Characterization of transient dispersion processes in an urban environment

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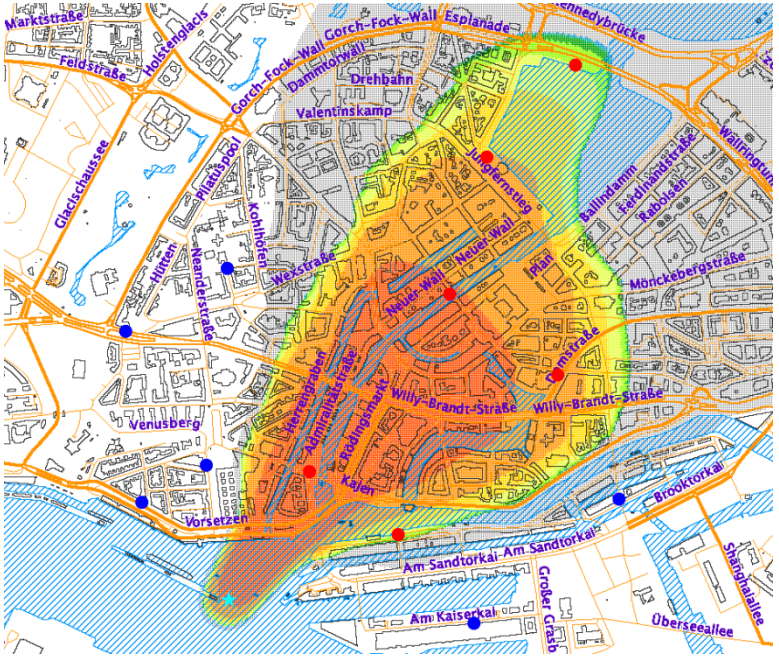
Federal Office of Civil Protection and Disaster Assistance



Technical Meteorology

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contents

- motivation
- representativeness of dispersion measurements
- comparison of dispersion results from wind tunnel measurements and numerical simulations
- summary

motivation

Technical Meteorology

- Validation of turbulence characteristics of Fast3d-CT (talk by D. Hertwig)
- Validation of the LES-based Emergency Response Tool CT-Analyst for a typical European city
- Evaluation of predicted concentrations, travel times and affected areas by comparisons with field and wind tunnel data

NRL Fast3d-CT Model

CT-Analyst

wind tunnel model

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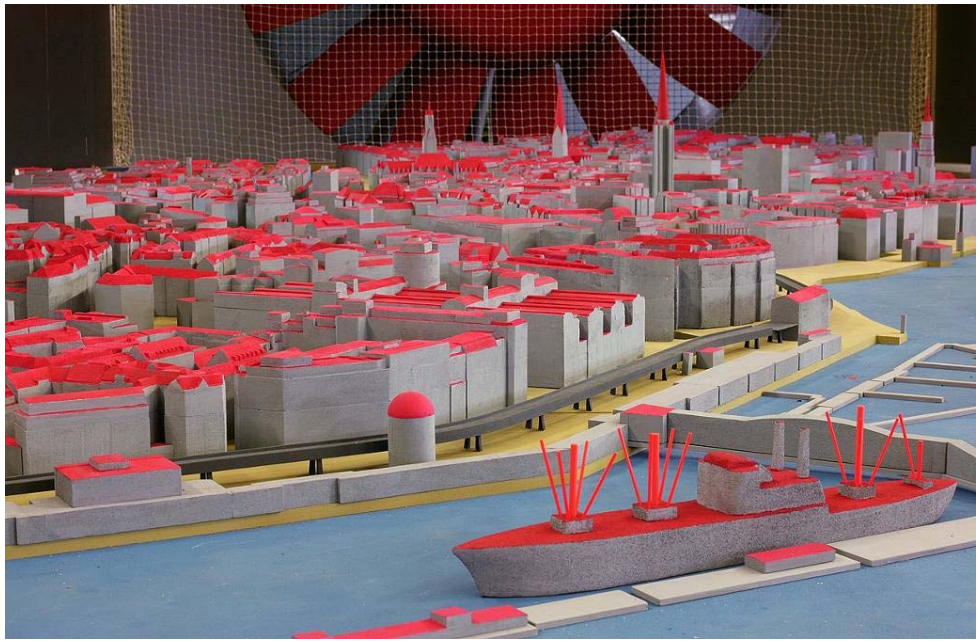
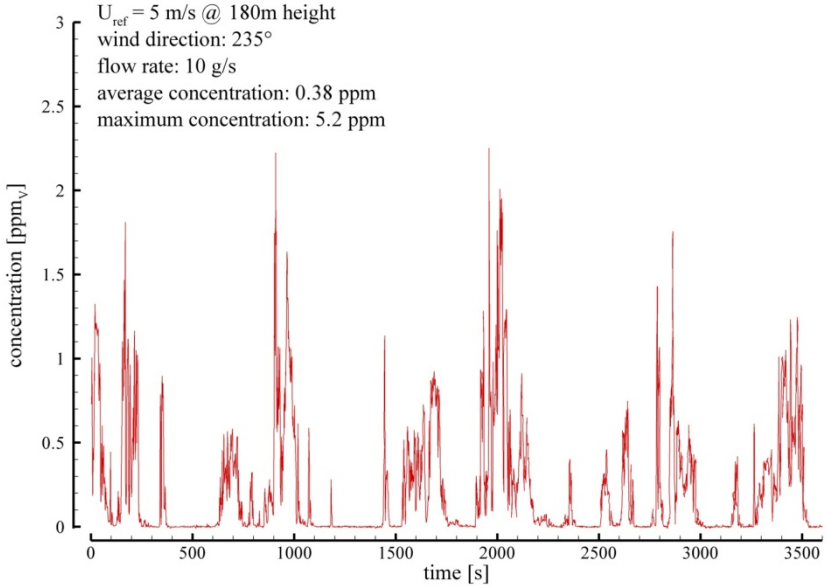
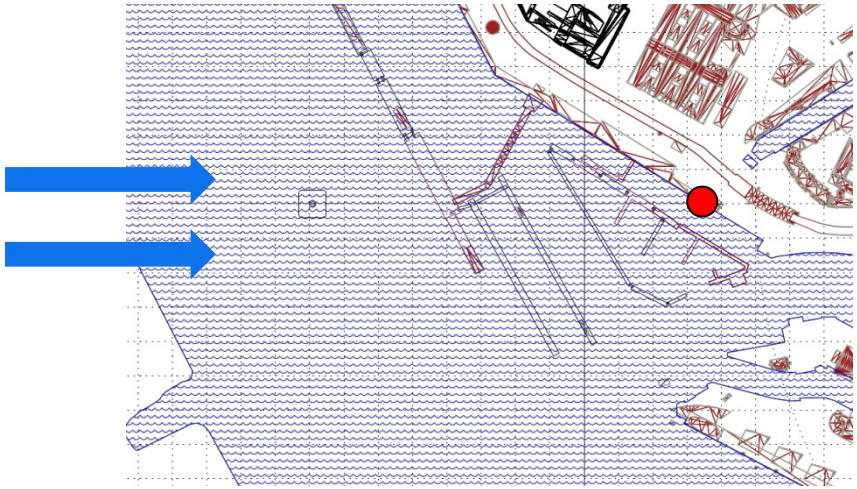
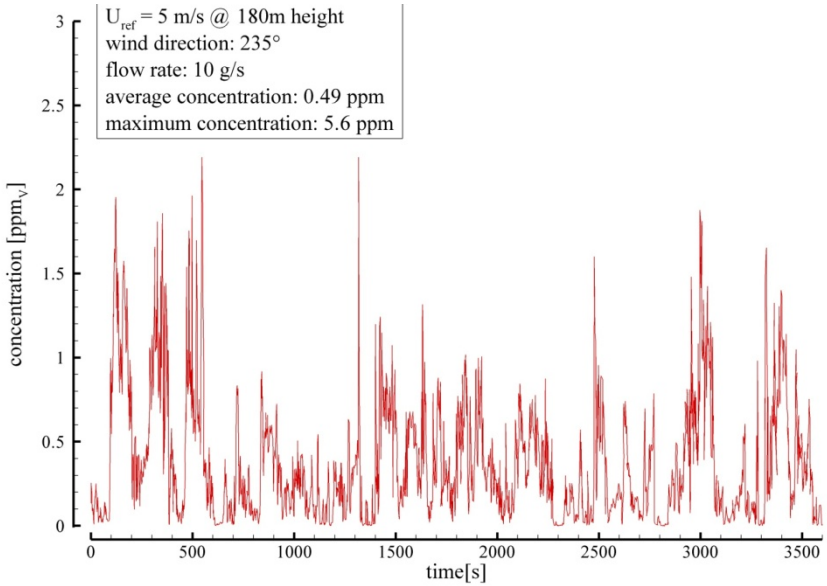
- wind speed 0 ... 20 m/s
- 3D probe positioning system
- model scale 1:350
- 1.4km x 3.7km
- wind direction 235°
- rough boundary layer flow (similar to full scale)

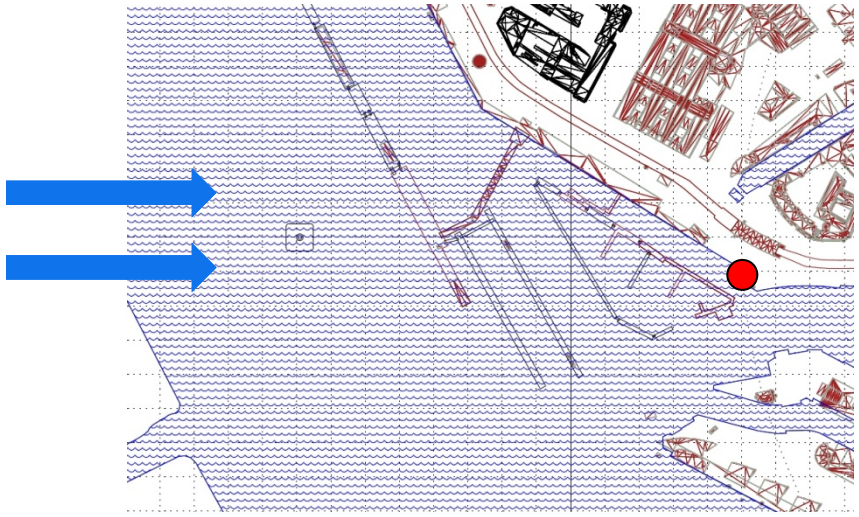


wind tunnel measurements









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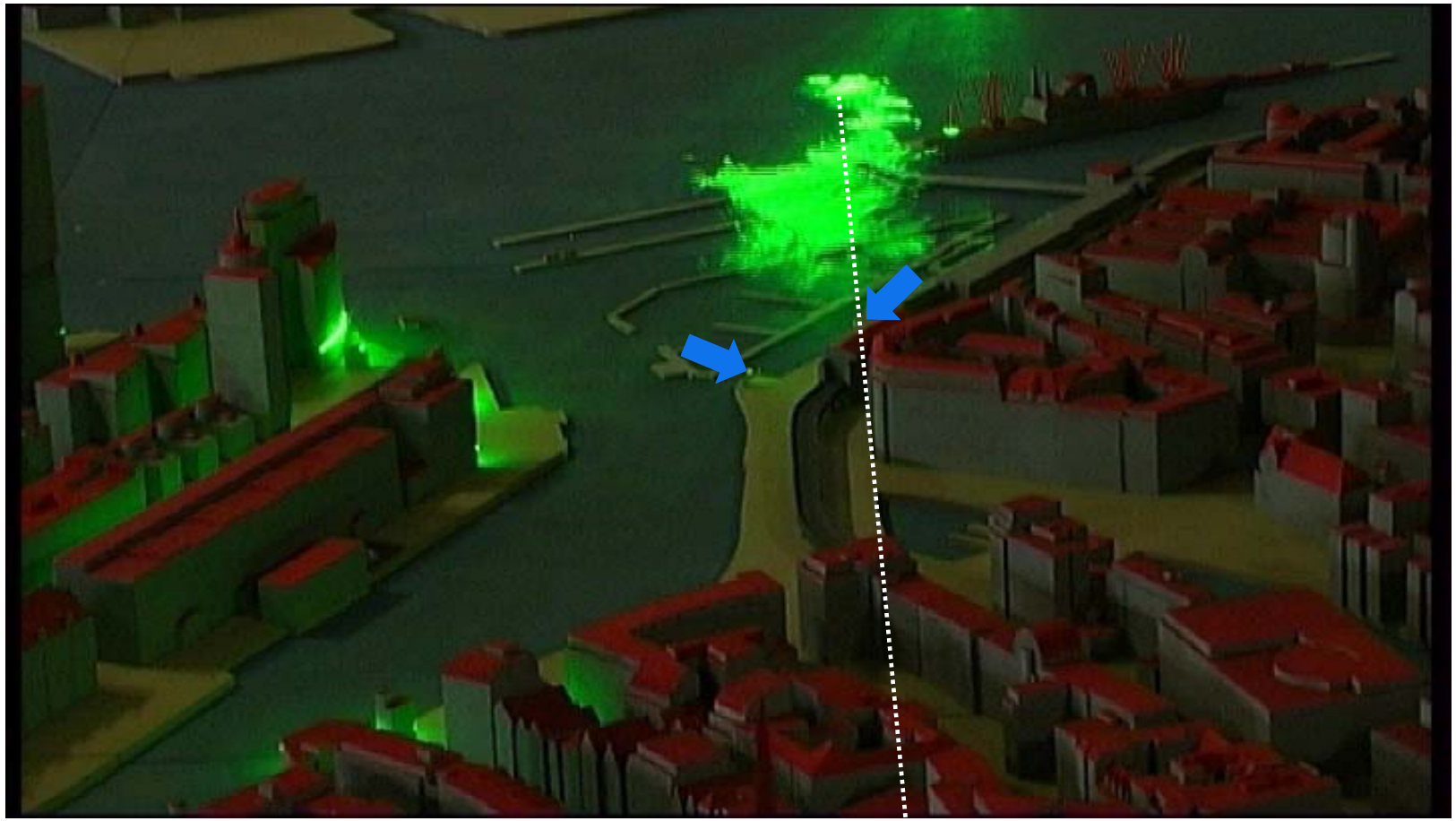
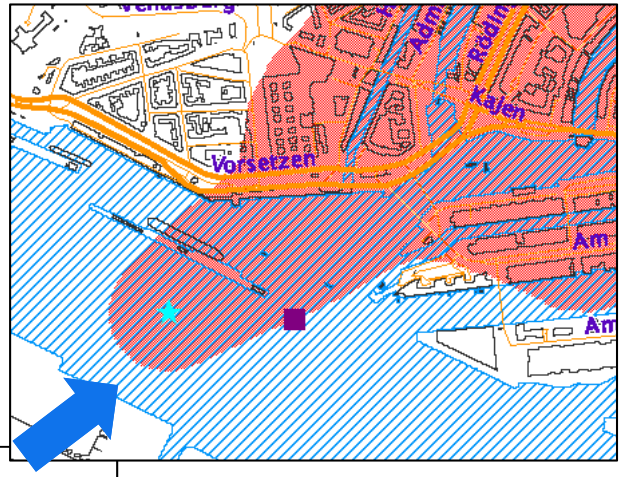
wind tunnel measurements

