

TWT1 Results

Lessons Learned

Effects of vegetation on flow in the
urban environment



May 2025



TWEET-IE / Twin Wind tunnels for Energy and the Environment –
Innovations and Excellence

HORIZON-WIDERA-2021-ACCESS-03-01 / PR# 101079125



Presenter:

Demetri Bouris (NTUA)

Contributors:

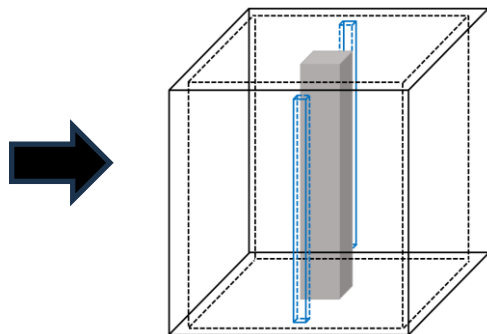
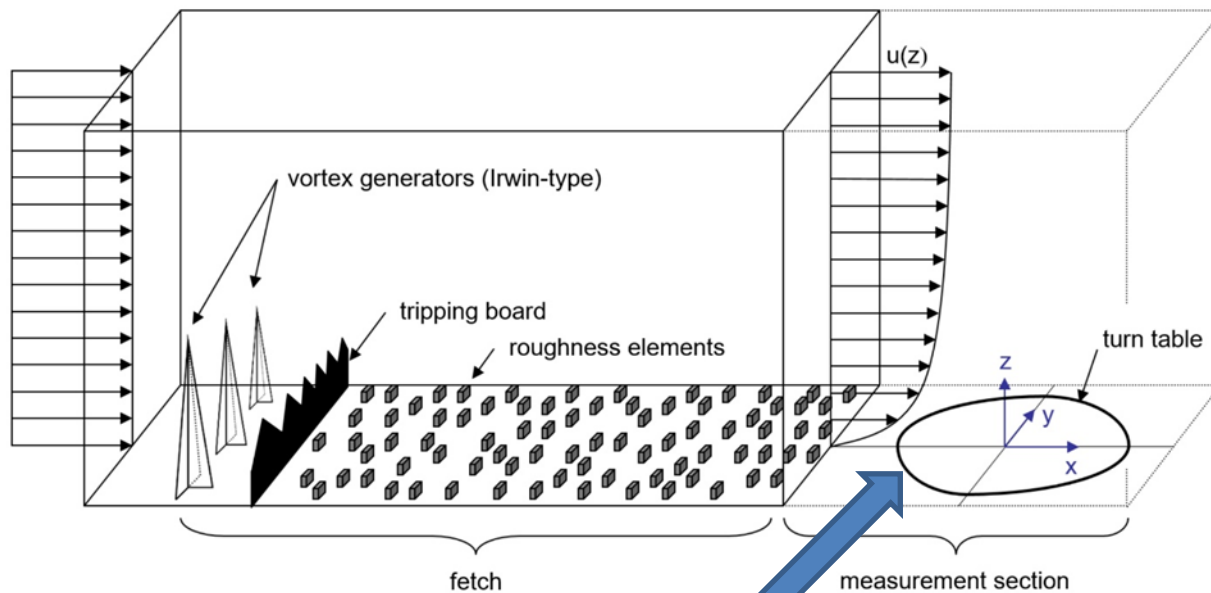
Vassiliki Pappa (NTUA)

Dr. Christof Gromke (KIT)

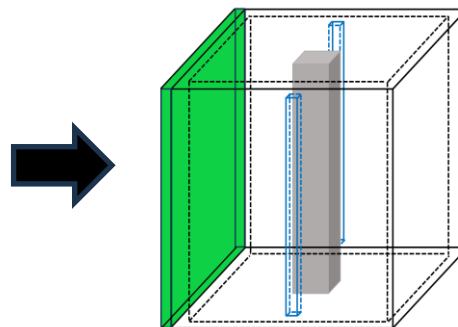
Prof. Demetri Bouris (NTUA)

TWT1 Effects of vegetation on flow in the urban environment

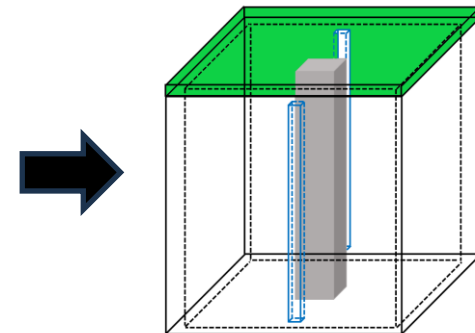
- Geometry - Measured configurations
- Wind tunnels
- Flow conditions in wind tunnels
- Measurement methods
- Comparison of measurements
- Discussion



