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What is H_{m0}? – Comparison of various measuring devices, validation in practice and discussion on wave height distribution

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Motivation

The motivation for this study was to clarify:

- How does measured wave heights compare?
- What is the impact on model validation (H_{m0})?
- What are the consequence for design (H_{max})?

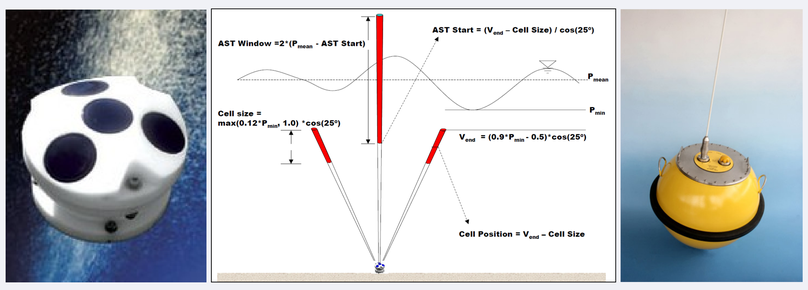
The case arises from a metocean study for an offshore wind farm project in the southern North Sea.

Measuring devices and model data

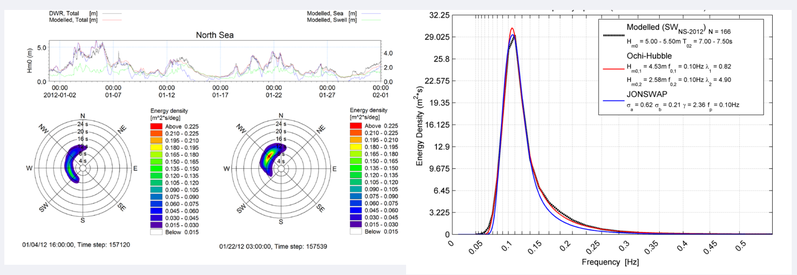
The measuring devices and model data comprised:

- Directional Wave Rider (DWR)
- Acoustic WAve and Current profiler (AWAC)*
- Spectral wave model of the North Sea (MIKE 21)

* Wave heights were based on surface track from a central array shooting straight up. Quality assurance of the data included spike removal and removal of wave data during periods of device misplacement (e.g. tilting).



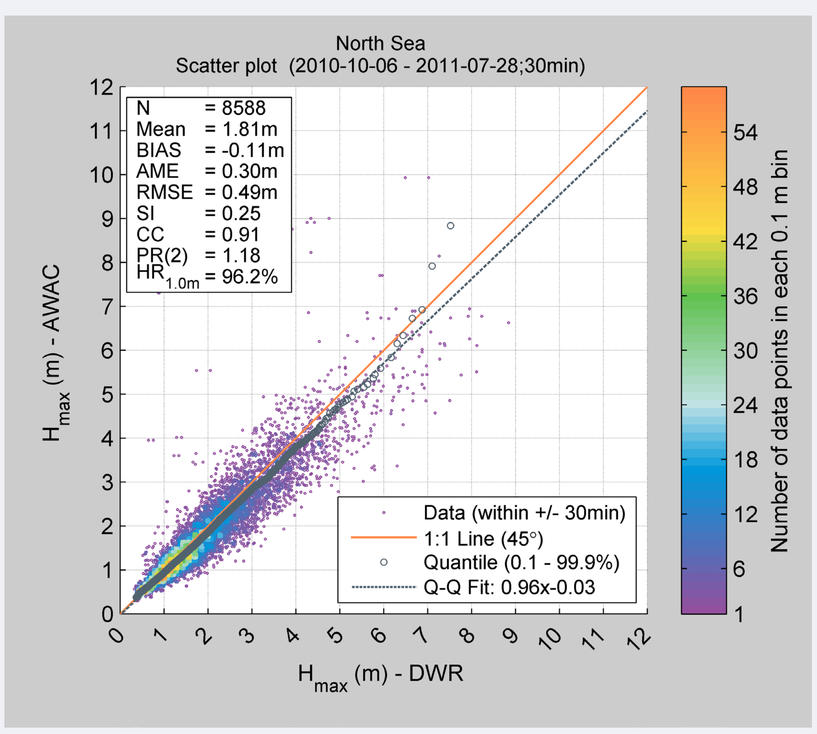
Illustrations of the AWAC ®Nortek and DWR ®Datawell



