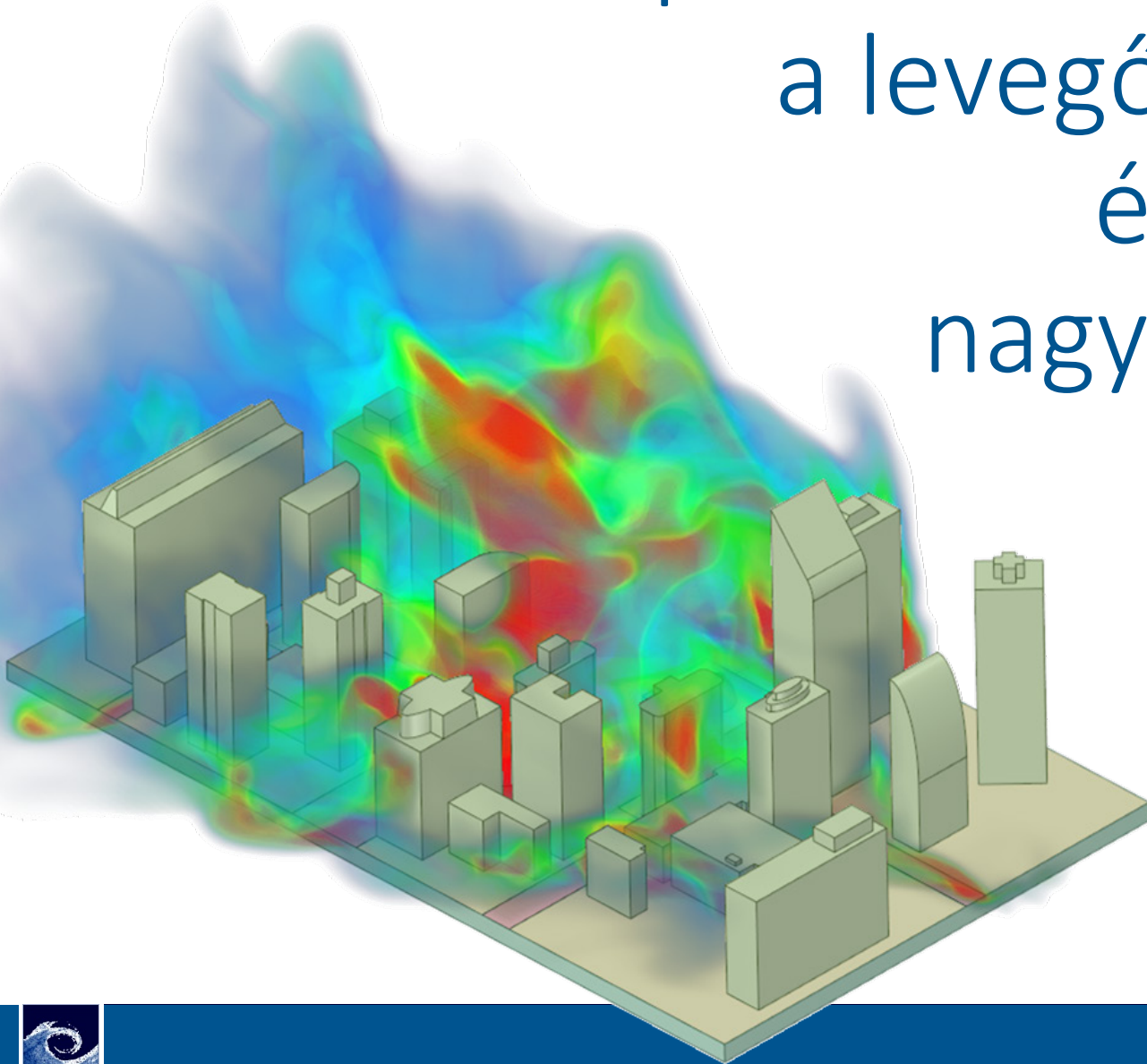


Épületmintázatok optimalizálása a levegőminőség javításának érdekében GPU alapú nagyörvény szimulációval



PAPP Bálint
KRISTÓF Gergely

Budapesti Műszaki és
Gazdaságtudományi Egyetem
Áramlástan Tanszék





ANSYS Discovery Live

- Rendkívül gyors, GPU alapú nagyörvény szimuláció (LES), kapcsolt hőtani szimulációval együtt
- A szennyezőanyag terjedés vizsgálata a diffúzió-hőtranszport analógia felhasználásával:

