Efficient Modelling of Unstructured Grids Using Janet

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Digital Terrain Modelling
Numerical Model Setup
Software Development
Consulting

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Overview

Short introduction to the Preprocessor Janet

Suggested grid generation concept for unstructured grids

Examples of unstructured grids with focus on unstructured orthogonal grids

Preprocessor Janet – a Short Introduction

The Preprocessor provides a generic interface to structured and unstructured grid generation

Special support is given to the numerical models Marina, Telemac (FEM) and UnTRIM (FV)

The software package assists the user in all relevant steps of model setup
(grid generation, editing, analysis, optimization and documentation)

Key features:

- support of triangular, quadrilateral and hybrid grids
- definition of geometric constraints via “constraint edges”
- different refinement techniques (barycentric refinement, advancing front refinement,...)
- quad grid generator to construct strict orthogonal quadrilateral grids
- common optimization methods for unstructured grids (e.g. Laplacian smoothing)
- specific optimization methods (e.g. orthogonality optimization for UOG)
- sub–grid approach: merging sub-grids of arbitrary element structure to an entire grid
- specific methods for mapping bathymetry data to the grids

Suggested Grid Generation Process (using Janet)

Generation of unstructured grids :

Step 0 : Digital Terrain Model
Provision of an adequate digital terrain model for the entire domain

Step 1 : Boundary Model
Setup the domain boundary

Step 2 : Decomposition Model, Structure Model, Sub-Domain Model
Definition and setup of sub–domains and geometric constraints (optional)

- Setup of triangular and quadrilateral sub-grids in areas of special interests
- Definition and setup of polylines as geometric constraints

Step 3 : Construction of the initial grid

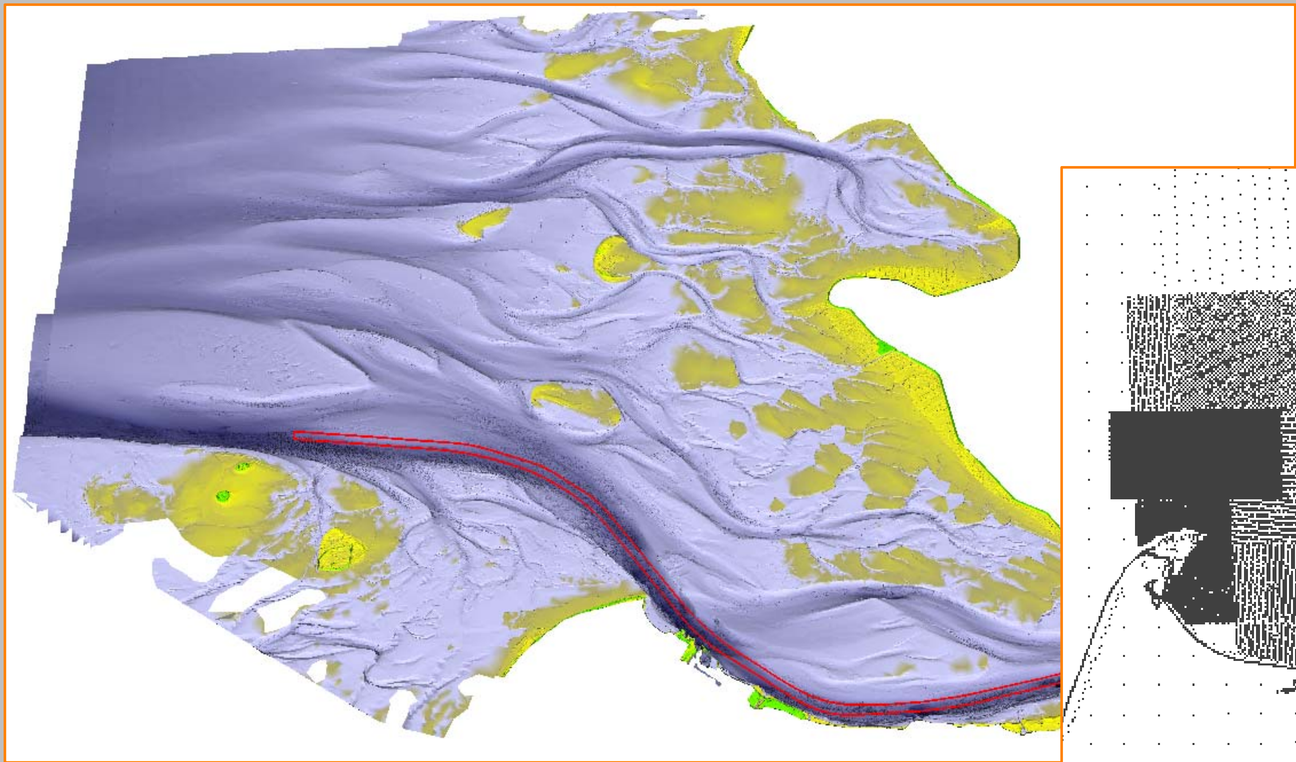
Step 4 : Grid modification until predefined criteria are fulfilled

Step 5 : Grid analysis

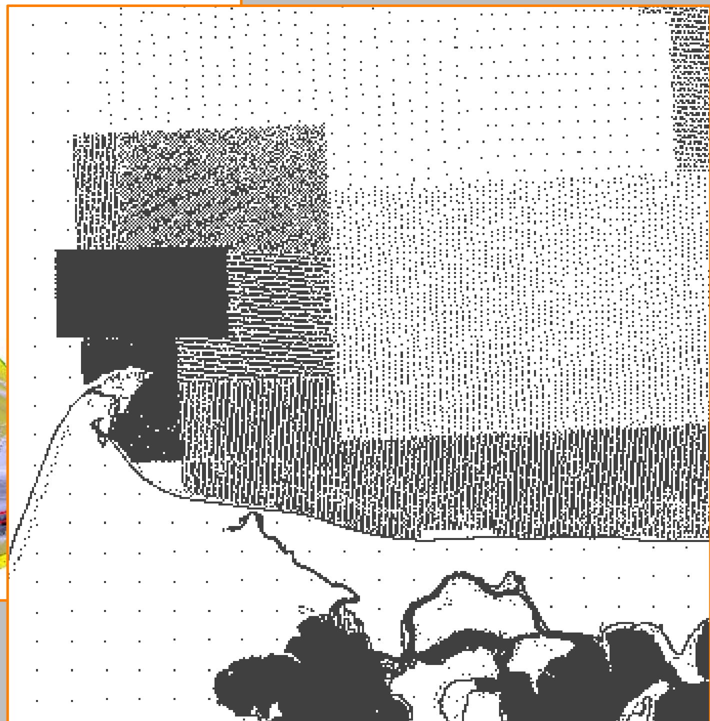
Step 6 : Grid optimization

Provision of an Adequate Digital Terrain Model for the Entire Domain

The digital terrain model forms the basis of all following grid generation steps



Digital terrain model (Elbe-Estuary)

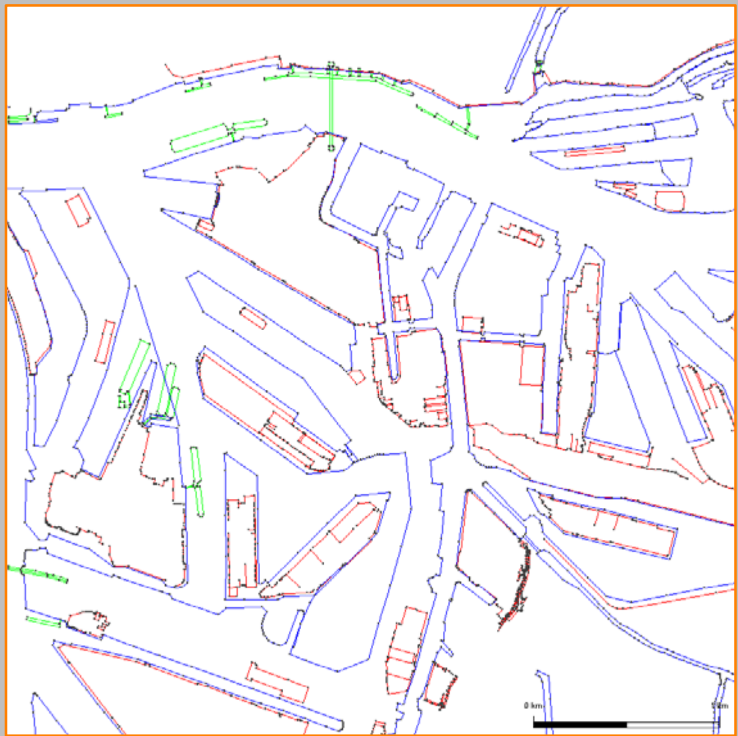


Digital terrain model drived from bathymetric soundings of different origin and years (Baltic Sea)

Setup the Domain Boundary

The domain boundary is created with Janet‘s Polygon-Editor:

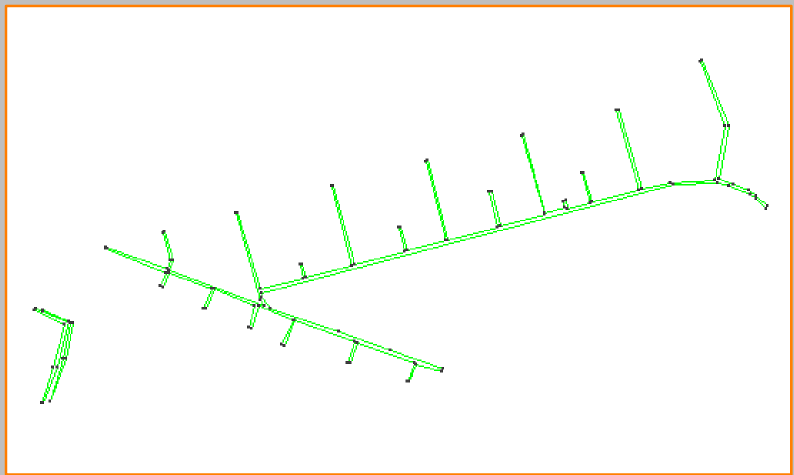
- Import polygon data from GIS- and CAD-Systems
- Select, delete and copy polygons
- Merge and split polygons
- Adjust resolution of polygons



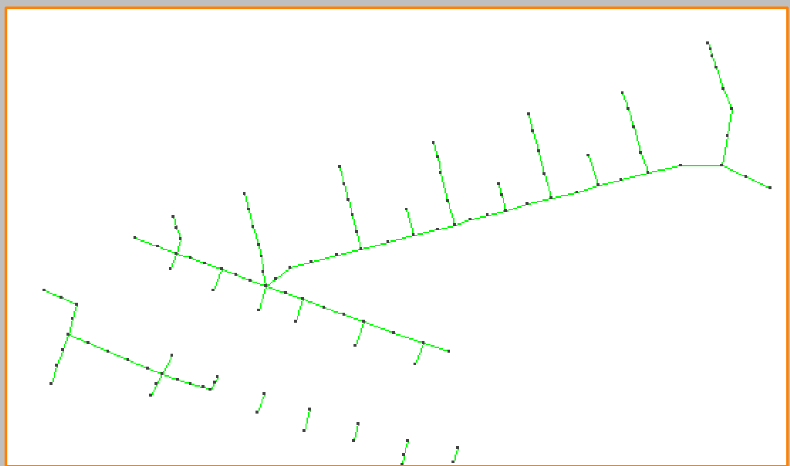
Raw polygon data

Created boundary polygon

Definition and Setup of Polylines as Geometric Constraints



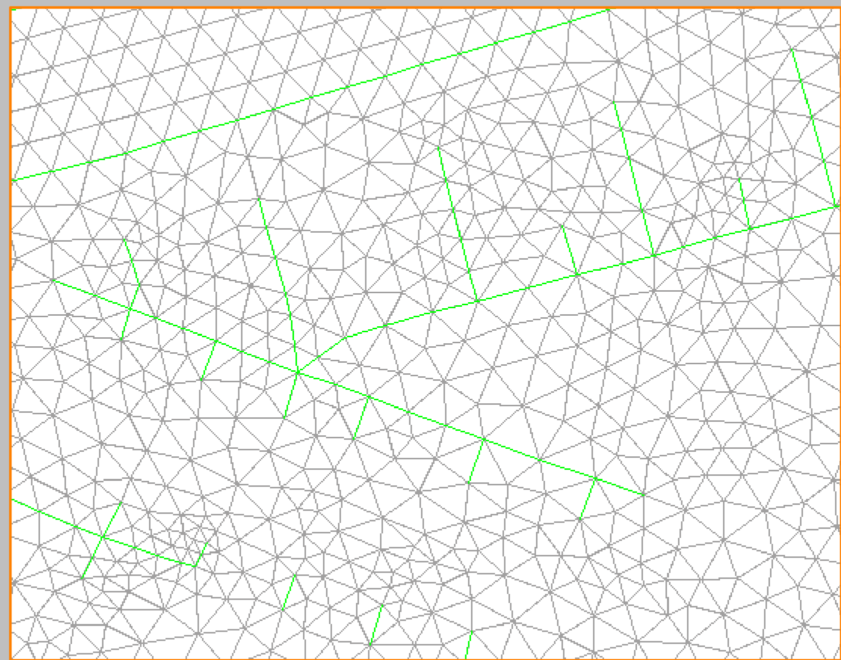
Selected raw polygon data



Modified polylines

Geometric constraints such as groynes, dikelines, etc. can be integrated in the model

Geometric constraints can be protected from modification in the grid generation process



Preview: constrained triangulation

Setup of Triangular and Quadrilateral Sub-Grids

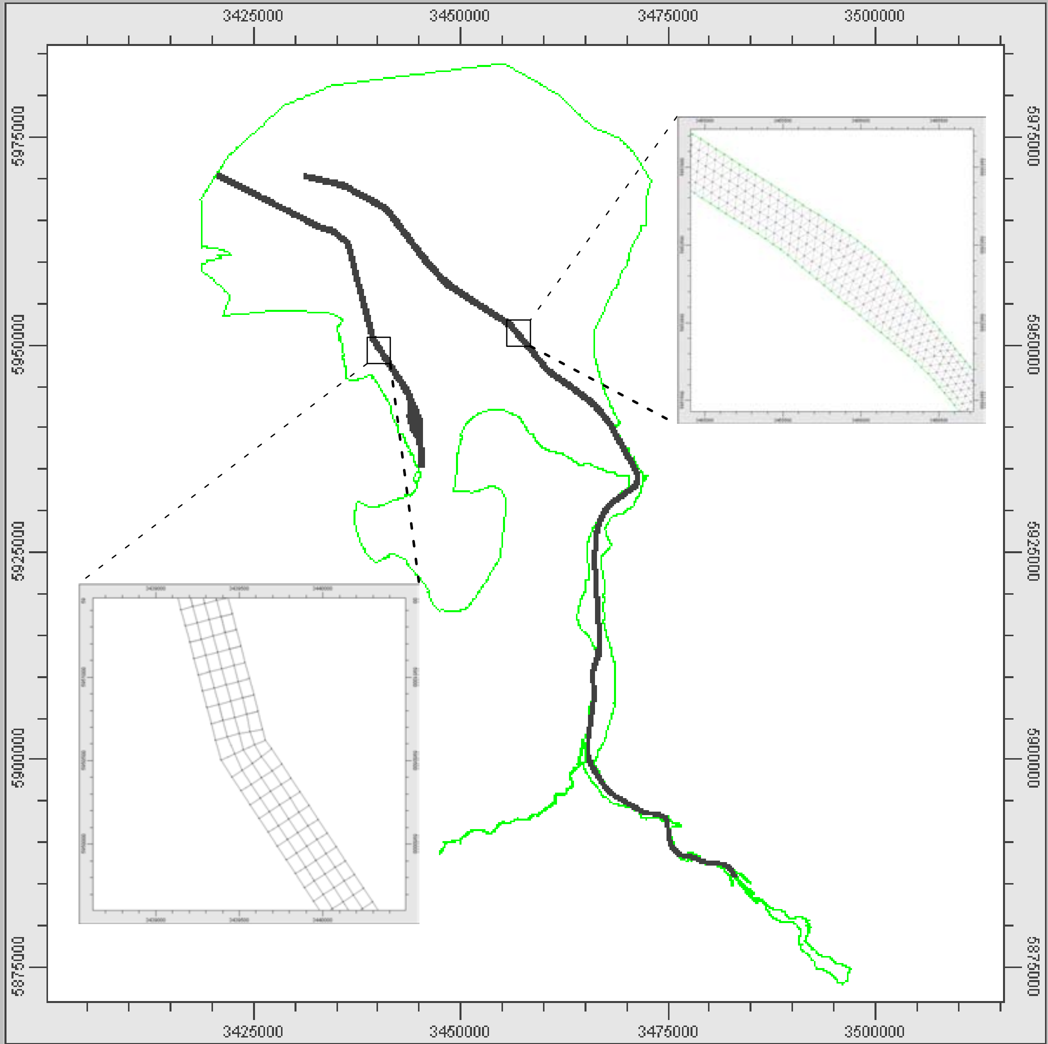
Sub-domains such as

fairways
rivers
harbours
etc.

