

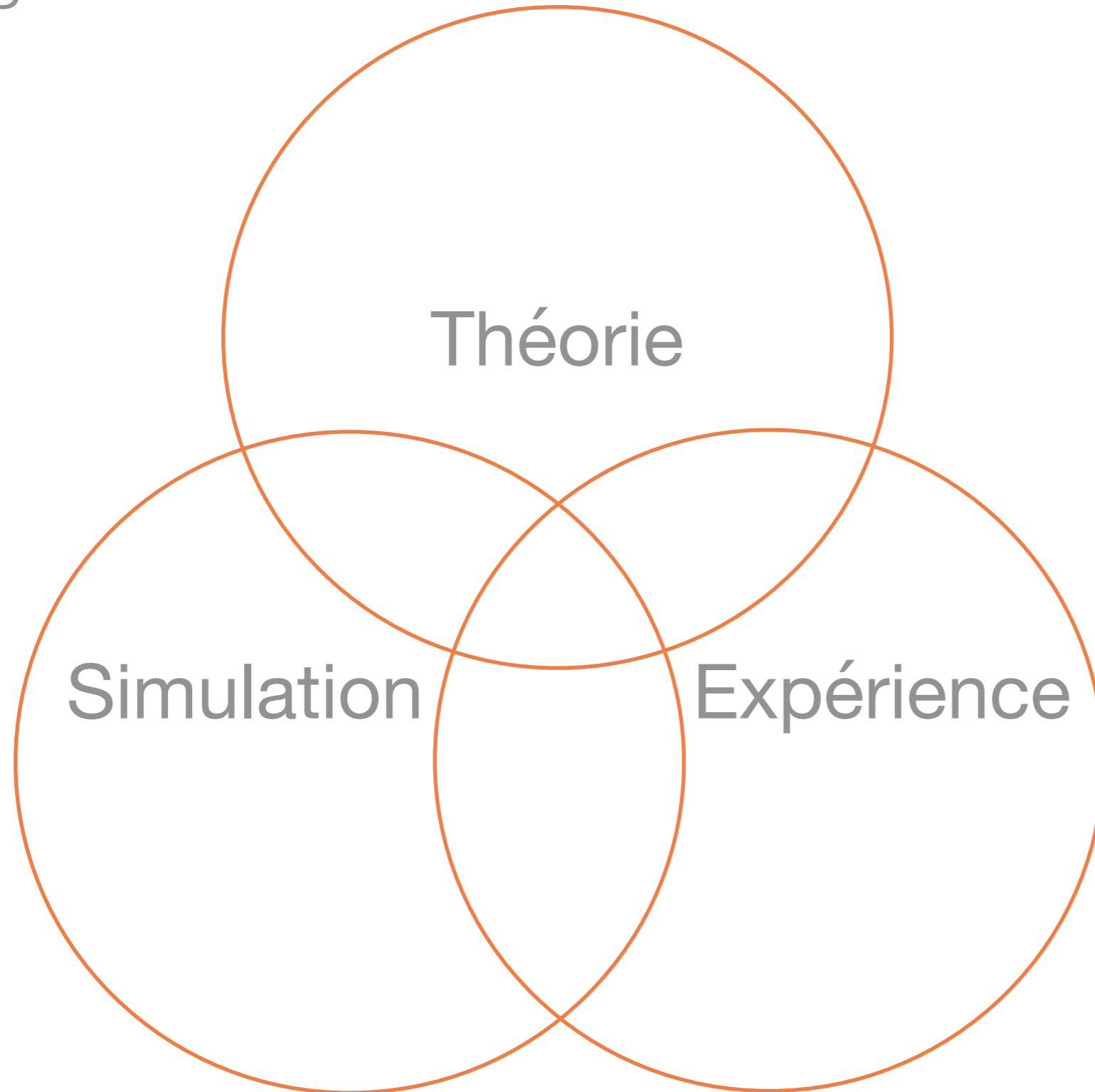
L'expérience a encore de beaux jours devant elle

François Rigo
Thomas Andrianne
Vincent Denoël

Motivation



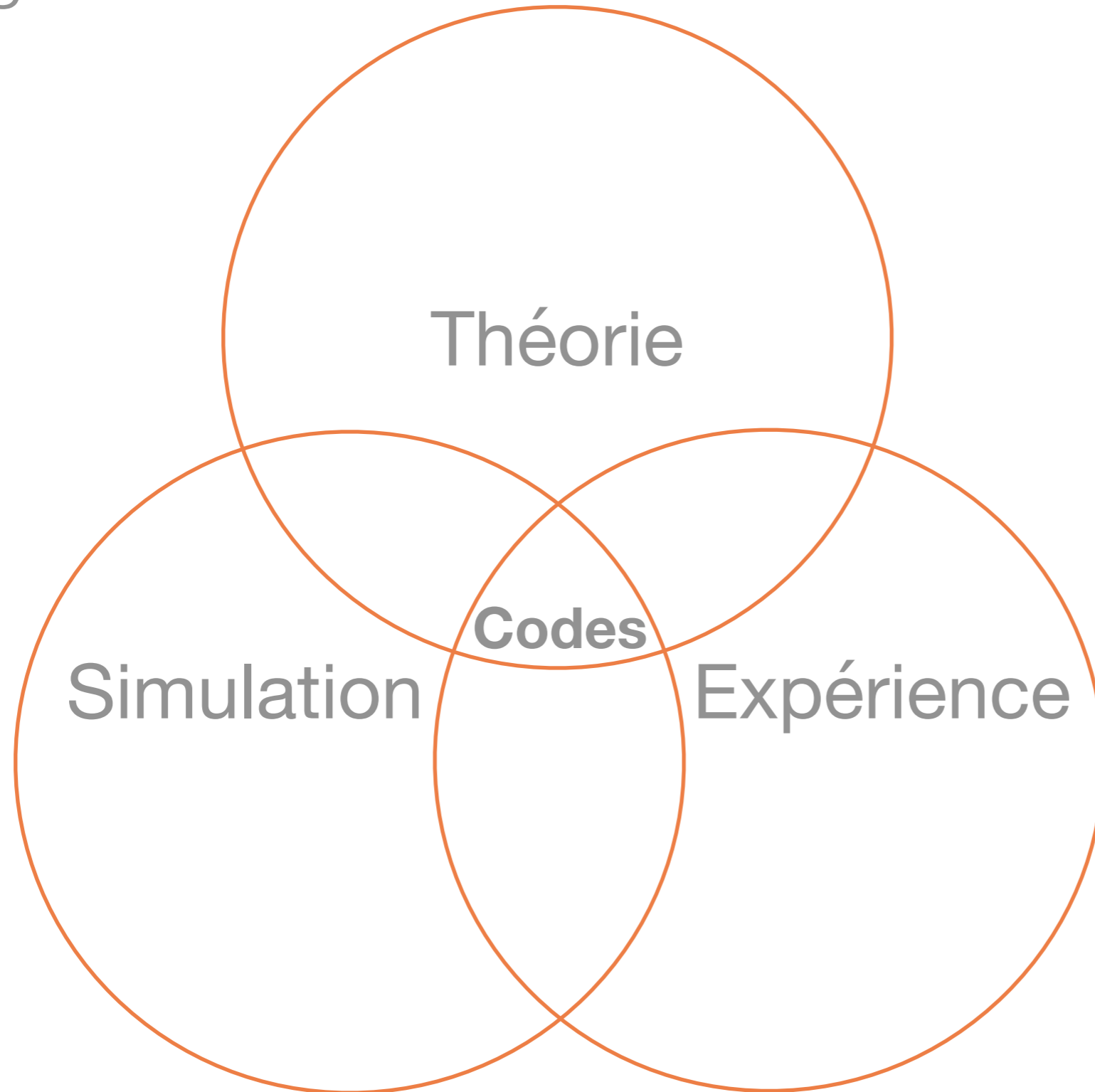
Design de structures soumises au vent ?



Motivation



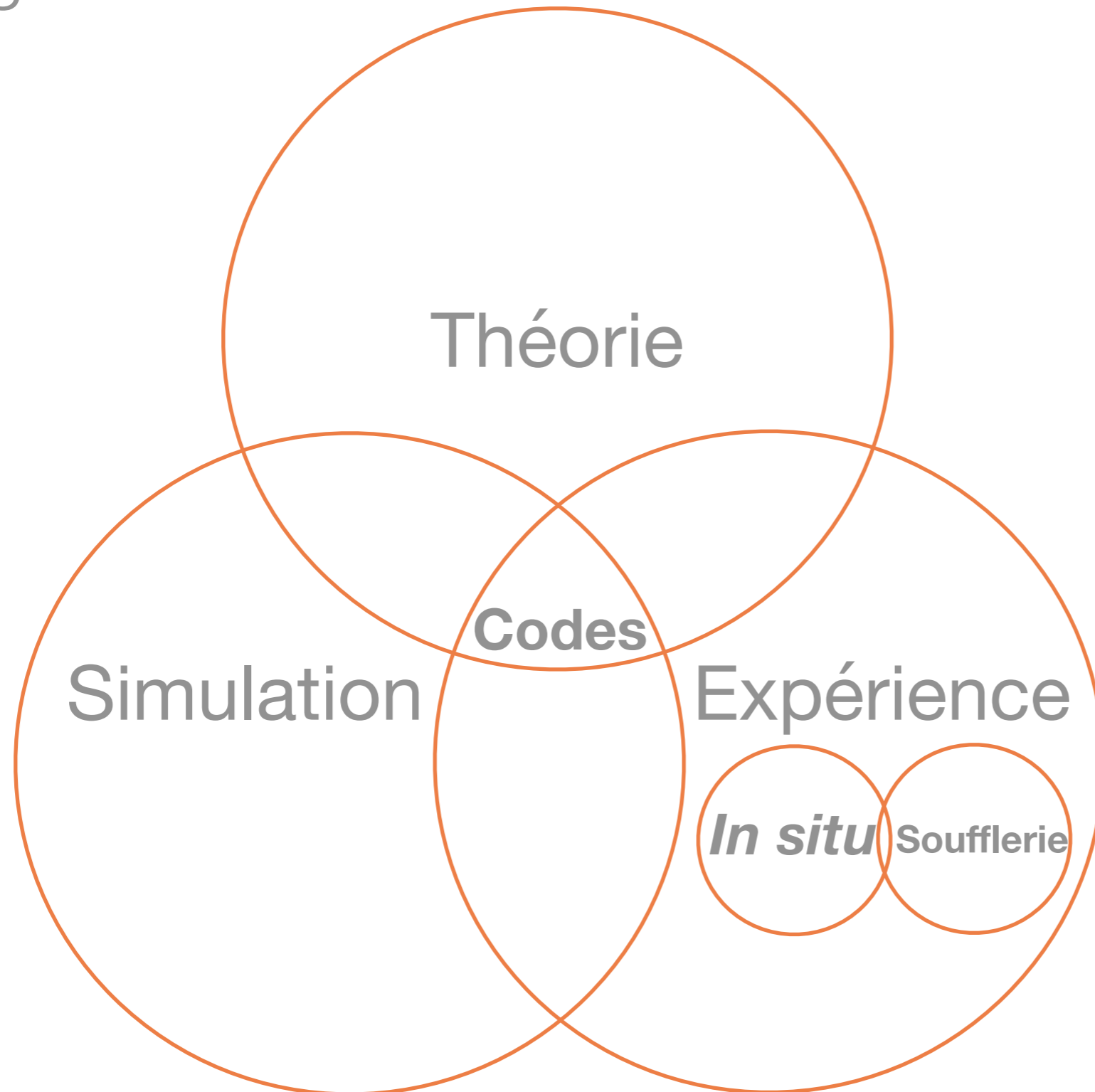
Design de structures soumises au vent ?



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Design de structures soumises au vent ?



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Design de structures soumises au vent ?

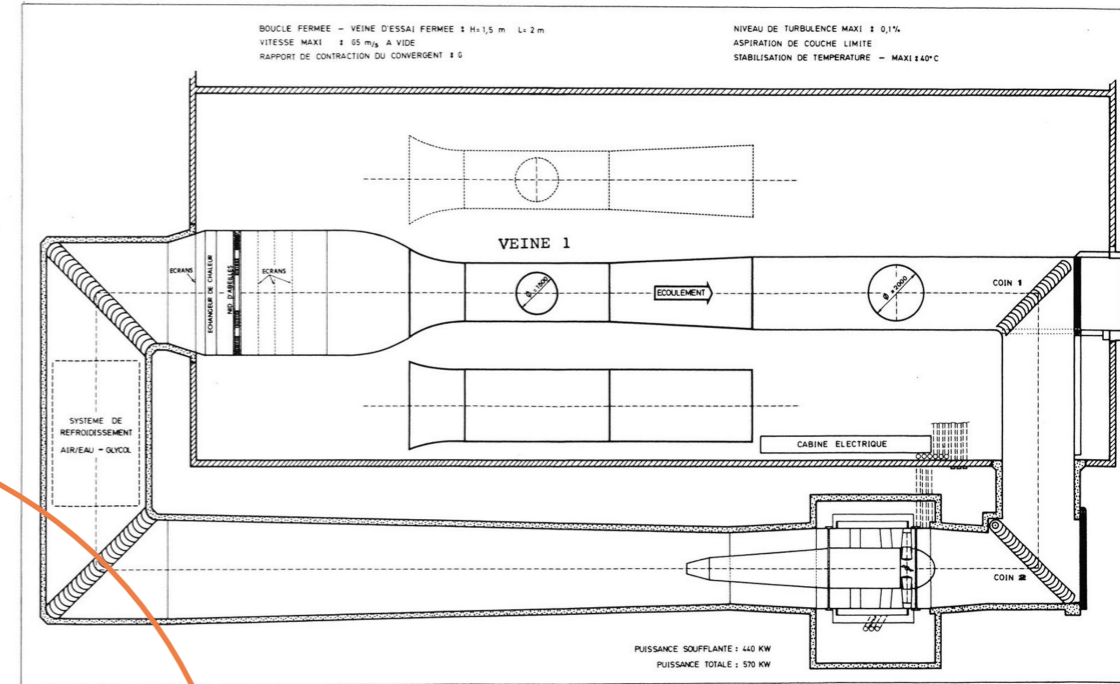
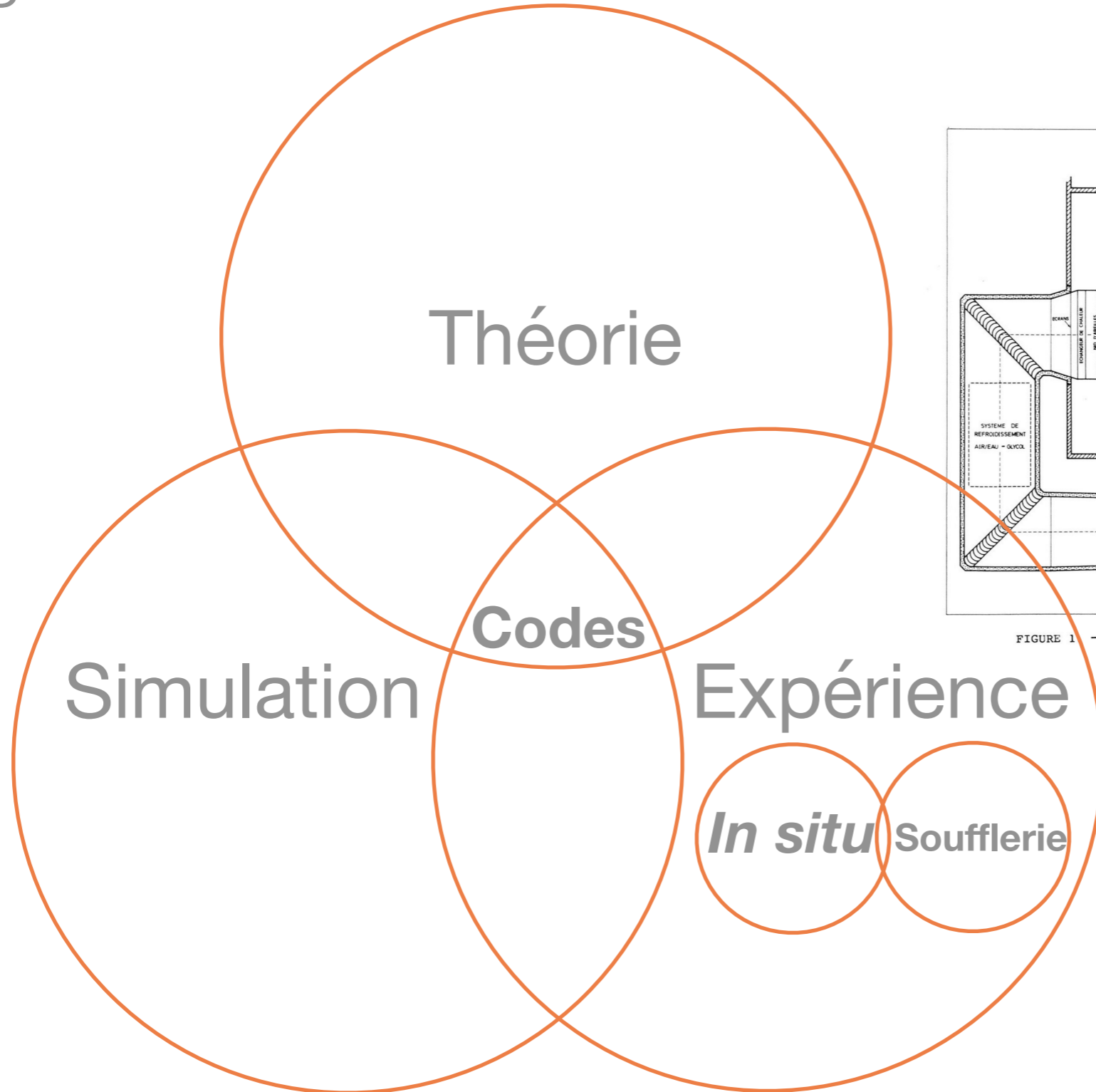


FIGURE 1 - VEINE 1 - BOUCLE POUR ETUDES D'AERONEFS ET DE VEHICULES AUTOMOBILES

Motivation



Design de structures soumises au vent ?

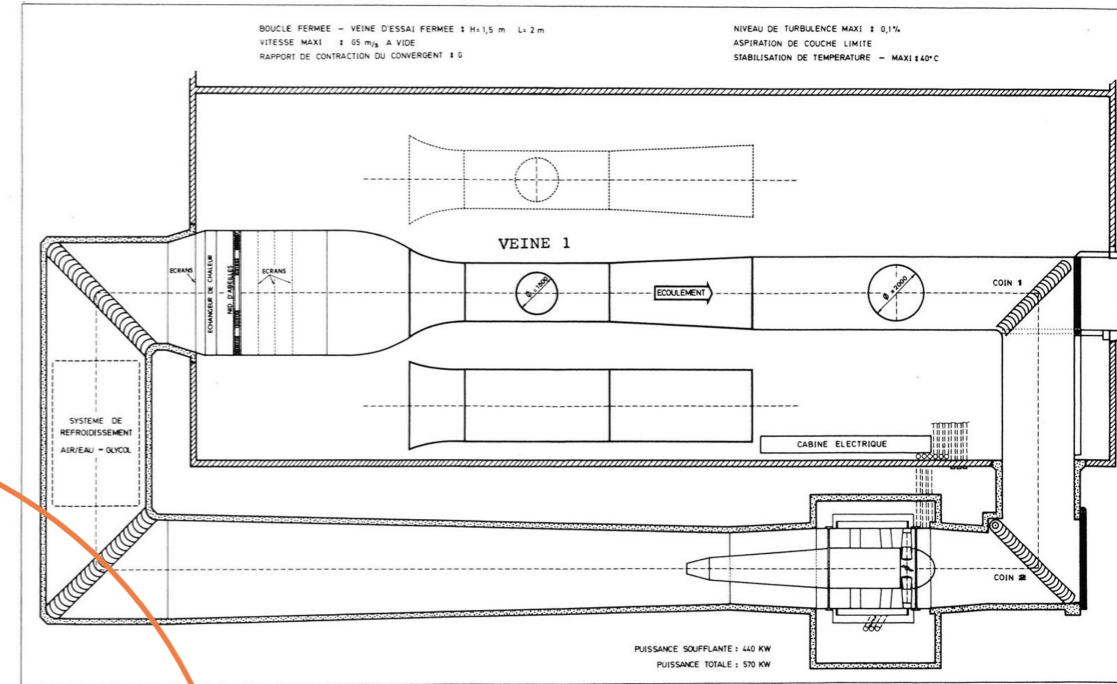
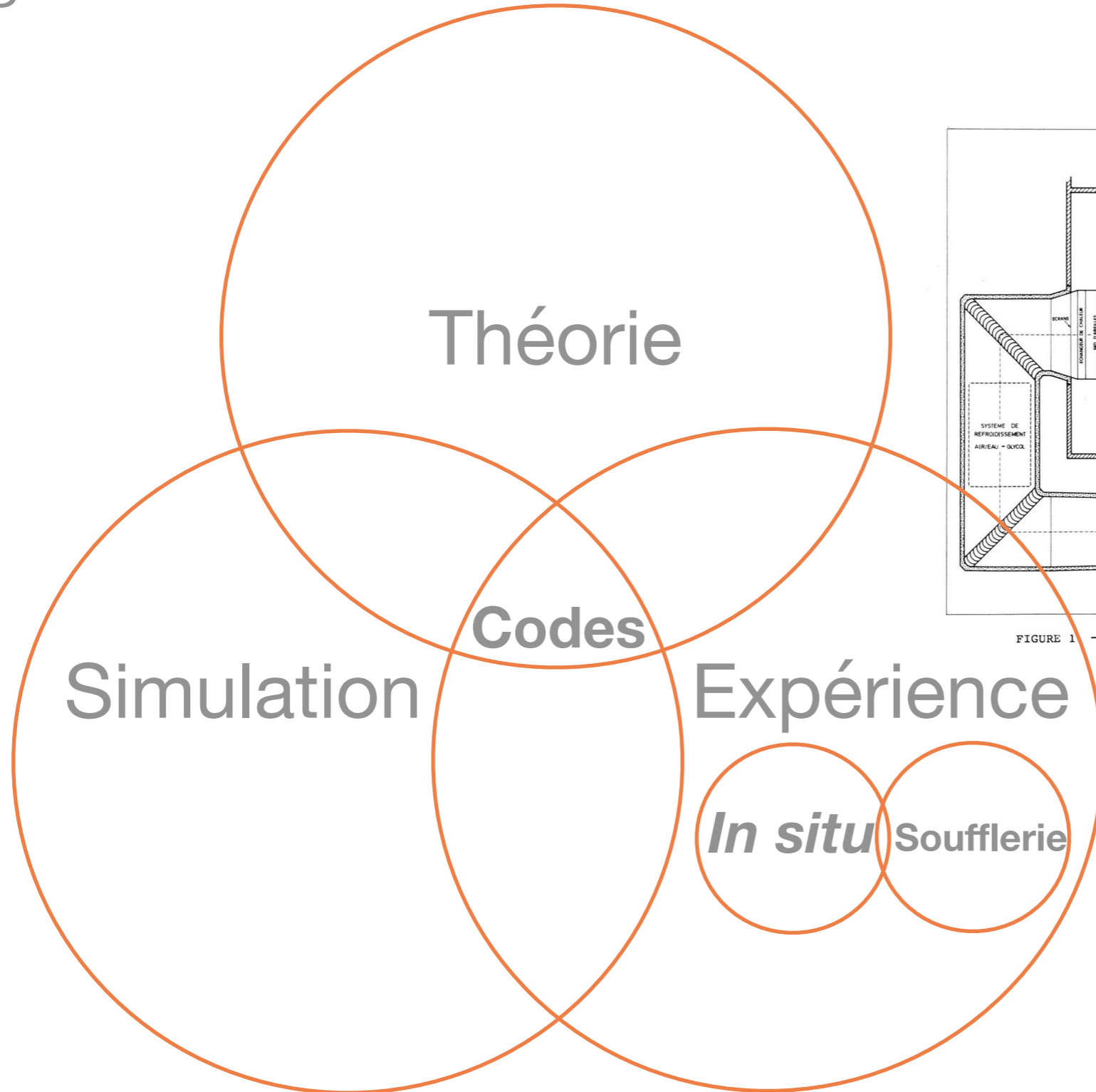


