

Automatic isobath generalisation

By integrating cartographic constraints in a surface-based approach

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(1st mentor)

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March 17th 2020

Contents

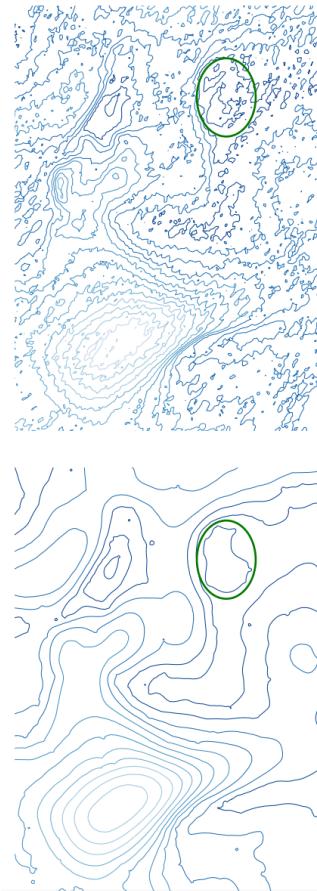
- Motivation and Problem statement
- Research objectives and Questions
- Related work
- Triangle region graph
- Methodology and Process
- Preliminary results
- Next stages

Isobath generalisation

- Cartographic constraints
 - Morphology Seabed shape
 - Legibility Readability
 - Functional Safety
 - Topology Topology
- Currently done manually
- Automation brings:
 - Economic benefits
 - Safety benefits

Problem statement

- Incompatible constraints
 - Chart scales
 - Smoother lines > less morphology
 - Increasing line separation > less morphology
 - Masking safe waters
- Automated process does not exist yet
 - Complex decisions
 - Cartographers insight
 - or Relation with data is destroyed

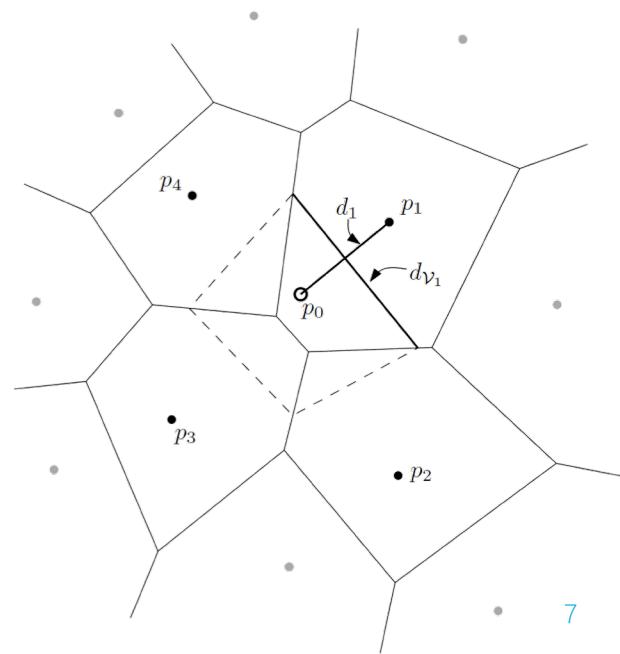


Research objectives

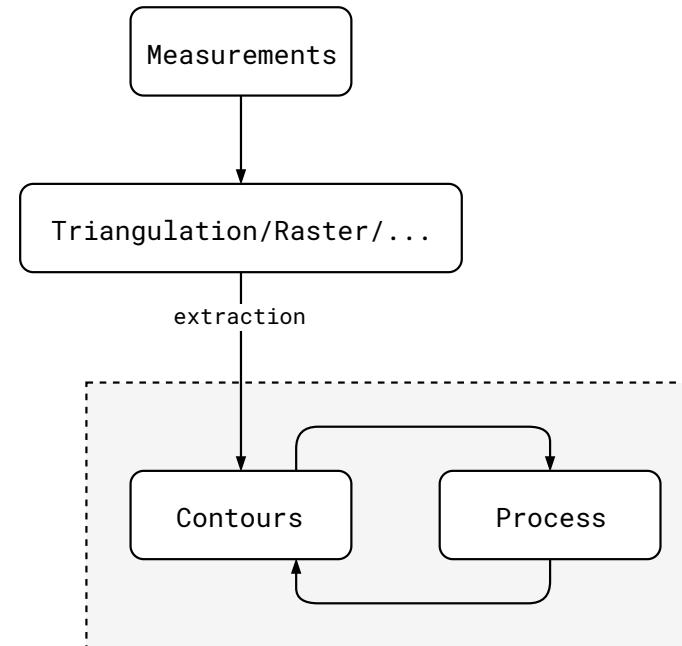
- Integrate *all* constraints in the process
- In such way, all constraints are valid and thus the information is not over-generalised
 - Eliminate human interference
 - Quantify generalisation constraints
 - Evaluate metrics directly within the process
 - Apply operators locally, rather than globally

Related work

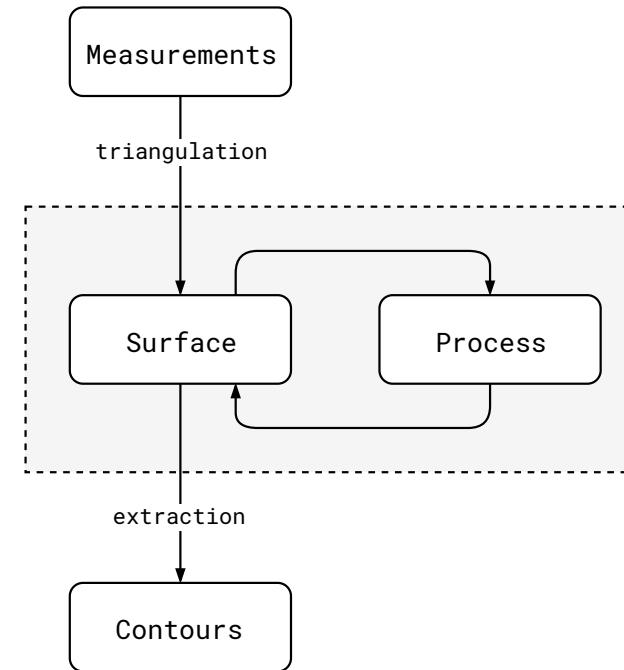
- Line-based generalisation
 - MAS > splines
- Surface-based generalisation
 - Navigational surface
 - Voronoi-based approach



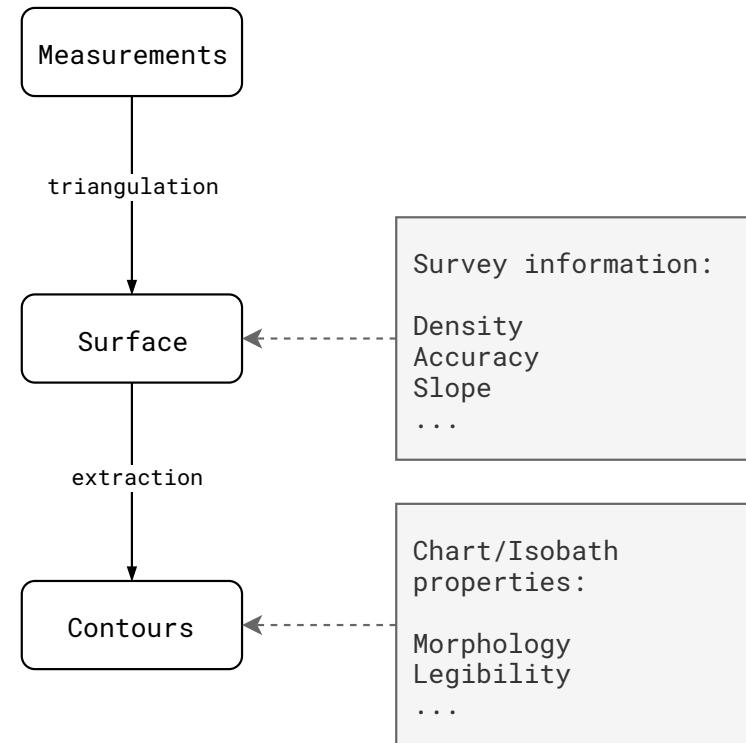
Line-based approach



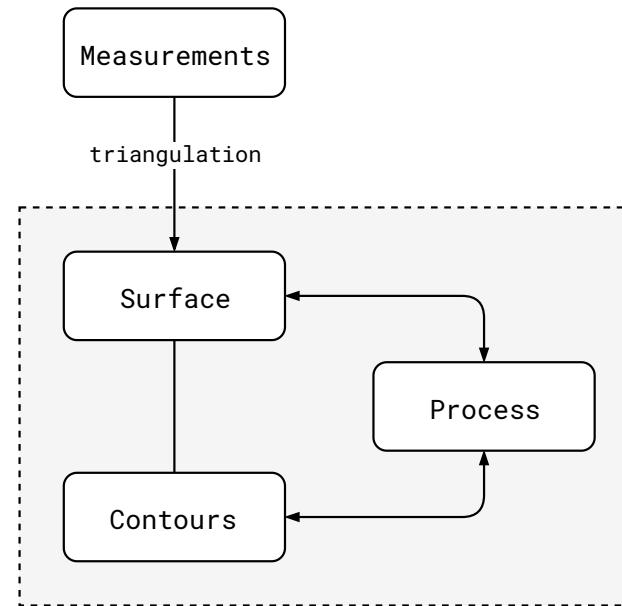
Surface-based approach



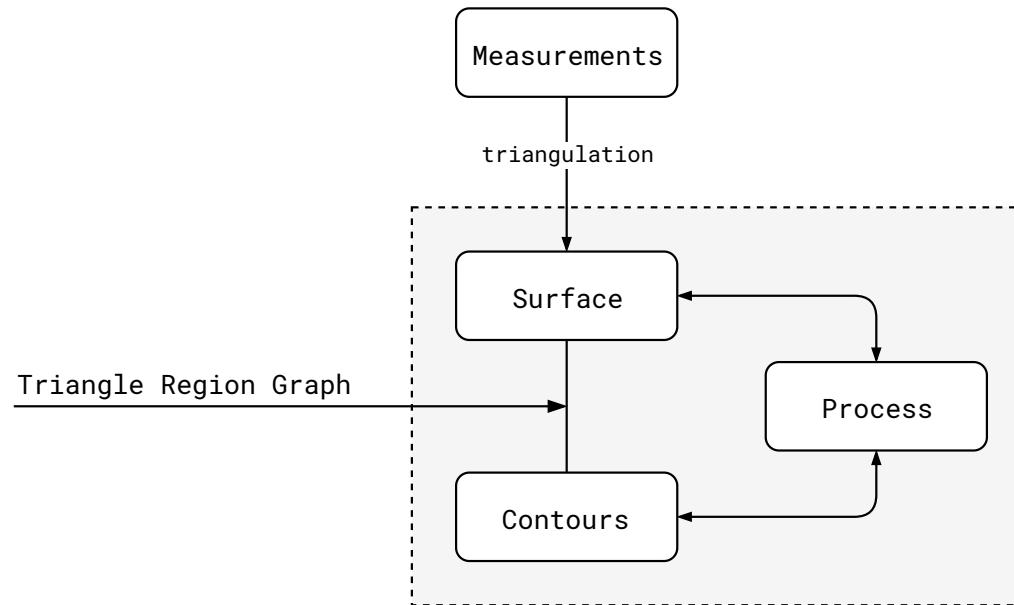
Information difference



Combined

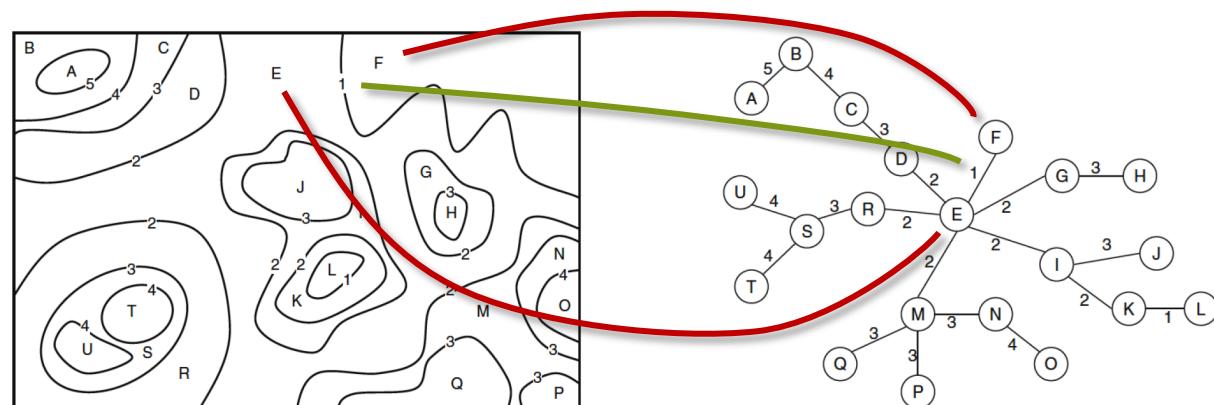


Combined

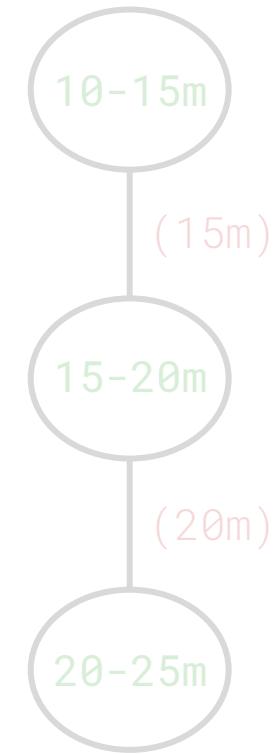
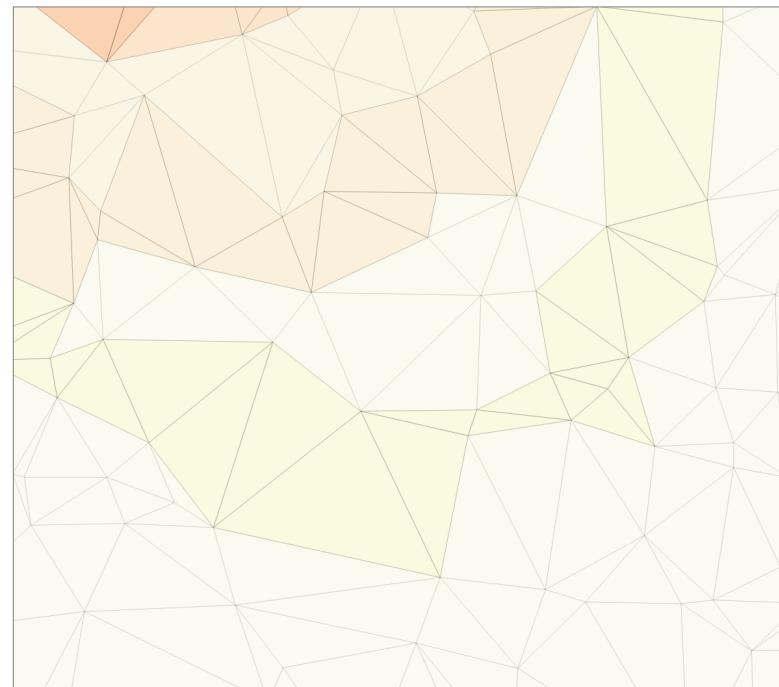


Triangle region graph (TRG)

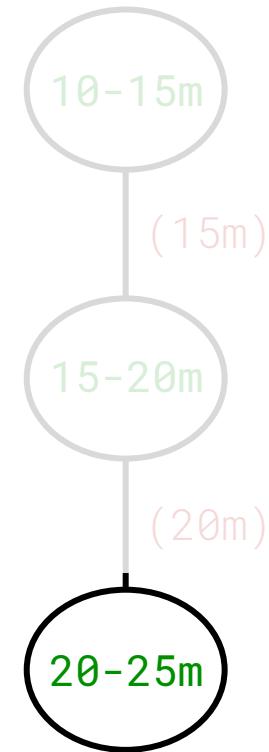
- Links together:
 - Inter-isobaths areas (depth areas > ENCs)
 - Isobaths (e.g. separation)
 - Triangulation (survey data)



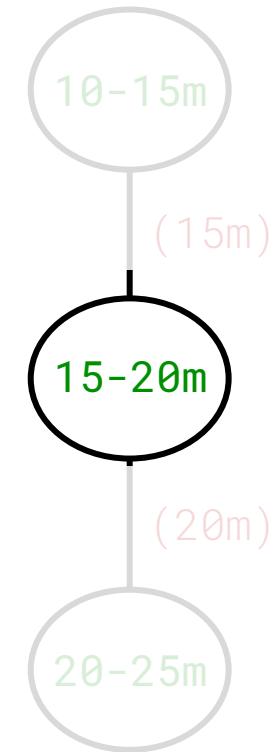
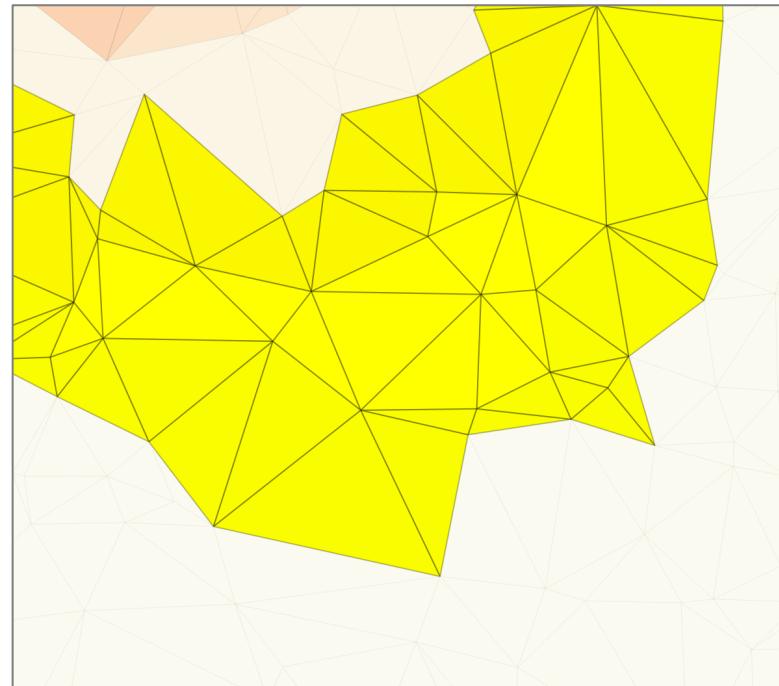
TRG Structure



