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Urban Meteorology

Mesoscale wind patterns over the complex urban terrain around Stuttgart investigated with dual-Doppler lidar profiles

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Characterization of ABL winds in an urban and mountainous surrounding

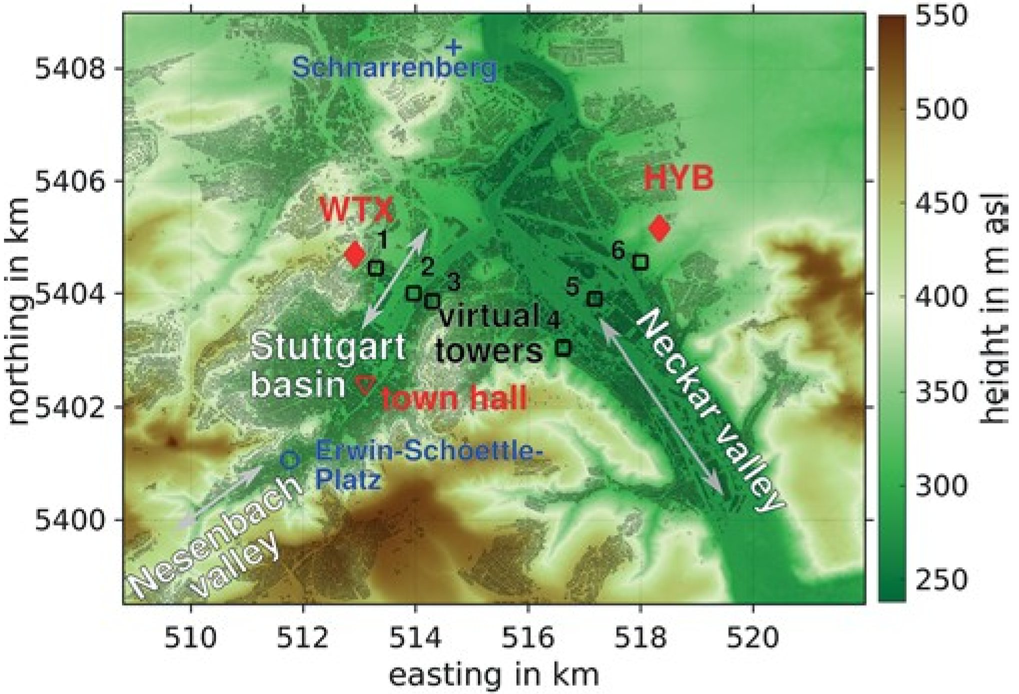
1) Is it possible to derive mesoscale flow characteristics in the ABL in highly complex urban terrain?
2) What flow characteristics do occur in the urban ABL and how are they affected by the topography?
3) How does the flow depend on ambient wind and atmospheric stratification?

