Bayesian Statistics to determine Aerodynamic Admittance based on measurements at a high-rise Building

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XII International Conference on Structural Dynamics

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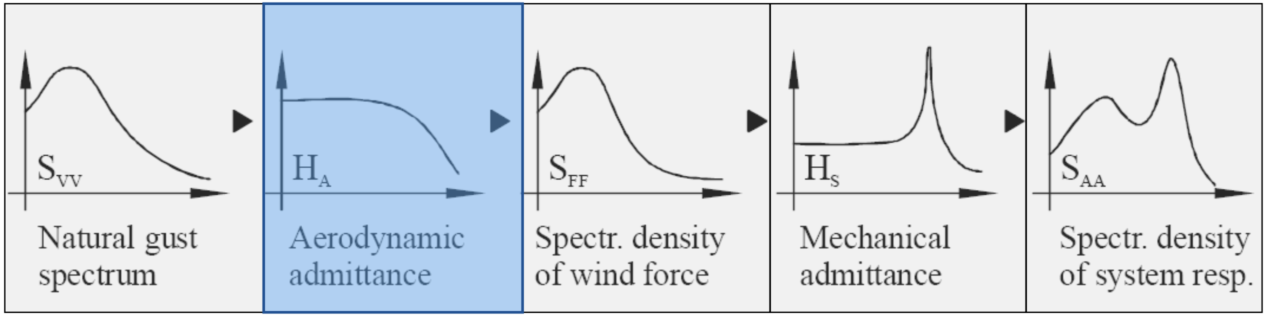
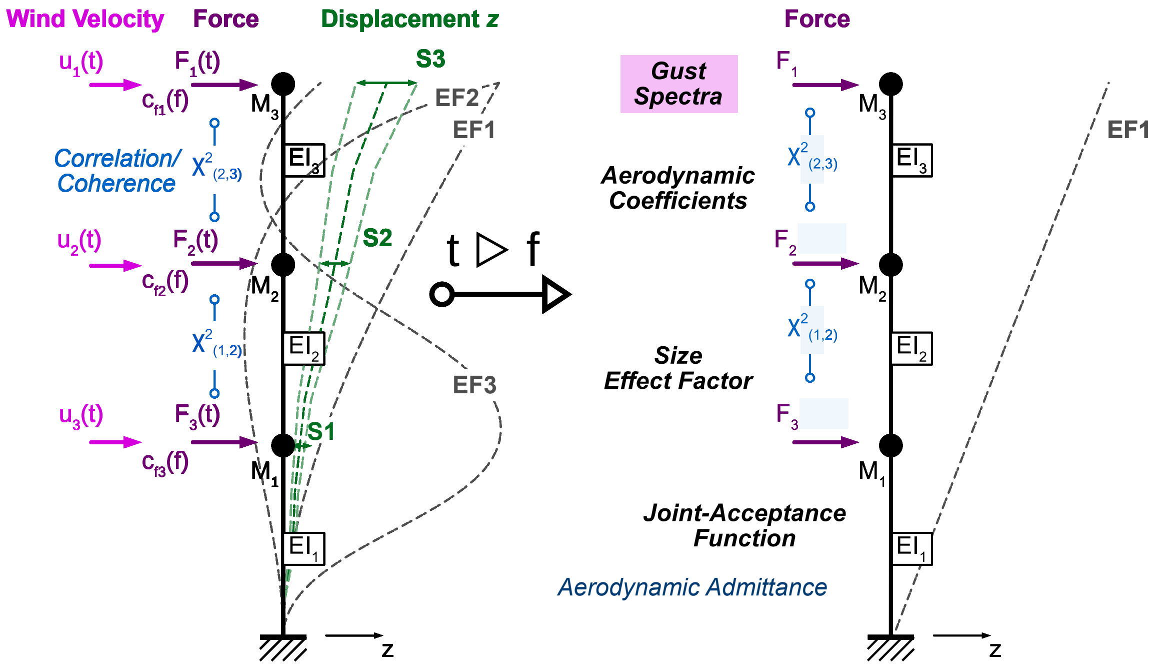
Introduction

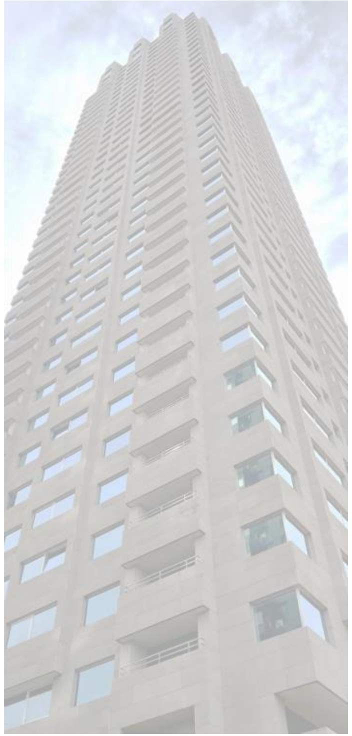
Davenport wind load chain



- Identification of **aerodynamic admittance (and wind force)**
- Spatial and temporal **correlation effects**
- Ongoing work, first phase: data, methods and first examples and results

Introduction

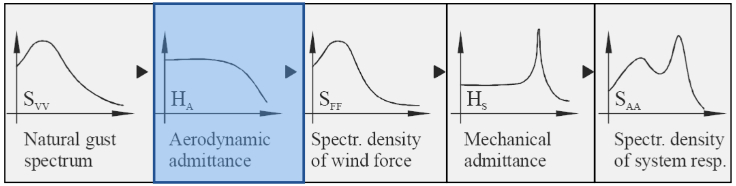




Introduction

Frequency Domain Approach

- Identification of **aerodynamic admittance**
- Spatial and temporal **correlation effects**

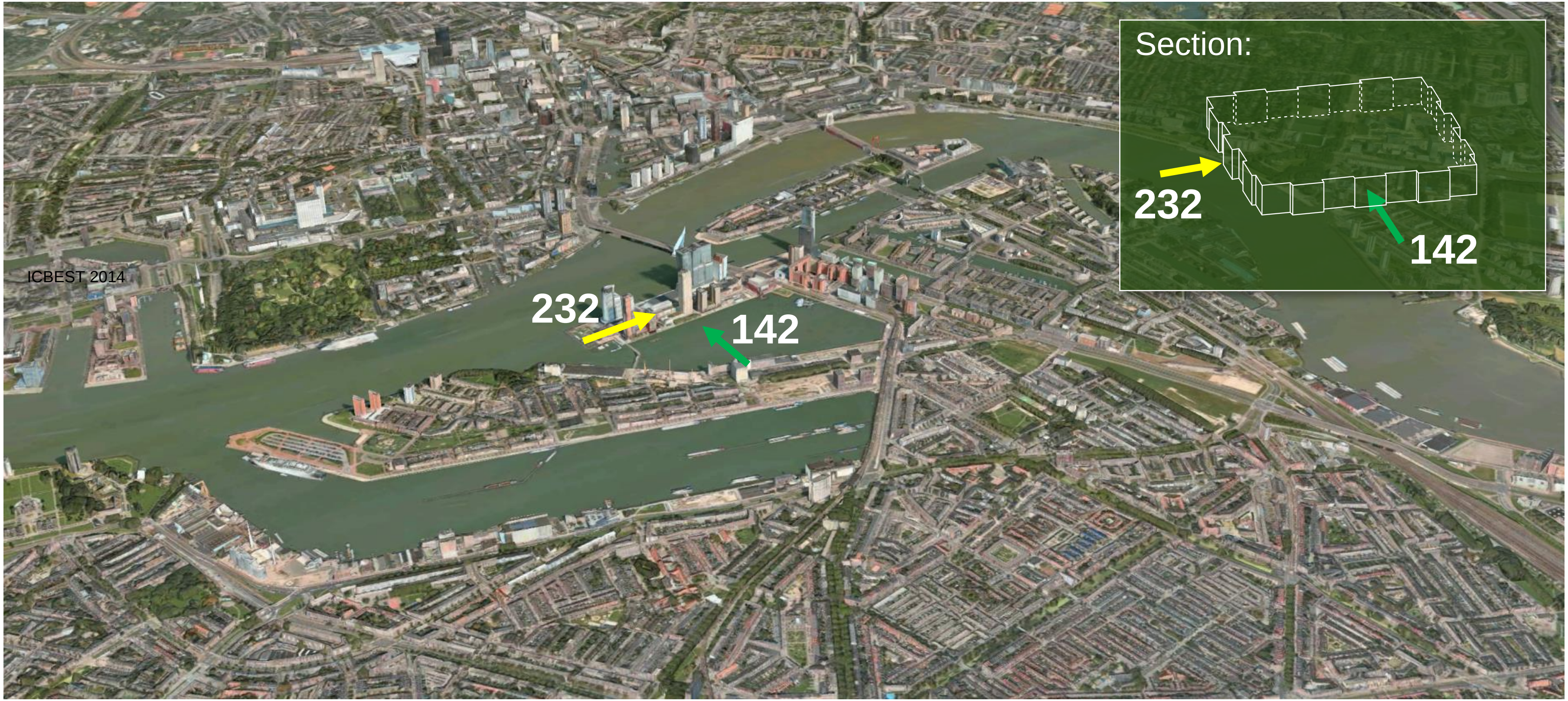


Three stages, representing different complexity (and uncertainity):