FIGURE 1 - VEINE 1 - BOUCLE POUR ETUDES D'AERONEFS ET DE VEHICULES AUTOMOBILES

TU/e Technische Universiteit
Eindhoven
University of Technology

**Atmospheric Boundary
Layer Wind Tunnel**





Améliorations techniques



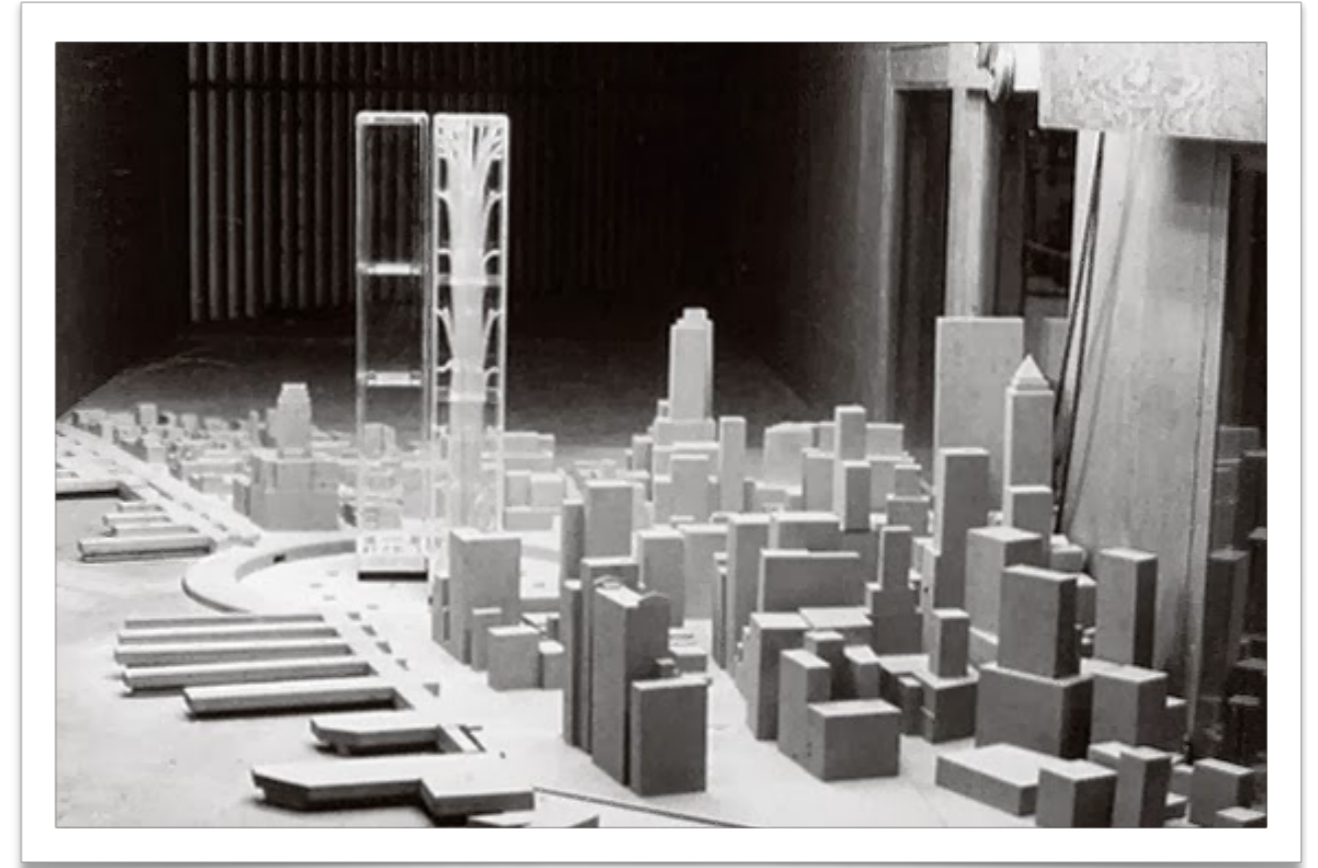
1964: Wind Tunnel Testing World Trade Center (Drs. J.E.Cermak and A.G. Davenport in the Colorado State University boundary layer wind tunnel)

Augmentation de la fréquence d'échantillonnage & densité de capteurs

Motivation

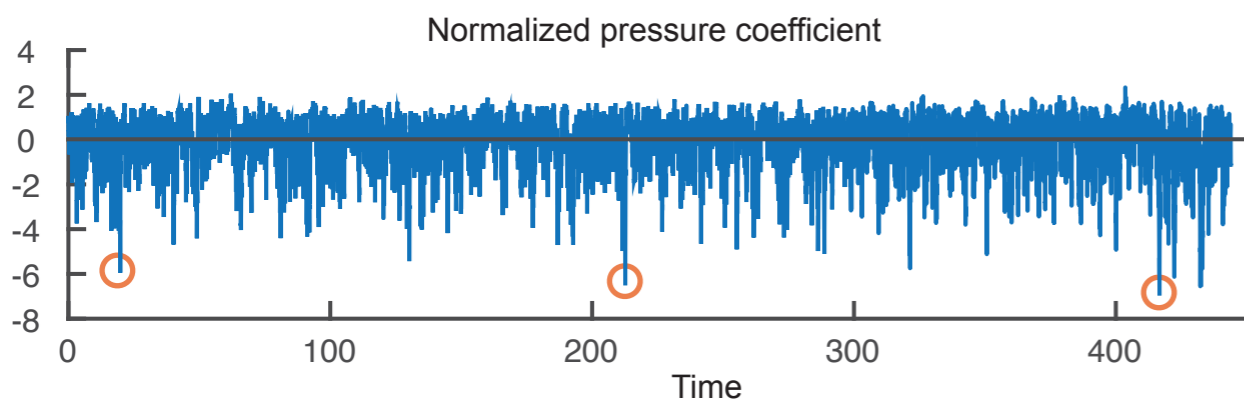


Améliorations techniques



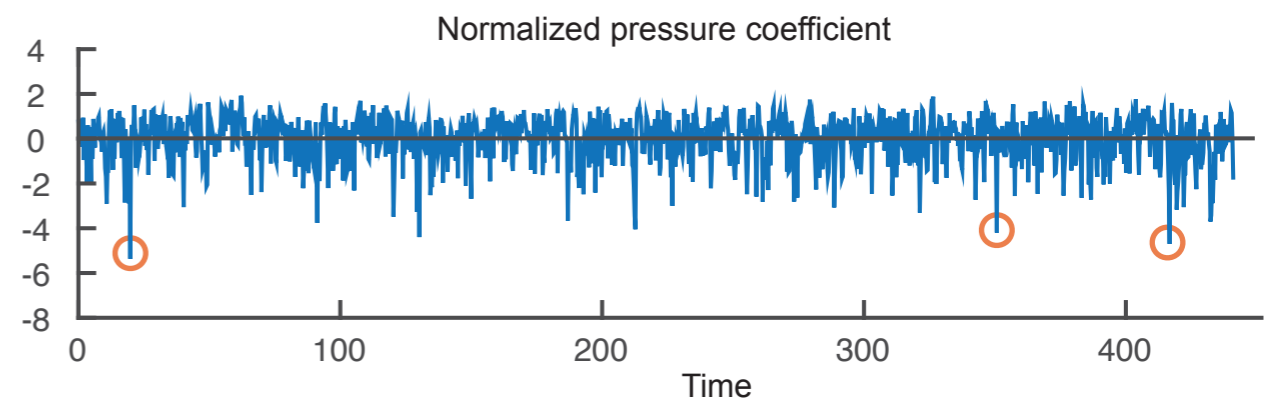
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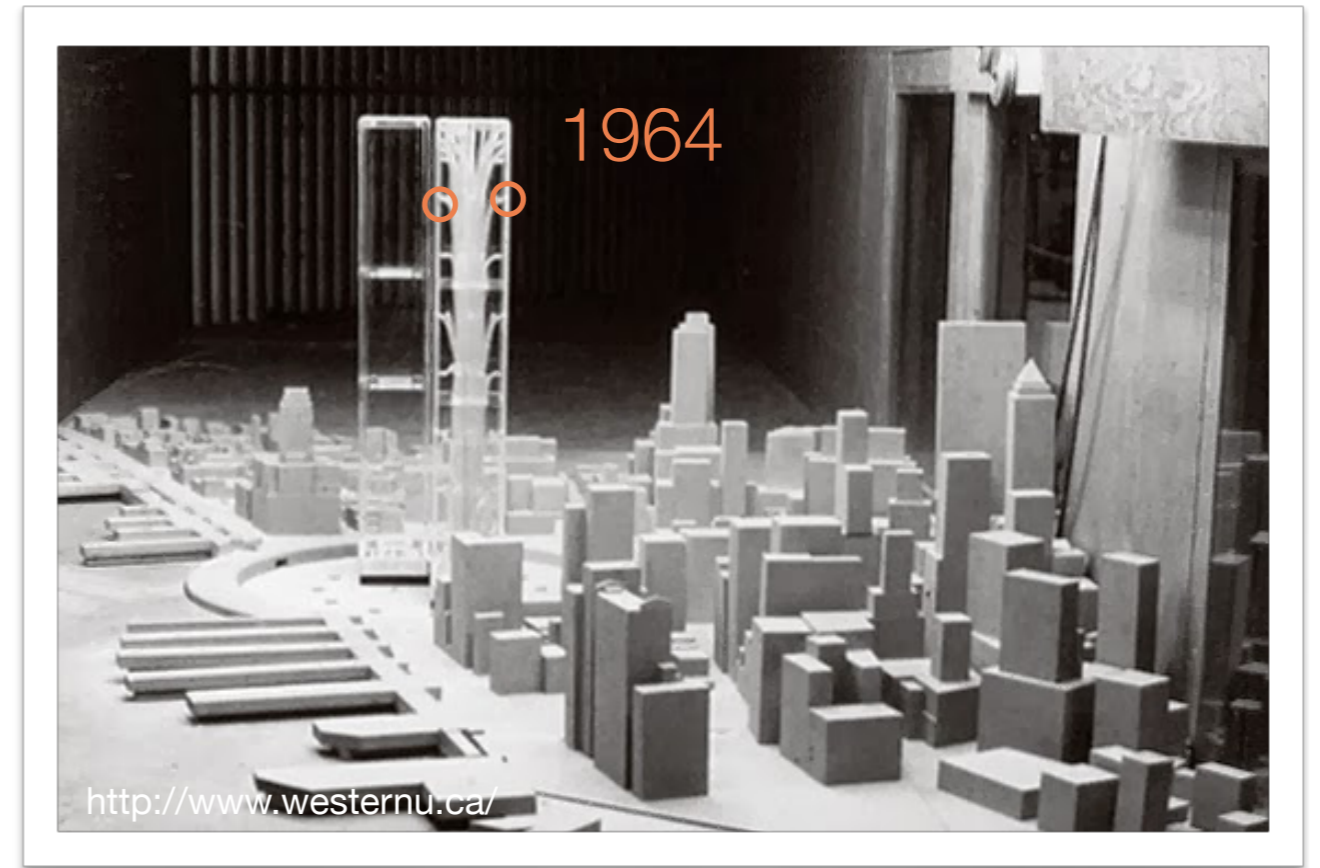
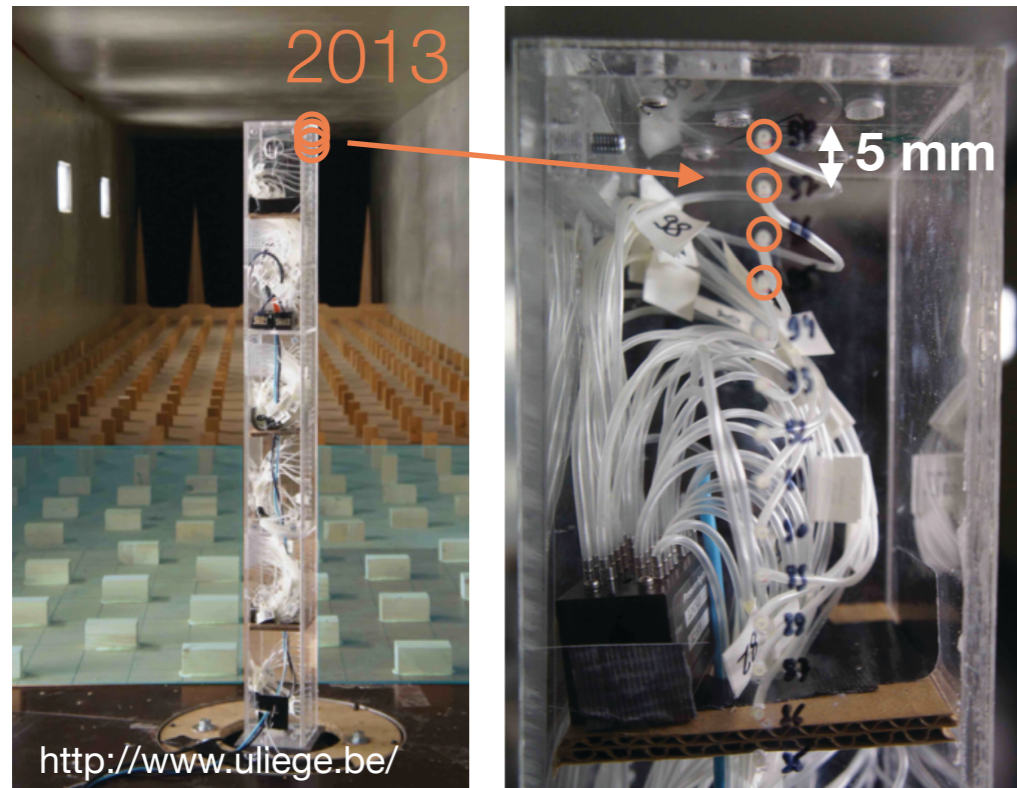


2018

Downsampled →



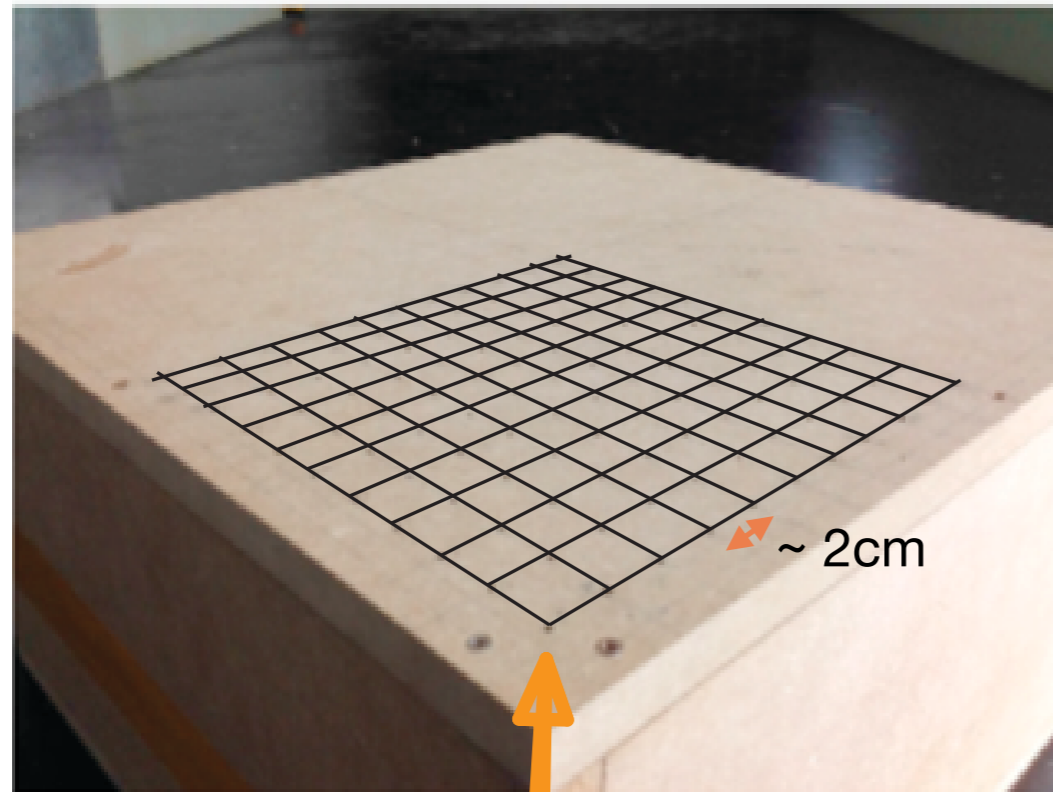
« 1964 »



