Quantification of wind-induced coupled vibrations of a high-rise structure

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A. J. Bronkhorst, C.P.W. Geurts

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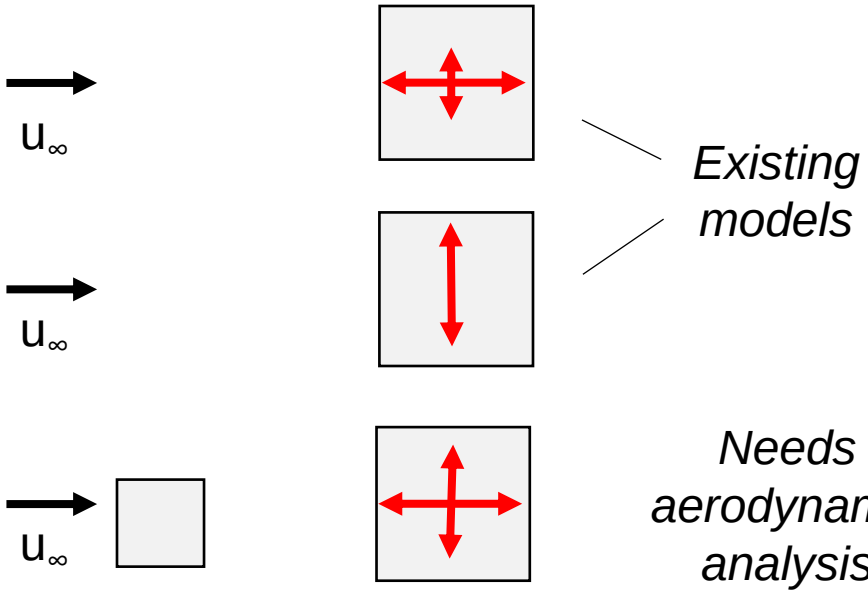
Introduction

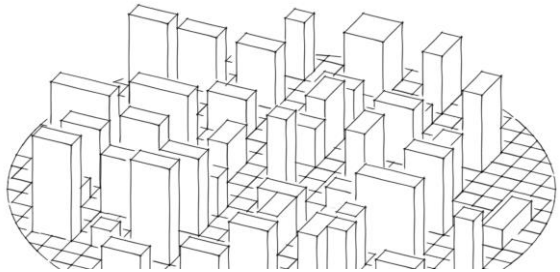
Wind induced Vibration Phenomena

- Gust induced Vibrations (GIV)
- Vortex Induced Vibrations (VIV)
- Wake Turbulence Vibrations (WTV)

