EGU26-20320, updated on 16 Jun 2026
https://doi.org/10.5194/egusphere-egu26-20320
EGU General Assembly 2026

RemoTrees: advancing scalable ground validation of satellite products with a new generation of autonomous satellite forest sensor nodes

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Forests are pivotal components of the global carbon cycle, yet satellite Earth Observation (EO) products for canopy condition, disturbance, and carbon flux proxies remain challenging to validate in remote and hard-to-reach regions where continuous ground measurements are scarce. The RemoTrees project was launched to bridge this gap by developing and deploying autonomous, low-power IoT, satellite enabled, multi-sensor systems and a harmonized data workflow that couples in-situ observations with EO information to improve the robustness and interpretability of carbon-cycle assessments under increasing climate extremes.

After the initial project phase focused on requirements, baseline demonstrations, and integration concepts, RemoTrees has progressed over the last two years to a technology maturation stage with successive device generations. A **beta version** of the RemoTrees node has been engineered and validated through laboratory characterization and pilot field deployments, enabling end-to-end testing of sensing, power autonomy, telemetry, remote management, and data continuity in operational forest conditions. These results directly informed iterative improvements leading to a **gamma (final) version**, targeting higher reliability, easier field maintainability, and improved data quality for EO calibration/validation use cases. Across these iterations, the project has refined a modular sensor approach to capture key variables relevant to forest functioning and stress—combining **under-canopy VIS–NIR radiometric observations** with complementary eco-physiological and environmental measurements (e.g., soil moisture, sap flow, and microclimate context)—and has strengthened data handling through structured metadata, quality control, and alignment with satellite acquisition constraints.

We present the RemoTrees mid-term status, highlighting the transition from concept to validated beta deployments and the consolidation into the gamma platform. Finally, we outline the next project steps: scaling deployments across different forest types, consolidating calibration and validation protocols, and advancing data-fusion strategies so that continuous ground observations can more effectively reduce uncertainties in EO-based carbon monitoring and support resilient

forest management.