Model and field performance data for VOC measurements by IR camera

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Introduction

DCMR at a glance

Joint environmental protection agency

Rotterdam Harbor area: a heavily industrialised and densely populated region.

Main tasks

- issuing permits
- monitoring compliance
- monitoring environmental quality

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Introduction

Industrial fugitive emissions

Introduction

Aims

1) determine performance characteristics IR camera
2) develop model for estimating performance IR camera under real field conditions

to that end

a) laboratory test: determining detection limit under multiple conditions
b) field study: determining detection limit under real field conditions
c) calibrate model with laboratory data (A) and compare with field data (B)

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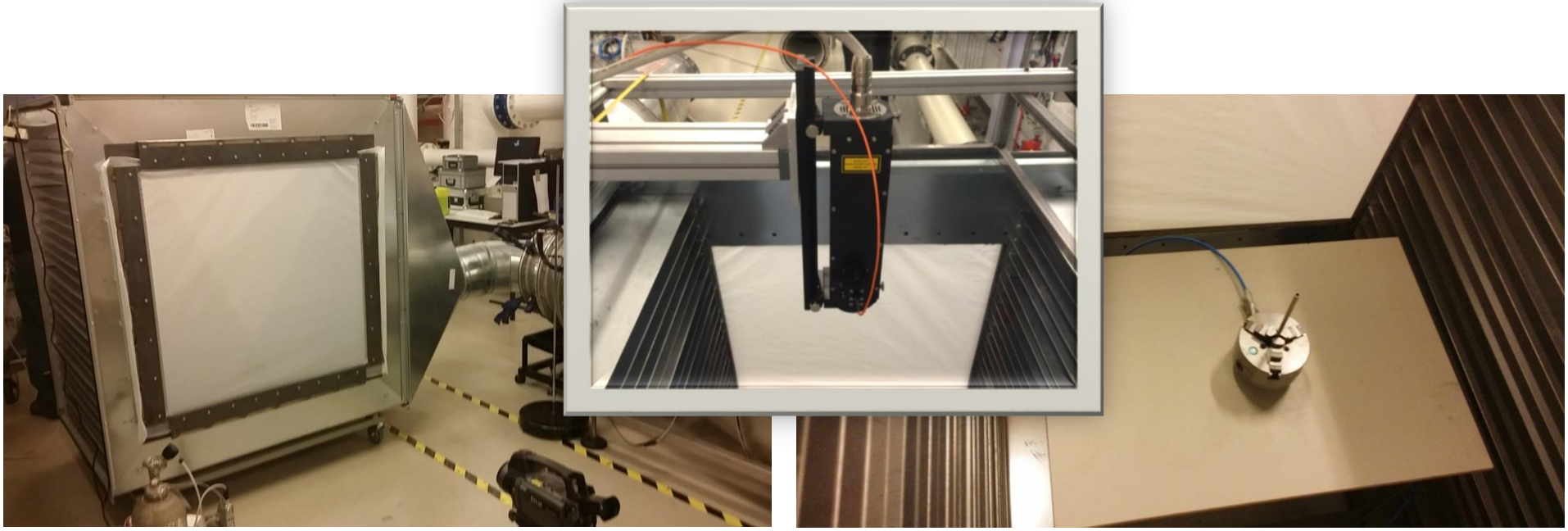
Laboratory experiments

Methods

Detection limit as a function of (1) temperature difference between the background and gas, (2) dilution of the gas, (3) wind speed, (4) viewing distance.



