Project information

Keywords
Ice; marine operations; ship ice interaction; ice wave interaction
Project title
Ice floe interaction with ships and waves - IFiSaw
Year
2015
Project leader
Karl Gunnar Aarsæther
Participants

SINTEF Nord

Universtitetet i Tromsø

Troms Offshore

Opelion AS

Flagship
Arctic Ocean
Funding Source

Funded by Framsentered "Polhavet" under the technology topic

Summary of Results

Project progress

As mentioned in the first proposal, the main research challenge of this project is to develop both a simulation model of broken ice fields in waves as well as introducing ship contact and the hydrodynamics of both vessel and ice floes. Now a new contact detection algorithm for ship-ice interaction has been developed in FhSim and the hydrodynamics of a square ice floe in waves are studied using WAMIT which is the most advanced set of tools available for analyzing wave interactions with offshore platforms and other structures or vessels (WAMIT Inc. (2013)). A preliminary validation of the contact and hydrodynamic models will be presented in a peer-reviewed paper (OMAE 2016) about the wave-driven impact of an ice floe on a circular cylinder.

1. Contact detection algorithm for ship-ice interaction

A contact algorithm for two objects with triangular surface meshing has been developed in FhSim (see e.g. Figures 1 and 2). Putative points of intersection between each pair of surfaces are located by assuming that each constituent mesh triangle edge represents an infinitesimal ray, then solving the ray-triangle intersection problem using the barycentric coordinate based solution presented by Möller and Trumbore (1997). The Möller-Trumbore algorithm is still considered today a fast algorithm which is often used in benchmarks to compare performances of other methods although.

As shown in Figures 1 and 2, the developed contact algorithm can be applied for simulating vessels and other structures interacting with ice. In principle, this algorithm can be applied to any convex objects with triangular surface meshing, but it still needs to be optimized for simulating a large number of contacting objects.

