Building Simulation Seminar

CIBSE, 2nd December 2009

Simulation of Combined Wind- and Buoyancy-driven Natural Ventilation of Buildings

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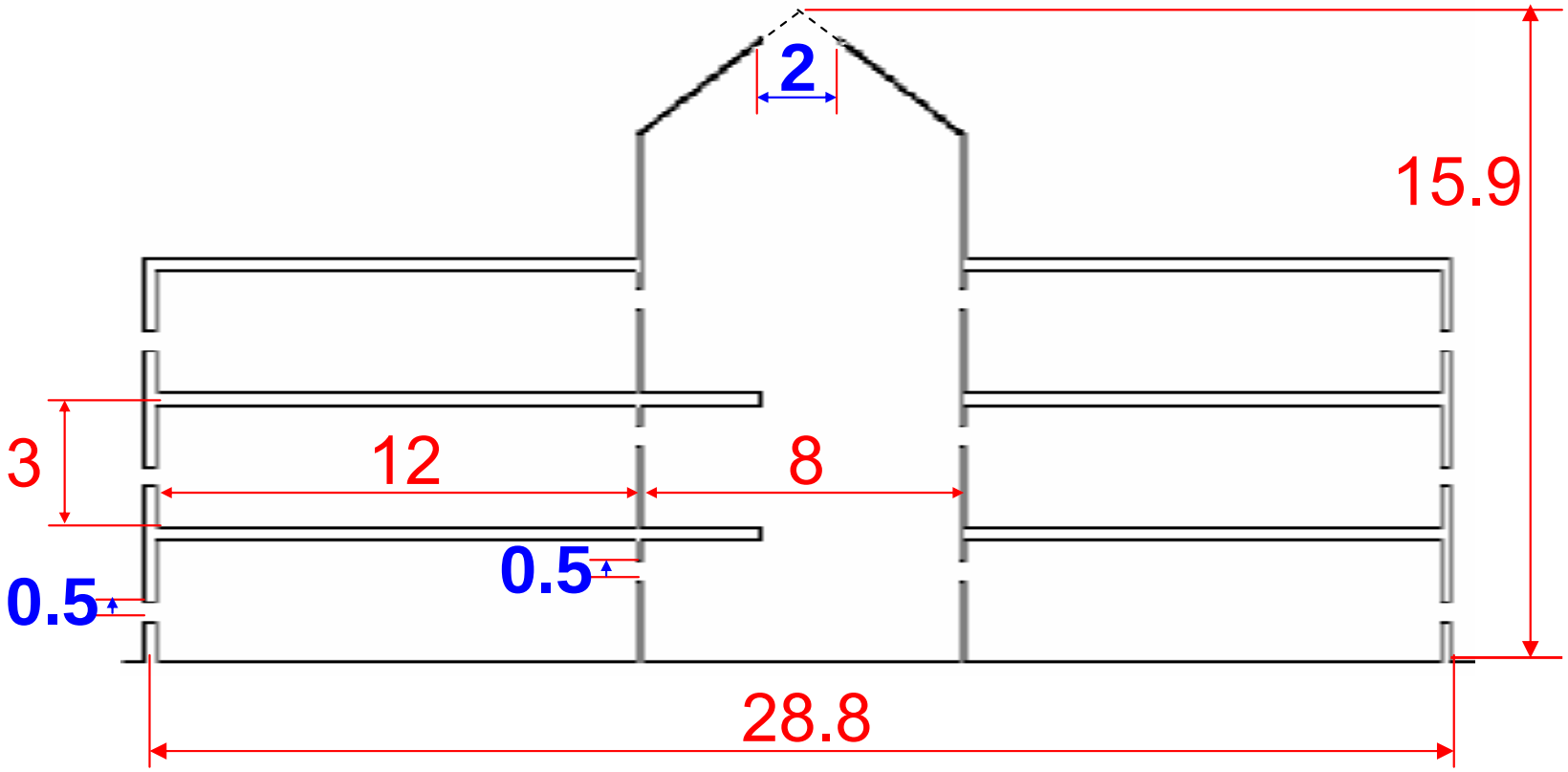
Overview

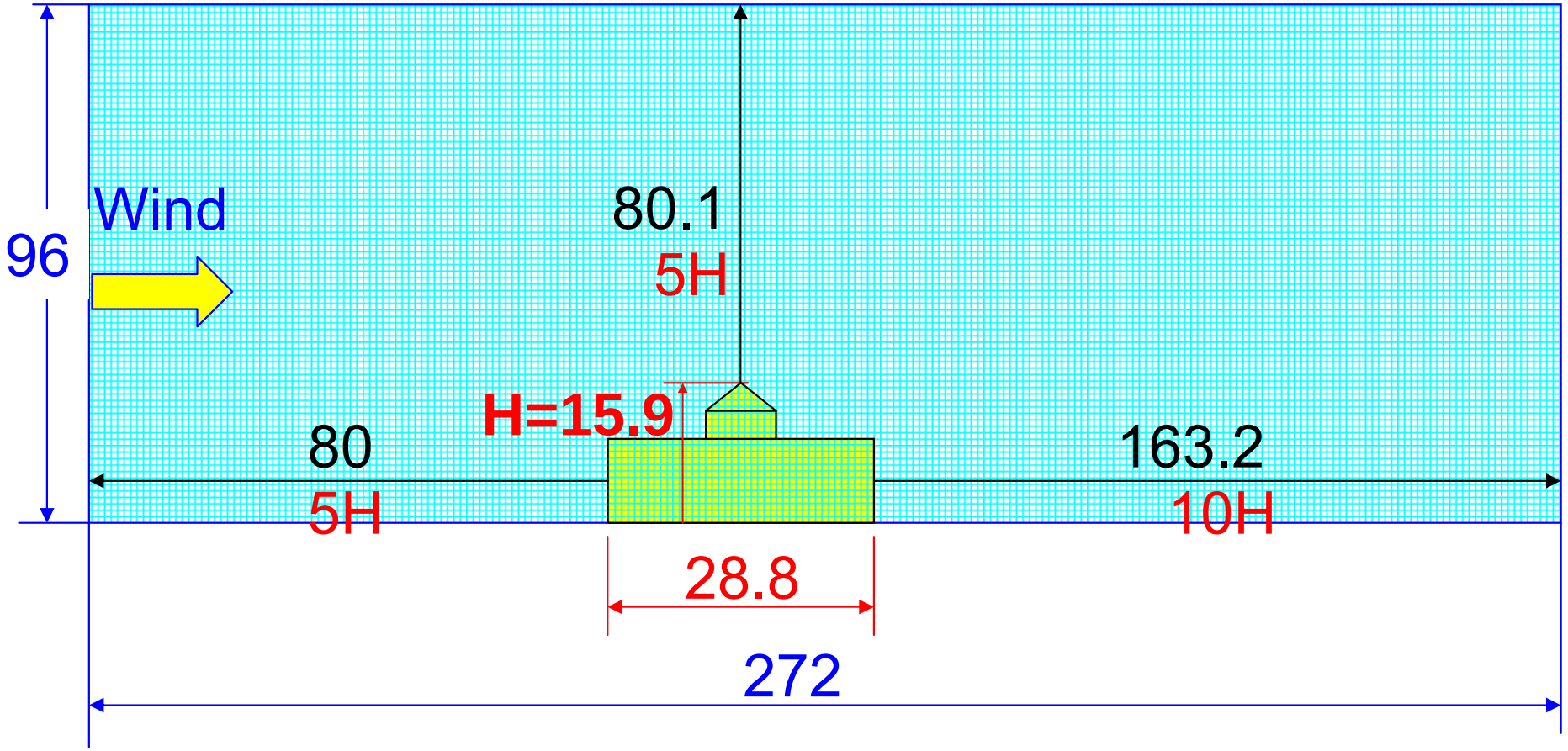
- Building
- Computational domain
- Buoyancy-driven natural ventilation
- Wind-driven natural ventilation
- Wind + buoyancy driven ventilation

