remote sensing

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Editorial

Editorial for Special Issue "Remote Sensing of Precipitation: Part II"

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1. Introduction

The ongoing and intensive consideration by the scientific community of the many facets of precipitation science constitutes a broad recognition of the significance of this indispensable component of the hydrologic cycle. The interest in the state-of-the-art scientific investigations of precipitation is maintained and even rejuvenated by current developments in the field, embracing the availability of new precipitation databases, technological improvements and methodological advances.

This Special Issue comprises a collection of papers embracing a wide range of aspects of precipitation science. This volume hosts 25 papers devoted to remote sensing applications in precipitation, which include studies on satellite precipitation retrievals together with their corresponding methodologies, weather radar precipitation estimations, the understanding of cloud and precipitation microphysical properties, precipitation downscaling, droplet size distribution, the performance of precipitation forecasts by numerical weather prediction models, precipitation retrievals from global navigation satellite systems, spatiotemporal precipitation distribution and its statistical characteristics, rain gauge- and satellite-based precipitation products and their comparisons and spatiotemporal distributions of precipitation modeling.

The next section summarizes the individual articles hosted in this Special Issue in alphabetical order based on the first author's name.

2. Overview of Contributions

Aminyavari et al. [1] studied the performance of ensemble forecasts for precipitation estimates by three numerical weather prediction models within THORPEX (The Observing System Research and Predictability Experiment of the World Meteorological Organization), as well as that of the IMERG (Integrated Multi-Satellite Retrievals for Global Precipitation Measurement (GPM)), during severe floods in Iran over the period of March and April 2019.

In the paper by D'Adderio et al. [2], precipitation estimates derived from the Italian ground radar network were used in conjunction with measurements from the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) to develop an operational-oriented algorithm (RAdar INfrared Blending algorithm for Operational Weather monitoring—RAINBOW) able to provide precipitation pattern and intensity. The algorithm evaluated surface precipitation over five geographical boxes in which the study area was divided.

In their study, Eldardiry and Habib [3] assessed the robustness of a probability weighted regional spatial bootstrap approach to estimate precipitation frequencies using radar data. Using the regional spatial bootstrap technique, they investigated two main issues that impact the use of radar-based Quantitative Precipitation Estimations (QPE) in deriving precipitation frequency estimates: (1) the typically short historical records of radar-based QPEs and (2) the effect of outliers in a precipitation maxima series that could possibly cause unrealistic spatial gradients in intensity–duration–frequency relations.

Ghada et al. [4] contributed with an analysis of the relationship between Z–R (reflectivity and rain rate) parameters and weather types in Central Europe, based on a

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Citation: Michaelides, S. Editorial for Special Issue "Remote Sensing of Precipitation: Part II". *Remote Sens.* **2021**, *13*, 136. https://doi.org/10.3390/rs13010136

Received: 30 December 2020
Accepted: 31 December 2020
Published: 4 January 2021

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comprehensive regional dataset of rain microstructure measurements at ten sites in the federal state of Bavaria, Germany. The authors investigated what the effect is of weather types on rain microstructures and whether there is a consistent variation in the Z–R parameters between weather types that would suggest opportunities to improve the QPE with radar-based methods.

The study by Giannaros et al. [5] presented the first attempt for introducing an assimilation of zenith tropospheric delay, derived from more than 48 stations of the Hellenic global navigation satellite systems network, into the operational Numerical Weather Prediction System of the National Observatory of Athens in Greece, which is based on the Mesoscale Weather Research and Forecasting model. The model was applied during seven high-impact precipitation events covering the dry and wet seasons in 2018.

The main objective of the study by Huang et al. [6] was to evaluate the performance of multiple Satellite Precipitation Products (SSPs) in depicting the spatiotemporal variations of summer precipitation over Taiwan, using more than 400 local rain gauges for comparison. The authors examined the competence of SSPs in studying the summer connective afternoon rainfall events, which constitute the most frequently observed weather patterns in Taiwan. The analysis mainly focused on the time periods that overlap in all the data investigated—that is, the summers of 2014–2017.