Examples of modelled frequency-direction spectra

Comparison of H_{max}

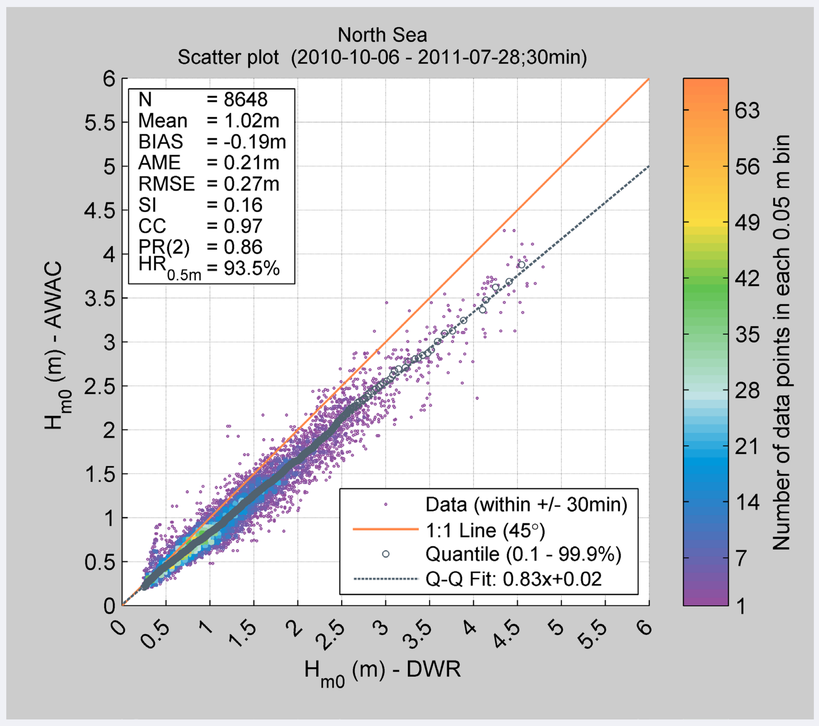
A comparison based on synchronized data of the two measuring devices indicated that the maximum wave heights of the AWAC and DWR agreed fairly well.



H_{max} measured by AWAC (depth 31 mMSL) vs. H_{max} measured by DWR (depth 33 mMSL)

Comparison of H_{m0}

- The significant wave heights measured by the AWAC were on average 19 cm lower than those measured by the DWR during the considered period (~1 year)
- The modelled significant wave heights extracted at the AWAC position were only 6 cm lower than those extracted at the DWR position for the same period
- Hence, accounting for the difference in geographical location, the average H_{m0} was 11 cm or roughly 10% lower for the AWAC compared to the DWR



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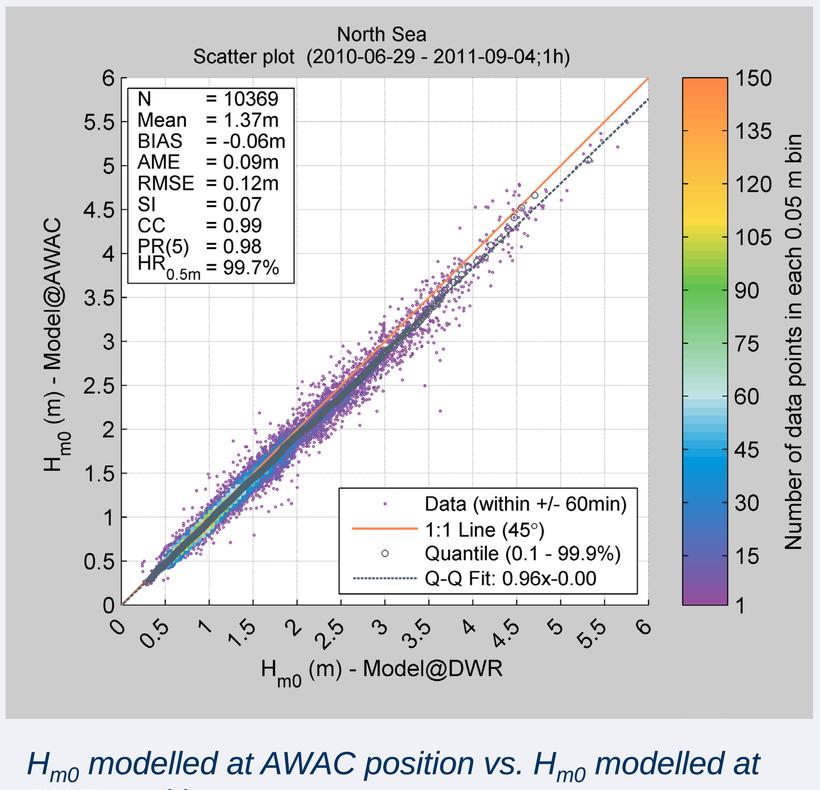


H_{m0} modelled at AWAC position vs. H_{m0} modelled at DWR position

- Similar deviations (~10%) in H_{m0} between AWAC and DWR were seen in an earlier study by DHI (confidential) for a locations with bi-modal seas (occurrence of wind-sea and swell) as well as in earlier studies made by the survey company
- According to personal communication with the provider of the measurements, the difference is most likely a result of differences in the post-processing methodology of H_{m0}

