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12. Data acquisition, Geo-processing, GIS, digital mapping and 3D visualisation

Massimiliano Cannata, Nils Oesterling, Adrian Wiget

Swiss Geological Survey
Swiss Geodetic Commission
Swiss Geotechnical Commission
Swiss Geophysical Commission
Scuola Universitaria Professionale della Svizzera Italiana
Open Source Geospatial Foundation

12.1

Detection of gross-errors into gravity data of IRAN by Kriging approach

Abdollahzadeh Makan*, Najafi Alamdari Mehdi *

**K.N.Toosi University of Technology, Faculty of Geodesy and Geomatics Engineering. 1364 Valiasr Street,Mirdaamaad Intersection,Tehran,Iran*
(m_abdollahzadeh@sina.kntu.ac.ir)

The main aim of this research is to refine Iranian gravity data based on linear prediction method. Iranian gravity dataset has been observed during a long time by different gravimeters and methods. Various kinds of systematic errors have affected the observations due to uncertainty of reference frames and equipments. Hence a refinement process of gravity data seems to be necessary.

Spatially correlated data such as gravity anomaly can be validated first by geographical techniques. It should be low pass filtered (trend removal) and then the map of the filtered data must be inspected. These are done by computing a high degree geopotential model, e.g. *EIGEN04C*, and *RTM* topography effect and then removing from the free air gravity anomaly. A gross error shows up as a chimney or volcano in the countered map. In This step about 1403 points were flagged as outliers.

The size of current gravity database makes it virtually impossible to check and correct the remaining suspected errors. Hence an automatic, or semi-automatic computer based method is needed. Correlations of spatially distributed database are used to detect gross errors. If a value differs more than usual from its neighbouring values, it may be a gross error. This strategy based on *simple Kriging* approach was used with great success. As a result a number of 490 points were eliminated in the numerical process.

The map of the outlier points is presented in figure1. As one can see, there are many blunders in Iranian gravity database. Most of them belong to NCC (Iranian National Carthogeraphic Center) observations, which have been measured along the precise leveling network. These gravity points should be investigated and may need to be remeasured. The new adjustment process seems to be necessary for NCC observed points.

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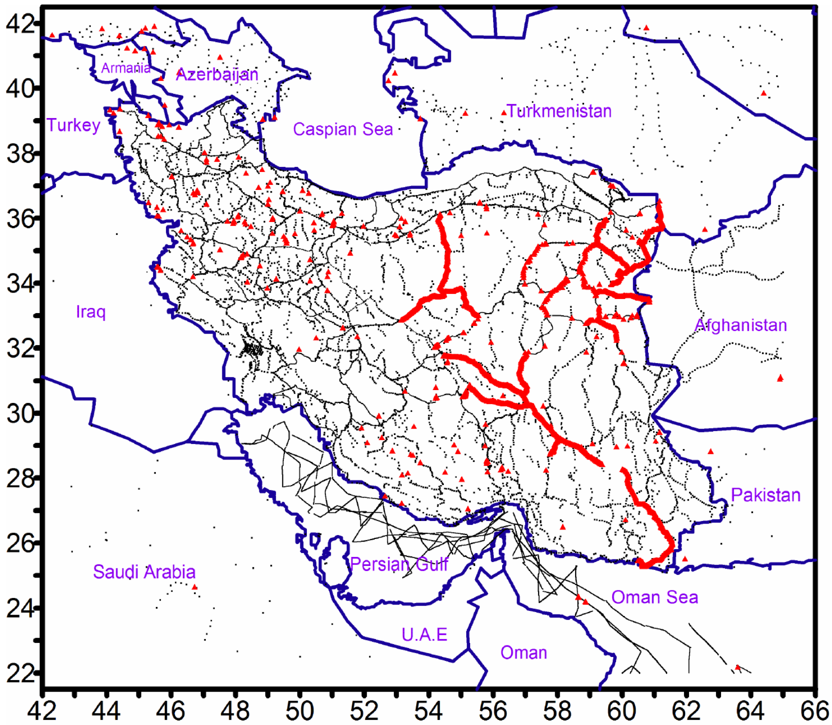

Figure1. Detected outlier gravity points (The red triangles)

12.2

The Sensor Observation Service (SOS)

Milan Antonovic

SUPSI - Institute of Earth Sciences, CH-6952 Canobbio (milan.antonovic@supsi.ch)

The SOS (Sensor Observation Service) aggregates readings from live, in-situ and remote sensors. The service provides an interface to make sensors and sensor data archives accessible via an interoperable web based interface.
The SOS is part of the OGC's SWE (Sensor Web Enablement) group of specifications.
The SWE Working Group, is establishing the interfaces and protocols that will enable a "Sensor Web" through which applications and services will be able to access sensors of all types over the Web.
This presentation introduce the main characteristic of all the SWE specifications and then explain extensively the SOS standard.

The SWE group of specifications are:

1. Observations & Measurements (O&M)
2. Sensor Model Language (SensorML)
3. Transducer Markup Language (TML)
4. Sensor Observation Service (SOS)
5. Sensor Planning Service (SPS)
6. Sensor Alert Service (SAS)
7. Web Notification Service (WNS)

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12.3
3D Geological Model of the Mont Terri Rock Laboratory

Roland Baumberger *, P. Bossart *, U. Eichenberger **, A. Kühni *, C. Nussbaum ***, Nils Oesterling *, E. Weber **

* *swisstopo, Swiss Geological Survey, Seftigenstrasse 264, CH-3084 Wabern, Switzerland*
** *Swiss Institute of Speleology and Karst-Research, CH-2301 La Chaux-de-Fonds, Switzerland*
*** *Geotechnical Institute Ltd, Fabrique de Chaux 65, CH - 2882 St-Ursanne, Switzerland*
Contact: roland.baumberger@swisstopo.ch

The Mont Terri Rock Laboratory is located in the Swiss Jura Mountains (Folded Jura, Mont Terri Anticline). It can be accessed via the security gallery of the Mont Terri Highway tunnel. Inside the mechanical, hydrogeological and geochemical properties of the Opalinus Clay Formation, a potential host rock for deep geological disposal in Switzerland, are being investigated. Since 1996 twelve partners from Europe and Japan carry out various kinds of experiments in this facility (developing test methodology, performing demonstrations and understanding processes).

Geological mapping in the region of the Mont Terri anticline was extensively performed during the last century (Laubscher, 1963). A vast amount of surface (geological maps) and sub-surface information (i.e. boreholes, tunnel profile maps) are available. However, these data have never been compiled to a 3D geological model. In order to better understand the regional geological setting around the Mont Terri rock laboratory and to prepare a basis for future hydrogeological and rock-mechanical models, swisstopo has decided to develop a 3D geological model of the Mont Terri anticline.

Using this model the subsurface geological setting of the Mont Terri region and its relationship to the galleries of the rock laboratory can be illustrated.
It is now possible to view stratigraphic boundaries, to follow the propagation of faults and to investigate regional tectonics. All these information can be correlated in a regional scale subsurface view. Additionally, the 3D model also gives important information on the consistency of the geological maps, cross-sections and drill holes.

3D modelling is an iterative and interpretive process, which proceeds over several steps. After data compilation a first, simplified 3D structural model is developed. Using that model, the correlation of structures, the discussion of different concepts, ideas and uncertainties lead to a second, refined interpretation of the geology near the rock laboratory. Subsequent refinement, interpretation and integration of new data are necessary to develop the final, detailed 3D geological model of the region of investigation.

For the successful development of a 3D geological model 1) a conceptual model of the overall geological setting and 2) the clearly defined purpose and application of the model are important prerequisites.

The development of the 3D model of the Mont Terri rock laboratory was a first step of swisstopo in the wide field of 3D geological modelling. Further projects are envisaged (such as a 3D geological information system or hydro-mechanical modelling), for which this first 3D model provides an important basis.

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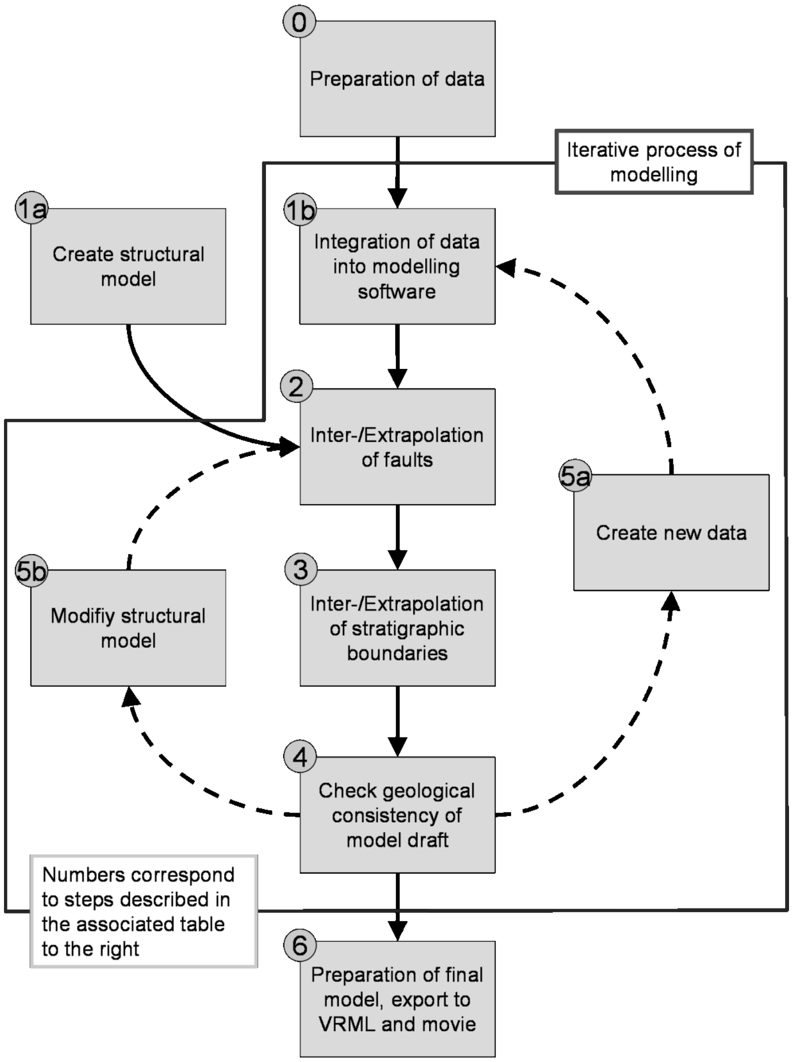

Figure 1. A possible workflow for the development of a 3D geological model (based on the experience of the Mont Terri geological model)

12.4

Bereitstellung digitaler Daten für verschiedene Nutzungen: Modellierung, Internet, Druckprodukte.

Kartografische Anforderungen, Produktions- und Darstellungsprobleme

Baumeler Andreas

Schweizerische Geotechnische Kommission, ETH-Zürich CAB E77, Universitätstrasse 6, 8092 Zürich (andreas.baumeler@erdw.ethz.ch)

Digitale Daten werden heute vor allem in drei Bereichen verwendet: als Grundlage bei Modellierungen (z.B. Hydrogeologie, 3D-Geologie) sowie für die Datenausgabe über Internet oder als Druckprodukt. Jede dieser Verwendungsmöglichkeiten stellt eigene Ansprüche an die Daten die zum Teil divergent sind (z.B. Lagegenauigkeit und Vollständigkeit der Daten bei der «Modellierung» gegenüber Lesbarkeit bei «Ausgabe Druck»). Die Verwendung eines einzigen unangepassten Datensatzes in allen oben genannten Gebieten ergibt ein suboptimales Ergebnis, da in mindestens einem Nutzungsbereich eine ungenügende wenn nicht falsche Datenrepräsentation auftritt.

Die Datensätze «Modellierung» und «Ausgabe Internet» sind sich recht nahe. Sie unterscheiden sich hauptsächlich durch die Anforderungen bei der Datennutzung. Während bei der eigentlichen Modellierung die vollständigen, lagegenauen Daten

verwendet werden und auf die Darstellung erst in zweiter Linie geachtet wird, muss bei der Ausgabe im Internet primär an die Darstellung bzw. die Lesbarkeit gedacht werden.
Von diesen beiden Datensätzen unterschiedet sich der Datensatz der Stufe «Ausgabe Druck» in stärkerem Masse. Dies ist auf folgende Punkte zurückzuführen:
1) Im Bereich «Modellierung» und «Ausgabe Internet» werden Daten laufend aktualisiert, sie sind im zeitlichen Bezug dynamisch während Druckprodukte einen Zeitauszug darstellen.
2) «Internet-Karten» sind interaktiv; durch die Möglichkeit des Ein- und Ausblendens von Themenebenen sind sie „polythematisch"; es ist möglich den dargestellten Objekten grosse Informationsmengen mitzugeben die bei Bedarf abgerufen werden können. Zudem kann die Symbologie mit dem Darstellungsmassstab verknüpft werden so dass bei Vergrösserung des Bildausschnittes mehr Objekte dargestellt werden können. Gedruckte Karten dagegen sind meistens „monothematisch"; ausgewählte Daten sind in einer festen Grösse dargestellt; die Menge der darstellbaren Objekte ist limitiert durch den Platz der zur Verfügung steht.

Trotz der genannten Einschränkungen sind gedruckte Karten eine unumgängliche Form der Datenpräsentation. Als einziges Medium erlauben sie eine hochauflösende Darstellung weitreichender, zusammenhängender Gebiete in grossem Massstab. Weiter haben sie eine hohe Wichtigkeit durch eine, von technischen Mitteln praktisch unabhängige, Benuzungsmöglichkeit. Nicht zuletzt steht die Tatsache, dass Druckprodukte bislang die einzige wirklich unproblematische Form der langfristigen Datensicherung darstellen.

