



**HAL**  
open science

## Impact of Volatile Organic Compounds from shipping emissions on air quality in the Channel

Erwan Volent, Liselotte Tinel, Stephane Sauvage

► **To cite this version:**

Erwan Volent, Liselotte Tinel, Stephane Sauvage. Impact of Volatile Organic Compounds from shipping emissions on air quality in the Channel. 2023 iCACGP-IGAC ECR online conference, Nov 2023, Online, France. 10.1021/es071686z.[2] . hal-04492881

**HAL Id: hal-04492881**

**<https://hal.science/hal-04492881>**

Submitted on 6 Mar 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.





**IMT Nord Europe**  
École Mines-Télécom  
IMT-Université de Lille

# Impact of Volatile Organic Compounds from shipping emissions on air quality in the Channel

By Erwan Volent

Supervisors : Prof. Stéphane Sauvage and Dr. Liselotte Tinel



Contact

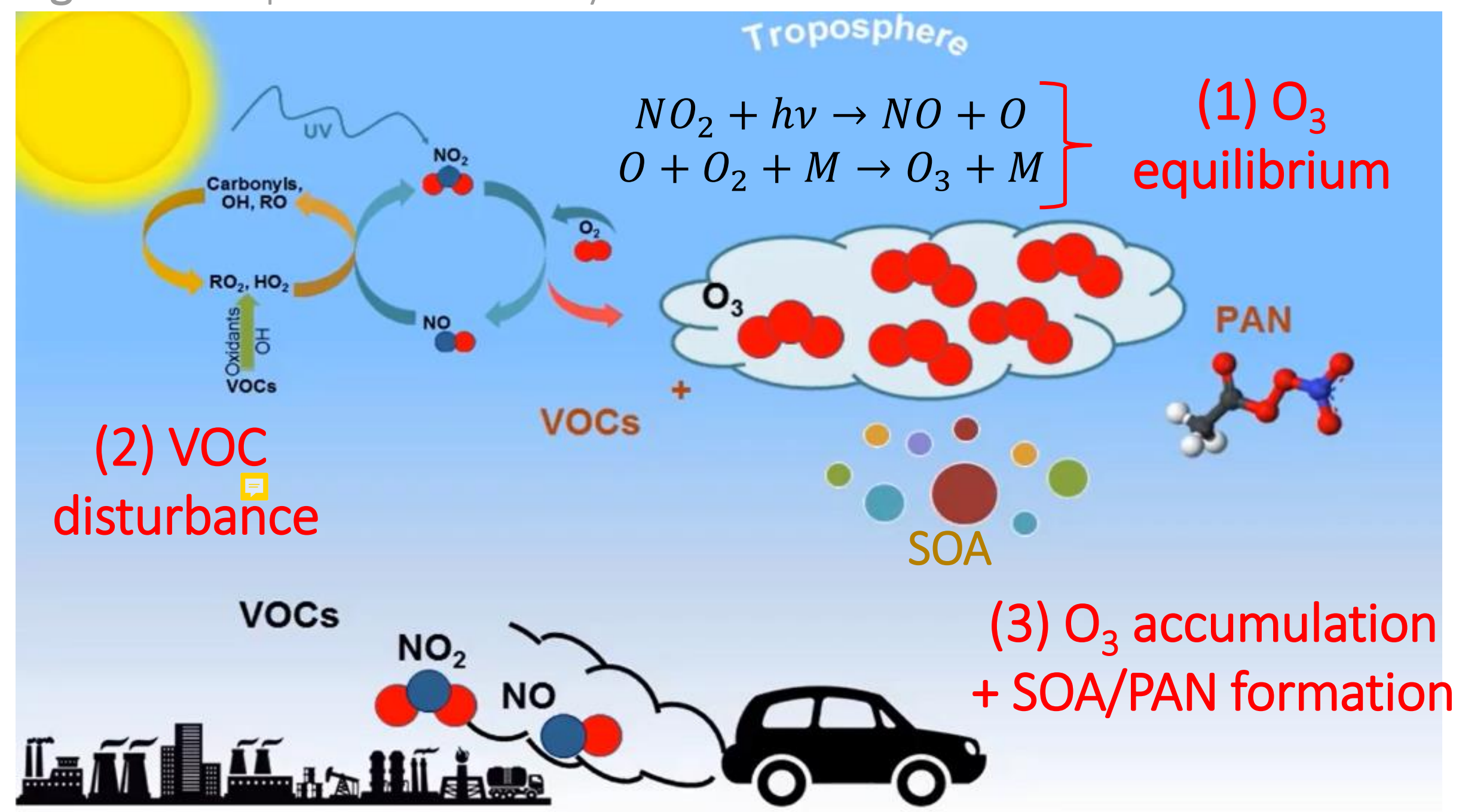
erwan.volent@imt-nord-europe.fr

Among the regulated sources of pollutants, shipping has a significant contribution to  $\text{NO}_x$  and  $\text{SO}_2$  global emissions and causes an estimated mortality of 64 000 people each year around the globe<sup>[1]</sup>. The regulations of maritime transport, Annex VI of MARPOL, was updated in 2020 lowering the sulfur content in marine fuel globally to maximum 0.5% in mass (from 3.5%). Specific Sulphur Emission Control Areas have been established where the emissions of sulphur are further restricted, such as the Channel between France and the U.K. However, other pollutants emitted by maritime transportation, such as VOCs or PM, are not regulated, although