Building configuration



Dimension: m

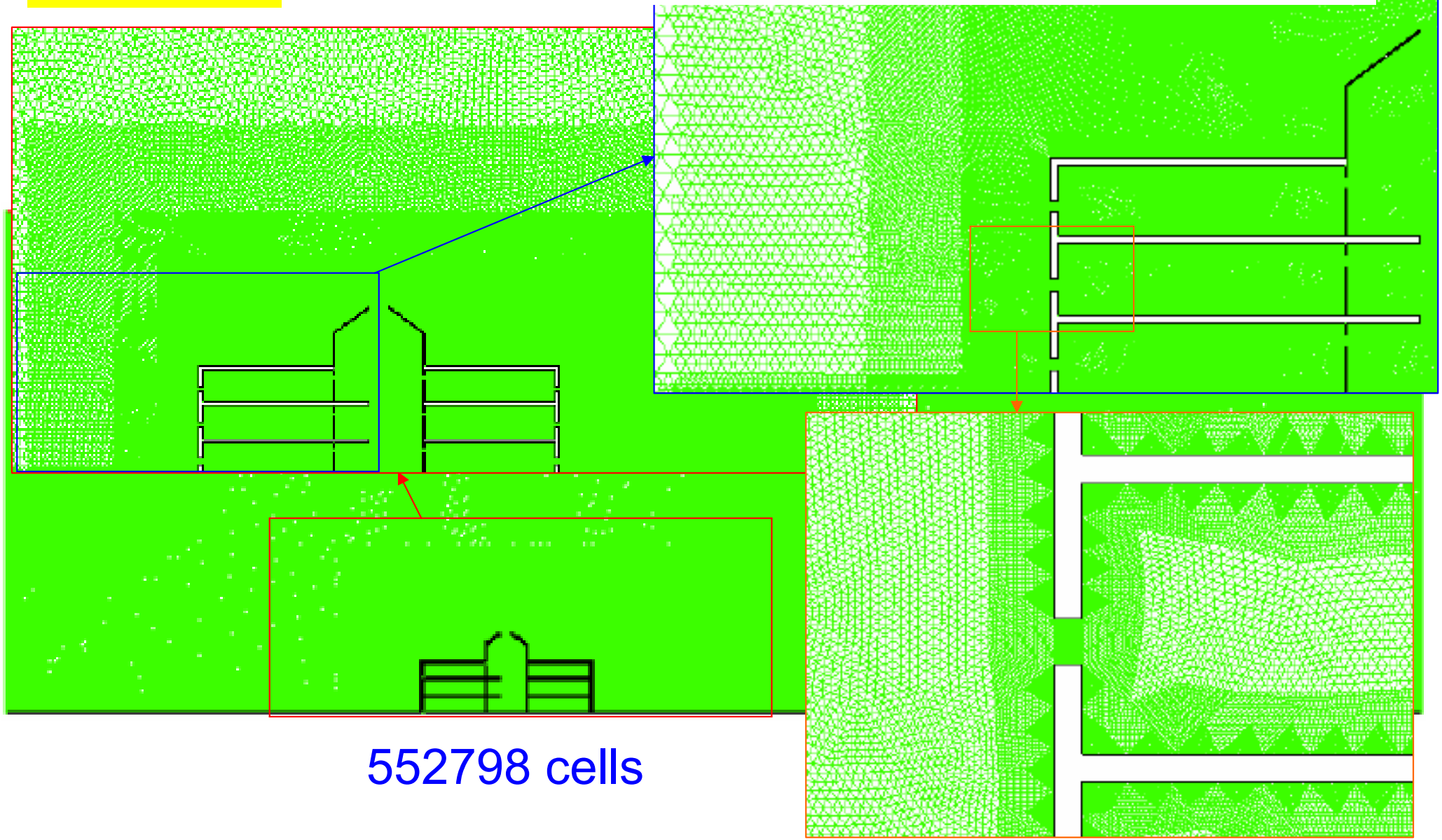
Computational domain



Dimension: m

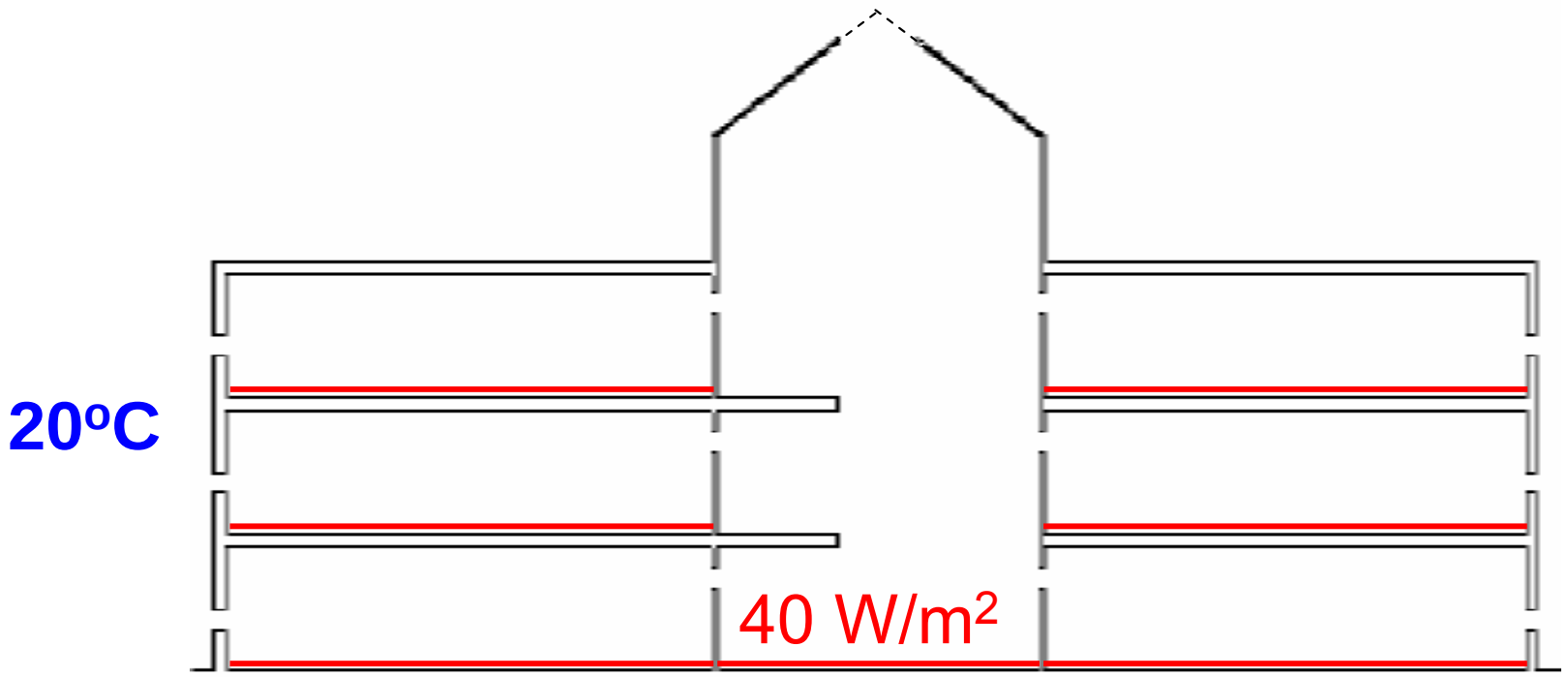
Model and mesh

FLUENT RNG k-ε model for buoyant turbulent steady flow

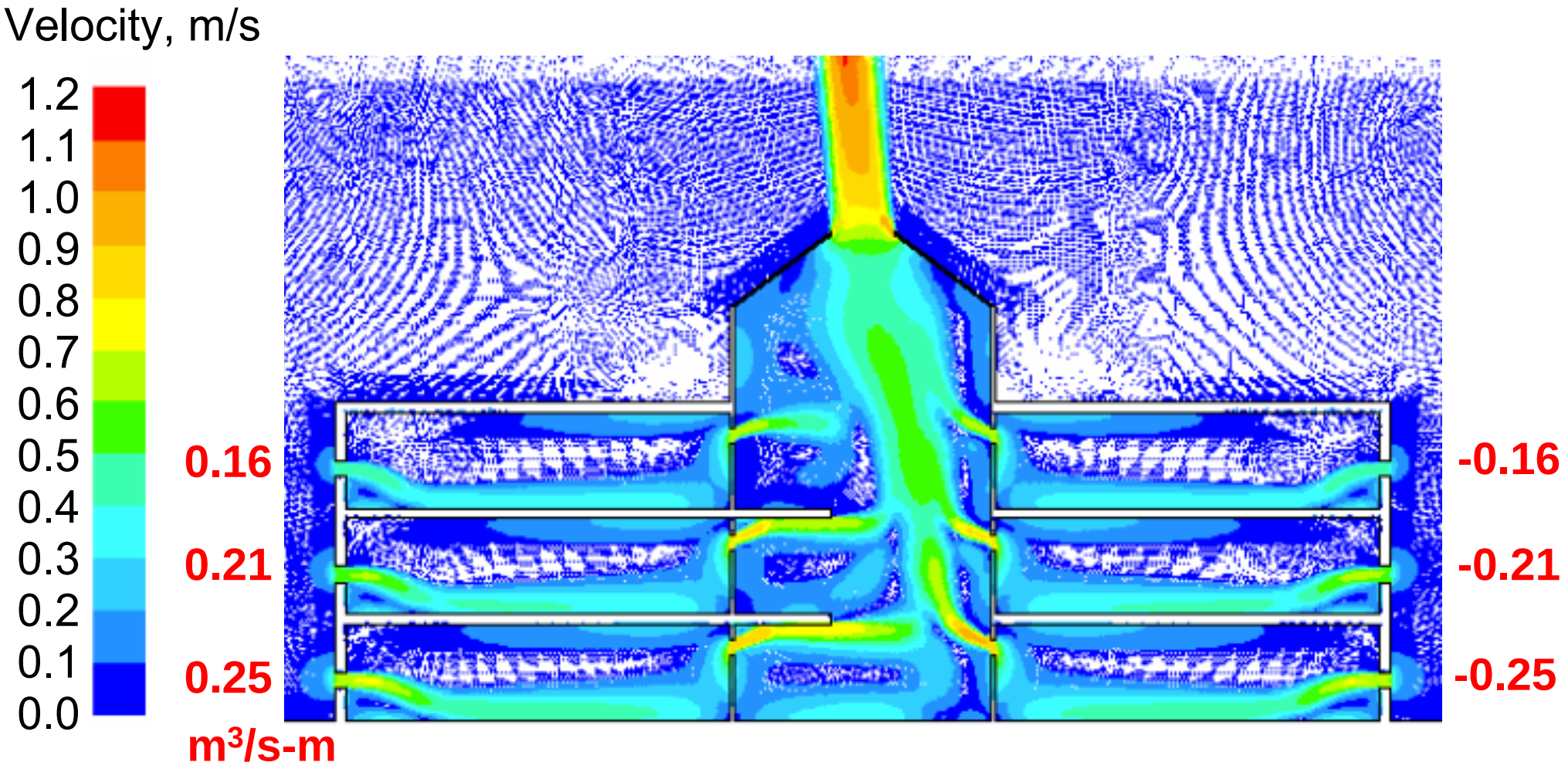


552798 cells

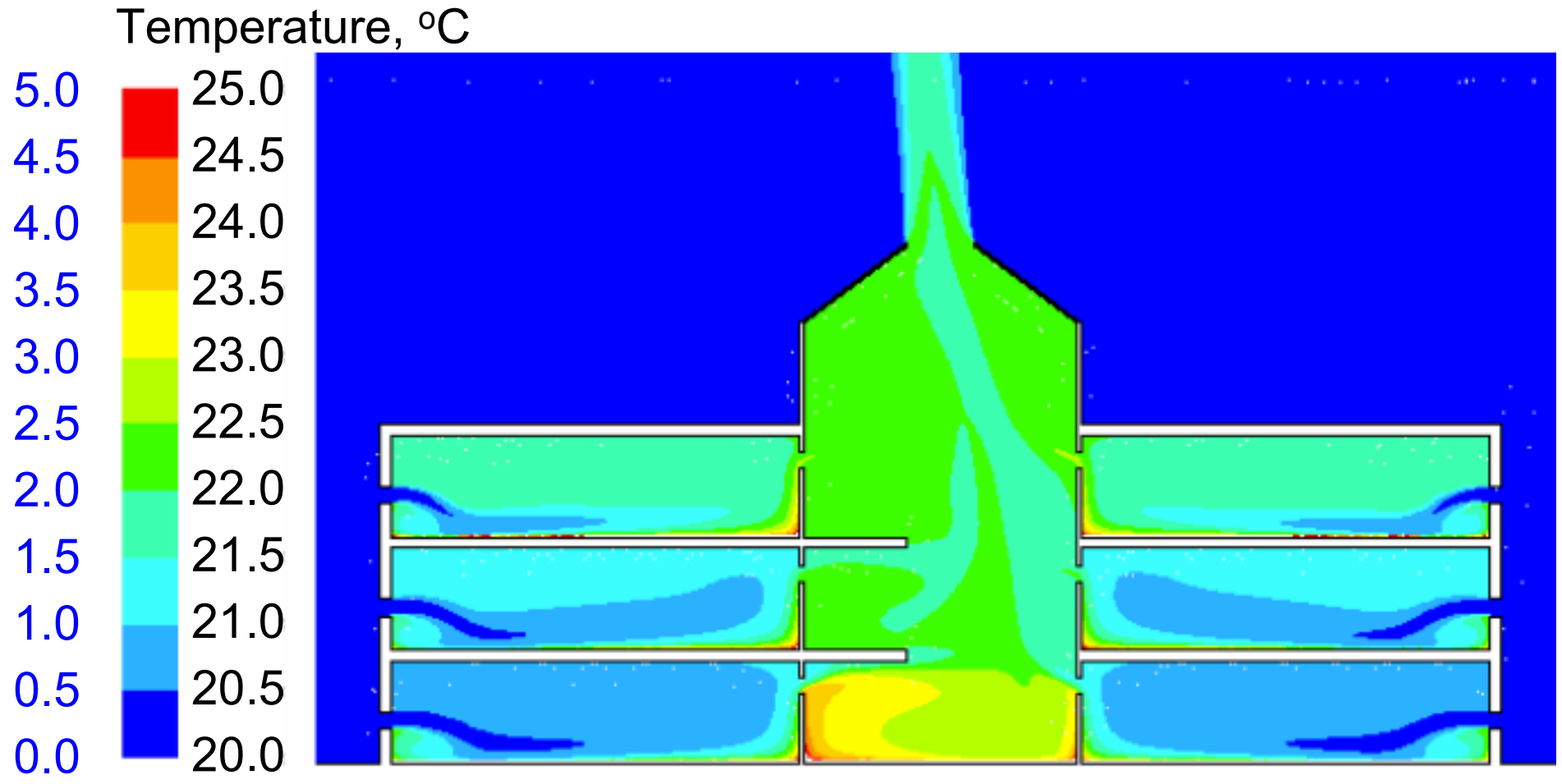
