

# 7th IAHR EUROPE CONGRESS

Innovative water  
management in a  
changing climate

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## organizers



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## Keynote Lectures

Jacques Ganoulis, UNESCO Chair/INWEB, Civil Engineering Department, Aristotle University of Thessaloniki, Greece	<i>Water Security Under Climate Change</i>	15
Maria P. Papadopoulou, Deputy Dean, School of Rural, Surveying & Geoinformatics Engineering National Technical University of Athens, Greece, Board President, Natural Environment and Climate Change Agency (NECCA)	<i>Water Governance: Tackling Climate Crisis Challenges</i>	16
Anton J. Schleiss, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland	<i>Research and Innovation Agenda for hydropower as catalyst for the energy transition in Europe</i>	17
Fotis Sotiropoulos, Provost and Senior Vice President for Academic Affairs Virginia Commonwealth University, United States	<i>Hydraulic Engineering in the Era of Extreme-Scale Computing and Data-Driven Modeling</i>	19

## RLR Rivers, Lakes and Reservoirs

Yannick Marschall, Laboratory of Hydraulics, Hydrology and Glaciology, ETH Zurich, Zurich, Switzerland	<i>Simulation of flow around a wall-mounted semi-ellipsoid – comparison of URANS and DES modelling approaches</i>	20
Ursula Stephan, Institute for Hydraulic Engineering and Calibration of Hydrometrical Current-Meters, Federal Agency for Water Management, Vienna, Austria	<i>3D numerical modelling of silting processes in a retention basin</i>	22
Koen Berends, Deltares, Delft, The Netherlands	<i>Assessing the impact of human aquatic vegetation removal on water levels by hydraulic analysis</i>	24
Serhat Kucukali, Hacettepe University, Ankara, Turkey	<i>Flow Resistance and Energy Dissipation in Brush Fish Pass</i>	26
Maria Gloria Di Chiano, Politecnico Di Milano (DICA), Milano, Italy	<i>Permeable Pavements Efficiency Under Clogging and Pollutants Load Removal</i>	28
Tatiana Máximo, Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal	<i>Hydrodynamics of Daphnia Magna Horizontal Migration: Phototaxis and Predatory Cues</i>	30
Georgios Vagenas, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Athens, Greece, Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research, Athens, Greece	<i>Comparative Assessment of Macroinvertebrate Habitat Suitability in Mediterranean (Greek) and Semi-Arid (Moroccan) River Reaches</i>	32
Ashkan Pilbala, University of Trento, Department of Civil, Environmental and Mechanical Engineering, Trento, Italy	<i>Evaluating Hydrological stressors by Monitoring Mussel Behaviours</i>	34
Stefan Haun, University of Stuttgart, Stuttgart, Germany	<i>MultiPAC as a tool to validate the success of restoration measures</i>	36
Sudesh Dahal, VAW, ETH Zurich, Switzerland	<i>1D numerical modelling of sedimentation propagation in a narrow reservoir</i>	38
El Mehdi Chagdali, EDF R&D - National Laboratory for Hydraulics and Environment (LNHE), Chatou, France	<i>Laboratory Design of Representative Real Shallow Basins for Validation of Numerical Models</i>	40
Konstantinos Kaffas, Faculty of Science and Technology, Free University of Bozen-Bolzano, Bolzano, Italy	<i>Preliminary Investigation of Reservoir Sedimentation Rates in the Italian Alps with SWAT model</i>	48

***RLR Rivers, Lakes and Reservoirs***

Øyvind Pedersen, Multiconsult, Oslo, Norway	Monte-Carlo simulation of sediment-related events in reservoirs as part of a risk-based decision making tool	50
Behnam Balouchi, Department of Civil and Environmental Engineering, Norwegian Institute of Science and Technology, Trondheim, Norway	Two-dimensional (2D) depth-averaged numerical modeling of a braided river morphodynamics upstream of a dam reservoir	52
Peter Mewis, Civil and Environmental Engineering, TU Darmstadt, Darmstadt, Germany	Morphodynamic Modeling of Graded Sediment Transport	54
Daniál Dehghan Souraki, UPC, Barcelona, Spain	A GPU Accelerated Tool for 2D Modelling of hydraulics and Sediment Transport	56
Nikolaos Efthymiou, World Bank, Independent Consultant, Greece	On the Vulnerability of Reservoirs to the Combined Effect of Sedimentation and Climate Change and the Contribution of Sediment Management as an Adaptation Strategy	58
Raphaël Gaillard, Watertracks, France	NESSIE and LISIE: Innovative underwater dredging robot techniques for reservoir sediment management	60
Sotirios - Theophanis Karalis, Polytechnic School/University of West Attica, Athens, Greece	New sediment yield models for greek mountainous catchments	62
Reshma Radhakrishnan, Department of Civil Engineering, Indian Institute of Technology Madras, Chennai, India	Geospatial assessment on morphodynamic evolution of Adyar River in India	64
Konstantinos Kaffas, Faculty of Science and Technology, Free University of Bozen-Bolzano, Bolzano, Italy	Preliminary Assessment of Soil Erosion and Sediment Yield During a Catastrophic Flash Flood Event	66
Hasan Esлами, Dept. of Civil and Environmental Engineering, Politecnico di Milano, Milan, Italy	On how bed load transport may change the equivalent roughness of a flow	68
<b>Eniko Anna Tamas, Faculty of Water Sciences, University of Public Service, Baja, Hungary</b>	<b>Relation of the observed water level decrease and morphological changes of the river channel in the middle Danube</b>	<b>70</b>
Vlassios Hrisanthou, Democritus University of Thrace, Xanthi, Greece	Modification of sediment transport formulas based on measurements: Application to streams of NE Greece	72
Vlassios Hrisanthou, Democritus University of Thrace, Xanthi, Greece	Adaptation of the Engelund-Hansen Formula to Nestos River, Greece	74
Eva Van Hofslot, Department of Environmental Sciences, Hydrology and Quantitative Water Management Group, Wageningen University & Research, Wageningen, The Netherlands	Sediment Yield in the Meuse Catchment using a distributed modelling concept	76
Benjamin Hohermuth, Laboratory of Hydraulics, Hydrology and Glaciology, ETH Zurich, Zurich, Switzerland	Fine sediment deposition in a restored river reach – case study Alpine Rhine	78
Ian Guymner, The University of Sheffield, Sheffield, United Kingdom	A small investigation of the effects of cylinder diameter on longitudinal dispersion coefficient	80
Jesus Leonardo Corredor Garcia, The University of Sheffield, Sheffield, United Kingdom	Mass and Momentum Transfer between Interacting Cylinder Wake: via Velocity Statistics	82
Victoria Barcala, Deltares, Utrecht, The Netherlands	Phosphate adsorption and diffusion model into iron-coated sand grains	84
Inez Plugge Porter, University of Sheffield, Sheffield, United Kingdom	Quantifying the Spatial Variation in On-/Off-shore Mixing in the Surf Zone	86

