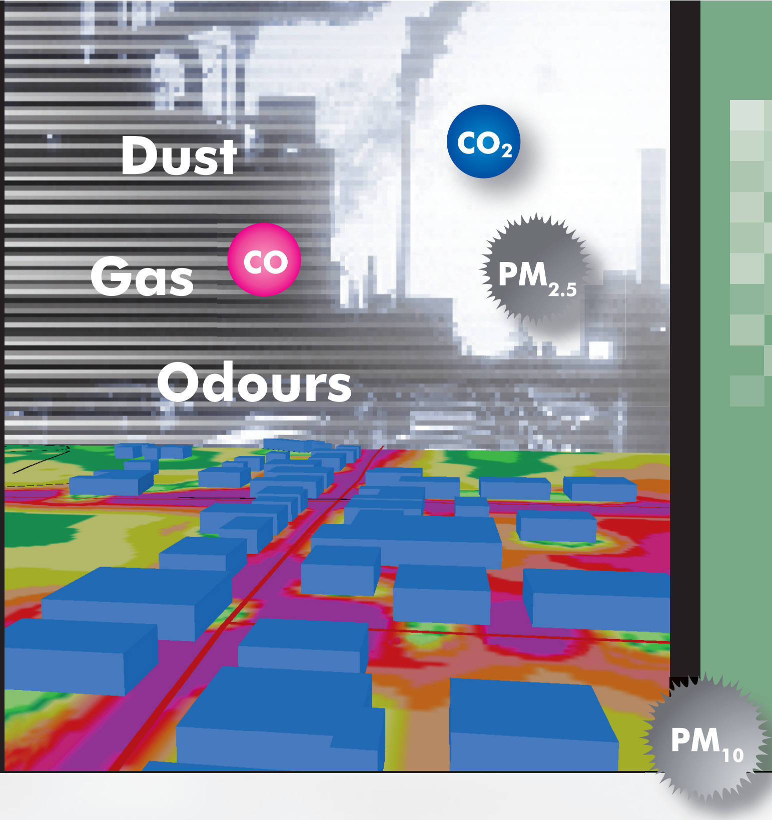
www.woelfel.de

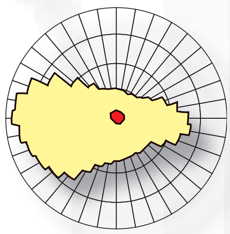


SO_2

NO_x

IMMI

Air dispersion modelling



Wölfel

IMMI Manual Air Pollution

3rd edition

Published by: Meßsysteme · Software GmbH + Co. KG
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1 Introduction

Since version 5.041 IMMI supports air pollution modeling. Various calculation methods are available and can be applied depending on the task, the type of pollutant and the involved regulation. For the German market the software offers pollution modeling following both TA Luft 1986 (Technical Instructions on Air Quality Control based on the Gaussian plume model) and TA Luft 2002 (Instructions based on the particle model); for Austria, the implementation of ÖNORM 9440 (Gaussian plume model).

IMMI allows transfer of the source geometries from one calculation model to the other, making it possible to compare results during the transition to the new model. However, caution is advised regarding pollutant types that do not offer a one-to-one correspondence. For example, a dust source is a unique element type in the implementation of TA Luft 1986, whereas representing one of several air pollutants assigned to a source following TA Luft 2002.

You should also be aware that the implementation of TA Luft 2002 is based on the calculation model AUSTAL2000 which is the public domain official implementation of the German VDI 3945 Part 3 sponsored by the German Federal Environmental Protection Agency. By using an external calculation kernel, the IMMI user interface is subjected to certain instructions, requirements and restraints. The software is basically designed to free the user as much as possible from operating the calculation kernel. Response messages issued by the kernel are nonetheless displayed and provide a means of control for the user, following the tradition of IMMI as a noise prediction software. These kernel messages may also be used for documenting the calculation process.

The implementation of TA Luft 1986 represents an original Wölfel development based on appropriate quality assurance standards: No external calculation model is involved here.

2 Calculation Method

The following calculation methods are implemented in IMMI:

Dispersion calculation methods:

- TA Luft 1986 – Technische Anleitung zur Reinhaltung der Luft [TA Luft 1986 – Technical Instructions on Air Quality Control]
- VDI 3945 Part 3: Environmental Meteorology – Atmospheric Dispersion Models – Particle Model, issued September 2000 and AUSTAL 2000
- ÖNORM 9440: Dispersion of pollutants in the atmosphere – calculation of the ambient air concentrations and determination of stack heights, issued November 1996
- GIRL - Geruchsimmissions-Richtlinie: Feststellung und Beurteilung von Gerüchen, issued September 2008
- Stern/Giebel: Empirical propagation formula for dispersion in the direct vicinity of emission sources – formula following STERN and GIEBEL, issued October 1995
- Canyon-Plume-Box Model (CPB): Addition to the Gaussian model for narrow road canyons where pollutants dissipate with delay and the concentration is therefore higher in these areas

Emission calculations:

- HBEFA: Handbuch für Emissionsfaktoren des Straßenverkehrs, Version 2.11 [HBEFA: Handbook emission factors for road transport]
- Copert: Computer program to calculate emissions from road transport
- Oldenburg-Study für Geruchsausbreitung [Oldenburg Study on Odor Dispersion]

3 Modeling in IMMI

3.1 IMMI Setup

In <**Project | Properties**> on the specifications tab, the dialog is now split in three stages to improve clarity.

First, set the **Topic** using the option buttons and choose **Noise, Aircraft noise or Pollutants**.

If the selected topic is **Pollutants**, you can set the required directive by choosing an approach in the selection box below. Choose between **Gauß / TA Luft 1986**, **Gauß / ÖNORM M9440** (Austrian air pollutant library) and **Lagrange / VDI 3945**.

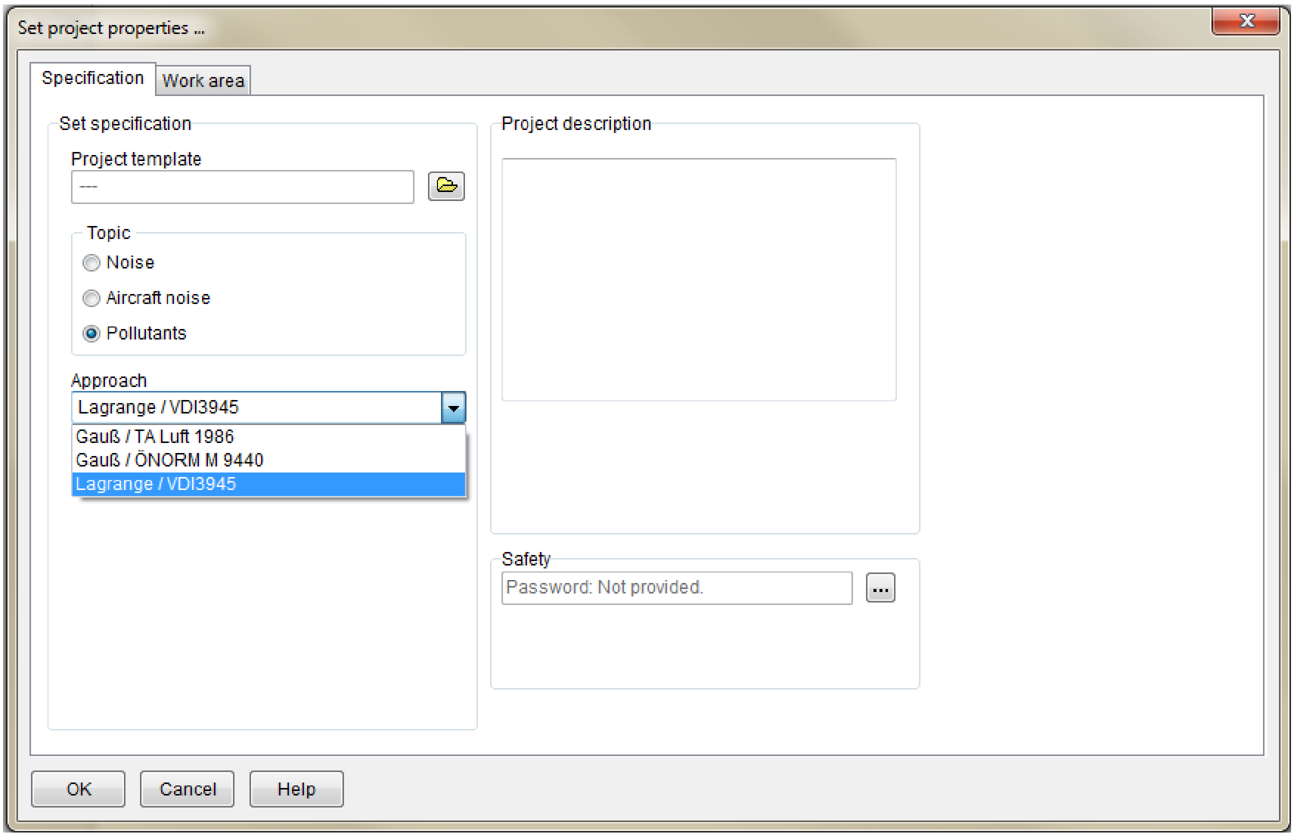


Figure 1: Select the topic "Pollutants" and the required approach

3.2 Implementation of Gauß / TA Luft 1986

IMMI offers an implementation for air pollution calculation following Appendix C of TA Luft 1986.

3.2.1 Parameters of the element library Pollutants following Gauß / TA Luft 1986

The general parameters for noise prediction are listed on the Pollutants tab of the **<Calculate | Calculation parameters | ... | Parameters for element libraries>** menu item.

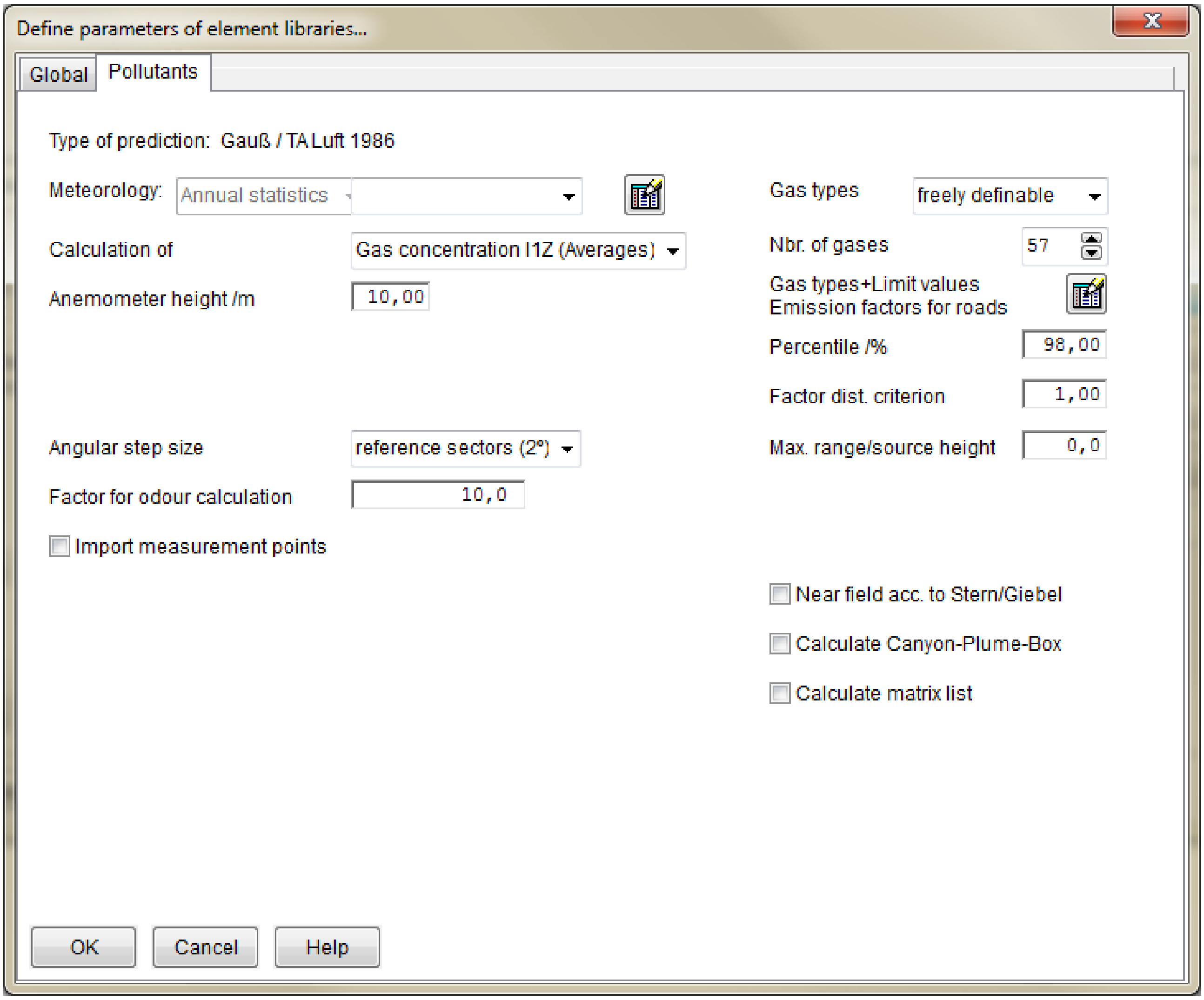
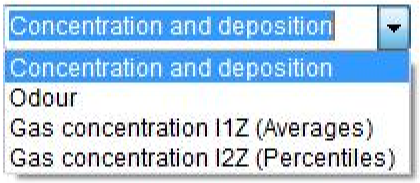


Figure 2: Parameter Pollutants (Gauß)

Enter the following parameters:

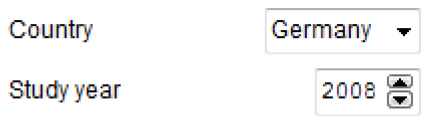
- **Meteorology**: This drop-down list box provides access to and allows you to select meteorological data. For more information, please refer to chapter Meteorology data on page 33.

- **Calculation of**: This drop-down list box provides the various calculation types available.

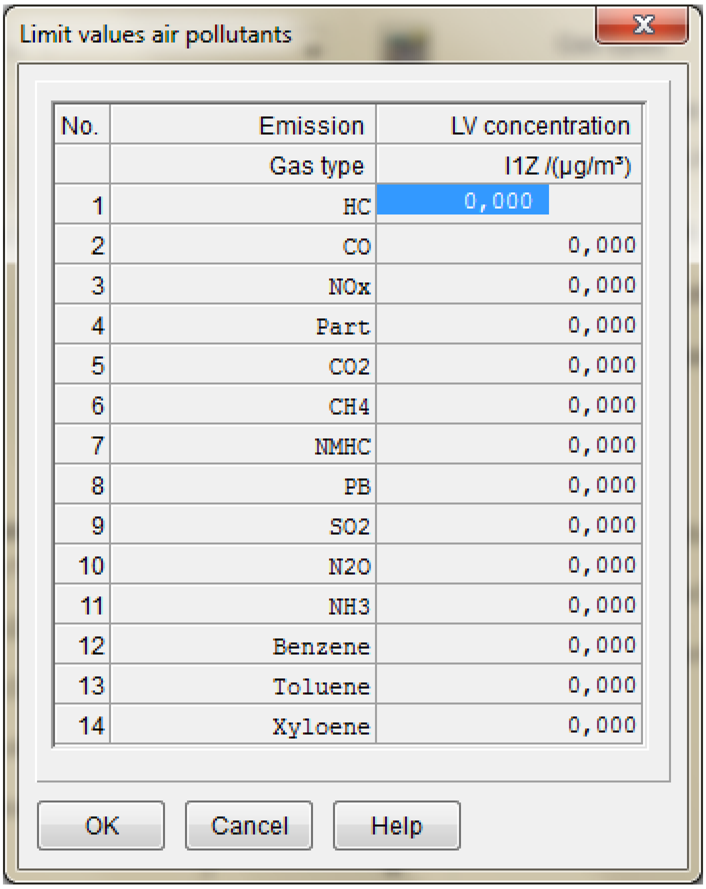


Select the calculation types according to the source types used in the project:
  - **Concentration and deposition**: belongs to dust sources
  - **Odour**: belongs to odor sources
  - **Gas concentration I1Z (Averages) or I2Z (Percentiles)**: can only be used for gas sources. The calculation is based on the formulas and equations of Annex C of TA Luft of 1986 and ÖNORM 9440 respectively. The additional rules and equations are applicable to odors.
- **Anemometer height/m**: effective measurement height above the ground. The default measurement height is 10 m.
- **Average wind velocity ua(m/s)**: Is displayed only for simplified meteorology.
- **Stability class (TA Luft)**: Is displayed only for simplified meteorology.
- **Angular step size**: According to TA Luft, a step size of 2° is required for some individual calculations (e.g. I2 values). 10° steps are certainly appropriate for first rough values (calculation time!).
- **Factor for odour calculation**: The default value is 10 for the factor-10 model. In special cases, e.g. if the sources are near the ground, other factors are applied. However, this should be agreed with the responsible person in charge at the approval/inspection authorities.
- **Gas types**: Depending on the emission entry, you can select **freely definable** (= select as desired), acc. to **Copert** and acc. to **HBEFA 2.1**.

Note: If you select the gas type acc. **to HBEFA 2.1**, two additional buttons will be available, i.e. **Country and Study year**, which allow you to additionally select from input data from Germany, Austria, and Switzerland and define the study year.



- **Number of gases**: Number of the gas types used
- **Gas types + Limit values**: Enter the gas types and limit values in this field:


Limit values air pollutants

No.	Emission	LV concentration
	Gas type	I1Z /(µg/m³)
1	HC	0,000
2	CO	0,000
3	NOx	0,000
4	Part	0,000
5	CO2	0,000
6	CH4	0,000
7	NMHC	0,000
8	PB	0,000
9	SO2	0,000
10	N2O	0,000
11	NH3	0,000
12	Benzene	0,000
13	Toluene	0,000
14	Xyloene	0,000

OK Cancel Help

Enter the gas types to be used for the project and allocate limit values to the individual gas types. The allocation of limit values is optional. Limit values serve to calculate conflict maps shown the spatial distribution of upward violations of the limit values at the receptors in the grid. The two columns (**Emission** and **LV concentration**) can be edited. Enter the name of the gases in the first column and the limit values in the second column.

If you select the calculation of gas types according to **Copert** or **HBEFA**, a specific number of gases is predefined.

- **Percentile /%**: In addition to the calculation of mean concentration values, IMMI also allows the calculation of percentiles. If the calculation follows Gauß/TA Luft 1986, the default setting is the 98th percentile; if it follows Gauß/ÖNORM M 9440, the default setting is the 95th percentile.
- **Factor distance criterion**: IMMI automatically separates line and area sources into single sources.

The following applies: li = f * si, where li is the length of the section and si is the distance of the center point of the section from the reception point. The factor f defines the degree of fine division of the source.

The density of these single sources is selected as a compromise between accuracy and calculation speed. Deviations can be set: the higher the factor, the more single sources will be distributed along the line or across the area.

- **Max. range / source height**: Allows you to limit the action radius of sources, e.g. if data records are very big.
- **Near field acc. to Stern/Giebel:** Utilization of an Austrian approach according to Stern/Giebel for determining the concentrations in case of a small-scale propagation (= 70 m distance from the source).
- **Calculate Canyon-Plume-Box**: The Canyon-Plume-Box model (CPB) is available for calculations according to Gauß/TA Luft 1986 and Gauß/ÖNORM M9440 respectively. For more detailed information about the CPB, please refer to the Annex Canyon-Plume-Box Model (CPB) on page 58.

3.2.2 IMMI Source types for air pollution calculation following Gauß / TA Luft 1986

With the IMMI air pollution module following TA Luft 1986 you can calculate the propagation of gases and dust according to TA Luft and determine the dispersion of odors following GIRL.

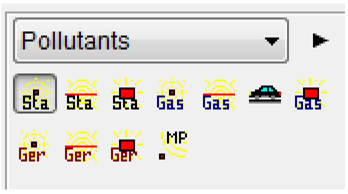


Figure 3: IMMI types of air pollutant sources following Gauß

The following types of pollutant sources can be modeled with IMMI:

	Point	Line	Area
Gas	X	X	X
Dust	X	X	X
Odor	X	X	X
Road traffic		X	

_Using different source types for modeling the pollutant types gas, dust and odor is based on the differences in the methods for calculating propagation. In the case of dusts, the portion of suspended particles is described by the Gaussian dispersion model, while the ‚source-depletion integral' is used to account for gravitational deposition on the ground. The Factor-10 model is used to calculate the dispersion of odors. Also, the input variables differ for all three pollutants, as well as the units used for results: **Gas and the portion of suspended particles in dust are expressed as concentrations in mg/m³**, while **ground deposition is defined as mass and is indicated in g/h**. **Odors, on the other hand, are converted from the artificial unit MGE/h on the emission side** to the percentage of time of odor perception at the reception point on the immission side. Also, you can determine the emission of odors according to the Oldenburg Study by defining the number of livestock units.

Road traffic is a source type of its own, because the calculation of emission is carried out with reference to the COPERT- or HBEFA/Mobilev-emission model.

3.2.2.1 General parameters for the element types point-, line- and area source

The dialogs for point-, line- and area sources differ only in the layout of the geometry input. You can enter the name for the source as a character string in the input field next to the internal, non-editable identification code.

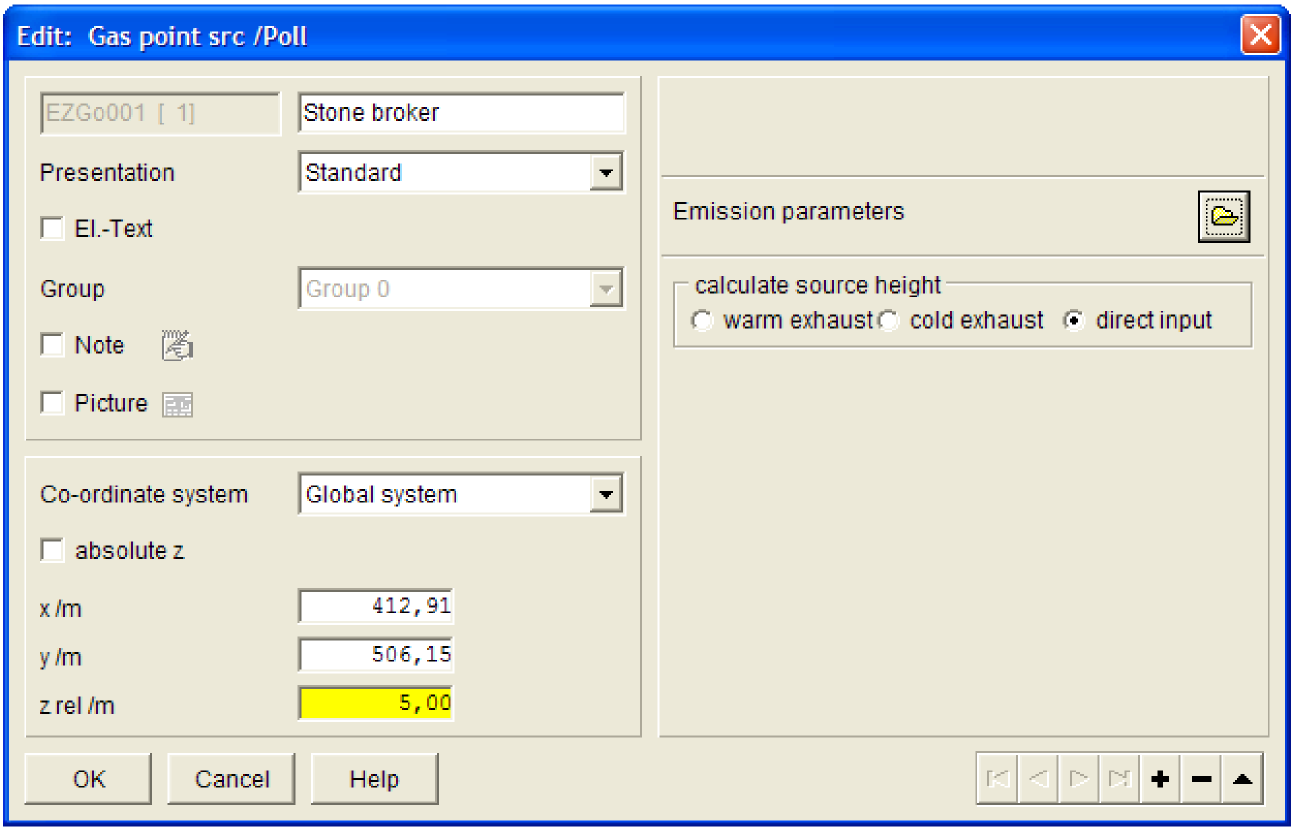


Figure 4: IMMI types of air pollutant sources following TA Luft 1986

- **Effective source height**: There are three methods for calculating the effective source height:
  - **Warm exhaust**: To calculate the effective source height, the software determines the heat flow in MW based on volume flow and temperature difference.

- **Cold exhaust**: The effective source height is determined based on the diameter of the exhaust and the vertical exhaust velocity.

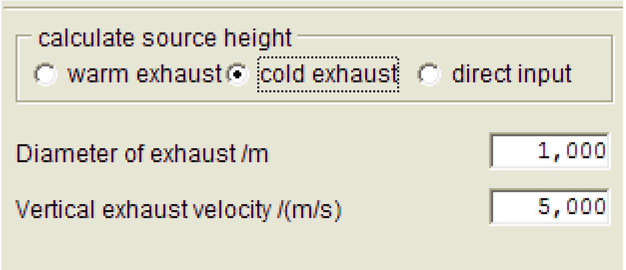


Figure 5: Input parameters for the selection "Cold exhaust"

- **Direct input**: The defined z-value of the coordinate is interpreted as the effective source height.

3.2.2.2 Source type gas

The propagation of gas is calculated following Formula I defined in TA Luft 1986.

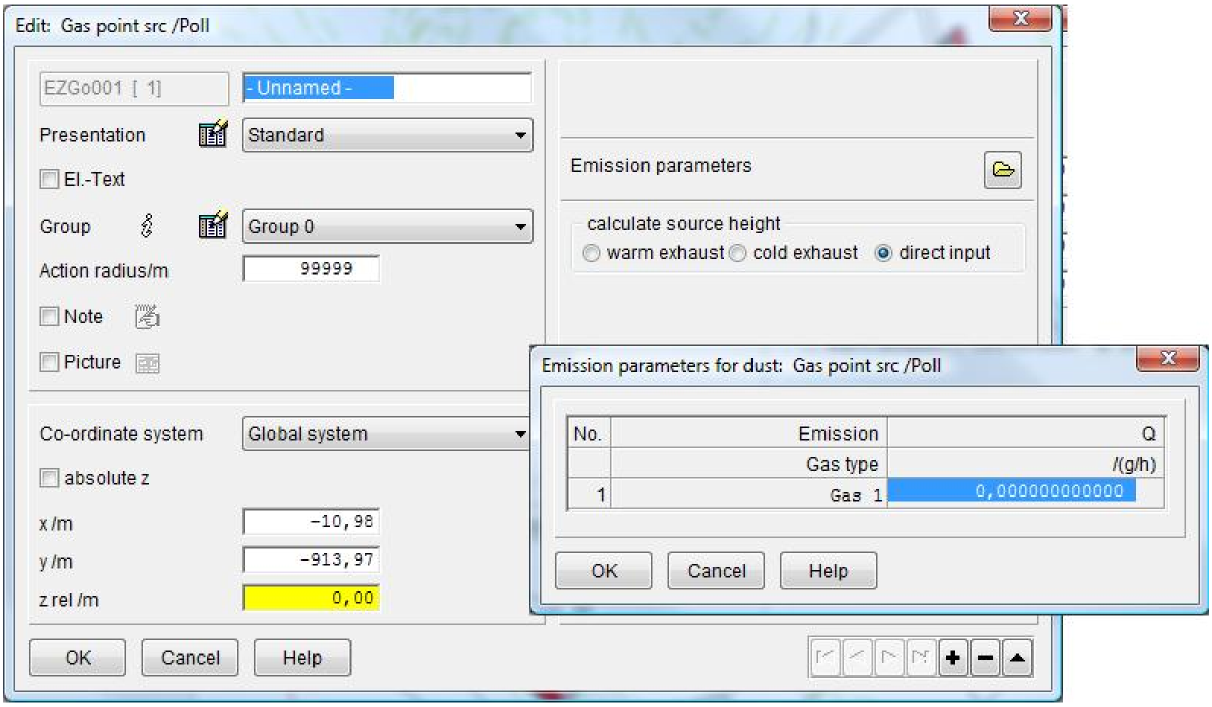


Figure 6: Input dialog gas point source

- **Emission parameters**: Click this button to open the emission dialog.
  - **Gas typ**: Name of the gas. The number of gas types are definable in the parameters dialog (Parameters of the element library Pollutants following Gauß / TA Luft 1986 on page 10)
  - **Q (g/h)**: Average hourly mass stream of the pollutant

Note: There is an example (Chimney.IPR) for applying gaseous sources in the IMMI installation folder at the following path: <**... | Examples | Gauss**>

3.2.2.3 Source type dust

The propagation of dust is calculated following Formula II defined in TA Luft. You can specify up to 4 dust particle classes.

