GROUP DISCUSSION ON MODELLING OF ENVIRONMENTAL CONDITIONS: OVERVIEW OF SOME CURRENT CHALLENGES IN BASIN WAVE MODELLING

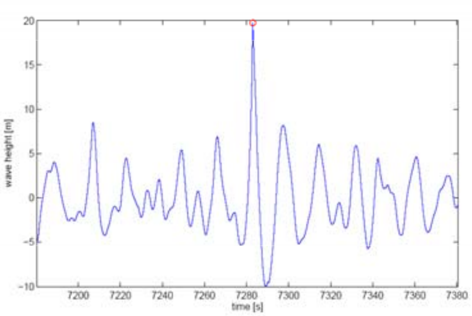
Janou Hennig

AGENDA

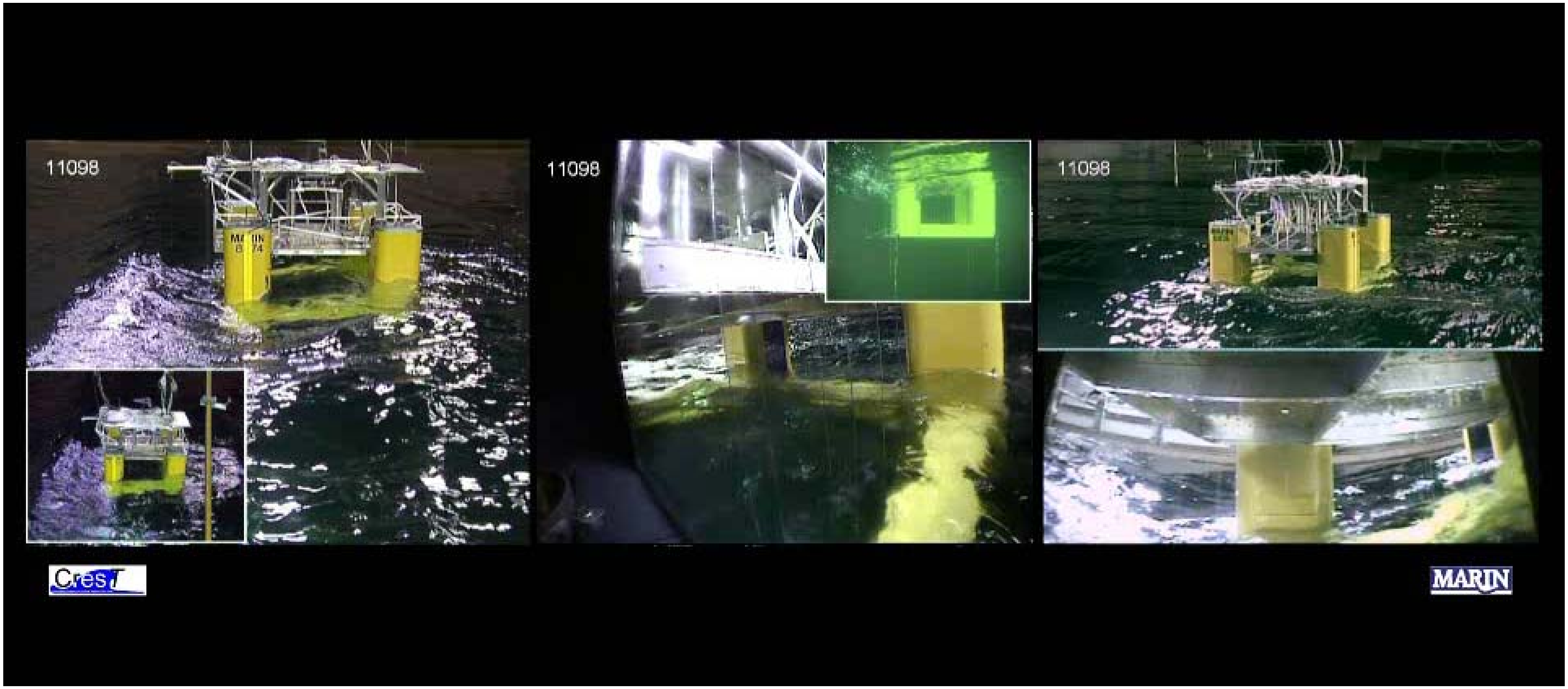
- Overview of some current challenges in basin wave modelling by Janou Hennig
- Modelling Nonlinear Seas – Challenges and achievements: a summary of recent JIP activities by Chris Swan
- Discussion (ca. 45 minutes)

