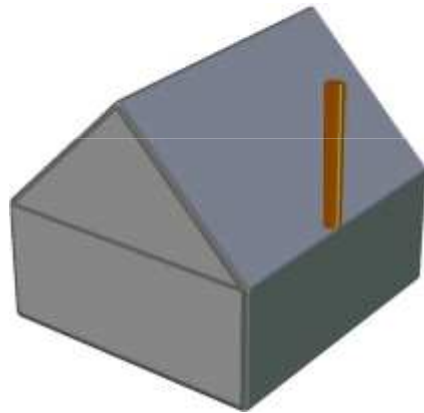


Smoke Dispersion from Stacks on Pitched-Roof Buildings: Model Calculations Using MISKAM in Comparison with Wind Tunnel Results



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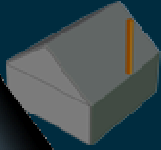
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Department of Atmospheric Environment



outline

scope

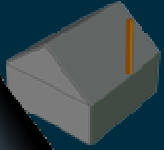
method

results

discussion

- ✓ Scope of the current work
- ✓ The methodology to reproduce the wind tunnel experiments in WinMiskam v6 & the employed case studies
- ✓ The results for a representative case study and the additional sensitivity tests
- ✓ Conclusions and discussion

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outline

scope

method

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discussion

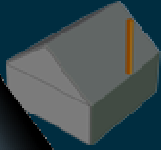
Study of the dispersion from Stacks:

- Increasing oil prices domestic increased significantly the use of wood combustion
- Residential wood combustion is a very significant source of particle pollution (Bari *et al.*, 2009).
- In Denmark this source is responsible for to more than half of the direct PM_{2.5} particle emission in the country (Glasius *et al.*, 2008)

question:

Selection of the appropriate stack height/ position





outline

scope

method

results

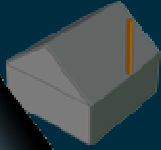
discussion

- Pollution modelling for urban air quality applications has been based mainly on operational models of an integral nature.
- Use of CFD models to address the same problems is increasing rapidly.
- Among available CFD models the Reynolds averaged Navier–Stokes (RANS) equation models are increasingly used.
- A number of studies supports the application of CFD tools
- An equal number of studies raises significant issues



question:

are CFD tools appropriate for this type of studies?
is MISKAM a reliable/ accurate tool for this type of studies?



outline

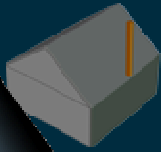
scope

method

results

discussion

- **Wind tunnel** experiments from:
Jensen A.B., "Røgspredning i områder med lav bebyggelse", Laboratoriet for varme - og klimateknik, DTH, 1984 (draft report).
 - *Variable stack height*
 - *variable roof slope*
- **Computational Programs:**
WinMiskam (*Miskam v5 and v6*),
Ingenieurbüro Lohmeyer GmbH & Co. KG
 - *k- ϵ turbulence model*
 - *Finite differences (structured Cartesian mesh)*
 - *Advection-diffusion equation for passive gases****Ansys Inc. Fluent & CFX***,
 - *k- ϵ turbulence model*
 - *Finite Volume*