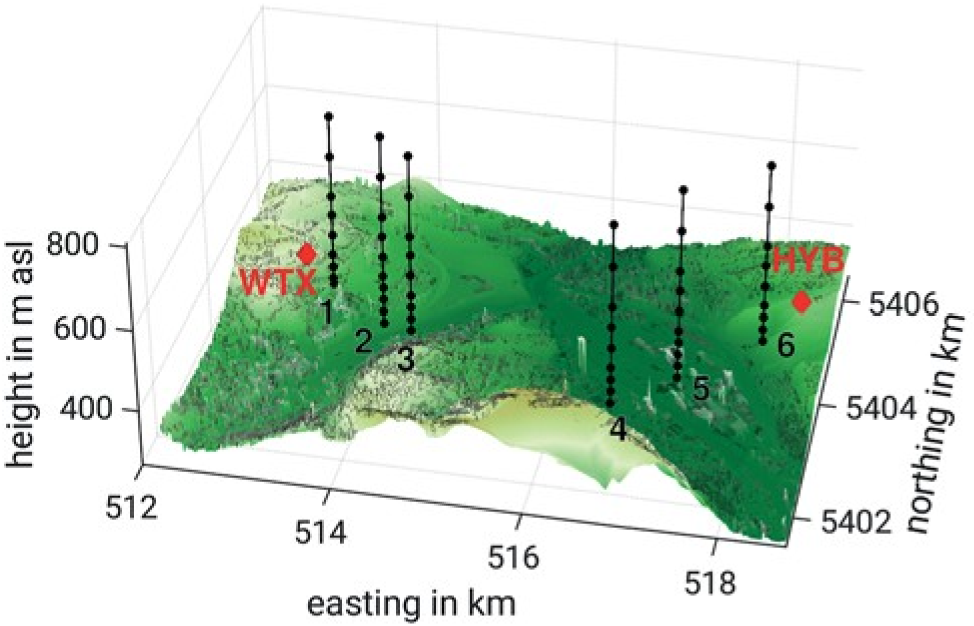
Background / Framework

- For the investigation of multi-scale processes determining the structure and evolution of the urban ABL, 3D observations and highly resolved urban climate models are needed:
- PALM-4U developed within [UC]^2 – Urban Climate Under Change, funded by BMBF

Measurement setup and devices

- 3 Doppler lidars (2 for virtual towers); MWR





Methods

- Synchronized stop-and-stare VT technique
- Horizontal wind is calculated from radial velocities by neglecting w

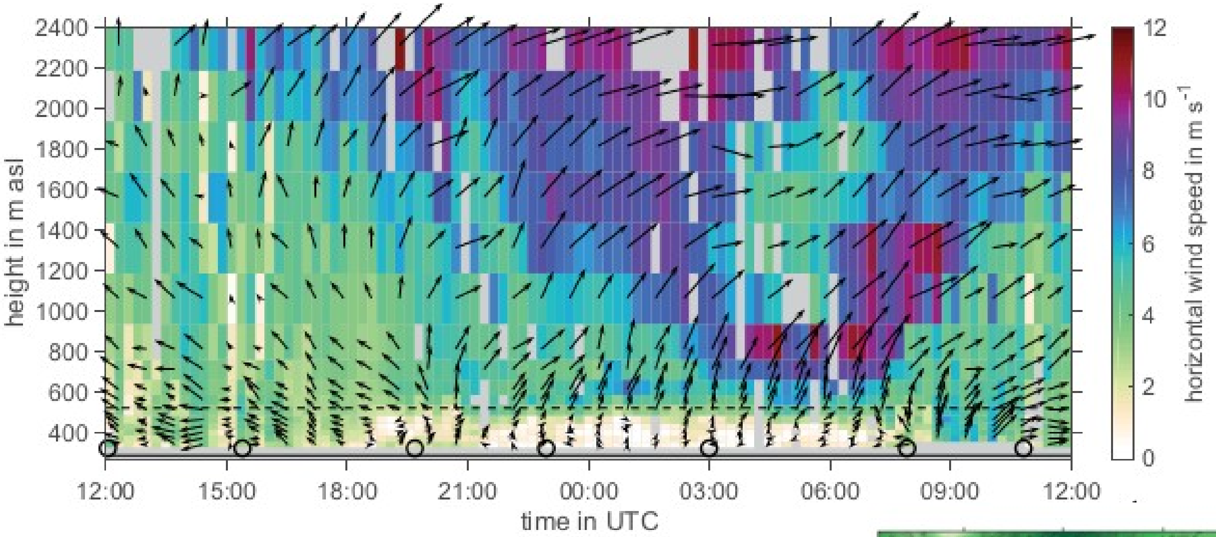
$$\Delta U = w \ \tan(\phi)$$

ϕ	SBL ($w = 0.1\,\mathrm{m\,s^{-1}}$)	CBL ($w = 2\,\mathrm{m\,s^{-1}}$)
8.4° (ϕ_{mean})	$0.02\,\mathrm{m\,s^{-1}}$ (0.3 %)	$0.30\,\mathrm{m\,s^{-1}}$ (5.9 %)
3.1° (ϕ_{median})	$0.01\,\mathrm{m\,s^{-1}}$ (0.1 %)	$0.11\,\mathrm{m\,s^{-1}}$ (2.1 %)
56.8° (ϕ_{max})	$0.15\,\mathrm{m\,s^{-1}}$ (3.1 %)	$3.05\,\mathrm{m\,s^{-1}}$ (61.1 %)