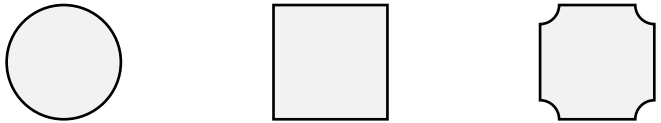


Introduction

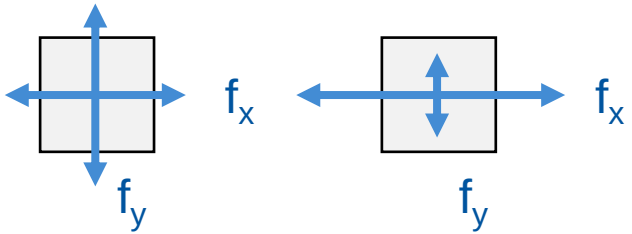
Further Influencing Parameters



- Surrounding



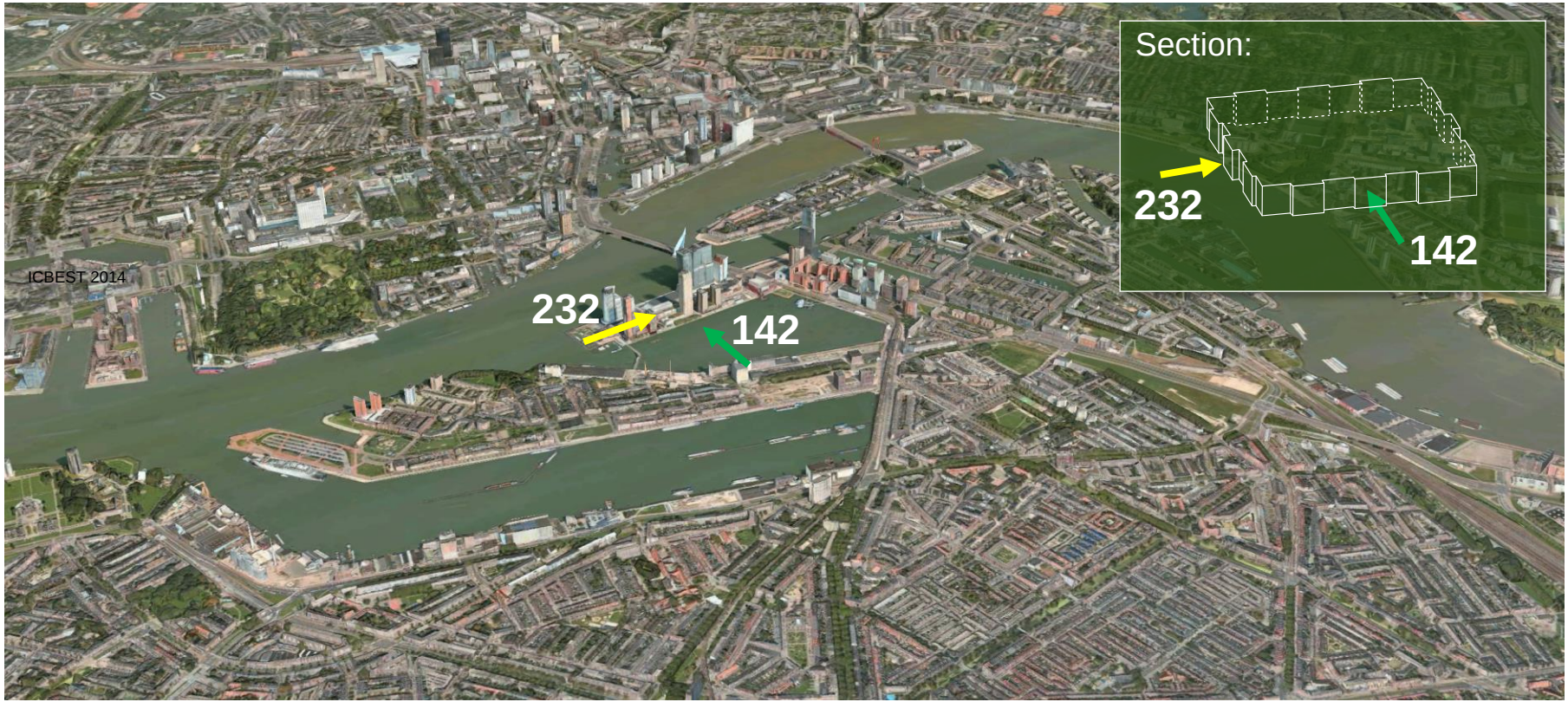
- Shape of the Cross-Section



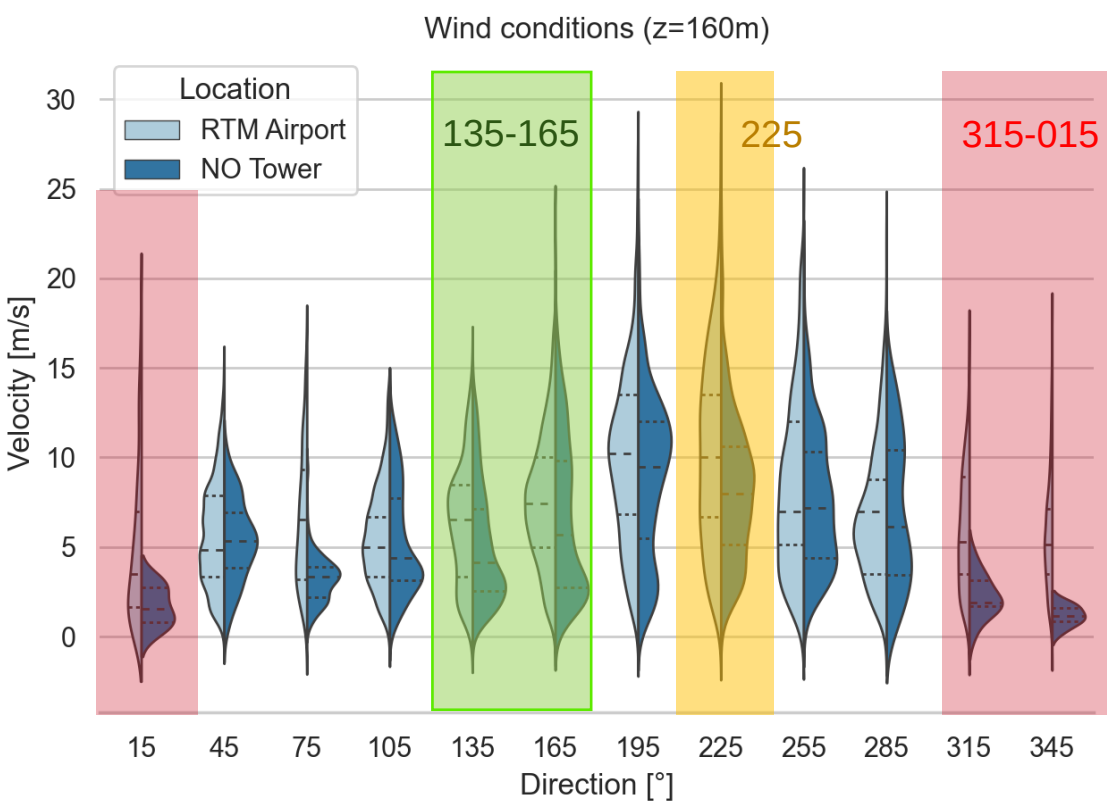
- Dynamic Properties

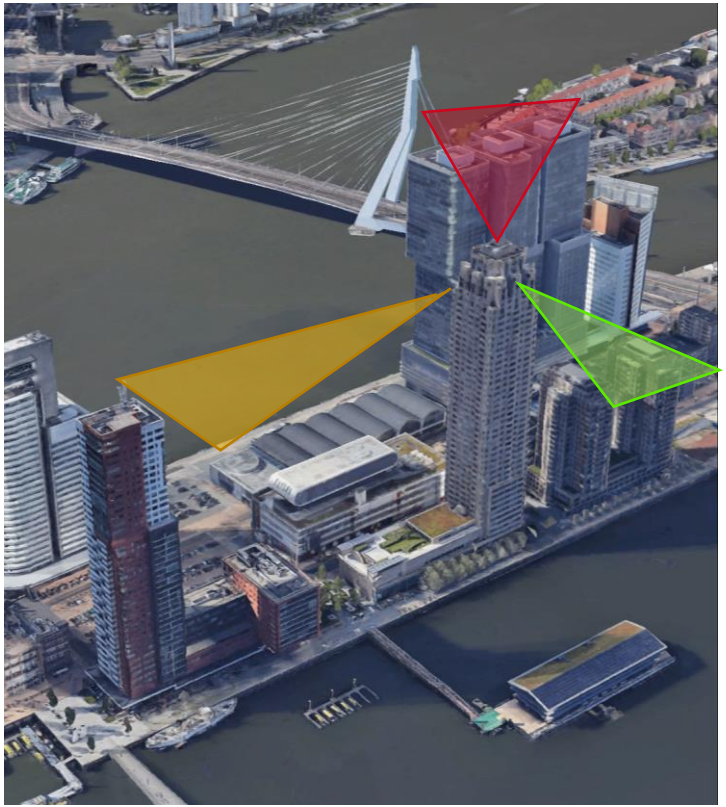
New Orleans, Rotterdam

New Orleans, Rotterdam – Surrounding



New Orleans, Rotterdam - Distributions of Wind





Pressure coefficients (BLWT)