outline

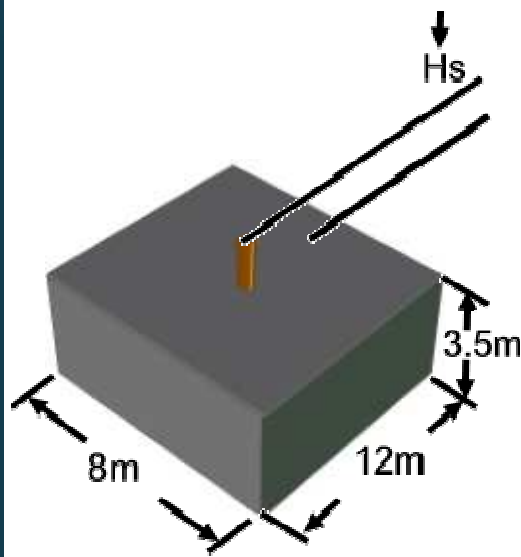
scope

method

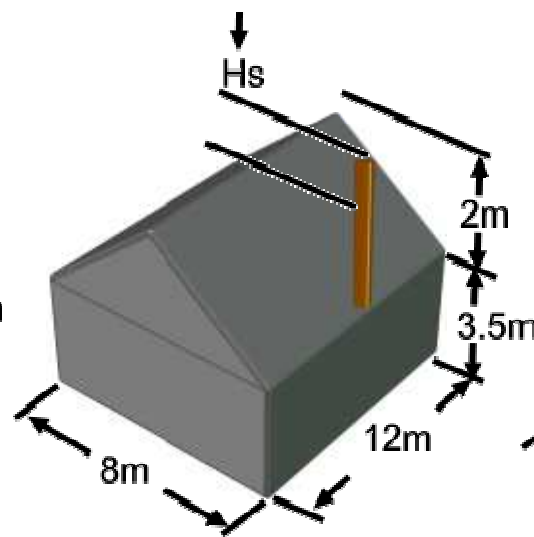
results

discussion

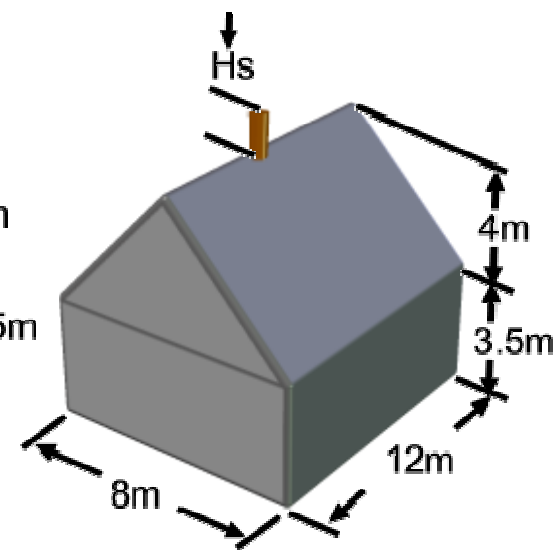
Three different types of buildings
stack height (H_s) varied from 0.0 m up to 8.0 m



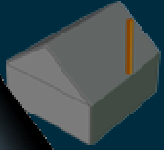
flat roof
stack at the center



30° roof
stack at the side



45° roof
stack at the center



outline

scope

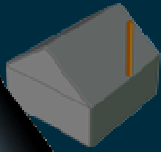
method

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Computational mesh

- Domain size
length: 100 m, width: 90 m, height: 70 m
- **Coarse** Resolution (mesh size)
building & near building: 0.5 m
expansion ratio: <1.2
- **Fine** Resolution (mesh size)
building & near building: 0.1 m
expansion ratio: <1.2



outline

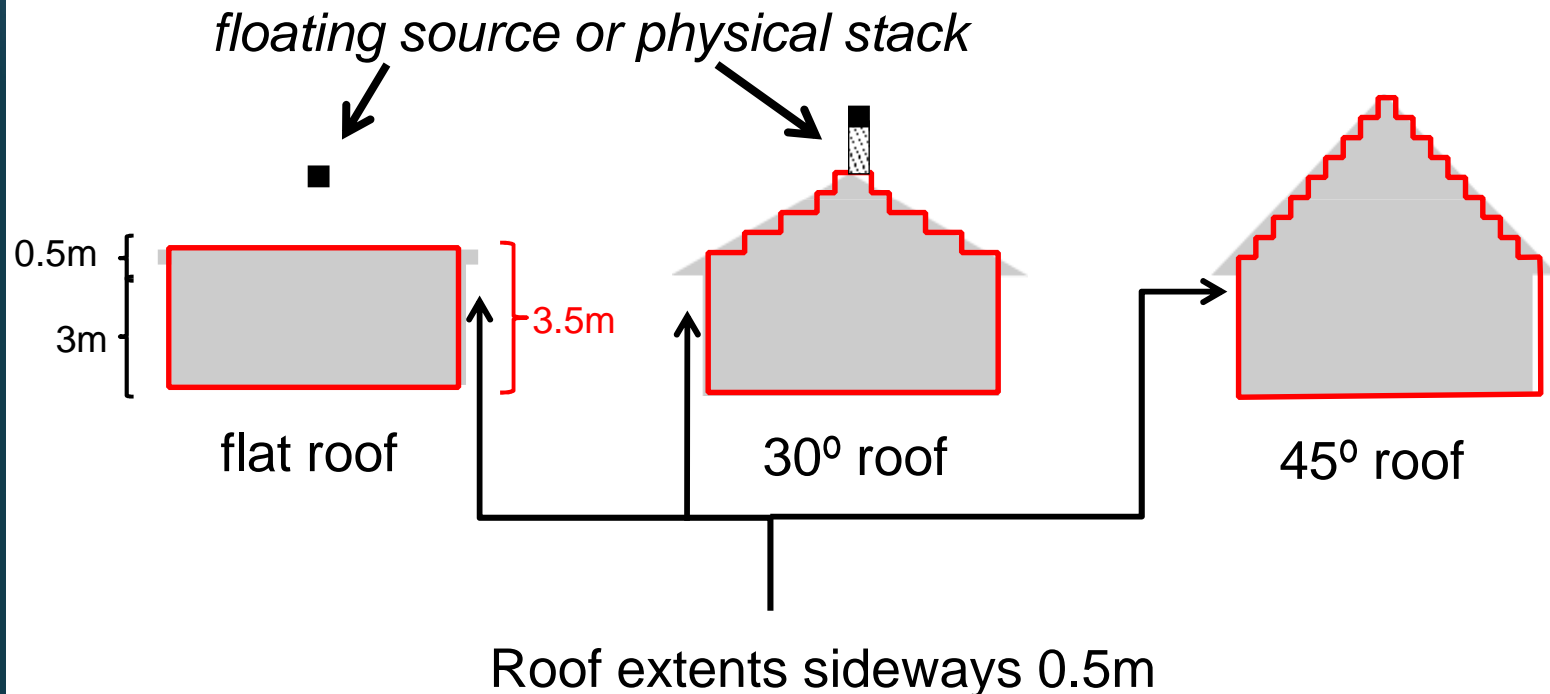
scope

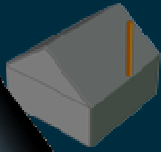
method

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Representation of the building and the roof is limited by the mesh resolution





