# IQMULUS

## ANALYSIS, REPRESENTATION AND COMPRESSION OF BIG GEOSPATIAL POINT CLOUDS – LAND, MARINE AND URBAN SCENARIOS - EXPLOITABLE OUTCOMES OF THE BIG DATA IP IQMULUS

(November 2012- October 2016)

www.iqmulus.eu

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IQmulus

SINTEF

Fraunhofer IGD

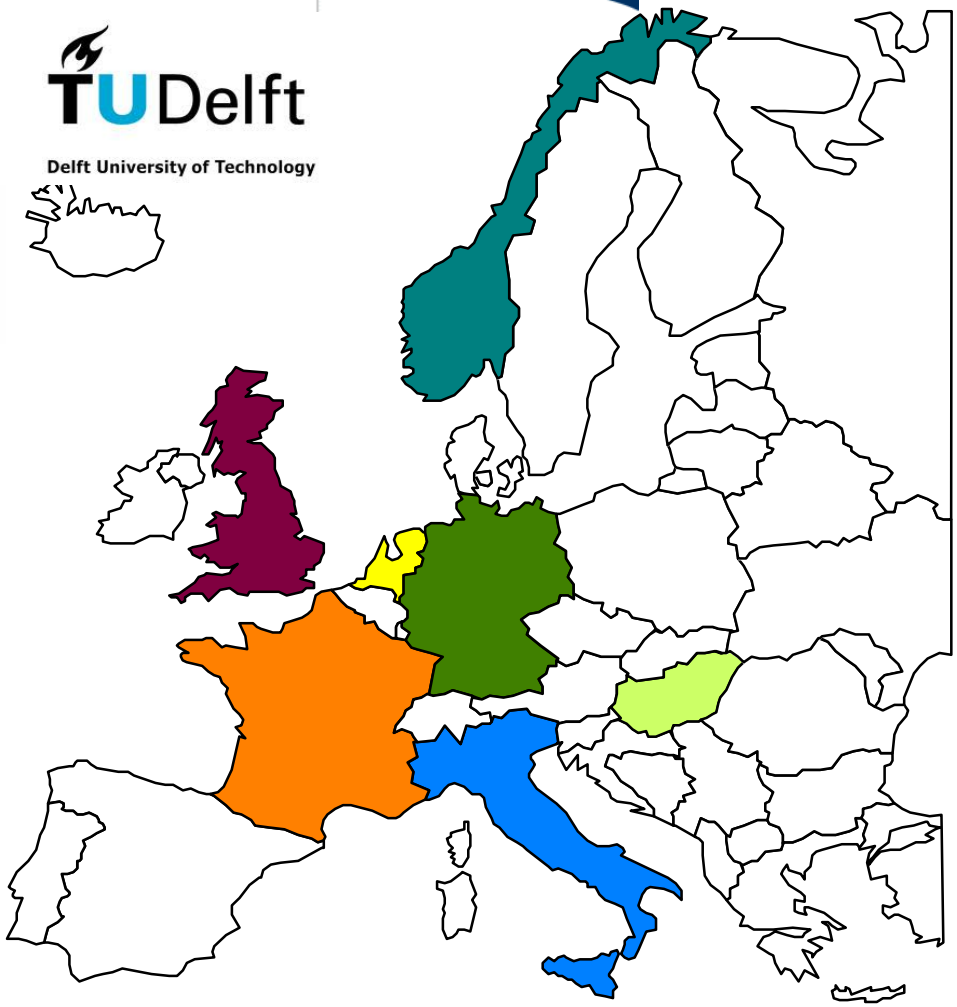
TU Delft
Delft University of Technology

HR Wallingford
Working with water

M.O.S.S.
Computer Grafik Systeme
Geoinformationssysteme

UCL

IGN
INSTITUT NATIONAL
DE L'INFORMATION
GÉOGRAPHIQUE
ET FORESTIÈRE



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UBO
université de bretagne occidentale

REGIONE LIGURIA

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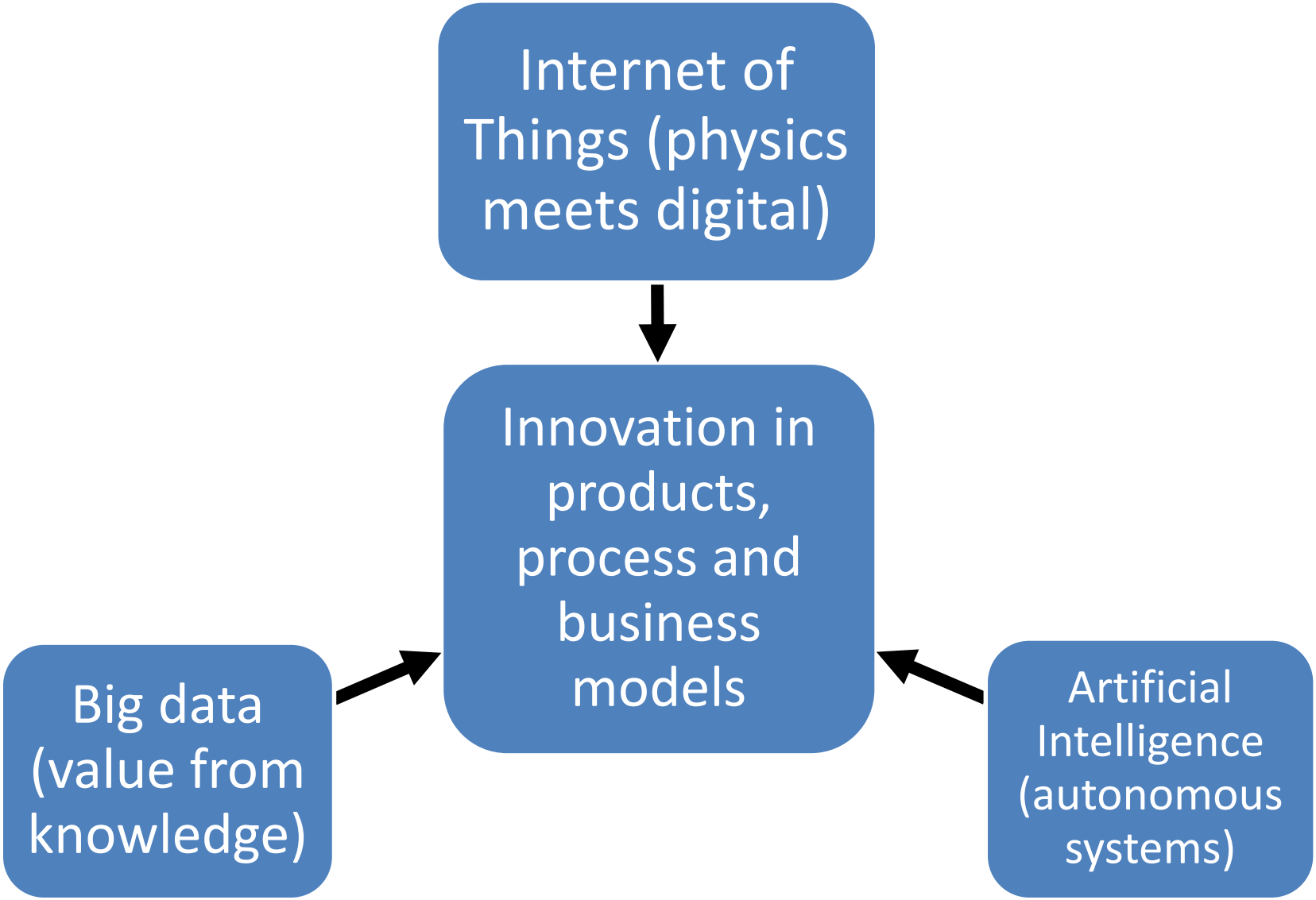
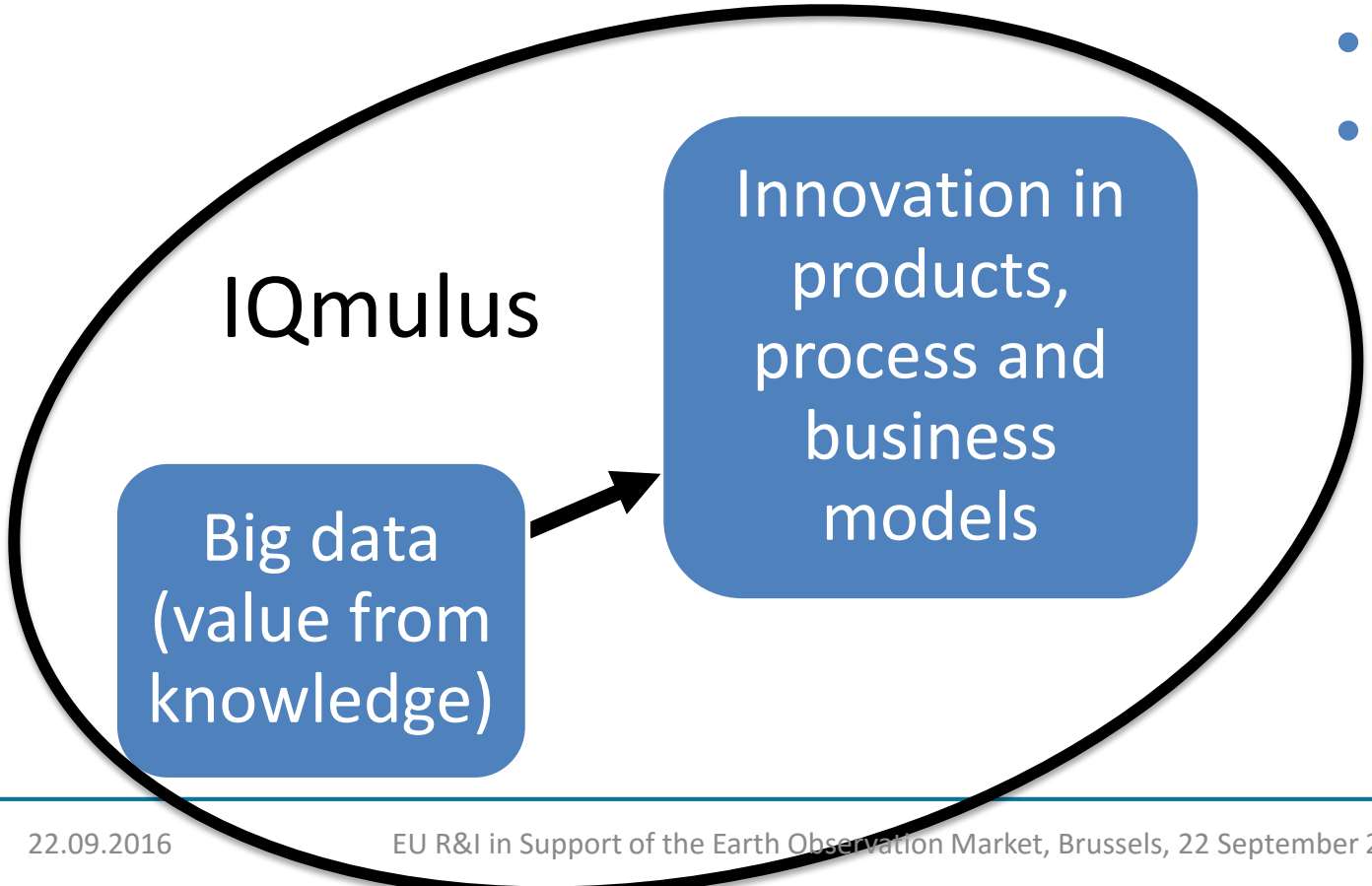
# TECHNOLOGIES DRIVING CHANGE