N

Directional

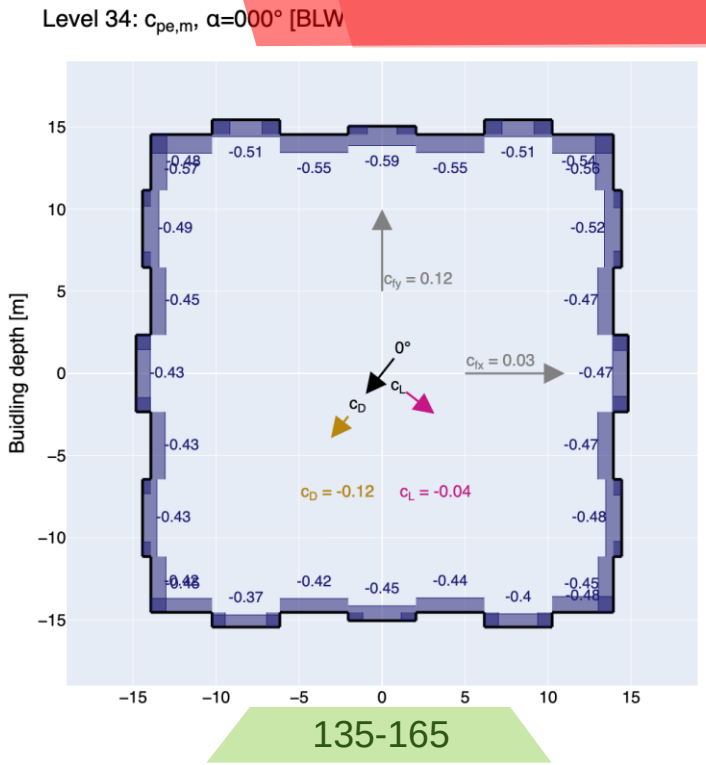
315-015

300-030

225

210-240

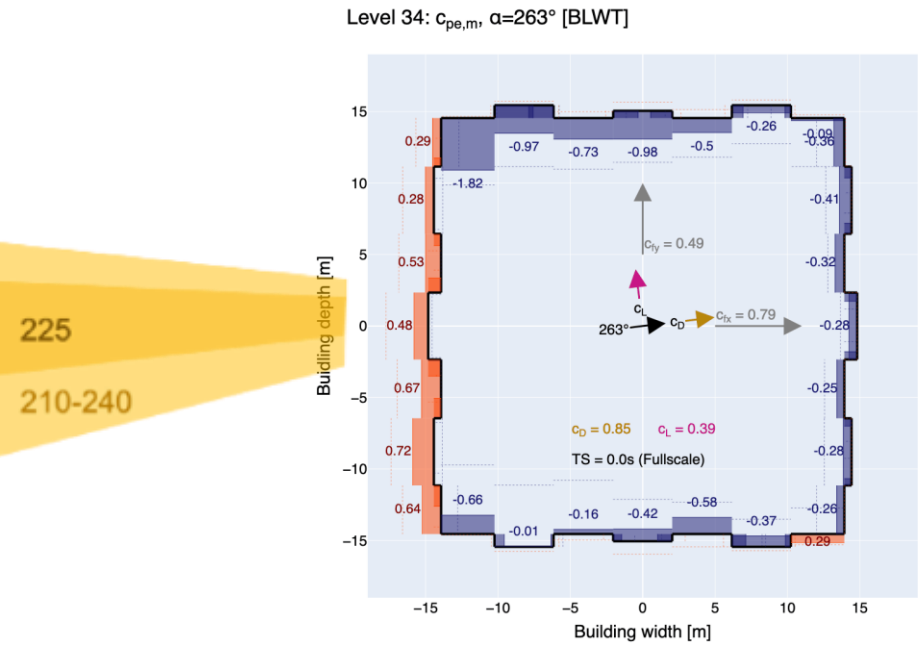
135-165

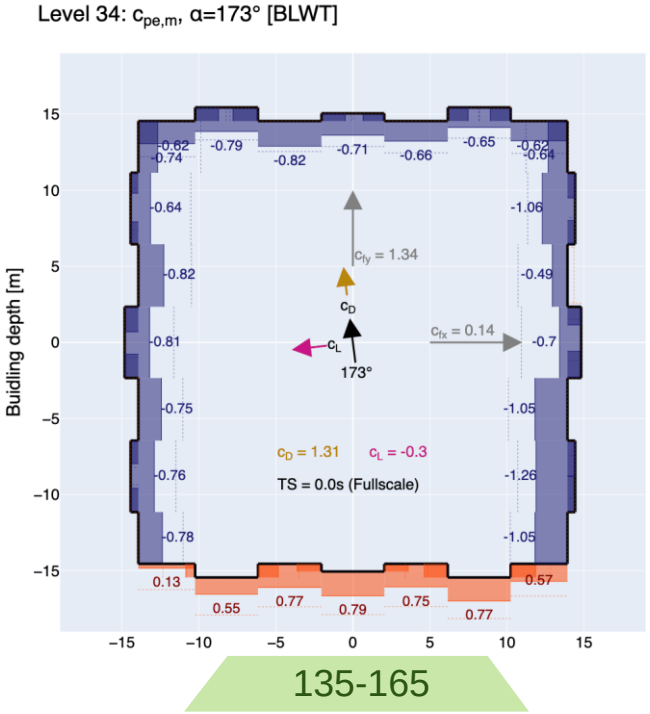


TNO Wind tunnel test, 2014

Pressure coefficients (BLWT)

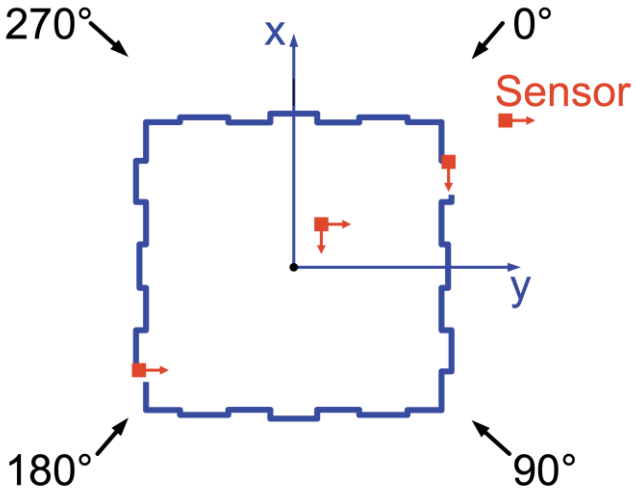
Transient





Instrumentation

Accelerations



Sensors at level 34 (114.6m)

Bronkhorst, Aj & Geurts, Chris. (2021). Long-term vibration and wind load monitoring on a high-rise building. ISMA2020

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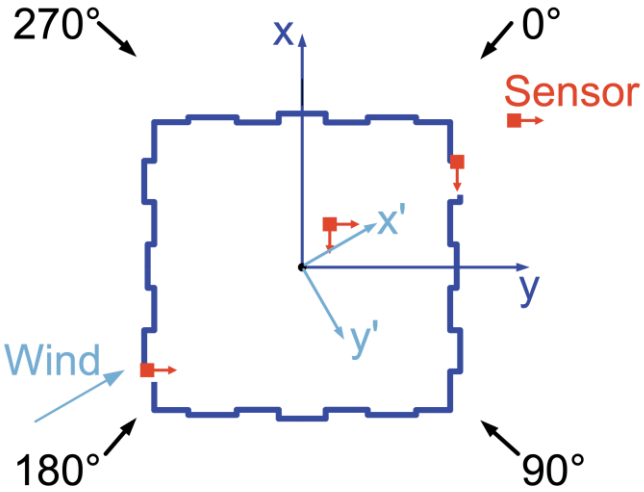

