ZÁRÓ SZAKMAI JELENTÉS
MECENATÚRA (MEC_21) pályázat
2. ALPROGRAM (MEC_SZ_21)

Magyarországon megrendezésre kerülő nemzetközi tudományos és innovációs rendezvények, konferenciák szervezése

EPR pályázat azonosító: 140695

Pályázó kutató: Dr. Hatvani István Gábor

Befogadó intézmény: ELKH, Csillagászati és Földtudományi Kutatóközpont

1. A rendezvény megnevezése: GeoMATES - International Congress on Geomathematics **in** Earth- & Environmental Sciences, and the 22nd Hungarian Geomathematical Congress

2. A rendezvény helyszíne és időpontja (város, helyszínt biztosító intézmény, kezdő és záró dátum):

Magyarország, Pécs; Pécsi Akadémiai Bizottság (PAB épülete); 2022.05.19-2022.05.21

3. A rendezvény honlapja (magyar és angol nyelven)[1]:

https://geomates.eu (csak angolul)

- **A szakmai tartalom összefoglalója felkerült-e a honlapra?**
  Igen, 3. pont, ami az alábbi cikkre mutat: https://pbkik.hu/2022/05/23/hirek/geomates22/
- **Van-e utalás a Mecenatúra program támogatására a rendezvény honlapján?**
  Igen, az oldal legalján a logó, a támogatói köszönetnyilvánítás, és az absztrakt kötetben a 3. oldalon
  https://geomates.eu/sites/default/files/Proceedings%20book_GeoMATES_2022_v2.pdf

[1] A felhívás 4.1. pontja értelmében a honlapnak a konferencia záró napját követően legalább egy évig nyilvánosan elérhetőnek kell maradnia.

4. A rendezvény igazolt[2] jelenléti létszáma:

90 fő

5. Külföldről érkezők jelenléti létszáma:

28

6. A rendezvény teljes regisztrált létszáma (online résztvevőkkel együtt):

95

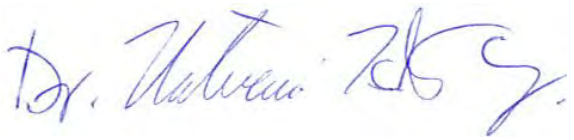
7. A megvalósult rendezvény rövid bemutatása, nemzetközi jelentősége, illetve jelentősége a magyar tudományos élet szempontjából (max. 2000 karakter):

A GeoMATES'22 konferencia, amely egyben a 22. Magyar Geomatematikai Ankét, friss tartalommal töltötte meg a nagy hagyományú rendezvény legújabb állomását immár hagyományosnak mondható helyszínén, az MTA Pécsi Területi Bizottságának székházában. A szervezők korábbi évekhez hasonló fókusztémák (rezervoár geológia, környezeti monitoring adatok feldolgozása, mérnökgeológiai geomatematikai alkalmazások, stb.) mellett, a konferencia hagyományos hallgatósága számára új tudományterületek képviselői felé is nyitottak. Ilyen témák voltak a klímaváltozás és extrémitások vizsgálata, vagy pl. az űrkutatás és távérzékelés kérdésköre.

A konferenciát megelőzően három kurzus került megtartásra: Dr. Manfred Mudelsee számos Science- és egy Nature cikk első szerzője idősorok trendanalíziséről, Prof. Szabó Norbert Péter (Miskolci Egyetem) többváltozós adatelemző módszerek környezeti adatokon való alkalmazásáról, míg Dr. Geiger János (Geochem Kft.) földtudományi adatokat terhelő bizonytalanság kérdéséről értekezett a résztvevőkkel.

A konferenciát Dr. Fedor Ferenc (az AFK elnöke) nyitotta meg és Prof. Stephen Mojzsis (CSFK és University of Colorado) és Qinghua Ding (University of California Santa Barbara) plenáris előadásaival indult és poszterelőadások bemutatásával zárult. Ezt követően 8 szekció került párhuzamosan megrendezésre, melyek elején egy-egy "keynote előadás" hangzott el Magyarország vezető felsőoktatási intézményeiből (pl. ELTE, PTE, ME) és ipari szereplőitől (pl. MOL Nyrt.), ezzel inspirálva a hallgatóságot a tudományos diskurzusra. A konferenciát Dr. Hatvani István Gábor zárta. Minden felsőoktatási intézmény, ahol geomatematikai műhely működik képviseltette magát. A 95 résztvevő (90 személyes és 5 online) több mint 15 országból, több mint 25 különböző intézményből, egyetemekről, állami-, és akadémiai kutatóintézetektől, vagy az ipari szférát képviselő cégektől érkezett. Összesen 50 előadás hangzott el közel 15 órányi tudományos tartalommal és 14 poszter került bemutatásra.

Kelt: Budapest, 2022.11.28



Pályázó kutató aláírása (vagy fokozott biztonságú elektronikus aláírás és időbélyegző)

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[2] Kérjük az alátámasztó dokumentum (pl. jelenléti ív) megküldését az EPR pályázati rendszeren keresztül, a pályázati ügyintéző címére.

Registration

GeoMATES – International Congress on Geomathematics in Earth- & Environmental Sciences, and the 22nd Hungarian Geomathematical Congress

GEOMATES 2022

19—21 May 2022, Pécs

MEC-Sz.21 140695

No.	Family name	First name	Country	Country of Origin	E-mail	Affiliation	Signature
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No.	Family name	First name	Country	Country of Origin	E-mail	Affiliation	Signature
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83.	**Tóth**	**Gergely**	HUNGARY		toth.gergely@mk.uni-pannon.hu	Pannon Egyetem	
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4.	Kovács József					ELTE TTK	
5.	Jordán Győző					Bálint Analitika	
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By signing the registration sheet, I agree and accept the privacy policy related to the event. Please note, that during the whole event the Organiser will provide video-, sound-, and photo recording. By registering for this event, the participant gives his/her consent to unlimited use of those materials prepared during the event by the Organiser. If the Participant is against this, he/she shall immediately notify the Organiser in writing about his/her objection before the end of event.

A jelenléti ív aláírásával igazolom, hogy a rendezvényhez kapcsolódó adatkezelési tájékoztatót megismertem és elfogadom. A Rendezvény teljes időtartama alatt a Szervező által megbízott fotós és videós által fotó-, videó- és hangfelvétel készül. Résztvevő a Rendezvényen történő Regisztrációval és a Rendezvényen történő részvételével hozzájárulását adja ahhoz, hogy a Rendezvényen róla fotó, kép- és hangfelvétel készüljön, melynek a Szervező vagy annak jogos felhasználója által történő korlátlan felhasználásához szintén hozzájárulását adja azzal, hogy a fotó, a kép- és hangfelvétellel és annak korlátlan felhasználásával kapcsolatban semmilyen jogcímen követelése nincs. Amennyiben a Résztvevőnek ez ellen kifogása van, a Rendezvény vége előtt azt a Szervezőnek haladéktalanul jelezze írásos formában.

GEOCHEM

NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION OFFICE HUNGARY

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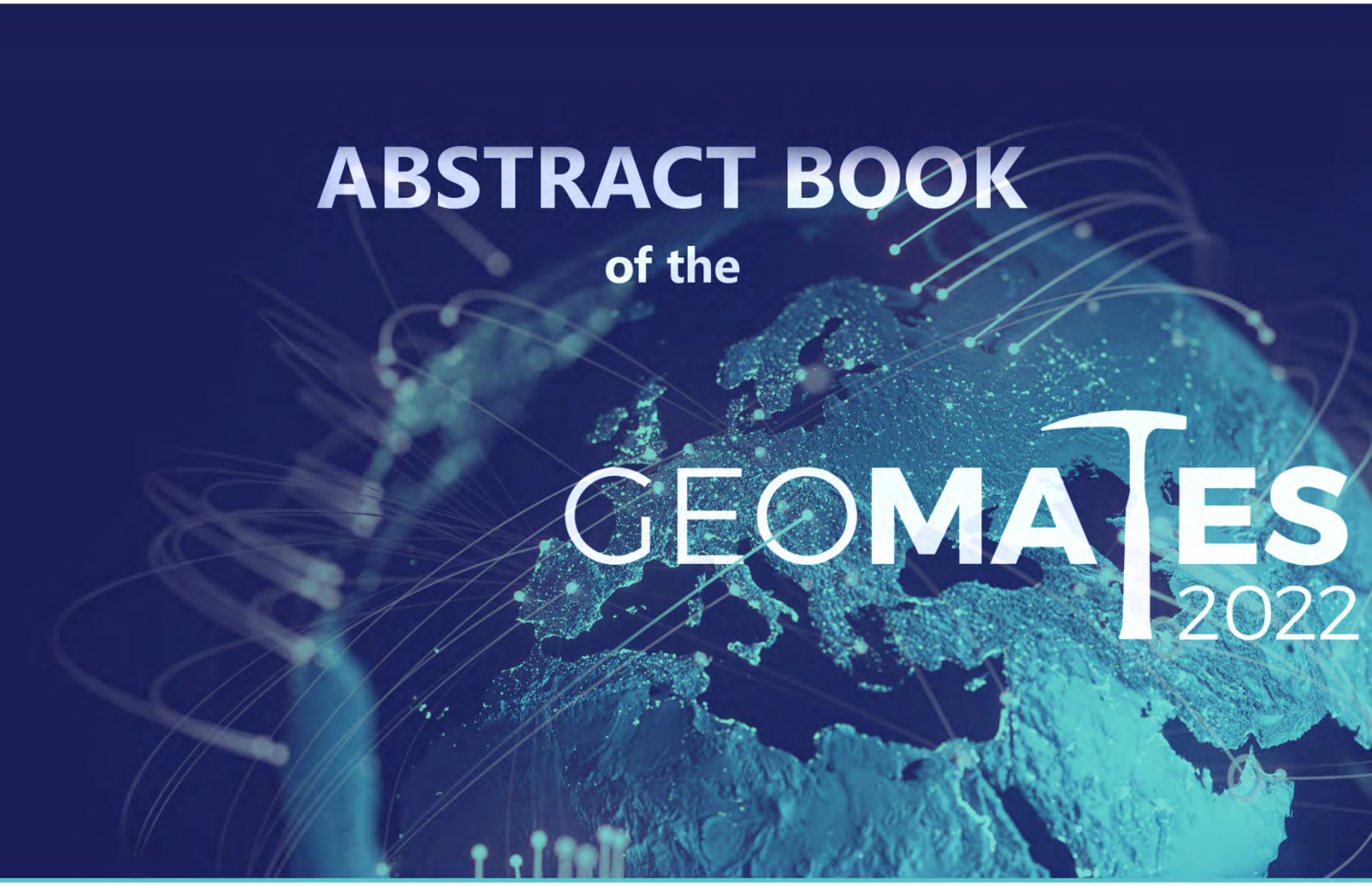

International Congress on Geomathematics in Earth- & Environmental Sciences

which is the 22nd Congress of Hungarian Geomathematicians

IMPRESSUM

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Subject Collection: Geomathematics

Organizers

Hungarian Geological Society (HGS)

Geomathematical & Informatics Section of the HGS

MTA CSFK
2ka Palæoclimate Research Group

Cluster of Applied Earth Sciences

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Hungarian Academy of Sciences, Geomathematical Subcommittee of Committee on Geology and the Regional Committee in Pécs

FUNDED by

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Project number MEC_SZ_21.

SCIENTIFIC PROGRAM

Thursday (19.05) – **Short courses** – pre-conference short courses by
Prof. Manfred Mudelsee (hybrid) – Grand Hall (1st floor)
Prof. Norbert Szabó-Péter (hybrid) – Lecture Hall (1st floor)
Dr. János Geiger (in person) – Study Hall (ground floor)
(Venue: MTA PAB, Pécs Regional Committee of the Hungarian Academy of Sciences H-7624, Pécs, Jurisics Miklós str. 44)

08:45-17:00 **Registration**
09:00-16:20 **Short courses**
11:00-11:15 **Coffee break**
13:15-14:00 **Lunch**
16:20-16:45 **Coffee break**
16:45-18:00 **Opening ceremony** with speeches by**:**

Ferenc Fedor - President of the Geomathematical and Informatics Section of the Hungarian Geological Society

17:00 – 18:00 **Plenary talks** by

Stephen Mojzsis ELKH; University of Colorado - Thermal consequences of impact bombardments to silicate crusts of terrestrial-type planets

Qinghua Ding University of California Santa Barbara - Enhanced jet-stream waviness induced by supressed tropical Pacific convection in boreal summer

Lobby

18:00-18:45 **Diverse faces of Geomathematics (posters) –** chair: Ferenc Fedor, János Geiger and István G. Hatvani

- **Márta Czuppon-Lázár** Karst hydrodinamic modelling in Aggtelek Region
- **Levente Molnár** Investigating the environmental effects of river-diversion on the river Danube (Hungary)
- **Ana Brcković** Employing machine learning algorithm for cross validating porosity velocity model
- **Marija Pejić** Correlation of Gamma Ray Spectrometry and Total Organic Carbon data using Artificial Neural Networks
- **Natalia-Silvia N. Asimopolos** Assessment of the geophysical data set to determine the characteristics of the anomalies.
- **Máté Krisztián Kardos** Application of different land use / land cover databases for estimating urban runoff delivered pollutant loads
- **Sándor Gulyás** Morphospace evolution and phenotypic variation of the endemic gastropod Microcolpia pareyssii from the Holocene deposits of Lake Petea

- **Naji Alwani** Geochemical characterisation of different mine waste materials using exploratory data analysis. A case study from the Recsk Mining Area, Hungary
- **My Ban Thi** Tracing the geographical origin of fruit and vegetable commodities using geochemical methods
- **Kinga Bokros** Attribution of heavy precipitation to anthropogenic climate change
- **Ferenc Ferdinánd Füzesi** Overview of Probabilistic Rock Slope Stability Analysis
- **Catarina Castro** Relationship between textural and petrophysical characters of Sandstones and Siltstones: A case study from Szentes area, Hungary
- **Emese Tóth** Discrete fracture network (DFN) modelling of the Boda Claystone and the implications for its hydrogeologic behavior
- **Patrik Pusztai** A New Method for Determining Propped Fracture Permeability