# TECHNOLOGIES IN IQMULUS

Geospatial big smart data

- Analytics
- Storage
- Cloud
- Workflows



# RELEVANCE OF IQMULUS FOR EARTH OBSERVATION DATA

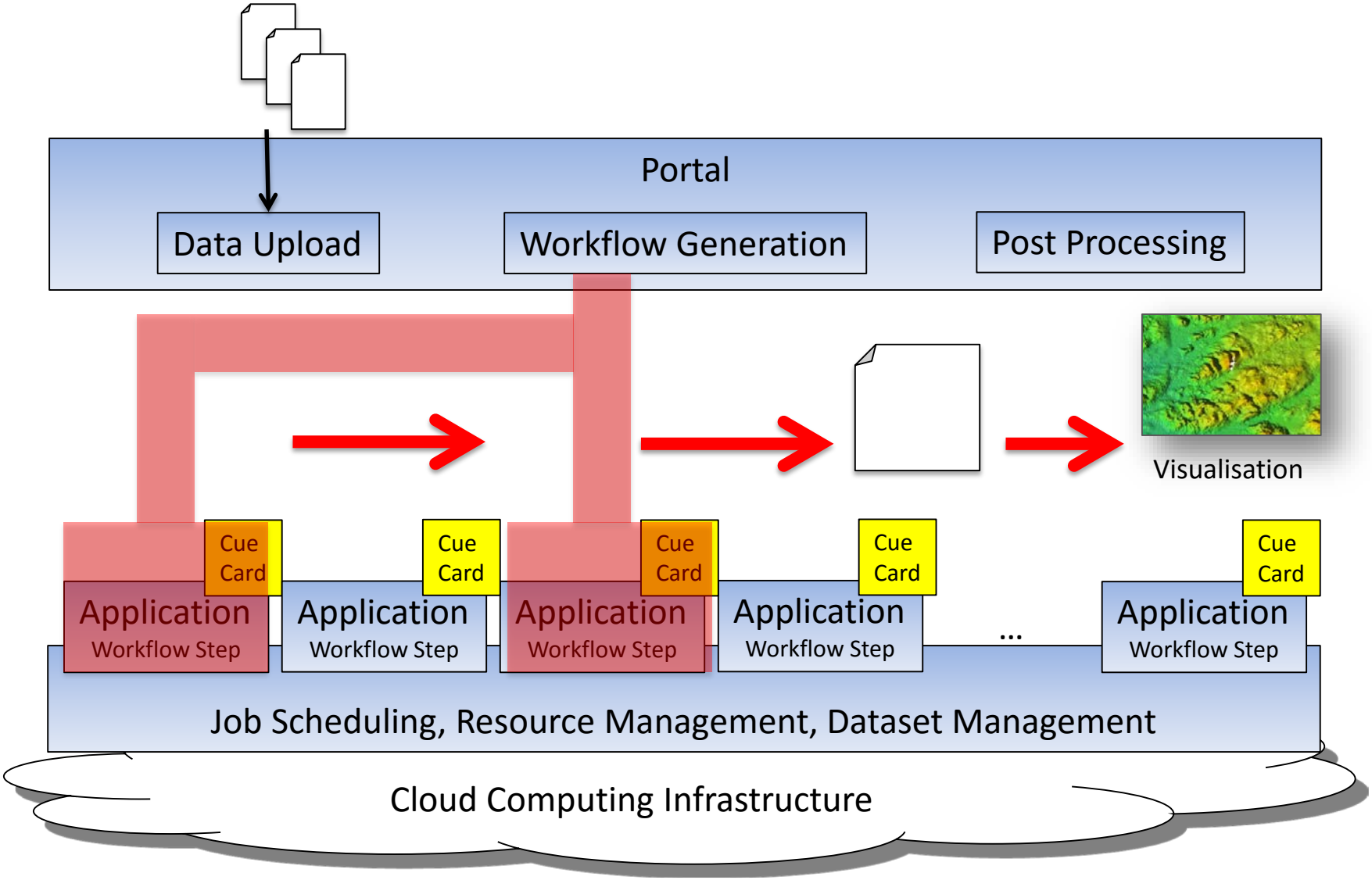
Similarities of data volume and data structures
New algorithms

## Earth observation data

- Big smart data
  - Data + context
- From satellites
- Regular structure
  - (x,y, z and or additional info)

## IQmulus addresses

- Big smart data
  - Data + context
- LIDAR, Photogrammetry, Satellites…
- Structured, semi-structured, unstructured
  - (x,y,z, additional info)


Portal
Data Upload
Workflow Generation
Post Processing
Visualisation
Cue Card
Application
Workflow Step
Cue Card
Application
Workflow Step
Cue Card
Application
Workflow Step
Cue Card
Application
Workflow Step
...
Cue Card
Application
Workflow Step
Job Scheduling, Resource Management, Dataset Management
Cloud Computing Infrastructure

# EXAMPLE OF TWO IQmulus WORKFLOWS

1. Deconfliction of overlapping bathymetry surveys
   - Creates a single locally refined spline surface/volume description from overlapping and possibly conflicting data sets using based on a predefined prioritization
   - A compact and accurate representation suited for visualization exploiting the power of GPUs (Graphical Processing Units)
   - The technology should be feasible for satellite imagery
2. Flood and Waterlogging Detection
   - Calculates from satellite images *vegetation index, soil index* and *water index*
   - Combines the above with information on *rivers and l*akes and *creates thematic maps*
   - Works for *Sentinel-2*, *Landsat* and *SPOT* satellite imagery – can be extended to other sensors

# 1. DECONFLICTION OF OVERLAPPING BATHYMETRY SURVEYS

Slides by:
Quillon Harpham, HR Wallingford
Jennifer Herbert, HR Wallingford
Vibeke Skytt, SINTEF

# EXAMPLE 'POINT CLOUD' APPLICATIONS

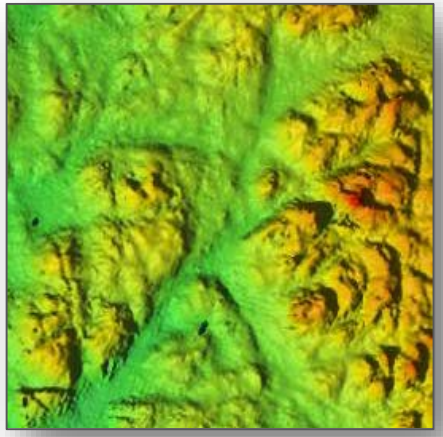
**Feature Extraction:** Identifying features present within point cloud data

**Scoring and Deconfliction:** Making sense of overlapping surveys

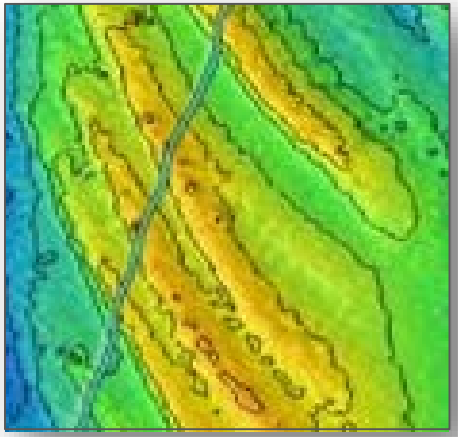
**Surface generation:** Creating a single, best surface from overlapping surveys with spline interpolation

**Creating best bathymetry**

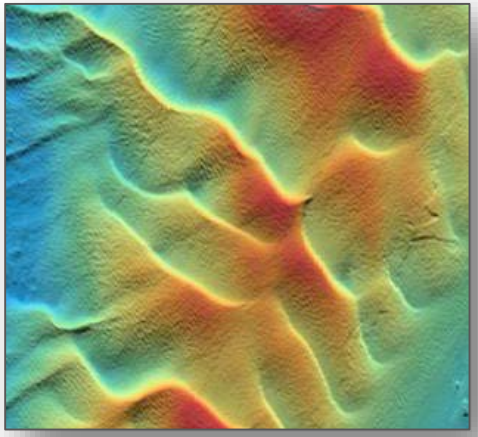
**Change detection:** Understanding changes in point cloud timeseries



Rocky beds



Sand banks



Dunes

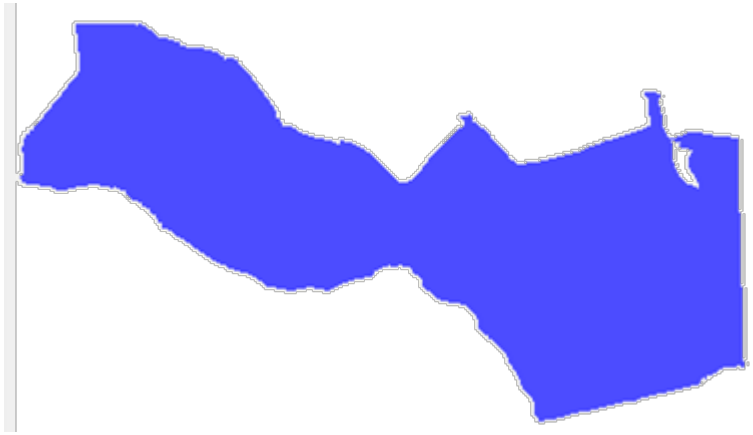
# SCORING AND DECONFLICTION

The automated solution is '**embarrassingly parallel**':

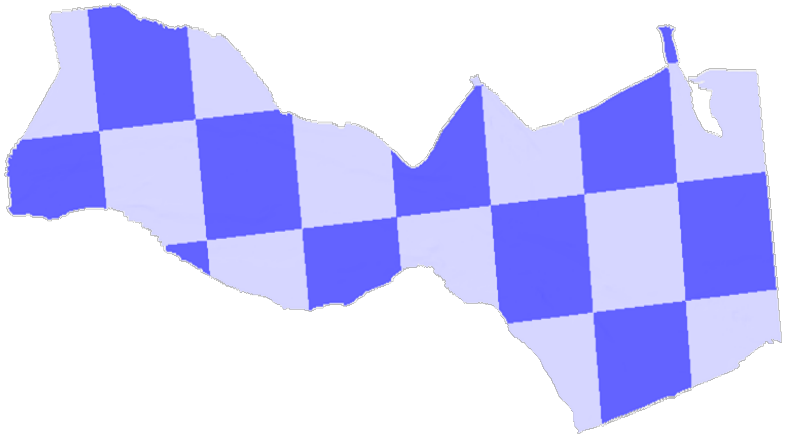
- Perform an evaluation of each survey according to a set of scientific criteria:
  - date
  - technique (sonar, looking over the side…)
  - number of points
  - MAX_EDGE_LENGTH_95PERCENTILE
  (Demonstrates the density of points in a survey by means of distance between neighbouring soundings)

- Results in a '**score**' for each survey.