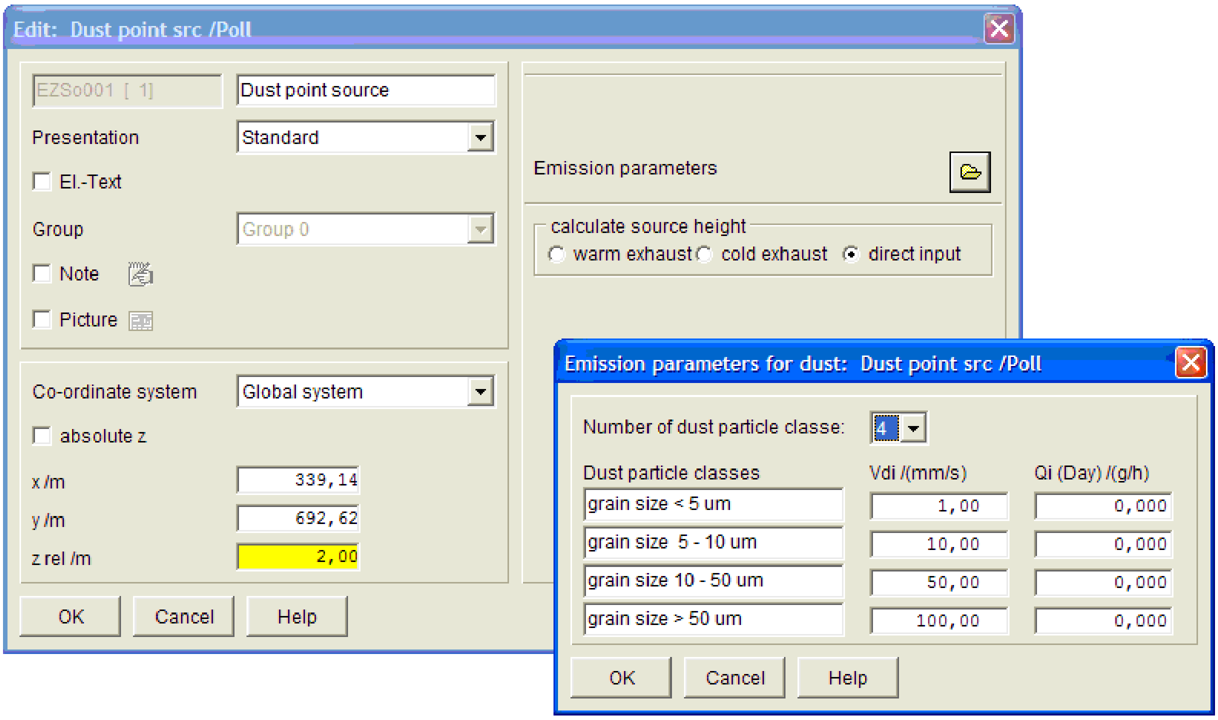


Figure 7: Input dialog dust point source

- **Emission parameters**: Click this button to open the emission dialog.
  - **Number of dust particle classes**: The valid range is 1 to 4 dust particle classes.
  - **Dust particle classes**: The name can be defined as an editable character string. The default classes correspond with the 4 dust particle classes described in TA Luft 1986. These texts can be edited as required by the user.
  - **Vdi/(mm/s):** Deposition velocity depending on the grain size of the particles. The values defined in TA Luft are set as defaults.

Note: The TA Luft 1986 recommends a standard value of 70 mm/s, in case the particle classes are not specified or the dust consists of an indefinable mixture of sizes that is defined by an emission mass Qi.

  - **Qi(Tag)/(g/h)**: Average daily mass stream in g/h to be defined for each dust particle class.

_**Note**: You can find an example (LoCoMess_E.IPR) for using dust sources in the IMMI installation folder at the following path: <**...** | **Examples** | **Gauss**>

3.2.2.4 Source type odor

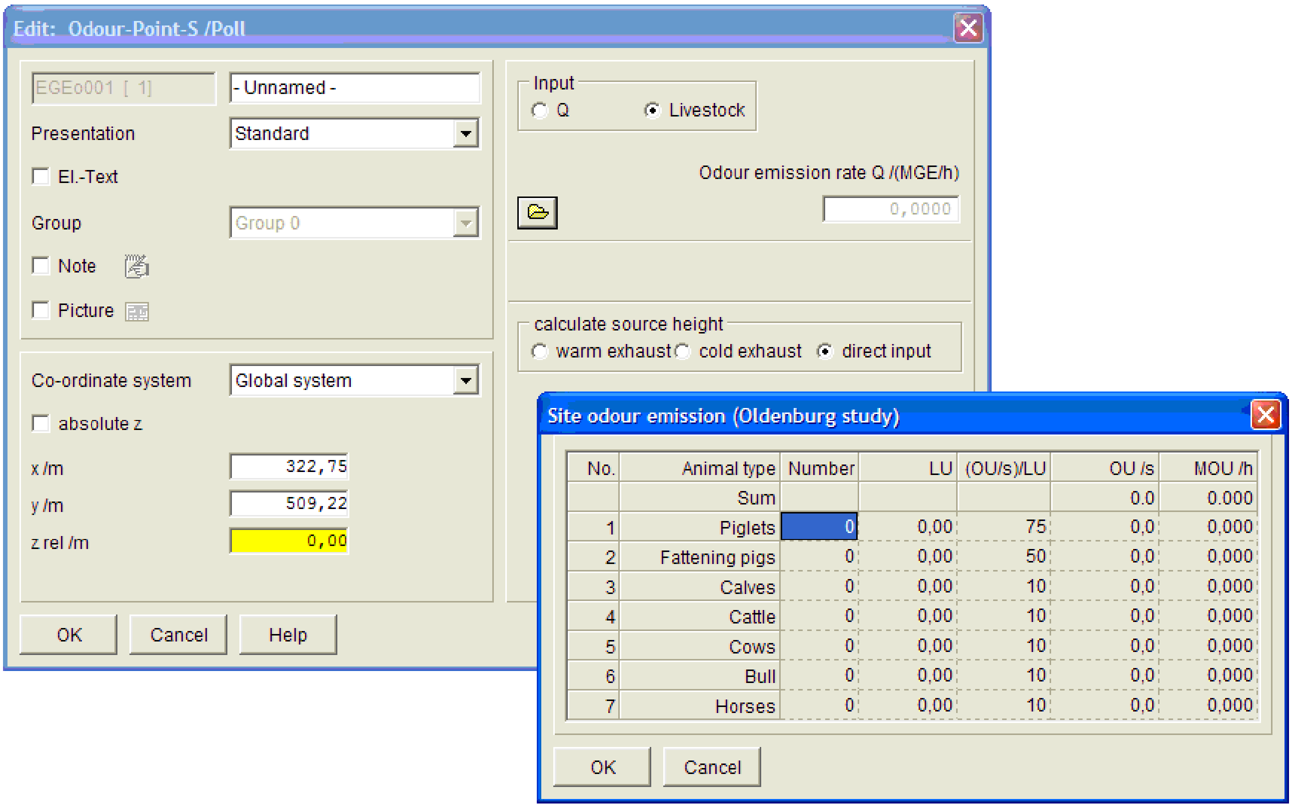


Figure 8: Input dialog for odor point source

- **Input**: The software provides 2 options for defining odor emission: either as a direct value by defining the odor emission rate **Q in MGE/h**, or with the **Livestock** input dialog following the Oldenburg study. With the input dialog you can define the number of individual animals of each animal type. Based on these data IMMI then determines the resulting livestock units (GV) and - depending on the animal type - the corresponding odor units per second (GE/s). Finally, IMMI calculates the mega odor units per hour (MGE/h).

Note: There is an example (odor_E.IPR) for using odor sources in the IMMI installation folder at the following path: <**...** | **Examples** | **Gauss**>.

3.2.2.5 Source type road

The source type road can be used as a line source to which you can either assign fixed emission mass streams of a defined value or emission mass streams following the COPERT- or HBEFA-emission model. Select the desired emission model in the Parameters of the element library Pollutants following Gauß / TA Luft 1986 on page 10 dialog.

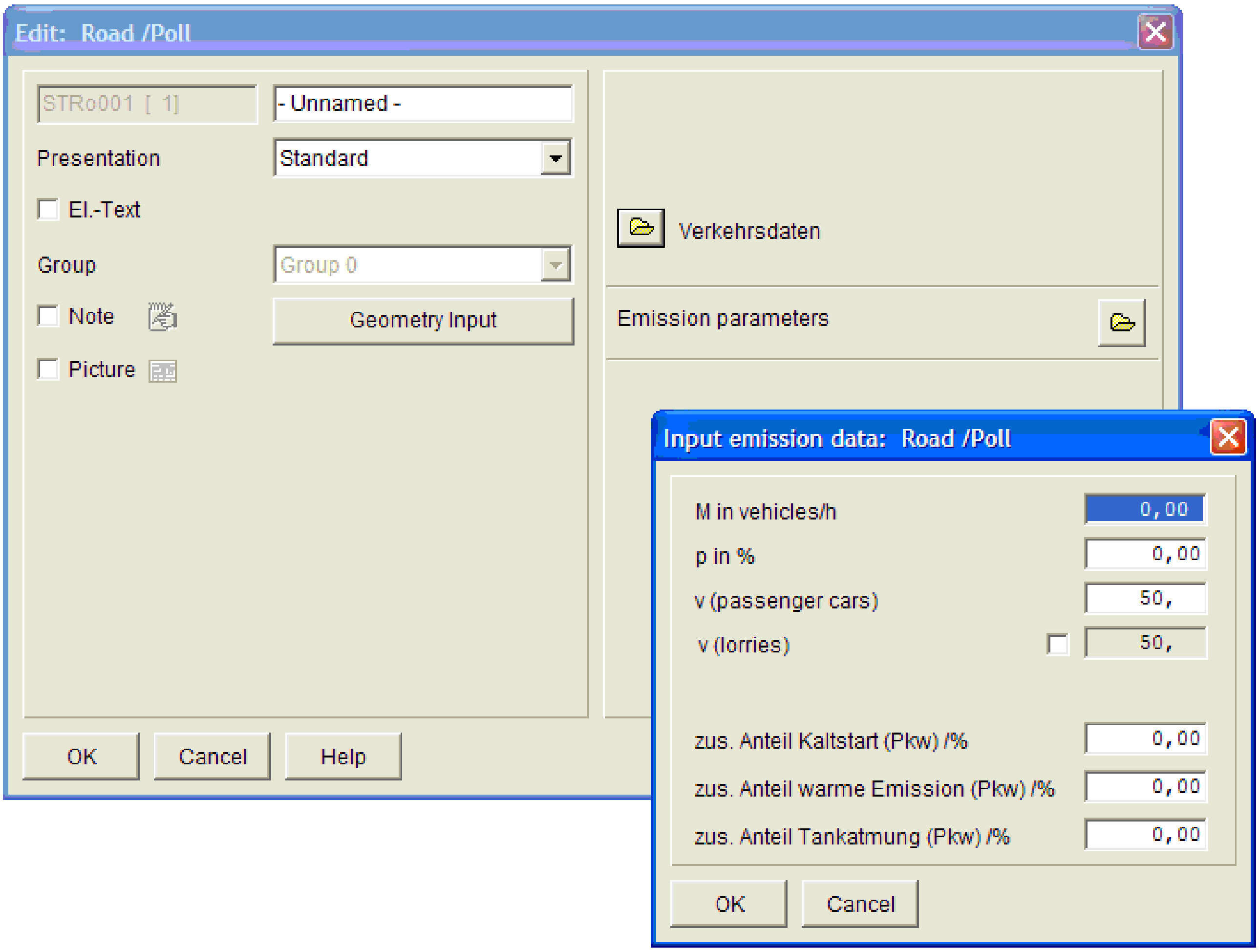


Figure 9: Input dialog for road source

The definition of traffic variables corresponds with the input fields provided for the emission model of the RLS 90. You can access and edit the values calculated here by clicking the **Emission parameters** button. Additionally, you can also define the parameters add. **factor coldstart (passenger cars) /%**, add. **factor warm emission (passenger cars) /%** and add. **factor diurnal breathing losses (passenger cars) /%**. The gas types and their respective positions in the table are predefined by the calculation selected in Parameters of the element library Pollutants following Gauß / TA Luft 1986 on page 10 and cannot be edited.

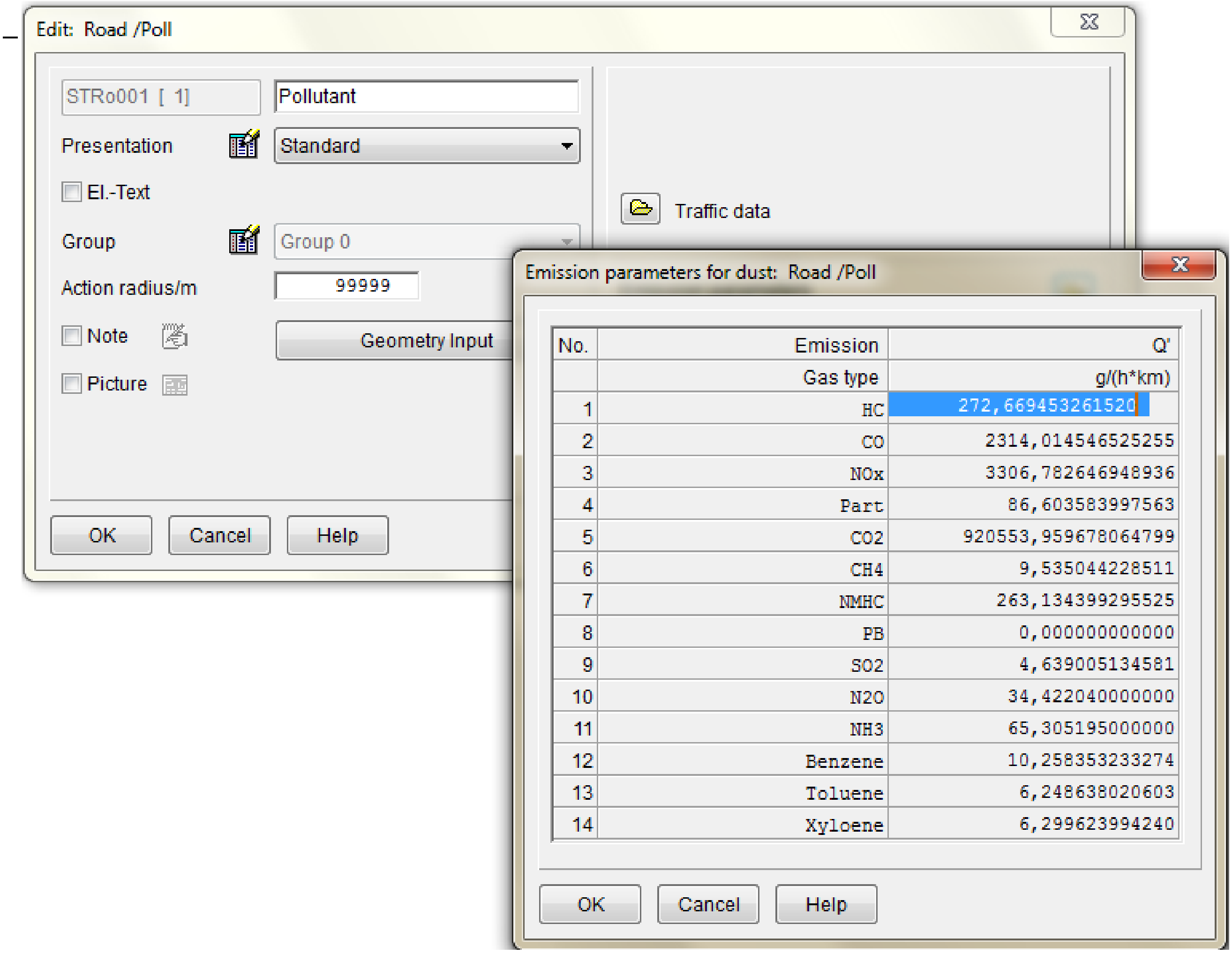
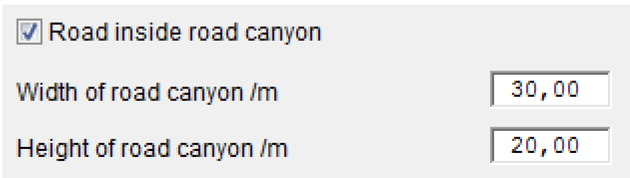


Figure 10: Input dialog for road source, emission parameters

- **Road inside road canyon**: Calculations according to the Canyon-Plume-Box model require that you specify whether the road is located in a road canyon.



- If yes, parameters Width of road canyon and Height of road canyon must be entered.

Note: It is not necessary to model the surrounding houses.

3.3 Implementation of Lagrange (AUSTAL2000)

Since version 5.1.5 IMMI supports air pollution modeling following the so-called Lagrange Particle Dispersion Model (VDI 3945 Part 3) as stipulated in TA Luft 2002.

Dispersion is actually calculated with the software Austal2000 provided by the Federal Environmental Agency (UBA). Invisible to the user, IMMI automatically takes care of starting the program and exchanging data. You need only operate the user-interface provided by IMMI. Naturally, as applies for all other IMMI libraries, a certain expertise regarding the new TA Luft is always required.

- According to the programming concept of AUSTAL2000 every project must be stored in a folder of its own.

Important Note: AUSTAL2000 calculations tend to cause problems when the project folder path is too long. Therefore, we recommend creating the project folder within the root of your hard drive or as a direct sub-folder of one of the main folders.

- To carry out a calculation AUSTAL2000 requires the parameters in the file „austal2000.txt" located in the project folder.
- The calculation report log is written to the file „austal2000.log" located in the same folder.
- For every gas or dust layer (concentration, deposition and statistical uncertainty) AUSTAL2000 creates in the project folder a unique file with the extension ".dmna".
- Basically, AUSTAL2000 does not differentiate between gas, dust and odor sources. This is the reason why IMMI only offers single-, line- and area sources of the type pollutant in connection with this calculation mode.
- The CPU times for pollution calculations, especially when calculating uneven terrains, have risen substantially in comparison to the calculations performed according to TA Luft of 1986.
- The AUSTAL2000 folder of the IMMI installation directory contains all programs required for calculations according to the Particle Model/TA Luft (see Installing AUSTAL2000).

Note: Since the AUSTAL2000G model was published, IMMI has featured an odor calculating function. The implementation of odors in AUSTAL2000G is based on the research report entitled “Die Entwicklung des Ausbreitungsmodells AUSTAL2000G” (Development of the AUSTAL2000G Dispersion Model) [14].

_In Germany, odors are rated according to the GIRL guideline (Geruchsimmissionsrichtlinie or Guideline for Odor Concentration and Impact) in its version of 29 February 2009. The rated odor hour frequencies for various animal species are taken into account in the current AUSTAL version.

Note: On request, IMMI now features an AUSTAL2000 calculation folder which can be set under <**Settings | Environment | Other**>. It is a default subfolder of the current IMMI installation named “AUSTALCALC”. The “austal2000.exe” program is permanently filed in the “austal2000” subfolder along with its auxiliary files. This option can be controlled via the AUSTAL2000: save results and protocols in IMMI project folder checkbox.

3.3.1 Installing AUSTAL2000

IMMI requires that an installation of AUSTAL2000 is located in the IWIN subfolder "Austal2000". This folder, including all of the AUSTAL2000 files, is automatically created when you install IMMI.

It is to be assumed that AUSTAL2000 will be continuously developed in the future. The files for the current version are available for free download on the Internet here: http://www.austal2000.de/austal2000.htm http://www.austal2000.de/austal2000.htm. Following, a list of files that must be installed in the AUSTAL2000 folder:

- austal2000.exe Program Austal
- rl_inter.exe CORINE land cover inventory
- rl.dat CORINE land cover inventory
- vdisp.exe Calculation of the hight of the source
- taldia.exe Diagnostic windfield model accounting for topography and buildings
- zg2s.exe Slope of terrain

3.3.2 Parameters of the element library Pollutants following Lagrange/VDI3945

The general parameters for noise prediction are listed under the **<Calculate | Calculation parameters | ... | Parameters for element libraries | Pollutants>** menu item. Any entries in the sections below **[in brackets and bold type]** indicate the particular parameter in AUSTAL2000. All parameters are listed and explained in the Annex.

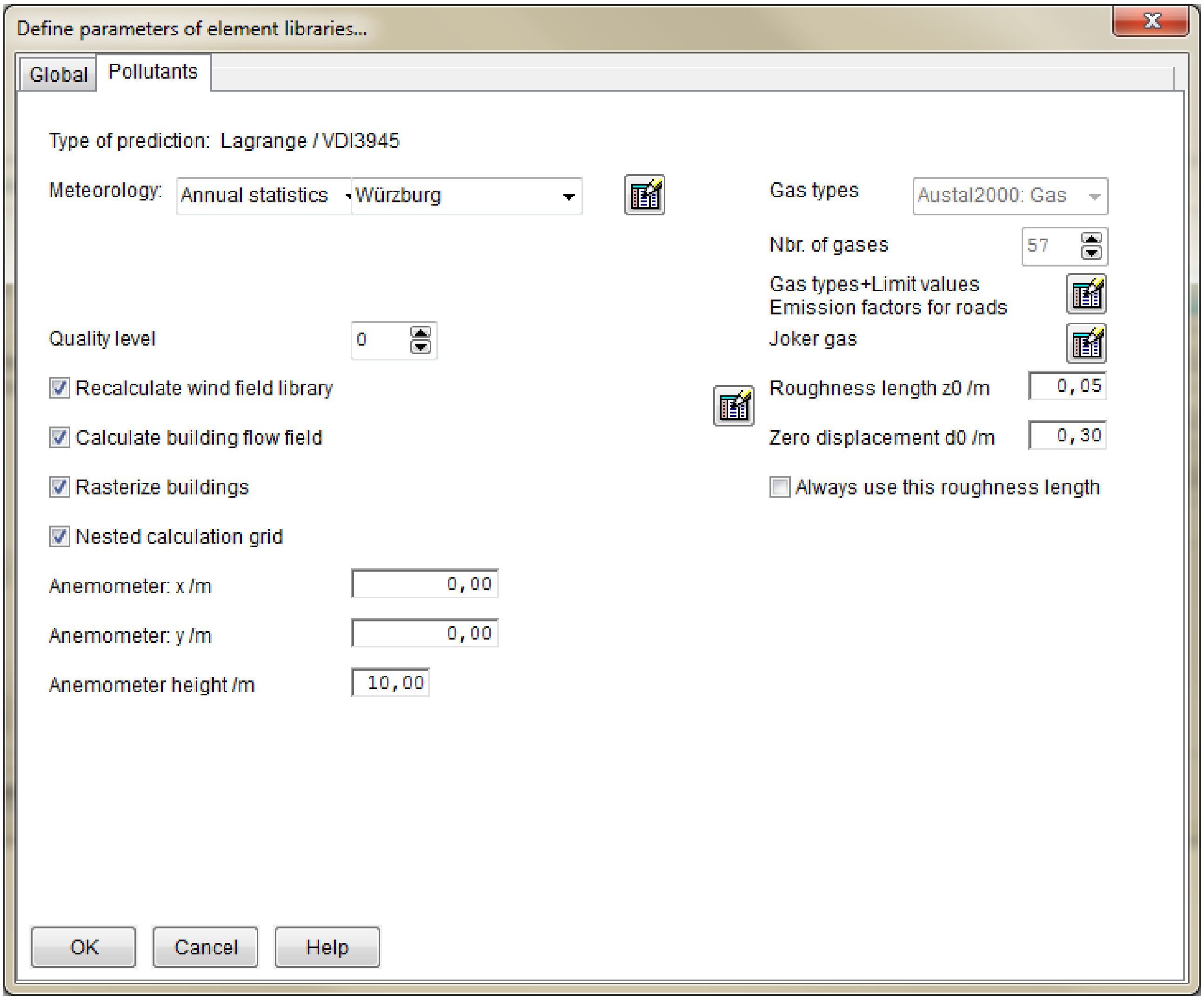


Figure 11: Parameters Pollutant (Lagrange)

- **Meteorology**: This drop-down list box provides access to and allows you to select meteorological data. Annual statistics and Time series are the available options. For more information, please refer to chapter Meteorology data on page 33.

  [as, az]

- **Quality level**: Quality level for defining the release rate of particles. Values range from –4 to +4; the default setting is 0. An increase by 1 causes the number of particles and therefore the calculation time to double. We recommend that you use –4 for "quick" rough calculations.

  [qs]

_▪ **Recalculate wind field library**: A wind field libraries which has already been calculated can be used for further grid calculations and does not have to be recalculated prior to each calculation run. The wind field library is filed as taldia.log in the AUSTAL2000 calculation directory. A wind field library can only be reused if the meteorology, the terrain and the housing have not been changed.

Note: Calculation of the wind field library can take a few hours, depending on the size of the project.

- **Calculate building flow field**: If you activate this checkbox, the flow field of buildings is calculated. If not, free propagation is assumed.
- **Rasterize buildings**: Buildings are rasterized in a file. This allows use of complex building structures.
- **Nested calculation grid**: Automatic use of calculation grids with varying step size, defined by AUSTAL2000 (see Nested grids on page 48)
- **Anemometer: x (rel.) /m and Anemometer: y (rel.) /m**: The position of the anemometer can be defined by entering the x- and y-directions. The starting coordinate with x = 0 and y = 0 is the map origin. The position of the anemometer is indicated by an icon on the map.

  [xa, ya]
- **Anemometer height /m**: Effective measurement height above ground. The default measurement height is 10 m.

  [ha]
- **Gas types**: The default setting is Austal2000-Gase and cannot be changed.
- **Number of gases**: The number of possible gas types is 57. If the Particle/TA Luft prediction type (under project properties) is selected, the number of gas types is automatically assigned.
- **Gas types + limit values**: AUSTAL2000 creates grid files with annual mean values, day mean values, hour mean values as well as deposition for a maximum of 14 pollutant types. The immission concentrations and the depositions are combined for all grain sizes of one particle type. Limit values can be specified for these immission values. The values specified according to TA Luft 2002 are already preset.

Limit values air pollutants

No.	Emission Gas type	LV concentration	LV concentration Day /(µg/m³)	LV concentration Hour /(µg/m³)	LV deposit /(mg/(m²*d))
1	SO2	50,000	125,000	350,000	0,000
2	NOx	0,000	0,000	0,000	0,000
3	NO2	40,000	0,000	200,000	0,000
4	Bzl	5,000	0,000	0,000	0,000
5	TCE	10,000	0,000	0,000	0,000
6	F	0,400	0,000	0,000	0,000
7	NH3	0,000	0,000	0,000	0,000
8	PM	40,000	50,000	0,000	350,000
9	As	0,000	0,000	0,000	0,004
10	Pb	0,500	0,000	0,000	0,100
11	Cd	0,000	0,000	0,000	0,002
12	Ni	0,000	0,000	0,000	0,015
13	Hg	0,000	0,000	0,000	0,001
14	Tl	0,000	0,000	0,000	0,002
15	CO	0,000	0,000	0,000	0,000
16	ODOR	0,000	0,000	0,000	0,000

OK Cancel Help

Figure 12: Limit values

Limit values are specified to allow the creation of conflict maps which show any upward violation of the particular limit values in a graphical diagram.

- **Joker gas**: Click the button to enter any name desired for the joker gas specified according to AUSTAL.
- **Roughness length z0/m:** AUSTAL2000 includes a function which allows automatic determination of the ground roughness using the CORINE land use register. (Caution: Gauss-Krüger or UTM coordinates! Only applicable in Germany!) In countries outside of the federal territory (e.g., in Austria), the roughness length must be entered directly. For more information, please refer to Appendix "Ground roughness according to the CORINE land use register" and to "TA Luft 2002". If the **Always use this roughness length** checkbox is activated, the values entered will be used for calculation.

Click the **- Select roughness length** button to display the table of the roughness lengths according to TA Luft 2002, Table 14. Double-click an entry to select the corresponding roughness length. The zero displacement will then be calculated automatically.

[z0]

- **Zero displacement d0/m:** Zero displacement for meteorological profiles. The default setting is d0 = 6 z0. For more information, please refer to Annex Displacement height on page 58 and to TA Luft 2002.

  [d0]

3.3.3 General parameters for the element types point-, line- and area source

The input dialogs for point-, line- and area sources vary only in regard to the definition of node coordinates, which is designed differently in each case.

You can enter a character string as name for the source in the input field next to the non-editable identification code automatically assigned by the program.

