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Is traffic still an important source of Volatile Organic Compounds in European urban areas?

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Summary

- Background and overview of VOC data in urban areas (RI-URBANS)
- PMF results and impact on ozone and SOA fromation: Marseille – France and Zurich – Switzerland
- Conclusion and perspectives
- France contribution to the IMP campaign EMEP/ACTRIS

ATMOSPHERIC POLLUTION: A GENERAL SCHEME – ROLE OF VOCS

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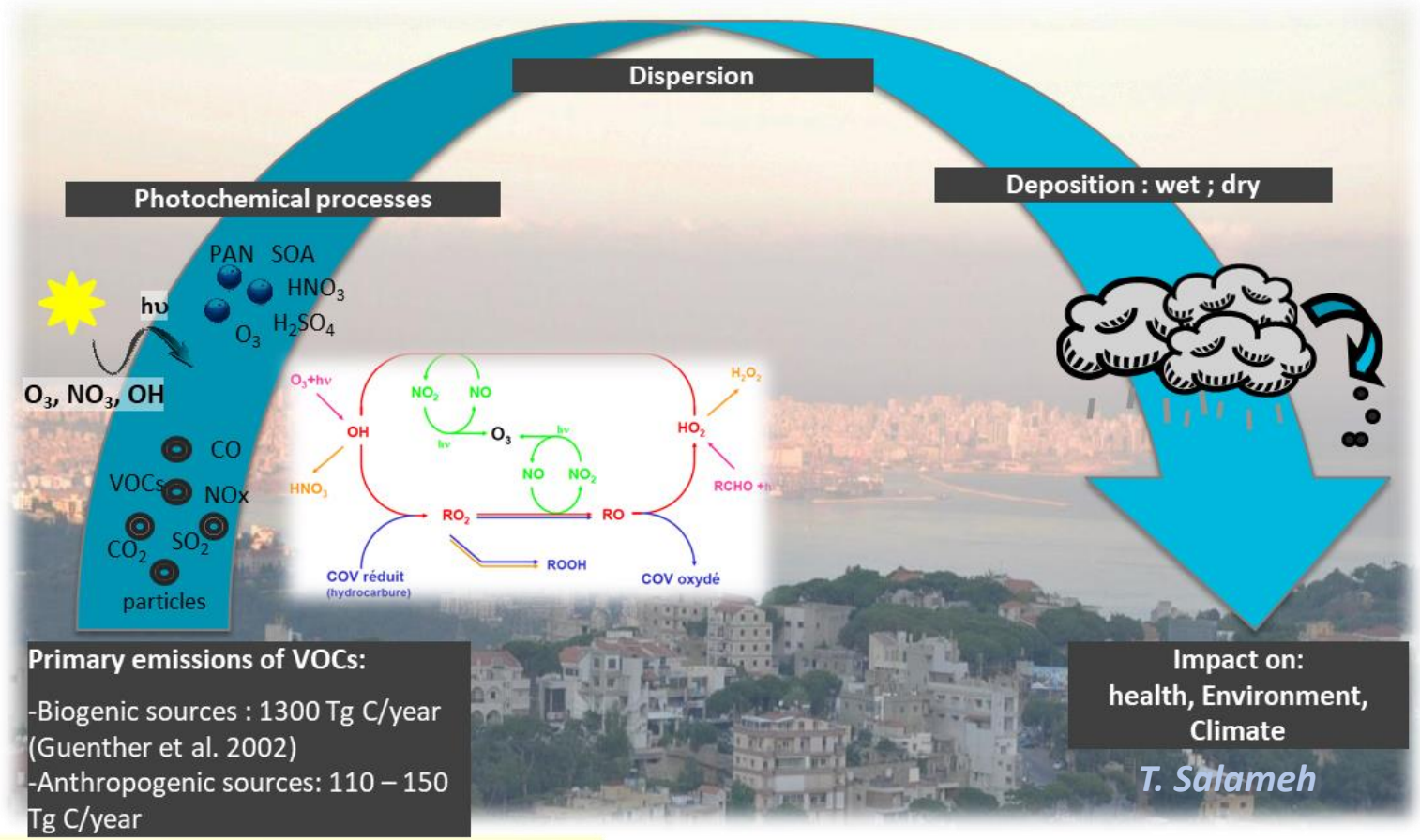
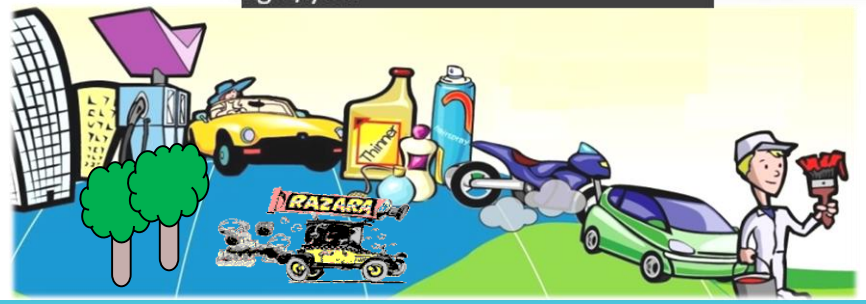
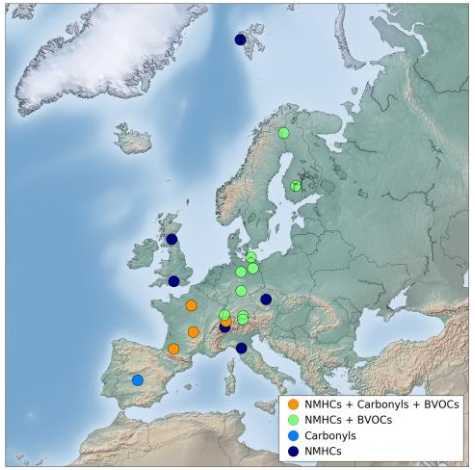




VOC monitoring in european urban sites?

