SAFE DESIGN OF SHIPS & OTHER MARINE STRUCTURES

using environmental contours and response-based methods

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- **Background**

- **Methodology**

- **Application**

BACKGROUND

Environmental Contours for SAfe DEsign 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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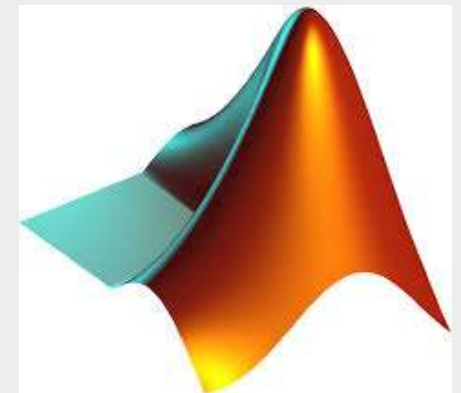[c]Shell Projects & Technology, Aberdeen AB12 3FY, United Kingdom.
[d]Department of Mathematics, University of Oslo, 0316 Oslo, Norway.
[e]Shell Projects & Technology, 1031 HW Amsterdam, The Netherlands.
[f]Shell Projects & Technology, London SE1 7NA, United Kingdom.

Research papers
(in preparation)

Software packages
https://ecsades.github.io/
(to be released)

