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Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes
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Nitrogen Deposition Modelling within NATURA 2000 appropriate assessment for roads

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Overview

- Introduction
- Assessment
- Composite of the total load
- Emission modelling
- Modelling of Nitrogen deposition
- Simplified Estimation
- Example

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Within NATURA 2000 appropriate assessments the question of impacts by nitrogen input in sensitive natural habitats becomes more and more important. The EU directive 92/43/EWG (habitats directive) defines a strict protection goal. It seems that in the European Union only a few countries have implemented this theme in a sophisticated manner within approval procedures for NATURA 2000 appropriate assessment.

Guidelines for approaches of approval practice

- There a many guidelines for the handling of the issues of nitrogen deposition in NATURA 2000. More are in preparation
- In order to systemize approaches and establish a guideline for approval practice, the German Federal Highway Research Institute (Bundesanstalt für Straßenwesen) initiated the R&D-Project 84.0102/2009 “Assessing the impact of nitrogen emissions of road projects on sensitive habitats”, published November 2013. (BASt 2013)

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- Long-time exposure to nitrogen depositions may lead to changes in species composition even with low doses.
- In the scientific world “critical loads” (CL) have been established to describe sensitivity of natural habitats to eutrophying (and acidifying) impacts of nitrogen deposition.
- There are **empiric** critical loads and **modelled** critical loads and research for both approaches is still in progress.

Critical Load (CL)

The CL defines the maximal input of the atmosphere, up to its attainment no significant harmful effects of Receptors (e.g. ecosystems, vegetation) are excepted.

Only elementary nitrogen (mass number N=14)

Unit: [kg $ha^{-1}a^{-1}$] or [eq $ha^{-1}a^{-1}$]

Range: ca. 5 to ca. 40 kg $ha^{-1}a^{-1}$

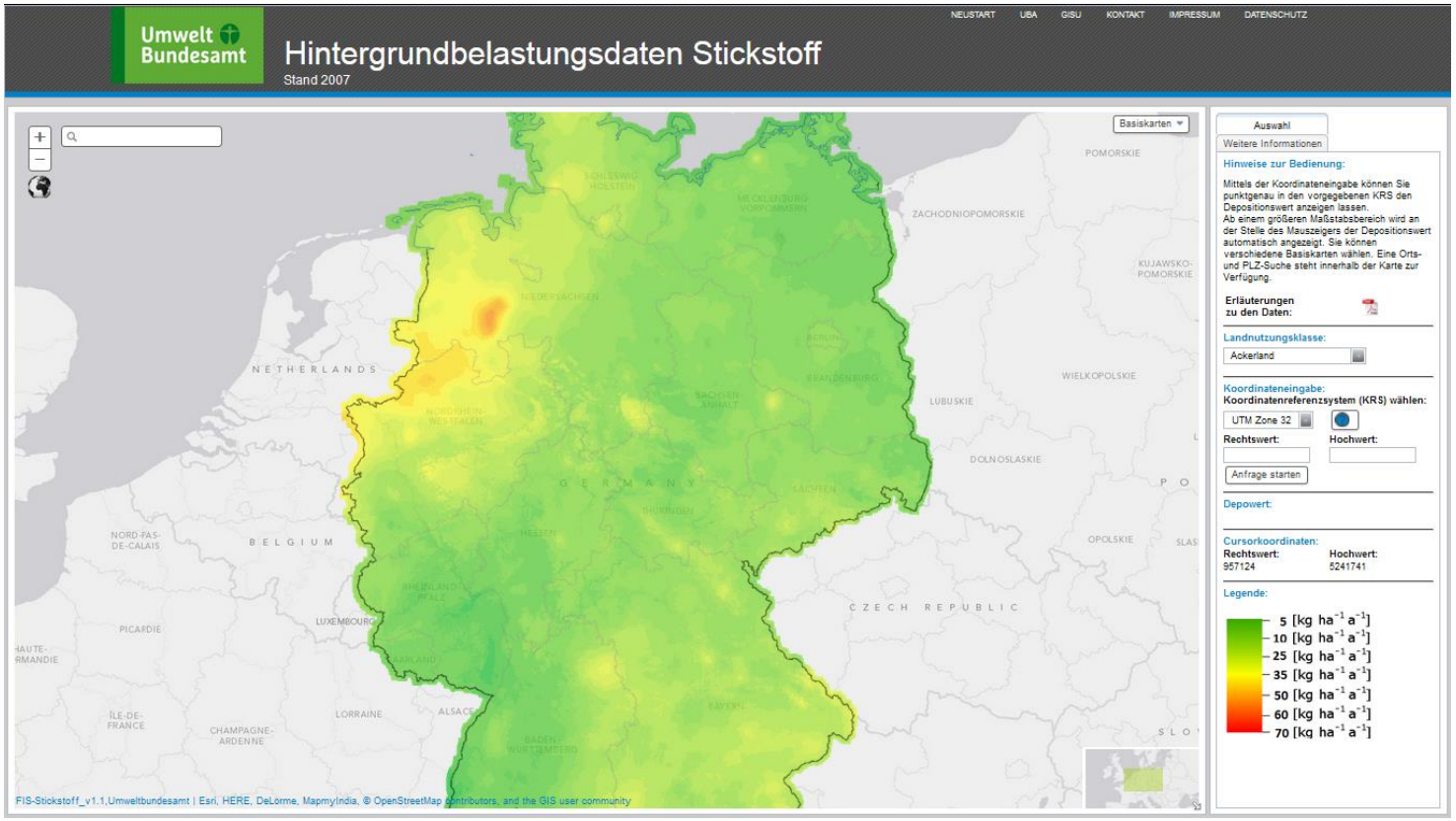
Determination of the CL

- Literature (e. g. List of Bern)
- BASt FE-Project 2013 Data Base
- Modelling with e.g. DECOMP.DE

Background Deposition

Recommendation of the German Federal Environment Agency (UBA) for the Background Deposition of Nitrogen in Germany for 2007 (gis.uba.de/website/depo1/)

- Update 2007
- Reduced and oxidized N-Component
- Wet and dry Deposition
- 1 km² Grid
- 9 Categories of Land cover
- Accuracy: 1 kg



An update is in Preparation.

Background Deposition Deciduous forests

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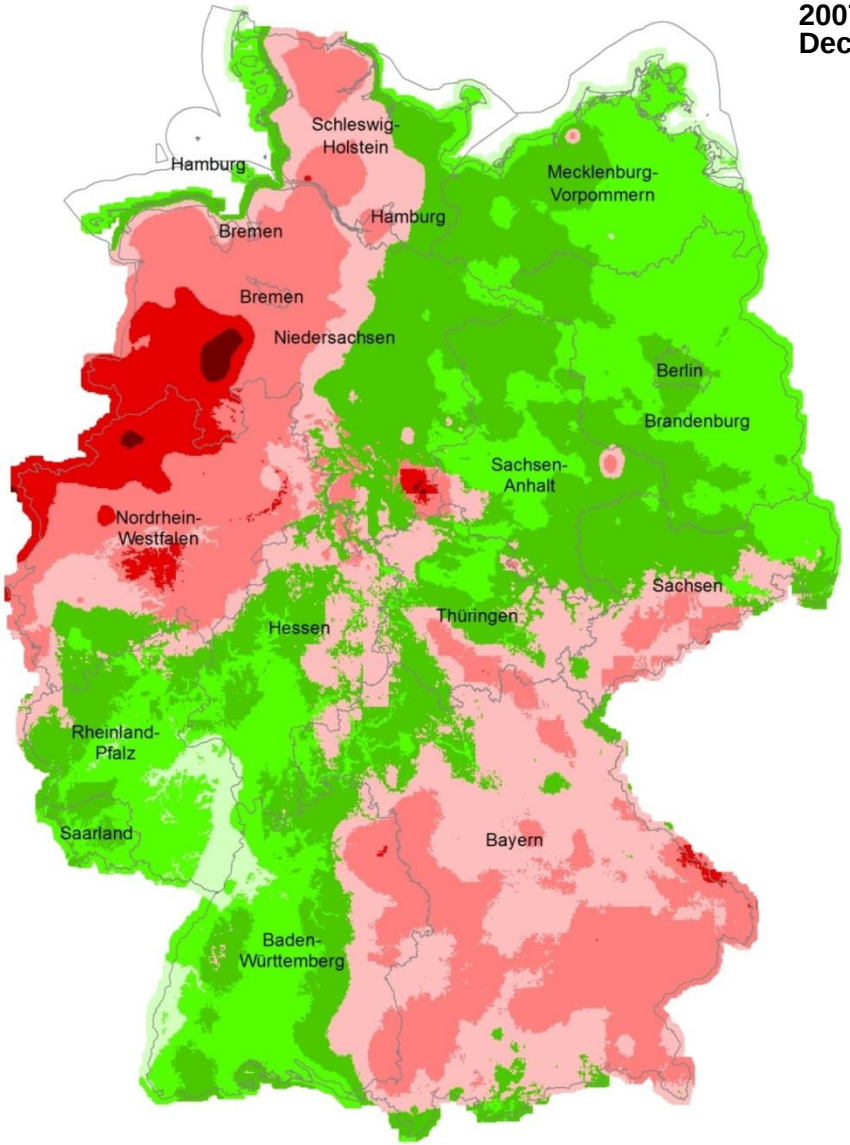
Estimated background loads for N-Deposition in Germany 2007:
Deciduous forests



Stickstoffdepostition in Laubwäldern

- 12 - 15 [kg N / ha a]
- 16 - 20 [kg N / ha a]
- 21 - 25 [kg N / ha a]
- 26 - 30 [kg N / ha a]
- 31 - 40 [kg N / ha a]
- 41 - 50 [kg N / ha a]
- 51 - 63 [kg N / ha a]

Database: UBA (http://gis.uba.de/website/depo1/)