INSIGHTS FROM RECENT INITIATIVES

- “CresT” Joint Industry Project (JIP): Models for realistic extreme (long-crested) waves and a design methodology for loading and response of floating platforms
- “ShorTCresT” JIP: Approaches to account short-crestedness in the design of offshore structures against extreme waves including an empirical design methodology and a tool to predict the largest crest in a given sea state



CREST: EXTREME WAVE-IN-DECK EVENTS ON A TLP



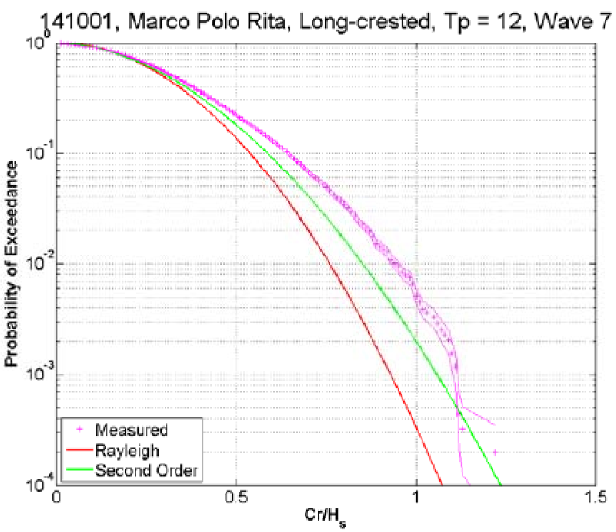
OVERVIEW

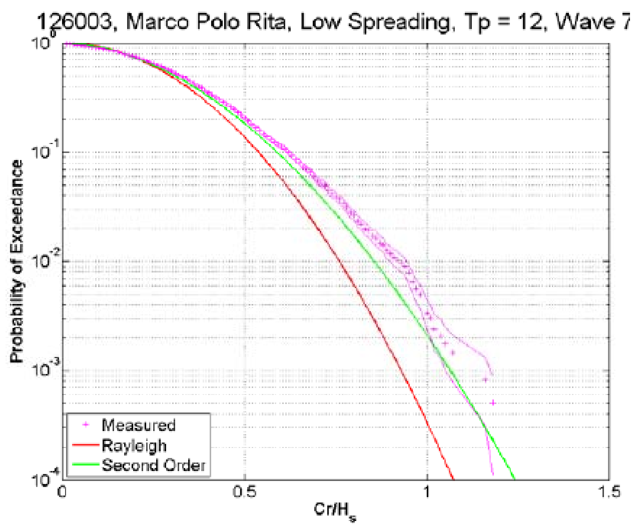
- How large do extreme waves get? Wave crest distributions due to
  - Sea state steepness
  - Wave spreading
- How do basin observations compare to field measurements?
- Calibration of realistically spread seas
- Some remaining challenges

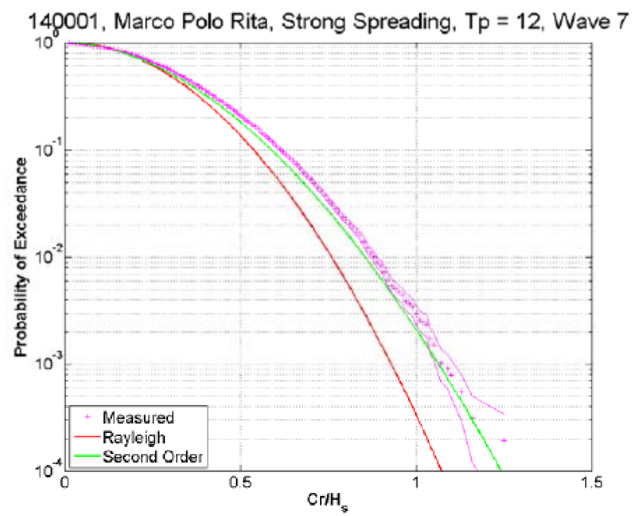
HOW LARGE DO EXTREME WAVES GET?