with special local requirements

can be defined,
created and
integrated

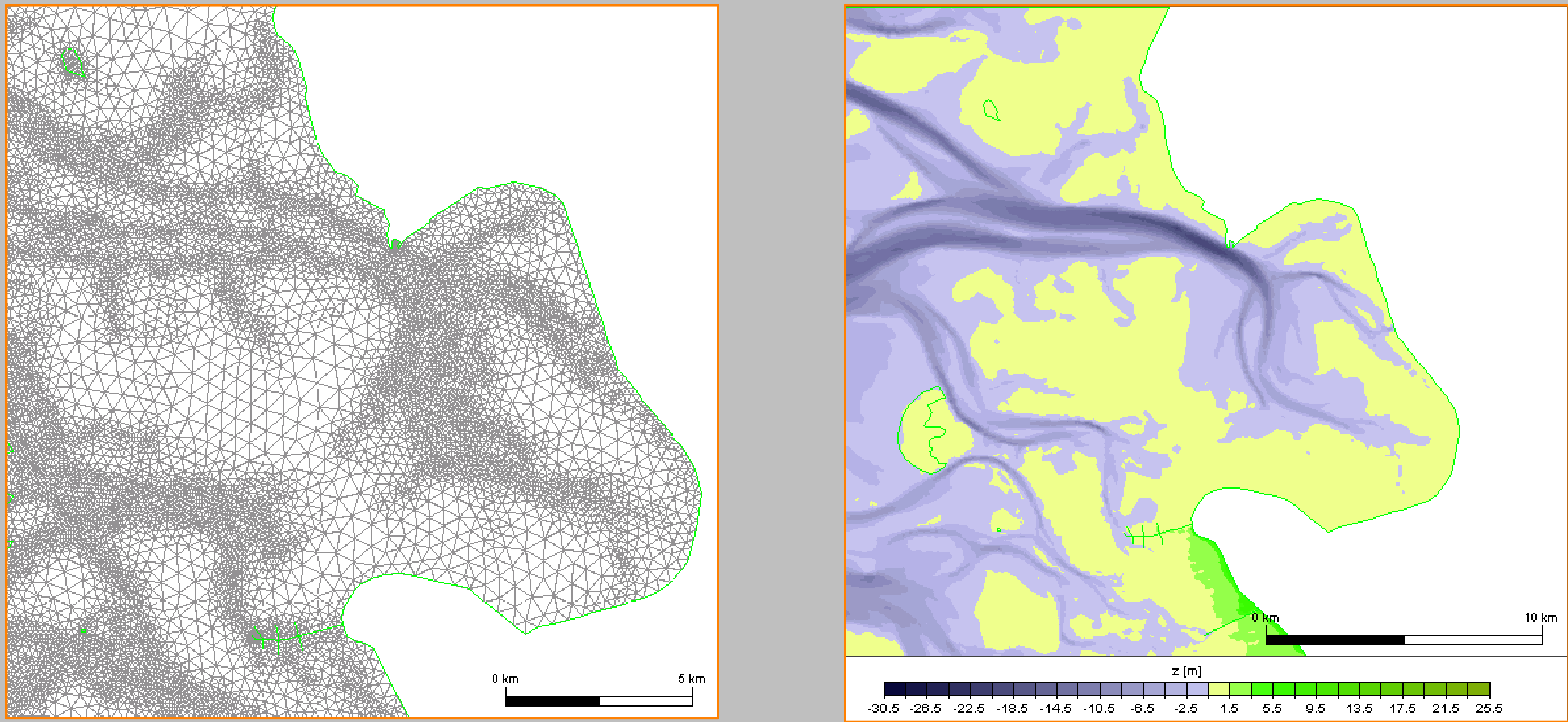
in the entire domain



Sub–domains for the fairways of the Jade-Weser-Estuary

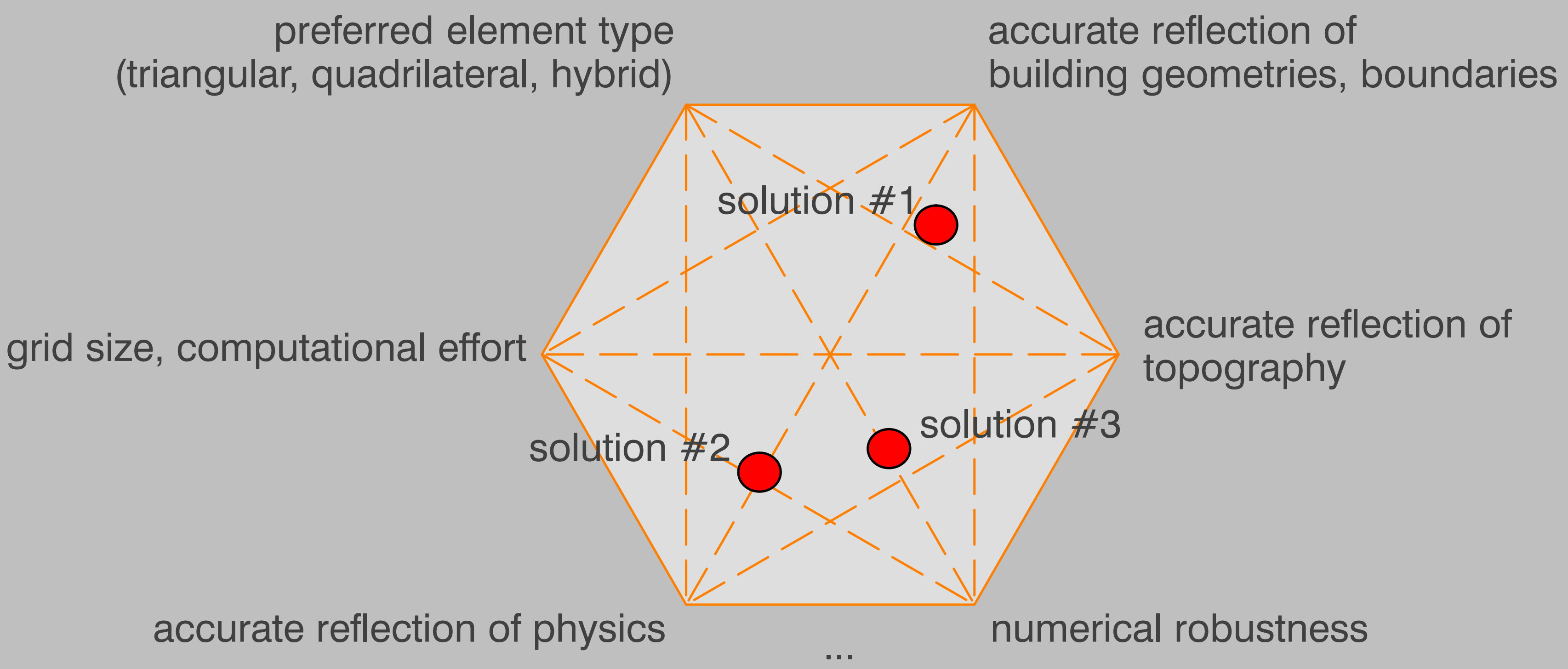
Automatic Grid Modification

Criteria-based grid modification allows the user to control grid generation for different aspects



Example of a triangular grid optimized with a “depth difference criterion” (to a digital terrain model)

Criteria Influencing the Grid Generation Process



Some of the above mentioned criteria are opposing

Suitable fulfillment of these criteria has to be found in respect to the application of the model

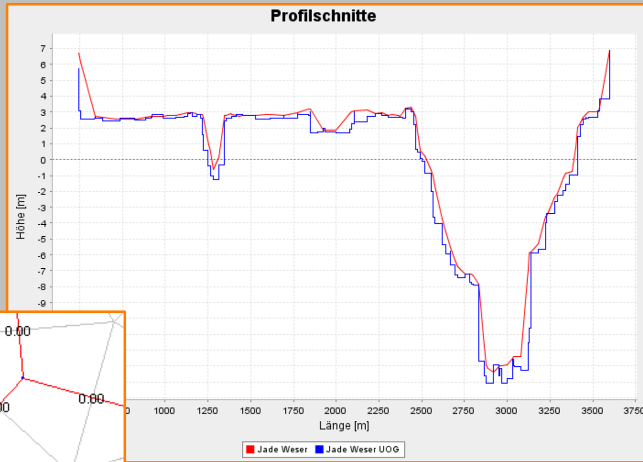
Grid Analysis for Different Assessment Parameters

Depth differences and volume analysis

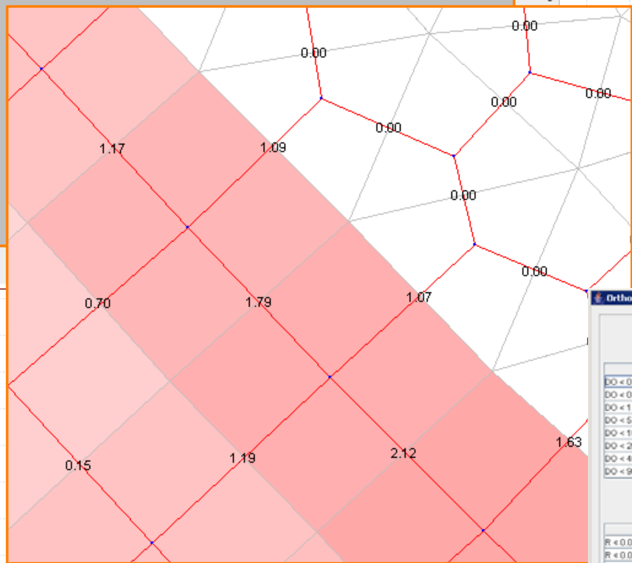
Grid quality parameters
(FE: shape, minimum angle, ...)
(UOG: orthogonality, minimum dx, ...)