Buoyancy only – Boundary conditions



Buoyancy only – Flow patterns



Buoyancy only – Temperature



Vr = 3 m/s ≈ 4 m/s wind speed in England for urban terrain

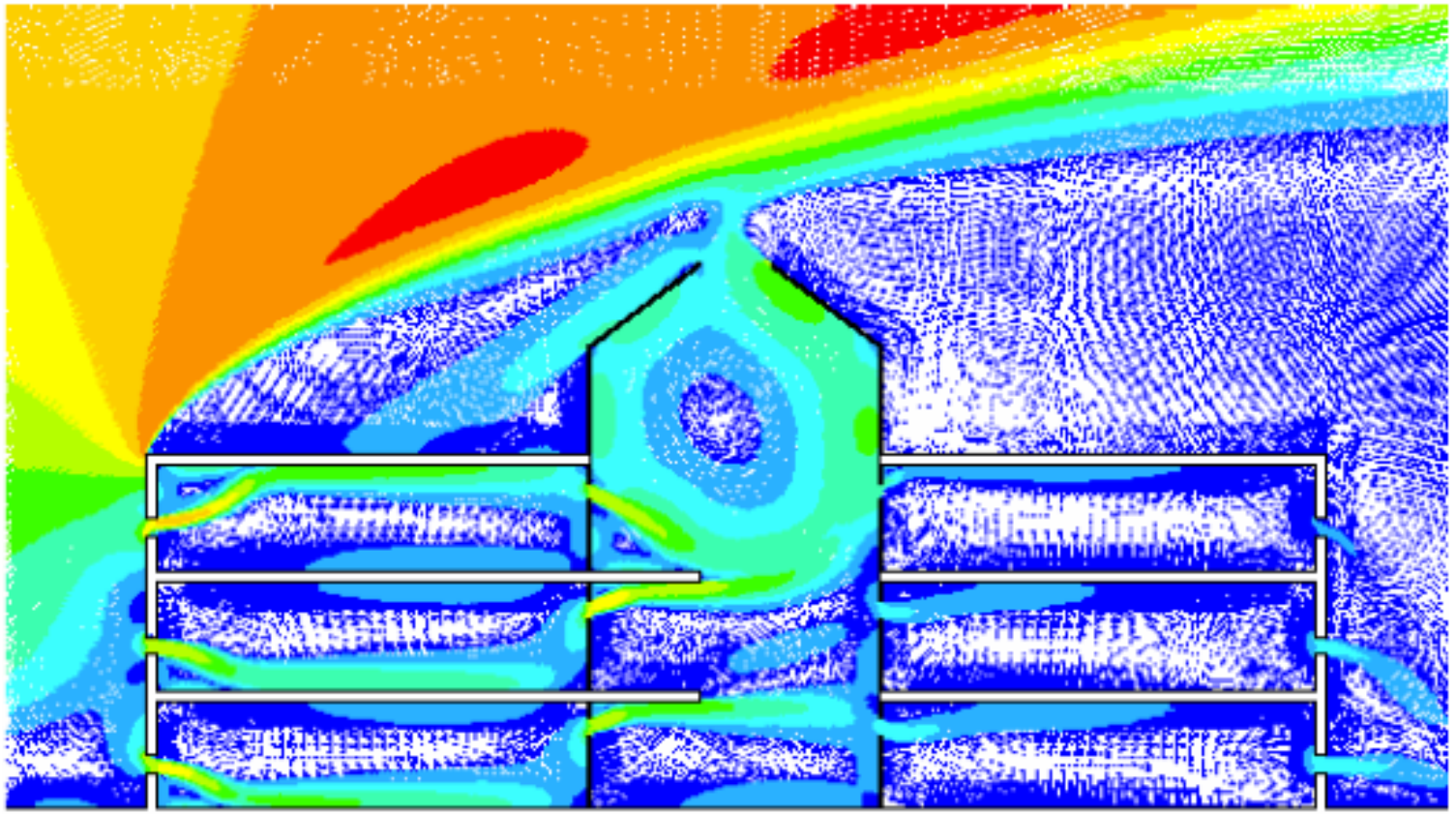
Wind only – Flow patterns

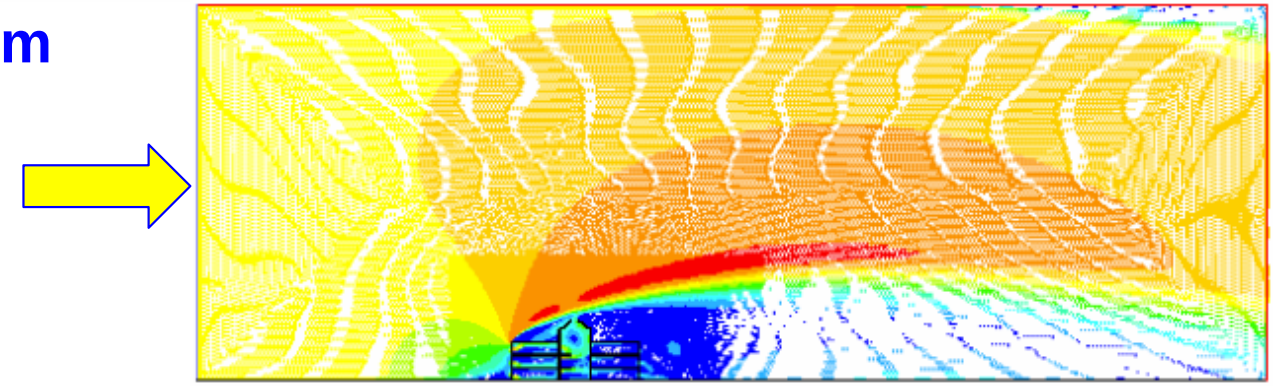
Velocity, m/s

4.4
3.96
3.52
3.08
2.64
2.2
