ADAPTATION OF A LAGRANGIAN PARTICLE-DISPERSION MODEL FOR THE USE IN RADIOPROTECTION AND RADIOECOLOGY

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INTRODUCTION

The assessment of doses resulting from radioactive substances released to the atmosphere requires the exact modeling of the atmospheric transport processes. Currently the Gaussian Plume Model (GPM) e.g. required by a German Administrative Regulation (*AVV*, 2005) underlying Radiation Protection Ordinance (*BMU*, 2001) is widely used in radiological impact assessments. Although this model has advantages like easy handling and short calculation time there are fundamental constraints such as insufficient consideration of building (especially cooling-tower) wakes or dispersion in complex terrain. In addition time-dependent variations of discharge and dispersion processes are not properly supported by the GPM. Furthermore the GPM according to the German regulations reaches it's limits when emissions from low sources have to be taken into account.

While the Lagrangian Particle-Dispersion Model[8] (LPM) properly deals with these challenges, there are some additional tasks for radiological dose assessment. Beside the calculation of the external dose from gamma-radiation caused by the plume itself, the wind-field and dispersion modules have to provide the terrestrial foodchain module with all necessary data to determine the dose-contribution from wash-out and fall-out. To assess the external dose contributions the model needs information about decay-rates and dose-coefficients as well as the energy deposition build-up factor and the linear attenuation coefficient.

METHODOLOGY

Using a LPM for radiological assessment the modeling has to be split in three parts: Wind-Field modeling, dispersion modeling and dose calculation. Once the interface exists it is possible to use every suitable wind-field model in accordance with the specific requirements. In this study a diagnostic wind-field model has been used. The particle dispersion model calculates the dispersion factor by the Lagrange algorithm as well as the deposition parameters the position and the shape of the plume. With the dispersion factor, the dose calculation model can determine the doses for the exposure path "inhalation". The deposition factor, which is calculated by the values of fall-out and wash-out, is used to determine the surface deposit activity. The dose calculation model needs these data to determine the ingestion dose via the transfer of radionuclides through the terrestrial environment. A special module calculates the external dose from gamma and beta radiation of the plume and the radiation from the radionuclides deposited on the ground. Many of the parameters used for dose calculation span between a wide range of values as they vary a lot in time and in space. Therefore the dose calculation models according to the German regulations mostly represent 95th percentile parameter values to produce upper-bound estimates for radiation exposure.

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[8] In this study the model LASAT developed by Ing.-Bureau Janicke (*Janicke, L.*, 2000) was used

