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Conrad Observatory

underground geophysical observatory

bmwfw
Bundesministerium für
Wissenschaft, Forschung und Wirtschaft

Preface

Earth observations have constantly played an important part in the lives of human beings. Mankind has always been fascinated with the world around it and humans have excelled in manipulating their environment. One of mankind's most interesting qualities is the unique aspiration to understand and explain natural phenomena they observe.

Our complex society and its economic, technical and social infrastructure are strongly affected by changing environmental conditions. The need for a better understanding of Earth and the environment in which we live has become increasingly apparent. Geophysical phenomena have an undeniable influence on our society, with earthquakes clearly dominating our awareness of such events. Austria takes pride in looking back on a long and pioneering tradition in earth sciences and boasts a great many world-renowned scientists in this field, for example Ferdinand von Hochstetter and Eduard Suess, who add to the country´s scientific reputation. The Central Institute for Meteorology and Geodynamics (ZAMG) is no exception in this regard and is proud of a large number of distinguished scientists in its ranks, including Karl Kreil, Julius Hann and Victor Conrad, who lent his name to the Observatory.

The Conrad Observatory does not only represent a logical step in a long tradition of cutting-edge research in Austria and an investment in the country's scientific landscape and future, but is also a commitment to supporting the continuation of scientific excellence. In order to understand the present condition of Earth it is essential to get familiar with the geophysical processes that cause change. The world of science has been continuously advancing over the centuries, and in the 21st century we have to face new challenges. The world has become smaller and international collaborations are more important than ever. The Conrad Observatory is Austria's contribution to the international network of Earth observatories by providing the scientific community with world-class geophysical research and development facilities.

I want to congratulate everyone who contributed to the success of the past few years and the tremendous accomplishments made.

Reinhold Mitterlehner
Federal Minister of Science, Research and Economy

Preface

Where there is active research, momentum and trendsetting jobs will follow.

The state of Lower Austria has invested roughly 600 million euros into the development of science and research establishments, and further large investments will follow in the coming years. Lower Austria hereby continues to take shape as a science and research state. Leading examples of this are the MedAustron Cancer Therapy and Research Center in Wiener Neustadt, the Institute of Science and Technology Austria in Klosterneuburg and the Karl Landsteiner University of Health Sciences in Krems. Even today one finds thousands of researchers, including over 17 000 students, in Lower Austrian research facilities. Through the investments of the state of Lower Austria, a state of knowledge has been brought forth.

In addition to the development of the axis of research, which stretches from Krems over Tulln towards Klosterneuburg and Wiener Neustadt, the state of Lower Austria has also put much value on the development of peripheral research sites. Such sites show that cutting-edge research is also possible in more rural areas. In 2002 the Conrad Observatory laid the foundation for a research establishment in the fields of meteorology and geodynamics, of which I, as Governor, am especially proud. It is very gratifying for Lower Austria that the Zentralanstalt für Meteorologie und Geodynamik (ZAMG) found the best geographical and geological conditions for the Observatory on the Trafelberg in southern Lower Austria, thereby ensuring that the state provides an important contribution in the realms of international research. The reputation of the state as a site for research is strengthened through this and draws researchers from all over the world.

In this regard I wish the Conrad Observatory further good development for the future,

Erwin Pröll
Governor of Lower Austria

Preface

This year's Conrad Observatory Journal not only highlights the variety and excellence of research conducted at this unique location over the last two years, but also marks a major milestone: the completion and the opening of the geomagnetic observatory. The geomagnetic tunnel and laboratory comprise the final stage of this prodigious project, which complements the Conrad Observatory and provides a valuable addition to the Austrian scientific landscape.

This geophysical observatory is far more than just the completed building complex. It is the sum of people committed to science and the knowledge it can offer. These include people with a vision of the benefits of geophysical research and the understanding of the importance of observatories for society and country. Furthermore, these include people who demonstrated foresight and remarkable endurance throughout many years of careful and tedious planning and thoughtful construction, as well as staff driven by the highest scientific standards and the commitment to national and international collaborations. But most importantly, these will also include future generations, whose responsibility it will be to rise to the challenge on the excellent work and high scientific quality already being done.

Honoring the wishes of Victor and Ida Conrad to establish a geophysical observatory par excellence in Austria, the result is remarkable and does not shy away from other international geophysical observatories in comparison. The most extraordinary feature of this observatory is the wide range of scientific disciplines that are and can be accommodated in one location. This reflects the circumstance that the complexity of the system Earth cannot be attempted to be explained by one single discipline alone, but is a highly interdisciplinary endeavor.

The new geomagnetic observatory offers vast resources for research and development next to permanent observation of Earth's magnetic field. Geomagnetism has always played an important role within the ZAMG ever since its foundation as "k.k. Centralanstalt für Meteorologie und Erdmagnetismus" 1851. Karl Kreil, its first director, conducted geomagnetic land surveys, the first in Austria for that matter, and dedicated much time to geomagnetic observations. Hence, the now completed observatory follows a long tradition of geomagnetic and geophysical research.

In this spirit,

Michael Staudinger
Director of the Central Institute for Meteorology and Geodynamics

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Sparkling Geomagnetic Field – Students Peek into the Eye of the Storm

Rachel Bailey, Barbara Leichter, Roman Leonhardt

With the maximum of the solar cycle approaching, an opportunity to study space weather and its effects on our planet arises. Three geomagnetic stations were set up across Austria with the help of local schools. The stations, measuring the direction and strength of the magnetic field with a high frequency, map the process of geomagnetic storms across Austria.

The solar maximum, which is the point at which the Sun reaches the end of its cycle and reverses the polarity of its magnetic field, occurs every 11 years. During this time clouds of energetic particles are thrown out from the Sun's surface and traverse the interplanetary void towards the top of Earth's atmosphere.

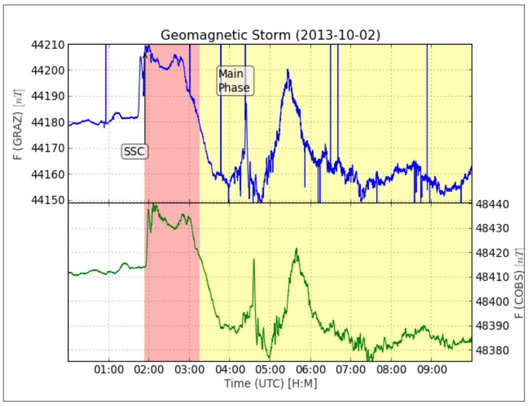

Figure 1: A storm onset measured by a station in Graz (above) and the Conrad Observatory (below).

The arrival of a particle cloud on our magnetosphere triggers a geomagnetic storm (Fig. 1). Strong geomagnetic storms have various effects noticeable by the general populace such as aurorae (northern lights), power failures and radio disruptions. Generally storms are only strong enough in far northern and southern latitudes (e.g. Norway, Australia) to cause disruptions, however during the strongest of storms aurorae have been visible in Norway, Austria, and as far down as Egypt.

The solar activity should be peaking in late 2013/early 2014, making this an ideal time to study the effects of geomagnetic storms in Austria. Through the Sparkling Science programme (BMWFW), which pairs research institutions with Austrian schools to promote science in a school setting, a collaboration between the ZAMG was set up. Three schools across Austria (situated in Graz, Tamsweg and Innsbruck) signed up. Each school received one station for the measurement of geomagnetic field variations in the variables F (field strength) and x, y, and z (the three field direction components).

The students carried out investigations into the best location for the setup of the stations after an introductory meeting where the basics of the project were explained. After choosing a few possible locations, the stations were investigated by a research team composed of students and ZAMG researchers (Fig. 2) and the best was chosen. The students then set up the stations themselves.

Figure 2: Students and ZAMG colleagues check a suggested area for magnetic disturbances.

The stations are currently running and measuring the geomagnetic field conditions continuously. Two stations have already recorded a geomagnetic storm “sudden commencement” (Fig. 1).

Acknowledgement
The research is funded by BMWFW Sparkling Science SPA04-124 “Sparkling Magnetic Field”.

For more project information and updates:
www.fb.com/SparklingGeomagneticField

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Variations of the Earth's magnetic field: dynamics and implications

Patrick Arneitz, Roman Leonhardt

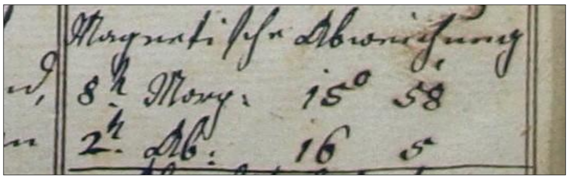
In the middle of the 19th century continuous measurements of the geomagnetic field on a global scale were initiated by the Göttinger Magnetic Union. However, for scrutinizing geodynamo processes and long-term field evolutions an expansion of the data further back in time is essential. Therefore, we will use historical records of man-made measurements as well as records from remanent magnetized rocks or archeological findings. Past geomagnetic field variations will be modelled on the basis of these data. The results can be used for archeological dating.

Figure 1: Sundial, Georg von Peuerbach, 1455
Credit: Universalmuseum Joanneum/N. Lackner.

Since the first determination of the whole geomagnetic field vector, magnetic declination has varied by more than 15 degrees in Austria in the last 150 years. To extend the knowledge about such variations further back in time, our first investigations dealt with direct historical measurements of the geomagnetic field. In this context, magnetic declination measurements have been carried out for navigational purposes already at the beginning of the last millennium. The oldest known declination value is based on a sundial by Georg von Peuerbach in 1451.

In general, there is a large variety of potential sources in central Europe. For example, instrument constructors would stamp magnetic declination values on sundials, compasses, globes and maps from the 15th to the 19th century. Compasses were used to appoint the direction of mining tunnels. The hypothesis that the orientation of churches was also obtained with the help of compasses was rejected during our investigations in Lower Austria and Northern Germany. The growing interest in the geomagnetic field leads to an increasing number of measurements and an improved accuracy in scientific expeditions and at observatories. Regular observations of declination and inclination have been performed since the beginning of the 19th century in the monastery Kremsmünster. Moreover, surveys by the k. k. Navy in the Adriatic Sea date from that period.

Historical measurements before the middle of the 19th century provide only directional information about the geomagnetic field. Therefore, paleo- and archeomagnetic methods are essential to obtain intensity values. Within the scope of this project archeological samples will be collected and their acquired remanent magnetization will be examined. Moreover, uncertainties of applied methods will be investigated. Therefore the comparison of historical and archeomagnetic data will be fruitful.



Magnetische Abweichung.
8h Morg: 15° 58
2h Ab: 16 5

Figure 2: Declination recorded in the yearbooks of monastery Kremsmünster.