Augmentation de la fréquence d'échantillonnage & densité de capteurs

- ▶ Possibilité de mieux capturer des événements extrêmes

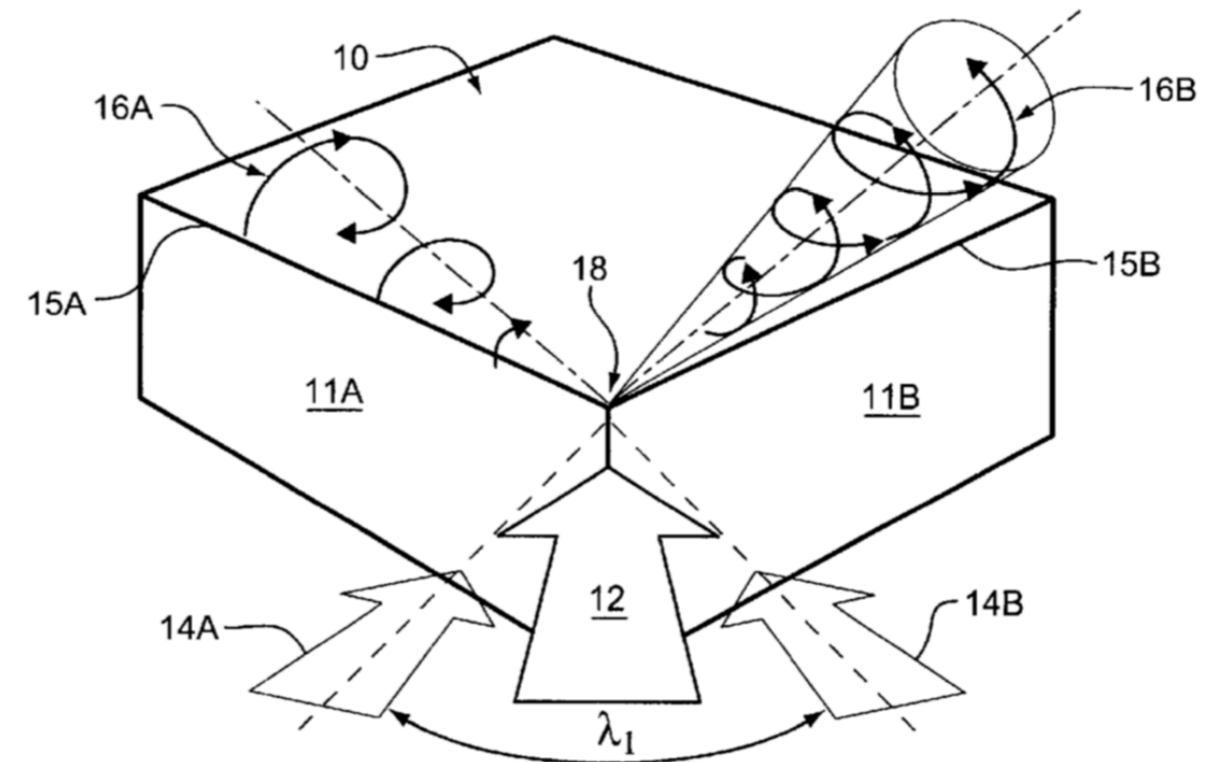
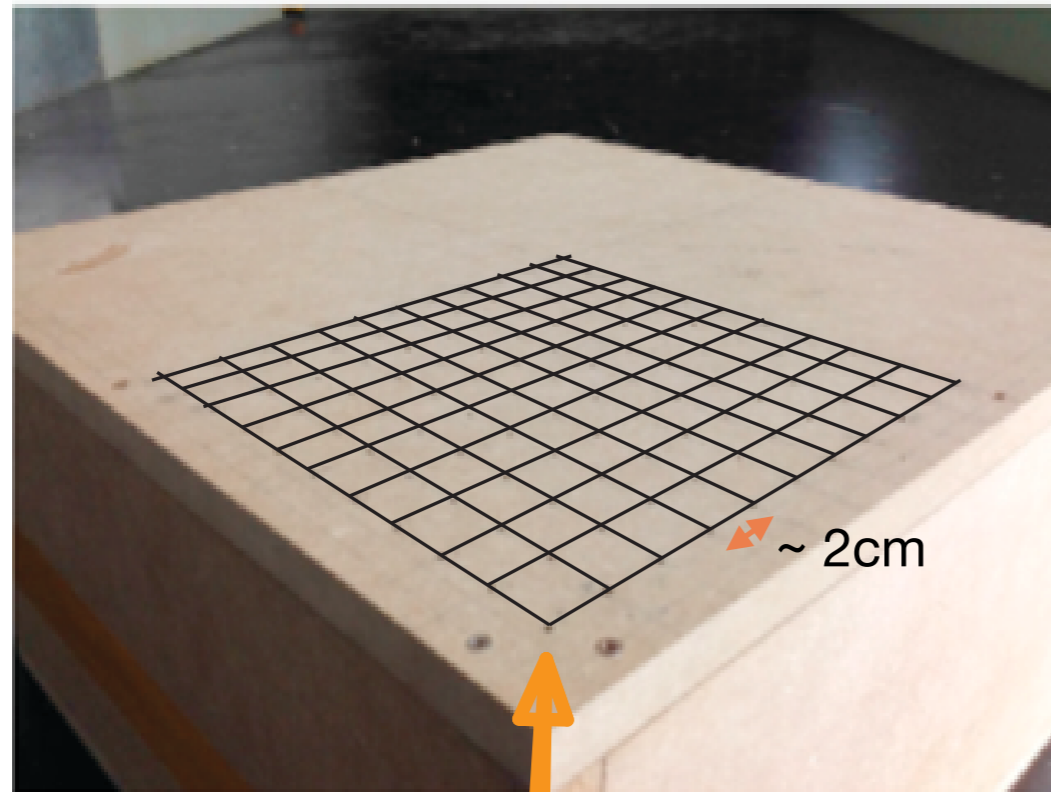
Exemple de setup expérimental



WIND TUNNEL
LABORATORY 

- ▶ Longues mesures : 371 heures (full scale), ($F_s = 500$ Hz)
- ▶ 45° d'incidence de vent
- ▶ Echelle géométrique 1/100, échelle de vitesse 1/3.5
- ▶ Catégorie de terrain III
- ▶ 1/4 du toit total étudié

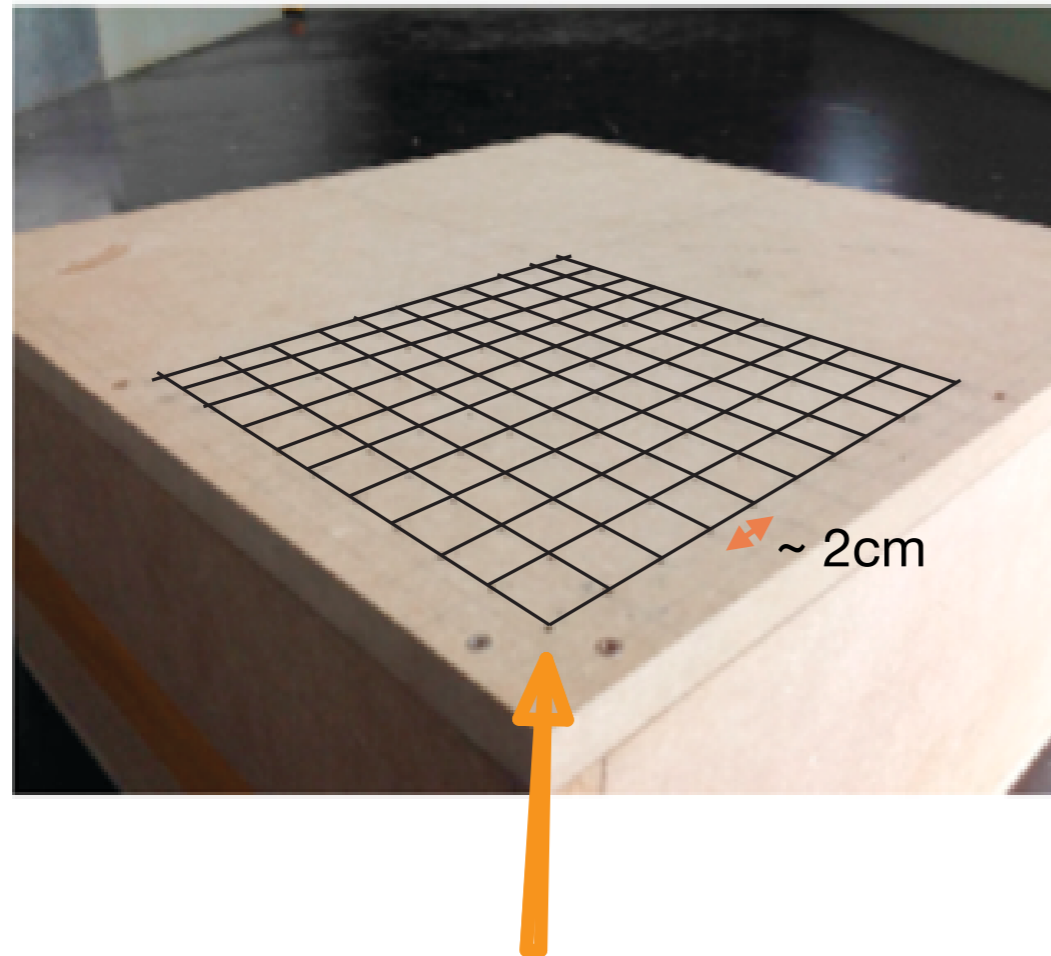
Exemple de setup expérimental



Banks et al. [2003]

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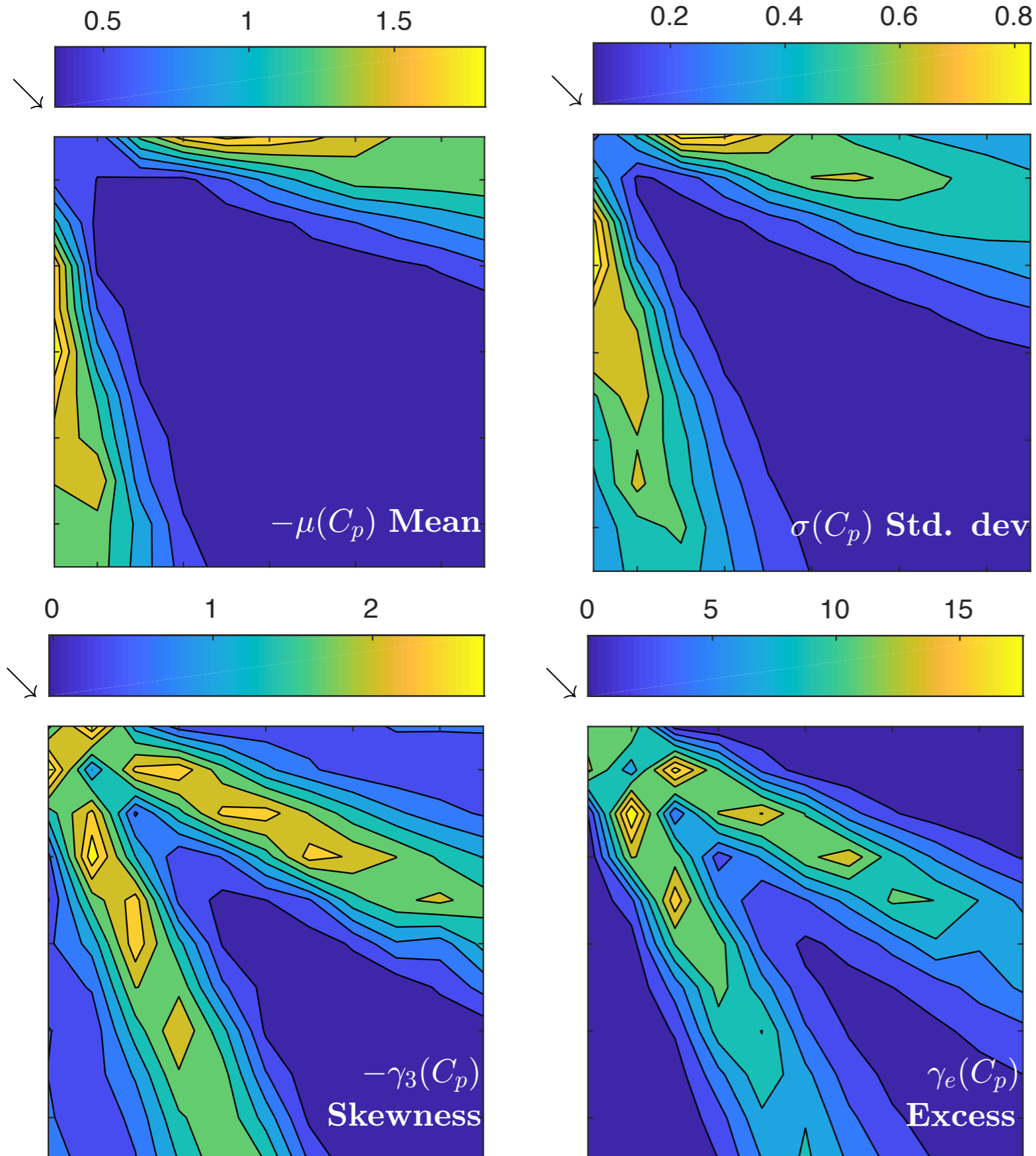
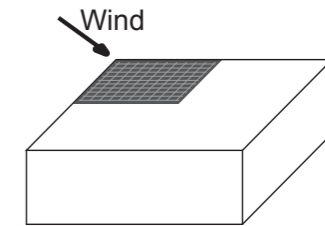
Exemple de setup expérimental



CPP [2016]

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Exemple de setup expérimental



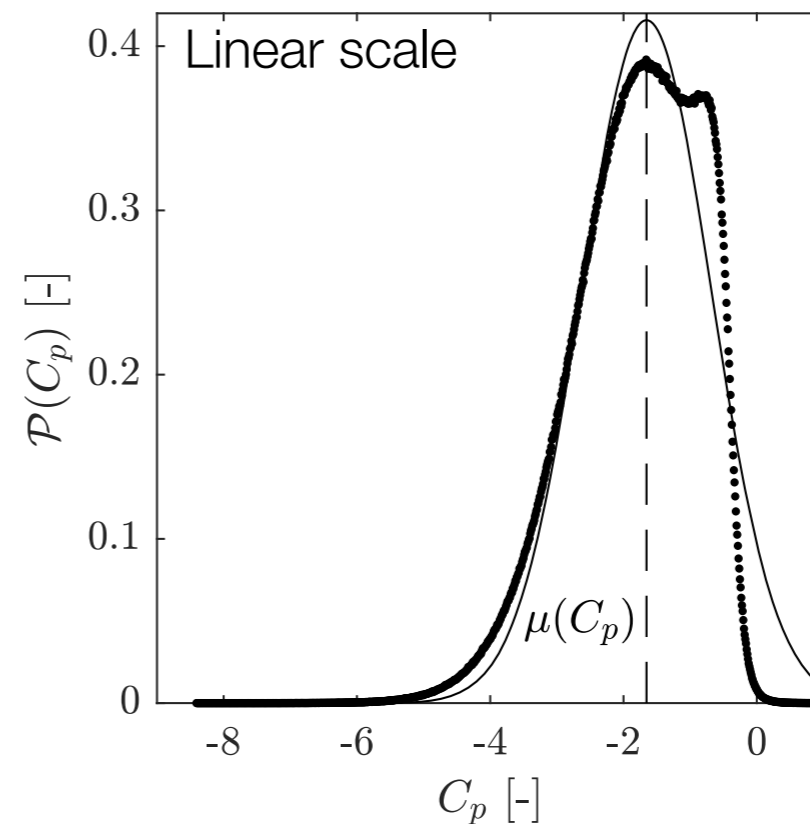
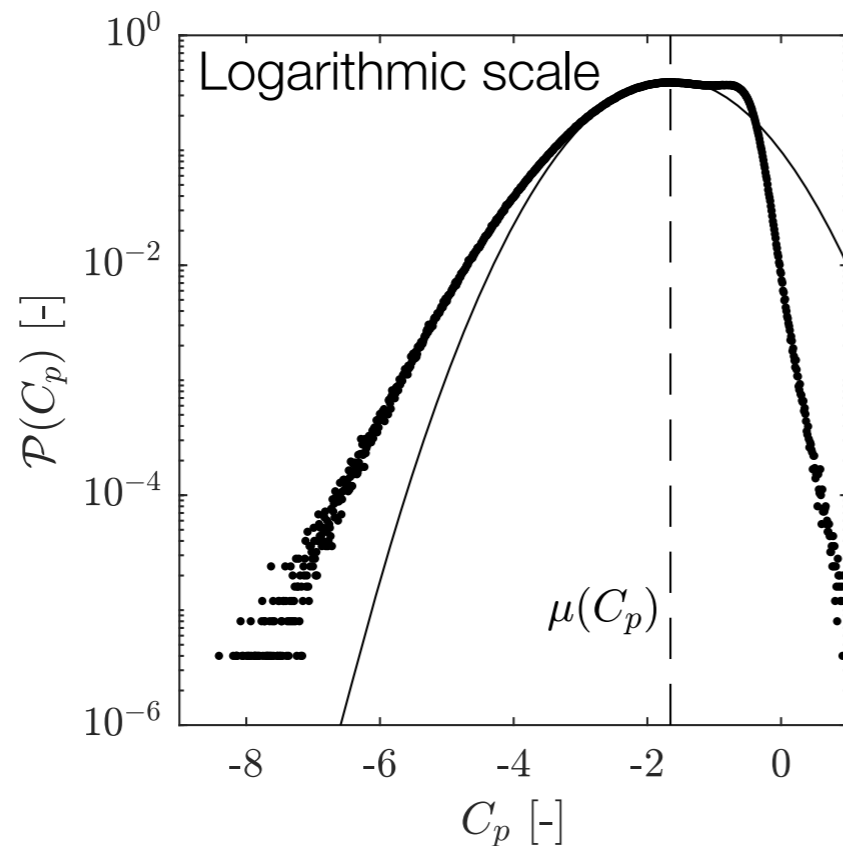
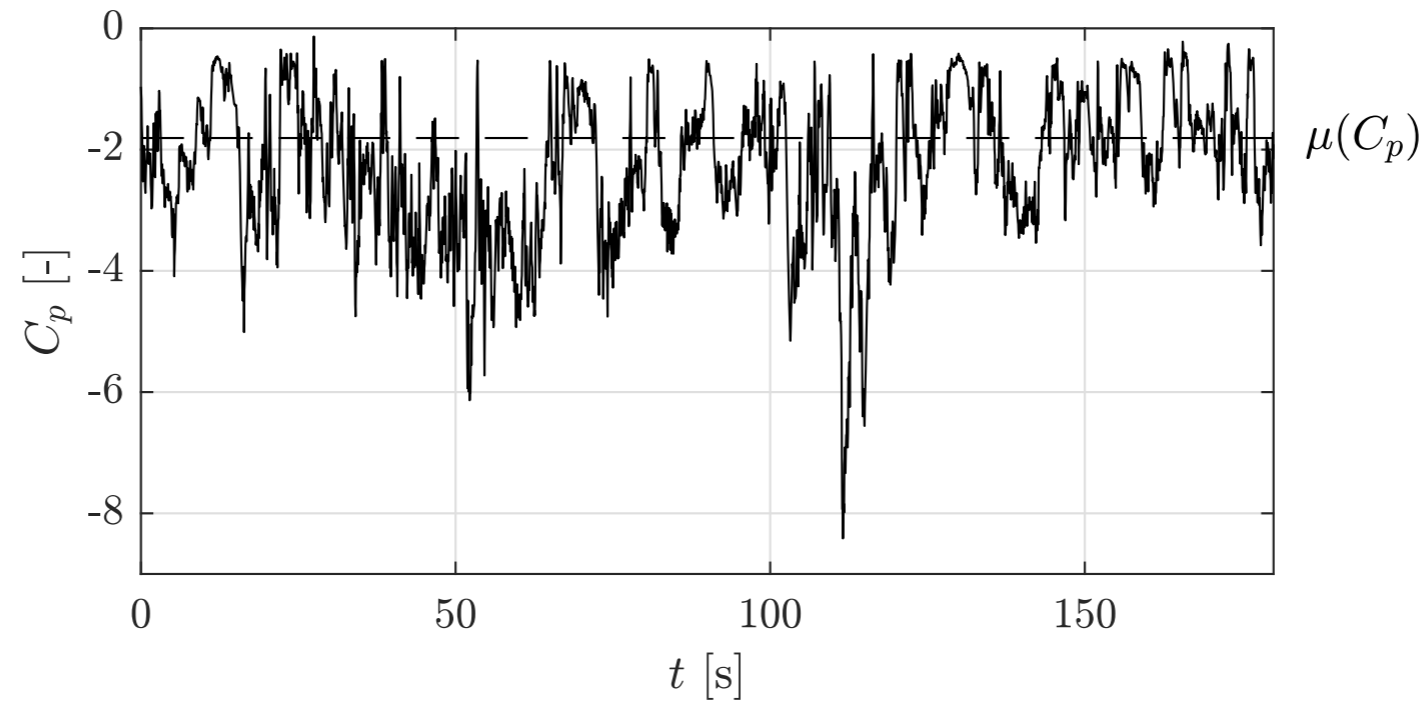
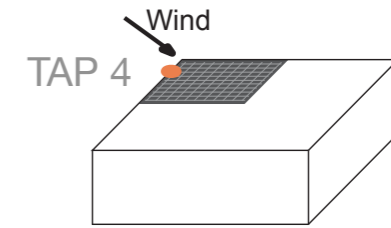
Statistiques de C_p

- ▶ Partie la plus intéressante dans les tourbillons de coin (qui s'ajoutent à la turbulence amont)
- ▶ Grande non-gaussianité et pics de pression négatifs