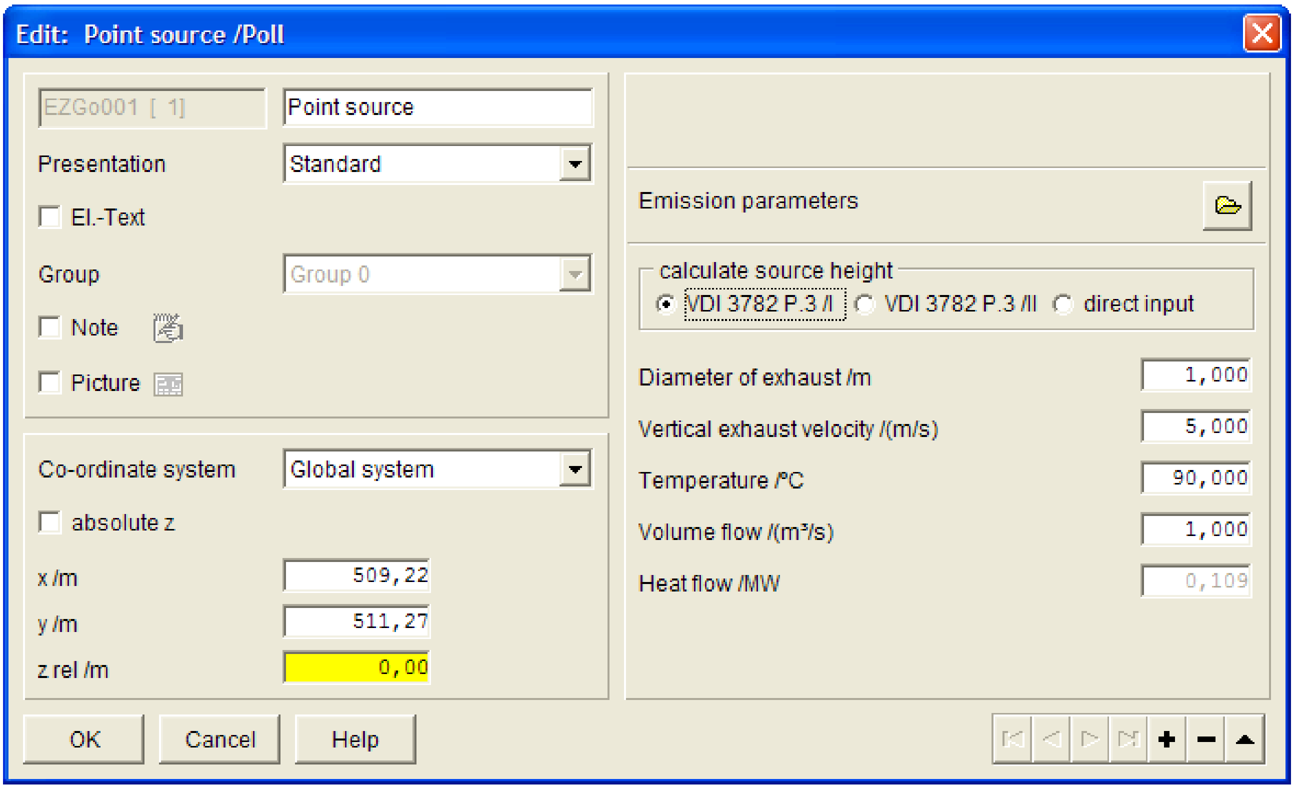


Figure 13: Input dialog for a point source following Lagrange

- **Emission parameters**: Here you can enter the emission.
- **Calculate source height**: There are three methods for calculating the effective source height:
  - **VDI 3782 Part 3/I**: Based on volume flow, temperature difference, vertical exhaust velocity and exhaust diameter, the program calculates the heat flow in MW for determining the plume rise.

[dq, vq, qq]

- **VDI 3782 Part 3/II**: The effective source height is determined on the basis of the exhaust diameter, the vertical exhaust velocity and the exhaust temperature.

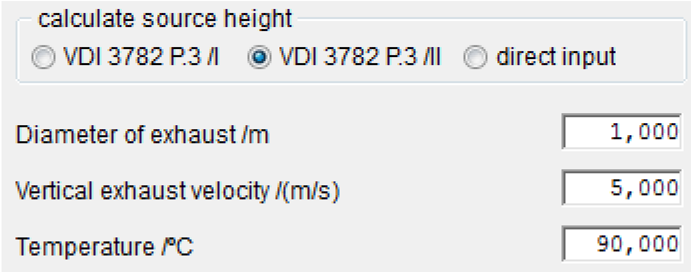


Figure 14: Parameters for the selection "VDI 3782 P.3/II"

[dq, vq, tq]

- **direct input**: In this case the defined z-value of the coordinate is used as effective source height.

[hq]

3.3.4 Source types

Pollution is calculated with these source types following the particle model of VDI 3945 Part 3 according to the definitions in TA Luft 2002.

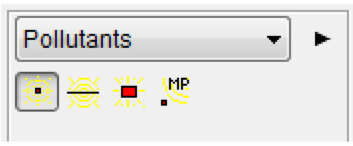


Figure 15: Source types of air pollutant following Lagrange

The following types of pollutant sources can be modeled with IMMI:

- Point source, e.g. chimney, exhaust pipe
- Line source, e.g. routes
- Vertical line source, e.g. belt conveyor
- Area source, e.g. biological filter
- Volume source, e.g. Windows and doors allotted around a building

The calculation kernel AUSTAL2000 supports 57 different air pollutant types (gases, dusts and odors). The abbreviations for the individual pollutants are explained in Appendix List of abbreviations for air pollutants on page 55. You can define emissions for all of these air pollutant types in IMMI. AUSTAL2000 internally defines the physical parameters for each parameter. Particles/dusts are therefore calculated differently than gases. In IMMI you can edit the outward directed parameters.

_3.3.4.1 Source types: point-, line- and area sources

The geometry dependent input of emission mass streams is the only other distinction that exists in addition to the differences in the input and editing of source coordinates due to geometry. Odor is always defined in MGE /h.

- **Point source**: Input value is always the emission mass stream (Q in g/h)
- **Line source**: Input value is either the emission mass stream (Q in g/h) or the length-based mass stream (Q` in g/h*km)
- **Vertical line source**: Input value is either the emission mass stream (Q in g/h) or the length-based mass stream (Q` in g/h*km)
- **Area source**: Input value is either the emission mass stream (Q in g/h) or the area-based mass stream (Q`` in g/h*km^2)
- **Volume source**: Input value is either the emission mass stream (Q in g/h) or the area-based mass stream (Q`` in g/h*km^2)

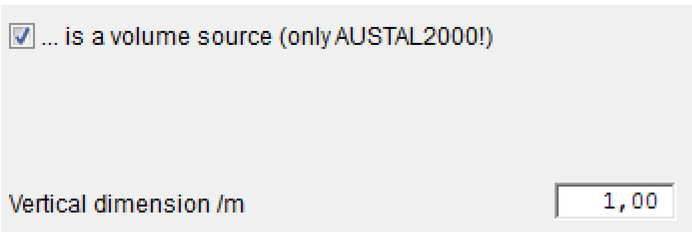
Note: There are examples for processing calculations following Lagrange in the IMMI installation folder at the following path: <**... | Examples | Lagrange**>.

3.3.4.2 Volume source and vertical source

The volume source and the vertical source do not represent any additional element types. They are entered via the input dialog for the point, line and area sound sources.

Volume source:

Enter the volume source in the input dialog of the area sound source. This requires that the ... is a volume source (only AUSTAL2000) checkbox be activated.

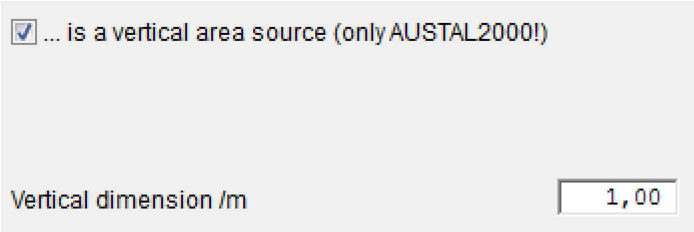


- **Vertical dimension /m**: Enter the vertical dimension of the source.

  [cq]

Vertical source:

Enter the vertical source in the input dialog of the line source. This requires that the ... is a vertical area source (only AUSTAL2000) checkbox be activated.



- Vertical dimension /m: Enter the vertical dimension of the source. **[cq]**

_3.3.5 Time-dependent Emission

To enter data for time-dependent emissions the required meteorology file must contain time data. In the input dialog for the source (point-, line- or area source) you can define the emission for each hour of the day. The emission characteristics can be defined for each weekday and calendar week.

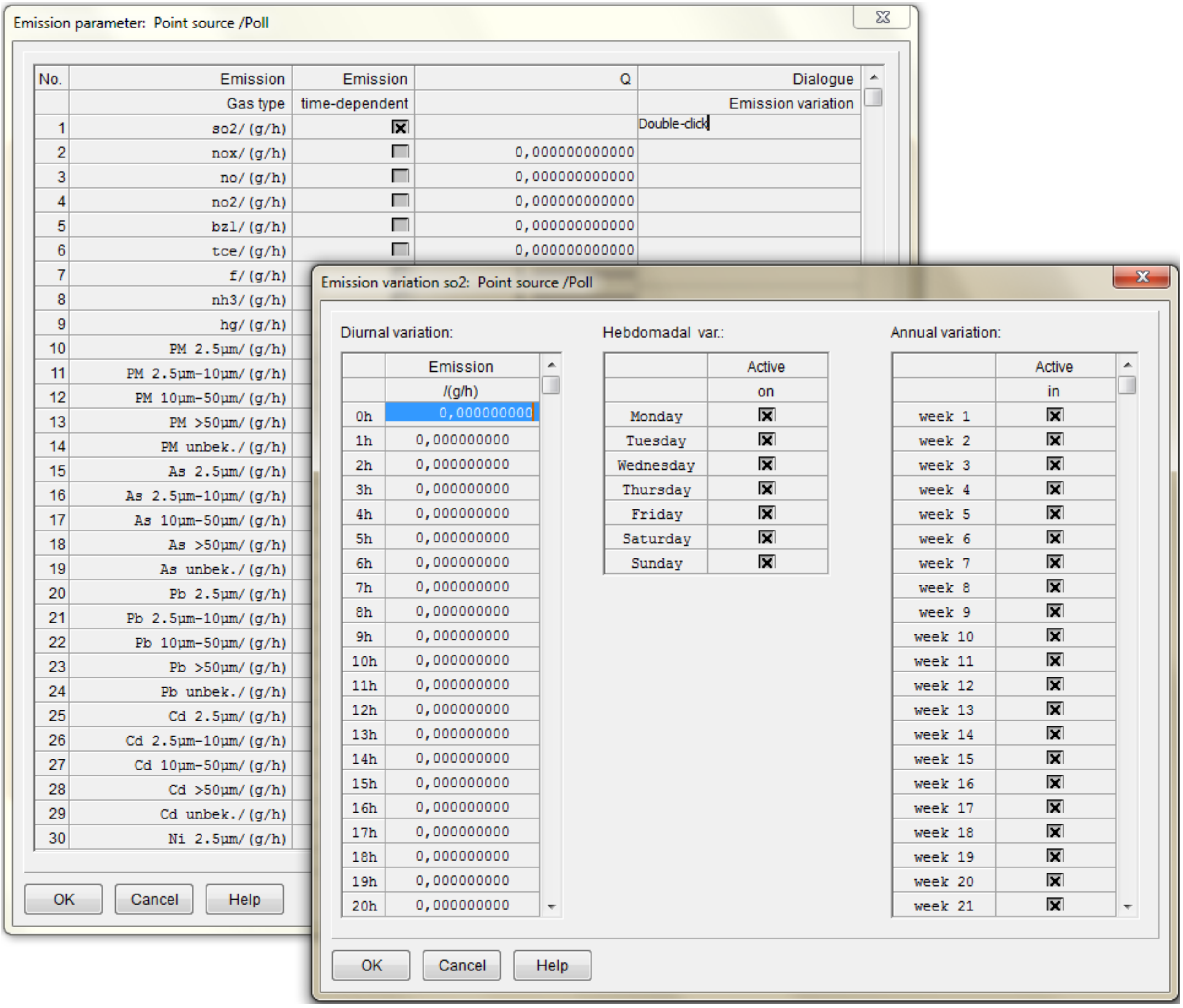


Figure 16: Definition of time-dependent emission

3.3.6 Air flow around buildings

IMMI: Procedure for modeling buildings for use in air flow calculations:

- Only elements of the type building are considered.

- IMMI determines the rectangular envelope for the element building. This means, that an axially parallel envelope is defined around all nodes of the element type building.
- The rectangular envelope is passed to AUSTAL2000 as the input value for buildings.

AUSTAL2000: Procedure for modeling buildings for use in air flow calculations:

- Buildings are defined as axially parallel cuboids standing on the terrain.
- Buildings are projected on an extra calculation grid (volout00.dmna).
- Buildings may not overlap with sources.

The wind field is calculated using the “taldia.exe” program (IMMI installation directory). As a result of the calculation, the program writes the “taldia.log” output file. Initially, a divergence-free wind field is calculated without any buildings. Then the building effects are incorporated into the file.

The rasterized buildings can be found in the “volout00.dmna” file which resides in the AUSTAL2000 calculation directory. In the data division, either 1 or 0 is listed for each cell of the calculation grid. If 1 is listed, the cell contains a building.

Note: Calculation of the wind field model may take some time, in which IMMI does not display any calculation time.

For more information on the determination of buildings in AUSTAL2000, please refer to the AUSTAL2000 Manual.

3.3.7 Transfer of IMMI Sources Geometry to AUSTAL2000

The geometry of the 3 element types is transferred to AUSTAL2000 by various parameters.

The relative height is always defined by the parameter **hp**.

- **Point source**

  The x- and y-coordinate of a point source in IMMI is defined by the parameters [**xq**] and [**yq**] in AUSTAL2000.

- **Line source**

  The x- and y-coordinate of the nodes (**xp** and **yp**) in a line source and the length between these nodes [**aq**] are transferred from IMMI to AUSTAL2000. In AUSTAL the angle between the nodes is defined by the parameter [**wq**].

- **Vertical line source**

  Additionally the parameter for the vertical dimension /m **[cq]** is necessary.
- **Area source**

  The x- and y-coordinate of the lower left node (**xp** and **yp**) in an area source and the lengths of the cuboid (**aq** and **bq**) are transferred from IMMI to AUSTAL2000. In AUSTAL the angle between the nodes is defined by the parameter [**wq**].
- **Volume Source**

  Additionally the parameter for the vertical dimension /m **[cq]** is necessary.

3.3.8 Converting Gauss sources to Lagrange sources

Existing projects created on the basis of the old Gauss model (TA Luft 1986) can be converted to projects following the Lagrange model (VDI 3945) with a single click.

When converting to Lagrange model the software automatically accepts the emissions of the element "Road" created following HBEFA 2.1. The following gas types are also accepted: CO (as Joker-gas), NOx, PM 2.5-10um, Pb, SO2, NH3 and Benzene.

4 Meteorology Data

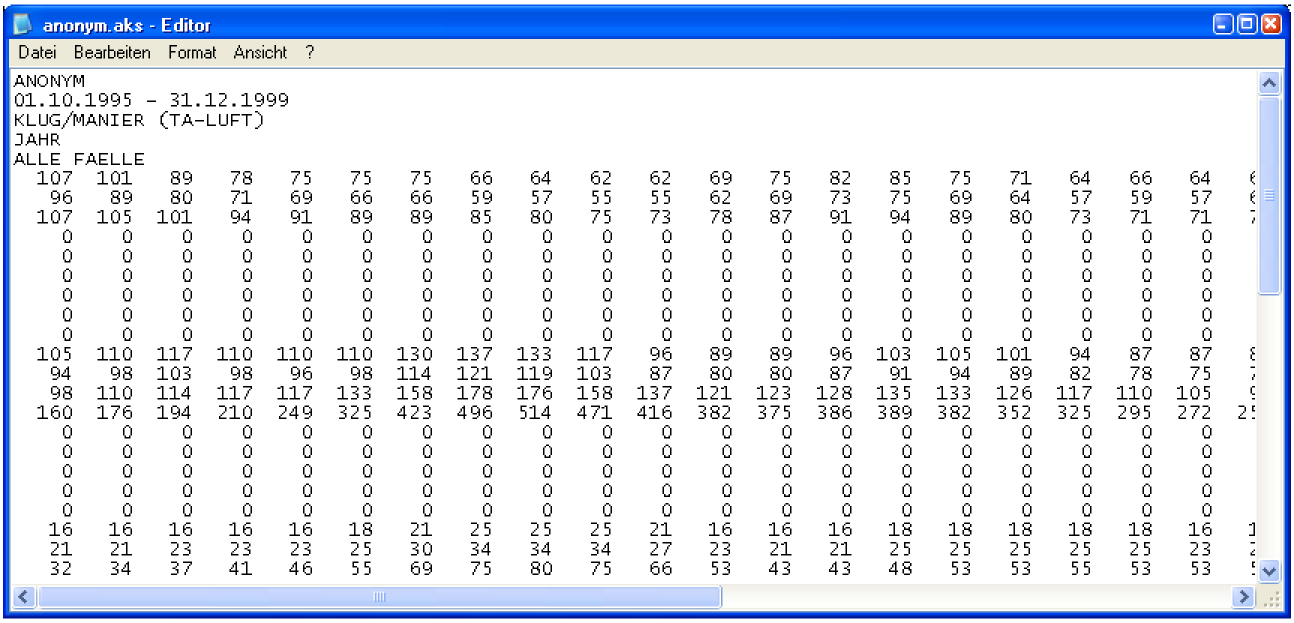
The dispersion of air pollutants can only be calculated in connection with suitable meteorological data.

In Germany the respective data is collected by the German Weather Service (DWD) who provides statistic and annual trend files, as well as time series. Increasingly similar services are being offered by private companies.

4.1 Structure of meteorological files

4.1.1 DWD - Format: Structure of annual statistics file

In Germany the text-files have a standardized structure following the example of the DWD-files. The image below shows a file listing of the annual statistics in the DWD-format:




```
ANONYM
01.10.1995 - 31.12.1999
KLUG/MANIER (TA-LUFT)
JAHR
ALLE FAELLE
  107  101   89   78   75   75   75   66   64   62   62   69   75   82   85   75   71   64   66   64
   96   89   80   71   69   66   66   59   57   55   55   62   69   73   75   69   64   57   59   57
  107  105  101   94   91   89   89   85   80   75   73   78   87   91   94   89   80   73   71   71
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  105  110  117  110  110  110  130  137  133  117   96   89   89   96  103  105  101   94   87   87
   94   98  103   98   96   98  114  121  119  103   87   80   80   87   91   94   89   82   78   75
   98  110  114  117  117  133  158  178  176  158  137  121  123  128  135  133  126  117  110  105
  160  176  194  210  249  325  423  496  514  471  416  382  375  386  389  382  352  325  295  272
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   16   16   16   16   16   18   21   25   25   25   21   16   16   16   18   18   18   18   18   16
   21   21   23   23   23   25   30   34   34   34   27   23   21   21   25   25   25   25   25   23
   32   34   37   41   46   55   69   75   80   75   66   53   43   43   48   53   53   55   53   53
```

Figure 17: DWD-file for annual statistics

- The first line contains the name of the region.
- Lines 2 to 5 contain information, e.g. on the period of observation. Although this information is ignored by IMMI, it must be contained in the file!
- Beginning with the 6. line, the file lists the wind frequencies for all directional sectors with a step size of 10°.
- Every line contains 36 values corresponding with the number of sectors beginning with the direction at 10°.
- Each value (integer!) is listed with 5 digits.
- There is no space between values.

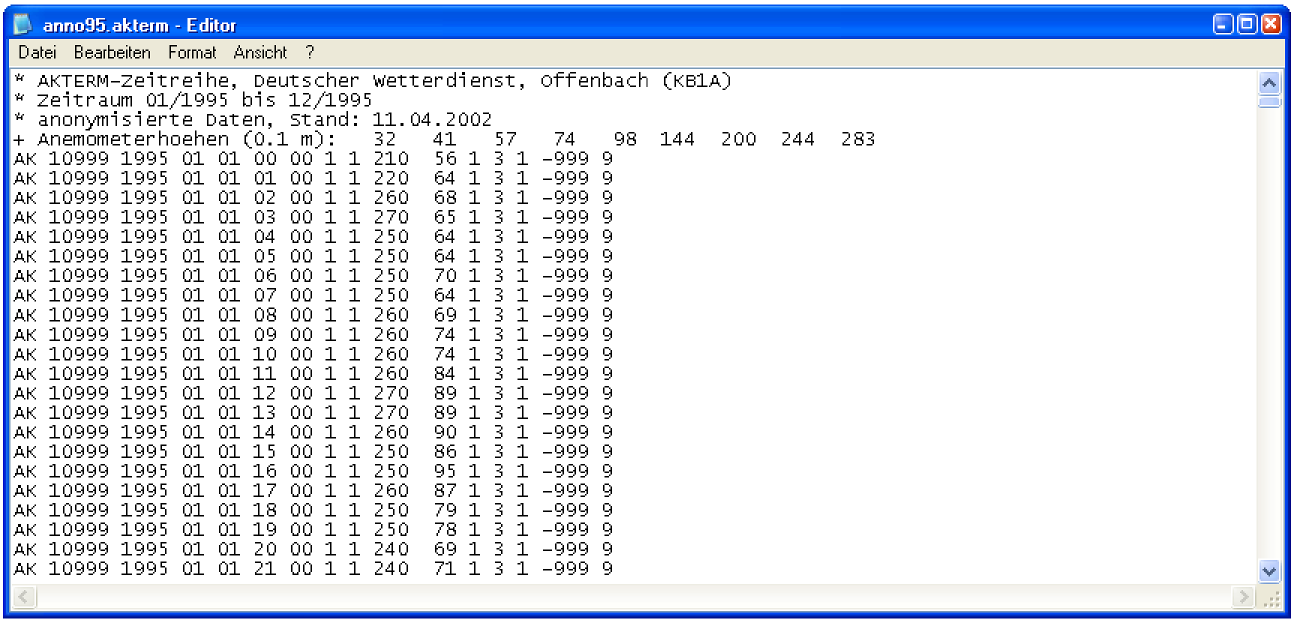
- Normally the DWD-file lists 9 consecutive lines grouped by wind velocity classes. The file contains 6 blocks with these groups according to the stability classes, i.e. a total of 54 lines with data.

  [as]

When using this module in foreign countries, it is necessary to re-format the foreign files containing meteorological data according to the DWD format. The conversion is not done automatically by IMMI, and must therefore be taken care of by the user. Exceptions to this rule: IMMI supports the import of Austrian data following ÖNORM M 9440 and of Belgian meteorological data following Bultynck-Malet (special case IBGE: The institute for environment management of the region Brussels-Capital utilizes a proprietary file format for meteorological data and stability classes following Bultynck-Malet).

4.1.2 DWD - Format: Structure of time series

The format of a time series file is as follows:




```
* AKTERM-Zeitreihe, Deutscher Wetterdienst, Offenbach (KB1A)
* Zeitraum 01/1995 bis 12/1995
* anonymisierte Daten, Stand: 11.04.2002
+ Anemometerhoehen (0.1 m):   32   41   57   74   98  144  200  244  283
AK 10999 1995 01 01 00 00 1 1 210  56 1 3 1 -999 9
AK 10999 1995 01 01 01 00 1 1 220  64 1 3 1 -999 9
AK 10999 1995 01 01 02 00 1 1 260  68 1 3 1 -999 9
AK 10999 1995 01 01 03 00 1 1 270  65 1 3 1 -999 9
AK 10999 1995 01 01 04 00 1 1 250  64 1 3 1 -999 9
AK 10999 1995 01 01 05 00 1 1 250  64 1 3 1 -999 9
AK 10999 1995 01 01 06 00 1 1 250  70 1 3 1 -999 9
AK 10999 1995 01 01 07 00 1 1 250  64 1 3 1 -999 9
AK 10999 1995 01 01 08 00 1 1 260  69 1 3 1 -999 9
AK 10999 1995 01 01 09 00 1 1 260  74 1 3 1 -999 9
AK 10999 1995 01 01 10 00 1 1 260  74 1 3 1 -999 9
AK 10999 1995 01 01 11 00 1 1 260  84 1 3 1 -999 9
AK 10999 1995 01 01 12 00 1 1 270  89 1 3 1 -999 9
AK 10999 1995 01 01 13 00 1 1 270  89 1 3 1 -999 9
AK 10999 1995 01 01 14 00 1 1 260  90 1 3 1 -999 9
AK 10999 1995 01 01 15 00 1 1 250  86 1 3 1 -999 9
AK 10999 1995 01 01 16 00 1 1 250  95 1 3 1 -999 9
AK 10999 1995 01 01 17 00 1 1 260  87 1 3 1 -999 9
AK 10999 1995 01 01 18 00 1 1 250  79 1 3 1 -999 9
AK 10999 1995 01 01 19 00 1 1 250  78 1 3 1 -999 9
AK 10999 1995 01 01 20 00 1 1 240  69 1 3 1 -999 9
AK 10999 1995 01 01 21 00 1 1 240  71 1 3 1 -999 9
```

Figure 18: DWD file for a time series

- Lines 1 to 3 contain information, e.g. on the time period of data collection. Although this information is ignored by IMMI, it must be contained in the file!
- The 5th and following lines contain the wind frequencies for every hour of the year, the wind direction and the stability classes on each line.

  [az]

4.2 Input of meteorological data in IMMI

The following meteorological conventions apply for manual input and the use of external meteo data:

- The wind direction is the direction from which the wind blows.
- North is "at the top" of the wind rose corresponding with 0 or 360 degrees.
- Rotational direction is clockwise.
- East = 90 degrees; South = 180 degrees; West = 270 degrees.

The input of meteorological data does not depend on the applied calculation model, respectively TA Luft 1986 or TA Luft 2002. It is common practice to import DWD files for applications in Germany.

For applications in Austria we recommend the use of meteorological data following ÖNorm M 9440.

In Belgium the pollution statistics following Bultynck-Malet are applicable for the region Flanders, while the meteorological data supplied by the IBGE are used for the region Brussels-Capital. The IBGE meteorology is directly supported by IMMI.

You can also enter meteorological data manually.

To enter meteorological data choose <**Calculate | Calculation parameters | Parameters for element libraries**>. The input dialog with the parameters for the pollution model always shows a line in the following manner (the dialog varies according to the calculation model selected in the project properties: TA Luft 1986, TA Luft 2002 or other models in the future):

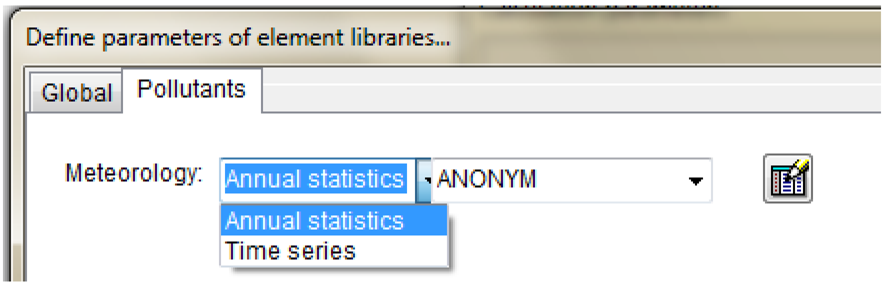


Figure 19: Dialog with a list of meteorological stations

To begin, you can distinguish between annual statistics and time series. With the selection list for the region you can define the meteorological file that is to be used in the current project. Click the button on the right side of the list to open the input dialog for managing meteorological files.