Finally, modelling of the geomagnetic field evolution will be performed with proper selection and weighting criteria for collected datasets. A Bayesian inversion method (Leonhardt and Fabian, 2007) will be used for a spherically harmonic representation of the field. The model results can be used for the interpretation of geodynamo processes, climatic changes or cosmic/solar particle impacts. Furthermore, adequate temporal field characteristics provide a valuable tool for archeological dating purposes.

Acknowledgement
The research is funded by FWF grant P24722-n19.

References:

Leonhardt R., Fabian K. (2007) Paleomagnetic reconstruction of the global geomagnetic field evolution during the Matuyama/Brunhes transition: Iterative Bayesian inversion and independent verification. Earth Planet. Sci. Lett., 253, 172-195.

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First steps toward the calibration of observatory magnetometers

Ramon Egli, Roman Leonhardt

Modern observatory magnetometers measure variations of the geomagnetic field vector with a resolution of ~1 ppm and a rate of 1-10 measurements/s. Instrument calibration is essential for obtaining a reliable record of field variations. The extremely quiet magnetic environment of the Conrad Observatory offers a unique location for the setup of a calibration system for precisely investigating the response of magnetometers to static and dynamic magnetic fields.

Special magnetometers are used in magnetic observatories for more than 150 years to obtain a continuous and accurate record of the Earth's magnetic field and its variations over time. More recently, similar magnetometers have been employed onboard of satellites (e.g. CHAMP, SWARM). Observatories measure slow geomagnetic field changes due to processes in the Earth core (so-called secular variations) and rapid changes related to interactions with the solar wind and the ionosphere.

Observatory magnetometers must meet most stringent requirements in term of sensitivity, accuracy, and long-term stability. Fulfilment of these requirements must be tested under controlled conditions in a magnetically quiet environment, far from nowadays ubiquitous disturbances produced by human activities. Furthermore, temperature variations must be avoided as far as possible.

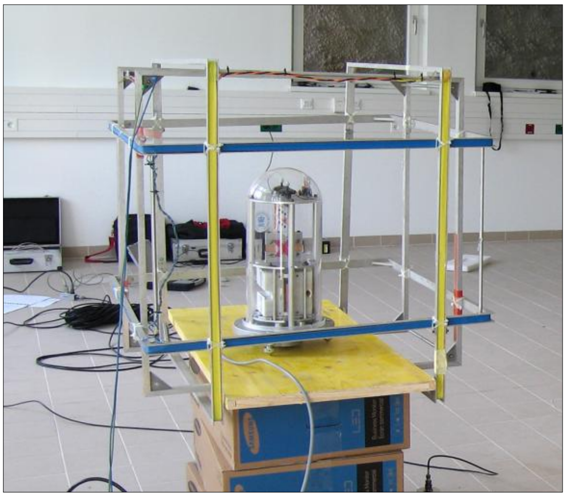

Figure 1: FGE fluxgate magnetometer placed at the centre of three pairs Helmholtz coils during a frequency response test.

Our Geomagnetic Observatory (GMO) offers ideal conditions that satisfy these requirements in large rooms that can host several equipments at the same time. Daily temperature variations in GMO tunnels, for instance, do not exceed 0.05°C.

For this reason, we are setting up a testing and calibration facility where precisely controlled, homogeneous magnetic fields are generated with a set of special coils. A first prototype is shown in Fig. 1. This prototype has been used to test the responses of a Caesium scalar magnetometer (Geometrics G823) and a FGE fluxgate magnetometer (DTU Space) to the following field conditions: (1) a sharp step occurring at a precisely known time, and (2) sinusoidal magnetic field variations in the 0.1-100 Hz frequency range.

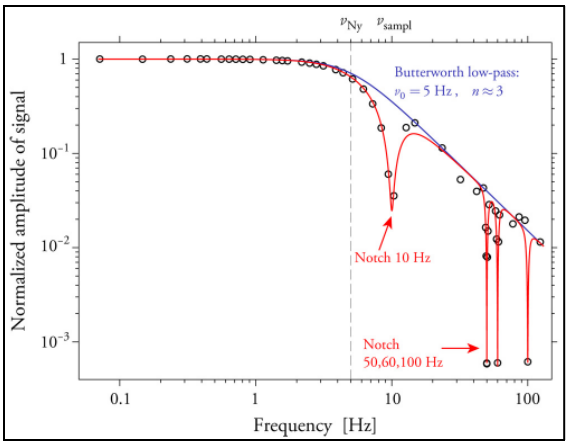

Figure 2: Frequency response of a Geometrics G823 Caesium magnetometer, measured with a sampling rate of 10 Hz (dots: measured, red: best fit model). The effects of analogue filters for the suppression of aliasing effects and disturbances at power supply frequencies (50 and 60 Hz) are clearly visible.

Sinusoidal field variations with ~200 nT amplitude have been used to probe the frequency response of the Cesium magnetometer, which is shown in Fig. 2.

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Geomagnetism

Calibration of a novel scalar magnetometer

Werner Magnes, Roland Lammegger, Andreas Pollinger, Michaela Ellmeier, Christian Hagen, Irmgard Jernej, Lorenz Windholz and Wolfgang Baumjohann

Scalar magnetometers measure the magnitude of the magnetic field with high absolute accuracy. A new type of an optically excited scalar magnetometer is currently being developed for space application by two research institutions in Graz, Austria. The use of a specific quantum-optical effect allows omni-directional measurements with an all-optical sensor design without magnetic feedback and excitation signals at the sensor. A first demonstration of the new instrument in space is planned aboard the Chinese Electro-Magnetic Satellite mission to be launched in December 2016.

A new type of scalar magnetometer, called Coupled Dark State Magnetometer (CDSM), is currently under development in a close cooperation between the Space Research Institute of the Austrian Academy of Sciences and the Institute of Experimental Physics of the Graz University of Technology.

The CDSM is an optically pumped magnetometer which uses the energy from a specifically modulated laser diode for exciting the electrons of rubidium atoms in order to measure the magnitude of the magnetic field (Lammegger 2008). The measurement is based on the Coherent Population Trapping (CPT) and Zeeman effects. The energy shift of the atomic levels is described by the so-called Breit-Rabi formula where only fundamental natural constants are contained. The switching between different CPT resonances enables omni-directional measurements, i.e., any angle between the magnetic field direction and the optical reference axis of the sensor.

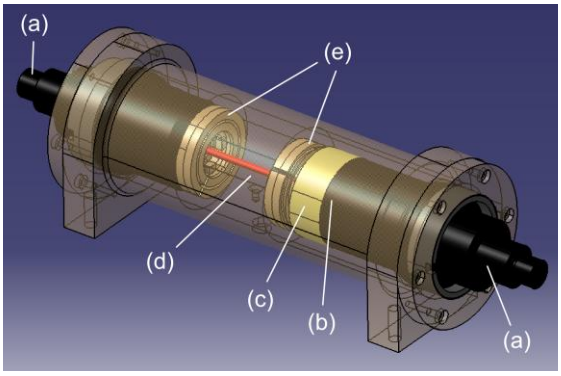

Figure 1: 3D model of the CDSM sensor with two fibre couplers (a), a polarizer (b), a quarter-wave plate (c), a 25mm long Rb-filled glass cell (d) mounted between two damping elements (e) and the sensor housing.

A prototype for space application has been built up since 2012 with funding from the Austrian Space Applications Programme and a Strategic Initiative of ESA (Pollinger 2013). The calibration of the CDSM will to a large extend take place in the new geomagnetic part of the Conrad Observatory by comparison with the reference instruments of the observatory. A first test measurement took place in March 2013 (Fig. 2) and a lot more testing is planned for 2014.

Figure 2: CDSM measures the Earth's magnetic field at the geomagnetic Conrad Observatory.

Beyond this activity, the Space Research Institute is highly interested in calibrating all sorts of space magnetometers in a specially equipped side tunnel of the observatory in the future.

References:

Lammegger R. (2008) Method and device for measuring magnetic fields. Patent WO 2008/151344 A3.

Pollinger P. (2013) Development and evaluation of a control unit for the Coupled Dark State Magnetometer. Dissertation, Graz University of Technology.

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D/I theodolite with cableless FLUXSET© magnetometer

László Hegymegi, János Szöllősy

Most widely used D/I flux theodolites for absolute observations have two separate units connected with cable. This solution is inconvenient because the instrument can be affected by external electromagnetic disturbances. This problem can be avoided if the magnetometer electronics is placed together or close to the sensor and the magnetometer is connected to the display unit via radio link. The final goal of our project is to develop a semi-automatic instrument and procedure to carry out absolute observations.

Simple construction and low power consumption of FLUXSET© magnetometers allow for putting them into a small box together with a battery. This box is mounted on the telescope of the theodolite. This way it moves together with the sensor during the whole measurement procedure. Any possible small magnetic moment will be cancelled by this method.

Display unit and magnetometer are connected by a radio link and the display can be placed to a large distance in order to avoid measurement disturbances. Measured data are transmitted to the display unit by a radio transmitter.

Figure 1: D/I theodolite with FLUXSET.

The display unit has a LED bar display in addition to large scale numbers. It indicates the operation of the radio connection and the output signal level including a sign when we are outside the measurement range. In order to decrease the power consumption the display has automatic luminosity control. Battery power is well enough for a whole day's operation.

To increase measurement accuracy the display unit is equipped with a GPS, which gives a precise time stamp to the data. They are stored in a memory by remote command. At the end of the measurement process the memory content can be uploaded to a processing computer via USB connection.

Figure 2: Magnetometer display.

Angle readings have to be entered manually to the computer but a digital encoder and radio transmission of angle data is under development.

Instrument charging needs 10 to 18 V DC or 100 to 240 V AC for convenient observatory and field use.

Technical specifications:

Theodolite	Zeiss THEO 010/020
Magnetometer	
operating range:	± 6 µT
measuring range:	± 200 nT
resolution:	0.1 nT
offset error:	± 1 nT, adjustable
Display unit	
characters:	54 mm (3½ digit+sign)
radio link:	2,4 GHz
working range:	> 15 m
operating time:	> 12 hr
charging time:	~ 8 hr

References:

Vértesy G., Gasparics A., Szöllősy J. (2000) High sensitivity field sensor. Sensors and Actuators, 85, 202-208.

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AUTODIF at CONRAD: towards an Automatic Magnetic Observatory

Jean Rasson, Alexandre Gonsette, Stephan Bracke

An automatic instrument allowing accurate measurement of the geomagnetic field direction was installed in CONRAD, a world première. Operation of the AUTODIF is fully automatic and performs a full vector attitude measurement every half hour with accuracy better than 6 arcseconds. AUTODIF will deliver absolute measurements able to calibrate the many CONRAD magnetometers.

Automatic magnetic observatories do not yet exist because the geomagnetic field vector orientation measurement needs a human operator. AUTODIF (Fig. 1) aims at changing this by performing the task automatically.

