Trend and spatial variability of ambient particle number concentration in Switzerland

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PNC in Switzerland

Particles in ambient air are a potential risk for human health. In Switzerland, motorised traffic is the main emission source for particles by number. The comprehensive monitoring of particle properties is the basis for an assessment of the effects of particles on humans.

Particle number concentration (PNC, particle diameter from 5 nm to 3 µm) has been measured in the framework of the Swiss National Air Pollution Monitoring Network (NABEL) at 6 locations since 2005 [1]. These measurements provide a good overview of the PNC situation in Switzerland. Differences in PNC are caused to a large extend by unequal traffic impact. PNCs have slightly decreased at all sites near settlements or traffic infrastructure over the last decade (Fig. 1). Temporal variations (diurnal, seasonal) in PNC are of similar significance than spatial variations. They largely result from variations in source activity (e.g. motorised traffic) and meteorology (Fig. 1).

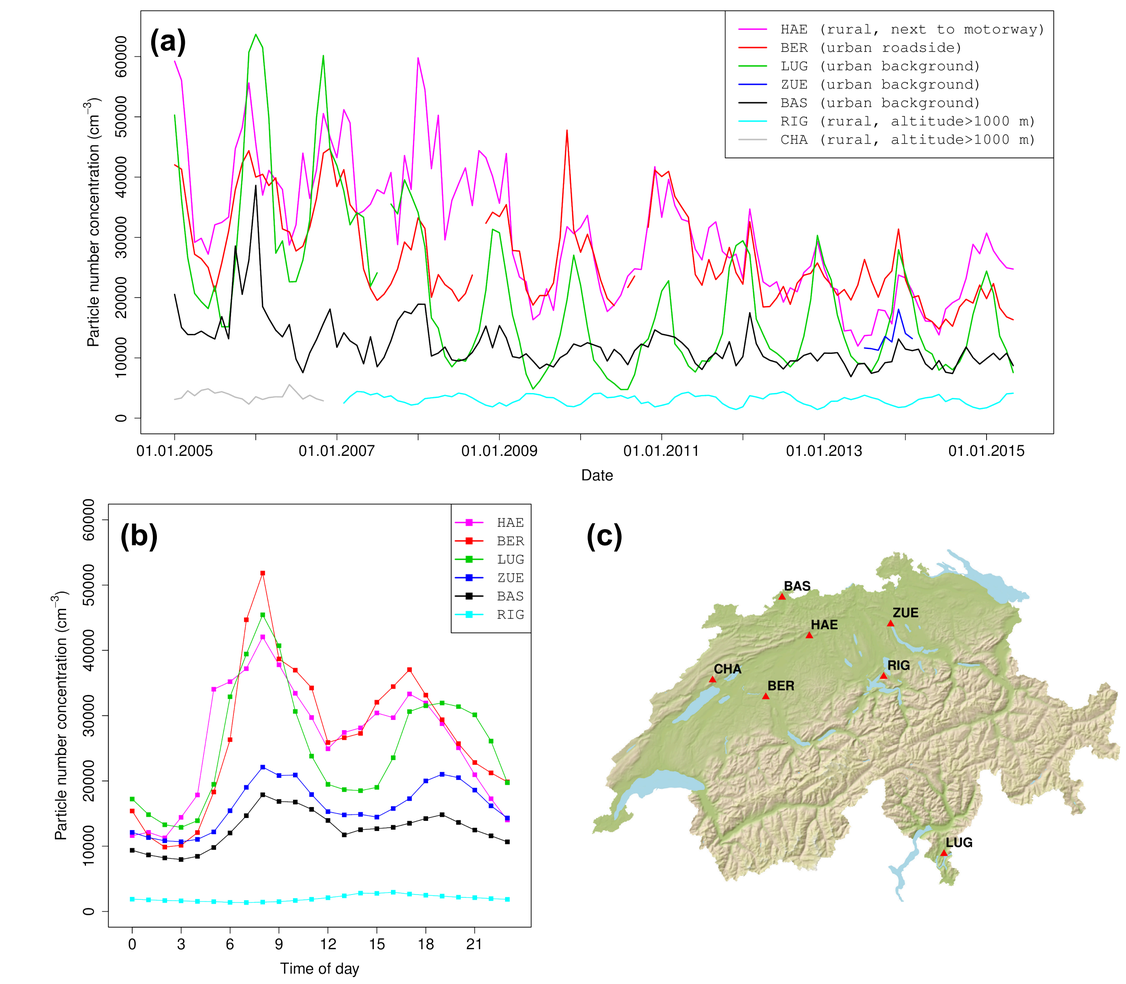

Fig. 1 (a) PNC time series of seven NABEL sites (montly mean values). **(b)** Diurnal variation of PNC (hourly mean values). Data period: Dec 2013-Feb 2014 (only working days). **(c)** Locations of NABEL sites for which PNC data is available. Data source: NABEL (FOEN/Empa) [1].

PNC in Zurich

Urban environments such as the city of Zurich are characterised by small-scale variations in emission source patterns, building density, land-use and topography. Thus, the PNC range within this confined area is similar to the range observed in Switzerland.

The analysis of data obtained at two monitoring sites (Fig. 2 (a/b); distance: ~900 m) provides interesting insights into temporal PNC variations. First, differences in PNC at a specific location from day to day can easily exceed 1-2·10^4 particles/cm^3 due to irregular source patterns and changes in meteorology (Fig. 2 (c)). Second, PNC at locations with heavy traffic on average may temporarily exhibit lower PNC levels than background sites during short time periods. Third, differences in PNC within Zurich are small in periods with low traffic and other source activities, e.g. between 0 and 4 a.m. (Fig. 2 (d)).