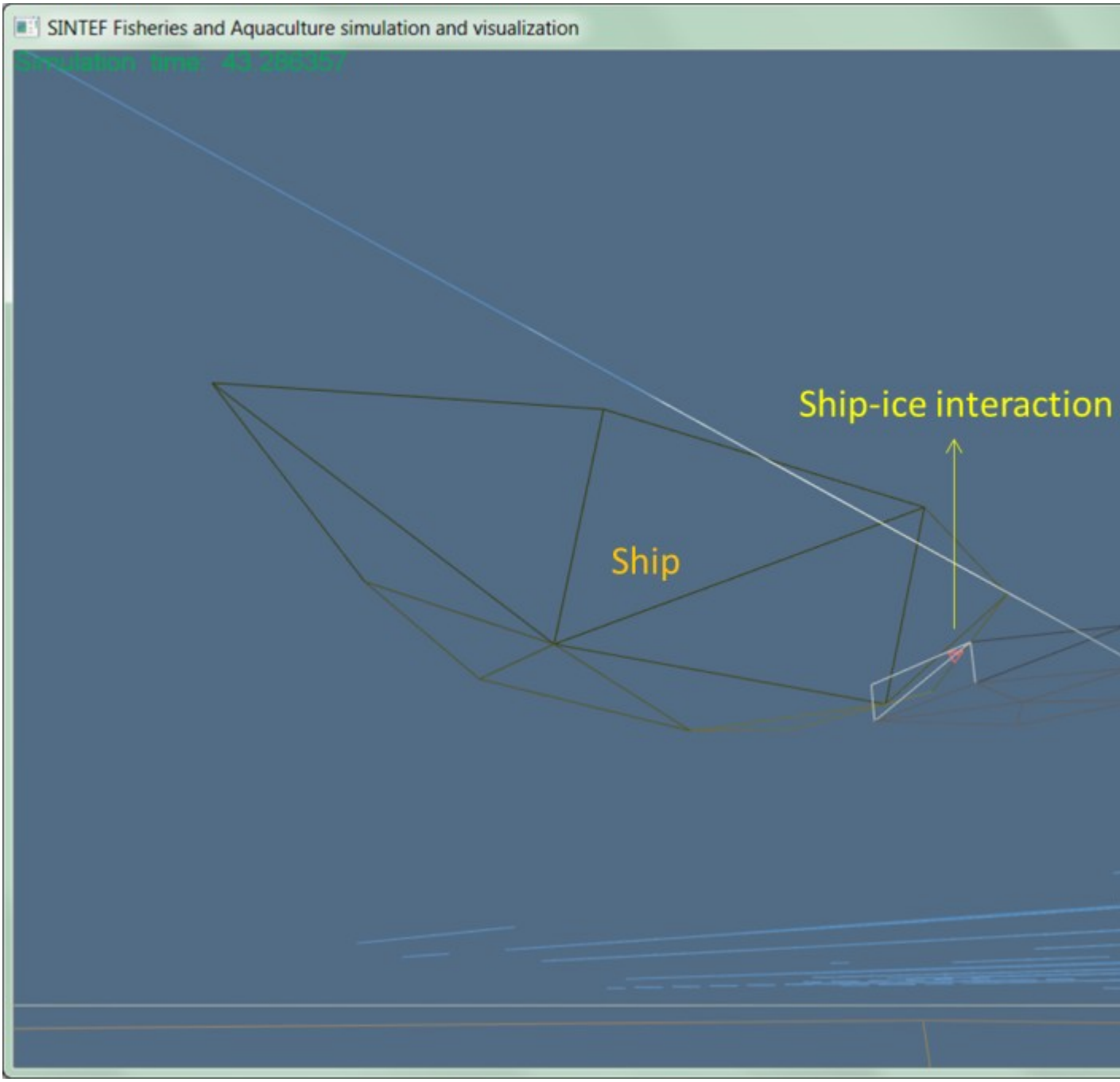


Figure 1. Illustration of the ship-ice interaction model in FhSim

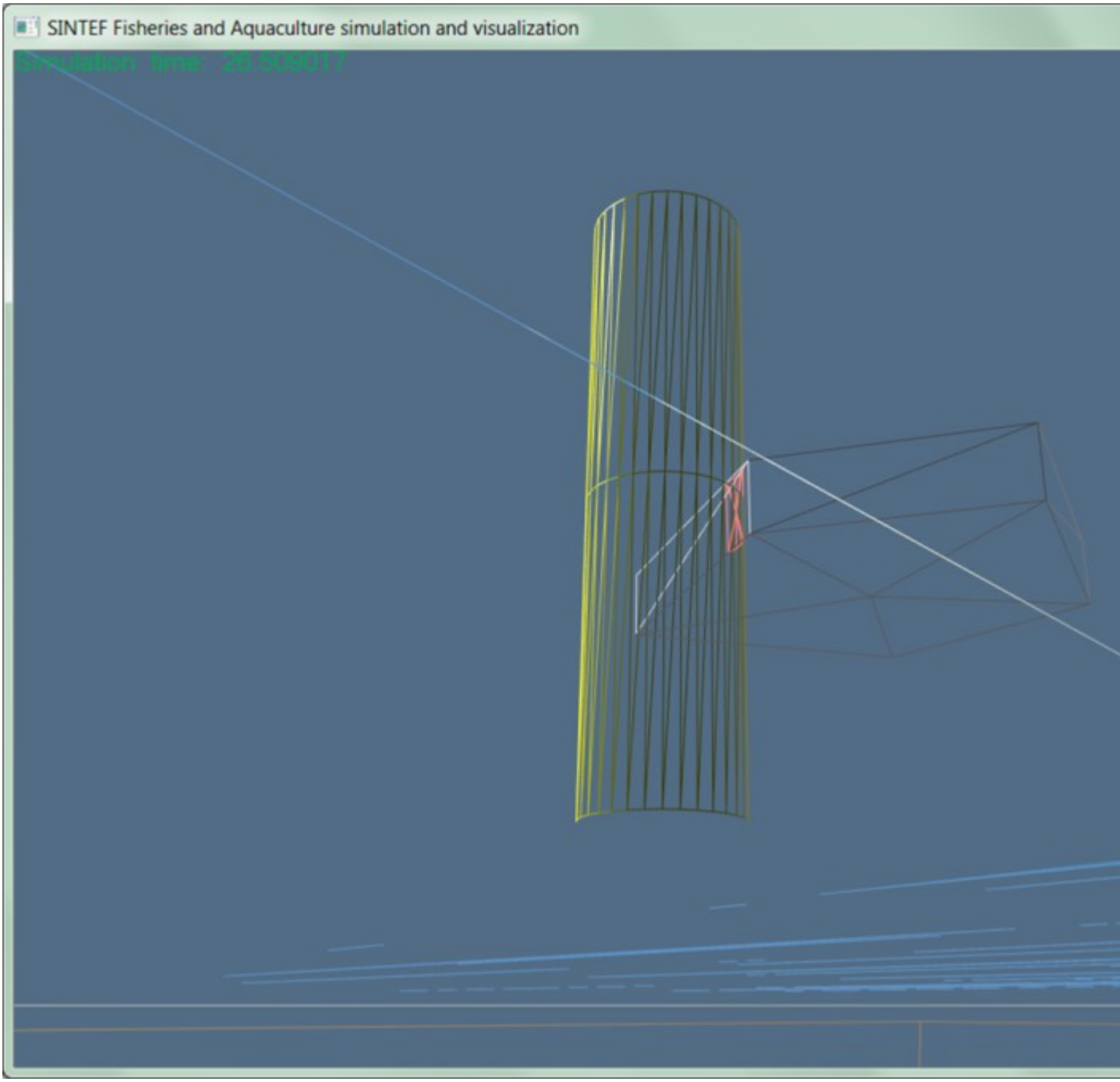


Figure 2. A screenshot from the preliminary simulation of wave-driven impact of an ice floe on a vertical circular cylinder (by FhSim)

2. Hydrodynamics of a square ice floe in waves

The hydrodynamics of a square ice floe in waves are studied using WAMIT, where the added-mass and damping coefficients of the ice floe when it is approaching a circular cylinder are calculated. Figures 4 and 5 give two examples of the varying added-mass and damping coefficients according to the distance between the ice and the cylinder (as illustrated in Figure 3). A combined polynomial and Gaussian fitting method is also applied to the calculated data sets, which makes it possible to accurately describe the hydrodynamics of the ice floe in FhSim by adjusting the relevant hydrodynamic coefficients according to the relative motion between the ice and the cylinder. The same strategy can also be applied to ship-ice interaction.