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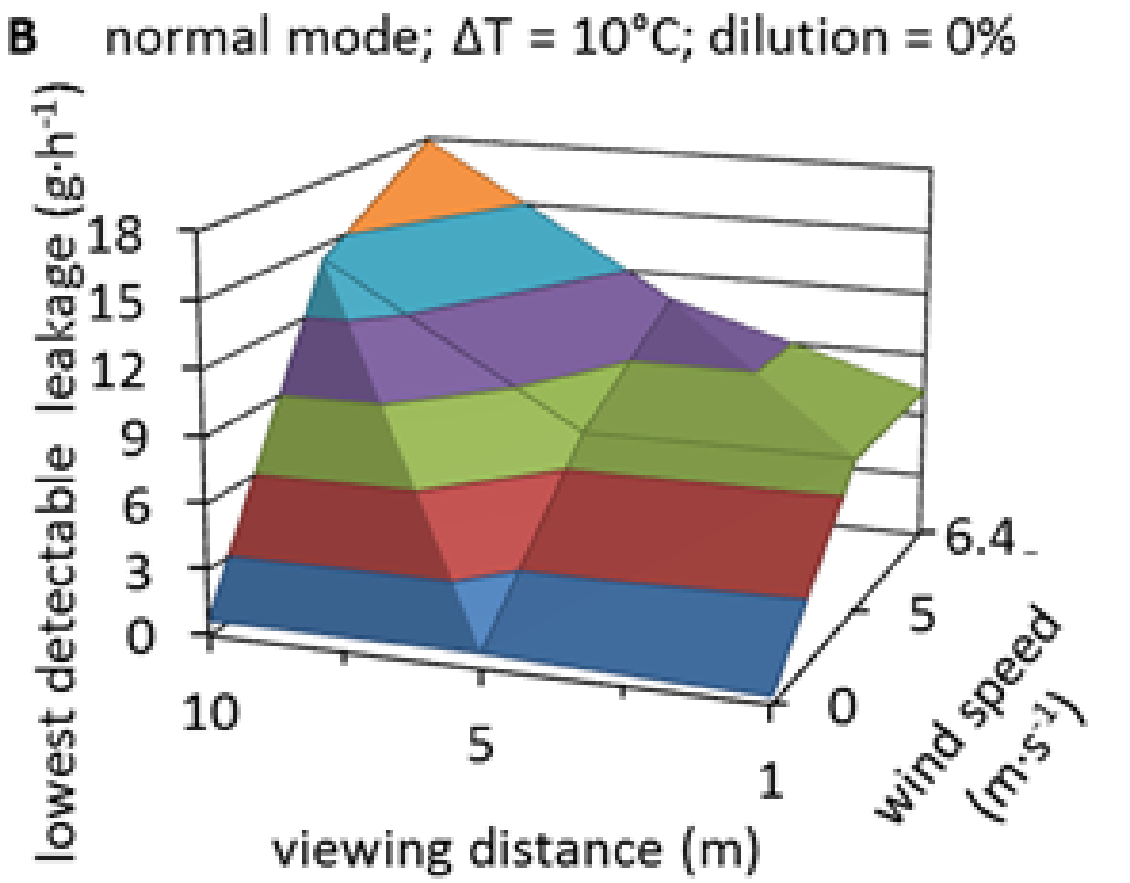
Laboratory experiments

