Session IIIa: Megacities and Metrology Needs for Supporting Greenhouse Gas Mitigation-Urban Greenhouse Domes

Pre-submitted Abstracts for Discussion Sessions:

1. Requirements for the high resolution satellite imagery of atmospheric GHG in view to monitor the emissions from large cities
Gregoire Broquet (LSCE)

2. Assessing the role of megacities on atmospheric CO_2: results for Paris from the CO_2-MegaParis project, France
Irène Xueref-Remy (LSCE)

Title: Requirements for the high resolution satellite imagery of atmospheric GHG in view to monitor the emissions from large cities

Speaker: Gregoire Broquet
Institute: LSCE

Abstract:

The space borne and high resolution (at 2 to 10 km resolution) imagery of CO_2 and CH_4 concentrations could be used to quantify the GHG emissions from the cities based on the atmospheric inversion approach. The CarbonSat mission, which is a candidate to the Earth Explorer 8 opportunity, and the proposition for measuring CO_2 with the Sentinel-5 mission are examples of plans that have been proposed for such an imagery. This study assesses the potential, depending on its space resolution, accuracy and precision, of such an imagery for monitoring the spatially integrated emissions from the Paris area. It is based on Observing System Simulation Experiments (OSSE) with a city scale atmospheric inversion framework. The system solves for hourly city emissions and natural fluxes 6 hours before a given satellite overpass. These 6 hours correspond to the period during which emissions produce CO_2 and CH_4 plumes that are directly seen by the satellite overpass. In the statistical framework of the inversion, we account for the existence of a prior knowledge on the hourly emissions (from an inventory) with 50% uncertainty in each hourly estimate. The link between the hourly emissions and the vertically integrated column of CO_2 and CH_4 are simulated using the spatial distribution of the Paris city emissions from the Airparif inventory, and an atmospheric transport model at 2-km horizontal resolution. Results based on an optimistic configuration of the experiments where most of the sources of errors are statistically well accounted for by the inversion system indicate the need for having a CO_2 imagery at a resolution higher than 5 km and a precision higher than 2ppm if willing to decrease the prior uncertainties in the 6-hour mean emissions by more than 50%. More complex experiments include more realistic estimates of errors that state-of-the-art inversion methods cannot properly account for (e.g. systematic measurement errors with spatially correlated patterns). These experiments indicate the critical need for controlling the systematic errors if willing to improve the current knowledge on the CO_2 emissions from cities such as Paris using CO_2 imagery. The monitoring of CH4 emissions from Paris seems more challenging since the typical amplitude of these emissions results in a signal that is too low compared to the precision of the CH_4 imagery from a mission such as CarbonSat. Other targets (e.g. areas with coal and gas extraction) would be more relevant for the CH_4 space imagery in the near term.

Title: Assessing the role of megacities on atmospheric CO2: results for Paris from the CO2-MegaParis project, France
Speaker: Irène Xueref-Remy
Institute: LSCE

Abstract:

On average, atmospheric CO_2 increases in the atmosphere at a rate of about 2 parts per million (ppm) per year, due to the accumulation of about half of the anthropogenic CO_2 emissions in the atmosphere (mostly from the combustion of fossil fuels), while the other half is being re-absorbed by the ocean and the continental biosphere. Today, more than 70% of global fossil-fuel CO_2 emissions come from punctual sources such as megacities. Paris is the third megacity in Europe and it emits about 15% of the total French emissions, while it covers only less than 2% of the national territory. Currently, most of the estimates of urban CO_2 emissions are given by bottom-up CO_2 emissions inventories, which rely on activity proxies and benchmarked emission factors. The associated uncertainties can be as high as several tenths of a percent, especially when it comes to discriminate the CO_2 urban emissions by emission sectors. Therefore, there is an urgent need for developing new methods to better Monitoring, Reporting and Verifying (MRV) CO_2 emissions from megacities, dedicated to provide robust results to policy makers for taking efficient decisions and actions in matter of controlling CO_2 anthropogenic emissions and mitigating climate change. Since 2009, the CO_2-Megaparis project aims to quantify CO_2 emissions from Paris using top-down approaches based on a synergy between atmospheric observations and modelling. For the first time, a mini-network of 3 greenhouse gases (GHG) monitoring stations was developed by LSCE in Paris agglomeration within the infrastructure of the regional air quality monitoring agency, AIRPARIF, completing 2 other GHG stations from the ICOS European greenhouse monitoring network. One of our urban station was located on top of the Eiffel tower above Paris megacity. The analysis of one year of data showed that Paris CO_2 emissions lead to a mean increase of the atmospheric CO_2 concentration in the mid-afternoon of 2 to 3 ppm, and is strongly season, windspeed and wind direction dependent: the CO_2 urban plume is characterized by a very large spatio-temporal variability and can reach about 60 ppm at low windspeeds on top of the Eiffel tower. In addition, analysis of correlations between CO_2, CO and $^{14}CO_2$ were carried out from field measurements and allowed an independent assessment of the inventories emission sectors. Furthermore, direct modelling of CO_2 at a very fine resolution (2x2 km2, 1h) was performed and matched well with the observations. Last but not least, inverse modelling efforts at the same resolution allowed a significant improvement of the regional inventory from Airparif. Finally, a campaign conducted during springtime and based on lidar facilities revealed that due to the effect of the urban heat island, the boundary layer height (that can be seen on the first degree as the man dilution factor of CO_2 emissions in the atmosphere), is 10 to 40% time higher in Paris than in surrounding rural areas: this is an important result that supports the implementation of urban canopy models in future fine scale urban CO_2 modelling framework. A synthesis of the different results will be presented, as well as an attempt of defining the strengths and weaknesses of the atmospheric approach to quantify urban CO_2 emissions. Contributions from sister studies (MultiCO2 - IPSL, Le CO_2 parisien - Ville de Paris 2030, CarboCount-City - KIC Climat...) will also be mentioned.