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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

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Introduction

Ammonia (NH_3) 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 NH_3 in ambient air⁶, along with the very large variability of NH_3 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 NH_3 concentrations derived from IASI (Infrared Atmospheric Sounding Interferometer), within two different regions : urban (Paris) and rural (Grignon).

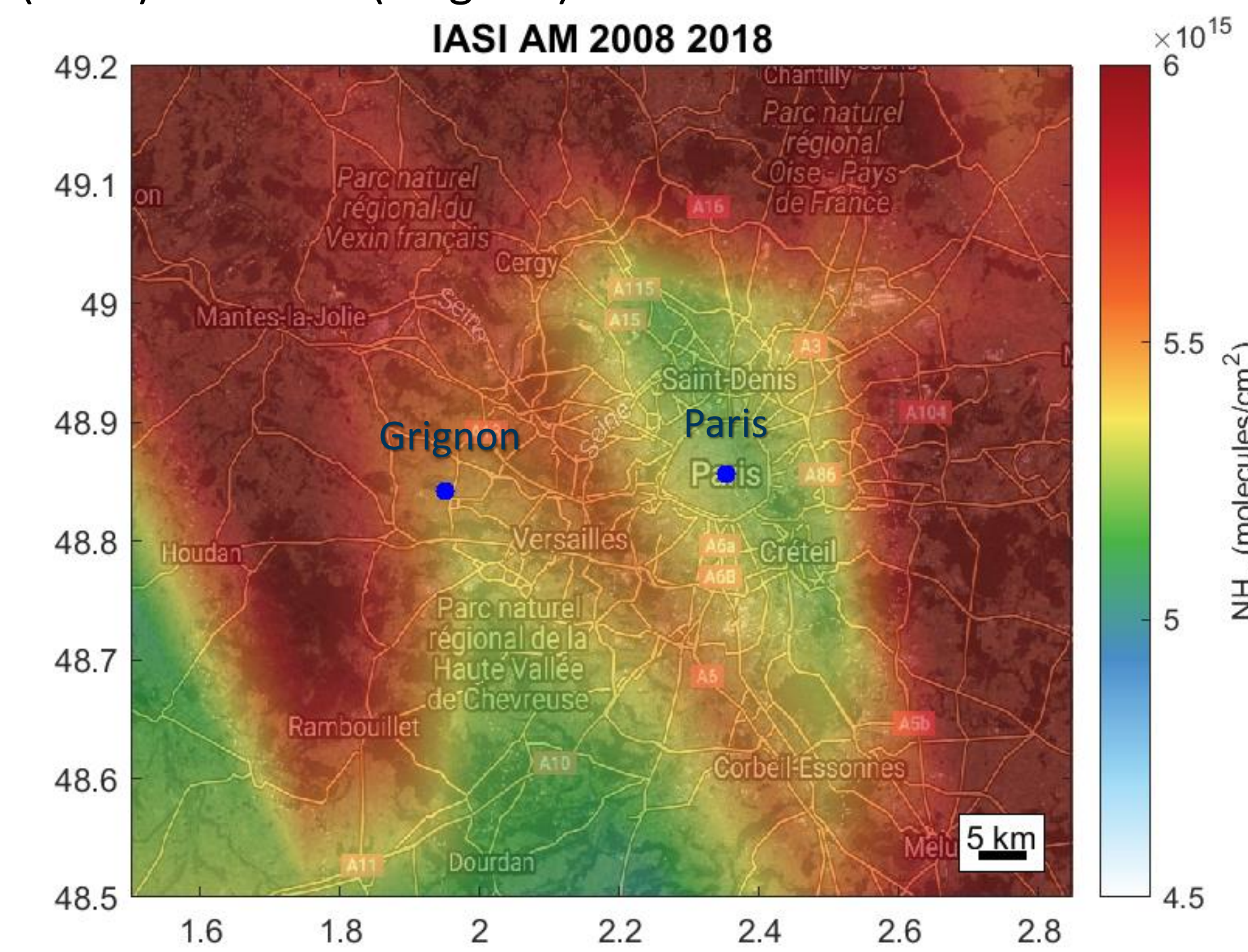


Figure 1 : map of morning NH_3 total column (molecules/cm²) derived from 10 years of IASI measurements with indication of 2 sites of interest (Paris and Grignon)

Method

The mini-DOAS is a ground-based open-path instrument based on the Differential Optical Absorption Spectroscopy technique (DOAS), which measures NH_3 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 NH_3 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