***RLR Rivers, Lakes and Reservoirs***

Donatella Termini, University of Palermo, Palermo, Italy	<i>Effect of vegetation on Mixing and Dispersion Processes at the apex section of a meander bend</i>	88
Adrien Lefauve, Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Cambridge, United Kingdom	<i>Buoyancy-driven exchange flows in inclined ducts: insights from laboratory experiments and mathematical modelling</i>	90

**ECS Estuaries, Coasts and Seas**

Rutger Siemes, University of Twente, Enschede, The Netherlands	<i>Idealised modelling of estuarine development affected by human interventions and climate change</i>	92
Damiano Baldan, Italian Institute for Environmental Protection and Research (ISPRA), Venice, Italy	<i>Non stationary analysis of extreme sea level events in Venice: implications for return levels estimation</i>	94
Charalampos Nikolaos Roukounis, National Technical University of Athens (NTUA), Athens, Greece	<i>An index-based method to assess the resilience of coastal urban areas to climate-change-related flooding: The case of Attica, Greece</i>	96
Vasileios Boumpoulis, University of Patras, Department of Geology, Laboratory of Engineering Geology, Rio, Greece	<i>Assessment of Coastal Vulnerability Index with emphasis on the geotechnical variable</i>	98
Christina Tsaimou, Laboratory of Harbour Works, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens (NTUA), Zografou, Greece	<i>Development of a Complex Vulnerability Index for Fishing Shelters – The Case of Cyprus</i>	100
Christina Tsaimou, National Technical University of Athens, Zografou, Athens, Greece	<i>Advanced Multi-Area Approach for Coastal Vulnerability Assessment</i>	102
Manuel Teixeira Manion, University of Twente, Enschede, The Netherlands	<i>Evaluation of emergent behaviours on anthropogenic shores with a cellular automata model</i>	104
Maurizio Brocchini, Università Politecnica delle Marche, Ancona, Italy	<i>Predicting Sediment pickup function using Genetic Programming</i>	106
Joost Willem Martijn Kranenburg, University of Twente, Enschede, The Netherlands	<i>The Importance of Vertical Structures in Determining the Cross-Shore Flux of Suspended Sediment in the Swash Zone</i>	108
Nicholas Dodd, University of Nottingham, Nottingham, United Kingdom	<i>Numerical investigation of swash-swash interaction using Nonlinear Shallow Water Equations</i>	110
Achilleas Samaras, Department of Civil Engineering, Democritus University of Thrace, Xanthi, Greece	<i>On the simulation of longshore sediment transport in the swash zone in linear wave models</i>	112
Ronja Ehlers, Norwegian University of Science and Technology, Trondheim, Norway	<i>Comparison of Sea Wall Erosion Modelling with a 3D CFD model against a 2D Shallow Water Equations Model with a Non-Hydrostatic Pressure Assumption</i>	114
Charalampos Doulgeris, Soil & Water Resources Institute, Hellenic Agricultural Organisation, Sindos, Greece	<i>Assessment of groundwater availability in the Rhodope aquifer under climate change conditions</i>	117
Valeria Todaro, University of Parma, Parma, Italy	<i>Local climate change assessment at five pilot sites in the Mediterranean region</i>	119
Ioanna Anyfanti, Technical University of Crete, School of Chemical and Environmental Engineering, Chania, Greece	<i>Application of a Fuzzy Inference System in Decision Making for Water Resources Management</i>	121
Vanessa Godoy, Universitat Politècnica de València, Valencia, Spain	<i>Innovative and accessible tool to support groundwater management in the Requena-Utiel and Cabrillas-Matacara aquifers in Spain</i>	123

***ECS Estuaries, Coasts and Seas***

Emmanouil Varouchakis, School of Mineral Resources Engineering, Technical University of Crete, Chania, Greece	125
Eftymios Chrysanthopoulos, National Technical University of Athens, Athens, Greece	127
Vanessa Godoy, Universitat Politècnica de València, Valencia, Spain	129
Nadim Coptay, Bogazici University, Istanbul, Turkey	131
Theofanis Karambas, Aristotle University of Thessaloniki, Thessaloniki, Greece	133
Daniel Clemente, Marine Energy - CIIMAR, Porto, Portugal, Department of Civil Engineering - FEUP, Porto, Portugal	135
Tiago Ferradosa, Faculty of Engineering of University of Porto, Porto, Portugal	137
Francisco Taveira-Pinto, Faculty of Engineering of the University of Porto (FEUP), Porto, Portugal; Interdisciplinary Centre of Marine and Environmental Research of the University of Porto (CIIMAR), Matosinhos, Portugal	139
Francisco Taveira-Pinto, FEUP – Faculty of Engineering of the University of Porto, Porto, Portugal	141
Anastasia K. Fragkou, School of Engineering, University of Edinburgh, Edinburgh, United Kingdom	143
Domenico Davide Meringolo, Dipartimento D.I.C.E.A.M., Università degli Studi Mediterranea di Reggio Calabria, Rende, Italy	145
Theofanis Karambas, Aristotle University of Thessaloniki, Thessaloniki, Greece	147
Weizhi Wang, Norwegian University of Science and Technology, Trondheim, Norway	149
Rita Carvalho, University of Coimbra, Coimbra, Portugal	151
Athanasios Dimas, Department of Civil Engineering, University of Patras, Patras, Greece	153
Stephen Nash, National University of Ireland Galway, Galway, Ireland	155
Androniki Kartsakali, University of Patras, Patras, Greece	157
Andreas Papadimitriou, Scientia Maris, Athens, Greece, National Technical University of Athens, Athens, Greece	159
Andreas Papadimitriou, National Technical University of Athens, Athens, Greece	161
<i>Blending geostatistics and geophysics to develop the hydrogeological structure of a coastal aquifer system</i>	
<i>Combined measurement techniques for the monitoring of hydrologic processes in the unsaturated zone</i>	
<i>Living-lab on improving groundwater governance in the Requena-Utiel aquifer</i>	
<i>Regional-Scale Modeling of Surface-Subsurface Flow: The Konya Closed Basin Case Study</i>	
<i>Numerical Modelling of Heaving Wave Energy Converter Arrays for Coastal Protection</i>	
<i>Powering offshore aquaculture through ocean renewable energy technologies</i>	
<i>Extending the application of offshore wind monopiles to intermediate water depths</i>	
<i>The impact of the SWAN model calibration on the energy production of wave energy converter systems</i>	
<i>Numerical assessment of alternative geometries of a shoreline wave energy converter</i>	
<i>Submerged bar in a 2-D representation by coupling spectral wave and coastal hydrodynamics models</i>	
<i>A Wavelet-based analysis of solitary wave forces at submerged rectangular barriers</i>	
<i>Perched beach nourishment against coastal erosion and flooding: Experimental and numerical simulation</i>	
<i>Hydrodynamic evaluation of Naissaar Harbour with a phase-resolved coastal wave model</i>	
<i>Wave Run-Up and Overtopping Quantification at Different Coastal Structures</i>	
<i>Numerical simulations of wave breaking over coastal vegetation as a beach protection solution</i>	
<i>Monitoring and Modelling of Coastal Change on a Dissipative Beach on the Southwest Coast of Ireland</i>	
<i>On the mechanism of enhancing renewal time through differential tidal forcing in coastal lagoons</i>	
<i>Accelerating coastal bed evolution predictions utilizing Numerical Modelling and Artificial Neural Networks</i>	
<i>Performance evaluation of the K-Means clustering algorithm for the prediction of annual bed morphological evolution</i>	