METHODOLOGY

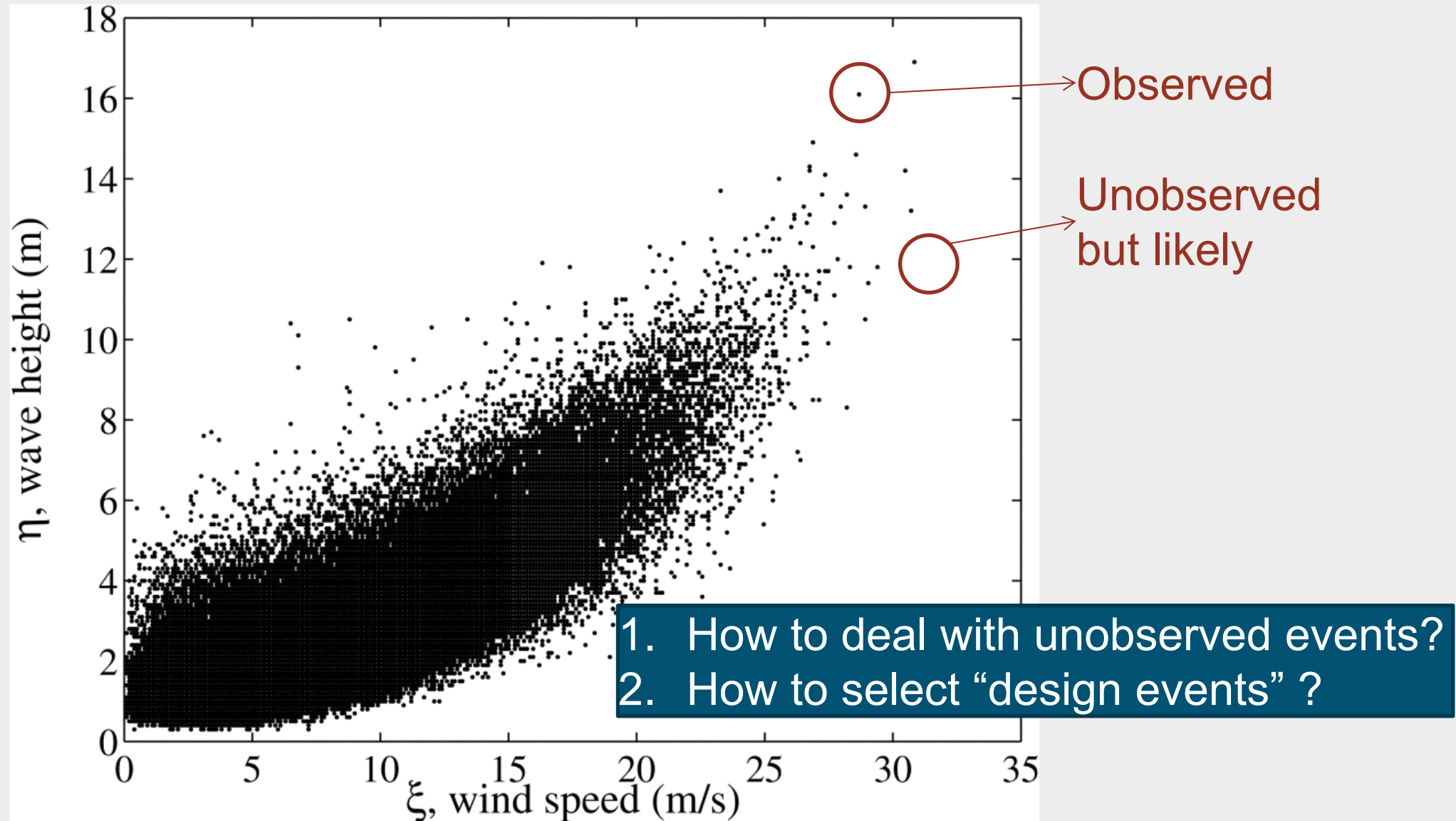**Environment**

- Wave height

- Wave period

- Wind speed

- …

Response

- Heave, pitch, roll, offsets

- Hull bending moment

- …

Observed

