFU, we have investigated the evolution of the riparian vegetation of the Maggia river floodplain using aerial photographs that cover three different periods: before the construction of the dams, after the construction and before the introduction of environmental flows, and, finally, after the introduction of the environmental flows. The mosaic of land cover classes shown in Fig. 1, which covers the time span between 1933 (predam period) and 2001 (postdam, regulated with constant environmental flows), puts in evidence the long-term narrowing of the active

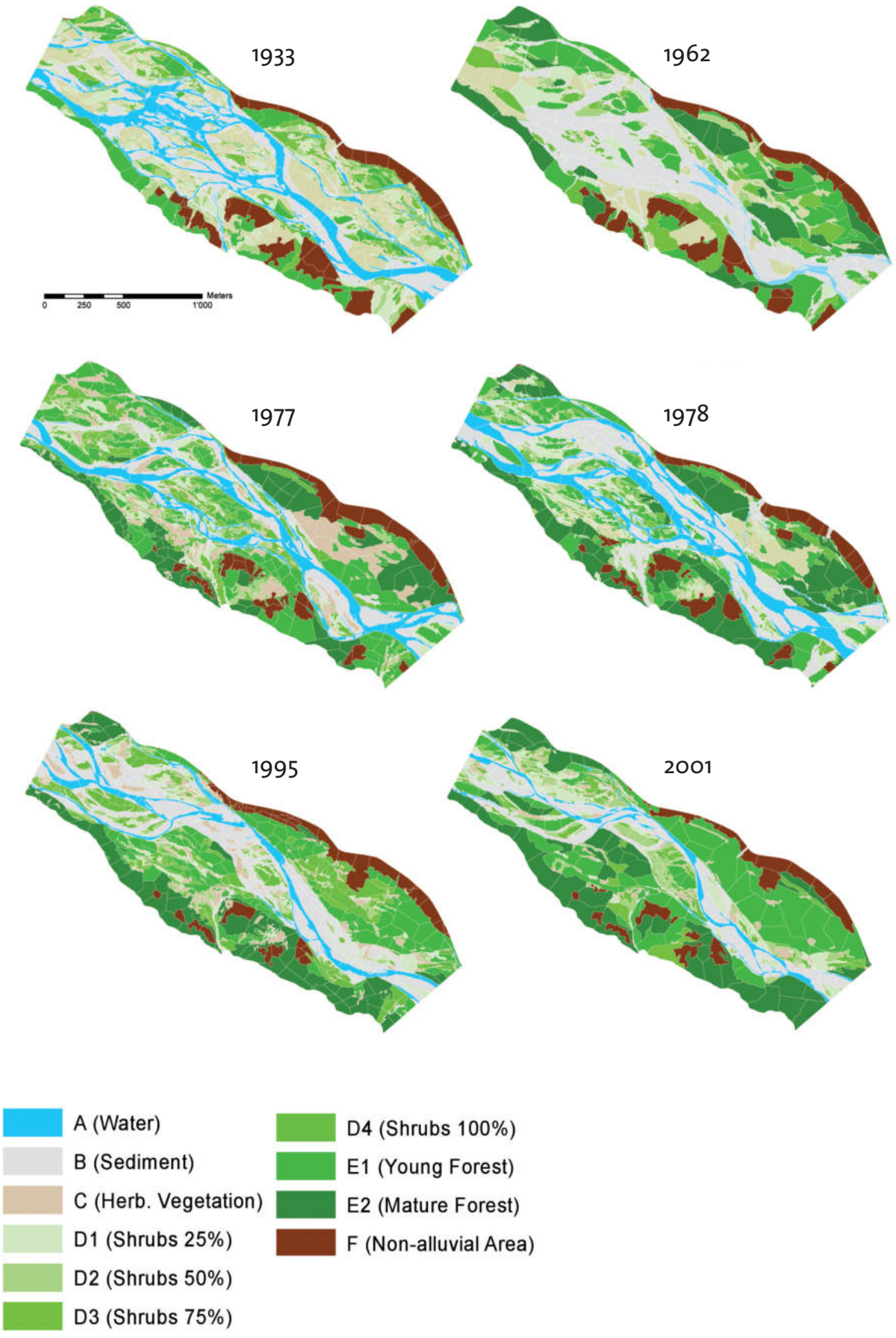


Fig. 1: Evolution of the mosaic of land cover in the braided area of the Maggia River, Tessin, Switzerland.

braided channel system, a decrease in pioneer vegetation stages, and a gradual maturing of the floodplain forest. The mosaic couple 1977-1978 shows conversely evidence of short-term response following the large 1978 flood, which reworked the channel bed, increased the morphological heterogeneity and uprooted vegetation through scouring.

By means of a stochastic model simulating the response of the vegetation to streamflow disturbances it has been possible to mimic the observed patterns through time (Fig. 2). The model responds to erosion during high flows and to plant colonization during low flows, also accounting for transitions from young to mature vegetation. Its simple structure allows the solution of the model equations in closed form, thus providing the analytical expression of the probability distribution of the different land cover categories. This makes possible its use for investigation of the floodplain vegetation dynamics in response to different regulation scenarios, thus supporting the planning needs of water authorities.

Mountain waters

Much of the water flowing from Swiss mountains originates from snow- and ice-melt. The manifest retreat of glaciers and the expected impact on them due to climate change will modify the streamflow regime. Predicting the time scale of these modifications is extremely important to assess the impact on hydropower production. Furthermore, understanding the magnitude of these modifications is a priority in countries where meltwater is the major freshwater source, from which agriculture and water supply depend. Extrapolation of recent observed trends has been often used to predict the timing of the glacier disappearence. However, the expected higher variability of climate, also characterized by higher winter precipitation amounts, may differ substantially from the past trends. To obtain realistic predictions of the evolution of glaciers in the mid- and long-term it is therefore necessary to account for the complexity of the involved physical processes and, in particular, to model the continuous mass balance of glaciers and its space variability.

While modelling the ablation phase of the mass balance can count on a rich scientific literature, the spatially explicit simulation of accumulation – thus accounting for the influence of topography and glacier morphology – was hardly investigated, especially in Alpine glaciers.

We have approached the problem by identifying the key processes in a hierarchical order of importance and by modelling those processes that are the main cause of variable snow accumulation on glaciers. These are the spatial variability of precipitation, and the snow redistribution due to wind and to avalanche processes. The snow redistribution has been the focus of a PhD thesis, which has produced a parameterized model of wind-driven snow redistribution that can be coupled with a slope stability threshold driven redistribution. These joint models have been coupled with an energy balance approach to obtain a prototype of a continuous mass balance glacier model, which can be forced with simulated or observed mean and vertical wind speed respectively. Despite the parsimonious approach the comparison of the simulated snow accumulation field with observations from a high resolution digital elevation model has provided very encouraging results, showing deviations from the observed accumulations that on average do not exceed 35% (Fig. 3). The prototype model is currently further investigated to improve its performance and to test its ability to simulate long term changes and thus respond to the needs of predicting the retreat of glaciers under climate change.

Hydrological extremes and precipitation

Another important challenge for engineering hydrologists is the mitigation of natural hazards. The flood events which occurred in Switzerland in the recent years have shown some limitations of our knowledge about the processes triggered by storm rainfall. Many modelling concepts are borrowed from hydrology and hydraulics of large size catchments and inappropriately transferred also to small and steep catchments. In contrast, Alpine catchments are characterized by intense events often occurring over very short time scales, and by strong coupling, interaction and feedack mechanisms along the chain of processes that lead a raindrop from the atmosphere to the floodplain. In this context, accounting for space-time variability of the processes at the appropriate scale and representing the interactions among processes in simulation models become a key issue for accurate predictions.

The intrinsic space-time variability of rainfall and its control by topography play a major role in this respect. Understanding the space-time variability of precipitation, especially in areas where the orographic controls are strong, requires observations that are characterized by high resolution in time and high density in space. Because the installation and maintenance costs of a dense network of raingage stations represent an increasing load on the budget of meteorological agencies, and large scale radars often suffer from visibility problems in complex topography, we are exploring the use of a local X-band weather radar located on the Kl. Matterhorn at an elevation of 3'883 m a.s.l. (Fig. 4)

The relevant research project is jointly funded by ETH Zurich and by Canton Wallis, which also acquired the radar. The device, which has been recently installed is capable of multiple horizontal resolutions. These depend on the beam radius and range from 100×100 m over a 10 km radius to 500x500 m over a 60 km radius. The focus of the investigation is on comparing the local radar performance with that of the operational MeteoSwiss C-band radar and ground observations collected at a high spatial resolution. The latter will be obtained by raingauge-based conventional measurements distributed across alti-

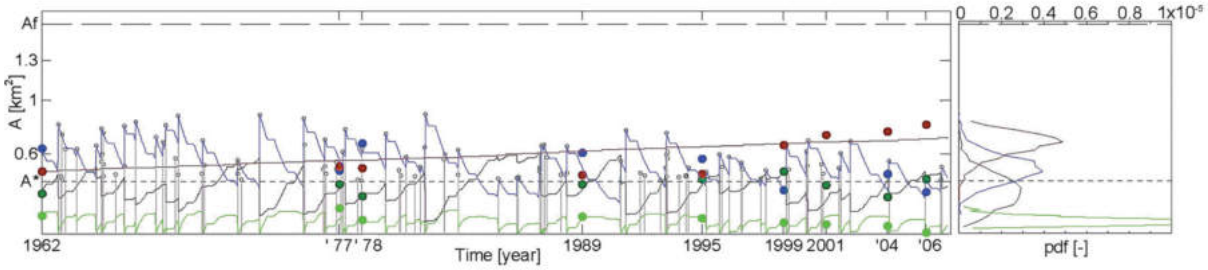


Fig. 2: Simulation of the evolution trajectories of land covers in the braided area of the Maggia River, Tessin, Switzerland. Color coded solid circles represent the spot observation for each land cover, color-coded lines show the reconstructed trajectories.

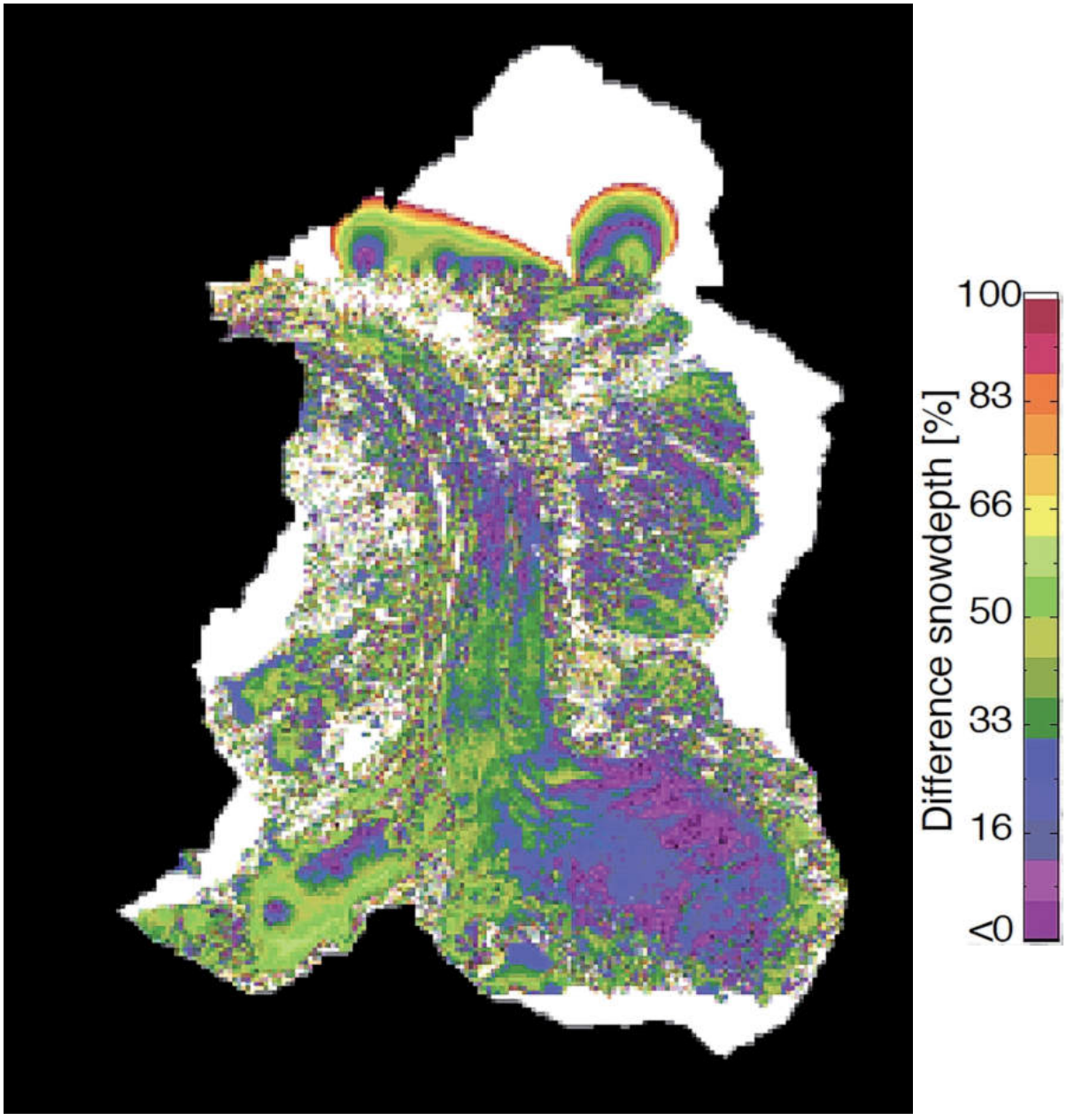


Fig. 3: Deviations of the predicted snow accumulation at the Haut Glacier d'Arolla (Valais, Switzerland) from the LIDAR-based measurements.

tudinal ranges and at various station densities during intensive observation periods.

The calibrated radar will allow to investigate, as a function of radar range and temporal resolution, the small scale space-time statistical structure of storm rainfall and its variability, as well as the scaling properties of the observed rainfall fields. In particular we will focus on the role of orography in defining the space-time structure of storm events characterized by different nature (e.g. convective vs frontal or winter vs summer). The radar data will be additionally used, jointly with those obtained from the raingauge network and from the C-band MeteoSwiss radar, to estimate storm rainfall fields by means of a combination of the three type of observations that minimizes the estimation uncertainty. The combination of the X- and C-band radar observations will be also used to further develop the ensemble radar estimation technique, already tested by MeteoSwiss, with the purpose of assessing the effect of higher resolution local information on the quantitative estimation of the uncertainty. Should these experiments be successful, new avenues for measuring storm rainfall in mountain regions would be opened. The preliminary results (Fig. 5) seem to be encouraging.

Outlook

Hydrology has increasingly become a science at the interface with other disciplines. Feedback mechanisms and interactions with other processes are and will be the main focus of present and future research efforts. Most of the questions pointing at the interaction of hydrological processes with other processes arise from real problems and engineering questions.

This is for instance the case of the multidisciplinary research project RECORD, which is addressing the problem of restoration of channelized rivers in the broad context of its effects on water quality, recovery of river ecological and hydraulic functionality and landscape improvement.

A multidisciplinary effort is also that of the project APUNCH, which aims at gaining a comprehensive and process chain based insight into the response of Alpine watersheds hit by storm rainfall events. The goal is to overcome the sectoral approach conventionally used to assess flood hazards, hillslope stability and debris flows by developing a framework that allows to simulate the concurrent onset of flood runoff, erosion and sediment mobilization, and hyperconcentrated and debris flows, which feed each other in a cause-effect-feedback mechanism that often leads to the collapse of protection structures.

In these and other research efforts an increasingly important role is finally played by the sizeable advancements in sensing technologies. On the one hand the progress made by satellite based remote sensing allows nowadays unprecedented space-time observations that overcome the limitations of conventional ground based point observations. On the other hand the miniaturization of sensors and the progress in storage and communication technology allow to design pervasive monitoring approaches also of processes for which measurements have been always difficult and thus of limited availability. This is a considerable improvement, which finally provides the possibility of acquiring data that are essential for the internal consistency validation of complex hydrological models, thus laying the basis for a new and more reliable generation of hydrological models.

Literature and useful links

P. Perona, P. Molnar, M. Savina and P. Burlando (2008). Stochastic sediment-vegetation dynamics in an Alpine braided river. *IAHS Publications*, 325: 266-274.
Dadic, R., (2008) Monitoring and Modelling Snow Accumulation Processes in Glacierized Alpine Basins; PhD Thesis No 17945, ETH Zurich.

X-band radar project: www.kmradar.ethz.ch
RECORD project website: www.record.ethz.ch
APUNCH project website: www.apunch.ethz.ch

Fig. 4: The X-band radar installed on the Kl. Matterhorn.

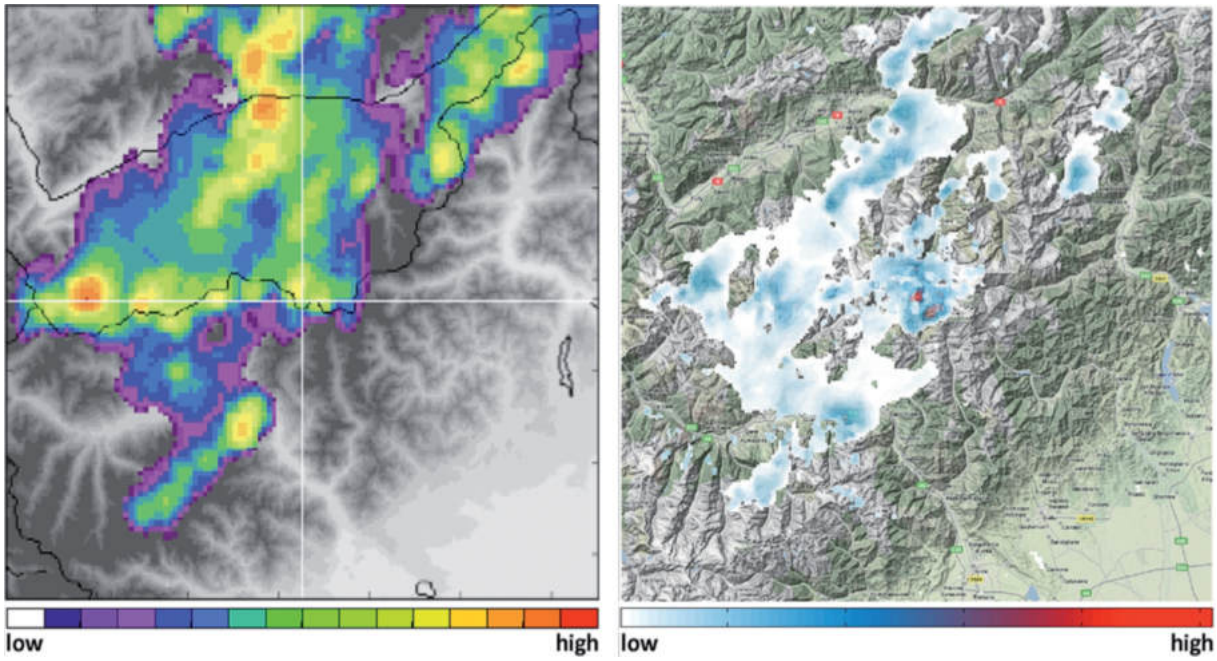


Fig. 5: Preliminary comparison between observations from MeteoSwiss radars (left) and from the Kl. Matterhorn X-Band (right). Both images cover an area of 120 x 120 km centered on the Kl. Matterhorn, Valais, Switzerland.

Particle Models in Civil and Environmental Engineering

We have built our world around phenomenological observations in our macro world. Today we can simulate most of these phenomena with many particle processes on much finer scales. Particle models allow a simplistic, yet fascinating glimpse into the mechanisms of the meso-, micro- or even nano worlds, and explain complex phenomena occurring in civil engineering materials.

by Falk K. Wittel und Hans J. Herrmann, Computational Physics for Engineering Materials / IfB

Over the last century continuum mechanics made a triumphal parade through basically all engineering disciplines, mainly due to its transformability into processible schemes and implementation on fast micro-processors. Unfortunately, many engineering problems are too complex for continuum descriptions. In this article we intend showing how this complexity emerges from models that consist of simple, dynamically interacting particles, and the multitude of important phenomena that can be understood by particle models. First, we describe the building blocks behind such models, before we demonstrate on several civil and environmental engineering examples how particle model simulations enable us to understand them.

Particles and Interactions

The elemental particles can be – like the problem itself – defined in one, two or three dimensions and can basically be of arbitrary shape. Restrictions are the computational cost, in particular for contact force calculations. For many problems, the simplest particle shapes, like discs, spheres or polygons are the best choice. If necessary, these can be agglomerated by kinematical coupling to form more complex shapes. The way particles are allowed to interact is the key point when simulating with particle models. On the one hand, frictional contacts of colliding particles have to be defined. This is important particularly when granular materials are modelled. Additionally, particles can interact, for instance with their surrounding matter, if interaction with an embedding fluid is of interest. If cohesive frictional materials are addressed, additional cohesive elements like springs, beams or any other structural element can be employed that are attached to particle boundaries or the centre of mass. Before respective examples are shown, we need to look at different solving strategies. The simplest way is the static analysis, when equilibrium states are calculated. Dynamic processes, however, call for dynamic time stepping schemes when either Newton equations of motion are solved iteratively or collision event driven strategies are employed. With these tools at hand, we can model different classes of problems like the dynamics of granular materials, fracture and fragmentation of cohesive frictional materials or stability problems like the packing of particle chains or structural collapse of concrete structures.

From Granular Matter to Complex Fluids

Granulates are ubiquitous in all engineering disciplines. They are basically conglomerations of discrete, solid particles. Their mechanical behaviour defies continuum mechanical descriptions, since single particle interactions form force chains and networks that span the entire assembly as illustrated in Fig. 1. Particle models contribute to the understanding of granular matter by using modern tools from statistical mechanics and powerful computers. Depending on particle size, property and the surrounding medium, a multitude of different important problems can be addressed. Here we only exemplify three problems, namely collapsing suspensions, particles with fluid interactions and charged particles.