- **flow visualization / continuous release**

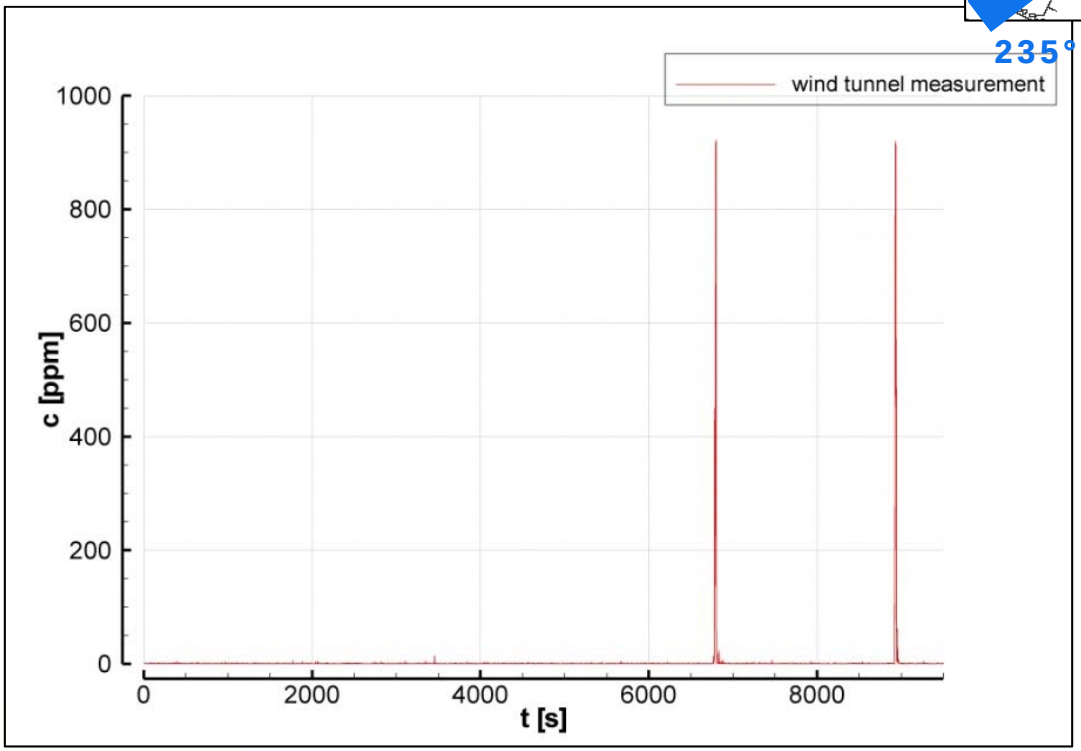


wind tunnel measurements

- **plume edge detection**



235°, wind speed of 5m/s @ 80m height



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wind tunnel measurements

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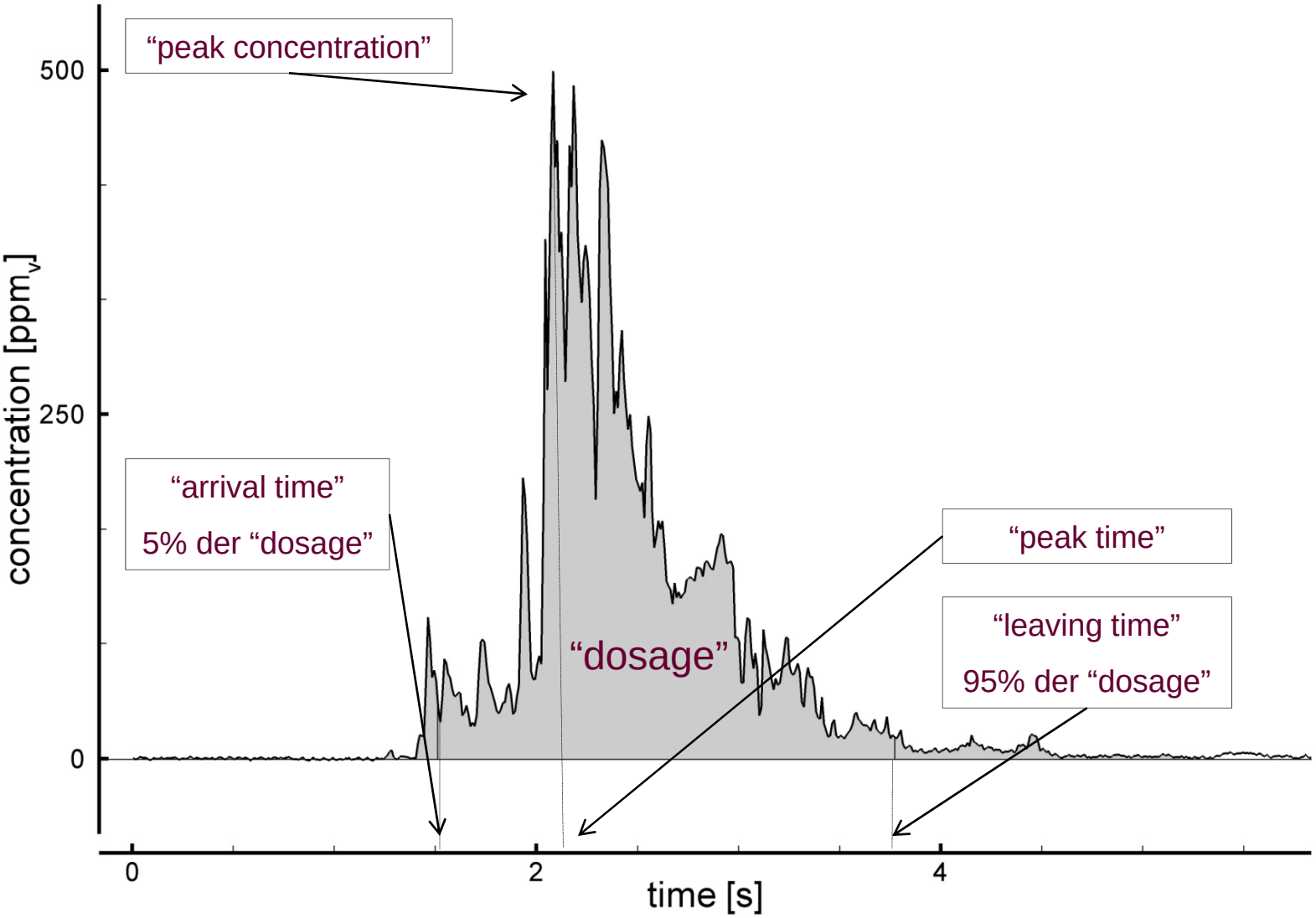
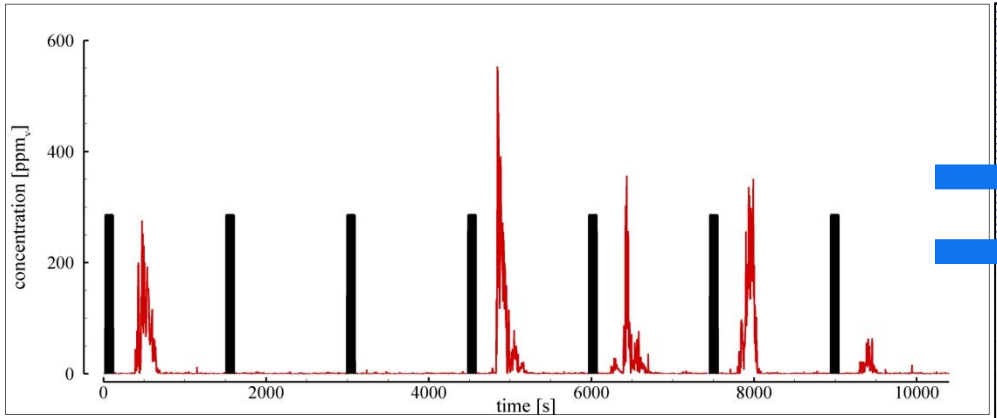
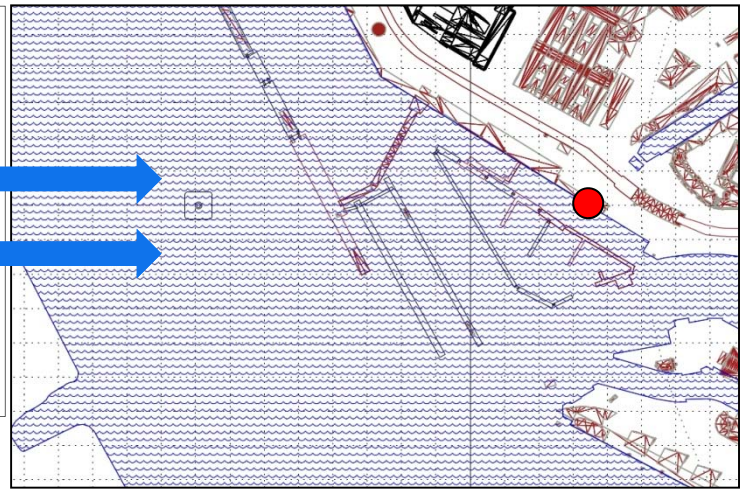
puff parameter

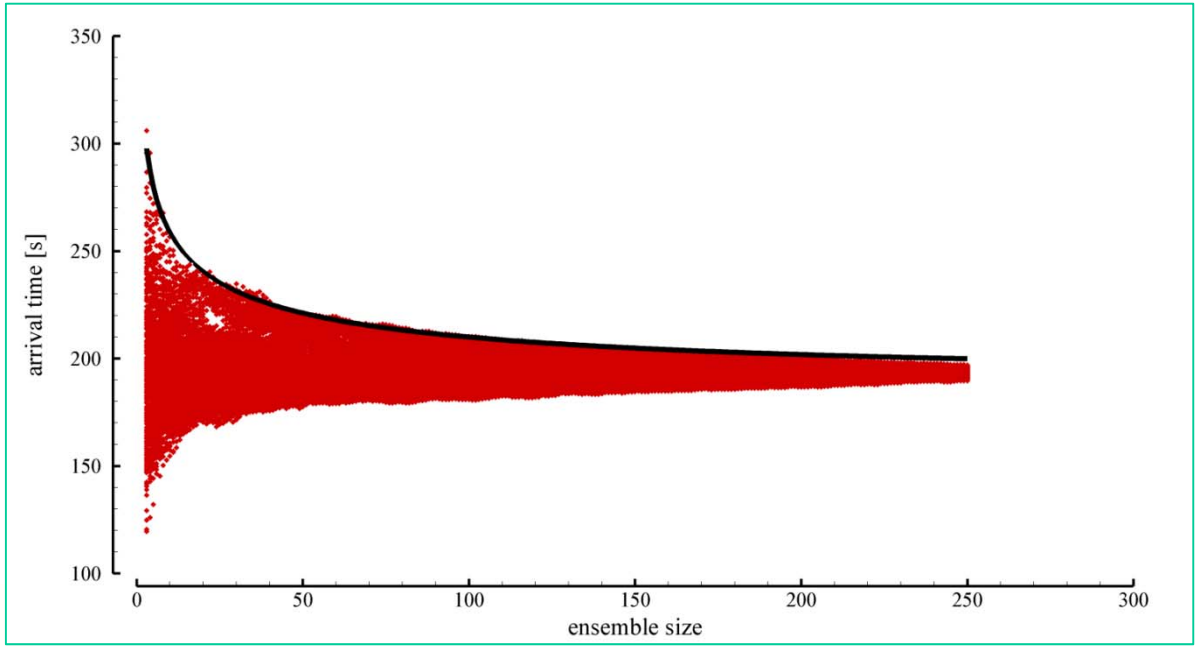


wind tunnel measurements





- 362 released puffs
- 262 puffs detected at measurement location
- Uref = 5 m/s @ 180m height



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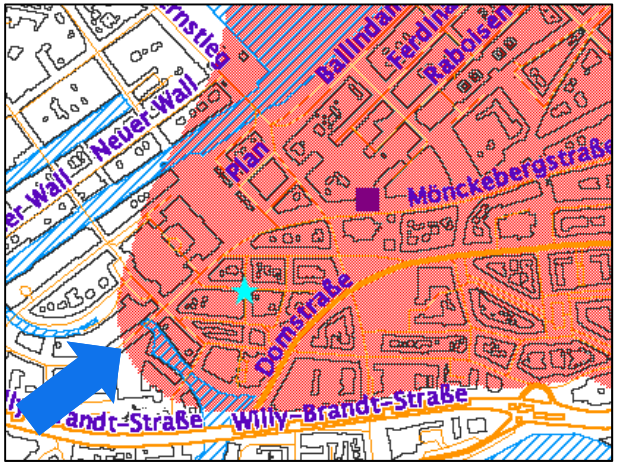
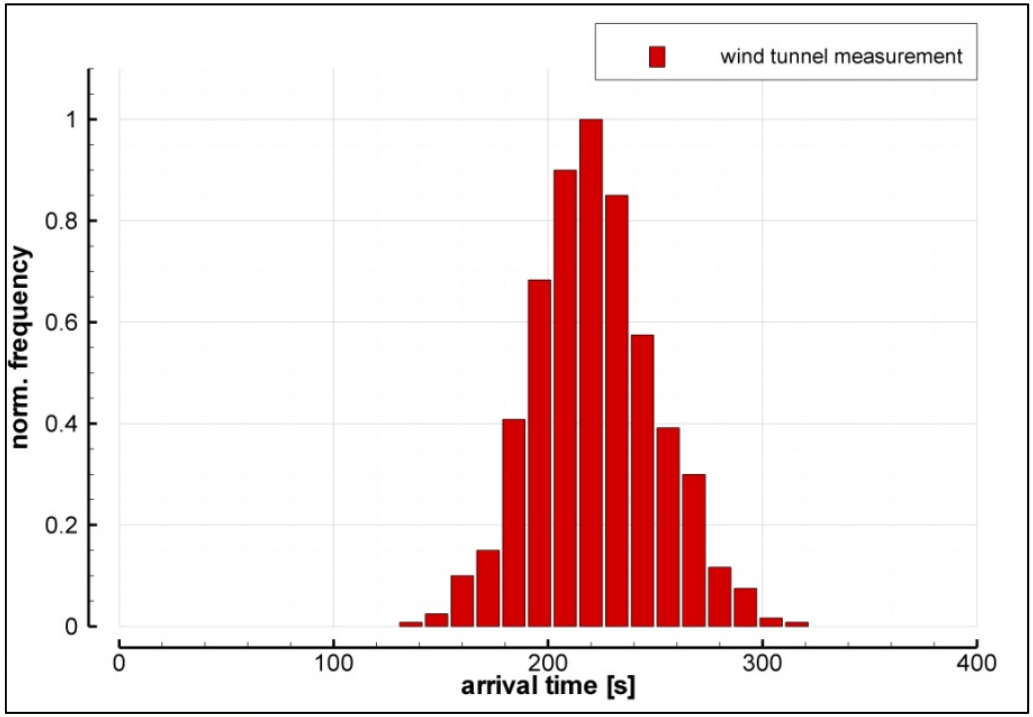
wind tunnel measurements

- travel time measurements



235°, wind speed of 5m/s @ 80m height



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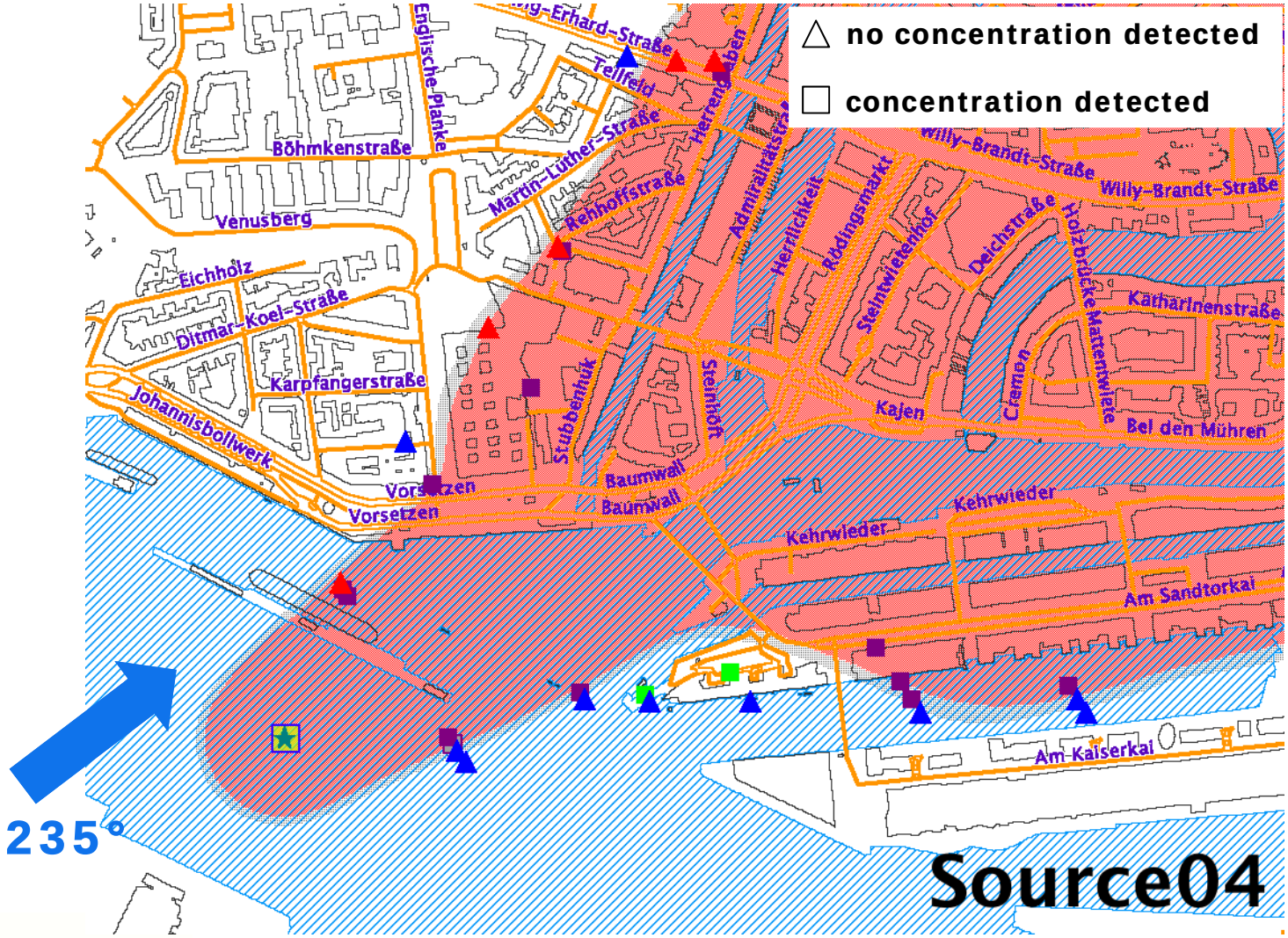
comparison of affected area