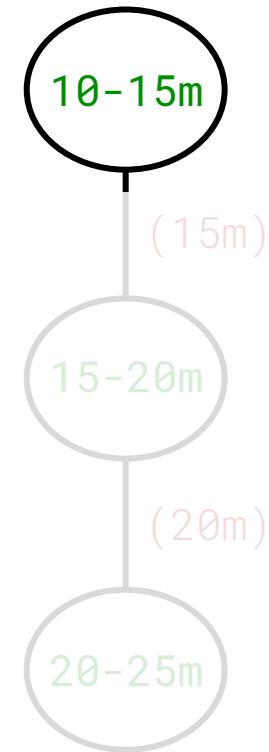
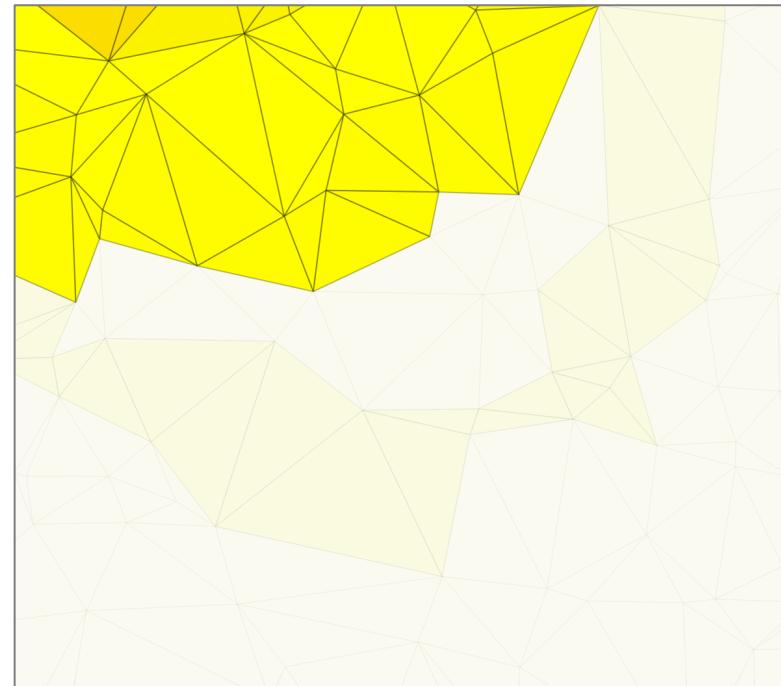
TRG Structure



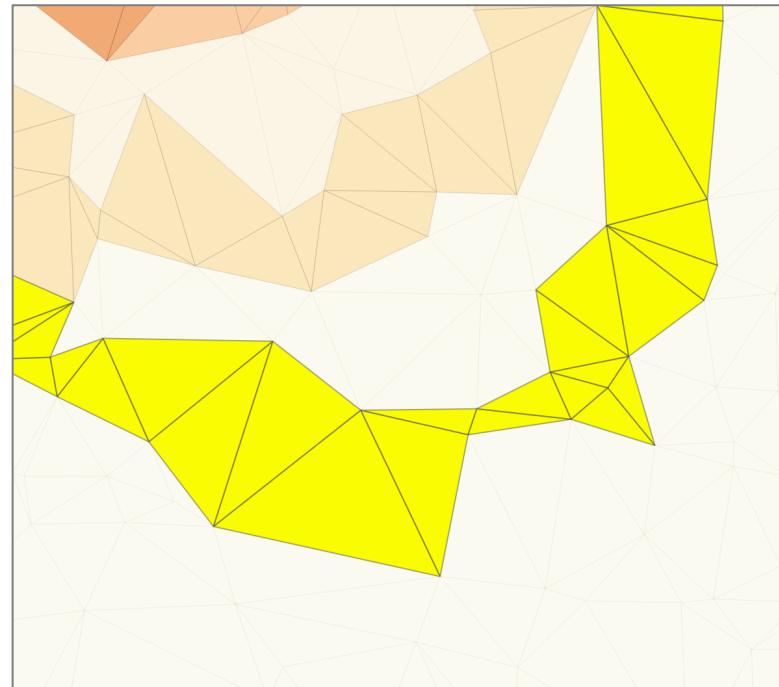
TRG Structure



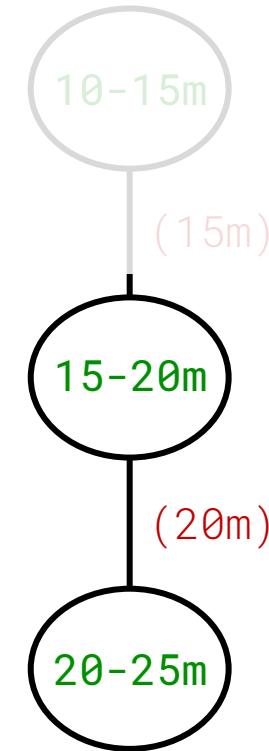
TRG Structure



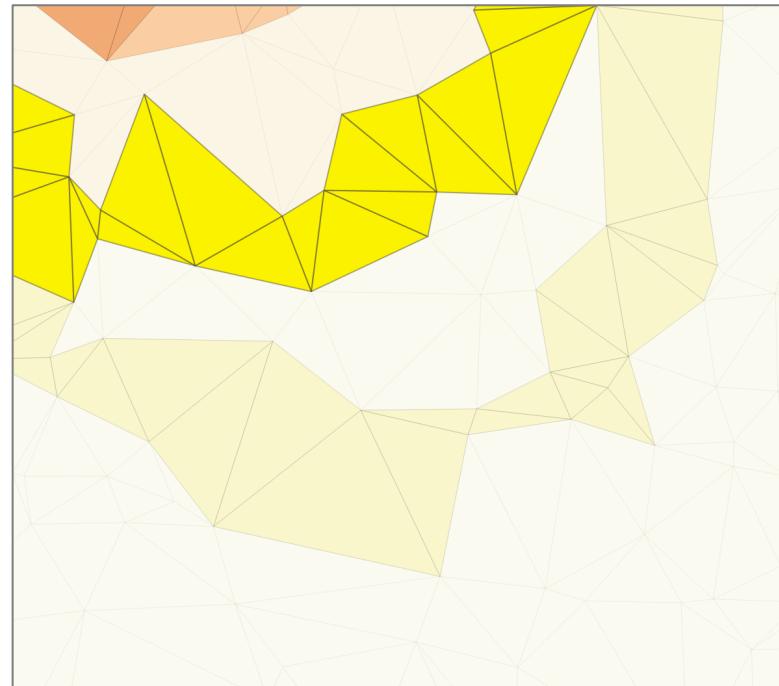
TRG Structure



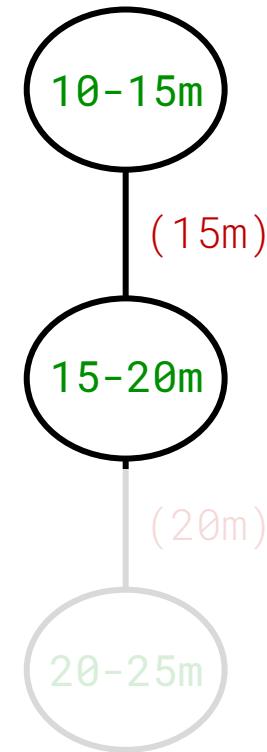
intersection



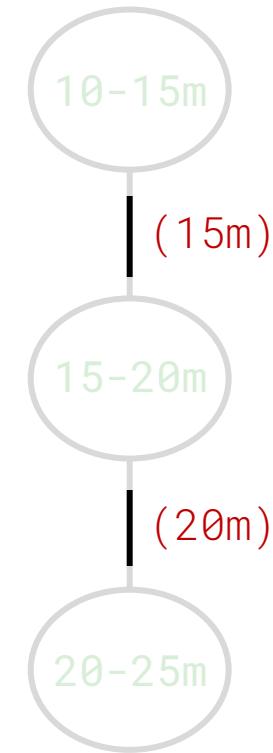
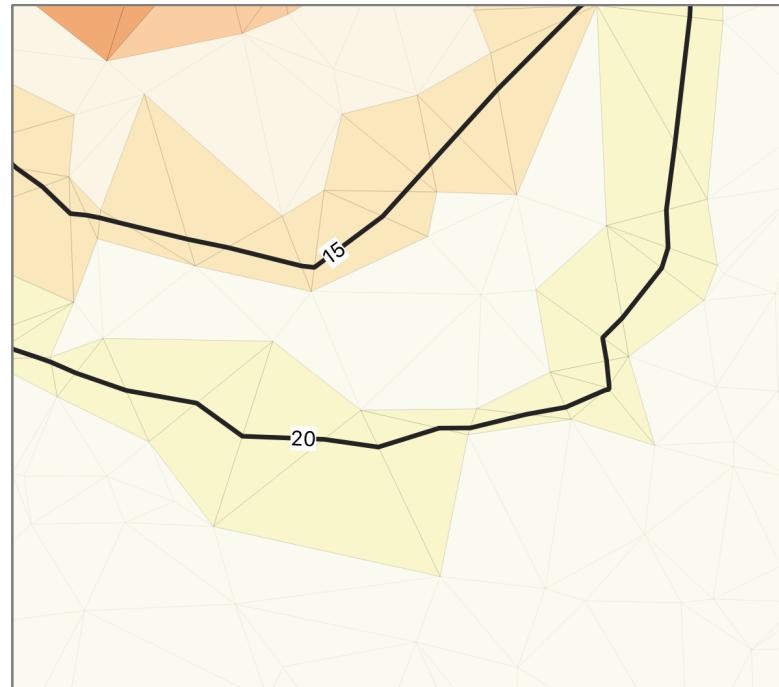
TRG Structure



intersection



TRG Structure



TRG Data

- Nodes[NodeID] [triangles] {tri, tri, tri, ... }
[region] int (> [float, float])
[deeper] {nodeID, nodeID, ... }
[shallower] {nodeID, nodeID, ... }
[boundary] {edgeID}
[holes] {edgeID, edgeID, ... }

 - Edges[EdgeID] [edge] [shallowNode, deepNode]
[closed] [Bool]
[value] [float]
- after/during isobath generation:
- [ordered_tris] {1: tri, 2: tri, ... }
 - [tri_segs] {1: [[vId, vId], [vId, vId]] }
 - [iso_geom] [[x,y], [x,y], ...]
 - [iso_pointers] [[x,y]: {tri, tri, ... }, ...]

TRG Operations

- Traverse from node and edges to:
 - Adjacent nodes (deeper or shallower)
 - Adjacent edges (deeper or shallower)
- Get triangles in node or edges
- Generate isobath geometries
- Generate depth areas (closed)
- Get triangles adjacent to an isobath-vertex
- Expand selected triangles by 'rings'
- Expand selected triangles by nodes

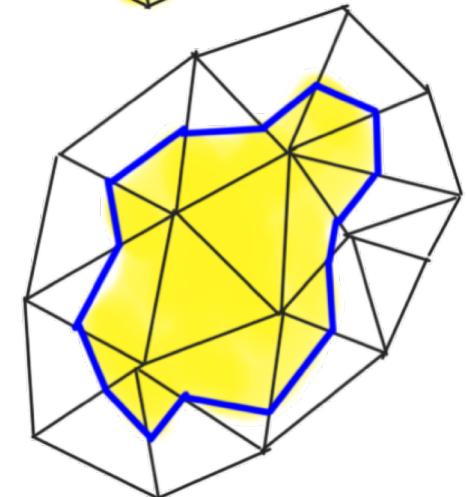
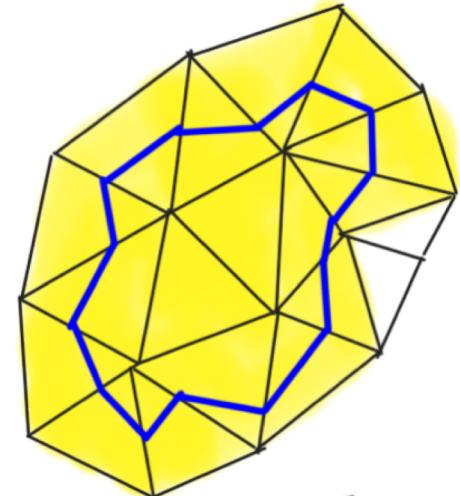
Methodology

Methodology

- Locally steer generalisation operators, where needed
- Build TRG to link: survey data > triangulation > isobaths
- Repeating process
 - Compute metrics
 - Identify conflicting points/vertices, nodes, triangles
 - Decide on conflict region expansion
 - Apply smoothing or densification

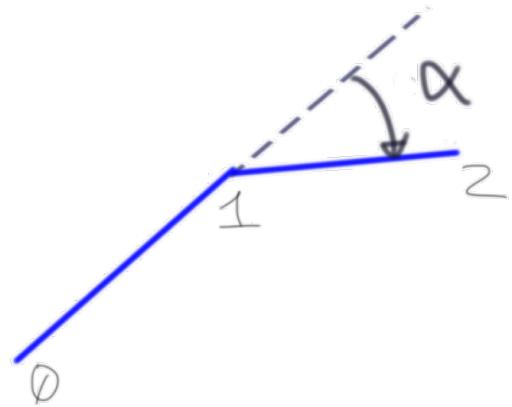
Metrics: Node area

- Full area > sum of triangles
- Isobath area > only if closed isobath
- Peaks need a minimum area
- Conflicts result in:
 - Nodes



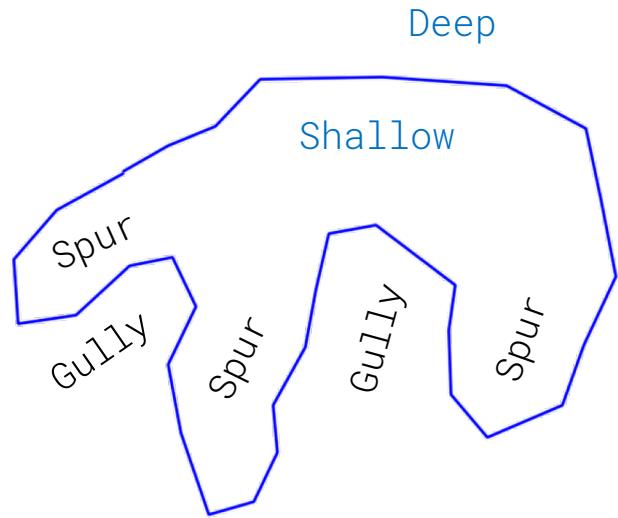
Metrics: Angularity

- Deviation from straight propagation
- Measure for smoothness of the line
- May be averaged for a full edge
- Maximum allowed angle
- Conflicts result in:
 - Isobath vertices

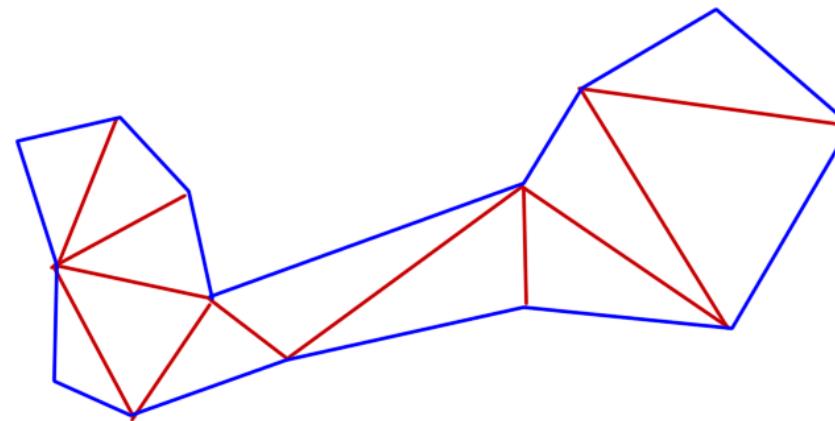


Metrics: Spurs and Gullies

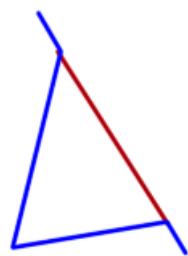
- Indents of isobaths
- Line separation
- Navigable gullies?
- Smoothness on detail level
- Minimum *width* of feature
- Conflicts result in:
 - Isobath vertices



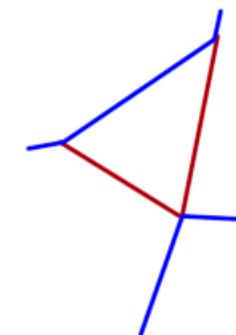
Metrics: Spurs and Gullies



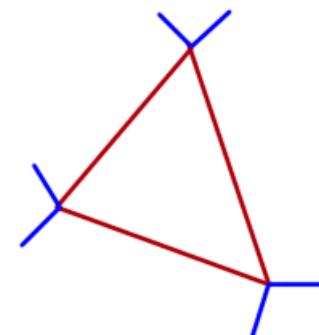
Metrics: Spurs and Gullies



1 segment

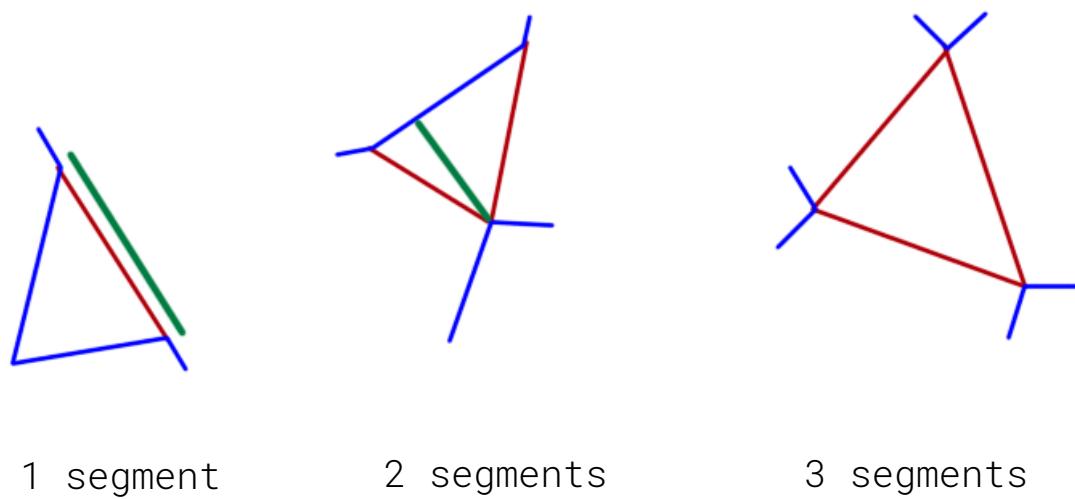


2 segments



3 segments

Metrics: Spurs and Gullies



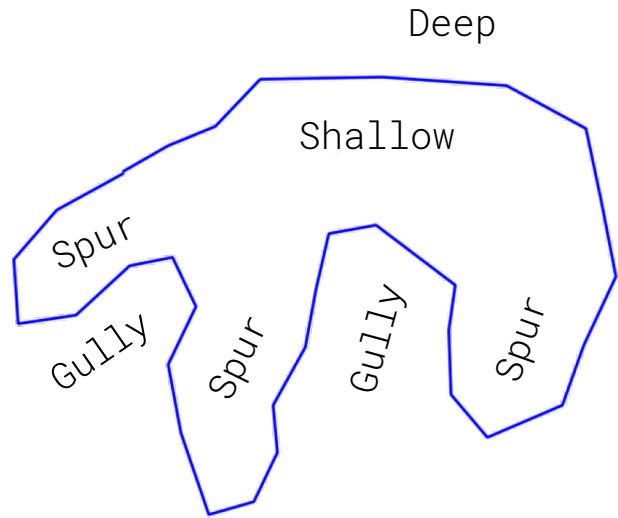
1 segment

2 segments

3 segments

Metrics: Spurs and Gullies

- Indents of isobaths
- Line separation
- Navigable gullies?
- Smoothness on detail level
- Minimum *width* of feature
- Conflicts result in:
 - Isobath vertices