Background Deposition Grassland

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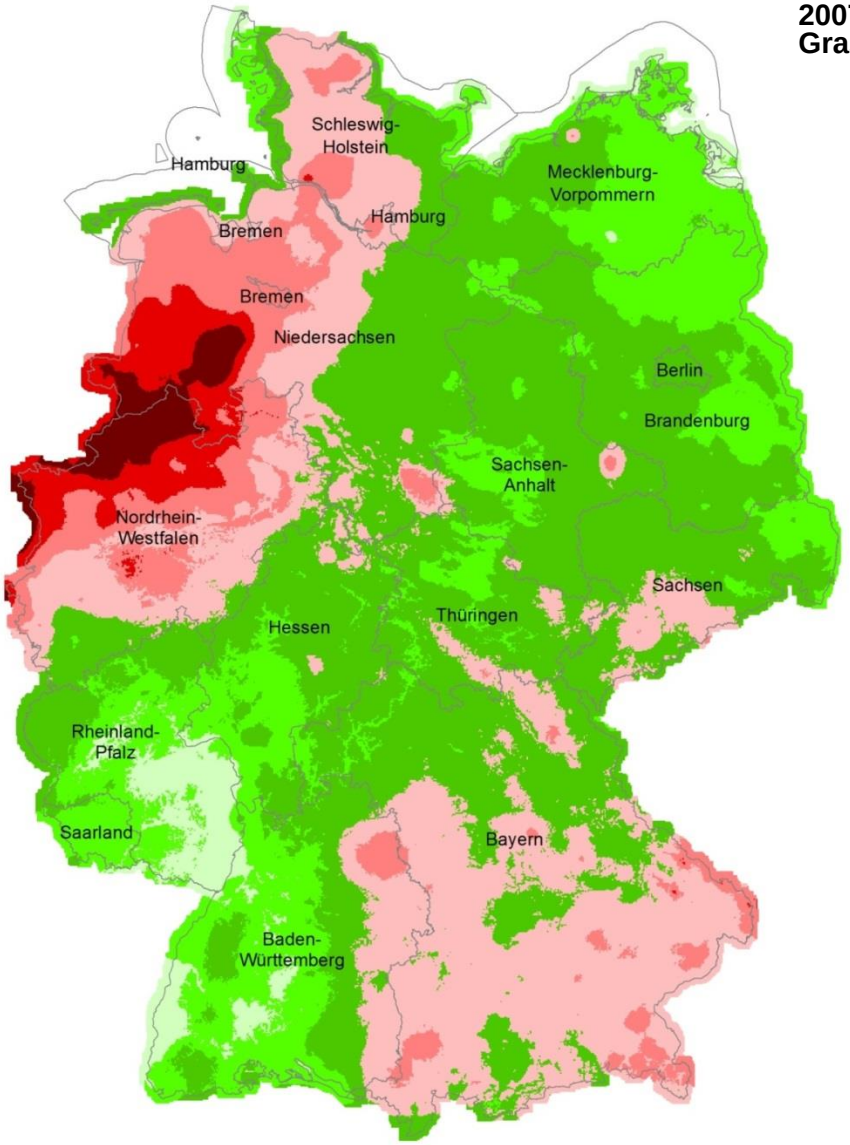
Estimated background loads for N-Deposition in Germany 2007:
Grassland / Meadows



Stickstoffdepostition in Wiesen

- 9 - 12 [kg N / ha a]
- 13 - 15 [kg N / ha a]
- 16 - 20 [kg N / ha a]
- 21 - 25 [kg N / ha a]
- 26 - 30 [kg N / ha a]
- 31 - 35 [kg N / ha a]
- 36 - 48 [kg N / ha a]

Database: UBA (http://gis.uba.de/website/depo1/)

Composite of the total load

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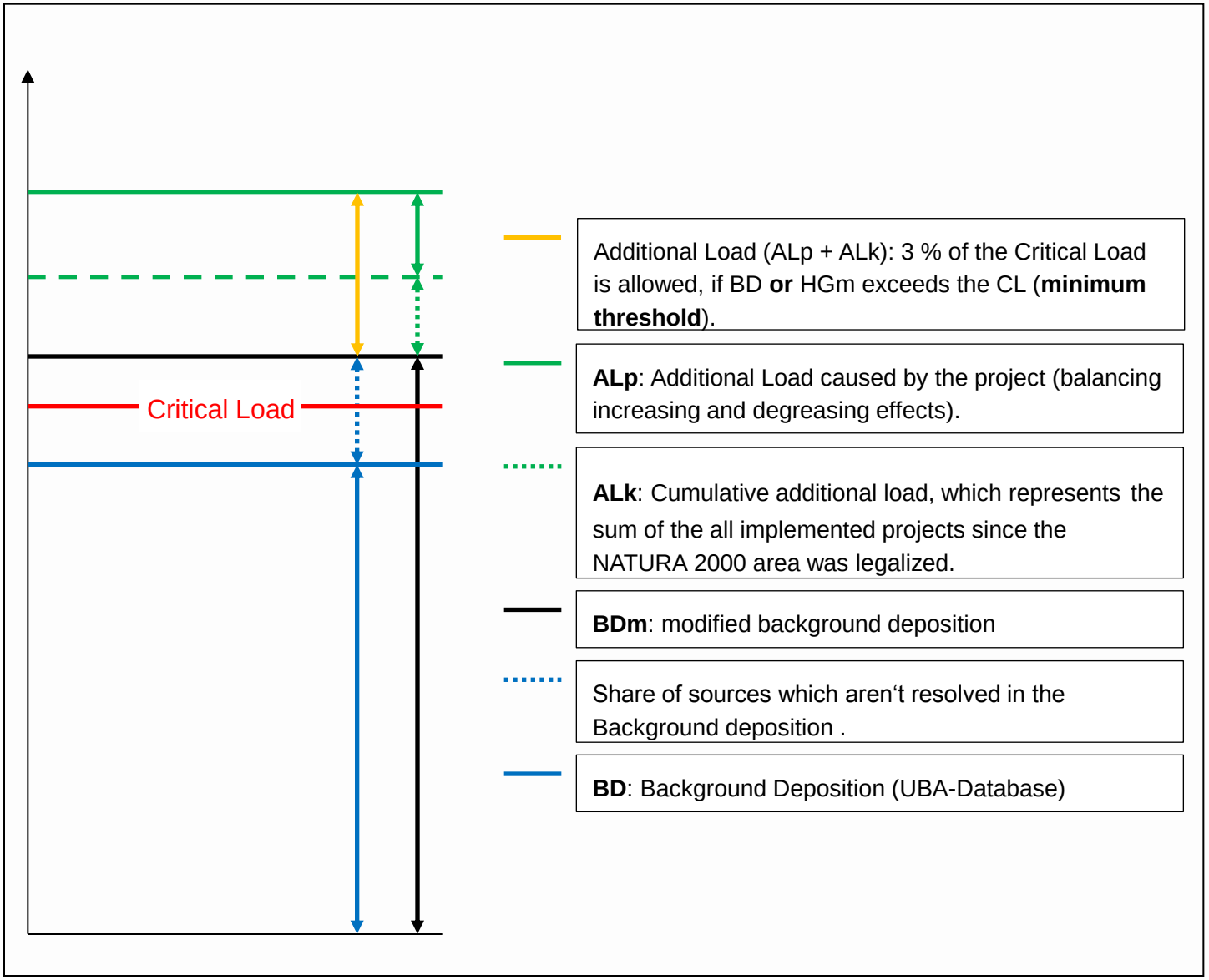
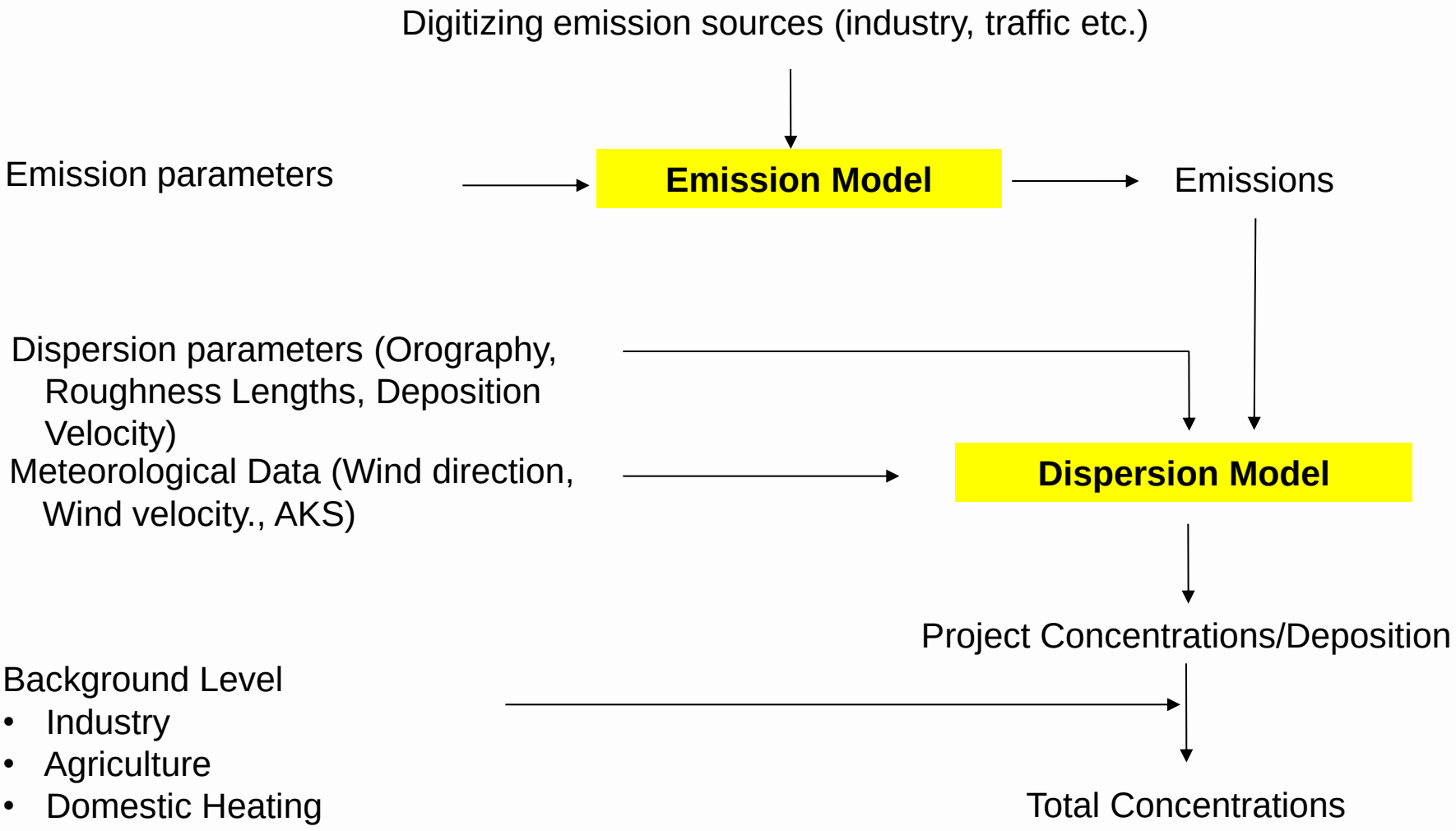



Digitizing emission sources (industry, traffic etc.)
Emission parameters
Emission Model
Emissions
Dispersion parameters (Orography, Roughness Lengths, Deposition Velocity)
Meteorological Data (Wind direction, Wind velocity., AKS)
Dispersion Model
Project Concentrations/Deposition
Background Level
• Industry
• Agriculture
• Domestic Heating
• Side Roads
• Emissions from long distance
Total Concentrations

Modelling vehicle Emission

- The significant emissions out of vehicle traffic are the chemical components oxides of nitrogen (NO, NO_2) und Ammonia (NH_3)
- In Germany, Austria, Switzerland, Norway and France is recommended to use the emission factors of the HBEFA (current version 3.2).
- The amount of vehicles and the share of heavy duty vehicles are considered.
- The year of interest should be defined for considering the fleet according to the norm of EURO
- Emission is calculated per time unit and road segment:
  Amount of vehicle * specific emission factor (NO_X and NH_3) VDI 3782 Bl. 7 (2003).

Dispersion model

The choice of the dispersion model accords to the local circumstances of the area of interest and the quality of the project goal.

