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Book of Abstracts

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Global disasters: a historical analysis and prediction

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The world is still experiencing a number of natural disasters that have had a serious impact on people's lives and the environment. In recent years, mainly through climate change and global warming, the scale and frequency of such phenomena has been increasing. Examples from recent years include the China earthquake in 2008 (magnitude of 7.9 on the Richter scale struck on the Sichuan province) or Hurricane Sandy in 2012 (more than 80,000 people died, one of the largest hurricanes ever to hit the east coast of the United States, estimated damages cost have been more than $70 billion).
This paper analyses 8 natural disasters over the last 60 years (1960-2018) divided by the continents, the number of natural disasters in relation to population and the number of natural disasters per continent area. In addition, the prediction of the number of individual natural disasters was determined using polynomial analysis for next 20 years. Figure 1 shows the distribution of natural disasters on continents per 1 million citizens and per 1000 square kilometres. It shows a great advantages of areas and people affected in the less developed countries.

Fig. 1. Distribution of natural disaster among continents per people and per are.

Authors in detail analysed distribution of each natural disaster on the continents and created a cartodiagrams based on 5-class classification for each disaster separately. Figure 2 shows example distribution of the floods in the analyzed period. It in a simple way showing a countries affected during 60 years by each disaster most.

Fig. 2. Numbers of floods distributed by countries

Except spatiotemporal distribution authors also prepared a 20-years forecasting of the appearances of the disaster globally. Figure 3 shows number of storms in analysed period with a 20-years forecast.

Fig. 3. Disasters charts from 1960-2018 with forecasts for the next 20 years.

As result authors showed a number of appearances of each disaster in each continent, countries affected by it most and a future trends.

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GNSS observation reduction data at the Institute of Geodesy and Geoinformatics

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Anomalous Refraction and its Influence on Digital Zenith Camera Measurements

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Atmospheric refraction is a phenomenon that occurs when light travels through the Earth's atmosphere. It is causing the apparent position of objects in the sky to appear slightly different from their true position, especially when they are near the horizon. Under normal conditions, atmospheric refraction should follow the laws of geometric optics and, knowing parameters of Earth's atmosphere, could be predicted using standard atmospheric refraction models.
However, anomalous refraction can occur under certain conditions, leading to deviations from the predicted refraction. Anomalous refraction in the atmosphere is caused by variations in the temperature and pressure of the air, which can lead to changes in the refractive index of the atmosphere.
Anomalous refraction is the main limiting factor of ground-based astrometric observation's precision, causing low-frequency irregular angular displacements of observed stars.
One of such observation types where anomalous refraction interferes with observation results are deflection of vertical measurements by digital zenith cameras (DZC). Deflection of vertical (DoV) is the angle between the direction of the gravity vector (plumbline) at a point on the Earth's surface and the ellipsoid's normal through the same point. Therefore, DoVs characterise the direction of Earth's gravity field and can be used for, e.g., geoid determination. DZCs use image coordinates of observed stars at the zenith direction and star catalogue data as high accuracy reference for DoV determination.
According to standard atmospheric refraction models, there should be no refraction effect at the zenith direction. However, anomalous refraction still exists at the zenith direction and affects also observations of DZCs.
Comprehensive study of Taylor et al. [1] on anomalous refraction impact on astrometric observations has approved that it ubiquitous and it is not directly dependent on ground weather conditions (temperature, wind speed, pressure). No correlation was found between simultaneous observations with two or even three closely located telescopes in TDI mode (Time-Delay and Integrate CCD readout or drift-scan mode). Taylor et al. concludes that source of anomalous refraction is at low heights (~10–100 m) and physical scale of involved turbulence cells is small (~2 m), and proposes a hypothesis that anomalous refraction might be caused by an atmospheric disturbance created by the dome or telescope itself or it is a result of the integration of quasi-stochastic atmospheric dynamics over the entire air column, with the greatest contributions originating in the surface layer.
Anomalous refraction has also been observed as an error source in several studies employing DZCs [2, 3, 4, 5]. Hirt [2] has used observations collected in the single site for 6 nights which is the only study of anomalous refraction using DZC. This study concludes that the anomalous refraction effect at the zenith reaches from 0.05 arcseconds up to about 0.2 arcseconds.
Attempt to understand anomalous refraction by using DZC VESTA (VErtical by STArs) of University of Latvia has been done by performing DZC VESTA observations at test site with four points during two-year time. Overnight (5–10 h long) observations were done during all seasons over various weather conditions. Initially one meteo-sensor measuring temperature, atmospheric pressure and relative humidity was installed on DZC VESTA.
The amplitudes of the observed zenith coordinate fluctuations reach several arcseconds, and the amplitudes of the final DoV values are within ~0.2-0.5 arcseconds during overnight session. Warm

weather front passing observation site caused high DoV amplitudes of ~0.5 arcseconds. For comparison, accuracy of DZC VESTA DoV values is 0.1 arcsecond for typical session of 45-60 minutes. DoV observations performed during warmer weather of summer months tend to have higher residuals. Apart from that, no correlation was found between result DoV residuals and atmospheric pressure.