_4.2.1 Elements in the input dialog for defining annual statistics

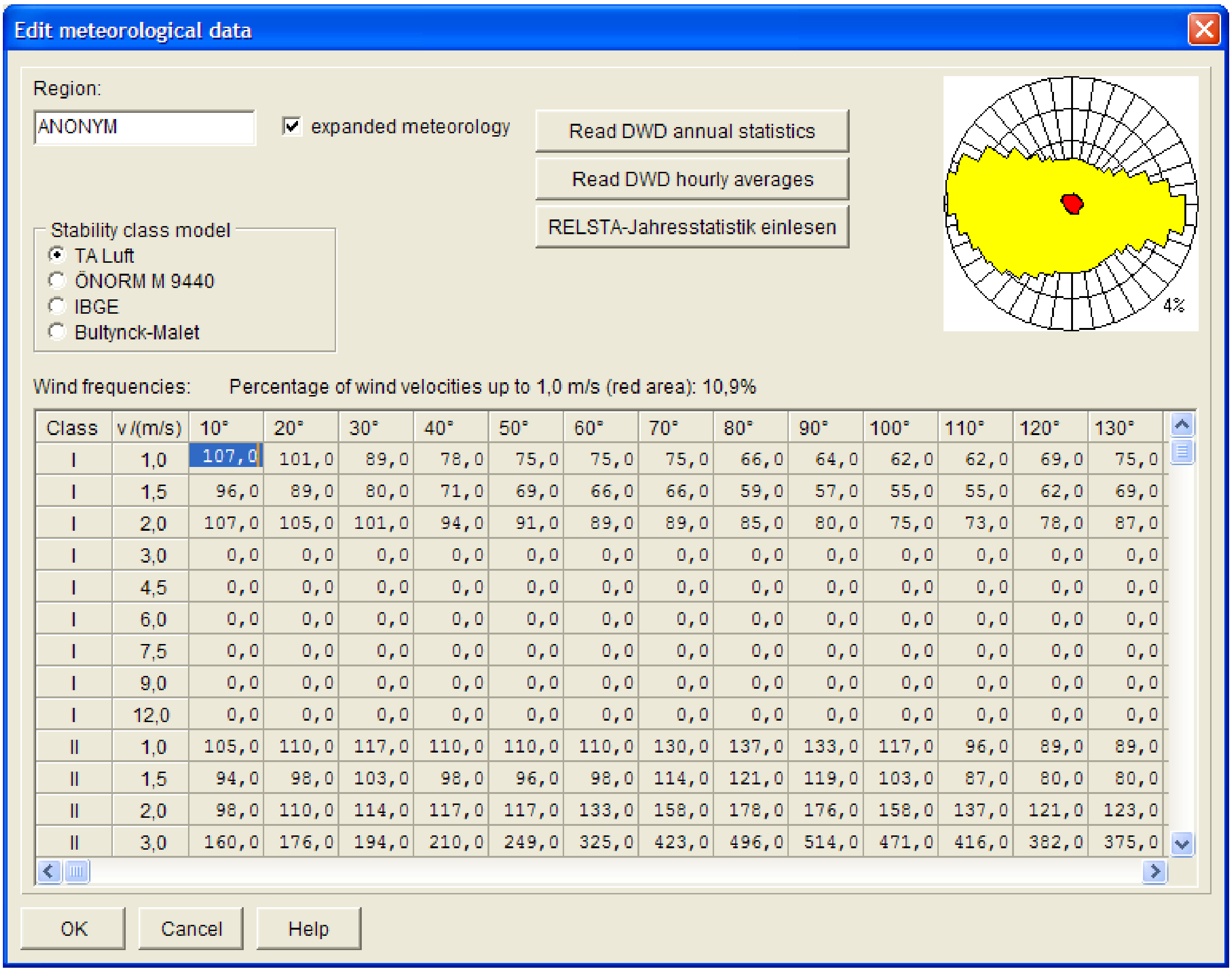


Figure 20: Input dialog for meteorological data – annual statistics

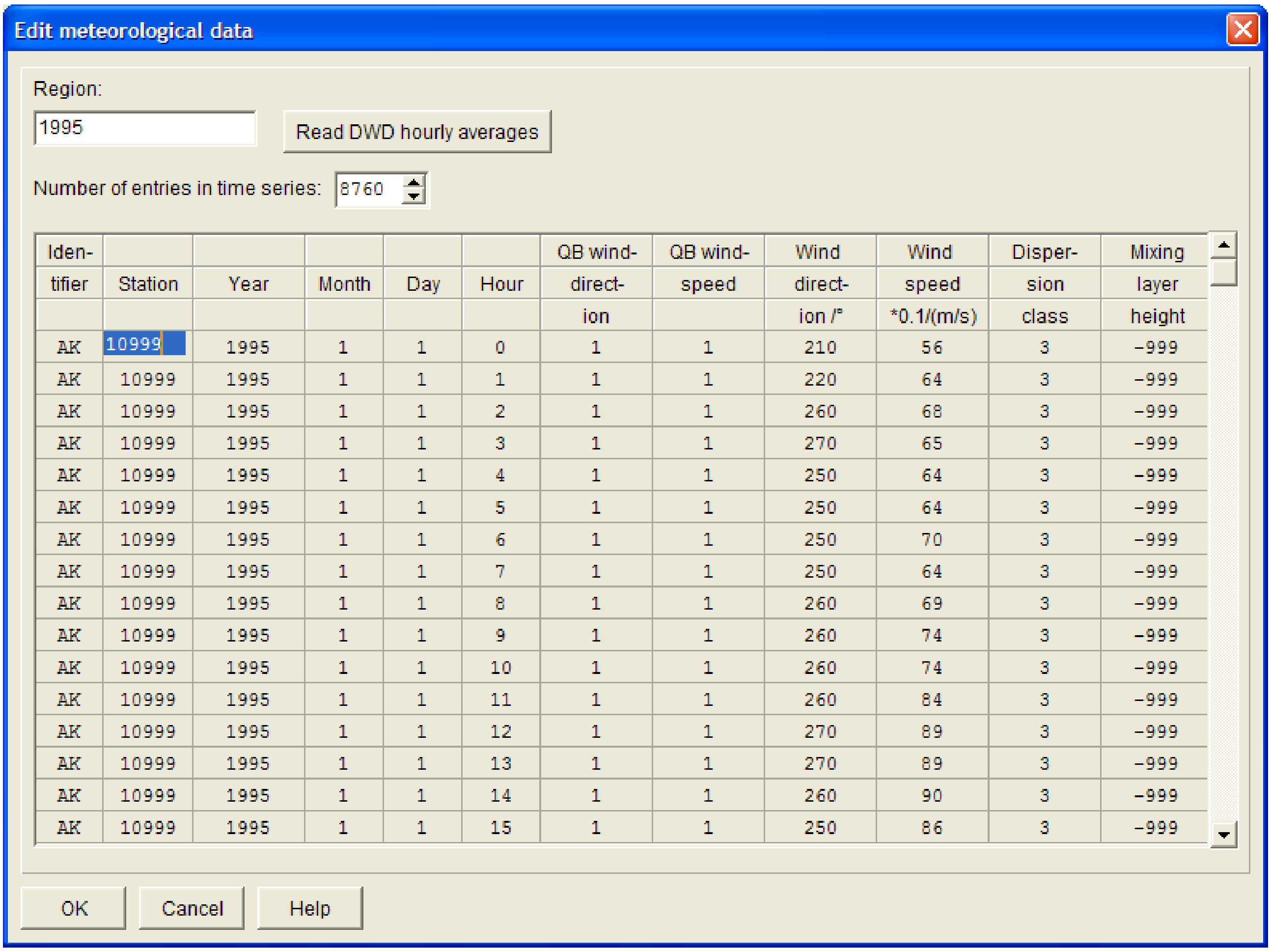
- **Region**: Name of the site where the measurement station is located
- **Read DWD annual statistics / Read DWD hourly averages**: starts the Windows file dialog for browsing and opening files. After selecting the appropriate DWD file, IMMI imports the entire data set. The result is displayed as shown above (in this case: annual statistics) and can be edited by the user.
- **Expanded meteorology**: This setting switches from the simple one line input to the commonly used two-dimensional and more extensive table for meteorological data and stability parameters. Expanded meteorology is a mandatory setting for TA Luft 2002.
- **Stability class model**: Selection of the suitable file format depending on the origin of the meteorology file.

- Germany: Maintain the TA Luft default
- Austria: Switch to ÖNORM M 9440
- Belgium: Select IBGE or Bultynck-Malet depending on the application.

- **Wind frequencies**: Two-dimensional table for the frequency distribution of possible combinations of wind direction, wind velocity and stability class.
- **Graphic image in the upper right corner**: Wind rose of frequencies per sector displayed in the form of a two-dimensional diagram (red indicates: low wind situations up to 1,0 m/s).

TIP: Left-click on the wind rose to copy the graphic to the clipboard for use in project reports.

4.2.2 Elements in the input dialog for defining a time series



Iden-tifier	Station	Year	Month	Day	Hour	QB wind-direct-ion	QB wind-speed	Wind direct-ion /°	Wind speed *0.1/(m/s)	Disper-sion class	Mixing layer height
AK	10999	1995	1	1	0	1	1	210	56	3	-999
AK	10999	1995	1	1	1	1	1	220	64	3	-999
AK	10999	1995	1	1	2	1	1	260	68	3	-999
AK	10999	1995	1	1	3	1	1	270	65	3	-999
AK	10999	1995	1	1	4	1	1	250	64	3	-999
AK	10999	1995	1	1	5	1	1	250	64	3	-999
AK	10999	1995	1	1	6	1	1	250	70	3	-999
AK	10999	1995	1	1	7	1	1	250	64	3	-999
AK	10999	1995	1	1	8	1	1	260	69	3	-999
AK	10999	1995	1	1	9	1	1	260	74	3	-999
AK	10999	1995	1	1	10	1	1	260	74	3	-999
AK	10999	1995	1	1	11	1	1	260	84	3	-999
AK	10999	1995	1	1	12	1	1	270	89	3	-999
AK	10999	1995	1	1	13	1	1	270	89	3	-999
AK	10999	1995	1	1	14	1	1	260	90	3	-999
AK	10999	1995	1	1	15	1	1	250	86	3	-999

Figure 21: Input dialog for meteorological data – time series

- **Region**: Name of the site where the measurement station is located

_▪ **Read DWD hourly averages**: starts the Windows file dialog for browsing and opening files. After selecting the appropriate DWD file, IMMI imports the entire data set. The result is displayed as shown above and can be edited by the user.

4.3 Managing Meteorology Files

In IMMI you can create two lists of meteorology files: One for annual statistics an the other for time series. A special type of database is available for each variety of data. Annual statistics are stored in the file "POLLMET.DAT" and the time series are stored in the file "POLLMETZR.DAT". You can manage any number of entries in this database.

Important note: In IMMI the TA Luft 1986 mode of the pollution module can also be used for continuous tape monitoring of pollutant emitting facilities. Therefore, the first entry in the database is reserved for the wind distributions applied when importing measurement points. In this case caution is advised as the current entry is overwritten without warning! The date of the respective measurement campaign is imported and used in the following format as the name for the current wind distribution, e.g. "Wind on 14.01.1999".

Currently, wind frequencies are recorded as integers and standardized back to 100. IMMI calculates distributions by percentage based on the cumulative frequencies.

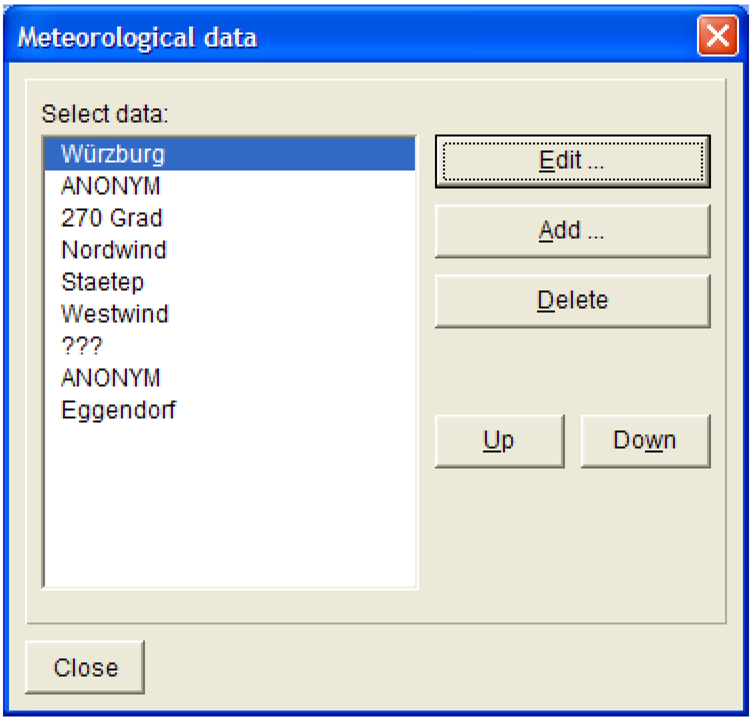


Figure 22: List of available meteorology files

- **Edit**: opens the input dialog described above for the selected (highlighted in blue) measurement station.
- **Add**: opens the input dialog described below for the definition of a new measurement station.
- **Delete**: deletes a measurement station from the list.
- **Up / Down**: move the selected measurement station one position up or down in the list

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Note: License agreements connected with the acquisition of digital meteorology data may prohibit the multiple usages of such data. We kindly request that these agreements be respected.

–

5 Pollution Calculation

5.1 Pollution Calculation according Gauß/TA Luft 1986

Pollution calculation includes calculating one or several of the following values for receivers at a chosen height depending on the source type used and the settings applied in the dialog <**Calculate | Calculation parameters | ... | Parameters for element libraries**>:

- **For gaseous sources**: The concentration (mass concentration in mm/m³) or a percentile
- **For dust sources**: The concentration of airborne dust and the dust deposition on the ground (in each case IW1 (mean value) and IW2 (percentile)).
- **For odor**: The percentage of odour nuisance hours for odor sources (odor frequencies in %).

Basically IMMI distinguishes between grid calculation and single point calculation.

5.1.1 Single point calculation

Single point calculation requires definition of one or several receivers with the element type **- Reception point** from the standard library. To execute the single point calculation choose <**Calculate | Pollution concentration**> or click the  button in the toolbar below the main menu.

Result lists can be exported: Text files, RTF files, MS EXCEL, MS WORD, HTML or into the clipboard. With IMMI you can also print lists directly. All of these functions (and more) can be accessed by right-clicking and choosing from the pop-up menu when a list is displayed.

Single point calculations generate two lists for documentation:

The **short list** shows the pollution concentration and the dust deposition for each "measurement point".

Tabelle 1: Single point calculation TA Luft 1986: Short list

Short list		**- Unnamed -**			
Noise prediction					
Variante 0					
		I1Z NO2		I1Z SO2	
		LV	Immiss.	LV	Immiss.
		/(µg/m³)	/(µg/m³)	/(µg/m³)	/(µg/m³)
IPkt001	IPkt	30,0	0,7	20,0	0,4

_In the "mid-size list" the pollution is displayed separately for each pollutant source.

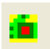
Tabelle 2: Single point calculation TA Luft 1986: Mid-size list

Short list		**- Unnamed -**							
Noise prediction									
Alle Elemente									
		I1Z Conc.		I2Z Conc.		I1Z Depos.		I2Z Depos.	
		LV	Immiss.	LV	Immiss.	LV	Immiss.	LV	Immiss.
		/(µg/m³)	/(µg/m³)	/(µg/m³)	/(µg/m³)	/(mg/m²d)	/(mg/m²d)	/(mg/m²d)	/(mg/m²d)
IPkt001	MP 16	0,0	0,2	0,0	6,2	0,0	0,2	0,0	7,7
IPkt002	MP 15	0,0	0,3	0,0	8,5	0,0	0,3	0,0	8,4
IPkt003	MP 14	0,0	0,3	0,0	5,1	0,0	0,3	0,0	5,8
IPkt004	MP 13	0,0	0,2	0,0	6,9	0,0	0,3	0,0	8,1
IPkt005	MP 12	0,0	0,8	0,0	24,5	0,0	1,2	0,0	33,2

5.1.2 Grid calculation

The receivers are distributed on a grid with constant step size. Although step sizes may differ between the x-axis and y-axis, the size always remains constant on each axis. Grids can be defined by the user: <**Grid | Definition | Dimension**>.

The result of a grid calculation is a two-dimensional display of a concentration or deposition field in the work area. The size of the calculated field is specified by the definition of the grid dimensions.

Grid calculation is executed either by choosing <**Grid | Calculate**> in the main menu or by clicking the  button in the toolbar below the main menu.

Pollution grids can be exported either as bitmap (.BMP), as vector file (.EMF or .DXF) or in various numerical/text-oriented formats for databases and text files. Special export options are available for users who have an ArcGIS interface license for IMMI. Choose <**Grid** | **Export**> to access the export options. For the graphical export use the following procedure: When the color grid is displayed in the work area frame, right-click and select the appropriate menu item (**Graphic Export of map and grid**) from the pop-up.

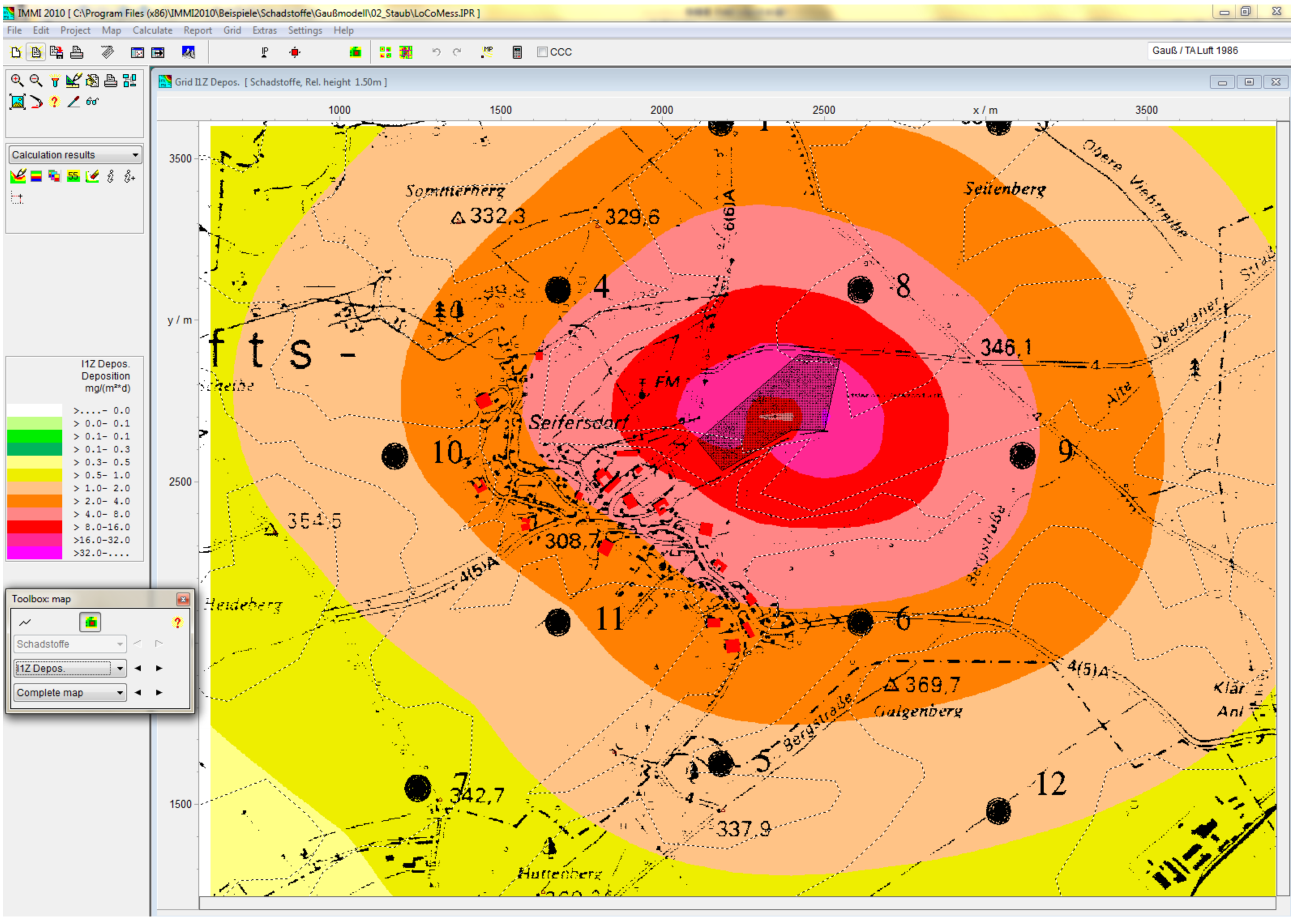


Figure 23: Pollution grid

5.2 Pollution Calculation according Lagrange / VDI 3945

The calculations executed following the Lagrangian Model/VDI3675 (TA Luft2002) are always grid calculations.

Essentially the grid calculation is processed according to the method defined in Gauss/TA Luft 1986. For more information see Pollution Calculation according Gauß/TA Luft 1986 on page 41 and following.

AUSTAL2000 calculates the annual mean value (j00) for all pollutant types. Additional parameters are calculated for some pollutants. See the following table:

_Tabelle 3: Pollutants

	Averaging Period			Grid File in AUSTAL2000
Pollutant	**Year**	**Day**	**Hour**	
SO2	j00	t03	s24	so2-j00z.dmna/ so2-t03.dmna/so2-s24z.dmna
NO2	j00		s18	no2-j00z.dmna/ no2-s18z.dmna
NOx	j00			nox-j00z.dmna
PM	j00 dep	t35		pm-j00z.dmna/ pm-depz.dmna/ pm-t35z.dmna
NH3	j00 dep			nh3-j00z.dmna/ nh3-depz.dmna
xx (= Jokergas)	j00 dep			xx-j00z.dmna/ xx-depz.dmna
Odor (= unweighted odor)	j00			odor-j00z.dmna
Odor_nnn (=Weighted odor)	j00			odor_nnn-j00z.dmna

j00: Annual mean for concentration/frequency of odour hours

dep: Annual mean deposition

tnn: Maximum daily mean with nn exceedances

snn: Maximum hourly mean with nn exceedances

The weighted odours are divided into animal species.

Tabelle 4: Overview odours for animals

Name	Weighting factor	Animal species
odor_040	0,40	only in Germany, state Baden-Württemberg!: Dairy cow with pup
odor_050	0,50	Dairy cow with pup
odor_060	0,60	only in Germany, state Baden-Württemberg!: Feeding pig, sow
odor_075	0,75	Feeding pig, sow
odor_100	1,00	only in Germany, state Baden-Württemberg!: Feeding poultry
odor_150	1,50	Feeding poultry

A grid will be calculated for each pollutant. The results have different units.

Tabelle 5: Overview Pollutant units

Pollutant	Unit
Gases (e.g. SO2)	µg/m^3
Dust (e.g. PM10)	kg/(ha*a)
Odour	Odor frequencies/%

5.2.1 Single point calculation

The particle model does not allow any explicit single point calculation. However, single point calculations are automatically integrated in grid calculation, provided single points (= element type “reception point”) are modeled in the active variant. In this case, AUSTAL2000 automatically carries out the single point calculation for all reception points. Results are listed at the end of the calculation protocol (austal2000.log) which is saved together with the results grid. The austal.log file is saved in the same folder as the IMMI project file.

Another way to access this file is by clicking on the  button in the toolbar.

Excerpt from the file austal.log / Results for single point calculation
==
PUNKT 01 02 03
xp 0 635 754
yp 0 794 856
hp 2.0 2.0 2.0
--------+---------+--------+--------+--------+--------
SO2 J00 4.5 276.6 285.0 µg/m^3
SO2 S24 273 2273 2068 µg/m^3
SO2 S00 852 3077 3074 µg/m^3
--------+---------+--------+--------+--------+--------
NO2 J00 3.3 207.4 213.8 µg/m^3
NO2 S18 239 1753 1666 µg/m^3
NO2 S00 639 2308 2306 µg/m^3
--------+---------+--------+--------+--------+--------
BZL J00 0.11 6.91 7.13 µg/m^3

--------+---------+--------+--------+--------+--------
PM DEP 0.0000 0.0011 0.0011 g/(m²*d)
PM J00 0.0 1.2 1.3 µg/m³

In AUSTAL2000 the points are automatically numbered. In this process point 01 in AUSTAL2000 corresponds with the reception point having the element number IPKT0001 in IMMI and so forth..

The x- and y-coordinates are listed for every point, along with the height and the results of the various layers (e.g. SO2 J00 etc.)

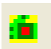
[**xp, yp, hp**]

Note: The first reception point is always created by IMMI automatically for the purpose of defining the calculation height (point 01). The number of reception points (IPKT) is limited to a total of 19.

5.2.2 Grid calculation

The receivers are distributed on a grid with constant step size. Although step sizes may differ between the x-axis and y-axis, the size always remains constant on each axis. Grids can be defined by the user: <**Grid | Definition | Dimension**>.

The result of a grid calculation is a two-dimensional display of a concentration or deposition field in the work area. The size of the calculated field is specified by the definition of the grid dimensions.

To execute grid calculation choose <**Grid | Calculate**> in the main menu or click the  button in the toolbar directly below the main menu.

The grid is calculated by the external calculation kernel AUSTAL2000. While the calculation progresses, the output data produced by AUSTAL2000 is passed to IMMI and the progress of the calculation is displayed in the calculation window.

Note: The grid step size for AUSTAL2000 calculations should be at least 15 m for both directions x and y (required by AUSTAL2000).

[**dd**]

The size of the grid area corresponds with the calculation grid in AUSTAL2000. The grid area, not the area of the map, is passed to AUSTAL2000 unless the grid area comprises the entire work area on the map.

Nonetheless, there will be differences between the definitions in IMMI and the definitions in AUSTAL2000. In IMMI a grid point is defined as the centre of a grid square while in AUSTAL2000 it is the lower left corner. Therefore, the deviation of the calculation grid always amounts to half the grid stepsize.

[x0 und y0 (= lower left corner of the calculation area)]

Note: The relative height of the calculated grid can be defined when doing grid calculations. IMMI selects the layer specified by AUSTAL2000 that is appropriate for the height desired. In AUSTAL2000 the heights of the boundary layer /m are as follows:

0 3 6 10 16 25 40 65 100 150 200 300 400 500 600 700 800 1000 1200 1500.

[**hp**]

Example: In AUSTAL2000 the 1. boundary layer "0" is used when a relative grid height of 2.99 m is defined in IMMI. The 2. boundary layer "3" is used for values above 3.00 m.

At the end of the calculation AUSTAL2000 creates a report and saves it in the austal.log file. IMMI automatically opens the log file and displays the content on the screen:

Immissionsraster		
Project file:	C:\AUSTAL\HEINING2Quellen\MUEGGENBURGER_nurFLQ.IPR	
Grid-File:	C:\AUSTAL\HEINING2Quellen\MUEGGENBURGER_nurFLQ.IRD	
calculated with:	C:\AUSTAL\HEINING2Quellen\MUEGGENBURGER_nurFLQ.IPR	
Variant:	Variante 0	
Calc. time:	00:06:38 h	
Calculated:	8/24/2010 9:15:14 AM	
Calculation area:	10 x 10 m	
	Area:	Work area
	dx: 10.00m	Resolution in x: 126
	dy: 10.00m	Resolution in y: 126
	x: from 3568120.0m	to 3569370.0m
	y: from 5931482.0m	to 5932732.0m
	Rel. height:	0.00m
Grid scale:	TA Luft (Immiss.-Konz.) | Massenkonz. /$\mu g/m^3$	
Access to grid data:	Complete grid loaded in memory.	

Statistical indicators						
Layer	minimum	maximum	average	standard deviation	q 0,1	q 0,9
pm-j00z (Konz.)	0,00	0,30	0,00	0,02	0,00	0,00
pm-depz (Depos.)	0,00	0,00	0,00	0,00	0,00	0,00
pm-t35z (Konz.)	0,00	0,50	0,01	0,03	0,00	0,00
Höhenraster	0,00	0,00	0,00	0,00	0,00	0,00

5.2.2.1 Statistical uncertainty

If it is possible to calculate the statistical uncertainty for the respective size, a separate file is created for each grid layer and saved with the identifier s, e.g. so2-j00s.dmna.

_These files can be imported via <**Grid | Import | AUSTAL2000 grid (statistics)**>.

Additional information on calculating the statistical uncertainty can be found in the AUSTAL2000 manual (austal2000.pdf) that is provided for your convenience in the IMMI installation folder.

5.2.2.2 Nested grids

To carry out grid calculations, the area to be calculated must be defined manually with a constant step size.

This method is inappropriate for calculations involving buildings, terrains and/or a multitude of sources. The grid used for calculating in the vicinity of sources and buildings should have finer meshes than that used in distant areas. For more detailed information, please refer to Chapter 3.8 of the AUSTAL2000 Manual (see IMMI installation directory).

Select <**Calculate | Calculation parameters | ... | Parameters for element libraries | Pollutants**> and use function **Nested calculation grid** to define whether calculation should be with or without a nested grid.

If you activate this function, the grid limits and step sizes are defined by AUSTAL2000. Although the list of calculation area definitions is still offered when grid calculation is started, the only parameter transferred to AUSTAL2000 is the grid height of the calculation area selected.

Note: Please ensure that the work area of your project is large enough. Any error in this respect is indicated by IMMI which displays an additional message informing the user that the grid limits (and therefore the limits required for the work area) set by AUSTAL2000 are documented in “taldia.log”.

The calculation grids [x0 and y0] and the grid step size [dd] defined by AUSTAL2000 are documented in the “Austal.log” file (see the example below):

```
Festlegung des Rechennetzes:
dd      16      32      64
x0     704     320       0
nx      48      48      34
y0     672     320       0
ny      52      48      34
nz      19      19      19
```

After completed calculation, the grids are automatically combined and displayed in IMMI as a single grid.

The partial grids can also be opened and displayed separately. Select the <**Grid | Import | AUSTAL2000 single grid**> menu item to open the file.

5.2.3 Terrain slope

The terrain slope is documented in the "austal.log" file and saved to file zg00_s.dmna. For example, the following sentence is output:

„Die maximale Steilheit des Geländes ist 0.52 (0.47)."