Exemple de setup expérimental



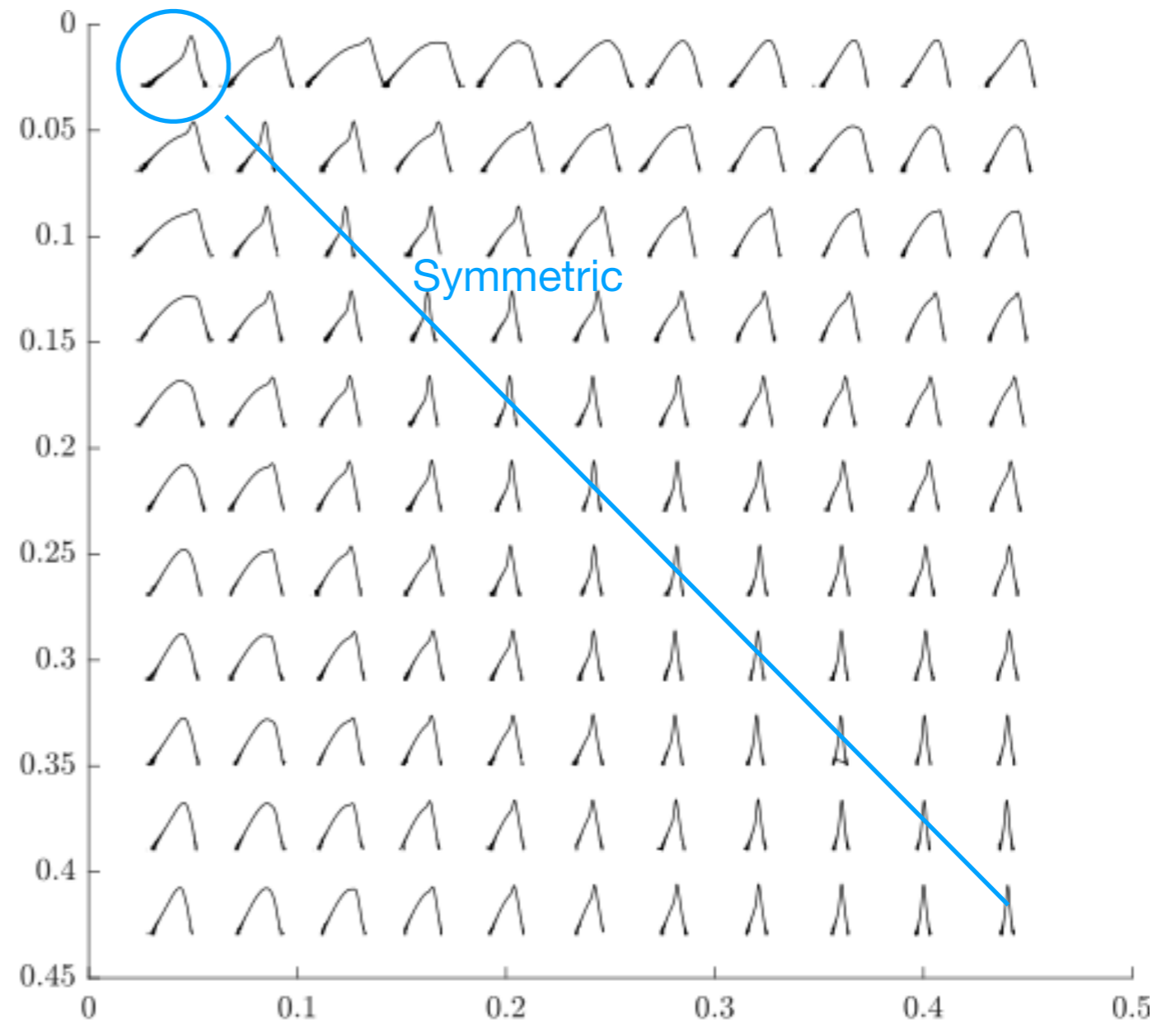
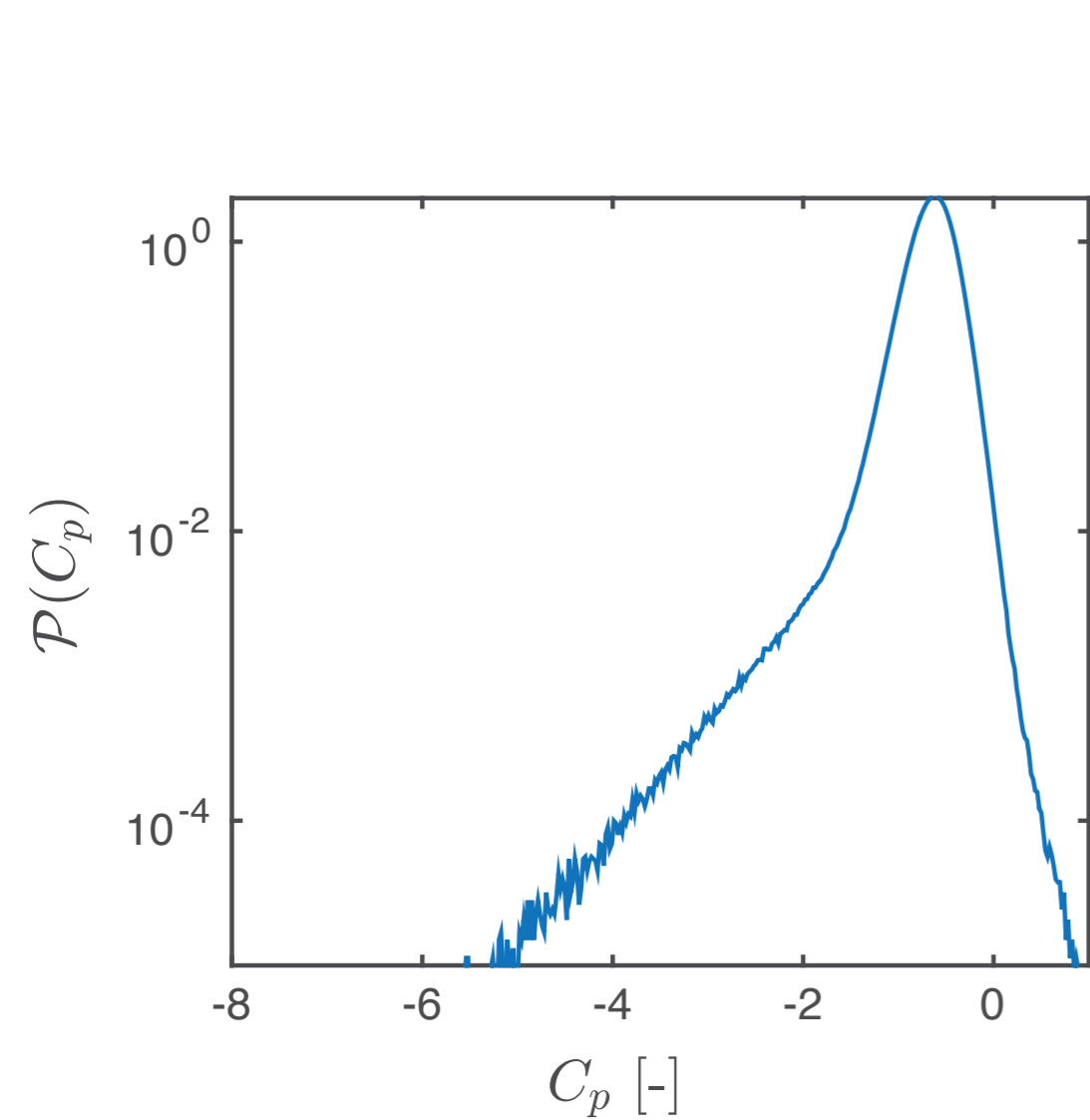
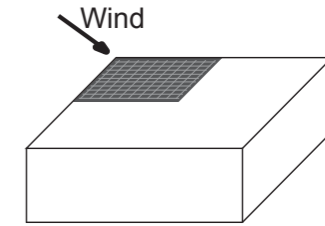
Exemple de coefficient de pression mesuré



