Comparing Extreme Wave Estimates from Hourly and Annual Data

Steven R. Winterstein
Civil & Environmental Engineering Department,
Stanford University, USA

Gudmund Kleiven
Norsk Hydro, Bergen, Norway

Øistein Hagen
Det Norske Veritas, Høvik, Norway

To be presented, ISOPE 2001
Paper No. 2001-IL-30. Stavanger

Basics:

Data:

Significant wave height $H_s(t)$=4$\sigma_\eta(t)$

$H_s(t)$ measured in Northern North Sea, every 3 hours

Continuous $H_s(t)$ measurements for

$\approx$ 18 years (base case)

$\approx$ 26 years (extended case)

Care about:

h_{100} = 100-year value of $H_s(t)$

Approaches:

Keep only annual maxima H_{ann}:

$P[H_{ann} > h_{100}] = .01$

$\rightarrow$ Solve for h_{100}

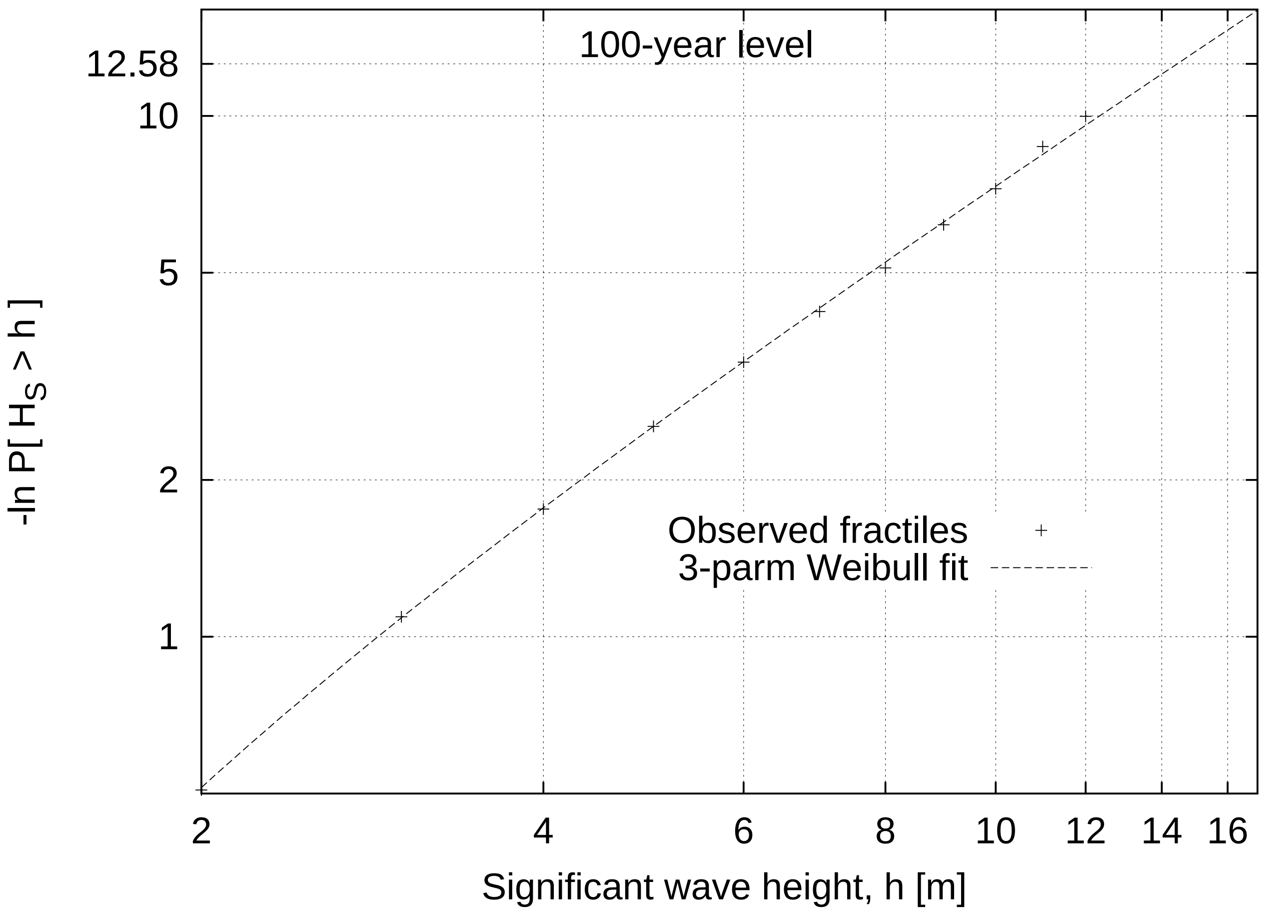
Keep all H_i (N=8 $\times$ 365=2920 per year):

