FRANZIUS-INSTITUTE
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Leibniz
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In-line Force on a Tripod Foundation Structure

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Introduction

- GIGAWIND *alpha-ventus* is funded by German Ministry (BMU) to support offshore wind energy development.
- The primary objective of the project: to optimize costs for the production and installation of offshore wind turbine foundations.
- The objective of this work: to determine non-breaking wave loads (required for fatigue limit state analysis) and their coefficients.

Methodology

- Morison equation (Morison et al., 1950):

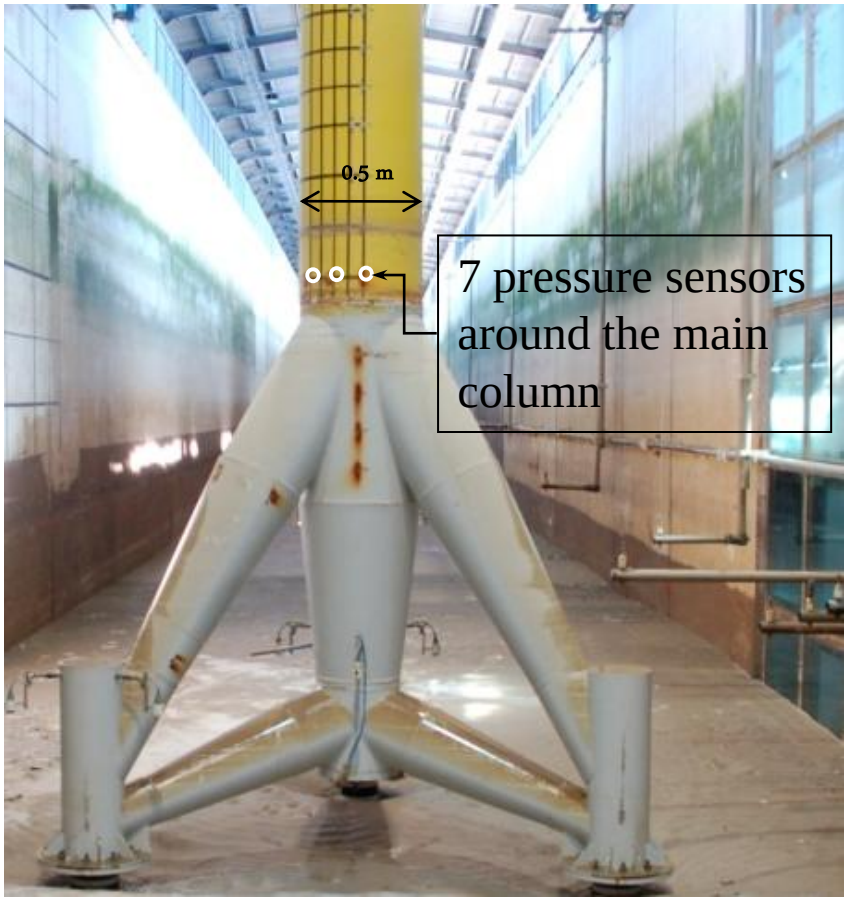
$$F(t) = \frac{1}{2} \cdot \rho \cdot C_D \cdot D \cdot u(t) \cdot |u(t)| + \frac{\pi}{4} \cdot \rho \cdot C_M \cdot D^2 \cdot \dot{u}(t)$$

- Pressures around the main column of the tripod are measured.

- Wave kinematics: by Airy, Stokes 2nd and Stokes 5th order.

- Two estimation methods are used to get the force coefficients (C_D and C_M):
  - Max-min method: The coefficients are determined at points:
    - ✓ When $u_x = u_x^{max}$, $a_x = 0$, and/or
    - ✓ When $u_x = 0$, $a_x = a_x^{max}$
  - Least squares method: the mean-squared difference between the predicted and measured force reduces to a minimum.