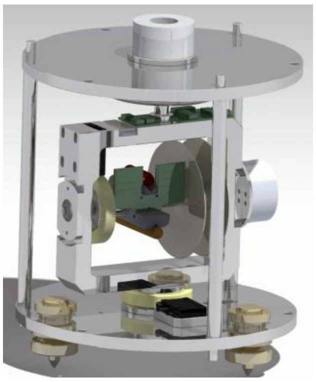

Figure 1: AUTODIF MKII v2.0. Note the special non-magnetic motors (in black) carrying out the rotations about horizontal and vertical axes normally performed by a human operator.

ZAMG and RMI of Belgium have been collaborating during many years in the construction of the Austrian geomagnetic observatory (our first contacts date back to 1982!). AUTODIF was acquired in 2008. A first test installation of the AUTODIF MKI was performed in 2009 in the seismic tunnel. In 2013, when the geomagnetic tunnel was ready, the current installation was planned.

AUTODIF is essentially a robotized theodolite with the extraordinary property that it is entirely non-magnetic. Therefore, the angles measured by this device are truly the ones that the natural geomagnetic field vector makes with our terrestrial reference frame (magnetic declination and inclination). Together with measurements from a proton magnetometer, the full geomagnetic vector is determined absolutely and opens the way to an automatic observatory.

This installation aims at a permanent presence on a pillar in the absolute section of the geomagnetic tunnel of the Conrad observatory (Fig. 2); therefore special precautions have been taken to ensure continuous and reliable operation over the lifetime of the instrument (Fig. 3). The accuracy in measuring the angles is better than 0.1 arcminute, the sampling rate of the measurement being adjustable, ranging from 4/hour to 1/week.

Figure 2: Installation location details. The insert shows a 50m distant corner cube, reflecting AUTODIF's laser beam. It is used as a directional reference.

Controls and data of AUTODIF are available over ZAMG's LAN and beyond in raw format and as final angular values. AUTODIF is designed, constructed and tested by RMI in its "Magnetic Valley" instrumentation facilities of Dourbes, Belgium (*info@magneticvalley.be*).

Figure 3: ZAMG scientists with Eng. Bracke, making a point during the installation of AUTODIF. Note the blue housing protecting the instrument from dust and humidity.

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Advanced LEMI magnetometers, compatible with the 1-second INTERMAGNET standard, deployed at Conrad Observatory

Andriy Marusenkov

The Conrad Observatory is a unique place, in terms of low anthropogenic electromagnetic noise and high temperature stability, for performing high-quality geomagnetic measurements. The important part of these measurements is a continuous registration of the Earth magnetic field variations. The brief information about the modern flux-gate variometers LEMI-025 and LEMI-036 installed at Conrad Observatory is given below.

The fluxgate magnetometers LEMI-025 and LEMI-036 were specially developed for the super sensitive measurements of 3 components of Earth magnetic field induction and its variations in accordance with the new 1-second INTERMAGNET standard (Table 1).

Table 1: Magnetometers parameters vs. INTERMAGNET One-second Data Specifications.

General specifications	Intermagnet requirements	LEMI-025 & LEMI-036
Time-stamp accuracy	0.01 s	< 0.0001s
Phase response	±0.01 s	±0.01 s max
Max. filter width	25 s	17 s
Amplitude Range	≥±4000 nT	±4000 nT
Data resolution	1 pT	1 pT
Pass band	DC to 0.2 Hz	DC to 0.5 Hz
Max. component orthogonality error	2 mrad	0.5 mrad *
Max. Z-component verticality error	2 mrad	0.5 mrad *
Pass Band Specifications [DC to 8 mHz (120 s)]		
Noise level	≤100 pT RMS	< 20 pT RMS
Max. offset error	±2.5 nT	±2 nT *
Max. scaling & linearity error	0.25%	0.2% scaling 0.01% linear.
Pass Band Specifications [8 mHz (120 s) to 0.2 Hz]		
Noise level	≤10 pT/Hz$^{1/2}$ at 0.1 Hz	7 pT/Hz$^{1/2}$ at 0.1 Hz
Max. gain/atten.	3 dB	0.6 dB atten.

* after calibration

In order to realize this design major attention was paid to principal characteristics and parameters such as frequency response and sampling synchronization accuracy as well as thermal and temporal stability and noise level. To fulfil such mutually contradictory requirements as small phase response delay and deep suppression of industrial noise, the specific combination of analogue and digital filters was realized in these instruments.

Both instruments are based on the same electronic units and fluxgate sensors. However, LEMI-036 was specially developed for the Conrad Observatory to be installed in an empty borehole with a diameter 0.2m or more. The fluxgate sensor is fixed at the suspended platform in order to automatically keep the horizontal level.

Figure 1: Flux-gate magnetometer LEMI-036.

References:

Turbitt C. et al. (2013) An Instrument Performance And Data Quality Standard For Intermagnet One Second Data Exchange, Proceedings of the XVth IAGA Workshop on Geomagnetic Observatory Instruments and Data Processing, BOLETIN ROA № 3/2013, p. 186-188.

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Detection and investigation of magnetic low-frequency noise near urban area

Niko Kompein, Rachel Bailey, Ramon Egli

Recent investigations in the course of the ZAMG City-Noise Project revealed a magnetic, low frequency noise content preceding the set in of high frequency noise early in the morning at the Cobenzl Observatory, Vienna. Investigations on this subject may lead to a temporal correlation regarding an undiscovered kind of artificial or natural source. A mobile 3-component sensor was used to gather magnetic field data at selected sites in Austria for further comparison. The Conrad Observatory, built into a tunnel in Trafelberg, Lower Austria, is secluded and hardly disturbed by urban influences, hence the magnetic records may be used as "undisturbed reference signals".

The first part of this project was to gather data with a 3-C fluxgate magnetometer at the reference sites of the Cobenzl and Conrad Observatories. The 3-C fluxgate data had to be resampled and temporally shifted for best fit of the observatory reference data. Furthermore, the calibration factors had to be determined regarding the two observatories.

Resampling was done using a Gaussian-weighted average, and the temporal shifting by calculating a Gaussian-weighted correlation coefficient. The calibration factors were determined by plotting the 3-C fluxgate data against the observatory reference data. The calibration factor of the 3-C fluxgate in regard to the observatory data is the first order term of the linear interpolation.

A long data series has been collected at the Cobenzl observatory as well as the first datasets from the Conrad observatory. These were used to get calibration factors.

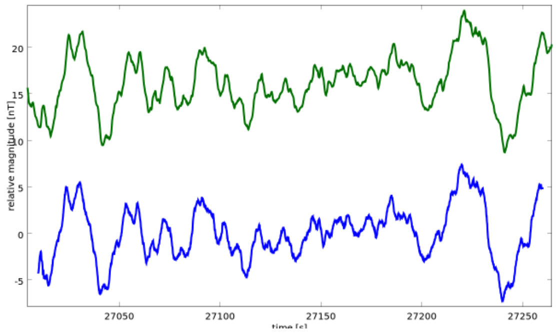

Figure 1: Magnitudes of relative total field change compared : 3-C fluxgate measurement (blue) at Cobenzl Observatory „Absolut-Haus“ pedestal compared to lemi-025 data of Cobenzl observatory (green) [nT] - both versus time in seconds (around 20 m distance between the two locations).

Figure 1 shows the comparison of the magnitude of the relative field change measured by the mobile 3-C fluxgate magnetometer to the Cobenzl Observatory data versus time in seconds. Although not visible lemi-025 data (green) is more smoother than the 3-C fluxgate data (blue).

In Figure 2 the magnitude of the relative total field change of the 3-C fluxgate (blue) is plotted versus the the above mentioned data in Figure 1 of lemi-025 (green). Hence the first-order term of the linear regression model is the calibration factor, which is around 0.97.

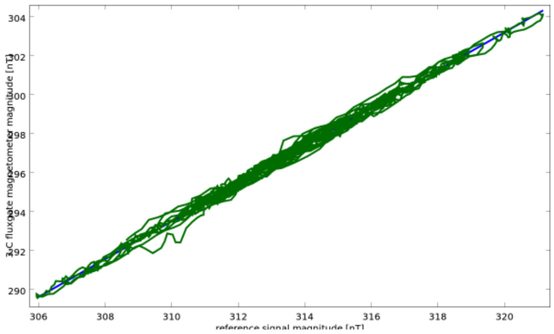

Figure 2: Linear regression model (blue) for above mentioned magnitude of relative total field change of 3-C fluxgate data with regards to Cobenzl observatory lemi-025 data (green) => calibration factor = 0.97.

A further objective in this project includes tests of system dependent noise behaviour of the 3-C fluxgate sensor while sampling at different sampling rates.

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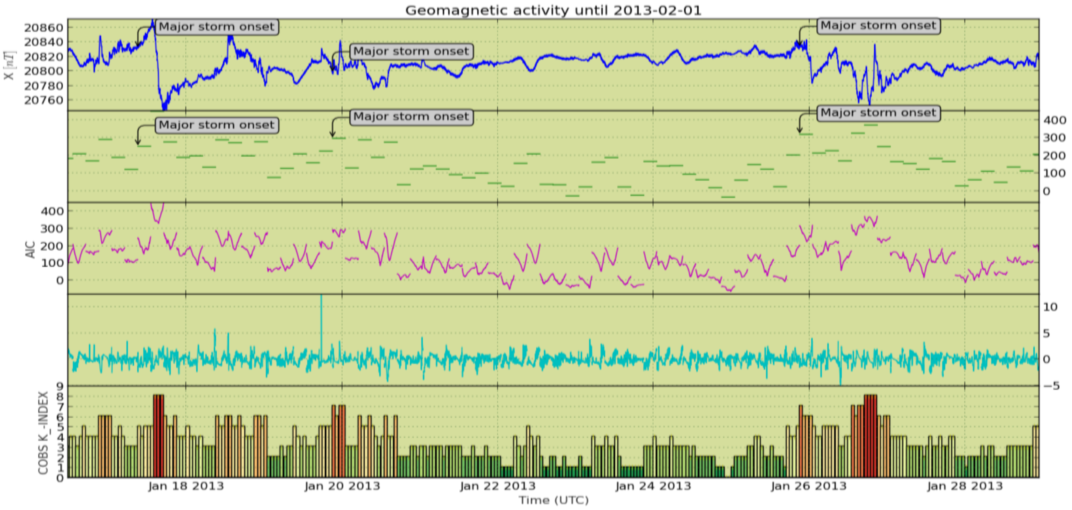
The real time recording and detection of geomagnetic storms

Virginia Fölserl, Roman Leonhardt

Geomagnetically induced currents are at the end of a space weather chain that originates at the Sun. During a geomagnetic storm, intense currents are produced in the magnetosphere and ionosphere creating time-dependent magnetic fields. At the Earth's surface these fields induce geomagnetic currents in powerlines. As a consequence, lots of technical disturbances have been reported. This article is about a geomagnetic storm detection software (GSDS), which filters, corrects and analyzes the data. Additionally, it targets on detecting geomagnetic storms in real-time and to automatically publish a current storm.



