Pollution in Paris assessed using the synergy of IASI satellite and the QUALAIR super-site ground-based observations

Camille Viatte[1], Nadir Guendouz[1], Yongli Wang[1], Gérard Ancellet[1], Anne Boynard[1,2], Sarah Safieddine[1], Julien Jumelet[1], Arjan Hensen[3], Martin Van Damme[4,5], Lieven Clarisse[4], Pierre Coheur[4], and Cathy Clerbaux[1,4]

[1]LATMOS/IPSL [2]SPASCIA [3]TNO [4]ULB-SQUARES [5]BIRA-IASB

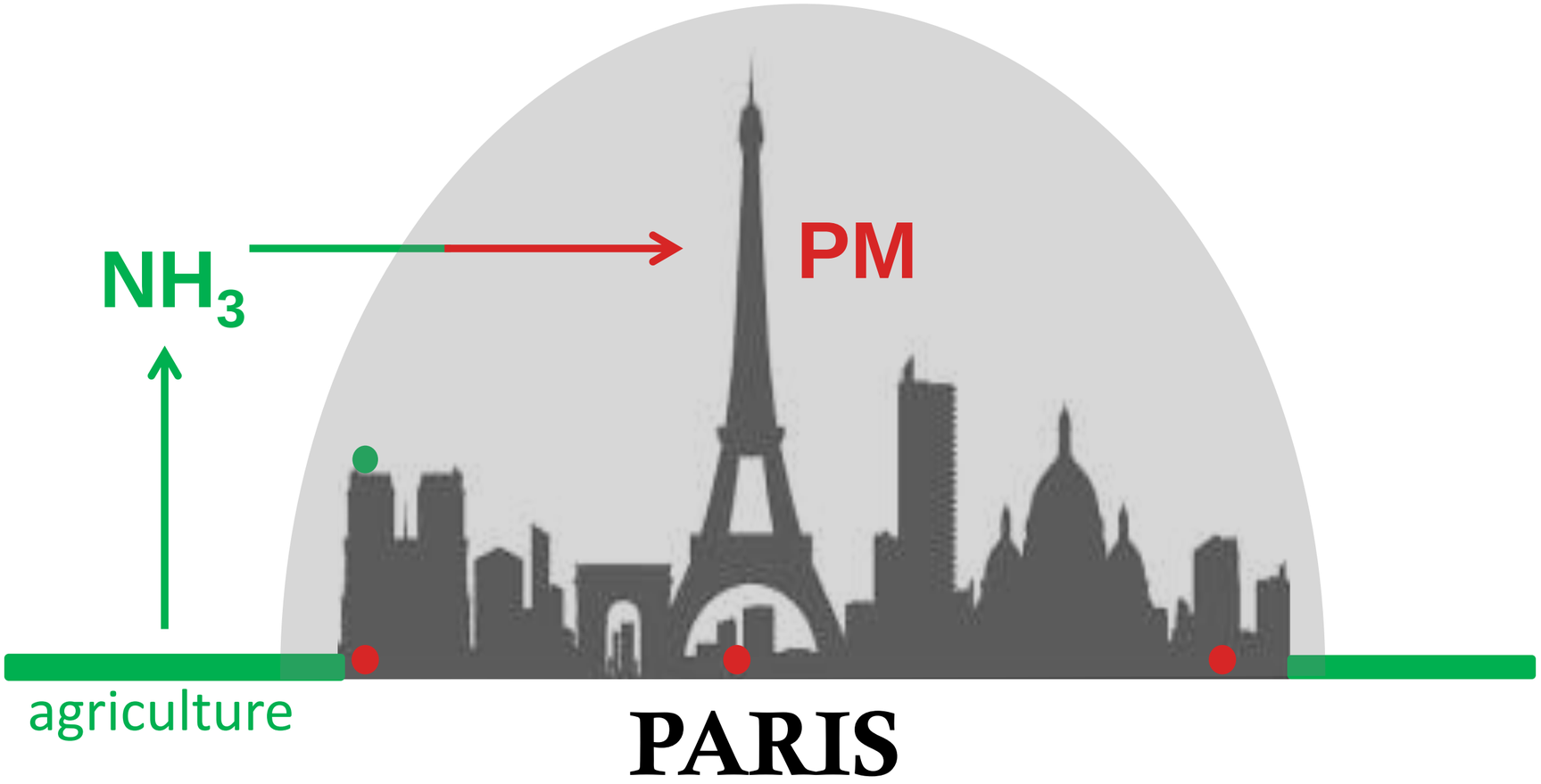
Urban pollution

Exposure to harmfull pollutant caused more than 20 000 premature deaths in Europe in 2020.

In Paris, air quality continues to improve but still nearly 90% of the residents are concerned by an exceedance of the WHO recommendations.

https://www.eea.europa.eu/publications/air-quality-in-europe-2022/; AirParif, 2023

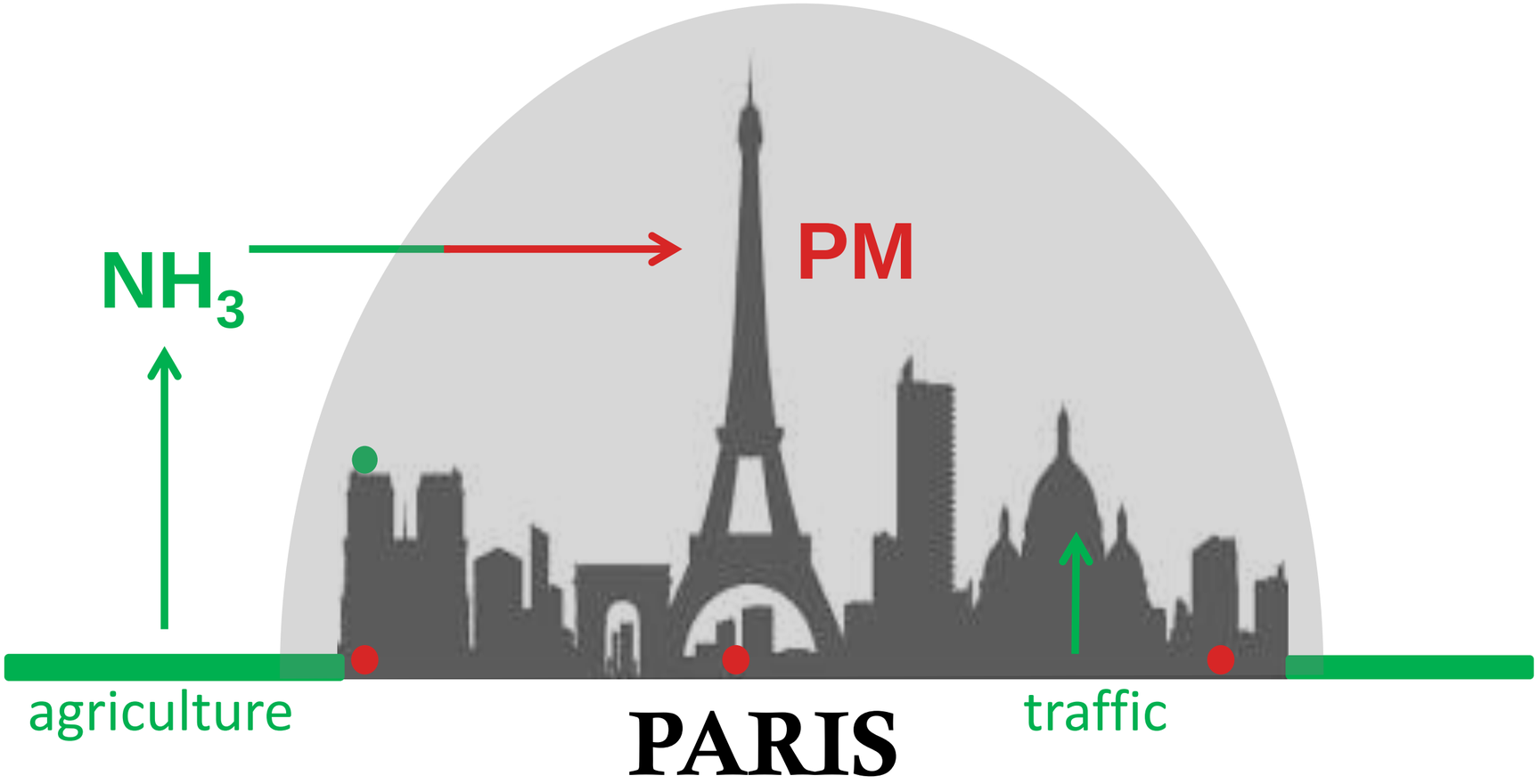
Urban pollution



● observations

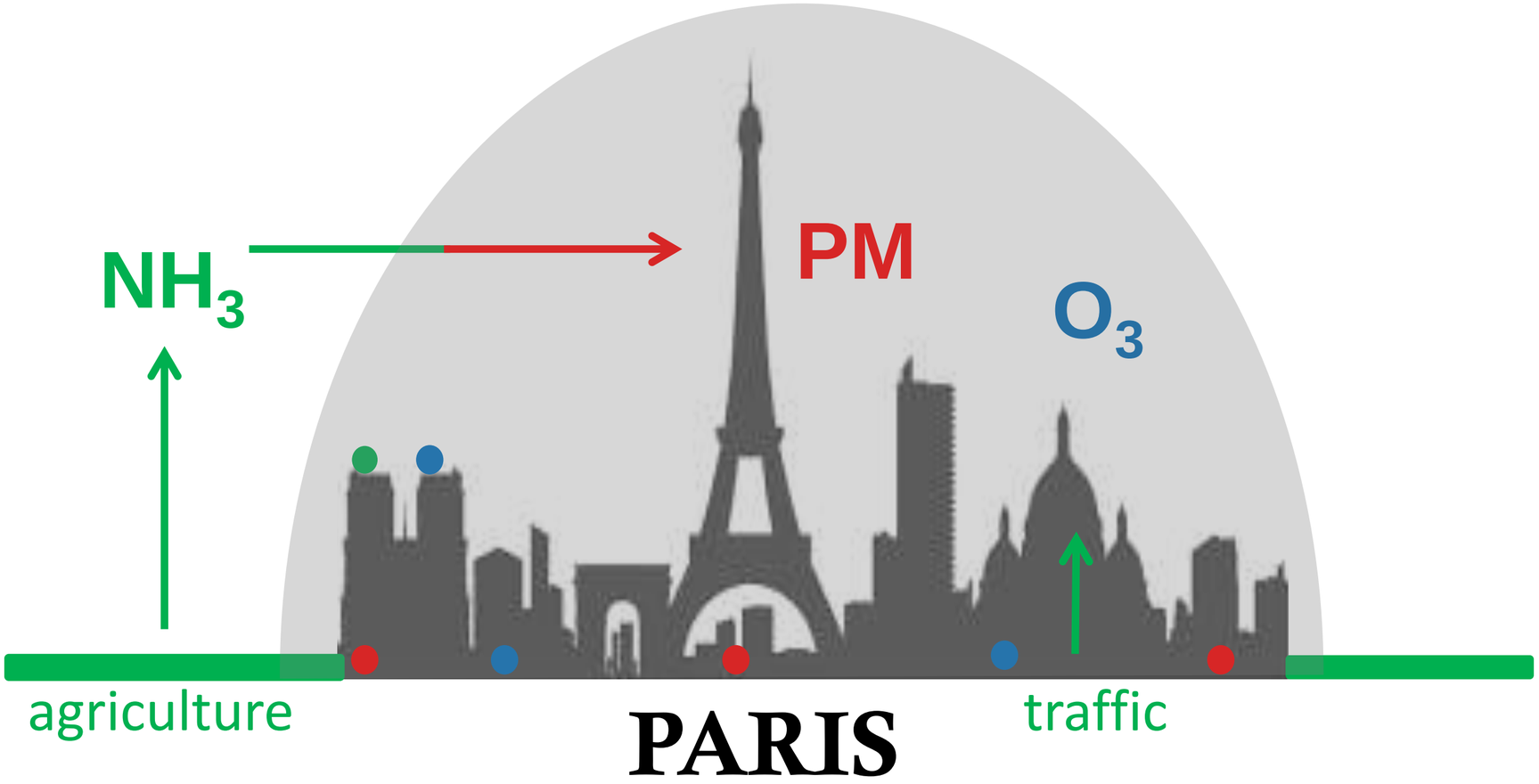
Petetin et al., 2016; Viatte et al. 2020; 2021

