Design of an ozone and nitrogen dioxide sensor unit and its long-term operation within a sensor network in the city of Zurich – supplementary materials

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1 Network of sensor units

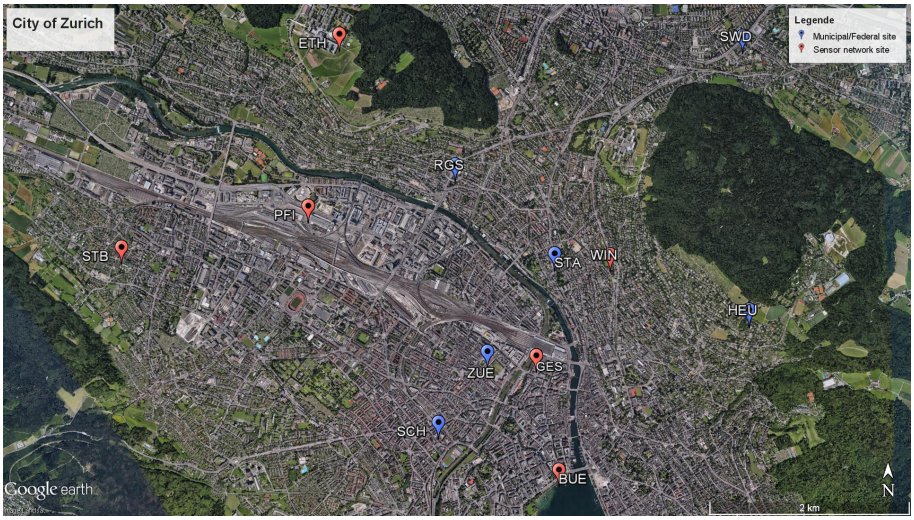

Figure 1. Map depicting the locations of the sensor units within the sensor network (red symbols) as well as of the municipal and federal air quality monitoring stations (blue symbols). The map was created with Google Earth.

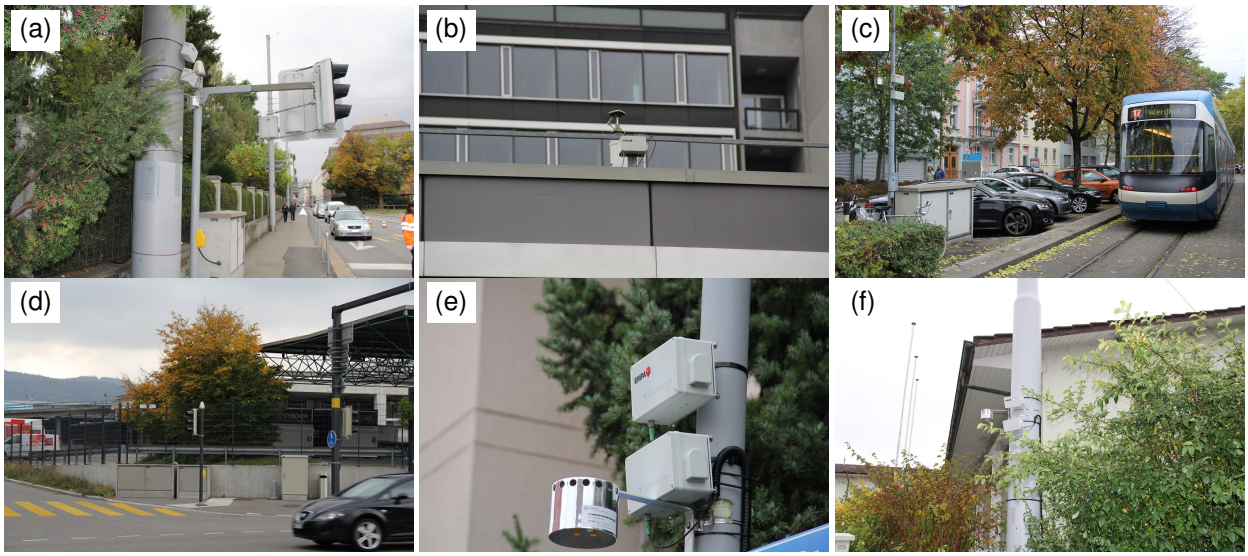

Figure 2. Pictures of the six locations where sensor units were operated: (a) BUE, (b) ETH, (c) GES, (d) PFI, (e) STB, (f) WIN. The pictures show the sensor units as well as the mounting of the NO_2 passive samplers.