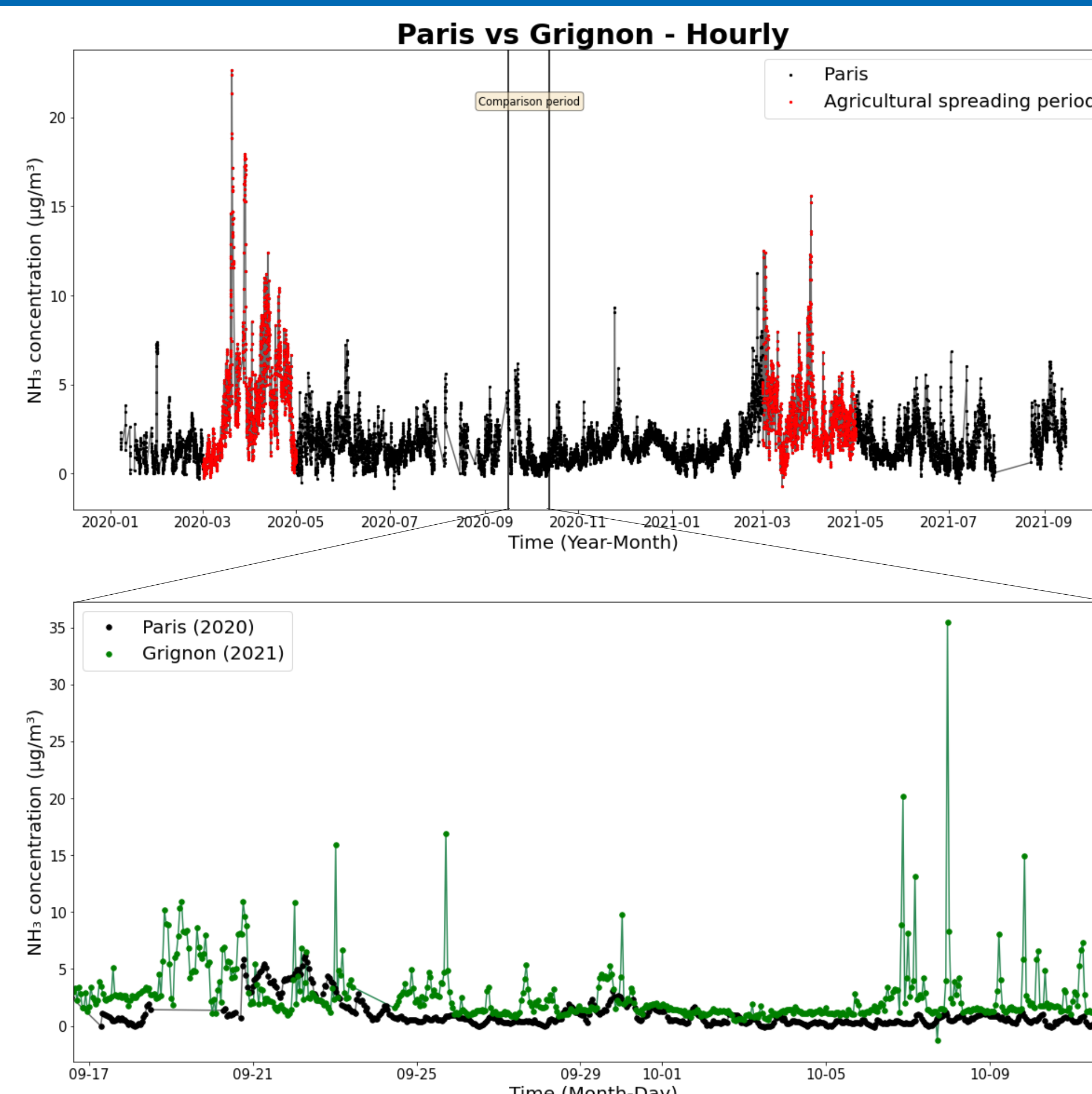


Figure 3 : Timeserie of NH_3 concentrations derived from mini-DOAS in Paris (Top) and Grignon with a focus on the comparison period (bottom)

1. Mini-DOAS in Paris

The average NH_3 concentration between January 2020 and September 2021 is $2.09 \pm 0.02 \mu\text{g}\cdot\text{m}^{-3}$. During springtime (March to May 2020 and 2021), the average NH_3 concentration is $3.84 \pm 0.05 \mu\text{g}\cdot\text{m}^{-3}$. Higher concentrations in spring are due to the transport of NH_3 from the surrounding regions during fertilizer spreading periods⁹.

