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Air Quality Measurements in Stuttgart Using Tethered Balloon

Introduction

The air quality measurements in Stuttgart are performed under the project "Urban Climate Under Change – [UC]²" which aims to develop, validate and apply an innovative urban climate model for entire cities

This project emphasizes to collect comprehensive observation data on weather, climate and air quality in three German cities, namely Berlin, Stuttgart and Hamburg

The balloon measurements provide the vertical profile of meteorological parameters and air pollutants

Local flow systems as well as inversion layers and its effect on pollutants are also investigated

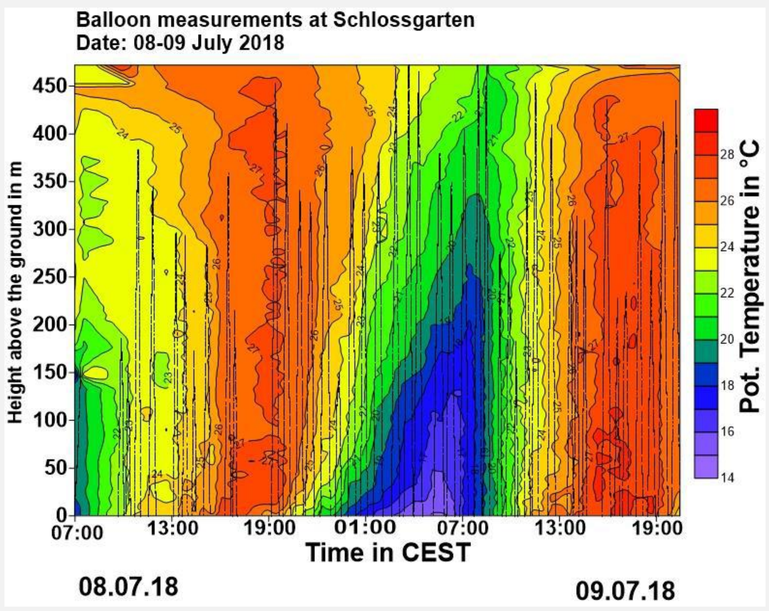
Instrumentation of the Balloon

- Meteorology: Wind speed, wind direction, temperature, relative humidity, air pressure
- Gas pollutants measured: O_3, NO, NO_2, NO_x
- Particles measured: Ultrafine particles (size range 0.01 to > 1.0 µm), fine particles (size range 0.3 to 20 µm) and Black Carbon

Results: Isopleth

Balloon measurements performed at “Stuttgarter Schlossgarten on 08.07.2018 and 09.07.2018. The isopleth provided an overview during the whole measurement campaign. The potential temperature helps to understand the stability of the atmosphere. The black lines show the actual soundings while the rest is interpolated using kriging model.