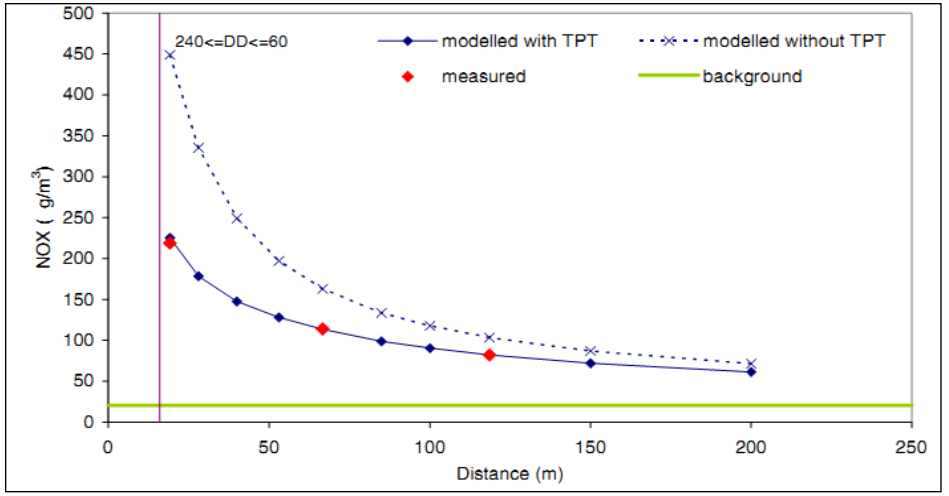
- Topography
- Meteorology,
- Nocturnal valley drainage flow
- Resolution of the model grid
- The method to calculate the deposition out of the concentrations.
- Roughness length
- Traffic induced turbulence

The Traffic Produced Turbulence could be considered to plublications of in BÄUMER (2003) and STERN, R. UND YAMARTINO, R.J. (2001).

Parameters:

- Amount of traffic (DTV),
- Amount of heavy duty vehicles,
- traffic velocity distinguished to light traffic and heavy traffic.,
- vertically model extent of the emission source
- wind velocity 1 m above the road.

The parameterization was evaluated to monitoring data, which were measured at a Danish motor way.



NOx-Concentrations (monitoring values and modelled values)
Koge Bugt Motorway in Danemark results of OML-HIGHWAY

Traffic Produced Turbulence land

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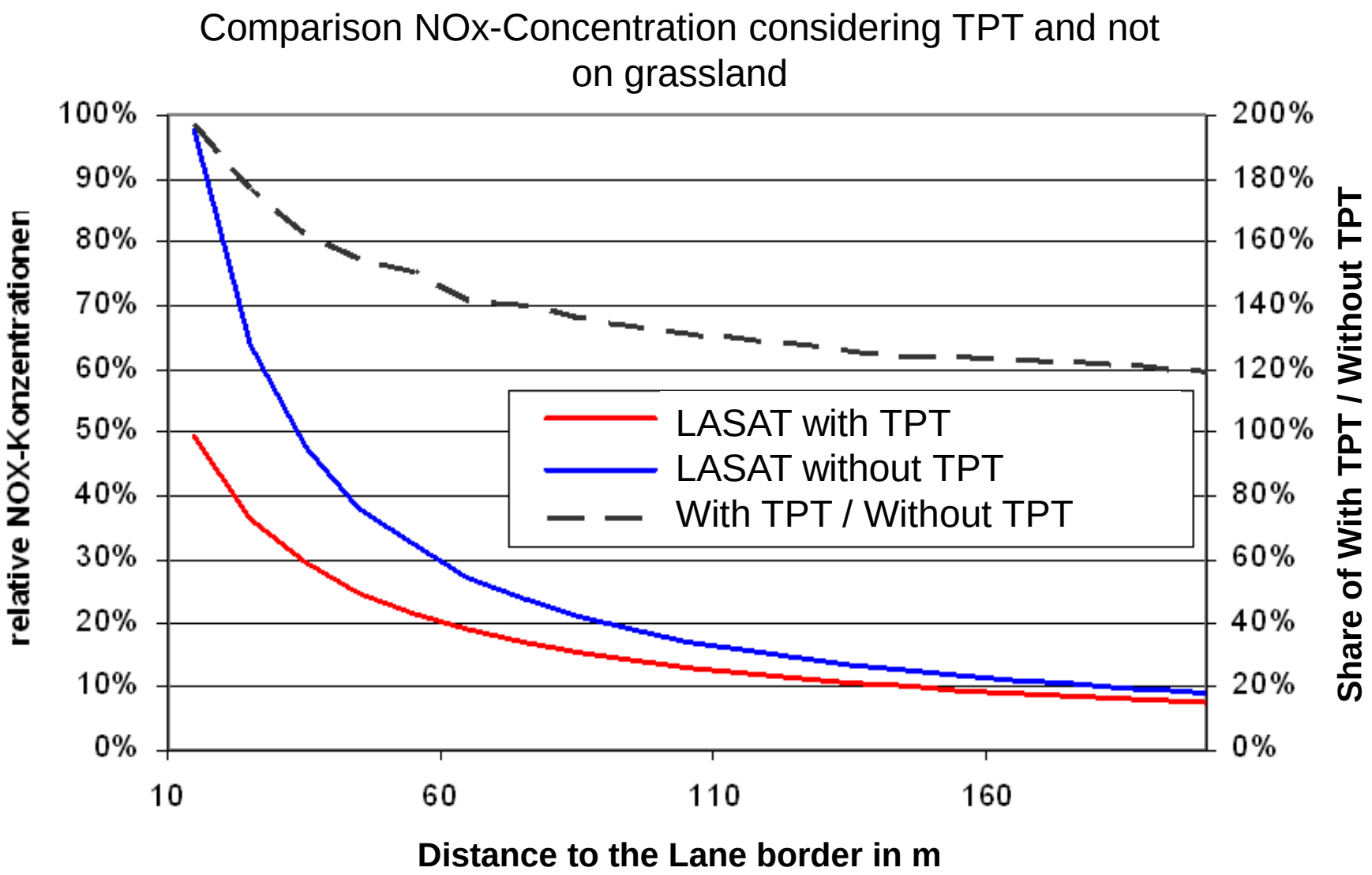

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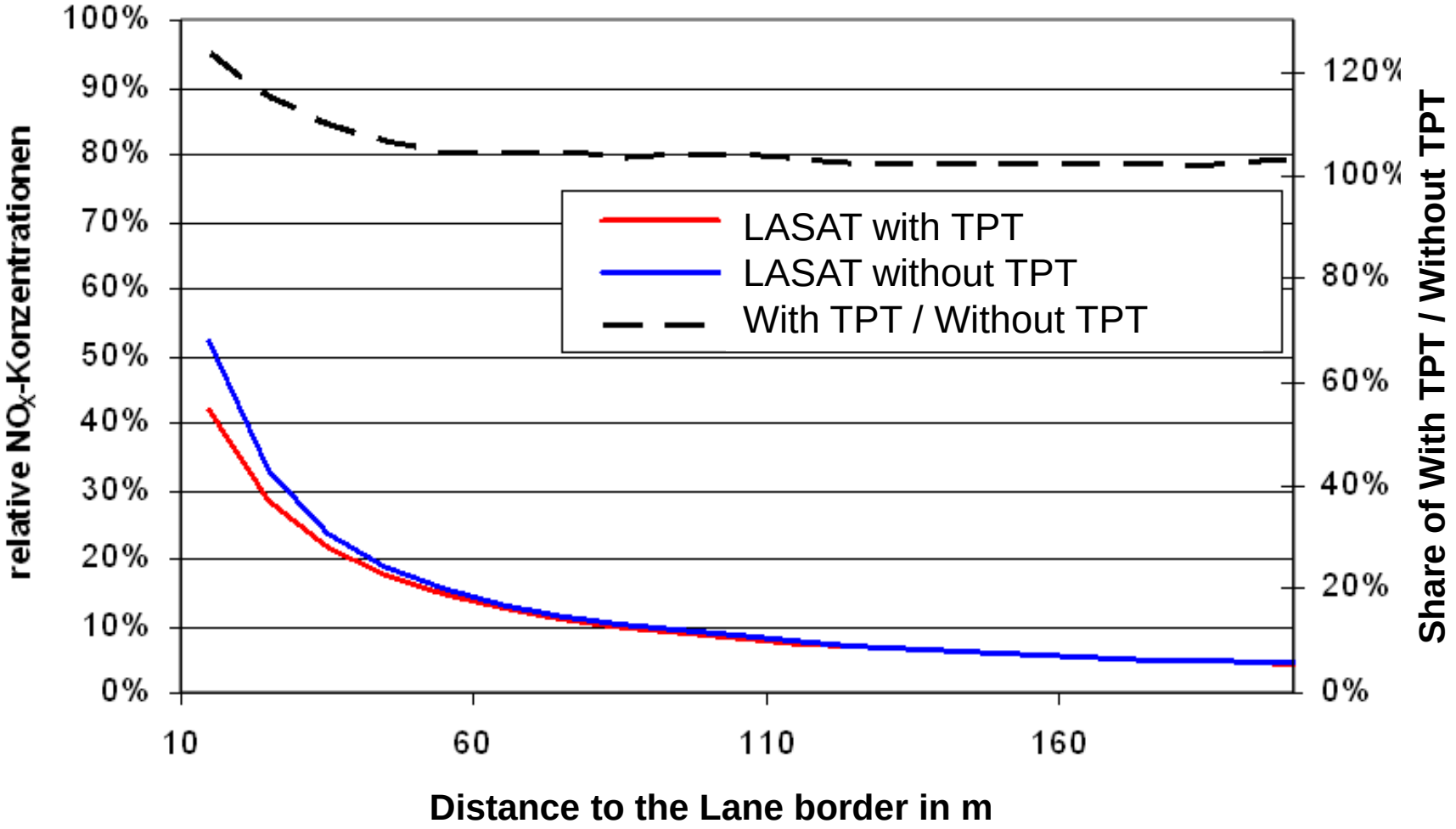
Comparison NOx-Concentration considering TPT and not on Forest land



Calculating the N-Deposition

Only the dry deposition has to be implemented for dispersion modelling projects, where only traffic emission source are considered. In this case the share of wet deposition is irrelevant.

DepN = c * Vd * Factor of stoichiometry * 3,1536

DepN = Deposition in kg * $ha^{-1}a^{-1}$

c = Air Concentration as annual mean at ground level in $\mu g/m^3$

Vd = Deposition Velocity (for dry deposition) in cm/s

Factor of stoichiometry = relative weight fraction of elementary nitrogen (N) of a chemically component
NO = 0,4666, NO_2 = 0,3043, NH_3 = 0,8235

The **Factor 3,1536** results out of the unit transformation.