19:30 - **Ice breaker party** – Details to be announced

Friday (20.05) Parallel sections in the Grand Hall and the Lecture Hall

Grand Hall

08:45-10:20 **Climate modelling, extremes, past & future –** chair: István G. Hatvani

- Keynote speaker: **István Geresdi - Challenges in the numerical simulation of climate**

- **Dániel Topál** Observation-model discrepancies in wind-driven Greenland melting impact sea-level rise projections
- **Attila Kovács** Application of a combined stochastic-analytical approach for spring discharge prediction
- **Péter Szabó** Seasonal temperature and precipitation record breakings in a warming world
- **Emília Dolgos** Western Mediterranean cyclones: changes through the last decades
- **Helga Chauke** Evaluation of projected climate change over the wine region in the Western Cape, South Africa

10:20-10:40 **Coffee break**

10:40-12:30 **Mathematical aspects of reservoir geology–** chair: János Geiger

- Keynote speaker: **István Nemes – Practical implications of applied geostatistical methods in mature hydrocarbon fields**

- **Szabolcs Gáspár Borka** Recall of a mature karstic reservoir in Nagylengyel, Hungary
- **Mihály Apró** Uncertainty of dual-porosity system characterization

- **Agra Adipta** Poisson Impedance and Lame's Parameter Extraction using Seismic Simultaneous Inversion to Discriminate Lithology and Pore-Fluid Detection: Lower Pannonian Case Study
- **Roland Dócs** Multiple steel capillary model: A new method of pressure drop modelling in porous rocks
- **János Geiger** Insight into the 'spaces of uncertainty' of stochastic simulations
- **Saja Abutaha** Assessing the representative elementary volume of rock types by X-ray computed tomography (CT) – a simple approach to demonstrate the heterogeneity of the Boda Claystone Formation in Hungary

12:30-14:00 **Lunch break**

14:00-14:50 **Conquering space - remote sensing –** chair: István G. Hatvani

- Keynote speaker: **Ferenc Fedor - Smart Reservoir Laboratory - Role of automation in Earth Sciences**

- **Anjar Tri Laksono** Analysis of Coastline Change on the Eastern Coast of Sicily, Italy Based on the Calculation of End Point Rate and Linear Regression Rate Statistical Parameters
- **Dang Hung Bui** Evaluating the performance of using multi-temporal radar imagery in land cover mapping

14:50-17:10 (with break) **Analysis of monitoring time series–** chair: Norbert Magyar

- Keynote speaker: **Győző Jordán - Analysis of Monitoring Time Series**

- **Bence Decsi** A Danube River Basin-wide attempt to determine a groundwater gradient-based threshold width for riparian zones
- **László Márkus** A Jump-Fractional-Diffusion Model for Karstic Spring Discharges Matching Fractal Dimensions
- **Nayara Azevedo de Castro Souza** Assessment of multidecadal precipitation seasonality in the Panama Canal Watershed

15:55-16:10 **Coffee break**

- **Fruzsina Kápolnainé Nagy-Göde** Geostatistical analysis of slope movement monitoring time series of Balatonakarattya-Balatonkenese high bank
- **Abdelrhim Eltijani** Modeling Holocene oxbow lake evolution through compositional data, multivariate statistics, and time series analysis, Great Hungarian Plain
- **Orsolya Szomolányi** Assessing the effect of physicochemical parameters and heavy metals on the biological status of surface waters based on Random Forest predictions

- **István Gábor Hatvani** Machine learning based model of the spatial distribution of meteoric water lines of modern precipitation across the Mediterranean
- **Laurentiu A. Asimopolos** Analysis of time series from geomagnetic observatories

Lecture Hall

08:30-10:20 **Geoinformatics and soil mapping–** chair: Gábor Szatmári

- Keynote speaker: **László Mucsi - Urban land use and land cover mapping using high spatial and temporal resolution satellite images**

- **Réka Pogácsás** Automatic detection of pre-Quaternary formations in the Dorog Basin, Hungary
- **Zsolt Kozma** Structural heterogeneity versus functional homogeneity – soil profile classification at a Hungarian lowland site
- **Gergely Tóth** Visualization concepts of European radon mapping efforts
- **Miklós Hegedűs** Indoor Radon map of residential houses in Mashhad, Iran
- **Nizom Farmonov** Crop type classification and yield assessment/prediction using Hyperspectral sensor (DESIS)
- **Dániel Erdélyi** Isoscape of precipitation stable isotopes across Europe - preview

10:20-10:40 **Coffee break**

10:40-12:30 **Data analysis in engineering geology–** chair: Ákos Török

- Keynote speaker: **László Kovács - Data analysis in engineering geology**

- **Petra Oláh** Slope stability analysis of an opencast lignite mine: comparison of deterministic and probabilistic methods
- **Andor Németh** Statistical analyses of destructive and non-destructive test results of heat-treated granite samples from Bátaapáti
- **Eszter Kuna** Overview of Aggregate Degradation Tests, Existing Standards, and the Empirical Relations Between the Different Degradation Parameters
- **Benedek András Lógó** Charpy impact test on sedimentary rocks
- **Ákos Török** Statistical evaluation of ultrasonic pulse velocity data of porous oolitic limestone
- **Sabuhi Tapdigli** Automated Replacement of Missing Well Logging Data Using Machine Learning and Deep Learning Approaches

12:30-14:00 **Lunch break**

14:00-14:50 **Case studies and best practices in environmental- and bio informatics, including palaeontology –** chair: Dániel Erdélyi

- Keynote speaker: **Sándor Gulyás - Form, function and the quantitative analysis of shapes in Earth and Life Sciences: old and new approaches**

- **Zsofia Varga** Flood susceptibility mapping in Hungary based on remote sensed images and machine learning methods
- **Camila Evelyn Rodrigues Pimenta** Congruence in types specific anthropogenic stressors for riverine ecosystems based on different biological elements

14:50-17:10 **Assessment of geophysical datasets –** chair: Marko Cvetković

- Keynote speaker: **Balázs Székely - "The long and winding ..." rivers: sinuosity as a geostatistical problem?**

- **Mátyás Krisztián Baracza** Inversion Methods Evaluation for Geologic Structure Assessment
- **Annamária Kis** Sample pre-screening methodology for increased precision U-Pb geochronology of zircon crystal
- **Hasan Al Hamoud Alatrash** Image segmentation and optimization of X-ray computed tomography images of porous materials: quantitative 3D characterization of the pore space

15:55-16:10 **Coffee break**

- **Marko Cvetković** Enhancing time to depth relation estimations in subsurface exploration using supervised neural networks
- **Mahmoud Ibrahim Abdelaziz** Inversion-Based 1D and 2D Fourier Transformation Algorithm for Solving the Incomplete Sampling Problem
- **Diaa Elsayed Sheishah** Implementation of geophysical methods to assess the structure and composition of artificial levees along Tisza and Maros Rivers, Hungary
- **Moataz Abdelrahman** Unsupervised Machine Learning Assisted Borehole Geophysical Inversion for Robust Reservoir Characterization

17:30-17:45 **Closing ceremony –**

István G. Hatvani - Secretary of the Geomathematical and Informatics Section of the Hungarian Geological Society and the Geomathematical Sub-committee of the Hungarian Academy of Sciences

Ferenc Fedor - President of the Geomathematical and Informatics Section of the Hungarian Geological Society

19:00-19:50 ***Gala Program*** **at the Kodály Center, Pécs, Breuer Marcell sétány 4, 7622**
Concert of the Pannon Philharmonic Orchestra
Antonio Vivaldi: *Concerto for two cellos in G minor (RV 531)*

20:05-22:30 Gala dinner at the Kodály Center

Saturday (21.05) –

10:00-12:00 **Excursion – A step to Smartlab – automation in geology** lead by Ferenc Fedor (meeting at 9.30 conference venue parking lot or at the laboratory site)

- **Geochem-**, and **Rock Study Ltd**s.

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Plenary lectures

Thermal consequences of impact bombardments to silicate crusts of terrestrial-type planets

Stephen J. Mojzsis[1*]

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Abstract

Post-accretionary impact bombardment is part of planet formation and leads to localized, regional, or wholesale global melting of silicate crust; less intense bombardment can create huge hydrothermal fields. Here, I generalize the effects of late accretion bombardments to extrasolar planets of different masses (0.1-10$M_\oplus$). One example is Proxima Centauri b, estimated at ~2× $M_\oplus$. I also model a 0.1$M_\oplus$ "mini-Earth"and "super-Earth" at 10$M_\oplus$, the approximate upper limit for a "mini-Neptune". Output predicts lithospheric melting and subsurface habitable volumes. The model consists of (i) stochastic cratering; (ii) analytical thermal expressions for each crater; and (iii) a 3-D thermal model of the lithosphere, where craters cool by conduction and radiation. I analyse impact bombardments using our solar system's mass production functions for 500 Myr. Surface temperatures and geothermal gradients are set to 20 °C and 70 °C/km. Total delivered mass for Earth is 7.8×10^{21} kg, and scaled to other planets based on cross-sectional areas, with 1.7×10^{21} kg for mini-Earth, 1.2×10^{22} kg for Proxima Centauri b, and 3.6×10^{22} kg for super-Earth. The impactors' SFD is based on our main asteroid belt. Impactor and target densities are set to 3000 kg m^{-3} and planetary bulk densities are assumed to be 5510 kg m^{-3}, omitting gravitational compression. Impactor velocity was estimated at 1.5 × v_{esc} for each planet, with 7.8 km s^{-1} for mini-Earth, 6.8 km s^{-1} for the Earth, 21.1 km s^{-1} for Proxima Centauri b, and 36.1 km s-1 for super-Earth. I assume fully formed crusts, so melt volume immediately increases due to impacts. Super-Earth reaches a maximum of ~45% of the lithosphere in molten state, whereas mini-Earth reaches a maximum of only ~5%. This is due to much higher impact velocities and cratering densities on the super-Earth compared to mini-Earth.

Key words: *Thermal modelling, impacts, exoplanets, late accretion*

Acknowledgements: Research Centre for Astronomy and Earth Sciences (CSFK), Konkoly Observatory, Oleg Abramov, Ramon Brasser, and Christian Koeberl.

Enhanced jet-stream waviness induced by supressed tropical Pacific convection in boreal summer

Qinghua Ding[1*] and Dániel Topál[1,2]

[1*]Department of Geography and Earth Research Institute, University of California-Santa Barbara, Santa Barbara, California, USA. qinghua@ucsb.edu

[2]Institute for Geological and Geochemical Research, Research Centre for Astronomy and Earth Sciences, Eötvös Loránd Research Network, H-1112, Budapest, Hungary

Abstract

A prominent change in the midlatitude flow, also described by some studies as a recent trend of extratropical circulation toward "wavier" or more "meandering" patterns, has been primarily attributed to forcing due to global warming and Arctic Amplification (AA). Furthermore, this "wavier" trend of large-scale circulation is believed to be in close connection with the abundance of extreme weather events in the Northern Hemisphere in recent decades. However, other research shows contradicting results that have placed the original idea under considerable public and scientific scrutiny. Here we highlight a new perspective by arguing that the suppression of tropical eastern Pacific convection induced by sea surface temperature cooling is of pivotal importance to explaining increased summertime midlatitude waviness over the past 40 years. A dual mechanism is suggested; through tropical forcing-generated Rossby-wave-train propagating within the jet waveguide and the reduced north-south temperature gradient due to the tropical cooling. This perspective indicates less of an influence from the Arctic amplification on the observed mid-latitude wave amplification and emphasizes the need to better predict the tropical Pacific SST variability in order to project the summer jet waviness and consequent weather extremes.

Key words: *extreme weather, climate change, tropical-extratropical teleconnections*

Part I - Climate modelling, extremes, past & future

Challenges in the numerical simulation of climate

István Geresdi

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Affiliation: professor

Abstract

Although our understanding about the climate system have significantly improved in the last 50 years, the forecast of the climates scenarios still has large uncertainty. The inconsistency among the outputs of the different numerical models reveals the problems due to the insufficient spatial resolution or the crude, model dependent parameterization of the wide scale of processes impact the climate. It is frequently cited that the climate models are an extension of the weather forecast models. Can the improvement of weather forecast models indicate continuous progress in the climate simulation, or can we interpret of the results of these models similar way? In this presentation, focusing on the numerical and parameterization techniques, the important, inherent characteristics of the climate models are unfolded.

Key words: *numerical simulation, climate model, parameterization*

Observation-model discrepancies in wind-driven Greenland melt impact sea-level rise projections

Dániel Topál[1,2,3], Qinghua Ding[2] and Thomas J. Ballinger[4]

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Abstract

Greenland ice sheet (GrIS) melt is projected to further accelerate and contribute to sea-level rise by 2100, despite possible limitations of climate models in capturing the GrIS's observed sensitivity to atmospheric circulation changes. Here, by imposing observed Arctic winds in a fully-coupled climate model with fixed anthropogenic forcing, we show that recent changes in the mid-to-upper-tropospheric circulation – featuring anticyclonic wind anomalies linked with tropical forcing – explain half of the observed Greenland surface warming and ice loss acceleration since 1990, suggesting a pathway for large-scale winds to potentially enhance sea-level rise by ~0.2 mm/year per decade. We further reveal fingerprints of this physical mechanism in paleo-reanalyses spanning the past 400 years, which heightens concern about a mismatch between observations and models of wind-driven adiabatic processes in causing rapid Greenland melt with major implications for global sea-level rise projections.

