EUREF 2014
Symposium

3-7 June, 2014

PROGRAM AND
ABSTRACT BOOK

www.nzt.lt/euref2014

ABSTRACT BOOK

MULTI-GNSS IN REAL TIME AND POST-PROCESSING
Chair: Rolf Dach, Wolfgang Soehne

STATUS OF THE IGS-MGEX PROJECT

Rolf Dach[1], Oliver Montenbruck[2], Lars Prange[1]
[1] AIUB, Bern, Switzerland
[2] DLR, German Space Operations Center, Oberpfaffenhofen, Wessling, Germany

The International GNSS Service (IGS) has organized the multi-GNSS experiment (MGEX) that is running since February 2012. It was initiated to establish the infrastructure and the processing capability for the numerous new signals and systems that are available or are under development in the landscape of GNSS. The experience from this MGEX is necessary to understand the new observation types well enough to include them into the operational processing chain of the IGS, which is used among others to contribute to a stable global reference frame.

The presentation will provide an overview on the current status of the infrastructure and analysis results obtained by different groups in the frame of MGEX. The current developments at the CODE analysis center in the frame of the MGEX campaign are highlighted.

POSKEN - THE NEW EUROGEOGRAPHICS KNOWLEDGE EXCHANGE NETWORK

Dave Lovell, Saulius Urbanas
Eurogeographics

EuroGeographics, the European association of National Mapping and Cadastral Authorities, decided to establish the new Positioning Knowledge Exchange Network (PosKEN) for 1) arranging the European platform for networking and sharing best practice and expertise in the field of GNSS positioning; 2) contributing in development of common standards, policies and guidelines in the positioning related services amongst National Mapping and Cadastral Authorities, i.e. maintaining RTCM, RTK/DGNSS surveying and others. The PosKEN will contribute implementing the new EuroGeographics strategy and will foster the current collaboration with EUPOS, EUREF, CLGE and other strategic partners by better coordinating expertise and delivering uniform European positioning services for European users.

AN ANALYSIS OF INTERSYSTEM BIASES FOR MULTI-GNSS POSITIONING

Alessandro Caporali, Andrea Dalla Torre
CISAS University of Padova, Padova, Italy

The capability of commercial receivers to track multiple GNSSs poses the problem of mutual alignments of reference frames and time scales. System biases should possibly be computed in advance and made known to the user, so that the only unknowns for code point positioning are the receiver coordinates and the receiver clock offset relative to a unique time scale. We have examined data from the five GNSS constellations GPS, GLONASS, Galileo, QZSS and BeiDou for four days in 2013, nine European stations and four different GNSS receivers, with the goals to a) evaluate the quality of the broadcast ephemeris relative to the precise orbits and clocks, when available (GPS, GLONASS, Galileo, QZSS), b) estimate systematic offsets of the time scales kept by each GNSS relative to GPS and c) investigate possible receiver dependent system biases. We report an agreement at the meter level between coordinates of satellites computed with broadcast ephemeris and precise orbits. Differences between broadcast and precise clocks are of up to ± few nanoseconds (1 ns = 10-9 s) for GPS (IGS products). For GLONASS the difference of the broadcast clock to the Russian (IAC) SP3 values is also smaller than ±10 ns, but rises to about 200 ns when the broadcast clock is compared to the combined IGL product of IGS. For QZSS the difference broadcast to SP3 products of the JAXA are also confined to ± 10 ns. For Galileo, for which data are broadcast in a test mode, we report different values depending on the F-NAV or I-NAV satellite clock model: using the SP3 products of Technical University of Munich (TUM), we report discrepancies between broadcast and SP3 of some tens of ns. System Time Biases lump together satellite dependent Differential Code Biases (DCB's), receiver dependent Inter System Biases (ISB's) and offsets of a given GNSS time scale to a reference (we assume GPS) time scale. The System Time Bias are typically of the order of 360 – 380 ns for GLONASS, quite consistently with broadcast or precise (IAC) ephemeris. For Galileo the biases are more variable and do depend on the use of broadcast or precise data. For QZSS we evaluate a QZSS to GPS System Time Bias very nearly constant in time. Its value differs of about 20 ns depending on the SP3 data source (TUM or JAXA). For BeiDou we find Time System Biases of the order of 10 to 100 ns depending on day and receiver type. Receiver dependent Time System Biases relative to GPS are quite evident in several different stations and are reasonably consistent across receiver type. We conclude by emphasizing the need for a monitoring activity of such inter-GNSS biases, both GNSS dependent and receiver dependent, and that appropriate means are devised for making them available to the final user.

TROPOSPHERIC CORRECTION MODEL IN SUPPORT OF PRECISE POINT POSITIONING

Michal Elias[1], Jan Dousa[2], Pavel Vaclavovic[2]
[1] CTU, RIGTC, Prague, Czech Republic
[2] RIGTC, Zdiby, Czech Republic

We show initial results of a new developments of tropospheric correction model focused primarily on support of GNSS positioning and navigation. The concept characterizes tropospheric correction model based on numerical weather data fields. The model provides calculation for zenith hydrostatic and wet delays at the surface and at any altitude up to 10 km.

The correction model supports a flexible parametrization including benefit of in situ meteorological observations. We compare the performance of selected approximations within the model when applying a closed loop with a numerical weather fields considered as reference. Additionally, we compared numerical weather field with respect to results from the GNSS final tropospheric product (IGS). Finally, we study a potential of supporting GNSS Precise Point Positioning with NWP data, in particular for the reduction of convergence period of a pseudo-kinematic solution.

ALBERDING-QC – A MULTI-PURPOSE GNSS SERVICE PERFORMANCE MONITORING TOOL

Tamás Horváth
Alberding GmbH, Wildau, Germany

Service provision with high quality is only possible by checking the availability and reliability of the data products. Alberding-QC is a new multi-purpose quality control tool designed for the continuous monitoring of real-time DGNSS, RTK and PPP services.

Alberding-QC has three software components to
- Monitor positioning accuracy and RTK fixing time / PPP convergence time
- Decode and analyse the contents of real-time GNSS data streams
- Monitor the availability and consistency of Ntrip streams

Alberding-QC is designed to help GNSS infrastructure operators quickly detect service outages and performance degradations. The software modules are integrated into a web-based graphical user interface, so that service operators can easily access the results, either in the network control centre or anywhere else.

Alberding GmbH is a leading developer and distributor of professional GNSS system solutions supporting precise positioning, GIS and navigation applications. The company has many years of experience in developing and operating customised monitoring solutions.

QUALITY CONTROL OF THE CZEPOS NETWORK

Miluse Snajdrova
Land Survey Office, Prague, Czech Republic

In the first stage of its operation, the main task of the CZEPOS network has been to provide correction data all over the territory of the Czech Republic. Quality of correction data was known only from the parameters given by manufacturer of technology or from the previous experiences of current providers of GNSS networks in the Europe. The first results of CZEPOS quality control were published after 2006. Initially, it had been single tests, but later, different permanent monitoring of quality was launched.

SKPOS® NETWORK SOLUTION QUALITY MONITORING

Branislav Droscak, Karol Smolik
Geodetic and Cartographic Institute, Bratislava, Slovakia

Effort to improve and develop activity in the field of georeference services provision led Geodetic and Cartographic Institute Bratislava as Slovakian position determination system (SKPOS®) administrator to creation of the new independent tool for online monitoring of SKPOS® network solution quality and to provision its results to public. „SKPOS® network solution quality" application was successfully developed by Geodetic control analysis section and has been available on the SKPOS® web page http://monitoringskpos.gku.sk from the 1 October 2013. Description of both the principle of the application and the first results achieved from its launch is described in the poster.

PROMOTING OF THE GEOSPATIAL SKILLS: GEOSKILLS PLUS PROJECT OF THE LEONARDO DA VINCI PROGRAMME

P. Dijkstra[1], J. Pirlot[2], V. Penkov[3], E. Parseliunas[4], M. Wijngaarde[5], K. Donert[6], D. Frigne[7], H. Westerbeek[8], K. Levoleger[1], D. Popovas[4], R. Obuchovski[4], D. Slikas[4], A. Buga[4]
[1] *Dutch Cadastre, Land Registry and Mapping Agency (NETHERLANDS)*
[2] *Belgian Order of Surveyors (BELGIUM)*
[3] *Geodesy, Cartography and Cadastre Agency (BULGARIA)*
[4] *Vilnius Gediminas Technical University (LITHUANIA)*
[5] *Council of European Geodetic Surveyors (BELGIUM)*
[6] *European Association of Geographers (BELGIUM)*
[7] *Flemish Association for Geographic Information (BELGIUM)*
[8] *GEO Employment Market (NETHERLANDS)*

"Exchange of best practices for transfer of innovation of GEO VET education to meet changing labour market needs in Europe following EU GEO policies" (Geo Skills Plus) is a European Commission funded project under DG Education and Culture, Leonardo da Vinci programme (Project No 2013-1-NL1-LEO05-12278). It began in October 2013 and will run until October 2015. Initiated by the Dutch and the Geo Employment

Market Foundation (SAGEO), the GeoSkill Plus Project is an ambitious project aiming to match labour market needs with geo education offer in Europe.