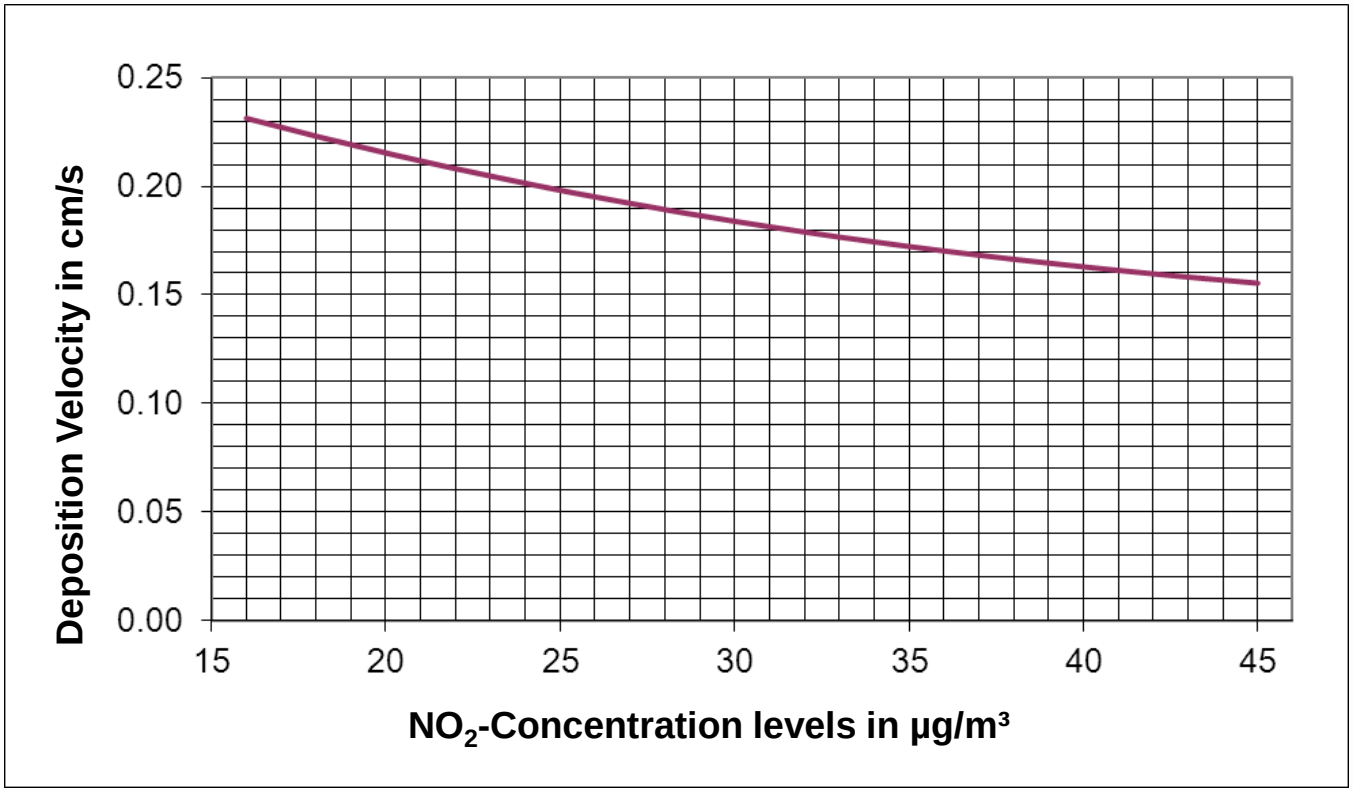
Deposition Velocity

- Deposition velocity could be get out of the literature. There is a large range of values, which are derived of measurement data. The German guideline VDI 3782 Bl. 5 (2006) gives an overview of the literature and define estimated values.
  → Recommended by the German Federal Environment Agency (UBA)

	Mesoskala	**Grassland**	**Forest**
	[cm/s]		
NO	0.05	-	-
NO_2	0.3	-	-
NH_3	1.2	1.5	2

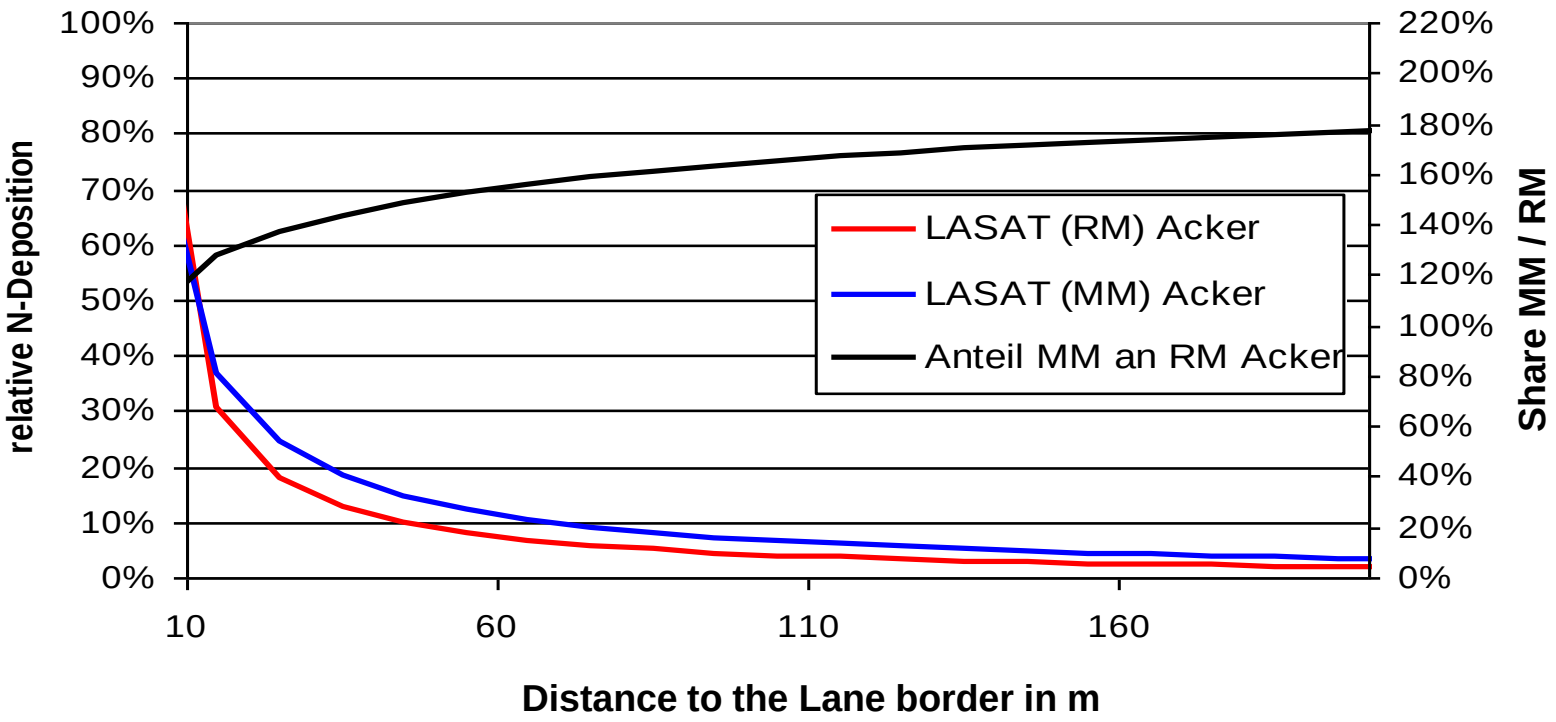
- The VDI 3782 Bl. 5 determinates simple values, which don't distinguish between different land cover types. Only the values for NH_3 distinguish between Grassland and forest.

Deposition Velocity for NOx



NO_X-Deposition Velocity according to NO_2-Concentration levels

Reduktions- u. Multiplikationsmethode



- The Multiplication method calculates always higher values than the Reduction method. For more realistic results it is recommended to implement the Reduction method.

Accuracy of the results

In Germany is an extensive discussion about the lowest value, which make sense to be evaluated. There are actors, who like to evaluate values in the resolution up to 1 N mole others up to 1 kg N $ha^{-1}a^{-1}$. In the last two years the specialist convention is prevailing, that the accuracy of the results is determinated to one decimal digit and values <= **0.3 kg N $ha^{-1}a^{-1}$** are irrelevant.

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- For the environmental assessments of road plans it is useful to have a conservatively and simplified method to estimate the maximal distance in which NATURA 2000 areas could be effected by exceeding of the critical load or the minimum threshold of 3% of the CL.
- It was part of the research project of BASt 2013 to calculate values for different cases.
- The emission calculation considered the following parameters:

Amount of vehicles per day:	**5 000**	**10 000**	**20 000**	**30 000**	**40 000**	**60 000**
Heavy duty vehicles (> 3.5t):	**10%**	**25%**				
Slope:	**0%**	**±4%**				
LOS:	**Free flow**					

Traffic Situations: Motorway>130 km/h, Motorway 100 km/h, National Road 100 km/h, National road with curves 100 km/h

→ 96 Combinations

N-Deposition Maximal Distances

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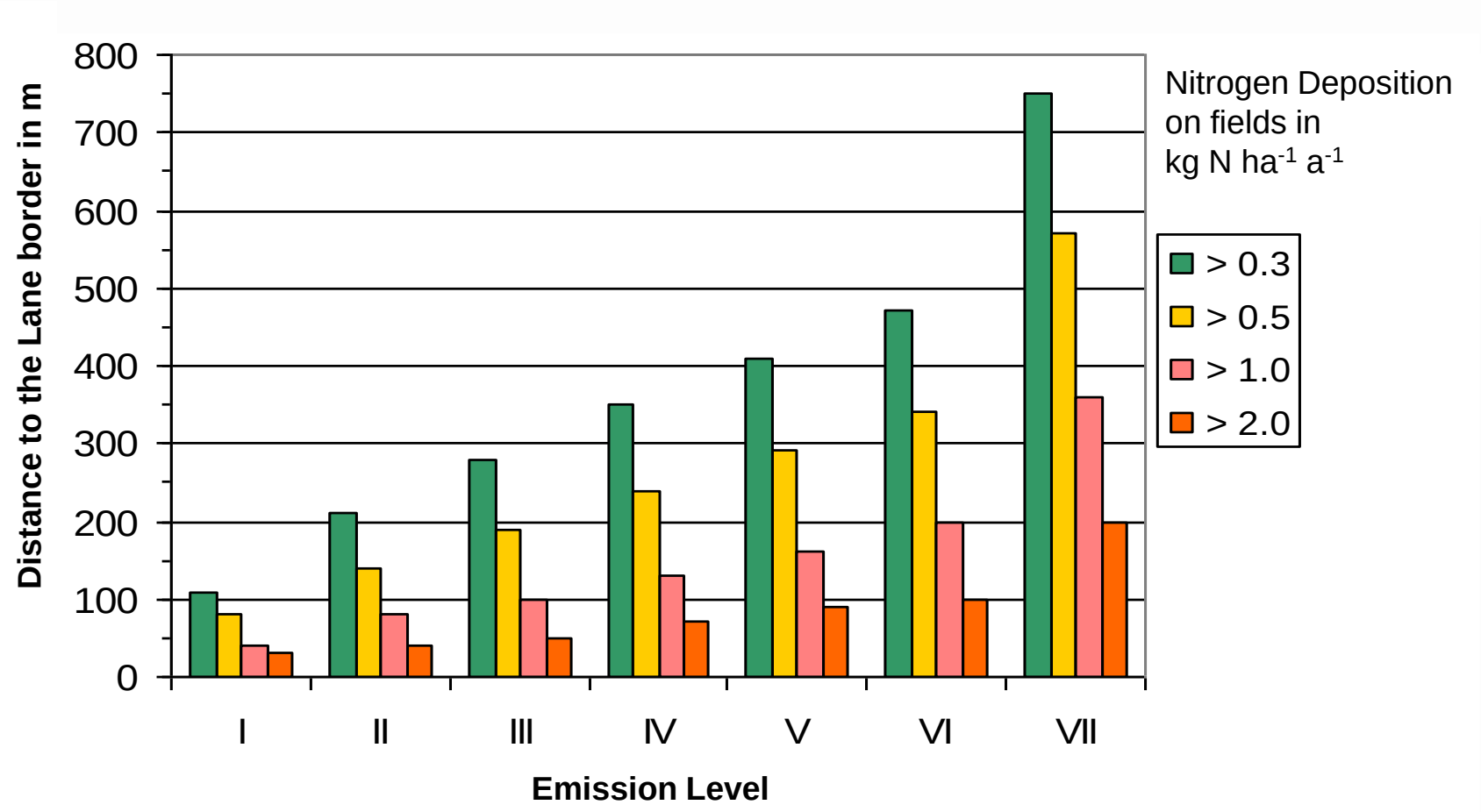

