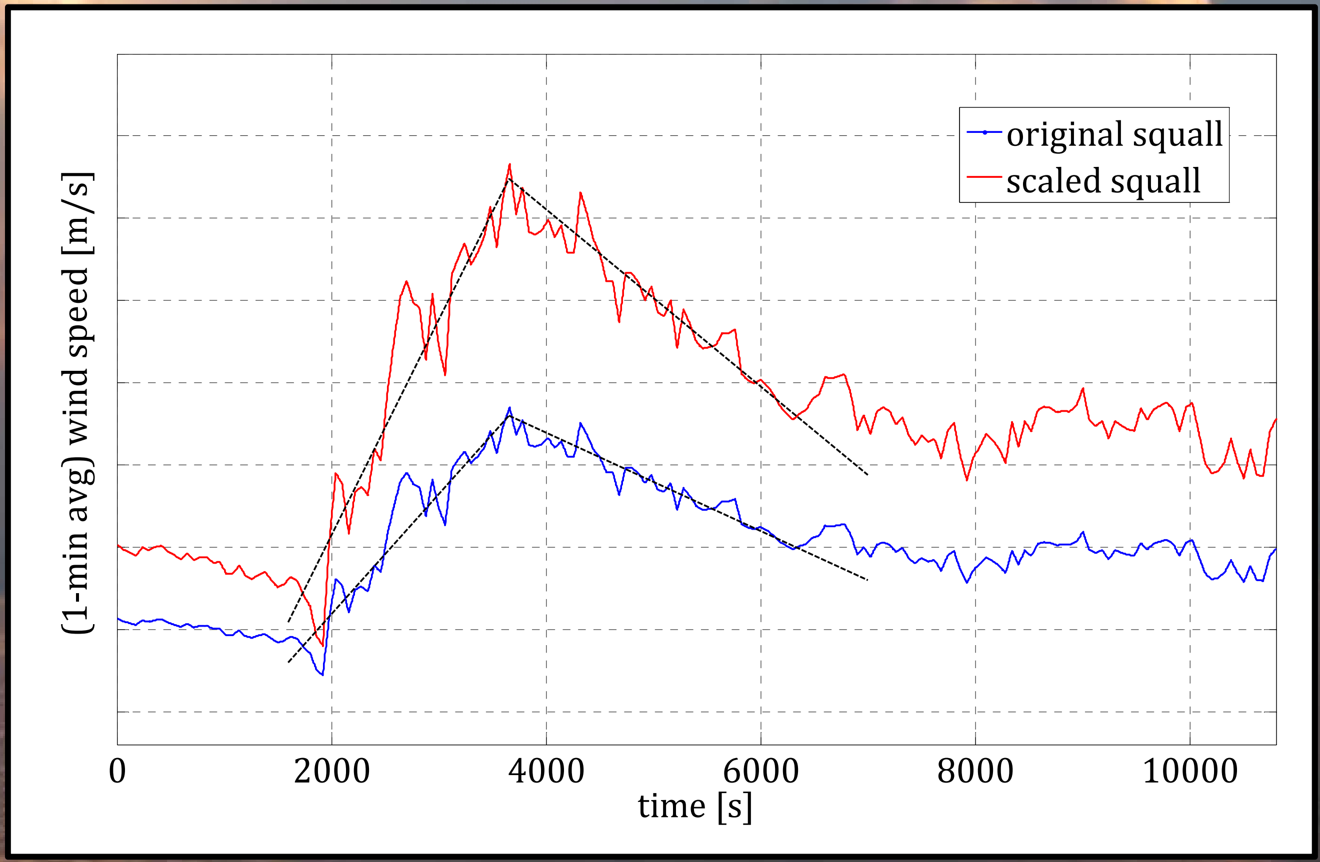
Response-based analysis of FPSO systems for squall loadings

OMAE2012 Rio de Janeiro

July 3rd 2012

OMAE2012-83633 - Joerik Minnebo - Amir Izadparast - Arun Duggal - René Huijsmans

Introduction

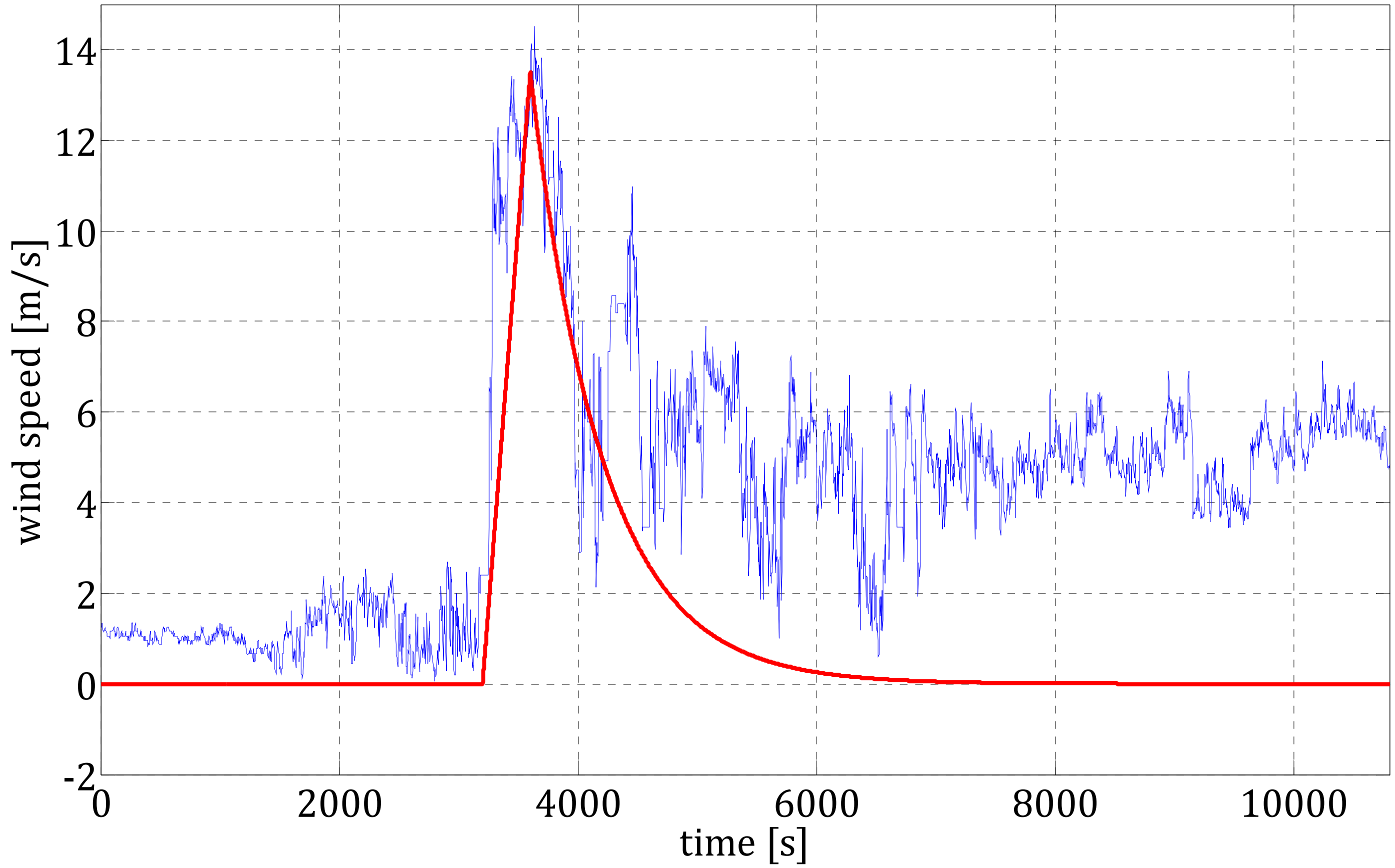


Research goals

Presentation outline

- Characterize the available squalls
- Influence of the individual squall parameters
- Compare the current design practice to a response based method

Squall characterization



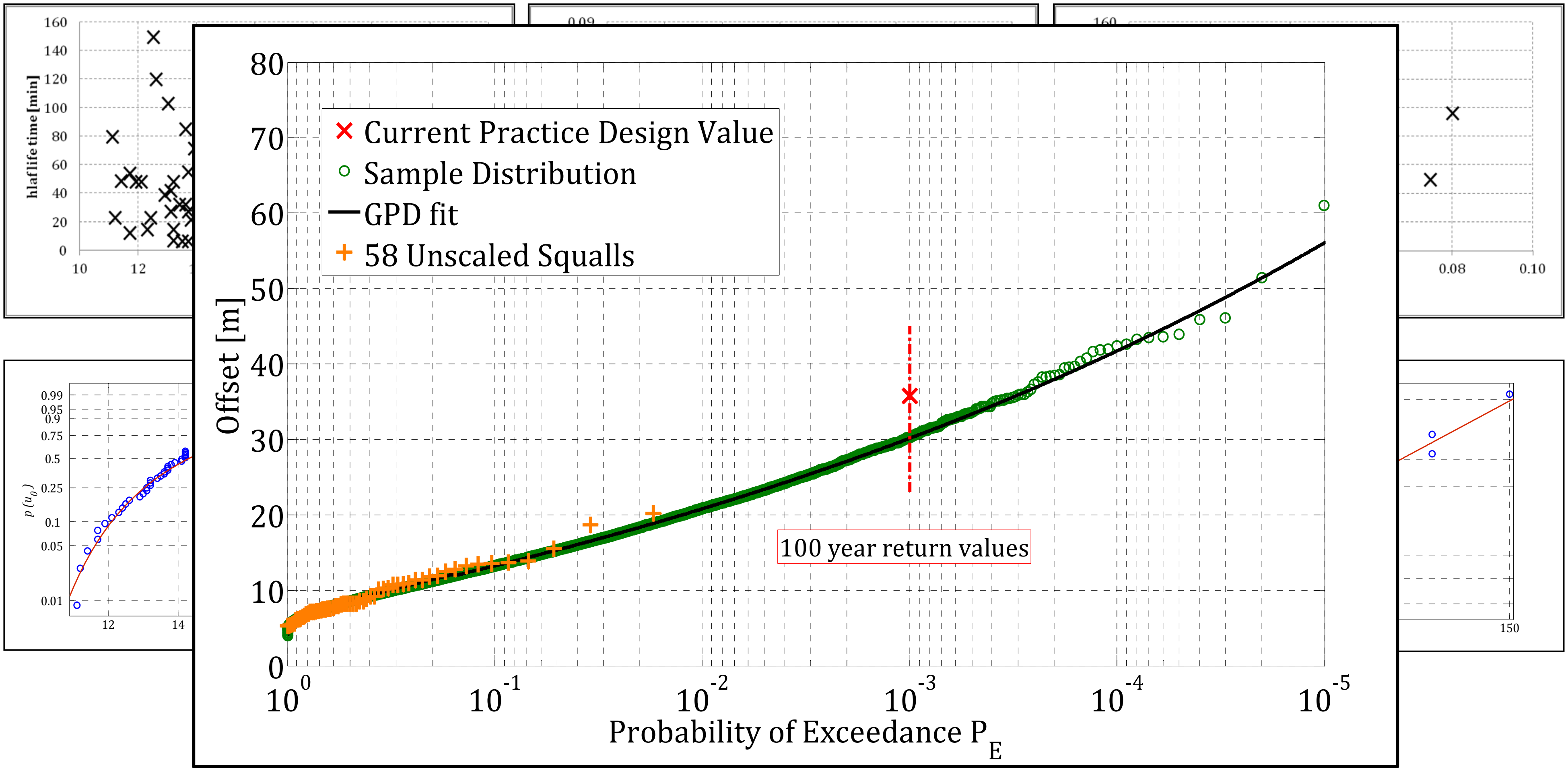
- Rising slope
- Peak wind speed
- Decay (half-life) time

