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Continuous spectral monitoring below forest canopies: an IoT-based approach

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Climate change and climate extremes are severely impacting forest ecosystems, threatening their functioning and diversity. Our ability to accurately monitor forest responses to climatic impacts, however, is limited. This study introduces and discusses the monitoring potential of Internet of Things (IoT) spectral sensors for continuous below-canopy radiation measurements. At the canopy scale, light partitioning into absorbed, reflected and transmitted light is strongly modulated by architectural parameters in addition to leaf level chemistry (canopy pigments and water content). These determine a high spatial, temporal and spectral variability of transmitted light, which requires a large sampling effort to be described at stands and forest scale. The recent availability of spectral sensors connected through IoT technologies is opening new possibilities in the dynamic characterization of forest canopy spectral features. The proposed approach enables the monitoring of structural and physiological traits continuously in time and on larger extents compared to hand-carried instruments. Key applications include validating satellite vegetation products, analyzing light quality variations, investigating tree responses to environmental stresses like drought and heatwaves, exploring the role of light quality in forest renovation, and understanding complex forest ecosystem interactions. We have yet to fully imagine potential applications that could go beyond traditional plant ecology boundaries, ranging from wildlife light preferences to tree insect damage monitoring. By providing continuous, high-resolution data from previously understudied forests, this approach bridges technological innovation with ecological research, potentially revolutionizing our understanding of forest functioning under changing climate conditions.