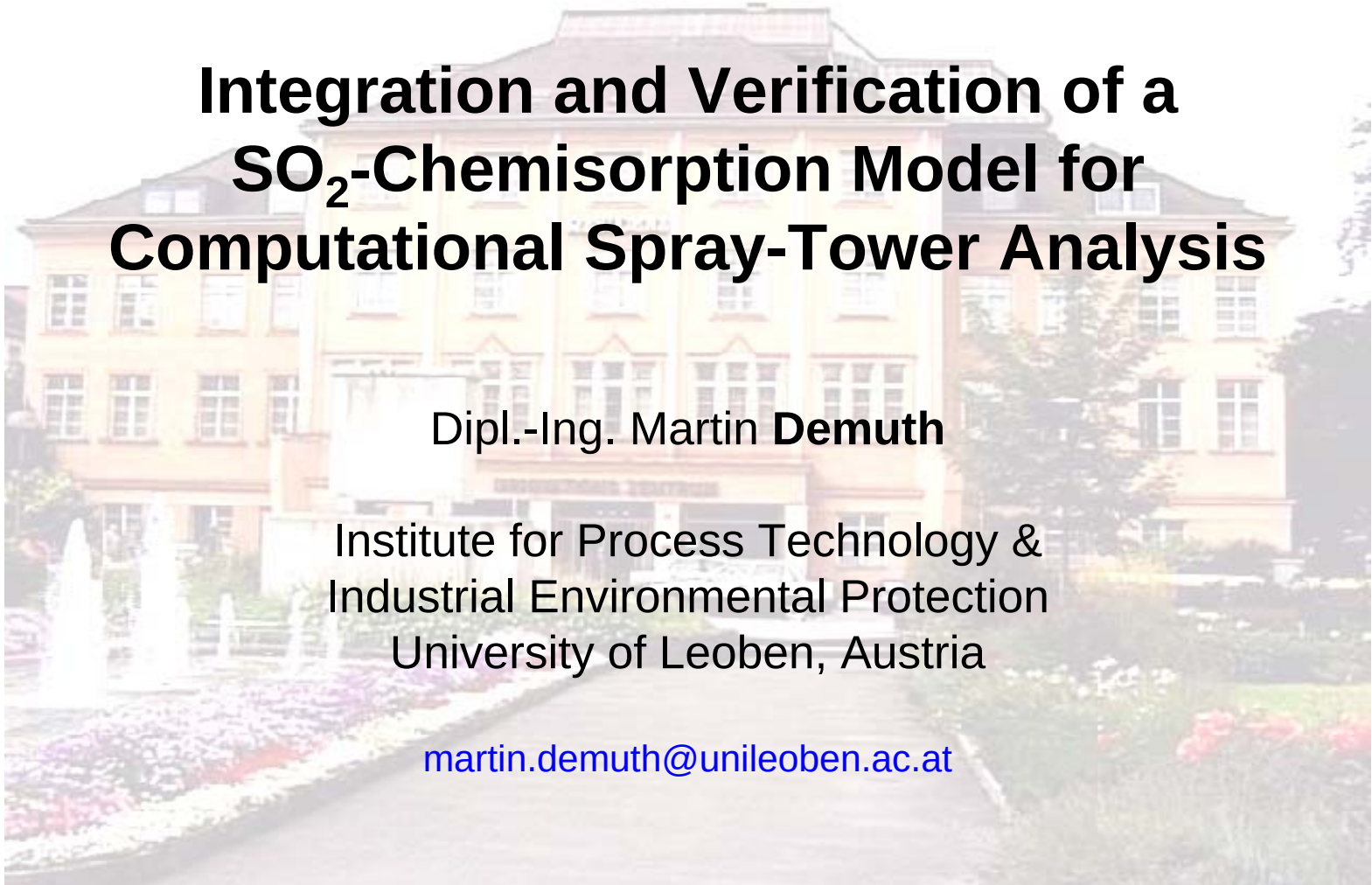

Integration and Verification of a SO_2-Chemisorption Model for Computational Spray-Tower Analysis

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General

- Introduction spray-tower
- Overview CFD-setup
- SO_2-chemisorption model

Verification

- Pending droplet experiment (pH-value progression)
- Pilot-scale scrubber (1.4 m diameter)
- Industrial-scale scrubbers (4.2 m, 15.3 m , 20 m diameter)

