

Abstract

The city of Stuttgart in Germany is very famous because of its air pollution problems. The air quality in Stuttgart is continuously monitored on the ground but there is not enough data available on the vertical profiles of meteorology and pollutants. The aim of this study is to obtain vertical profiles of meteorological parameters and pollutants in order to investigate the impact of inversion on the air quality of the city of Stuttgart. These vertical profiles help to understand the behavior of temperature inversion, pollutants and their relationship to each other. In order to obtain these vertical profiles, tethered balloon system is used. The measurements were carried out in "Stuttgarter Schlossgarten" near the city center of Stuttgart. The profiles were obtained by ascending the balloon from the ground up to a height of maximum 470 meters and then descending it back to the ground. One complete sounding (ascent and descent) took around 30 to 40 minutes. A total of 43 soundings were carried out continuously for around two days in July 2018 in the period when strong inversion was expected. In the measurement period, high pressure weather conditions were observed, i.e. clear skies, no rain, low wind speeds, which is a prerequisite for the temperature inversion (very stable weather). Hence a strong inversion was observed during the night time which trapped the pollutants.

Introduction

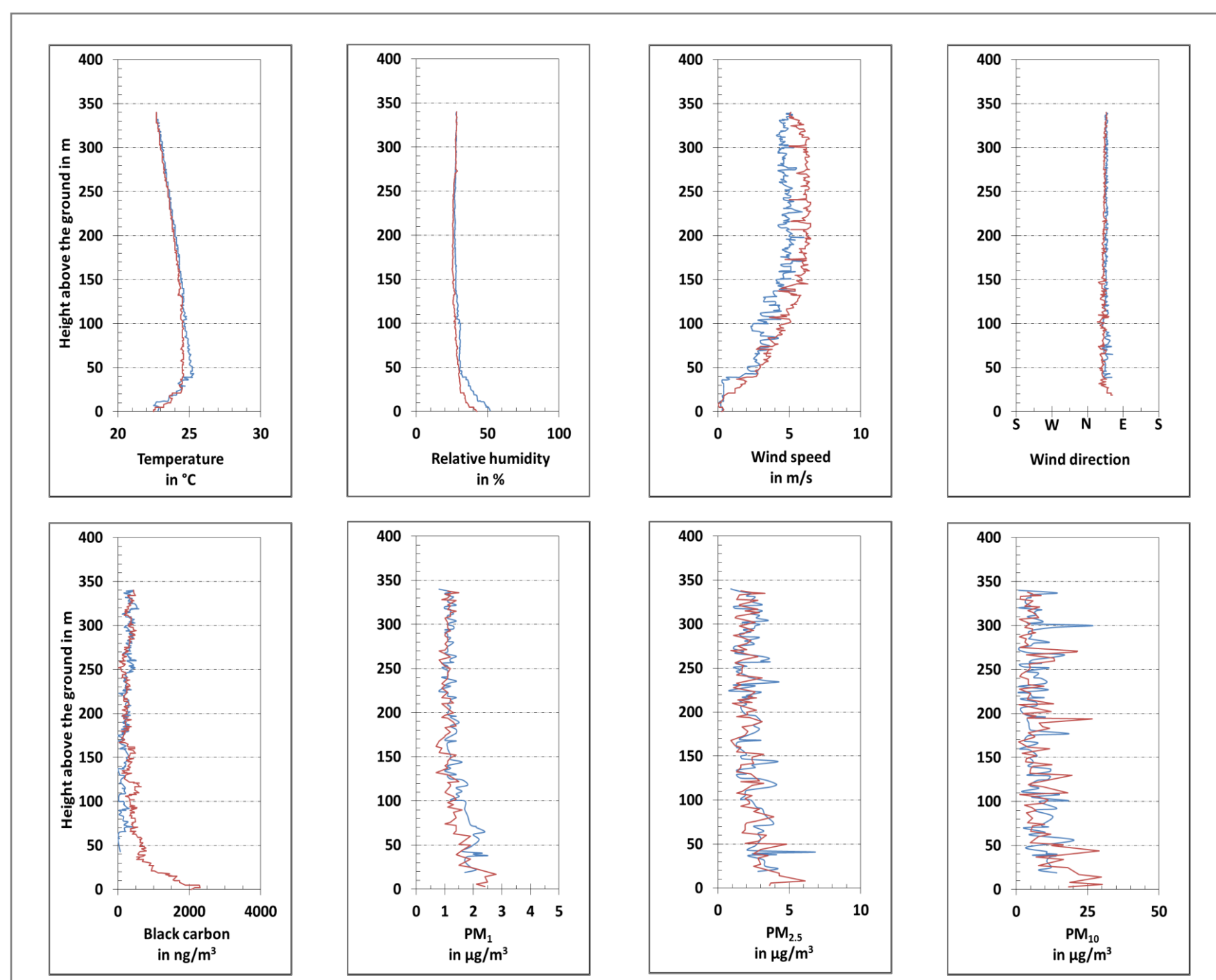
- The air quality measurements in Stuttgart were performed under the project "Urban Climate Under Change – [UC]2" which aims to develop, validate and apply an innovative urban climate model for entire cities
- This project emphasizes to collect comprehensive observation data on weather, climate and air 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 were also investigated