OMAE2006-92328

OMAE2011-49855

Squall characterization

Correlations and distributions



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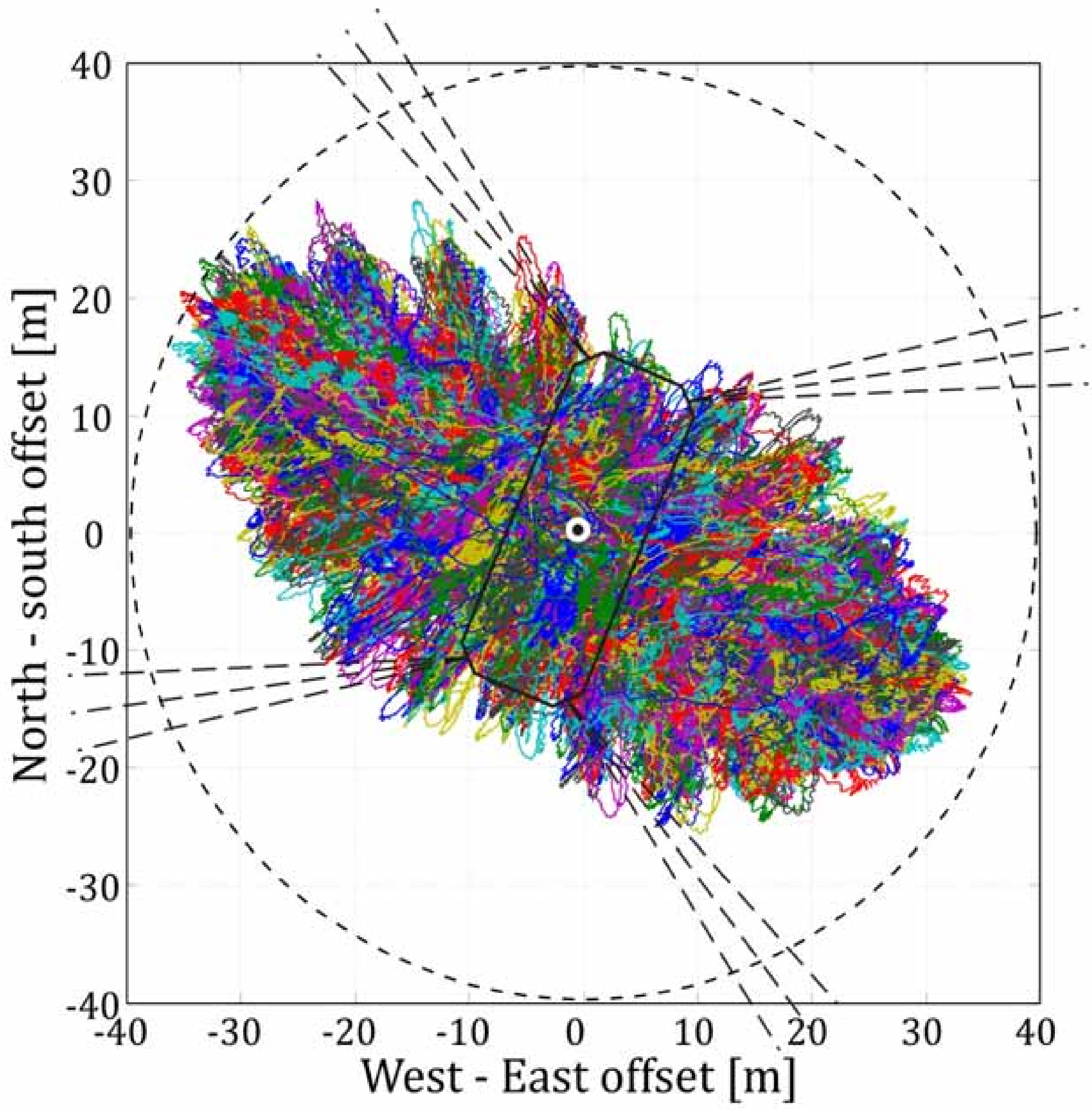
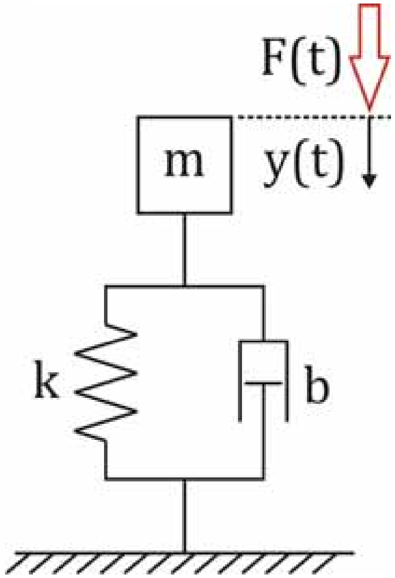
Spread Mooring Analysis





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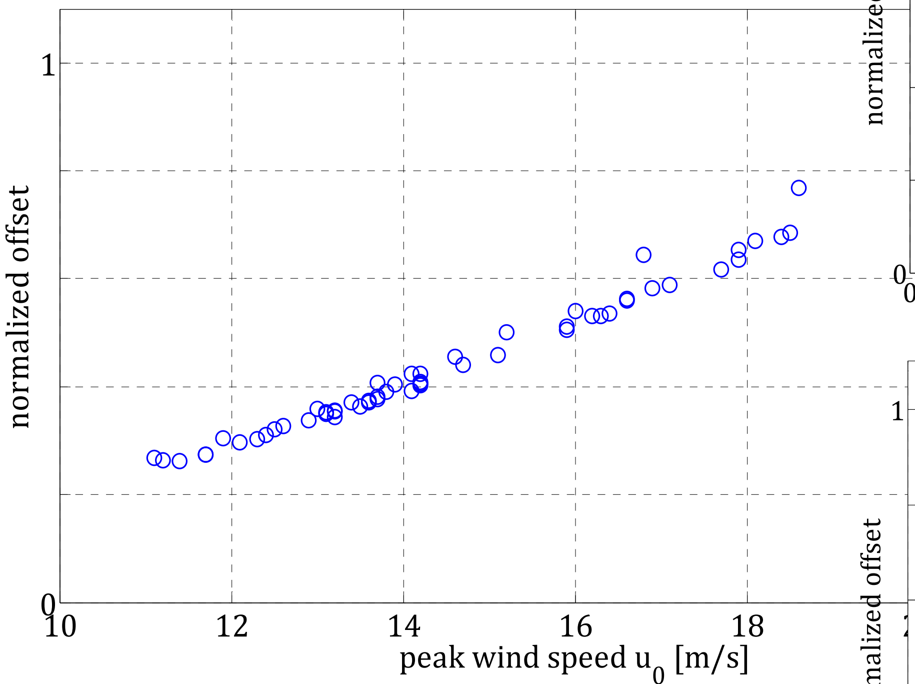
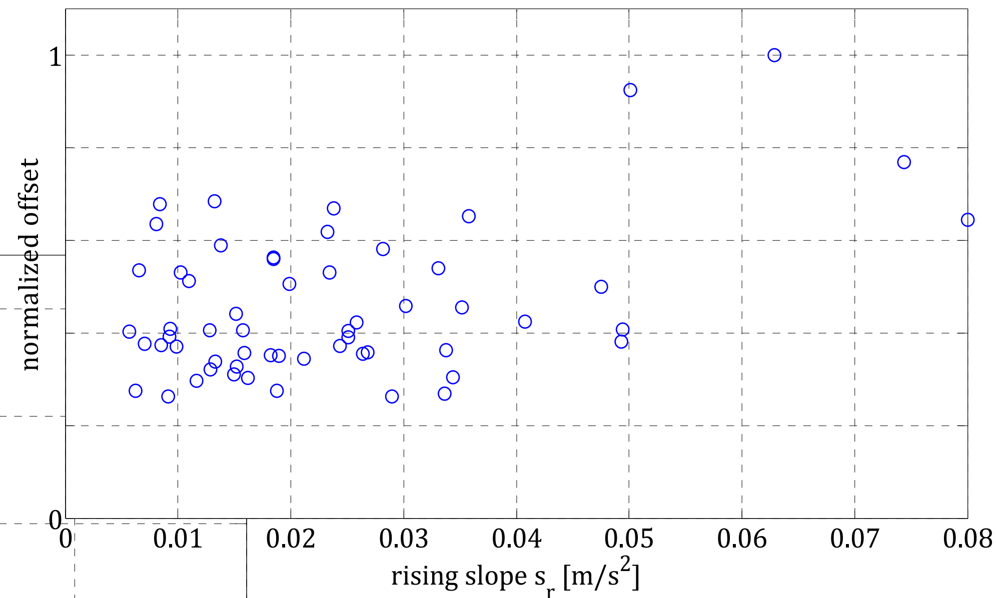
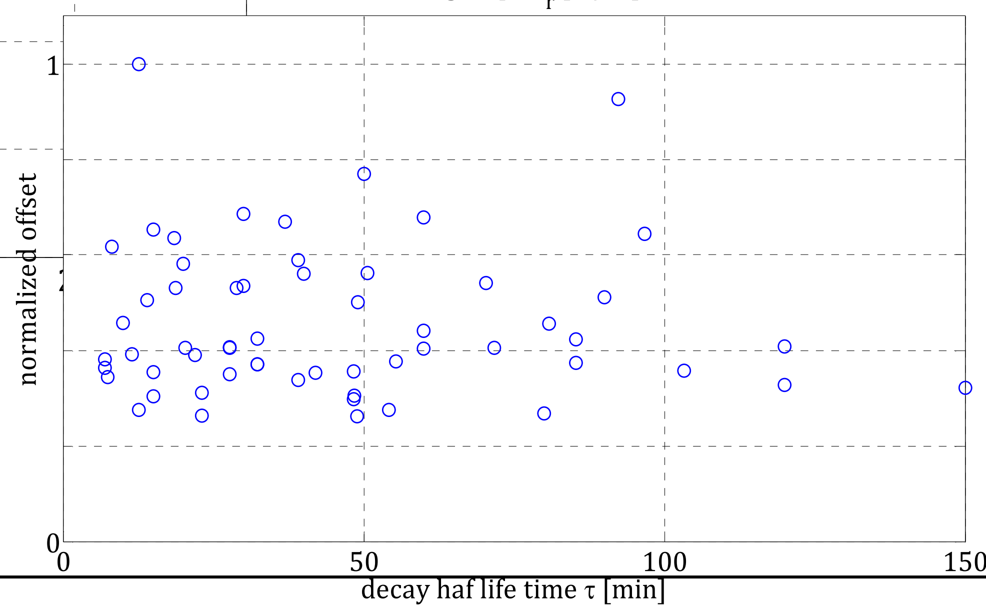
Spread Mooring Analysis

