Quality control process of in-situ INFLUX tower-based observation data

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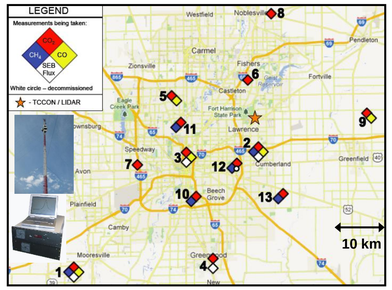
Introduction and background

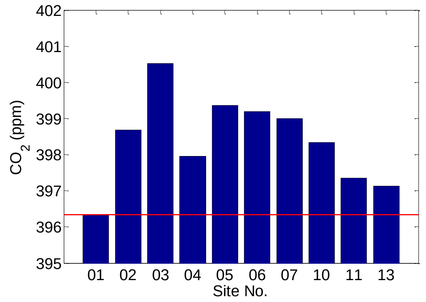
The Indianapolis Flux Experiment (INFLUX) was designed to develop top-down methods for measurement and modeling of urban fluxes of greenhouse gases (GHG) such as CO_2 and CH_4 to the atmosphere with 10% uncertainty at spatial resolution of 1km and time resolution of one hour. Accurate in-situ greenhouse gas data are the basis of the top-down, inverse modeling system for estimating urban fluxes. There are twelve observation towers located in and around Indianapolis, where the measurements of CO_2, CH_4 and CO are being taken.

Since city-wide anthropogenic sources result in a low enhancement (less than 5%) to atmospheric concentrations relative to the background concentration, a small bias in the observation data can result in a large bias in the computed fluxes.

The accuracy of GHG observation data can be influenced by the quality control (QC) process used for error detection, instrument calibration and error correction. At present, different QC processes are used by different organizations, which may result in non-ignorable difference. In an effort to standardize the QC process for greenhouse gas measurement data, a comprehensive QC process was developed with a four-step procedure, and some of important parameters of the process were discussed.



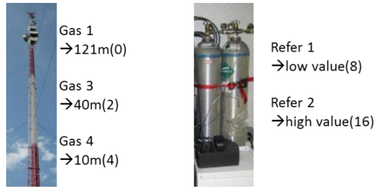
Distribution of INFLUX towers



Observed averaged CO_2 concentration in Indianapolis (Sep. – Oct. 2013). Red line is concentration of site01 which can be regarded as baseline

Major challenges

- Large amount of real-time data, heterogeneous data stream
- High requirement of data accuracy, stability and consistency
- Data screening facing various errors (Mechanical, electrical, software problems, etc.)
- Careful data rejection due to switch of gas sources.

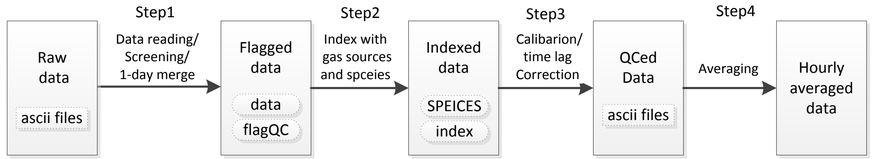


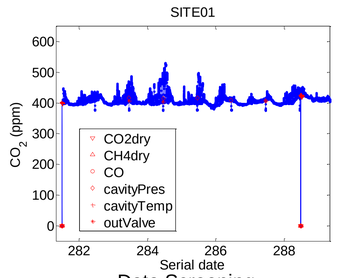
Gas sources for site01 (3 sampling gases and 2 reference gases)

Flow diagram of QC process

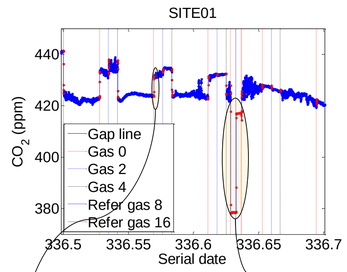
The purpose of the QC process includes:

- Identifying suspicious values , instrument errors etc.
- Plausible correction (calibration, time lag, etc.)
- Averaging of data at different frequencies

