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Working with water



SAFE DESIGN OF SHIPS & OTHER MARINE STRUCTURES

using environmental contours and response-based methods

24 May 2018

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- Background
- Methodology
- Application



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BACKGROUND

Environmental Contours for Safe DDesign of Ships and other marine structures (ECSADES)

- ECSADES is a research project funded by Forskningsrådet and Innovate UK through the ERA-NET call.
- It is a collaboration between DNV GL (project manager), University of Oslo, Shell UK, and HR Wallingford.
- The project focuses on how to account for extreme environmental conditions in the safe design of ships and other marine structures.



A review of environmental contours and response based methods for designing marine structures.

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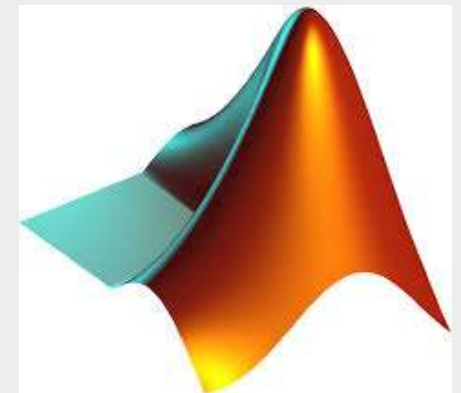
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^eShell Projects & Technology, 1031 HW Amsterdam, The Netherlands.

^fShell Projects & Technology, London SE1 7NA, United Kingdom.

Research papers
(in preparation)

Software packages
<https://github.com/ecsades>
(to be released)





