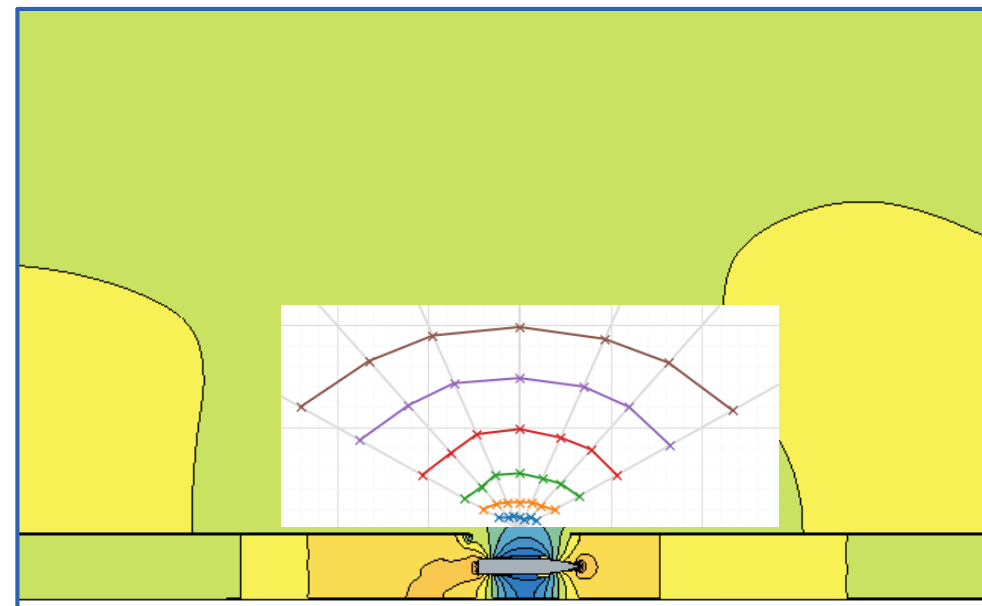


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Influence of the return current and the primary wave of a passing ship on harbour hydrodynamics

MASHCON 2025

Bruges, 21 May 2025



Content

1. Introduction

- a) Influence of a passing ship on harbour hydrodynamics
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- I. Ship wave formation in the waterway
- II. Entrance of waves into the harbour
- III. Diffraction in the harbour basin

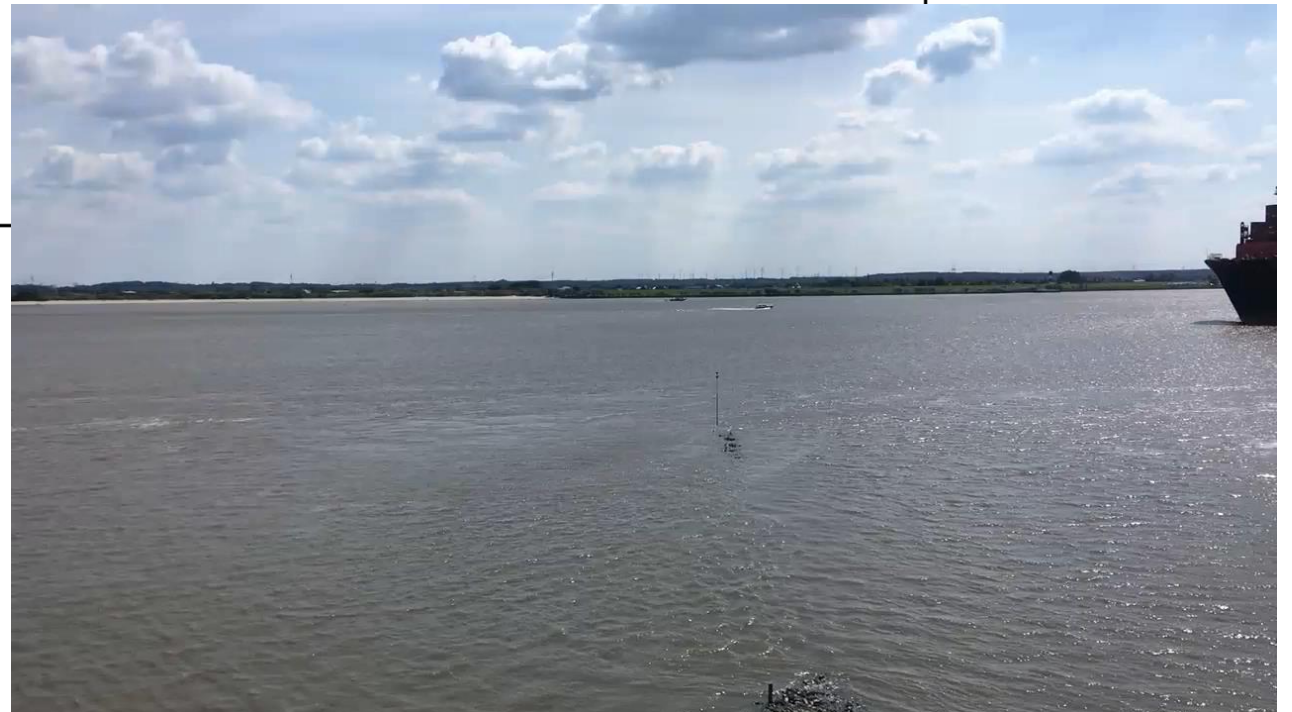
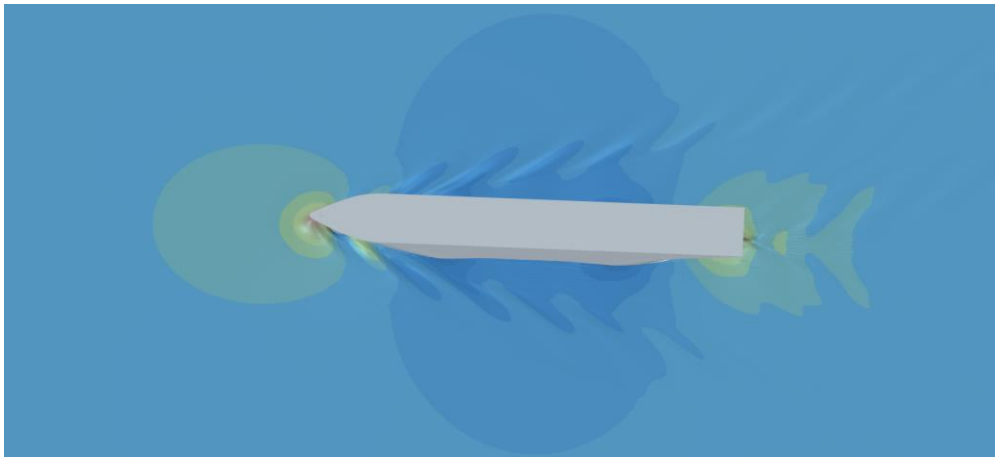
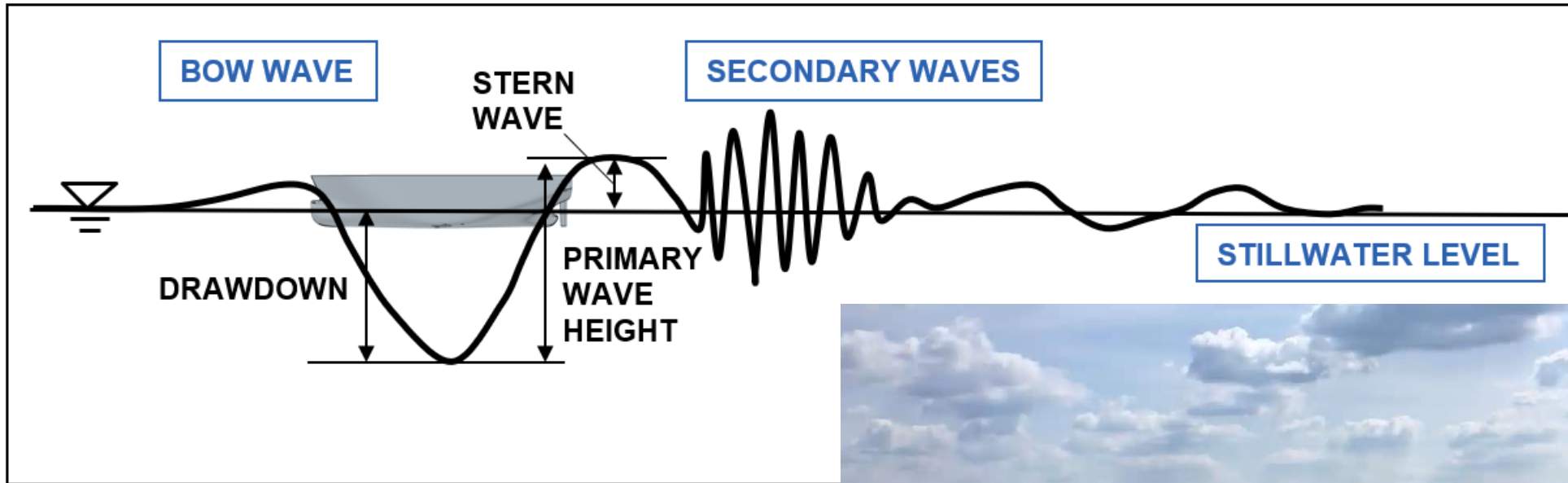
3. Conclusions on important parameters

