

Air Quality Measurements at Marienplatz, Stuttgart using Continuous Monitoring Station

Introduction

Air quality measurements in Stuttgart are performed under the project "Urban Climate Under Change [UC]²" funded by German Federal Ministry of Education and Research (BMBF)

This project aims to develop, validate and build an urban climate model to simulate the atmospheric processes in cities ranging from small area such as a street canyon to a larger area such as a city

Under this project continuous measurements at Marienplatz for a period of around six years (March 2017 – December 2022) is planned

Marienplatz is located in the path of fresh cold air flows blowing from terrains of Kaltental at night and proceeding towards the valley in city center; is the appropriate location to study the pollutant concentration

Parameters measured

Air quality parameters:

Instrument	Measurement principle	Measured parameters	Accuracy	Resolution
Aerosol spectrometer	Light scattering	Particulate Matter (PM) with size range 0.25 – 32 µm	5 %	0.1 µg/m ³
Aethalometer	Light attenuation	Black Carbon (BC)	30 ng/m ³	1 ng/m ³
NO ₂ / NO / NO _x monitor	Chemiluminescence	NO ₂ , NO, NO _x	0.5 %	0.1 ppb
Ozone monitor	UV absorption	O ₃	2 %	0.1 ppb
CO monitor	NDIR absorption	CO	1 %	0.1 ppm

Meteorological parameters:

Instrument	Measurement principle	Measured parameter	Accuracy	Resolution
Weather station	Negative Temperature Coefficient (NTC) resistor	Air temperature	0.5 °C	0.1 °C
	Capacitive humidity sensor	Relative humidity	5 %	0.1%
	Micro Electro Mechanical Sensor (MEMS)	Atmospheric pressure	1.5 hPa	0.1 hPa
	Pyranometer	Global radiation	2 %	1 W/m ²
Wind sensor	Ultrasonic time of flight	Wind speed	0.2 m/s	0.1 m/s
	Ultrasonic time of flight	Wind direction	10 °	1 °
Precipitation sensor	Tipping bucket system	Precipitation intensity	2 %	2 cm ³