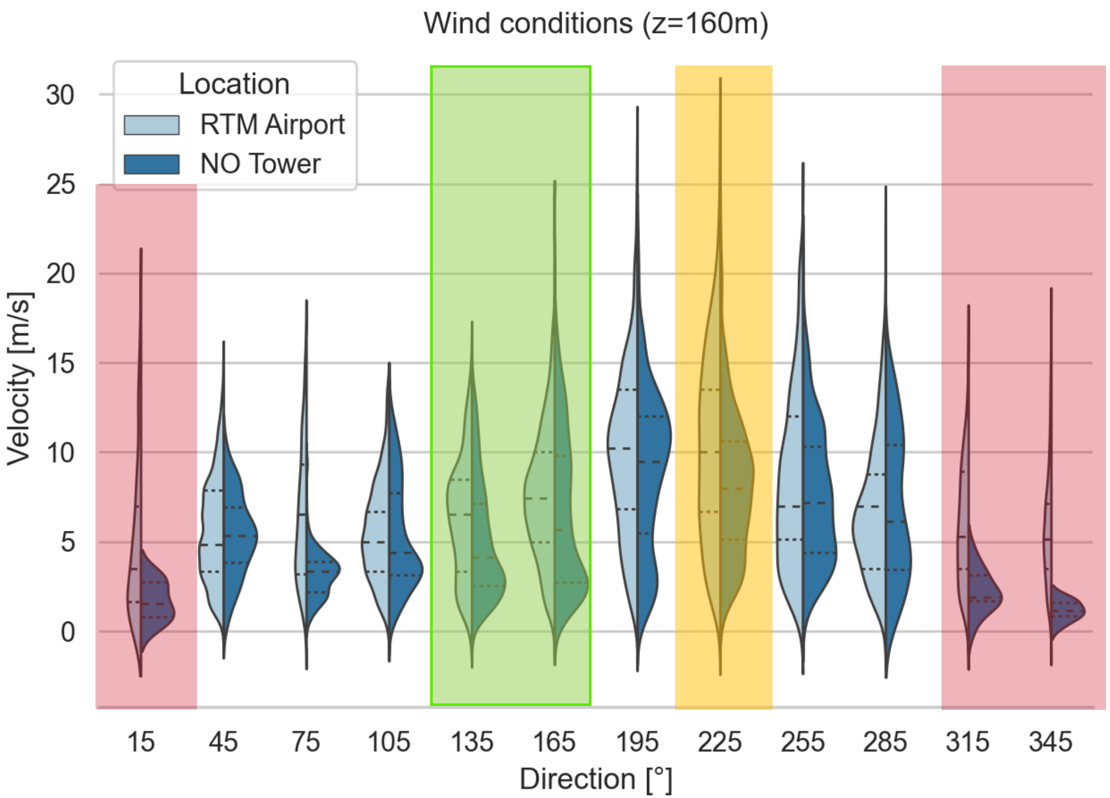
Stage a: Size effect function for a single storey
Stage b: Joint acceptance function
Stage c: Influence of neighbouring structures

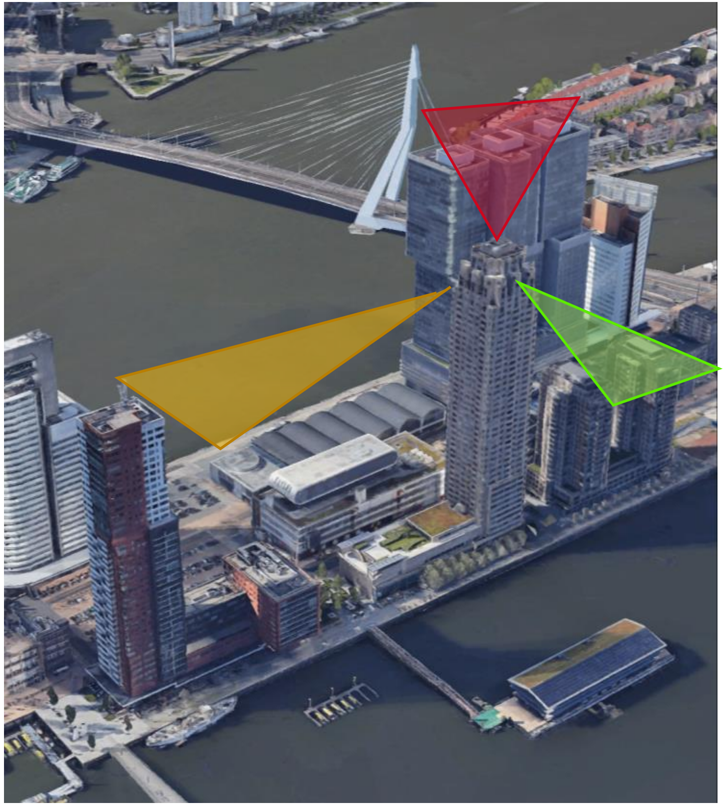
New Orleans, Rotterdam

New Orleans, Rotterdam – Surrounding



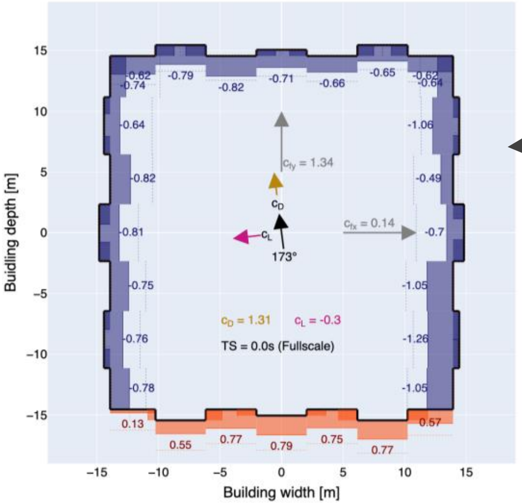
New Orleans, Rotterdam - Distributions of Wind