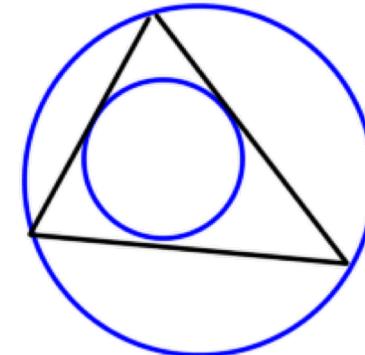


Metrics: Triangle area

- Simple triangle area
- Where to densify
- Maximum value
- Conflicts result in:
 - Triangle

Metrics: Triangle aspect ratio

- Simple triangle area
- Where to densify
- Maximum value
- Conflicts result in:
 - Triangle



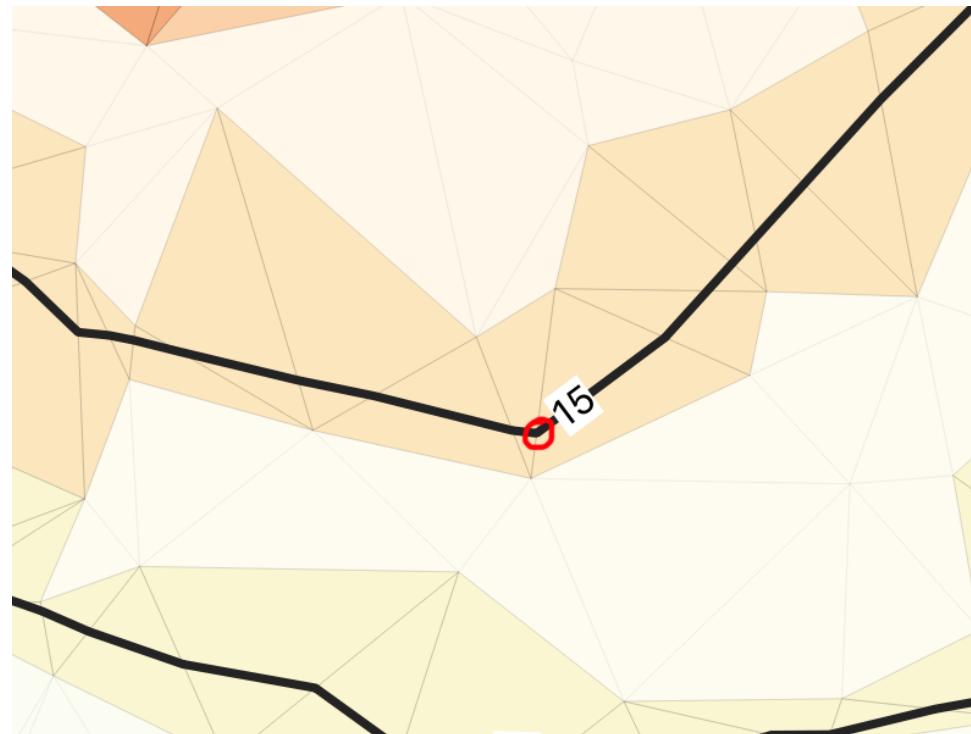
Process and Implementation

<https://www.github.com/willemvanopstal/hydropolator>

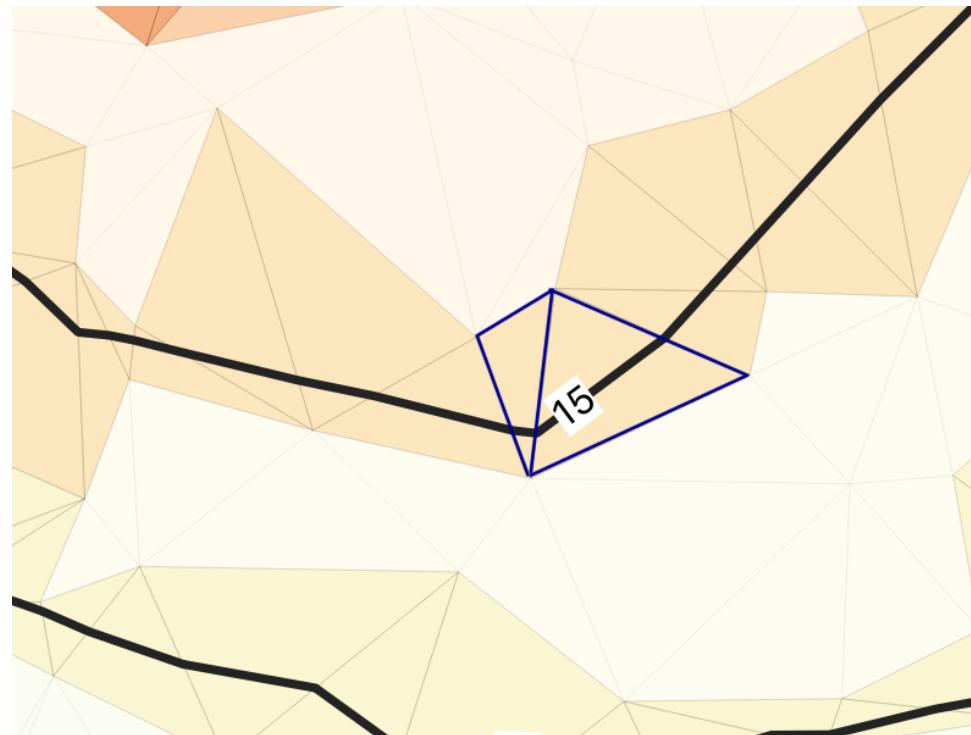
Process and implementation

- Generate TRG > Isobaths > Metrics
- Metrics with threshold results in:
 - conflicting nodes get all node triangles
 - conflicting triangles
 - conflicting isobath vertices get adjacent triangles
- Possibly extend these triangles
- Extract vertices of extended triangles
- Add vertices to smoothing queue
- Apply operator

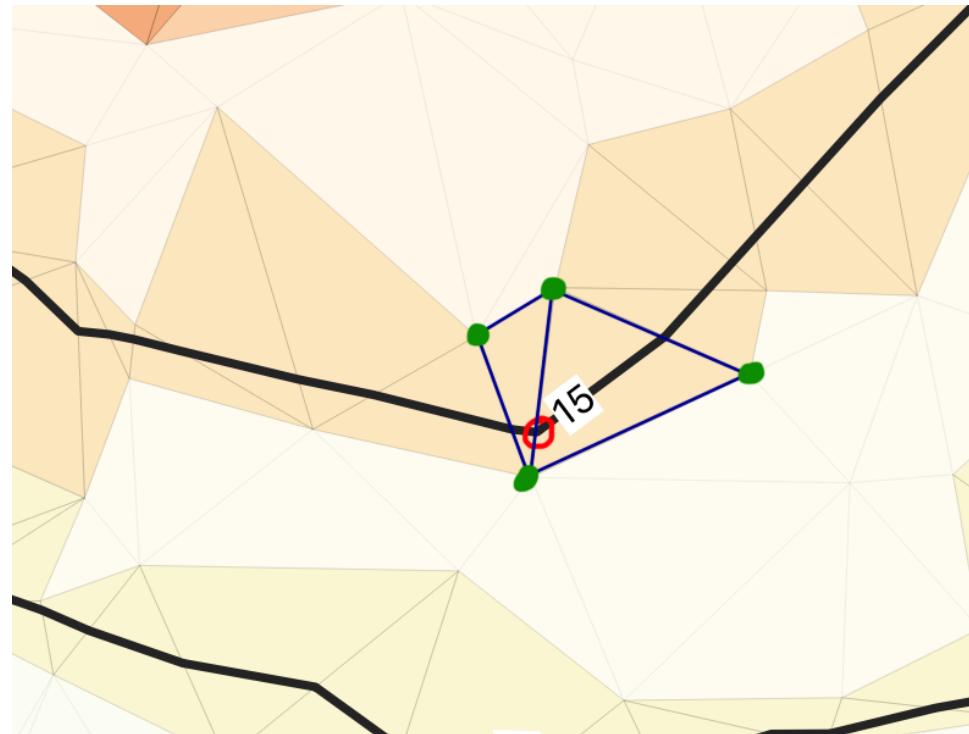
Conflicting isobath-vertex



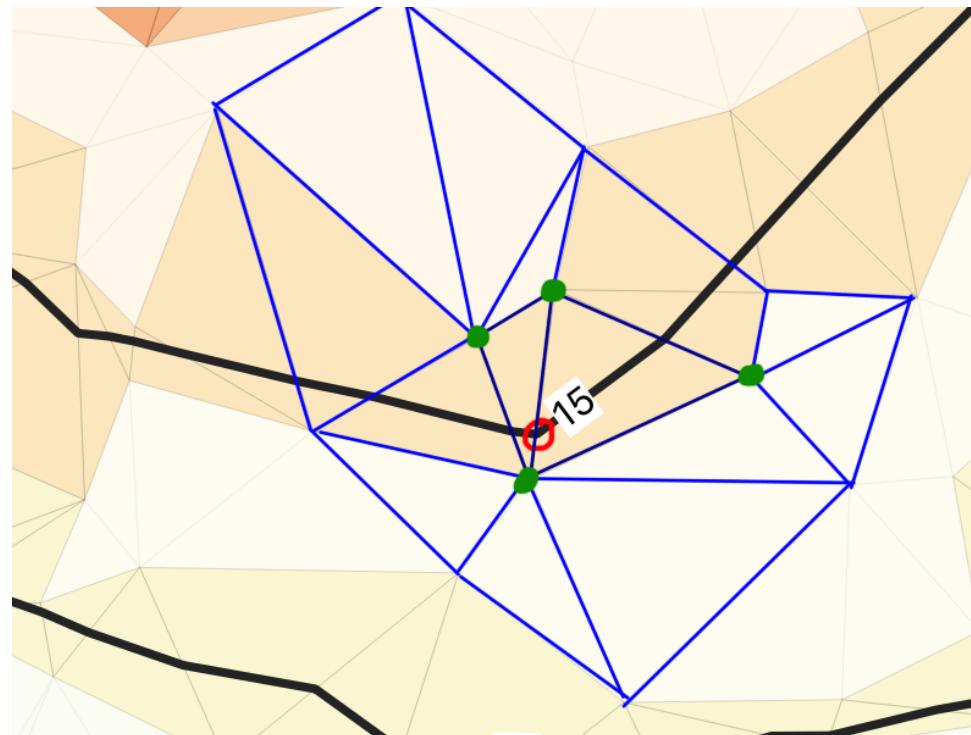
Adjacent triangles



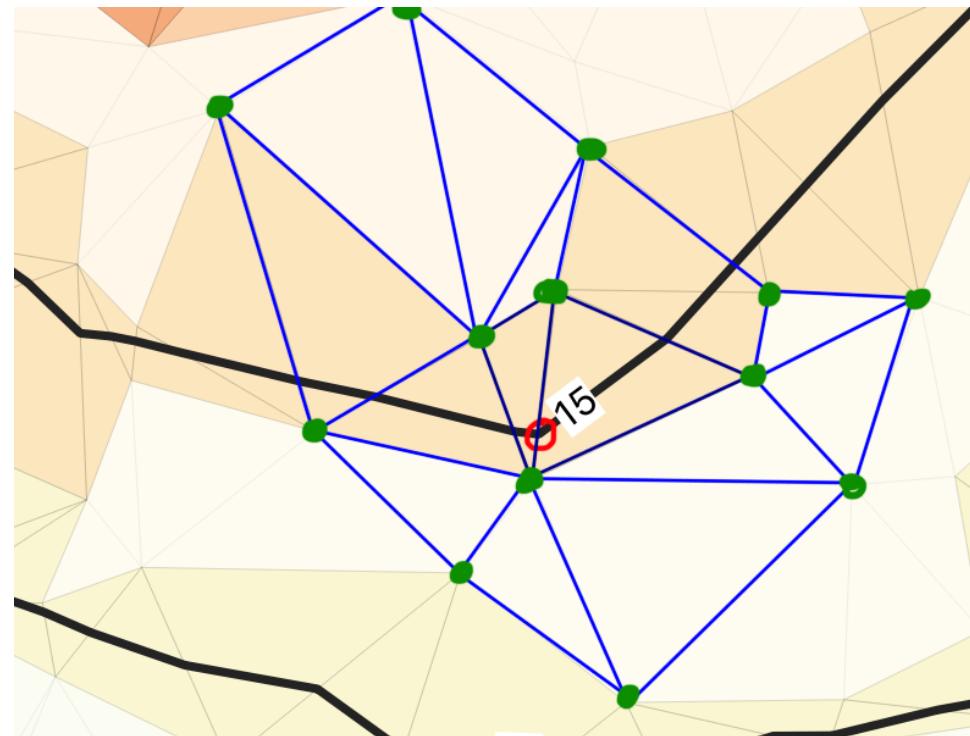
Vertices to smooth



Possibly extend region (rings)



Vertices to smooth



Process and implementation

```
paramDict = {'prepass': 1,  
            'densification': 3,  
            'maxiter': 100,  
  
            'angularity_threshold': 1.0,  
            'spurgully_threshold': None,  
            'spur_threshold': 15,  
            'gully_threshold': 25,  
            'aspect_threshold': 4,  
            'size_threshold': 60  
            'seg_threshold': 100,  
            }
```

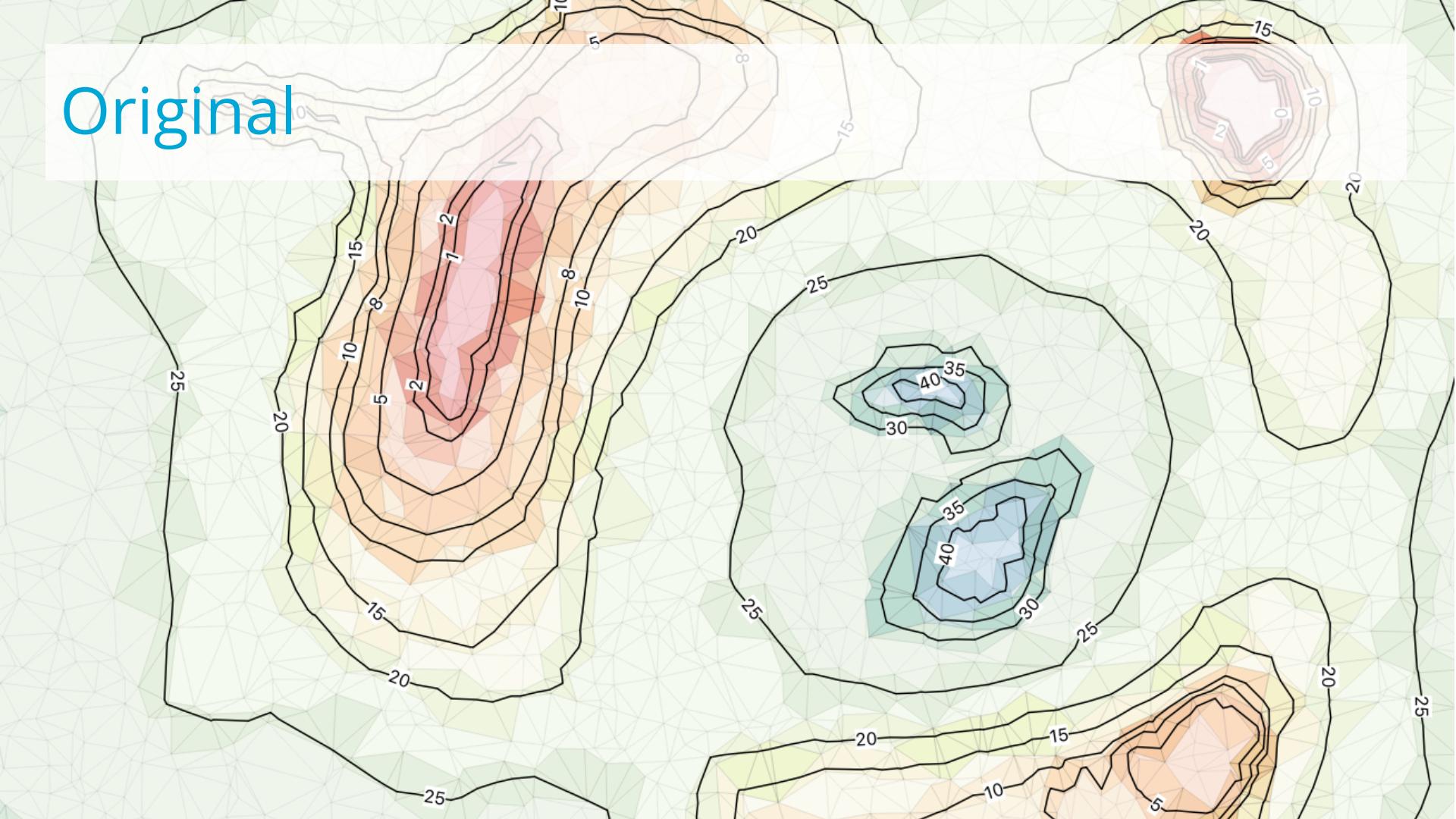
Process and implementation

- Modular approach, makes it possible to adapt the process

```
paramDict[ 'process' ] = [  
    [['angularity', 'r', 1], ['spurs', 'r', 1], ['gullys', 'r', 1], 0],  
    [['angularity', 'r', 2], ['spurs', 'r', 2], ['gullys', 'r', 2], 0],  
    [['angularity', 'r', 4],  
     ]  
  
paramDict[ 'densification_process' ] = [  
    ['angularity', 'r', 1],  
    ['aspect-edges', 'r', 0],  
    ['size-edges', 'r', 0]  
]
```

