Individual Wave Height and Wave Crest distributions

Full scale measurements – North Sea

Background

- Recent JIP's (Crest and ShortCrest) do not firmly conclude on recommended distributions to be used for Wave Heights and Crest Heights
- Both JIP's agree that further investigations are required
- When estimating extreme waves for platform design, selection of Wave Height distribution and Crest Height distribution is of fundamental importance

- As part of an internal R&D project, Statoil has studied measured wave data that facilitates analysis of Individual Wave Heights and Crest Heights

- The initial results from this work is presented herein

Content

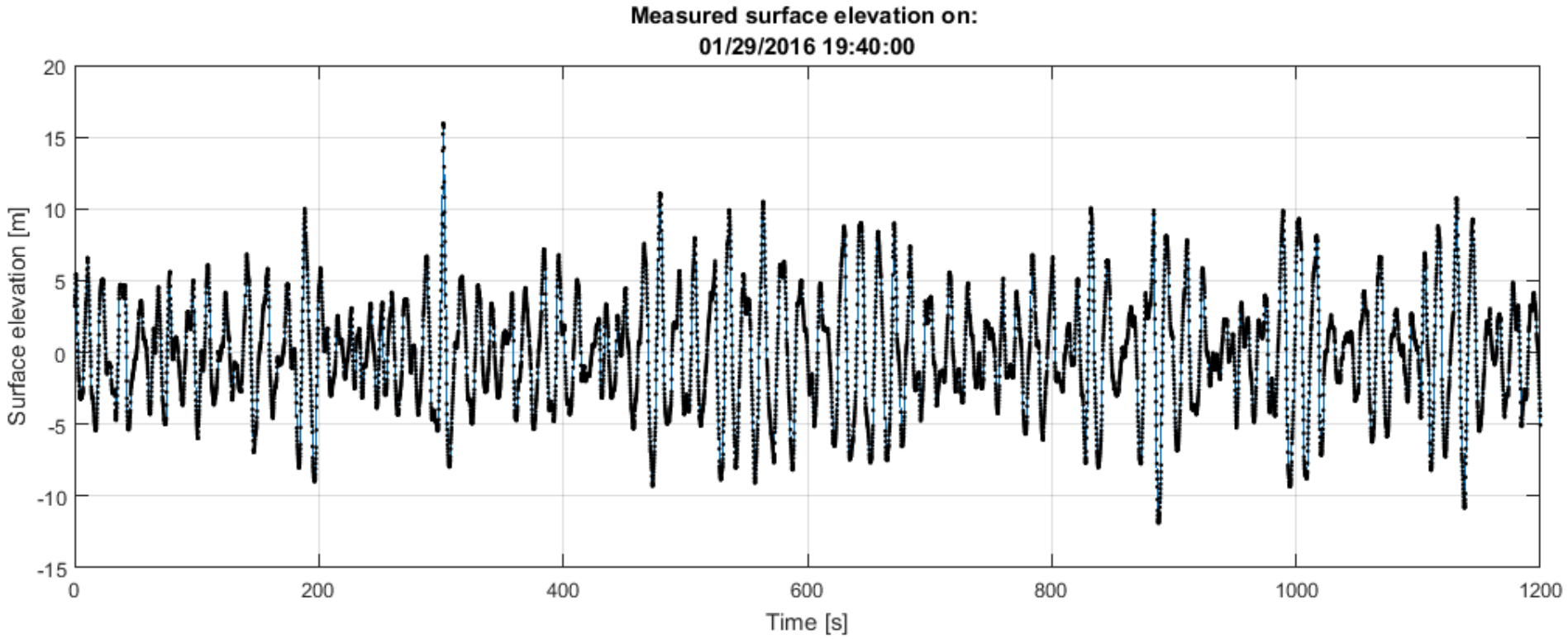
- Data Sources
  - WaveRadar REX
  - Wavescan Buoy
- Compare data from the two sources
- Distributions from WaveRadar REX
- Distributions from Wavescan Buoy
- Summary