PDF de pression de vent sur le toit



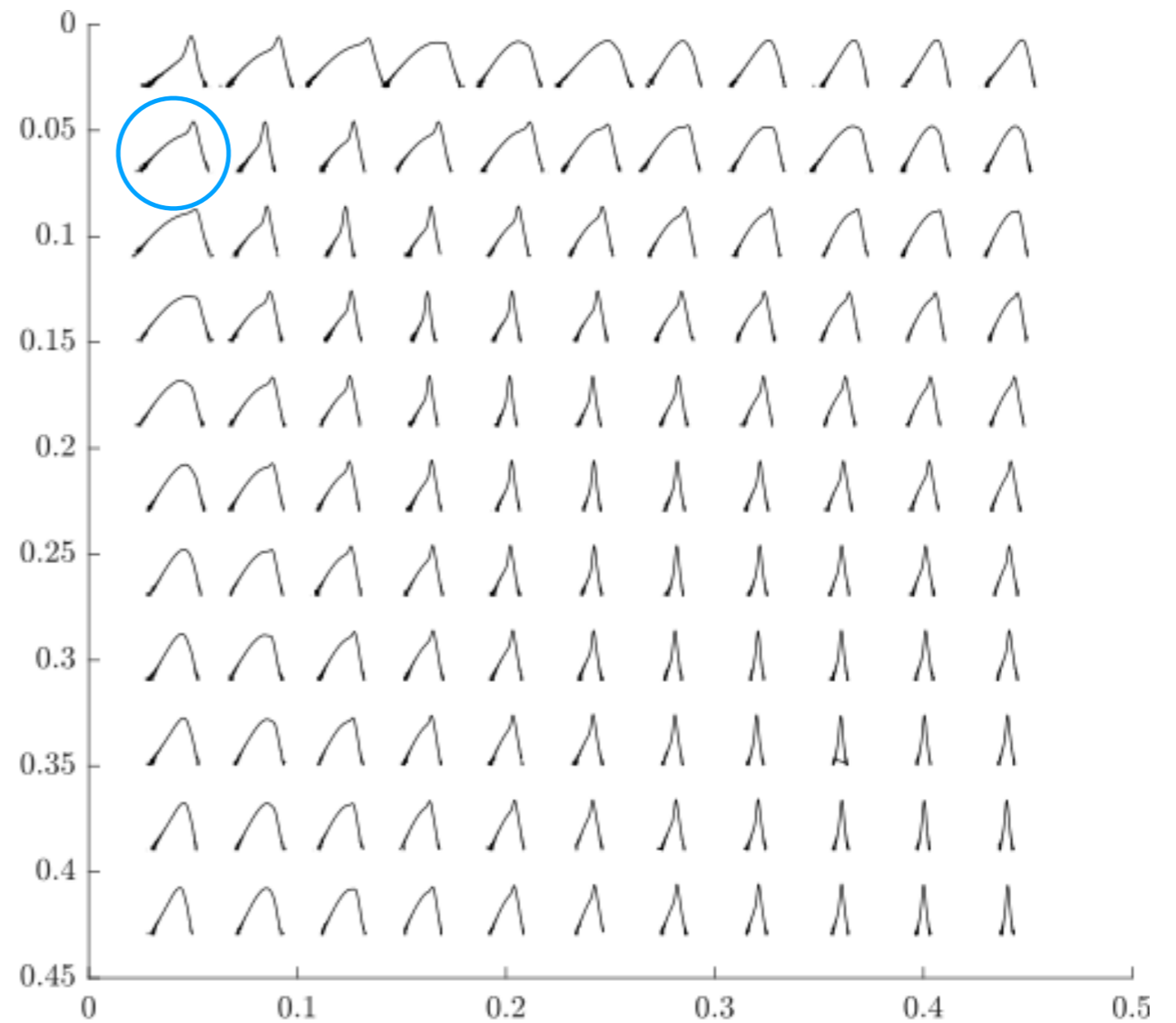
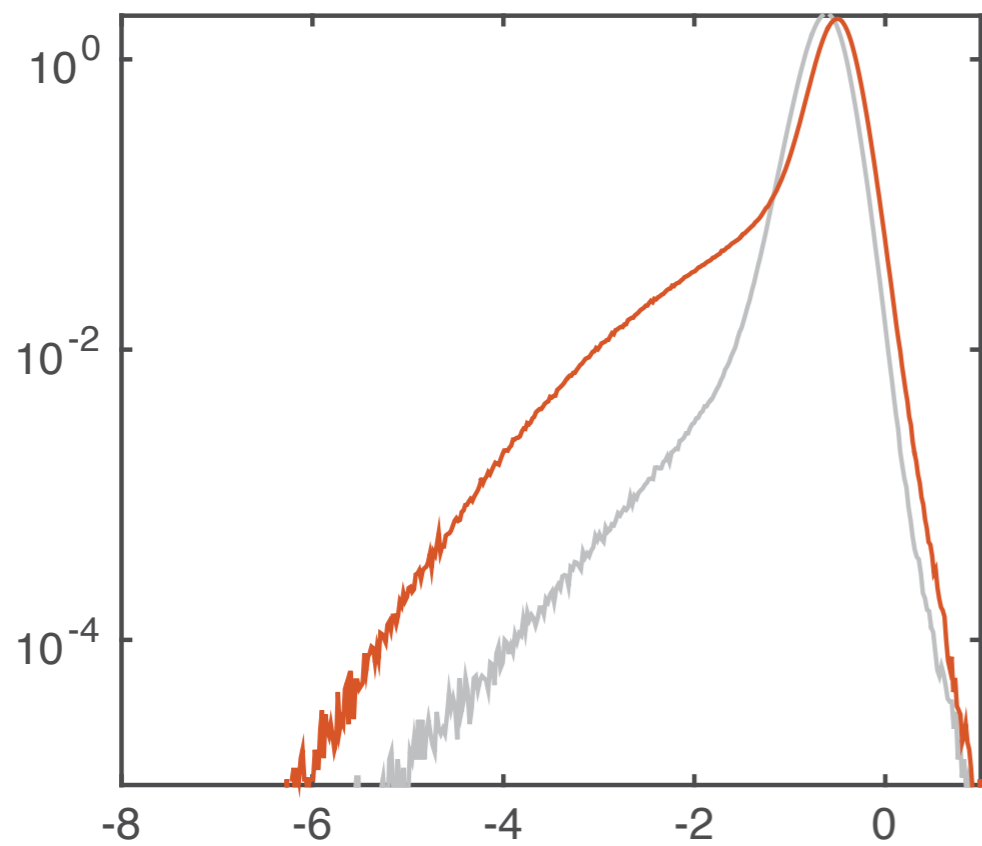
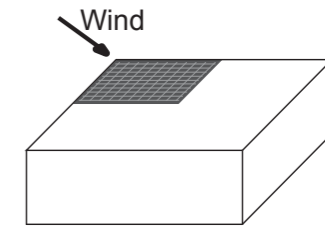
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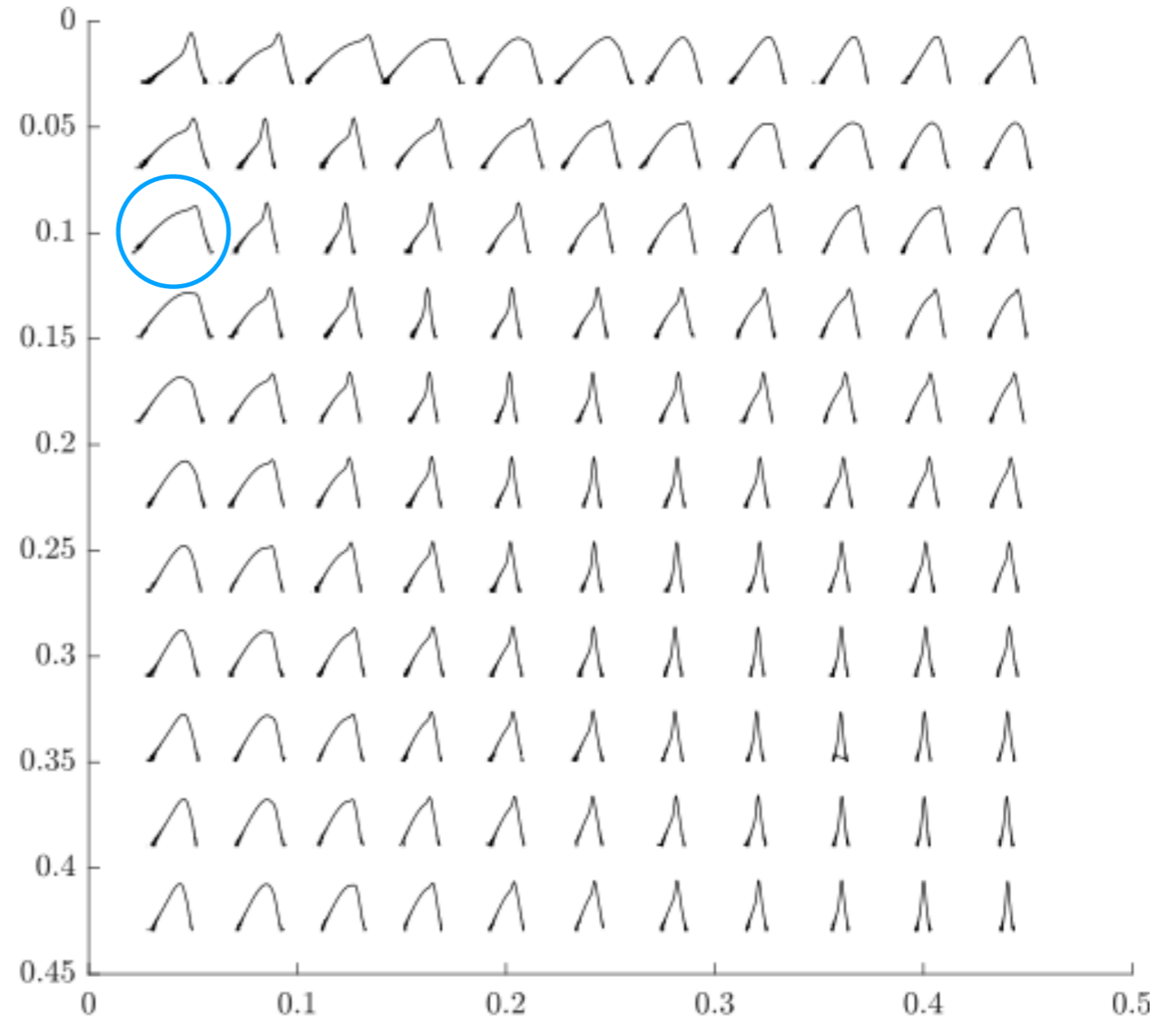
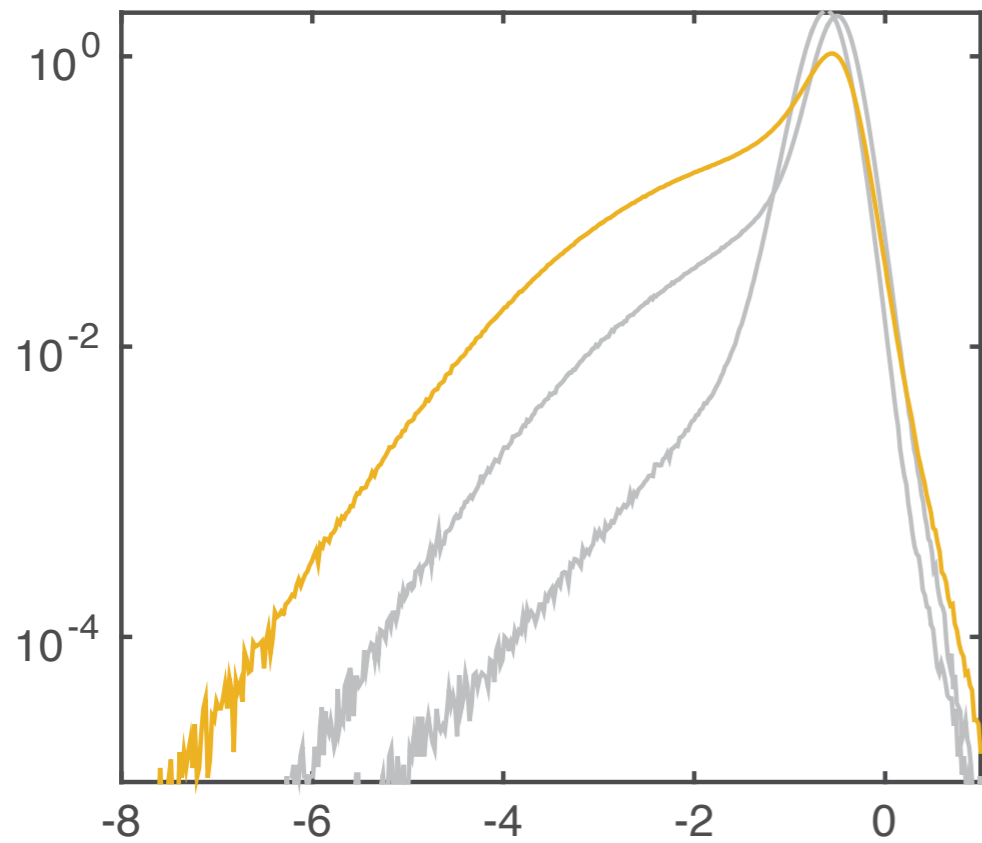
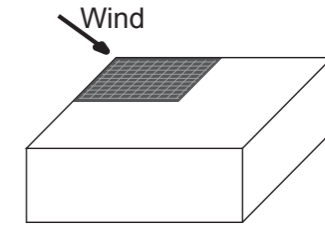
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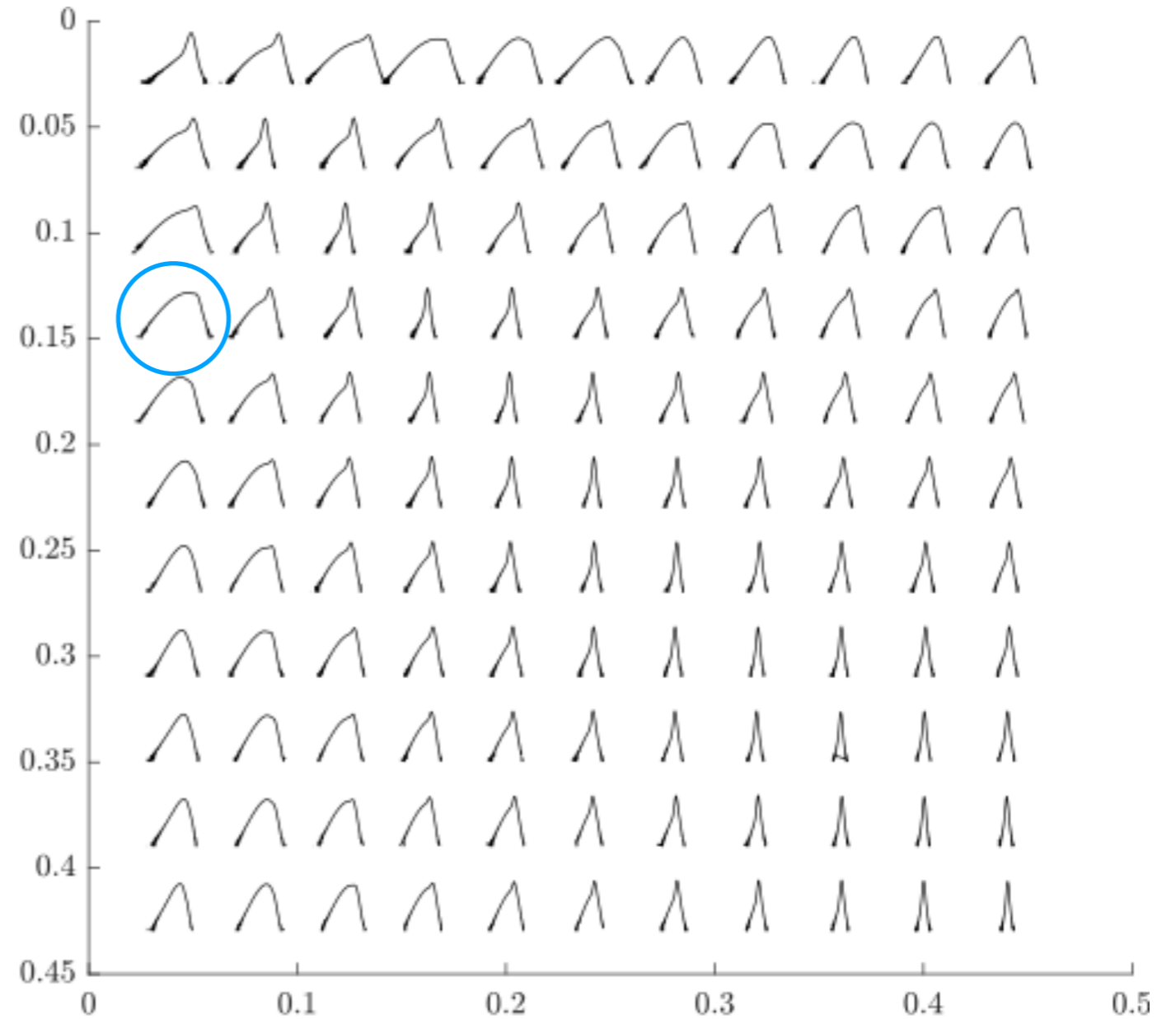
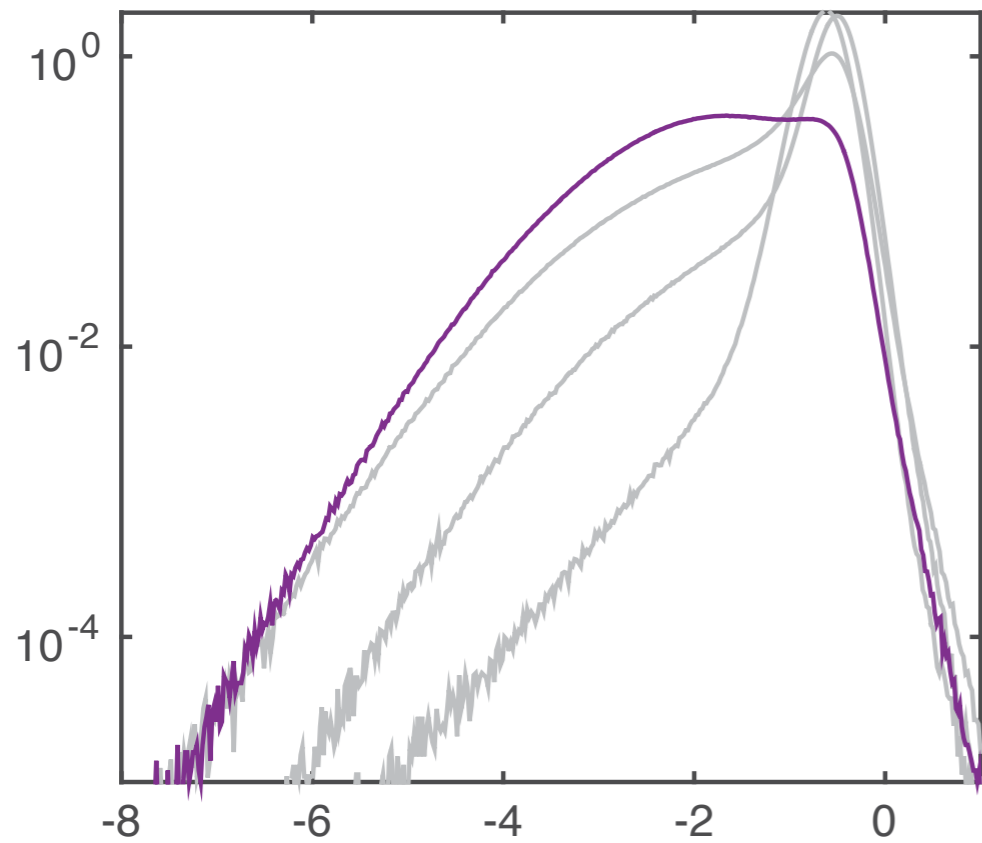
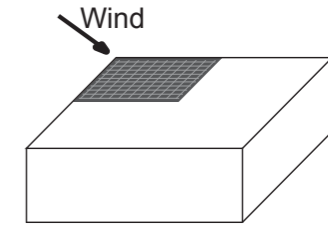
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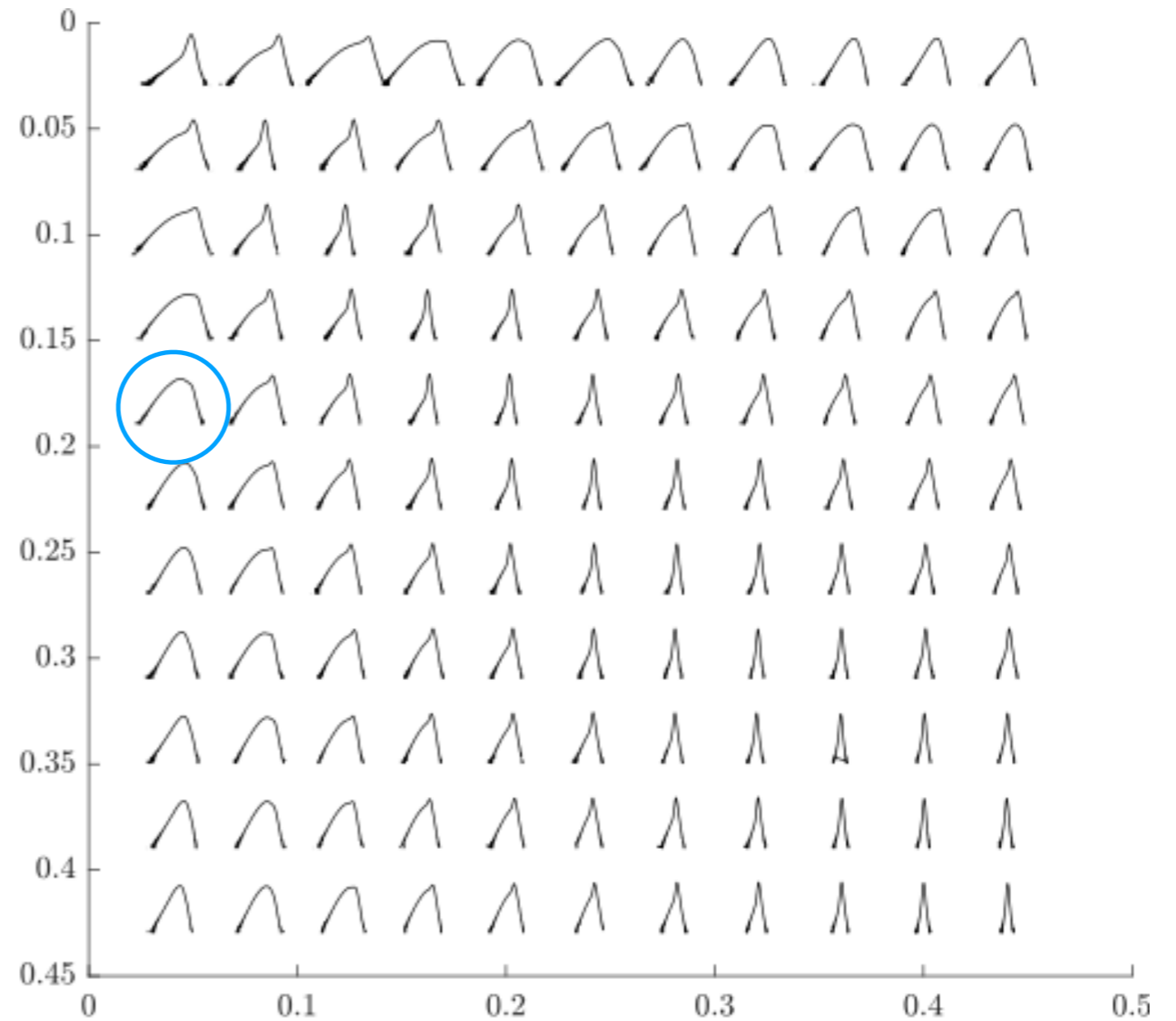
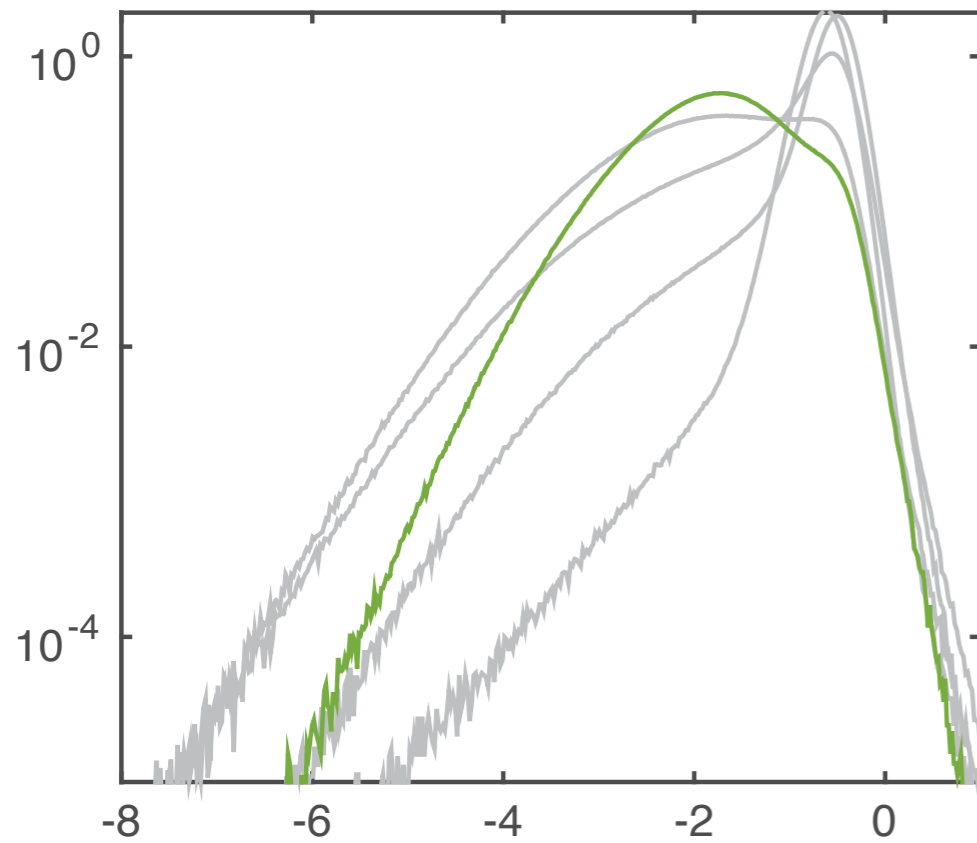
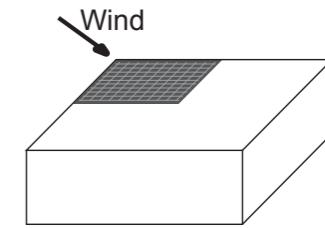
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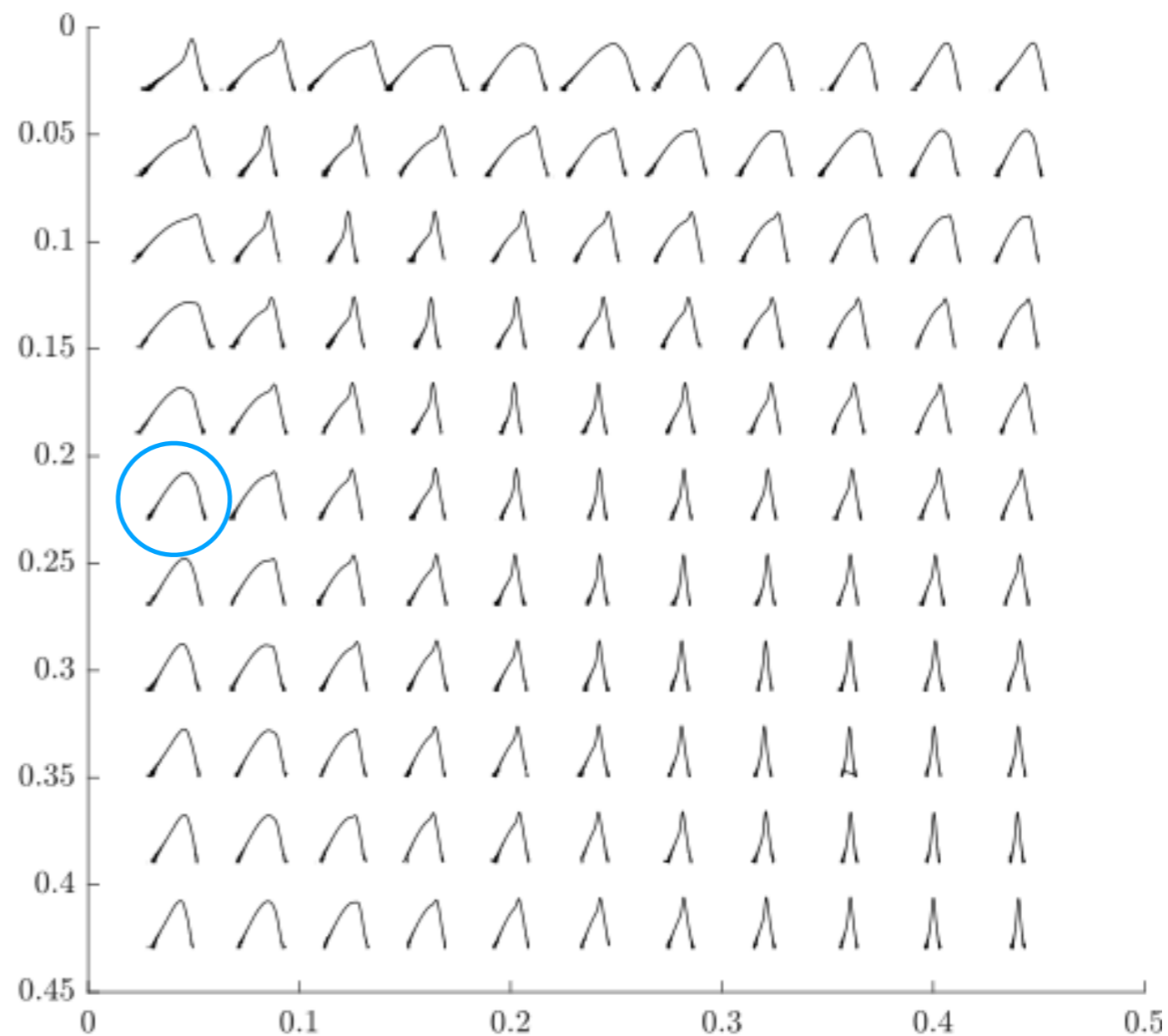
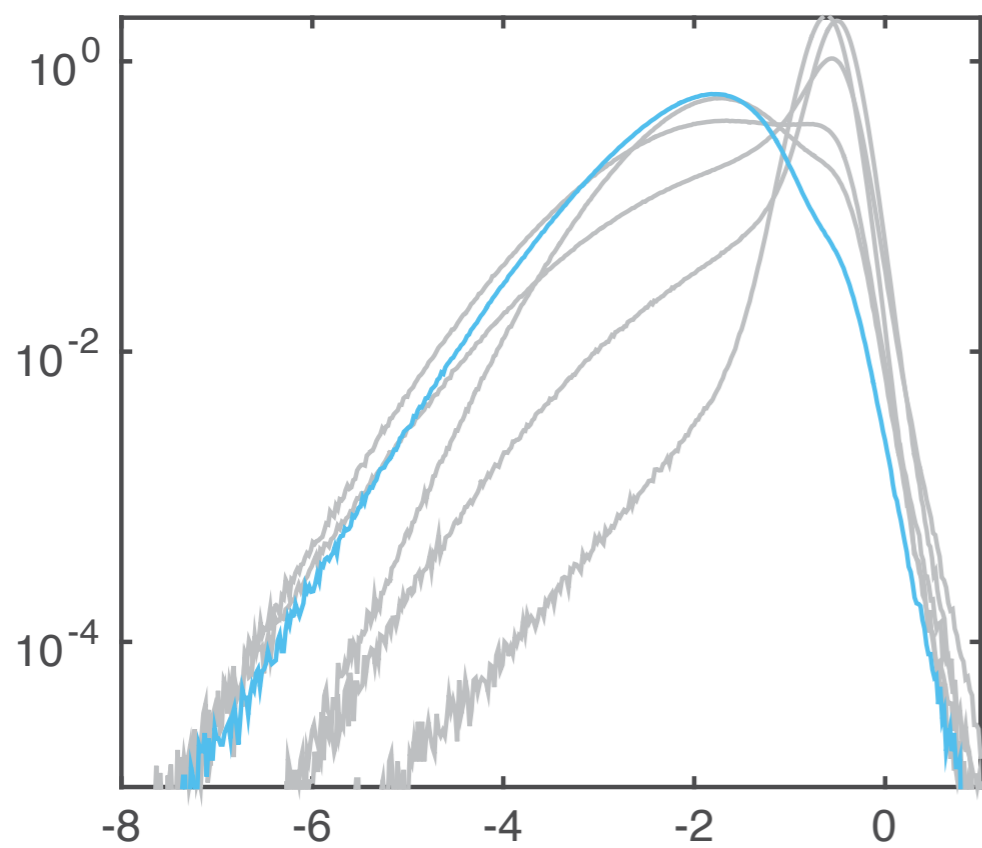
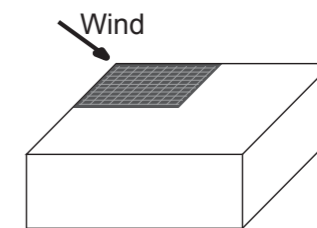
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PDF de pression de vent sur le toit