Results

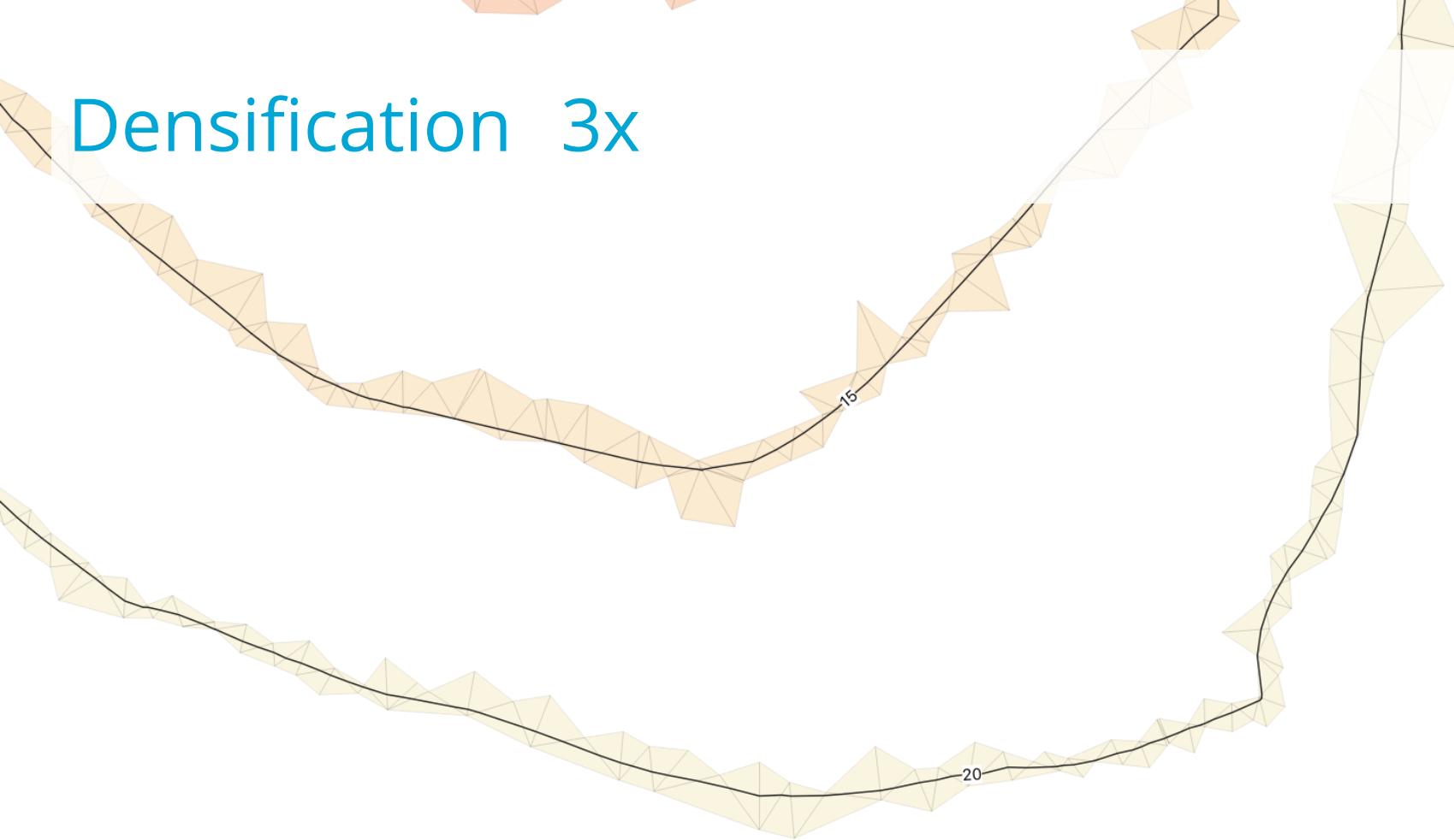
Original



Densification 3x



Densification 3x



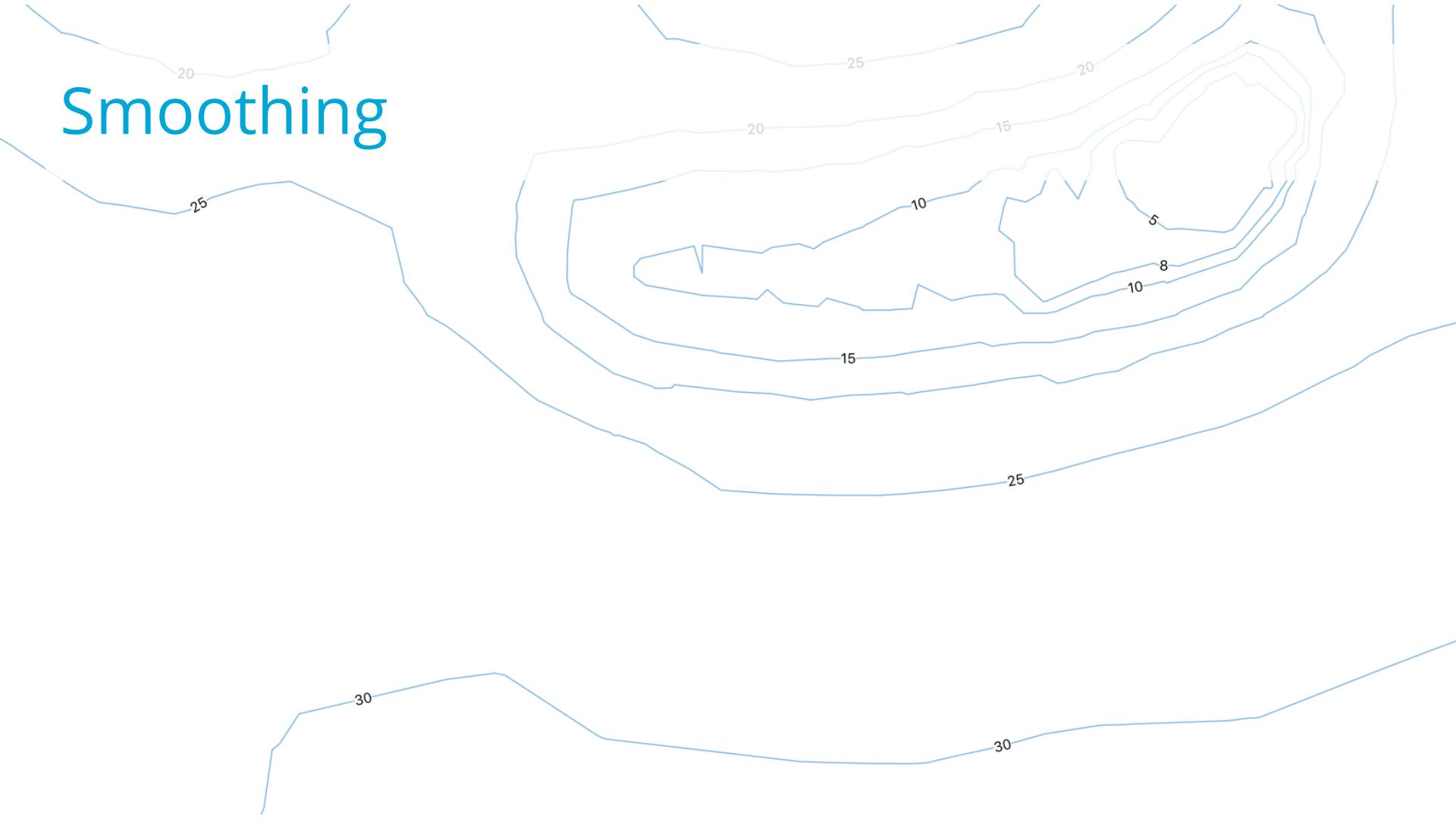
Densification 3x



Densification 3x

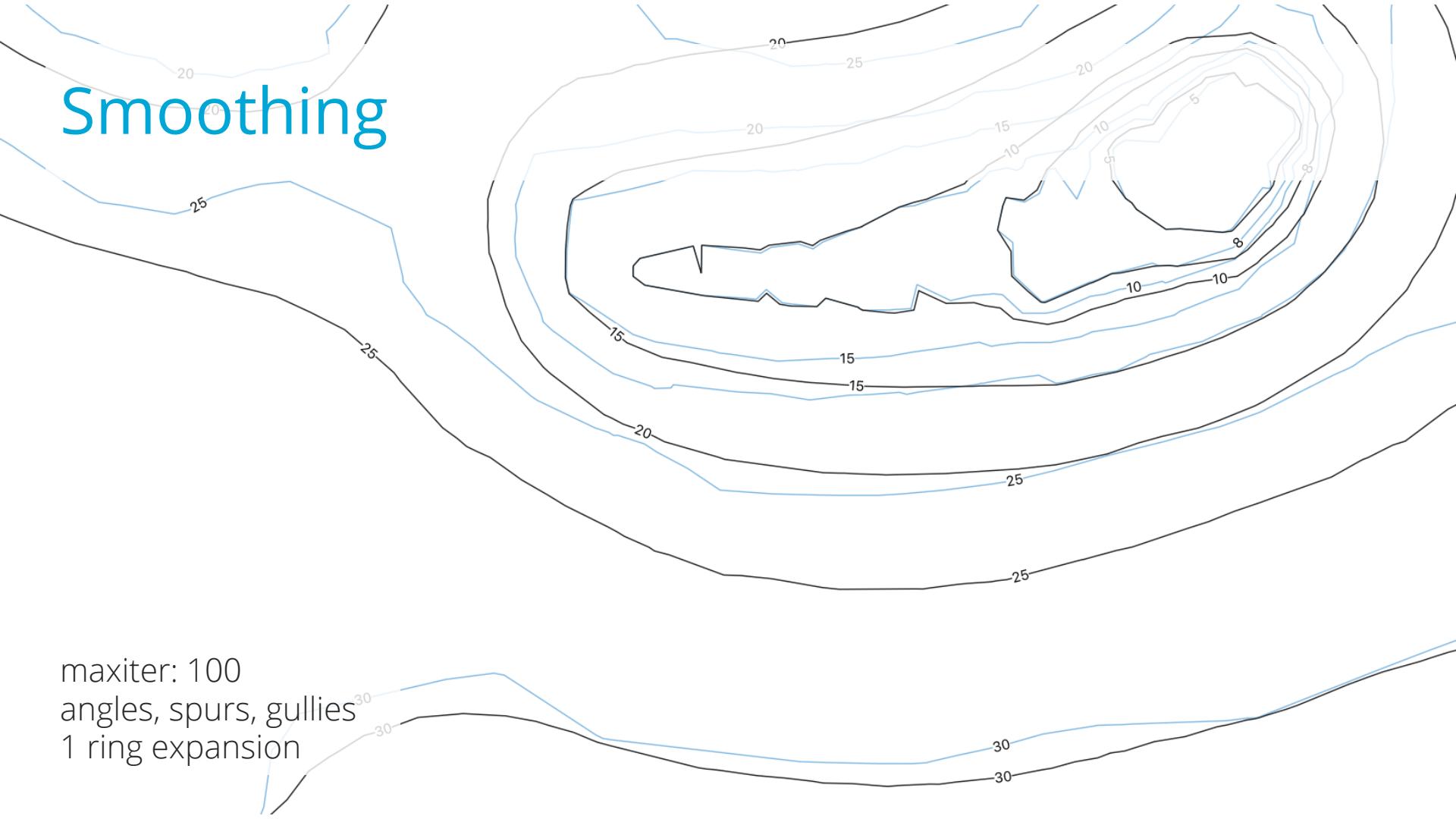


Smoothing



Smoothing

maxiter: 100
angles, spurs, gullies
1 ring expansion



Smoothing (extremer)