# TILING



**One data survey: 131 million points**



**Surface set approximating data set after being split into regular tiles**

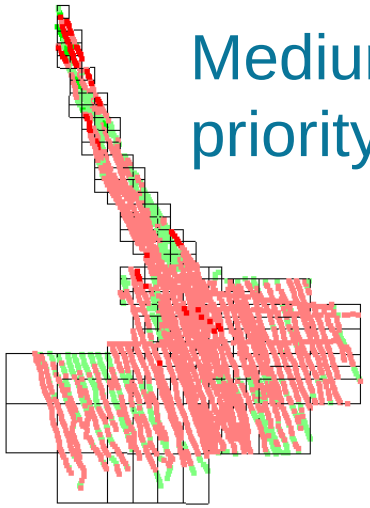
Many data sets are **too large** to approximate by a single surface:

- Many operations for each single point (execution time)
- Memory limitations (risk of crash)
- Resulting surface becomes cumbersome to handle (subsequent execution time)

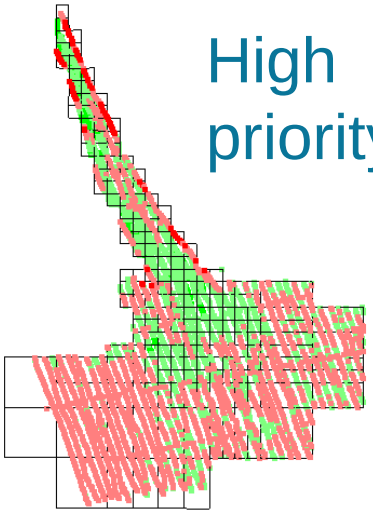
# TILING

- The **input data** for each execution of the surface approximation is **reduced** therefore the **memory limit** of the computer is not exceeded.
- **Enables parallelization** on computation nodes.
- Regular tiling gives easy manoeuvring in the tiles, but highly **varying number of points** for each tile.
- 4-sided tiles correspond to the **domain of the surface** to be created by spline interpolation, therefore reduced need for trimming.
- Surfaces are **created with an overlap** and later reduced to ensure an almost seamless combined surface

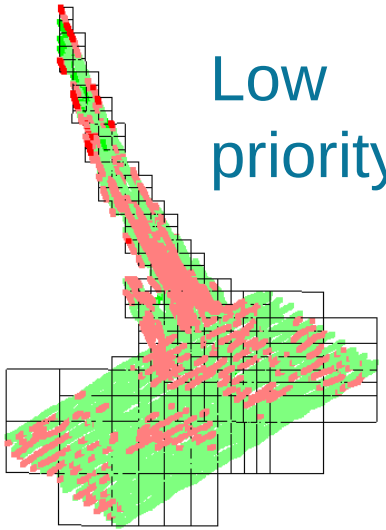
# DECONFLICTION (REFERENCE SPLINE SURFACE)



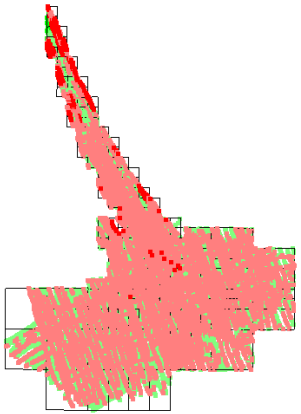
Medium priority



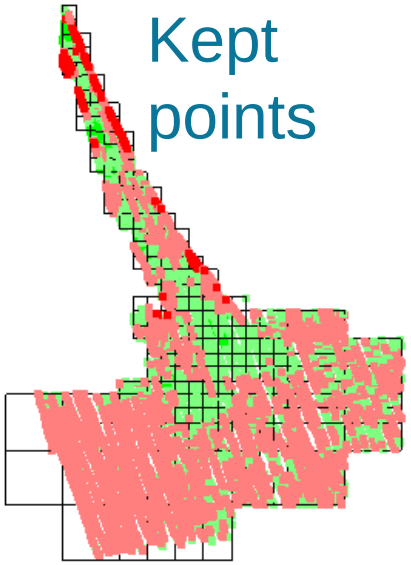
High priority



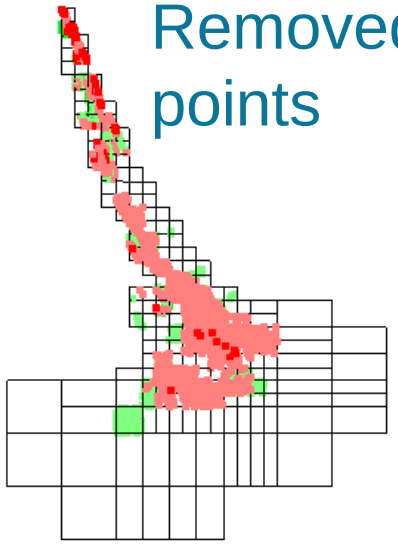
Low priority



All data points classified by their distance to the reference surface, red points above and green points below. Clearer colour means larger distance.



Kept points



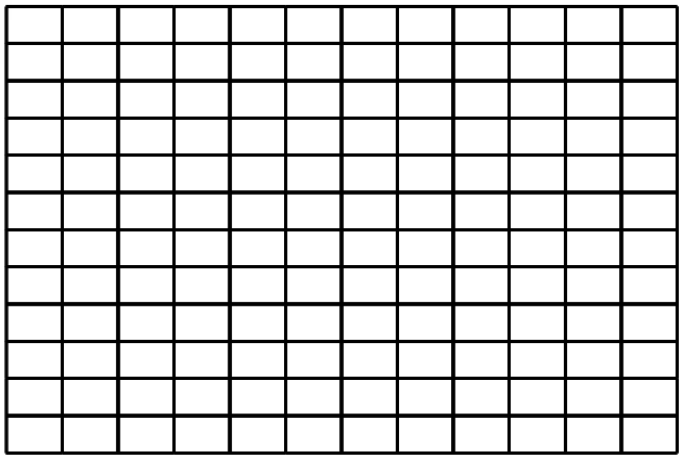
Removed points

# APPROXIMATION OF 280 MB POINT CLOUD. THRESHOLD 0.5 M. INITIAL SURFACE.

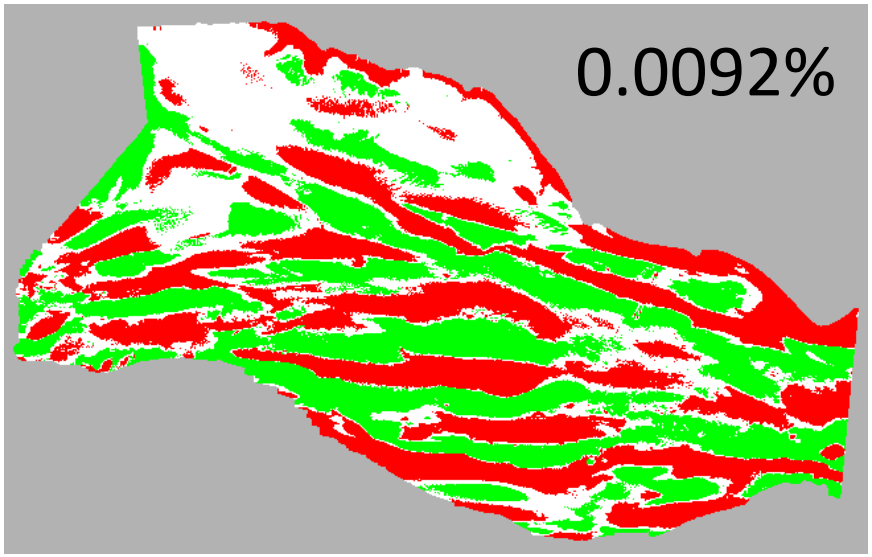
Data courtesy HR Wallingford, SeaZone

| Number of points | 14.6 mill |
|---|---|
| No. of coefs. | 196 |
| Surface file size | 26 KB |
| Max. dist | 12.8 m. |
| Average dist | 1.42 m. |
| No. of points, dist > 0.5 m | 9.9 mill |

Approximating surface



Polynomial patches in the parameter domain of the surface

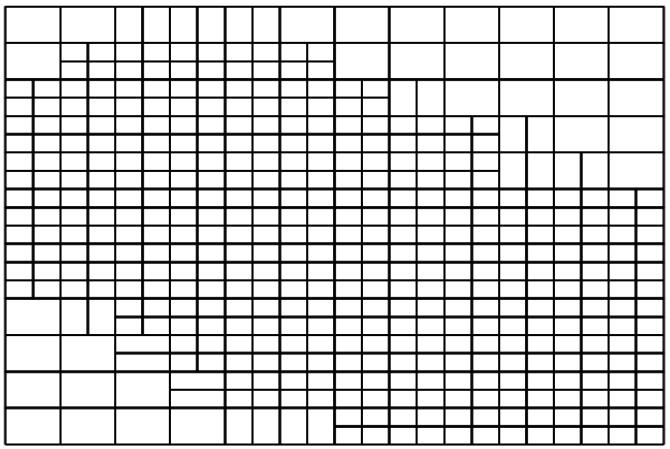



Distance field, while points less than 0.5 m distance, red points above, green below surface

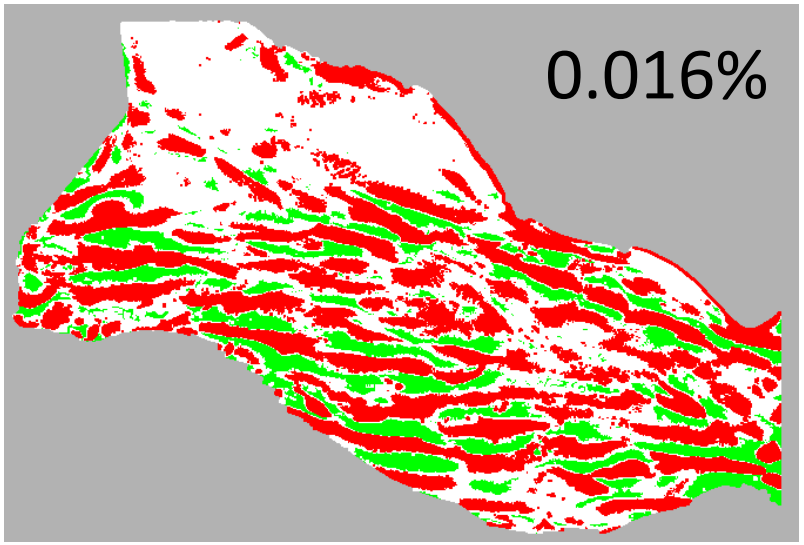
# APPROXIMATION OF 280 MB POINT CLOUD. THRESHOLD 0.5 M. AFTER ONE ITERATION.

Approximating surface

| Number of points | 14.6 mill |
|---|---|
| No. of coefs. | 507 |
| Surface file size | 46 KB |
| Max. dist | 10.5 m. |
| Average dist | 0.83 m. |
| No. of points, dist > 0.5 m | 7.3 mill |



Polynomial patches in the parameter domain of the surface

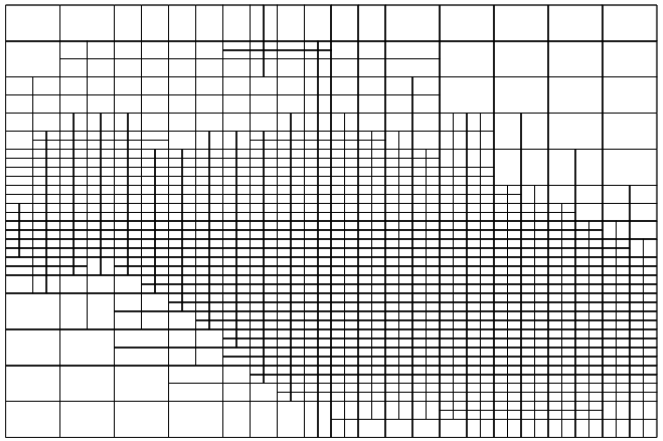



Distance field, while points less than 0.5 m distance, red points above, green below surface

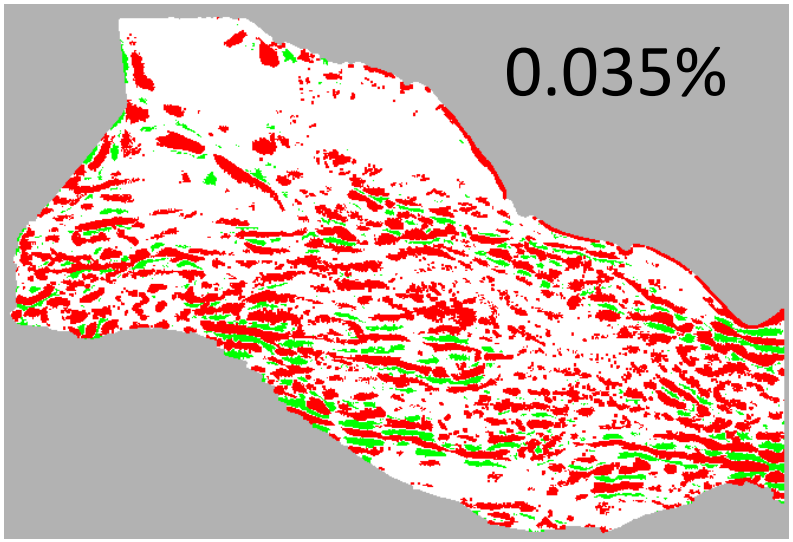
# APPROXIMATION OF 280 MB POINT CLOUD. THRESHOLD 0.5 M. AFTER TWO ITERATIONS.

