

The relevance of stack height in industrial plants upon air pollutant concentrations

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EU air quality directive (2008/50 EG, 2024/2881 EU)

- Defines limit values for pollutants

Adaptation into national regulations

Directives for the administration

- Define unclear legal terms
- Guideline for practical implementation of certain requirements EU Air Quality directive
- In Germany: TA Luft (2021), in Bulgaria amongst others НАРЕДБА № 1 от 27.06.2005

One of the first steps of air pollution control

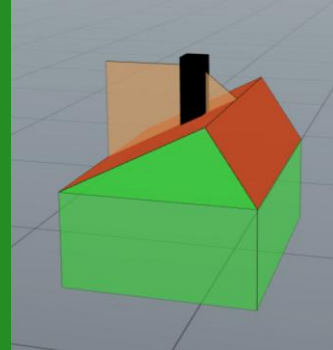
- Sufficient stack height reduces ground level pollution
- Emission reduction can lead to lower stack heights and thus lower construction costs: incentive to reduce emission loads

Determined stack height can be used as source height in dispersion calculation

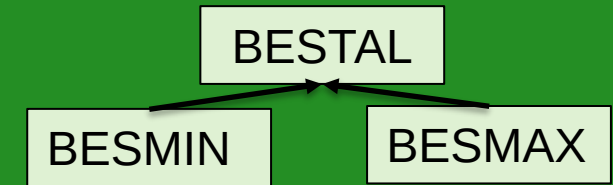
- Determination of conflicts with annual, daily or hourly limit values
- Requirement for permission

Stack height determination in Germany

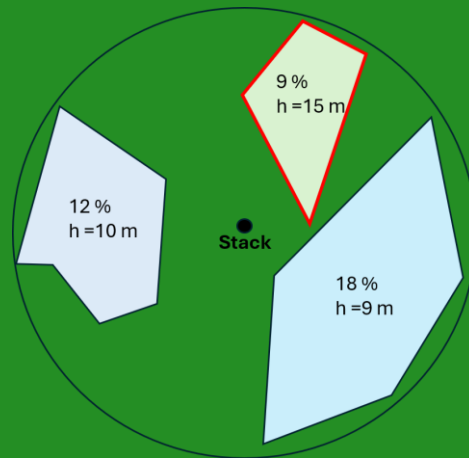
Step 1:
Emission into free
air flow



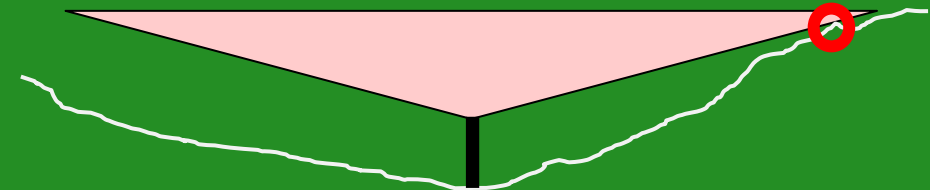
Step 2:
Stack height
depending
on emission

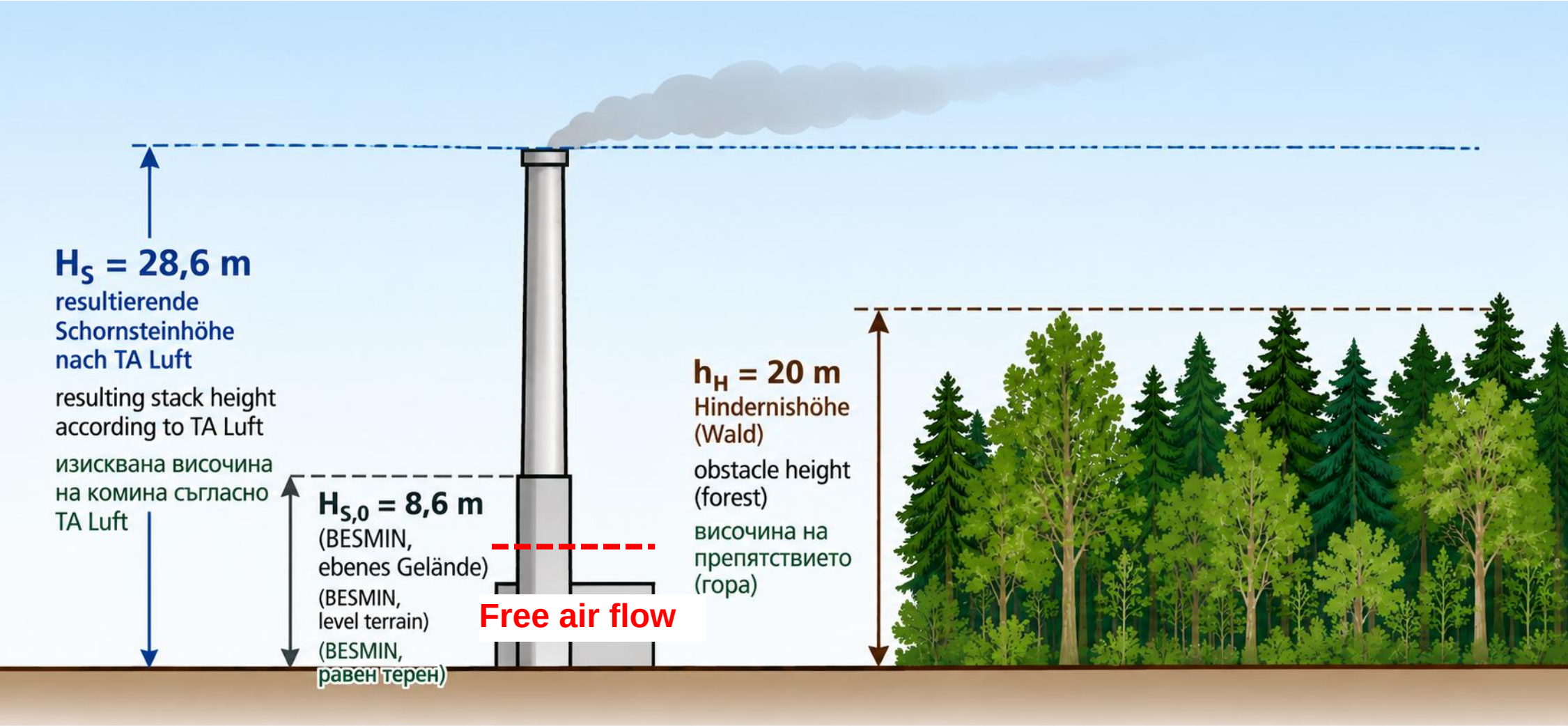


Step 3:
Additional term
for effects of
surrounding
buildings and
vegetation



Step 4:
Correction for influence of terrain
structures





The plume rise is the vertical component caused by thermal and/or dynamic uplift of exhaust gas.

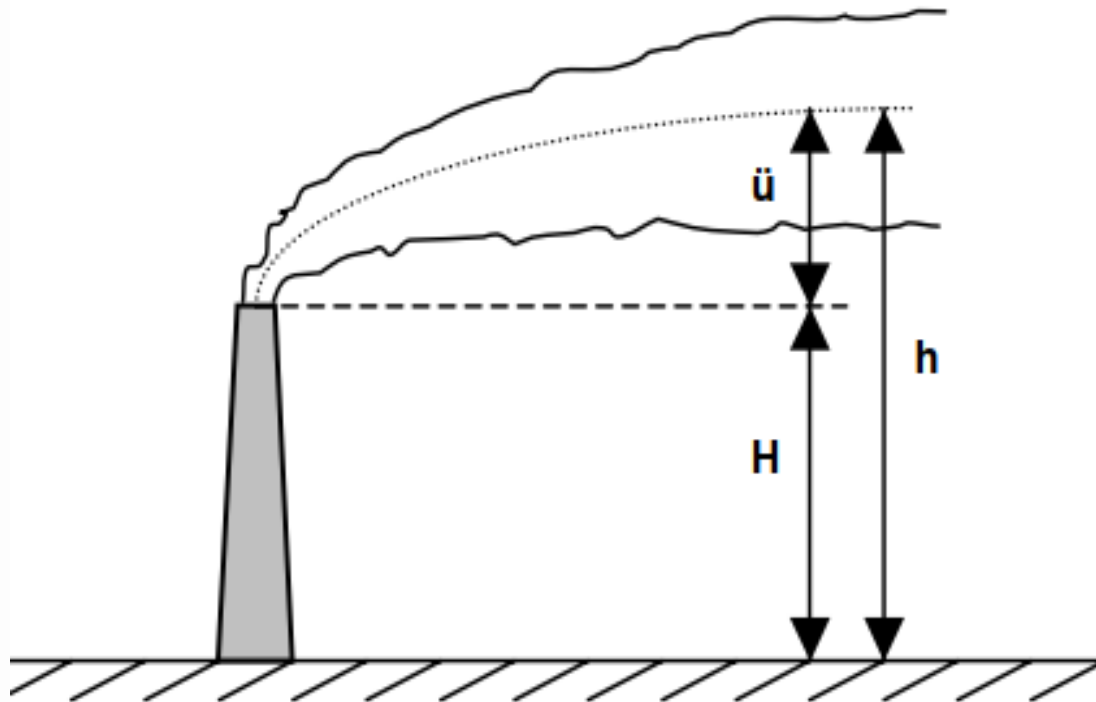


Image source: https://www.hlnug.de/fileadmin/dokumente/luft/ausbreitungsrechnung/glossar_internet.pdf

