

EGU25-4248, updated on 23 Jan 2026

<https://doi.org/10.5194/egusphere-egu25-4248>

EGU General Assembly 2025

© Author(s) 2026. This work is distributed under the Creative Commons Attribution 4.0 License.



Characterisation and Calibration of Low-Cost IoT Monitoring Systems for Extreme Environmental Conditions

Laura Mihai¹, Cristina Toma¹, Razvan Mihalcea¹, Karolina Sakowska², Loris Vescovo³, Luca Belelli Marchesini³, Valerio Coppola⁴, Francesco Renzi^{4,5}, and Riccardo Valentini⁴

¹National Institute for Laser, Plasma and Radiation Physics, CETAL, Photonic Investigations Lab., Magurele, Romania (laura.mihai@inflpr.ro)

²Italian National Research Council (CNR), Roma, Italy (karolina.sakowska@ibe.cnr.it)

³Fondazione Edmund Mach (FEM), Forest Ecology Unit, San Michelle All'Adige, Italy (lucca.belellimarchesini@fmach.it)

⁴Nature 4.0 Benefit Company SRL, Italy (rick@unitus.it)

⁵University of Tuscia DIBAF, Italy

Monitoring forests in hard-to-reach locations and under extreme climatic conditions requires reliable, long-term data collection systems. Low-cost devices are increasingly being developed for this purpose; however, deploying these systems without thorough characterisation and calibration can compromise data quality. This work emphasises the importance of fully characterising and calibrating such systems prior to installation to ensure accuracy and reliability over extended periods. This study was conducted as part of the RemoTrees project, which aims to develop a unique IoT tree monitoring system equipped with satellite communication and designed to withstand extreme environmental conditions. A set of the alpha version prototypes, developed within the project, was evaluated in this work. The evaluation focused mainly on a set of low-cost environmental monitoring devices equipped with radiometric sensors measurements. The key performance parameters were assessed, including signal-to-noise ratio (SNR), irradiance sensor detector nonlinearity, sensitivity to temperature variations, and angular response influenced by the diffusive optics. Each parameter was analysed to determine system performance under close to real-world conditions, using both laboratory and in situ validation setups. Key findings revealed that without proper optics used the accuracy of irradiance measurements are significantly influenced. Improvements on the system design and on calibration procedures were implemented to address these issues, improving the overall accuracy and stability of the systems. By addressing these challenges, the systems demonstrated enhanced robustness and suitability for long-term environmental monitoring in extreme conditions. This study underscores the necessity of rigorous pre-deployment testing and calibration for low-cost monitoring devices, particularly when deployed in challenging environments. The findings contribute to advancing the development and deployment of cost-effective technologies for environmental monitoring, enabling more sustainable and accessible data collection practices in forests under extreme climatic conditions.