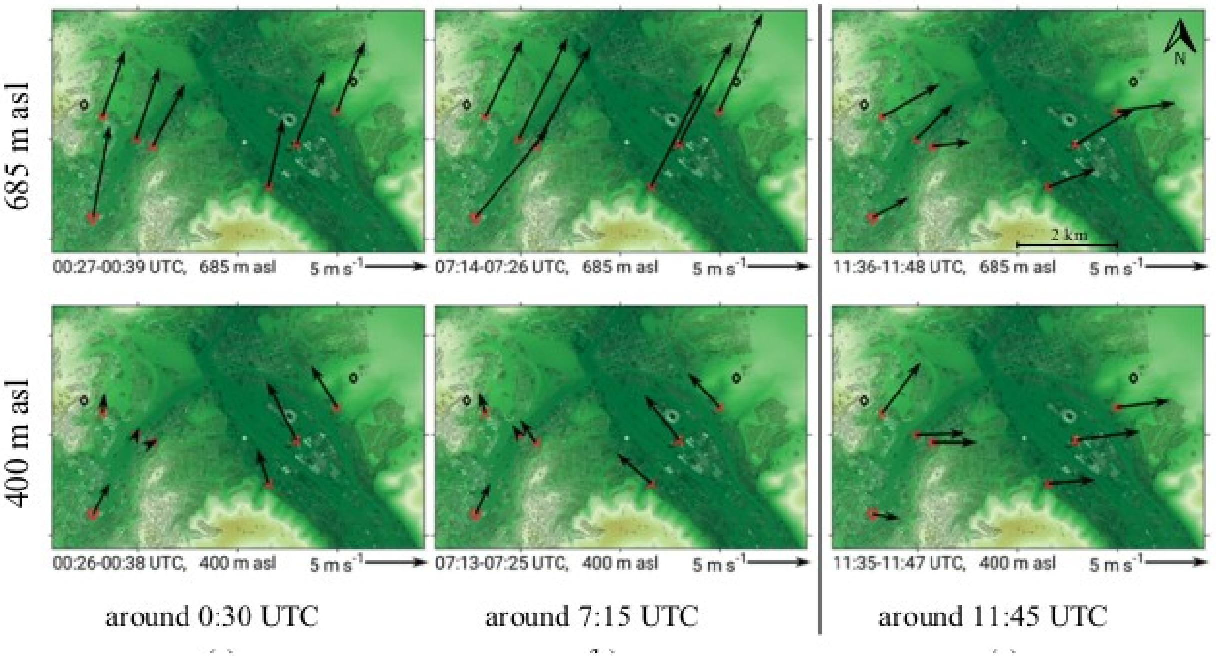
- Bulk Richardson number using MWR

$$BRN = \frac{g\,\Delta\theta_v\,\Delta z}{\theta_v\,[(\Delta u)^2 + (\Delta v)^2]}$$