1.76
1.32
0.88
0.44
0.0

m³/s-m

Bouyancy only





Vr = 3 m/s

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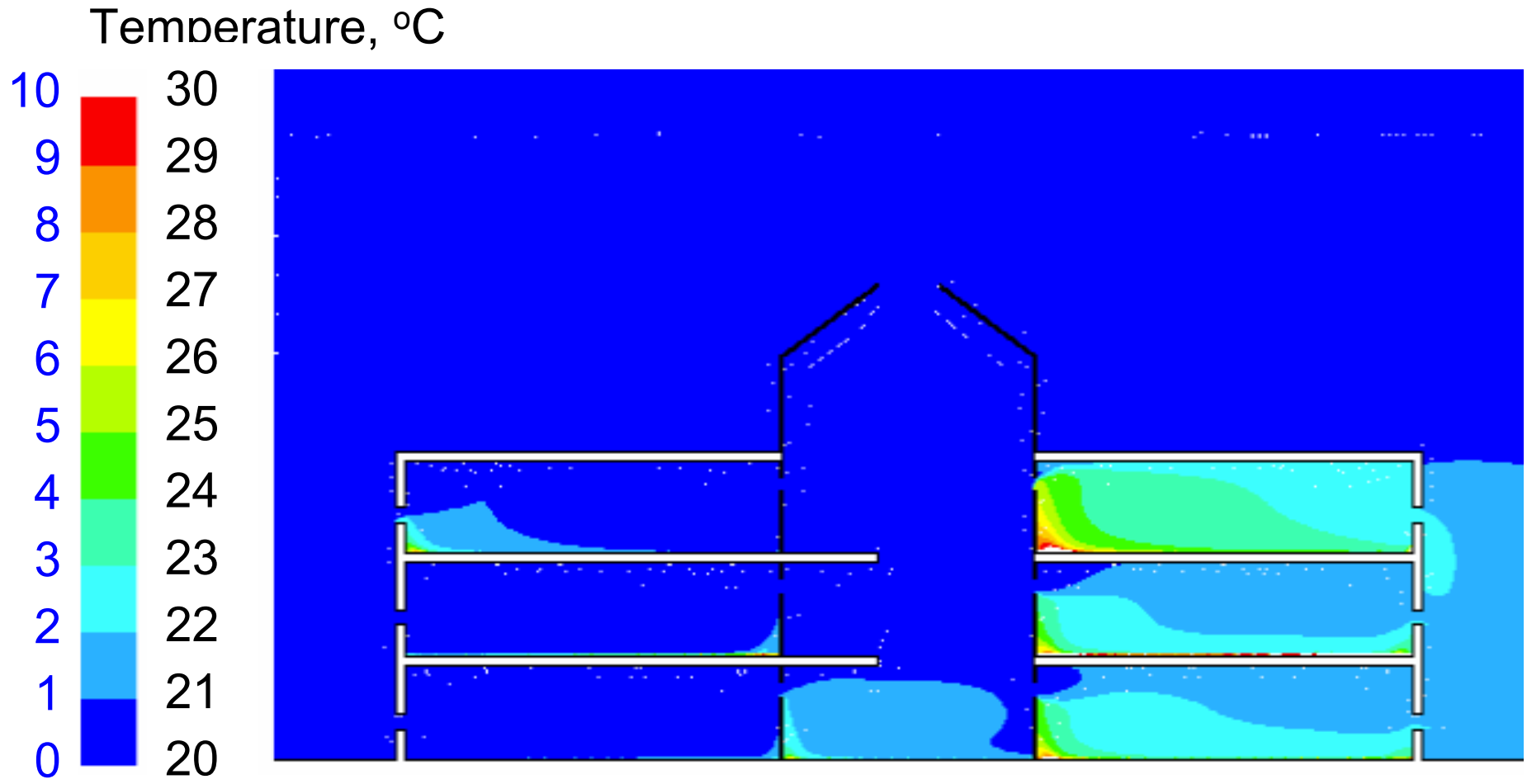
Wind only – Temperature



Vr = 3 m/s

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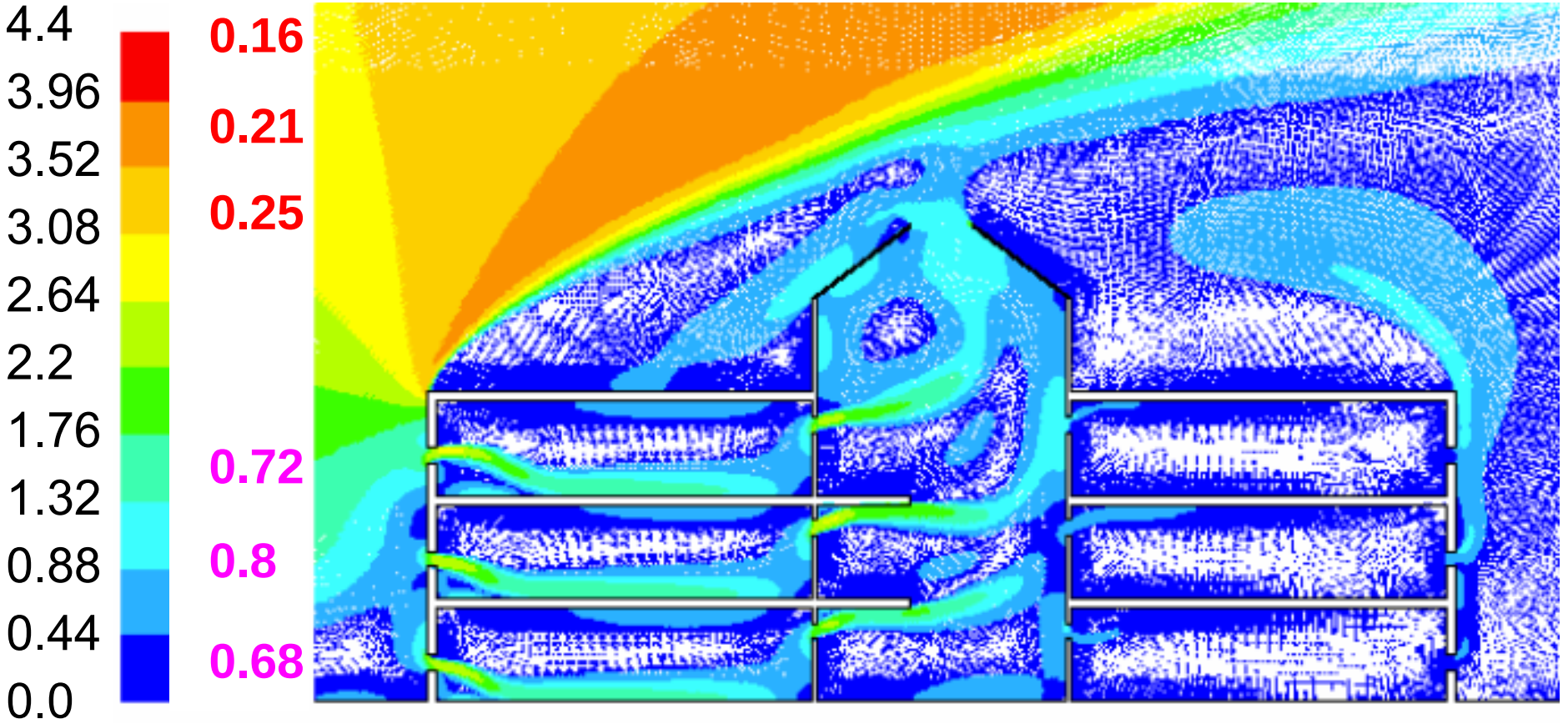
Wind + buoyancy – Flow patterns