Results: Windrose

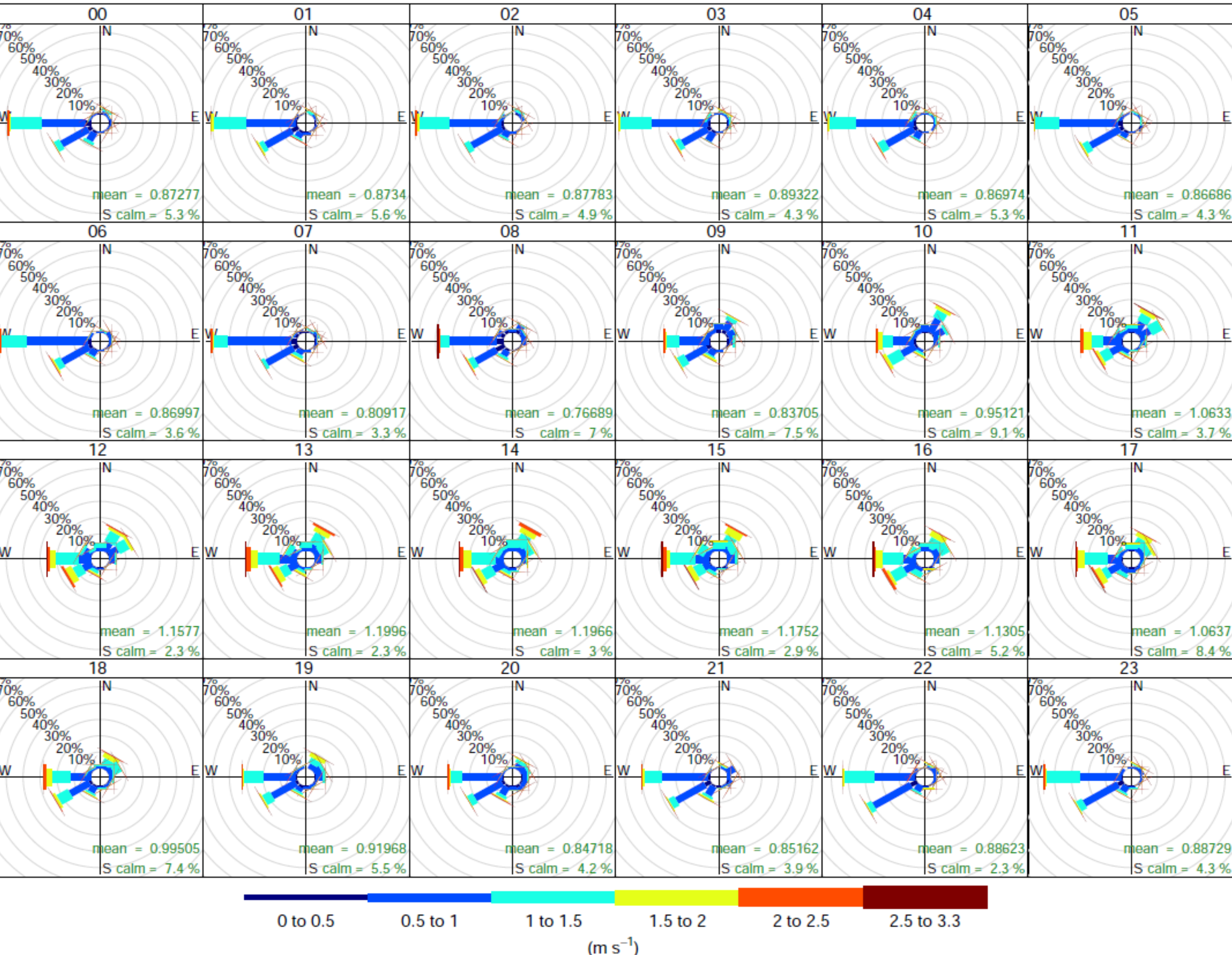
Change in wind direction was observed at different times of the day, i.e. during the night and during the day

During the night from 7 P.M. to 8 A.M. in the morning, the dominated wind direction was west southwest

During the day from 9 A.M. until 6 P.M., a significant amount of wind came from northeast