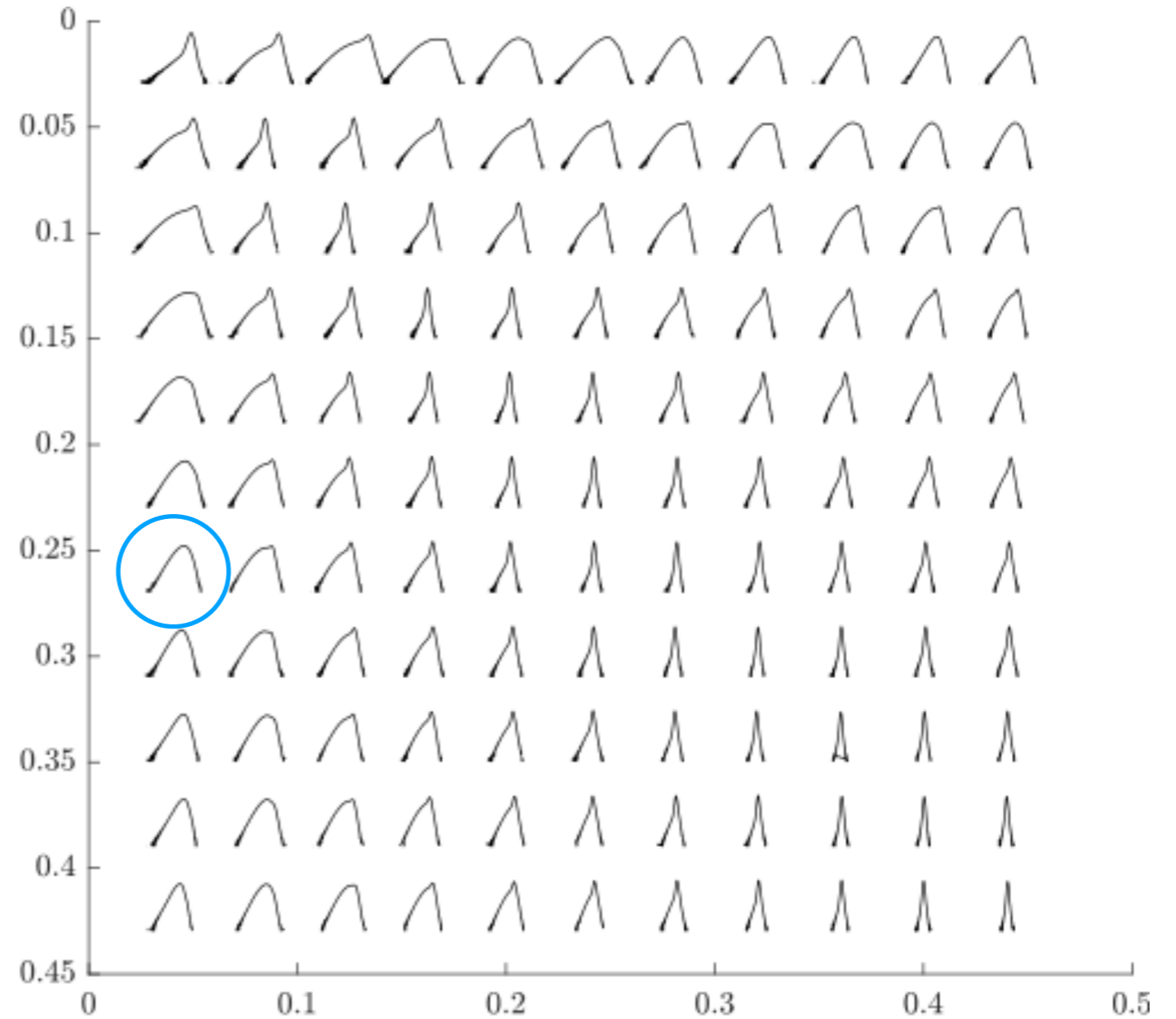
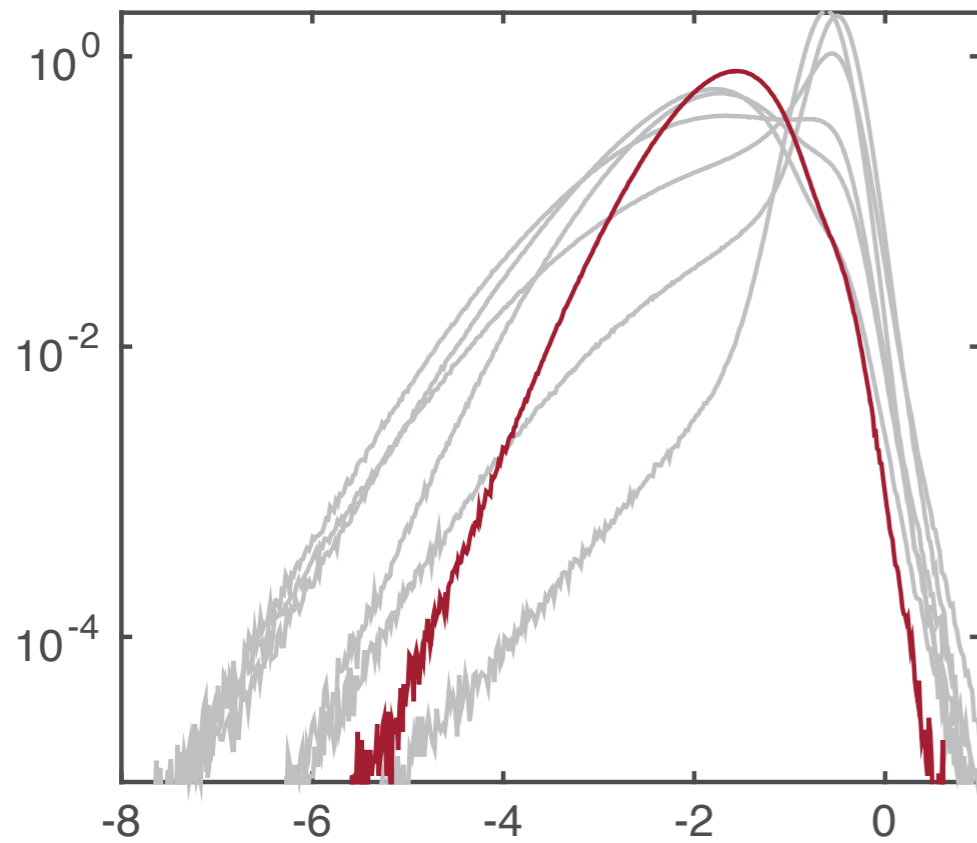
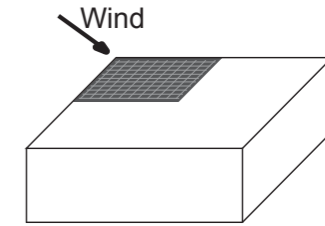
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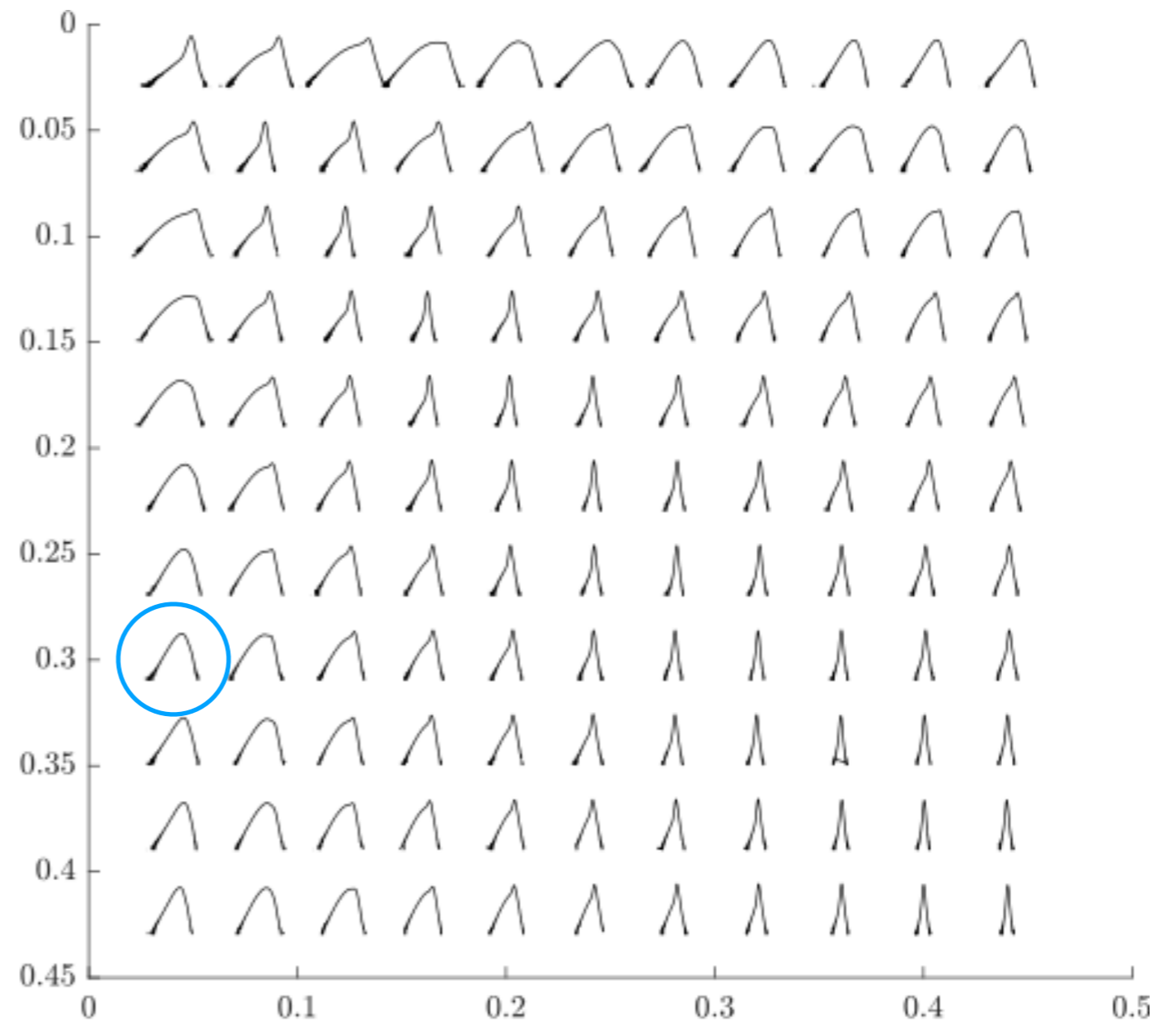
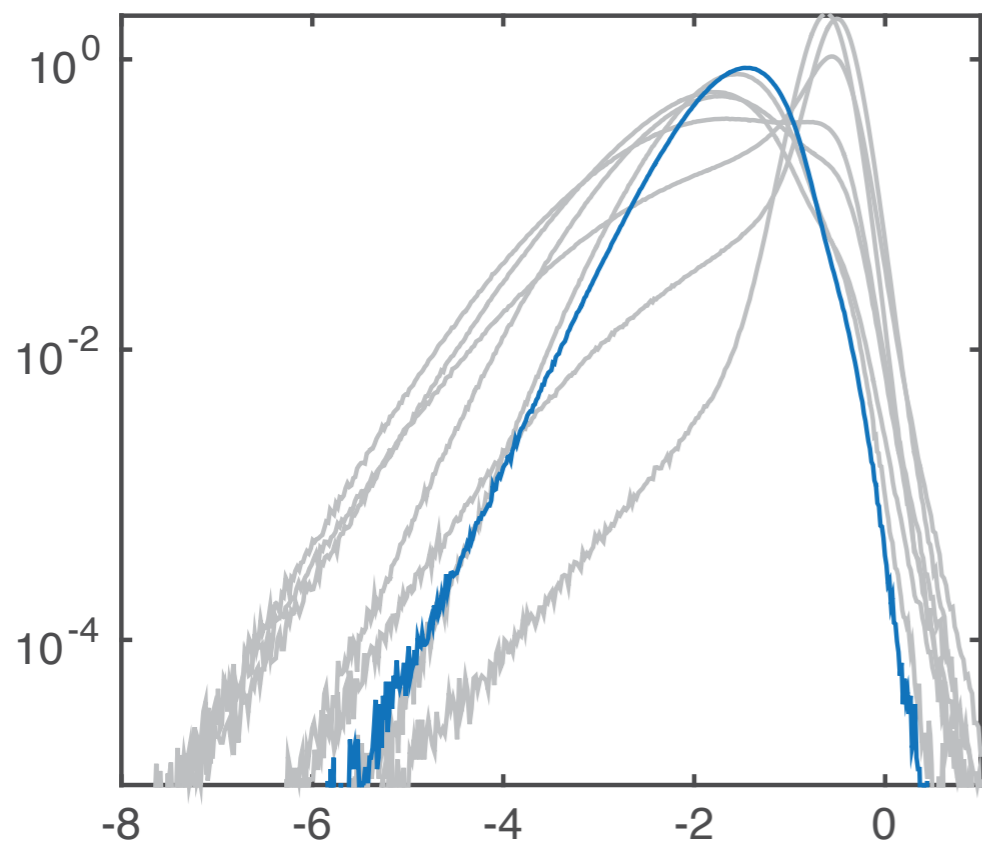
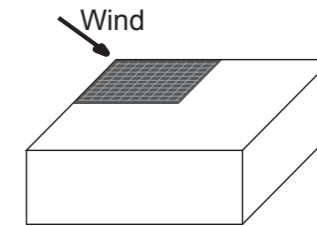
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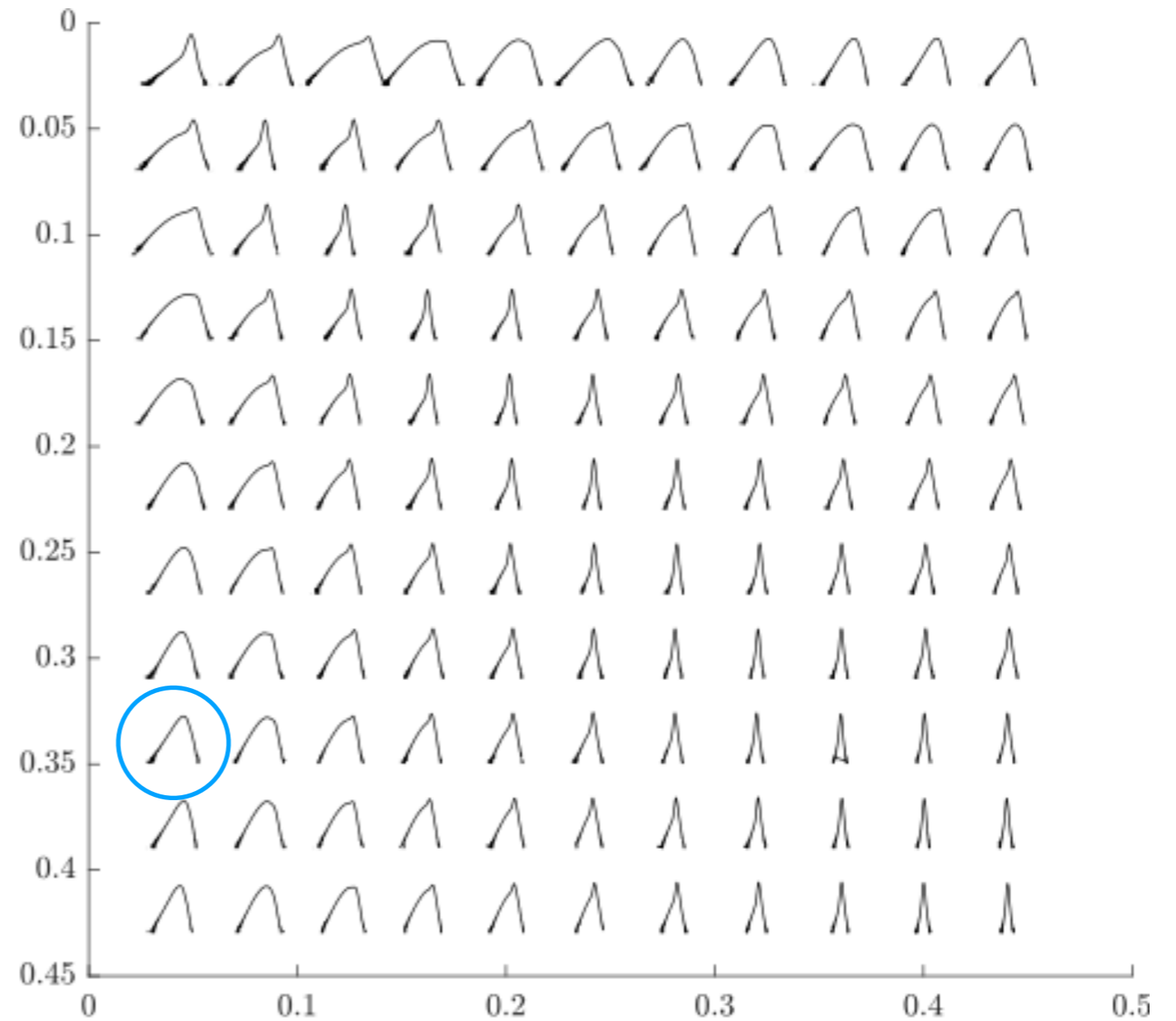
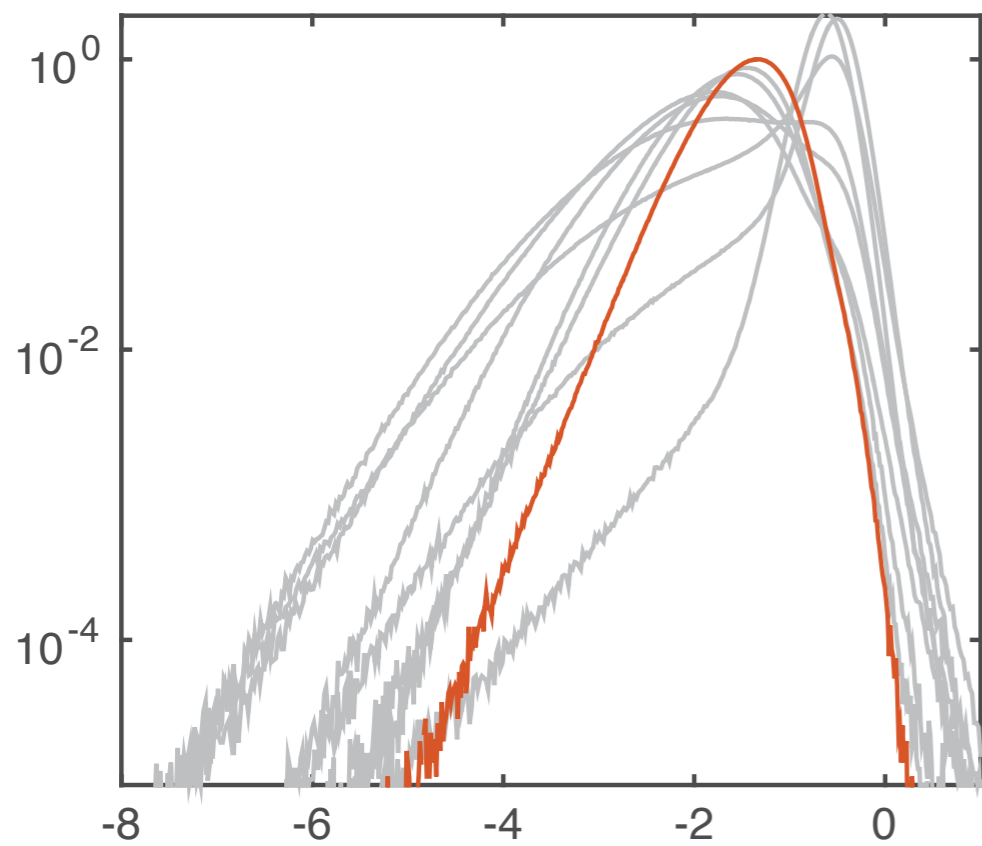
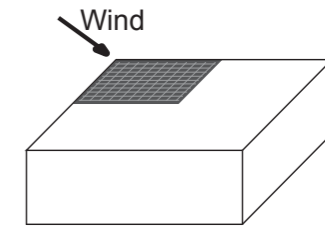
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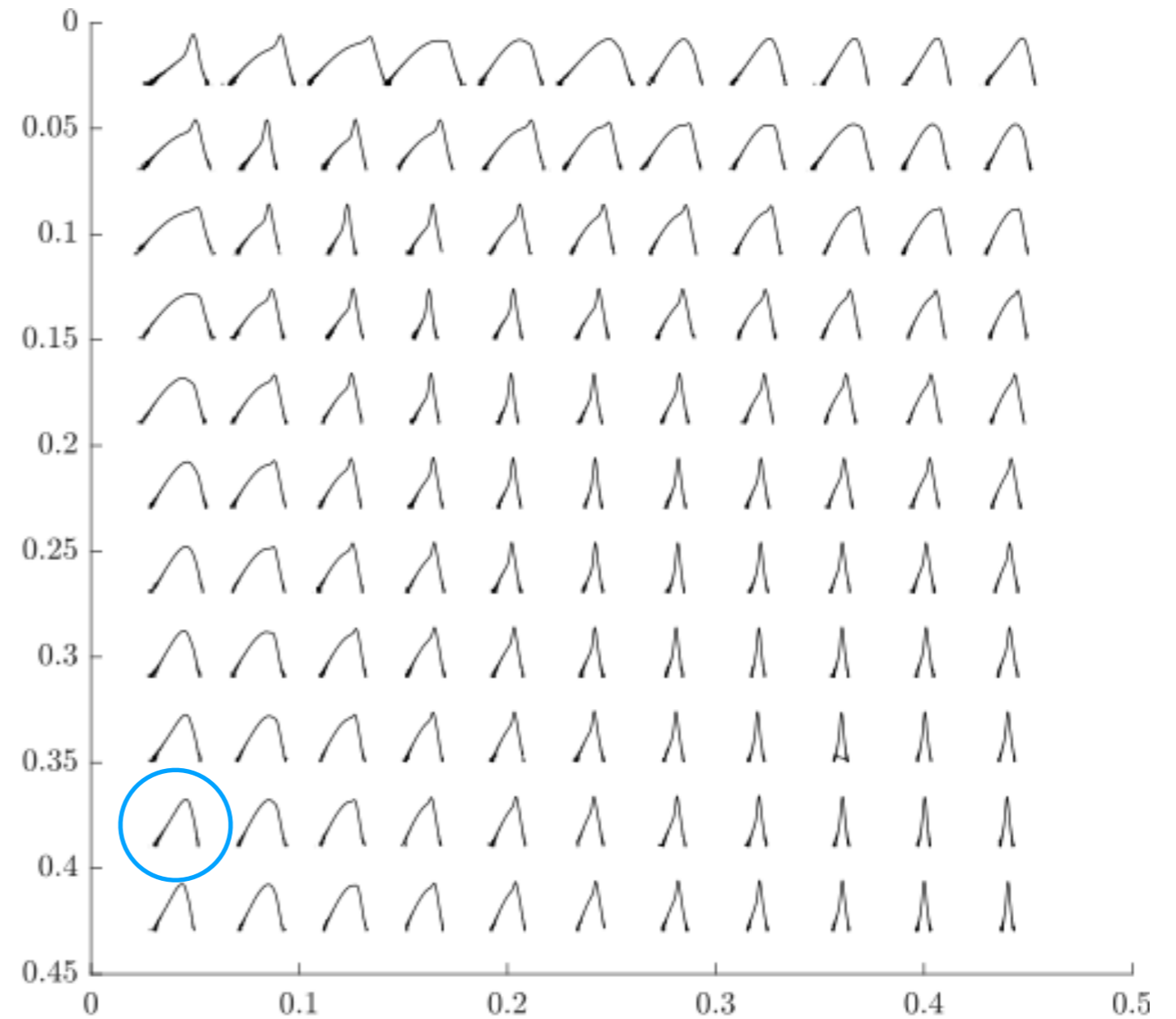
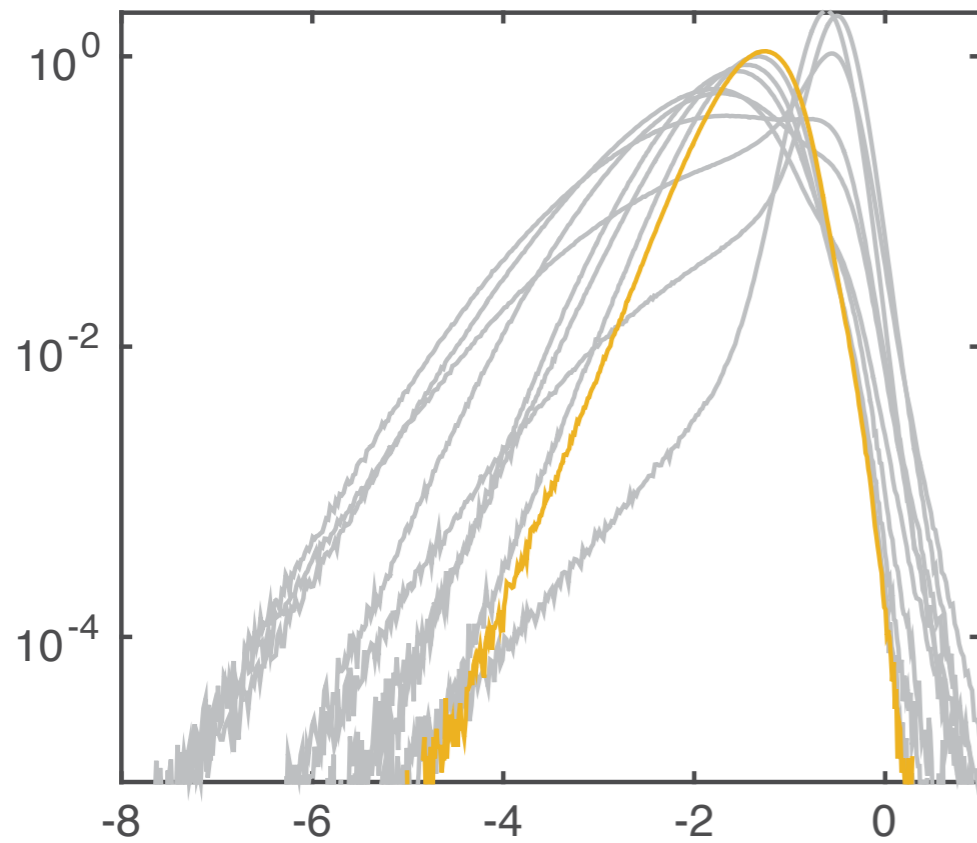
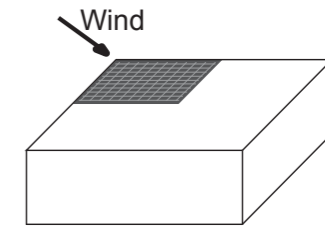
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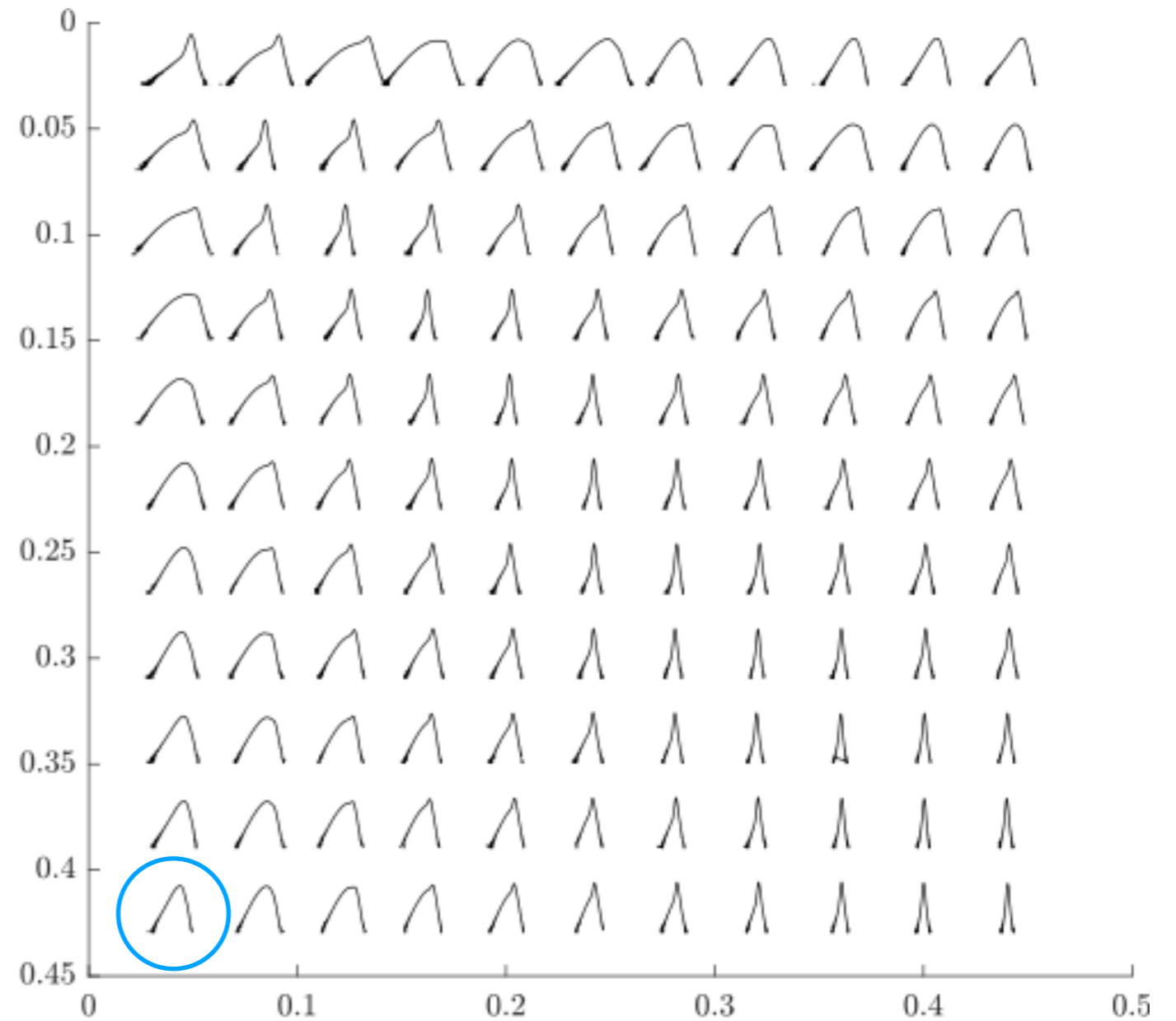
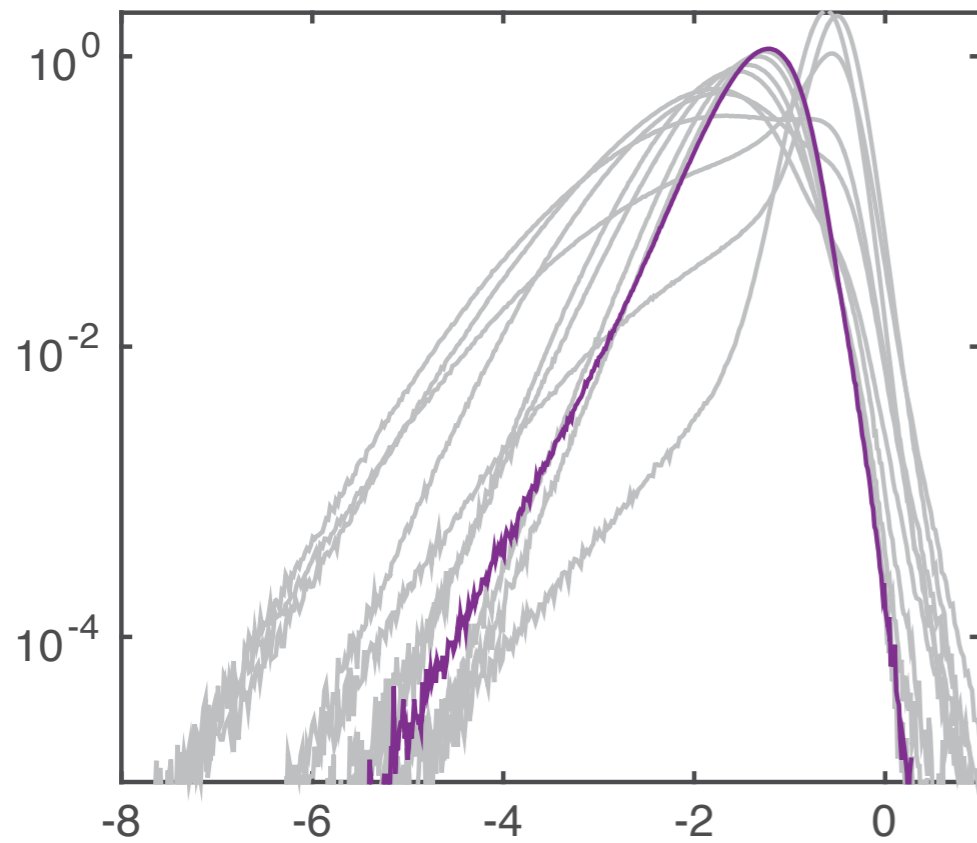
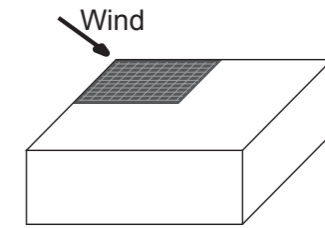
Exemple de coefficient de pression mesuré