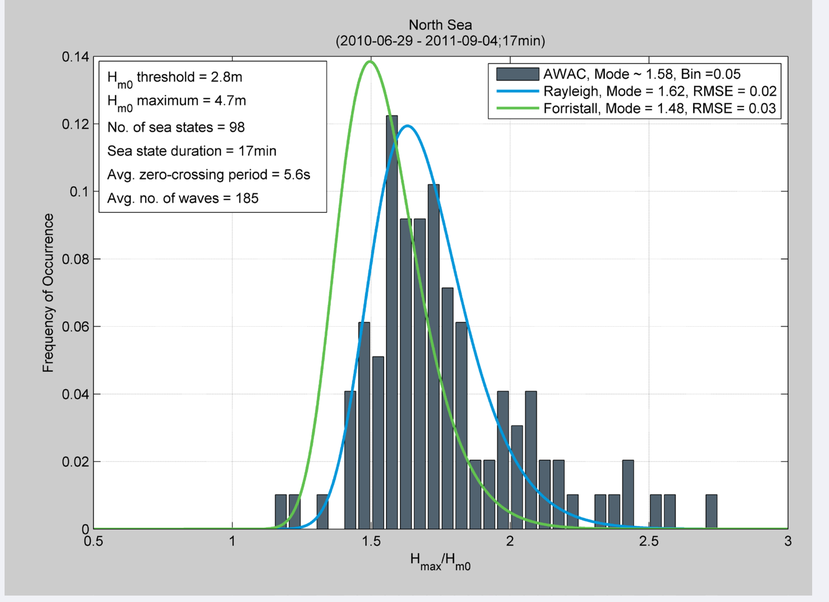
References

[1] Tromans, P.S. and Vanderschuren, L., Response Based Design Conditions in the North Sea: Application of a New Method, OTC 7683, pp. 387-397, 1995.

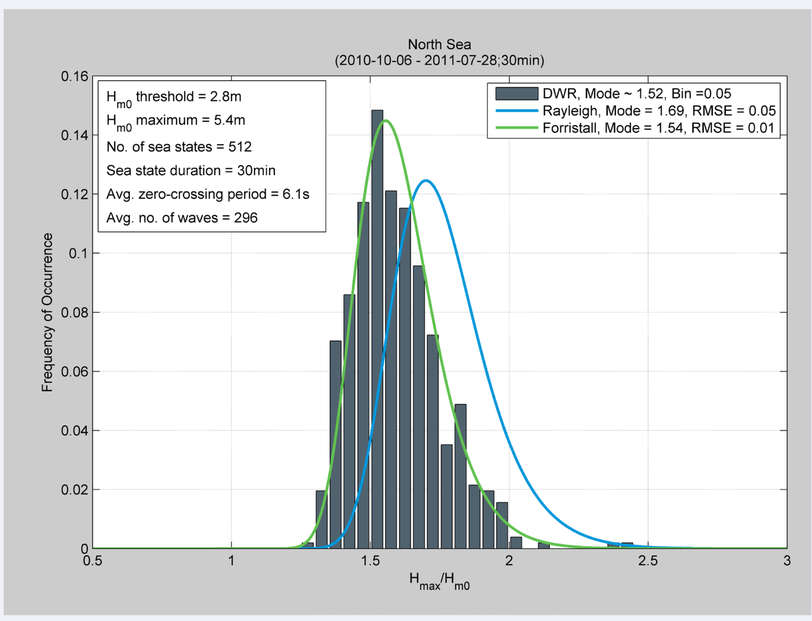
Wave height distributions

For the Rayleigh and Forristall short-term individual wave height distributions, the probability distribution of the extreme wave height (H_{max}), of a given number of events (N), conditional on the most probable value (H_{mp}), is given by, see (Tromans and Vanderschuren, 1995)[1]:

$$P\left(H_{\max} \mid H_{mp}\right) = \exp\left(-\exp\left(-\ln N\left(\left(\frac{H_{\max}}{H_{mp}}\right)^{\beta} - 1\right)\right)\right)$$



H_{max}/H_{m0} distribution of AWAC data for H_{m0} > 2.8m



H_{max}/H_{m0} distribution of DWR data for H_{m0} > 2.8m

An extreme value estimate of $H_{max,100yr}$ based on Forristall was found to be about 10% lower compared to that of Rayleigh, i.e. roughly corresponding to the deviation in H_{m0} between the AWAC and the DWR.

Summary of conclusions

- The average H_{m0} was roughly 10% lower for the AWAC compared to the DWR (unexplained by location), while H_{max} agreed fairly well on average.
- For high sea states, the DWR data conformed to the Forristall wave height distribution while the AWAC data conformed to the Rayleigh distribution – resulting in 10% difference in $H_{max,100yr}$ estimates
- It was not possible to prefer data from one measurements device over the other as there seemed to be no available guidelines or general agreement about the topic (differences are likely related to the post-processing methodologies)
- The modelled H_{m0} had a low BIAS compared to the DWR data (not surprising since significant amounts of DWR data was applied for calibration)

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