Velocity, m/s

Bouyancy only



m^3/s-m

0.85
0.88
0.77

0.16
0.36
0.42

Wind only

Vr = 3 m/s

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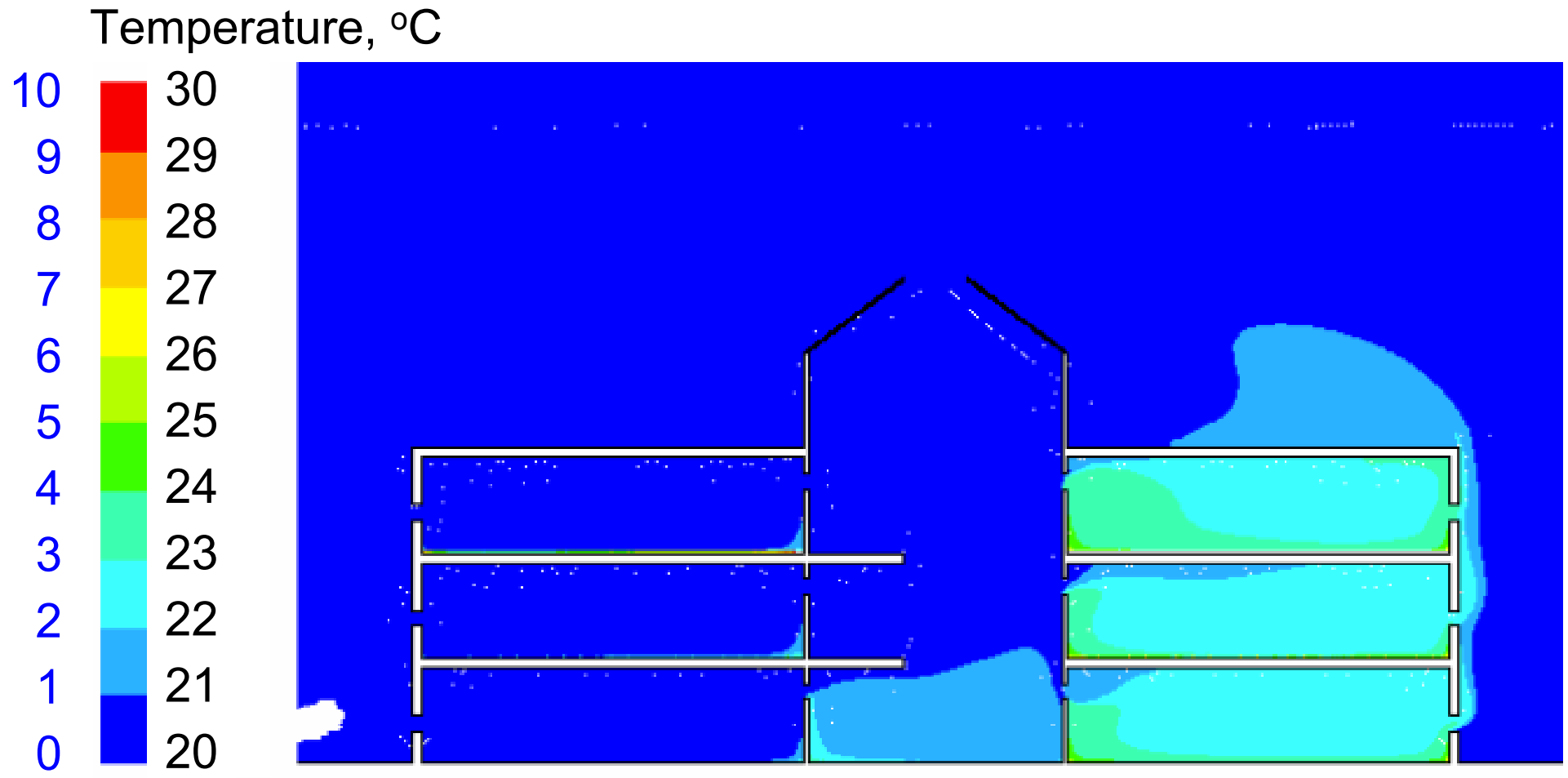
Wind + buoyancy – Temperature



Vr = 2 m/s ≈ 4 m/s wind speed in England for city terrain

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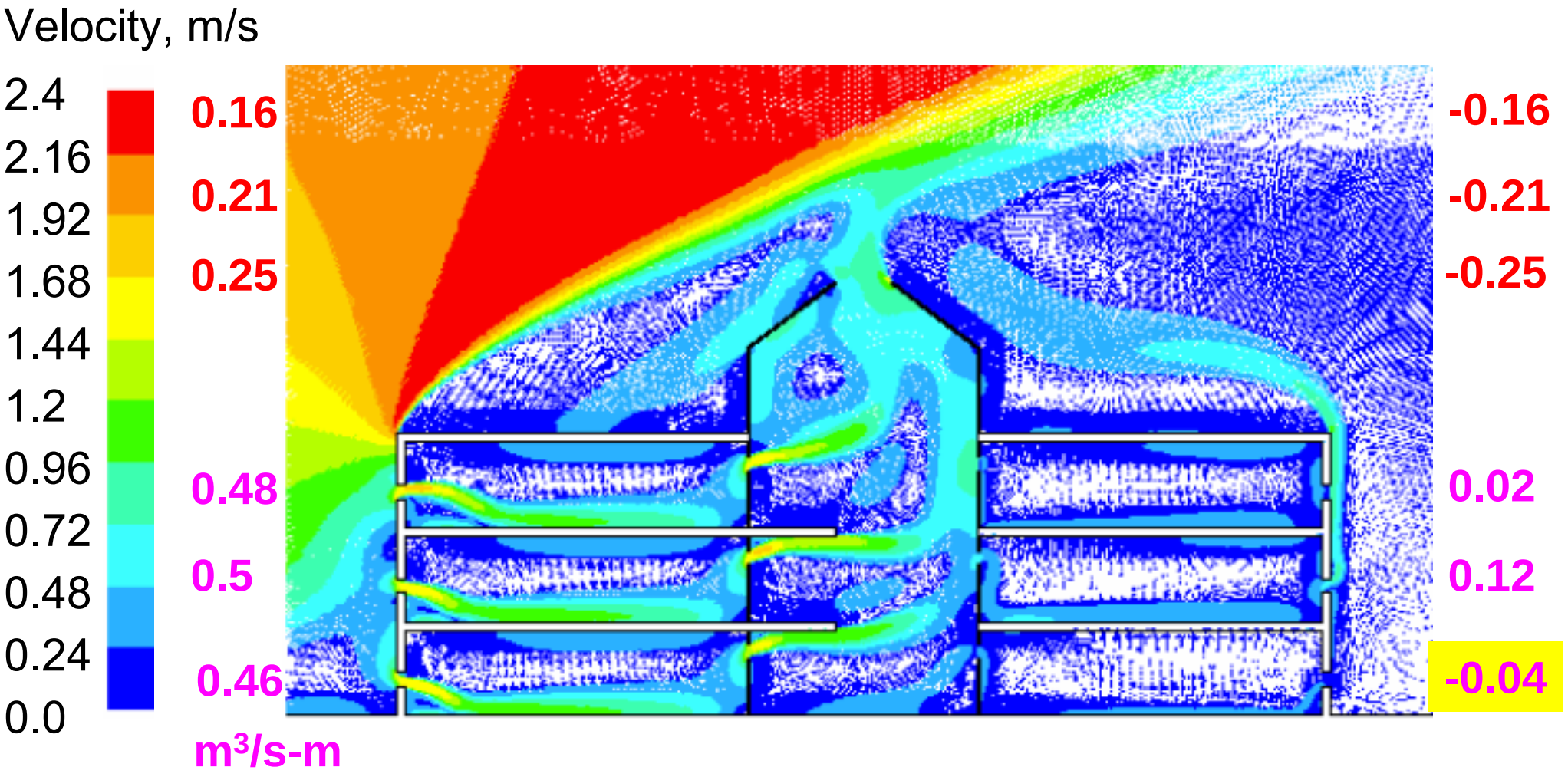
Wind + buoyancy – Flow patterns