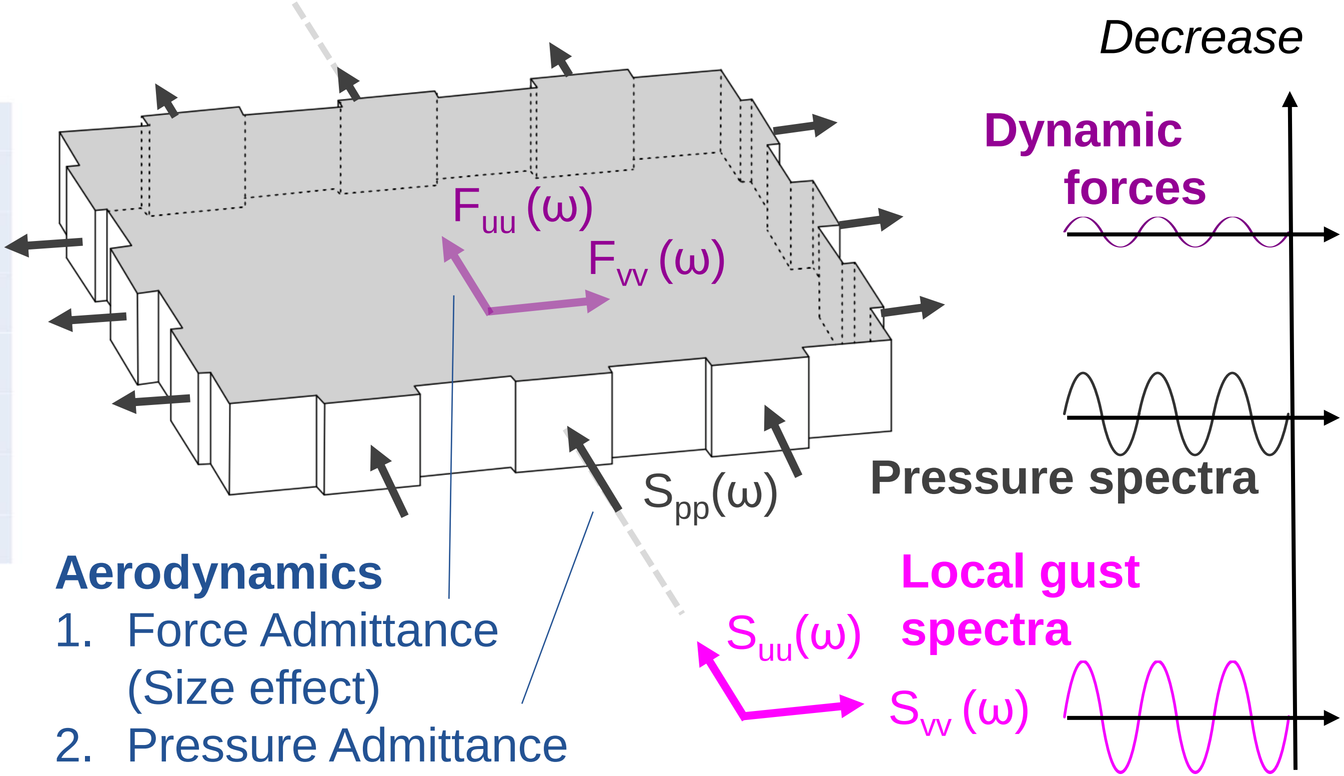




Stage a: Storey loading

Size effect





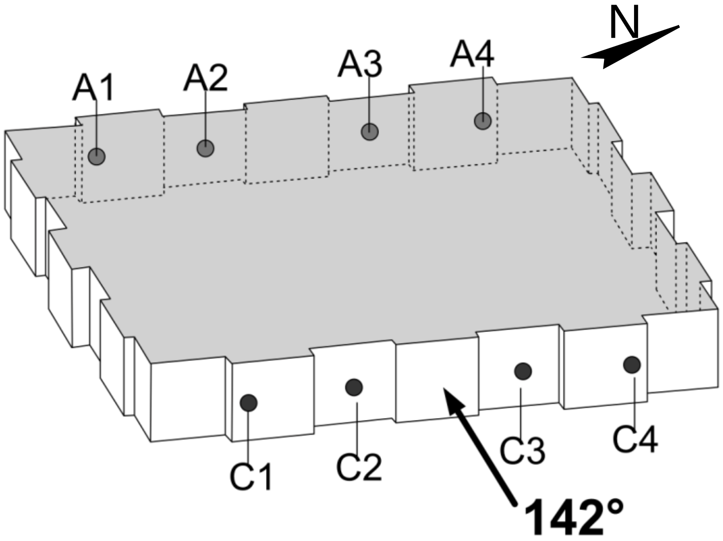
Aerodynamics

1. Force Admittance (Size effect)
2. Pressure Admittance

Stage a: Storey loading

Used full-scale data

- 4+4 external pressure taps (windward and leeward)
- Sampling rate 20Hz
- Chosen: year 2020
  22 hours, v=10-11 m/s
- Database accessible



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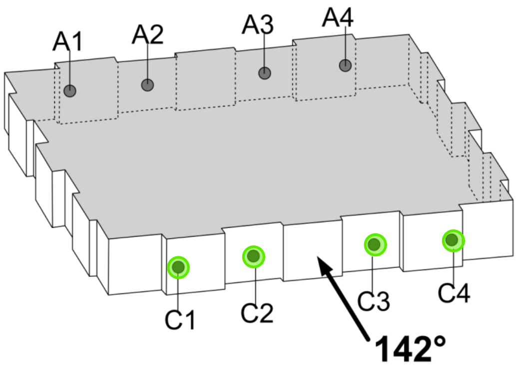
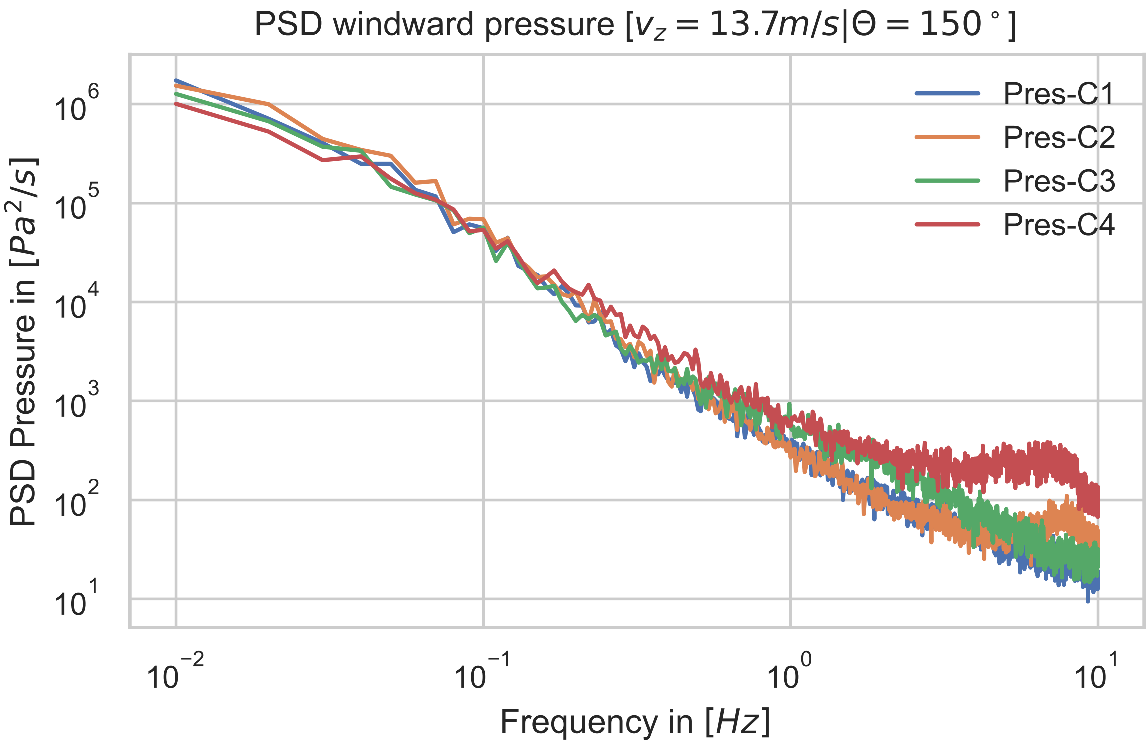
Stage a: Storey loading

Pressure spectra

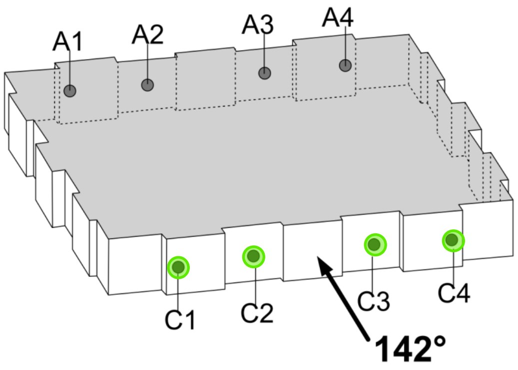


Data: Year 2020, φ=130°-150°,
u=11-12 m/s, 22 Events à 1 hours



Stage a: Coherence

Windward taps



Data: Year 2020, φ=130°-150°,
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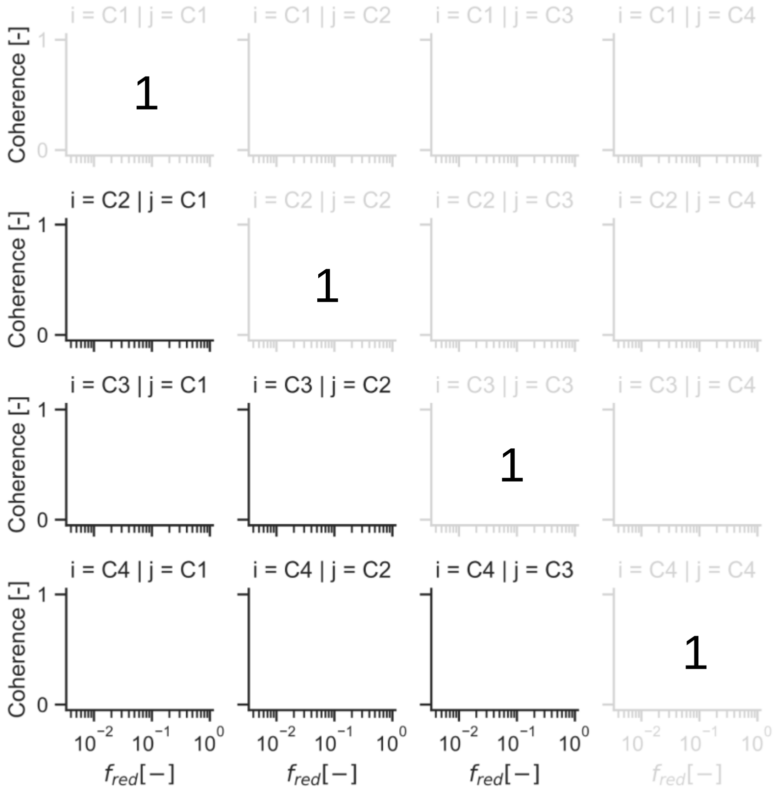
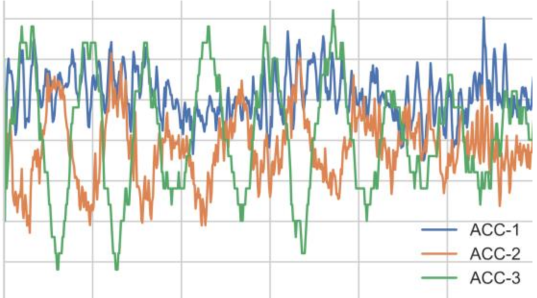