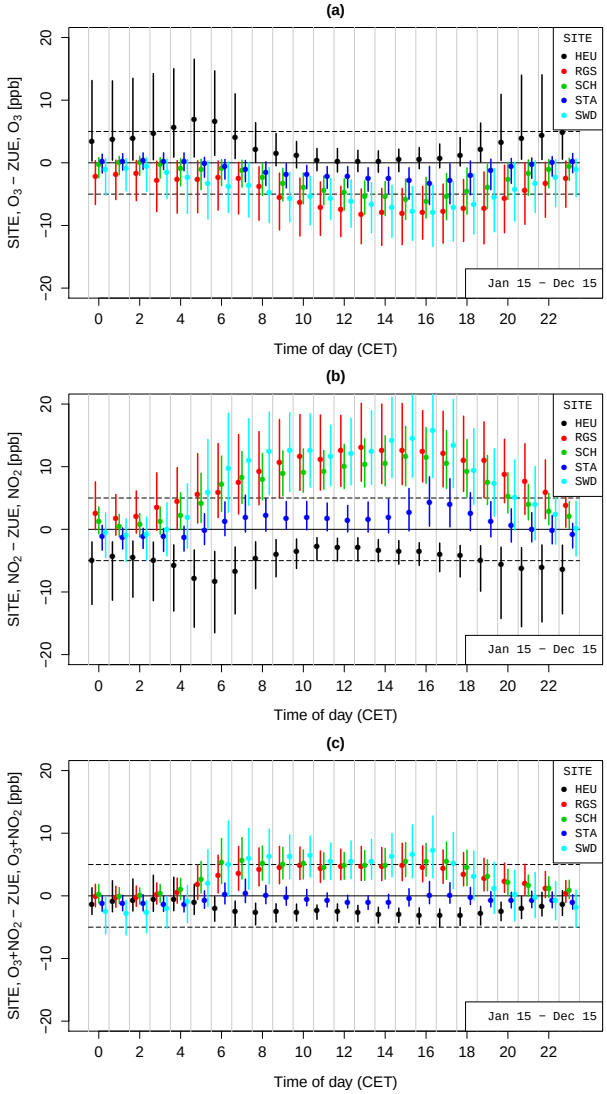

Figure 3. Differences in 30 minutes values of O_3 (a), NO_2 (b) and the sum of NO_2 and O_3 (c) concentration between sites HEU, RGS, SCH, STA and SWD and site ZUE, respectively, in 2015. The points depict the respective median difference and the lines depict the range between the 25% and the 75% quantiles of the differences.

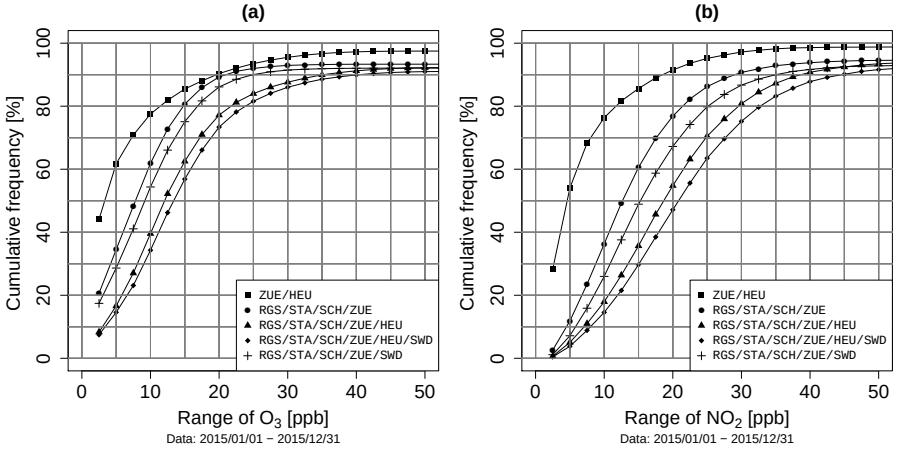

Figure 4. Cumulative distribution of O_3 (a) and NO_2 (b) concentration ranges. Range of NO_2 and O_3 denote the difference between the maximum and the minimum average 30 minutes NO_2 and O_3 concentrations, respectively, measured at AQM sites being part of five defined site groups. The sites being part of each group are listed in the legend. 100% refers to the maximum possible number of 30 minutes values in the year 2015. Cumulative distributions remain below 100% due to calibration and maintenance periods and instrument failures.