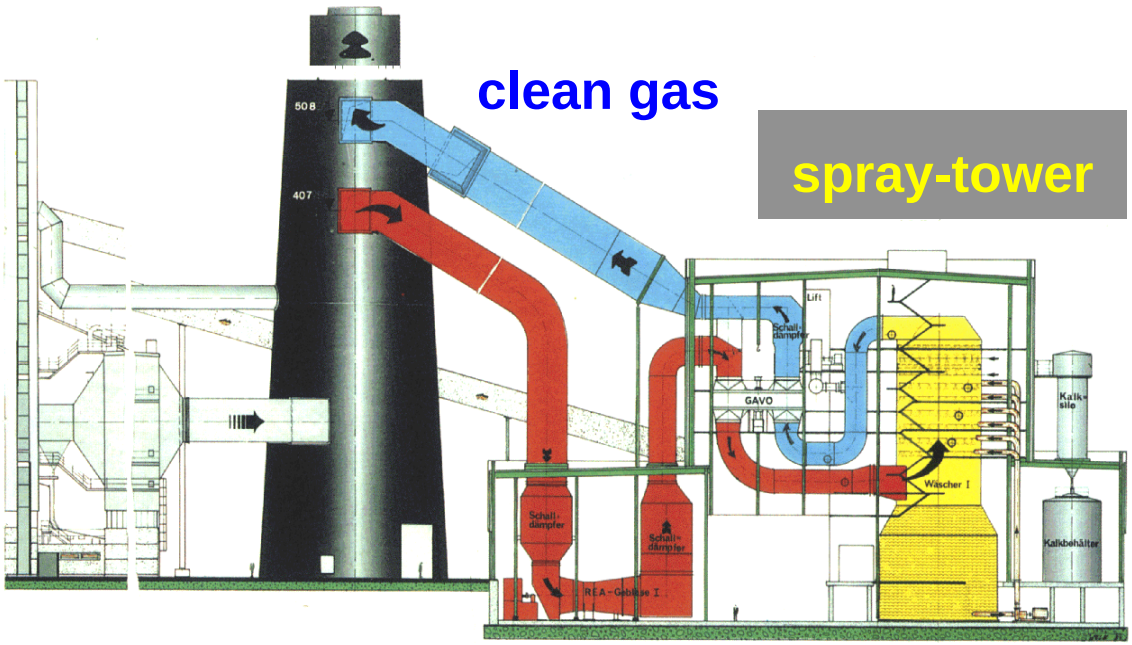
Injection of limestone slurry into the flue-gas stream for SO_2-absorption