- Analysis of (a lot of) basin and field wave data
- Wave crest statistics depend on sea state steepness and spreading

- Effect of spreading ($\cos^{2s}$), as measured at MARIN



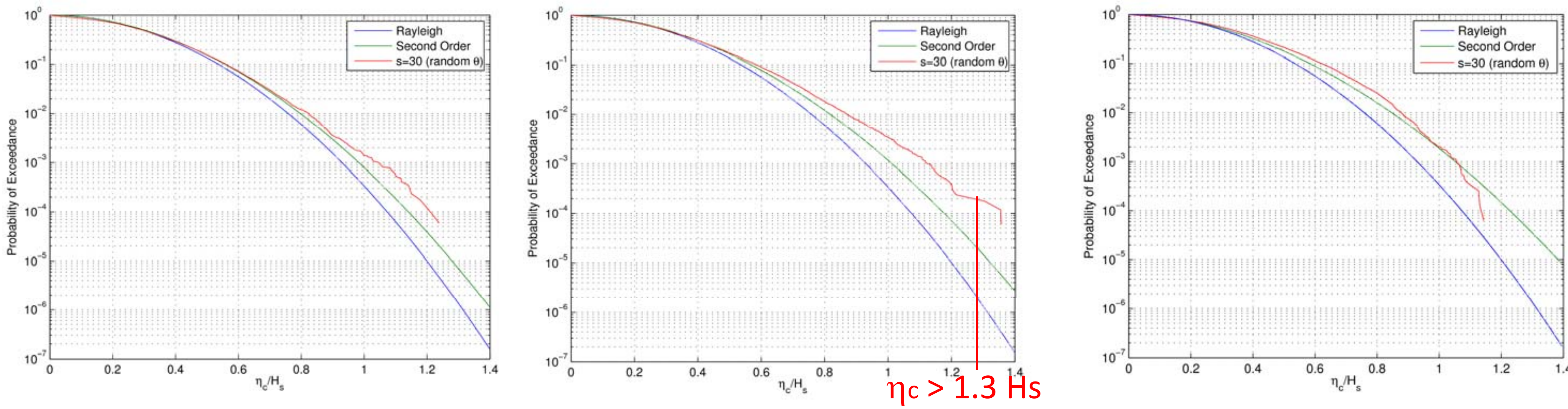




Long crested, low spreading (s=15) and strong spreading (s=4)

HOW LARGE DO EXTREME WAVES GET?

- Effect of sea state steepness (S1), as measured at Imperial College
  - Amplification beyond second order
  - Reductions due to wave breaking



H_s=10 m (S1=3.7%), H_s=15 m (S1=5.6%) and H_s=20 m (S1=7.5%)