Key words: *Greenland ice sheet, atmospheric circulation, sea-level rise*

Application of a combined stochastic-analytical approach for spring discharge prediction

Attila Kovács[1,2]

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Abstract

A novel combined stochastic-analytical approach has been developed for the prediction of spring discharge time series based on regional climate model projections. This approach integrates the advantages of traditional stochastic methods with physics-based analytical baseflow models.

While hydrograph peaks (flood) originate from direct recharge into the aquifer, baseflow originates from the release of water from the low permeability rock matrix. For this reason, it is not possible to adequately describe these two different physical processes with one regression function. While flood peaks can be approximated by regression functions, baseflow requires the application of physics-based analytical functions.

The combined modelling method involved regression analysis between rainfall and discharge peaks. Baseflow was simulated using 2D analytical solutions (Kovács 2003, Kovács et al 2005), where fitting parameters were calibrated based on historical rainfall and discharge data.

A combined stochastic-analytical modelling of the Bukovica and Bijela spring flows (Durmitor area, Montenegro) was undertaken using RCP4.5 and RCP8.5 scenarios of the EURO-CORDEX climate model ensemble. The applied model scenarios predicted the probability and magnitude of discharge which were represented through Flow Duration Curves.

Key words: *karst, spring discharge, climate change, modelling*

References

KOVÁCS, A. (2003): Geometry and hydraulic parameters of karst aquifers: A hydrodynamic modelling approach. PhD thesis, University of Neuchatel.

KOVÁCS, A., PERROCHET, P, KIRÁLY, L. & JEANNIN, P-Y. (2005): A quantitative method for the characterization of karst aquifers based on spring hydrograph analysis. Journal of Hydrology, Vol. 303, pp. 152-164.

Seasonal temperature and precipitation record breakings in a warming world

Péter Szabó*, Judit Bartholy, Rita Pongrácz

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Abstract

Climate change is inevitable, and leads to new climatic records at regional levels. Although anthropogenic global warming is well-accepted within the scientific community, not all climate indices justify anthropogenic impacts on the environment. One possible measure is the detection of the record breaking high or low values. Since there is a clear shift towards the higher temperature values, the ratio of daily record high temperatures to record lows indicates the acceleration of the human-induced climate change. The main purpose of this analysis is to determine how many record highs/lows are broken within a given year, and how large of an area is affected within the Carpathian region. This enables us to assess the potentially high impacts. The analysis is based on the statistical fact that the number of temperature or precipitation records decreases in time for a stationary climate (when mostly natural variability occurs).

The assessment focuses on the broader region around Hungary and distinguishes the past from 1971 and the future periods from 2021. The analyses use fine-resolution, gridded daily data sets: (1) an ensemble of Euro-CORDEX regional climate model simulations, including both the rather optimistic RCP4.5 and the pessimistic RCP8.5 future scenarios, (2) a homogenized, high-quality observational data only for Hungary, (3) the newest European E-OBS observational data.

Key words: *temperature, pre*

cipitation, observations, regional climate models, Hungary

Western Mediterranean cyclones: changes through the last decades

Emília Dolgos[1*], Rita Pongrácz[1], Judit Bartholy[1]

[1*]ELTE Eötvös Loránd University, Institute of Geography and Earth Sciences, Department of Meteorology, 1117, Hungary, Budapest, Pázmány P. st. 1/A., emilia08@student.elte.hu

Abstract

The Mediterranean region is considered as one of the most vulnerable areas to climate change. In this region mid-latitude cyclones play a key role of shaping the weather and the climate. In order to prepare and to adapt to future climate changes a better understanding of Mediterranean cyclones is essential. That is why we aim to analyze western Mediterranean cyclones based on reanalysis data and the newest historical simulations of global climate models. The statistical climatological analysis of such large data sets requires a special approach. First, we locate potential low pressure systems in the region, then, we identify the tracks of these cyclone centers. As a validation, we compare the results between the reanalysis and the model data. The changes in frequency, intensity and duration are evaluated. For the analysis mean sea level pressure and precipitation are considered from 1901 to 2020, with 6-hour temporal resolution and as daily amounts, respectively. The study continues with the evaluation of future trends using different climatic scenarios representing different anthropogenic impacts.

Key words: *Global climate models, low pressure systems, precipitation, cyclone tracks*

Acknowledgements

Research leading to this paper has been supported by the Hungarian National Research, Development and Innovation Fund under grants K-120605 and K-129162.

Evaluation of projected climate change over the wine region in the Western Cape, South Africa

Helga Chauke [1*], Rita Pongrácz [2]

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[2]ELTE Eötvös Loránd University, Department of Meteorology

Abstract

There are no doubts that global warming affects most subcontinental regions around the World, including South Africa, which is in the focus of the current study. The latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR6 published in 2021) indicates that South Africa is still among the most vulnerable countries, with the occasional severe impacts of droughts that occurred in the Western Cape in 2018, for example. There is a specific interest in this region because it is the heart of South African viniculture. Hence, this study aimed to analyse the climate change projections over the wine region. For this purpose, monthly-scale ooutputs from 18 Region Climate Model (RCM) simulations publicly available from the Coordinated Regional Climate Downscaling experiment (CORDEX) under the African domain with the resolution of ~25 km were analysed, focusing on the business-as-usual scenario with increasing emission and the mitigation scenario (i.e., RCP8.5 and RCP4.5, respectively). The historic period of 1981-2000 was used as the reference data for the study with the targeted future periods 2021-2040, 2041-2060 and 2080-2100. Some models projected decrease in precipitation in all regions during the growing season and an increase in temperature by the end of the century in the high emission scenario. Regional climate change greatly affects cultivars, so there has been a decline in wine production and loss of grapevine cultivation area due to a shift towards less favourable climatic conditions.

Key words: *Viniculture, RCP scenarios, precipitation, temperature*

Part II - Mathematical aspects of reservoir geology

Practical implications of applied geostatistical methods in mature hydrocarbon fields

István Nemes*

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Abstract

By 2018 approximately 75-80% of the world's total oil production originated from mature fields, that (combined with the urge for reduced unit-prices) put pressure on operators to allocate increased effort to these mature fields (O'Brien et al., 2016). Generally, these fields have decades of production history with a vast amount of data reflecting a wide vintage and quality range, making re-development and optimization planning challenging. On the other hand, the risks of a green field are principally mitigated or even eliminated, the surface facilities are in-place and there is an understanding of the subsurface (Nemes et al., 2021). A recent field development well in Sávoly, Hungary has proven, that significant incremental production can be reached in complex, mature reservoirs by integrated work. A horizontal well was drilled in a fractured carbonate reservoir, that also boosted additional stages of field re-development.A full-scale field re-assessment was started in Baitugan field, Russia based on the subsurface investigations performed in the last 5 years. A wide range of in-filed applications were implanted and delivered additional production in a field with 70 years of production history. Four formations are on production with >500 wells drilled. Focused production optimization activities in MOL Hungary started in 2015, and by now the project became one of the main pylons of resting production decline and maximizing recovery. Via the experiences gathered a glimpse can be taken into the palette of opportunities revealed. All these results are heavily relying on geological and engineering methods, that are mainly based on mathematical, statistical, and geostatistical approaches. Although the direct link between these is often fading away, hence the talk aims to put this link in the spotlight.

Key words: *mature field, geostatistical methods, hydrocarbon, in-field applications*

References

NEMES, I., SZILÁGYI SEBŐK, SZ., CSATÓ, I. (2021): Challenges of a mature Russian field's re-development – advantages and disadvantages of quick-look geological modelling. Central European Geology, 64/2, 74–90.

O'BRIEN, J., SAYAVEDRA, L., MOGOLLON, J. L., LOKHANDWALA, T., LAKANI, R. (2016): Maximizing mature field production - A novel approach to screening mature fields revitalization options. SPE 180090.

Recall of a mature karstic reservoir in Nagylengyel, Hungary

Szabolcs Borka[1*]

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Abstract

Nagylengyel (West-Hungary) – in a Cretaceous, karstified carbonate reservoir – is the second biggest Hungarian hydrocarbon field considering initial oil in-place volume. Karstic reservoirs possess unique porosity, permeability and dynamic flow patterns which are challenging to be captured and modelled. In this work mainly well-based methods are presented for determination of karstic and non-karstic facies since onshore seismic is not able to map the major karst features due to scale difference.

Nevertheless, the investigated two reservoir blocks have been producing by more than 200 wells since the 1950s, so mainly old, poor-medium quality data is available. Integration of the drilling data (lost-of-circulation zones, bit drops, rate-of-penetration log), production data (welltests, perforations, production history) and well logging (resistivity and acoustic logs, producing-while-drilling log) yielded a robust way to infer subsurface caverns and caves (karst facies) in the reservoir (Fernández-Ibáñez et al., 2019). For the 3D facies modelling, sequential indicator simulation was used.

According to the facies vertical-proportion curve, an upper and a lower karstified zone can be identified which implies to an autogenic karst system, even though bit drops in meters suggest also allogenic attributes. In order to incorporate this concept and preserve this two-level feature during the simulation, 'artificially' low vertical range of semivariogram was preferred.

Hence, the resulting facies model reflects the two-leveled structure. As it has been shown, even in case of old log set, karst features can be observed based on appropriately selected well data.

Key words: *karst, carbonate, well log, simulation*

References

FERNÁNDEZ-IBÁÑEZ, F., MOORE, P. J. & JONES, G. J. (2019): Quantitative assessment of karst pore volume in carbonate reservoirs. AAPG Bulletin, V. 103, No. 564, 1111-1131

Uncertainty of dual-porosity system characterization

Mihály Apró[1*]

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Abstract

Dual-porosity characterization is always challenging, especially if limited data is available. In these cases, reservoir modelling and underlying characterization is usually charged by significant uncertainty. This paper focus on these uncertainty factors, and present their handling thorough specific geological and static geomodelling workflow. Aim of the study was to support a field development project to increase the production of a brecciated, fractured, metamorphic reservoir by planning a new field development well. The gas-condensate reservoir – in the scope of the study – was discovered in 2015 and is being produced since then with intensively increasing water rate. Among other factors, uncertainty of the reservoir top horizon and the gas-water contact, in a way that the uncertainty of the bulk volume had to be quantified regarding the initial in-place volume calculation. Appropriate understanding of the fault-related reservoir compartmentalization was key for determining the spatial distribution of the in-place volume and positioning the new field development well. Characterization of the petrophysical parameters (porosity, water saturation) and understanding of their spatial distribution was limited by the only available production well (X-K-1) and one other offset well (X-19) of the reservoir. The resistivity image log (FMI) of the X-K-1 well helped to characterize the orientation stats of fracture system and to create valuable inputs for the discrete fracture network model, however the parametrization (e.g. aperture) of the fractures was partially based on analogies due to the limited available core (10 cm). Considering the multiple uncertainty levels of the reservoir characterization, several equiprobable scenarios have been provided for reservoir simulation combining binary sensitivity and stochastic uncertainty analysis, from which low, mid and high cases have been selected for dynamic simulation.

Key words: *fractures, uncertainty, dual-porosity, limited data, field development*

Poisson Impedance and Lame's Parameter Extraction using Seismic Simultaneous Inversion to Discriminate Lithology and Pore-Fluid Detection: Lower Pannonian Case Study

Agra Adipta[1*]

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Abstract

The Lower Pannonian reservoir units in Pannonian Basin are well known as a prominent productive and principal reservoir in the region. The reservoir unit has been known deposited in a fluvial-deltaic environment with interbedded sandstone bodies within thick shales. On the given research area, the previous proven discoveries have been supported with Drill Stem Test (DST) data that concludes there were two gas-sand intervals with one tight gas interval. This research has been carried out in order to discriminate the lithology and pore-fluid distribution throughout the research area by utilizing seismic pre-stack simultaneous inversion to generate P-Impedance (Zp), S-Impedance (Zs), and Density (ρ). Poisson Impedance and Lame's Parameter Lamda-Mu-Rho (λμρ) are later the derived parameters in which are deemed sensitive to differentiate the lithological and pore-fluid variability. The obtained simultaneous inversion results yielded in gas bearing reservoirs are characterized by relatively low P-Impedance (Zp), and moderate S-Impedance (Zs). Poisson Impedance shown as low value followed by the Lame's Parameter in which resulted low λμ (Incompressibility) and relatively moderate μρ (rigidity). Based on the presented results, the combination of P-Impedance (Zp), S-Impedance (Zs), Poisson Impedance and Lame's Parameters are a valuable analysis for highlighting improved distribution of gas bearing sandstone reservoir.

Key words: *Lame's Parameter, Poisson Impedance, Simultaneous Inversion, Gas Reservoir*

Acknowledgements

Authors would like to acknowledge TEKH Special Collage for the financial support.

Multiple steel capillary model: A new method of pressure drop modelling in porous rocks

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Abstract

Production capacity of any hydrocarbon reservoir is the most important question that needs to be answered. This depends on both the obtainable drawdown between the well and reservoir and the petrophysical properties (pore size distribution, wettability properties, saturations etc.) of the porous rock material.

Permeability, introduced by Darcy is the parameter describing restrictions present during fluid flow in porous media. Although this method is the one currently accepted and implemented in the industry it has a major flaw because it considers flow in the geometric (total) rather than the effective volume, where it truly develops.

During this study a new approach of flow restriction modelling was found, where flow restrictions, measured from sandstone plug samples were compared with the theoretic flow volumes which are equal to the total pore volumes, constructed of steel capillaries of equal diameter. Results show that flow restrictions of incompressible fluids in sandstone can be demonstrated by the new model.

Key words: *Darcy equation, porous system, petrophysical properties, theoretical mode*

Acknowledgements

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Insight into the 'spaces of uncertainty' of stochastic simulations

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Abstract

This paper brings new insight into the analysis of spaces of uncertainty by considering the natural groups of realizations and the variance decomposition. A generalized k-means algorithm is used to reveal the general structure of the space of regional uncertainty. Two maps describe the spatial features of the clusters. The average map contains mean values calculated at grid nodes, and the variance map shows the diversity of simulated values at each grid node. Spatial features are said to be certain if seen on each average map. The variance map measures the local uncertainty of the spatial features.