Results



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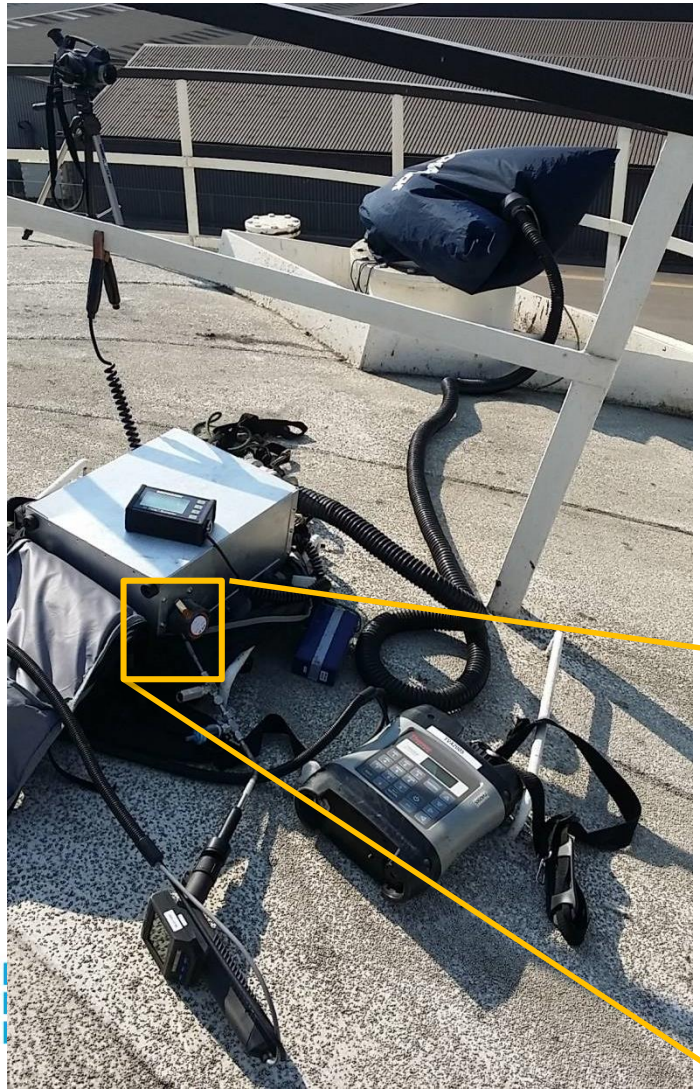
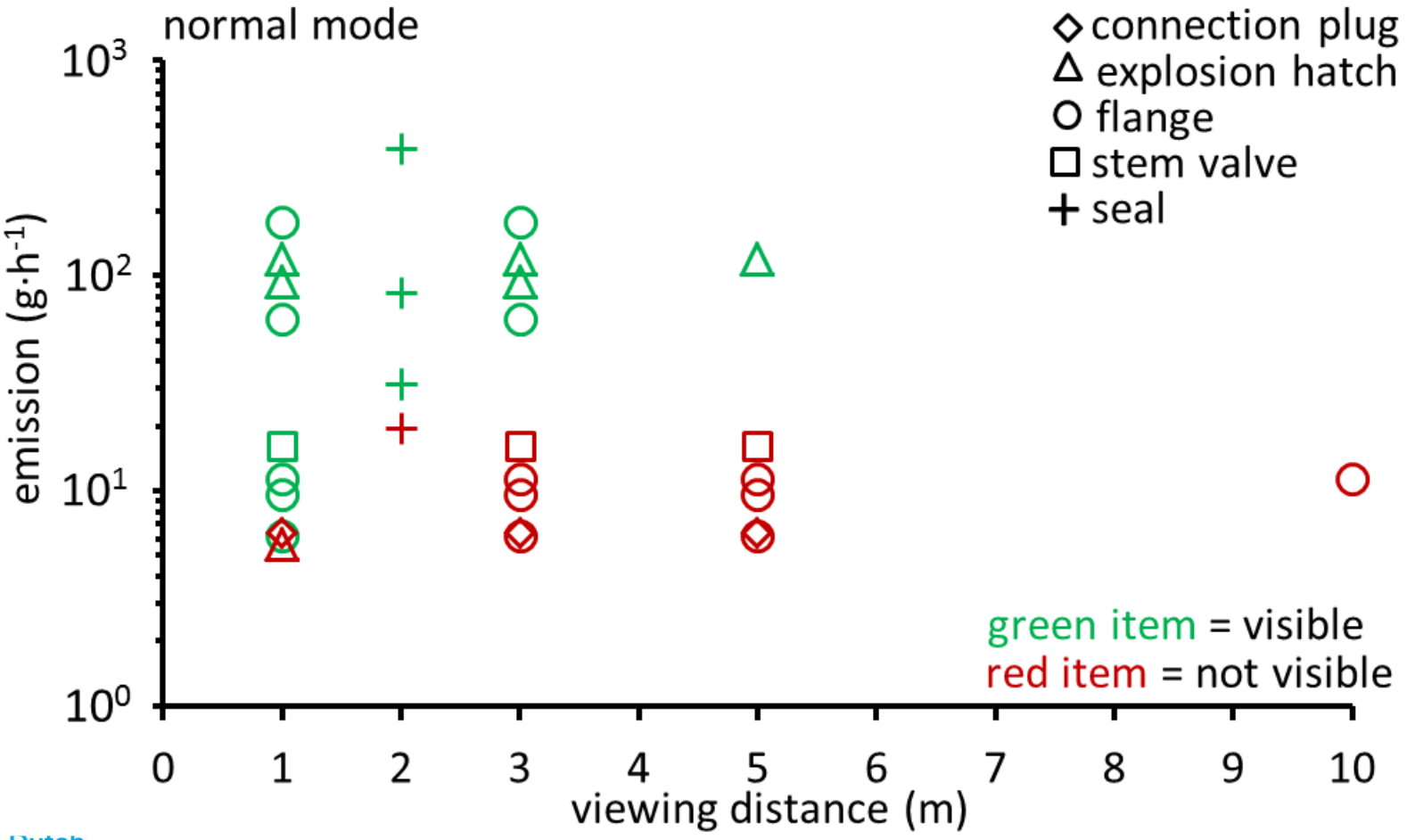
Field study