Analysis toolset: Bayesian Statistics

Brief overview

- Conditional statistics (“revising predictions in light of relevant evidence”)
- Prior model assumption + new data (evidence) ▷ Posterior model

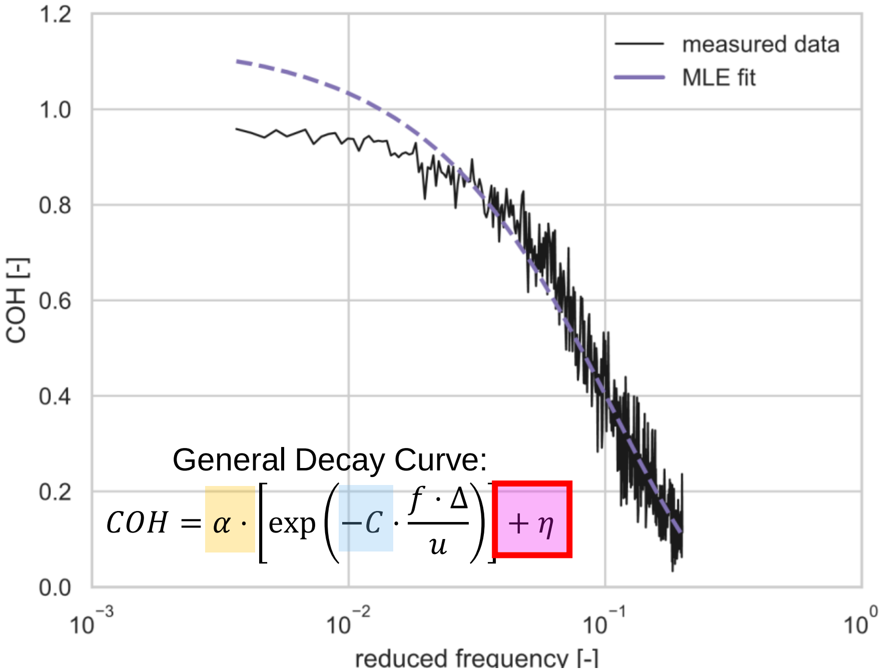


Combined Signals + noise η(t)

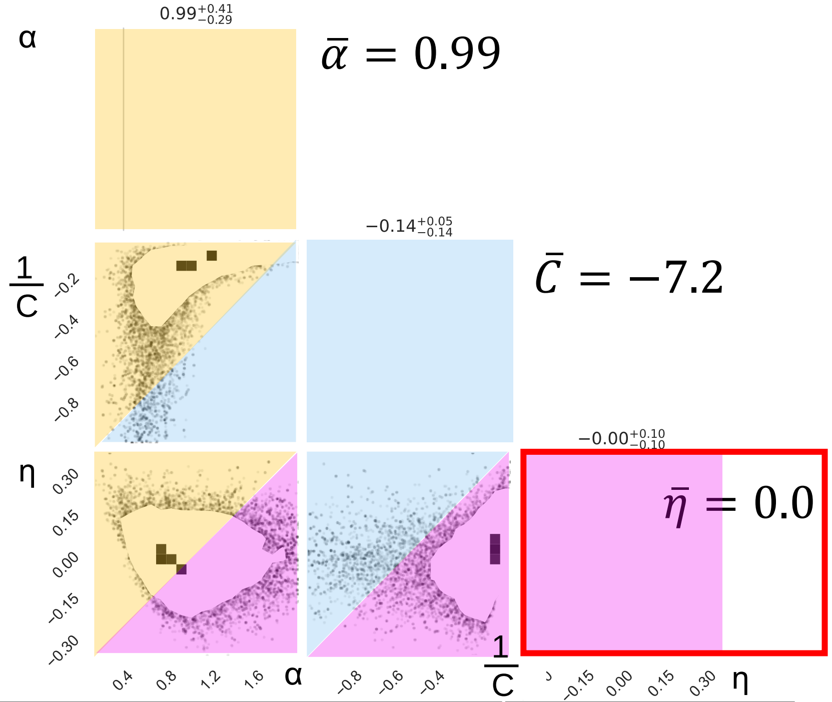
- Each new data set enables a Bayesian update (self-learning algorithm, machine learning)
- Statistics of model parameter (not just data)
- We learn about the model!

Stage a: Results [Coherence]

MLE Result [windward: C1-C2, Δ=6.0m]



Bayesian inference [MCMC]

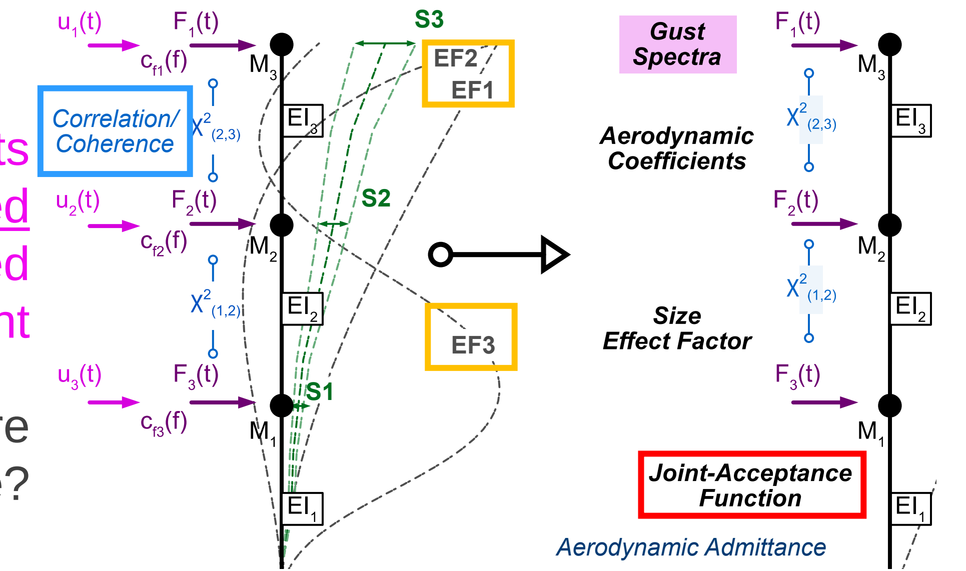


Stage b: Joint Acceptance Function

tion

Measurements of <u>undisturbed</u> wind speed over height

Pressure admittance?