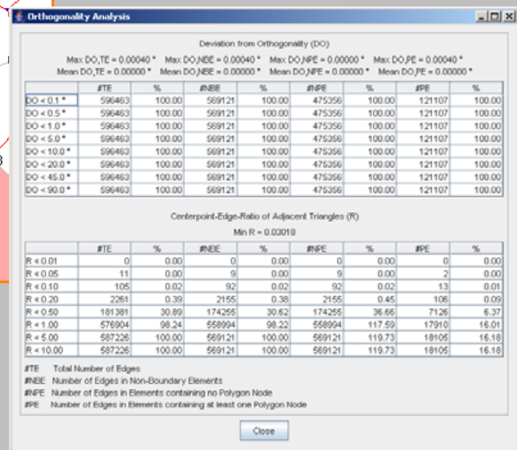
Cross-section analysis

2D and 3D visualization



Cross-section





Orthogonality Analysis

Deviation from Orthogonality (DO)

Max DO,TE = 0.00040 ° Max DO,NBE = 0.00040 ° Max DO,NPE = 0.00000 ° Max DO,PE = 0.00040 °
Mean DO,TE = 0.00000 ° Mean DO,NBE = 0.00000 ° Mean DO,NPE = 0.00000 ° Mean DO,PE = 0.00000 °

	#TE	%	#NBE	%	#NPE	%	#PE	%
DO < 0.1 °	596463	100.00	569121	100.00	475356	100.00	121107	100.00
DO < 0.5 °	596463	100.00	569121	100.00	475356	100.00	121107	100.00
DO < 1.0 °	596463	100.00	569121	100.00	475356	100.00	121107	100.00
DO < 5.0 °	596463	100.00	569121	100.00	475356	100.00	121107	100.00
DO < 10.0 °	596463	100.00	569121	100.00	475356	100.00	121107	100.00
DO < 20.0 °	596463	100.00	569121	100.00	475356	100.00	121107	100.00
DO < 45.0 °	596463	100.00	569121	100.00	475356	100.00	121107	100.00
DO < 90.0 °	596463	100.00	569121	100.00	475356	100.00	121107	100.00

Centerpoint-Edge-Ratio of Adjacent Triangles (R)

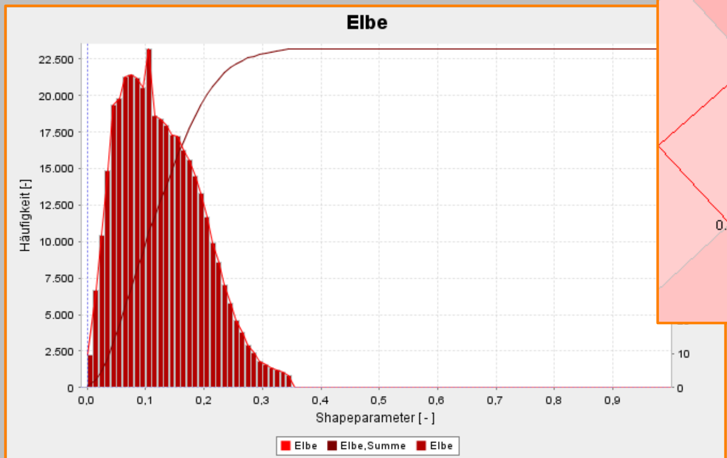
Min R = 0.03018

	#TE	%	#NBE	%	#NPE	%	#PE	%
R < 0.01	0	0.00	0	0.00	0	0.00	0	0.00
R < 0.05	11	0.00	9	0.00	9	0.00	2	0.00
R < 0.10	105	0.02	92	0.02	92	0.02	13	0.01
R < 0.20	2261	0.39	2155	0.38	2155	0.45	106	0.09
R < 0.50	181381	30.89	174255	30.62	174255	36.66	7126	6.37
R < 1.00	576904	98.24	558994	98.22	558994	117.59	17910	16.01
R < 5.00	587226	100.00	569121	100.00	569121	119.73	18105	16.18
R < 10.00	587226	100.00	569121	100.00	569121	119.73	18105	16.18

#TE Total Number of Edges
#NBE Number of Edges in Non-Boundary Elements
#NPE Number of Edges in Elements containing no Polygon Node
#PE Number of Edges in Elements containing at least one Polygon Node

Close

Orthogonality analysis

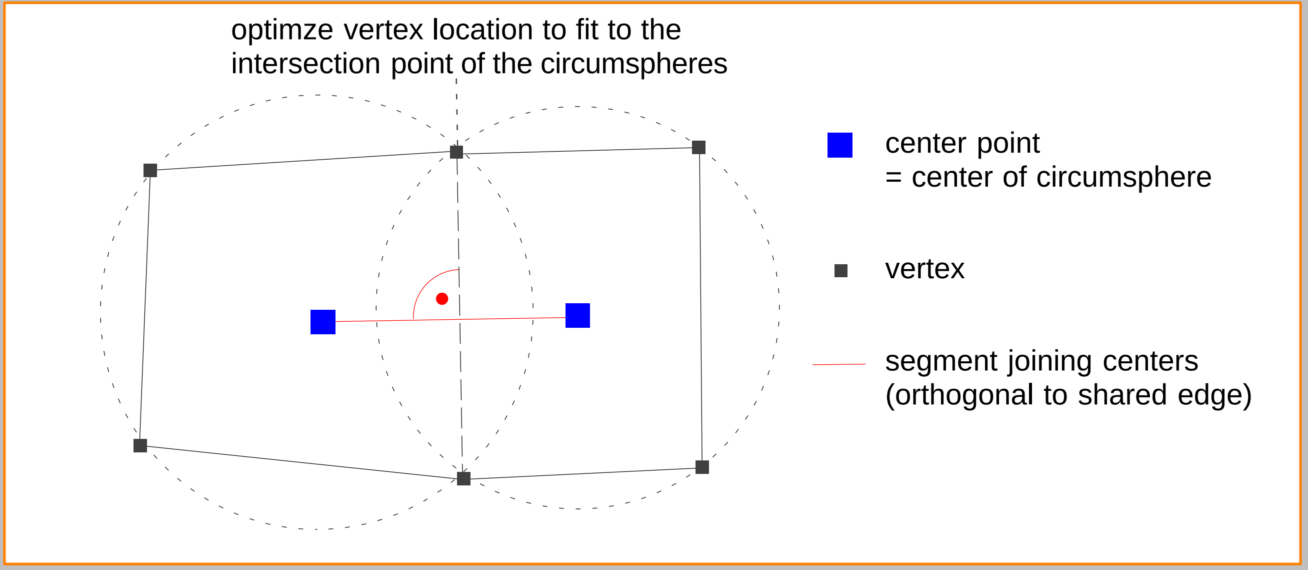


Shape parameter analysis

Grid Optimization

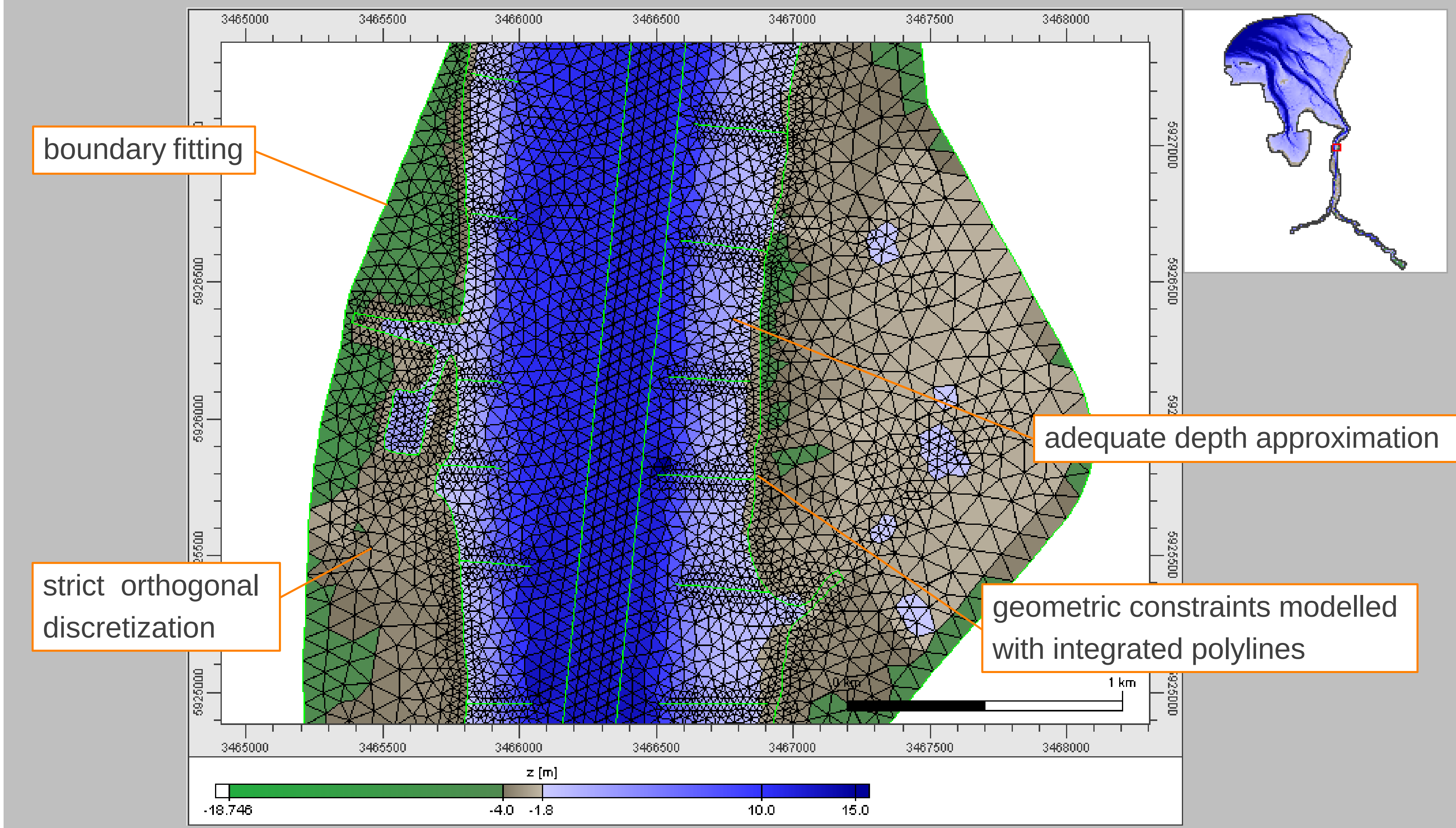
Algortihmic optimization methods are offered to:

- improve the geometrical quality of elements
- improve the topological quality of patches
- minimize differences to a digital terrain model
- improve triangles and quadrilaterals for orthogonality



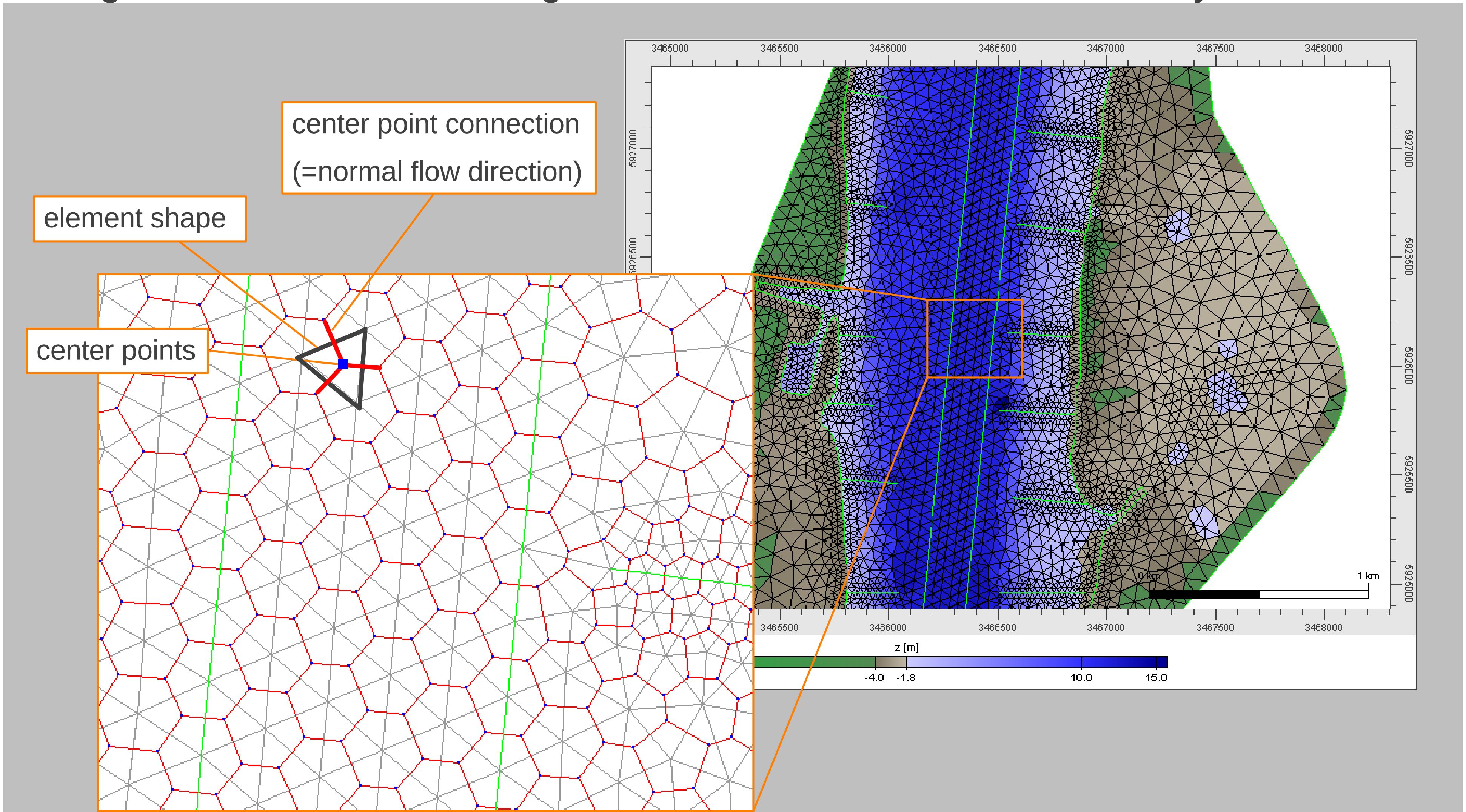
Example: schematic function of the “orthogonality operator“ to optimize unstructured orthogonal grids

