Ingenieurbüro Lohmeyer
GmbH & Co. KG
Karlsruhe and Dresden

Ministry of Environment and Water
of Bulgaria

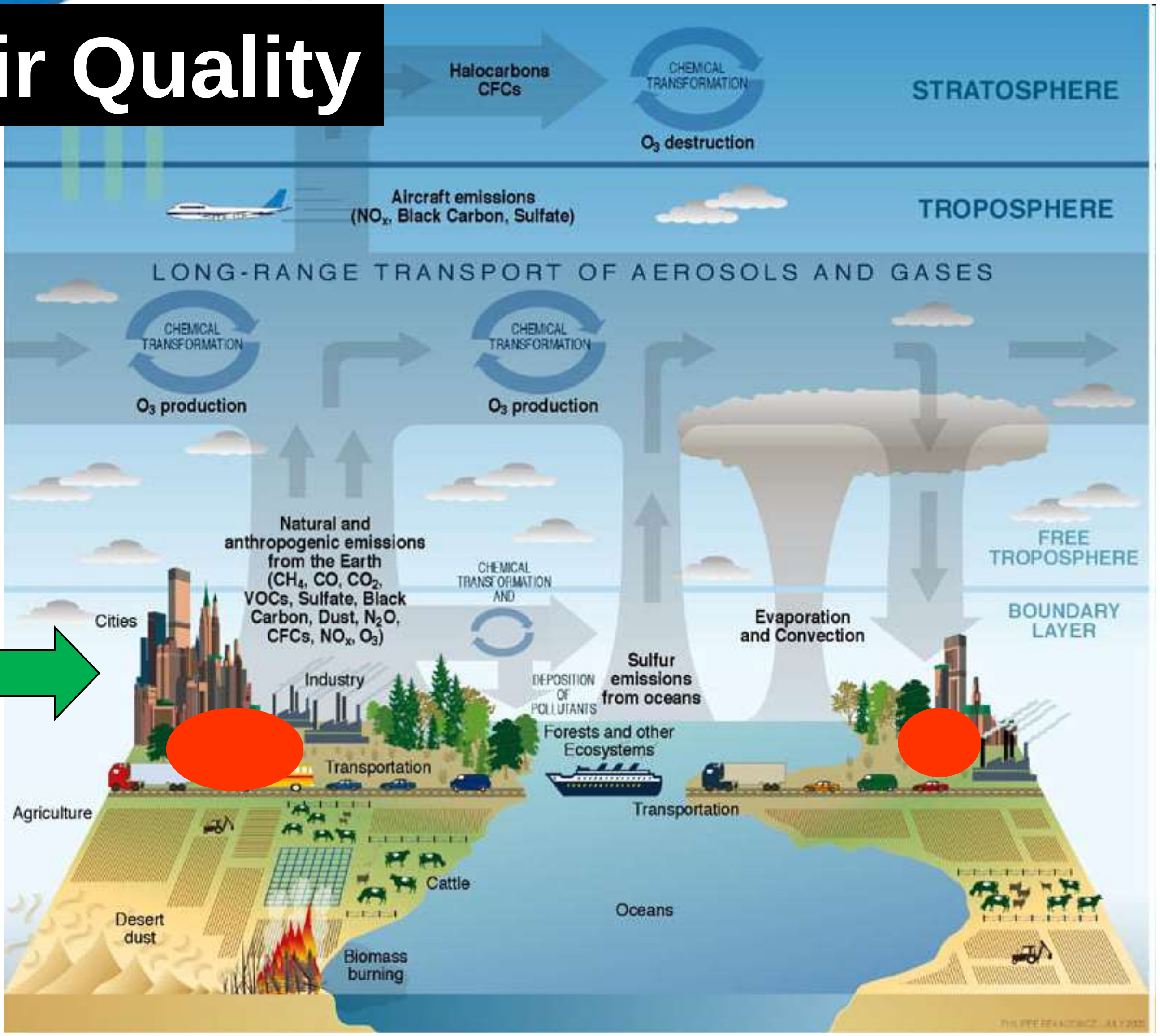
Transfer of knowledge for the implementation of Directive 2008/50/EC in Bulgaria

Dispersion Modeling
- BasiS -

Wolfgang J. Müller, Helmut Lorentz

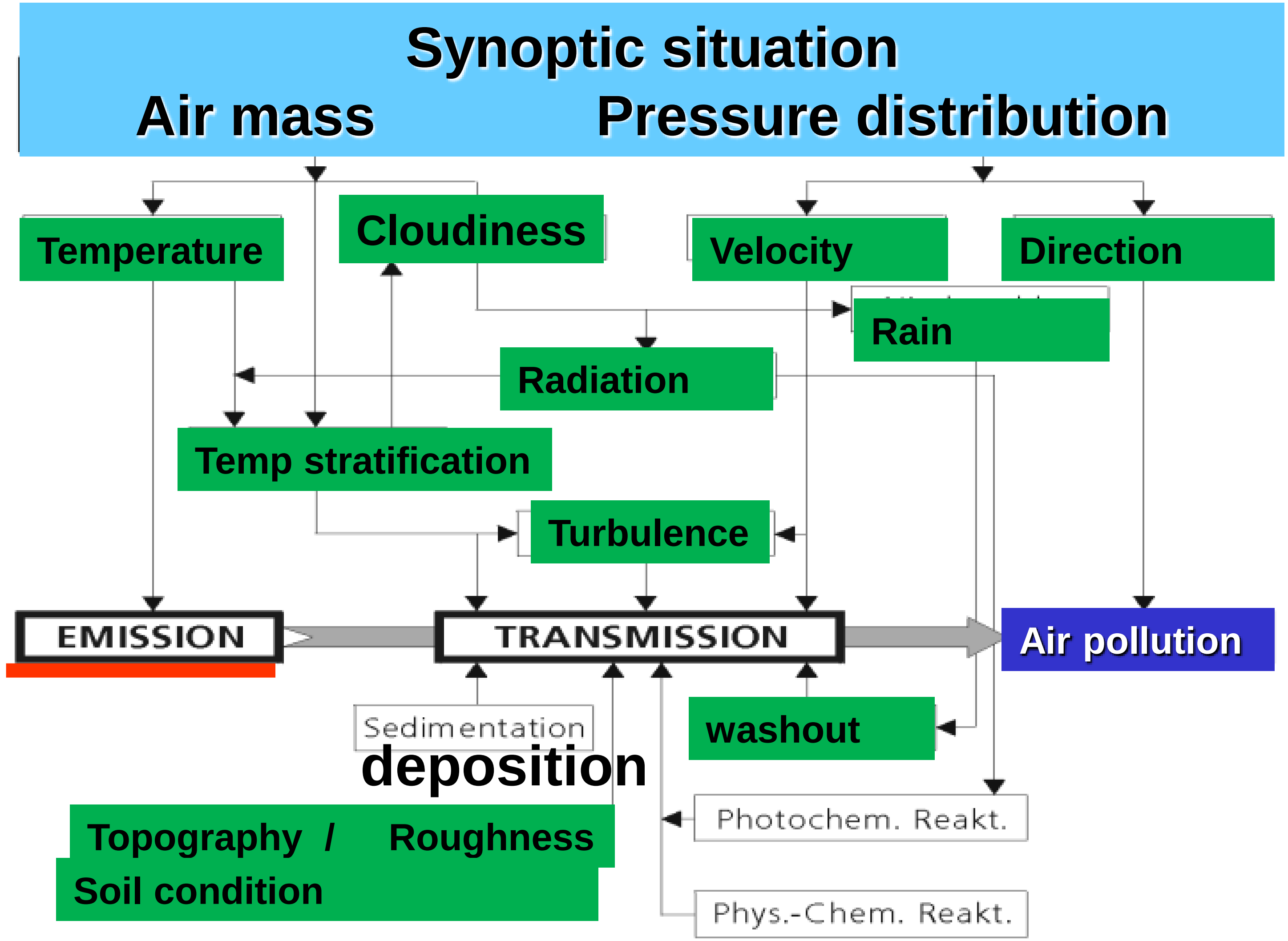
Workshop Plovdiv
19th – 20th Mai 2015

Air Quality



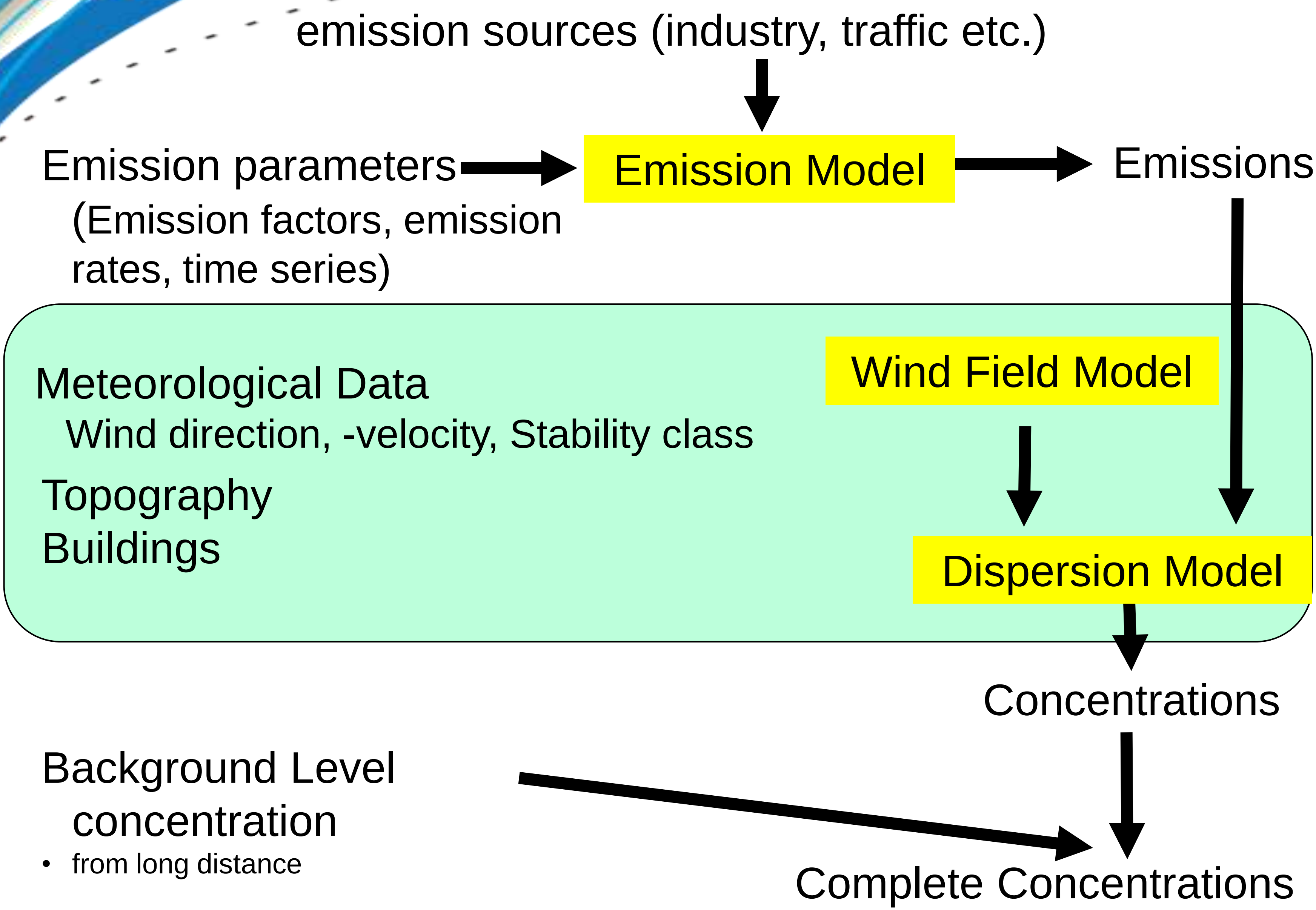
Halocarbons
CFCs
CHEMICAL TRANSFORMATION
O_3 destruction
STRATOSPHERE
Aircraft emissions
(NO_x, Black Carbon, Sulfate)
TROPOSPHERE
LONG-RANGE TRANSPORT OF AEROSOLS AND GASES
CHEMICAL TRANSFORMATION
O_3 production
CHEMICAL TRANSFORMATION
O_3 production
Natural and anthropogenic emissions from the Earth (CH_4, CO, CO_2, VOCs, Sulfate, Black Carbon, Dust, N_2O, CFCs, NO_x, O_3)
CHEMICAL TRANSFORMATION AND
DEPOSITION OF POLLUTANTS
FREE TROPOSPHERE
BOUNDARY LAYER
Cities
Industry
Evaporation and Convection
Sulfur emissions from oceans
Forests and other Ecosystems
Transportation
Transportation
Agriculture
Cattle
Oceans
Desert dust
Biomass burning

TRANSMISSION



Nach Fortak, ergänzt

Air Quality Modeling



Main Source Groups

Emission = Activity x Emission Factor

TRAFFIC

- hot emissions
- cold start emissions
- evaporative emissions

depends on
road network,
vehicle mix,
mean driving speed

RESIDENTIAL COMBUSTION

- room heating
- water heating
- solvent use

from measurements/
literature - dependent
on energy needed,
fuel used and heating systems