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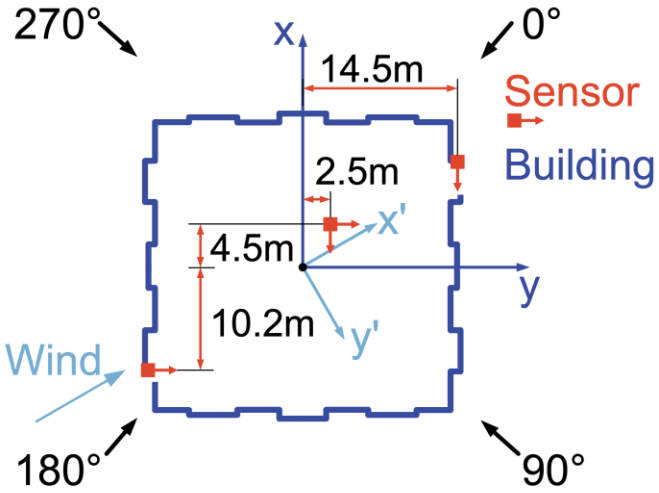

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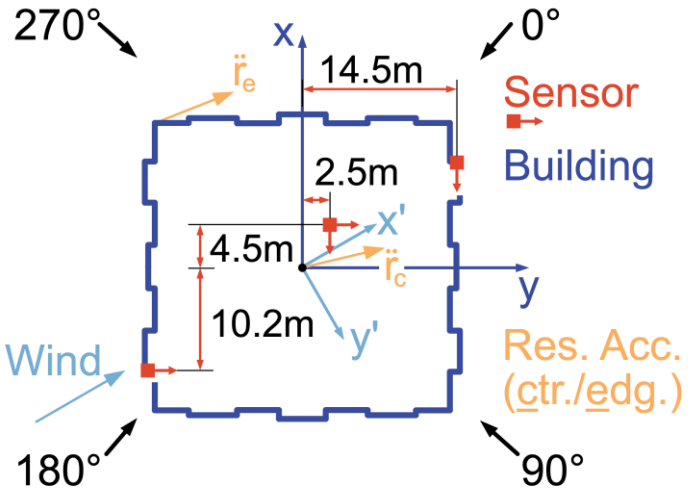

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Data Handling

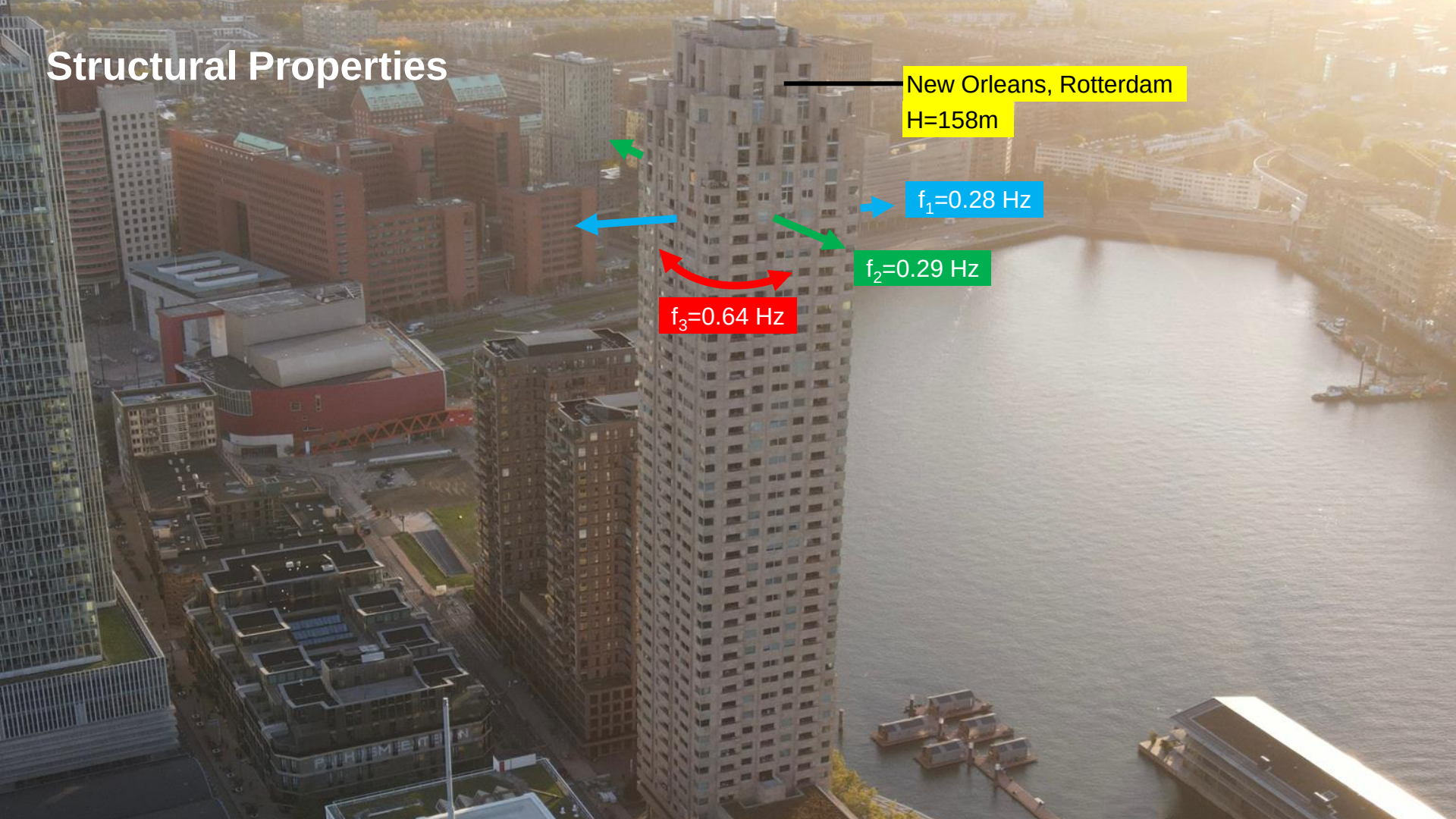
Available Data and Storage

- Data range covers 2012-2020
- Two monitoring data sets: statistical hourly data and raw data with 20Hz
- Weather data of the nearby airport Rotterdam-Den Haag
- All data converted from ASCII to SQL database