Introduction: Influence of a passing ship on harbour hydrodynamics

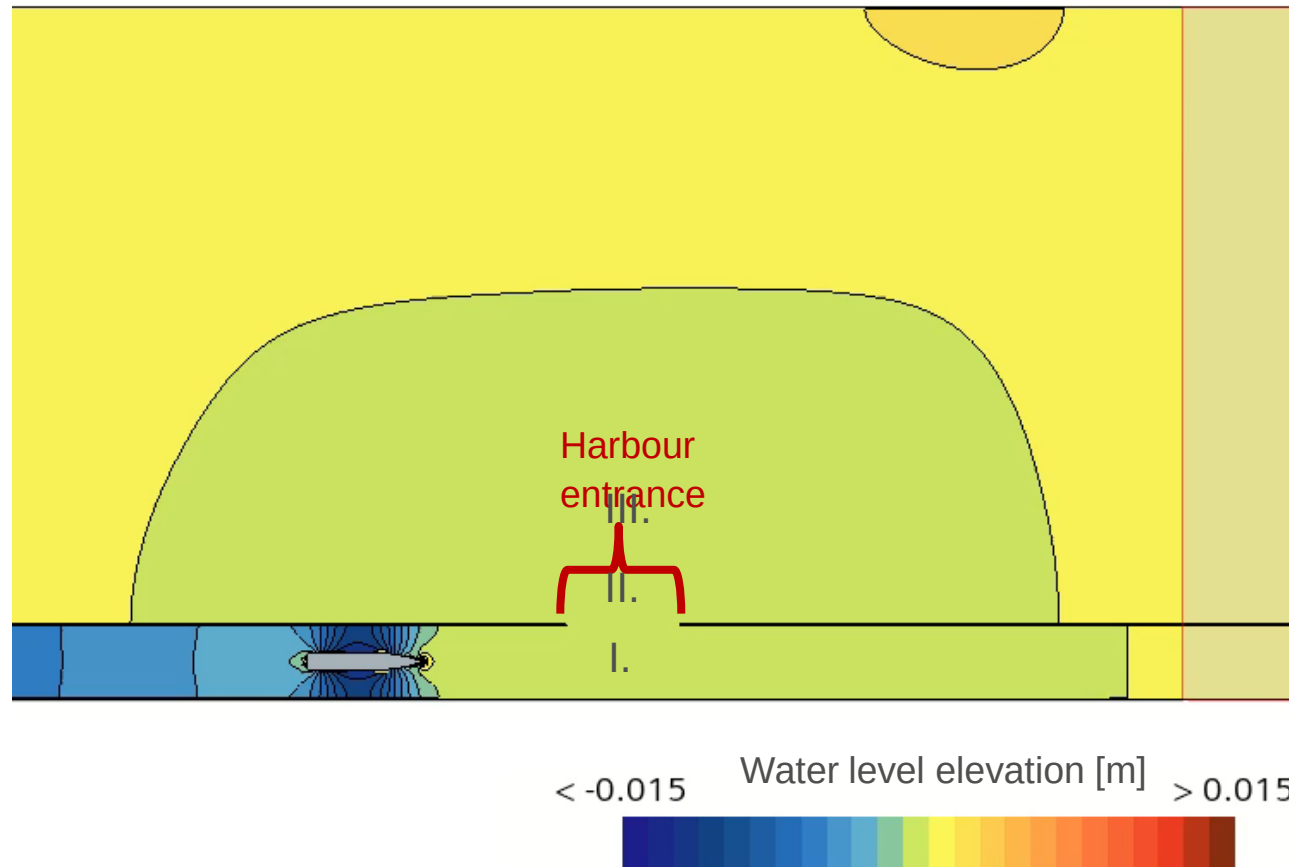


Source: *Uliczka, K.*, Grundsatzuntersuchung zur Reduzierung langperiodischer, schiffserzeugter Belastungen von Sportboothäfen an Seeschiffahrtsstraßen (am Beispiel des Hamburger Yachthafens), 2010