outline

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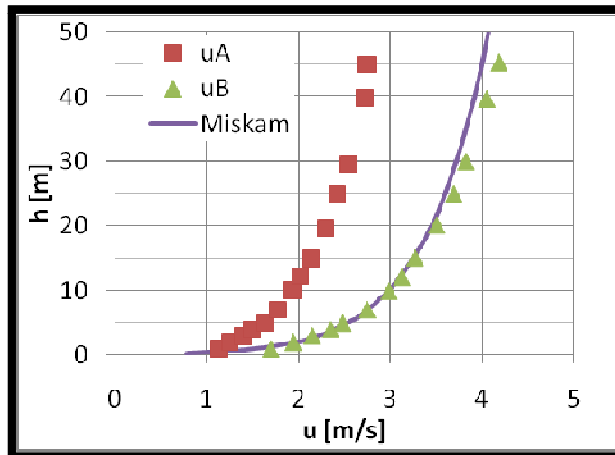
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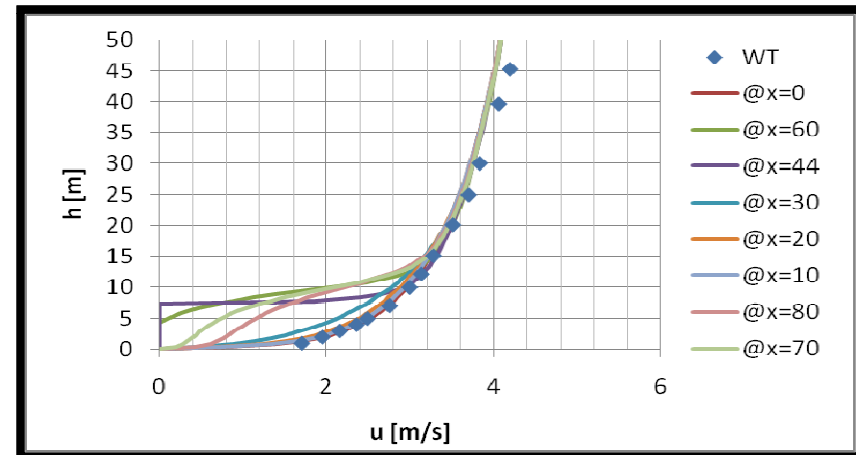
Wind tunnel measurements/data

Wind profile: $u_A^* = 0.19 \text{ m/s}$; $u_B^* = 0.28 \text{ m/s}$
 $z_o = 0.13 \text{ m}$

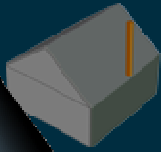
Roughness: ground 0.10 m
walls 0.01 m



Comparison of profiles @ the inlet



Calculated profiles @ various x positions



Dispersion from Low Stacks on Pitched-Roof Buildings

[1/5]
graphs outline

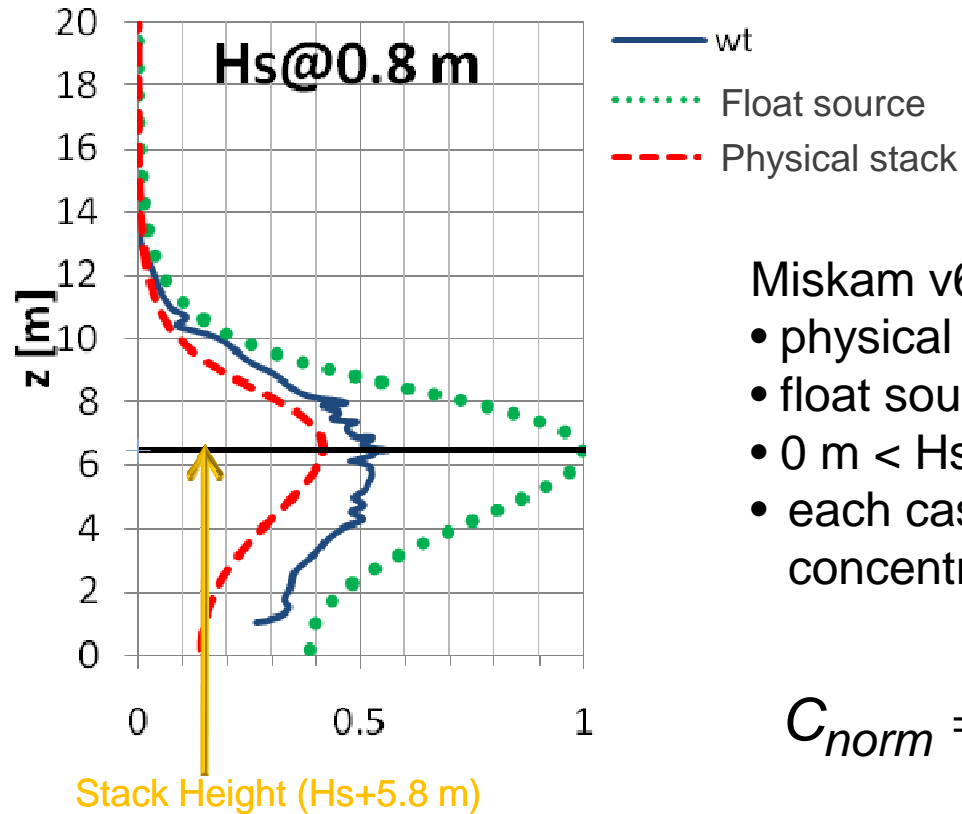
outline

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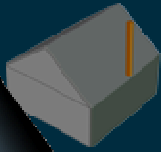


