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MODEL COMPARISON STUDY - LASAT vs. GRAL

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Abstract: In the frame of environmental assessments (expertise or impact statements) the application of dispersion models is required. One purpose of this study is, after a recent implementation of the micro scale dispersion model GRAL (Graz Lagrangian Model) at ZAMG, a comparison of its performance with the longer used dispersion model LASAT (Lagrange Simulation of Aerosol-Transport). LASAT conforms to the VDI guideline 3945 Part 3 (particle model) and forms the basis of the dispersion model AUSTAL2000, it can as well as GRAL be used to perform simulations of air pollutant transport in complex terrain. As compared to LASAT, GRAL is adapted particularly for the simulation of low wind or calm conditions. The dispersion calculation in GRAL can be optionally linked to the prognostic wind field model GRAMM (Graz Mesoscale Model), while in LASAT the calculations are usually based on a diagnostic wind field model. GRAMM is the meteorological driver for the GRAL model system, especially developed for environmental assessment studies on the local scale in complex terrain. GRAL can simultaneously calculate line sources (3D, also bridges), area sources, point sources and tunnel portals. Using existing evaluation data sets and some practical examples, simulations with both LASAT and GRAL are conducted. The results are compared and possible differences and agreements are discussed. The application of the model GRAL for future environmental queries is investigated as well as the practical application of both models concerning preparation, analysis and interpretation of the results.

Key words: *dispersion models, GRAL, LASAT, environmental assessments*

INTRODUCTION

GRAL is a 3-d Lagrangian particle model developed at the Institute for Internal Combustion Engines and Thermodynamics, Graz University of Technology, Austria (Öttl et al. 2009). GRAL can optionally use flow fields computed by the prognostic wind field model GRAMM (Öttl et al. 2005). GRAMM (Graz Mesoscale Model) is the meteorological driver for the GRAL model system which was especially developed for environmental assessment studies on the local scale in complex terrain. Main features of GRAMM are prognostic non-hydrostatic wind fields, terrain following grid, implicit time integration, computation of surface energy balance. A land surface scheme can be utilized as well. In contrast to diagnostic wind field models, dynamic effects due to obstacle influenced flows can be well represented with a prognostic wind field modeling approach.

GRAL can simultaneously calculate line sources (3D, also bridges), area sources, point sources and tunnel portals. At tunnel portals, source strengths, exit velocities, temperature differences and the traffic influence on the tunnel jet are taken into account (). The model system uses special algorithms to account for low wind or calm conditions.

LASAT (Lagrange Simulation of Aerosol Transport), version 3.1, (Janicke, 2009), is a Lagrangian model for the simulation of the dispersion of trace elements in the atmosphere. LASAT conforms to the VDI guideline 3945 Part 3 (particle model; VDI, 2000). This is a model type that is demanded by the German Technical Instruction on Air Quality Control (TA Luft, 2002) and was developed by JANICKE Consulting on behalf of the German Federal Environmental Agency. The model calculates the dispersion of passive trace substances in the lower atmosphere (up to about 2000 m altitude) in the local and regional surrounding (up to distances of about 150 km). The terrain can be plain or structured and it may contain buildings. For complex terrain, a diagnostic wind field model is integrated in the meteorological pre-processor. The diagnostic wind field model also takes into account the flow around buildings; in this case, the recirculation and the increased turbulence that develops on the lee side are parameterized.

Since GRAL is still under implementation process at ZAMG only some first results and model runs with it are presented. For this study the following existing evaluation data set was applied: The experiment was conducted at a single located pig stable near Uttenweiler in Germany (Bächlin et.al. 2002). During 15 single experiments odour together with SF6 tracer gas measurements were performed at two cross sections downwind the farm. The concentrations at 12 receptors at 2 m height (measuring points) were considered, where the coordinates of the receptors are partly varying for the different experiments. The average interval of the experiments was 10 minutes at roughness length 0.01 m, with emission rates for SF6 are 0.1217 kg/h or 0.2525 kg/h , where relatively high wind speed and only neutral atmospheric stability were considered. More details on the different experiments are discussed as follows:

RESULTS

Experiment B

In the experiment B the wind speed is 3.9 m/s. The measurements for all the experiments were conducted with a sonic anemometer and a cup anemometer in 10 m above height. The grid size for the simulations with the GRAL is 2.5 m x 2.5 m x 1 m with a vertical stretching factor of 1.0. Figure 1 depicts the concentrations calculated with the two models for the 12 receptor points in [µg/m³] in comparison to the measurements. In this case the measurements and the model results from LASAT as well as from GRAL agree quite well. Figure 2 shows the concentrations calculated with the two models vs. each other.

