Geophysical Research Abstracts
Vol. 20, EGU2018-9452, 2018
EGU General Assembly 2018

Carbosense : A Low-cost CO_2 Sensor Network at Regional and Urban Scale

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The use of low-cost atmospheric sensors is gaining wide interest because of rapid innovations in sensing, data transmission, and data analysis. Dense measurement data, combined with extensive data analysis and modelling, bears great potential to gain insight into sources, transport and impact of air pollutants and greenhouse gases. Within this context, the Swiss project Carbosense proposes a unique, dense CO_2 low power sensor network. Carbosense strives at improving the quantification of anthropogenic CO_2 emissions and CO_2 fluxes of the biosphere, two source categories that are highly variable in space and time. This is important in the context of CO_2 budgets, and enhances our ability to assess CO_2 reduction measures at the regional and urban scale.

The Carbosense network is designed around (i) 300 nodes of battery-powered CO_2 low-cost diffusive NDIR sensors (SenseAir LP8), (ii) 20 temperature stabilized, mains powered NDIR low-cost instruments (SenseAir HPP) with active sampling and reference gas connection, and (iii) four high-precision laser spectrometers (Picarro G1301/G2302/G2401, CRDS) as reference instruments. Network deployment started in July 2017 and covers all of Switzerland. The sensors are mounted at Swisscom radio transmitter locations, at MeteoSwiss meteorological stations, and at lamp or electricity poles within urban areas and transmit their data over Swisscom's new Low Power Network (LPN). One special focus is the city of Zürich, where more than 40 low-cost sensors have been deployed.

All 300 LP8 CO_2 sensors have been integrated by Decentlab with a relative humidity and temperature sensor and with LoRaWAN communication. The sensors were characterized in climate and pressure chambers with respect to CO_2 (350 to 1000 ppm), temperature (-5 to 50 ˚C) and pressure (770 to 1010 hPa), and were placed outdoors next to a Picarro reference instrument for several weeks to several months. For calibration, a sensor model was developed based on Beer-Lambert law, relating the raw signal of the IR detector to the true CO_2 mixing ratio, determined by CRDS, and referenced to the WMO scale.

This presentation will focus on the data collected in the city of Zurich since August 2017. Extensive characterization of sensor behavior in the field was performed using statistical methods and machine learning by combining three sources of information: (i) the initial chamber calibrations, (ii) the parallel operation with a Picarro before deployment, (iii) using periods with strong winds and correspondingly small spatial gradients to align the signal offsets of all sensors.

The wealth of available data is being exploited by several approaches. These include the comparison of multiple sensors at the same site, clustering with respect to meteorology, and spatial mapping of CO_2 using geostatistical methods. Furthermore, a mesoscale atmospheric transport model at 250 m spatial resolution is currently developed for the Zürich region to link the urban measurements to emission and transport based model output.