Response Characteristics





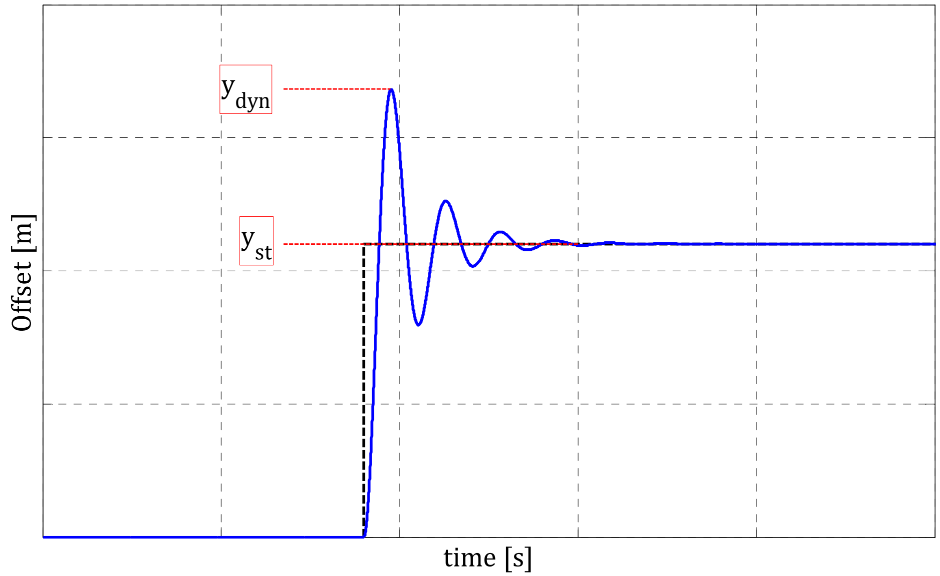


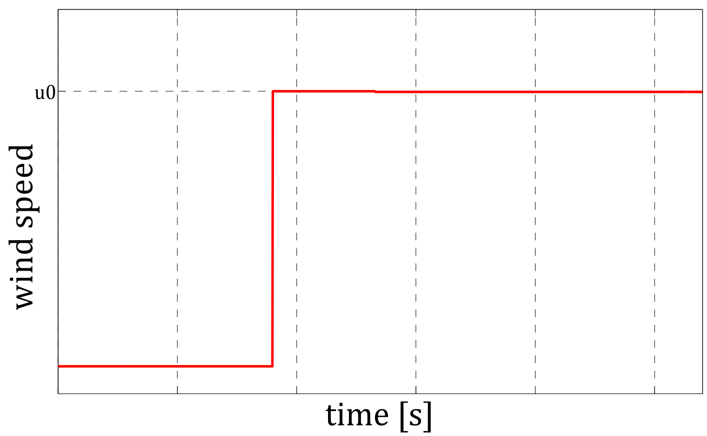
Spread Mooring Analysis

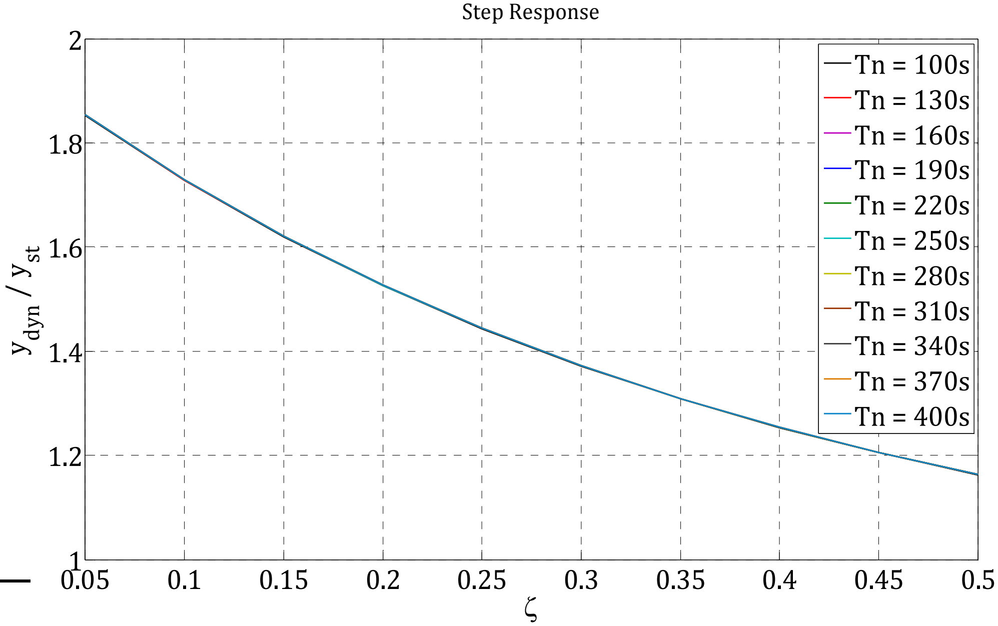
Response Characteristics

$$y_{st} = \frac{\rho C_w A_y}{2k} u_0^2 = C_{st} u_0^2$$

$$\alpha = {y_{dyn}} \Big/ {y_{st}}$$

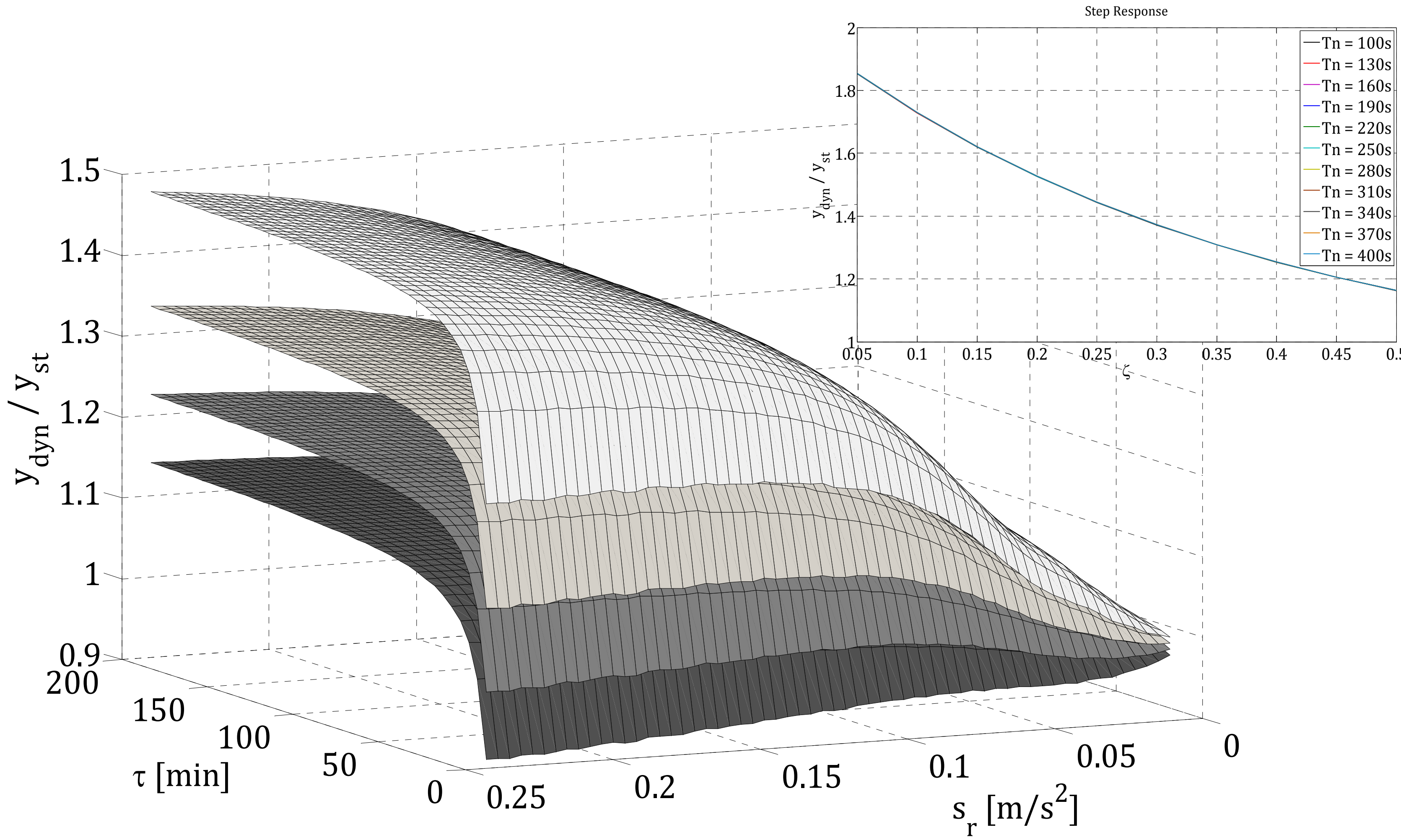






Spread Mooring Analysis

Response Characteristics



Design Value Estimation

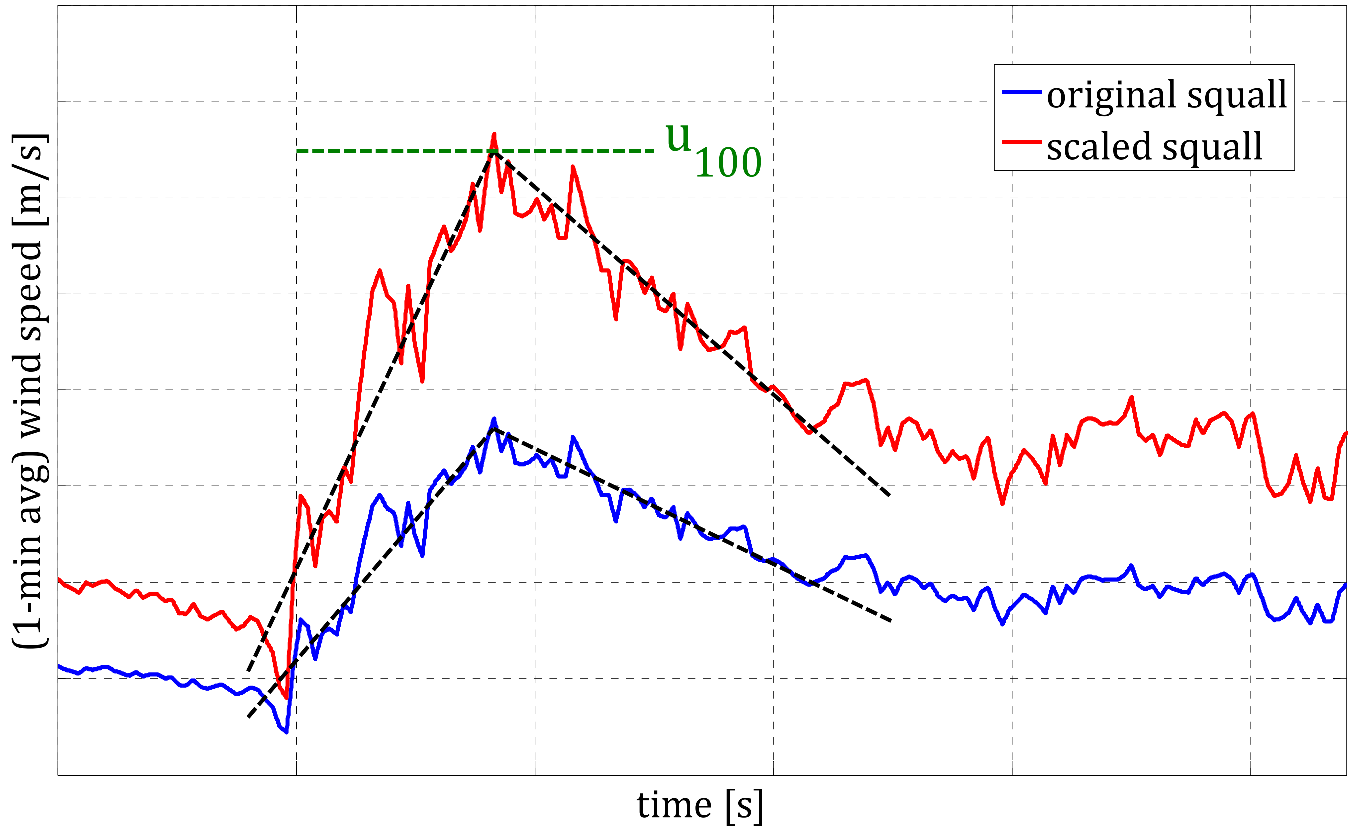
"The 100 year event"