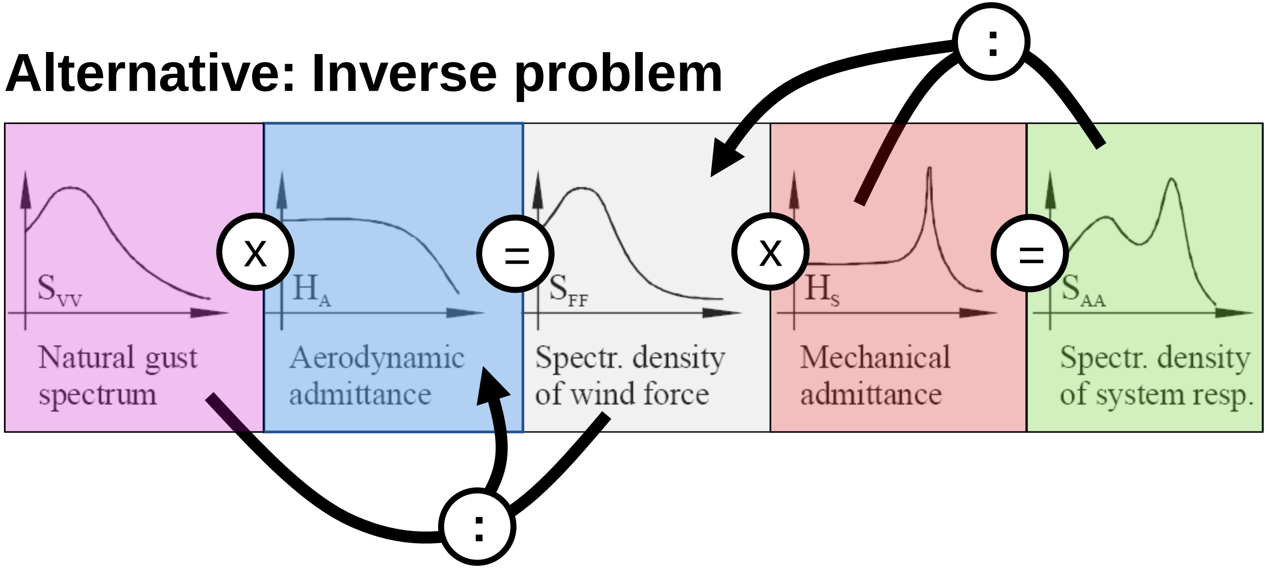


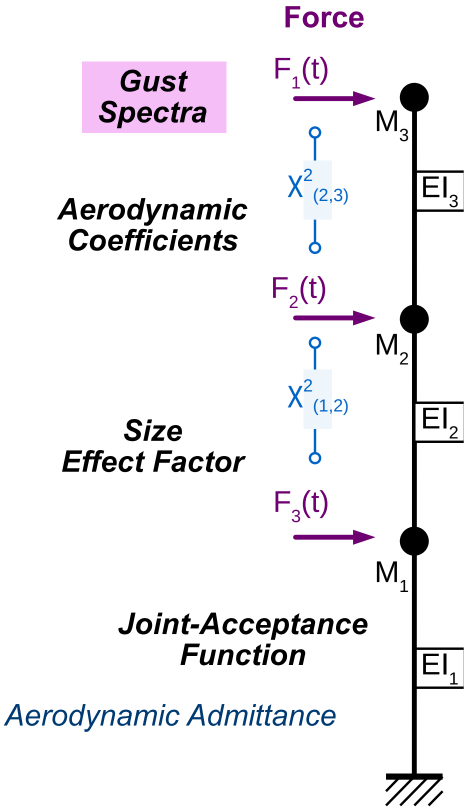
$$J_k^2 = \frac{\int_0^H \int_0^H \Phi_k(z_1)\, \gamma_{uu}(z_1 z_2)\, \Phi_k(z_2)\, dz_1 dz_2}{\int_0^H \int_0^H \Phi_k(z_1)\, \Phi_k(z_2)\, dz_1 dz_2}$$

Cheynet, E.: Influence of the Measurement Height on the Vertical Coherence of Natural Wind
January 2019, DOI: 10.1007/978-3-030-12815-9_17
Proceedings of the XV Conference of the Italian Association for Wind Engineering