3 Sensor calibration

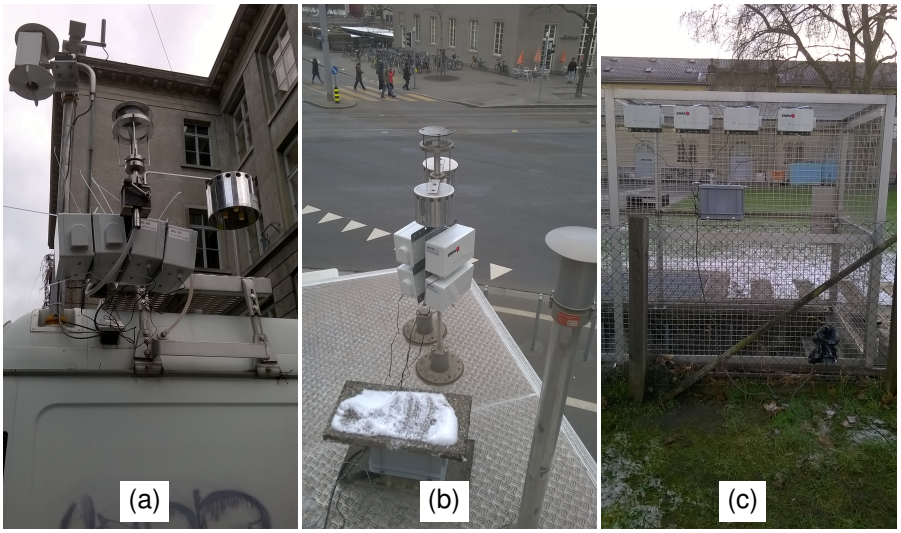

Figure 5. Pictures of the sensor units running in parallel with instruments of the air quality monitoring stations RGS (a), SCH (b) and ZUE (c) during sensor calibration.

4 Processing of the data from the sensor units

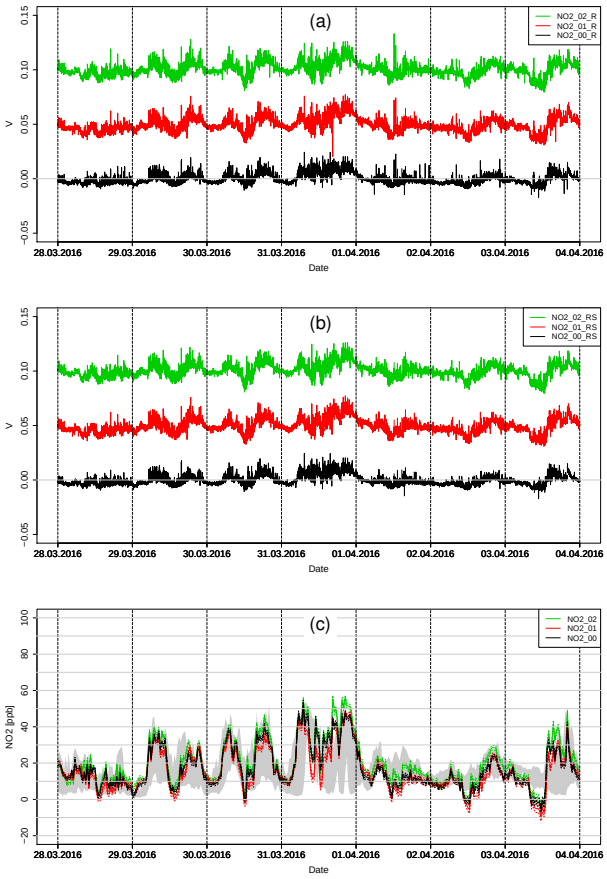

Figure 6. Illustrative example of the data processing of NO_2 sensors from the sensor units. (a) Raw sensor data of the three NO_2 sensors integrated in the sensor units back-transformed to the Volt scale (1 minute values). Time-series are shifted by 50 mV, respectively, in order to improve the clarity. (b) Pre-processed sensor output (1 minute values). (c) Final NO_2 time-series of 30 minutes mean values. The band depicted in grey indicates the range of the 30 minutes mean NO_2 concentrations measured at the AQM sites HEU, RGS, SCH, STA and ZUE (see Fig. 1 for the respective site locations).