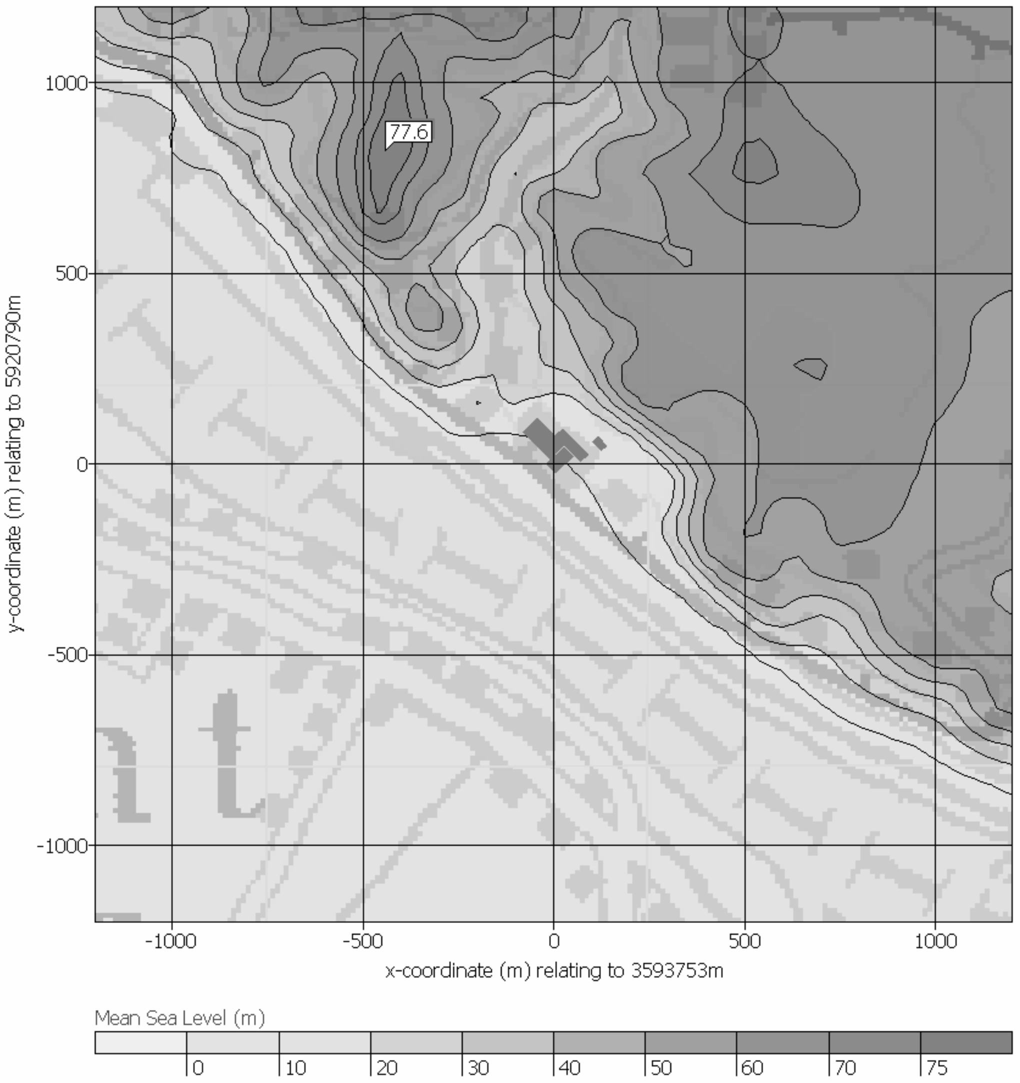

Fig. 1; *Terrain elevation of the investigation-area in meters above Mean Sea Level (coordinates relating to Gauß-Krüger coordinate system)*

In Figure 1 the terrain elevation as well as the relevant buildings in the area of investigation are shown. The emission source is located at the point of origin in a height of 150 m above ground level. The differences in elevation of about 70 meters result in slopes with aspect-ratios of about 1:5. This fact clearly indicates the use of a particle model which considers complex orography.

COMPARISON OF DISPERSION FACTORS

The Figure 2 shows the locations and the values of each dispersion factor calculated by the Gaussian Plume-Model and the Lagrangian Particle Model for average annual meteorological conditions. The values of the dispersion-factor calculated by GPM and LPM do not differ as much as the location of the factor does. While the value of the dispersion factor calculated by the GPM is nearly 50% higher than the one calculated by the LPM, its location is much closer to the emission source (approx. 200m).

The German Administrative Regulation requires the determination of the specific location of the highest possible radiation exposure using the GPM. Therefore, the dispersion factor calculated by the GPM represents an upper bound estimate which is not likely to be exceeded.