METHODOLOGY



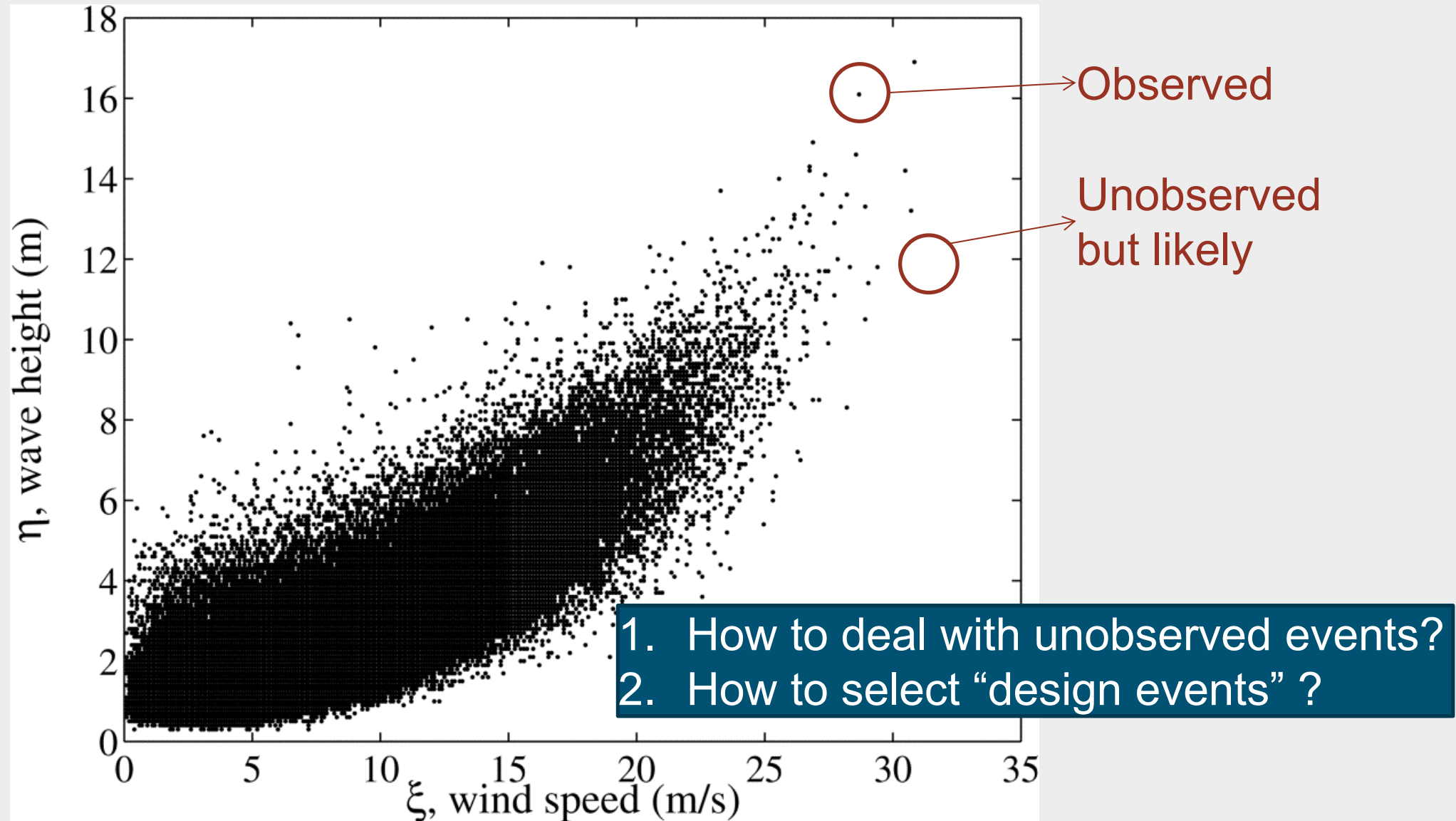
Environment

- Wave height
- Wave period
- Wind speed
- ...



Response

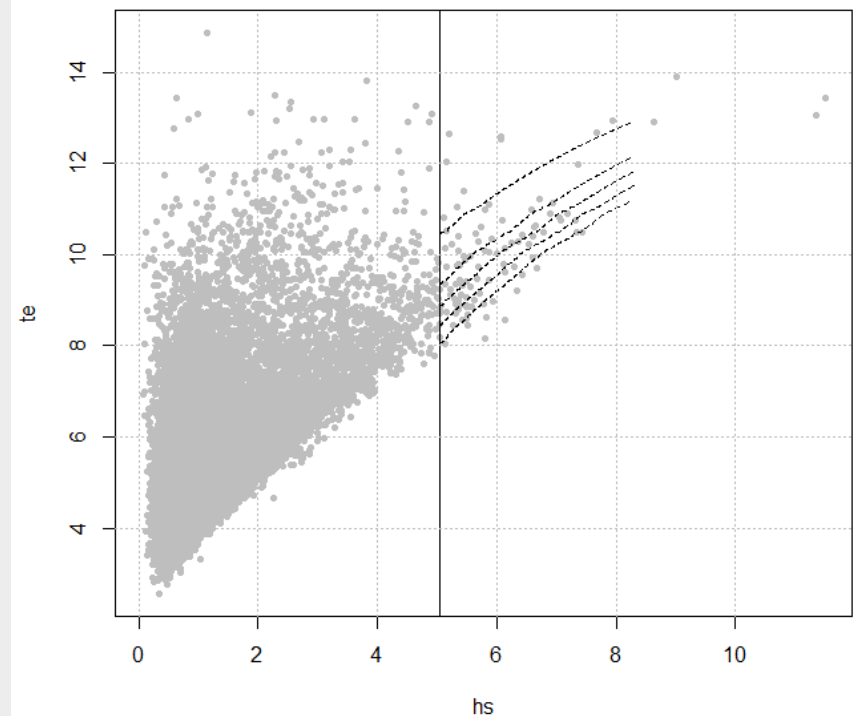
- Heave, pitch, roll, offsets
- Hull bending moment
- ...