There are two reasons behind the diversity of stochastic realizations. The first is geological heterogeneity. The next is the diversity of paths applied to visit grid nodes during the calculation. They can be analyzed by decomposing the variance of the pooled realizations into within-groups (WGV) and between-groups (BGV) components. Under the constraint of a particular grid geometry, the first one reflects the local stability or uncertainty of the estimation. The next one may express the lateral variability of the property analyzed. To study the variability of WGV and BGV, two series are constructed from the increasing number of realizations. Whenever the WGV is larger than the BGV, the resulting maps are under the effect of the numerical instability of the simulation, while when BGV is larger than WGV, the resulting maps are controlled by the geological heterogeneity.

The calculations are demonstrated using data of a delta plain reservoir.

Keywords: *Kspace of uncertainty, Stochastic simulation, Variance decomposition, k-means clustering*

Assessing the representative elementary volume of rock types by X-ray computed tomography (CT) – a simple approach to demonstrate the heterogeneity of the Boda Claystone Formation in Hungary

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Abstract

The present pilot study confirms the use of Representative Elementary Volume (REV) to quantify the inhomogeneity of CT densities of rock constituents of the Boda Claystone Formation. Thirty-two layers, 2 m core length, of this formation were studied. Two rock types were appointed based on the dominant rock-forming component: clayey siltstone (20 layers) and fine siltstone (12 layers). The application of the Autoregressive Integrated Moving Averages, Statistical Process Control (ARIMA SPC) method to define Representative Elementary Volume (REV) of CT densities (Hounsfield unit values) affirmed the following results: i) the highest REV values corresponded to the presence of sedimentary structures as well as the high ratios of siltstone constituents (> 60%). ii) the REV average of the clayey siltstone was (5.86 cm^3) and (6.54 cm^3) of the fine siltstone. iii) normalized REV percentages of the clayey siltstone and fine siltstone on the scale of the core volume studied were 19.88% and 22.84%, respectively. iv) whenever the corresponding layer did not reveal any sedimentary structure, the normalized REV values would be below 10%.

The internal void space in layers with sedimentary features might explain the exceptional textural heterogeneity and the high REV values. The drying process of the core sample might also have played a significant role in increasing erroneous pore proportions by volume reduction of clay minerals, Particularly within sedimentary structures, where authigenic clay and carbonate cement were presumed to be dominant.

Key words: *Hounsfield Unit (HU), Autoregressive Integrated Moving Averages (ARIMA), Statistical Process Control (SPC) technique*

Part III - Conquering space - remote sensing

Smart Reservoir Laboratory - role of automation in Earth Sciences

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Abstract

One of the biggest challenges is how far we can go in automation to replace humans. Climate change, the COVID pandemic, and the "modern" wars have shown the vulnerability of our society, economy, and the drawbacks of globalization. It has become even more important to review supply chains, to address the issue of social distancing, and rapidly open up renewable energy sources and energy storage options. These problems are accumulating in the knowledge-intensive service sector, especially in laboratories. Laboratory measurements require highly qualified specialists. H_2 and CO_2 disposal studies, especially in reservoir conditions, are hazardous and require new approaches. But is it possible to build a fully automated laboratory? A pioneering concept is the modular and transportable Smart Reservoir Laboratory (SRL), which is an on-site equipped reservoir laboratory capable of measuring porosity, permeability, ultrasonic velocity, and electrical and thermal conductivity under reservoir conditions. The concept is to load the core plug into the instrument, set up a measurement program, which can include numerous pressure and temperature steps, and finally just start the measurement. Human intervention is only required during sample change. By operating the automated system remotely, dangerous experiments (e.g. H_2) can be performed as well. The instrument can be serviced using AR and trained on a VR device, which means that travel costs can be significantly reduced. The implementation of concept has been underway for more than ten years (Fedor 2016). The presentation will outline the challenges, achievements, pitfalls, current situation and future directions of its development. And, beyond engineering, what does it have to do with mathematics, especially geomathematics?

Key words: *Smart Reservoir Laboratory, petrophysics, automation*

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Analysis of Coastline Change on the Eastern Coast of Sicily, Italy Based on the Calculation of End Point Rate and Linear Regression Rate Statistical Parameters

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Abstract

The eastern coast of Sicily is prone to changes due to human activities, sea-level changes, marine natural hazards, fluctuations in sediment supply, and uplift. This phenomenon will impact the resilience of infrastructure and settlements in the area. Therefore, this study aims to analyze the coastline changes of eastern Sicily over the last 50 decades with a case study of the Catania to Syracuse provinces. The method applied in this study is the analysis of Landsat image from 1972 to 2021, which then calculates the statistical parameters of End Point Rate (EPR) and Linear Regression Rate (LRR) using the Digital Shoreline Analysis System (DSAS) to obtain information on the average of accretion and erosion rates. The study results demonstrate that the average accretion and erosion rates on the eastern coast of Sicily are 1.39172 m/year and -0.85858 m/year. The highest accretion and erosion rates reached 4.55 m/year and -8.99 m/year. This study concludes that the eastern coast of Sicily changes towards the sea, or in other words, there is an expansion of the coastal area.

Key words: *Accretion, Erosion, Coastline Change, Sicily*

Acknowledgements

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Evaluating the performance of using multi-temporal radar imagery in land cover mapping

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Abstract

Using multi-temporal satellite imagery can help improve the efficiency of land cover mapping. However, in tropical regions, obtaining multi-temporal optical images is often a challenge due to dense cloud cover. This study was conducted to evaluate the performance of using multi-temporal images from radar sensors, which were not affected by clouds, in land cover mapping in Binh Duong province, Vietnam. A set of 24 Sentinel-1 images acquired in 2020 with an interval of 12-18 days were collected. The images were pre-processed, calculated Haralick texture features for both VH and VV bands, and resampled to a spatial resolution of 30 meters. To determine the best combination, a forward stepwise selection approach based on a random forest algorithm was applied, and a six-class classification scheme was used. The results showed that the 16-date combination gained the highest mapping result with an overall accuracy of 76.6%. In addition, taking into account the trade-off between classification efficiency and cost of processing time, the optimal integration could be the seven-date combination. It achieved an overall accuracy of 76.1% with the producer's and user's accuracies ranging from 45% to 93.1%. Compared to using single-date radar images, the overall accuracy was improved by about 9.5%, and the producer's and user's accuracies were improved by about 4.68% to 33.33%. Overall, these results prove the potential of using multi-temporal radar images in land cover mapping in the absence of optical images.

Key words: *land cover mapping, multi-temporal, radar sensor, random forest algorithm*

Acknowledgements

This study was supported by Hungarian Scientific Research Funds in the project of "Time series analysis of land cover dynamics using medium- and high-resolution satellite images" (NKFIH 124648K).

Part IV - Analysis of monitoring time series

Analysis of Monitoring Time Series

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Abstract

Monitoring of environmental processes and parameters is a pressing demand of global climate change and increasing wide-spread environmental pollution under the conditions of global population growths, and accelerating economic and technological development. The need for monitoring and assessment of temporal changes including climate-induced catastrophic events such as flash floods and landslides, has been recognised by UN resolutions (e.g., Resolution 3/6. Managing Soil Pollution), EU legislation (e.g., Water Framework Directive), and International Initiatives (e.g., Global Earth Observation System of Systems; GEOSS). This study overviews the main features of temporal process such as such long-term trend, cycles, seasonality, diurnal periodicity, autocorrelation and sudden events (transients). Change in the variation (heteroscedasticity) receives a particular attention. Methods of the detection and characterisation of temporal features are presented from classical time series analysis (TSA), to wavelet analysis and signal processing techniques. Multivariate time series are also discussed. Abundant case studies are presented for high-resolution (15 minutes) monitoring data series to monthly and quarterly series. A practical outlook on the EU legislative water quality monitoring trend analysis is also provided.

Key words: *time series, multivariate data analysis, water pollution*

A Danube River Basin-wide attempt to determine a groundwater gradient-based threshold width for riparian zones

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Abstract

Several proposals have been drawn up to improve the ecological status of watercourses in the European Union, while the results and consequences of their implementation seem to be mixed for the time being. Hydromorphological conditions, nutrient enrichment, land use conditions in riparian zone and their combined effect were identified as the most dominant stressors on ecological status of watercourses. Land use related effects (e.g., nutrient load from agricultural fertilizer usage) are partially transmitted via shallow groundwater.

Our aim was to delineate those (focus) zones of watercourses' riparian areas, where a significantly greater potential of ecosystem services regarding watercourse ecological status was offered. We estimated local horizontal groundwater gradients between watercourses and groundwater monitoring wells for all watercourses of various sizes (differentiated by Strahler order) in four countries of Danube River Basin. Gradients were calculated from monthly averaged time series of nearly 5.000 monitoring wells and the elevation of the riverbed (as an approximation of groundwater level at the watercourse) of the nearest watercourses.

Based on our results, the zones could be clearly delineated based on groundwater gradient threshold widths determined for each watercourse size category. This width was on the order of magnitude or greater than suggested by previous topic-specific research. Using the determined threshold width, we identified a significant land use conflict that exists for some countries of Danube River Basin: the proportion of agricultural land is higher within the determined active zone, than outside of it.

Key words: *Riparian zone, land use conflict, groundwater-surface water interaction, ecosystem services*

A Jump-Fractional-Diffusion Model for Karstic Spring Discharges Matching Fractal Dimensions

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Abstract

A recent study (Borbás et al. 2020) estimated and analyzed fractal dimensions for several karstic springs' daily discharge data series in Northeast Hungary. That research notably lacked a dynamic model, creating key features of discharge series and giving back those fractal dimensions. Here we fit the superposition of fractional Ornstein-Uhlenbeck and compound Poisson processes to four of those discharge series with similar fractal dimensions. The model fits well according to traditional goodness-of-fit measures; beyond that, the fractal dimensions also match, and simulations from the model show an appealing visual fit. When the fractal dimension is not taken into account in the modeling, the simulated accumulated discharges appear to exceed the realistic ones, misleadingly indicating a higher volume of water outflow from the karstic aquifer.

Key words: *Karstic Spring Discharge, Fractal Dimensions, Fractional Ornstein-Uhlenbeck Process, Jump-Diffusion*

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Assessment of multidecadal precipitation seasonality in the Panama Canal Watershed

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Abstract

Precipitation is one of the most important meteorological parameters so that understanding rainfall patterns and the weather systems that generate them is of critical importance in numerous areas ranging from agriculture to flood risk management. However, consideration of only the amount of precipitation does not give a full picture of rainfall regimes (Knoben et al., 2019). This study provides new insight into the spatiotemporal (seasonal) behavior of precipitation across the ~3000 km^2 of the Greater Panama Canal Watershed (GPCW) based on the long-term monthly rainfall record acquired at 28 meteorological stations across the GPCW that have been recording daily precipitation over the past seven decades. After deriving the long term seasonals (2000-2017) for each station, these were grouped using hierarchical cluster analysis (HCA) resulting in three distinctive groups across the region: (i) a group of high-elevation stations along the northern portions of the GPCW, (ii) an northwestern group of stations closest to the Caribbean Sea (iii) and an southeastern group proximal to the Pacific Ocean. HCA months with similar rainfall patterns were identified for each group. Lastly, it was explored how El Niño-Southern Oscillation (ENSO) affects precipitation patterns across the region considering an extreme warm ENSO event during 2015-16. It is hypothesized that the influence of different weather systems connected to the Pacific Ocean and Caribbean Sea would result in a strong climatological gradients. Stations located in the northern area had the highest average daily precipitation, influenced by topography and the interaction of ITCZ movement and weather systems over the Caribbean Sea. The stations of the southwestern area recorded less rainfall because of topographic barriers and the different character of Pacific and Caribbean weather systems. Analysis of the extreme warm ENSO effect revealed that both Pacific and Caribbean regions of the GPCW suffered a rainfall deficit during 2015-16, especially during the December-May dry season.

Key words: *precipitation seasonality, cluster analysis, Panama Canal, El Niño-Southern Oscillation*

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Geostatistical analysis of slope movement monitoring time series of Balatonakarattya-Balatonkenese high bank

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Abstract

In the eastern basin of Lake Balaton, there are still some minor movements today, which can unfortunately be increased in volume when extreme weather conditions occur. This study aims to explore the effects of rainfall and water level on slope stability through analysis of a data set of 2-year monitoring time series.

The slope monitoring system includes several inclinometers and Cassagrande piezometers. The analysis of monitoring time series is also complemented by rainfall and water level data series. Similar but longer-term data series were analysed by Maio et al. (2020) which provided a methodological example for this study.

The results show the connections between hydrogeological conditions in the Pannonian sedimentary series of the high shore, the relationship between groundwater levels, rainfall periods and subsurface displacements. The results are compared with previous results, supported by models (Kápolnainé Nagy-Göde & Török, 2022) and past movements.

Key words: high bank, inclinometer, Casagrande piezometer, rainfall and lake water level time series

Acknowledgements

We would like to thank Geovil Ltd for the excavation data, the regular provision of movement and groundwater monitoring data and for their professional support. We are grateful to the Central Transdanubian Water Directorate for the precipitation and lake water level data series.