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Project "Accuracy improvement of the astrogeodetic measurements and development of their dual application" is carried out thanks to the donation of "MikroTik", which is administered by the University of Latvia Foundation.

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RELIABILITY OF OUTLIERS AND THEIR EVOLUTION IN GNSS CLOCK PRODUCTS

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Time is crucial in GNSS (Global Navigation Satellite System) systems such as GPS, GLONASS, Galileo and Beidou, it is measured with a high precision, enabling accurate position of the receiver. Thus receiver's clock must be very accurate to enable accurate position and a number of error-producing factors (e.g. multipath, atmosphere impact) must be included into processing.. Time and/or accurate position determination is important in many fields such as navigation, surveying, meteorology and even in finance.
In this presentation authors analysed a number of clock correction products in terms of number and magnitude of outlier observations in four GNSS systems based on final MGEX products for the years 2014-2021. Among this time there where available 120 satellites: 37 Beidou, 26 Galileo, 32 GPS and 25 GLONASS satellites. Authors analysed phase, frequency and noise data. Figure 1 shows a sample raw phase data of selected satellites, which shows a different change and nature of clock correction course in time, e.g. line, polynomial, random etc.

Fig. 1. Phase data of selected satellites: C46 (Beidou) and G32 (GPS).

First derivate of the phase in time is a frequency (Figure 2), which allows to see a quite different nature of the graphs courses between GNSS systems, satellite blocks and between clocks types.

Fig. 2. Frequency data of selected satellites: C24 (Beidou) and E01 (Galileo).

The Allan deviation (ADEV) and it's modificated version allows for determine a noise characteristic for analysed time series and it is a common tool for atomic clock stabilities analyses. Figure 3 shows the HDEV (Hadamard deviation, modificated version of ADEV) of selected satellites, which allows for detect based of the graph course noise type characteristic for selected satellites and its intervals. Figure 4 is similar to Figure 3, but allows for comparison HDEV changes year-to-year.

Fig. 3. Yearly Hadamard deviation of selected satellites: C46 (Beidou) and E01 (Galileo).

Fig. 4. Multidimensional Hadamard deviation selected satellites: C46 (Beidou) and G32 (GPS).

As results authors find a couple of new phenomena, e.g. stability of the GPS and GLONASS systems (in general) are better than the BeiDou and Galileo systems, which means that repeatability of the clock corrections are more consistent in time.

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Accuracy improvement of the astrogeodetic measurements and development of their dual application

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The goal of the project is to Improve existing astrogeodetic measurement methods of the institute of geodesy and geoinformatics and adapt them for possible dual applications.

The results of the project will help understanding the effect of anomalous refraction on vertical deflection measurements performed with a digital zenith camera (DZC).

To achieve the highest possible level of accuracy of DZC measurements, efforts should be made to eliminate or minimize the effects of error-causing factors such as anomalous refraction. Studies have been conducted around the world to explain
anomalous refraction, as it is a major source of error in astrometric observations. A particularly extensive study has been conducted by Taylor (2013). Possible causes of anomalous refraction include the rippling of atmosphere layers with different density, horizontal gradients of atmospheric layer density, and others,but there is no conclusive explanation for the origin of anomalous refraction. However, it is very likely that its origin could be up to a height of 60 m above the ground.

Within the framework of the project, several meteo sensors and a drone (UAV) for lifting the meteo sensor to a height of up to 100 m have been purchased. Typically, one DZC measurement session lasts 45-70 minutes (average about 50). This is the time required to "hold" the meteo sensor in the air to obtain information about the atmospheric processes taking place during the measurement session.

A space object optical tracking system for positional astrometric observations has been developed at the LU GGI. Currently, the first optical observations of satellites (geostationary and flying in high Earth orbits (above ~ 10,000 km)) have been made. Evaluation of the alternative system applications showed that it is possible to adapt the image processing and analysis and mechatronics control algorithms used to process images of space objects and track their trajectories. New application is possible - optical identification of low-flying objects such as drones, by searching objects in the sky background images by specific colour, contrast, configuration, and motion. The drone purchased within the framework of the proposed project will be used to develop a low-flying object identification solution.