VOC monitoring



Sites measuring and reporting EMEP level 2 VOCs for the year 2020 (EMEP report, 2022), Lack of oxy-VOCs and terpenes measurements

Global & regional VOC observations coordinated within GAW (WMO website)

RI-URBANS: Overview of VOCs database available in EBAS

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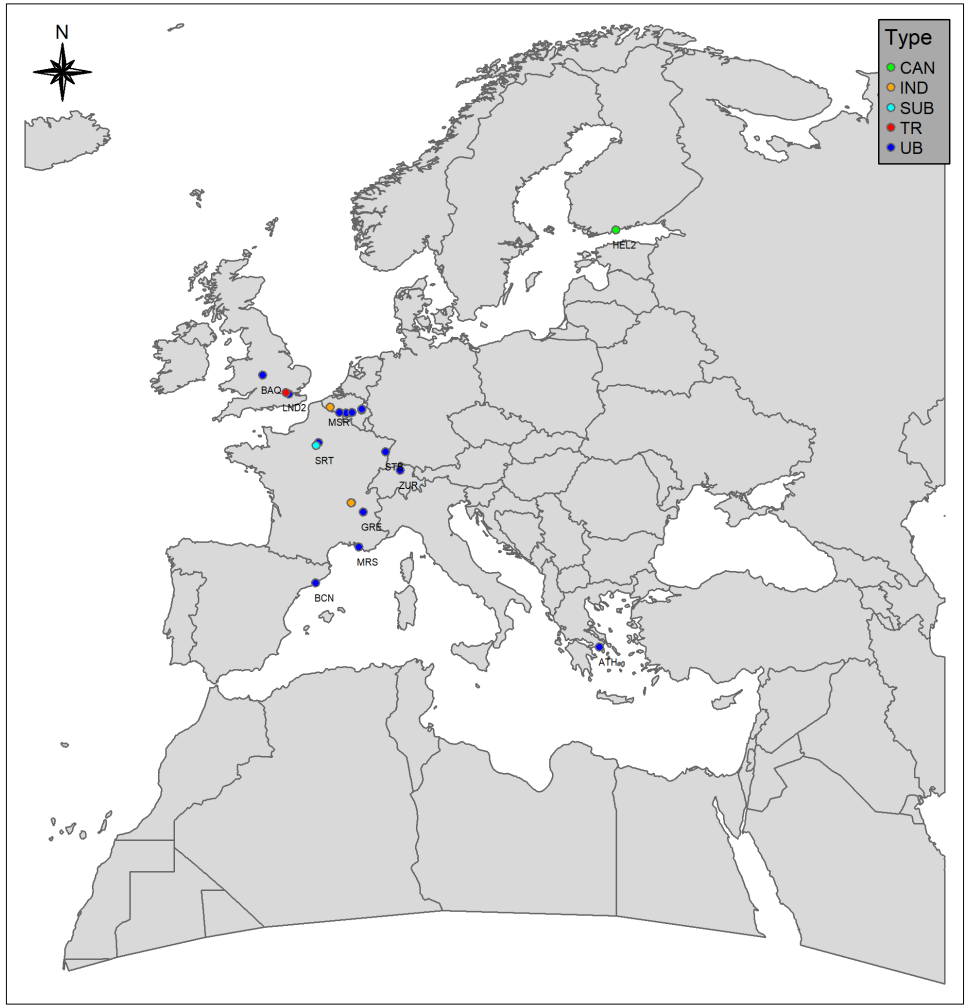
21 European sites of different typology: (15 urban background (UB), 3 industrial (IND), 1 suburban (SUB), 1 traffic related (TR) and 1 street canyon (CAN))

Measurements: 13 sites with VOC online sampling (mainly by TD-GC-FID but also TD-GC-MS, PTR-MS) and 8 sites with VOC offline sampling (mainly with sorbent tubes and canisters)

VOCs reported: NMHCs (common species BTEX), OVOC (4 sites), BVOC (2 sites), halogenated VOCs (few sites); with associated metadata

Time resolution: hourly (online sampling), 24 h 1 day out of 2 (offline sampling)

Age of the datasets: from few years to 20 years
Temporal coverage: >75%, except few years for few sites ~50%
% of outliers: < 0.5%