## UHH Urban Hydrology and Hydraulics

Luis Mesquita David, LNEC - Laboratório Nacional de Engenharia Civil, Lisboa, Portugal	<i>SINERGEA - Real-time forecasting system for managing floods, bathing water quality and wastewater energy consumption</i>	163
Amin Talei, Discipline of Civil Engineering, School of Engineering, Monash University Malaysia, Subang Jaya, Malaysia	<i>Acoustic Rainfall Sensing in Urban Environment Using Machine Learning</i>	165
Sadegh Partani, University of Bojnord, Bojnord, Iran	<i>Spatiotemporal Variation of Precipitation and Temperature in Iran at the Past Five Decades</i>	167
Erica Orsi, Università degli Studi della Campania Luigi Vanvitelli, Aversa, Italy	<i>The Hydrologic Performance of Green Roofs in Urban Environment: A State-of-the-Art Analysis of Select Literature</i>	169
Ian Guymer, The University of Sheffield, Sheffield, United Kingdom	<i>Predicting mixing in benched surcharged manholes</i>	171
Giuseppe Tito Aronica, Department of Engineering, University of Messina, Messina, Italy	<i>Influence of storm drain inlet locations on urban pluvial flooding hazard at local scale</i>	173
John Sansalone, University of Florida, Gainesville, United States	<i>Optimization of urban drainage clarifier configurations with a CFD-ML tool: DeepXtorm</i>	175
Fabian Funke, University of Innsbruck, Innsbruck, Austria	<i>Common malfunctions in urban drainage and their impact on surface flooding based on an integrated 1D/2D hydraulic model</i>	177
Stefania Anna Palermo, University of Calabria, Rende, Italy	<i>Environmental assessment of a new Green Wall system: experimental results on runoff reduction and nutrients leaching</i>	179
Antonio Lastra, Canal De Isabel II, Madrid, Spain	<i>Development of a warning system for the risk of flooding associated with the urban drainage network</i>	181
Giovanna Grossi, University of Brescia, Brescia, Italy	<i>Modelling the integrated drainage network to support the management of the hydraulic risk: a case study in Northern Italy</i>	183

## FDCC Floods, Droughts and Climate Change

Marcello Arosio, Scuola Universitaria Superiore IUSS Pavia, Pavia, Italy	<i>Indirect impacts: a weak point in the flood risk chain addressed by a graph approach</i>	185
Alessio Radice, Politecnico di Milano, Milan, Italy	<i>A weak point at the geomatics/hydraulics interface: Creating a river model geometry between conflicting needs of a large domain and a high resolution</i>	187
Lisdey Verónica Herrera Gómez, Department of Civil and Environmental Engineering, Politecnico di Milano, Milan, Italy	<i>Flume validation of hydraulic resistance models for arboreal vegetation</i>	189
Antonia Dallmeier, Technical University Munich, Munich, Germany	<i>An Integrative Approach to Hydrological and Hydrodynamic Modelling of Flood Events</i>	191
Leon Frederik De Vos, Technical University Munich, München, Germany	<i>A Simple and Efficient Approach to Automatic Calibration of 2D-Hydraulic Models</i>	193
Yunus Oruc, Alter International Engineering and Consultancy Co., Sarajevo, Bosnia and Herzegovina	<i>Comparing Direct 2D and 1D-2D Coupled Hydraulic Modeling Approaches for Flood Hazard Quantification</i>	195
Sofia Lalikidou, Department of Civil Engineering/Duth, Xanthi, Greece	<i>Comparison of one- and two-dimensional model for possible flood prediction. The case of Kimmeria watershed</i>	197

***FDCC Floods, Droughts and Climate Change***

George Mitsopoulos, Department of Water Resources and Environmental Engineering, School of Civil Engineering, NTUA	<i>Identification of the weak points in the application of a methodology for the design of Flood Early Warning Systems in Climate Change Conditions –The case of the town of Mandra, Attica, Greece</i>	199
Ramesh Teegavarapu, Florida Atlantic University, Boca Raton, United States	<i>Evaluation of Monthly Precipitation and Temperature Trends in the U.S.</i>	201
Theano Iliopoulou, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Greece	<i>A parsimonious approach for regional design rainfall estimation the case study of Athens</i>	203
Hamzah Faquseh, University School for Advanced Studies - IUSS Pavia, Pavia, Italy, University of Brescia, Brescia, Italy	<i>Climate Change indicators: the evolution of the snow cover in Lombardy over the last 15 years</i>	205
Sergio Vicente Serrano, Spanish National Research Council, Zaragoza, Spain	<i>Cross-interactions of ecological and hydrological droughts in the central Spanish Pyrenees</i>	207
Christopher Papadopoulos, Democritus University of Thrace, Alexandroupolis, Greece	<i>A new hybrid fuzzy probabilistic approach for the analysis and classification of meteorological and hydrological drought</i>	209
Athanasios Loukas, School of Rural and Surveying Engineering/ Aristotle University of Thessaloniki, Thessaloniki, Greece	<i>Flood modelling and mapping based on a spatial distributed roughness coefficient estimation framework</i>	211
Igor Leščešen, Department of Geography, Tourism and Hotel Management, Faculty of Sciences, University of Novi Sad, Trg Dositeja, Novi Sad, Serbia	<i>Extreme discharge analysis of the largest river in South-eastern Europe</i>	213
Marco Lompi, Department of Civil and Environmental Engineering, University of Florence, Firenze, Italy, Department of Civil Engineering: Hydraulics, Energy and Environment, Universidad Politécnica de Madrid (UPM), Madrid, Spain	<i>Impact of climate change on the hydraulic risk downstream the Eguí Dam (northern Spain) quantifying flood losses</i>	215
Virginia Rosa Coletta, DICATECh, Politecnico Di Bari, Bari, Italy, Water Research Institute, National Research Council, Bari, Italy	<i>Developing an adaptive strategy for urban flood risk management using a participatory exploratory modelling approach</i>	217
Alessandro Pagano, IRSA-CNR, Bari, Italy	<i>A decision support tool for emergency operations on drinking water supply systems</i>	219
Harm Duel, Deltares, Delft, The Netherlands	<i>New perspectives on droughts under a changing climate: nature- based solutions</i>	221
Carlos Benítez Sanz, Emgrisa, Madrid, Spain	<i>Approaching the valuation of costs and benefits of Nature-based Solutions on climate adaptation against drought</i>	223
Natalia Limones, University of Seville, Spain, Seville, Spain	<i>Insights into siting of sand dams in the Angolan drylands</i>	225
Dimitrios Malamataris, Soil and Water Resources Institute, Hellenic Agricultural Organization “DEMETER”, Sindos, Thessaloniki, Greece	<i>Determining Nature-based Solutions and Key Performance Indicators to address Water – Ecosystem – Food Nexus Challenges in Pinios River Basin, Greece</i>	227
Nicholas M. Georgiadis, Mediterranean Institute for Nature and Anthropos	<i>Traditional stone wells: A green infrastructure to tackle water scarcity in small arid islands</i>	229
Leon Kapetas, Urban Innovative Actions, Belgium	<i>Smart Blue Green roofs of Amsterdam: how drought-proof are they?</i>	231
Denis Istrati, University of Nevada, Reno, United States	<i>Advanced numerical modelling of large debris impact on piers during extreme flood events</i>	233