Unobserved but likely

1. How to deal with unobserved events?
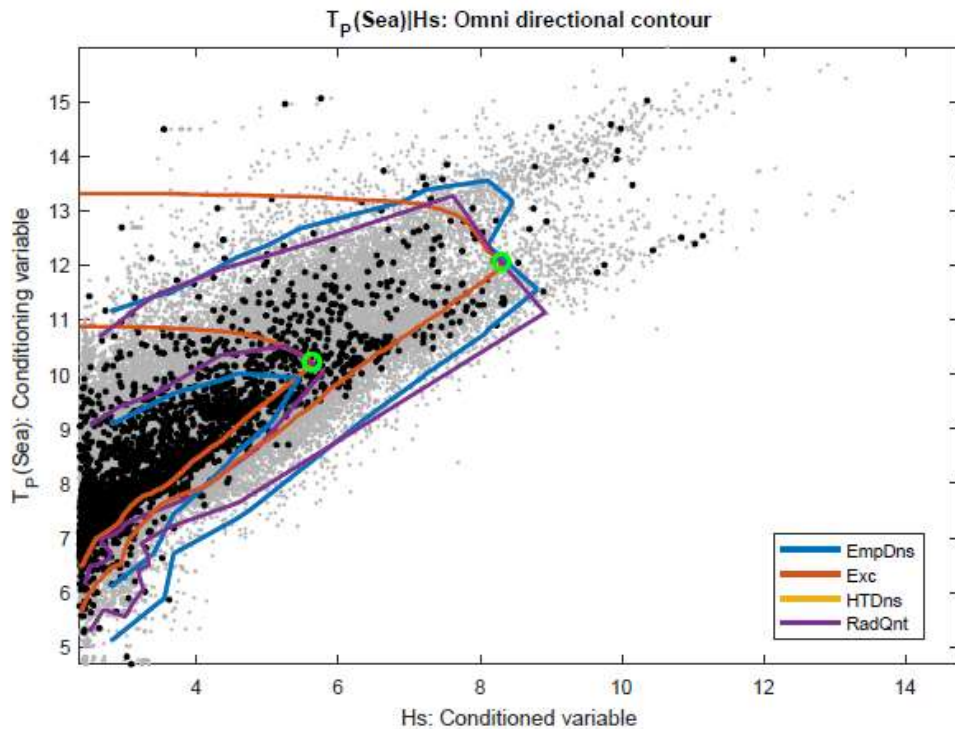2. How to select "design events" ?

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- 