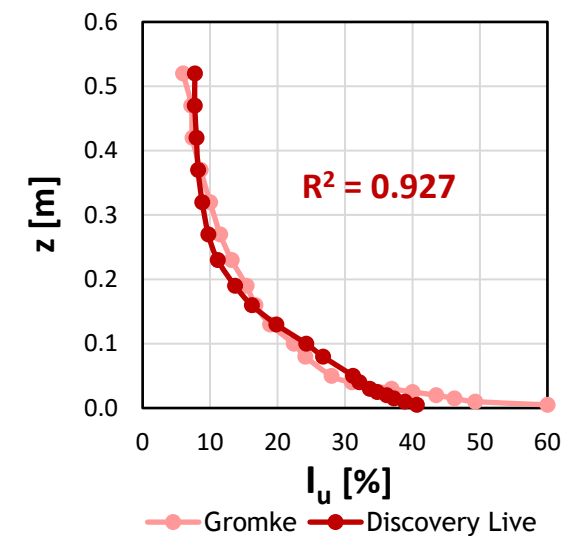
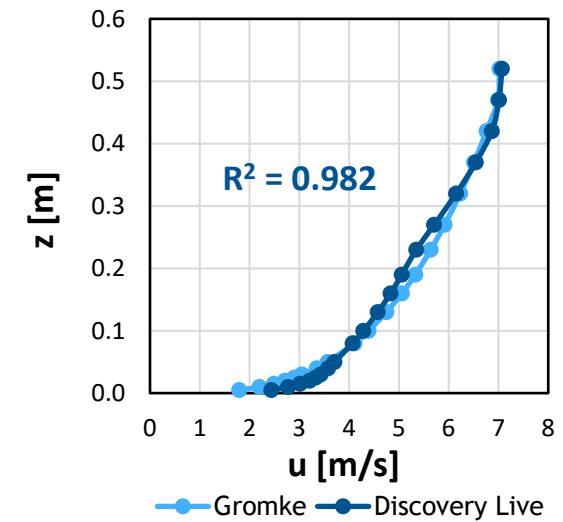
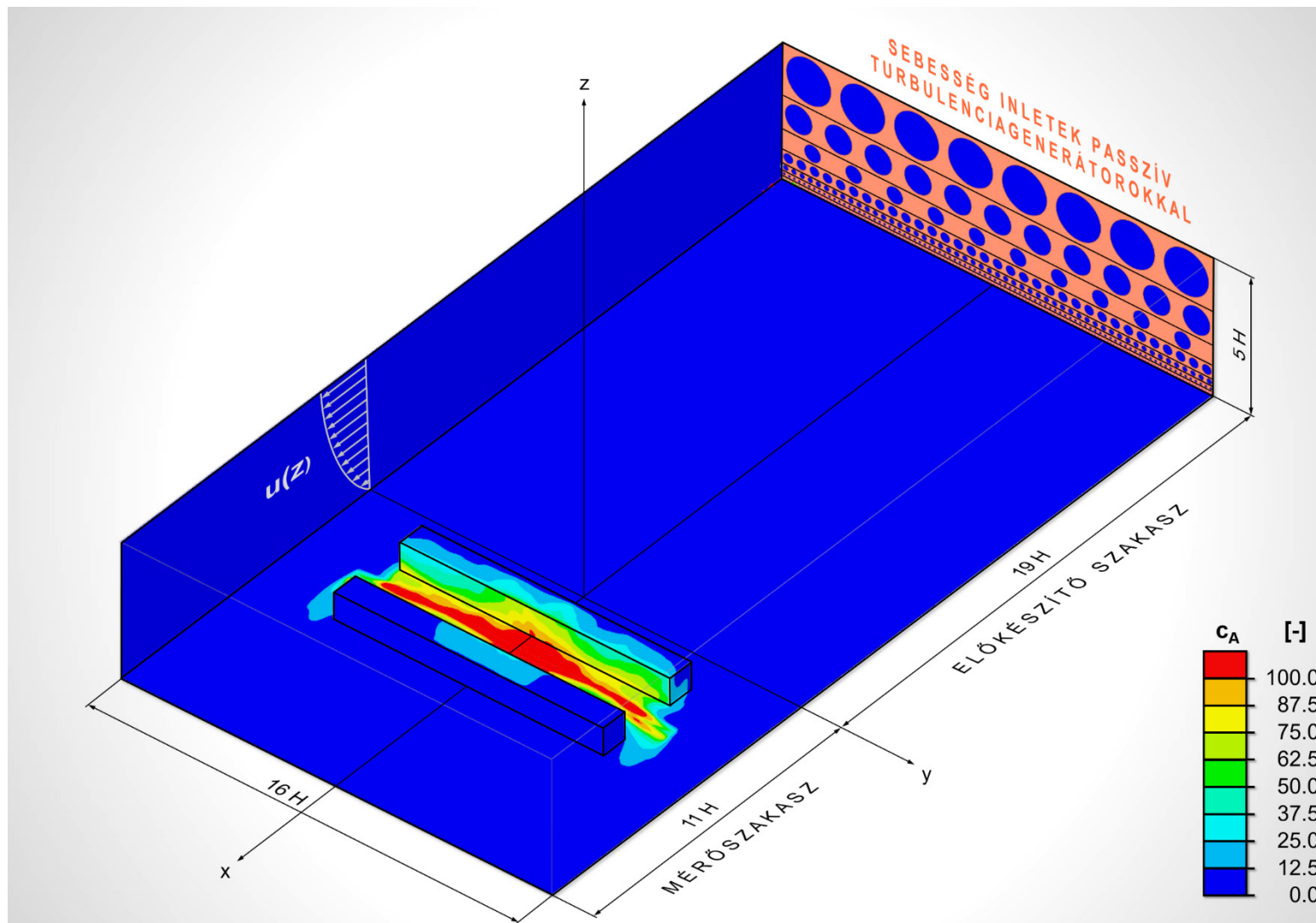
➤ Diffúzió: $\frac{dc}{dt} = \nabla \cdot (D \nabla c) \quad \rightarrow \quad c^+ = \frac{U_H H}{Q_l} c$

➤ Hőtranszport: $\frac{dT}{dt} = \nabla \cdot (a \nabla T) \quad \rightarrow \quad c^* = \frac{U_H H \rho c_p}{Q_l} T \quad c_A = \frac{U_H A \rho c_p}{Q_A} T$