Inspired by quicksand, a substance that is shrouded in mystery by adventure books and legends, we create a particle model for collapsing suspensions or soils. It has been repeatedly argued that since the density of sludge is typically larger than that of water, a person cannot fully submerge and therefore cannot be really "swallowed up" by any quicksand. We study this using a 2D particle model with contact dynamics. The starting point is a suspended structure generated by ballistic deposition of cohesive discs. In the next step, an intruder is dropped into the suspension, leading to partial

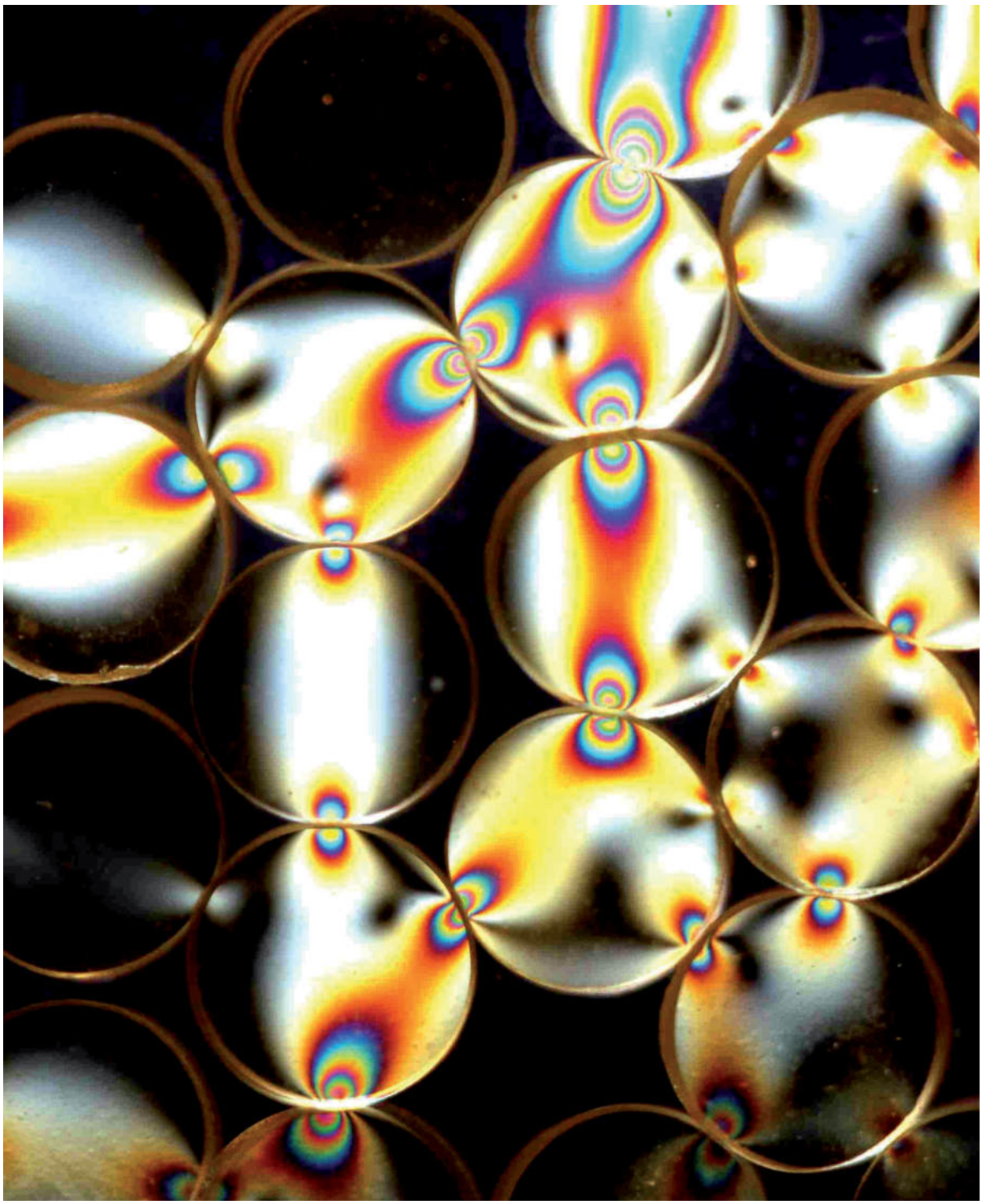


Fig. 1: Force chains in a vertically loaded random packing of photo elastic discs. (FKW, HJH)

destruction of the structure along its trajectory (Fig. 2). By using this approach, we capture the microscopic description of the essential physical processes underlying the dynamics of collapse of the system that exhibits the behaviour of a complex fluid. The direct comparison of the model with natural quicksand gives identical shear strength both in the unperturbed and collapsed states. Interestingly, our intruder can be trapped by the collapsing suspension that deposits on top, even though its density is smaller than that of the sludge.

The example for suspended soil did not consider fluid-particle interaction. In contrast, a model for fluid flow through layers of densely packed grains cannot neglect fluid-particle interactions. Such systems are characterized by a strong hydrodynamic interaction between the grains and the ambient fluid. To further complicate matters, we introduce two fluids: a liquid and a gaseous one that is separated by a liquid-gas interface which has a strong impact on the dynamics of the system. Our system consists of three phases: solid grains, water and air. The simulations start with a densely packed layer of grains completely submerged in water. Pressurized air is then injected at a fixed position leading to a growing air bubble. The bubble grows by displacing both the liquid and the grains (Fig. 3). Liquid is pushed back into the capillary pores defined by the neighbouring grains. Since grains move, capillary pores continuously rearrange. The air first invades the largest pores. Since the grains also move, these invaded pores open even more due to the forces exerted by the advancing air.

Up to now, particle collisions had no consequences for the properties of particles. Imagine if each collision goes along with contact electrification, building up significant charges on the individual grains (Fig. 4). In nature, this happens during desert sand storms that produce sparks and noticeable radio interference. The same is known for charged particle clouds that regularly lead to devastating dust explosions, e.g., in coal or grain plants. Little is known about charged granular gas and even the nature of the electrostatic charging itself is still a puzzling phenomenon. However, particle models are top candidates to comprehend the dynamics of these complicated processes, including long-range interactions for attraction and repulsion of charges, and charge transfer when particles collide. We model this by a set of self-driven particles inside a box that produce a charge each time they collide. As time goes by, a charge profile builds up with particles on the top that are even levitated (Fig. 5). Certainly particles with opposing charge attract each other. A small cohesive force is also used for contacting particles in the collapsing soil model. However, to create models for cohesive solids, additional cohesive elements need to be incorporated.

From fracture to fragmentation

Strong cohesive forces are responsible to maintain the integrity of engineering materials. In particle models, this is achieved by connecting the particles by combinations of elements of arbitrary rheological behaviour like linear or nonlinear springs, beams, or dashpots, just to name but a few. The simulations basically all follow the scheme that first a material section is assembled by particles and cohesive elements. When the system is loaded, consecutively cohesive elements are weakened or removed as a reaction to a mechanical or thermal load that exceeds the element's failure criteria. The secret of the success of this model approach lies in the local dynamic interaction of particles that can reproduce the complex behaviour that emanates from failure processes on small length scales inside the material. This is exemplified by studies on three different types of fracture, namely creep fracture of asphalt, dynamic crack propagation inside a brittle, disordered material, and a full three dimensional simulation of impact comminution.

Asphalt fails in a very peculiar way, especially in fatigue damage. This is due to microcracks that not only form, but also completely heal when crack surfaces contact again during mechanical or thermal load cycles. The competition between microscopic damage accumulation and the healing of defects basically determines the lifetime of a costly highway construction. In our simulations, we allow cohesive elements to accumulate damage and, if compressed again, to heal completely. If an element is damaged, part of its load is dynamically redistributed to its neighbours. If they cannot bear the additional load, damage grows (Fig. 6). By this approach, the detailed process of damage, fracture and failure of the solid is revealed, providing excellent agreement with experiments and, more importantly, open access for material design of specific asphalt mixtures.

Due to the dynamic nature of the particle interactions, such models are powerful tools in the study of dynamic fracture processes. These incorporate the interaction of the stress release wave due to postcritical crack growth with the stress field in front of the crack leading to crack tip instabilities. The resulting crack branching has strong influence on the further crack propagation speed, crack roughness and the energy release rate. We apply simulations to study the interplay of the material heterogeneity with the branching instability and resulting crack surface (Fig. 7). For computational reasons, particle contacts are neglected and only the part of the system is solved that contains the crack tip with a sufficiently large environment.

Engineering materials are often particle compound materials or agglomerates of finer aggregates. To break up the agglomerates for reuse or to produce finer powders, they are, for example, impacted on a target. Particle models with cohesive beamtruss elements are ideal for studying the impact fragmentation. With such models the simulation of the fracture and fragmentation processes that take place simultaneously during a very small time interval can be captured. Various fragmentation mechanisms, their origin, evolution and interaction during the process can be studied in detail. It was found that damage initiates and grows from the inside to the outside with a quasiperiodic angular distribution. The final shape

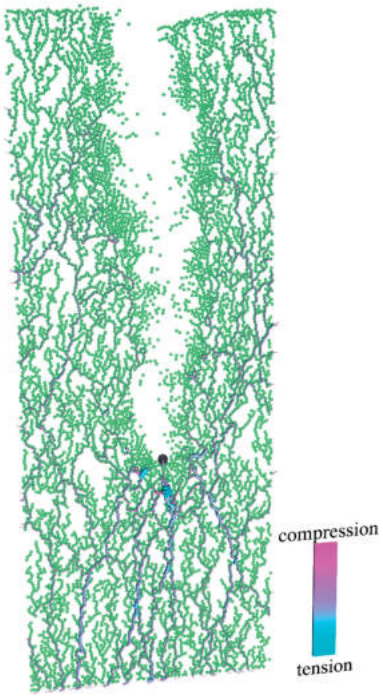


Fig. 2: Collapsing particle suspension due to a falling intruder. Force chains are displayed by their magnitude (thickness and colour). (D. Kadau, HJH)

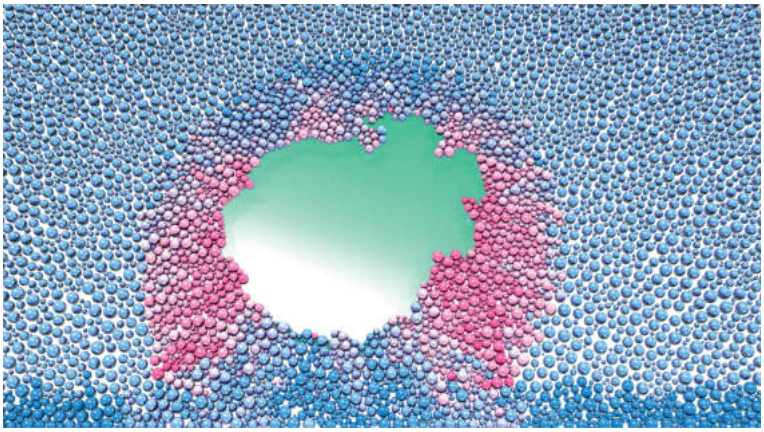


Fig. 3: Interaction of a particle packing with an expanding gas bubble. Colours represent velocity magnitudes. (J.L. Vinningland, HJH)

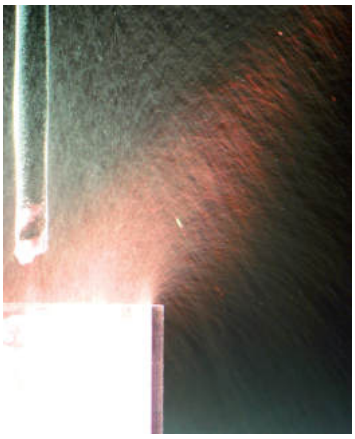


Fig. 4: «Granular fountain». Glass particles are violently ejected out of the jar by electro-static forces after they were charged only by pouring them through an acrylic tube. (FKW, HJH, T. Shinbrot)

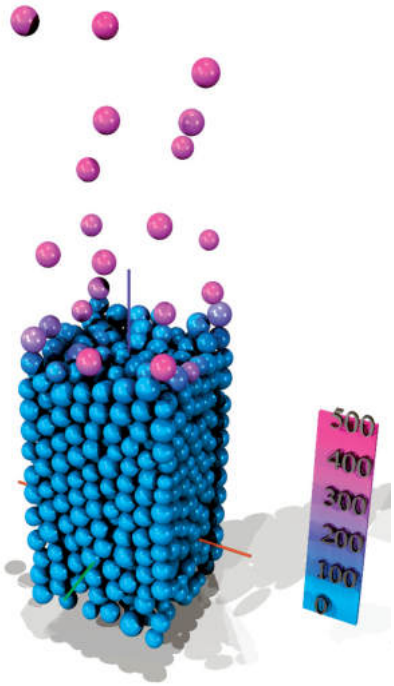


Fig. 5: Snapshot of the simulation for electrostatic charged particles due to contact electrification when particles collide. Colours represent charge in meV. (T. Pähtz, HJH, T. Shinbrot)

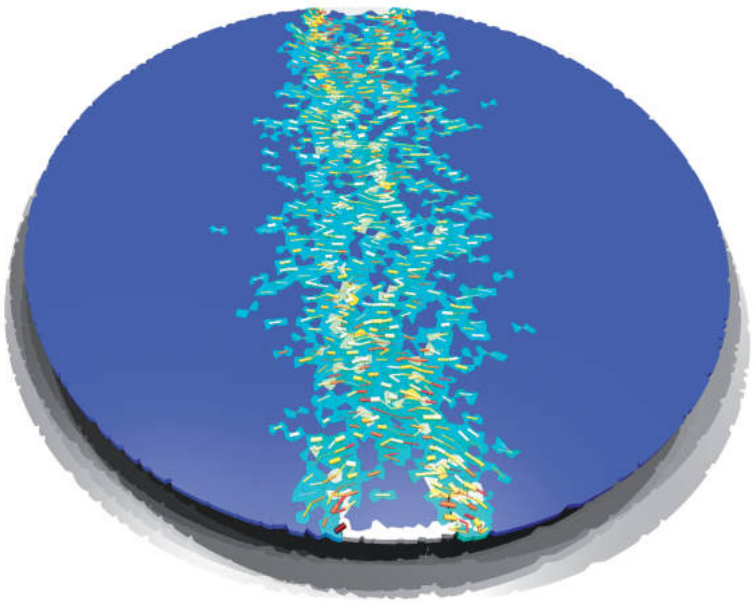


Fig. 6: Snapshot of a Brazilian test. Polygon colours represent the spatial damage level, while beam colours represent the breaking times. (H. Carmona, F. Kun, HJH)

of the experimentally observed large wedge-shaped fragments could be reproduced and explained. If more energy is accessible, these pieces further fragment (Fig. 8). Simulation models for fragmentation are the future means for optimizing milling processes with respect to certain size distributions, minimal powder production and minimal energy input for various material systems.

From stability to collapse

The formation or demolition of structures can be the result of series of global and local instabilities due to multiple buckling and body contacts. When structures are formed, we talk about their morphogenesis, while their demolition is a progressive collapse. Both processes are of dynamic nature and need to incorporate simultaneous multibody contacts, both of which are essential parts of particle model simulations. We give two examples, one for the morphogenesis of a growing chain of particles in a constrained 2D space and one for a progressive collapse of a slab floor construction.

We simulate the pushing of a chain of particles connected by elasticplastic beams into a circular cavity from opposing sides. The particle chain is set to behave like a metal wire of certain thickness. When we push, the wire buckles and forms loops until the cavity is filled with stabilizing loops, making it almost impossible to inject more wire (Fig. 9). Therefore, the system is self-stabilizing. By studying this simple system, we were able to construct a phase diagram for characteristic morphologies in the plasticity-wire-friction space. We found excellent agreement with experiments on various metal wires ranging from scaling relations for packing densities and loop formation to the structural stiffness.

In a further example, we allow elements to fail again. Starting from the regular geometry of a simplified slab floor construction, we add gravity and remove parts of a column. Element properties are chosen to represent concrete with steel reinforcement. Large displacements, local ruptures and momentum transmissions due to contacts between structural elements are naturally considered by the simulation procedure. Depending on a morphology parameter for (Fig. 10). Progressive collapse goes along with a multitude of sequential failure mechanisms due to the impact of rubble with intact portions of the structure. Interestingly, lateral bending failure of columns due to piling rubble in the basement is observed, a mechanism that can only be captured by such a model approach.

Future trends

Today particle models are capable of accurately describing local processes like those shown. However, the number of particles is limited by available computational resources. Fortunately, in many cases, only a small portion of particles is really needed in active zones, while the rest, for instance, are only used to represent the elastic foundation. Hybrid methods are increasingly used to take advantage of this fact. For example, particle models can be used for the discretisation of the damage zone, while the Finite Element Method (FEM) is utilized to model the surrounding domain. Fig. 11 demonstrates this technique called bridging scale or handshake method on a 3D simulation of a notched bar impact test with edge-to-edge coupling. It is our belief that hybrid methods together with advanced homogenization schemes will be the right track for particle models on the way from research-driven studies to become a valuable numerical technique of broad applicability in engineering.

Fig. 7: Dynamic model fracture with severe crack branching simulated via a moving lattice method. Colours represent breaking time intervals. (FKW, HJH)

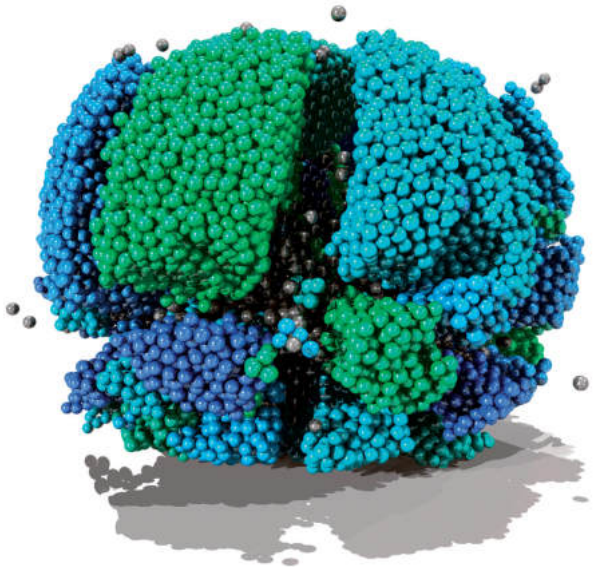


Fig. 8: Impact fragmentation of a bulk sphere vertically impacting a hard ground. Particles are coloured according to the fragment they belong to. (H. Carmona, FKW, HJH)

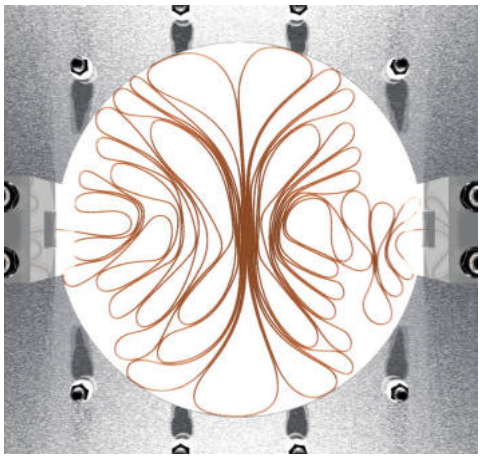


Fig. 9: Simulation of the final morphology of an elastic-plastic particle chain pushed into a circular cavity. (N. Stoop, FKW, HJH)

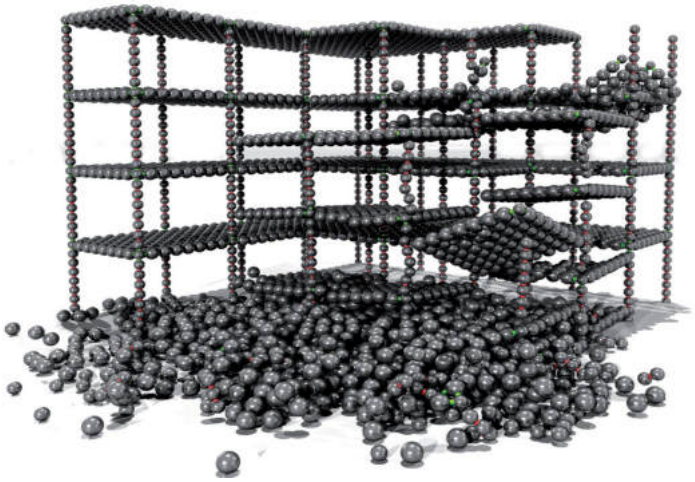


Fig. 10: Snapshot of the progressive collapse of a simplified slab floor construction. (E. Masoero, FKW, HJH)

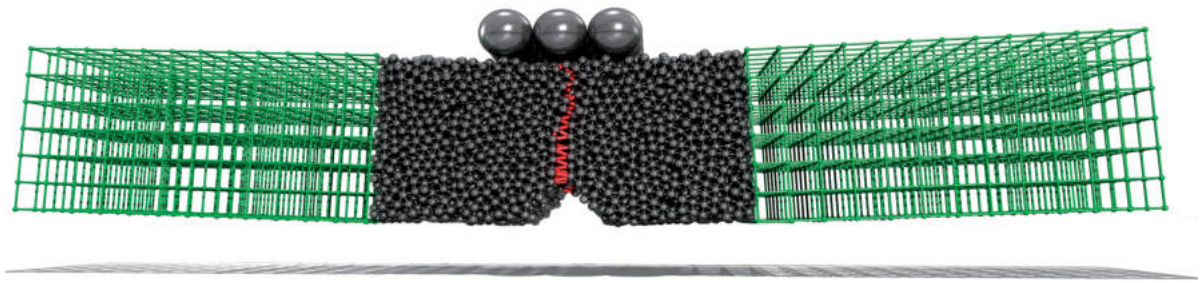


Fig. 11: Hybrid FE-DE Simulation of the Charpy Test with edge-to-edge coupling. (M. Fuhr, FKW, HJH)

Typhoon hazards and risk modeling

Joint research project between ETH Zurich and AON Re, Japan.

by M. Graf, K. Nishijima, M. H. Faber / IBK;
Projektpartner: AON Re, Japan

In a joint project between ETH Zurich and AON Re, Japan the group on risk and safety at IBK has developed a probabilistic typhoon hazard model and a model for assessing the typhoon risks for insured buildings in Japan. Bayesian Probabilistic Nets were utilized to develop the models which were implemented into a PC environment based software tool. Sub-models are formulated for all phases of the typhoon hazard process starting with the occurrence of typhoons, over the spatial and temporal development of typhoons including landfall and possible filling and ending with the probabilistic characterization of extreme wind speeds at any location in Japan.