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)
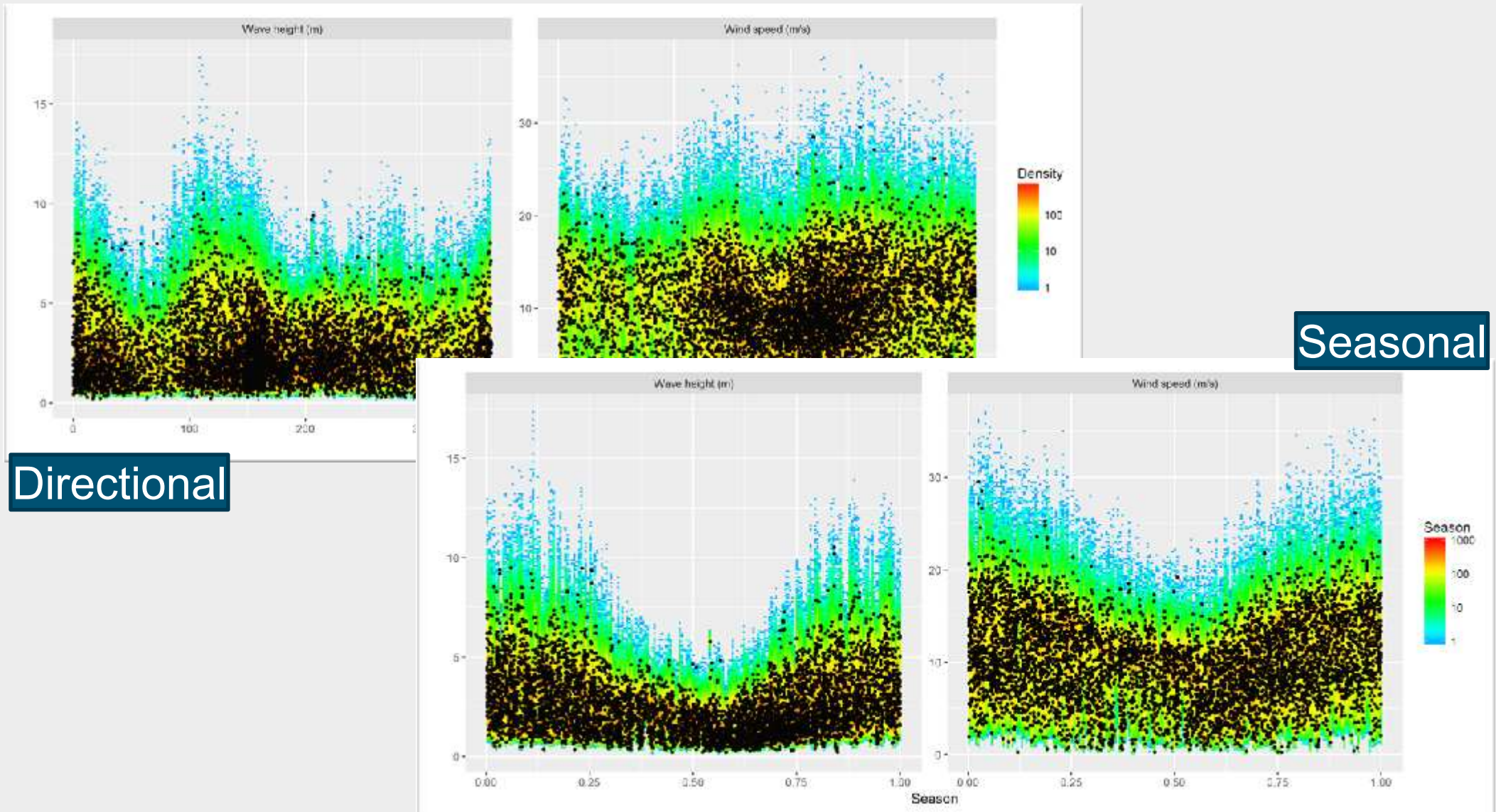for multivariate tail distribution**
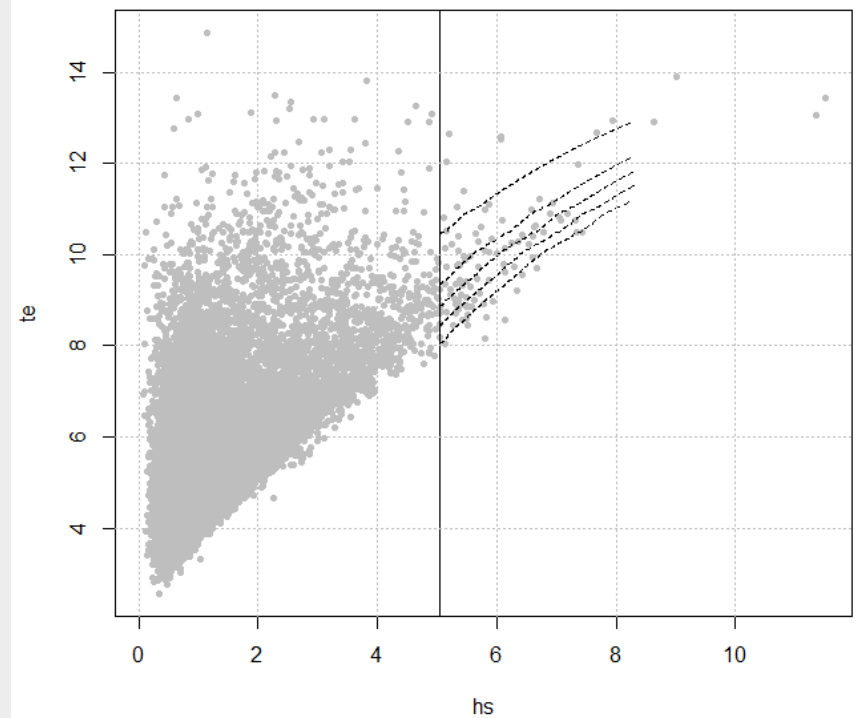
A collection of popular contours included in the package