The Sun alternates between quiet and very active phases in a period of ~11 years. During so-called coronal mass ejections (CME) charged particles are ejected in form of plasma clouds, which can reach the Earth after a few hours to days. If the polarisation of the plasma-cloud is opposing the polarity of the Earth's magnetic field, both magnetic fields connect. This enables electric particles to enter the Earth's atmosphere and to induce geomagnetically currents (GIC), for example in power lines.

The most famous GIC event took place in 1989 over Quebec, Canada. The current caused a major blackout. On October 30, 2003, 50,000 people were affected by power blackout in Malmö, Sweden. As a side effect wonderful auroras were visible all over Europe.

The Sun is at the maximum of its activity cycle right now. For this reason it is important to analyze GICs in order to identify eventual vulnerabilities of the power grid and, ideally, to forecast their consequences in advance to extenuate or prevent appreciable damage.

The Conrad Observatory is equipped with magnetometers that permanently detect field intensity and variations in three dimensions. The measured data is supplied to a storm detection software which supports automated data filtering, correction and analyzation. This software is capable of detecting geomagnetic storms in real time. The aim of this project is to provide information to the relevant authority on geomagnetic induced currents, which can potentially damage the infrastructure of the Austrian power grid.

Acknowledgement
The research is funded by bmvit through the FFG FEMtech project 839473 "GeomagnetischeStürme".

References:

Wik M., Viljanen A., Pirjola R. et al. (2008) Calculation of geomagnetically induced currents in 400 kV power grid in southern Sweden, SPACE WEATHER, VOL. 6, 1(1-2)
Pirjola R. (2000) Fundamentals about the flow of geomagnetically induced currents during mafnetic storms, IEEE Trans. Plasma Sci., 28(6), 1867 -1873.

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Realization of a borehole for the installation of geomagnetic instruments

Kurt Kogler, Christoph Black

The preparation of two deep wells of 140 and 240m depth are an essential component in the construction of the geomagnetic observatory on the Trafelberg at Muggendorf. The construction of an underground tunnel system about 30m below ground level with longitudinal and transverse tunnels for measuring the x- and y-direction are complemented with two deep boreholes for the implementation of geomagnetic measurements in the third dimension, i.e. the z - direction. The company Züblin Foundation Engineering, a subsidiary of Austrian construction company STRABAG was awarded the contract for the execution of these deep wells in October 2011 by the BIG (Federal Real Estate Company).

Special Technical challenges:

According to the client planning two deep boreholes (TB1A and TB2A) with drilling depths of 140m and 240m were required. Furthermore, the installation of a protective casing with an inner diameter of 240mm was provided. Special requirements of this tender were the adherence of verticality with a drilling accuracy of <1%, the injection of the annular space between the borehole wall and casing tubes, as well as the guarantee of absolute water tightness of the finished borehole. Another challenge was presented by the demand for a "anti-magnetic production", i.e. all built-in and remaining materials in the borehole are non-magnetic.

Figure 1: Borehole with casing.

Execution of drilling operations:

The execution of the drilling was done with a so-called "truck - rotary - drilling rig" with a weight of approximately 60 tons. With this rig, both the required core drilling, as well as the necessary “Rotationsspülbohrungen” and the pilot holes could be carried out with the down-the-hole hammer. The borehole No.TB1A was drilled without major problems, made up to 140m depth and the well casing was installed.

However, while drilling the borehole No.TB2A a karst cave was struck at a depth of about 110m below ground. This led to a significantly additional expenditure by backfilling with cement grout, bentonite and finally gravel grit 4/8 in the amount of about 150m³ and a considerable time delay regarding the completion of the drilling operations.

Installation of the well casing:

After pumping out the well casing the shallow borehole No.TB1A demonstrated no problems regarding tightness in the 240-meter-deep hole. However, in borehole No.TB2A a low but constant water influx was observed.

Ultimately, this led to the decision to remove the built-in PVC pipe of borehole No.TB2A by “überbohren” with a special tool over the entire length. The borehole was further widened to a larger diameter of about 440mm and a GRP piping DN280mm was placed.

Figure 2: Magnetic control measurements of No.TB2A.

This work was successfully carried out in the summer of 2013 and borehole No.TB2A was handed over to the client after a pressure test and 8 weeks of control measurement, in order to detect potential leaks, on 14 October 2013.

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Geomagnetic Observatory in Muggendorf on Trafelberg

Gerald Kaufmann, Ernst Eichinger

The location of Muggendorf Conrad Observatory is ideal due to the remoteness as well as the constant climatic conditions for earthquake research, observation of Earth's gravity and geomagnetic field measurements. The first stage, opened in 2002, comprises an underground research and training center for seismology and gravimetry. With the second stage the research center was complemented with the discipline of geomagnetism.

After an extensive and thorough planning phase the construction of the geomagnetic part of the Conrad Observatory started in April 2010. The geomagnetic observatory is a so-called "Low Noise Facility", which is guaranteed by its non-magnetic underground construction within the limestone of the Trafelberg, lower Austria.

This location is free of natural and artificial electromagnetic interference. Within the tunnels the ambient temperature is constant with negligible seasonal fluctuation. Therefore optimal conditions for high-precision geophysical measurements are achieved.

As part of the project a tunnel system was built with a total length of approximately 1,000m covering an area of approximately 2,500m^2. The main gallery (Fig.1) is 400m long. It runs from the south, where the entrance building is located, to the north.

Figure 1: Main tunnel during construction.

Four shorter transverse tunnels branch off from the main tunnel to the east and west in which the measuring devices are housed. Two additional short connecting tunnels run parallel to the main tunnel.

Two boreholes, 100m and 200m deep, allow for three-dimensional measurements. The realization of two perfectly straight and waterproof boreholes was a major challenge. Within in the scope of this project such construction task was performed and solved for the first time in Austria. In addition to the tunnel system a 600-square-foot entrance and operating building (Fig.2) was constructed.

Figure 2: Entrance and operating building.

In order to eliminate any disturbances on the measurements within the research institutions, only non-magnetic materials could be used. Therefore, all components were tested prior to installation regarding their magnetic properties. For example, the wooden fire doors have non-magnetic screws and conduits for the wiring are designed in plastic.

In September 2013 the construction project, including the deep drilling, was completed.

Table 1: Numbers, data, facts.

Start of construction	April 2010
End of construction	September 2013
Tunnel area	approx. 2.500m^2
Total length	approx. 1.000m
Borehole 1	approx. 100m depth
Borehole 2	approx. 200m depth

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Influence of atmospheric processes on gravity – At what scales?

Manfred Dorninger, Bruno Meurers, Sandro Oswald

Atmospheric processes influence high-precision gravity measurements over a broad range of frequencies. Besides air pressure, the knowledge of the vertical distribution of water in the atmosphere is essential to ensure reliable results. However, it is rather unknown at what temporal and spatial scale does this parameter influence the gravity signal. Is it adequate to provide a rather rough mean value on a larger scale or do we need highest possible resolution in both temporal and spatial scales?

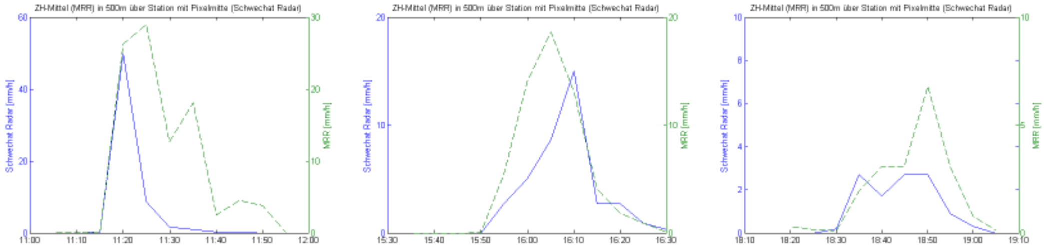

Figure 1: Rain rates (mm/h) for the lowest 1000m height interval for WRX (blue) and MRR (green).
Left: Type A: 27 Mai 2011 11h00-12h00 UTC , centre: Typ B: 3 Juni 2011 15h30-16h30 UTC and right: Typ C: 27 Mai 2011; 18h00-19h10 UTC. Note the different scaling of the axes.

Water in the atmosphere in terms of vertical integrated liquid water content (VIL) causes short-term variations in the gravity signal. The correction of these disturbances is crucial to get meaningful geodynamic results (Meurers, et al., 2011). VIL is determined from two different data sources measuring at different scales. Data from the dual Doppler weather radar (WRX) in Schwechat are compared to data from the vertical-pointing micro rain radar (MRR) positioned at the Conrad Observatory (COBS). The direct line from the WRX to the observatory is about 60 km. VIL can be extracted from both data sources but on very different scales. One WRX data point represents a mean value for a cube of 1x1x1km every 3 and 5min. By contrast one MRR data point represents a mean value for a height interval of 100m and 30sec mean.

In a first step MRR data are upscaled to allow for a comparison of the two data sources. One has to note that the scanned volume of the MRR represents less than 1 per mille of the WRX volume.

The WRX suffers from the fact that strong convective cells in the direct line between Schwechat and the COBS dampen the radar beam and result in an underestimation of the precipitation amount above the COBS. Depending on the propagation direction (along the direct line) of the precipitation systems three characteristic weather regimes can be identified (Fig. 1). Type A: Weather systems moving from southwest to northeast. WRX underestimates precipitation on the later stage of the weather system. Type B: Weather systems moving from northeast to southwest: WRX underestimates precipitation at the beginning of the event. Type C: Stratiform precipitation events. Both measurement systems perform equal. An example for a Type B event is given in Fig. 2).

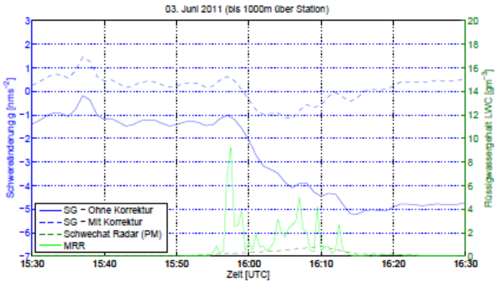

Figure 2: Type B event:
Non-corrected (blue-solid) and rain corrected (blue-dashed) gravity signal.
Liquid water content measured by MRR (green-solid) and WRX (green dashed).

References:

Meurers B., Dorninger M., Blaumoser N. (2011) Atmospheric signals in the SG gravity record at Conrad Observatory, Austria. Geophys Res Abstr, 13, 12747.

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Absolute gravity measurements at the Conrad Observatory by the University of Luxembourg

Olivier Francis

Absolute gravity measurements have been performed twice at the Conrad Observatory by a team from the University of Luxembourg. The two main objectives are the calibration of the superconducting gravimeter and the determination of its instrumental drift. This project is a long-term collaboration with the colleagues from the BEV and the University of Vienna who conduct absolute and superconducting gravity observations at the Conrad Observatory.