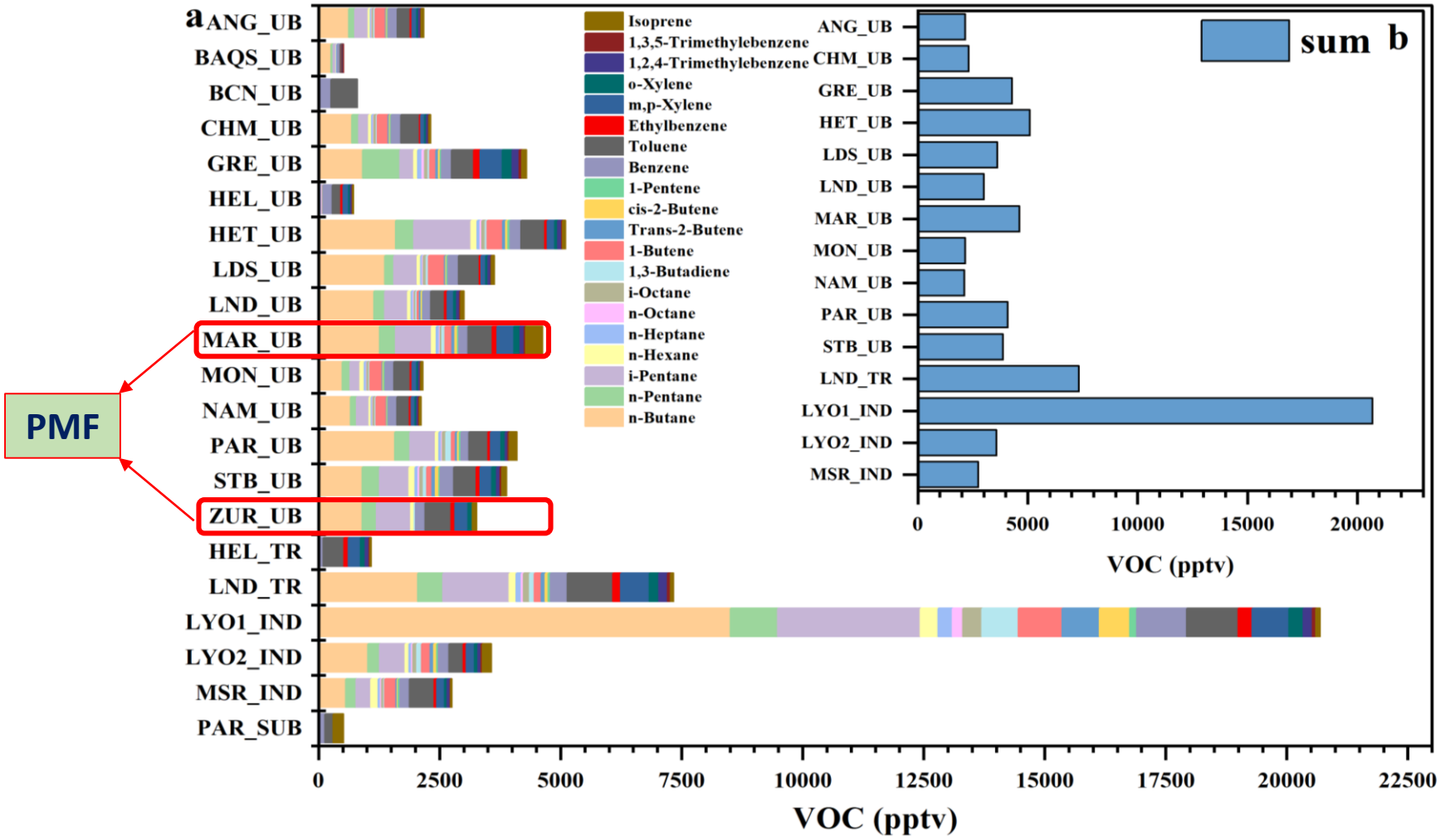


European Commission

HORIZON 2020

RI URBANS

Overview of VOC concentrations at the 21 sites



Liu et al, 2024 in preparation

(a) 21 most often measured VOCs concentrations from the 21 sites and
(b) the total VOC concentrations only for sites measuring >16/21 VOCs

VOC source apportionment at 2 European sites: Marseille - France and Zurich - Switzerland

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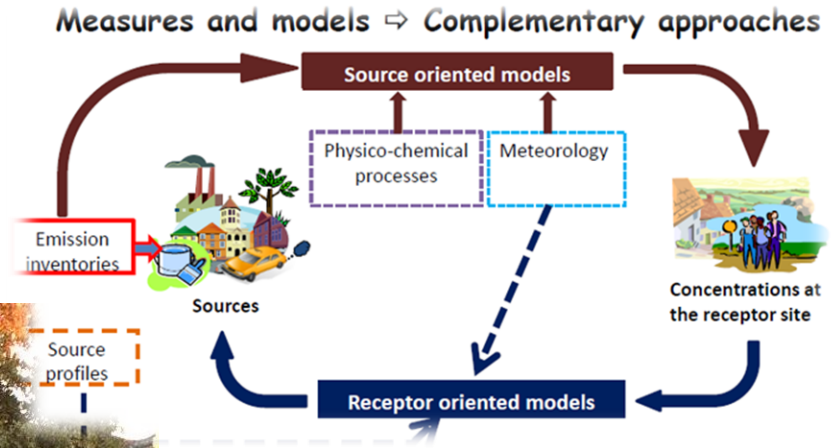
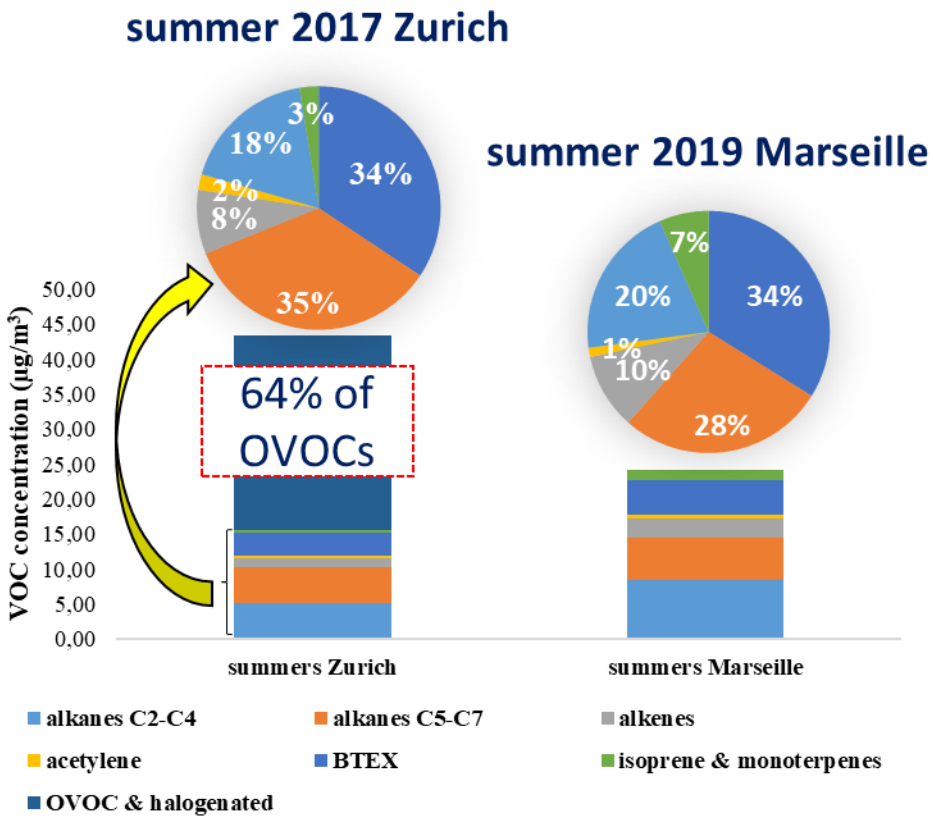
Marseille dataset: C2 – C16
NMHC from March 2019 to August 2020

