



Conference Abstract

Photoacoustic CO₂ sensor collocation method at SMEAR Estonia

Isabele Todeschini[‡], Emílio Graciliano Mercuri^{§,‡}, Steffen Noe[§], Ulrich Norbistrath[‡], Matevž Zorec[‡]

[‡] Federal University of Parana, Curitiba, Brazil

[§] Estonian University of Life Sciences, Tartu, Estonia

[‡] Tartu Ülikool, Tartu, Estonia

Corresponding author: Emílio Graciliano Mercuri (emiliomercuri@gmail.com)

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Abstract

The research project aims to develop and install environmental monitoring systems in hemi-boreal ecosystems, utilizing low-cost technologies and artificial intelligence (AI). The proposal integrates sensors to measure atmospheric CO₂ by the collocation method, calibration and analysis methods are based on machine learning.

The initiative seeks to understand atmospheric dynamics in forests (Järvselja Experimental Forest, Estonia), evaluating carbon responses to environmental changes. The systems are field-calibrated using certified reference equipment and enhanced with AI models, such as Random Forest and XGBoost, to ensure data precision and reliability. Sensors will be used to measure gas exchanges and carbon dynamics, contributing to understanding these ecosystems' role in carbon sequestration.

Several correction techniques were used to verify the ability of machine learning models to improve measurements, Fig. 1 shows the Taylor Diagram of the comparison between AI models. The calibration was done for the sensors at 30 meters on the main tower of SMEAR Estonia, which were installed next to the pipe that sucks air for analysis in the reference equipment. The CO₂ concentration in ppm, temperature and relative humidity (3 variables measured by the SCD41 sensor) were used as input data and the objective was to train the algorithms to estimate the CO₂ concentration in ppm measured by the Los Gatos equipment at 30 meters high. The analysis indicates that for this case the

Random Forest (RF) and XGBoost non-linear regression models performed better than the multiple linear regression (MLR) model. Fig. 2 shows the time series of CO2 reference concentration and SCD41 sensor corrections using Multiple Linear Regression (MLR) and Random Forest (RF).

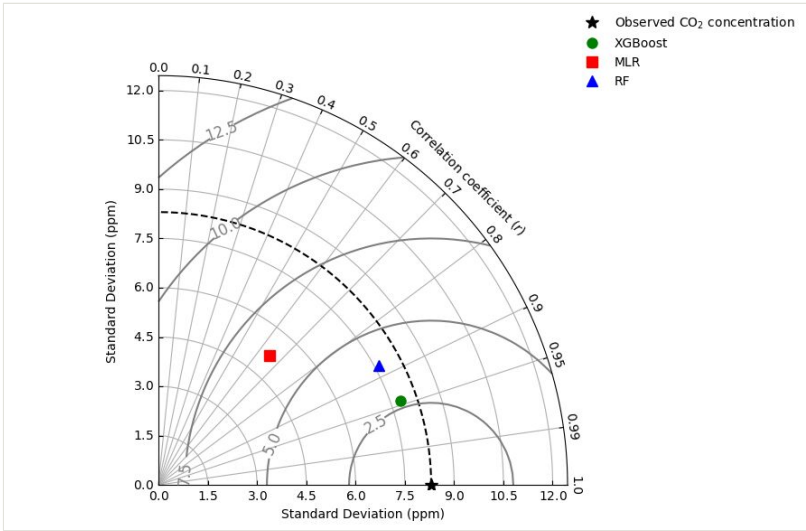


Figure 1. [doi](#)
Taylor diagram showing statistical comparison of reference CO2 concentrations and SCD41 sensor corrections using Multiple Linear Regression (MLR) (red square), Random Forest (RF) (blue triangle) and XGBoost (green circle). The star represents the reference CO2 data.

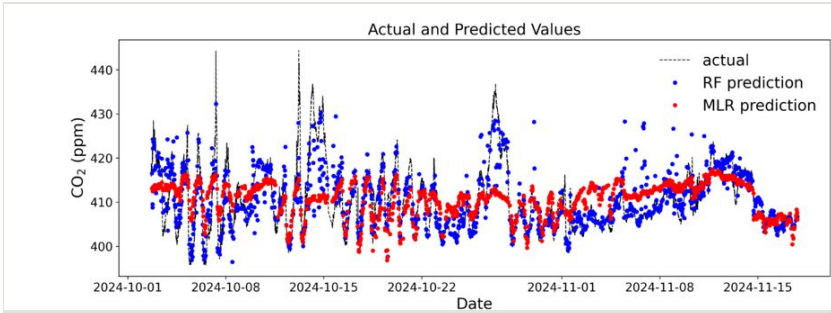


Figure 2. [doi](#)
Time series of CO2 reference concentration and SCD41 sensor corrections using Multiple Linear Regression (MLR) and Random Forest (RF).

With an interdisciplinary focus, the proposal collaborates with national and international institutions, such as SMEAR Estonia, and promotes human resource training, the generation of long-term data, and the publication of scientific results. The project also aims to influence public policies and democratize environmental monitoring, strengthening awareness of air quality and climate change.

Keywords

Microcontrollers, Internet of Things, Artificial Intelligence, Air Pollution, Carbon Balance

Presenting author

Steffen Manfred Noe

Presented at

ORAL

Conflicts of interest

The authors have declared that no competing interests exist.