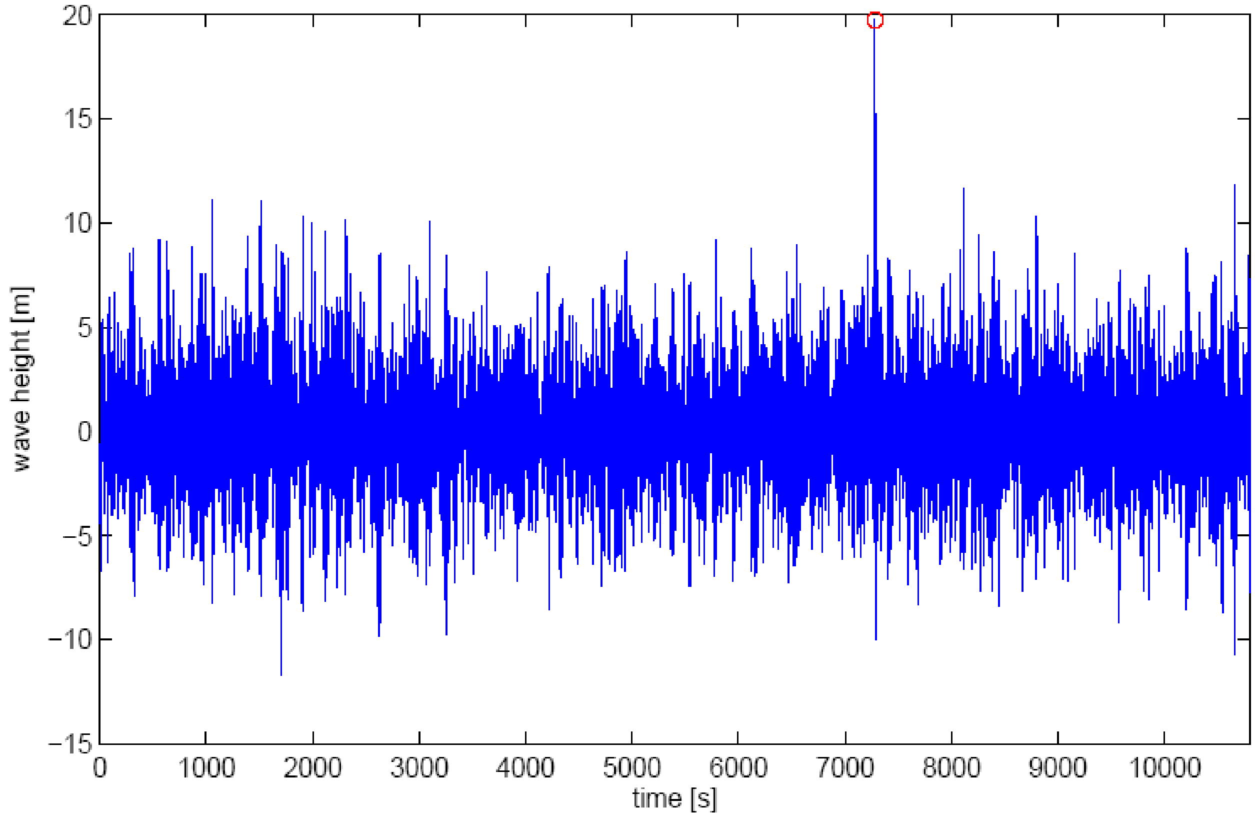
$$S_1 = \frac{2\pi}{g}\frac{H_s}{T_1^2}$$

- Model tests show same extreme waves despite different methods of wave generation and dimensions in different basins

MARIN

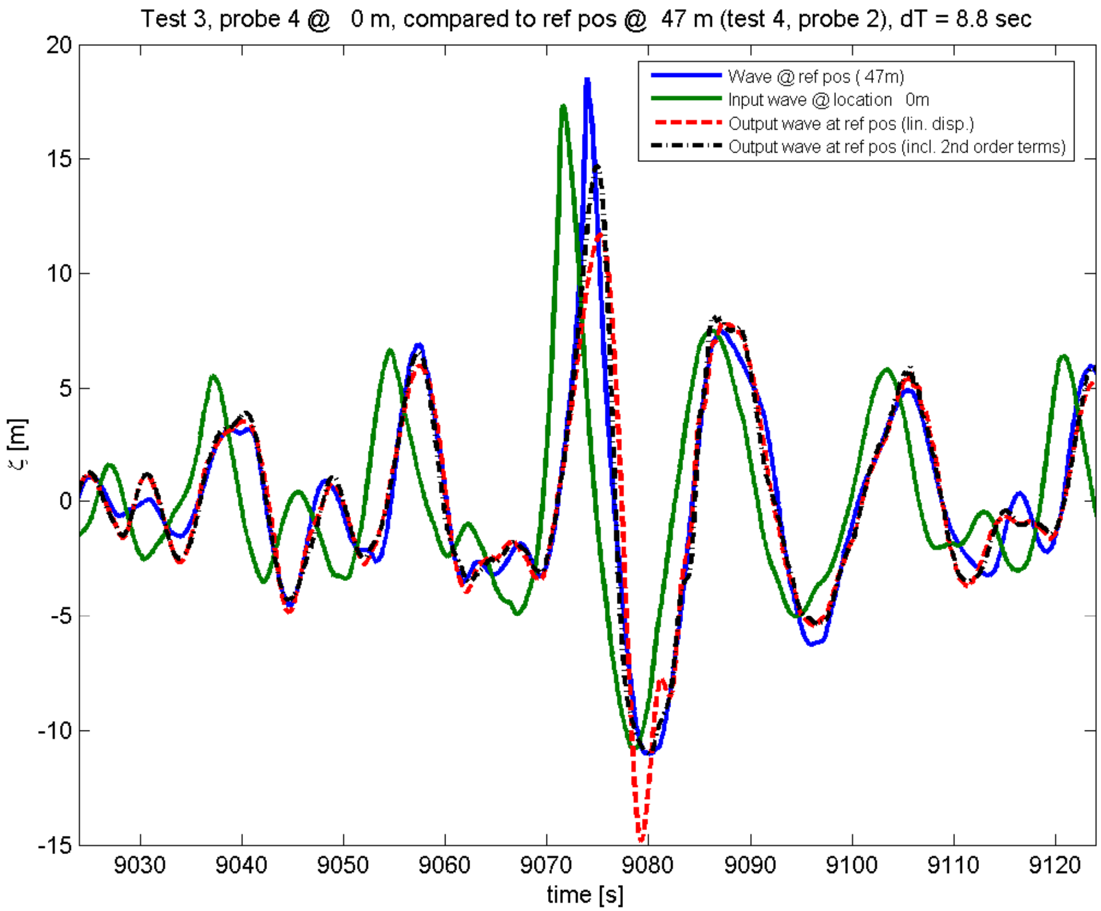
WHY THAT DEVIATION FROM LINEAR AND SECOND ORDER WAVE THEORY?