VOCs are of importance in the atmospheric chemistry processes, notably because of their role in harmful ozone and SOA formation in proximity of densely populated coastal zones. This raises the following questions: what are the VOCs emitted by ships under these new emission norms, what are their emission rates and their impact on air quality? Few studies considered the speciation of VOC, yet speciated data is crucial to provide reliable gas-phase atmospheric chemistry modelling. This study presents the analysis of a dataset obtained during a one-month intensive field campaign in the harbour of Dunkirk in the North of France, which is the third biggest French port. The site was located near ferry and cargo terminals and provides high time resolution measurements of VOCs, using a PTR-ToF-MS, and many other parameters (meteorology, particles, gases). Data analysis allowed the identification of 67 ship plumes on a two days period of favorable meteorological conditions, harbour office entries and tracers like  $\text{SO}_2$ . The current goal is to present emission factors that represent the mass of pollutant emitted by the combustion of one kilogram of fuel in real condition with a diversity of ships, to better characterize shipping impact on pollutant levels in a harbour. Statistical methods show that we overestimate emission rates of VOCs compared to past measurements at the stack of a ferry, although our VOCs emission factors are inferior to those of  $\text{SO}_2$ , CO and  $\text{CH}_4$  which are consistent with the existing factors<sup>[3,4]</sup>.