plume edge detection



comparison of affected area

Technical Meteorology

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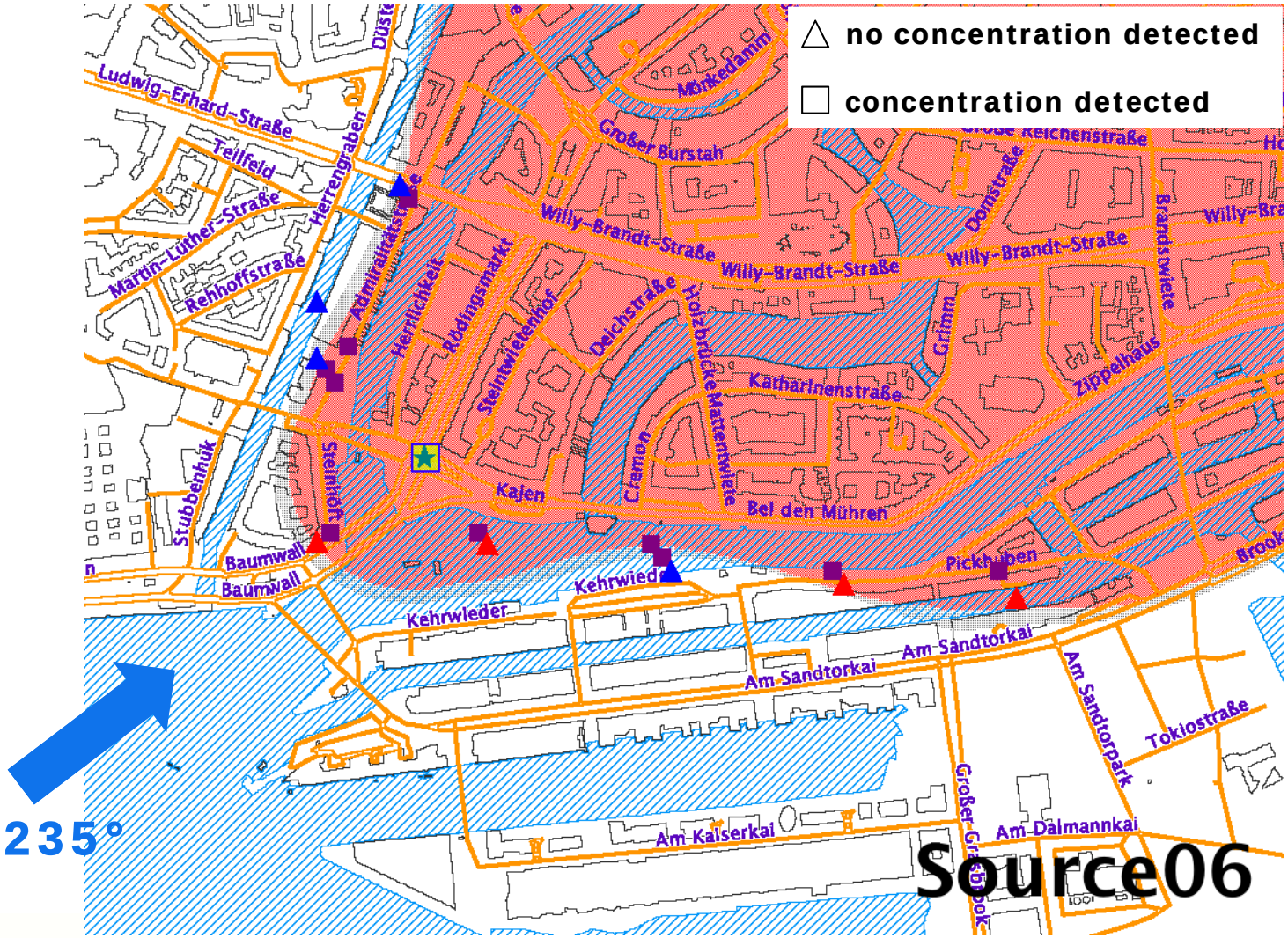
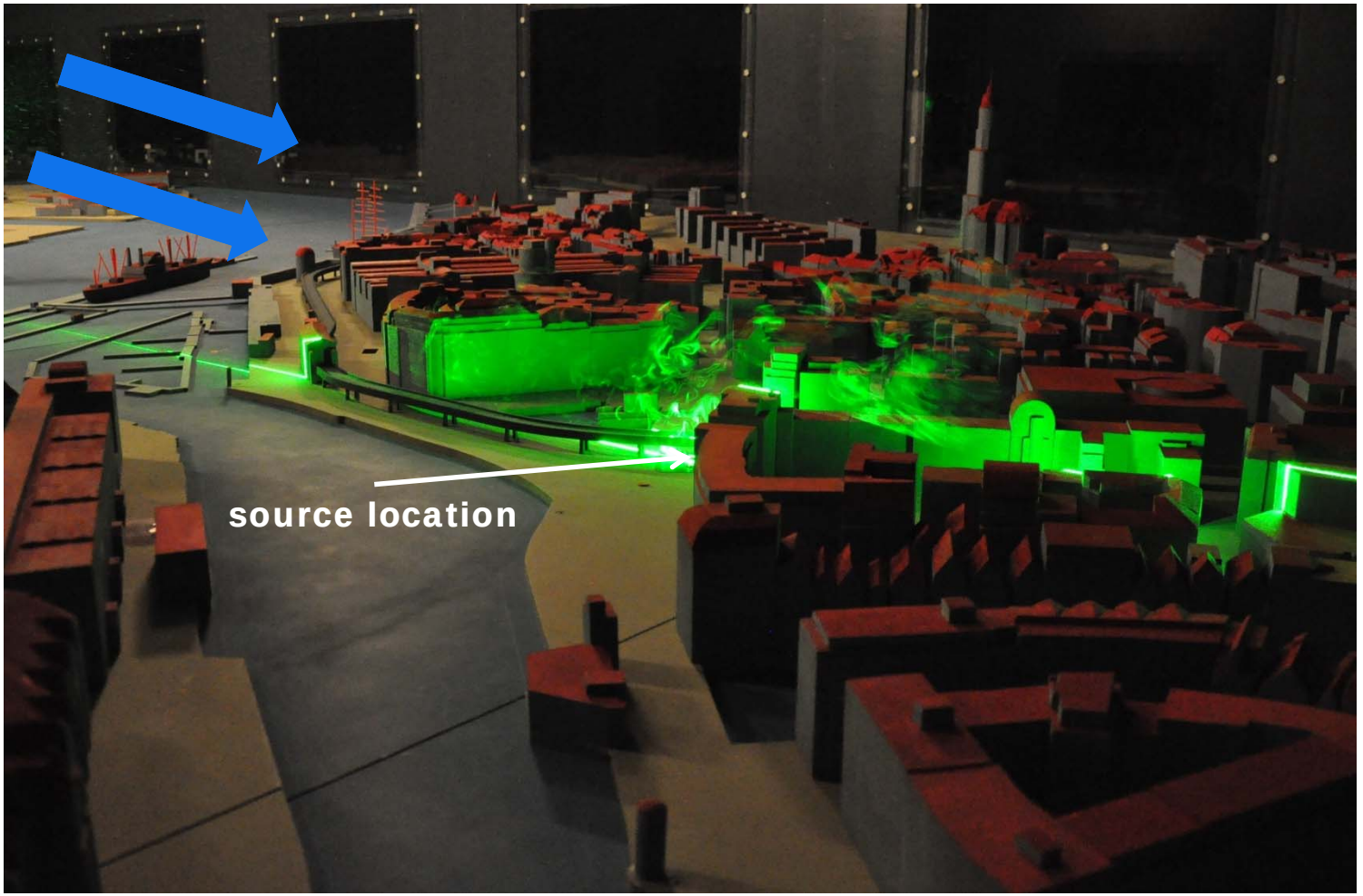


comparison of affected area

- **plume edge detection**



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comparison of affected area

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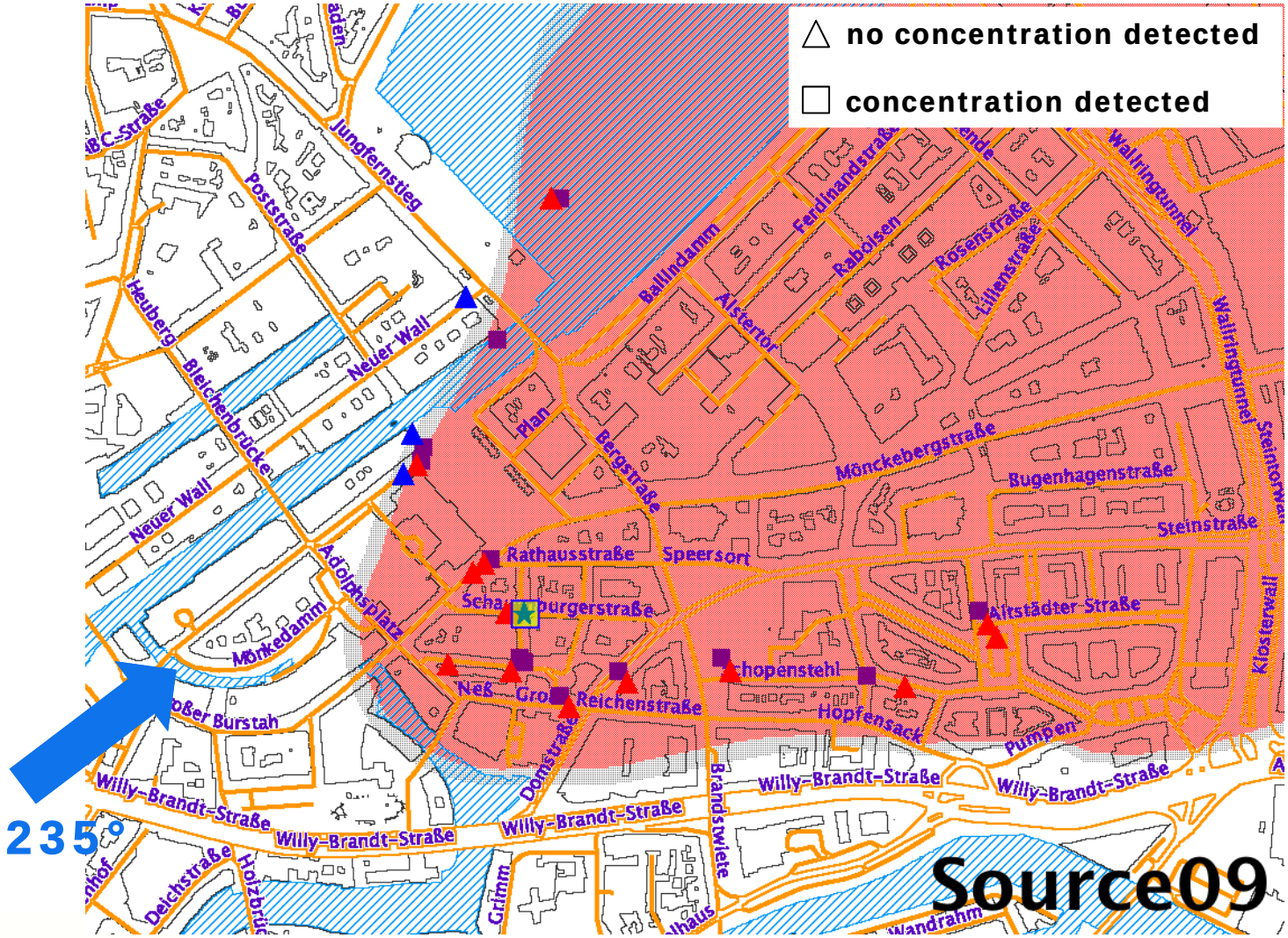
plume edge detection



summary / outlook

- two field campaigns in Hamburg and systematic wind tunnel measurements were carried out to characterize dispersion phenomena in a typical European city
- dispersion processes in an urban area are complex and can not completely be characterized by field tests
- wind tunnel measurements provides the possibility to generate statically representative validation data
- the prediction of the affected area coincides with the results of wind tunnel measurements
- a comparison of measured and predicted concentrations will be done in the near future

Questions?

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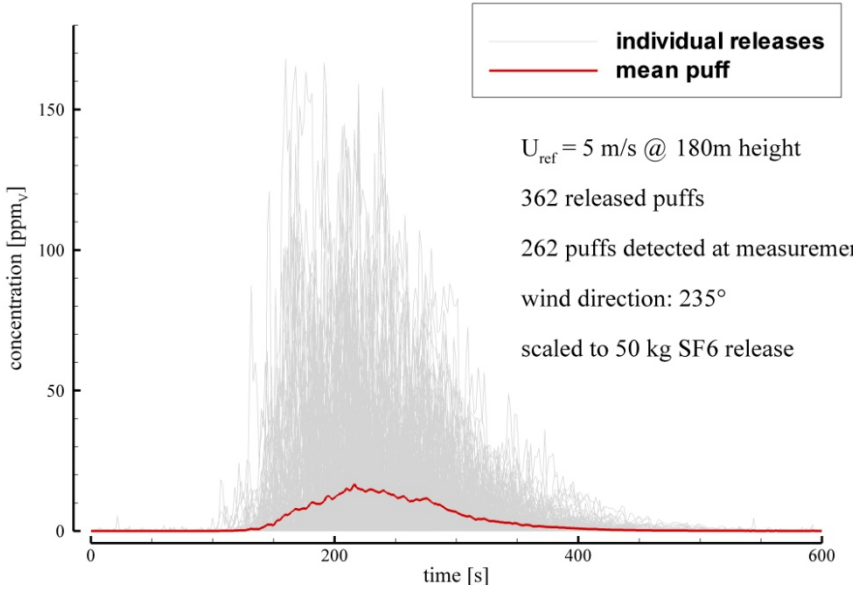
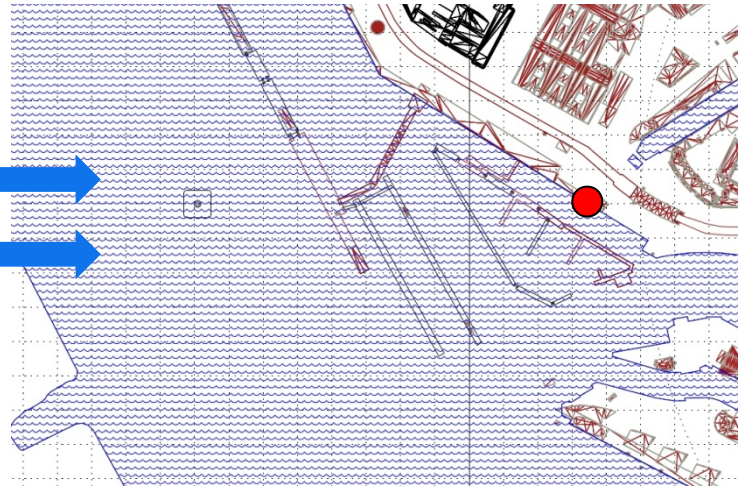
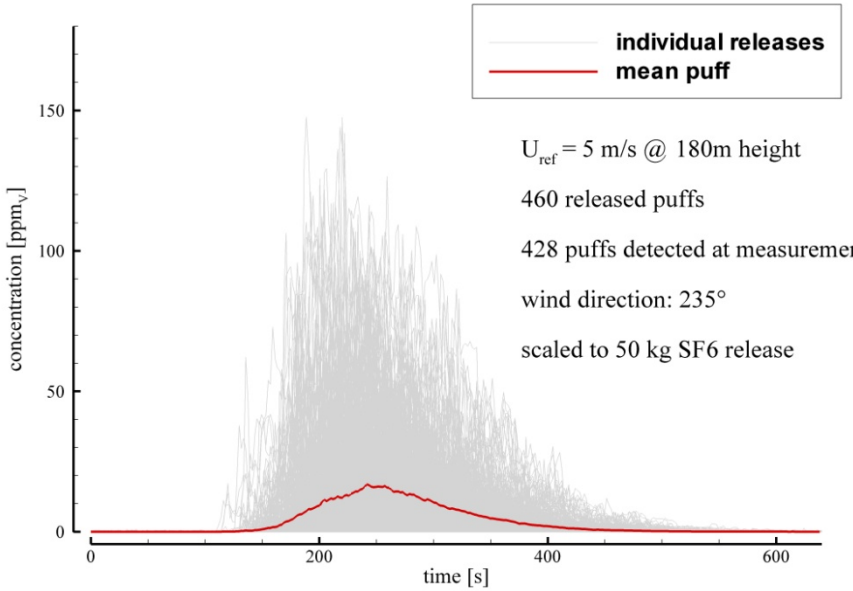
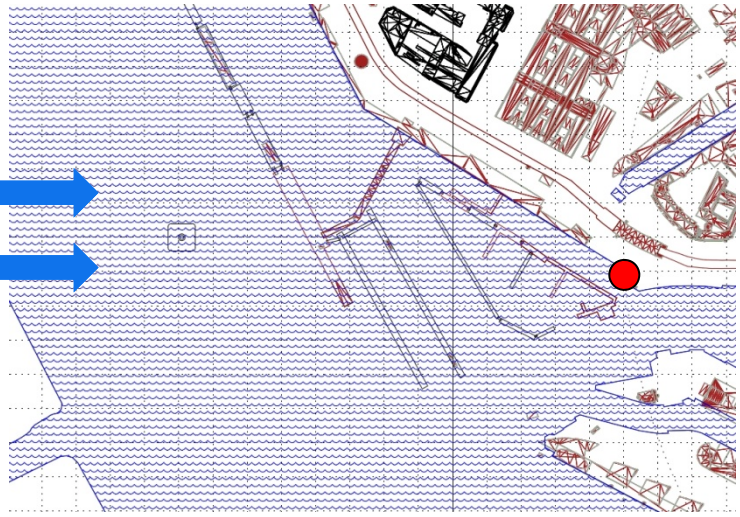
additional slides

wind tunnel measurements









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numerical model

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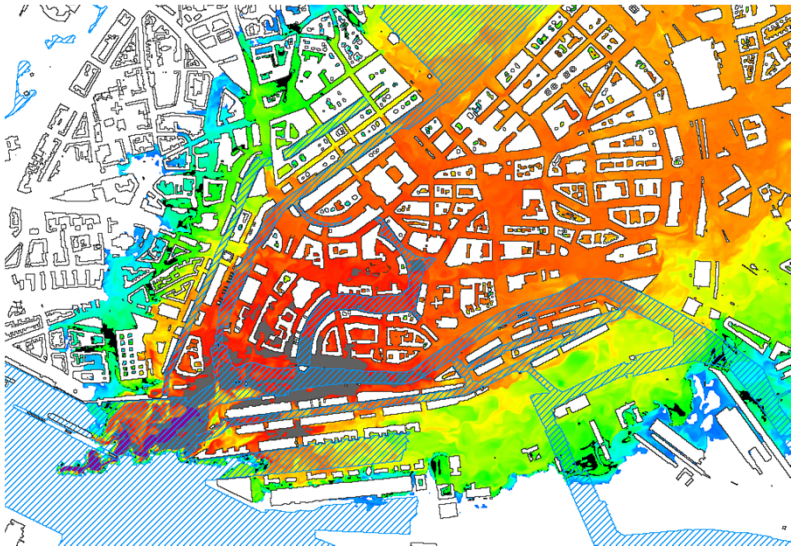
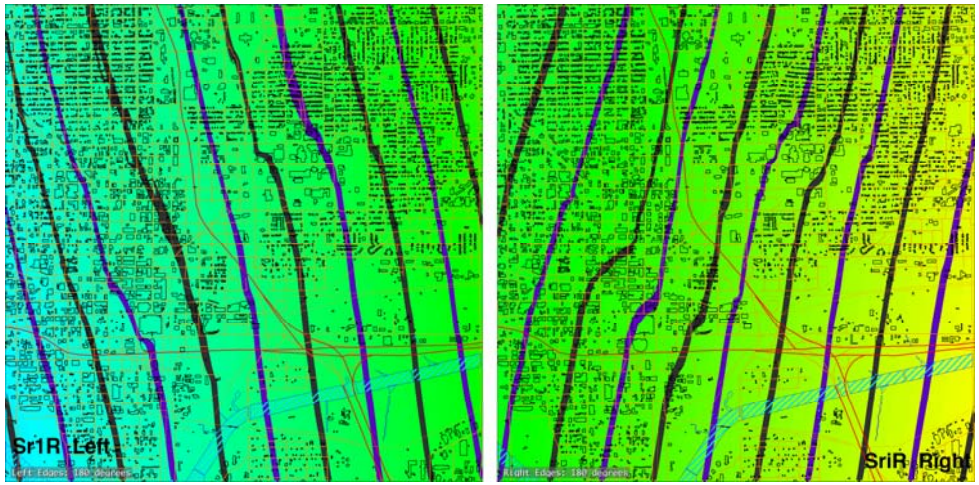
- 3D CFD LES calculations are run on a Supercomputer generating Dispersion Nomografs™
- CT-Analyst® utilizes Dispersion Nomografs™ to provide real-time, accurate plume displays
- Capable of delivering real-time plume model requests in micro-seconds