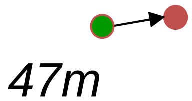
- Analysis of MARIN basin wave suggests involvement of third order effects



Ac/Hs=1.5, Hmax/Hs=2.50

ANALYSIS WITH LINEAR DISPERSION AND 2ND ORDER WAVE THEORY

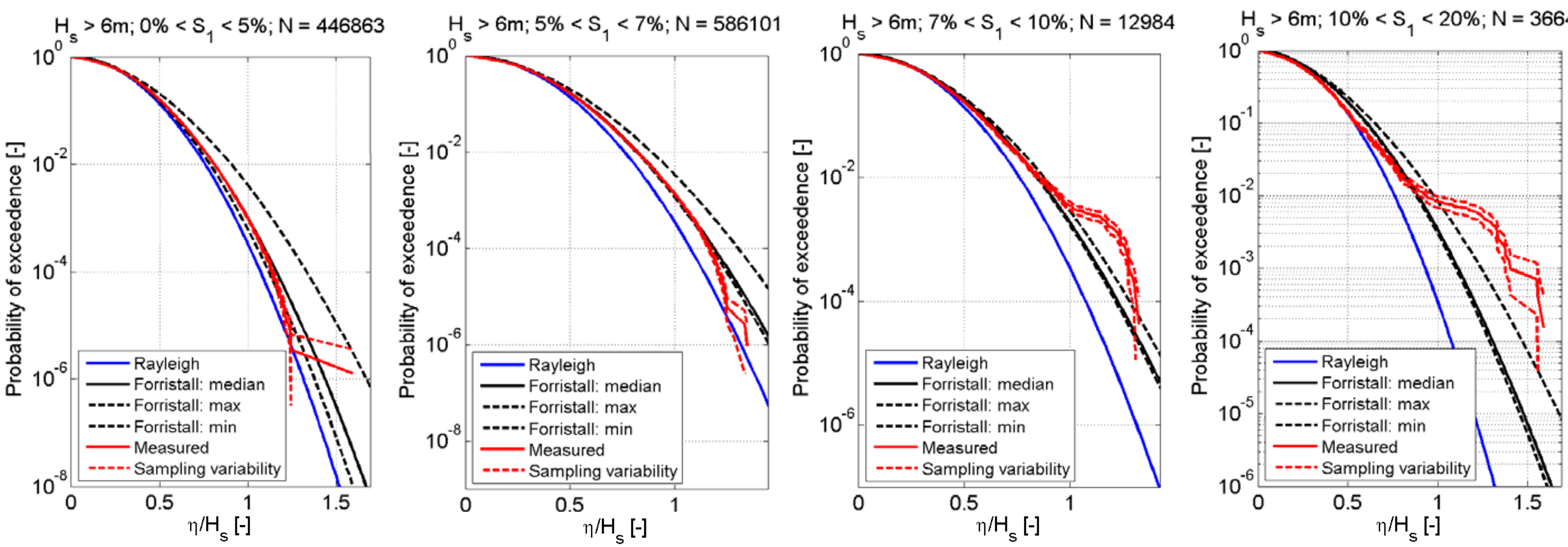




- Strong wave-wave interaction during focusing of underlying wave => wave crest steepening and increase of propagation speed