Definition of the primary ship wave used in this presentation

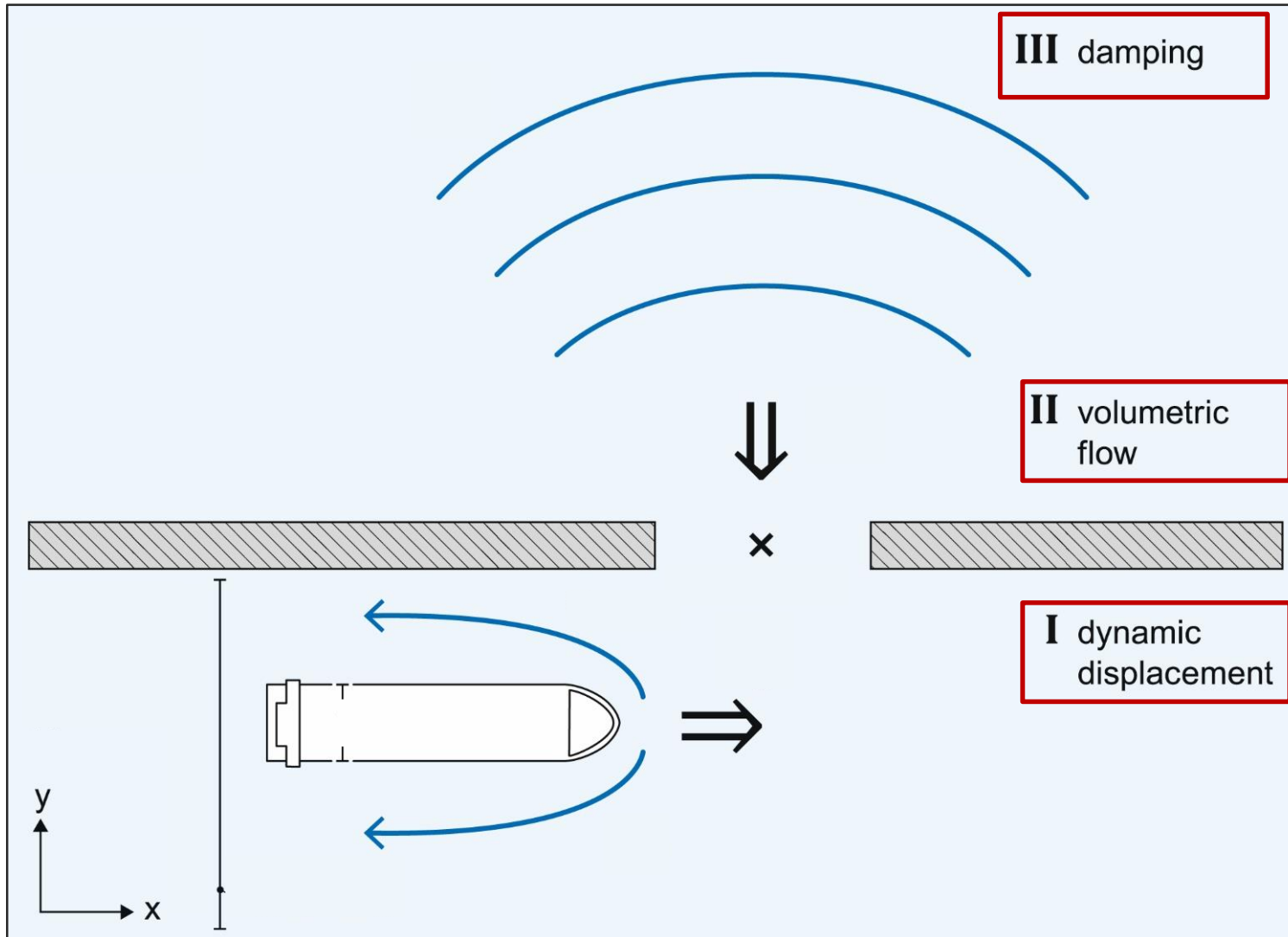


Problem representation in CFD (Star-CCM+)



- I. Ship passes harbour entrance
- II. Return current and primary wave enter the harbour
- III. Diffraction and damping of primary wave

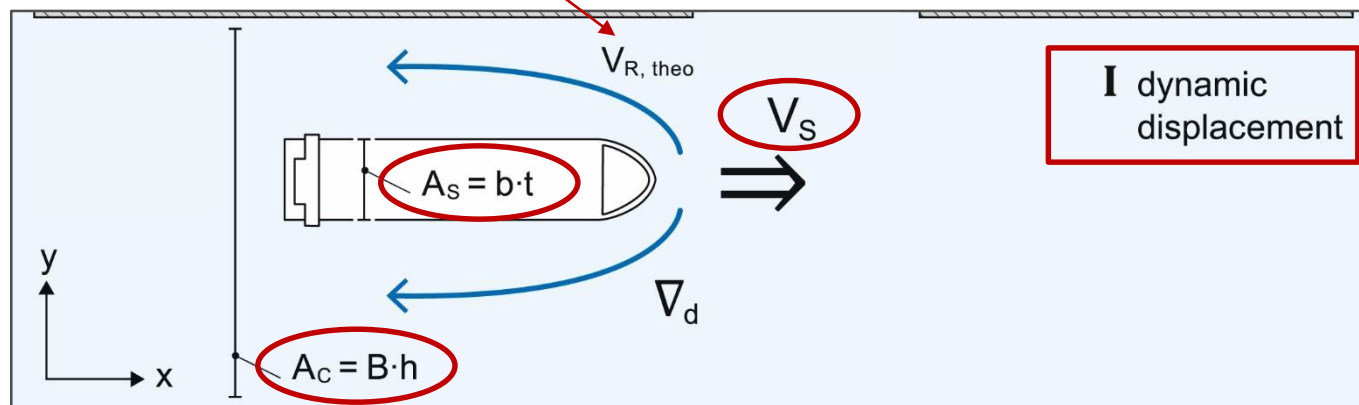
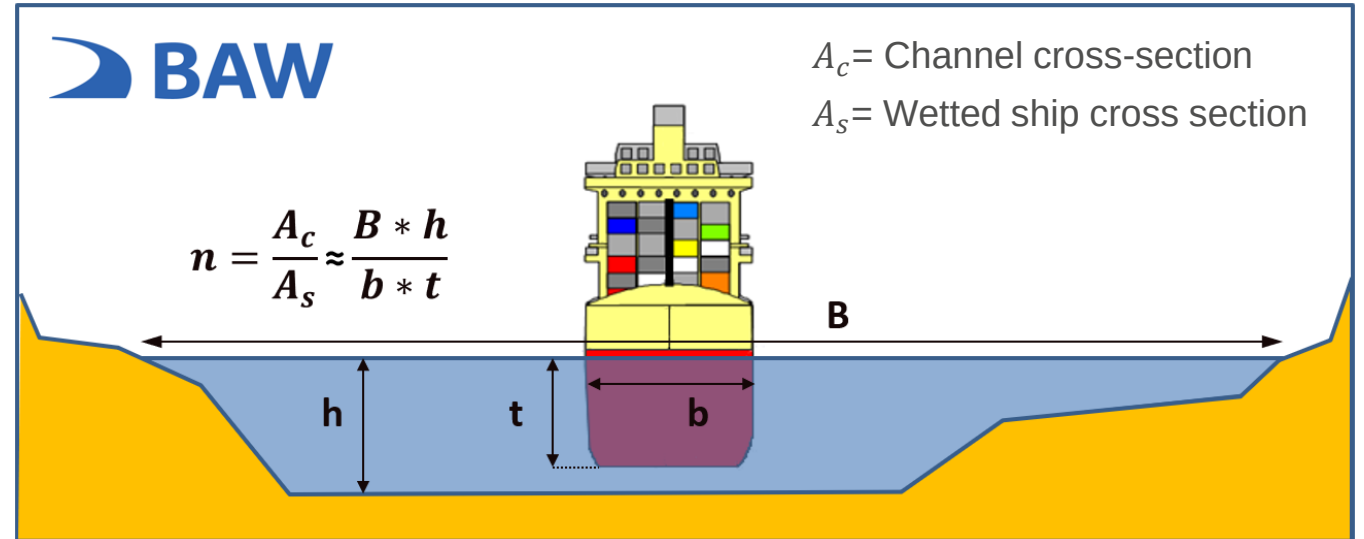
Schematic representation of the ship passage problem