***FDCC Floods, Droughts and Climate Change***

Aris Psilovikos, Department of Ichthyology & Aquatic Environment, University of Thessaly, Volos, Greece	235
Fotis Sotiropoulos, Mechanical and Nuclear Engineering, Virginia Commonwealth University, USA	237
Georges Kesserwani, University of Sheffield, Sheffield, United Kingdom	239
Evangelos Rozos, Institute for Environmental Research & Sustainable Development, National Observatory of Athens, Athens, Greece	241
Elpida Panagiotatou, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Greece, Athens, Greece	243
Andrew Hogg, University of Bristol, Bristol, United Kingdom	245
Ioanna Zotou, Centre for the Assessment of Natural Hazards and Proactive Planning & Laboratory of Reclamation Works and Water Resources Management, School of Rural, Surveying and Geoinformatics Engineering, National Technical University of Athens, Zografou, Athens, Greece	247
Ino Papageorgaki, National Technical University of Athens, Athens, Greece	249
Andrea Paindelli, Aquatec, Barcelona, Spain	251
Elisa Coraggio, University of Bristol, Bristol, United Kingdom	253
David Jenkins, Department of Physics and Mathematics, School of Science and Technology, Nottingham Trent University, Nottingham, United Kingdom	255
Enrique Soriano Martín, Department of Civil Engineering: Hydraulics, Energy and Environment, Universidad Politécnica de Madrid, Madrid, Spain	257
Dimitrios Konispoliatis, National Technical University of Athens, Zografou, Greece	259
Panayiotis Dimitriadis, National Technical University of Athens, Athens, Greece	261
Vasilis Bellos, Department of Environmental Engineering, Democritus University of Thrace, Xanthi, Greece	263
Georgios Spiliotopoulos, University of Thessaly, Volos, Greece	265
Ioannis Kourtiis, National Technical University of Athens, Zografou, Greece	267
<i>An Integrated Hydrologic/Hydraulic Analysis of the Mediane "Ianos" Flood Event in Kalentzis river basin, Greece</i>	
<i>3D flood flow predictions in large-scale rivers using data-driven physics-informed machine learning algorithms</i>	
<i>Microscopic simulation of human response dynamics during a flood-induced evacuation from a football stadium</i>	
<i>Bayesian coupling of hydrological models for simulation of extreme flood events</i>	
<i>Mathematical Modelling of Nature-Based Solutions for flood risk reduction under Climate Change conditions</i>	
<i>Mathematical models of erosive flash floods, huaycos and lahars</i>	
<i>Sensitivity of a coupled 1D/2D model in input parameter variation exploiting Sentinel-1-derived flood map</i>	
<i>Semi-distributed rainfall-runoff modelling using landscape classification</i>	
<i>LIFE BAETULO Project: an example of Climate Change adaptation to cope with flash floods in urban areas based on a multi-risk Early Warning System</i>	
<i>Hyperparameter tuning in a machine learning prediction model for surface water quality using high-frequency input data</i>	
<i>Slide Model-Invariant Prediction of Landslide-Tsunamis Using Machine Learning</i>	
<i>Impact of climate change on floods and hydrological dam safety with a stochastic rainfall generator and a rainfall-runoff model</i>	
<i>Theoretical Hydrodynamic Formulation for Wave Interactions with Permeable Cylindrical Elements</i>	
<i>Assessing the spatial impact of the skewness-ratio originating from the time irreversibility and long-range dependence of streamflow in flood inundation mapping</i>	
<i>Reconstructing a flood event: collecting field data and numerical modelling</i>	
<i>Effects of nonlinearity on crest dimensions of extreme waves in random seas</i>	
<i>Point-to-pixel comparison of a satellite and a gauge-based Intensity-Duration-Frequency (IDF) curve: The case of Karditsa, Greece</i>	



***FDCC Floods, Droughts and Climate Change***

Kevis Mbonyinshuti, Edf Lnhe, Chatou, France	<i>Improving flooding hazard numerical models through satellite observations</i>	269
Antonija Harasti, University of Zagreb Faculty of Civil Engineering, Zagreb, Croatia	<i>Principal Component Analysis in development of empirical scour formulae</i>	271
Evangelos Findanis, Department of Rural and Surveying Engineering, Faculty of Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece	<i>The implicit information nature of hydrological uncertainty: estimating and detangling components of uncertainty</i>	273
Kevin Flora, Stony Brook University, Stony Brook, United States	<i>The Effect of Vegetation on High-Fidelity Modeling of Natural Rivers</i>	275
Anabela Oliveira, Hydraulics and Environment Department/LNEC, Lisboa, Portugal	<i>A multi-hazard WebGIS platform to share coastal observatories data and model predictions</i>	277
Andreas Tsihrintzis, National Technical University of Athens, Athens, Greece	<i>Drought identification using the DrinC model based on gauge and satellite meteorological data</i>	279
Sarah Dickel, Department of Hydraulic Engineering and Water Resources Management, University of Kassel, Kassel, Germany	<i>Flood mitigation through the combination of barrage management and polder operation</i>	281

