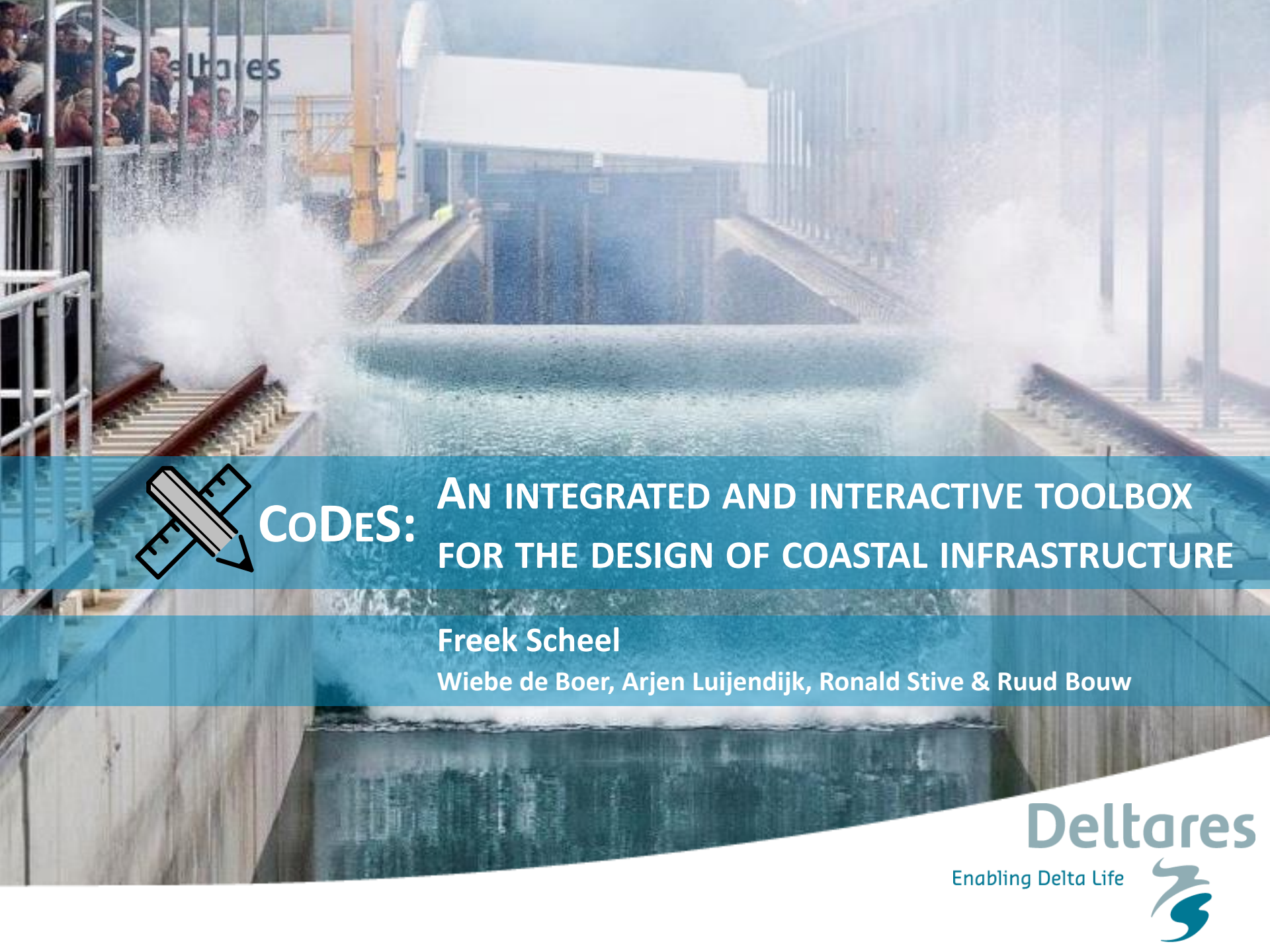


CoDeS: An integrated and interactive toolbox for the design of coastal infrastructure

Freek Scheel

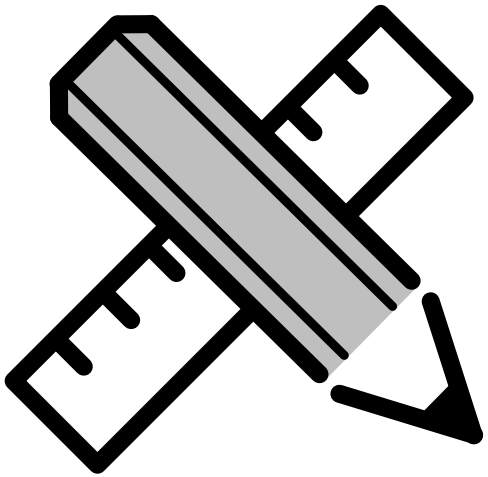
Wiebe de Boer, Arjen Luijendijk, Ronald Stive & Ruud Bouw

Deltares

Enabling Delta Life

Content

- Motivation
- Introduction to CoDeS
- Overview of functionality
- Impression of key functionalities
  - Generic data
  - CoDeS tools
- Highlights & conclusions
- Future developments



1. Motivation

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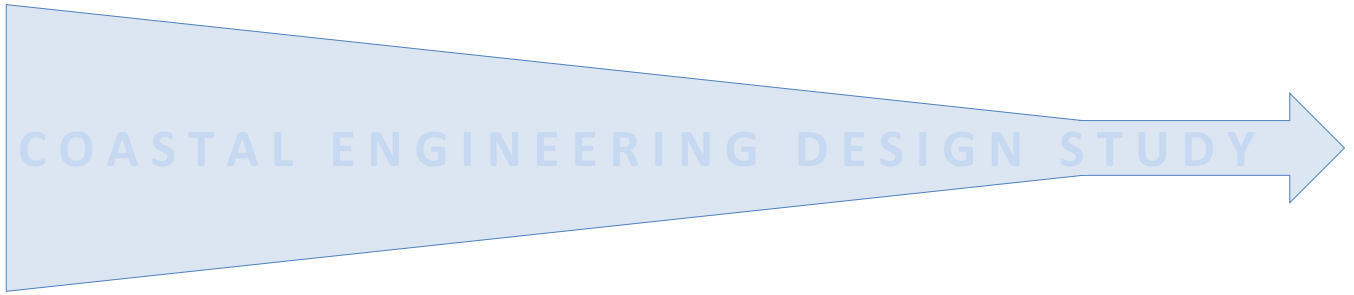
- Research questions
- Problem definition



- Answers
- Solutions

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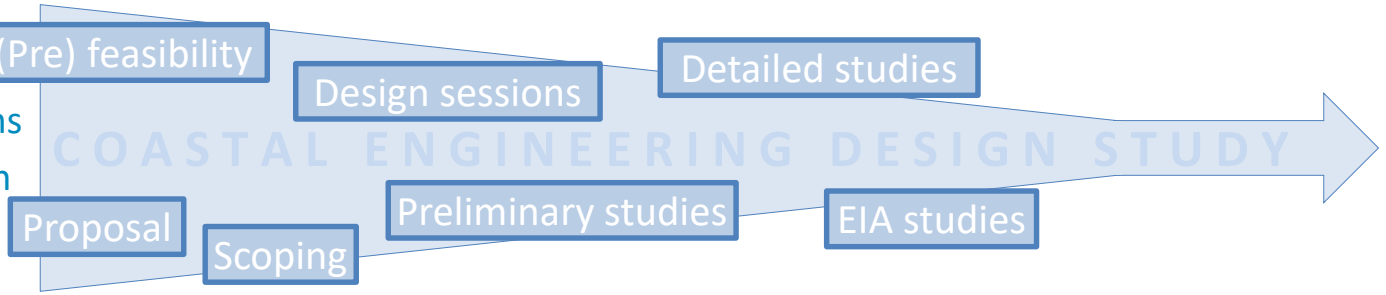

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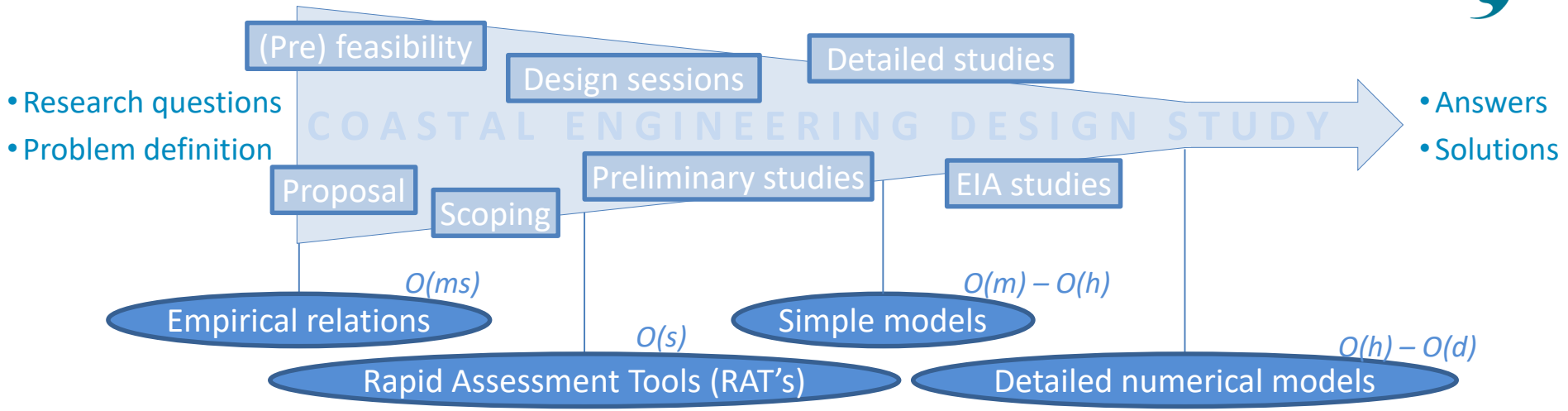

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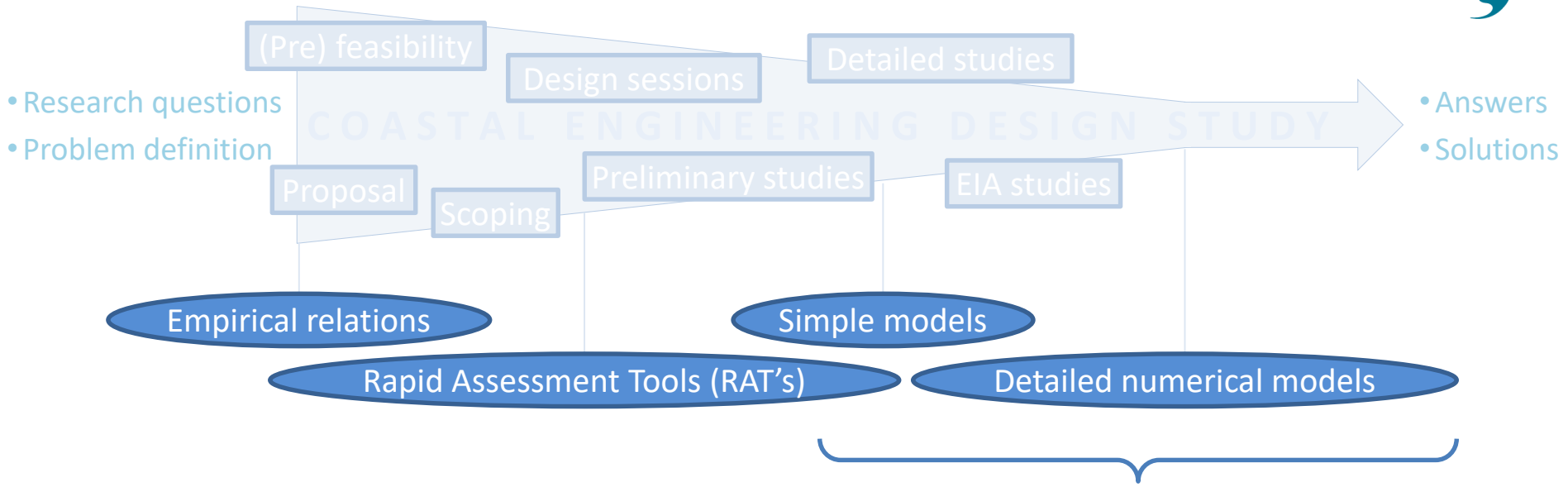
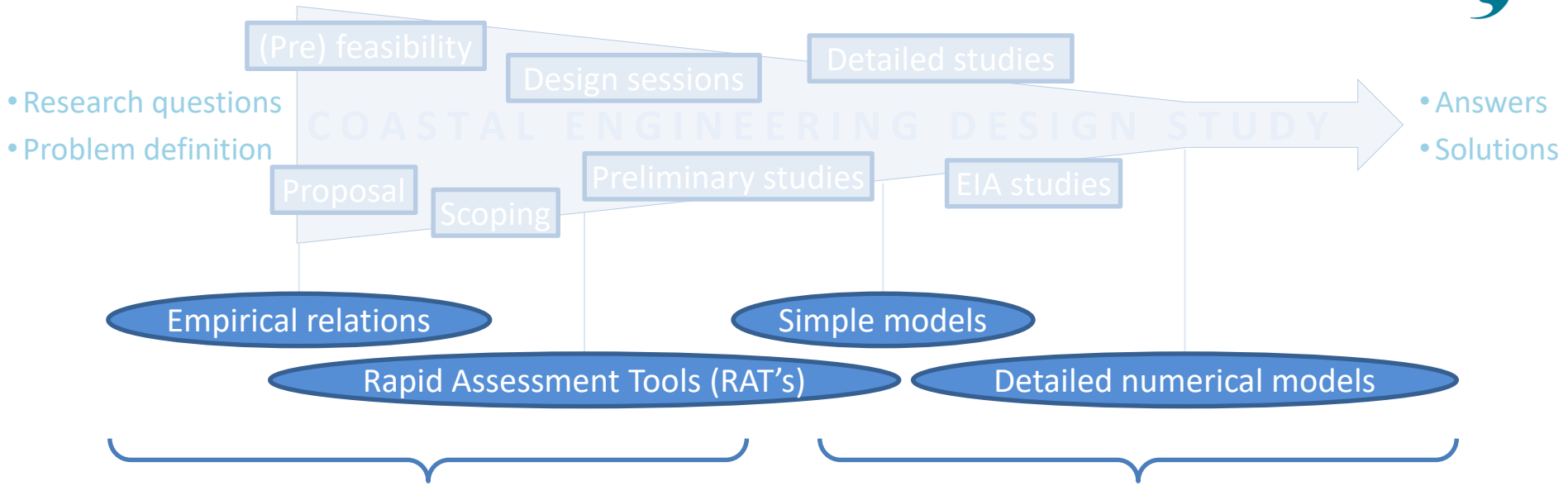


