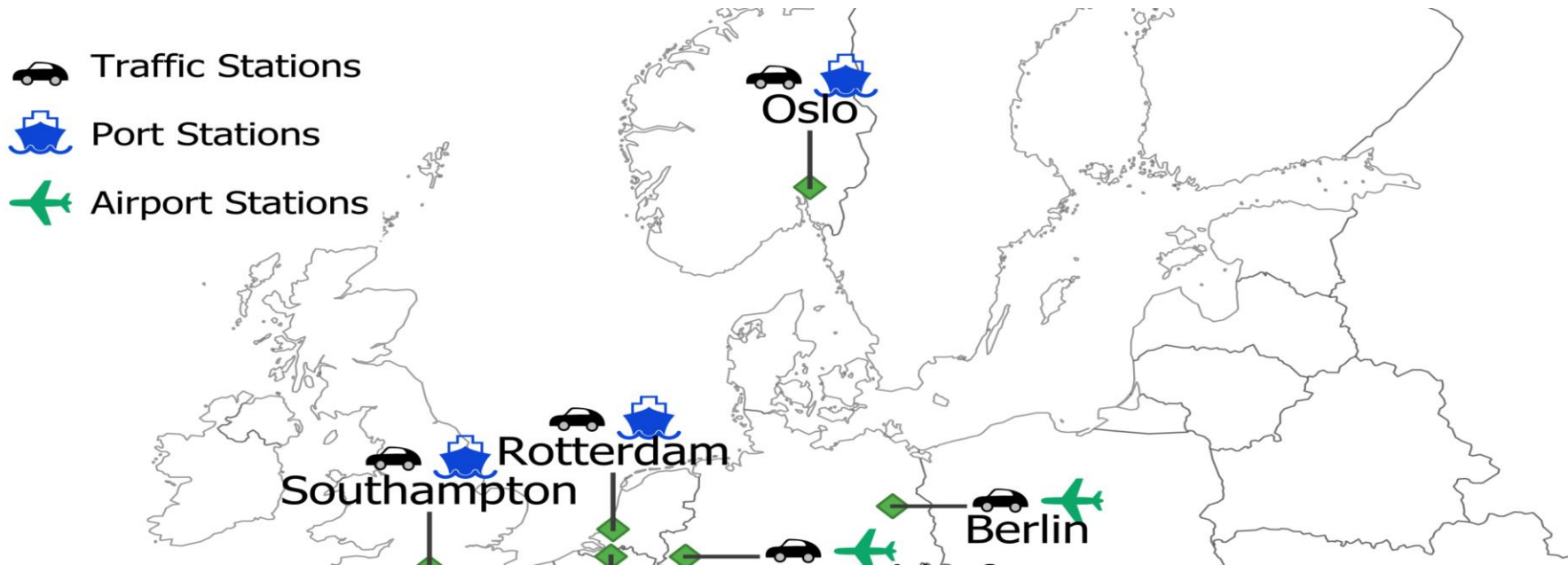




ADVANCING URBAN VOC MONITORING: INSIGHTS FROM THE NET4CITIES PROJECT AND MOBILE PTR-TOF OBSERVATIONS

28.04.2026 | ARCHITA RANA, ROBERT WEGENER, MAX GERRIT ADAM, HIMADRI SHEKHAR BHOWMIK, RENE DUBUS, LUKAS KESPER, DIETER KLEMP, FRANZ ROHRER

NET4CITIES PROJECT

- ❑ An EU-funded project measuring transport-related air and noise pollution across 11 cities in 10 countries, providing harmonized and comparable datasets.
- ❑ Focus on emerging pollutants, among them volatile organic compounds (VOCs), ultrafine particles (UFPs), and ammonia (NH₃), to improve understanding of urban emission sources and their impacts.
- ❑ Contributing to the implementation of the EU's Zero Pollution Action Plan and the new EU Air Quality Directive (EU/2024/2281).

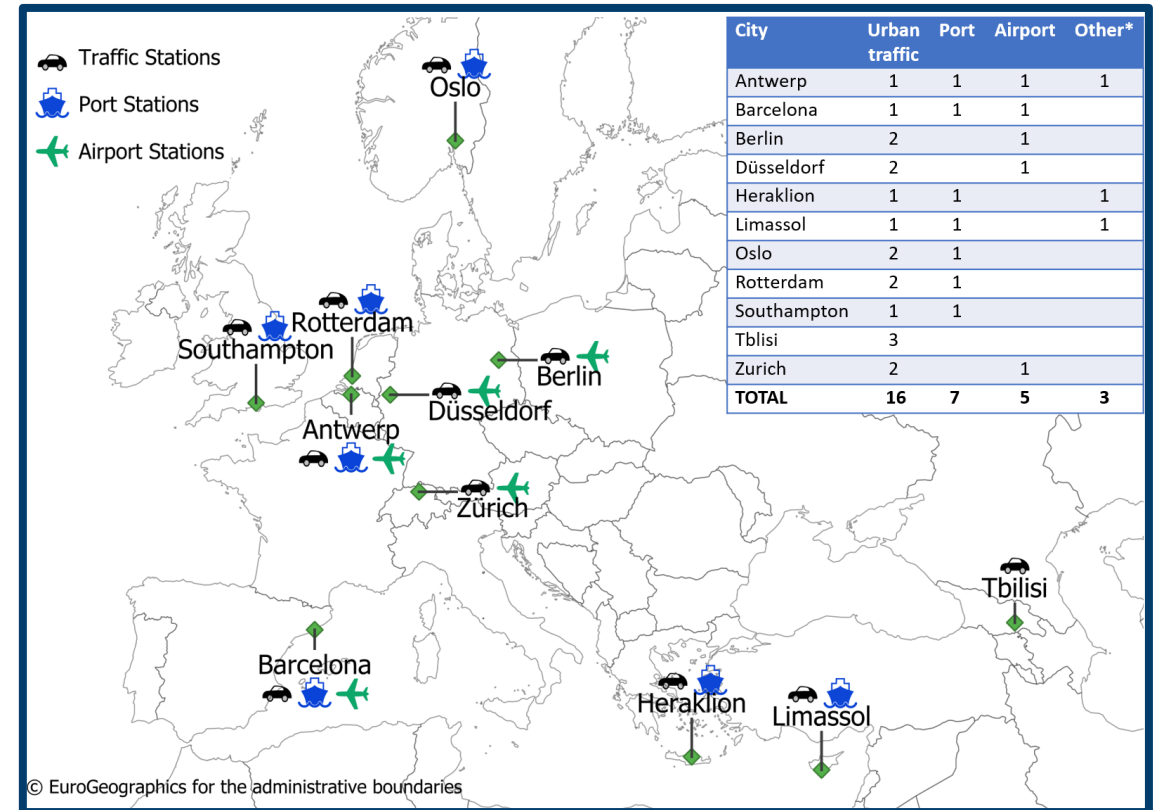
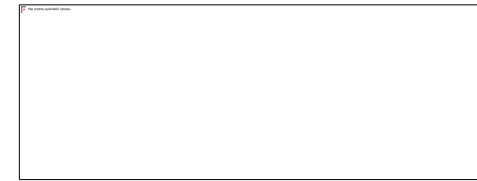


Figure: Monitoring network across 11 cities in 10 European countries, showing Traffic, Port, and Airport station types.