$Le = \frac{a}{D} = 1$ 1 1



A numerikus szélcsatorna

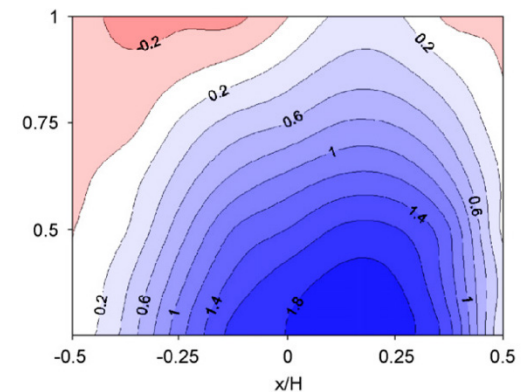
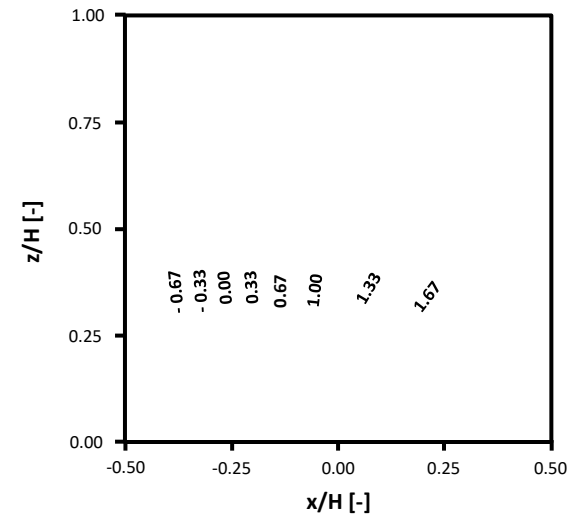
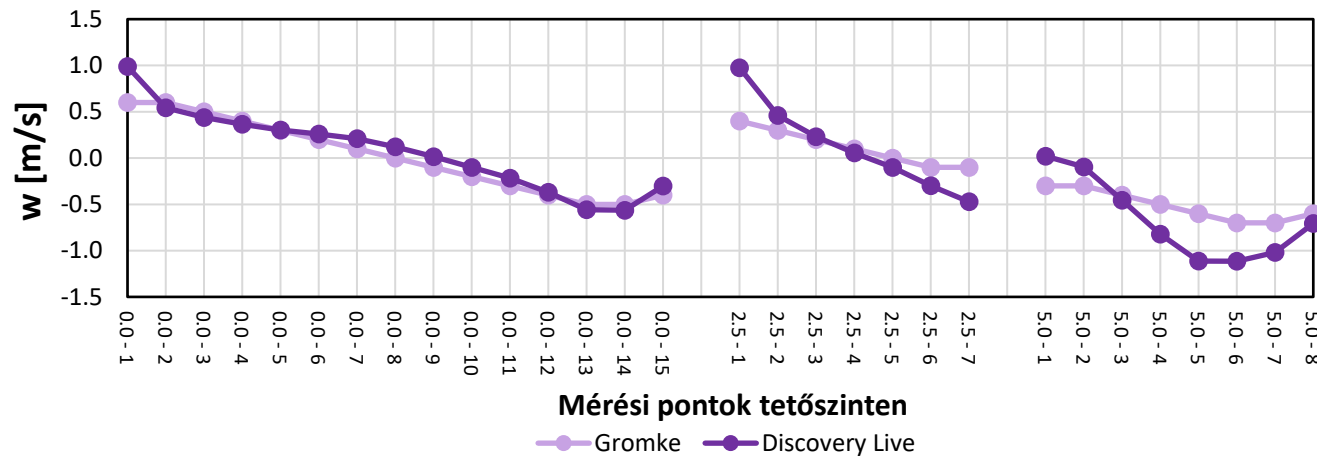
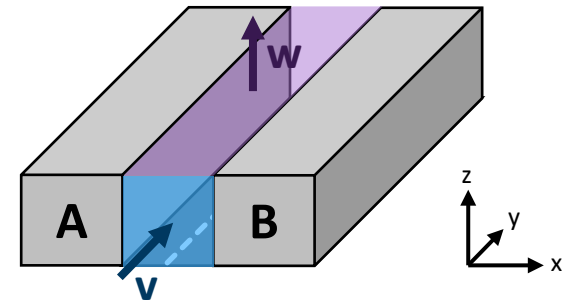
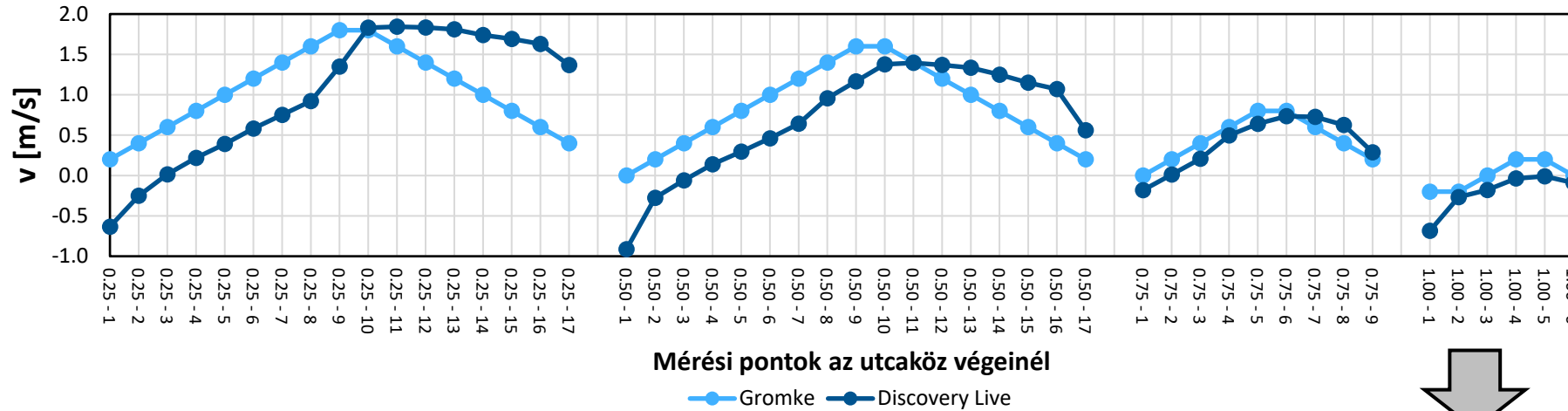


Átlagsebesség

Turbulencia-intenzitás



A sebességmező validációja

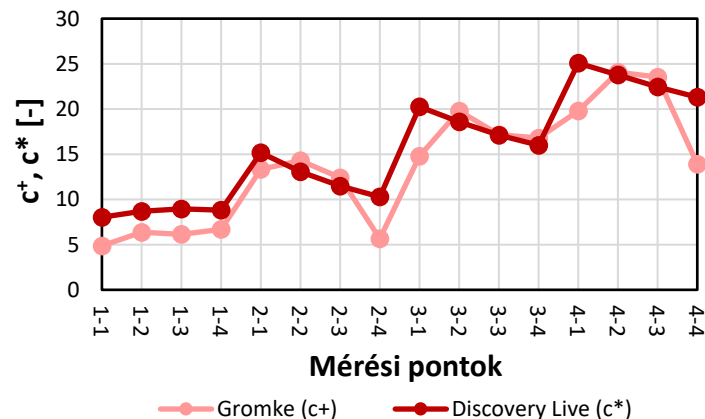


A szennyezőanyag-eloszlás validációja

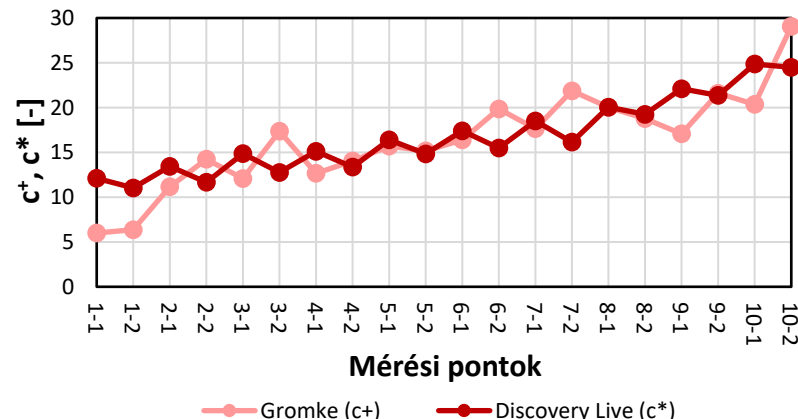
Kristóf, G.; Papp, B. (2018)
Application of GPU-Based Large Eddy
Simulation in Urban Dispersion Studies
Atmosphere 9 (11), 442.