Increasingly complex physics, therefore

- Computationally demanding
- Hardly interactive
- Hard to integrate disciplines
- Professionally developed & validated

1. Motivation



Not consistently developed, potential for:

- Discipline integration
- Uniform and clear visualizations
- Validation and robustness
- Interactivity

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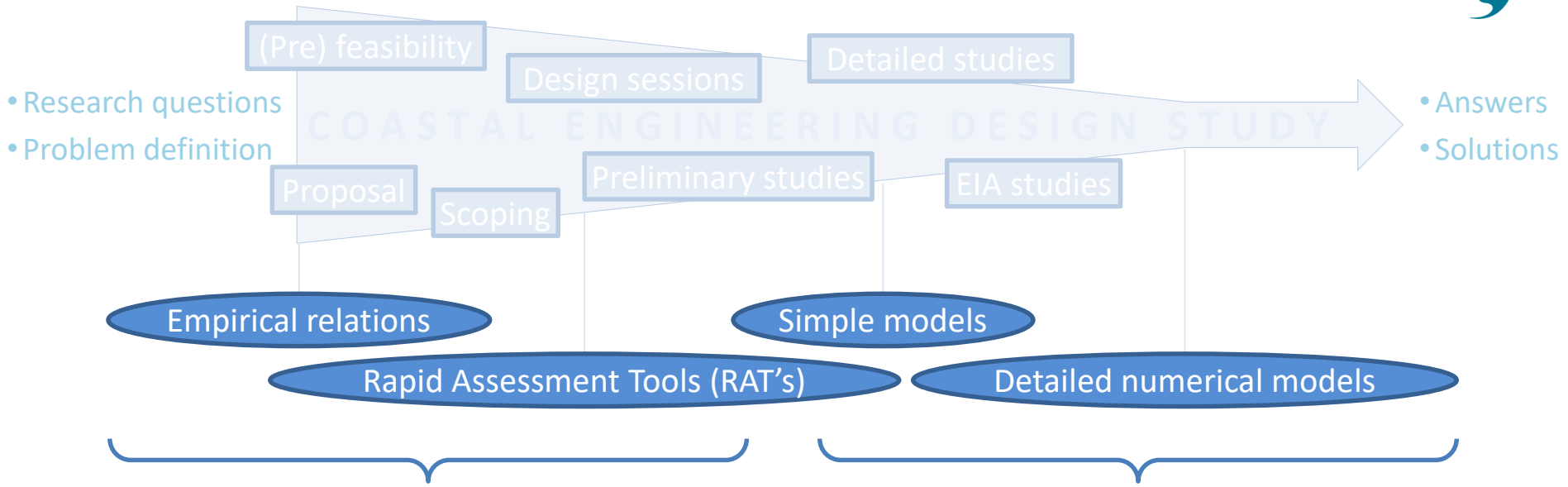

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Increasingly complex physics, therefore

- Computationally demanding
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CoDeS Tools (Coastal Design & Support Tools) are aimed at harvesting this potential

2. CoDeS – Introduction

What is CoDeS [1]

- A framework in which tools from different disciplines are implemented, with focus on:
  - Validation
  - Consistency
  - Robustness

  } Gain confidence in basic tools

  - Discipline integration → Optimizing designs
  - Interactivity (fast tools) → Communication with clients & stakeholders (design sessions)

- Supporting clients & stakeholders in early design phases of interventions in coastal systems

- Developed in a consortium formed by:
  - Royal HaskoningDHV – Enhancing Society Together; Witteveen + Bos; Deltares – Enabling Delta Life

- Developing an open community in which engineers can contribute to the framework

[1] *CoDeS tools → Coastal Design & Support Tools*

3. CoDeS – Overview

Deltares
Enabling Delta Life

Generic data

- Settings
- Coastline
- Bathymetry
- Structures
- Waves
- Tide
- Sediment

CoDeS Tools

- Coastline dynamics
- Breakwater design
- Wave penetration
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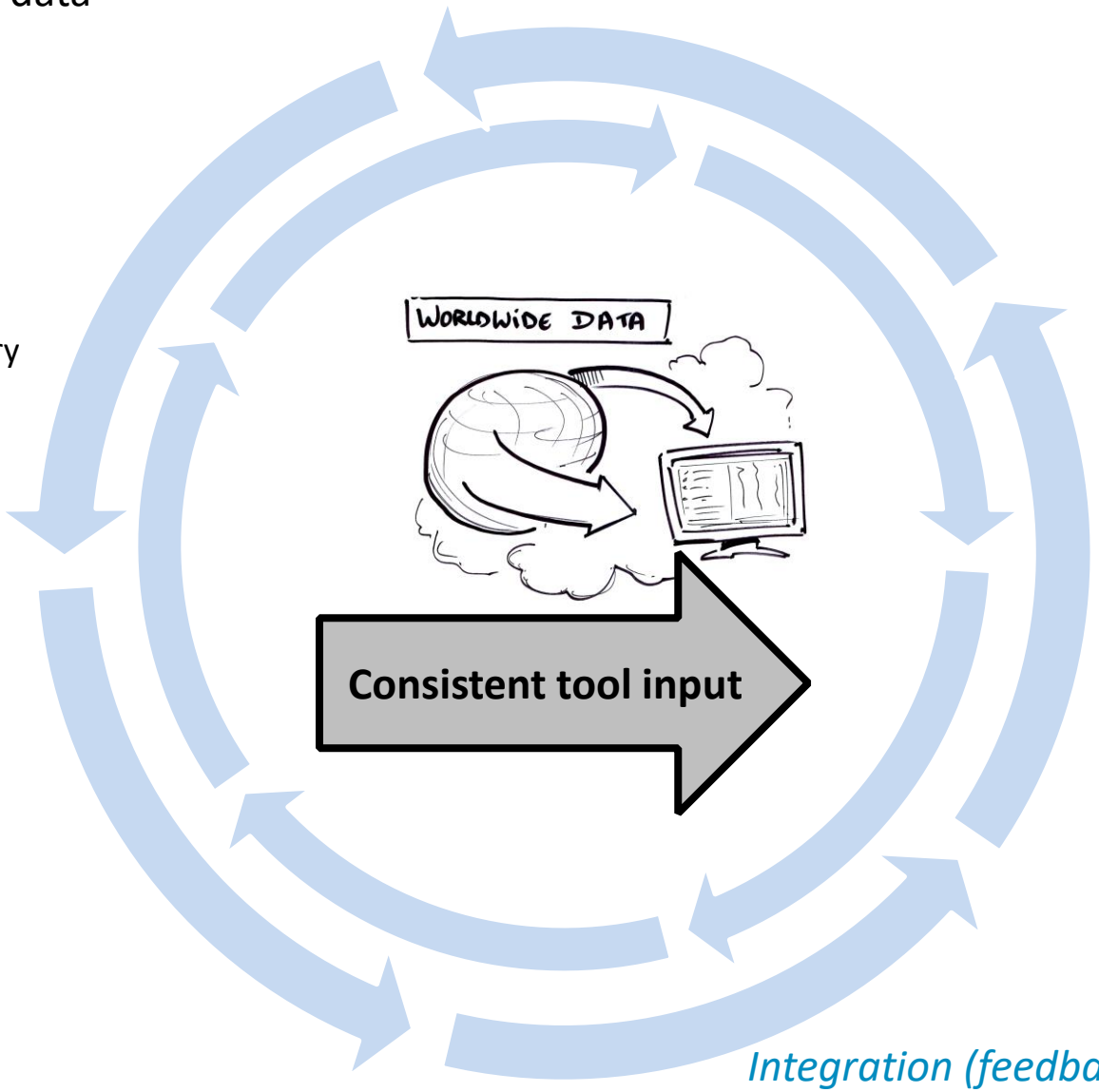

CoDeS Tools

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Integration (feedback) between all tools

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4. CoDeS – Generic data – Bathymetry

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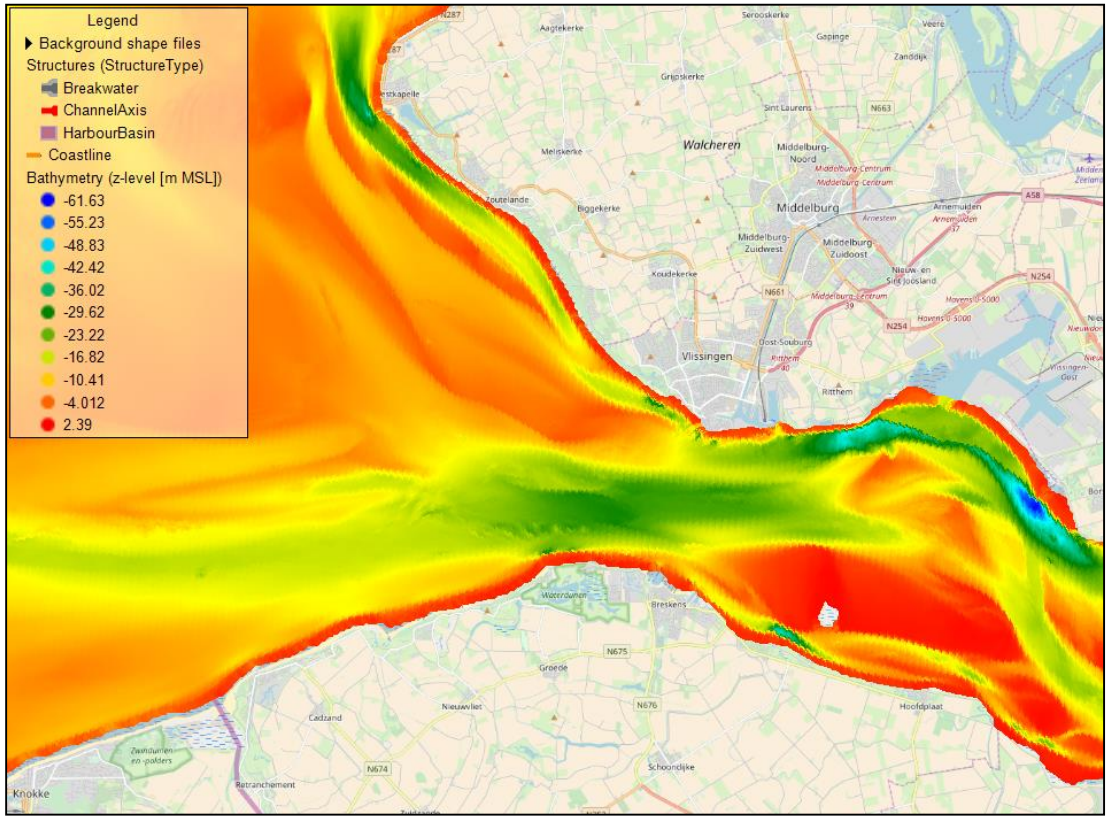