The aim of this two-year project is to enable European countries to exchange best practices and innovation with each other regarding the mismatch between Europe's geospatial vocational education and training and the geospatial labour market. There is a growing need for well-trained students at all levels – vocational, bachelors, masters – in the field of geospatial technologies. This is because there are a growing number of jobs available in land surveying, mapping data collection, data processing, data delivery and turning data into information. The Geo Skills Plus project will host activities such as workshops, roundtables, surveys and desk-top studies, where the European geospatial community will be involved.

Session 2

GNSS FOR EARTH SCIENCES
Chair: Rosa Pacione, Carine Bruyninx

HOW CAN GNSS BASED GEODESY IMPACT ON SOLID EARTH RESEARCH? AN EXAMPLE FROM THE KEFALONIA (GREECE) SEISMIC EVENTS OF JANUARY/FEBRUARY 2014

Alessandro Caporali
CISAS University of Padova, Padova, Italy

The application of Space Technology to Crustal Dynamics and Earthquake Research dates back to the late 70's, when NASA initiated the Crustal Dynamics Project. In Europe the WEGENER Project (Working Group of European Geoscientists for Earthquake Research) formed under the auspices of the TU Delft and IfAG, which promoted the construction of Transportable Laser Systems for tracking LAGEOS, Starlette and other geodetic satellites. A number of sites, primarily in Greece and Turkey, could be repeatedly measured throughout the 80's and 90's. These mobile sites operated in conjunction with permanent SLR sites in West and East Europe. The study of the Earth rotation and the relationship between the Terrestrial and Celestial Reference Frames was contributed primarily by VLBI sites, within the MERIT project of IAU/IUGG.

With the advent in the late 80's of GPS, and now GNSS, the availability of low cost equipment of simple use produced   a dramatic shift in scientific focus. From the absolute motion of isolated sites somehow tied with a hypothetically rigid lithospheric block, the attention shifted to the concept of regional reference frame, and on the deformations taking place at or near the borders of tectonic units, and within tectonic units. Such deformations have typical wavelengths of some tens to few hundreds of km, and therefore necessitate not only of a denser and homogeneous network, but also a timely and standardized processing standards. Consequently GNSS geodesy became very attractive not only to NMA's seeking a geodetic infrastructure for Cartography and GIS, but also to Solid Earth Research.

In Europe the EPN is the infrastructure which serves the needs of NMA's but has also a very high potential for the EPOS project, which is the leading initiative in European Solid Earth Research. In the case of seismic events the measured displacement of EPN sites, or of sites tied to the EPN in a rigorous manner, is a key complement to seismologic data and other satellite data, in particular DInSAR. By GNSS we can measure very accurately not only the instantaneous jump in the spatial coordinates in coincidence with the nucleation of the seismic energy, but also the postseismic relaxation which can be related to the viscosity of the mantle.

The Kefalonia seismic sequence of January/Feburary 2014 is a recent and interesting case in which the coseismic displacements of Greek stations are compared with the predictions of a theoretical model, based on independent seismological data. The large shear strain in the area surrounding the Kefalonia Transform Zone measured by GNSS, the local statistical seismicity from historical data and an estimate of the typical regional stress drop can help in putting upper limits to the maximum expected magnitude of seismic events in the area, which is a key parameter for seismic hazard studies.

DEVELOPMENTS TOWARDS USE OF EXTERNAL TROPOSPHERIC MODELS IN GNSS POSITIONING AND NAVIGATION

Jan Dousa, Michal Eliaš
RIGTC, Zdiby, Czech Republic

The tropospheric signal path delay reaches up to 2.4 meters in the zenith above the GNSS antenna, and up to tens of meters in low elevations. While a hydrostatic part of the troposheric delay can be accurately calculated using precise atmospheric pressure at a site, a real difficulty in the modeling is caused by about 10 % of the total path delay caused by partial water vapour pressure. So called wet delay, which is highly variable in time and space, can not be accurately modeled using in situ observations and additional information about the vertical atmospheric profile is important. The troposphere modeling is a limiting factor in various GNSS positioning and navigation applications, in particular when it concerns of highly kinematic solutions suffering from a correlation between tropospheric path delays and other parameters. Along with a continuous enhancement in numerical weather prediction in terms of the timeliness, resolution and accuracy, data from external meteorological sources will become more interesting in support of troposphere modelling for real-time GNSS applications. In the presentation, we introduce a new concept of the tropospheric wet delay approximation applicable to an augmented or blind correction models and, finally, we show its potential exploitation in kinematic precise point positioning.

EXPERIENCES WITH GNSS DATA DISSEMINATION USING GSAC AND ITS POTENTIAL USAGE IN EPOS AND THE EPN

Quentin Baire[1], Carine Bryuninx[1], Guenter Stangl[2], Wolfgang Soehne[3],
Erwin Wiesensarter[3], Jean-Luc Menut[4], Benedikt Gunnar Ofeigsson[5],
Gianpaolo Cecere[6], Luigi Falco[6]

[1] Royal Observatory of Belgium, Brussels, Belgium
[2] Observatory Lustbuehel Graz, Graz, Austria
[3] Bundesamt für Kartographie und Geodäsie, Germany
[4] Observatoire de la Côte d'Azur, France
[5] Icelandic Meteorological office, Iceland
[6] Istituto Nazionale di Geofisica e Vulcanologia, Italy

Working Group 4 (WG4) of the European Plate Observing System (EPOS) aims at using Geodesy Seamless Archive Centers (GSACs) to provide access to RINEX GNSS data. GSAC is a software developed by UNAVCO in partnership with CDDIS and SOPAC, starting more than ten years ago. It is a web service designed for geodesy archives, providing data and metadata to the users. A data center can set up a so-called GSAC repository to provide discovery and dissemination of its GNSS data to the user community.

In addition, a so-called federated GSAC – i.e., a service with access to several autonomous (and GSAC-capable) data centers without copying or changing their data – can offer a gateway to the information of all local GSACs. Consequently, there is no need for a centralized data center within the framework of EPOS.

The Royal Observatory of Belgium (ROB) has installed and tested GSAC in order to evaluate its potential usage for providing access to EPN data and metadata. This presentation gives an overview of the features of GSAC, its possible integration in the EPN with regard to the existing data centre infrastructure and the upcoming plans of EPOS WG4.

GNSS AND TACHYMETRY FOR MONITORING THE STABILITY OF PERMANENT REFERENCE STATIONS

Elmar Brockmann[1], Rolf Dach[2], Daniel Ineichen[1], Peter Mahler[3], Stefan Schaer[1]
[1] Swiss Federal Office of Topography swisstopo, Wabern, Switzerland
[2] AIUB, Berne, Switzerland
[3] FHNW, Basel, Switzerland

The paper shows results of a monitoring campaign where the GNSS masts of the permanent stations ZIM2 and ZIMM were monitored with tachmetry (using Leica GeoMoS) and GNSS during 2 weeks in summer 2013. The GNSS results are derived from short baseline analyses (long static as well as kinematic) and from kinematic Precise Point Positioning (PPP). The order of magnitude of the measured deformations and the comparison of the results of the different methods is the main focus of the paper.

INVESTIGATION OF UNCERTAINTY OF GNSS-BASED DISTANCE METROLOGY USING EPN DOUBLE STATIONS DATA

Jan Cisak[1], Lukasz Zak[1], Katarzyna Stepniak[2], Pawel Wielgosz[2], Volodymyr S. Kupko[3], Alla Y. Olijnyk[3], Aleksei Liubzhyn[3], Yevgen Zanimonskiy[4]

[1] Institute of Geodesy and Cartography, Warsaw, Poland
[2] University of Warmia and Mazury, Olsztyn, Poland
[3] NSC "Institute of Metrology", Kharkiv, Ukraine
[4] Institute of Radio Astronomy of NAS, Kharkiv, Ukraine

Nowadays surveyors and researchers in geosciences are facing the challenge of measuring distances over several hundreds of meters up to 1 kilometre with uncertainties at a single millimeter level and below. Electronic distance meters and GNSS are available for this task and long length metrology complies with GNSS-based short distance measurements. Both approaches, however, are currently not capable of achieving traceability to the SI definition of the meter with one or even sub-millimetre uncertainty over the respective distances.

The presented results were obtained in the framework of a research project aimed at fostering the measurements up to 1 kilometre traceability to SI units. The work is dedicated to a better understanding of the uncertainty of GNSS-based distance metrology. The influence of the troposphere, near-field effects and multipath on the distance measurements uncertainty will be studied in optimized configurations.