Miskam v6

- physical stack
- float source
- $0 \text{ m} < H_s < 8 \text{ m}$
- each case normalized to max concentration of all H_s

$$C_{norm} = \frac{C}{C_{max|all}}$$

Vertical profile of concentration 15 m downwind from the stack



Dispersion from Low Stacks on Pitched-Roof Buildings

[2/5]

30deg;Miskam v6;Float vs Physical

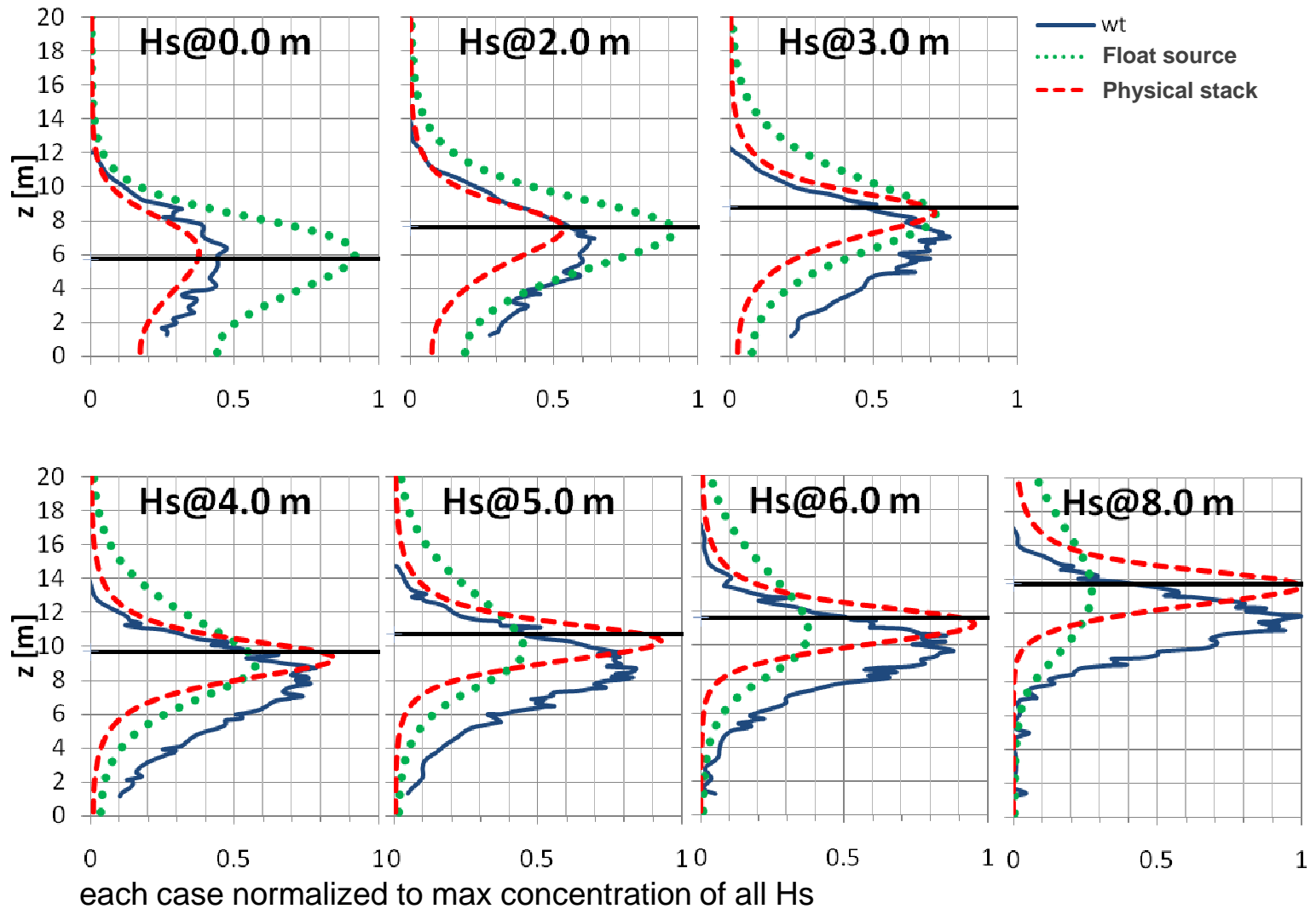
outline

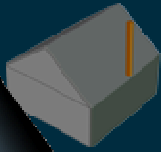
scope

method

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discussion





Dispersion from Low Stacks on Pitched-Roof Buildings

[3/5]