EFFECT OF SEA STATE STEEPNESS IN FIELD DATA

- Field data confirm basin observations and show similar trends in wave crest distributions due to wave amplification and breaking



$$S_1 = \frac{2\pi}{g}\frac{H_s}{T_1^2}$$

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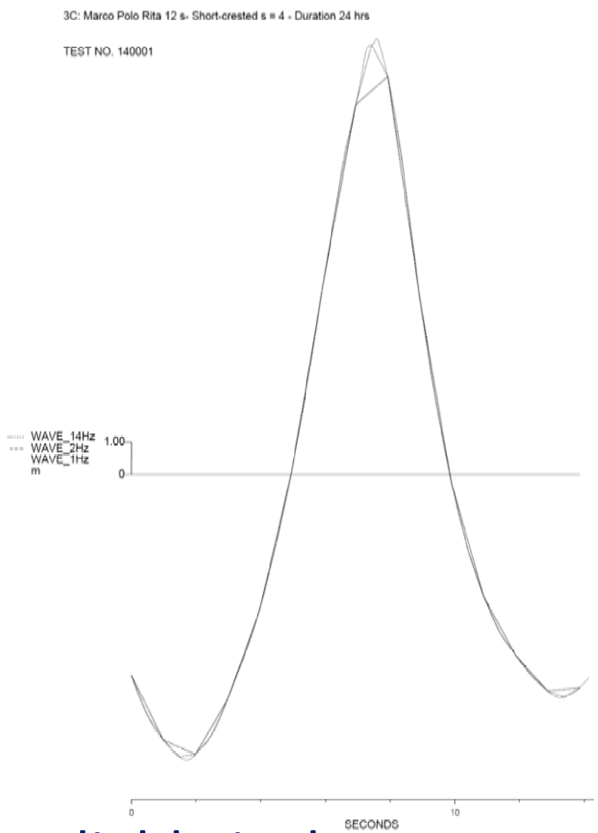
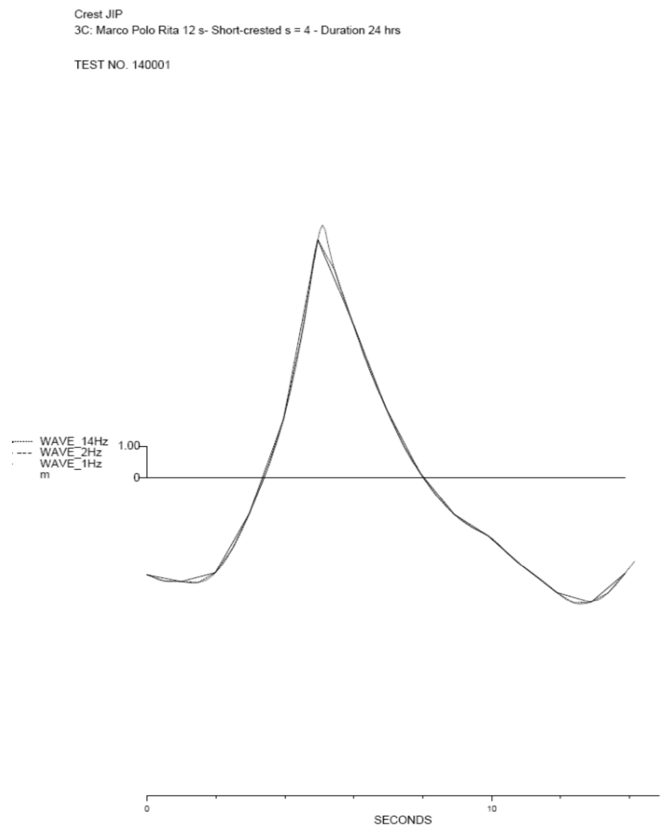
USE HIGHEST POSSIBLE SAMPLING RATE FOR FIELD MEASUREMENTS

- Effects low of sampling rates (14 Hz, 2 Hz, 1 Hz):





- How reliable is the measured field “reality” to be modelled in the basin?

