A Novel In-situ Monitoring Technology for Hard-to-Reach Forests Supporting EO Land Product Validation

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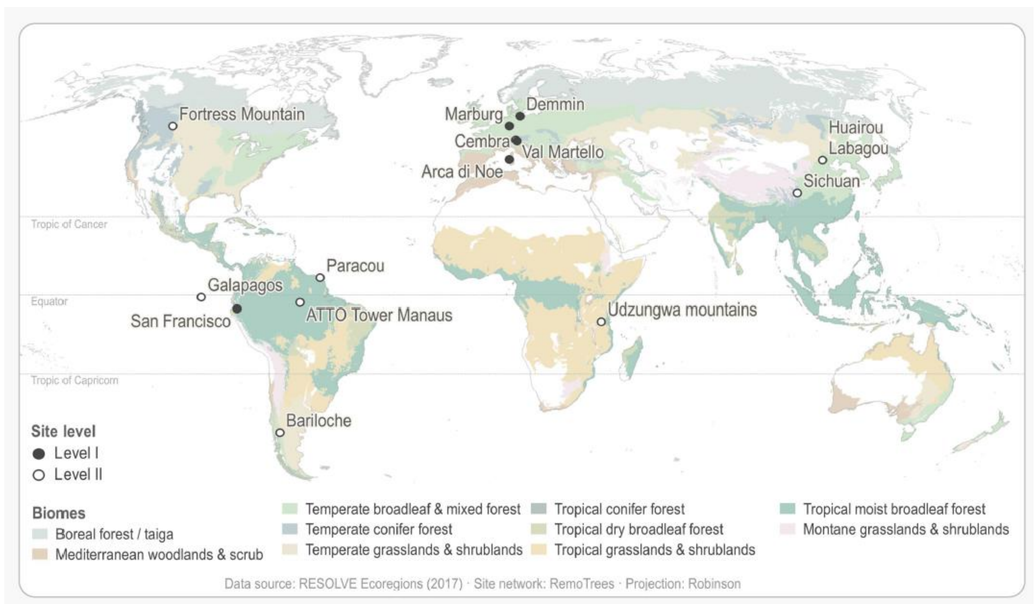
Funded by the European Union

RemoTrees context and sampling

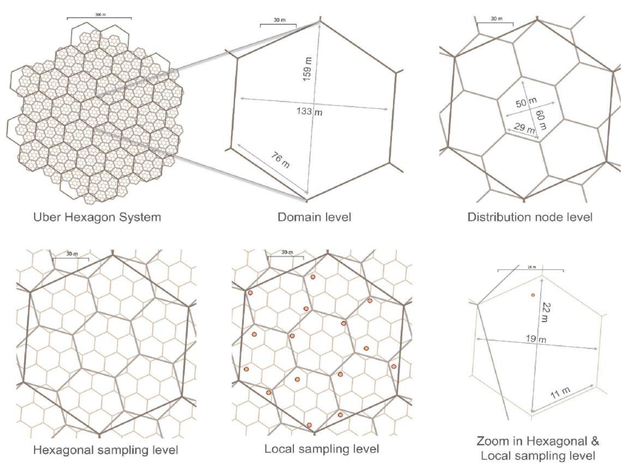


Forests play a key role in the Earth climate system, yet in-situ observations remain scarce in remote and hard-to-reach areas. The Horizon Europe RemoTrees project was conceived to address the lack of in-situ data in remote forests and complement Earth Observation efforts to monitor climate change effects on forest ecosystems.

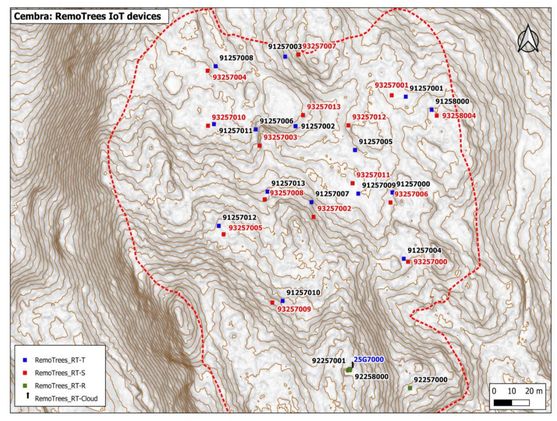
RemoTrees develops autonomous IoT-based monitoring systems for remote forests, providing continuous measurements of stem growth, stem moisture, sap flow, incoming radiation, canopy transmittance and reflectance, soil moisture, and meteorological parameters. These measurements support the retrieval of up to four Essential Climate Variables (ECVs): LAI, fAPAR, soil moisture and above-ground biomass change. RemoTrees aims to strengthen the Copernicus in-situ component and also support the calibration and validation of Earth Observation (EO) land products in hard-to-reach areas.