H ... stack height
 $\ddot{u}$... exhaust gas plume rise
 h ... effective source height

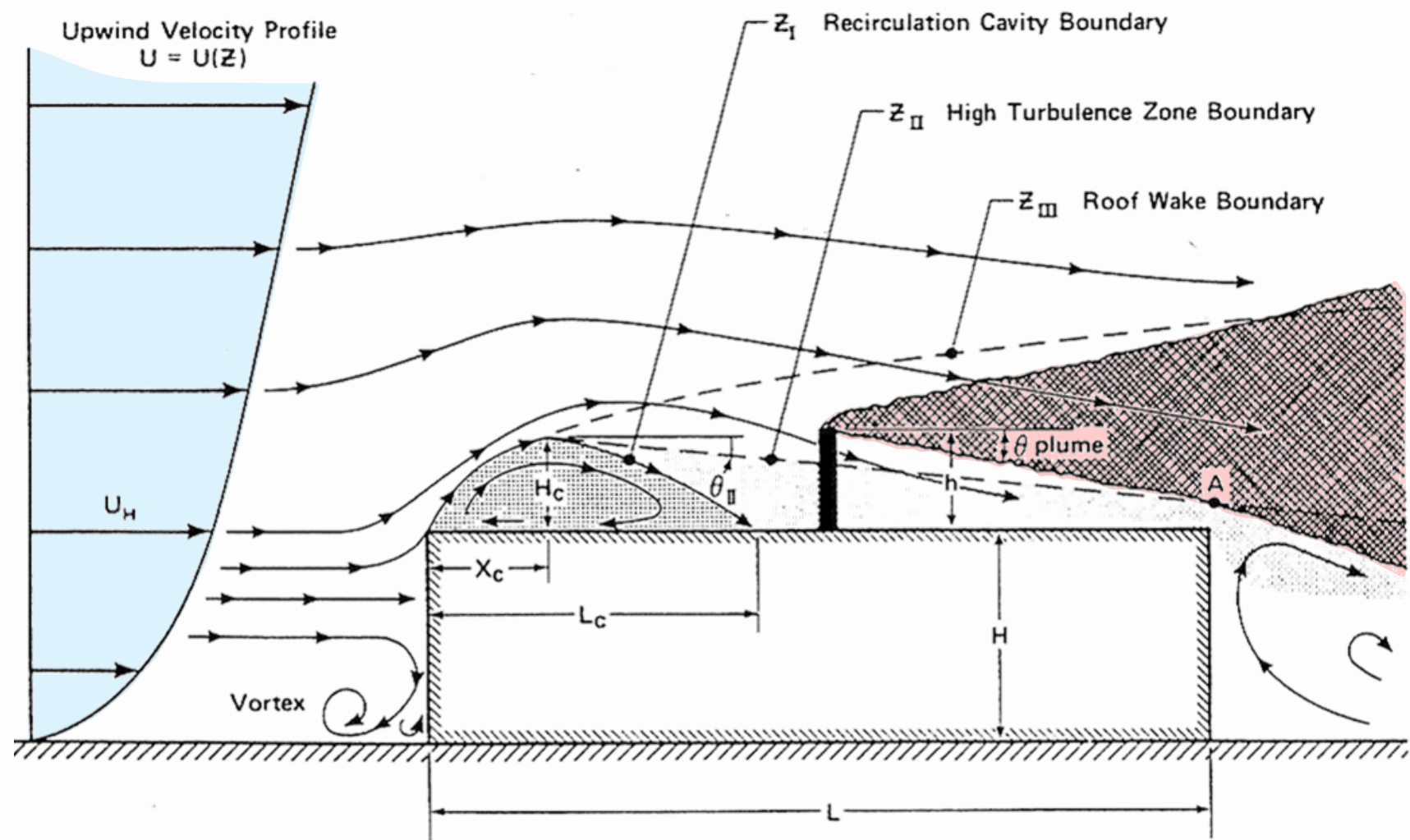
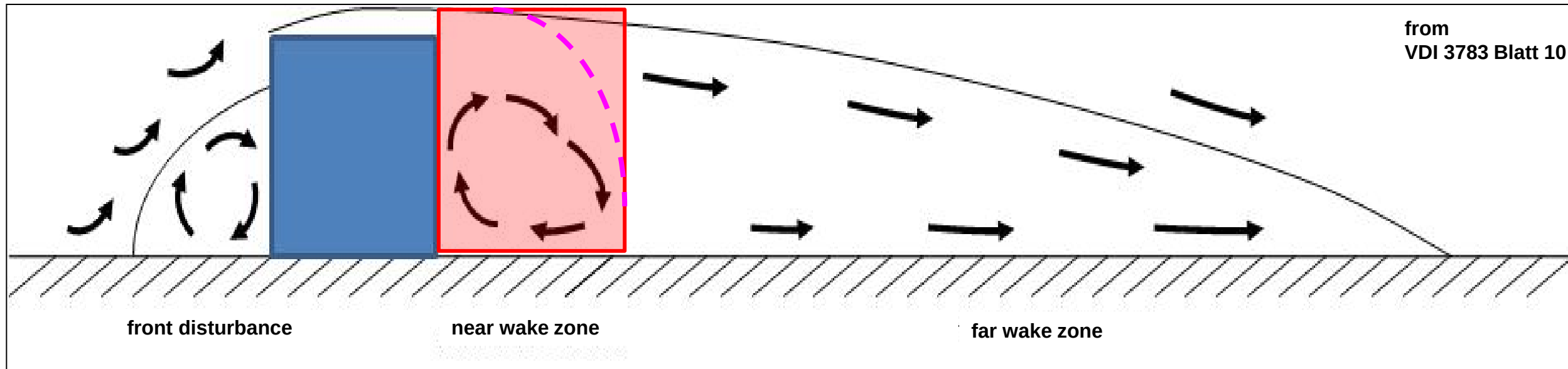


Fig. 2 Three flow zones over a building roof for wind perpendicular to the upwind face