Bei vorausschauender Projektplanung können die einzelnen Produkte einfach voneinander abgeleitet werden. Die Datenaufnahme mit lagegenauer Objekterfassung bildet die gemeinsame Grundlage. Bei geologischen Karten werden sie durch Ergänzungen (Interpretation) zu einem Gesamtbild vervollständigt. Aus diesem Grunddatensatz, der im Bezug auf die Objektivität den höchsten Grad aufweist, können die Produkte in der Reihenfolge «Datensatz Modellierung» → «Ausgabe Internet» → «Ausgabe Druck» abgeleitet werden.

Die Aufbereitungsschritte sind folgende:
Bei der «Ausgabe Internet» sind für festegelegte Massstabsstufen Generalisierungen der dargestellten Themenebenen abzuleiten. Ebenfalls ist über die Programmsteuerung festzulegen, bei welcher Vergrösserungsstufe welche Daten sichtbar sein sollen.
Für die «Ausgabe Druck» müssen weiterreichende Arbeiten vorgenommen werden. In Druckprodukten kommt der Lesbarkeit ein wesentlich höherer Stellenwert zu als dies bei der «Ausgabe Internet» der Fall ist. Hochqualitative Druckprodukte sind wissenschaftlichen Zeichnungen vergleichbar: sie weisen einen hohen Stilisierungsgrad auf und versuchen damit neben der eigentlichen Widergabe der objektiven Fakten die zugrunde liegende wissenschaftliche Idee klar hervorzuheben. Die Voraussetzung dafür ist eine konsequente Überarbeitung der Daten: Flächen brauchen eine minimale Grösse, Bänder eine minimale Breite. Der Linienverlauf muss klar sein und den Lesefluss lenken. Die dargestellten Punktinformationen müssen so platziert werden, dass sie sich oder andere Objekte nicht abdecken. Diese Schritte erfordern teilweise starke Eingriffe in den ursprünglichen Datensatz: die Lagegenauigkeit der Objekte wird verändert, Objektklassen werden nach dargestelltem Thema gewichtet und damit verstärkt d.h. überdimensioniert dargestellt.

12.5

Digitale Kartografie für GIS und Kartendruck mit Grafikprogrammen

Baumeler Andreas

Schweizerische Geotechnische Kommission, ETH-Zürich CAB E77, Universitätstrasse 6, 8092 Zürich (andreas.baumeler@erdw.ethz.ch)

Grafikprogramme wurden bisher vor allem für Digitalisierungs- und Gestaltungsarbeiten von Druckprodukten verwendet. Für den Zweck der GIS-Daten-Erfassung wurden sie als ungeeignet betrachtet, da sie zum einen weder über Werkzeuge zur Georeferenzierung oder Attributierung verfügten und es zum anderen nicht möglich war konsistente Daten zu produzieren.
Neuere Entwicklungen in professionellen Grafikprogrammen (Illustrator, Freehand) erlauben eine gleichartige Datenhandhabung und Datenhaltung wie GIS-Programme. Das bedeutet, Flächen, Linien und Punkte können konsequent als Objekte dargestellt werden. Jedes dargestellte Element gehört einer vorgegebenen Klasse an die weiter attributiert werden kann. Die Georeferenzierung erfolgt über eine Programmerweiterung; Geometrie, Klassenzugehörigkeit und Attribute der Objekte können auf diese Weise in GIS-Programme exportiert werden. Ebenso sind Import und Bearbeitung von GIS-Dateien möglich

Die Vorgehensweise der Datenerfassung über Grafikprogramme bietet zwei wesentliche Vorteile:
1) rasche und einfache Datenerfassung durch Verwendung von Bézierlinien
2) freie Gestaltung der kartografischen Elemente, der dargestellten Objekte und der Maquette. Damit ist die Möglichkeit der Druckausgabe in hoher Qualität gegeben

Bézierlinien beschreiben einen Kurvenverlauf mathematisch mit wenigen Ankerpunkten. Damit ist eine präzise Erfassung komplexer Kurvenverläufe möglich Korrekturen und Anpassungen können einfach durchgeführt werden. Für den Export in GIS werden die Bézierlinien in Polylinien konvertiert. Mit Hilfe eines Zusatzprogrammes des Institutes für Kartografie (IKA, ETH-Zürich) kann diese Konvertierung gesteuert und mit hoher Präzision durchgeführt werden.

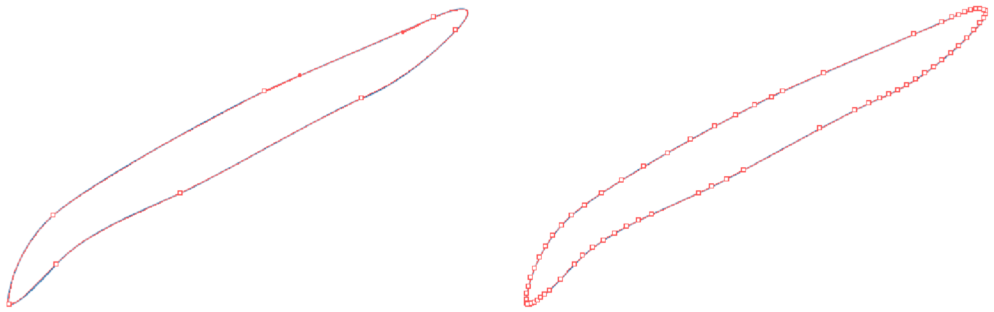

Abbildung 1: Vergleich der Liniendarstellung durch Bézierlinien (links) und Polylinien (rechts) nach dem Konvertierungschritt.

12.6

The relevance of digital data and techniques to applied geosciences

Beer Christoph* & Beres Milan*

*Swiss Geological Survey, Federal Office of Topography swisstopo, Seftigenstrasse 264, CH-3084 Wabern (christoph.beer@swisstopo.ch)

Geoinformation has become one of the most important components of the national economy. An added value is thereby created in economic, administrative and everyday activities. The current market volume of the private geoinformation market is estimated to total 500 Mio. Swiss Francs per year (Fig.1). In comparison to estimates in 2002, the market volume has increased by 300 Mio. Swiss Francs, equivalent to 5% growth per year.

The operational meaning of digital technology is in the making of existing data useful, in the transfer of knowledge and in the networking and co-ordination of data sources down to the customer groups. The most modern technology is essential for handling digital data, particularly in knowledge management. Such technology permits the association of simple datasets for the purpose of recognizing their significance and eventually gaining practical information from them. If this new information is linked with existing information and knowledge, then more knowledge can be generated. Increased knowledge improves the understanding of phenomena and the development of innovative solutions.

Together with the free market use, digital geodata and geoinformation have substantial social and economical uses. They are indispensable for making clear and comprehensible decisions and for engaging the public in important political decisions and social developments. Geoinformation is becoming increasingly important in practically all aspects of life. Various studies of cost-use analyses show that the economical use of digital geoinformation is 4 to 10 times higher than its production cost.

Digital geodata are a raw material with the highest potential in the supply chain. On the one hand there is the one-time profit margin within the value chain of a data-producing enterprise. But since geodata and geoinformation reside in a network of various customers and multiple refinement stages, their added value becomes enormous.

In short, Geodata are a top-ranking good in both political and economical regards.

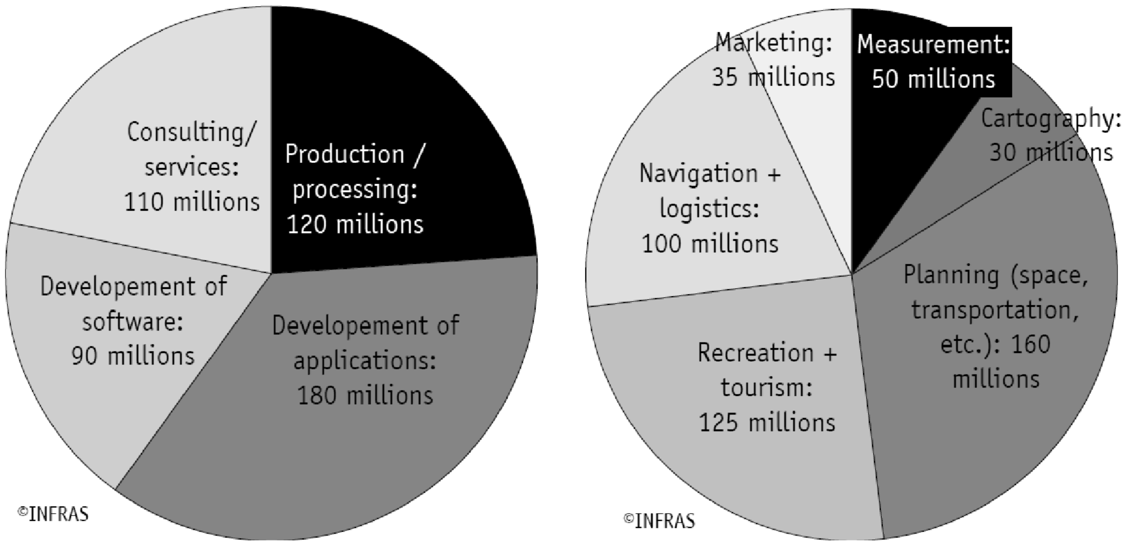

Figure 1: Current market volume categorized by providers (left) and applications (right).

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12.7

GIS-supported Geology and Fieldwork in the Eastern Greater Caucasus

Bochud Martin*, Mosar Jon*

**Science de la Terre, Département des Géosciences, Université de Fribourg, Chemin du Musée 6, CH-1700 Fribourg (martin.bochud@unifr.ch)*

The evolution of new GIS-supported technologies allowed modifying the habits of geologist, especially in the field, during data acquisition and mapping. Sturdy field-computers and GPS have the same importance as field-books and maps.
For the last 5 years, the tectonics group of the University of Fribourg works with portable field-computers and GPS in remote locations of the Eastern Greater Caucasus. Expeditions often require work in areas with no electricity other than supplied by batteries. Presently we use Xplore field-computers equipped with GPS and ArcGIS Desktop capabilities. In addition, we use sophisticated high precision Trimble GeoXH GPS mini-computers with antennas and ArcPad (both from ESRI) to work in the field.

Using this tools makes it possible to introduce all types of measurements directly in a geodatabase. Our geodatabase includes all structural data such as: bedding, schistosity, faults and associated lineations such as striations, axial planes, fold axis, samples location and description as well as pictures. Each datum can be linked with a detailed description, drawings and/or photos. More importantly it allows the geologist in such remote areas to always find its exact position. This is important in regions with no detailed topographic maps and no geology maps. We than rely on satellite imagery and documents scanned and georeferenced. It allows us also at any time to retrieve data already available in the database.

In Azerbaijan the availability of essential data such as topographic maps turned out to be impossible. Especially topographic or geological maps at scales 1:25000 or 1:50000 fall under military restrictions. However the large resources of the www made it possible to find Russian maps at 1:100'000, free satellite images from Landsat (Geocover and ETM+ with the seven spectral bands), digital elevation model at 90 meters from the Shuttle Radar Topography Mission (SRTM) and a geodatabase with all locality and place names of Azerbaijan. The place name geodatabase allowed to homogenize the place names and to avoid some misunderstanding in papers.

Before leaving to the field, we export the data from the geodatabase to the GPS PDA. In the field we work mostly with the handheld GPS (Trimble GeoXH), and the computer tablets (Explore). At the end of each field day, we transfer new measurements in our geodatabase, where it is than possible to make more detailed annotations, but also modifications or corrections. The updated database is subsequently available for the following days. It can also be used by different groups working in neighbouring areas.
The use of a GIS-database improves the efficiency and extends the boundaries of the geological research, making it possible to share them with co-workers and making them available through the www. The biggest problem with geodatabase is generally not to create, but to fill them with data. Working in the field with PDA and field computer allows filling the geodatabase directly. GIS software now offers numerous possibilities and tools for mapping but also for sophisticated calculations, to compare data, to combine maps and data and to create our own maps.

Similar databases have been developed in international projects such as MEBE in response to the demands and needs of supporting groups from the oil industry. On a more local scale similar needs are expressed by local authorities and other institutions collecting data and surveying the environment.

In addition, we are in the process of implementing these tools for mapping exercises in geology on a bachelor level. It allows the students to develop a multidisciplinary approach to “classic geological mapping”! This is perceived by students as a stimulating exercise otherwise often considered “uninteresting”.

5-years experience in field-work in remote areas of the Greater Caucasus have shown that the field computer and GPS handheld computer are rugged enough to tolerate difficult field conditions such as heat and shock as well as rain, or even short immersion in water (student falling into river with equipment!). The only shortcomings are that they cannot (should not!) be used as hammer or as magnifying lens!

12.8

The National Spatial Data Infrastructure

Buogo Alain*, Buser Rolf*, Sonney René*, Wiget Adrian**

**Federal Office of Topography swisstopo, Coordination, Geo-Information and Services (COGIS), Seftigenstrasse 264, CH-3084 Wabern*
*** Federal Office of Topography swisstopo, Geodesy, Seftigenstrasse 264, CH-3084 Wabern (adrian.wiget@swisstopo.ch)*

Geographical information is data which is spatially referenced by means of coordinates, place names, postal addresses or similar criteria. 60 to 80 percent of all political and economic decisions are of spatial nature. The Swiss federal administration, mandated by the Federal Act on Geoinformation (GeoIG) and lead-managed by COGIS, the Coordination, Geo-Information and Services Division of the federal office of topography swisstopo (www.swisstopo.ch) follows the strategy to facilitate the integration of the widest possible selection of data, to make access easier and to promote the application of this data through the coordination and harmonisation of geographical information. With wider and more intensive usage, greater economic benefit can be achieved from the geographic information which is already available. This will add value for all those involved – federal, cantonal and local government, organisations in the private sector and the scientific community as well as the general public.