Episodic absolute gravity measurements are carried out at the Conrad Observatory by the team of the Geophysics Laboratory of Luxembourg. The last-born generation of the FG5 absolute gravimeter (manufacturer Micro-g LaCoste Inc., USA) is used to determine the absolute values of the gravity acceleration, g. This is a transportable instrument (Fig. 1) measuring the free fall acceleration of a mass in a vacuum cylinder. The positions of the mass during the free fall are measured with an interferometer using an Iodine stabilized laser. A rubidium clock steered by GPS provides the accurate timing. The accuracy is approximately 2 10-9 of g.

Figure 1: Absolute gravimeters side-by-side with the superconducting gravimeter at the Conrad Observatory (FG5-242 from Austria, FG5X-216 from Luxembourg with the glass tube and SG GWR C025).

The absolute gravity measurements (Fig. 2) are used to determinate the scale or calibration factor of the relative superconducting gravimeter GWR C025 operating continuously at the Conrad Observatory. They also allow us to estimate the instrumental drift of the SG.

The calibration of the SG requires taking measurements for 3 to 4 consecutive days, preferably when the gravity variations are the largest (i.e. during a maximum of the Earth tides).

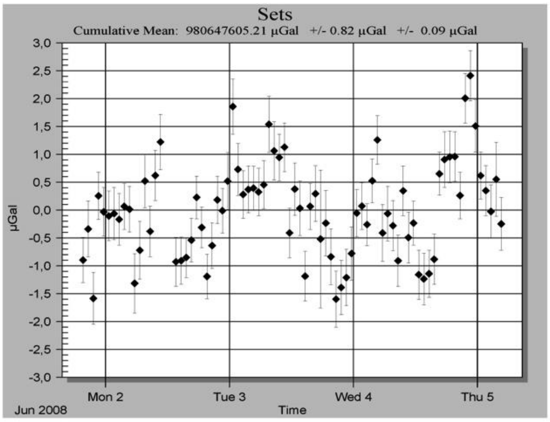

Figure 2. Results of the absolute measurements from the 1st to the 5th of June 2008 corrected for Earth tides, atmospheric pressure and polar motion effects.

The Luxembourg absolute gravimeter already visited two times the Conrad Observatory in June 2008 and 2012. During the measurements, our colleagues from the Federal Office of Metrology and Surveying (BEV) take advantage of the opportunity to measure with their own absolute gravimeter to check that both absolute meters are operating properly.

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Absolute Gravity Measurements with the Austrian FG5 Absolute Gravimeter at the Conrad Observatory (CO): Results and Problems

Christian Ullrich, Diethard Ruess

Since 2010 absolute gravity measurements have been performed with the absolute gravimeter (AG) FG5/242 at the CO. The FG5 gravimeter was acquired in cooperation between BEV and ZAMG. The measurements are mainly used for the calibration of the superconducting gravimeter (SG). Although the FG5 gravimeters represent the latest standard in absolute gravimetry, the measurements were affected by a Helium concentration in the gravity lab of the SG.

Absolute gravity measurements have been performed at the CO since 2010 with the AG FG5. The AG uses a laser to track the free-fall position of an object that forms one arm of an interferometer. The timing of the optical fringes is measured using a commercial rubidium atomic clock (Symmetricom SA.22c). These clocks are very robust and have a low drift rate (a few mHz per year).

Both the laser and the clock are calibrated regularly at the BEV metrology department. The calibration of the clock in October 2011 showed that there was a strong drift of 50 mHz in one year, which is unusual for such clocks. This led also to some small changes in gravity, which did not coincide with the SG signal. The next calibration in December 2011, immediately after measurements at COBS, showed again a large drift and an increased measurement uncertainty.

Therefore, this clock was replaced by a new one. After storing the AG in the gravity lab the new clock was again outside the normal drift rate (Fig. 1).

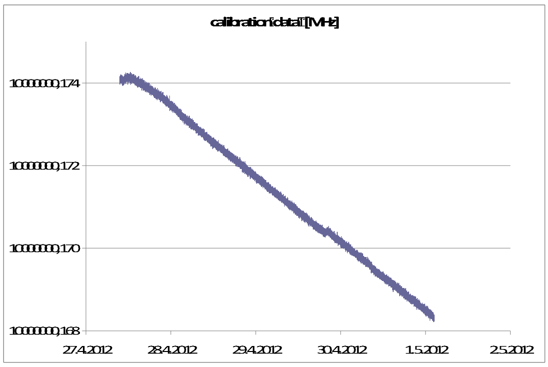

Figure 1: Drift rate of the rb-clock (5 mHz in 4 days), after storing the AG for a few months at CO gravity lab (calibrated at BEV).

After a lot of investigations, a specialist from the firm that manufactured the clock, Dr. R. Michael Garvey (Symmetricom®, Inc. Consulting Scientist), told us: “Helium is known to permeate the Rubidium cell and causes excessive frequency offset. Once removed from the Helium environment, the Helium is discharged and the Rubidium returns to normal operation”.... “the sensitivity of Rubidium standards to Helium is extreme. It is very difficult to quantify in most situations (who knows how much Helium is in the atmosphere of a particular lab at any given time?) but exposure to Helium gas in almost any concentration is very detrimental to the long term performance of the device.” Another clock was purchased and is now operated outside the gravity lab and the calibration results are correct now.

The manufacturer (Microg LaCoste) of the AG-FG5 presented some quantitative investigations about the influence of Helium on the clocks of their AG’s for the first time at the IAG SYMPOSIUM ON TERRESTRIAL GRAVIMETRY in St. Petersburg 2013.

Therefore all gravity measurements of the Austrian FG5/242 were checked carefully for the clock influence. The drift rate of the clock was used to reprocess the gravity data, which was regularly detected at the BEV metrology department. Fortunately a lot of results, especially outside the gravity lab of CO, are within the usual measurement uncertainty of the AG-FG5, which was also demonstrated at ECAG 2011.

References:

Francis O. et al. (2013) The European Comparison of Absolute Gravimeters 2011 (ECAG-2011) in Walferdange, Luxembourg: results and Recommendations. Metrologia 50 (2013) 1-12.

Bloch M., Mancini O., Mc Clelland T., Performance of rubidium and quartz clocks in space. Frequency electronics,Inc.

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Comparative measurements of 3 relative spring gravimeters and the GWR SG025 for calibration purposes

Judith Benedek, Márta Kis, András Koppan, Bruno Meurers, Gábor Papp, Eszter Szűcs, Norbert Blaumoser

In tidal analysis as well as in geodynamical research the knowledge of accurate scale factors of relative spring gravimeters has crucial importance. In order to determine the instrumental response (calibration factor) of Scintrex CG-5, LCR-G949 and LCR-G220 gravimeters comparative measurements were carried out at Conrad Observatory (ZAMG) between 12/12/2012 and 04/05/2013 co-located with the SG GWR-C025.

A special problem was that - contrarily to the SG25 and CG5 - the two LCR-G meters were not equipped with feedback systems. The LCR-G949 was registering by using a CCD ocular while LCR-G220 uses the CPI output voltage. The transfer functions of LCR-G gravimeters are expected to be non-linear and dependent on the beam position. After data pre-processing (e.g. spike and step elimination) a standard tidal analysis was computed by using the ETERNA software package (Wenzel 1996) to determine the instrumental response in the frequency domain. Then a comparison and adjustment with the SG data was carried out to achieve the proper scale factors in the time domain.

Figure 1: GWR-025, Scintrex CG-5, LCR-G 949 and LCR-G 220 at the Conrad Observatory.

Due to the slightly non-linear instrumental drift of LCR-G the four months data sets were analysed also in daily sequences. After applying convolution filters to every SG and LCR segment both the daily phase between the two time series and the daily scale factors were computed. The latter can be assigned to the daily mean beam position and in this way the discrete scale function is determined for the 1500 µGal wide measuring range.

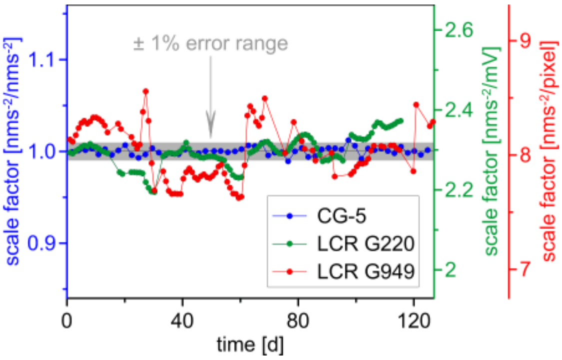

Figure 2: Temporal scale factor variation derived by analyzing data of non-overlapping 2 days' intervals.

The temporal variation of scale factors is displayed in Fig. 2. Table 1 lists the average scale factors obtained in the time domain. The relatively high standard deviations for the LCR gravity meters is due to the dependency of the scale factor from the tilt and beam position.

Table 1: Time domain calibration.

	CG5	LCR220	LCR949
Scale factor	1.00004	2.29596	8.03474
Std-dev	0.00432	0.03898	0.25223
unit	nms^{-2}/nms^{-2}	nms^{-2}/mV	$nms^{-2}/pixel$

Average scale factors.

Acknowledgement

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References:

Wenzel H.G. (1996) The nanogal software: earth tide data processing package eterna3.30. Bulletin d'Informations Marées Terrestres, vol. 124, 9425-9439.

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Hydrogeology and Geology at the Trafelberg

Sabrina Deisl, Norbert Blaumoser, Roman Leonhardt

Besides other parameters such as air pressure and temperature, the hydrology of an area can have great influence on geophysical measurements. Hydrology becomes a more complex factor particularly in the region of the Conrad Observatory, which is situated in a carbonate region. Furthermore, the hydrogeology, which describes the interaction between water and rocks, and the geology become important parameters.

Figure 1: Folded Wetterstein limestone along a forest road.

The Trafelberg belongs to the northern limestone Alps, which are characterized by their karst phenomena. The majority of the mountain is located in Unterberg nappes (Triassic) and only part of the northern slope is situated in Reisalpen nappes (Triassic). Both Unterberg nappes and Reisalpen nappes belong to tirolikum.

The main lithological units in the area of Trafelberg are, from oldest to youngest, the Gutensteiner limestone (Anis), the Wetterstein limestone (Ladin – Cordevol), the Wetterstein dolomite (Ladin – Cordevol) and the Dolomia Principale Formation (Oberkarn – Obernor). Due to the large amount of folds in the underground, as seen in Figure 1, the structure of the mountain is fairly complex in parts. The layers of the units dip towards the south.