Triangular Unstructured Orthogonal Grid of the Jade-Weser-Estuary



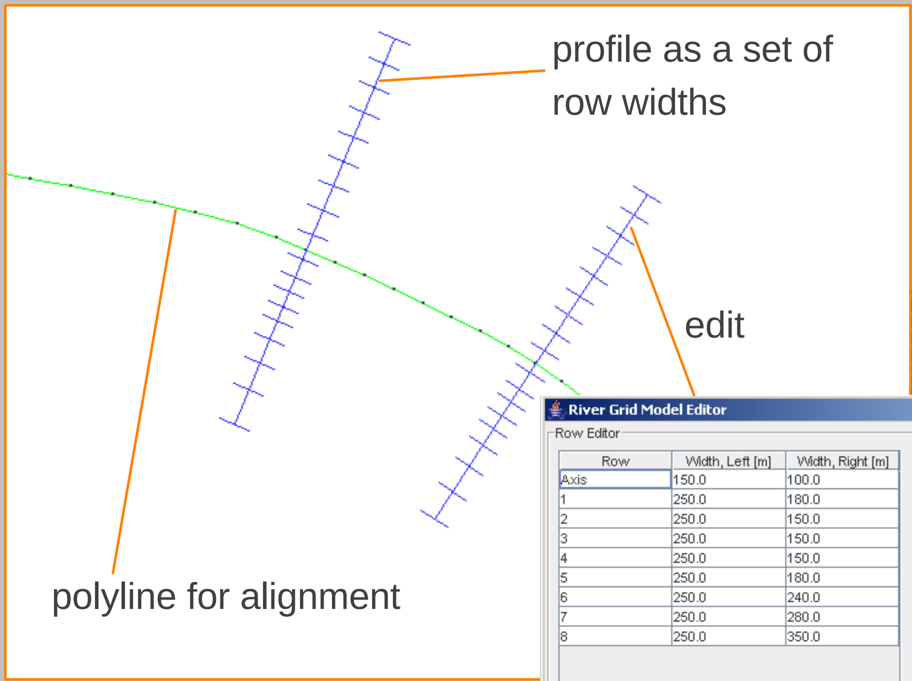
Unstructured orthogonal grid

Triangular Unstructured Orthogonal Grid of the Jade-Weser-Estuary

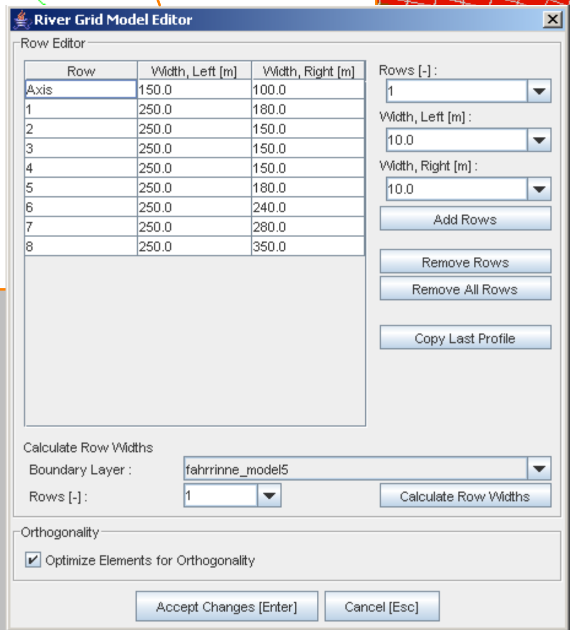


Specific view on unstructured orthogonal grid

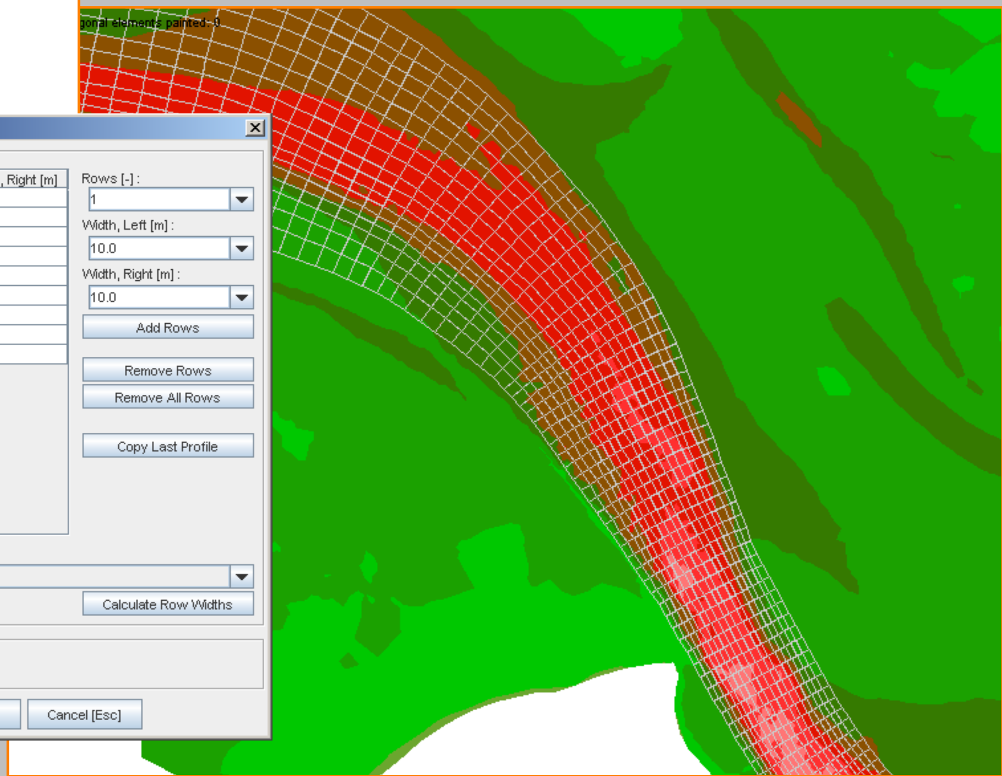
Generation of Quadrilateral Sub-Grids for the Elbe-Estuary



Quad grid model for automatic grid generation



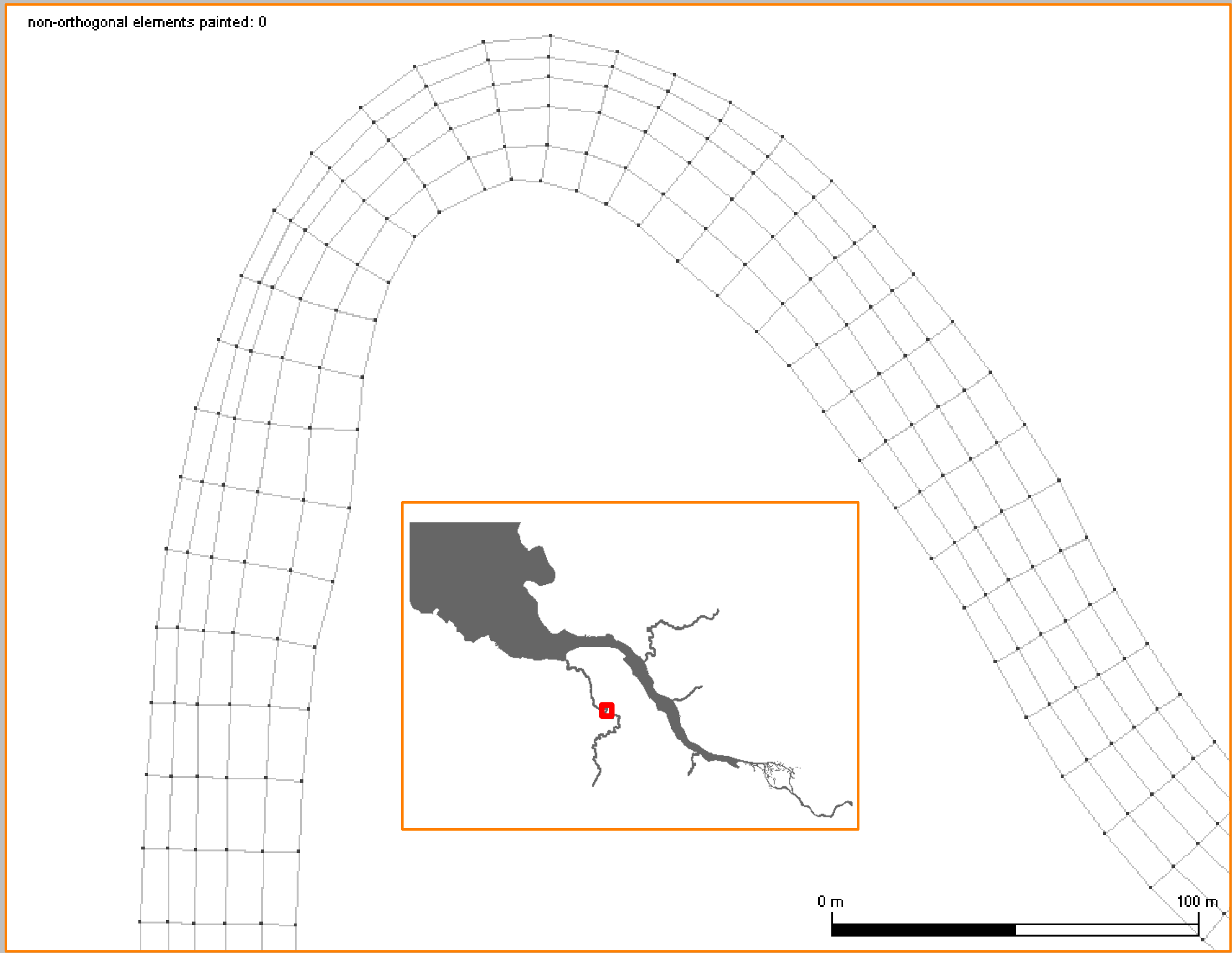
Profile editor



Orthogonal quad grid of the fairway with isobaths of the DTM

Generation of Quadrilateral Sub-Grids for the Elbe-Estuary

Quad grid for the River Oste



Orthogonal quad grid

Modelling Requirements

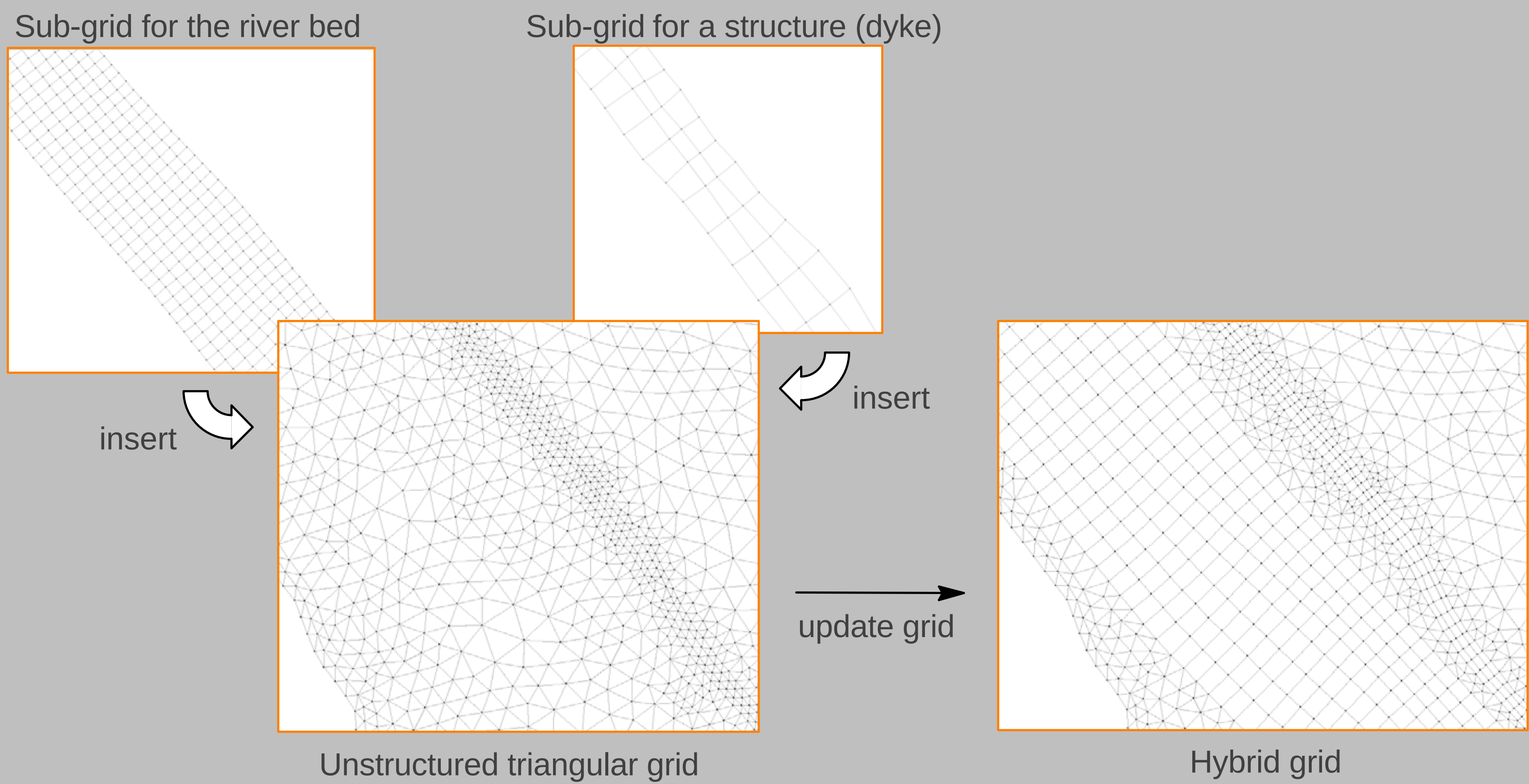
constant number of quads (5) per cross section