The terrain slope across the complete calculation area can be visualized in IMMI. Select the <**Grid | Import | AUSTAL2000 grid**> menu item to import the grid file for the terrain slope (zg00_s.dmna).

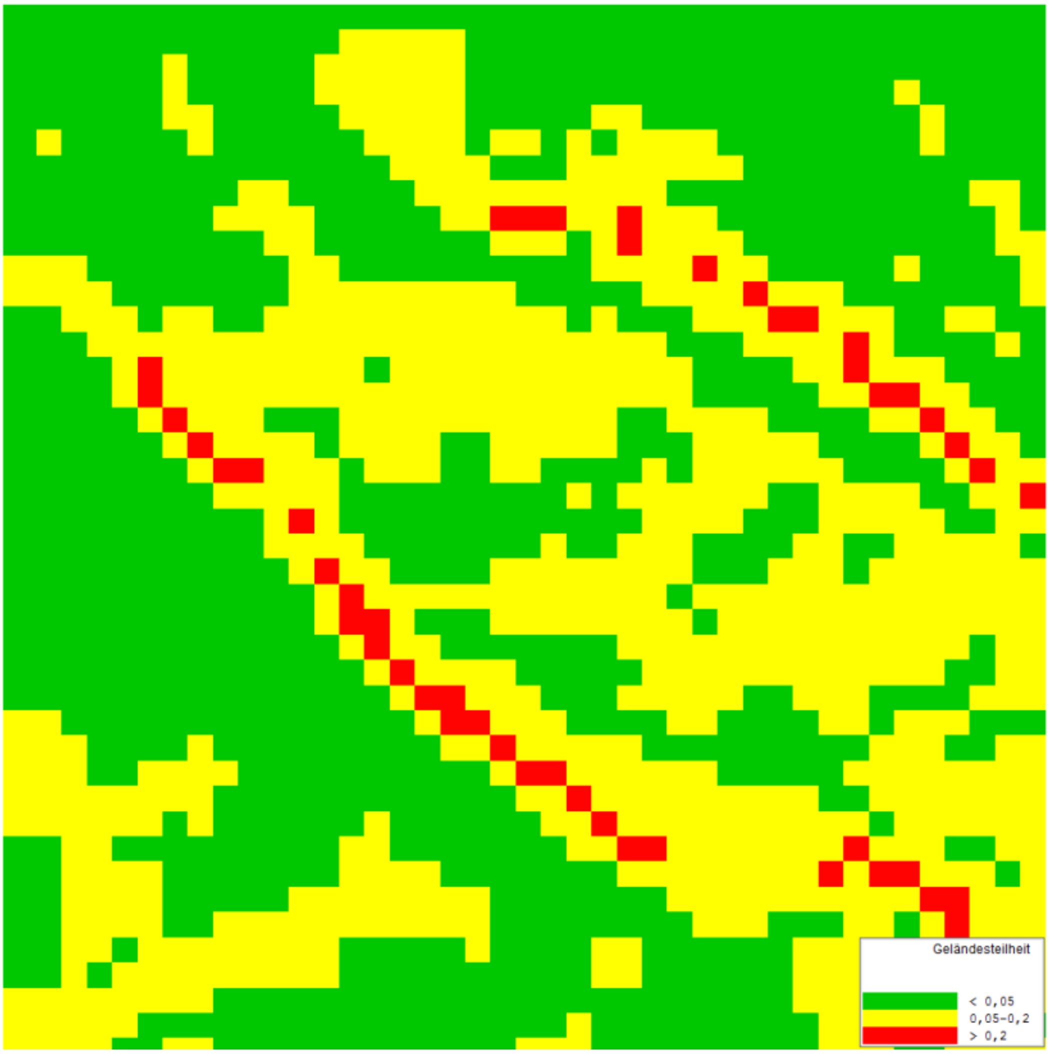


Figure 24: Example Terrain slope

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6 Conflict map

Choose <**Grid | Processing | Evaluate**>, click **Evaluate** and choose **Conflict map for air pollutants** from the drop-down list to create conflict maps for air pollution grids. With this option you can compare the calculated concentrations or dust depositions with the defined limit values.

Choose <**Calculate | Calculation parameters | Parameters for element libraries**> and select the **Pollutants** tab to open the dialog for defining limit values for pollutants.

The limit value for annual mean concentration of SO_2 is 50 µg/m³. The following image shows the conflict map for SO_2 (= concentration – limit value).

The regions where the actual values exceed the defined limit value are indicated by color.

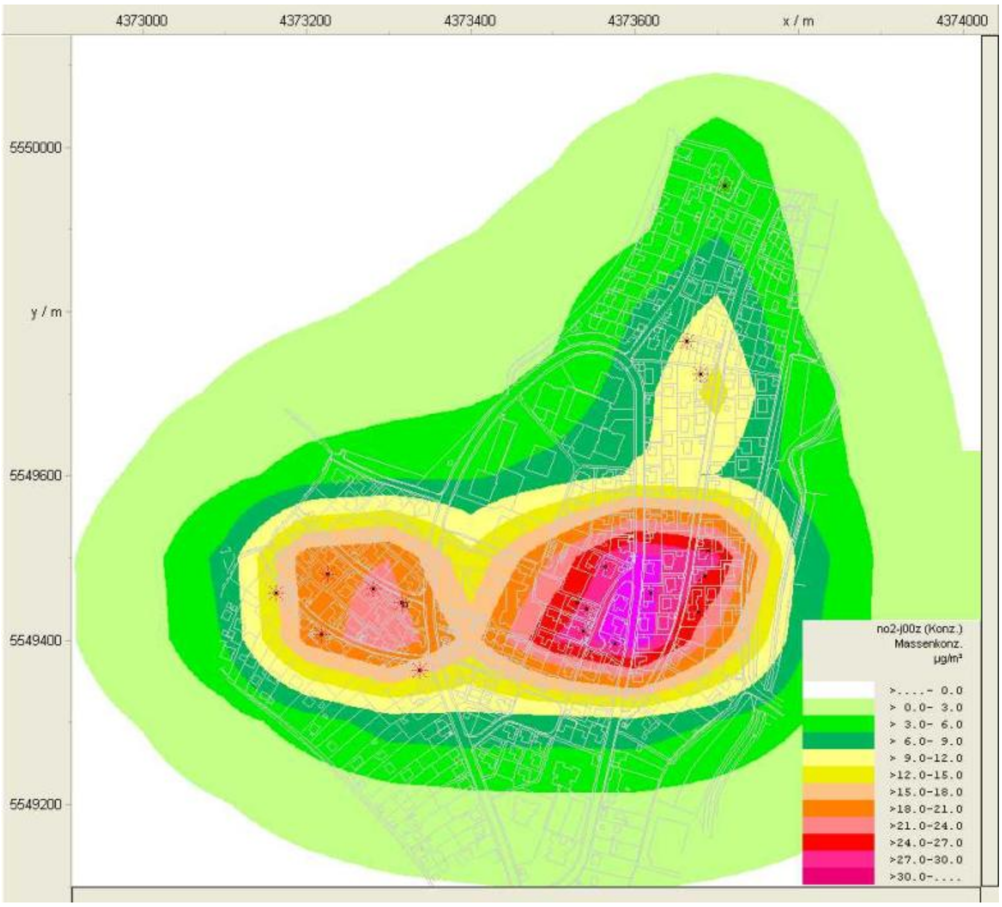

Figure 25: Conflict map from SO2

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7 Literature

For detailed information on the AUSTAL2000 program, please refer to:

- AUSTAL2000: Programmbeschreibung zu Version 2.2 (Program Description of Version 2.2), published on 2006-03-25, Ingenieurbüro Janicke, Dunum

Related literature:

- TA Luft 2002: Technical Instructions on Air Quality Control dated 24 June 2002
- TA Luft 1986: Technical Instructions on Air Quality Cntrol dated 27 February 1986
- VDI 3945 Sheet 3: Environmental Meteorology – Atmospheric Dispersion Models – Particle model of September 2000
- ÖNORM M 9440: Dispersion of pollutants in the atmosphere – Calculation of ambient air concentrations and determination of stack heights, published in November 1996
- Stern/Giebel: Empirical dispersion equation for the concentration situation in the immediate vicinity of emission sources – Formula according to STERN and GIEBEL, Edition October 1995
- HBEFA: Handbook for Emission Factors for Road Transport, Version 2.1: Oldenburg, Jörg: Geruchs- und Ammoniak-Emissionen aus der Tierhaltung, Kiel 1989
- Copert: Computer programme to calculate emissions from road transport
- GIRL 2008: Determination and assessment of odor concentrations (Guideline for Odor Dispersion and Impact) as amended on 29 February 2008 with reasons and interpretations
- VDI 3783 Sheet 13: Environmental meteorology – Quality control concerning air quality forecast – Plant-related pollution control – Dispersion calculation according to TA Luft, Draft of December 2007
- MLuS 02: Merkblatt über Luftverunreinigung an Straßen ohne oder mit lockerer Randbebauung, Forschungsgesellschaft für Strassen- und Verkehrswesen, Edition 2002
- Hotchkiss, R.S. and F.H. Harlow, 1973. Air Pollution Transport in Street Canyons
- Oldenburg, Jörg: Geruchs- und Ammoniak-Emissionen aus der Tierhaltung, Kiel 1989

_▪ By order of: Landesanstalt für Umweltschutz (Karlsruhe), Niedersächsisches Landesamt für Ökologie (Hildesheim), Landesumweltamt NRW (Essen). Summary report: LUTZ JANICKE, ULF JANICKE: Die Entwicklung des Ausbreitungsmodells AUSTAL2000G, Berichte zur Umweltphysik, Number 5, ISSN 1439-8222, Hrsg. Ing.-Büro Janicke, Dunum (August 2004), see www.janicke.de.

- VDI 3782 Bl. 3: Dispersion of air pollutants in the atmosphere – Determination of plume, edition of June 1985

8 Appendix

8.1 List of abbreviations for air pollutants

	Pollutant		
Abbreviation	**German**	**English**	**French**
SO2	Schwefeldioxid	sulphur dioxide	dioxyde de souffre
NOx	Stickstoffoxide	nitrogen oxide	oxyde d'azote
NO	Stickstoffmonoxid	nitrogen monoxide	monoxyde d'azote
NO2	Stickstoffdioxid	nitrogen dioxide	dioxyde d'azote
Bzl	Benzol	benzene	benzène
TCE	Tetrachlorethan	trichloroethylene	trichloroéthane
F	Fluorwasserstoff	hydrogen fluoride	fluorhydrique
NH3	Ammoniak	ammonia	ammoniac
PM	Schwebstaub	particulate matter	particules en suspension
As	Arsen	arsenic	arsenic
Pb	Blei	lead	plomb
Cd	Kadmium	cadmium	cadmium
Ni	Nickel	nickel	nickel
Hg	Quecksilber	mercury	mercure
Tl	Thallium	thallium	thallium
Xx	Jokergas	free user-defined gas	gas au choix de l'utilisateur
COV	VOC Flüchtige organische Verbindungen	VOC volatile organic compounds	COV composés organiques volatils
CH4	Methan	methane	méthane
CO	Kohlenstoff-monoxid	carbon monoxide	monoxyde de carbone
CO2	Kohlenstoffdioxid	carbon dioxide	dioxyde de carbone
N2O	Distickstoff-monoxid	dinitrogen oxide	protoxyde d'azote
HAP	PAK polyzyklische aromatische Kohlenwasserstoffe	PAH polycyclic aromatic hydrocarbon	HAP hydrocarbures aromatiques polycycliques

¯8.2 Surface roughness following the CORINE land cover inventory

The surface roughness is determined based on the average roughness length z0. See the following table for details:

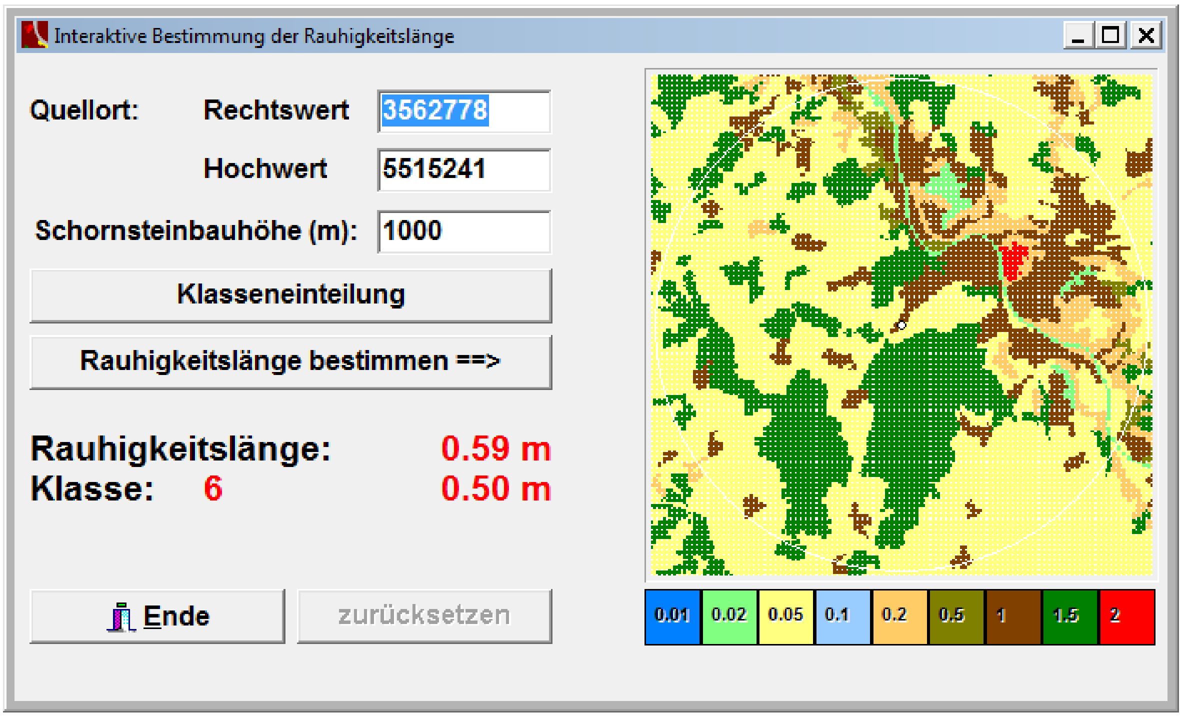
Tabelle 6: Surface roughness

z0 in m	CORINE classes
0.01	Beaches, Dunes and Sands (331); Water bodies (512)
0.02	Dump sites (132); Pastures (231); Natural grassland (321); Sparsely vegetated areas (333); Salt marshes (421); Intertidal flats (423); Water courses (511); Estuaries (522)
0.05	Mineral extraction sites (131); Sport and leisure facilities (142); Non-irrigated arable land (211); Glaciers and perpetual snow (335); Coastal lagoons (521)
0.10	Airports (124); Inland marshes (411); Peat bog (412); Sea and Oceans (523)
0.20	Road and rail networks (122); Green urban areas (141); Vineyards (221); Complex cultivation patterns (242); Agriculture and natural vegetation (243); Moors and heath land (322); Bare rock (332)
0.50	Port areas (123); Fruit trees and berry plantations (222); Transitional woodland shrub (324)
1.00	Discontinuous urban fabric (112); Industrial, commercial and public units (121); Construction sites (133); Coniferous forests (312)
1.50	Broad-leaved forests (311); Mixed forests (313)
2.00	Continuous urban fabric (111)

The file “rl.dat” contains a land cover inventory for Germany. The program for determining the roughness length “rl_inter.exe” is stored in the IMMI installation folder inside the folder “austal2000”. The following section contains an excerpt from the manual for this program:

RLinter Tool – Determine the Roughness Length with Rlinter

The program RLinter (rl_inter.exe) is made available by Mr. H. Thielen (GRS, Cologne). It is designed to interactively determine the roughness length z0 in the vicinity of a source.



In the provided input fields enter the coordinates (coordinate system axis name: “Hochwert” = X direction North, “Rechtswert” = Y direction East) and the height of the source. In case of widespread sources enter the centre of the source. It is not required that Gauss-Krueger coordinates be relative to the third meridian strip. The programme will automatically calculate the conversion. Click the button labelled „Rauhigkeitslänge bestimmen“ („Determine roughness length“) and the programme produces the roughness length calculated based of averaging and the allocation to a pre-defined roughness class.

The graphic representation on the right side of the window shows the distribution of roughness in a circular area around the source with a radius equal to the height of the building multiplied by a factor of 10. The legend beneath the graphic shows the colours allocated to the respective roughness lengths. The distribution of colours gives an overview of how inhomogeneous the surface area actually is and helps the user decide as to whether additional examinations are required for determining the influence of the roughness of the terrain. This tool can also be used to examine how a change in land use influences the average roughness of the terrain. For this function you need to first click on a new roughness class in the legend and then on the respective fields within the graphic to which this new value is meant to be assigned. This process may be repeated several times with various classes. The programme calculates the new roughness length following each modification. Click the button labelled “zurücksetzen” (“reset”) to return to the previous state.

Click **Klasseneinteilung** („Classification”) to display the allocation of land use classes to the respective roughness classes.

_To exit the programme click the **Ende**("Quit") button.

8.3 Displacement height

The displacement height d0 is a common term in urban meteorology and is expected to lie between the surface and the average height of the roughness elements (vegetation and building structures). The displacement height is defined as 6 times.

8.4 Canyon-Plume-Box Model (CPB)

The CPB model is a supplement to the Gaussian model and is intended for narrow road canyons, where pollutants can escape with a delay only and therefore have a higher concentration there.

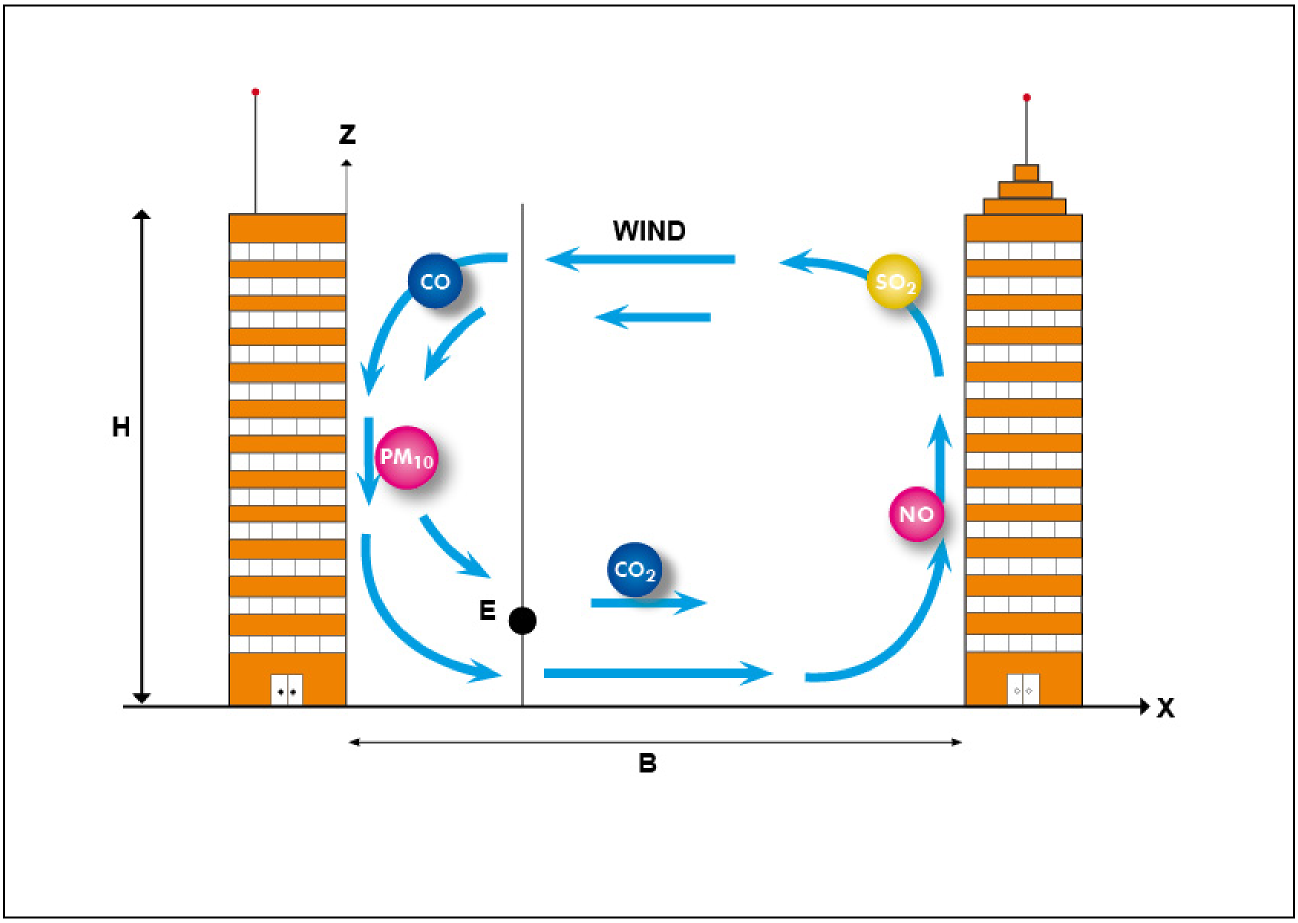
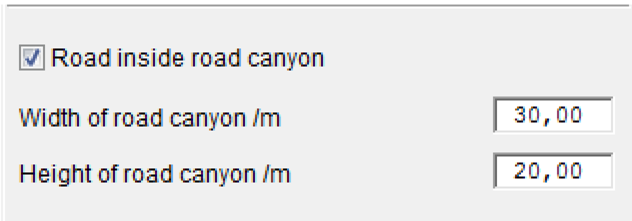


Figure 26: CPB model

Activate the CPB model by checking the “Calculate Canyon-Plume-Box” checkbox in the dialogue for calculation parameters (“Pollutants” tab).

Define for each pollutant road individually whether it is located in a road canyon:



Also define the width and height parameters relevant for the calculation. Explicit modeling of the surrounding buildings is not necessary.

While carrying out dispersion calculation, IMMI automatically checks whether the particular reception point is located inside a road canyon and, if yes, activates CPB calculation in addition to normal dispersion calculation according to the Gaussian model. The particular meteorological situation is taken into account. The system checks in particular whether the requirement for recirculation is met. Recirculation can start only if the wind direction differs from the direction of the road axis for the particular road section by at least 20 degrees.

Note 1: Since global radiation is not explicitly included in the meteorological data, IMMI must estimate this global radiation in relation to the particular propagation class and the wind velocity at the level of the top edge of the road canyon. Since global radiation is incorporated in propagation calculation through a complicated formalism, it is very difficult to estimate the associated error in dispersion calculation.

We will check whether it is possible to enter global radiation explicitly. Since the Canyon-Plume-Box model according to Hotchkiss/Harlow has not been verified for individual meteorological situations, the collection of global radiation data for 54 meteorological situations (6 propagation classes, each with 9 wind velocities) in Germany and 66 meteorological situations in Austria respectively would require a huge amount of work.

Note 2: Inside road canyons, increased dispersion concentration must be expected, whereas a lower concentration due to housing can be assumed away from roads. For that reason, we expanded the “housing” element type in IMMI to be suitable for the propagation calculation of pollutants. You can define a reduction in concentration in percent for each 100 m of propagation distance. CPB, together with the function of attenuation by housing, expands the scope of application of the Gaussian model to a considerable extent.

_We intend to add the parameter of “Concentration reduction” in housing areas through selection of a specific housing situation (e.g. “loose housing” or “closed row of houses”).

8.5 Input parameters in AUSTAL2000

Parameter	Number of parameter	Description
ab	(nb)	Dimension of buildings in x-direction, if no rotation is present (default value 0). A building is defined as a cuboid that can be rotated around its vertical axis. Without rotation the parameters xb and yb designate from a top-view the lower left corner of the cuboid while cb defines the vertical dimension (the cuboid always rests on the ground). The parameters ab and bb define its dimension in x- and y-direction. The angle wb indicates a counter-clockwise rotation around the lower left corner in degrees. Cylindrical buildings (e.g. cooling towers) can be defined by using a negative value for bb, the value indicating the diameter of the cylinder. In this case the value of the parameter ab must be 0, xb and yb indicate the centre of the base, and wb is ignored.
aq	(nq)	Dimension of the source in x-direction, if no rotation is present (default value 0). A source is defined as a cuboid that can be rotated around its vertical axis. Without rotation the parameters xq and yq designate the lower left corner of the cuboid as seen from a top-view, while hq defines the distance to the ground. The parameters aq, bq and cq indicate the dimensions in x-, y- and z-direction. The angle wq defines a counter-clockwise rotation around the lower left corner in degrees.
as	(1)	Name of the frequency statistics for propagation situations (AKS). If the AKS is not available in the project folder, you need to set the path relative to the project folder or define an absolute path. If no time series zeitreihe.dmna is available in the project folder (see Chapter 7), then, to carry out a calculation, as needs to be defined for a statistic or az for an AKTerm.
az	(1)	Name of the meteorological time series (AKTerm) (cp. As).

Parameter	Number of parameter	Description
bb	(nb)	Dimension of the building in y-direction, if no rotation is present (default value 0), cp. ab.
bq	(nq)	Dimension of the source in y-direction, if no rotation is present (default value 0), cp. aq.
cb	(nb)	Vertical dimension of the building (default value 0), cp. ab.
cq	(nq)	Vertical dimension of the source (default value 0), cp. aq.
d0	(1)	Displacement d0 of the meteorological profile (default value 6z0).
dd	(nn)	Horizontal step size of the calculation grid (default value for calculations without building is the smallest defined average source height hq+0.5*cq, with a minimum value of 15m). In x-direction the calculation grid consists of nx points starting at x0, in y-direction accordingly. If location and size of the calculation area are not defined and there are no buildings, then the area chosen for calculation is so, that for every source a circle with 50 times the average source height lies inside the calculation area. The default mode for processing calculations with buildings makes use of nested grids, where location and size of the grids are relative to the configuration of the building and the source (see Chapter 11).
dq	(nq)	Diameter of the source (default value 0). This parameter is only used for calculating the plume rise, cp. qq.
gh	(1)	Name of the file containing the digital terrain model (in the format Arcinfo-GRIDASCII), if the terrain profile zg00.dmna is not yet available. Otherwise this parameter is only used to indicate that the calculation is intended for complex terrain. In this case an asterisk will suffice as parameter value (see Chapter 9). The maximum slope inclination is indicated in the log file.
gx	(1)	Y-Gauss-Krueger coordinate of the system origin. When needed, e.g. for calculating z0, the defined coordinates are converted to the 3rd meridian strip (this is indicated in the log file. Valid range for displaying in the 3rd meridian strip: $3279000 \leq gx \leq 3957000$.
gy	(1)	X-Gauss-Krueger coordinate of the system origin (cp. gx). Valid range for displaying in the 3rd meridian strip: $5229000 \leq gy \leq 6120000$.

Parameter	Number of parameter	Description
ha	(1)	Anemometer height ha above terrain (default 10 m + d0). When using an AKTerm with definitions of anemometer height for all roughness classes, the programme per default applies the appropriate value that corresponds with the defined z0.
hh	(nz + 1)	Vertical grid defined by the z-coordinates of the boundary points of the layers as height above terrain. The default setting for calculations without buildings is hh 0 3 6 10 16 25 40 65 100 150 200 300 400 500 600 700 800 1000 1200 1500. For calculations with buildings see qb. This parameter will only produce an effect, if the option NOSTANDARD is also set (see parameter os).
hp	(np)	Height of the monitor point (rating point) above terrain (default value 1.5).
hq	(nq)	Height of the source (lower edge) above terrain (no default value available, this parameter must be defined by the user), cp. aq.
lq	(nq)	Liquid water content of the plume in kg/kg when discharging exhaust fumes with a cooling tower (default value 0). If the value set for this parameter is larger than 0, the plume rise for the concerning source is calculated following VDI 3784 Sheet 2. lq can be defined dependent on time.
nx	(nn)	Number of grid points in x-direction, cp. dd.
ny	(nn)	Number of grid points in y-direction, cp. dd.
nz	(nn)	Number of grid points in x-direction. It is not necessary to define this parameter. It is automatically set by the programme. The programme always defines the number as the maximum value nz as specified by hh. Only in case of nested grids with buildings, the number for the finest grid is chosen so that it extends to twice the height of the tallest building.
os	(1)	Character string for the definition of options. If several options are defined, the keyword/value pairs need to be separated by semicolon. The following options are available for standard calculations: NESTING: Instead of an individual grid with uniform mesh size, the programme generates nested grids with varying mesh sizes.