Long time series of vector components, derived from processing GNSS data from double EPN stations, were generated. They provide extremely rich information on variability of GNSS solutions that together with the external data enables qualitative and quantitative analysis of those variations as well as their reliable statistical estimate. The experiments performed concerned the investigation of the response of the measuring system to tropospheric perturbations as well as to site specific effects vs. measured distance. Numerical experiments conducted indicate that the potentiality of GNSS positioning is not fully exploited in high-end applications. Also, analysis of time series of GNSS solutions may result in improvement of modelling of GNSS observations and GNSS-based distance metrology.

PRESENT STATUS OF EPOS GNSS WORKING GROUP

Rui Fernandes
SEGAL (UBI/IDL), Covilhã, Portugal

WG4 – "EPOS Geodetic Data and Other Geodetic Data" is the Working Group of the EPOS project in charge of defining and preparing the integration of the existing Pan-European Geodetic Infrastructures that will support European Geosciences, which is the ultimate goal of the EPOS project. The WG4 is formed by representatives of the participating EPOS countries (23) but it is also open to the entire geodetic community. In fact, WG4 also already includes members from countries that formally are not integrating EPOS in the Preparatory Phase.

The geodetic component of EPOS (WG4) is dealing essentially with Research Infrastructures (RI) focused on continuous operating GNSS (cGNSS) that can also be used for Solid Earth research. In this respect, the future interaction with the EUREF community is a key aspect of the efforts being developed. In fact, many of the members of EPOS are also active participants (at several levels) of the EUREF community.

We will discuss the plans for the implementation of the thematic and core services (TCS) for geodetic data within EPOS and the related business plan. We will focus on strategies towards the implementation of the best solutions that will permit to the end-users, and in particular geo-scientists, to access the geodetic data, derived solutions, and associated metadata using transparent and uniform processes. Current proposals and remaining open questions will be openly analyzed.

COST ACTION ES1206: ADVANCED GNSS TROPOSPHERIC PRODUCTS FOR MONITORING SEVERE WEATHER EVENTS AND CLIMATE (GNSS4SWEC)

Jonathan Jones
Met Office, Exeter, United Kingdom

Global Navigation Satellite Systems (GNSS) have revolutionised positioning, navigation, and timing, becoming a common part of our everyday life. Aside from these well-known civilian and commercial applications, GNSS is now an established atmospheric observing system which can accurately sense water vapour, the most abundant greenhouse gas, accounting for 60-70% of atmospheric warming. Water vapour observations are currently under-sampled and obtaining and exploiting additional high-quality humidity observations is essential to severe weather forecasting and climate monitoring.

COST Action ES1206 addresses new and improved capabilities from developments in both the GNSS and meteorological communities to address these requirements. For the first time, the synergy of multi-GNSS (GPS, GLONASS and Galileo) will be used to develop new, advanced tropospheric products, exploiting the full potential of multi-GNSS water vapour estimates on a wide range of temporal and spatial scales, from real-time monitoring and forecasting of severe weather, to climate research. In addition the Action will promote the use of meteorological data in GNSS positioning, navigation, and timing services and stimulate knowledge and data transfer throughout Europe.

GPS STATIONS IN GREENLAND AND THEIR CAPABILITY

Per Knudsen, Shfaqat Abbas Khan
DTU Space – Geodesy, Lyngby, Denmark

The Greenland GPS network (GNET) was established in 2007-2009 and includes more than 55 permanent GPS stations. The main purpose of the network is to create data

platforms for monitoring and study geophysics processes like surface dynamics and tectonics. The network is able to map the velocity fields associated with, plate motion, postglacial rebound and improve our understanding of tectonic processes and present-day ice mass changes in Greenland, allowing scientists to quickly detect and analyze any abrupt changes in the rate of ice loss in this region. Recent analyses of the GNET data show that the entire network is uplifting in response to past and present-day changes in ice mass. Superimposed on longer-term trends, an anomalous 'pulse' of uplift accumulated at many GNSS stations during an approximate six-month period in 2010. This anomalous uplift is spatially correlated with the 2010 melting day anomaly (Bevis et al., 2012) and show the capability of the EPOS-GNSS station to monitor present changes in the climate.

ACCURACY ANALYSIS OF LOCAL TEC MAPS DERIVED USING LIMITED NUMBER OF GNSS STATIONS

Anna Krypiak-Gregorczyk[1], Yevgen Zanimonskiy[2], Andrey Sopin[2], Volodymyr Lisachenko[2], Alex Paznukhov[2], Paweł Wielgosz[1]
[1] University of Warmia and Mazury in Olsztyn, Olsztyn, Poland
[2] Institute of Radio Astronomy of NAS, Kharkiv, Ukraine

Accurate ionospheric total electron content (TEC) maps derived for limited areas are useful for calibration of the ionospheric delay for space measurement techniques like, e.g., decameter radio astronomy. Many of decameter telescopes are located in areas with sparse regional/national networks. Their operators have to rely on low number of surrounding GNSS in order to derive TEC maps. Such scenario exists in the system of radio telescopes-interferometers around the UTR-2 base telescope located in Kharkov area.

This paper aims at the evaluation of the accuracy of local ionospheric TEC maps. produced from GNSS measurements collected over a limited area. Example local TEC maps were derived based on data from 10 GNSS stations located in central Poland. Then the local maps were compared to regional and continental TEC maps. The regional TEC maps were produced from GNSS data using all in view satellites observed at 144 EPN and ASG-EUPOS stations located in Poland and surrounding countries. CODE's European ionosphere maps served as reference continental maps. The comparisons were carried out for the selected days in 2013 characterized by various ionospheric/geomagnetic activity. Correlations of TEC and kp-index variations for the investigated days on the background of whole year were also analyzed. It was demonstrated that the local ionospheric mapsmay be useful for correcting of radio telescope data and also for detection and investigation of the ionosphere response to geomagnetic disturbances.

FROM SEVERE WEATHER TO REAL-TIME PPP GNSS POSITIONING- RECENT RESEARCH ACTIVITIES AT GNSS&METEO WUELS

Witold Rohm, Jan Kaplon, Karina Wilgan, Paweł Hordyniec, Tomasz Hadaś, Jarosław Bosy
GNSS&Meteo Working Group, Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental and Life Sciences, Wrocław, Poland

Over the last decade a rapid development in GNSS meteorology strengthen the cooperation between positioning and meteorology communities. The list of synergies between GNSS and meteorology is long and still growing: near real-time and real-time troposphere retrievals schemes, assimilation of GNSS observations in numerical weather prediction models (NWP), use of NWP model outputs and meteorological sensors in positioning, GNSS observations and tomography retrievals as an important data source in nowcasting, radio occultation (RO) atmosphere profiles as one of the core product for weather prediction.

The GNSS&Meteo Working Group from Wroclaw University of Environmental and Life Sciences was established in 2008 to tackle the challenges of GNSS meteorology. The WG together with its national and international partners is actively pursuing research in: near-real and real-time estimation of troposphere parameters using national CORS, integrating NWP models outputs with ground-based GNSS and meteorological observations, studying the applicability of RO observations for the lower part of the atmosphere, applying troposphere models to enhance positioning, using GNSS troposphere products such as troposphere delay, gradients, tomography retrievals in nowcasting. This paper presents recent outcomes of our research in the field of GNSS meteorology and positioning. We show also currently available products freely disseminated to the public.

EXPLOITATION OF GROUND-BASED GNSS FOR METEOROLOGY AND CLIMATE STUDIES IN BULGARIA/SOUTHEAST EUROPE

Tzvetan Simeonov, Guergana Guerova, Nadezhda Yordanova
Sofia University, Sofia, Bulgaria

Atmospheric sounding using the Global Navigation Satellite Systems (GNSS) is a well established research field in Europe. At present, GNSS data from more than 1,800 stations are available for model validation and assimilation in state-of-the-art models used for operational numerical weather prediction Centers in Europe. Advances in GNSS data processing is making possible to also use the GNSS data for climatic trend analysis, an emerging new application. In Bulgaria and Southeast Europe the use of GNSS for atmospheric sounding is currently under development. As a first step the Sofia University Atmospheric Data Archive (SUADA) is developed. SUADA is a regional database and includes 1) GNSS tropospheric products (over 22 000 000 individual observations) and derivatives (over 55 000) from five GNSS processing strategies and 37 stations for the period 1997-2013 with temporal resolution from 5 minutes to 6

hours and 2) Radiosonde IWV data (over 6 000 observations) for station Sofia (1999-2012). The first application of the SUADA data is a study of long term variation of IWV over Bulgaria during the 2007 heat wave. The second application is a study of 22 severe weather events in 2012 assiated with intense rainfall with frontal or convective origin.