NH_3 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_3 concentrations measured in September-October 2021 in Grignon is 2.55 times higher than the average NH_3 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

Paris Grignon

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_3 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_3 variability

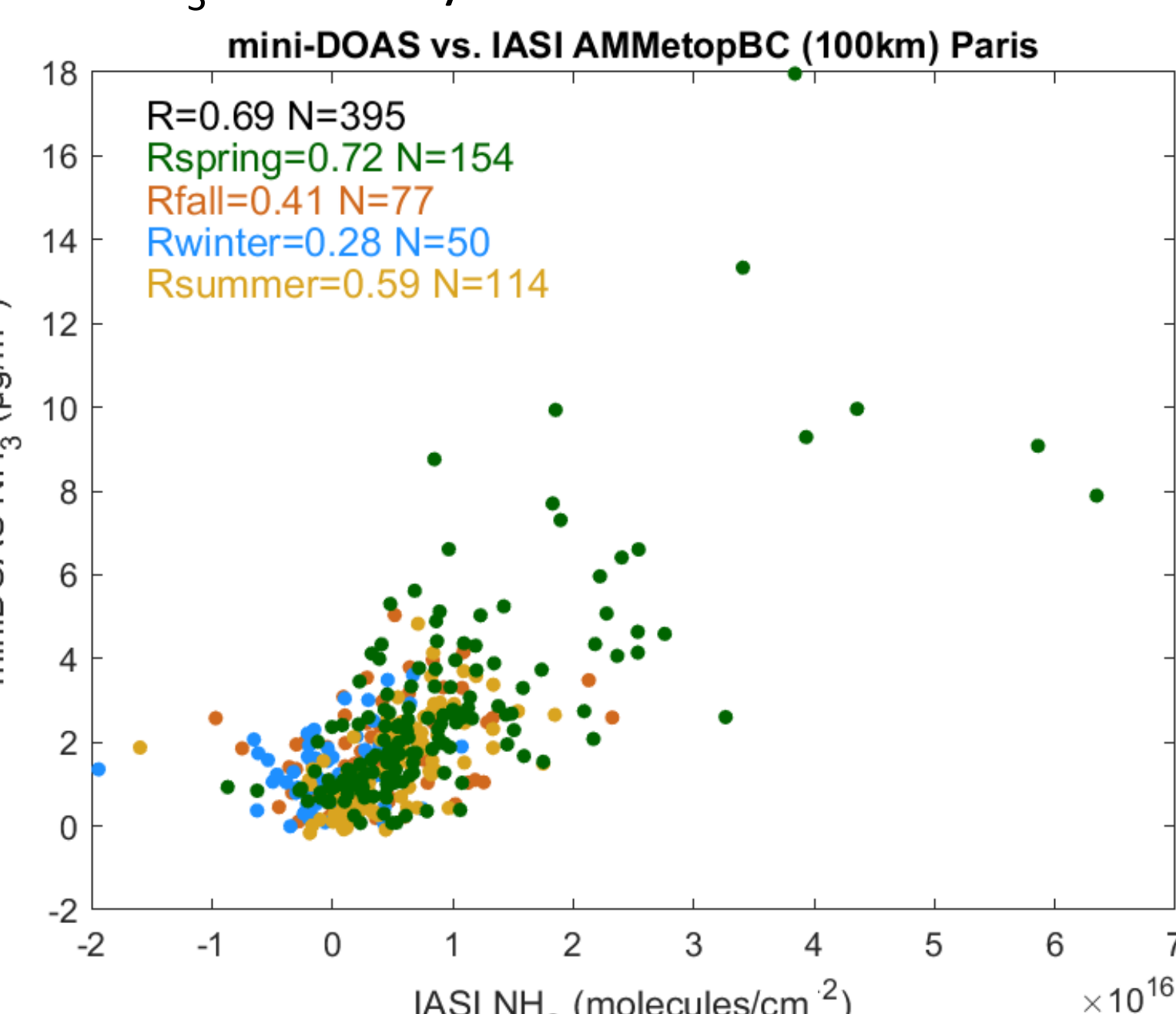


Figure 5 : IASI NH_3 as a function of mini-DOAS NH_3 concentrations. Color refers to seasons