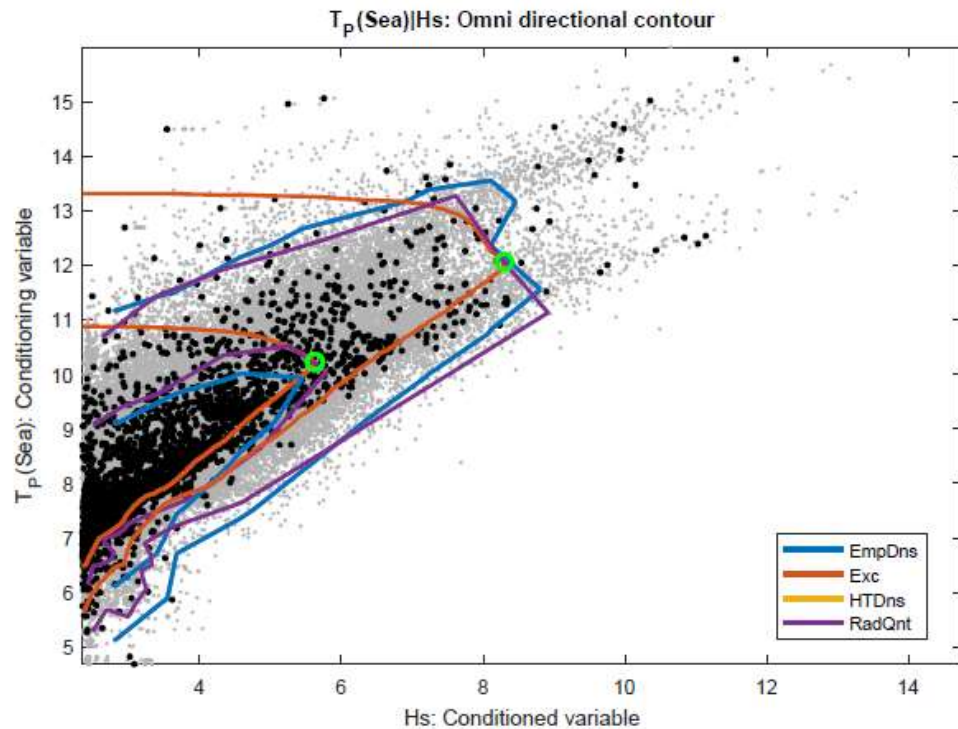
Dealing with unobserved events

- Estimating the probability of rare or unobserved events
- Based on the Heffernan-Tawn model (or alternative models)
- Flexible for all types of extremal dependences (unlike most copula based models)