Precipitation measurements from a second-generation PARSIVEL disdrometer deployed in Beijing, Northern China, were analyzed by Ji et al. [7] in order to investigate the microphysical structure of raindrop size distribution and its implications on polarimetric radar applications. Rainfall types were classified and analyzed in the domains of the median volume diameter and the normalized intercept parameter.

Krietemeyer et al. [8] investigated the performance of the Precise Point Positioning technique for the estimation of the zenith tropospheric delays by using a recently introduced low-cost dual-frequency receiver connected to antennas of ranging quality with and without applying relative antenna calibrations. Additionally, using Level 1 data, they investigated how well the (un-)corrected single-frequency data from the dual-frequency receiver can be used for meteorological applications.

Laverde-Barajas et al. [9] focused their research on a spatiotemporal object-based bias correction method to reduce several systematic errors in storm events estimated by satellite. The method, called Spatiotemporal Contiguous Object-based Rainfall Analysis for Bias Correction, uses the main storm characteristics of the satellite and observed events detected to remove errors due to displacement in space and time and volume. This method was evaluated over the lower Mekong Basin in Thailand to correct several storm event types in IMERG during the monsoon seasons from 2014 to 2017.

Le Coz et al. [10] proposed to gauge-adjust satellite-based estimates with respect to position by using a morphing method. This approach takes both the position and the intensity of a rain event into account, and its potential was investigated with two case studies. In the first case, the rain events were synthetic, represented by elliptic shapes, while, in the second case, use was made of real data from a rainfall event occurring during the monsoon season in Southern Ghana. In the second case, the satellite-based estimate IMERG was adjusted to gauge data from the Trans-African Hydro-Meteorological Observatory (TAHMO) network.

In the framework of JAXA's Global Satellite Mapping of Precipitation (GSMaP) project, the GSMaP Near-Real-Time Precipitation Products were generated (GSMaP_Gauge_NRT), aiming to improve the accuracy of the near-real-time product of GSMaP. Lu and Yong [11] used GSMaP_Gauge_NRT to validate their performance by using gauge observations over Mainland China.

Lu et al. [12] proposed a two-step framework to improve the accuracy of satellite precipitation estimates. The first step was data merging based on the optimum interpolation, and the second step was downscaling based on geographically weighted regression. The IMERG product was used to demonstrate the effectiveness of the above two-step procedure in the Tianshan Mountains, China.

The primary purpose of the study by Ma et al. [13] was to conduct a comprehensive analysis of an extremely heavy rainfall event that hit Guangdong Province, China, from 27 August to 1 September 2018. Their analysis was based on various in situ and remote sensing observations, including rain gauges, polarimetric radars, disdrometers and reanalysis data, to gain a better understanding of the epic flood events. In particular, the study aimed to explore the potential of polarimetric radars to resolve the microphysics and quantify the precipitation.

Maghsood et al. [14] conducted a thorough validation of the IMERG product over Iran. The study focused on investigating the performance of daily and monthly IMERG products by comparing them with ground-based precipitation data at synoptic stations throughout the country during 2014–2017. The spatial and temporal performance of the IMERG was evaluated using eight statistical criteria.

Nawaz et al. [15] highlighted the performance evaluation of gauge-based and satellite-based gridded precipitation products at the annual, winter and summer monsoon scales by using a multiple statistical approach over Punjab Province, Pakistan. The results revealed that the temporal magnitude of all the gridded precipitation products was different and deviated up to 100–200 mm with the overall spatial pattern of underestimation and overestimation from north to south.

Rahman et al. [16] assessed the performance of a soil moisture-to-rain algorithm that can be used for direct precipitation estimation from in-situ and/or satellite-based soil moisture observations. The algorithm makes use of the inverted soil water balance equation. Their study covered four different climate regions of Pakistan using rain gauge observations. The assessment was carried out on a daily scale in the period 2000–2015.