- Current Design Practice
- Response Based Methods

- Spread moored FPSO
- 800m water depth
- T_n = 290s
- ξ = 0.4

Design Value Estimation

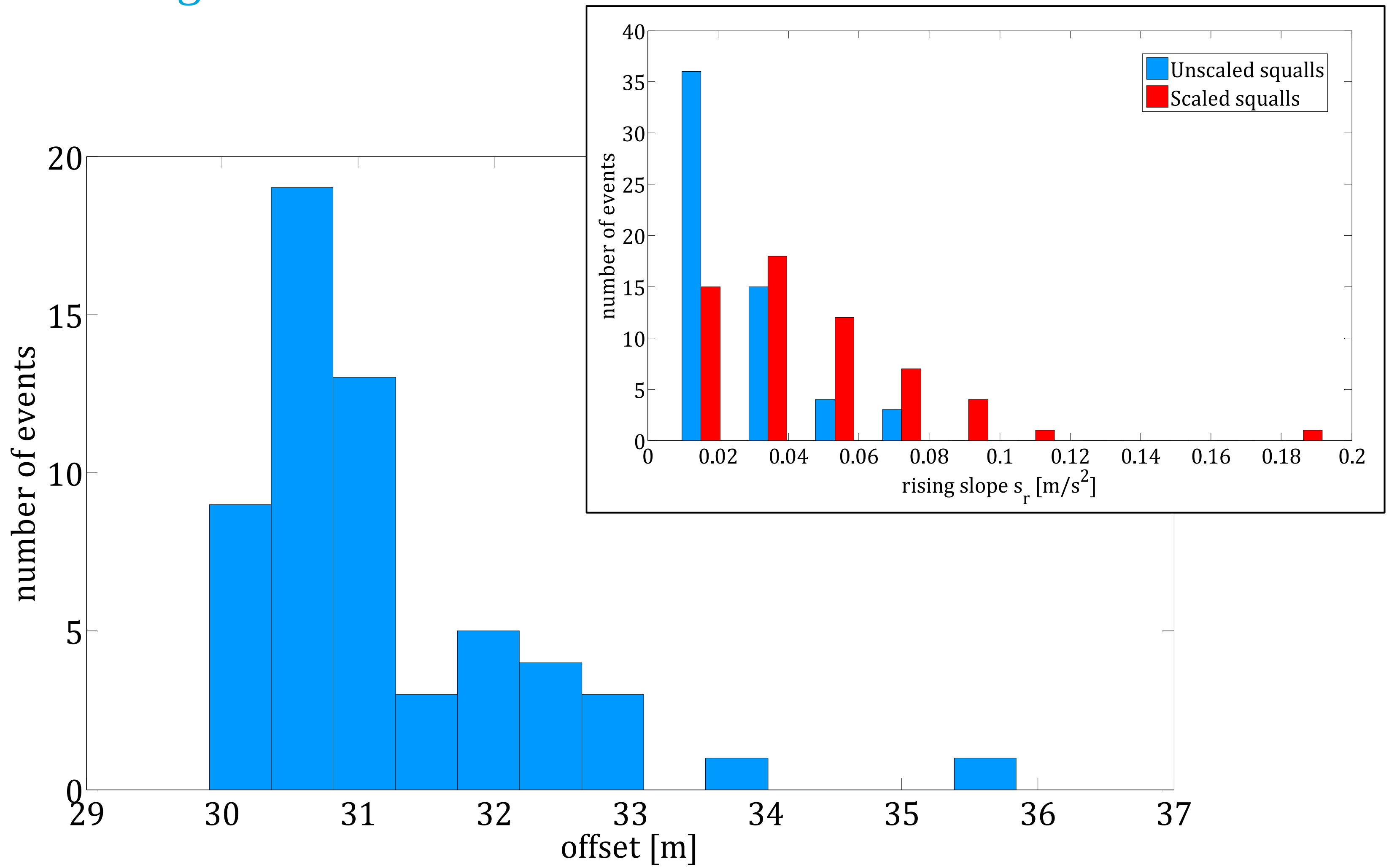
Current Design Practice



$$u_{100} = 27.3 m/s$$

Design Value Estimation

Current Design Practice

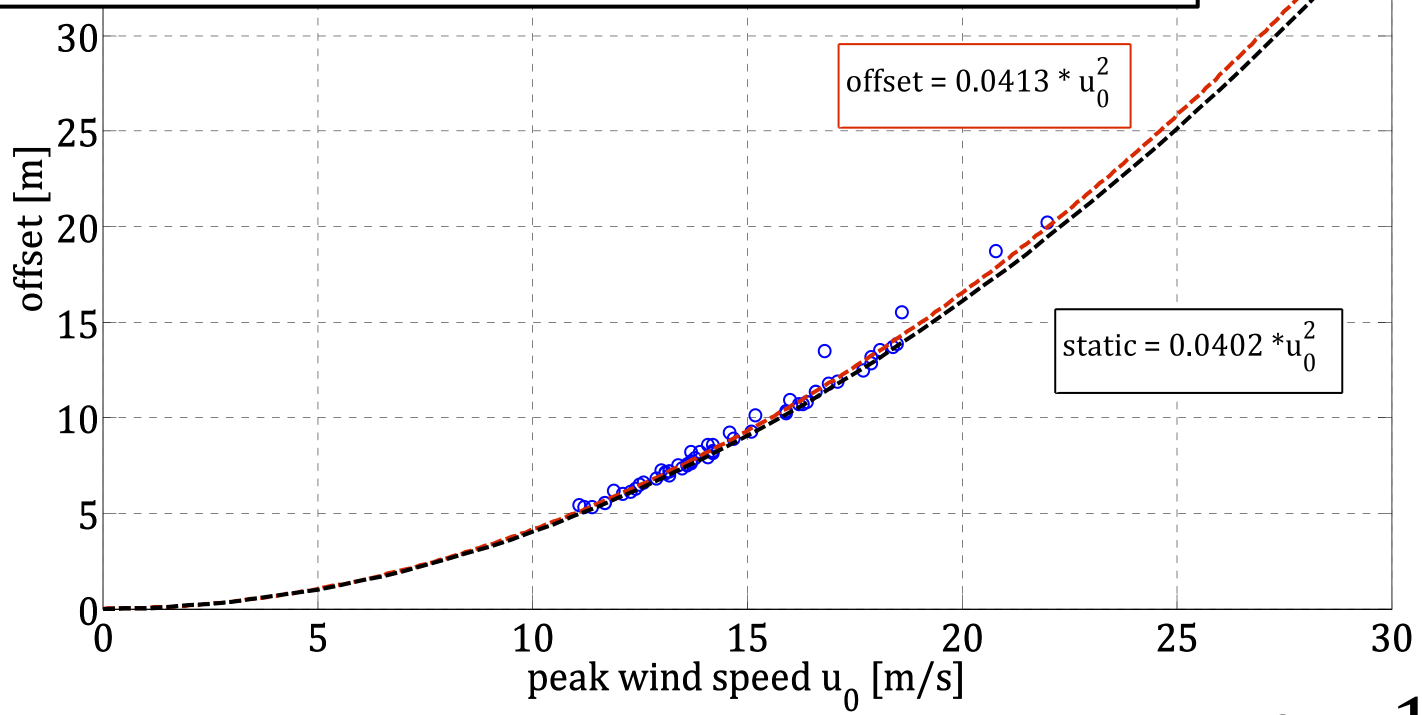


$$y_{100} = 35.8m$$

Design Value Estimation

Response based on dynamic amplification

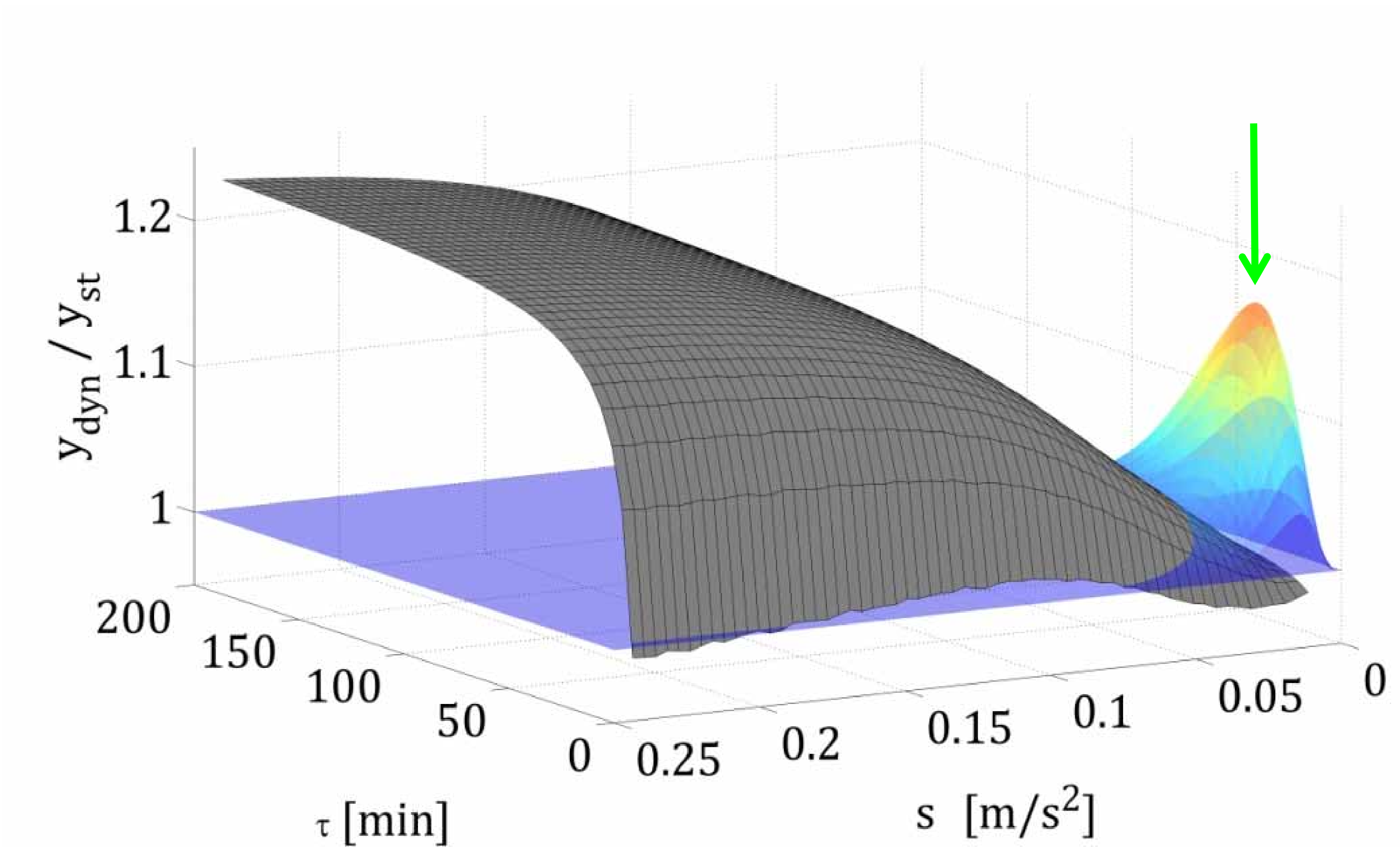
$$y_{st} = \frac{\rho C_w A_y}{2k} u_0^2 = C_{st} u_0^2 = 0.0402 \times u_0^2$$



$$\alpha = 1.027$$

Design Value Estimation

Peak wind speed relation and dynamic amplification

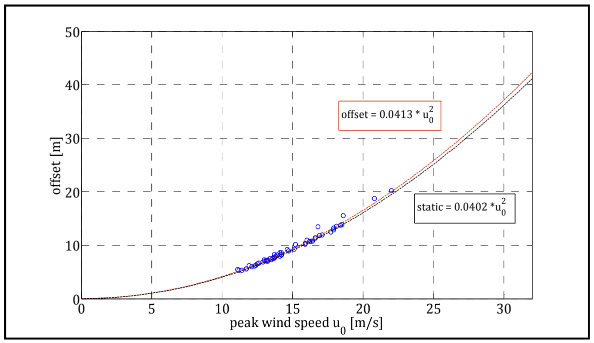


$$E\langle s_r, \tau \rangle \rightarrow \alpha = 1.024$$

Design Value Estimation

Peak wind speed relation and dynamic amplification

$$y_{dyn} = \alpha y_{st}(u_0) = \alpha C_{st} u_0^2$$



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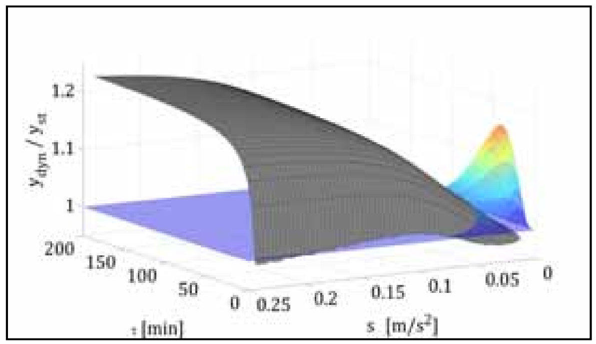

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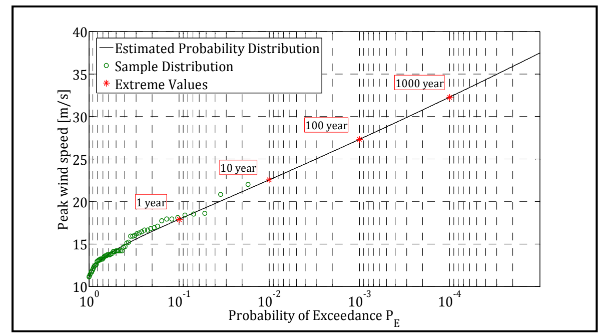
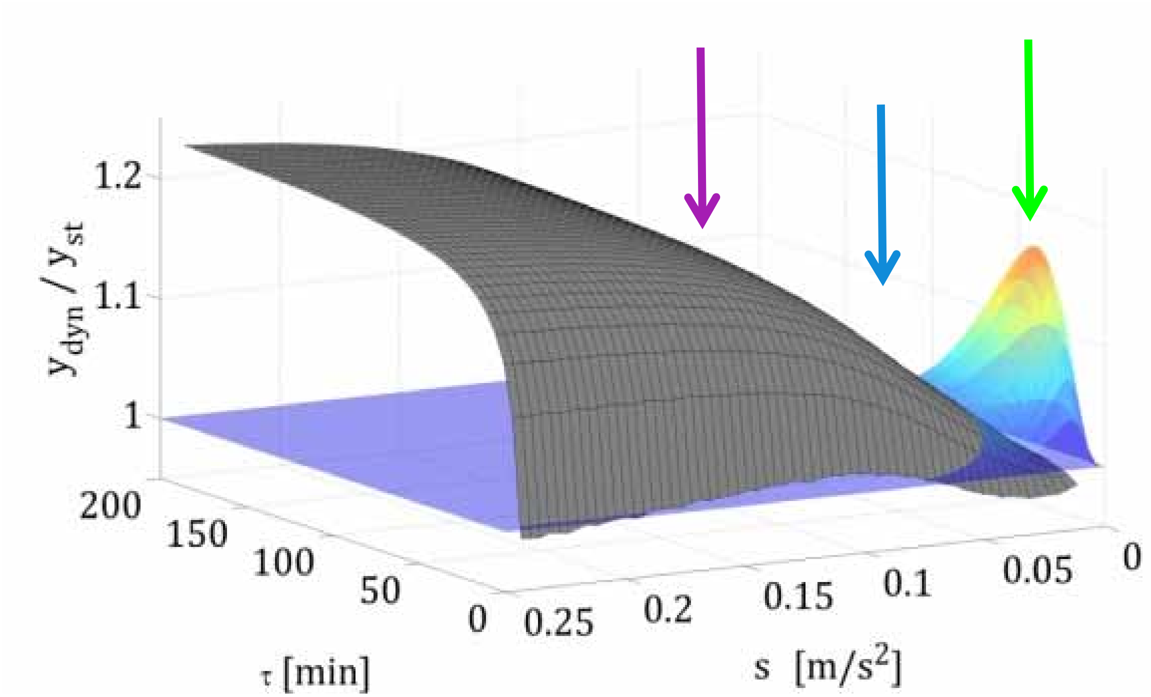


$$P_E(y_{dyn}) = 1 - \exp\left(- \left[1 + \xi \left(\frac{\sqrt{\left({}^{y}/_{\alpha\, C_{st}} \right)} - \mu}{\sigma} \right) \right]^{-\frac{1}{\xi}} \right)$$

