remote sensing

MDPI

Editorial

Recent Advancement in Remote Sensing Technology for Hydrology Analysis and Water Resources Management

Weili Duan [1,2,*], Shreedhar Maskey [3], Pedro L. B. Chaffe [4], Pingping Luo [5,6], Bin He [7,8], Yiping Wu [9] and Jingming Hou [10]

1 State Key Laboratory of Desert and Oasis Ecology, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China
2 College of Resources and Environment, University of Chinese Academy of Sciences, Beijing 100049, China
3 Department of Water Resources and Ecosystems, IHE Delft Institute for Water Education, 2611 AX Delft, The Netherlands; s.maskey@un-ihe.org
4 Key Laboratory of Subsurface Hydrology and Ecological Effects in Arid Region, Ministry of Education, Chang'an University, Xi'an 710054, China; pedro.chaffe@ufsc.br
5 Department of Sanitary and Environmental Engineering, Federal University of Santa Catarina, Florianópolis 88040-900, Brazil; lpp@chd.edu.cn
6 School of Water and Environment, Chang'an University, Xi'an 710054, China
7 Guangdong Key Laboratory of Integrated Agro-Environmental Pollution Control and Management, Institute of Eco-Environmental and Soil Sciences, Guangdong Academy of Sciences, Guangzhou 510650, China; bhe@soil.gd.cn
8 National-Regional Joint Engineering Research Center for Soil Pollution Control and Remediation in South China, Guangzhou 510650, China
9 Department of Earth and Environmental Science, School of Human Settlements and Civil Engineering, Xi'an Jiaotong University, Xi'an 710049, China; yipingwu@xjtu.edu.cn
10 State Key Laboratory of Eco-Hydraulics in Northwest Arid Region of China, Xi'an University of Technology, Xi'an 710048, China; jingming.hou@xaut.edu.cn
* Correspondence: duanweili@ms.xjb.ac.cn

Citation: Duan, W.; Maskey, S.; Chaffe, P.L.B.; Luo, P.; He, B.; Wu, Y.; Hou, J. Recent Advancement in Remote Sensing Technology for Hydrology Analysis and Water Resources Management. *Remote Sens.* **2021**, *13*, 1097. https://doi.org/10.3390/rs13061097

Received: 1 March 2021
Accepted: 11 March 2021
Published: 13 March 2021

1. Introduction

Water is undoubtedly the most valuable resource of human society and an essential component of the ecosystem. Under climate change and human activities, water resources management for sustainable socio-economic development presents many challenges around the world, especially in arid regions and high-altitude regions, with sparse in situ hydro-meteorological monitoring networks. Rare and uncertain hydrological information generally causes uncertainty in hydrologic modeling and eventually impedes continuous water resources management.

In recent decades, remote sensing (RS) technology has been developed rapidly to obtain sufficient information on hydrological state variables including precipitation, temperature, soil moisture, water levels, evapotranspiration, flood extent, flow velocity, river discharge, and land water storage over regional/global areas, especially in those remote regions where measurements are not feasible or can only be carried out under very difficult circumstances with high costs. This remote sensing information could be the input files for integrated hydrodynamics or hydrological or hydrometeorological models to simulate and assess water resources and water-related issues, largely supporting the development of more efficient hydrological models and water resources management.

Therefore, in order to fully understand recent advancements in remote sensing technology for hydrology analysis and water resources management, this special issue hosts 18 papers devoted to remote sensing in hydrology and water resources management. The volume includes studies on satellite remote sensing for water resources management, water quality monitoring and evaluation using remote-sensing data, remote sensing for detecting the global impact of climate extremes, the use of remote sensing data for improved calibration of hydrological models, and so on.

The following section concludes the individual articles hosted in this Special Issue in alphabetical order according to the first author's name.

2. Overview of Contributions

Based on the fuzzy C-means algorithm and L-moment-based regional frequency analysis method, Chen et al. [1] evaluated the performance of 3B42-V7 satellite-based precipitation product on extreme precipitation estimates compared with the China Gauge-based Daily Precipitation Analysis (CGDPA) product in China.