**Keywords :** Volatile Organic Compounds, shipping, sources, emission factors

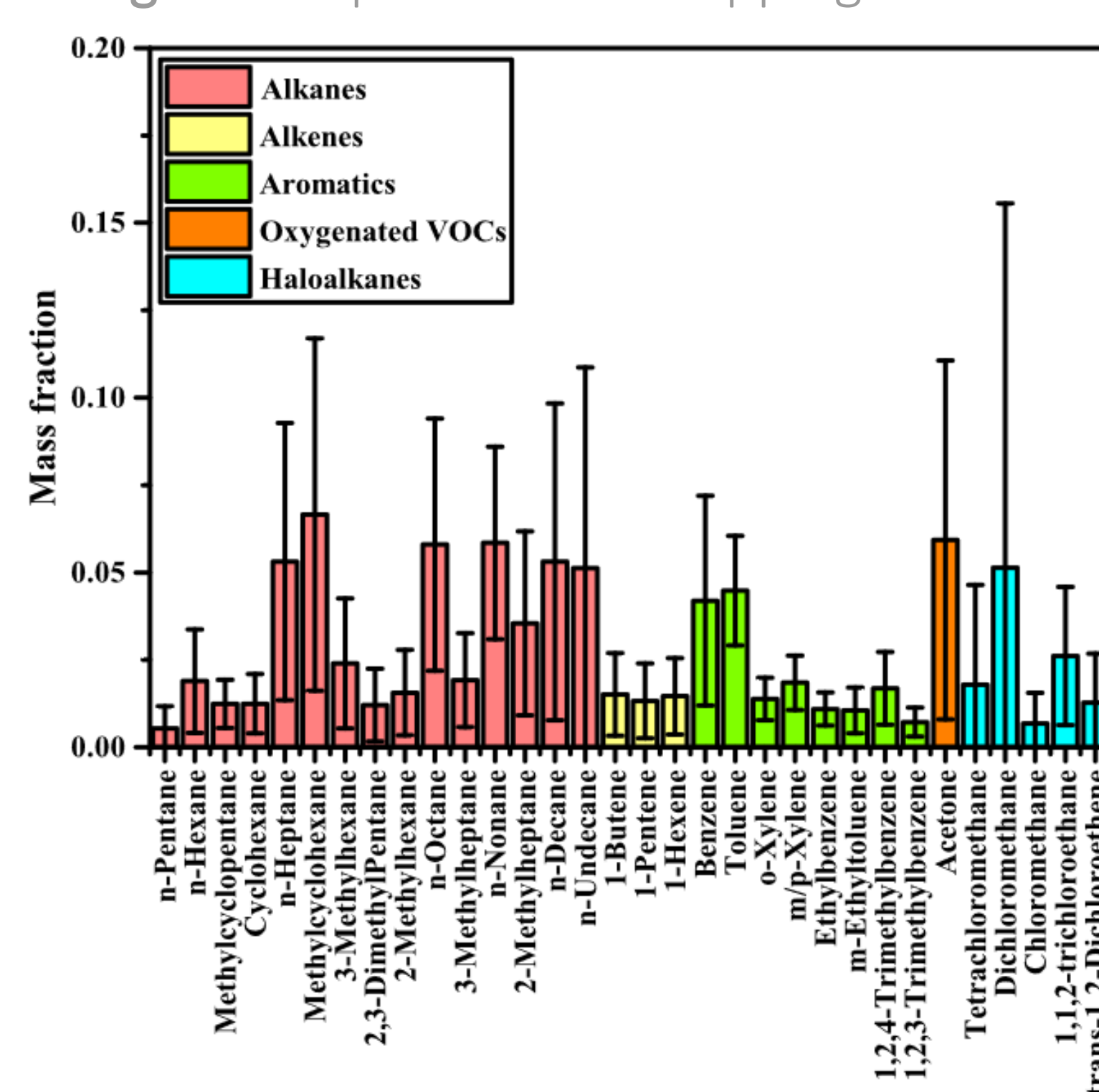
## 1. Scientific context

Fig. 1 Atmospheric chemistry of VOC in urban areas