INDUSTRY

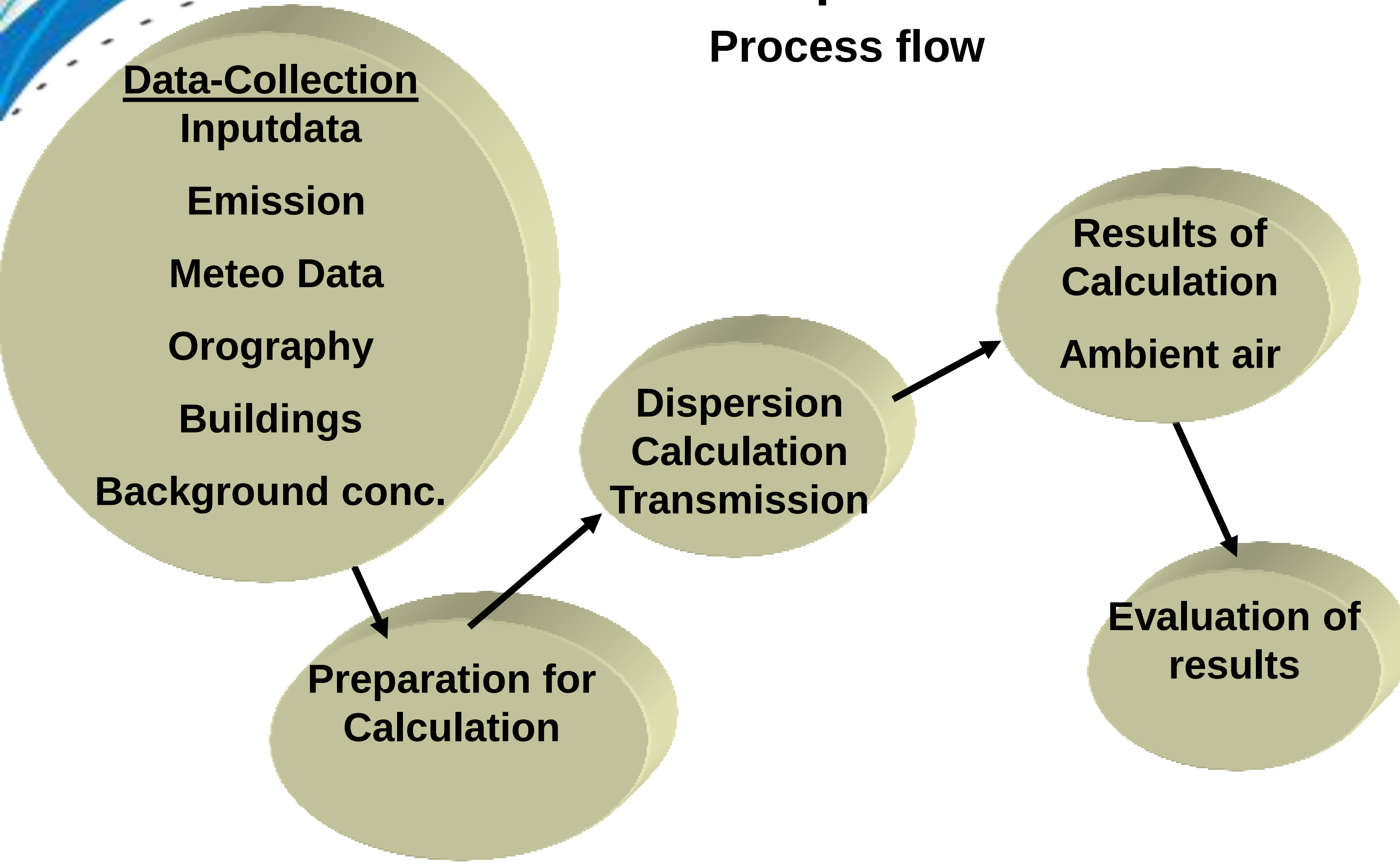
- emissions due to combustion and production

from measurements/
literature; dependent
on industrial sector,
energy needed, fuel
used; material throughput

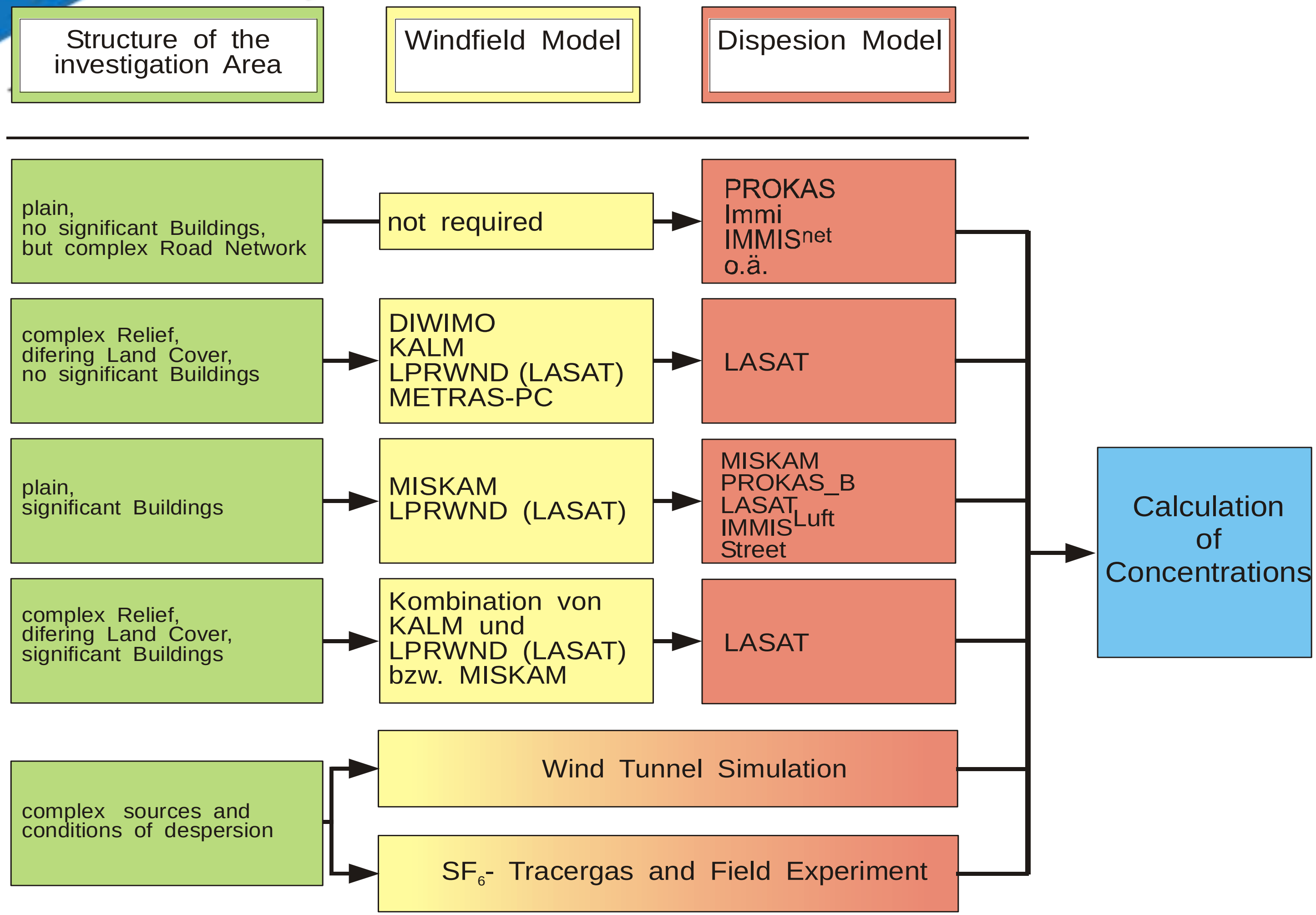
Dispersion model

Check of Dispersion Calculation Report

Process flow



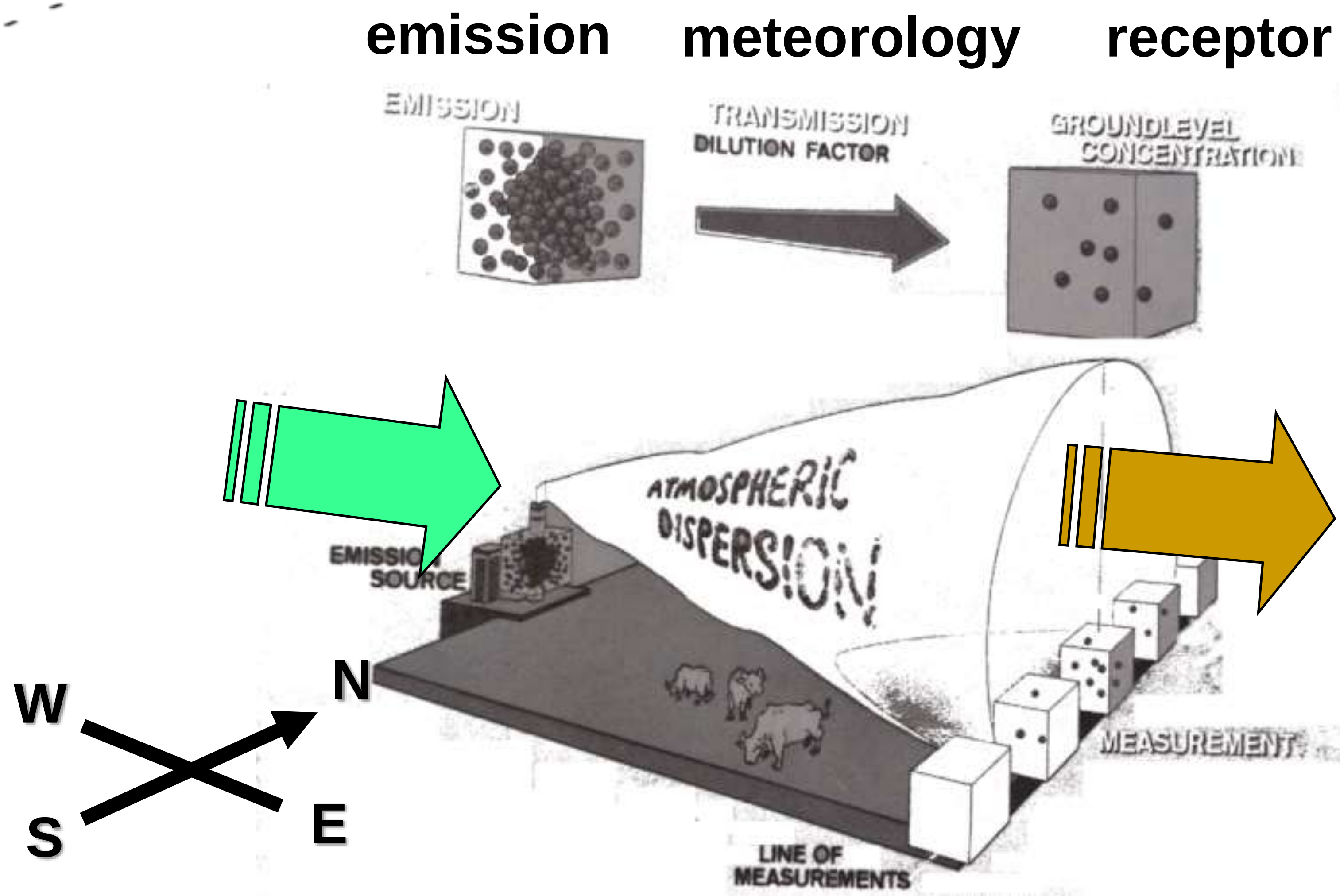
Which Model?



DIWIMO, LPRWND: diagnostic Windfield Model
KALM : Nocturnal Flow Model

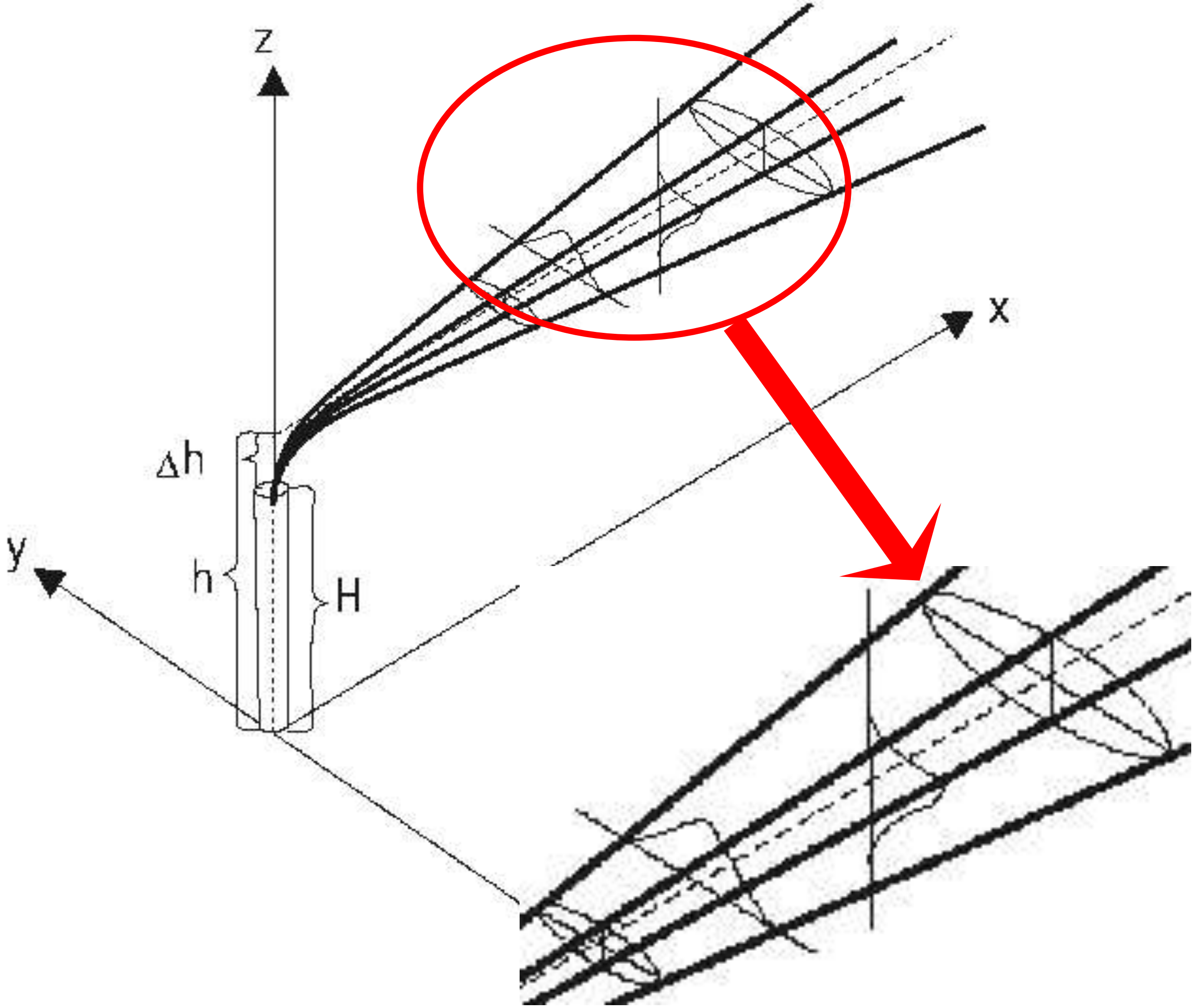
METRAS-PC : meso-scaled prognostic Model
MISKAM : micro-scaled prognostic Model