Urban pollution



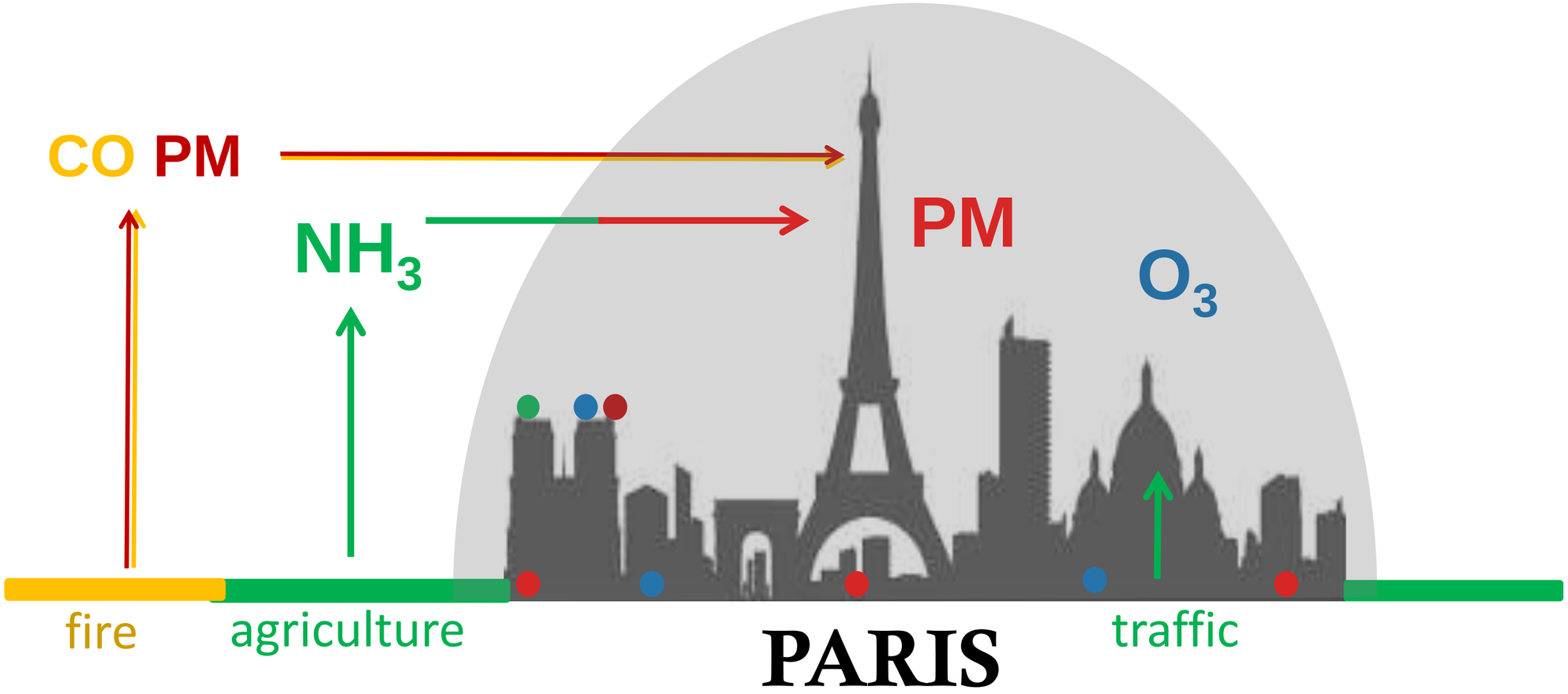
Cao et al., 2021

Urban pollution



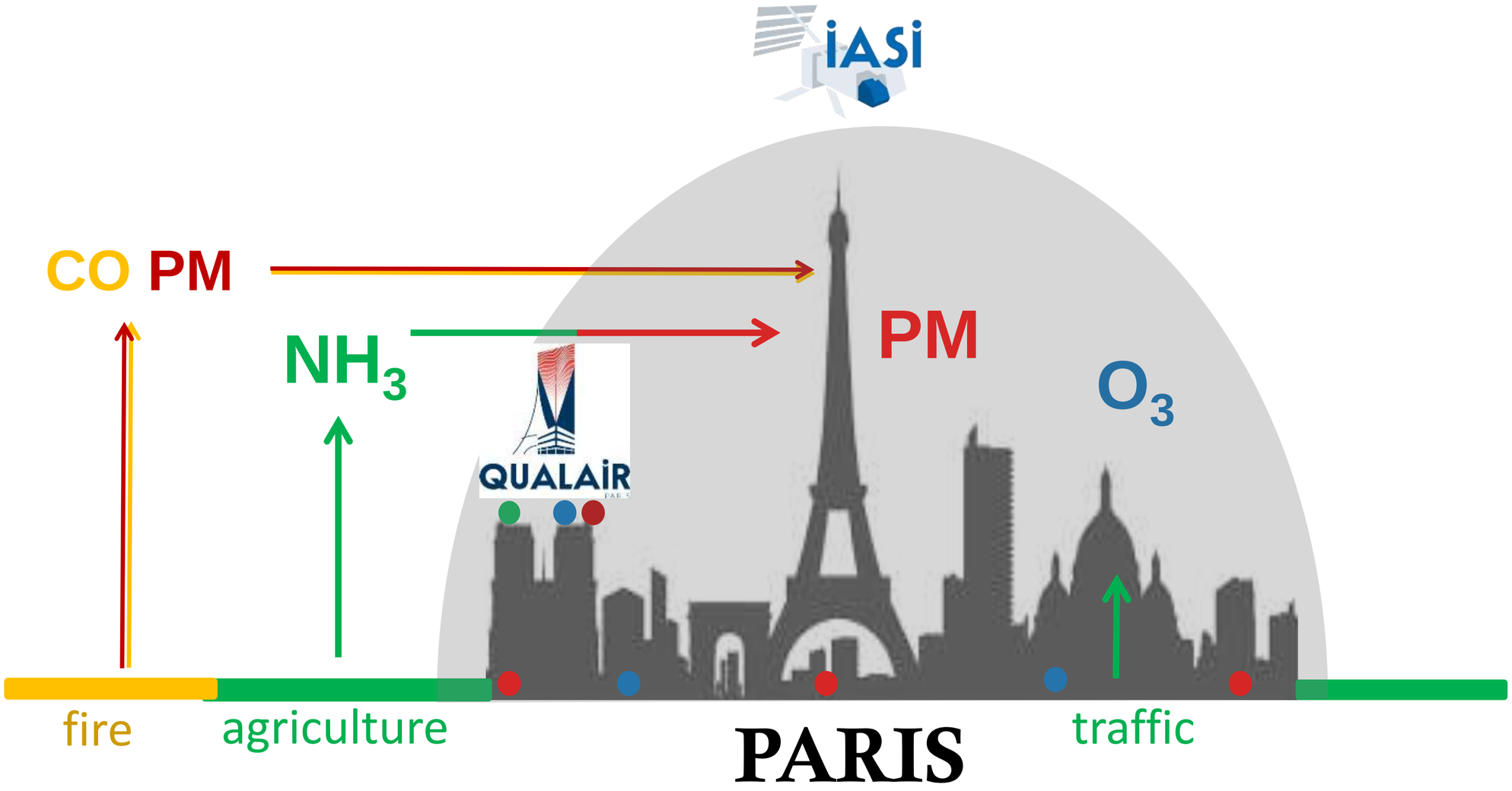
Fowler et al., 2008

Urban pollution



Chen et al. 2021, Baars et al. 2021

Urban pollution



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Seine
Conflans-Sainte-Honorine
Roissy-en-France
Tremblay-en-France
Villepinte
Forêt
domaniale de
Saint-Germain
Argenteuil
Saint-Denis
Aulnay-sous-Bois
Claye-Souilly
Aubervilliers
A104
Saint-Germain-en-Laye
Nanterre
QUALAIR
Paris
Montreuil
A86
Noisy-le-Grand
Torcy
Boulogne-Billancourt
A4
Seine
Plaisir
A12
Champigny-sur-Marne
Versailles
Créteil
A6a
A6B
A106
Montigny-le-Bretonneux
Massy
A6

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Volten et al., 2012; Viatte et al., 2023

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Volten et al., 2012; Viatte et al., 2023

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O_3 and aerosol LIDARs

miniDOAS

photometer

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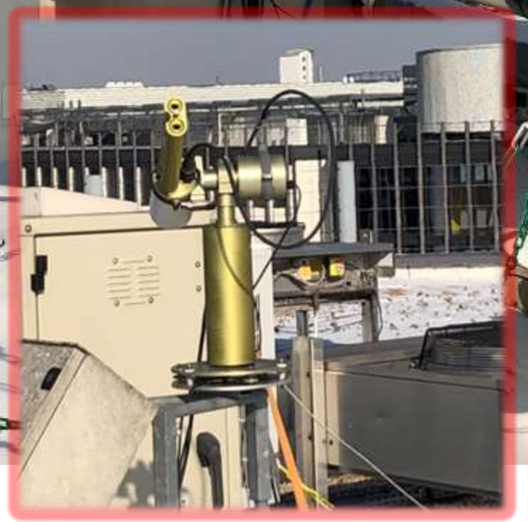
Volten et al., 2012; Viatte et al., 2023