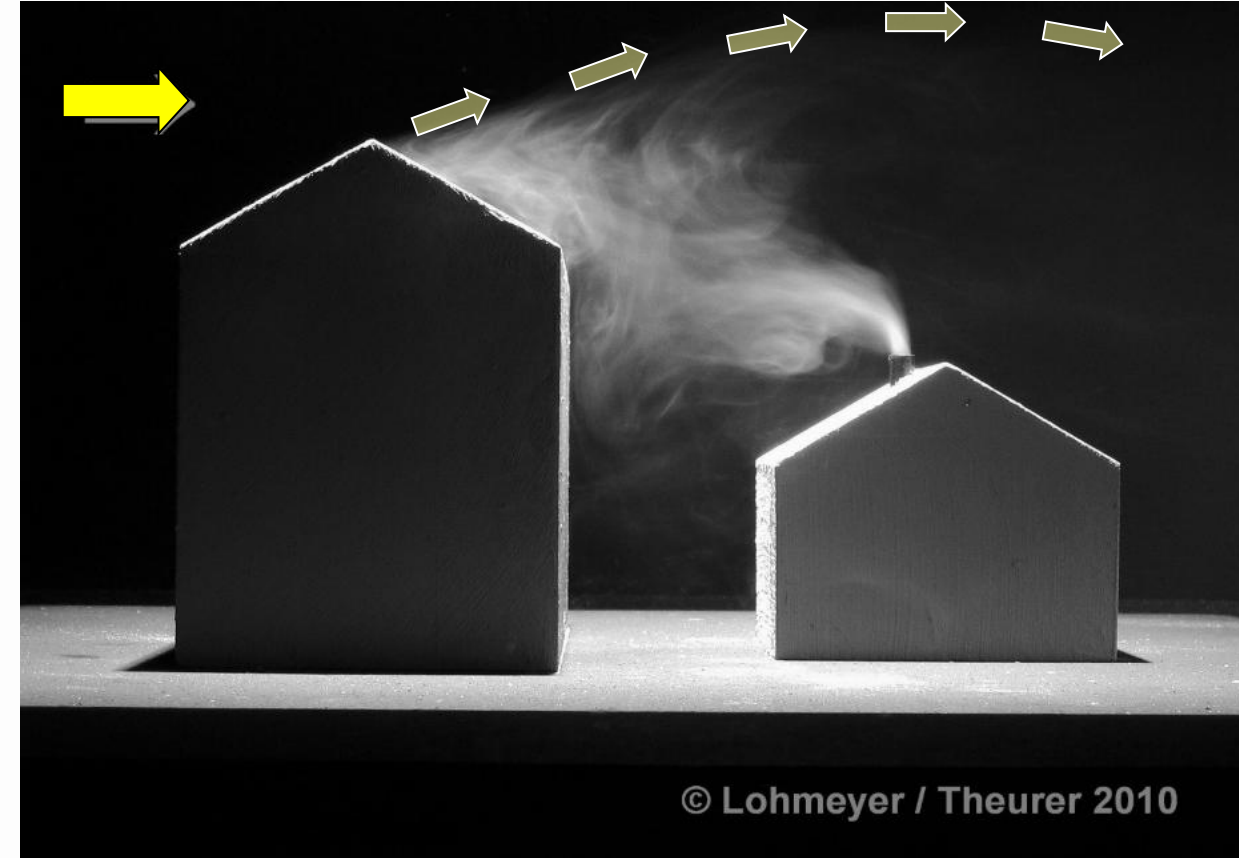
Wilson (1979): Flow Pattern over Flat-roofed Buildings and Application to Exhaust Stack Design. ASHRAE Transactions Vol. 25 part 2

⇒ Wind direction



Minimal requirement: stack should reach above the near wake zone

- Buildings create displacement, turbulence and wake zones
- If the stack height is too low, the plume of exhaust gas may enter the building's wake zone
- Consequence: Downwash effects and increased emissions at ground level
- Conclusion: **The stack must therefore rise above the impact zone of the neighbouring buildings**

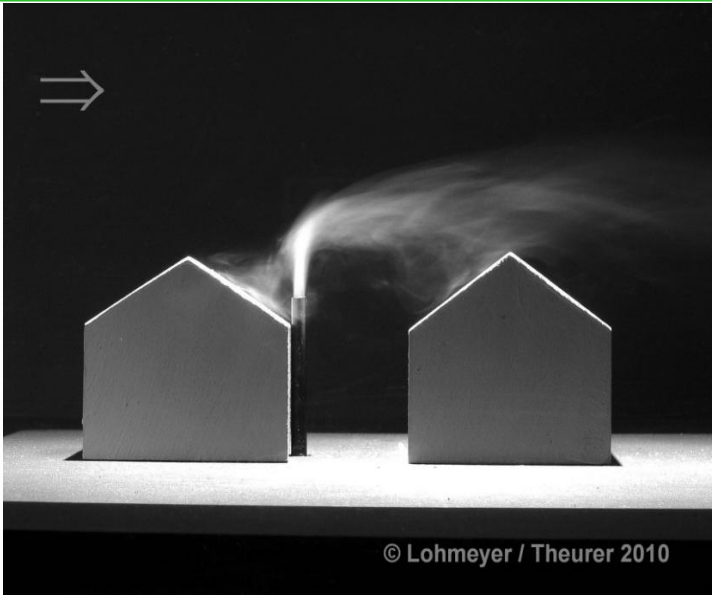
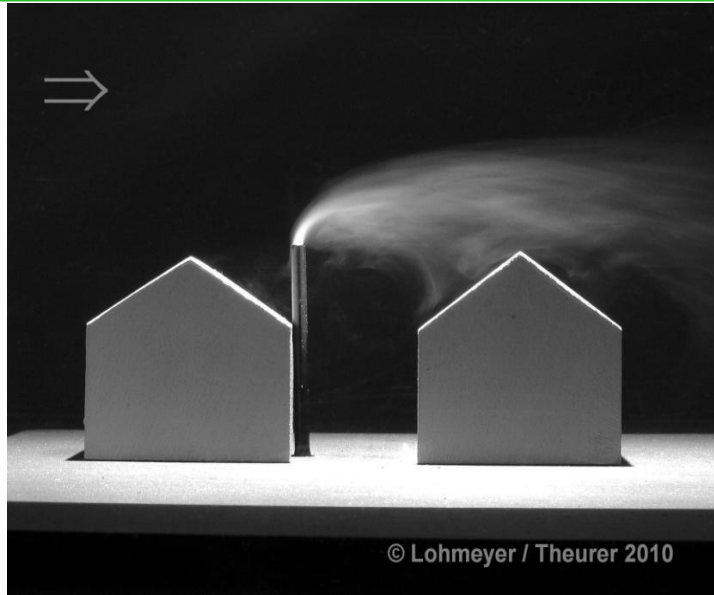
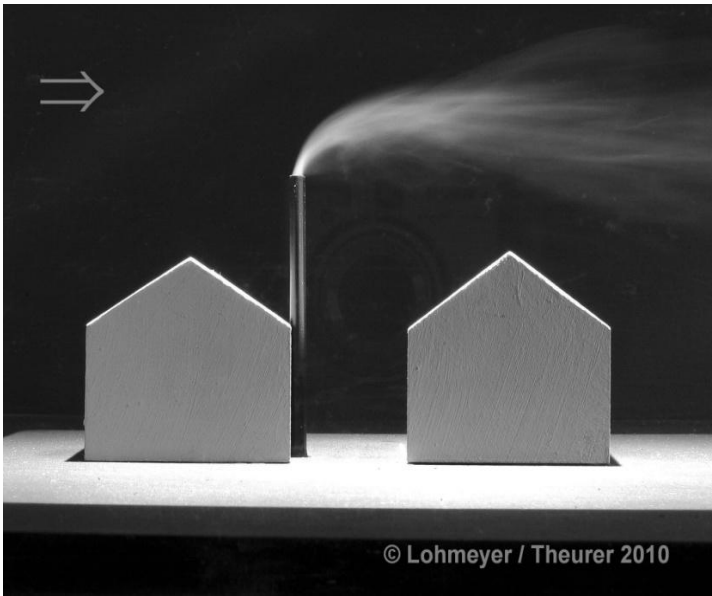
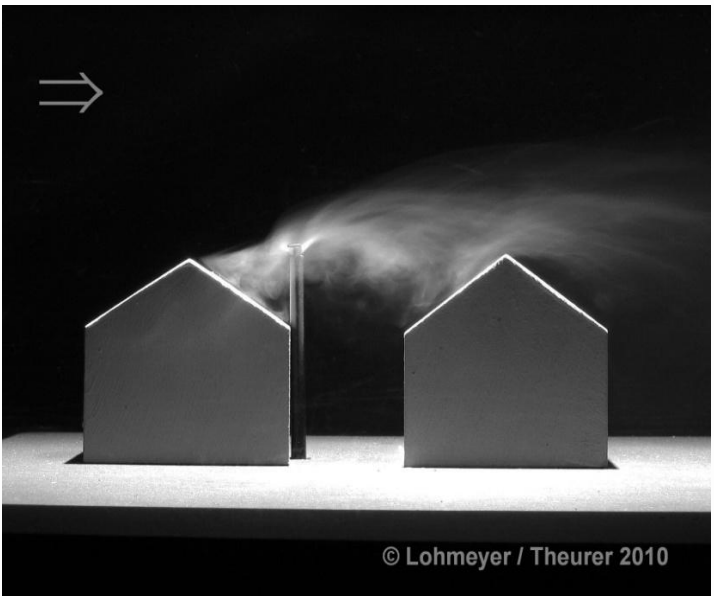


