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THE DECISION SUPPORT SYSTEM LASAIR: NEW FEATURES FOR EVALUATING DIRTY BOMB SCENARIOS

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Abstract: In present times, there still is a fear that terrorists might thread population in an urban environment to enforce illegal demands. A possibility is to disperse explosive material combined with radioactive substances somewhere in public areas (dirty bomb- or RDD- (radiological dispersive device) scenario.
A decision support model (LASAIR) has been developed to assist in such a case providing quick and basic information on the radiation exposure. The paper gives an overview of the model, new features like influence of orography, the use of wind field models in urban areas or the harmonisation of turbulence parameterisation as well as the validation of the model according to explosion experiments.

Key words: *Malevolent attacks, dirty bomb, Lagrangian- Particle-Model, decision support.*

INTRODUCTION

In present times there still is a fear that terrorists might aim with an act of violence against population in an urban environment to enforce illegal demands. An often-discussed possibility is to disperse explosive material combined with radioactive substances somewhere in public areas. This is called a dirty bomb- or RDD- (radiological dispersive device) scenario.

In such a case, it is essential to get as quickly as possible a clear picture of the potential threat. This means that the possible radioactive concentration in surrounding areas and the contribution to the pathways that lead to the exposure of the population are assessed and counter measures are recommended.

THE DECISION SUPPORT SYSTEME LASAIR

An existing systeme programme LASAT, (Janicke, L., 1983, 1985) based on Lagrangian Particle Simulation has been adapted to meet the requirements of such a dirty bomb scenario. Conducted by the German Federal Office for Radiation Protection (BfS) and in charge of the German Federal Ministry for Environment, Nature Preservation and Reactor Safety and (BMUB) the programme LASAIR (Walter, H.2008, Walter, H. and G. Heinrich, 2011)) has been developed which is able to give a first and rapid overview of atmospheric dispersion, ground activity, deposition and different exposition pathways (inhalation, ground- and cloud shine) after an instant release of radioactive material.
The systems programme can be used by radiation emergency authorities that are responsible for emergencies within the different German States. The programme has been developed in the year 2000 and was continuously upgraded until now.
The new model (LASAIR, Lagrangian Simulation of the Dispersion and Inhalation of Radionuclides) is able to simulate an explosion of an RDD with additional radioactive material and computes the dispersion in the planetary boundary layer. In order to assess the dose to the population the inhalation, ground- and cloud shine doses to individuals can be computed. The model has been introduced as a rapid decision support system within the Federal Office for Radiation Protection and authorities in Federal States in Germany.

LASAIR FEATURES

Special attention has been directed to the usage of the programme in emergency cases. The programme can be run on a laptop, is extremely easy to handle and allows the user only a strictly straight forward step by step usage in order to grant a maximum security feeding the programme with input data.
To model just needs basic necessary meteorological input as

- wind speed and wind direction
- stability class
- roughness length in the vicinity
- amount of explosives
- radionuclide and activity

Output of the model is activity concentration, deposition, ground shine, cloud shine, inhalation dose and time dependant information (activity, dose) in different scales.

One example for the output is depicted in Fig. 1.

Figure 1. Example of output from LASAIR with basic information of the scenery (Varna airport (VAR), Bulgaria) for decision makers (Simulation, not real!)

The new version of LASAIR (Version 4, April 2014) now includes the following features additionally:

- actual turbulence parameterisation (harmonized in Germany),
- verification according to radioactive dispersion experiments with Tc-99m,
- worldwide orography and individual topography,
- rapid online integration of urban structures,
- use of Open Street Maps for EU or worldwide operation.