These results, together with historical damage observations made available by AON Re, facilitated establishing the portfolio loss distribution. Emphasis has been given to the consistent treatment of uncertainties, facilitating that the contributions to the uncertainty of the total losses from each sub-model may be assessed. This information may be utilized for the focusing of future research efforts.

The developed model facilitates risk updating such that the losses can be estimated probabilistically in the event of an evolving typhoon as a function of the available information regarding location, central pressure, direction and velocity (Fig. 1 and 2).

Ultrafiltration

Ultra-low Pressure Ultrafiltration for Decentralized Water Disinfection in Developing Countries

by M. Peter-Varbanets, W. Pronk, F. Hammes / Eawag;
W. Gujer / IfU

Presently, about 1.1 billion people lack access to safe drinking water. Although ultrafiltration technology has become affordable for decentralized water treatment in developing countries, its widespread application is limited by membrane fouling. It is generally assumed that operating ultrafiltration systems on untreated river water in a dead-end mode without backflushing, cross-flow and addition of chemicals will result in a continuous decline of water flux, formation of the fouling layer and clogging. However, our results show that an after initial decrease, flux stabilizes at a value of 4-10 L/h/m2 for at least 5 month of operation at ultra-low pressure conditions (40-110 mbar) (Fig. 3).

Investigations of the fouling layer with Confocal Laser Scanning Microscopy showed a relatively inhomogeneous, porous layer containing active biomass (Fig. 4A). Suppression of the biological activity by a disinfectant lead to a continuous decrease of flux and formation of a dense and homogeneous layer (Fig. 4B).

Thus, our results show that biofouling, assumed so far to be a major limitation for membrane operation, actually stabilizes the flux under ultra-low pressure. While no pumps, chemicals or process control is required, the system costs can be kept low (about 0.7 - 2 $ per household and year).

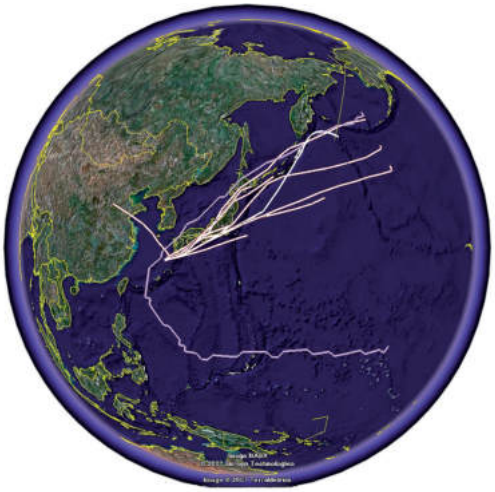


Fig. 1: Illustration of simulated typhoon tracks conditioned on information from an evolving typhoon. Post processing screen print using Google Earth™.

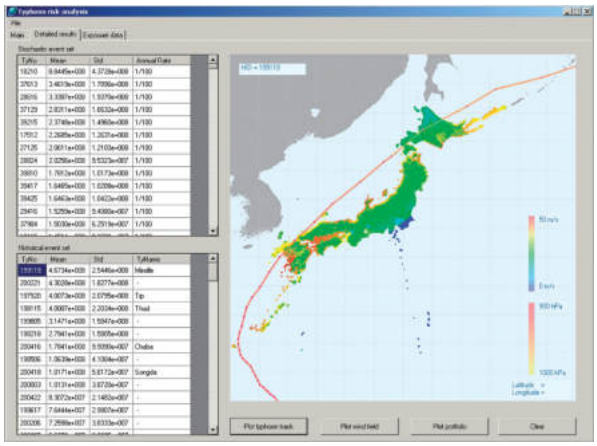


Fig. 2: Screen print from the developed typhoon risk modeling tool "Typhoon risk analysis" showing a simulated typhoon track and the corresponding wind speed field at surface level.

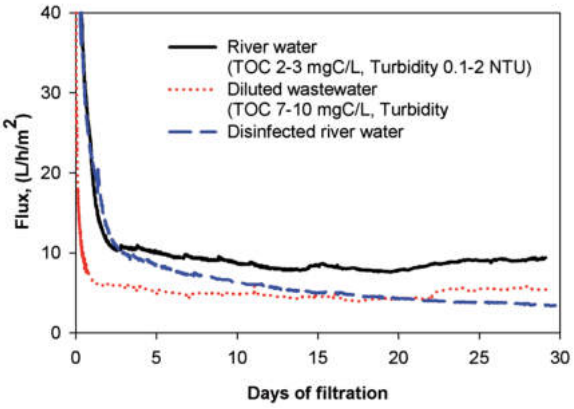


Fig. 3: Membrane flux during 30 days of operation of ultrafiltration (100 kDa cut-off) membrane without backflushing, cross-flow or cleaning.

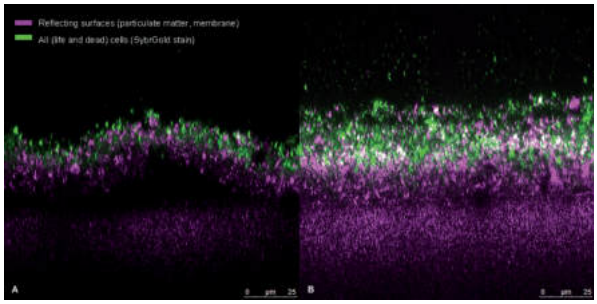


Fig. 4: Images of the cross-section of the membrane and the fouling layer accumulated during 14 days of filtration of river water (A) and river water disinfected with Sodium Azide (B) obtained with the Confocal Laser Scanning Microscope (Leica SP5).

Unexpected Flow Pattern in aeration tanks of waste water treatment plants

Aeration tanks are the key element of waste water treatment plants and their mixing regime largely determines plant performance as well as operational and control stability.

by M. Gresch, D. Braun, W. Gujer / IfU / Eawag

For experimental detection of large scale mixing, continuous measurements of reactive tracers are a new, relatively cheap but very promising approach. Using ammonia, which is a main pollutant, as a tracer substance offers the advantage of long term monitoring without any process intervention.

We developed a monitoring system for continuous and distributed measurement of ammonia based on ion selective electrodes (Fig. 1). The system was operated in an aeration tank of the waste water treatment plant Werdhölzli, Zurich. These types of reactors are designed as dispersive plug flow reactors. However, we observed concentration time series that showed a very different behavior: Instead of a steady decrease of ammonia along the reactor, we detected inversely phased oscillations in ammonia concentration at both sides of the reactor and an extinction of the fluctuations in the central plane of the reactor.

Measurements with acoustic Doppler velocimeters, which were performed in collaboration with the Laboratory of Hydraulics, Hydrology and Glaciology, showed that the oscillations clearly have a hydraulic cause as they also occur in flow velocities. Finally we are able to explain instabilities in the aeration control loop that appear during night times with these fluctuations and the settings used for the control loop. Computational fluid dynamics will now be used to further analyze this phenomenon.

Physical simulation of sturzstroms within the ETH Geotechnical Drum Centrifuge

Sturzstroms are a hazardous natural phenomenon.

by B. Imre, J. Laue, S.M. Springman / IGT

They emerge from large rock slides or rock falls and display a fast, far reaching run-out (Fig. 2).

Their exploration is intrinsically tied to the ETH professors Albert Heim und Kenneth Jinghwa Hsü. Beside the known empirical relation between run-out and failure volume a further universal pattern of sturzstroms is the intensive fragmentation of the rock mass involved. The latter imposes the question how long-run out, hence prolonged high kinetic energy, and substantial amounts of energy dissipated by fragmentation are energetically feasible together. The present doctoral research aims to contribute to the development of an energetically consistent explanation for the run-out and fragmentation of sturzstroms. To derive such a model, physical simulations have been performed within the Geotechnical Drum Centrifuge at the Institute for Geotechnical Engineering (Fig. 3).

Within this modelling environment it was possible to simulate the fragmentation of rocks within rock slides successfully. These experiments were filmed by the Swiss Television and broadcasted at 25/05/2008. A videostream can be downloaded from http://www.sf.tv/sf1/einstein/sendung.php?docid=20080529

Fig. 1: Monitoring system for flow velocities (Acoustic Doppler Velocimetry, collaboration with VAW) and continuous ammonia detection system.

Fig. 2: Contemporary depiction of the sturzstrom of Goldau by Franz Xaver Triner, 1807. After about 5 km, the rock masses reached lake Lauerz causing a deadly tsunami.

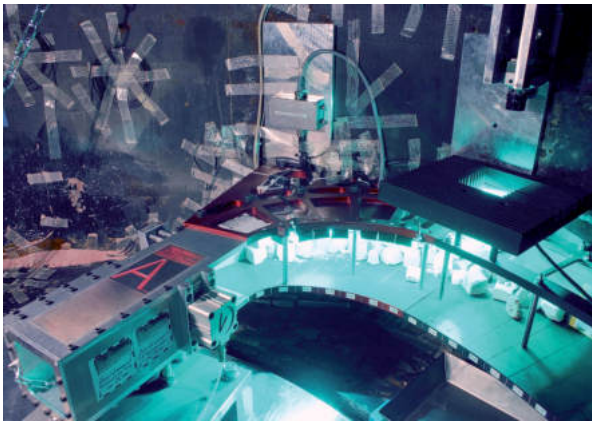


Fig. 3: View onto one of the two simulation-channels mounted within the drum centrifuge. On the left-side the hopper is shown, containing the experimental rock material. The trap-door of the hopper can be opened pneumatically in flight. Adjacent to the hopper, which represents the source area of a sturzstrom, an acceleration and a run-out channel are located. These channels represent the transit and the deposition zones respectively.

Linking hydrological modelling to ecology in the Okavango Delta, Botswana

In the north-eastern corner of Botswana, in the semi-arid Kalahari, the Okavango River spreads out into a huge wetland area known as the Okavango Delta.

by Ch. Milzow, V. Burg, W. Kinzelbach / IfU

All incoming flows are eventually lost to the atmosphere by evaporation and transpiration, but on their way they provide the basis for the biodiversity and beauty of the wetlands. Hydrological modelling of the wetlands has allowed for a better understanding of the mechanisms controlling the flows, and of the changes that are to be expected under the threat of global warming. We went one step further by asking what influence the hydrological changes will have on the different ecoregions of the wetlands.

We investigated the relation between hydrological conditions and ecoregions present in the wetland area. A good correlation was found between the simulated depth to groundwater and the mapped ecoregion types. We used this dependency to translate simulated future hydrological conditions to maps showing the future distribution of ecoregions. We could identify zones and their respective ecoregions that are particularly vulnerable to environmental changes triggered by global warming or upstream water abstractions from the Okavango River (Fig. 1).

Real-time modelling and real-time control of the well field Hardhof, Zurich

The first world-wide real-time management of a groundwater plant.

by H. Hendricks Franssen, F. Stauffer, G. Bauser, W. Kinzelbach / IfU

About 15% of the drinking water of the city of Zurich is groundwater pumped in the Hardhof area (Zurich). Diffuse groundwater pollution below the city centre of Zurich and warm Limmat water infiltrating into the aquifer in summer, are a potential threat for the quality of the drinking water pumped at Hardhof. The management of the Hardhof well field (four pumping wells, three recharge basins and twelve infiltration wells) can be optimized such that the risk of abstracting water of bad quality is reduced. For the optimization process a, 3D finite element model of unsaturated-saturated groundwater flow, heat and contaminant transport coupled to a 1D model for river hydraulics was developed and calibrated with the help of historical observations.

But even well-calibrated models will increasingly deviate from measurement data if they are used as operational models in real-time. Therefore, Ensemble Kalman Filtering (EnKF) was implemented together with the 3D model to assimilate measurement data for correcting model predictions in real-time. EnKF combines in an optimal sense model predictions and measurement data, taking into account the different sources of uncertainty. It could be shown that real-time updating gives much better model predictions than a conventional approach on the basis of a calibrated model (Fig. 2). In addition to the real-time model, a control module was designed and implemented, to steer the groundwater works automatically regarding several quality criteria. The control module was tested in off-line mode with the help of historical data and the groundwater flow model (Fig. 3). The different models work currently in real-time at the Water Works Zurich and extract the most recent measurement data from a database to actualize the model predictions. They are used on a daily basis as a decision support system for an optimal management.

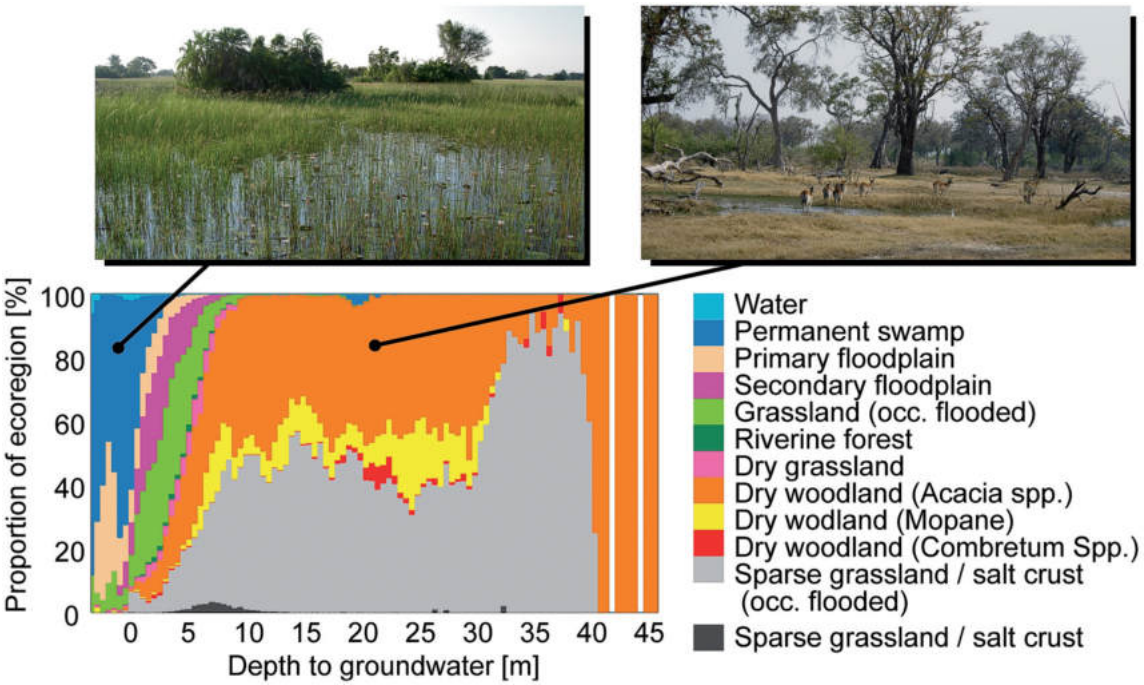


Fig. 1: Relation between observed ecoregion types and simulated depth to groundwater. Pictures illustrate the threatened permanent swamp (left) and dry acacia woodland (right).

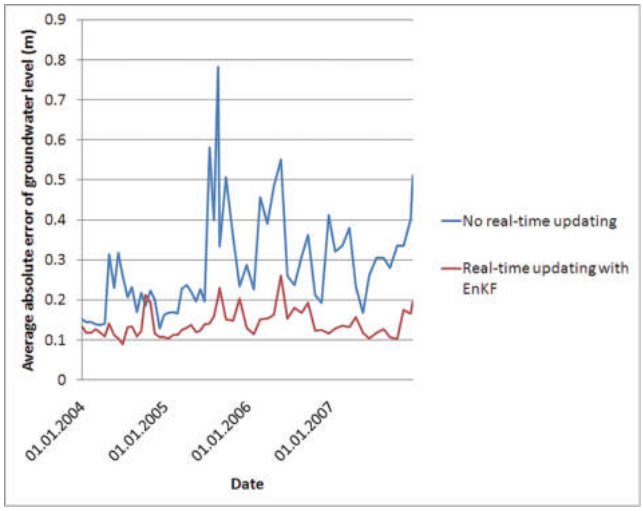


Fig. 2: Comparison between a conventionally calibrated model, which is not updated in real-time and the same model updated in real-time, for predictions of the groundwater level in the Limmat aquifer below the city of Zurich. The average absolute prediction error is calculated over 87 measurement locations.

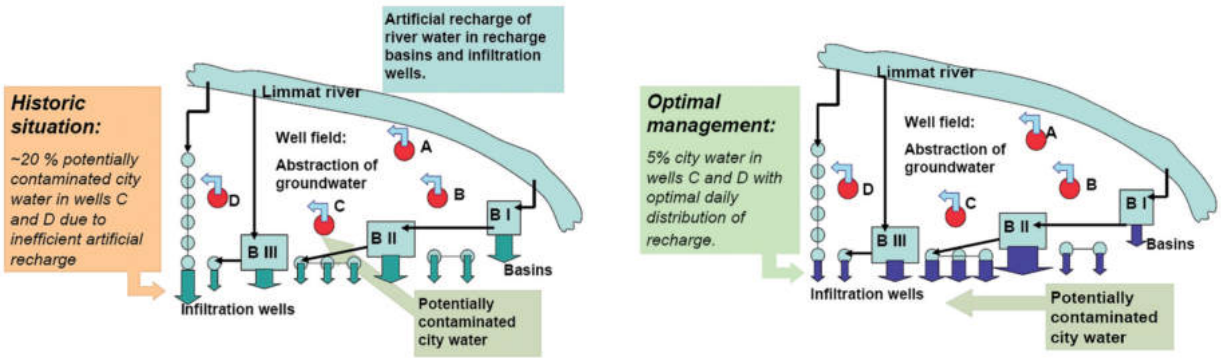


Fig. 3: Schematic representation of the pumping and artificial recharge system at the Hardhof site. River water is artificially recharged in the basins in order to create a hydraulic barrier against the water from the city of Zurich (green arrows). The amount of artificial water is optimized (blue vertical arrows) by means of the automatic control procedure. As a result, less city water reaches the pumping wells.

Watershed and Drainage Tracking

The concepts of watersheds and catchment basins naturally arise in Geomorphology and play a fundamental role in e.g. water management, landslide or flood prevention.

by E.M. Fehr, D. Kadau, H.J. Herrmann / IfB

Furthermore, there are important applications in Image Processing, Medicine and Physics. Catchment or drainage basins are geographical regions that drain through a river or any other natural water sink and its borders are called watersheds or simply divides.

Concerning surface flows only, a strict mathematical definition of watersheds is possible. Using this definition we developed a general and efficient algorithm to determine watersheds on Digital Elevation Model (DEM) data. We call this algorithm Watershed and Drainage system Tracking (WDT Fig. 1). With its sublinear complexity, WDT allows us to study systems as large as 10^8 in a few cpu seconds on a normal workstation. The study of the statistical properties of watersheds on random terrain showed that they are fractals with mass dimension $D_f = 1.211 \pm 0.001$. which is similar to the dimension of paths in Minimum Spanning Trees (MST). Hence there is a close relationship between the problem of watershed delineation and those of Percolation and MST.

On DEM data of real landscapes, e.g. Alps and Himalaya, we determined a mass dimension $D_f^{alps} = 1.10 \pm 0.01$, $D_f^{him} = 1.11 \pm 0.01$, respectively. Using Fractional Brownian Motion (FBM) we constructed a model, with a tuneable mass dimension for watersheds. Thus, we could build the bridge between random and real landscape results (Fig. 2), showing the consistancy of our results.

Acoustic Monitoring of Concrete Bridges

A continuous acoustic monitoring system was operational for two years on a post-tensioned road bridge.

by S. Fricker, T. Vogel / IBK

As part of a research project a continuous acoustic monitoring system was operational for two years on a post-tensioned road bridge to evaluate the practical use of acoustic emission techniques. Due to its rather small dimension, the ambient noises from constant but manifold traffic, the ongoing deterioration process and the knowledge gained by the periodical inspections, the Ponte Moesa in Roveredo, Canton Grisons was an appropriate test object to install continuous acoustic monitoring.

Several spontaneous wire breaks as well as artificial wire breaks arranged as blind tests have been detected, classified and localized by the monitoring system. The acoustic monitoring was compared with conventional invasive examination and halfcell potential measurement. As a consequence of the monitoring and the further assessments, the owner decided to remove the bridge.

The replacement provided the opportunity to inspect the bridge intrusivly by opening the ducts to confirm the detected wire breaks. This information would be difficult to obtain, if the bridge had to sustain in service. Four sections in the region, where most of the wire breaks had occurred, were cut off and examined separately on a yard not affecting the progress of the construction work. The sections were 4.70 m long and 1 m wide (Fig. 3).

Age, character and cause of the wire breaks were determined by the detailed examinations. The reason and the extent of the insufficient grouting and of the corrosion were assessed, too. Furthermore, the accuracy of localization of the acoustic monitoring was discussed and the different influences on the localization were evaluated (Fig. 4).