LANDSLIDES VULNERABILITY MODELLING – LAVMO PROJECT, FIRST RESULTS

Olga Sykioti[1], Demetrios Paronis[1], Panagiotis Elias[1], Spiridon Neoskosmidis[1], George Drakatos[1], Aggeliki Marinou[2], Demetrios Anastasiou[2], Konstantinos Chousianitis[3],Aikaterini Kavoura[4],Vassilis Zaharis[2],Zisopoulos Thanassis[2], Nikolaos Sabatakakis[4], Vassilis Anastasopoulos[4], Konstantinos Nikolakopoulos[4], Demetrios Paradisis[2], Pierre Briole[5]

[1] National Observatory of Athens, Penteli, Greece

[2] National Technical University of Athens, Athens, Greece

[3] National Observatory of Athens, Athens, Greece

[4] University of Patras, Patra, Greece

[5] CNRS, Ecole Normale Superiieure, Paris, France

The "Landslide Vulnerability Model – LAVMO" project aims at creating a persistently updated electronic platform which will help to monitor, predicting and assessing risks related with landslides. Landslides are recognized as natural hazards having a major social–economic impact and represent a significant risk for citizens as well as infrastructures. Data from Engineering Geology, Satellite active remote sensing of C-band and X-band acquisitions, Optical Satellite Imagery and GPS Measurements will be fused in order to provide a comprehensive information representation. The synergistic use of satellite and in situ measurements in order to understand and validate landslide mechanisms is essential. Moreover, the validation of a Landslide Vulnerability Model based on data and decision fusion methods will be designed in order to support decision making organizations. Within this framework, three landsliding areas have been selected to be investigated as case studies in the Gulf of Corinth area.

In the present study, preliminary results of LAVMO project concerning the modelling and monitoring of a number of cases are presented.

Specifically, very high resolution SAR data of TERRASAR-X and RADARSAT-2 are being acquired over the study areas. Permanent GPS stations have been installed inside the landsliding bodies of both study areas as well as outside. Repetitive GPS campaigns are being performed, simultaneously with the borehole/inclinometric measurements. Additionally, Ground Penetrating Radar (GPR) will be used to map the layers of the landslides. Very high resolution (wordview, quickbird) optical data are being acquired for both study areas. Exploiting the cross-correlation technique the horizontal deformation will be estimated.

STATUS REPORT OF THE EPN TROPOSPHERE COORDINATOR

Wolfgang Söhne
Federal Agency for Cartography and Geodesy, Frankfurt am Main, Germany

Zenith Total Delay (ZTD) parameters are estimated during network processing within the EUREF Permanent Network (EPN) for several years now. Within the EPN, the ZTD are combined since 2001 when the Special Project "Troposphere Parameter Estimation" started. Since 2007 the combination switched over to routine operation. The products, combined SINEX TRO files and summary files of the combination process can be downloaded via ftp from the EUREF data centres, as well as site-specific ZTD and bias plots are displayed on the web page of the EPN Central Bureau (EPN CB).

While the combination procedure has not been changed significantly during the past years, the individual contributions have been subject to several changes, e.g. switching to Bernese Software Version 5.2, introducing GLONASS in the processing, changing the mapping function, and last but not least introducing new LACs and passing existing LACs.

One interesting issue is the comparison or combination of the EPN results with other ZTD solutions. This covers on the one hand inter-technique comparisons, e.g. with results from VLBI (Heinkelmann et al., 2013), radiosondes, weather models, etc. Results from comparisons with VLBI and with radiosonde data are displayed at the web page of the EPN CB as well.

On the other hand, the EPN consists of several sites with more than one station. Comparing time series of the various results of both stations, e.g., coming from the EPN analyses could support detecting e.g. anomalous behaviour of one of the stations as shown by Brockmann et al., 2013.

This presentation summarizes the recent changes concerning the EPN troposphere product and shows the effect of the above mentioned changes on the ZTD time series and time series differences in more detail. Moreover, the presentation shows the results for some co-located or neighbouring EPN stations (approx. 27 examples have been analyzed). With respect to the 2D or 3D distance between the stations the usefulness and the limitations of such time series will be discussed.

TROPOSPHERIC DELAY GRADIENT MODELLING IN ASG-EUPOS NETWORK AND ITS IMPACT ON COORDINATE STABILITY

Katarzyna Stępniak[1], Paweł Wielgosz[1], Karolina Szafranek[2]
[1] University of Warmia and Mazury in Olsztyn, Olsztyn, Poland
[2] Military University of Technology, Warsaw, Poland

In the state of the art applications of GNSS the troposphere is the ultimate accuracy limiting factor. In order to achieve the highest accuracy of the precise GNSS analysis low elevation data should be processed, i.e., down to 3 degrees. However, in such case tropospheric gradients should be considered. Also, in its guidelines for the EPN

Analysis Centres, EUREF TWG recommends to estimate tropospheric gradients using Chen and Herring model.

In this paper we investigate the influence of the tropospheric gradient estimation in processing of national networks. In particular, stability of the reference station coordinates in ETRF2000 frame was analyzed. GNSS data from over 100 stations of the Polish national ASG-EUPOS network were processed for a period of 90 days using the Bernese software. The average distance between the reference stations used is 70 km. The influence of the gradient estimation and its temporal spacing on the resulting coordinates were analyzed. In addition, different data elevation cutoff angles were considered.

The initial results show that the improvement in position accuracy and coordinates stability is significant, not only in horizontal, but also vertical coordinate components. The best results were obtained when estimating four gradient parameters per day with 3-degree elevation cut off angle.

AN ANALYSIS OF THE KEFALONIA SEISMIC SEQUENCE OF JAN. 26 - FEB. 3, 2014

J. Zurutuza[1], A. Caporali[1], C. Bruyninx[2], R. Fernandes[3], A. Ganas[4], M. Lidberg[5],
A. Kenyeres[6], G. Stangl[7], H. Steffen[5]
[1] University of Padova, Padova, Italy
[2] Royal Astronomical Observatory, Brussles, Belgium
[3] University of Corvilha, Corvilha, Portugal
[4] National Observatory of Athens, Athens, Greece
[5] Lantmateriaet, Gaevle, Sweden
[6] Satellite Geodetic Observatory FOMI, Budapest, Hungary
[7] BEV-OeAW, Graz, Austria

The Kefalonia Transform Zone (KTZ) is a major discontinuity zone between the Apulian platform to the NW and the Hellenic Trench to the SE. KTZ is a seismically active dextral transform fault decoupling the continental collision along the coasts of NW Greece and the oceanic subduction along the western part of the Hellenic arc. Between January and February 2014 a seismic sequence on the KTZ culminated in two major events of very similar magnitude and hypocentral location: the Mw 6.09 event of Jan 26 and the Mw 6.14 event of Feb. 3 have estimated epicen-ters within a few km on the western side of Kefalonia Island, at a hypocentral depth less than 10 km. We report discontinuities in the time series of the coordinates of the National Observatory of Athens (NOA) GNSS stations VLSM on Kefalonia Island and PONT on Lefkada Island, which fit very well the expected sur-face dislocation which can be predicted for an elastic half space using the measured fault plane solutions as input. We estimate from the mean velocities of the GNSS stations in the area an average strain rate of 225 ±20 nstrain/year along the KTZ. Based on the regional statistical seismicity (87 events from 1862 to 2014 in the magnitude range 5.1 to 7.4), we find that a maximum magnitude of 7.4 (the event recorded in 1867) implies a relatively low stress drop Δ6<0.5 MPa, consistently with global estimates of the lateral variation of the stress drop. We also

find that this value of the stress drop is quite sensitive to the a and b values of the regional Gutenberg-Richter relation, rather than the assumed maximum magnitude.

OBSERVING CO-SEISMIC DISPLACEMENTS USING 1-HZ DATA FROM A NETWORK OF REFERENCE STATIONS: A COMPARISON OF DIFFERENT DATA PROCESSING METHODS

Michail Gianniou
National Cadastre and Mapping Agency S.A., Athens, Greece

GPS data recorded at 1 Hz at stations of the Hellenic Positioning System (HEPOS) are being processed to detect co-seismic displacements. Two different data processing methods are tested: geodetic relative positioning in kinematic mode and Precise Point Positioning (PPP). A strong earthquake (Mw=6.4) occurred in western Greece near Andravida on 8 June 2008 is used to compare the two approaches. Co-seismic coordinate variations of up to 69 mm (peak to peak) and coordinate rates of up to 45 mm/s have been estimated.

For baselines ranging between 67 and 118 km in length the two tested methods were found to be equivalent regarding their ability to detect horizontal displacements, whereas PPP proved to be more sensitive in detecting vertical displacements. For the effective estimation of the arrival time of the surface seismic waves at a station we propose the computation of station velocities. Furthermore, station velocities proved to be suitable for the determination of the duration of the dynamic displacements at a station.

Keywords: Co-seismic displacements; 1-Hz GPS data; Precise Point Positioning; HEPOS.

APPLICATION OF GNSS OBSERVATION RESULTS TO DETERMINATION OF THE GROUND DEFORMATIONS

Diana Haritonova, Janis Balodis, Ansis Zarins, Augusts Rubans, Inese Janpaule
Institute of Geodesy and Geoinformation, Riga, Latvia

Global Navigation Satellite Systems play a principal role in understanding the movements of the Earth's surface. Permanent observation stations record GNSS data. After collecting and processing the data provides precise information on the continuous changes of the GNSS station positions.