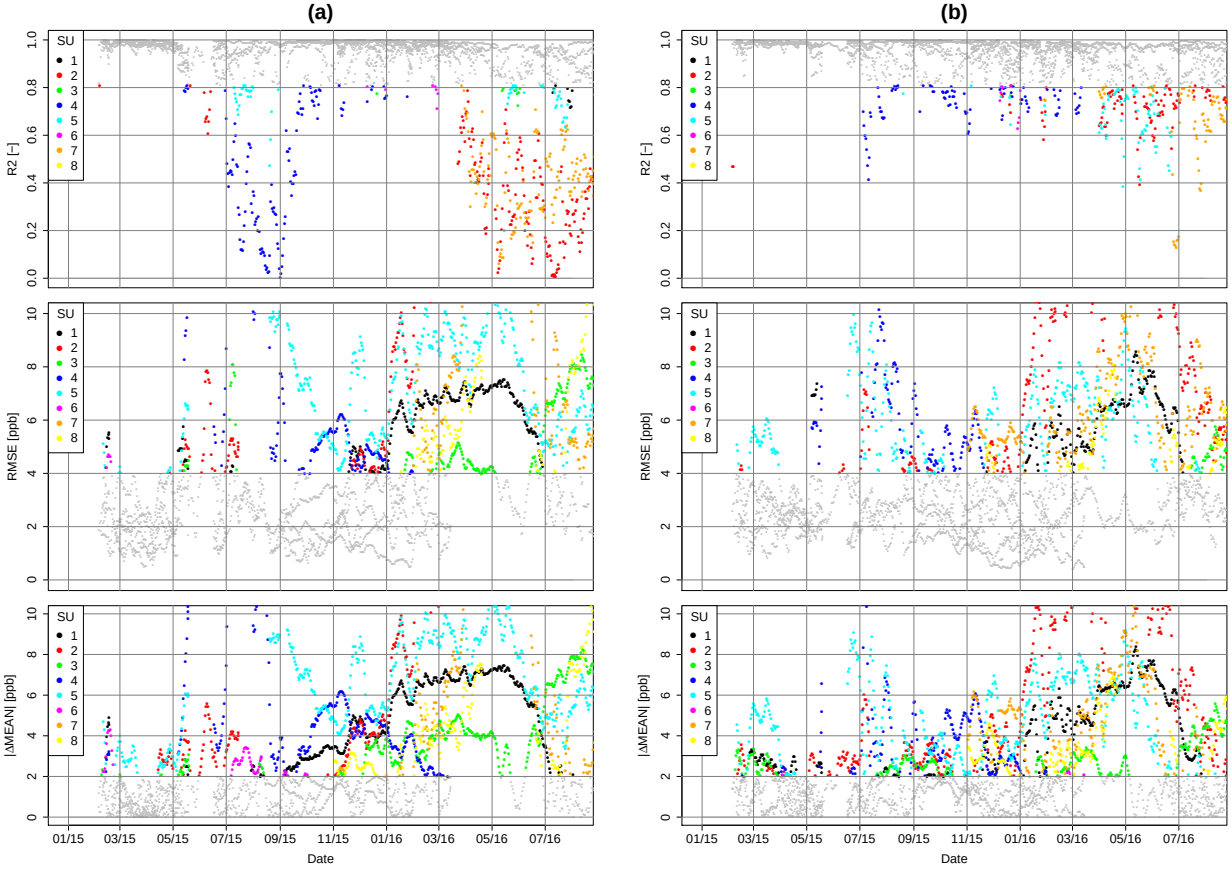

Figure 7. Comparison of measurements from the redundant O_3 sensors integrated in the SUs by means of the 7 days rolling R2, root mean square and absolute average difference based on 30 minutes NO_2 concentrations. There are $n(n-1)/2$ values for n integrated sensors per day. Only time periods are considered when the SUs were calibrated or operated in the sensor net. The values in (a) are derived from data set 1 which is based on a linear fit only. The values in (b) are derived from data set 3 (initial and remote calibration based on Eq. 6).