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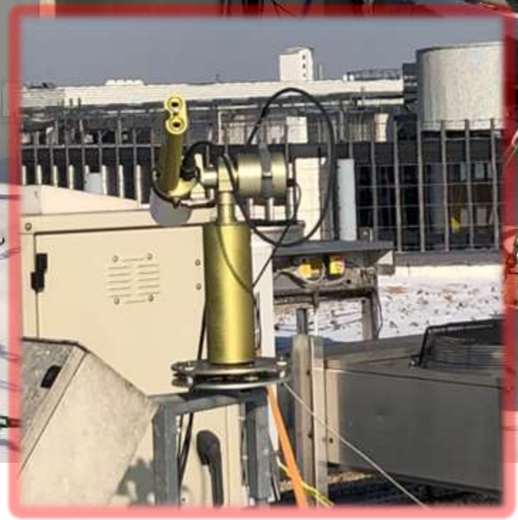
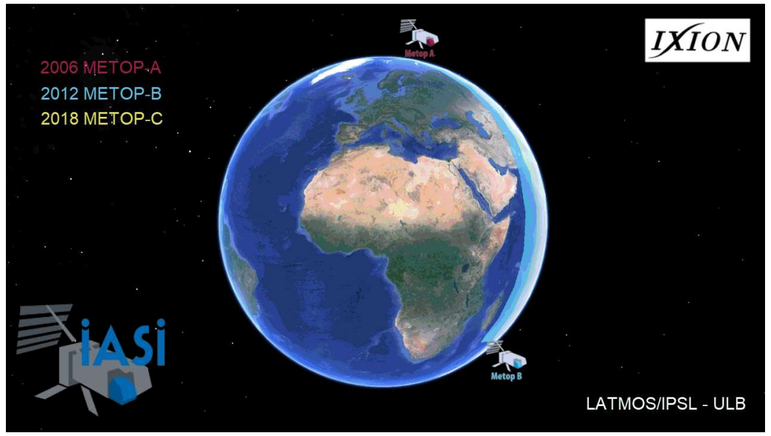
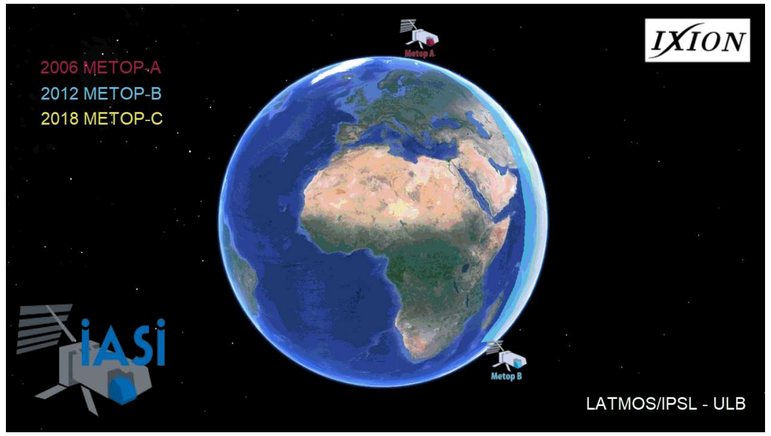
Volten et al., 2012; Viatte et al., 2023

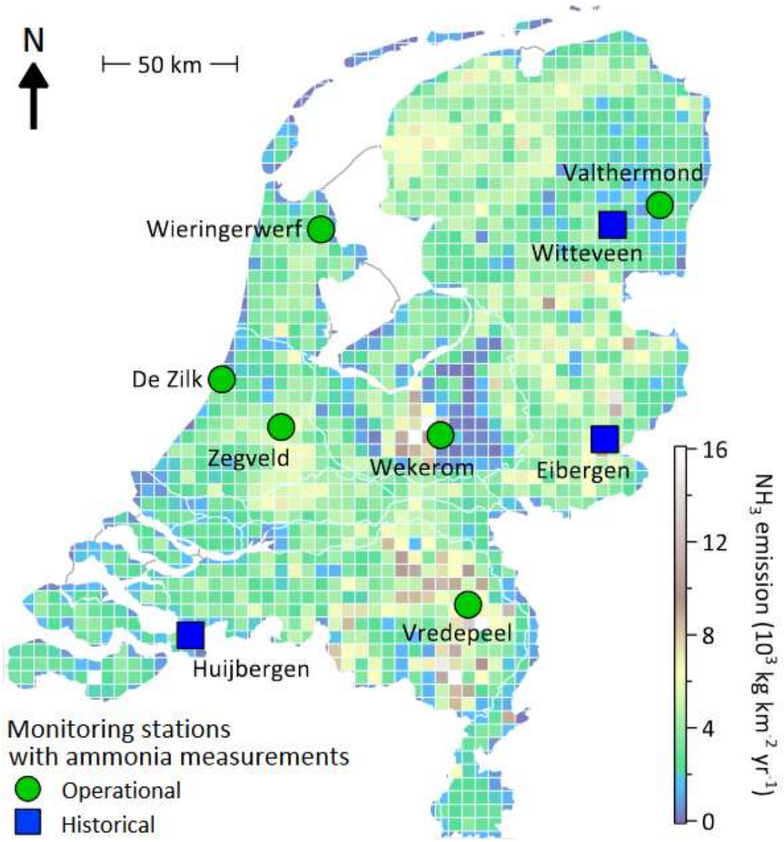


NH_3 concentrations and variabilities over Paris



NH_3 concentrations and variabilities over Paris

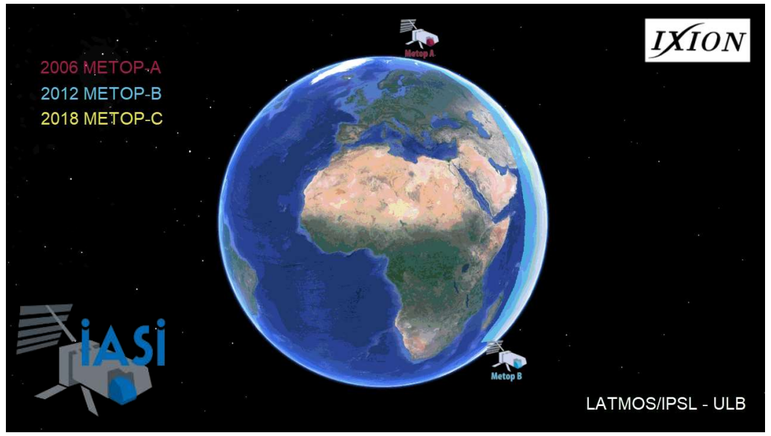




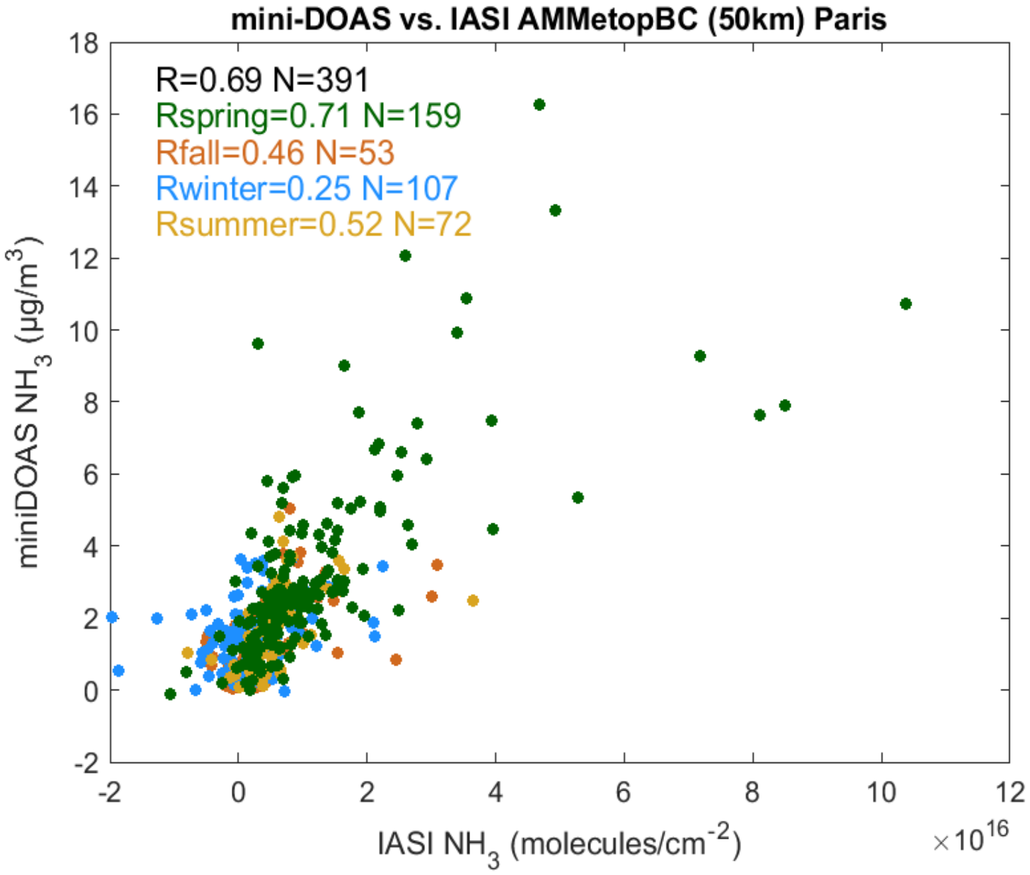
Berkhout et al., 2017

The miniDOAS is a UV open-path spectrometer installed at QUALAIR since January 2020.
It can measure a wide range of ammonia concentrations (from 0.5 to 200 µg.m^{-3}) day and night.
It is a suitable instrument for NH_3 monitoring and is part of the Dutch National Air Quality Monitoring Network.