Design Value Estimation

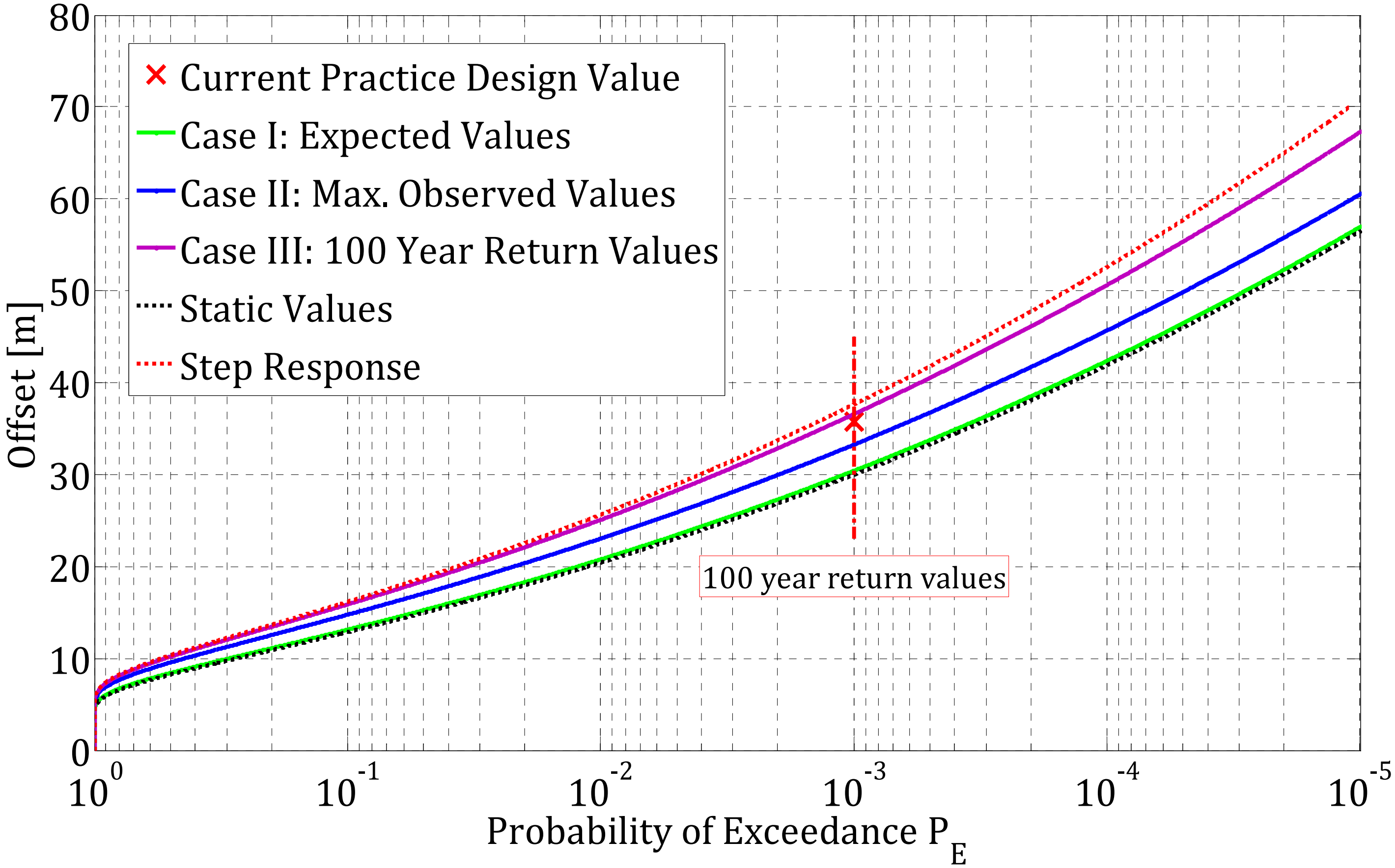
Peak wind speed relation and dynamic amplification



- Case I Expected Values
- Case II Maximum Observed Values
- Case III 100 Year Return Values

Design Value Estimation

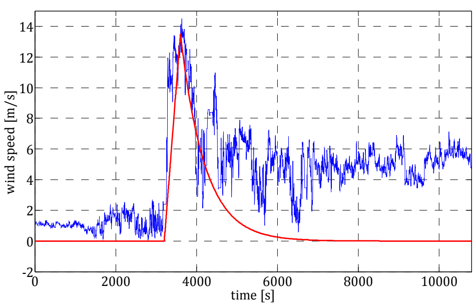
Peak wind speed relation and dynamic amplification

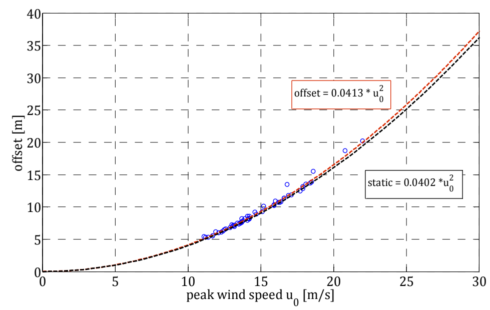


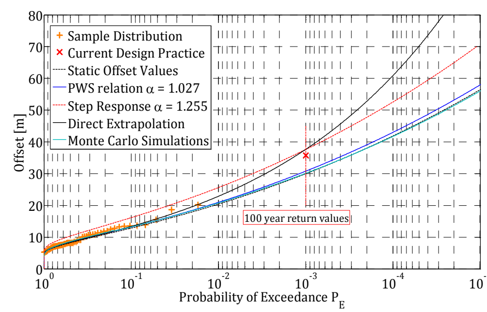
$\alpha = 1.024$ $\qquad$ $\alpha = 1.110$ $\qquad$ $\alpha = 1.213$

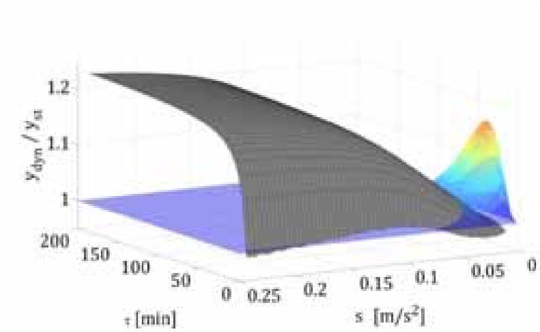
Conclusions

- Characterized the squall events
- Found the governing response characteristics
- Compared the different DVE methods
- CDP for spread moored is highly conservative
- Best method is based on response knowledge









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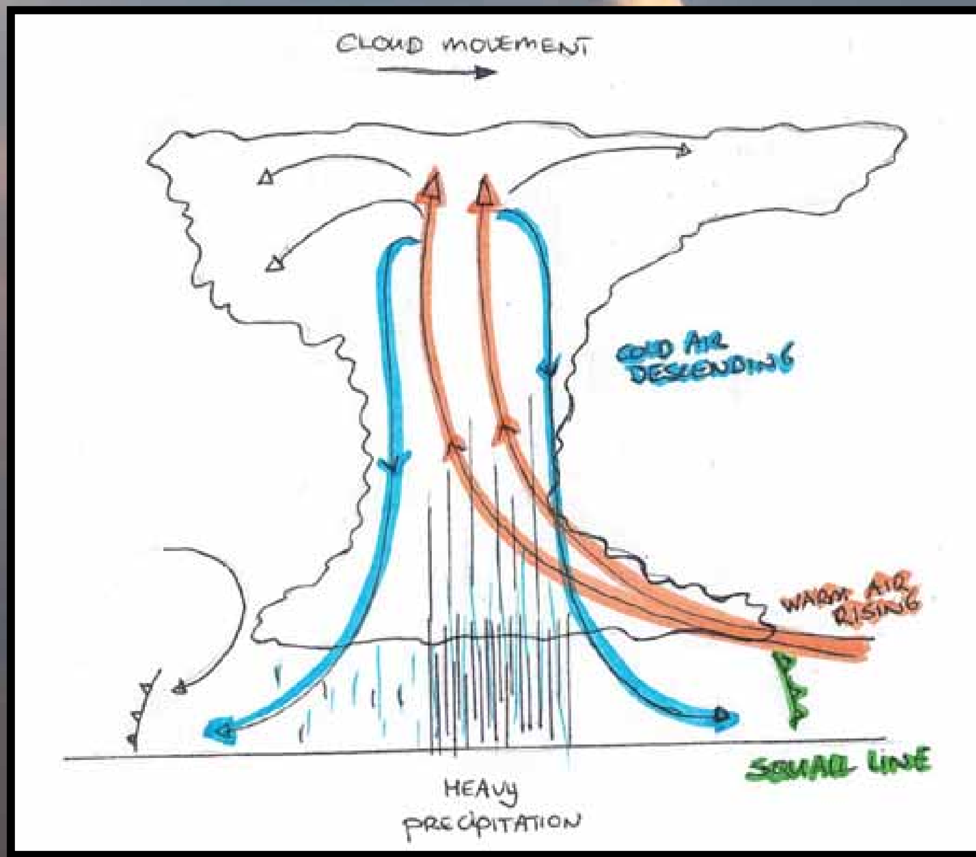
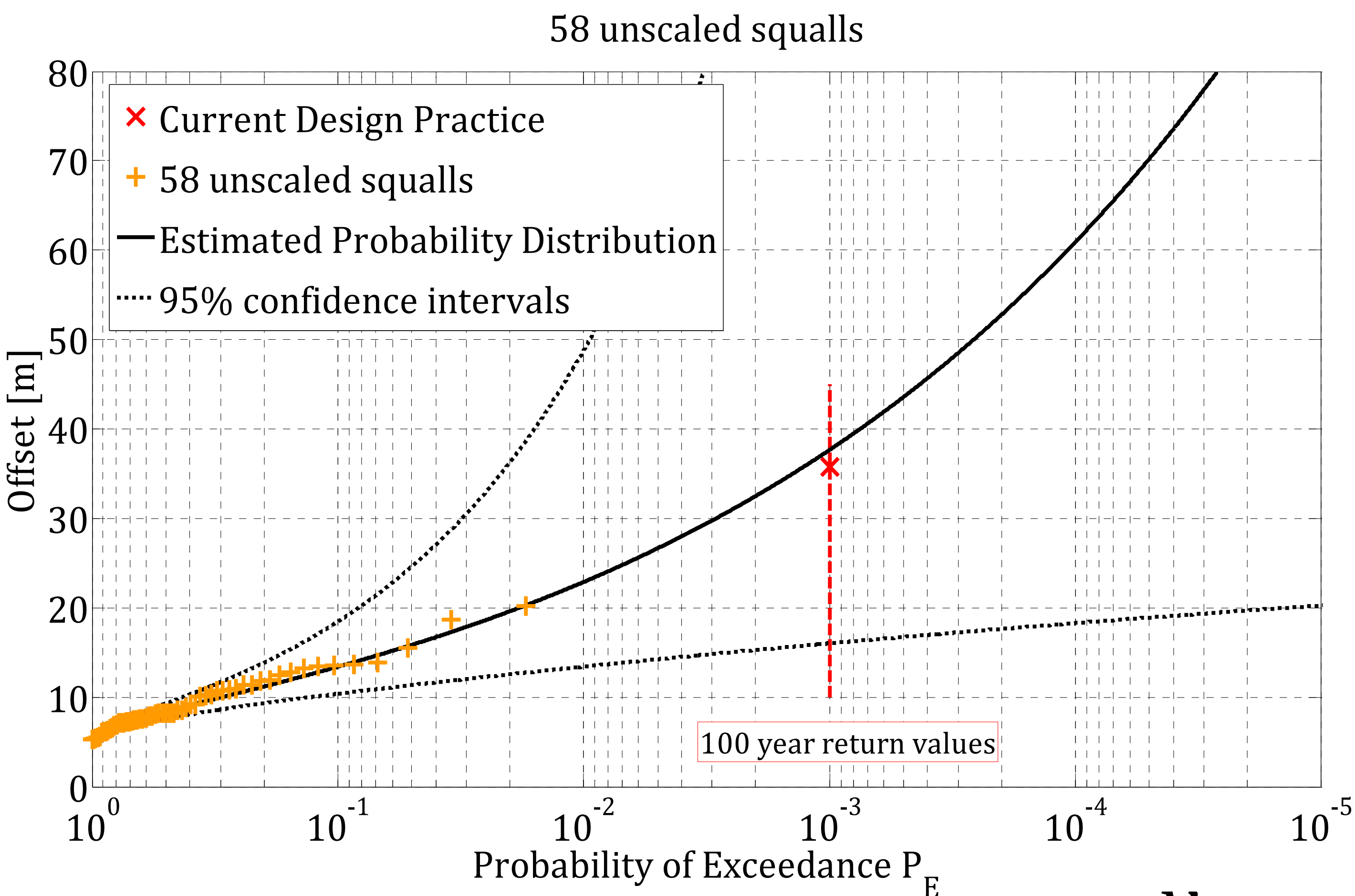
Introduction