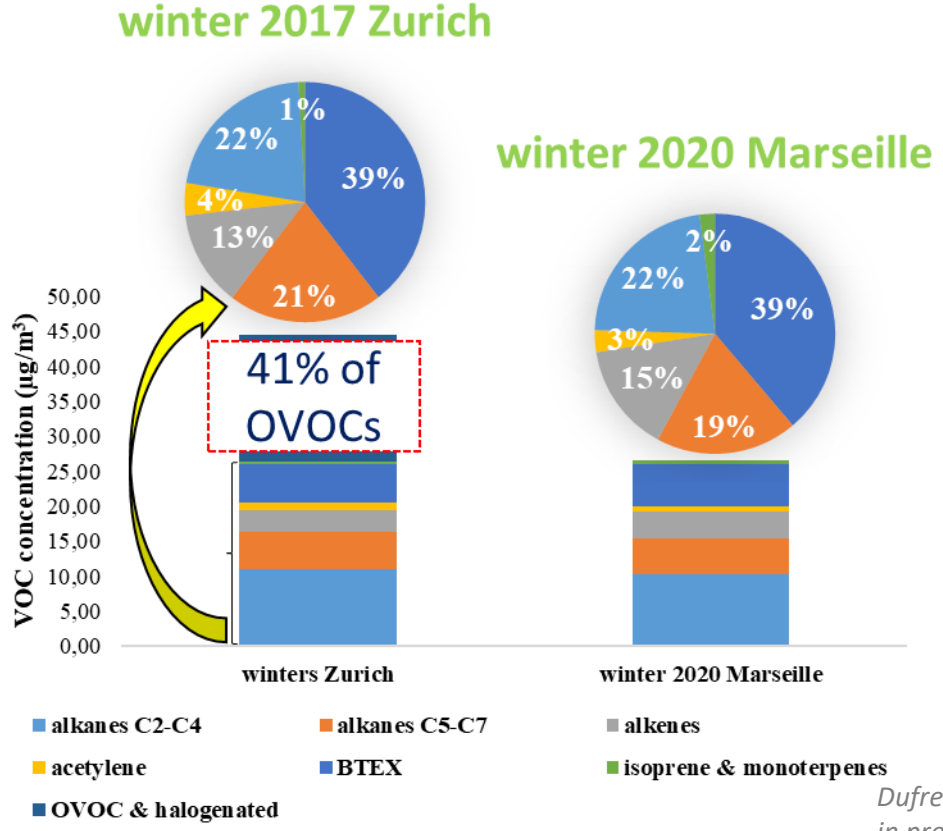
Zurich dataset: C2 – C9
NMHC & C1 – C5 OVOC for 2016 & 2017



Comparison on VOC concentrations, seasonal variability, major chemical families, and on potential major sources (SA with EPA PMF 5.0)

Comparison of VOCs at 2 urban sites: Marseille - France and Zurich - Switzerland





Dufresne et al, 2024 in preparation

For the same list of VOCs: **very similar profiles** of measured NMHC families each season – **summer** and **winter**

OVOCs: important part of VOCs concentration in urban atmosphere

PMF results: Marseille – France and Zurich – Switzerland

	Zurich	Marseille
Nb species	Between 26 & 29 (including NMHC & OVOC)	Between 42 & 62 (only NMHC)
Nb factor	6	8
r^2 model vs measurement	Between 0.87 & 0.99	Between 0.87 & 0.94
Bootstrap > 0.6?	✓	✓
Nb species in common	23	

List of potential VOC sources identified in both cities, over the seasons:

Zurich

Solvent use
Road transport
Local emissions
Heating / wood burning
Urban background
Natural gas

Marseille

Traffic exhaust
Fuel evaporation from traffic
Industrial 1 (Plastic production)
Industrial 2 (Port activities)
Regional and local urban background
Residential heating
IVOC
Biogenic

Dufresne et al, 2024 in preparation

How to attribute a PMF factor to a source profile?