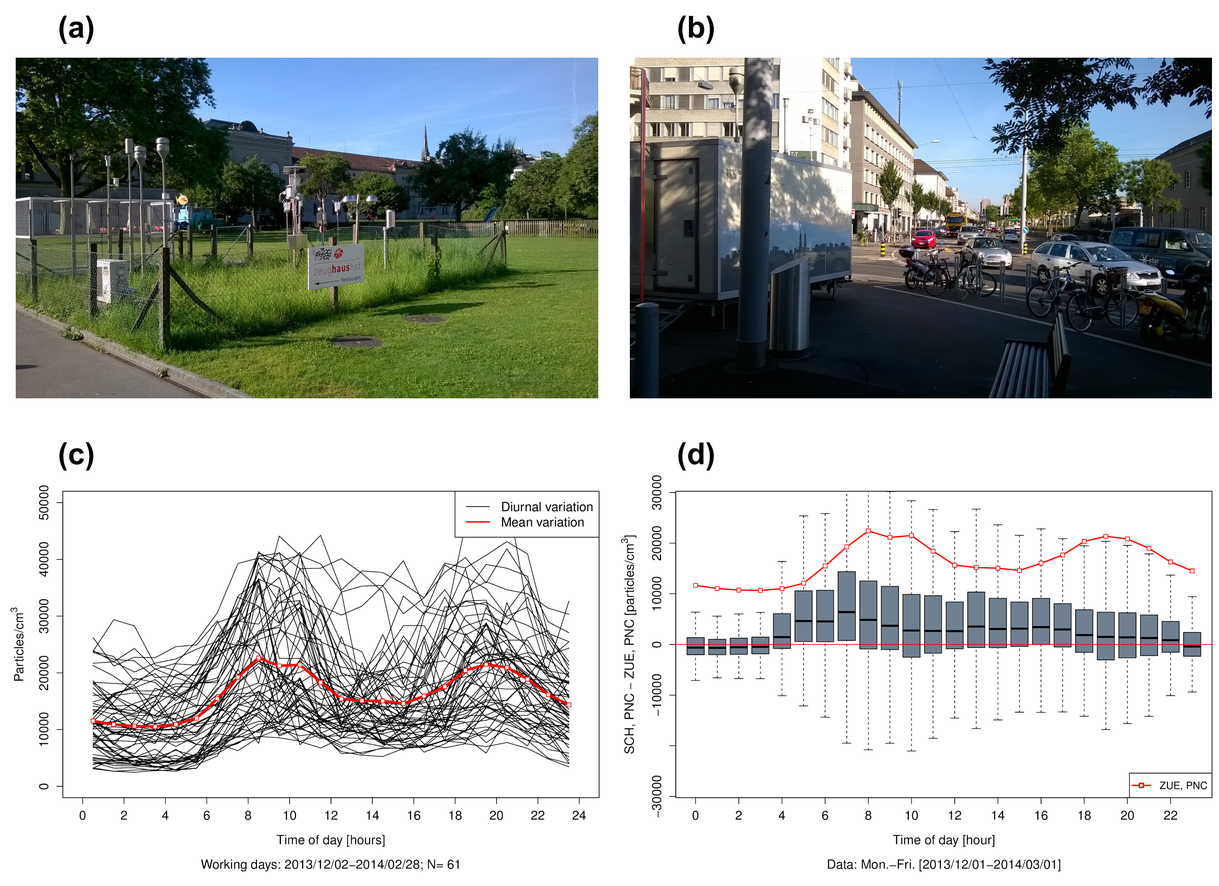

Fig. 2 (a) View of the NABEL site ZUE (Kaserne, Zurich). **(b)** View of the UGZ site SCH (Schimmelstrasse, Zurich; operated by the City of Zurich). **(c)** Diurnal variations (hourly mean values) of PNC at ZUE at working days in winter. **(d)** Differences of 1 minute PNC values simultaneously measured at sites SCH and ZUE. The average diurnal PNC variation of ZUE is depicted in red.

PNC maps for Zurich

We derived PNC maps for the city of Zurich with 10 m by 10 m spatial and 30 min temporal resolution based on statistical modelling utilising PNC measurements from the OpenSense mobile sensor network [2] (Fig. 3). The maps cover the periods July-Sept 2013 and Dec 2013-Feb 2014. They allow the analysis of small-scale differences in PNC levels