The federal strategy for geographical information is also in accordance with the EU directive INSPIRE (Infrastructure for Spatial Information in Europe). In order to implement the strategy and to access the enormous amount of available data, it is proposed to set up a user-friendly, decentralised but networked system. Such a national spatial data infrastructure (NSDI) depends on political, organisational, financial, legal and technical components. First of all it is essential to create an organisational framework for the activities of partners in Switzerland involved in the implementation of the NSDI: Federal, cantonal and local governmental bodies and other organisations like SOGI, the Swiss Organisation for Geographic Information (www.sogi.ch). To this end, the e-geo.ch “impulse programme” was launched in order to build and promote a network of contacts and a project management organisation covering the whole of Switzerland.

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12.9
FOSS4G: open source tools for geoinformation

Massimiliano Cannata*

**Institute of Earth Scences – SUPSI, Trevano, C.P. 72, CH-6952 Canobbio*

This presentation is an introduction to FOSS4G and what it is about. Introducing the concepts of Open Source Software, Open Source Geospatial foundation, and related geoinformation projects. The goal of the presentation is to welcome newcomers who might like to learn more about FOSS4G and join in the effort.

A large number of geoinformation software has been developed during the last decade. During their evolution often they took inspiration each others and now as a result they are quite similar in capabilities: generally they all (i) manage numerous data format, (ii) produce customizable map visualization, (iii) handle attributes, vector, raster and image data types, (iv) perform general and spatial query/analysis, (v) produce web services, (vi) provide web-GIS interface.
Generally software can be subdivided in two classes: the proprietary software and the Free and Open Sources Software (herein referred to as FOSS).
The first class describes software offered for sale or license, where the users are not allowed to see the source code. Nor are they able to modify the code for their own use or to distribute to others. The vendor is the only proprietary of the software and the user just acquire a licence for use it as it is. On the contrary FOSS denote some user freedom rights such as to run, copy, distribute, study, change and improve the software. As described in the Web-Site of the Free Software Foundation (FSF [1]) the word "free" refers to four kinds of user freedom:

- The freedom to run the program, for any purpose.
- The freedom to study how the program works, and adapt it to any needs.
- The freedom to redistribute copies.
- The freedom to improve the program, and release the improvements to the public, so that the whole community benefits.

For the second and fourth points access to the source code is a precondition.
In order to guarantee this freedom, FOSS are usually licensed under the GNU General Public License (GPL): GPL licence makes restrictions that forbid anyone to deny these rights. Distributed copies of a GPL licensed program, whether gratis or for a fee, must give the recipients all the original rights of freedom; thus the distributor must also make sure that users, too, receive or can get the source code.
While proprietary software grown pushed by commercial goals and concentrated theirs efforts in developing "easy to use" software, FOSS grew to solve problems and develop projects – often governmental or research projects – resulting in high effective but often not friendly software and therefore delegated to a small niche of geoinformation specialists.
The FOSS4G (Free and Open Source Software for Geoinformation) term denote all the FOSS related to geoinformation. Some of them (actually the most diffuse) are today associated in the Open Source Geospatial foundation (OSGeo [2]).
OSGeo, is a not-for-profit organization whose mission is to support and promote the collaborative development of open geospatial technologies and data. The foundation provides financial, organizational and legal support to the broader open source geospatial community. It also serves as an independent legal entity to which community members can contribute code, funding and other resources, secure in the knowledge that their contributions will be maintained for public benefit. OSGeo also serves as an outreach and advocacy organization for the open source geospatial community, and provides a common forum and shared infrastructure for improving cross-project collaboration.
Some of the OSGeo detailed goals are:

- To provide resources for foundation projects - eg. infrastructure, funding, legal.
- To promote freely available geodata - free software is useless without data.
- To promote the use of open source software in the geospatial industry (not just foundation software) - eg. PR, training, outreach.
- To encourage the implementation of open standards and standards-based interoperability in foundation projects.
- To ensure a high degree of quality in foundation projects in order to build and preserve the foundation "brand".
- To make foundation and related software more accessible to end users - eg. binary "stack" builds, cross package documentation.
- To provide support for the use of OSGeo software in education via curriculum development, outreach, and support.
- To encourage communication and cooperation between OSGeo communities on different language (eg. Java/C/Python) and operating system (eg. Win32, Unix, MacOS) platforms.
- To support use and contribution to foundation projects from the worldwide community through internationalization of software and community outreach.

Currently OSGeo Projects include web mapping (deegree, Mapbender, MapBuilder, MapGuide Open Source, MapServer, OpenLayers), desktop applications (GRASS GIS, OSSIM, Quantum GIS, gvSIG), geospatial libraries (FDO, GDAL/OGR, GEOS, GeoTools), metadata catalog (GeoNetwork), and other projects (Public Geospatial Data, Education and Curriculum).

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12.10

The "cadastre géologique" of the canton of Vaud: a geoinformatic tool to collect, manage and publish geological data.

Giorgis David*

Office de l'information sur le territoire (OIT), DINF, Av. de l'Université 5, 1014 Lausanne (david.giorgis@vd.ch)

The "cadastre géologique" of the canton of Vaud was created to collect, store and distribute systematically, information coming from boreholes and other mechanical underground investigations. An information system was developed, mainly based on web technology. This system contains cartographic overview, borehole insertion (with online e-form) and tracking, as well as the possibility to attach documents. In addition, data extraction and creation of different user's profile is also possible.
This gathering information constitutes part of the geoscience knowledge's base which is then processed by Geographic Information Systems (GIS) to integrate the various sources of information and produce derived graphics, maps and models describing the underground characteristics. It allows the better integration of geology and three-dimensional planning in the different processes of landscape management, in a perspective of sustainable development.
Presently, these geological information, have been used for seismic microzonation mapping and other regional projects (for example : evaluation and mapping of resource for ground source heat pump system) will integrate intensively these data.
The "cadastre géologique" web application can be shared by other cantons (currently three are concerned) and possibility of collaboration with other public administrations is open and welcome, in order to use common tools to collect, manage and publish geological data.

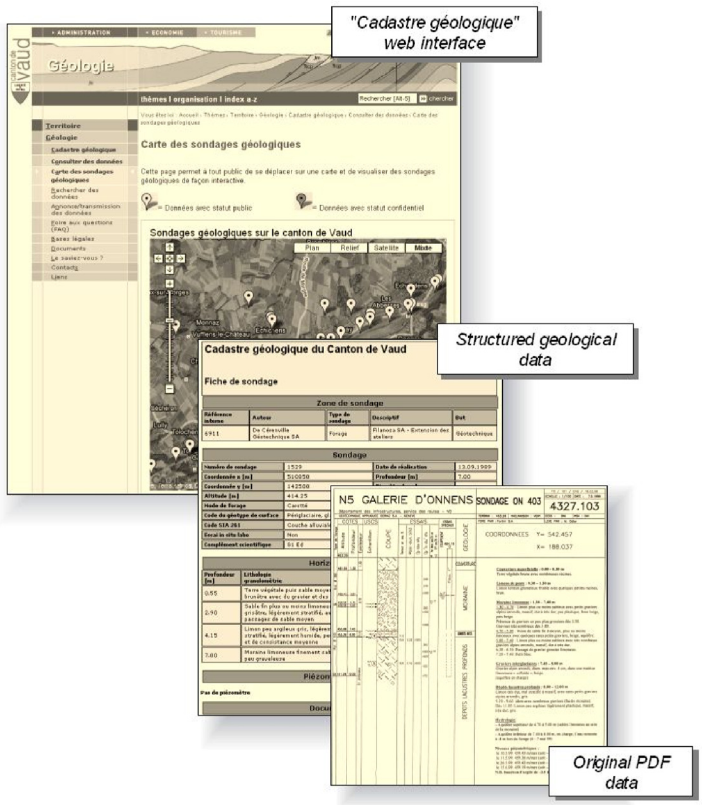

Figure 1. Example of screenshots from the "cadastre géologique" web portal (www.geocad1.vd.ch). This web application is written in PHP using MySQL (Open Source components).

12.11

Borehole Evapometer measurements: Detection of zones with different hydraulic conductivities in the Opalinus Clay

Lukas Glur*, Paul Bossart*, Martin Herfort**, Edi Meier*** & Christophe Nussbaum****

** Swisstopo, Route de la Gare 65, CH-2882 St-Ursanne.*
*** Swiss Federal Nuclear Safety Inspectorate HSK, CH-5253 Villigen-HSK,*
**** Edi Meier und Partner AG, Jägerstrasse 2, CH-8406 Winterthur.*
***** Institut Géotechnique, Route de la Gare 65, CH-2882 St-Ursanne*

The estimation of physical parameters such as hydraulic conductivity or evaporation rate in different structural and lithological units of the Opalinus Clay is very important for assessing safe radioactive waste disposal. This study was carried out in the Mont Terri rock laboratory in the framework of the evaporation logging experiment. New equipment, the borehole evapometer, has been developed by swisstopo in recent years. The borehole evapometer is now ready for in-situ hydraulic testing in very low permeable formations.

The present aim of this evaporation logging experiment is to detect zones with varying hydraulic conductivities in the Opalinus Clay, which were measured by HSK and swisstopo. Of particular interest is the comparison between the excavation damaged zone (EDZ) and undisturbed Opalinus Clay. The measurements were carried out at several depths along three boreholes cutting through the EDZ.

The borehole evapometer is a tool for estimating the evaporation rate and the hydraulic conductivity in a packed-off borehole test interval of 1m length. This method uses a constant air flow through the borehole test interval. By measuring differences in relative humidity and temperature, the evaporation rate and the resulting hydraulic conductivity can be calculated. The integrated evaporation rate over the whole test section can be obtained, as well as local evaporation rates along fractures cutting the borehole wall.

Several experimental set-ups and procedures were applied and compared, including variations in duration, frequency, spatial, temporal and instrumental resolution, air-flow direction, imposed humidity difference, borehole inclination and time of day. The results were compared with drillcore mappings, high-resolution optical televiewer (DOPTV) and seismic measurements of the respective boreholes (Yong 2007) and mineralogical analysis of core samples.

The measurements of temperature, humidity as well as the derived evaporation rates and hydraulic conductivities (k) depend strongly on the experimental procedure and the borehole history. A correlation with the extent of the EDZ and with borehole depth is visible. The calculated k values range from 10-13 to 10-15 m/s and are comparable to undisturbed Opalinus Clay. Temperature decreases and absolute humidity increases with borehole depth in all tested boreholes. The method is suitable for determining small-scale k values in low-permeability formations.

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12.12

Dynamic Monitoring of Load Tests by Kinematic Terrestrial Laser Scanning

David Grimm* & Hans-Martin Zogg*

Institute of Geodesy and Photogrammetry ETH Zurich, Wolfgang Pauli-Strasse 15, CH-8093 Zurich ([grimm, zogg]@geod.baug.ethz.ch)

In relation with maintenance works of the runway at the Hamburg Airport in Germany, a convenient method to reinforce the soil surrounding the concrete runway was subject of investigation. A fixing of the soil is important with regard to aircrafts accidentally passing over the runway. To prove the suitability of the soil fixings, load tests were performed on three different purpose-built test fields (Figure 1).

For these tests, the aircraft was simulated by a crane with a weight of about 200 tons. The crane drove backwards into the test fields. Besides the sinking of the crane into the test fields, the size of the bow wave, which occurs on the first wheel while driving into the mud, was of main interest. The surface of the test fields had to be permanently monitored during the test drives.

For the dynamic monitoring of the occurring bow wave, three different geodetic measurement methods were considered: photogrammetry (videogrammetry), kinematic terrestrial laser scanning (TLS), and range imaging (RIM). Finally, the monitoring was performed by kinematic TLS. Photogrammetry would have required additional illumination of the scenery. Furthermore, the soil surface was homogeneous and colour variances could hardly be detected. The RIM technology, a new measurement technology for geodetic engineering (Kahlmann & Ingensand, 2007), did not fulfil the requirements in terms of measurement accuracy. Nevertheless, this new technology allows the acquisition of full 3D-images and promises big advantages compared to traditional measurement methods for the future. In addition, the soil was expected to be wet and partially inundated. Thus, a requirement of the used laser scanner had to be the feasibility to measure through a layer of water with a thickness of several centimetres (Vogel, 2008).

Consequently, the profile laser scanner SICK LMS200-30106 by Sick AG (Zogg & Grimm, 2008) was mounted underneath the crane in front of the crane wheel for the dynamic monitoring of the occurring bow wave during the load tests (Figure 2). The laser fan was adjusted along the driving direction of the crane (Figure 3). The crane was additionally tracked by three total stations for the localisation in a global coordinate system. For the detection of the bow wave size, the relative position of the profile scanner was sufficient. The surface, which had not been run over yet by the crane, served as horizontal reference for the profiles. This also enabled the elimination of inclination variations of the profile scanner along the driving direction.

To make possible a practicable analysis of the measurements, particular software was developed. The software automatically classified the point cloud into points on the wheel and points on the soil surface. Thus, the height of the bow wave could be detected in each scanning profile (Figure 4 and Figure 5). Finally bow waves with a size of up to 18 cm could be located. Accordingly, the tests pointed out that kinematic TLS was a qualified measurement method for this particular application.