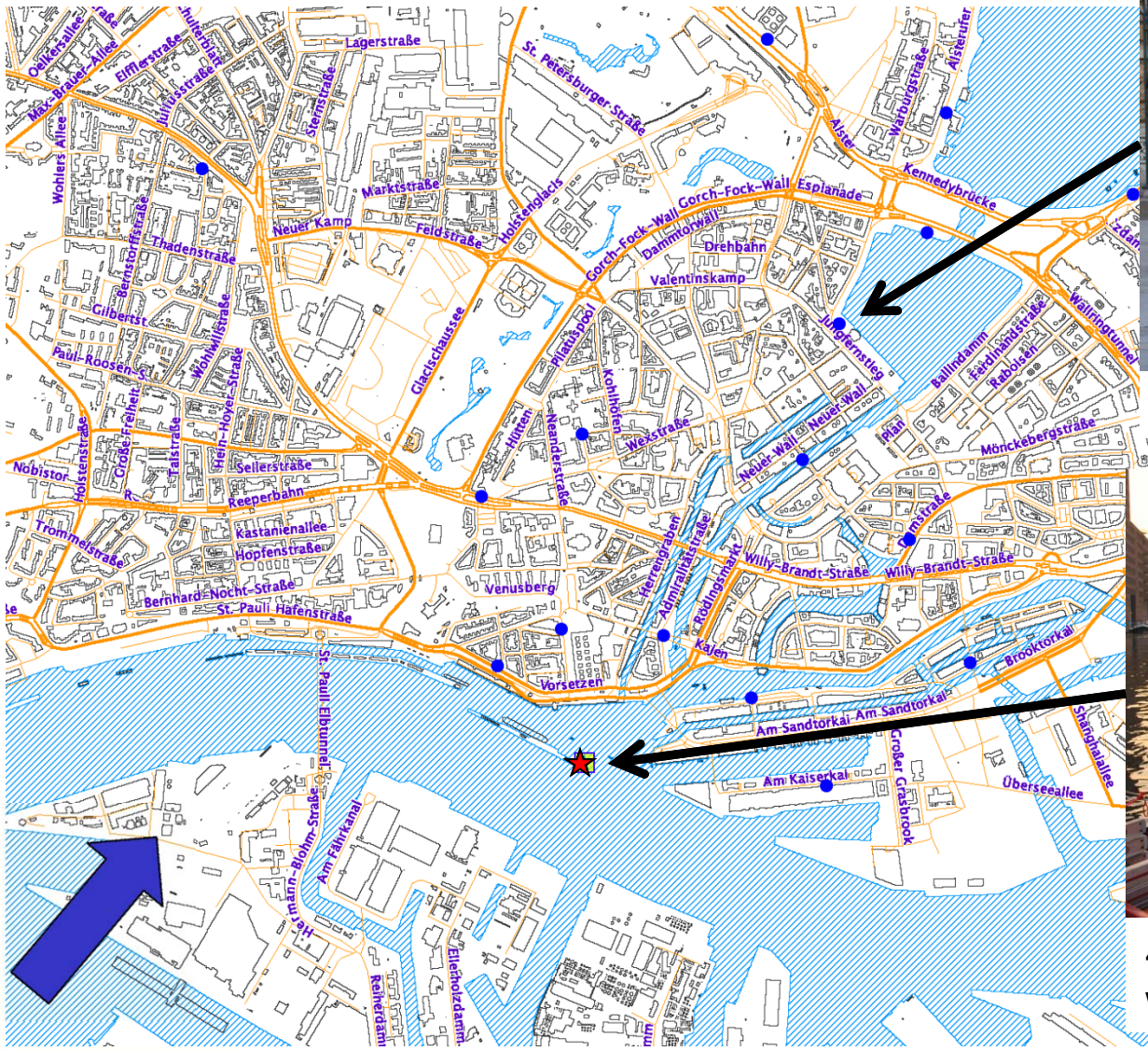
NRL Fast3d-CT Model



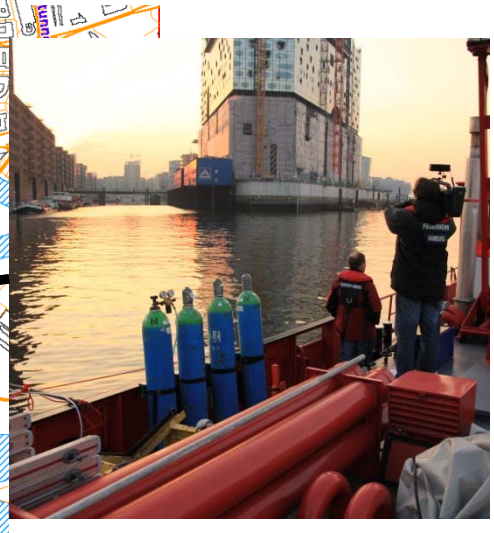
“Nomograf” Generator Subsystem

field measurement

- 2 field tests in the city of Hamburg



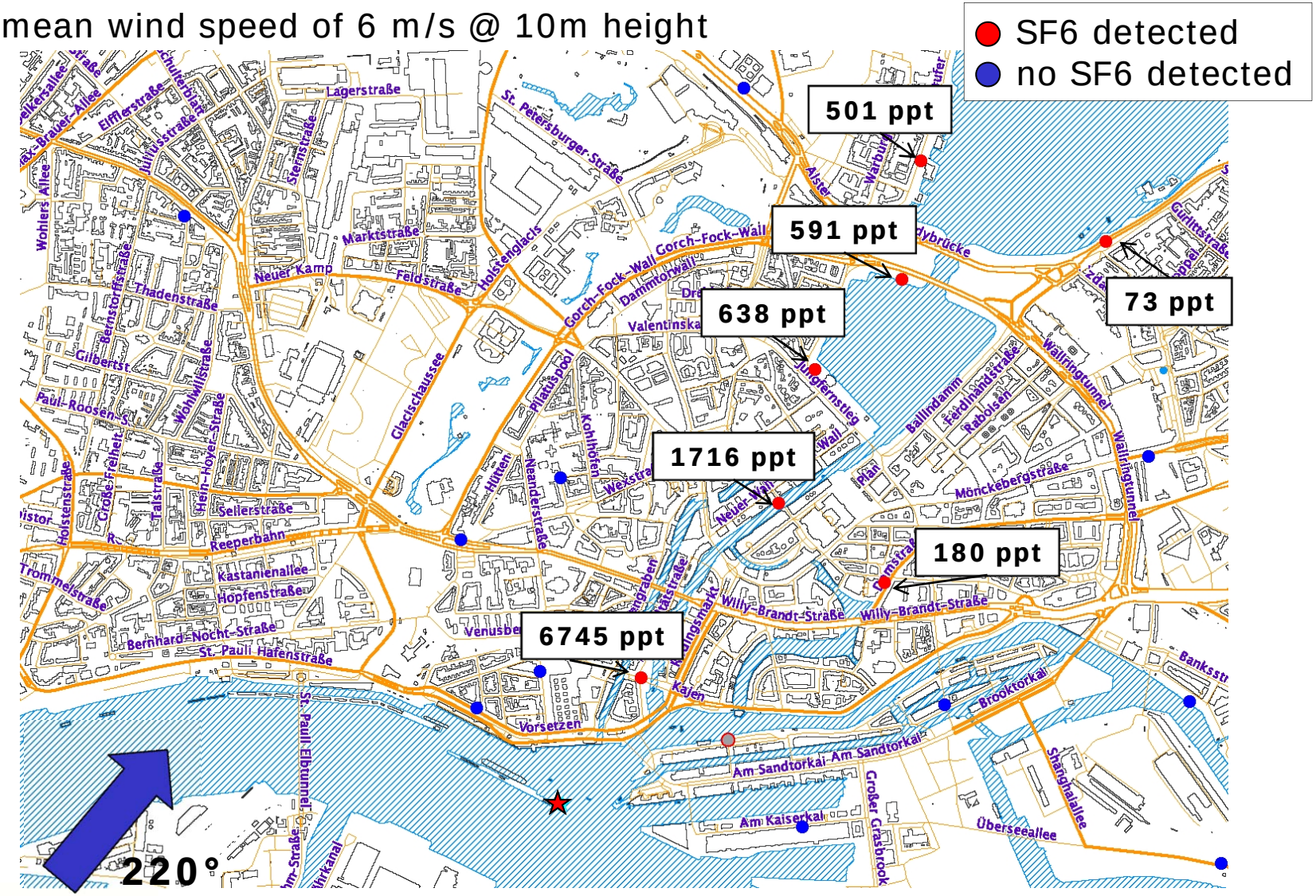
20 bag samplers



45min release of SF6 with 1 g/s

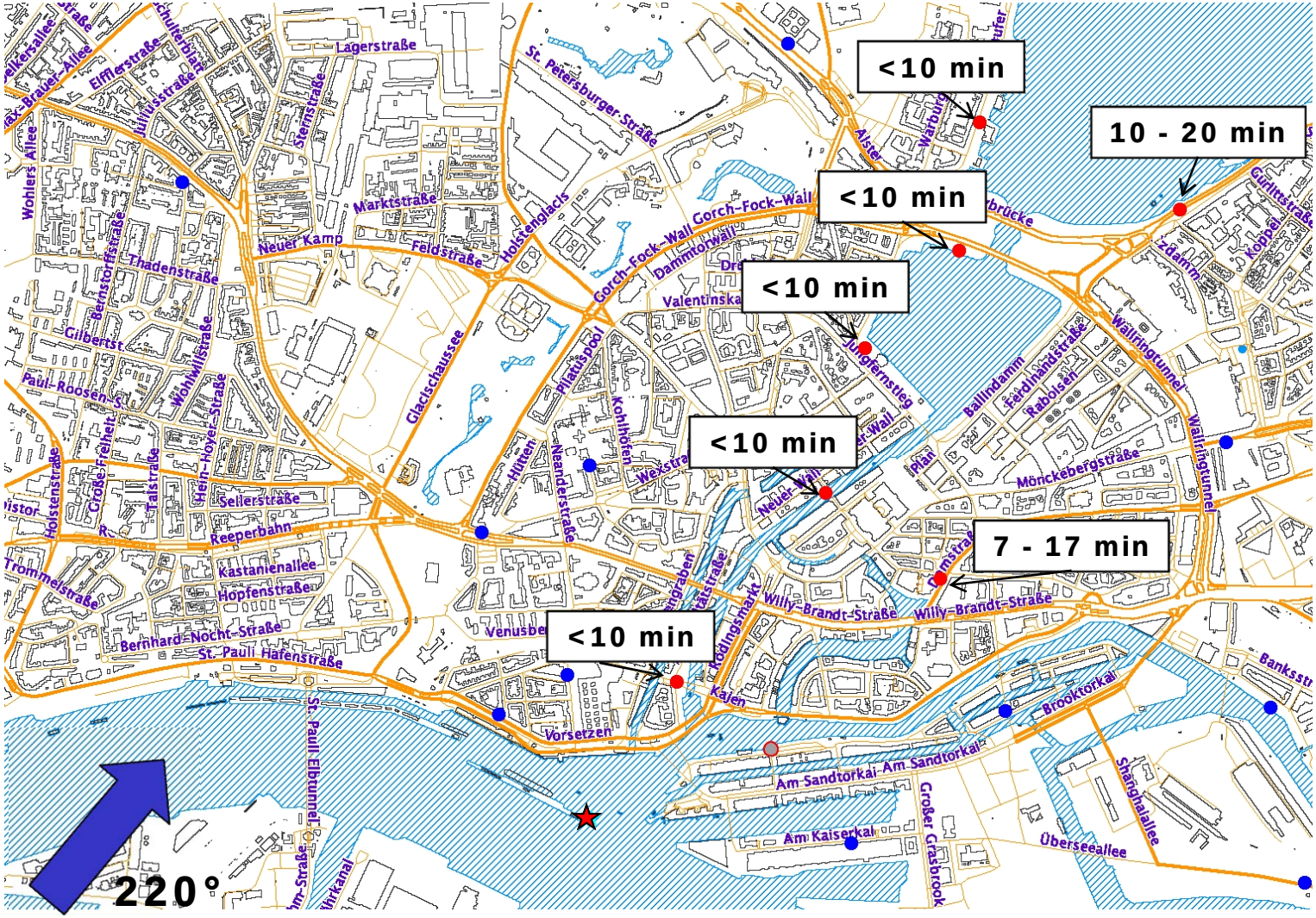
field measurement

- affected area
- mean wind speed of 6 m/s @ 10m height



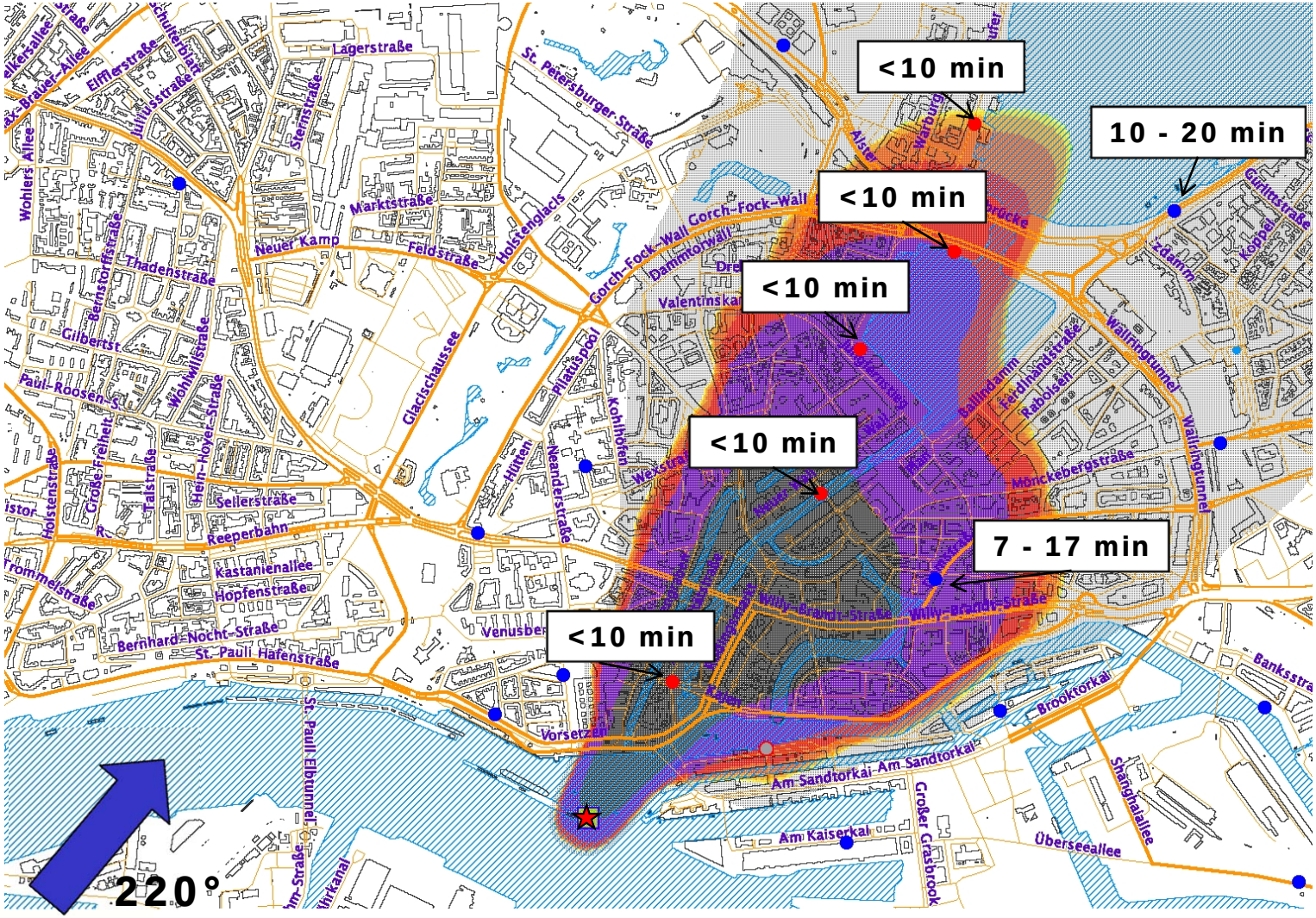
field measurement

- measured travel time
- mean wind speed of 6 m/s @ 10m height



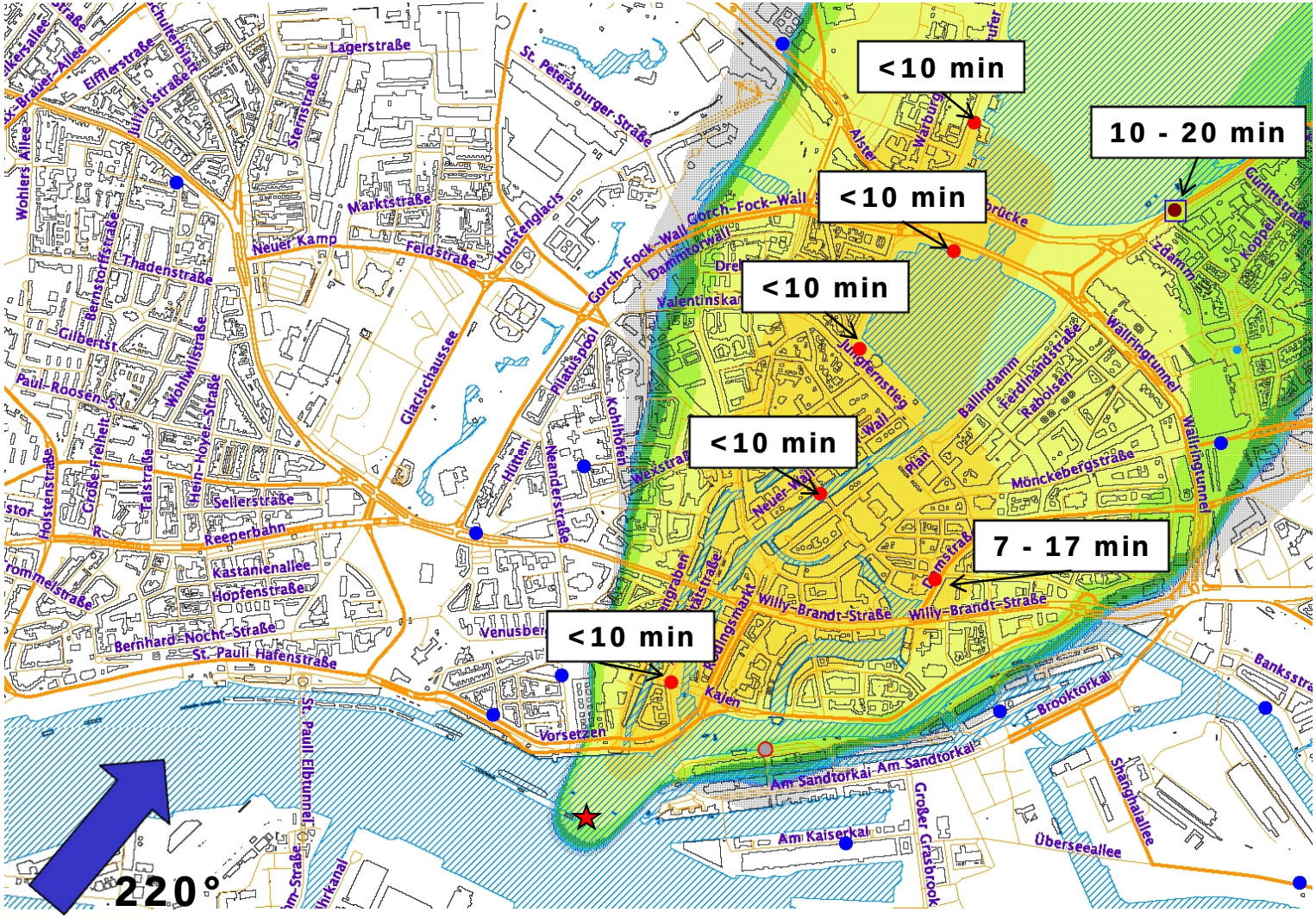
travel time comparison

- modeled dispersion after 5 minutes
- mean wind speed of 6 m/s @ 10m height