Heffernan-Tawn (2004) for multivariate tail distribution



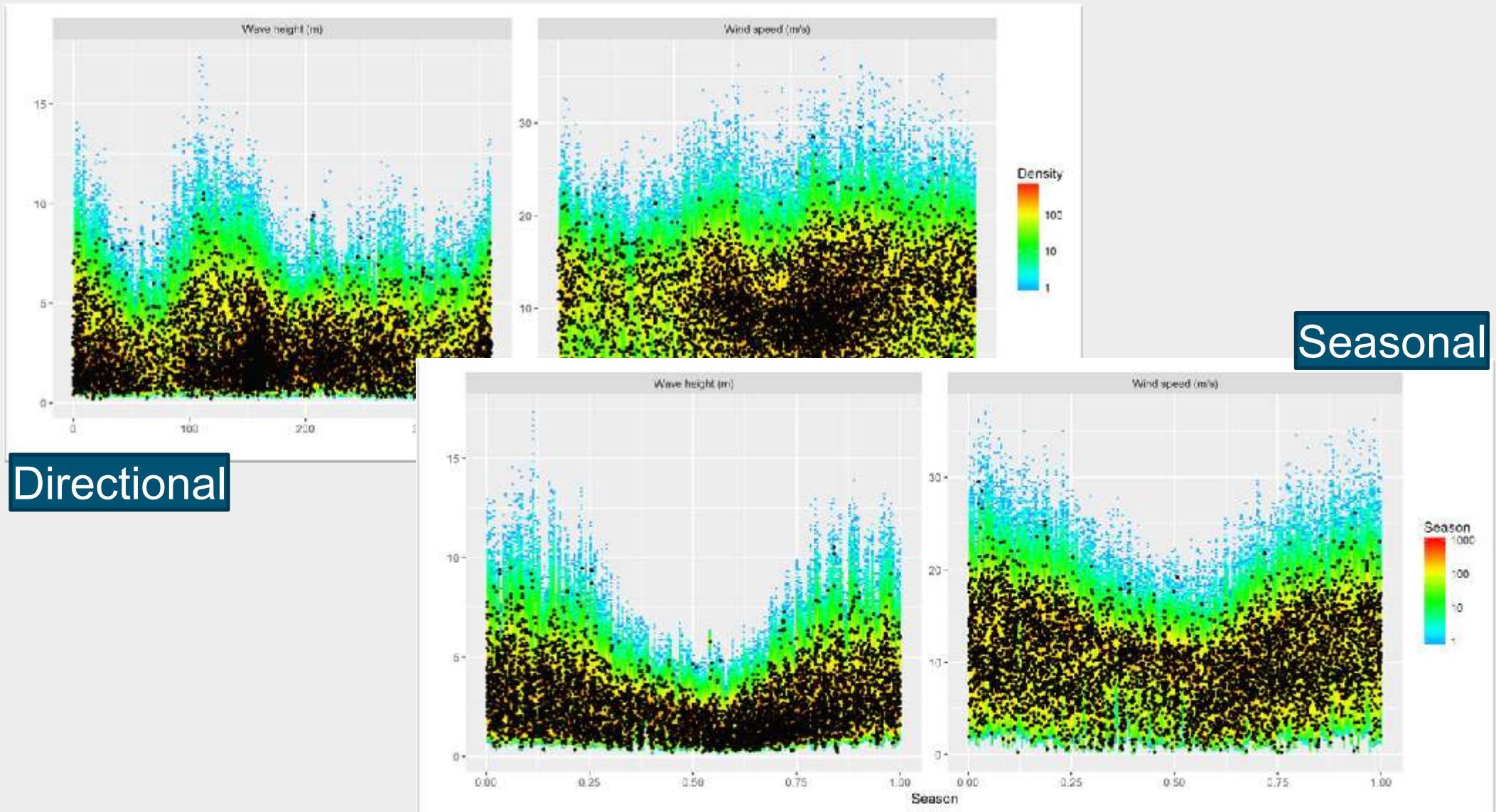
Dealing with design events



A collection of popular contours included in the package

- Based on the simulated events or fitted distribution
- Draw the contours using the preferred method
- Select “design events” on the contours for the desired return periods

Accounting for covariate effects



Software package content at release



Joint
exceedance
contours

Iso-density
contours

IFORM
contours

Direct-
sampling
contours

- A collection of contours
- State-of-the-art multivariate statistical models
- Extreme value analysis with covariate effects
- User guide and plenty of examples
- ... and more to come

Unknown Response

- The mathematical form of the response is unknown or costly to calculate
- Use Heffernan-Tawn or alternative
- Application of contours to fitted statistical distribution

Approximate Response

- The response can be approximated
- Heffernan-Tawn with the approximate response as the condition
- Application of the contours to the simulated data

Accurate Response

- The response is mathematically known or can be estimated accurately
- Construct response surface or use response-based analysis



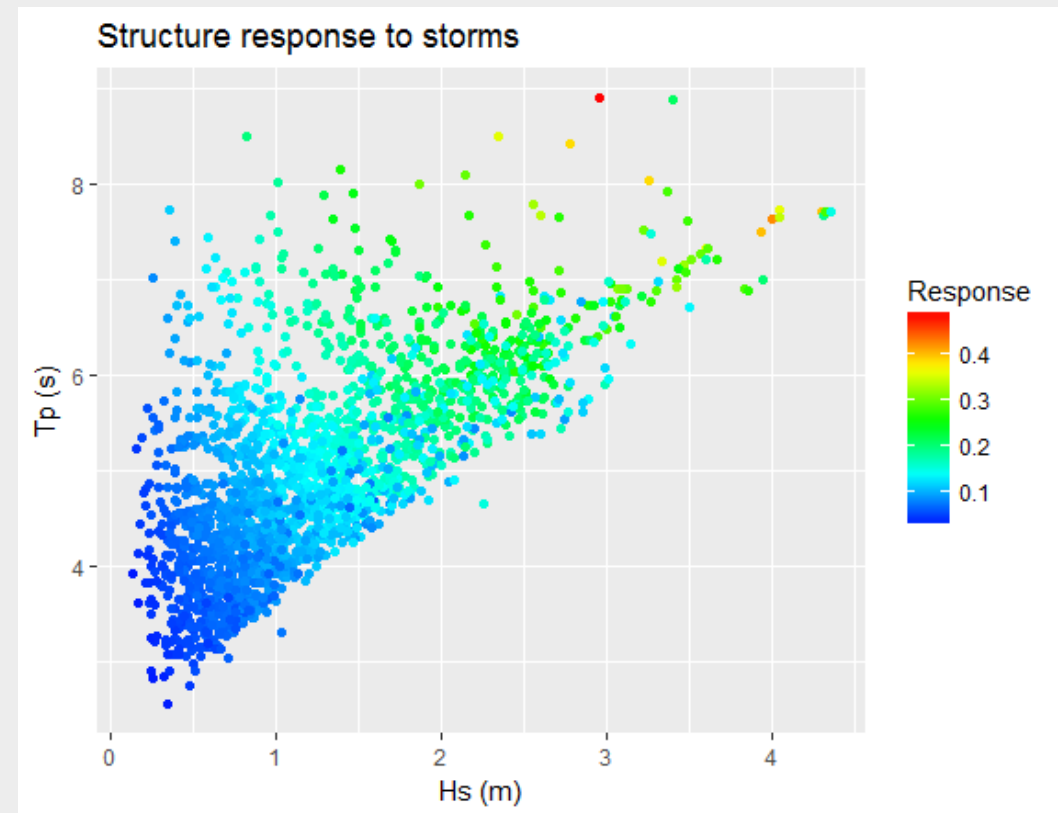
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APPLICATION