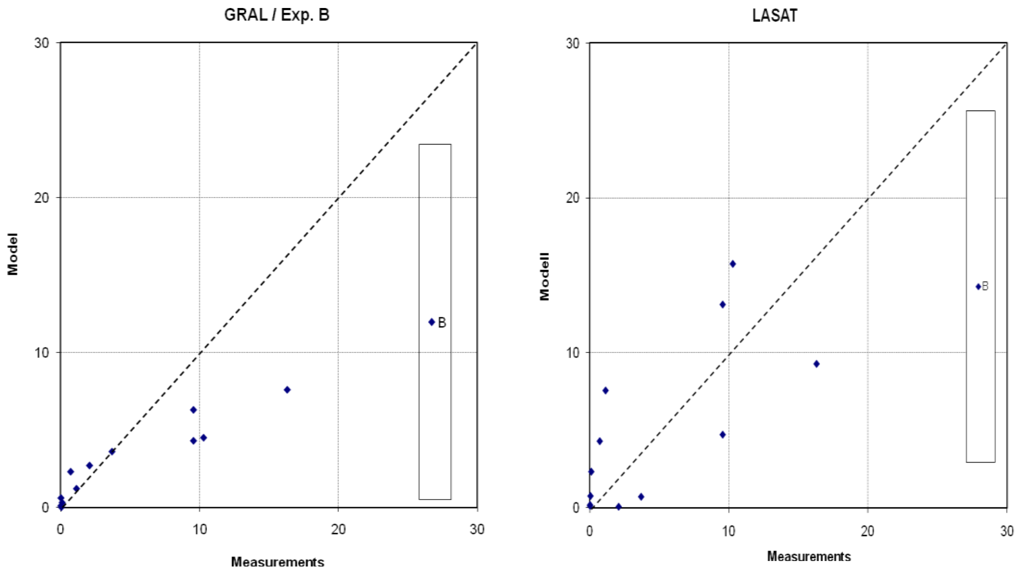

Figure 1: Modelled concentrations in [µg/m³] with GRAL (left) and LASAT (right) at the receptor points in comparison to the measurements for the experiment B.

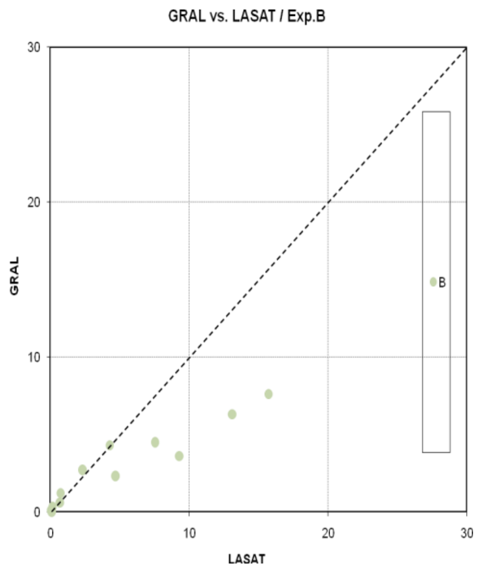

Figure 2: Comparison of the modelled concentrations for the experiment B.

Experiment C:

The wind speed in this case is 4.6 m/s. Figure 3 shows a comparison of the modelled concentrations. In this case the results from GRAL conform to those from LASAT well. The same can be said in a comparison between the mean value of the measurements and the mean value computed with GRAL, respectively with LASAT.

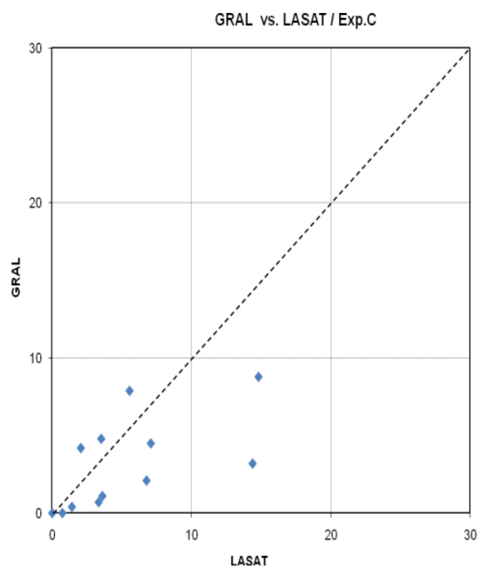

Figure 3: Comparison of the modelled concentrations for the experiment C.

Figure 4 presents comparisons of both models (GRAL and LASAT) with the measurements for all computed scenarios (from B to O). In general the observed concentrations are captured well by both models.