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Figure 1. Test field for the load tests.

Figure 2. 2D-laser scanner mounted underneath the crane.

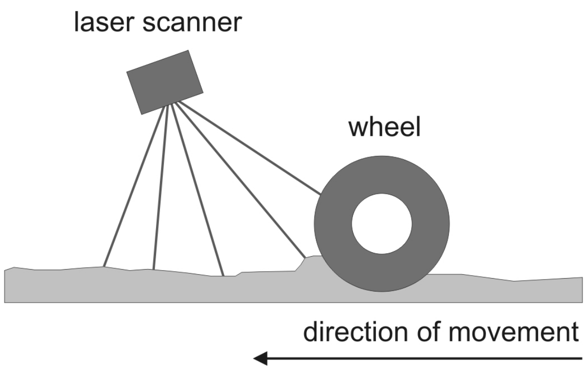

Figure 3. Measurement setup.

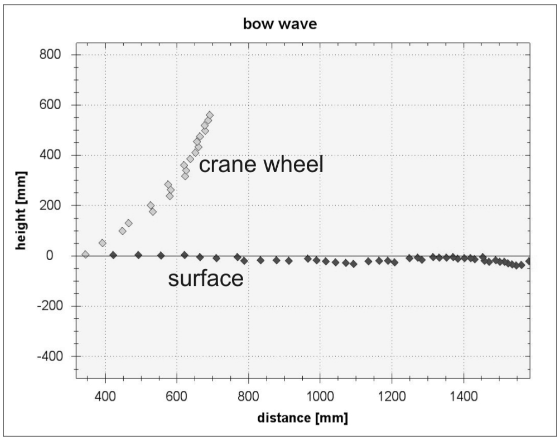

Figure 4. Profile measurements before the crane entered into the test field.

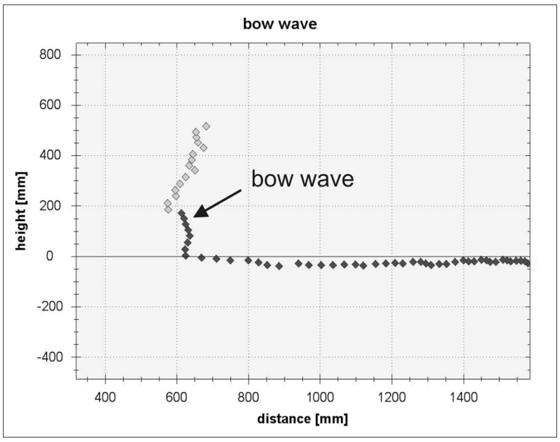

Figure 5. Detection of bow wave while driving into the test field.

12.13

Geomorphologic mapping of Lake Lucerne - the potential of high-resolution bathymetry data

Hilbe Michael*, Anselmetti Flavio S.*, Eilertsen Raymond** & Hansen Louise***

**Eawag, Swiss Federal Institute of Aquatic Science and Technology, CH-8600 Dübendorf; michael.hilbe@eawag.ch*
***Geological Survey of Norway (NGU), N-9296 Tromsø*
****Geological Survey of Norway (NGU), N-7491 Trondheim*

Water bodies are major «blank areas» on the sheets of the Geological Atlas of Switzerland. Geomorphologic and geologic data for the lake floors included in these maps are sparse and only few published geological maps of Swiss lakes exist (e.g. Schindler, 1976). These are mainly based on single beam echosounder data, reflection seismic profiles and surface sediment samples. However, the acquisition and evaluation of large amounts of data covering entire lakes are laborious and may nevertheless fail to yield a sufficiently high resolution required to detect small-scale features on the lake floor. Recently collected high-resolution swath bathymetry data for parts of Lake Lucerne now provide a digital terrain model of the lake bottom with a resolution similar to that of airborne laser scanning on land, allowing an accurate identification of sublacustrine morphologic features.

A raster dataset with a cell size of 1 m was acquired using a Geoacoustics GeoSwath interferometric sonar system at 125 kHz coupled with accurate GPS positioning (swipos-GIS/GEO service). At this scale, it is possible to image not only small structures, but also surface textures of the lake floor. Backscatter intensity recorded along with depth data gives additional information on the properties of the sediment. Comparing the new data with existing limnogeologic studies (e.g. Schnellmann et al., 2005; Strasser et al., 2007) allows the mapping of for instance subaqueous slides, rockfall deposits and moraine ridges.

Using the large Weggis slide (Schnellmann, 2005; Figure 1) as an example, further details can be resolved. The slide covers most of the gently dipping northern slope of the Vitznau basin and was triggered by an earthquake in 1601 A.D. The scar, a 4 to 7 m-high step, can be traced along the slope over a distance of more than 6 km. The intact Holocene sediment drape above the scar is characterised by a smooth surface with diffuse depressions and elevations representing pre-existing glacial features or older slide scars. The sliding surface below the scar has a rough texture and consists of glacial deposits and bedrock (high backscatter amplitude and visible bedding) under a thin post-slide cover (Strasser et al., 2007). Chunks of apparently undisturbed sediment and minor mass flow deposits rest on a slope terrace. Deformation of the basin plain sediments resulting from gravitational loading by the slump deposits at the toe of the slope is expressed by an array of arch-shaped ridges on the flat lakebed.

Merging the new data with existing high-resolution terrain models will provide a seamless view on the geomorphology of lakes and their catchments. The integration of the swath bathymetry and backscatter data with selected reflection seismic profiles and sediment samples can be an efficient approach to complement geologic maps within water bodies.
This study was funded by the Federal Office of Topography (swisstopo), the Federal Office for the Environment (BAFU) and the Federal Department of Defence, Civil Protection and Sport (VBS).

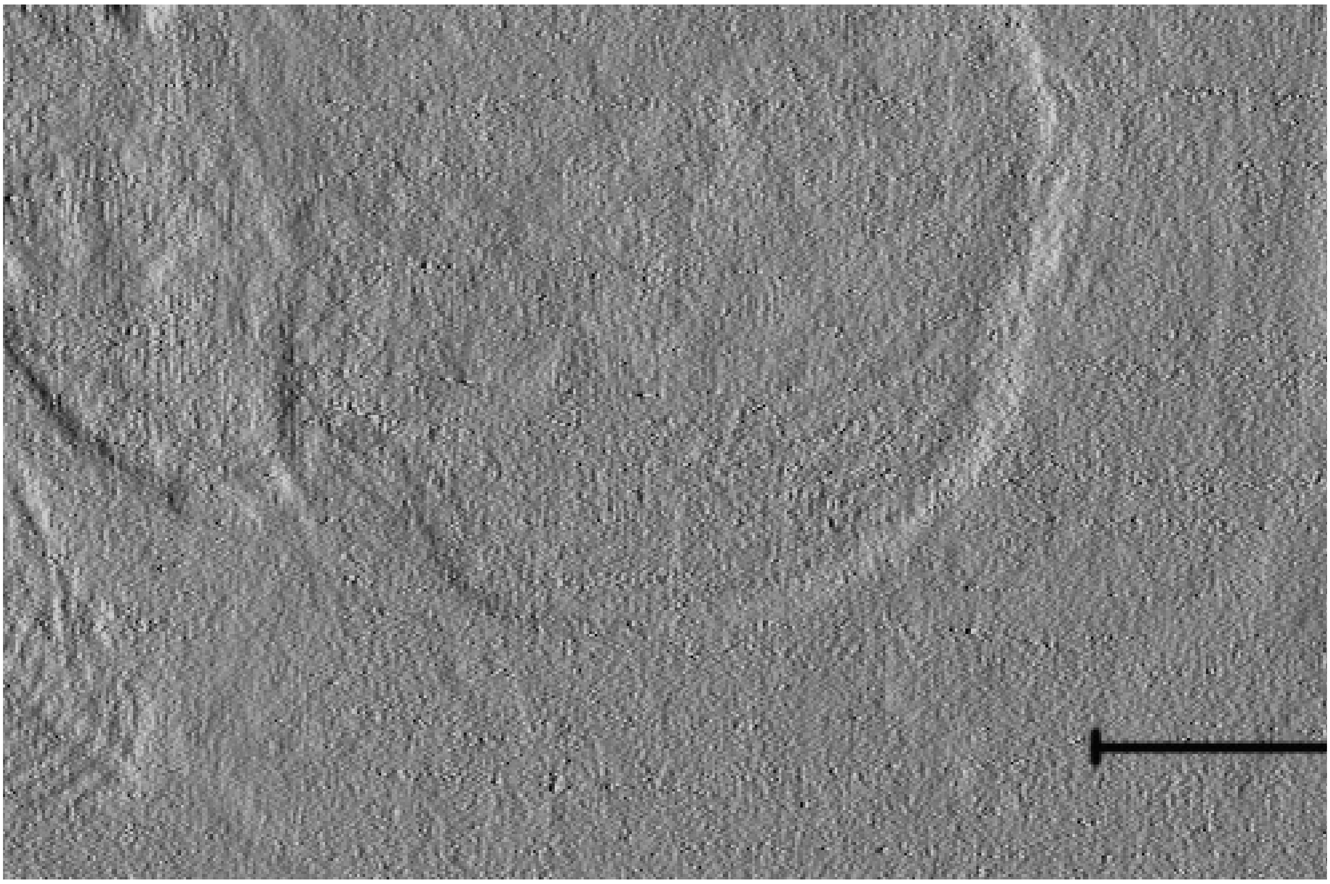

Figure 1: Shaded relief of the Weggis slide showing a prominent slide scar, different surface textures on the sliding plane and deformation features on the basin plain. Illumination from east.

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12.14

A 3D geological model of North-East Switzerland, a GIS solution

Jordan Peter*, Schwab Marco*, Schneider Heinz*, Schnellmann Michael**, Weber Hanspeter**, Neaf Henry*** & Alber Wilfried****

** Böhringer AG, Mühlegasse 10, 4104 Oberwil*
*** Nagra, Hardstrasse 73, 5430 Wettingen*
**** Büro für angewandte Geologie, Vadianstrasse 41a, 9000 St. Gallen*
***** Albert Consulting, Altenburgstr. 30, 5430 Wettingen*

This paper presents a geological 3D model of northern Switzerland (from Oensingen to Lake Bodan). It consists in a 25m raster grid corresponding to the DEM25 of the Federal Office of Topography. It is based on an extensive collection of data about the underground: geological maps, historical isolines maps, borehole data, seismic data and geological profiles were used to construct the elevation of 4 important geological horizons. The raw data are the basis for the construction of isolines that were designed from experts in a GIS environment and only them where used as input for interpolation. In order to model the discontinuities and faults, the construction of isolines and the interpolation were performed in separated segments and merged in a further step.
This extensive work of transposition of geological data into Isolines originates in the facts that all classical interpolation methods (IDW, Spline, Kriging) applied on points do not correctly represent the geological pattern expected between hard data (e.g. boreholes). Geological interpretation and accepted geological concepts have also better been integrated into the model.
The resulted model represents finally the stage of knowledge about the extent of a geological horizon and incorporates an "interpolated" summary of numerous source of information about the underground. This opens the door for landuse management in the vertical dimension, underneath the biosphere.

12.15

Analysing landslide features through scale using the wavelet transform – Theory and application to the earth flow type landslide of Travers (Switzerland)

Kalbermatten Michael*, Turberg Pascal**

** Laboratoire de systèmes d'information géographique, Ecole Polytechnique Fédérale de Lausanne, Ecublens, CH-1015 Lausanne (michael.kalbermatten@epfl.ch)*
*** Laboratoire de géologie de l'ingénieur et de l'environnement, Ecole Polytechnique Fédérale de Lausanne, Ecublens, CH-1015 Lausanne*

The analysis of specific features of a landslide is often conducted through visual terrain assessment. In recent years, LIDAR (LIght Detection And Ranging) data acquisition has made it possible to produce high resolution (0.5-2 meters resolution) digital elevation models (DEM). The visual analysis of high resolution DEMs is a new way used by geologists to characterise landslide features through the abstraction of scale-dependent features. Thus, the geologist carries out a multiscale analysis of the high resolution DEM due to the fact that geological features (composing a landslide e.g.) are not visible at one specific scale, but nested in each other.

The wavelet transform (Mallat, 2000), is a localized frequency analysis (or filter) for image generalization. It is possible to divide the continuous scale into discrete scale intervals. At each discrete scale level (or generalization level), we can analyse high frequency structural features and reconstruct these features at high resolution.

We present a case study where we assess the scale dependence on a landslide located near Travers (Val-de-Travers, Canton of Neuchâtel, Switzerland). A LIDAR survey had been carried out one month after the landslide. Derived from these raw elevation data points, collected through LIDAR, a DEM was interpolated (1 meter resolution).

The study area was visually and geologically analysed by a geologist. Thereafter the results were compared to the images obtained by the wavelet transform details coefficients.

In our presentation we show that there are significant links between geological features and the wavelet-transform results. They can be related to the evaluation of the stability over the observed area but also to the sliding mechanism itself. The features that we have detected can be classified through the intervals of discrete scale defined by the transform and thus could lead to associate a specific scale to the identification of a particular process (slide, flow, etc.) or a particular characteristic of the landslide (thickness, geological heterogeneity, etc.). In that sense, it could greatly help in hazard and risk assessment.