Model calculation



Previous Gauss Model

Gauß Model
(TALuft 1986
AUSTAL86)



Restrictions of GAUSS Model

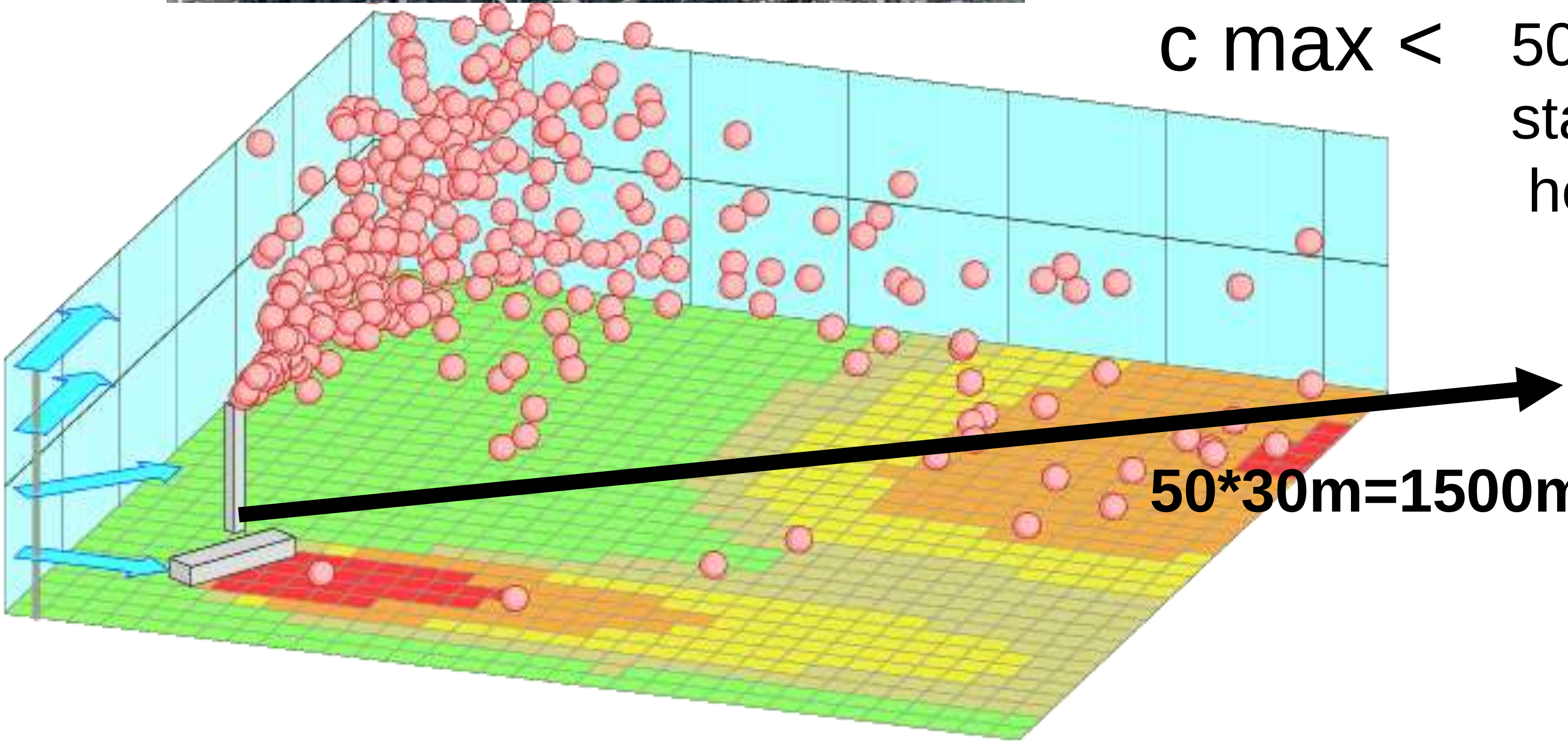
- Wind- and Turbulence fields are homogeneous in space and time
- Flat, homogeneous terrain
- Constant source strength
- invalid by calm, low windspeed
- Statistic of Dispersion Classes

- Dispersion parameters by experiments
- Dispersion coefficients valid in the range approx. 100 m ----------------------10 km

- Results:Annual Mean Value, 98% Percentile

Typical calculation area

c max < 50* stack height

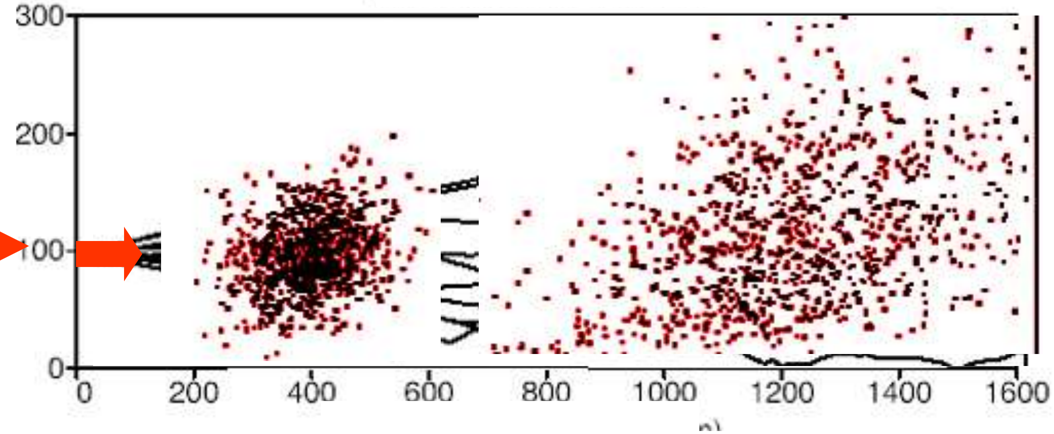


Langrange model

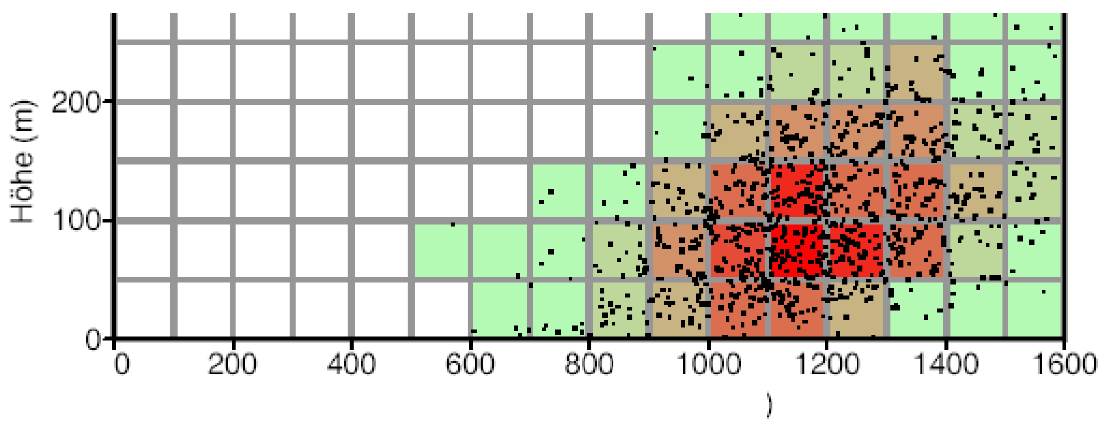
0…….80 Particle position 240 sec

Height (m)

Emission
1000 Particles
Height 100 m



Calculation of Concentration by mass of particie per each cell volume, Time 240 s



GAUSS Modell - Land /Sea Wind

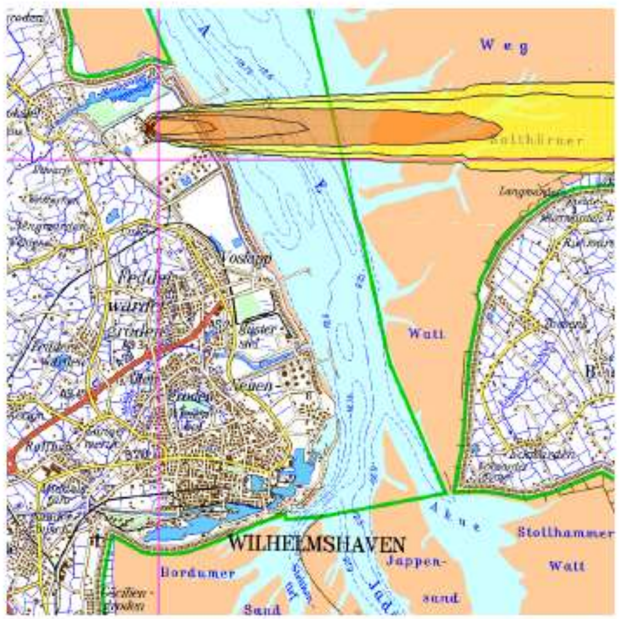
Stationary approach

Source at height 30 m;
Release during 60 seconds;
Wind from West, then turning to East

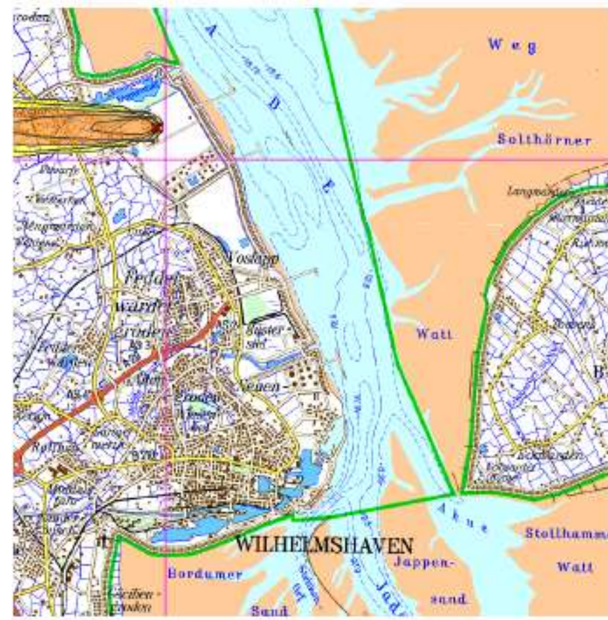
Wind from West

Activity near ground in Bq/m^3

Westwind



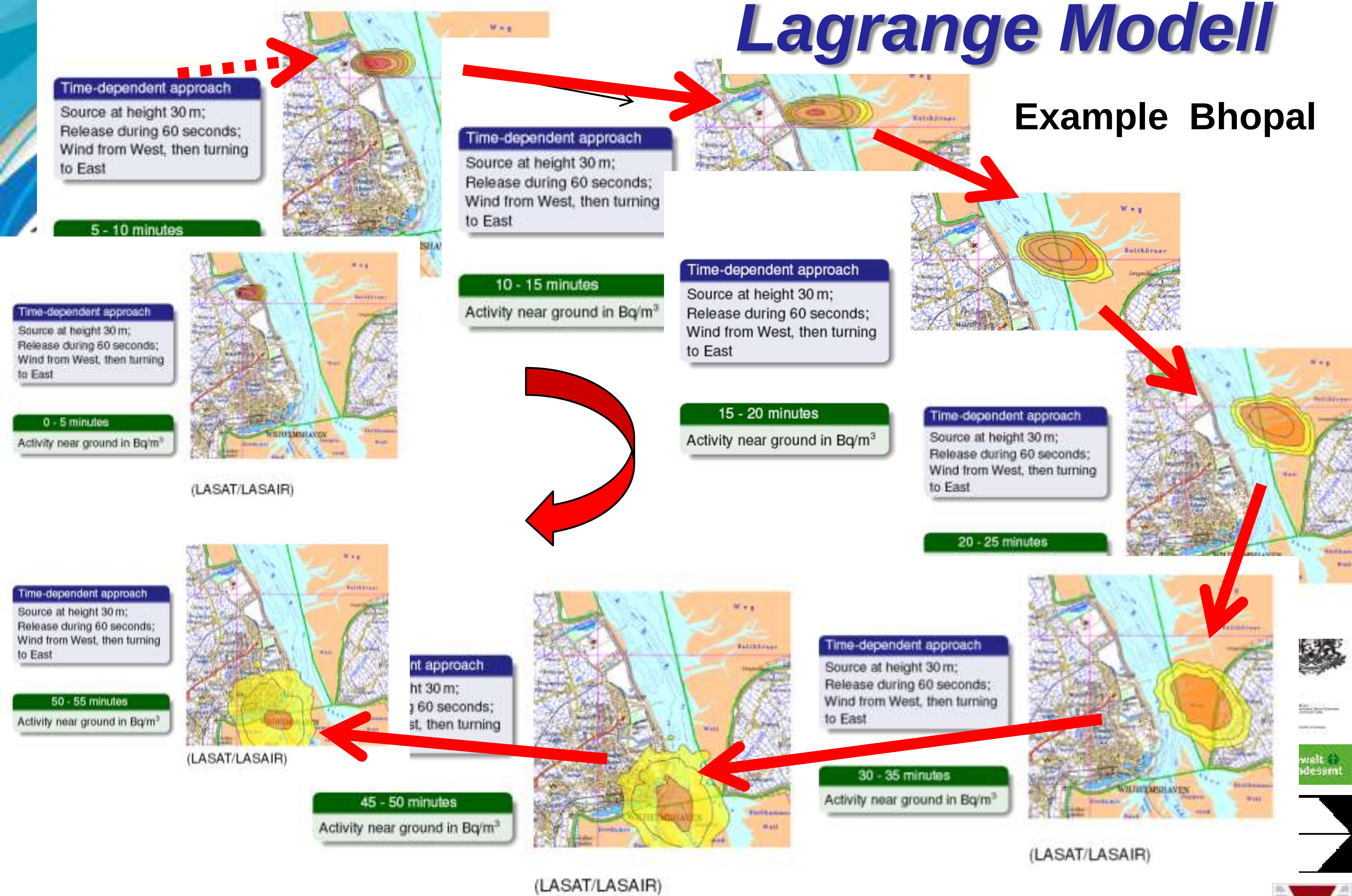
Eastwind



Nach Janicke

Lagrange Modell

Example Bhopal



Parameters influencing calculation

Traffic

- Number of vehicles per h → Emission
- Share of vehicle types → Emission
- Traffic situation → Emission
- Turbulence due to car velocity → Air flow

