SORBONNE UNIVERSITÉS

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Thesis proposal

Title: **First ground based FTIR-TCCON measurements of CO_2 in a European megacity: comparison with a rural site and validation of satellite measurements**

Scientific domain: Physics and infrared molecular spectroscopy

Key words: Ground-based passive remote sensing (FTIR), molecular spectroscopy, infrared, Fourier transform spectrometry, Radiative transfer, carbon dioxide, greenhouse gases monitoring, satellite measurements, validation, TCCON

Joint supervision: Yes ☐ No ☒

Joint PhD (cotutelle): Yes ☐ No ☒

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Subject description (2 pages max.): Cliquez ici pour entrer du texte.

Due to their large societal impacts, atmospheric pollution and air quality as well as greenhouse gas emissions are major challenges for sanitary authorities and environmental scientists. More than 70% of CO_2 emissions originate from urbanized areas, in particular from megacities. A very recent strategy aims to develop measurement techniques for the monitoring and quantification of atmospheric pollutants close to their sources of emissions.

As the second largest European megacity, the Paris urban area produces about 13% of the French CO_2 emissions, providing a privileged place for the study of urban CO_2 emissions from the space (satellite missions led by international agencies as NASA, ESA, JAXA …). At the same time, the international network TCCON (Total Carbon Column Observing Network), which is dedicated to the validation of satellite measurements, unites high-resolution FTIR instruments (Fourier Transform InfraRed Spectrometer), which operate in solar absorption from the ground. The transmitted solar radiation contains absorption bands of many atmospheric trace gases, which provide fundamental information for determining their atmospheric abundances. Quantitative FTIR spectroscopy can reach a

very high precision of better than 0.5 ppmv (0.1%) in CO_2 measurements. This high level of precision requires an excellent knowledge of the different sources of uncertainty, however. In 2015, LERMA will install the first TCCON instrument in a European megacity, located in the center of Paris at the campus of UPMC/Sorbonne Universités. The TCCON-Paris site will provide an essential contribution for the validation of satellite XCO_2 measurements over urban regions (XCO_2 stands for the mixing ratio of CO_2 measured by TANSO-FTS onboard GOSAT satellite, or by OCO-2, …). Since 2012, LERMA maintains a scientific collaboration with the Institute of Environmental Physics (IUP) of the University of Bremen in Germany, who operates the TCCON site located in the Orléans forest about 100 km away from Paris. The close neighborhood of the two TCCON sites (one urban, the other more rural) provides a unique opportunity for the validation of satellite instruments, especially for the new and upcoming space missions (OCO-3, CarbonSat and MicroCarb), which benefit from an improved spatial resolution in order to detect the CO_2 gradients associated to local sources (hot spots).

The main aim this PhD thesis is to develop a methodology for better exploiting global XCO_2 measurements from space by combining them to ground-based observations in a European megacity. The candidate will participate in measurement campaigns and/or in comparisons between the two TCCON sites at Paris and at Orléans (France), using an independent and mobile low-resolution (0.5 cm^{-1}) instrument (either a lab made mobile FTIR, a VERTEX from IUP of Bremen or a EM27sun instrument from KIT-IMK (Karlsruhe), depending on their availability). This site inter-validation will allow to: 1/ optimize the instrumental performances and better characterize the uncertainties (due to spectroscopic parameters, instrumental bias, spectral resolution…) in order to study the differences between both sites; 2/ validate the Paris instrument as compared to TCCON-Orléans; 3/ characterize the specificity of each site; 4/ quantify the possible biases or gradients; and 5/ study the impact of the Parisian megacity on the atmospheric CO_2 concentration as compared to the background level in the Orléans forest. A stay of two to four months at the IUP of Bremen (Germany) is planned for familiarization in the use and validation of satellite data. The candidate will demonstrate the capability of the XCO_2 measurements to observe the Parisian CO_2 plumes using satellites and TCCON ground-based observations. The student will also study the spatio-temporal representativeness of the XCO_2 observations. The expected results will be used for establishing an observation strategy and an analysis protocol for satellite and ground-based measurements in order to precisely quantify megacity-CO_2 from the space. This PhD is part of a larger international collaboration with the IUP of Bremen and other collaborators (LSCE (France), KIT-IMK (Germany), Caltech (USA)).

Two major publications in the domain of the thesis proposal: Cliquez ici pour entrer du texte.

1/ Y. Té, E. Dieudonné, P. Jeseck, F. Hase, J. Hadji-Lazaro, C. Clerbaux, F. Ravetta, S. Payan, I. Pépin, D. Hurtmans, J. Pelon and C. Camy-Peyret, Carbon monoxide urban emission monitoring: a ground-based FTIR case study, J. Atmos. Oceanic Technol., 29, 911-921, (2012). DOI: 10.1175/JTECH-D-11-00040.

2/ Lopez, M., Schmidt, M., Delmotte, M., Colomb, A., Gros, V., Janssen, C., Lehman, S.J., Mondelain, D., Perrussel, O., Ramonet, M., Xueref-Rémy, I., Bousquet, P., CO, NOx and 13CO2 as tracers for fossil fuel CO2: results from a pilot study in Paris during winter 2010 Atmos. Chem. Phys. 13 7343–7358. (2013). DOI:10.5194/acp-13-7343-2013