AQ + NOISE MEASUREMENT INSTRUMENTS

Instrument	Species and time period	Measurement description
Partner: Airmodus 	UFP (24/7): 2+years	- CEN (ACTRIS) approved UFP detector, Condensation Particles (Number) Counter. - Working fluid propylene glycol.
Partner: ZHAW (Zurich, Switzerland) 	LDSA (24/7): 2+years	- Lung Deposited Surface Area (20-350 nm). - Measurement of SA by diffusion charging.
Partner: Cyl (Cyprus Institute) 	Black Carbon (BC): 2+years	- Aethalometer AE33 measuring absorption coefficient b_{abs} - For transport and biomass sources
Partner: NILU (Oslo, Norway) 	NH ₃ Passive samplers: 1 years	- Sampler impregnated with oxalic acid. - Analysis based on photometry.
Partner: Cyl (Cyprus Institute) 	PM ₁₀ Filter: 1 year	- Source attribution for exhaust/non-exhaust emission. - Analysis in the Cyl.
Partner: Cirrus Research 	Noise Monitoring (24/7): 2+years	- Continuous noise level recording. - GDPR-compliant (no audio).
Partner: Telraam 	Telraam Outdoor traffic counter: 2+years	- Video-based counting, measurement of distance from the road and the height. - Unobstructed view of traffic, GDPR-compliant



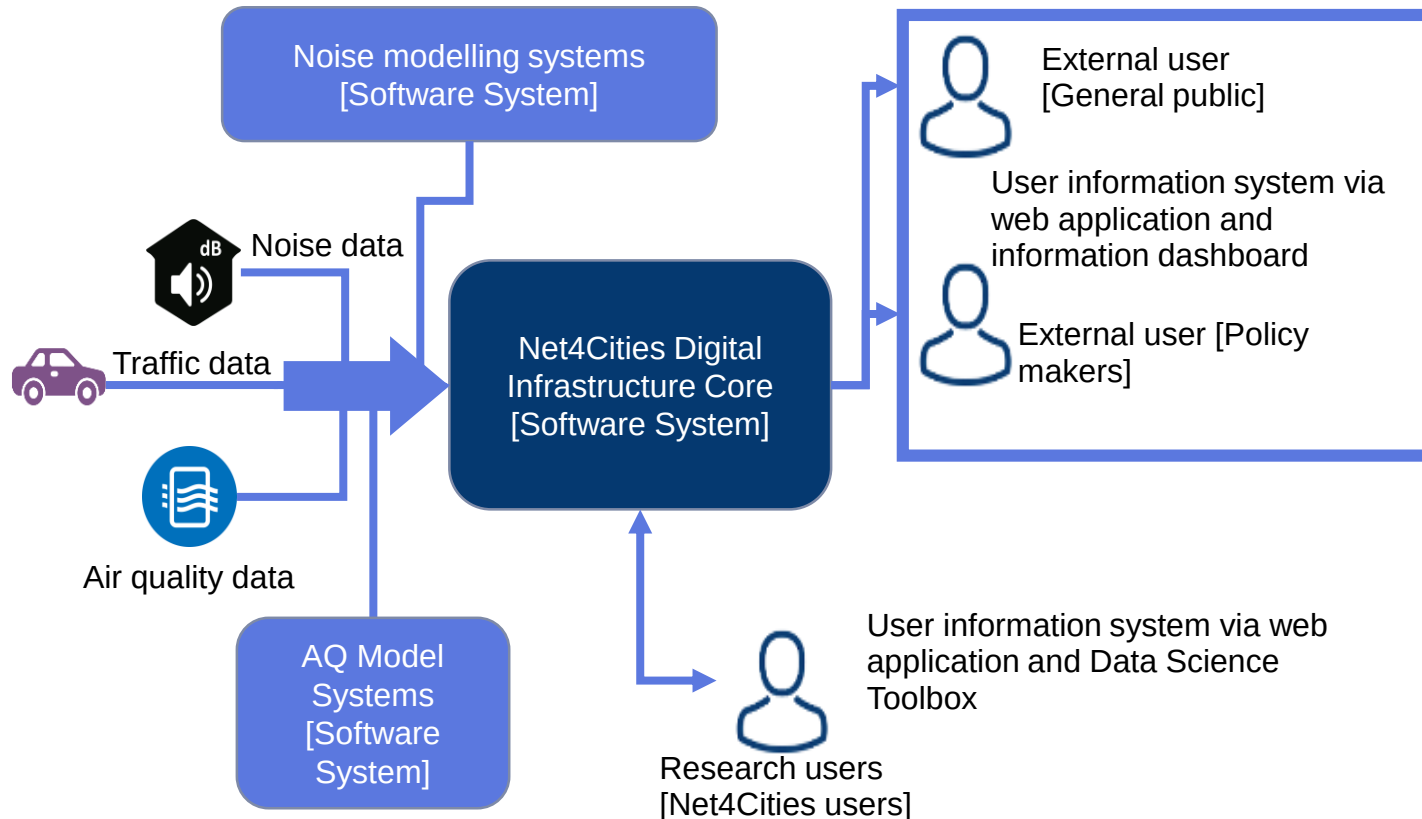
Partner: FZJ

Canister: 1 year

- NO, NO₂, O₃, N₂O, CO₂, CH₄, CO, and VOCs.
- Passivated SilcoCan canisters with ozone depletion filter.

PROJECT OVERVIEW

DATAHUB



- ❑ Net4Cities datahub: A digital infrastructure integrating noise, traffic, and air quality dataset into a central hub serving researchers, policymakers, and the public.
- ❑ Net4cities studio will also be created with datasets, recommendations, and policy support tools integrated into a web-based solution.