$P[H_i > h_{100}] = .01/N$

$\rightarrow$ Solve for h_{100}

Small Problem: May get different h_{100}'s

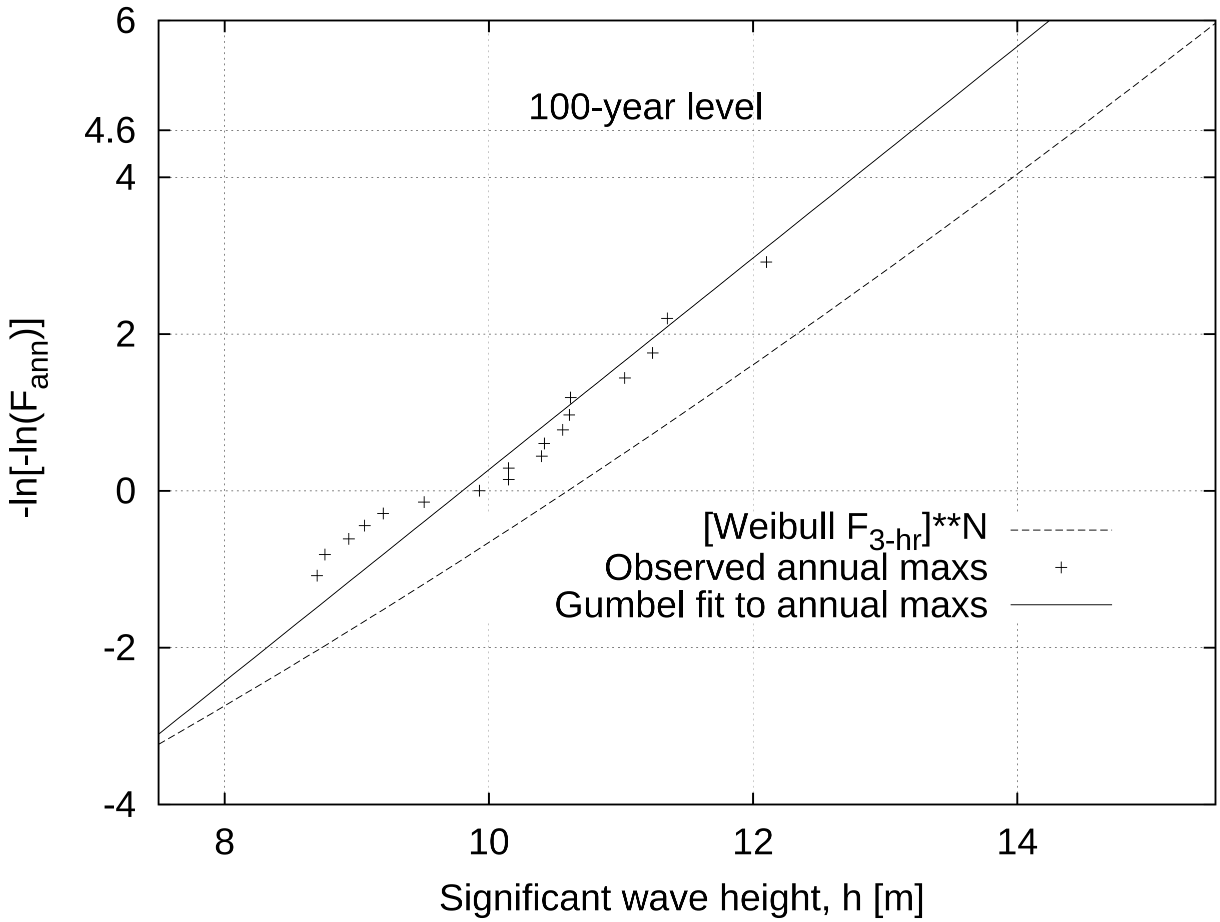
Method 1: All 3-hr H_s



Method of moments used to fit 3-parameter Weibull model to all $H_s(t)$

Result: h_{100}=14.5m

Method 2: annual H_{ann}



$$F_{ann} = \text{ Gumbel model } \rightarrow h_{100} = 13.2\text{m}$$
$$F_{ann} = [\text{Weibull } F_{3-hr}]^N \rightarrow h_{100} = 14.5\text{m}$$

