

GMMC - Ocean engineering

Igor Rychlik

`rychlik@math.chalmers.se`

Centre for Mathematical Sciences

Chalmers

The Group

- **Chalmers:** Baxevani A., Åberg S., Mao W., Ringsberg J., Rychlik I., Galtier T.
- **LTH Lund:** Bengtsson A., Podgórski K., Wegener J.
- **Oslo:** Brodtkorb P-A.
- **Bretagn:** Ailliot P., Mombet V., Provosto M., Olagnon M.
- **UNC US:** - Leadbetter M.R.

Motivation for research:

Due to globalisation, increase of energy costs, possible climate change, vessels, offshore structures, are (will be) exposed to different loads than were design against.

Hence one needs to monitor/describe actual loads acting on vessels, estimate probability for fatigue failure and design inspections intervals.

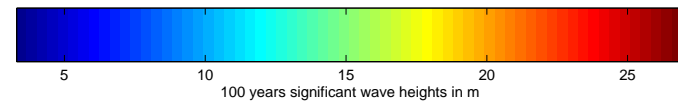
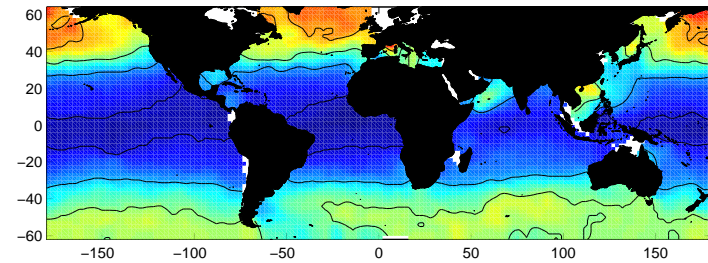
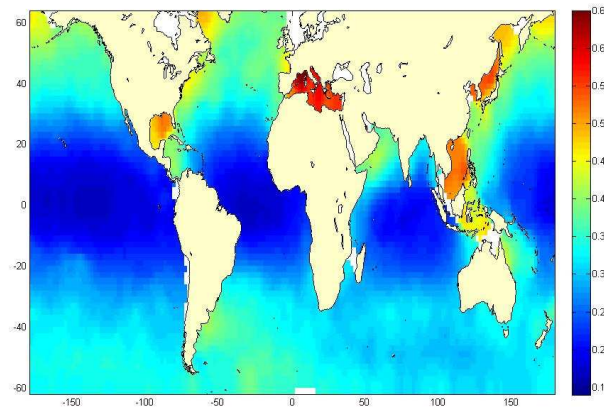
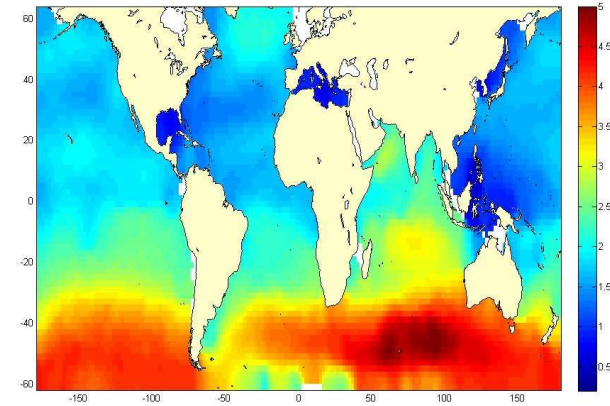
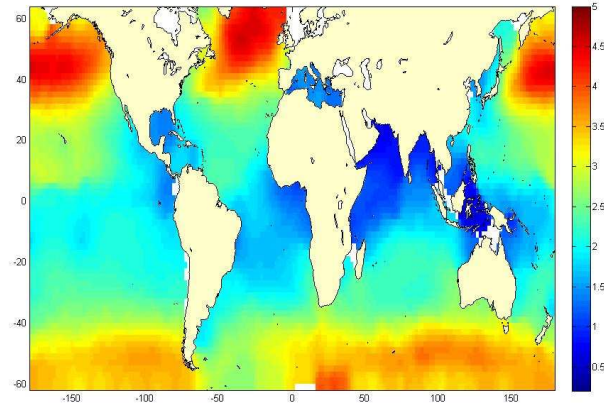
General concern for risks associated with maritime operations calls for better mathematical methods to describe time-space variability of environment and more detailed modeling of responses of structures to the loads.

Spatio-temporal models:

Models used for analysis of satellite, wind and pressure velocity data. Possible applications in estimation

- of long term risks for fatigue damage,
- frequency of dangerous sea conditions meeting offshore structures - 100 years waves, storms.
- or planning of ship routs that minimize the expected fatigue damage and fuel consumption.

Median H_s in Feb., Aug., std. of $\ln(H_s)$, 100 years H_s



Papers 2007:

- [] Baxevani, A., Rychlik, I. (2007) Fatigue Life Prediction for a Vessel Sailing the North Atlantic Route, *Probabilistic Engineering Mechanics*, **22**, pp. 159-169.
- [] Baxevani, A. Borget, C. and Rychlik, I. (2007) Spatial Models for the Variability of the Significant Wave Height on the World Oceans. *Proceedings of the 17th ISOPE conference*
- [] Baxevani A., Caires S. and Rychlik I. (2007) Spatio-temporal statistical modelling of significant wave height, *Environmetrics* to appear.

