

Application of Remote Sensing and GIS in Drought and Flood Assessment and Monitoring

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1. Introduction

Driven by global change and population pressure, droughts and floods have been two of the most serious natural hazards, leading to crop losses and economic havoc in many areas and ultimately affecting more people globally than any other natural hazard [1–4]. As mentioned in the 2021 by the Intergovernmental Panel on Climate Change (IPCC) Group 1 Report, the average global temperature increased by about 1.07 °C during 2010–2019. The report also warns of more frequent and intense extreme weather and climate events, describing a potential proliferation of droughts and floods [5]. Over the past few decades, extreme events of floods and droughts have increased [6], such as the severe heatwave and droughts of Europe in 2003 and 2018 [7,8], the flood that occurred in Pakistan in 2010 [9], the western Russian drought in 2010 [10], etc. Future changes are particularly drastic in regions that include many developing nations, societies which are especially vulnerable to global climate change. Under future climate conditions, the hydrological cycle will be forced to accelerate, and many areas of the world are projected to experience increased occurrences of extreme weather and climate events [11,12]. As droughts and floods are complex hydrological systems, they deserve a multidisciplinary monitoring effort in order to conduct appropriate and timely hazard assessments. Recently, remote sensing and GIS-based techniques have been widely applied to obtain synoptic and punctual overviews of basin-scale monitored areas [13,14]. It is clear that the application of remote sensing and GIS can potentially provide an extra contribution to drought and flood assessment and monitoring, for instance, in terms of accuracy of results, amount of information obtained, temporal availability, and so on.

In this Special Issue, we attempted to discuss and address the applications of remote sensing, GIS and other state-of-the-art techniques in drought or flood monitoring and hydrological hazards assessment. To fulfill these objects, we strongly invited contributions on various droughts or flood monitoring indexes from satellites and other data resources such as high time resolution and high-resolution imaging, or the Gravity Recovery and Climate Experiment (GRACE). Considering that the processes of hydrological hazards such as droughts and floods are complex, research based on machine learning and modeling was also included in this Special Issue. The investigative approach characterized by the integration of disciplines at different scales of vision and precision represents a modern effort to strive for a more complete understanding of drought and flood processes and, therefore, a better hazard evaluation.



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2. Summary of This Special Issue

Amongst the papers in this Special Issue that represent examples of the state of the art of remote sensing application in drought assessment was that submitted by Cui et al. [15], in which the authors study the influence of climate background on drought events in mainland China. In fact, droughts are one of the most serious natural hazards in China, but they are also complexly affected by climate change. By considering water content as a whole index, the terrestrial water storage changes (TWSCs), derived from GRACE time-variable gravity fields, have constituted a useful dataset in hydrology research [13,14]. In this case, a drought severity index (denoted as GRACE-DSI) derived from TWSCs was applied, analyzing the role of the drought-related factors (e.g., precipitation, evapotranspiration) and extreme climate events (e.g., El Niño–Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO) events) in the formation of droughts. The results of this study are valuable in the efforts to understand the formation mechanism of drought events.

Floods are also one of the most serious natural hazards, which can lead to crop losses and economic havoc in many areas, affecting more people globally than any other natural hazard. In this Special Issue, four interesting manuscripts based on the GIS technique were published, providing new insights about spatiotemporal patterns and modes of rainstorm, the impact of rainfall movement direction, and the modeling of flood forecasting. Liu et al. [16] used a manifold learning algorithm method of machine learning to analyze rainstorm patterns, which is considered to be essential for improving the precision and accuracy of flood forecasts and constructing flood disaster prevention systems. This research analyzed the spatial–temporal characteristics of heavy rain in Beijing and Shenzhen in China and found the key factors (topography and water vapor) to be diverse in different regions. The proposed method provided a possible way to analyze spatio-temporal distribution characteristics of rainfall, which can help stakeholders to establish strategies to reduce flood risks in different regions.

Liu et al. [17] proposed an approach to identify the characteristics of rainstorms of a short duration in urban areas from their temporal and spatial dimensions. This study case identified the typical spatiotemporal modes of rainfall and the reconstruction of the process of modes of Beijing in China. The result showed that there were three modes of rainstorms in the Beijing urban area, information which can be applied to rainstorm forecasting and flood prevention in inner urban areas. The authors stated that this approach provides more complete characteristics identification, including of its temporal and spatial dimensions, than traditional methods for considering a rainfall as one complete process.

Liu et al. [18] found rainfall movement direction to be a significant rainfall variability in urban floods, which is always ignored when comparing with rainfall intensity and duration. This study provided a very innovative insight into the impact of spatial–temporal rainfall variations on urban floods. In total, 1313 rainfall scenarios with different combinations of rainfall intensity and rainfall movement direction in the typically rainy city of Shenzhen in China were analyzed to investigate the effect of rainfall movement direction. They concluded that the impact of rainfall movement direction is almost symmetrical and is associated with the direction of the river. The closer rainfall movement direction is to the linear directional mean of rivers, the larger the peak runoff of section will be. The authors stated that rainfall movement direction is significant to urban peak runoff in the downstream reaches, something which should be considered in urban hydrological analysis.

Another example of monitoring floods is the research published by Liu et al. [19] about improvement of a floods elements correction model of the ridge estimation-based dynamic system response curve (DSRC-R). They proposed a new criterion called the balance and random degree criterion, considering the sum of squares of flow errors (BSR) to optimize the ridge coefficient in the DSRC-R method. The results indicated that the techniques can greatly shorten the search time of the ridge coefficient in optimization, which will improve operational efficiency and enhance the real-time flood forecasting performance.

Besides droughts and floods, water quality deterioration has become a serious hydrological hazard of late [20,21]. The rest of the two published papers were both related to

water quality. These two papers published here showing different study cases are very interesting. Chen et al. [22] studied the changes in the environmental quality of surface water during the “13th Five-Year Plan” period (2016–2020) in Heilongjiang Province, the location of the most important grain production base and the province with the highest latitude in China. They concluded that the population, the primary industry, the tertiary industry and forestry are the main factors affecting the change in water environment quality in Heilongjiang Province. This study provided a case analysis for water quality of Heilongjiang province in China, which will be helpful to regional water environment protection.

Zhang et al. [23] investigated the temporal and spatial patterns of surface water quality in China since the reform and opening-up program based on the monitoring of datasets. They indicated that the temporal change trend in surface water quality in China presented a “fluctuating changes stage–rapid deterioration stage–fluctuations stalemate stage–rapid improvement stage” pattern. They also concluded that the current regional surface water quality of China still has a polluted status. They stated that the potential for the continuous reduction in major pollutant discharges had become more challenging, and the marginal cost for pollution control had increased. This study provided a case analysis for the water quality of a whole country, which will be helpful to national water environmental protection.

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