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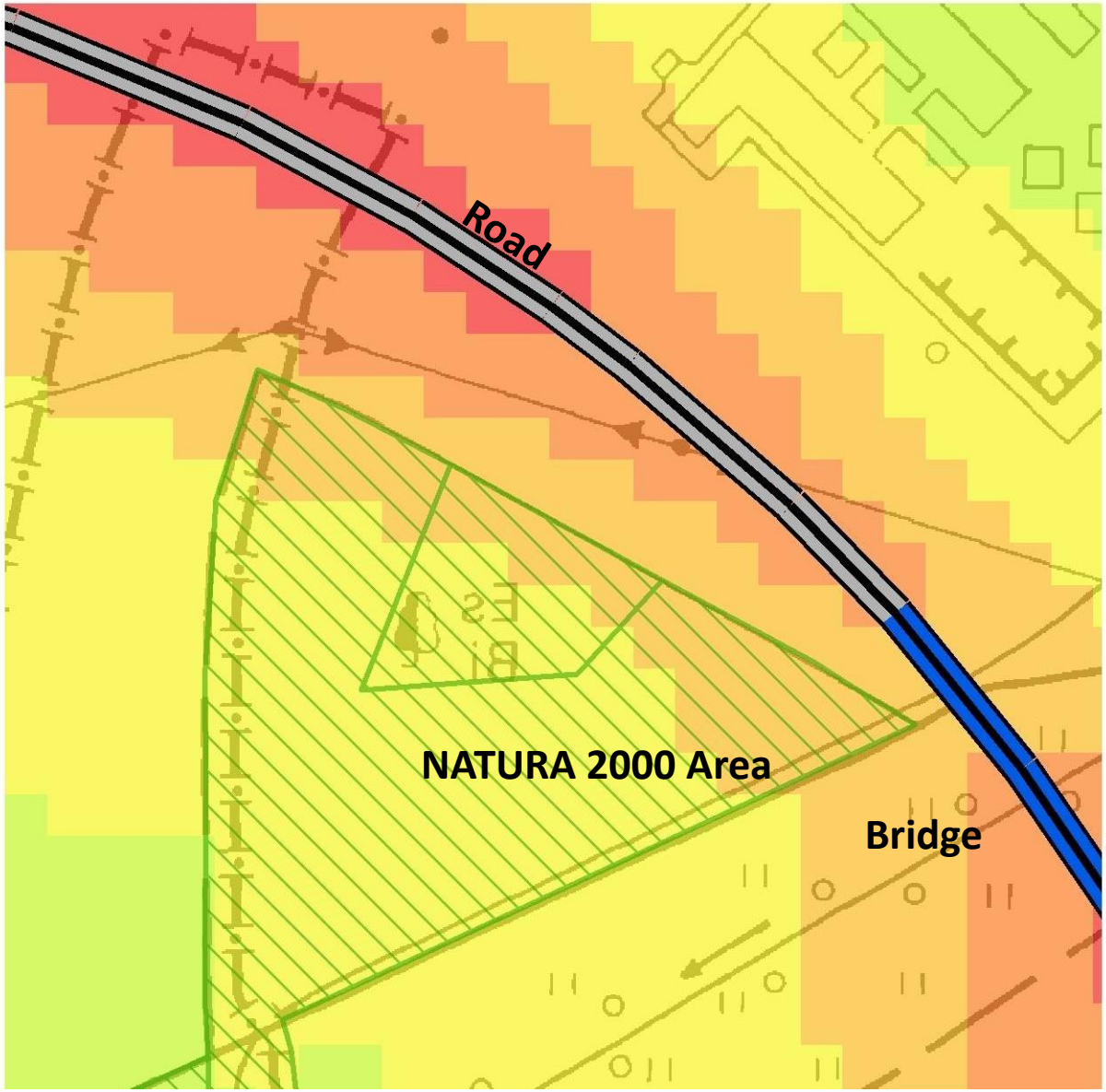

Nitrogen Depositionen
Traffic

[kg N/[ha * a)]

- **0**
- **> 0**
- **> 0,2**
- **> 0,3**
- **> 0,5**
- **> 0,7**
- **> 1,5**

Minimum threshold value Exceeded

Example

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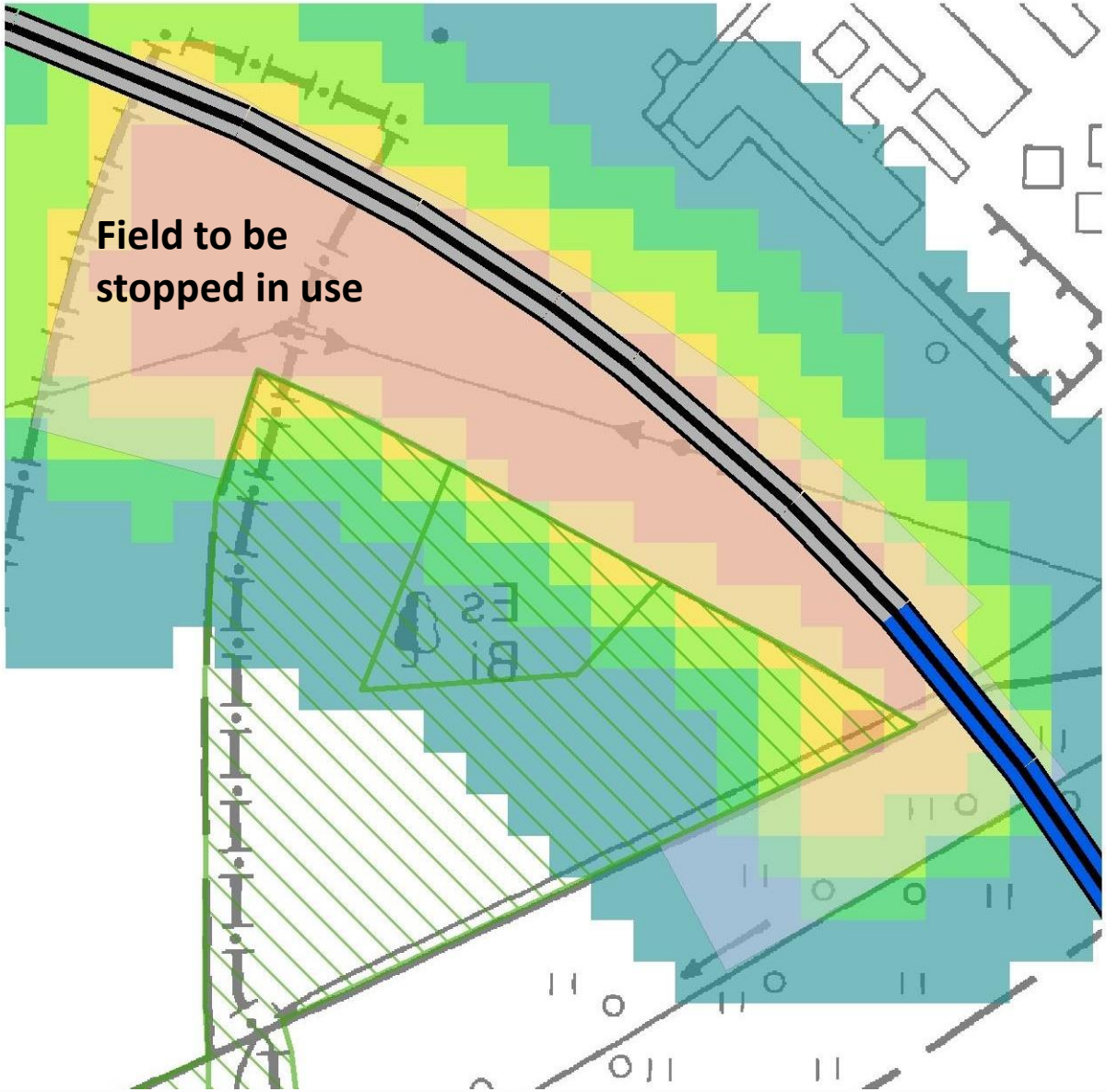

Nitrogen Depositionen
Fertilisation

[kg N/(ha*a)]

- 0.00
- 0
- > 0
- > 0.3
- > 0.5
- > 0.7
- > 1.5

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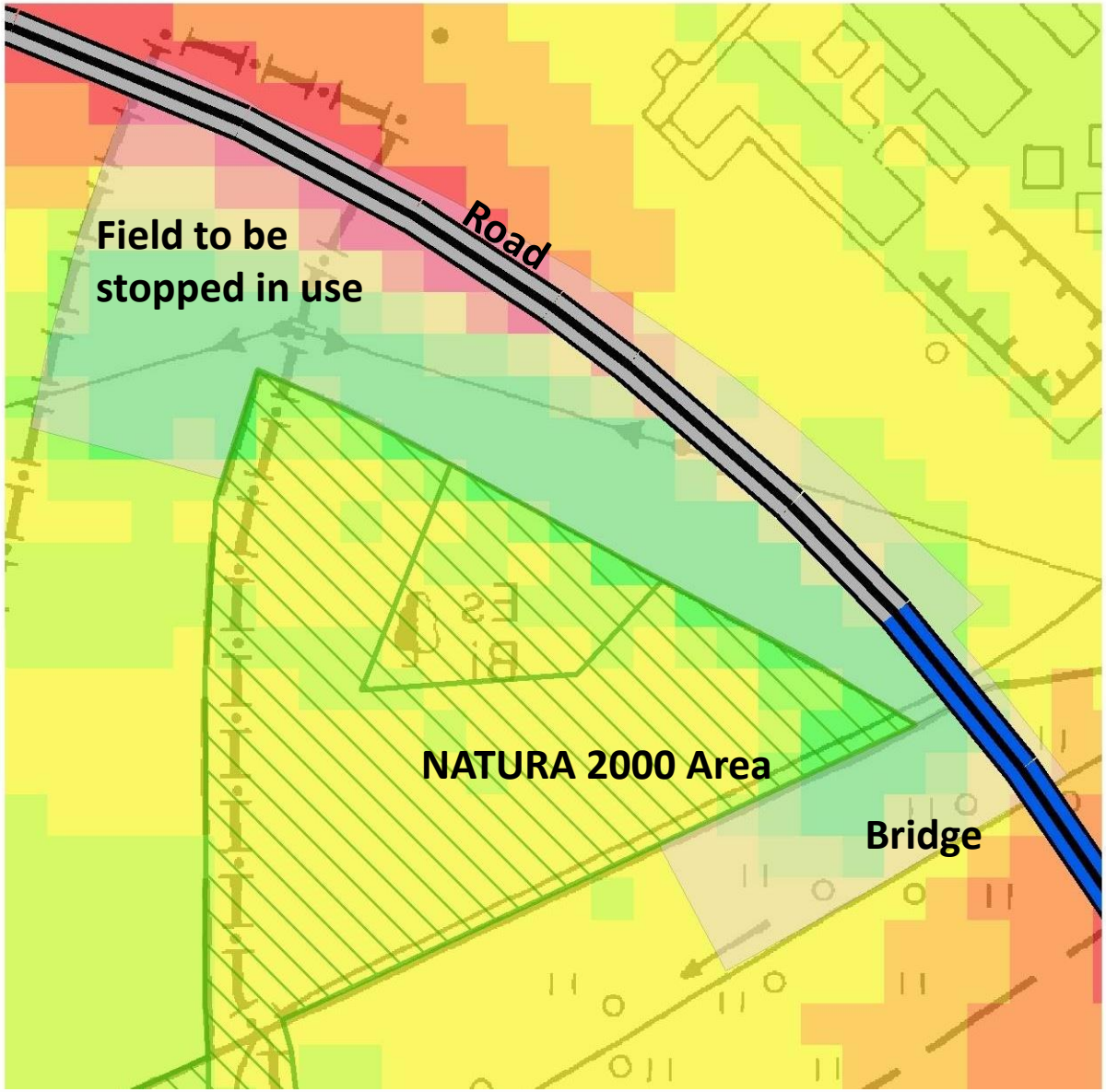