Approximating surface

| Number of points | 14.6 mill |
|---|---|
| No. of coefs. | 1336 |
| Surface file size | 99 KB |
| Max. dist | 8.13 m. |
| Average dist | 0.41 m. |
| No. of points, dist > 0.5 m | 3.9 mill |

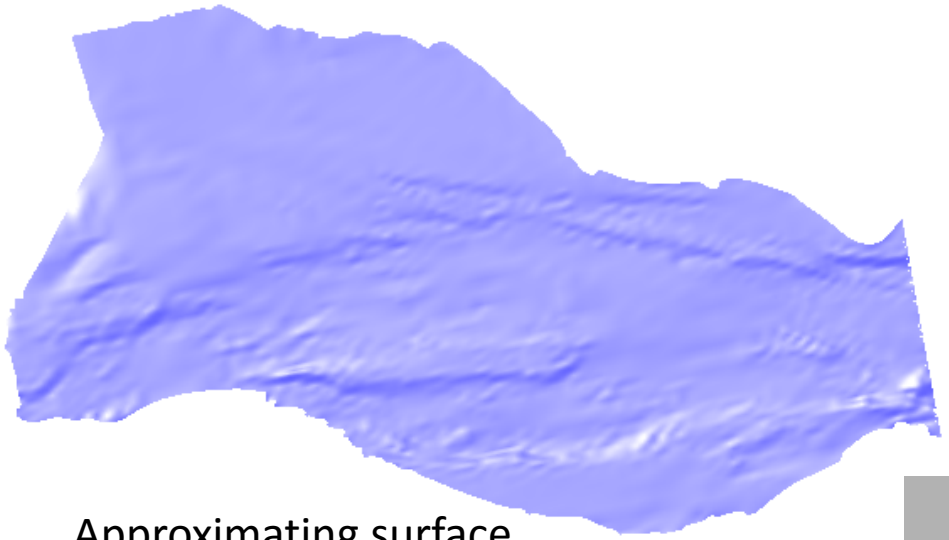


Polynomial patches in the parameter domain of the surface



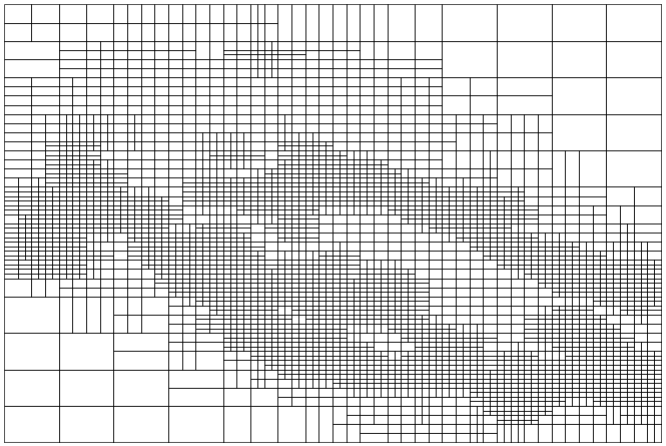

Distance field, while points less than 0.5 m distance, red points above, green below surface

# APPROXIMATION OF 280 MB POINT CLOUD. THRESHOLD 0.5 M. AFTER 3 ITERATIONS

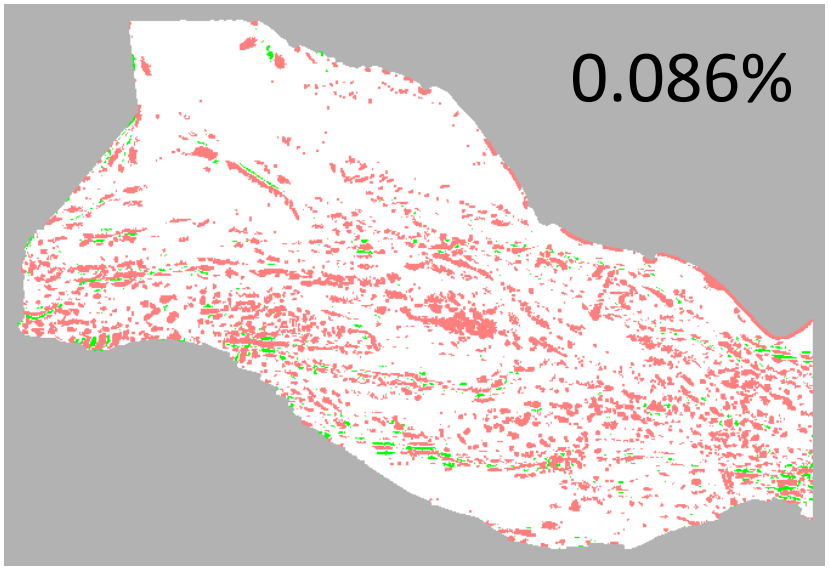


Approximating surface

| Number of points | 14.6 mill |
|---|---|
| No. of coefs. | 3563 |
| Surface file size | 241 KB |
| Max. dist | 6.1 m. |
| Average dist | 0.22 m. |
| No. of points, dist > 0.5 m | 1.4 mill |

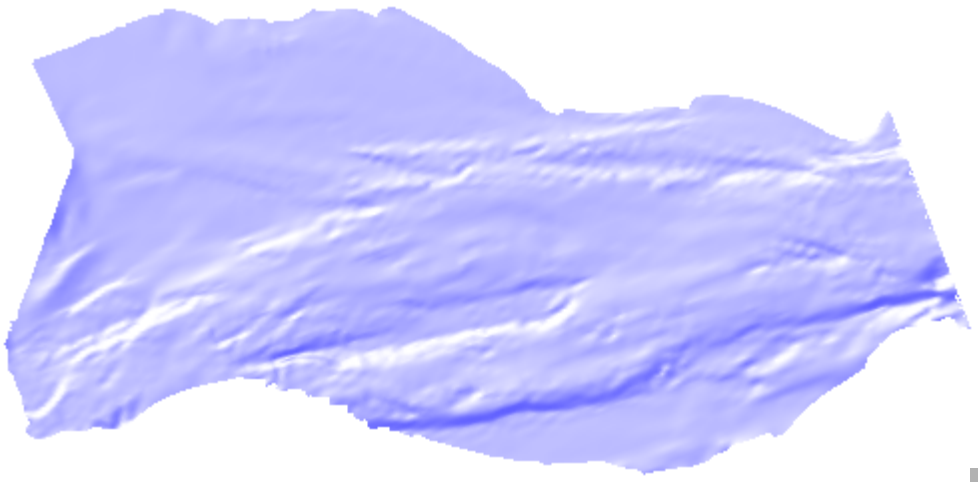


Polynomial patches in the parameter domain of the surface



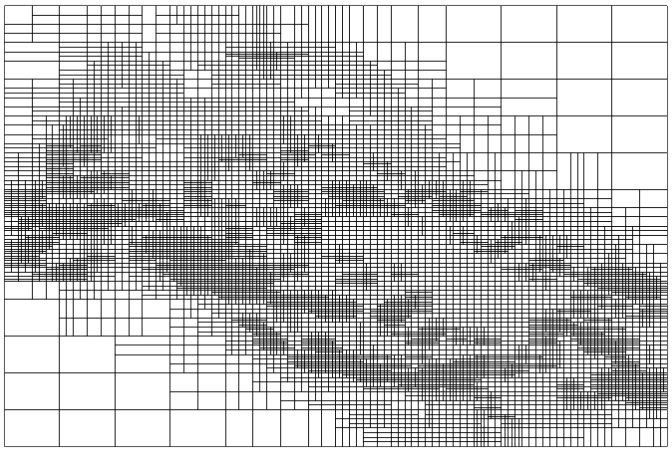

Distance field, while points less than 0.5 m distance, red points above, green below surface

# APPROXIMATION OF 280 MB POINT CLOUD. THRESHOLD 0.5 M. AFTER 4 ITERATIONS

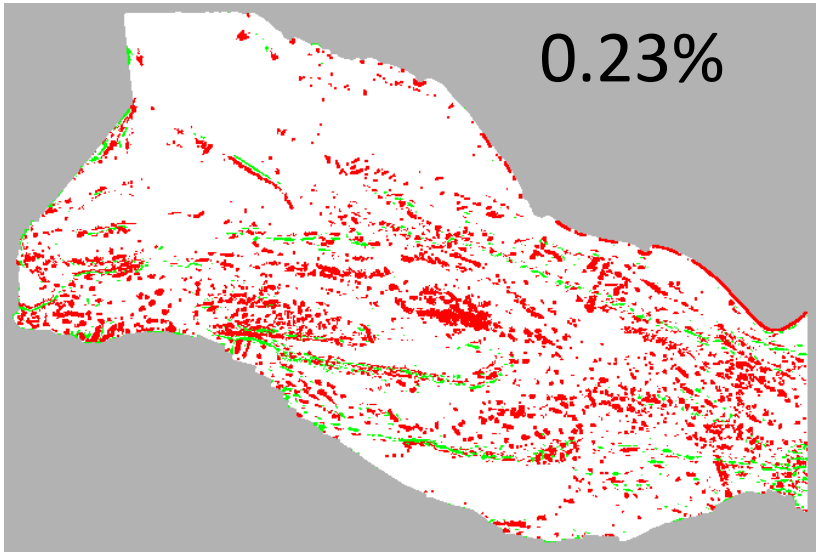


Approximating surface

| Number of points | 14.6 mill |
|---|---|
| No. of coefs. | 3563 |
| Surface file size | 630 KB |
| Max. dist | 6.0 m. |
| Average dist | 0.17 m. |
| No. of points, dist > 0.5 m | 0.68 mill |