The GNSS observations of both Latvian permanent networks – EUPOS®-Riga and LatPos, have been collected for a period of 6 years – from 2008 to 2013. Bernese GPS Software Version 5.0 has been used to obtain daily network solutions with the data of reference stations from EUREF Permanent Network (EPN) and the input data sets from International GNSS Service's (IGS) data bases.

Using post-processing computation results the research on Earth's surface horizontal and vertical movements of the territory of Latvia has been performed. An approximate model of local ground deformations has been derived. Research results show that obtained station velocities correspond with the information on Latvian tectonic faults.

The subdaily coordinate changes of EUPOS®-Riga and LatPos stations have been studied as well. For this purpose, Bernese GPS Software was applied in kinematic mode for 45-day observation period. The post-processing kinematic results with additional information of possible influences on the data quality of some stations allowed to detect multipath effect and signal noise affected by the impact of weather conditions. With the view of continuing geodynamic studies in Latvia using global data, a project of automated multifunctional optical tracking device is under construction in the Institute of Geodesy and Geoinformation of the University of Latvia. It will be based on Alt-Alt type mount and will have three configurable optical channels; two of them are high-class optical systems with 16" apertures. Optical systems can be configured with different sensors, including CCD matrix for astrometric imaging and fast high sensitivity detectors for SLR operations. The digital image channel can be used for near-space object detection and for accurate real-time positioning system calibration. The device will be capable of SLR observations of GNSS satellites, offering a number of possibilities to improve GNSS data accuracy.

Session 3

ETRS89: PRESENT AND FUTURE
Chair: Martin Lidberg, Elmar Brockmann, Ambrus Kenyeres

MAINTENANCE AND DENSIFICATION OF THE ITALIAN GNSS NETWORK

Alessandro Caporali, Joaquin Zurutuza, Mauro Bertocco, Riccardo Corso
CISAS University of Padova, Padova, Italy

The Rete Dinamica Nazionale (RDN) of Istituto Geografico Militare (IGMI) consists of 100 permanent stations uniformily distributed in the national territory. The RDN was adjusted at epoch 2008.0 in the ETRF2000 frame and approved as class B network at the 2009 EUREF Symposium. It includes 28 EPN stations, of which 10 are also IGS sites. Because of interplate motions of some mm/yr relative to the ETRF2000 frame, it is necessary to recompute the network periodically. Within the project CISIS – NSPR, the University of Bologna, Politecnico of Milano and University of Padova, in conjunction with IGMI and CISIS, recompute periodically the RDN, with densifications. We report on the reprocessing (repro2) of the RDN in the time frame 2008-2013, with addition of several stations to a total of ca 400 sites. Precise and consistent coordinates are necessary in support of RTK regional networks, cadastral surveying as well as monitoring of regional deformations in seismic areas.

STANDARDIZATION OF NATIONAL SHIFT GRIDS FOR THE TRANSFORMATION BETWEEN NATIONAL PROJECTED REFERENCE FRAMES AND ETRS89

Lennard Huisman
Kadaster, Apeldoorn, Netherlands

With the advent of GPS in the 1990's, systematic distortions of the national projected reference frames were detected by many National Mapping Agencies (NMA's). To deal with these distortions, the general approach of the NMA's was to collect data at control points using both GPS and classic surveying methods. From coordinate differences at the control points between GPS and classic methods, the size of the distortions were determined. Many countries have mapped the distortions to regular spaced grids (shift grids) containing shift values to either projected coordinates (including but not limited to Belgium, The Netherlands and Great Britain) or ellipsoidal coordinates.

Over the years a de-facto standard, the Canadian National Transformation version 2 (NTv2), for shift grids applied to ellipsoidal coordinates was realized and the usage of NTv2 has been implemented by GIS software manufacturers. The definition of shift grids for projected coordinates has not been standardized and NMA's have made available tools using their own file formats, software and specific interpolation methods. As a result the precise transformation procedures that use shift grids for projected coordinates have not been implemented by GIS software manufacturers. This lack of implementation in GIS software causes issues when transforming data in the national projected reference frames to ETRS89 and vice versa, e.g. to fulfill INSPIRE requirements.

To make available the national shift grid for GIS software users, one might consider making available the national shift grid in the NTv2-format. Unfortunately the relation between shift grids for projected coordinates and shift grids for ellipsoidal coordinates is height dependent. In other words, depending on the height of a point, the result of a transformation using shifts for projected coordinates will be different to the result from a transformation using shifts for ellipsoidal coordinates.

This contribution illustrates the height dependency between shift grids for projected coordinates and shift grids for ellipsoidal coordinates for the Dutch case. Since the solution for eliminating the height dependency results in a complex transformation procedure, standardization of the shift grids for projected coordinates is proposed as a preferred alternative. Standardization allows for implementation of shift grids for projected coordinates in GIS software.

REPROCESSING ACTIVITIES AT SWISSTOPO (LPT)

Daniel Ineichen, Elmar Brockmann, Stefan Schaer
Federal Office of Topography swisstopo, Bern, Switzerland

The LPT performed a reprocessing of GNSS data covering a time spam of more than 15 years (from January 7, 1996 to April 16, 2011). A total number of about 175 sites

was processed, covering data from the permanent networks of EUREF and AGNES (Switzerland), as well as from useful densification sites of the networks of neighbouring countries. The processing was done using the Bernese GNSS Software Version 5.2, relying on GNSS orbit and ERP products from the CODE 2011 reprocessing series.

In this paper, the experiences made with the reprocessing of such a big GPS/GLONASS data set, as well as the results using new models and consistent processing strategies are presented. Furthermore, an attempt is made to combine the solutions from the reprocessed series with the solutions of the ongoing operational processing.

THE MAINTENANCE OF SWEREF 99, INCLUDING THE USE OF A DEFORMATION MODEL

Lotti Jivall
Lanmäteriet, Gävle, Sweden

The Swedish ETRS 89 realization SWEREF 99 is now 15 years old. Since the definition of the coordinates in the summer 1999, there have been crustal deformations within Sweden up to roughly 15 cm in height and 2 cm in the planar coordinates due to the post-glacial rebound. This is not a problem when performing measurements to close-by points, but remembering that SWEREF 99 is defined by the sparse network of SWEPOS class A stations and that SWEREF 99 is mainly accessed through the SWEPOS services, which operate over larger areas, these deformations are slowly becoming a problem. Replacing SWEREF 99 with an updated ETRS 89 realization with a later internal epoch is not a good solution. A lot of efforts have been taken to implement SWEREF 99 on national, regional and local levels, e.g. 90% of the local authorities are now using SWEREF 99 in their daily work.

Instead, a deformation model has been implemented in SWEPOS post-processing service, SWEPOS network RTK service and in the process for determining new coordinates of SWEPOS stations.

EUROPEAN DENSE VELOCITY FIELD BASED ON THE INTEGRATION OF THE NATIONAL ACTIVE GNSS NETWORK PRODUCTS

Ambrus Kenyeres
FOMI SGO, Budapest, Hungary

The dense national permanent GNSS networks are not only serving the general surveying practice in real-time mode, but they deployed at the long-term reference frame maintenance and geodynamic studies relying on their homogeneously analyzed data. Within the ongoing EPN densification, lead by the EPN Reference Frame Coordinator, the national active networks are integrated and a homogeneous, dense position and velocity product is derived using the EPN as backbone infrastructure.

The only way to get a uniform, homogeneous cumulative solution from national to global scales is the integration done relying on the weekly SINEX product level in order to minimize inconsistencies (e.g. site naming, discontinuities). The integration is done with the CATREF software (Altamimi et al, IGN) using the Minimum Constraint approach. The derived position and velocity product will be an essential material for various geokinematic studies (PGR, intraplate and plate boundary zone investigations), and also for the better definition and realization of ETRS89. This work is very well inline with the goals of e.g. EPOS, EUREF (WG on Deformation Models), CEGRN, EUPOS, IAG (WG on Unified Dense Velocity Fields).

The preparatory work is well in progress, several years of weekly SINEX files are already available and analyzed from 15 countries, and considering the 7 more countries with negotiation phase the full continental coverage will be reached this year. The database contains more than 2000 sites.

In this paper a status report is presented, including data issues to be solved (antenna PCV). The latest test velocity field solution, with related interpretation options are shown as well.

