# Volatile Organic Compounds: Concentrations and Fluxes at a Belgian Mixed Forest Site

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## 1. Introduction

#### i) Background

Above-canopy  $CO_2$  turbulent flux measurements have been performed at Vielsalm, Belgium (BE-Vie) since the 90s. From 2009 to 2011, these fluxes were extended to include a selection of VOCs often exchanged between terrestrial ecosystems and the atmosphere, using a PTR-Quad-MS instrument. Recently, we returned to the site with new instruments to extend characterization by including a plethora of additional VOCs and ozone.

## 2. Campaign description

ICOS Integrated Carbon Observation System

### i) Site description

**Mixed forest** ecosystem in the Integrated Carbon Observation system (ICOS) network located in the Belgian Ardenne at about **450 m a.s.l.** and characterized by a **temperate maritime climate.** 

#### ii) Objectives

Obtain **multi-year** data at the mixed forest site in Belgium to identify VOCs and their abovecanopy fluxes. Quantify the role of **biophysico-chemical processes** in the **soil-canopy-atmosphere** continuum affecting VOC concentrations and fluxes.



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Fig 1: Schematic representation of measurement site.

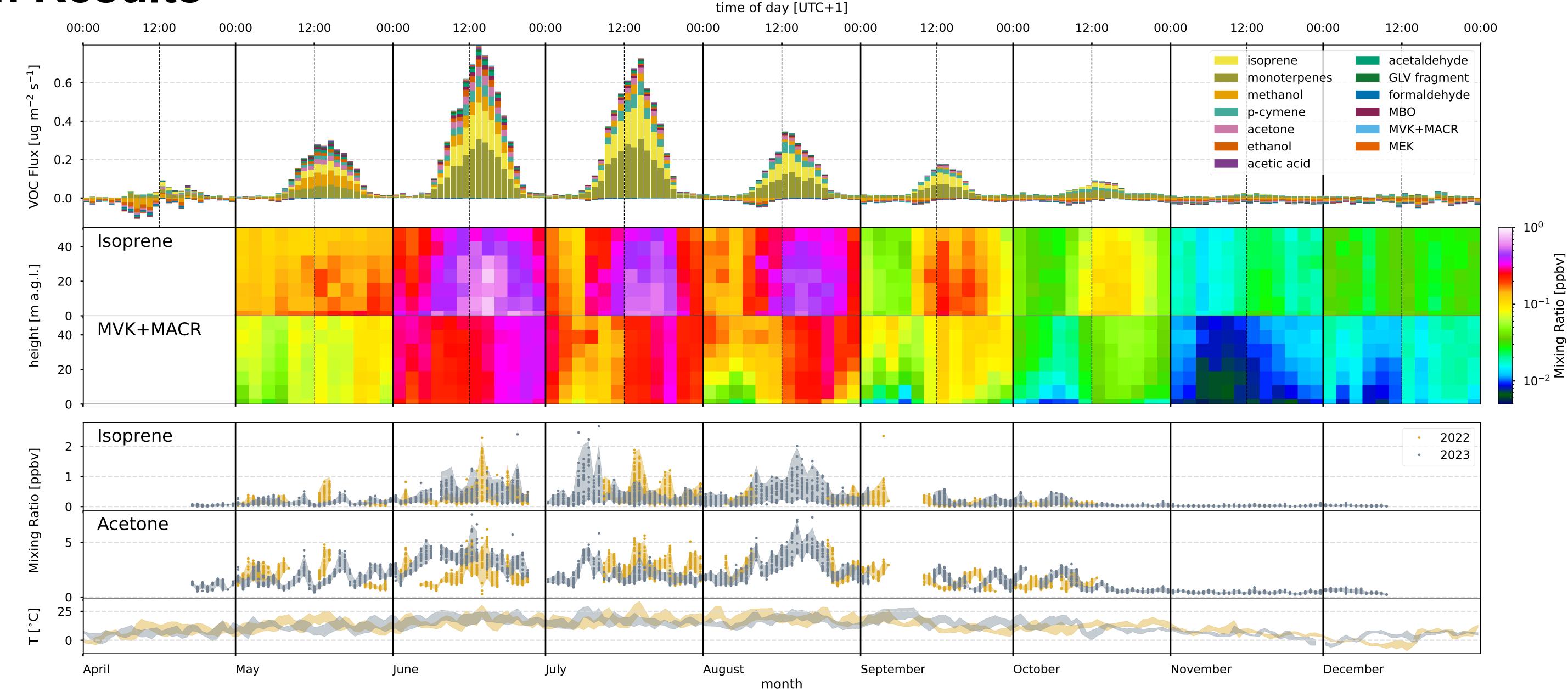
#### ii) Instrumentation

- **PTR-TOF-MS** (PTR-TOF-4000, Ionicon Analytik GmbH): sample **above-canopy** (52 m a.g.l.), **trunk space** (3 m a.g.l.; 2023), **profile** (trunk space + 5 points along tower)
- Sonic anemometers: above canopy, trunk space (2023), profile (2 instruments)
- Above canopy **fluxes** calculated by eddy covariance (GEddySoft, based on InnFlux)

## 3. (O)VOC quantification

	Campaign operations	Spectrum analysis	Mass selection	Process and select calibrations	(O)VOC quantification	
	<ul> <li>Calibration every 3-4 days using an Apel-Riemer VOC standard</li> </ul>	<ul> <li>Ionicon Data Analyser (IDA)</li> <li>Mass scale calibration</li> </ul>	<ul> <li>Density based self clustering algorithm with applications of noise</li> </ul>	<ul> <li>Quantify RH dependence (as done by de Gouw et al., 2002)</li> </ul>	<ul> <li>Calibrated VOCs, low uncertainty (16 VOCs)</li> </ul>	