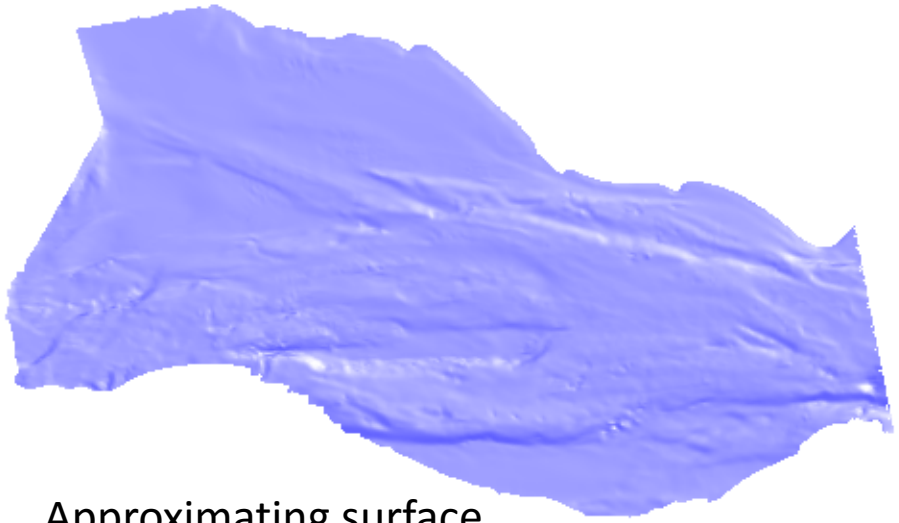


Polynomial patches in the parameter domain of the surface



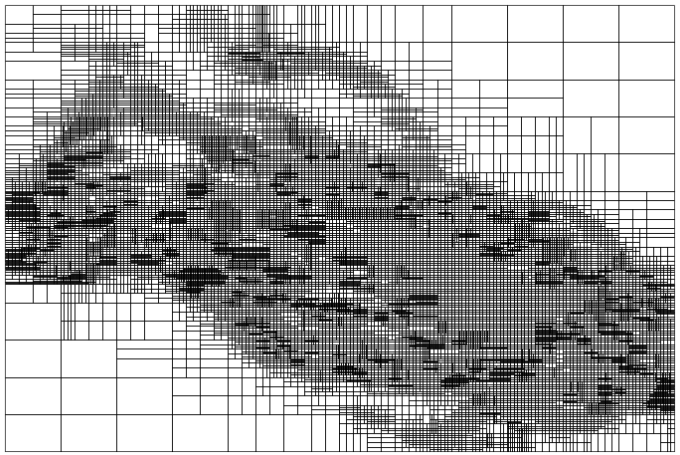

Distance field, while points less than 0.5 m distance, red points above, green below surface

# APPROXIMATION OF 280 MB POINT CLOUD. THRESHOLD 0.5 M. AFTER 5 ITERATIONS.

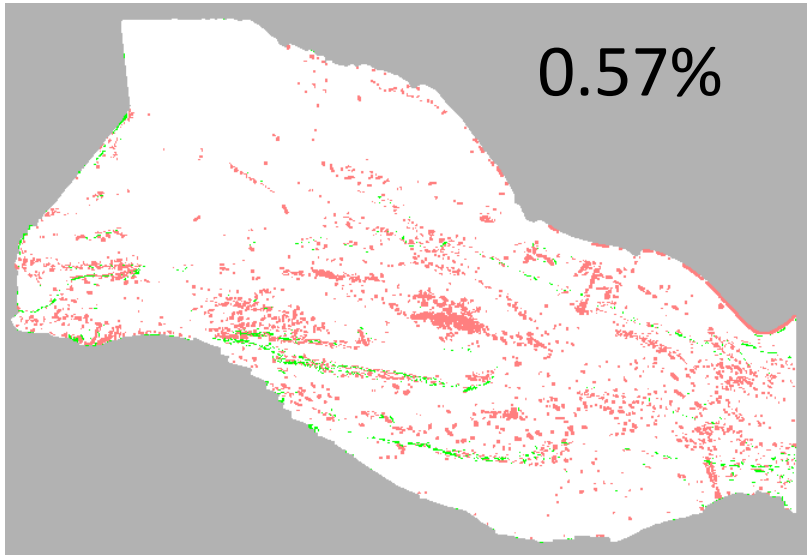


Approximating surface

| Number of points | 14.6 mill |
|---|---|
| No. of coefs. | 9273 |
| Surface file size | 1.6 MB |
| Max. dist | 5.3 m. |
| Average dist | 0.12 m. |
| No. of points, dist > 0.5 m | 244 850 |

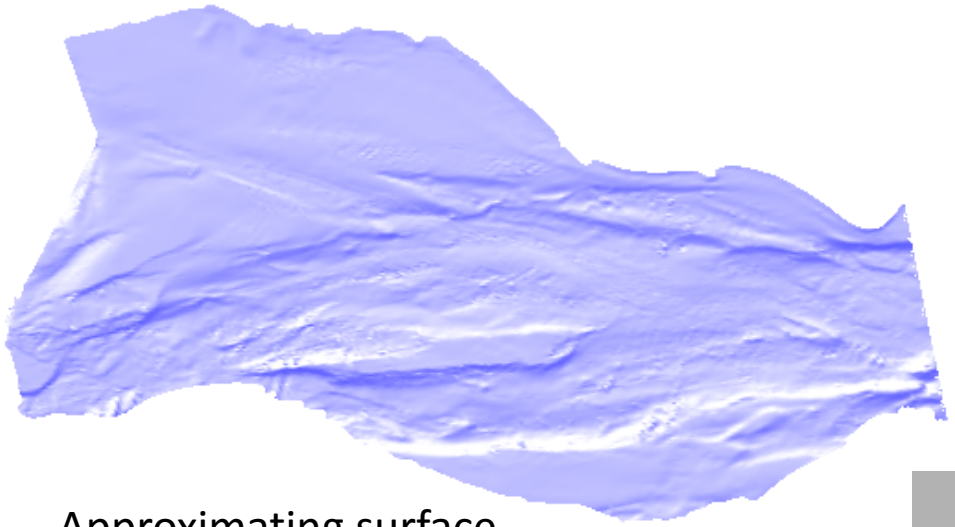


Polynomial patches in the parameter domain of the surface



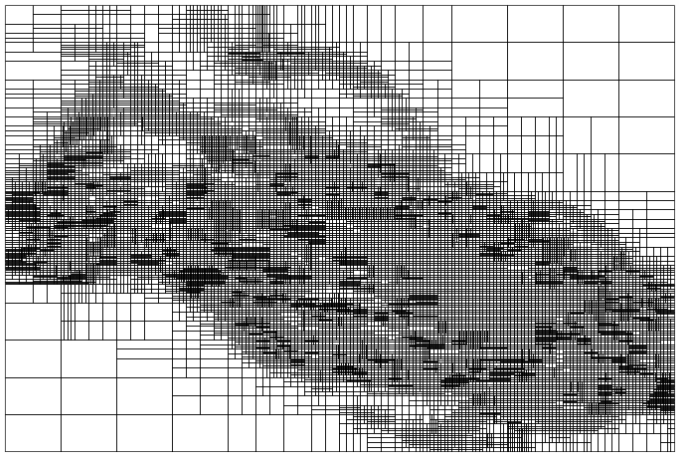

Distance field, while points less than 0.5 m distance, red points above, green below surface

# APPROXIMATION OF 280 MB POINT CLOUD. THRESHOLD 0.5 M. AFTER 6 ITERATIONS

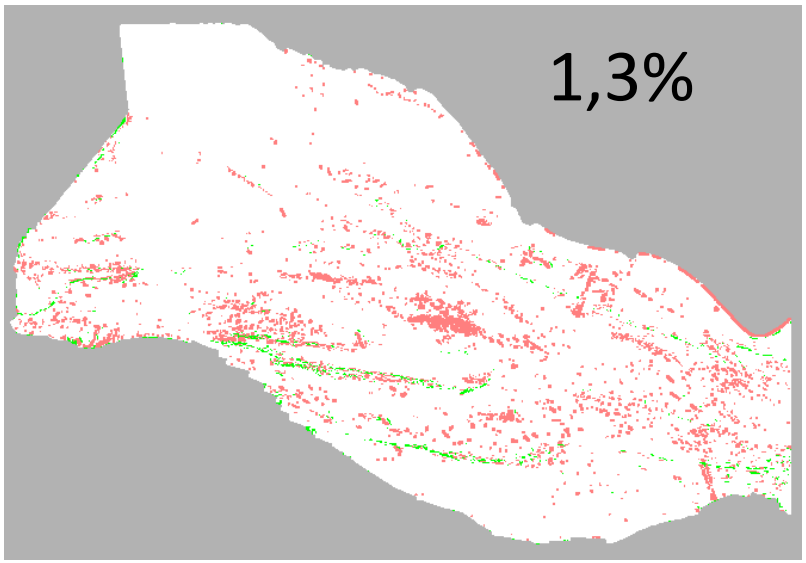


Approximating surface

| Number of points | 14.6 mill |
|---|---|
| No. of coefs. | 52595 |
| Surface file size | 3.7 MB |
| Max. dist | 5.4 m. |
| Average dist | 0.09 m. |
| No. of points, dist > 0.5 m | 75 832 |

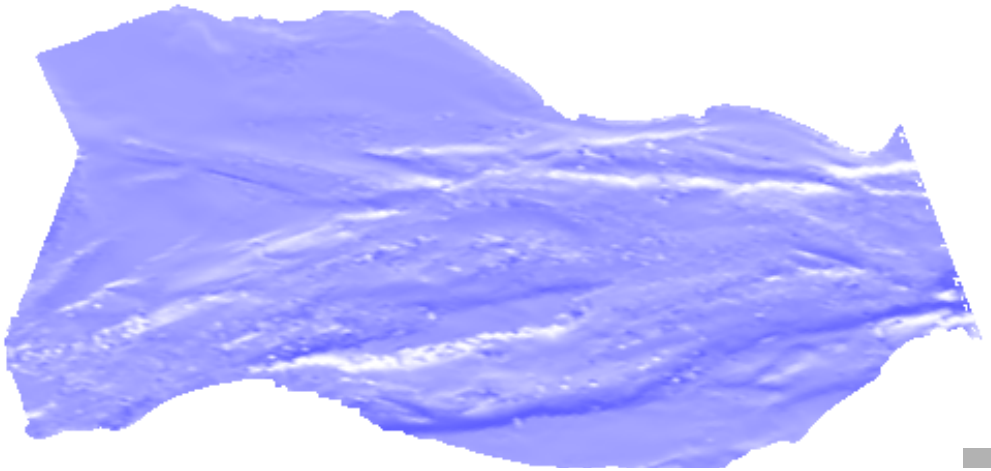


Polynomial patches in the parameter domain of the surface



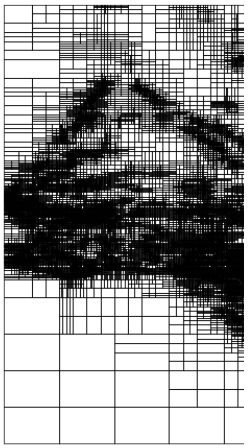

Distance field, while points less than 0.5 m distance, red points above, green below surface

# APPROXIMATION OF 280 MB POINT CLOUD. THRESHOLD 0.5 M. AFTER 7 ITERATIONS



| Number of points | 14.6 mill |
|---|---|
| No. of coefs. | 52595 |
| Surface file size | 7.0 MB |
| Max. dist | 5.3 m. |
| Average dist | 0.08 m. |
| No. of points, dist > 0.5 m | 20 148 |