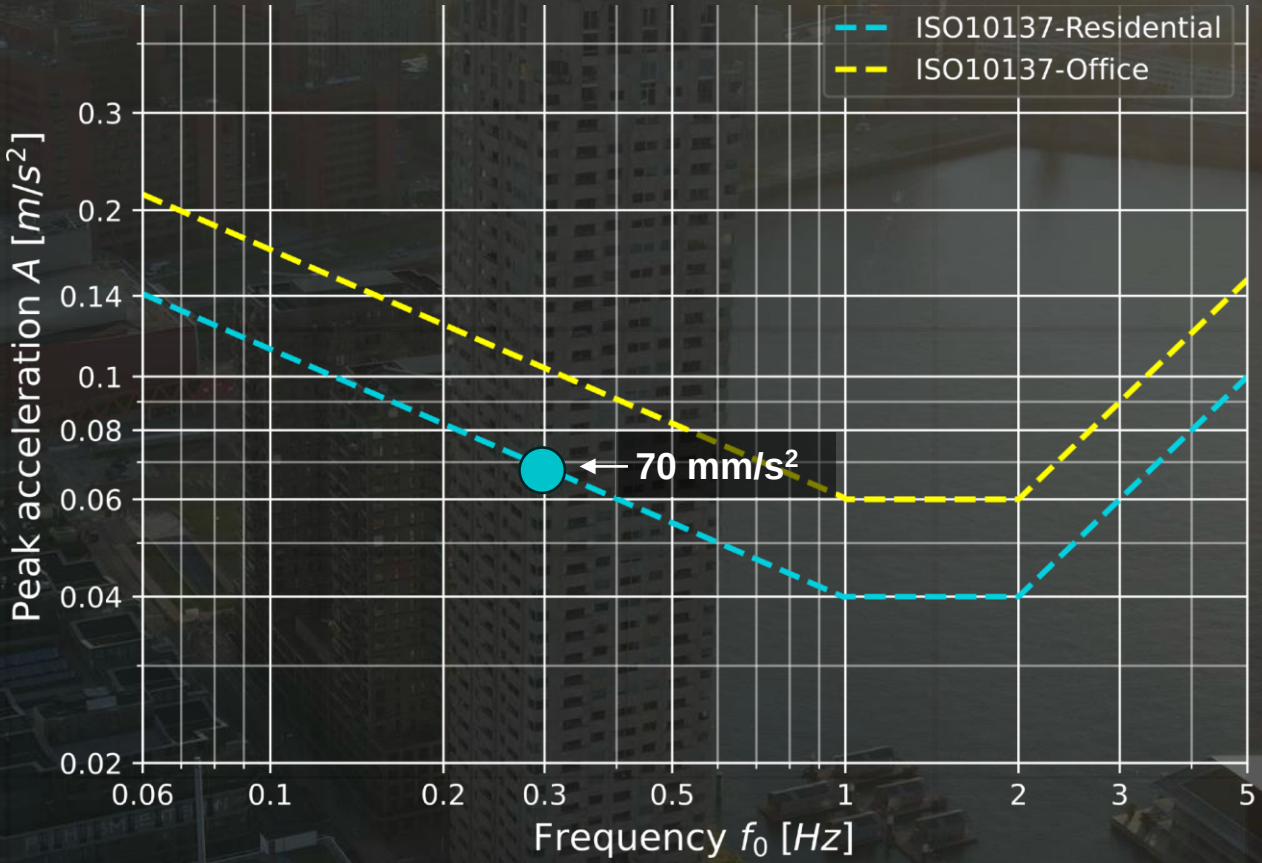
Filtering

- Wind speed classes (v_{low}=8m/s, Δv=2 m/s)
  130.885 datasets (28% of oberservation time)
- Directionwise filtering (ΔΦ=10°)
- Filtering time of complete dataset ≈ 5 hours (≈1.5 TB raw data)