Wake zone of neighbouring building

- Ensuring sufficient dilution of exhaust gases at nearby buildings
- Even if stack is unobstructed by the building, the exhaust plume can reach nearby buildings
- At crucial points (windows, ventilation openings), the exhaust gases must be sufficiently diluted
- Conclusion: **The distance from and height of neighbouring buildings must be taken into account when determining the required stack height**



protecting exposed areas

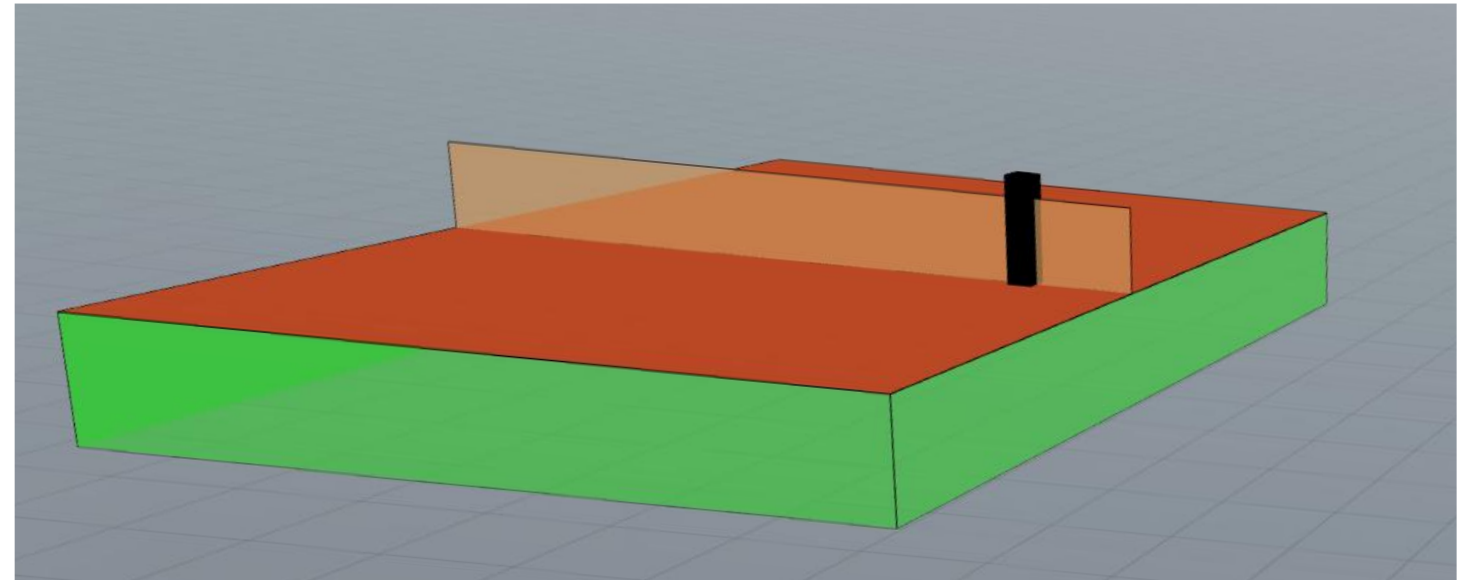


Plant:

- 2 combustion engines,
- 1 Building (5 m building height)
- Required stack height: 8.8 m

Stack:

- Diameter: 0.2 m
- Temp: 180 °C
- Exhaust gas vel.: 15 m/s
- Mass flow: 0.2 g/s NO_x

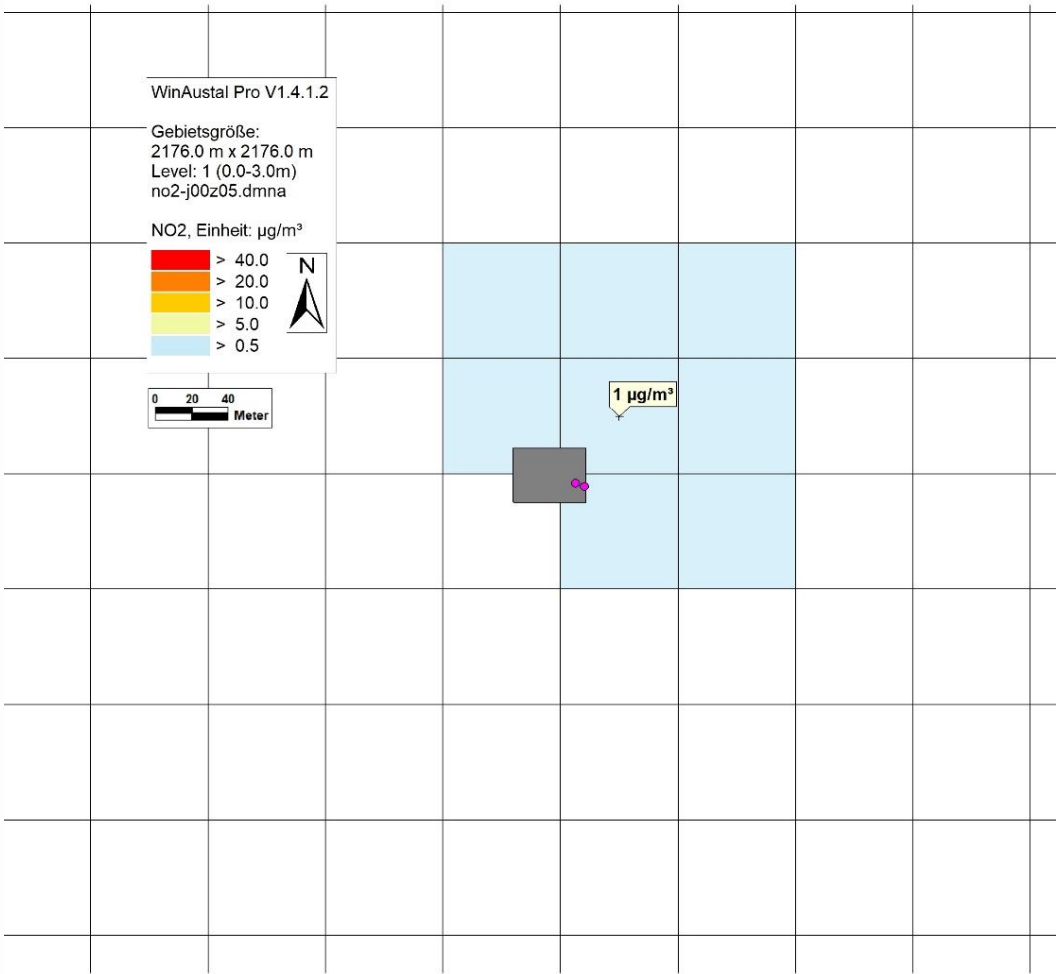


Scenario 1: emission at 8.8 m (free air flow)

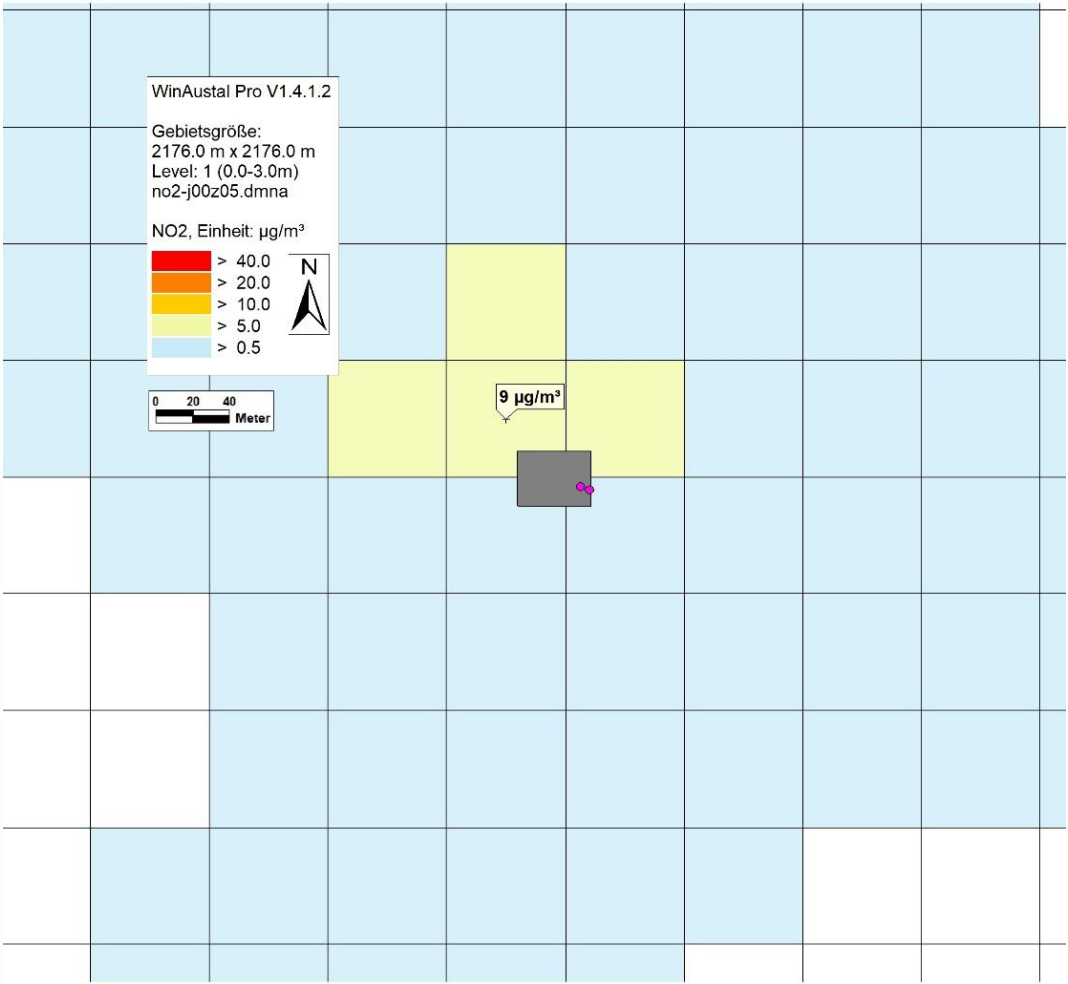
Scenario 2: emission at 8 m (obstructed by building)

