Dynamic Dispersion Modelling of Odours and Aerosols

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Outline

- Introduction
- Nast3D
- Structure and first tests of STAR3D
- Validation systems for STAR3D (offline/online system)
- Summary & Outlook
Transmission of dust particles from animal houses
For a time-resolved description of the particle distribution the Navier-Stokes-equations

\[
\frac{\partial \vec{u}}{\partial t} + (\vec{u} \cdot \nabla) \vec{u} + \nabla p = \frac{1}{\text{Re}} \Delta \vec{u} + \vec{g}
\]

\[\nabla \vec{u} = 0\]

are solved by Nast3D, a program developed at the Division of Scientific Computing and Numerical Simulation at the University of Bonn.

The software calculates the numerical solution for the pressure \( p \) and the velocity field \( \vec{u} \) in the centre of the cells of the 3dim. grid.
STAR3D = **Simulated Transmission of AeRosols 3D**

Based on the wind field calculated by Nast3D the motion of the aerosol particles can be expressed by the following equation:

\[
\frac{\partial x}{\partial t} = \alpha_w \cdot \vec{u} + \lambda \cdot \vec{e} + \vec{v}_{sed}
\]

- **Velocity of the particle**
- **Coupling to the wind field**
- **Diffusion of the particles**
- **Sedimentation of the particles**

**STAR3D**

**Simulated Transmission of AeRosols 3D**
STAR3D

Course of the simulation

- Modelling of the landscape, buildings, emission sources; definition of particle properties
- Calculation of dynamic fluid field (NaSt3D)
- Dynamic visualisation of aerosol distribution, analysis of data
- Calculation of particle trajectories (considering the particle's physical properties)
The software was tested in a trial scenario

- dimensions of the simulated region 100m x 100m x 25m
- grid width 1m
- barn with 5 chimneys as emission source
- a second barn as obstacle
- total simulated time period of 600s
- south westerly wind (5 m/s)
STAR3D

Animated visualisation of the result
The immission is mostly distributed in the direction of the wind (sw direction)
Tracer-Aerosol

requirements

• no environmental hazard, no danger to men and animals
• clearly traceable
• easy and efficient detection
• universally applicable (offline and online-system)
• low-cost

Pictures: GE Energy
universal particle analyzer (Offline-System)

Image processing (autofocus)

control

CCD

focusing optic

beam splitter

object slide

mirror

beam splitter

upper light source - white - uv 375nm

lower light source - white - uv 375nm
system specifications

- four light sources
  - transmitted-light, UV and white
  - reflected-light, UV and white
- transparent and non-transparent slides can be scanned
- resolution: 7 pixel = 1µm
- up to 5000 pictures per hour
- particle area and shape analysis
Offline system

Example images of tracer aerosol particles
Offline system

Aerosol particles are found automatically by a software based on the OpenCV library.

Here different particle sizes are colour-coded.
Offline system

size distribution of aerosol particles found on an object plate.

The object plate was dusted in a sedimentation chamber.
Online system

- Uv-source
- optical filter
- scatter center
- laser (red)/splitter
- UV 375nm
- TOF
- UV source
- volume flow controller
- I2U-amplifier
- detector
- filter
- AD-converter
- processor
- tracer-concentration
Summary & Outlook

• The dynamic dispersion modelling software STAR3D has been developed

• It allows the simulation of the dispersion of aerosol particles

• Two validation systems are developed to prove the results of the simulation

• The offline system works properly, the online system is currently under development

• A field survey to prove both (simulation and validation systems) is under way