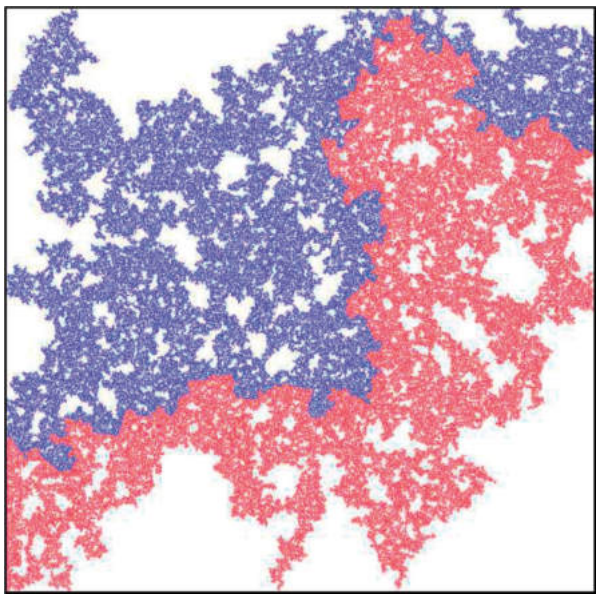


Fig. 1: Drainage systems on a random digital elevation map. Red sites drain to the bottom edge and blue sites drain to the top edge. Here, only sites visited by our algorithm are shown.

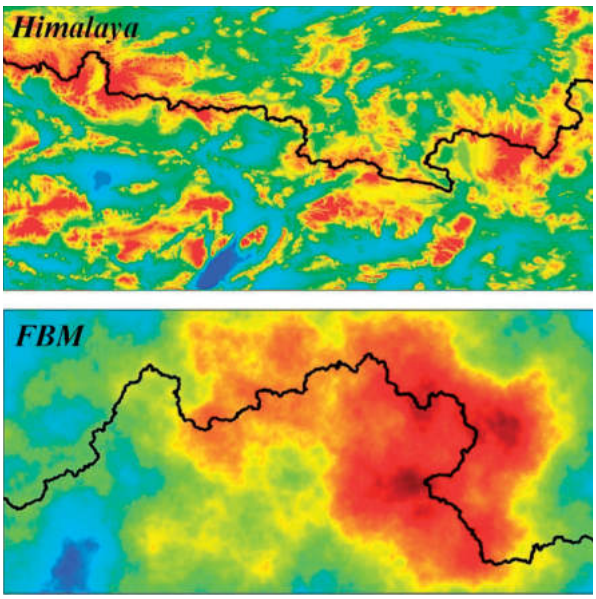


Fig. 2: Digital elevation map data representation for a part of the Himalaya and a fractional brownian motion sample; highest peaks are red and lowest valleys are blue; the black line indicates the watershed we determined.

Fig. 3: Cutting of the four sections.

Fig. 4: Opened tendon with insufficient grouting.

Crack detection and deformation measurement for concrete under uniaxial compression

In this Master project, the crack formation in different concretes under uniaxial compression was investigated by means of digital image correlation.

by D. Caduff, J.G.M. van Mier / IfB

To monitor the fracture behaviour of normal concrete, high performance concrete and foamed concrete, the surface deformations of specimens were measured with the system VIC 3D from LIMESS (strain distribution on the basis of digital image correlation).With this measurement system, it is possible to collect the mechanical properties (Young's modulus, Poisson`s ratio, volume change) and to observe the crack propagation on the surface of the specimen until the compressive strength was reached. Both plain steel platens and Teflon were used as load application system. The loaded specimens were impregnated to check the accuracy of the VIC-3D measurement system.

Fig. 1 (a) and (c) shows the calculated strain distribution from VIC 3D on the specimens surface of the normal concrete. Shear cracks were detected on both specimen surfaces with the plain steel platens, whereas vertical cracks appeared with Teflon. The impregnated crack patterns (Fig. 2 (b) and (c)) correspond well with the recorded crack patterns from VIC 3D. If crack spacing becomes too small, VIC-3D cannot distinguish individual cracks anymore, which are still visible in the impregnated sample. The measurement system VIC 3D can be used for detecting the crack distribution at the specimen's surface. The advantage of the system is that two sides of a specimen can be monitored at the same time. For a truly three dimensional phenomena like compressive fracture this is quite essential. Due to the resolution of VIC 3D, the first cracks were detected at a stress level of 70%.

Publication:
D. Caduff, "Einaxiale Druckversuche: Risserkennung und Deformationsmessung mit VIC-3D", *Masterarbeit*, ETH Zürich, D-BAUG, IfB, 2008.

Microfiber Reinforced Cement

Fiber-Pullout Tests were perfomed on microfiber reinforced cement to determine the maximum pullout force and the pull-out behavior of a single steel micro fiber.

by C. Rieger, J.G.M. van Mier / IfB

For this purpose single steel finewires were embedded in a cement matrix and were pulled out. The steel wire with a diameter of 0.05mm was embedded 2mm in the cement matrix. Two different types of steel wire were used for the tests. One type of wire is annealed (temperature treated) and one is unannealed.

The pullout tests were perfomed with a tensile loading stage that can be used in the Environmental Scanning Electron Microscope (ESEM). This testing device was developed especially for this purpose at IfB. Testing in the ESEM gives the opportunity to observe the pullout of the fine steel wire from the cement matrix.

Figure 3 shows an example of the fiber pullout in ESEM. Optical measurements can be made during the test. The pull-out-displacement is measured with a displacement transducer mounted on the tensile loading stage. Figure 4 shows typical pullout behaviors with the two different types of steel as an example. Specimens with unannealed steel fibers show a higher capacity for pullout strength than specimens with annealed fibers. The maximum pullout strength ist just below the fiber strength, where it is noted that the unannealed wire shows a higher strength than the annealed wire.

Publication:
C. Rieger and J.G.M. van Mier, "Pullout of Micro-fibers from Hardened Cement", in *Proceedings Int'l. Conference on 'Advanced Concrete Materials'*, Stellenbosch, South Africa, 2009 (in press).

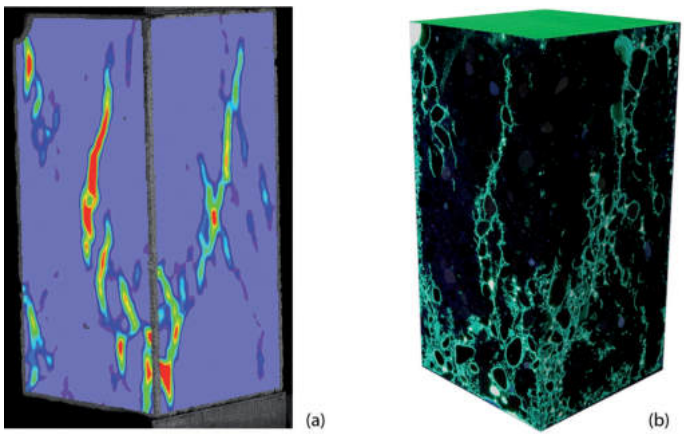


Fig. 1 (a) and (b): Crack pattern of normal concrete with steel platens as boundary condition.

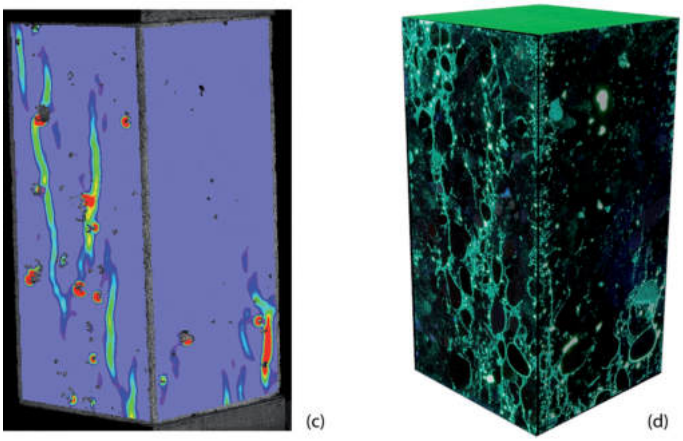


Fig. 2 (c) and (d): Crack pattern of normal concrete with Teflon platens as boundary condition.

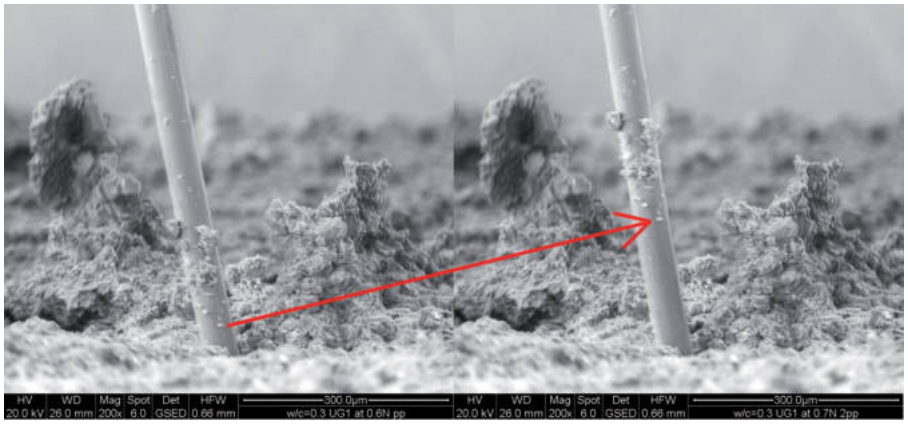


Fig. 3: Two stages of fiber pullout in ESEM.

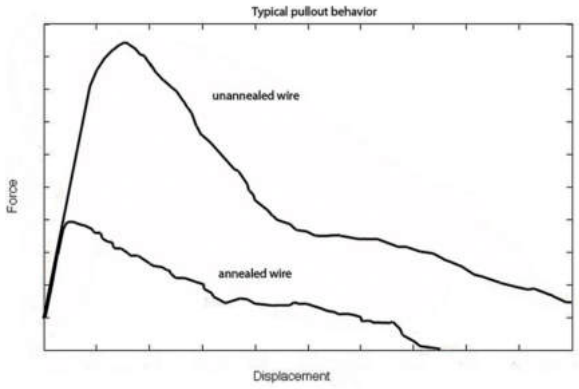


Fig. 4: Typical pullout behavior of unannealed and annealed wire.

Fracture Patterns in Foamed Cement visualised by means of Computed Tomography

Fracture of foamed cement was studied using an in-situ miniature loading device constructed for installation inside a desktop X-ray tomography scanner.

by D. Meyer, J.G.M. van Mier / IfB

From a test 3D information of crack growth inside a sample is obtained. The loading device can operate under a closed-loop deformation control; also it is possible to use force-control. The obvious advantage is that crack growth can be monitored in a specimen while under load and no specimen handling is needed between the various scans at different loading stages (Fig. 1).

For the tests we used specimens cored from three different mixtures of foamed cement produced with varying amounts of foam (viz. 30, 50, and 70% by volume).

To minimize the effect of friction between the sample and the loading platens special Teflon (PFTE)-grease-Teflon sandwiches were used. The crack growth proceeded parallel to the loading direction as can be seen from Figure 2. After an experiment crack patterns are reconstructed in three dimensions, quantified and a comparison of lattice simulations using exactly the same foamed material structure as in the test specimens is made.

Publication:
D. Meyer, H.-K. Man and J.G.M. van Mier, "Fracture of Foamed Cementitious Materials: A Combined Experimental and Numerical Study", in '*Mechanical Properties of Cellular Materials*', (Zhao, H. and Fleck, N.A., eds.), Proceedings IUTAM Symposium held at LMT-Cachan, Paris, France, September 17-21, 2007, IUTAM Book series 12, Springer Science + Business Media (2009), pp.115-123.

Simulation of Fracture Pattern on Foamed Cement using 3D Lattice Models

In this project a numerical study was done to simulate the fracture behaviour of foamed cement.

by H.-K. Man, J.G.M. van Mier / IfB

Small cylinders subjected to uniaxial compression were simulated. A simple lattice model is used, in which the material is discretized as a network of short beam elements.

The bubble structure of the cement is scanned with a X-Ray tomography scanner, and a procedure was developed to map the measured structure directly into the numerical model. This has the obvious advantage that the identical foam structure can be used in the physical experiments and in the numerical simulation (Fig. 3).

In analogy to the physical experiments specimens with different porosities (30%, 50% and 70%) are simulated. Fracture patterns of the simulations can be visualized in 3D (Fig. 4). In the end, a direct comparison of the fracture mechanism is made between the lattice simulations and the experiments.

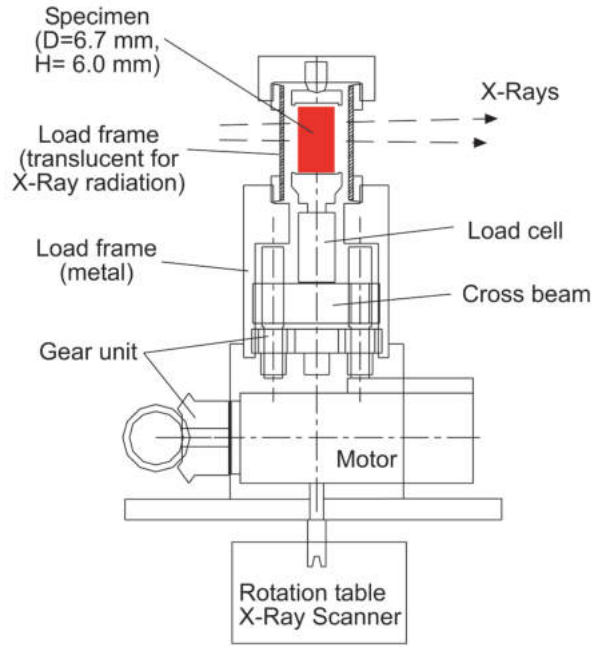


Fig. 1: Loading stage for in-situ compression tests inside a desktop X-ray tomography scanner

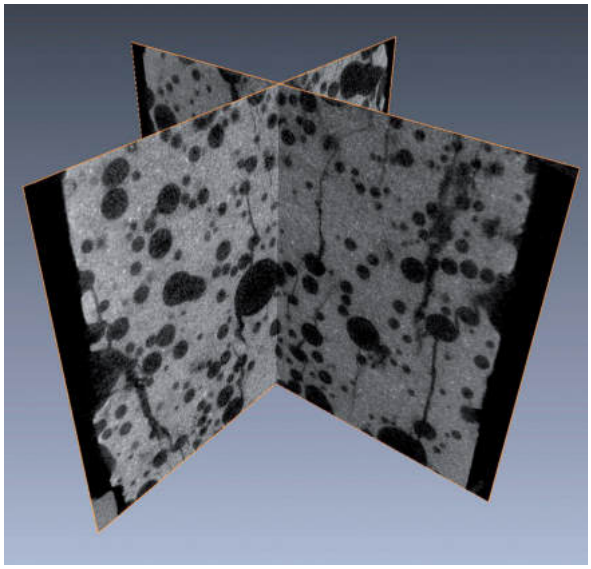


Fig. 2: Crack patterns in two vertical sections of a small cylindrical specimen.

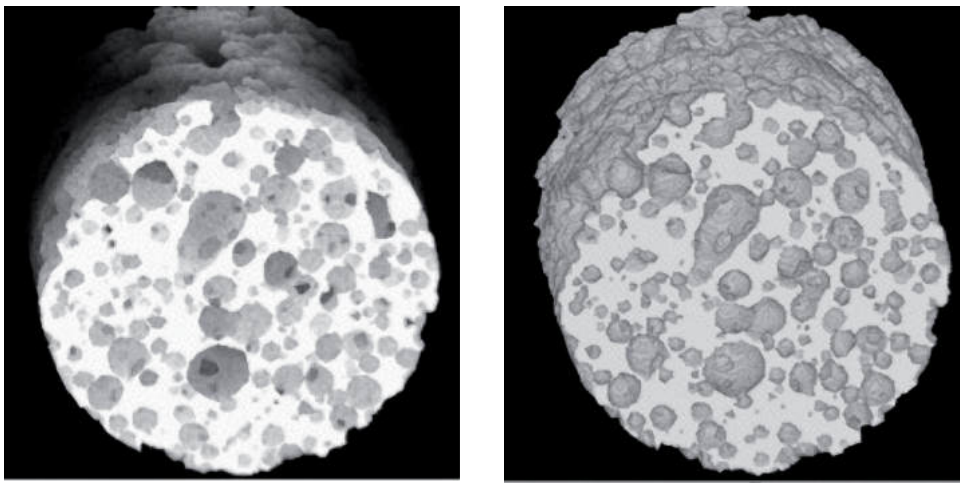


Fig. 3: Comparison between the scanned structure and the 3D lattice model.

Fig. 4: Three-dimensional crack patterns at different stages.

Investigation of fracture behaviour of wooden materials using acoustic emission analysis and video image correlation

The fracture behaviour of industrial made wooden materials (particleboards, OSB, MDF, plywood) under tensile loading was tested and compared using Video Image Correlation (VIC 2D measurement) and Acoustic Emission Analysis.

by O. Walter, P. Niemz / IfB;
A.J. Brunner, EMPA Dübendorf

Using the VIC 2D equipment, the displacement of pixels applied on the specimen surface during the test cycle is quantified by filming them with a high definition CCD camera. Locally elevated strain concentrations can thus be easily identified. Additionally, the location of damage and fracture, respectively, was derived from the (ultrasonic) acoustic emission signals (using four sensors).

It was concluded that both methods allow a prediction of the fracture location. From VIC 2D data, the fracture location could be predicted with fairly high accuracy (Fig. 1). With an energy-filter procedure applied to the acoustic emission signals the prediction of the fracture from Acoustic Emission Analysis could be improved when many signals were located.

This method is expected to contribute to optimizing the structure of derived timber products. The investigation is supplemented by fractography in an ESEM, as well as by tests with a low-load testing machine within the ESEM or stereo microscope, respectively. The aim is to model the fracture behaviour of materials and to produce derived timber products with improved adaptation to their use.

Quality and performance increasing: Optimisation of wood bondings

In modern timber constructions often bonded elements such as glued laminated timber (glulam), cross-laminated solid wood panels or cellular boards are applied.

by S. Hering, T. Gereke, P. Niemz / IfB, Holzphysik

The structural collapse of the hall in Bad Reichenhall and other similar catastrophes in winter 05/06 clearly pointed up how necessary precise knowledge of the adhesive bond line in practise is. Besides the bonding quality, questions concerning the long term behaviour under varying mechanical and climatic exposure are of main interest. It is evident that crack formation and deformations in cross-laminated solid wood panels and delamination in glulam, parquet or laminated wood panels have to be inhibited.

At IfB, work group Wood Physics, investigations to the improvement of wood bonding, to moisture induced stresses and deformations in laminated wood panels and to the mechanics of adhesive bond lines under mechanical and climatic exposure are proceeded. By means of finite-element models the hygroscopic warping of laminated wood panels with an induced climate gradient is investigated dependent on different panel structures (Fig. 2).

The objective is a mathematical optimisation to minimise expensive experiments. We also perform calculations of bond lines concerning the behaviour under variable loads (temperature, humidity, changing climate, permanent load) to simulate its behaviour by means of finite-elements (Fig. 3).

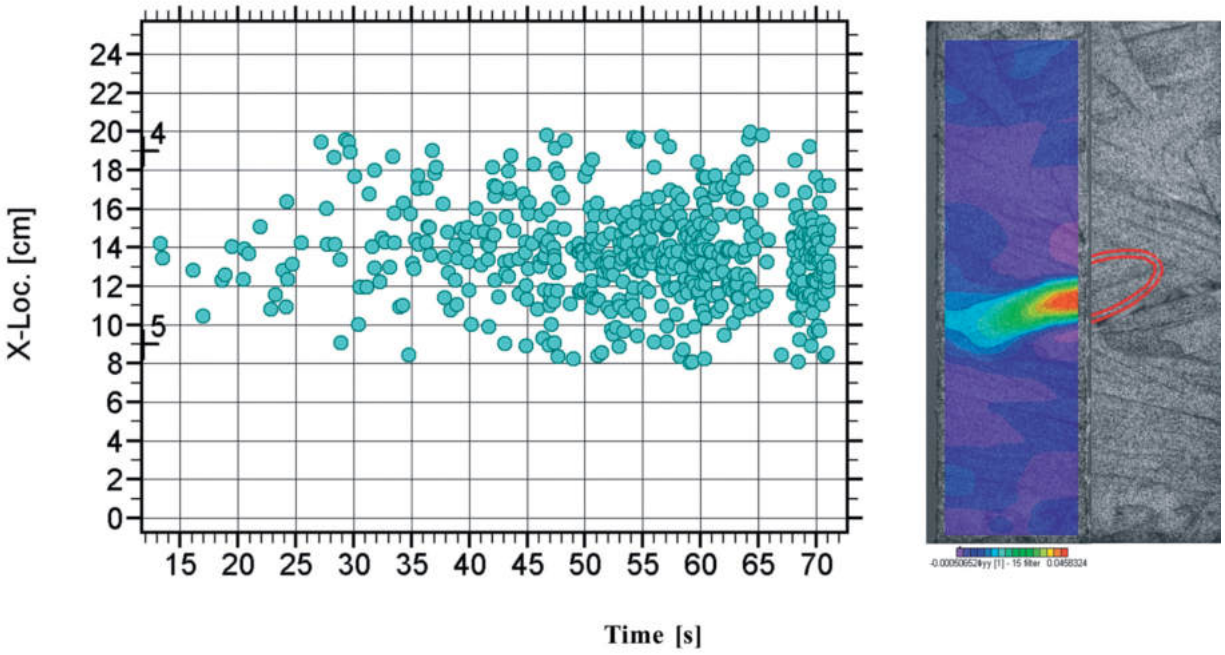


Fig. 1: Fracture behaviour of an OSB board under quasi-static tensile load. Left: with acoustic emission analysis (linear signal location along the specimen axis). Right: with video image correlation (strain distribution about 20 seconds before failure).