Annual mean NO₂ concentration

Emission in **free air flow**

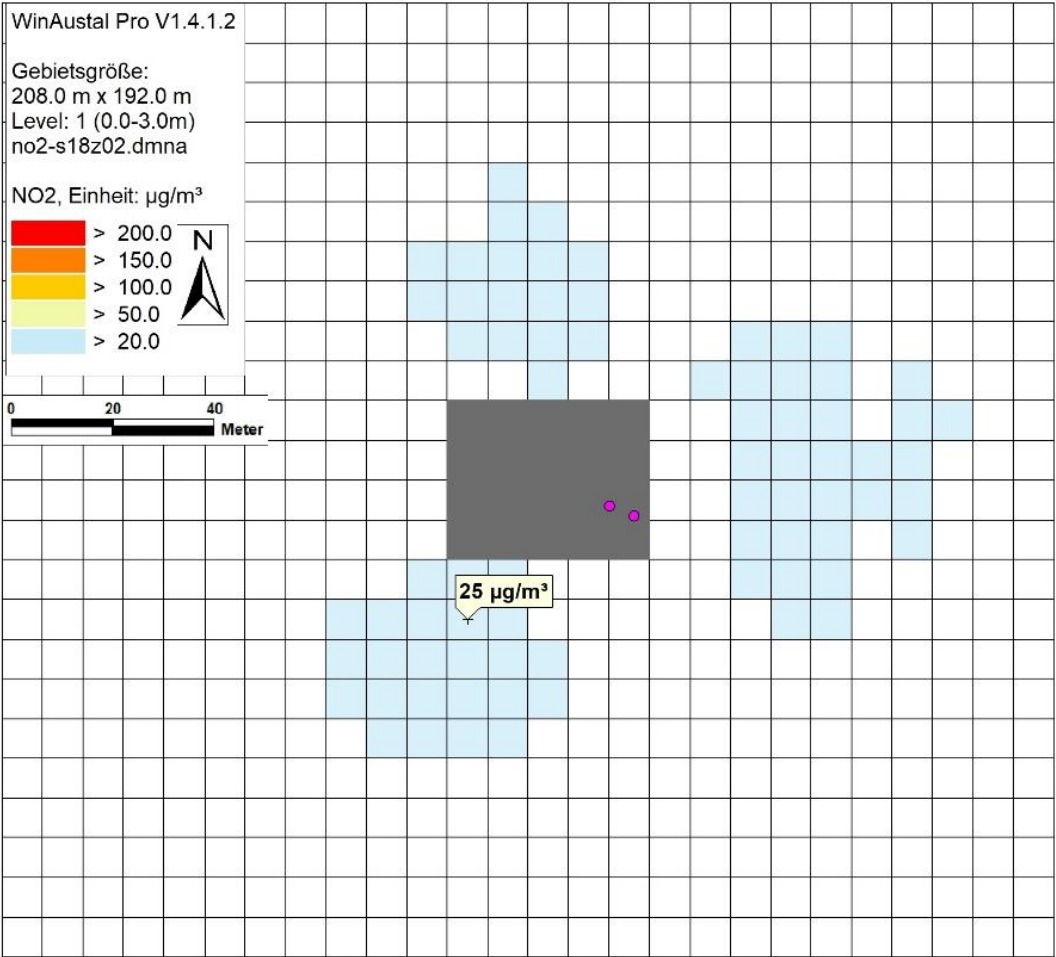


Emission **obstructed by building**

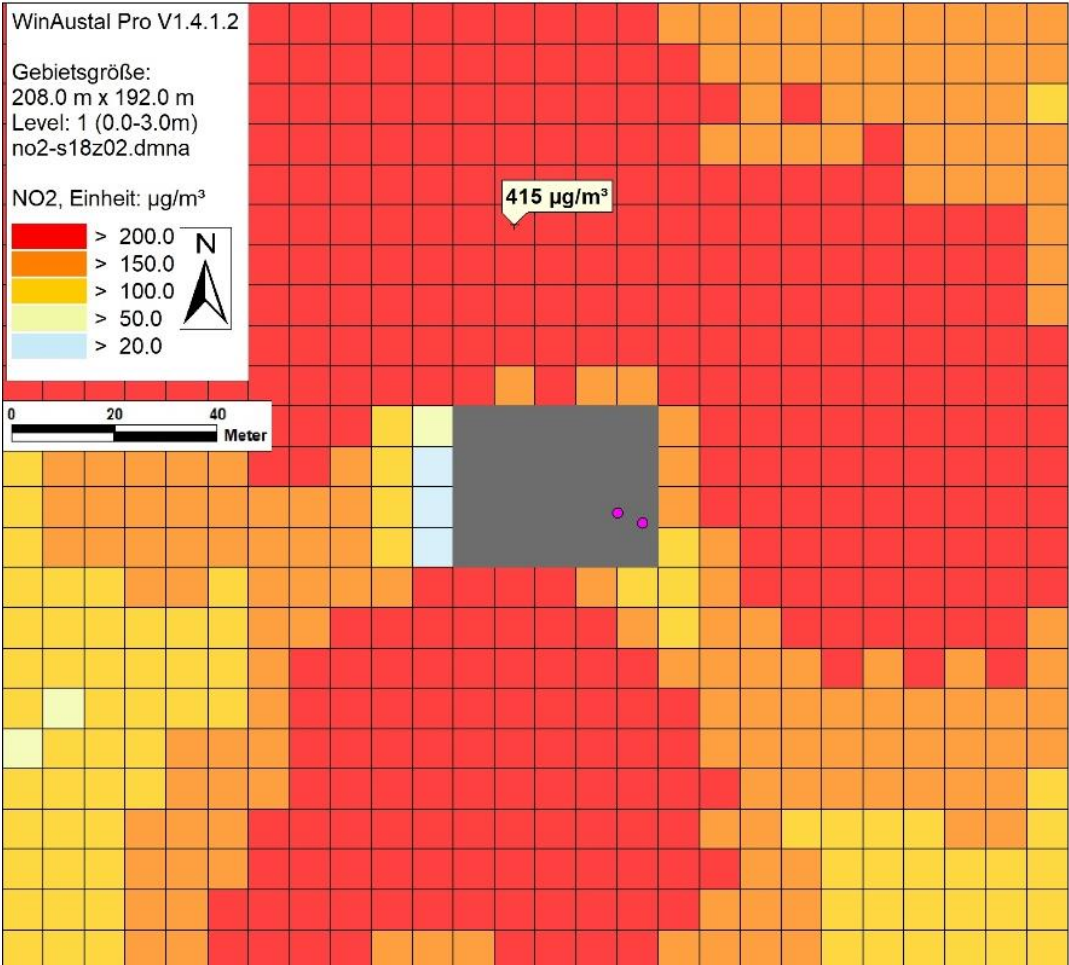


hourly mean NO₂ concentration (18 exceedances)