between different locations in the city of Zurich in terms of diurnal, weekly and seasonal variations (Fig. 4). The results show a clear dependency of PNC on location characteristics (e.g. emission sources) and meteorology.

Therefore, the computation of meaningful quantities that are based on PNC$_{(location,\ time)}$ requires that the PNC field is accurately known with a much denser spatial resolution than measurements alone can provide. Further, the use and interpretation of quantities deduced from averaged PNC data has to be done with caution due to the large temporal variations in PNC. Similarly, this holds true for PNC data obtained during different time periods.

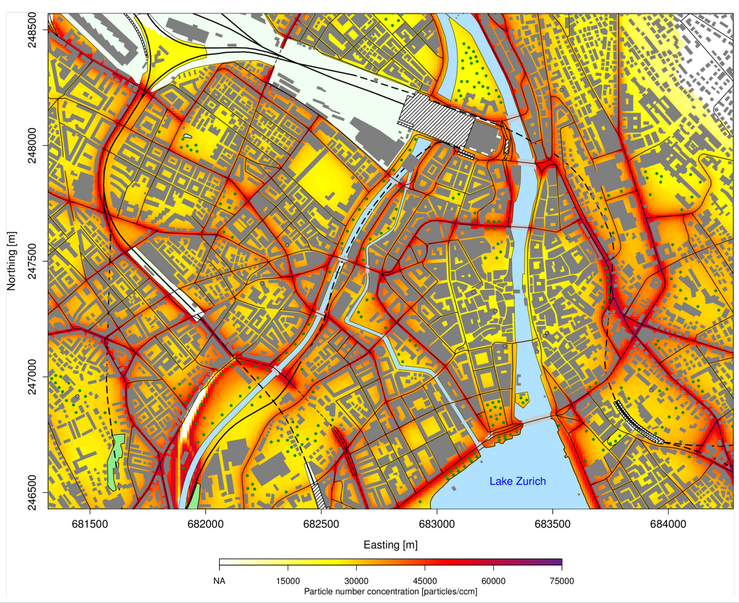

Fig. 3 PNC example map of Zurich (working day, 08:30 a.m., winter 2013/2014).