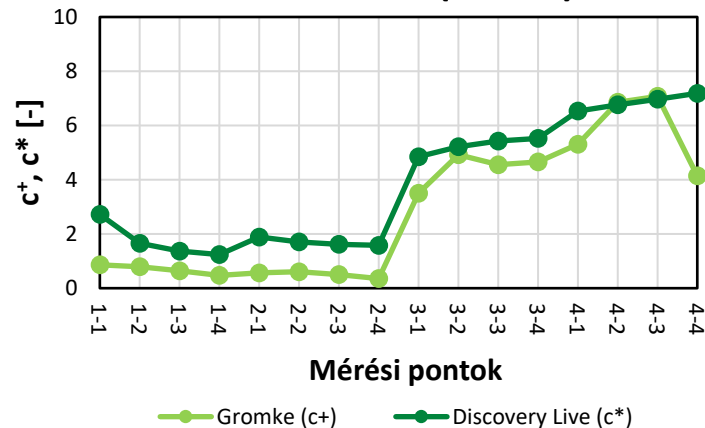
Szél alatti fal (Wall A)



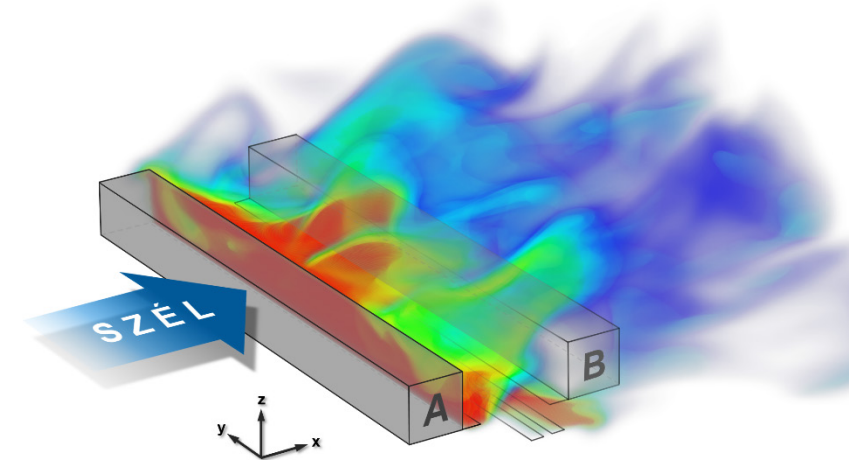
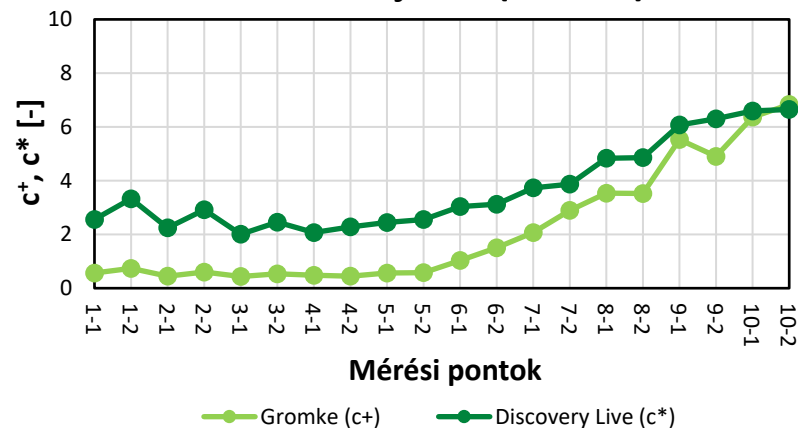
Szél alatti járda (Floor A)



Szél felőli fal (Wall B)



Szél felőli járda (Floor B)



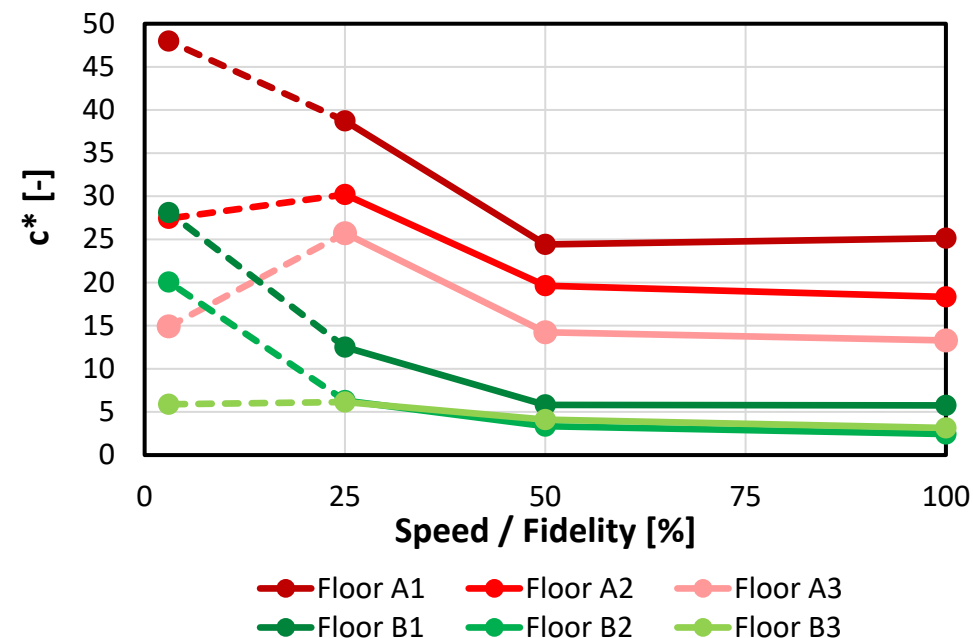
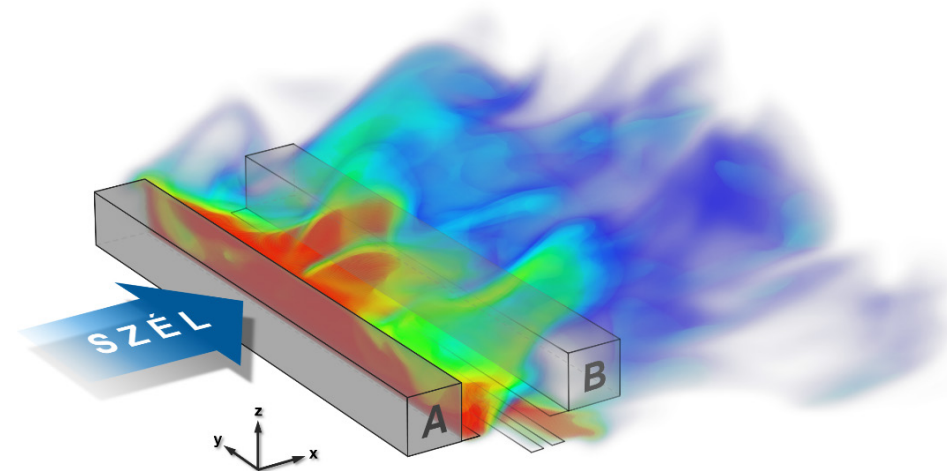
Validációs mérőszám	Eredmény	Ideális
Korrelációs együttható	0.955	1
Hit rate	0.667	1
FAC2	0.792	1
FB	- 0.124	0
MG	1.158	1
NMSE	0.075	0
VG	1.232	1