Design Value Estimation

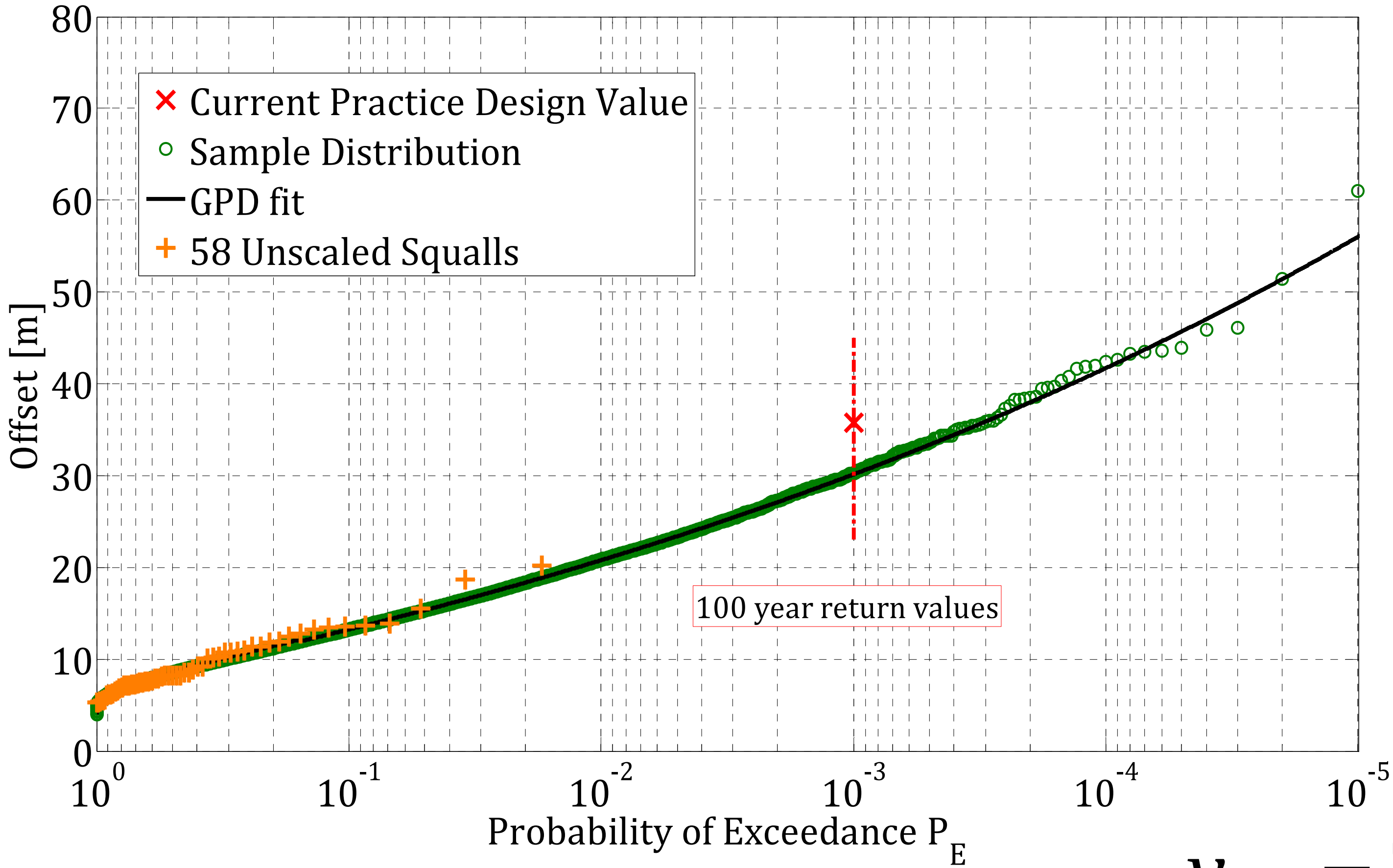
Direct Extrapolation



$$y_{100} = 37.6m$$

Design Value Estimation

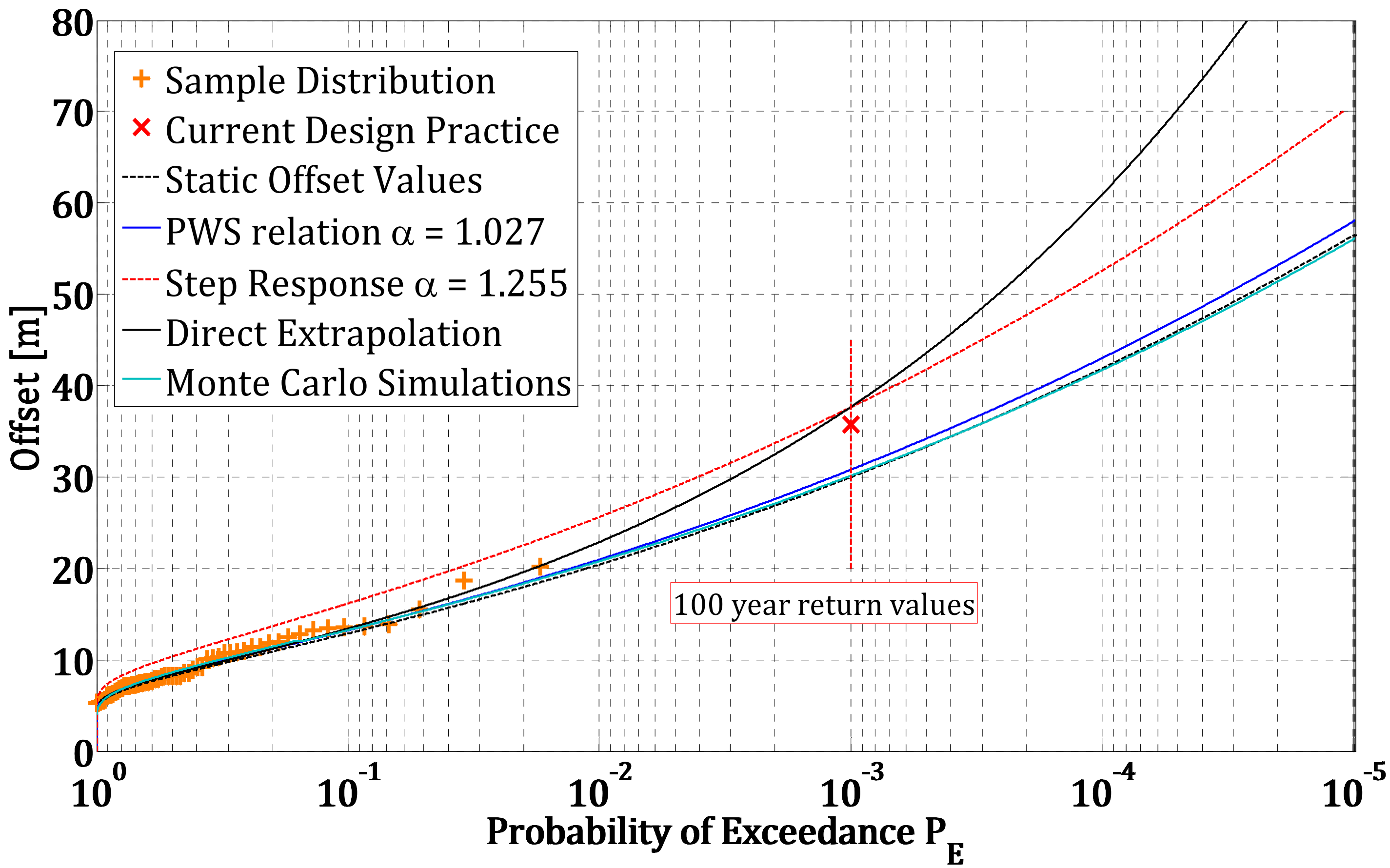
Monte Carlo Simulations



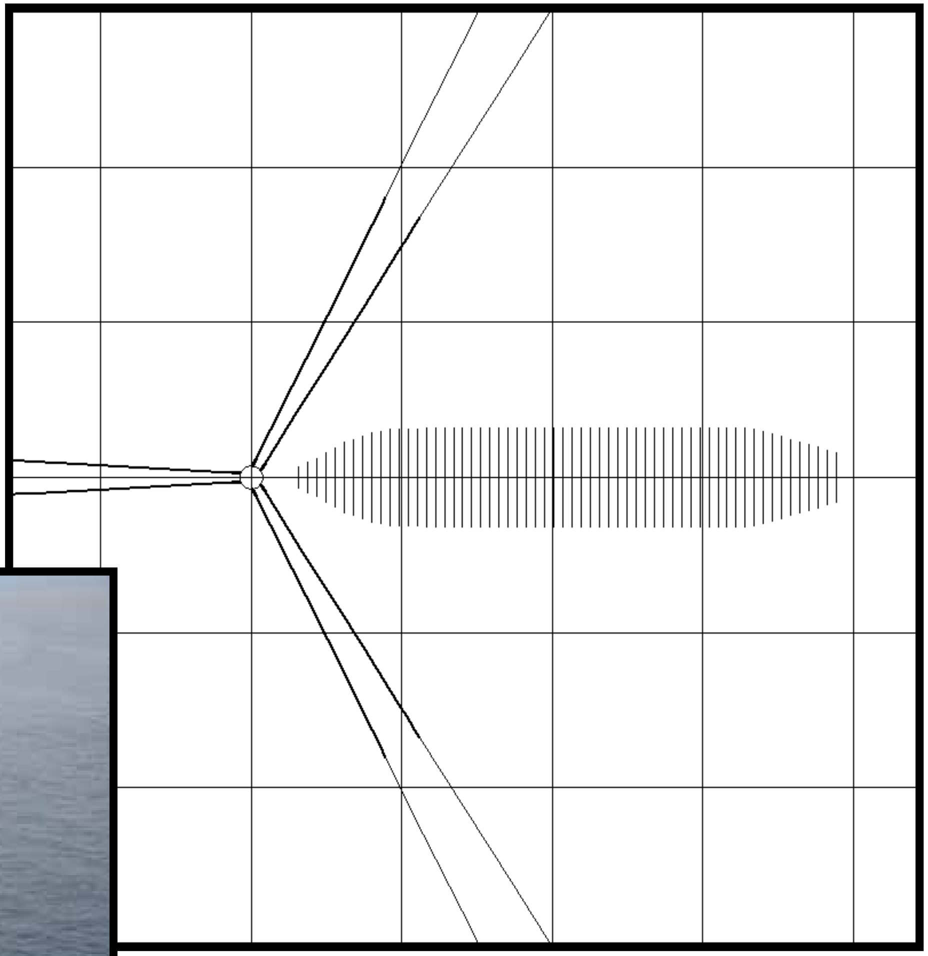
$$y_{100} = 30.0m$$

Design Value Estimation

Peak wind speed relation and dynamic amplification