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Modeling Holocene oxbow lake evolution through compositional data, multivariate statistics, and time series analysis, Great Hungarian Plain

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Abstract

This work represents an integrated multi-proxy approach for analyzing the past environment and Palaeohydrological changes during the Holocene in the Southeastern Great Hungarian Plain, based on compositional data coupled with principal components analysis, K-mean clustering, discriminant analysis, and Time series analysis. Although grain size analysis is a crucial tool for reconstructing sedimentary environments, the traditional methods for characterizing grain size distribution possess limitations by ignoring the compositional constraint of the grain size and by using only part of the distribution. This study approaches these problems by applying the centered log-ratio transformation for the data set followed by multivariate analysis, which enables the utilization of the whole distribution; time series analysis is applied to detect cyclic and regular behavior for identifying and quantifying the evolution processes of the oxbow lake. These approaches resulted in statistically robust analysis and a geologically significant evolution model. The continuous wavelet transforms applied for coarser, finer grain size fractions and magnetic susceptibility revealed cyclic trends of oxbow lake evolution attributed to changes in autogenic processes. Active channel deposition and two significant flood events were preceded by probably natural leaves during the early Holocene. However, this pattern repeated during the middle Holocene with minor channel activity. The channel probably became abandoned during the late Holocene with the development of Tie channel deposits.

Keywords: *Grain size distribution, compositional data, time series analysis, oxbow lake*

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Assessing the effect of physicochemical parameters and heavy metals on the biological status of surface waters based on Random Forest predictions

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Abstract

Water Framework Directive (European Commission, 2000) aims to reach good ecological status in all European surface water. As biological quality elements determine ecological status to the greatest extent, defining biological status reliably is highly important. Since biological sampling is very expensive and time-consuming, predictive methods can help reduce the sampling frequency, moreover, with a good prediction, measurements can be eliminated. Linkages between physicochemical variables and biological status are very complex, thus basic statistical methods are not sufficient for the classification of biological quality elements. A machine learning data-driven method, such as random forest can be helpful in this problem.

The study was performed with the Hungarian surface water quality monitoring database for the period 2013-2019, and we used the random forest to predict biological status from annual mean physico-chemical monitoring data. Status was predicted with 26-53% error on a five-grade scale with 5 selected physicochemical parameters for phytoplankton and phytobenthos in lowland small watercourses, highland small watercourses, and big rivers. The predicting variables were selected according to their importance determined by the Gini index. Predictions tended to be better by 4-6% in most cases if heavy metals were included besides basic physicochemical parameters.

Key words: *Random Forest, Biological classification, Water Framework Directive, Surface water monitoring data*

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Machine learning based model of the spatial distribution of meteoric water lines of modern precipitation across the Mediterranean

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Abstract

The covariance of stable hydrogen (δ^2H) and oxygen (δ^{18}O) isotopes in local precipitation (local meteoric water line – LMWL) serves as a benchmark in isotope hydrological or paleoclimatological applications. However, the isotope hydrometeorological monitoring network is still sparse in many parts of the Mediterranean, and the degree of spatial data coverage is insufficient to address current needs. To remedy this weakness a spatially continuous interpolated geostatistical product of the LMWLs of modern precipitation across the Mediterranean has been developed. The LMWLs of the stations with data for more than four years between 2000 and 2015 were calculated using reduced major axis regression and interpolated across the region using statistical (inverse distance weighting to the power of 1 and 2) and machine learning methods (random forest and support vector machine learning). Random forest interpolation with buffer distance gave the best performance in the out-of-sample verification, and was thus used to derive the final interpolated product. A detailed comparison with previous local/regional estimations showed that the model presented here concurs with those, albeit with minor deviations in certain regions. With the present results, it became possible to assess how well grounded are the concepts of the Eastern- and Western Mediterranean Meteoric Water Lines for the 21st century.

Key words: *meteoric water line, stable isotopes, RMA regression, machine learning, precipitation*

Acknowledgements

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Analysis of time series from geomagnetic observatories

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Abstract

The purpose of this study is to analyse geomagnetic field recorded as time series in geomagnetic observatories. First, we selected recordings from five INTERMAGNET observatories, during major geomagnetic disturbances and geomagnetic storms. A geomagnetic storm is a temporary disturbance of the Earth's magnetosphere caused by solar coronal mass ejections, coronal holes or solar flares. Solar wind shock wave typically strikes the Earth's magnetic field 24 to 36 hours after the event and its pressure changes modify the electric currents in the ionosphere.

We calculated the variation of the correlation coefficients, with mobile windows of various sizes, for the recorded geomagnetic components from observatories situated at different latitudes and latitudes. Also, we have used for this purpose a series of filtering algorithms, spectral analysis and wavelet with different mother functions at different levels. Wavelets allow local analysis of magnetic field components through variable frequency windows. Windows that contain longer time intervals allow us to extract low-frequency information, average ranges of different sizes lead to extraction of medium frequency information, and very narrow windows highlight the high frequencies or details of the analysed signals.

The data used in this paper are acquired within the Surlari Observatory, and additional information from other observatories to characterize the geomagnetic storms analysed, we obtained from the specialized sites such as www.intermagnet.org and www.noaa.gov.

Numerical analyses performed on the basis of these data allowed us to perform comparative studies between the data recorded in different geomagnetic observatories as well as planetary physical parameters.

Key words: *Time series of geomagnetic field, Spectral analysis, Wavelet coherences, Geomagnetic storms.*

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Part V - Geoinformatics and soil mapping

Urban land use and land cover mapping using high spatial and temporal resolution satellite images

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Abstract

Today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050. Not only the urban area growing has an impact on environment, but the inner urban area change has also strong effect on urban climate, water balance etc.

Monitoring of urban areas using high spatial and temporal resolution satellites imageries based on the analysis of spatial scale of urban reflectance. This information can be used for pixel or subpixel based classification technics in urban land cover mapping. The results of these applied methods will be presented using Szeged town land cover mapping as an example.

For long term land use and land cover mapping multispectral satellite images taken by Landsat and Sentinel 2 satellites during 5 years (1986, 2003, 2015, 2020 and 2022) were analyzed. The images were mosaicked and segmented, and four landscape metrics at the patch level, namely, the mean patch size, total edge, mean shape index, and fractal dimension were calculated. Texture variance was calculated using and Random forest and histogram-based gradient boosting classification tree classifiers were applied.

According to the results, texture variance and landscape metrics can significantly improve the thematic accuracy of land use classification over spectral-based classification. Change analyses performed using predicted maps provide a detailed image of the land use changes that had occurred during the 30-year period.

Key words: *geoinformatics, remote sensing, data fusion, classification, land use, land cover*

Automatic detection of pre-Quaternary formations in the Dorog Basin, Hungary

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Abstract

Due to the increasing accuracy and the growing range of available data sources classification methods offer promising opportunities for the preparatory works of geological mapping (Albert & Ammar, 2021). The current research used Sentinel II satellite imagery, DEM and ecosystem information to help identify priority sites for geological mapping in the Dorog Basin on a study area of 86.86 km^2. Since the mappable rock outcrops in the study area are pre-Quaternary in age, the primary objective was to identify the Quaternary and pre-Quaternary surfaces.

The classification was performed in SAGA GIS version 7.9.1 using the Random Forest Classification (ViGrA) tool. For training areas, circles of 1 pixel size covering up to ~6% of the total area were selected around randomly generated points, which were annotated with information from the archive geological map of the Dorog Basin. As predictor variables, 14 morphometric, 6 mineral and one ecosystem index layer were processed as rasters (spatial resolution ~25m). The preparation method of training areas was automated via python programming in PyCharm using the algorithms of QGIS. The classification was carried out for 30 models in settings where the tree count and the sampling were systematically varied. Results were cross validated six fold, with accuracy result ranging from 82.35% to 86.83%.

The cross validation results confirmed that modelling can be a useful tool to support field mapping in detecting pre-Quaternary outcrops even on vegetated areas.

Key words: *classification, random forest, geological mapping, automatization*

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Structural heterogeneity versus functional homogeneity – soil profile classification at a Hungarian lowland site

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Abstract

There is a recurring question in environmental science, whether the spatial heterogeneity of soils is also accompanied by notable variation of soil hydrological behaviour. Our aim was to investigate the "structural heterogeneity versus functional homogeneity" issue in a Central European alluvial area using soil maps from the DOSoReMI.hu and pedon-scale soil water simulations. The 700 km^2 study site is situated in a deep floodplain of River Tisza, dominated by loamy, silty clay loam and clay soils. The soil conditions were represented by 100 m spatial resolution maps for six standard GSM depths, yielding 407 different vertical combinations of USDA soil texture classes. We used these soil profiles to set up and run 407 models in Hydrus-1D, different only in their soil hydraulic parametrisation. The simulations represented lowland conditions with daily time steps covering a 10-year period. Hydrological indicators were derived from the simulation results (water coverage duration, actual evapotranspiration, average root zone saturation and groundwater level, etc.). Soil profiles were classified (i) based on their soil features and (ii) using the derived hydrological indicators. This latter functional classification resulted in a strongly non-linear distribution with few notable outlier soil profiles and many profiles leading to closely clustered indicators.

Key words: *soil hydrology, functional evaluation, Hydrus-1D, alluvial soils*

Acknowledgements

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Visualization concepts of European radon mapping efforts

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Abstract

Radon is a radioactive noble gas, originating from uranium content in the ground. It is considered one of the major causes of lung cancer, making regulatory control necessary. The European Union requires the Member States to introduce reference levels for indoor radon concentrations to assure public safety through a Radon Action Plan. Regulating radon concentrations requires a large number of measurements so it is necessary to optimize the allocation of limited measurement capacity. The indoor radon concentration and the exposure from radon depend on many factors, but it can be assumed that geology is a major factor in the variation of indoor radon, which can be expressed as geogenic radon potential. There have been many different approaches for visualizing the data, such as displaying discrete points, interpolation between points, interpolation over different sized administrative areas, and raster maps, which resulted in the patchwork map of the 2005 Overview of radon surveys in Europe. Currently the University of Pannonia participates in mapping the Hungarian radon situation according to the current European Union concept, standardizing the input data as a raster map consisting of the means over 10×10 km grid cells for both annual indoor radon concentration in ground-floor rooms of dwellings and geogenic radon potential. The ongoing indoor radon survey uses CR-39 nuclear track detectors at minimum 20 locations in four three month periods for a year, while the geogenic radon survey measures soil permeability and soil gas radon concentration at minimum 5 locations per cell preferably located near settlements.

Key words*: indoor radon, geogenic radon potential, raster map*

Indoor Radon map of residential houses in Mashhad, Iran

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Abstract

Radon and its progenies are the main contributors to the inhalation dose for the public. Radon maps can identify high-risk areas with profound economic and social consequences. A high-resolution, accurate and statistically reliable map is essential for raising public awareness and informing government policy; enabling the development of a cost-effective approach to reducing the population's exposure to radon. There are two types of maps used for this purpose, indoor radon maps based on indoor radon measurements (as applied in this study) and geogenic radon maps based on geological information.

In this study, indoor radon maps were created using ArcGIS 10.7 and a 1 km ×1 km grid, testing three interpolation techniques: inverse distance weighting, ordinary kriging, and empirical Bayesian kriging. The arithmetic mean of the cells was used to predict the average indoor radon concentration on the ground floor in cells where no data were available. The accuracy of the techniques was assessed using six indicators: mean absolute error, root-mean- square error, root-mean-square log error, index of agreement, percentage bias and coefficient of determination. Spatial distribution maps of indoor radon concentrations in Mashhad were plotted using the three interpolation techniques. Radon concentrations were lower than expected in the eastern residential areas and higher in the central and southern regions. Taking into account spatial autocorrelation between cells, radon predictions ranged from 65 Bq m^{-3} to 260 Bq m^{-3}, similar to the average values found in the region. Inverse distance weighting had the best statistical parameters for predicting radon concentration in the area.

Key words: *indoor radon, geogenic radon potential, raster map, kriging*

Crop type classification and yield assessment/prediction using Hyperspectral sensor (DESIS)

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Abstract

Developments in space-based hyperspectral sensors, advanced remote sensing techniques and machine learning algorithms can help measure, model, estimate yield production and monitor crops to prevent potential losses and ensure global food security. Leveraging these achievements, we used new generation DLR Earth Sensing Imaging Spectrometer satellite imagery to classify main crop types with machine learning and forecasting crop yield using statistical analysis before the harvesting stage in Mezőhegyes, south-eastern Hungary. DESIS images from June 2021 during the growing season were used to classify crops (hybrid corn, soybean, sunflower, and winter wheat) and predict sunflower crop yield. Random Forest supervised classification algorithm was applied to automatically map crops over agricultural lands. Map accuracy assessment was conducted to evaluate classification performance and best accuracies achieved with two combinations of the images throughout the growing stage. A Robust method was developed to predict sunflower crop yield using a multiple linear regression model between 235 hyperspectral DESIS bands and crop yield data at a pixel and field level. DESIS image acquired on June 16 was found best correlative with observed yield data provided by a combine harvester equipped with the yield monitoring system. Category based training model (i.e., 1-2 t\ha, 2-3 t\ha, 3-4 t\ha and 4 or above t\ha) was developed and tested and validated in other fields. Our model obtained a better result with Root Mean Square Error ranging from 230 t\ha to 328 t\ha from validation parcels. DESIS data provides high spectral features within the visible and near-infrared wavelength range from 400 to 1000 nm, resulting in 30 m spatial resolution has potential to observe the different crop type growth and estimate the volume of the harvest, which is crucial for farmers, smallholders and decision-makers.

Key words: *hyperspectral remote sensing, random forest, multiple linear regression, sunflower*

Isoscape of precipitation stable isotopes across Europe - preview

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Abstract

An accurate picture of the spatial distribution of stable isotopes in modern precipitation is highly demanded for many hydrological, paleoclimatological and ecological applications. In the present study we aim to investigate the performance of various interpolation techniques when predicting the spatial distribution of precipitation stable isotopes across Europe using monthly data from the Global Network of Isotopes in Precipitation (GNIP) extended with data from literature for 2011-2015. In the research, machine learning (ML): specifically random forest (RF) and RF with buffer distance (RFsp; Hengl et al. 2007) interpolation is employed relying on different sets of predictors. The obtained results are compared to a similar recent product (PisoAI; Nelson et al. 2021) using another ML method (gradient boosting) relying only on GNIP data as training data. The modeling performance was compared using (i) three stations present in both studies and (ii) with 13 randomly chosen stations, 10% of the total. Saturation vapor pressure ranked as the most important predictor in RF, while monthly air temperature was the most importance in RFsp. For the 3 stations mutually excluded from the training sets, RFsp provided comparable results to PisoAI: $RMSE_{RFsp}$=1.38 $RMSE_{PisoAI}$=1.54 at Basel-, $RMSE_{RFsp}$=2.35 $RMSE_{PisoAI}$=2.32 at Charches-, and $RMSE_{RFsp}$=3.91 $RMSE_{PisoAI}$=3.24 at Rovaniemi stations. RFsp and RF presented the best prediction performance providing the lowest RMSE for 8 and 2 cases out of the 13 validation stations, respectively.