CoDeS Tools

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- Interactive flow fields

- Define cross-shore profiles and/or load spatial fields
- Work with different coordinate systems
- Create and modify bathymetry data:

4. CoDeS – Generic data – Bathymetry

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Enabling Delta Life

Generic data

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- Structures
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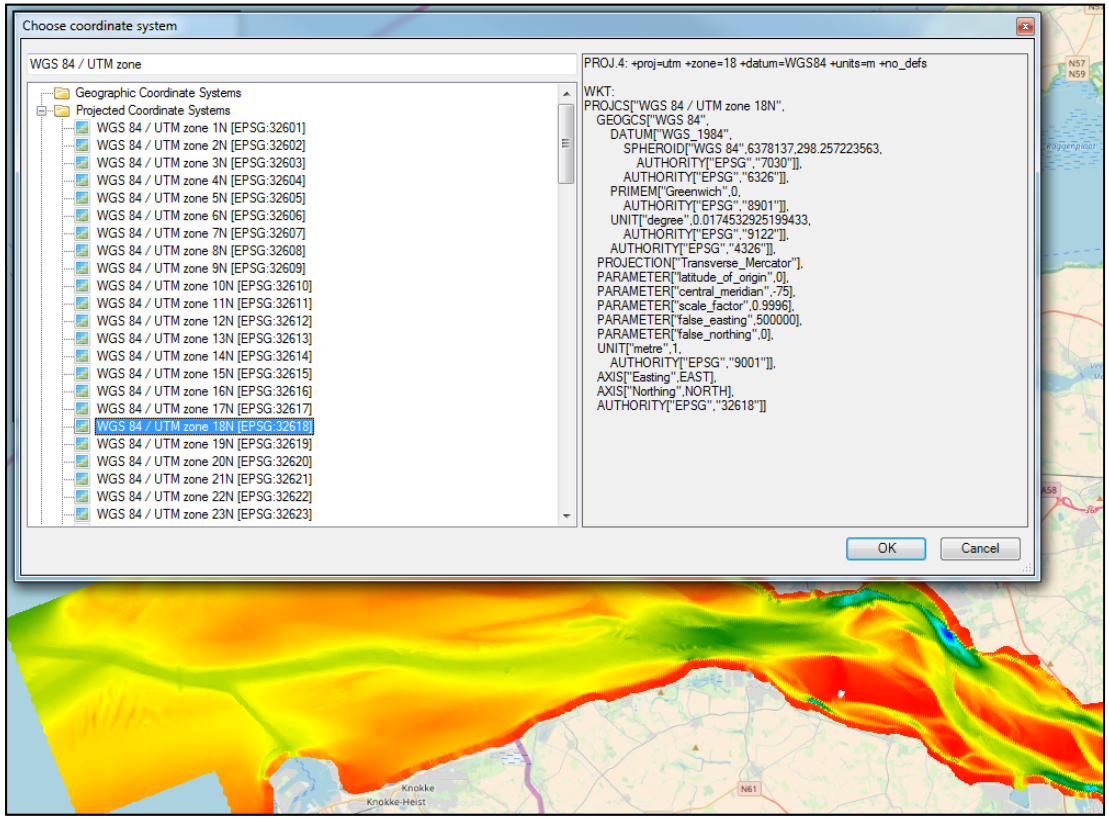

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Waves
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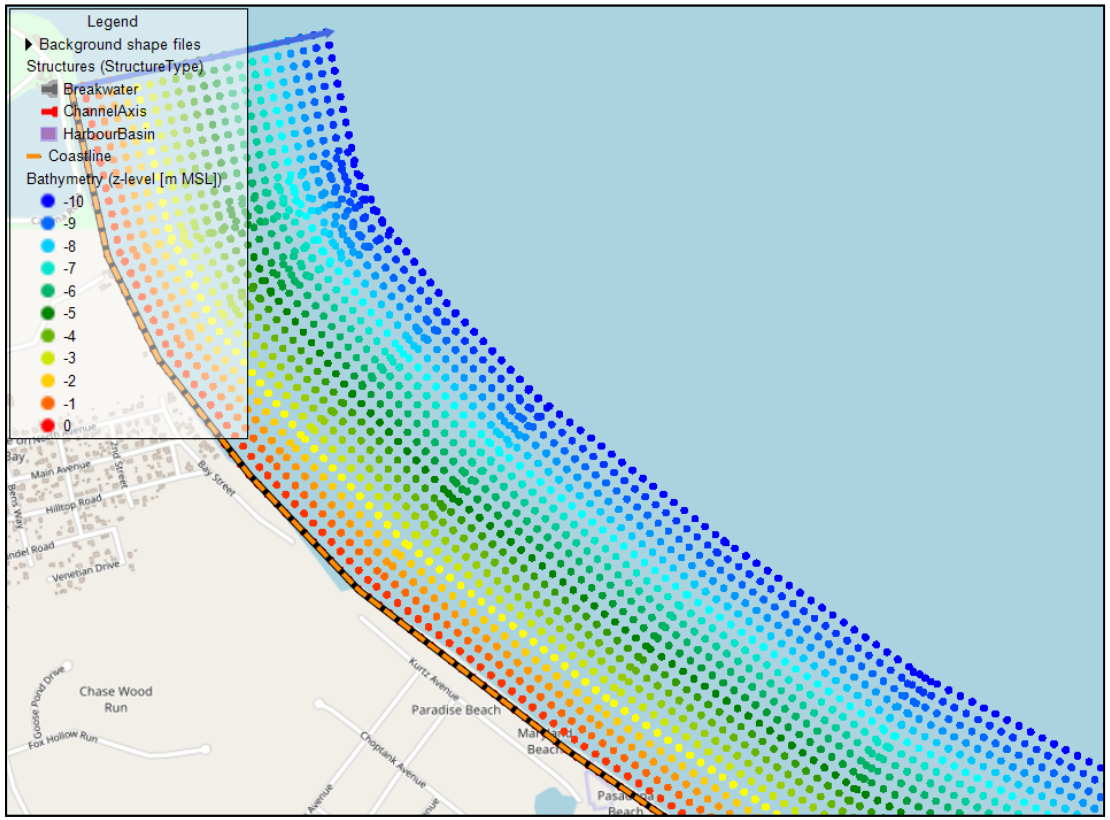

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Interactive flow fields

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Deltares
Enabling Delta Life

Generic data

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Bathymetry

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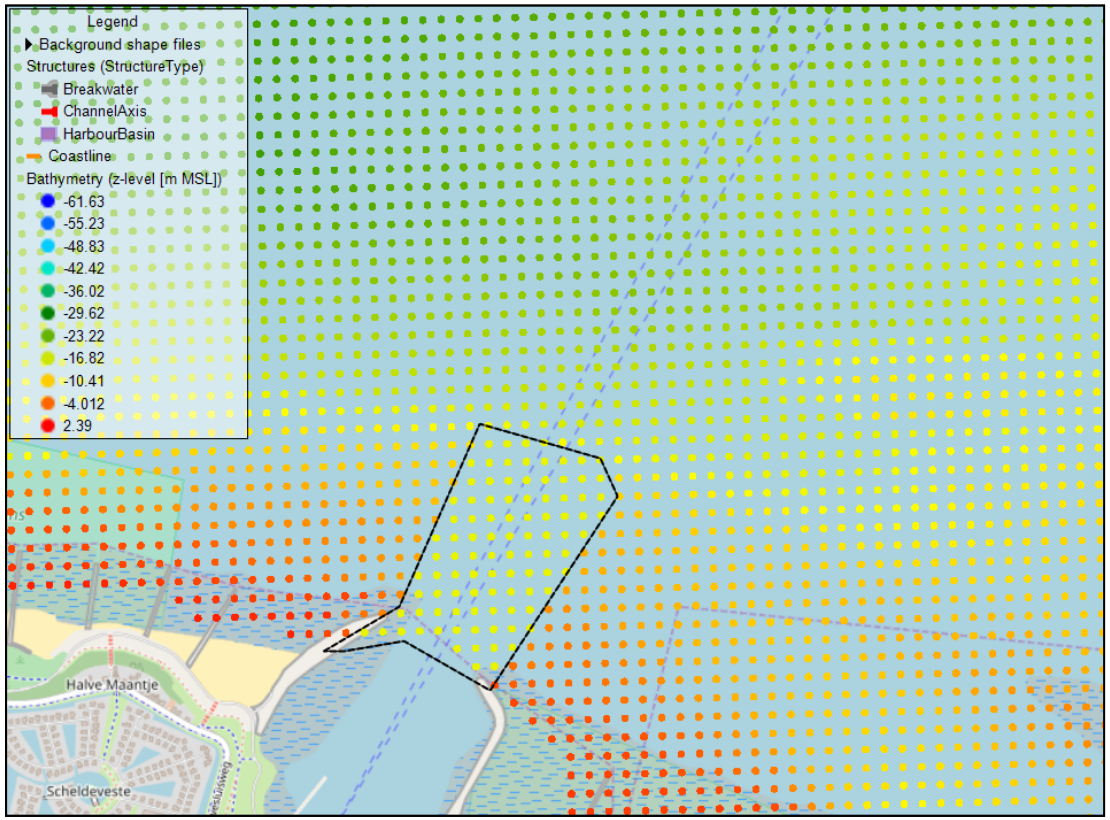

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CoDeS Tools

Coastline dynamics

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Interactive flow fields

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4. CoDeS – Generic data – Structures

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Enabling Delta Life

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Enabling Delta Life

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Waves

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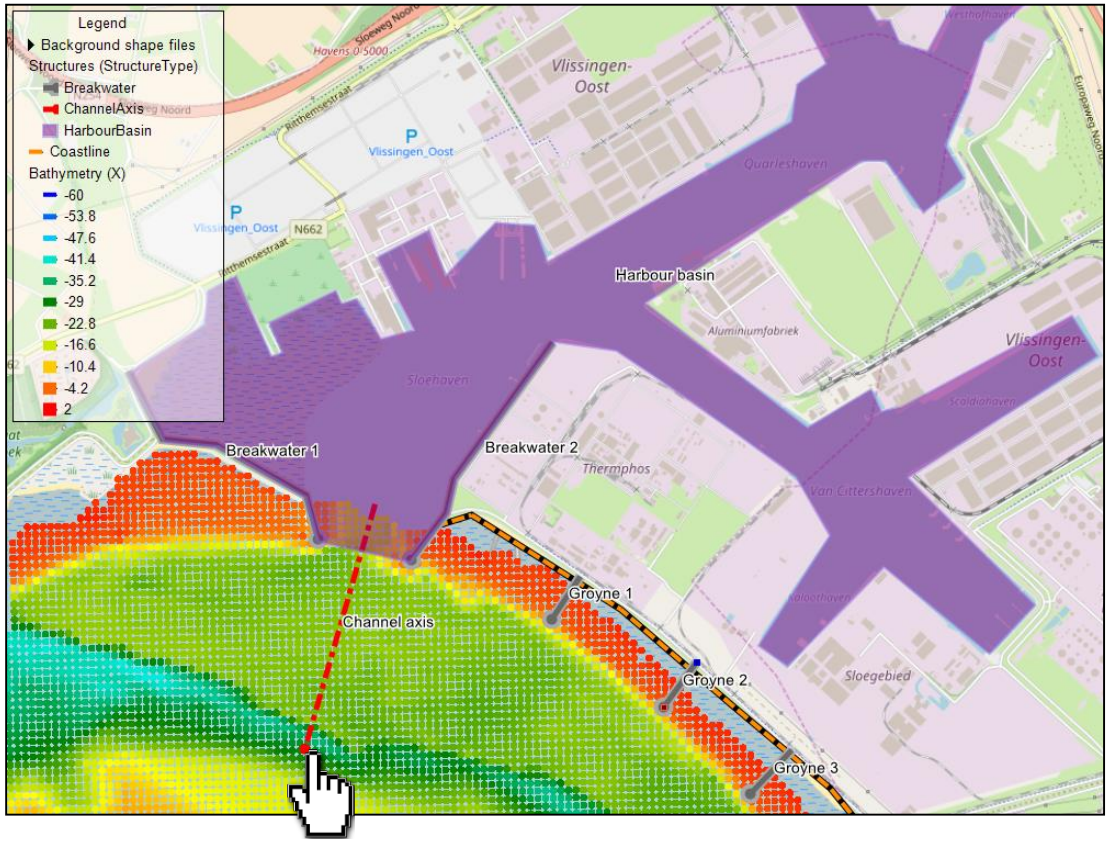

CoDeS Tools

Coastline dynamics

Breakwater design

Wave penetration

Channel sedimentation

Harbour basin siltation

eCoDeS

Interactive flow fields

- Design & manage structures, harbour basin, channel axis, etc.