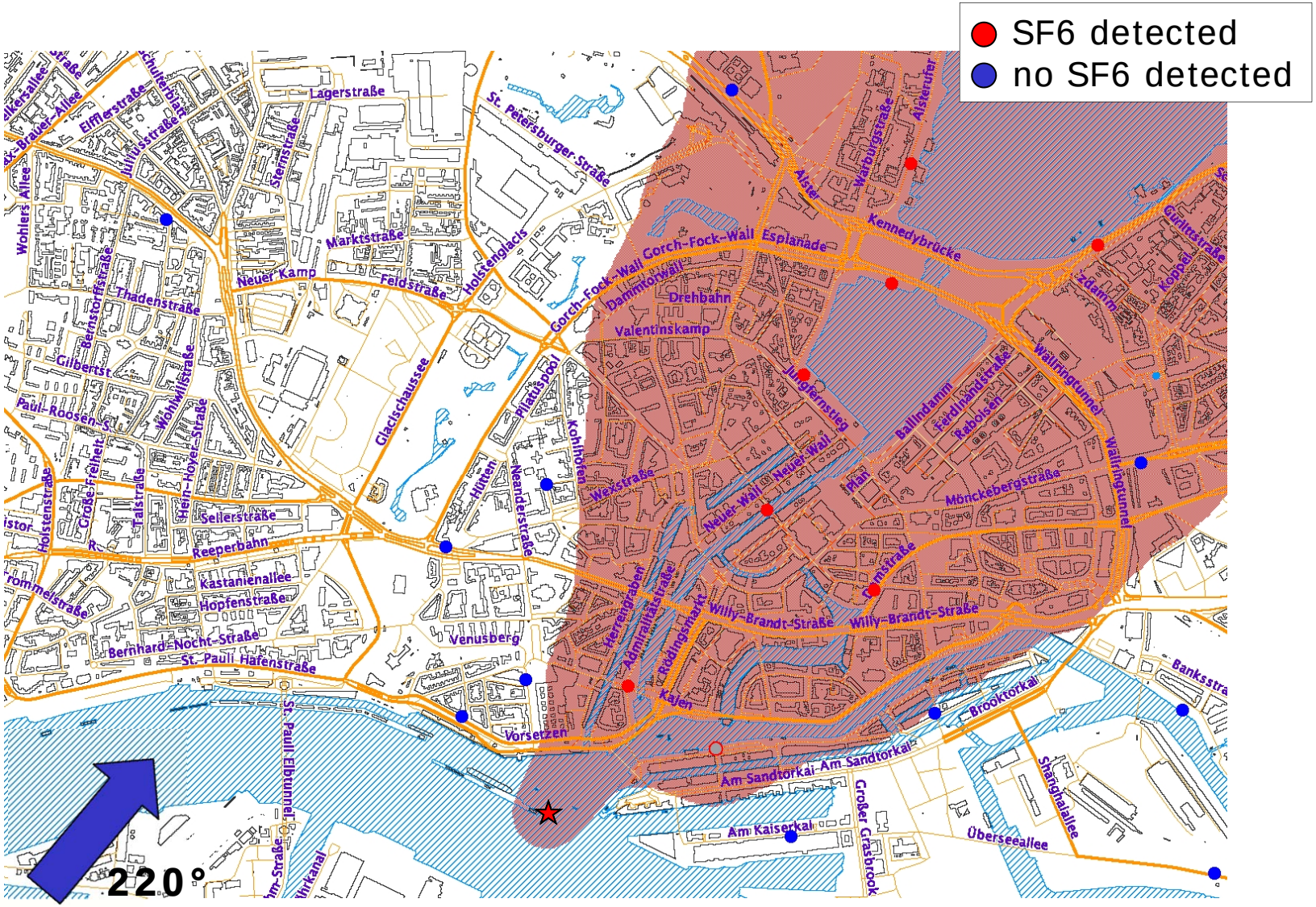


travel time comparison

- modeled dispersion after 10 minutes
- mean wind speed of 6 m/s @ 10m height



comparison of affected area



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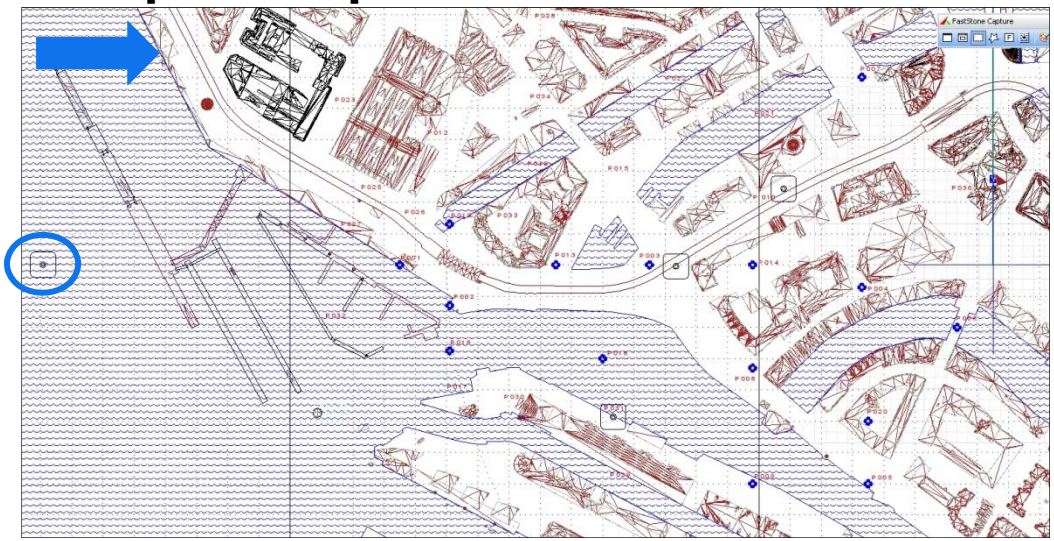
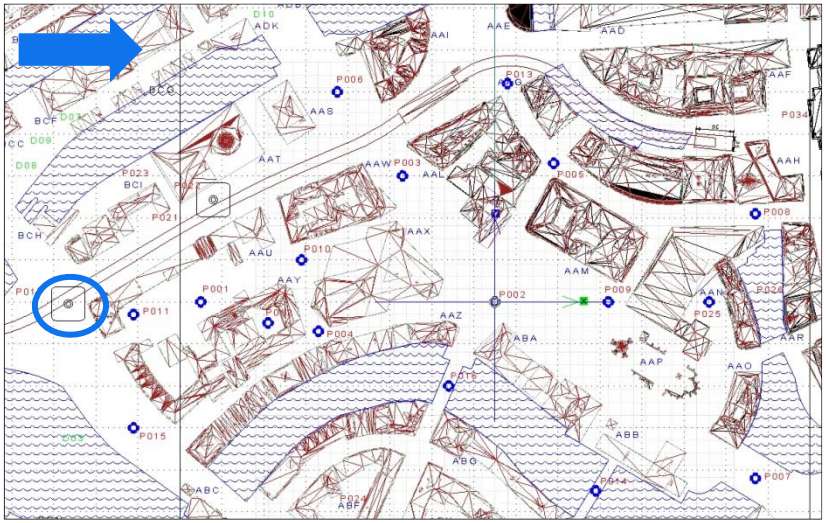
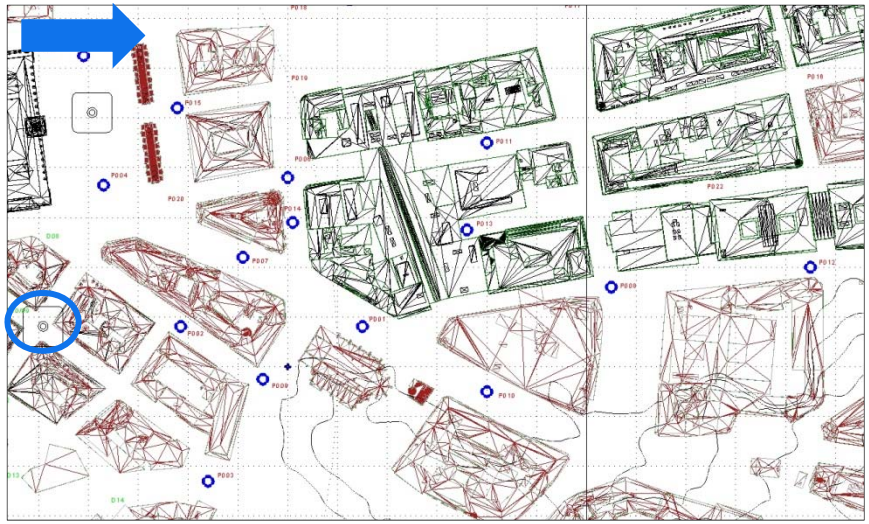
- **measurement locations of puff dispersion measurements**







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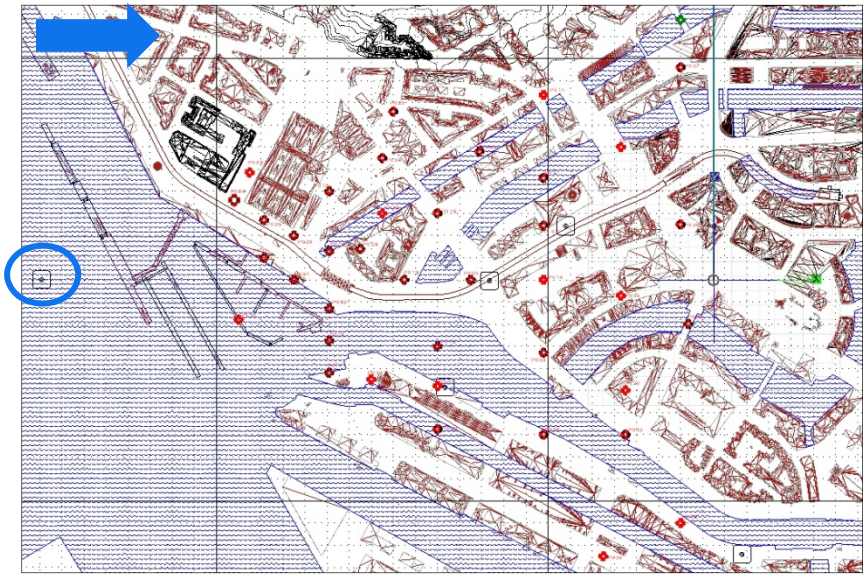
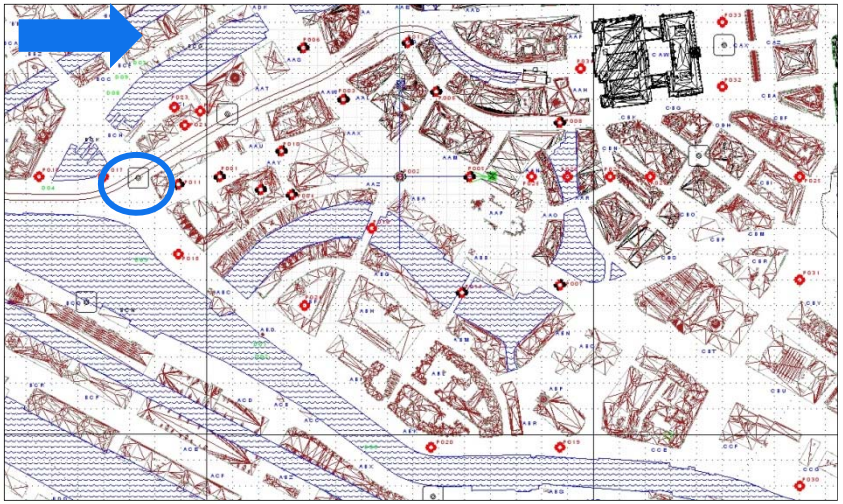
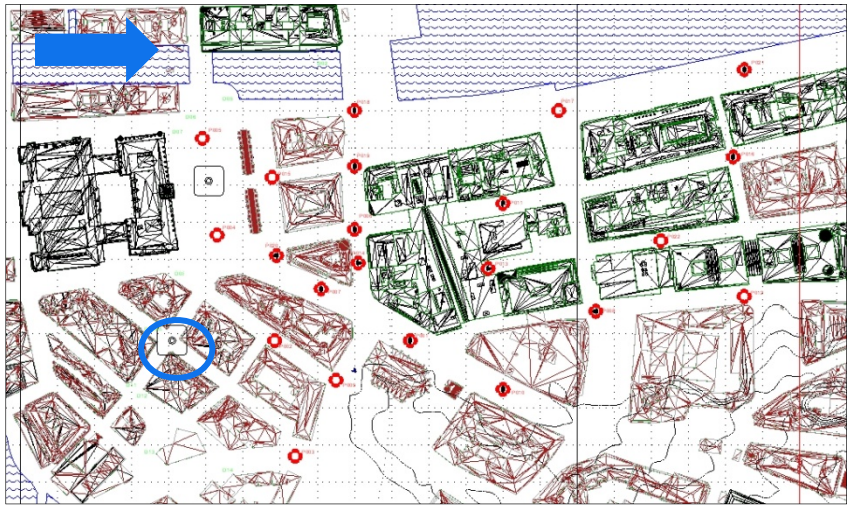
- **measurement locations of continuous release measurements**







