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Evaluation of ammonia concentrations derived from IASI using a ground-based instrument (mini-DOAS) over two different areas (urban and rural) in France

Nadir Guendouz, Camille Viatte, Martin van Damme, Lieven Clarisse, Pierre-François Coheur, Cristelle Cailteau-Fischbach, Cathy Clerbaux

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Introduction

Ammonia (NH₃) is an atmospheric pollutant mainly emitted by the agricultural sector¹. Increasing availability of such reactive nitrogen species causes major impacts on the environment (species extinctions², impact on the ecosystem^{1,3}, public health⁴ and climate change⁵).

Due to the difficulty of measuring NH₃ in ambient air⁶, along with the very large variability of NH₃ concentrations in space and time, there are too few systematic and representative ground-based measurements around the world⁷.

Objective

In this context, we used a state-of-art ground-based instrument (mini-DOAS) to evaluate NH₃ concentrations derived from IASI (Infrared Atmospheric Sounding Interferometer), within two different regions : urban (Paris) and rural (Grignon).

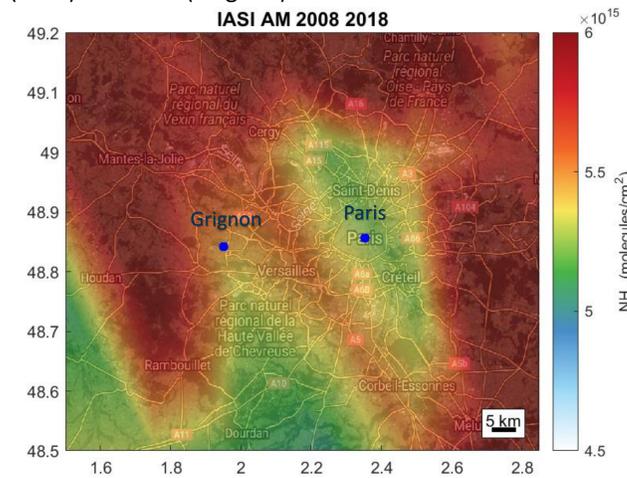


Figure 1 : map of morning NH₃ total column (molecules/cm²) derived from 10 years of IASI measurements with indication of 2 sites of interest (Paris and Grignon)

Method

The mini-DOAS is a ground-based open-path instrument based on the Differential Optical Absorption Spectroscopy technique (DOAS), which measures NH₃ concentrations in the UV-Visible between 200-230 nm every 10 seconds⁸. 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 NH₃ 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

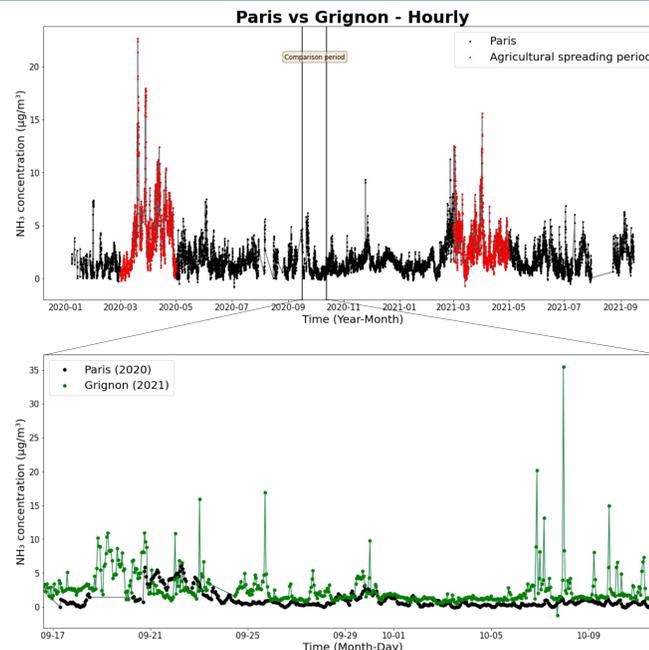


Figure 3 : Timeserie of NH₃ concentrations derived from mini-DOAS in Paris (Top) and Grignon with a focus on the comparison period (bottom)

1. Mini-DOAS in Paris

The average NH₃ concentration between January 2020 and September 2021 is 2.09 +/- 0.02 µg.m⁻³. During springtime (March to May 2020 and 2021), the average NH₃ concentration is 3.84 +/- 0.05 µg.m⁻³. Higher concentrations in spring are due to the transport of NH₃ from the surrounding regions during fertilizer spreading periods⁹.

NH₃ 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

NH₃ concentrations measured in September-October 2021 in Grignon is 2.55 times higher than the average NH₃ 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 NH₃ 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 NH₃ variability

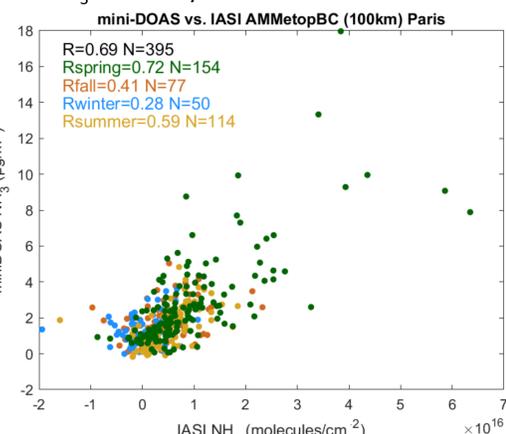


Figure 5 : IASI NH₃ as a function of mini-DOAS NH₃ concentrations. Color refers to seasons

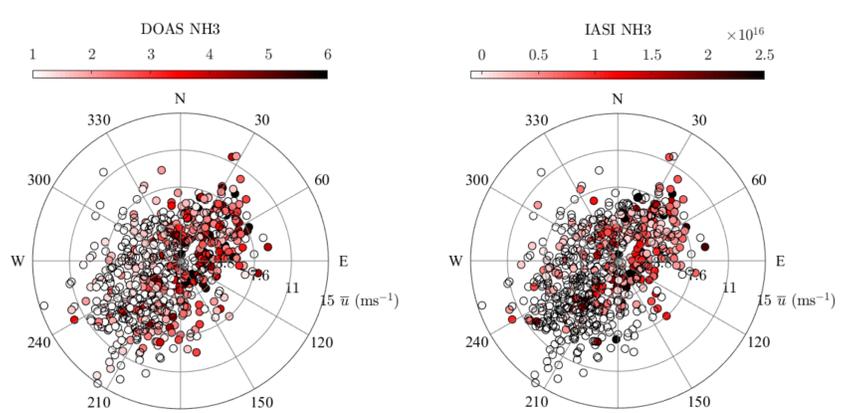


Figure 6 : Pollution roses of NH₃ in Paris derived from the mini-DOAS (left) and IASI (right) instruments

Conclusions

- Using 2 years of continuous NH₃ measurements derived from the mini-DOAS in Paris, seasonal variability of NH₃ concentrations is assessed. Higher concentrations are found during springtime due to spreading practices in the surrounding regions.
- NH₃ 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 NH₃ concentrations coming from the northeast.
- The mini-DOAS dataset will be used in the future to contribute further to the evaluation of the IASI NH₃ product over relevant sources.

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