

## Introduction

Ammonia (NH<sub>3</sub>) is an atmospheric pollutant mainly emitted by the agricultural sector<sup>1</sup>. Increasing availability of such reactive nitrogen species causes major impacts on the environment (species extinctions<sup>2</sup>, impact on the ecosystem<sup>1,3</sup>, public health<sup>4</sup> and climate change<sup>5</sup>).

Due to the difficulty of measuring NH<sub>3</sub> in ambient air<sup>6</sup>, along with the very large variability of NH<sub>3</sub> concentrations in space and time, there are too few systematic and representative ground-based measurements around the world<sup>7</sup>.

## Objective

In this context, we used a state-of-art ground-based instrument (mini-DOAS) to evaluate NH<sub>3</sub> concentrations derived from IASI (Infrared Atmospheric Sounding Interferometer), within two different regions : urban (Paris) and rural (Grignon).

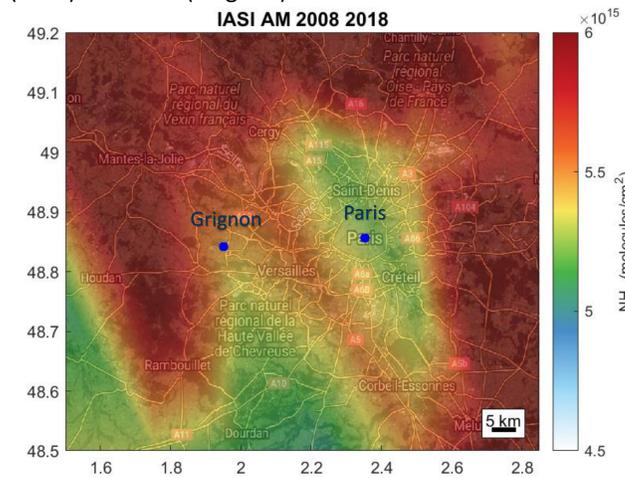


Figure 1 : map of morning NH<sub>3</sub> total column (molecules/cm<sup>2</sup>) derived from 10 years of IASI measurements with indication of 2 sites of interest (Paris and Grignon)

## Method

The mini-DOAS is a ground-based open-path instrument based on the Differential Optical Absorption Spectroscopy technique (DOAS), which measures NH<sub>3</sub> concentrations in the UV-Visible between 200-230 nm every 10 seconds<sup>8</sup>. It was installed within the QUALAIR facility (Paris city-center) since December 2019.

In this work, mini-DOAS observations performed in Paris (January 2020 - September 2021) and at Grignon (September 2021 - October 2021) are presented. Comparison of the mini-DOAS hourly NH<sub>3</sub> concentrations coincident to the IASI morning measurements (Metop B and C) is discussed.



Figure 2 : Mini-DOAS in Paris (left) and in Grignon (right)

## Mini-DOAS – Urban vs. Rural

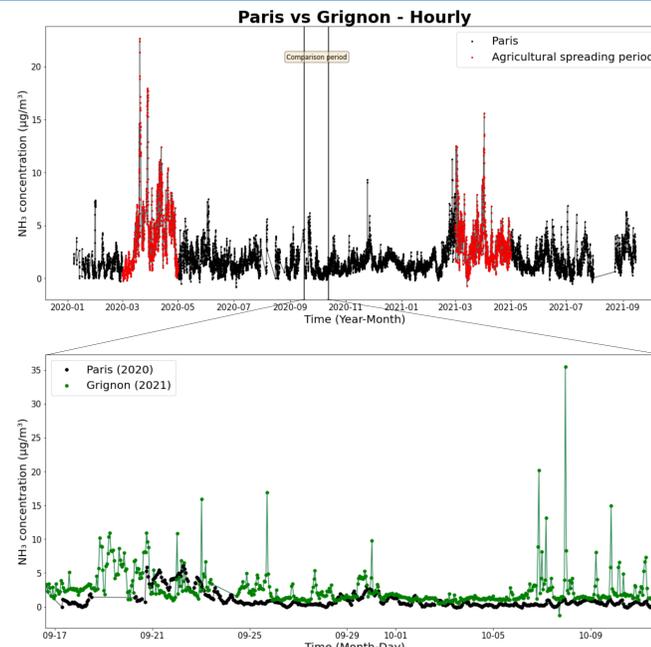


Figure 3 : Timeserie of NH<sub>3</sub> concentrations derived from mini-DOAS in Paris (Top) and Grignon with a focus on the comparison period (bottom)