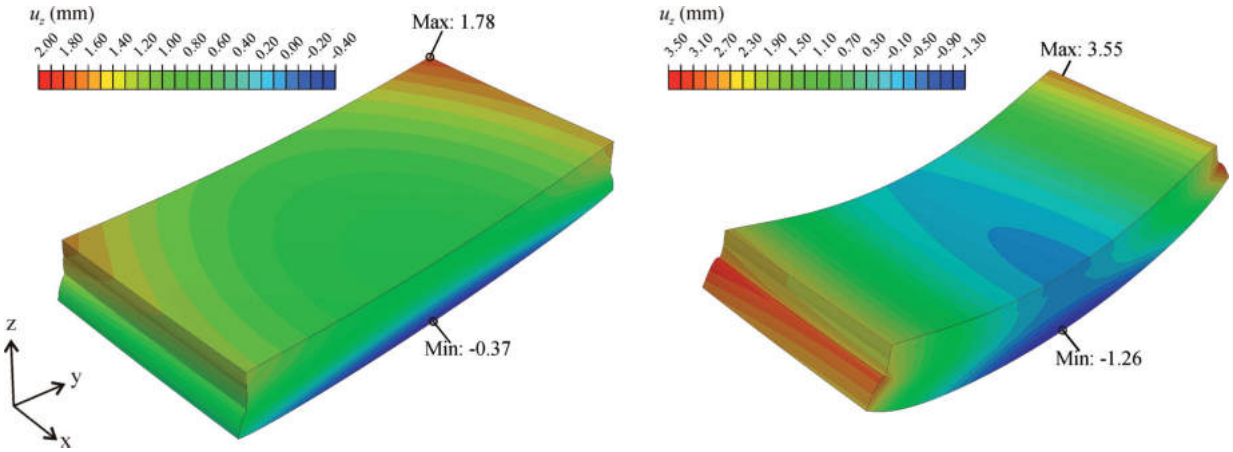


Fig. 2: Deformations of three-layered cross-laminated wood panels due to moisture gradient 65/100% relative humidity (top/ bottom surface). Left: spruce cross-laminate (layer thickness 10mm). Right: spruce-MDF-laminate (10mm spruce outer layers and 16mm MDF middle layer); one half of the panels is displayed.

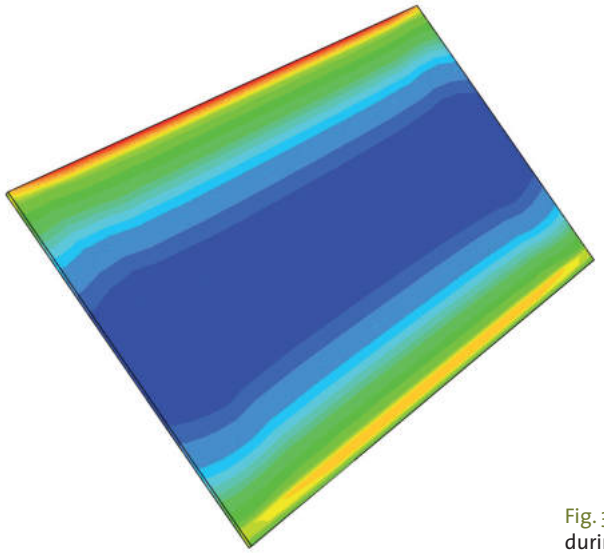


Fig. 3: Shear stress distribution in the adhesive bond line during tensile-shear test

Adhesive Penetration in Wood: Experiments

The adhesion phenomenon is relevant to many scientific and technological areas and has become a very important field of study in recent years.

by P. Hass, P. Niemz / IfB
M. Stampanoni, Institute for Biomedical Engineering (ETH / UNIZ)

To model the procedures inside a bonding, detailed information about the morphology and the geometry of the bondline and the wood-adhesive interphase is required (Fig. 1). Therefore, the penetration behaviour of different adhesives and the impact of various influencing factors (e.g. viscosity, pressing pressure, growth ring angle) on the penetration process have to be analysed.

3D-investigations of glue lines have been carried out, using the synchrotron-micro-tomography facility TOMCAT at the Swiss Light Source (SLS; Paul-Scherrer- Institute (PSI), Villigen (CH)). In this study, the penetration behaviour of three different adhesive systems - polyurethan (PUR), polyvinylacetat (PVAC) and urea-formaldehyde (UF) – into beech wood (*Fagus sylvatica* L.) has been observed.

This technique showed to be very suitable for the purpose of characterising glue lines in wood, as the pathway of the adhesive into the porous network of the wood could be tracked down and be visualized (Fig. 2). Obvious differences between the systems were detected. PUR penetrated much deeper into the wood than the two other systems, leaving only little adhesive in the actual glue line. This behaviour was due to the usage of prepolymers (unconditioned laboratory adhesives), which had a long curing time and no filling material, which might have been able to reduce the penetration. PVAC and UF did penetrate much lesser into the wood, leaving a distinct glue line between the two wooden adherents (Fig. 3).

Adhesive Penetration in Wood: Simulations

In this work, we simulate the penetration of the adhesive into wood using the lattice Boltzmann method.

by M. Mendoza, F.K. Wittel und H.J. Herrmann / IfB

We describe wood as an anisotropic porous medium. For this purpose we implement a lattice Boltzmann model including the free surface method, the macroscopic surface tension terms and the anisotropic permeability tensor. This way we obtained a powerful tool for the simulation of the adhesive penetration in the wood taking into account the surface tension and the anisotropy of the medium from a macroscopic point of view.

We choose a permeability tensor field based on experimental data of the wood density of a sample of spruce wood. The final system contains three layers of one year ring of this wood type with an inclination of 45 degrees with respect to the adhesive penetration direction. A constant pressure was applied on the adhesive to induce the penetration inside the wood structure. We realize an array of 90×90 cells (each cell has a length of 0.14mm). After 20000 time steps (each being 1ms) we can see the penetration of the adhesive in the wood Figure 4.

The colors represent the level of fluid in each cell, being yellow for cells with 100% of fluid and black for cells without fluid i.e. only wood structure, average colors exist where the fluid can not fully fill the cell due to the existence of the wood structure.

Ongoing work deals with the effect of adhesive hardening on the penetration front and consequences for the bond lines mechanics.

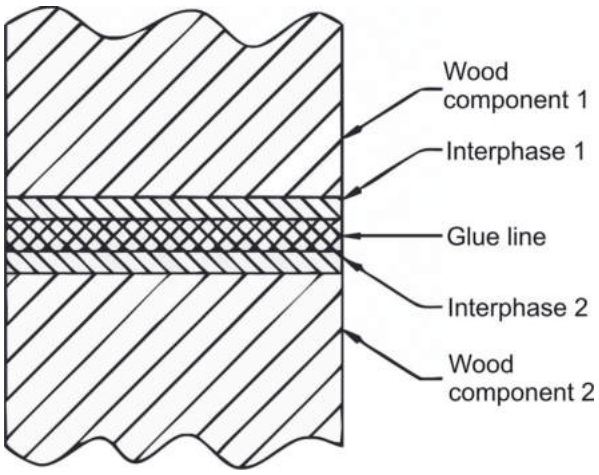


Fig. 1: Adhesive bond composition.

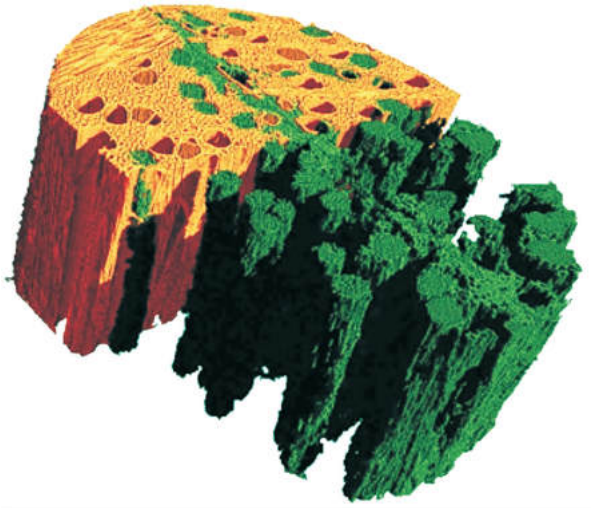


Fig. 2: Adhesive penetration into wood (reconstruction of synchrotron data set).

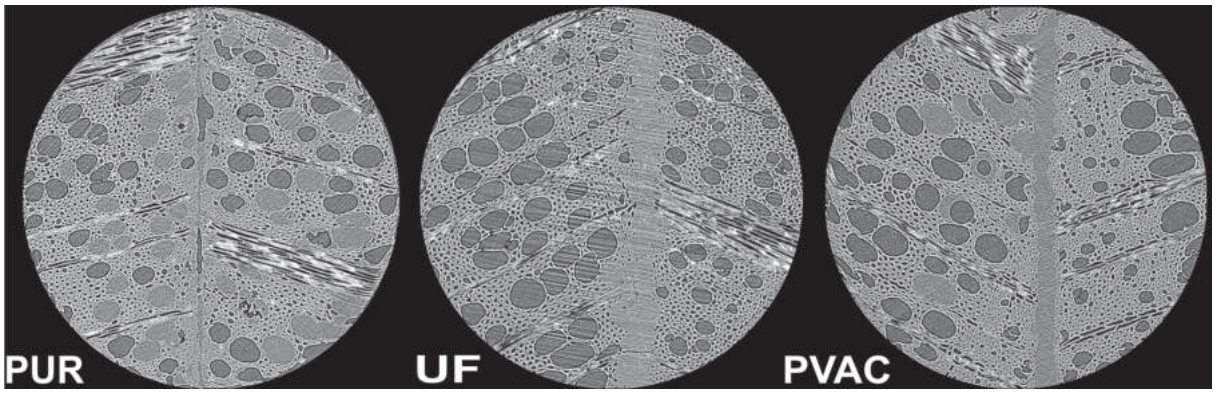


Fig. 3: Different penetration behaviour of various adhesive systems.

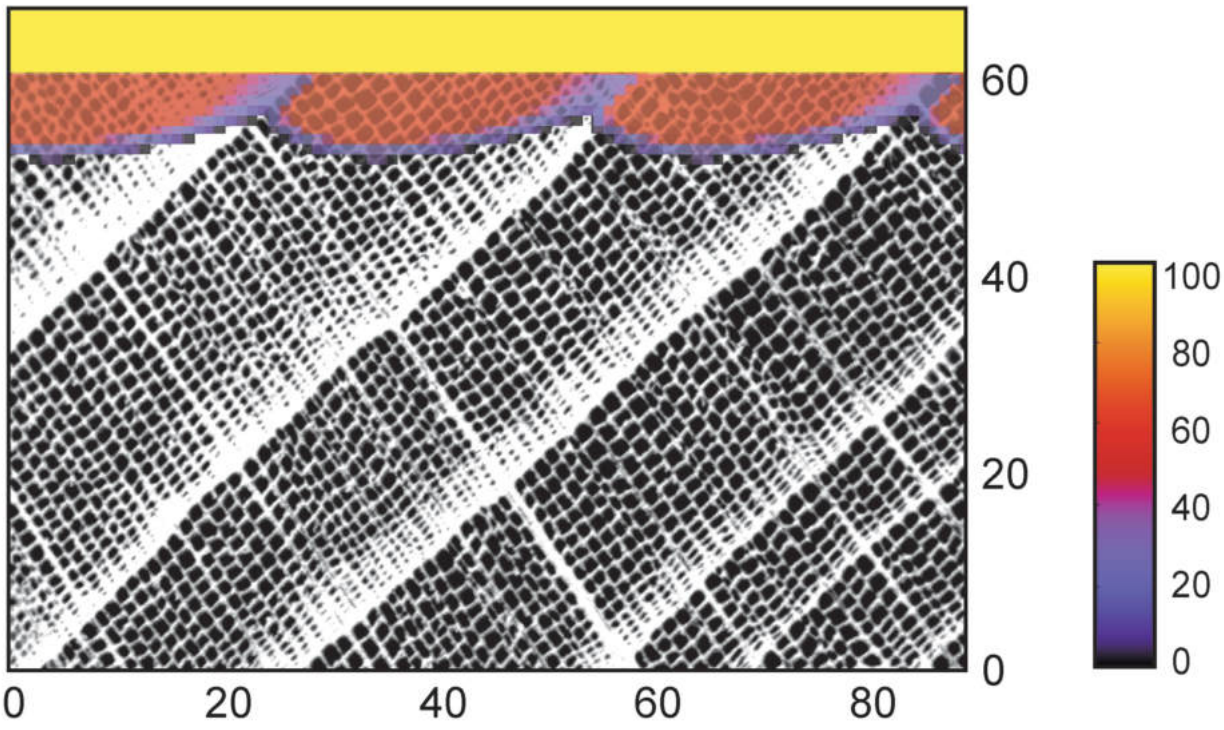


Fig. 4: Penetration of the adhesive fluid into the porous structure of spruce wood.

NETLIPSE

NETLIPSE (Network for the dissemination of knowledge on the management and organisation of large infrastructure projects in Europe)

by F. Wadenpohl, H.R. Schalcher / IBB

Large infrastructure projects are always a great challenge in terms of management. That is due to the extent of such projects in spatial and monetary aspects, the political impact and the singularity. Because these projects are mostly unique on a national scale, a comparison on an international scale is advisable.

Within the EU-sponsored research project NETLIPSE, 15 large transport infrastructure projects in Europe have been investigated for 'best practices' and 'lessons learnt'. At this, the focus of the study has been put on the management and organisation of these projects. To assess the 15 case studies, a clustering containing the eight following themes has been used: (1) Objectives and scope, (2) Stakeholders, (3) Finance, (4) Organisation and management processes, (5) Risks, (6) Contracting, (7) Legal Procedures and (8) Knowledge and technology. The research is based on on-site interviews with different participants as the main source of information. A cross-case analysis revealed cross-national similarities as well as country- and project-specific peculiarities.

Common issues within the different case studies have been especially discovered in the fields of (1) scope changes, (2) risk management and (3) stakeholder management. In this context, the different approaches towards social and political stakeholders and thereby the resulted negative impacts or contrariwise the gained benefits clearly showed the necessity for the development of defined strategies for the integration of stakeholders into the planning and execution of large infrastructure projects.

The impact of on-board ticket sales on public transport schedule reliability

Study commissioned by PostAuto AG, Switzerland (Zurich region) and Verkehrsbetriebe Glattal (VBG)

by S. Buchmüller, R. Dorbritz, M. Lüthi, U. Weidmann / IVT

The Züricher Verkehrsverbund (ZVV) is in the process of purchasing a new generation of stationary ticket sales machines. An important consideration in the planning process was the impact of on-board ticket sales on schedule reliability. However, there is little up-to-date data available on the impact of on-board ticket sales on public transport operations and schedule reliability. Therefore, the IVT was asked to examine the on-board ticketing process in detail and to define limits for on-board ticket sales in the Zürich region.

The analysis consisted of measuring the duration of each part of the on-board ticket sales process in a laboratory setting (taking account of various influence factors such as type of ticket purchased (Fig. 1), whether the passenger was carrying baggage, etc.) and comparing these data with observations made of bus operations in the field.

Analysis results showed that the boarding process takes 15 to 45 seconds longer if at least one ticket is sold (compared to the situation where customers only board the bus but do not need to purchase a ticket). This time varies significantly depending on the customer, the driver, and especially on the type of ticket being purchased (Fig. 2). The laboratory measurements also showed that the bus journey times were an average of two minutes longer due to on-board ticket sales, and in some cases were up to six minutes longer. Based on an average trip time of 25 to 30 minutes, the on-board sales process adds 6-10% to travel time, but can add up to 20%; this means that on-board ticket sales can reduce schedule reliability and make it difficult for passengers to make connections. Increasing reserve times can reduce these impacts but this is expensive and therefore it is generally recommended that ticket sales by drivers be reduced to the extent possible.

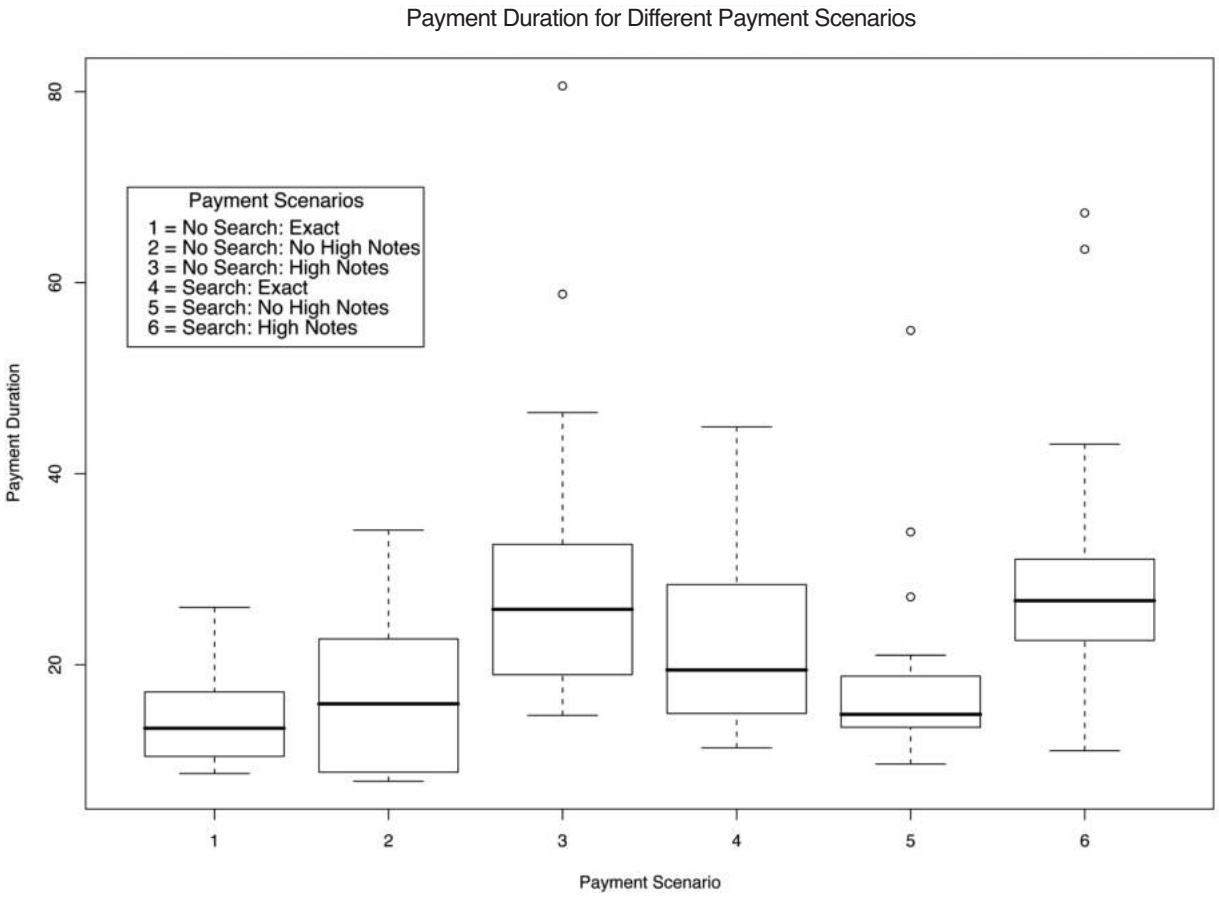


Fig. 1: Time needed to purchase ticket based on type of payment: (types 1-3: money is ready; types 4-6: passenger must search for money; types 1 &4: exact change; types 2 & 5: coins and low denomination bills; types 3 & 6: high denomination bills (CHF 50, CHF 100)), results of laboratory measurements.

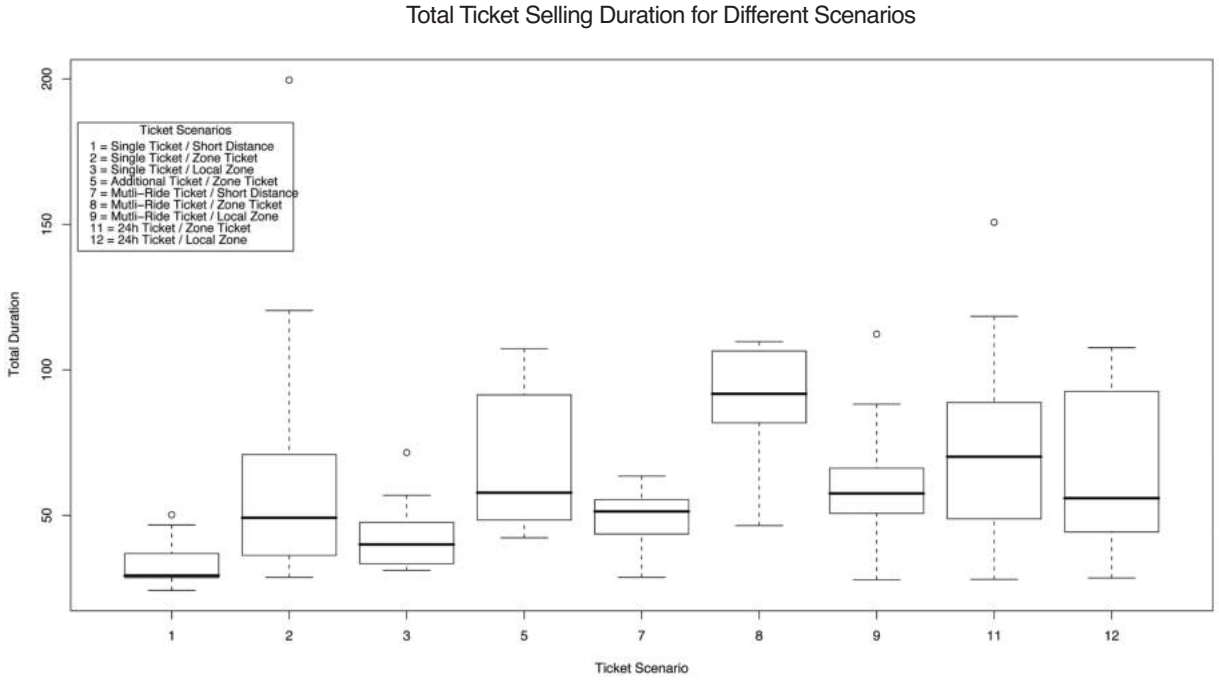


Fig. 2: Box plot: ticket sales time based on ticket type, results of laboratory measurements.

