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NUMERIC DISPERSION CALCULATIONS FOR EVALUATION MEASURES AND PREDICTION OF PARTICULATE MATTER EMISSIONS BY SURFACE MINES

1. What is particulate matter?

Particulate matter, also known as "finedust", consists of airborne particles whose aerodynamic diameter is under 10 µm, so the international term is particulate matter 10 or short PM_{10}. Particles of this size are able to deeply penetrate the lungs and are therefore able to cause serious health damages. For this reason, the European Commission has set limit values and also issued rules and regulations regarding the monitoring of air quality. At the moment, an annual limit value for the particle size PM_{10} of 40 µg/m³ applies as well as a daily limit value of 50 µg/m³, which must not be exceeded on more than 35 days a year. Presumably in 2010 these limit values will be further put up to an annual limit value of 20 µg/m³, the daily limit value will be retained, but may only occur on 7 days a year.

In addition to that, a limit value for the particle size $PM_{2,5}$ will be introduced, first as a guideline value, but it is supposed to be legally binding from the year 2015. So far, only annual limit values have been defined, a further tightening of this limit value from 25 to 20 µg/m³ is already intended for the year 2020.

Unfortunately it is already evident, that the current PM limit values are not always and not in any place observed. There is virtually no area that is not more or less pre-polluted by particulate matter. This is due to the fact that dust is a natural part of air and thus is present everywhere. What is more, particles of this size are to a significant part subject of remote transport. The Sahara-Sand-Events which actually happen here in Europe are an example for this. In addition to that, PM also forms in a secondary way, which means, it results from chemical conversion processes in the atmosphere.

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2. Dust sources in surface mines

In the mining industry operating open pits emissions result from various sources.

On one hand, surface mines have a higher erosion- and emission-potential due to their spatial extent and the mostly missing vegetation. The dust discharges partly diffuse from the open mining surfaces by winderosion.

On the other hand, particulate matter evolves because of its operations and the related processes from defined single sources. To be mentioned, stationary operational processes such as mining or dumping of lignite or waste by bucket wheel escavators or spreaders. Especially at conveyor belt transfer points or at places where a spreader dumps material increased dust emissions arise. These are fix sources.

All vehicles moving around the surface mine constitute mobile sources, the dust emissions discharged by them are especially high, when the material is being transported on open loading areas. Roads and belt facilities within the surface mine are also significant dust sources, which are line sources. The material lying on roads or is conveyored on belts is exposed to wind erosion, just as material on unpaved roads. The material on roads is additionally subject to strong mechanical load.

To what extent surface mines contribute to particulate matter problems in the environment and which operational processes are significantly responsible for this, however, can not be finally judged. In order to examine the particulate matter formation in quantity and quality numeric dispersion calculations can be used next to measurements. They are an important monitoring and forecasting method.

3. Forecasting by numeric dispersion calculations

Numeric models allow simulating the dispersion of particles in the atmosphere and can calculate their concentration. Typical matter of use are for example calculations for assessment procedures, local or regional air quality studies or environmental risk assessments.

It is possible to calculate the particulate matter concentrations of any number of emitters and the simulation of their effective range. The result is an exact dust register of the examined area (Fig. 1).

So, by using dispersion calculations it becomes possible to forecast the particulate matter situation, what can be included in dust reducing action plans or to check planned measures for the expected effects.

Dispersion calculations have to be in conformance with the requirements of the Federal Immission Protection Law in Germany. The technical requirements are drawn in the German Regulation on Air Quality (TA Luft). There it is defined, that dispersion calculations have to be accomplished with the Lagrangian Particle Model. The official technical reference model of this is the software AUSTAL2000. The model system was developed in a research project on behalf of the German Environmental Agency (UBA) and is set up and varified in conformance with the German Guideline VDI 3945. The Environmental Agency uses this model for the monitoring of the air quality in Germany. Although mainly applied as a regulatory standard tool in Germany, AUSTAL2000 is increasingly applied in other European countries.