4. CoDeS – Generic data – Structures

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Enabling Delta Life

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4. CoDeS – Generic data – Waves

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Enabling Delta Life

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4. CoDeS – Generic data – Waves

Deltares
Enabling Delta Life

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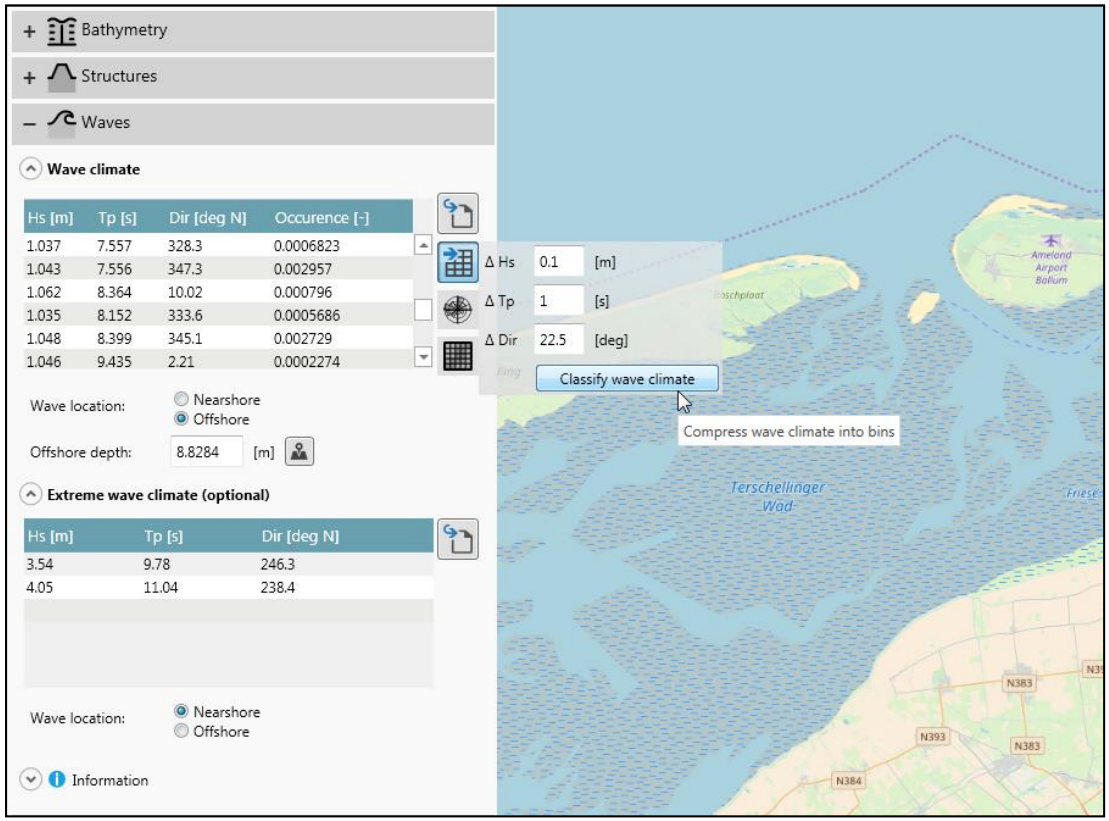

Coastline dynamics

Breakwater design

Wave penetration

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Harbour basin siltation

eCoDeS

Interactive flow fields

- Load wave data (time series, climates, extreme waves)
- Instantly create joint occurrence tables & wave roses:
- Wave climate input reduction (bin compression)
- Offshore → nearshore wave transformation in all tools (linear wave theory)

4. CoDeS – Generic data – Waves

Deltares
Enabling Delta Life

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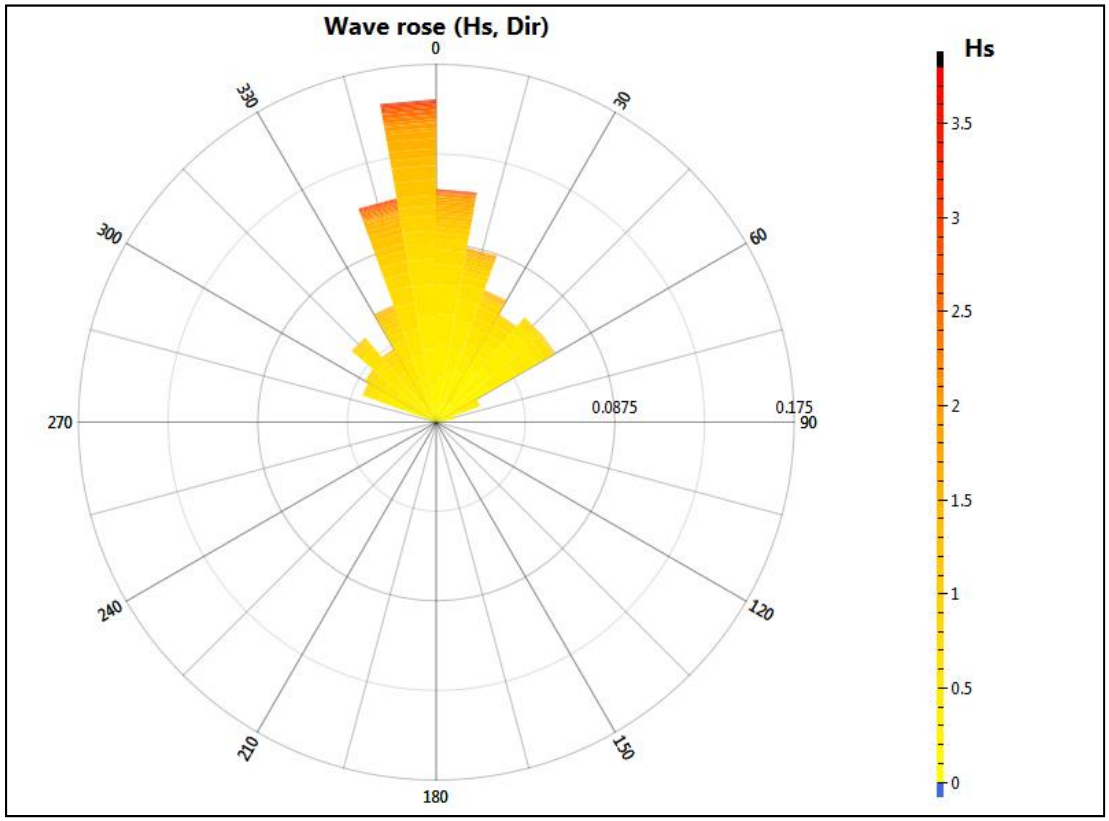

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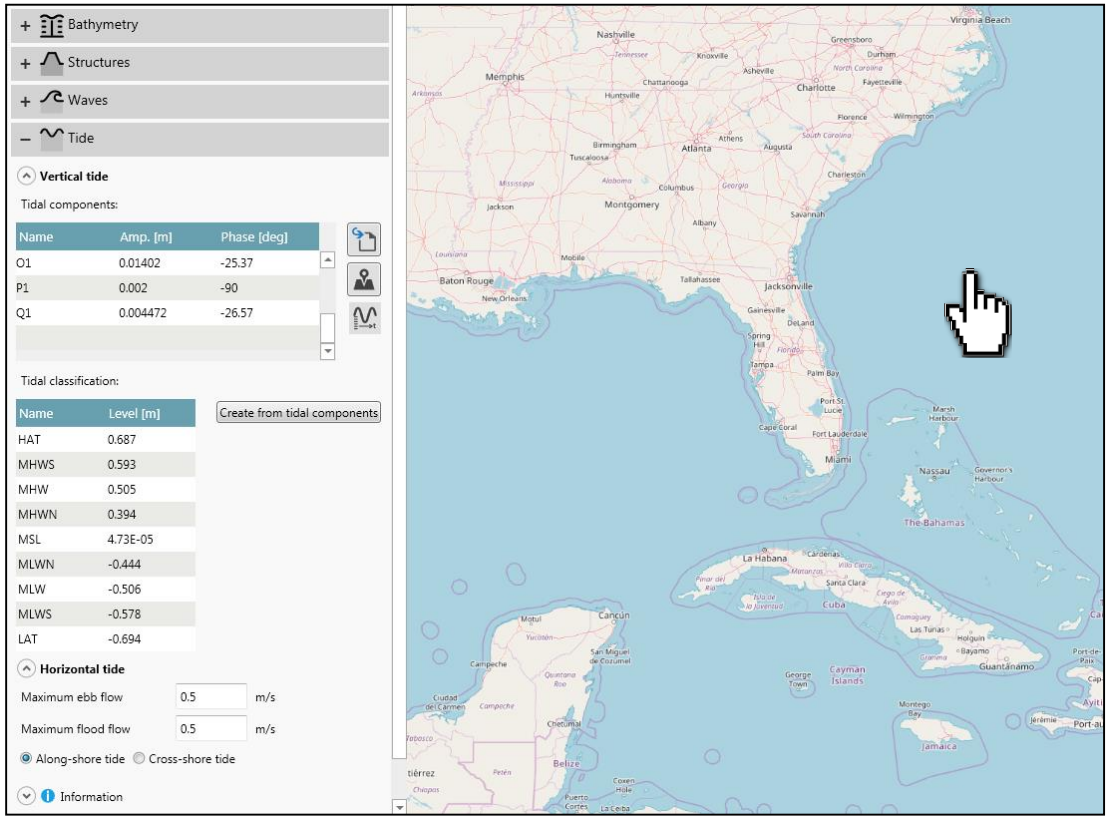

CoDeS Tools

Coastline dynamics
Breakwater design
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- Obtain tidal components anywhere on earth (TPXO 8.0)
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4. CoDeS – Generic data – Tide

Deltares
Enabling Delta Life

Generic data

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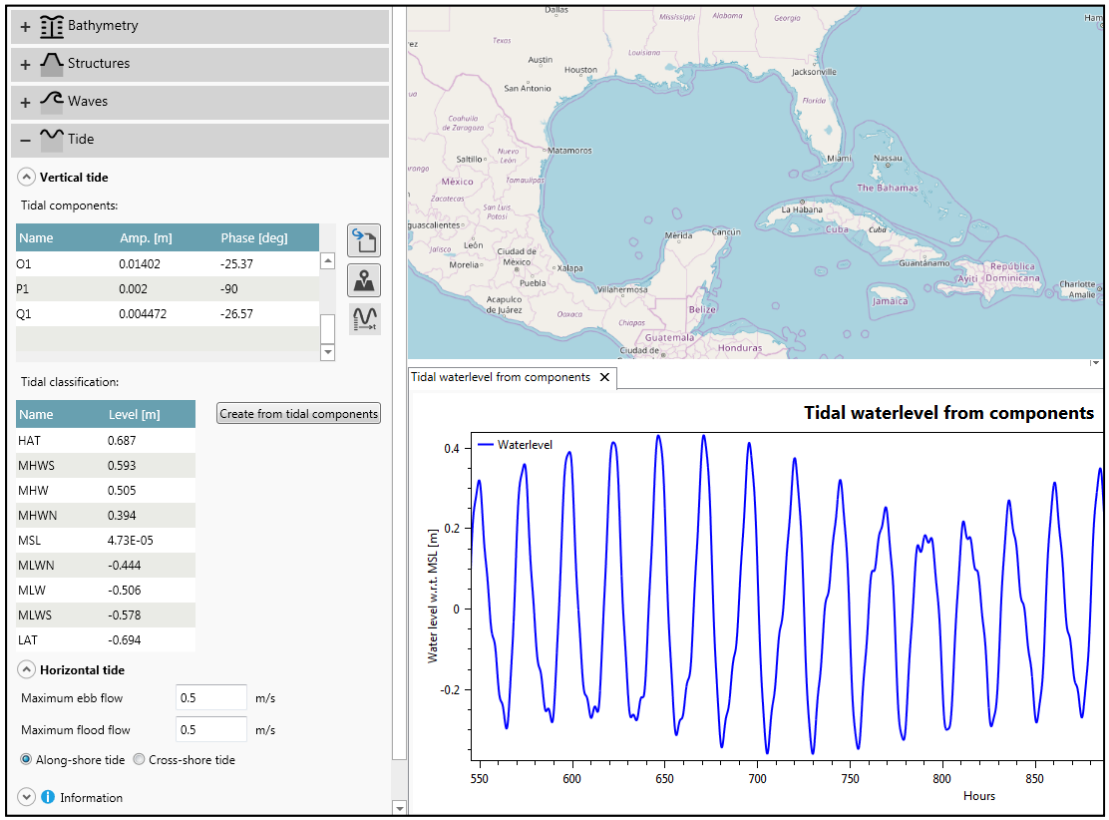