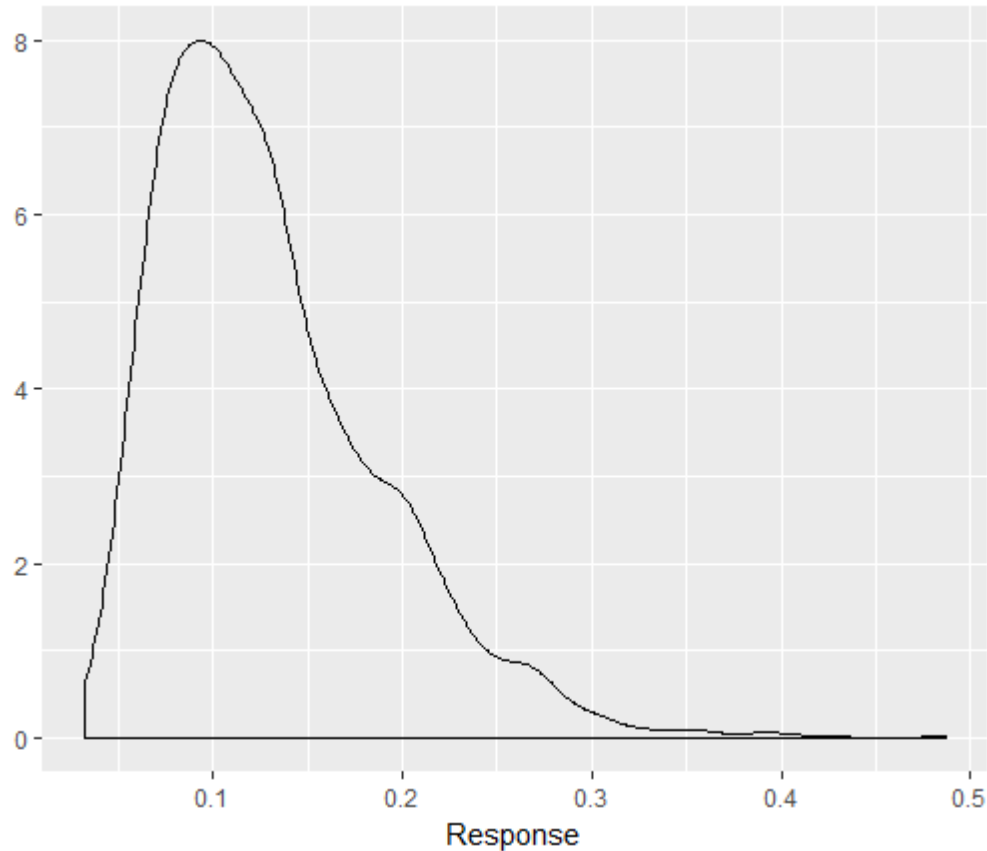
Example A – statistical model

- An offshore structure with the key response approximated
- Driving variables are wave height (H_s) and period (T_p)
- Input data cover 2,000 storms over 15 years
- Need distribution for H_s/T_p when the response is above 10- and 100-year level

