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LONG-TERM ISOPRENE (BVOC) FLUXES IN THE AMAZON RAINFOREST BY RELAXED EDDY ACCUMULATION COUPLED TO GC/PID (REAPER)

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Abstract: Understanding the role of Biogenic Volatile Organic Compounds (BVOCs) in atmospheric chemistry and their impact on oxidants and aerosol formation is essential for global environmental research. BVOC emissions, primarily sourced from biogenic processes, pose a challenge due to the vast diversity of vegetation and ecosystems, as well as temporal changes in land use. While prevalent BVOC emission models categorize vegetation into functional types, the variability in environmental parameters and temporal fluctuations within natural canopies remains inadequately represented. This study introduces an innovative device system designed to address these challenges by integrating the Relaxed Eddy Accumulator and Gas Chromatograph Photoionization Detector (REAPER) in real-time measurement of isoprene fluxes. The system is portable, cost-effective and lightweight, easily to deploy in remote environments. By enabling high temporal resolution measurements, this device overcomes limitations associated with traditional techniques and offers accurate chromatograms. The novel instrument also facilitates real-time data transmission through a cloud-based platform, allowing access to meteorological data, calculated parameters, chromatograms and flux results. This feature supports the deployment of these systems across a wide range of sites and integrates them into existing flux tower networks. In conclusion, this research contributes to the advancement of isoprene fluxes measurement techniques and validation of satellite-based retrievals of isoprene abundances providing a valuable tool for scientists studying atmospheric chemistry and its impacts on the environment in diverse ecosystems, ultimately aiding in our understanding of the complex interplay between biogenic processes and atmospheric chemistry. The REAPER is installed in the ATTO tower in the Amazon rainforest and continuously measures Isoprene every hour within parts per billion (ppb) content. All the meteorology and chemistry data are sent through the Internet anywhere in the world to measure the BVOCs fluxes.

Keywords: BVOC, Amazon, REA, Isoprene, GC/PID.

INTRODUCTION

Global reactive carbon emissions are estimated at 2.4 Pg annually, with significant contributions from carbon monoxide (0.6 Pg), methane (0.5 Pg), isoprene (0.5 Pg), and other volatile organic compounds (0.8 Pg). About half of these emissions are from terrestrial vegetation, with the rest from technological sources, biomass burning, and microbes. Isoprene, primarily emitted by tropical vegetation, plays a crucial role in plant physiology and atmospheric chemistry due to its high reactivity, leading to various oxidation products and secondary organic aerosols that impact climate. The Amazon rainforest is a significant source of isoprene but estimating its emissions is challenging due to biodiversity and limited observational data. Accurate isoprene modeling is hindered by uncertainties in emission factors and the effects of extreme weather conditions, which are expected to increase with climate change. Current measurement techniques using gas chromatographs and mass spectrometers, though precise, are not well-suited for long-term field use in remote areas like the Amazon, necessitating the development of new, robust instruments for better spatial and temporal coverage.

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METHODS

This research aims to develop and evaluate an instrument based on the REA methodology to measure BVOC fluxes globally in real-time, addressing the lack of empirical data in current climate models. The REAPER device segregates atmospheric air based on vertical wind velocity, collecting samples into reservoirs for upward and downward air currents. Designed to be cost-effective, energy-efficient, and robust, the REAPER channels air samples to an online GC-PID, focusing on isoprene and other VOCs. It generates real-time data on meteorological parameters, stores the information on Google Drive, and interfaces with the GC-PID via a Raspberry Pi or Ethernet connection. The REAPER, deployed in the Amazon rainforest in May 2023 at the ATTO site, includes three main components: a control unit, a segregator enclosure, and a GC unit with a PID. This innovative system provides crucial data for improving climate models by capturing detailed BVOC flux measurements in remote locations.

FINDINGS AND ARGUMENT

During the initial testing phase of the REAPER instrument in Dr. Alex Gunther's laboratory at the University of California Irvine, comprehensive evaluations ensured that the system met anticipated parameters, generating new ß values. Verification involved introducing the heat flux equation to rigorously assess the ß coefficient's accuracy. Data was collected every two seconds and synchronized through Google Drive, with new ß coefficients calculated every 30 minutes. Chromatograms generated every 50 minutes allowed real-time monitoring of flux results. Data was organized into two sheets on Google Drive: "Segregation Data," containing meteorological observations, and "REA Data," storing critical study parameters, including ß coefficients and heat flux. Custom-coded analysis in RStudio revealed a notable correlation between heat flux, diurnal and nocturnal cycles, and temperature variations, with ß coefficients ranging from 0.30 to 0.45, indicating proper system functioning. These insights are crucial for accurately determining the flux of compounds like isoprene, with consistent patterns observed during the Amazon rainforest campaign from September 12, 2023, to the present, across different seasons.

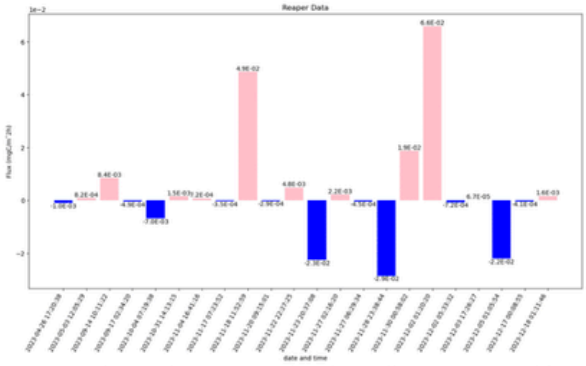

Figure 1 shows the magnitude of the fluxes captured by the REAPER over the period of deployment in the Amazon.

CONCLUSIONS

The study highlights the successful validation of the REAPER instrument, demonstrating its capability to accurately measure and segregate BVOC fluxes based on vertical wind velocity (Figure 1). The system's performance, as indicated by consistent ß coefficient values and reliable correlations with heat flux and temperature variations, confirms its potential for real-time, high-resolution monitoring. The instrument's robustness and effectiveness were proven during the Amazon rainforest campaign, showing consistent results across different seasonal transitions. This suggests that the REAPER can significantly enhance empirical data collection for climate models, particularly in remote and diverse environments.

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