**TCEM Theoretical, Computational and Experimental Methods**

Giovanni La Forgia, Department of Civil and Mechanical Engineering, University of Cassino and Southern Lazio, Cassino, Italy	<i>LES investigation on entrainment in intrusive gravity currents interacting with internal solitary waves</i>	283
Aristeidis Bloutsos, Department of Civil Engineering, University of Patras, Patras, Greece	<i>Terminal height predictions of inclined plane negatively buoyant jets</i>	285
Katrin Kaur, Tallinn University of Technology, Tallinn, Estonia	<i>Numerical study of turbulence characteristics of bidirectional flow through a trapezoidal channel</i>	287
Haoran Shi, Ecological Engineering Laboratory (ECOL), Environmental Engineering Institute (IE), Faculty of Architecture, Civil and Environmental Engineering (ENAC), École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland	<i>The surface pattern of unconfined, hyperpycnal river plume plunging</i>	289
Panagiotis Prinos, AUTH, Thessaloniki, Greece	<i>Vegetation effects on natural convection in sloping waterbodies due to solar radiation</i>	291
Maria Rita Maggi, Department of Engineering, Roma Tre University, Rome, Italy	<i>Gravity currents flowing over roughness elements</i>	293
Maria Rita Maggi, Roma Tre University, Roma, Italy	<i>Gravity currents flowing down a non-uniform slope</i>	295
Andrew Hogg, University of Bristol, Bristol, United Kingdom	<i>The motion of gravity currents that simultaneously flow on and drain from a step</i>	297
Angelos Kokkinos, Hydraulics laboratory, Department of Civil Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece	<i>Numerical experiments of asymmetric gravity currents collision with LES</i>	299
Alan Cuthbertson, School of Science and Engineering, University of Dundee, Dundee, United Kingdom	<i>Experimental Study of Multiple Turbidity Currents and Their Deposits in Response to a Simultaneous Slope Break and Loss of Confinement</i>	301
Jacopo Busatto, Roma Tre University, Roma, Italy, Institute of Marine Science, National Research Council, Rome, Italy	<i>Atmosphere – Ocean interaction in the Agulhas Current Region</i>	303

**TCEM Theoretical, Computational and Experimental Methods**

Janek Laanearu, School of Engineering, Tallinn University of Technology, Tallinn, Estonia	<i>Hydraulic modelling of interfacial processes for two-layer maximal exchange</i>	305
Alan Cuthbertson, University of Dundee, Dundee, United Kingdom	<i>Numerical simulations of density-driven exchange flows generated across a submerged trapezoidal sill-channel</i>	307
Łukasz Przyborowski, Institute of Geophysics Polish Academy of Sciences, Warszawa, Poland	<i>Experiments on macroplastic storage in rivers with spur dikes</i>	309
Luca Solari, Department of Civil and Environmental Engineering - University of Florence, Firenze, Italy	<i>Investigation of plastic presence in the river sediment of the Arno River (Italy)</i>	311
Lara Valentić, Research Centre of the Slovenian Academy of Sciences and Arts, Ljubljana, Slovenia	<i>Presence of microplastics in two karst springs for drinking water in Slovenia</i>	313
Yannick Fuchs, Technical University of Munich (TUM), Walchensee, Germany	<i>Using Drum Screen Units to Stop Transported Macroplastics in Rivers</i>	315
Alexandra Murray, DHI A/S, Hørsholm, Denmark	<i>Freshwater Macroplastic Transport Based on Global Hydrological Modelling</i>	317
Francesco Coscarella, Dipartimento di Ingegneria Civile, Università della Calabria, Rende (CS), Italia	<i>Estimation of the energy dissipation rate with the Kolmogorov 4/5-law in turbulent flows on gravel beds</i>	319
Hendrik Jongbloed, Wageningen University, Delft, The Netherlands	<i>Fitting tidal models to cross-sectional ADCP data in estuarine environments</i>	321
Serhat Kucukali, Hacettepe University, Ankara, Turkey	<i>Monitoring Fish Passage Hydrodynamics with Hydroacoustic Measurement Techniques: A Case Study for Çataloluk Small Hydropower Plant in Turkey</i>	323
Irene Cavallieri, Department of Civil Engineering, University of Ferrara, Ferrara, Italy	<i>Flow field investigation by means of ADCP for the evaluation of hydropower propellers installed at open channel</i>	325
Stéphane Fischer, Ubertone, Schiltigheim, France	<i>A new hyperband acoustic profiler - Suspended particulate matter monitoring in the river in France, example on the Rhône and Isère river</i>	327
Arianna Varrani, Institute of Geophysics PAS, Warsaw, Poland	<i>Measuring near-bed flow field in shallow quasi-uniform flow conditions with the use of an Ultrasonic Velocity Profiler</i>	329
Aristotelis Mavrommatis, National Technical University of Athens, Athens, Greece	<i>Velocity Distribution Above Different Types of Simulated Vegetation</i>	331
Bart Vermeulen, Wageningen University, Wageningen, The Netherlands	<i>Dealing with temporal and spatial variations in specific sediment attenuation for ADCP based suspended sediment estimates</i>	333
Sándor Baranya, Budapest University of Technology and Economics, Budapest, Hungary	<i>Bedload transport assessment with ADCP in a large gravel bed river</i>	335
Flóra Pomázi, Department of Hydraulic and Water Resources Engineering, Faculty of Civil Engineering, Budapest University of Technology and Economics, Budapest, Hungary	<i>Assessment of acoustic features of clay-silt suspended sediment from numerous observed particle size distributions and dual-frequencies</i>	337
Zhangjie Peng, Department of Civil and Structural Engineering, The University of Sheffield, Sheffield, UK	<i>Disaggregation Phenomena in Mixing Processes During Laminar-Turbulent Acceleration in Pipe Flows</i>	339
Denis Istrati, University of Nevada, Reno, Reno, United States	<i>Creative experimental testing of transient tsunami bore impact on a realistic skewed bridge</i>	341