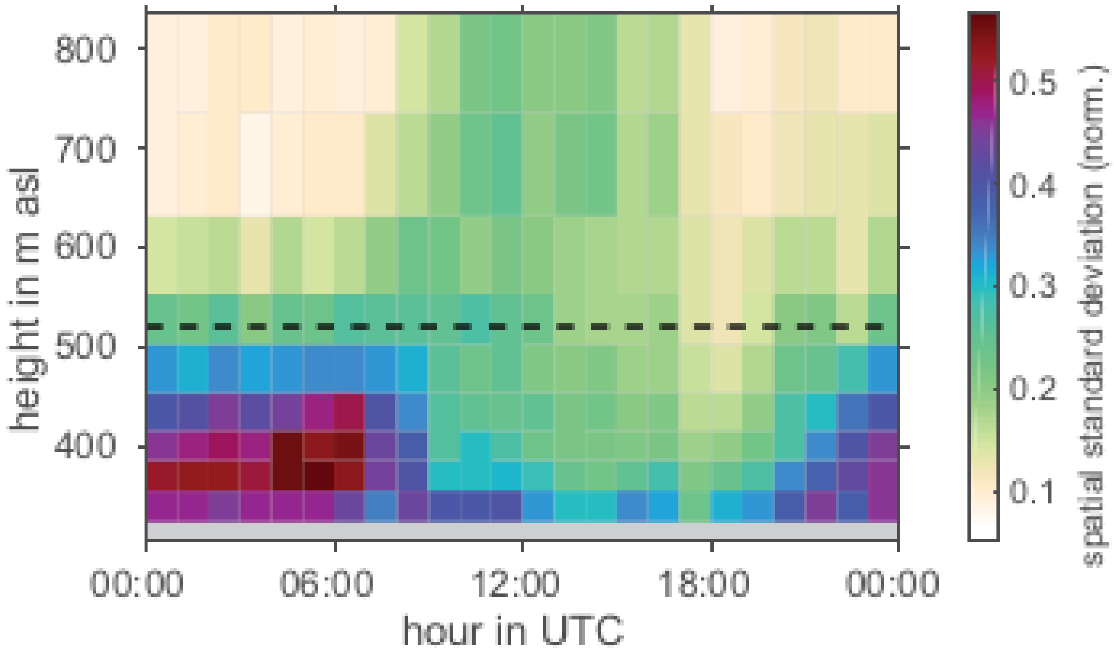
Case study



- High pressure / fair weather day in summer
- Thermally-driven down-valley wind

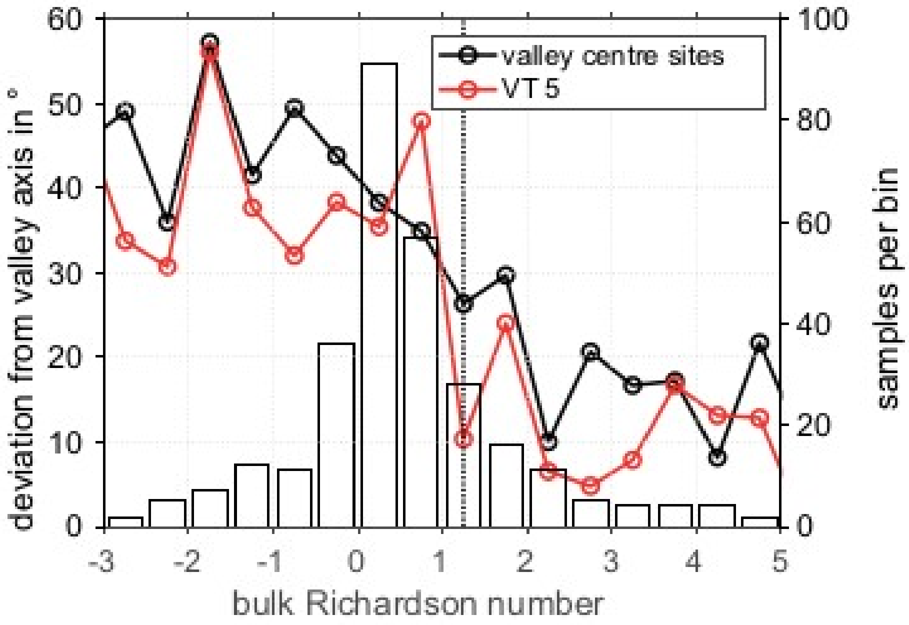


Spatial variability in wind field

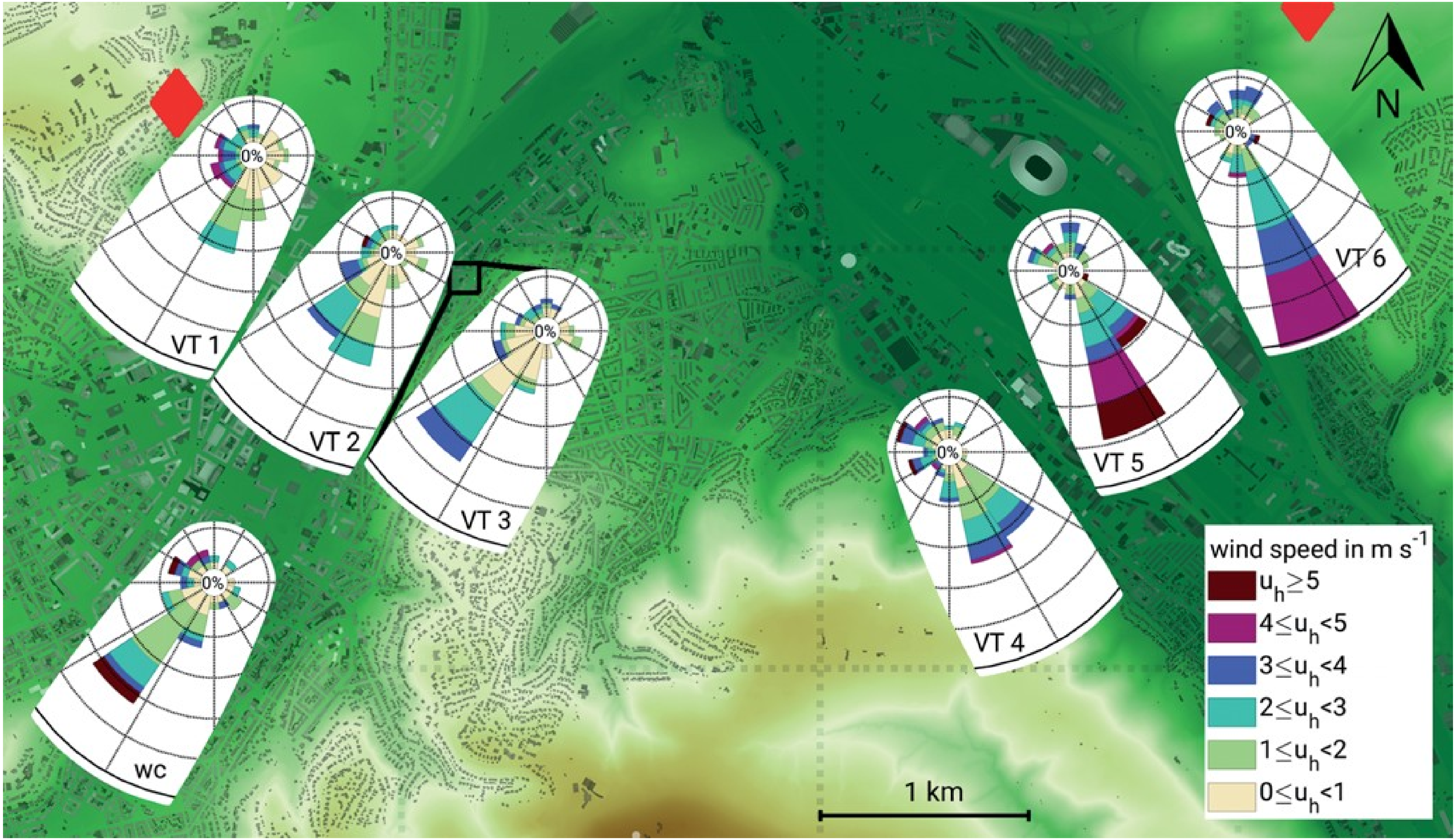


- 1 month composite of hourly normalized spatial STDDEV of horizontal wind speed for all VT

Dependence on stratification



- Median absolute deviation of the low-level wind direction from the along valley axes



VT 1
VT 2
VT 3
VT 4
VT 5
VT 6
WC
0%
N
1 km
wind speed in m s-1
u_h≥5
4≤u_h<5
3≤u_h<4
2≤u_h<3
1≤u_h<2
0≤u_h<1

Conclusions

1) Is it possible to derive mesoscale flow characteristics in the ABL in highly complex urban terrain?

VT suitable if carefully processed (filtering and temporal averaging necessary)

Conclusions

2) What flow characteristics do occur in the urban ABL and how are they affected by the topography?

Nighttime down-valley wind near the surface observed for stable stratification

Above ridge: decoupled, large scale forcing (LLJ)

Conclusions

3) How does the flow depend on ambient wind and atmospheric stratification?

Flow coupled for BRN smaller than critical value

Basin outflow for dynamically stable cases

Review

- Good setup for VT
- No investigation of urban effects (still in the title)
- Small data set for statistical analysis
- No discussion of different weather patterns during that period