

Modeling and Remote Sensing of the Forest Ecosystem

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Forests cover around one-third of the global land surface, store about half of the terrestrial carbon, and are the dominant contributors to terrestrial net primary production. As the largest carbon pool of terrestrial ecosystems, the forest ecosystem plays a critical role in both the global carbon cycle and climate change mitigation. Time-series monitoring is essential for understanding forest ecosystem processes and forest response to anthropogenic activities and climate change. In recent decades, satellite records have offered the potential to monitor forest changes by combining diverse remote sensing sources including optical, synthetic aperture radar (SAR), light detection and ranging (LiDAR), and microwave sensors. Remote sensing data from different sources and with various land surface process models could provide better spatial coverage with high resolution, and are available for long-term time series, which can enable the effective global mapping and monitoring of forest trends. In light of these advantages, we organized this Special Issue, “Modeling and Remote Sensing of the Forest Ecosystem”. This Special Issue covers potential topics including the response of forest dynamics to anthropogenic activities and climate change; time-series change detection and trend analyses of forest ecosystems; the impacts of climate extremes (e.g., drought to wetness) on the forest ecosystem; the monitoring of forest biomass and carbon dynamics; the mapping of forest structure parameters.

In this Special Issue, we are pleased to present a collection of 12 insightful articles that highlight the latest advancements in forest ecosystem research. Among these, five articles focus on the inversion of forest structural parameters and biomass, as well as an analysis of forest ecosystem functions [1–6]. These studies employ advanced modeling techniques and remote sensing data to better understand the complex relationships between forest structure, biomass, and ecosystem processes. Several articles integrate remote sensing data, such as ICESat-2, airborne laser scanning, and UAV-based imagery, to map forest attributes like canopy height, stem diameter, and biomass distribution. Others focus on understanding how forest fragmentation, topography, and land-use changes affect ecosystem functions like carbon storage, biomass, and biodiversity. Modeling techniques, including machine learning and the InVEST model, are widely applied to predict future scenarios and optimize forest management strategies. Three articles focus on the impact of climate change on vegetation dynamics across different regions [7–9]. They emphasize the role of climate variables such as temperature, precipitation, and sunshine duration in shaping vegetation coverage and phenology. The research highlights how vegetation responds to changes in land surface temperature, urbanization, and other environmental



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factors, with varying patterns of growth, biomass, and seasonality. Three articles focus on the impact of vegetation changes on streamflow variation and hydrological processes in different regions of China [10–12]. They use advanced methods like the Budyko equation and elastic coefficient analysis to quantify how vegetation, climate, and human activities influence surface runoff and streamflow. The results indicate that vegetation growth has a generally positive effect on streamflow reduction, with varying contributions across regions. The studies highlight the importance of understanding the interplay between climate, vegetation, and hydrology for water resource management and ecological restoration efforts in different river basins.

The contributions in this issue provide valuable insights into how remote sensing technologies and computational models can be leveraged to enhance our understanding of forest dynamics. These articles not only discuss the technical methodologies used to derive forest structural parameters but also explore the implications of these findings for forest management, biodiversity conservation, and climate change mitigation. Together, these articles offer a comprehensive perspective of the role of remote sensing and modeling in advancing forest ecosystem research, addressing key challenges in monitoring, analyzing, and managing forest ecosystems in the face of global environmental changes. We hope that this collection will inspire further research and foster the development of innovative solutions for sustainable forest management.

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References

1. Luo, Y.; Qi, S.; Liao, K.; Zhang, S.; Hu, B.; Tian, Y. Mapping the Forest Height by Fusion of ICESat-2 and Multi-Source Remote Sensing Imagery and Topographic Information: A Case Study in Jiangxi Province, China. *Forests* **2023**, *14*, 454. [[CrossRef](#)]
2. Gallagher-Duval, X.; van Lier, O.R.; Fournier, R.A. Estimating Stem Diameter Distributions with Airborne Laser Scanning Metrics and Derived Canopy Surface Texture Metrics. *Forests* **2023**, *14*, 287. [[CrossRef](#)]
3. Liu, L.; Liu, Y.; Lv, Y.; Li, X. A Novel Approach for Simultaneous Localization and Dense Mapping Based on Binocular Vision in Forest Ecological Environment. *Forests* **2024**, *15*, 147. [[CrossRef](#)]
4. Liu, C.; Du, W.; Cao, H.; Shen, C.; Ma, L. Aboveground Biomass and Endogenous Hormones in Sub-Tropical Forest Fragments. *Forests* **2023**, *14*, 661. [[CrossRef](#)]
5. Wang, J.; Xu, H.; Yang, Q.; Li, Y.; Ji, M.; Li, Y.; Chang, Z.; Qin, Y.; Yu, Q.; Wang, X. Topographic Variation in Ecosystem Multifunctionality in an Old-Growth Subtropical Forest. *Forests* **2024**, *15*, 1032. [[CrossRef](#)]
6. Li, L.; Ji, G.; Li, Q.; Zhang, J.; Gao, H.; Jia, M.; Li, M.; Li, G. Spatiotemporal Evolution and Prediction of Ecosystem Carbon Storage in the Yiluo River Basin Based on the PLUS-InVEST Model. *Forests* **2023**, *14*, 2442. [[CrossRef](#)]
7. Ren, H.; Chen, C.; Li, Y.; Zhu, W.; Zhang, L.; Wang, L.; Zhu, L. Response of Vegetation Coverage to Climate Changes in the Qinling-Daba Mountains of China. *Forests* **2023**, *14*, 425. [[CrossRef](#)]
8. Yang, Y.; Yao, L.; Fu, X.; Shen, R.; Wang, X.; Liu, Y. Spatial and Temporal Variations of Vegetation Phenology and Its Response to Land Surface Temperature in the Yangtze River Delta Urban Agglomeration. *Forests* **2024**, *15*, 1363. [[CrossRef](#)]
9. Tabunshchik, V.; Gorbunov, R.; Gorbunova, T.; Safonova, M. Vegetation Dynamics of Sub-Mediterranean Low-Mountain Landscapes under Climate Change (on the Example of Southeastern Crimea). *Forests* **2023**, *14*, 1969. [[CrossRef](#)]
10. Wang, Y.; Liu, Z.; Qian, B.; He, Z.; Ji, G. Quantitatively Computing the Influence of Vegetation Changes on Surface Discharge in the Middle-Upper Reaches of the Huaihe River, China. *Forests* **2022**, *13*, 2000. [[CrossRef](#)]

11. Jia, M.; Hu, S.; Hu, X.; Long, Y. Response Mechanism of Annual Streamflow Decline to Vegetation Growth and Climate Change in the Han River Basin, China. *Forests* **2023**, *14*, 2132. [[CrossRef](#)]
12. Ji, G.; Yue, S.; Zhang, J.; Huang, J.; Guo, Y.; Chen, W. Assessing the Impact of Vegetation Variation, Climate and Human Factors on the Streamflow Variation of Yarlung Zangbo River with the Corrected Budyko Equation. *Forests* **2023**, *14*, 1312. [[CrossRef](#)]

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