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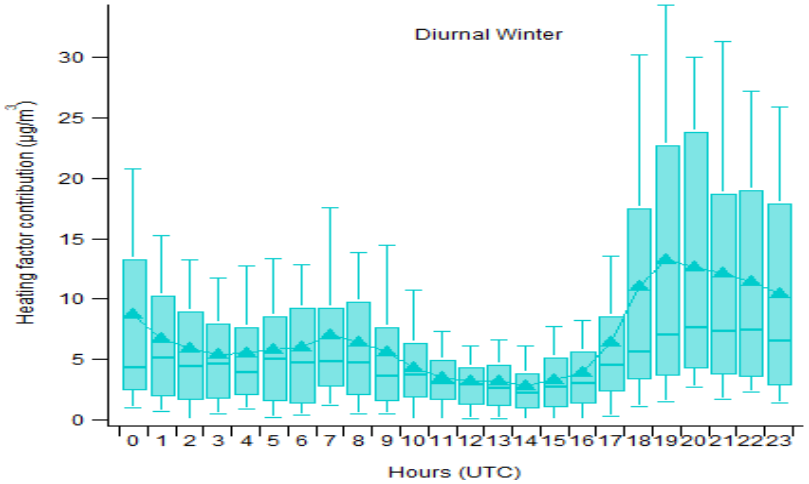
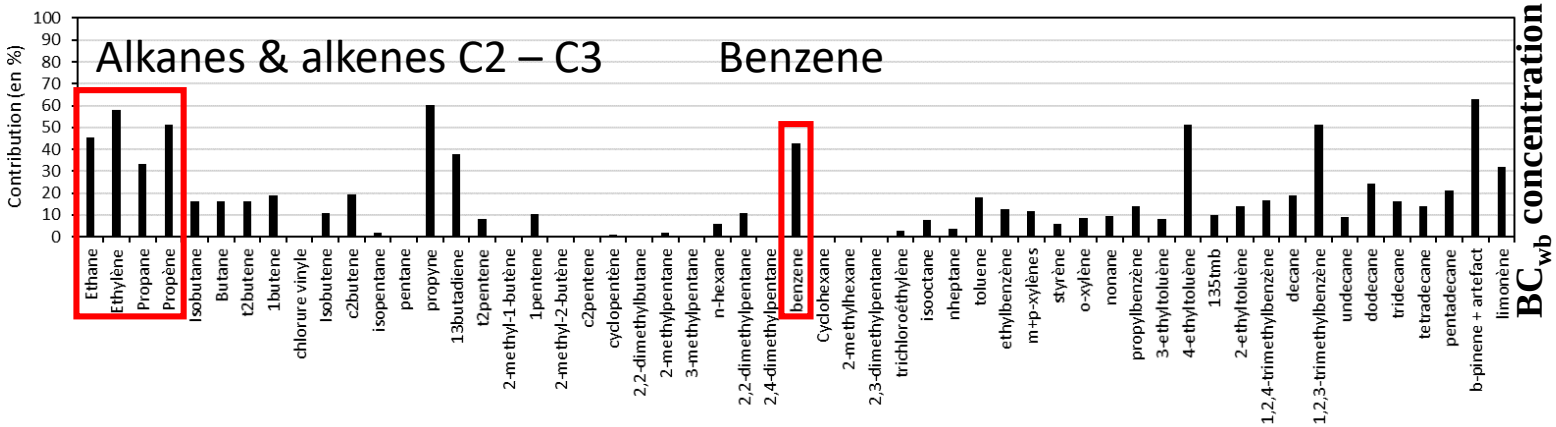
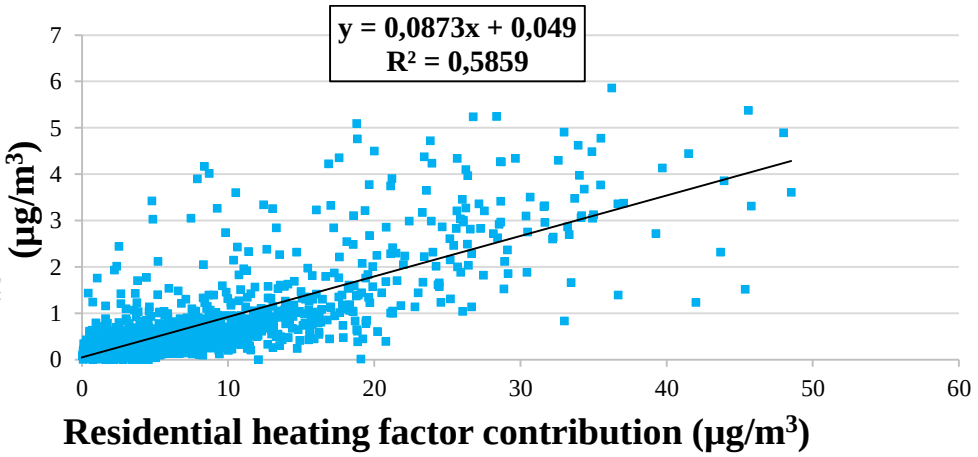
Case of Marseille in winter 2020 – residential heating:

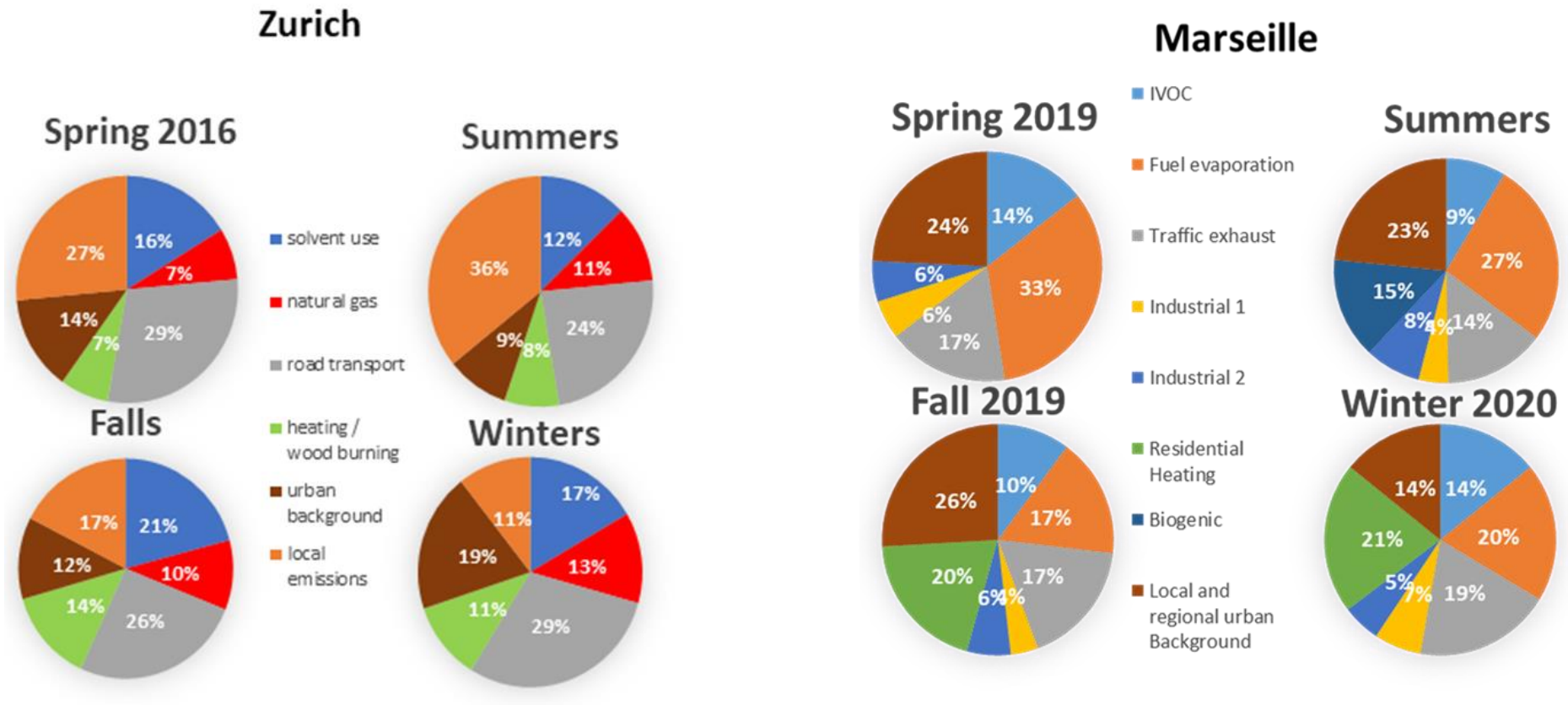
- Knowledge on the **VOC fingerprint** of the source
- **Diurnal profile** of factors contribution
- Comparison with **ancillary data**







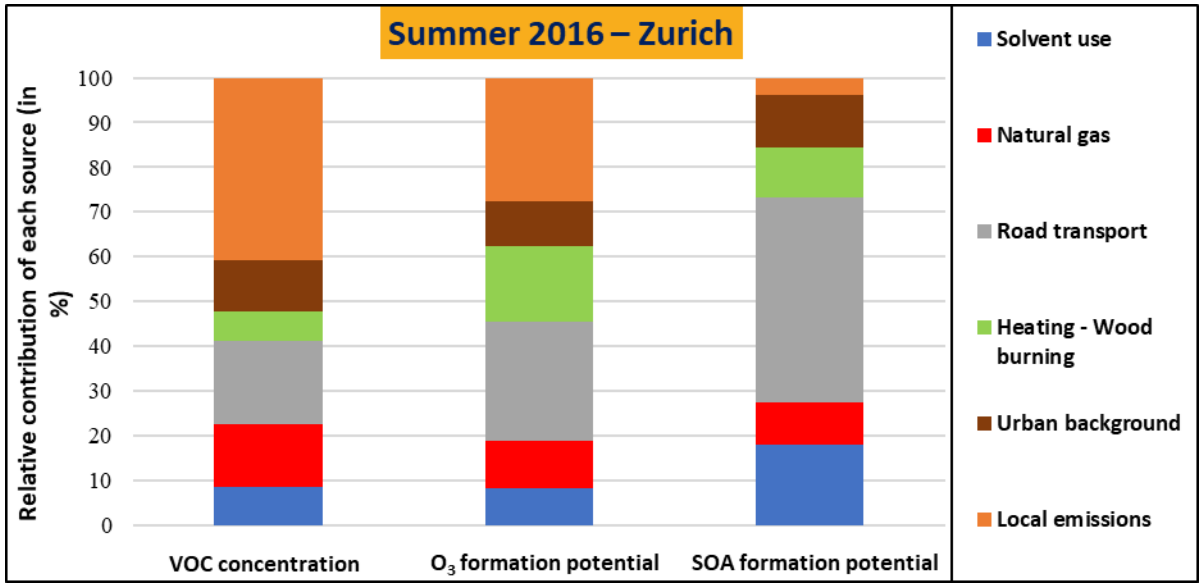
PMF results: Marseille – France and Zurich – Switzerland