ACTIVITIES IN THE FRAME OF EPN ANALYSIS COMBINATION CENTRE

Karolina Szafranek[1], Andrzej Araszkiewicz[1], Mariusz Figurski[1], Tomasz Liwosz[2], Grzegorz Nykiel[1]
[1] Military University of Technology, Warsaw, Poland
[2] Warsaw University of Technology, Warsaw, Poland

Since June 2013 responsibilities of the EPN Analysis Combination Centre are performed by consortium of the Military University of Technology (MUT, Warsaw, Poland) and the Warsaw University of Technology (WUT) . The presentations gives an overview of the results of one-year activity of new ACC. During this time new scripts for combining LACs solutions were prepared and reference frame used for combined solutions was updated (IGb08 is currently in use). First routine combinations by the MUT/WUT consortium (weekly final and daily rapid solutions) were published in the beginning of 2014 (GPS week 1768).
Besides, ACC, together with the EPN Central Bureau, coordinates LACs activity and takes care about EPN stations distribution among them. Changes in the network introduced recently and updates of Guidelines for EPN AC will be also presented during presentation.

SOME METROLOGICAL ISSUES OF GNSS POSITIONING: CASE STUDY THE CZECH REPUBLIC

Jaroslav Šimek
RIGTC - GO Pecny, Zdiby, Czech Republic

According to the Act of Surveying and Mapping, which is currently in force in the Czech Republic, all measurements in the public interests must be carried out by measuring devices calibrated or verified according to the rules and regulations given in the Act of Metrology. While traditional surveying uses the geometric quantities (lengths, angles) that can be directly reproduced by measuring devices, GNSS-based observation techniques provide 3-D position, i.e. a combination of three geometric (length) quantities which are the result of computations related to an adopted reference frame. In this respect, it is not so straightforward to meet the requirements of the Act. This is because the GNSS receiver/antenna system is not typical measuring device from the point of view of metrology, which can be calibrated against a standard. Moreover, the results (3-D positions) are influenced by a number of external effects. In the Czech Republic a GNSS test and calibration baseline, which is realized by a set of fixed points monumeted in the earth´s surface, was approved by the Czech Metrology Institute as a Czech reference standard (ECR standard) for the 3-D positioning. It is used by the users who carry out geodetic GNSS measurements to meet the requirements posed by the Act of Surveying. Some metrological aspects of the problem and parameters of the calibration baseline are discussed in more detail.

RESEARCH ON TRANSFORMATION MODELS IN CROATIA

Matej Varga, Marijan Grgić, Tomislav Bašić
Faculty of Geodesy, Zagreb, Croatia

A common problem in geodesy is the transformation of coordinates from local to the modern global datum. Global geodetic datum which is currently used in Croatia is HTRS96 (Croatian Terrestrial Reference System for the epoch 1995.55) which is a realization of the ETRS89 based on a GRS80 ellipsoid. Old geodetic datum (called HDKS) was defined in the 19th century for the territory of Austro-Hungarian Empire on the local ellipsoid Bessel with a trigonometric reference point Hermannskögel and was realised by the triangulation networks of different orders of accuracy (1st, 2nd, 3rd). This research investigates the threedimensional (3D) coordinate transformation models for transformation from a local HDKS datum to a global HTRS96 datum. Transformation models which have been studied are: Molodensky (3-p), Molodensky standard and abridged [5] (5-p), Helmert Bursa-Wolf [3, 6] and Molodensky-Badekas [2, 5] (7-p), affine (8, 9 and 12-p), multiple linear regression [1] and GRID transformation (7-p Bursa-Wolf + distortion modelling) [4]. Computations of transformation parameters (p) for all transformation models were done using 5055 common points across the territory of Croatia for which coordinates are known both in local and global datum. The quality and comparison of transformation models was done on 145 control points from the positional residuals calculated as differences between the known and transformed plane coordinates.

A RIGOROUS APPROACH FOR ALIGNING REGIONAL NETWORKS TO GLOBAL REFERENCE FRAMES BASED ON THE HELMERT TRANSFORMATION

Antonios Vatalis[1], Christopher Kotsakis[2], Fernando Sansò[1]
[1] DICA - Politecnico di Milano, c/o Polo Regionale di Como, Como, Italy
[2] Department of Geodesy and Surveying, Aristotle University of Thessaloniki, Thessaloniki, Greece

The densification of the International Terrestrial Reference Frame (ITRF) by regional network solutions is a fundamental task in current geodetic practice with great importance for various Earth science applications. For this task two alternative strategies are mainly used to optimally express the station positions of a regional network in a global reference frame, namely (i) constraining the coordinates of a selected subset of stations to their known ITRF values within the network adjustment algorithm or (ii) aligning an estimated solution of the regional network to ITRF using a posterior coordinate transformation based on the well known Helmert transformation model. The latter approach is generally considered to be vulnerable due to the so-called network effect on the estimation of the Helmert transformation parameters, a fact that has been shown to cause apparent biases in the ITRF transformed coordinates of a regional network. The aim of this paper is to expose another hidden effect in the network transformation approach which actually represents a more critical threat (than the network effect) in frame densification problems. This particular effect stems from the negligence of the stochastic correlation between the coordinates of the reference and new stations during the regional solution transformation into the global frame. Following a rigorous leastsquares formulation for the frame alignment problem, we show that the coordinate covariances in the initial frame of the regional network solution affect the optimally transformed coordinates with respect to the global frame through easily computable correction terms, similar to those found in least-squares collocation theory. These correction terms are neglected in the standard implementation of the network transformation approach, however their consideration theoretically improves the consistency with the constrained network approach in frame densification problems.

To further verify and also quantify this improvement, a number of numerical examples are presented in this paper using EPN weekly combined solutions and their expressions to the ITRF2008 frame based on the different densification strategies.

THE BENCHMARK TEST OF THE EPN-REPRO2 CAMPAIGN

Christof Voelksen[1], Andrzej Araszkiewicz[2], Rosa Pacione[3], Karolina Szafranek[2]
[1] Bayerische Akademie der Wissenschaften, Munich, Germany
[2] Military University of Technology, Warsaw, Poland
[3] e-GEOS, ASI/CGS-Matera, Matera, Italy

During the past years it has been realized that the analysis of global as well as regional GNSS networks are affected by different factors like the reference system realization,

correction models, analysis strategies and software packages. Therefore products provided by the IGS or the individual analysis centres in the form of precise orbits, ERPs, clocks and coordinates are dependent on these different factors that were available at the time of generating these products. Consequently inconsistencies in the coordinates or troposphere products are clearly visible and also affect the generation of ETRS89. Some Local Analysis Centres of the EPN are currently preparing a second reprocessing campaign, EPN-Repro2, for the entire EPN. The aim is to estimate consistent coordinates and troposphere products for the entire lifespan of the EPN by using reprocessed orbits, clock and ERP products based on the IGS08. These products, generated by the IGS ACs', are partly ready or are to be delivered in the next months.

A first step is the realization of a so called benchmark test. This test is used to compare the results from three different software packages that are used for the analysis, which are BERNESE 5.2, GAMIT 10.5 and GIPSY 6.2. Also different analysis strategies, e.g. tropospheric mapping functions, will be tested in order to achieve the best performance. The presentation will focus on the results of this benchmark test and present recommendations for the EPN-Repro2 project.

REPROCESSING OF THE CEGRN NETWORK AND ITS IMPACT ON THE GEODYNAMICS OF CENTRAL EUROPE

J. Zurutuza[1], A. Caporali[1], M. Barlik[2], M. Becker[3], C. Bruyninx[4], R. Fernandes[5], L. Gerhatova[6], G. Grenerczy[7], H. Habrich[8], J. Hefty[6], J. Ihde[8], A. Kenyeres[7], S. Krauss[9], M. Lidberg[10], D. Medak[11], G. Milev[12], M. Mojzes[6], M. Mulic[13], O. Odalovic[14], T. Rus[15], J. Simek[16], J. Sledzinsk[2], G. Stangl[9], K. Szafranek[17], F. Vespe[18], G. Virag[7], B. Stopar19

[1] University of Padova, Padova, Italy
[2] Warsaw University of Technology, Warsaw, Poland
[3] Technische Universitaet Darmstadt, Darmstadt, Germany
[4] Royal Observatory, Bruxelles, Belgium
[5] University of Corvilha, Corvilha, Portugal
[6] Slovak University of Technology, Slovakia
[7] Institute of Geodesy Cartography and Remote Sensing, Budapest, Hungary
[8] Bundesamt fuer Kartographie u. Geodaesie, Frankfurt, Germany
[9] Austrian Academy of Sciences and BEV, Graz, Austria
[10] Lantmäteriet, Gävle, Sweden
[11] University of Zagreb, Zagreb, Croatia
[12] Bulgarian Academy of Sciences, Bulgaria
[13] University of Sarajevo, Sarajevo, Bosnia and Herzegovina
[14] Geodetic Authority of Serbia, Serbia
[15] National Centre for Geodesy, Cartography Phogrammetry and Remote Sensing, Romania
[16] Research Institute of Geodesy, Topography and Cartography, Czech Republic
[17] Military Institute of Technology, Warsaw, Poland
[18] Agenzia Spaziale Italiana, Italy
[19] University of Ljubljana, Ljubljana, Slovenia

The IAG Working Group on "Integration of Dense Velocity Fields in the ITRF", the EUREF Working Group on Deformation Models and the project EPOS encourage initiatives

aiming at estimating velocities of GNSS sites in a rigorous manner, both for reference frame applications and 3D tectonic deformation problems. Thirteen measurement campaigns between 1994 and 2013 with epoch and permanent GNSS stations make the CEGRN network one of the most regularly and accurately surveyed networks for scientific applications in Europe. We have reprocessed the CEGRN GNSS (GPS+GLONASS) data with the Bernese Software 5.2 using consistent IGb08 orbits and antenna models and aligned the resulting network to ETRF2000 Reference Frame using the position and velocities of Class A stations of the EUREF Permanent Network (EPN). The intent is to bring down to regional, i.e. Central European scale the same standard of accuracy as the EPN long-term solution.