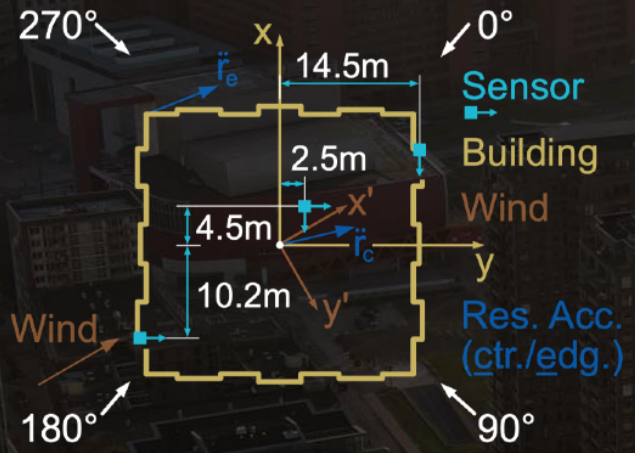
Structural Properties

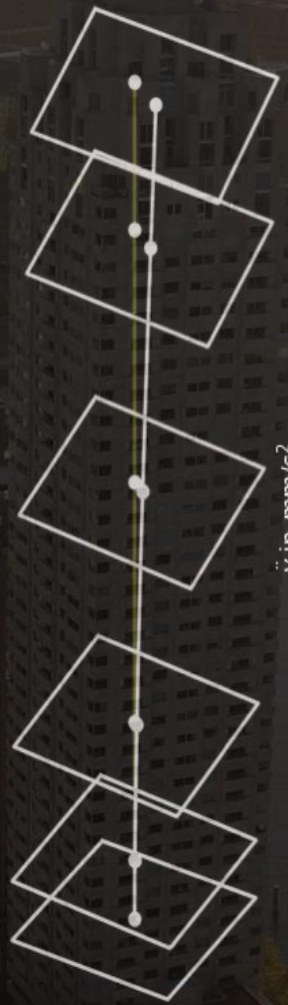


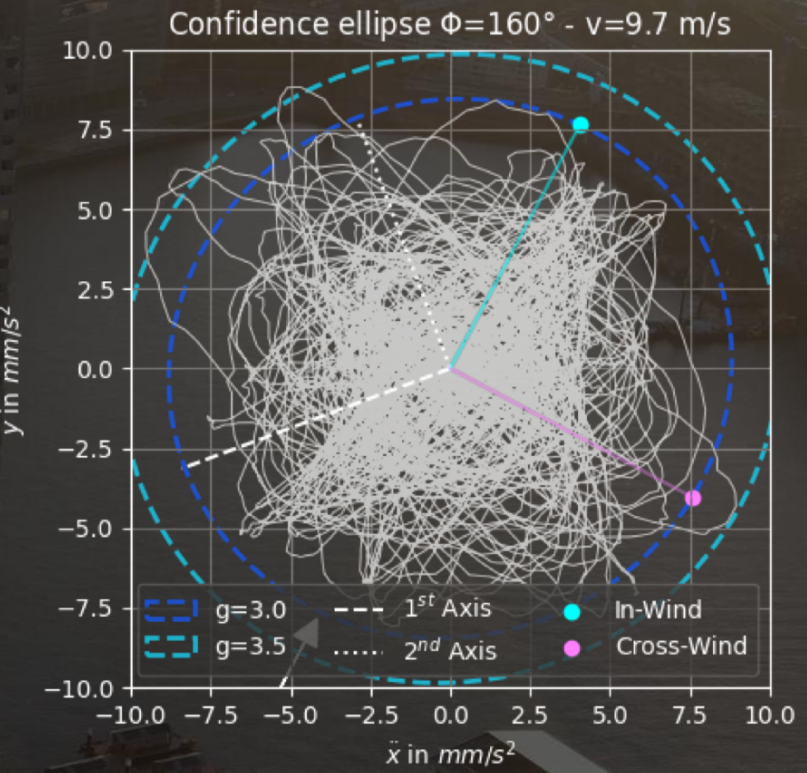
Results (Artifical Time Series)



Results (Single Event)

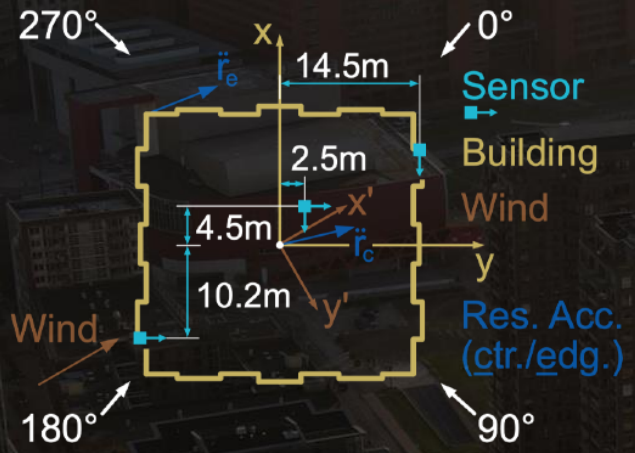


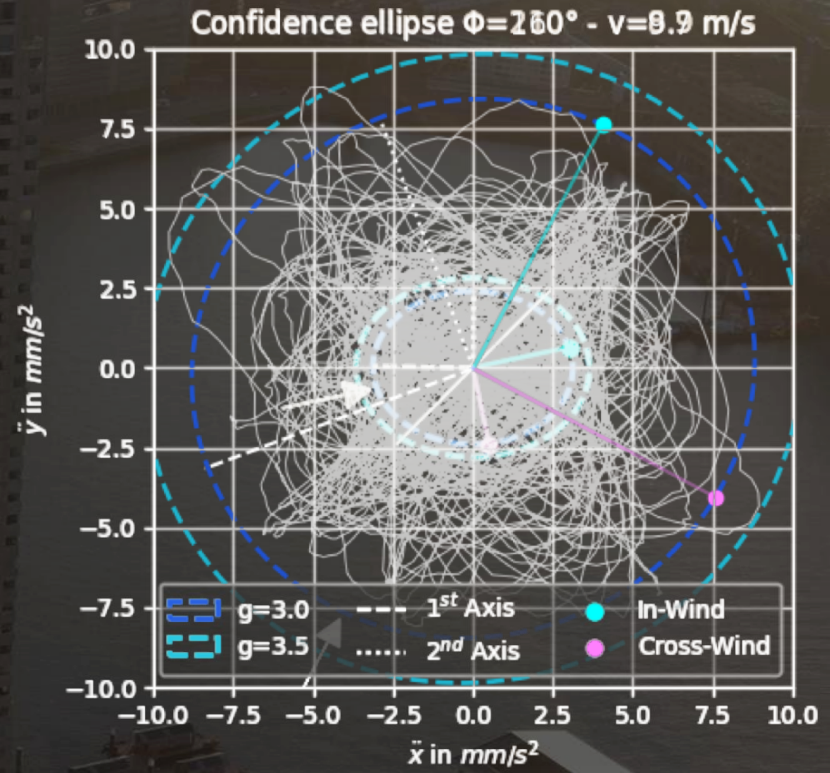




x,y trajectories and Mahalanobis distances (two confidence levels)