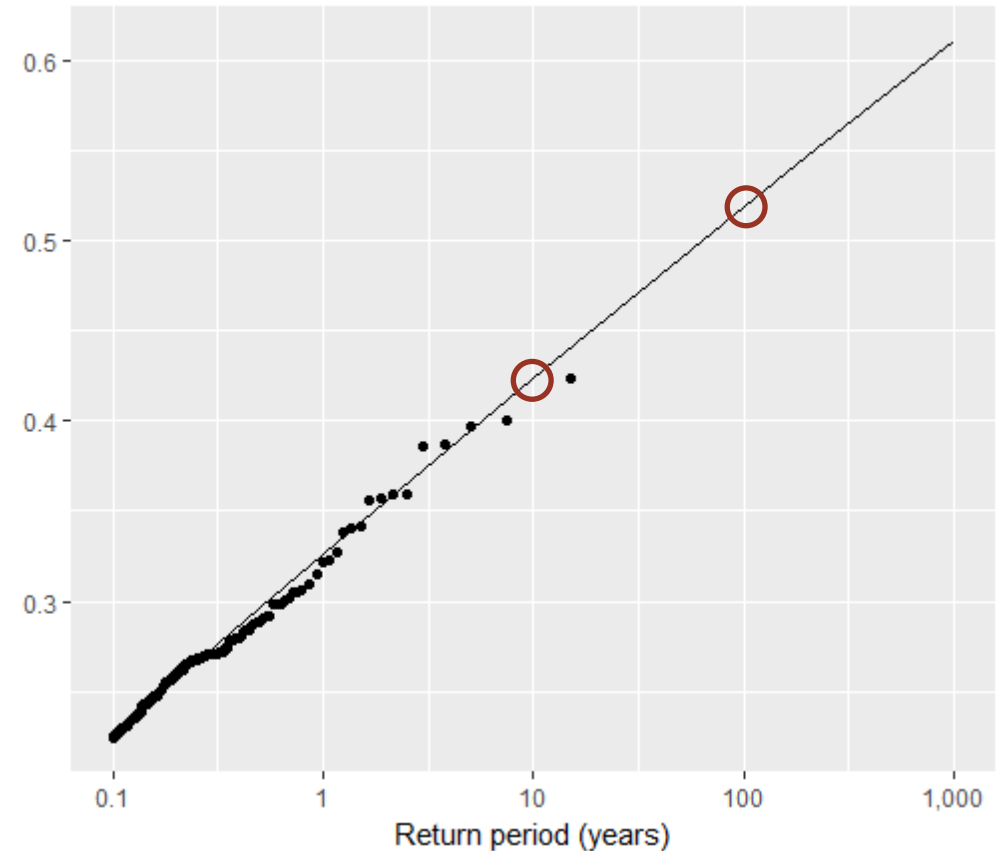


Example A – response analysis

Response distribution

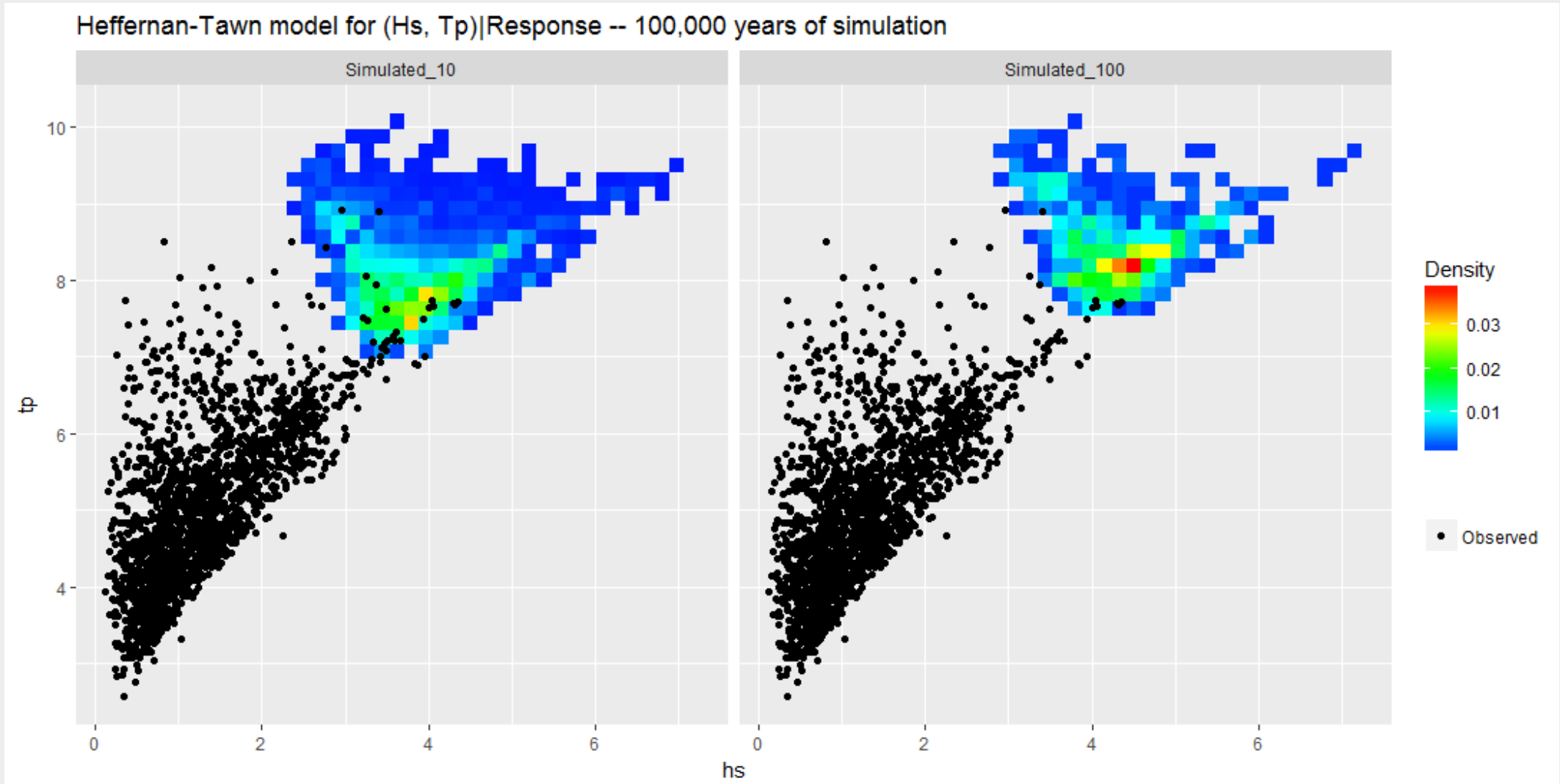


Extreme response levels



Peaks-over-threshold model

Example A – conditional simulation



