Dynamic Dispersion Modelling of Odours and Aerosols

HARMO 12 Conference
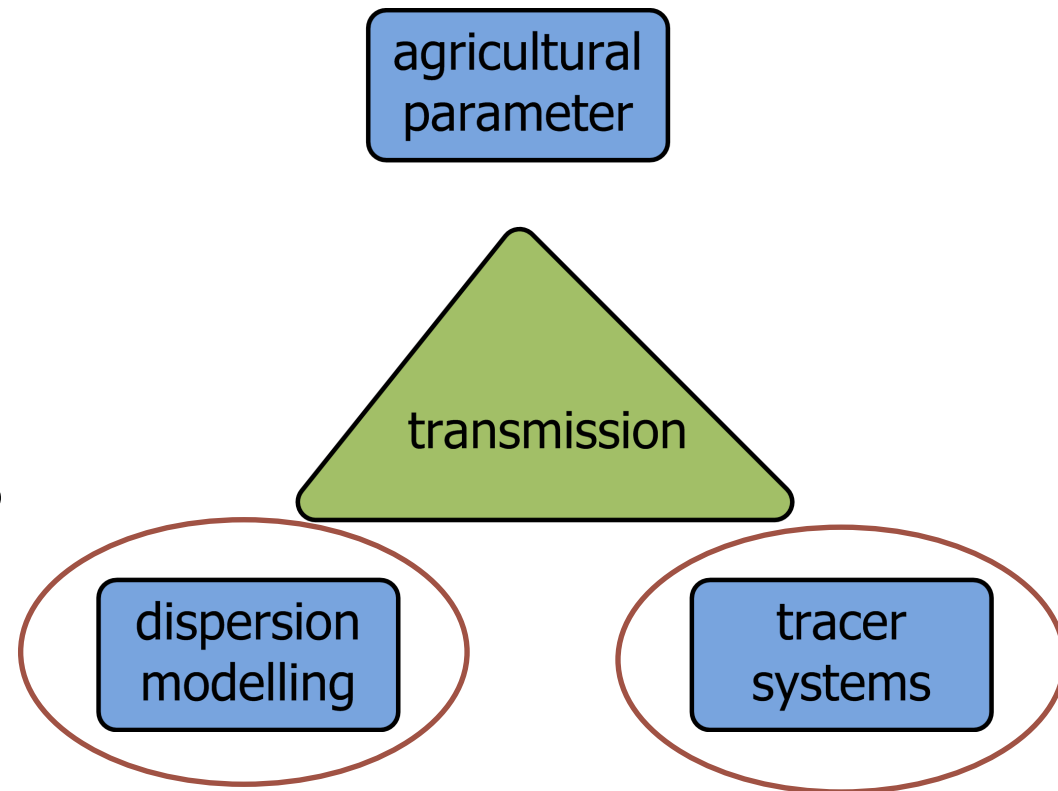
P. Lodomez[1], E. Rosenthal[1], J. Henseler[2], W. Büscher[2] and B. Diekmann[1]

[1] Physics Institute, Bonn University
[2] Inst. for agri. cult. Engineering, Bonn University

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Outline

o Introduction

o Nast3D

o Structure and first tests of STAR3D

o Validation systems for STAR3D (offline/online system)

o Summary & Outlook

Transmission of dust particles from animal houses

agricultural parameter

transmission

dispersion modelling

tracer systems

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Nast3D

For a time-resolved description of the particle distribution the Navier-Stokes-equations

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

$$\nabla \vec{u} = 0$$

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 u in the centre of the cells of the 3dim. grid.