COLLECTION AND ANALYSIS OF VOC AND TRACE GASES

- Once a month, first Wednesday from 08:00-09:00 LT
- Calibration: 74-component standard NMHC gas standard
- VOCs from C2 to C12 are separated

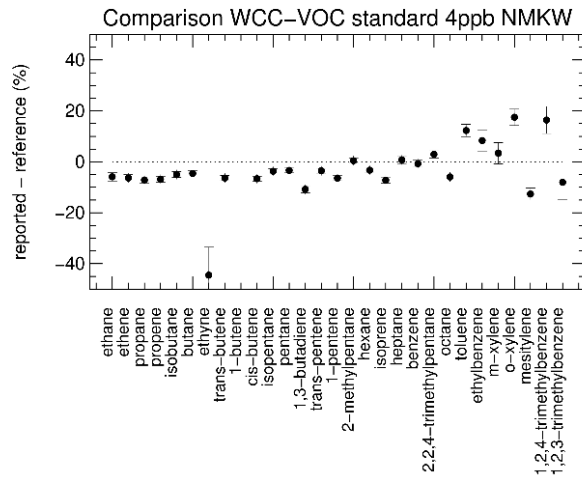
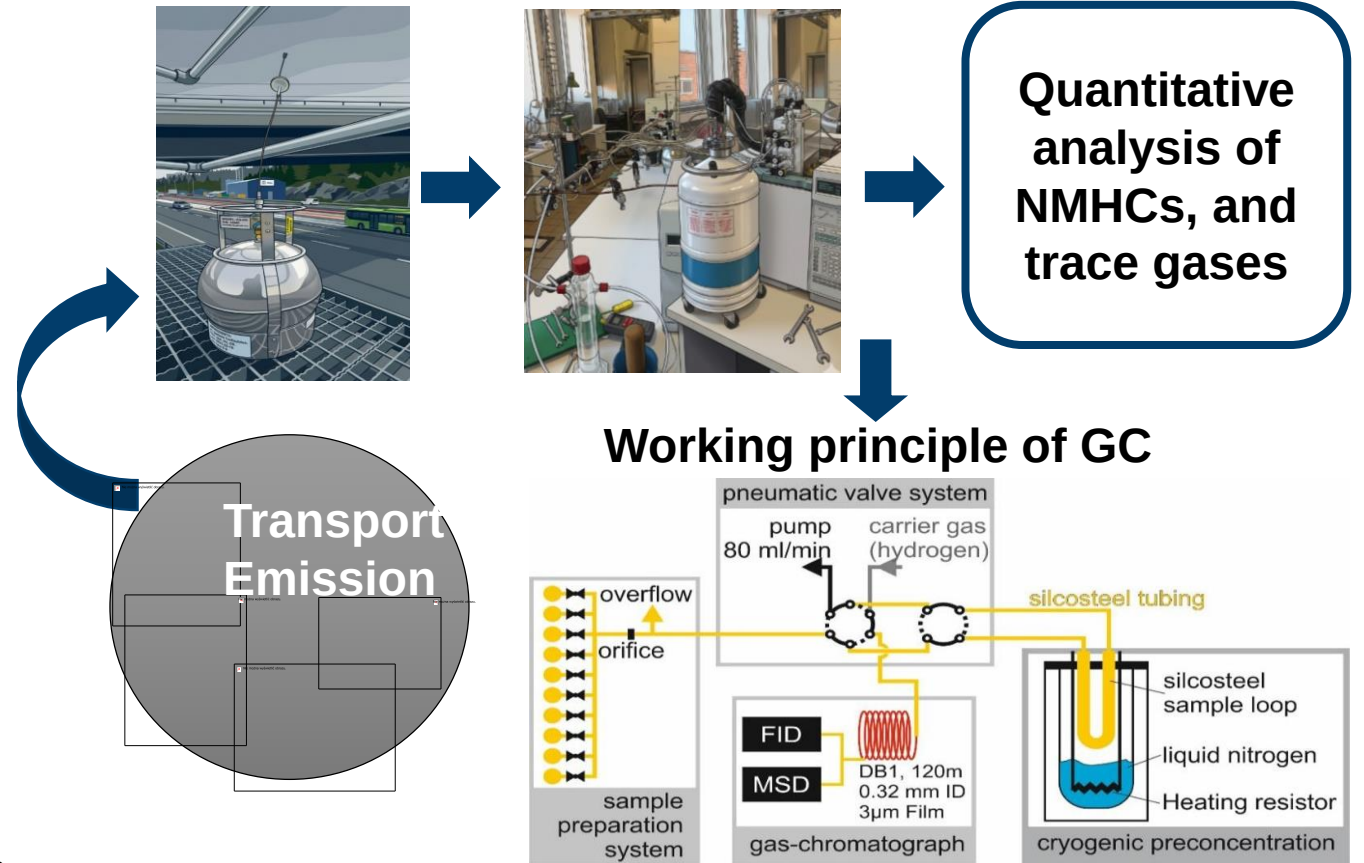


Figure: Deviation of the 74-component NMHC standard from the WCC-VOC reference.



THE CONCEPT OF OH REACTIVITY

- The production of secondary pollutants depends on the reactivity towards OH of both VOC and NO_x rather than the mixing ratio.

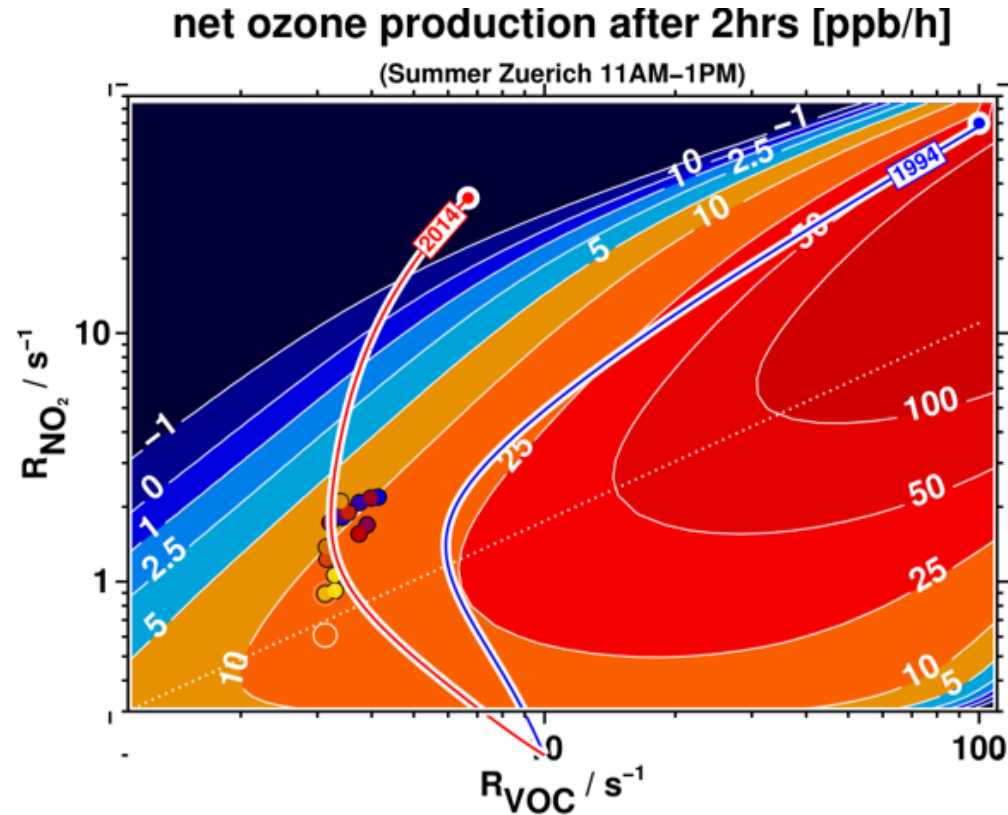
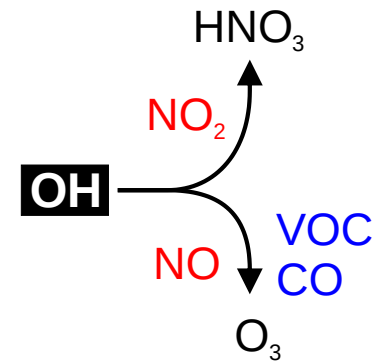
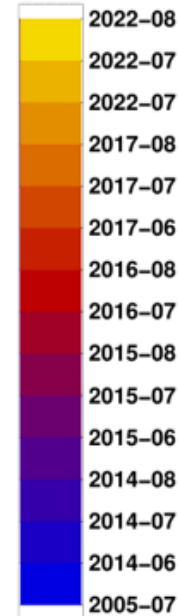