### 1. Mini-DOAS in Paris

The average NH<sub>3</sub> concentration between January 2020 and September 2021 is 2.09 +/- 0.02 µg.m<sup>-3</sup>. During springtime (March to May 2020 and 2021), the average NH<sub>3</sub> concentration is 3.84 +/- 0.05 µg.m<sup>-3</sup>. Higher concentrations in spring are due to the transport of NH<sub>3</sub> from the surrounding regions during fertilizer spreading periods<sup>9</sup>.

NH<sub>3</sub> concentrations averaged in springtime 2020 are 1.32 times higher than in 2021 in Paris. Meteorological conditions (precipitation) could explain this difference.

### 2. Mini-DOAS comparison Paris vs. Grignon

NH<sub>3</sub> concentrations measured in September-October 2021 in Grignon is 2.55 times higher than the average NH<sub>3</sub> concentrations measured in Paris during the same period in 2020.

The proximity of the Grignon farm to the mini-DOAS measurements at this rural area most likely explains this difference.

## Comparison IASI vs. mini-DOAS

Radius (km)	Paris		Grignon	
	N	R	N	R
600	533	0.38	24	0.46
100	395	0.69	23	0.25
50	311	0.67	18	0.43
30	253	0.66	13	0.75
10	35	0.57	2	1.00

Figure 4 : Evaluation of correlation coefficients (R) between the mini-DOAS and IASI (for different radius) in Paris and Grignon

### 1. Comparison in Paris and Grignon

To assess the representativeness of the mini-DOAS NH<sub>3</sub> observations, we have compared both data using different spatial criteria for IASI measurements (600, 100, 50, 30, and 10 km radius circle around Paris).

In Paris, the best agreement between the mini-DOAS and IASI is found to be at 100 km whereas in Grignon, is found to be at 30 km.

Possible reasons for this difference might be:

- 1) The altitude of the mini-DOAS instrument (40 m at Paris vs. 0 m at Grignon) impacts the representativeness of its observations
- 2) Local emissions from agricultural sources (farm) at the rural site of Grignon drive NH<sub>3</sub> variability

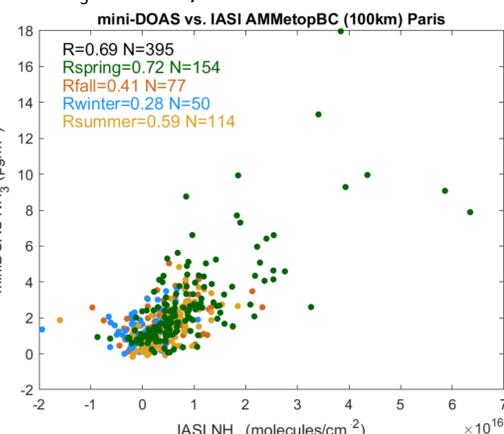


Figure 5 : IASI NH<sub>3</sub> as a function of mini-DOAS NH<sub>3</sub> concentrations. Color refers to seasons

