LASPORT - A MODEL SYSTEM FOR AIRPORT-RELATED SOURCE SYSTEMS BASED ON A LAGRANGIAN PARTICLE MODEL

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INTRODUCTION

LASPORT (LASAT for airports) is a program system for the calculation of airport-related emissions and concentrations. For the dispersion calculation it incorporates the Lagrangian dispersion model LASAT (Lagrangian simulation of aerosol transport).

LASPORT was developed in 2002 on behalf of the German Airports Association (ADV) and has been used to assess the local air quality at several European airports (e.g. Düsseldorf, Frankfurt, Heathrow, Zürich). It has been applied in a variety of projects guided by EUROCONTROL, among other in the context of model inter-comparisons, sensitivity studies, and comparisons with measured concentrations (see e.g. *Fleuti, E. et al.*, 2005, 2006).

LASPORT is, along with ALAQS-AV and ADMS-Airport, one of the three European candidate models addressing local air quality at airports that were submitted in 2006 to the International Civil Aviation Organization (ICAO/CAEP).

THE PROGRAM SYSTEM

A graphical user interface provides the following tools:

- Definition of source groups, emissions, and other calculation parameters
- Calculation of overall emissions for each source group and trace substance
- Preparation, start, and control of the dispersion calculation
- Result analysis and visualization

The source groups explicitly accounted for are:

- Aircraft traffic (landing and takeoff - LTO - cycle)
- Auxiliary power units APU)
- Ground power units (GPU)
- Ground support equipment (GSE)
- Motor traffic (airside and landside)

Other sources can be defined in form of point, line, and volume sources with individual emission strengths. Source locations are defined either interactively or directly in form of text files. From these specifications, the time-dependent source elements and input files for the dispersion program LASAT are created.

The exhaust dynamics of the emissions from aircraft engines are accounted for by a power-dependent, directed exit velocity and turbulence characteristics. For other source groups, thermal rise is covered parametrically. Chemical conversion of NO to NO_2 is accounted for with the help of linear, stability-dependent conversion rates. An integrated diagnostic wind field model is applied for dispersion calculations with terrain profiles and/or buildings. Alternatively, three-dimensional wind fields produced by other meteorological models can be applied.

The dispersion calculation is carried out on the basis of a meteorological time series with (typically) hourly means of wind velocity, wind direction and a measure of the atmospheric stability (e.g. Monin-Obukhov length). The result of a dispersion calculation is the time series of concentration distributions for each trace substance in form of hourly means, from which long-time and short-time assessment values according to EU directives are derived.

The general structure of the program system is depicted in Figure 1. The user input (files directly provided or created by the user interface) is transformed by module LspTrans to LASAT input files. All input and output files in connection with LspTrans, LASAT, and the evaluation procedure are text files with fully documented formats. Together with a detailed model description in reference books, guidelines, and publications, a high transparency of the program system is aimed for.

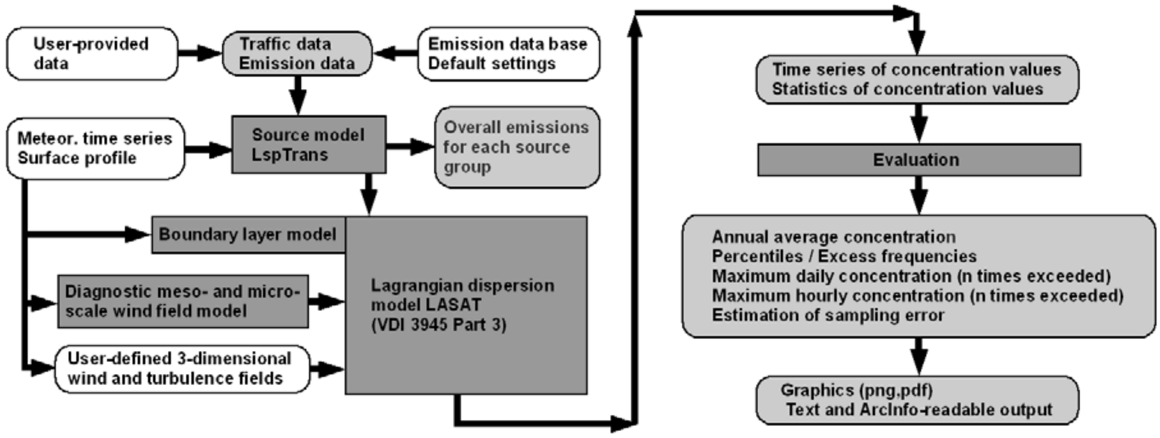

Fig. 1; General structure of the program system LASPORT.