maxiter: 100

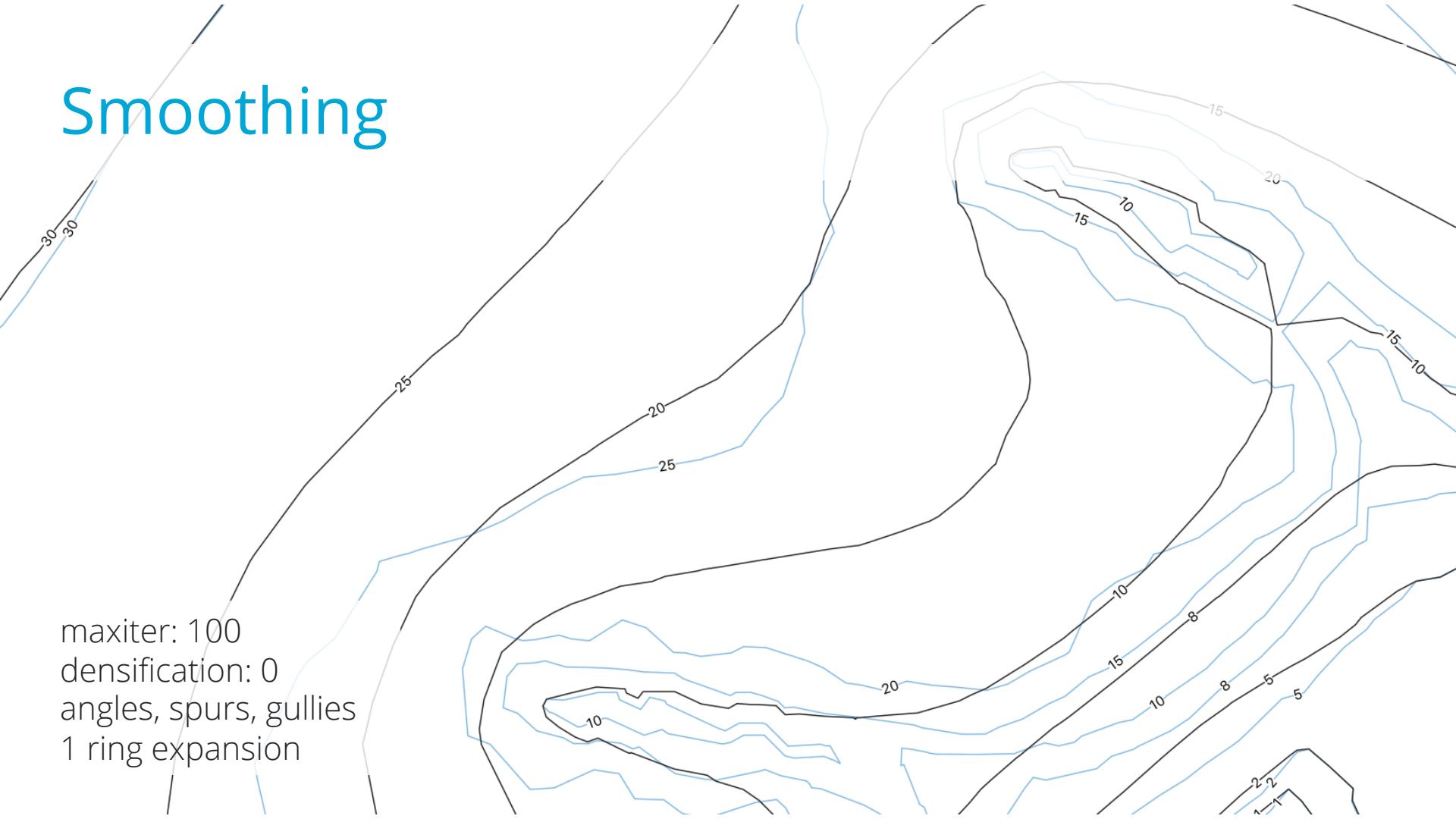
angles, spurs, gullies
2 ring expansion

Smoothing and Densification



Smoothing

maxiter: 100
densification: 0
angles, spurs, gullies
1 ring expansion



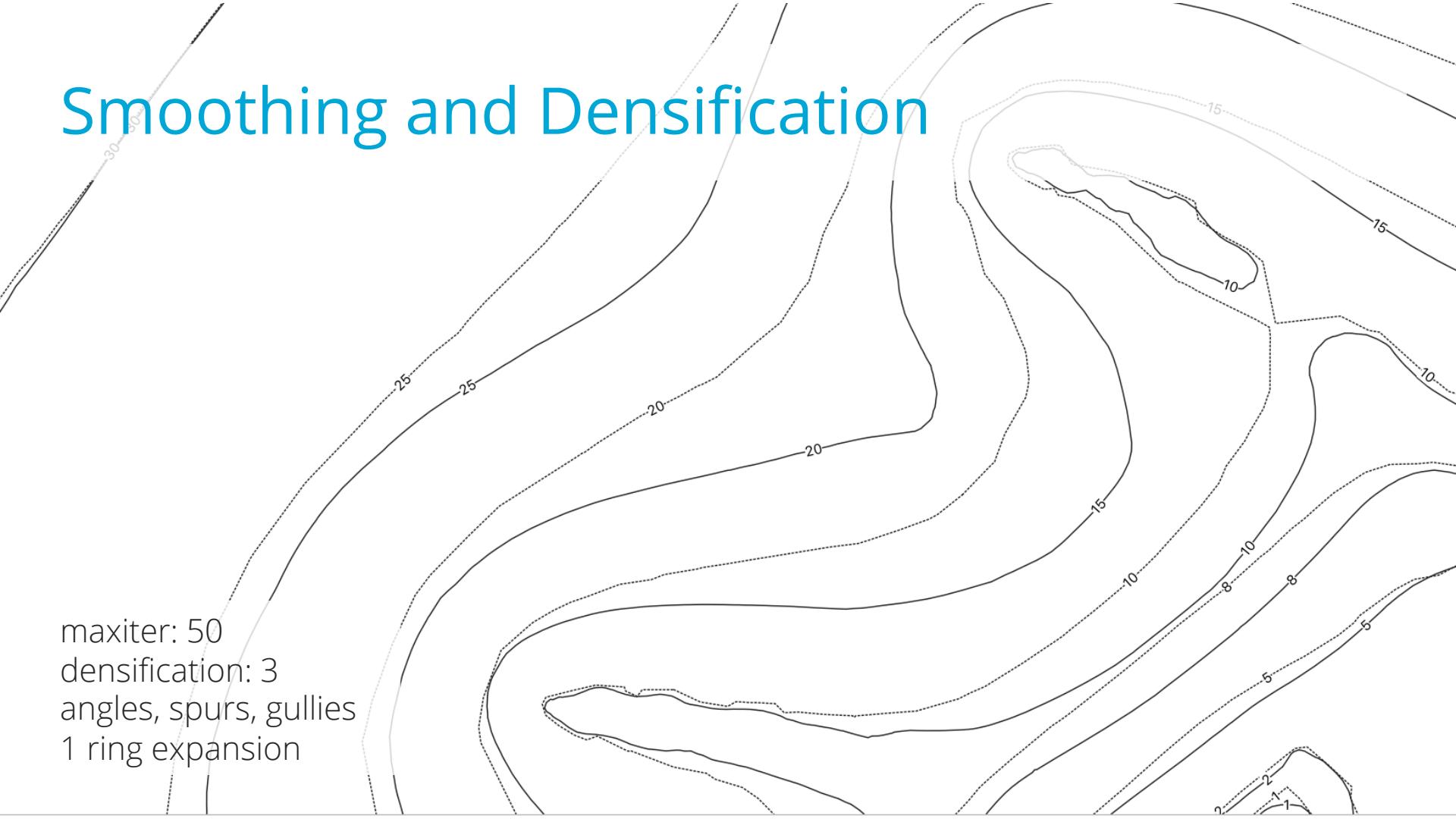
Smoothing

maxiter: 100
densification: 0
angles, spurs, gullies
1 ring expansion



Smoothing and Densification

maxiter: 50
densification: 3
angles, spurs, gullies
1 ring expansion



Smoothing angles only



Smoothing angles only

maxiter: 100
densification: 0
angles
1 ring expansion



Smoothing angles only

maxiter: 100
densification: 0
angles
1 ring expansion



Smoothing angles only + densification

maxiter: 50
densification: 3
angles
1 ring expansion



Smoothing angles only + densification

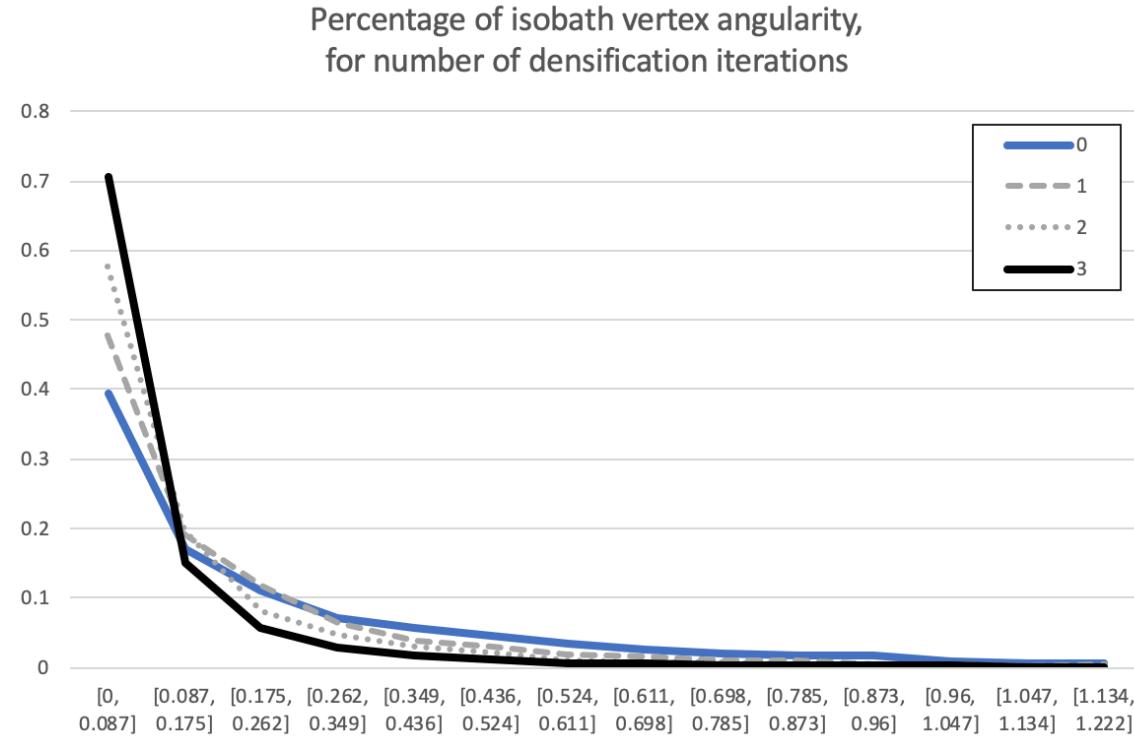
maxiter: 50
densification: 3
angles
1 ring expansion



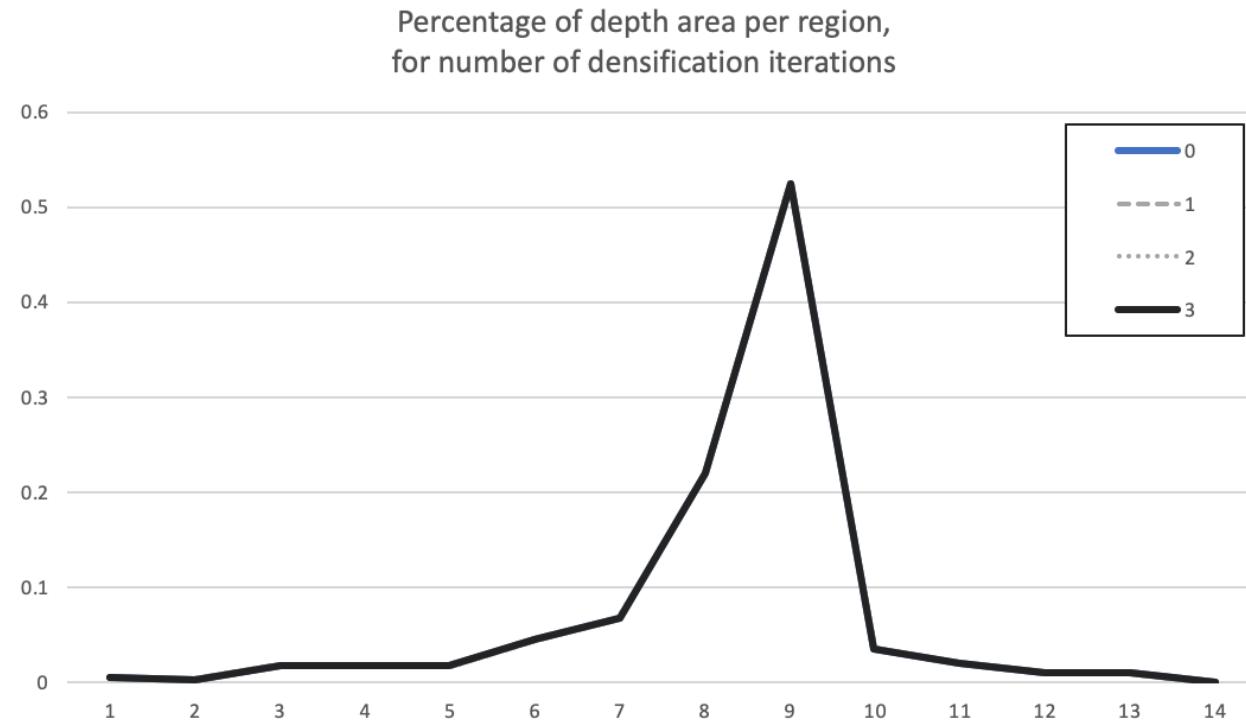
Validation

- Visual inspection
- Quantification
 - Absolute changes in depth values
 - Minimum depth changes in depth values
 - Areas of depth areas
 - Angularities
- Safety assumed to be valid, by process definition
- Topology also assumed to be valid, can be checked

Quantification: Densification

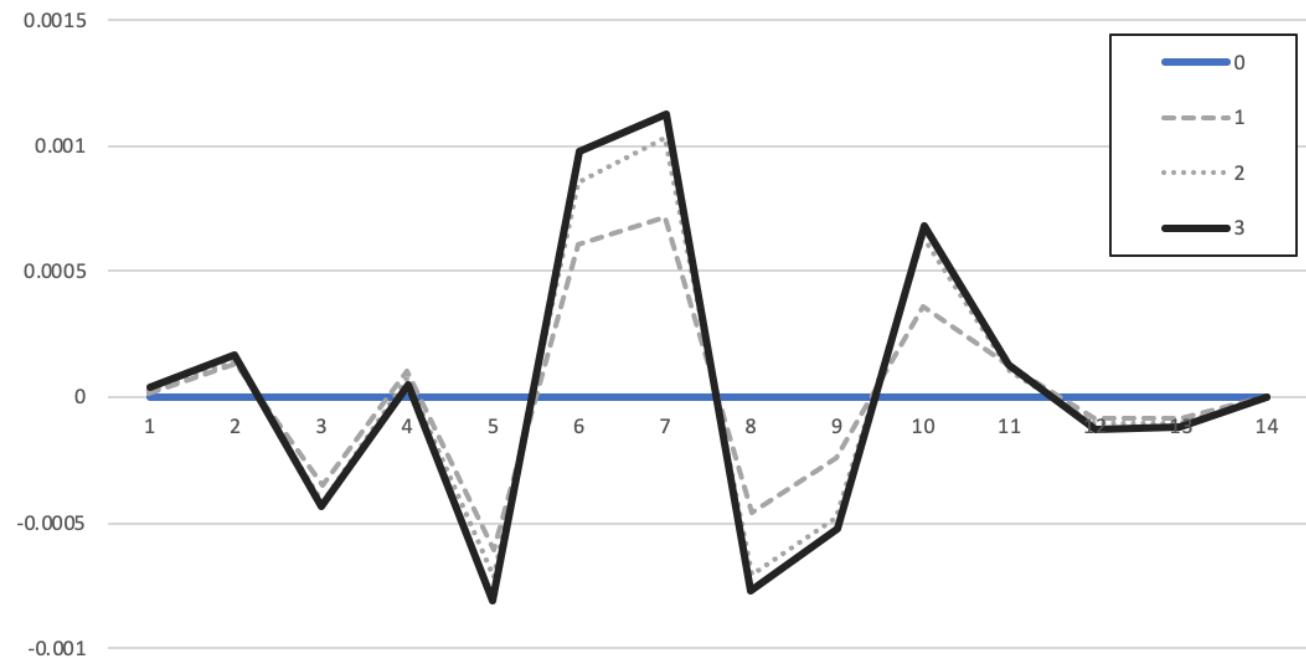


Quantification: Densification

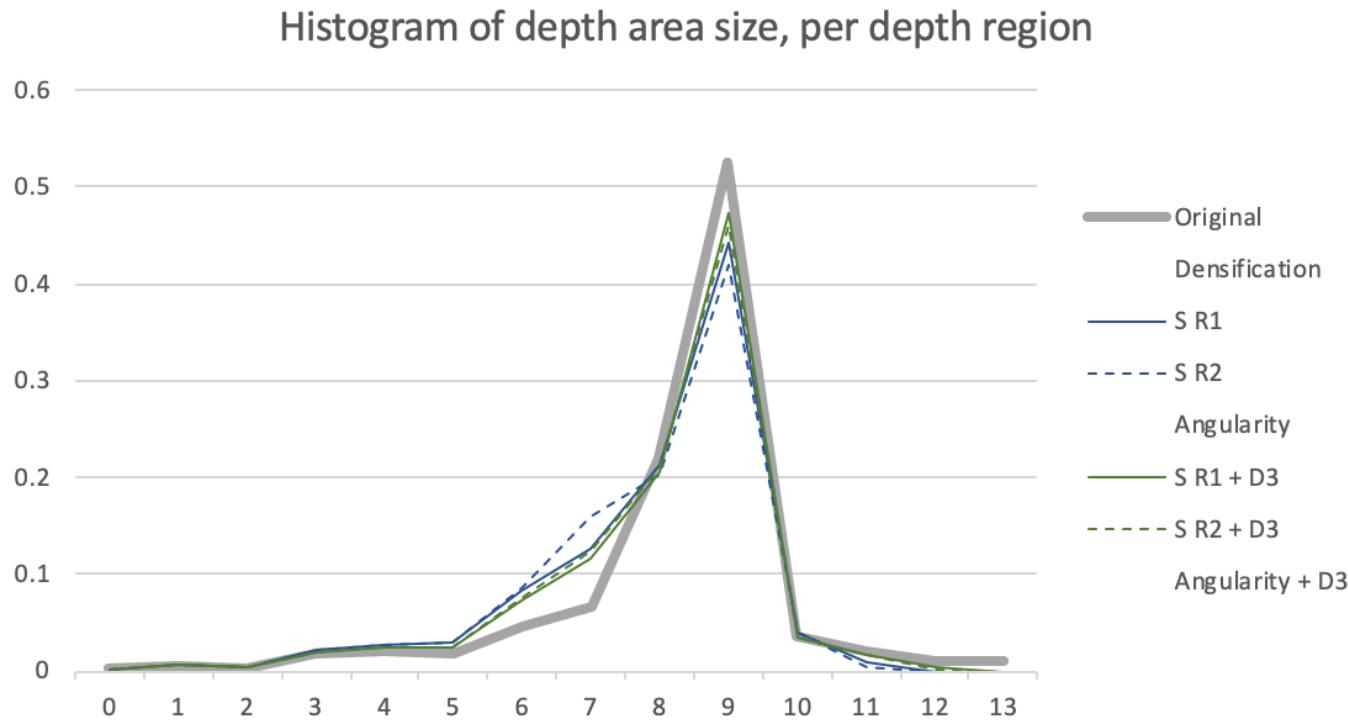


Quantification: Densification

Depth area change in absolute percentages w.r.t. original situation
for number of densification iterations