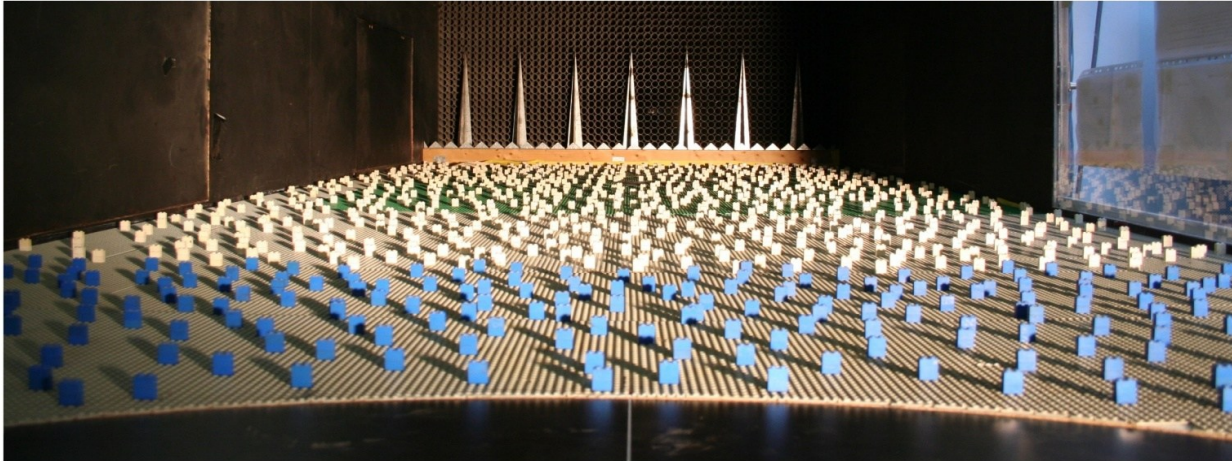
a) Bare Building



b) Façade greening



c) Rooftop greening

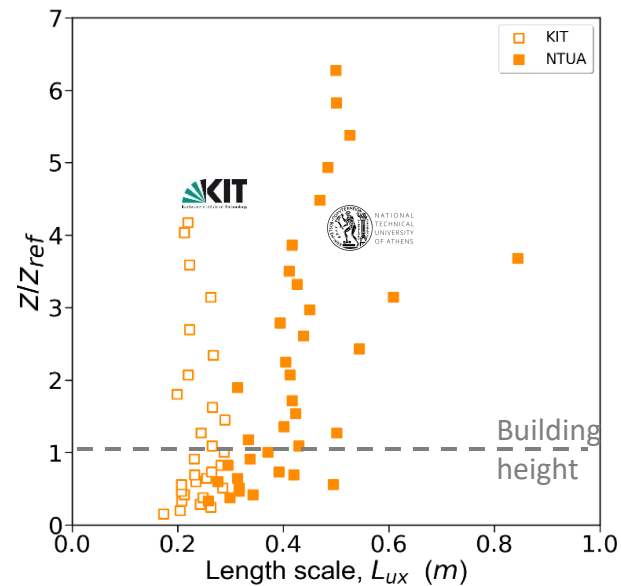
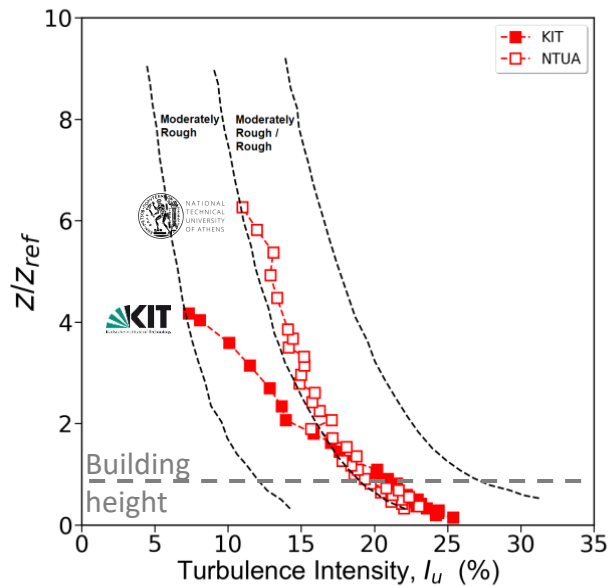
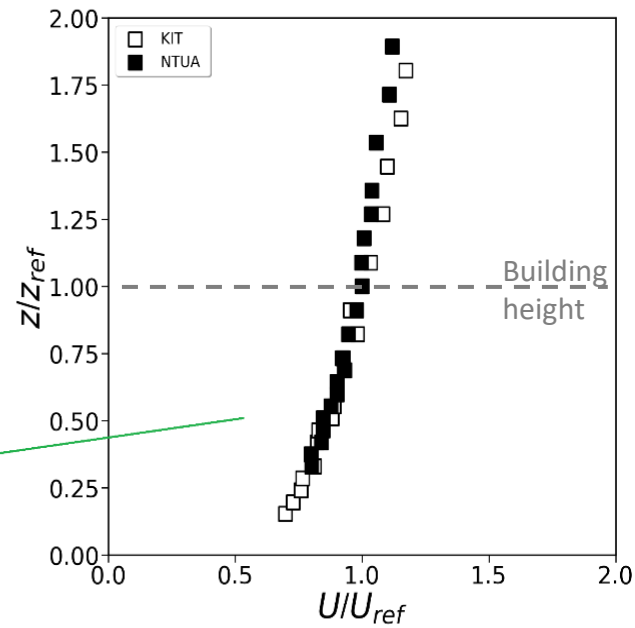
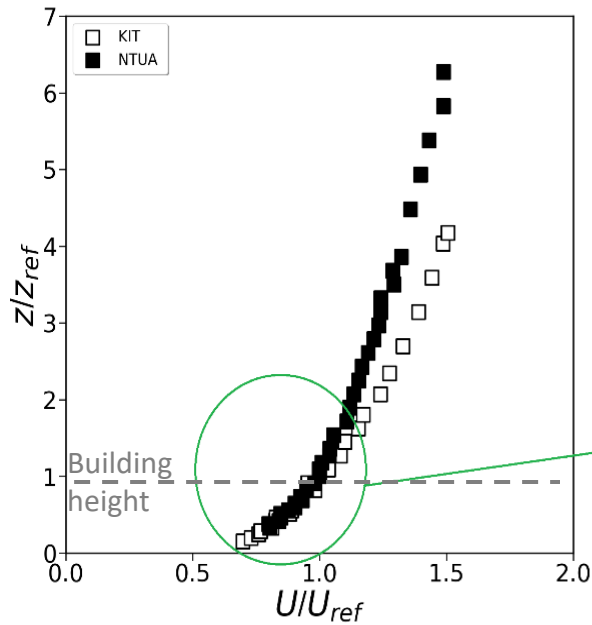


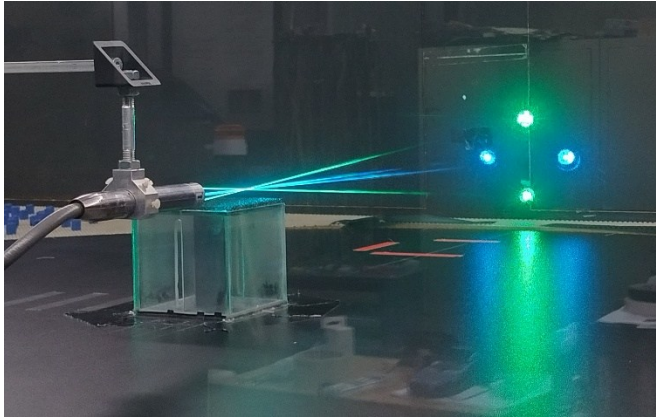
Closed loop (width \times height): 2.0 m \times 1.0 m