Methods



Field study

Results



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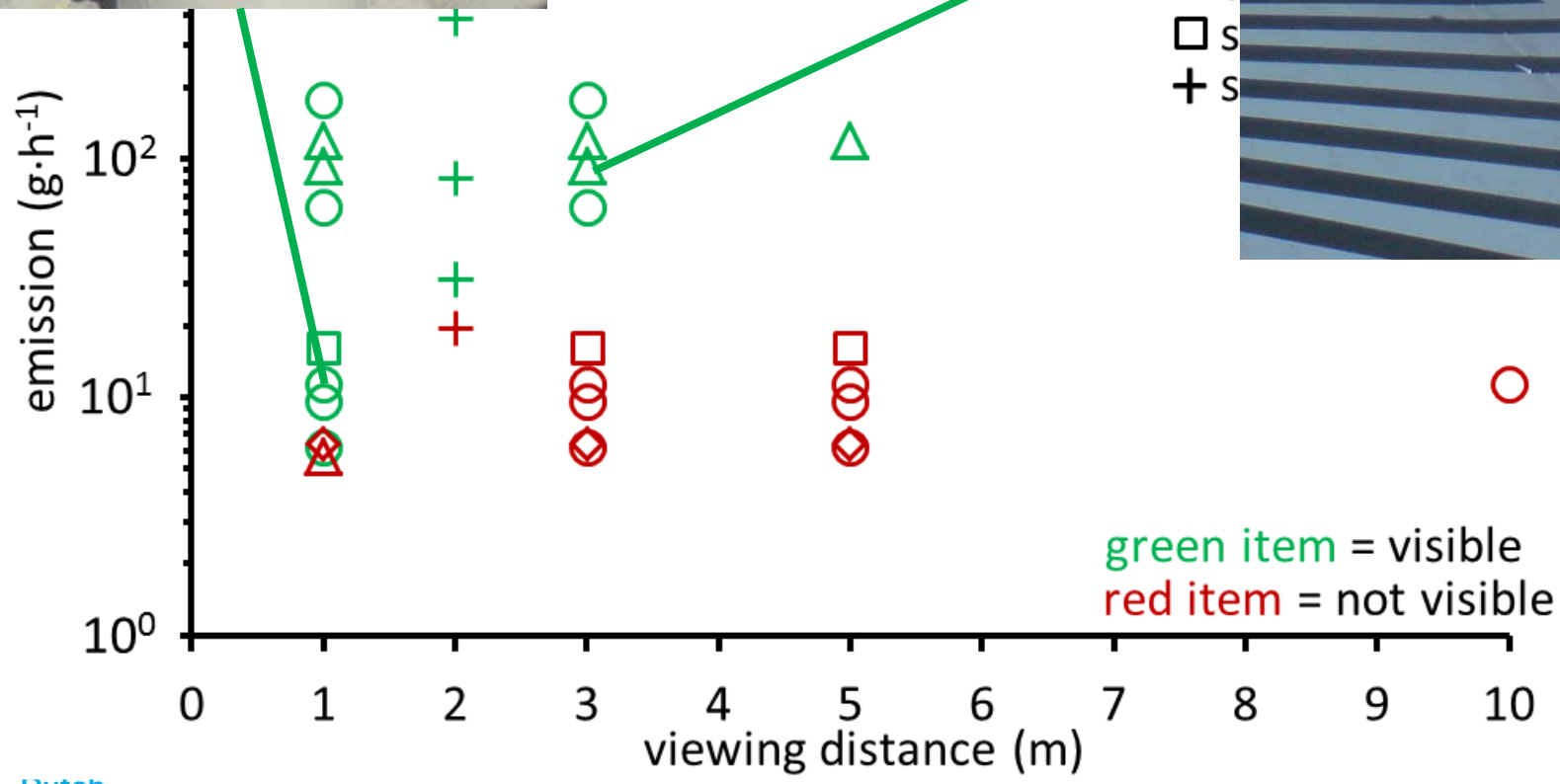
Field study



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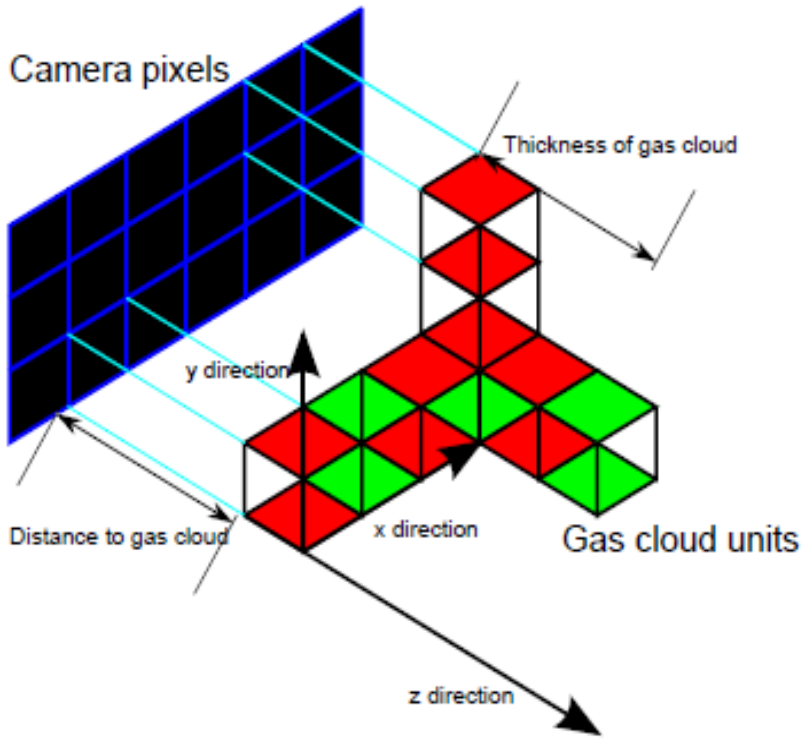
Modelling of the camera image in Matlab




```
%% The Background (objects)
epsb1=0.85;  %emissivity background (concrete)
epsb2=0.93; %emissivity background (glass)
Tb=280;     %Temperature background [K]
Bb=8*pi*h*c./labda.^5*1./(exp((-h*c)./(labda*Tb*k))); %I
matrixb=Systemsize;
matrixb(1:size(matrixb,1)/2,:)=epsb1; %matrix represent
matrixb(size(matrixb,1)/2+1:size(matrixb,1),:)=epsb2; %a
```

```
%% Total System
MatrixSystem=Systemsize;%preallocating
concl=conc.*l; %out of for loop is faster
dlabda=labda(2)-labda(1);
tic
for i=1:length(labda)
        taug=exp(-alphag(i)*concl); %transmittance gas
        MatrixSystem=MatrixSystem+Gaussian(labda(i))*(ma
end
MatrixSystem=dlabda*MatrixSystem;
toc
imshow(MatrixSystem,[]) %Creating the image
title('The system with varying concentrations')
```