Industry /Domestic Heating sources

- Mass Flow concentration → Emission
- Exhaust parameter → Air flow

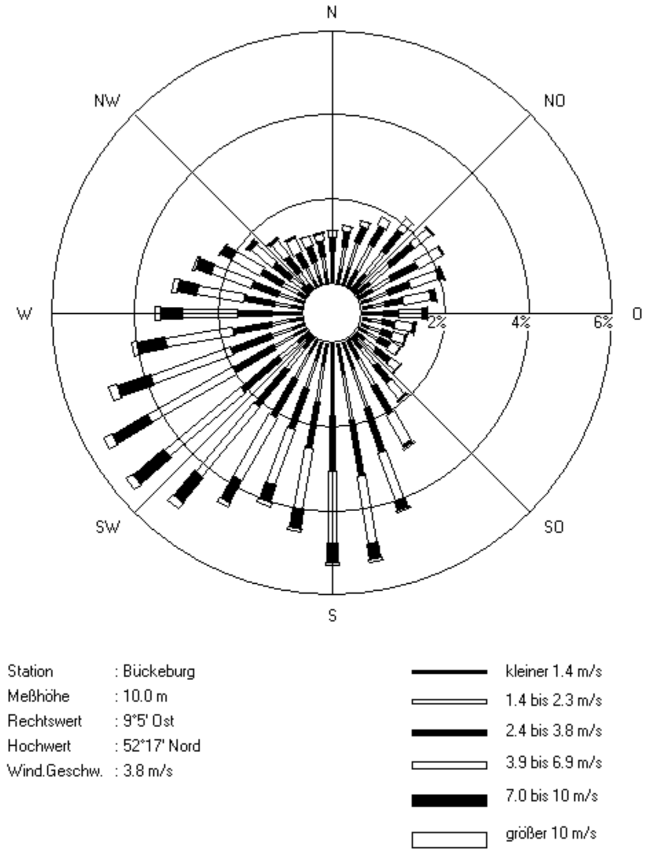
Topography

- Deep and narrow valleys → Air flow
- Nocturnal valley drainage flow → Air flow
- Slope of street → Emission

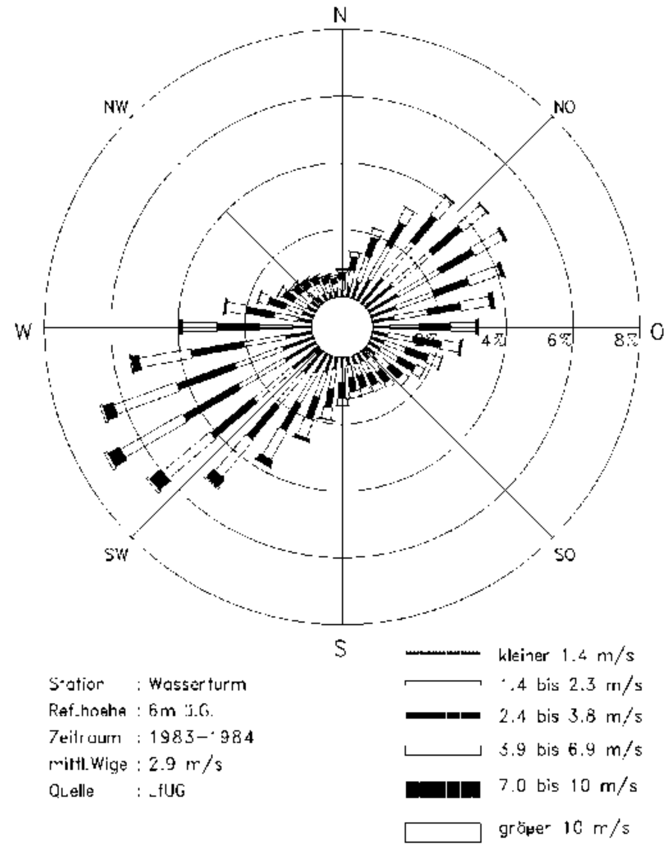
Buildings

- Density and height of buildings
- Distance between buildings at the roadside
- Street canyon width → Air flow

Representative wind direction needed !

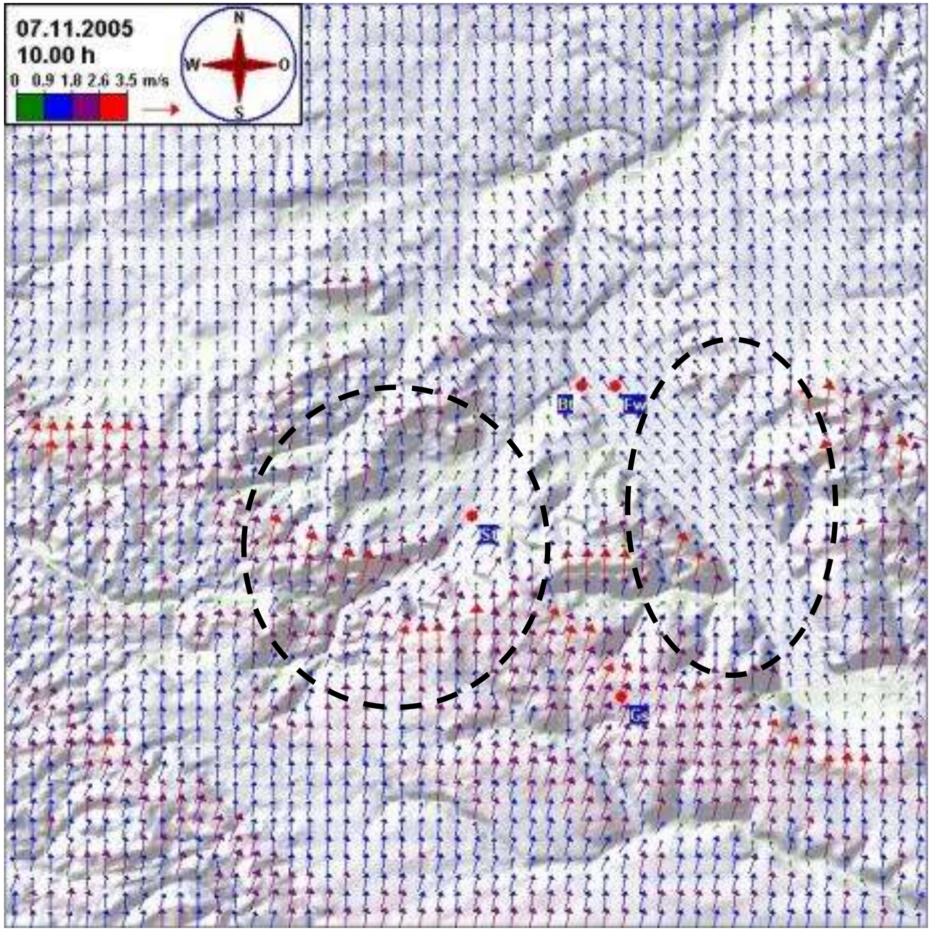


or



?

Influence Topography



Changing of
wind direction and
wind velocity

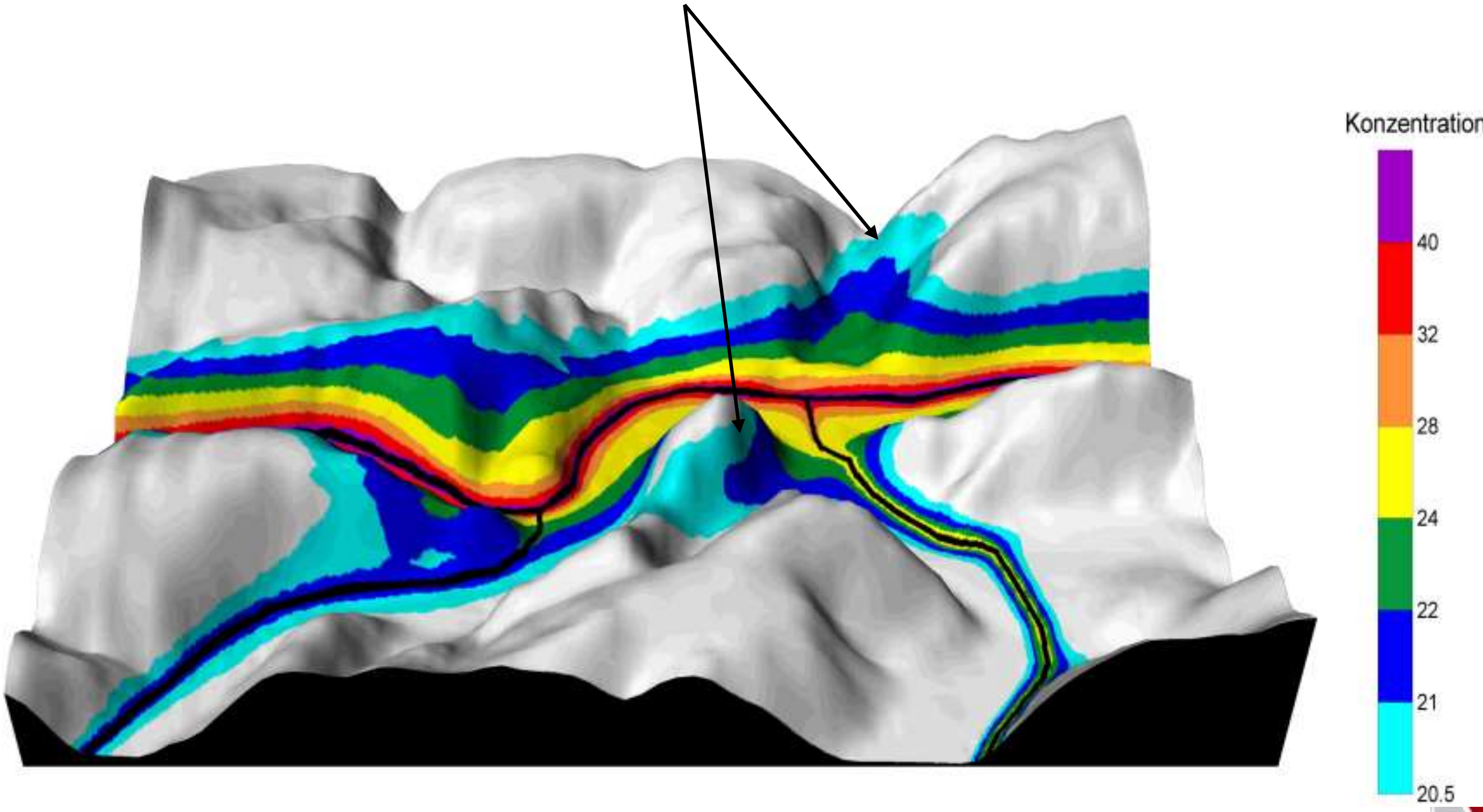
e.g. area of Stuttgart

www.stadtklima-stuttgart.de → "Online calculation of wind fields
Based on point measurements, calculation of wind fields every 30 minutes

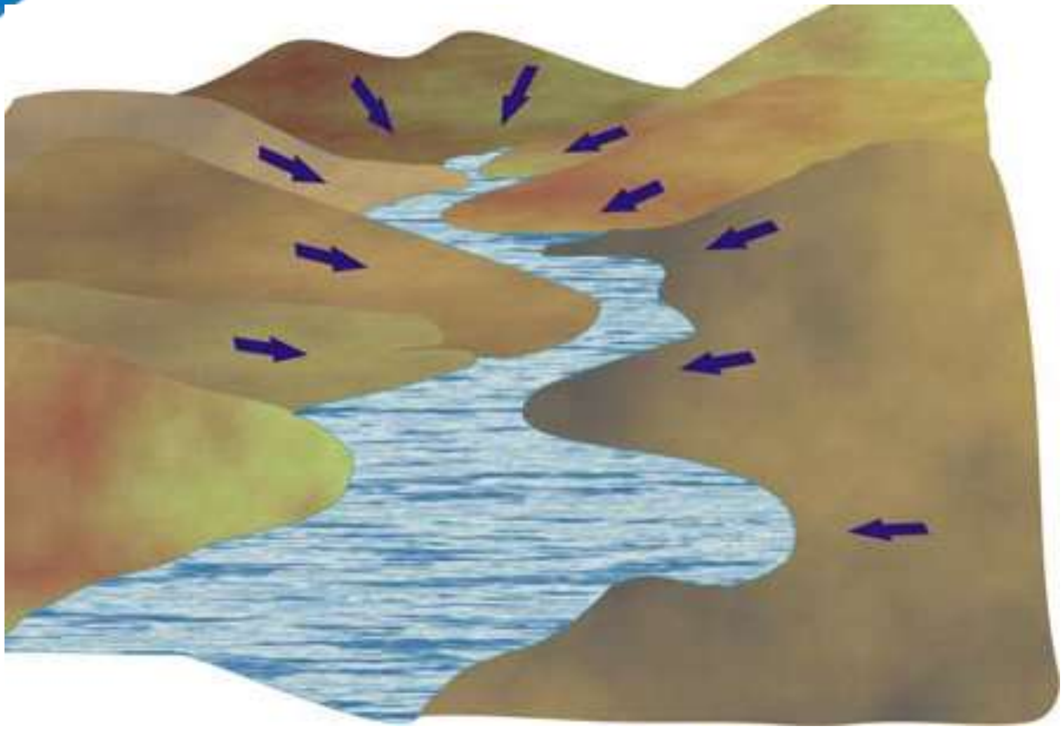
Example Topography

LASAT

- Concentration field influenced by streamlines in topography



Nocturnal Drainage Flow (1)



During nights with few clouds and slow wind velocities the air at the ground cools down and flows gravity driven because of their higher density following the slope of terrain.