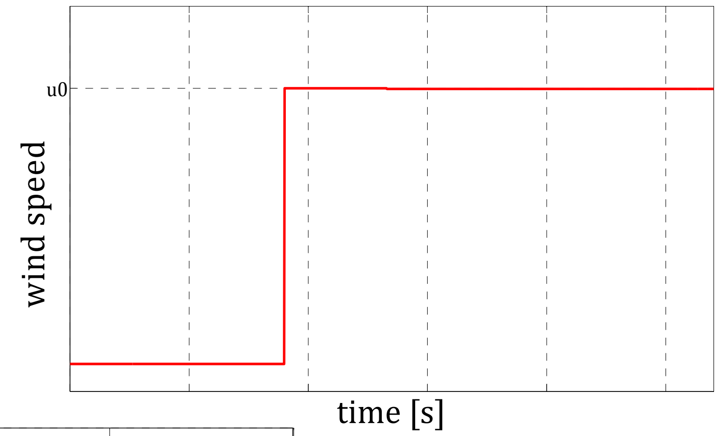


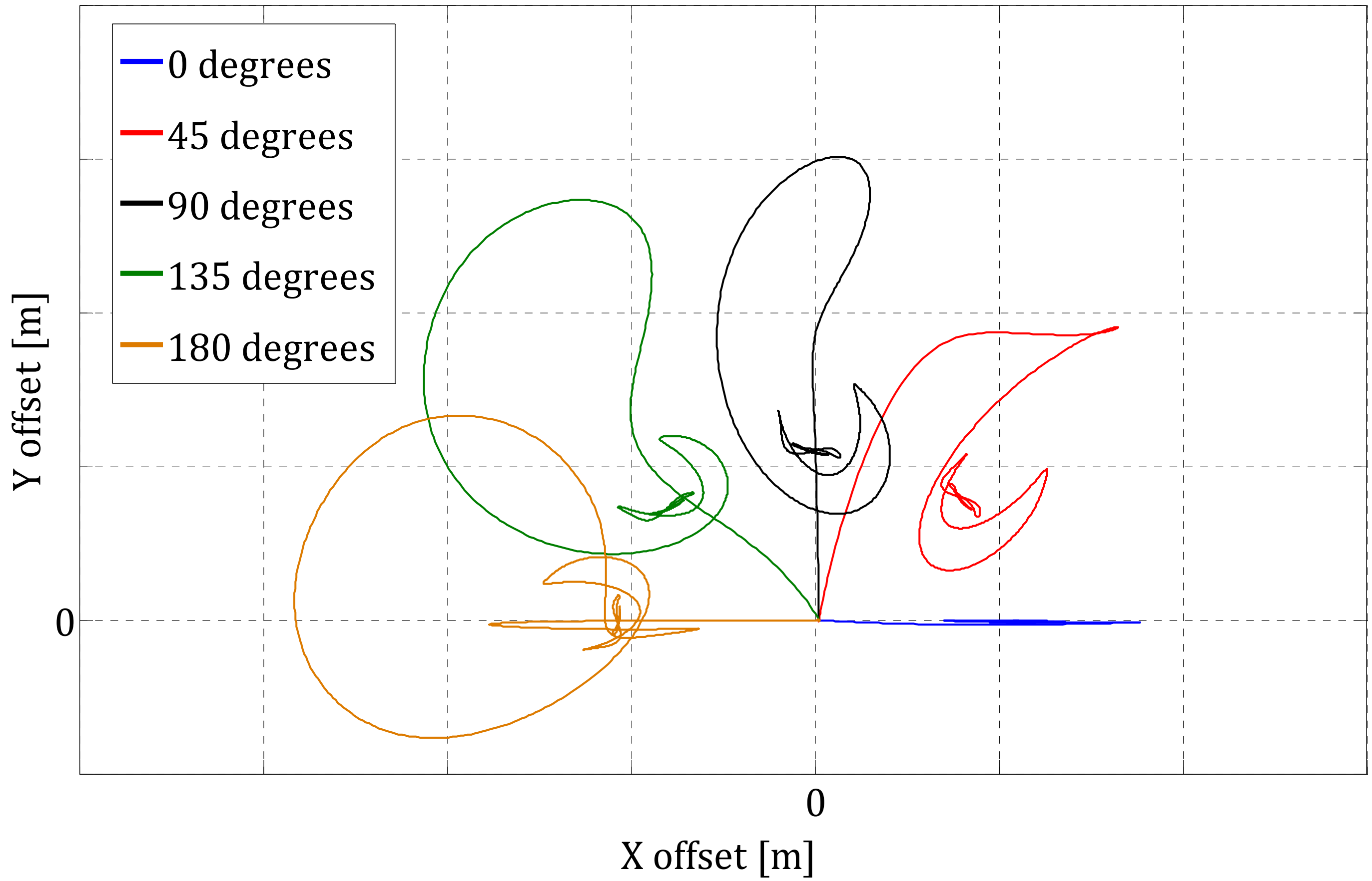
Turret Mooring



Turret Mooring

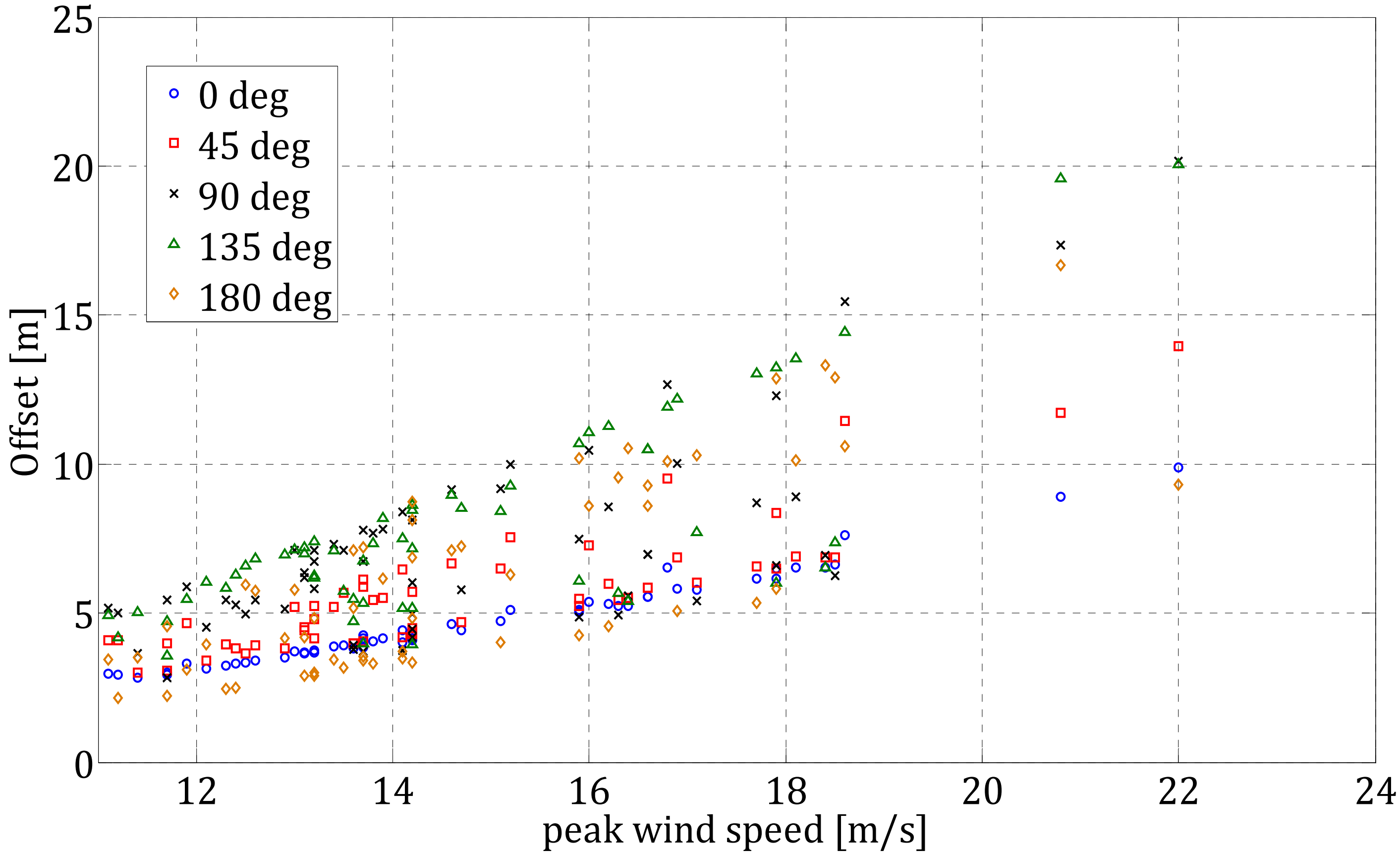
Response characteristics





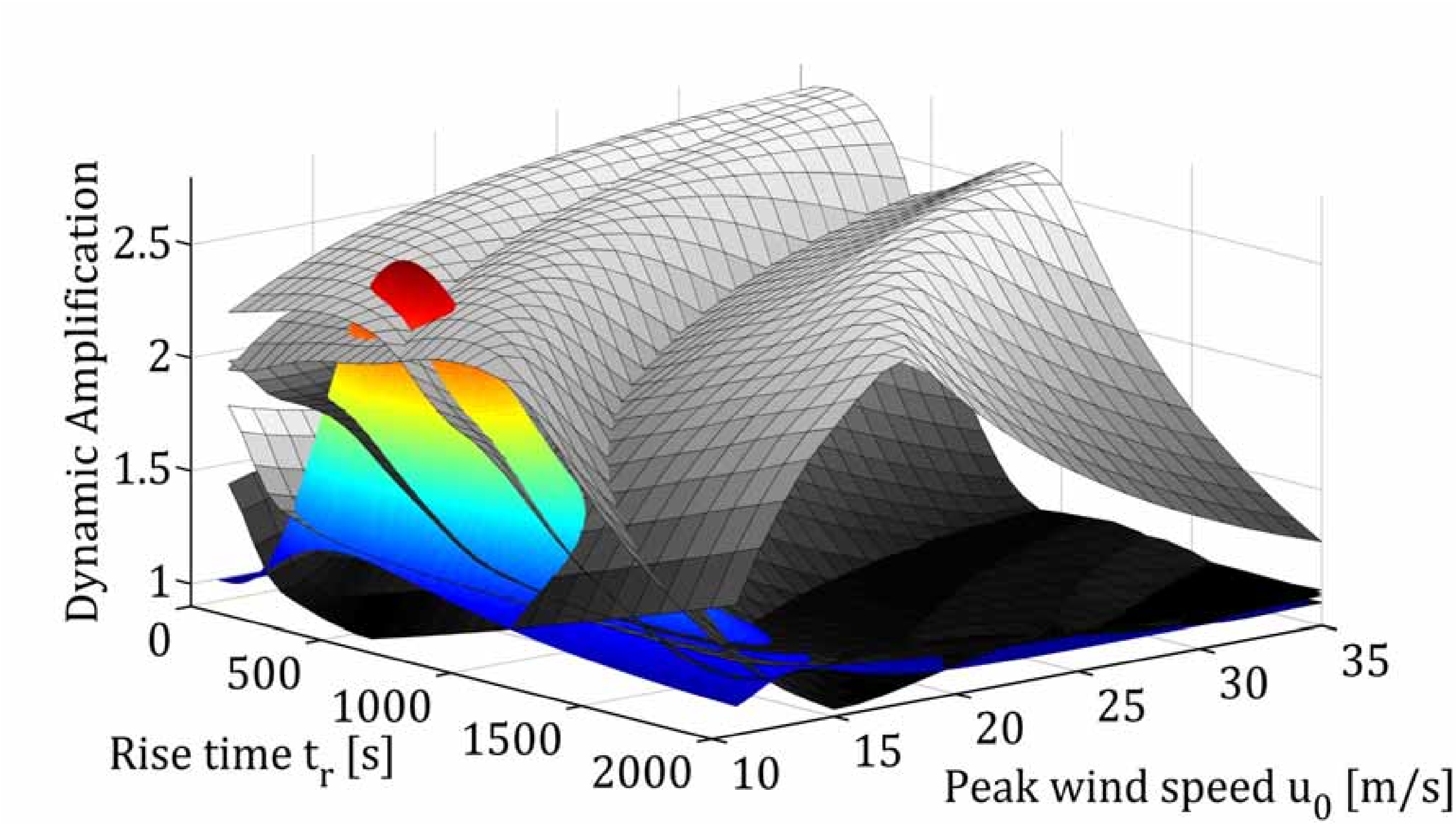
Turret Mooring

Response characteristics



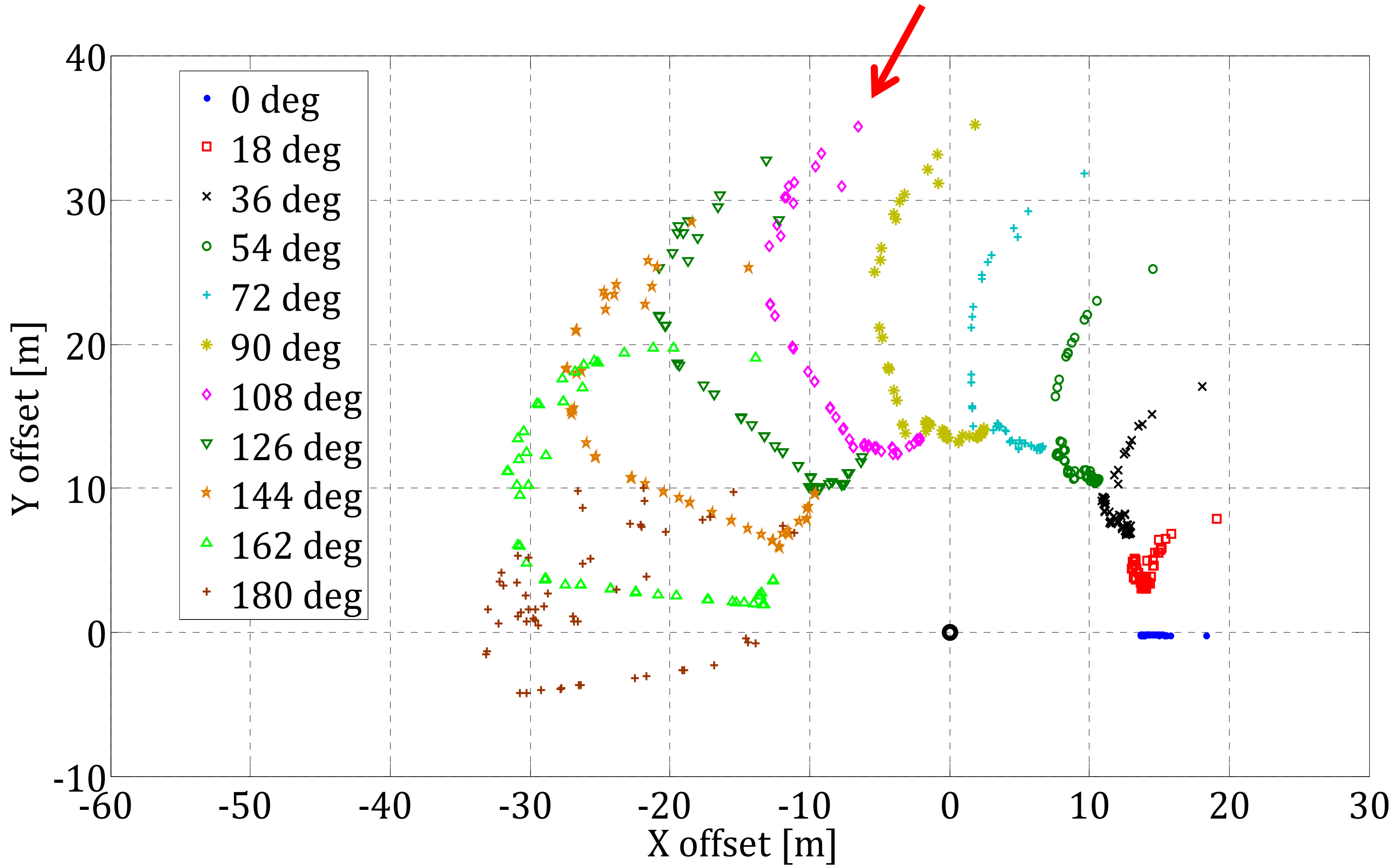
Turret Mooring

Response characteristics