stack

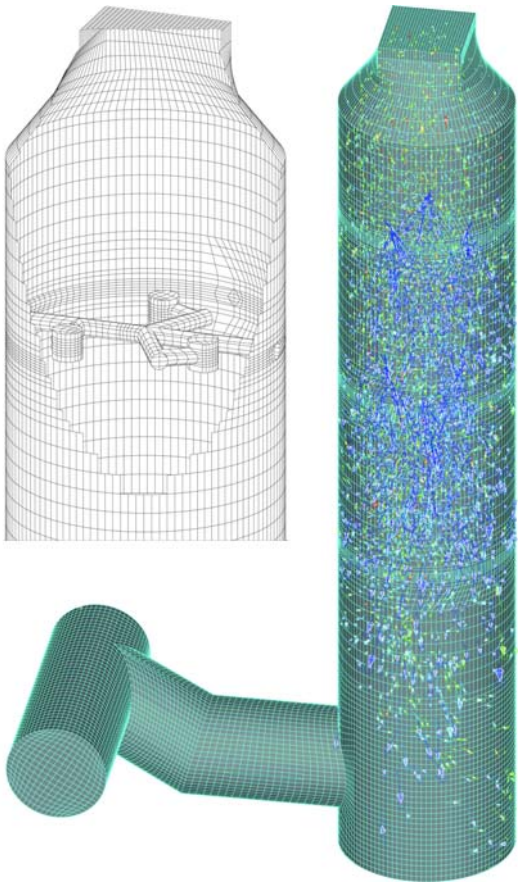
clean gas

spray-tower

power plant

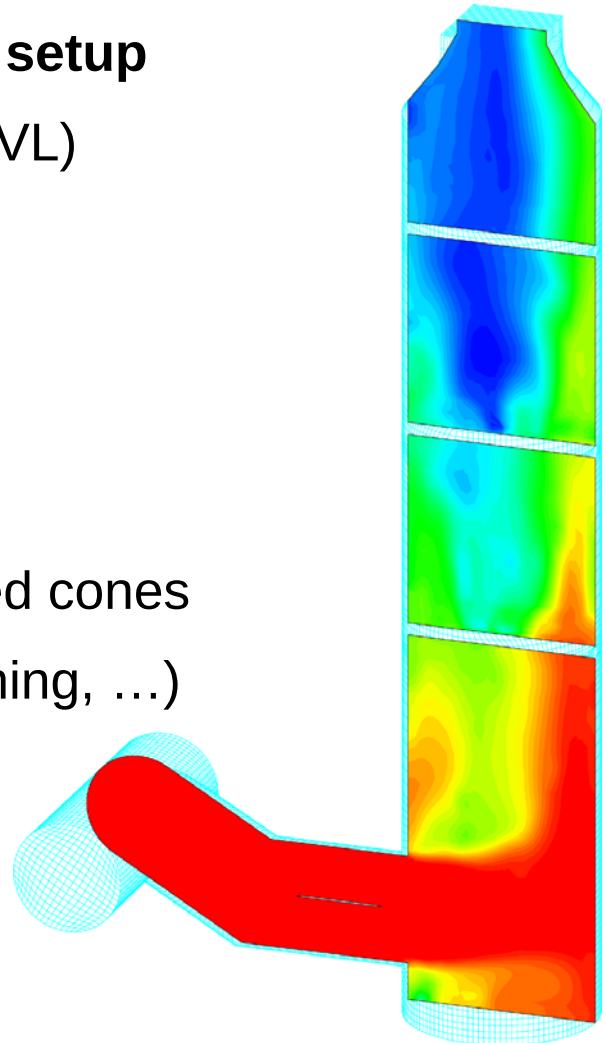


raw gas



Computational fluid dynamics - setup

- Commercial code: Fire 7.3 (AVL)
- Euler-Lagrange
- Mesh: Hexahedrons only
- Transient (time-step 5 ms)
- k-ε-turbulence-model
- Spray: Two-way-coupling, modelled cones
- Wall-interaction (impinging, splashing, …)
- SO_2 - absorption



Reactions:

Washing zone: $SO_2 + CaCO_3 \Rightarrow CaSO_3 + CO_2$

Sump: $CaSO_3 + ½\ O_2 \Rightarrow CaSO_4$

- **Components:** $CaCO_3$, $CaSO_3$, $CaSO_4$, H_2O, SO_2, CO_2, air
- **Species:** $[SO_2]$, $[CO_2]$; $[H^+]$, $[OH^-]$, $[HSO_3^-]$, $[SO_3^{2-}]$, $[HCO_3^-]$, $[CO_3^{2-}]$
- **Equations (8):** Ion-product H_2O, diss.1 H_2SO_3, diss.2 H_2SO_3, S-total, diss.2 H_2CO_3, C-total, electro-negativity, mass-balance

2-step-absorption

• SO_2(gas) → absorption → SO_2(droplet) [kinetics]

• Droplet chemistry ($CaCO_3$/$CaSO_3$/$CaSO_4$/H_2O/SO_2/CO_2/air) [equilibrium]

(normally computed iteratively by solving 8 independent algebraic equations)

„ion-lookup-table“

• All quasi-instantaneous chemical reactions combined and precalculated

• 5 input, 8 output-parameters

• 5 steps, linear inter- und extrapolation

• Reduction of computation-time!

SO_2-absorption
Contents (continued)

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- Introduction spray-tower
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- Pilot-scale scrubber (1.4 m diameter)
- Industrial-scale scrubbers (4.2 m, 15.3 m , 20 m diameter)