→ Nocturnal valley drainage flow

Nocturnal drainage flow from elevated plains and valleys
as well as accumulation of cold air at the gound (Baumgartner, 1963).

Nocturnal Drainage Flow (2)

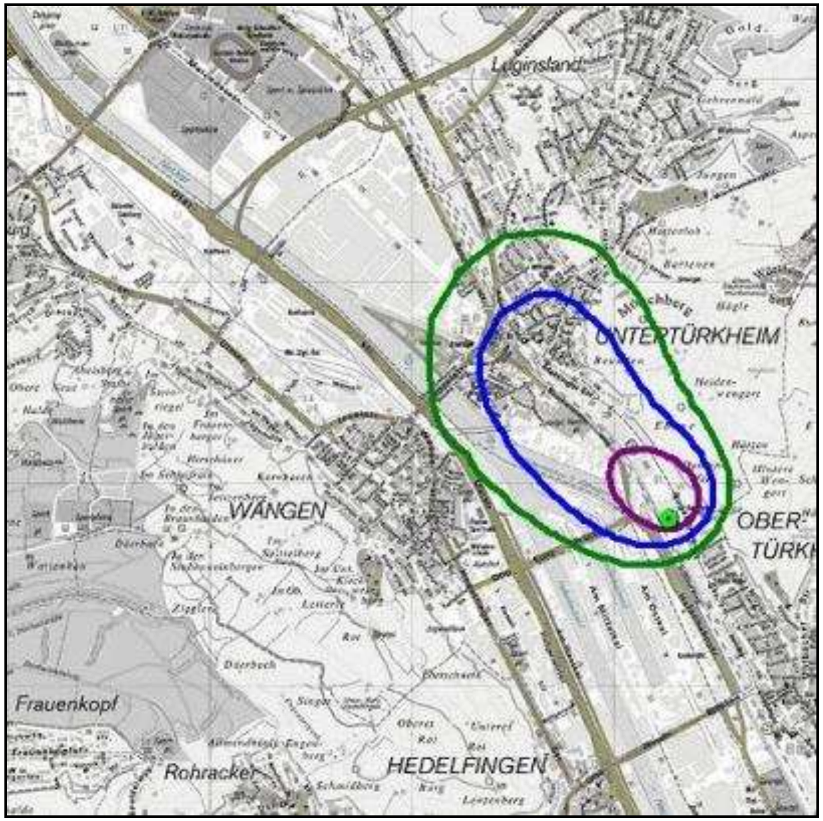
22.12 Uhr

22.11 Uhr

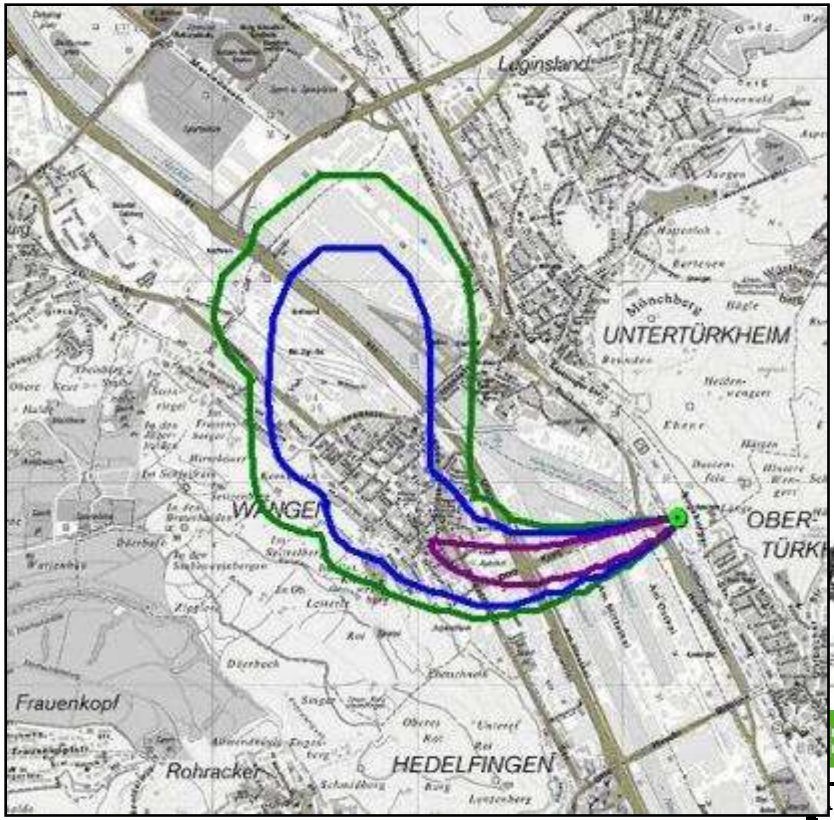
22.10 Uhr

Smoke following the drainage flow at the ground into the valley.

Example Nocturnal Drainage Flow



Distribution of pollutants
<u>without</u> nocturnal drainage flow



Distribution of pollutants
<u>with</u> nocturnal drainage flow

Spatial scales of hot spot - models

represent

Micro	*Traffic*	Where the highest concentrations occur to which the population exposed street segment no less than 100 m length at traffic-orientated sites
Local	*Industry*	250 m × 250 m at industrial sites
	Urban *Suburban*	integrated contribution from all sources representative for several square kilometres
Regional	*Rural*	not be influenced by agglomera-tions or industrial sites in its vicinity
	Eco system	>5 km away from built-up areas, representative for at least 1 000 km^2