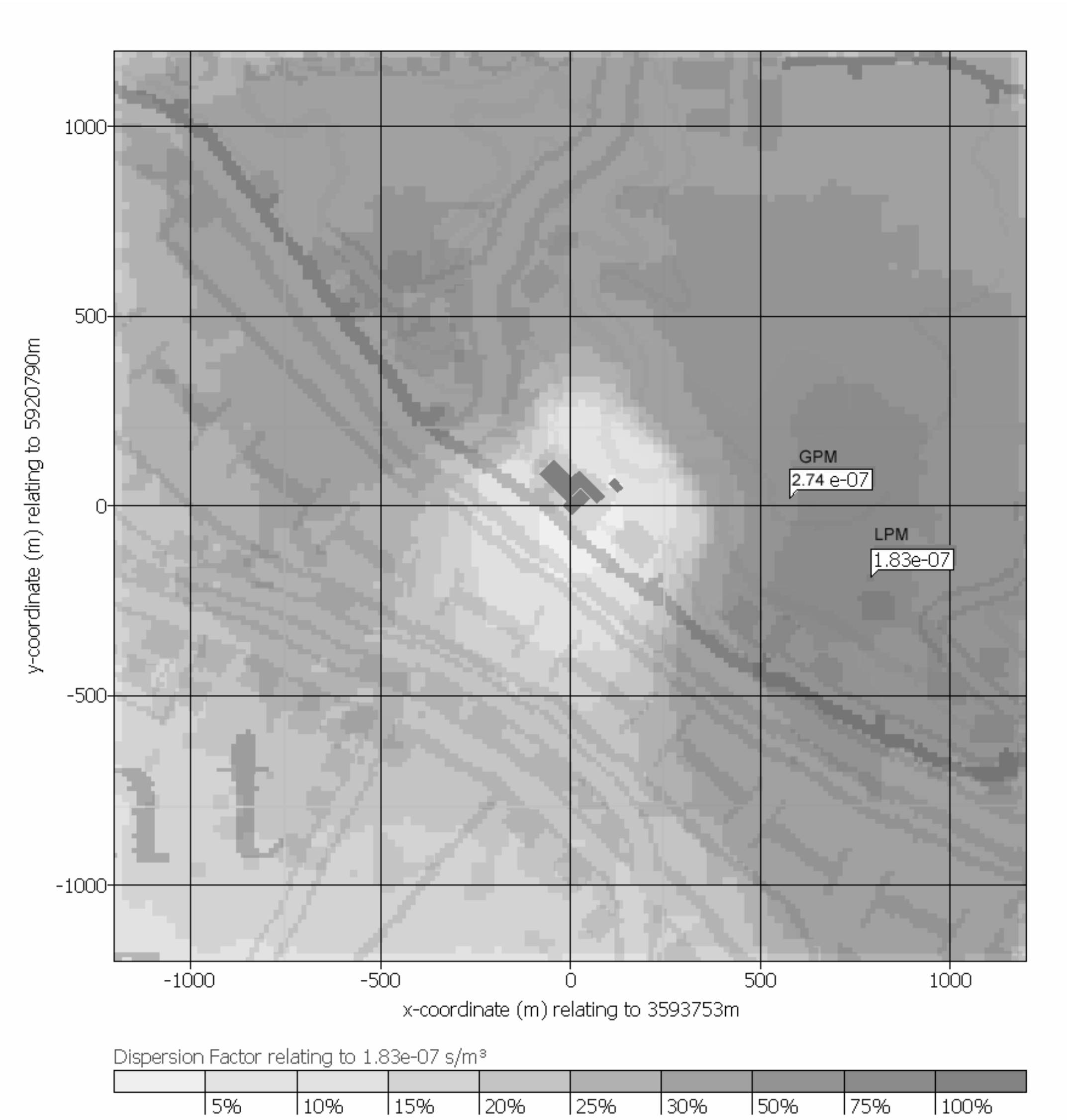

Fig. 2; Comparison of annual average dispersion-factors calculated by the Gaussian Plume Model (GPM: 2,74x10^{-7} s/m^3) and by the Lagrangian Particle Model (LPM: 1,83x10^{-7} s/m^3,coordinates relating to Gauß-Krüger coordinate system)

EXTERNAL DOSE CALCULATION

Calculating the external dose, the contributions of gamma-submersion, beta-submersion and radiation from gamma-surface deposit require special calculation modules as well as an additional parameter-set such as dose rate conversion factors, build-up factors, linear attenuation coefficient etc.