Figure: Local ozone production rate (ppb/h) for typical summertime conditions in Germany as a function of VOC and NO₂ reactivity (RVOC and RNO₂)

From: Ehlers, C., et al. (2016). "Twenty years of ambient observations of nitrogen oxides and specified hydrocarbons in air masses dominated by traffic emissions in Germany." *Faraday Discussions* 189: 407-437.

Month

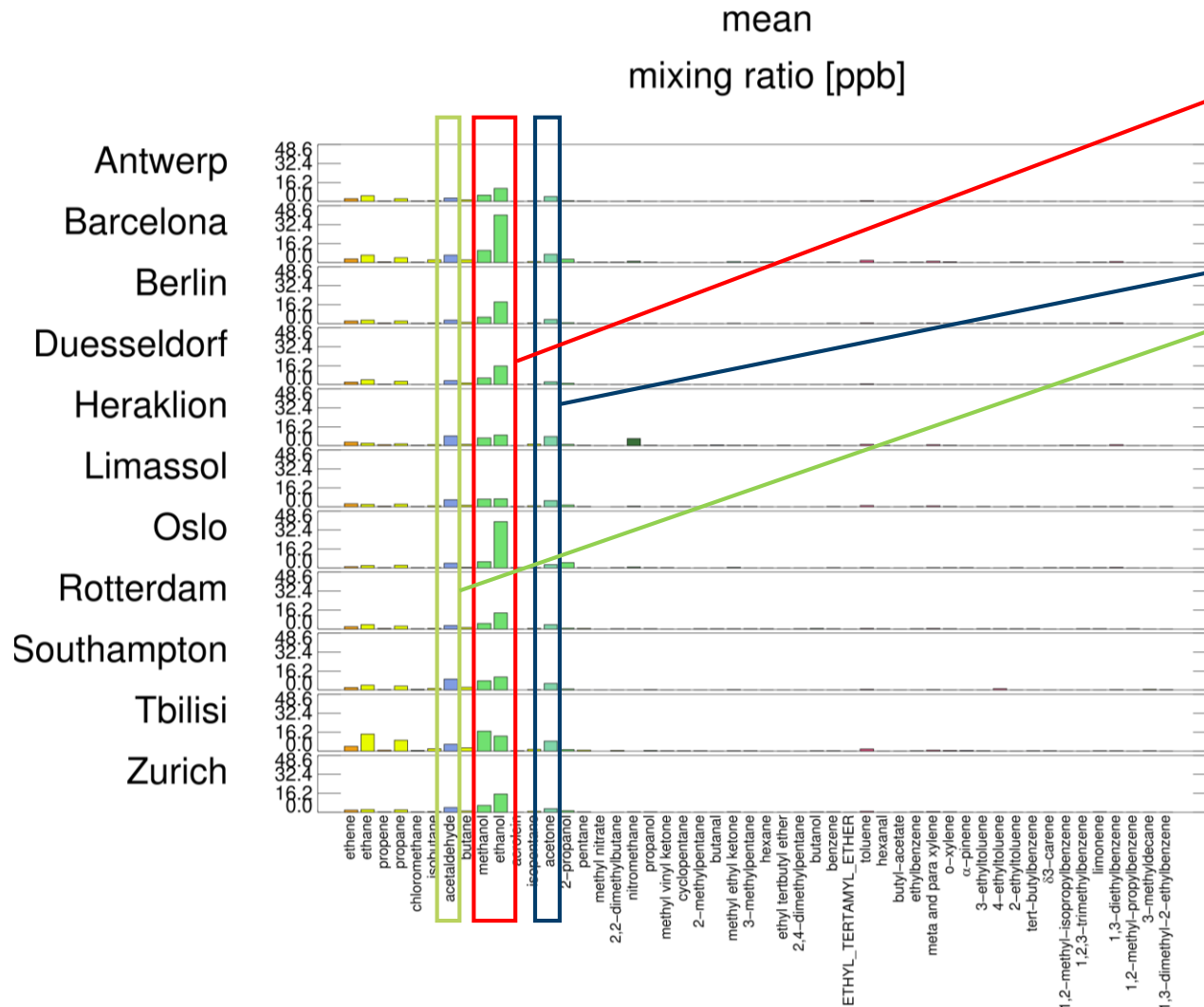