An improved water change tracking (IWCT) algorithm was proposed by Han et al. [2], which could remove built-up shade noise and correct omitted water pixels by taking the time-series data into consideration and was applied to evaluate water changes in Tianjin during the period 1984–2019.

Using the Global Land Surface Satellite (GLASS) leaf area index (LAI), Hu and Mo [3] used a remote sensing-based process to model spatial-temporal patterns of the actual evapotranspiration (ETa) and available water resources in the Mekong River Basin from 1981 to 2012.

In order to reduce and quantify parameter uncertainty in hydrological simulations, Hui et al. [4] attempted to introduce additional remotely sensed data (such as evapotranspiration (ET)) into the Soil Water Assessment Tool in the Guijiang River Basin (GRB) in China and found that the simulation accuracy of ET was substantially improved when adding remotely sensed ET data.

Kulua et al.'s [5] study compares measurements of evapotranspiration (ET) from a commercial vineyard in California using data collected from the Small Unmanned Aerial Systems (sUAS) and the Earth Observation System (EOS) sources for 10 events over a growing season using multiple ET estimation methods. This study indicates that limited deployment of sUAS can provide important estimates of uncertainty in EOS ET estimations for larger areas and also improve irrigation management at a local scale.

Based on the Tropical Rainfall Measuring Mission (TRMM) 3B42 3-hourly, daily, and 3B43 monthly rainfall data, the rainfall erosivity (RE) was quantified by Li et al. [6]. They found that all three TRMM rainfall products can generally capture the overall spatial patterns of RE and could be used to assess the risk of soil erosion.

By developing an allocation factor, Ma et al. [7] proposed a new field-scale ET estimation method to quantitatively evaluate field-level ET variations and allocate coarse ET to the field scale. Results from the new method can fully meet the demands of wide application for controlling regional water consumption, which is beneficial to effective management and control of water resources.

Muhadi et al. [8] reviewed the potential and the applications of light detection and ranging (LiDAR) technology in flood studies, and pointed out that LiDAR-derived data are very useful in flood mapping and risk assessment, especially in the future assessment of flood-related problems.

In developing countries, generally, water resources management is highly restricted because of the lack of high-precision measurement of precipitation in large areas. Nowadays, the Integrated Multi-satellite Retrievals for GPM (IMERG) can offer a new source of precipitation data with high spatial and temporal resolution. Therefore, Nascimento et al. [9] evaluated the performance of the GPM products in the state of Paraná, Brazil, from June 2000 to December 2018.

Peng et al. [10] evaluated the performances of six gauge-adjusted-version satellite precipitation datasets in the Bosten Lake Basin, a typical arid land watershed of Central Asia, which provides a reference for the hydrological and meteorological application of satellite precipitation datasets in Central Asia with sparse in situ hydro-meteorological monitoring networks.

Based on water levels from satellite altimetry and surface areas from optical imagery, Schwatke et al. [11] developed a new approach for estimating water volume variations of lakes and reservoirs. The method was applied to investigate volume changes in 28 lakes and reservoirs located in Texas.

The study by Sirisena et al. [12] evaluated the use of measured streamflow and RS-based ET data to calibrate a Soil and Water Assessment Tool (SWAT) and evaluate the performances for Chindwin Basin, Myanmar. The results indicated the advantage of remote-sensing-based and multiple data sources for calibration of hydrological modelling in data poor basins.

By interpreting satellite imagery from 1990, 2000, and 2015, Sun et al. [13] investigated the dynamic evolution of the desert-oasis ecotone in the Tarim River Basin and then predicted the near-future land-use change based on the cellular automata-Markov (CA-Markov) model.

After collecting high frequency (moderate-resolution imaging spectroradiometer) MODIS images, altimetry, and data from the Hydroweb database, Sun et al. [14] delineated the detailed hydrological changes of 15 lakes in three basins—Inner Basin, Indus Basin, and Brahmaputra Basin—on the southern Tibetan Plateau.