STAR3D

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:
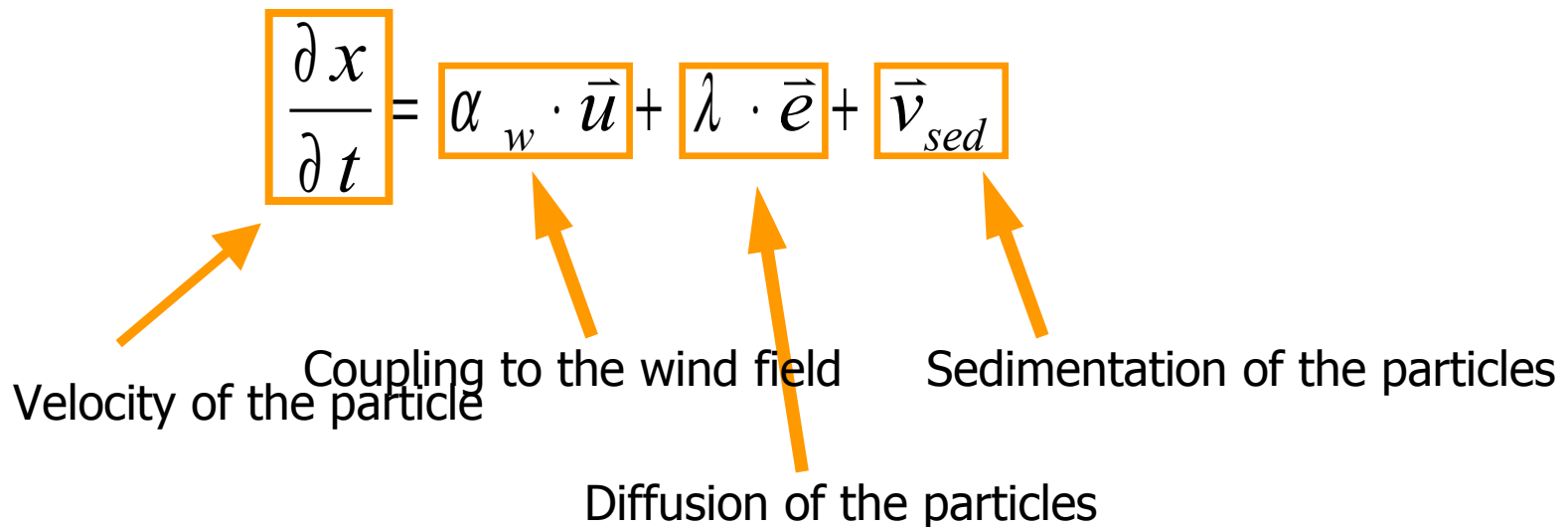
$$\frac{\partial x}{\partial t} = \alpha_w \cdot \vec{u} + \lambda \cdot \vec{e} + \vec{v}_{sed}$$
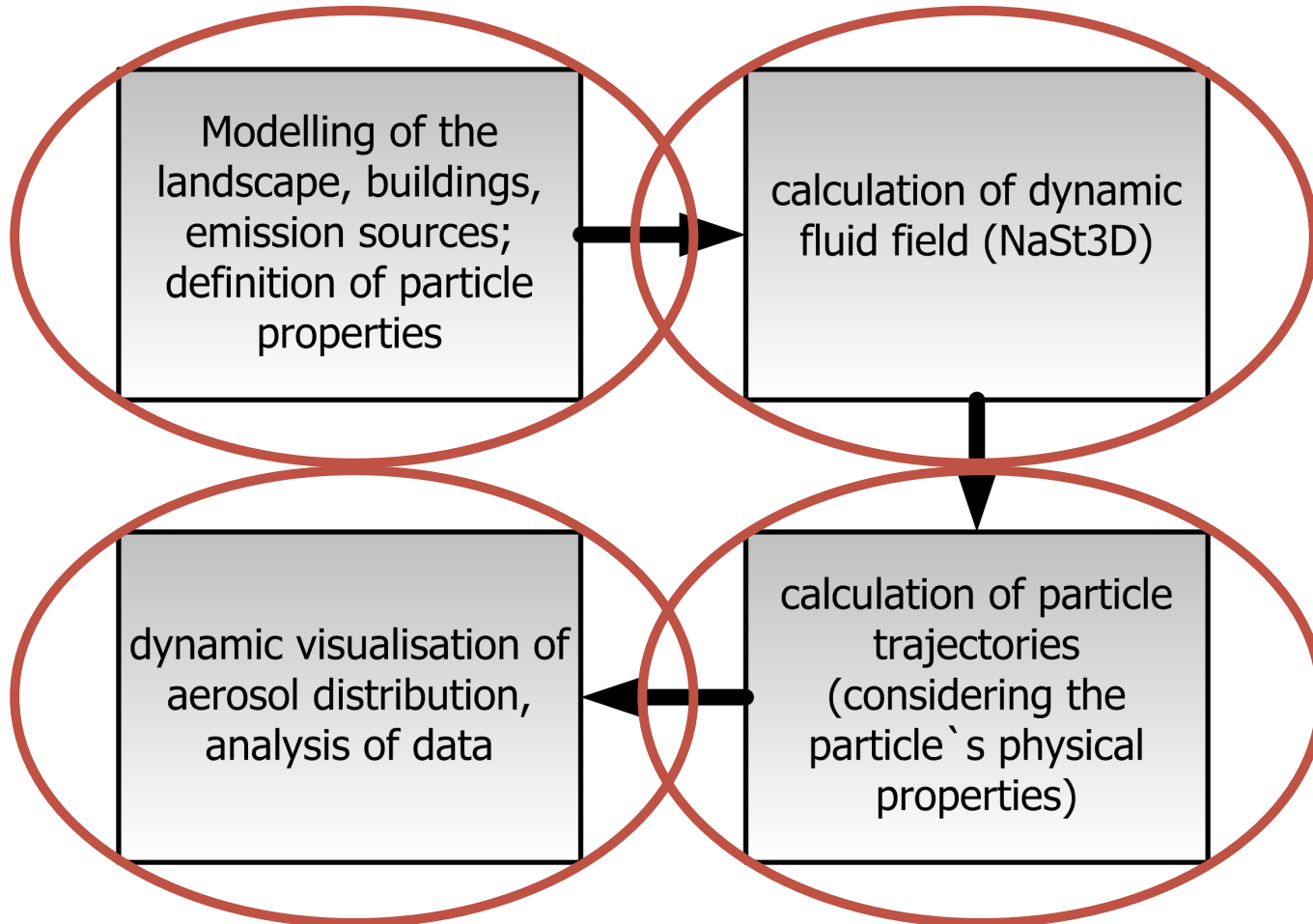
Velocity of the particle