Vr = 2 m/s

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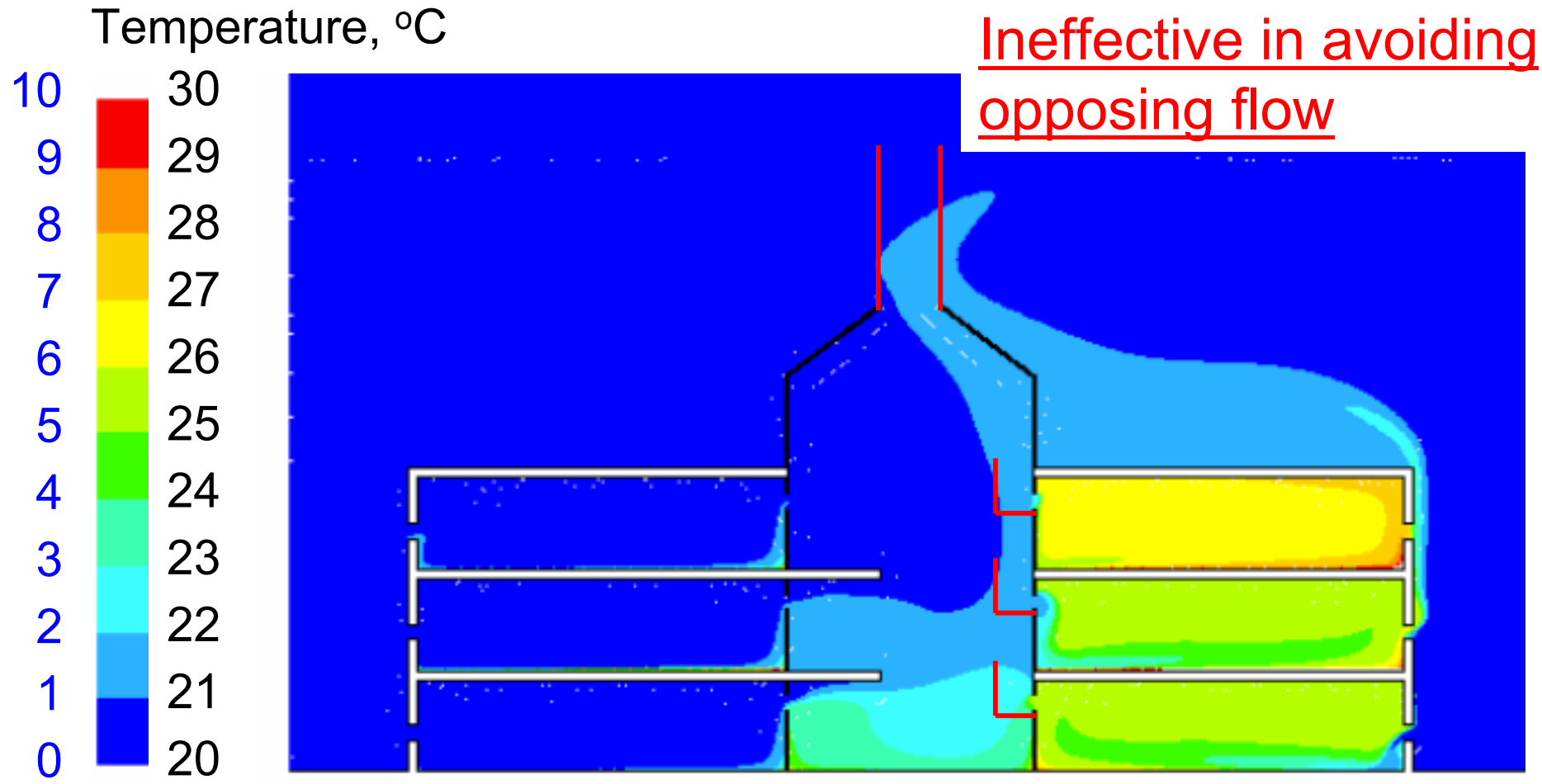
Wind + buoyancy – Temperature



Temperature above ambient, °C

Vr = 1 m/s

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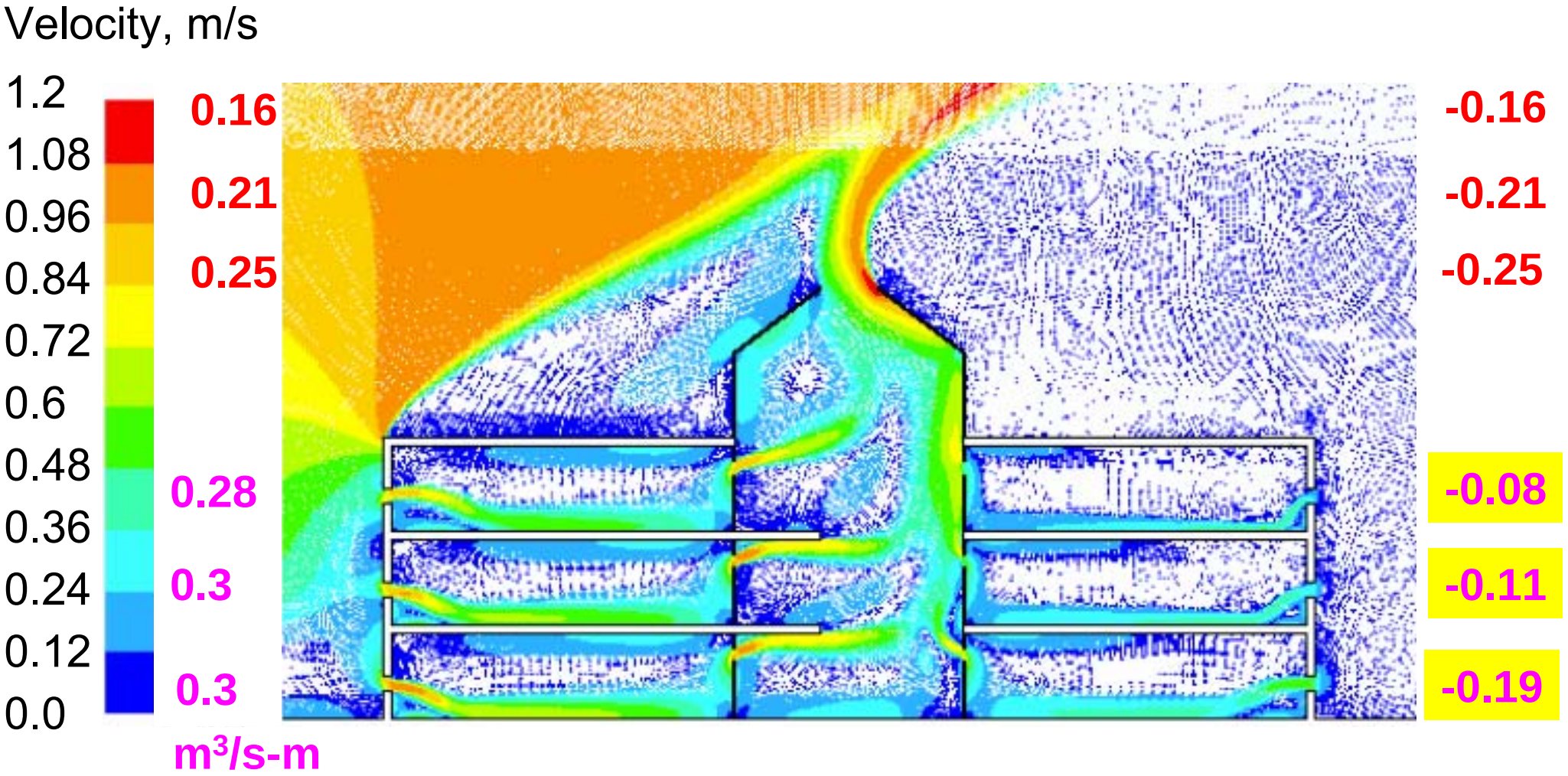
Wind + buoyancy – Flow patterns