RemoTrees Site network across contrasting ecoclimatic conditions. Level 1 (Beta prototype), Level 2 (Gamma prototype)



Hierarchical sampling at site level based on the Uber hexagon system (H3)



RemoTrees device deployment at the Cembra Level 1 site (Italy).

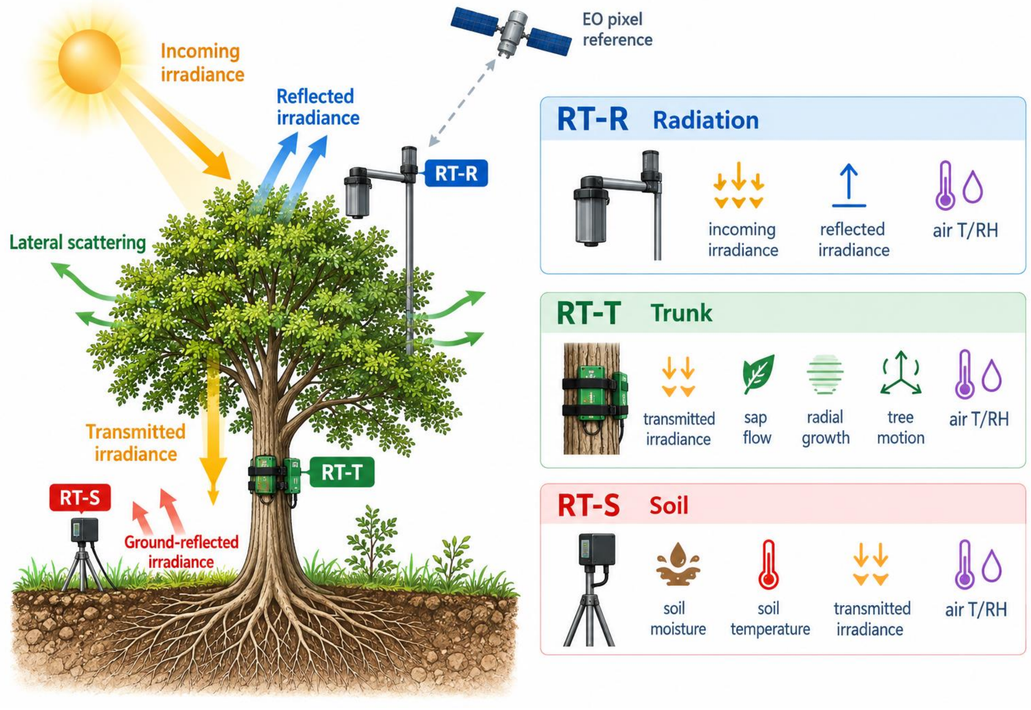
From RemoTrees measurements to biophysical variables

Laboratory calibration supported improvements to the RemoTrees beta system



RemoTrees (RT-T) device Beta prototype installed at Cembra (Italy)

RemoTrees radiometers provide multispectral measurements covering the VIS–NIR range.



1- Estimate PAR (PPFD) from multispectral irradiance

$$PAR = \sum_i E_i \, \lambda_i \, \Delta\lambda_i \frac{1}{hcN_A}$$

E_i: spectral irradiance; λ_i: wavelength; $\Delta\lambda_i$: bandwidth

2- Estimate FIPAR from above- and below- canopy PAR

$$FIPAR_{2F} = 1 - T$$

T: PAR transmittance $T = \frac{PAR_{trans}}{PAR_{inc}}$

$$FIPAR_{3F} = 1 - T - R$$

R: above-canopy PAR reflectance $R = \frac{PAR_{refl}}{PAR_{inc}}$

3- Estimate PAI from FIPAR

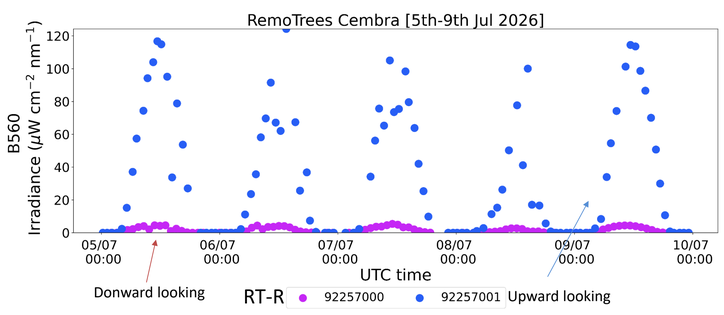
From Beer-Lambert law: $T = e^{-k\,PAI}$