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4. CoDeS – Generic data – Consistent tool input

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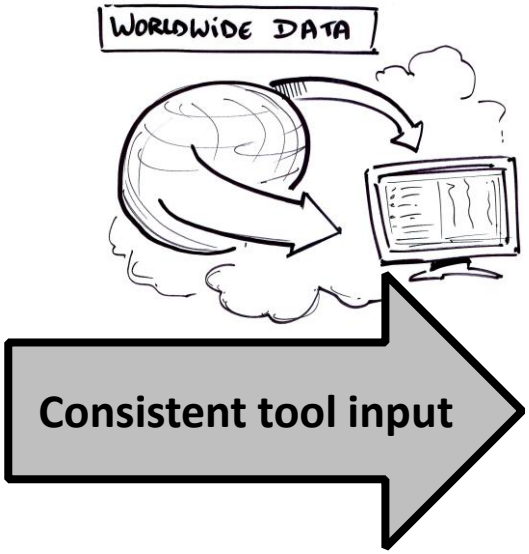

CoDeS Tools

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4. CoDeS – CoDeS Tools – Coastline dynamics

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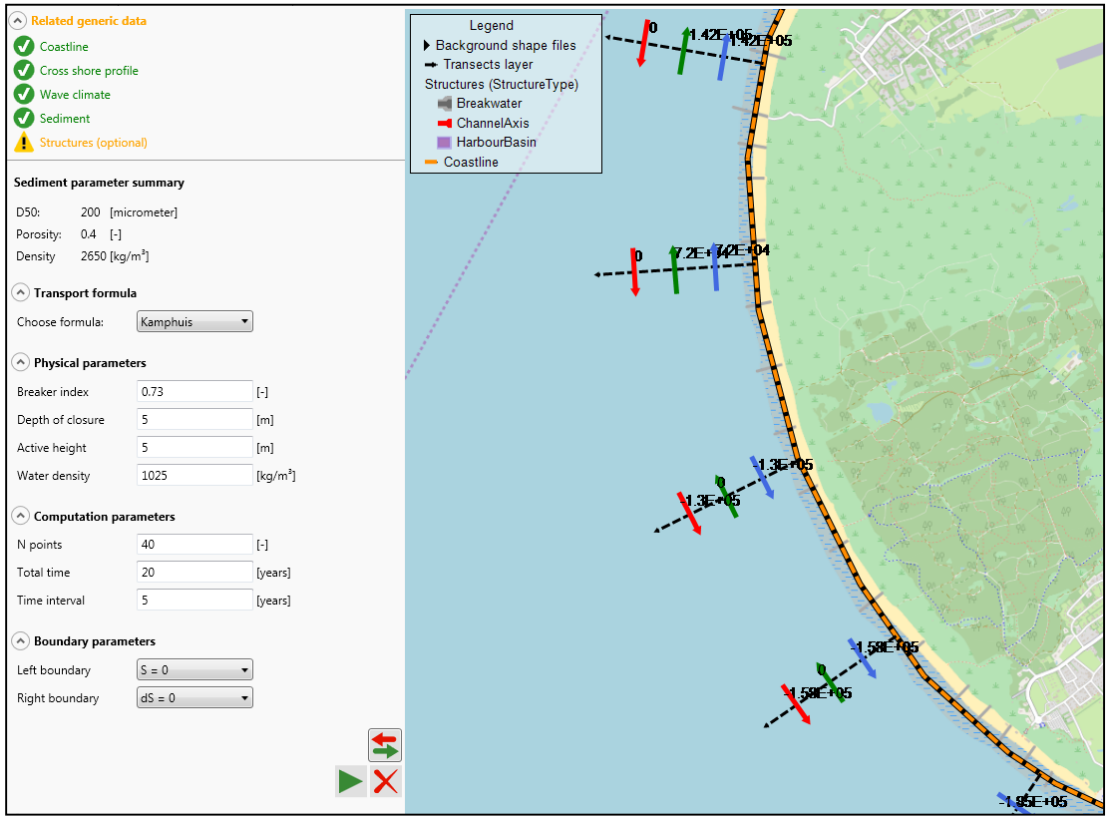

Coastline dynamics

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eCoDeS

Interactive flow fields

- Inspect S-ϕ curves
- Gross/net alongshore transports (CERC & Kamphuis)
- Coastline dynamics, incl. structures (Pelnard-Considère)

4. CoDeS – CoDeS Tools – Coastline dynamics

Deltares
Enabling Delta Life

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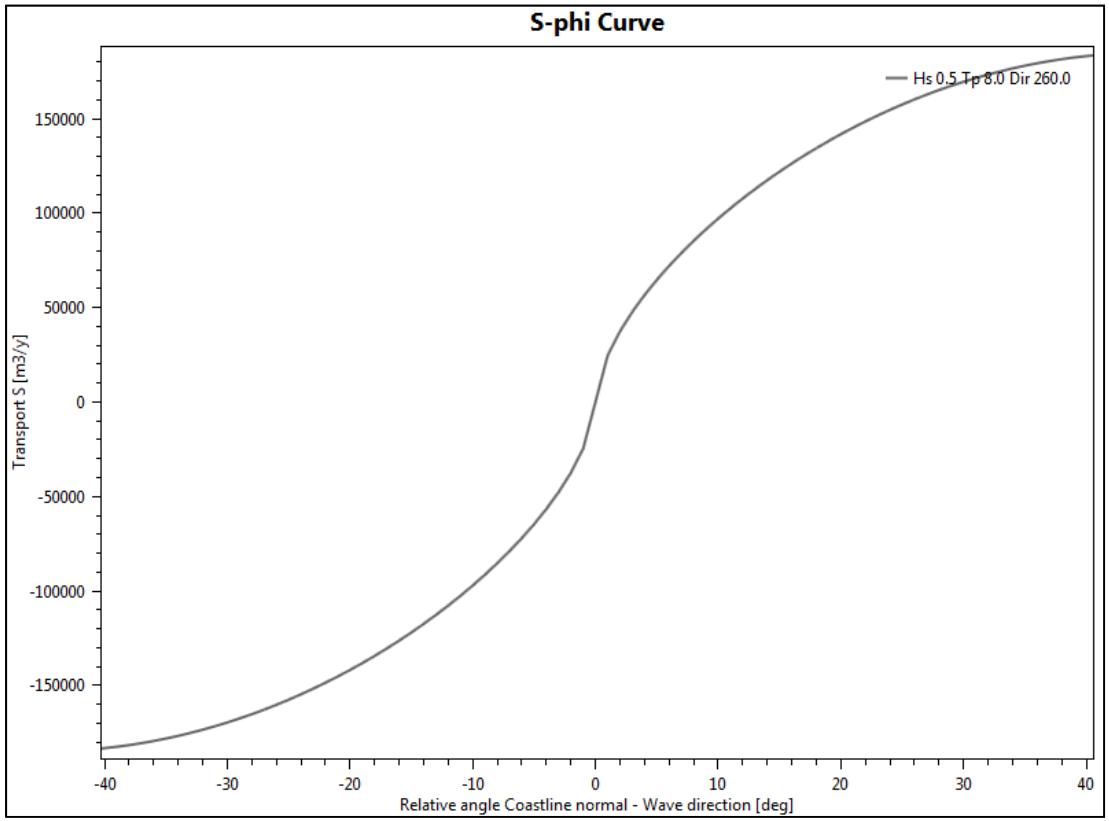

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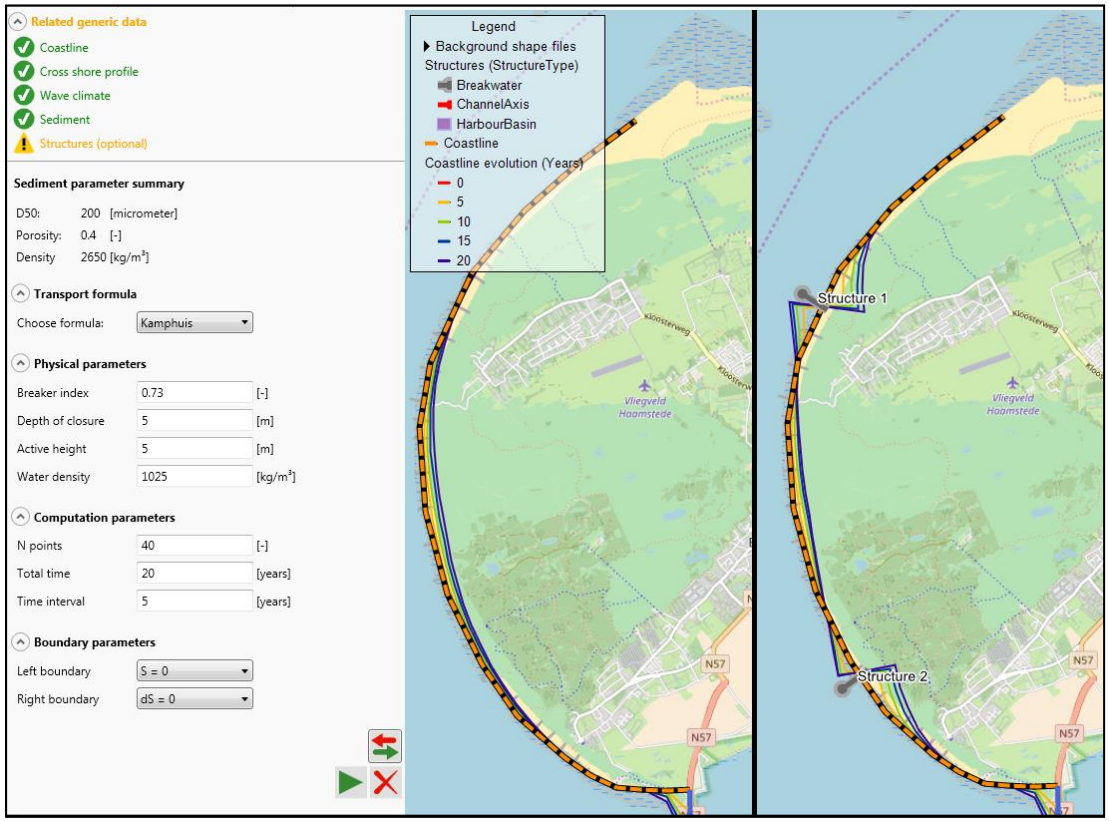

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4. CoDeS – CoDeS Tools – Breakwater design