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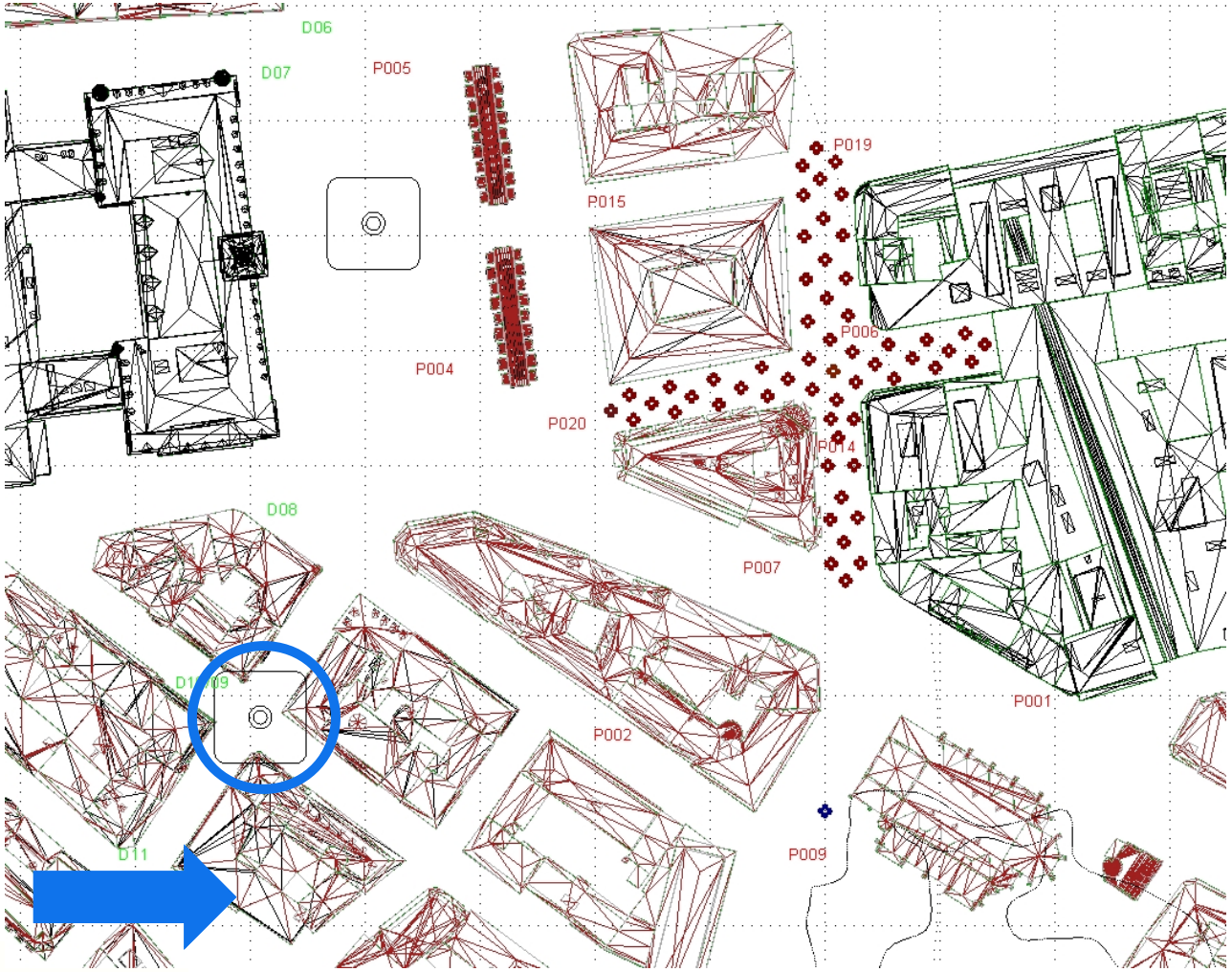
- **local variability**



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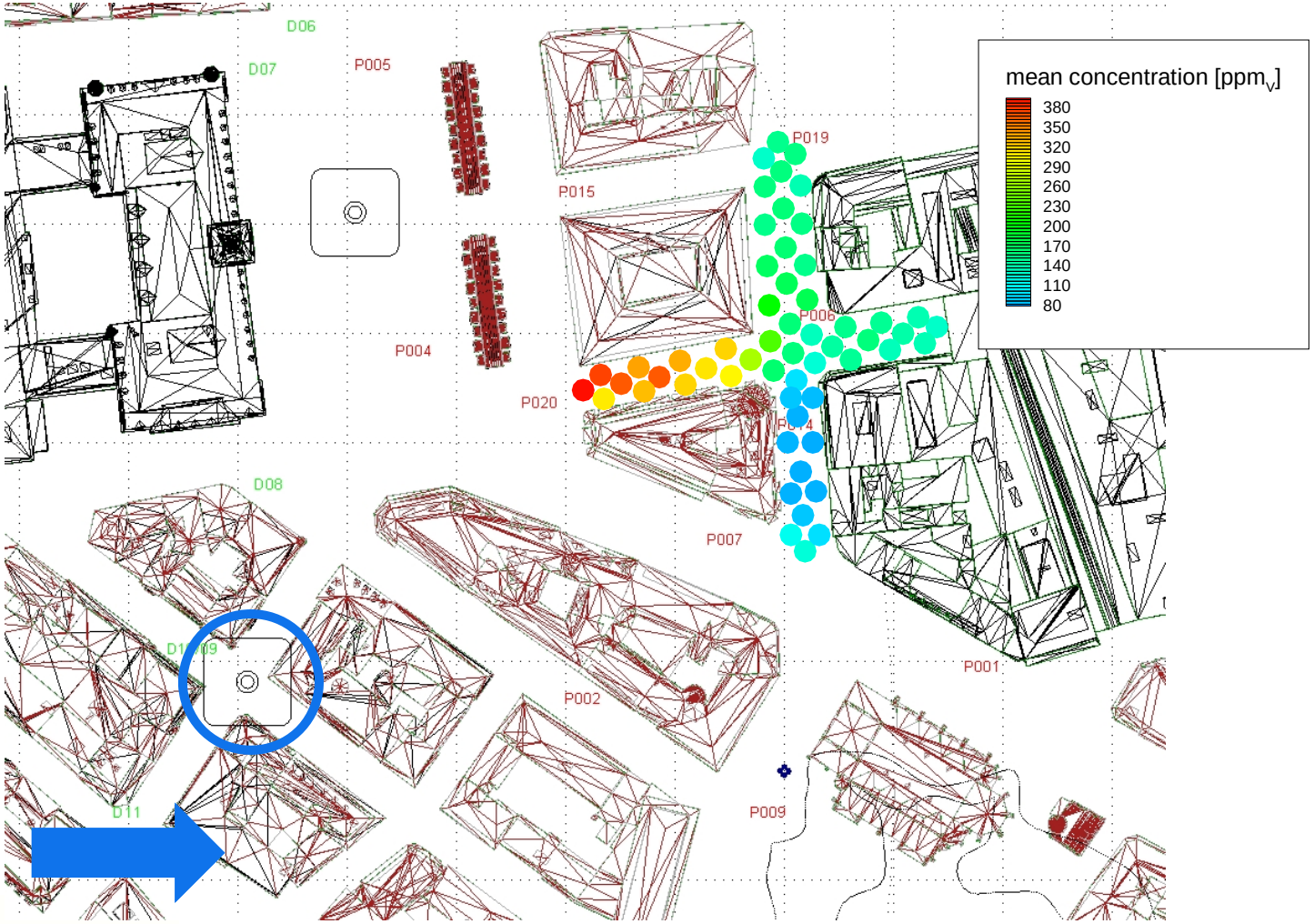
- **local variability**



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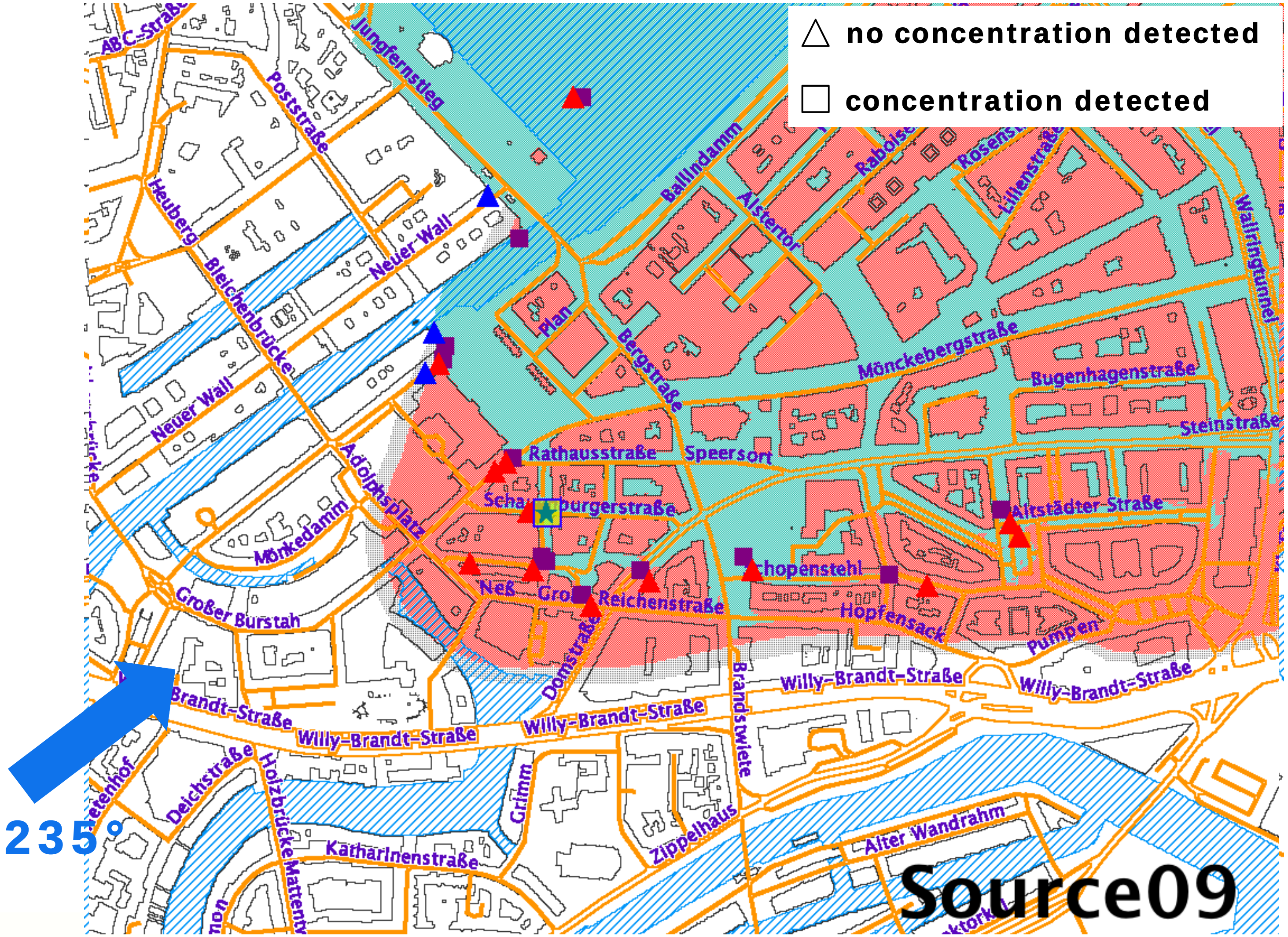
- **plume edge detection**



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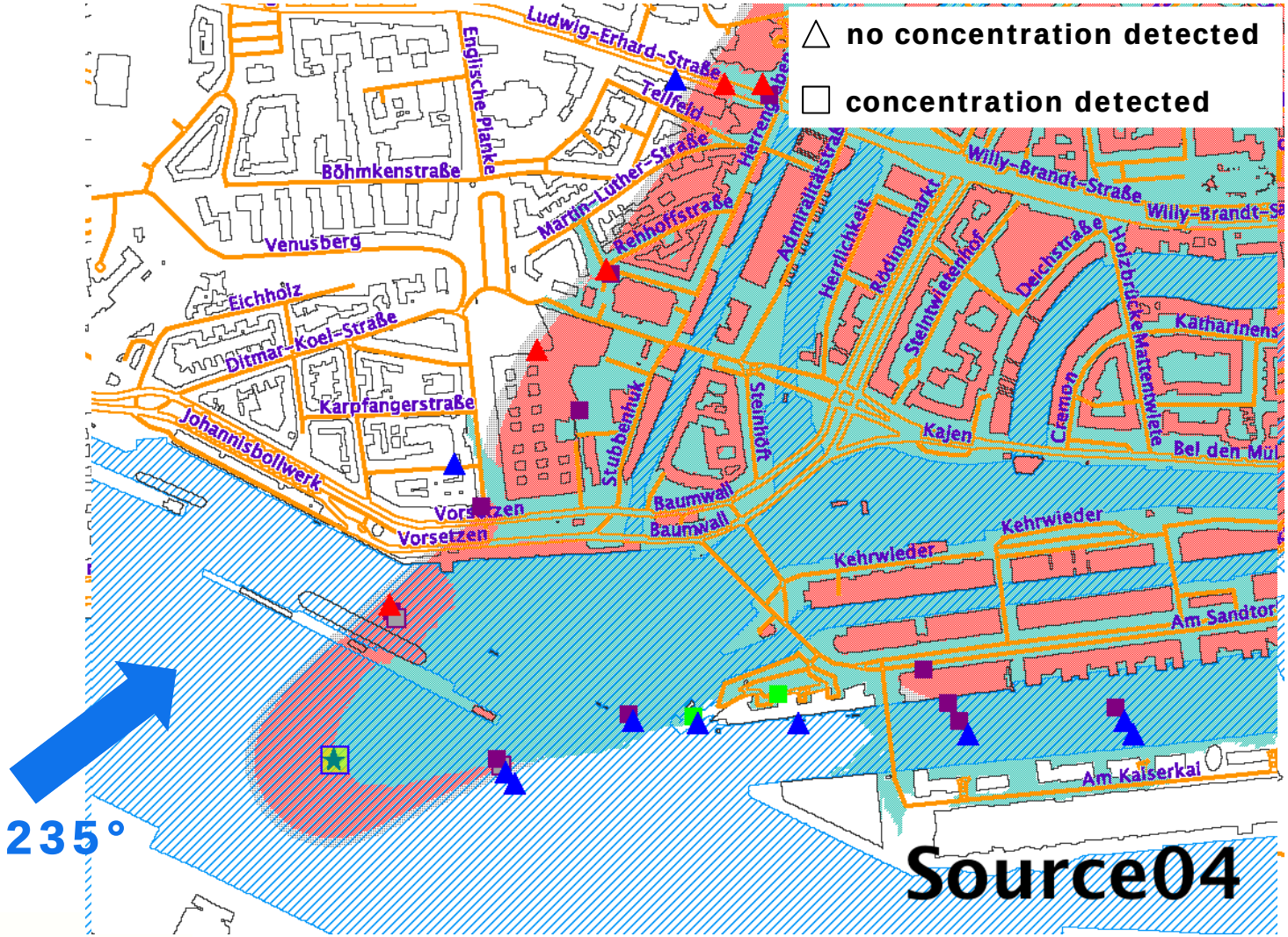
plume edge detection



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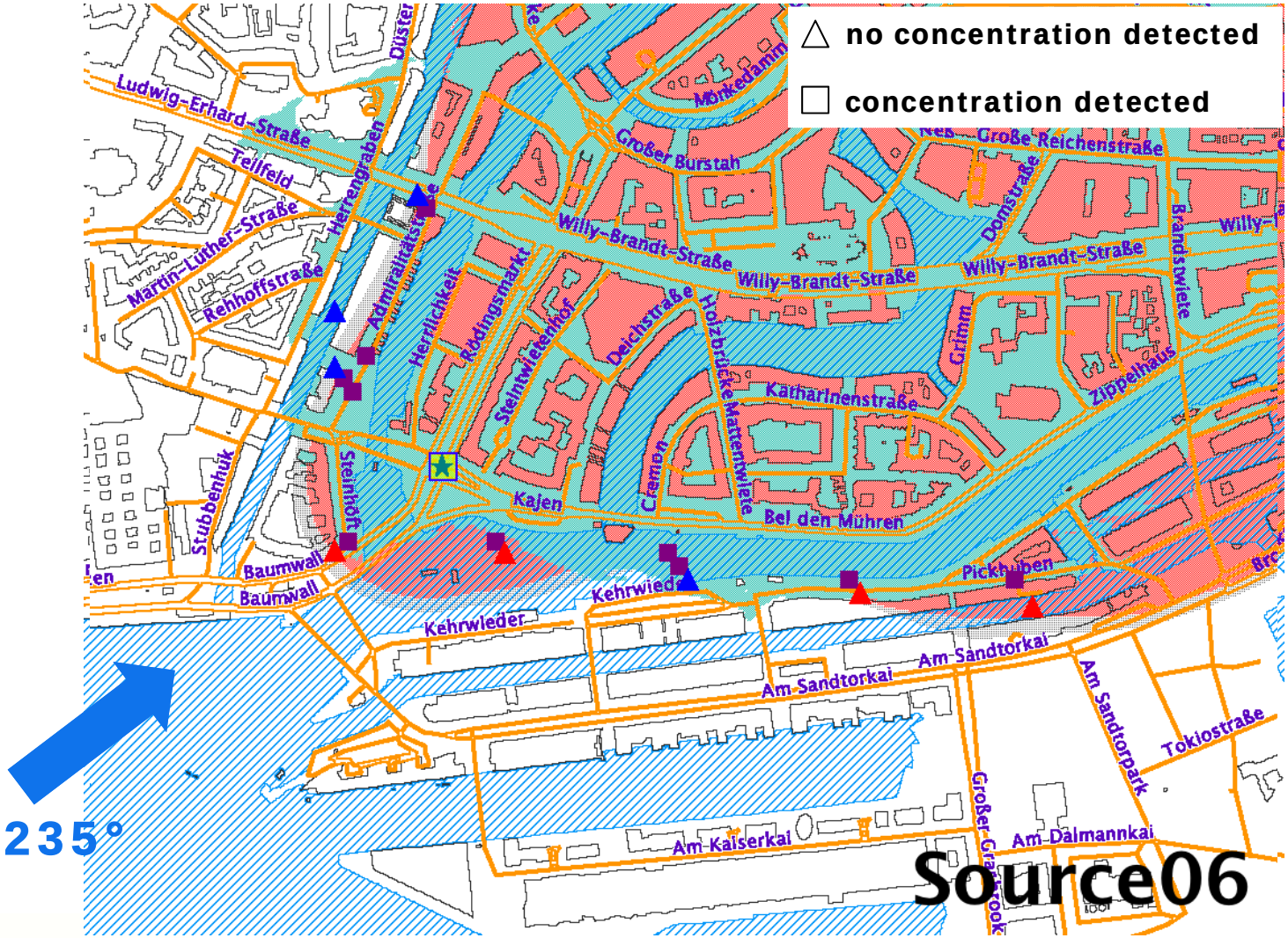
plume edge detection