Nitrogen Depositionen
Traffic - Fertilisation

[kg N/[ha * a)]

- 0
- > 0
- > 0,2
- > 0,3
- > 0,5 CL überschritten
- > 0,7
- > 1,5

Thanks for your Attention!

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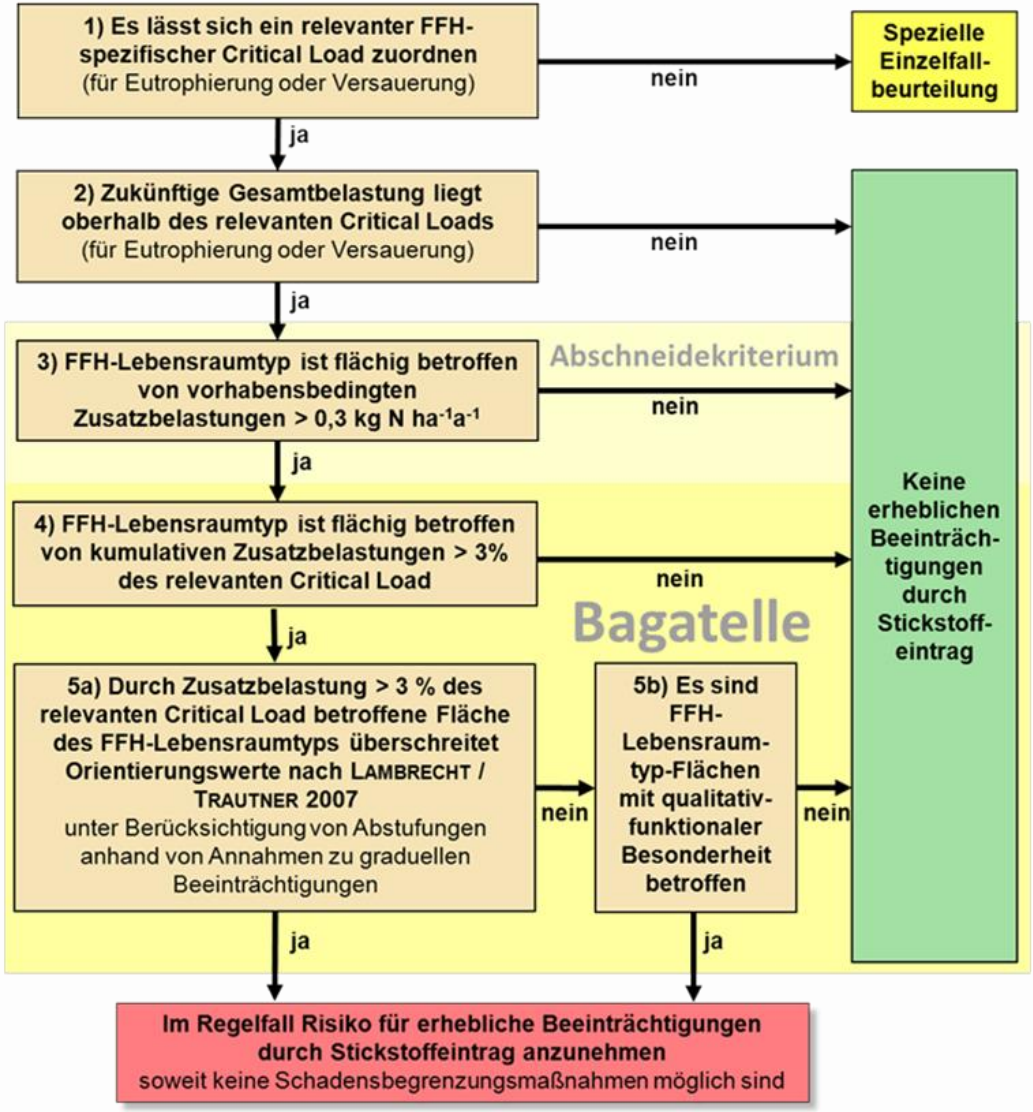
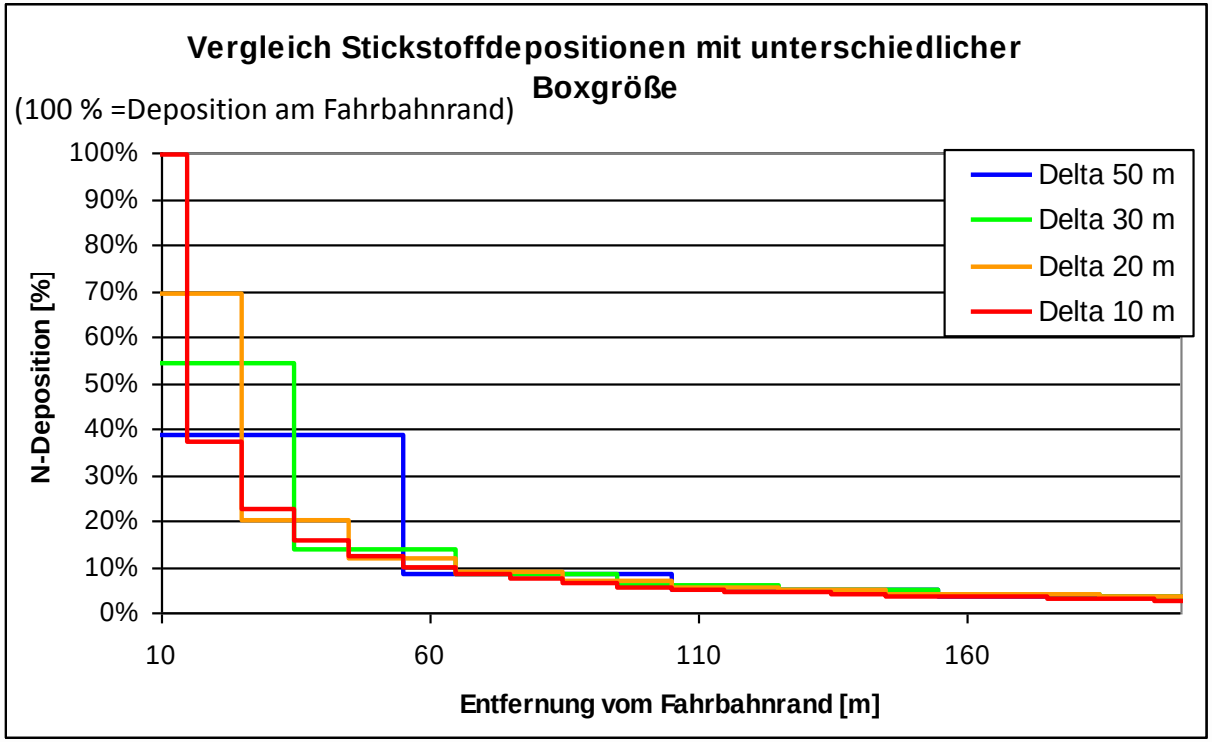
Bagatellschwelle
Eine Bagatellschwelle bezeichnet eine quantitative Größe, die auf der Basis des Verhältnismäßigkeitsgrundsatzes die Grenze zwischen (potenziell) erheblichen Beeinträchtigungen und lediglich bagatellhaften Beeinträchtigungen definiert. In Fällen, in denen die Gesamtbelastung den Critical Load überschreitet, werden Bagatellschwellen für die Höhe eines zusätzlichen Stickstoffeintrags (= **3 % des maßgeblichen Critical Loads**) und für den Flächenumfang davon betroffener FFH-Lebensraumtypen definiert.

Abschneidekriterium
Ausgehend von der Fachdiskussion zum Thema hat das BVerwG anerkannt, dass sehr niedrige vorhabensbedingte Stickstoffeinträge in FFH-Lebensraumtypen nicht zu erheblichen Beeinträchtigungen führen müssen. Ein projektbezogen anwendbares unteres Abschneidekriterium wird hier bei **0,3 kg N $ha^{-1}a^{-1}$** (24 eq $ha^{-1}a^{-1}$) angesetzt. Diese Schwelle ist aus der Nachweisgrenze für die Messung von Immissionskonzentrationen für NO_X und NH_3 abgeleitet und liegt deutlich unterhalb nachweisbarer Wirkungen auf die Biodiversität.

Bewertungschema



Einfluss Gitterauflösung



Die Wahl der horizontalen Auflösung des Rechengitters hat insbesondere für den Nahbereich der Quelle eine große Bedeutung. In Fahrbahnnähe, wo der Gradient am stärksten ist, entsteht durch eine zu grobe Gitterauflösung der größte Fehler. Es sollte daher darauf geachtet werden, dass, wenn Beurteilungsflächen in Straßennähe liegen, eine hohe Auflösung gewählt wird.

- Zwischen Trasse und Beurteilungsgebiet sowie im Beurteilungsgebiet selbst liegt die gleiche Landnutzung vor.
- Das Untersuchungsgebiet darf kein relevantes Höhenrelief aufweisen.
- Es muss ausgeschlossen werden, dass keine besonderen lokalen, meteorologischen Bedingungen wie z. B. Kaltlufteinfluss das Windfeld beeinflussen.
- Das Untersuchungsgebiet muss sich außerhalb von dichter Bebauung befinden.
- Es sind nur Prognosehorizonte größer gleich 2020 zu betrachten.
- Die zu betrachtenden DTV-Werte liegen in einem Bereich von 5 000 bis maximal 60 000 Kfz/24h.
- Der Schwerverkehrsanteil darf maximal 25 % betragen.
- Die mittlere Windgeschwindigkeit und die Austauschbedingungen im Untersuchungsgebiet müssen denen der verwendeten Meteorologie entsprechen.