NH_3 concentrations and variabilities over Paris



January 2020 to June 2022

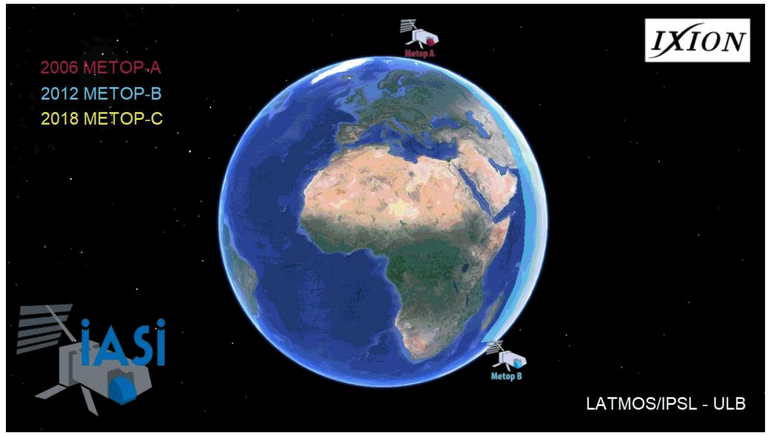


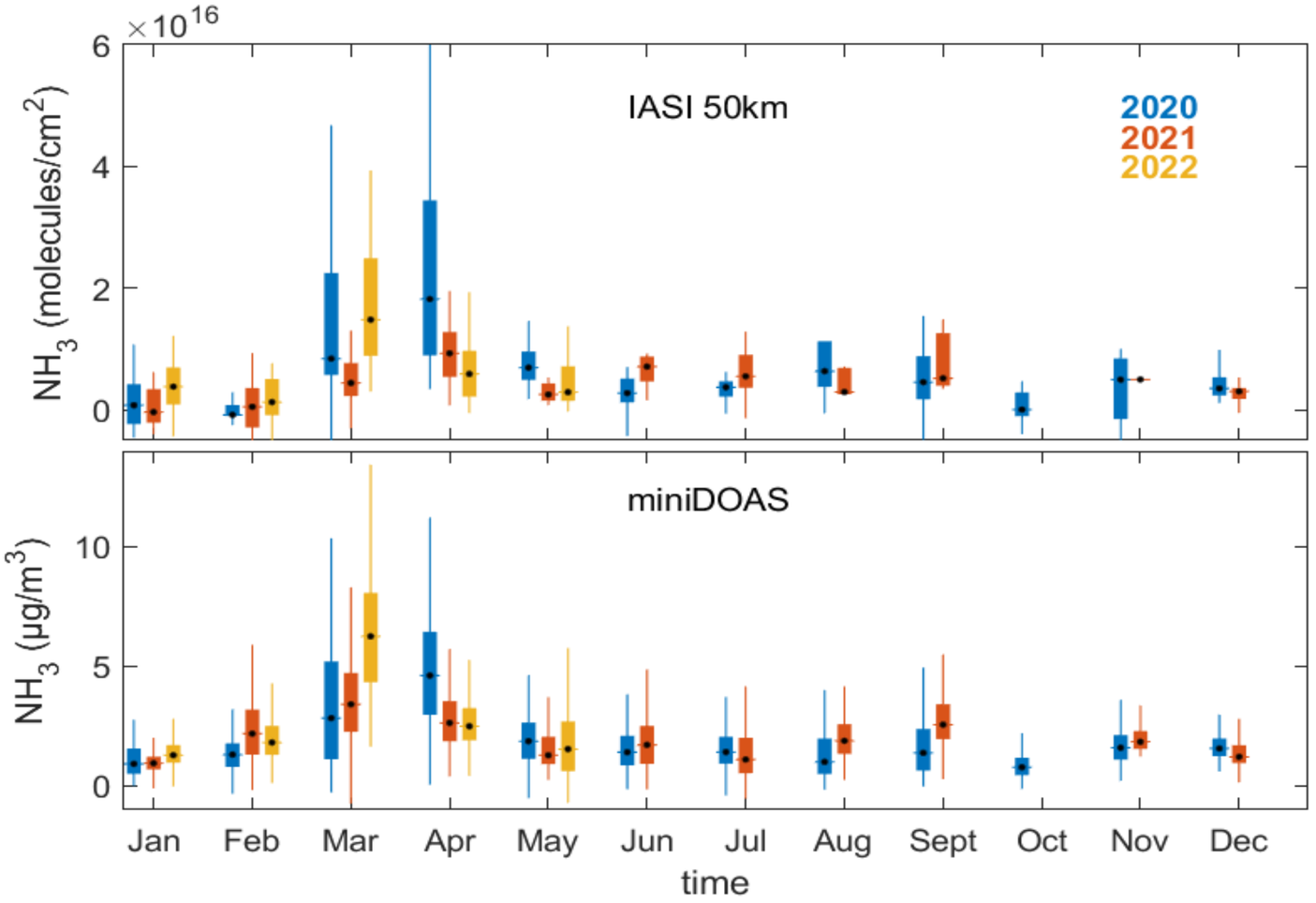
We only compare miniDOAS data recorded within the same hour as the IASI morning overpass time.

- The miniDOAS and IASI are in moderate agreement with Pearson correlation of 0.69.
- The best agreement is in spring.
- The lower correlations in fall and summer could reveal specific NH_3 sources in the close vicinity of the miniDOAS.

Viatte et al. 2023

Impact of agriculture on NH_3 concentrations in Paris

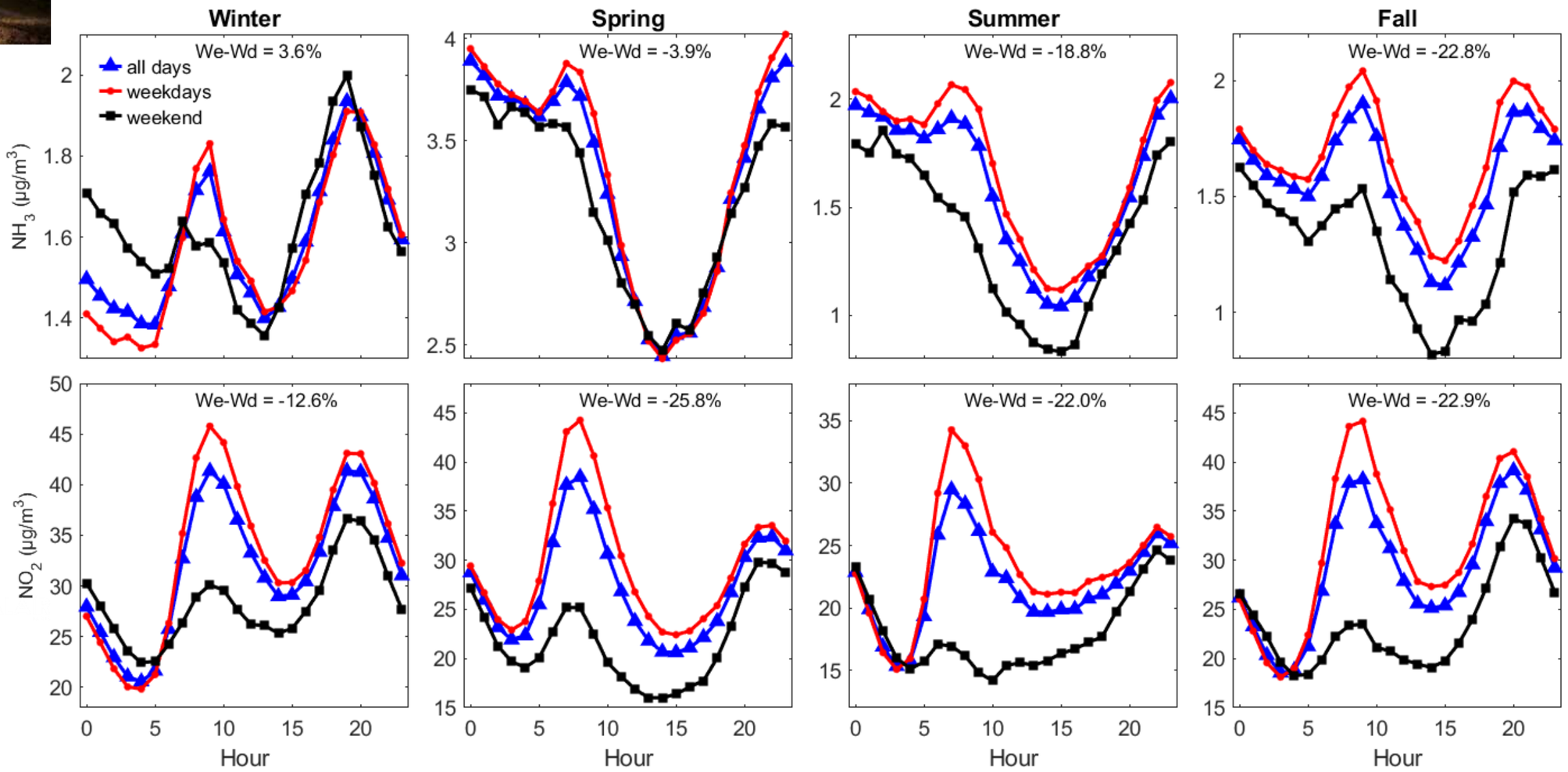




- In spring, NH_3 concentrations measured in Paris are enhanced by a factor of 2 compared to the other seasons
- The inter-annual variability of peaks depends on meteorological conditions. These influence the timing of agricultural practices, the volatilization of NH_3 from the soil into the atmosphere, and the transport of NH_3 over Paris.

Viatte et al. 2023

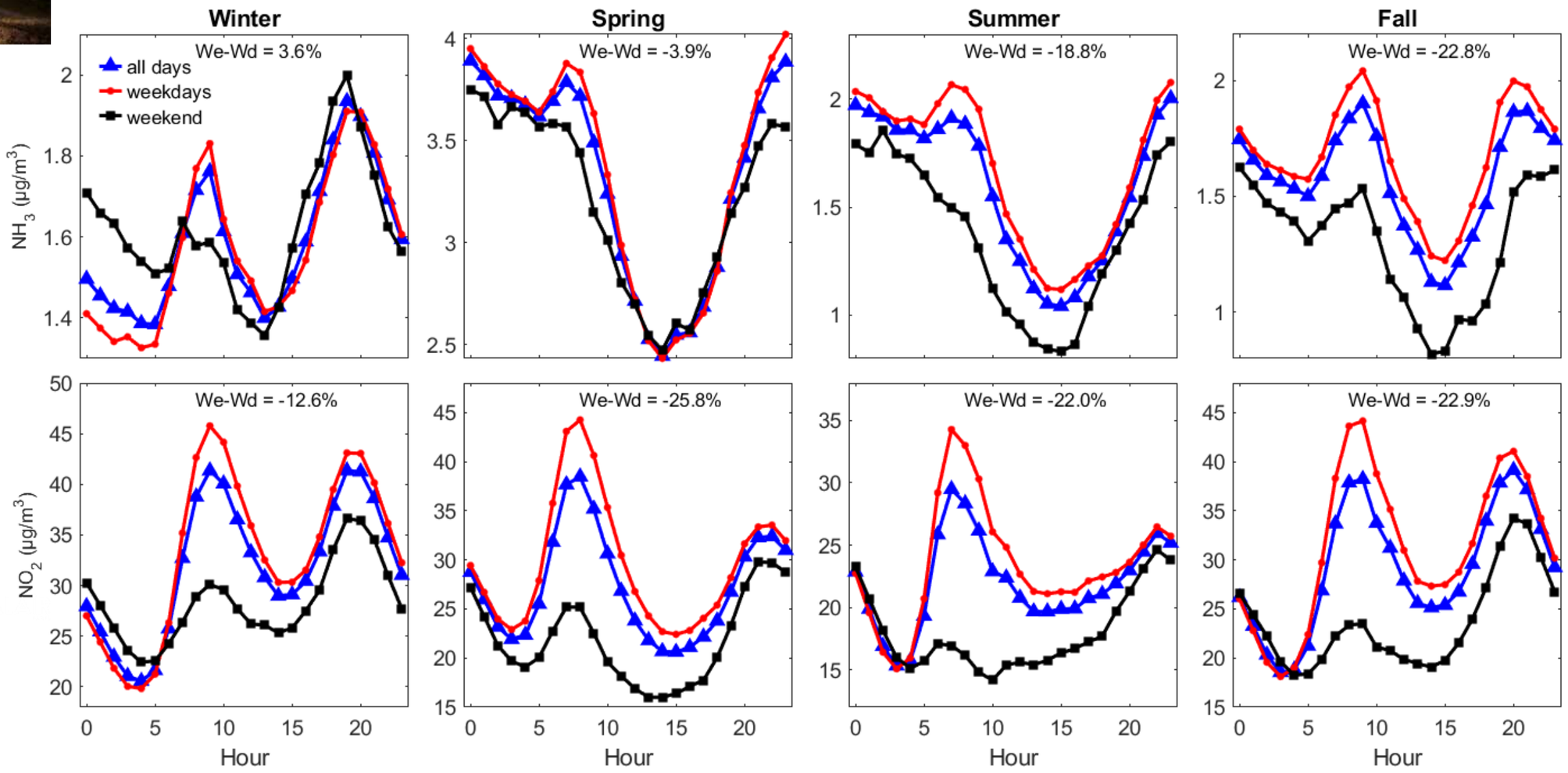
Effect of road traffic on NH_3 variability in Paris



- The diurnal variability of NH_3 concentrations shows a visible increase in the morning in all seasons. Between 5:00 and 8:00 am, road traffic in Paris increases by a factor of 4, and NH_3 concentrations rise by more than 20% in winter and fall, and by around 3% in summer and spring.