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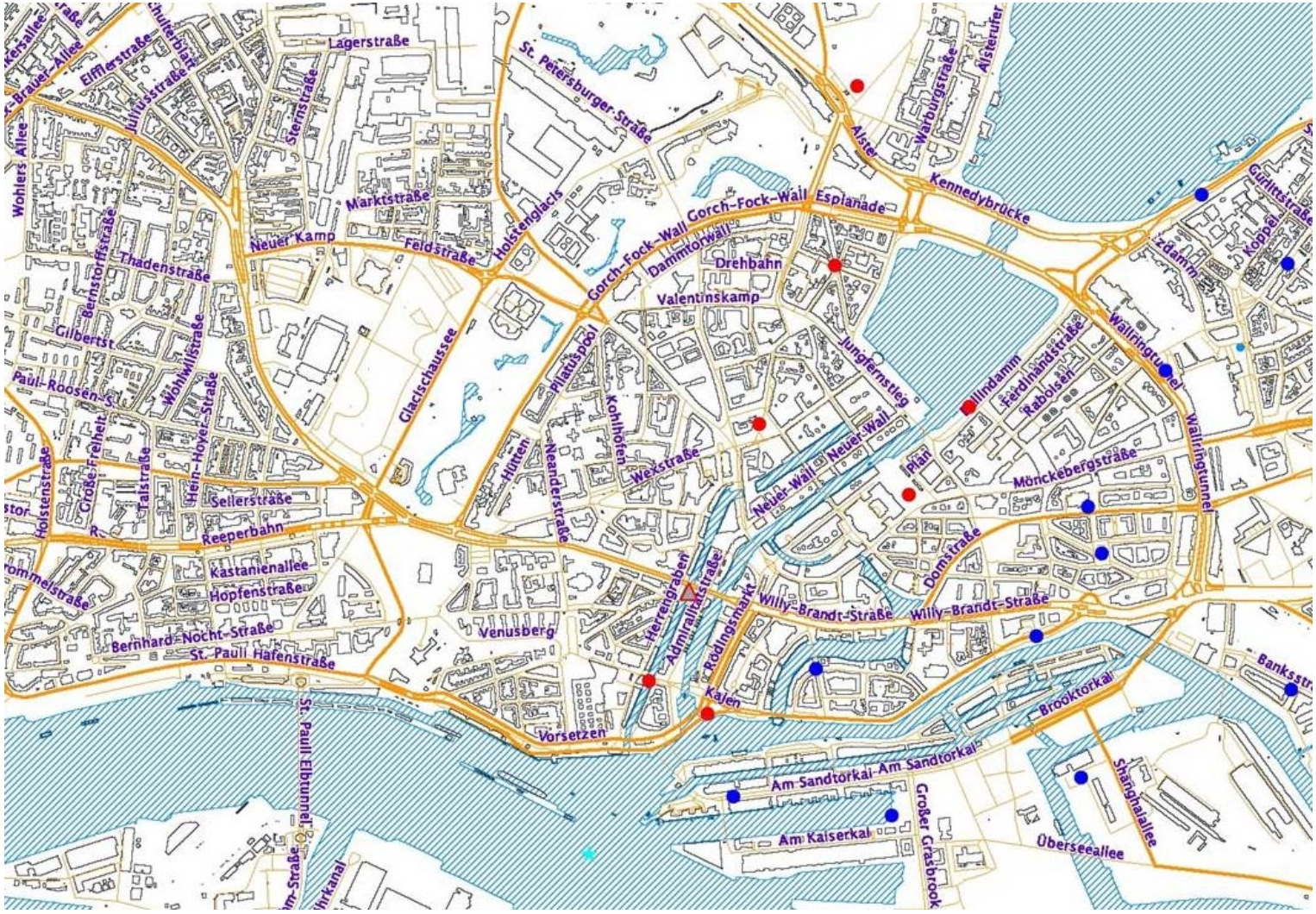
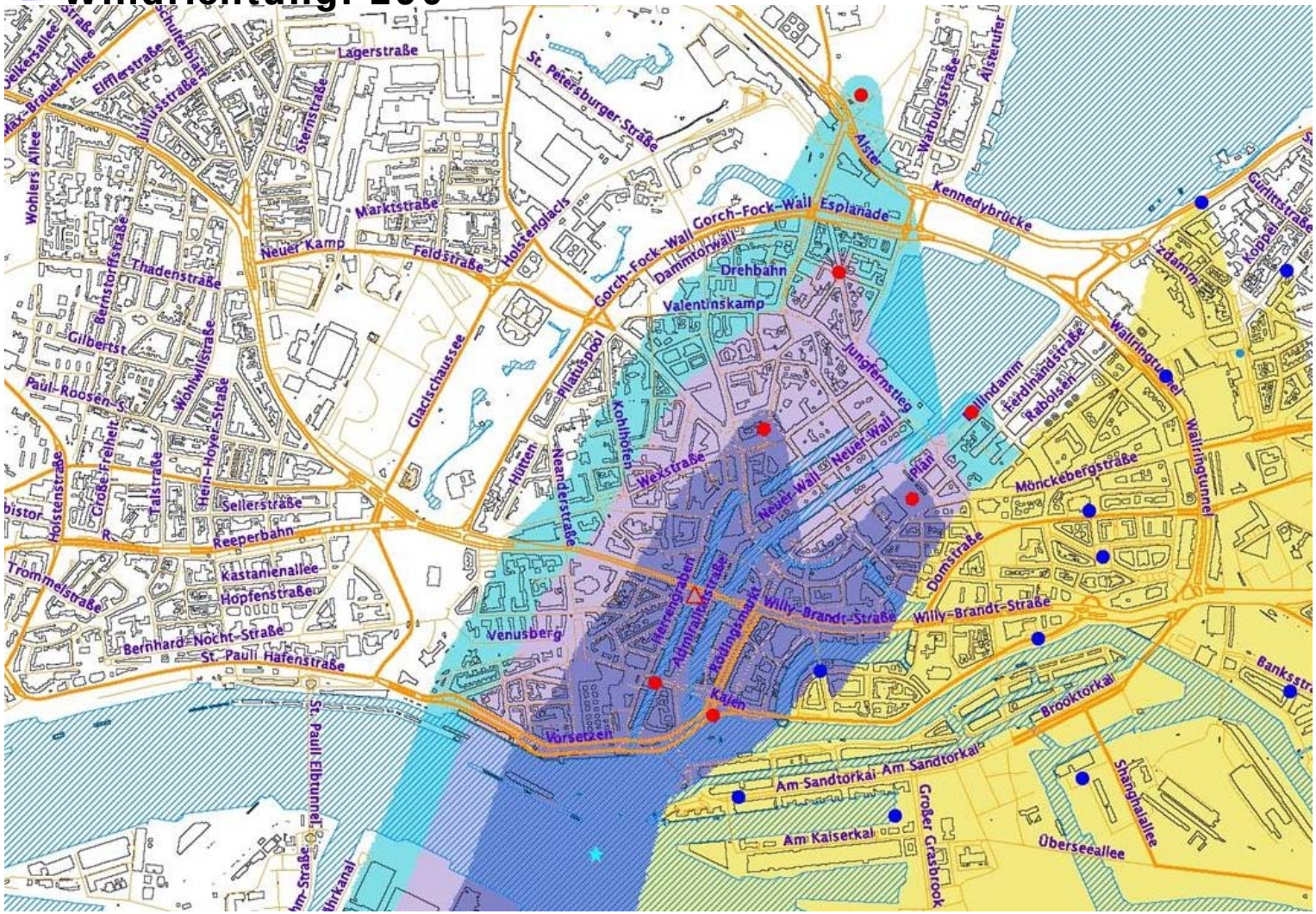
- **Stationen an den SF6 gemessen wurde**



Hamburg Pilot Project

- **Berechneter Quellbereich**
- **Windrichtung: 190°**



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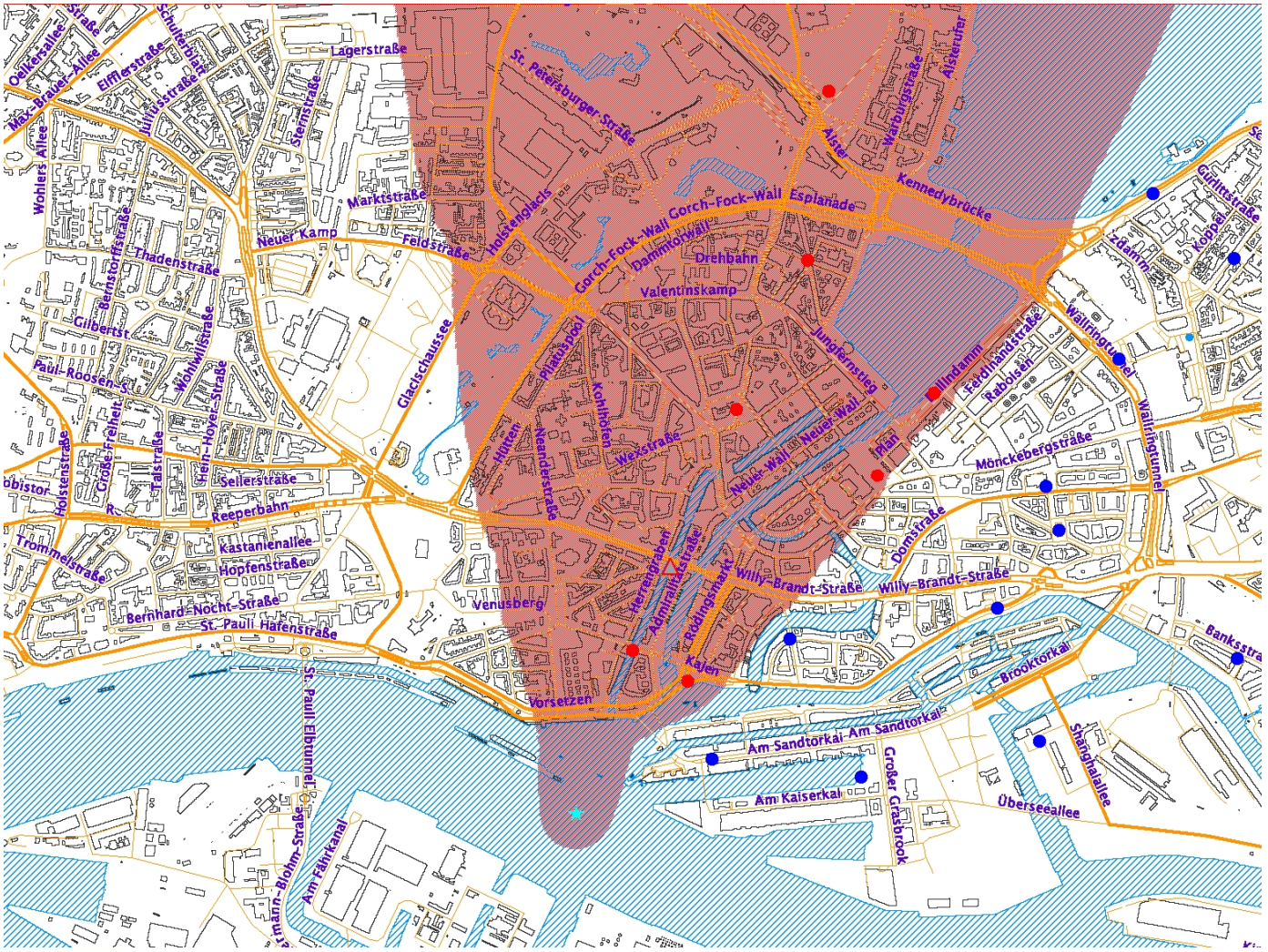
- **Berechneter Einflussbereich**
- **Windrichtung: 190°**



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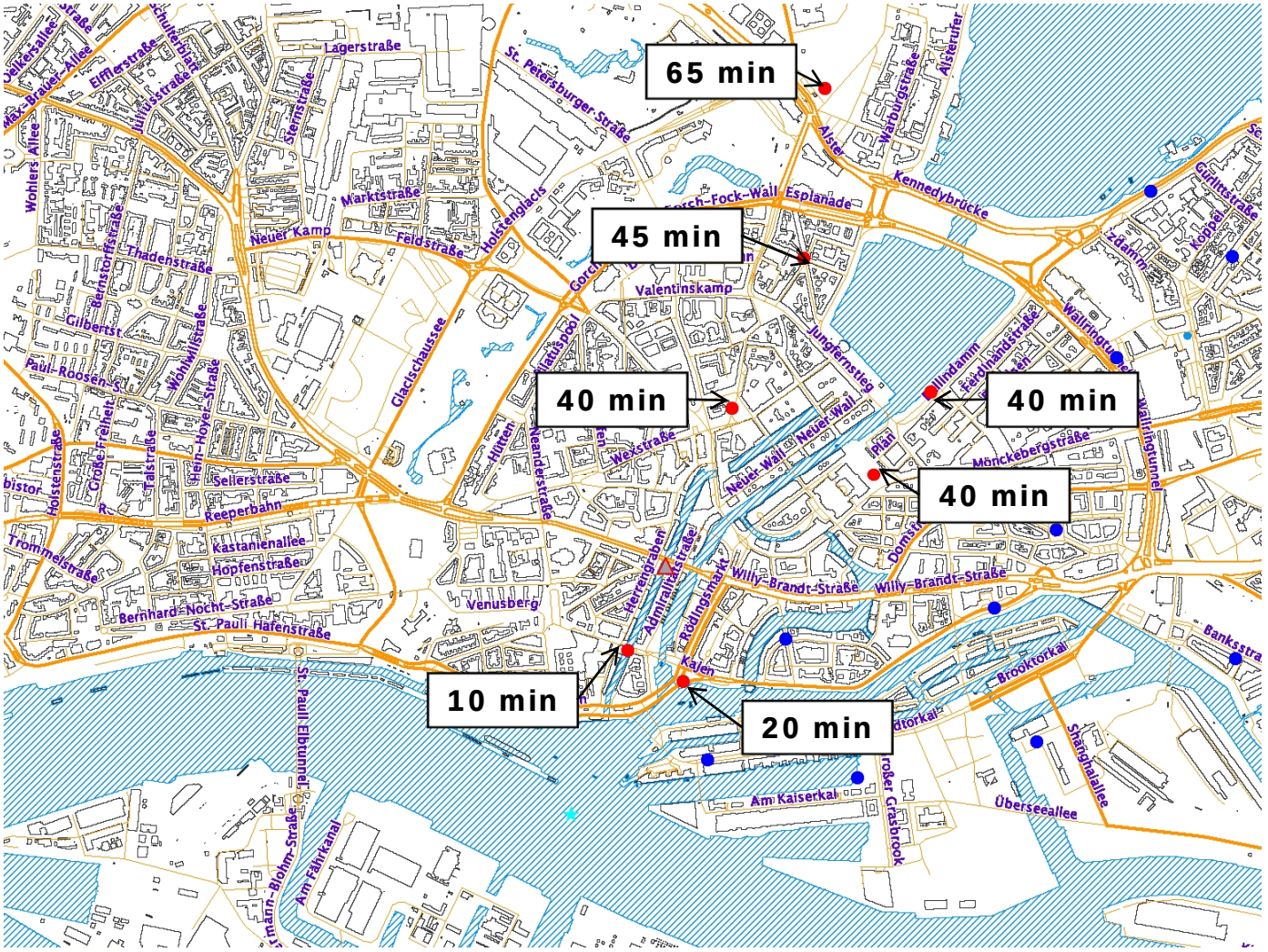
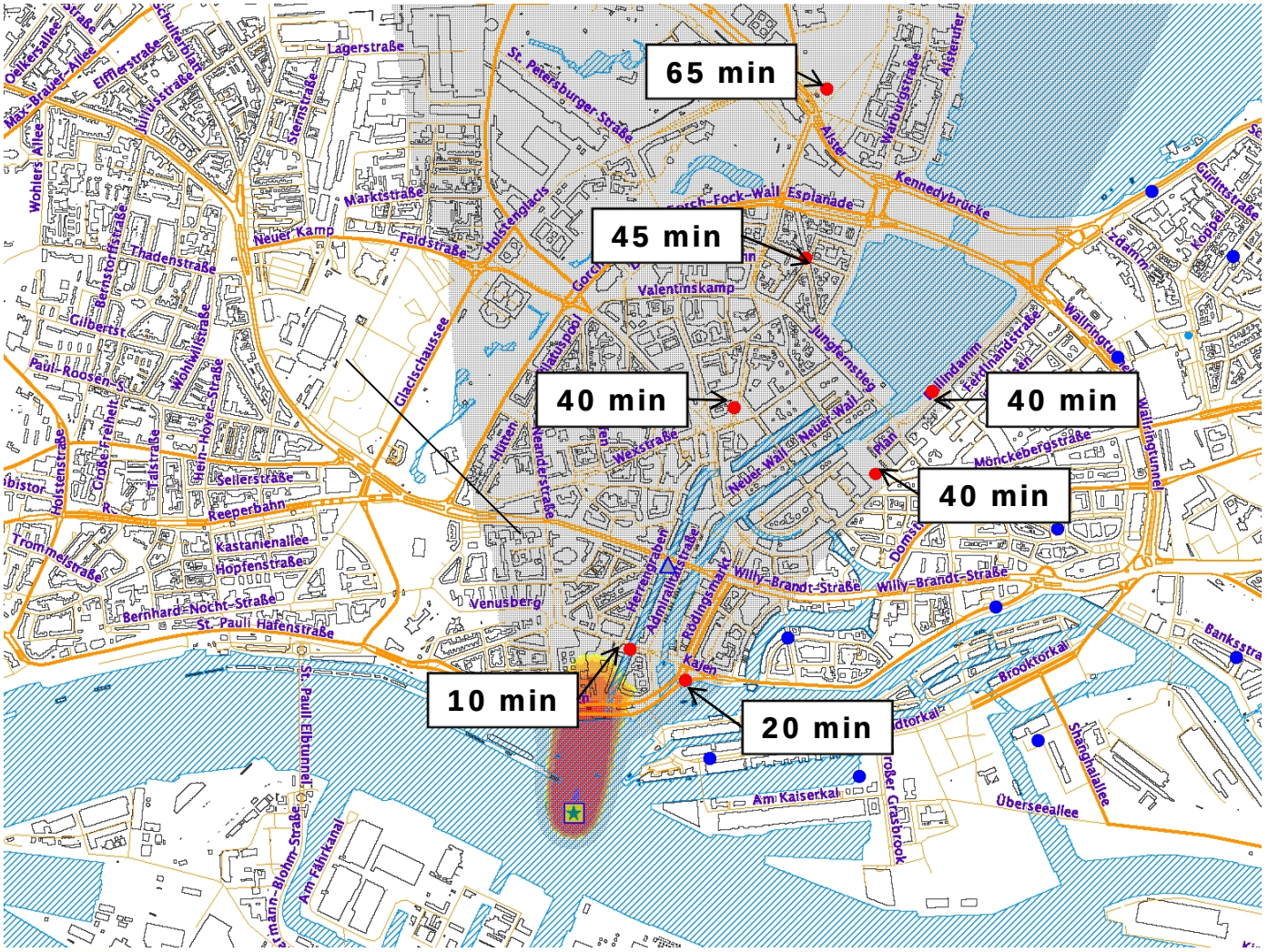
Gemessene Reisezeiten