Springs are of great interest concerning hydrology, however there are no springs on the Trafelberg itself. The closest spring rises at the northern border of the mountain, near the cave Myralucke (“Myra Hole”). This spring is the origin of the brook Myrabach, which flows along the northern side of the Trafelberg to the east. Instead of springs many, mainly small water holes were observed on the mountain. These are nurtured by surface precipitable water draining off. Particularly at the time of snow melt or fierce precipitation are water discharges observed in the gutters.

A hollow, which is situated close to the Seismic Gravimetric Observatory (SGO) and has been filled with sediment over time, is of particular interest for geophysical observers. Due to the great body of sediment, it has the potential to staunch water. Such a large body of water so close to the SGO is of high importance to gravimetric measurements, which can be strongly influenced by local hydrological conditions. This is especially important if the subsurface water flow leads beneath the SGO because of the local joints and karst phenomena.

Acknowledgement
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References:

Wessely G. (2006) Geologie der österreichischen Bundesländer: Niederösterreich. Wien, Geologische Bundesanstalt.
Summenberger (1991) Puchberg am Schneeberg 1: 50 000 – Geologische Karte der Republik Österreich, 75, Verl. D. Geologischen Bundesanstalt, Wien.

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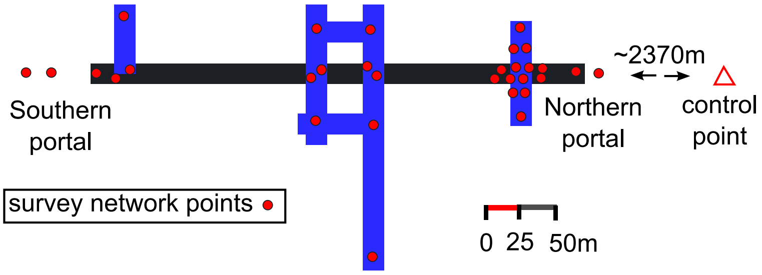
Precise Geodetic and Astronomic Measurements at the Geomagnetic Observatory Trafelberg (GMO)

Georg Friedl, Franz Blauensteiner, Diethard Ruess

The knowledge of astronomical orientation is necessary for geomagnetic observations. Also the stability of the observatory building has to be checked by using geodetic methods. That is the reason for stabilizing a network of geodetic benchmarks in and above the gallery of the GMO. The heights of the benchmarks are determined by precise levelling, the positions above using GPS and inside using a precise theodolite. The astronomical orientation was fixed by target boards (in German "Mire").



Topics:

- Determination of the azimuth for the orientation of the magnetometer
- Determination of the azimuths to target boards ("Miren") inside and outside the gallery
- Primary fixing of benchmarks to verify the stability of position und height

Procedure:

Nonmagnetic vertical benchmarks of fillister headed aluminium were used inside the gallery, outside there were stabilized brass benchmarks. The distant objective ("Fernmire" at "Bettelmannkreuz") is made of a 2m metallic rod in a concrete base about 2.4 km north of the gallery.

Heights: The heights were determined using a digital levelling equipment Trimble-DiNi03. The levelling network is linked with the levelling benchmarks of the Seismic-Gravimetric-Observatory (SGO) and with the precise levelling network of the BEV. 52 new benchmarks were stabilized (42 inside, 10 outside). The levelling length of the loop through the gallery and back above is about 1600 m. The loop error amounts 0.15 mm.

Positioning: The global position was done twice at two points by GPS measurements over 24 hours. The network was optimized using the program system PANDA (**P**rogram for **A**djustment of geodetic **N**etworks and **D**eformation **A**nalysis) for simulation. The measurements were carried out using the precise theodolite Trimble S8 with two sets in both circle plains.

Azimuth: The determination of the azimuth will be done by astronomical observation of the Polaris on three benchmarks: southern portal, northern portal and distant objective ("Bettelmannkreuz"). That makes two bidirectionally measured azimuths: Gallery axis => long-term objective and northern portal => long-term objective. These measurements were carried out using the theodolite Kern-DKM2A. Two survey points are still not finished.

Results:

Heights: 52 benchmarks, levelling length ~ 1600 m, loop error 0.15 mm

Survey network:
Points: 33
Observations:
Distances: ~230
Angles: horizontal ~250, vertical ~250
Reached accuracy:
Semi major axis of error ellipse of network points between 0.3 and 0.7 mm

Azimuth southern to northern portal ± 1.3"

This task was a very interesting challenge and enabled us to test the technical feasibility under laboratory conditions.

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Tropospheric Zenith Delays for Trafelberg at Extreme Conditions

Günter Stangl

The height differences at the GNSS station Trafelberg at certain dates have led to the thesis that this phenomenon is triggered by heavy snowfall or rain and the insufficient estimation of the sudden changes in the troposphere. Therefore the estimated values of the zenith delay are checked against those from the nearest meteorological stations. While the values of the stations are consistent, they are not conform with GNSS estimation.

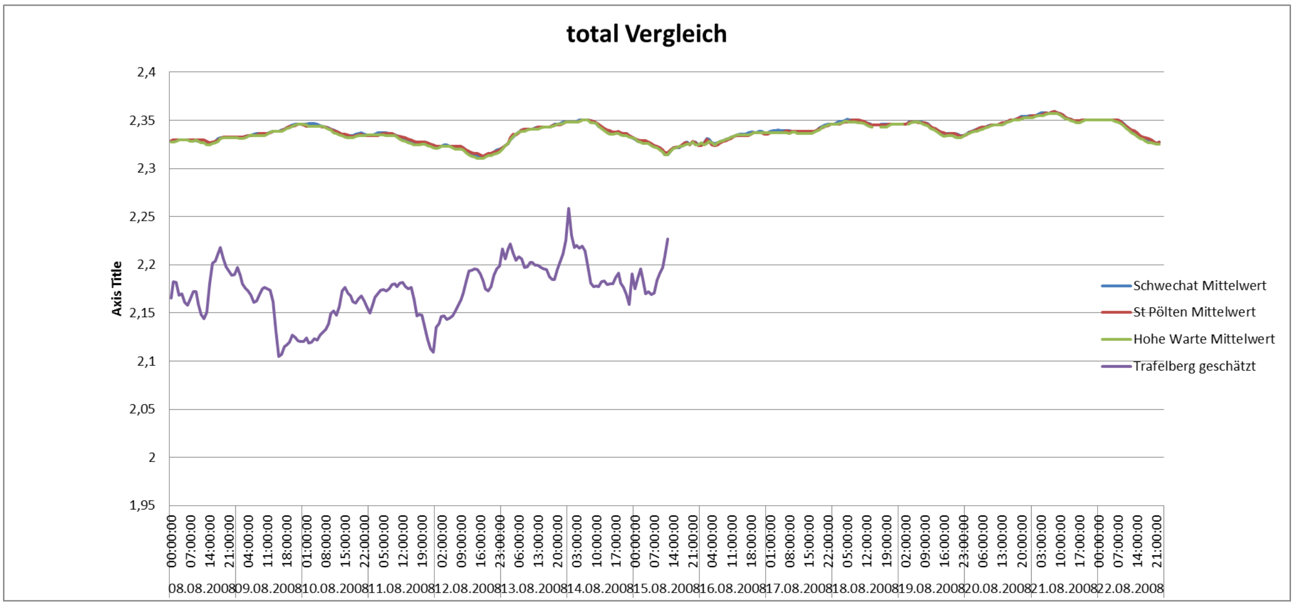

Figure 1: Comparison of total zenith delays, derived from meteorological stations, against GNSS estimations.

The time series of the GNSS station TRF2 (Trafelberg) shows some outliers in height at certain dates. The outliers (20-30mm) remain for one or more days. When investigating such events it turned out that they go hand in hand with extreme weather conditions, e.g. heavy snowfall or heavy rain. The hypothesis was that the estimation of the troposphere was not sufficient and a part of the wrong estimation affects the up coordinate because both are closely related.

Therefore, meteorological parameters (pressure, temperature, and humidity) of the surrounding meteorological stations are compared to the GNSS estimations at the basis of the TZD (total zenith delay). See Figure 1 when it rained heavily. As can be seen there is a bias of about 15cm which can be explained by the fact that when the meteorological stations reduces the pressure to a certain level, a zero height is suggested. More interesting is the behaviour of these days. While all 4 stations are very consistent at the mm-level the estimated TZDs show some erratic jumps up to 5cm which are not realistic.

One reason for the jumps is that the TZDs are estimated day by day without any boundary condition at midnight. The absolute mean value of the day has a big statistical freedom of moving well at the 5cm level varies by 5cm. Thus, when combining TZDs with a time series, boundary conditions should be introduced to reduce the daily jumps. As the figure shows this is unfortunately not enough, because there are still unrealistic short-term (hourly) peaks. More realistic is the time lag by which GNSS estimates the humidity in the clouds before the meteorological stations can detect it. Some peaks could also point to a more complicated structure of the troposphere than the meteorological stations could detect (e.g. inversion layers of the temperature). It would be helpful if a radiosonde could be used to check this.

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Subsurface Radon Monitoring at Conrad Observatory – Insight in natural Radon variations and environmental influences

Wolfgang Hasenburger, Gideon Steinitz, Roman Leonhardt

The radiometry project described here lasted from September 2012 until April 2013. The experiment was set up in the rear section of the seismic tunnel at COBS due to constant environmental parameters like temperature and pressure all over the year. The main goal of this project was to get a first insight in natural Radon (Rn) variation patterns in this region. Combined with measurement of atmospheric environmental parameters (surface temperature, pressure, snow height and precipitation), results showed a distinct correlation between temperature rises above 0°C and subsequent snow melting periods.

Measurements of natural gamma radiation give a first insight on variations of natural Radon (Rn) gas in the area of the Conrad Observatory, Lower Austria. These measurements, executed subsurface in the carbonate host rock of the Trafelberg within a concrete cased tunnel, started in September 2012 and lasted until 1st of April 2013. Besides Rn environmental parameters, which are monitored at the Observatory since November 2012, have been used for correlation with Rn variations and identifying possible environmental influences on the Rn signal, which is the main goal of this study. The experiment has been divided into two stages: 1) Rn monitoring with Pb shielding of the sensor and an additional Rn source until November 2012 and 2) Rn monitoring of natural Rn flux without source and shielding, combined with a contemporaneous monitoring of the environmental parameters temperature, rainfall, snow cover and pressure from November 2012 until April 2013.

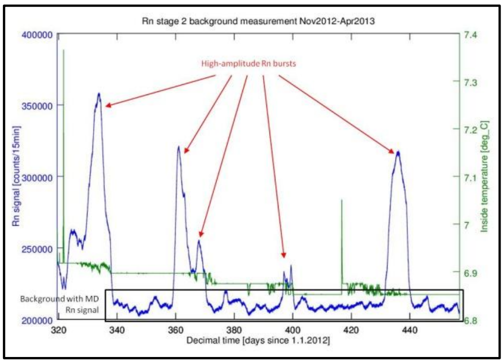

Figure 1: Measured signal of second stage with tunnel temperature lasting from November 2012 until April 2013 (138 days).