Wave distributions under stationary conditions:

Distributions of geometrical wave characteristics:
wavelength, wave height, steepness, velocity.

- Probability of meeting dangerous waves - risk for capsizing,
- Length and energy in a wave group.
- Frequency, shape and life time of extreme waves.

Papers 2007:

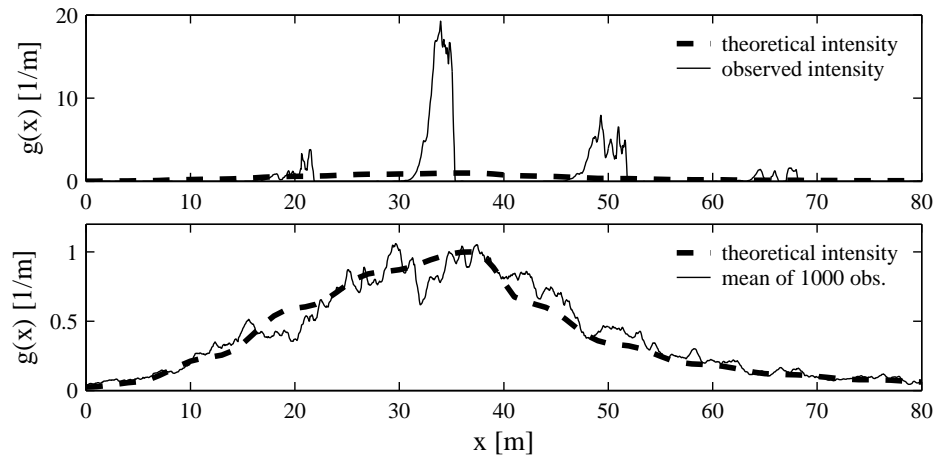
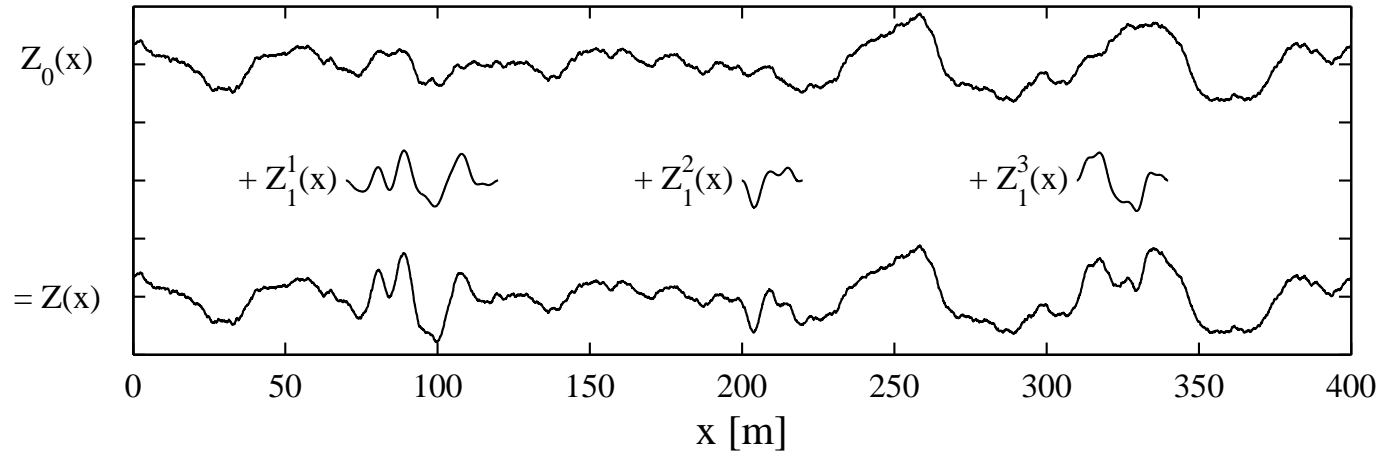
- [] Åberg S., Rychlik I. (2007) Doppler-shift approximations of encountered wave statistics, *Ocean Engineering* to appear.
- [] Podgórski, K., and Rychlik, I. (2007) Envelope Crossing Distributions for Gaussian Fields, under revision for *Probabilistic Engineering Mechanics*.
- [] Rychlik I. and Leadbetter M.R. (2007) Estimating capsized risk for a vessel in a following sea. *ISI 2007 meeting in Lisbon* pp. 1-4

Responses to environmental loads

Evaluation of risks for fatigue damage and/or extreme responses of vessels offshore structures to combined wave - wind loads.

- Non-linear systems with Gaussian inputs.
- Non Gaussian loads.
- Superposition of loads - transients.

Transients



Papers 2007:

- [] Bengtsson A., K., and Rychlik, I. (2007) Uncertainty in fatigue life prediction of structures subject to Gaussian loads, submitted.
- [] Bogsjö, K., and Rychlik, I. (2007) Vehicle fatigue damage caused by road irregularities, submitted.
- [] Gupta S., Rychlik I. (2007) Rain-flow Fatigue Damage due to Nonlinear Combination of Vector Gaussian Loads, *Probabilistic Engineering Mechanics* **22** pp. 231-249.

Other problems:

Ergodicity and its lack.

How long should one measure for reliable damage estimation?

Random models of material strength (FCC, SP group).

WAFO program package system that are used for fatigue analysis and wave modeling (Oslo, FCC, LTH).