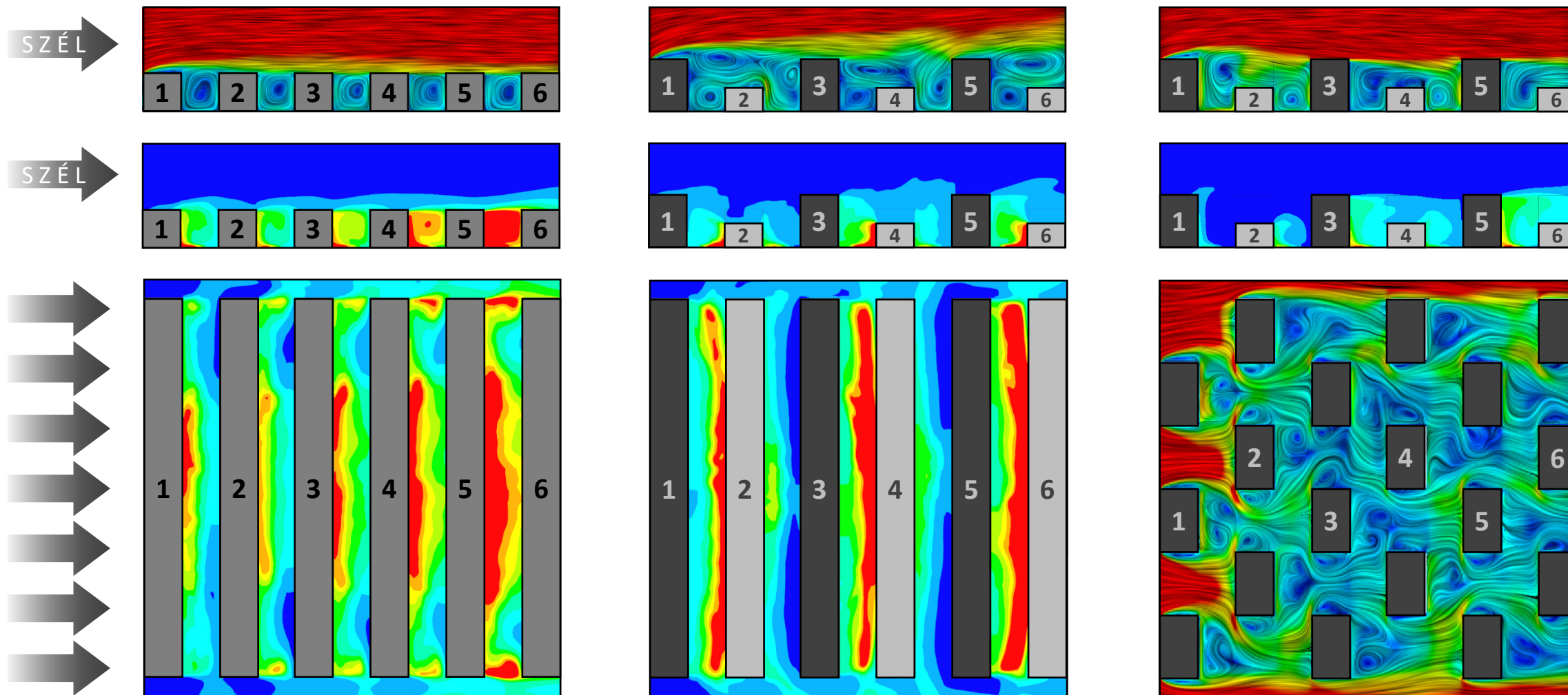
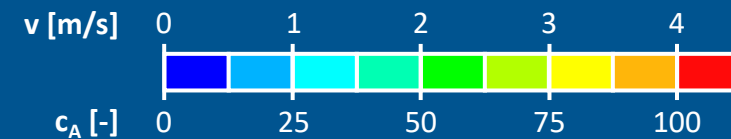
- Equidistant Cartesian mesh
- Courant-szám: $C = \frac{u_{max} \Delta t}{\Delta x} \approx 0.5$
- Becsült térbeli és időbeli diszkretizáció:

Speed/Fidelity [%]	Cellaméret [mm]	Bizonytalanság [%]	Cellaszám [millió]	Időlépés [s]
100	7.74	± 0.58	9.0	$5.2 \cdot 10^{-4}$
50	9.71	± 3.04	4.5	$6.9 \cdot 10^{-4}$
25	15.52	± 1.72	2.1	$9.4 \cdot 10^{-4}$
3	38.33	± 4.36	0.074	$3.0 \cdot 10^{-3}$