Vr = 1 m/s

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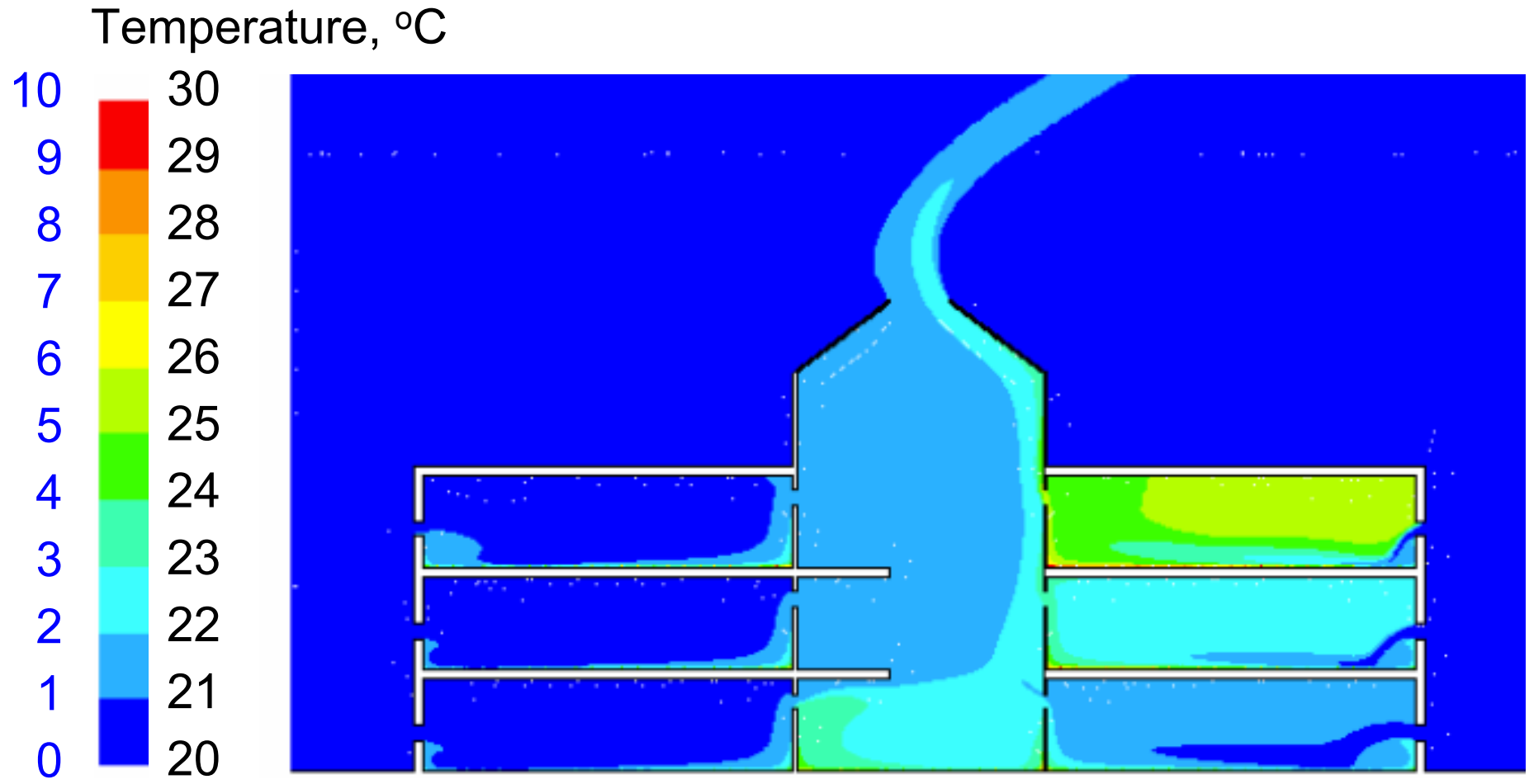
Wind + buoyancy – Temperature



Reducing windward opening size @ Vr = 3 m/s

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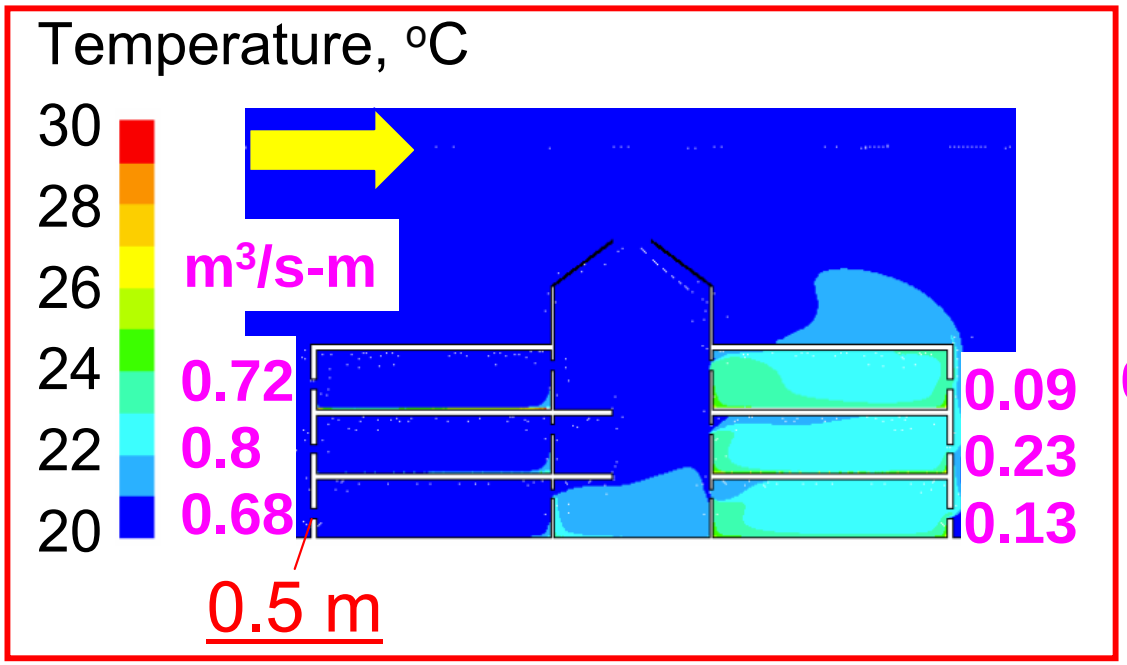
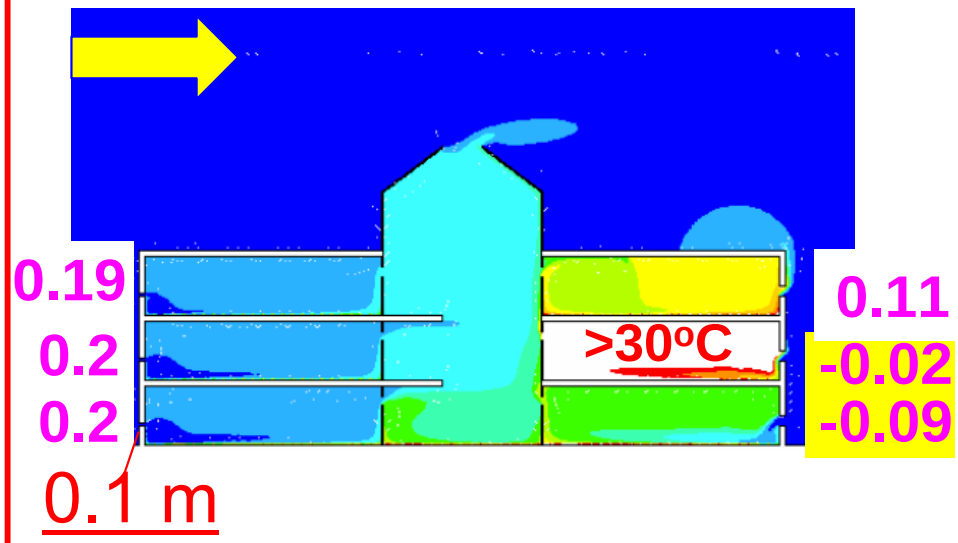
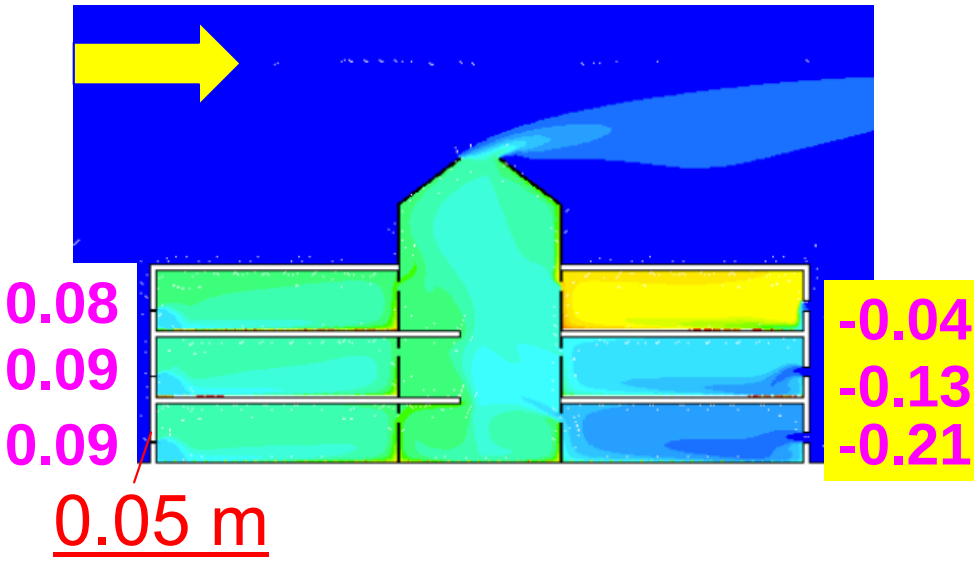
Wind + buoyancy – Temperature