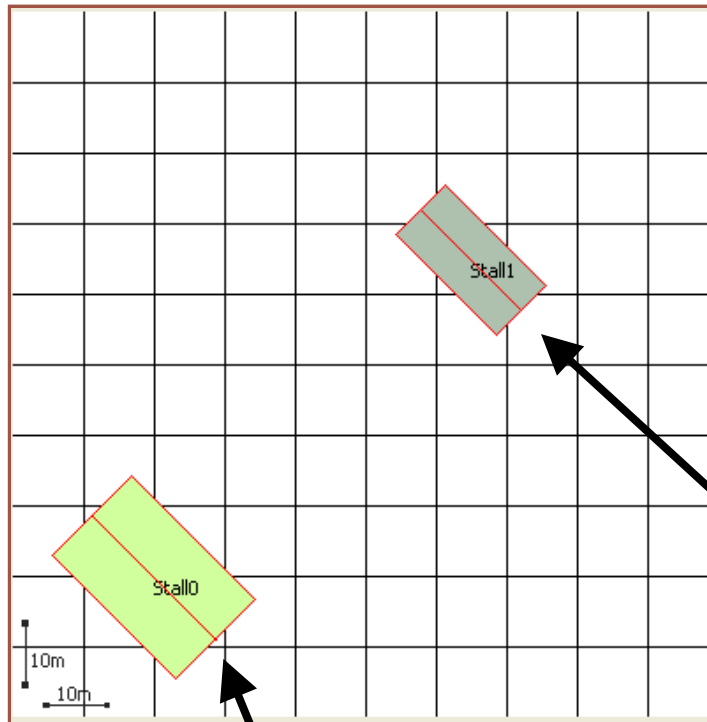Coupling to the wind field

Diffusion of the particles

Sedimentation of the particles

STAR3D

Course of the simulation