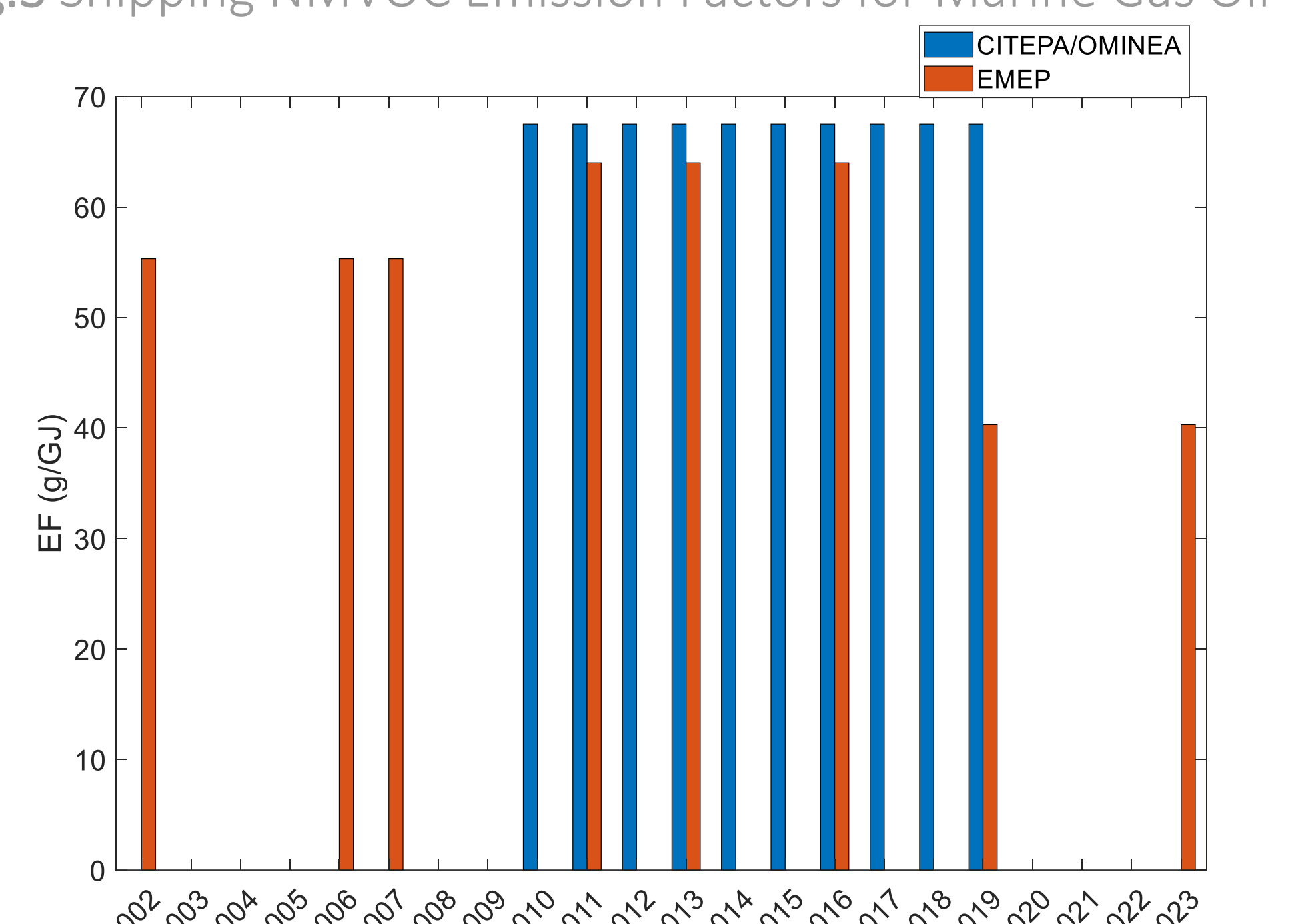
→ VOC emission can lead to **Photochemical Smog**  
→  $\text{O}_3$  formation is dependant of  $\text{VOC}/\text{NO}_x$