Viatte et al. 2023

Effect of road traffic on NH_3 variability in Paris



- NO_2 concentrations are systematically lower on weekends than on weekdays, and the same is true for NH_3 concentrations in fall and summer. This would indicate a significant traffic source of NH_3 in Paris.

Viatte et al. 2023

O_3 tropospheric column during summer pollution in Paris

We analyse various datasets to characterize summer pollution events in Paris during the 2022 ACROSS (Atmospheric ChemistRy Of the Suburban foreSt) campaign.

IAGOS — IN-SERVICE AIRCRAFT FOR A GLOBAL OBSERVING SYSTEM

O_3 in situ measurements

QUALAIR

O_3 vertical profiles from a UV DIAL LIDAR

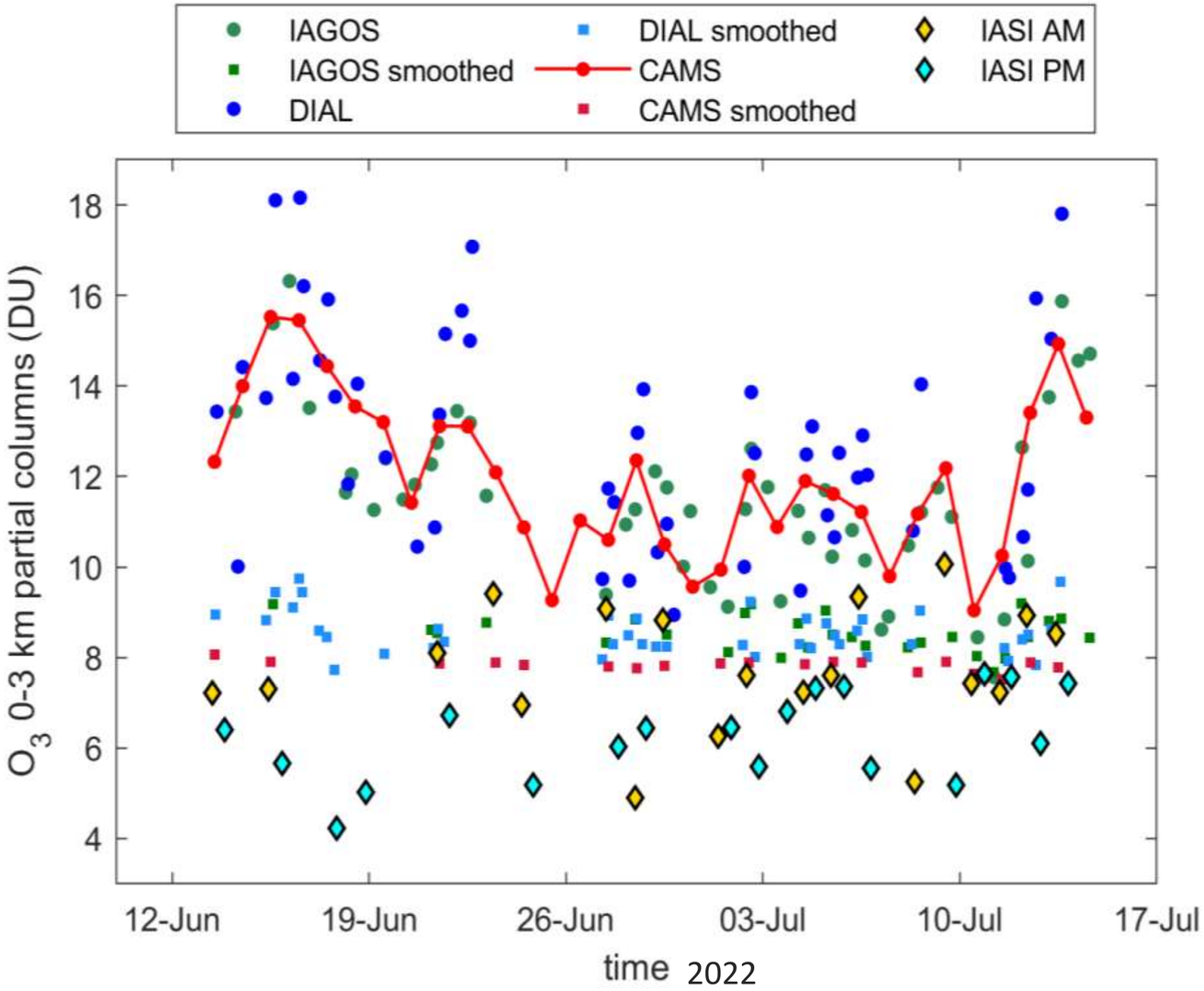
Atmosphere Monitoring Service
atmosphere.copernicus.eu

O_3 concentrations

IASI

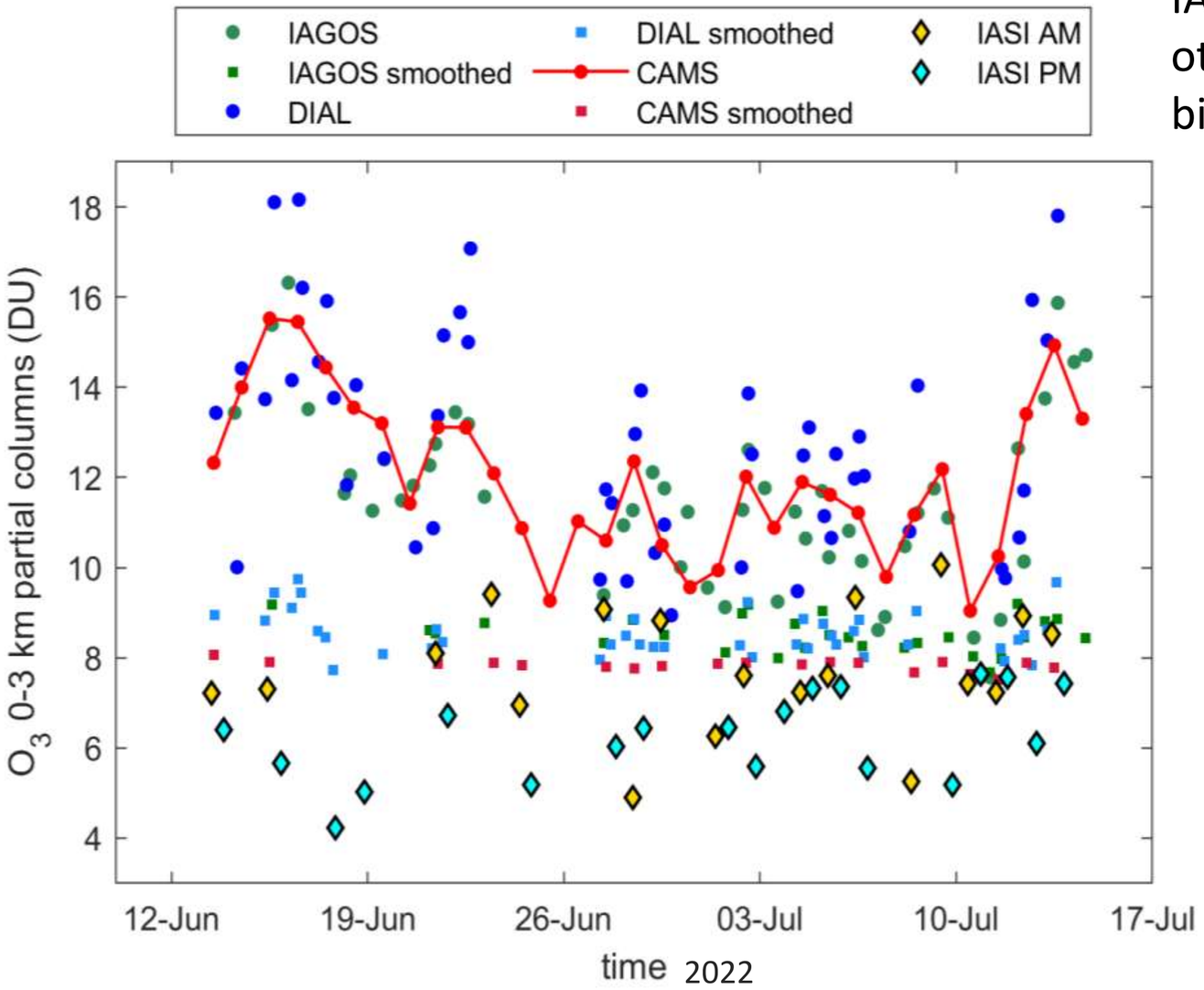
O_3 0-3 km partial columns (AM and PM)

O_3 tropospheric column during summer pollution in Paris



Ancellet et al. 2024

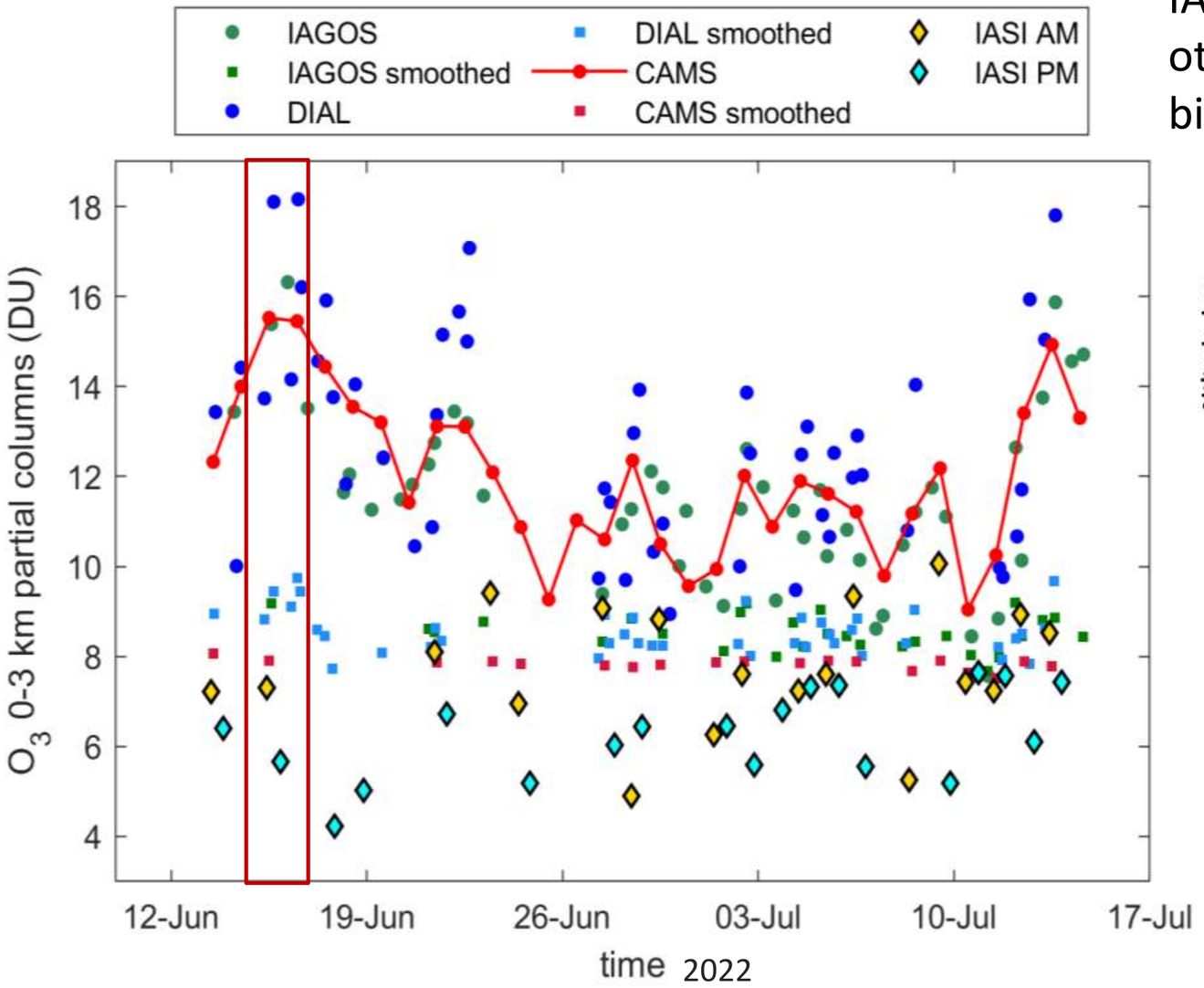
O_3 tropospheric column during summer pollution in Paris



IASI O_3 partial columns are overall lower than others data raw and smoothed columns, with biases of the order of **1-3 DU**.