Subproblem I: Dynamic Displacement

Theoretical return current:

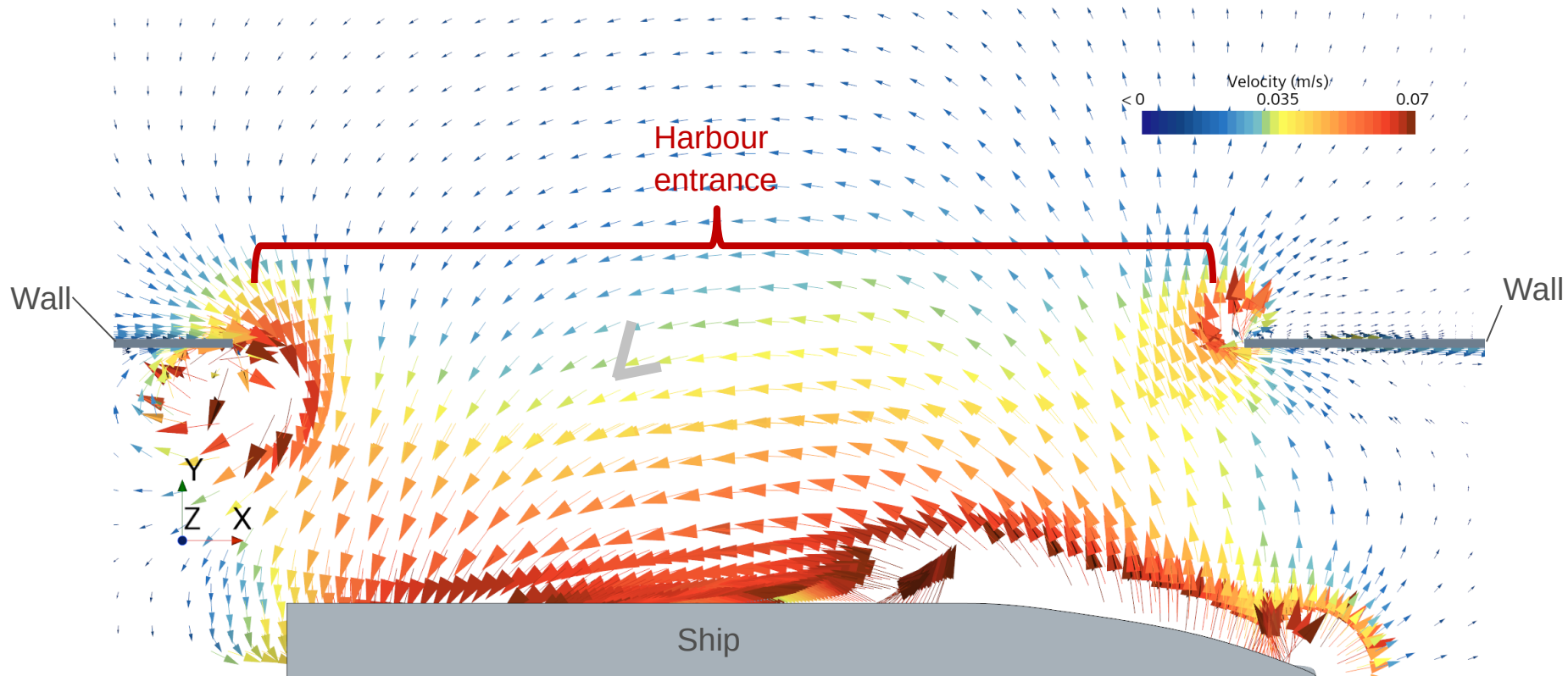
$$v_{R,theo} = \frac{\nabla_d}{A_c} = \frac{v_s}{n}$$



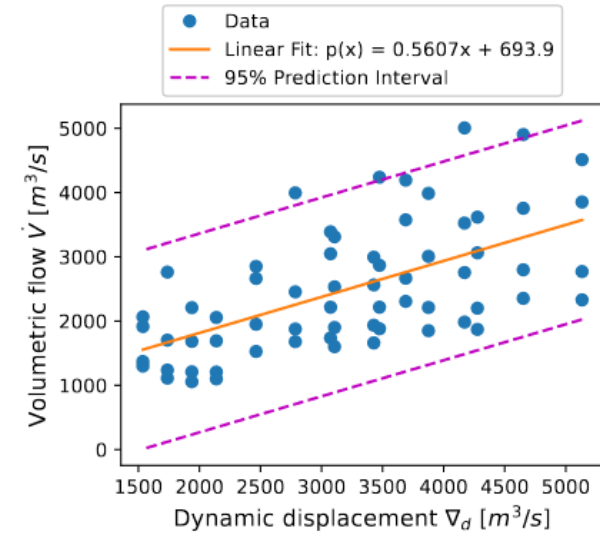
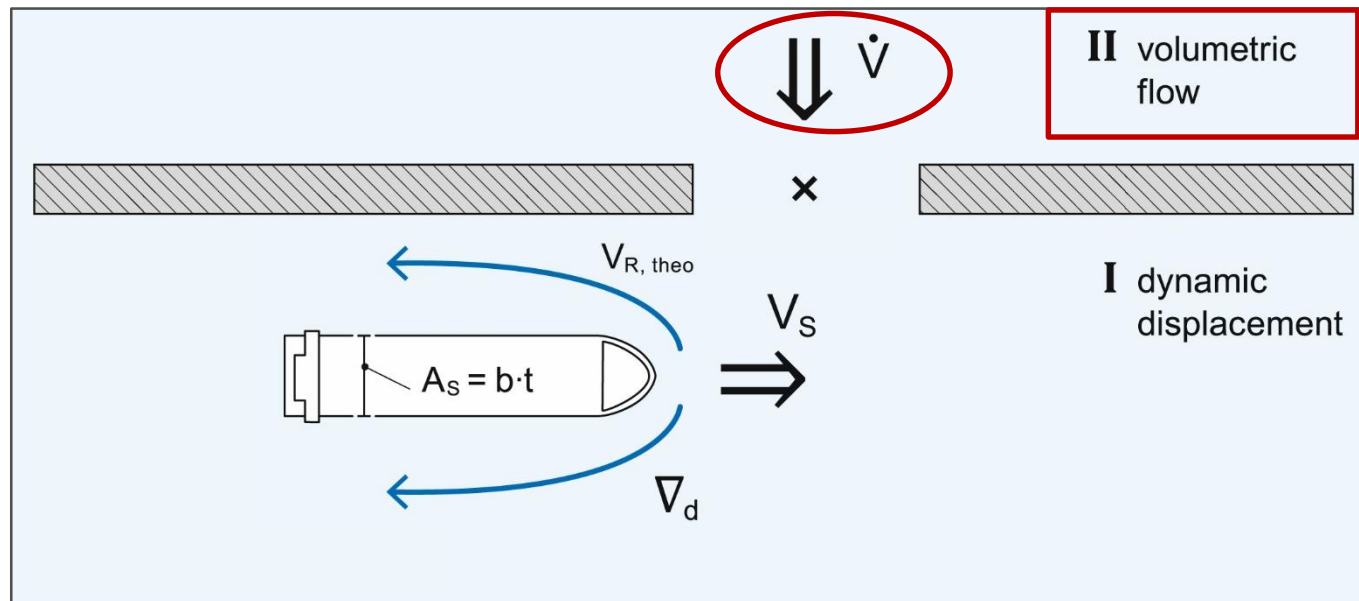
$$\nabla_d = A_s * v_s \text{ [m}^3/\text{s]}$$