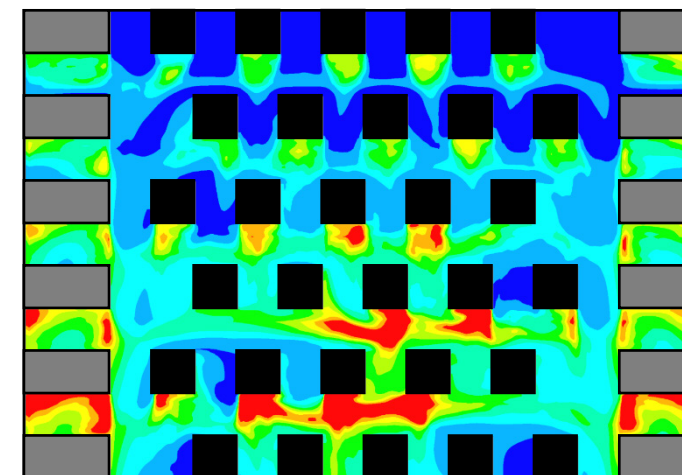
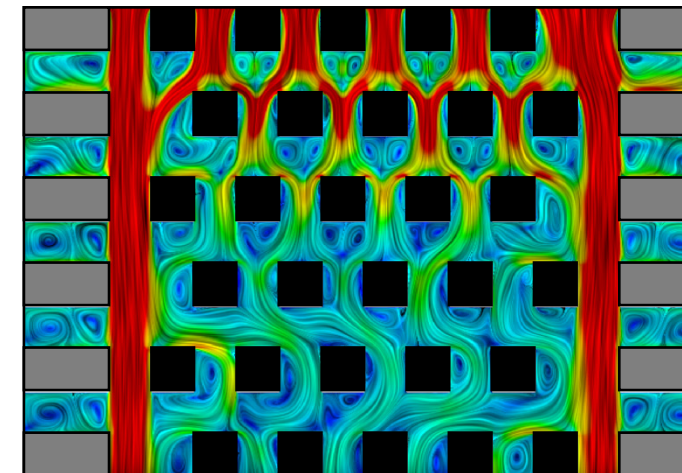
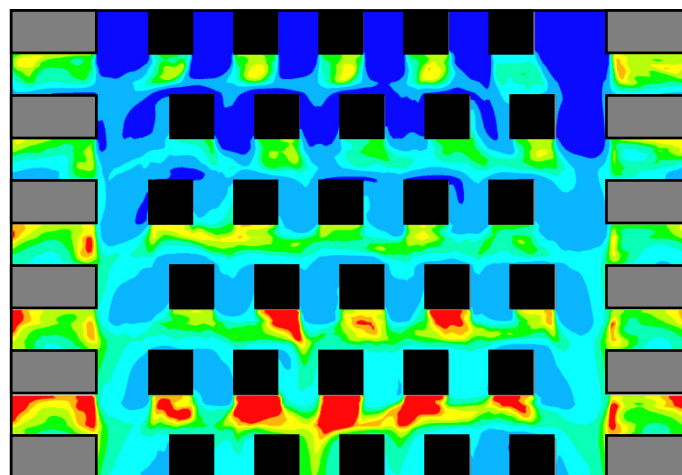
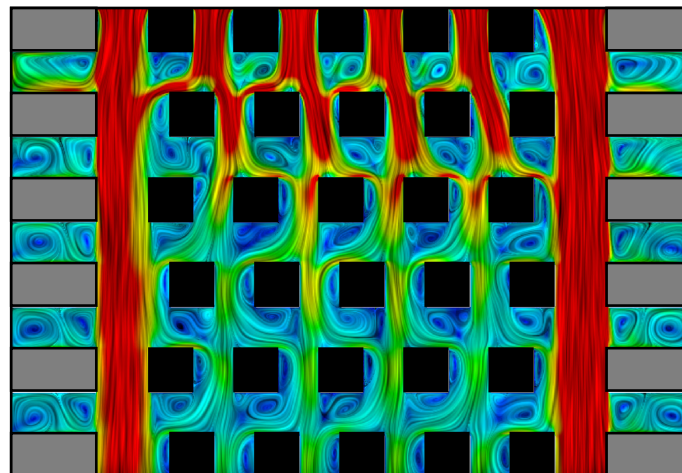
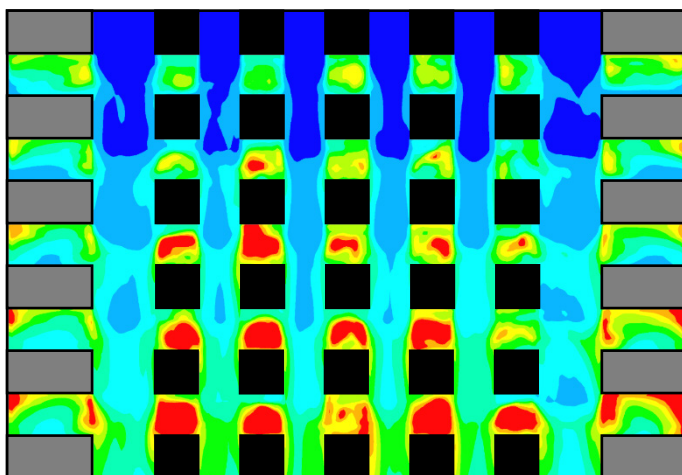
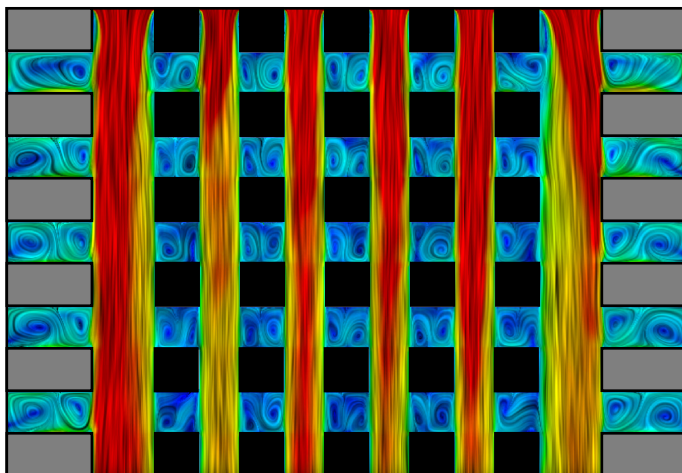
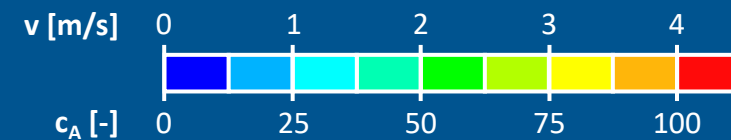
GPU: NVidia GTX 1080Ti (VRAM: 11GB)