Key words: *stable isotopes, machine learning, precipitation*

Acknowledgements

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Part VI - Data analysis in engineering geology

Data analysis in engineering geology

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Abstract

Due to the complex behavior of both intact rocks and real rock masses the traditional approaches of technical mechanics often fail. A large amount of in situ and laboratory measurements proved that the generally applied isotropic, homogeneous, non-rheological and linear elasticity approach for rocks yields either needless supporting solutions (and costs) or non-identified risks and dangers. The lack of the plausible data on the real pattern of the primary rock stress field (as initial loads on the structures to be designed) causes similar problems. Nevertheless, engineers, the main users of data gained from the engineering geological and rock mechanical researches, have generally aversions to apply more complicated equations and solutions in everyday static design tasks instead of those traditional ones that represents the technical level of the past centuries.

Firstly, the usual steps of the engineering geological knowledge acquisition will be listed, from the conceptual model creation to the integrated, multidisciplinary evaluations by analyzing their possible uncertainties and errors. The presentation demonstrates why a much more complicated mathematical treatment of the realistic rock substances would be essential, by presenting practical examples provided by RockStudy's laboratory. The most frequently applied so-called elastic material constants and the failure envelopes/mechanisms of intact rocks, the description and measuring methods of geometrical and mechanical features of discontinuities will be analyzed, just as the virgin rock stress determinations. Conditions for accomplishing valid numerical modeling are introduced. We also present some examples of how the development and application of appropriate GIS-based expert systems integrating the data to be evaluated can facilitate the work of engineers.

The presentation comes to the conclusion that engineering geology requires the effective help of geomathematical community for elaborating new, powerful methods on the mentioned fields.

Key words: *Engineering geology, Rock mechanics, Numerical modelling, GIS-based expert system*

Slope stability analysis of an opencast lignite mine: comparison of deterministic and probabilistic methods

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Abstract

Visonta is located at NE region of Hungary, where opencast lignite has been extracting since the 1970s. There are three mining areas one is already recultivated, the second is under recultivation, and the third one is still cultivated. The name of cultivated mine is Eastern no. III, where it was necessary to design high-altitude slopes and ensure their stability.

Mining on the Eastern no. III is scheduled to shut down in 2025.

The decommissioning of the drainage wells around the Eastern no. III mine is scheduled for completion at the end of 2025. The slope should be designed based on water level maps for water level heights after the wells are shut down, so that the mine will be stable in 2050 when the final water level is reached.

100-150 shear strength tests were performed from 5 different soil types, after the statistical processing of the data, in addition to the deterministic one, probability-based stability tests are also performed.

The area has a very diverse geology, with alternating cohesive soils and granular soils, and the study of stability is a very interesting and challenging task.

Key words: *slope stability, groundwater, lignite, statistical analysis*

Statistical analyses of destructive and non-destructive test results of heat-treated granite samples from Bátaapáti

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Abstract

In the underground galleries of Bátaapáti, Southern Hungary, medium- and low-level radioactive waste is being stored in a granitic geological environment. Monzogranite is the most common lithotype in the rock body of the Mórágy Granite Formation. In order to examine the changes in the granitic rock environment in response to mechanical effects, it is necessary to study, among other parameters, the changes in response to thermal effects. Accordingly, rock mechanical tests were carried out on cylindrical monzogranite specimens before and after thermal treatment. The samples were heated in an electric oven for 4 hours at temperatures of 250°C, 500°C, 625°C and 750°C, respectively. The measurements included non-destructive tests on bulk-density, ultrasound velocity of both P- and S- waves and Duroskop rebound values, furthermore, uniaxial compressive strength tests of the samples were also measured. Statistical analyses of the data were carried out. The data shows that both destructive and non-destructive test results tend to decrease significantly when the temperature increased. Test results such as Duroskop rebound, bulk-density, P- and S-wave velocities and UCS values correlate with high R value as a function of temperature, namely these values decrease with increasing temperatures.

Key words: *granite, heat-treatment, destructive test, non-destructive test, statistical analysis*

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Overview of Aggregate Degradation Tests, Existing Standards, and the Empirical Relations Between the Different Degradation Parameters

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Abstract

The purpose of the paper is to give an overview of the international literature that deals with the mechanical weathering of aggregate materials. One of the main products of the mining industry is crushed stone which is an essential material in structure construction as concrete aggregate, in road construction as asphalt aggregate and in railway construction as ballast aggregate, etc. Due to the application fields, it is required to evaluate the durability of these aggregates. Since an economical and durable design cannot be achieved without knowing the resisting capacity of the used stone materials to abrasion, crushing, impact, and disintegration. The paper summarizes the most frequently used laboratory tests developed to determine the resistance to these stresses. It introduces various national standards emphasizing their differences and examines the possibility of test result comparability in respect of geology and practical application. The research also presents several empirical relations from the literature between the different degradation parameters.

Keywords: *aggregate degradation, crushing resistance, impact resistance, abrasion resistance*

Charpy impact test on sedimentary rocks

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Abstract

In building material testing, the Charpy impact test is a known and widely used test method. Its advantage is that it is simple, quick to perform and has already proven its usefulness in many materials (for example metals MSZ EN ISO 148-1: 2017).

From tunnel blasting to quarrying or to carving, natural stone materials are subjected to a variety of sudden forces. The Charpy impact test can simulate these sudden forces. As the test specimen can be of any temperature and water saturation, it is excellent for the closest possible examination of different natural conditions. During the laboratory experiments, several different types of sandstone samples were examined, such as permian red sandstone and green sandstone. Three different conditions were examined for each rock, air dry, water-saturated, and frozen. A similar test method is discussed by Furuzumi et al. (2006a, 2006b), and Komurlu (2019), among others. The aim of this series of experiments is to find a correlation between the failure of rocks for impact energy and their compressive and tensile strengths. For sake of simplicity a linear fittingand a polynomial approximation are suggested to calculate the strength functions. The relative errors of the approximations were also calculated.

Key words: *Charpy impact test, sedimentary rock, mechanical properties*

Acknowledgements

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Statistical evaluation of ultrasonic pulse velocity data of porous oolitic limestone

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Abstract

Oolitic limestone was considered one of the most popular stones in Hungary and was used to construct several historical structures, such as churches, monuments, and fortresses. To preserve our national heritage, it is necessary to understand the mechanical properties of this stone using non-destructive test methods that can be applied in the monitoring of heritage structures. In this study, oolitic limestone samples collected from the Sóskút quarry and from building sites are analysed. From the blocks, cylindrical samples were drilled and tested under laboratory conditions. Two slightly different lithotypes of oolitic limestone were selected for laboratory tests. The ultrasonic wave propagation was considered a non-destructive method for measuring compression wave (P wave) and shear wave (S wave). Two different ultrasonic measurement devices (GEOTRON and Pundit) were used for testing stone specimens. An automatic P- and S-wave detection method based on the transmission method was applied to the raw data to evaluate the data sets of measurements. Finally, statistical analysis was performed on density, ultrasonic P- and S-wave velocity values. The results suggest that it is possible to make difference between the two very similar lithotypes based on ultrasonic pulse velocity and density results. Scattering in the results indicates the inhomogeneity of the test specimens and the effects of the void ratio on the density and ultrasonic pulse velocity.

Key words: *Oolitic limestone, ultrasonic sound testing, P- and S-waves, void ratio*

Automated Replacement of Missing Well Logging Data Using Machine Learning and Deep Learning Approaches

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Abstract

Machine Learning and Artificial Neural Networks are becoming more and more popular in the practice of geosciences and petrophysics domains. We can utilize Machine Learning and Deep Learning methods in several ways within petrophysics, including automating outlier detection, property prediction, facies classification, etc.

Wireline logs provide the in situ physical properties of geological formations under the subsurface and can be utilized for hydrocarbon, water, gas, or mineral exploration. Wireline log, such as bulk density, resistivity, sonic, and neutron, are the input data of formation evaluation analysis in reservoir geophysical studies. However, at some depth intervals, wireline log values might be missing due to operational or quality problems in the logging operation. To overcome this issue, an innovative approach to reconstructing well logs is proposed using machine learning and deep learning methods. Based on other complete logging features such as natural gamma-ray intensity, caliper logs, the missing well log values are predicted by data-driven machine learning algorithms, namely linear regression, Random Forest, and Artificial Neural Networks, respectively. A grid-searching Machine Learning algorithm is applied to encounter a variety of hyperparameters for the best prediction score. The relative importance of various input features is analyzed to extract weakly sensitive features and prioritize data with a strong correlation with the target variables during the training process.

In the proposed workflow, synthetic spontaneous potential, acoustic, compensated neutron logs are generated to replace missing wireline logs in a Hungarian hydrocarbon field that included caliper, natural gamma-ray, and resistivity logs. Model competition between a set of Machine Learning algorithms such as Linear Regression, Artificial Neural Networks (ANN), and Random Forest was used to select the best algorithm based on the coefficient of determination (R Square) of the validation dataset. Obtained results show that Artificial Neural Networks and Random Forest generated the best prediction of synthetic SP, AC, CN logs compared to the simple Linear Regression algorithm used. This approach may be powerful preprocessing tool to increase the reliability of inverse problem solution, rock typing or any other formation evaluation.

Key words: *Well logging, Machine Learning, Artificial Neural Network, Missing Data, Hungary.*

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Part VII - Case studies and best practices in environmental- and bio informatics, including palaeontology

Form, function and the quantitative analysis of shapes in Earth and Life Sciences: old and new approaches

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Abstract

Morphometrics is the heart of quantifying variation in forms. Traditional morphometrics uses various distance-based measurements for capturing the major features of the analyzed objects. These parameters thus carry fused information on size and shape variations. The correct definition of shape allows for the separation of size in shape analysis, and this gives the foundation of a new revolutionary morphometrics: geometric morphometrics.

Geometric morphometrics (GM) has increasingly become an important tool in assessing and studying shape variation in a wide variety of scientific fields in natural, life, social and material sciences including paleontology, geology as well. The GM toolkit has unparalleled power to quantify shape. Here, we assess the state of the field of shape analysis including GM and provide an overview of the techniques available to assess shape, including aspects of visualization, statistical analysis, phylogenetic control, and more.

Key words: *form, shape, geometric morphometrics, overview*

Acknowledgements

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Flood susceptibility mapping in Hungary based on remote sensed images and machine learning methods

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Abstract

The Europe's flood disasters could be exacerbated by the combined effects of global warming and human factors, just think of last year's floods in Western Europe, which claimed lives. For this reason, proper spatial and temporal monitoring to identify areas exposed to floods is key to reducing risks and losses by preventing. One of the most common methods for identifying and analyzing flood hazards and risk areas based on one-dimensional or two-dimensional hydrological models. Another solution could be flood susceptibility maps based on multi-criteria decision analysis (MCDA), which are increasingly using remote sensing solutions.

In this study, we present three machine learning models (support vector machine, logistic regression, and random forest) for generating a flood sensitivity map using satellite imagery, soil databases and GIS tools. We examined the accuracy and contribution of machine learning methods to floods and flood risk areas. For our model we created a flood inventory map, and as flood influencing factors we chose aspect, curvature, distance to rivers, distance to roads, elevation, landuse/cover, normalized difference vegetation index, rainfall, slope, profile curvature, soil type, plan curvature, topographic wetness index, stream power index, topographic roughness index and sediment transport index. For coding we used Python.

As result we present a Multicollinearity Test to detect if there is a high correlation among the two or more independent variables in a multiple regression model. In closing we explored the possibilities of drone-based remote sensing.

Key words: *Flood susceptibility mapping, Machine Learning Models, Multicollinearity Test*

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Congruence in types specific anthropogenic stressors for riverine ecosystems based on different biological elements

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Abstract

Rivers are one of the most essential natural resources for living beings, with cultural, social, economic, and historical significance. The water quality evaluation and monitoring are crucial for water resource management programs that need regulation and monitoring. As a result of this it is necessary to assess the quality of the water as part of the ecosystem such as analyzing the enrichment of nutrients in the water bodies (based on category, type and geographical location), considering the influence of confounding factors on the nutrient-biology interaction. The main objective in this study was to compare the EQR (Ecological Quality Ratio) values obtained in rivers in Hungary with the limit values of nutrients stipulated by the Water Framework Directive (WFD) for freshwaters and observe the main taxonomic and ecological communities associated with conditions of good condition for their future preservation. We used macroinvertebrates and diatoms as ecological communities for the interaction with the nutrients (parameters). For macroinvertebrates the analysis showed that the BOD, PO4-P, TOC and Conductivity were the highest performing nutrient parameters that achieved the threshold range for all five river typologies and for diatoms the best performing parameters within the threshold limit for all the river typologies were COD, DO, NH4-N, and TOC. A comprehensive review of Hungary's river EQR evaluations suggests a good/moderate ecological status. Some efforts must be made to improve water safety and promote environmental awareness, which would necessitate a collaborative approach including researchers and stakeholders (from the water industry and government representatives).

Key words: *Ecological Quality Ratio, Water Framework Directive, Freshwater, Nutrients.*

Part VIII - Assessment of geophysical datasets

"The long and winding …" rivers: sinuosity as a geostatistical problem?