Simple representation of the gas cloud, modeled as cubes with a uniform concentration. Not all the cubes are drawn, for clarity

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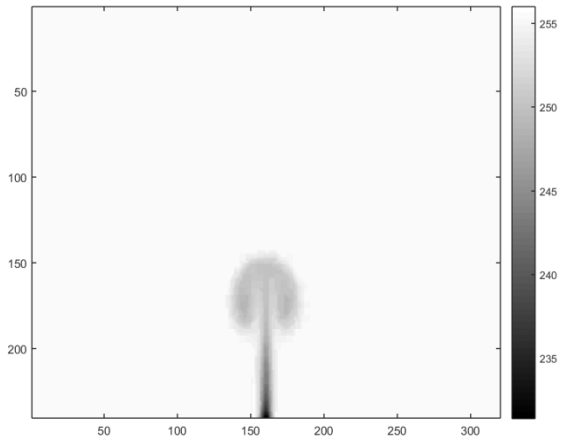
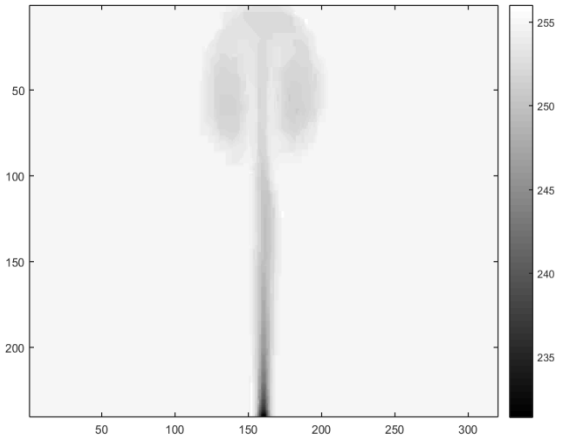
CFD modelling