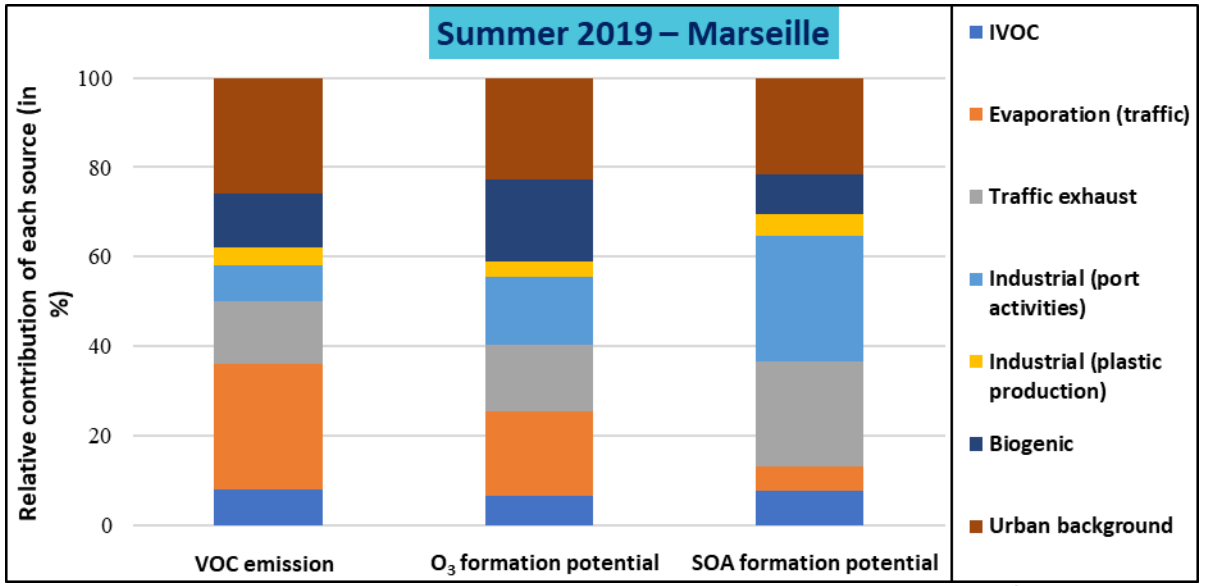


Solvent use is an **important source** of VOCs in **Zurich** (12% – 21%) but was **not identified** in **Marseille**
Season-dependent sources (biogenic, heating)
Industrial impact: Industrial 1 (Plastic production) & Industrial 2 (Port activities)

Dufresne et al, 2024 in preparation

Contribution of sources to ozone and SOA formation potential in Marseille and Zurich





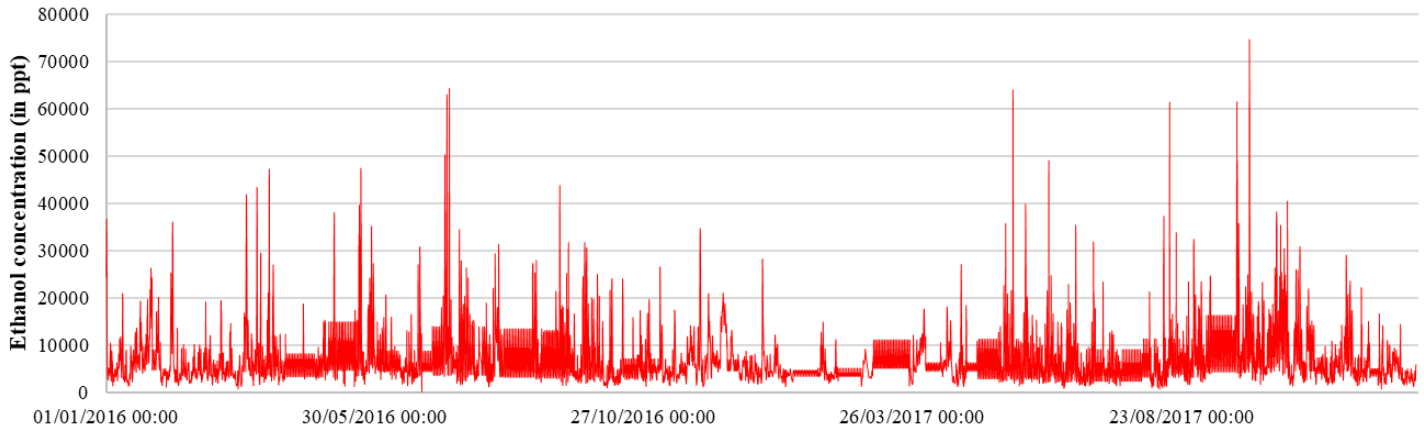
Dufresne et al, 2024 in preparation

- Summer 2016 in **Zurich**:
  - **local emissions** explain the **majority of VOCs** measured concentrations and have the **highest O_3 formation potential** but the **lowest SOA formation potential**
  - **Road transport and solvent use** have the **highest SOA formation potential**

- Summer 2019 in **Marseille**:
  - **Port activities** explain only **8% of VOCs** measured concentrations but have the **highest SOA formation potential** followed by **traffic exhaust**
  - **Biogenic factor** highly contributes to ozone formation

Conclusion & perspectives

- **21 Urban and Suburban** VOCs datasets added to EBAS
- Marseille and Zurich show **similar profile** for common VOCs for **all seasons**
- **8** different sources identified in **Marseille** and **6** in **Zurich** over the four seasons: **traffic** (exhaust and fuel evaporation) is still an important source ***BUT*** new **emerging sources** (solvent use) when taking into account additional tracers (OVOC and biogenic)
- **Significant OVOCs** contribution in Zurich (**41% up to 64%)** ; tracers for **source identification (solvent use)**
- **Ethanol concentrations very high** (background and variability) in Zurich not considered in PMF analysis: **Correlation with road transport factor** (ethanol in fuel) & **Correlation with solvent use factor; other? (party)**