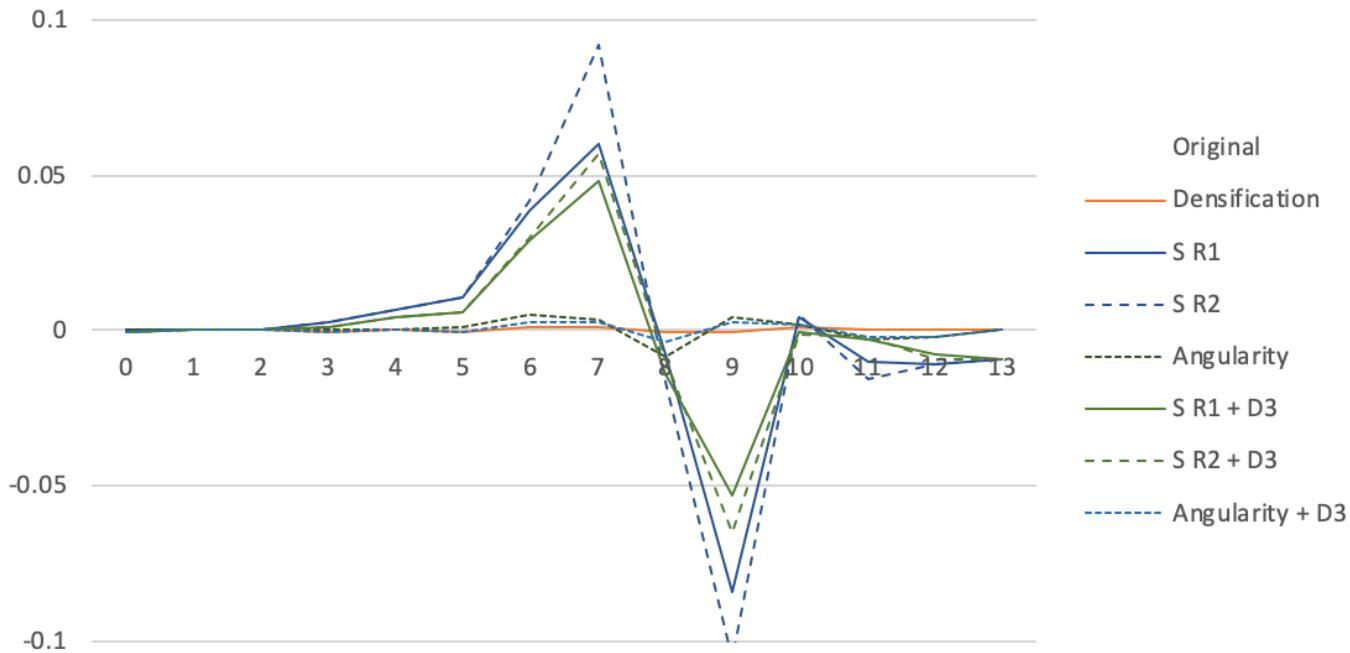


Quantification: Depth areas



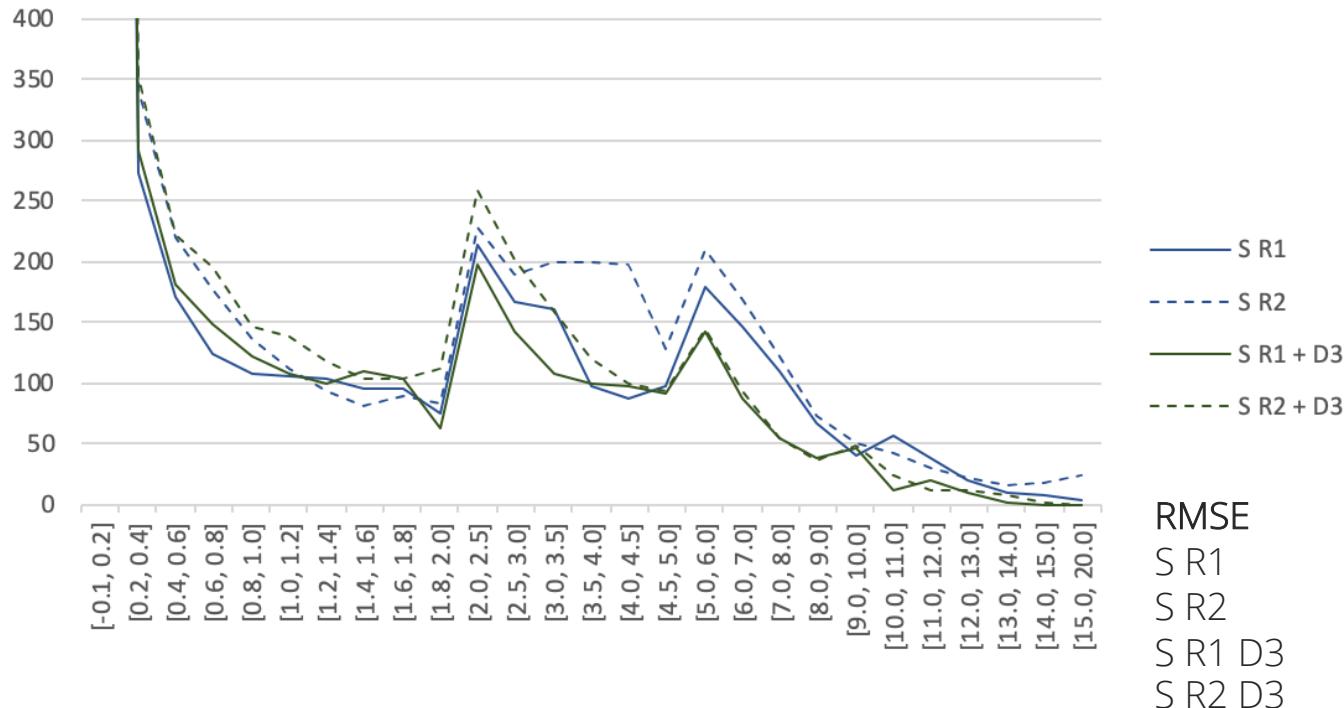
Quantification: Depth areas

Change in percentage of total area, per depth region



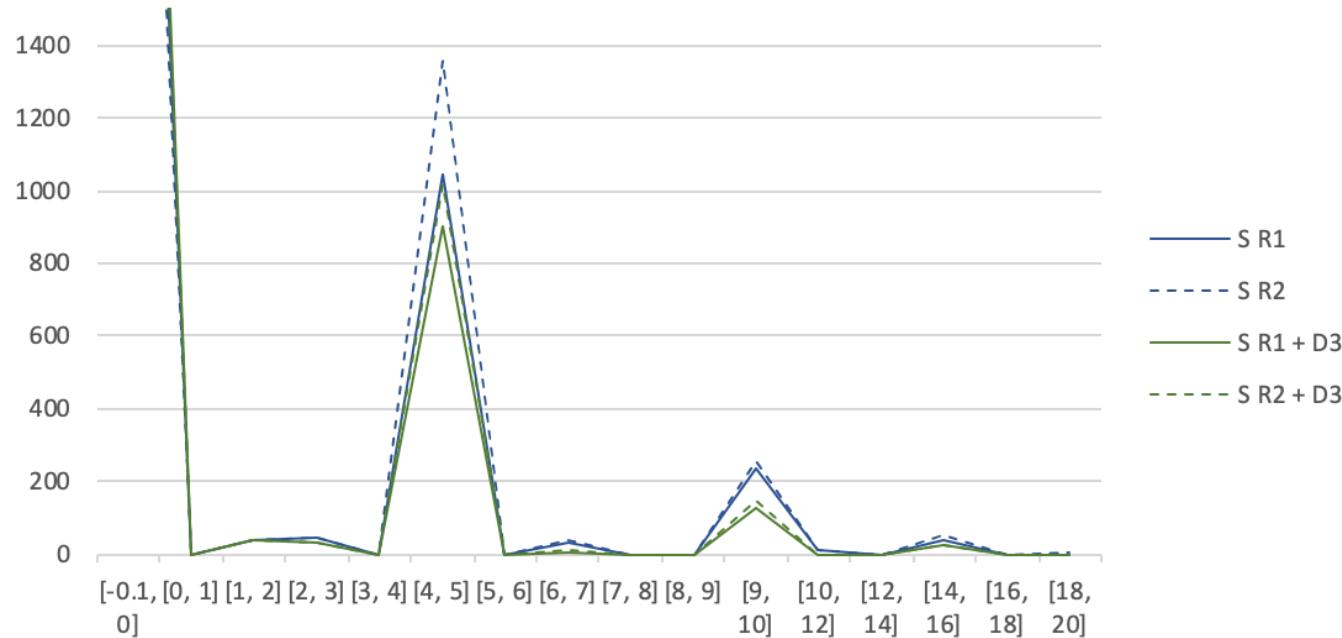
Quantification: Absolute changes

Absolute change in depth values, binned



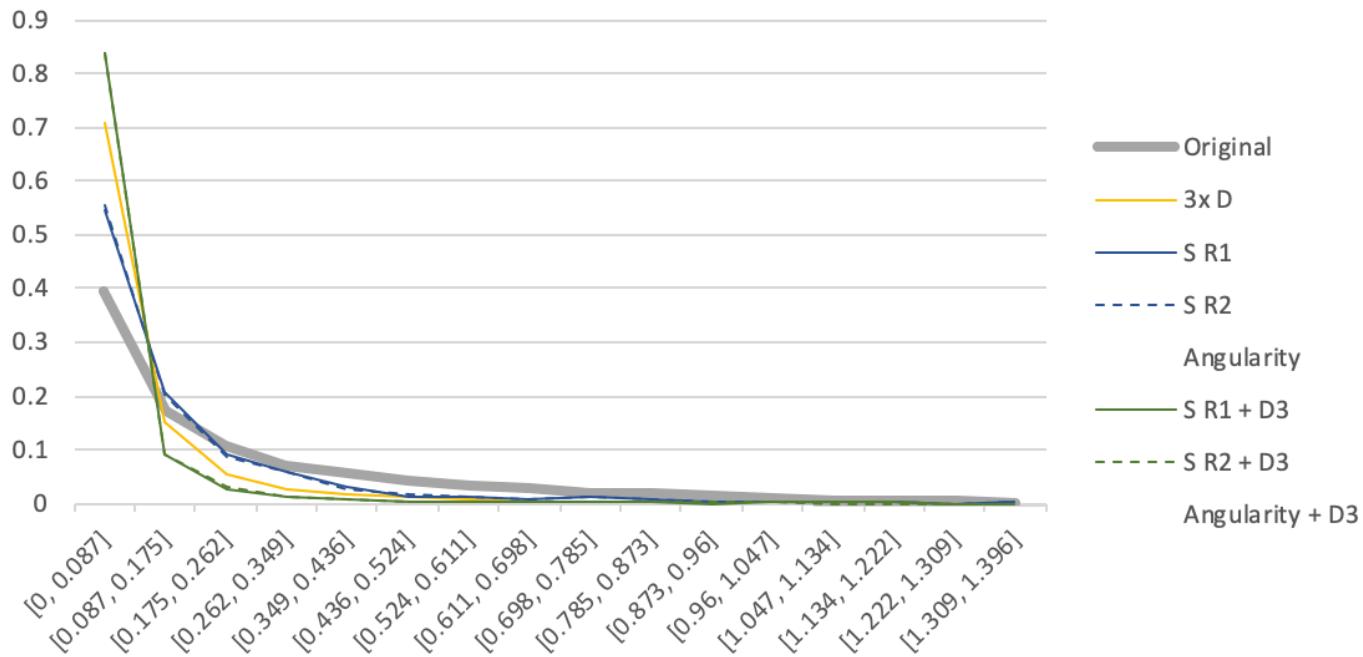
Quantification: Minimum depth

Change in expected minimum depth, binned



Quantification: Angularities

Histogram of angularities in isobaths



Next

Next stages

- Translate desired chart properties into metrics
 - To process data
 - To validate
- Test on real data, with real chart scales
- Decide on proper validation measures
- Investigate effect of different
 - Metrics
 - Regions of application
 - Smoothing and densification

Next stages

- Extend metrics
 - Smoothness
 - Same-level isobath separation (aggregation of peaks)
 - Isobath segment lengths
- Improve code
 - Local region graph updating
 - Remove unnecessities
- Validation with different data
- Validation with different methods (surfonoi)

Thank you!

Willem van Opstal

Martijn Meijers

(1st mentor)

Ravi Peters

(2nd mentor)

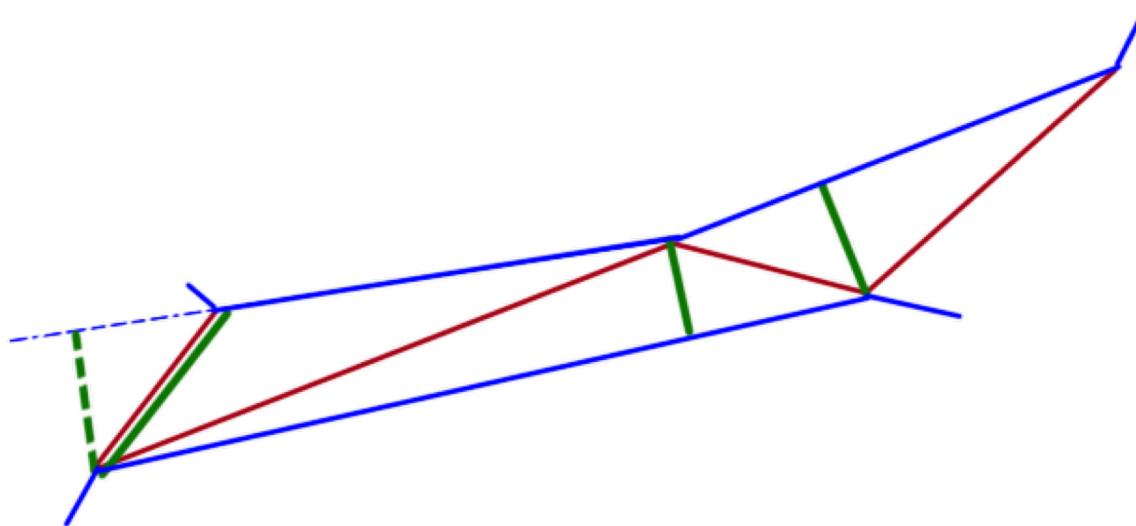
March 17th 2020

Administratie

- P3 Afronden
 - P4 datum kiezen, (co-reader, delegate)
- Co-reader
- P4 inschrijven
 - 9 april
 - Inclusief handtekeningen
- P4
 - 14 mei – 29 mei

Additional slides

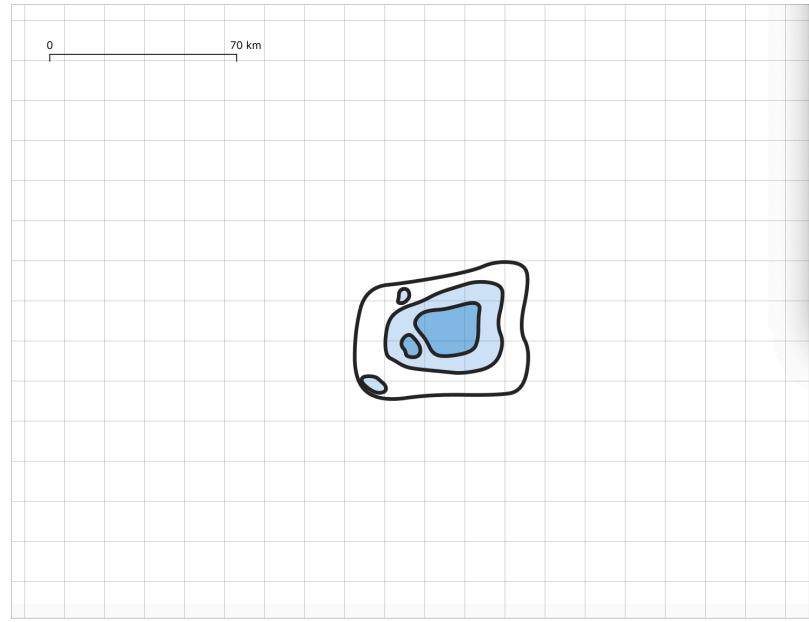
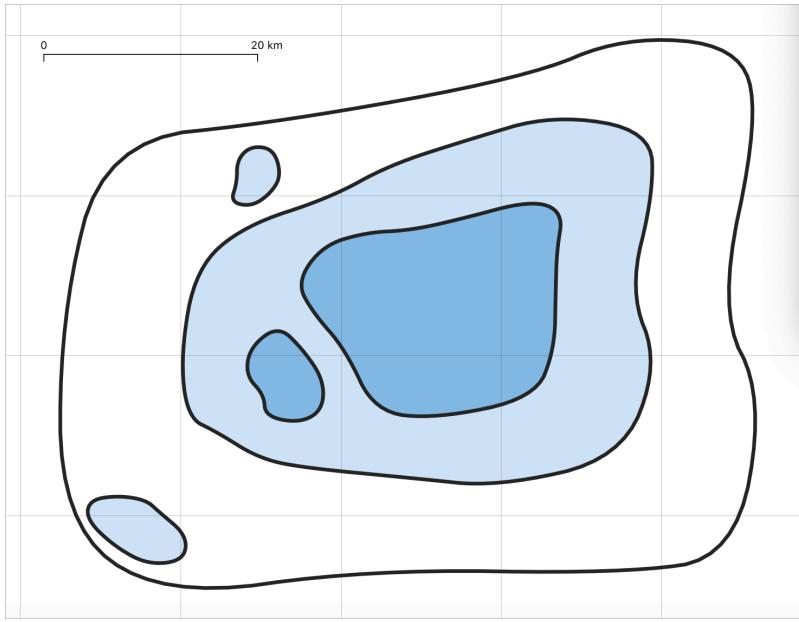
Metrics: Spurs and Gullies

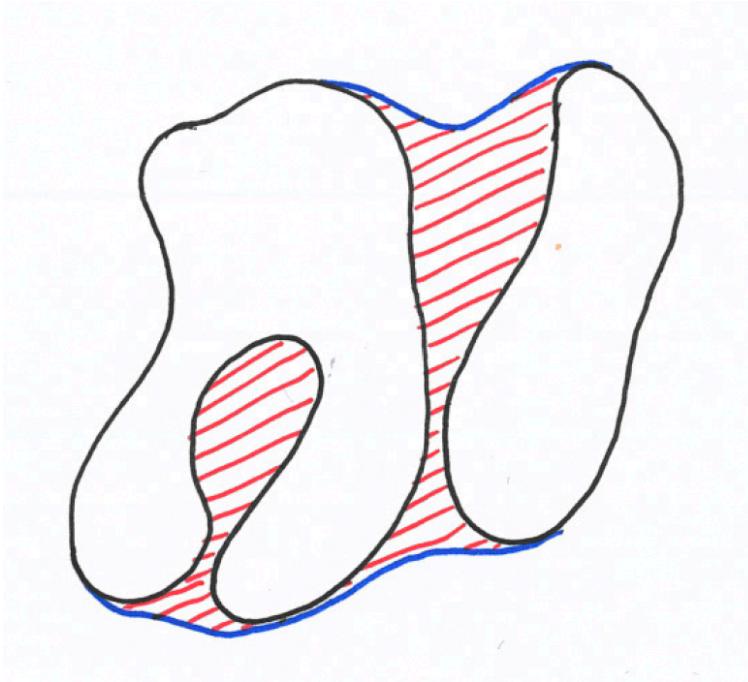
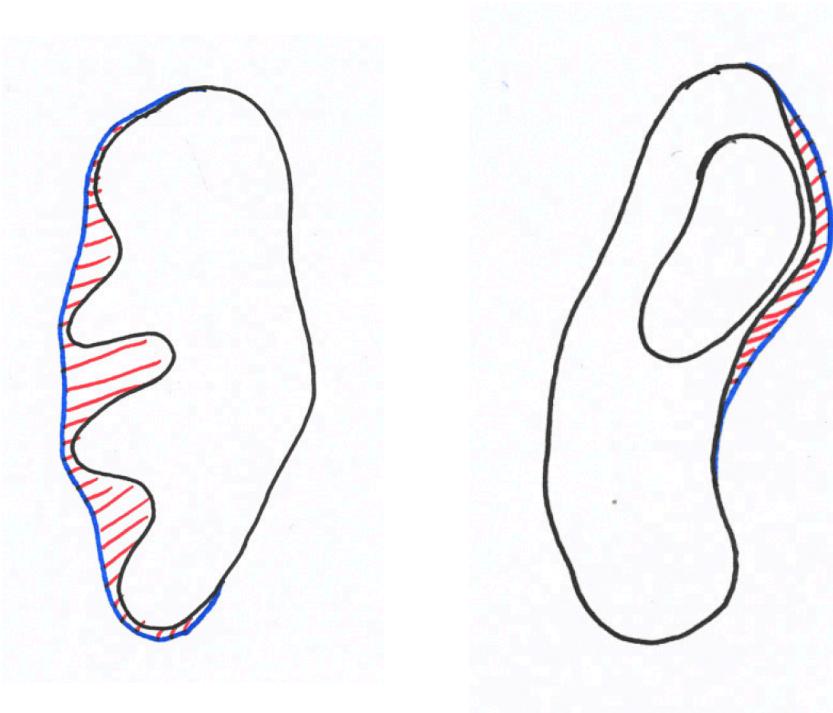


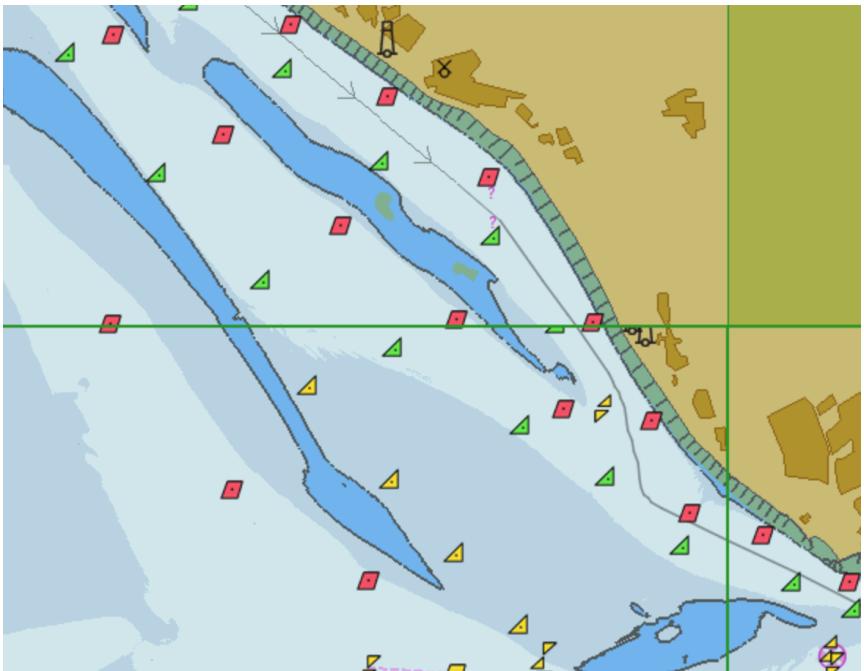
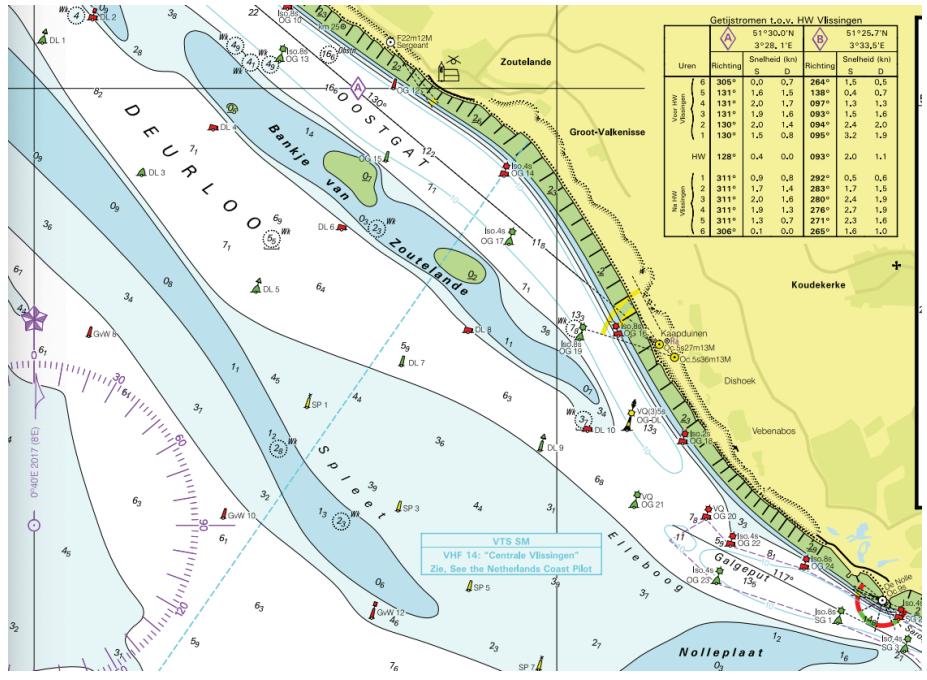
Process and implementation