Ancellet et al. 2024

O_3 tropospheric column during summer pollution in Paris



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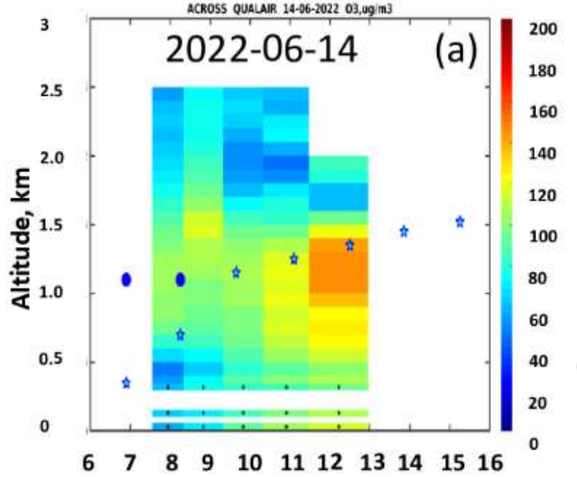
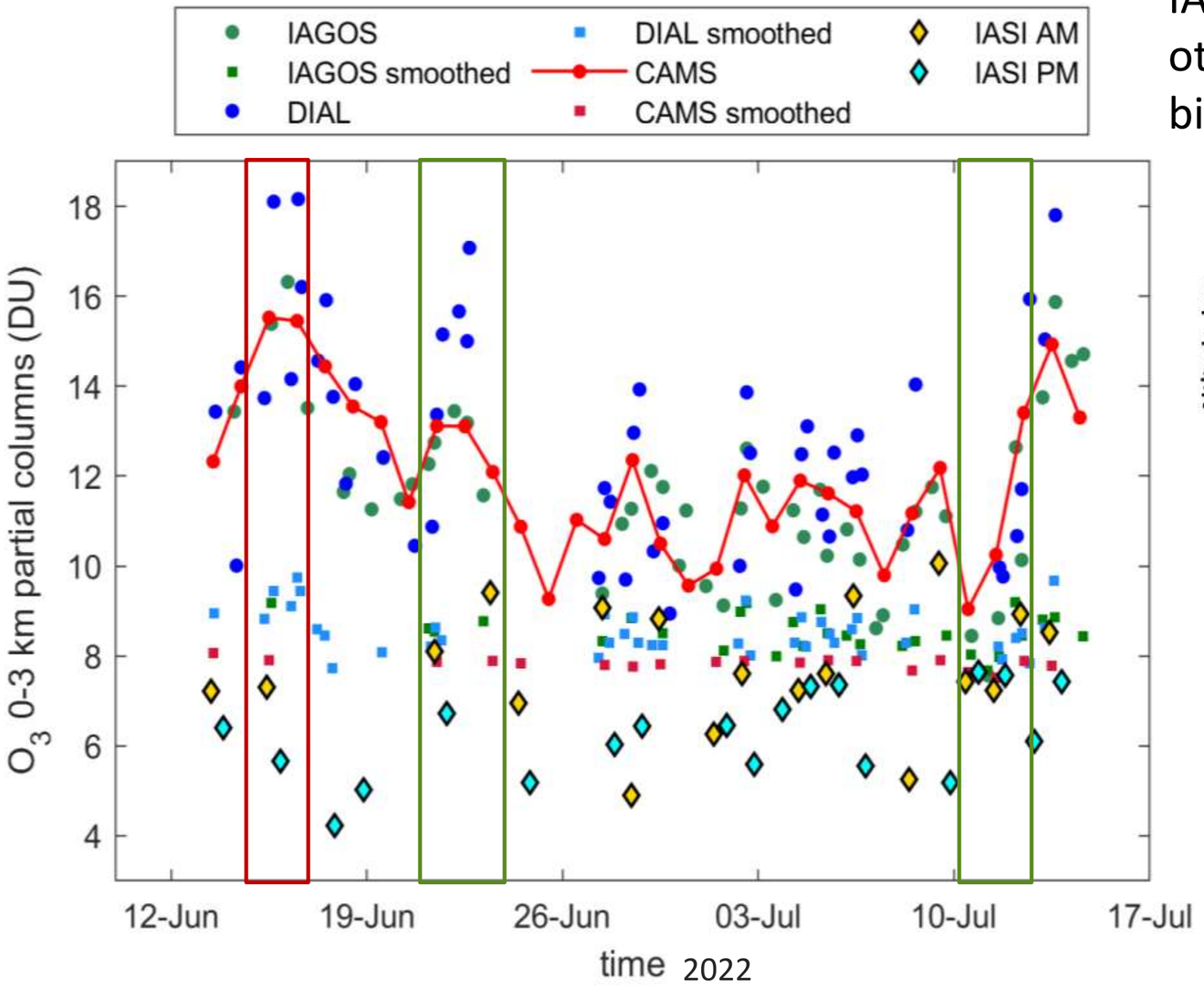


Ancellet et al. 2024

O_3 tropospheric column during summer pollution in Paris



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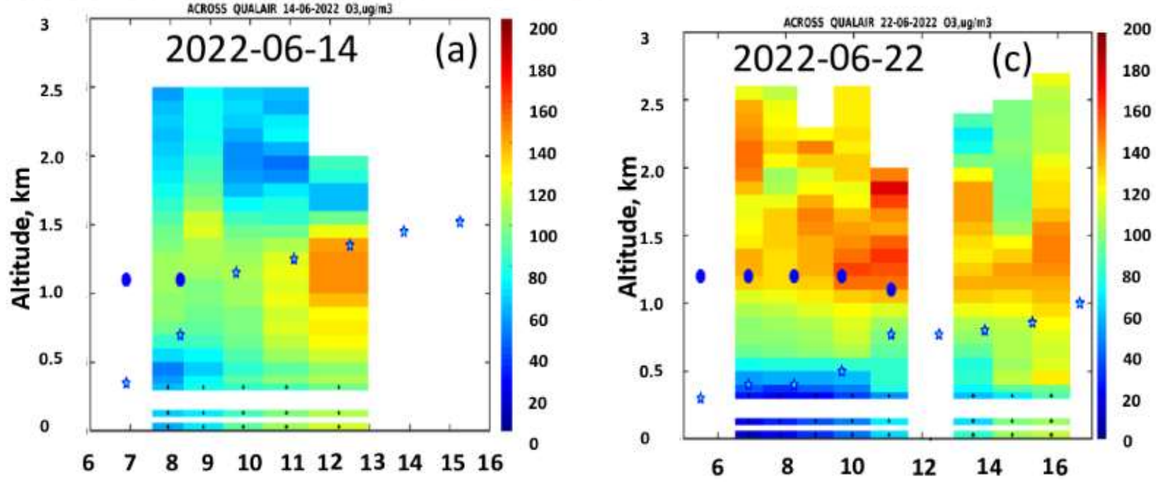

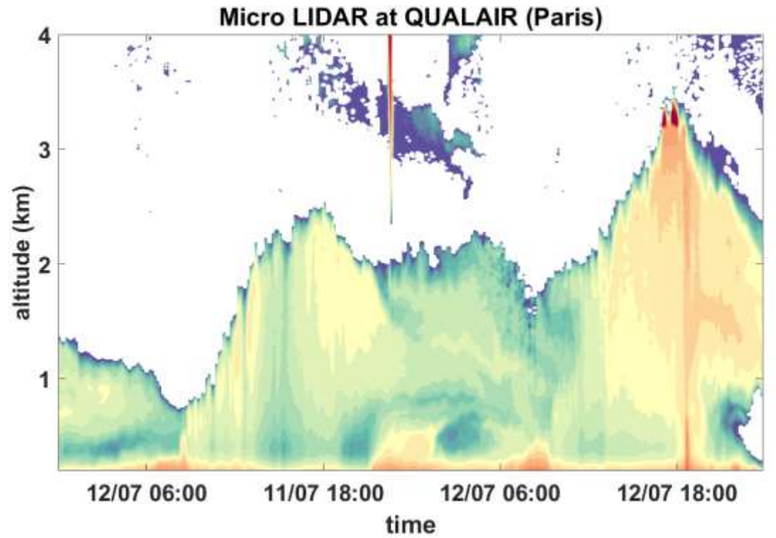

Ancellet et al. 2024

O_3 tropospheric column during summer pollution in Paris

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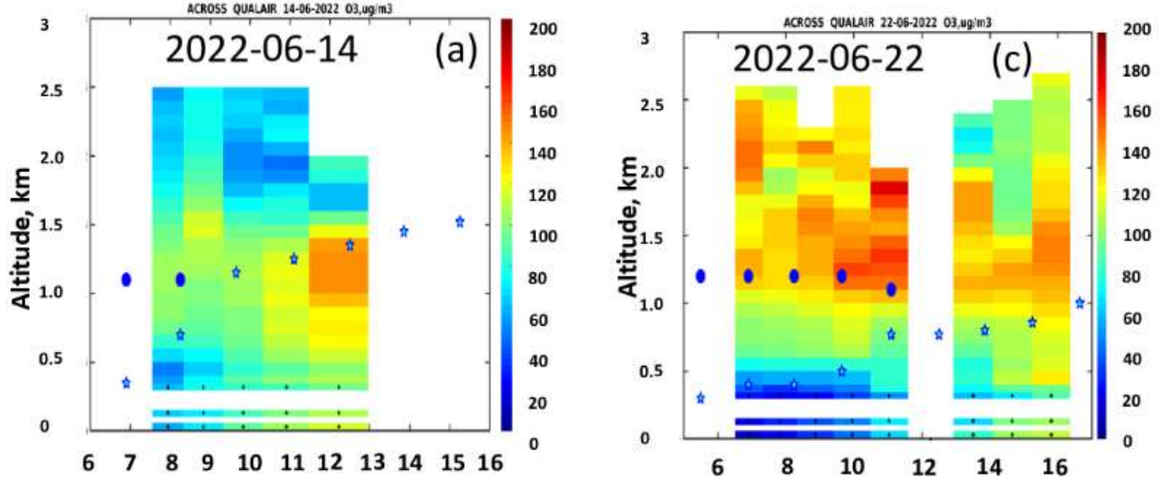