Deltares
Enabling Delta Life

Generic data

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CoDeS Tools

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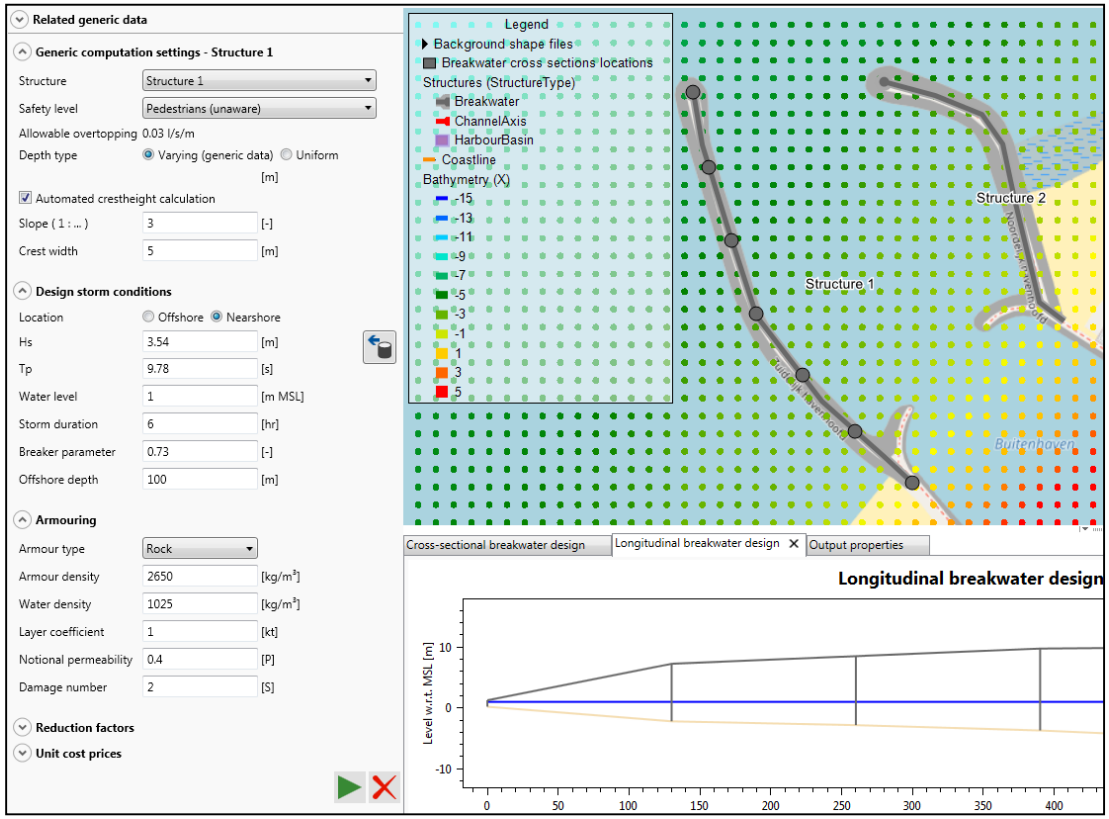

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eCoDeS

Interactive flow fields

- Design rubble mound breakwaters (rock manual)
- Due to varying waves, bathy, overtopping, safety levels, etc.
- Armor, filter & core layer design, dimensions, volumes & costs estimate

4. CoDeS – CoDeS Tools – Breakwater design

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Enabling Delta Life

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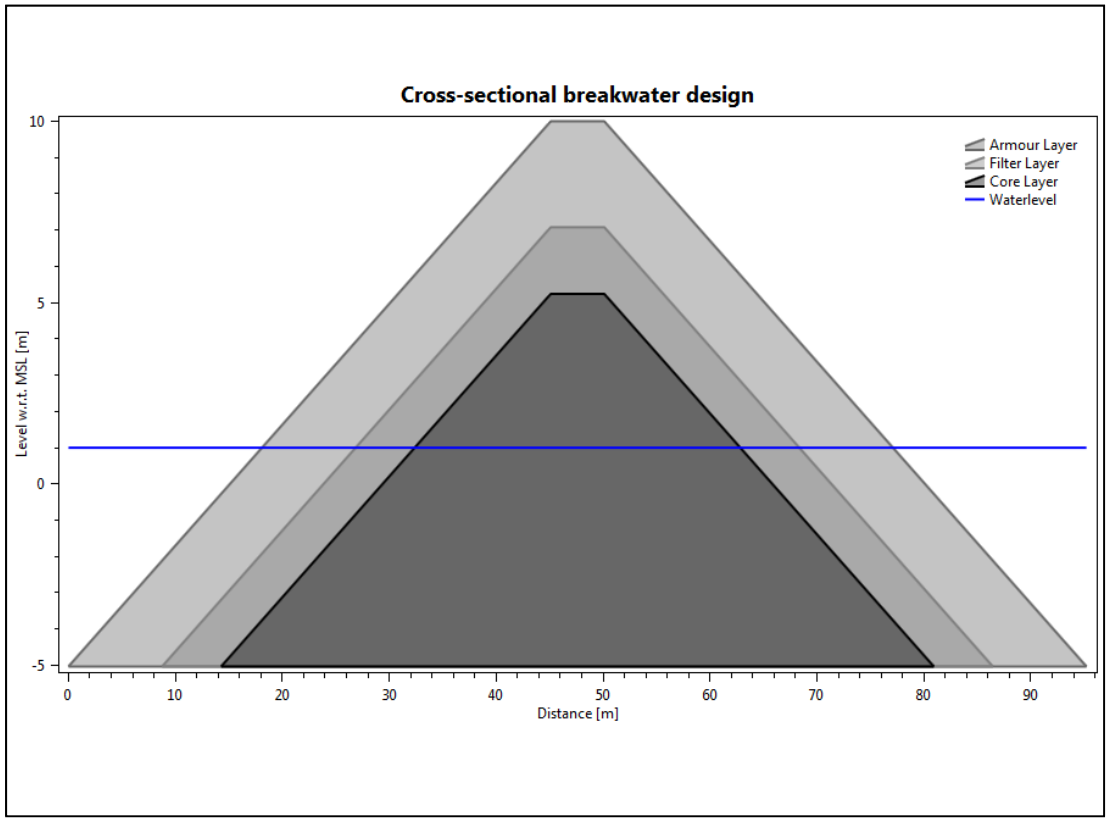

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4. CoDeS – CoDeS Tools – Wave penetration

Deltares
Enabling Delta Life

Generic data

CoDeS Tools

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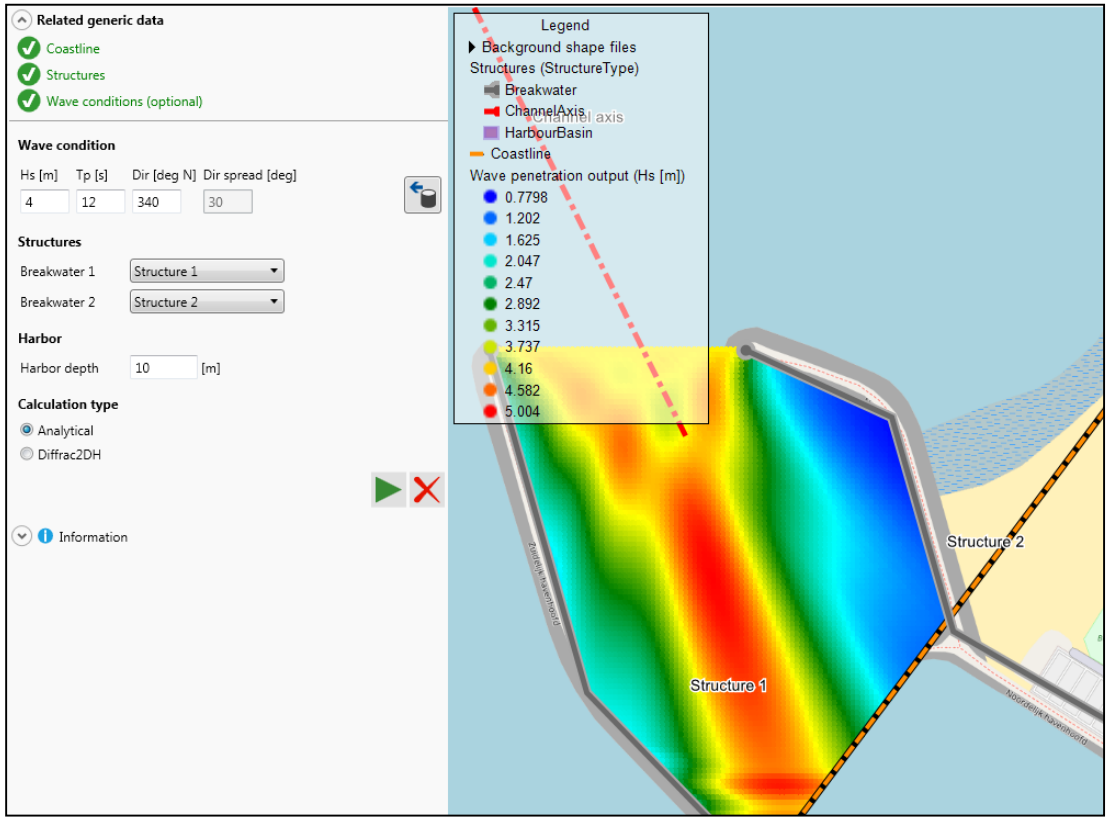
Sediment



Coastline dynamics

Breakwater design

Wave penetration

Channel sedimentation

Harbour basin siltation

eCoDeS

Interactive flow fields

- Wave penetration in a harbour basin, based on diffraction patterns
- Combined Sommerfeld solutions (Cornu spirals) or DIFFRAC-2DH

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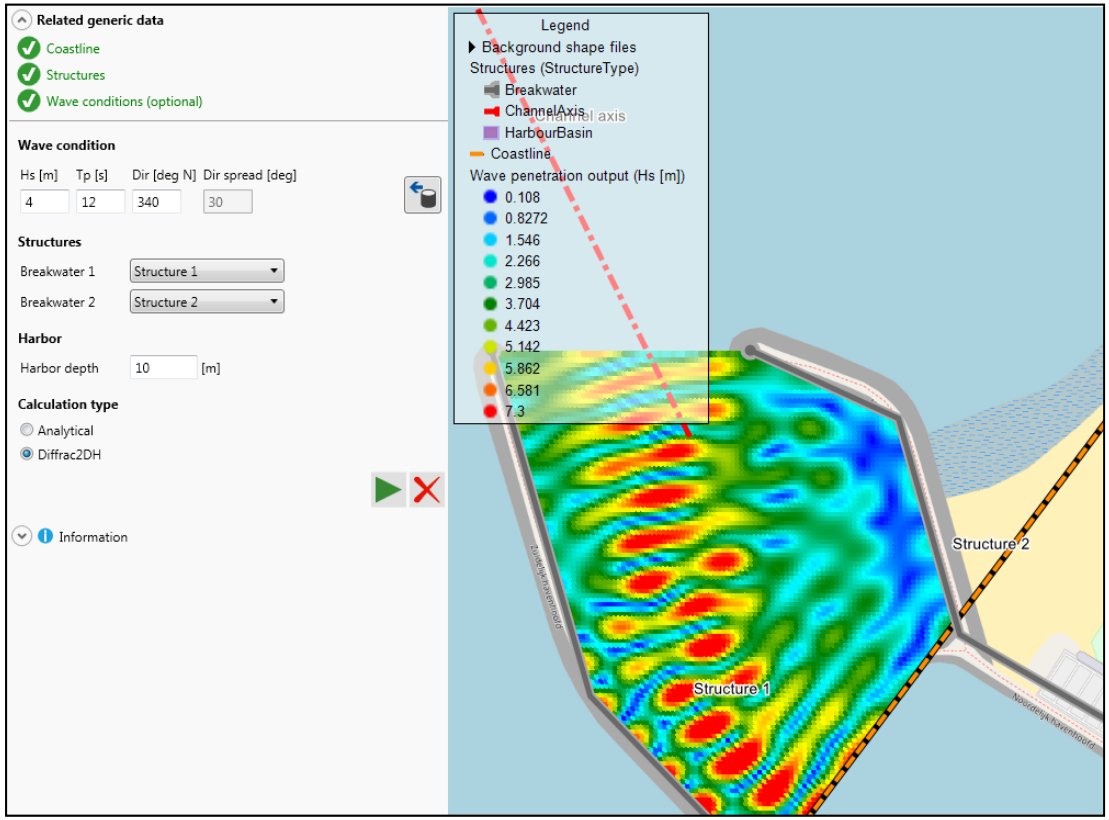

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4. CoDeS – CoDeS Tools – Channel sedimentation