Within the project it is planned to perform:

Recording of meteo parameters during DZC VESTA measurements;
Processing and interpretation of the obtained data, development of recommendations – describe conditions under which it is possible to minimize the impact of anomalous refraction;
Development and adaptation of optical object identification software for various tasks;
Acquisition of optical images of low-flying objects for testing identification software.
The recommendations developed during the project will be used not only by LU GGI researchers performing vertical deflection measurements with VESTA, but also by users of other zenith cameras in the world.

The achieved results will be the basis for higher technological readiness level (TRL) research for the development of solutions for the identification of moving objects. The implementation of the project will increase the competence and competitiveness of researchers at the University of Latvia at the international level, facilitating the attraction of foreign funding and involvement in international scientific cooperation projects. The equipment purchased for the implementation of the project after the project will be used to ensure and strengthen the research capacity of the LU GGI, as well as to serve for the preparation and implementation of other research and applied project applications.

The research and methodology developed during the project will be applied in future measurements of zenith cameras. International cooperation in this field will be encouraged.

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The 1884 SLR Station in Riga: A Review of the Current Situation

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The SLR station 1884 Riga started in 2021 a process of upgrading several components of the SLR system and adding new components and capabilities. The new local ties, has been measured, replacing the 1996 solution. A full recalibration of the SLR system was done using the latest local ties. The new ITRF2020 coordinate solution for the SLR 1884 Riga is significantly improved in relation to the ITRF2008 and ITRF2014 solutions. This is a consequence of the new hardware introduced, the improvement of operation procedures, both software and operators training, and the full and regular system calibrations carried out since 2014. The 2023 results show that our system currently has a range bias of the order of 1 cm, precision of <5 mm and current normal point RMS is 3mm. Our station is now at the ILRS global network top third in the range bias long- and short-term stabilities and normal point precision. We present an overview of the latest developments in satellite photometry and event timing.

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Two-Year Long Digital Zenith Camera VESTA Deflection of Vertical Measurements at the Test Site

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In 2016 design of a digital zenith camera (DZC) (named VESTA – VErtical by STArs) for deflection of vertical (DoV) component measurements was completed in the Institute of Geodesy and Geoinformatics (GGI) of the University of Latvia [1]. The DoV at a point on the Earth is a measure of how much gravity normal has been inclined by local anomalies such as terrain and geological features. Several units of VESTA have been developed and assembled in GGI, series of successful observations have been performed and applied for calculation of regional quasi-geoid parameters [2]. In 2019 one unit after international tender was sold to the Louisiana State University (USA) and is successfully working there.
Differently from other known DZCs [3, 4, 5, 6], VESTA is a highly portable instrument (12 kg, mounted on a light tripod) and can be operated by a single person. It consists of a small (16 inch) vertically oriented telescope with a CCD camera and attached computer-controlled focuser, mounted on a rotating levelable platform. All involved equipment and actuators are controlled by an on-board computer; the process of measurements is almost completely automated and requires operator intervention only for setting up. A measurement session typically includes zenith star observations in 30-90 rotation positions, usually 10 short exposure frames in each position. Star field images are complemented with high sensitivity tiltmeter data, thus providing link to both star-defined orientation in inertial coordinate system and gravity field direction. A minimal measurement session takes less than an hour and offers about 0.1 arc second DoV accuracy; longer sessions give more accurate results.
Post-processing of measurements includes analysis of star field images, automated star image identification with reference catalog data (a subset of GAIA catalog is currently used), calculation of apparent places of stars (using NOVAS vector astrometry package), calculation of projections of ellipsoidal zenith on CCD image, corrections for instrument tilt, and, finally, calculation of DoV. The whole process is automated and requires only minimal operator intervention.
More detailed analysis of optimal measurement conditions and error sources of DZC VESTA is currently performed. This study focuses on testing various parameters of DZC VESTA measurement session: session length, image binning, exposure time; monitoring changes of DoV values over 2-year time at the same site and considering influence of external conditions: average number of observed stars, temperature, humidity, pressure, wind speed, sky, microseismic.
For measurement purpose, a test site with 4 points at a 50x50 meter distance was established and DoV measurements by DZC VESTA were started there in May 2021. Moreover, measurements were continued for two years to obtain DoV time series at all 4 points of the test site, so currently regular measurements are completed.