$$R_{\text{VOC}} = \sum k_{\text{OH}+\text{VOC}_i} \times [\text{VOC}_i]$$

$$R_{\text{NO}_2} = k_{\text{OH}+\text{NO}_2} \times [\text{NO}_2]$$

VOC CONCENTRATION

Variation in VOC mixing ratio across cities

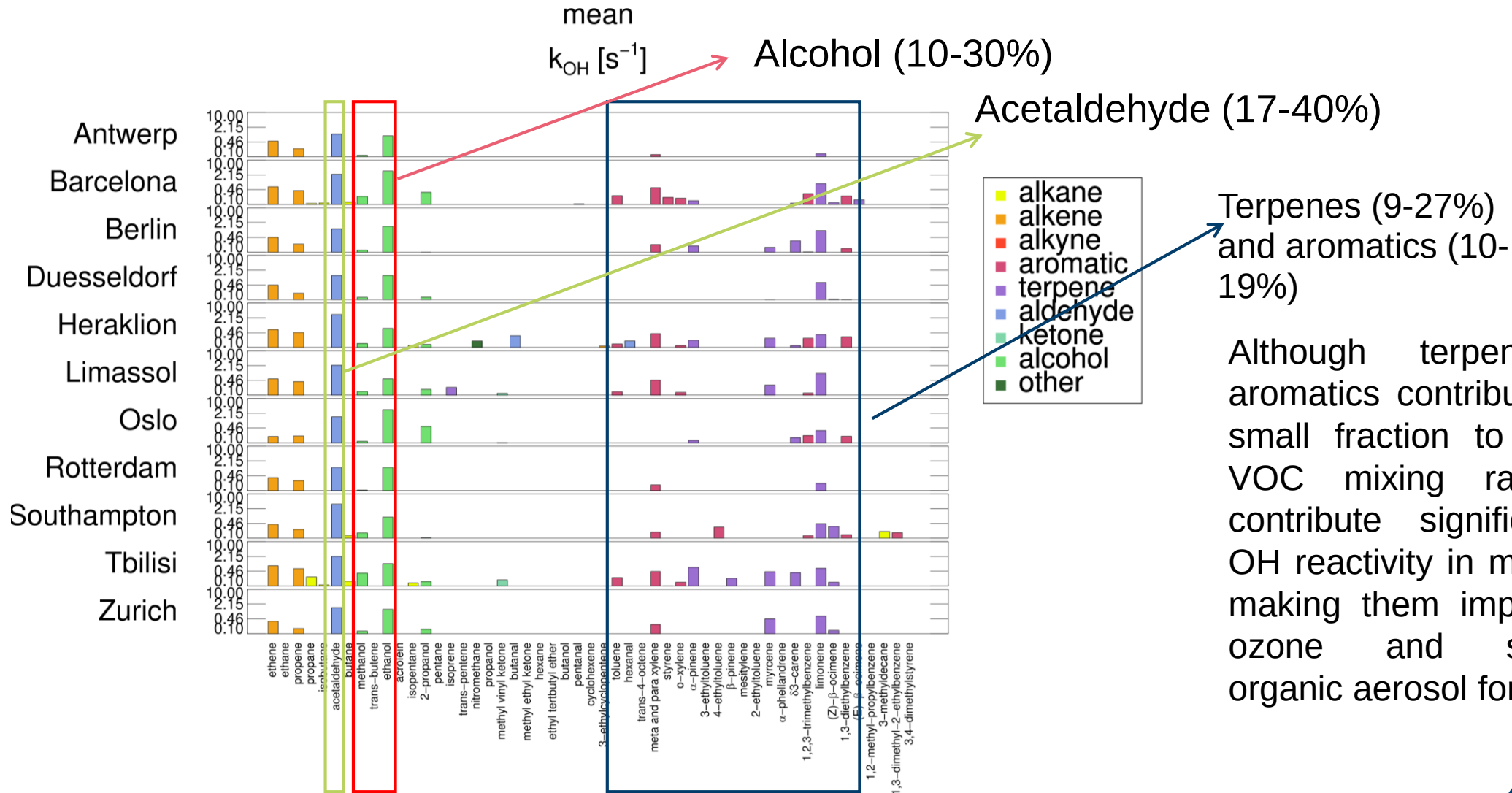


Ethanol (15-58%)
and methanol (8-19%)
dominate total VOC

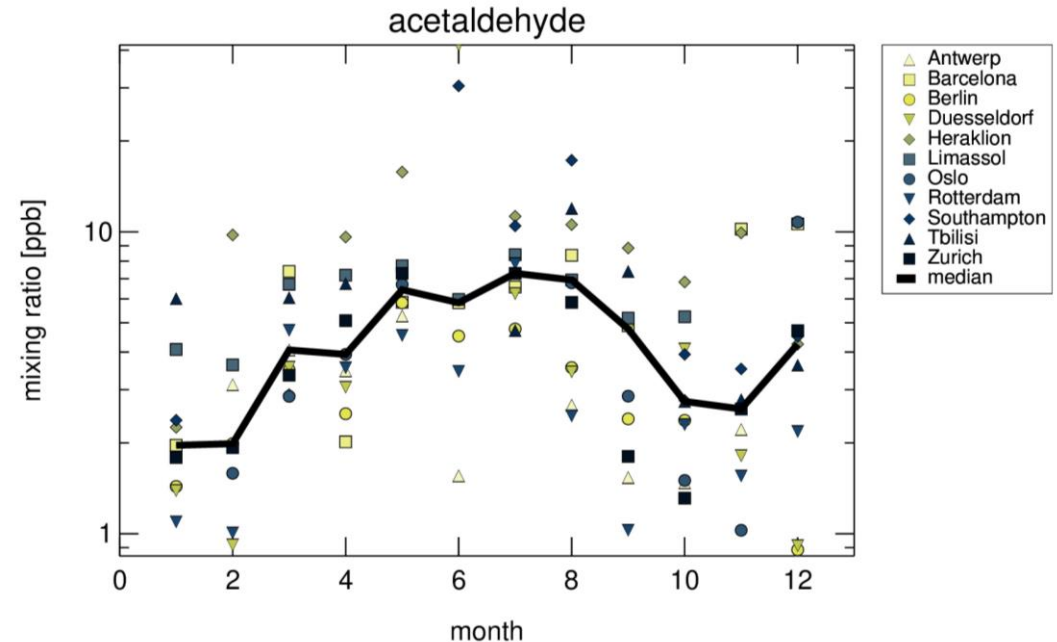
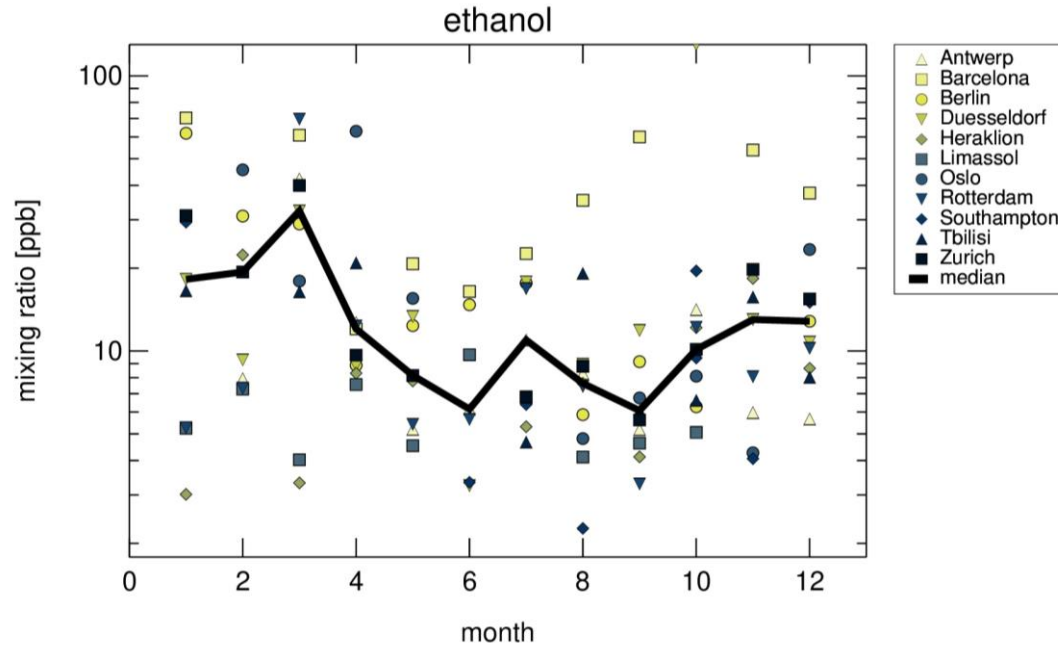
Acetaldehyde (6-15%)
and acetone (4-13%)
across cities