Turret Mooring

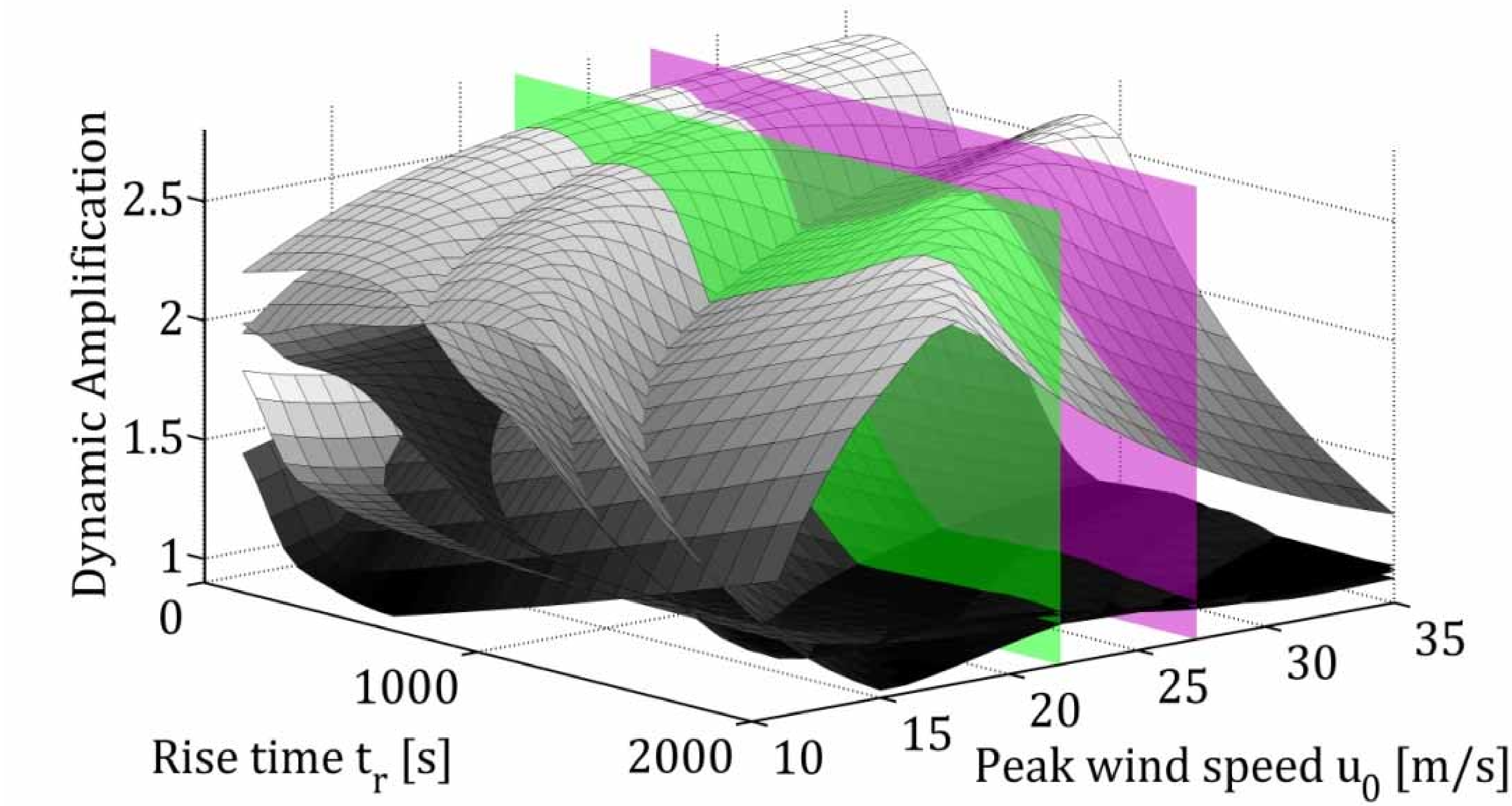
Current Design Practice



$$y_{100} = 35.7m$$

Turret Mooring

Dynamic Amplification limitations

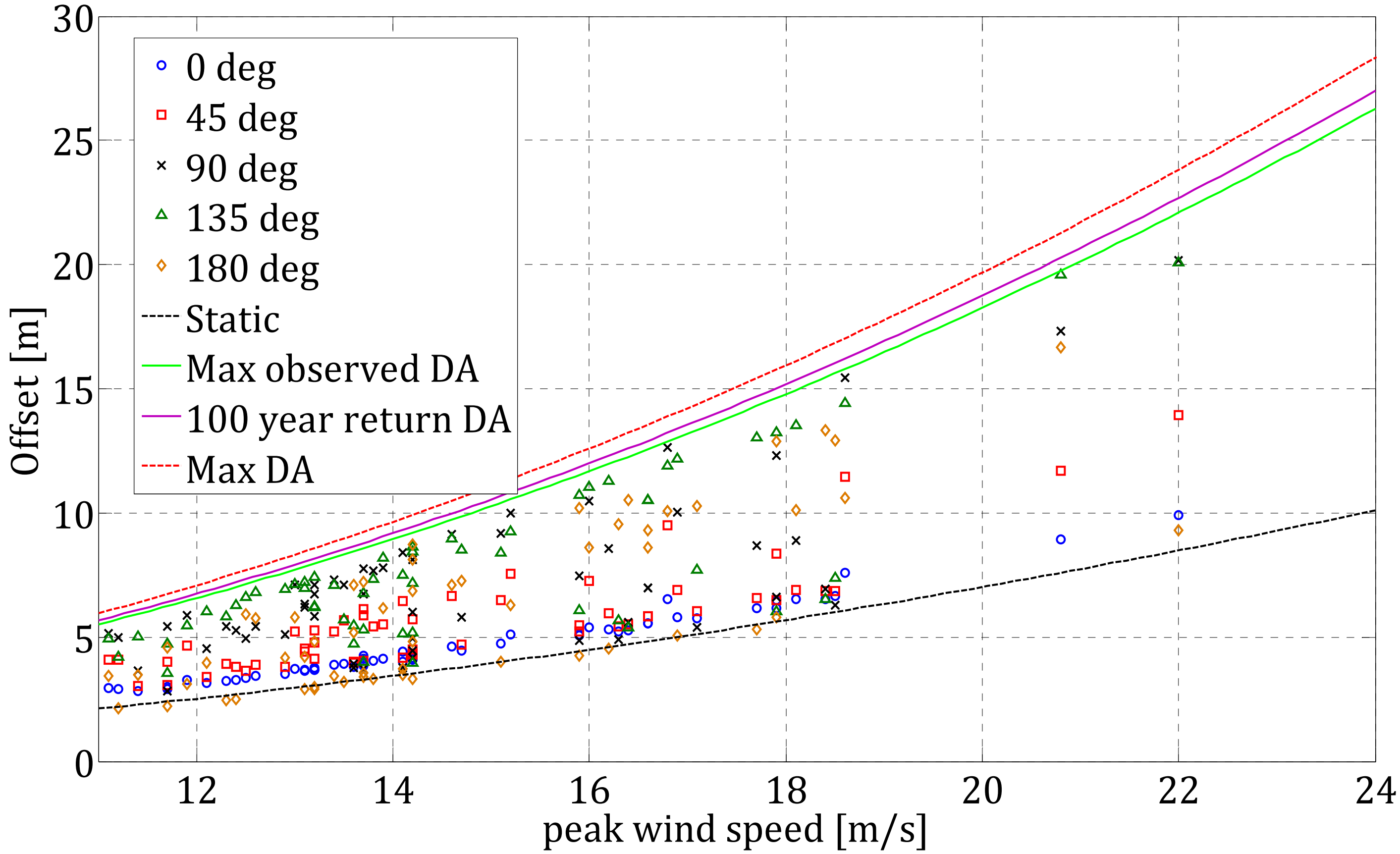


$\alpha = 2.60$

$\alpha = 2.67$

Turret Mooring

Dynamic Amplification limitations



Turret Mooring

Dynamic Amplification limitations