- 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

Directional

Seasonal

Software package content at release

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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

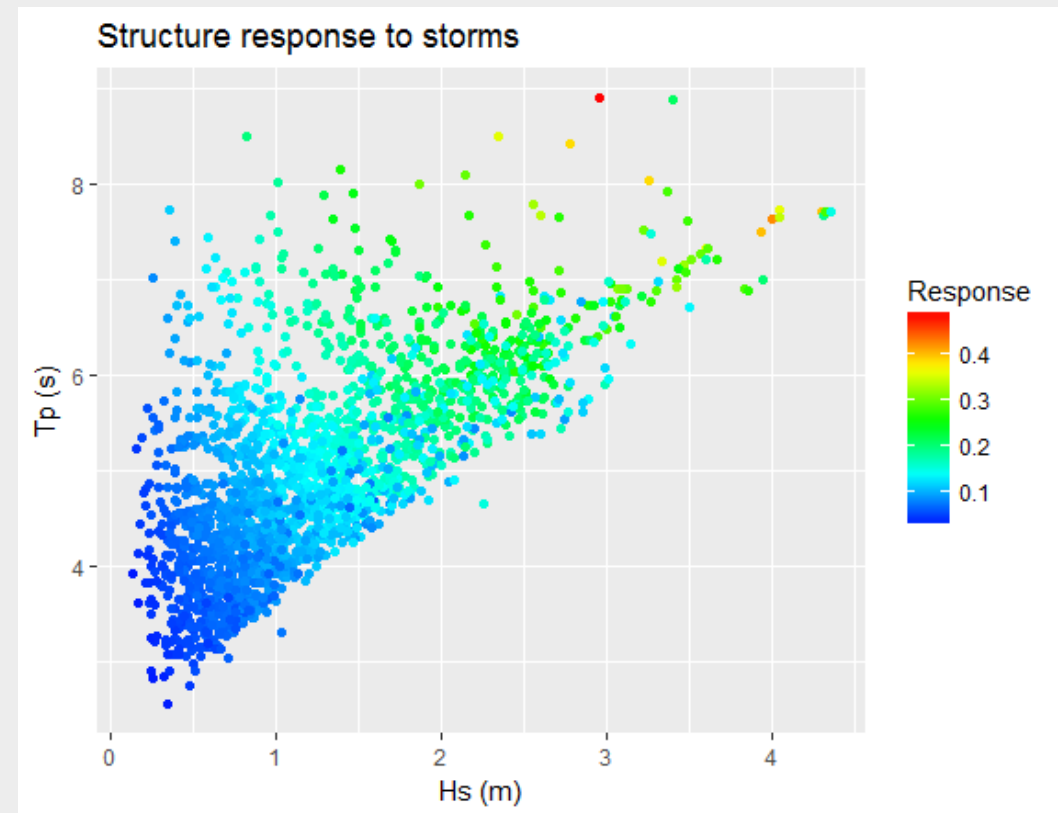- Construct response surface or use response-based analysis