Pending droplet experiment
pH-value progression - comparison

Variation of τ_{exp} until similar ph-value progression is reached

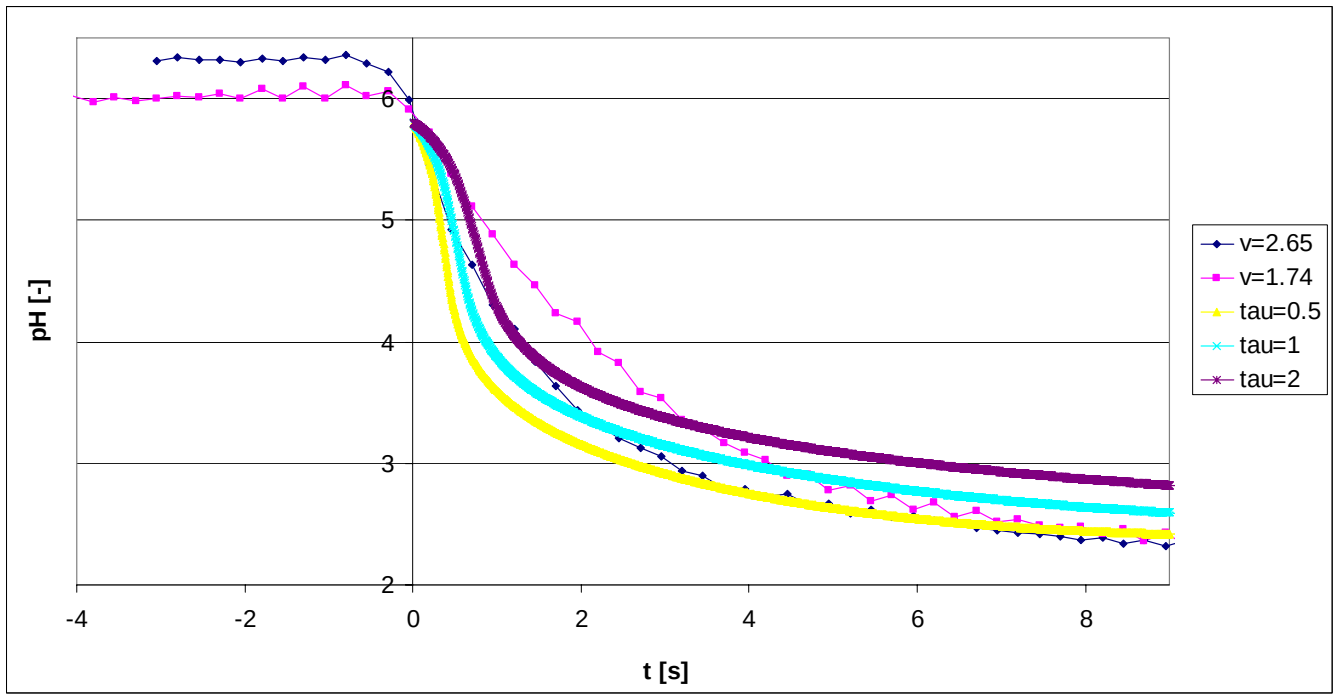
(some parameters are far out of the scale of those in scrubbers);

faster decrease because of instantaneous mixing (simulation);