<table>
<tr><th>Parameter</th><th>Number of parameter</th><th>Description</th></tr>
<tr><td></td><td></td><td>-NESTING: No grid nesting is generated for calculations with buildings.
SCINOTAT: All calculated concentration or deposition values are shown in scientific notation (exponential notation with 4 significant digits).
Variations of the standard behaviour are made possible by the NOSTANDARD option.
With this option the definition of the parameter hh is activated (see hh). The following and more definitions can be made in combination with the NOSTANDARD option:
BS=cBS: The value cBS is used as rating threshold for calculations with the substance odour.
SPECTRUM In case of sedimenting dust the mass within a grain size class is evenly distributed across the grain size range and the sedimentation speed is calculated for each particle according to its aerodynamic diameter.
When using the NOSTANDARD option, the roughness length is not automatically rounded to one of the 9 standard values following TA Luft.</td></tr>
<tr><td>qb</td><td>(1)</td><td>Quality level for the automatic definition of the calculation grids and the vertical grid when processing calculations with buildings (default value 0). The lowest vertical interval always has a dimension of 0 to 3 m. Above this the vertical grid has a mesh size of Δz until it exceeds twice the height of the tallest building. The mesh size then increases by 50% per interval in integer steps until it reaches the proximate value of the standard grid (see hh). For values above this the base points of the standard grid are used.[13] The finest grid has a horizontal mesh size of Δx. The values for Δx and Δz are defined as follows:</td></tr>
<tr><td></td><td></td><td><table>
<tr><td>qb</td><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>1</td></tr>
<tr><td>Δx</td><td>32</td><td>16</td><td>8</td><td>4</td><td>2</td></tr>
<tr><td>Δz</td><td>6</td><td>4</td><td>3</td><td>3</td><td>2</td></tr>
</table></td></tr>
<tr><td>qq</td><td>(nq)</td><td>Heat flow Mq of the exhaust gas in MW (default value 0) for calculating the plume rise following VDI 3782 Sheet 3. The heat flow is calculated based on the exhaust gas temperature Tq (in</td></tr>
</table>

Parameter	Number of parameter	Description
		°Celsius) and the volume flow (f) under standard reference conditions R14 (in m3/s) according to the following formula: Mq = 1.36 · 10−3 · (Tq − T0) · R with T0=10 °Celsius. If only the parameter qq is defined and vq is not, the plume rise is calculated following VDI 3782 Sheet 3 including nothing but the thermal contribution (as in the old TA Luft). The impulse contribution can only take effect, if both vq and dq are larger than 0. Qq can be defined time-dependent. If the parameter qq is used, the parameter tq should not be defined or have the value 0.
qs	(1)	Quality level for the definition of the particle release rate (default value 0). Raising the quality level by 1 results in doubling the number of particles and thereby decreases the statistical uncertainty (variance) by the factor 1/p2. However, this also doubles the required CPU time. Correspondingly, decreasing the value will have the reverse effect. The standard AKS calculation is done with at least 43 000 000 particles, AKTerm with at least 63 000 000 particles.
rb	(1)	Name of the file containing the rasterised building outline (DMNA format). This file can be used alternatively to explicitly define buildings (cp. ab). The data part is two-dimensional and contains for every cell of the grid in integer notation the number of vertical intervals with a dimension of dz for defining the height of the building. The width of the interval dz, the left border x0, the lower border y0 and the mesh size dd of the grid must be recorded in the file header. The grid is not required to coincide with the applied calculation grid. Analogous to the explicitly defined buildings, its cells will be automatically rasterised on the calculation grid before the calculation is executed.
rq	(nq)	Relative humidity of the plume in percent when discharging exhaust fumes with a cooling tower (default value 0). If the value set for this parameter is larger than 0, the plume rise for the concerning source is calculated following VDI 3784 Sheet 2. rq can be defined dependent on time.
sd	(1)	Beginning number for the random number generator (default value 11111). By selecting a different number the programme

Parameter	Number of parameter	Description
		will generate a different series of random numbers. Thus, a different sample will be available in the results.
sq	(nq)	Time scale TU (see VDI 3945 Sheet 3 Chapter D5) If this parameter is defined, the plume rise is calculated following the procedure specified in VDI 3945 Sheet 3 Chapter D5. In this case the parameter vq is interpreted as additional velocity U. Sq can be defined time-dependent.
ti	(1)	Character string for the identification of the project. This label is recorded in all files generated during calculation.
tq	(nq)	Exhaust gas temperature in degrees Celsius (default value 0) for calculating the plume rise. tq can be defined time-dependent. If the parameter tq is used, the parameter qq should not be defined or have the value 0.
vq	(nq)	The exhaust velocity of the gas (default value 0), cp. qq. This parameter only takes effect, if the parameter dq is set to a value larger than zero. vq can be defined time-dependent.
wb	(nb)	Rotation angle of the building around a vertical axis through the lower left corner (default value 0), cp. ab.
wq	(nq)	Rotation angle of the source around a vertical axis through the lower left corner (default value 0), cp. aq.
x0	(nn)	Left (western) boundary of the calculation area, cp. dd.
xa	(1)	x-coordinate of the anemometer position (default value 0). The position of the anemometer must be inside the calculation area.
xb	(nb)	x-coordinate of the building (default value 0), cp. ab.
xp	(np)	x-coordinate of the monitor point (rating point).
xq	(nq)	x-coordinate of the source (default value 0), cp. aq.
y0	(nn)	Lower (southern) boundary of the calculation area, cp. dd.
ya	(1)	y-coordinate of anemometer position (default value 0), cp. xa.
yb	(nb)	y-coordinate of the building (default value 0), cp. ab.
yp	(np)	y-coordinate of the monitor point (rating point).
yq	(nq)	y-coordinate of the source (default value 0), cp. aq.
z0	(1)	Roughness length z0. If this parameter is not defined, it is automatically calculated based on the CORINE land cover inventory (requires gy and gy) and rounded to one of the values specified in TA Luft. If several sources are defined, the

Parameter	Number of parameter	Description
		calculation is processed by first calculating a specific value of z0 for every source and then a mean value z0. Individual values are rated with the squared source height. The calculated value is recorded in the log file.

9 Tutorial: Example for a calculation following Gauss

In the following exercises you will partially modify the files supplied with your demo version of IMMI. This will only work for all of the following tasks, if you install the IMMI version on your hard drive.

Normally you will be able to continue with the exercises, although the results will differ from those described in the tutorial. If you want to reproduce the same results as in the exercises, you should install the IMMI demo version on your PC. Don't worry; the deinstallation will remove all residual data from your computer.

9.1 Calculation of propagation for a point source

You will learn how to operate the program with the simplest conceivable example of a single pollutant source. From the construction of the emitter on the screen to the first single point and grid calculation, this example already contains everything you need to know for processing a simple project.

A simple example (industrial chimney on level terrain) will take you step-by-step through the practical stages of processing a pollution calculation in IMMI. Of course, there are always alternative approaches to such calculations apart from the one described here. After you have arrived at a result with the recommended procedure, you can start exploring the other features of the program. Here we consider the descriptions of the menu system as recommended reading.

9.2 Running the program

Double-click on the program icon to run IMMI. Close the help window and start with a new "empty" project.

_9.3 Preparation

In an IMMI project you can model pollutant sources and sound sources simultaneously. Choose <**Project | Properties**> and use the option buttons in the Topic section for selecting the desired prediction type: noise, aircraft noise or air pollution.

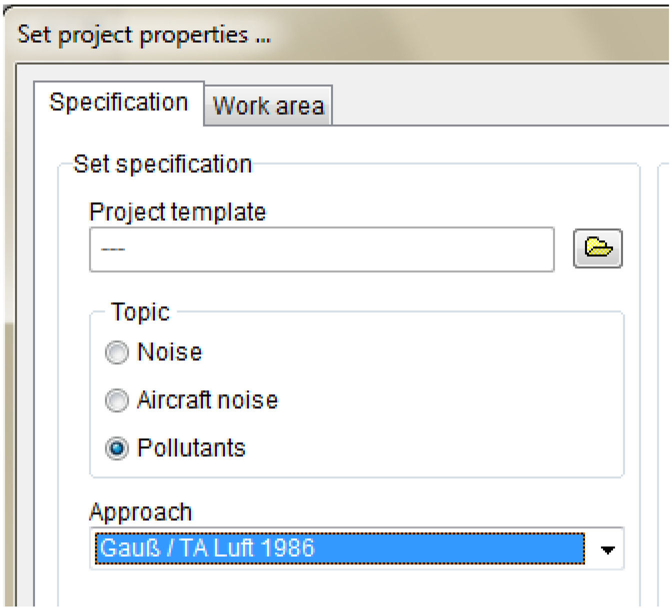


Figure 27: Gauß: Setting the project properties

As topic choose **Pollutants** and select the Gaussian plume model **Gauß / TA Luft** from the list of available approaches below.

Open the **Work area** tab in the dialog and accept the preset dimensions of the work area as follows:

- x/ m 0 to 1000
- y/ m 0 to 1000
- z/ m 0 to 100

Terrain height in the corners:

- z1 to z4 0 m

Click OK to accept these values.

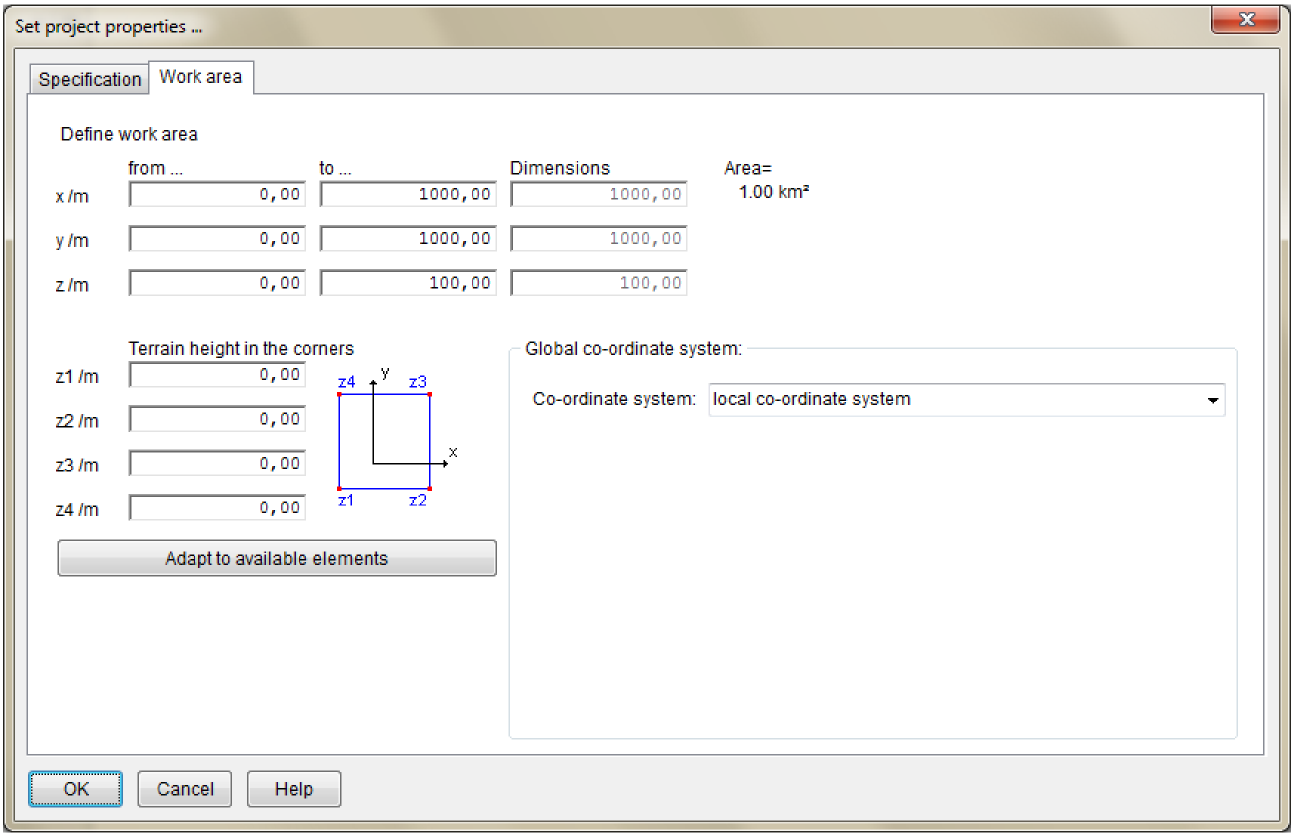


Figure 28: Definition of the work area

9.4 Input of meteorology data

- Choose <**Calculate | Calculation parameters | Edit | Parameters for element libraries**> and select the **Pollutants** tab for the following dialog:

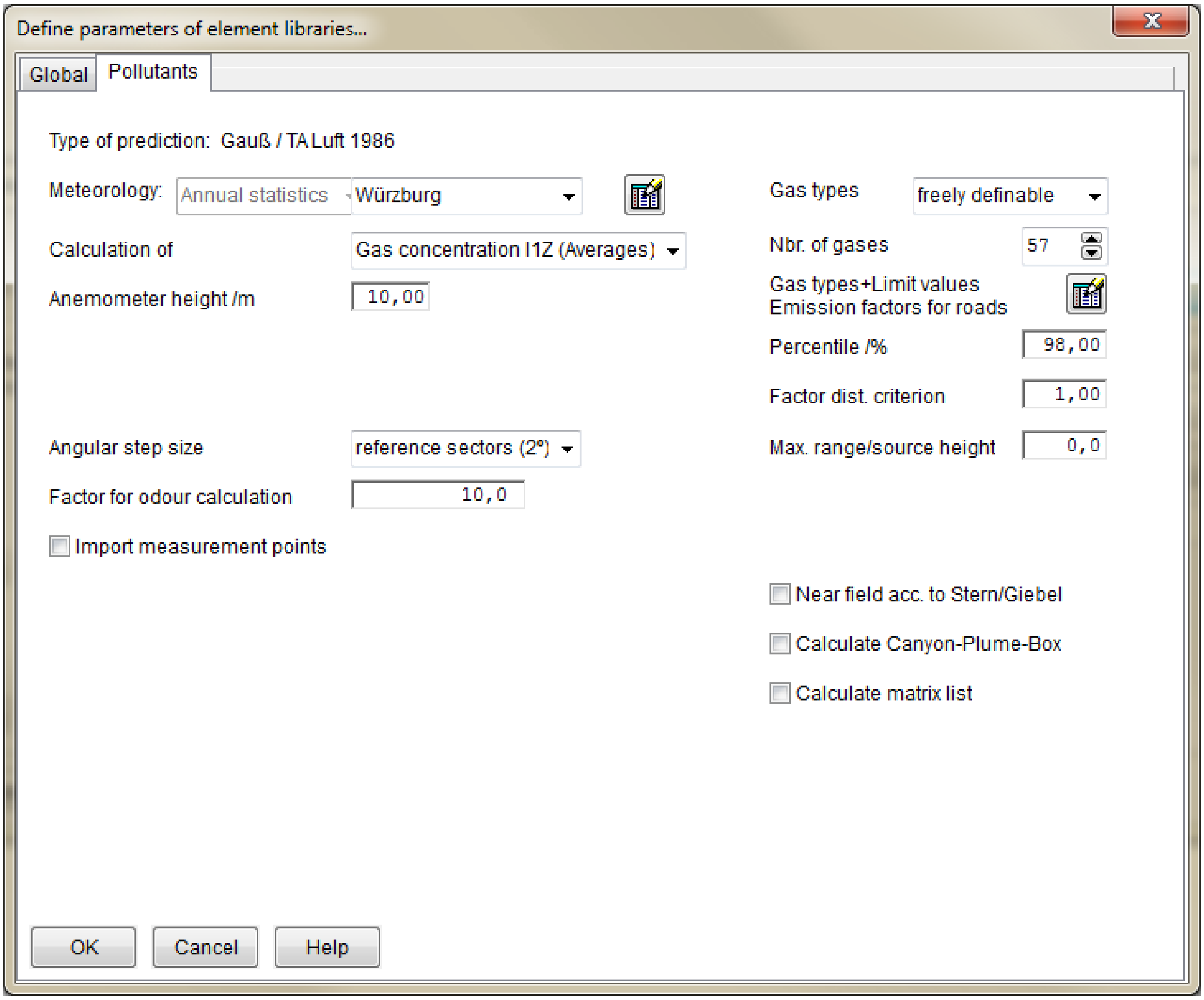


Figure 29: Dialog with parameters for pollution modeling following TA Luft 1986

- Click the button next to Meteorology - . In the list of active meteorological stations, click **Add** ... to open the dialog for editing the meteorology file. Verify if the selected option is **TA Luft** and click on the button labelled **Read DWD annual statistics**.

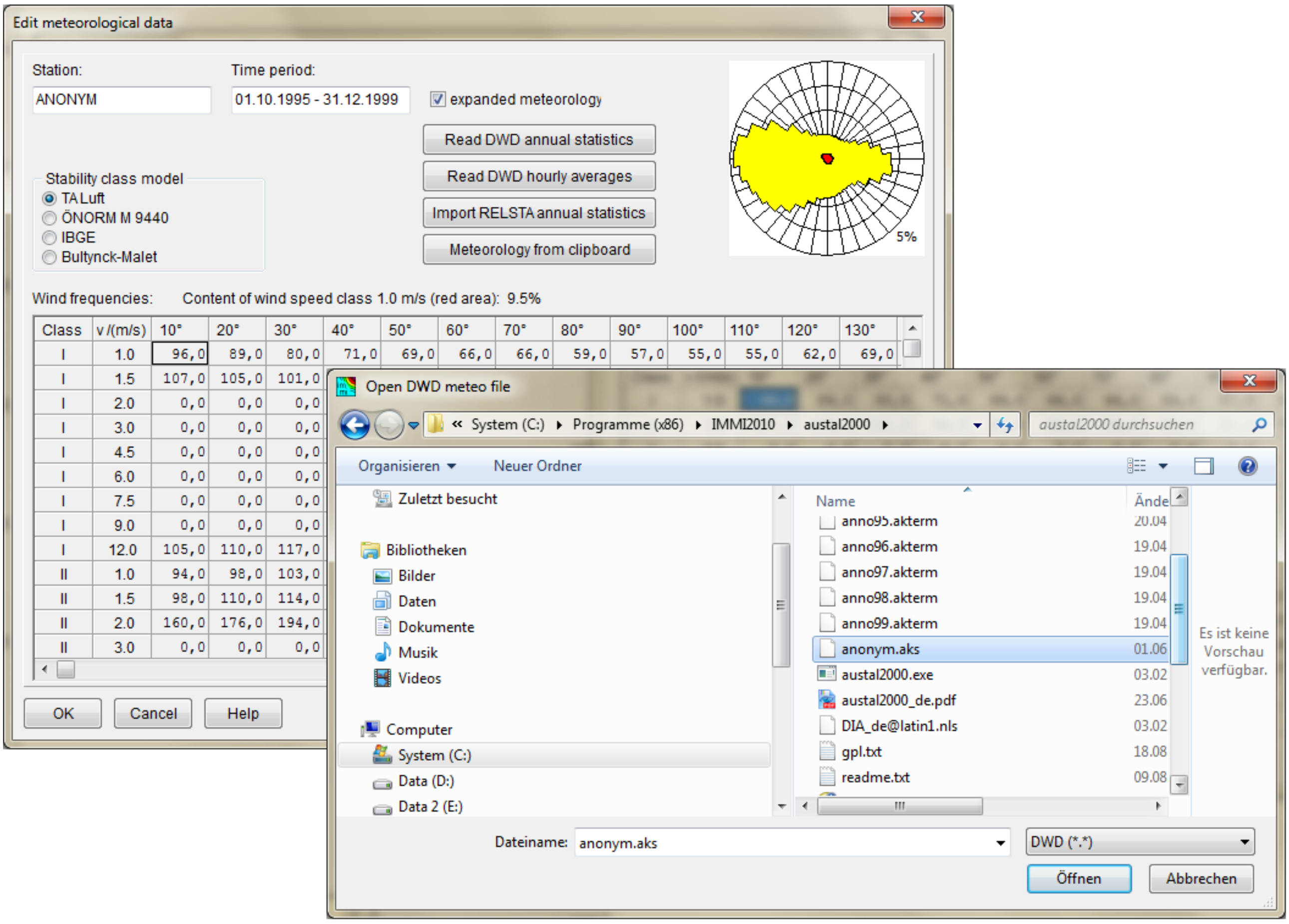


Figure 30: Dialog for editing meteorology data with open file browser for selecting a DWD AKS file to be imported

- In the Windows file browser search for the file **anonym.aks** in the IMMI folder on your hard drive (after having installed the software). The file should reside in the folder **austal2000**. Find and select the file as shown above and click **Open** to read the file. The program returns a message stating the DWD file has been read successfully. Click **OK** to confirm.
- Return to the **Define parameters for element libraries ...** dialog and select **ANONYM** as the regional setting from the drop-down list.
- Set the Angular step size for the calculation from **reference sectors (2°)** to simplified sectors (10°). This setting will certainly suffice for the calculation in this tutorial.
- Click **OK** to leave the **Parameters for element libraries...** dialog and enter the **Map**, the most important and frequently used component in IMMI.

9.5 Definition of gas types

- Choose <**Calculate | Calculation parameters | Edit | Parameters for element libraries**> and select the **Pollutants** tab.

- Set the Nbr. of gases of 2

- Choose the  - **Gas types and limit values** and enter the names of the gases.
- Enter for the first gas **NO2** and for the second gas **SO2**.

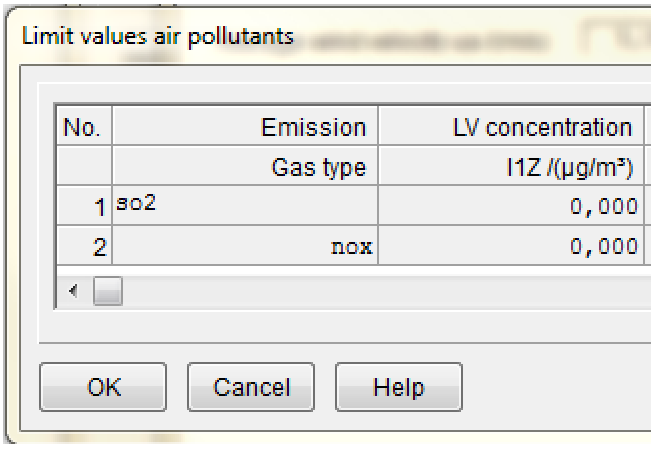


Figure 31: Eingabe der Gasarten

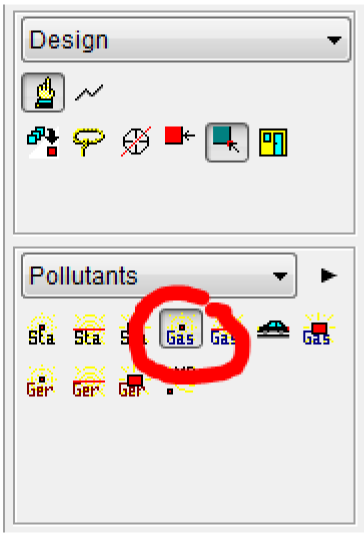
- Close the dialogue **OK** and close all other dialogues.

9.6 Geometry and element parameter input

The “toolbox”, normally located on the left side of the screen, contains a variety of buttons providing access to special functions.

In the following steps you will design the source geometry of a pollutant source with the mouse on the screen:

- Set the appropriate element library by switching from **Standard** to **Pollutants**.



- Click the element type button **Gas point source** (Gas point src /Poll) and the  - **Draw elements** button in the toolbox and create the point source by clicking in the center of the map.
- Now move the cursor in the center of the coordinate system (approximately x, y = 500m, 500m). Left-click and the element is created.
- This action immediately opens the dialog for editing the element. Modify the parameters for the point source by entering the following values:
  - Name for the point source is **Industrial chimney**
  - Emission parameters / mass stream **Q: 3600 g/h for NO2 and 250 g/h for S02**
  - Source height: Choose **direct input**.

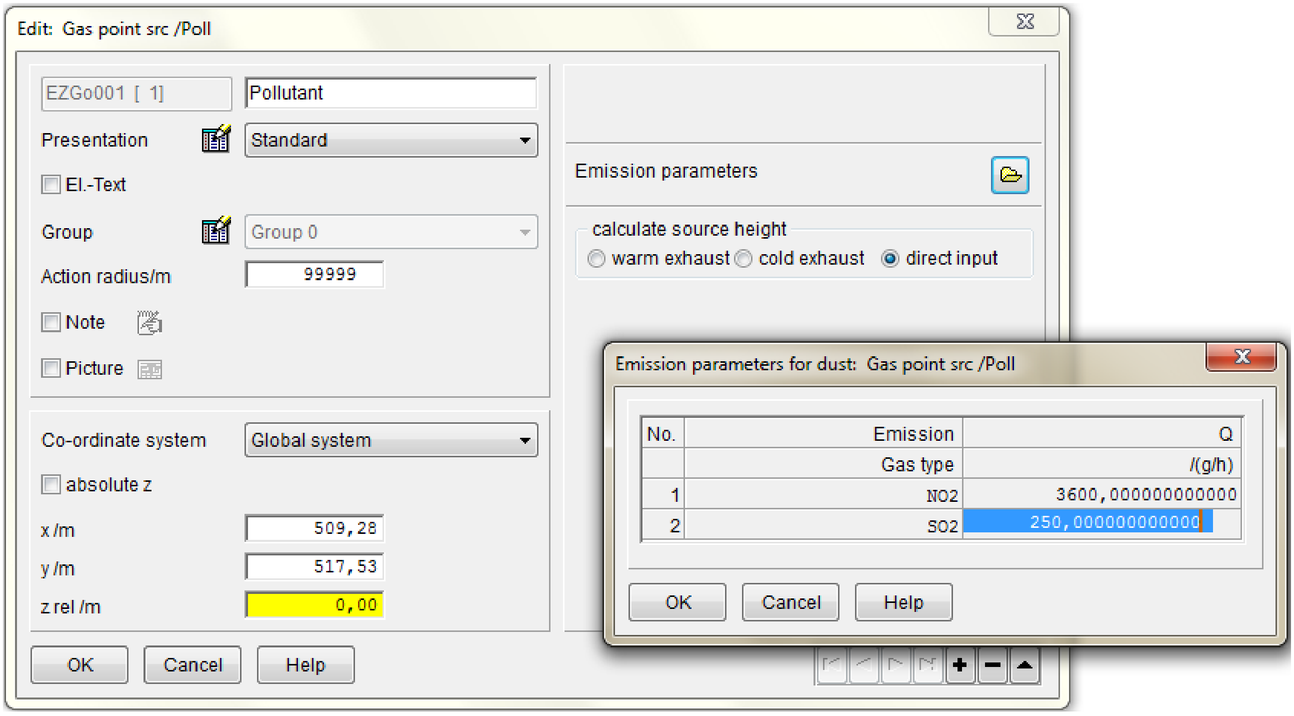
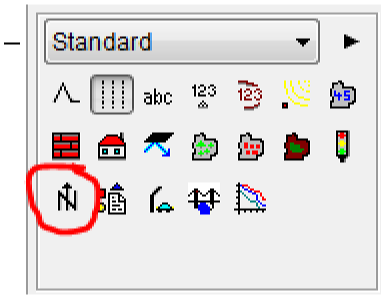


Figure 32: Parameter of the source

- Set the height to zrel = 20 m.
- The creation of the source is now completed. Click **OK** to leave the dialog.

9.7 Define North

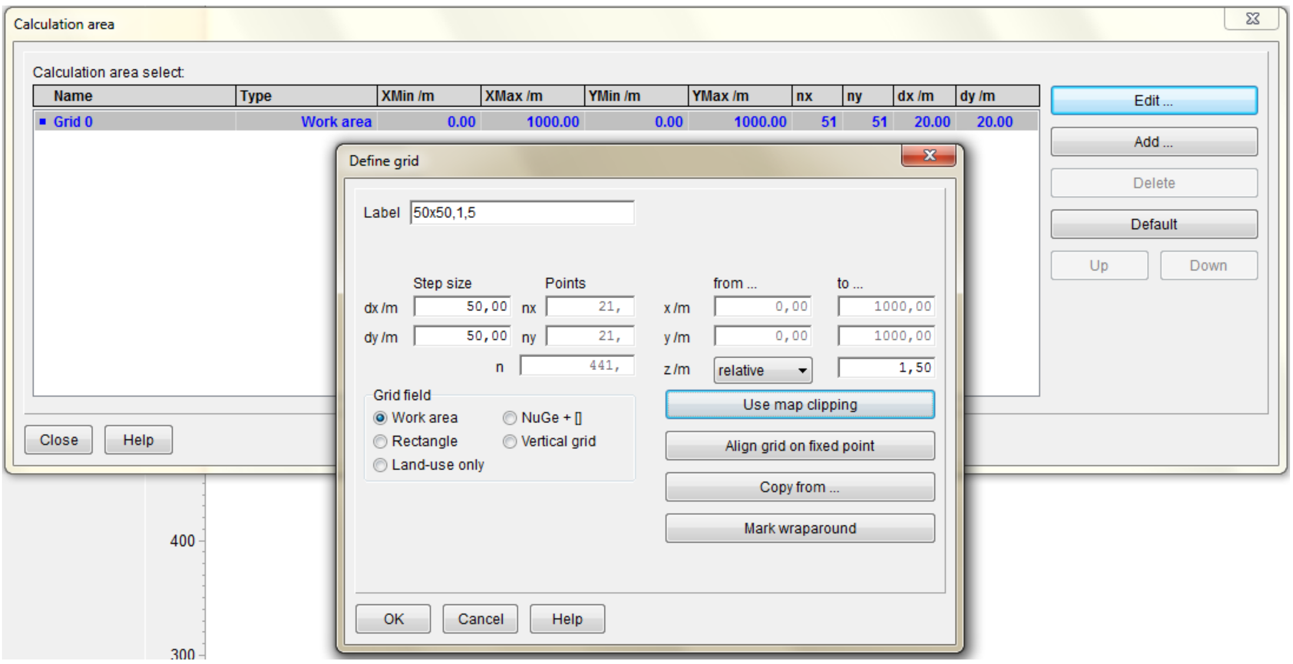
In the toolbox select **Standard** for library instead of **Pollutants**. Here you can define the parameters for elements which are independent from the selected directive or guideline, e.g. the Compass.