**TCEM Theoretical, Computational and Experimental Methods**

Eugene Retsinis, National Technical University of Athens, Athens, Greece	343
James Yang, Vattenfall AB, R&D Hydraulic Laboratory, Stockholm, Sweden, Civil and Architectural Engineering, Royal Institute of Technology, Stockholm, Sweden	345
Olivier Eiff, Karlsruhe Institute of Technology, Karlsruhe, Germany	347
Olivier Eiff, Karlsruhe Institute of Technology, Institute for Hydromechanics, Karlsruhe, Germany	349
Steven Weijis, University of British Columbia (ubc), Vancouver, Canada	351
Vasilis Bellos, Department of Environmental Engineering, Democritus University of Thrace, Xanthi, Greece, School of Civil Engineering, National Technical University of Athens, Athens, Greece	353
Hung Tao Shen, Clarkson University, South Burlington, United States	355
Susanna Dazzi, Department of Engineering and Architecture, University of Parma, Parma, Italy	357
Georgios Vagenas, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Athens, Greece; Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research (HCMR), Athens, Greece	359
Saba Mirza Alipour, University of Agder, Grimstad, Norway	361

**WREM Water Resources and Energy Management**

Kennedy Costa Da Conceicao, Universidad De Santiago De Chile, Santiago, Chile	363
Nena Ioannidou, School of Engineering, Civil Engineering Department, Democritus University of Thrace, Xanthi/Kimmeria, Greece	365
Daisuke Nohara, Kajima Technical Research Institute, Chofu, Japan	367
Ierotheos Zacharias, Department of Civil Engineering, University of Patras, Patras, Greece	369
Luisa Fernanda Uribe Laverde, Universidad Nacional Abierta y A Distancia UNAD, Bogotá, Colombia	371

**WREM Water Resources and Energy Management**

Markus Reisenbüchler, Technical University of Munich, Munich, Germany	<i>Integration of small-scale hydropower in water management: A case study from Shakimardan, Uzbekistan</i>	373
Meysam Majidi Nezhad, Department of Astronautical Electrical and Energy Engineering (DIAEE), Sapienza University of Rome, Rome, Italy	<i>Digital Twins for Ports Facilities Management</i>	375
Achilleas Samaras, Department of Civil Engineering, Democritus University of Thrace, Xanthi, Greece	<i>Towards integrated modelling of Watershed-Coast System morphodynamics in a changing climate: A critical review from a coastal engineering perspective</i>	377
Panagiota Keramea, Democritus University of Thrace, Xanthi, Greece	<i>Operational Oil Spill modeling forced by real-time met-ocean forecasts: A hypothetical scenario for the North Aegean Sea</i>	379
Paraschos Melidis, Democritus University of Thrace, Xanthi, Greece	<i>Heavy metals monitoring along the Laspias and Lissos Rivers</i>	381
Georgios Sylaios, Democritus University of Thrace, Xanthi, Greece	<i>Assessing the Coastal Erosional Processes in Strymonikos Gulf (Northern Greece) by blending satellite imagery with observed and simulated waves</i>	384
Georgios Sylaios, Laboratory of Ecological Engineering and Technology, Department of Environmental Engineering, Democritus University of Thrace, Xanthi, Greece	<i>C2RCC algorithm recalibration for the assessment of Chlorophyll-a concentration in shallow coastal lagoons</i>	386
Aristeidis Bloutsos, University of Patras, Patras, Greece	<i>Modelling Sediment Diffusion during the construction of the EAST-MED POSEIDON Natural Gas Pipeline</i>	388
Athanasios Serafeim, Department of Civil Engineering, University of Patras, Patras, Greece	<i>Leakage estimation and optimal sizing of pressure management areas using probabilistic and hydraulic modeling tools: Application to the water distribution network of the Historical Center of Patras.</i>	390
Nikos Mellios, University of Jijel, Jijel, Algeria	<i>Bayesian hierarchical modelling as a tool to assess lakes suitability for recreational use</i>	392
Rita Carvalho, University of Coimbra, Coimbra, Portugal	<i>Hydraulic Manifold Flow Problem: Analytical and Numerical Solutions</i>	394
Panagiotis Kossieris, National Technical University of Athens, Athens, Greece	<i>FIWARE-enabled smart solution for the optimal management and operation of raw-water supply hydraulic works</i>	396
Miltiadis Gymnopoulos, National Technical University of Athens, Athens, Greece	<i>Setting the basis of a Smart Platform for the Systematic Monitoring and Control of the Water Supply Network of Tilos Island</i>	398
Armando Di Nardo, Università della Campania Luigi Vanvitelli, Aversa, Italy	<i>SWANP 4.0: a novel release of software for water network analysis, partitioning and protection of water distribution networks</i>	400
Georgia-Konstantina Sakki, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Athens, Greece	<i>Stress-testing for water-energy systems by coupling agent-based models</i>	402
Luís Mesquita David, LNEC - Laboratório Nacional de Engenharia Civil, Lisboa, Portugal	<i>SINERGEA - Energy: Modelling energy consumption in wastewater systems during rainfall events</i>	404
Aris Psilovikos, Department of Ichthyology & Aquatic Environment (DIAE), University of Thessaly, Volos, Greece	<i>Average hyper-annual rainfall as a regional variable in Central Macedonia: use of a geostatistical approach to identify areas with drought trends</i>	406
Konstantinos Katsifarakis, Aristotle University of Thessaloniki, Thessaloniki, Greece	<i>Optimal management of wedge-shaped aquifers using genetic algorithms</i>	408

**WREM Water Resources and Energy Management**

Nikos Pelekanos, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Athens, Greece	Identifying water consumption profiles through unsupervised clustering of household timeseries: the case of Attica, Greece	410
Caterina Capponi, Department of Civil and Environmental Engineering, University of Perugia, Perugia, Italy	Laboratory simulation of transients in looped water distribution network	412
Modesto Pérez-Sánchez, Universitat Politècnica De València, Valencia, Spain	The sustainable development goals are linked with the improvement of a wastewater treatment plant. A case study in Spain	414
Petra Amparo López-Jiménez, Universitat Politècnica De València, Valencia, Spain	Do urban water systems contribute to compliance of the SDGs?: case studies in Eastern Spain	416
Alexandra Ioannou, Civil Engineering Department, University of Thessaly, Volos, Greece	Systemic Resilience Analysis through a Water-Energy-Food-Climate Nexus Approach	419
Eleni Fotopoulou, School of Civil Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece	A HEC-HMS model for the Aliakmon River digital twin	421
Despoina Charchousi, National Technical University of Athens, Athens, Greece	Synergies between ecosystem services and land uses: Preliminary assessment results	423
Giorgos Mitsopoulos, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Athens, Greece	Modelling fish movement trajectories in rivers	425
Kennedy Costa Da Conceicao, Universidad De Santiago De Chile, Santiago, Chile	Removal of irgasan, ibuprofen, amoxicillin and paracetamol from water using organic residues under a bibliometric-statistical analysis	427
Azin Amini, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland	Experimental investigations on plunge pool protection measures for Ilarion Dam in Greece	429
Mike Spiliotis, Department of Civil Engineering, School of Engineering, Democritus University of Thrace, 671 00 Xanthi, Greece	Assessment of a Precipitation- Runoff relation based on a new fuzzy adaptive regression	431