Closed loop (width \times height): 3.5 m \times 2.5 m

		KIT	NTUA
Free stream velocity, u_∞		5.0 m/s	5.0 m/s
Power Law	$\frac{u(z)}{u_{ref}} = \left(\frac{z-d}{z_{ref}} \right)^\alpha$ <p>$d=0, z_{ref}=H=110 \text{ mm}$</p>	$U_{ref} = 3.27 \text{ m/s}$ $\alpha = 0.28$	$U_{ref} = 2.36 \text{ m/s}$ $\alpha = 0.22$
Logarithmic Law	$\frac{u(z)}{u_*} = \frac{1}{\kappa} \left(\ln \frac{z-d}{z_0} \right)$	$u_* = 0.25 \text{ m/s}$ $z_0 = 1.80 \text{ mm}$	$u_* = 0.22 \text{ m/s}$ $z_0 = 1.45 \text{ mm}$
Reynolds number, $Re_H = U_H H / \nu$ $Re_{crit} = 10000$ (VDI, 2000)		23500	16500
Scale factor, M (VDI, 2000)		1:300	1:270





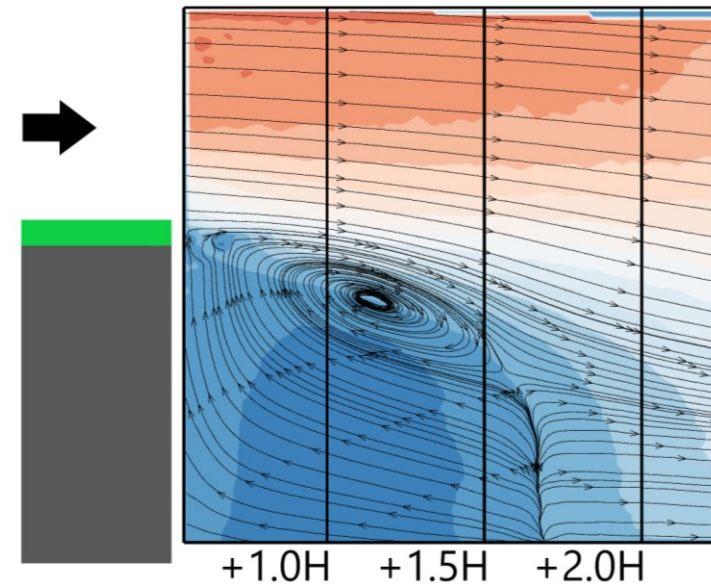
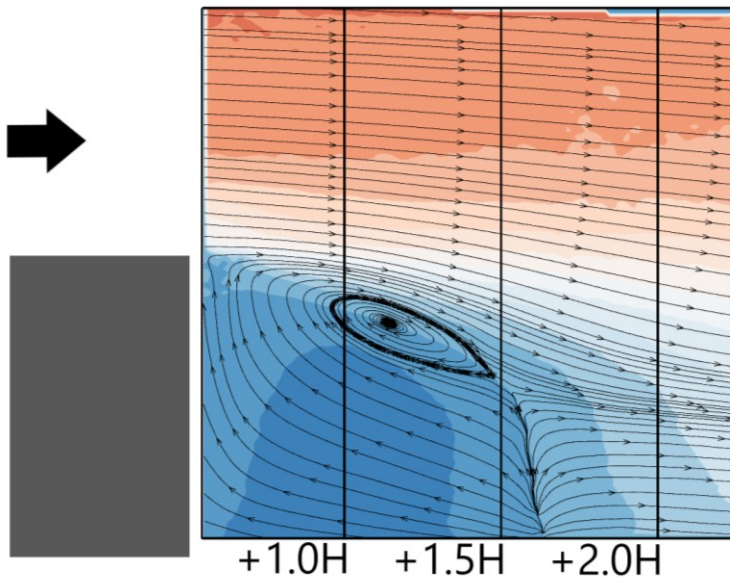
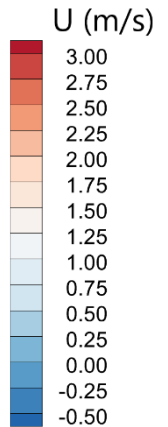
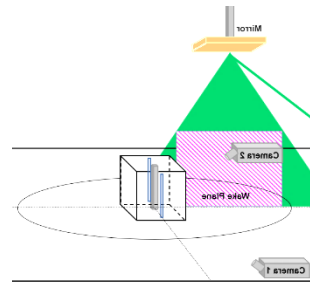
2D LDV : u-v or u-w

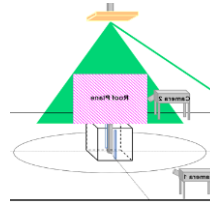
- 3 profiles/ roof, sidewall, wake
- $f_{\text{sampling}} = 250 \text{ \& } 500 \text{ Hz}$
- $t_{\text{acquisition}} = 120 \text{ sec}$
- uncertainty : $\delta_U / U_H < 0.4 \%$