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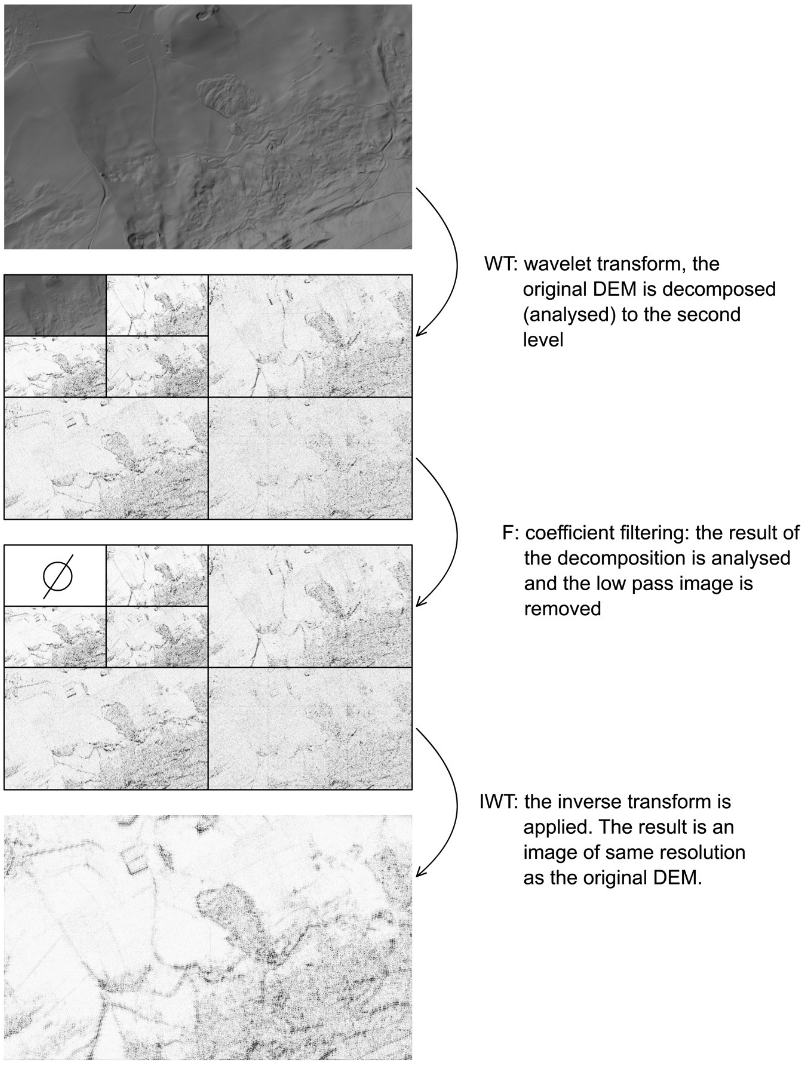

Figure 1. Wavelet transform – analysis, filtering and synthesis.

12.16

"GeoKernels.org": kernel-based methods for spatio-temporal data. Analysis, modelling and geo-visualisation

Kanevski Mikhail*, Pozdnoukhov Alexei*, Timonin Vadim*

**Institute of Geomatics and Analysis of Risk (IGAR), University of Lausanne, CH-1015 (Mikhail.Kanevski@unil.ch)*

This poster presents general problems and approaches to spatial data analysis, modelling using machine learning (Artificial Neural Networks and Statistical Learning Theory) and visualisation using GIS tools and web-mapping. A range of examples (available online at the www.geokernels.org website) are presented which illustrate the theory of machine learning algorithms (adaptive data-driven methods) case studies including topo-climatic modelling and software modules. Web server contains also several teaching-oriented interactive tools highlighting the properties of the methods of spatial data acquisition, analysis, modelling and mapping. An example devoted to the operational use of machine learning approaches presented in the poster and available at (see www.geokernels.org) concerns an automatic web-service for online real-time temperature mapping.

The map presented in Figure 1 was generated automatically and is based on the measurements from 70 stations of MeteoSwiss. The profile of the temperature along the route is presented as a one-dimensional graph (bottom-right). The Google Earth satellite image is used as a background image.

Figure 2 presents an example of interactive spatial data input and automatic spatial classification using Support Vector Machines (SVM) which is a workhorse of Statistical Learning Theory. Parameters of the model were chosen automatically with a leave-one-out cross-validation procedure.

Future developments deal with adaptation, testing and validation of machine learning models for automatic spatio-temporal data analysis, modelling and geo-visualisation of raw data and the results, including simulated data and real case studies from environmental pollution, natural hazard risk mapping, and renewable resources assessments.

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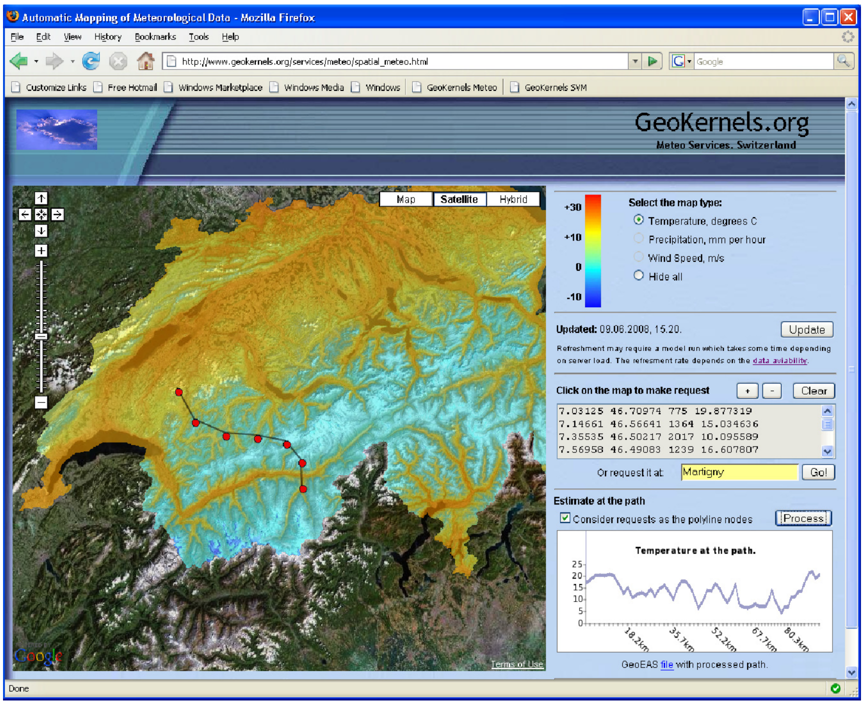


Figure 1. Online mapping of the current air temperature in Switzerland.

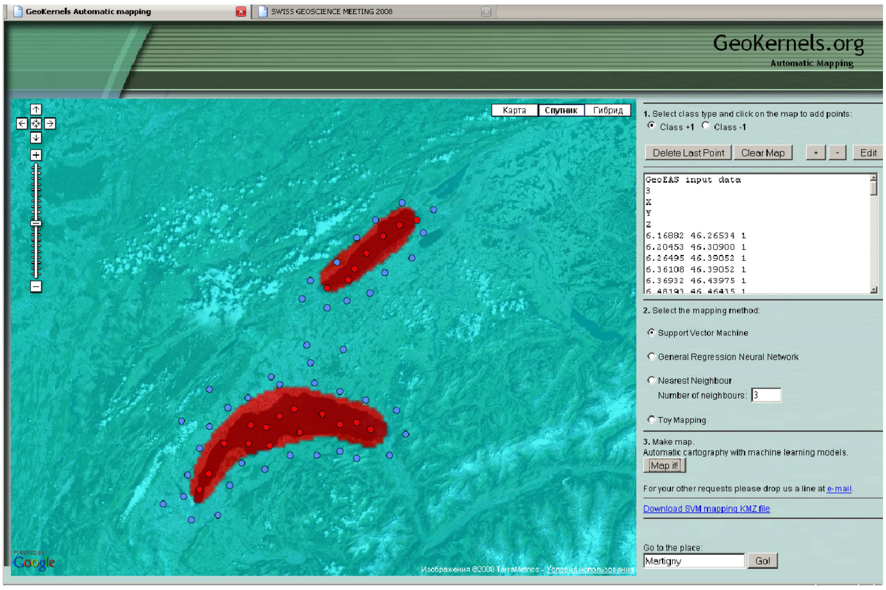


Figure 2. Result of a binary classification task using an interactive SVM model.

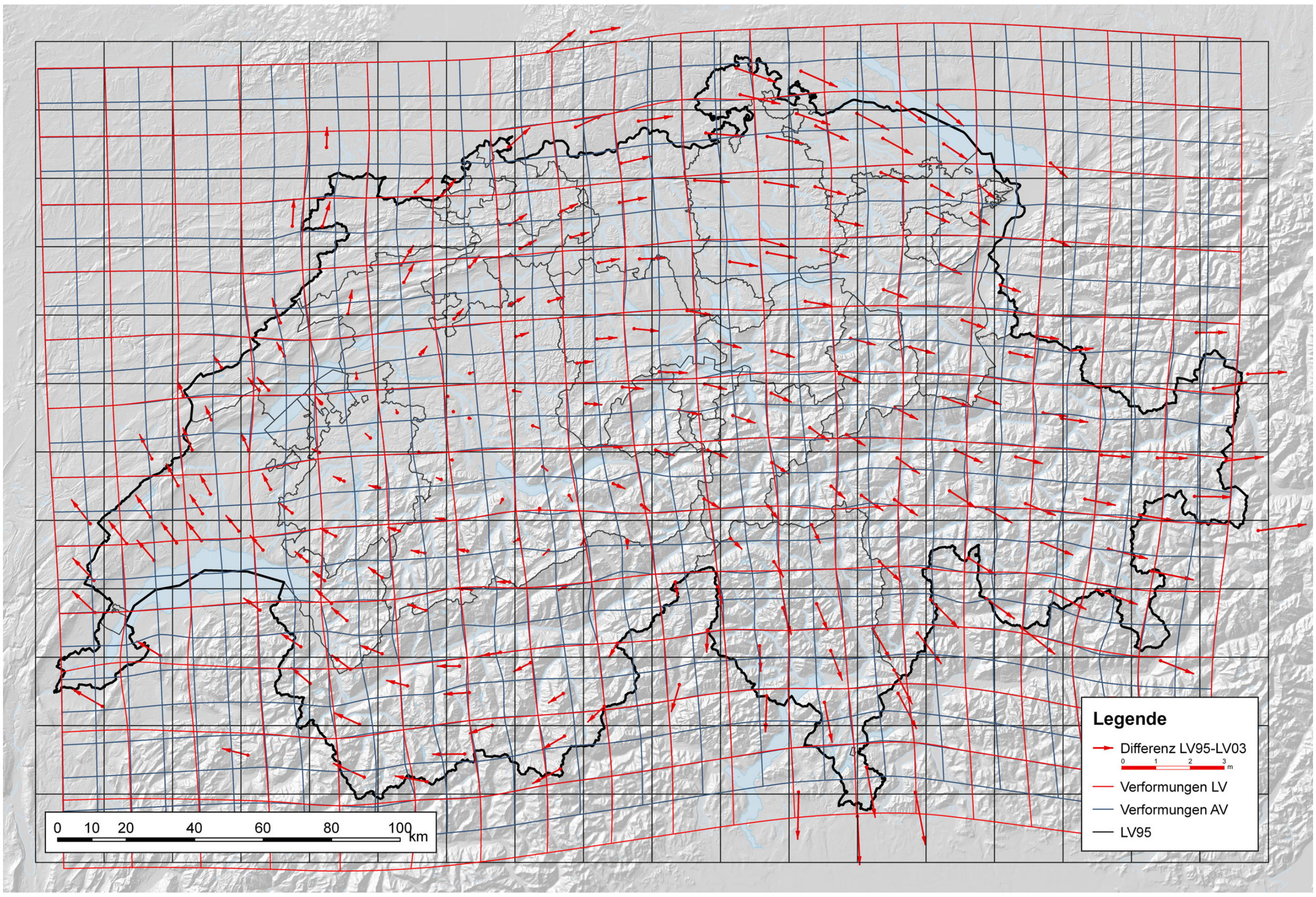
12.17

New coordinates for Switzerland: Completion of the Swiss national triangular transformation network for precise transformations between the old reference frame LV03, the new LV95 and global ones like ETRF

Kistler Matthias, Brockmann Elmar, Marti Urs, Métraux Cédric, Papafitsorou Ageliki, Ray Jérôme, Schlatter Andreas, Vogel Bruno, Wiget Adrian and Wild Urs.

swisstopo, Seftigenstrasse 264, 3084 Wabern
matthias.kistler@swisstopo.ch

The year of 2007 saw the completion of a basic geographical data-set of the greatest importance for the establishment of the national spatial data infrastructure SDI, the national triangular transformation network. This new data-set permits the elimination of the systematic deformations resulting from the first Federal survey of Switzerland completed in 1903 which reached a maximum of 2 to 3 m as well as the local distortions from the cadastre survey on the cantonal level.
Switzerland was subdivided into almost 12'000 triangles, each having its own affine transformation parameters matched to local conditions. In addition, to prove the accuracy of the transformation, the cantonal authorities have measured almost 50 000 control points. The results were excellent: on average, geographical data in Switzerland can now be transformed into the new, error-free LV95 reference frame or in a global one like ETRF with an accuracy of 3 cm.
The national triangular transformation network will also be implemented in the Swiss Positioning Service swipos as a new real-time option with GPS correction as well as "old reference frame adaptation": GPS users, who have to work in the old, for many applications still valid LV03 datum, can so position or measure with an accuracy of a few centimetres without establishing a local fit. Furthermore a new software Reframe including all relevant transformations (position / height) and the geoid undulations for Switzerland was released as client version as well as web service. The accuracy of the transformation can be accessed through a web GIS application for everywhere in Switzerland.
It is foreseen, that the new reference frame LV95 will be introduced for all geobasis data regulated by federal law by 2016 at the latest.