STAR3D

The software was tested in a trial scenario

10m
10m
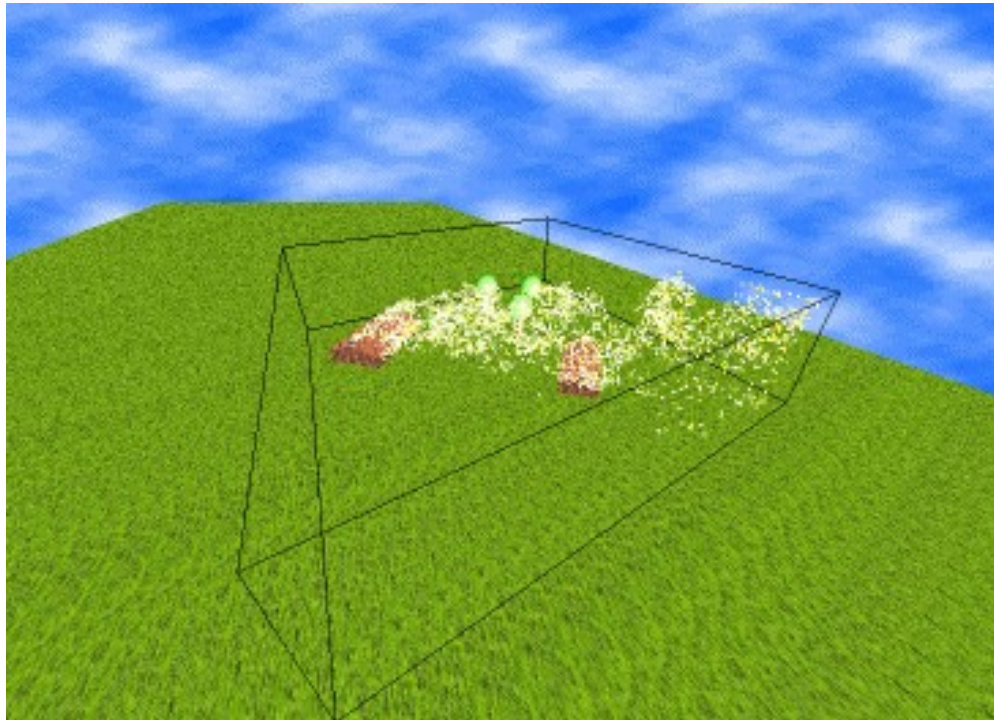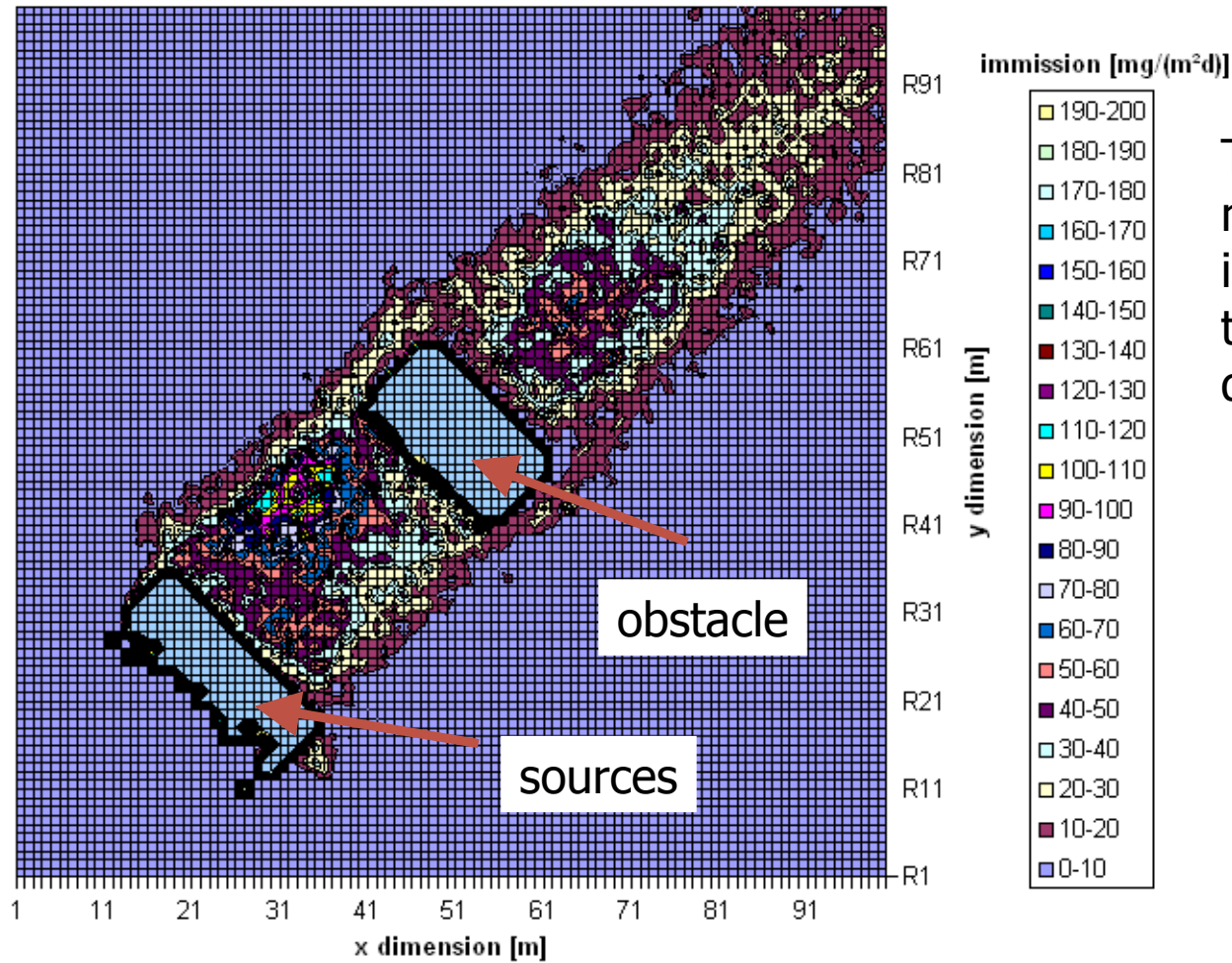
Stall1