Example B – contours

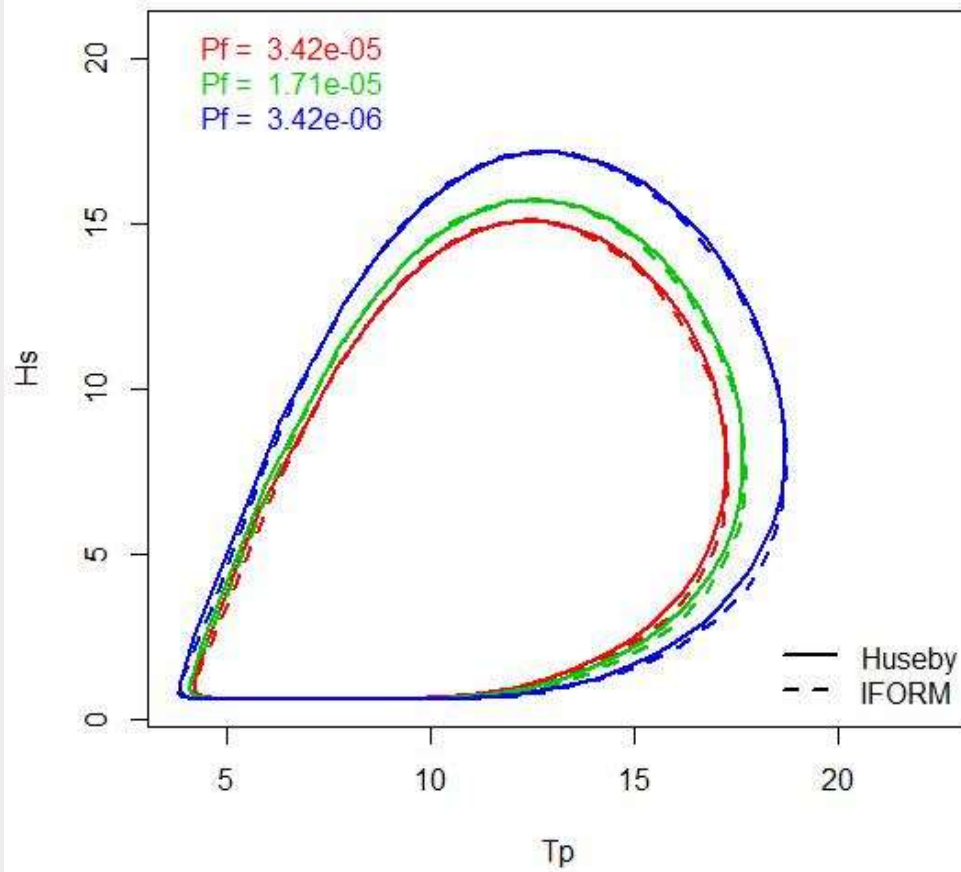
Erik Vanem (2017) A comparison study on the estimation of extreme structural response from different environmental contour methods, Marine Structures, 56 (2017), 137-162.