Dynamics and delimitation of commuting areas

SNF/DFG project: Spatial accessibility and the dynamics of commuting in Germany and Switzerland 1970 to 2005.

by V. Killer / IVT

This project focuses on the change in structure of work commuting and, respectively, the commuters' behavior as a function of accessibility and spatial distribution of population since 1970. In Switzerland and Germany, commuting distances and the complexity of commuter flows have increased steadily over the years. The functional commuting areas are neither clearly identifiable, nor fixed to administrative boundaries.

Traditional methodological procedures for delimiting these areas assign each municipality to a single catchment area. One possibility for defining functional areas is the Intramax algorithm (Flowmap 7.2). This algorithm ignores the overlaps and the differentiation between incoming and outgoing flows, however. This year, new procedures were developed to identify overlapping commuting areas and possible clustering of the origin and destination flows within a single catchment area.

Functional commuting areas of incoming and outgoing flows are alternativiely delimited by the confidence interval ellipse, a methodology based on activity space research (Fig. 1). This method has the advantage that attributes besides the catchment area can be measured and quantitatively compared, such as the shape, shift, or angle with regard to the next centre. With this set of measures, the following hypotheses should be testable: whether the suburban areas have uncoupled from the corresponding core cities over time; and whether such independence of suburbia has a traffic-reducing effect.

Loading behaviour of flexible raft foundations

Raft foundations are often used as cheap structural elements to transfer the loads of a building to the subsoil.

by A. Arnold, J. Laue

Even though those foundations are easy to construct, the soil-structure interaction is more complex than for other types of foundations.

In the framework of a doctoral thesis, the bearing behaviour and the load distribution of raft foundations are investigated considering different kinds of load application and the effects of stiffening members such as walls and frost protection strips. For that purpose, tests in the drum centrifuge of the Institute for Geotechnical Engineering are conducted (Fig. 2). While testing simple geometries as single columns supported by rectangular rafts it is visible that the stress distribution is affected by the stiffness of the raft and the soil.

These tests also show that there is a relationship between the amount of load, the transition between stiff and flexible response and the influence on the load distribution. On the given example, the foundation behaves stiffly at small loads, showing more flexible behaviour for increasing load (Fig. 3). This relationship could be measured in a physical model test using tactile pressure pads at the interface. This knowledge of the stress distribution between the foundation and the subsoil is important to connect the real soil structure interaction with the current state of the art of the design of slab structures and thus will help improving the design methods to provide both economical and safe design solutions.

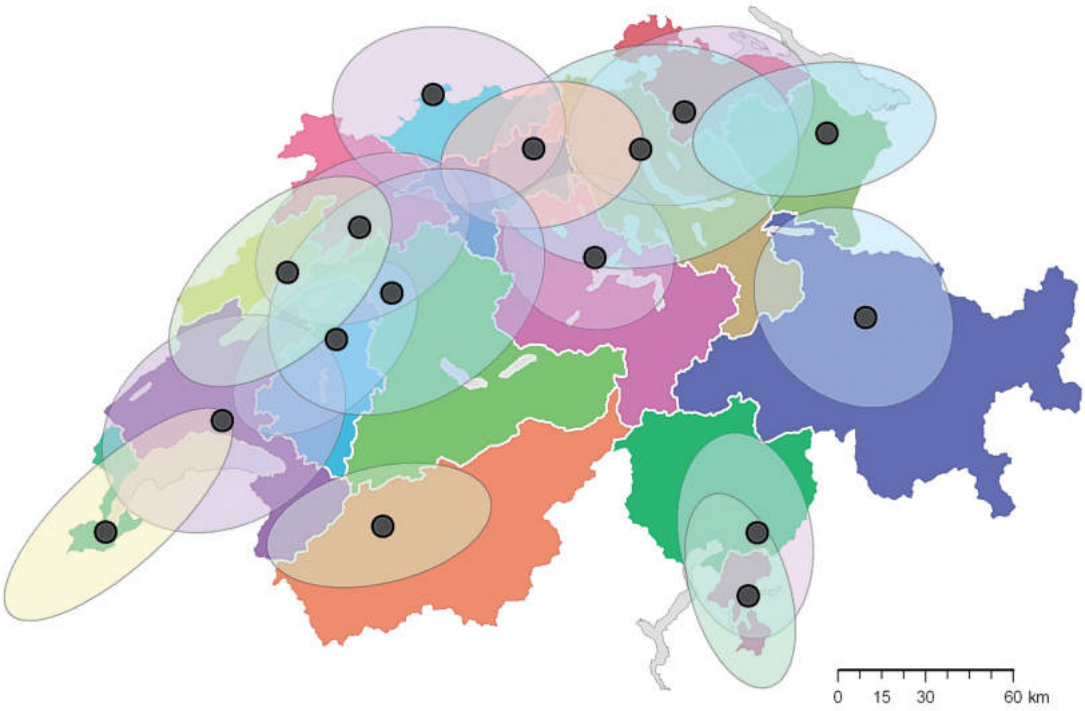


Fig. 1: Demarcation of the incoming commuting overlapping areas with the confidence interval ellipse compared to the labour market regions of Switzerland in 2000.

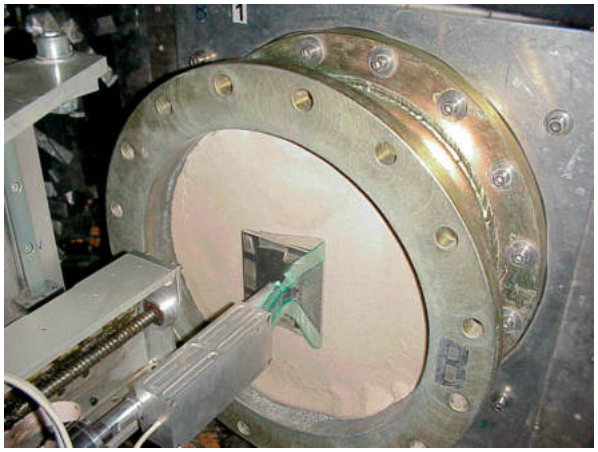


Fig. 2: Centrifuge model test on a rectangular foundation (11.2 times 11.2 cm equivalent to a prototype of 5.6 times 5.6 metres). The foundation is loaded by a central column and the tactile pressure pad is visible under the foundation.

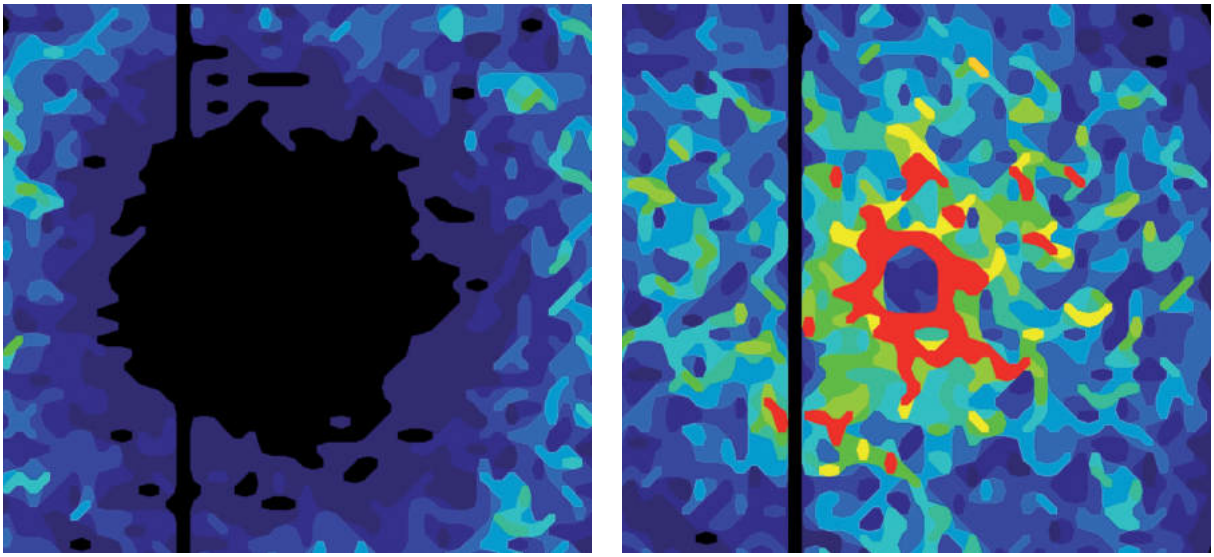


Fig. 3: Stress distribution at the interface between the foundation (membrane dimensions: 11.2 times 11.2 cm) and the soil. Left: Stiff behaviour under a small load. Right: flexible behaviour of the foundation under higher loads. The colour coding shows black for minimal till no loads and red for the highest loads transferred.

Experiment in the gallery: the mountain is moving...

The purpose of the international rock laboratory of Mount Terri in St. Ursanne (Canton of Jura, Switzerland) is to study the Opalinus-clay, especially concerning its suitability as host rock for the storing of radioactive waste.

by St. Schütz, T. Kohoutek / IGP

In the course of this year the laboratory has been extended by an additional gallery. Within this extension the engineering geologists of ETH Zurich conducted an experiment which aimed at investigating the behaviour of the rock during quarrying. Along with different geotechnical sensors, geodetic measurement equipment has been placed in the tunnel.

The geodetic registration of the rock movement was carried out by two fix total stations and additionally with the aid of a laser scanner of the latest generation (Fig. 1). The total stations of which one was situated in a parallel gallery and the other one in the new tunnel (Fig. 2), measured the displacements to defined points (prisms) once an hour. Each evening, after approximately every 1.5 m of tunnelling, five new prisms were mounted in the cross-section of the gallery and added to the setup of the monitoring system. In addition, the whole length of the experiment was captured by laser scanner. Such a combination of measurement techniques makes a detection and measurement of movements as well as volume vectors possible. Apart from documentation this automatic measurement system also served for safety purposes; since no air-placed concrete has been applied in order to allow for movements of the rock, a functional warning system (which could be realised with the total stations) was a prerequisite.

The measurement conditions in tunnels are never ideal due to dust, heat, vibrations, etc. and in addition there were numerous prisms in a confined area. Although the measurement systems reached their limits, the obtained data look promising. After the analysis of these data, the results will be assessed and interpreted within a PhD thesis in the field of engineering geology.

First International Conference on Machine Control and Guidance (MCG)

Over 130 participants from 17 different countries attended the 1st International Conference on Machine Control & Guidance from June 24 to 26, 2008 at the Hönggerberg Campus of ETH Zurich.

by W. Stempfhuber / IGP

Over the last two decades, different kinematic applications in the field of road-, airport- and rail-construction as well as mining have been automated by geodetic measurement systems and methods. Also in the field of agriculture applications, yield mapping and documentation based on GPS have seen a significant upturn since 1990. Almost 20 years later, many solutions have been established in machine control and guidance applications. For this reason, the Professorship of Geodetic Metrology and Engineering Geodesy organised the 1st International Conference on Machine Control & Guidance at the Hönggerberg Campus of ETH Zurich (www.mcg.ethz.ch) (Fig. 3).

The emphasis of the MCG conference was placed on kinematic measurement, agriculture and construction application, data processing and verification as well as on machine control. 35 scientists and system developers reported on their research projects and the current state of the art in this field. Besides a poster session, manufacturers and sponsors presented their solutions in small exhibitions (Fig. 4).

The feedback of computer scientists and the geomatics-, cybernetics- and mechanical engineers and has been positive. Looking over the impressive scenery around Lake Zurich, the technical discussions were deepened at the social event. During the closing session all participants and the scientific committee agreed on the need of a second conference treating this topic which will take place in 2010 at the University of Bonn.

Fig. 1: Laser scanner point cloud: Because there is no air-placed concrete the rock structures are visible. Volume changes can be detected by comparison with later scans.

Fig. 2: View from the total station console: The prisms are ordered in profiles approximately 1.5 m apart. The total station was used for tunnelling and the heading face. In addition to the geodetic and geotechnical measurements geologists were mapping the surface of the tunnel every evening.

Fig. 3: Audience of the "1st International Conference on Machine Control & Guidance" with over 130 participants from 17 countries.

Fig. 4: Lively technical discussions also during the coffee breaks.

The new astro-geodetic on-line system DAEDALUS

The principal aim of the newly developed astro-geodetic system DAEDALUS is to enable a low-cost determination of deflections of the vertical and astronomical azimuths.

by S. Guillaume, B. Bürki, P. Sorber, H.-G. Kahle / IGP

This is achieved by using a standard tachymeter augmented by (1) an appropriate CCD camera for automatic extraction, identification and measurement of stars without human intervention, (2) a low-cost GPS receiver for the acquisition of precise epochs and (3) an easy-to-use windows-based software for the control of the different sensors and real-time processing (Fig. 1).

The first successful observations were performed during the geodetic project course 2008 (GPC 08) in Greece. Comparisons of deflections of the vertical with the high accurate zenith camera system DIADEM revealed that DAEDALUS achieves precisions of up to 0.2-0.3 arc seconds with the advantage of high portability and flexibility. Measurements performed on top of the cliff on the island of Alonissos (Fig. 2) revealed significant deflections of the vertical of up to 20 arc seconds.

Crustal deformation along the North Aegean trough

The North Aegean trough (NAT) forms the boundary between the Eurasian plate and the Aegean microplate.

by M. Müller, A. Geiger, H.-G. Kahle / IGP

The North Aegean sea belongs to the seismically most active regions in Greece. Five earthquakes with magnitudes greater than 6 in the last thirty years clearly support the seismic hazard encountered there (Fig. 3). Modern techniques of satellite geodesy enable the accurate determination of crustal deformation in view of seismic risk assessment. Recently installed continuous GPS sites and campaign-type measurements allow the derivation of important boundary conditions along the tectonic structure.

Information about the kinematic field of the North Aegean sea reveals characteristics of the interaction between both plates along the NAT. A significant change of velocity difference from 21 mm/yr to 11 mm/yr was detected along the trough from East to West (Fig. 4). In addition, north-south extension is witnessed by strain rates reaching up to 100 nstrain/yr.

The results clearly identify the North Aegean trough as the westerly continuation of the North Anatolian fault zone (NAF) into the Northern Aegean Sea. It can be considered as one of the geodynamically most active fault zones in the Hellenic part of the Eastern Mediterranean.

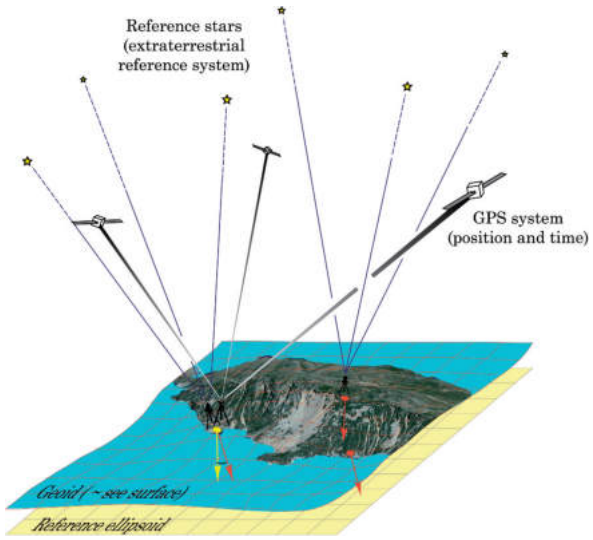


Fig. 1: Measurement concept of DAEDALUS: the observations of stars are used for the computation of the direction of the plumb line (red arrows, normal to the geoid). The GPS measurements are used for the determination of the position (yellow arrow, normal to the reference ellipsoid) and for precise timing of the stellar observations.

Fig. 2: Measurements with DAEDALUS on top of the steep cliff on the island of Alonissos (GPC 08), 300 meters above sea level.

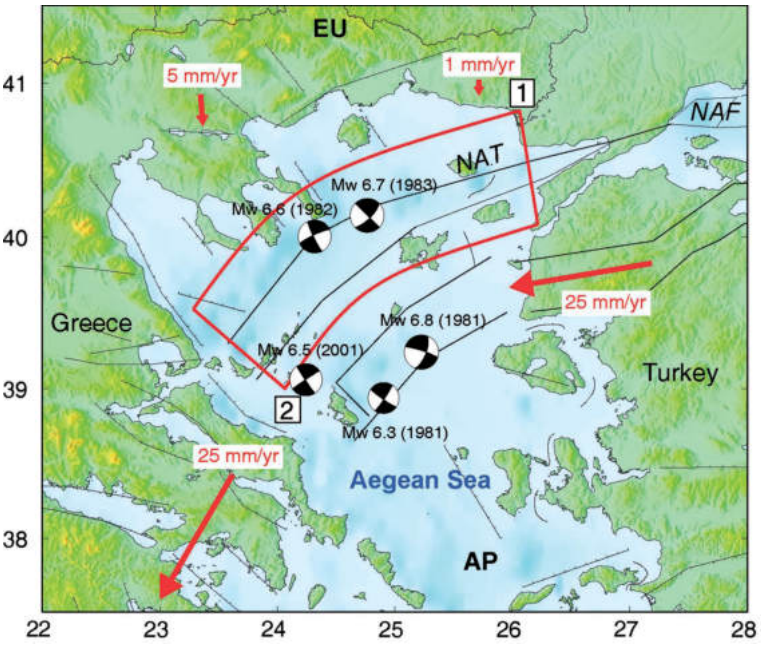


Fig. 3: Fault plane solutions of earthquakes (Mw>6) in the North Aegean sea (according to USGS-NEIC) and generalized GPS-velocities (red arrows). AP: Aegean microplate, EU: Eurasian plate, NAF: North Anatolian fault zone, NAT: North Aegean trough.

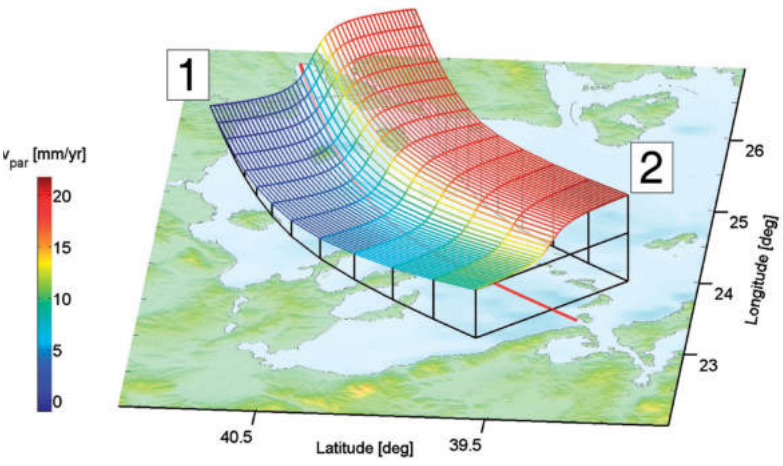


Fig. 4: Modeled velocity differences along the North Aegean trough (NAT). Vpar: fault-parallel velocity component.

Future improvements of the tomographic water vapor determination by GPS

Where and when will the next hydrological extreme occur?

by F. Hurter, D. Perler, A. Geiger, H.-G. Kahle / IGP

This is one of the intriguing questions whose answer shall be tackled during the next years. The successful forecast of hydrological hazard is closely related to the prediction of heavy rain events. Predicting heavy rain events, in turn, relies on precise information on the spatial distribution and development of water vapor within the troposphere. At GGL, tools have been developed to assess the water vapor content within the atmosphere by means of GPS measurements.

So far, the effect of rain on GPS measurements has been neglected, since it is rather small compared to the effect caused by water vapor. This introduced small errors in the results of the afore-mentioned tools used for water vapor determination in the atmosphere. In a newly launched project at GGL (within CCES project APUNCH; PI Prof. P. Burlando), the influence of rain shall be accurately modelled and quantified using external information such as weather radar images (Fig. 1). This will improve our capabilities to «x-ray» the atmosphere with respect to its water vapor distribution and ultimately lead to an improved forecast of heavy rain events.

Rolling Stones

The project Lithotracker investigates possibilities for detecting movements of stones in water currents.

by A. Villiger, A. Geiger/ IGP

The usual geodetic measurement methods, such as satellite based positioning will fail underwater and, therefore, new approaches have been devised in an ETH medal awarded master thesis.

The Lithotracker is a synthetic stone which will be carried along with the current and sedimented at another location. During these movements the stone is exposed to rotations and accelerations. In an experimental set-up, two low-cost 3D accelerometers were mounted diametrically on a rotating wheel. The rotations were extracted by synchronising the recorded accelerations by correlation methods and Kalman filtering without using any gyroscopes.

A 12 cm large spherical prototype containing two low-cost 3D g-sensors was exposed to diverse accelerations to simulate the acting forces caused by the water flow (Fig. 2). The studies have shown that start and stop of a movement are reliably detected (Fig. 3). Even though information about the gravity field and the static states are available it remains difficult to exactly derive trajectories. This is due to an undetermined rotation parameter and to insufficient sensitivity of the system. However, this simple and cheap approach can be used to retrieve information on special applications.