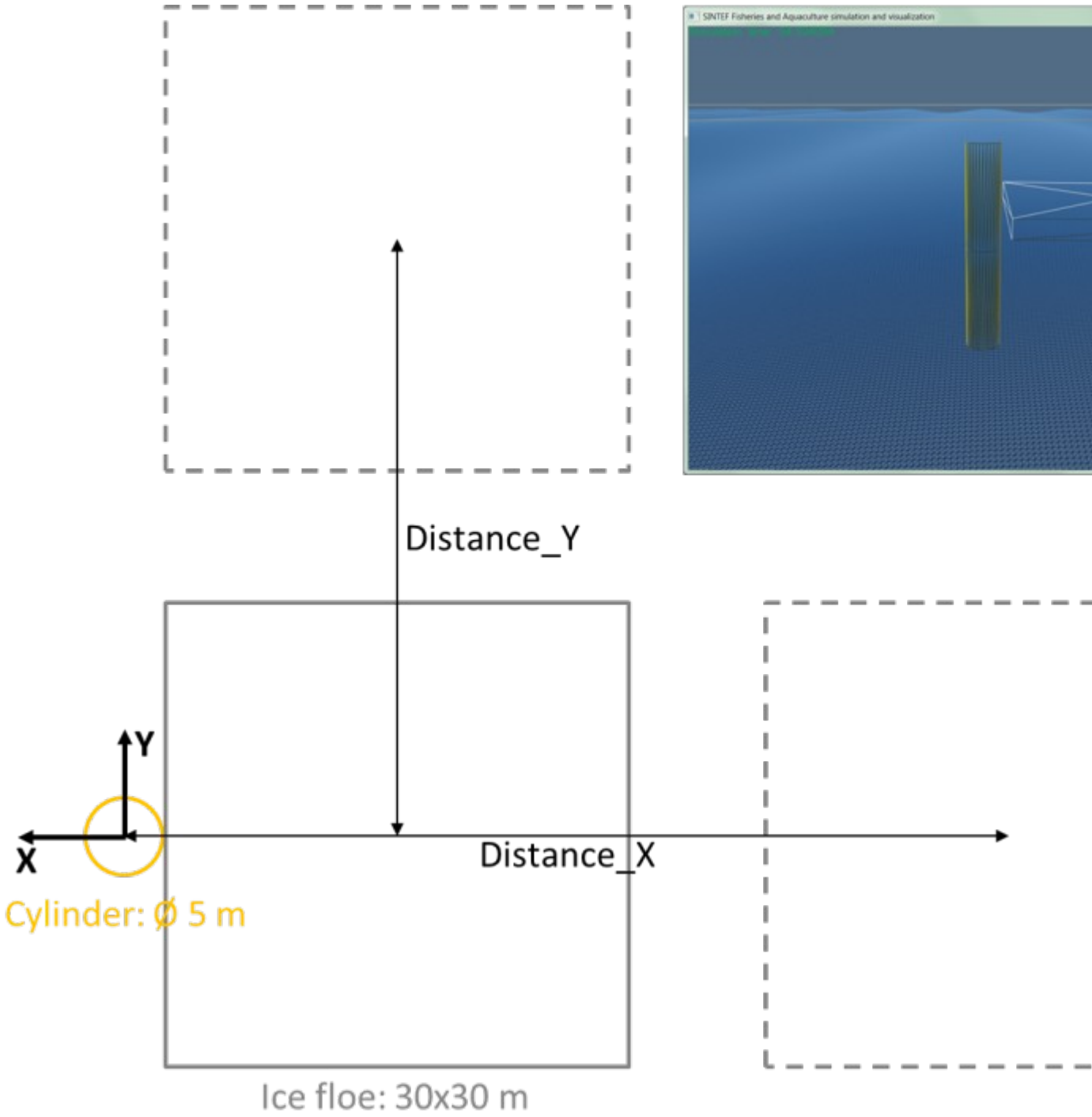


Figure 3. Illustration of a square ice floe approaching a circular cylinder (driven by wave)