- Modules

```
'angularity' > isobath vertices  
'spurs'      > isobath vertices  
'gullys'     > isobath vertices  
'size'       > nodes  
'aspect'     > triangles  
'area'       > triangles  
  
'r'          > expand rings  
'n'          > select entire node  
'nn'         > expand neighboring nodes  
'sn' / 'dn'  > expand shallow or deeper node only
```

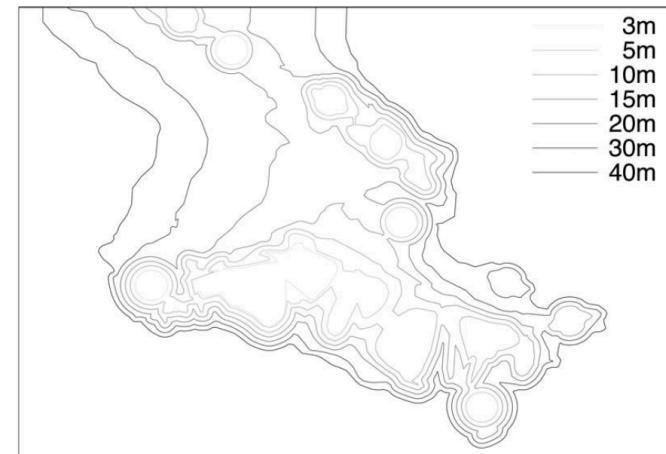






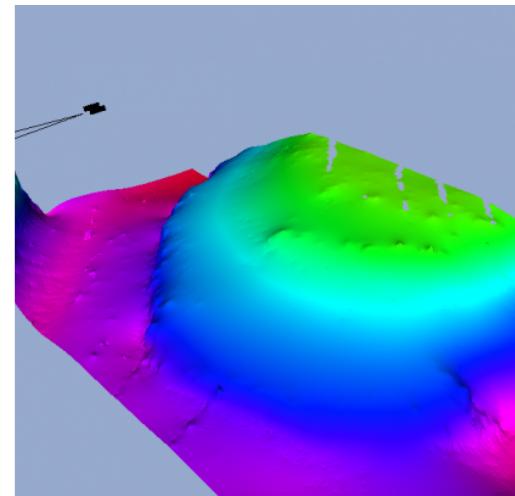
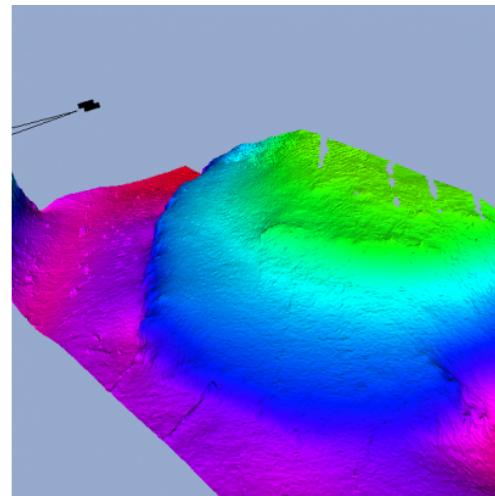
Line-based generalisation

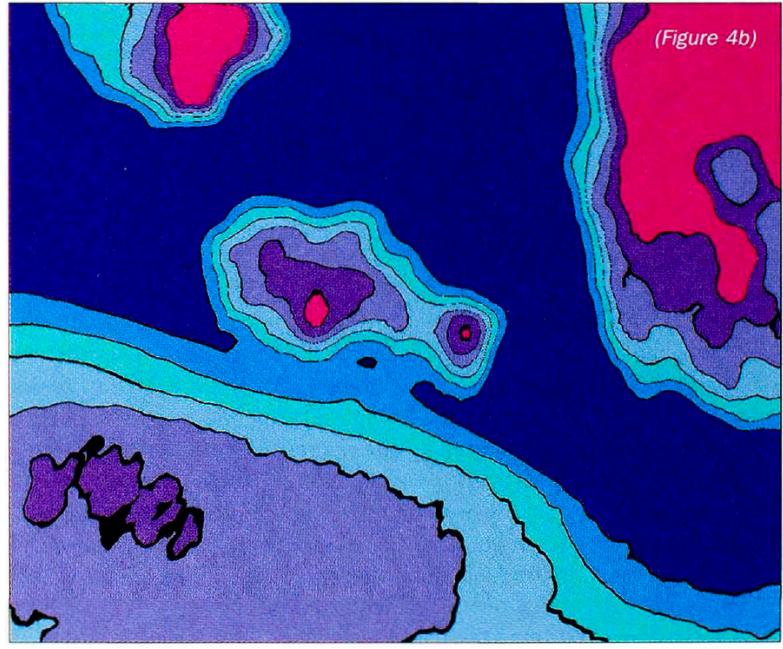
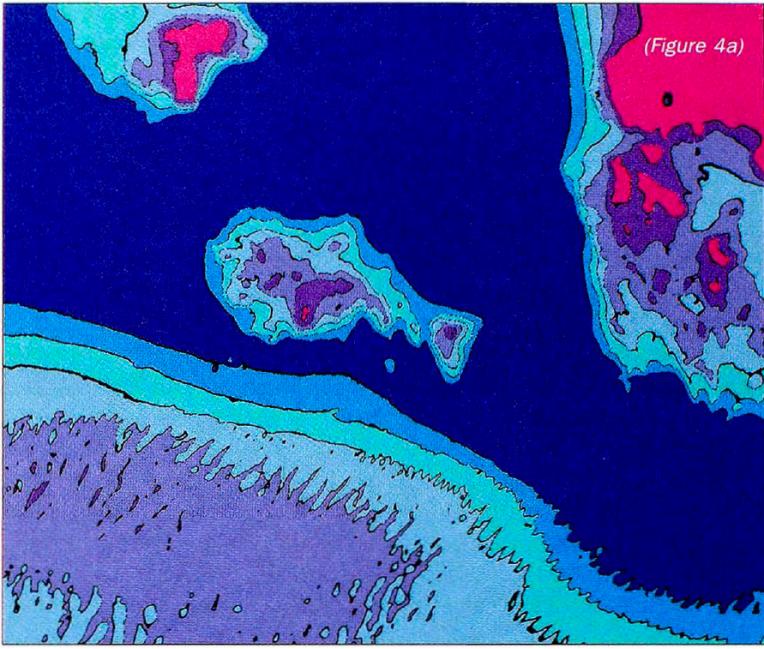
- Multi-agent system
 - Rules and operators
 - Snake-spline model
- Lack a connection with survey data



Navigational surface

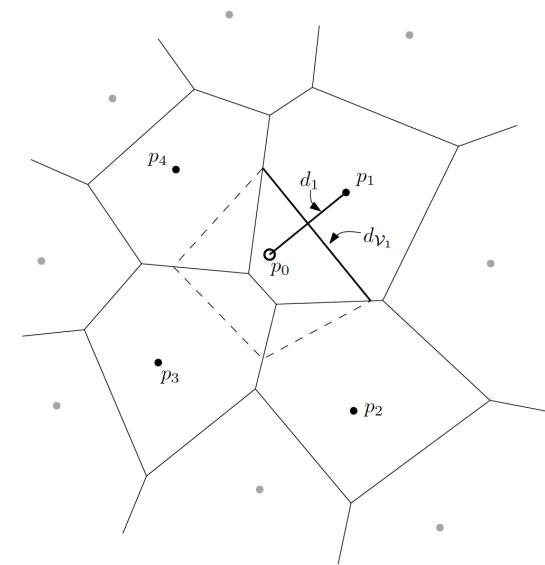
- Raster or vector (triangulation)
- Survey data can be integrated
- Moving the surface only upwards guarantees safety
- Double buffering

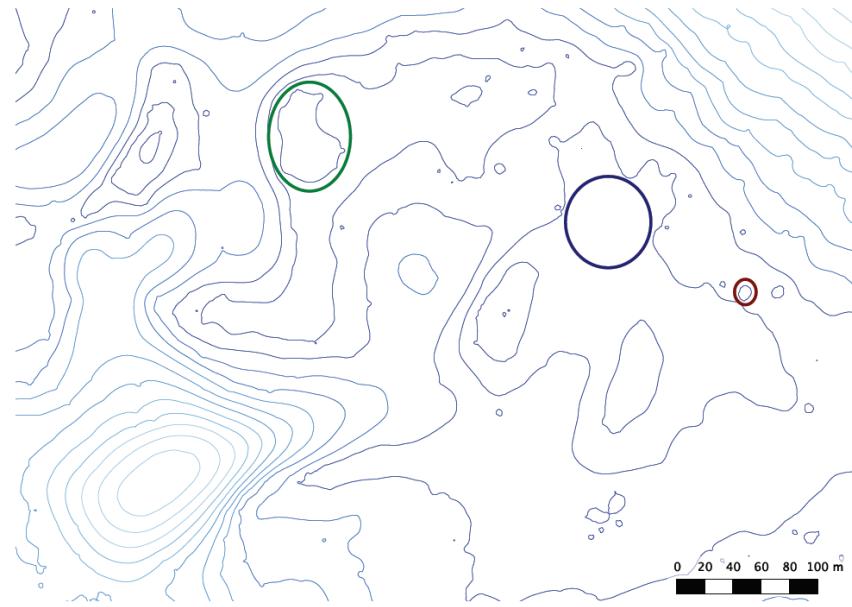
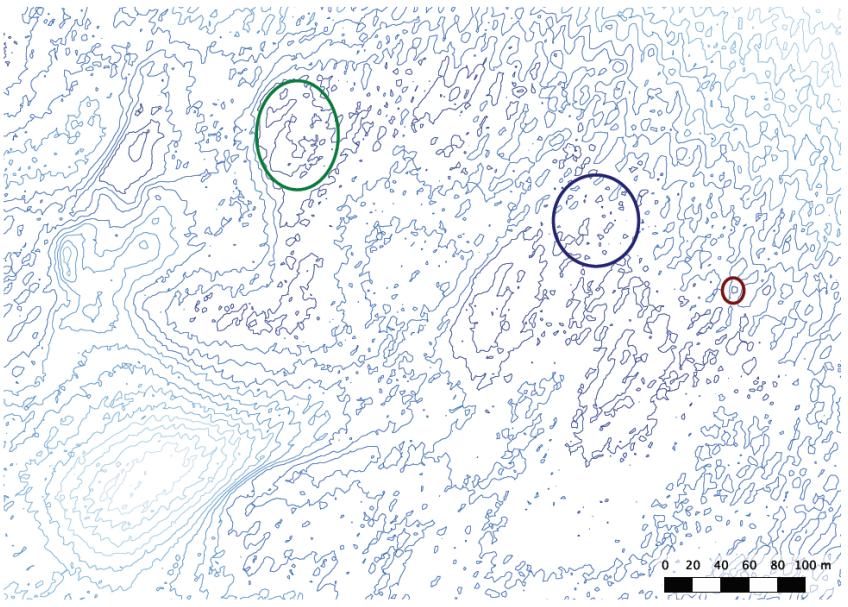




Voronoi-based generalisation

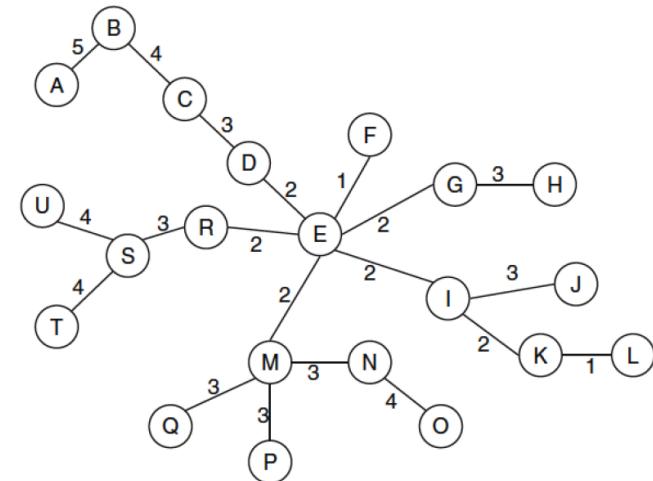
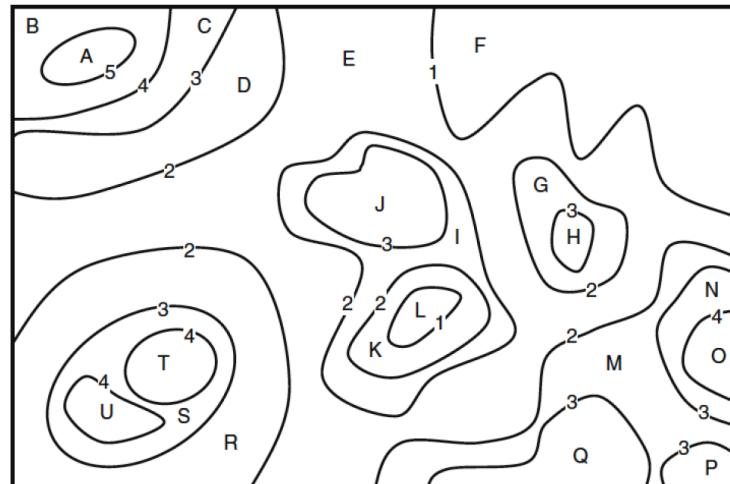
- Generates a smooth surface
 - Thus smooth isobaths
- Laplace interpolation
 - Smooth, local, anisotropic, Parameter-independent, linked to surface
- Iterative approach
 - Smoothing, densification
- When is it good enough?





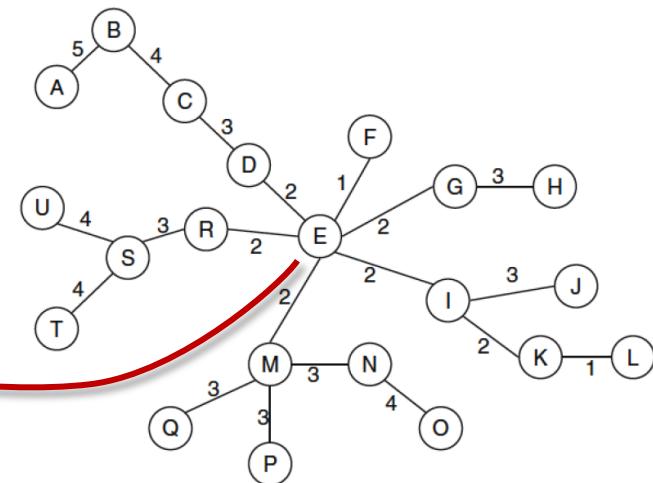
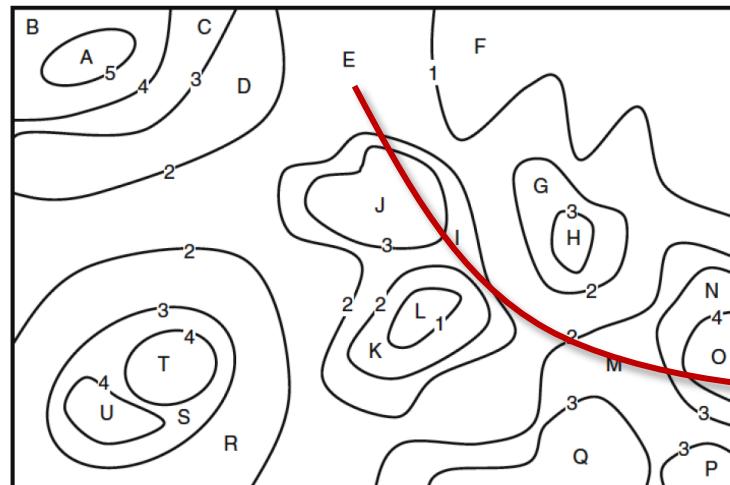
Region graph

- Establish relations between isobaths (not the triangulation)
- Region graph based on inter-isobath area
- Isobaths implicitly defined: edges