Fig. 2 VOC profile from shipping at berth<sup>[2]</sup>



→ Various VOC emitted from the ships

Fig.3 Shipping NMVOC Emission Factors for Marine Gas Oil

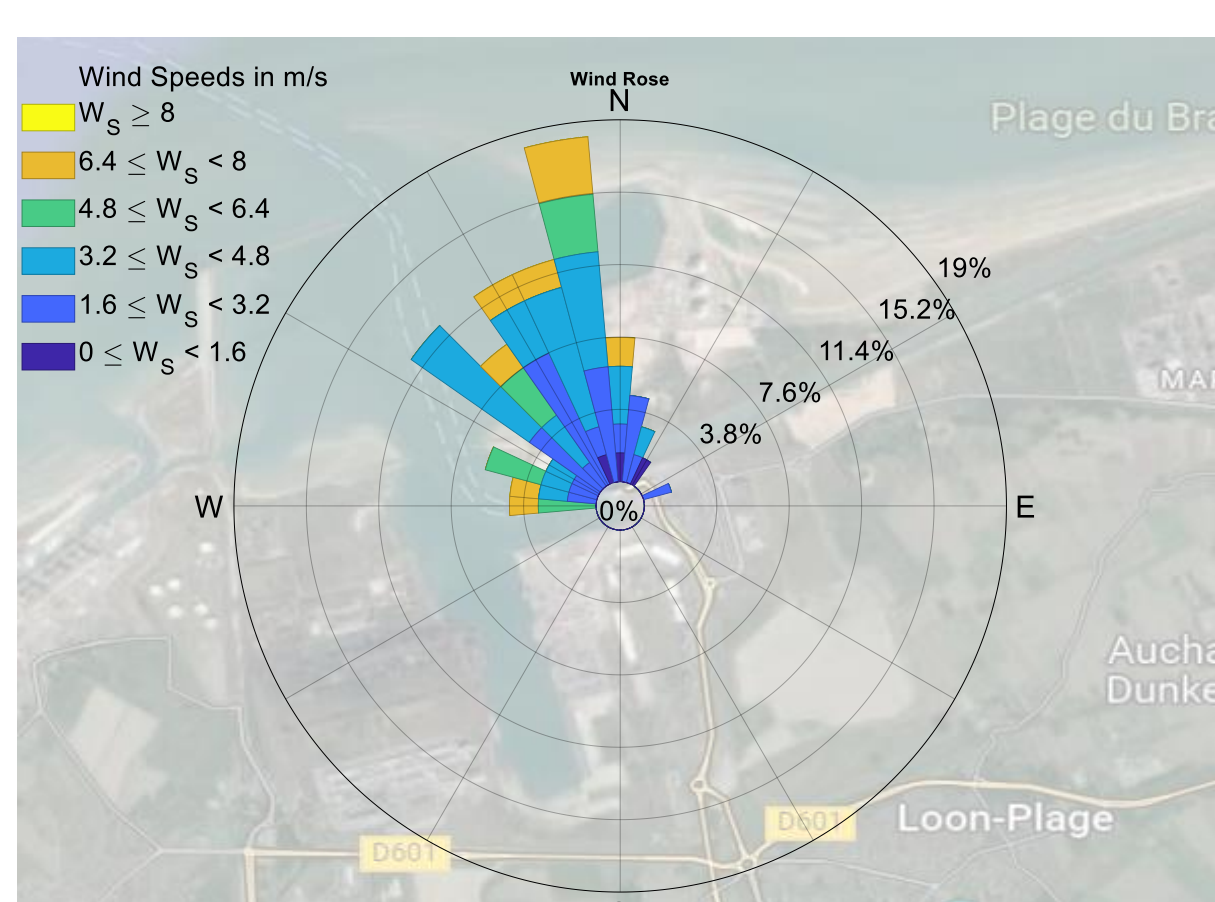


→ Yet no speciation is used in emission factors for atmospheric modelling

**What are the VOC emitted by the ships and their contribution in shipping emissions ?**

## 4. Emission factors

Fig. 6 Wind rose of September 15<sup>th</sup> to 19<sup>th</sup>

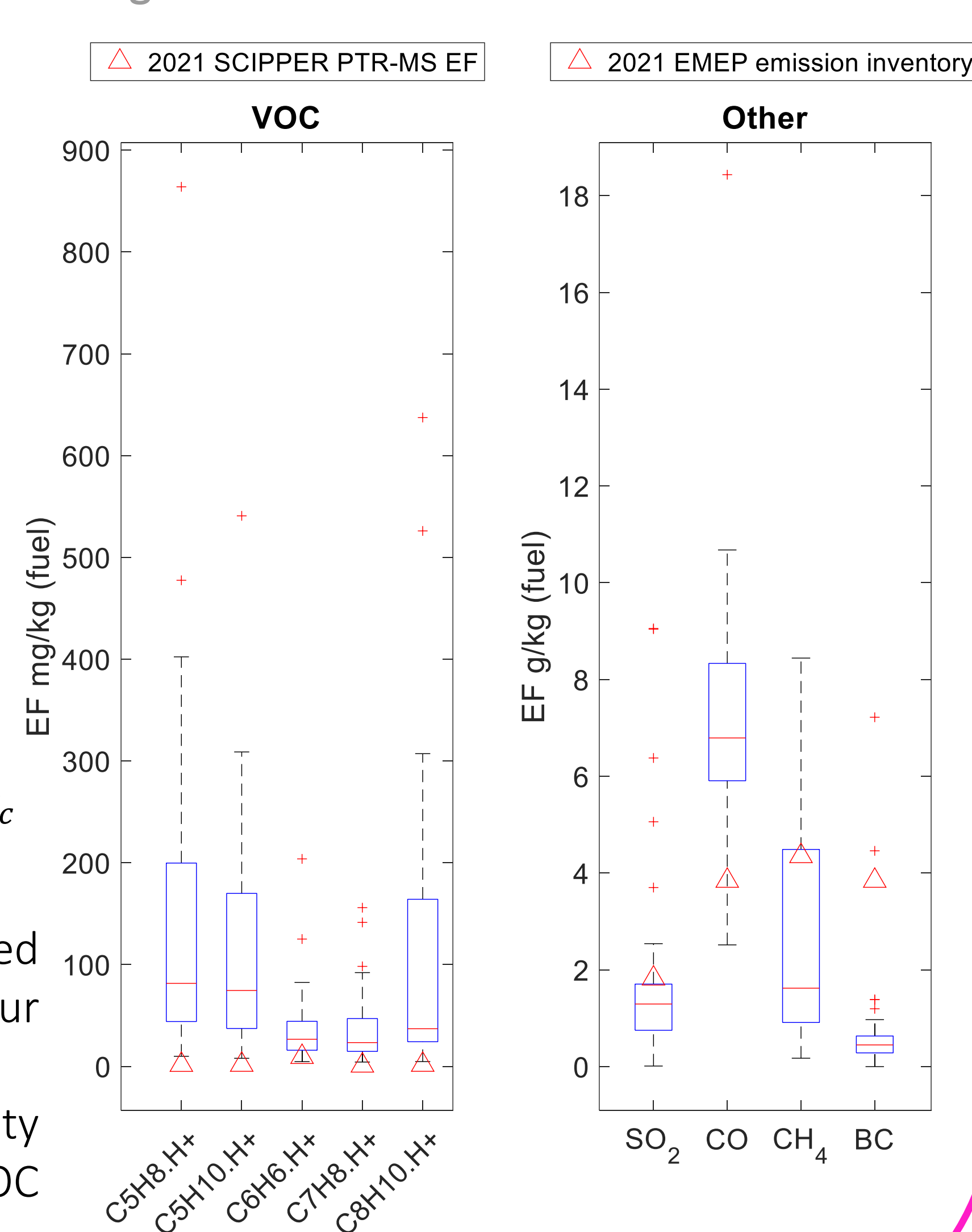


→ 67 peaks of ferry ships plumes were identified based on video recording, AMS correlation and  $\text{SO}_2$  gradients

$$EF_i (\text{g} \cdot \text{kg}^{-1}) = \frac{\Delta x_i (\mu\text{g} \cdot \text{m}^3)}{\Delta \text{CO}_2 (\text{mg} \cdot \text{m}^3)} \cdot \frac{M_C}{M_{\text{CO}_2}} \cdot w_c$$

→ Background concentration is defined as the 2<sup>nd</sup> percentile of a one-hour interval on both sides of the peak  
→ Good reproduction of low-reactivity gases EF but low consistency of VOC possibly