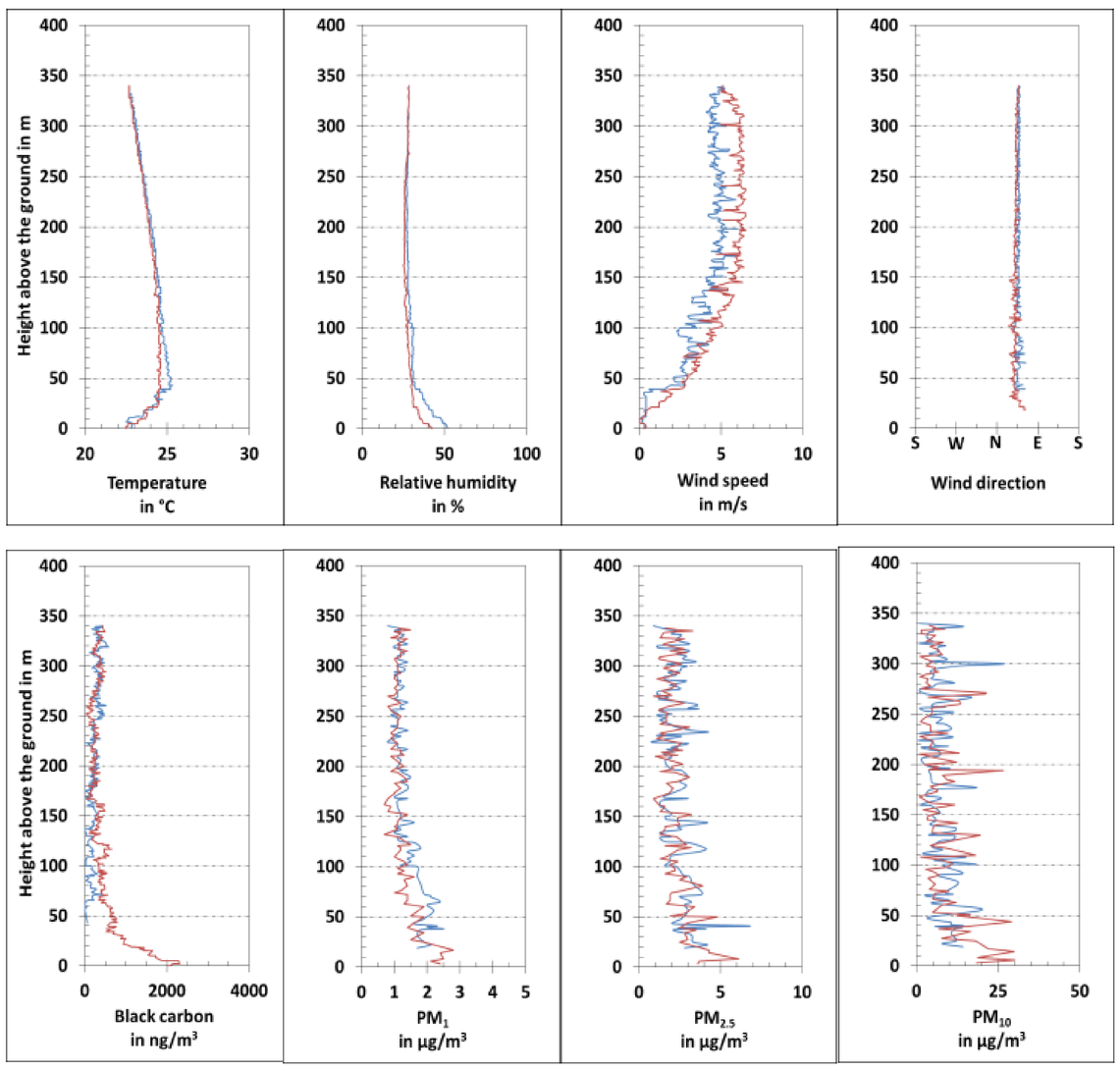
- The temperature varied from 14 °C to 30 °C with higher temperatures during the day and lower during the night
- A temperature inversion from the night of 08.07.2018 till the morning of 09.07.2018 was observed
- The height of the surface inversion increased during the night culminating in the elevated surface inversion with a maximum height of 300 m above ground at 07:00 CEST on 09.07.2018
- Stable atmosphere during the inversion period



Results: Vertical Profiles

Balloon measurements performed at “Stuttgarter Schlossgarten” on 08.07.2018. The sounding started at 20:52 CEST and ended at 21:20 CEST. The blue line shows the values during ascent and the red line during descent. The results show the following:

- Temperature inversion at around 50 meters above ground
- Lower wind speeds closer to the ground due to obstacles
- Stable wind direction during the whole sounding
- Relatively higher black carbon and particle concentration near the ground till the inversion layer as compared to the concentrations above the inversion layer
- Stable conditions above the inversion layer for the wind as well as for the pollutants



Conclusions

The measurements have shown that the method of obtaining vertical profiles with a tethered balloon provides a good overview to study the distribution of pollutants in the atmosphere from ground up to a height of 470 m above ground.

It was observed that the pollutants got trapped in the inversion layer and the pollutant concentrations measured within the inversion layer was relatively higher than without the inversion.

Another interesting relationship was observed between the variation of altitude and pollutants i.e. the concentration of the pollutants was relatively higher at the ground as compared to the upper region.

There was good vertical mixing of pollutants during the day when no temperature inversion was observed. During the night, the temperature inversion lead to lower PBL and prevented vertical mixing of pollutants.

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More information regarding this research can be found in the following publication:
Samad, A.; Panta, A.; Uprety, D.; Vogt, U. Vertical distribution of particulate matter, black carbon and ultra-fine particles in Stuttgart, Germany,” *Atmospheric Pollution Research*, vol. 11, no. 8, pp. 1441–1450, 2020.
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