Spatial scales of hot spot - models

represent

Where the highest concentrations occur to which the population exposed

Traffic **Screening model PROKAS, prognostic MISKAM**

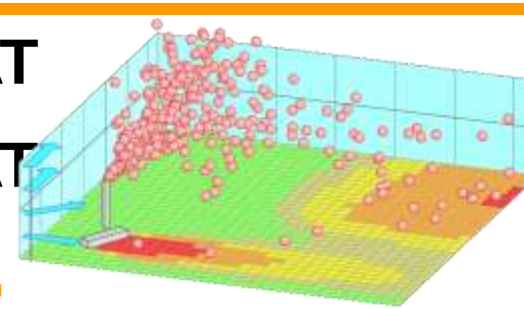
Micro

Industry **AUSTAL2000, LASAT**

Local

Urban **AUSTAL2000, LASAT**

Suburban



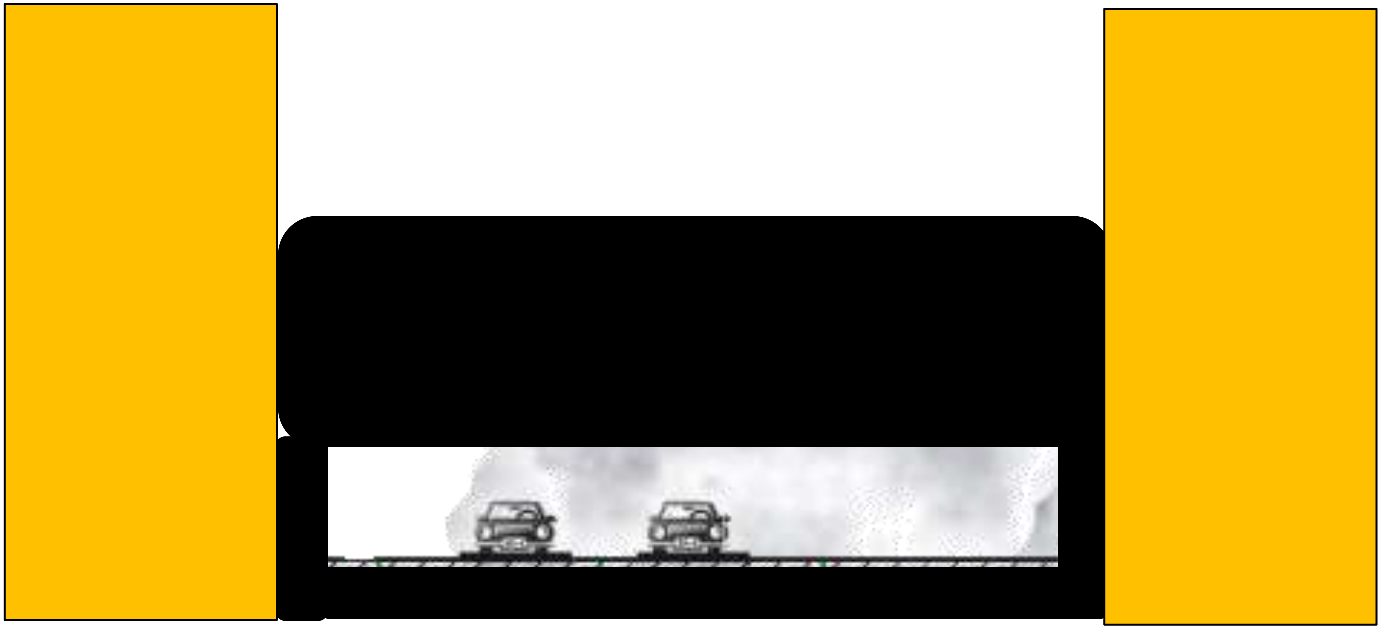
Rural **LASAT, EURAD**

Regional

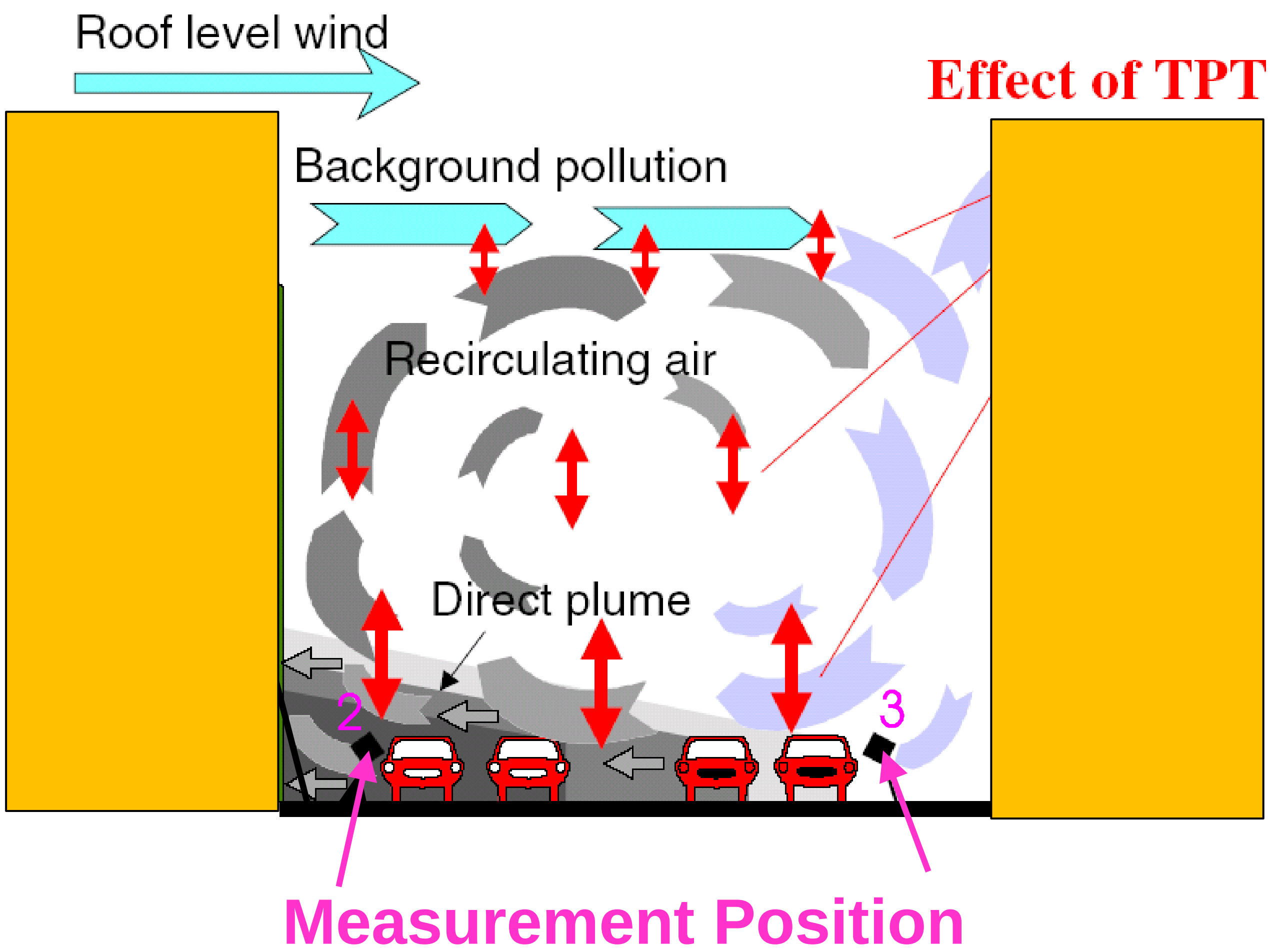
Eco system **LASAT, EURAD**

Free Dispersion

garage → street canyon



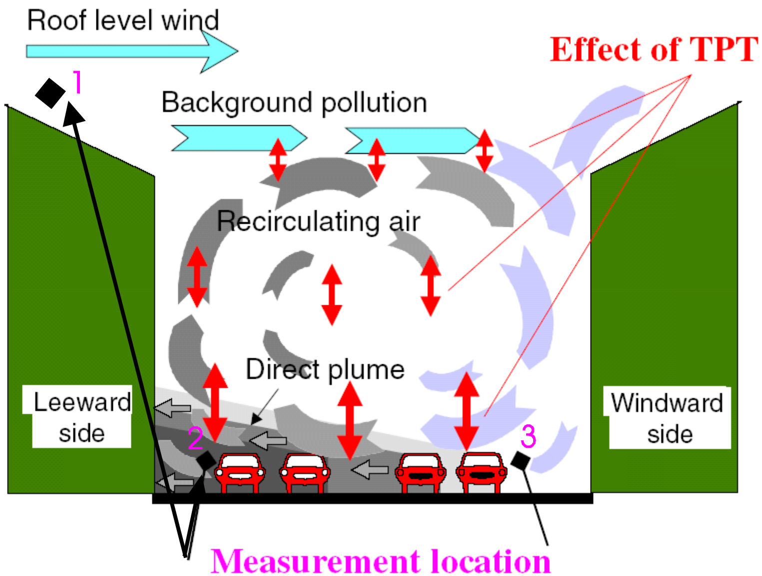
Street Canyon



Bursa Beyazit Cd. NO_2 mean conc µg/m³

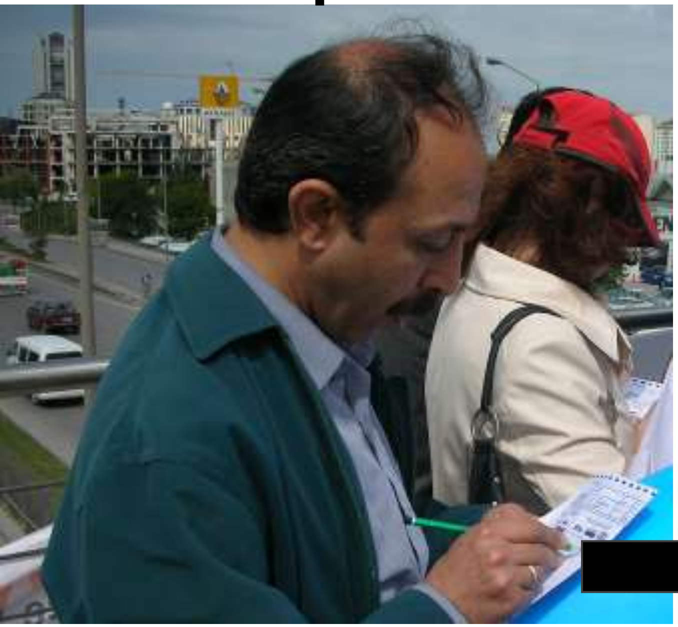
microscale

Traffic

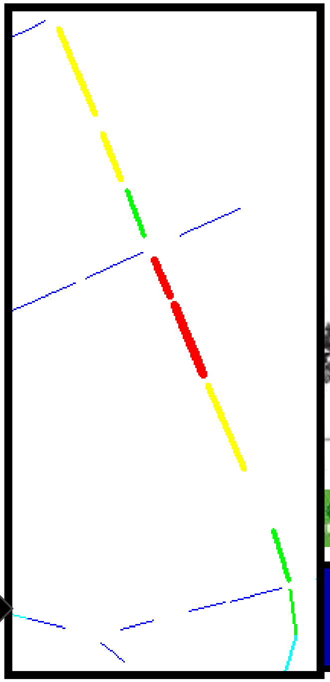


model

Collect input data



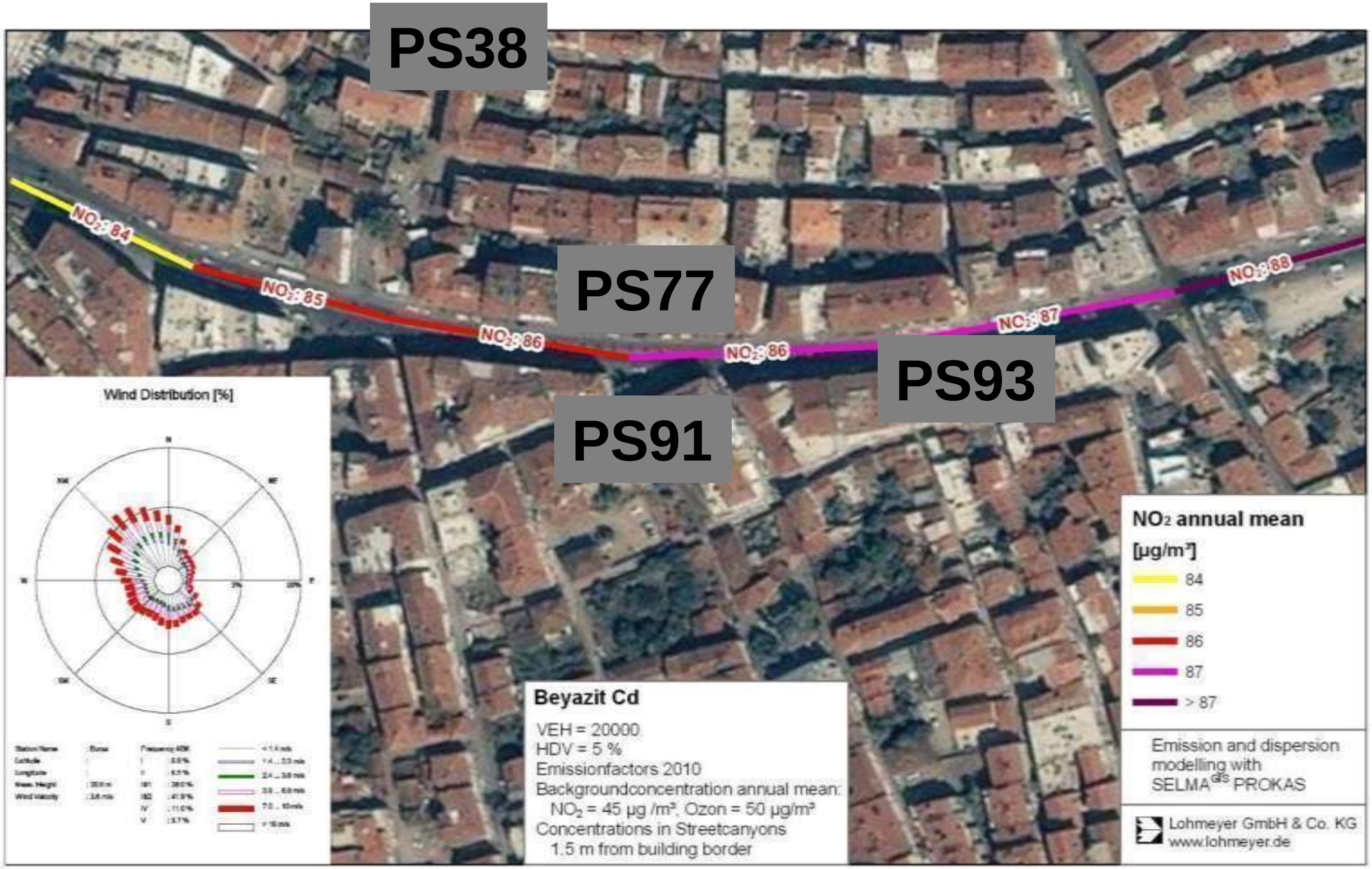
- Mean daily traffic volume DTV
- Fraction of High Duty Vehicles
- Vehicle speed
- Traffic rules, e.g. traffic lights
- Number of lanes
- Percentage of Stop & Go
- Longitudinal gradient of roads