- Click-select the element type **Compass**.
- Move the cursor to any position on the map as desired (near the border of the map is recommended) and left-click to create the compass element. The edit dialog is opened in the moment you let go of the mouse button.
- In this simple exercise we will leave the direction of the compass unchanged: The arrow pointing upwards indicates that this is the definition for north. In case you need to orient your map to north you can make the necessary adjustments by defining the exact known deviation with the up and down arrows next to the field "Angle/°".
- Close the dialogue with **OK**.
- Save the project via **<File | Save project as ...>**.

9.8 Definition of the reception grid

- <**Grid | Definition | Dimension**> opens the list of grids.
- Click **Edit**.



- Modify the step size to 50 m for x and y.

- Define the relative height (of the grid) by entering 1.5 m for z.
- Click **OK** to leave the dialog and **Close** to close the grid list.

9.9 Calculation of a reception grid

To execute a grid calculation choose <**Grid | Calculate**>. If you leave the checkbox **Show while calculating** activated you can watch the rendering of the color grid on the screen while the calculation progresses.

A common PC with up-to date specifications should require no more than 20 seconds to calculate the defined 441 reception points. The display in the map should be more or less as shown in the image below. You can see how the grid is made up of the previously defined 50m x 50m squares.

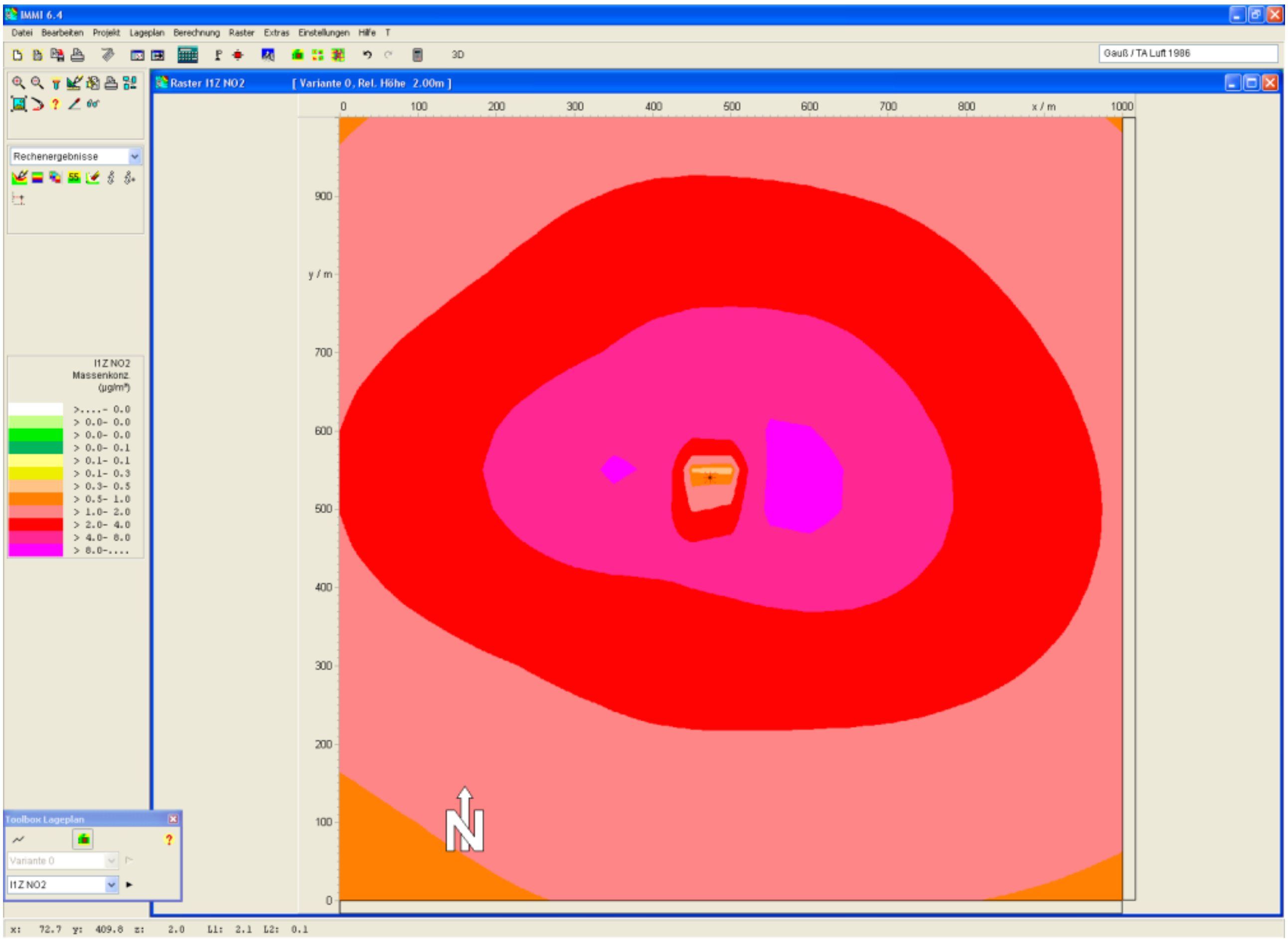


Figure 33: Immissionsrater (50 m x 50 m Rasterschrittweite) für NO2

You may wonder about the change of colors in the graphical display while the calculation progresses. This is due to the rescaling of the display that is executed by the program during calculation.

The resulting grid could also be displayed differently, e.g. by interpolating the grid.

–

10 Tutorial: Example for a calculation following Lagrange

Since Version 5.1.5, IMMI has featured a function for calculating dispersion according to the Lagrangian Particle Model mentioned in TA Luft 2002 (VDI 3945 Sheet 3).

Dispersion as such is calculated by AUSTAL2000 or AUSTAL200G, a program made available by the German Federal Environmental Agency. IMMI automatically calls the program and exchanges data. Being unaware of this operation, the user can continue handling the program in IMMI. As is the case with all other IMMI libraries, the new TA Luft also requires professional expertise.

The example below is intended to make you familiar with calculations according to the Lagrange Model/VDI3945 and requires that you are experienced in IMMI.

_10.1 Task

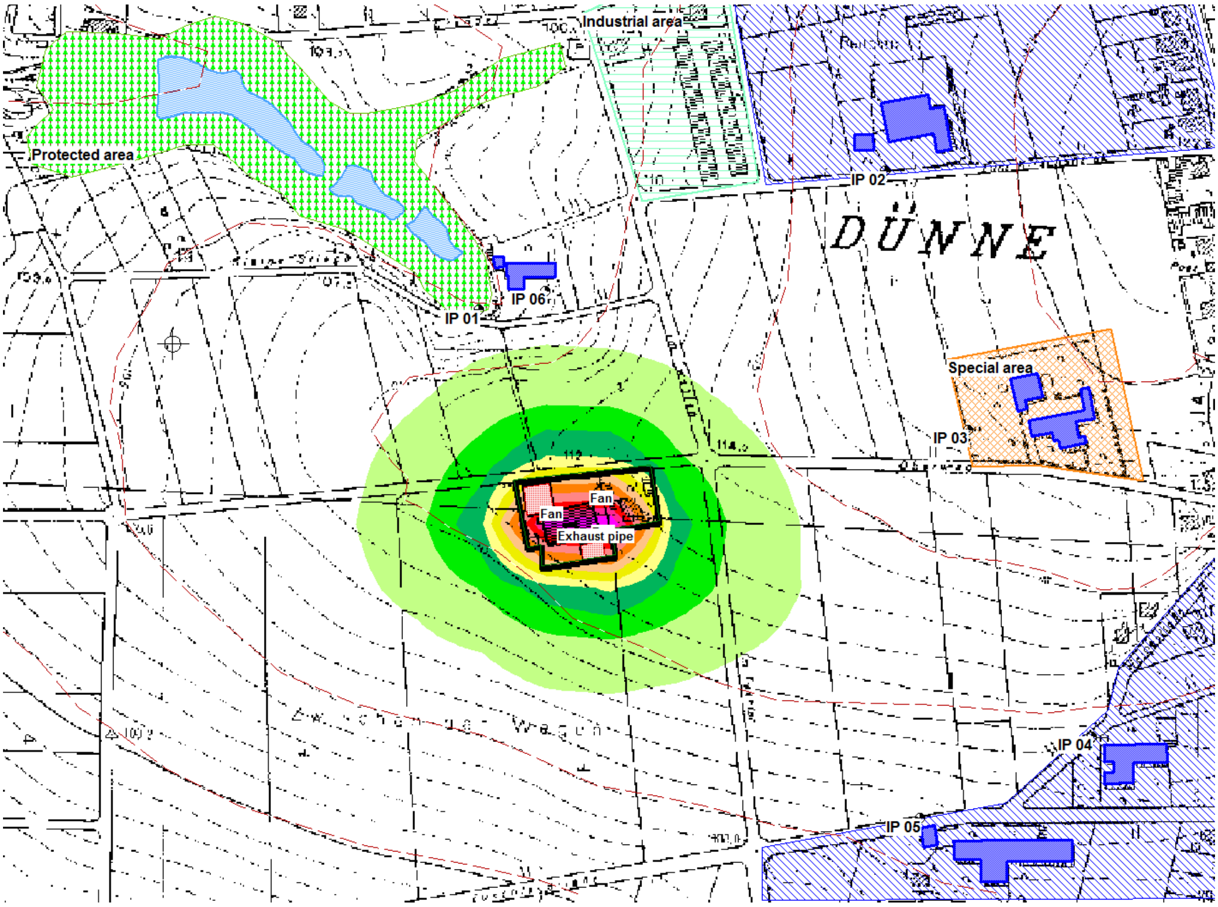


Figure 34: Map overview

Assume that a farm for feeding pigs is being established outside of the provincial town of Dünne. This requires a test of the developing odor and ammonia exposures.

The test is to verify that there will not be any adverse effects on the nearby nature protection areas and residents.

Odors are evaluated according to the Guideline for Odor Dispersion and Impact (Geruchsimmissionschutzrichtlinie, GIRL 2008).

GIRL Number 3.1 mentions the following concentration values (relative frequency of odor hours in relation to the total annual hours) for various land-use areas:

Tabelle 1: <u>Immissionswerte IW für verschiedene Nutzungsgebiete</u>

Wohn- /Mischgebiete	Gewerbe- /Industriegebiete	Dorfgebiete
0,10	0,15	0,15

It must be ensured that the ammonia which is produced through stock breeding and may have an adverse effect on the flora if it reaches a certain immission concentration will not affect the nature protection areas.

10.2 Project setup – Importing the background image

Open the prepared project.

- Select <**File | Open Project ...**> and open the **Farm.IPR** project from the IMMI installation directory (...\Examples\Lagrange).
- Look at the set parameters under <**Project | Properties**> an.

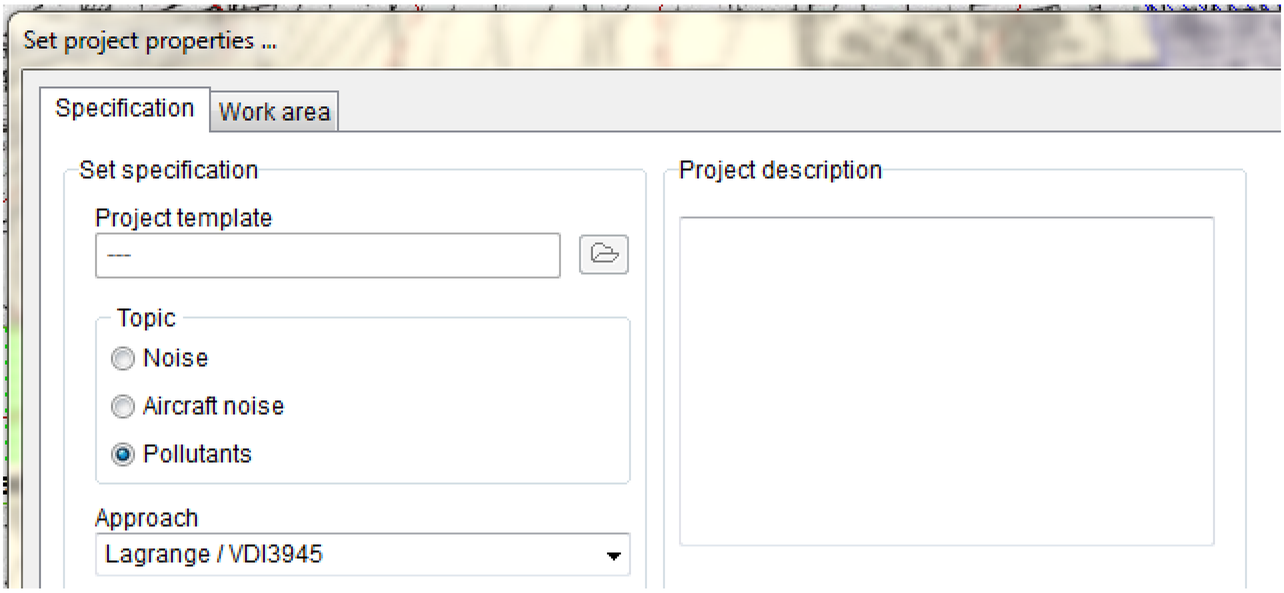


Figure 35: Project properties for calculations according to the Lagrange Model

- Make yourself familiar with the project.

Importing the background image

_▪ Select <**Map | Install | Open background image**> and open the background image named Dünne.jpg.

▪ Click on Add and Search, go to folder Beispiele (...\Examples\Lagrange) and open DÜNNE.JPG.

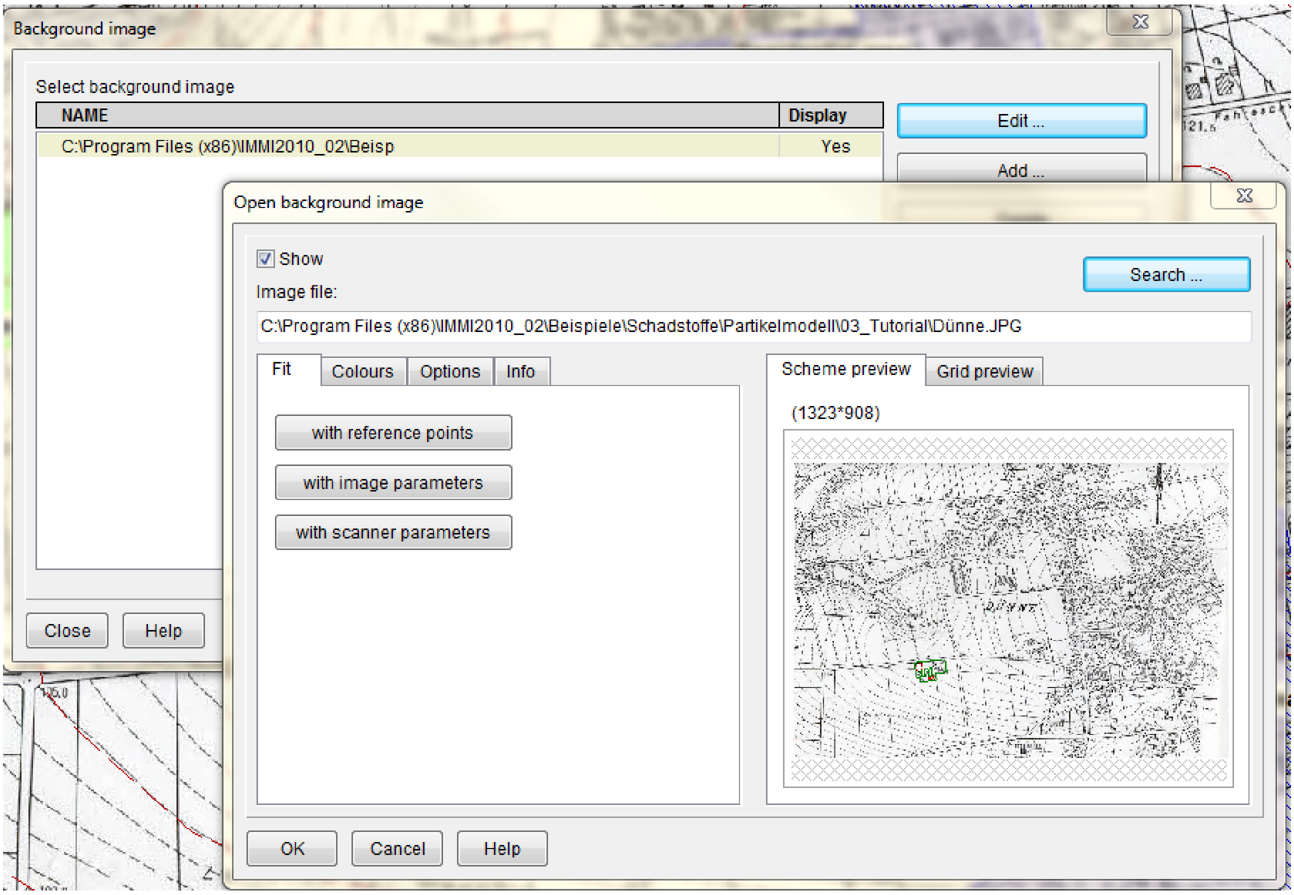


Figure 36: Importing the background image

▪ The background image is georeferenced and is imported automatically.

▪ Click **OK** to confirm and close the dialogs.

10.3 Creating the sources / Entering the emission data

▪ The imported background image shows the new stable with fans and adjacent liquid manure cistern.

▪ Zoom in to get a closer view of the facility (see figure below).

- Select element library Pollutants/**Area source** and click on - **Draw element**. Start to model the liquid manure cisterns (red in the figure).

Figure 37: Map of the feeding facility

- The input dialog relating to the source opens automatically

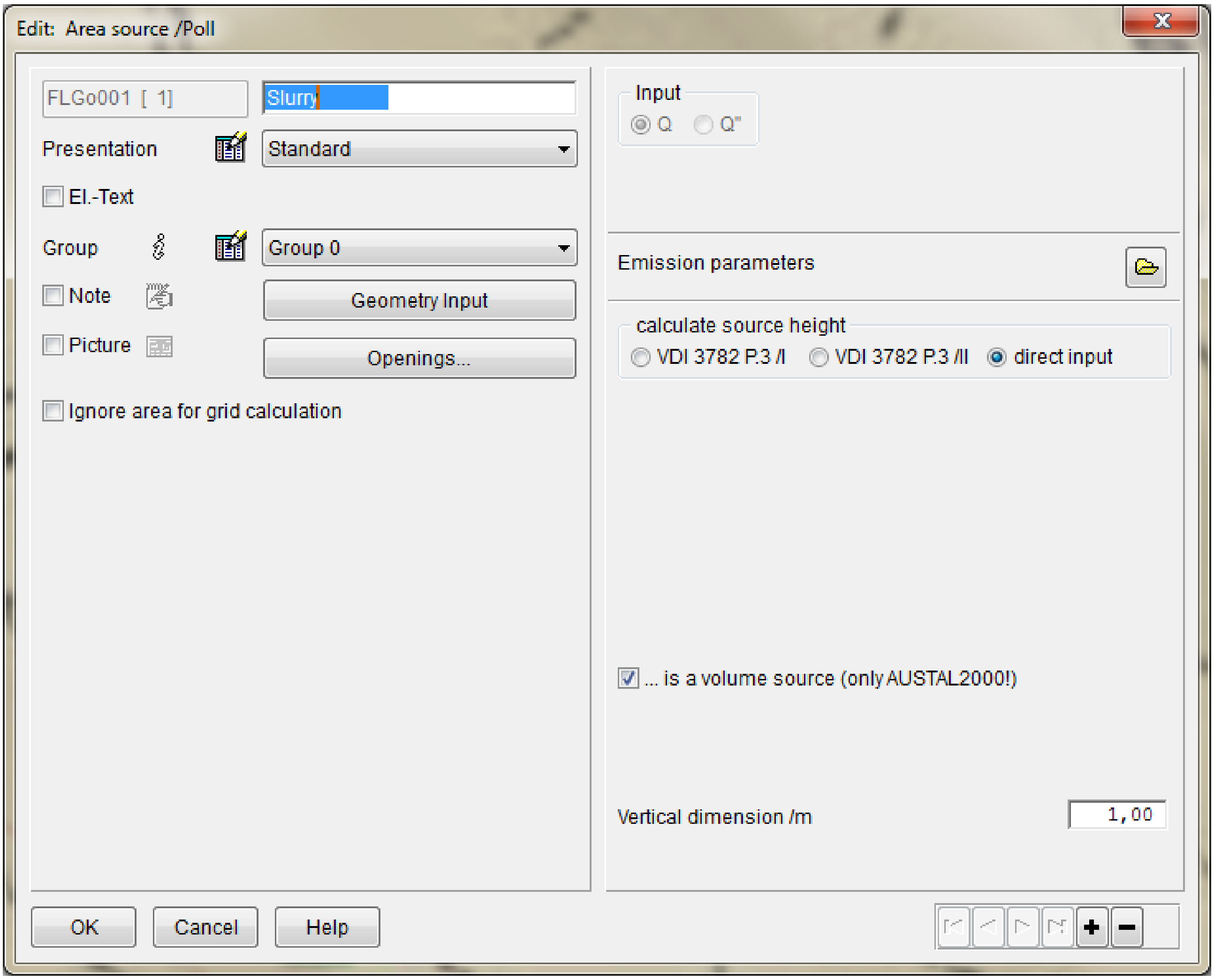


Figure 38: Volume source input dialog (volume source = slurry)

- Enter a **name** and activate the **vertical dimension/m** checkbox. The vertical dimension is **1 m**.
- Close the dialog. Repeat the above steps for the second source.
- Click on  - **Emission parameters** and enter **4.72 MGE/h under Odor** for either source.
- Then set the single point sources at the following coordinates.
- Go to - **Point source** in the tool box and left-click approximately on the area defined by the coordinates listed below. The input dialog is opened. The coordinates can be corrected under x and y.

Name	x/m	y/m
Fan	470923,00	5786154,00
Fan	470920,00	5786133,00
Exhaust pipe	470884,00	5786145,00
Fan	470900,00	5786133,00

- The exhaust pipe is a single point source. The fans must be entered as vertical line sources.

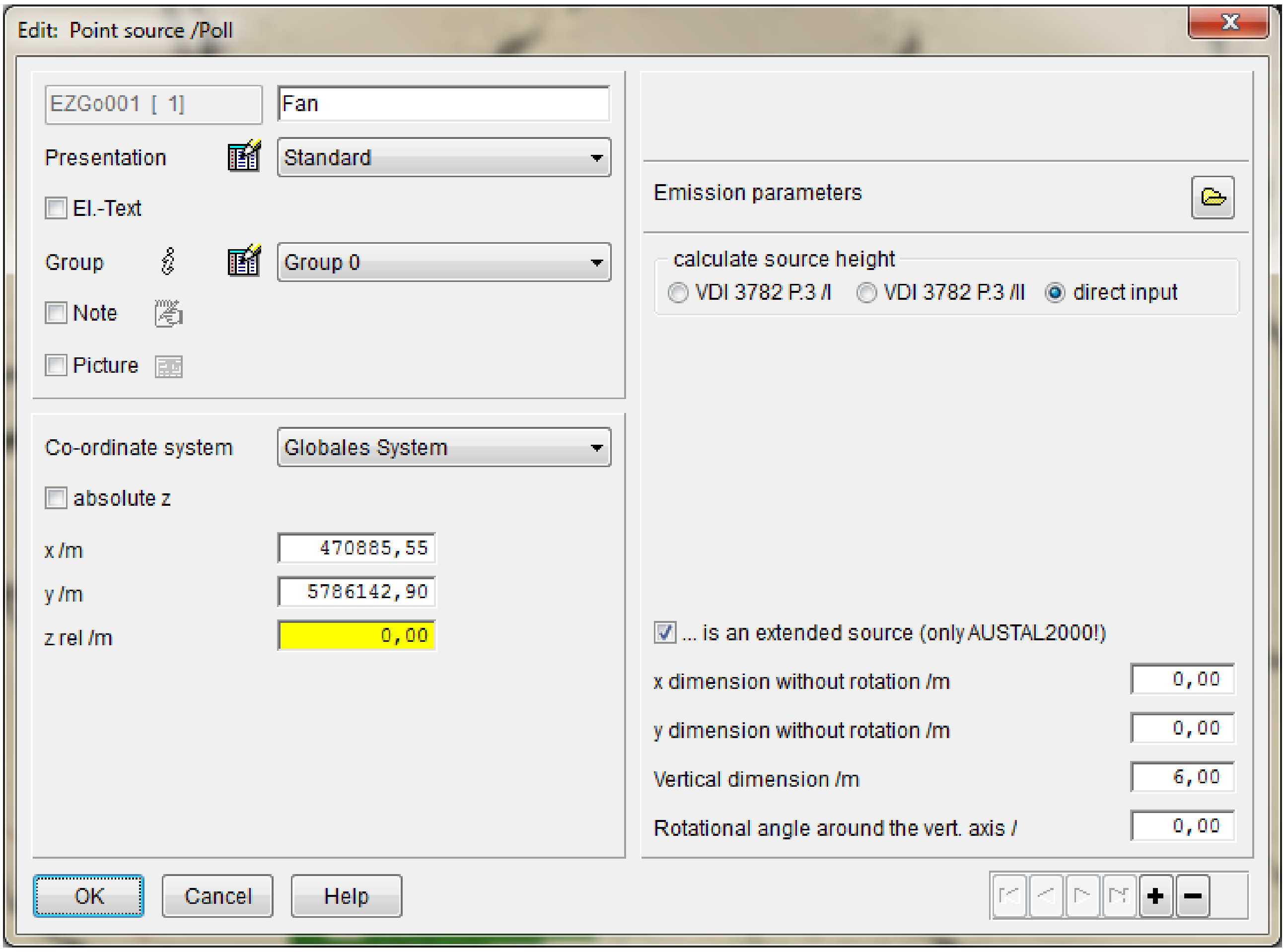


Figure 39: Input dialog for the vertical source

- Activate the **... is an extended source** checkbox and enter **6 m under Vertical dimension**.
- Click on  - **Emission parameters** and enter **180.2 g/h under nh3 and 3.56 MGE/h under odor 075** (for feeding pigs) for all single point sources.
- Check the **EL.Text checkbox**. This will automatically label the elements.

10.4 Drawing additional elements – buildings

The buildings of the surrounding residents are already plotted in the map. Draw the stable and the residential building in the next step.

Figure 40: Map of the feeding facility

Since this is a simplified example without building flow field, help lines are sufficient to represent the buildings.

- Select - **Help line** from the **Standard** library.
- Plot the buildings shown in blue on the image.
- Select **Houses as Presentation** from the input dialog.
- Draw in the stable in the next step.
- Since the stable should be shown in green, a new element display must be created.

Defining and assigning the element display

- Open the <**Settings | Display attributes | Additional attributes**> menu item.

- Select a green color as shown below and enter **Stable** in the Label box.