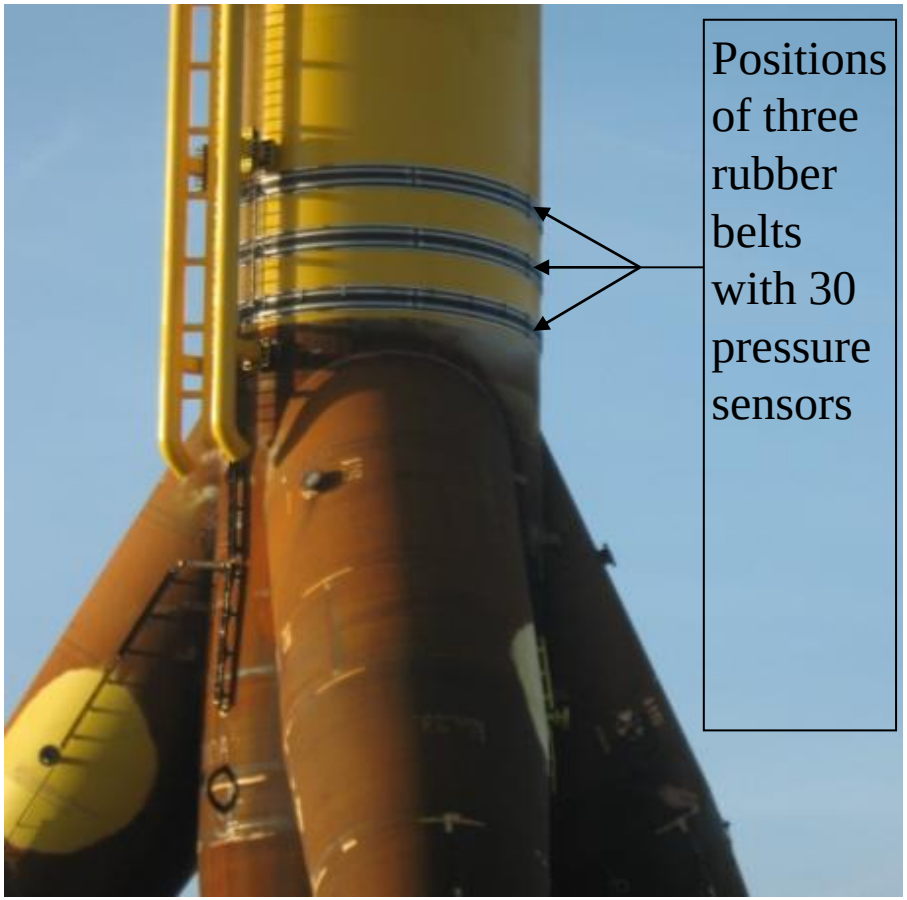
Physical model (GWK) and prototype (at the test field *alpha-ventus*)