30deg; Miskam v6 vs CFX

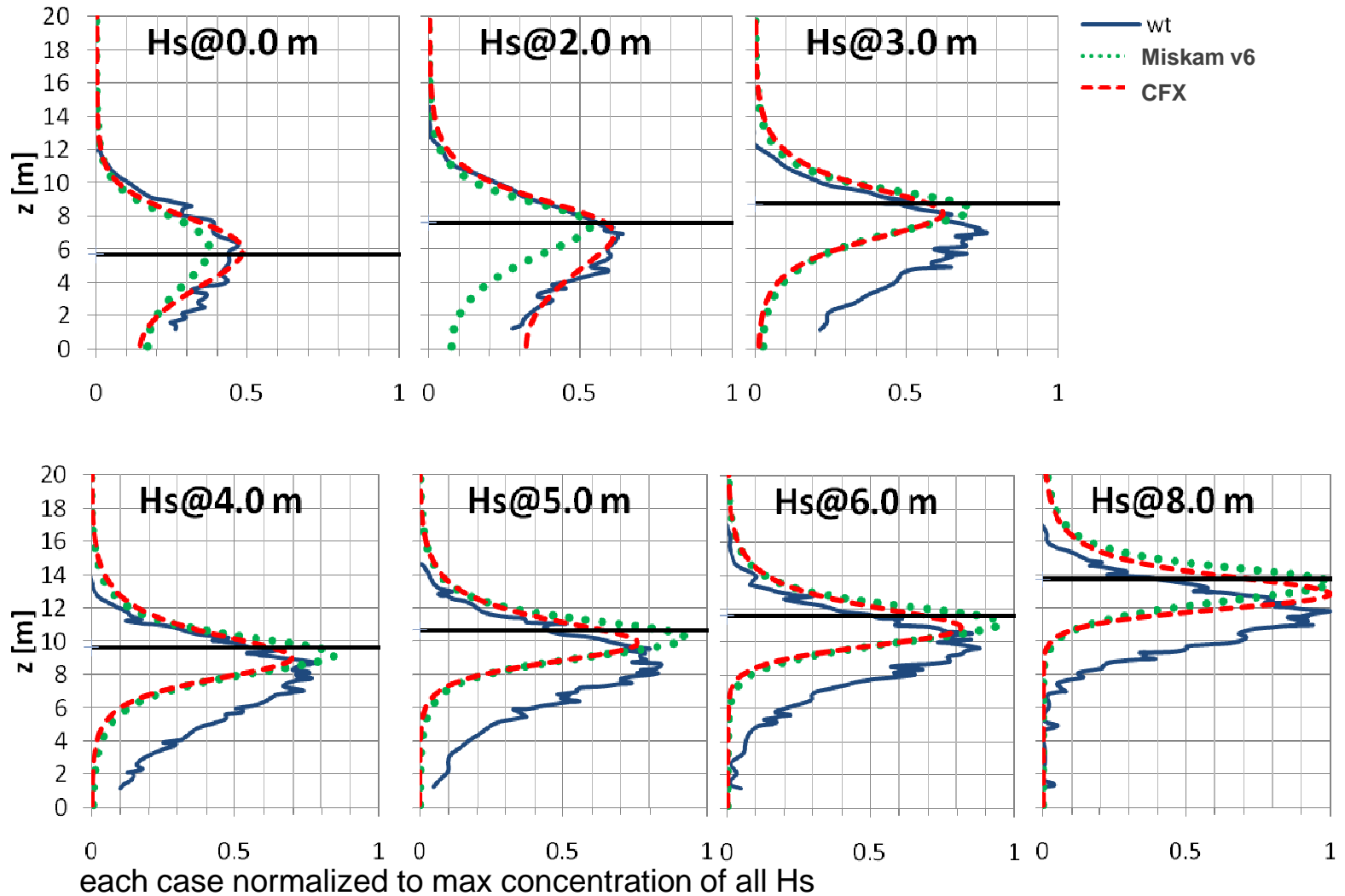
outline

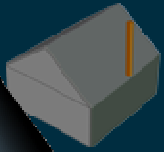
scope

method

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discussion





outline

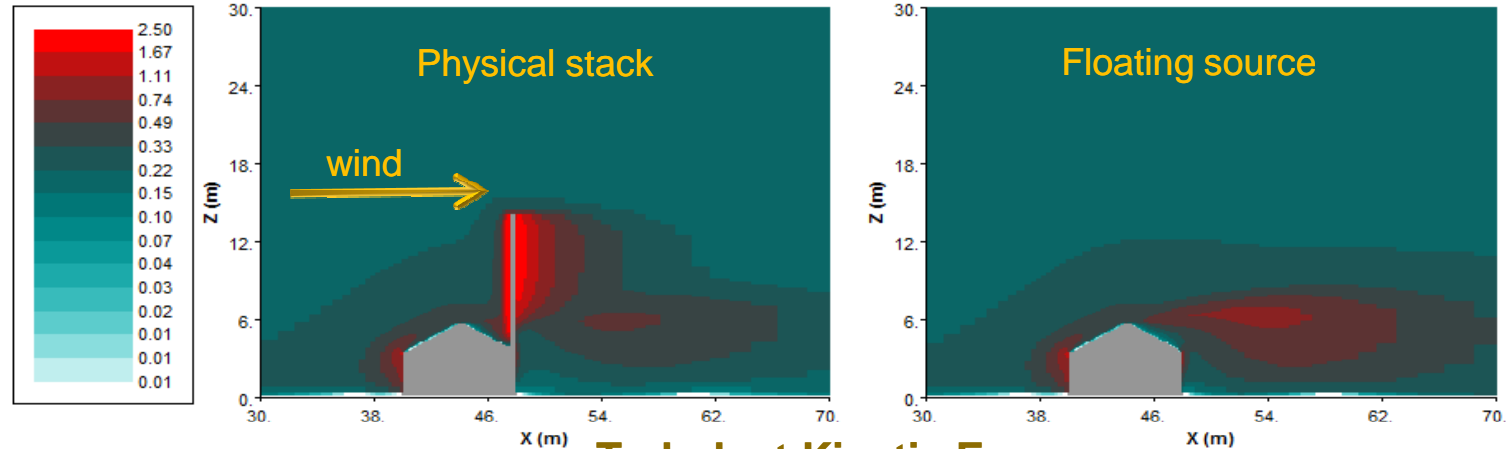
scope