Stall0

obstacle

emission source

- 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

STAR3D

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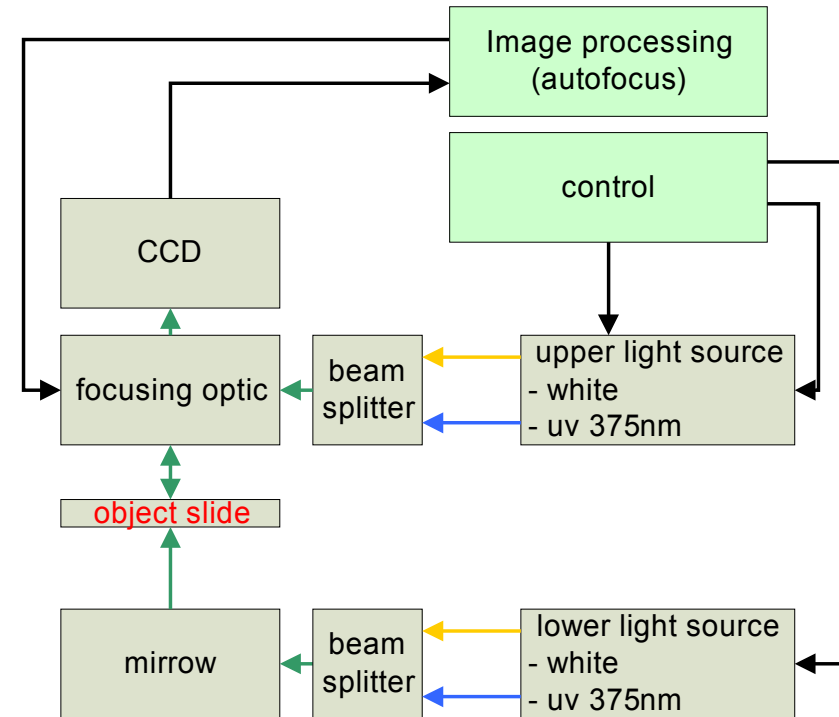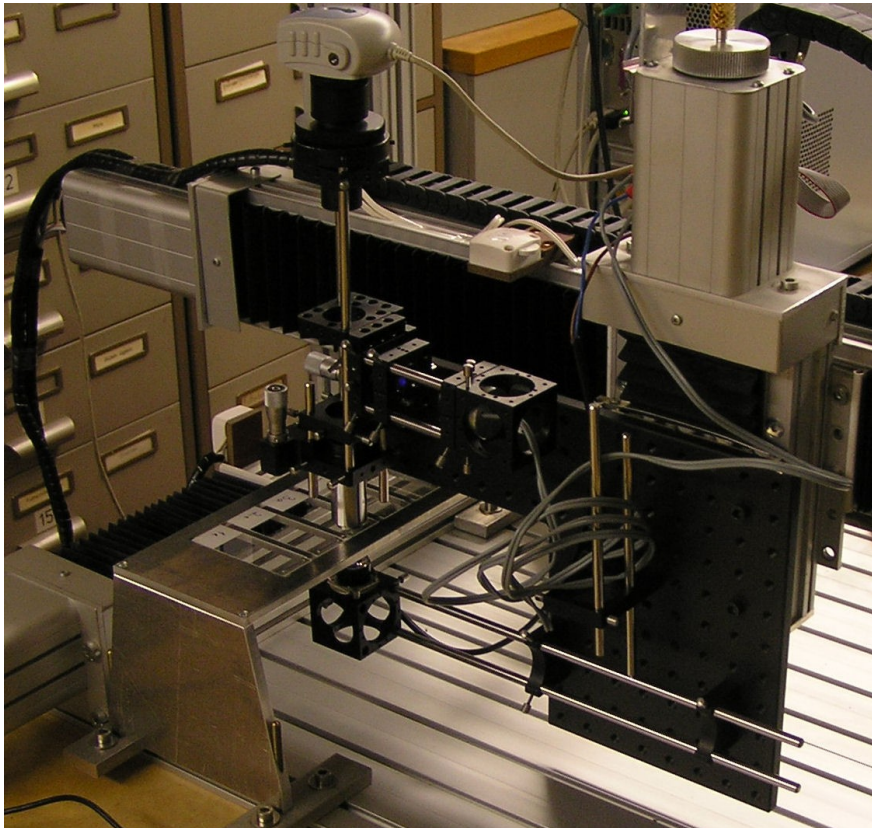
Tracer-Aerosol

requirements

• no environmental hazard, no danger to men and animals

• clearly traceable

• easy and efficient detection

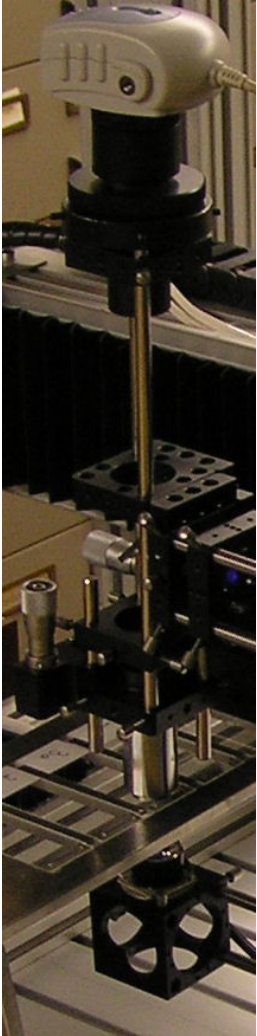• universally applicable (offline and online-system)

• low-cost

Pictures: GE Energy

universal particle analyzer (Offline-System)