Traffic Data

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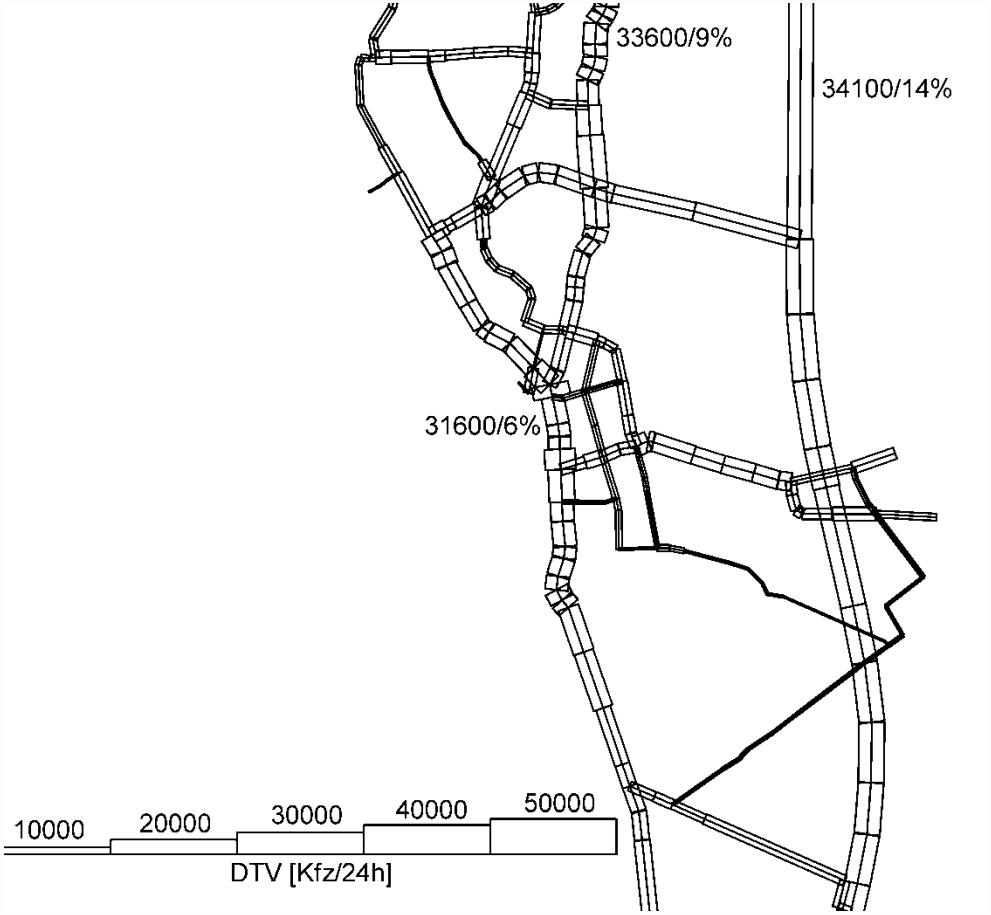


- Mean daily traffic volume DTV
- Fraction of High Duty Vehicles
- Vehicle speed
- Traffic rules, e.g. traffic lights
- Number of lanes
- Percentage of Stop & Go
- Longitudinal gradient of roads
- Noise barriers etc.

General Formula:

Number of Vehicles X **Emission Factor** = **Total Emission per road segment**

Available data in praxis:

- **Total Amount of Vehicles**
- **Heavy duty vehicles (>3.5t)**

Vehicle Categories
Cars Motorcycles Light duty Vehicles
Heavy duty Vehicles Public Buses Coaches

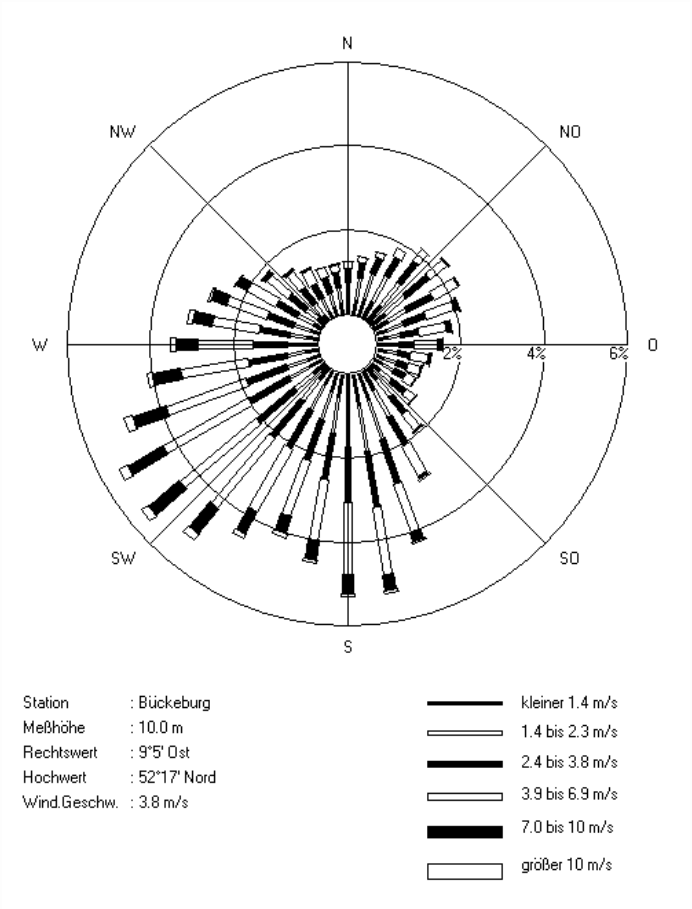
Share factors differentiated according to

Highway
Regional Road
Urban Road

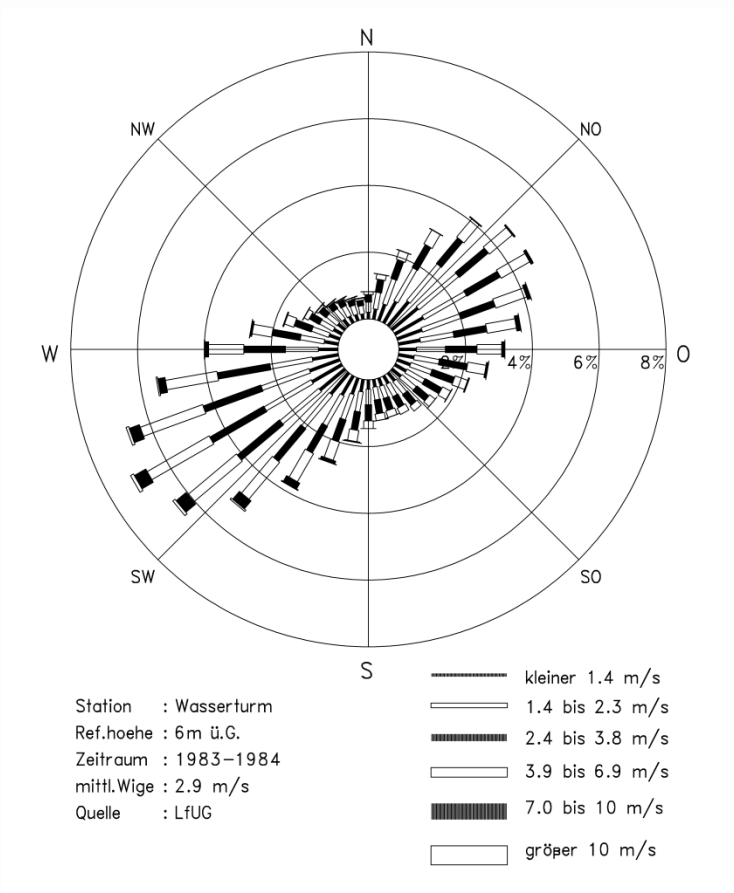
Aggregated Categories
Light Vehicles
Heavy Vehicles

Eingangsdaten Meteorologie

Meteorological data representative for the area of investigation



or



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Influence Topography

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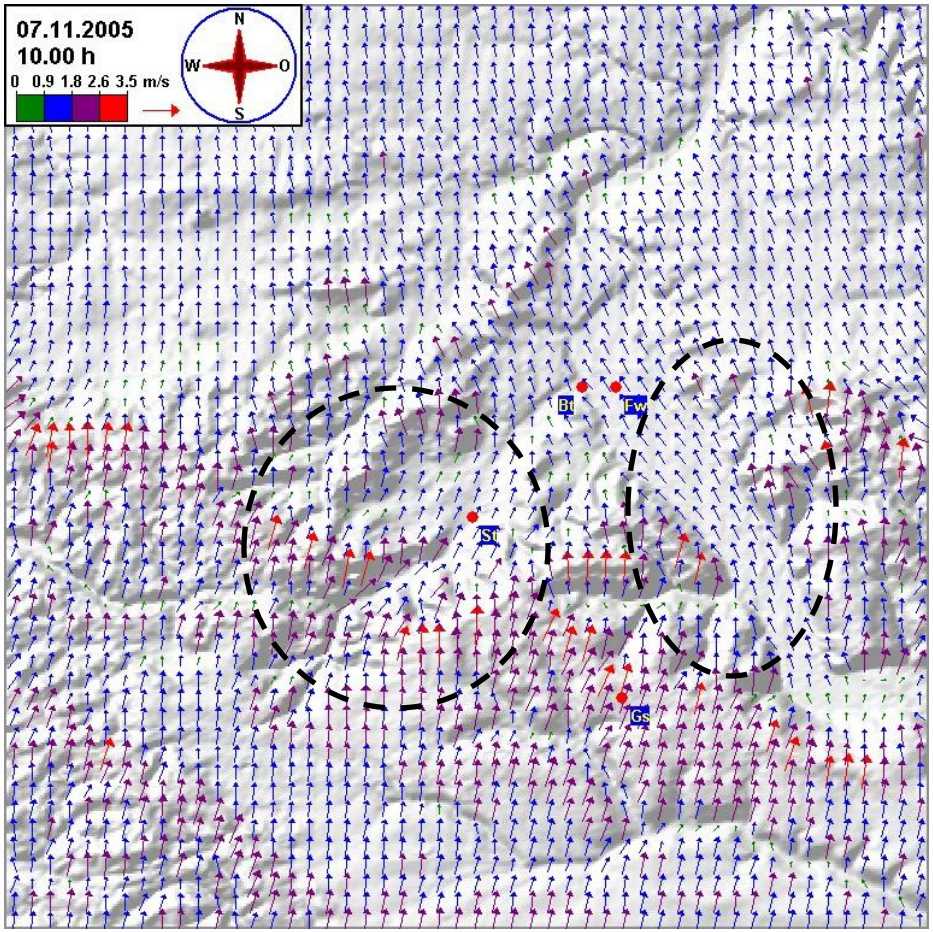