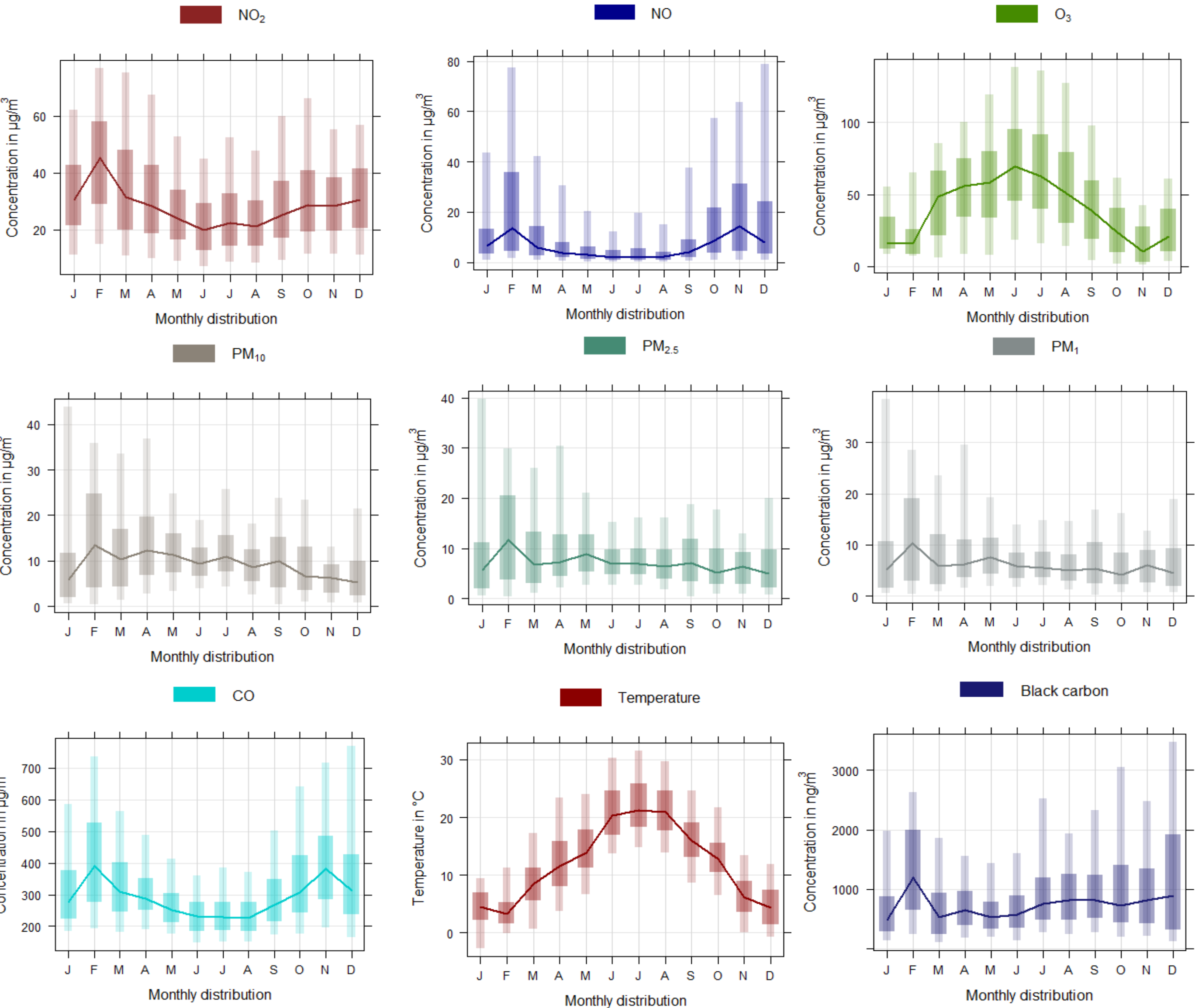
The wind speed during the daytime was around 0.5 m/s higher than the wind speed during the night

Stable wind conditions were observed during the inversion period



Results: Annual variation of monthly values

The seasonal variation of different parameters was evaluation using daily average values to calculate the monthly distribution and an average was taken for each month for the years 2017, 2018 and 2019. For the months of January and February, the averages were taken only for the years 2018 and 2019 as the measurements started in March 2017. O₃ concentrations increased in summer as compared to winter period as it is a product of photochemical reactions for which sunlight is necessary. The maximum O₃ concentration was measured in the month of June while the minimum O₃ concentration was measured in November. An increase in concentration for both CO and BC is measured in the winter season as compared to the summer, which was assumed to be due to more combustion processes and heating in winter. Higher nitrogen oxide concentrations were observed in winter as there are more inversion days in winter as compared to summer, that inhibits the dilution and transport of pollutants when they are emitted and in turn the concentration increases. For the PM, it was seen that the concentration of PM₁₀, PM_{2.5} and PM₁ were not much different from one another highlighting the fact that particle distribution of the PM measured at this location is mostly fine.



Conclusions

- Major wind direction at Marienplatz was west southwest
- The meteorological influence on pollutant concentration had a significant effect on the air quality of the area
- Relatively high concentrations of NO and NO₂ are observed during rush hours on weekdays
- Increase in temperature showed a decline in CO concentration due to reduced domestic heating
- Temperature rose results proved that relatively warm air was blowing from northwest, northeast and southeast direction towards Marienplatz because of the city traffic and concrete structures.
- The cold airflows from west and southwest direction brought cold and fresh air into the city as the temperature of the air coming from this direction was low and less polluted as compared to the air coming from the city side.