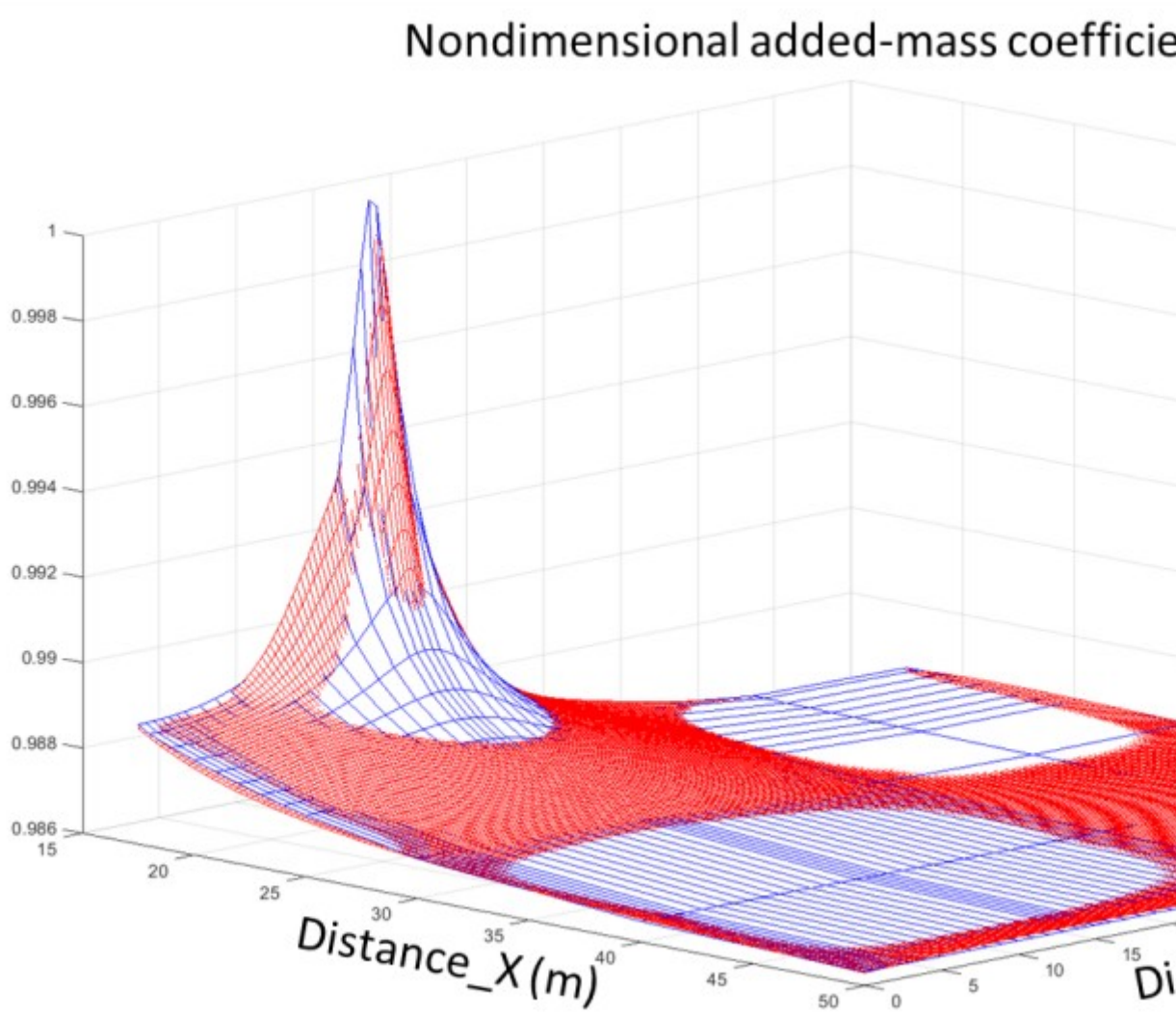


Figure 4. An example of the calculated (by WAMIT) and fitted add-mass coefficient