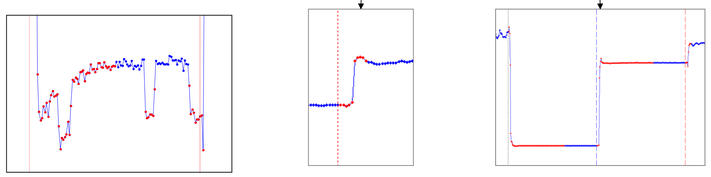




Data Screening



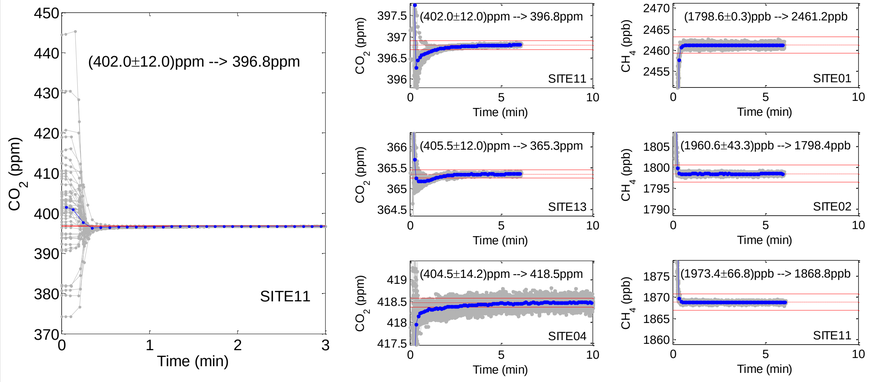
Data separation



Data rejection of gas sample and reference gas

Data rejection criteria

- It takes several minutes for the reference gas/air sample to reach the instrument cavity and the measurements to be stable.
- Transition time: 3 / 5 min (CO_2), 0.5 min (CH_4)

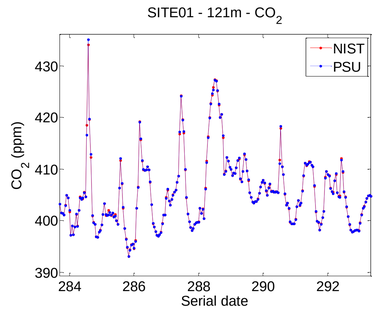


Instrument response of transition from air sample to reference gas

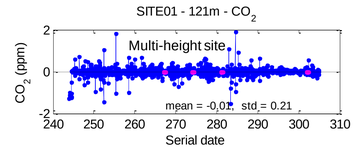
Comparison with PSU

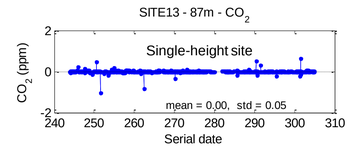
QC'ed hourly data processed by NIST were compared with that from PSU for a period of two months

- Most of points show very good consistency.
- Differences are random with mean value less than 0.05 ppm. standard deviation are less than 0.3 ppm for single-height sites and less than 1.5 ppm for multi-height sites.
- Differences are mainly due to different strategy of data screening and rejection. Multi-height sites need more data rejection when being separated.



Comparison of the QC'ed hourly data





Differences ($\Delta C_{1h} = C_N - C_P$)

Conclusions

1. A comprehensive QC process was developed with a four-step procedure including effective data screening, reliable separation of different sources of gas, calibration correction and time lag correction.
2. Two-month data comparison showed very good consistency, indicating that both QC procedures are efficacious and robust.
3. Standardized QC process should be implemented, with step by step documented procedures, to keep the data accuracy and comparability at the highest standards.

References

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2. N L Miles, S Richardson, T Lauvaux, et al. Tower-based CRDS greenhouse gas measurements in an urban environment, Calibration, field tests, and results from the INFLUX project. 16th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases, and Related Measurement Techniques, 2013
3. A E Andrews, J D Kofler, M E Trudeau, et al. CO2, CO, and CH4 measurements from tall towers in the NOAA Earth System Research Laboratory's Global Greenhouse Gas Reference Network. Atmos. Meas. Tech., 2014, 7: 647-687.