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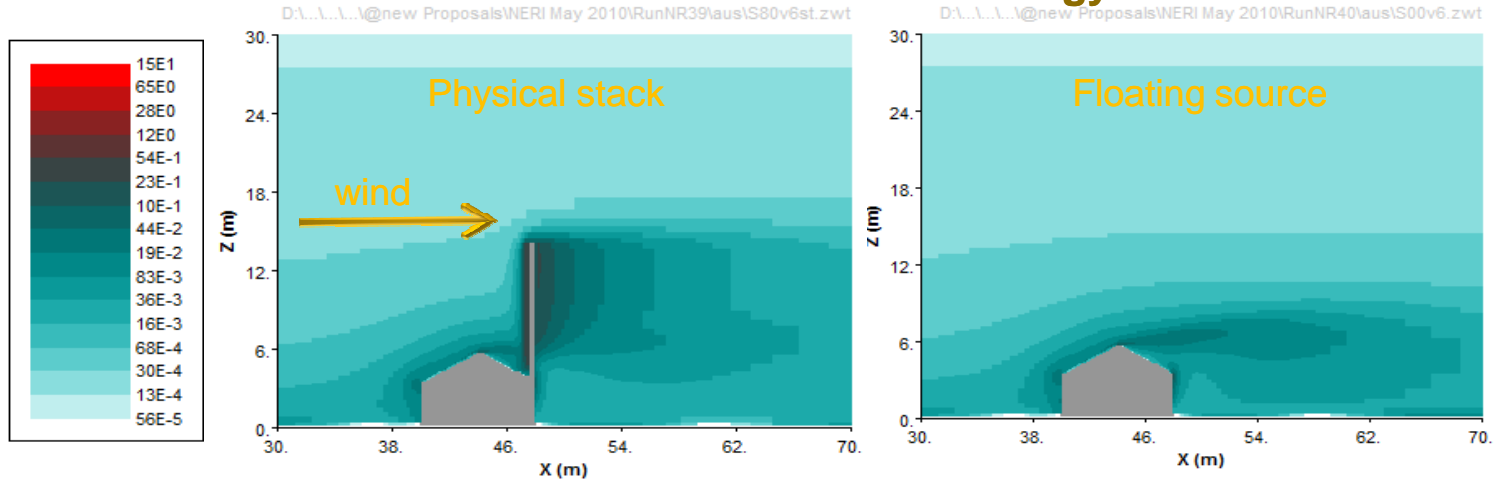
results

discussion

Contour plots @ vertical along wind cut

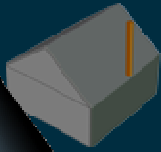


Turbulent Kinetic Energy



Turbulent Eddy Dissipation





Dispersion from Low Stacks on Pitched-Roof Buildings

[5/5]