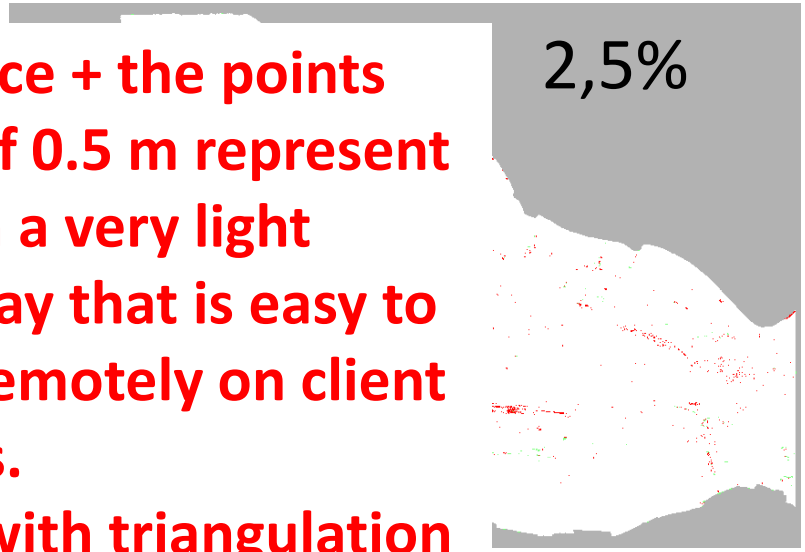
Approxima



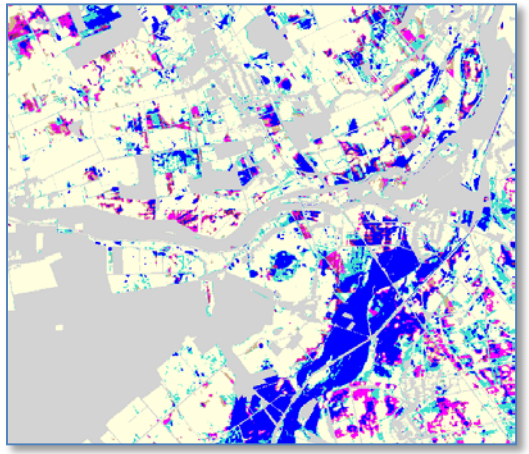
Polynomial p
parameter domain of the surface

**The LR B-spline surface + the points outside the tolerance of 0.5 m represent the information in a very light weight and compact way that is easy to transfer and visualize remotely on client devices.**

**Can also be combined with triangulation to represent none smooth component.**




s than 0.5 m
een below surface



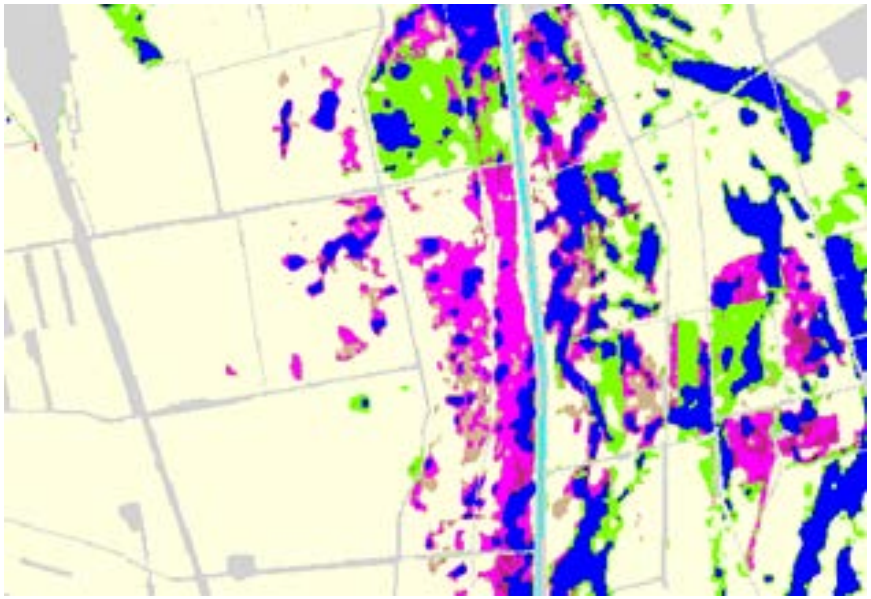
# 2.
# FLOOD AND WATERLOGGING DETECTION

Slides by:
Angéla Olasz, Roberto Giachetta, Binh Nguyen Thai
Institute of Geodesy, Cartography and Remote Sensing (FÖMI), Budapest, Hungary

# LS3 WORKFLOW: FLOOD AND WATERLOGGING DETECTION

*User Story:*

*„I want to quickly delineate and categorize flooded areas based on satellite/aerial imagery and combine it with existing spatial datasets to provide decision makers with information and maps for damage assessment."*



Source: Consolidated user requirements, Deliverable D1.2.2

# EXPECTED IMPROVEMENTS

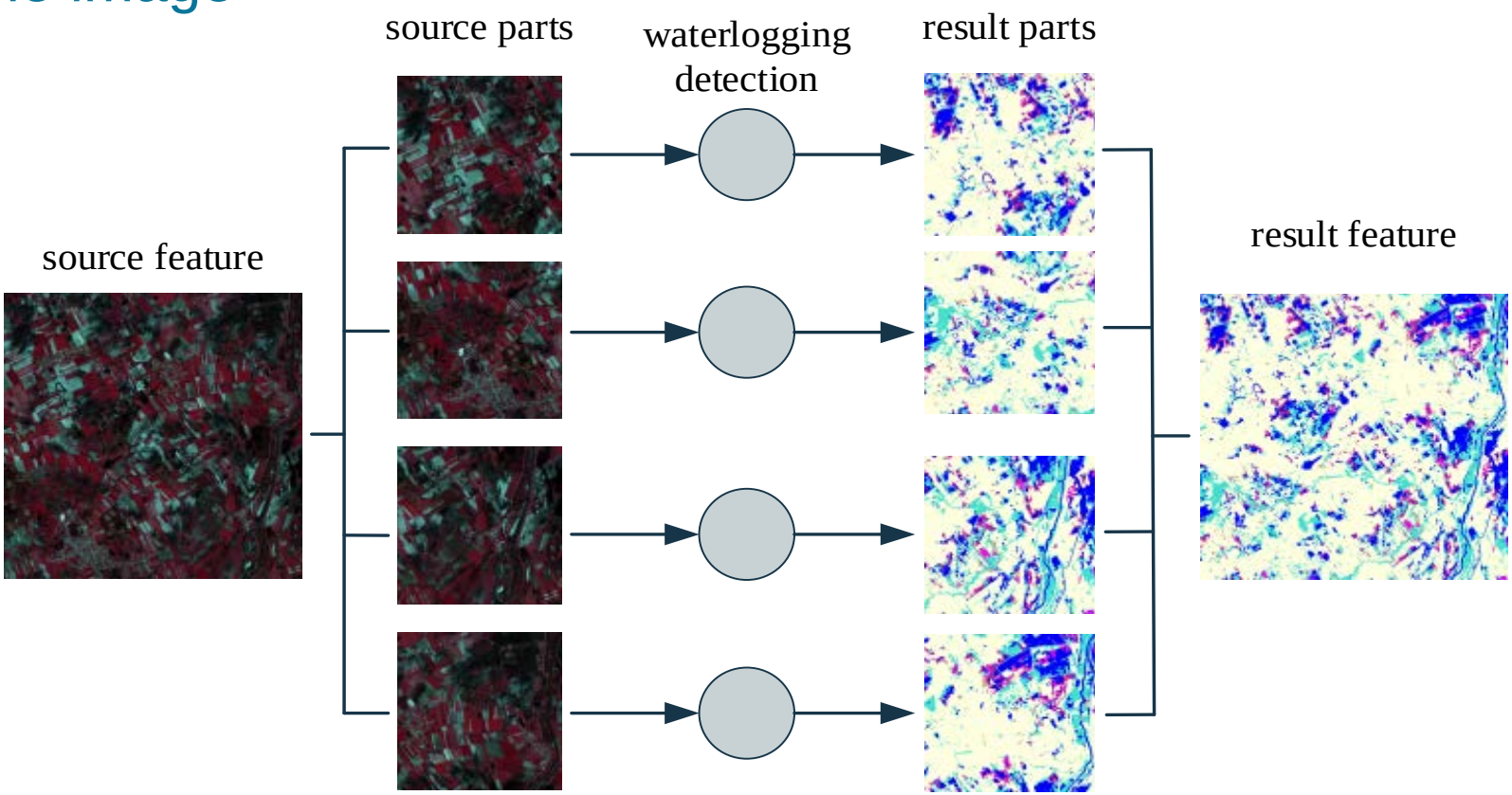
*Motivations:*

- *Operational cooperation with civil protection and water authorities*
- *National Agricultural Risk Management System (MKR)*
- *EU-wide mapping of water bodies from HR satellite imagery*
- *Country-wide delineation of lakes and ponds from orthophotos*

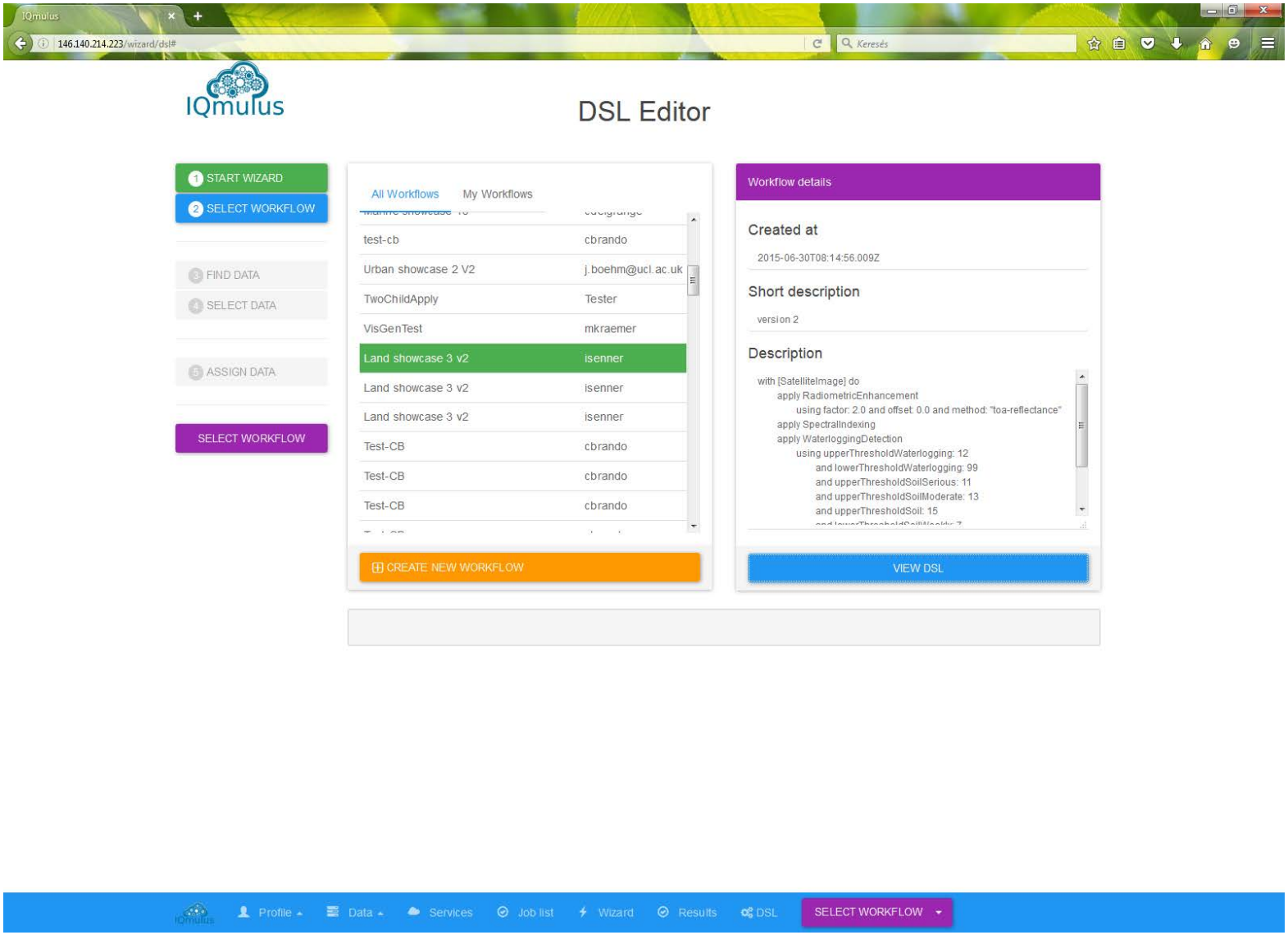
- Faster, more automated processing to enable more iterations to improve results
- Processing on huge areas and/or high-resolution data
- Better use of available processing power and human resources
- More interactivity to determine appropriate parameters (thresholds)
- Smarter algorithms to extract relevant information more efficiently