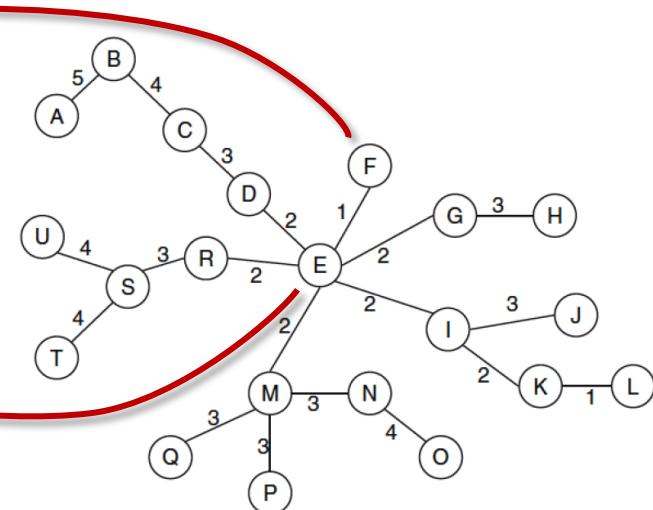
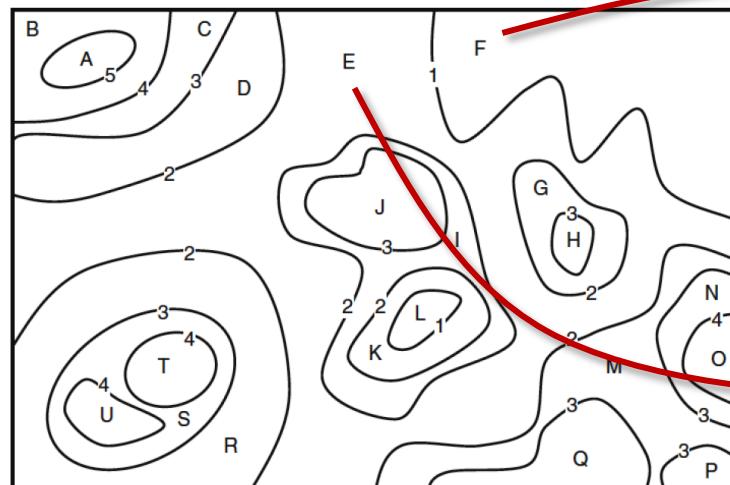
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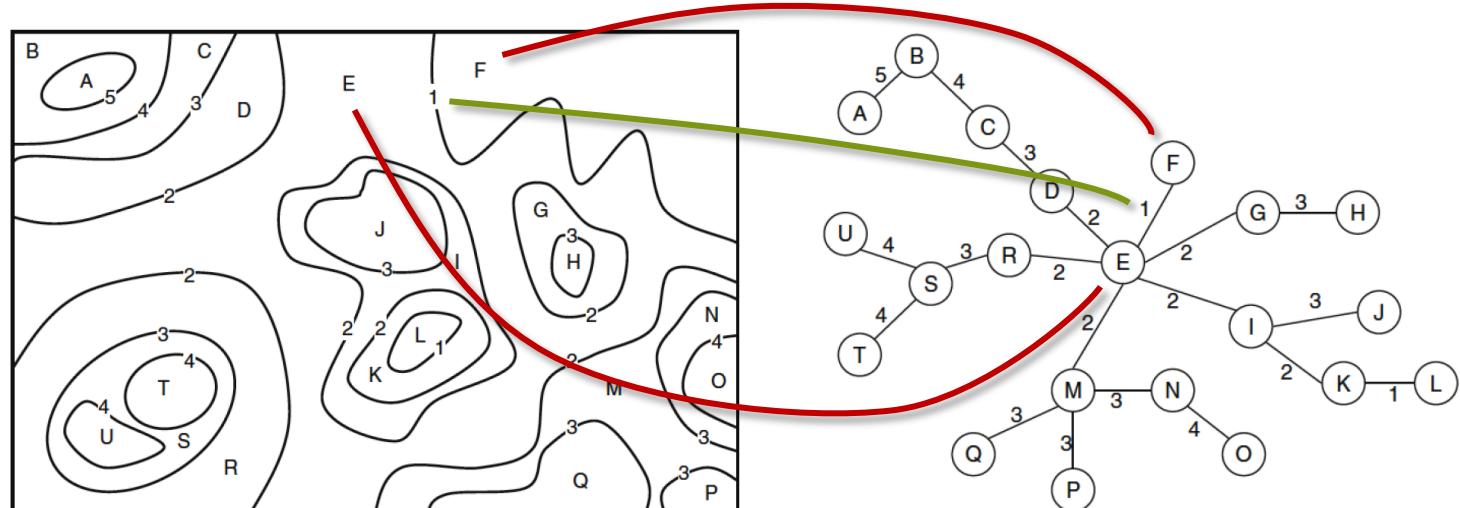
Region graph

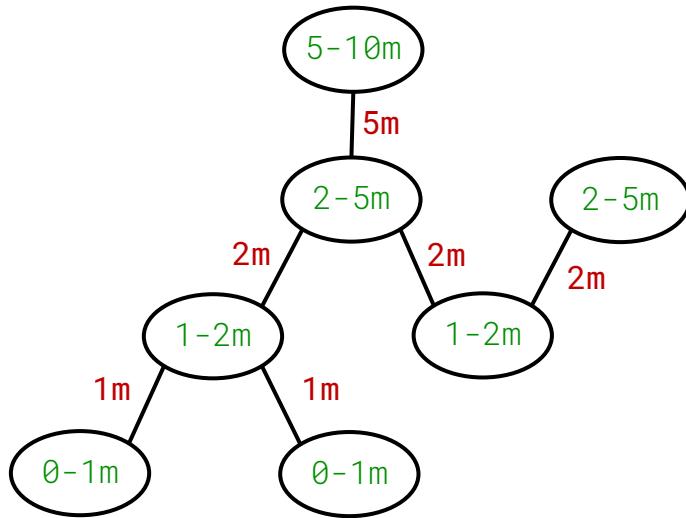
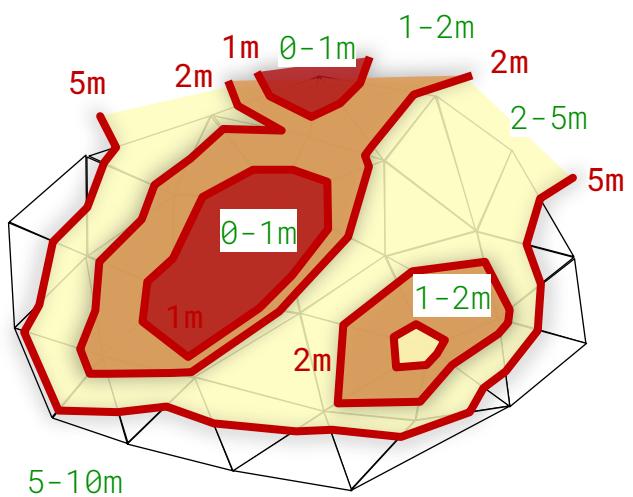
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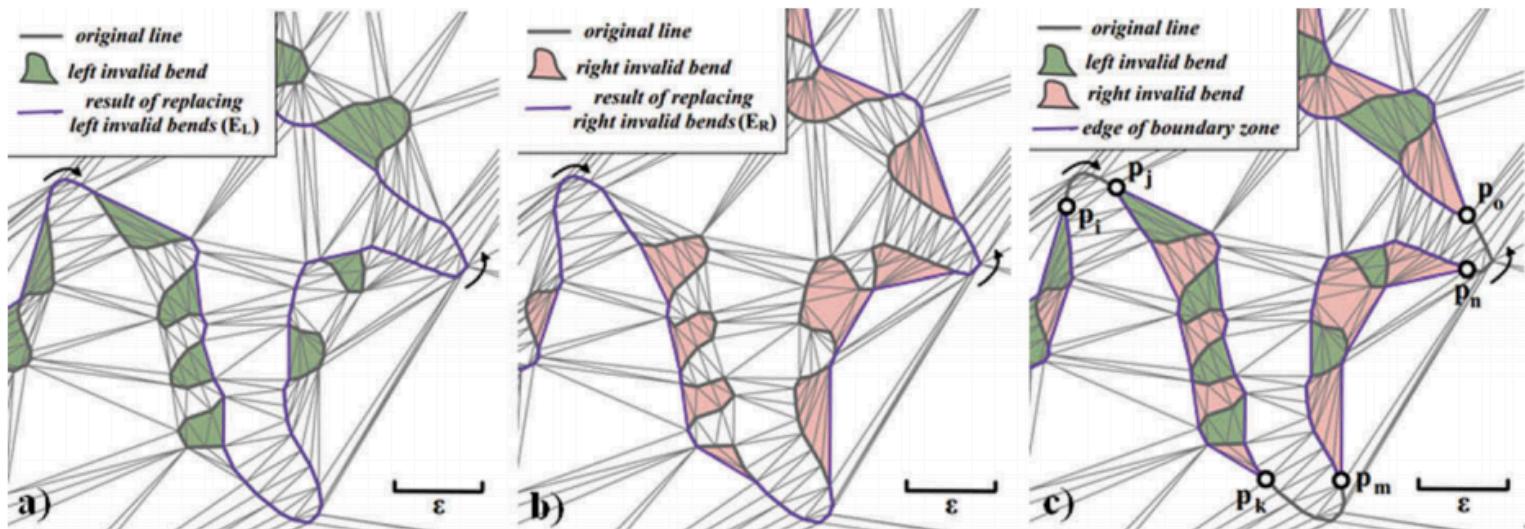


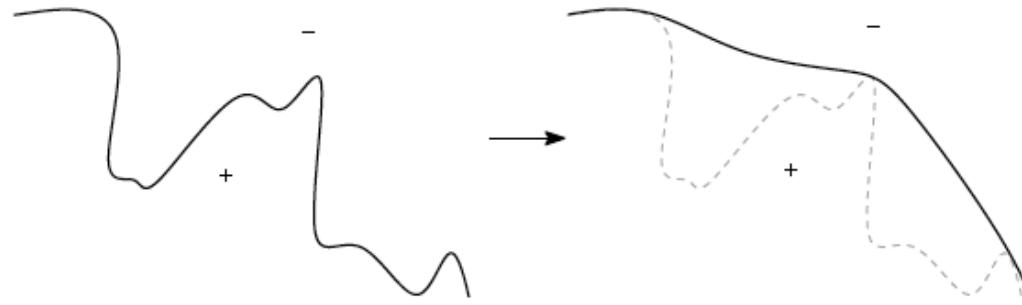
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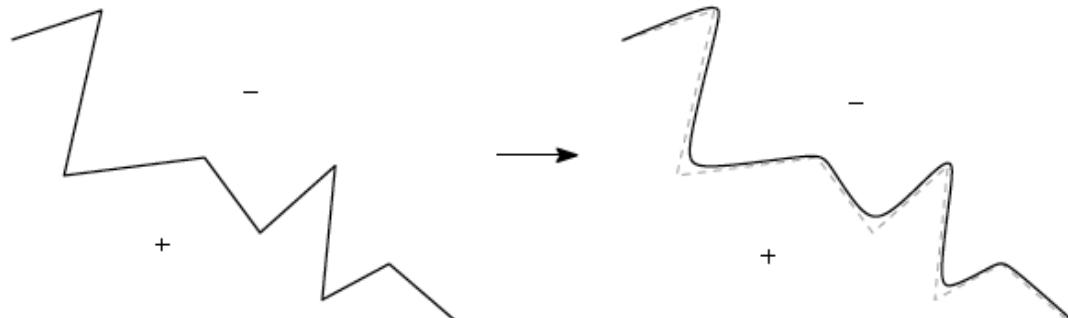




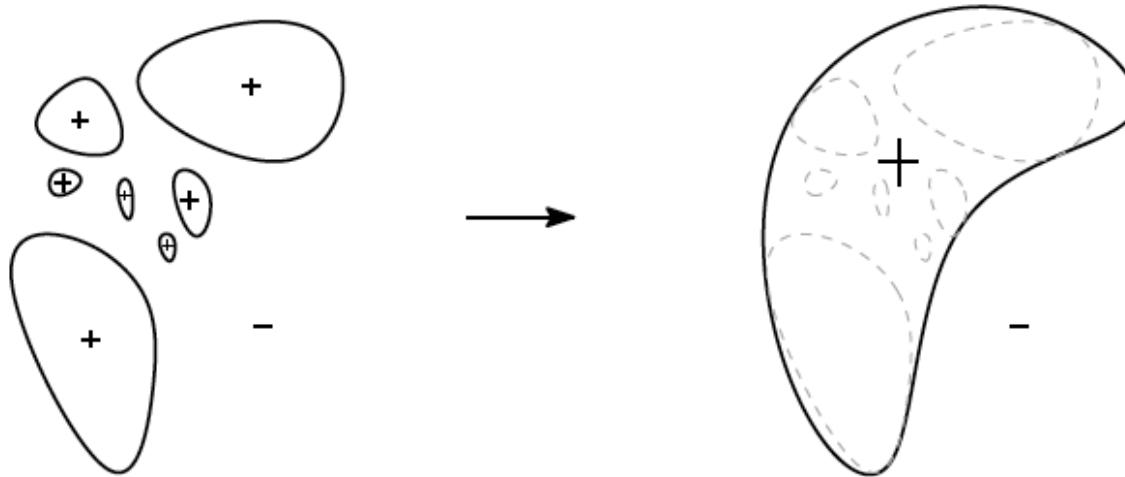




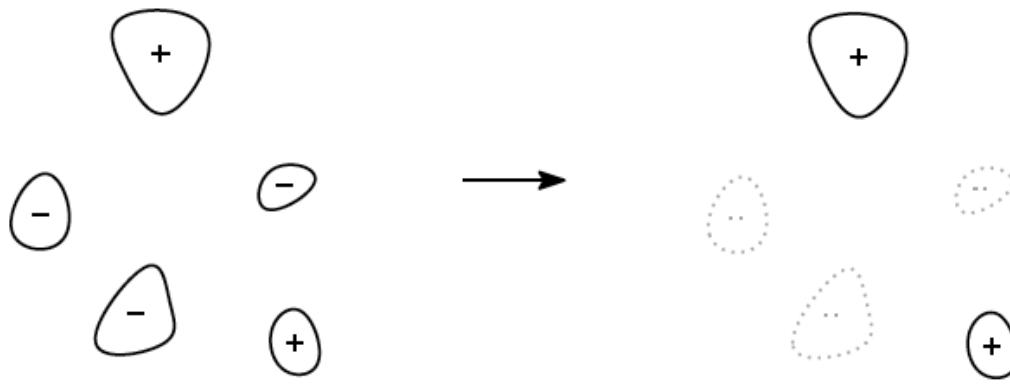
(a) Simplification



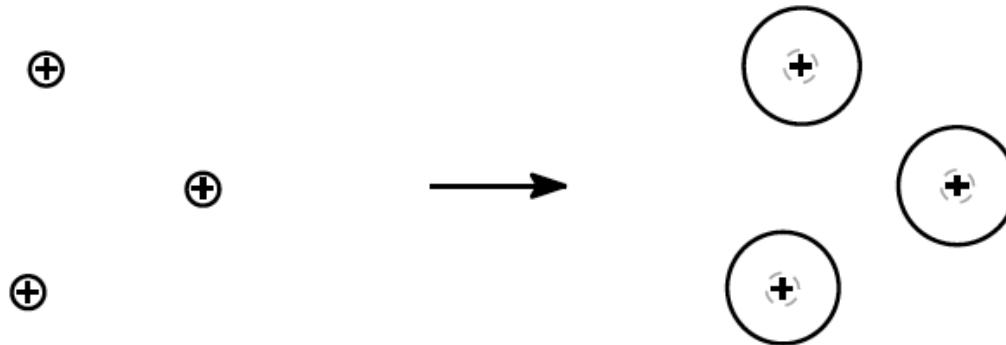
(b) Smoothing



(c) Aggregation



(d) Omission

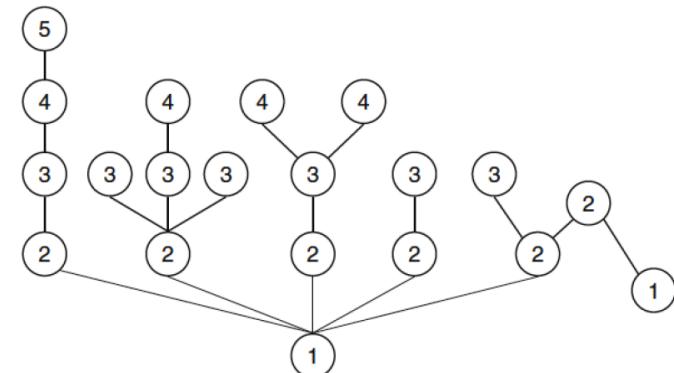
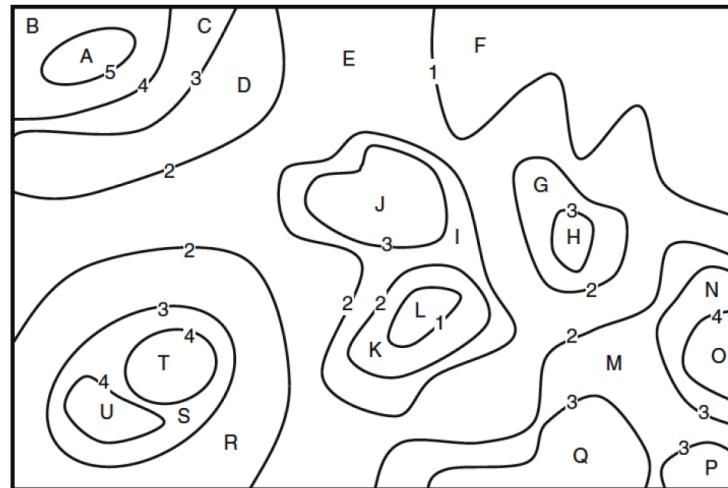


(e) Enlargement

Contour tree

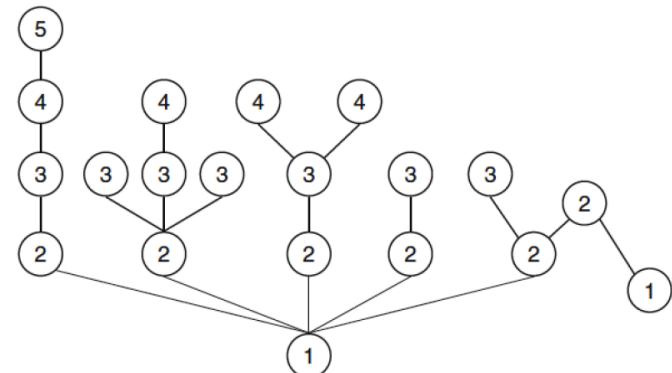
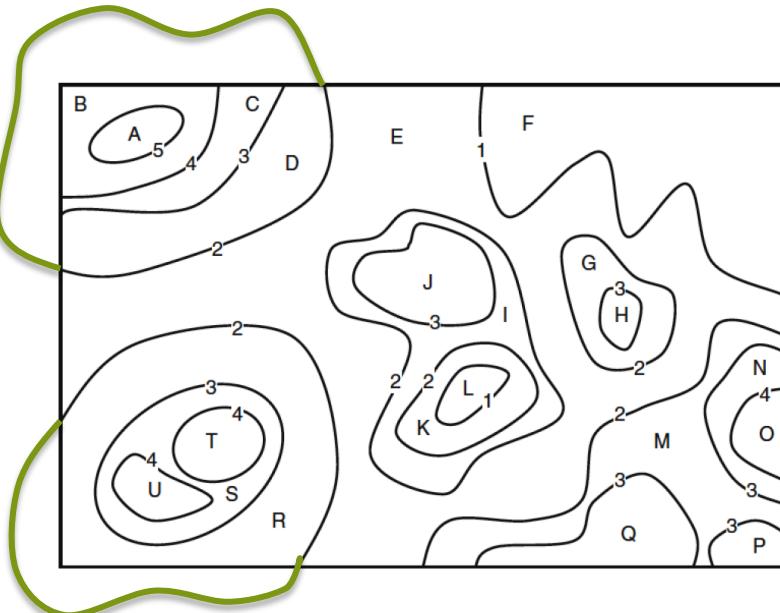
- Establish relations between isobaths

(not the triangulation)



Contour tree

- Contour tree cannot handle boundaries, difficult to create



Contour tree

- Contour tree cannot handle boundaries, difficult to create