turbulence; 30deg roof

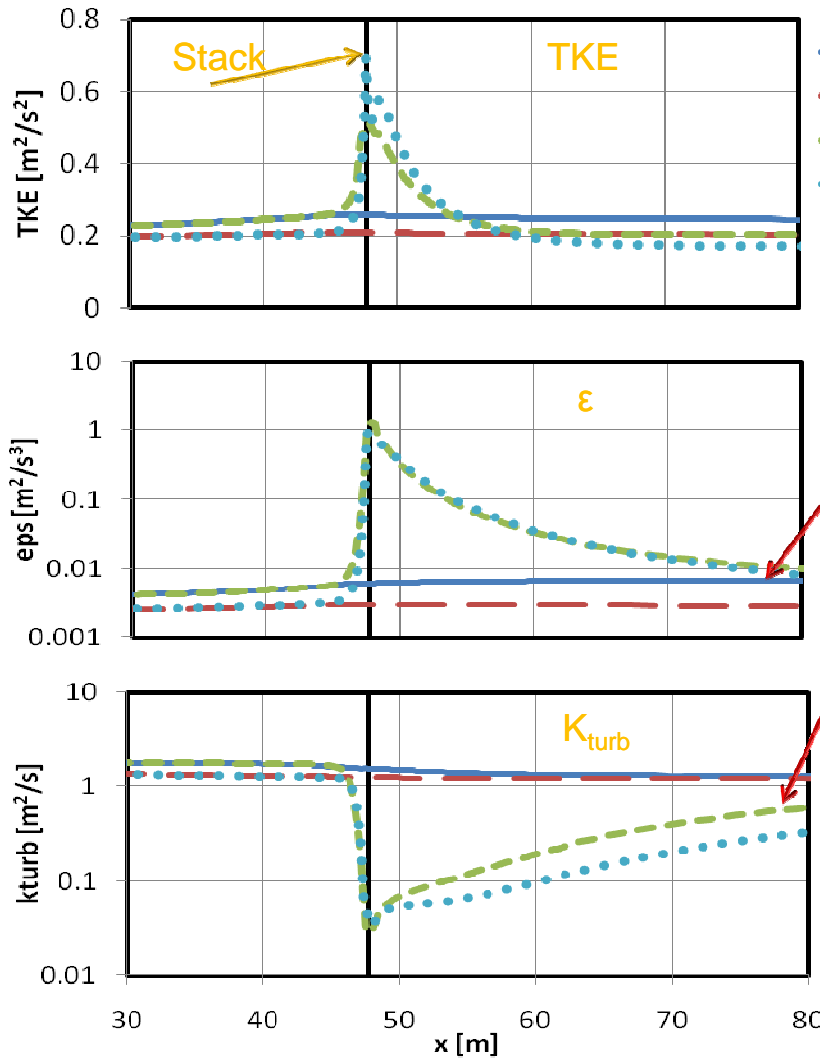
outline

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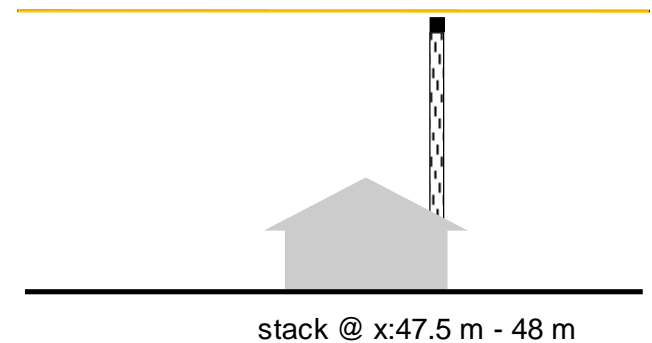


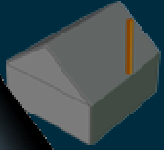
— CFX base
 - - M base
 - - CFX Stack
 ··· M Stack

Base case:
building without stack

the “k-ε syndrome” (R. Berkowicz)
Is more profound in Miskam & also
influences K_{turb}

Horizontal cross-line @8.0 m





outline

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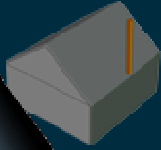
Question 1:

Selection of the appropriate stack height/ position

Relation of stack height and roof-slope on the dispersion of smoke from woodstoves

- Wood firing guide – toolbox
- Chimney height: rules and recommendations
- Sample collection of input

- For more details please contact
Helge Olesen, NERI, DK



outline

scope

method

results

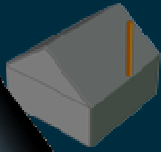
discussion

Question 2:

Is MISKAM (either CFD) appropriate for this type of studies (i.e regulatory)

- The inlet wind profile is adequately simulated and maintained along the domain
- a physical stack represented in the model demonstrates an unexpected large influence on the results PROBABLY:
 - the MISKAM ($k - \epsilon$) approach to calculate the diffusion coefficient,
 - the incorrect employment of the boundary conditions by MISKAM, (e.g. roughness of the vertical walls)
 - the lack of sufficient wind tunnel data to examine MISKAM performance on the simulation of turbulent kinetic energy, dissipation and dispersion
- CFD tools are useful air pollution tools and reliable when are employed by experienced personnel and after validation

Thank you...



Dispersion from Low Stacks on Pitched-Roof Buildings

[1/7]