Result: Vertical Profiles

For the balloon measurements performed at "Stuttgarter Schlossgarten" on 08.07.2018 vertical profiles of one sounding is shown. 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



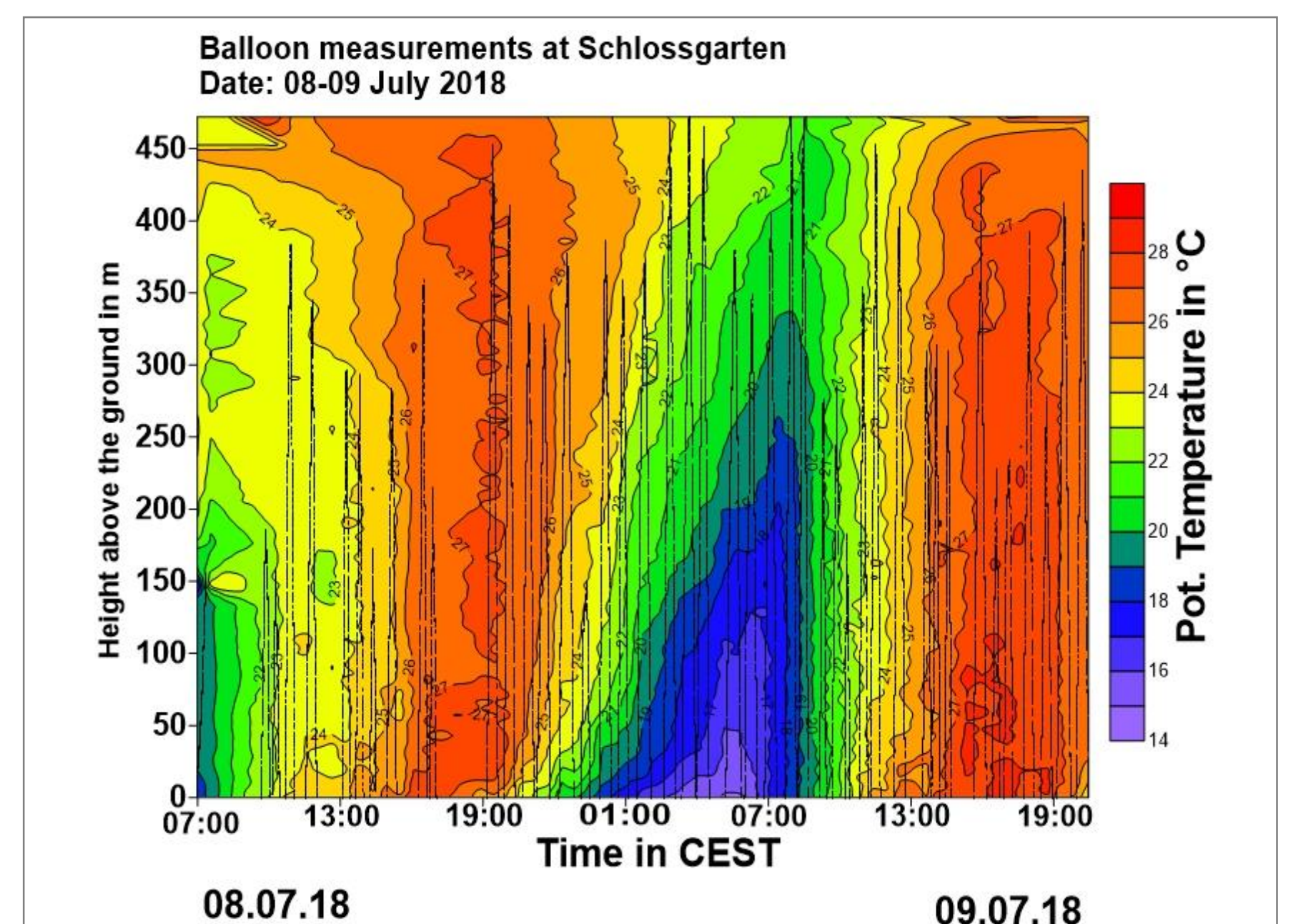
Instrumentation of the Balloon

- Meteorology: Wind speed, wind direction, temperature, relative humidity, air pressure
- Gas pollutants measured: O₃, NO, NO₂, 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 (BC)

Result: Isopleth

The isopleth provides an overview during the whole measurement campaign.. The isopleth diagram of potential temperature for the balloon measurements performed at "Stuttgarter Schlossgarten" from 08.07.2018 to 09.07.2018 is shown. 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. Following facts can be seen

- The potential 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 was observed



Conclusions

- The measurements have shown that the method of obtaining vertical profiles with a tethered balloon provides a good overview of the study of the distribution of pollutants in the atmosphere
- The pollutants get trapped in the inversion layer which in turn increases the concentration of pollutants within the inversion layer
- Stable weather conditions play an important role in the air quality situation of the city of Stuttgart

References

Samad, A., U. Vogt (2017): Untersuchung der Vertikalstruktur von meteorologischen Parametern und deren Auswirkungen auf die vertikale Ausbreitung von Luftverunreinigungen – Ergebnisse von Fesselballonmessungen in Stuttgart im Rahmen des BMBF Projektes 3DO. METTOOLS X, 25. bis 27. September 2018 in Braunschweig, Tagungsband S. 90.