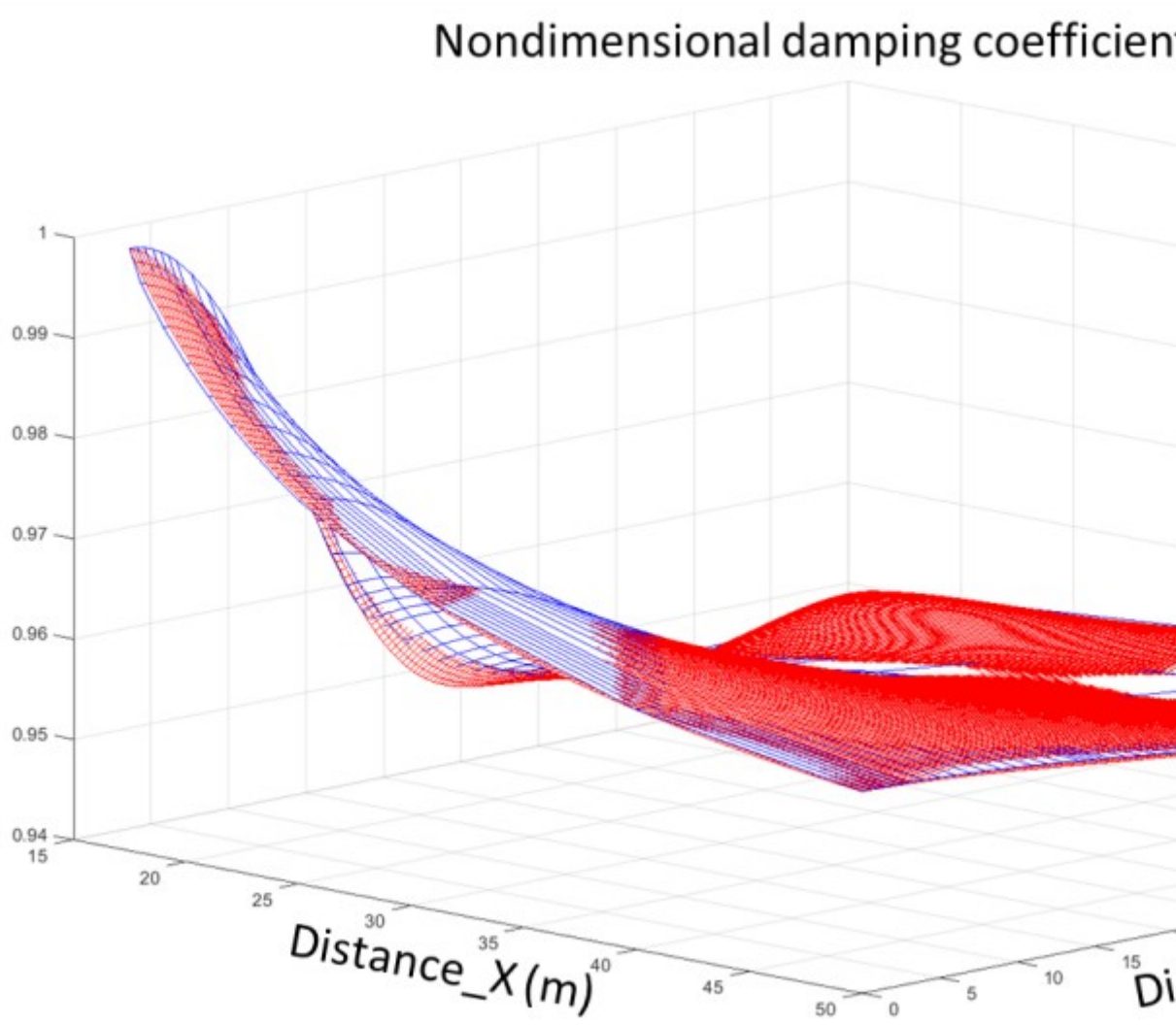
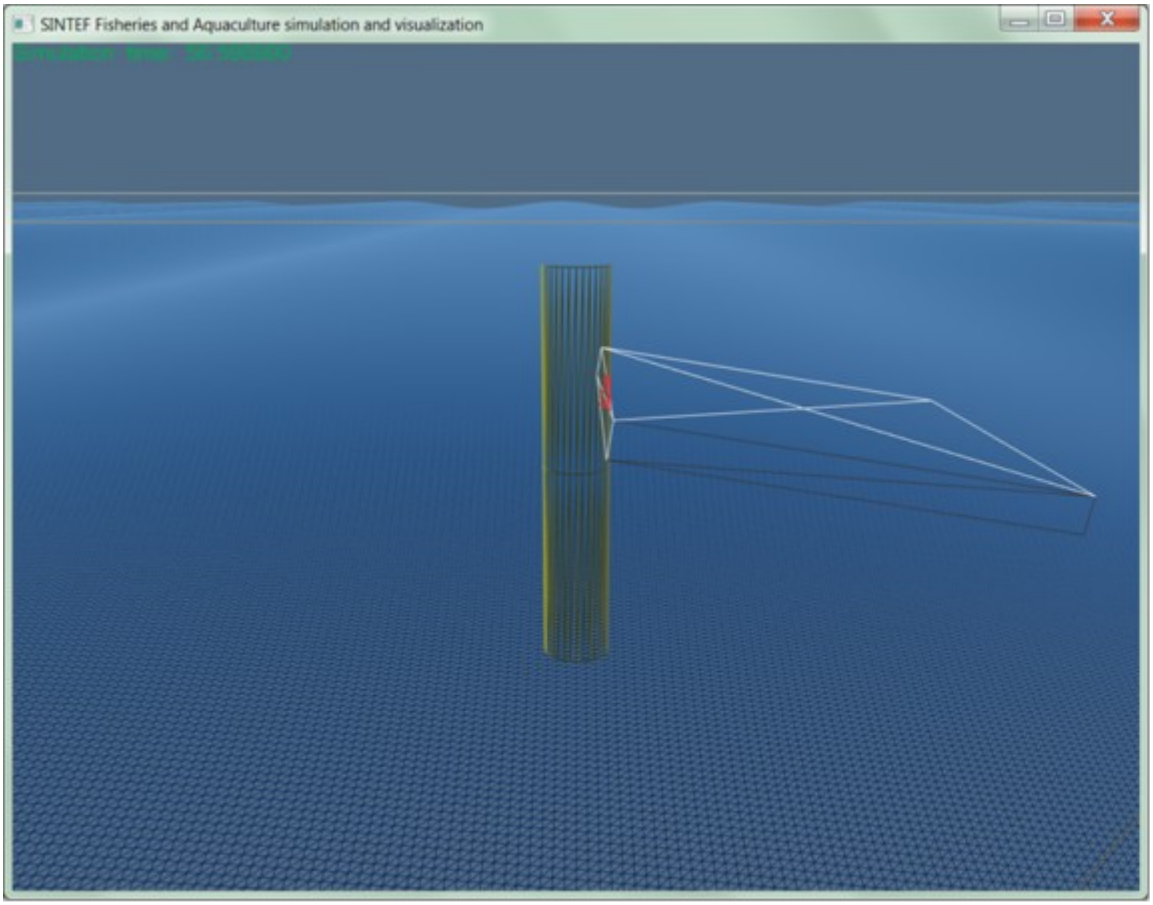