Retalis et al. [17] performed a comparative analysis of the IMERG high-resolution product and Tropical Rainfall Measuring Mission (TRMM) 3B43 product. These satellite-based precipitation fields were validated against rain gauges over the island of Cyprus for the period from April 2014 to June 2018. Satellite precipitation estimates were compared with the gauge records on a monthly and an annual basis.

In an effort to elucidate the strengths and weaknesses of recently released gridded precipitation datasets, Sherifi et al. [18] conducted a comprehensive evaluation of the performances of several such datasets at daily and monthly timescales. The study was performed over Austria using a dense network of gauges of 882 stations. The evaluation was carried out based on continuous and categorical statistical metrics for the period from June 2014 to December 2015.

Sharma et al. [19] evaluated four precipitation datasets from the two satellite-based precipitation products, namely IMERG (version 06B) and GSMaP (version 07), against 388 rain gauge observations concerning their spatial and seasonal accuracy over Nepal. Their performances were analyzed for their tendencies and discrepancies depending on the different elevation ranges and relative intensities on a daily and monthly timescale from March 2014 to December 2016.

The study by Sokol et al. [20] focused on Linear Depolarization Ratio values derived from vertically pointing cloud radars and the distribution of five hydrometeor species during 38 days with thunderstorms that occurred in 2018 and 2019 in Central Europe within the vicinity of the radar used in the study. The study showed improved algorithms for de-aliasing, the derivation of vertical air velocity and the classification of hydrometeors in clouds.

The main objectives of the contribution by Sun et al. [21] were (a) to investigate the spatial distribution of precipitation changes using daily, daytime and nighttime records from 2393 weather sites across China; (b) to study the quantification of the performances of selected products in detecting precipitation trends on a sub-daily scale with different validation metrics through a comparison with gauge observations and (c) to identify the metric-based optimal products at a sub-daily scale.

In the research by Ullah et al. [22], a new downscaling methodology was developed using the Digital Elevation Model to delineate into three geospatial predictors, i.e., elevation, longitude and latitude, in an empirical distribution-based framework (EDBF). Two different satellite-based precipitation datasets, such as the GPM-based multitemporal precipitation data for the prediction of high-resolution downscaled weighted precipitation from 0.1° to 0.05° > resolution, and the GPM and the TRMM datasets for the verification of proposed methodology were used over the humid southern region of Mainland China.

In the study by Xie et al. [23], an OTT Parsivel-2 (Kempten, Germany) Disdrometer was used to measure raindrop spectra from 10 August 2018 to 10 August 2019 at Yulin Ecohydrological Station, Shaanxi Province, China. The precipitation events obtained were classified as stratiform and convective, based on the rainfall intensity classifying process. The Drop Size Distribution characteristics of Yulin Station were obtained, and the results can help to understand the microphysical characteristics of precipitation and their impact on the mechanism of soil erosivity in the semi-arid area.

The study by Yang et al. [24] aimed to evaluate the accuracy of the latest five GPM and TRMM rainfall products across monthly, daily and hourly scales based on ground rain gauge measurements between January 2009 and December 2017 in the Shuaishui River Basin of Eastern-Central China. For the evaluation, a total of four continuous and three categorical metrics were calculated based on satellite precipitation product (SPP) estimates and historical rainfall records at 13 stations over a period of nine years from 2009 to 2017.

Zhang et al. [25] established a spatial and temporal distribution model of precipitation in Hubei Province, China from 2006 to 2014 based on the data of 75 meteorological stations. This paper applied a geographically and temporally weighted regression kriging model to precipitation and assessed the effects of timescales and a time-weighted function on precipitation interpolation.

3. Conclusions

This Special Issue aimed at enlightening and updating the scientific community involved in precipitation science to the current progress in important areas of the remote sensing of precipitation through the presentation of state-of-the-art data sources and technological advances, as well as relevant methodological approaches. This collection of papers aspires to stimulate further research in the remote sensing of precipitation.

Funding: Silas Michaelides was supported by the EMME-CARE project, which received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no. 856612, as well as matching co-funding by the Government of the Republic of Cyprus.