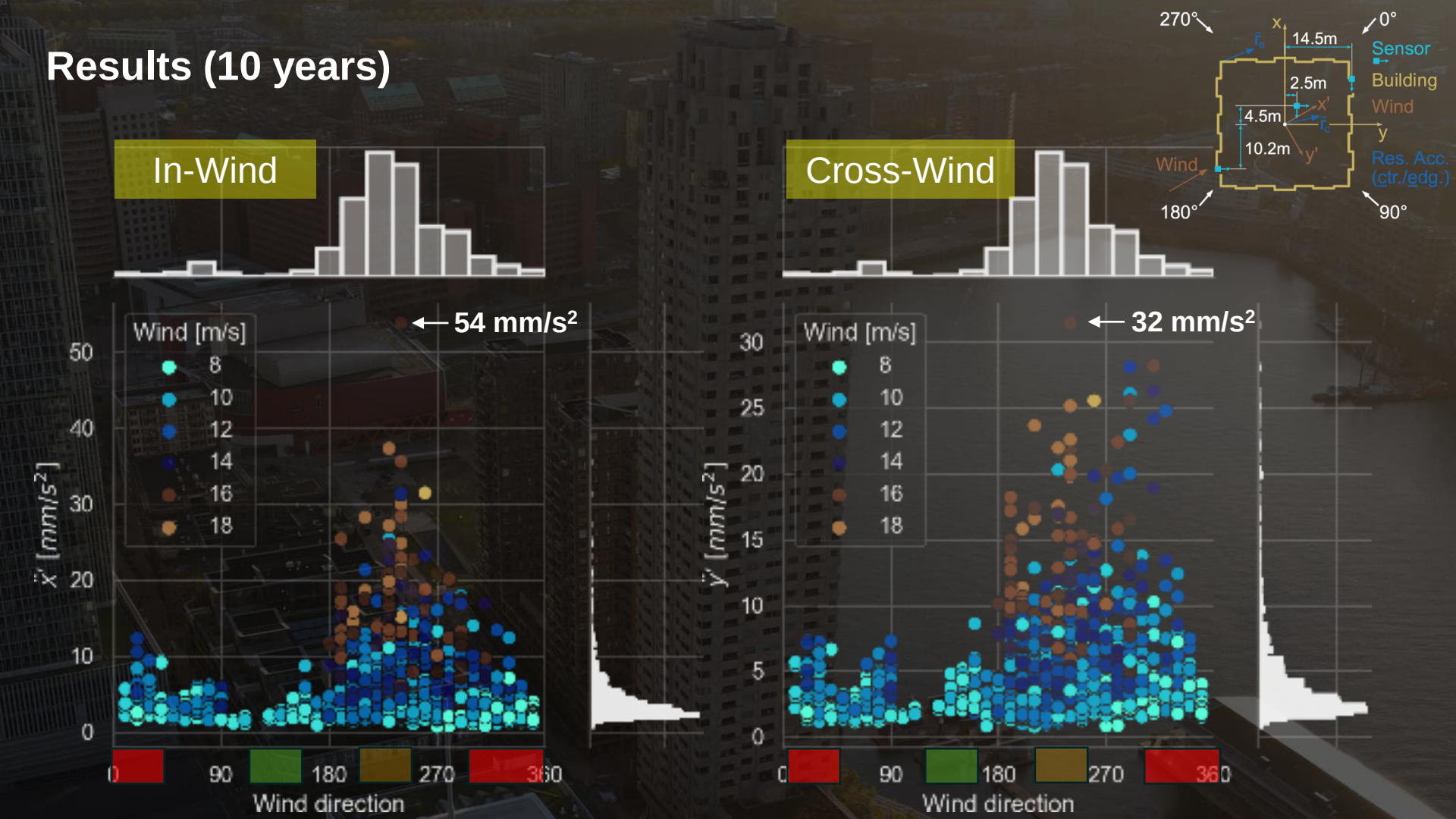
Results (10 years, 200-220°)



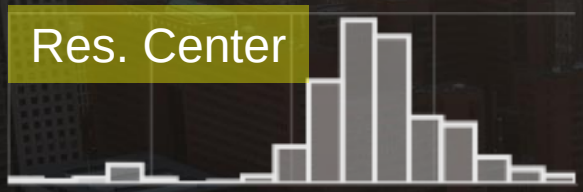


Mahalanobis distances (two confidence levels)

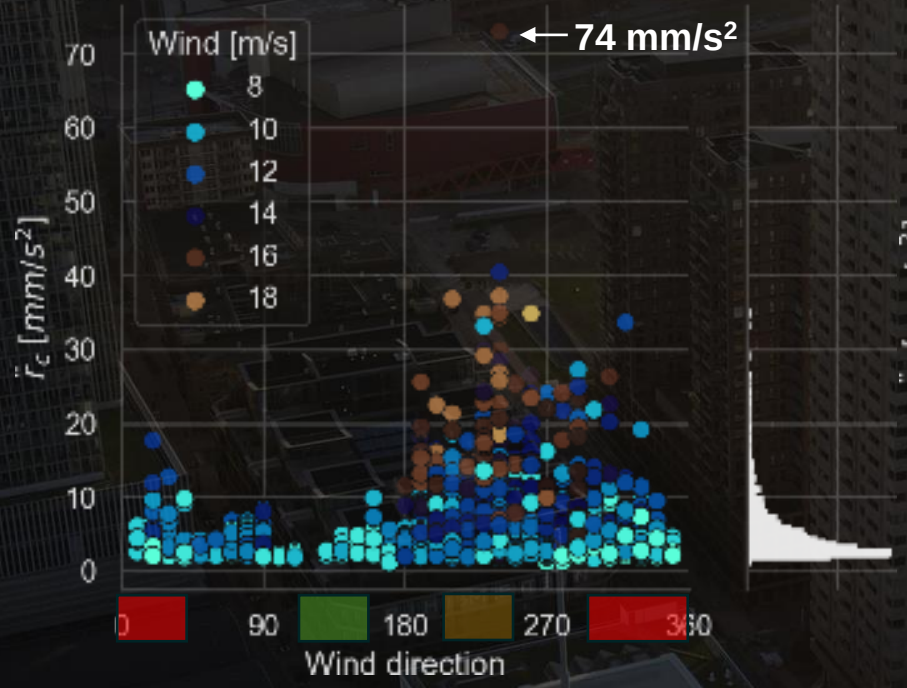
Results (10 years)



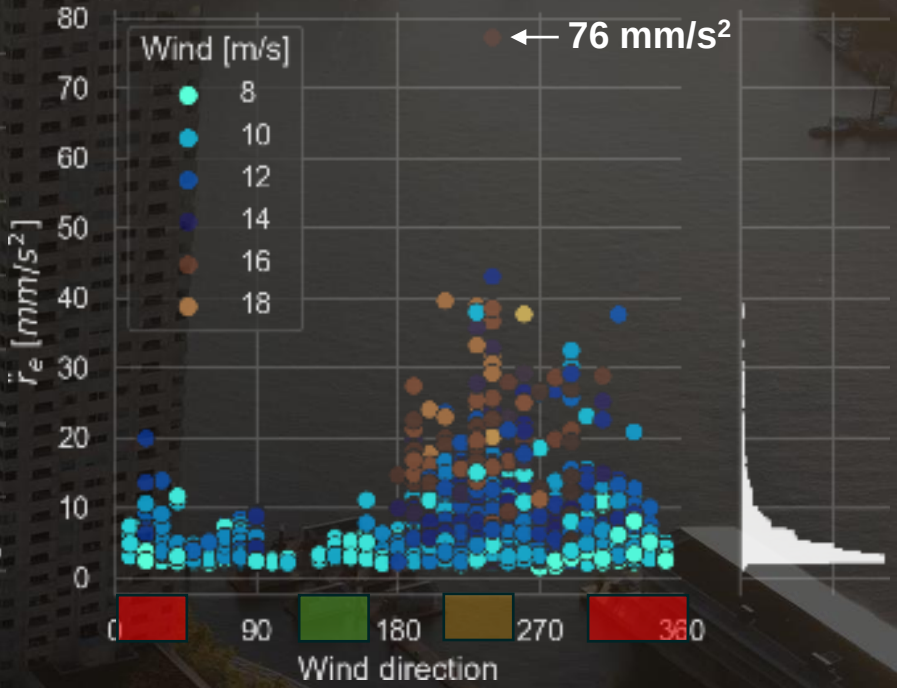
Results (10 years)