APPLICATION

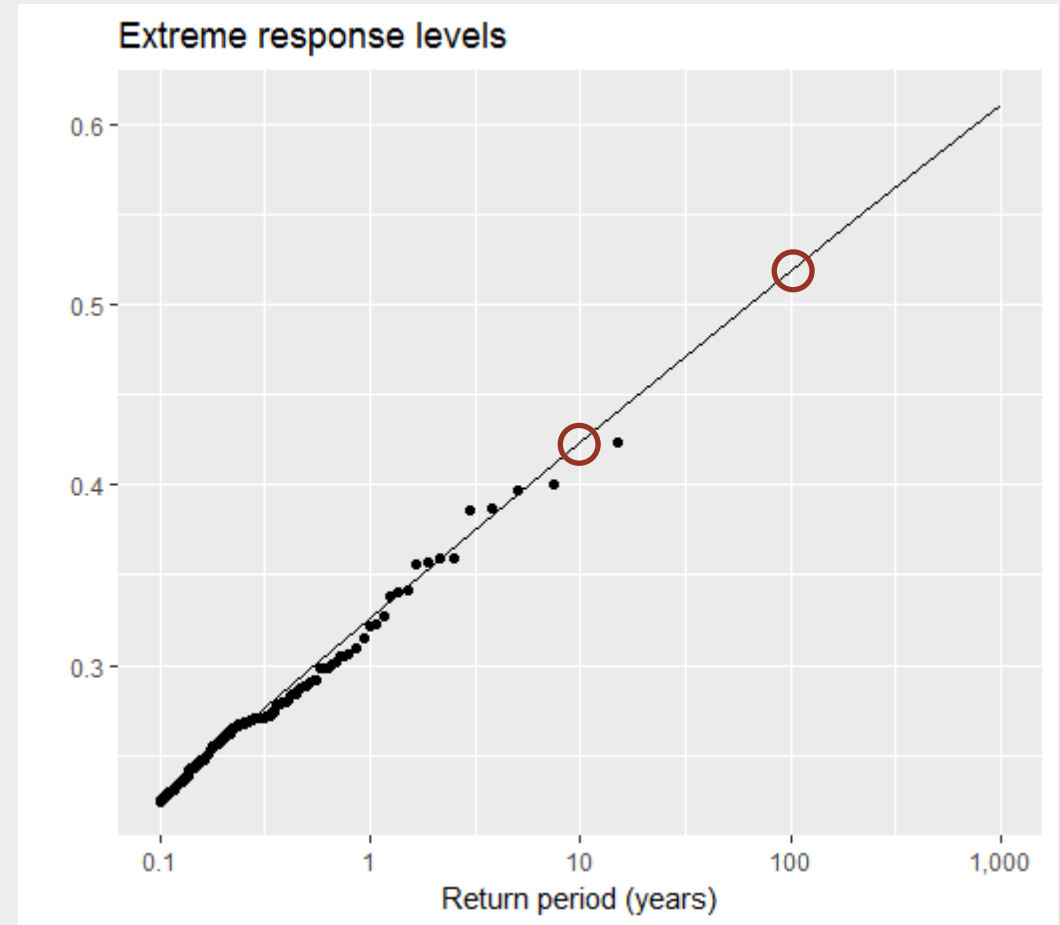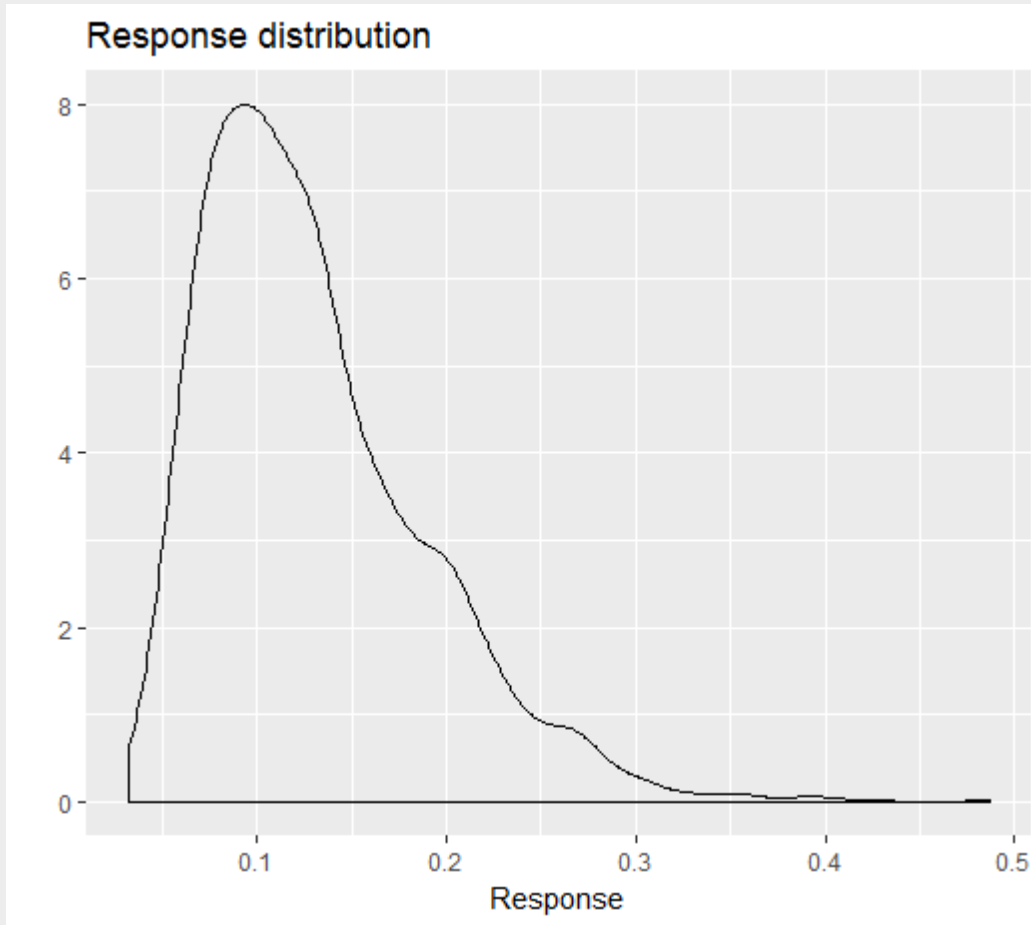- An offshore structure with the key response approximated