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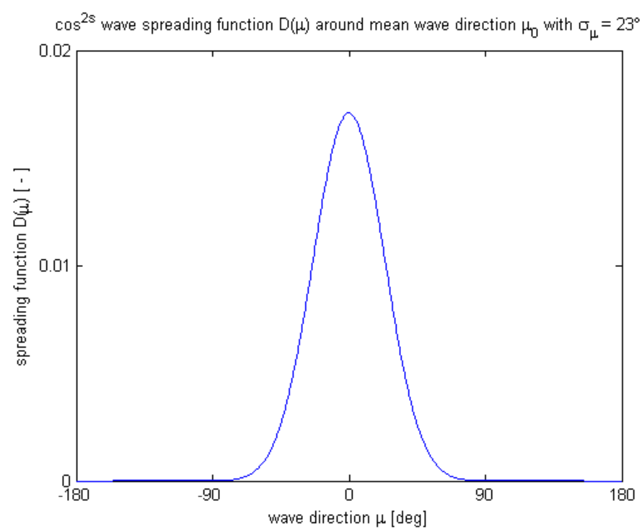
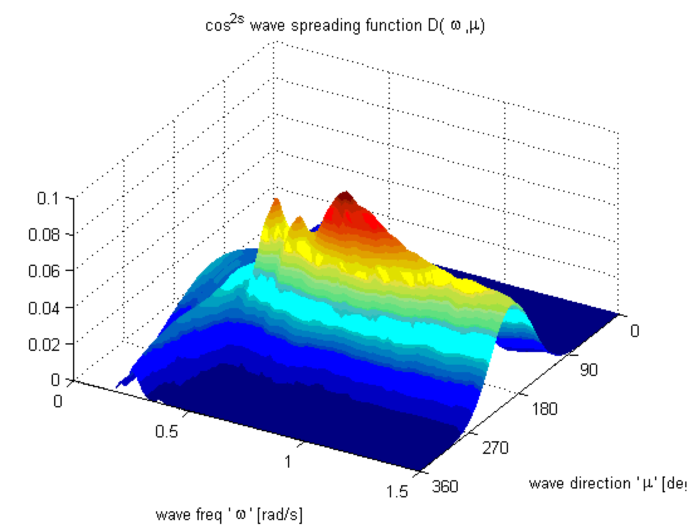
FREQUENCY DEPENDENT SPREADING FUNCTION D (COSINE-2S MODEL) FOR FETCH-LIMITED SEAS