even though, good resemblance

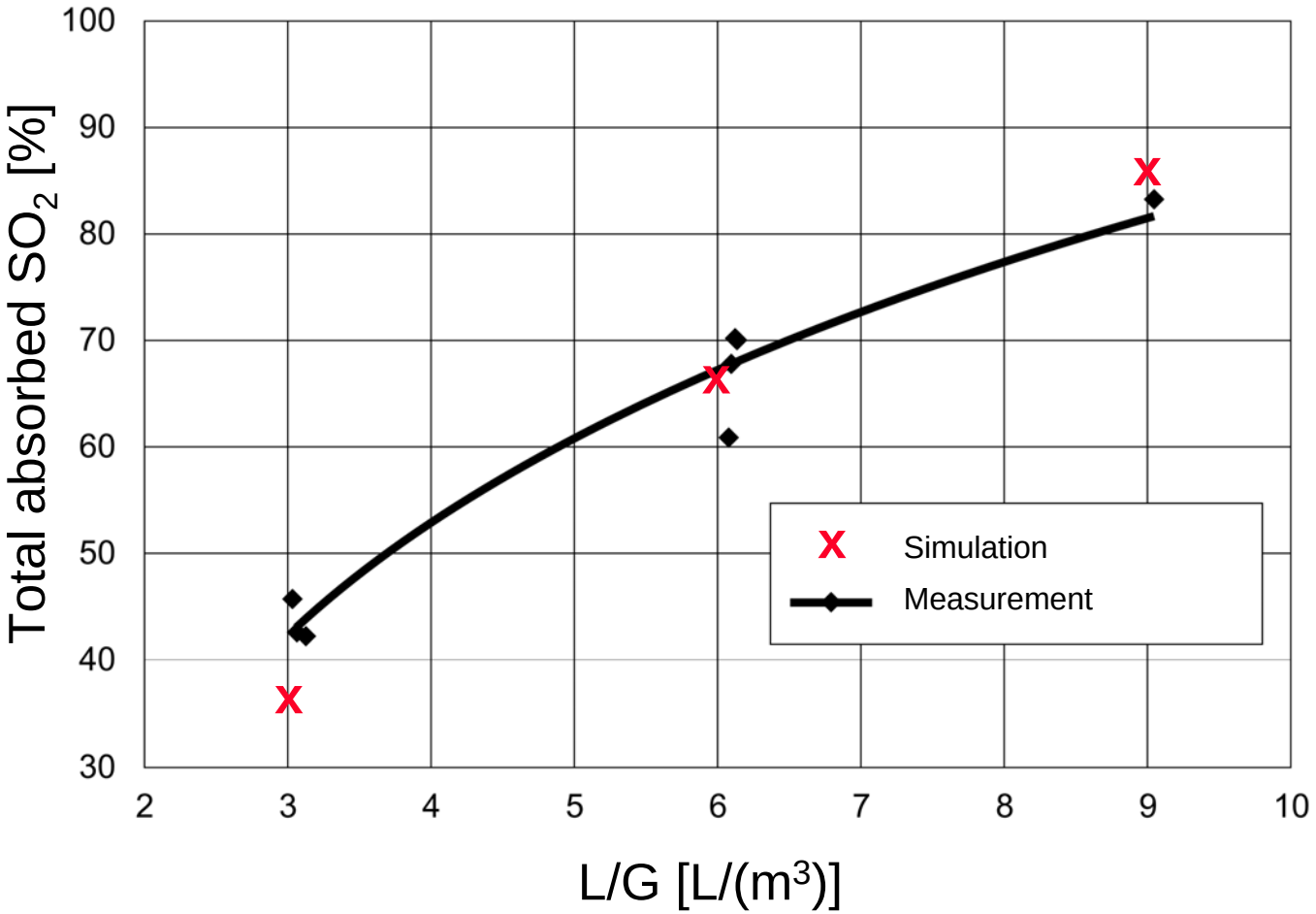
„*pending* droplet“

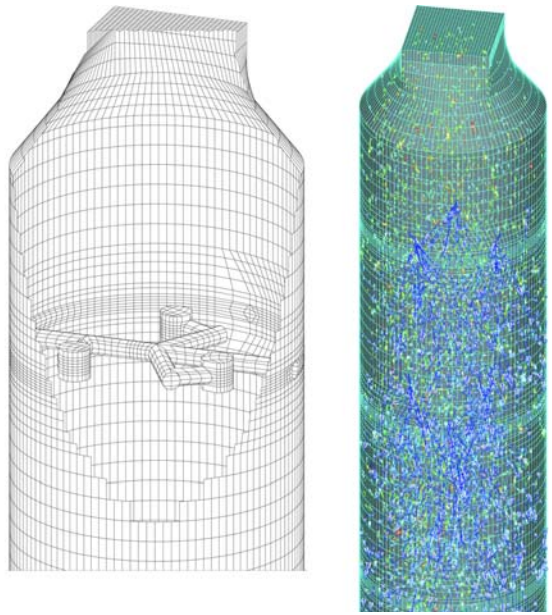
- 2.7 mm droplet
  - no alkalinity
  - layer model
- v_{Gas} = 2 m/s (about)
- 4000 vol.ppm SO_2



Pilot-scale scrubber *Sostanj* (1.4 m diameter)

Total absorbed SO_2 over L/G





Simulation

- good trend coverage
- stronger effect of the influence: ratio L/G

Industrial-scale scrubber (4.2 m diameter)

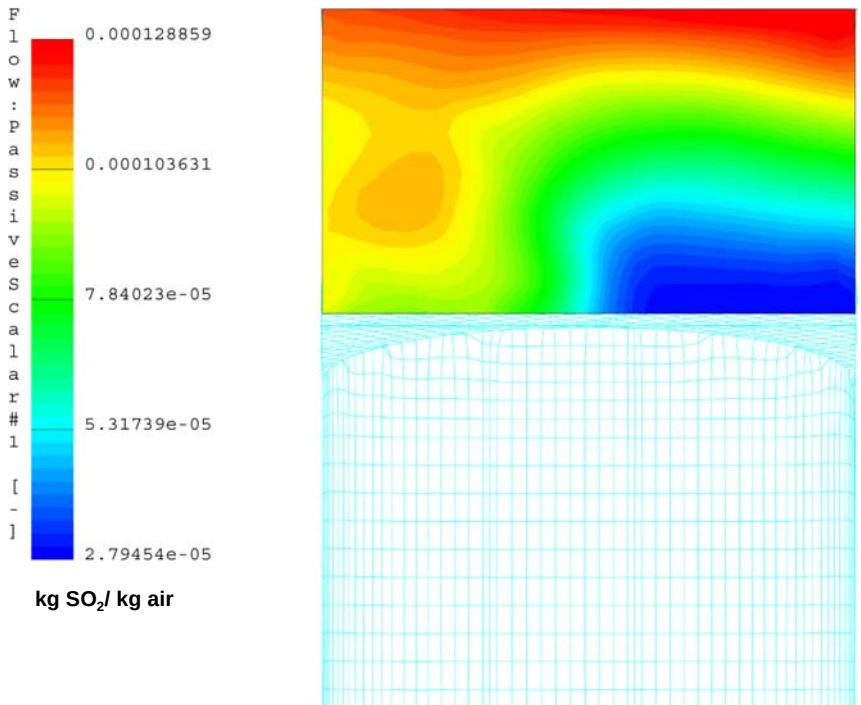
Total absorbed SO_2 and measurement (outlet)