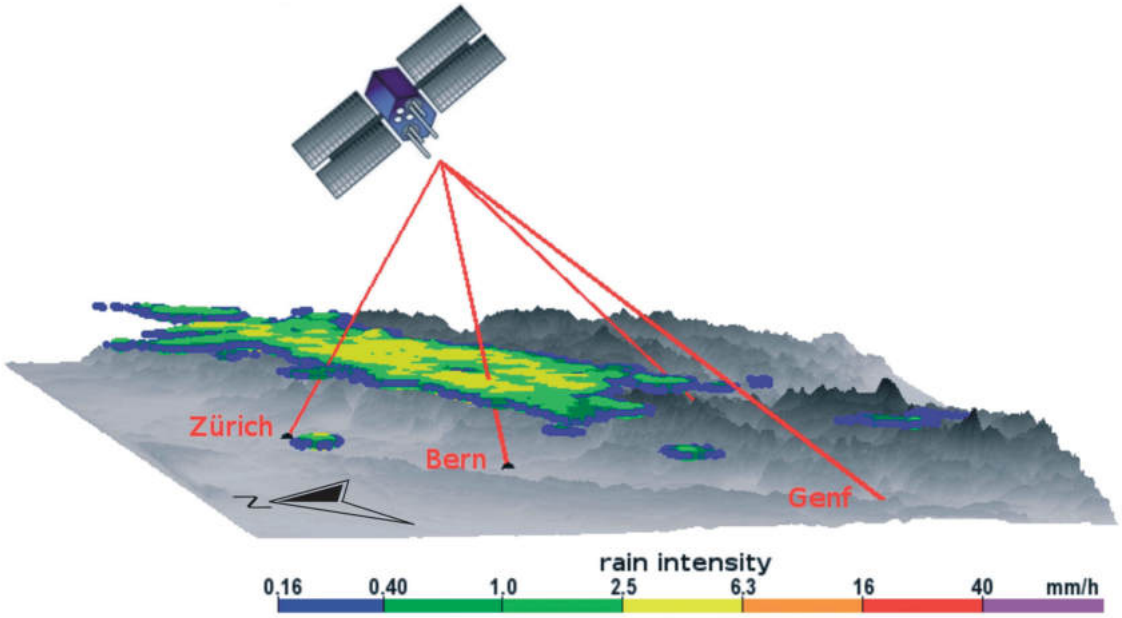


Fig. 1: External information, such as rain intensities obtained from weather radar, will provide valuable information to better correct GPS measurements for the influence of rain events. Source of radar data: MeteoSwiss.

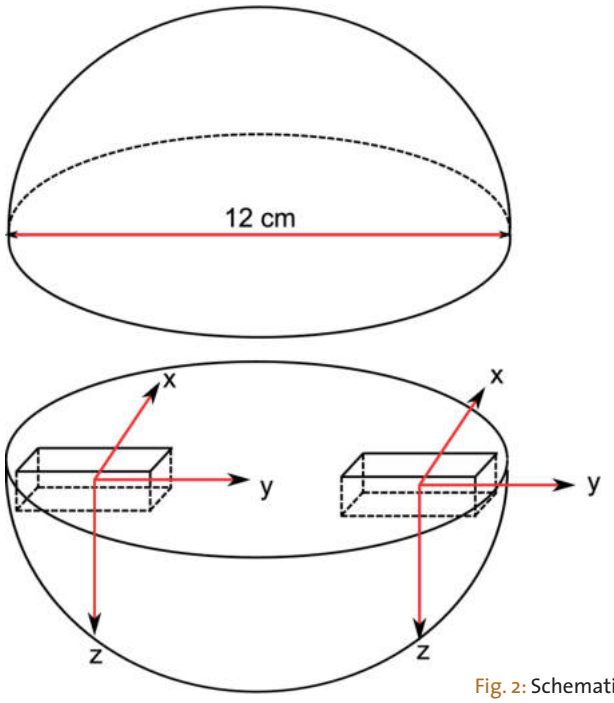


Fig. 2: Schematic set-up of the prototype.

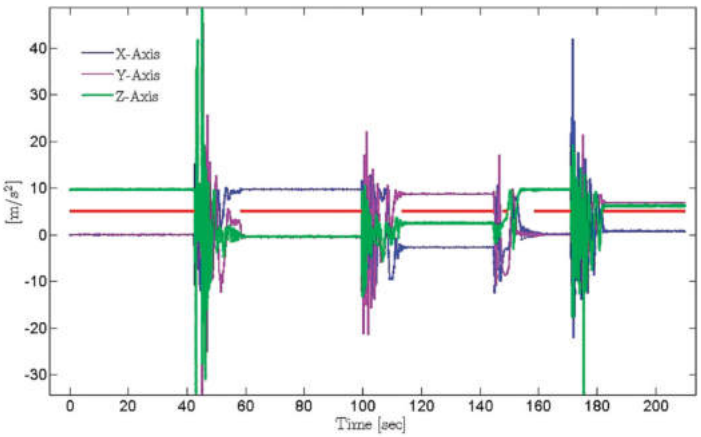


Fig. 3: The figure shows the measured accelerations from one 3-axis g-sensor. The static states (red line) are reliably detected.

When Bridges Begin to Rock

This year's exercise for the Engineering Geodesy course in the Geomatics Master Program was to determine the eigenfrequency of a bridge.

von R. Mautz, St. Schütz / IGP

A nearly 100 m high filigree steel lattice formwork bridge that crosses the Sitter river near St. Gallen served as test object (Fig. 1). The students planned diverse measurement set-ups independently. Each student group installed their chosen instruments simultaneously so that at one point in time various laser scanners, self-made digital cameras, differential GPS receivers, tachymeters, inclinometers and accelerometers were ready to capture the swinging of the bridge (Fig. 2). After carrying out a zero reference measurement without pedestrians, the exciting part began. The students jumped on the bridge enthusiastically in order to make sure that their instruments register the harmonic signals.

However, the actual work starts afterwards: from a huge amount of data, the eigenfrequencies in vertical, longitudinal and cross direction have to be determined. The techniques in theoretical mathematics and physics such as the Fourier analysis that have been studied well during the Bachelor Program are now applied with actual practice. Although the interpretation of the data is still ongoing, we can clearly state an eigenfrequency around 2 Hz. At the end of the term each group will give a presentation of their results.

How attractive is Mount Athos? ETH students measure the Holy Mountain

By tradition graduate students at the Department of Civil, Environmental and Geomatics Engineering of ETH Zurich attend the Geodetic Project Course (GPC) at the end of their studies.

by B. Bürki, S. Guillaume, S. Büttler, C. Forrer, F. Gigon, S. Haeberling, D. Näpflin, R. Wolf, H.-G. Kahle / IGP

The general goal is to carry out the project planning, perform the practical field work, and to process the data at their own initiative. In addition the course offers to get practice in team work.

The GPC 08 has been organized in the region of the Northern Sporades in the North Aegean Sea, Greece. The main target consisted of a precise determination of the Equipotential surface at sea level, called geoid. One method to determine the normal vector to the geoid is the observation of the direction of the local plumb line (red lines in Fig. 5) by means of astro-geodetic measurements to the stars. In order to accomplish this task a group of students climbed to the top of the Holy Mountain (2033 m ü. M., Fig. 3).

The transport of the material during the 6 ½ hours lasting ascent in the hot sun of July was taken over by 6 mules (Fig. 4). The successful measurements around Mount Athos clearly revealed, that the gravitational attraction of the mountain corresponds to a geoid high reaching 62 cm (Fig. 5).

Fig. 1: Steel lattice formwork bridge near St. Gallen. Locals call it „Gaageli-Brugg" – a name that refers to its swinging.

Fig. 2: Besides traditional surveying instruments like GPS-receivers or tachymeters, unconventional self-made constructions were installed, such as the web camera in the lower right. The use of diverse instruments allowed an insight into the possibilities and limitations of the equipment.

Fig. 3: The Holy Mountain ATHOS (2033 m.a.s.l.) located at the tip of the peninsula in the Northern Aegean Sea (Greece).

Fig. 4: Break of the material-convoi with mules during the ascent to the Holy Mountain.

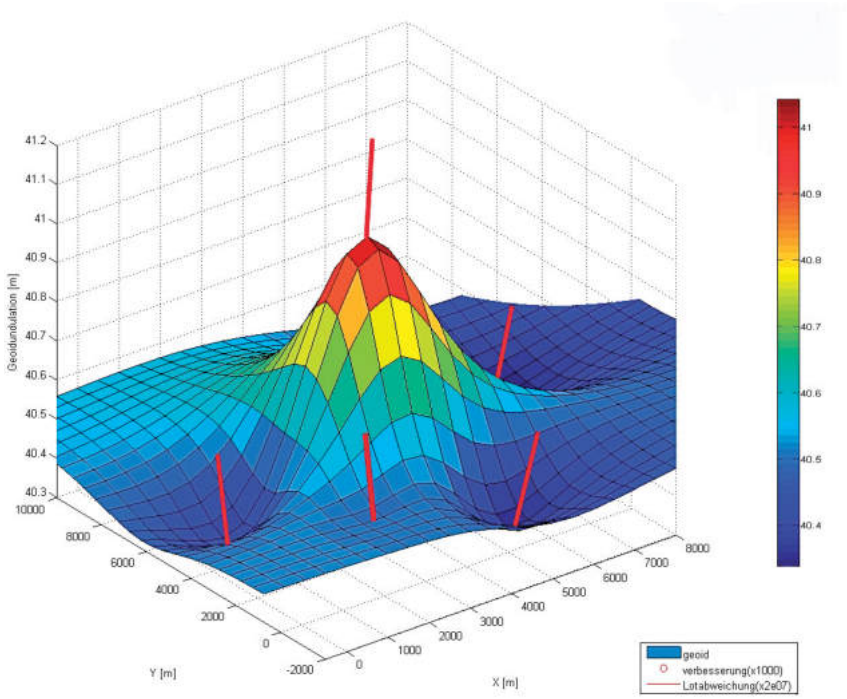


Fig. 5: The surface of the geoid in the area of Mount Athos. The gravitational attraction of the mountain increases the geoid by 62 cm. The red lines indicate the direction of the local plumb line (normal to the geoid) which have been observed by students of Geomatics Engineering and Planning at ETH during the Geodetic Project Course 2008 in Greece.

Bow Wave Detection in Conjunction with Load Test

Within the framework of maintenance works on the runways at Hamburg Airport, a convenient method to reinforce the soil adjacent to the concrete runway was investigated.

by D. Grimm / IGP

To check the suitability of the soil fixings, load tests were performed on three different purpose-built test fields. For these tests a crane with a weight of about 200 tons drove backwards into the test fields. Besides the sinking depth of the crane, the size of the bow wave - which occurs in the front of the first wheel when driving into the mud - was of main interest.

As the bow wave is only formed while driving, a kinematic measuring method had to be considered. The chosen method consisted of a profile laser scanner, mounted underneath the crane in front of the crane wheel (Fig. 1).

For a practicable analysis of the measurements, special software was developed. The results of the measurements are scan profiles which show a part of the wheel, the bow wave and the surface which had not been run over by the crane yet. With a measurement frequency of 75 Hz the laser scanner provided enough profiles to monitor the dynamic bow wave. In order to determine the height of the bow wave the two dimensional coordinate system was related to the untouched planar surface. This also allowed for the elimination of inclination variations of the profile scanner along the driving direction. Finally, a bow wave height of about 18 cm was determined (Fig. 2)

Day and Night Monitoring of Water Vapor

Keeping Track of Water Vapor around the clock.

by St. Münch, B. Bürki, H.-G. Kahle / IGP

Water vapor is the most important greenhouse gas in the earth's atmosphere. Man-made global climate change is considerably amplified by positive feedback effects of water vapor. Atmospheric water vapor is the limiting factor in achieving high accuracies in applications of satellite geodesy. Since it cannot be modelled adequately it has to be obtained instrumentally.

The Geodesy and Geodynamics Lab (GGL) and the Institute for Analytical Sciences (ISAS, Berlin-Adlershof) form a partnership in the development of high-precision solar spectrometers. In a new joint project which also includes the Geoforschungszentrum Potsdam, an improved third generation spectrometer is currently developed and constructed.

A small frequency band in the near infrared is used for analysis. This permits the use of a simplified optical layout and thus allows a significantly more compact construction of the instrument(Fig. 3a). The steering electronics of the spectrometer itself and its tracking telescope is directly integrated in the autonomously working measurement system which is hermetically sealed (Fig. 3b/c). Deployment of ultrasensitive optical sensors for data acquisition, target aiming and amplification electronics yields the possibility to use not only direct sunlight but also moon light with an approximately one million times weaker intensity. This leads to a nearly day and night coverage monitoring of the tropospheric water vapor.

Fig. 1: Setup of the 2D laser scanner on the crane

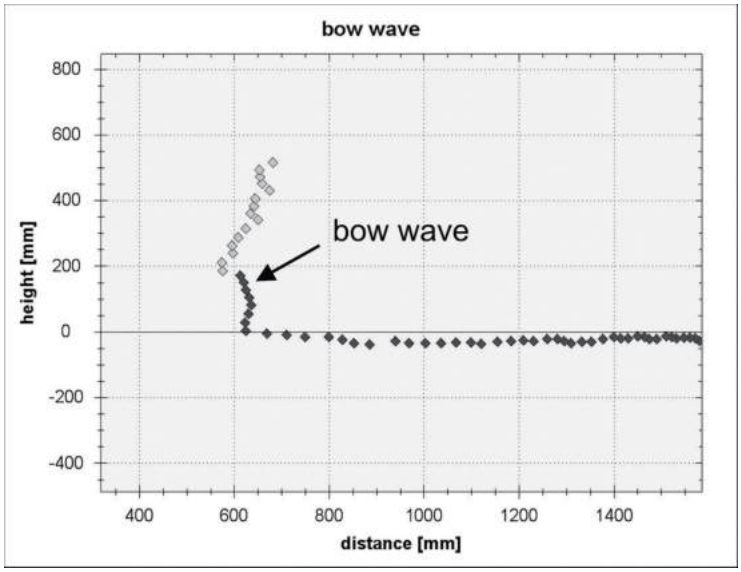


Fig. 2: Detection of the bow wave in the longitudinal section

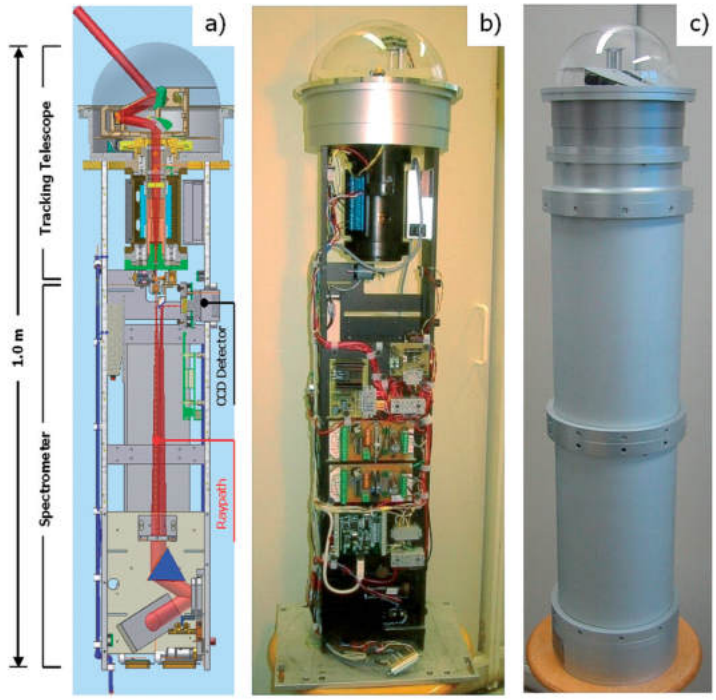


Fig. 3: (a) Mechanical and Optical Layout of the "Solar Lunar Spectrometer for Atmospheric Research" consisting of a Tracking Telescope and the actual spectrometer.
(b) Steering electronics (c) Spectrometer mounted in its robust and hermetically sealed aluminum enclosure.

How slant is the North Aegean Sea?

Geomatics Engineering students detected relatively large gradients in the sea level of up to 9 cm/km at the west coast of Alonissos (Northern Sporades, Greece) (Fig. 1A).

by Ph. Kehl, Ph. Limpach, H.-G. Kahle / IGP

Similar gradients of up to 8 cm/km have been measured seaward of the Holy Mountain Athos (Fig. 1B).). Steep fault zones in the Earth's crust and corresponding sedimentary fillings are likely the reason for the slant sea surface offshore Alonissos. On the other hand, the gravitational attraction of Mt. Athos causes the gradient of the sea surface in its coastal region.

The measurement system developed at the GGL consists of five geodetic GPS receivers and two ultrasonic ranging sensors, which were installed on a yacht (Fig. 2). The instantaneous sea surface, corrected for tides, barometric pressure and other dynamic effects, allows for the determination of a sea surface height that corresponds to the geoid. This method reveals local inhomogeneities, which cannot be detected by satellite radar altimetry. The North Aegean Trough is of particular interest due to its seismotectonic activity. Its dynamics can be further studied by incorporating the sea surface topography (Fig. 1) as additional modelling constraints.

Analytically generated rock representation in topographic maps

Expressiveness and limitations of computer-aided cliff drawings derived form digital terrain models.

by Ch. Häberling, T. Dahinden, L. Hurni / IKA

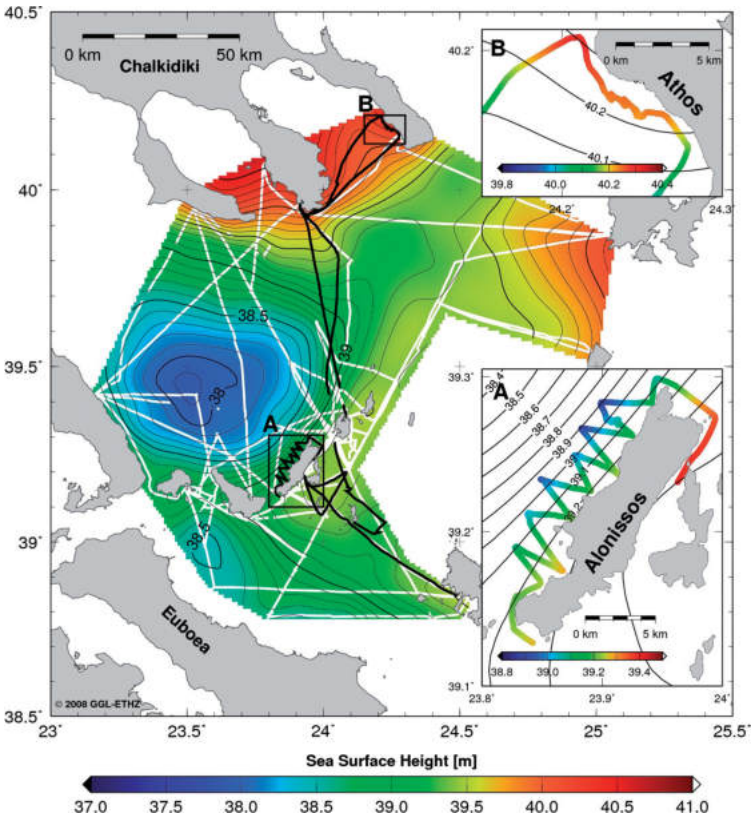
The cartographic representation of rocks and cliffs is authentically characterizing a mountainous region on a topographic map.

Depending of the degree of realism, the symbolisation of rocks supports the map user for orientation in the mountainous terrain. A research project at the Institute of Cartography aimed at investigating different methods for analytical generation of rock symbols. Therefore, algorithms were developed which analyse high-resolution digital terrain models to generate graphical patterns for rock depiction in an orthogonal projection. In a second phase, the perception and the interpretation of such irregular structural patterns were tested by potential map users. This should prove the expressiveness in comparison to manually designed rock drawings (Fig. 3).

First of all, the graphic components of different rock symbolisation were analysed. Components in this sense are homogenously or gradually coloured areas, regular or irregular patterns (mostly with rock hachures), surface structures (by bump mapping), shaded areas, edge representations, or 3D textures (by texture mapping). These separated components were automatically visualised by means of the developed raster-based routines (Fig. 4).

Then, their impact on potential applications had to be tested before they were combined to complex rock representations. And last, the final representations were enriched by other topographic map elements (like contour lines, spot heights, or symbolised land use patterns) for being evaluated by potential user groups. By doing so, the limits of the algorithms and possibilities for improvement could be shown.

The qualitative studies showed that often a representation of break lines combined with tinted rock zones can be ▶



◄ Fig. 1: Sea surface topography in the Northern Sporades (Greece). Black tracks were measured during the Geodetic Project Course (GPC). White tracks originate from previous campaigns. The insets A and B show details of the corresponding areas.

▲ Fig. 2: The measurement system combines GPS measurements (yellow) with ultrasonic ranging measurements (red/white).

Fig. 3: Manually scribed rock depiction, as applied in the Swiss Topographic Map Series at the scale of 1:25000 (© swisstopo, Wabern).

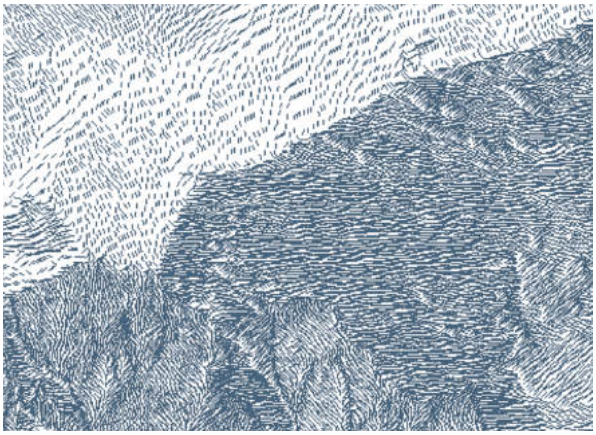


Fig. 4: Analytically generated rock hachures based on the steepness and the aspect of the digital terrain model DHM25 (© swisstopo, Wabern).

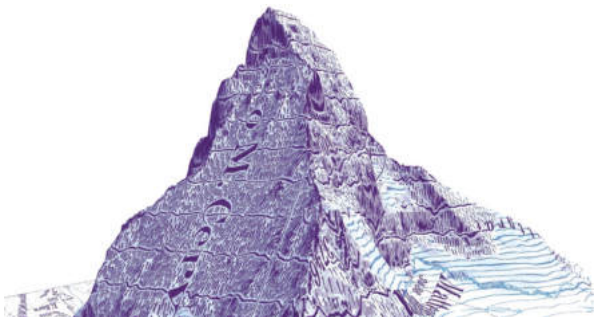


Fig. 5: Perspective view showing the Matterhorn, derived from a digital terrain model and textured by the analytically generated rock depiction using buffered hachures and combined with other geodata (© swisstopo, Wabern).

better interpreted as the well-known rock hachures of the Swiss Topographic Map Series. Additionally, a rock representation can be improved by appending a shading of the rock areas. This helps to recognise the shape of the terrain explicitly, especially in perspective views of digital terrain models (Fig. 5).

Cartographic line symbolisation

In a recent research project, the classical design of cartographic lines has been analysed and algorithmic solutions for an optimal display have been worked out.