LAGRANGIAN PARTICLE MODEL

In contrast to Gaussian or Eulerian models, the concentration distribution in a Lagrangian particle model is not derived from an analytical solution or a numerical solution of the advection-diffusion equation, but the dispersion process itself is modelled by simulating the transport and diffusion of a representative sample of trace particles utilizing a random walk process. The concentration is derived from the calculated particle positions for a given volume element and time interval (see Figure 2). In this way, a realistic description of the dispersion both in space in time can be achieved.

Advantages of the model type include:

- It is independent of calibration parameters.
- It is applicable to non-stationary dispersion situations.
- Sources of any shape and number can be accurately and simultaneously handled.
- In the near field of sources it gives a more accurate description of the dispersion as compared to models based on the classical equation of diffusion.
- Dynamic effects of the source exhaust can be accounted for in detail.
- 3-dimensional wind and turbulence fields can be applied.

Especially the first items make the model well suited for airport applications.
LASAT is a Lagrangian particle model (see e.g. *Janicke L.*, 1983, 2000, 2002) set up and verified in compliance with the German guideline VDI 3945 Part 3 (2000). Since almost 17 years it has been applied as a standard tool for air quality assessments by national and local authorities, consulting companies, and industrial companies in Germany and neighbouring

countries, since 12 years also for airport air quality studies. LASAT served as the basis for the development of the dispersion model AUSTAL2000, the official reference model of the Technical Instruction on Air Quality Control in Germany (*TA Luft, 2002*), for more details see *Janicke, U. and L. Janicke* (2007).

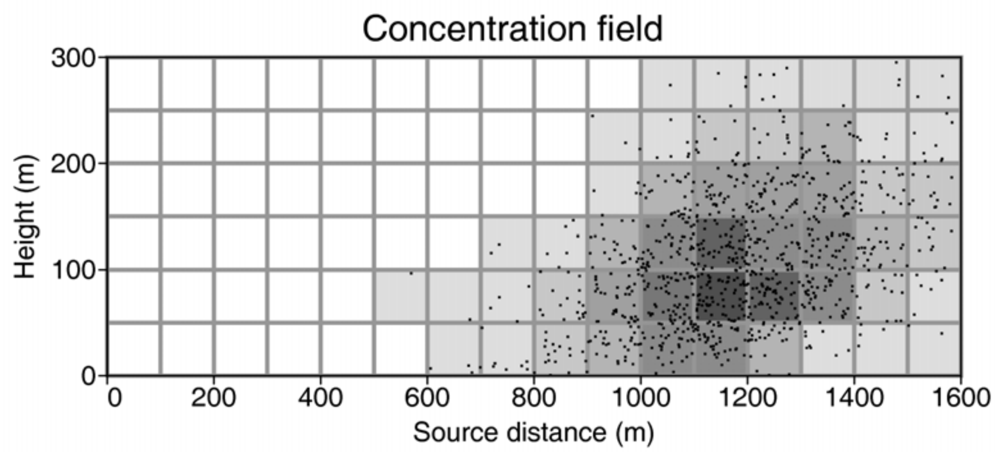

Fig. 2; Working with particles in a Lagrangian particle model. A vertical intersection of a cloud of simulation particles (black points) from which the concentrations in each cell of a regular grid is derived (encoded here as background colour of each cell).

AIRCRAFT TRAFFIC – MONITOR VERSUS SCENARIO CALCULATION

Within LASPORT, aircraft traffic can be accounted for on the level of individual aircraft (monitor calculation) or on the basis of generalized traffic information (scenario calculation).

In a monitor calculation, aircraft traffic is accounted for by individual, moving line sources with time-dependent emission strengths (time resolution typically 10 seconds). Aircraft traffic is specified in a movement journal. Typical applications are detailed studies of actual aircraft traffic and comparisons with time-resolved concentration measurements.

In a scenario calculation, aircraft traffic is projected on systems of stationary line sources with hourly-based emission strengths. Only general information about aircraft traffic is required like average distributions over runways and average time courses. A scenario calculation is suited as well for prognosis scenarios, where a detailed movement journal is not available.

APPLICATIONS

Usage as a standard program package

LASPORT is designed as a standard program package that can be applied by any airport without the need of other programs or data bases. It is a stand-alone system with default settings for most input parameters and a trade-off between the complexity of available input data and the required practicability.

Sensitivity analyses

As most of the LASPORT settings are accessible to the user, a variety of sensitivity analyses can be performed (see e.g. *Fleuti, E. et al.*, 2006; *Janicke, U.*, 2006). An example is shown in Figure 4.