=> Input parameters:
 v_s, t, n

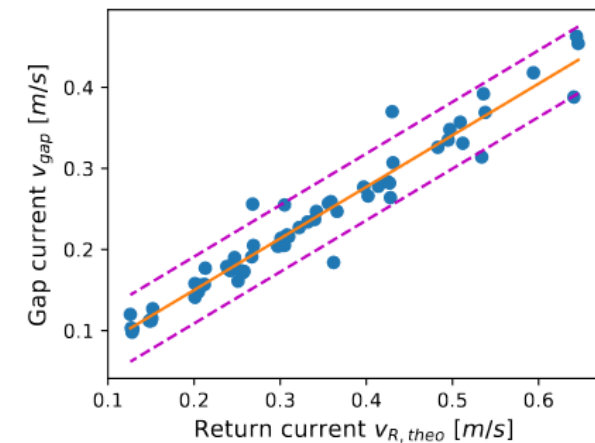
Subproblem I: Dynamic Displacement- Return current



Subproblem II: Volumetric flow out of the harbour basin

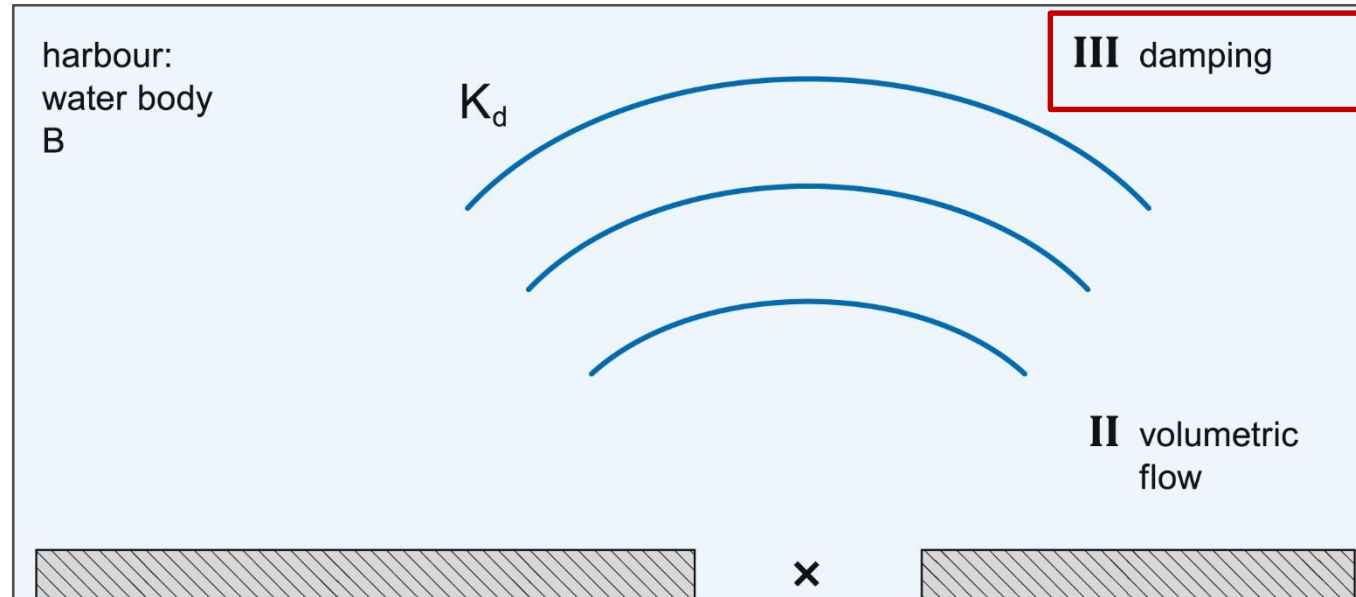


$$\nabla_d = A_s \cdot v_s$$



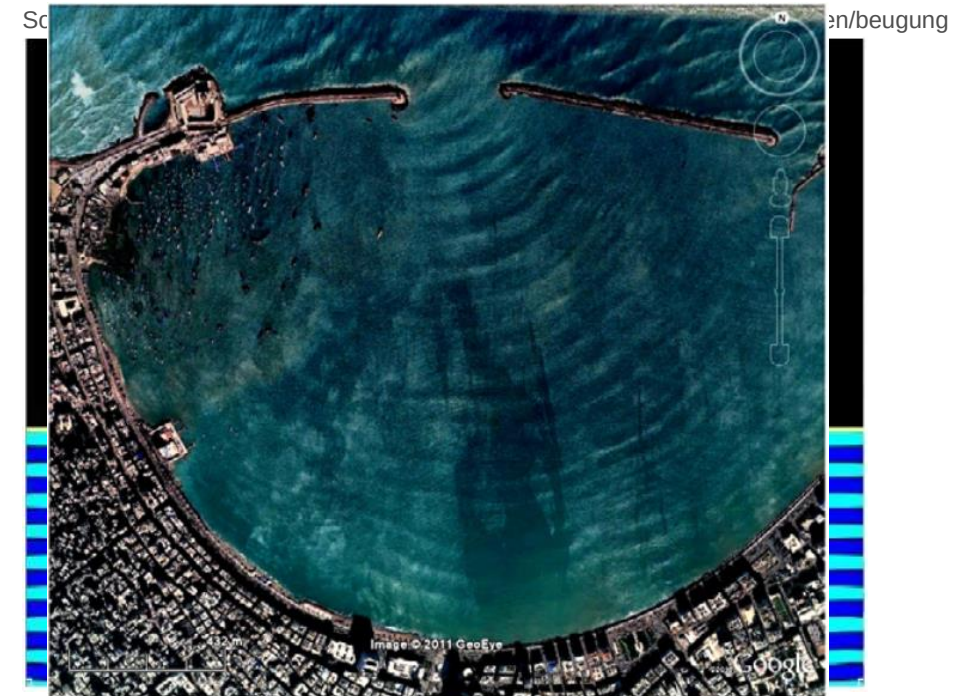
$$v_{R, theo} = \frac{\nabla_d}{A_c}$$

Subproblem III: Diffraction and damping of the primary wave



Source: <https://www.log-web.de/chemie/Bindung/atombindung/erkl%C3%A4rung/beugung.htm>