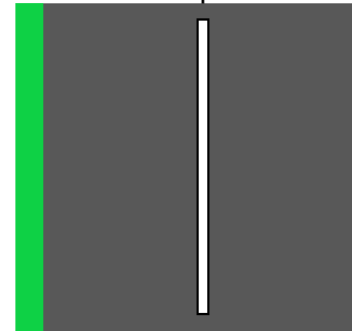
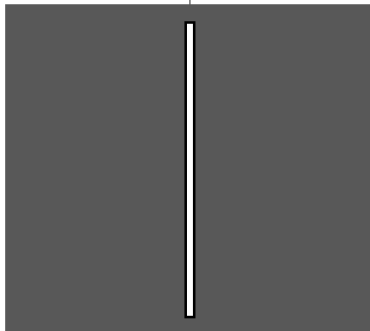
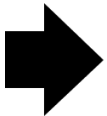
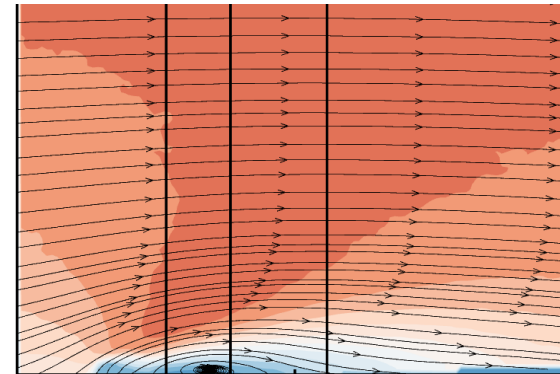
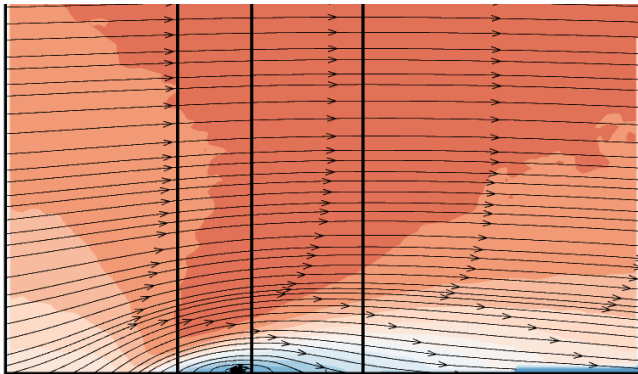
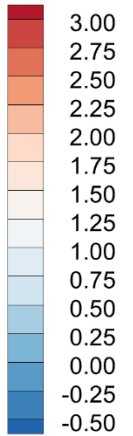
2D-2C PIV (u-v) & 2D-3C PIV (u-v-w)

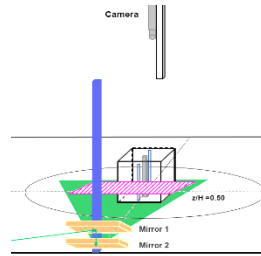
- Four planes (1.8x1.8H) :
roof, 2x sidewall, wake
- 2000 PIV image pairs / Plane
- $f_{\text{sampling}} = 7.2 \text{ Hz}$
- min. resolved velocity : 0.11 m/s



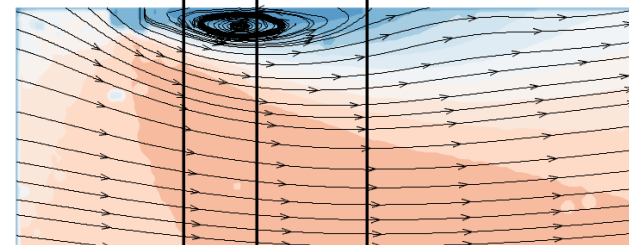
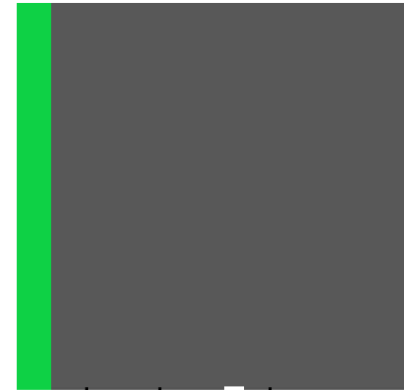
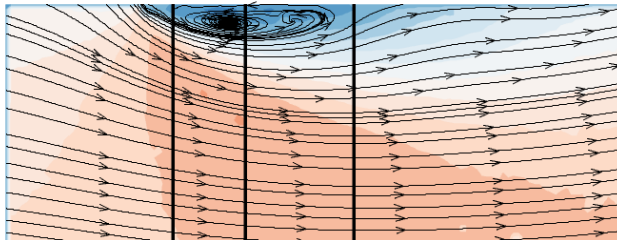
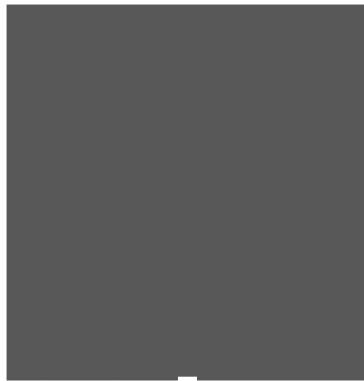
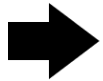
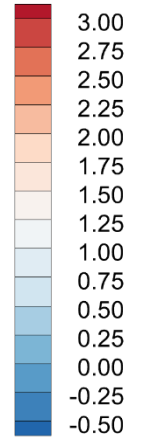


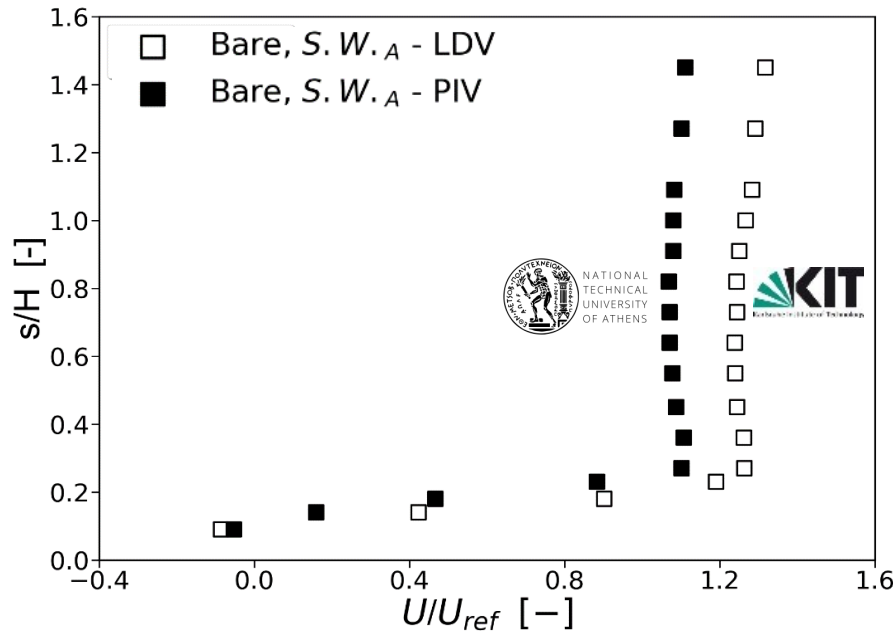
U (m/s)