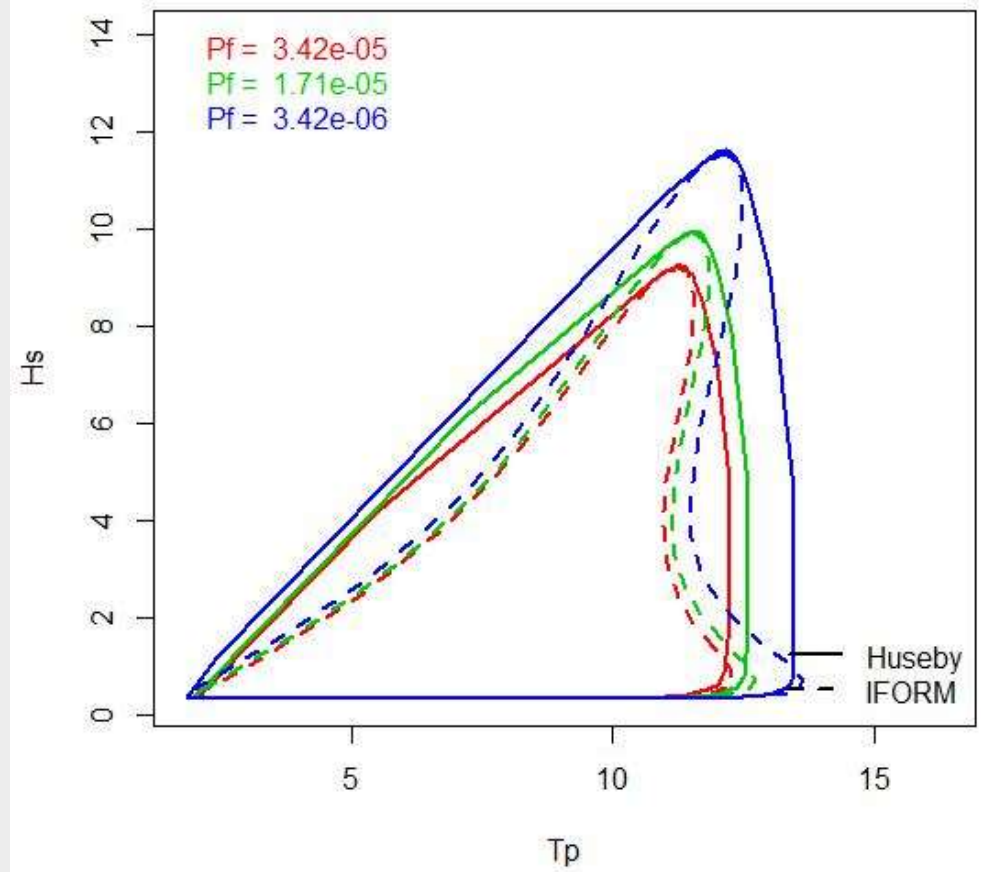
- IFORM vs direct-sampling
- Four offshore locations
- H_s , T_p joint distribution

Example B – sample outcome

Environmental contours
North Atlantic



Environmental contours
North West Australia





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