Deformations of the reference frame of 1903 still in use today (LV03 = red grid with the deformations from the national survey and the blue grid including also the local distortions from the cadastre level) compared to the new Swiss reference frame of 1995 (LV95 = black grid). The red arrows point from LV03 (red) to LV95 (black) and thus also the direction and amount of the local deformation.

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12.18

The National Gravity Network of Switzerland

Urs Marti

Federal Office of Topography swisstopo, Geodesy, Seftigenstrasse 264, CH-3084 Wabern (urs.marti@swisstopo.ch)

In 2003, a project LSN2004 (Landesschwerenetz 2004) was started by swisstopo to modernize the national gravity network of Switzerland. This new network is based on the existing gravity network of 1995 and is connected to several stations of the European gravity network UEGN. In this project, 4 new absolute stations were established and some existing ones were re-measured with the FG5 absolute meter of the Federal Office of Metrology (Metas). So today, the Swiss absolute (zero order) gravity network consists of about 15 stations, which are mostly located in stable buildings and far away from traffic and ground water zones.

In order to improve the accuracy and stability of the network, additional high precision relative measurements between the absolute stations are performed with SCINTREX-CG5 gravity meters in collaboration with the University of Lausanne and ETH Zurich. With repeated observations, the accuracy of LSN2004 should also allow the first determination of gravity changes and derived vertical movements in Switzerland.

The densification of the zero order network (1st and 2nd order network) is performed by relative measurements on stable levelling and GPS benchmarks. This network consists of about 120 stations.

Based on this national gravity network (LSN), the detailed observations are performed. One data set of more than 5000 points is located along the national levelling lines and is used for the reduction of levelling observations and the determination of rigorous orthometric heights.

The second important detailed data set of more than 32'000 points was collected and re-processed by the Swiss Geophysical Commission and the University of Lausanne. It covers the whole country and is presented in the form of 1:100'000 gravity anomaly maps. This data set is a very important contribution to the determination of the Swiss geoid model and is used for geophysical and geological interpretation.

The poster shows the concepts of LSN2004, presents the observations performed so far and gives an overview of the available gravity measurements in and around Switzerland.

Figure 1. Absolute gravity stations in and around Switzerland.

12.19

COLTOP 3D: A software dedicated to analyze relief using large DEM and massive 3D-imaging cloud points

Metzger Richard, Jaboyedoff Michel & Oppikofer Thierry

Institute of Geomatics and Risk Analysis , University of Lausanne, 1015 Lausanne (richard.metzger@unil.ch)

The increasing precision of ground-based Lidar technologies makes possible to perform more detailed systematic structural and morphological analyses than ever reached before. Using the orientation of each single collected vertex, a point cloud data set can be represented by a 3D image where each single point has a color defined by the local dip and strike direction, which allows a very simple slope analysis. This can also be applied to any surface reconstructed through the data set, making the detection of planar structures within a cliff, i.e. in the presence of overhangs, possible, which is not with classical 2D digital elevation models. Such simple analyses applied to 3D clouds of points make it possible to quickly identify structural features affecting topography. They open new perspectives in relief analysis. This paper describes the basis (kernel) of a software (Coltop-3D) which is dedicated to perform these tasks.

More specifically, the paper will focus on:

1. data organisation and management, as terrestrial laser scanners allow for capturing dense 3-dimensionnal data set (up to millions of points) on the surface of an object, within a few minuts. Without such organisation , the post-treatment and the standard operating use of such large data set may impair an in-depth analysis for specific applications, such as landslide and rockfall analysis.

2. dip and strike direction estimation from raw data points. Numerous work have pinpointed that eigenanalysis of the covariance matrix of a local neighborhood can be used to estimate local surface properties, and hence the normal. Once the normal is known, it is straightforward to compute the dip and strike direction. Moreover, it will be shown that eigenanalysis may be used to semi-automatically remove folliage from data sets.

A case study (Hegguraksla cliff site, located in the Norway) will also be presented.

12.20

A GIS approach for tsunami risk assessment

Monia Molinari*, Massimiliano Cannata*

**Institute of Earth Sciences – SUPSI, Trevano, C.P 72, CH-6952 Canobbio*

The tragic event of Sumatra brought to the international attention a natural phenomenon that is well known by most inhabitants of coastal areas: the tsunami. During the event of the 26th December 2004, a series of unusual high waves, up to 15 m, hit the coastal regions of Indonesia, Sri-Lanka, India, Thailand, Bangladesh, Maldives, Somalia and Kenya causing over 230˙000 victims.
Although these natural disasters cannot be avoided, their effects, such fatalities or damage to property, can be reduced through preventive and adequate protection measures. With respect to this goal the availability of flood risk maps would certainly help to foster the development of mitigation measures.
For this reason a procedure that enable GIS users to conduct tsunami risk assessment by means of a series of GRASS scripts that implement the approach proposed in Federici et al. (2006) and validated in Cannata et al. (2007) was created.
This procedure allows to assess the maximum vertical height of the tsunami wave at the coast (run-up) and the subsequent inundation on the mainland. The procedure takes into account local morphological characteristics, vegetation and urbanization through the usage of a digital terrain model, landuse, and cadastre map.
This presentation illustrates the procedure through a case study located in Olbia, a Mediterranean city on the Sardinia island's east coast.

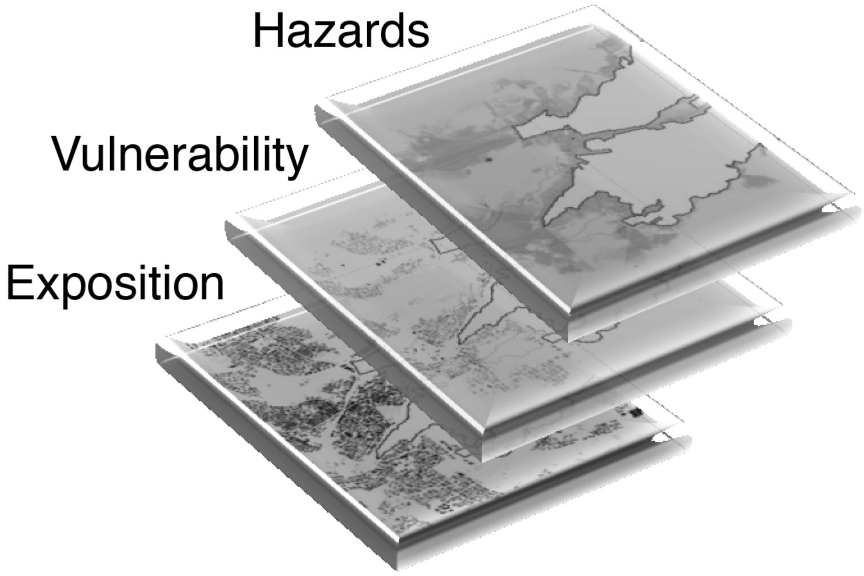

Figure 4. Steps of the tsunami risk assessment and respective maps.

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12.21

The Geological Information System Switzerland

Oesterling Nils*, Kühni Andreas*, Kündig Rainer**

**Swiss Geological Survey, Federal Office of Topography swisstopo, Seftigenstrasse 264, CH-3084 Wabern (nils.oesterling@swisstopo.ch)*
***Swiss Geotechnical Commission, ETH-Zürich CAB E77, Universitätstrasse 6, 8092 Zürich*

Geological information is of great importance for society because it is implied in a large number of products of our everyday life. Traffic constructions like roads and railway tunnels and the supply with fossil energy resources are only the most obvious products for which geological know-how is crucial. But even common products like toothpaste and cat litter would not exist without geological information and knowledge.

For a wide range of disciplines in the geo-sciences geological information is an important basis for decision-making processes. For instance, information on the stability of bedrock and superficial deposits is essential for choosing specific building sites for houses, tunnels, etc. Questions concerning the search for radioactive waste disposal sites can only be answered with the help of geological data and information. Furthermore geological data supply basic information for the preparation of natural hazard maps, a topic, which is becoming increasingly import in recent years (e.g. extreme flooding of Swiss rivers in the summer of 2005 and rock fall directly striking a car on the Gotthard Highway (A6) in 2006).

To be able to address the challenges of the modern society described above, it is essential that geological information is easy accessible. Recent developments and advancements of IT-technologies like the Internet, GIS, Web-Services, etc. enables us to distribute and exchange the required information in an interoperable way, so that everyone who need information, can use it easily.

Like some other Geological Surveys, the British Geological Survey (BGS) for instance, gives numerous examples for applications of their geological data, its respective importance and how data and services can be presented and distributed via the internet (cf. http://www.bgs.ac.uk/britainbeneath/; http://www.bgs.ac.uk/ services/home.html). The accessibility of data is easy and in many cases free of charge and the relevance and importance of such data is easy understandable for professionals and laymen.

Compared to the UK, geological information in Switzerland is only poorly accessible. This is on the one hand, because complete geological coverage of Switzerland on the detail scale is not achieved yet, and on the other hand, because geological investigations and its coordination in Switzerland are carried out by a large number of institutions (e.g. Platform Geosciences of the Swiss Academy of Natural Sciences (scnat), Swiss Geological Survey (SGS), Swiss Geotechnical Commission (SGTK), Swiss Geophysical Commission (SGPK), Geological Institutes of Swiss universities, and different other organisations). As a consequence tasks and responsibilities of the different institutions are often not clearly visible and access to existing geological data and services is difficult. Restricted communication between the players of the “Geo-Scene” and missing coordination of activities enhances this problem.

To overcome the problems mentioned above, the development of an Information System for Geology in Switzerland is intended. Such a centralised, web based information system not just makes the existing geological and geo-scientific datasets and services available, but also gives an overview of the Geo-Scene Switzerland and its national and international organisational integration. Furthermore, geological terms and selected sites of the swiss geology (e.g. Glarner Hauptüberschiebung at Lochseite, Schwanden, Glarus) are described and presented for non-professionals.

As part of the National Spatial Data Infrastructure of Switzerland (NSDI) the Geological Information System is thought to be the gateway to geo-sciences in general and to geological sciences in Switzerland in particular.

The primary objectives of such an information system are:

- Make existing geological data available and web accessible
- Visualise the organisational integration of the players of the swiss Geo-Scene
- Develop a centralised information-platform for professionals, semi-professionals and laymen
- Strengthen the public awareness of geology and geo-sciences in Switzerland

12.22

GIS helps water resources management

Fabio Oliosi*, Stéphane Storelli**

** ESRI Géoinformatique SA, rte du Cordon, 7 1260 Nyon, Switzerland (F.Oliosi@ESRI-Suisse.ch)*
*** Centre de Recherches Energétiques et Municipales (CREM), Rue des Morasses 5, CH-1920 MARTIGNY (stephane.storelli@crem.ch)*

In Alpine regions like in other areas around the world, local administrations (communes) have the duty to manage water resources and distribution. The quality, the available quantity and the cost of water may vary spatially, from valley to valley and from village to village. Very often, when big differences exist, a waste of this precious resource may occur along the distribution channel. Web GIS technology may help to share geographic knowledge and improve water cycle management.
With a financial aid of the Swiss Confederation[1], a group of private firms, public administrations and universities are currently carrying out a project on Integrated Municipal Facilities Management of Water Resources (SyGEMe), in western Switzerland.
SyGEMe’s goal is to build up a common IT infrastructure and web services to support small water network managers. GIS is the best platform to carry out specific analysis over a bigger water basin and helps managers to synchronize their actions on the network.
This paper presents some interesting aspects of this project and emphasizes the role of GIS.