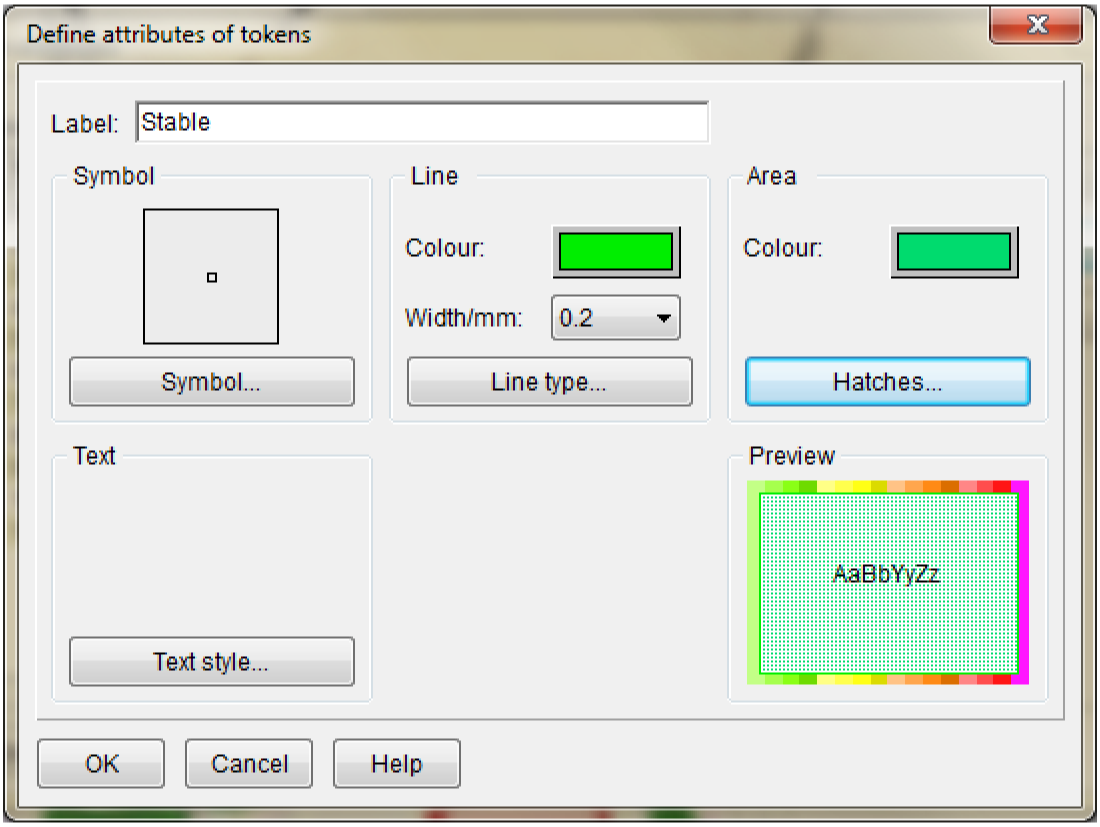


Figure 41: Defining an additional color attribute

- Close the dialogs.
- Open the help line edit dialog and select **Stable from the Presentation** list box. The building will now be shown in green.
- Save the project.

Note: The filename extension of IMMI project files is .IPR.

10.5 Setting reception points

Reception points are to be set in the vicinity of the nearby residential housing area.

- Select - **Receiver point** from the **Standard** element library.
- Set a total of 6 reception points in front of the surrounding buildings. The figure below shows the approximate position.

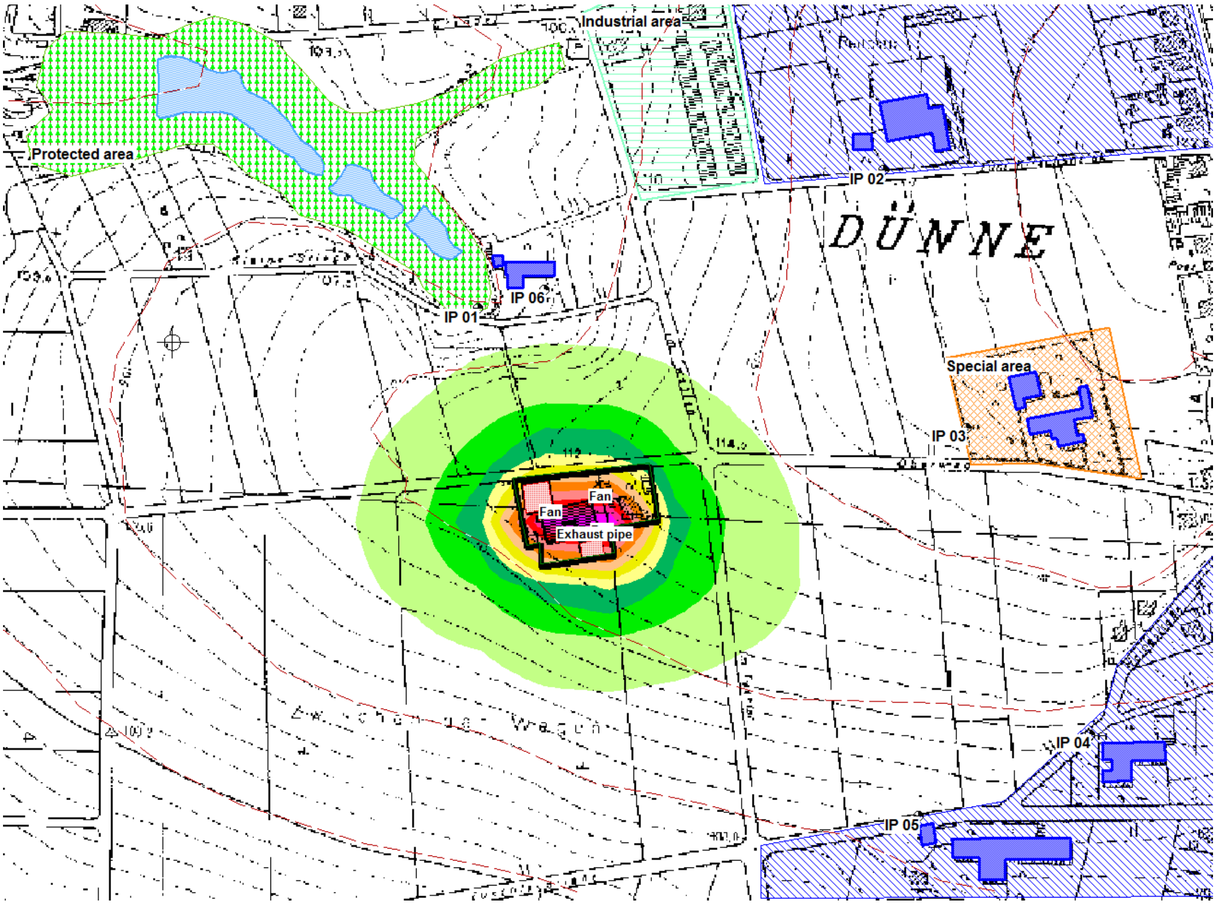


Figure 42: Map overview

Reception point positions

IP 1	471177,52	5785908,14
IP 2	471315,95	5785969,46
IP 3	471254,67	5786221,57
IP 4	471128,73	5786424,84
IP 5	470873,43	5786316,96
IP 6	470836,49	5786307,97

- Select **1.8 m as the relative height** of the reception points.
- Activate the element display (EL-Text).

10.6 Importing the meteorology / Parameters for calculation

The meteorological data (annual statistics) of the nearest measuring station of the Deutscher Wetterdienst (DWD) must be imported for calculation.

- Select the <**Calculate | Calculation parameters | Edit | Parameters for element libraries | Pollutants**> menu item to import the DWD file.

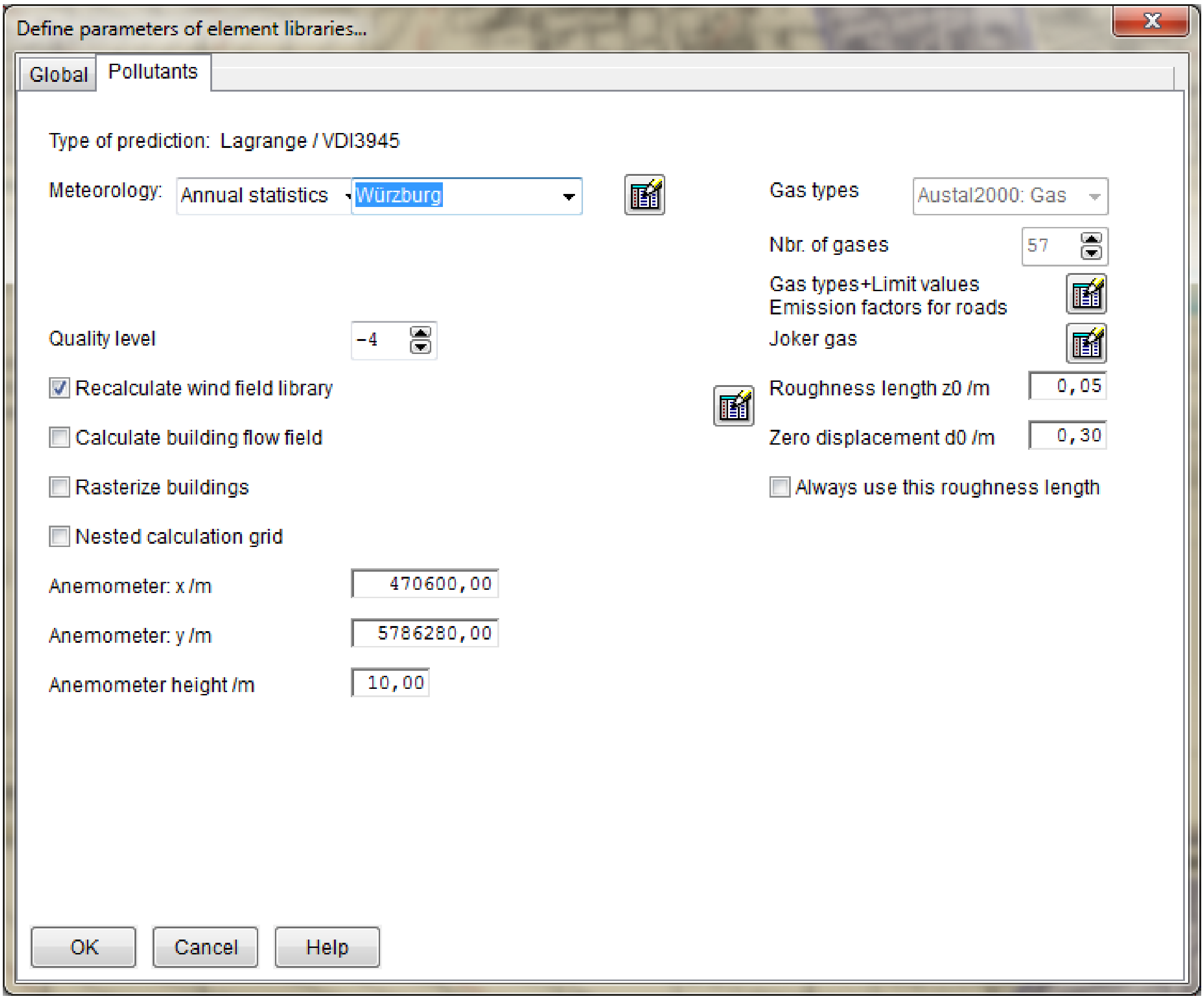
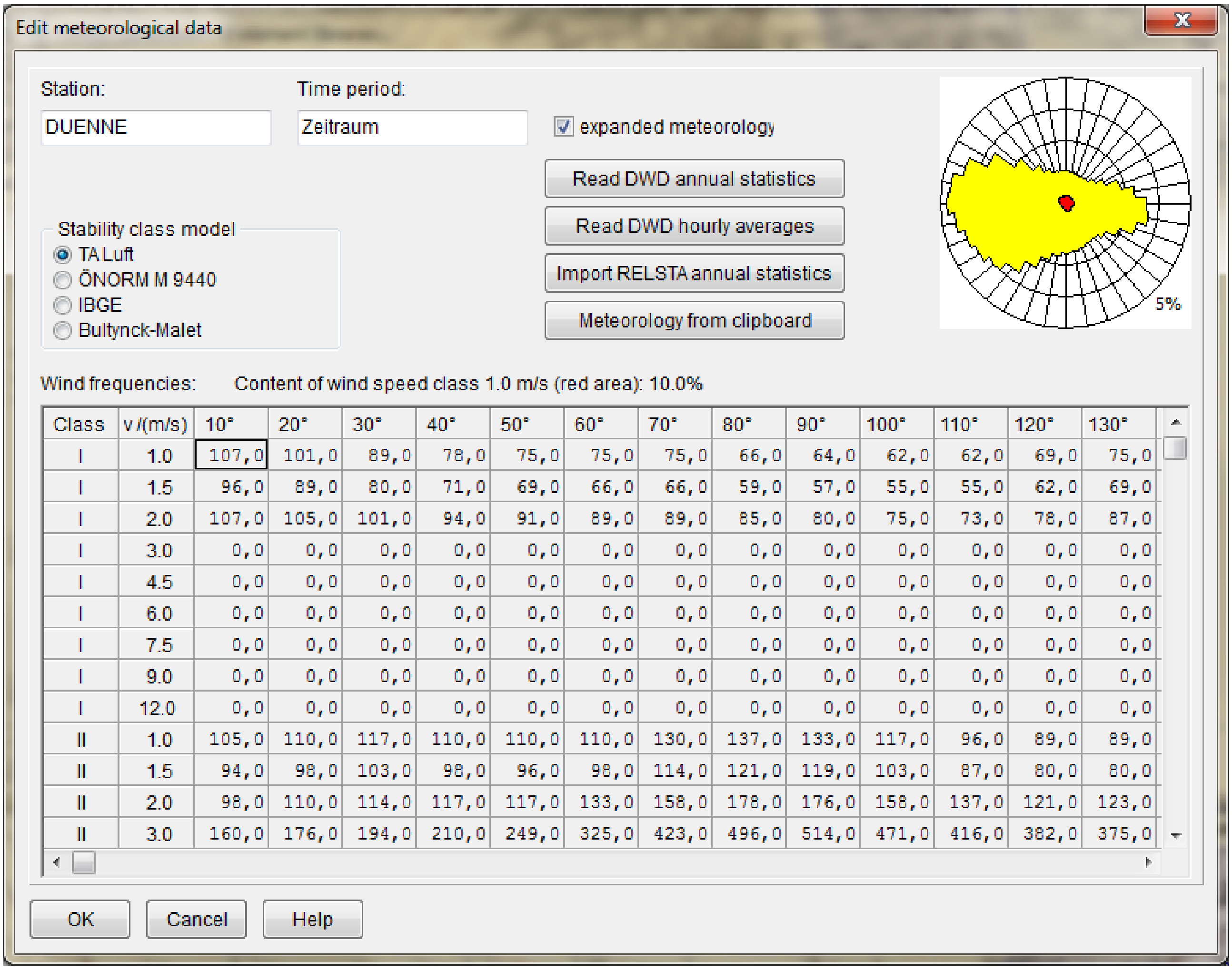


Figure 43: Parameters of the pollutants element library in IMMI according to Lagrange Model

- Click on  - Edit reference list.
- Click on **Add** and **Read DWD annual statistics**.

_ ▪ Select and open the **Dünne.aks** file.



Class	v /(m/s)	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°
I	1.0	107,0	101,0	89,0	78,0	75,0	75,0	75,0	66,0	64,0	62,0	62,0	69,0	75,0
I	1.5	96,0	89,0	80,0	71,0	69,0	66,0	66,0	59,0	57,0	55,0	55,0	62,0	69,0
I	2.0	107,0	105,0	101,0	94,0	91,0	89,0	89,0	85,0	80,0	75,0	73,0	78,0	87,0
I	3.0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
I	4.5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
I	6.0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
I	7.5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
I	9.0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
I	12.0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
II	1.0	105,0	110,0	117,0	110,0	110,0	110,0	130,0	137,0	133,0	117,0	96,0	89,0	89,0
II	1.5	94,0	98,0	103,0	98,0	96,0	98,0	114,0	121,0	119,0	103,0	87,0	80,0	80,0
II	2.0	98,0	110,0	114,0	117,0	117,0	133,0	158,0	178,0	176,0	158,0	137,0	121,0	123,0
II	3.0	160,0	176,0	194,0	210,0	249,0	325,0	423,0	496,0	514,0	471,0	416,0	382,0	375,0

Figure 44: Importing meteorology data

- The file is being imported.
- Click on **OK** to confirm the successful import of the DWD data.

Note: Click on the wind rose in the upper right corner to copy it to the clipboard.

- Click on **OK** and then on Close to return to the Define parameters of element libraries ... dialog.
- Select **Duenne** from the Region list box.

10.6.1 Building flow field/wind field

The building flow field is irrelevant in our example.

- Deactivate the **Calculate building flow field** and **Rasterize buildings** checkboxes.

- Activate the **Recalculate wind field library** checkbox to calculate the wind field (taldia.exe).

10.6.2 Anemometer height – Roughness length z(0) and zero displacement d(0)

Since the project is provided with UTM coordinates, the roughness length is automatically calculated by the program.

The zero displacement is calculated according to the formula d(0) = 6*z(0).

- Do not change these parameters.
- The zero displacement and the roughness length are automatically calculated by the rlinter.exe program.
- Enter the following **coordinates under Anemometer x/m and y/m:**
  x/m: 470612
  y/m: 5786278

_▪ The parameters in this dialog should now be set as shown in the figure below.

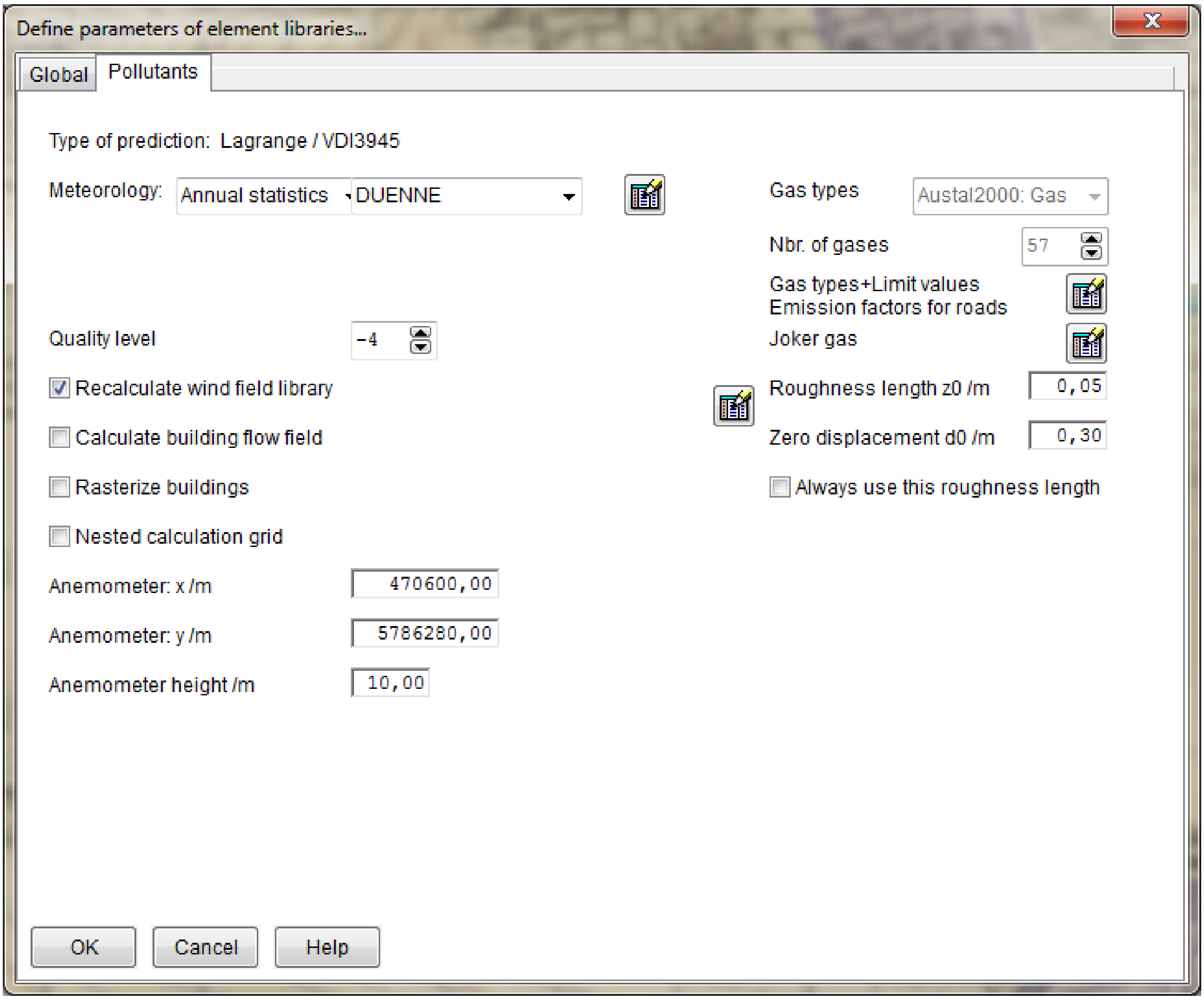


Figure 45: Calculation parameters

10.7 Defining the calculation area / Starting grid calculation

The next step defines the calculation area.

We recommend that you select a grid step size of at least 50 m.

As a result, the complete work area will be calculated with a grid step size of 50 m in our example.

- Select the <**Grid | Definition | Calculation area**> menu item to define the grid.
- Click on **Add**.

- Assign a name to the grid in the Label box and enter **50 in each of the dx/m and dy/m** boxes. The relative height of the grid is **2 m.**

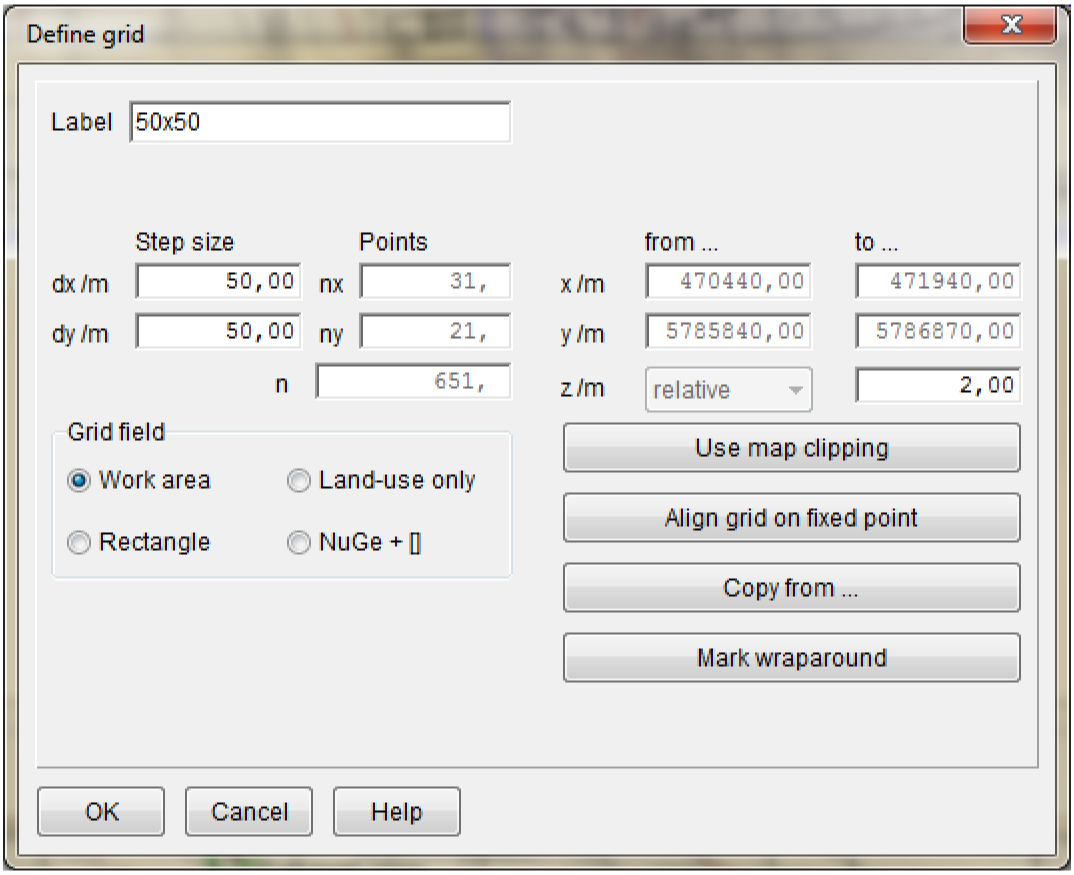
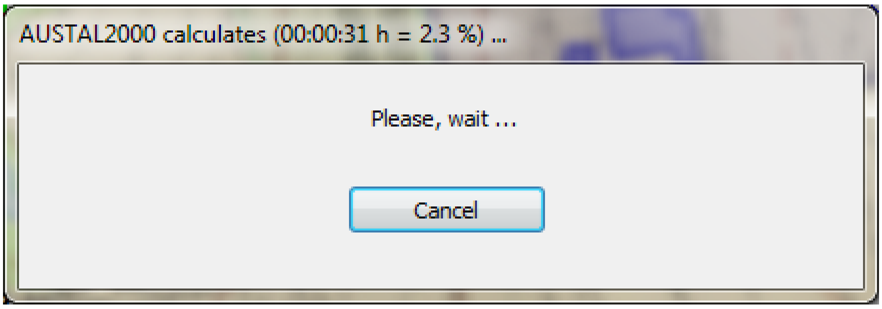


Figure 46: Defining the grid

- Close the dialogs.
- Click on - **Calculate grid** in the speed button bar directly below the main menu bar. Click on **OK** to start calculation.

IMMI starts calculation in the external AUSTAL2000 calculation core. The calculation progress is shown in the calculation window.



_The result of the grid calculation is an area display of a concentration or deposition field in the work area. The extension of the calculated field is defined by the grid dimensions. Calculation takes a few minutes. The calculation time varies depending on the capacity of your computer.

- After completed calculation, AUSTAL2000 writes a report to the “austal.log” file. IMMI opens this file automatically after calculation is completed and displays its content on the screen.

10.8 Results

The AUSTAL2000 result file, i.e., AUSTAL.LOG is automatically displayed after the grid has been calculated.

- Study the calculation results.

Tabelle 7: Auswertung der Ergebnisse

```
Auswertung der Ergebnisse:
==========================

    DEP: Jahresmittel der Deposition
    J00: Jahresmittel der Konzentration/Geruchsstundenhäufigkeit
    Tnn: Höchstes Tagesmittel der Konzentration mit nn Überschreitungen
    Snn: Höchstes Stundenmittel der Konzentration mit nn Überschreitungen

WARNUNG: Eine oder mehrere Quellen sind niedriger als 10 m.
       Die im folgenden ausgewiesenen Maximalwerte sind daher
       möglicherweise nicht relevant für eine Beurteilung!

Maximalwerte, Deposition
========================
NH3     DEP : 26.37 kg/(ha*a) (+/-  0.8%) bei x=  550 m, y=  300 m ( 12,  7)
=============================================================================

Maximalwerte, Konzentration bei z=1.5 m
=======================================
NH3     J00 : 15.49 µg/m³ (+/-  0.2%) bei x=  500 m, y=  300 m ( 11,  7)

Maximalwert der Geruchsstundenhäufigkeit  bei z=1.5 m
=====================================================
ODOR     J00 :  43.2 %     (+/- 0.26 ) bei x=  500 m, y=  300 m ( 11,  7)
ODOR_075 J00 :  43.2 %     (+/- 0.26 ) bei x=  500 m, y=  300 m ( 11,  7)
ODOR_MOD J00 :  32.4 %     (+/-  ?   ) bei x=  500 m, y=  300 m ( 11,  7)
=============================================================================
[redacted]
Auswertung für die Beurteilungspunkte: Zusatzbelastung
======================================================
PUNKT              01         02         03         04         05         06         07
xp                  0        738        876        815        689        433        396
yp                  0         68        129        382        585        477        468
hp                1.8        1.8        1.8        1.8        1.8        1.8        1.8
------------+-----------------+-----------------+-----------------+-----------------+-----------------+-----------------+-----------------
NH3     DEP     1.53  3.9%     3.00  2.8%     3.50  2.5%     5.04  1.8%     3.71  2.3%     7.14  1.7%     8.48  1.6%  kg/(ha*a)
NH3     J00     0.68  1.9%     1.38  1.3%     1.46  1.3%     2.07  0.9%     1.52  1.1%     3.10  0.8%     3.82  0.7%  µg/m³
ODOR     J00      1.8  0.1       3.6  0.3       4.2  0.5       5.4  0.5       3.9  0.3       6.2  0.5       7.6  0.6   %
ODOR_075 J00      1.8  0.1       3.6  0.3       4.2  0.5       5.4  0.5       3.9  0.3       6.2  0.5       7.6  0.6   %
ODOR_MOD J00      1.3  --        2.7  --        3.1  --        4.1  --        2.9  --        4.6  --        5.7  --   %
=============================================================================

2009-01-28 16:14:32 AUSTAL2000 beendet.
```

The function bar allows exporting the table to various formats. The table can be re-opened at any time by clicking on the  button in the tool box.

- Close the list by clicking on the cross in the upper right corner.

Note: The austal.log file resides in the project directory.

- Save the grid by selecting <**Grid | Save**>.

Note: The filename extension of IMMI grid files is .IRD.

The calculated reception point grid is displayed on the screen. The grid displayed shows the annual mean value for nitrogen dioxide (no2-j00z).

The concentrations of all emitting gases and dusts as well as the height data are saved within the scope of a project. The Display grid dialog allows you to open more maps than one so that you can simultaneously view the different grid data on the screen.

Congratulations! You've just finished your first project!

Table of figures