**POSTER PRESENTATIONS**

Gabriel Ibarra-Berastegi, University Of the Basque Country, Bilbao, Spain	Future water availability in the Iberian Peninsula according to the CMIP6 projections: How to teach water engineers to make the calculations?	433
Hannah Schwedhelm, Chair of Hydraulic and Water Resources Engineering, Technical University Munich, Munich, Germany	Macro Meets Meso: Evaluation of Fish Mesohabitat in Rivers in the Context of Macrohabitat Regions	435
Alicia Sanz-Prat, Research Institute of Water and Environmental Engineering, Universitat Politècnica de València, Valencia, Spain	Identification of the kind of sorption isotherm and its parameters by a Bayesian formulation of the Ensemble Kalman Filter	437
Alexandros Kotsovos, Rural, Surveying and Geoinformatics Engineering/National Technical University of Athens, Athens/Zographou, Greece	Performance evaluation of urban storm drainage systems under rare rainfall events: The example of the city of Argos, Argolis region, Greece	439
Gabriele Farina, DICATAM, University of Brescia, Brescia, Italy	A simple method for the enhancement of river bathymetry in LIDAR DEM	441
Evgenia Kolttsida, National Technical University of Athens, Athens, Greece	Hydrological modeling in experimental catchment in urban and peri-urban environments	443

**POSTER PRESENTATIONS**

Igor Ljubenkov, Water Development Ltd., Split, Croatia	<i>Floods of Dinaric karst fields: case studies from Dalmatia (Croatia)</i>	445
Vito Bacchi, National Laboratory for Hydraulics and Environment, EDF R&D, France	<i>Towards a methodical approach for modelling runoff during extreme rainfall events on large catchment using 2D Shallow Water Equations</i>	447
Ioannis Kourtis, National Technical University of Athens, Zografou, Greece	<i>A Multi-Criteria Analysis Framework for Assessment of Nature-Based Solutions (NbS)</i>	449
Zhiwei He, University of Cambridge, Cambridge, United Kingdom	<i>Influence of urban pattern on rainfall-runoff processes</i>	451
Natalia Limones, University of Seville, Spain, Seville, Spain	<i>Traditional Nature-based Solutions for rural drought resilience in the Cuvelai basin, Angola. How surface water monitoring can support better decision-making and management.</i>	453
Elissavet Feloni, School of Civil Engineering, National Technical University of Athens, Iroon Polytechniou 5, 15780, Greece,	<i>Rainfall intensity – duration patterns for flood occurrence in Attica region</i>	455
Apollon Bournas, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Athens, Greece	<i>Implementation of the Gridded Flash Flood Guidance Method in the Mandra Basin in west Attica, Greece</i>	457
Nils Ruther, NTNU (Norwegian University of Science and Technology, Trondheim, Norway	<i>Investigating velocity fluctuation by means of ADV at compound channel with installed hydropower propeller turbines</i>	459
Chit Yan Toe, Delft University of Technology, Delft, The Netherlands	<i>Physical aspects of modelling for plastic debris motion in the disturbed flow</i>	461
Maria Ponce, Institute for Modelling Hydraulic and Environmental Systems, University Stuttgart, Stuttgart, Germany	<i>Effects of microplastic particles on cohesive sediment erosion</i>	463
Massimo Guertero, University of Bologna, Italy	<i>Gauging suspended sediment concentration in coastal waters by means of proxy acoustical methods</i>	465
Claudia Adduce, Roma Tre University, Rome, Italy, National Research Council - Research Institute of Marine Science, Rome, Italy	<i>River-Sea System Connectivity: Analysis of River Plume Dispersal in the Northern Adriatic Sea</i>	467
Maria Fernanda Sobierajski Gisi, Université Lyon, INSA Lyon, DEEP, Villeurbanne, France, The University of Melbourne, Melbourne, Australia, Université Lyon CNRS UMR 5600 Environnement Ville et Société, Lyon, France	<i>Low-cost turbidimeter: from the washing machine to the research field</i>	469
Alessandro Pagano, IRSA-CNR, Bari, Italy	<i>Using Participatory System Dynamics Modelling for analyzing Water-Energy-Food Nexus resilience: the Lower Danube case study</i>	471
Anastasios Perdios, Department of Civil Engineering, University of Patras, Patras, Greece	<i>Detection of pressure regulation malfunctions and issuance of alerts in water distribution networks</i>	473
Angeliki Vlassopoulou, National Technical University of Athens, School of Mining and Metallurgical Engineering, Athens, Greece	<i>Groundwater Modelling of Managed Aquifer Recharge facilities for the optimal management of coastal aquifer systems</i>	475
Athanasios-Foivos Papanthanasiou, National Technical University of Athens, Athens, Greece	<i>Evaluation of an HRES using pumped-storage or hydrogen storage for water and energy demands in Skyros island</i>	477
Athanasios Loukas, School of Rural and Surveying Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece	<i>An Integrated Climate Change Assessment of Water Resources of Coastal Agricultural Watersheds: The case of Almyros Basin, Greece</i>	479

## Relation of the observed water level decrease and morphological changes of the river channel in the middle Danube

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### ABSTRACT

This work is a continuation of works by Goda et al. (2007) and Tamás et al. (2021) that were prompted by the drying of floodplains and problems in the water supply of irrigation and drainage canal networks in the whole middle Danube region. Previous works focused on hydrology and showed a constant lowering of water levels, which indicated the deepening of the riverbed. In the present study, the relationship between indicators of morphological changes and the decrease in low water levels at Gauging Stations (GS) is sought. At this stage, results confirm a continuous deepening of the riverbed. Despite small correlation coefficient values between low water levels ( $Z_{\min}$ ) and percentage increase in the cross-sectional areas in the sand bed part of the investigated reach, the linear decreasing trend in  $Z_{\min}$  is evident.