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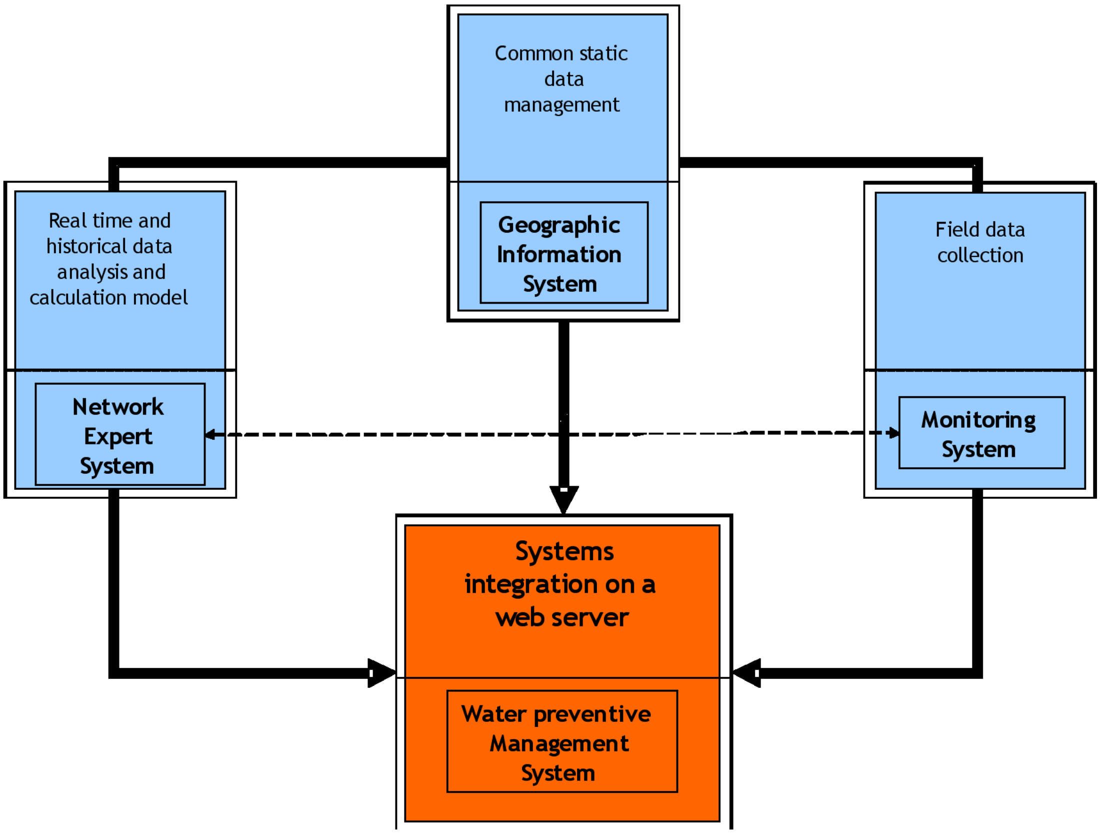

Figure 1. SyGEMe main related components

12.23

The geotype concept to develop GIS oriented analysis in engineering geology applications

Parriaux Aurèle*, Turberg Pascal*, Kalbermatten Michael**, Golay François**, Lance Jean-Marc

* *Laboratoire de géologie de l'ingénieur et de l'environnement, Ecole Polytechnique Fédérale de Lausanne, Ecublens, CH-1015 Lausanne (pascal.turberg@epfl.ch)*
** *Laboratoire de systèmes d'information géographique, Ecole Polytechnique Fédérale de Lausanne, Ecublens, CH-1015 Lausanne*
****Etablissement d'assurance contre l'incendie et les éléments naturels du Canton de Vaud, Avenue Général Guisan 56, CH-1009 Pully*

In territorial projects where geological information and GISs are coupled to perform spatial analysis, an explicit definition of geological descriptors is required. Thus, a conceptual model of the geological diversity has to be set up, according to the goal of the project, to differentiate the relevant units of the underground.
Here, a conceptual model of the geology for the canton of Vaud, Switzerland, is proposed. This model basically adapts the information of the Swiss geological atlas. It is composed of 41 geological units called "geotypes". Twenty of them are used to define hard rocks, principally on petrographical considerations, and the last 21 define quaternary deposits essentially on sedimentological criteria. The principles, requirements, conditions and objectives of this model are discussed.
This geotype model was applied to map the foundation soils all over the canton of Vaud (3200 km^2) in the frame of its seismic microzoning. This large scale cartographic project, where different contractors worked in parallel, was associated to a GIS concept specifically designed for the geotype model. This GIS concept is explained.
We describe why this combined geological-GIS method was necessary during the realization phase of the project, how it significantly enhanced the overall capacity of spatial analysis and in which way data maintenance will be simplified.

Main results from this case study are pointed out and discussed:

- Realization of the first synthetic geotype map of the canton of Vaud (figure 1) and associated map of foundation soils;
- Geological consistency between maps realised by different authors;
- Transparency and traceability of the successive data processing operations, from raw geological information to end products;
- Valorisation of the geological information to be combined in the future to other territorial information through GIS (e.g. digital elevation models (DEMs), comprehensive development area maps, geological cadastre).
- GIS capacity for easy re-actualization of maps.

Adaptations of this method to other geological environments or for other engineering projects (natural hazards, groundwater protection) are ongoing developments.

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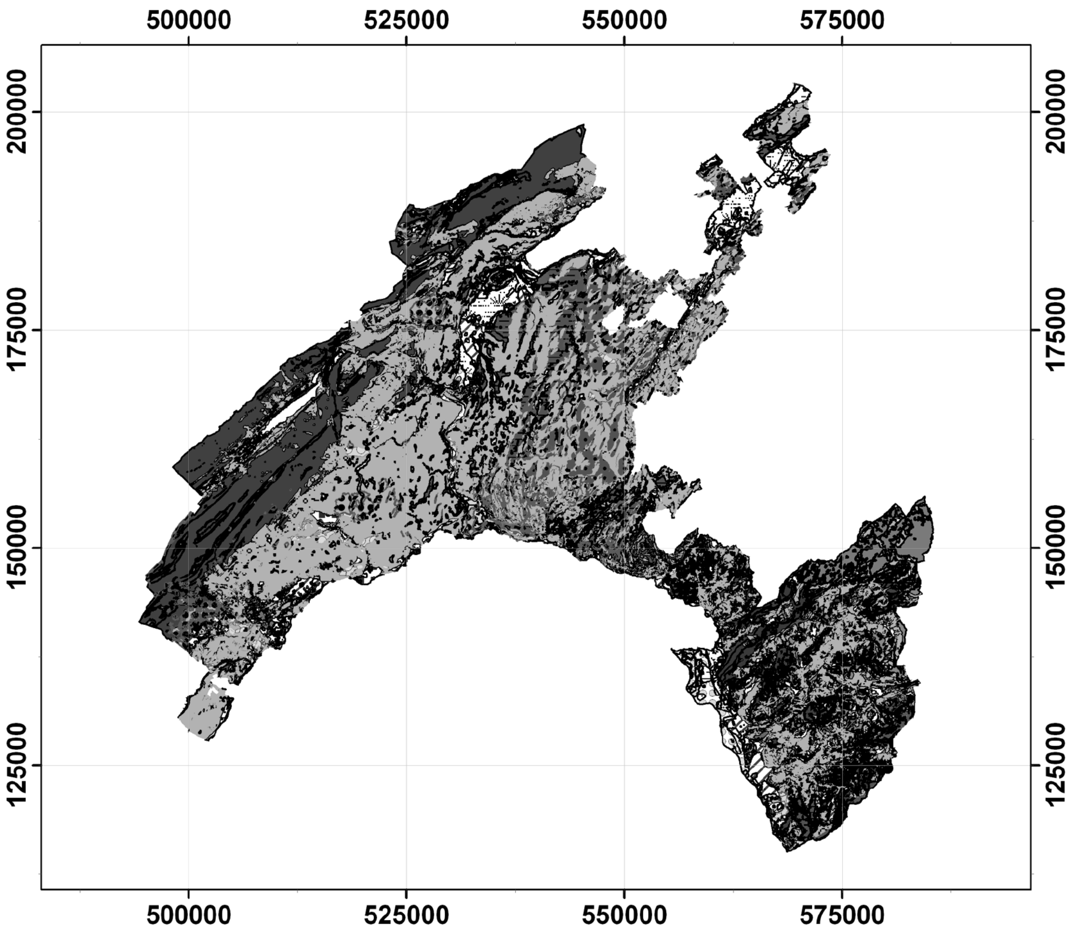

Figure 1: First ever synthetic representation of the geological conditions over the whole surface of the canton of Vaud, Switzerland, according to the geotype method described in this paper.

12.24

Hydrogeology and geochemical characteristics of groundwater in a porous aquifer connected with two karst systems, in Southern Switzerland.

Sebastián Pera*

Istituto Scienze della Terra, Via Trevano, CH-6952 Canobbio

Groundwater origin and hydrogeological processes strongly affects geochemical evolution of water within the aquifers. Because of that several studies uses major ion geochemistry as tracers giving insights on groundwater flow processes. This methodology has been applied successfully in different hydrogeological contexts (Grassiand and Cortecci, 2005; Dafny et al, 2006; Wang et al, 2006;).

The Laveggio aquifer, located in southern Switzerland, is an important source of drinking and industrial water for the Mendrisiotto district. Constituted by glacial and fluvioglacial deposits, it fills a valley developed over an important structural feature: the Lugano Line (IGIC, 1989). The aquifer, discharging to the Lugano lake is laterally limited by two important karst systems: The Monte Generoso and The Monte San Giorgio basins. Due to the structural evolution of the area the two karst systems have distinctive characteristics, the Monte Generoso Basin constituted mainly by limestones outcorps while in the San Giorgio basin dolomites are present (Bernoulli, 1964).

Several monitoring campaigns were carried out by the public authorities in order to acquire information about the quality of groundwater. 17 wells were sampled during several years and samples analyzed for major elements, pH, temperature, conductivity and some organic pollutants.

In this work geochemical data was directly interpreted and spatially represented by using a geographic information system (GIS). We used the results of the chemical analysis to study the hydrodynamic of the aquifer and the relationship with the karst systems.

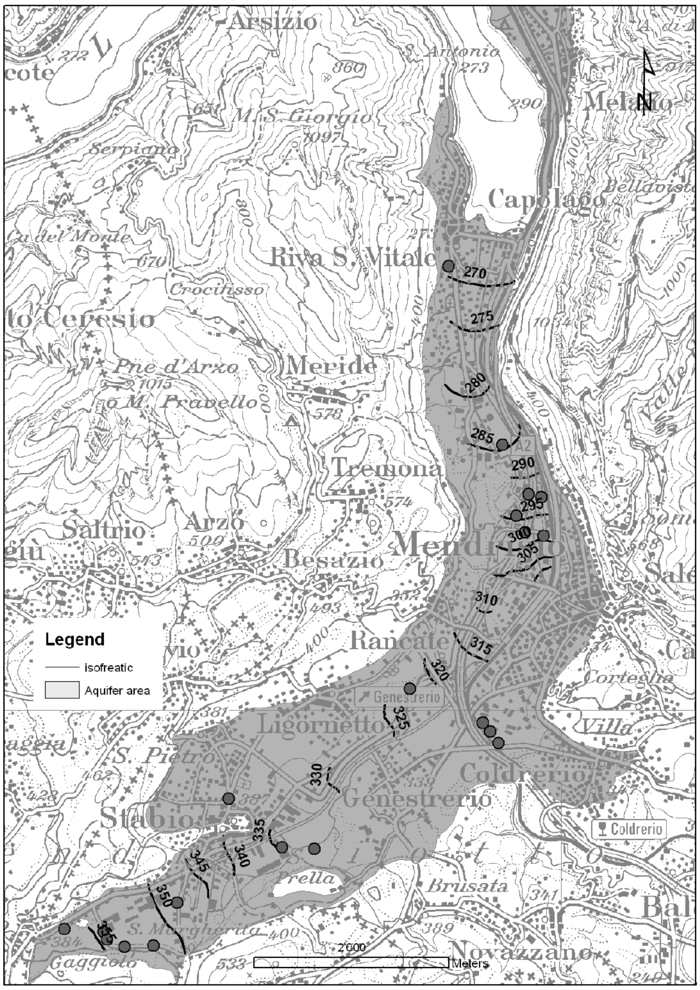

Figure 1. showing Laveggio aquifer and rsampling stations.

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12.25

GIS modelling: a first step toward 3D geology with the "Sion" map

Sartori Mario *, Ornstein Pascal* , Schreiber Lucien* and Jemelin Laurent**

**CREALP – Research center on alpine environment, Industrie 45, CH-1951 Sion (mario.sartori@terre.unige.ch)*
*** Swiss Geological Survey, Federal Office of Topography swisstopo, Seftigenstrasse 264, CH-3084 Wabern*

Problematic.- How to optimize the geologic field mapping and the data processing to produce a consistent GIS geological model of the territory optimized for spatial analysis? What are the additional data and interpretations needed to make this GIS model useful for subsequent 3D developments? What are the constraints for placing the GIS model at the center of a Swiss geological data storage system?

Aim of the "Sion" project.- This long-term project is based on collaboration between the Crealp and the Swiss Geological Survey for the achievement of the geological cover of the Valais territory, a priority task for natural hazards management. New methods and new tools are tested as part of the geological mapping and GIS modelling of the Sion sheet (Geological Atlas of Switzerland 1:25'000). The aim is also to allow the geologist cartographer to build from its analogical and digital field data a GIS project fully compatible with a global geological information system.

Constraints.- The GIS project has to be fully compatible with the Swiss Geological Survey Data Model and to reach a perfect topological consistency. The GIS model also has to allow the export of data toward the Swisstopo cartographicclassically editing process in order to produce classical analogical maps without loss of quality.

"Sion" Methodology.- In comparison with a classically edited geological map, this method needs more interpretation from the authors in order to build (where possible) separated bedrock and drifts layers in a "2.5D" model, a necessary step toward future 3D analysis abilities. The Data Model of the GIS should be defined before- and refined during- the field acquisition. The editing of the data in the GIS follows a construction technique solving the problems of superposition of lines and polygons edges shared by several layers. Only polyline- and point-type layers are used to edit the topology of the objects. Besides defining the objects and their attributes, it is necessary to attribute all the lines after their semantic significance (often multiple). The whole spatial model, including polygon-type layers, is finally derived from these construction layers.

Specific geological GIS software.- The implementation of the "Sion" method could be problematic without a specifical GIS tool able to manage the complex Data Base, the full attribution of lines and objects, so as to make topological and semantic validations. ToolMap is an open-source, cross-platform (Windows, Linux, Mac) software developed by CREALP and Swisstopo. Data Base management and GIS edition functions are specifically designed to create a GIS project from the geological data according to the "Sion" Method.

Results.- Feasibility of placing GIS modelling at the center of the Geological Atlas production process is presently tested with the "Sion" sheet. New potentials in term of geotechnical and hydrogeological analysis are provided thanks to the integrated tectonic sketch making possible to define in any point the nature of the bedrock, proven or supposed. Later steps toward 3D modelling would be possible if data on drifts thickness are available. The Data Base management of such a GIS model is complex, but it will be highly simplified by the use of ToolMap. This complexity stimulates in the other hand homogenization between adjacent sheets through semantic clarification of objects definition and through stratigraphical and tectonic revisions.