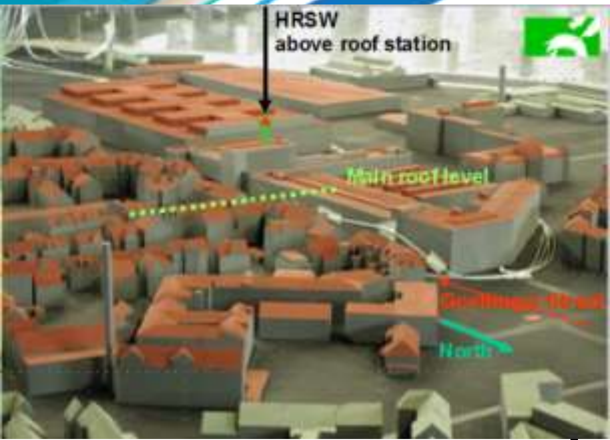


Bursa Beyazit Cd. NO2 mean conc µg/m3, microscale

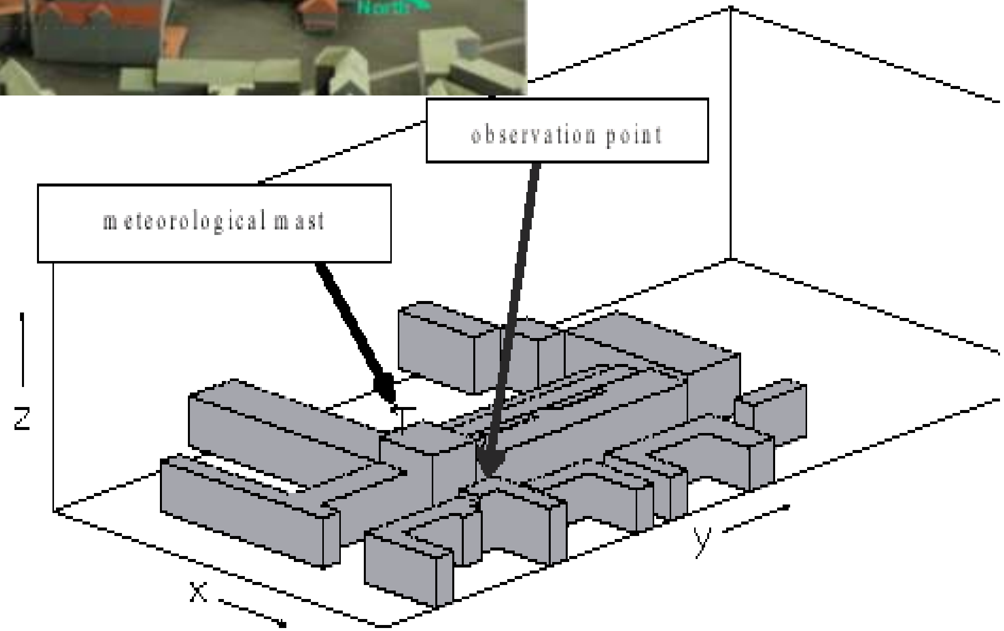
Model

PS Passiv Sampler Nov2012 –Feb 2013

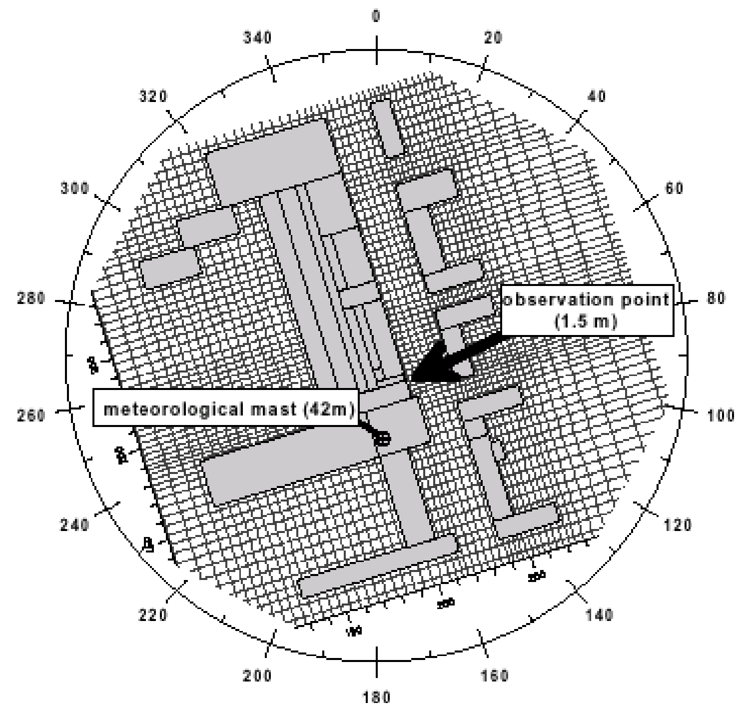




Windtunnel +MISKAM



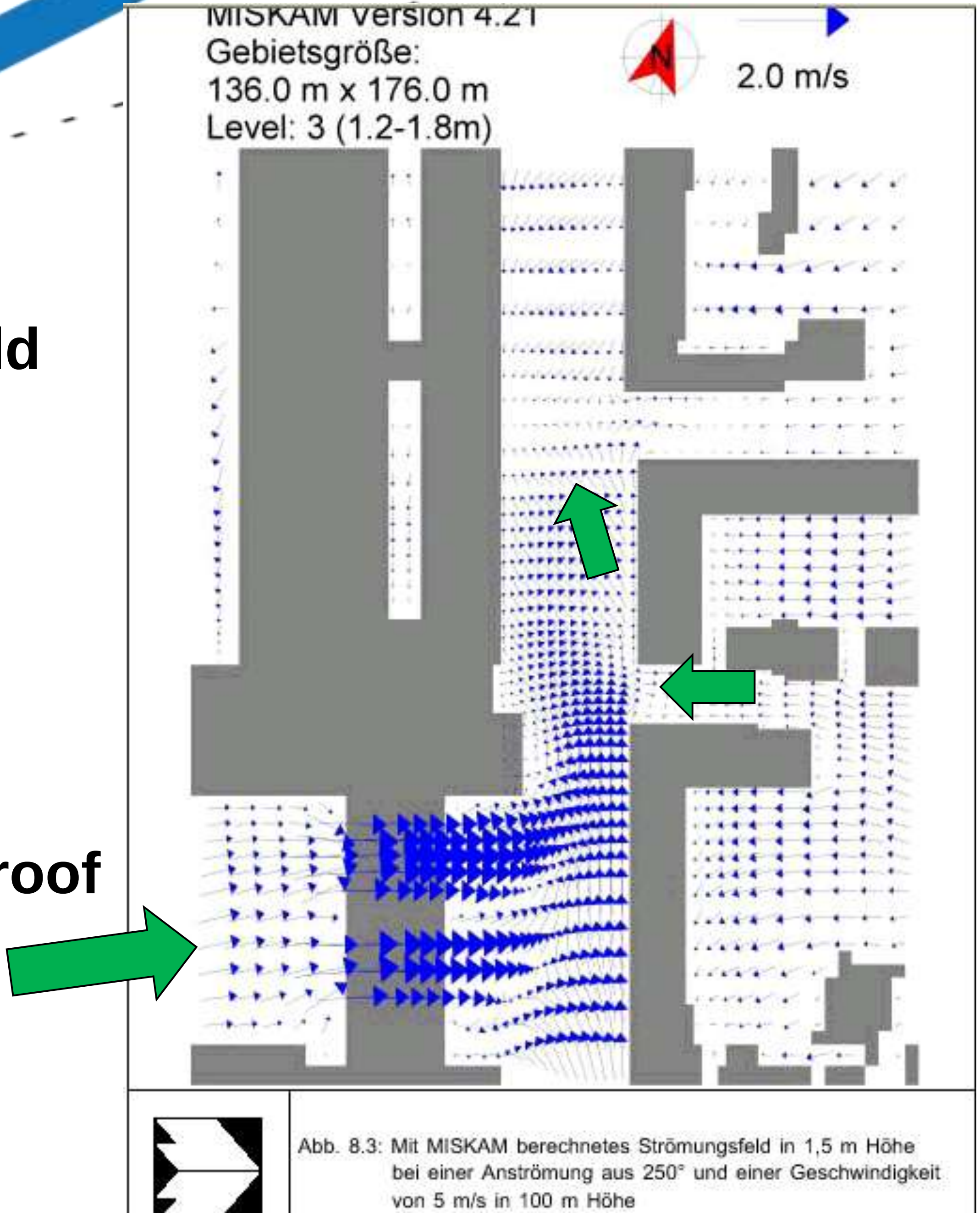
Central part of the modelling domain.



Top view on the modelling area. The grey areas indicate buildings. The mesh shows the resolution of the grid. The circular axis gives the direction with respect to North