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The movement of GPS positioning dicrepancy clouds at a mid-latitude region in March 2015

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MITESENS - R&D on Navigation State Estimation, Flight Control and Georefe¬ren-cing Tasks for an auto¬nomous UAV System for Mites Detection in the Era of Digital Horticulture 4.0

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The aim of the MITESENS project (www.h-ka.de/iaf/mitesens) in the Laboratory for GNSS and Naviga¬tion is an UAS based monitoring system (UAS = Unmanned Aerial System with an UAV as carrier platform) for spider mites infestation in greenhouse cultivations for the early infestations of plant leaves with spider mites.
The autonomous UAV flight over the plant stand is controlled with a newly developed MITESENS UAS flight control (FC). The respective hardware development for the multisensory and IEEE 1588 time synchronized GNSS/MEMS/Optics FC box is also part of the R&D project. The FC determines out- and indoors the 18 para¬¬meters navigation state vector y(t) (3D-position, 3D-velocity, 3-acceleration, 3D-rotation rates, 3D-rotation rate changes), which is georeferenced in the ETRF89, or generally in the ITRFyyyy.zzzz.mm, using optionally DGNSS and PPP.
In a first instance y(t) is the essential com¬ponent of the FC controlling the desired trajectory and attitude. As flight control FC types, the development of a PID control, and of a multi predictive control (MPC) are carried out. The PID control type is used to set up the georeferenced building model (BIM) of a greenhouse from the UAV optics of the camera and/or the lidar sensorics, by operating the UAV with a remote control. The MPC control is used in further for the general mission of mites detection and monitoring by the UAS being equipped also with a multispectral camera, where the UAS is autonomously flying out- and indoors. Indoors the UAS is using the digital twin of the greenhouse BIM model as an AI-based feature recognition vision component of the FC, providing the position infor¬ma¬tion from the ERTF89 or ITRFyyy.zz.¬mm BIM instead from GNSS, in the navigation state esti¬ma¬tion y(t) and MPC control.
Con¬ceptionally the navigation y(t) is not used only as a reference for the FC, but y(t) also forms the com¬mon core for all computational operations. So all images contain y(t) as metadata. A first further task of the UAS is the generation of an ERTF89 or ITRFyyy.¬zz.¬mm geo¬refe¬renced 3D voxel model of the plants by a bundle block adjustment of the RGB cameras (ZED 2i) data with known exterior orien-ta¬tion as component parts of y(t). Further y(t) in the image metadata is used for the geo¬refe¬rencing of the acquired spectral image data. The acquired hyperspectral images infor¬ma¬tion is on wavelengths between 500nm and 900nm. This image information is evaluated using AI (XGBoost classi¬fication based on a decision tree algorithm) on dividing the infestation probability of the leaves into three classes (green, yellow and red) with a prediction accuracy for the spider mite infestation above 85%. The classified hyperspectral metadata images are then pixelwise

calculated back to the ERTF89 or ITRFyyy.zz.¬mm referenced 3D plant stand using y(t), creating in that way a classified 3D voxel model. In order to realize a simple and spatially clear representation of the recorded spider mite infestation for horticultural prac¬tice, the classified 3D voxel data are converted into a 2D plan map view of the green¬house infestation situation.
The complete MITESENS UAS is presented. The focus is on the mathematical models, algorithms and software of the out- and indoor navigation state y(t) estimation and SLAM, the MPC based control for the auto¬nomous flight, the 3D voxel model generation, and the back projection of the classified images to receive the classified 3D voxel model of the mite infestation. The results are of the MITSENS UAS development are shown

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Application of Surface Models in Crisis Management

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When the threat of a crisis formed, it transforms into the development of the crisis and when it moves into the phases of escalation, the spatial situation of the specific event area should be considered as an important influencing factor. The impact of the spatial situation is very individual for a specific area of crisis development, while maintaining many unifying elements of the nature of the impact also in different cases. Using the knowledges of a specific spatial situation, the crisis management staff prepares and makes decisions for predicting crises, limiting their development and escalation, as well as for the organization of coping processes.
In the last two centuries, the best-known documents of territorial knowledge were the cartographic materials of territories, which can be considered as the results of territory modeling in two-dimensional planes of the territory of the area in plans and topographic maps. However, at the same time, when it was possible, three-dimensional terrain models of the territories were also requested, created and used. Their creation was time-consuming and limited in use, but they offered well-presented and understandable territory models.
As digital technologies integrate with mapping technologies, the creation and use of three-dimensional terrain situation models began to improve and expand significantly, offering new opportunities for crisis management.
The development of modeling created opportunities for users to visually evaluate the situation of the area and its impact possibilities in a 3D view, to make accurate measurements and to use automated or semi-automated analytical functions on computers. The opportunities for crisis management to provide themselves with more complete forecasts and action justifications for decision-making increased. For monitoring the development of the situation, the use of modeling options offers a significant value of quality and timesavings.
Development of situation the use of three-dimensional terrain digital models in crisis management measures is in dynamic development. It is significantly limited by the requirements for safe and proven solutions, which today's developments, prototypes and capabilities cannot yet support with a large history of experience and safety testing.
However, when dealing with the integration of 3D models in crisis management processes, there is an intensive work of specialists in the development of specific solutions and safety tests of their use. These activities are also limited by the acute lack of availability of fully trained geoinformation specialists - a shortage.