concentration; 30deg roof

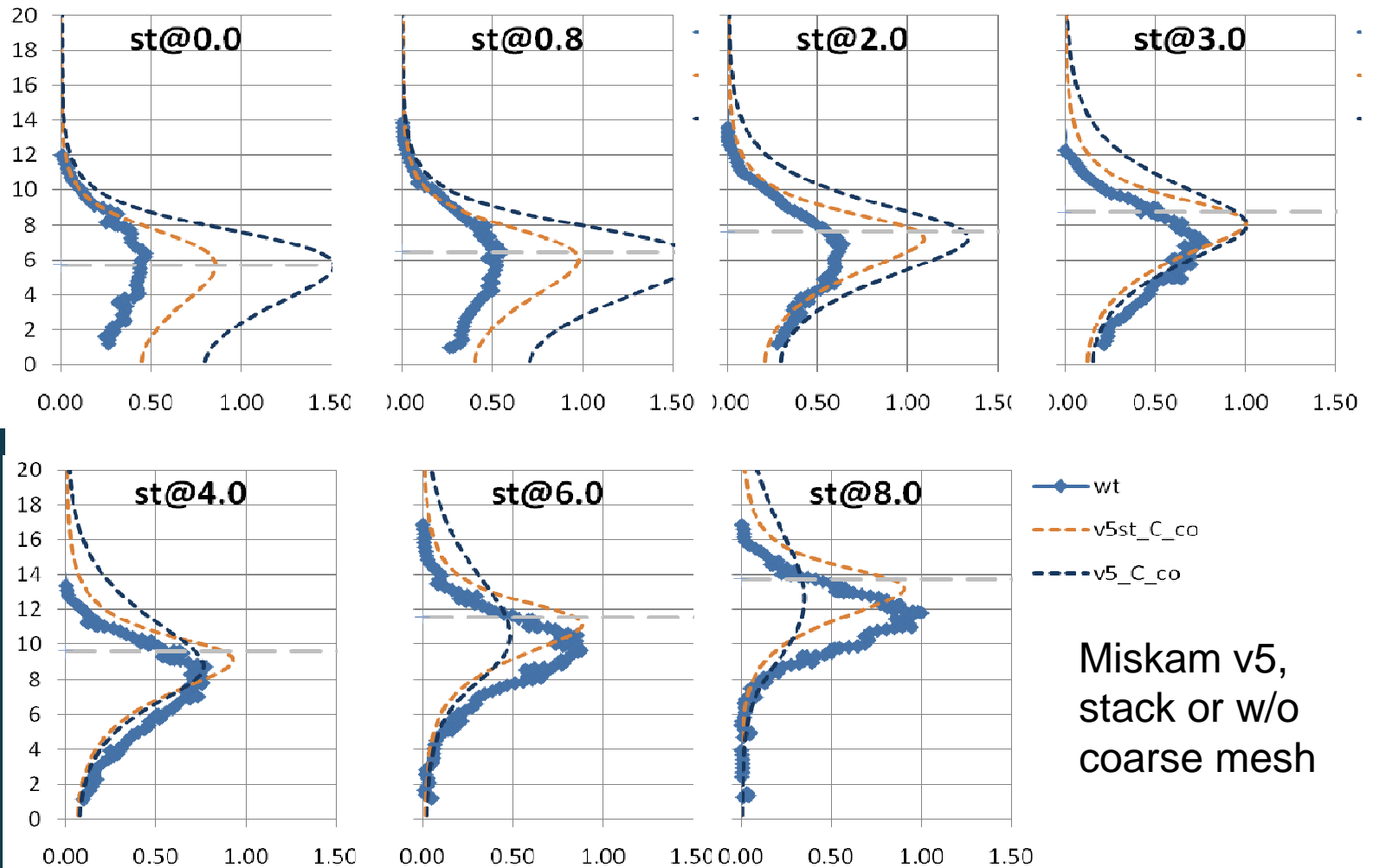
outline

scope

method

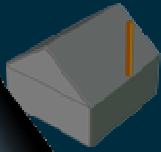
results

discussion



Each case normalized to max concentration st@3.0





Dispersion from Low Stacks on Pitched-Roof Buildings

[6/7]

turbulence; 30deg roof

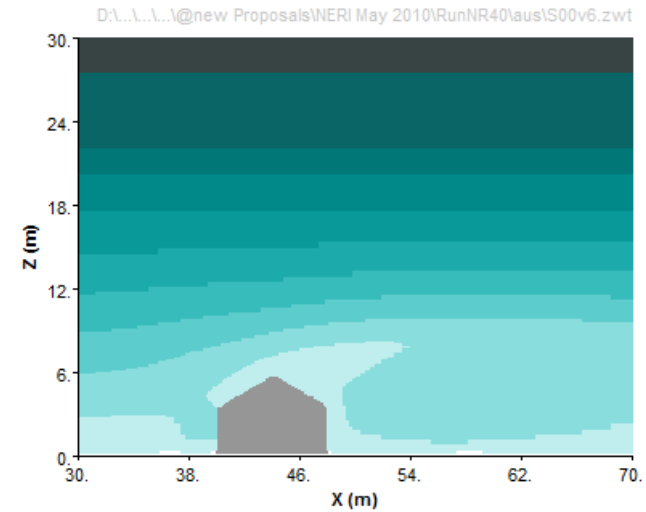
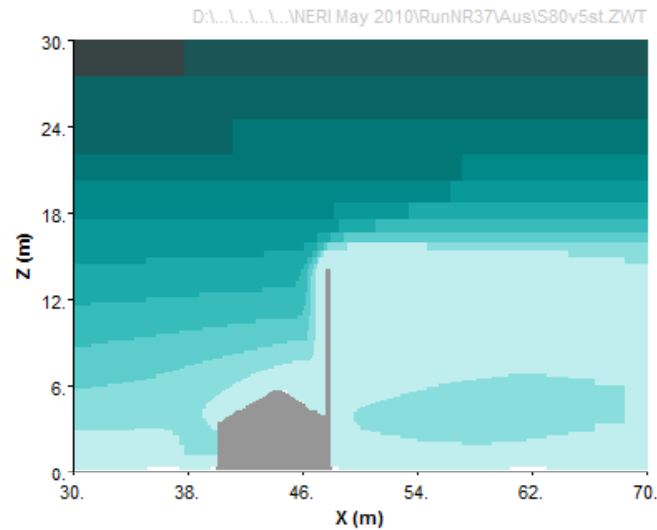
outline

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Turbulent Diffusivity
Miskam v6