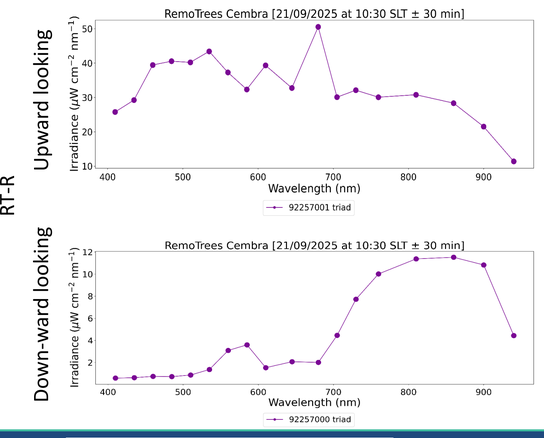
$$PAI = -\frac{\ln(1 - FIPAR)}{k}$$

$FIPAR$: 2-flux or 3-flux estimate
k: effective extinction coefficient

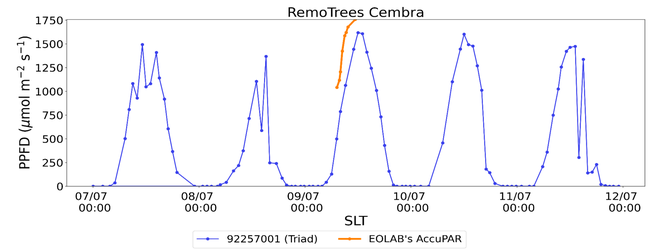
Preliminary results

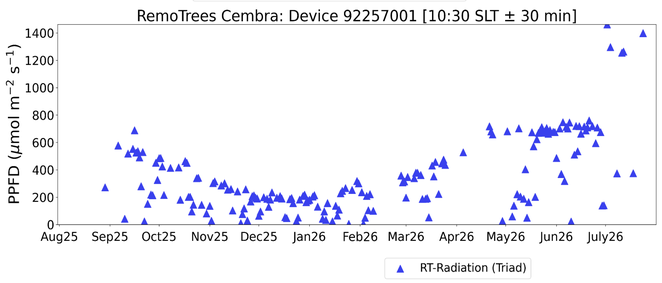
RemoTree data

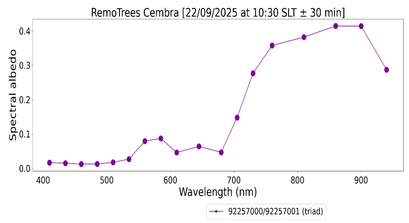


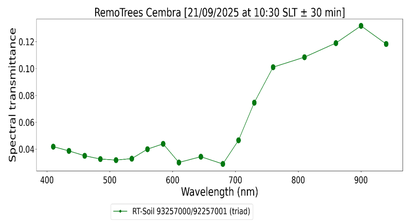


RemoTree derived quantities

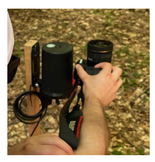


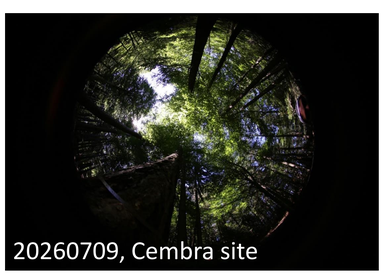






DHPs acquired at each RT device as part of the site characterization will be used to calibrate/validate the PAI/FIPAR estimates







Outlook

- **RT device deployment is ongoing, with several sites already operational.**
- **Preliminary RT data are currently under analysis and quality control, prior to the derivation of biophysical parameters.**
- **DHP measurements were acquired at each RT device location, complemented by a field campaign at Cembra (following CEOS-FRM protocols) to support the calibration and validation of RT-derived PAI and FIPAR estimates.**

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