# PARALLEL EXECUTION

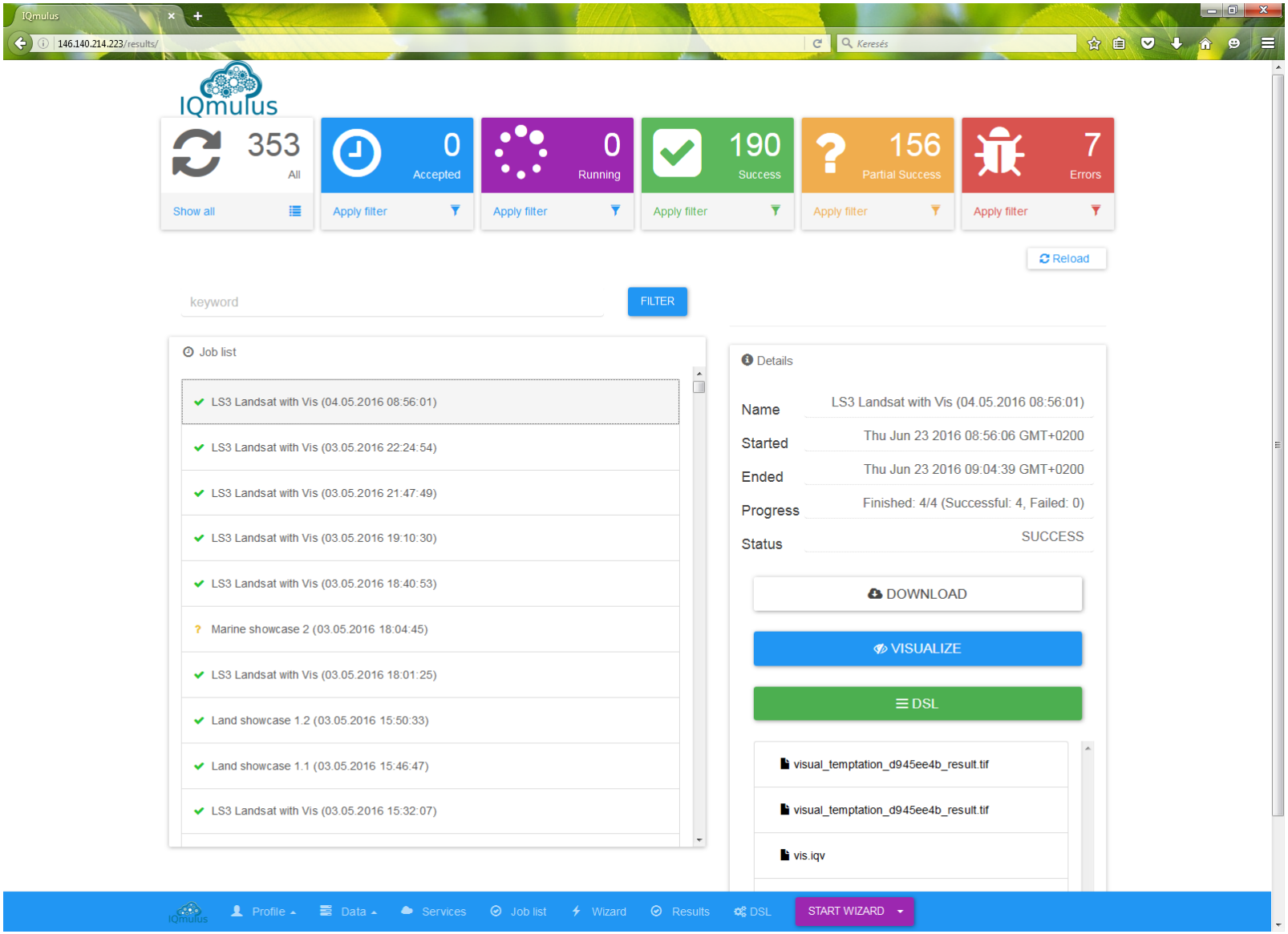
- The detection process can be performed pixel-wise, thus the operation can be performed in parallel on any part of the image