Fig. 7 Calculated emission factors



→ Impact of distance and representativity

## 3. Field campaign

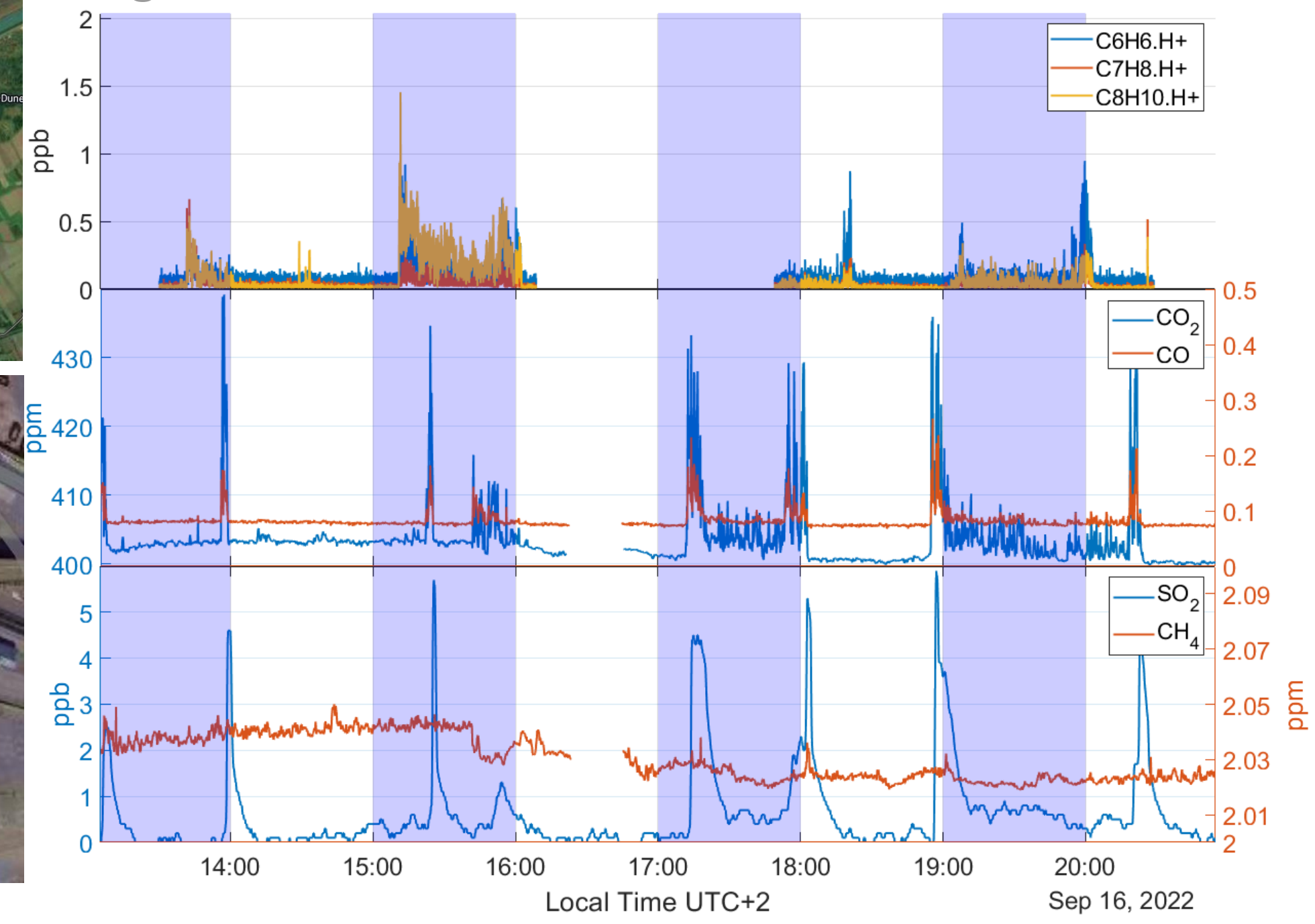
→ Measurement site of September 2022 : Dunkirk harbour (northern France)

→ PTR-MS for the measurements of  $> 300 \text{ m/z}$  VOCs, completed with  $\text{CO}/\text{CH}_4/\text{CO}_2$  monitor, AMS, auxiliary meteorological data and harbour office entries

Fig. 4 Measurement site



Fig. 5 Partial time series



→ Good correlation of peaks with the presence of ship in the harbour  
→ Same behaviour from September 15<sup>th</sup> and 19<sup>th</sup>  
→ Period of reference to calculate emission factors of shipping in Dunkirk

## 5. Conclusion and perspectives

→ Good consistency of EF of  $\text{SO}_2$ , CO and  $\text{CH}_4$  Emission Factors with EMEP emission inventory guidebook of 2021 taken from the SCIPPER Project  
→ Lower PTR-MS  $\text{m/z}$  emission factors compared to low-reactivity gases, but greater than previous on-board measurement at the stack  
→ Our dataset allows us to calculate emission factors in real condition focusing on the harbour, with a higher population and diversity of ships compared to previous exhaust emission measurements of one ship

## References

- [1] Corbett, James J., James J. Winebrake, Erin H. Green, Prasad Kasibhatla, Veronika Eyring, et Axel Lauer. « Mortality from Ship Emissions: A Global Assessment ». *Environmental Science & Technology* 41, n° 24 (December 1<sup>st</sup>, 2007): 8512-18. <https://doi.org/10.1021/es071686z>.
- [2] Xiao, Qian, Mei Li, Huan Liu, Mingliang Fu, Fanyuan Deng, Zhaofeng Lv, Hanyang Man, Xinxin Jin, Shuai Liu, et Kebin He. « Characteristics of Marine Shipping Emissions at Berth: Profiles for Particulate Matter and Volatile Organic Compounds ». *Atmospheric Chemistry and Physics* 18, n° 13 (July 6<sup>th</sup>, 2018): 9527-45. <https://doi.org/10.5194/acp-18-9527-2018>.
- [3] EMEP, « Air Pollutant Emission Inventory Guidebook 2019 », Update 2021, December 2021.
- [4] The SCIPPER Project, « Ship On-Board Emissions Characterisation », 30 June 2022. <https://www.scipper-project.eu/library/>.