12.26

ToolMap – 'SION' method: development of a new GIS Framework for digital geological mapping

Schreiber Lucien*, Ornstein Pascal*, Sartori Mario*, Kuehni Andreas**

**CREALP – Research center on alpine environment, Industrie 45, CH-1951 Sion (lucien.schreiber@crealp.vs.ch)*
*** Swiss Geological Survey / Federal Office of Topography (Swisstopo)*

With the constant development and the spreading of use of information systems as well as modelling, analysing and visualisation tools, the need for digital data is increasingly growing. During the last few years, this trend was strongly marked in geosciences especially in fields such as engineering geology and geological mapping.

Classically, a geological map gives a 2-D modelling of a complex 3-D environment. Mapped entities are defined by i) a collection of geologic features which carry a geometry (point, line, polygon) in association with numerous descriptive attributes (e.g. lithological, chronological, structural, morphological ones) and ii) the relationships between these objects. Handling information required to build digital geological maps implies of first analysing and extracting semantic content of the geologic objects and of identifying their spatial relationships.

Since a few years, CREALP has developed, in close collaboration with the Swiss Geological Survey (SGS), the 'SION' method, an innovative approach for implementing geological maps in digital format using GIS technology. This methodology aims at providing a consistent geological GIS fulfilling a number of strong requirements like:

- Storing and modelling geological objects in an exhaustive and accurate way through a robust data model
- distributing the geologic features in relevant layers according to their geological meaning
- developing an efficient method for geometrical construction of the digital map solving issues related to superposition of objects associated with multiple layers.
- implementing a data model offering powerful capabilities of analysis (spatial and non-spatial).

As a natural extension of this technique, CREALP launched in 2006 the development of ToolMap a standalone software program that fully implements the principles that underlie the method. ToolMap provides tools that abstract, organize and transform field data to the relevant digital datasets used to generate the digital geological map and derived geothematic maps. This is achieved through the integration in ToolMap of i) a versatile relational database that allows the handling of geospatial data (geometry and attributes) with various levels of complexity and ii) a GIS engine with the associated tools for editing, geoprocessing and validating data (topological and semantic rules).

This open-source and cross-platform (Windows, Linux, Mac) software is actually developed in coordination with the SGS in the framework of the production of maps of the Geological Atlas of Switzerland at 1:25 000 scale (GA25). The Beta version was recently tested for successfully implementing the new geological data model that underlies the geological information system of Switzerland being developed by the SGS.

Although initially dedicated to digital geological mapping, ToolMap is very suitable for handling other types of data because of its open design and its comprehensive functionalities.

ToolMap and its built-in concept offer a new technical framework for a full integration of GIS technology into the geological map production cycle (fig. 1). The close combination of a step-by-step process and dedicated tools is a pledge for ensuring constant quality and consistency in the production of digital geological maps. This GIS-centred approach offers the ability for the geologist to enhance field data acquisition and map accuracy by combining, at each stage of geological mapping, geological data with other geo-spatial datasets such as DEM, digital orthophotos, multi-scale topographic maps.

This way, geological surveys and geoscientists can increase use and usability of their data by providing more powerful digital cartographic products especially in terms of spatial analysis and geological data management.

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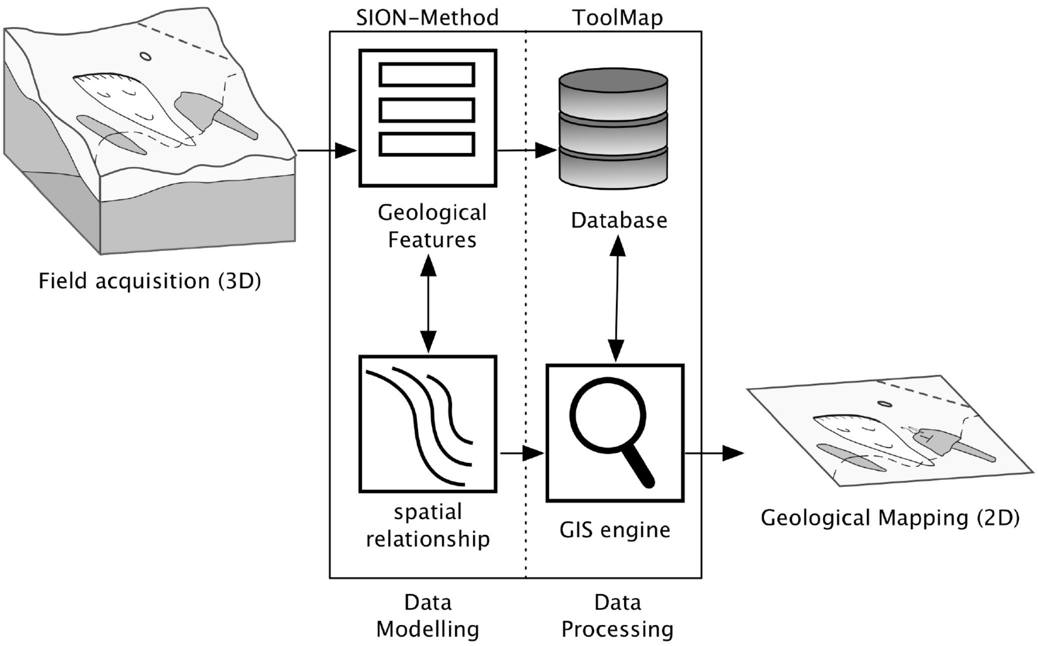

Figure 1. GIS Framework for digital geological mapping consisting of two components: the SION-Method and ToolMap software

12.27

Real-Time Mapping and Monitoring Capability of Geological Features by Airborne Laser Scanning

Jan Skaloud*, Philipp Schaer*, Phillip Tomé**, Yannick Stebler*

*EPFL-TOPO, Station 18, CH-1015 Lausanne (jan.skaloud@epfl.ch)
**Nemerix, PO Box 425, CH-6928 Manno (philip.tome@nemerix.ch)

The amount of unstable rock in the Alps is expanding with the retreat of glaciers. The terrestrial 3-D laser scanning has become a standard technique to monitor movement of some of them. For instance, the Northern wall of Eiger has been monitored by means of a commercial device placed on the opposite side of the valley. However, the area of rock movement that can be monitored by this approach is limited in size by a) the characteristics of the neighbouring relief; b) the accessibility of the monitoring side; c) the ranging attributes of the scanner. The nature of Alps is such that these limits are exceeded in many zones of natural hazards related to the slope movement.

We present a rapid way of obtaining the 3D laser point cloud for the purpose of monitoring by means of Airborne Laser Scanning (ALS). The ALS technology is well established in generating Digital Surface Models (DSM) and Digital Terrain Models (DTM) over larger surfaces. However, the traditional ALS is not suitable for mapping steep terrain or cliffs. Also, the monitoring capabilities of this technology are limited by the lapse of time between data acquisition and data processing. Such delay is related to the trajectory evaluation as well as to the amount of data produced by the airborne scanner. Depending on the nature of the work and the system used, it can take from hours to days to generate the 3D laser point cloud after the flight execution. We introduce an ALS system that drops all these inconveniences.

The Scan2map system has been under development at EPFL with various partners over the last decade (Fig.1). It combines GPS, INS, ALS and a medium format digital camera in one solid mount which can be used in nadir or oblique configuration during the same flight; hereby allowing mapping horizontal (valley bottoms) and vertical features (cliffs) while maintaining optimal geometry between the scanner and the mapped object. More recently, the functionality of the Scan2map has been extended 1) to improve the monitoring of the scanning progress (Fig. 2); 2) to generate the 3D laser point cloud in real-time (Fig.3); 3) to analyze the quality of the point cloud within the flight. If the communication between the on-board and reference GPS receivers is established, the accuracy of the real-time generated point cloud is obtained at cm-level and corresponds to that of post-processing. The resulting data are then ready to be fed to movement/deformation analysis tools as in the case of 3D terrestrial laser scanning.

The paper presents the system concept and characteristics, the strategy adopted for data processing and communication as well as results from actual missions.

Figure 1. Handheld mapping system (Scan2map) installed in a helicopter.

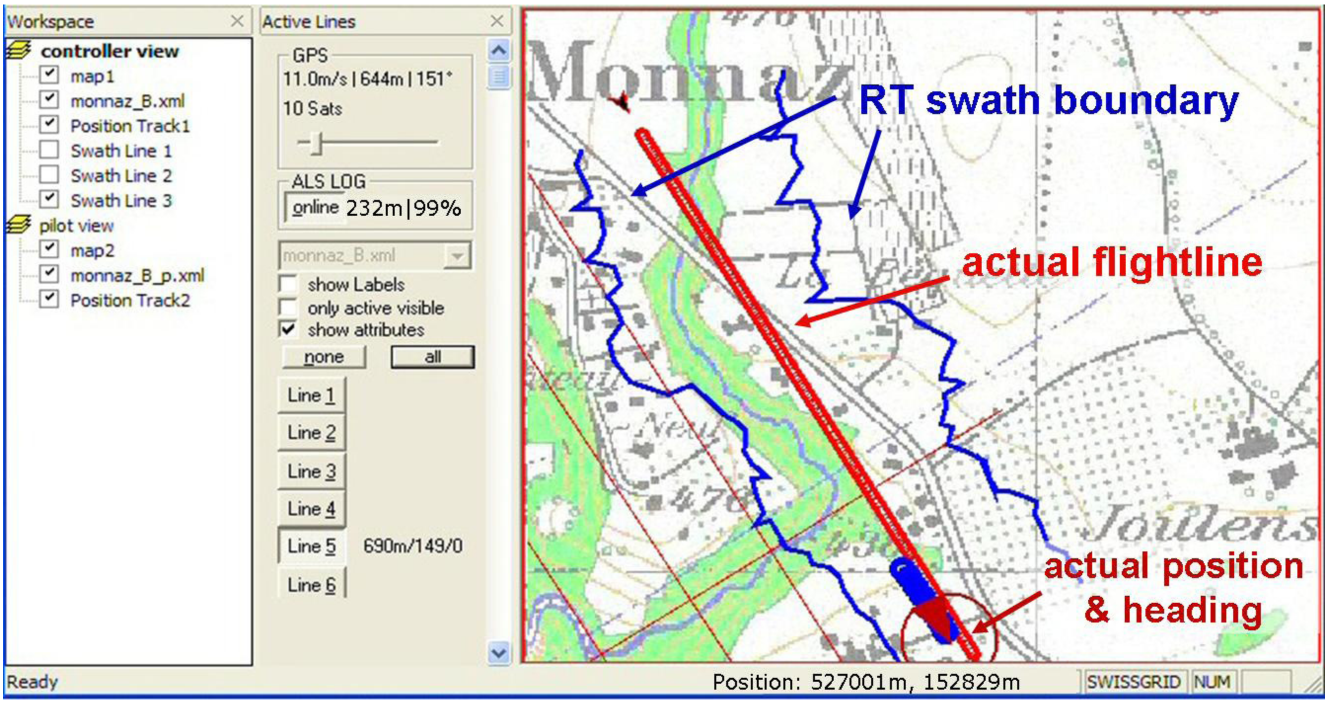

Figure 2. Overview of main functionalities of the flight management interface.

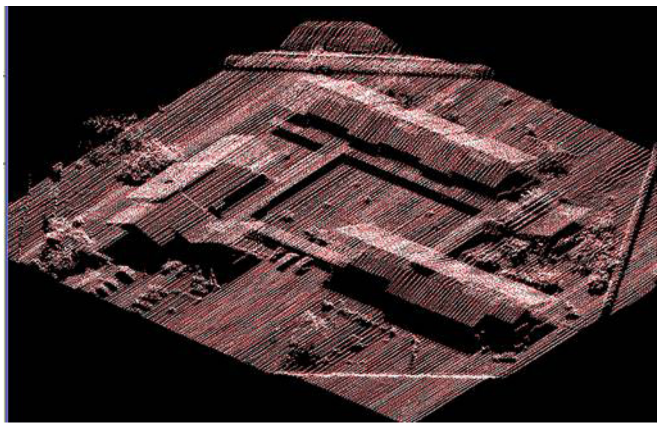

Figure 3. Laser point cloud generated in real-time with cm-level accuracy.

12.28

Estimation of local tectonic movements using continuous GNSS network

Villiger Arturo*, Heller Oliver*, Geiger Alain *, Kahle Hans-Gert*, Brockmann Elmar**

*Geodesy and Geodynamics Lab, Institute of Geodesy and Photogrammetry, ETH Zürich (arturo.villiger@geod.baug.ethz.ch)
**Swisstopo*

The objective of project TECVAL is to assess local crustal movements with modern geodetic techniques in an area north of the Rhône valley extending from Martigny to Raron. Although the Valais is a region of relatively high seismic activity within Switzerland, the deformation rates reveal small amounts only. Nevertheless, the main challenge is to detect these movements by GPS at a high level of significance.

The stations for the evaluated network are part of the Automated GPS Network (AGNES), operated by Swisstopo, or built up for this project and run by ETHZ. In order to determine movements relative to the Eurasian plate and to assess a new rotation pole the network includes European stations from IGS and RGN. The relative time series are evaluated in a local topocentric coordinate system. Due to the small tectonic velocities seasonal and other disturbing effects have to be taken into account. To this end the time series have to be available for at least a few years. To determine the velocities from time series a robust estimator has been used. This approach significantly reduces the influence of outliers. After the robust elimination of outliers the final velocity is determined by a least square estimation.

In order to verify the achieved results in this area the uplift can be compared to a model calculated from levelling measurements.