Data Sources (1/2)

- WaveRadar REX (SAAB/Rosemount)
  - Measures distance to the water surface
  - One location (North Sea)
  - Water depth 190 m
  - Installed since 2004
  - 20 min sea states
  - A total of 182,646 sea states (~7 years)
  - Output every 20 min
  - 7.68 Hz sampling rate (9216 values per sea state)

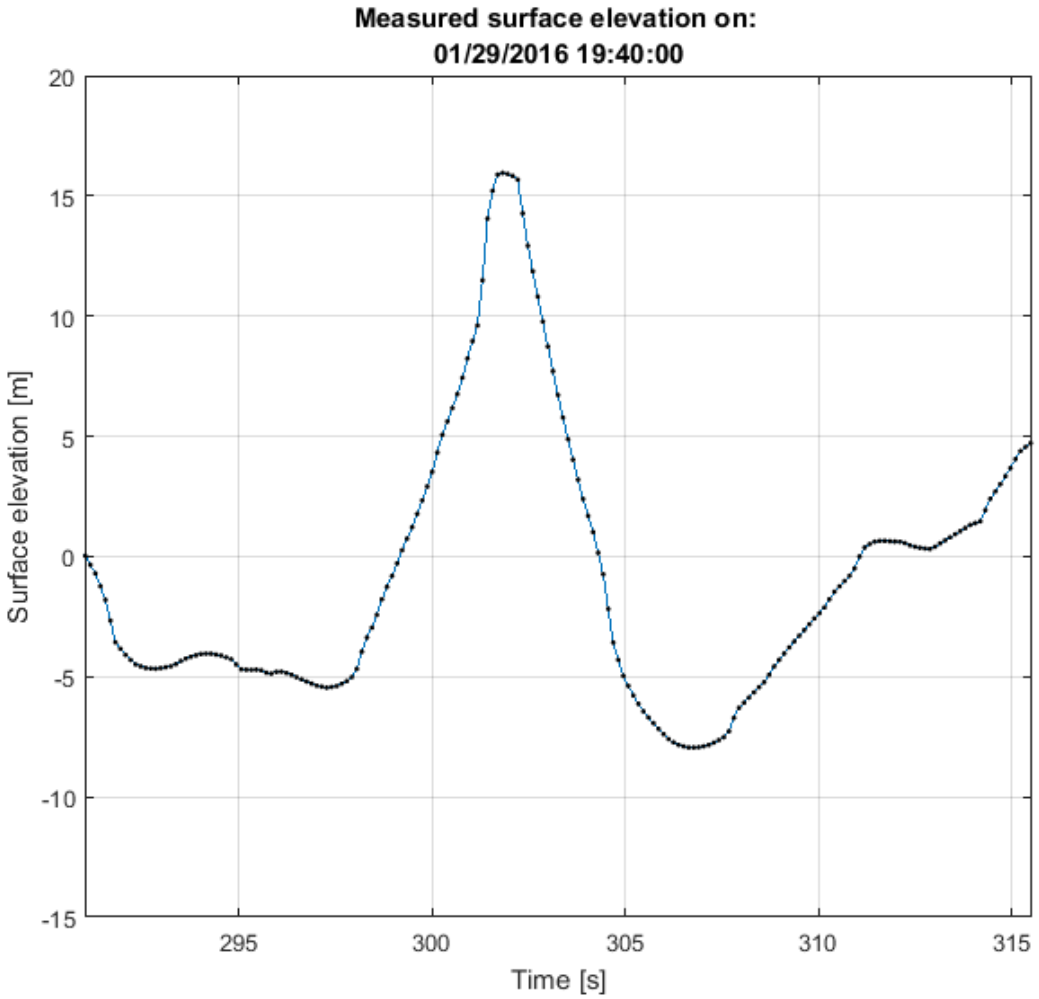
Data example from WaveRadar

- H_S 15.6 m
- Hmax 23.9 m



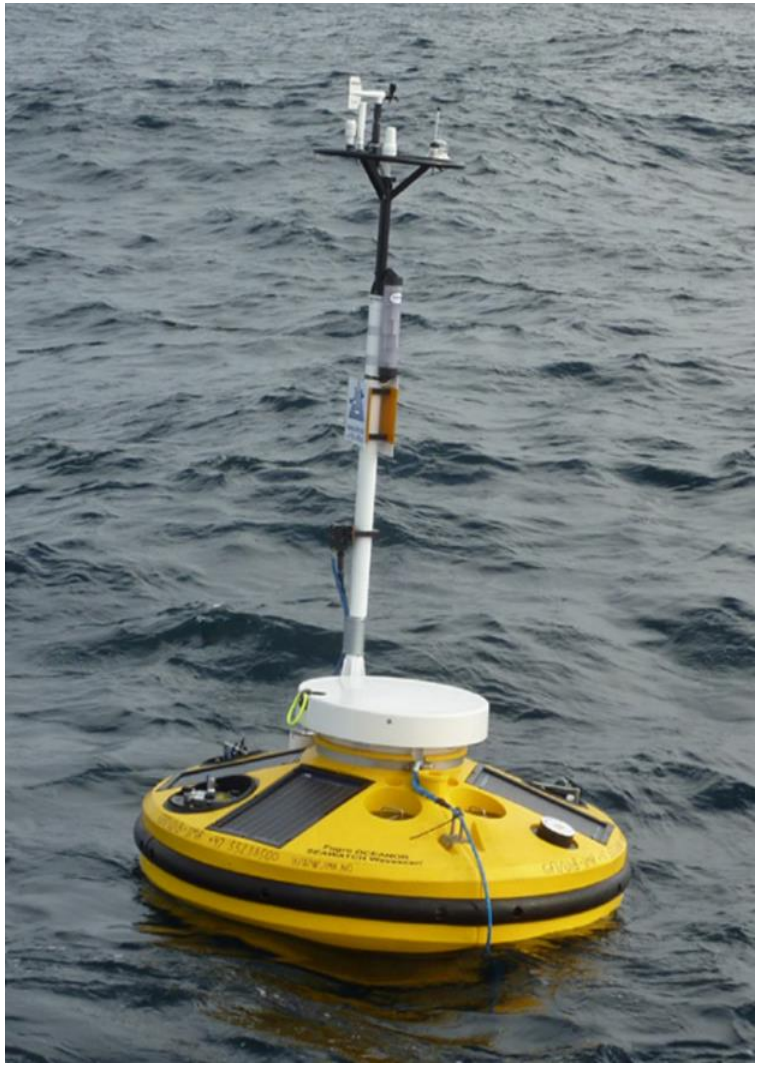
Data example from WaveRadar

- H_S 15.6 m
- Hmax 23.9 m



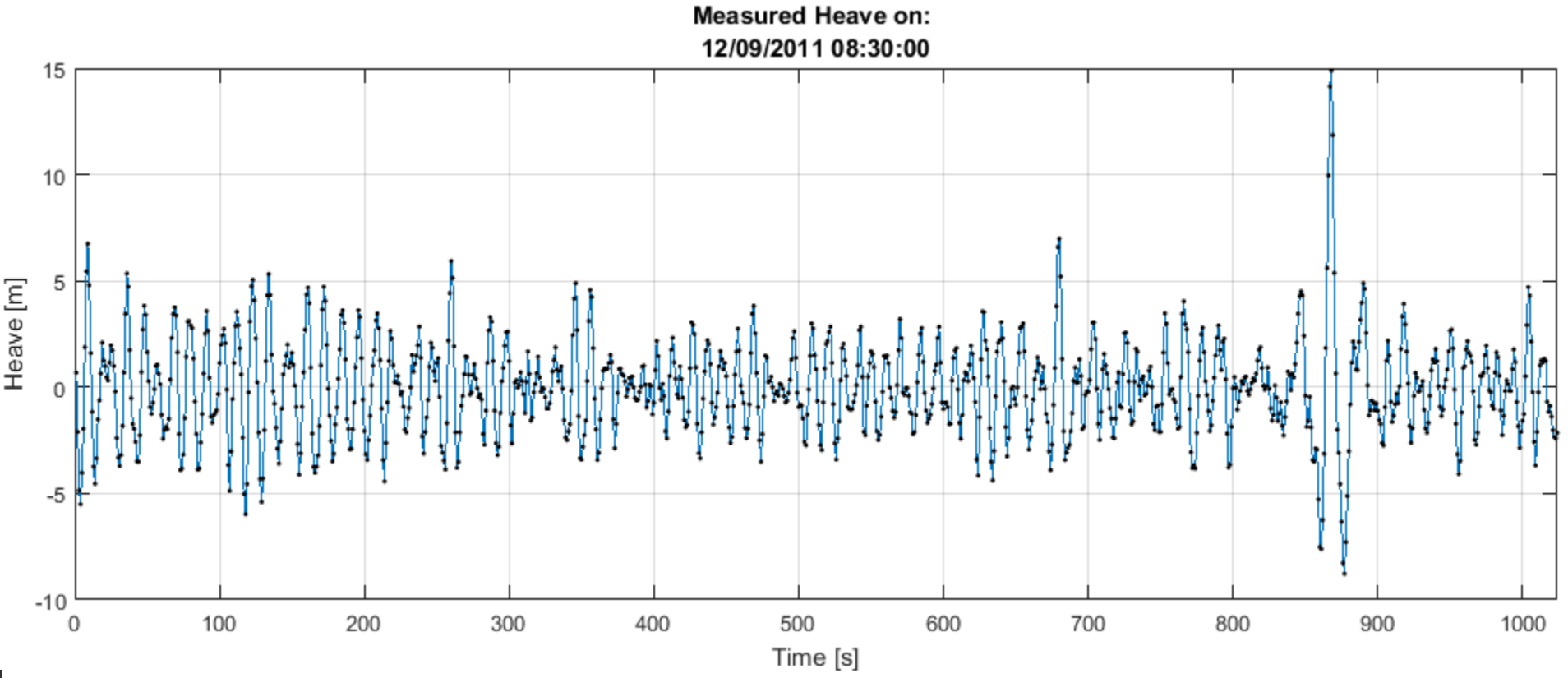
Data Sources (2/2)

- Wavescan Buoy (Fugro Oceanor)
  - Measures vertical acceleration
  - Five locations (North Sea)
  - Water depths between 100-190 m.
  - Installed in period 2011-2015
  - 17 min sea states
  - Output every 30 min
  - A total of 260,000 sea states (~15 years)
  - 1 Hz sampling rate (1024 values per sea state)