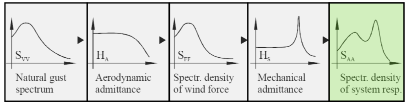
Stage b: Joint Acceptance

Alternative: Inverse problem

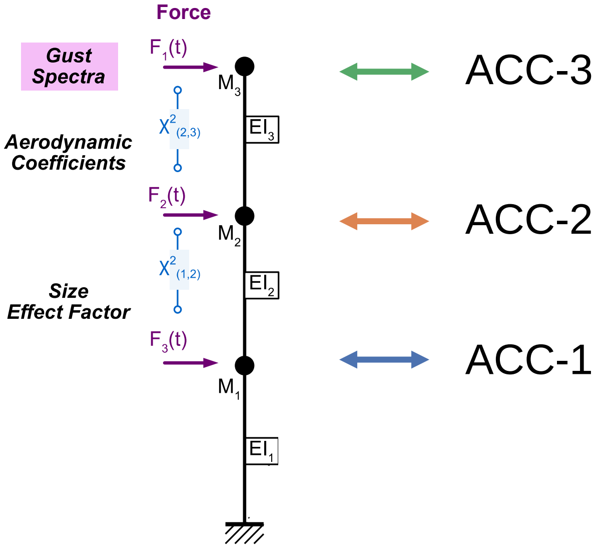


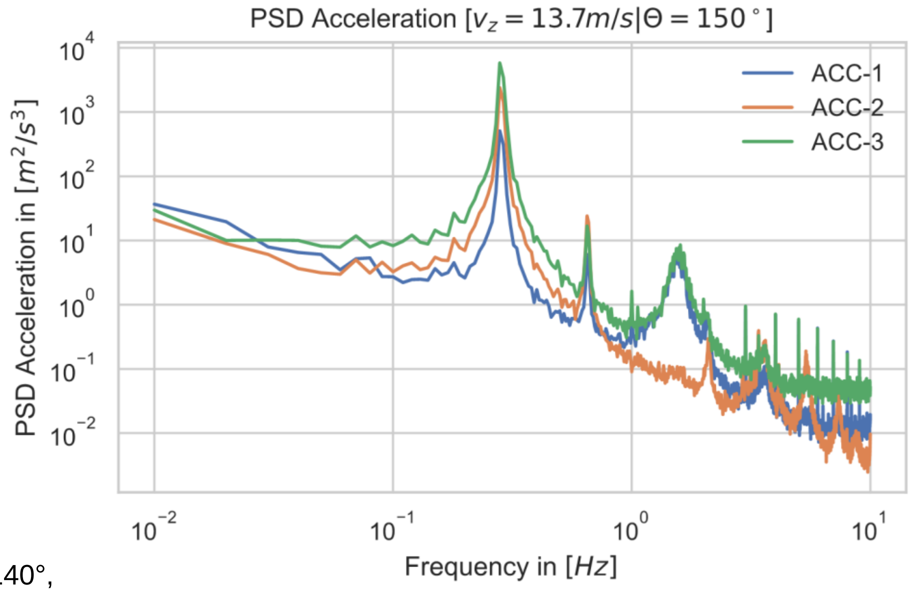


Stage b: Joint Acceptance

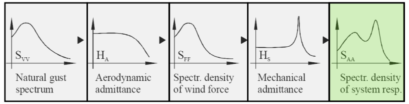


Data of acceleration

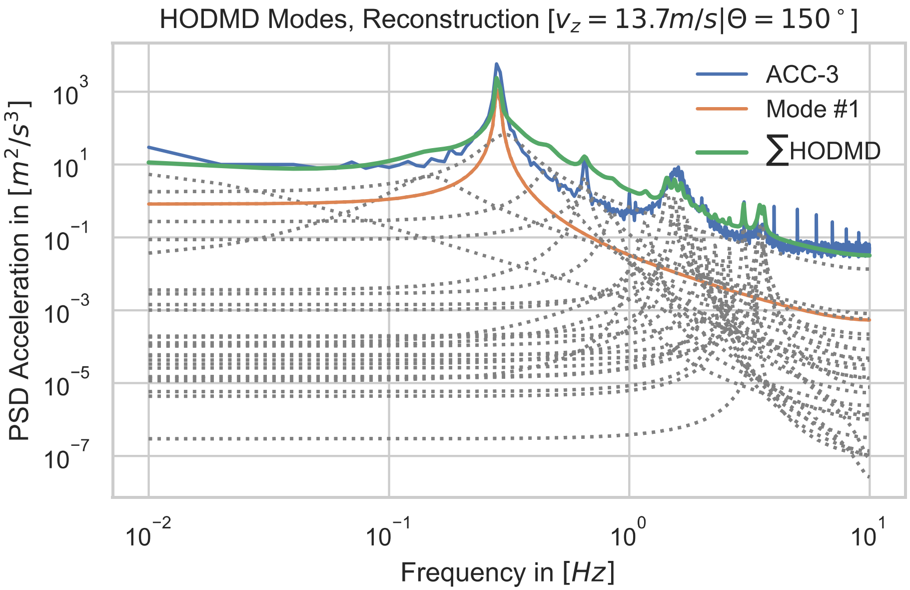


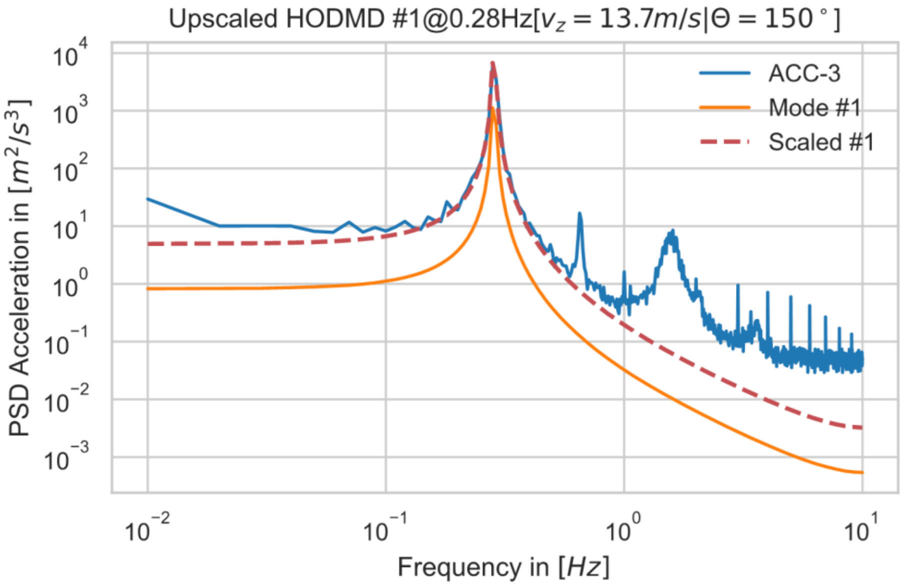


Data: Year 2020, φ=140°,
u=13.7 m/s, 1 hours

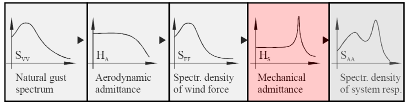


Decompostion of response

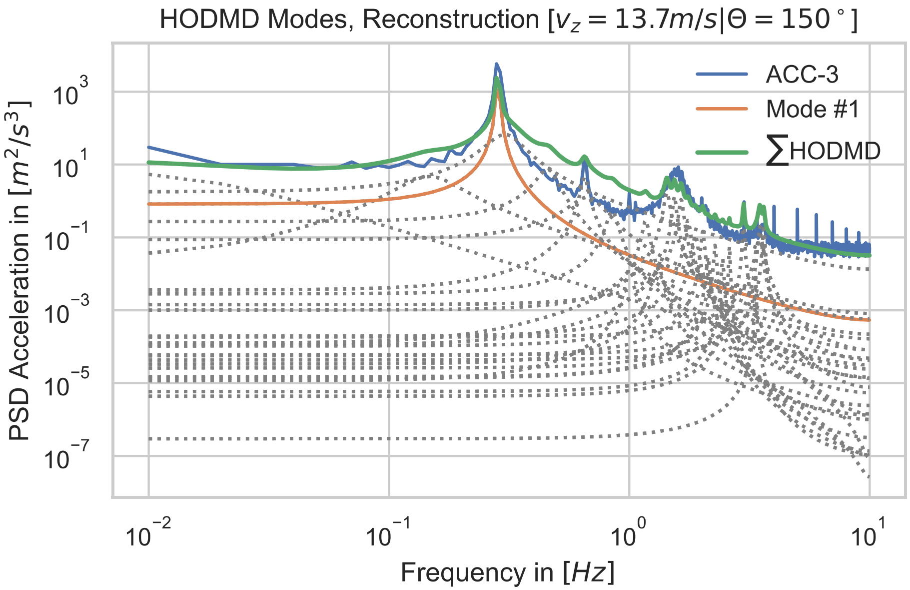


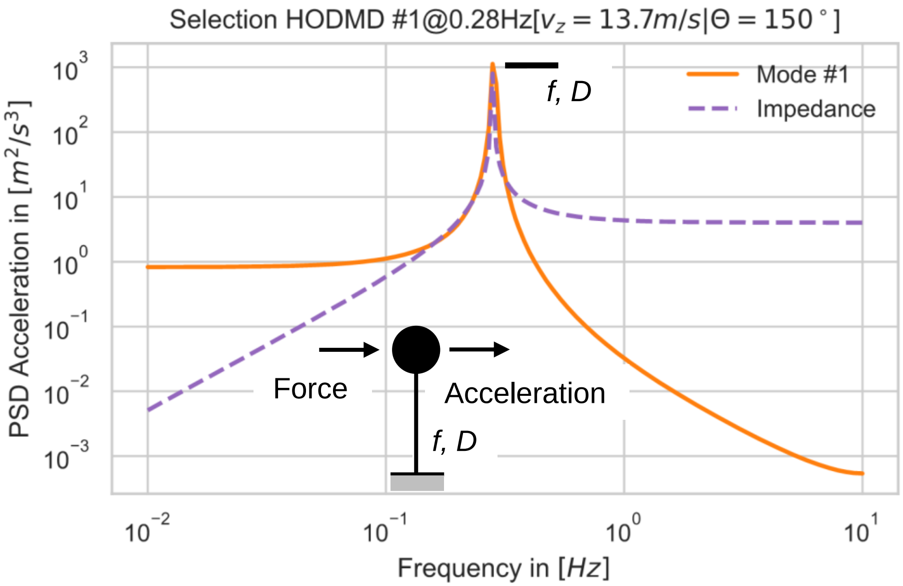