Acknowledgments: As the Guest Editor of this Special Issue entitled "Remote Sensing of Precipitation: Part II", I would like to thank all the authors of the papers that are included in this volume. The collaboration with all the authors was close, and this led to the highest possible scientific quality of the present volume. I am also thankful to the reviewers of the submitted manuscripts who added value to the volume by providing timely and thorough reviews with comments and recommendations to the authors. Last, but not least, I wish to express my gratitude to the editorial staff of Remote Sensing for their efforts in completing this task.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Aminyavari, S.; Saghafian, B.; Sharifi, E. Assessment of Precipitation Estimation from the NWP Models and Satellite Products for the Spring 2019 Severe Floods in Iran. *Remote Sens.* **2019**, *11*, 2741. [CrossRef]
2. D'Adderio, L.P.; Puca, S.; Vulpiani, G.; Petracca, M.; Sanò, P.; Dietrich, S. RAINBOW: An Operational Oriented Combined IR-Algorithm. *Remote Sens.* **2020**, *12*, 2444. [CrossRef]
3. Eldardiry, H.; Habib, E. Examining the Robustness of a Spatial Bootstrap Regional Approach for Radar-Based Hourly Precipitation Frequency Analysis. *Remote Sens.* **2020**, *12*, 3767. [CrossRef]
4. Ghada, W.; Bech, J.; Estrella, N.; Hamann, A.; Menzel, A. Weather Types Affect Rain Microstructure: Implications for Estimating Rain Rate. *Remote Sens.* **2020**, *12*, 3572. [CrossRef]
5. Giannaros, C.; Kotroni, V.; Lagouvardos, K.; Giannaros, T.M.; Pikridas, C. Assessing the Impact of GNSS ZTD Data Assimilation into the Wrf Modeling System during High-Impact Rainfall Events over Greece. *Remote Sens.* **2020**, *12*, 383. [CrossRef]