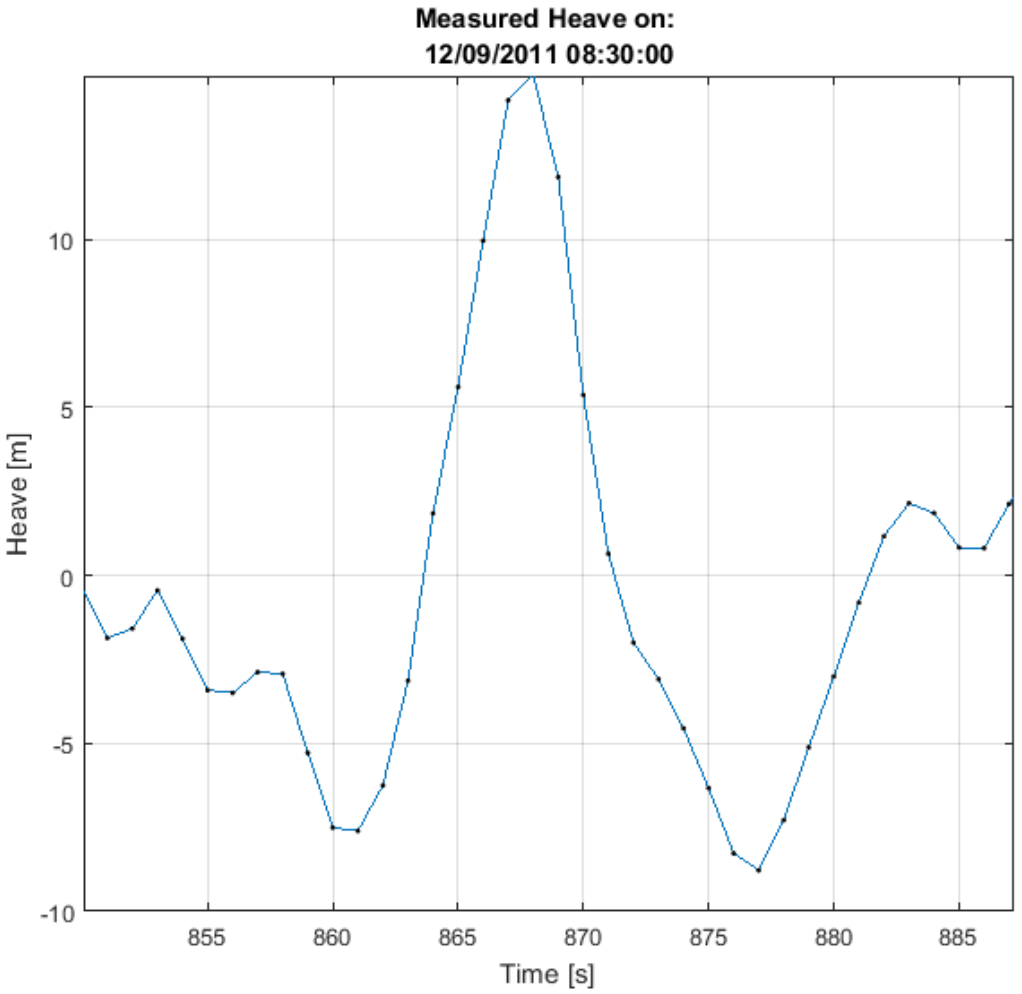
Data example from Wavescan Buoy

- H_S 9.0 m
- Hmax 23.7 m

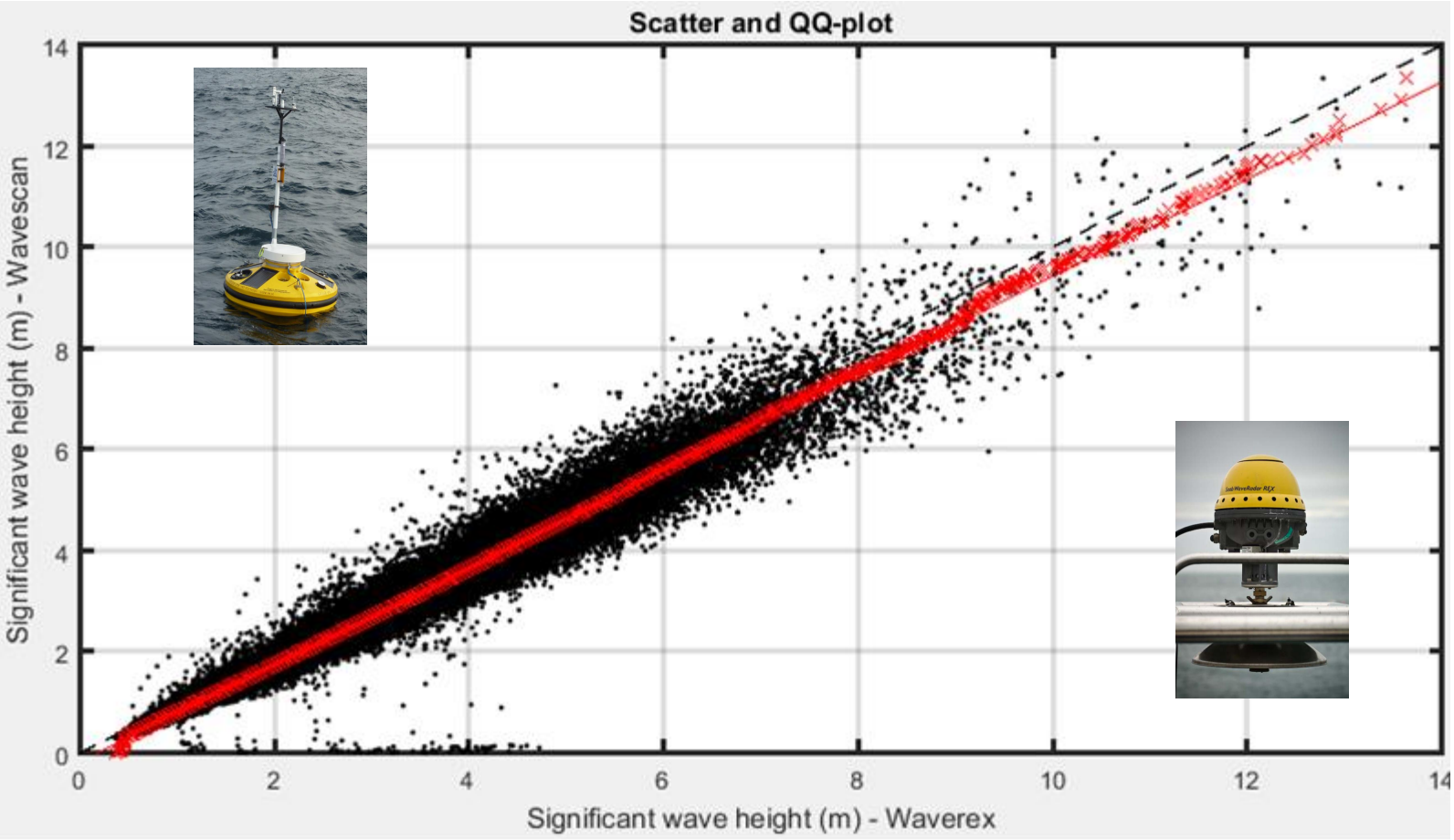


Data example from Wavescan Buoy

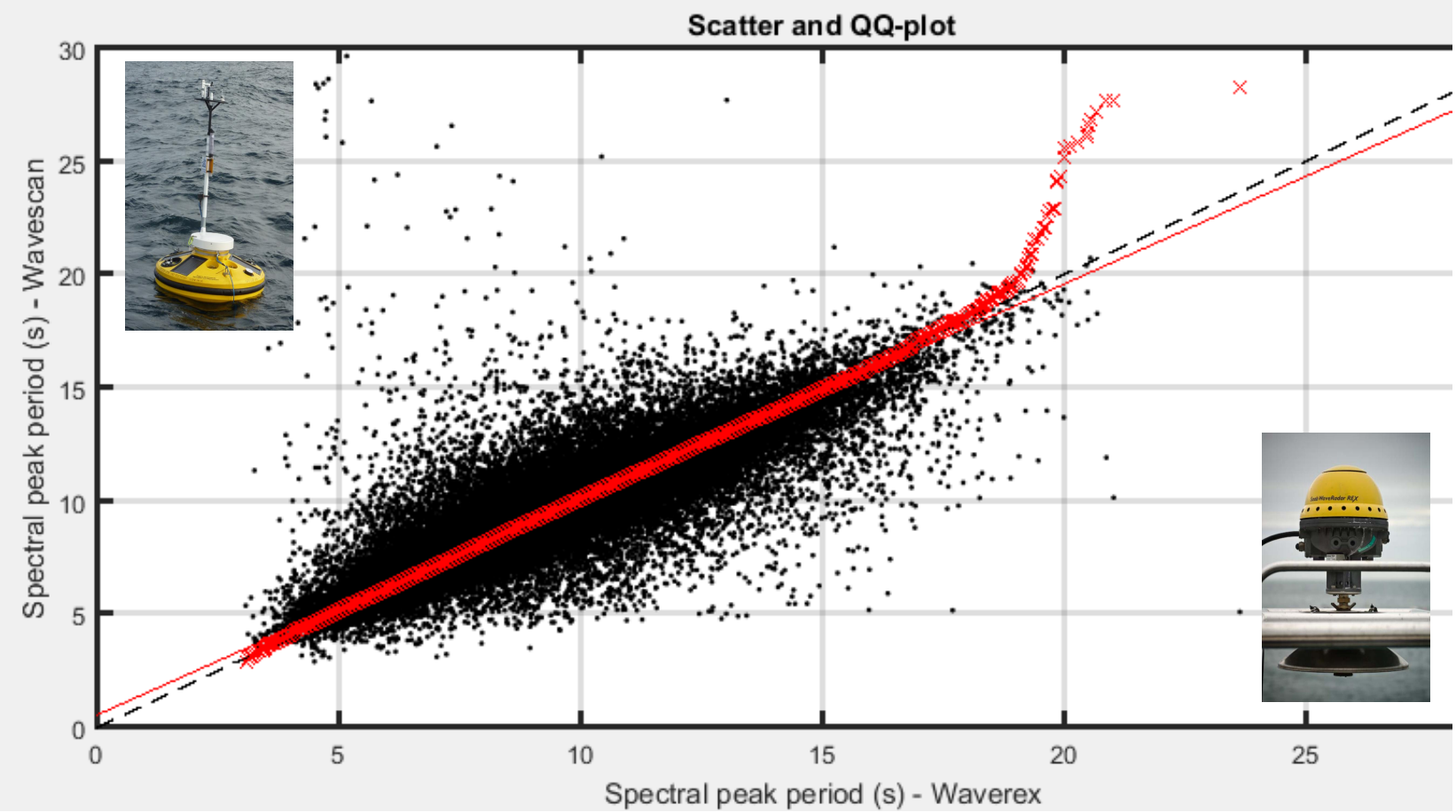
- H_S 15.6 m
- Hmax 23.9 m



Comparison – Significant wave height



Comparison – Spectral peak period



WaveRadar REX

Wave Height

Crest Height

WaveRadar REX

Wave Height

Crest Height

WaveRadar REX

Wave Height

Crest Height

WaveRadar REX

Wave Height

Crest Height

WaveRadar REX

Wave Height

Crest Height

WaveRadar REX
Crest sensitivity to Steepness

Crest Height Distribution

Hs>6m and Steepness < 5%

Crest Height Distribution

Hs>6m and 5% < Steepness < 7%

Crest Height Distribution

Hs>6m and Steepness > 7%