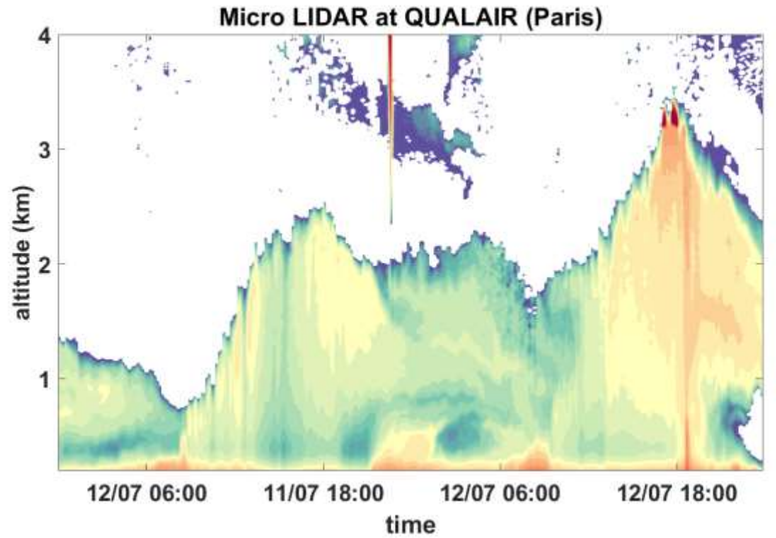

IASI O_3 lowermost partial columns (0-3km) have a significant negative bias, but it can be flagged by looking at the maximum altitude level of the lower tropospheric O_3 plume, and/or the altitude of the PBL.

Ancellet et al. 2024

Wildfire plumes over Paris

Wildfires generate plumes which can be traced by CO because of its long lifetime.

Wildfire plumes over Paris

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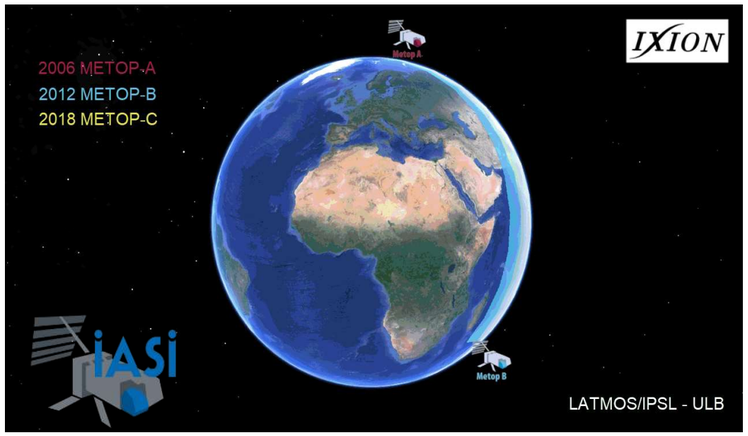
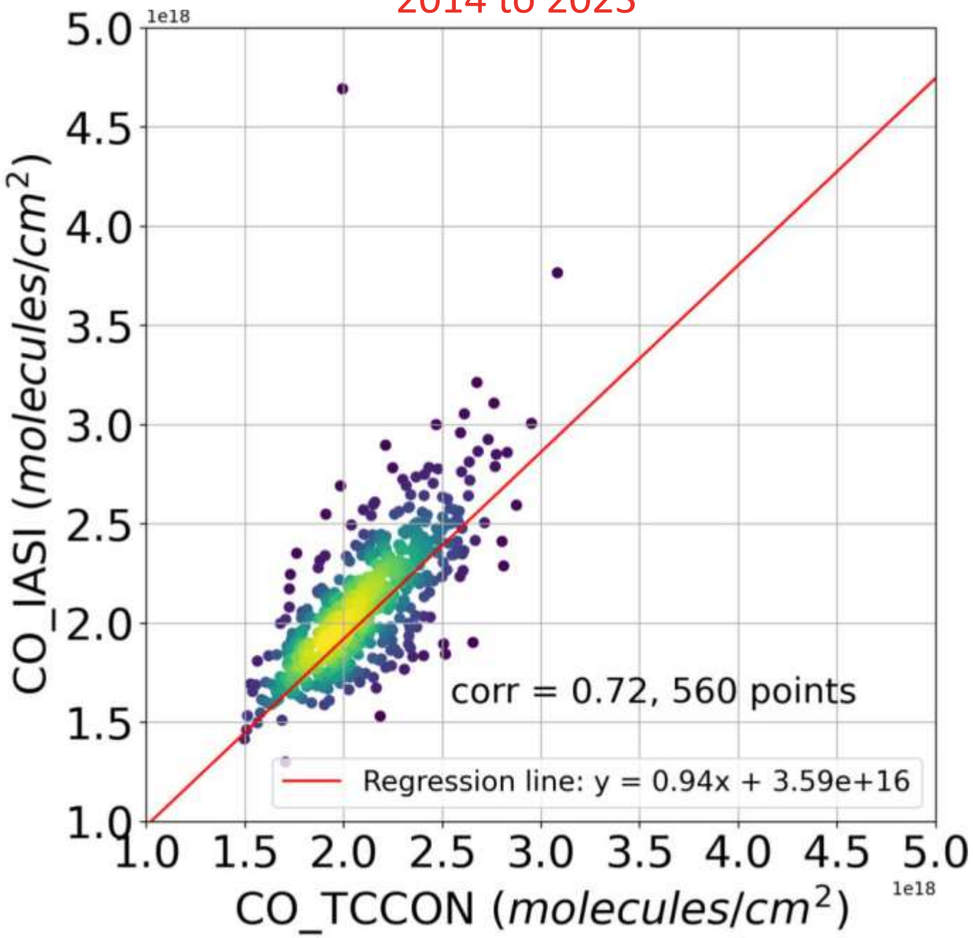


TCCON total carbon column observing network

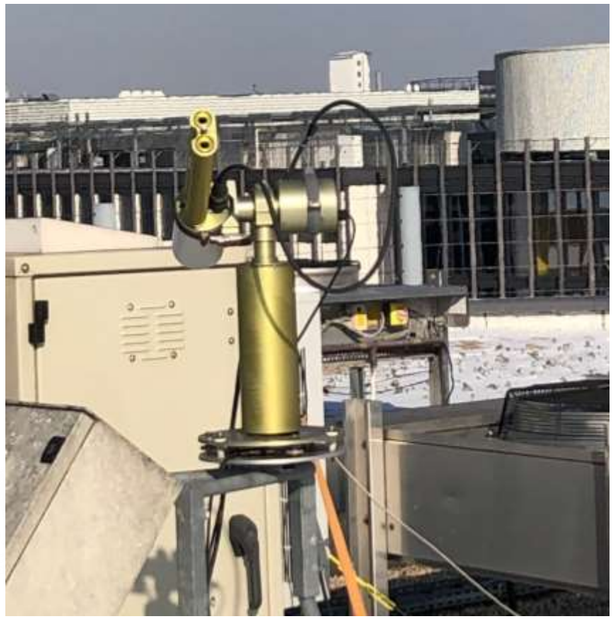
QUALAIR

2014 to 2023



Wildfire plumes over Paris

We have developped a methodology to automatically detect wildfires using the synergy of observations, based on :



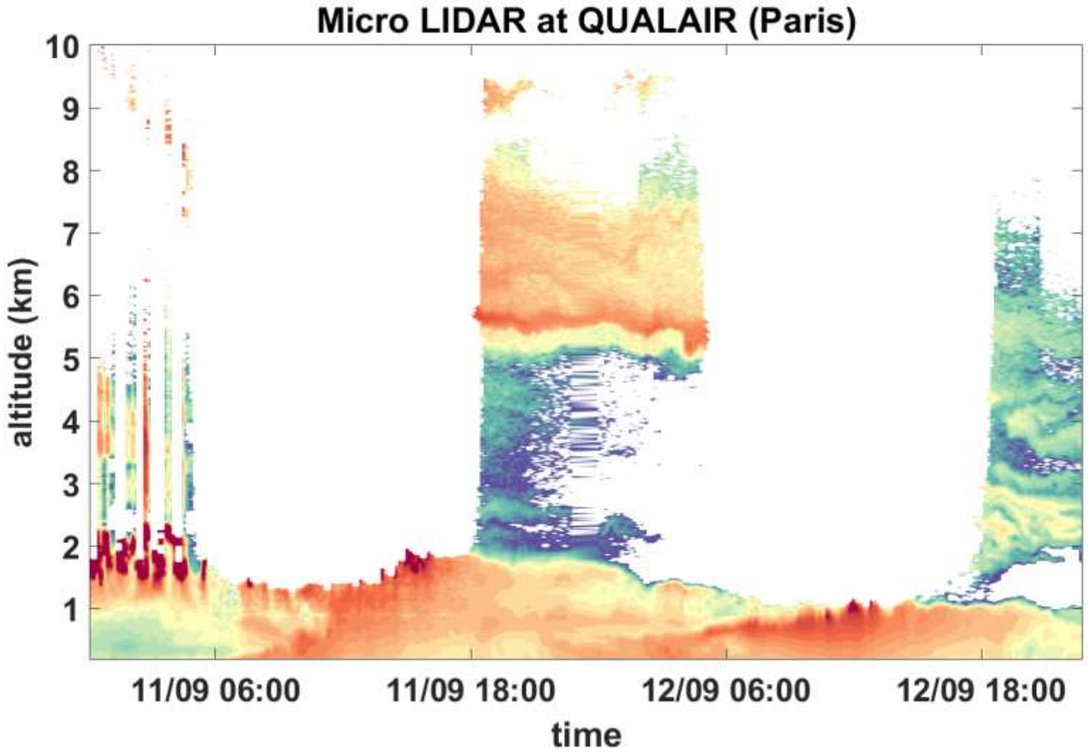
Aerosol Optical Depth (AOD), fine mode AOD, Volume size distrubution Hu et al.2022