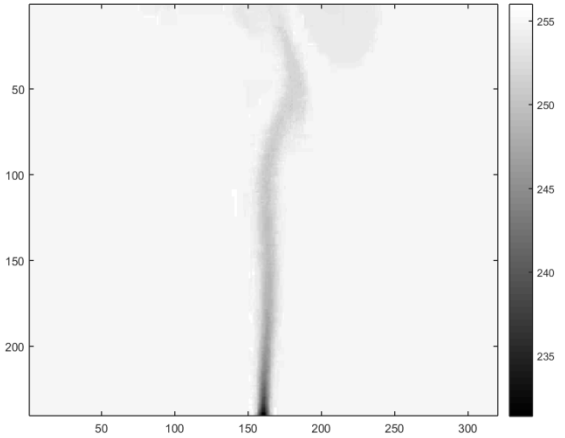
RESULTS: CFD simulation



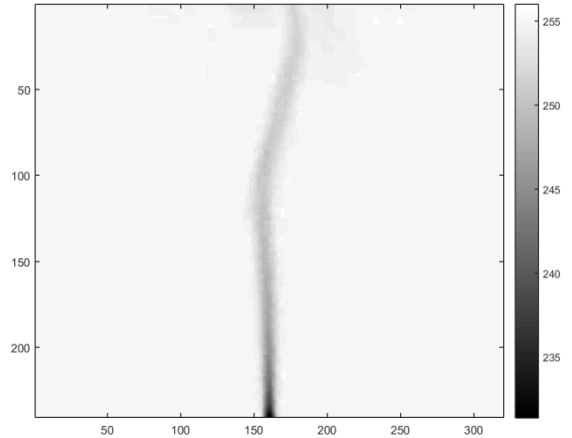
frame time = t_2



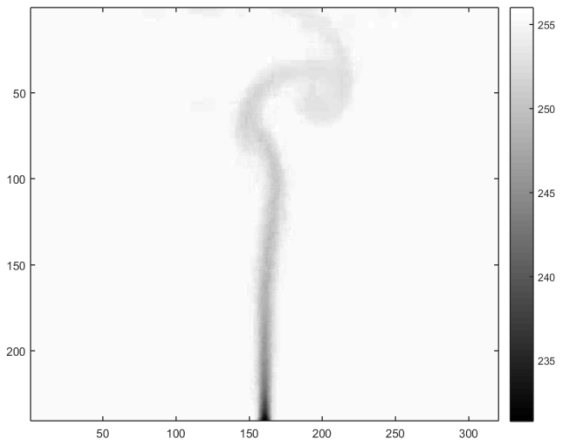
frame time = t_3



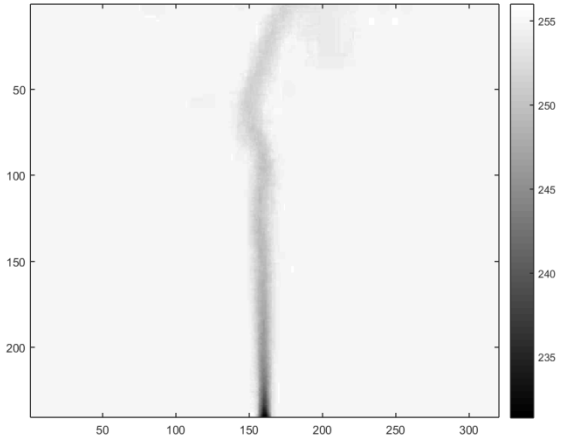
frame time = t_{10}



frame time = t_{20}

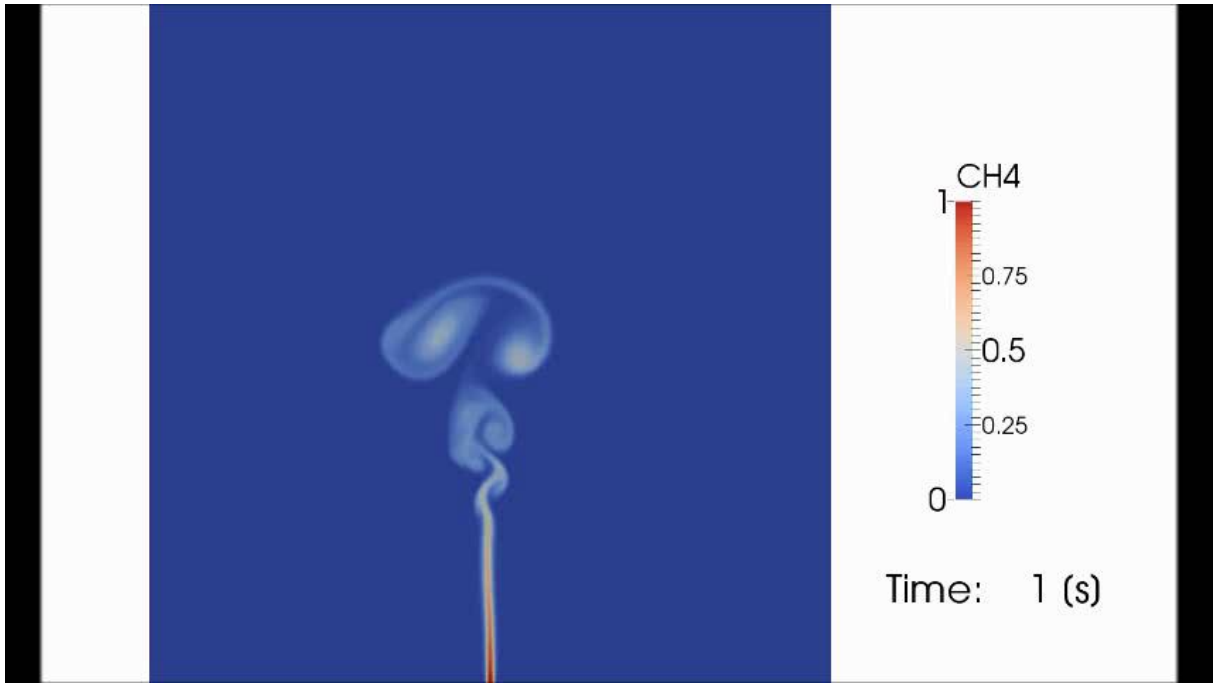


frame time = t_{29}



frame time = t_{30}

CFD MODELLING



Case: no wind