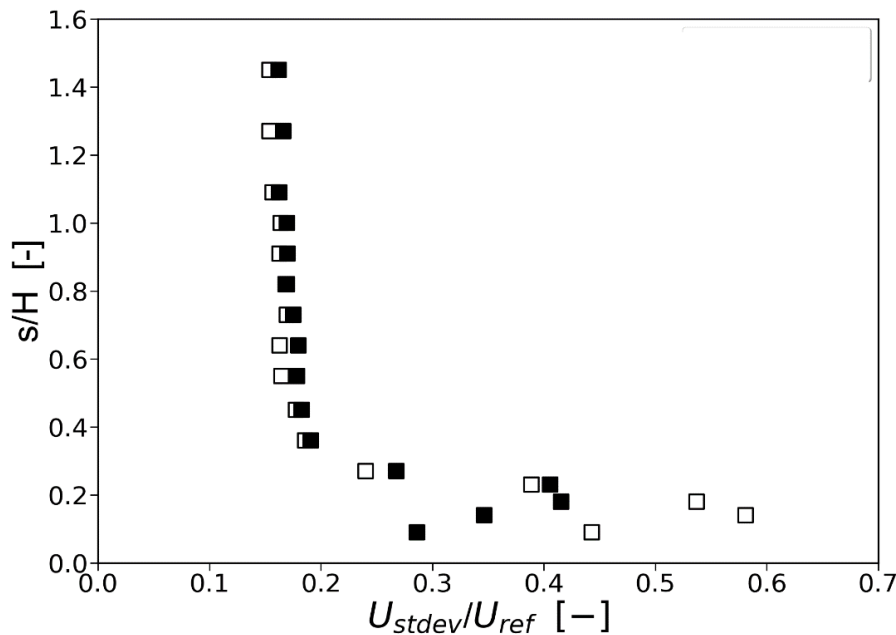
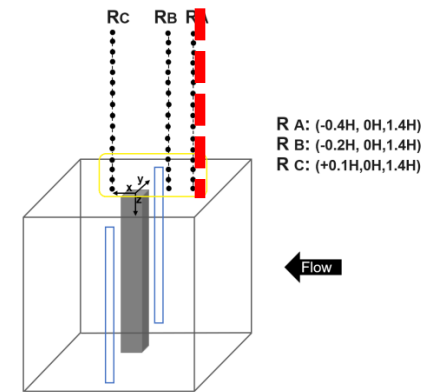


U (m/s)

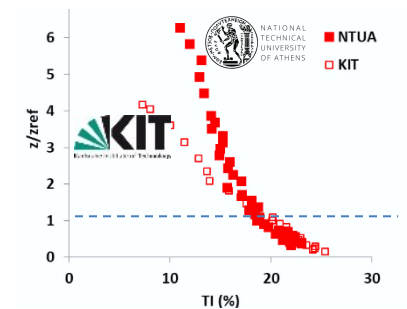
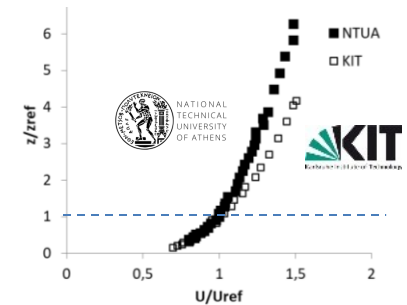