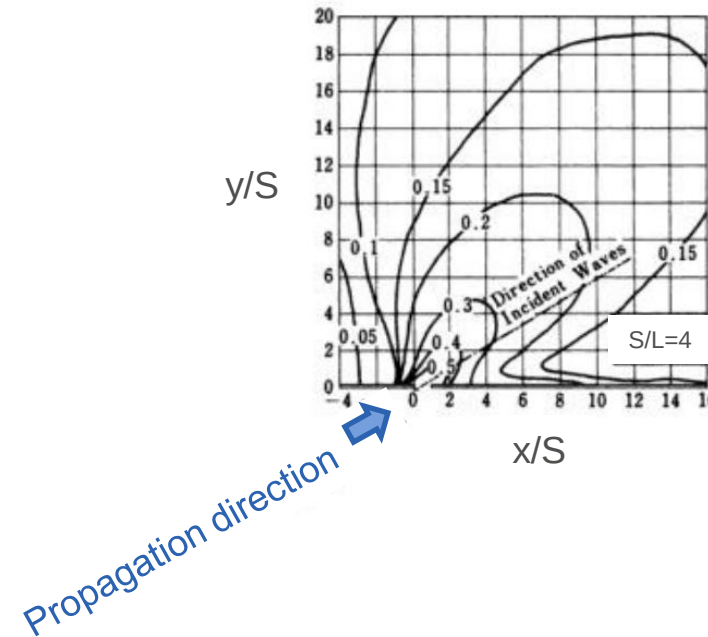
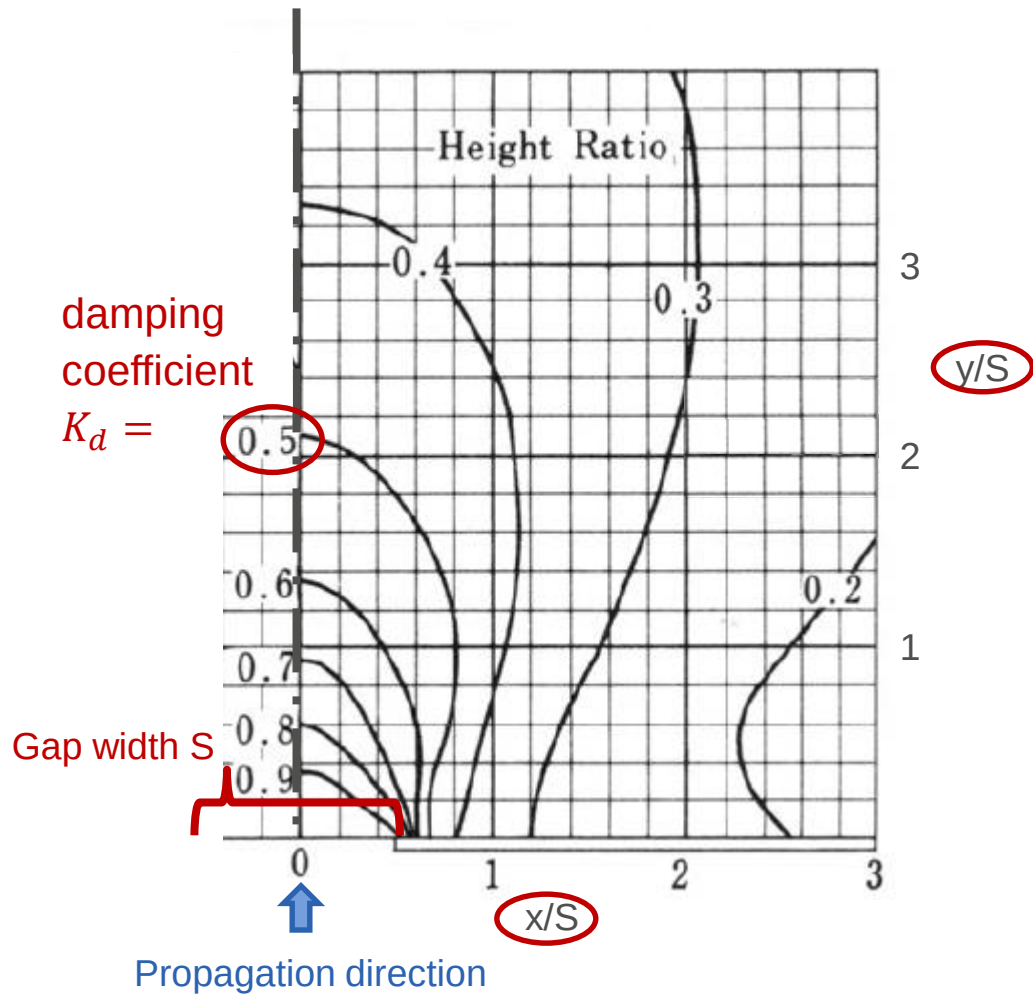
Propagation direction ↘



Harbour of Alexandria (Egypt). Source: Logiurato, F., Teaching waves with Google Earth