Total absorbed SO_2

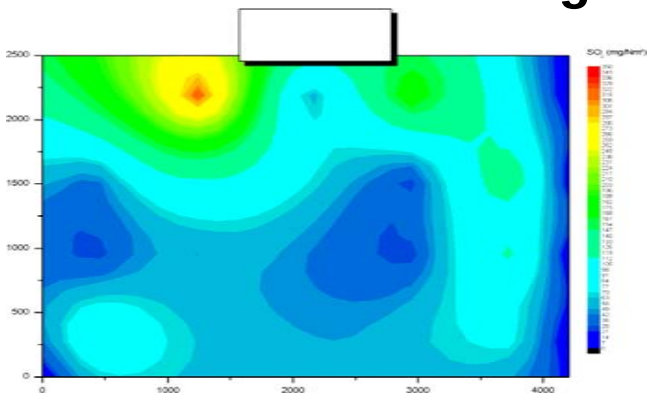
Measurement: 90 %

Simulation: 88 %

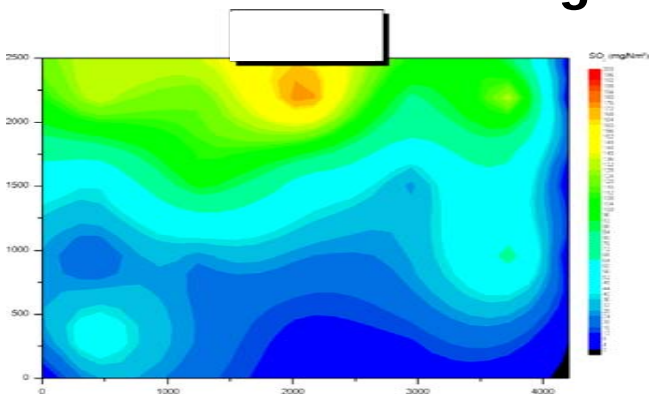
max: 250 mg SO_2 / m_N^3



max: 350 mg SO_2 / m_N^3



max: 200 mg SO_2 / m_N^3



Industrial-scale scrubber (15.3 m diameter)

Total absorbed SO_2

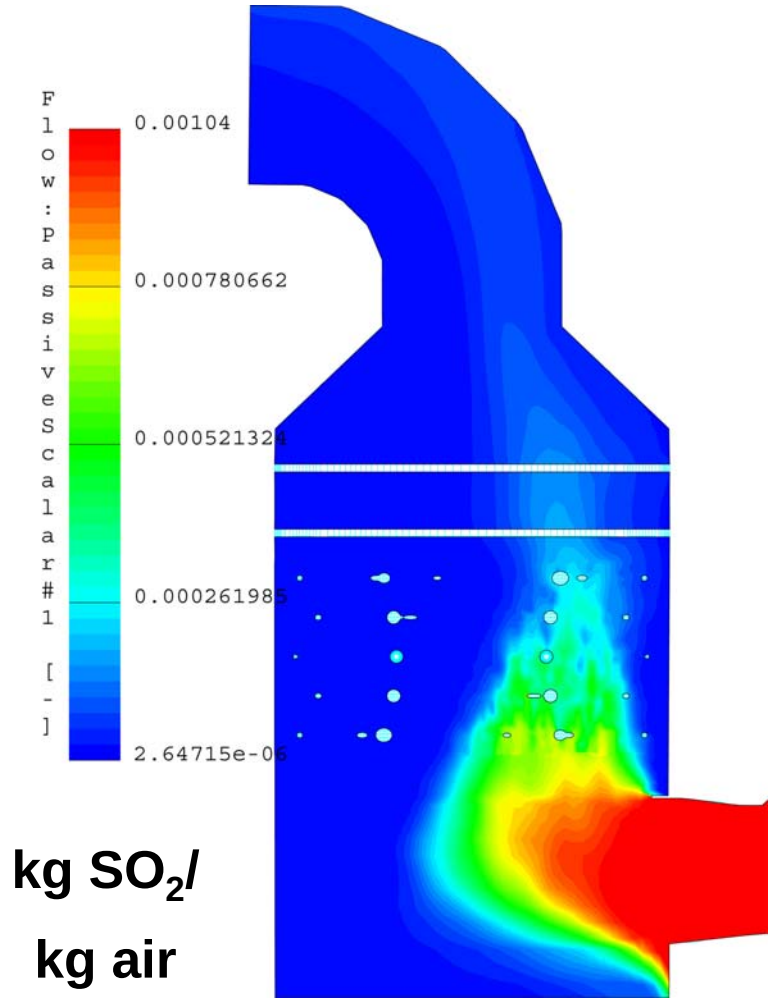
Total absorbed SO_2

Measurement: 95 %

(spray banks 2-4)