Reducing opening sizes → similar flow rates

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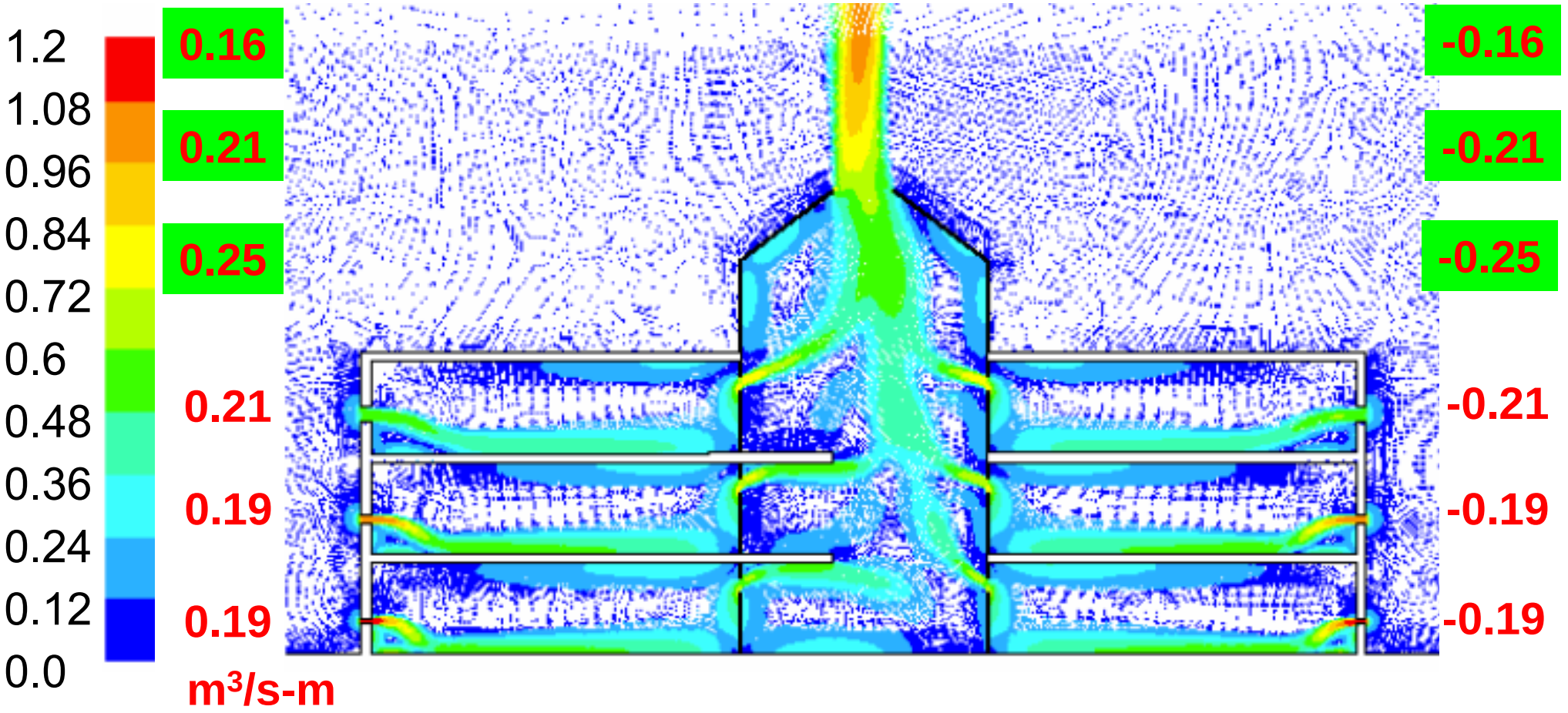
Buoyancy only – Flow patterns

0.5 m openings



Reducing opening sizes → similar flow rates

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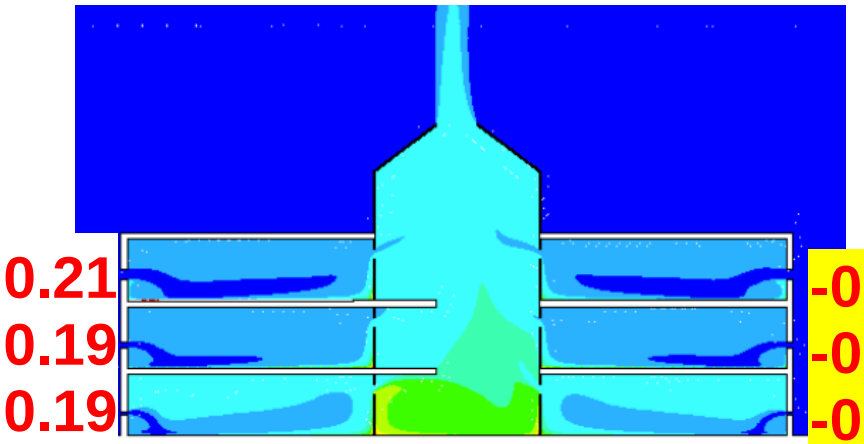
Temperature

Temp, °C

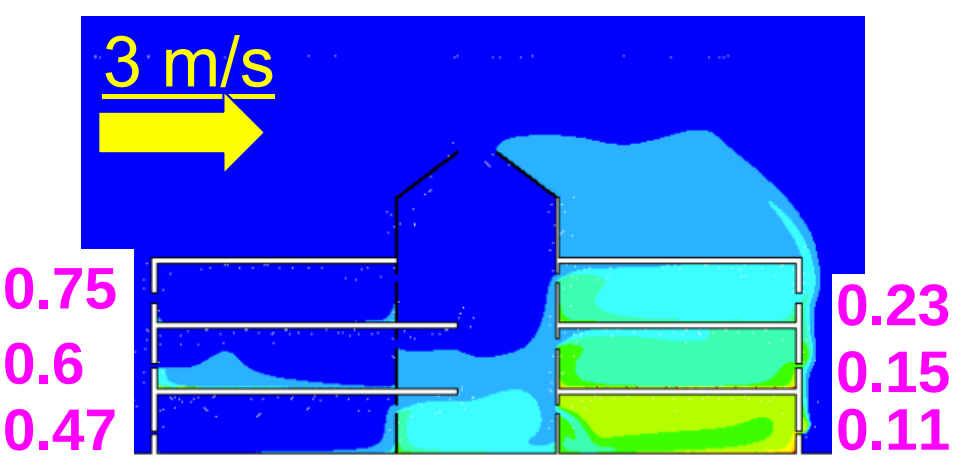
30
28
26
24
22
20

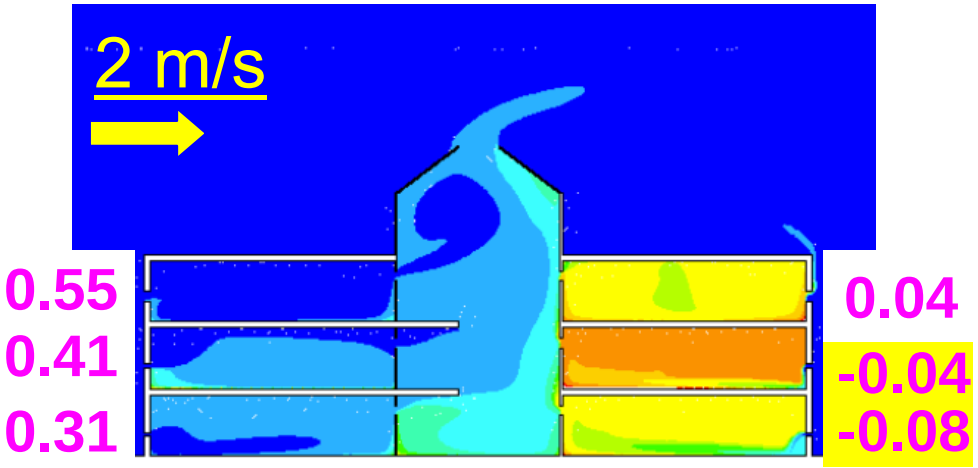
Buoyancy only



m³/s-m

Wind + buoyancy





Concluding remarks

Design of buoyancy-driven natural ventilation for complex buildings with possible presence of simultaneous assisting and opposing wind effects should ensure minimising the opposing effect by

1. Intelligent control of inlet vents to prevent excessive wind flow into the building from the wind side,

2. Accelerating removal of room air from outlet vents, e.g. with the aid of wind-driven devices such as turrets and turbines, to depressurise the building,

3. 1 + 2

- Mechanical/mixed mode ventilation