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Editorial

Modern Developments in Flood Modelling

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1. Introduction

Flood modelling is among the most challenging scientific task because it covers a wide area of complex physical phenomena associated with highly uncertain and non-linear processes where the development of physically interpretive solutions usually suffers from the lack of recorded data.

The objective of the Special Issue, titled "Modern Developments in Flood Modelling", is to define and discuss several related topics, aiming to provide new insights within the geoscientific domain on the use of new remote sensing datasets in the service of flood modelling, on new methodologies addressing complex problems such as joint probability theory and rainfall maximum modelling at different temporal scales, and on strategies for reproducing catastrophic events in data-scarce areas and modelling flood risk with new tools in coastal areas.

This Special Issue comprises thirteen contributions tackling the above-mentioned goals. Our issue received a high number of diverse submissions, with an 82% acceptance rate.

2. Contributed Papers

The articles in this Special Issue address a wide variety of topics reflecting the challenges mentioned above. Their details are briefly presented below.

The paper "Regional Ombrian Curves: Design Rainfall Estimation for a Spatially Diverse Rainfall Regime" [1] by Theano Iliopoulou, Nikolaos Malamos and Demetris Koutsoyiannis demonstrates new insight in modelling regional ombrian curves (I.D.F curves) by providing a new parsimonious model of the extreme rainfall properties at any point in a given area. The curves were constructed following a newly revisited mathematical formulation of single-site curves coupled with a new regionalization approach. The results showed that the model efficiently captures the spatial variability of extreme rainfall in the area, covering scales from 5 min to 48 h.

The paper "Forensic Hydrology: A Complete Reconstruction of an Extreme Flood Event in Data-Scarce Area" [2] by Aristoteles Tegos, Alexandros Ziogas, Vasilis Bellos and Apostolos Tzimas presents a state-of-the-art approach to reconstructing catastrophic flooding events in data-scarce areas. The study focused on the recent catastrophic flooding event, namely medicane Ianos, which substantially affected the town of Karditsa, Greece. A rainfall–runoff CN-unit hydrograph model was combined with a hydrodynamic model based on a 2D shallow water equations model. Having used numerous remote sensing rainfall datasets along with satellite flooding footage and videos posted to social media sites such as Facebook, the catastrophic event was reconstructed efficiently in a high-complexity area associated with low-lying flooding fluvial and pluvial water paths.

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The paper "Predicting Urban Flooding Due to Extreme Precipitation Using a Long Short-Term Memory Neural Network" [3] by Raphaël A. H. Kilsdonk, Anouk Bomers and Kathelijne Wijnberg presents a long short-term memory (LSTM) neural network model to predict flood time series at 230 manhole locations present in the sewer system of the city of Amersfoort. According to the authors, it is the first time that an LSTM was applied to such a large sewer system in addition to a wide variety of synthetic precipitation events in terms of precipitation intensity. It was concluded that the LSTM could accurately predict the timing and volume of flooding for the large number of manholes for historic precipitation events and that the LSTM was able to reduce forecasting times, demonstrating the applicability of using this methodology as an early flood-warning system in urban areas.

The paper "Flood Exposure of Residential Areas and Infrastructure in Greece" [4] by Stefanos Stefanidis, Vasileios Alexandridis and Theodora Theodoridou exhibits the first nationwide spatial assessment of flood exposure in residential areas and infrastructures in Greece. Spatial analysis and open access data were used to illustrate the variations in flood exposure. The ratio of the urban fabric, transportation and social, industrial and commercial infrastructures in 100-year flood zones was evaluated, as well as the spatial pattern of the exposure. Based on the authors' view, the proposed methodology could serve as a roadmap for integrated flood risk assessment, as the results can be easily overlaid with other spatial data for further analysis.

The paper "Identifying Modelling Issues through the Use of an Open Real-World Flood Dataset" [5] by Vasilis Bellos, Ioannis Kourtis, Eirini Raptaki, Spyros Handrinos, John Kalogiros, Ioannis Sibetheros and Vassilios Tsihrintzis deals with the reconstruction of the flood wave that hit the town of Mandra (Athens, Greece) on 15 November 2017. The flash flood event was caused by a huge storm which was part of the Medicane Numa-Zeno. The works used in the reconstruction were associated with (a) the post-event collection of 44 maximum water depths and (b) hydrodynamic simulation employing the HEC-RAS and MIKE FLOOD software. Calibration strategies in computationally demanding cases were considered, and whether the calibrated parameters can be blindly transferred to another simulator (informed modeling) was tested.

The paper "Differentiated Spatial-Temporal Flood Vulnerability and Risk Assessment in Lowland Plains in Eastern Uganda" [6] by Godwin Erima, Isa Kabenge, Antony Gidudu, Yazidhi Bamutaze and Anthony Egeru was developed to map flood inundation areas along the Manafwa River, Eastern Uganda, using HEC-RAS integrated with SWAT models. The aim was to evaluate the predictive capacity of SWAT by comparisons with streamflow observations and to derive, using HECRAS, the flood inundation maps. The overall outcome demonstrated the benefits of combined modeling systems in predicting the extent of flood inundation.

The paper "Numerical and Physical Modeling of Ponte Liscione (Guardialfiera, Molise) Dam Spillways and Stilling Basin" [7] by Monica Moroni, Myrta Castellino and Paolo De Girolamo provides new insights into dam-related studies by combining computational fluid dynamics and physical models. The work deals with the 1:60 Froude-scaled numerical model of the Liscione (Guardialfiera, Molise, Italy) dam spillway and the downstream stilling basin. The model was scaled according to the Froude number, and fully developed turbulent flow conditions were reproduced at the model scale. From the analysis of the results of both the physical and the numerical models, it was found that the stilling basin is undersized with a significant impact on the erodible downstream river bottom in terms of scour depths.