6 mm nozzle
100 L/h methane

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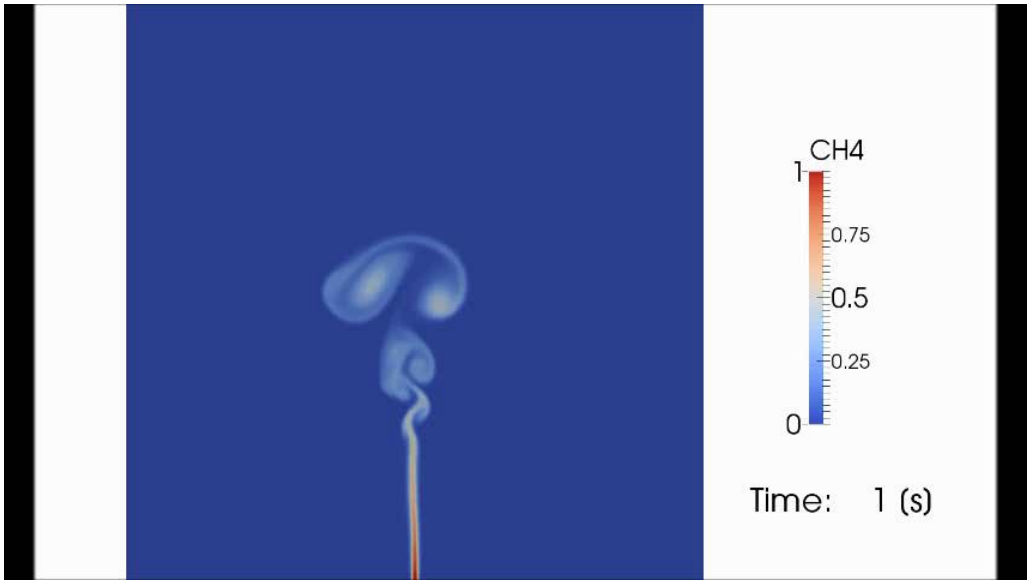
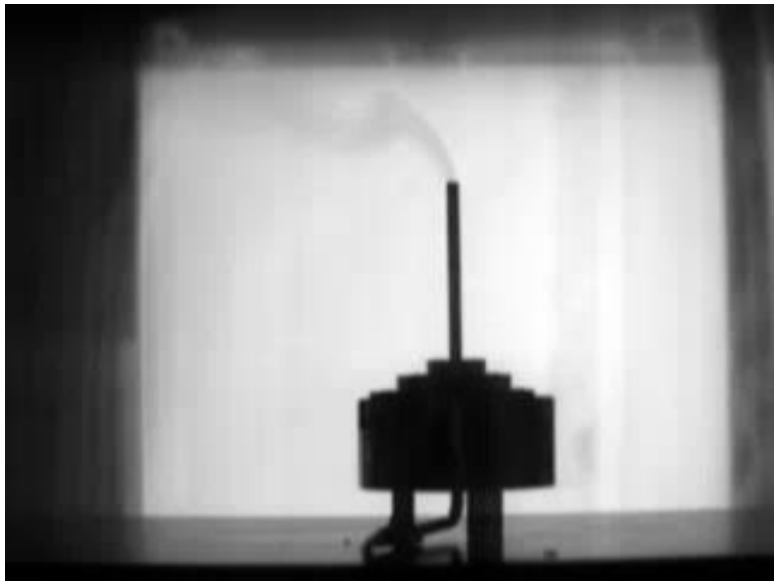
Modelling vs lab experiment





Case: no wind

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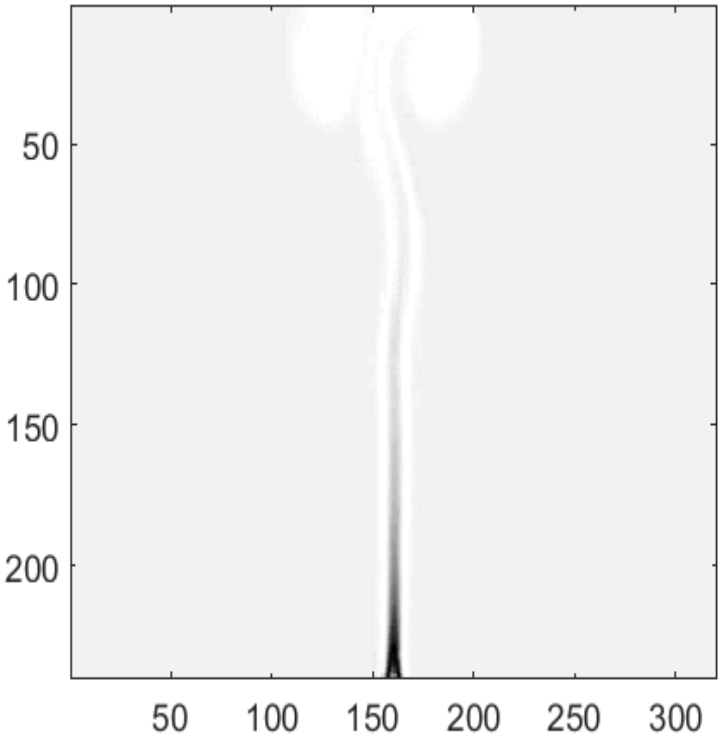
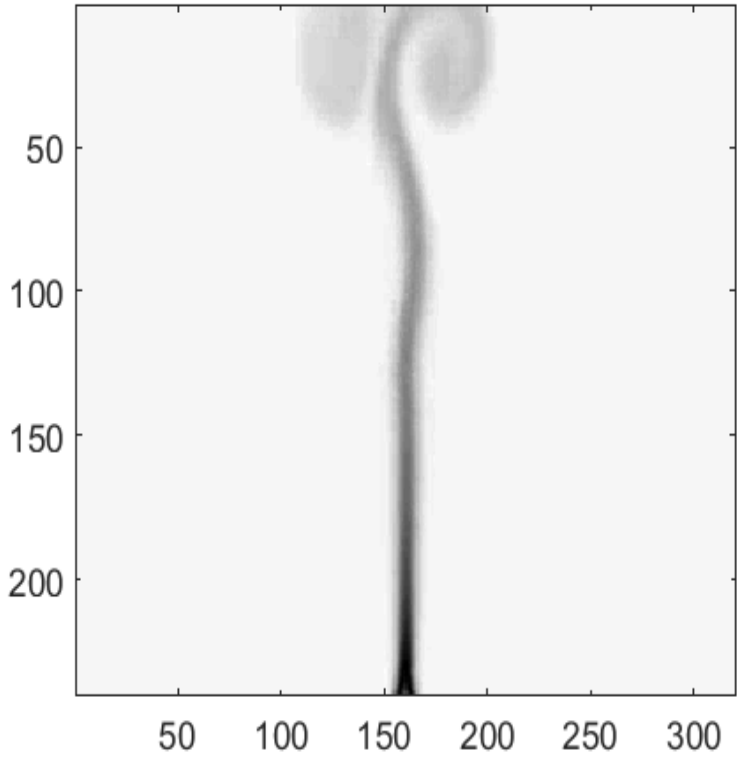
Modelling example: Influence of temperature difference