6. Huang, W.R.; Liu, P.Y.; Chang, Y.H.; Liu, C.Y. Evaluation and Application of Satellite Precipitation Products in Studying the Summer Precipitation Variations over Taiwan. *Remote Sens.* **2020**, *12*, 347. [CrossRef]
7. Ji, L.; Chen, H.; Li, L.; Chen, B.; Xiao, X.; Chen, M.; Zhang, G. Raindrop Size Distributions and Rain Characteristics Observed by a PARSIVEL Disdrometer in Beijing, Northern China. *Remote Sens.* **2019**, *11*, 1479. [CrossRef]
8. Krietemeyer, A.; van der Marel, H.; van de Giesen, N.; ten Veldhuis, M.C. High Quality Zenith Tropospheric Delay Estimation Using a Low-Cost Dual-Frequency Receiver and Relative Antenna Calibration. *Remote Sens.* **2020**, *12*, 1393. [CrossRef]
9. Laverde-Barajas, M.; Corzo, G.A.; Poortinga, A.; Chishtie, F.; Meechaiya, C.; Jayasinghe, S.; Towashiraporn, P.; Markert, A.; Saah, D.; Son, L.H.; et al. St-Corabico: A Spatiotemporal Object-Based Bias Correction Method for Storm Prediction Detected by Satellite. *Remote Sens.* **2020**, *12*, 3538. [CrossRef]
10. Le Coz, C.; Heemink, A.; Verlaan, M.; ten Veldhuis, M.C.; van de Giesen, N. Correcting Position Error in Precipitation Data Using Image Morphing. *Remote Sens.* **2019**, *11*, 2557. [CrossRef]
11. Lu, D.; Yong, B. A Preliminary Assessment of the Gauge-Adjusted near-Real-Time GSMaP Precipitation Estimate over Mainland China. *Remote Sens.* **2020**, *12*, 141. [CrossRef]
12. Lu, X.; Tang, G.; Wang, X.; Liu, Y.; Wei, M.; Zhang, Y. The Development of a Two-Step Merging and Downscaling Method for Satellite Precipitation Products. *Remote Sens.* **2020**, *12*, 398. [CrossRef]
13. Ma, Y.; Chen, H.; Ni, G.; Chandrasekar, V.; Gou, Y.; Zhang, W. Microphysical and Polarimetric Radar Signatures of an Epic Flood Event in Southern China. *Remote Sens.* **2020**, *12*, 2772. [CrossRef]
14. Maghsood, F.F.; Hashemi, H.; Hosseini, S.H.; Berndtsson, R. Ground Validation of GPM IMERG Precipitation Products over Iran. *Remote Sens.* **2020**, *12*, 48. [CrossRef]
15. Nawaz, Z.; Li, X.; Chen, Y.; Nawaz, N.; Gull, R.; Elnashar, A. Spatio-Temporal Assessment of Global Precipitation Products over the Largest Agriculture Region in Pakistan. *Remote Sens.* **2020**, *12*, 3650. [CrossRef]
16. Rahman, K.U.; Shang, S.; Shahid, M.; Wen, Y. Performance Assessment of SM2RAIN-CCI and SM2RAIN-ASCAT Precipitation Products over Pakistan. *Remote Sens.* **2019**, *11*, 2040. [CrossRef]
17. Retalis, A.; Katsanos, D.; Tymvios, F.; Michaelides, S. Comparison of GPM Imerg and TRMM 3B43 Products over Cyprus. *Remote Sens.* **2020**, *12*, 3212. [CrossRef]
18. Sharifi, E.; Eitzinger, J.; Dorigo, W. Performance of the State-of-the-Art Gridded Precipitation Products over Mountainous Terrain: A Regional Study over Austria. *Remote Sens.* **2019**, *11*, 2018. [CrossRef]
19. Sharma, S.; Chen, Y.; Zhou, X.; Yang, K.; Li, X.; Niu, X.; Hu, X.; Khadka, N. Evaluation of GPM-Era Satellite Precipitation Products on the Southern Slopes of the Central Himalayas against Rain Gauge Data. *Remote Sens.* **2020**, *12*, 1836. [CrossRef]
20. Sokol, Z.; Minářová, J.; Fišer, O. Hydrometeor Distribution and Linear Depolarization Ratio in Thunderstorms. *Remote Sens.* **2020**, *12*, 2144. [CrossRef]
21. Sun, S.; Shi, W.; Zhou, S.; Chai, R.; Chen, H.; Wang, G.; Zhou, Y.; Shen, H. Capacity of Satellite-Based and Reanalysis Precipitation Products in Detecting Long-Term Trends across Mainland China. *Remote Sens.* **2020**, *12*, 2902. [CrossRef]
22. Ullah, S.; Zuo, Z.; Zhang, F.; Zheng, J.; Huang, S.; Lin, Y.; Iqbal, I.; Sun, Y.; Yang, M.; Yan, L. Gpm-Based Multitemporal Weighted Precipitation Analysis Using Gpm_imergdf Product and Aster Dem in Edbf Algorithm. *Remote Sens.* **2020**, *12*, 3162. [CrossRef]
23. Xie, Z.; Yang, H.; Lv, H.; Hu, Q. Seasonal Characteristics of Disdrometer-Observed Raindrop Size Distributions and Their Applications on Radar Calibration and Erosion Mechanism in a Semi-Arid Area of China. *Remote Sens.* **2020**, *12*, 262. [CrossRef]
24. Yang, X.; Lu, Y.; Tan, M.L.; Li, X.; Wang, G.; He, R. Nine-Year Systematic Evaluation of the GPM and TRMM Precipitation Products in the Shuaishui River Basin in East-Central China. *Remote Sens.* **2020**, *12*, 1042. [CrossRef]
25. Zhang, W.; Liu, D.; Zheng, S.; Liu, S.; Loáiciga, H.A.; Li, W. Regional Precipitation Model Based on Geographically and Temporally Weighted Regression Kriging. *Remote Sens.* **2020**, *12*, 2547. [CrossRef]