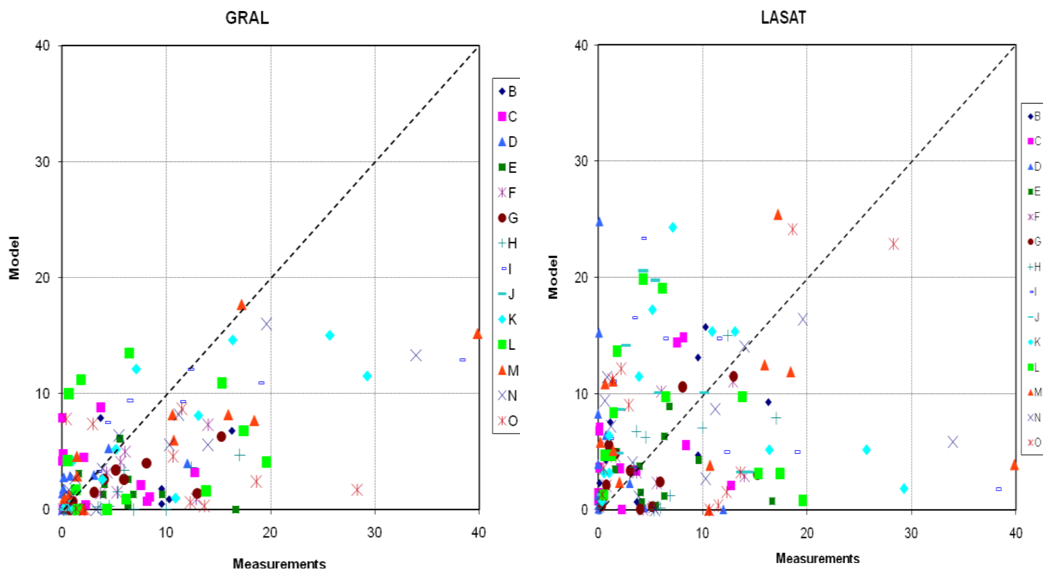

Figure 4: Comparison of the modelled concentrations for all the calculated scenarios with the measurement for GRAL (left) and LASAT (right). The concentrations are in [µg/m³].

Figure 5 (left) presents comparisons of the models GRAL versus LASAT for all calculated scenarios. For the most of the scenarios the both models agree well. Figure 5 (right) depicts comparisons between GRAL and the Gaussian model ONGAUSSplus (ONG+) for the data set. In general, for the most cases the concentrations (at 12 receptors at 2 m height) computed with GRAL conform quite well to the output from ONG+. The concentrations are in [µg/m³].

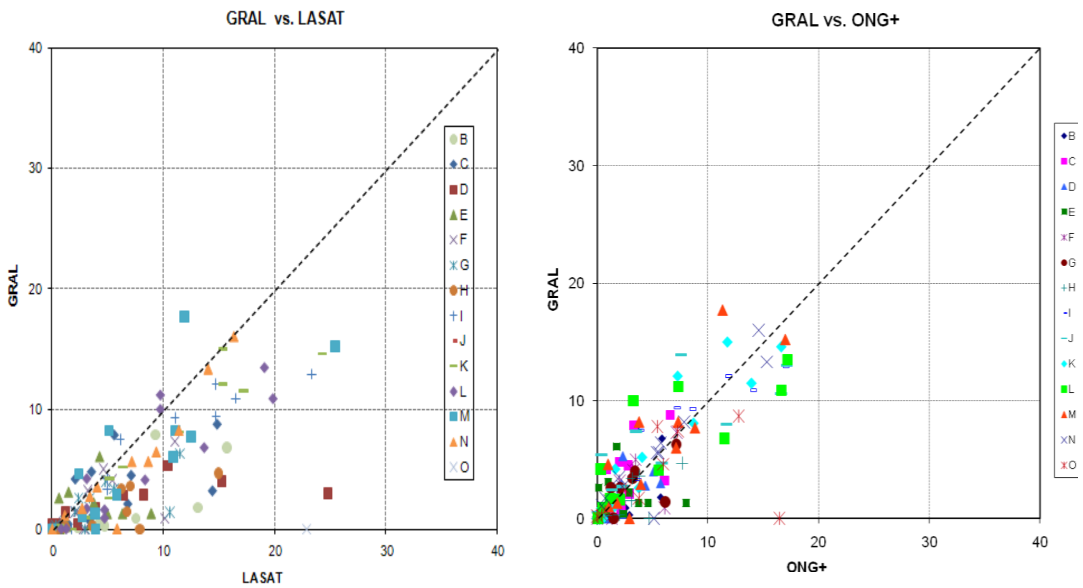

Figure 5: Comparison of the modelled concentrations for all calculated scenarios with GRAL and LASAT (left) and GRAL versus ONG+ (right). The concentrations are in [µg/m³].

CONCLUSIONs

For meeting regulatory requirements the application of dispersion models is required. The model LASAT has been already applied at ZAMG in the frame of environmental assessments. The model GRAL is currently in implementation phase at ZAMG. One purpose of this study was a comparison of its performance with the LASAT. Using existing evaluation data set some simulations were done with both LASAT and GRAL and possible differences and agreement were discussed. In general both models represent quite well the observed concentrations. Based on the calculated scenarios can be summarized, that in most of cases the results from GRAL agree well to the results from LASAT, respectively to those from ONG+. More investigations and model runs are needed to be conducted with GRAL in order to better understand its performance as well as for the successful implementation and application of the model at ZAMG for future environmental queries.

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