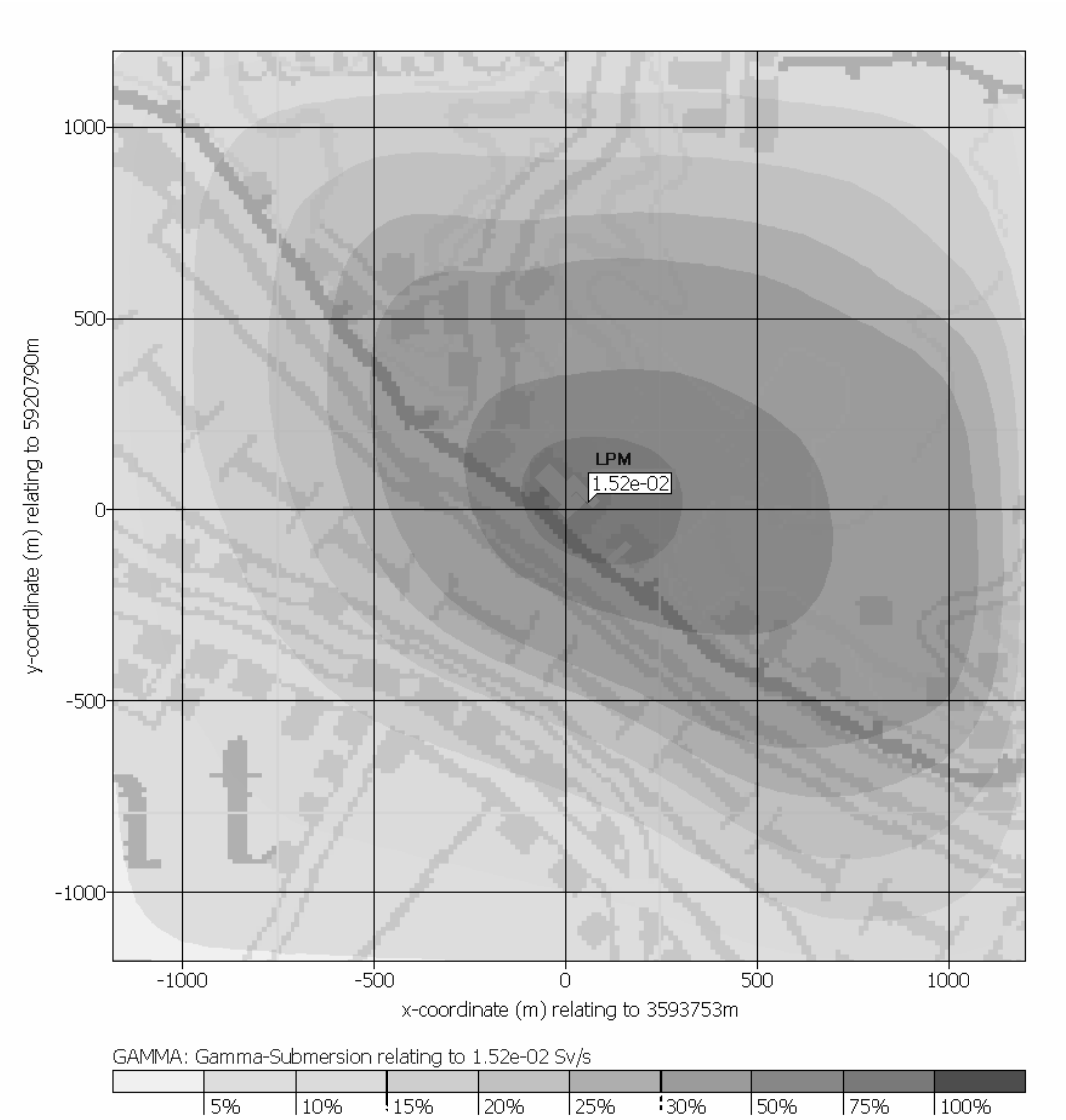

Fig. 3; Average annual dose rate on the surface for the gamma-submersion calculated by the Lagrangian Particle Model (LPM) coordinates relating to Gauß-Krüger coordinate system

In Fig. 3 the distribution of the average annual dose rate on the surface for the gamma-submersion is shown. The shape of the distribution results from the annual meteorological conditions that were also used for the calculation of the dispersion factor. In addition to the gamma submersion dose rate the gamma surface deposit and the beta submersion have to be determined. To estimate the surface deposit dose rate fall out and wash out have to be calculated from the values of dry and wet deposition of the relevant radionuclides. The maximum dose rate of 1.52 Sv/s produces an annual dose from gamma submersion of approximately 0.5 µSv.

CONCLUSIONS AND FUTURE GOALS

The results of this first comparison show that there is a quite good accordance of the value of the distribution factor but less accordance for the location of its specific amount. To obtain the total amount of the radiation exposure using a wind-field model, a particle dispersion model and a radiological model, all these modules have to be coupled by using specific interfaces. This is a procedure not very easy to handle and consumes a lot of computer time. In addition some of the results are calculated redundantly in different modules.

At this time the calculation of the dispersion factor considering the influence of complex terrain and buildings does not contain an algorithm to estimate the thermal lift of cooling tower plumes. There is an evidence given in literature (*Nester, K.; Verenkotte, H.*, 1982) that the merging of the emission plume with the cooling tower plume is able to modify the dispersion of airborne substances. An algorithm for this effect should be established in the future.

In the German regulations for Radioprotection no model is implemented to estimate the realistic exposure to radiation. The model used at this time only holds parameter sets for an upper bound estimate of the resulting doses. There are discussions in progress to promote the development of a realistic radioecological model holding realistic input parameter-sets.

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