### 1. Morphological data

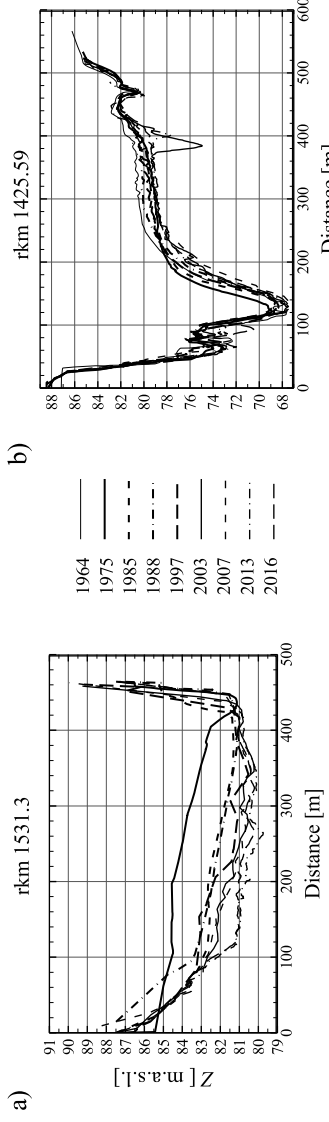
The datasets for this study were provided by the Directorate for Inland Waterways in Serbia and the Lower Danube-valley Water Authority in Hungary. These include cross-sectional data either of the regularly surveyed, inventory cross-sections of the two authorities or at GSs' locations along the 300 km long reach from river km (rkm) 1560 (Dunaföldvár, Hungary) to rkm 1255 (Novi Sad, Serbia). In 60 years, there are seven comparable bathymetric surveys for both countries. The data from older surveys were available only in the paper as either depth maps or cross-sections, so they were digitized. In the case of depth maps, cross-sections were extracted after the digitization of the map. In newer surveys, cross-sections were recorded digitally, using an echo sounder synchronized in operation with an RTK GPS.

After the conformance of the datums in the two countries, the cross-sections were plotted in AutoCAD software. To provide a common ground for comparisons along the investigated reach, a reference water level was adopted. *Étage Navigable* (EN), defined by the Danube Commission in 2012 for each GS, was increased by 2 m. Such a choice of the reference water level is based on visual observations of each cross-section, and it is justified by the fact that this water level (EN + 2 m) is close to bank full level but remains within the main channel. A cross-sectional area below EN + 2 m was then chosen as a starting point for the analysis of the riverbed incision.

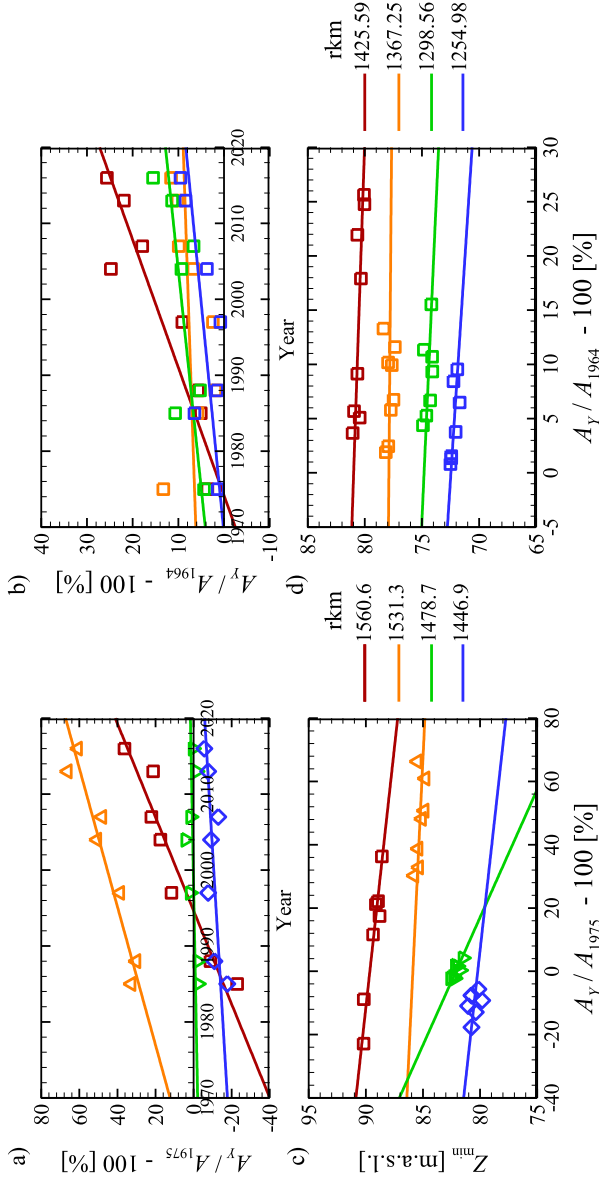
### 2. Results

The evolution of the two chosen cross-sections is presented in Fig.1. The incision may be due to a negative sediment balance caused by river regulation works with cutoffs at the end of the 19th century, extensive dredging in the 20th century and the construction of several Hydro Power Plants in the upstream reaches (Habersack et al. 2019).

Figure 2 shows the percentages of cross-sectional area changes and the correlation between these changes and the minimum water levels at GSs along the Middle Danube River reach. It is readily noticeable that the cross-sectional areas are constantly increasing (Figs. 2a, b). This increase correlates to the decrease in minimum water levels at each GS (Figs. 2c, d). The percentage increase in the cross-sectional area, when compared to the first survey, changes at the rate of 1.6% yearly at the upstream end of the reach to 0.16% yearly at the downstream end (Table 1). The linear decreasing trend in  $Z_{\min}$  is evident from Figs. 2c, d.



**Fig. 1.** Cross-sections evolution at a) GS Paks and b) GS Bezdan; at GS Paks bathymetric data are available from 1975 and for GS Bezdan from 1964.



**Fig. 2.** Percentages of cross-sectional area changes a) and b) with reference to the initial survey ( $A_Y/A_{ref}-100$ ) and the correlation of minimum water levels and percentages of cross-sectional area changes c) and d) at gauging stations in the Middle Danube River reach.  $A_Y$  is the cross-sectional area in any year,  $A_{1975}$  and  $A_{1964}$  are reference cross-sectional areas ( $A_{ref}$ ) for the first survey in Hungary and Serbia, respectively.

**Table 1.** Rates of increase in the cross-sectional area with reference to the first survey  $A_Y / A_{ref} - 100 = a \text{ Year} - b$ , reference years (ref) are 1975 for GSs in Hungary and 1964 for GSs in Serbia

Name of GS and river km	a	b	Name of GS and river km	a	b
Dunaföldvár, rkm 1560.60	1.62	3239.6	Bezdan, rkm 1425.59	0.59	1172.1
Paks, rkm 1531.30	1.10	2149.8	Bogojevo, rkm 1367.25	0.27	526.51
Baja, rkm 1478.70	0.08	152.36	Bačka Palanka, rkm 1298.56	0.17	339.07
Mohács, rkm 1446.90	0.24	489.29	Novi Sad, rkm 1254.98	0.16	323.13

### 3. Conclusions

With the present study of the morphological changes in the middle Danube, the incision along the entire reach is proven by the increase in cross-section areas. The rate of change of the cross-sectional area decreases going downstream, which corresponds to the findings for the water level decrease in Tamás et al. (2021).

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