Simulation: 96.5 %

(spray banks 1-4)



kg SO_2/

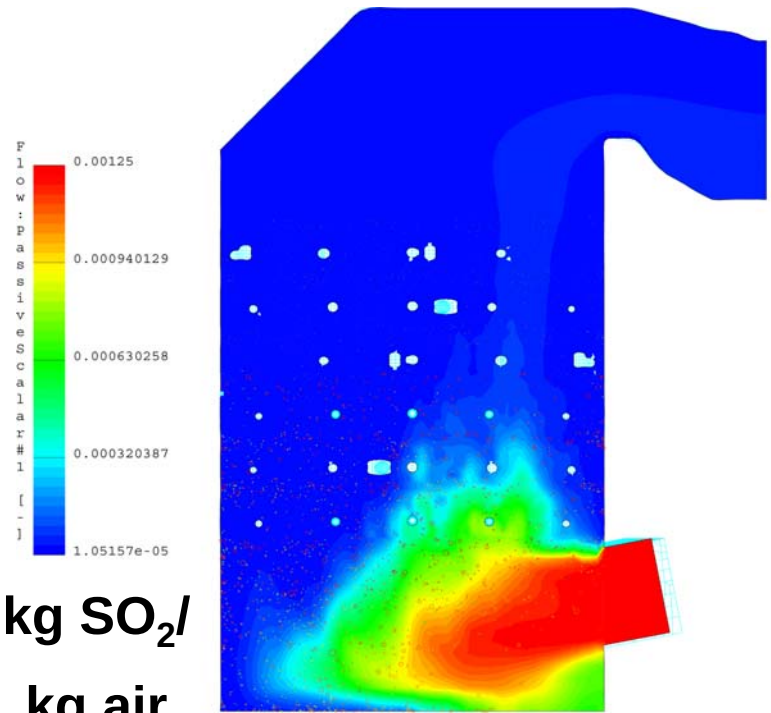
kg air

Industrial-scale scrubber *Heyden* (20 m diameter)

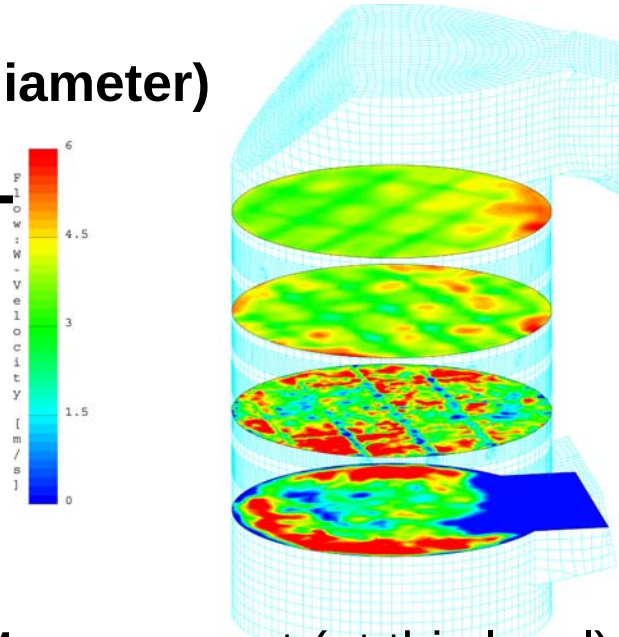
Total absorbed SO_2

- 1600 mg SO_2 / (m_N^3) at the entry
- Lower 4 spray-banks activated

Total absorbed SO_2 95.5 %

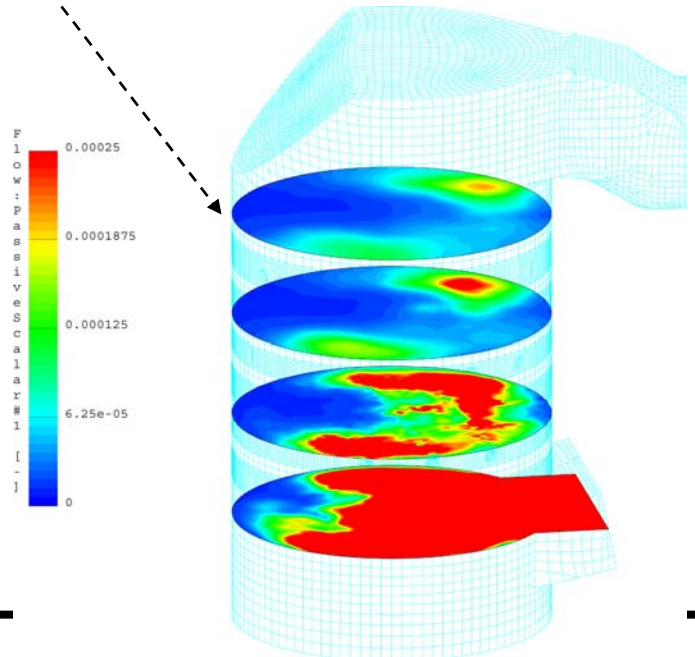


kg SO_2/ kg air



v_{UP} [m/s]