This paper presents first results of the CEGRN densification of the EPN: we review the input data, the processing strategies and the results, in terms of positions, velocities and Helmert parameters. Possible further combination, in a rigorous geodetic sense, with multiyear regional solutions, for example in Greece and Italy, processed with similar standards have an important potential to quantify the deformation field, for example in the Balkans.

DIGITAL ZENITH CAMERA FOR GEODETIC PURPOSES IN LATVIA

Janis Kaminskis[1], Inese Janpaule[2], Ansis Zarins[2]
[1] RTU, Riga, Latvia
[2] LU GGI, Riga, Latvia

Development of a digital zenith telescope optical system and telescope prototype and analysis of experimental vertical deflection measurements for applications in Latvian geodetic network has been performed at the Institute of Geodesy and Geoinformation (GGI), University of Latvia. An original optical system for a digital zenith telescope was computed and a patent application has been submitted.

The astro-geodetic method is known since mid-20th century, however with little recognition, since the acquisition and processing of high quality data was time and labor consuming process. During the recent decades due to the emergence of site geocentric coordinate acquisition using GNSS, charge-coupled device (CDD) imaging technologies, high resolution electronic tiltmeter technologies and extensive, high accuracy reference star catalogues, this method has become increasingly popular. The research has yielded that astro-geodetic methods provide a faster result with a smaller number of measurements than in the case of gravimetric methods. In order to apply and expand the astro-geodetic method in Latvia and improve precision of Latvian geoid model, vertical deflection measurements will be performed in Latvia.

SOLVING THE REFERENCE STATION WEIGHTING PROBLEM IN MINIMALLY CONSTRAINED NETWORKS

Christopher Kotsakis
Aristotle University of Thessaloniki, Thessaloniki, Greece

The aim of this paper is to present a general solution of the weight choice problem for the reference stations in minimally constrained network adjustment. Our treatment is based on the accuracy optimization of the estimated network coordinates over all possible choices of minimum constraints at the reference stations. The optimal criterion considers the joint effect of the data and datum noise on the estimated coordinates and it is implemented over an arbitrary subset of the network stations. The final solution leads to a flexible treatment of the datum choice problem for minimally constrained networks by allowing the weight matrix of the reference stations to be tuned to various options regarding the frame quality in the adjusted network. Some numerical examples with regional GNSS network solutions are finally presented to demonstrate the practical impact of our theoretical results.

PRÉPARATION FOR ITRF2013

Zuheir Altamimi
Institut National de l'Information Géographique et Forestière (IGN), Paris, France

The paper will address key questions regarding the ITRF2013 preparation: frame specifications (origin, scale, orientation and their time evolution) and how they will relate to ITRF2008; non-linear station motions (seasonal signals and post seismic deformations) and how they will be modeled; local ties and station co-motions and how they will be weighted, taking into account technique discrepancies at co-location sites. A particular emphasis will be given to assess the stability of SLR origin as well as SLR and VLBI scales over the entire observation history of both techniques. To answer these questions, early submissions to ITRF2013 of technique solutions will be analyzed, otherwise operational technique products will be used instead.

HEIGHT AND GRAVITY
Chair: Markku Poutanen, Martin Lidberg

RESTRICTED MAXIMUM LIKELIHOOD ESTIMATION OF SPATIAL COVARIANCE PARAMETERS OF GEODETIC DATA

Wojciech Jarmołowski
University of Warmia and Mazury in Olsztyn, Olsztyn, Poland

Least-squares collocation (LSC) and kriging are common tools for spatial data modeling. Various geophysical, geodetic, oceanographic, meteorological or other spatial data data are gridded, interpolated in points or processed via composed algorithms, employing LSC, kriging or other kind of least-squares estimation. The time component is becoming also more and more frequent in data modeling. The data have, however, various spatial resolutions, dependent on the instruments, costs and other factors. This contributes to the noise covariance matrix, the determination of which is more complicated than creation of the signal covariance matrix.

A quite large number of analytical approximations of the spatial covariance are proposed in the literature. Usually, a few parameters can modify the shape of the function to approximate the local correlation better. The work presents the estimation of the parameters of planar covariance model, as an example. The parameters of the correlated signal covariance model and the parameters of uncorrelated noise are estimated by restricted maximum likelihood (REML) and verified by cross-validation (CV), proving usefulness of REML in this application. Precise estimates of the covariance parameters are essential in LSC, especially in the case of sparse data or increased accuracy requirements. The data used for the testing are gravity anomalies and topography, due to considerable variance of their signal at higher frequencies.

DEFINITION AND REALIZATION OF THE EVRS: HOW DO WE WANT TO CONTINUE?

Gunter Liebsch[1], Axel Rülke[2], Martina Sacher[1], Johannes Ihde[2]
[1] Federal Agency for Cartography and Geodesy, Leipzig, Germany
[2] Federal Agency for Cartography and Geodesy, Frankfurt am Main, Germany

Precise leveling observations are used in the most European countries in order to realize the official national vertical reference frames (VRF). These national leveling networks supplemented by connections across the borders are the basic information for the current realization of the European Vertical Reference System (EVRS) - the European Vertical Reference Frame (EVRF) introduced in 2007. Beside the traditional infrastructure for height determination based on leveling benchmarks, users in probably all European countries are provided with a model of the national height reference

surface (e.g. geoid or quasigeoid model). It's a matter of fact that an increasing number of customers use satellite positioning techniques for the determination of (physical) heights with respect to the national VRF. One can expect, that the user interest in a common model of the European height reference surface, like the European gravimetric quasigeoid (EGG2008), will also increase in future. An indication of this is the chart datum working group of the Baltic Hydrographic Commission, which intend to introduce a common chart datum over the Baltic Sea based on the EVRS and its realization. Some countries have already adopted a geoid or quasigeoid model as the basis for their VRF. Taken the current situation and the development into account, we should intensify our considerations about the definition and future realizations of the EVRS.

The very successful satellite gravity field missions of the last decade, especially the gravity field and steady-state ocean circulation explorer (GOCE), have made global gravity field models with an accuracy of 1 to 2 cm and a spatial resolution of about 100 km available. This opens unique possibilities for the validation and realization of vertical reference frames. It can be shown, that the overall error budget of i) physical heights obtained by leveling and gravity information along the leveling lines, ii) ellipsoidal heights obtained by GNSS and iii) gravimetric quasigeoid heights is in the order of a very few centimeter for a large part of Europe if one takes into account the inconsistencies of the corresponding reference frames.

Based on experiences during the modernization of the German vertical reference frame since 2006 as well as investigations of the benefit of GOCE based gravity field models for the unification of vertical reference frames within the ESA funded project GOCE+HSU, we want to discuss several aspects which raised in this context, e.g.

- Realization of EVRS with different concepts
- Unification of standards for spatial and gravity related reference frames, EVRS conventions
- Alignment of EVRS and ETRS89 datum
- Density, quality, timeliness of leveling, GNSS, and terrestrial gravity data.

TRANSITION FROM THE NATIONAL TO EVRS VERTICAL SYSTEM IN POLAND

Marcin Ryczywolski
Head Office of Geodesy and Cartography, Warsaw, Poland

Currently the Polish Height Reference System consists of two official geodetic vertical datums. First one used since year 2000 is called PL-KRON86-NH (also as Kronsztadt 86), represents the normal heights system referenced to mean level of Baltic Sea, obtained from tide-gauge in Kronsztadt near Sank-Petersburg. Second vertical datum was introduced by The Head Office of Geodesy and Cartography in 2012 by the legal act devoted to spatial reference system in Poland. New vertical datum is called PL-EVRF2007-NH, and it was introduced as a consequence of moving towards EVRS. By the year 2020, PL-EVRF2007-HN should replace PL-KRON86-NH frame. By this time both vertical datum will be used simultaneously. Within the new legal act also new

transformation models for height and new quasi-geoids were introduced.

The poster presents information about realization of PL-KRON86-NH and PL-EVRF2007-NH, their mutual comparison and as well to the newest World and European geoids models. Also the concept of new transformation models is presented.