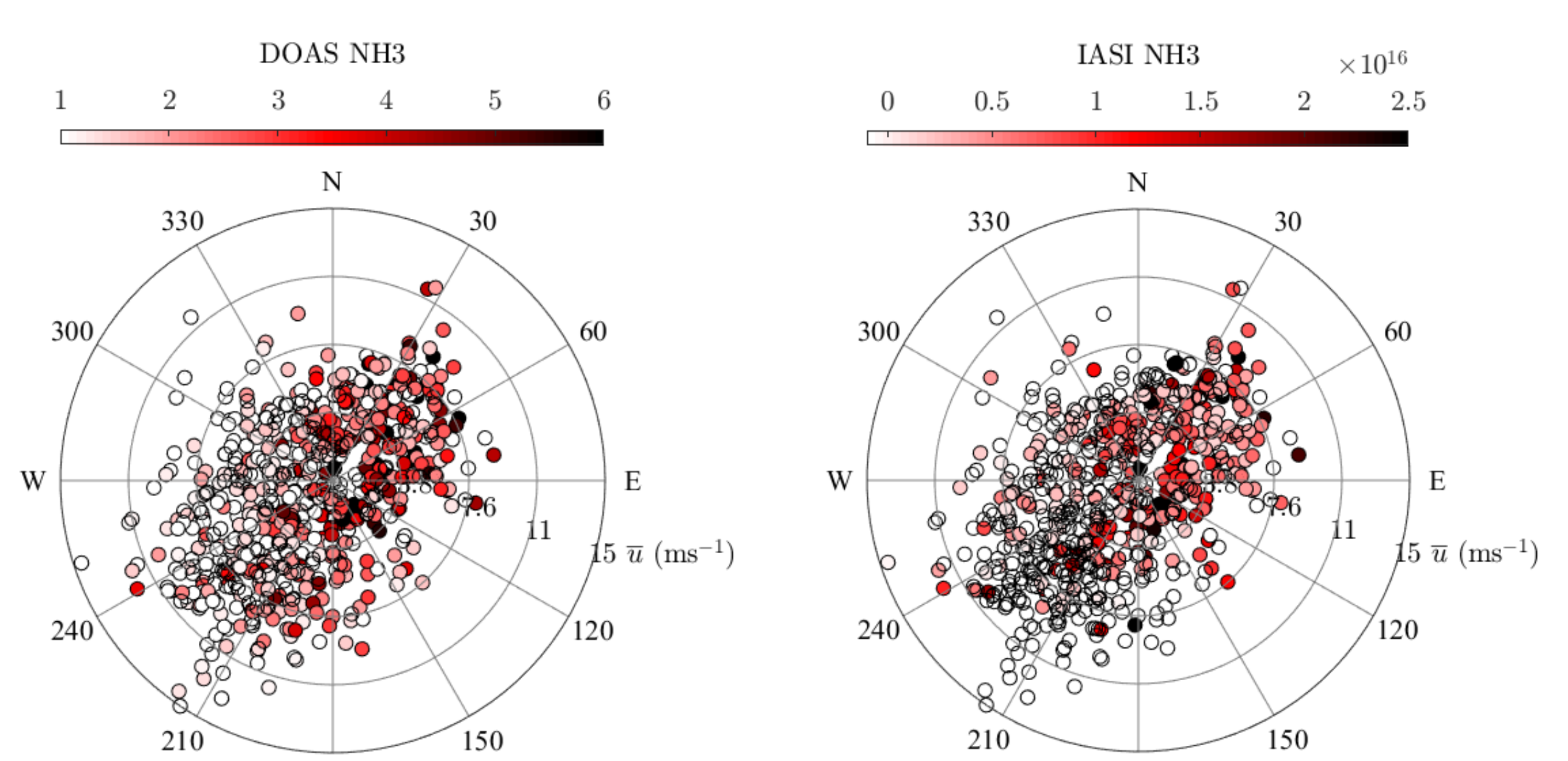


Figure 6 : Pollution roses of NH_3 in Paris derived from the mini-DOAS (left) and IASI (right) instruments

Conclusions

- Using 2 years of continuous NH_3 measurements derived from the mini-DOAS in Paris, seasonal variability of NH_3 concentrations is assessed. Higher concentrations are found during springtime due to spreading practices in the surrounding regions.
- NH_3 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_3 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_3 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/atm11101092>.
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>.