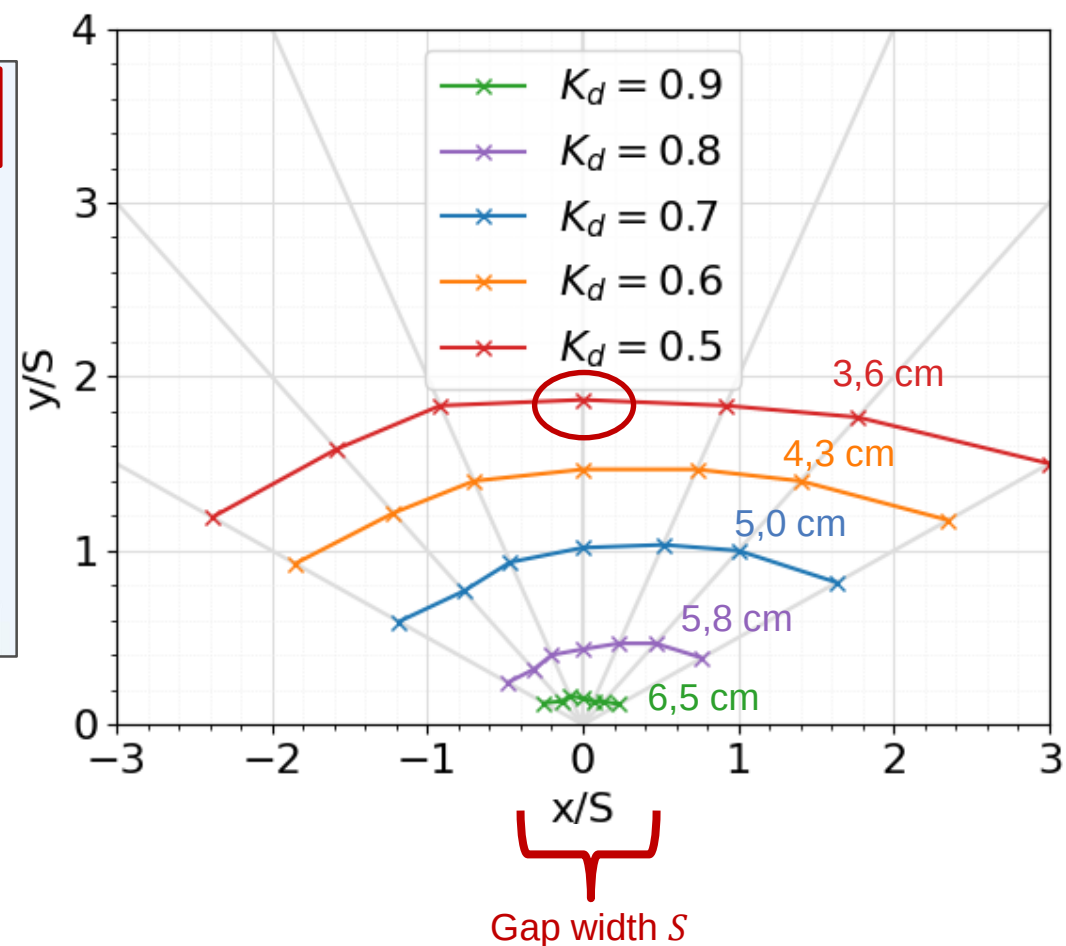
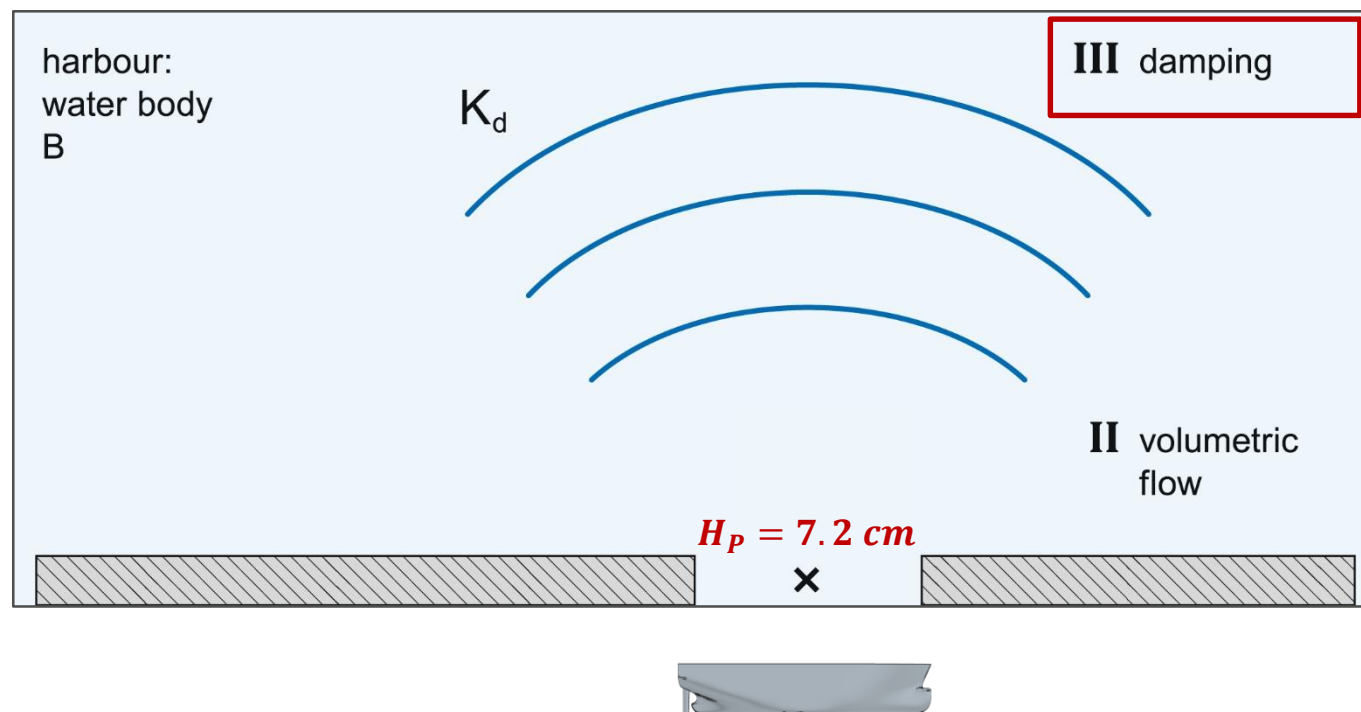
Propagation direction ↑