Fig. 3; Monitor versus scenario calculation (Zürich Airport). Left: Snap-shot of aircraft traffic in a monitor calculation, showing the line segments that 12 aircraft pass in the depicted 10-second interval. Right: Stationary line sources for taxiway emissions in a scenario calculation.

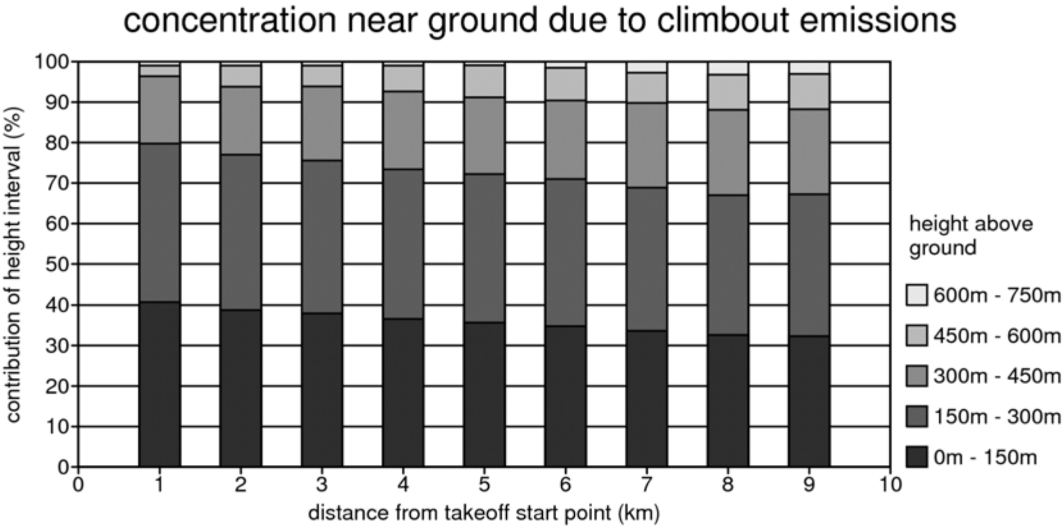

Fig. 4; Sensitivity analyses. Contribution of different height layers to the concentration near ground at 9 monitor points for the climb out emission of a single aircraft (Janicke, U., 2006).

Local air quality studies

LASPORT can be used to assess the local air quality at and in the vicinity of airports, both for airport contributions only and in combination with regional models, see Figure 5 for an example.

Licensing procedures

LASPORT is currently applied in the licensing procedures of Frankfurt Airport and Munich Airport.

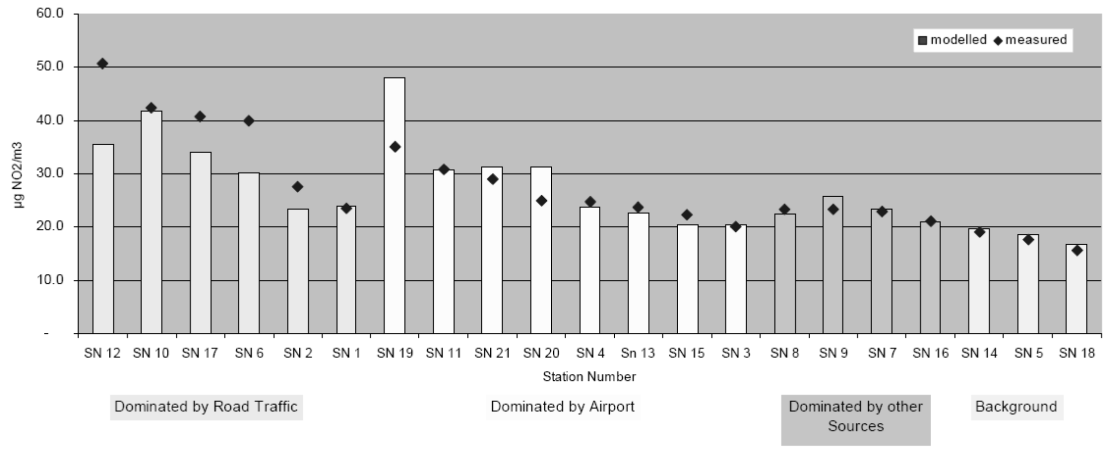

Fig. 5; Local air quality studies. Modelled versus measured NO_2 concentration (annual mean) at different monitor stations around Zürich Airport (Fleuti, E. and P. Hofmann, 2005).

OUTLOOK

Present work on LASPORT focuses on the following topics:

- Adjustments to requirements of CAEP.
- Interfaces and linkage to external aircraft-related data bases.
- Operational LTO replacing certification LTO.
- NO/NO_2 conversion modelling.
- Parameterisation of exhaust dynamics.

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