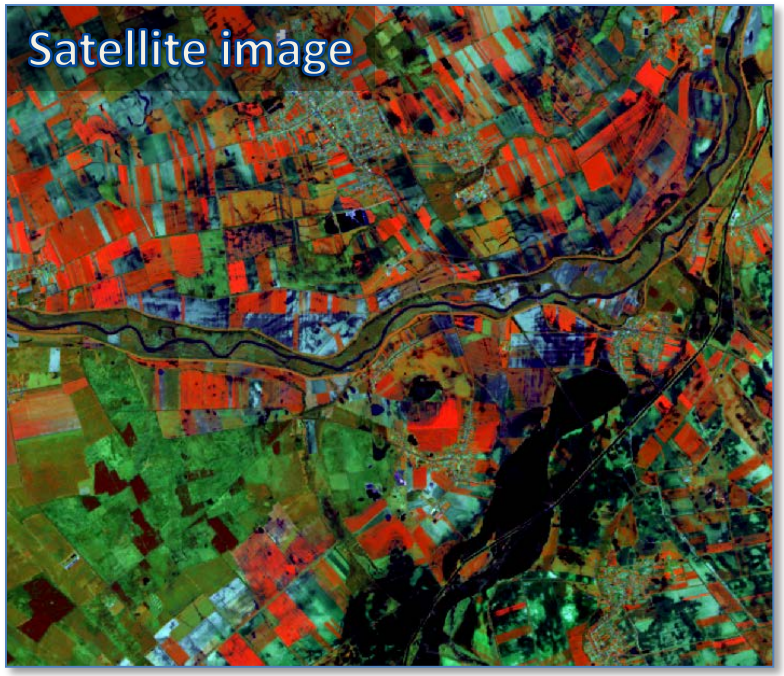
# RUNNING WORKFLOW THROUGH THE GUI

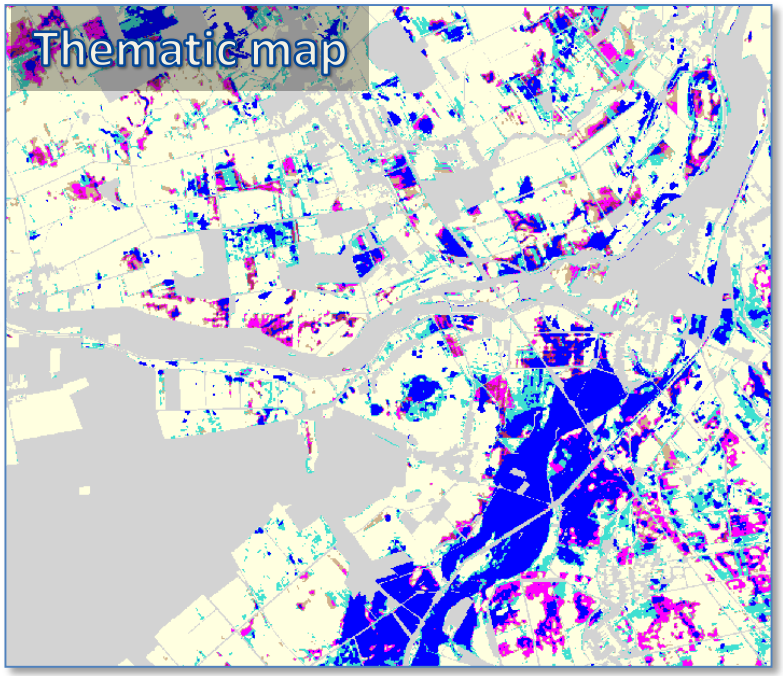


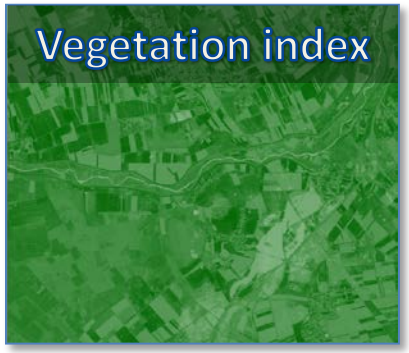
# RUNNING WORKFLOW THROUGH THE GUI



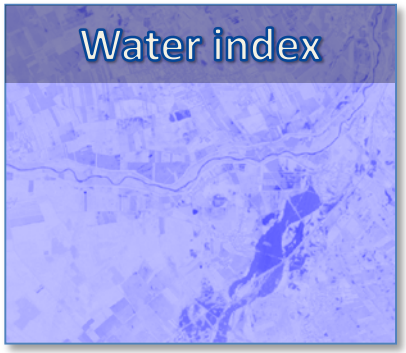
# PROCESSING: INPUT & RESULTS

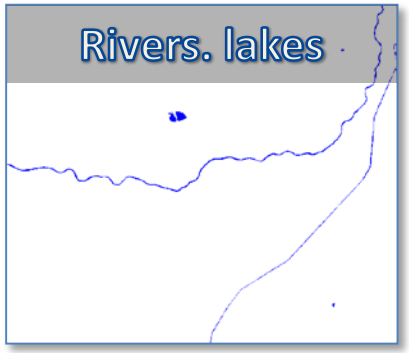


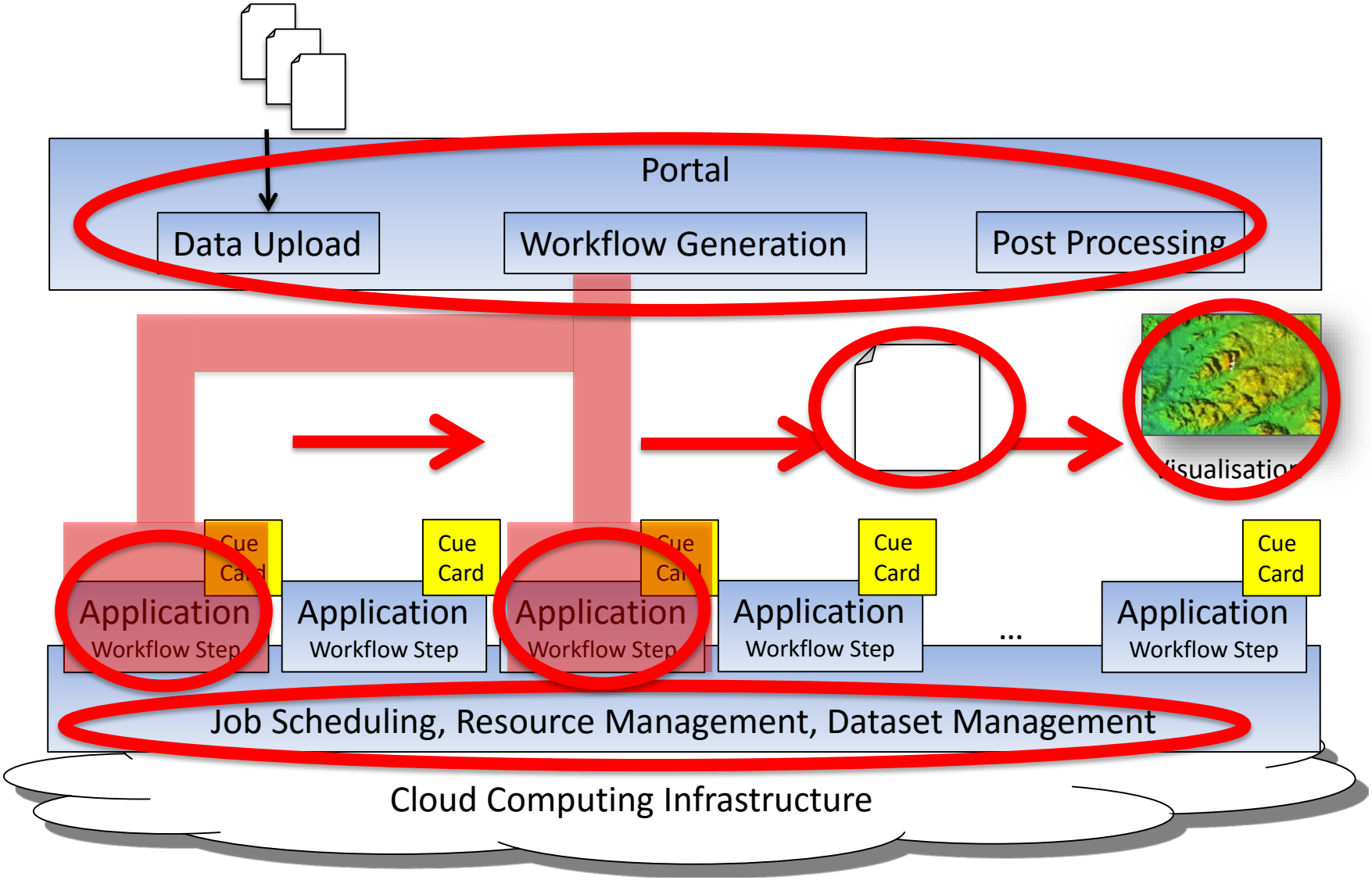




# CONCLUSIONS AND OUTLOOK

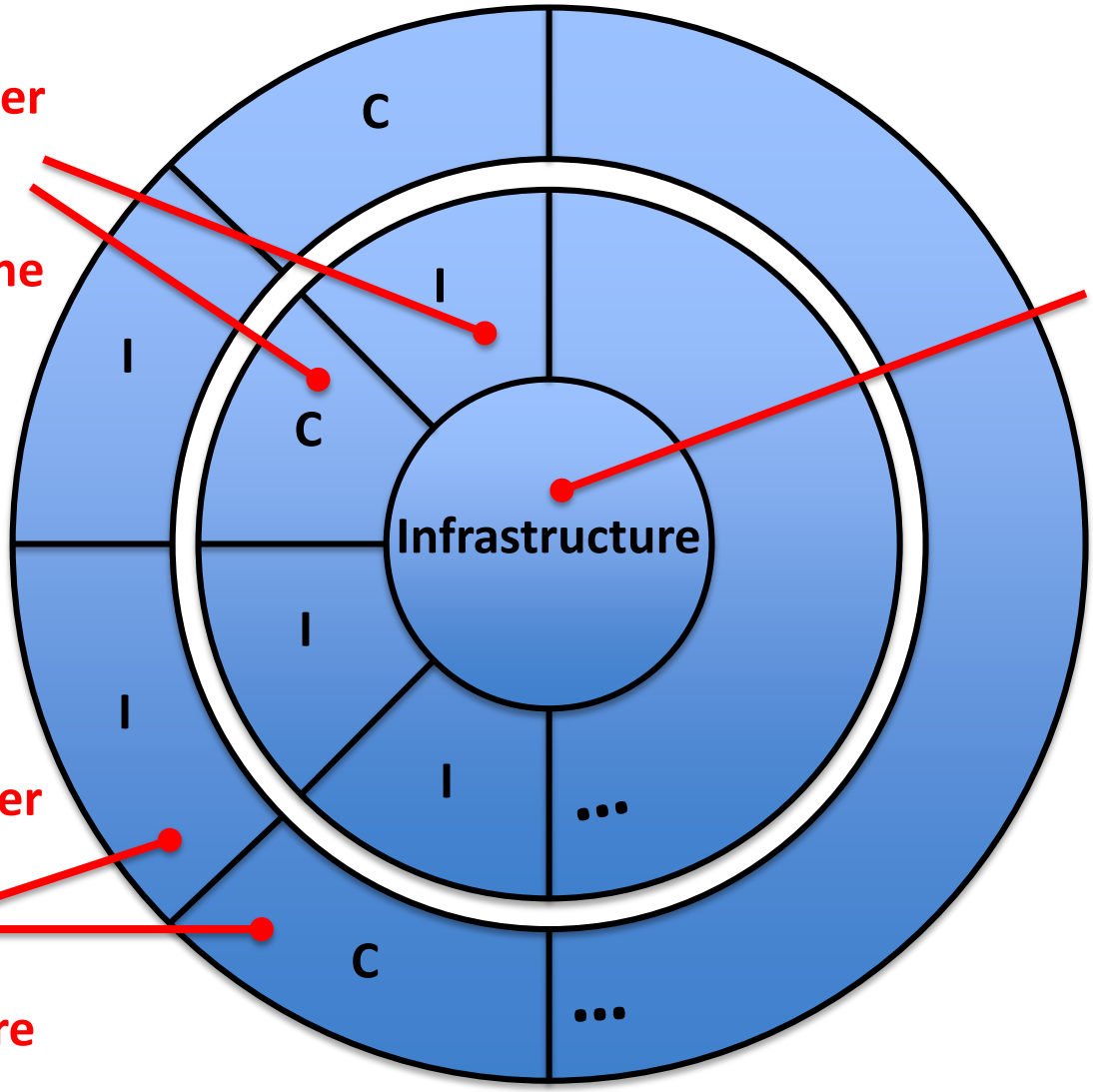
- Distributed and automated processing of satellite imagery for mapping flood and waterlogging is implemented
- Automatic preprocessing implemented based on image metadata parsing
- Algorithms for image analysis are implemented on a uniform platform - quicker, more efficient than the previous solution
- Important exploitation path for the post-project period: replacement of the old solution with IQmulus LS3 workflow
- Works for *Sentinel-2*, *Landsat* and *SPOT* satellite imagery – can be extended to other sensors


Portal
Data Upload
Workflow Generation
Post Processing
Cue Card
Application
Workflow Step
...
Job Scheduling, Resource Management, Dataset Management
Cloud Computing Infrastructure

# Exploitation

# EXPLOITATION ROSE

**Common and Individual partner exploitable outcomes dependent on the Infrastructure**




**Common exploitable outcome (IGD and MOSS)**

**Common and Individual partner exploitable outcomes independent of the Infrastructure**

**Common and individual exploitable outcomes includes:**

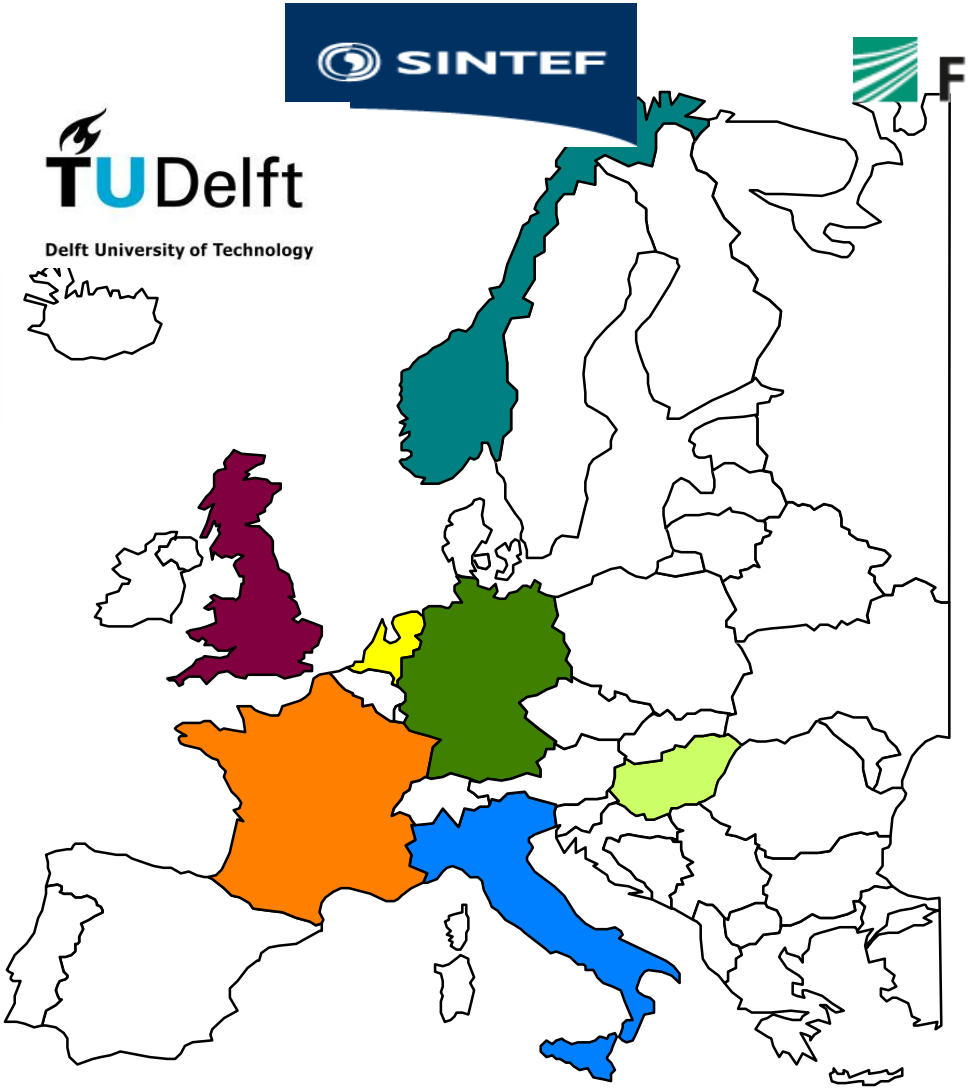
- **Infrastructure**
- **Workflows**
- **Processing services**
- **Visualization**

# SELLING POINT

*"…engagement with the two most relevant OGC (Open Geospatial Consortium) working groups (Point Cloud and Big Data) has indicated that the associated communities are some way off producing formal standards and toolsets which could be shaped by IQmulus partners."*

*IQmulus Exploitation Plan version 3.*

- IQmulus Selling Point is the presence of leading-edge workflow solutions to 'Point Cloud, Coverage and Volumetric Data' processing aspects of the geospatial data market place.


SINTEF
Fraunhofer
IGD
TU Delft
Delft University of Technology
HR Wallingford
Working with water
M.O.S.S.
Computer Grafik Systeme
Geoinformationssysteme
UCL
IGN
INSTITUT NATIONAL
DE L'INFORMATION
GÉOGRAPHIQUE
ET FORESTIÈRE
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