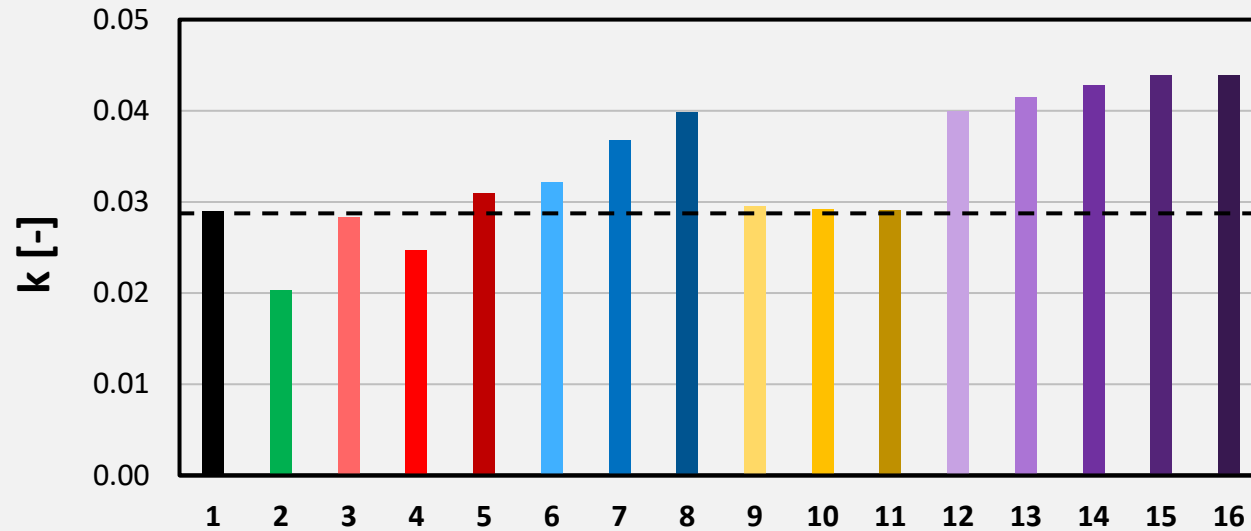
Komplex épületmintázatok



Komplex épületmintázatok



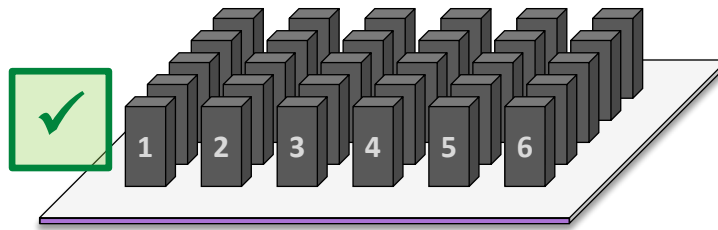
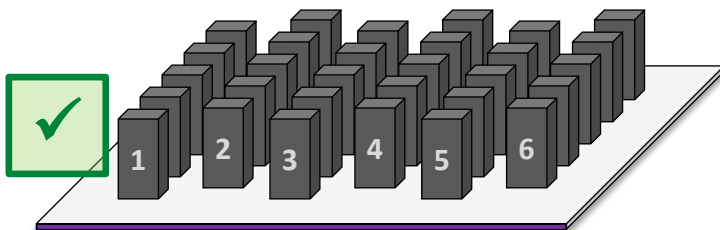
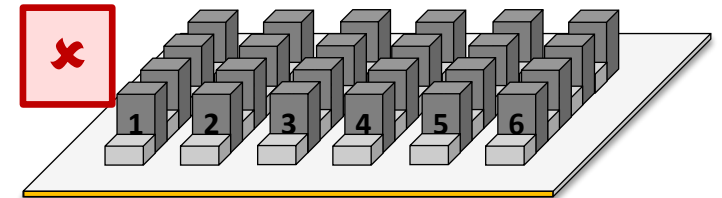
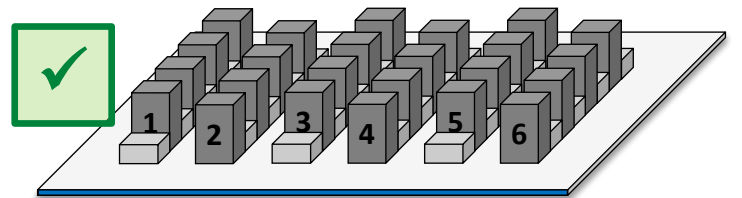
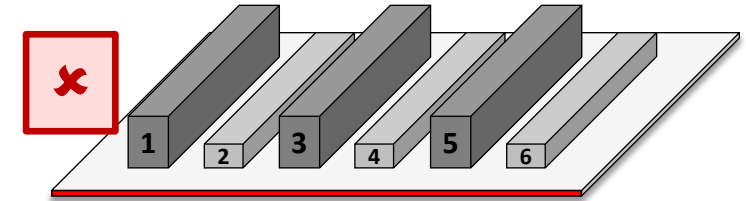
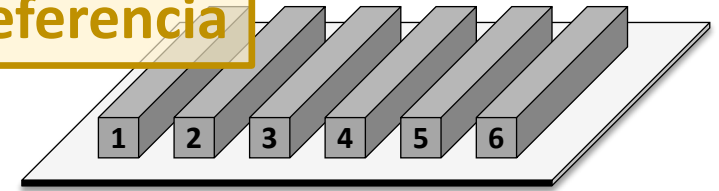
A komplex épületmintázatok összehasonlítása



Stanton-szám: $St_m = \frac{h_m}{\rho u}$

Az átszellőzés hatékonysága: $k = \frac{1}{\langle c_A \rangle}$

Referencia



Click an object. Double-click to select an edge loop. Triple-click to select a solid.

Active...

Sketch

Edit

Setup

+ Solution Add...

Külső áramlás (External)

Air (Gromke) (Default)

Initial Temperature 0 °C

Outlet Pressure 0 kPa

Slip Symmetry

Flow Velocity 3.4 m/s

Flow Velocity 5.5 m/s

Flow Velocity 9 m/s

Flow Velocity 10 m/s

Flow Velocity 12 m/s

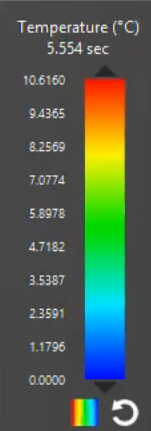
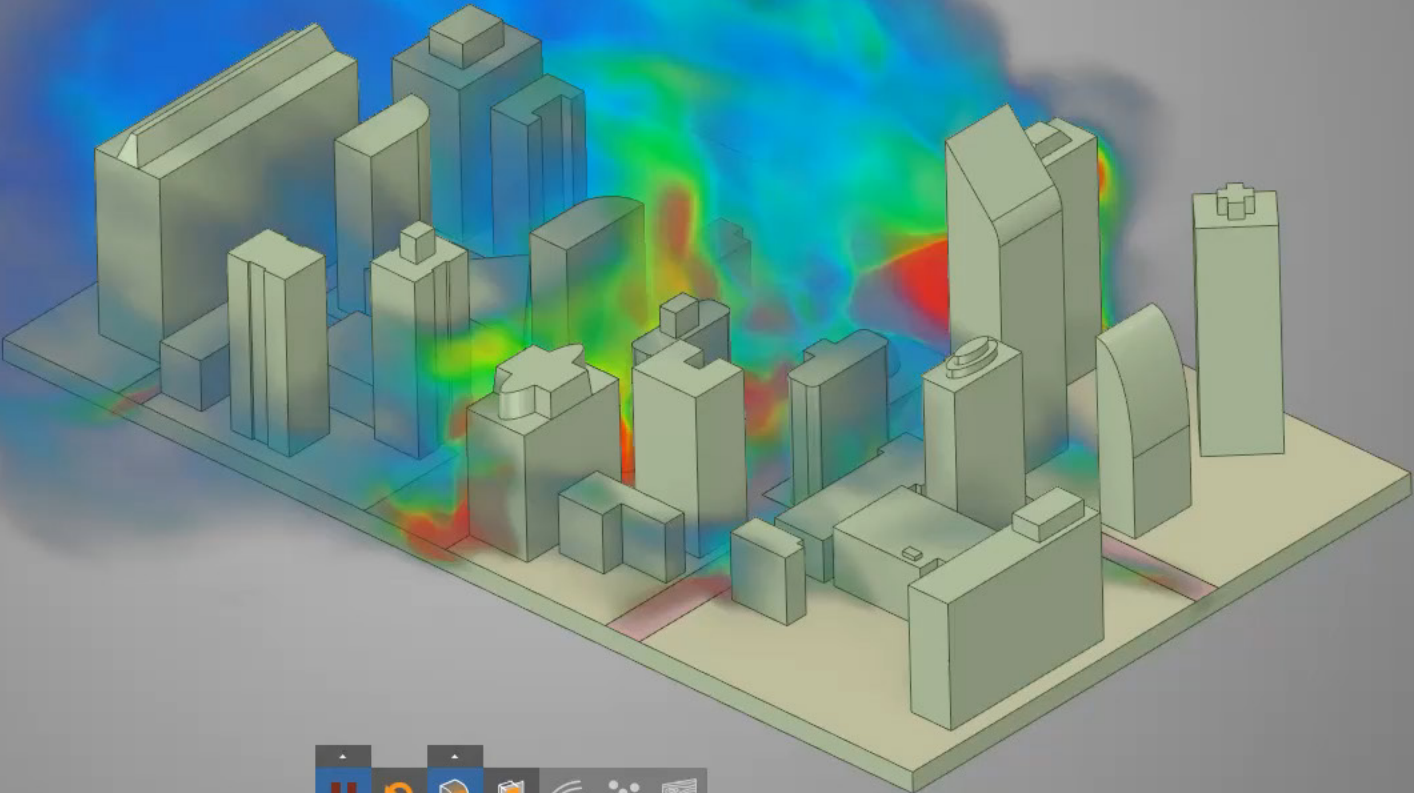
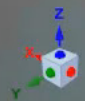
Flow Velocity 8.5 m/s

Flow Velocity 10.6 m/s

Heat Flow 1000 W

Calculations

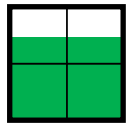
- PHH



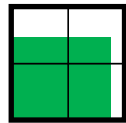
Szennyezőanyag-terjedés atmoszférikus határrétegben elhelyezett realisztikus városmodell esetén

A hálóinterferencia módszer

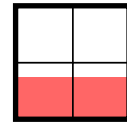
Hogy bontja fel az egyenközű háló a geometriát?