asymmetric profiles for better alignment to isobaths

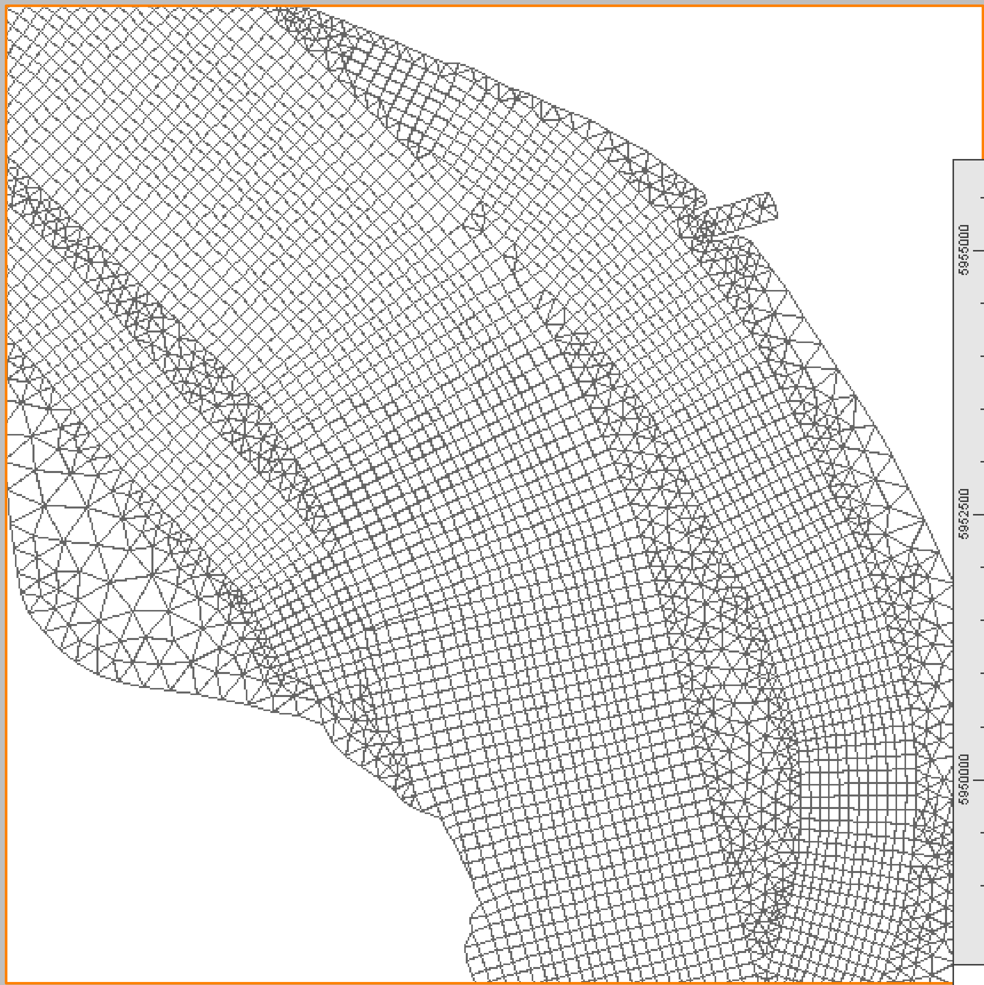
sharp curvatures

Sub-Grid Insertion to Generate Hybrid Grids

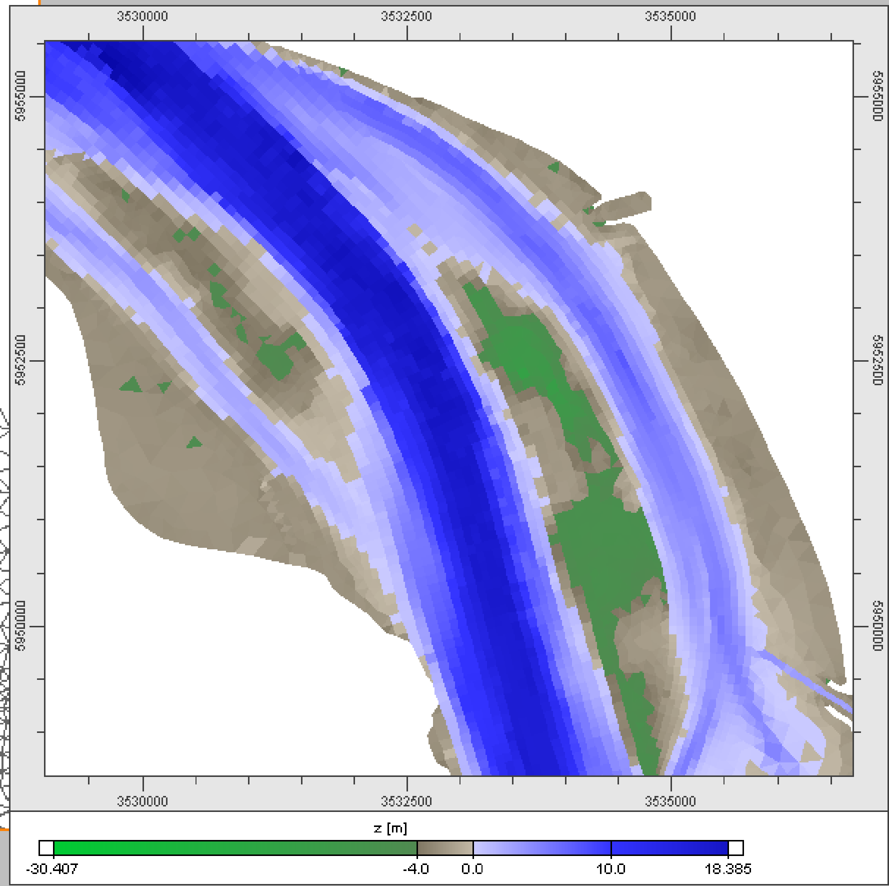
Coupling sub-grids to an entire grid using the grid insertion function of the preprocessor



Hybrid Grid of the Elbe-Estuary (Prototype)