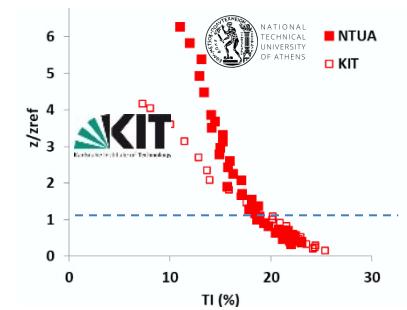
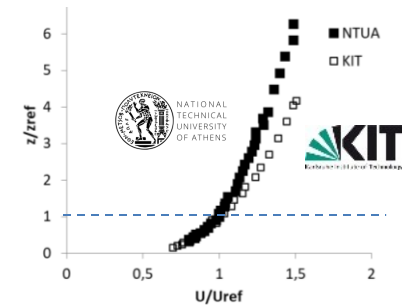
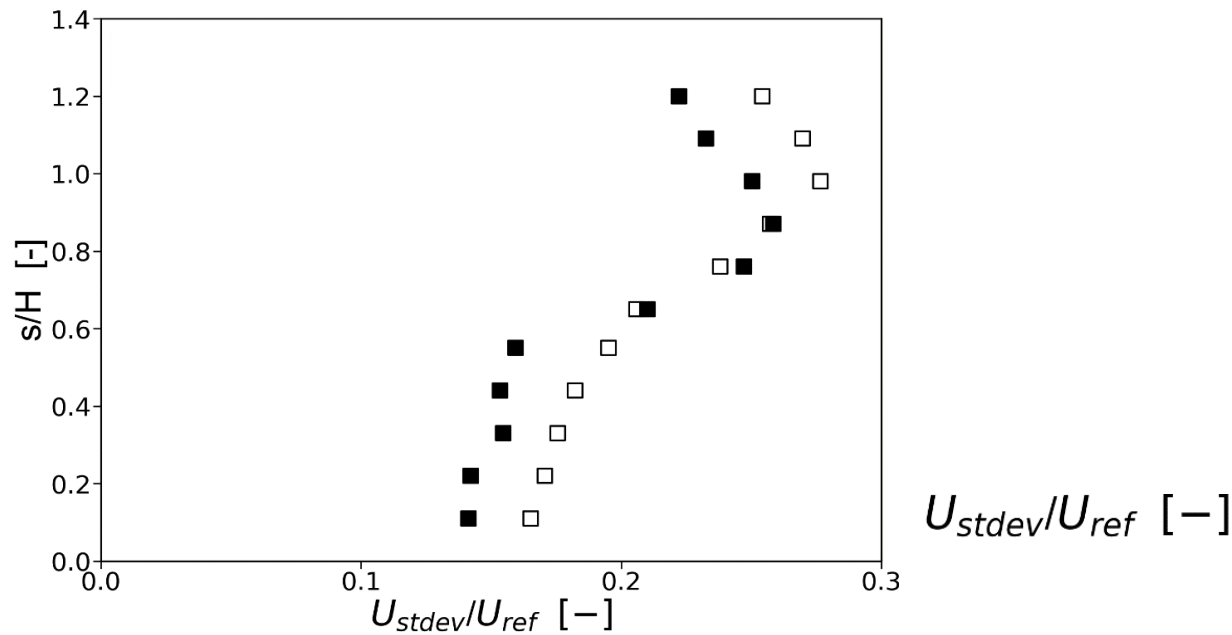
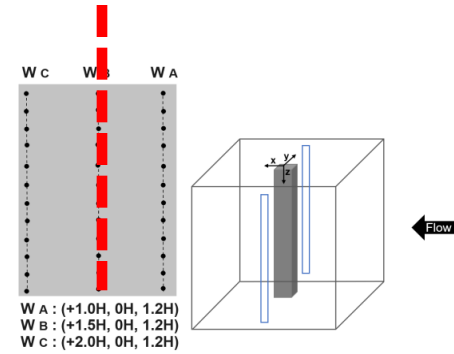
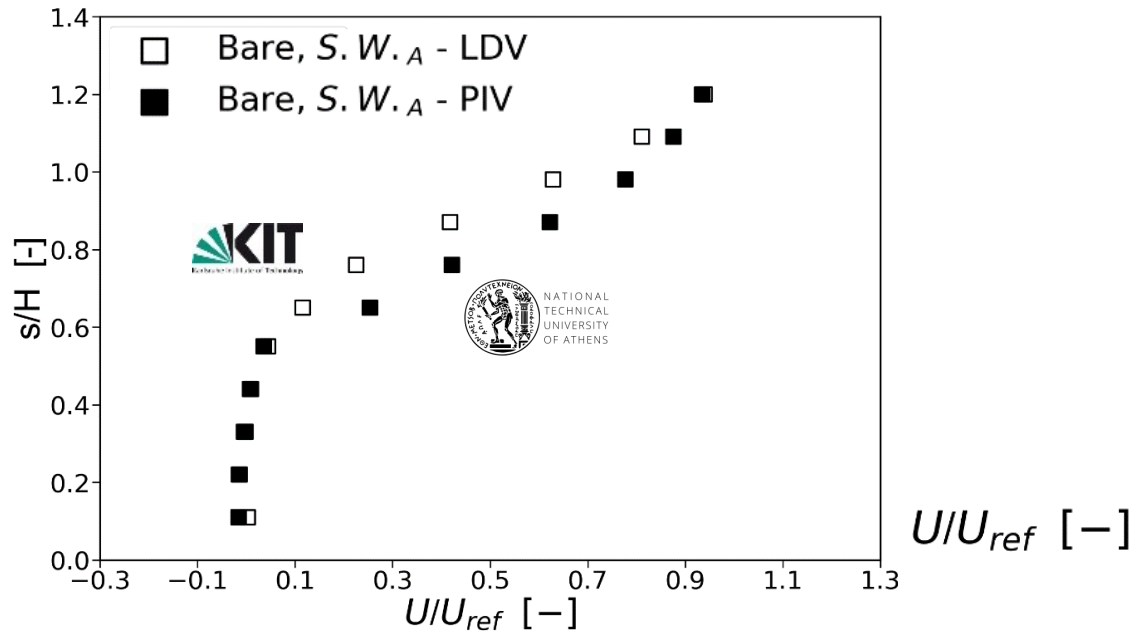