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Abstract

The calculation of sinuosity (length along a curve/distance between two endpoints) has been widely used in a variety of disciplines in recent decades. The original idea was to derive some useful descriptors to characterise the behaviour of meandering rivers. Since studies have shown that river sinuosity is a function of different factors (water discharge, slope, sediment load, tectonic forcing), it is now common practice to do the reverse: infer other factors from the sinuosity.

To disentangle the effects of these factors themselves is a problem (e.g. tectonic movements), but the inherent geostatistical problem of the calculation method itself has received little attention so far. In order to calculate the variable sinuosity, we work with different window sizes (fixed lengths along the river) and calculate values for these overlapping sections. This by definition implies a very strong (spatial) correlation between sinuosity values. This behaviour contradicts the need to detect the effect of, e.g., a tectonic fault crossing the river at a certain position, as many overlapping windows along the valley may be affected.

To reduce the effect and to draw robust conclusions, we can compute a so-called sinuosity spectrum, which does not circumvent the problem of spatial correlation, but at least puts it on a stronger statistical basis by trying to make the results independent of the window sizes chosen by the experimenter. Cluster analysis of the sinuosity spectra may solve this problem partially: correlated sections can in some cases be separated and thus compared with the independent phenomenon (here: tectonics).

Key words: *Sinuosity, Meandering rivers, Spatial correlation, Cluster analysis*

Inversion Methods Evaluation for Geologic Structure Assessment

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Abstract

Combined geoelectric inversion (CGI) method applications are presented with new results. CGI techniques for geological structures identification are applied in this study using Fourier series expansion. Different versions, 1.5D, 2D and CGWI inversion variants are tested on both synthetic and field data. The field measurements are performed during stone exploration in an active quarry on the southwestern slopes of Mátra mountains, in northern Hungary. The results are compared with those using the well-known RES2DINV inversion software regarding Root-Mean Square (RMS) estimation error in data distance and other parameters derived from the covariance matrix.

Key words: *Geologic structures, geoelectric inversion, Wenner array, RES2DINV*

Sample pre-screening methodology for increased precision U-Pb geochronology of zircon crystal

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Abstract

Nowadays zircon is the most common mineral of the geological U-Pb dating method. One of the main barriers of getting properly time-resolved and reliable zircon age data is just the internal heterogeneity of the zircon crystals themselves. For overcoming that limitation, we defined a four-step pre-examination protocol to be followed before the texture-related U-Pb geochronology aimed data collection on zircon: 1. determination of morphology types of zircon, 2. internal texture of zircon were identified in details on by comparison of the cathodoluminescence (CL) and back-scattered electron (BSE) contrasts using scanning electron microscope (SEM), 3. characterization of the structural state, chemical composition of zircon zones was determined by Raman spectroscopy and electron probe microanalyses (EPMA), 4. determination of mineral inclusions in zircon based on EPMA.

Accordingly, the strongly radiation-damaged zones, HFS (high-field-strength elements)-rich mineral inclusions could be excluded from the U-Pb age determination, because these zircon zones are not so resistant toward to the fluid-driven replacement processes (Putnis, 2009). In the case of the alteration of previously radiation-damaged zircon zones we have to take into account the possibility of Pb loss during the replacement reaction, which can modify and disturb the precise U-Pb age determination (Nasdala et al., 1998). With the help of the four-step pre-examination method of zircon crystals the yield of the age data was between 80 – 100%, instead of 50 – 60 %.

Keywords: *zircon, four-step pre-examination, crystal structure state, U-Pb geochronology*

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Image segmentation and optimization of X-ray computed tomography images of porous materials: quantitative 3D characterization of the pore space.

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Abstract

High-resolution X-ray computed tomography (CT) is a novel technology ideally suited to a wide range of geological investigations. It is a quick and non-destructive method to produce images that correspond closely to serial sections through an object. Image segmentation plays a crucial step for data interpretation and final evaluation of XCT images. We studied the performance and accuracy of some basic segmentation techniques in the analysis of the pore space and matrix voxels obtained from a 3-D volume of X-ray tomographic (XCT) grayscale rock images. The segmentation and classification accuracy of unsupervised (K-means, modified Fuzzy c-means, Minimum cross-entropy, and Type-2 fuzzy entropy) and supervised Naïve Bayes methods were tested using an XCT tomogram of a carbonate reservoir rock. K-fold- cross-validation techniques were applied in the evaluation of the accuracy of the unsupervised and supervised machine learning classifiers. The validation of the segmentation results was determined based on parameter extraction, visual inspection and comparison to a reference image. Training Naïve bayes classifier with feature vectors resulted from unsupervised techniques showed fair segmentation accuracy. The segmentation scheme was applied to the whole data set to segment X-ray computer microtomography rock images and to estimate the pore spaces and pore size diameters in the rocks. The measured porosity obtained from XCT was in good agreement with those obtained by mercury injection for both studied samples. A review of the main pore network construction techniques is then presented. Followed by parameter extraction and 3-D pore network evaluation.

Key words: *Micro-X-ray computer tomography, porous media, unsupervised clustering, supervised clustering.*

Acknowledgements

Many thanks for Dr. Janos Geiger for his continuous support and advice. 3d Lab Tests were carried out at the Institute of Physical Metallurgy Metalforming and Nanotechnolgy University of Miskolc. Prof. Dr. Mertinger Valéria is thanked for her generous help Filep Adam for measuring the samples.

Enhancing time to depth relation estimations in subsurface exploration using supervised neural networks

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Abstract

Conventional methods of solving time to depth relations needed for successful interpretation of seismic data and later construction of geological model include vertical seismic profiling and construction of synthetic seismogram based on available well log data from acoustic and density well logs. However, when re-evaluating the potential of mature basins that had its peak exploration and production in the pre-1990's, this data is often lacking and/or the spatial distribution data is too irregular. As the main controlling factor of the acoustic properties of the rocks is lithology in relation to compaction, we propose the usage of "sandstone to shale" ratio and general lithology in regard to the stratigraphic interval (Pliocene, Upper Miocene, Lower and Middle Miocene and Base Neogene categories) along with burial depth as a controlling factor for determining time to depth relations in wells lacking data for the abovementioned conventional approach. In this way the time to depth relation is controlled as permeable versus impermeable lithologies based on the interpretation of conventional well logs. Initial research was performed using data from four wells with vertical seismic profiling data using the multi-layer perceptron networks. Successfulness of the learning was tested on one additional well which also had vertical seismic profiling measurements. The successfulness of the prediction, although lower than in learning dataset, proved to be more accurate than using the time to depth relations from the nearest well.

Key words: *Artificial neural networks, seismic, wells, hydrocarbon exploration*

Acknowledgements

This work has been supported in part by Croatian Science Foundation under the project «GEOlogical characterization of the Eastern part of the Drava Depression subsurface intended for the evaluation of Energy Potentials» (UIP-2019-04-3846).

Inversion-Based 1D and 2D Fourier Transformation Algorithm for Solving the Incomplete Sampling Problem

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Abstract

In geosciences, the incomplete sampling problem is of great importance since the field data measurements are sometimes missing or lost and generally riddled with gaps due to several natural and/or artificial conditions. The traditional Fourier transformation approach is usually used for the complete sampling designs, so it is not applicable in this case. Therefore, a newly developed inversion-based 1D and 2D Fourier transformation MATLAB codes are provided to achieve such an aim of data processing. In this inversion, the series expansion method is employed to discretize the Fourier frequency spectrum, approximating the expansion coefficients as the solution to the over-determined inverse problem (Dobróka et al., 2015; Dobróka et al., 2017). For quick and accurate determination of the elements of the Jacobian matrix, the Hermite functions are constructed as basis functions making use of the favor that they are eigenfunctions of the Fourier transformation. Moreover, the most frequent value method is used to handle the problem of the scale parameters by iteratively calculating the Cauchy Steiner weights through an internal iteration loop in a manner that minimizes data loss. In this study, the inversion method is applied to equidistantly and non-equidistantly sampled incomplete synthetic 1D wavelet as well as the 2D synthetic magnetic datasets at different missing data percentages. The results indicated the inversion method's efficiency and stability in both the space and frequency domains, making it highly recommended to treat diverse data taken via other geophysical tools.

Key words: *Fourier transformation, Inversion, Series expansion, Missing data*

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Implementation of geophysical methods to assess the structure and composition of artificial levees along Tisza and Maros Rivers, Hungary

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Abstract

Artificial levees have a major importance in protecting human lives and infrastructure. They are essential elements in terms of flood protection. To guarantee their stability, integrated and continuous surveys including geophysical and geotechnical methods are needed. Levees along the rivers in Hungary were constructed more than 150 years ago, and they were heightened several times therefore investigations are required to assure their performance in flood risk mitigation. The lack of the necessary information about their structure and internal composition might cause high risks. The aim of our investigation was to utilize non-invasive geophysical techniques, primarily electrical resistivity imaging with the validation of geotechnical investigations at definite locations to investigate and compare the compositional and structural variations of two different levee sections along River Tisza and River Maros. Integrating the analysed drilling data with ERT profiles showed that the main composition of investigated Tisza levee sections is silt in its different grain sizes fine, medium and coarse, however, the investigated section of Maros levee showed all grainsize from silt to sand. Several relationships between different physical parameters were plotted to study the nature of constituting levee materials. It was found that the more homogeneous is the composition the stronger the relationships between parameters.

Keywords: *Tisza River, Maros River, levee composition, Electrical Resistivity Tomography (ERT), flood risk, Drillings.*

Unsupervised Machine Learning Assisted Borehole Geophysical Inversion for Robust Reservoir Characterization

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Abstract

Borehole inversion is time-intensive and necessitates extensive manual input as well as strong prior information. Conventional inversion methods are restricted by the small number of measured logs at certain depth points. Furthermore, this low overdetermined inversion scheme makes the inversion process highly sensitive to noise. The interval inversion was introduced to enhance the overdetermination ratio, which inverts an interval of data points to estimate the petrophysical parameters (Dobróka and Szabó, 2011). In this research, an unsupervised machine learning technique represented in new K-mean clustering was used for an automatic determination of such zone parameters. The approach depends on automatically predefining the different layers' boundaries using a robust K-means cluster technique as a priori information for the inversion procedure using Levenberg-Marquardt and Singular Value Decomposition techniques. The MFV-cluster algorithm shows an increase in the grouping performance compared to the Euclidean norm (Szabó et al., 2021). To check the stability of the MFV-cluster, the algorithm was repeated 100-times with randomly initial centroids, which shows that the convergence of the clustering algorithm is highly independent of the initial location. The reservoir characterization procedure in highly heterogeneous plays can count on the proposed technique in identifying the different zone parameters and separating between sublayers which are different inhomogeneity degrees.

Key words: *MFV-Cluster, Borehole Geophysics, Inversion, Interpretation*

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Part IX - Diverse faces of geomathematics (posters)

Karst hydrodinamic modelling in Aggtelek Region

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Abstract

In order to better understand the climate effects on the hydrodynamics of karst we conducted a detailed research in the Aggtelek karst area (NE Hungary). Besides analysing geochemical and hydrological data, we established a monitoring network in 2020 that includes 22 wells and springs which are visited every month to measure physical/chemical field parameters and water samples are collected for chemical and stable isotope analyses. Utilizing this data set, we aim at grouping these springs by cluster and discriminant analysis. In addition, the time series of these data provided an opportunity to find temporal changes in the investigated parameters as function of meteorological conditions. Furthermore, we conducted reservoir modelling using the bucket model Gardenia by applying available spring discharge data and measured meteorological time series. Gardenia was applied on two adjacent karstic catchments that feed the Jósva, and Nagytohonya springs. Our goal is to investigate climate change impacts through spring discharge forecasting using regional climate model projections.

Key words: *karst, hydrodinamic modelling, Aggtelek*

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Investigating the environmental effects of river-diversion on the river Danube (Hungary)

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Regulation of natural water flows has reduced the groundwater connectivity in riparian ecosystem globally, impacting shallow groundwater cycle with consequences to both biotic and abiotic components. Impacts on ecosystems can only be understood by analysing available data through time periods that represents sufficiently long intervals to monitor changes. The study area is located in Hungary along the river Danube and is represented by 211 shallow groundwater monitoring stations with an hourly sampling frequency from 2000 to 2020. A section of the river was diverted and natural water flow was reduced to support the artificially created channel and the Gabčíkovo (Bős) hydroelectric power plant, respectively. The aim of the study was to investigate the effect of river diversion on the shallow groundwater system by determination of the main driving factors, their spatial distribution, temporal displacement and importance. The time period of a major flood event in 2013 was selected to conduct dynamic factor analysis to achieve these goals. The obtained results were compared to normalised time series data of surface water levels as well as calculated water flows in 4 different sections on the river Danube. The dynamic factors were also correlated to further environmental data. Results show that the Danube is the most important driving factor of the shallow groundwater levels in the study area.

Key words: *Danube, dynamic factor analysis, river diversion, shallow groundwater*

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Employing machine learning algorithm for cross validating porosity-velocity model

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Abstract

As the technology and acquisition methods of geophysical exploration have developed, the data acquired have also become more complex in its volume. While obtaining data from various sources has become more accessible in some ways, the need to enhance interpretation methods has become even more important. In this context, machine learning has emerged as a solution for highlighting hidden or unknown relationships between different scale data. The relationship between 3D seismic volume and well data could be effectively analyzed using the Self-organizing maps (SOM) algorithm in an unsupervised learning process. The self-organizing map is an artificial neural network that emphasizes patterns in samples by clustering and classifying them into various sets. It has been proven successful in accentuating information about geological features and predicting missing attributes in different geophysical parameters. The study area is located in the Drava Depression, which is known for extensive surveys conducted. The SOM algorithm was used to create low-dimensional maps in order to reduce the dimensionality of 3D seismic data and to predict missing acoustic and density logs based on data measured in a few boreholes. This method has been utilized to produce maps of porosity distribution and velocity models in the study area.