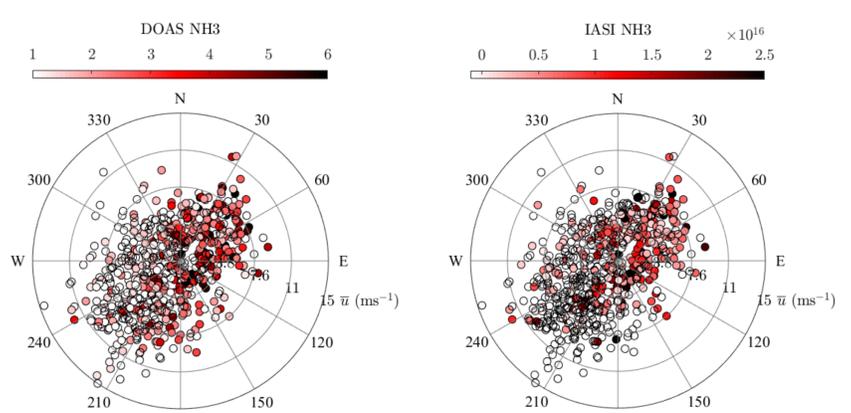


Figure 6 : Pollution roses of NH<sub>3</sub> in Paris derived from the mini-DOAS (left) and IASI (right) instruments

## Conclusions

- Using 2 years of continuous NH<sub>3</sub> measurements derived from the mini-DOAS in Paris, seasonal variability of NH<sub>3</sub> concentrations is assessed. Higher concentrations are found during springtime due to spreading practices in the surrounding regions.
- NH<sub>3</sub> concentrations in the rural area of Grignon is found to be more than 2 times higher than in the urban region of Paris.
- This first evaluation of IASI measurements by the mini-DOAS show similar results with better agreement in a 100 km and 30 km area in Paris and Grignon, respectively.
- The agreement between IASI and the mini-DOAS is higher in spring (R = 0.72) when both instruments monitor NH<sub>3</sub> concentrations coming from the northeast.
- The mini-DOAS dataset will be used in the future to contribute further to the evaluation of the IASI NH<sub>3</sub> product over relevant sources.

## References

1. Fowler et al. 2013. « The Global Nitrogen Cycle in the Twenty-First Century ». Philosophical Transactions of the Royal Society B: Biological Sciences 368 (1621): 20130164. <https://doi.org/10.1098/rstb.2013.0164>.
2. Hernández et al. 2016. « Nitrogen Pollution is Linked to US Listed Species Declines ». BioScience 66 (3): 213-22. <https://doi.org/10.1093/biosci/biv211>.
3. Rockström et al. 2009. « Planetary Boundaries: Exploring the Safe Operating Space for Humanity ». Ecology and Society 14 (2): art32. <https://doi.org/10.5752/E0140203>.
4. Lelieveld et al. 2015. « The Contribution of Outdoor Air Pollution Sources to Premature Mortality on a Global Scale ». Nature 525 (7569): 367-71. <https://doi.org/10.1038/nature15317>.
5. Myhre et al. 2013. « Radiative Forcing of the Direct Aerosol Effect from AeroCom Phase II Simulations ». Atmospheric Chemistry and Physics 13 (4): 1853-77. <https://doi.org/10.5194/acp-13-1853-2013>.
6. Von Bobrutski et al. 2010. « Field inter-comparison of eleven atmospheric ammonia measurement techniques ». Atmospheric Measurement Techniques 3 (1): 91-112. <https://doi.org/10.5194/amt-3-91-2010>.
7. Nair et al. 2020. « Quantification of Atmospheric Ammonia Concentrations: A Review of Its Measurement and Modeling ». Atmosphere 11 (10): 1092. <https://doi.org/10.3390/atmos11101092>.
8. Volten et al. 2012. « Two Instruments Based on Differential Optical Absorption Spectroscopy (DOAS) to Measure Accurate Ammonia Concentrations in the Atmosphere ». Atmospheric Measurement Techniques 5 (2): 413-27. <https://doi.org/10.5194/amt-5-413-2012>.
9. Viatte et al. 2020. « Atmospheric Ammonia Variability and Link with Particulate Matter Formation: A Case Study over the Paris Area ». Atmospheric Chemistry and Physics 20 (1): 577-96. <https://doi.org/10.5194/acp-20-577-2020>.