The paper "Wetland Vulnerability Metrics as a Rapid Indicator in Identifying Nature-Based Solutions to Mitigate Coastal Flooding" [8] by Narcisa Gabriela Pricope and Greer Shivers presents a rapid method to quantify changes in ecosystem dynamics with the use of wetland vulnerability assessments to prioritize potential locations for NBS implementation. Exposure risk using 100- and 500-year special flood hazard areas, 1–10 ft of sea level rise scenarios and high-tide flooding and sensitivity using time series analyses of Landsat 8-derived multispectral indices were quantified. The work underlines the critical importance of conserving or restoring brackish and freshwater marshes and swamp forests, even though they represent a minority of the wetland types present in the highly populated Atlantic Coastal Plain region.

The paper "Trivariate Joint Distribution Modelling of Compound Events Using the Nonparametric D-Vine Copula Developed Based on a Bernstein and Beta Kernel Copula Density Framework" [9] by Shahid Latif and Slobodan Simonovic demonstrates the use of a D-vine copula in the nonparametric fitting procedure to model trivariate joint probability analyses of storm surges, river discharge and rainfall in compound flood risk assessments. A trivariate distribution can demonstrate the risk of compound phenomena more realistically, such as storm surges, rainfall and river discharge, rather than considering each contributing factor independently or in pairwise dependency relations. This work introduced the vine copula approach in a nonparametric setting by introducing Bernstein and Beta kernel copula density in establishing trivariate flood dependence.

The paper "Assessing the Impact of the Urban Landscape on Extreme Rainfall Characteristics Triggering Flood Hazards" [10] by Yakob Umer, Victor Jetten, Janneke Ettema and Gert-Jan Steeneveld presents a configuration of the WRF model developed for the city of Kampala, Uganda. The use of the WRF model to study the deep convection over Kampala required a special configuration, which requires the proper position and extent of the city in order to better consider the spatial contrast between the city and Lake Victoria. The study provides an explicit and alternative satellite-derived urban fraction in the WRF model. The study contributes to the emerging understanding of the usability of high-resolution urban fractions from remote sensing images to properly account for the impact of urban heterogeneity on extreme rainfall events.

The paper "Water Level Forecasting in Tidal Rivers during Typhoon Periods through Ensemble Empirical Mode Decomposition" [11] by Yen-Chang Chen, Hui-Chung Yeh, Su-Pai Kao, Chiang Wei and Pei-Yi Su demonstrates a parsimonious model that performs ensemble empirical mode decomposition (EEMD) and stepwise regression to forecast the water level of a tidal river. The proposed model is conceptually simple and highly accurate, providing reliable forecasts for a given location 1 h ahead using the observed ocean components at the down-stream gauging stations and the corresponding stream component the water stages at the upstream gauging stations.

The paper "Evaluation of Various Resolution DEMs in Flood Risk Assessment and Practical Rules for Flood Mapping in Data-Scarce Geospatial Areas: A Case Study in Thessaly, Greece" [12] by Nikolaos Xafoulis, Yiannis Kontos, Evangelia Farsirotou, Spyridon Kotsopoulos, Konstantinos Perifanos, Nikolaos Alamanis, Dimitrios Dedousis and Konstantinos Katsifarakis investigated flood modelling sensitivity against geospatial data accuracy using the following DTM resolutions in a mountainous river sub-basin of Thessaly's Water District (Greece): (a) open 5 m and (b) 2 m data from Hellenic Cadastre (HC) and (c) 0.05 m data from a topographical mission using an unmanned aerial vehicle (UAV). RAS-Mapper and HEC-RAS were used for 1D (steady state) hydraulic simulation regarding a 1000-year return period. The flood modelling results were analyzed via a statistical analysis based on the correlation matrix presenting linear relationships between input data variables (i.e., elevation, slope, sinuosity ratio) and cross section-specific results, including flow characteristics (i.e., Froude number, hydraulic radius), flood extents and flow depths. The correlation results indicated strong linearities, namely riverbed elevations vs. cross-section ID numbers, and weaker linearities (e.g., riverbed elevations and hydraulic radii and Froude number vs. flood extents).

The paper "CoastFLOOD: A High-Resolution Model for the Simulation of Coastal Inundation Due to Storm Surges" [13] by Christos Makris,, Zisis Mallios, Yannis Androulidakis and Yannis Krestenitis demonstrates a new numerical code (CoastFLOOD) with high-resolution (5 m $\times$ 5 m) raster-based, storage-cell modelling of coastal inundation via Manning-type equations in a decoupled 2D formulation at local-scale (20 km $\times$ 20 km) lowland littoral floodplains. The new model is based on the well-established LISFLOOD model and uses outputs of either regional-scale storm surge simulations or satellite altimetry data for sea level anomalies. The presented case studies demonstrated model applications at 10 selected coastal sites of the Ionian Sea (east-central Mediterranean Sea) and confirm the capability of the new model to reproduce past flooding events.

3. Conclusions

Since we have been conducting research in the field of flooding for more than a decade, and considering the remaining challenges within flooding assessment research, this Special Issue was a great opportunity to discover ideas and promote new techniques across the geosciences community.

As Guest Editors, we are enthusiastic about the successful completion of the SI, as it presents highly diverse and valuable works. We trust that the selected research papers will be a valuable contribution to the domain of geosciences in the years to come.

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