ACTUAL TURBULENCE PARAMETERISATION (HARMONIZED IN GERMANY)

Investigating literature one will find a huge amount of different atmospheric dispersion models. They have been developed according to different demands and applications. It is one aim of the HARMO-Organisation to provide harmonisation for the dispersion models in such a way that the application of different models e.g. in an emergency, will lead to similar results.
In Germany, the VDI (Verein Deutscher Ingenieure, Association of German Engineers) supports strongly the idea of harmonisation in different aspects. One of it is to develop state of the art standards for the turbulence parameterisation in mesoscale dispersion models. In the course of 2014 the basic work for a new turbulence parameterisation based on measurements at a weather mast close to the city of Hamburg in the northern part of Germany will be completed. This parameterisation will end in a guideline that is applicable for all modelers (VDI 3783, Blatt 8; voraussichtlich 2014 Gründruck/ 2015 Weißdruck) and shall set a standard in Germany but as well in other countries.
The new turbulence parameterisation will be implemented in LASAT and therefore in LASAIR making sure that the scientific improvement will be available for the model users.

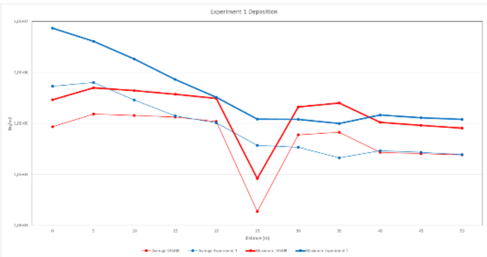
VERIFICATION OF LASAIR ACCORDING TO RADIOACTIVE DISPERSION EXPERIMENTS WITH TC-99m

The National Radiation Protection Institute (NRPI) of the Czech Republic (SURO, www.suro.cz/en) has conducted several experiments with explosive material combined with the radionuclide Tc-99m in the region of Kamena, some 60 km southwest of the main capital city Prague.

The experiment site is a flat area with an extension of approximately 70 x 50 m² and surrounded by trees with a height of roughly 5 – 20 m. In close vicinity (100 m) there is a smooth hill (to the north) and a building area (to the east). In experiment 4 additionally some obstacles in form of cubic elements have been placed close to the explosion site to simulate cars, busses or small buildings. The description of the experiments can be found in Prouza et al, 2010.

Within the IAEA MODARIA-project (International Atomic Energy Agency, Modelling and Data for Radiological Impact Assessments) several groups of modellers have used these data to validate their models. First results have been published in Thiessen et al., 2011.

Four experiments of the Kamena series have been simulated with LASAIR. The graphs can be seen in Fig. 2 – 5. They show the deposition data [Bq/m²] basically downward from the explosion centre. The blue coloured lines represent data from the experiment; the red coloured lines represent the LASAIR simulation data. Solid lines show the averaged maximum of the measurements (solid blue) as well as the averaged maximum of the LASAIR simulation (solid red); thin lines represent data on the downwind axis. The average data have been plotted to eliminate fluctuations in the measurement data set due to the very fine measurement grid size of only 5 m.



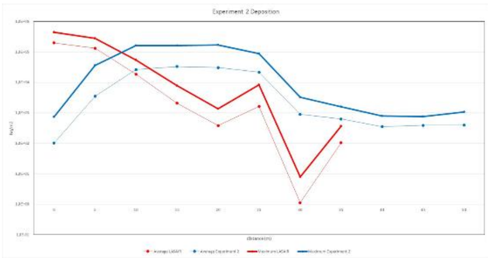
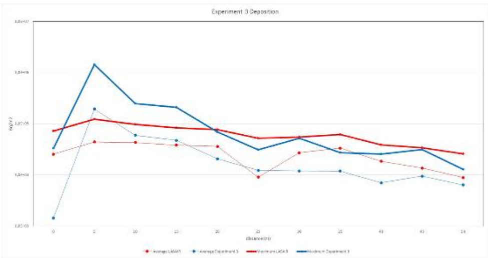


Figure 2 and 3. Comparison of deposition data from the Kamena experiment 1 and 2 with LASAIR results



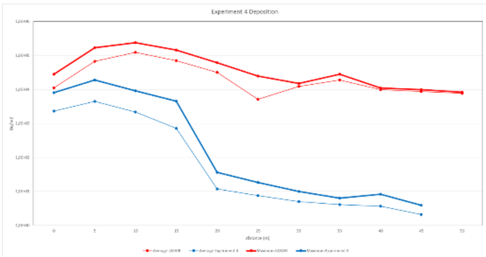


Figure 4 and 5. Comparison of deposition data from the Kamena experiment 3 and 4 with LASAIR results