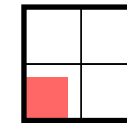
Felbontott



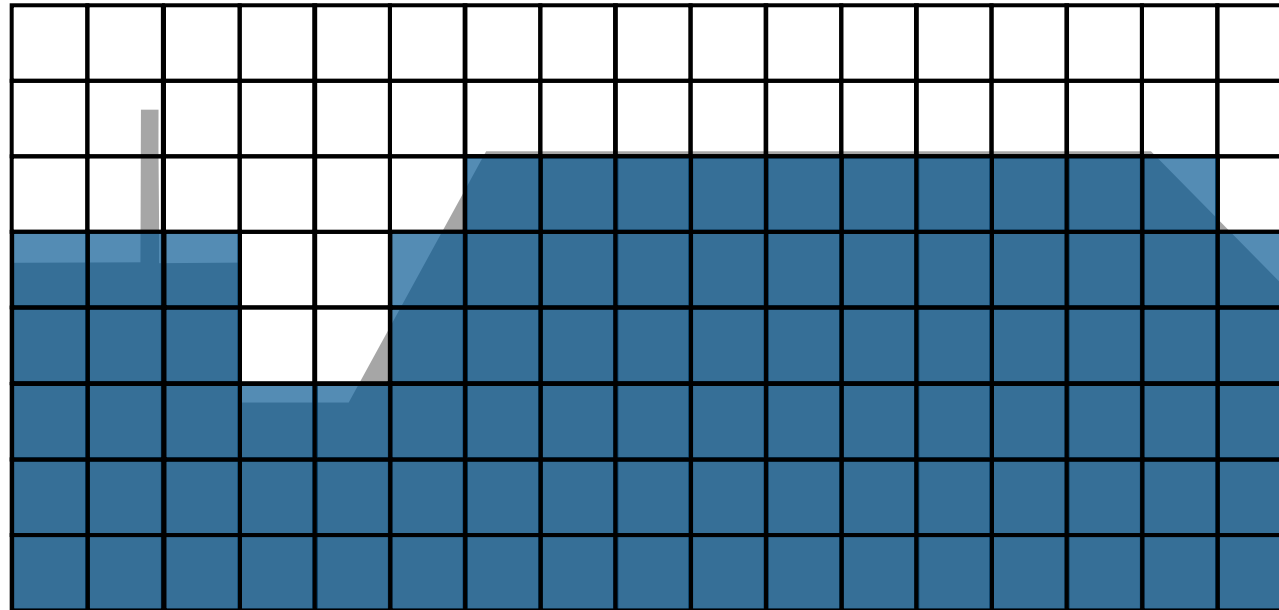
Felbontott



Nem felbontott

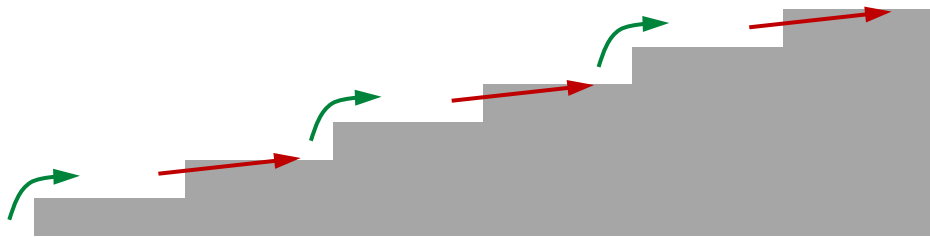


Nem felbontott



A hálóinterferencia módszer

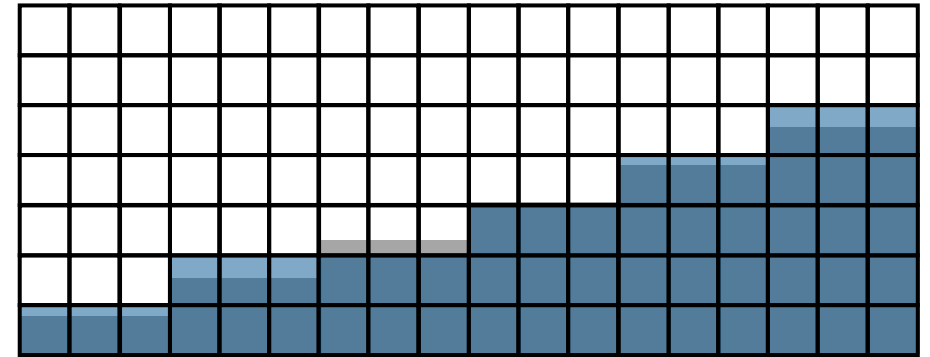
- 1) Az áramvonalak vizsgálata: mely lépcsők vannak felbontva (**resolved**) és melyek nem (**skipped**)?



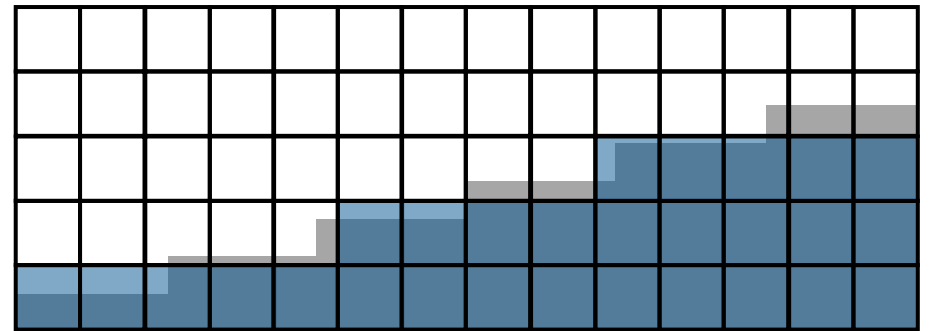
- 2) Interferencia minta: **RRSRRR**
- 3) Elméleti hálóméret-sorozatok interferencia-sémáinak vizsgálata
- 4) Azon cellaméret-intervallum meghatározása, melyben az interferencia sémák az eredetivel megegyező mintát mutatnak:

$$\Delta x \pm u$$

RRSRRR



RSRSRS



SRSRRS