Wave Height Distribution Wavescan Buoy

H_S > 0m

H_S > 6m

Change normalization parameter

- Ratio of H_S / $H_{1/3}$ in WaveRadar data is ~1.06
- Subsampling WaveRadar data to 1Hz increases the ratio (but not H_S)
- Ratio of H_S / $H_{1/3}$ in Wavebuoy data is ~1.10, dependent on sea state and converges toward 1.06 in high sea states
- Instead of normalizing the individual wave heights from the buoy with H_S, we normalize it by 1.06* $H_{1/3}$

Wave Height Distribution Wavescan Buoy

H_S > 0m

H_S > 6m

Crest Height Distribution – Wavescan Buoy

H_S > 0m

H_S > 6m

Total Wave Height Distribution

Summary

- The surface elevation data from WaveRadar REX, with high sampling rate, seems to be of very high quality and only limited QC is required
- The heave data from buoy, with 1 Hz sample, requires comprehensive and subjective QC
  - Low sampling frequency hampers the quality of the wave and crest heights
  - In addition, the crest heights are underestimated due to the Lagrangian motion of the buoy in the crest (cancelling out 2nd order effects)
- The data shows excellent agreement with Forristall distributions for both Wave and Crest Heights
- Higher order crest effects are identified in some sea states including some severe sea states. In other severe sea states, second order effects are cancelled out
- Overall, the data supports the assumption of a second order crest distribution when performing a long term analysis

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