Hypotheses:

Clustering:

All 3-hr H_s data highly correlated

F_{ann}=F^N_{3-hr} assumes independence; tends to overestimate h_{100}

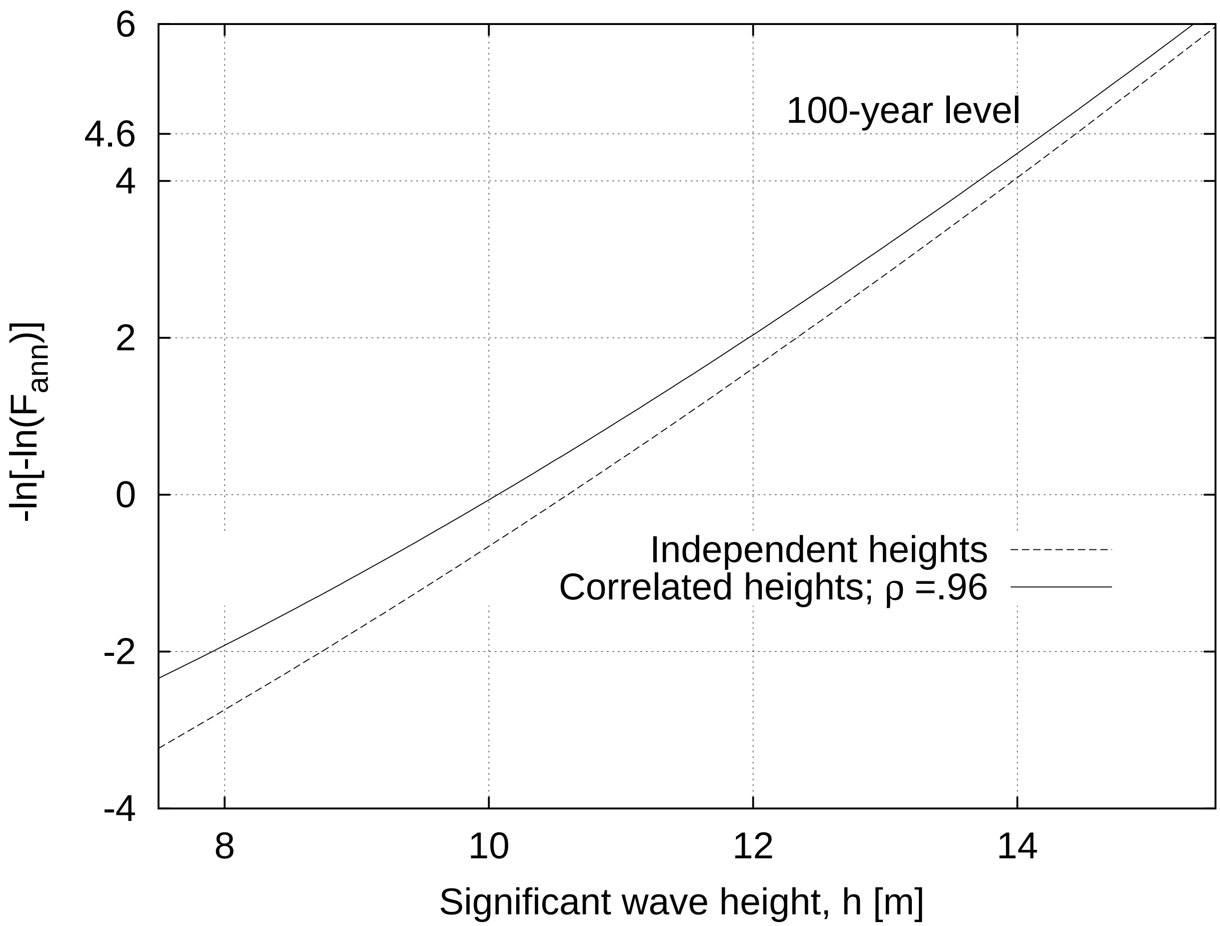
Favors h_{100}=13.2m based on annual maxima