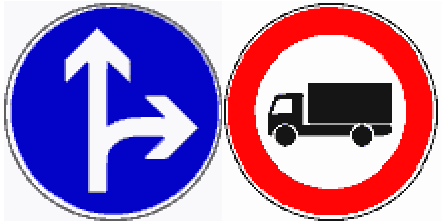
Windfield in 1.5 m height

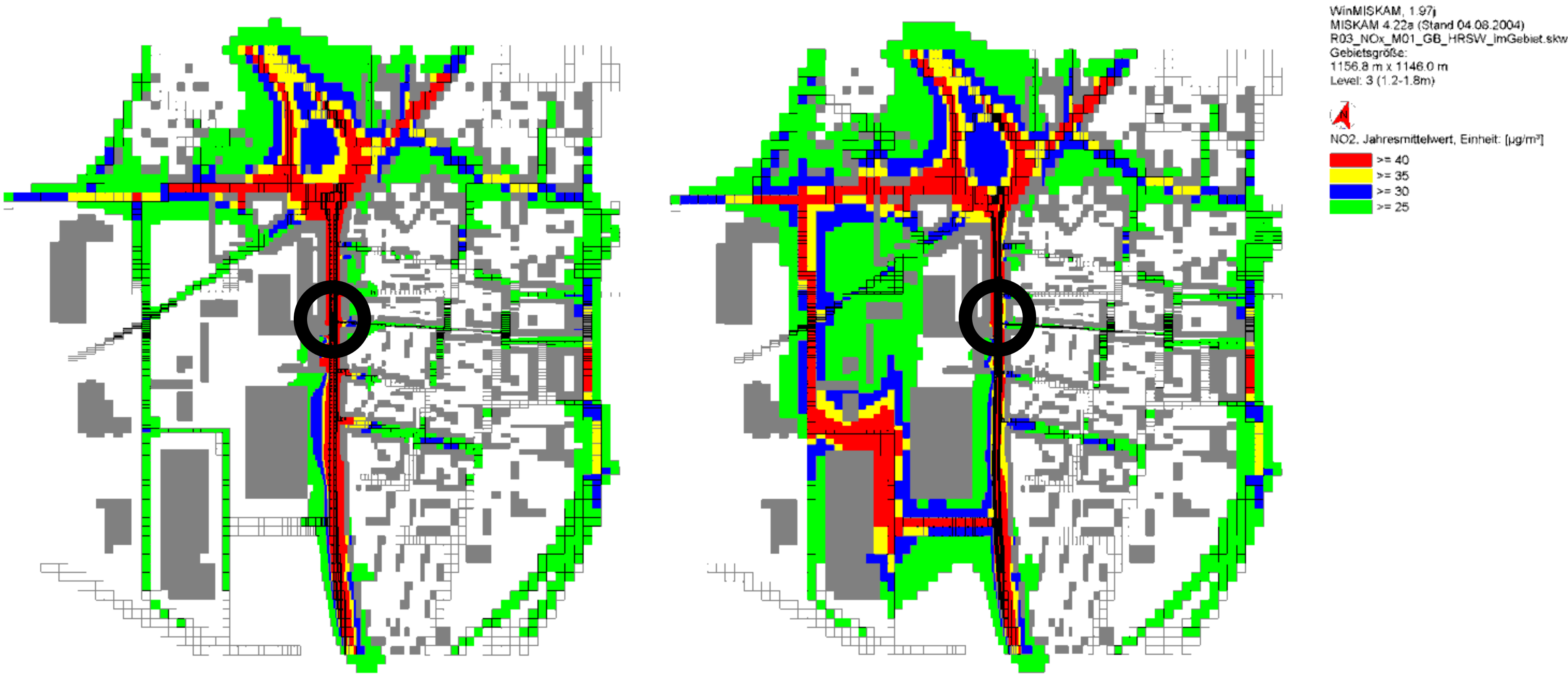
Above roof



Detailed 3 dimensional dispersion calculation
MISKAM
microscale

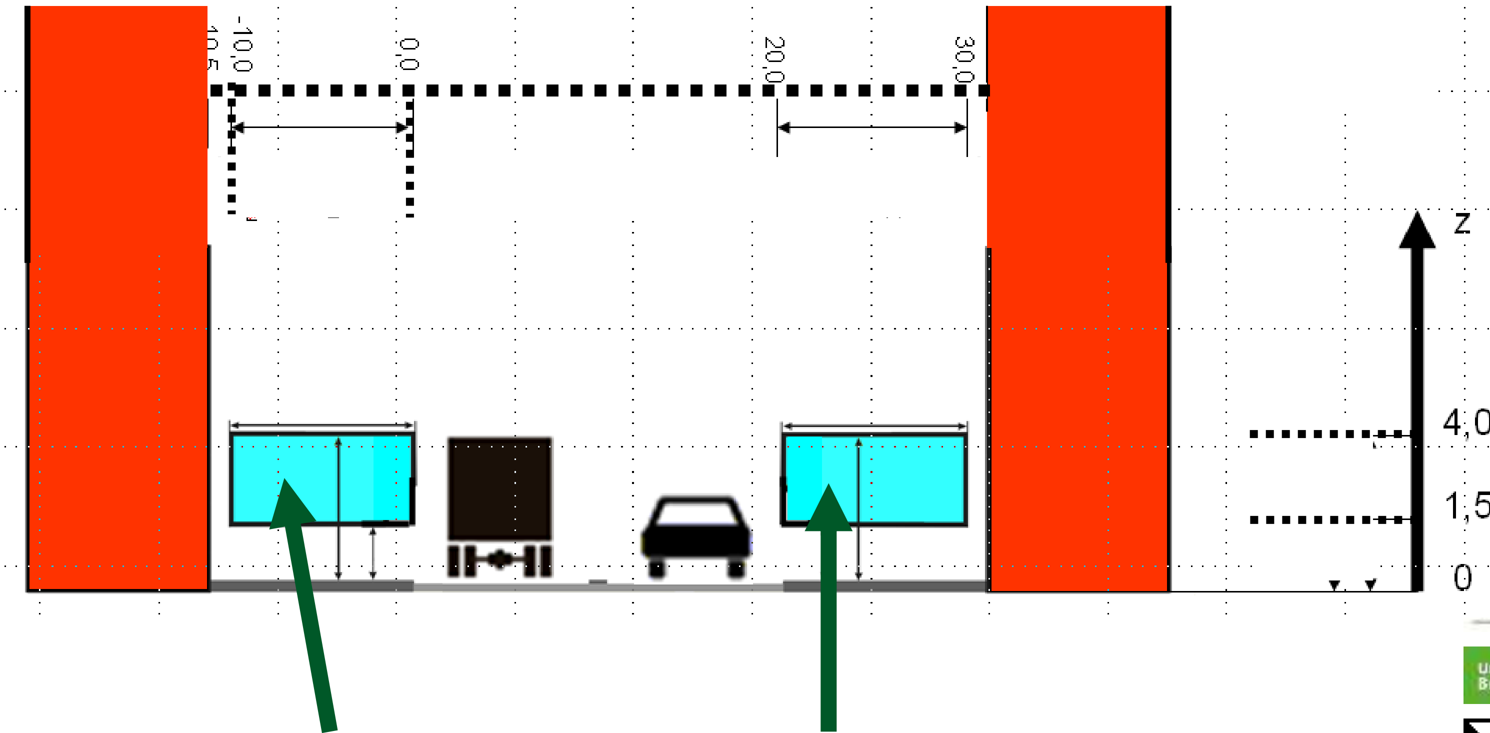
NO_2 annual mean 61 µg/m³ **44 µg/m³**





EU Directive: siting traffic station

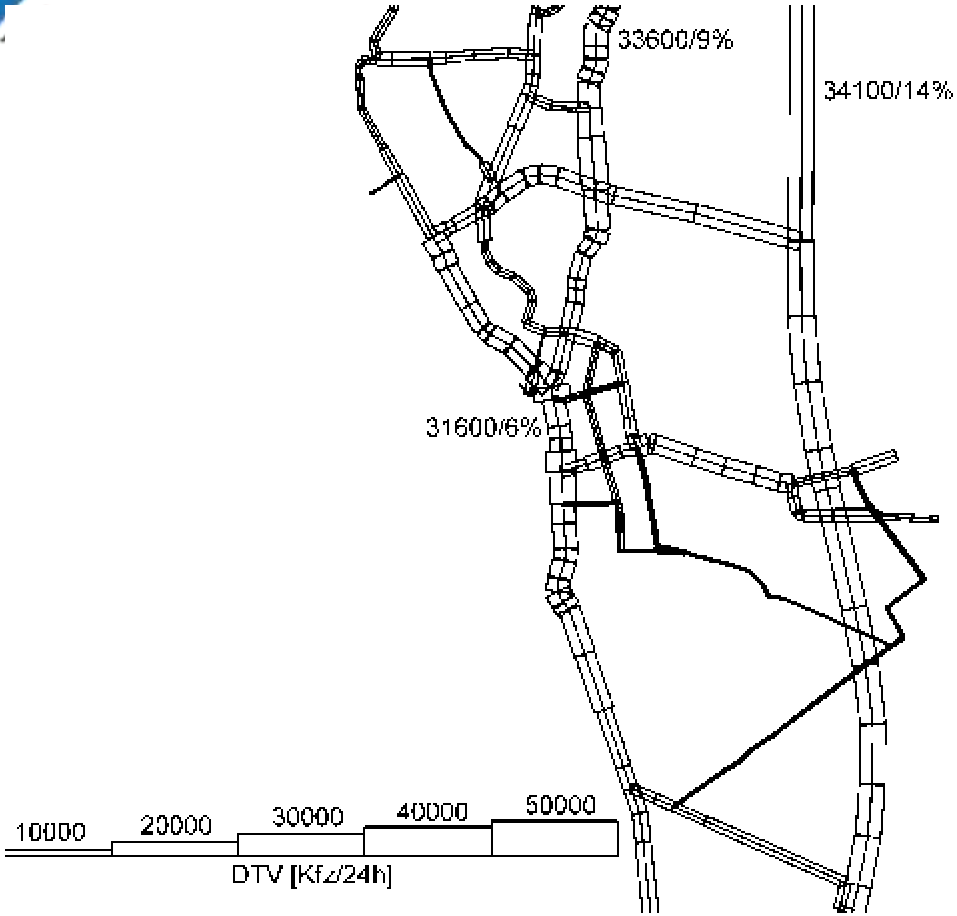
street canyon



Area for monitor inlet

Area for model calculation

Data Traffic

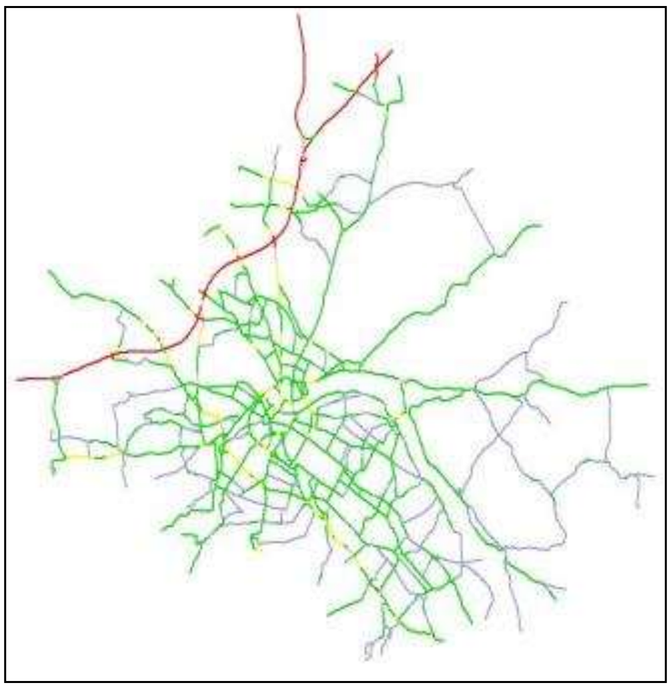


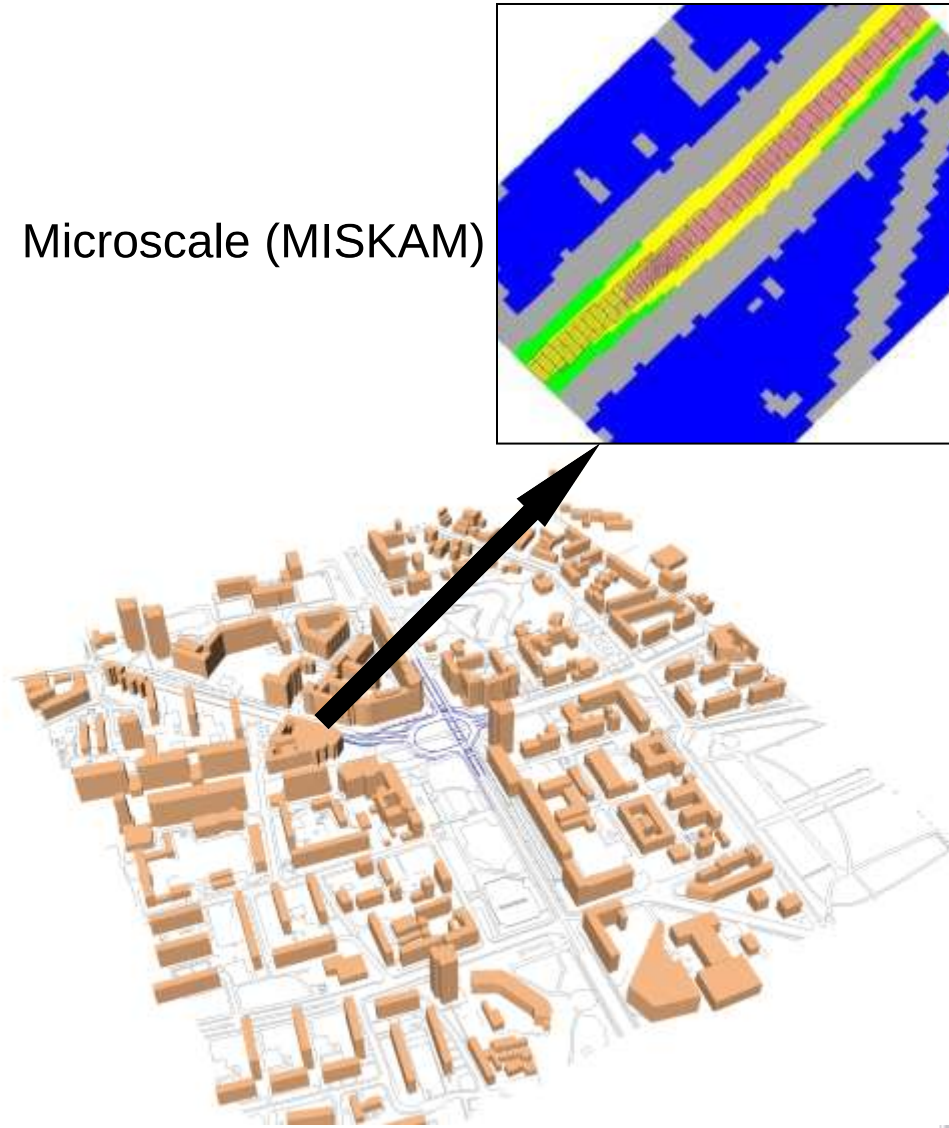
- Mean daily traffic volume DTV
- Fraction of High Duty Vehicles
- Consumption Fleet (EURO1..6)
- Vehicle speed
- Traffic rules, e.g. traffic lights
- Number of lanes
- Percentage of Stop & Go
- Longitudinal gradient of roads
- Noise barriers etc.

Cityscreening

Screening (PROKAS_B)

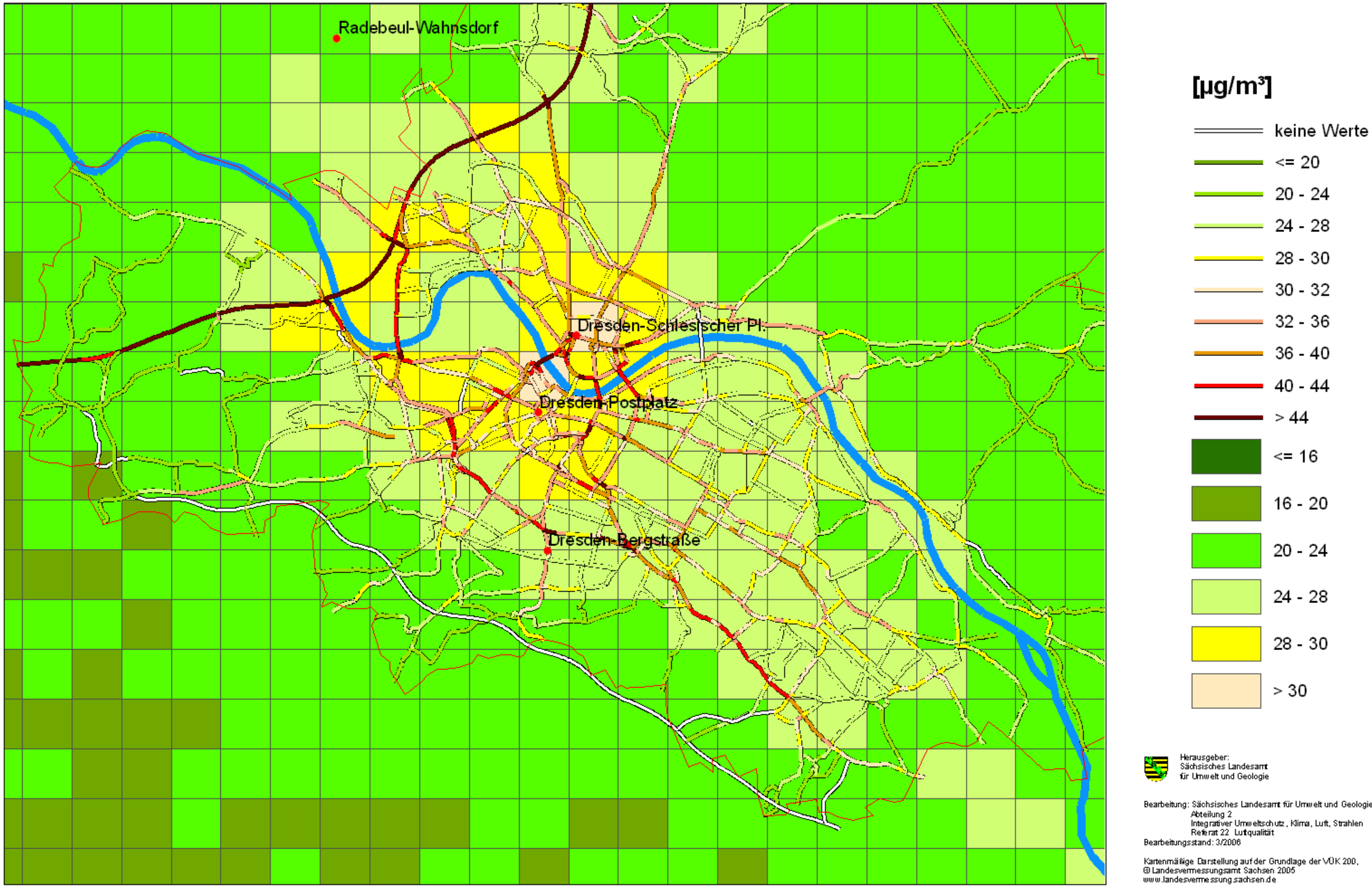
Microscale (MISKAM)





Example Cityscreening

Modellierte Jahresmittelwerte der PM_{10} - Belastung (Mittel 2001-2005)



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Abteilung 2
Integrativer Umweltschutz, Klima, Luft, Strahlen
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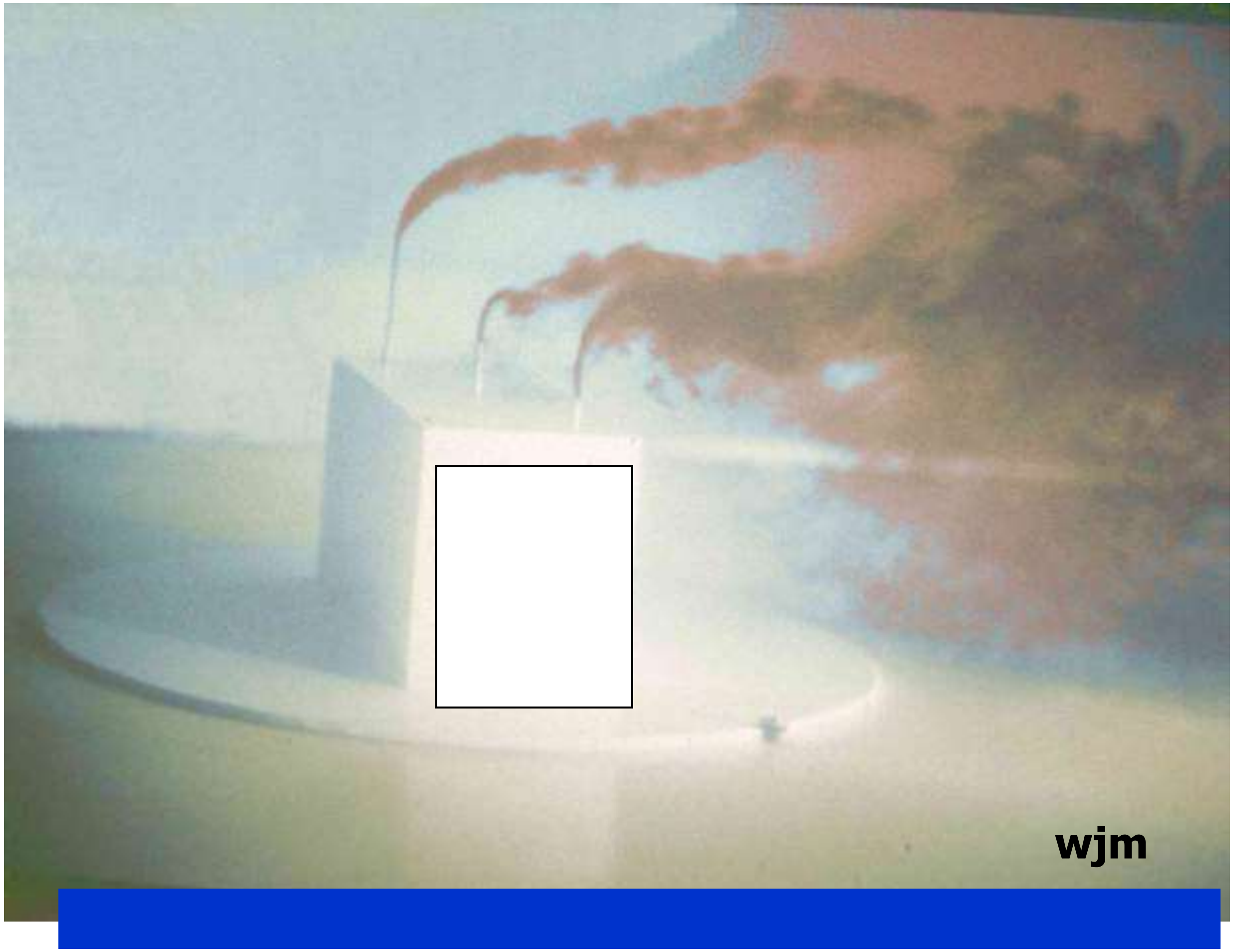
Bearbeitungsstand: 3/2006

Example microscale

densely built up area, downtown – NO_2-levels calculated by MISKAM

Stack & Building effect

Height of stack above roof!!



Next steps:

collect facts

analyze

use screening model

locate monitoring stations

analyze

modeling… Forecast…Measures …

public information

Clean Air Plan