- Driving variables are wave height (Hs) and period (Tp)

- Input data cover 2,000 storms over 15 years

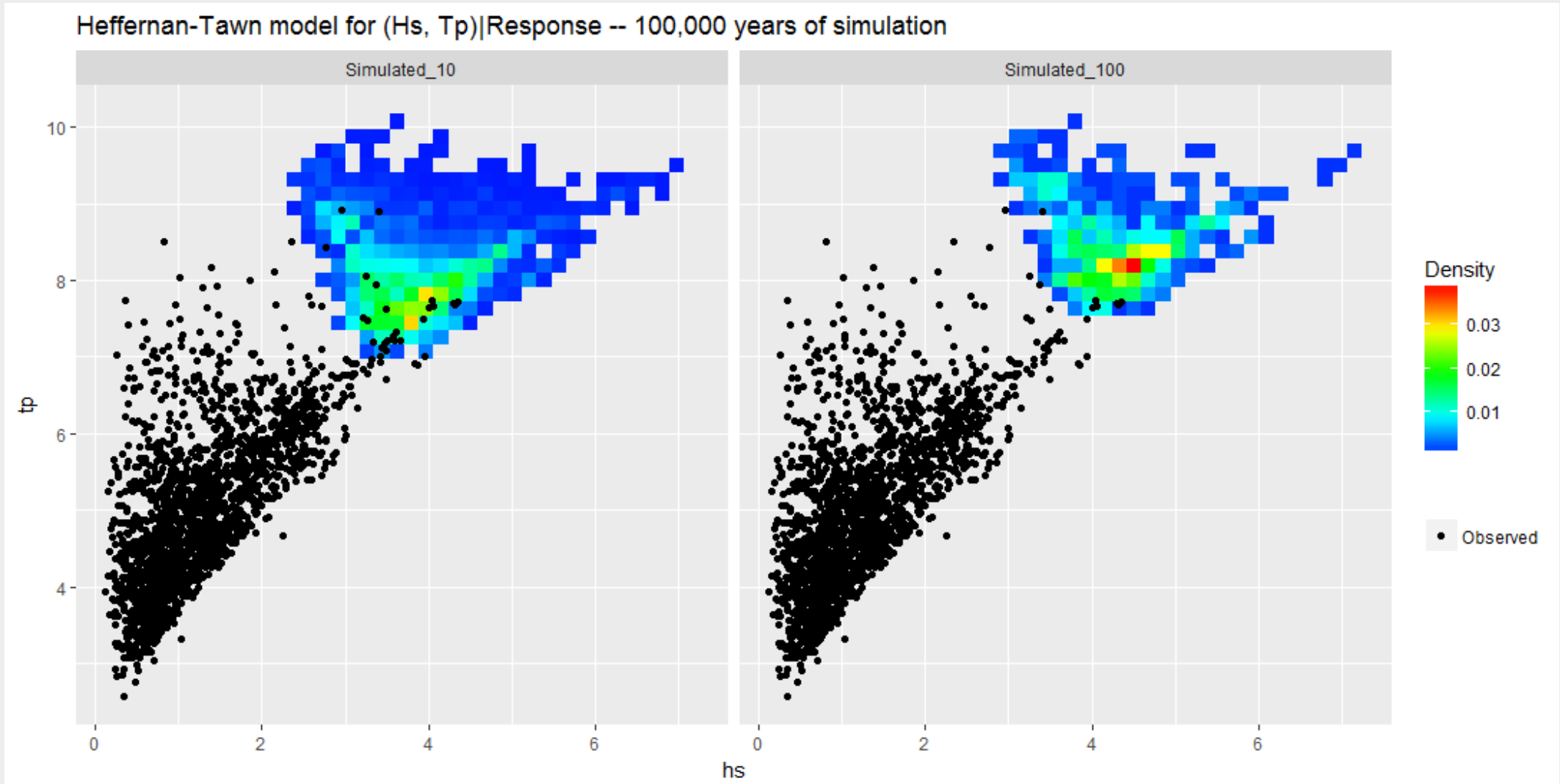- Need distribution for Hs/Tp when the response is above 10- and 100-year level