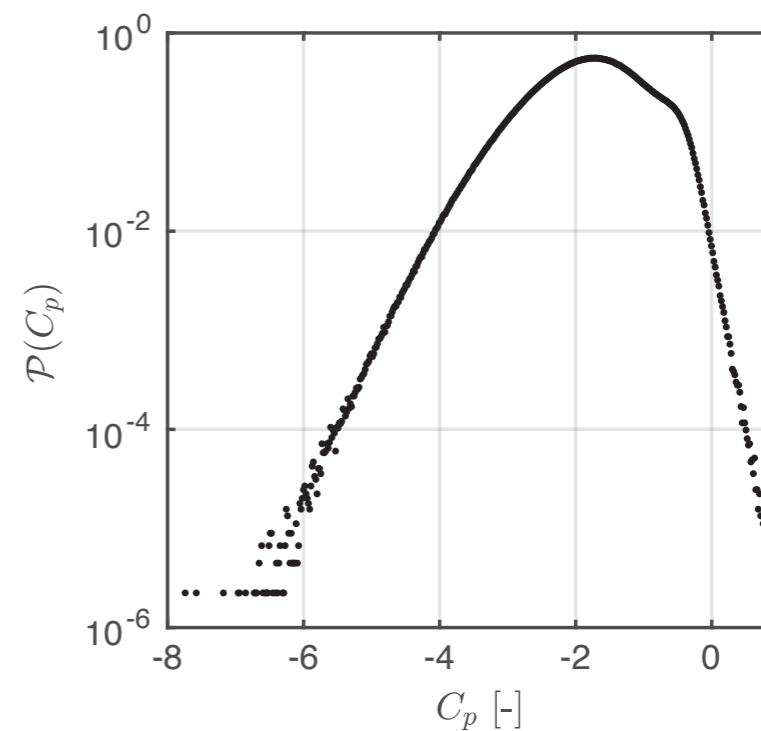
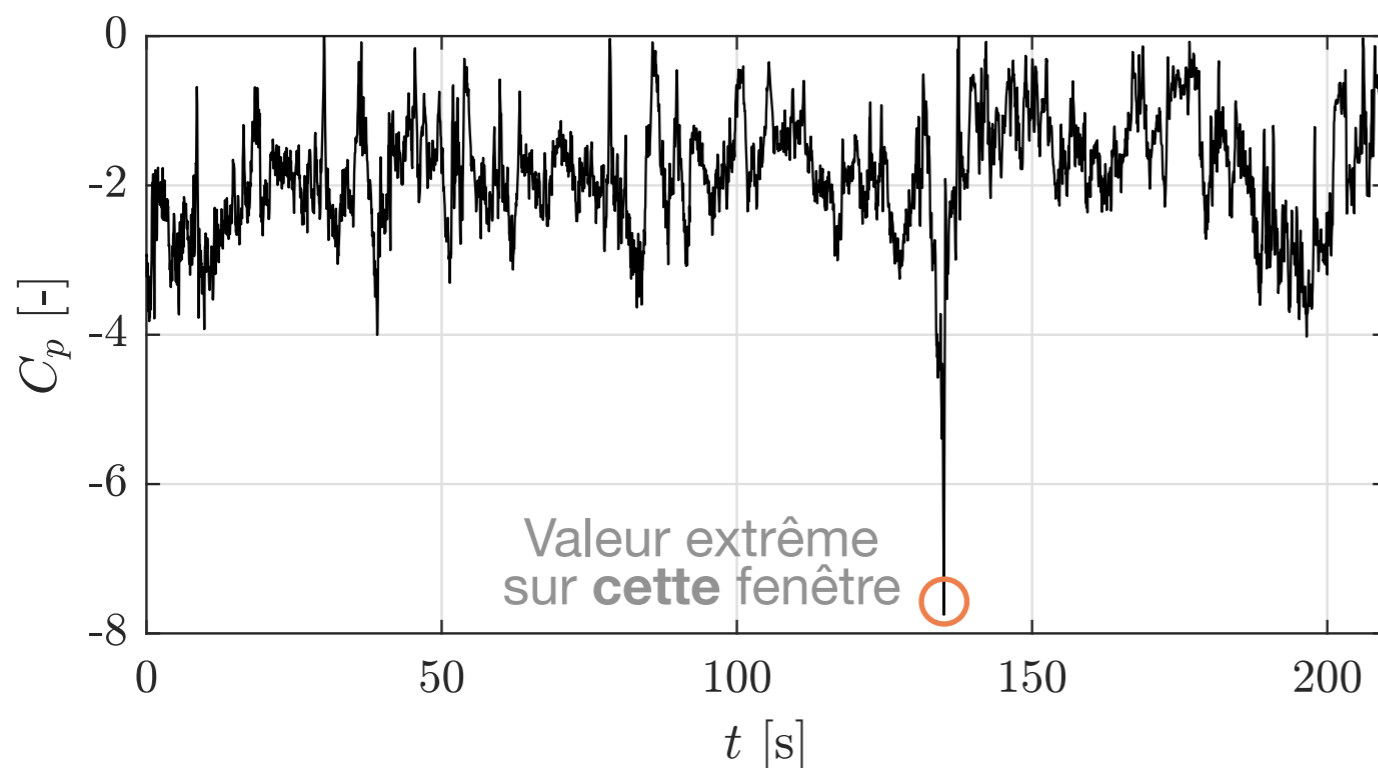
PDF de pression de vent sur le toit



Exemple de coefficient de pression mesuré

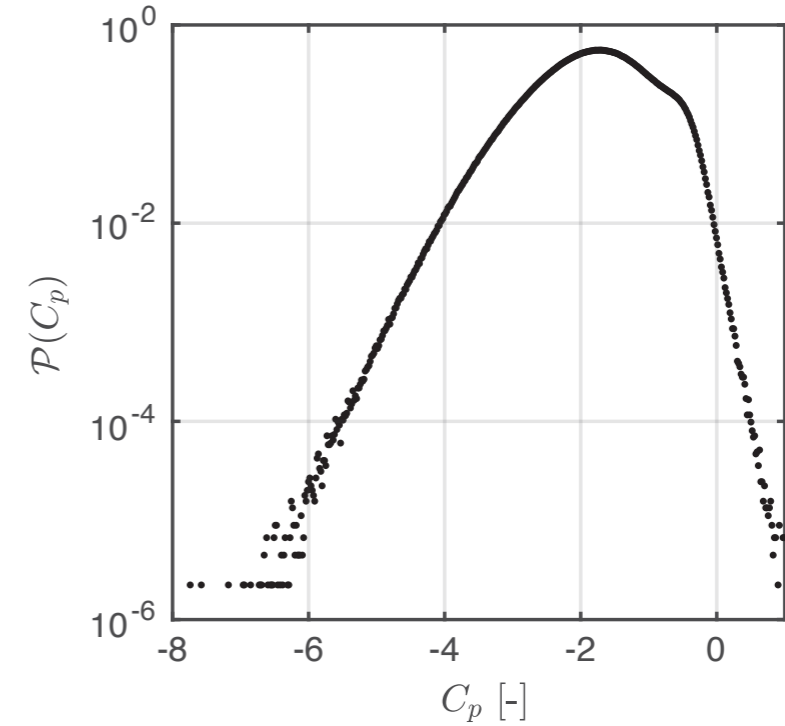
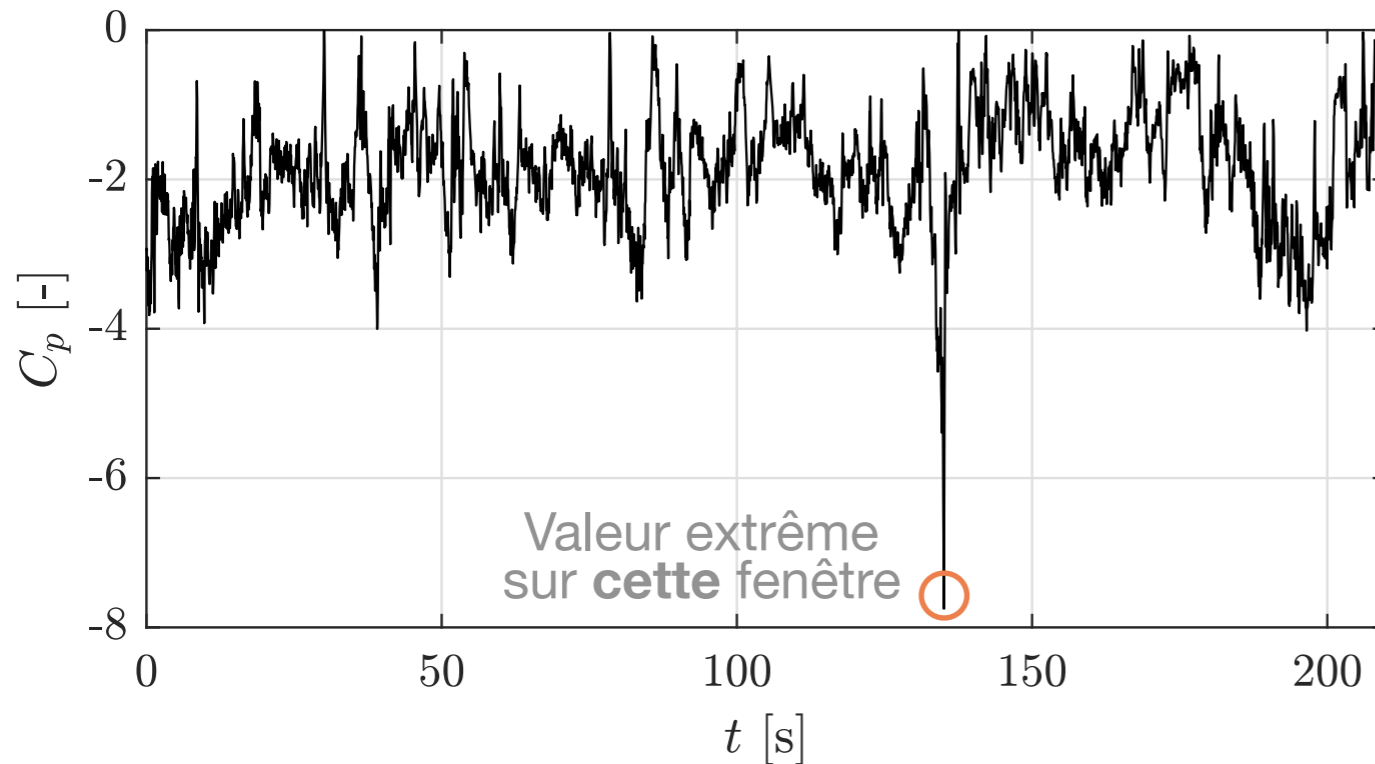


Design de cladding



Comment déterminer une valeur (max) de design pour une période de retour ?