Emission in **free air flow**



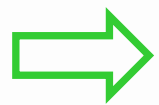
Emission **obstructed by building**



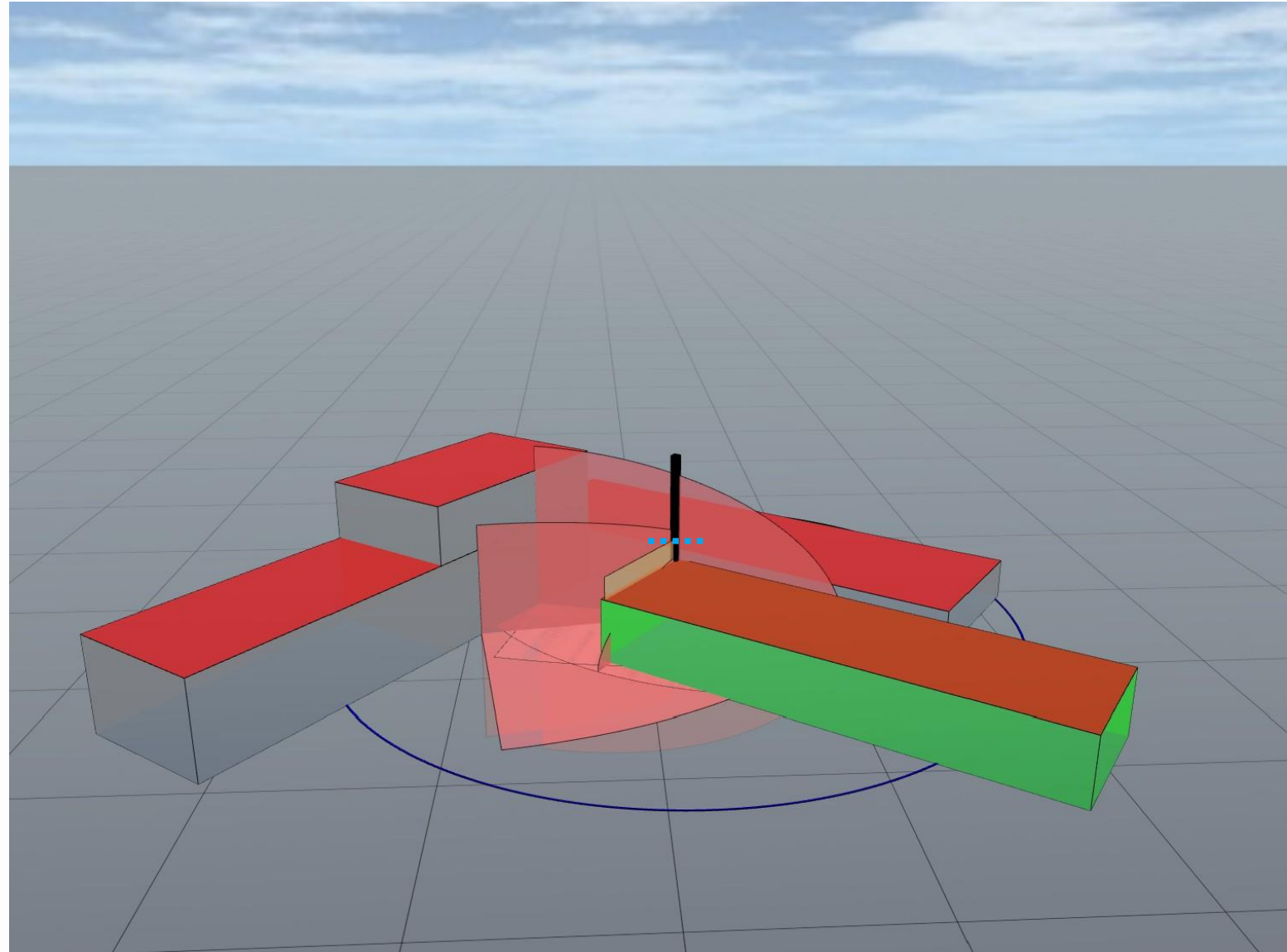
Case study 2: stack height

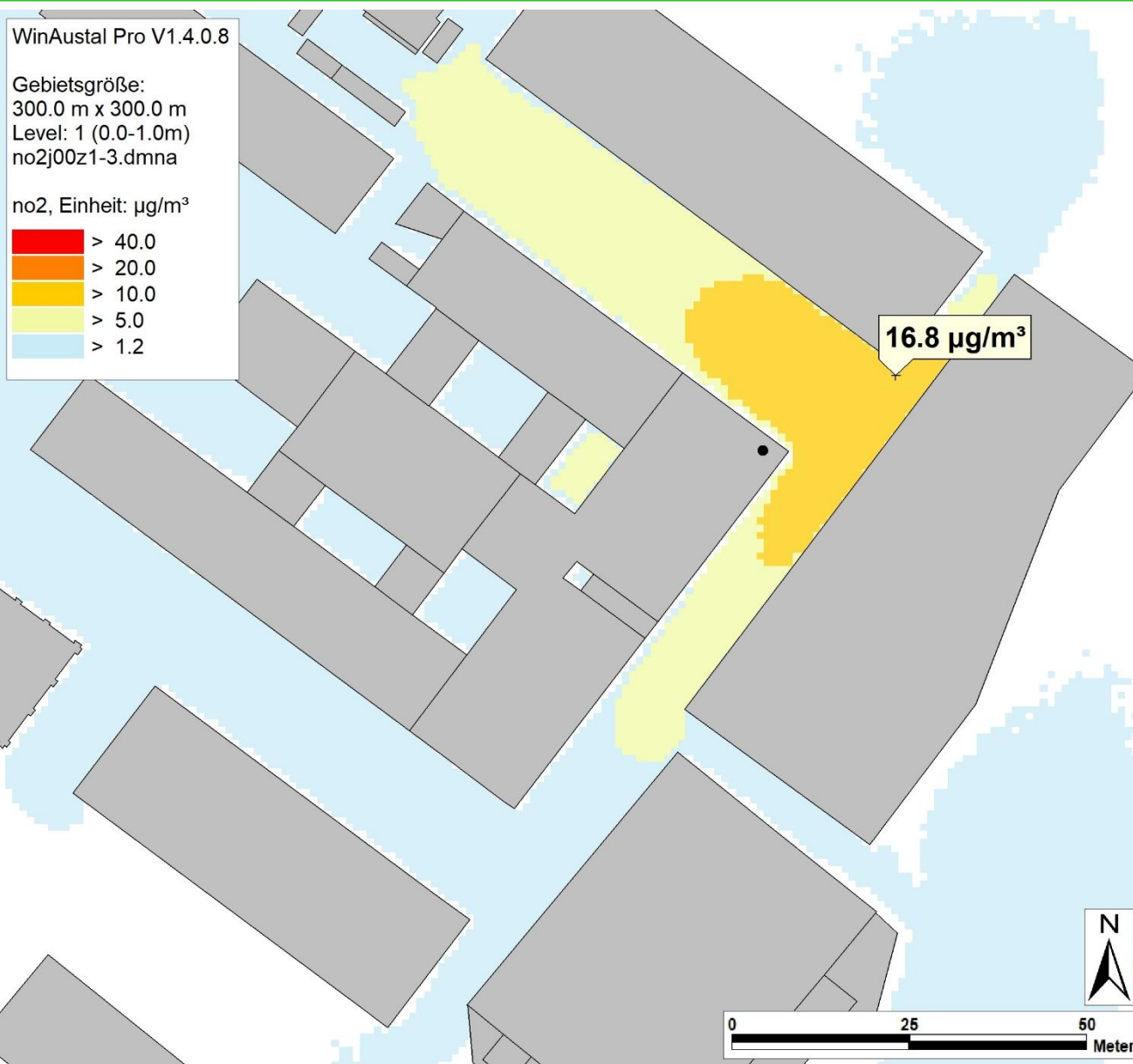
Step 2:

- Due to static constraints, a stack reaching the height needed for free dispersion cannot be realised
- Maximum height to be realised due to statics and building costs: 15 m (above the influence of the building housing the heating plant, shown in blue)
- Exhaust gas treatment economically not feasible

