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Editorial

Advances in Large-Scale Flood Monitoring and Detection

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Received: 28 August 2018; Accepted: 30 August 2018; Published: 3 September 2018

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Abstract: The last decades have seen a massive advance in technologies for Earth observation (EO) and environmental monitoring, which provided scientists and engineers with valuable spatial information for studying hydrologic processes. At the same time, the power of computers and newly developed algorithms have grown sharply. Such advances have extended the range of possibilities for hydrologists, who are trying to exploit these potentials the most, updating and re-inventing the way hydrologic and hydraulic analyses are carried out. A variety of research fields have progressed significantly, ranging from the evaluation of water features, to the classification of land-cover, the identification of river morphology, and the monitoring of extreme flood events. The description of flood processes may particularly benefit from the integrated use of recent algorithms and monitoring techniques. In fact, flood exposure and risk over large areas and in scarce data environments have always been challenging topics due to the limited information available on river basin hydrology, basin morphology, land cover, and the resulting model uncertainty. The ability of new tools to carry out intensive analyses over huge datasets allows us to produce flood studies over large extents and with a growing level of detail. The present Special Issue aims to describe the state-of-the-art on flood assessment, monitoring, and management using new algorithms, new measurement systems and EO data. More specifically, we collected a number of contributions dealing with: (1) the impact of climate change on floods; (2) real time flood forecasting systems; (3) applications of EO data for hazard, vulnerability, risk mapping, and post-disaster recovery phase; and (4) development of tools and platforms for assessment and validation of hazard/risk models.

Keywords: hydroinformatics; flood mapping; flood monitoring; floodplains; rivers dynamics; DEM-based methods; geomorphology; data scarce environments

Introduction to the Special Issue

The impact of flooding is becoming increasingly pressing worldwide for several reasons [1,2]. Population growth, urbanization in alluvial areas, land use change and climate change are only some of the key factors impacting on a potential growth of floods risk. Therefore, the international community is struggling to better understand the dynamics of floods in order to provide proper planning, management and real-time forecasts.

One of the most disputed aspects is certainly climate change, whose impact is controversial and difficult to quantify. On the other hand, the steady growth of impervious surfaces and reduction of forested areas produces an undoubted increase of floods. Moreover, the exponential expansion of urban areas, frequently placed nearby rivers, makes this issue even more complex (e.g., [3,4]). Therefore, there is a huge need for new modelling applications in order to quantify and forecast floods and also to evaluate the impact of such events.

Recent studies have offered a number of innovative strategies in order to support the derivation of flood quantiles (e.g., [5–7]); to provide large scale flood mapping with simplified procedures applicable also in data scarce environments [8–16], to support flood risk management over large scales [17,18] and also to improve flood inundation monitoring with new remote sensing algorithms or exploiting social media (e.g., [19–21]). All these topics are crucial to advance our capacity to cope with floods in a changing environment.

The present special issue was promoted with the aim to provide an overview on the experiences that researchers from different parts of the world have on large scale flood monitoring, prediction and risk. The collection of papers selected introduces several these aspects, presenting novel techniques, reviews and case studies. In the following, we summarize the contents of each specific manuscript and its contribution to the topic.

The first manuscript is the one by Perera et al. [22], that explores the changes of flood impact in future climatic scenarios. The authors modelled the entire hydrological system of the Mekong basin with the TOPMODEL (BTOP) hydrological model at 20 km resolution, and the Lower Mekong Basin (LMB) area with a rainfall-runoff-inundation (RRI) model at 2 km resolution. This latter model was used to specifically analyze floods under the aforementioned climatic conditions in order to support flood management and water policy of the LMB.

The impact of climate change on rainfall statistics is introduced in the manuscript by De Paola et al. [23], which analyzed historical and projected time series of two African cities, Dar Es Salaam (TZ) and Addis Abeba (ET). The authors showed that both time series have non-stationary behavior that should be considered for engineering applications.

An important and relevant research subject is related to flood risk in ungauged basins or large scales that share the common problem of data unavailability. In this regard, an interesting contribution is presented by Ekeu-wei and Blackburn [24], who outlined a review of flood modelling and mapping processes, and the data required by these techniques. They also offer an analysis about potentials, limits and uncertainties of currently available remotely sensed datasets, highlighting how essential these open-access datasets are especially in ungauged basins of developing countries.

The problem of flood management on large metropolitan areas is also tackled also by Moufar et al. [25]. They investigate the feasible countermeasures to mitigate the floods in the Metro Colombo area providing baseline for future flood risk management and mitigation in the area. It must be mentioned that the studied area is a densely populated area of the world (with approximately 3400 inhabitants per square kilometer).

On a similar note, Papaioannou et al. [26] propose a methodological approach for implementing the EU Floods Directive in ungauged basins, with a specific focus on relatively small catchments mainly affected by fluvial flash floods. The proposed approach was applied on the Volos metropolitan area (central Greece) and validated against the flood event of 9 October 2006, using observed flood inundation data. Results highlighted that although typical engineering practices for ungauged basins introduced major uncertainties in flood risk management in urban areas, the hydrological experience may counterbalance the missing information ensuring quite realistic outcomes.

In this context, Peña and Nardi [27] investigated on a DEM-based interpolation method for upscaling flood inundation models. Results indicate the possibility of performing large scale inundation simulations in seconds maintaining a consistent representation of major flooding dynamics. The proposed method taking advantage of largely available DTMs for cost-effective parsimonious flood hazard modelling and mapping.

Besides flood extent, the inundation depth is also a key parameter for flood property damage/human losses. Hydrologic and hydraulic models are traditionally used for predicting these depth values, although their reliability depends strictly on the underlying assumptions in the model adopted. Javaheri et al. [28] propose a framework to improve flood depth estimates and reduce the error between model predictions and observations. The overall scope of the authors is to improve streamflow predictions of the National Water Model (NWM) by using a data assimilation scheme to dynamically update water level estimates in rivers.

Oddo et al. [29] introduce a simple geomorphic approach for flood depth assessment with remote sensing. This information, coupled with detailed land use data, provides rapid initial estimates of flood impacts which can provide valuable information to decision makers in the wake of extreme events.

Nowadays, the extent of inundated areas and the evolution of water expansion and regression can be effectively monitored using remotely sensed data acquired by aircraft and satellites. In this regard, Lacava et al. [30] present a sensor-independent multi-temporal approach called RST-FLOOD, where Robust Satellite Techniques (RST) are applied to detect flooded areas. In particular, the application of the RST-FLOOD methodology for the flood event that affected Basilicata and Puglia regions (southern Italy) in December 2013 is illustrated. Moderate Resolution Imaging Spectroradiometer (MODIS) and, for the first time, Suomi National Polar-orbiting Partnership (Suomi-NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) imagery have been used, highlighting the great usefulness of an integrated system for a continuous monitoring of flood phenomena at large spatial scale.

In conclusion, this special issue provides a wide spectrum of results and a good overview of the research activities carried out in Large Scale Flood Monitoring and Detection.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflicts of interest.

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