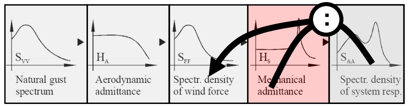
Stage b: Inverse Solution



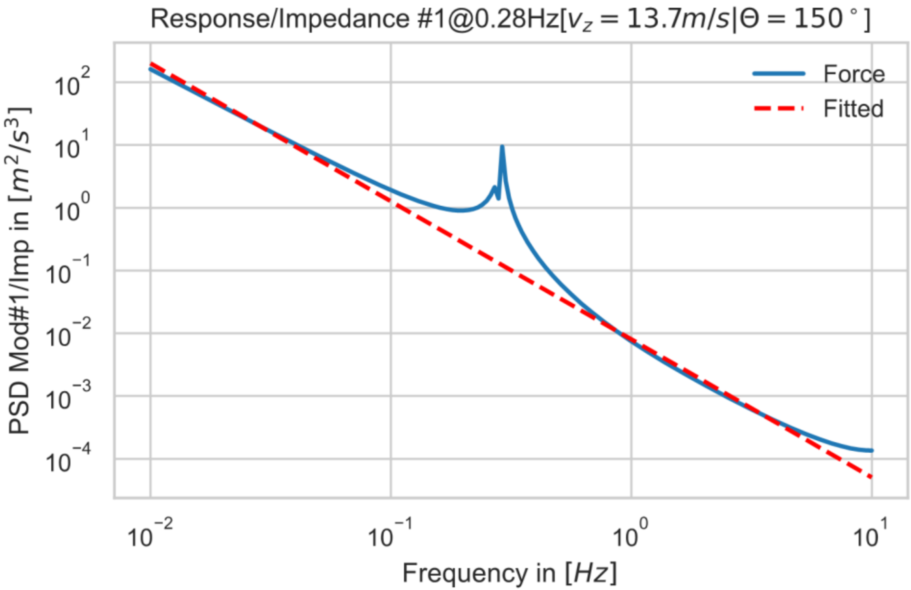
Impedance as mechanical transfer

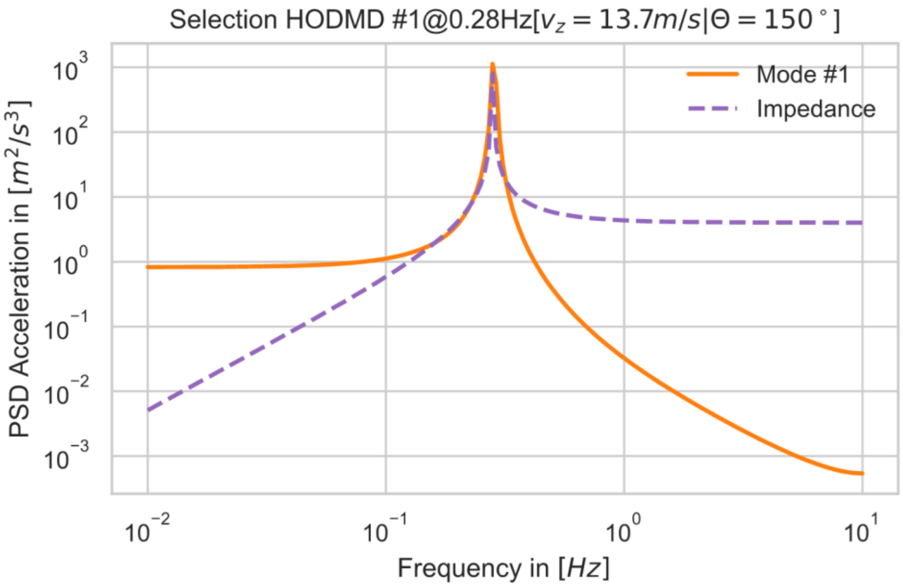




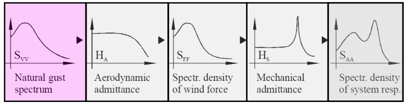


Aerodynamic Force

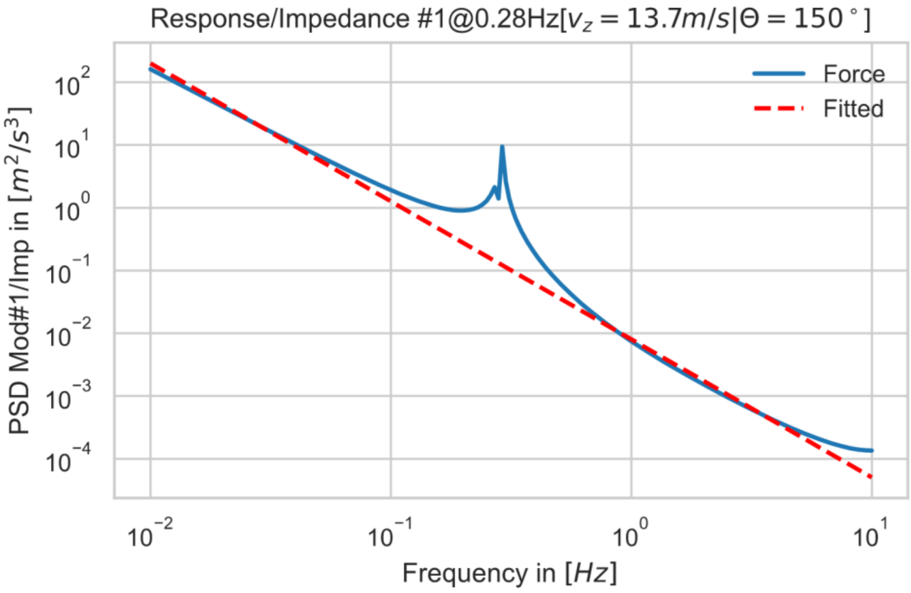


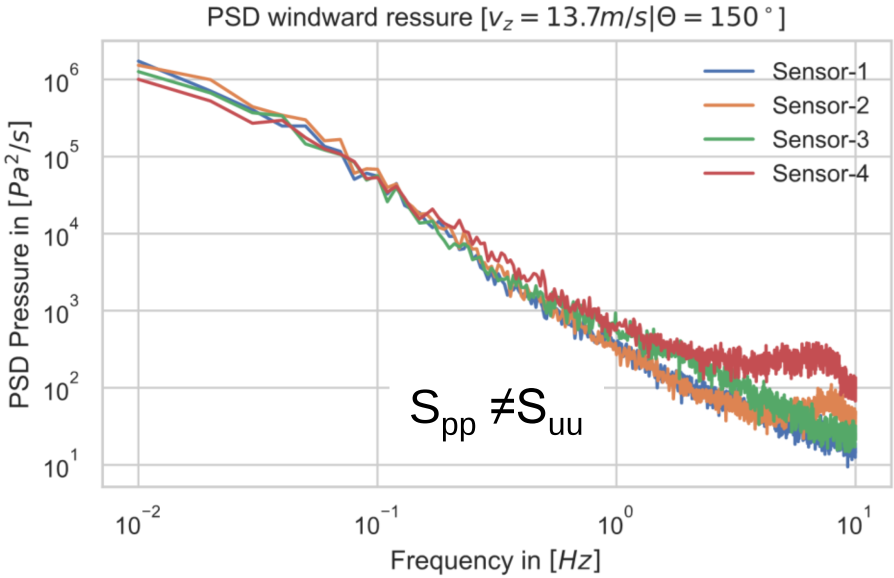


Stage b: Inverse Solution

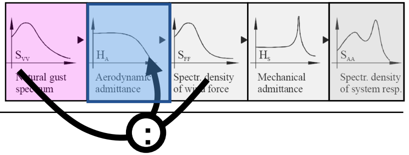


Gust spectrum

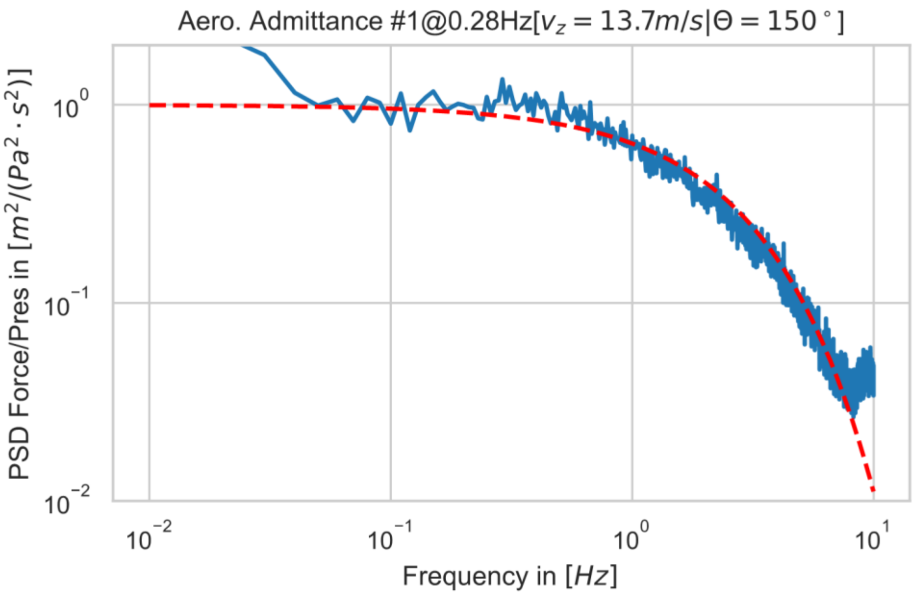


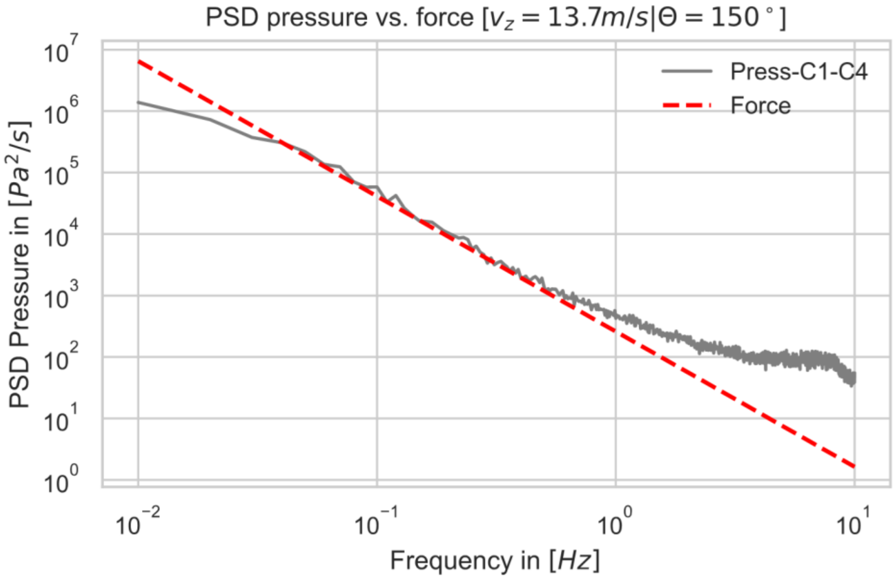


Stage b: Inverse Solution



Joint acceptance function

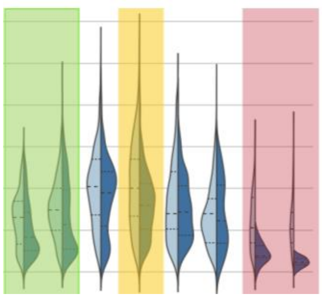