Key words: *Self-organizing maps, 3D seismic data, well logging data, Drava Depression*

Acknowledgements

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Correlation of Gamma Ray Spectrometry and Total Organic Carbon data using Artificial Neural Networks

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Abstract

In the Croatian part of the Pannonian Basin System, near Voćin, a 45.9 m long stratigraphic section was recorded. Concentrations of naturally occurring radioelements (K, U, Th) and dose rate were measured, and 33 samples were taken to measure TOC (*Total Organic Carbon*). According to Lüning & Kolonic (2003), time-consuming organic geochemical analyses can be replaced by gamma ray spectrometry in black shale systems, but shallow-marine organic-rich systems, similar to ours, are generally characterized by the absence of a stable U/TOC relationship. An attempt was made to establish a correlation between the measured values of natural radioactivity and the TOC values of the samples using artificial neural networks (*ANNs*). Our results show that there is a moderate correlation between uranium and dose rate (*DR*) concentrations with TOC, but there is insufficient data so far to train ANNs properly. The radiometric data were obtained with a gamma-ray spectrometer and the values TC (*Total Carbon*) and TIC (*Total Inorganic Carbon*) were determined with Analytik Jena multi EA 4000. TOC was calculated from TC and TIC. Radiometric data supplemented by additional analyses can be used for sequence stratigraphic analysis (Omidpour et al, 2021), which could be the next step in this research, and provide more input variables for ANNs.

Key words: *Gamma Ray Spectrometry, Total Organic Carbon, Artificial Neural Networks, Correlation*

Acknowledgements

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Assessment of geophysical dataset on the degree of regionality of anomalies

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Abstract

The gravity and magnetic anomalies separation operation consists in determining the number of sources, the characteristics of each (depth, density, shape, and dimensions) so as to result in cumulative total anomaly, measured at the Earth's surface. There are various methods for achieving this separation of anomalies. We present some examples of the use of the moving average method and the polynomial tendency surfaces. In particular, we presented the results of the mobile average with different windows compared to the tendency surfaces with different degrees, for a case study in Eastern Carpathians mountains. We used, for this study, gravimetric data for the WGM2012 model: Bouguer anomaly, Free Air anomaly and altitude. Also, we used the deep geological sections, national geomagnetic maps and catalogues of measurements from the archive of geophysics portal of the Geological Institute of Romania. Other data used for depth correlations were the isobath maps of the Moho, Conrad and the geoid surface.

For the study of deep tectonics based on all the data used we used the correlation coefficient between various parameters, calculated in movable windows of different sizes both in plan and in space. For this we have developed specific calculation programs. Polynomial trend surfaces analysis contributes to the recognition, isolation and measurement of trends that can be calculated and represented by analytical equations, thus achieving a separation in regional and local variations. The analytical expressions of the polynomial trends based on the least squares' method were calculated, highlighting the regional trend caused by the deep structures.

Key words: *Polynomial tendency surfaces, geophysical anomalies, correlation's analysis, deep structures.*

Acknowledgements: *Thanks for the financing from project PN19450301, contract 28N/2019.*

Application of different land use / land cover databases for estimating urban runoff delivered pollutant loads

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Abstract

In a 1.5-year monitoring program, the rainfall-induced urban runoff was sampled in 8 pilot catchments located in various Hungarian cities. Nutrient (N, P) and heavy metal (As, Cd, Cr, Cu, Ni, Pb, Sb, Zn) contamination of the samples was characterized by the mean concentration/load value of each runoff event. In this study, we relate (i) event mean concentrations/loads to event characteristics; and (ii) mean / median site loads to site land use characteristics derived from the following databases: (i) The Ecosystem Map of Hungary (HMoA, 2019); (ii) the OpenStreetMap database; along with three Copernicus (Copernicus, 2018) databases: the (iii) Corine Land Cover database, the (iv) Urban Atlas and the (v) Impervious Density layer.

It was found that event loads show high and significant Pearson-correlation with the maximum rainfall intensity ($r = 0.49 – 0.94$, $p<0.05$ in 90% of the cases) and the total rainfall amount ($r = 0.2 – 0.92$, $p<0.05$ in ~50% of the cases), medium correlation with the duration of the event and the mean rainfall intensity; and low correlation with the duration of the preceding dry period (regardless of substance and location).

Location-specific median values for P, Cu, Ni, Pb, Sb, Zn event mean concentrations were highly correlated with the area share of roads according to the Ecosystem Map ($r = 0.68 – 0.88$, $p<0.05$) and the total road length per catchment area according to the OpenStreetMap roads layer ($r = 0.67 – 0.87$, $p<0.05$) and with high impervious density. Statistical models combining 3-4 most significant land use and rainfall characteristics predicted Cd, Cu, Pb and Zn loads with an adj.-R^2 of 0.39 – 0.50.

Key words: *Nutrient load, Heavy metal contamination, Urban stormwater, Water quality monitoring*

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Morphospace evolution and phenotypic variation of the endemic gastropod Microcolpia pareyssii from the Holocene deposits of Lake Petea

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Abstract

This work presents the results of extensive morphometric analysis of modern and subfossil specimens of *Microcolpia parreyssii* of the thermal water Lake Petea using outline analysis (EFA, Hangle). The most important residual shape component (RSC1) capturing 95% of total shape variation is seen in the width changes of the shells with larger ones generally slender and smaller ones generally more inflated. The only difference between the early Holocene and late Holocene forms is the appearance of shouldering. Other shell ornamentation (keels, ribs) appears in various forms in several original morphotypes reflecting individual variability. Morphospaces are generally overlapping throughout the entire Holocene with most of the specimens constrained to a certain area. This overlap imply that expansions may refer to the emergence of higher morphological variances (ecophenotypes) because of recurring environmental changes recorded by geochemical and sedimentological parameters. Recent specimens seem to be well separated from the morphospace of the subfossil ones implying that the taxa stabilized in modern times.

Key words: *Lake Petea gastropods, geometric morphometrics, ecophenotypic variation, morphospace evolution*

Acknowledgements

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Geochemical characterisation of different mine waste materials using exploratory data analysis. A case study from the Recsk Mining Area, Hungary

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Abstract

Mining activities inevitably generate contaminants in high quantities that can pose a risk to soil, water, biota and humans. This article describes a systematic method to understand the geochemical properties of various waste heaps and to investigate the waste material of a flotation mud and a waste rock dump coming from a high-sulphidation type epithermal copper-lead mineralization of the Lahóca-Hill in the Recsk Mining Area. Altogether 48 samples were collected from the uppermost oxidising zones and the lower reducing zones of a waste rock heap (H7) and a tailings heap (H7) in order to assess the geochemical properties of the waste material and to enable the comparison of the behaviour of the potential toxic elements in the two types of waste from the same mineralisation weathering under continental climatic conditions. Element concentration in the samples was determined by ICP-MS and ICP-OES methods. Mineral phases were detected by X-ray diffraction (XRD). The mobility of each element was estimated using a simple formula followed by univariate and bivariate data analysis methods. Results show that the potentially toxic elements are present in varying concentrations in the two studied wase heaps, even though they are originating from the same mineralization. They also behave differently in the studied waste heaps in terms of mineral composition, mobility and speciation. A unique approach is needed for each type of waste heap in order to facilitate a successful remediation or secondary raw material extraction.

Key words: *mine waste, geochemistry, contamination*

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Tracing the geographical origin of fruit and vegetable commodities using geochemical methods

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Abstract

This study focuses on the determination of connection between the chemical compounds of fruits (apple and pear) and vegetables (paprika and potato) as well as of soils for the geographical origin tracement by means of geochemical methods. Fruit, vegetable, soil samples were collected at 14 locations in Hungary, taking into consideration the geochemical provinces of Hungary. Soil sampling was performed according to the FOREGS Geochemical Baseline Program sampling protocol. Based on statistical data analysis, the three examined parts of the fruits (peel, flesh and seed) showed significantly different characteristics for both the main and trace elements. The difference in chemical composition between the examined fruit types (apples and pears) and between their different parts became apparent. The same results were observed for vegetables and their examined parts (peel, flesh and pith). The data clearly demonstrates the strong effect of fertilizers on the chemical composition of the topsoils, both in terms of the main elements and trace elements. Characteristic soil chemical element associations (fingerprint) were observed in the topsoil and in the subsoil horizons as well. Results confirmed that there is a correlation between the chemical composition of the soils and the element content of the plants, mainly reflected in the association of the chemical elements. From this point of view, the geochemical methods seem to be suitable for the tracing the geographical origin of fruits and vegetables.

Key words: *Traceability, geological origin, chemical element content, food safety*

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Attribution of heavy precipitation to anthropogenic climate change

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Abstract

Precipitation is a key meteorological variable affecting many economic sectors as well as vegetation. Both the excess and lack of precipitation may result in severe consequences, thus, it is important to analyze the climate projections in order to properly adapt to possible changes. In this research we focus on the heavy precipitation days (when P > 20 mm), and evaluate the past and future trends of this extreme index. The attribution to anthropogenic activities is carried out for the past with comparing the simulations with natural forcings only and historical runs (i.e. including anthropogenic effects as well). In addition, the analysis for the future considers two different scenarios with different anthropogenic forcings. For this purpose, we use (i) gridded, homogenized observational data from the Hungarian Meteorological Service covering Hungary (1971-2020), (ii) outputs of 8 global climate model simulations from CMIP6 (1900-2014), and (iii) outputs of 6 regional climate model simulations with RCP4.5 and RCP8.5 scenarios from Euro-CORDEX (2006-2100).

Our results for summer and spring were not statistically significant, therefore, we selected the period from May to September when convective atmospheric processes result in heavy precipitation. The preliminary results show an increase in most parts of Hungary in the last few decades.

Key words: *Hungary, observations, climate models, summer*

Overview of Probabilistic Rock Slope Stability Analysis

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Abstract

The purpose of the paper is to give an overall view of a highly developing approach to a common engineering geological task, the rock slope stability analysis with a probabilistic design method. This topic has extensive and diverse literature, from the stochastic and mathematical models of the shear strength, through the distributions of the input parameters, to the convenient usage in civil engineering practice. The aim of this study is to provide an up-to-date and comprehensive overview of the literature background of these research areas. The paper presents the assessment of the probability of failure and the reliability of the slope concepts. The variety and distributions of the required physical and geometrical parameters and conditions will also be discussed. Furthermore, to demonstrate the practical benefits of the probabilistic method, the paper introduces different acceptance criteria and concerns the topic of risk management.

Keywords: *rock slope stability, probability analysis, reliability analysis, open-pit mine*

Relationship between textural and petrophysical characters of Sandstones and Siltstones: A case study from Szentes area, Hungary

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Abstract

The quantification and characterization of various textural parameters and petrophysical properties of rock bodies located in the Szentes Geothermal Field, southern part of the Great Hungarian Plain (Balint & Szanyi, 2015), is an ongoing study carried out based on interpretation of core descriptions and data analysis of the grain size distribution measured by GEOCHEM. The application of geomathematical concepts for the elaboration of Geological Models allow us to systematic record, order and compare data from different parameters (Agterberg, 1974), while the interpretation of the sedimentary textures in the cores provides the vertical depositional facies (Reineck & Singh, 2012). By using the grain size fractions, applying correlation profiles to describe the relation between the measured parameters, and comparing the results to the petrophysical parameters, is it possible to produce a detailed relation between these characters during the depositional process, and therefore, characterize the past framework of the depositional environment system within the area of study.

Key words: *Szentes, depositional environment, geological model*

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Discrete fracture network (DFN) modelling of the Boda Claystone and the implications for its hydrogeologic behavior

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Abstract

Fracture network modelling and a hydrological evaluation were performed in a well more than 900 m deep that penetrated the Boda Claystone Formation, a potential host rock for high-level nuclear waste disposal facilities in Hungary. Fracture networks generally follow a fractal-like pattern that is independent of lithology and structural evolution. This appearance allows modelling of fractal networks at any scale using measured geometric data of the fractures.

The fracture network geometry was generated with a discrete fracture network algorithm, in which the permeability and porosity of the system can be calculated if the aperture of the fractures is known. The hydrological aperture of the fractures was estimated via an aperture calibration based on a comparison of the measured and modelled permeability values. Flow zone indices were calculated for numerous sections along the well, designating hydraulic units, in which the fluid flow-controlling properties are internally even. Based on these, most parts of the well behave uniformly, while three narrow zones differ significantly. The first zone is located in the upper 100 m of the well probably formed due to weathering. The second zone is located at approximately 400 m, where a large-scale structural boundary is presumed. In the third zone at 700 m, a lithological change greatly affects the hydrological properties, but the influence of tectonic processes cannot be ruled out.

Key words: *DFN modeling, radioactive waste repository, flow zone indicator, fracture aperture calibration*

A New Method for Determining Propped Fracture Permeability

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Abstract

Proppant is one of the most important components of a hydraulic fracture process that can have a significant effect on the productivity of an oil or gas well. Proppant can be considered as an unconsolidated, heterogeneous granular packing, and the different correlations that can predict the particle friction factor of such systems may be utilized to estimate the permeability of the packings. Such correlations generally consider the frictional pressure drop induced by the proppant particles and frequently ignore the pressure drop caused by the surface of the apparatus. Combining an analytical model that accounts for the pressure drop induced by the fracture wall with the models would be practical to increase the application of the different models. As the frictional pressure drop correlations usually contain the porosity as a parameter, determining its value under reservoir conditions efficiently is a key element in this method. A new measurement method has been developed that reproducibly predicts the porosity of proppant-packs and further facilitates this new approach. As the different correlations were developed under different conditions than the proppant-packs are usually applied, offering deductions, and possible improvements to the model can facilitate further studies in this area.

Key words: *fracture permeability, mixed proppant-pack, modified particle friction factor, proppant porosity under closing pressure*

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Postscript

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