Hamburg Pilot Project

- **Berechnete Ausbreitung nach 10 Minuten**
- **Windgeschwindigkeit in 10m Höhe: 0.7 m/s**



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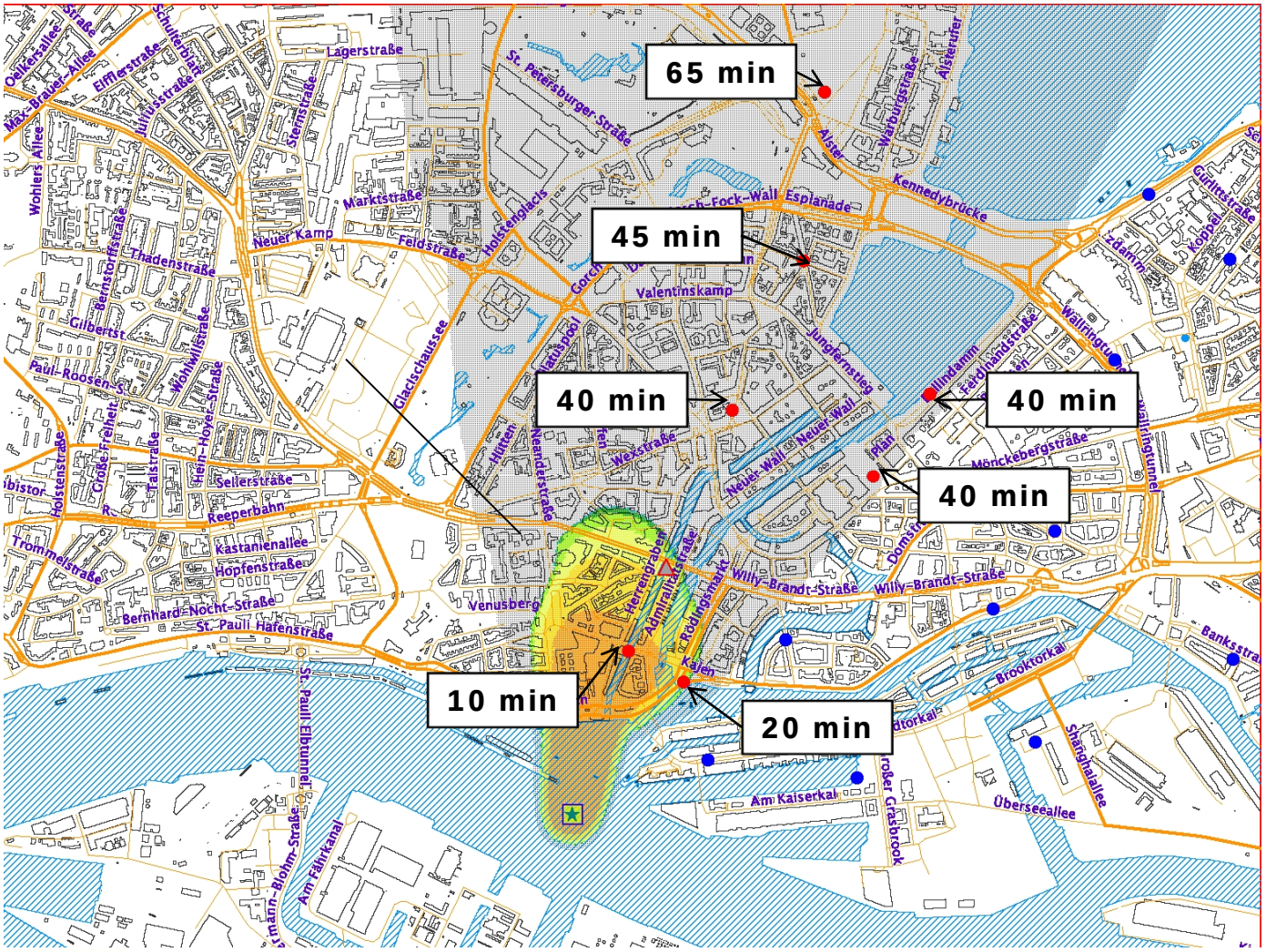
- **Berechnete Ausbreitung nach 20 Minuten**
- **Windgeschwindigkeit in 10m Höhe: 0.7 m/s**



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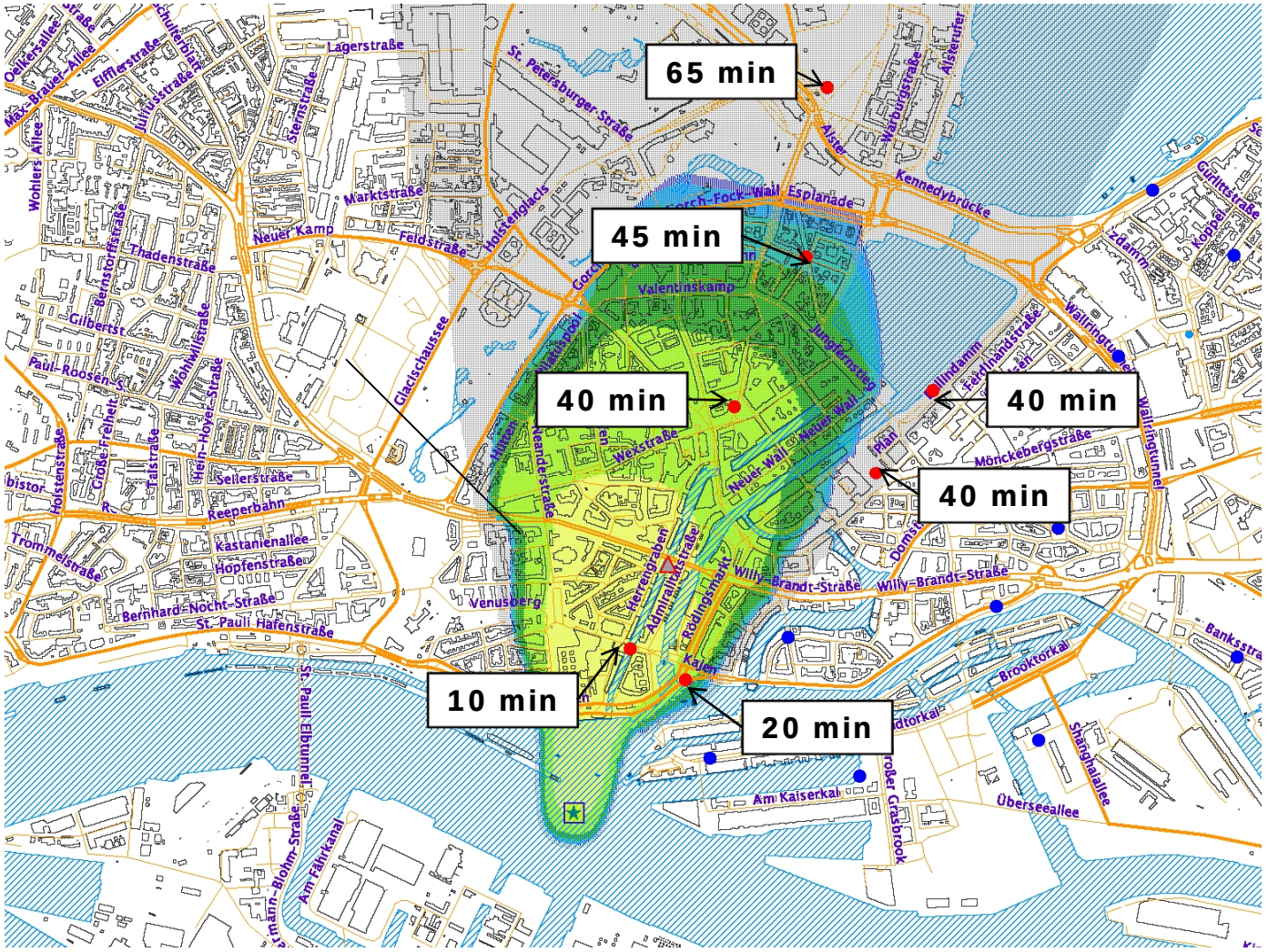
- **Berechnete Ausbreitung nach 40 Minuten**
- **Windgeschwindigkeit in 10m Höhe: 0.7 m/s**



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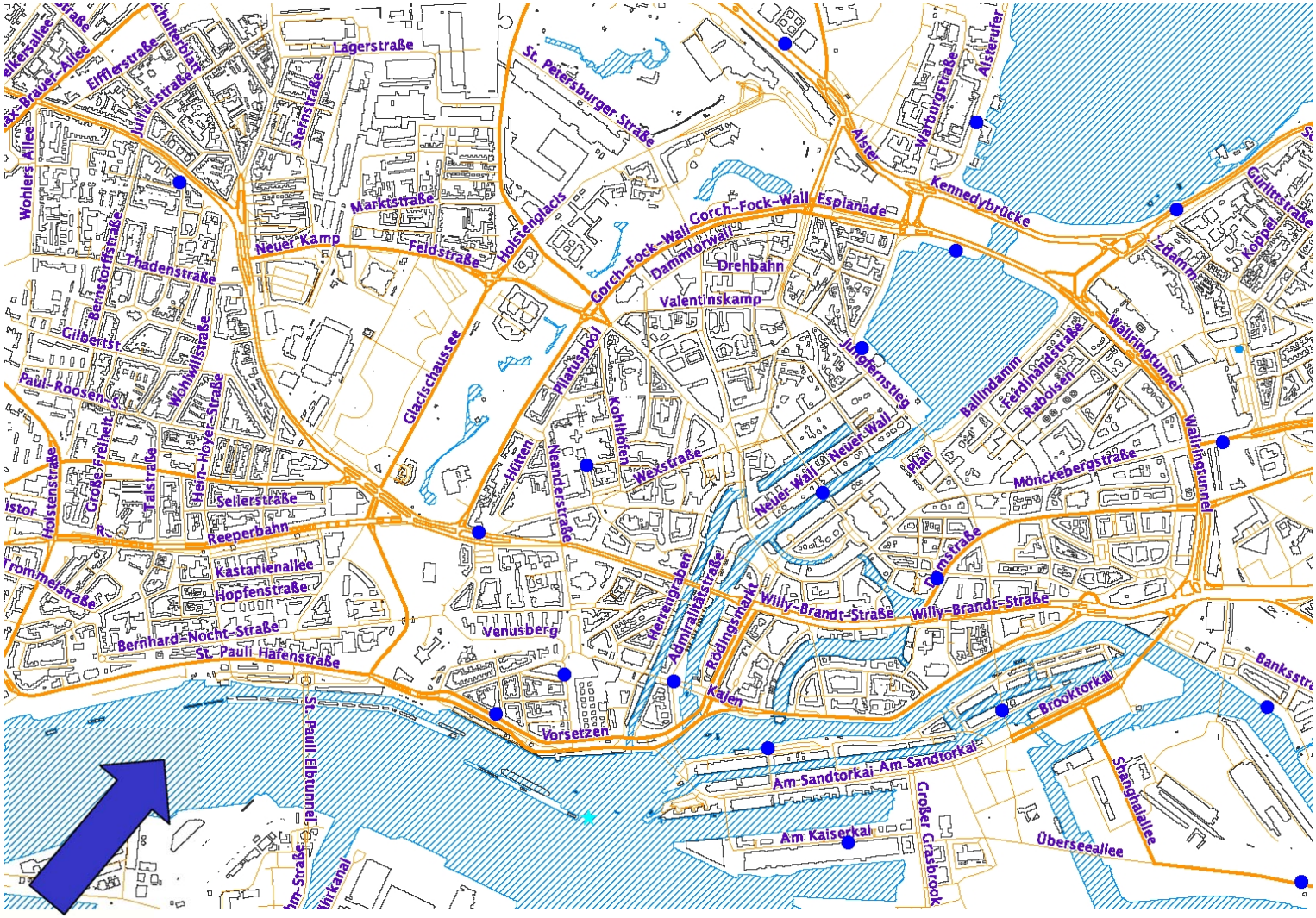
- **Messstellenplan**



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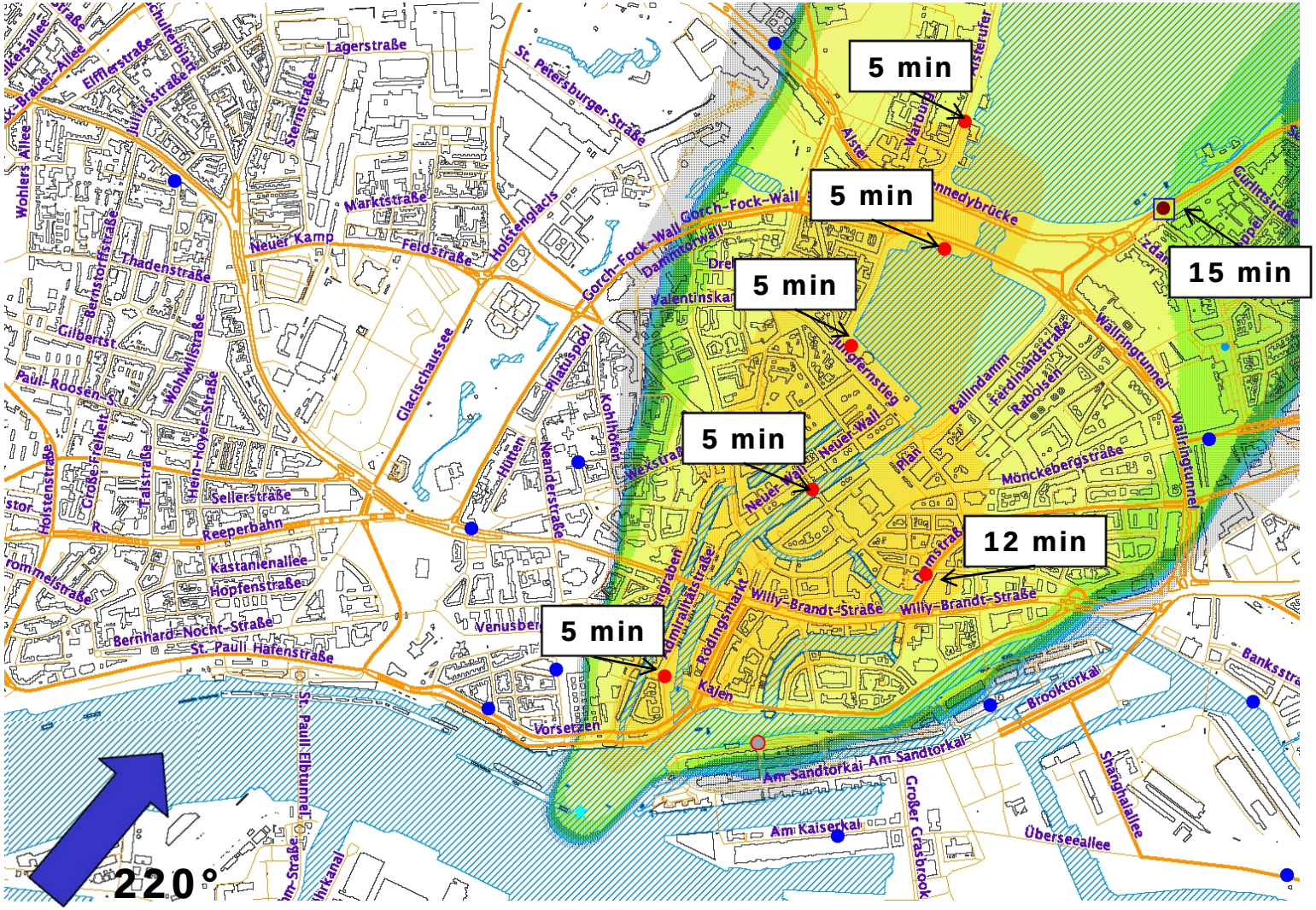
- **Berechnete Ausbreitung nach 10 Minuten**
- **Windgeschwindigkeit in 10m Höhe: 6 m/s**



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- **maximum concentrations**
- **release rate: 2 g/s**