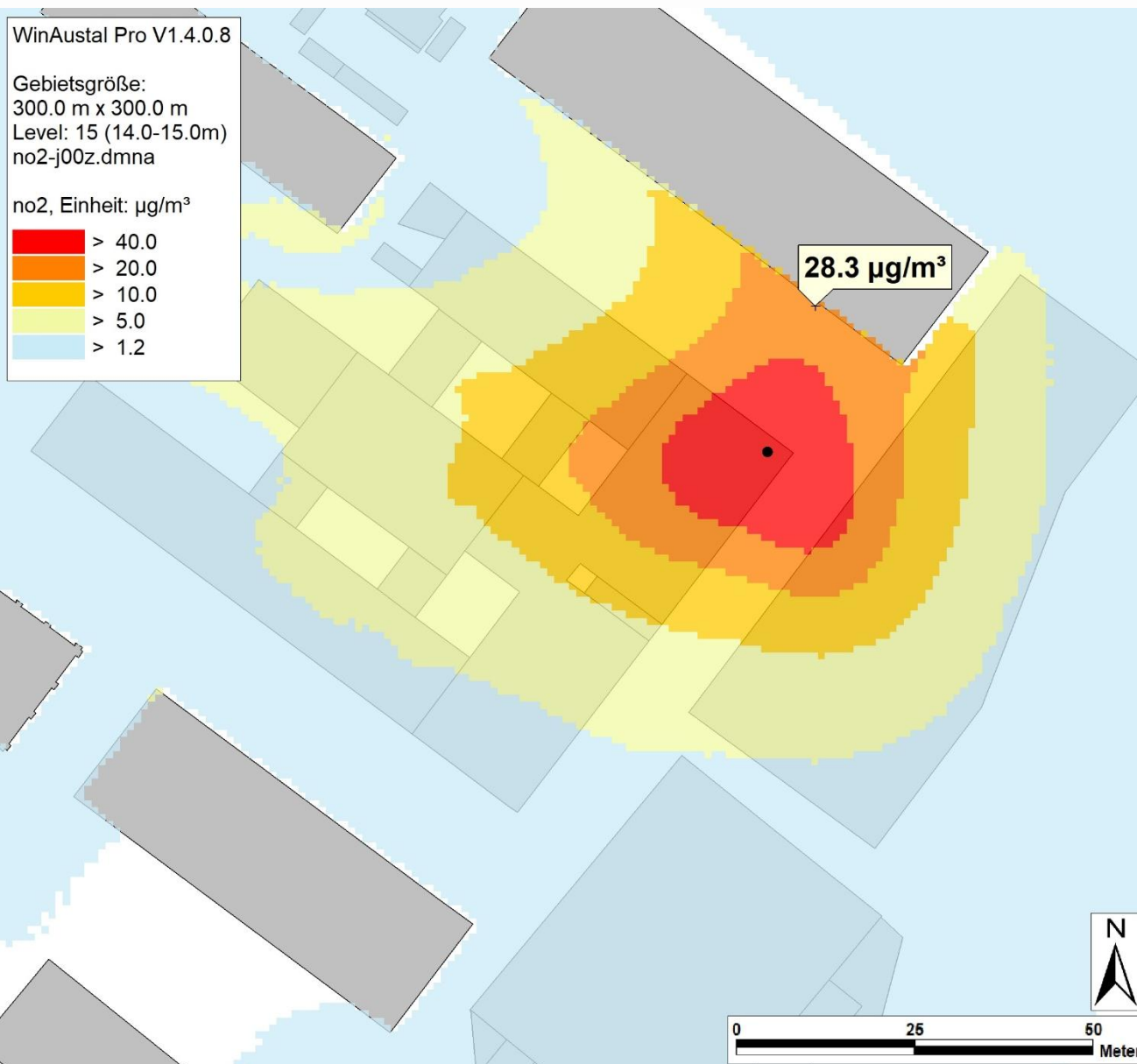


Dispersion modelling to determine possible pollutant concentrations

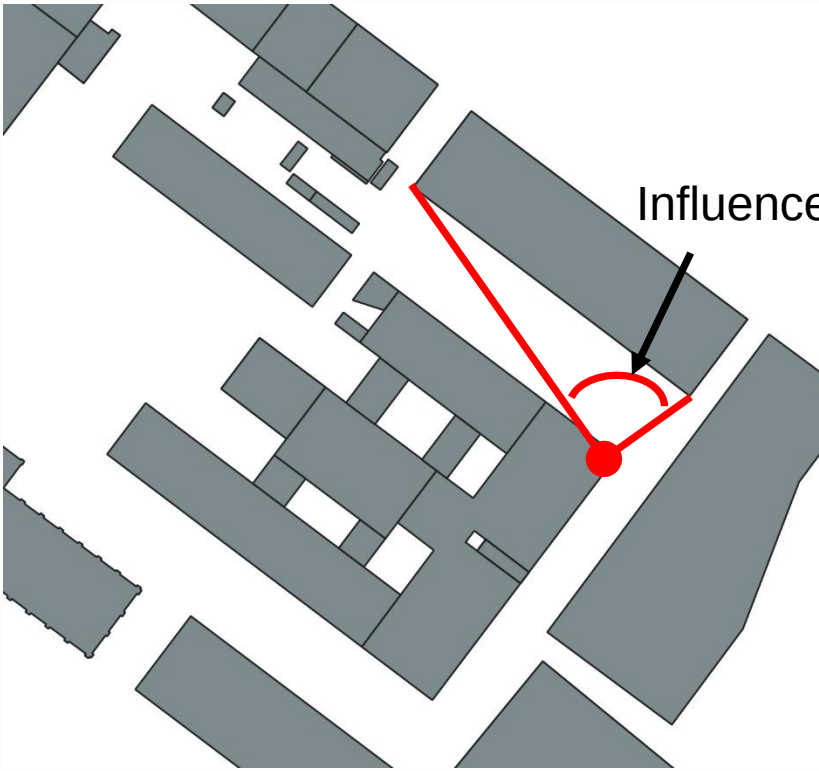




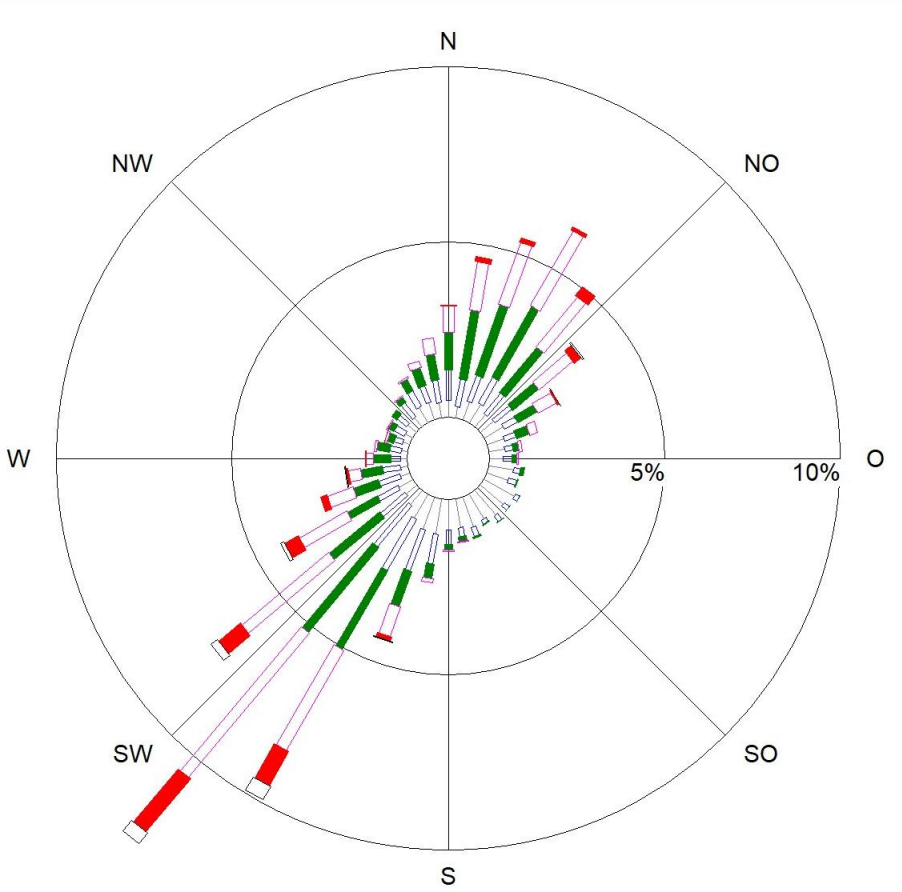
- Microscale prognostic wind field model MISKAM (RANS, $k-\epsilon$)
- Dispersion model AUSTAL
- Source height 15 m
- **No plume rise**
- Horizontal grid size 1 m
- Concentrations shown at **ground level** (0-3 m above ground)
- Result:
 - high pollutant concentrations
 - Permission probably not granted