Figure 5. An example of the calculated (by WAMIT) and fitted damping coefficient

3. Preliminary validation of the contact and hydrodynamic models (to be finished)

A preliminary validation of the contact and hydrodynamic models is proposed by simulating the wave-driven impact of an ice floe on a circular cylinder and comparing with the model tests introduced by McGovern and Bai (2014) (see e.g. in Figure 6). The hydrodynamic effects (see e.g. Figures 4 and 5) on the impact process will be the main focus of this study.



(a) Simulation (by FhSim)

Figure 6. An illustrative comparison between the simulation (by FhSim) and the model test (McGovern and Bai (2014))

Further work

• In principle, the present contact detection algorithm can be applied to any convex structure-ice interaction, but it still needs to be optimized for simulating a large number of contacting objects (e.g. ice floe fields in the order of 1000 bodies).

• The hydrodynamics of the ice floes with different shapes (typically rectangular or pentagonal) and in different wave conditions (frequencies) need to be further investigated and parameterized.

• An appropriate prototype ship is important for numerical modelling and further validation of the numerical method. Case study material will be provided by the industry participants and the ice simulation model will be combined with a simulation model for ships with subsea equipment attached as well as fishing gear.

• Final scenario studies will be defined together with the industry participants. The simulation models and scenarios will be used as input to reliability studies of arctic marine operations by UiT.

References

WAMIT, Inc., 2013. WAMIT USER MANUAL Version 7.0. www.wamit.com/manual.htm.

Möller, T. and Trumbore, B., 1997. Fast, minimum storage ray-triangle intersection. Journal of Graphics Tools, 2(1): 21-28.

McGovern, D.J. and Bai, W., 2014. Experimental study of wave-driven impact of sea ice floes on a circular cylinder. Cold Regions Science and Technology, 108: 36-48.

For the Management

Due to reduced funding for the first year, the project was started in earnest in the second half of 2015 and there is still work to be com,pleted within the allocated budget for 2015. The project will have a meeting between SINTEF and UiT to prepare for involvement of stundets and faculty members based on the acheived results to date. Future worl will be planned.

Published Results/Planned Publications

The paper "Numerical Study of Wave-drive Impact of a Sea Ice Floe on a Circular Cylinder" has been subitted to the OMAE2016 conference (ASME Int. Conference on Ocean, Offshore and Arctic Engineering). The draft paper will be forwarded

Budget in accordance to results

The project will utilize its allocated budget for 2015 and will complete activities.

Could results from the project be subject for any commercial utilization

No

Conclusions

There has been a (slow) start, but the results are starting to appear. We beleive the project should be continued and will resubmit the application for continued funding in 2016 adjusting for completed activities in 2015.