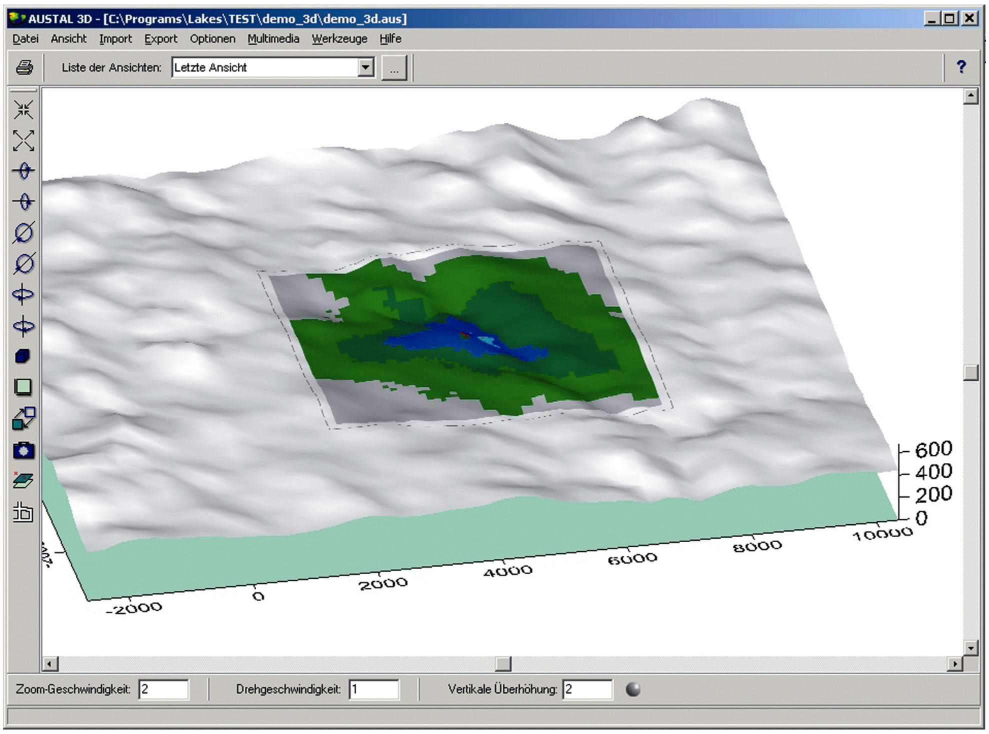

Fig. 1. Example of an output file of dispersion calculations

Unlike to selective measurements it is possible to get a complete emission dispersion register of an examined area for a complete year. That means, you get all calculated values at each point of the horizontal resolution of your examined area. What is much more economical and faster than to use a measurement-network for a complete year.

The results include the annual average value and the deposition area of the overall dust. The daily limit values are already displayed with its quantity of exceedances.

4. Example

In the Rhenish Lignite District the German Environmental Agency operates several measuring stations. In addition, RWE operates ist own measuring devices in and around their fields.

In 2005 and 2006 the daily limit value had been exceeded more than 35 times in the vacinity of the Hambach surface mine. The 36th exceedance entails the necessity of drawing up an action plan to determine measures to reduce the particulate matter pollution. Therefore, an action plan was drawn up for the Hambach surface mine, another action plan followed for the Garzweiler surface mine in 2006.

In consideration of this occurrence, an analysis was made for a prospective lignite surface mine to determine, whether and to what this mine would lead to particulate matter pollution in its vicinity. Figure 2 shows one of three selected reference years, where the mining operations would move close to adjacent settlements, what had to be seen as critical regarding the particulate matter concentrations in this villages

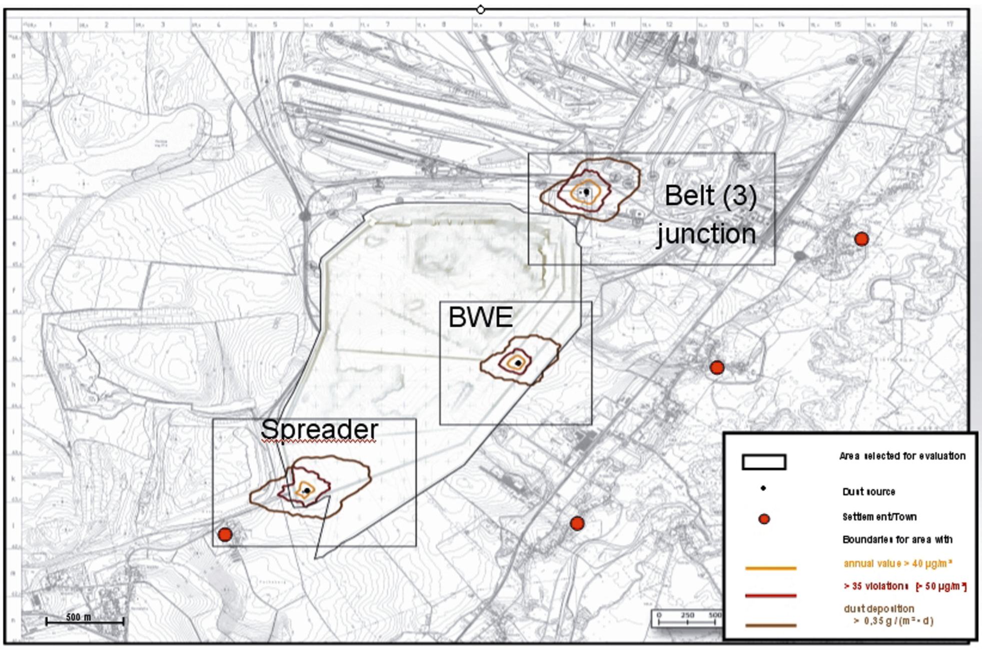

Fig. 2. Numeric dispersion calculation of a prospective lignite surface mine

On the basis of the planned excavation quantity and the development of the mine including the use of equipment and other data, the particulate matter dispersion could be calculated for selected point sources. A digital terrain model was included as well as a meteorological time series of the area.

The results were hourly values of the emission situation for particulate matter as well as for coarse particles for a whole year. As the effective range of individual sources could be calculated this way the minimum distance to be respected became known in order to avoid increased particulate matter concentrations in the vicinity of the mine. The simulation program already yielded the daily average values in elaborated form. This means that for each grid point of the calculated area the 36th highest value was put out. Since the daily limit value of 50 µg/m³ may occur only 35 times a year the calculation result show in what distance from the dust source the limit value can be adhered to.

On top of that the influence of individual emitters could be selectively quantified and thus yield an important contribution to the planning of reduction methods. Using the results it was also possible to create wind direction analyses based on harmful substance wind roses. So, it was possible to make statements on which wind conditions have an adverse effect regarding the dust situation and when increased particulate matter concentrations could be expected. So, dispersion calculations can thus provide a forecast on whether or not and to what extent particulate matter concentrations can be expected in the vicinity of surface mines and the results could be included into the planning of dust reducing measures.

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