Measurement (at this level)

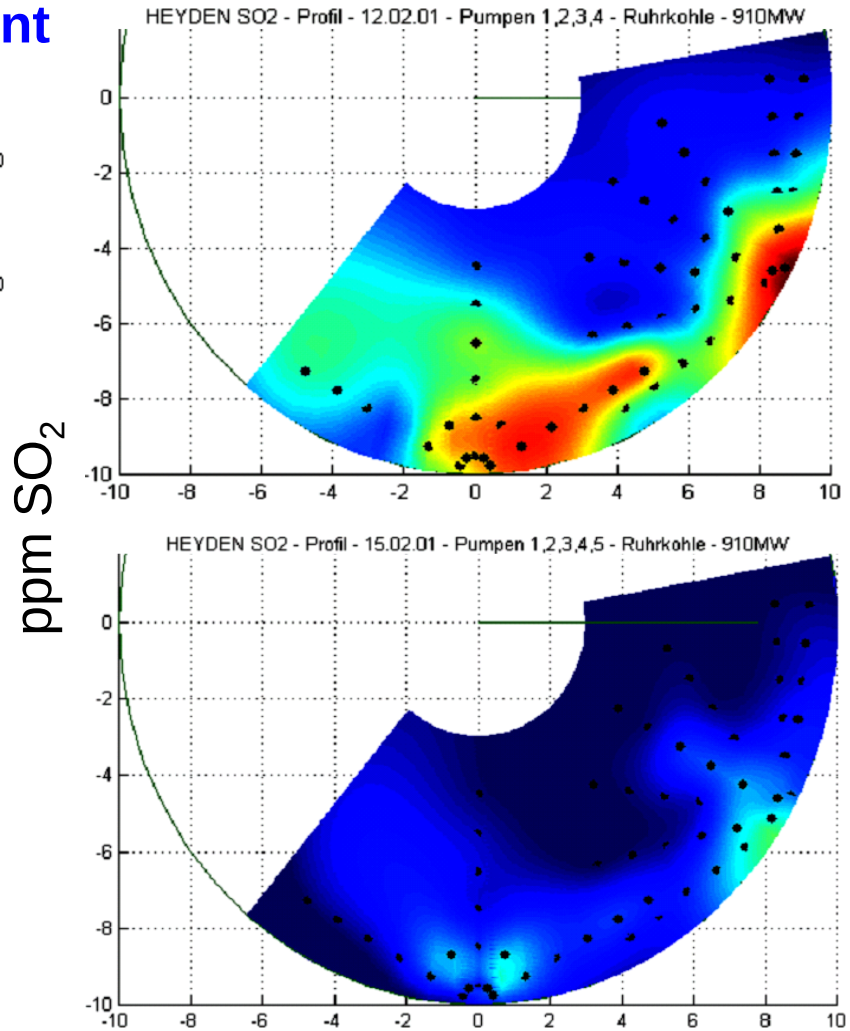


kg SO_2/ kg air

Industrial-scale scrubber *Heyden* (20 m diameter)

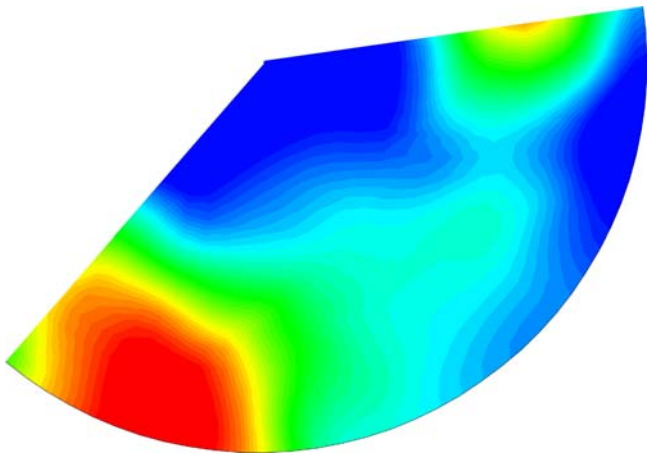
Comparison: Measurement and simulation

Measurement



Simulation

Cut z = 39 m (rotated)



Scale: 15 – 50 ppm SO_2