The observed Rn signal consists of two different, independent components: a) non-periodic "high-amplitude Rn bursts" and b) non-periodic multi-day (MD) Rn signal in the background as well within the mentioned bursts (Fig. 1) Periodic signals, like diurnal or semi-diurnal, are not found. The temperature inside the tunnel was almost at 6,9°C with variations below 0,1°C throughout this period.

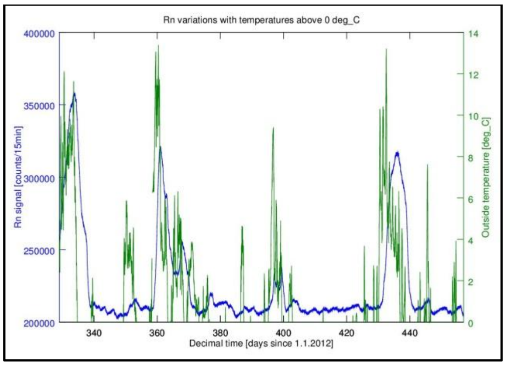

Figure : Rn signal and outside temperatures >0°C from November 2012 until April 2013.

The Rn signal was compared to environmental data, especially outside temperature (Fig. 2) and subsequent changes of snow melting periods (T > 0°C) and periods with T < 0°C. Results showed that the above mentioned "high-amplitude Rn bursts" coincide with melting periods with a small time lag. A model for the origin of this phenomenon was then created, suggesting snow cover as blocker for Rn gas emitting into atmosphere and within melting periods being brought down into the rock with melting water. Analysis of non-periodic multi-day Rn signals combined with atmospheric pressure and temperature may indicate an influence of both but requires additional experiments to verify this hypothesis.

References:

Hasenburger W. (2013) Subsurface Radon Monitoring at Conrad Observatory, Austria. A first insight in natural Radon variations and environmental influences. Bachelor Thesis. University of Leoben.

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Site effect investigation of seismic stations at the Conrad-Observatory

Yan Jia, Nikolaus Horn, Wolfgang Lenhardt

This study investigates three co-located stations with different conditions (CONA in the tunnel, CSNA in the free field and a station located in a borehole) at the Conrad-Observatory, Austria. We found the borehole station showed the lowest noise level overall, while the tunnel station CONA presents a lower noise level than the free filed station CSNA. The borehole station is more sensitive to detect teleseismic signals and primary phases of mining induced events, while the free field station CSNA can well detect primary phases of local and regional explosions.

Seismic stations CONA, CSNA and COBA are located at the Conrad Observatory on the Trafelberg near Muggendorf in Lower Austria, about 50 km southwest of Vienna. The three stations are co-located with the maximum distance around 200 meters to each other. The tunnel station CONA is located inside of a 148-meter tunnel, while the free field station CSNA is situated outside of the Conrad Observatory. The borehole station (called COBA in this paper only) is found in a 100-meter borehole inside of the Observatory.

Noise spectra were calculated and averaged over three time intervals: 0 to 4, 8 to 12 and 12 to 16 GMT and compared in Figure 1 (only HHZ is presented). The top graph illustrated spectra from all stations over all three intervals. Benefitting from the borehole isolation from local noise and certain noise amplification, station COBA (blue) presented the lowest noise level. Compared to station CSNA (green), CONA (red) demonstrated a relatively lower noise level and confirmed effective noise isolation in tunnel. The bottom three graphs in Figure 1 compare noise for each time interval. A significant low noise level is found at station COBA in the high frequency range. In the night hours, the noise level at CONA is closer to the curves from CSNA but during the day hours, CONA noise level is only slightly higher than the one at COBA and much lower that the one at CSNA. In summary, the borehole is more effective to isolate stations from noise and to remove some noise amplification than the tunnel. The tunnel station shows lower noise level compared to the station in the free field.

Table 1: Detection reprocessing.

Valid Detections	CONA	CSNA	COBA
Associated	130	124	131
Unassociated	97	100	100
All Valid	227	224	231
FalseDetections	1268	1239	1392

To investigate the dependence of the detection performance on station sites, we re-ran the waveform data processing for a period of the entire month in May 2009 and compared the results with detections in our catalogue. Table 1 summarizes this comparison. Station COBA made not only the most valid detections but else the most false detections. Extremely high numbers of false detections for all stations were caused by some human activities close to the stations, since they only appeared between 7 to 15 GMT from Monday to Friday. Station COBA has a better performance in detecting teleseismic signals and primary phases of the mining induced events. Station CSNA is more sensitive to primary arrivals of local and regional mining but less capable to detect secondary phases of induced events and teleseismic signals. Generally all three stations delivered a poor performance in detecting secondary phases. Further investigation will be needed.

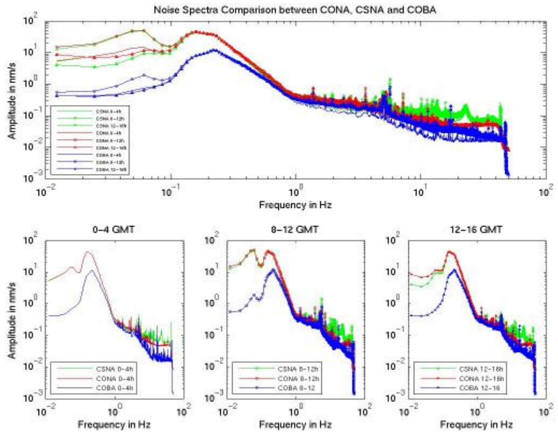

Figure 1: Noise spectra comparison between CONA, CSNA and COBA.

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Two strong earthquakes near Ebreichsdorf

Christiane Freudenthaler, Christa Hammerl, Helmut Hausmann, Nikolaus Horn, Yan Jia, Wolfgang Lenhardt, Rita Meurers, Anton Vogelmann

Two strong earthquakes with a magnitude of 4.2 followed by 25 aftershocks occurred near Ebreichsdorf in 2013. A summary is given about seismograms, spectral analysis, focal mechanism and historic seismicity around Ebreichsdorf.

The southern Vienna Basin was shaken at 4:06 CEST on Sep. 20th and at 19:17 CEST on Oct. 2nd by two earthquakes both with a magnitude of 4.2 and depths around 12 km. The epicenters were located in the southeast of Ebreichsdorf (47.92° N, 16.41° E and 47.93° N, 16.40° E). The earthquakes were well registered on all broadband stations operated by the Austrian Seismological Service and also recorded on the nearby strong-motion stations in Wiener Schwadorf and in Vienna. Until the end of October there were 27 quakes recorded and eight among them were felt by the residence. Figure 1 illustrates seismograms registered at the station CONA, situated in the Conrad-Observatory, while Figure 2 presents spectra for the CONA waveforms. The seismogram on Oct. 2 contains more high-frequent energy, compared to the one on Sep. 20. The spectral analysis for these two seismograms confirmed this observation. Higher spectral amplitudes can be found in a frequency range of 7-10 Hz on the Pg spectra in the range of 4-12 Hz on the Sg spectra for the quake on Oct. 2.

Seismicity in the southern Vienna Basin was mainly caused by a horizontal displacement along a deep-seated vertical fault, which pushes the eastern part of the crust towards the east. Focal mechanism studies from ZAMG (Figure 3) in cooperation with the Vienna University of Technology revealed a mainly lateral displacement for Sep. 20 quake, and similar solutions for the quake on Oct. 2 and the main shock from the swarm in 2000 at the same epicentre.

According to historical earthquake studies, Ebreichsdorf is a well-known epicenter for stronger earthquakes during the past centuries. The earliest quake documented for damages, occurred in 1590. The strongest quake with a magnitude of 5.0 took place in Ebreichsdorf in 1938. This quake resulted in damages to walls in almost all houses in the epicentral area. Some of the wall cracks were even centimeter wide. Chimneys were damaged. In Baden balustrades fell down, while in Vienna's district Favoriten even some of the industrial chimneys collapsed. Another significant swarm occurred in Ebreichsdorf in 2000, which followed a shock on July 11 with a magnitude of 4.8. This main shock caused wall and plaster damages in many buildings in the epicenter.

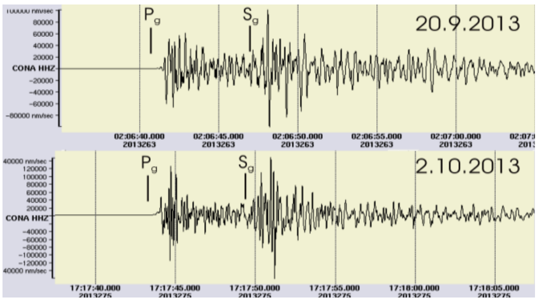

Figure 1: Seismograms of these two earthquakes recorded at CONA.

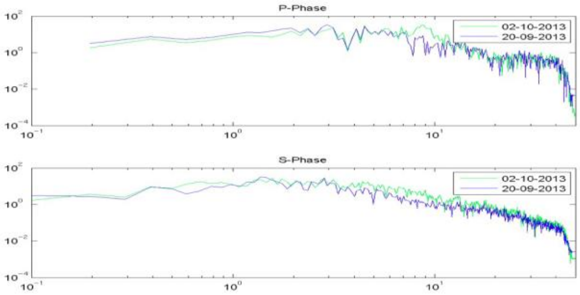

Figure 2: Comparison of spectra.

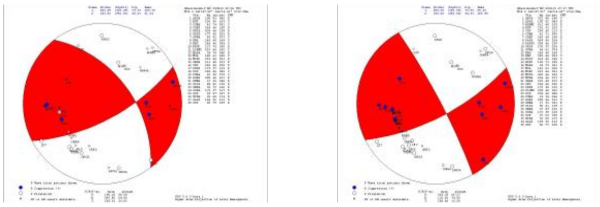

Figure 3: Focal mechanisms by ZAMG.

References:

Hammerl C., Lenhardt W. (1997) Erdbeben in Österreich, Leykam Verlag.

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Earthquakes in Lower Austria

Christa Hammerl, Wolfgang Lenhardt

The results of two projects funded by the Provincial Government of Lower Austria were combined to investigate the historical and recent earthquake activity since 1000 A.D. to ensure a high level of scientific research on seismicity in Lower Austria. The study represents the first comprehensive investigation of such detail on the topic of earthquakes in this area.

In order to improve the seismic hazard assessment in Lower Austria, our study focused mainly on the research of gaps between 1000 and 1589 – no earthquakes were known in the relevant area – and completion of the catalogue for the period between 1600 and 1900, which comprises 18 earthquakes for this period and the restudy of 13 damaging historical earthquakes in this area. In every century – with the exemption of the 20th century, from which just macroseismic data points from the original maps were collected – new information of earthquakes from contemporary historical sources (Fig. 1) could be gathered. After being transcribed and critically discussed, most of those data indicated an earthquake, and a large number of them could even be analyzed and parameterized.