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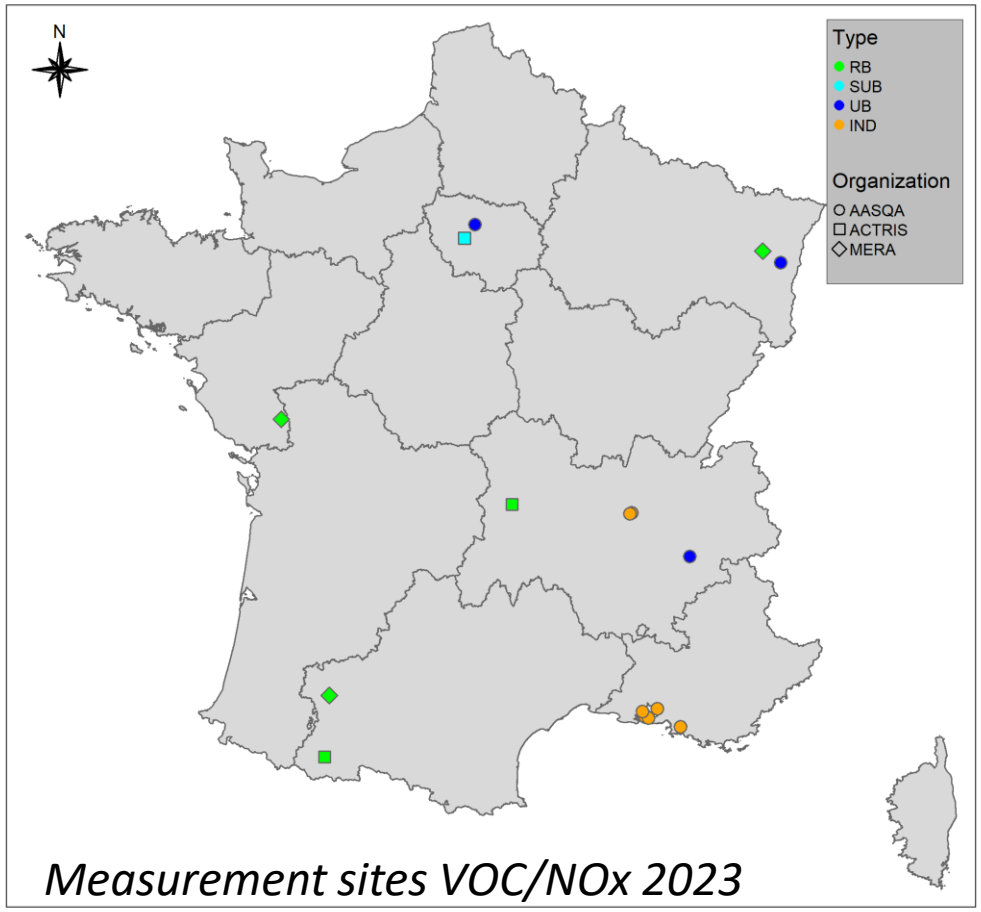
LCSQA
Laboratoire Central de Surveillance de la Qualité de l'Air

National strategy of VOC (&NOx, & methane) observations

Ongoing implementation



Measurement sites VOC/NOx 2023

- Harmonized implementation of ozone & SOA precursors over France
- Twin-site : **Regional vs. Urban** contribution
- Source identification and contribution : **anthropogenic & biogenic**
- Evaluate and improve local emission inventories (=> CTM models)

Contribution to the IMP EMEP/ACTRIS campaign in September 2024

IMPORTANT

Cross-calibration between participating sites

ACTRiS CiGas

VOC measured with the implemented TD-GC-FID system for NMHC and OVOC measurement in France

Methanol	***Biogenic, solvent use, combustion***	**Butane**	*Natural gas, fuel evaporation*	**Trans-2-butene**	*Combustion, fuel evaporation*	**1,3,5-trimethylbenzene**	*Combustion, fuel evaporation, solvent use*
Ethanol	***Biofuels***	**i-pentane**	*fuel evaporation*	**Cis-2-butene**	*Combustion, fuel evaporation*	**Isoprene**	*Biogenic mainly, combustion*
Formaldehyde	*Photochemistry of isoprene*	**Pentane**	*fuel evaporation*	**1-pentene**	*Combustion, fuel evaporation*	**P-cymene**	***Biogenic mainly***
Acetaldehyde	***Photochemistry, solvent use***	**i-hexane**	*fuel evaporation, exhaust emissions*	**Trans-2-pentene**	*Combustion, fuel evaporation*	**Limonene**	***Biogenic mainly***
Methacrolein	***Photochemistry of isoprene***	**Hexane**	*fuel evaporation, exhaust emissions*	**Cis-2-pentene**	*Combustion, fuel evaporation*	**β-Myrcene**	***Biogenic mainly***
propanone	***Biogenic, solvent use,***	**Heptane**	*fuel evaporation, exhaust emissions*	**Benzene**	*Combustion*	**α-pinene**	***Biogenic mainly***
MVK	***Photochemistry of isoprene***	**i-octane**	*fuel evaporation, exhaust emissions*	**Toluene**	*Combustion, fuel evaporation, solvent use*	**β-pinene**	***Biogenic mainly***
MEK	***Biogenic***	**Octane**	*fuel evaporation, exhaust emissions*	**Ethylbenzene**	*Combustion, fuel evaporation, solvent use*	**Camphene**	***Biogenic mainly***
Ethyne	*Combustion*	**Ethene**	*Combustion*	**M,p-xylenes**	*Combustion, fuel evaporation, solvent use*	**Δ-Carene**	***Biogenic mainly***
Ethane	*Long-lived species, natural gas*	**Propene**	*Combustion*	**O-xylene**	*Combustion, fuel evaporation, solvent use*	**1,8-cineole**	***Biogenic mainly***
Propane	*Long-lived species, natural gas*	**1,3-butadiene**	*Combustion, industrial sources*	**1,2,4-trimethylbenzene**	*Combustion, fuel evaporation, solvent use*		
i-butane	*Natural gas, fuel evaporation*	**1-butene**	*Combustion, fuel evaporation*	**1,2,3-trimethylbenzene**	*Combustion, fuel evaporation, solvent use*		

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Thank you for your attention!

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