Model scale: 1/12; D = 0.5 m

H_s=0.5–0.71 m; T_p=2.8–5.5 s

Water depth = 2.5 m; Measured level: -0.25 m

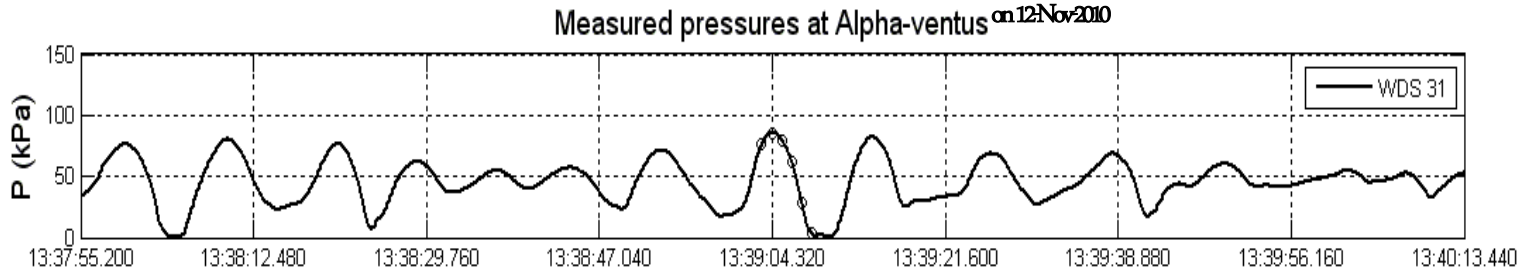


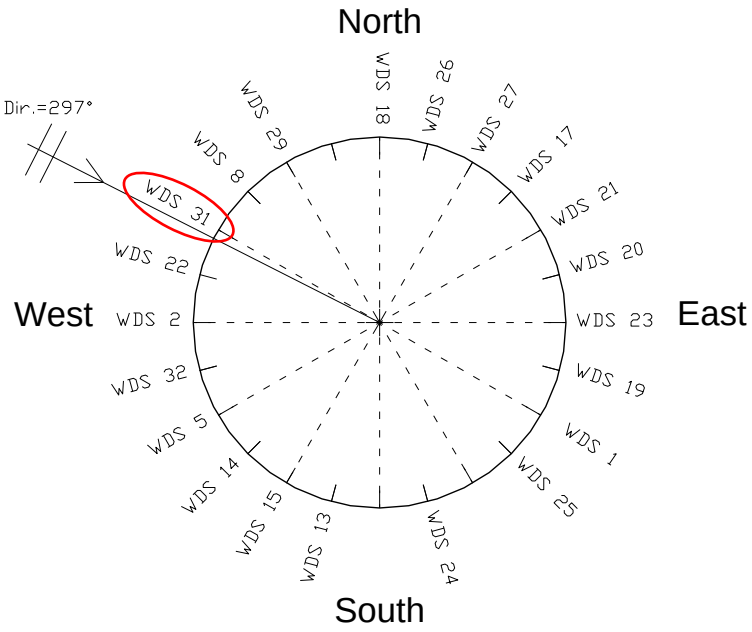
Tripod M7: D = 6 m

Measured levels: -1.75 m, -0.75 m and +0.25 m LAT

Measurements since February 2010