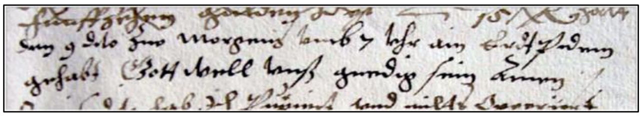

Figure 1: Earthquake report for 9. May 1591 (Stiftsarchiv Klosterneuburg).

The famous earthquake of 1590 – known as the “Neulengbach earthquake” – was also studied in great detail. Numerous new sources were found, already known sources anew interpreted. The “new” epicentre Ried am Riederberg is located more to the east of the previous assumed location in Neulengbach and is closer to Vienna. This new epicentral location explains the damage to Vienna, the capital of Austria and the lack of damage to Sankt Pölten.

Altogether more than 10.000 messages related to 322 earthquakes were analyzed, of which about 200 earthquakes occurred prior to 1900. In about 100 cases, the earthquakes could not be finally parameterized in terms of location and epicentral intensity because of poor information. The whole data set included also 21 fake quakes, all of which referred to storms and other causes before 1900 (Fig. 2).

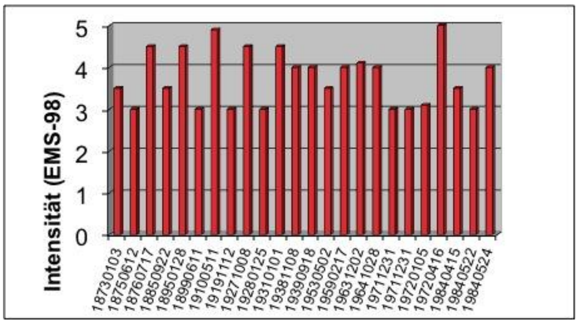

Figure 2: Seismic history of Sankt Pölten.

For the first time MDPs (macroseismic data points) are available for each earthquake. A list of locations includes all MDPs (Fig. 3) for Lower Austria between 1000 and 2009, this means that for each locality in Lower Austria the seismic history can be given.

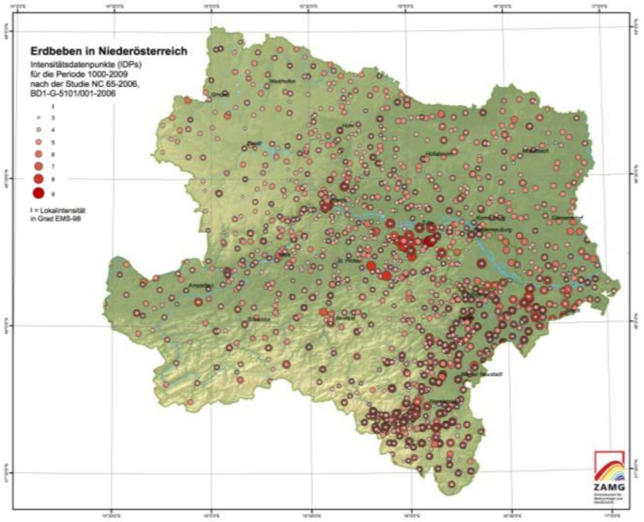

Figure 3: MDPs – Macroseismic data points. The figure shows all localities, where earthquakes were felt or caused damage in Lower Austria.

References:

Hammerl C., Lenhardt W. (2013) Erdbeben in Niederösterreich von 1000 bis 2009 n. Chr. Abh.Geol.B.-A., Bd.67.

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Detecting meteorites with Infrasound

Ulrike Mitterbauer

Within the framework of a co-operation with the German Institute BGR (Bundesanstalt für Geowissenschaften und Rohstoffe) a mobile Infrasound-Array was deployed for the first time in Austria. Data were collected and processed using WinPMCC (Pouillot et al., 2008) and Seimic Handler. Several signals of interest were detected and compared with ground truth information.

A mobile station consisting of four sites was deployed and tested in the timeframe between January and April 2013. All sites were equipped with MB2000 sensors. Figure 1 shows the sensorbox with microbarometer included.

Figure 1: Sensorbox.

On 15th of February a meteorite entered the atmosphere around 9:20 local time close to the city Tschjelabinsk in a distance of 3200 km from the station. Signals arrived from 7:00 UTC at the station (Figure 2). Due to the small aperture and the long periods of the signal it was not possible to calculate a clear azimuth and velocity, but a comparison with signals of station IS26DE of the IMS-Network showed a similar signal at that time. A FK-Analysis calculated with Seismic Handler of the data resulted in an azimuth North East of the array.

On the 14th of February the Austrian Military tested a supersonic aircraft in the close vicinity (25 km distance) of the array. The boom can be seen clearly in the registration as a N-wave signal (Figure 3). The detected back-azimuth and the calculated velocity (363 m/s) are in good agreement with the expectations.

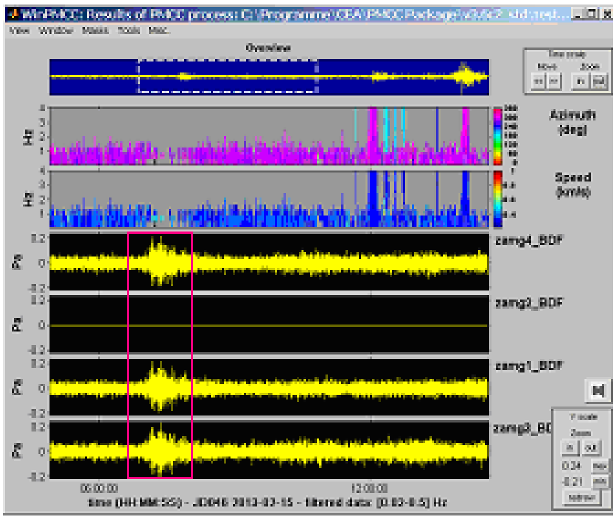

Figure 2: Registrations zamg1-4 of the meteorite (Filter 0,02-0,5Hz).

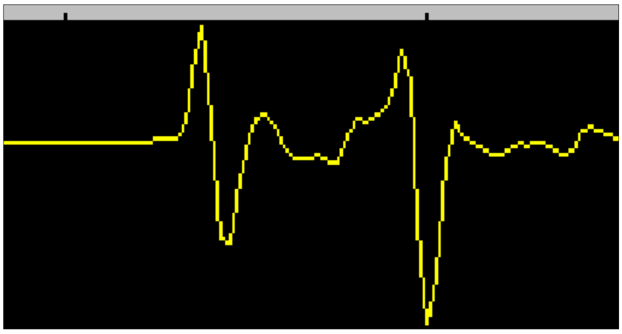

Figure 3: N-shaped signal of a supersonic aircraft.

References:

Pouillot Ch., Chavy C., Quicke G. (2008): WinPMCC User Manual, Axlog Ingenierie, 64p.

Seismic Handler: http://www.seismic-handler.org/

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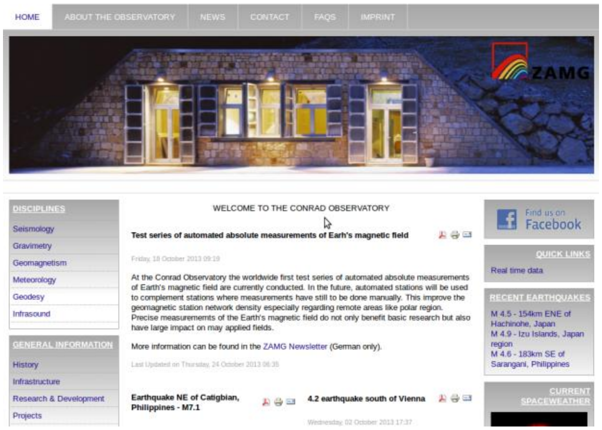
Public relations activities at the Conrad Observatory

Barbara Frasl

2013 was an exciting year for the Conrad Observatory and great effort has been put into increasing public awareness and scientific recognition of the observatory as a high profile observation and research facility. The observatory's website was transformed into a high quality access point for both scientists and the public. Furthermore, the observatory staff participated in outreach events, university studies as well as many tours.

The virtual home of the Conrad Observatory saw multiple changes and improvements over the last year. Many sections on articles and projects were updated and restructured to achieve a uniform appearance. The website is generally maintained as a bilingual resource in English and German. New sections were added especially regarding detailed information on the infrastructure of both underground facilities. In addition, the website provides a restricted area for staff and project partners to access real-time data of the respective instruments.



WELCOME TO THE CONRAD OBSERVATORY

Test series of automated absolute measurements of Earh's magnetic field

Friday, 18 October 2013 09:19

At the Conrad Observatory the worldwide first test series of automated absolute measurements of Earth's magnetic field are currently conducted. In the future, automated stations will be used to complement stations where measurements have still to be done manually. This improve the geomagnetic station network density especially regarding remote areas like polar region. Precise measurememts of the Earth's magnetic field do not only benefit basic research but also have large impact on may applied fields.

More information can be found in the ZAMG Newsletter (German only).

Last Updated on Thursday, 24 October 2013 08:35

Earthquake NE of Catigbian, Philippines - M7.1

4.2 earthquake south of Vienna

Wednesday, 02 October 2013 17:37

RECENT EARTHQUAKES

M 4.5 - 154km ENE of Hachinohe, Japan
M 4.9 - Izu Islands, Japan region
M 4.6 - 183km SE of Sarangani, Philippines

Figure 1: Website of the Conrad Observatory (*http://www.conrad-observatory.at*).

The Conrad Observatory is also well-represented on social media sites. The respective Facebook site reached 187 likes by January 2014. On a regular basis information on activities at the observatory, geomagnetic storms, recent earthquakes, news as well as Earth science trivia were posted. Extremely popular and very well received was the “June 2013 Photo Challenge: COBS Impressions!” highlighting one photo a day of the observatory and its trademark items.

Many efforts to increase public awareness were of a more physical nature. A small delegation participated twice at the science and education initiative “Marktplatz der Wissenschaf[f]t”. First, in July at the “Junge Uni der FH Krems” and second, in September at the “European Researchers Night” in St.Pölten.

Figure 2: Science communication event „Marktplatz der Wissenschaf[f]t“ initiated by the state of Lower Austria.

A great opportunity in gaining insights into communication science was provided by the University of Vienna by partaking as a research subject in the course “Öffentlichkeitsarbeit” run by the Department of Communication. The wide range of new ideas will surely find application in the upcoming years.

Another big milestone in outreach was marked by the preparation of a new information pamphlet which was initially distributed at the EGU 2013 in Vienna.

Although there was no open day in 2013, the Conrad Observatory was still a popular destination for many field trips by researchers, students of the Earth Sciences and the public. In November 2013 the ORF broadcasted a segment on the Conrad Observatory in Ö1's program “Vom Leben der Natur” (04.11.2013).

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