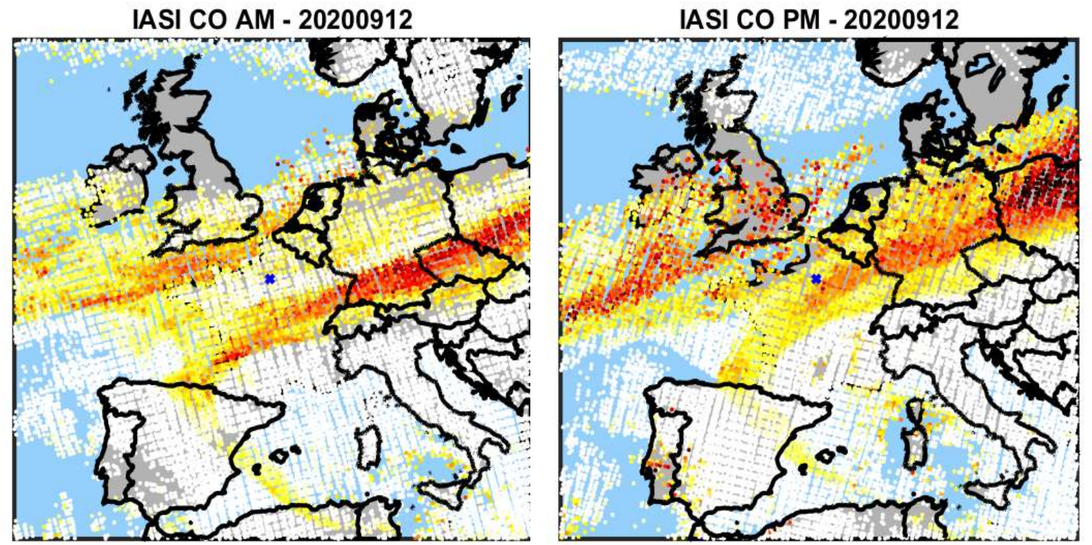
Aerosol backscatter LIDAR

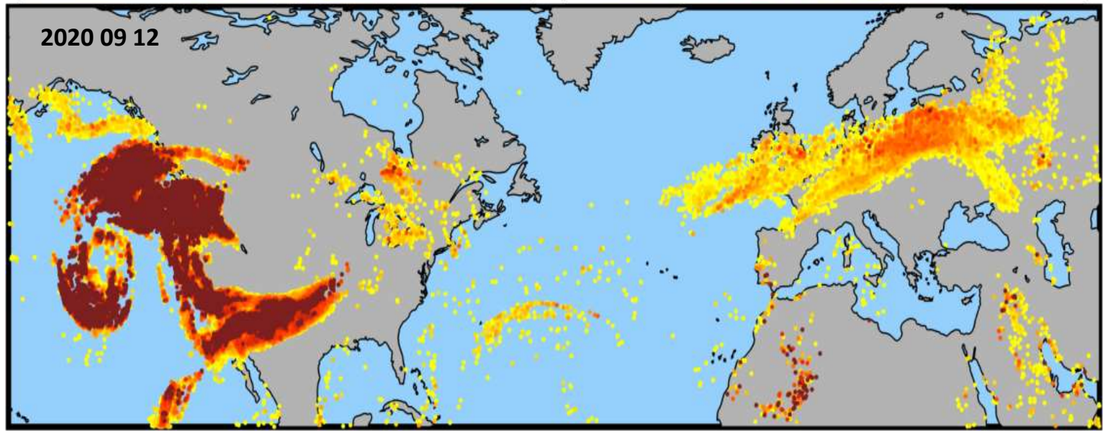
IASI CO total column over Paris

Wildfire plumes over Paris

- CO TCCON columns exceeds 1.5 times the monthly climatology.

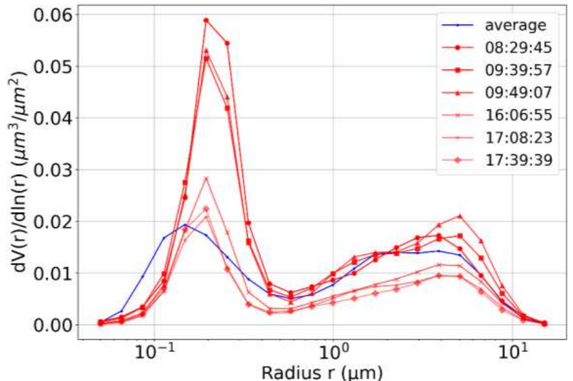






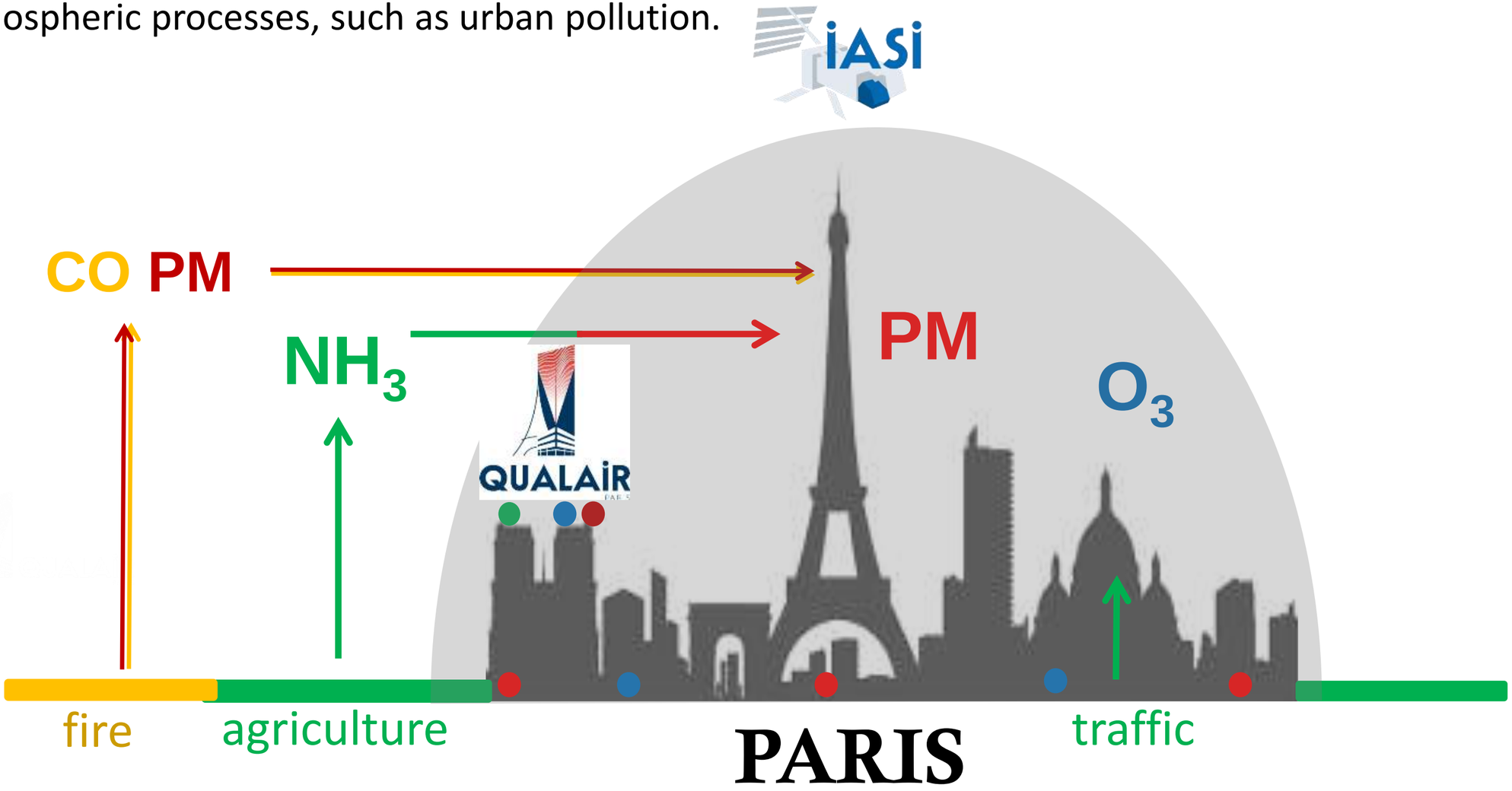
Credit Maya George

- The volume size distribution of the aerosols shows the dominance of the small particles.



Conclusions

Ground-based measurements are used to validate satellite observations.
Using satellite observations of IASI in complement to ground-based measurements is helpfull to study atmospheric processes, such as urban pollution.



Conclusions

Ground-based measurements are used to validate satellite observations.
Using satellite observations of IASI in complement to ground-based measurements is helpfull to study atmospheric processes, such as urban pollution.

Perspectives

NH_3 concentrations have just become regulated in Europe.

In order to help building an operational network in France, we have developped a project, which aims to study the representativeness of NH_3 surface measurements in support to satellite observations.

PROJET ROSAS : 2024-2026

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

ROSAS
Représentativité des Observations de Surface d'Ammoniac atmosphérique en appui à l'exploitation des données Satellites

Représentativité des Observations de Surface d'Ammoniac atmosphérique en appui à l'exploitation des données Satellites

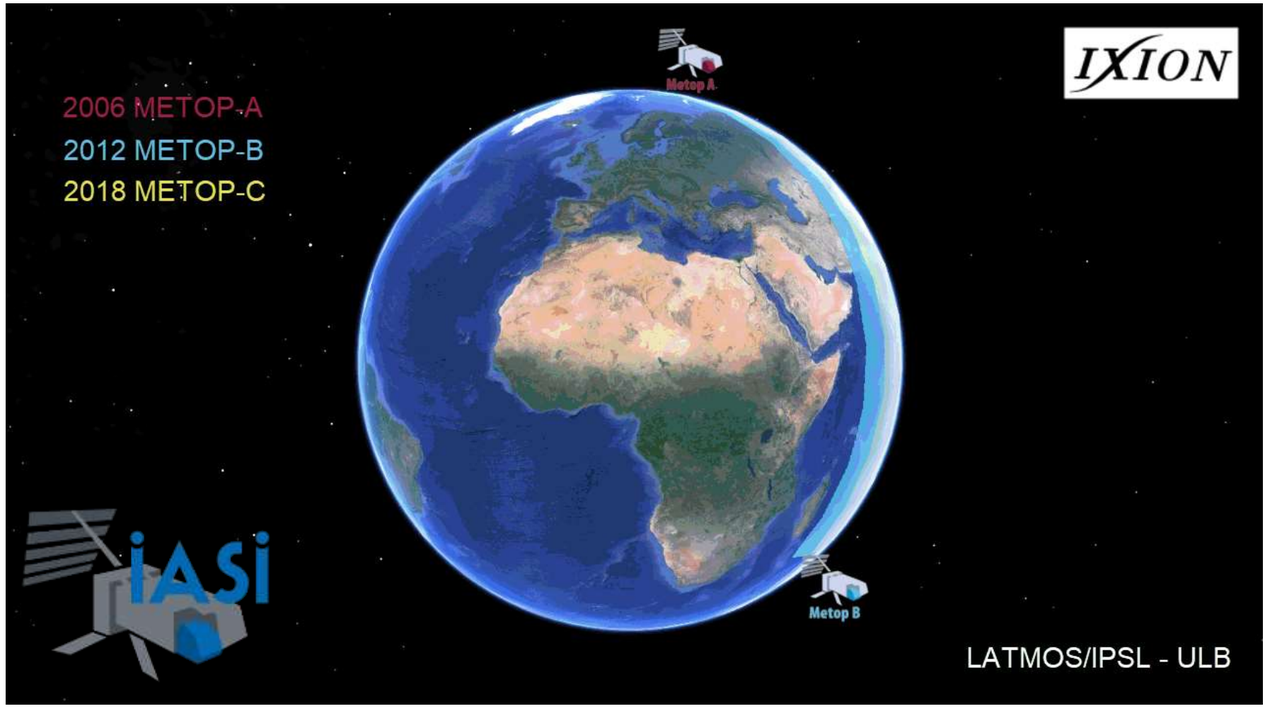
votre parten'air Atmo AUVERGNE-RHÔNE-ALPES

AtMO GRAND EST

LATMOS

air BREIZH Observatoire de la qualité de l'air

Thank you for your attention



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