Measurements from *Alpha-ventus*

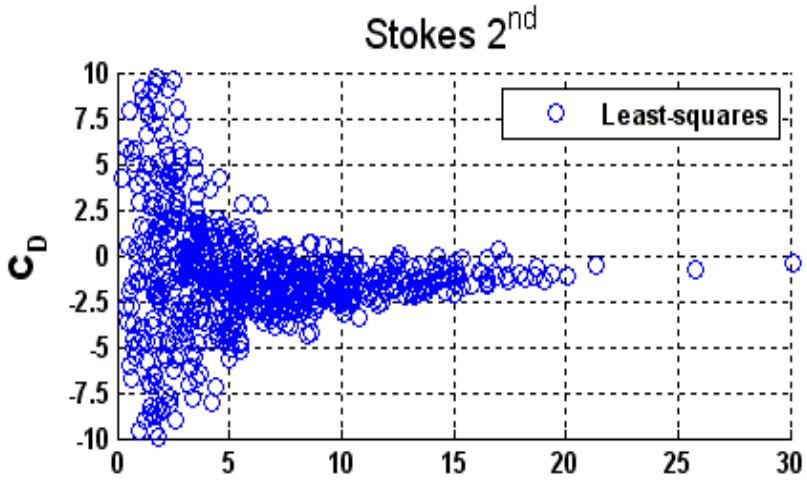


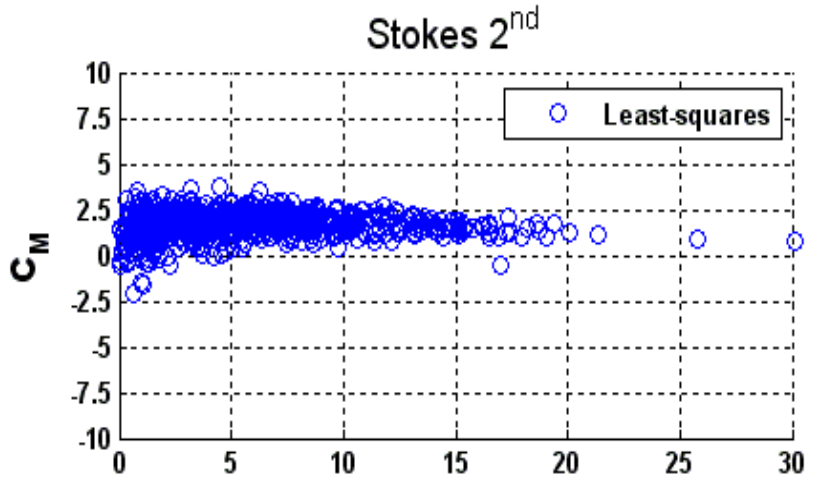


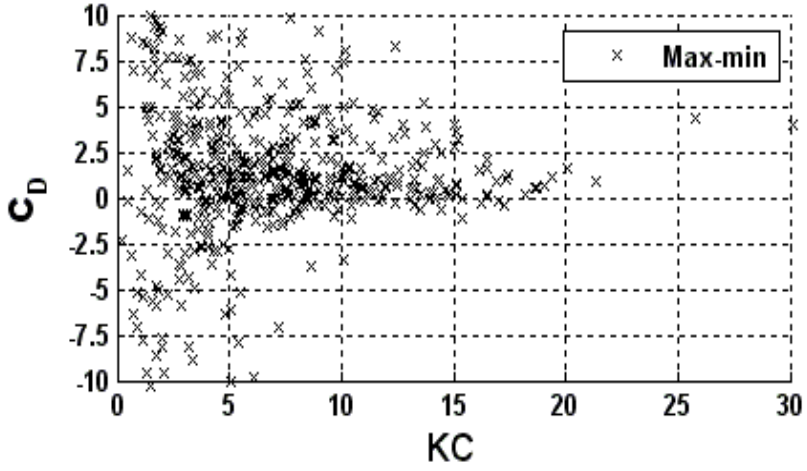
The data are recorded on 12-Nov-2010 from 13:19 to 13:50.

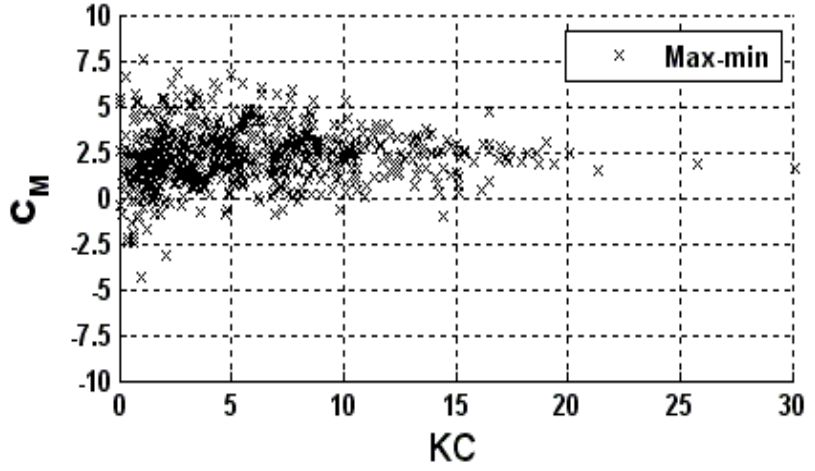
H_s = 7.25 m; T_p = 11,1 s; Dir. = 297° (FINO1)