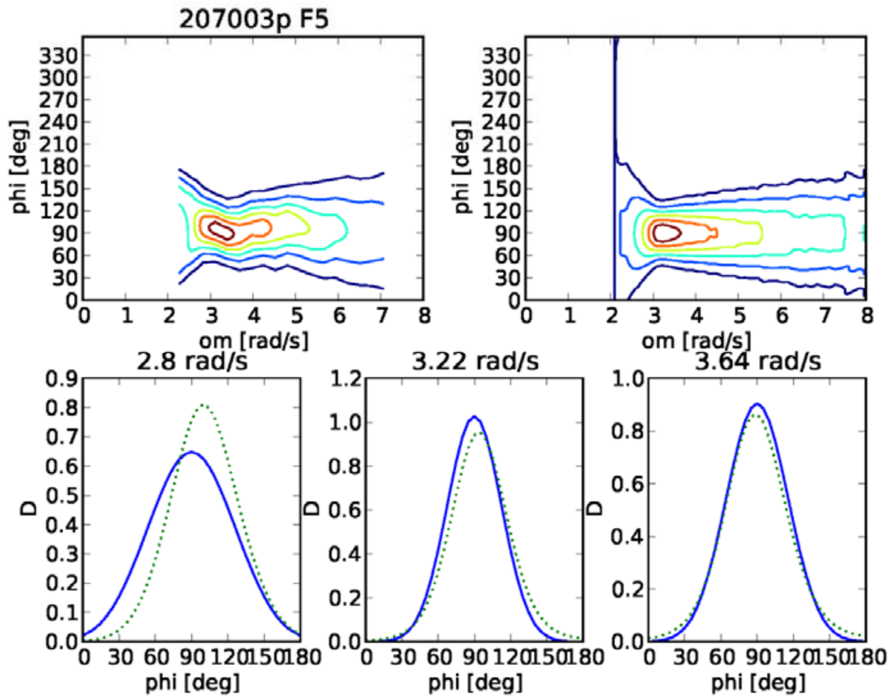


$$D(\theta) = \cos^{2s}\left(\frac{\theta - \theta_m}{2}\right)\Big|\, \theta \in [0, 360]$$

$$s(\omega) = \begin{cases} 15.5\left(\frac{\omega}{\omega_p}\right)^{9.47} & , \frac{\omega}{\omega_p} < 1 \\ 13.1\left(\frac{\omega}{\omega_p}\right)^{-1.94} & , \frac{\omega}{\omega_p} \geq 1 \end{cases}$$

Ewans spreading (1998):
Reduced directional spreading at spectral peak

DIRECTIONAL CALIBRATION

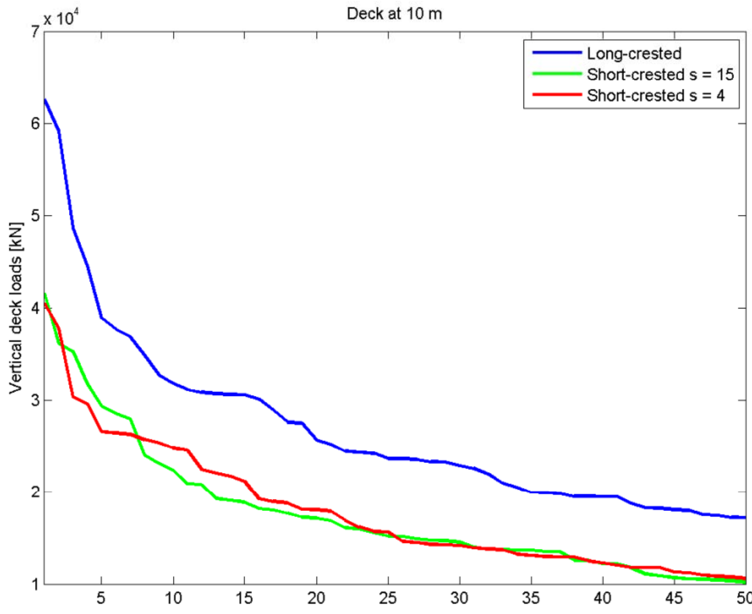


- Second attempt of directional wave calibration at MARIN:
  - Measured directional spectrum (top left) in comparison with theoretical directional spectrum (top right, base case, Ewans spreading, seed 1)
  - Directional distribution at selected wave frequencies at model scale (below mid: peak frequency)

MARIN

EFFECT OF SPREADING ON TLP LOAD STATISTICS

- Load statistics show a step change due to wave directionality (crests at least as long as the platform dimensions)



(Crest heights same for all three cases)

SOME REMAINING CHALLENGES

- How to relate sea state statistics to loading statistics?
- What are the kinematics and statistics of different types of breaking waves and how can they be determined?
- To quantify the loading due to breaking waves, model tests are currently the option of choice. However, what are the scale effects involved and how conservative are the results?

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QUESTIONS?

GROUP DISCUSSION

- Identify current needs for new developments in modelling of environmental conditions in basins and numerical methods

SOME REMAINING CHALLENGES

- How to relate sea state statistics to loading statistics?
- What are the kinematics and statistics of different types of breaking waves and how can they be determined?
- To quantify the loading due to breaking waves, model tests are currently the option of choice. However, what are the scale effects involved and how conservative are the results?
- How can we make sure that we choose the wave realizations to represent the specified extreme wave conditions; how many seeds, or, which measurement duration do we need?
- How to consider basin effects, particularly on shallow water?
- How shall we show statistical variability in the results?
- How do we make sure that we know what we have to model, in view of possibly biased field measurements?

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THANK YOU!

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