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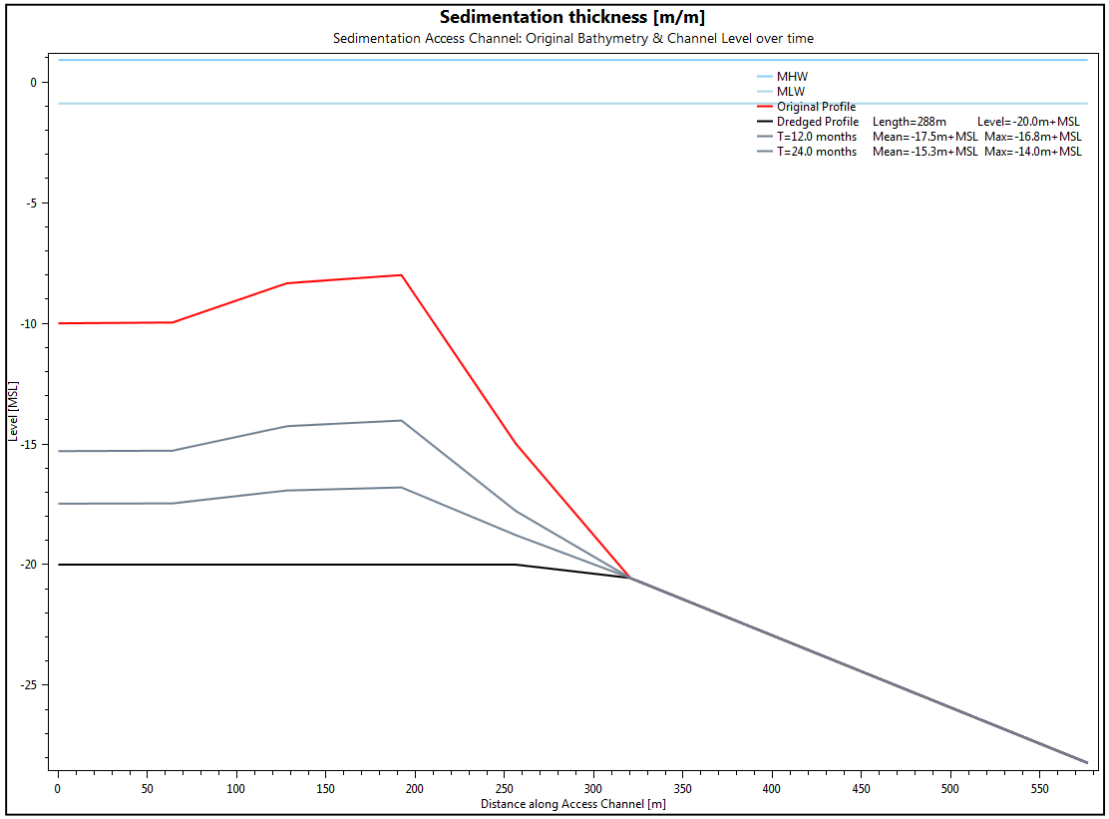

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Interactive flow fields

- Sedimentation in access channel (based on v. Rijn tool SEDPIT)
- Morphodynamic feedback loop & automated sensitivity analysis
- Along & cross channel visualizations & bulk quantities
- Due to tide, waves, sediment characteristics & geometry

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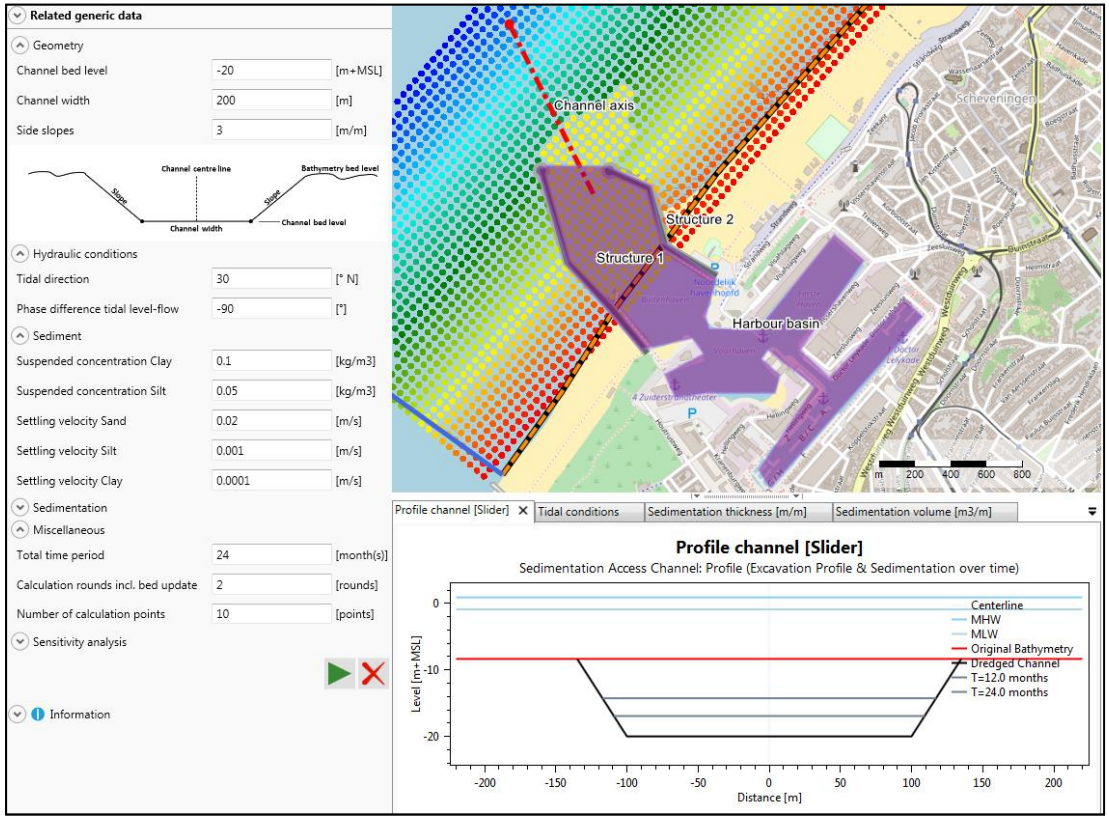

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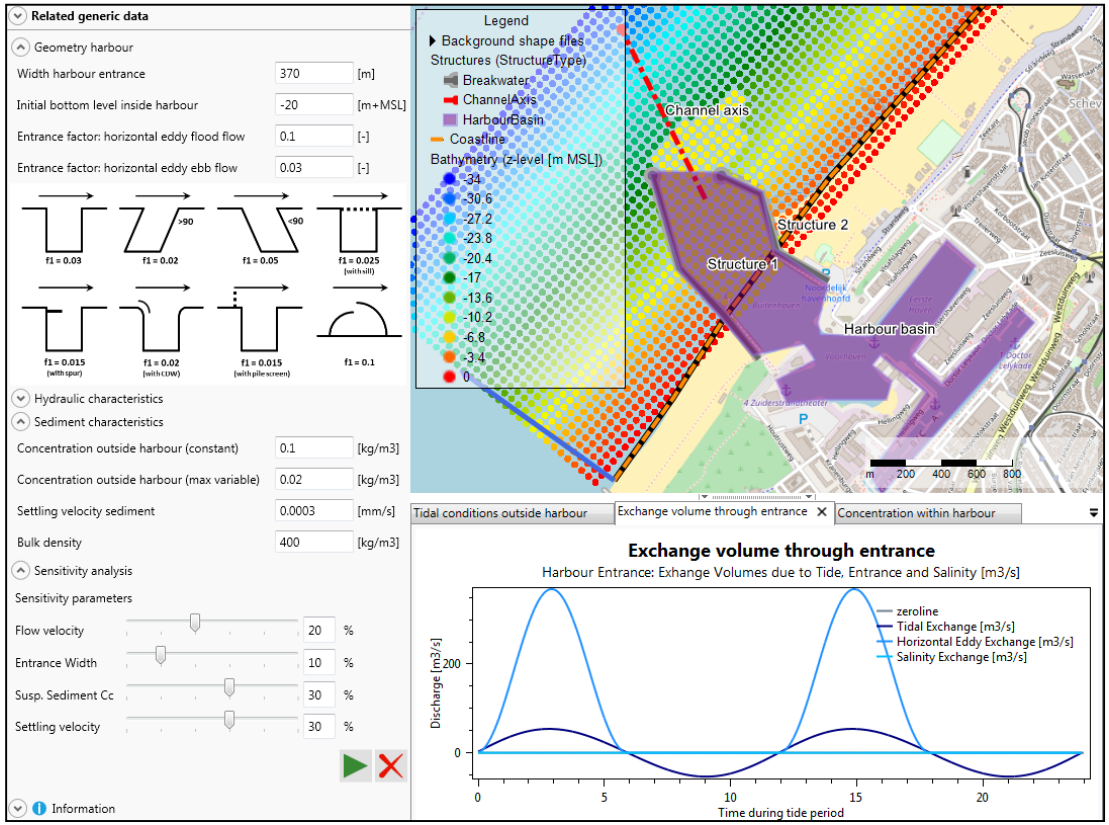

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- Concentrations, siltation quantities & automated sensitivity analysis
- Due to tide, sediment characteristics & geometry

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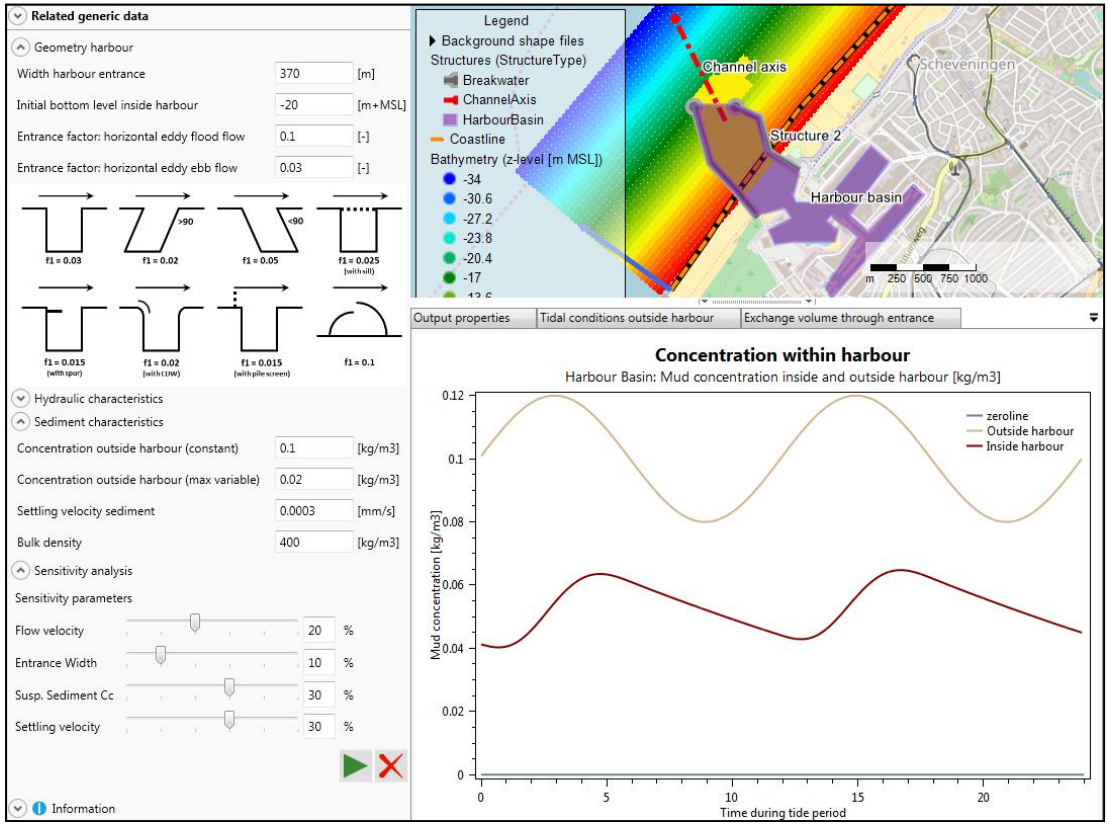