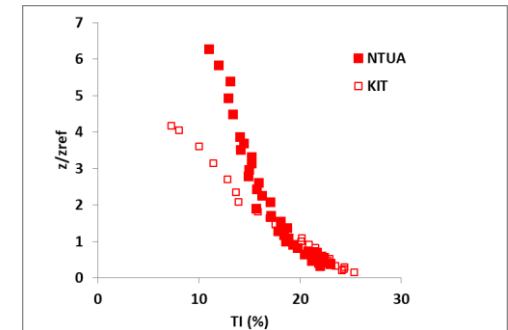
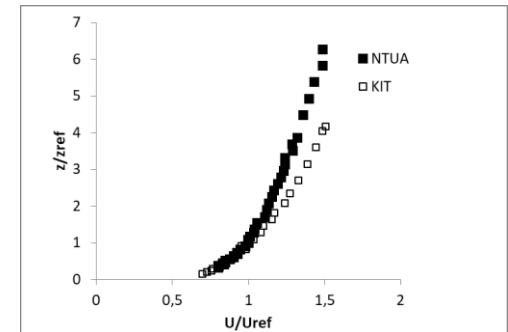
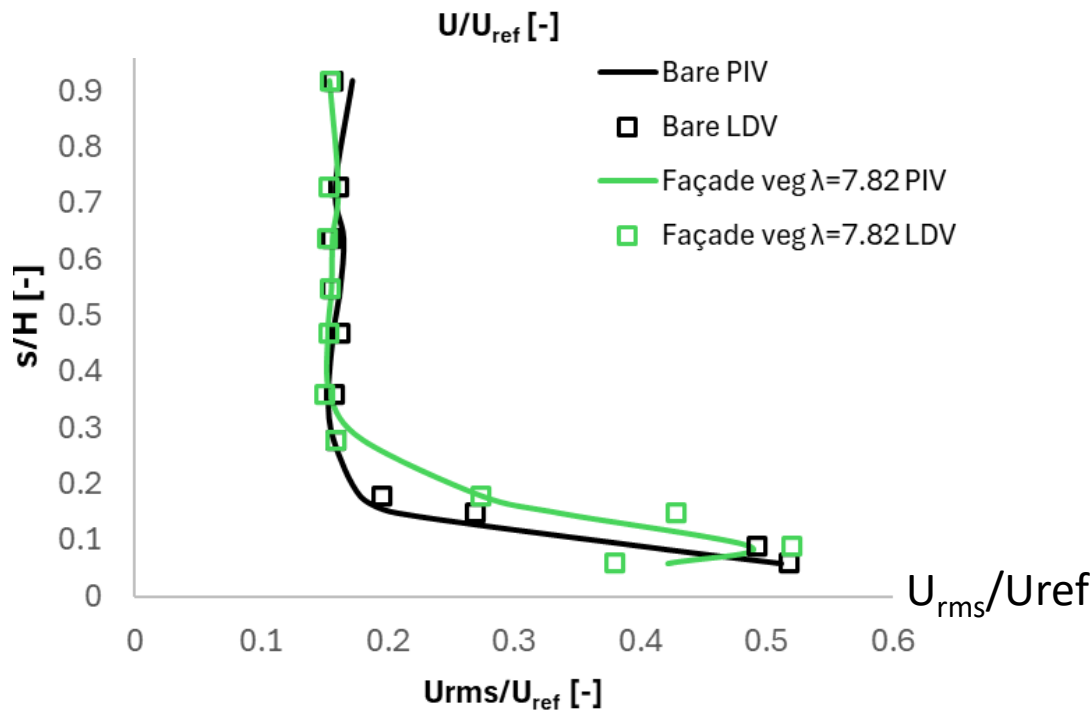
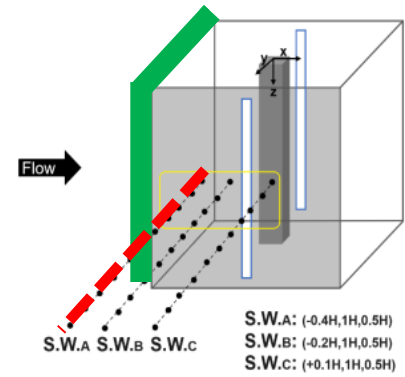
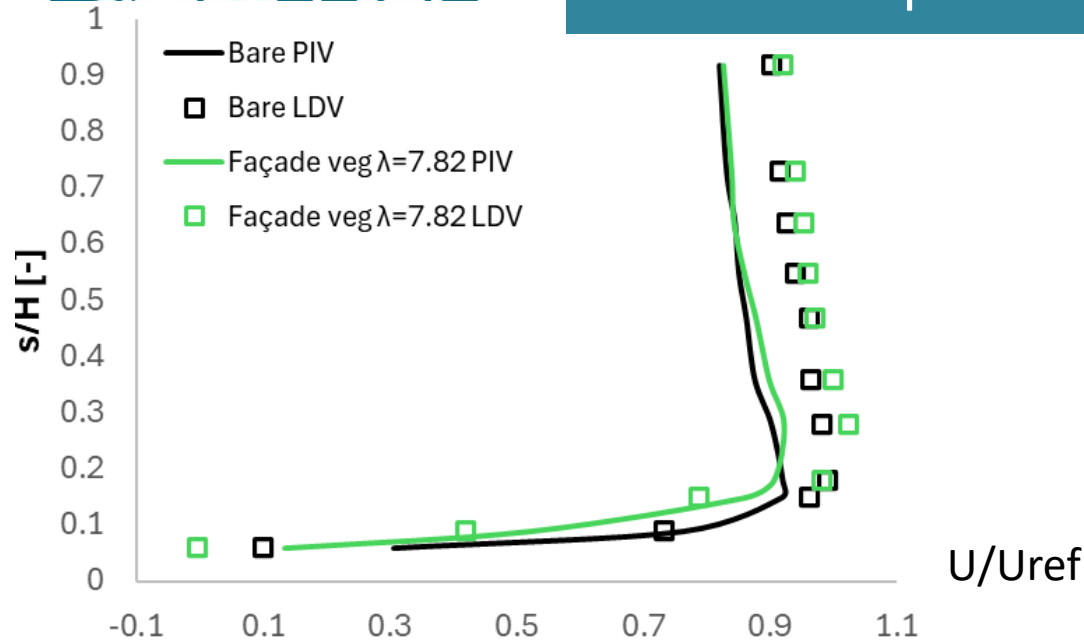
$U/U_{ref} [-]$