Image processing (autofocus)

control

CCD

focusing optic

beam splitter

upper light source
- white
- uv 375nm

object slide

mirrow

beam splitter

lower light source
- white
- uv 375nm

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system specifications

- four light sources

  -transmitted-light, UV and white

  -reflected-light, UV and white

- transparent and non-transparent slides can be scaned

- resolution: 7 pixel = 1µm

- up to 5000 pictures per hour

- particle area and shape analysis

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Offline system

Example images of tracer aerosol particles

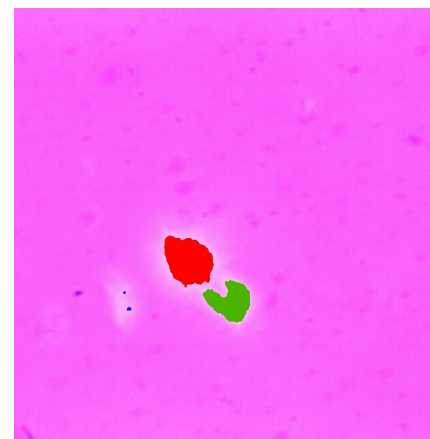
tracer particles

20µm

Offline system
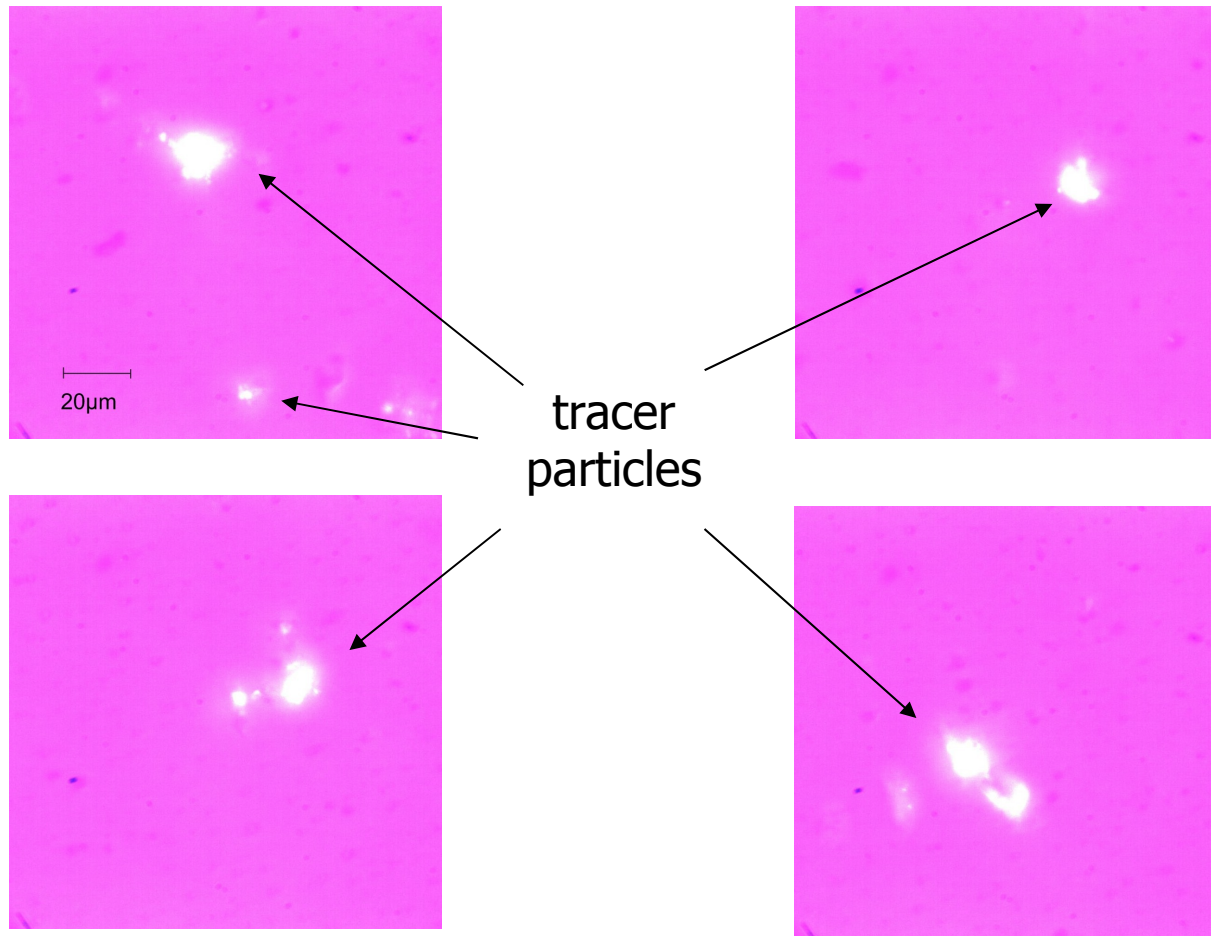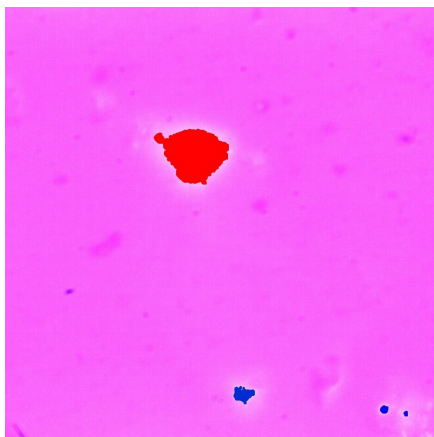
Aerosol particles are found automatically by a software based on the OpenCV library.