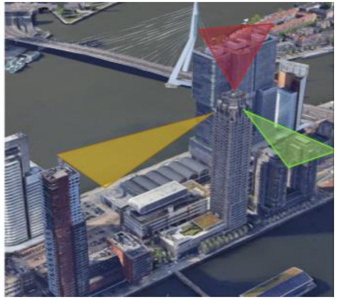


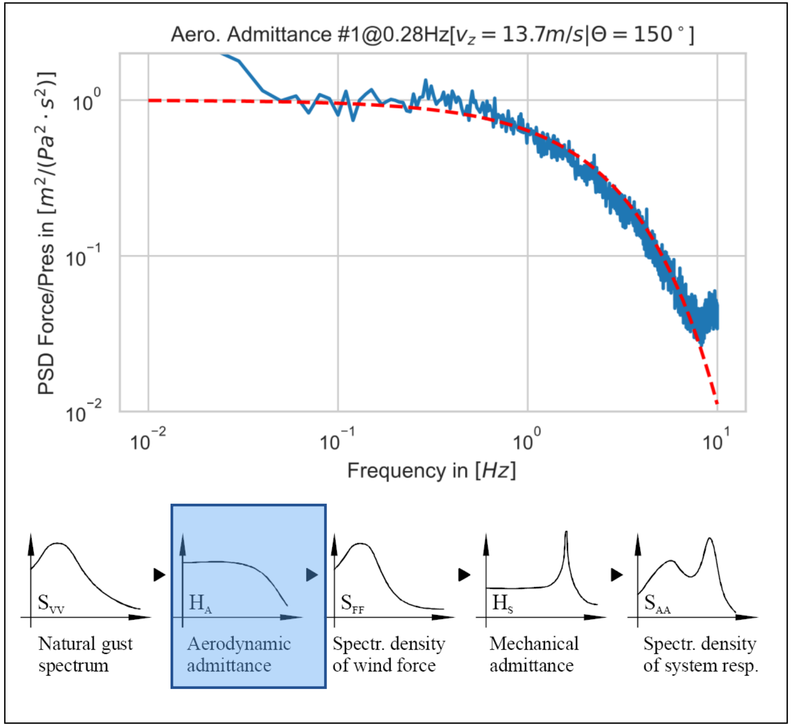
Stage b: Results

Joint acceptance function

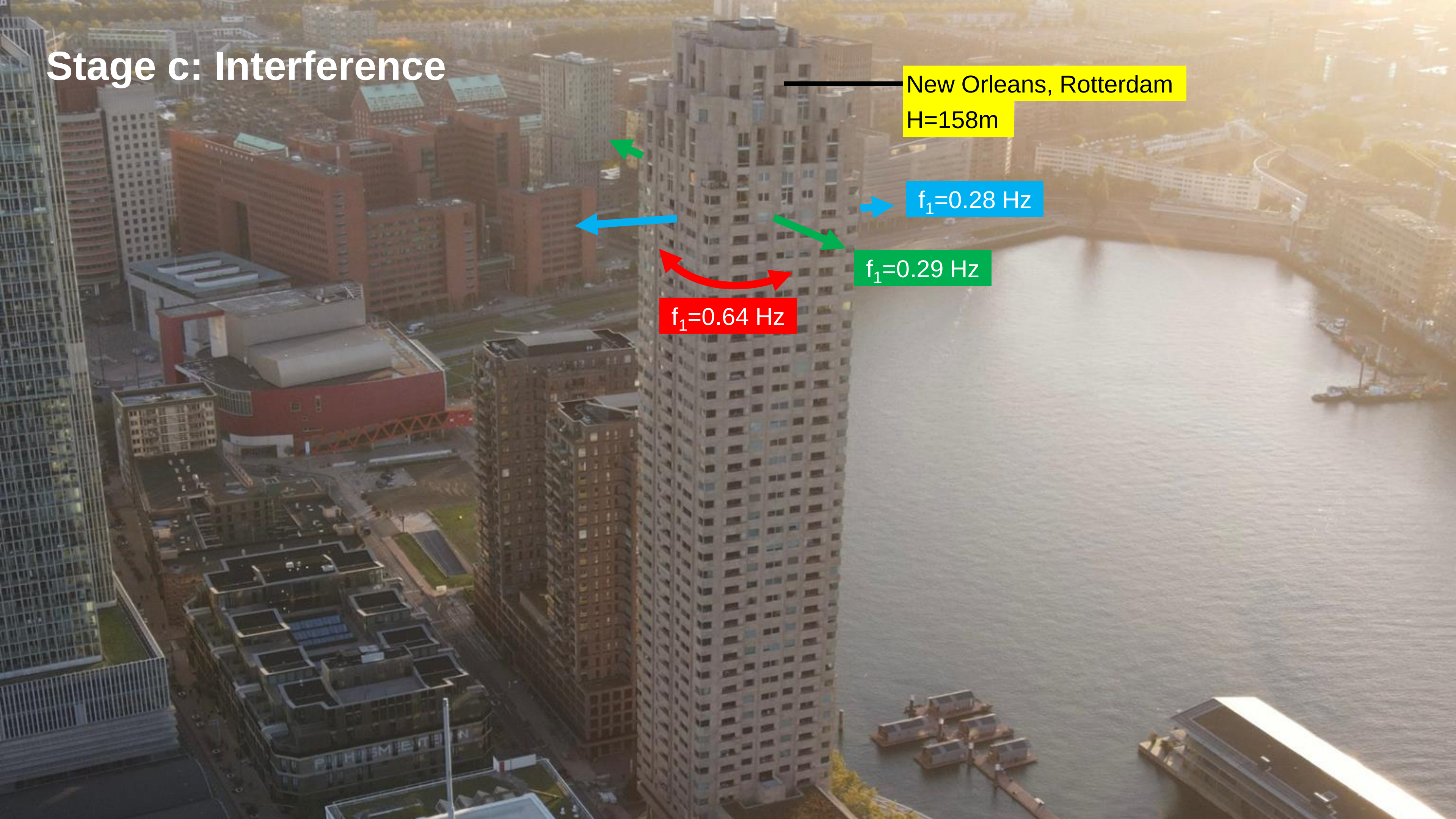
- Consideration of S_{uu} inst. of S_{pp}
- Comparison to models
- Influence of higher modes
- Consideration of more data
- Bayesian posterior of admittance
- Influence of interference (stage c)



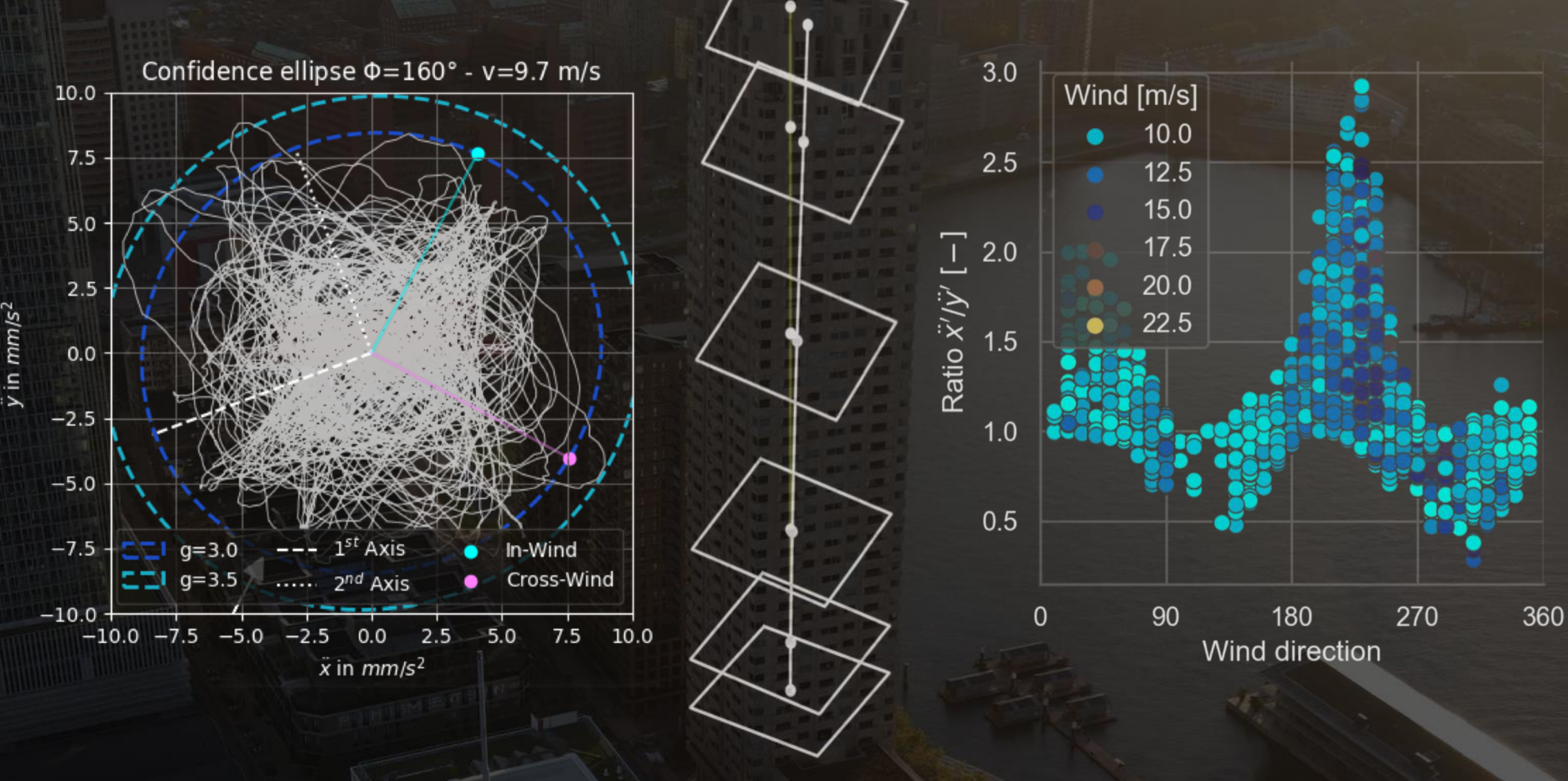




Stage c: Interference



Stage c: Interference



Thank you

This work was performed in the research project "HIVIBE"

Please see acknowledgement in the abstract.