ON THE ACCURACY OF GLACIAL ISOSTATIC ADJUSTMENT MODELS WITH SPECIAL ATTENTION TO ICE MODELS

Holger Steffen
Lantmäteriet, Gävle, Sweden

The mass of an extensive ice sheet deforms the Earth's crust into the mantle, leading to surface depressions of several hundreds of meters underneath the ice. Beyond the ice-covered area, a peripheral bulge up to a few tens of meters develops around the ice sheet due to the bending of the elastic lithosphere outside the ice-covered area and flow of mantle material underneath. During and after the deglaciation phase, the mass redistribution is reversed, forcing uplift of the formerly glaciated areas and subsidence of the peripheral bulge. This dynamic response of the Earth during glacial cycles is known as glacial isostatic adjustment (GIA), which is, due to the viscoelastic and thus time-delayed behaviour of the mantle, still observable today, especially in North America and northern Europe.

GIA models that describe this process are developed since decades. In a simple manner, these models can be described as a combination of an Earth model and an ice model. They are evaluated, verified and improved with several different types of observations. In most studies, the ice model is a fixed parameter and with the help of observations Earth's rheology is investigated. However, there are different types and generations of ice models, which usually do not provide levels of uncertainty.

The talk will review the different Earth and ice models available and discuss the accuracy of these models in view of the ice model used.

FROM BHS-77 TO EVRS: LATVIA EXAMPLE

Ivars Aleksejenko
Latvian Geospatial Agency

Post glacial rebound in Fenoscanndia area is reason of land uplift process and strongly impact changes of geoid, sea level and height. Baltic States historically have height systems definition closely connected directly to Baltic Sea.

Last 50 years heights in Latvia was connect with Kronstadt tide gauge in Sankt-Petersburg. Due to land uplift, loss of benchmark and political changes new 1st order levelling campaign was started at beginning of year 2000.

Levelling strategy was used synergy of Soviet time levelling instruction together with latest digital achievement in instrument and levelling rod manufactory. Alternative measurement method with so called 8 measurement principle was used. New 1st order levelling polygons inside the Latvia were established using as much as possible historical benchmarks. Totally ten 1st order polygons were established over the country and 5 polygons for capital Riga.

1st order levelling and checking works were finished at year 2011 and at autumn of 2011 part of data was provide to European Vertical reference system calculation centre in Leipzig, Germany. After incorporation of new Latvia levelling data in EVRF2007 a new realization was obtained. 16 points, with new EVRF2007 data, were choosing for adjustment of 1st order network and definition of realization of Latvian height system in epoch 2000.

Legalization of Latvian height system for daily used is in process from year 2012 so far community of surveyors and geodesists agree with need for new system. In new Latvian Geospatial information conception change and upgrade of reference system is aim number one for Geodesy.

EUROPEAN VERTICAL REFERENCE SYSTEM IN LITHUANIA

Tomas Ladukas[1], Jurgita Spuraite[1], Jolita Aldoniene[1], Robertas Aleliunas[1], Renata Traceviciene[1] , Eimuntas Parseliunas[2] , Boleslovas Krikstaponis[2]
[1] National Land Service, Vilnius, Lithuania
[2] Institute of Geodesy, Vilnius Gediminas Technical University, Vilnius, Lithuania

Activities of Lithuanian National Geodetic Vertical Reference Network (NGVRN) establishment are going on since 1998. The goal of NGVRN establishment is a creation of new Lithuanian height reference suitable for present period practical and scientific needs. The Lithuanian Geodetic Vertical First Order Network consists of five polygons. Perimeter of the network is ca. 1900 km. Its development was finished in 2006. But this network is not dense enough to transfer the geodetic vertical system to the all territory of Lithuania and to improve the geoid model. It is necessary to dense available First Order Geodetic Vertical Network by developing the Second Order Geodetic Vertical Network.

The territory of Lithuania is divided into five regions. Borders of the regions are First Order Network levelling lines and lines connecting Lithuanian national Vertical Network to the corresponding networks of the neighbouring countries. The regions are called: South, East, North, West and Centre. The design of the Second Order Geodetic Vertical Network is presented. The necessary density, accuracy of the geopotential numbers and ellipsoidal heights are discussed. Some results of the geodetic measurements are presented too.

NATIONAL REPORTS
Chair: Jan Krynski

NATIONAL REPORT OF ALBANIA

Arben Xhialli
ASIG

EUREF14: NATIONAL REPORT OF AUSTRIA

Guenter Stangl[1], Erich Imrek[2], Philipp Mitterschiffthaler[1], Diethard Ruess[2], Ernst Zahn[2]
1 Federal Office of Metrology and Surveying, Graz, Austria
2 Federal Office of Metrology and Surveying, Vienna, Austria

NATIONAL REPORT OF BELARUS

Nadezhda Rudnitskaya
UE "Belaerocosmogeodesia", Minsk, Belarus

NATIONAL REPORT OF BELGIUM

Carine Bruyninx et al
Royal Astronomical Observatory, Brusseles, Belgium

NATIONAL REPORT OF BULGARIA

Tzvetan Simeonov
Sofia University

NATIONAL REPORT OF CZECH REPUBLIC

J. Douša[1], V. Filler[1], J. Kostelecky[1], J. Kostelecky jr.[1], J. Šimek[1], P. Štěpánek[1]
J. Nágl[2], M. Lederer[2], J. Řezníček[2]
[1] Research Institute of Geodesy – Geodetic Observatory Pecný
[2] Land Survey Office

NATIONAL REPORT OF CROATIA

Margareta Premužić, Marijan Marjanović, Ivan Malović
State geodetic administration, Zagreb, Croatia

NATIONAL REPORT OF DENMARK

Per Knudsen et al
DTU Space - Technical University of Denmark

NATIONAL REPORT OF ESTONIA

Priit Pihlak
Estonian Land Board

NATIONAL REPORT OF FINLAND

Pasi Häkli
Finnish Geodetic Institute, Masala, Finland

NATIONAL REPORT OF FRANCE

Anne Duret et al
Institut National de l'Information Géographique et Forestire (IGN)

NATIONAL REPORT OF GERMANY

Johannes Ihde et al
Federal Agency for Cartography and Geodesy

NATIONAL REPORT OF GREECE

Michail Gianniou, Dimitrios Mastoris, Eleni Mitropoulou
National Cadastre and Mapping Agency S.A., Athens, Greece

NATIONAL REPORT OF HUNGARY

Ambrus Kenyeres
FÖMI Satellite Geodetic Observatory

NATIONAL REPORT OF ITALY

Alessandro Caporali et al
University of Padova, Department of Geosciences

NATIONAL REPORT OF LATVIA

Ivars Aleksejenko et al
Latvian Geospatial Agency

NATIONAL REPORT OF LITHUANIA TO EUREF 2014

Tomas Ladukas[1], Jurgita Spuraite[1], Jolita Aldoniene[1], Robertas Aleliunas[1], Eimuntas Parseliunas[2]
[1] *National Land Service, Vilnius,Lithuania*
[2] *Institute of Geodesy, Vilnius Gediminas Technical University, Vilnius,Lithuania*

NATIONAL REPORT OF MACEDONIA

Srechko Tasevski
Agency for real estate cadastre

NATIONAL REPORT OF MONTENEGRO

Predrag Femic
Real estate administration

NATIONAL REPORT OF THE NETHERLANDS

Lennard Huisman[1], Pieter van Waarden[2], Hans van der Marel[3]
[1] Kadaster, Apeldoorn, Netherlands
[2] Rijkswaterstaat, Delft, Netherlands
[3] Delft University of Technology, Delft, Netherlands

NATIONAL REPORT OF NORTHERN IRELAND

Geoff Bell
LPS

NATIONAL REPORT OF POLAND TO EUREF 2014

Jan Krynski[1], Jerzy B. Rogowski[2]
[1] Institute of Geodesy and Cartography, Warsaw, Poland
[2] Department of Geodesy and Geodetic Astronomy, Warsaw University of Technology, Warsaw, Poland

NATIONAL REPORT OF PORTUGAL

Joao Torres
SPUIAGG

NATIONAL REPORT OF SLOVAKIA

Branislav Droscak et al.
Geodetic and Cartographic Institute

NATIONAL REPORT OF SLOVENIA

Klemen Medved et al
Surveying and Mapping Authority

NATIONAL REPORT OF SPAIN

Marcelino Valdes Perez de Vargas
Instituto Geografico Nacional

NATIONAL REPORT FROM SWEDEN

Martin Lidberg, Tina Kempe, Lotti Jivall, Holger Steffen
Lantmäteriet, Gävle, Sweden

NATIONAL REPORT OF SWITZERLAND

Elmar Brockmann
Swiss Federal Office of Topography swisstopo, Wabern, Switzerland

NATIONAL REPORT OF TURKEY TO EUREF 2014 SYMPOSIUM

Ali Ihsan Kurt
General Command of Mapping, Ankara, Turkey

NATIONAL REPORT OF UNITED KINGDOM

Mark Greaves
Ordnance Survey