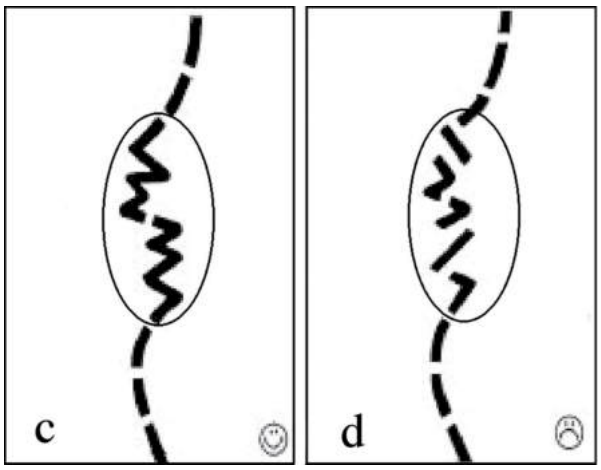


Fig. 1: Cartographic instructions by comparison of map examples.

by H. Bär, F. He, L. Hurni / IKA

As a graphic element, lines play an important role in almost every map. Lines not only structure and clarify the map contents, they also delimit, separate and join the various map features and thus substantially contribute to a precise description of space. During the rather long history of cartography, innumerable different line styles have emerged: simple lines, double and multiple lines, filled lines or asymmetric lines but also some more decorated lines such dashed, dotted, and dash-dotted lines. In this context, the proper display of line interactions (e. g. junctions, crossroads, and subways) is also of major importance.

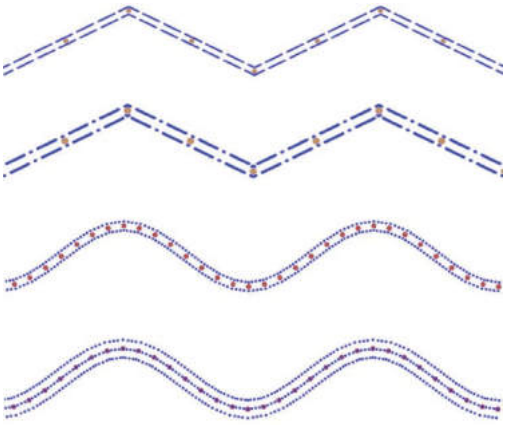


Fig. 2: Cartographic creation of dotted and dashed double lines.

Cartographic knowledge is often taught by comparison of poor and favourable map examples (Fig. 1). This knowledge is little formalized and has rarely found its way into commercial software products. Neither geographic information systems nor vector graphics applications sufficiently support the creation of proper cartographic lines.

Recently, a research project has addressed the problem of cartographic lines. Numerous examples from literature have been collected, classified, and analysed. Finally, algorithmic solutions for optimal line display have been worked out. As an example, figure 2 shows the automated creation of dotted and dashed double lines. Starting from the skeleton of a line, the key positions are calculated and the gaps are symmetrically and equally distributed in between such that they are always at corresponding positions on both sides along the path.

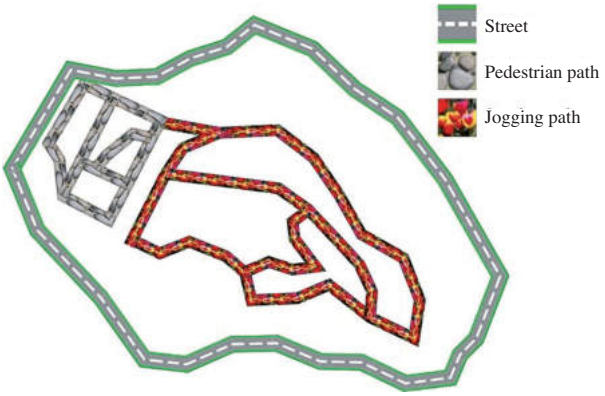


Fig. 3: Natural-looking line symbolisation by means of texture mapping.

The project was not only restricted to traditional cartographic lines that arose from the former scribing technique, but also explored the capabilities of more natural-looking line symbolisations. For this purpose, the so-called texture mapping technique has been used to draw lines by repetitively placing small images along a path. Figure 3 shows a part of such a symbolized road and path network around the campus of ETH Hönggerberg.

Facts and Figures

Organisation Chart D-BAUG

Department Conference

Head of Department

Faculty Conference

Curriculum Committee

Departmental Administration, Offices, Laboratories, Workshops

Institute Directors Conference

Conference on Examinations

Institutes

IBB	Construction Engineering and Management
IBK	Structural Engineering
IfB	Building Materials
IfU	Environmental Engineering
IGP	Geodesy and Photogrammetry
IGT	Geotechnical Engineering
IKA	Cartography
IRL	Spatial and Landscape Planning
IVT	Transport Planning and Systems
VAW	Hydraulics, Hydrology and Glaciology

Curricula

Civil Engineering (CE)

Environmental Engineering (EE)

Geomatic Engineering and Planning (GP)

Spatial Development & Infrastructure Systems (SDIS)

Institutes (Date: 31 December 2008)

IBB Institute for Construction Engineering and Management


Prof.
G. Girmscheid


Prof.
H.R. Schalcher


Prof.
H. Wallbaum (AP)

IBK Institute of Structural Engineering


Prof.
M.H. Faber


Prof.
M. Fontana


Prof.
P. Marti


Prof.
T. Vogel


Prof.
A. Dazio (AP)

IfB Institute for Building Materials


Prof.
H.J. Herrmann


Prof.
J.G.M. van Mier


Prof.
P. Niemz (TP)


Prof.
B. Elsener (TP)

IfU Institute of Environmental Engineering


Prof.
P. Burlando


Prof.
W. Gujer


Prof.
S. Hellweg


Prof.
W. Kinzelbach


Prof.
F. Stauffer (TP)


Prof.
F. Siegrist
(TP; EAWAG)

IGP Institute of Geodesy and Photogrammetry


Prof.
A. Grün


Prof.
H. Ingensand


Prof.
H.-G. Kahle


Prof.
A. Geiger (TP)

IGT Institute for Geotechnical Engineering


Prof.
G. Anagnostou


Prof.
A. Puzrin


Prof.
S.M. Springman

IKA Institute of Cartography


Prof.
L. Hurni

IRL Institute of Spatial and Landscape Planning


Prof.
B. Scholl


Prof.
A. Grêt-Regamey

IVT Institute of Transport Planning and Systems


Prof.
K.W. Axhausen


Prof.
U. Weidmann


Prof.
H.P. Lindenmann
(TP)


Prof.
P. Spacek
(TP)

VAW Laboratory of Hydraulics, Hydrology and Glaciology


Prof.
M. Funk (TP)


Prof.
W. Hager (TP)

(AP) = Assistant Professor
(TP) = Titular Professor

Faculty

Retirements and Demissions:

Prof. Markus Boller (TP; EAWAG)		31. 5. 2008
Prof. Alessandro Carosio	Geographic Information Systems and Theory of Errors	31. 7. 2008
Prof. Hans-Erwin Minor	Hydraulic Structures	31. 7. 2008
Prof. Willy A. Schmid	Landscape and Environmental Planning	30.9. 2008

Appointments:

Prof. Adrienne Grêt-Regamey	Landscape and Environmental Planning	1.10.2008

Students D-BAUG (Date: 4 November 2008)

	BSc		MSc [1]		Total			Doctoral Students			Disserta-tions
Curricula	♂	♀	♂	♀	♂	♀	T	♂	♀	T	T
Civil Engineering	366	64	99	**23**	465	87	**552**	101	24	**125**	
Environmental Engineering	129	53	51	**36**	180	89	**269**	20	8	**28**	
Geomatic Engineering & Planning [2]	45	20	50	**16**	95	36	**131**	26	12	**38**	
Total	**540**	**137**	**200**	**75**	**740**	**212**	**952**	**147**	**44**	**191**	**38**

1) Including diploma students
2) Including MSc SDIS

Staff D-BAUG (in FTE, Date: 31 December 2008)

P	AP	TP	Senior Scientist	SA	Scientific Staff	Technical Staff (incl. ICT)	Admin. Staff	Apprentices	D-BAUG Staff Total
22.6	2.0	9.0	3.5	47.1	228.4	61.6	36.5	5.0	415.7

P = Professor
AP = Assistant Professor
TP = Titularprofessor
OA = Senior Assistant
Scientific Staff = Doctoral students, Post-Docs, Assistants
FTE = Full-Time Equivalent

Figures without Student Assistants, Hourly Wage Employees, Trainees, "occupied Workplaces"

Master of Advanced Studies (MAS), Certificate of Advanced Studies (CAS), Courses

	Institute	Title
MAS ETH	IRL / IVT / NSL	Spatial Planning
MAS EPFL	EPFL + VAW / IfU	Hydraulic Engineering
CAS ETH	IRL / NSL	Spatial Development
CAS ETH	IGP / IKA	Spatial Information Systems
CAS ETH	IBK / IVT et al.	Risk and Safety of Technical Systems (responsible body: D-MAVT)
PhD Programme	IRL	International PhD Program "Perspectives of Spatial development in European metropolitan regions"
Postgraduate Course	IBB / TU Graz / BTU Cottbus	5th International Summer Academy 'Project Management'
Postgraduate Course	IBB	2nd International Summer Academy in Sustainable Construction
Summer School	IGP	International School in Archaeology - '3D-Modeling in Archaeology and Cultural Heritage'
Summer School	IGP	3rd ISPRS Student Consortium
Course	IBK	Design of Fiber Reinforced Concrete Structural Members
Course	IBK / FBH	Fire Safety in Timber Structures - Research Aspects
Course	IBK / Pro Holz	Fire Safety in Timber Structures
Course	IGP / IKA	Model Based Integration of Spatial Data in GIS as Key to their Use
Course	IGP / IKA	Introduction to object-oriented Programming with Java for the GIS Development
Course	IGP / IKA	Products from Photogrammetry and Remote Sensing and their Integration into a GIS
Course	IGP / IKA	From GIS Data to Interactive Web Map
Course	IGP / IKA	Open Source GIS with GRASS und Quantum GIS
Course	IGP / IKA	Efficient work with VBA (Visual Basic for Applications)
Course	IGP	Geografic Information Systems
Course	IGP	Satellite Geodesy
Course	IVT	Introduction to Estimation and Forecast of Traffic Demand

Workshops, Symposia, Congresses

Date (in 2008)	Event	Institute	Topic
4 - 5 January	Seminar	IGP	ISPRS Technology Transfer Caravan, Hanoi, Vietnam
9 January	Seminar	IVT	Route Choice and Traffic Information Systems
24 - 25 January	Workshop	IfB	'Rencontre de Physique Statistique'
24 - 26 January	Congress	IVT	ITo8.rail: Closing the Loop - Capacity and Quality of Railway Systems
1 February	Seminar	IVT	Cities after "Peak Oil"
4 - 5 February	Workshop	IBK	Robustness of Structures – COST-Action TU0601
7 February	Workshop	IGP	ESRI User Group of ETH Zurich
11 - 12 February	Workshop	IGP	International GIS-cooperation Graz-Munich-Zurich
11 - 15 February	Workshop	IKA	6th ICA Mountain Cartography Workshop on Mountain Mapping and Visualisation
25 February	Seminar	IVT	Indian Transport Research
25 - 26 February	Workshop	IGP	6th International ARIDA (Association for Real Time Imaging and Dynamic Analysis) workshop 'Innovation in 3D measurement, modeling and visualization'
7 March	Meeting	IVT	Traffic Engineers' Day
9 - 14 March	Symposium	IfB	Physical Aspects of Fracture Scaling and Size Effect
17.March	Meeting	IVT	European UrbanSim Users' Meeting 2008
1.April	Workshop	IRL / NSL	Tools in City Planning and Spatial Development
8.April	Symposium	IRL / NSL	Railway and Spatial Development for Europe lined on the North-South Transversale
10.April	Meeting	IVT	The Periphery: Partially Full Regions or Regions Fully Apart?
8.May	Workshop	IRL / et al.	The Planning of Space+. Internet-based Summary of Sustainability in Land Use Potentials
15 May	Colloquium	IGT	Automatic Tunnelling in Loose Rock
22 May	Seminar	IVT	Agent-Based Simulation of Traffic Demand
27 May	Symposium	IfB	Granular Matter, Zurich
30 May - 2 June	Conference	IRL	ACE - Ecosystem Services, Naples, Florida, USA
5 June	Workshop	IfU	35th Discussion Forum, Assessment of Water Use within LCA
10 June	Seminar	IVT	Spatial Representation and Destination Choice: What are the Consequences of Modifying Reality?
10 June	Colloquium	IGT	Swiss Tunnel Colloquium: ATG, Lucerne, 'Injektion als Bauhilfsmassnahme im Vortrieb'
10 June	Workshop	IGP	SOGI Workshop 2 - GIS/SIT
15 - 17 June	Workshop	IGP	3rd Meeting of the Comitato Scientifico Italo-Svizzero per la Geoinformazione (CSISGI)

Workshops, Symposia, Congresses (cont.)

Date (in 2008)	Event	Institute	Topic
16 - 18 June	Symposium	IBB	8th Nordic Symposium on Building Physics, Copenhagen, Denmark
19 June	Meeting	IBK	Structural Safety of Garages
23 - 25 June	Workshop	IBK	Interdisciplinary Workshop on Rockfall Protection
24 - 26 June	Congress	IGP	1st International Conference on Machine Control & Guidance, ETH Zurich
5 - 6 July	Congress	IGP	ISPRS Congress Youth Forum
7 July	Seminar	IVT	Multi-Objective Signal Control for Urban Environments
23 July	Colloquium	IGT	Unsaturated Soils
4 - 8 August	Conference	IfB	Discrete Simulation of Fluid Dynamics, Florianopolis, Brazil
5 - 9 August	Conference	IfB	Computational Physics, Ouro Preto, Brazil
2 September	Congress	IBK	14. Holcim Concrete Day
3/10/16 September	Seminar	IVT	Road Safety Audit
5 September	Congress	IBK	Seismic Safety of Buildings: Legal and Liability Issues
10 - 12 September	Symposium	IGP	3rd Baltic Swiss Geodetic Science Week, Tallinn/Estonia
11 September	Meeting	IRL	'Landmanagement ermöglicht optimierte Ressourcennutzung' (co-organized with Geosuisse, IGS, sia-BWL, BLW, CH-AGRAM)
11 - 12 September	Symposium	VAW	New Requirements on Hydraulic Engineering
15 September	Colloquium	IfB	2nd colloquium 'Current issues in wood research' at the University of Natural Resources and Applied Life Sciences (BOKU), Vienna
20 - 21 September	Workshop	IGP	ISPRS Workshop - Airborne Laser Technology and Data Processing
25 September	Seminar	IVT	Urban Development "Zürich West"
2 October	Symposium	IBK / IVBH	YES-08 Young Engineers' Symposium (IABSE)
6 - 11 October	Workshop	IfB	Alert Workshop, Aussois, France
7 October	Seminar	IVT	'Dynamische Umlegung'
12 - 18 October	Workshop	IRL / ISOCARP	Limmatvalley
13 October	Seminar	IVT	Congestion Pricing for Tel Aviv - Plans and Travelers' Response Modeling
27 - 31 October	Conference	IfB	Nonextensive Statistical Mechanics, Foz do Iguacu, Brazil
28 October	Seminar	IVT	Tramway "Bern West"
28 October	Workshop	IBK / Stanford University / JCSS	Structural Robustness, Stanford University, CA, USA
30 October	Seminar	IVT	Possibilities of Tackling Traffic Problems in Agglomerations and Cities
31 October	Meeting	IRL	'Kultur- u. Vermessungsingenieure ETHZ, Diploma 1978'
7 November	Symposium	IGT	Autumnal Symposium SGBF-SSMSR 2008: Creep Problems in Geotechnics
14 November	Seminar	IRL	AGS - Urban Futures
17 November	Colloquium	IfB	Current wood research projects at the Institute for Building Materials, weekly colloquium for the practise
20 November	Colloquium	IVT / ISB / IRL / ILA	What does "Land-Use Planning" mean?
20 November	Symposium	IRL / NSL	Questions in Spatial Planning and Spatial Development
20 - 21 November	Workshop	IGP	AHORN, 'Der Alpenraum und seine Herausforderungen im Bereich Orientierung, Navigation und Informationsausstausch'
3 - 4 December	Meeting	IVT	Public Transport Forum, Oberhofen
4 December	Seminar	IVT	Endangered Traffic Networks
11 December	Colloquium	IGT	Construction Aid Measures in Tunnel Engineering

Honours

Name	Institute	
Prof. Dr. Michael H. Faber	IBK	Promotion to Full Professor for Risc and Safety, 1.2.2008
Prof. Dr. Fontana Mario	IBK	IAFSS Appreciation
Prof. Dr. Grün Armin	IGP	Brock Gold Medal Award, ISPRS
Prof. Dr. Grün Armin	IGP	Certificate of Recognition, ISPRS, for excellent service to ISPRS as Chair of ISAC during the period 2004-2008
Prof. Dr. Grün Armin	IGP	ISPRS Honorary Membership
Prof. Dr. Gujer Willi	IfU	"Goldene Eule VSETH 2008" for best lecturing professor in D-BAUG
Prof. Dr. Gujer Willi	IfU	Credit Suisse Award for Best Teaching 2008
Prof. Dr. Gujer Willi	IfU	Honarary Membership of IWA

Honours (cont.)

Prof. Dr. Hurni Lorenz	IKA	Medida-Price 2008 (Media Didactic University Price) for GITTA 'Geographic Information Technology Training Alliance' (Joint Project with University of Zurich [Lead], EPFL, FHNW and other partners)
Prof. Dr. Hurni Lorenz	IKA	Editor-in-chief for the Swiss World Atlas per 01.01.2009
Prof. Dr. Marti Peter	IBK	Fellow of the American Concrete Institute
Dr. Amiri Parian Jafar	IGP	Otto-Hamberg Award for the Best Paper, Aerospace Testing Seminar
Dr. Akça Mehmet Devrim	IGP	Silver Medal ETH Zurich for excellent Dissertation
Dr. Dreyer Jennifer	IBB	Construction Engineering Sponsorship Award
Dr. Gamisch Tobias	IBB	Silver Medal ETH Zurich for excellent Dissertation
Dr. Grêt-Regamey Adrienne	IRL	Silver Medal ETH Zurich for excellent Dissertation
Dr. Holzner Markus	IfU	Silver Medal ETH Zurich for excellent Dissertation
Dr. Juraske Ronnie Saner Dominik	IfU	Poster, 2nd Price; Conference 'Reliable Data for Waste Management', Vienna
Dr. Piatti Barbara	IKA	Fellow of the Institute for Advanced Study, Berlin, 2010/11
Dr. Remondino Fabio	IGP	VSMM Best Paper Award for the article "A multi-resolution methodology for archaeological survey: the Pompeii Forum"
Caduff Daniel	IfB	SIKA Price for excellent Master Thesis
Casanova Alessio	IfB	SIKA Price for excellent Master Thesis
Custer Rocco	IBK	Culmann Price
Dürrenmatt David J.	IfU	ETH-Medal
Dürrenmatt David J.	IfU	Willi-Studer-Price
Eisenbeiss Henri Pueschel Hannes Sauerbier Martin	IGP	Youth Forum Best Paper Award ISPRS, 21st Congress, China, Beijing
Fasler Daniela	IGP	2nd Rank, Price for young scientists of Photogrammetry Remote Sensing and Geoinformation - in memoriam of Prof. Dr. Karl Kraus, 3-Country Conference SGPBF, DGPF, OVG
Fasler Daniela	IGP	Phil-Alp-Price of the Academy of Science, Switzerland, ICAS (Interakademische Kommission Alpenforschung)
Fasler Daniela	IGP	Geosuisse Award
Frei Pascal	IBK	VSV Price for excellent Diploma Work
Gerber Adrian	IBB	Construction Engineering Sponsorship Award
Guillaume Sébastien	IGP	Willi-Studer-Price
Guillaume Sébastien	IGP	ETH-Medal
Hanusch Thomas	IGP	ESF (European Science Foundation) Awarded paper
Hauswirth Dominik	IGT	Willi-Studer-Price
Hauswirth Dominik	IGT	ETH-Medal
Hauswirth Dominik	IGT	Best Graduate Student in Civil Engineering 2008
Huguenot Delphine	IBK	Culmann Price
Kläusler Oliver	IfB	Award for Studies (Research in Engineered Wood Products) from the Association of the German Wood-based Panels Industry
Knobloch Markus	IBK	IAFSS Best Thesis Award (Europe/Africa) 2005/2007
Löhrer Rafael	IBK	Culmann Price
Niederegger Philipp	IBK	Best Presentation on Young Engineers' Symposium 2008 (yes-IABSE)
Peyer Fabio	IfU	ETH-Medal
Rabaiotti Carlo	IGT	'Inverse Analysis in Road Geotechnics: ETH Delta', XIX European Young Geotechnical Engineers' Conf., 2nd best paper and presentation, Györ, Ungary
Raveglia Elio	IBK	Security Award 2008 VBSF
Regli Lukas	IfB	VSS Price
Rüttimann Markus	IGT	Culmann Price
Salzmann Christoph	IfU	Willi-Studer-Price
Schindler Dietrich	IBB	Construction Engineering Sponsorship Award
Schneider Thomas	IGT	Culmann Price
Schütz Stephan	IGP	Geosuisse Award
Schwager Markus	IGT	Hatt-Bucher-Price (2nd rank)
Somaini Diego	IBK	Hatt-Bucher-Price (1st rank)
Somaini Diego	IBK	Best Presentation on Young Engineers' Symposium 2008 (yes-IVBH)
Villiger Arturo	IGP	ETH-Medal
Villiger Arturo	IGP	Willi-Studer-Price
Zweidler Simon	IBK	Hatt-Bucher-Price (3rd rank)
Pooley Emma	IGT	Silver Medal in the Time Trials, Summer Olympic Games 2008, Peking, China

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Date: 1 March 2009

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