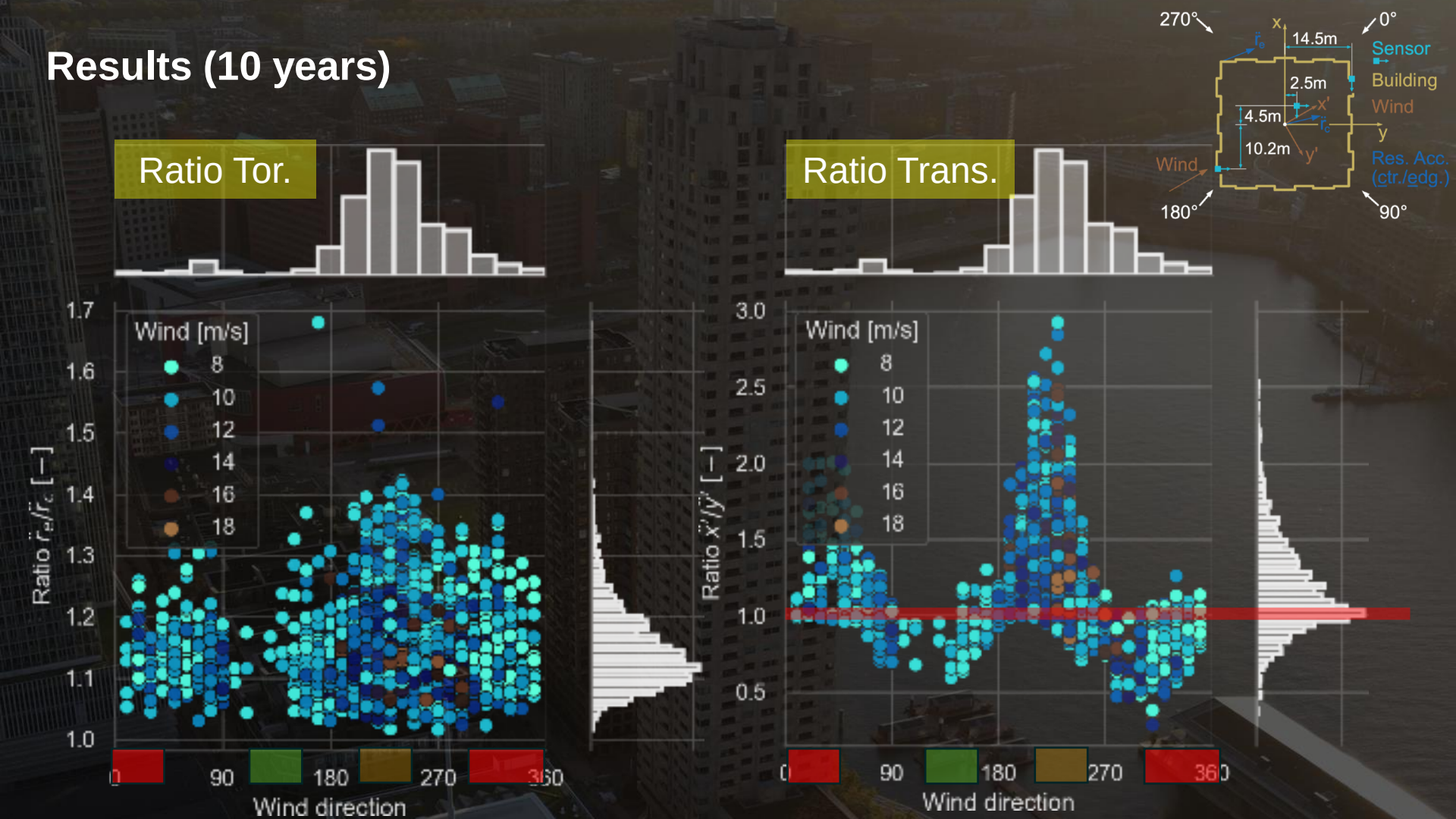
Res. Center



Res. Edge



Results (10 years)

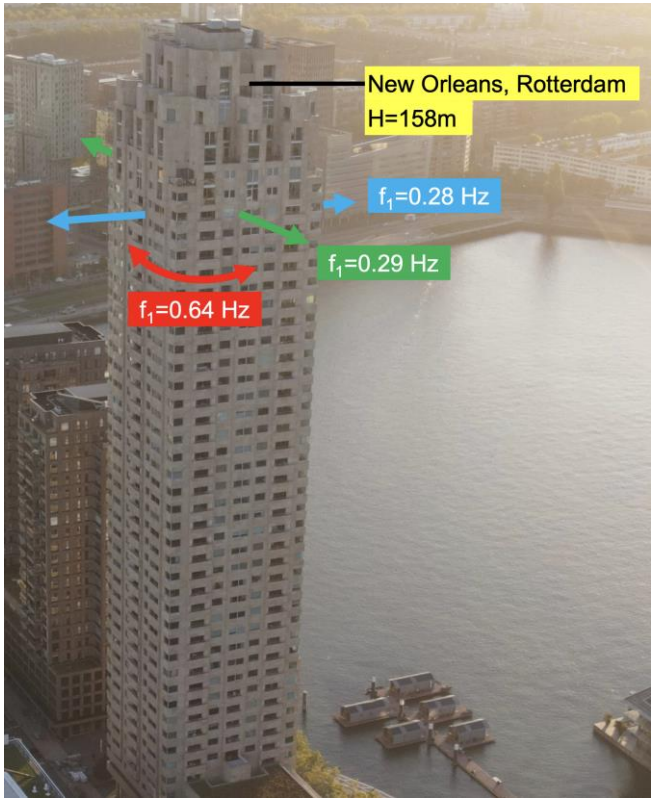


Results

Main Findings

- High-rise building with squared cross-section typically show similar Eigenfrequencies, leading to coupled behaviour
- Cross-transversal vibrations can be described by enveloping elliptic shapes
- In the wake flow: decrease of VIV (cross-wind) and increase of WTV (in-wind)

In complex terrain, transient analysis based on BLWT and structural properties tests is necessary



Thank you

This work was performed in the research project “HIVIBE”

Please see acknowledgement in the abstract.