Because remote sensing and reanalysis quantitative precipitation products are inevitably subject to errors, Tang et al. [15] proposed a novel daily-scale precipitation bias correction framework to combine these precipitation products from various institutions. The framework was applied to do error correction for multi-source weighted-ensemble precipitation in the Lancang-Mekong River Basin.

Through combining the Weather Research and Forecast (WRF) model with the three-dimensional variation (3DVar) data assimilation system, Xu et al. [16] put the satellite data assimilation to wind speed simulation in wind resource assessments in Guangdong, China.

In the paper by Yang et al. [17], five gridded precipitation products including Multi-Source Weighted-Ensemble Precipitation (MSWEP), CPC Morphing Technique (CMORPH), Global Satellite Mapping of Precipitation (GSMaP), Tropical Rainfall Measuring Mission (TRMM) Multi-Satellite Precipitation Analysis 3B42, and Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN) were evaluated against observations in the Yellow River Basin, China, at daily, monthly, and annual scales during 2001−2014.

Using multiple satellite data, Zhou et al [18] analyzed the spatiotemporal changes of hydrological elements in semiarid areas from 2002 to 2014 and their effects on vegetation, which demonstrated that the application of satellite data could significantly improve the water assessment capability in semiarid areas.

3. Conclusions

This Special Issue aimed to summarize the recent advancement in remote sensing technology for hydrology analysis and water resources management. In general, remote sensing technology can improve land-surface and hydrologic modeling from three aspects including model inputs (watershed information, atmospheric information, boundary conditions, etc.), state estimation (data assimilation), and model calibration and parameter estimation. This special collection of papers aspires to stimulate further research into the remote sensing technology of hydrology analysis and water resources management.

Funding: This research was funded by the National Natural Science Foundation of China (Grant No. 41971149), the Tianshan Xuesong Program (Grant No. 2019XS10), and the Program for High-Level Talents Introduction in Xinjiang Uygur Autonomous Region (Grant No. Y941181).

Acknowledgments: As the Guest Editor of this Special Issue entitled "Remote Sensing in Hydrology and Water Resources Management", we would like to thank all the authors who contributed towards this volume. We are also thankful to the reviewers of the submitted manuscripts who added value to the volume by providing timely and thorough reviews with comments and very constructive feedback to the authors. Last, but not least, we wish to express our gratitude to the editorial staff of Remote Sensing for their collaboration and prompt efforts in completing this task.