The Figures show that the difference in the deposition data for experiment and model is in general rather small, especially in experiment 3, however significant in experiment 4. Major differences be explained by the fact, that the meteorological situations during the experiments have been rather difficult as the wind speed and wind directions had big variations due to the trees in the close vicinity. In one experiment (4) the wind direction changed seconds after the blast and within approximately 10 seconds to the opposite wind direction, probably due to thermal influences which caused very likely the big differences as can be seen in Fig. 5. Above that, one has to recognize that dispersion models are stretched to the limits when dealing with instantaneous releases.

The comparison will continue with another two experiments in Kamena and a new experiment in Boltice (Czech Republic, 2014)

ONLINE INTEGRATION OF URBAN STRUCTURES

The application of the decision support system LASAIR aims especially for the usage within urban areas. This area is dominated by buildings in different height and extensions, which will influence the wind flow as well as the dispersion. To consider both effects a new procedure has been implemented in LASAIR. Using OSM (Open Street Map, www.openstreetmap.org) LASAIR has a special menu that allows loading specific maps from OSM servers in different scales and preparing them for the use in the programme. After loading of the maps the user can define different buildings in the centre of the area regarded (see Fig. 6) online in the programme just by a few mouse clicks. This is a quite simple method and the mass consistent flow model in LASAIR (lprwnd) is a simple tool as well; however the effect of buildings can now be studied in detail.

Figure 6. Definition of buildings (cubic elements) on the base of OpenStreetMaps in LASAIR in a city center

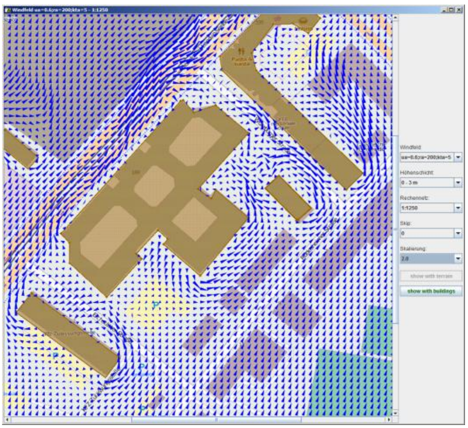


Figure 7. Mass consistent diagnostic wind field situation based on buildings in the center of a city (see Fig. 6). Main wind direction is SSW, the influence of buildings to the wind field can be seen by the wind vectors

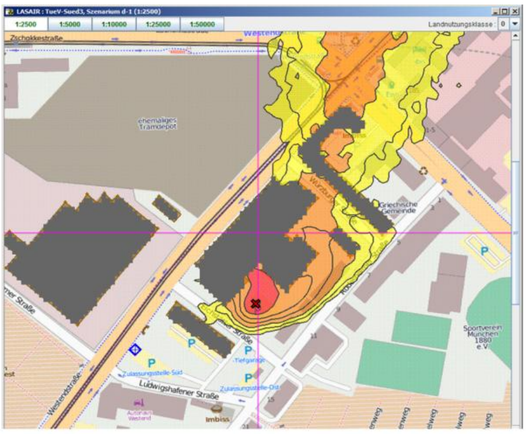


Figure 8. Graph for decision makers giving essential information on the radiation exposure (here inhalation) after the explosion (see as well Fig. 6 and 7). The explosion site is marked with an “X” (Simulation, not real!).

The online integration of urban structures into the simulation with LASAIR offers the opportunity either to study effects of buildings on the atmospheric dispersion as well gives a better picture in an emergency case for the dispersion influenced by buildings regarding affected areas or where measure have to be taken. The definition of the buildings on the base of the Open Street Maps is completed within a few minutes.

After more than a decade in developing LASAIR, the model has proven to be a simple but sophisticated tool for the assessment of a dirty bomb scenario. Further applications of LASAIR in scientific context are presently accomplished within the IAEA/MODARIA project (study of additional explosion experiments in Boletice (Czech Republic) and of routine releases from a conventional power plant close to Sostanj (Slovenia)) and will be published after the end of the project.

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