Example A – response analysis

Peaks-over-threshold model

Example A – conditional simulation

Heffernan-Tawn model for (Hs, Tp)|Response -- 100,000 years of simulation
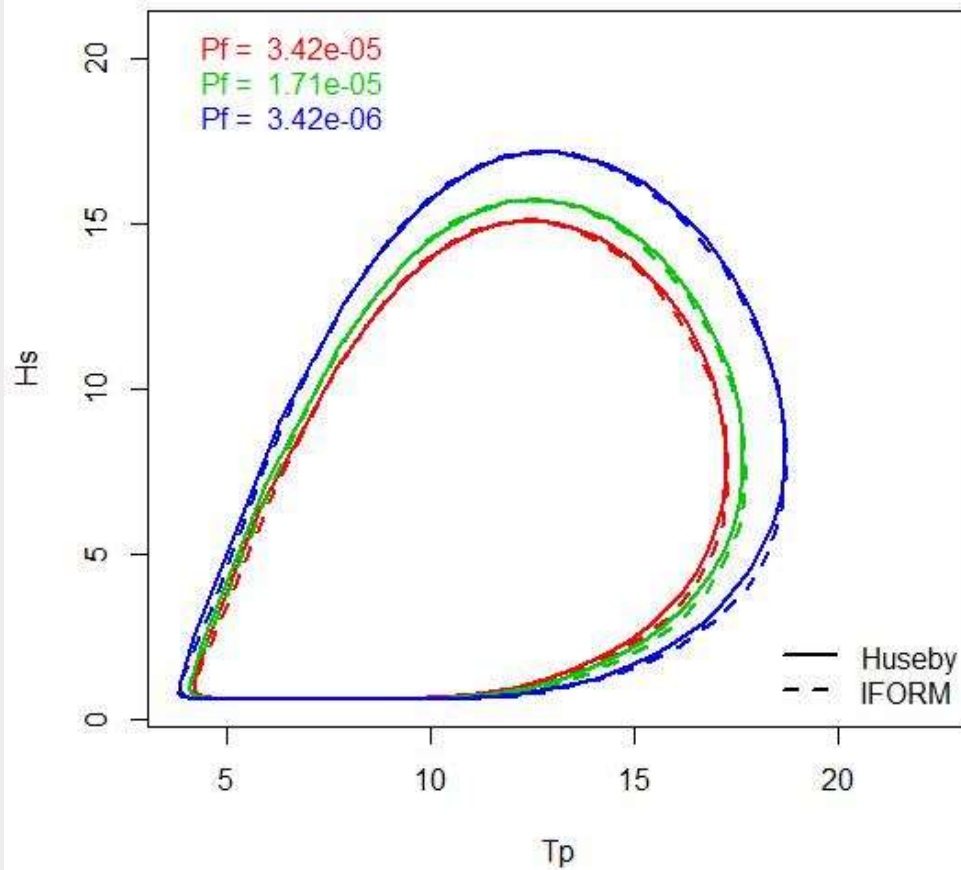
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Erik Vanem (2017) A comparison study on the estimation of extreme structural response from different environmental contour methods, Marine Structures, 56 (2017), 137-162.
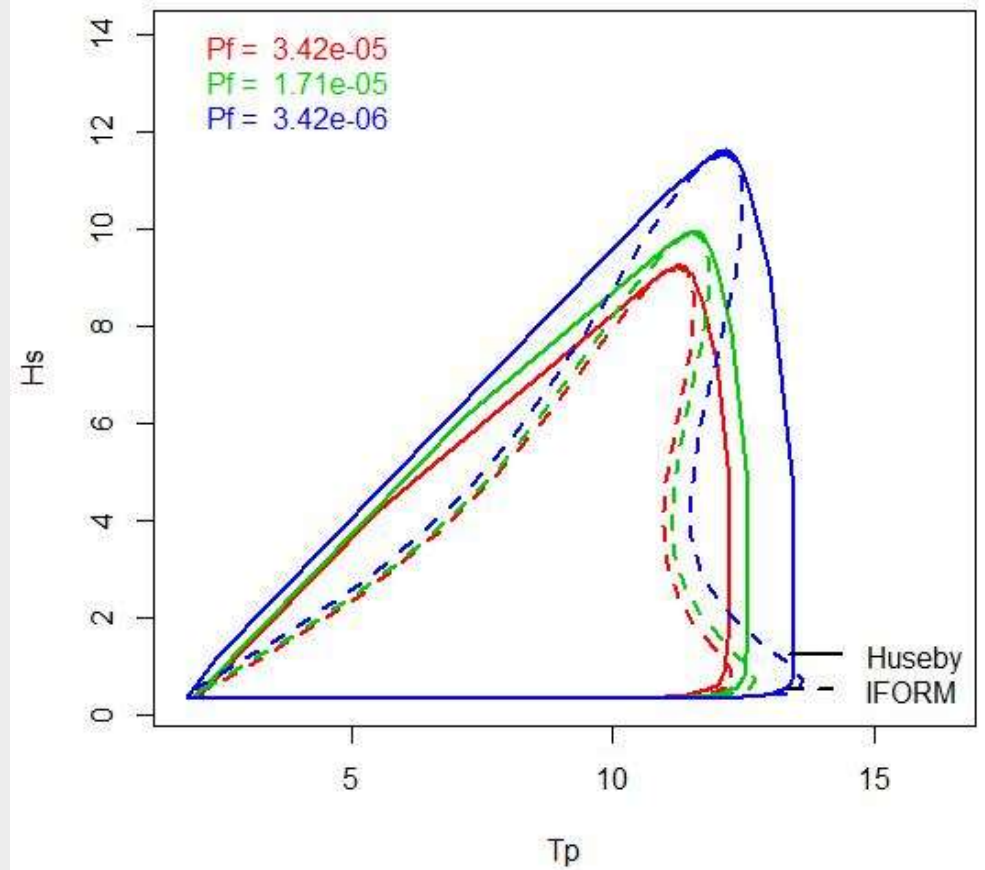

- ■ IFORM vs direct-sampling
- ■ Four offshore locations
- ■ Hs, Tp joint distribution

Example B – sample outcome

Thanks. Questions?

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