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

References

1. Chen, J.; Wang, Z.; Wu, X.; Lai, C.; Chen, X. Evaluation of TMPA 3B42-V7 Product on Extreme Precipitation Estimates. *Remote Sens.* **2021**, *13*, 209. [CrossRef]
2. Han, X.; Chen, W.; Ping, B.; Hu, Y. Implementation of an Improved Water Change Tracking (IWCT) Algorithm: Monitoring the Water Changes in Tianjin over 1984–2019 Using Landsat Time-Series Data. *Remote Sens.* **2021**, *13*, 493. [CrossRef]
3. Hu, S.; Mo, X. Attribution of Long-Term Evapotranspiration Trends in the Mekong River Basin with a Remote Sensing-Based Process Model. *Remote Sens.* **2021**, *13*, 303. [CrossRef]
4. Hui, J.; Wu, Y.; Zhao, F.; Lei, X.; Sun, P.; Singh, S.K.; Liao, W.; Qiu, L.; Li, J. Parameter Optimization for Uncertainty Reduction and Simulation Improvement of Hydrological Modeling. *Remote Sensing.* **2020**, *12*, 4069. [CrossRef]
5. Kalua, M.; Rallings, A.M.; Booth, L.; Medellín-Azuara, J.; Carpin, S.; Viers, J.H. sUAS Remote Sensing of Vineyard Evapotranspiration Quantifies Spatiotemporal Uncertainty in Satellite-Borne ET Estimates. *Remote Sens.* **2020**, *12*, 3251. [CrossRef]
6. Li, X.; Li, Z.; Lin, Y. Suitability of TRMM Products with Different Temporal Resolution (3-Hourly, Daily, and Monthly) for Rainfall Erosivity Estimation. *Remote Sens.* **2020**, *12*, 3924. [CrossRef]
7. Ma, Z.; Wu, B.; Yan, N.; Zhu, W.; Zeng, H.; Xu, J. Spatial Allocation Method from Coarse Evapotranspiration Data to Agricultural Fields by Quantifying Variations in Crop Cover and Soil Moisture. *Remote Sens.* **2021**, *13*, 343. [CrossRef]
8. Muhadi, N.A.; Abdullah, A.F.; Bejo, S.K.; Mahadi, M.R.; Mijic, A. The Use of LiDAR-Derived DEM in Flood Applications: A Review. *Remote Sens.* **2020**, *12*, 2308. [CrossRef]
9. Nascimento, J.G.; Althoff, D.; Bazame, H.C.; Neale, C.M.U.; Duarte, S.N.; Ruhoff, A.L.; Gonçalves, I.Z. Evaluating the Latest IMERG Products in a Subtropical Climate: The Case of Paraná State, Brazil. *Remote Sens.* **2021**, *13*, 906. [CrossRef]
10. Peng, J.; Liu, T.; Huang, Y.; Ling, Y.; Li, Z.; Bao, A.; Chen, X.; Kurban, A.; De Maeyer, P. Satellite-Based Precipitation Datasets Evaluation Using Gauge Observation and Hydrological Modeling in a Typical Arid Land Watershed of Central Asia. *Remote Sens.* **2021**, *13*, 221. [CrossRef]
11. Schwatke, C.; Dettmering, D.; Seitz, F. Volume Variations of Small Inland Water Bodies from a Combination of Satellite Altimetry and Optical Imagery. *Remote Sens.* **2020**, *12*, 1606. [CrossRef]
12. Sirisena, T.A.; Maskey, S.; Ranasinghe, R. Hydrological Model Calibration with Streamflow and Remote Sensing Based Evapotranspiration Data in a Data Poor Basin. *Remote Sens.* **2020**, *12*, 3768. [CrossRef]
13. Sun, F.; Wang, Y.; Chen, Y.; Li, Y.; Zhang, Q.; Qin, J.; Kayumba, P.M. Historic and Simulated Desert-Oasis Ecotone Changes in the Arid Tarim River Basin, China. *Remote Sens.* **2021**, *13*, 647. [CrossRef]
14. Sun, F.; Ma, R.; He, B.; Zhao, X.; Zeng, Y.; Zhang, S.; Tang, S. Changing Patterns of Lakes on The Southern Tibetan Plateau Based on Multi-Source Satellite Data. *Remote Sens.* **2020**, *12*, 3450. [CrossRef]
15. Tang, X.; Zhang, J.; Wang, G.; Ruben, G.B.; Bao, Z.; Liu, Y.; Liu, C.; Jin, J. Error Correction of Multi-Source Weighted-Ensemble Precipitation (MSWEP) over the Lancang-Mekong River Basin. *Remote Sens.* **2021**, *13*, 312. [CrossRef]
16. Xu, W.; Ning, L.; Luo, Y. Applying Satellite Data Assimilation to Wind Simulation of Coastal Wind Farms in Guangdong, China. *Remote Sens.* **2020**, *12*, 973. [CrossRef]
17. Yang, Y.; Wu, J.; Bai, L.; Wang, B. Reliability of gridded precipitation products in the Yellow River Basin, China. *Remote Sens.* **2020**, *12*, 374. [CrossRef]
18. Zhu, Y.; Luo, P.; Zhang, S.; Sun, B. Spatiotemporal Analysis of Hydrological Variations and Their Impacts on Vegetation in Semiarid Areas from Multiple Satellite Data. *Remote Sens.* **2020**, *12*, 4177. [CrossRef]