Statistical Uncertainty:

Estimate h_{100}=13.2m based on only 18 maxima; uncertain due to limited sample size

Favors h_{100}=14.5m based on larger data set

Hypothesis 1: Correlation



Correlation coefficient $\rho_{i,i+1}$=0.96

Nonetheless, h_{100}=14.2m (reduces by only 0.3m)

Hypothesis 2: Uncertainty

Prediction of h_p=p-th fractile:

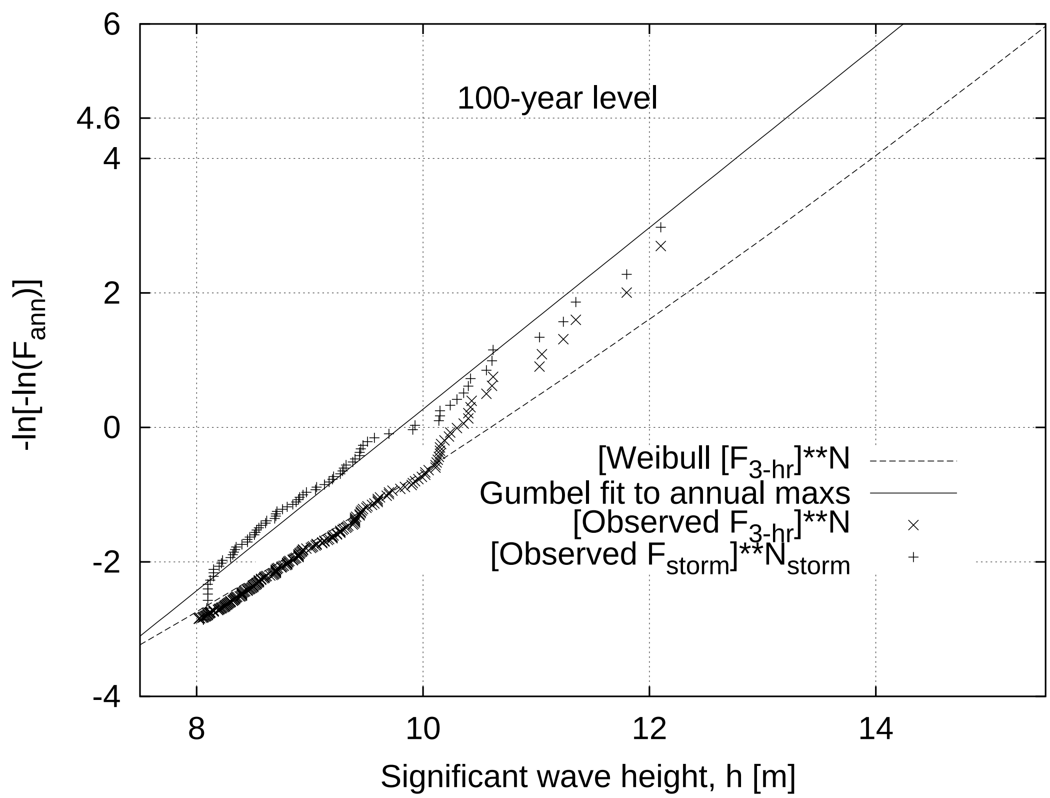
$$h_p = \mu_H + k_p \sigma_H$$

General case:
Var$[h_p] = \frac{\sigma_H^2}{n}[1 + k_p^2(\frac{\alpha_4 - 1}{4}) + k_p \alpha_3]$

Gumbel case:
p=.99, k_p=3.16, α_3=1.4, α_4=5.4
Var$[h_p]$ = [0.9 m]^2

Difference:
14.5-13.2=1.3 = 1.4 std devs
(somewhat unlikely)

Consider all ordered data



F_{ann}=[Observed $F_{3-hr}]^N$ if independent

Data diverge from Weibull fit above $\approx$ 10m

Supports benefits of fitting tails, peak storm values over threshold, etc