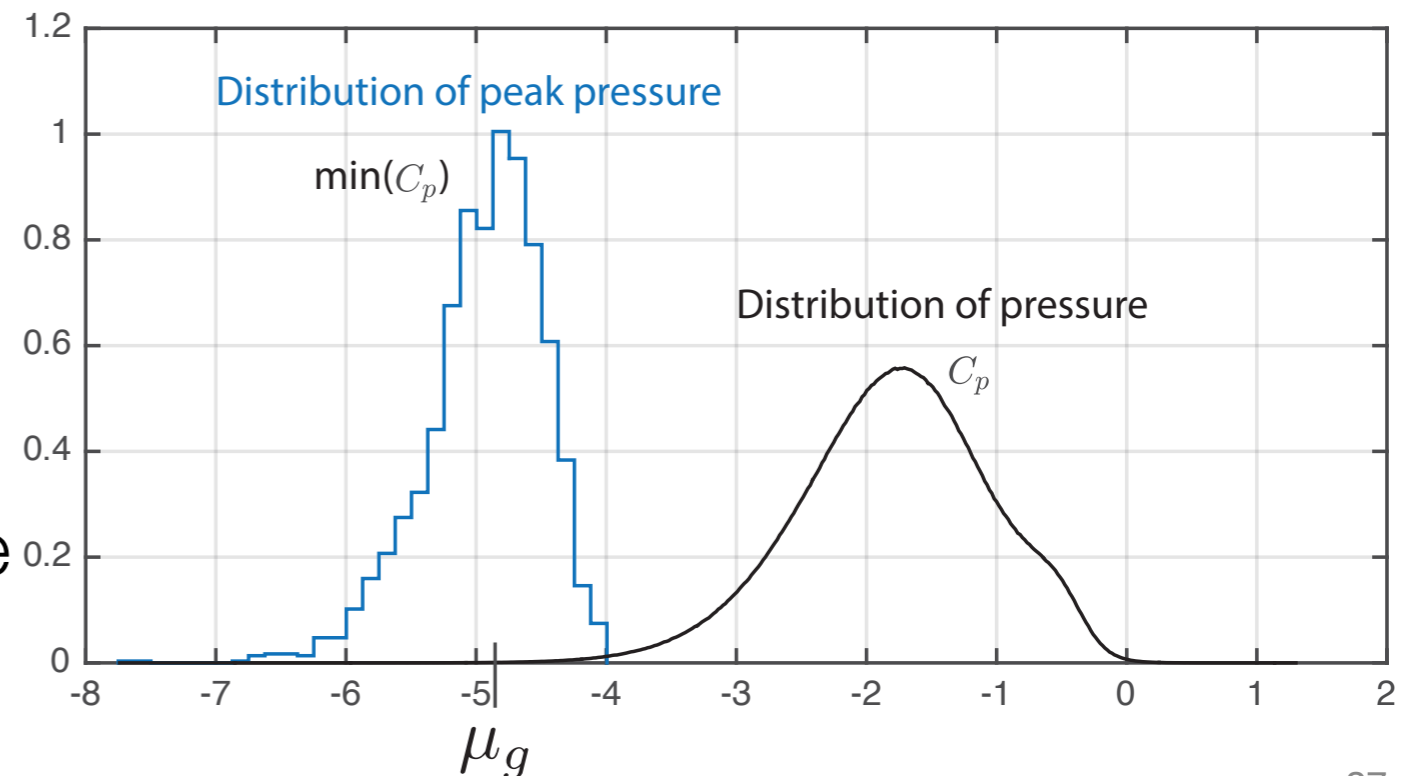
Design de cladding



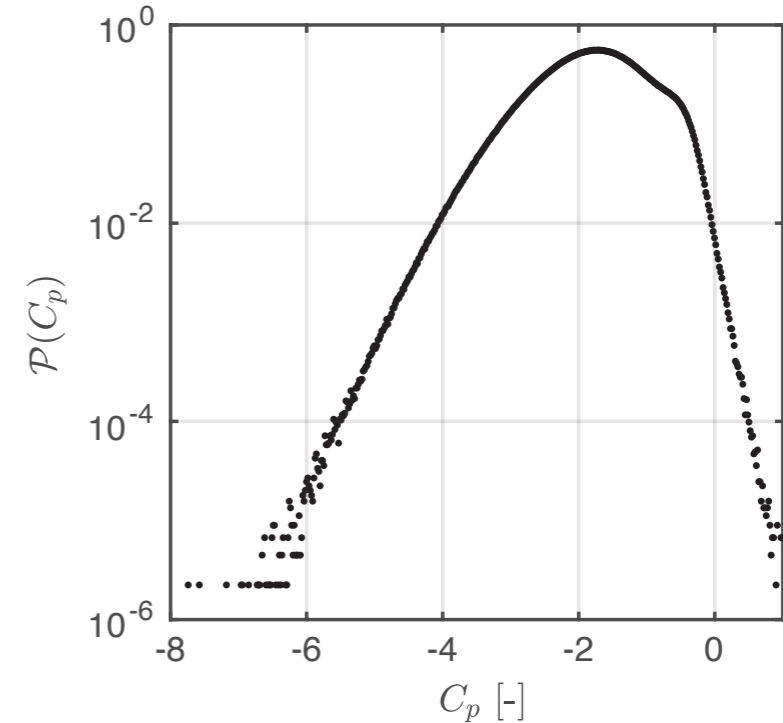
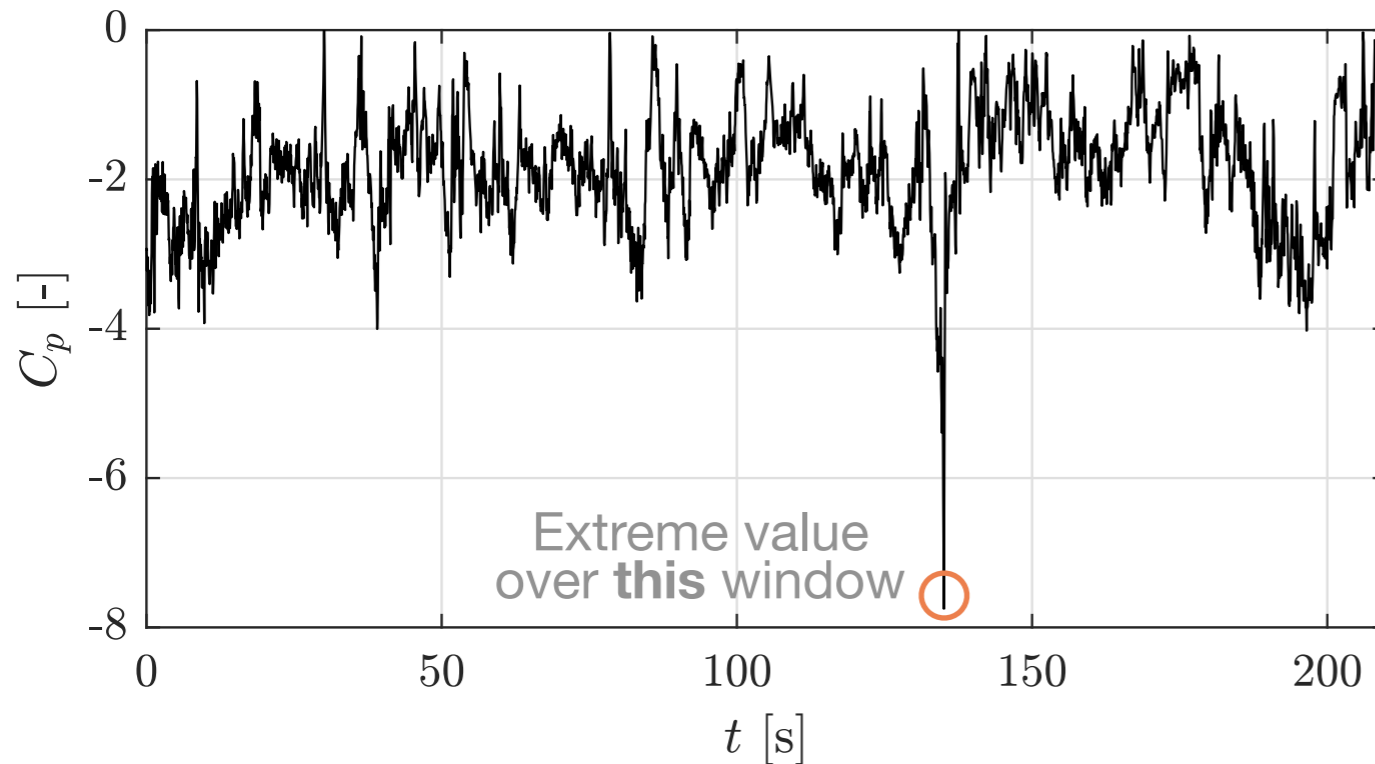
Comment déterminer une valeur (max) de design pour une période de retour ?

- **Option 1**: répéter les mesures, calculer les statistiques.

371 h > 2220 fenêtres > histogramme

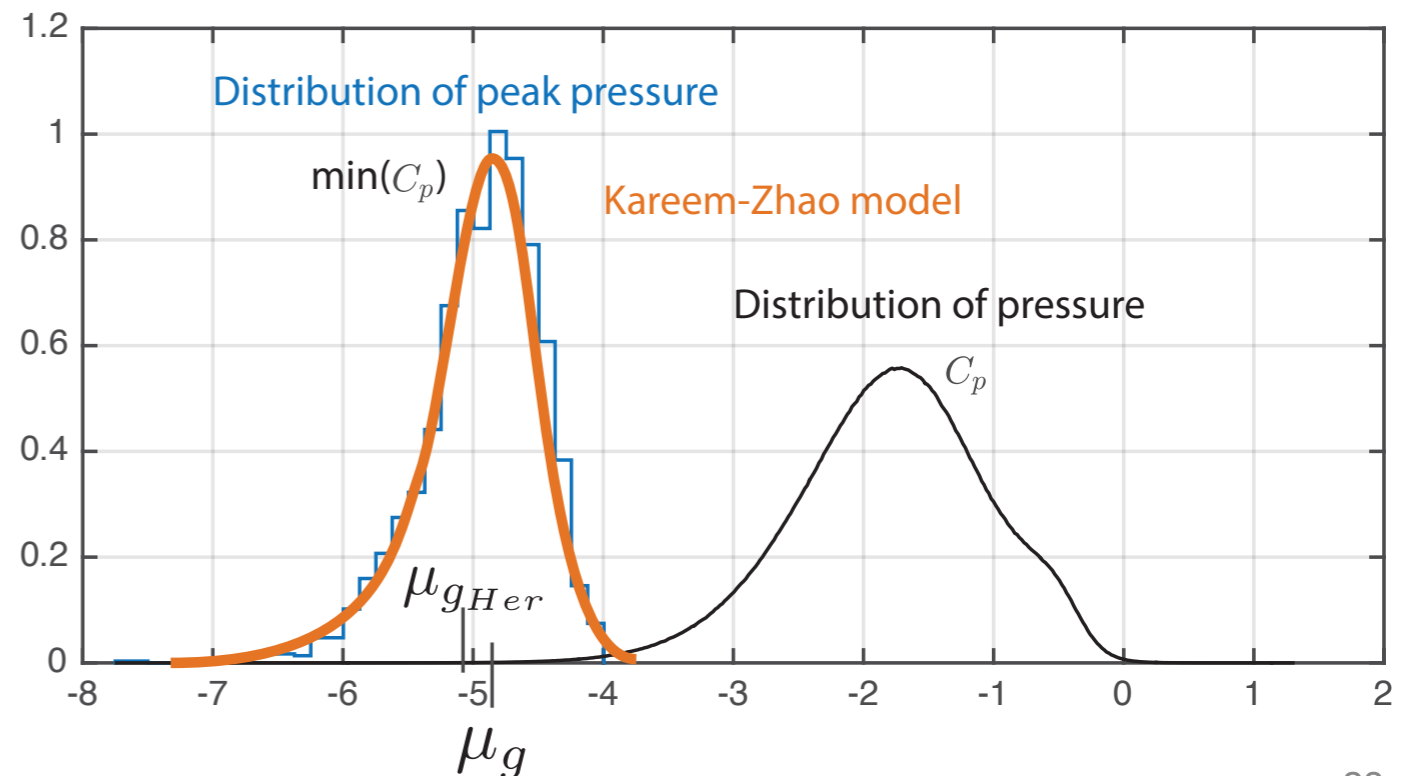


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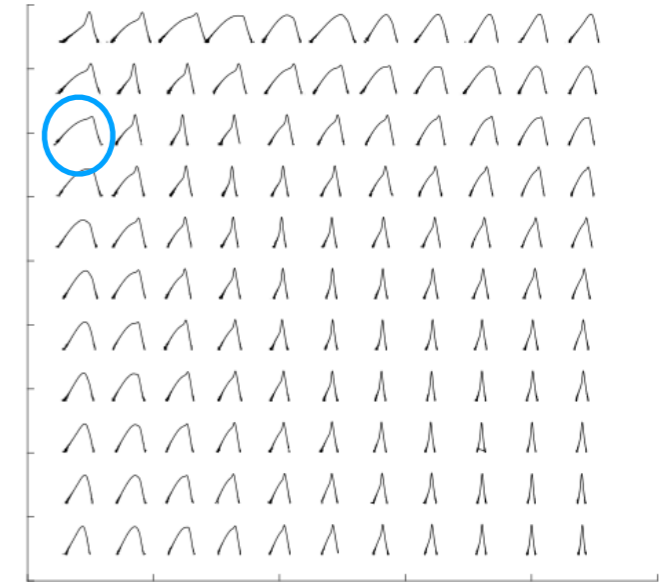
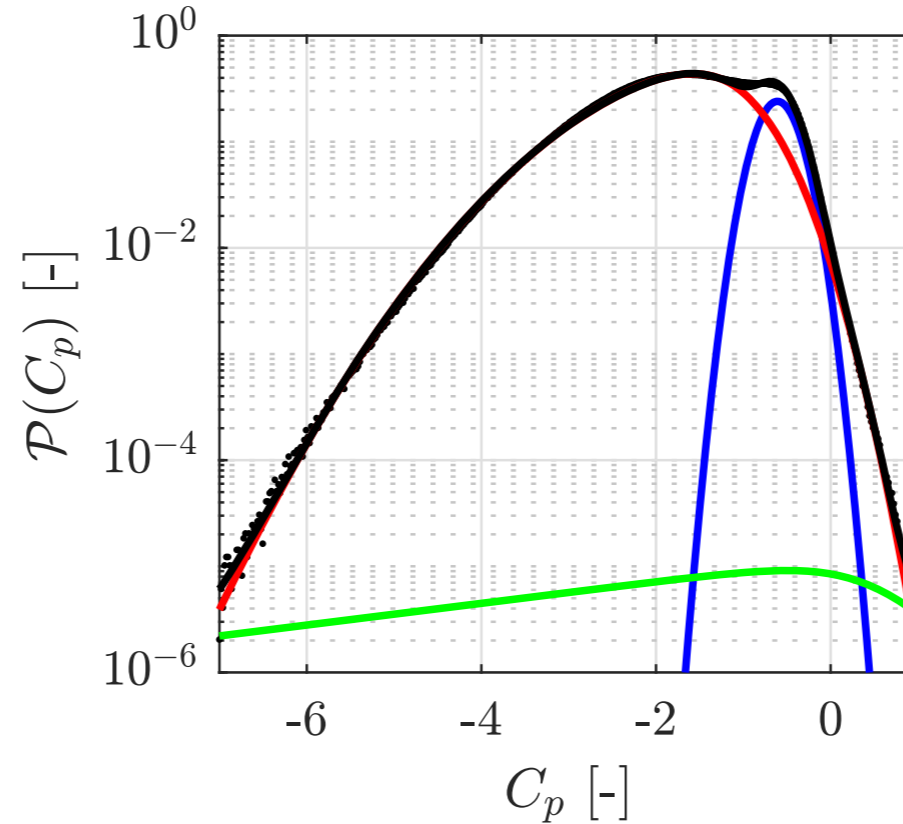
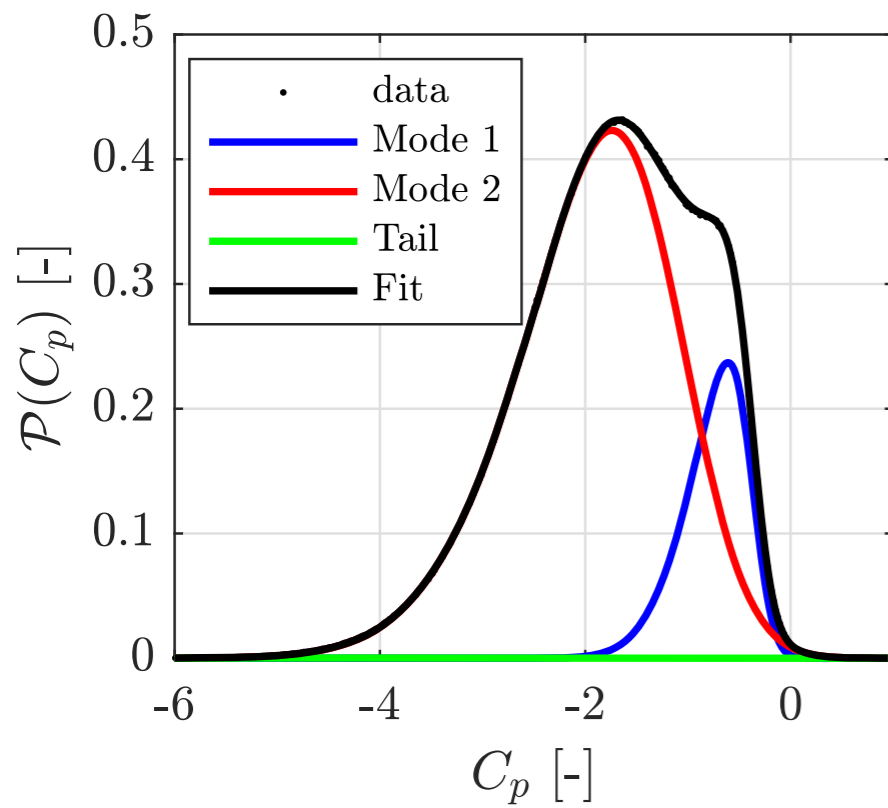


How to determine a maximum (design) value for a given return period ?

- ▶ **Option 1:** répéter les mesures, calculer les statistiques
- ▶ **Option 2:** modèle de facteur de pointe (Kareem - Zao)



Skew gaussian-exponential mixture model



Décomposition des PDF en 2 modes **Mode 1**

- ▶ **Mode 1** turbulence
- ▶ **Mode 2** tourbillons

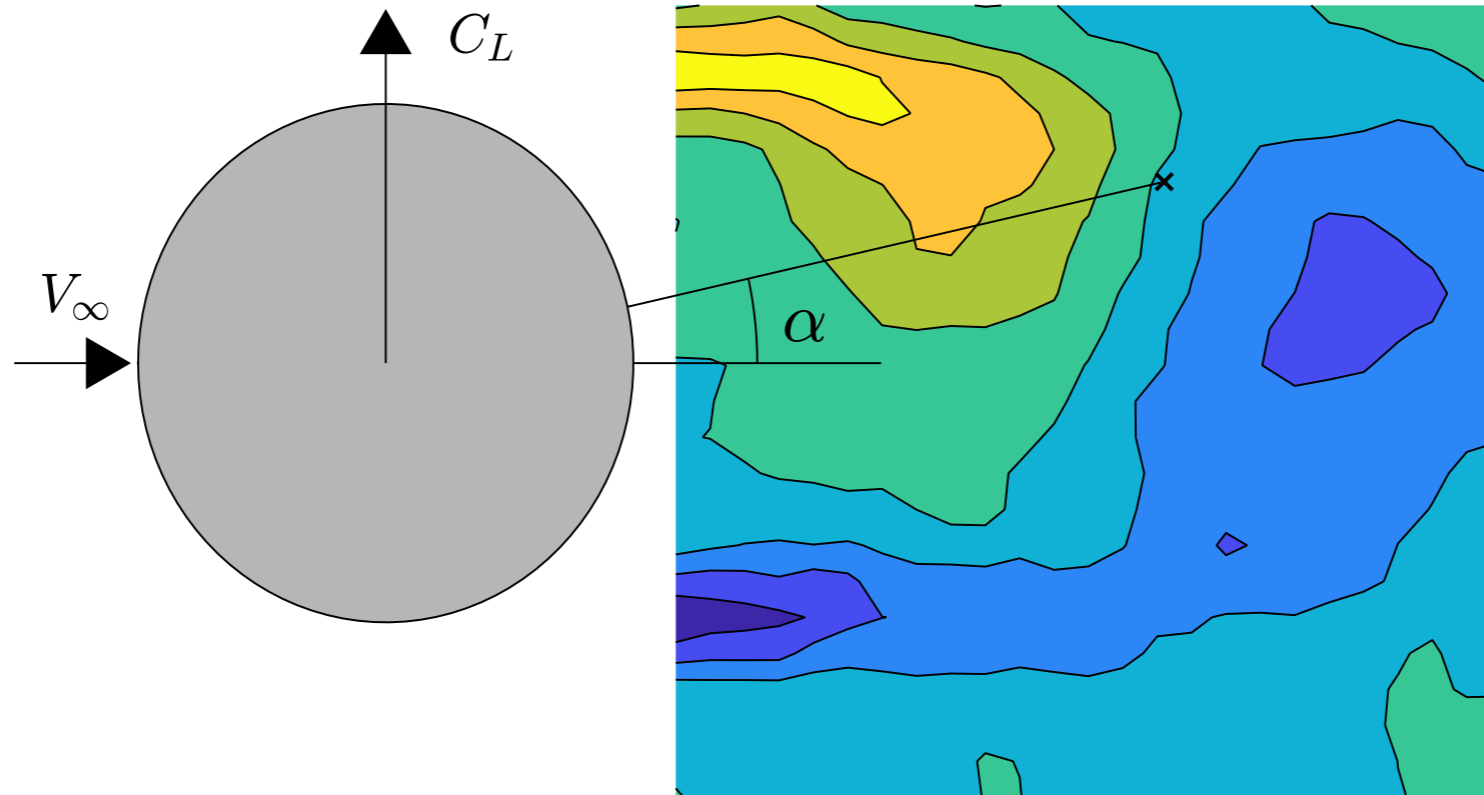
$$P(x) = \sum_{i=1}^{n_1} w_{SG,i} P_{SG,i}(x) + \sum_{i=1}^{n_2} w_{SHS,i} P_{SHS,i}(x)$$

Ajustement avec méthode de **fitting** (e.g. least-squares)

Autres méthodes de visualisation & suite



PIV sur un cylindre avec détachements tourbillonnaires



Merci !
Questions ? Commentaires ?
(on se voit au drink)

François Rigo
Thomas Andrianne
Vincent Denoël