Results from GWK

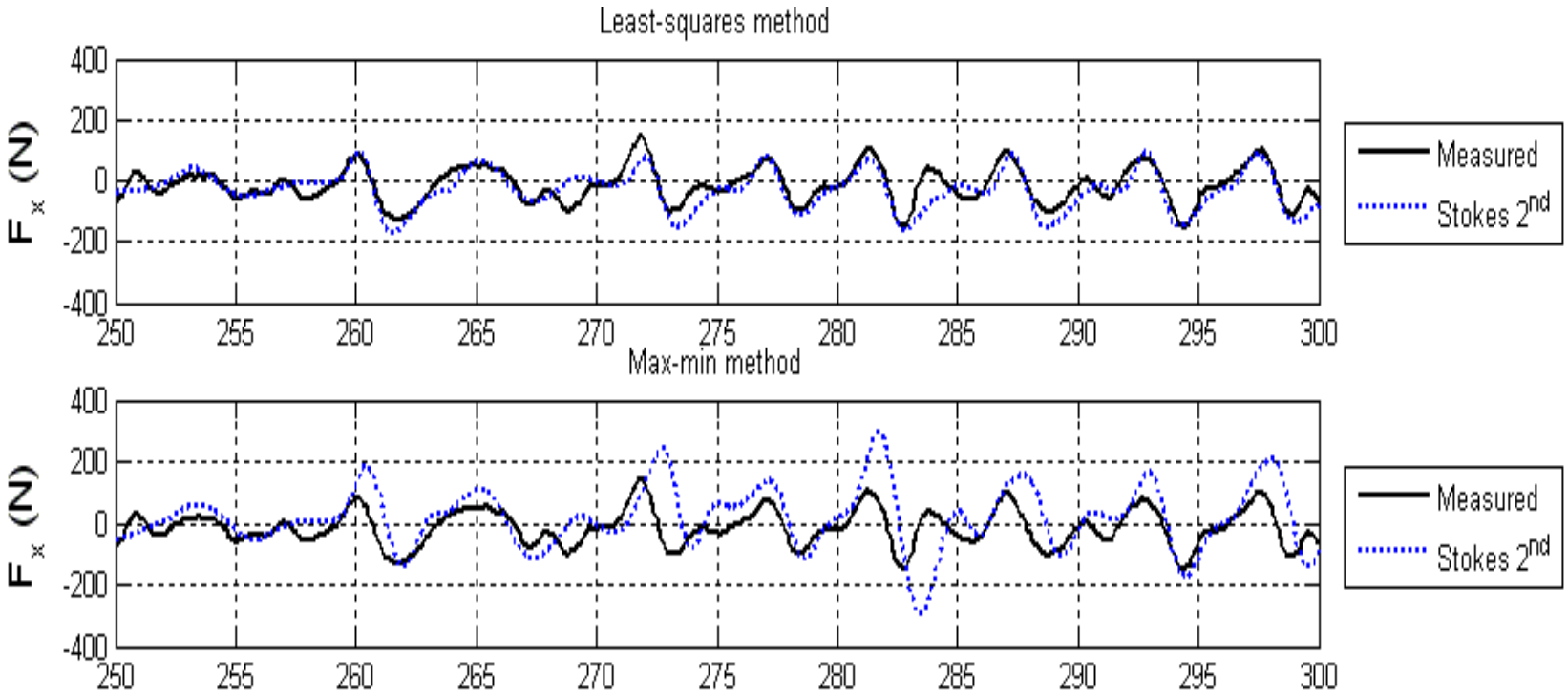








Results from GWK



Conclusions

- The wave force coefficients in Morison's equation are quite sensitive to the method used for estimating them.
- The least-squares method in combination with Stokes wave theories results the predicted forces fit quite well to the measured forces.
- The drag coefficient C_D shows significant scatter at low KC-numbers (KC < 5).
- The inertia coefficient C_M shows small scatter in the range of KC-numbers = 1 - 20 and its mean value = 1.59 to 1.82 with a standard deviation = 0.71 to 0.75.

Source: DOTI 2009