Changing of
wind direction and **wind velocity**

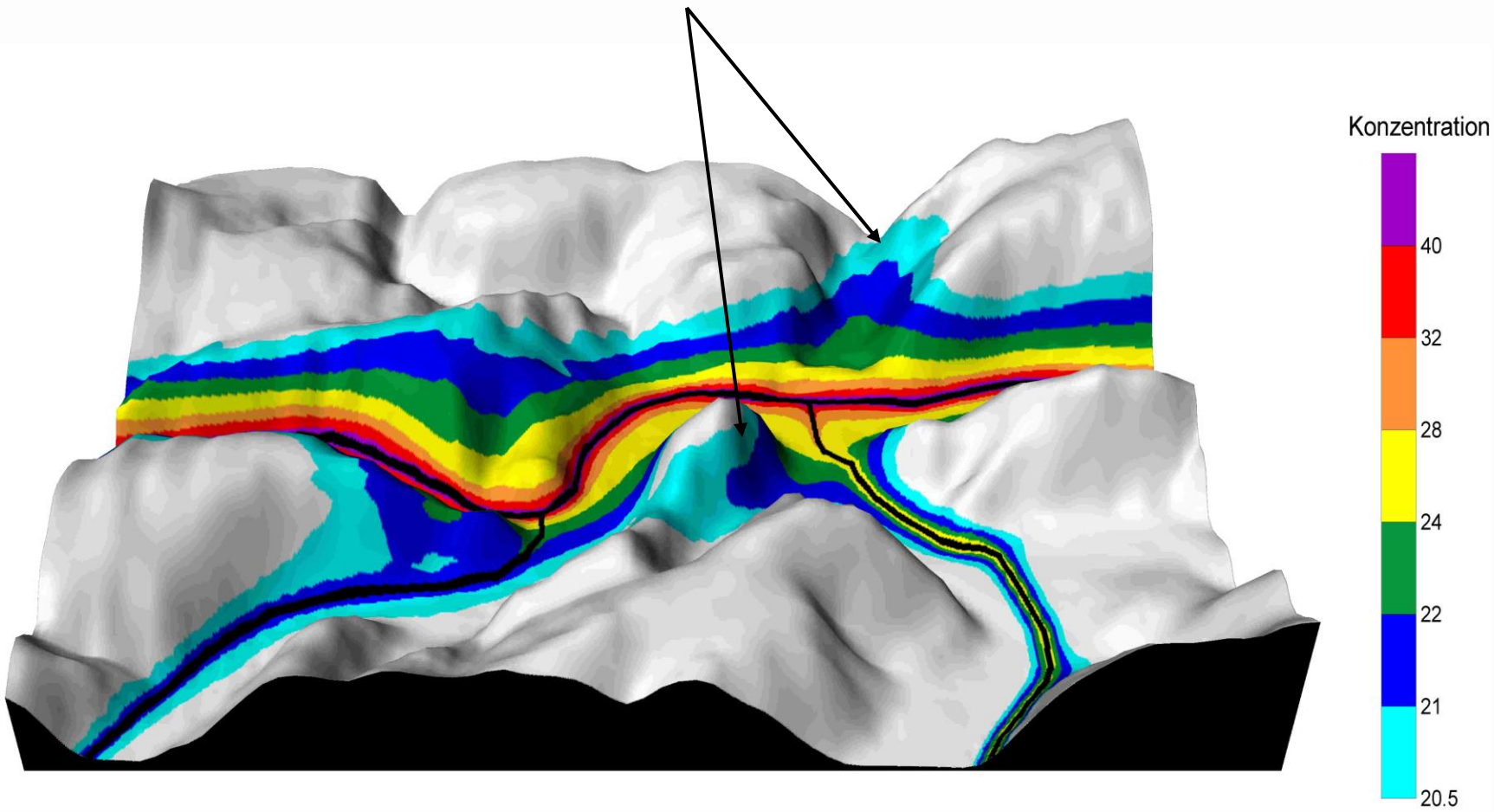
e.g. area of Stuttgart

www.stadtklima-stuttgart.de → “Online Windfeldberechnung” (calculation of wind fields)

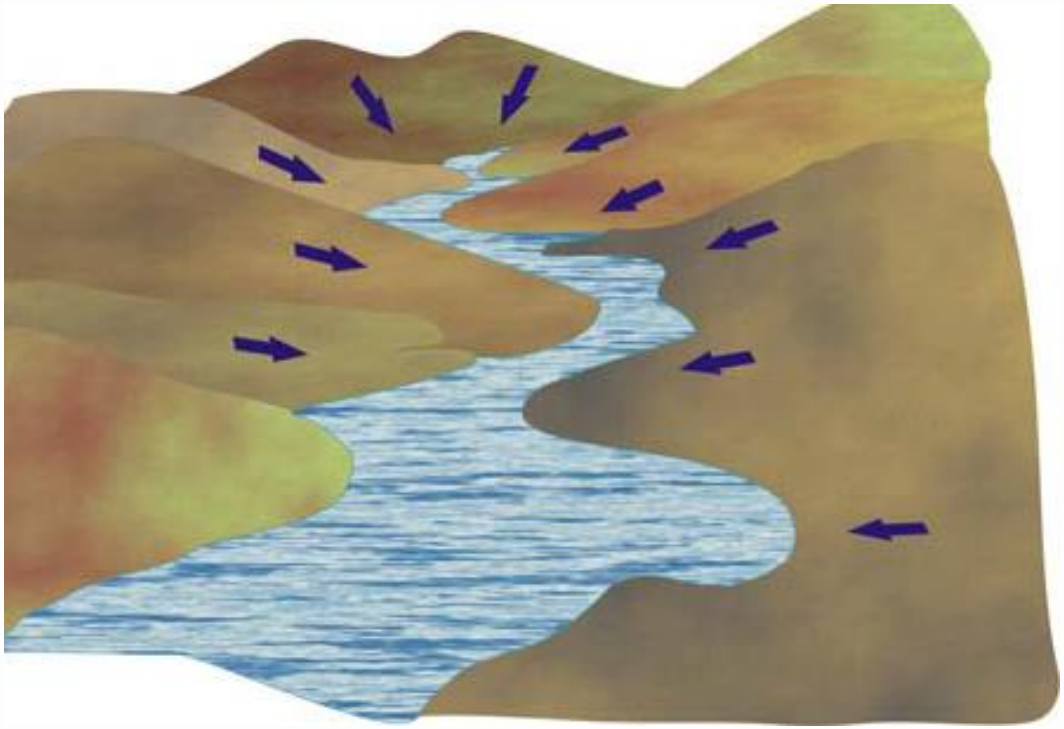
Based on point measurements calculation of wind fields every 30 minutes for the area Stuttgart.

Influence Topography

Concentration field. Calculated by LASAT



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 (3)

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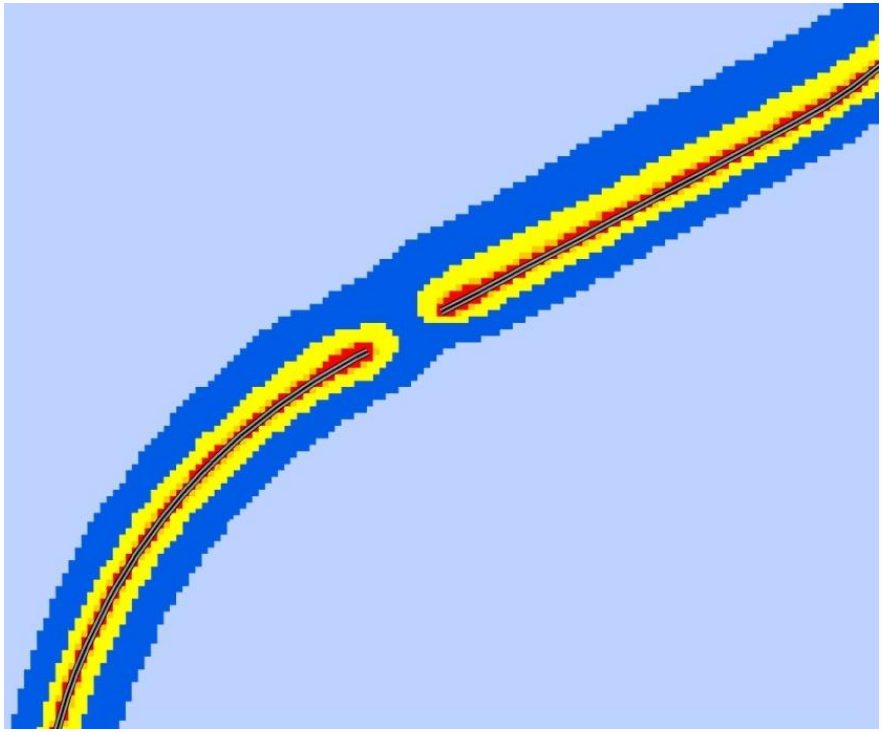
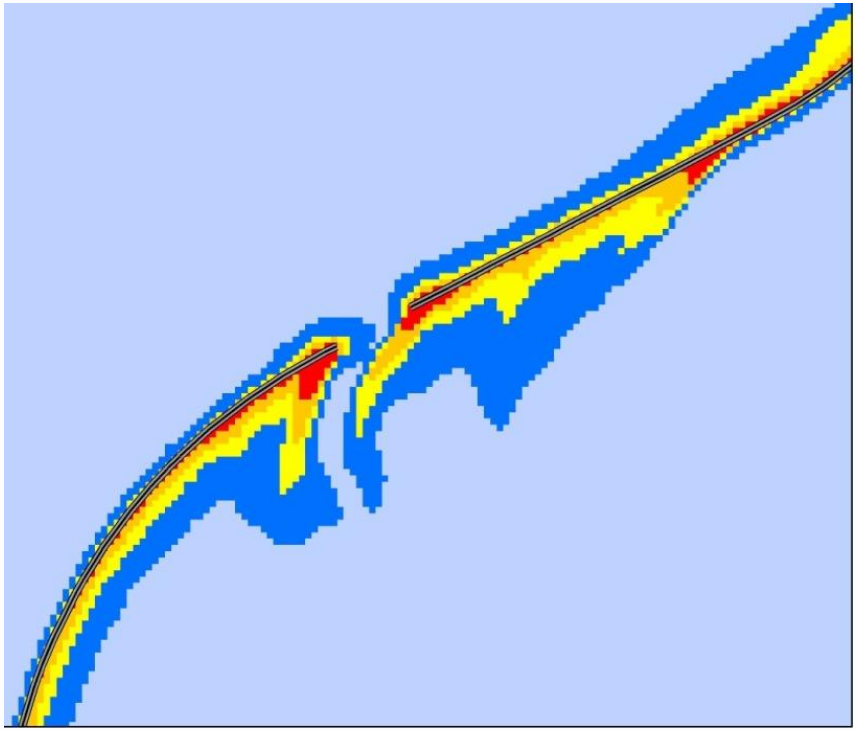


Ohne Berücksichtigung von Kaltluftwindfeldern



Mit Berücksichtigung von Kaltluftwindfeldern

Mitigation Measures

- Reduzierung der Reisegeschwindigkeit
- Reduzierung des Verkehrsaufkommens DTV bzw. SV
- Reduzierung der Straßenlängsneigung
- Lärmschutzwände bzw. -wälle
- Führung der Trasse im Tunnel oder in einer Einhausung
- Führung der Straße als aufgeständerte Brücke
- Vergrößerung des Abstandes zwischen Trasse und sensiblen Lebensraumtypen
- Sonderfall: Reduzierung von Stickstoffeinträgen aus Düngevorgängen von stillzulegenden landwirtschaftlichen Nutzflächen

Traffic Emission Factors HABEFA

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- Measured and modelled
- Only exhaust emission
- Emission per Vehicle differentiated according to vehicles Categories
- Level of Service describing the traffic flow
- Fleet according to the norm of EURO and year
- Traffic Situation Vehicle speed, Stop&Go
- Road Categories
- Road slope