b) $\Delta T = 0.5\ ^{\circ}C$, flowrate = 10 l/h



b) $\Delta T = 15\ ^{\circ}C$, flowrate = 10 l/h

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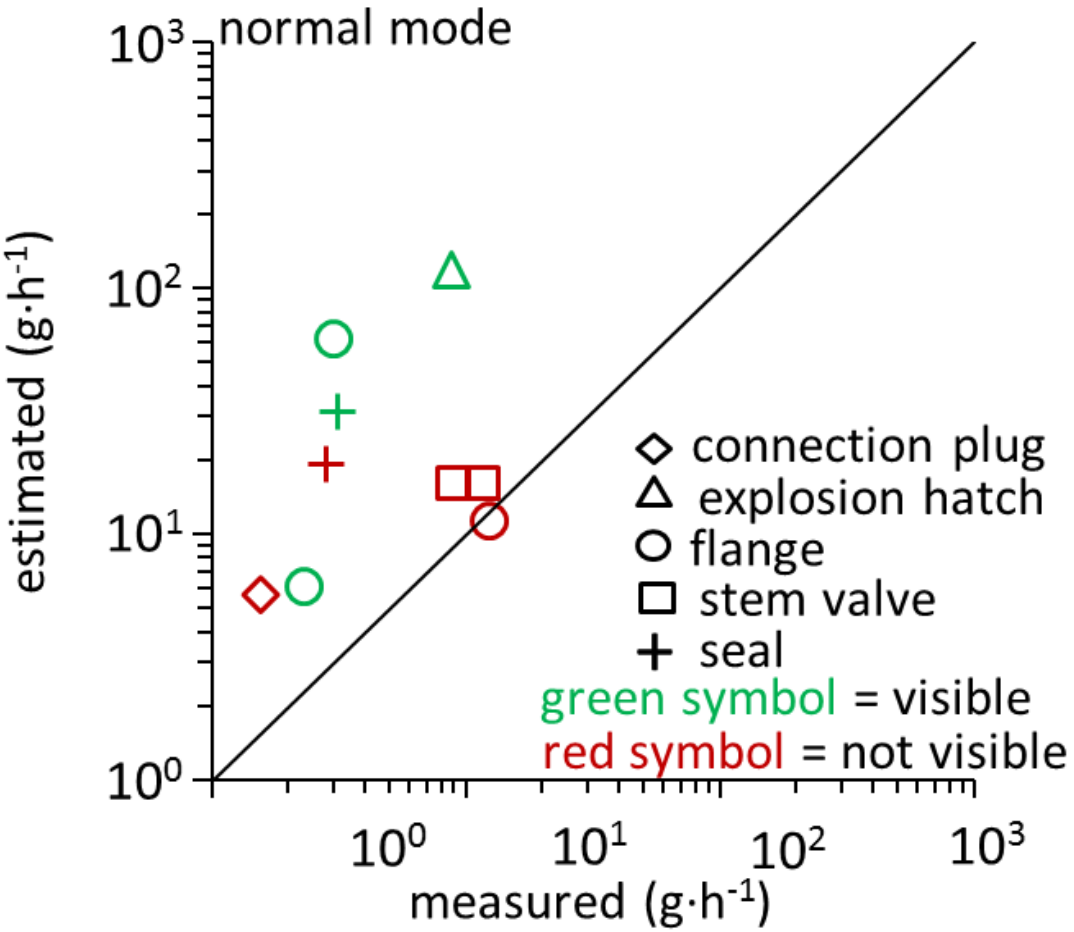
Model vs field

Results



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CONCLUSIONS

1. *Field Study*: detection limit of sniffing technique was lower than IR camera → use combination of both techniques in Leak Detection And Repair programs (LDAR).

2. *Model Equation*: provides a first estimation of minimum leak rate (g/h) → estimation of real leak rate is better, but notoriously complex.

3. *Camera Response Model*: some assumptions had to be made as data on e.g. IR band pass filter are not disclosed by the manufacturer.

ACKNOWLEDGEMENT

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