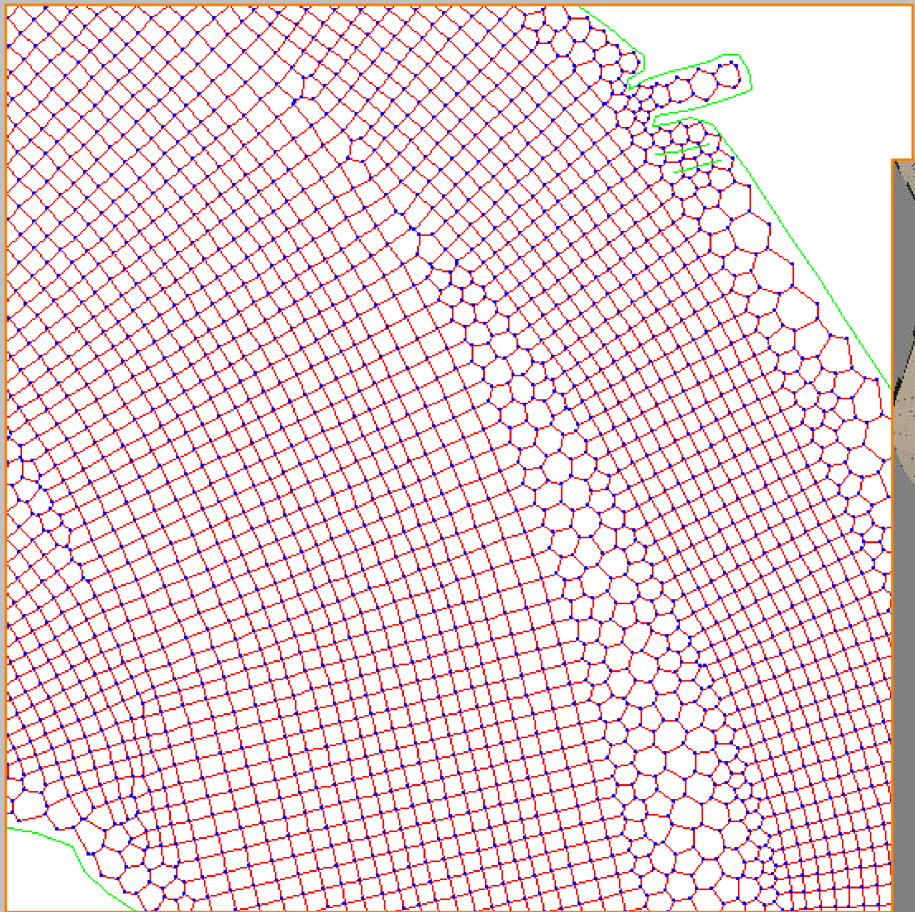


Discretization of the orthogonal hybrid grid

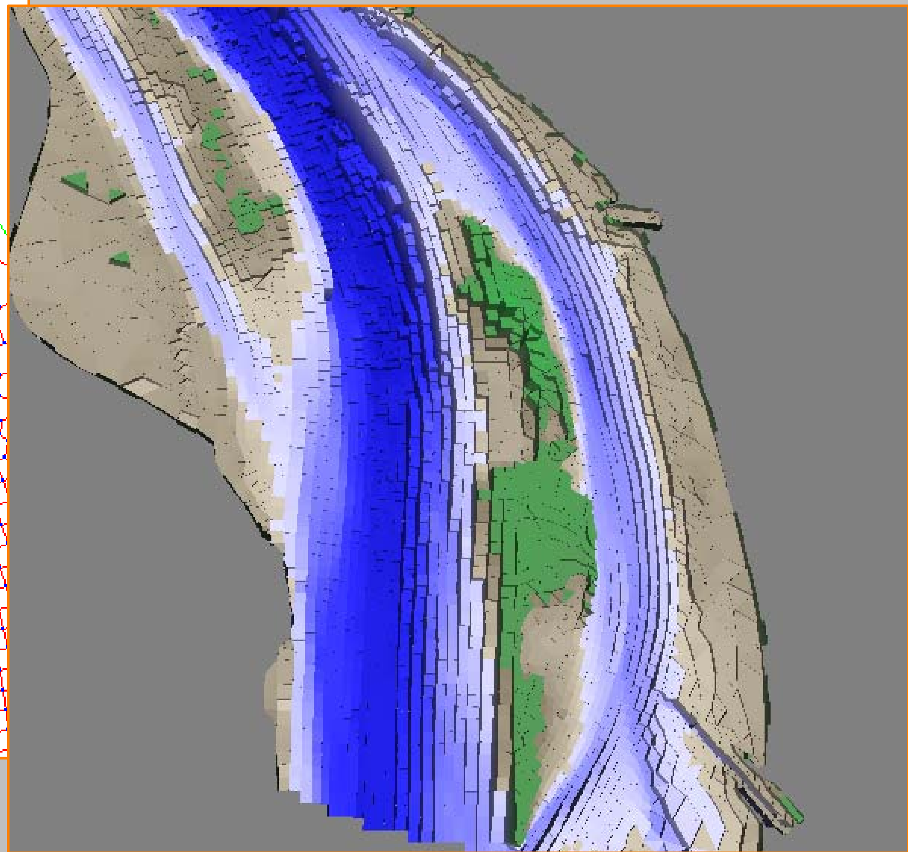


Surface representation

Hybrid Grid of the Elbe-Estuary (Prototype)

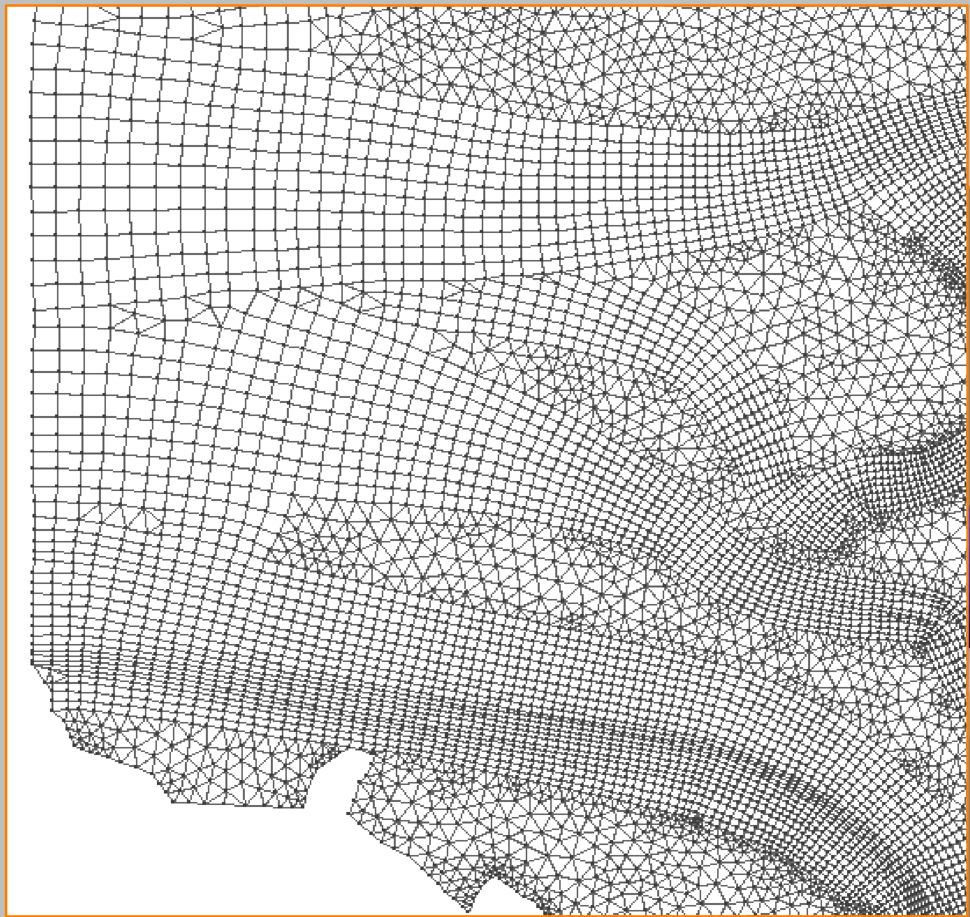


Center points and flow directions

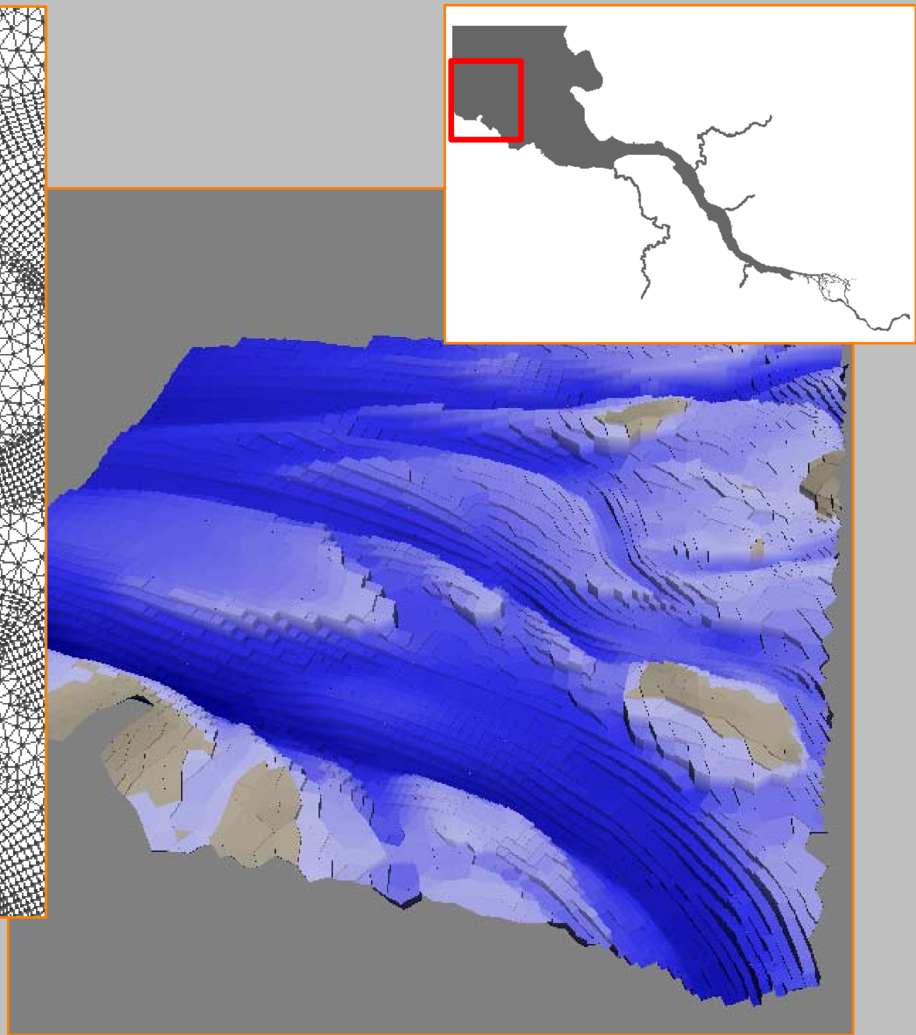


3D-presentation

Hybrid Grid of the Elbe-Estuary (Prototype)



Discretization of the orthogonal hybrid grid



3D-presentation

Thank you for your attention!