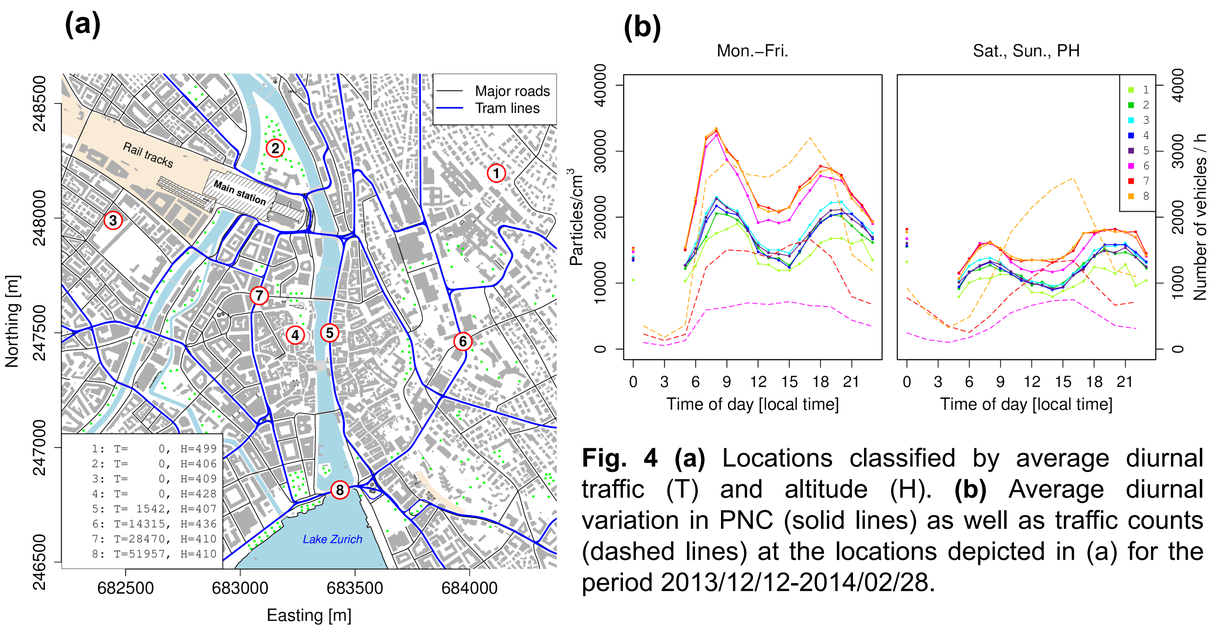

Fig. 4 (a) Locations classified by average diurnal traffic (T) and altitude (H). **(b)** Average diurnal variation in PNC (solid lines) as well as traffic counts (dashed lines) at the locations depicted in (a) for the period 2013/12/12-2014/02/28.

Summary and conclusions

- PNC levels in Switzerland are closely related to the proximity of the location to motorised traffic.
- Temporal PNC variations (diurnal, seasonal) at sites impacted by heavy traffic are large (typically larger than the range of annual mean PNC in Switzerland).
- The computation of quantities that are based on PNC$_{(time,location)}$ requires the modelling of the PNC field with adequate spatial and temporal resolution.

References:

[1] Empa, 2013. Technischer Bericht zum Nationalen Beobachtungsnetz für Luftfremdstoffe (NABEL). Swiss Federal Laboratories for Materials Science and Technology.

[2] Hasenfratz et al., 2015. Deriving high-resolution urban air pollution maps using mobile sensor nodes. *Pervasive and Mobile Computing*, 16 (2015) 268–285.

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