Key words: Crisis management, cartographic, threedimensional models, 3D view, terrain digital models.
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Towards wellbeing concept based on environmental data, geospatial data and dynamic modelling

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Moment Tensor Solution From Waveforms Of The Earthquakes In Central Lesser Antilles

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In the paper, a method is presented for moment tensor inversion of only direct waveforms registered at only limited number of seismic stations. The method is based on an inversion approach described in (Malytskyy 2010, 2016) where a version of matrix method has been developed for calculation of direct waves in horizontally layered half-space from the point source represented by its moment tensor. The inversion scheme consists of two steps. First (forward modeling), propagation of seismic waves in vertically inhomogeneous media is considered and a version of matrix method for calculation of synthetic seismograms on the upper surface of the horizontally layered isotropic medium is developed. The point source is located inside a layer and is represented by seismic moment tensor. The displacements on the upper surface are presented in matrix form in frequency and wave number domain, separately for far-field and near-field (Malytskyy 2016). Subsequently, only the far-field displacements are considered and the wave-field from only direct P- and S-waves is

isolated with application of eigenvector analysis reducing the problem to system of linear equations (Malytskyy 2016). Subsequently (inverse modeling), spectra of the moment rate tensor components are calculated using a solution of generalized inversion and transformed to time domain by applying the inverse Fourier transform. The 1D crustal model used in all the inversions of waveforms is listed in Table 1. The duration of direct waves at the stations is estimated visually from the records, and accounting for the delays of reflection-conversion phases at the station corresponding to the model (Table 1) at a respective epicentral distance and source depth. As a rule, the duration of direct P-waves approximately varies between 0.3 s and 1.2 s. The highest frequency, on the other hand, is controlled by assumption of the point source and corresponds to a wavelength larger than linear dimensions of the fault, often less than 1 km in small earthquakes.

Table 1. The 1D crustal model used in the inversion of waveforms (Gonzalez et.al 2017).

Thickness, km Velocity Vp, km/s Velocity Vs, km/s ρ, kg/m3
3 3.5 1.99 2318
12 6.0 3.41 2717
15 7.0 3.98 2968
190 8.0 4.55 3291

Using the method presented in the current paper focal mechanisms of four small earthquakes in the Central Lesser Antilles are retrieved. The mechanisms independently determined for the same earthquake from its waveforms at different single stations turned out almost identical. The mechanisms are also compared with focal mechanisms estimated by full waveform inversion (Gonzalez et.al 2017). A conclusion is drawn out that the method will be useful when focal mechanisms can't be obtained by other methods, the problem typical for regions with low seismicity and insufficient number of seismic stations.
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Fig. 1. Map of the stations (triangles) used for determining the moment tensor solutions

As result, we first propose to compare the mechanisms independently determined for the same earthquake from its waveforms at different single stations. For the earthquake of 2014-05-14 they turn out almost indistinguishable between the stations SAM, SLBI, ILAM and SAM, SLBI, ILAM, MPOM (Fig.1) and only slightly differ from the mechanism estimated by full waveform inversion (event 10, Gonzalez et.al 2017), the same as for the earthquake of 2013-10-24 between the station ABD and stations ABD, DHS, DSD (event 5 Gonzalez et.al 2017), which at least means that despite all the uncertainties the unique solution exists and is reproducible. Finally, the focal mechanism solutions for the two earthquakes: 2014-08-09 and 2013-10-18 determined here by inversion of direct waveforms are compared to those estimated by full waveform inversion (events 21 and 3, Gonzalez et.al 2017). Larger differences however are present between the nodal planes for these earthquakes. There again a number of reasons may be why the solutions turn out different, the solutions estimated for small earthquakes by full waveform inversion also prone to a set of uncertainties. The subject deserves wider and deeper discussion, beyond however the frames of the present paper.

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