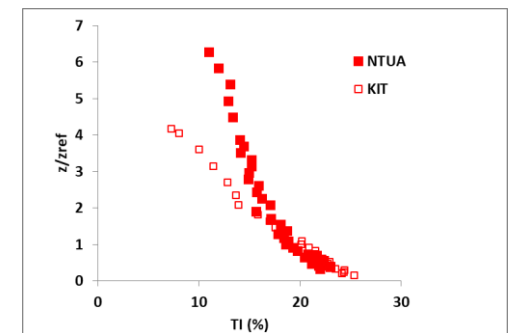
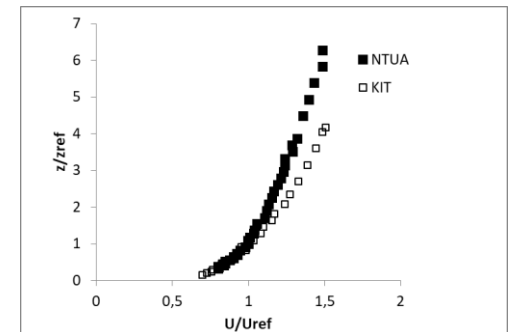
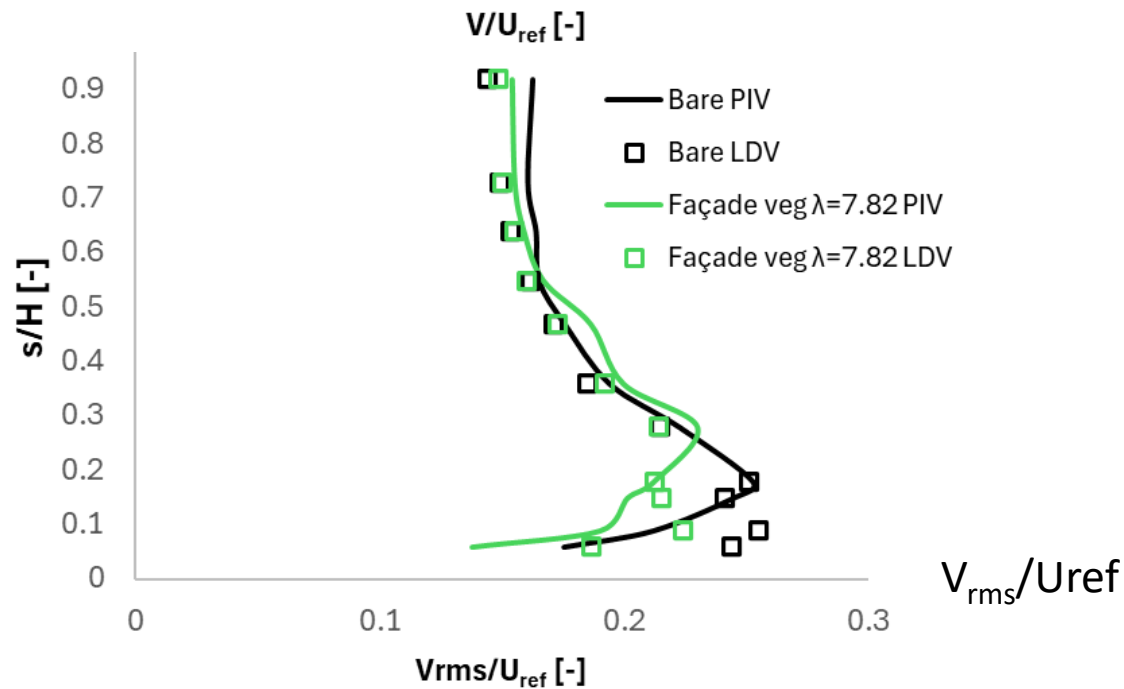
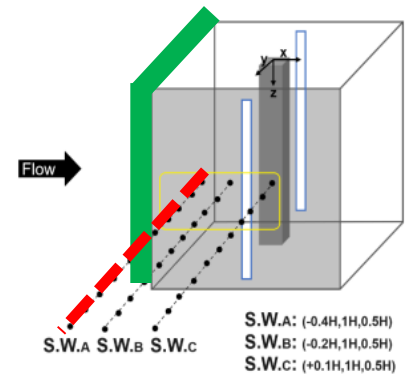
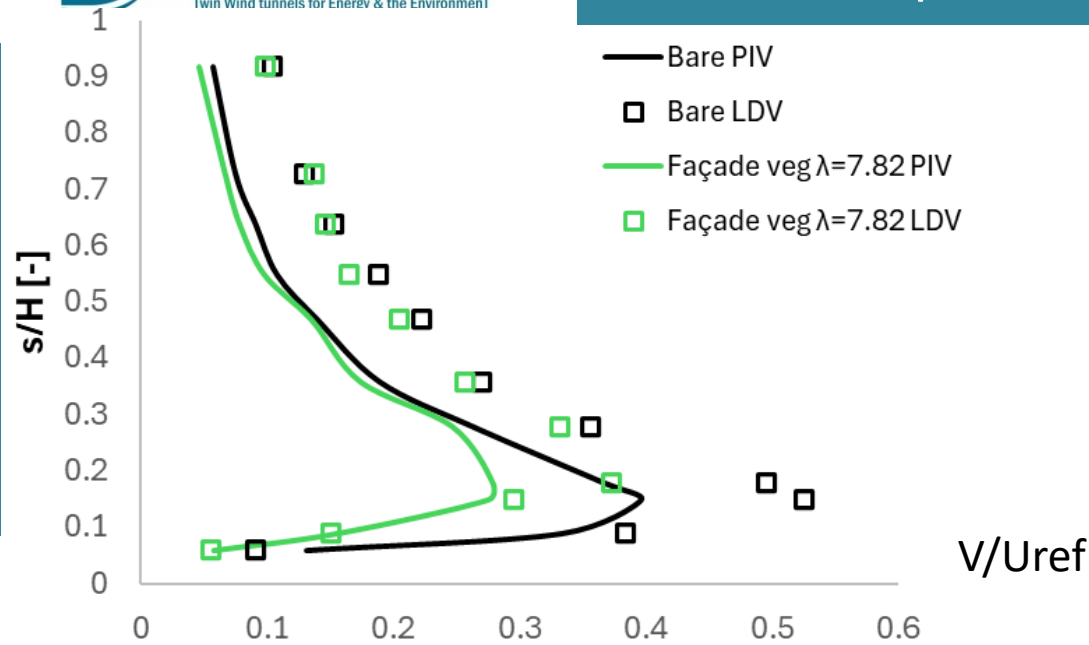


$U_{stddev}/U_{ref} [-]$









TWT1 Effects of vegetation on flow in the urban environment

- Qualitative agreement between measurements in different wind tunnels
- Quantitative differences observed.
 - Significance ?
 - Different upstream profiles of mean and turbulence ?
 - Different methods ?
- Good agreement in the trends of the effect of vegetation

TWT1 Effects of vegetation on flow in the urban environment

- Results in Book of Reference on project web page
- Data on Zenodo. 220 downloads (350 views)
- Pappa V., Gromke C., Bouris D. (2024), Flow past a building with surface greening : PIV and LDV measurements in two wind tunnels, PHYSMOD 2024 – International Workshop on Physical Modelling of Flow and Dispersion Phenomena, August 28 - 30 2024, Ecole Centrale de Lyon, Ecully, France.
- Pappa V., Gromke C., Bouris D. (2024), Twin wind tunnel tests of flow past a building with openings and façade and rooftop greening 9th International Colloquium on Bluff Body Aerodynamics and Applications, 29 July - 2 August 2024, University of Birmingham, UK.
- Παππά Β., Gromke C. (2024), Μπούρης Δ., “Δίδυμες μελέτες σε αεροσήραγγες της ροής γύρω από κτήριο με φυτεμένη όψη και δώμα”, ΡΟΗ 2024 - 12ο Πανελλήνιο Συνέδριο Φαινόμενα Ροής Ρευστών, 15 -16 Απριλίου, 2024, Θεσσαλονίκη

- Assistant Prof. Christoph Irrenfried (TU Graz, Austria)
 - RANS simulations and experimental analysis of bare building results with side ventilation.
- Assistant Prof. Janssen Xing Zheng (City University of Hong Kong)
 - LES simulations of bare building with side openings and façade greening results.
- Ph.D. student Nikos-Petros Pallas (NTUA)
 - Data assimilation combining RANS simulation of the bare building case with the corresponding dataset (Inlet hotwire profiles, Stereo PIV measurements).
- Dr. Theodore Potsis (Concordia University, Canada)
 - LES simulations of bare building with side openings and façade greening