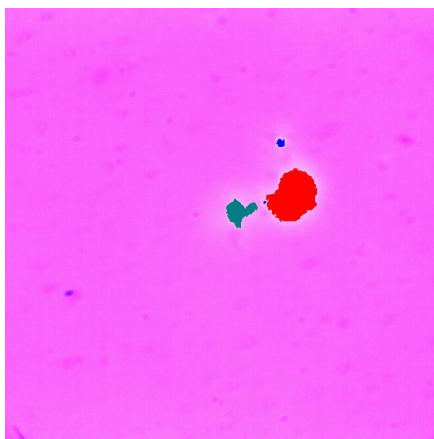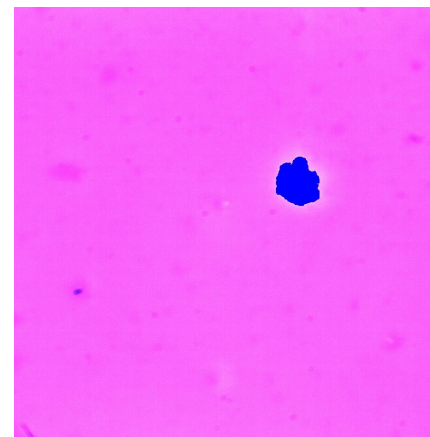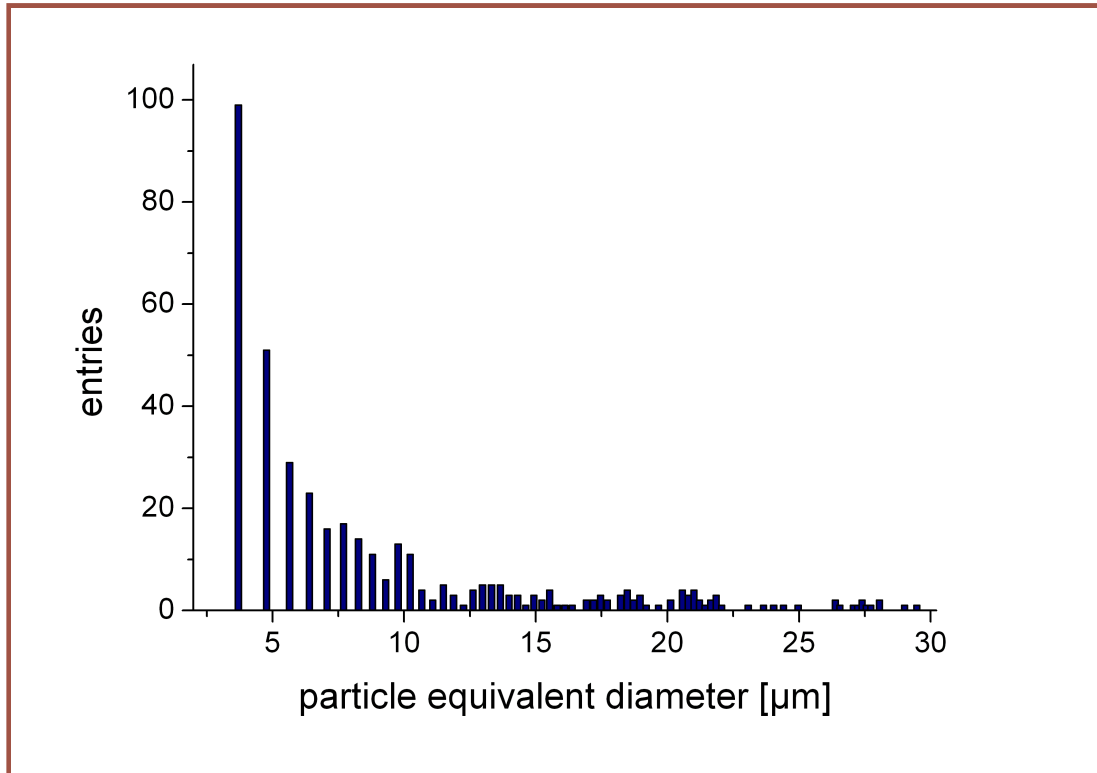
Here different particle sizes are colour-coded.
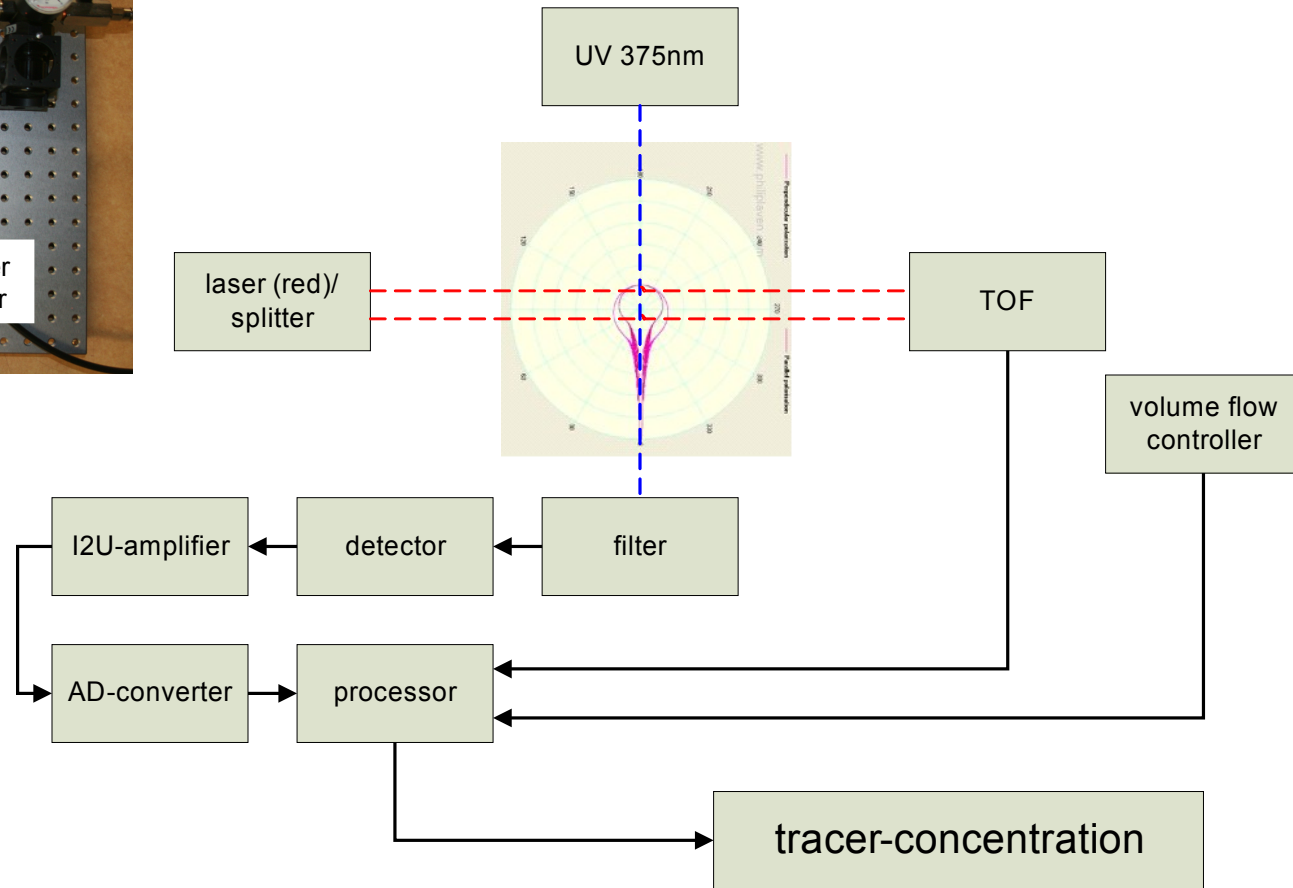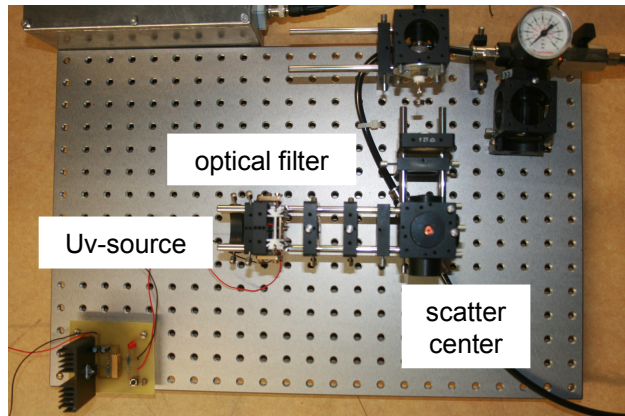
Offline system

size distribution of aerosol particles found on an object plate.

The object plate was dusted in a sedimentation chamber.

Online system

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