- ❑ Alcohol (28-73%) and alkane (10-36%) are the dominated compound class followed by aldehyde and ketones.
- ❑ Terpenes contributes $\leq 1\%$ while aromatics contribute $\leq 6\%$

OH-REACTIVITY OF VOCS (LOG-SCALE)

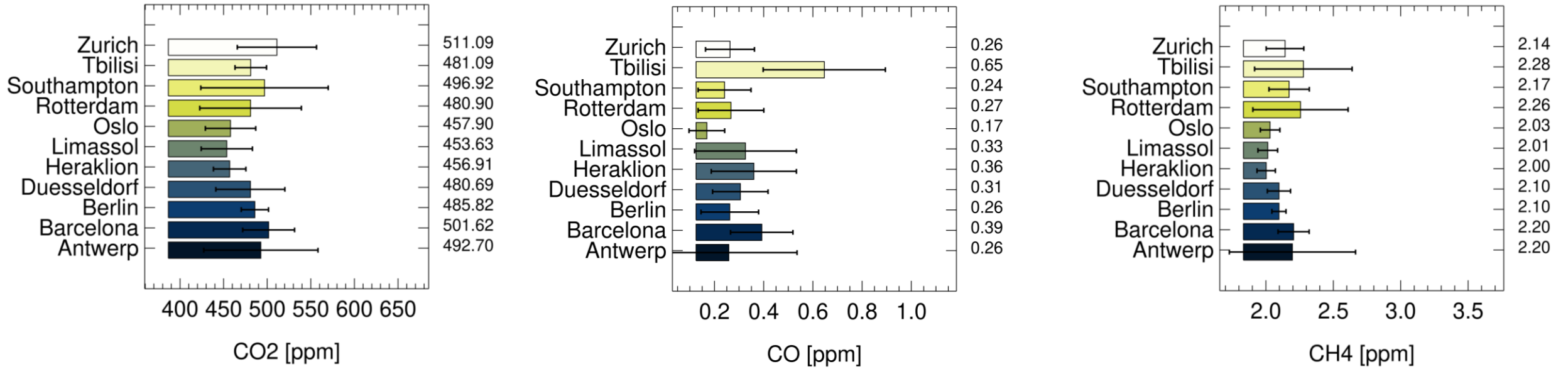


SEASONAL VARIATION IN VOCS



- ❑ Winter ethanol peak can be due to use of windshield washer fluid and weaker photochemical sink
- ❑ Summer acetaldehyde peak can be from photochemical production

GHGS FROM CANISTER MEASUREMENT



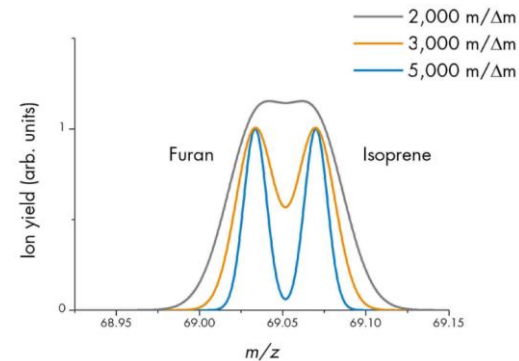
- ❑ CO₂ was highest in Zurich and lowest in Limassol.
- ❑ High CO concentration observed in Tbilisi, which was more than three times higher than of Oslo.
- ❑ CH₄ highest petrochemical-dominated port cities (Antwerp, Rotterdam).

MOBILAB - The Mobile Laboratory

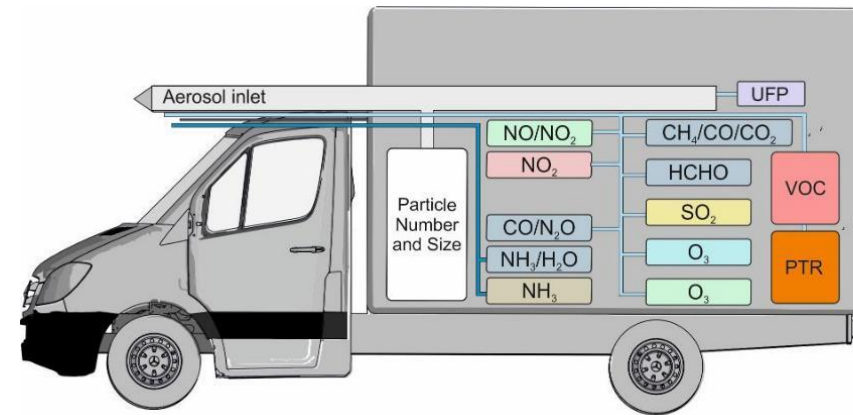
- ❑ Equipped with high time resolution measurement technology for particles and gases.
- ❑ Allows mobile and stationary measurements.



Comparison

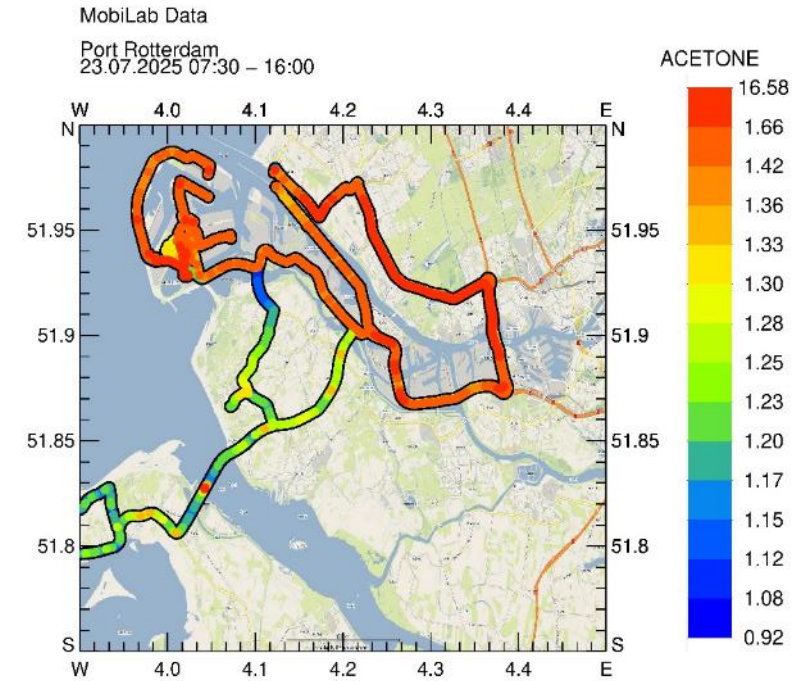
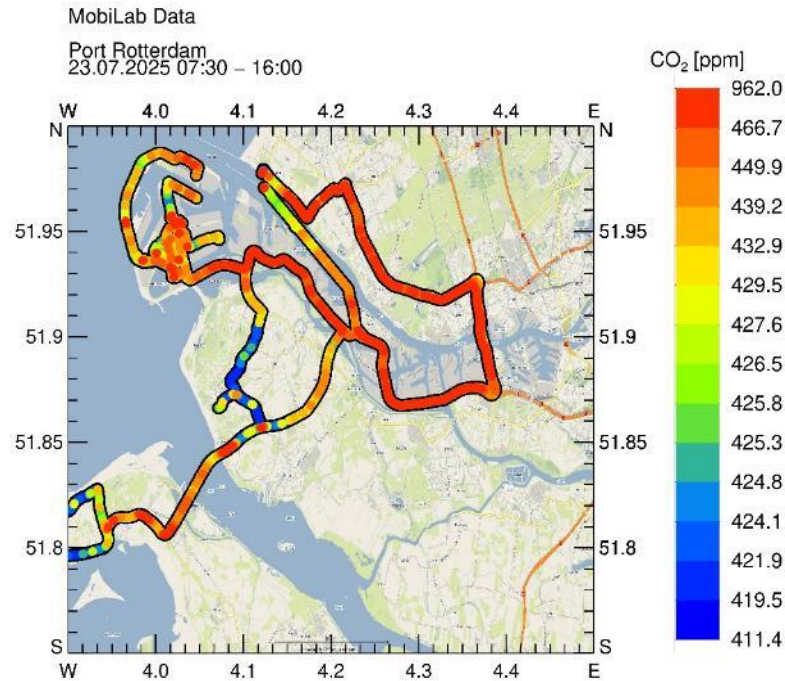