Diffraction diagrams for ocean waves



Source: Goda, Y.: *Random Seas and Design of Maritime Structures*, 2000

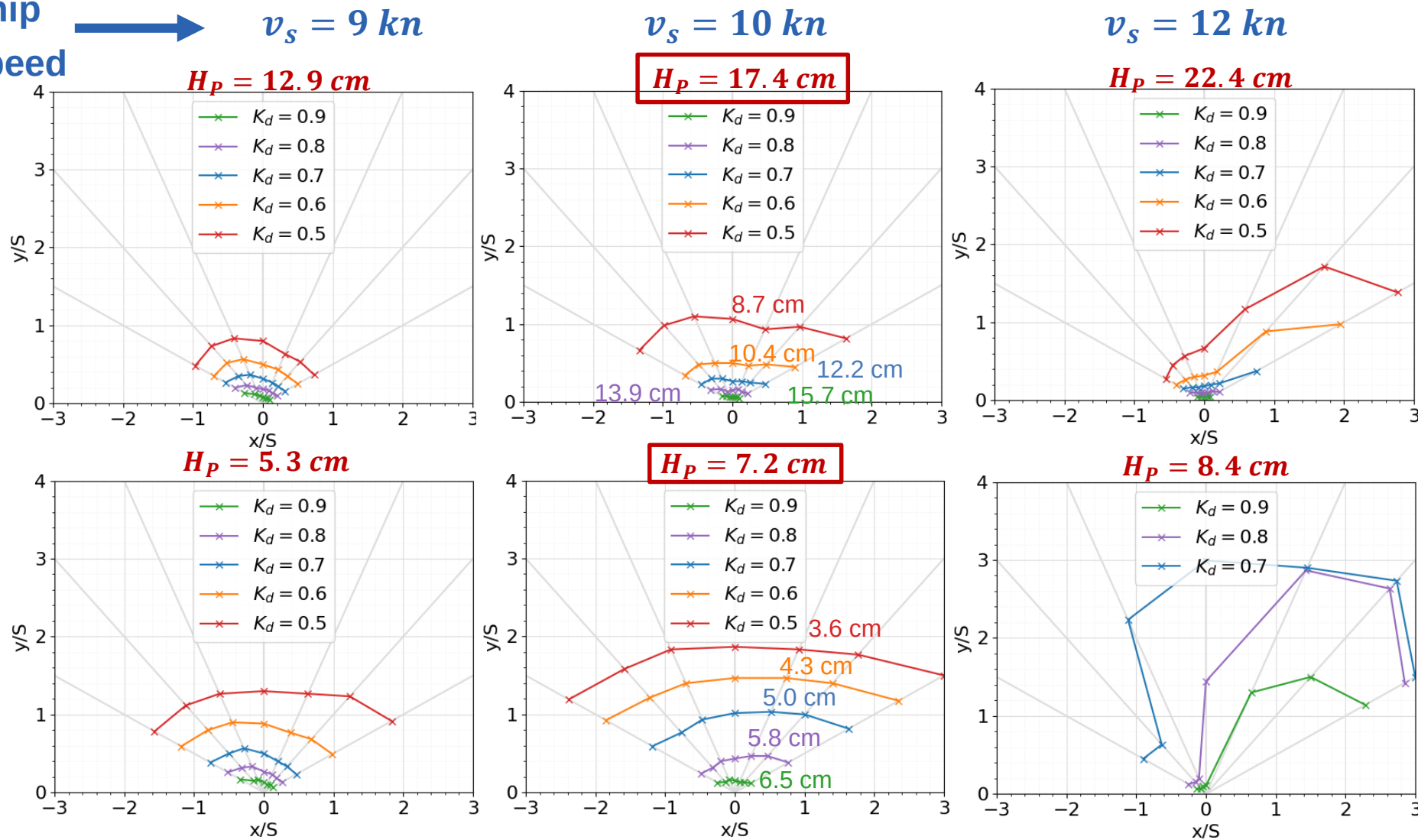
Subproblem III: Diffraction and damping of the primary wave



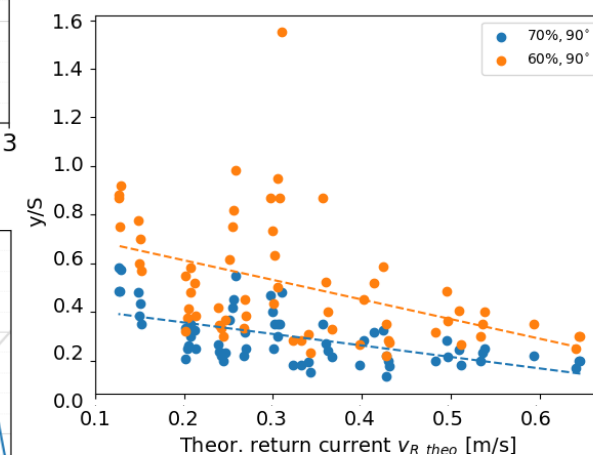
Subproblem III: Diffraction and damping of the primary wave. Results

Ship
speed

Channel width



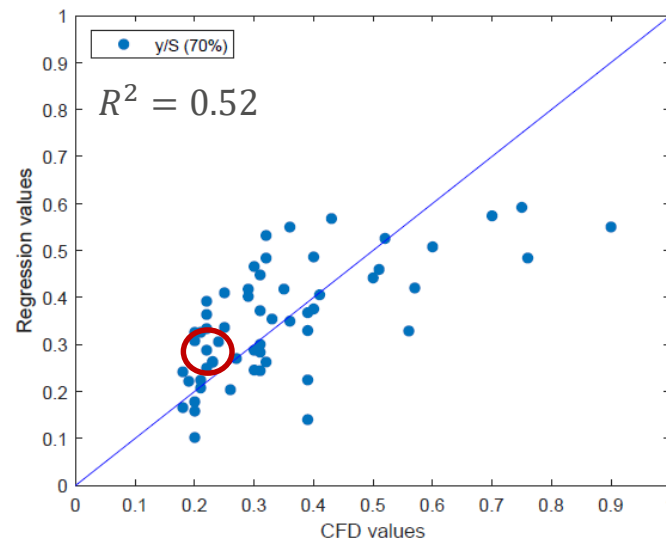
$$v_{R,theo} = \frac{v_s}{n}$$



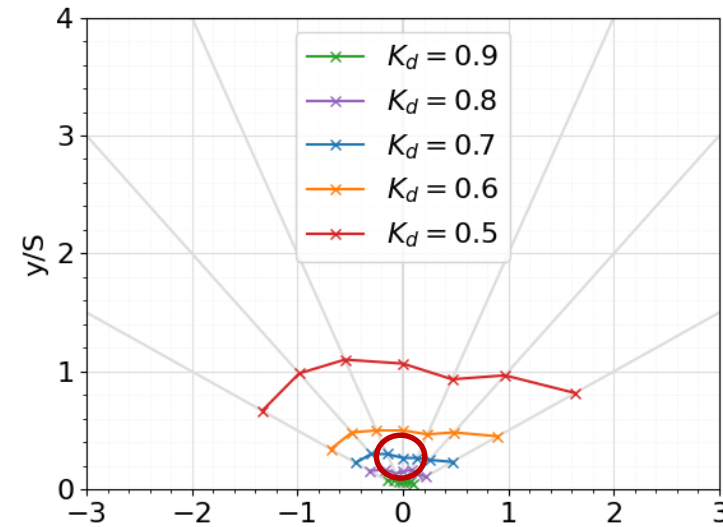
Summary: Problem description by means of physical parameters

Multiple linear regression:

$$\frac{y}{S} (70\%) = -0.30475 + 0.0066805 * t + 0.041055 * v_s + 0.0023352 * \frac{B}{2}$$



$t = 14,5 \text{ m}$
 $v_s = 10 \text{ kn} = 5.14 \text{ m/s}$
 $B = 240 \text{ m}$



$$\frac{y}{S} (70\%) = 0.2834$$

Conclusions

1. The channel width plays a significant role for the height of the generated primary wave.
2. For fast ships, the primary wave propagates asymmetrically into the harbour basin.
3. Usually, damping of the primary wave in a harbour basin is different from the damping of ocean waves.
4. **The strength of the damping can be estimated from basic ship and channel parameters.**
5. (In relative terms, large waves are damped earlier than small waves.)
6. **In absolute terms, large primary waves at the harbour entrance are to be avoided.**
This is realised by a low ship velocity and an adequate distance to the harbour entrance when passing.

Thank you for your attention!

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