

Sorbonne Université/China Scholarship Council program 2021

Thesis proposal

Title of the research project: Towards a combined NDACC/TCCON site at Paris for integrated climate and air quality studies above a European megacity

Keywords: atmosphere, remote sensing, urban atmospheric pollution, NDACC and TCCON networks

Joint supervision: no

Joint PhD (cotutelle): no

Thesis supervisor: Yao TÉ & Christof JANSSEN

Email address of the thesis supervisor: yao-veng.te@sorbonne-universite.fr

& Christof.janssen@sorbonne-universite.fr

Institution: Sorbonne Université

Doctoral school (N°+name): ED564 Physique en Ile de France

Research laboratory: Laboratoire d'Études du rayonnement et de la Matière en

Astrophysique et Atmosphères (LERMA)

Address of the laboratory: Case 76 – Tour 33-32 - 2ème étage – 4, Place Jussieu, 75005 Paris

Name of the laboratory director: Benoit SEMELIN

Email address of the laboratory director: benoit.semelin@obspm.fr

Subject description (2 pages max):

1) Study context

The increase of greenhouse gases and chemically active species in the atmosphere and their impact on climate change and air quality are among the most important environmental problems for sanitary authorities and environmental scientists. The monitoring of these atmospheric pollutants is required for understanding the climatic and atmospheric composition changes. A recent strategy aims to develop measurement techniques for the monitoring and quantification of atmospheric pollutants close to their sources of emission. It is essential to quantify these emissions and their variability on the regional scale. As the third largest European megacity, the Paris urban area covers about 2% of the French territory and produces about 15% of the CO₂ emissions in France. Long-term and regular observations are crucial to characterize the variability and long-term trends of the atmospheric trace gases. The international Network for the Detection of Atmospheric Composition Change - Infrared Working Group (NDACC-IRWG) brings together more than twenty ground-based Fourier Transform spectrometers (FTS) that perform ground based direct solar absorption measurements in the mid-infrared to allow for global and long-term observation of a large variety of atmospheric components, from reactive species (H₂CO, C₂H₆), through atmospheric pollution precursors (CO, O₃) to greenhouse gases (CH₄, N₂O, CO₂).

2) Details of the proposal

The Laboratoire d'Études du Rayonnement et de la Matière en Astrophysique et Atmosphères (LERMA) operates a high-resolution FTS located at the Campus of Pierre et Marie Curie (Jussieu), in the center of Paris downtown. The FTS-Paris instrument^{2,3} provides integrated measurements of greenhouse gases and atmospheric pollutants important for air quality and climate in the Ile de France region. This instrument has joined the Total Carbon Column Observing Network (TCCON⁴) in 2014, becoming the first TCCON station in a European megacity. TCCON stations are dedicated to monitor carbon cycle related species, like CO₂ and CH₄ through absorption measurements in the near infrared, but observations and measurements can also be performed in the mid-infrared using the same type of spectrometer. Consequently, the FTS-Paris spectrometer has also performed measurements in the spectral ranges used by the NDACC network for monitoring chemically active atmospheric pollutants causing urban pollution and impacting air quality. The LERMA group has built strong international collaborations with French local labs/institutes (CNES, LATMOS, LMD, LSCE, ...), but also with both TCCON and NDACC-IRWG networks partners: KIT-IMK (Germany), BIRA-IASB (Belgium); Caltech (USA),

...

The principal aim of this PhD project is to set up a new NDACC site at the Jussieu campus, such as to establishing measurements of chemically active species in parallel to the TCCON measurements already going on. The candidate will be in charge of the analysis of all NDACC measurements recorded until now. He or she will gain experience in using radiative transfer algorithms and understand ground-based FTIR remote sensing. He or she will learn how to operate the FTS-Paris spectrometer to continue providing regular and long-term measurements in accord to international standards. The LERMA group actually uses the radiative transfer codes PROFFIT⁵ and GFIT⁶ for retrieving column abundances of atmospheric species. In order to join the NDACC network, the candidate will implement the SFIT4⁷ code, which is recommended by NDACC. He or she will improve the retrieval of all atmospheric species observed by the FTS-Paris instrument taking into account elevated background levels for certain pollutants which are characteristic of the megacity environment. Analyses in Paris are particularly challenging due to the presence of nearby sources of pollutants and consequently increased concentrations in the lower layers of the atmosphere. The candidate will be in charge of fulfilling the requirements to formally join the NDACC network. Scientifically, the candidate will investigate not only the characterization of the instrumental performances, but also the impact of different parameters on the uncertainties of the retrieval (due to spectroscopic parameters, instrumental bias, spectral resolution...). With the long-term data being available, the candidate will study and characterize the

variabilities and the long-term trends of the atmospheric trace gases observed by FTS-Paris. He or she will be led to seek and characterize the origin of sources (local emissions, long-distance transport, ...).

3) References

¹ <https://www2.acom.ucar.edu/irwg>

² Té et al., The Fourier transform spectrometer of the UPMC University QualAir platform, Rev. Sci. Instrum, 2010

³ Té et al., Seasonal variability of surface and column carbon monoxide over megacity Paris, high altitude Jungfrauoch and Southern Hemispheric Wollongong stations, ACP, 2016

⁴ Wunch et al., The Total Carbon Column Observing Network, Phil. Trans. R. Soc. A, 369, 2087-2112, (2011). DOI: 10.1098/rsta.2010.0240.

⁵ PROFFIT (PROFile FIT) is developed by F. Hase of the Karlsruhe Institute Technologies (KIT)

⁶ GFIT is the official code used by each TCCON station

⁷ <https://wiki.ucar.edu/pages/viewpage.action?pageId=402424651>

4°) Profile of the Applicant (skills/diploma...)

Master 2 in Physics or equivalent, basics of atmospheric sciences and some knowledge in optics, programming experience, team working capability.

Contacts:

Thesis supervisor

Dr. Yao TÉ & Dr. Christof JANSSEN

Email address of the thesis supervisor: yao-veng.te@sorbonne-universite.fr & Christof.janssen@sorbonne-universite.fr