The resolution allows the separation of isobaric masses



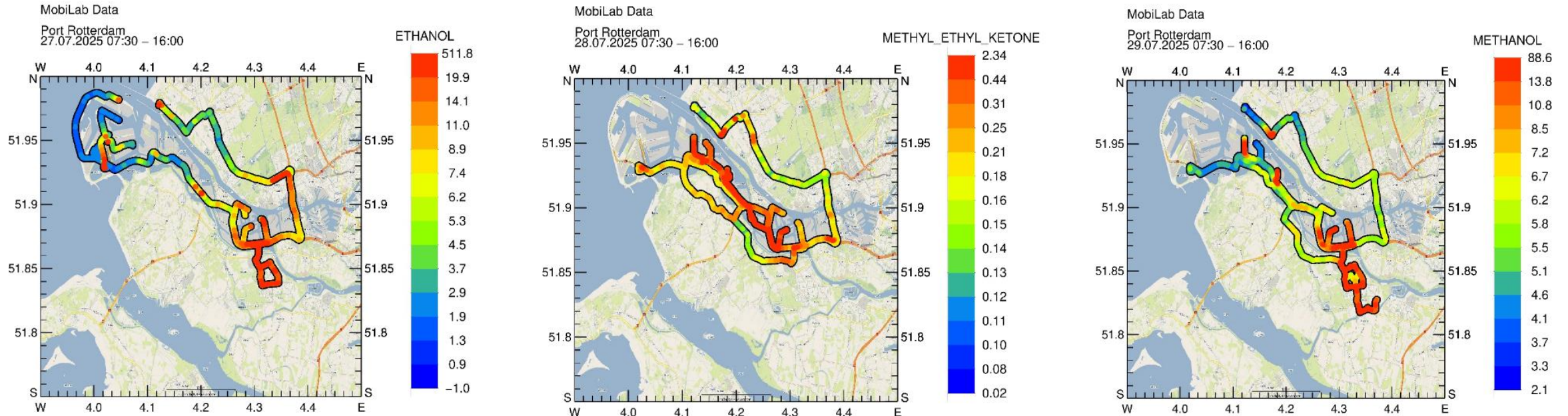
Methods:

- | | |
|---|--|
| Iterative cavity-enhanced DOAS (ICAD) | Off-axis Integrated Cavity Output Spectroscopy |
| Cavity Attenuated Phase Shift (CAPS) | Pulsed Fluorescence |
| Electrical Low Pressure Impactor (ELPI) | UV Adsorption |
| Cavity Ringdown Spectroscopy (CRDS) | Gas Chromatography / Mass Spectrometry (offline) |
| Condensation Particle Counter (CPC) | Proton Transfer Time-of-Flight Mass Spectrometer |



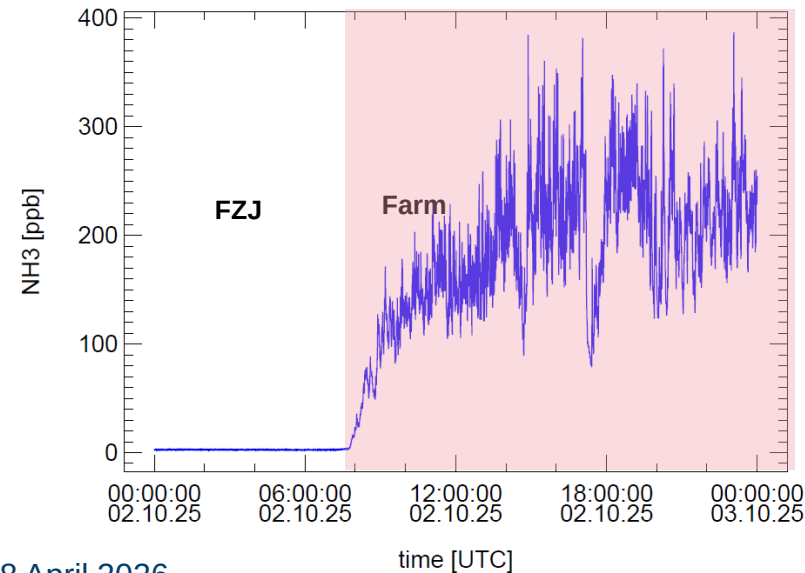
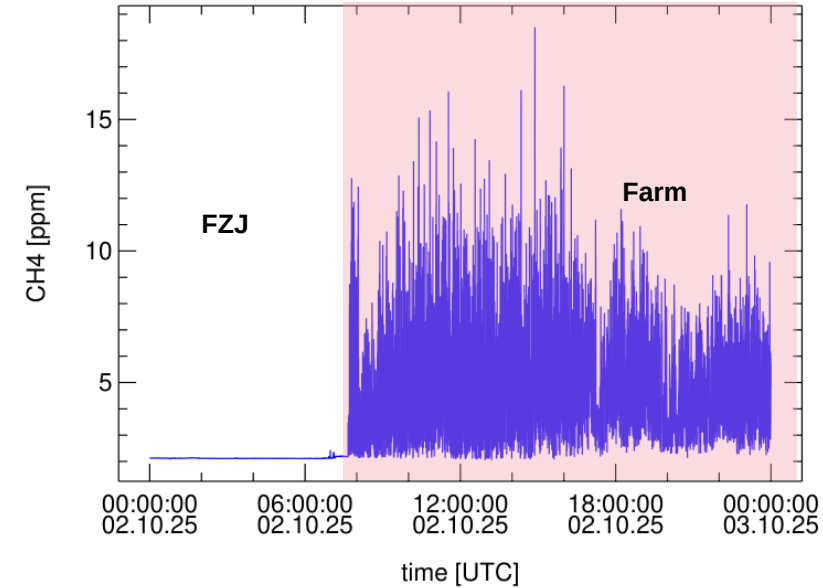
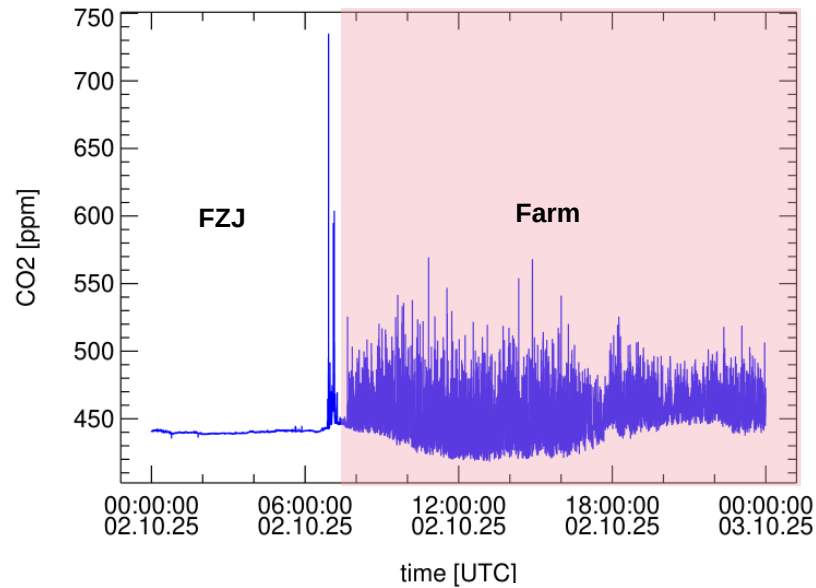
- ❑ The 2000 km, 10-day Mobilab traverse captured multiple distinct source environments such as refinery, harbour road, urban background
- ❑ High concentration observed at refinery clusters and along harbour road while urban background show low values