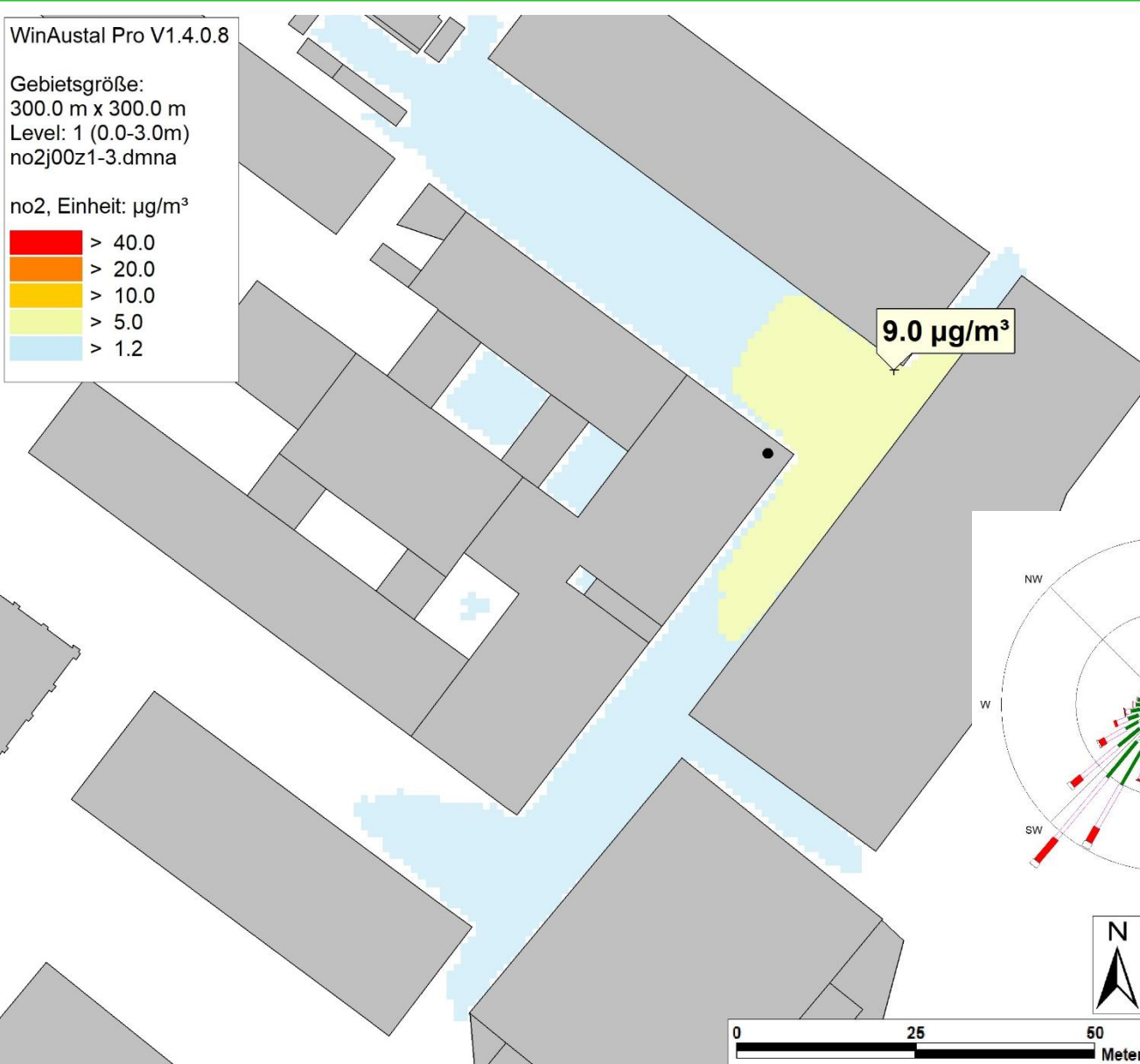
- Microscale prognostic wind field model
MISKAM (RANS, $k-\epsilon$)
- Source height 15 m
- **No plume rise**
- Horizontal grid size 1 m
- Concentrations shown at **source height**



Local wind distribution



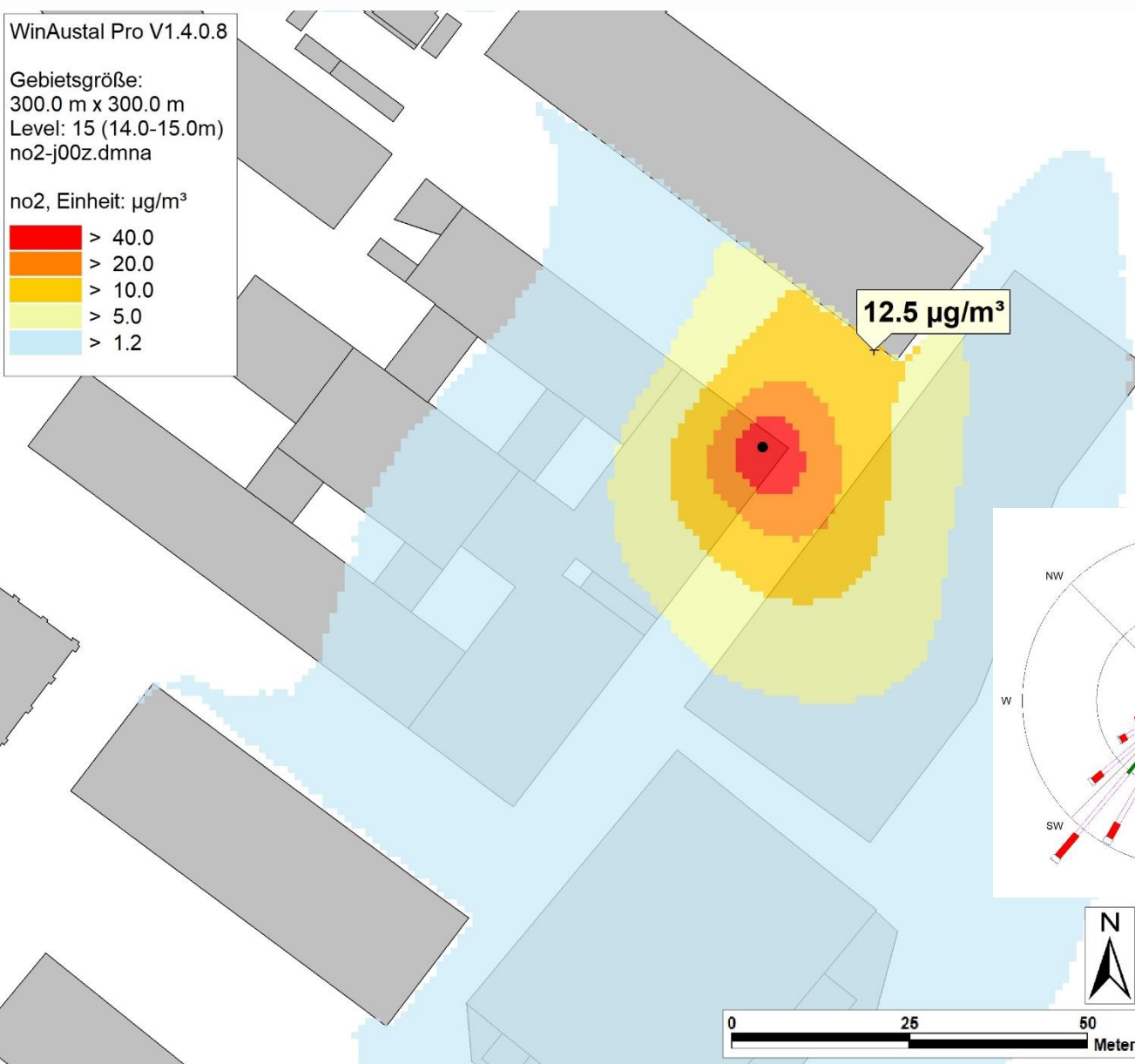
Case study 2: results modified approach



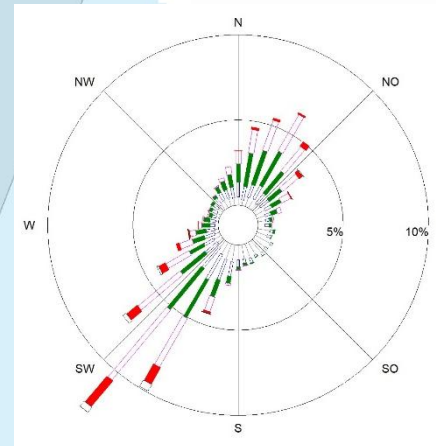
- Microscale prognostic wind field model MISKAM (RANS, $k-\epsilon$)
- Source height 15 m
- **plume rise for winds from southern directions**
- Concentrations shown at **ground level** (0-3 m above ground)

Result:

- model results more realistic
- lower pollutant concentrations
- permission might be possible



- Microscale prognostic wind field model
MISKAM (RANS, $k-\epsilon$)
- Source height 15 m
- **plume rise for winds from southern
directions**
- Concentrations shown **at source level**



Vielen Dank für Ihre Aufmerksamkeit



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