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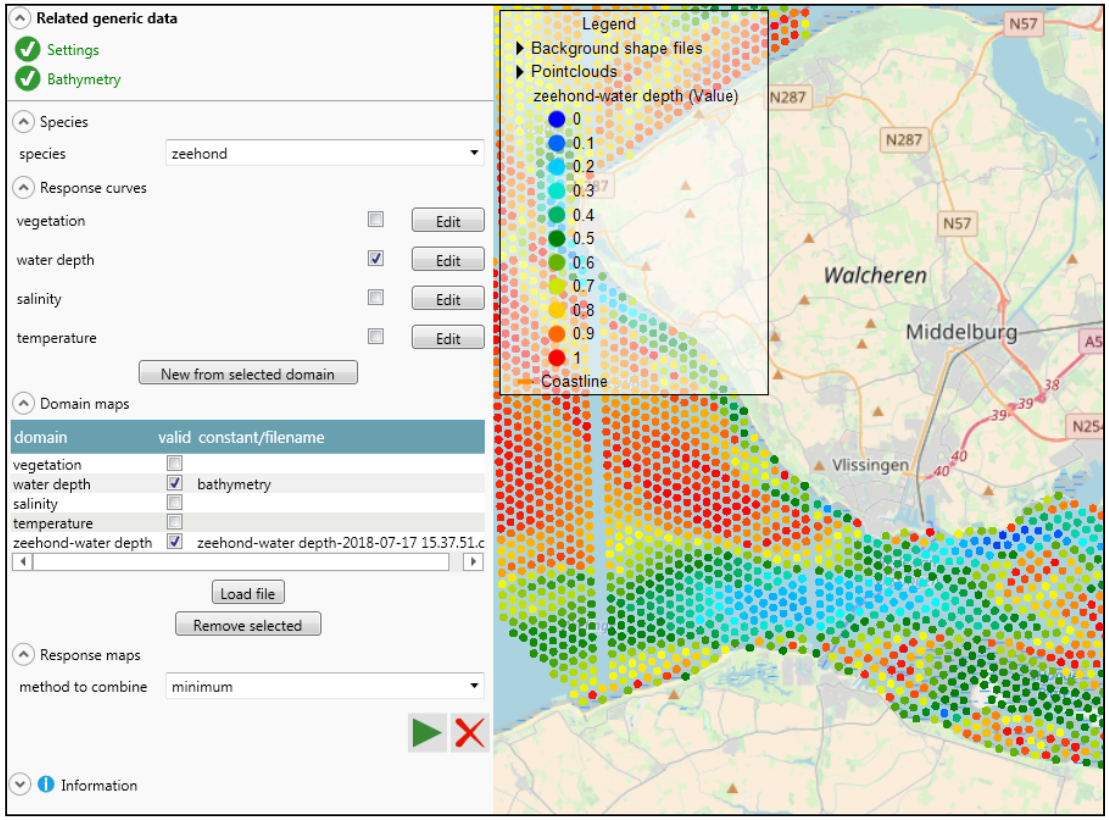

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- Suitability maps for different species, based on their response curves
- Multi-variable dependencies & integrated species database
- Inter-dependencies between species (e.g. a prey – predator cycle)

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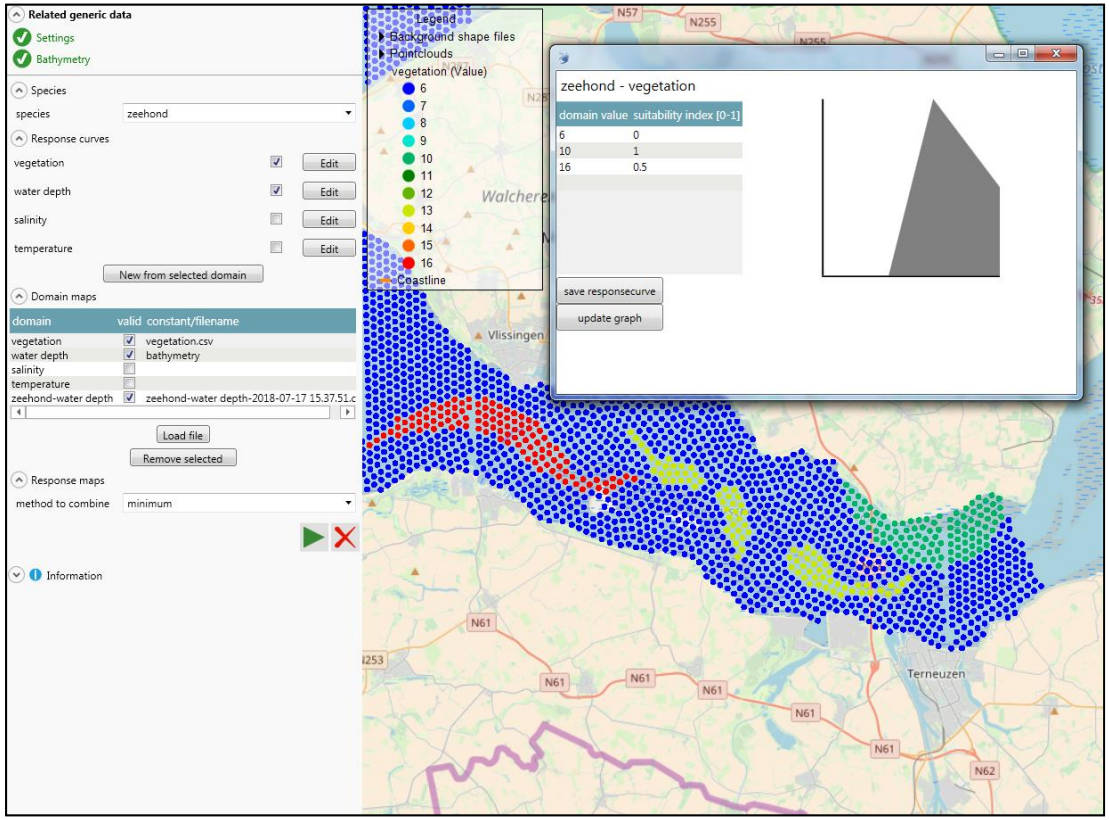

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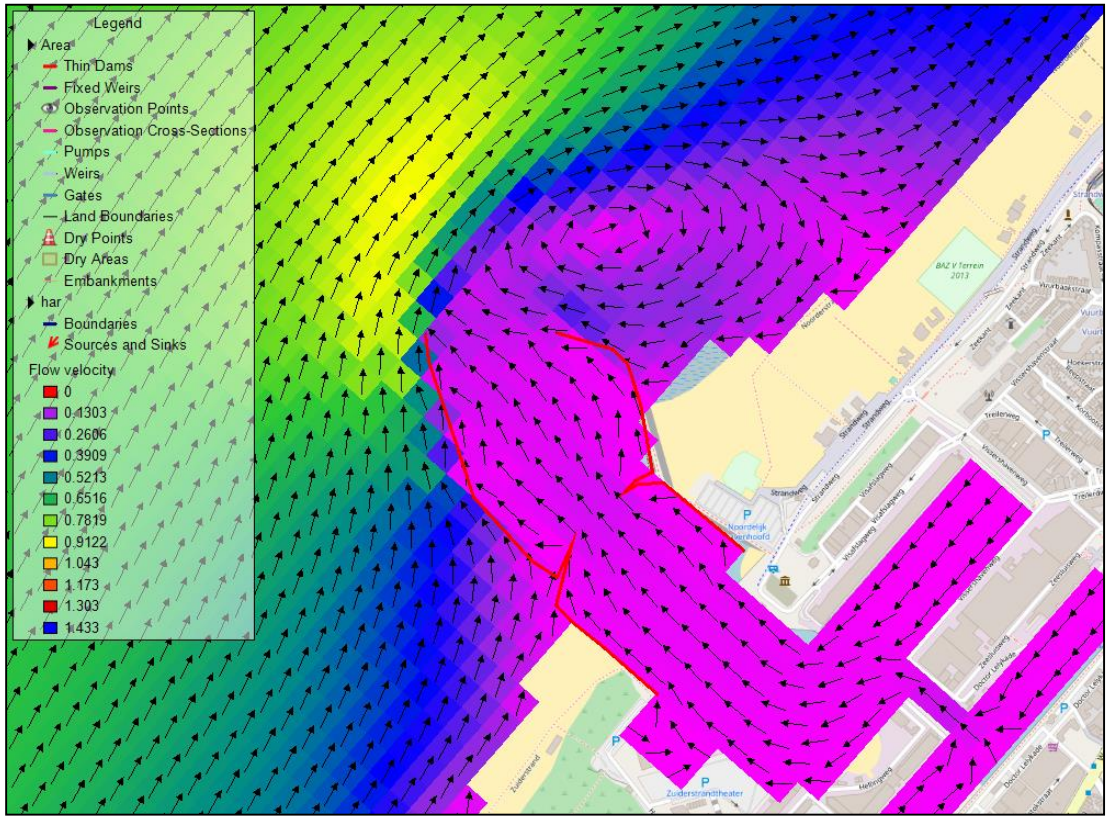

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- Automatic Delft3D Flexible Mesh model based on harbour design
- Design can be changed while the model runs (instant results)

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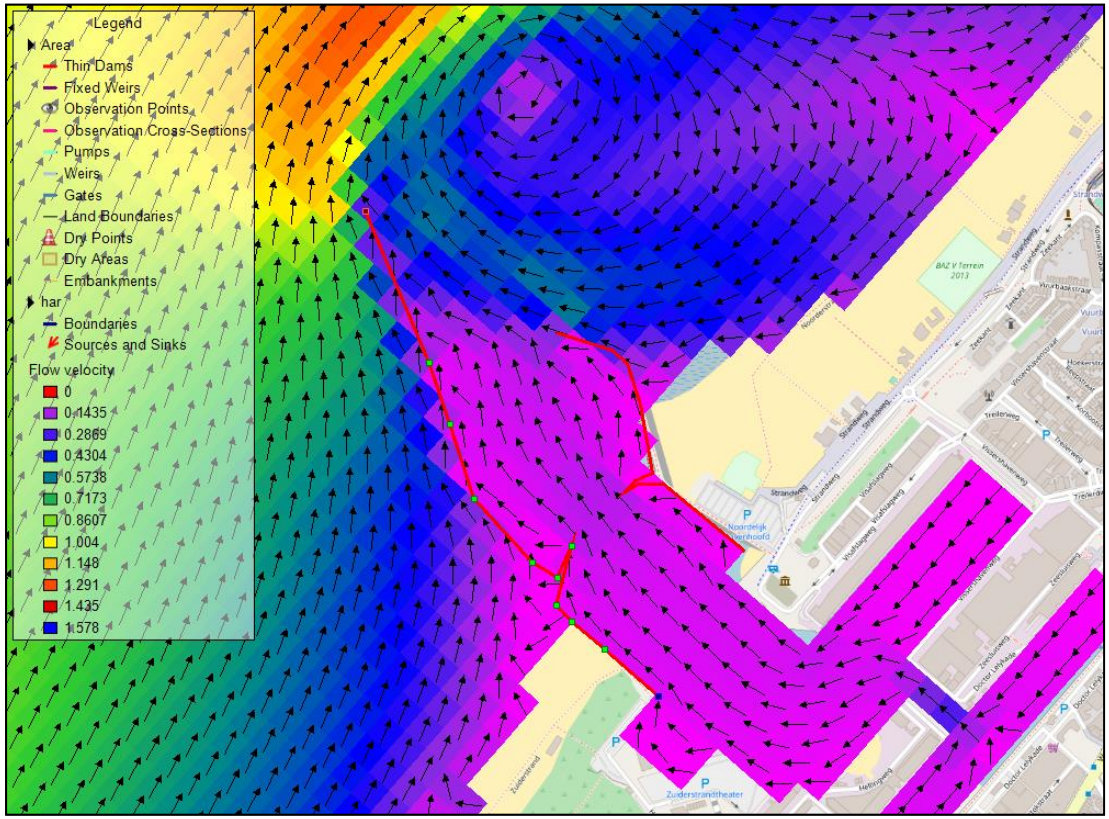

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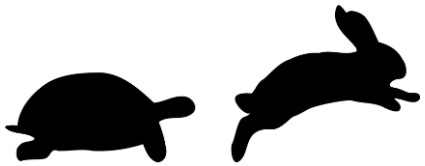
5. Highlights & conclusions

- CoDeS tools are fast & interactive
- Reproducibility & validation through version control & test bed
- Integration of different disciplines & tools
- Applicable anywhere on earth with uniform tool input
- All physics & mathematics scripted in Python



- In practice, CoDeS proved very useful during:
  - Early stages of a project (e.g. tender/proposal, (pre) feasibility, desk studies)
  - Interactive design sessions
  - Engagement, understanding, communication & education of stakeholders

6. Future developments

- Following
  - CoDeS pilot *(2014 – 2015)*
  - CoDeS 1.0 *(2015 – 2016)*
  - CoDeS 2.0 *(2017 – 2018)*

- We are open to welcome new partners for CoDeS 3.0, focusing on:
  - Data?
    - E.g. metocean databases, remote sensing derived data, statistics
  - Coasts/ports?
    - E.g. nautical aspects, channel design, port design, nourishments, reclamations, dredge plumes
  - Offshore renewables?
    - E.g. extreme conditions, workability, metocean conditions, energy islands/offshore hubs

- Feel free to approach me during the conference to discuss or ask for a demo!

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