MEASUREMENT ROTTERDAM 27.07.2025 - 28.07.2025



Ethanol and Methanol are sharply elevated at the refinery cluster in the western port area and along Harbour Road, while urban residential zones register near-background values.

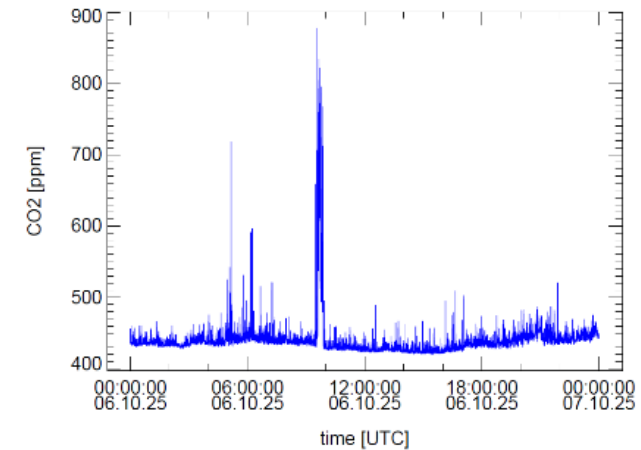
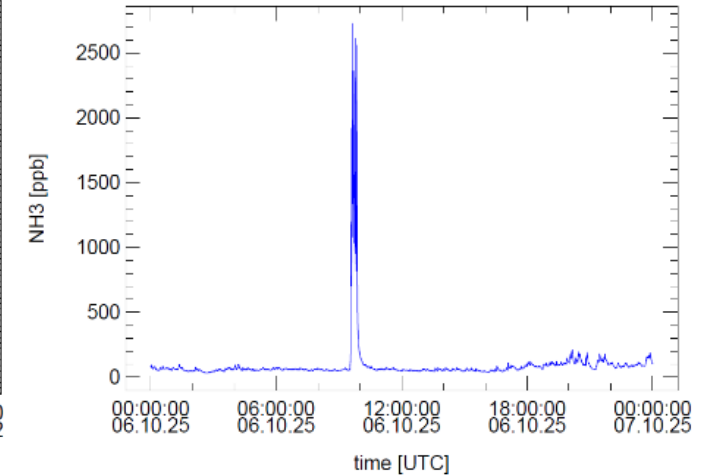
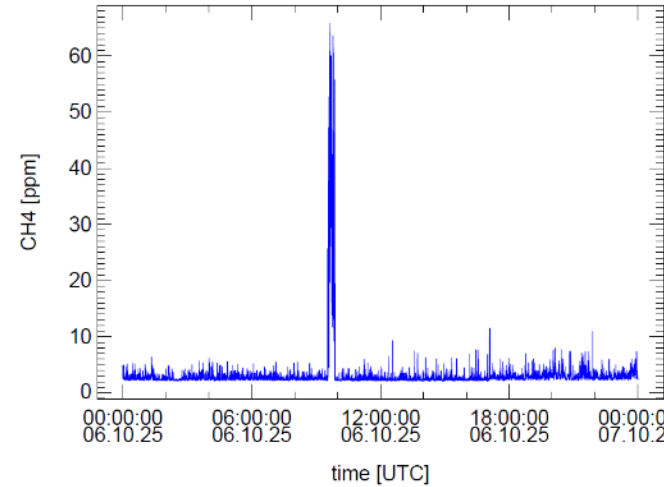
MOBILAB - MEASUREMENTS AT FARM IN JULICH



All three gases show a sharp, simultaneous increase upon entry into the farm, confirming the farm as the dominant emission source.

MOBILAB

MEASUREMENTS AT FARM IN JULICH



- ❑ Up to 60 ppm CH₄ and 2.5 ppm NH₃ in the barn.
- ❑ CO₂ peaks to ~900 ppm with periodic sharp spikes, correlated with the CH₄ and NH₃ peaks

CONCLUSION



Net4Cities:

- ☐ VOC concentration is dominated by ethanol and methanol; Terpenes and aromatics exhibit high OH reactivity despite low concentration.
- ☐ Fresh traffic emissions are prevalent across most cities during entire measurement period; however, several locations show signatures of mixed air masses.

Mobile and stationary measurements:

- ☐ Equipped with high-resolution particle and trace gas instrumentation alongside PTR-MS, provides a robust framework for high-resolution pollution mapping at major transport hubs.
- ☐ Canister-based GC-MS measurements can be complemented by PTR-MS to provide a more robust understanding of pollution dynamics.

Thank you



More about Net4Cities here:



Questions?

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You can find us here: <https://www.fz-juelich.de/en/ice/ice-3/research/reactive-trace-substances>