	<ul> <li>Zero measurements every 4.5h</li> </ul>	<ul> <li>Peak stability timings</li> <li>Automated peak identification</li> <li>Peak area calculation</li> </ul>	<ul> <li>number of clusters found: 811 (2022), 1002 (2023)</li> <li>Cut on cluster width based on instrument resolution</li> </ul>	<ul> <li>Transmission curve based on non-fragmenting calibrated VOCs</li> </ul>	<ul> <li>Uncalibrated; from first principles based on literature, moderate uncertainty (11 VOCs)</li> </ul>	
		<ul> <li>Near daily IDA analysis</li> </ul>	<ul> <li>number of clusters selected: 609 (2022), 416 (2023)</li> <li>Cut on fraction of data below limit of detection retained 224 (2022)</li> </ul>	<ul> <li>Calculate calibration coefficients for all VOCs in the gas standard</li> </ul>	<ul> <li>Uncalibrated; from first principles using defaults, high uncertainty</li> </ul>	a a a a
		Li	limit of detection retained 224 (2022)	Li	using defaults, high uncertainty	

### 4. Results



**Fig 2:** Top, monthly median diel profile of VOC fluxes (for the 13 most exchanged VOCs), calculated using the eddy covariance method. Second and third rows, monthly median diel vertical concentration profiles of isoprene and its oxidation products, respectively. Fourth and fifth rows, daily 10 minute average concentrations in 2022 (yellow) and 2023 (gray) for isoprene and acetone, respectively. Bottom row, daily temperature in 2022 (yellow) and 2023 (gray).

## 5. Conclusion & Preliminary Analyses

Two growth seasons of VOC concentrations in a mixed forest environment were obtained and are currently being analysed. Preliminary results:
60% of NMVOC-OH reactivity originates from tracers present in the calibration gas standard.
Mixed forest site, nearby saw-mill and industrial sites complicate VOC concentration analysis.

#### Bi-directional exchange of low molecular mass OVOCs, deposition enhanced with RH. Emission bursts for selection of compounds after bud break. 10 compounds account for 90% of total exchanged mass.

### 6. Prospects

#### Measurements

The 2024 campaign has started in early June and is currently ongoing.
In 2025, a campaign is scheduled at this site with added NO<sub>x</sub> measurements.

#### Data analysis

Perform a flux driver
 analysis, using data from
 ICOS ecological follow-up.
 Apply matrix
 factorization to identify
 mesoscale sources.

#### Modelling

 Compare fluxes with emissions from MEGANv3.
 Apply 1-D canopy model with chemistry (FORCAST).
 Perform a Lagrangian inversion of vertical profiles.

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